Space Research

1998 – 1999

in Switzerland

Artist's impression of XMM-Newton (ESA/Ducros)

Schweizerische Akademie der Naturwissenschaften SANW
Académie suisse des sciences naturelles ASSN
Accademia svizzera di scienze naturali ASSN
Academia svizra da scienzas natüralas ASSN
Swiss Academy of Sciences SAS

Contents

1 Introduction

The Committee for Space Research of the Swiss Academy for Natural Sciences coordinates and stimulates space research in Switzerland. It also maintains contacts with international organisations and in particular with ESA's science programme and COSPAR. It is thus responsible to produce every second year a report on space science activities in Switzerland for the COSPAR general assembly. This booklet is this report for the period 1998–1999.

Space reasearch in Switzerland is undertaken by many groups in the universities, federal institutes of technology and some private companies. The funding for this research comes mainly from these intitutions, the Swiss national science foundation and the federal governement. The research is not organised centrally. It is rather the sum of the efforts of the individual groups. It is hoped that the present report will give to the readers an idea of the richness of this research branch and help to identify the actors in Switzerland.

The Swiss organisation of space research in a large number of individual groups in many institutions makes it difficult to summarise in few lines the strengths of the programme. This is nonethless attempted in the next subsections. Our way of proceeding has the strength to allow groups to enter collaborations (mostly international) with a large variety of arrangements and a minimum in burocracy. It also makes it possible to develop unconventional ideas.

The bulk of the report is given by a number of contributions from individual research groups from many intitutions in Switzerland. Each has reported on their own research projects. These reports are expected to give the readers enough information to find the projects of interest to them and to locate the main institutes involved in Switzerland. Further information can be sought from the quoted literature or directly with the involved groups. The scattered nature of our space activities and the sometimes fuzzy boundaries of the subject also make it difficult to be complete in this report. Readers in Switzerland who may find that their activity was missed are invited to contact the commission for space research, c/o ISDC, 16,ch d'Écogia, CH-1290 VERSOIX.

Information on addresses of individuals and institutions may be obtained from the Swiss Space Office, Ms K. Bloch, Hallwylstrasse 4, CH-3003 BERNE.

1.1 Astrophysics, Solar system planets, Magnetosphere, Material science

Swiss scientists are strongly involved in the classical space research. They take part as well in the hardware developments for space missions (astronomical, Earth-Sun relations or Solar system exploration projects) as in researches based on the utilisation of existing instruments or on the retrieval from the archives of different missions.

All these research activities are performed in the framework of a fruitful international cooperation. They cover a wide range of projects from the astronomy in all wavelengths, the study of comets, of the Sun and the interplanetary medium, of the Moon and Mars. For astronomy, Swiss scientists use coherently and efficiently the complementarity of space and ground based instrumentation. Most of the space projects are implemented within the European Space Agency (ESA) Science programme (SOHO, XMM-NEWTON, INTEGRAL, FIRST, PLANCK, MARSEXPRESS, ROSETTA, etc.). Nevertheless some groups have developed bilateral collaborations with national space agencies like NASA for example (HESSI, IMAGE, AMS projects). In addition

to that, we have to mention two space centres in Switzerland. One is the International Space Science Institute (ISSI) in Bern which has developed its successful activities around the interdisciplinary interpretation and in depth studies of data from multi-experiment, multi-spacecraft programmes. The other one is the INTEGRAL Science Data Center (ISDC located close to the Geneva Observatory, which is the data world center of the imaging and spectroscopy gamma ray astronomy satellite of ESA INTEGRAL.
The Swiss scientists will also make use of the International Space Station (ISS) for experiments like SOVIM (PMOD Davos), ACES (Neuchâtel Observatory) or AMS (Geneva University). They will be placed on board of the ISS in a few years from now.
The diversity and requirements of projects where Swiss scientists are involved, sometimes in collaboration with Swiss industry, allow to push back the limits of their knowledge and their technical skill. Moreover they also play an important role for the formation of young engineers and scientists.

1.2 Earth Observation activities in Switzerland during 1998 and 1999

Earth Observation activities are carried out at many Universities, Federal Research Institutes and the Federal Institute of Technology. Especially active are: the Universities of Berne (Astronomical Institute), Basel (Institute of Meteorology, Climatology and Remote Sensing), and Zurich (Remote Sensing Laboratories); the ETH Zurich (Computer Vision Lab and the Institute for Geodesy and Photogrammetry); and the Federal Institute for Forest, Snow and Landscape research as well as the Swiss Meteorological Institute. In addition, it is worthwhile noting the establishing of two value added companies, which are not exclusively bound for commercial activities but are also project leaders in research projects.
These Swiss actors are collaborating with agencies, institutes, laboratories, museums, research centres, and companies within Switzerland and around the world, the main partners being located in Austria, Canada, France, Germany, Italy, the Netherlands, Sri Lanka, and UK. Activities are based on a fleet of Earth Observation satellites from ESA, the USA, India, Canada and Japan and can be grouped under four themes:

1. Technical and preparatory studies; basic research

   The projects listed below are very upfront, aiming at the development of new techniques, the extraction of new information from existing data, or the creation of virtual reality in a 3D landscape.

   - terrain geocoding without manual tiepoints
   - upscaling of land surface processes from local to regional to global scale
   - extraction of bio- and geophysical parameters from the vegetation cover's backscattering
   - radiation and heat flux in complex alpine terrain
   - representation of meteorological effects within interactive 3D landscape simulation

2. Research activities with application potential

   The projects under this theme base themselves on proven data taking techniques and aim at refining the extraction of information. For real-time or near-real-time applications,

faster processing is a clear objective as is the technology transfer from University to value added companies. The pre-operational or prototype systems thus created carry often the potential for real operational services.

- natural hazards and disaster monitoring system for the production of damage maps
- geophysical displacement and subsidence mapping at millimetre to meter scale
- alpine monitoring system for major planning projects
- rice yield predictions in Sri Lanka and Thailand to allow the government to take measures to guarantee price stability
- forest maps over regions with limited information available (Siberia) to support a sustainable forest management
- geo-ecological processes in particular the snow melt over large areas
- snowmelt at high latitudes and its consequences on climate and terrain conditions
- potential of imaging spectroscopy for environmental analysis in inland waters
- cloud-top products for weather forecasting and climate change analysis
- life cycle analysis of heavy precipitation events on the Southern side of the Alps
- archaeology: ancient irrigation systems in Yemen

3. Operational applications and services

   Projects in this section have either the objective of developing an operational product and service or continue to offer such a service. Some of them have good commercial prospects, other serve world-wide research communities.

   - daily and seasonal snowmelt and runoff forecasting in Switzerland
   - development of operational tools for forest fire detection and burnt surface mapping
   - development of climate analysis maps for planning purposes (land use, urban development)
   - orbit determination of GPS (accuracy 5 cm) and estimation of Earth Rotation parameters (accuracy 5 mm)
   - geodynamics of the solid Earth (gravity field, precision positioning, movement of continental plates)
   - space debris survey campaigns

4. Instruments, Data retrieval, and Centres of Competence

   In this last group one can find the first Swiss instrument development for Earth Observation and a project dealing with intelligent retrieval mechanisms from an ever increasing national archive for Earth Observation satellite data.

   - development of the APEX spectrometer as testbed for spaceborne instruments and as precursors for planned land surface process mission.
   - retrieval system for the rapidly growing volume of EO data

   Finally, the competence of the RSL Zurich has led ESA to declare this laboratory the European ASAR Expert Support Laboratory (main activity: product studies and simulations)

1.3 Microgravity Research in Switzerland during 1998 and 1999

The closing of MIR-operations and the anticipation of an operational ISS (International Space Station) have severely limited the flight opportunities for experiments in weightlessness during the past two years leading to a reduced Swiss participation in ESA-NASA programmes. While the assembly of the ISS will fully occupy the US Space Shuttle fleet, users in Switzerland will prepare their future experiments on the ISS by making use of parabolic flights and sounding rockets. There will be only two Space Shuttle flights dedicated to research in weightlessness between now and 2002.

2 Astrophysics

2.1 Symbiotic binaries

Institute: Institute of Astronomy, ETH Zürich

Principal Investigator: Prof. H. Nussbaumer

Co-investigators:
PD Dr. W. Schmutz
Dr. Th. Dumm
Dr. D. Folini
Dr. U. Mürset
Dr. H. Schild
Dr. R. Walder

Method: Theory. Research based on direct observations with existing instruments or retrieval from the archives: ISO, ROSAT, HST, IUE, ORFEUS. We also heavily rely on ground based telescopes at ESO, CFHT, WHT, OHP.

Purpose of research: We study symbiotic binary stars in their late stage of evolution. Mass exchange and stellar radiation are the crucial processes of interaction. Heavy mass-loss is certain from the cool giant, and it is also observed in some of the hot white dwarf companions. Mass-loss is detected either directly as a stellar wind, or it manifests itself in the nebular environment. We study the physical properties of the stellar atmospheres, the rate and mechanisms of stellar mass loss, and the fate and chemical composition of the matter lost. As mass loss may occur on both stars, we are faced with the hydrodynamical problem of colliding winds and their shock zones, and in some cases there may be mass-accretion on the white dwarf from the wind of the red giant. The study of the corresponding physical properties and processes demands observationally a wide wavelength coverage, space observations are therefore crucial.

Status: Symbiotic stars contain a red giant and an active white dwarf. The interaction of both winds creates a highly structured nebular environment. We have developped computer codes to treat in three dimensions the hydrodynamic phenomena which occur in that nebular environment. Because of the wide range of temperatures, from cool dust (at around 1000 K) to high temperature wind-wind collision fronts (higher than 1'000'000 K), we need to cover the spectral domain from hard X-ray to the infrared. The red giant is studied preferentially with ISO and from ESO ground based telescopes, whereas the hot companion as well as the winds and the nebular structure are studied with observations from IUE, ORFEUS, ROSAT, ISO, and HST. We have again been successful with an application for observing time on HST for the observing cycle 9.

Publications:
We have published a variety of relevant articles in refereed journals, and conference reviews, the following three are just representatives of different applications and instruments involved.

1. T. Dumm, D. Folini, H. Nussbaumer, H. Schild, W. Schmutz, R. Walder: 2000, Astron.Astrophys., 354, 1014. A wind accretion wake in RW Hydrae?

2. Dumm, W. Schmutz, H. Schild, H. Nussbaumer: 1999, Astron.Astrophys., 349, 169.

Circumstellar matter around M-giants in symbiotic binaries: SY Muscae and RW Hydrae.

3. H. Nussbaumer: 1998, ESA SP-413, 333 (invited review). IUE and our understanding of symbiotic stars.

Abbreviations:

CFHT:	Canadian-French Hawaii Telescope
ESO:	European Southern Observatories
HST:	Hubble Space Telescope
ISO:	Infrared Space Observatory
IUE:	International Ultraviolet Explorer (the archives are now an important source of information)
OHP:	Observatoire de Haute Provence
ORFEUS:	Orbiting and Retrievable Far and Extreme Ultraviolet Spectrometer
ROSAT:	Röntgen Satellit
WHT:	William Herschel Telescope

2.2 Calibration of Nearby Type Ia Supernovae as Standard Candles

Institute: Astronomisches Institut der Universitaet Basel
In cooperation with:
The Carnegie Observatories, USA;
National Optical Astronomy Observatories, USA;
and the Space Telescope Science Institute, USA.

Principal Investigator: A. Sandage (Carnegie)

Co-investigators:
L.Labhardt (Basel)
F.D. Macchetto (STScI)
N. Panagia (STScI)
A. Saha (NOAO)
G.A. Tammann (Basel)

Method: Research based on existing instuments:
Hubble Space Telescope / Wide Field and Planetary Camera

Purpose of research: The Hubble Space Telescope (HST) has been used to determine the distances of six selected galaxies by means of their Cepheid variables. Cepheids are the most reliable distance indicators in astronomy. The Cepheids in the six target galaxies are too faint to be dicovered and observed from the ground and require HST. The galaxies have been selected because they have produced well observed supernovae of type Ia (SNe Ia). Using only *relative* distances we have demonstrated that blue SNe Ia are by far the best "standard candles" i.e. that they repeat their absolute luminosity at maximum light with amazing accuracy. If only the *absolute* amount of this luminosity was known, they would be ideal distance indicators out to very large distances (their extremely high luminosity allows them to be observed at truly cosmological distances).
It is here that the SNe Ia jump in whose parent galaxies have known Cepheid distances and whose true luminosity is therefore known. If their *mean* true luminosity is applied to 35 more distant SNe Ia (out to recession velocities of 30000 km/s), one can map the cosmic expansion field with unparalleled accuracy.

The result is best summarized by the Hubble constant H_0 which is found to be H_0 60 km/s/Mpc with an error of hardly more than 10%. The corresponding expansion age of the Universe, taking also into account the cosmological constant Λ (which has recently been derived from still more distant SNe Ia), is 15×10^9 years which is in perfect agreement with all other independant distance determinations. Forthcoming Cepheid distances for relatively local SNe Ia will be used to strengthen their luminosity calibration and hence to narrow down the possible range of H_0.

Status: In 1999 repeated images were obtained of the target galaxy NGC 4527 (host of SN 1991T) with the Wide Field Camera of the HST. Data reduction and analysis are in progress. Another galaxy (NGC 3982, host of SN 1998aq) will be observed in summer 2000.
Image processing of these unique datasets is a both complex and laborious task. The extremely undersampled data from WFPC2 pose interesting challenges in the way of extracting maximum information of faint stars in crowded fields. There is also a great paucity of calibration standards and data to tie observations to a standard photometric system. After having developed a self-consistent approach to cope with this situation utilizing sophisticated programs for object detection and photometry, we recently examined the methodology of obtaining Cepheid-based distances from WFPC2 images by analyzing the sources of error and how these propagate to the derived distances.
Futhermore, we are exploring the differences in both quantity and quality of photometric measurements (and thus the derived distances) obtained by applying different software packages to the same set of data.

Publications:

1. Saha, A., Sandage, A., Tammann, G.A., Labhardt, L., Macchetto, F.D., & Panagia, N. 1999, Astrophys. J. 522, 802-838: Cepheid Calibration of the Peak Brightness of Type Ia Supernovae. IX. SN 1989B in NGC 3627

2. Saha, A., Labhardt, L., & Prosser, Ch. 2000, Publ. Astronom. Soc. Pacific, 112, 163-176: On Deriving Distances from Cepheids Using the Hubble Space Telescope

3. Parodi, B.R., Saha, A., Sandage, A., & Tammann, G.A. 2000, Astrophys. J., in press: Supernova type Ia luminosities, their dependence on second parameters, and the value of H_0

2.3 Search for ionized material around Cyg X-3

Institute: Institut for Astronomy, ETH Zuerich)
In cooperation with:
Institut for Astronomy, Honolulu
Joint Astronomy Centre, Hilo

Principal Investigator: Werner Schmutz

Co-investigators:
Laird Close (IfA, Honolulu)
Tom Geballe (JAC, Hilo)
John Rayner (IfA, Honolulu)
Hans Schild (IfA, Zuerich)
William D. Vacca (IfA, Honolulu)
Rolf Waslder (IfA, Zuerich)

Method: Research based on existing instuments:
Observations with the Hubble Space Telescope

Purpose of research: Abstract of the HST proposal (Proposal Id: 07838)
Models of the evolution of massive binaries predict that a few such objects should survive the common envelope phase and result in systems containing a compact object plus a Wolf-Rayet star (c+WR). According to these models, a vast amount of stellar material is lost during the common envelope phase prior to the c+WR phase. We propose to test these models by searching for the presence of this circumbinary material around the only known c+WR object: Cyg X-3. Since the large reddening towards Cyg X-3 prevents any investigation in the optical, deep exposures with NIC-2 and the Pa-alpha narrow band filter centered on Cyg X-3 will be used to image the system at high spatial resolution. By exposing NIC-1 and NIC-3 in parallel, we will simultaneously cover spatial scales up to 100. (Although NIC-3 will be out of focus its Pa-alpha images will still be superior to ground-based images.)
We have already attempted to image Cyg X-3 from the ground using adaptive optics techniques on a 4m telescope. Our exposure yielded a marginal detection of extended nebular emission. While further ground based observations will not significantly inprove upon these images, observations with NICMOS will yield much deeper images. Our goal is to obtain a clear detection of the nebular Pa-alpha emission, the strength of which can be used to estimate the initial mass of the WR star; its morphology can be used to constrain models of the mass loss during the common envelope phase.

Status: Observations obtained in two visits of 3 orbits and 4 orbits, respectively, on March 25, 1998 and August 27, 1998.
Data reduction is finished and the data analysis is on-going. First results have been published. A publication (together with results from ground based observations) in ApJ is in preparation.

Publications:

1. First results are published in:
   Schmutz W., Vacca W.D., Close L., Rayner J., Geballe T.R., Schild H., Walder R., 1998. In: Freudling W., Hook R. (eds.) NICMOS and the VLT: A New Era of High Resolution Near Infrared Imaging and Spectroscopy. ESO CWP No. 55, p. 123–132 HST NICMOS Observations of Circumstellar Matter Around CYG X-3

2. A publication in a major journal is in preparation:
   Vacca et al. 2000, ApJ, in preparation.

Abbreviations:

HST:	Hubble Space Telescope
NICMOS:	Near Infrared Camera and Multi-Object Spectrometer

2.4 VIRGO Investigation on SOHO

Institute: PMOD/WRC, Davos
In cooperation with:
IRMB, Bruxelles
IAC, Tenerife
SSD of ESA
Noordwjik (only H/W institutes)

Principal Investigator: Claus Frohlich

Co-investigators:

Andersen, B., Anklin, M.,Appourchaux, T.,
Berthomieu, G., Crommelynck, D.A., Dewitte, S., Domingo, V.,
Finsterle, W., Gough, D.O.,
Jimènez, A., Joukoff, A., Leifsen, T., Pap, J.M.
Provost, J., Roca-Cortès, T., Sekii, T.,
Toutain, T., Wehrli, C.

Method: Research based on existing instuments:
VIRGO (Satellite)

Purpose of research: Solar irradiance variability and Helioseismology with two type of absolute radiometers, sunphotmeters and a luminosity oscillation imager.

Status: Running Experiment on a running spacecraft

Publications:

1. Toutain, T., Appourchaux, T., Fröhlich, C., Kosovichev, A., Nigam, R. and Scherrer, P.: 1998a, Asymmetry and frequencies of low-degree p-modes and the structure of the sun's core, Astrophys. J. 506, L147 – L152.

2. Fröhlich, C. and Lean, J.: 1998b, The sun's total irradiance: Cycles and trends in the past two decades and associated climate change uncertainties, Geophys. Res. Let. 25, 4377 – 4380.

3. Appourchaux, T., Fröhlich, C., Andersen, B., Berthomieu, G., Chaplin, W., Elsworth, Y., Finsterle, W., Gough, D., Hoeksema, J., Isaak, G., Kosovichev, A., Provost, J., Scherrer, P., Sekii, T. and Toutain, T.: 2000, Observational upper limits for low-l solar g modes, Astrophys. J., in press.

Abbreviations:

VIRGO:	Variability of Irradiance and Gravity Oscillations
SOHO:	Solar and Heliospheric Observatory

2.5 SIMBA Balloon Experiment

Institute: PMOD/WRC, Davos
In cooperation with: Observatoire de Geneve

Principal Investigator: Claus Frohlich

Co-investigators:

Anklin, M., Pepe, F., Wehrli, C.,

Method: Research based on existing instuments: SIMBA
Instrumentation used for SIMBA flights (the 1998 one was the seventh in a series). Balloon

Purpose of research: Solar irradiance variability and check of instruments in space: VIRGO on SOHO

Status: N/A

Publications:

1. Anklin, M., Wehrli, C., Fröhlich, C. and Pepe, F.: 1999, Total solar and spectral irradiance measured in France during a stratospheric balloon flight, in B. Kaldeich (ed.), 14th ESA Symposium on European Rocket and Balloon Programmes and Related Research, ESA SP-437, ESA Publications Division, Noordwijk, The Netherlands, 537–740.

Abbreviations:

SIMBA:	Solar Irradiance Monitoring from Balloons
VIRGO:	Variability of Irradiance and Gravity Oscillations
SOHO:	Solar and Heliospheric Observatory

2.6 SOVIM Investigation on ISS

Institute: PMOD/WRC, Davos
*In cooperation with:*IRMB, Bruxelles
SSD of ESA, Noordwjik
(only H/W institutes)

Principal Investigator: Claus Frohlich

Co-investigators:
Appourchaux, T., Crommelynck, D.A., Dewitte, S., Domingo, V.,
Fleck, B., Joukoff, A., Lean, J., Ruedi, I.,
Schmidtke, G., Thuiller, G., Wehrli, C.

Method: Research based on existing instuments:
2 type of radiometers (PMO6-V, DIARAD), SPM, TASS (Satellite)

Purpose of research: Solar irradiance variability and spectral redistribution with two type of absolute radiometers and sunphotmeters (continuation of VIRGO, but no helioseismology)

Status: Planing in due course, manufacturing started

Publications:

1. Thuiller, G., Fröhlich, C. and Schmidtke, G.: 1999, Spectral and total solar irradiance measurements on board the international space station, Proceedings of the 2nd European Symposium on the Utilisation of the International Space Station, ESA Publications Division, ESA SP 433, Noordwijk, The Netherlands, 605 – 611.

Abbreviations:

SOVIM:	Solar Variability and Irradiance Monitoring
VIRGO:	Variability of Irradiance and Gravity Oscillations
SOHO:	Solar and Heliospheric Observatory

2.7 XMM - RGS; X-Ray Multi Mirror Mission, Reflection Grating Spectrometer

Institute: Paul Scherrer Institut
In cooperation with:
SRON,
MSSL,

Columbia Univ.,
Swiss Industry

Principal Investigator: A. Zehnder, Bert Brinkman, S. Kahn, G. Branduardi

Method: Detector
Development and construction of own instruments:
Housing and Cooling System, Door Mechanism, Front End Electronics

Purpose of research: ESA's XMM satellite, launched on December 10, 1999, studies high-energy processes across the universe with unprecedented sensitivity. Its large collecting area combined with its imaging and spectral capabilities will give access to thousands of X-ray sources, ranging from nearby planets and comets to stars, supernovae, and distant galaxies. XMM achieves high energy resolution in the combined first and second order of diffraction in the wavelength range between 5 and 35 Angstrom. During its anticipated lifetime of ten years, a wealth of new insights into astrophysical processes is expected.

Status: XMM was launched after a flawless launch campaign on December 10, 1999. The commissioning phase which checked out and tested the spacecraft and its instruments began on 4 January. Since that date, the satellite has shown that it is functioning in orbit entirely as planned and that its X-ray and optical cameras are living up to expectations, as was vividly shown in the very first images officially presented on 9 February. Besides preparing for the operational phases of the instrument PSI lately was busy with performing thermal measurements on the Flight Spare Model of RGS.

Publications:

1. A.C. Brinkman et al., "The Reflection grating spectrometer on-board of XMM", SPIE vol 2808, 463, 1996

2. A.C. Brinkman et al., "The Reflection Grating Spectrometer on XMM", proceedings of the first XMM workshop, vilspa.esa.es, 1998

3. J.W. den Herder et al., "Description and Performance of the Reflection Grating Spectrometer on board XMM", SPIE Conference, Munich 2000

Abbreviations:

MSSL:	Mullard Space Science Laboratory
RGS:	Reflection Grating Spectrometer
SRON:	Space Research Organisation of the Netherlands
XMM:	X Ray Multi Mirror Mission

2.8 Integral radiation environment monitor irem

Institute: Paul Scherrer Institut / Laboratory For Astrophysics
In cooperation with:
CS AG
ESA ESTEC

Principal Investigator: Dr. Alex Zehnder

Method: Development and construction of own instruments:
Radiation monitors for space environment measurement and for spacecraft dose/dose rate status check and alert

Purpose of research: Radiation environment in space causes serious hazards for manned and unmanned space missions. Several satellites suffered large damages due to high radioactive dose obtained e.g. during sun related events like solar mass injections. In addition to such random phenomena, there are permanent radiation belts of trapped particles around the Earth's. Similar belts were already discovered around all planets and moons where magnetic fields are present. Therefore, for any space exploration one must take into account malfunctioning probability and lifetime reduction factors due exposure to space radiation.
The PSI monitor will be mounted on board of the INTEGRAL ESA mission to be launched in 2001. The IREM's main task will be to detect radiation environment of the satellite, report it to the health monitoring system and issue alert signals in case of radiation danger. It will allow the mission control system to protect sensitive devices by turning them off or switching into sleeping mode.
The IREM will also enhance scientific mission objectives with helping to determine on-line charged particle background in INTEGRAL detectors. In addition to spacecraft related functions, the IREM will conduct permanent survey of the radiation environment producing actual maps of proton and electron spectra around the Earth. It will allow for necessary updates of existing static radiation models and will give impact on development of dynamic ones.
As the mission begins during solar maximum it will be also possible to determine active and transition phase sun effects on the space particle population. This data are indispensable for studying Earth-Sun correlation's and for space weather forecasting. As the IREM will fly simultaneously with other similar instruments it will be possible to perform global mapping greatly improving existing knowledge about proton and electron radiation environment in space.

Status: The IREM fabrication entered the latest phase. The EM model of the monitor was successfully tested and calibrated in 1998. Its integration tests in Alenia(Torino) were completed during 1999. The FM is already manufactured and currently subjected to series of full performance tests. The random vibration tests and radioactive sources check were also completed. Calibration runs using proton beams and electrons are scheduled for April 2000. Subsequent delivery to Alenia is planned for end the month. In Alenia the detector will undergo integration procedures and tests on board of the spacecraft.
In addition to HW production, the monitors requires extensive calculations of its response capabilities. They must be supported and verified by careful calibration runs with protons, electrons and gamma rays. The response data bank for stand alone monitor is already completed for these particles. The full response function additionally requires including of the satellite and its instruments. Preparation of the whole data base to calculate responses for monitor mounted on the spacecraft has already started.

Publications:

1. "SREM detector mass model for response function calculations"
   W. Hajdas, PSI Annual Report 1997/ Annex IIIA, p156

2. "Simple instruments for continuous measurements of trapped particles"
   P.Buehler et al., ESA SP-392 Symposuim on Environment Modeling for Space Based Applications, ESTEC, Noordwijk 1996, p87

3. "Radiation Environment Monitor", P.Buehler et al., Nucl. Inst. and Meth. A368(1996) 825

Abbreviations:

INTEGRAL:	International Gamma-Ray Astrophysics Laboratory
IREM:	Integral Radiation Environment Monitor
PSI:	Paul Scherer Institute
LAP:	Laboratory for Astrophysics
CS AG:	Contraves Space AG
ESA:	European Space Agency
ESTEC:	European Space Research and Technology Centre
HW:	Hardware
SW:	Software
EM:	Engineering Model
FM:	Flight Model

2.9 The Sun in Time

Institute: Paul Scherrer Institute, Laboratory for Astrophysics (M. Güdel)
In cooperation with:
SRON, Utrecht, Netherlands
Villanova University
JILA, University of Colorado, Boulder, CO, USA
Jet Propulsion Laboratory, Pasadena, CA, USA
ESTEC, The Netherlands

Principal Investigator: M. Güdel (PSI)

Co-investigators:
M. Audard (PSI)
E.F. Guinan (Villanova Univ.)
R. Mewe (SRON)
E. Gaidos (JPL)
S.L. Skinner (JILA)
F. Favata (ESTEC)

Method: Research based on existing instuments:
ROSAT, EUVE, ASCA, BeppoSAX, XMM-Newton, FUSE, complemented with ground-based radio observations (VLA)

Purpose of research: By studying a sample of stars with masses and sizes like the Sun's, but with different rotation periods and thus ages, we can infer the role of declining rotation periods on the operation of the magnetic dynamo in a star like the Sun. By implication, we derive information about the young Sun, which is of prime importance for the formation of planetary atmospheres and the prebiotic Earth. The project will indicate to what extent the overall magnetic activity level reflects in the coronal heating efficiency, the coronal temperature structuring, and coronal abundances. Important implications for the conditions in young planetary atmospheres are drawn.

Status: From the analysis of a comprehensive sample of ROSAT, ASCA, BeppoSAX, and EUVE data, we have derived the temperature stratification of the coronal plasma at different

stages of a solar-mass star's evolution. Characteristic temperature decay laws suggest that coronal heating works with an increasing efficiency for increasing activity level.
Presently, several sets of EUVE data are being analyzed to complete the coverage of the EUV region for all ages of a solar-type star. We are constructing spectral irradiance tables of the Sun at different ages from the optical to the X-ray range. SAX data have been obtained and are being analyzed.
Complementary radio data from young solar analogs have given upper limits to the mass loss of the young Sun and have constrained the maximum optical luminosity at the epoch of the formation of the solar system. A particularly active young solar analog has been identified in the 47 Cas system. The companion appears to be a solar analog at an age of about 100 Myr as derived from its properties in the X-ray, radio, and infrared regime.
At the other end of the age range, we have derived X-ray properties of alpha Centauri, a close stellar analog to the present-day Sun.

Publications:

1. Güdel, M., Guinan, E. F., and Skinner, S. L. (1997)
   The X-Ray Sun in Time. A Study of the Long-Term Evolution of Coronae of Solar-Type Stars.
   The Astrophysical Journal, 483, 947

2. Gagne, M., Valenti, J. A., Linsky, J. L., Tagliaferri, G., Covino, S., Güdel, M. (1999)
   The Active Corona of HD35850
   The Astrophysical Journal, 515, 423

3. Güdel, M., Gaidos, E. (2000) Deep VLA Observations of Young Solar Analogs.
   In 11th Cambridge Workshop on Cool Stars, Stellar Systems, and the Sun. Eds. R. G. Lopez and & R. Rebolo (San Francisco: PASP), in press

Abbreviations:

ASCA:	Advanced Satellite for Cosmology and Astrophysics
BEPPOSAX:	Satellite per Astronomia in Raggi X (X-ray satellite, Italy/Netherlands)
EUVE:	Extreme Ultraviolet Explorer
FUSE:	Far-Ultraviolet Explorer
ROSAT:	Röntgensatellit
VLA:	Very Large Array
XMM-NEWTON:	X-Ray Multi-Mirror Mission of ESA

2.10 Coronal and flare structures on magnetically active stars

Institute: Paul Scherrer Institute, Laboratory for Astrophysics (M. Güdel)
In cooperation with:
JILA, University of Colorado, Boulder, CO, USA
CASA, University of Colorado, Boulder, CO, USA
The Institute of Space and Astronautical Science ISAS) Sagamihara, Japan
ETHZ, Zürich
SRON-Utrech

Principal Investigator: M. Güdel (PSI)

Co-investigators:

M. Audard (PSI)
K. W. Smith (PSI/ETHZ)
A. O. Benz (ETHZ)
S.L. Skinner (JILA)
J. L. Linsky (JILA)
A. Brown (CASA)
F. Nagase (ISAS)
R. Mewe (SRON/Utrecht)

Method: Research based on existing instuments:
ASCA, ROSAT, XMM-Newton, coordinated with ground-based radio (VLA, VLBA) and optical observatories

Purpose of research: Several extremely active stars with saturated coronae are observed in different X-ray and multi-wavelength campaigns in order to study:

1. the physics of coronal heating in luminous, very hot coronae,
2. the physics and structure of large coronal flares,
3. the geometric structure of active coronae. Multiwavelength studies allow us to probe different layers of the atmosphere and different physical mechanisms.

Status: UX Ari, a RS CVn-type active binary, has been observed with ASCA, the VLA, and VLBA. A large, gradual outburst in soft X-rays has been interpreted with a two-ribbon flare model including an approximate treatement of radiative and conductive losses. Geometrically large ($\sim 1R^*$) magnetic structures are suggested. We also find that during the early flare phases, the elemental abundances of the coronal plasma change considerably, indicating that chromospheric material is fractionated and selectively brought into the corona. Near-simultaneous VLBA observations show that the pre-flare corona is very extended as well ($>$ the stellar components), with indications of ordered magnetic fields on length scales of the binary separation (as seen in polarization maps). We have extended these studies to pre-main sequence stars with unusually high levels of X-ray activity. Further observations have been implemented into the XMM-Newton guaranteed time project in which we participate.

Publications:

1. Güdel, M., Linsky, J. L., Brown, A., Nagase, F. (1999), Flaring and Quiescent Coronae of UX Arietis: Results from ASCA and EUVE Campaigns. Astrophys. J., 511, 405
2. Smith, K. W., Güdel, M., Benz, A. O. (1999), Radio Counterparts to Extreme X-Ray YSOs. Astron. Astrophys., 349, 475
3. Beasley, A. J., Güdel, M. (1999), VLBA Imaging of Quiescent Radio Emission from UX Arietis Astrophys. J., 529, 961

Abbreviations:

ASCA:	Advanced Satellite for Cosmology and Astrophysics
ROSAT:	Röntgensatellit
SAX:	Satellite per Astronomia in Raggi X

VLA: Very Large Array
VLBA: Very Large Baseline Array
XMM-NEWTON:
X-Ray Multi-Mirror Mission of ESA

2.11 Stellar Physics with XMM-Newton

Institute: Paul Scherrer Institute, Laboratory for Astrophysics (M. Güdel)
In cooperation with:
SRON, Utrecht, The Netherlands
MSSL, London
Columbia University, New York

Principal Investigator: M. Güdel (PSI) & Rolf Mewe (SRON)

Co-investigators:

Several researchers at SRON, MSSL, Columbia, PSI/ETHZ (XMM-Newton RGS Science Team)

Method: Research based on existing instuments:
The Reflection Grating Spectrometers (RGS) on board of XMM-Newton

Purpose of research: PSI is responsible for the construction of a part of the Reflection Grating Spectrometer on board of the ESA Cornerstone Mission XMM-Newton, launched in December 1999. Like the other PI/CoI institutes, PSI will participate in a large guaranteed observing program. PSI has, together with SRON/Utrecht, taken the responsibility to set up a science-driven observing program for stellar physics, including cool stars (coronae) and hot stars (winds, in collaboration with ETHZ). The data will provide unique access to high- resolution spectroscopy of coronal plasmas (density, velocity, temperature, emission measure diagnostics) as well as to imaging and variability studies by also making use of the EPIC cameras. Further, we have access to a large sample of sources observed in the Calibration/Performance-Verification phase during the first three months of the mission.

Status: The RGS Consortium has set up working groups across the participating institutes, concentrating on a number of science topics. Our stellar working group has performed extensive feasibility studies using newly constructed effective areas and response matrices, and has thus established two coherent projects (one on cool stars, the other on hot stars). The total observing time of 905 ks for about 30 bright stellar targets has been fine-tuned by agreements with other, non-RGS XMM working teams. The target list is presently used to define a number of new projects. As a result of the feasibility investigations, a characterisation of the RGS instrument in terms of diagnostics capabilities is now available for use by the community at large.
Actual observations started shortly after the commissioning phase, in January 2000. First results show that the science performance of the instrument is nominal. The first two stellar sources show bright X-ray spectra rich in atomic emission lines at many ionization stages.

Publications:

1. Güdel, M., Mewe, R., Brinkman, A. C., Kaastra, J. S., Paerels, F., Kahn, S., Rasmussen, A., Harra-Murnion, L., (1998), X-Ray Spectroscopy Diagnostics with XMM: New Propsects for the Physics of Thermal, Optically Thin Plasmas. Proceedings of the First XMM Workshop, Ed. M. Dahlem,

2. Paerels, F., Brinkman, A., den Herder, J.W., de Vries, C., den Boggende, A., Mewe, R., Kaastra, J., Kahn, S., Rasmussen, A., Decker, T., Stern, M., Cottam, J., Spodek, J., Branduardi-Raymont, G., Güdel, M., Liedahl, D.A., Erd, C., (1998), High-Resolution Spectroscopy with XMM. Proceedings of the First XMM Workshop, Ed. M. Dahlem, `http://astro.estec.esa.nl/XMM/news/ws1_top.html`

3. Güdel, M., Mewe, R. (1998), X-Ray Spectroscopy Diagnostics with XMM and AXAF: Prospects and Challenges. 10th Workshop on Cool Stars, Stellar Systems, and the Sun. Cambridge, July 15-19, 1997. Eds. R. A. Donahue & J. A. Bookbinder (San Francisco: Astronomical Society of the Pacific), 1051

Abbreviations:

EPIC: European Photon Imaging Camera on board of XMM-Newton
RGS: Reflection Grating Spectrometer on board of XMM-Newton
XMM-NEWTON: X-Ray Multi-Mirror Mission of ESA

2.12 Alpha Magnetic Spectrometer (AMS)

Institute: University of Geneva
In cooperation with:
ETH Zurich
international collaboration of 41 institutes worldwide

Principal Investigator: Prof. S. C. C. Ting, MIT

Co-investigators:
David Vite
among more than 100 co-investigators

Method: Development and construction of own instruments:
development, construction and usage of a new detector to measure the charged components of cosmic ray outside the atmosphere.
Others: ISS and STS

Purpose of research: The abundance of matter and the apparent absence of antimatter nuclei (antihelium, anticarbon) in the universe is one of the great puzzles in particle physics and cosmology. Theories which predict either the existence of antimatter in segregated domains or the total absence of antimatter require speculative new physics ingredients and lack experimental data to be confronted with. One of the main purposes of the AMS experiment is to search for antimatter in cosmic radiation, with a sensitivity of at least four orders of magnitude better than presently achieved.
The improvement in sensitivity that AMS will provide for the search for antimatter will be critical in the goal of detecting cosmic rays from potential antimatter domains. Previous experiments have lacked the sensitivity required to sample the extragalactic component of cosmic rays in our galaxy. Evidence for the existence of antimatter domains cannot be inferred from the presence of antiprotons in cosmic rays since these can be produced in collisions of ordinary high energy cosmic rays with ordinary interstellar matter. Unlike this secondary production of antiprotons, it is exceedingly difficult to produce heavier antinuclei by such processes. Antihelium and anticarbon nuclei can only be produced by stellar nucleosynthesis processes in antimatter domains.

AMS will also be able to make a number of important measurements of cosmic ray physics, in addition to the search of antimatter. The long term exposure of AMS on ISS will lead to data of unprecedented precision on the cosmic ray flux and its variations. The study of electrons and positrons is also particularly interesting as their propagation in the interstellar space is affected by many mechanisms that heavier particles are insensitive to, like synchrotron radiation, bremsstrahlung and Compton scattering of photons, as well as the cosmic microwave background. The ratio of positrons over electrons is an important tool to determine the origin of the electric component of cosmic rays. AMS will also be able to improve the precision of isotopic composition measurements of the light isotopes of H, He and Li, which will lead to a better understanding of cosmic ray propagation.

AMS has also the opportunity to be the first instrument capable of measuring astrophysical photons up to TeV energies. With AMS-01, photons converted in the upper elements of the detector were observed using the tracking detector. With the AMS-02 electromagnetic calorimeter, photons will also be observed at a higher rate using the tracker as a veto for charged particles. Since the direction will be measured with excellent resolution both for converted and non-converted photons, the point source flux sensitivity will be very good.

Status: The accomplishments of the AMS-01 mission on Space Shuttle flight STS-91 went far beyond the original goals of a technical test-flight, and rich physics results can be extracted from the collected data. The analysis of more than 50 million recorded events is being carried out, and the first few papers have been already published.

From the improved understanding of the cosmic radiation and background gathered from these results, the design of the final detecor to be installed on ISS has been revised towards more ambituos goals. The permanent magnet will be replaced by a superconducting one of much higher field strength. The completed and extended spectrometer will thus provide an almost tenfold increase in momentum range for charged particles, up to TeV energies. Several specialized detectors will be added to allow the identification of individual particles over the full energy range. The design of the components is frozen and construction has started. Tests and calibration of prototypes and final detector components using e.g. particle beams at CERN are being performed.

Experience during the precursor flight has shown that the design of the central tracking detector is fully adequate and that no principle modifications are foreseen for AMS-02. The AMS-01 central tracking detector was composed of six planes of double sided silicon microstrip detectors, partially equipped, being at the time the largest operating detector of its kind. For AMS-02, the higher energy range and the new field configuration require the number of inner silicon layers to be increased from four to six, resulting in a total of eight double sided sensors layers, providing more redundancy and a better rigidity resolution at high particle momenta. The complete tracker will be composed of 192 modules; a few performance improvements are planned on the tracker components.

Finally, the addition of a new type of detector will allow to identify electrons and positrons at even higher energies, using the synchrotron radiation of ultra-high energetic particles in the earth magnetic field. The efficiency of this detector crucially depends on the background. One major component of this background consists of charged particles in the keV energy range. Since this flux is not known well enough, an optimization of the detector layout cannot yet be done. It is planned to fly PSRD, a prototype of the detector, as a small payload on a Space Shuttle flight in early 2001, to measure this low energy flux with high precision. The construction of this PSRD will be completed by September 2000.

Publications:

1. G. M. Viertel and M. Capell, the AMS Collab., The Alpha Magnetic Spectrometer, Nucl. Inst. Meth. A419 (1998) 295

2. J. Alcaraz et al., the AMS Collab., Search for Antihelium in Cosmic Rays, Phys. Lett. B461 (1999) 387

3. J. Alcaraz et al., the AMS Collab., Protons in Near Earth Orbit, Phys. Lett. B472 (2000) 215

Abbreviations:

AMS:	Alpha Magnetic Spectrometer
AMS-01:	first version of the detector, flown on the Space Shuttle Discovery STS-91 mission, June 2-12, 1998
AMS-02:	second version of the detector, to be installed on ISS for a period of data taking of a few years
ISS:	International Space Station
STS:	Space Transportation System (US Space Shuttle)
PSRD:	Prototype Synchrotron Radiation Detector, to be flown as a small payload on a Space Shuttle in early 2001

2.13 Cryogenic Receivers for the HIFI Spectrometer

Institute: Institute of Astronomy, ETH Zurich
In cooperation with:
SRON, Groningen, The Netherlands

Principal Investigator: T. de Grauuw

Co-investigators:
A. O. Benz
W. Baechtold (ETHZ)

Method: Development and construction of own instruments:
Construction of Development Model of common optics and Flight Model of common optics and mixer assemblies. Low noise and low power amplifiers (HEMT) for intermediate frequency amplification.

Purpose of research: The HIFI instrument on FIRST (forth cornerstone of ESA) will measure spectral lines of cosmic molecules in the range 100 to 800 microns, a wavelength range that cannot be observed from Earth. The satellite will be located far away from Earth and have the advantage of zero contamination by terrestrial water and oxygen absorption. It will be ideal to search for water in protoplanetary accretion disks and for oxygen and ozone in extrasolar planets in addition to highly red-shifted lines of distant galaxies in the early universe.

Status: Teh project has been accepted as a Swiss PRODEX contribution to FIRST in 1999. The development of HEMT ampifiers at ETH (Microwave Lab.) has started. Demonstration devices have been developed and tested. The design of the common optics part and mixers assemblies have started at SRON and ETH (Inst. Astronomy) is in the learning phase. The plans will be finalized at the end of June and an ITT will be issued by ESA in mid September 2000. Actual construction in Swiss industry will start after December 2000. Phase B of our

contribution will finish in August 2001, when the Development Model will be delivered to SRON.

Abbreviations:

HIFI:	Heterodyne Instrument for FIRST
FIRST:	Far InfraRed Absolute Spectrophotometer
HEMT:	High Electron Mobility Transistor
SRON:	Space Research Organization of the Netherlands

2.14 The Geodynamics Observatory at Zimmerwald

Institute: Astronomical Institute University of Berne (AIUB)
In cooperation with:
Swiss Federal Office of Topography (Wabern)

Principal Investigator: Prof. W. Gurtner

Co-investigators:
Dr. T. Schildknecht
Prof. G. Beutler

Method: Observation of Artificial Earth Satellites using Laser (distance) and CCD (direction) techniques.

Purpose of research:

1. determination of the earth's gravity field
2. determination of absolute station positions (with respect to the Earth's center of mass)
3. contribution to the realization of the ITRF coordinate and velocity field (ITRF = International Terrestrial Reference Frame).
4. contribution to the determination of the earth's rotation
5. contribution to the precise orbit determination of various satellites (e.g., remote sensing, altimeter)
6. CCD observation of space debris and satellites
7. Contribution to the connection of the quasar- and the star- reference frames.

Zimmerwald is as tracking station member of the International Laser Ranging Service (ILRS). The research is also within the frame of other international collaborations like, e.g., the IERS (International Earth Rotation Service), NASA's DOSE (Dynamics of the Solid Earth); IADC (Inter-Agency Space Debris Coordination Committee); IGS (International GPS Service).
Time line: Permanent activity since 1984.

Status: Fully operational, nighttime and daylight tracking of laser satellites. High precision CCD observations may be made using different focii. Several Space Debris Survey Campaigns were performed in the Geostationary Orbit Region.

Publications:

1. Gurtner, W., E. Pop, J. Utzinger (1998). "Automation and Remote Control of the Zimmerwald SLR Station". Proceedings of 11th International Workshop on Laser Ranging Instrumentation, pp. 404-412, Bundesamt fuer Kartographie und Geodaesie, Frankfurt.

2. Schildknecht, T., U. Hugentobler, M. Ploner (1998). "Optical Surveys of Space Debris in GEO". Advances in Space Research, Vol. 23, No. 1, pp. 45-54, 1999.

3. U. Hugentobler, M. Ploner, T. Schildknecht, and G. Beutler (1998). "Determination of resonant geopotential Terms using optical Observations of geostationary Satellites". Advances in Space Research, Vol. 23, No. 4, pp. 767-770, 1999.

2.15 Interdisciplinary interpretation and in-depth studies of data from multi-experiment, multi-spacecraft programmes

Institute: International space science institute (ISSI)

Principal Investigator: J.Geiss

Co-investigators:

B. Hultqvist
G. Paschmann
R. von Steiger

Method: In the ISSI programme, space scientists are invited to pool their data and results and to work closely with theorists and modellers and scientists working in related fields (ground-based observations or laboratory investigations). Basic modes of operation

- Study projects are set up on specific scientific themes and carried out through workshops attended by international scientists by invitation;
- Research projects can also be proposed and executed by international scientific teams;
- Individual scientists visit ISSI for variable extended periods of research.

Purpose of research: ISSI's programme is presently focused on the Solar System Sciences including astronomical implications and comprises the following major areas: Heliospheric physics, Solar terrestrial physics, Cometary physics and chemistry, Solar wind and solar processes, Planetary Physics, and Astrophysics and Cosmological questions.

Status:

Heliospheric physics
As anticipated in the last report to COSPAR, the third volume in the Space Sciences Series of ISSI, Cosmic Rays in the Heliosphere, was published in January 1998. It was edited by Professor Lennard A. Fisk, University of Michigan; Professor J.R. Jokipii, University of Arizona; Professor George M. Simnett, University of Birmingham; Dr. Rudolf von Steiger, ISSI; and Dr. K.-P. Wenzel of ESA/ESTEC, Noordwijk. The publication also appeared in Space Science Reviews (Vol. 83, 1 and 2, January 1998).
The third in a series of workshops on Corotating Interaction Regions (CIR) Structuring the Minimum Heliosphere was held at ISSI 8–13 June 1998. The two previous workshops took

place in Germany. Convenors were Professor André Balogh of Imperial College, Dr. John T. Gosling of Los Alamos Scientific Laboratories, Professor J.R. Jokipii of the University of Arizona, and Dr. Horst Kunow of the University of Kiel. The proceedings, edited by the convenors and Dr. Reinald Kallenbach, have been published as the seventh SSSI volume in July 1999 and also appeared in Space Science Reviews (Vol. 89,1–2).

The working group on Interstellar Dust in the Solar System, chaired by Priscilla Frisch (University of Chicago) and Eberhard Grün (Max-Planck-Institut für Kernphysik, Heidelberg), developed into a team workshop held on 12–16 October 1998. Attendees of the workshop were 36 scientists working on interstellar dust, the local interstellar medium, the heliosphere, meteorites, interplanetary dust particles, and interstellar dust within the heliosphere. Its results will appear in a special section of the Journal of Geophysical Research in May 2000.

Following a convenors' meeting 13–15 July 1998, a workshop on the topic of Cosmic Rays and Earth was held 21–26 March 1999. The focus was on the role of neutron monitors, invented by John Simpson in 1948, in the investigation of this radiation, on the science enabled by the unique neutron monitor dataset, and on continuing opportunities to use these data to solve outstanding problems. The workshop brought together 35 scientists involved in the ground-based neutron monitor network, space missions, and experts in heliospheric physics.

Solar-terrestrial physics

The project described in the last report Source and Loss Processes of Magnetospheric Plasma was completed with the publication in April 1999 of Volume 6 of Space Sciences Series of ISSI and also appeared in Space Science Reviews (Vol. 88,1–2).

Editors are Bengt Hultqvist, Marit Øieroset, Götz Paschmann, and Rudolf Treumann. Group meetings on two key chapters were held in September 1998 and the core group met for a final time in November 1998. Although work was finished in the previous business year, the first ISSI Scientific Report, Analysis Methods for Multi-Spacecraft Data, edited by Götz Paschmann and Patrick W. Daly, appeared in July 1998. Since then, it received the Book Award of the Basic Science Section of the International Academy of Astronautics (IAA).

The next major ISSI project in the field of solar-terrestrial physics is devoted to Auroral Plasma Physics. The aurora, whose spectacular visible displays have fascinated mankind for ages, is perhaps the most intriguing phenomenon in all of space plasma physics. Strong particle acceleration and wave-particle interaction effects play key roles in its formation, which to a large extent is organised by large-scale currents aligned with the magnetic field.

One of the greatest challenges is the explanation of the extremely narrow width of auroral arcs. It is one of the key phenomena at the end of the Sun-Earth connection chain, but the underlying physical processes should be ubiquitous in the entire universe.

Although the aurora has been studied for a long time, decisive progress — in particular regarding the clarification of the nature of the acceleration process, the fundamental role of the current systems, and the interplay between particles and fields — has been made only through the recent Freja and FAST satellite missions.

A core group for the new project held its first meeting 30–31 March 1999. Members of the core group are Joseph E. Borovsky of Los Alamos National Laboratory, Charles W. Carlson of the University of California, Berkeley, Gerhard Haerendel of the Max-Planck-Institut für extraterrestrische Physik, Bengt Hultqvist of ISSI, Hannu Koskinen of the Finnish Meteorological Institute, Kristina Lynch of the University of New Hampshire, Göran Marklund of the Royal Institute of Technology (KTH) in Stockholm. Götz Paschmann, Director at ISSI, is the project leader. The first workshop was held 25-29 October 1999 with the participation of 26 invited scientists. A second workshop is planned in Spring 2000. The goal is the publication of a

comprehensive book in late 2001 (Vol.14 of the Space Science Series of ISSI).

Cometary physics and chemistry

The comet research programme of ISSI is focused on the origin and nature of cometary constituents. This topic is of great significance because comets are made up of the most pristine material preserved in the solar system. Comets have retained a much larger fraction of the volatile elements C and N than even the carbonaceous chondrites, and there is evidence that a significant fraction of the dust and certain molecules or radicals in the ices are of pre-solar origin.

A workshop on The Origin and Composition of Cometary Material was held at ISSI 14–18 September 1998. The convenors were Kathrin Altwegg of the University of Bern, Pascale Ehrenfreund of the University of Leiden, Johannes Geiss of ISSI, and Hans Rickman of the Astronomical Observatory Uppsala. The workshop was attended by 35 invited scientists from different fields, including cosmochemists, radioastronomers, mass spectrometrists and modellers of cometary and interstellar processes.

The data discussed at the workshop were mainly those obtained in 1986 in the coma of Comet Halley by the Giotto spacecraft of ESA and the Vega spacecraft of the Soviet Union and more recently by remote spectroscopy in the comae of the bright comets Hyakutake (1996) and Hale-Bopp (1997). The results of the workshop have been published in the October 1999 issue of Space Science Reviews and as Volume 8 of the Space Sciences Series of ISSI. Editors were:K.Altwegg, P. Ehrenfreund, J. Geiss and W. Huebner.

Solar wind and solar processes

A workshop on Solar Composition and Its Evolution: From Core to Corona was held 26–30 January 1998, with the participation of 38 scientists. Convenors were Dr. Claus Fröhlich, Physikalisches-Meteorologisches Observatorium, Davos; Professor Douglas Gough, University of Cambridge; Professor Nicolas Grevesse, Université de Liège; Professor Martin C.E. Huber, ESA/ESTEC; and Dr. Sami Solanki, Swiss Federal Institute of Technology (ETH), Zurich. The proceedings, edited by Dr. Claus Fröhlich, Professor Martin C.E. Huber, Dr. Sami Solanki, and Dr.Rudolf von Steiger were published in the October 1998 issue of Space Science Reviews (Vol.85,1–2) and as Volume 5 of the Space Sciences Series of ISSI.

In an expansion of the ISSI programme in the direction of Earth sciences a workshop on the topic of Solar Variability and Climate was held 28 June – 2 July 1999. The workshop was convened by Eigil Friis-Christensen (Danish Space Research Institute, Copenhagen), Claus Fröhlich (Physikalisch-Meteorologisches Oberservatorium Davos/World Radiation Center), Joanna Haigh (Imperial College, London), Manfred Schüssler (Kiepenheuer Institut, Freiburg), and Sami Solanki (ETH, Zurich), and attended by about 40 scientists from the solar and climate communities. One of the main conclusions of the workshop was that the solar forcing, direct or indirect, is an important factor affecting the Earth's climate, possibly including the observed warming in the first half of this century.

The warming in the past 20 years is clearly beyond what may be attributed to solar variability, and must be significantly influenced by anthropogenic greenhouse gases. The workshop will result in Volume 11 in the Space Sciences Series of ISSI, edited by the convenors (except S. Solanki) and Rudolf von Steiger (ISSI, Bern).

Planetary science

Two working groups met in July and October 1998 to establish a plan in this area. As a result, a workshop From Dust to Terrestrial Planets was organized at ISSI on 15–19 February 1999. Convened by Willy Benz of the University of Bern, Günter W. Lugmair of the Max-Planck-

Institut für Chemie, and Frank A. Podosek of Washington University in St. Louis, Missouri, the mandate of the workshop was the detailed assessment of the available astronomical, chronological, geochemical and dynamical constraints of the first period of inner solar system evolution. It was attended by about 30 scientists. The resulting publication, Volume 9 of the Space Sciences Series of ISSI, is in print.
In Spring 2000, ISSI will hold a workshop on The Evolution of Mars in Spring 2000 In anticipation of the workshop a Working group met in September 1999 on The Absolute and Relative Chronology of Mars and Moon

Astrophysics and cosmological questions
The proceedings volume on Primordial Nuclei and Their Galactic Evolution, edited by Dr. Nikos Prantzos of the Institut d'Astrophysique de Paris, Dr. Monica Tosi of the Osservatorio Astronomico di Bologna, Italy, and Dr. Rudolf von Steiger of ISSI, appeared as Volume 4 of the Space Sciences Series of ISSI and as Volume 84, Numbers 1 and 2 (April 1998) of Space Science Reviews.
The next ISSI project in this area concerns The Astrophysics of Galactic Cosmic Rays. This project consists of two workshops in October 1999 and May 2000. Convenors are: Dr. Luke Drury of the Dublin Institute for Advanced Studies, Professor Donald Ellison of North Carolina State University, Professor J.R. Jokipii of the University of Arizona, Dr. Jean-Paul Meyer of the Service d'Astrophysique, Saclay, Professor Dieter Muller of the University of Chicago, and Professor Heinrich Völk of the Max-Planck-Institut für Kernphysik, Heidelberg.
The first workshop was held on 18–22 October 1999, and was attended by 24 international scientists. A second workshop will be held in May 2000, the results to be published in a volume in the Space Science Series of ISSI in July 2001 and in Space Science Reviews.

International teams
Apart from the Workshops and Working Groups a second very important component of the science activities at ISSI is represented by the International Teams. These consist of two to 15 scientists from different institutions, usually of different nationalities and different areas of expertise, who assemble to discuss in depth particular scientific question. Unlike the Workshops that are initiated by the Institute, international Teams are initiated by proposals from the community at large.
The teams generally meet repeatedly for one to several weeks duration within a fixed limit of ISSI support of 26 (wo)man-weeks per year. Two (or more) year projects are acceptable subject to a re-confirmation after each year. The results of such activity is reported in papers in scientific journals. The team activity is organized and directed by a leader, who has initiated the proposal to ISSI. Although the teams are in close contact with ISSI's scientific staff, they work by and large independently to complete their project.
Teams may be set up at any time. Proposals are selected after review by external referees and the ISSI Directorate. In the reporting period about 14 Teams were active at ISSI in each year involving yearly some 120 participants and about 160 manweeks of activity. This surpasses the corresponding average yearly Workshop activity discussed above. Teams address scientific issues the main Areas of ISSI activity, mostly in Solar and Heliospheric Physics and Solar Terrestrial Physics, and a smaller but increasing number in Cometary and Planetary Physics and in interdisciplinary areas. A complete list of the teams is given in the ISSI annual reports and at the web site `http://issi.unibe.ch`

Individual visiting scientists
Individual scientists are invited to spend extended periods at ISSI, working on scientific subjects

at the forefront of research in areas of interest to ISSI. Their stay may include periods of joint activity with other colleagues. The results of this research are published in scientific journals, with appropriate acknowledgement of ISSI. During the reporting period, 25 individual scientists were active at ISSI for different periods of time extending from two weeks to two months.

Publications:
In addition to the Space Sciences Series of ISSI , which has grown to 8 volumes in the reporting period, a large number of papers have been published by ISSI visitors and staff scientists in scientific journals as a result of the scientific activity at ISSI. They are not reported here for want of space but they can be found listed in the ISSI annual reports.

2.16 Radio to X-ray variability of the quasar 3C 273

Institute: Geneva Observatory and INTEGRAL Science Data Centre
In collaboration with:
several Institutes mainly in Europe

Principal Investigator: T. Courvoisier

Co-investigators:
R. Walter
S. Paltani
M. Tuerler

Method: Satellites: EXOSAT, GINGA, ROSAT, IUE, CGRO

Purpose of research: The bright quasar 3C 273 is the object of repeated multi-wavelength observations from the radio domain to gamma rays. These observations have provided spectral energy distributions that span more than 15 decades of the electromagnetic spectrum. Over 20 years of data are now available, providing one of the largest sets of data on an Active Galactic Nucleus. These data provide strong constraints on the models for the physiscal origin of the radiation of quasars. Since many different physical processes are involved in the QSO phenomenon, the multi wavelength data we obtain allows to some extent to establish the relationships that exist between the emission components.

Status: A large data base covering more than 15 orders of photon energy and 20 years of observations is being organised in Geneva. These data will be collectively published. Analysis of the correaltions between the emission properties in the different spectral bands is in process.

Publications:

1. The quasar 3C 273 T. J.-L. Courvoisier The Astronomy and Astrophysics Review 9,1, 1998

2. 30 years of multi-wavelength observations of 3C 273 Tuerler M. et al. Astronomy and Astrophysics Suppl. 134, 89, 1999

2.17 Variability of Active Galactic Nuclei in the ultraviolet domain

Institute: Geneva Observatory and INTEGRAL Science Data Centre

Principal Investigator: T. Courvoisier

Co-investigators:
S. Paltani
M. Tuerler

Method: Satellite: IUE

Purpose of research: We are using a compilation of all low dispersion IUE data on Active Galactic Nuclei to study the variability of these objects in a statistical way. Having access to all the IUE data (spanning from 1978 to 1995) provides a large number of objects in each of the classes of AGN and allows us to deduce the variability characteristics of the subclasses and a comparison of these. It is found that all classes vary in a similar way. Only the distribution of the number of objects as a function of the variability shows some difference between the classes. This result is rather unexpected. The variability characteristics of the objects are poorly correlated with other properties of the objects (like luminosity, redshift etc).
The results obtained illustrate the importance that a well organised and accessible archive of space data can have.

Status: We published the compilation of all the data in 1992, since then we have been using the data to describe the variability of AGN and to use these descriptions to test models of these sources.
The properties of the continuum variability and in particular its dependence on the luminosity of the objects has been studied.
The properties of the line variations have also been published.
This project is moving towards the analysis of the X-ray variability of AGN.

Publications:

1. Courvoisier T.J.-L. and Paltani S., 1992, ESA SP 1153 A and B.
2. Tuerler M. and Courvoisier T.J.-L., 1998, A+A 329, 863
3. Thèse de M. Tuerler, Université de Genève, mars 2000

2.18 ISO observations of Active Galactic Nuclei

Institute: Geneva Observatory and INTEGRAL Science Data Centre

Principal Investigator: T. Courvoisier

Co-investigators:
M. Polletta

Method: Satellite: ISO

Purpose of research: We have observed narrow line Seyfert galaxies and quasars with ISO in the far infrared domain. Both programs aim at understanding the difference between those AGN that are radio loud and those for which the radio emission is very weak. Both categories of AGN have very similar properties in the other spectral domains and the origin of the difference is unclear. It is thought that radio emission is related to the presence of a jet, this would mean that the question we ask is equivalent to asking why some AGN have jets and not the others.

Status: The data have been gathered, they have been analysed in great details. One paper on the Seyfert galaxies has been published and the results presented at international conferences. The paper corresponding to the data set on quasars is in the final stage of preparation.

Publications:

1. ISOPHOT observations of narrow line Seyfert 1 galaxies Polletta M. and Courvoisier T.J.-L. 1999, A&A 350, 765

2.19 INTEGRAL Science Data Centre (ISDC)

Institute: Geneva Observatory and INTEGRAL Science Data Centre
In collaborations with:
several institutes in Europe, Russia and the US

Principal Investigator: T. Courvoisier

Co-investigators:
R. Walter
ans members of the international consortium

Method: Satellite: INTEGRAL

Purpose of research: The Geneva Observatory was active in the elaboration of the gamma ray mission INTEGRAL concept that was accepted as a medium mission by ESA in June 1993. INTEGRAL will be an imaging and spectroscopy gamma ray astronomy satellite. Launch is foreseen in 2002.
INTEGRAL will be open to the scientific community at large. It is, therefore, essential to provide the community with the tools necessary to reduce and interpret the data from the instruments. The ISDC has been awarded the task of developing and operating a centre that will provide the users with an adequate level of support to use the mission data. The ISDC will also perform a standard set of analysis on the data and archive the data and the results of this analysis. In addition the ISDC will look at the data in near real time to detect transient sources and other unexpected results.
The ISDC is a centre attached to the Geneva Observatory.

Status: The ISDC was accepted by ESA in 1995. The staff is now building up and the development of the INTEGRAL data analysis system is in full speed.

Publications:

1. The Astronomical community and the INTEGRAL mission. in "2nd INTEGRAL workshop: the transparent Universe" ESA Sp-382, pp 581.

2.20 Planck Data processing

Institute: ISDC
In collaboration with:
the two consortia that propose instruments on the Planck mission.

Principal Investigator: T. Courvoisier

Purpose of research: It is proposed that Switzerland contributes to the first steps of the Planck data processing. The ISDC is gathering an important experience in this domain that can be used in the context of other missions. This will provide access to the Swiss astronomers to the Planck data and thus allow us to participate fully in the exploration of the structures revealed by the cosmic microwave background.

Status: Parts of the Planck data analysis that are to be provided by the ISDC are being defined.

2.21 SOHO/CELIAS: Solar Wind and Suprathermal Particles. Abundances of elements, charge states and isotopes and kinetic properties of heavy ions

Institute: Physikalisches Institut, University of Bern
In cooperation with:
Max-Planck-Institut fuer Extraterrestrische Physik, Garching, Germany
Max-Planck-Institute fuer Aeronomie, Lindau, Germany
University of Maryland, College Park, NH, USA
University of New Hampshire, Durham, NH, USA

Principal Investigator: Prof. Peter Bochsler, Physikalisches Institut, University of Bern

Co-investigators:
H. Balsiger
K. Bamert
J.M. Weygand
P. Wurz

Method: Research based on existing instruments:
CELIAS instrument on the SOHO mission
Satellite

Purpose of research: Investigation of the solar wind composition. Abundances of approximately 20 elements and their isotopes are studied in detail for different solar wind conditions. Diagnostics of coronal conditions with charge state distributions of heavy ions. Study of the temporal evolution of transient events (e.g. Coronal Mass Ejections) in the main energy range of the solar wind and for suprathermal particles.

Status: SOHO was launched on December 2nd, 1995. The CELIAS instrument is still operating nicely. Data anaylsis, interpretation, and modelling are in progress. In addition, post-launch calibration in the Mefisto calibration facility of the Univesity of Bern using the flight spare instrument is under way.

Publications:

1. P. Wurz and A.H. Gabriel, "Wind Acceleration Processes," ESA SP-446 (1999) 87-95.

2. M.R. Aellig, H. Holweger, P. Bochsler, P. Wurz, H. Gruenwaldt, S. Hefti, F.M. Ipavich, and B. Klecker, "The Fe/O Elemental Abundance Ratio in the Solar Wind," the elaboration of signal oriented intelligent agents. Solar Wind Nine, AIP (1999), 255-258. the elaboration of signal oriented intelligent agents. the elaboration of signal oriented intelligent agents.

3. P. Bochsler, F.M. Ipavich, J.A. Paquette, J.M. Weygand, and P. Wurz, "Determination of the Abundance of Aluminum in the Solar Wind with SOHO/CELIAS/MTOF," J. Geophys. Res. (2000) in press.

Abbreviations:

SOHO:	Solar and Heliospheric Observatory
CELIAS:	Charge, Element and Isotope Analysis System

2.22 Coronal holes versus quiet Sun

Institute: Institute of Astronomy, ETHZ, CH-8092 Zürich

Principal Investigator: S.K.Solanki

Co-investigators:
K.Stucki
J.O.Stenflo
M.C.E. Huber

Method: Research based on existing instuments:
SOHO (SUMER,CDS)

Purpose of research: The aim of the project is to determine the thermal, dynamic and if possible magnetic structure of the upper solar atmosphere, i.e. the chromosphere, the transition zone and the corona, and to identify the underlying physical processes

Status: The opportunity provided by SUMER of observing line profiles at high spatial and spectral resolution allows us to determine plasma properties, in particular flow velocities in the chromosphere, transition region and lower corona. In order to obtain more information on physical processes in coronal holes, which are known to be the source of the fast solar wind and the primary example of coronal heating in regions with an excess of one magnetic polarity, we focussed our work on data sets containing coronal holes as well as quiet Sun regions.
Line parameters were calculated for 26 spectral lines, chosen to cover a wide range of formation temperatures, using a Gaussian fitting method. The data were thus reanalysed using a technique differing from the moment method (described by Doyle et al., 1997) which we used earlier (Stucki et al, 1998). The Gaussian method has the advantage that blends are treated better.
We averaged the intensity, line shift, and line width parameters in two sectors corresponding to coronal holes and the quiet Sun, respectively. The improved statistics, together with the fact that we could eliminate the center to limb effect using the roll data at the same heliospheric angle as the position of the coronal hole, allowed us to confirm the results obtained earlier with the moment method at a higher level of confidence. We find that the line widths are slightly increased inside the hole, indicating higher non-thermal velocities for almost all lines. But most interesting are the line shifts displaying a distinct trend towards larger blueshifts (relative to the quiet Sun) for higher ion temperature in the coronal hole, which may be evidence of solar wind outflow at low altitudes in coronal holes (Stucki et al, 1999a).
Hassler et al. (1999) found that a relationship exists between the outflow velocities seen in Ne VIII and the chromospheric magnetic network structure. We extended their work by analysing more spectral lines and quantifying the correlation between the velocity of the plasma at different temperatures and the intensity of network structures. Using the fit parameters of the 26 spectral lines analysed earlier, correlation coefficients between line shifts and intensities were calculated. The shifts of the hotter lines were compared to the intensities of cooler lines at the same spatial location, since the latter show the correlation between the velocity of the plasma at different temperatures and the intensity of network structures. Using the fit parameters of the 26 spectral lines analysed earlier, correlation coefficients between line shifts and intensities

were calculated. The shifts of the hotter lines were compared to the intensities of cooler lines at the same spatial location, since the latter show clearly the network. We confirm Hassler's result that the Ne VIII line at 770.41 Angstroems shows increasing blueshift with increasing intensity of N IV at 765.15 Angstroems in both, quiet Sun and coronal holes regions. We found, however, that this result depends on the choice of spectral line. In particular, for lines formed below 3×10^5 K we need to distinguish between coronal holes and the normal quiet Sun. Thus the chromospheric lines show a larger redshift in the network for both coronal hole and quiet Sun regions. Most transition-region lines show the same trend in the quiet Sun but the opposite trend inside the coronal hole.
Finally, lines formed above 3×10^5 K show a decreasing redshift with increasing intensity in both coronal holes and the quiet Sun (this includes the Ne VIII lines). This suggests a difference in the acceleration mechanisms of the fast and slow solar wind (Stucki et al, 1999b).

Publications:

1. Stucki K., Solanki S.K., Ruedi I., Stenflo J.O., Brkovic A., Schuehle U., Wilhelm K., Huber M.C.E., 1998 (VII. International Plasma Astrophysics and Space Physics Conference) Kluwer, Dordrecht, in press.

2. Stucki K., Solanki S.K., Ruedi I., Stenflo J.O., Brkovic A., Schuehle U., Wilhelm K., Huber M.C.E., 1999 , Space Science Reviews 87: 315 (Proc. 7th SOHO Workshop, "Coronal Holes and Solar Wind Acceleration").

3. Stucki K., Solanki S.K., Ruedi I., Schuehle U.,1999, Proc. 8th SOHO Workshop, "Plasma Dynamics and Diagnostics in the Solar Transition Region and Corona", Eds: B. Kaldeich, ESA SP-446.

2.23 Dynamics and Heating of the Solar Chromosphere and Corona

Institute: Institute of Astronomy, ETH Zürich

Principal Investigator: K. Solanki

Co-investigators:
A. Brkovic
J.O.Stenflo
I. Rüedi
M.C.E. Huber

Method: Research based on existing instuments:
CDS, EIT, MDI and SUMER instruments onboard the SOHO satellite and SXT instrument onboard the YOHKOH satellite.

Purpose of research: The project aims at a better understanding of the structure, dynamics and energetics of the upper solar atmosphere. The project consists of 3 parts.

Part 1) Variability in the quiet solar atmosphere
The study of solar variability could provide clues for understanding how the solar chromosphere, transition-region and corona are heated, since heating events, be they due to magnetic reconnection or the dissipation of wave pulses, are expected to produce transient brightenings in the emission from the relevant atmospheric layers. The Coronal Diagnostic Spectrometer (CDS)

onboard the SOHO satellite has been used to obtain movies of quiet Sun regions at disc centre. These movies were used to study brightness variations of solar features at three different temperatures sampled simultaneously in the chromospheric He I 584.3 A, the transition region O V 629.7 A and coronal Mg IX 368.1 lines.

Part 2) Blinker analysis
Blinkers are transient brightenings seen in the extreme ultraviolet. They are candidates for microflare activity at transition-region temperatures. Their thermal energy content is reported to be on the order of 10^{25} ergs or 10^{-6} times that of a "standard" flare.
The same data used for Part 1) were used for this work as well.

Part 3) Tests of solar loop models
The aim of this work is to test simple relations between fundamental properties (temperature, length, pressure and heating rate) of quasi-steady coronal loops, as well as to test loop model of Landini & Mosignori Fossi. We use observations carried out using several instruments onboard SOHO (CDS, EIT and MDI) as well as the soft X-ray telescope (SXT) on YOHKOH.

Status:

Part 1) Variability in the quiet solar atmosphere
This work was completed. The main results: Significant variability on all time scales and all locations in the quiet Sun has been observed in the 3 observed spectral lines, which cover a temperature range from 20'000 K to 1'000'000 K. The relative brightness fluctuations are independent of the absolute intensity in all atmospheric layers. The brightness fluctuations are dominantly due to brightness changes on time scale less than 80 minutes and longer than 5 minutes. Brighter regions show better correlation in time between any 2 lines and are more variable than darker regions.

Part 2) Blinker analysis
This work was partly completed. The main results: The blinkers are present both in the network and in the intranetwork. Their average life-times are between 10 and 20 minutes. The energy and size, energy and ratio and ratio and size are well correlated, while other pairs of parameters describing the blinkers are poorly correlated. It seems that blinkers are often time-structured. The energy, size and intensity ratio of a blinker were well fit with the power law distributions, $dN = AX^{\alpha}dX$. The values alpha for the energy distributions were between -2 and -1. This result hints that blinkers alone can't heat the corona.
The spatial correlation of blinkers seen in 2 lines shows large temporal variations.
The blinkers are not always simultaneously seen in all three lines.
We plan to analyse co-aligned observations with SUMER and CDS.

Part 3) Tests of solar loop models
This work was partly completed. The main results: There is an excellent agreement between the measured and predicted loop pressure, while predicted top temperatures are always higher than the measured values by less than 20%. Also the predicted and measured cross-section radius show agreement within the errorbars, although the predicted value is slightly higer than observed one.

Publications:

1. Brkovic A., Ruedi I., Solanki S.K., et al., 2000 Astronomy & Astrophysics 353, 1083

2. Brkovic A., Ruedi I., Solanki S.K., 1999 Proceedings Eigth SOHO Workshop, "Plasma Dynamics and Diagnostics in the Solar Transition Region and Corona", Eds. J.-C. Vial

& B. Kaldeich-Schurmann ESA SP–446, 119

3. Landini M., Brkovic A., Landi E., Ruedi I., Solanki S., 1999 Proceedings Eigth SOHO Workshop, "Plasma Dynamics and Diagnostics in the Solar Transition Region and Corona", Eds. J.-C. Vial & B. Kaldeich-Schurmann ESA SP–446, 423

2.24 Spectroradiometric in-orbit intercalibration of the UV investigations on SOHO

Institute: Inst. of Astronomy, ETH Zentrum, CH-8092 Zürich
In cooperation with:
INTEC, HTA Bern, Morgartenstr.2c, CH-3000 Bern

Principal Investigator: S.K. Solanki

Co-investigators:
A. Pauluhn
J.O.Stenflo
M.C.E. Huber

Method: Research based on existing instuments:
CDS and SUMER on SOHO
Evaluation and intercalibration of a large data set of quiet sun measurements from the two instruments on board of SOHO.

Purpose of research:
The intercalibration programme of the two telescopes and spectrometers SUMER and CDS on SOHO was designed in order to continuously monitor and compare their performance.
For this purpose a special observing sequence was established which consists of simultaneous measurements of the two instruments of a common area on the solar surface that is devoid of active regions (quiet Sun). These measurements have been made in three wavelengths regularly once per month since SOHO's routine observations started in March 1996.
Additionally, the large data set provides a good basis for statistical investigations of the long term behaviour of the quiet Sun.

Status: The quiet Sun radiance values of CDS and SUMER have been compared for the time period from March 1996 until the loss of spacecraft in June 1998. The instruments show reasonably good agreement in all three wavelength bands under study. The statistical analysis of the large data sets resulted in accurate fits of theoretical distribution functions. Also, the period after SOHO's recovery has been investigated. Currently the last available measurements (Aug. 1999 to Dec. 1999) of the CDS-SUMER intercalibration programme INTERCAL_1 are prepared for analysis and comparison.

Publications:

1. Intercalibration of SUMER and CDS on SOHO
I. SUMER Detector A and CDS NIS
A. Pauluhn, I.Rüedi, S.K. Solanki, J. Lang, C.D. Pike
U. Schühle, W.T. Thompson, J. Hollandt, and M.C.E. Huber
Appl. Opt., Vol.38, 34, 7035-7046 (1999)

2. Statistics of quiet Sun extreme ultraviolet intensities (in preparation)

3. Intercalibration of SUMER and CDS on SOHO. II. SUMER Detector A/B and CDS NIS (in preparation)

Abbreviations:

SOHO:	Solar and Heliospheric Observatory
SUMER:	Solar Ultraviolet Measurements of Emitted Radiation
CDS:	Coronal Diagnostic Spectrometer

2.25 Reconstruction of solar irradiance variations from the surface distribution of the solar magnetic field

Institute: Inst. of Astronomy, ETH Zentrum, CH-8092 Zürich
In cooperation with:
Institut für Astronomie, Universität Wien

Principal Investigator: S.K. Solanki

Co-investigators:
M.Fligge
Y.C.Unruh
J.O.Stenflo

Method: Research based on existing instuments:
MDI ...
to extract the surface distribution of solar magnetic features as a function of time and
VIRGO ...
to compare the reconstructions to measured total and spectral irradiance variations.

Purpose of research: There is an urgent need for detailed studies of the effect of man-made greenhouse gases on the Earth's atmosphere and climate. One of the unknown boundary conditions for models of the evolution of the Earth's climate is the future variation of the solar irradiance (i.e. the total solar brightness measured at the Earth). Although it is qualitatively known that the solar irradiance variations are caused by the Sun's magnetic field, the quantitative connection between the two is virtually unexplored. Without this knowledge it may be impossible to predict solar irradiance variations. Our aim is to put the connection between the structure and distribution of solar magnetic features and the solar brightness on a firm quantitative basis and to enhance our understanding of this connection.

Status: We modelled solar irradiance variations based on variations of the surface distribution of the solar magnetic field. The irradiance reconstruction makes use of sunspot and facular contrasts calculated as a function of wavelength and limb angle on the Sun. The position and size of magnetic features on the solar disk are extracted from full-disk magnetograms obtained by the Michelson Doppler Interferometer (MDI) onboard the SOHO spacecraft.
After the model proved to be able to successfully reproduce short-term solar irradiance variations on time-scales of days to weeks, we now turn to significantly longer time-scales, hence, addressing variations on time-scales of the solar cycle length.
First, preliminary results show that even on those time-scales it is the solar surface magnetic field which is responsible for most (if not all) of the observed irradiance variations.

Publications:

1. M. Fligge, S.K. Solanki, Y.C. Unruh, 2000, Astron. Astrophys. 353, 380-388

2. MY.C. Unruh, S.K. Solanki, M. Fligge, 1999, Astron. Astrophys. 345, 635-642

3. MM. Fligge, S.K. Solanki, Y.C. Unruh, 2000, Space Science Review, in press

Abbreviations:

SOHO:	Solar and Heliospheric Observatory
VIRGO:	Variability of solar Irradiance and Gravity Oscillations

2.26 High Energy solar Spectroscopic Imager HESSI

Institute: Paul Scherrer Institut SSL Berkeley, GSFC NASA, JPL, Univ. Delft
In cooperation with:
Robert Lin, SSL

Principal Investigator: Alex Zehnder, Brian Dennis, Frank van Beek

Method: Imager:
Development and construction of own instruments:
Telescope structure; Aspect Systems including optics, electronics and s/w
Satellite

Purpose of research: The primary object of HESSI is to study the explosive energy release in solar flares. HESSI will image flares with spatial resolution ranging between 2 and 35 arcseconds over the energy range 3 keV to 20 MeV. The system is based on Fourier-transform imaging in connection with high-resolution Ge-detectors. HESSI uses 9 Rotating Modulation Collimators (RMCs), each consisting of a pair of widely separated (1.55 m) grids mounted on the rotating spacecraft. The grid pitches range from 34 micron to 2.75 mm in steps of sqrt(3). This gives angular resolutions that are spaced logarithmically from 2.3 arcseconds to 3 arcmin, allowing sources to be imaged over a wide range of angular scales.

Purpose of research: The flight hardware of the imager including the Solar Aspect system (SAS) has been delivered to the Space Sciences Laboratory of UC in Berkeley for integration with the spectrometer and the satellite structure at the end 1999, the Roll Angle System (RAS) followed early 2000. Prior to delivery extensive measurements and cross-calibrations between the Twist Monitoring System (TMS) and several coordinate measuring machines before and after the environmental tests demonstrated the precision and stability of the alignment to be on the order of 5 arcseconds. The SAS has been calibrated in direct observations of the sun at PSI, for the calibration of the RAS stars were observed from the Jungfrau Joch.

Publications:

1. R.P. Lin and the HESSI Team, "The High Energy Solar Spectroscopic Imager (HESSI) Small Explorer mission for the next (2000) solar maximum", SPIE Proc. 3442 (1998), pp. 2-12

2. M. Fivian, J. Bialkowski, W. Hajdas, R. Henneck, A. Mchedlishvili, P. Ming, K. Thomsen, A. Zehnder, G. Hurford, D. Curtis, D. Pankow, "Calibrating the aspect systems of the High-energy solar spectroscopic imager (HESSI)", SPIE (2000)

3. K. Thomsen, J. Bialkowski, F. Burri, M. Fivian, W. Hajdas, A. Mchedlishvili, P. Ming, J. Welte, A. Zehnder, and The HESSI Team, "Calibrating the aspect systems of the High-energy solar spectroscopic imager (HESSI)", SPIE (2000)

Abbreviations:

HESSI:	High Energy Solar Spectroscopic Imager
RAS:	Roll Angle System
RMC:	Rotating Modulation Collimator
SAS:	Solar Aspect System
TMS:	Twist Monitoring System

2.27 Heating of the Quiet Solar Corona

Institute: Institute of Astronomy, ETH Zurich
In cooperation with:
Institute d'astrophysique, Univ. Paris, Orsay

Principal Investigator: A. O. Benz (ETHZ)

Co-investigators:
S. Krucker (University of Cal., Berkeley)
Delaboudiniere (U.Paris, Orsay)

Method: Satellite
Research based on existing instuments: SoHO/EIT
Development and construction of own instruments:
coordinated with ground-based radio telescopes

Purpose of research: The solar corona is heated by an unknown process to more than one million degrees. The heating is suspected to draw energy from the coronal magnetic field. We investigate heating events, which we observe in the corona in EUV iron lines. We take advantage of the higher dynamic range of the events in quiet regions. The quiet corona has been found to fluctuate in time and space. Thus single events can be isolated and searched for causes and origins of the energy release. The weaker fluctuations can be compared statistically. The major question is whether the variability is similar to full scale flares and what amount of energy is injected in this way. The characteristics of the fluctuations are similar to regular flares some five orders of magnitude more powerful.

Status: Joint observations have started in summer 1996. Presently the main emphasis is on data evaluation. Currently there is still one person working on the data full time in average. The data is extremely interesting as it reveals important insight into the old problem of solar heating. End of project in 2000.

Publications:

1. S. Krucker, A.O. Benz: (2000) Are Heating Events in the Quiet Solar Corona Small Flares? -Multiwavelength Observations of Individual Events Solar Physics, in press

2. A. O. Benz, S. Krucker:(1999) Heating Events in the Quiet Solar Corona: multiwavelength correlations Astronomy and Astrophysics 341, 286-295

3. A. O. Benz, S. Krucker:(1998) Heating Events in the Quiet Solar Corona Solar Physics 182, 349-363

Abbreviations:

SOHO: ESA cornerstone mission operated jointly with NASA since Nov.1995

2.28 High Energy Solar Spectroscopic Imager (HESSI) data analysis

Institute: Institute of Astronomy, ETH Zurich
In cooperation with:
University of California, Berkeley, USA
Goddard Space Filght Center, Greenbelt, USA
Paul Scherrer-Institut, Villigen, CH

Principal Investigator: R. P. Lin

Co-investigators:
A. O. Benz (ETHZ)
B.R. Dennis (Goddard SFC), A. Zehnder (PSI)

Method: Satellite
Development and construction of own instruments:
At ETH Zurich the build-up for a data center has started. Science data analysis software, user interface and internet connections are produced.

Purpose of research: The energy release of flares is initially a nonthermal process that accelerates electrons and ions to relativistic velocities. They can best be studied by emissions in hard X-rays, gamma-ray lines and radio waves. An Small Explorer class satellite is being built by NASA with a strong Swiss envolvement. The Experimental HESSI Data Center (HEDC) is planned to be developed for the coming years at ETH Zurich to distribute HESSI data in Europe.

Status: Hardware and software are developed mainly at UCB, GSFC and PSI. The satellite was damaged by an erroneous vibration test and is currently under close inspection. A delay of 6 months has to be expected.

Publications:

1. R.P.Lin et al.: (1997) The High Energy Solar Spectroscopic Imager (HESSI) Small-Class Explorer, Proposal in response to NASA AO-97-OSS-03

2. A.O. Benz, A. Csillaghy, M.J. Aschwanden: (1997) Metric Spikes and Electron Acceleration in the Solar Corona, Astronomy and Astrophysics 309, 291-300

3. S. Krucker, A.O. Benz, L.W. Acton, T.S. Bastian,: (1997) Yohkoh observations of the source regions of solar, narrowband, millisecond spike events Astronomy and Astrophysics 317, 569-579

Abbreviations:

HESSI: SMEX Explorer mission to be launched in July 2000
PHOENIX: Radio spectrometer of ETH Zurich in Bleien, near Graenichen, AG
VLA: Very Large Array, radio interferometer in New Mexico

2.29 Particle acceleration and coronal heating

Institute: Paul Scherrer Institute, Laboratory for Astrophysics (M. Güdel)
In cooperation with:
SRON, Utrecht, Netherlands
Villanova University, Villanova, PA, USA
JILA, University of Colorado, Boulder, CO, USA
Harvard-Smithsonian Center for Astrophysics, Cambridge, MA, USA

Principal Investigator: M. Güdel (PSI)

Co-investigators:
M. Audard (PSI)
R. Mewe (SRON)
E.F. Guinan (Villanova Univ.)
S.L. Skinner (JILA)
J.J. Drake (CfA)
V. Kashyap (CfA)

Method: Research based on existing instuments:
EUVE, ASCA, BeppoSAX, XMM-Newton; coordinated with ground-based radio (VLA) and optical observatories

Purpose of research: We study and simulate observational parameters that probe the role of particle acceleration and flare energy release in coronal heating of active stars. The statistical distribution of flares in energy provides crucial information on the role of explosive energy release in the coronal heating process. Long, uninterrupted observations in the EUV and X-ray regimes are used for statistical investigations. Since a number of different objects are used for this study, we also investigate the dependence of coronal heating on fundamental parameters (rotation, age, etc). Differential emission measure distributions probe the distribution of plasma in temperature both during flares and during quiescence. Such distributions can be modeled by performing hydrodynamic computer simulations of flare-heated magnetic coronal loops. The accelerated electrons reveal themselves by their observable gyrosynchrotron emission at radio wavelengths.

Status: Emission measure distributions have been reconstructed from ASCA/EUVE observations. They reveal a characteristic two-bump structure in temperature, with most plasma being present at 5-10 MK and at 20-30 MK. Simple hydrodynamic simulations of a large sample of statistically distributed (in time, energy, and duration) flare energy release events show very similar two-peak structures when averaged in time. This points at episodic coronal heating and supports the microflare heating hypothesis. Light curve analysis has been performed using long, uninterrupted observations from the EUVE data archive and from newly proposed dedicated observations with durations of up to 44 consecutive days. The statistical analysis of several dozens of flares shows that they are distributed in energy according to a power law with a power-law index that favors a dominant contribution of small flares to the observed radiation. Depending on the validity of the power-law at lower energies, a large fraction of the coronal energy release may be related to flares. We have found that the flare occurrence rate correlates well with the overall X-ray luminosity of the investigated stars, further underlining their prominent role. The statistical results also agree with the observed tendency of more active stars showing hotter coronal plasma.

The radio gyrosynchrotron emission turns out to be very well correlated with the amount of emission measure in the hotter portion of the plasma, suggesting that accelerated electrons are crucial for the coronal heating mechanism. This project will be continued by using a large amount of XMM observing time now scheduled in the guaranteed time section in which we participate.

Publications:

1. Audard, M., Güdel, M., Guinan, E. F. (1999), Implications from EUV Observations for Coronal Heating of Active Stars The Astrophysical Journal, 513, L53

2. Audard, M., Güdel, M., Drake, J. J., Kashyap, V. L. (2000) EUV Flare Activity of Late-Type Stars The Astrophysical Journal, submitted

3. Güdel, M., Audard, M., Guinan, E. F., Mewe, R., Drake, J. J., Alekseev, I.Y., (2000) The Ups and Downs of AD Leo in Eleventh Workshop on Cool Stars, Stellar Systems, and the Sun. Ed. R. J. Garcia Lopez, R. Rebolo, & M. R. Zapatero Osorio (San Francisco: ASP), in press

Abbreviations:

ASCA: Advanced Satellite for Cosmology and Astrophysics
EUVE: Extreme Ultraviolet Explorer
VLA: Very Large Array
XMM-NEWTON: X-Ray Multi-Mirror Mission of ESA
BEPPOSAX: Satellite per Astronomia in Raggi X (X-ray satellite, Italy/Netherlands)

3 Earth observation

3.1 Advanced Query and Retrieval Techniques for Remote Sensing Image Databases

Institute: Computer Vision Lab, ETHZ, Zuerich/CH
In cooperation with:
German Aerospace Center DLR, Oberpfaffenhofen/D
Swiss Center for Scientific Computing, Manno/CH

Principal Investigator: Dr. Klaus Seidel, ETHZ, CH 8092 Zuerich

Co-investigators:
Prof. Luc Van Gool, ETHZ, CH 8092 Zuerich
Prof. Mihai Datcu, DLR, D 82234 Wessling

Method: Research based on existing instuments:
Data Archivation and Content-based querying

Purpose of research:
The project aims at designing systems with flexible behaviour and intuition for information retrieval from large image archives. It focuses on research to find and demonstrate solutions for the three following questions:

1. Which are the stochastic models best suited to characterize certain classes of images? Images are seen as particular realization of stochastic processes. Their intrinsic complexity is very high and they are disturbed by intricate phenomena. Thus, their modelling is not an easy task. We start research for elaboration of methods for learning probability distributions over sensory data, such that we can build a library of models for particular classes of images. The research aims mainly to apply and further develop the methods of Bayesian networks.

2. How to design image information retrieval systems able to accommodate to rapidly growing volume of archived data, fast diversification of data types, evolution and continuously changing user interests? Here, to arrive at practical and optimal solution, we first study two modelling aspects:

   (a) the modelling of variability of the image features and methods of generalization and summarization and,

   (b) the stochastic modelling of the user interaction from the point of view of learning the user's behaviour. We bring a new dimension in the design of the image archive systems: the index as a multidimensional and time evolving signal.

3. How to give to the users of distributed very large image archives the feeling they can work in real time? The problems to be solved are the optimal design of the tasks at server and client sites, and objective will be the study of information representation in layered structures ranging from low level image data as visualization of mental representations up to the abstract knowledge structures for courses of action and the elaboration of signal oriented intelligent agents.

The expected results of the research are intended to enhance the expertise in signal modelling, avant-garde visual communication systems, and information retrieval from large image archives, with applications in remote sensing, and focused on high and very high resolution imagery. The algorithms and methods to be elaborated during the project will be integrated in a prototype system for content-based query and retrieval of information from large remote sensing image archives.

Status: A demo system giving an impression of the envisaged goals is available under `http://www.vision.ee.ethz.ch/~rsia/`

Publications:

1. Datcu, M., Seidel, K., and Walessa, M. (1998). Spatial information retrieval from remote sensing images. Part I: Information theoretical perspective. IEEE Trans. on Geoscience and Remote Sensing, 36(5):1431 1445.

2. Schröder, M., Rehrauer, H., Seidel, K., and Datcu, M. (1998). Spatial information retrieval from remote sensing images. Part II: Gibbs Markov random fields. IEEE Trans. on Geoscience and Remote Sensing, 36(5):1446 1455.

3. Schröder, M. (1999). Interactive learning in remote sensing image databases. In IEEE Intern. Geoscience and Remote Sensing Symposium IGARSS 99. Ranked 2nd in the student prize paper award.

3.2 Combined Remote Sensing for Natural Disaster Monitoring CIRSTEN

Institute: Institute for Geodesy and Photogrammetry, ETH Zurich
In cooperation with:
Gamma Remote Sensing AG, Bern

Principal Investigator: Dipl.-Ing. Marc Honikel

Method: Satellite

Purpose of research: Recent natural disasters like landslides, flooding or forest fires have shown the need for natural risk management in Europe, as they endanger directly public health and cause severe damages on the national economy. In order to improve the efficiency of existing hazard management practices, we proposed a natural hazard and disaster monitoring service for sensitive areas. The project addresses the localisation and mapping of natural hazards using SAR and optical data from earth observation satellites. Remote sensing data offer a regular information for prevention and damage assessment of natural disasters and provide large scale environmental monitoring and updating capabilities.
The results are stored as information layers in a geographic information system (GIS), which enables a user friendly access and compatibility with pre- existing databases. The final product is a fast, inexpensive and ready to use service for the prevention and management of natural hazards.

Status: Our ongoing activities focus on the monitoring of the damages, caused by the winter hurricane Lothar in Switzerland and are divided in three parts:

1. Change detection for disaster monitoring SAR images with their all-weather and day- and night-time capabilities are a valuable and, compared to optical data, cheap source for

environmental monitoring. In contrast to optical imagery, cloud occlusions do not occur due to the microwave properties and a regular data supply of an area is guaranteed within the repeat pass interval of the sensor. SAR sensors are very sensitive to ground properties and are able to measure centimetre scale ground changes, which enables a wide range of remote sensing change detection applications, including disaster monitoring by change detection. The main parameters to be retrieved from the SAR change detection are the localisation and extent of affected areas with amplitude and interferometric coherence information from an images series from before and after the event.

2. DEM generation Stereo-optical DEM generation will provide the elevation data needed, as stereoscopy is robust and accurate in most types of terrain. The high degree of automatisation and the little terrain dependency of the accuracy make stereo-optical DEM generation the DEM source of choice.
   SPOT is the preferred satellite sensor for optical imagery at the moment and offers a multi-time data coverage of the whole world. This redundancy offers the opportunity to select appropriate stereo pairs (e.g. little cloud coverage) for DEM generation over the affected area. DEM generation will improve with the next generation of high-resolution optical sensors, which are now operated and provide high resolution and accuracy DEMs due to their sensor and along track capabilities.

3. Data Integration Several procedures will profit directly from data integration: Geocoding of SAR slant range images to an appropriate map projection. This is required for the geo- referencing of the information retrieved from the SAR sensor and its comparison and combination with information from other sensors or data sources within a GIS. The DEM offers also the opportunity to enhance the parameter retrieval (backscatter, phase) for the improvement of the change detection from the SAR images. It will be used to remove the contribution of the terrain inclination in the SAR backscatter signal (flattening).
   Interpretation of SAR imagery needs skilled operators, as it is based on different physical principles than the human eye is used to. In comparison, optical imagery is much easier to interpret as it reflects the scene in the visible spectrum. By embedding the disaster detection results in the optical images the resulting damage map profits from both sensors and can easily be interpreted even from less skilled operators.

Publications:

1. Honikel, M., Wegmueller U.. "A Method for the Forest Fire Damage Assessment with SAR and Optical Remote Sensing Data", Proc. 3rd Int. Conf. on Data Fusion,EARSEL SIG Data Fusion, pp. 129-136, Jan. 26th-28th, 2000, Sophia Antipolis, France

Abbreviations:

SAR:	Synthetic Aperture Radar
DEM:	Digital Elevation Model

3.3 SAR Imaging for Boreal Ecology and Radar Interferometry Applications (SIBERIA)

Institute: Gamma Remote Sensing AG
In cooperation with:
European Partner Institutes

Principal Investigator: Christiane Schmullius (DLR, Germany)

Co-investigators:
Urs Wegmüller (Gamma) and others

Method: Research based on existing instuments:
ERS SAR, JERS SAR

Purpose of research: The main objective of the CEO Environment and Climate Programme is the generation of information for dedicated customers using Earth Observation data sources and techniques. In line with this objective, the SIBERIA project aims to produce an extensive forest map of a geographical region for which only limited information is currently available but for which detailed information is of immense scientific, environmental and commercial interest, both to specific customers and to the general population.
The forest map will be derived primarily from state-of-the-art satellite data and remote sensing techniques. These include multitemporal and interferometric data from dual-frequency space-borne radar instruments, which, although relatively recent in development, have shown huge potential for the mapping and monitoring of the Earth's surface, especially in regions where cloud cover is persistent.
The primary objective of the project is to support the development of sustainable management policies and regimes at the strategic and operative levels in order to manage the Russian forest resources in an efficient and ecological way. This development is to be based on up-to-date information on forest resources and related variables where existing inventory material is to be validated and confirmed. The proposed forest map will serve as a unique planning and monitoring tool for the sustainable management of the natural resources of Siberia, for ist socio-economic development and for a better understanding of the role of boreal forest in climate change.
Gamma Remote Sensing's main responsibility is the SAR and interferometric processing of the data of the Japanese JERS-1 satellite. Furthermore, Gamma participates in the methodological research for the forest and topography mapping algorithm development.

Status: Methodology almost ready to be passed to the map producer. Gamma's main task, the JERS SAR data processing is to 80% finished.

Publications:

1. Dammert P. and U. Wegmüller, JERS INSAR DEM quality assessment for a boreal test site, Proceedings of IGARSS'99, Hamburg, 28 June-2 July 1999 (D03_03).

2. A. Wiesmann, T. Strozzi, and U. Wegmüller, JERS SAR and Interferometric Processing for the boreal forest mapping project SIBERIA, Proceedings of IGARSS'99, Hamburg, 28 June-2 July 1999 (DD01_03)

3. Wiesmann A., U. Wegmüller, and T. Strozzi, JERS SAR processing for the boreal forest mapping project SIBERIA, Proceedings of CEOS SAR Workshop, 26-29 October 1999, Toulouse, France, 1999.

3.4 ALPMON - Inventory of alpine-relevant parameters for an alpine monitoring system using remote sensing data EU-4th Frameprogramm, Environment

Institute: WSL, Swiss Federal Institute for Forest, Snow and Landscape Research,

8903 Birmensdorf
In cooperation with:
Joanneum Research Graz (A), Remote Sensing Data Engeneering (I), University of Freiburg (D) University of Munich (D), Austrian Research Centre Seibersdorf (A)

Principal Investigator: Dr. H. Mauser, M. Catalini, L. Waser

Method: Research based on existing instuments:
Processing of satellite data with geocoding, atmospheric correction, topographic normalisation, classification

Purpose of research: ALPMON envisages the compilation of an alpine monitoring system by means of satellite data and GIS. With this system, harmonized basic information for major planning projects in alpine regions should be made available. The components of the monitoring system will, firstly, be derived from the results of classification of high resolution satellite images of different sensors and, secondly, be extrapolated from thematic maps. The information levels, the processing of satellite data and data handling in the GIS will be harmonized in the involved countries. To demonstrate the feasibility of the developed monitoring system, specific applications will be performed in close co-operations with national customers. The test site for the Swiss contribution is the Swiss National Park, for which classified satellite data will serve as a basis for national park research and management.

Status: ALPMON was aimed at the compilation of a basic landscape data base for an alpine monitoring system by means of the analysis of Landsat TM, SPOT and other high resolution satellite images of alpine landscapes selected for their typical characteristics, which serves as the basis for planning tasks. Primary information on the nature and state of vegetation and of residential areas for ALPMON were compiled solely by means of remote sensing. An important objective was the testing of operational and semi operational processing methods which permit as precise a compilation of specified parameters as possible.
The feasibility of the alpine monitoring system was tested on European level (Alpine Convention) and on national level. The Swiss Customer was the Swiss National Park, which is in need of a spatially comprehensive inventory of grass areas, forest stand characteristics (tree species composition, stand density, natural age class) and non- vegetated areas for the monitoring of erosion and vegetation development.
For the fullfilment of these requirements, Landsat TM, SPOT pan and IRS-1C pan data were acquired. The raw satellite data was geocoded to the rectangular coordinate system of the Swiss topographic map 1:25'000. Radiometric corrections included the topographic normalization after Minnaert. Most user requirements from our local customer were classified and verified against reference data, which consisted of 104 reference areas. These were initially delineated stereoscopically from infrared aerial photographs and then verified during a 5-day field survey. Periodic meetings were held in the course of the project to discuss further requirements and classification results.
The results produced by ALPMON cover most of the user requirements. From the list of required applications, only one application was tested for its feasibility by the Swiss National Park. All the classification results delivered to the Swiss National Park were integrated into two ongoing mountain ungulate projects. The monitoring of grazing areas of red deer is one of the applications for which classified remotely sensed data serves as input to better understand

the habitat analysis of red deer. Information on the distribution of grassland at different times of the year and open forest shows potentially used grazing areas. Classification results were also used to build a virtual world for the red deer, in order to model their behavior. Results of the feasibility of these satellite classifications have not been established yet, as the work is still ongoing.

Publications:

1. Catalini, M., 1999. Landschaftsveränderungen im Schweizerischen Nationalpark: Was kann die Satellitenbild-Fernerkundung bieten?, Cratschla 2 / 1999.

2. Schmitt, U., Catalini, M., Schardt, M., Waser, L., Zini, E., 2000. Inventory of alpine-relevant parameters for an Alpine monitoring system using remote sensing data. Proc. ISPRS, Amsterdam, July 2000, in prep.

3. Catalini, M., Haller, R., Abderhalden, W., 2000. Operationalization of High-alpine National Park Inventory using Multi-Sensoral Satellite Imagery for assisting red deer habitat monitoring. Proc. EARSeL, Dresden, June 2000, in prep.

Abbreviations:

ALPMON:	ALPine MONitoring
EARSEL:	European Association of Remote Sensing Laboratories
GIS:	Geographic Information System
ISPRS:	International Society for Photogrammetry and Remote Sensing

3.5 Study of the synergy of hyperspectral-multispectral data (scaling of spectrally derived land-surface parameters)

Institute: RSL, Dept. of Geography, University of Zurich
In cooperation with:
European Space Agency

Principal Investigator: Dr. Tobias Kellenberger

Co-investigators:
Prof. K.I.Itten

Method: Aircraft, Satellite
Research based on existing instruments:
HyMap, SPOT VEGETATION, NOAA/AVHRR, IRS-1C WIFS, Landsat ETM+
Others: Ground based instruments

Purpose of research: In the framework of ESA's new strategy for Earth Observation in the post-2000 time frame, four research/demonstration missions, focusing on advancing in understanding of the different Earth system processes have been proposed. One of the missions is dedicated to the study of land-surface processes and their interactions with the atmosphere. This Land-Surface Processes and Interaction Mission (LSPIM) focuses on the measurement of surface characteristics such as albedo, reflectance, bidirectional reflectance distribution function (BRDF) and surface temperature which are linked to the processes driving bio/geophysical and biochemical variables. Even though this mission was not selected in fall 1999 as first core mission, the ESA Programme Board stressed the importance of the LSPIM mission.

The primary goal of the LSPIM mission is the provision of bio-geophysical variables to increase the understanding of bio-geophysical processes and land atmosphere interactions at the local scale and advance the understanding of these processes and interactions on global scale.
The HyMuS study (HYperspectral-MUltispectral Synergy - scaling of spectrally derived land-surface parameters) focusses on the upscaling aspect of LSPIM. The objective of the study was to investigate the effects of scaling, aggregating or lumping on optical remote sensing data and derived biophysical/biochemical parameters, serving as input in land-surface process models at local up to global scale.
The different land-surface processes vary from local scale (homogeneous plots) over regional scale (uniform land cover plots) up to global scale. The variation of the land-surface processes are frequently non-linear over scales with respect to the parameters which they are determined. The non-linearity sets limits to the degree of spatial and temporal averaging of input data that can be performed for a given level of error when modelling the processes.

Status: The first part of the study is based on a hyperspectral data set of the HYMAP sensor with 5m spatial ground resolution. The data was taken in 1998 over a rural region in Switzerland. Three different case parameters which serve as input into canopy models, describing primary production, have been selected: The normalized difference vegetation index NDVI, the MERIS global vegetation index (MGVI), and the normalized difference water index NDWI.
Seven different cases have been performed to analyse the effects of upscaling from 5m to 1km spatial resolution and to establish a link of the upscaled data to NOAA/AVHRR and SPOT VEGETATION data. From these investigations requirements for the upscaling of land surface parameters have been derived which can be applied to similarly structured regions.
In the running second part of the study, we will focus on upscaling data sets with large coverage but less spectral resolution. Based on a Landsat ETM+ scene of Eastern Switzerland, the effects of landsurface heterogeneity in the upscaling approach will be investigated. Establishing a spectral, spatial and informational link from spatially high resolved data (ETM+, SPOT HRVIR, IRS) to global data sets (SPOT VEGETATION, NOAA/AVHRR) will be of high priority. The study will demonstrate the scaleability of NDVI, MGVI and NDWI from local scale up to global scale. Large scale sensors with global coverage (AVHRR, VEGETATION) may profit from smaller scale sensors with global access (e.g. LSPIM mission).

Publications:

1. Kellenberger T.W., Dickerhof C., Schläpfer D., 2000; Study Of The Synergy Of Hyperspectral-Multispectral Data - scaling of spectrally derived land-surface parameters; Final report of ESA-Contract 13397/98/NL/GD; RSL - Remote Sensing Laboratories, University of Zürich, Switzerland

Abbreviations:

AVHRR:	Advanced Very-High Resolution Radiometer (Sensor of NOAA)
ESA:	European Space Agency
HRVIR:	High Resolution Visible and Infrared Sensor of the SPOT-4
HYMAP:	Hyperspectral scanner from HyVista Corporation of Australia
IRS-1C:	Indian Remote Sensing Satellite
LANDSAT:	ETM+ Landsat Enhanced Thematic Mapper Plus (multispectral Scanner)
LSPIM:	Land Surface Processes and Interactions Mission
MGVI:	Meris Global Vegetation Index
NDVI:	Normalized Difference Vegetation Index

NDWI: Normalized Difference Water Index
PRISM: Processes Research for Imaging Spectrometry Mission
SPOT: Système pour l'observation de la terre
VEGETATION: Multispectral scanner on board SPOT-4 (1km resolution)

3.6 APEX-Airborne PRISM Experiment

Institute: Remote Sensing Laboratories, University of Zurich
In cooperation with:
European Space Agency / PRODEX

Principal Investigator: Prof. Dr. K.I. Itten

Co-investigators:
Dr. Michael Schaepman
Dr. Daniel Nueesch

Method: Aircraft
Development and construction of own instruments:
Airborne Imaging Spectrometer (APEX) as simulator for spaceborne instruments

Purpose of research: Based on the present demand for airborne and spaceborne imaging spectroscopy data in remote sensing, the European Space Agency (ESA) has initiated a project to build a new generation airborne hyperspectral imager named APEX.
APEX is an acronym used for Airborne PRISM Experiment, whereas PRISM is the main payload on one of ESA's planned Earth Explorer Missions Core Missions named LSPIM (Land Surface Processes and Interactions Mission).
APEX is a pushbroom imager with 300 spectral channels in the 400–2500 nm wavelength region, and with 1000 pixels across track. It will be flown in an aircraft at operating altitudes between 4 and 10 km having a spatial resolution of 2–5 meters.
The mission objectives of APEX are mainly being a simulator, calibrator, and validator for spaceborne multispectral and hyperspectral instrument (such as PRISM). APEX furtheron shall foster the application development for hyperspectral imaging in Europe and worldwide. The project shall be an European answer to the scientific success of American hyperspectral instruments. Its specifications are state-of-the-art in resolution and overall radiometric performance.

Status: In spring 2000 the phase B (detail definition phase) of the project could be successfully finished. The construction of this unique instrument will start in summer 2000. The Remote Sensing Laboratories are the Principle Investigator together with Belgian partners.
The hardware is to be built by a Swiss-Belgian industrial team consisting of Alcatatel Switzerland, the Swiss Aircraft Company and the Belgium Optical Company OIP. The very crucial detectors for the Visible, near infrared, and short wave infrared part of the spectrum are developed by European companies in parallel to the project. An American backup solution is available.
RSL is responsible for the scientific management of the project, for industrial consulting concerning the specialities of imaging spectrometer instrument, and for the construction of the Processing and Archiving Facility (PAF). The latter will be an universal, database driven system supporting the processing and distribution of all APEX data acquisitions. Sophisticated

information technology tools are used for a versatile processing system, which will be persistent throughout the operational phase of the instrument.

Publications:

1. Itten K.I., Schaepman M., De Vos L., Hermans L., Schlaepfer H., and Droz F., 1997: APEX-Airborne Prism Experiment a New Concept for an Airborne Imaging Spectrometer. 3rd International Airborne Remote Sensing Conference and Exhibition, ERIM, Copenhagen (DK), Vol. I, pp. 181-188.

2. Schaepman M., Schläpfer D., Börner A., Bojinski S., and Itten K.I., 1999: APEX-Airborne PRISM Experiment: A new Airborne Hyperspectral Imager for the Simulation of ESA's Land Surface Processes and Interactions Mission. Proc. ISSR, Las Vegas, p. 11.

3. Schläpfer D., Schaepman M., Börner A., and Itten K.I., 1999: Calibration Concept for the Airborne PRISM Experiment (APEX). 4th Int. Airb. R. S. Conf. and Exh., ERIM, Ottawa, CA, Vol. II:8-15.

Abbreviations:

APEX:	Airborne PRISM Experiment
LSPIM:	Land Surface Processes and Interactions Mission
PRISM:	Process Research by Imaging Spectrometry Measurement
RSL:	Remote Sensing Laboratories

3.7 Monitoring of Snow Cover in Mountainous Terrain with SAR-Data

Institute: Remote Sensing Laboratories, University of Zurich

Principal Investigator: Prof. Dr. H. Haefner

Co-investigators:

J. Piesbergen
Dr. D. Small
St. Biegger
H. Hoffmann
Prof. Dr. D. Nüesch

Method: Satellite
Research based on existing instuments:
ERS-1/2; Radarsat ScanSAR; Landsat TM; NOAA-AVHRR

Purpose of research: Methods were developed and successfully tested to apply SAR-data for monitoring geoecological processes in high mountain terrain in particular of the wet snow cover. Using the multitemporal optimal resolution appraoch" (MORA) concept, and merging ERS with Landsat TM or NOAA-AVHRR data, and a DEM, the snowmelt process could be monitored in detail in various watersheds and over large areas.

Status: under progress

Publications:

1. Haefner H., Piesbergen J., Holecz F.: Methods of Snow Cover Monitoring with Active Microwave Data in High Mountain Terrain. EARSeL Workshop "Remote Sensing of Land Ice and Snow", University of Freiburg, ed. Dr. Stéfan Wunderle, EARSeL, Paris, pp. 123-130, 1997.

2. Haefner, H. & Piesbergen, J.: Monitoring high mountain snow cover using data fusion techniques. Int. Archives of Photogrammetry and Remote Sensing, XXXII/7, Budapest, 1998, pp. 350–356.

3. Haefner H. et al.: Estimation of snow cover over large mountainous areas using RADARSAT ScanSAR. Proc. Symposium "Remote Sensing and Hydrology 2000", Santa Fé, 2 April 2000 (to be published).

3.8 Remote sensing in snowhydrology: Snowmelt-Runoff forecasting in a changing climate

Institute: Remote Sensing Laboratories, University of Zurich
In cooperation with:
Institute for Communciation Technology, ETHZ

Principal Investigator: Dr. K. Seidel

Co-investigators:
Prof. Dr. H. Haefner (GIUZ)
C. Ehrler (IKT and GIUZ)
Dr. J. Schaper (IKT and GIUZ)

Method: Satellite
Research based on existing instuments: Landsat-TM / SPOT

Purpose of research: Within the framework of this longterm Research Program, supported by the Swiss National Research Foundation, the continuous monitoring of the accumulation and melting process of the snowpack and of the water equivalent in its regional differentiation was fully operationalized for three main basins in the Swiss Alps (Rhine above Felsberg Rhone above Sion; Ticino above Bellinzona).
The results are used for daily and seasonal snow melt runoff forecasts applying the Snowmelt Runoff Model (SRM), and for simulating the alterations of the snowcover and run-off in a changing climate for various defined climate scenarios.
To refine the model, research is under progress to separately determine the ice cover of the glaciers and to simulate the run-off from melting ice.

Status: under progress, run-off forecasting operational

Publications:

1. Ehrler, C.: Klimaänderung und alpine Schneedecke. Auswirkungen auf das Abflussregime am Beispiel des Einzugsgebiets "Rhein-Felsberg". Schlussbericht NFP 31, Hochschulverlag AG an der ETH, Zürich, 117 p., 1998.

2. Schaper, J. Martinec, J. und Seidel, K.: Distributed mapping of snow and glaciers for improved runoff modelling. Hydrological Processes, 13, 1999, pp. 2023-2031

3. Haefner, H. und J. Piesbergen: High Alpine Snow Cover Monitoring using ERS-1 SAR and Landsat TM Data., IAHS Publication, No. 242, 1997.

3.9 Reconstruction of the ancient cultural landscape along the old incense road in Yemen

Institute: Remote Sensing Laboratories, University of Zurich
In cooperation with:
Staatliches Museum für Völkerkunde, München

Principal Investigator: Prof. Dr. H. Haefner

Co-investigators:
U. Brunner
St. Kohler
O. Bosshard
W. Raunig

Method: Research based on existing instuments:
MOMS, Landsat TM, aerial photography

Purpose of research: The reconstruction of the ancient cultural landscape, in particular of the irrigation systems, is systematically advanced combining satellite imagery, aerial photography and field work. This led to a much better understanding of the geography of ancient South Arabia, and establishes Arabia Felix as an independent, important, fertile cultural region based on well adapted irrigation agriculture.

Status: under progress

Publications:

1. Brunner, U. [1997]:Geography and Human Settlements in Ancient Southern Arabia, in: Arabian Archaeology and Epigraphy, May 1997, 20 pp.

2. Kohler, St., Haefner, H., Gharaei, M., Bosshard, O. und Brunner, U.: Annäherung an antike Hochkulturen aus dem Luft- und Weltraum. In: Daum W., Müller W., Nebes N. und Raunig W. Hrsg.: Im Land der Königin von Saba, Kunstschätze aus dem antiken Jemen, Staatl. Museum für Völkerkunde München, IP Verlag, 2000, pp. 238-246.

3.10 Swiss Terrain-Geocoding and Interferometry

Institute: Remote Sensing Laboratories, U of Zurich
In cooperation with:
Canadian Space Agency

Principal Investigator: Dr. David Small

Co-investigators:
Dr. Francesco Holecz
Dr. Erich Meier
Prof. Dr. Daniel Nüesch

Method: Research based on existing instruments: RADARSAT-1

Purpose of research: The project aims to demonstrate terrain-geocoding of multimode RADARSAT imagery, and improve radiometric calibration by developing image simulation and normalization techniques.
It also sets out to test RSL's InSAR processor on RADARSAT single look complex input data, and to develop algorithms for terrain-geocoding and radiometric calibration of ScanSAR (multiple beam) satellite images.
A further goal is development of automated geocoding methods whereby no manual tiepoint selection is necessary for refinement of the SAR geometry. Such automation is possible in regions like the Swiss Alps, where correlation between an image simulation calculated through combination of a DEM and a rough geometry (platform position and pixel spacings) provides offsets and offset trends that in turn provide the refined geometry for a precision terrain geocoding (and possibly also improved image simulation). Processing techniques developed for RADARSAT will later also find applicability with ENVISAT Advanced SAR (ASAR) data from the satellite due for launch in 2001.

Status: The terrain geocoding of single-beam scenes has been tested on many scenes, and is operational. Integration of illuminated area (image simulator) has also been used on many scenes (also other sensors) and is in use for radiometric calibration (normalization).
ScanSAR geocoding approaches have been designed and are being compared. Automated geocoding methods are being tested and refined. Image simulation is being used for quantitative investigation of the effects of nominal incidence angle on the relationship between radar and map geometries.
Automated refinement of the geometry using image simulation (esp. in mountainous areas) is being tested on multiple datasets.

Publications:

1. Small D., Holecz F., Meier E., Nüesch D., Barmettler A. (1997-1998): Geometric and Radiometric Calibration of Radarsat Images, Proc. of ADRO Symposium (on CD), Montreal, Canada, Oct. 13-15, 1998.

2. Small D., Holecz F., Meier E., Nüesch D. (1998): Absolute Radiometric Correction in Rugged Terrain: A Plea for Integrated Radar Brightness, Proc. of IGARSS 1998, Seattle, USA, July 6-10, 1998, pp. 330-332.

3. Small D., Holecz F., Meier E., Nüesch D. (1998): Radiometric Normalization for Multimode Image Comparison, Proc. of EUSAR 1998, Friedrichshafen, Germany, May 25-27, 1998, pp. 191-194.

Abbreviations:

ADRO:	Application Development and Research Opportunity
CSA:	Canadian Space Agency
IGARSS:	International Geoscience and Remote Sensing Symposium
RSAT:	RADARSAT
RSL:	Remote Sensing Laboratories
SAR:	Synthetic Aperture Radar

3.11 Product development for mapping and monitoring of land cover dynamics in tropical areas

Institute: Remote Sensing Laboratories (RSL), Dept. of Geography, University of Zurich
In cooperation with:
Sarmap S.A., Banco geoconcept, Barbla Schmid, Zurich
National Resource Management Service (NRMS), Sri Lanka
European Space Agency (ESA)

Principal Investigator: Prof. Dr. K.I. Itten

Co-investigators:
Prof. Dr. Daniel Nüesch
Dr. U. Frei
R. Fischer
P. Schmid

Method: Research based on existing instuments: ERS SAR, Radarsat

Purpose of research: Multitemporal radar images are being classified for mapping the areal extent of irrigated paddy fields. These measurements, together with ancillary data, allow for an early rice yield prediction, what in turn allows the government to take appropriate measures to guarantee price stability.
The project is carried out within the European Space Agency's Data User Programme (DUP), that intends to stimulate end user markets for data products generated from spaceborne Earth observation data, in particular data gathered by ERS- and ENVISAT instruments.

Status: For a Sri Lankan test site, some prototype maps have been generated, and the suitability of ERS data has been assessed. The developed algorithms are now being verified using a second test site in Thailand. In parallel, the experimental software is being upgraded for operational use. In view of the possibilities offered by ENVISAT (to be launched in 2001), simulation of data products derived from the ASAR instrument is on-going

Publications:

1. Frei U., Spoerri S., Stebler O., Holecz F., 1999: Rice Field Mapping in Sri Lanka using ERS SAR Data, Earth Observation Quarterly no. 63, ESA publications division, ESTEC, Noordwijk, The Netherlands, ISSN 0256-596X

Abbreviations:

DUP:	Data User Programme
ERS:	European Remote Sensing Satellite
ESA:	European Space Agency
NRMS:	National Resource Management Service (Sri Lanka)
RSL:	Remote Sensing Laboratories

3.12 ENVISAT ASAR Expert Support Laboratory: Alternating Polarisation Mode Product Study and Simulation

Institute: Remote Sensing Laboratories, U of Zurich
In cooperation with:
European Space Agency (ESTEC)

Principal Investigator: Prof. Dr. Daniel Nuesch

Co-investigators:

Dr. Paolo Pasquali
Dr. Francesco Holecz
Adrian Schubert
Dr. David Small

Method: Research based on existing instuments:
Shuttle Imaging Radar Mission C (SIR-C)

Purpose of research: The performed research focused on the simulation and assessment of the capabilities of the Alternating Polarisation (AP) mode of the ASAR radar instrument. Simulations were performed based on existing SIR-C raw datasets in S16 mode (Quad-Pol, interferometric mode). The simulations consisted of synthesizing raw data conforming to ENVISAT acquistion modes (HH-VV,HH-HV, and VV-VH polarisations) while respecting the ASAR instrument characteristics to form various simulated ASAR Products.
SLC, PRI, as well as level-0 products were simulated using the existing SIR-C datasets and knowledge of the ASAR physical and orbital-platform differences between the two systems.
The use of SIR-C C-band pairs having ASAR-compatible baselines permitted assessment of the feasibility of AP-mode SLC products for interferometric applications. The potential interest of various polarisation combinations was investigated for the PRI, SLC, and GEC products.

Status: RSL has completed the research described above. However, a new contract with the European Space Agency (ESA) and the Politecnico in Milan is beginning, and will involve further development working towards a prototype system for processing ENVISAT ASAR image, AP, and wide swath mode (WS) data.
Specifically, RSL will supply ESA with program modules furthering their existing array of tools, enabling them to generate synthetic interferograms based on a DEM and ENVISAT orbit information.
Software will be developed within the multipartner project software that enables interferometric combination of ASAR image products from IM, AP, and WS modes.

Publications:

1. Pasquali P., Small D., Holecz F., Meier E., Nuesch D. (1998): Study of the ENVISAT ASAR Alternating Polarization mode: Preliminary Results, Proc. of EUSAR'98, Friedrichshafen, Germany, May 25-27, 1998, pp. 335-338.

2. Pasquali P., Small D., Holecz F., Schubert, A., Meier, E., Nuesch, D., First Results of the Envisat-ASAR Alternating Polarization Mode Simulation Study, Proc. of CEOS SAR Workshop, ESA-ESTEC, February 3-6 1998

3. Pasquali P., Small D., Holecz F., Schubert, A., Meier, E., Nuesch, D., ENVISAT ASAR ESL Alternating Polarisation Mode Product Study and Simulation: Final Report, written in fulfillment of ESA Contract 12374/97/NL/PR, Remote Sensing Laboratories, University of Zurich, Switzerland, 1999

Abbreviations:

AP:	ENVISAT ASAR Alternating Polarisation Mode
ASAR:	Advanced Synthetic Aperture Radar

ESA:	European Space Agency
ESL:	Expert Support Laboratory
GEC:	Geocoded Ellipsoid Corrected
IM:	ENVISAT ASAR Image Mode
PRI:	Precision Image
RSL:	Remote Sensing Laboratories
SIR-C:	Shuttle Imaging Radar, Mission C
SLC:	Single Look Complex
WS:	ENVISAT ASAR Wide Swath Mode

3.13 Operational system for forest fire detection and burnt surface mapping

Institute: CompanySarmap SA Cascine di Barico CH- 6989 Purasca
In cooperation with:
Intercooperation, Bern
Chevrier SA, Sion
Canadian Forest Service (CFS)
European Space Agency (ESA)

Principal Investigator: Paolo Pasquali

Method: Research based on existing instruments: ERS SAR & ATSR

Purpose of research: The aim of this project is to implement and operationalize a tool tailored to the detection of forest fires and mapping of burnt surface areas, taking advantage of the synergetic use of ERS SAR/InSAR and ATSR data.
The project is carried out within the European Space Agency's Data User Programme (DUP), that intends to stimulate end user markets for data products generated from spaceborne Earth observation data, in particular data gathered by ERS- and ENVISAT instruments.

Status: The first software prototype developed in C++ and integrated in the ArcView environment has been delivered to ESA/ESRIN for the Software Acceptance Tests. In the meantime, of the three selected test sites (Canada, Madagascar and Italy) first products are being generated and sent to various institutions for evaluation.

Publications:
None

3.14 Differential SAR interferometry for geophysical displacement mapping

Institute: Gamma Remote Sensing AG

Principal Investigator: Urs Wegmüller (Gamma)

Co-investigators:
Tazio Strozzi
Charles Werner
Andreas Wiesmann (Gamma)

Method: Research based on existing instuments:
ERS SAR, JERS SAR

Purpose of research: The main objective of this project is the development of a differential SAR interferometry methodology as a tools for geophysical displacement mapping at mm to m scale.
At present the main application investigated is land subsidence. Investigated sites include Bologna and other location in the Po river Valley, Mexico City, Las Vegas, and the German Ruhrgebiet.
Recently we also started to investigate glacier motion as another application for the same technique.

Status: The methodology is well understood and pretty high robustness is achieved. Aapplication demonstration examples were generated.
The results achieved for Bologna and Abano Terme were well received by the local subsidence research community. Validation with levelling data allowed to confirm the expected high precision of this spaceborne method.

Publications:

1. Strozzi T., L. Tosi, L. Carbognin, U. Wegmüller and A. Galgaro, Monitoring Land Subsidence in the Euganean Geothermal Basin with Differential SAR Interferometry, Proceedings of FRINGE, Liège, Belgium, 10–12 November 1999.

2. Wegmüller U., T. Strozzi, A. Wiesmann and C. Werner, Land Subsidence Mapping with ERS Interferometry: Evaluation of Maturity and Operational Readiness, Proceedings of FRINGE 99, Liège, Belgium, 10–12 November 1999.

3. Strozzi T., U. Wegmüller and G. Bitelli, Monitoraggio della subsidenza con l'interferometria SAR differenziale: metodologia ed esempi, Convegno Conoscenza e Salvaguardia delle Aree di Pianura, Ferrara, 8–11 Nov. 1999.

Abbreviations:

SAR:	Synthetic Aperture Radar
ERS:	European Remote Sensing Satellite

3.15 Investigation of the Potential of Imaging Spectrometry as an Earth Observation Method for Environmental Analysis

Institute: RSL, Dept. of Geography, University of Zurich

Principal Investigator: Prof. Dr. Klaus Itten

Co-investigators:
Dr. Michael Schaepman
Dr. Daniel Schläpfer

Method: Simulation, Theory, Satellite, Aircraft
Research based on existing instruments: MOS, CASI, GER1500
Others: Ground based instruments

Purpose of research: Within this project the potential of imaging spectroscopy for the investigation of different natural systems is investigated. In the ongoing phase, special emphasis is

being put on the analysis of inland waters and the development of a relational database system for the management of a spectral database.
The focus in limnology will be the development of algorithms for the detection of water constituents (chlorophyll a, colored dissolved organic carbonates, suspended particulate matter) with imaging spectrometry. The advantage of this method is the enlarged knowledge of spatial information of constituents and mixing processes in lakes. New possibilities can be achieved in biology (biological production, monitoring of the trophic state), physics (horizontal mixing) and in environmental techniques (restoration of lakes). Several campaigns in Lake Zurich, Lake Zug and Lake Constance were performed which will serve as database for the validation of these algorithms.
The primary goal of a spectral database for imaging spectroscopy data is the link between spatial and spectral data. The analysis of these metadata requires a systematic collection of reference spectra, which can be accessed using relational database. Input and output of spectra is feasible either via web-based interface or command line scripts. In addition to that, on-line analysis tools allow for further investigation and comparison of these spectra.

Status: Atmospheric correction and air-water-interface modelling algorithms have been implemented and tested with regard to a sensitivity analysis of spectra to lake water constituents. Different inversion techniques for the retrieval of suspended matter have been compared and applied to several airborne hyperspectral image scenes of Swiss lakes. Performance evaluation of the algorithms has been carried out and the results compared to on-site data.
As for the database part, conceptual work has resulted in a database scheme, which describes the spectral "aspect of reality" by means of entities and attributes. The underlying relational database system represents a well-known and reliable basis for data processing, whereas users can query from and feed data to the database interactively. Heterogeneous data from various spectroscopic sources, such as BRDF measurements, spectral radiometer data, and eventually image data, can now be homogenized and retrieved by using a common denominator. The identification of an appropriate data model as well as suitable technology could be completed and led to the implementation of a prototype that demonstrates all functionalitites.

Publications:

1. Keller P., Keller I., and Itten K., 1998. Combined hyperspectral data analysis of two Alpine lakes using CASI and DAIS 7915 imagery. Proceedings EARSeL Workshop 1998 in Zürich, Switzerland, pp. 237-243.

2. Schläpfer D., Schaepman M., Bojinski S., and Börner A., 1999. Calibration and Validation Concept for the Airborne Prism Experiment (APEX). Accepted for print in Canadian Journal of Remote Sensing.

Abbreviations:

MOS:	Modular Optoelectronic Scanner
CASI:	Compact Airborne Spectroscopic Imager
GER:	Geophysical Environmental Research
BRDF:	Bidirectional Reflectance Distribution Function

3.16 Polarimetric Synthetic Aperture Radar Interferometry (POL-InSAR) in L-band for the Extraction of geo- and biophysical parameters

Institute: University of Zurich-Irchel, Department of Geography, Remote Sensing Laboratories

(RSL), Winterthurerstrasse 190, CH-8057 Zürich

Principal Investigator: Prof. Dr. D. Nüesch

Co-investigators:
O. Stebler

Method: Research based on existing instruments:
spaceborne:
mission: Space Radar Laboratory (SRL, NASA/JPL)
sensor: Shuttle Imaging Radar System C (SIR-C, NASA/JPL)
platform: Space Shuttle (NASA)
airborne:
sensor: Experimental SAR (ESAR/DLR)

Purpose of research: The purpose of this project is to extract geo- and biophysical parameters from space- and airborne POL-InSAR (polarimetric synthetic aperture radar interferometry) L-band (1.3GHz) data.
The POL-InSAR method requires full polarimetric scattering matrix data in an interferometric acquisition configuration. POL-InSAR improves the performance of conventional scalar SAR interferometry by exploiting the wave polarization, allowing a more sophisticated physical interpretation of SAR interferograms. SAR interferometry enables the extraction of topographic heights. If interferometric scattering matrix data are available, complex interferograms can be decomposed into independent interferograms of eigenpolarizations that can be related to certain scattering mechanisms (coherent eigenvector-target decomposition).
Further, it is the goal of this project to understand these L-band scattering mechanisms and to describe the physical properties of the scattering media, especially for vegetation covers, characterized by multi-layer morphologies (crown-branches-trunk-ground). The inversion problem of POL-InSAR measurements has to be solved and geo- and biophysical parameters such as topographic heights beneath vegetation covers, vegetation heights/extinction and general geometric properties of vegetation volumes have to be retrieved. Since the spaceborne as well as the airborne data are acquired in a (multi- temporal) repeat pass mode, different baselines (normal distance between flight tracks) are available, allowing for a more accurate estimation of the required POL-InSAR parameters.
In parallel, different scattering scenarios are being modelled in order to improve the evaluation of the POL-InSAR measurements. Field campaigns are carried out during the project phase to collect appropriate ground reference data.

Status: Up until now, the study has concentrated on the analysis of spaceborne POL-InSAR measurements acquired by the Space Shuttle/SIR-C sensor during the SRL2-mission in 1994. During that time, the system was flown in a unique multi-baseline POL-InSAR configuration. We used this data set to evaluate the potential of the POL-InSAR technique and to establish the corresponding algorithmic framework. A consistent and comprehensive model was built up to study the polarimetric response of natural targets (so called "distributed targets").
Under the hypothesis that L-band wave propagation through a random vegetation volume is polarization independent, the model assumes a random volumetric structure over a multi-polarizing ground scatterer. It was possible to locate the individual scattering mechanisms within a forest canopy vertically and to derive corresponding vegetation heights (differential POL-InSAR heights).
For a further validation of the achieved results, the ongoing project will focus additionally on an

airborne data set (ESAR/DLR), flown in an identical configuration as the spaceborne case. The higher spatial resolution will help to derive more detailed information about the polarimetric backscattering response of vegetation covers. Finally, additional geometric properties of the vegetation structure will be extracted.

Publications:

1. O. Stebler, R. Brodbeck, P. Pasquali, D. Nüesch, "Multibaseline POL-InSAR experiment for the estimation of the scattering processes and their spatial distribution within vegetation layers", submitted for publication in Proc. of IEEE IGARSS 2000, Honolulu, 24-28 July, 2000.

2. O. Stebler, P. Pasquali, and D. Nüesch, "Investigation of multi- baseline singular value estimation within POL-InSAR measurements", Proc. of EUSAR 2000, Munich, 23-25 May, 2000.

3. P. Pasquali, O. Stebler, D. Small, F. Holecz, and D. Nüesch, "SAR Polarimetric Interferometry Experiments", Proc. of PIERS Workshop on Advances in Radar Methods", Baveno, 20-22 July, 1998.

Abbreviations:

SAR:	(synthetic aperture radar)
INSAR:	(interferometric SAR)
POL-INSAR:	(polarimetric InSAR)

3.17 MOSAIC (Modelling of snowmelt and its consequences)

Institute: Institute of Meteorology, Climatology and Remote Sensing (MCR Lab), University Basel, Spalenring 145, CH 4055 Basel

Principal Investigator: PD Dr. Dieter Scherer

Co-investigators:
Prof. Dr. Eberhard Parlow

Method: Research based on existing instuments:
Landsat-TM, ERS 2, Field measurements

Purpose of research: The project is working on different aspects of snowmelt and it's consequences, especially in high latitudes. Their spatial structure and course of development, metamorphism and depletion are consequences of climatic and terrain conditions, as well as their dependence on structure and state of the sublayer. Snow covers strongly modify not only the regional climate, but also geomorphic processes, soil development, vegetation and fauna, and finally life conditions and economic possibilities by influencing energy balance and water budget.
The snowmelt period has its own dynamics. The occurrence of so called slush streams can reach catastrophic dimensions under extreme meteorological conditions. Research in carried out in the Kärkevagge catchment area in Northern Sweden.

Status: On-going research with help of a SNF-PhD grant

Publications:

1. Scherer, D., M. Gude, M. Gempeler & E. Parlow (1998): Atmospheric and hydrological boundary conditions for slushflow initiation due to snowmelt. Annals of Glaciology 26, p. 377-380.

2. Gude, M. & D. Scherer (1998): Snowmelt and slushflows: hydrological and hazard implications. Annals of Glaciology 26, p. 381-384.

3. Gude, M. & D. Scherer (1999): Atmospheric triggering and geomorphic significance of fluvial events in high-latitude regions. Zeitschrift f. Geomorphologie, N.F., Suppl.-Bd. 115, p. 87-111.

3.18 Orbit Determination and Estimation of Earth Rotation Parameters using the U.S. Global Positioning System (GPS)

Institute: Astronomical Institute University of Berne (AIUB)
In cooperation with:
Swiss Federal Office of Topography (Wabern)
Bundesamt fuer Kartographie und Geodaesie (Frankfurt)
Institut Geographique National (Paris)

Principal Investigator: Prof. G. Beutler

Co-investigators:
Dr. U. Hugentobler

Method: Theory. Research based on the US GPS and a set of about 100 GPS receivers (plus auxiliary instrumentation) distributed world-wide.

Purpose of research: CODE is one of seven Analysis Centers of the IGS, the International GPS Service for Geodynamics. At CODE the orbits for the entire satellite system (24 satelltites), the earth rotation parameters (x and y coordinates of the pole on the surface of the earth, the drift of UT1-UTC = length of day), and atmospheric data (tropospheric delay parameters for each observing site) are estimated on a daily basis. The accuracies are at present 5 cm for the satellite positions, 5 mm for the position of the pole and about 0.03 msec/d for the length of day. Since 1 January 1995 global ionosphere models are made available for each day through CODE, too.
In recent years the emphasis at CODE was put on high time resolution (two hours) for earth orientation parameters and on the estimation of nutation parameters of short period (below 30 days). Other activities concern time transfer using GPS at the sub-nanosecond level over intercontinental baselines and orbit modelling of low Earth orbiting satellites carrying GPS receivers.
Time line:
permanent activity since 21 June 1992.

Status: fully operational

Publications:

1. Schaer, S. (1999), "Mapping and Predicting the Earth's Ionosphere Using the Global Positioning System", Geodaetisch-geophysikalische Arbeiten in der Schweiz, Vol. 59, Schweizerische Geodaetische Kommission, Zuerich, Switzerland, `ftp://ftp.unibe.ch/aiub/papers/` .

2. Rothacher, M., T.A. Springer, G. Beutler, R. Dach, U. Hugentobler, D. Ineichen, S. Schaer, U. Wild, A. Wiget, E. Brockmann, C. Boucher, E. Reinhart, H. Habrich (1999). "Annual Report 1998 of the CODE Processing Center of the IGS." IGS 1999 Annual Report, IGS Central Bureau, Editors J.F. Zumberge, D.E. Fulton, R.E. Neilan, JPL, Pasadena, November 1999.

3. Springer, T.A., G. Beutler, M. Rothacher (1999), "Improving the Orbit Estimates of GPS Satellites", J. Geodesy, 73, 147-157.

Atmosphere

3.19 Airborne Millimeter- and Submillimeterwave Observing System (AMSOS)

Institute: Institute of Applied Physics, University of Bern

Principal Investigator: Niklaus Kämpfer

Co-investigators:
Dietrich Feist, Andreas Siegenthaler

Method: Research based on existing instuments:
Retrieval of the altitude distribution of atmospheric trace gases from the observationon of pressure broadened rotational lines in the millimeter- and submillimeter range and validation of satellite data
(Aircraft, Satellite)

Purpose of research: The AMSOS instrument in its configuration to measure the transition of water vapor at 183.31 GHz and for ozone at 175.45 GHz is operated from a Learjet of the Swiss Air Force in order to measure the altitude distribution of these trace species in the middle atmosphere (altitude range from approx. 15 km to 80 km) from the tropics to the arctic.
Flights are performed once per year in different seasons since the early nineties for water vapor and for ozone since 1999. Water vapor in the upper troposphere and in the middle atmosphere not only plays a role in the radiation budget of the Earth but also affects the ozone chemistry in the stratosphere. In addition mesospheric watervapor mirrors an increase in methane release at the Earth surface. Further, water vapor is an ideal tracer of dynamical processes.
We intend to expand our research and expertise in the physics of atmospheric water vapor which has been steadily improved. Based on the most successful results from the analysis of our previous aircraft and Space Shuttle experiment, we continue to investigate the seasonal and latitudinal variability of middle atmospheric watervapor. A modification of the instruments allows the detection of a transition of ozone. Flight campaigns to the arctic vortex allow to study ozone depletion during the arctic winter. These projects are part of EC-projects WAVE and EuroSOLVE.

Status: We had two flight campaigns in the context of the EC-project THESEO and EuroSOLVE in Feb. 1999 and March 2000 respectively. During both campaigns the latitudinal range from the subtropics to the north pole was covered.
So far, we have been able to retrieve preliminary latitude cross-sections of H_2O and O_3 for the 1999 campaign. The analysis shows a distinct change in the vertical profiles north of 55° N.

The profile peaks appear at lower altitudes north of this region. This suggests a downward motion of air masses from above. It appears that we have crossed the polar vortex boundary between 55–60° N on our flight to Kiruna.
This would be consistent with the observed downward motion as well as the lower volume mixing ratio values at higher latitudes for both tracers. The absolute values of H2O volume mixing ratio appear to be biased low by about 2 ppm from what other measurements of stratospheric H_2O have shown before.We believe that this is a problem with the temperature data sets that have been used in our retrievals. The O_3 profiles show a maximum at mid latitudes which might be due to an observation by chance of an air parcel that has been transported from an area with much higher O_3 volume mixing ratio but this has to be verified by back-trajectory calculations.
The measurements during the EuroSOLVE campaign in March 2000 were accompanied by measurements of the temperature profile with an airborne temperature LIDAR onboard NASA's DC-8. This will be very helpful because it will be the first time that we will able to use measured instead of modelled temperature profiles for our retrievals.

Publications:

1. Peter, R., Stratospheric and measospheric latitudinal water vapor distributions obtained by an airborne millimeter-wave spectrometer, J. Geophys. Res., 103(D13), 16,275-16,290, 1998.

2. Siegenthaler, A., Feist, D.G., Zalesak, L., Murk, A. and Kämpfer, N., Airborne Microwave Measurements of Stratospheric Ozone from 20ř N to 75ř N during February 1999, Proc. 5th workshop on stratospheric ozone, St.Jean de Luz, 1999

3. Feist, D.G., Zalesak, L., Murk, A. and Kämpfer, N., Airborne Microwave Measurements of Stratospheric Water Vapor From the Tropics to the Arctic During the THESEO Campaign, Proc. 5th workshop on stratospheric ozone, St.Jean de Luz, 1999

Abbreviations:

WAVE:	Water VApor Experiment
THESEO:	Third European Stratospheric Experiment on Ozone
EUROSOLVE:	European SAGE Ozone Loss and Validation Experiment

3.20 Cloudmap

Institute: Institute of Geodesy and Photogrammetry, ETHZ
In cooperation with:
UCL (GB), KNMI (NL), DLR (D), FUB (D)

Principal Investigator: J.-P. Muller, UCL (GB)

Method: Research based on existing instuments:
ERS-2 ATSR2, MOMS, MOS, Terra EOS MISR, Meteosat-6/-7
Development and construction of own instruments:
ground-based stereo imager system
Satellite

Purpose of research: The main scientific objective of the project is the development of new cloud-top products (heights, type, optical thickness, effective droplet size), especially for cirrus

clouds, from existing and new sensors for weather forecasting and climate change analysis. There are three different techniques which are studied and compared: brightness temperature (CO2 slicing method), stereoscopy and Oxygen A-band. The new cloud products are validated with multi-resolution contemporaneous observations from space sensors and ground-based active and passive remote-sensing instruments.
The role of ETH Zuerich, Institute of Geodesy and Photogrammetry, is to provide algorithms for stereo photogrammetric data analysis. It includes sensor modelling of linear CCD arrays and matching of satellite- and ground-based cloud images. For the ground-based images, an own imager system is developed.

Status: Stereo pairs from different satellite sensors (ATSR-2 on ERS-2, MOMS from Priroda mission) and at various resolutions (18m - 1km) have been processed into cloud-top heights. All images were enhanced and radiometri- cally equalized before the matching to get more texture, especially within clouds, and to correct the illumination differences of the two looking angles. The matching was done with the Multi-Photo Geometrically Constraint Matching Software developed at our institute, which is based on Least-Squares Matching. If the sensor model is known and unrectified data could be used, the constrained mode of the matching was applied which improves the problems with multiple solutions in the low-texture clouds.
A ground-based imager system has been developed. It consists of two Kodak DCS460 colour digital CCD cameras with wide-angle lenses, with a horizontal distance of about 1 km, both connected to a laptop for camera control and image storage and to a GPS receiver for high-precision time synchronization. A fieldwork campaign was carried out in the Rhine Valley, Switzerland, within the MAP-SOP (Mesoscale Alpine Programme - Special Observation Period) from October, 7 - October, 22, 1999.
The development of a mathematical and stochastic sensor model for linear CCD sensors was started. The model takes into account parameters describing the sensor configuration, i.e. the number of lenses used (in case of multiple lines), the number of lines simoultaneously acquired, the number of CCD segments of each line CCD (in case of optically butted CCDs) and the type of stereo viewing (across/along track).

Publications:

1. Poli, D., Seiz, G., Baltsavias, E., 2000. Cloud-top height estimation from satellite stereo pairs for weather forecasting and climate change analysis. Paper accepted for oral presentation at ISPRS Congress, Amsterdam, 16-23 July 2000.

2. Seiz, G., Baltsavias, E., 2000. Satellite-and ground-based stereo analysis of clouds during MAP. Paper accepted for oral presentation at EUMETSAT Users Conference, Bologna, 29 May - 2 June 2000.

3. Seiz, G., Baltsavias, E., 2000. Cloud mapping using ground-based imagers. Paper accepted for oral presentation at ISPRS Congress, Amsterdam, 16-23 July 2000.

3.21 Realistic representation of meteorological effects within interactive 3D landscape visualizations

Institute: Remote Sensing Laboratories, Dept. of Geography, University of Zurich

Principal Investigator: Prof. Dr. Daniel Nüesch

Co-investigators:
Hilko Hoffmann
Dr. Urs Frei

Method: Research based on existing instuments:
NOAA AVHRR, Landsat TM, Spot HRV, Areal Photographs

Purpose of research: The rendering of realistic landscape visualizations implies the consideration of atmospheric parameters. The goal of this project is to visualize as many different real weather situations as realistic as possible. The modeling is mainly based on data of the NOAA AVHRR instrument.
Cloud and fog masks are derived from current NOAA passes. For cloud masking Derrien's threshold based method is used. Software has been developed to combine cloud masks, geotypical textures, lighting and color parameters and data from meteorological ground stations and translate them into computer graphic structures. New polygon saving methods have been developed to achieve real-time rendering of different cloud types together with a geospecific landscape representation in 3 dimensions. The processing chain starting at the receiving station of AVHRR data and ending at the running visual simulation is widly automated in order to allow visualizations of current weather situations on a daily basis.

Status: The software developed within this project has been successfully tested with several real weather situations. The comparison of real photos taken on the ground and their representation in the virtual world supplies attractive results. The automatic processing chain has been established. New methods are under way to visualize dynamic weather changes.

Publications:

1. Hirtz Ph., Hoffmann H., Nuesch D., 1999:Interactive 3D Landscape Visualization: Improved Realism through use of Remote Sensing Data and Geoinformation, IEEE Proceedings Computer Graphics International, June 7-11, 1999, Canmore Alberta, Canada

3.22 Mesoscale Alpine Project (MAP)

InstitutInstitute of Meteorology, Climatology and Remote Sensing (MCR Lab), University Basel, Spalenring 145, CH 4055 Basel
Principal Investigator: Dr. Roland Vogt

Co-investigators:
Prof. Dr. Eberhard Parlow

Method: Satellite
Research based on existing instuments:
Landsat-TM, airborne thermal IR data, Field measurements

Purpose of research: Spatially distributed analysis of radiation and heat fluxes parallel to micrometeorological field experiments under complex alpine terrain conditions.

Status: On-going research with help of a SNF-PhD grant

3.23 Climate Analysis Maps for Planning Aspects of Solothurn/Switzerland (CAMPAS)

Institute: Institute of Meteorology, Climatology and Remote Sensing (MCR Lab), University Basel, Spalenring 145, CH 4055 Basel

Principal Investigator: Prof. Dr. Eberhard Parlow

Co-investigators:
PD Dr. Dieter Scherer
Dr. Ute Fehrenbach

Method: Satellite
Research based on existing instuments: Landsat-TM, ERS 2.

Purpose of research: Analysis of the climate of the region of Cantone Solothurn/Switzerland as part of the Data User Programme (DUP) funded by ESA supplying site-specific and aggregated climate information and planning recommendations according to the requirements of planning authorities.

Status: On-going research financed by ESA-DUP

Publications:

1. Fehrenbach, U (1999): Analyse und Bewertung lokal- und regionalklimatisch wirksamer Faktoren in der Region Basel. (= PhD Thesis Science Faculty Univ. Basel), stratus 6, ISBN 3-85977-245-7

2. Scherer, D., U. Fehrenbach, H.-D. Beha & E. Parlow (1999): Improved Concepts and Methods in Analysis and Evaluation of the Urban Climate for Optimizing Urban Planning Processes. - Atmospheric Environment, 33, p. 4185–4193.

3. Fehrenbach, U. and Scherer, D. (2000): Consequences of spatial resolution transformations for land-use classification. - In: Remote Sensing in the 21st Century: Economic and Environmental Applications (ed. Casanova, J.L.), Balkema Publishers. Rotterdam: 113-117.

3.24 Life cycle analysis of heavy precipitation events on the southern side of the Alps

Institute: Swiss Meteorological Institute
In cooperation with:
University of Berne

Principal Investigator: Martin Bolliger

Co-investigators:
HansPeter Roesli
Dr. Peter Binder

Method: Research based on existing instuments:
Rapid scan data from the geostationary Meteosat-6 satellite

Purpose of research: The aim of this project is to investigate with the help of satellite images of Meteosat-6 the life cycle of heavy precipitation systems occurring on the southern side of the Alps. Meteosat-6 provided during MAP SOP (07.09.99-15.11.99) a special dataset with rapid scan data of a limited region (Alpine area) with a time resolution of 5 minutes. This high temporal resolution will help to study shortlived features like single convective cells and the enhancement of convection through topography in all available satellite channels (visible, infrared and water vapour).
With this dataset the life cycles of precipitation systems are investigated. Special attention will be given to the development/decay of stratiform and convective regions, respectively. Evaluated convective or stratiform regions will be compared with the radar network of MAP SOP.

Status: Recent work of this project is to programme tools for the investigation of rapid scan data from the MAP SOP provided by the Meteosat-6 satellite. In a first step, presumed convective regions in the satellite pictures will be detected by simple methods such as the variability of the brightness temperature of the cloud tops.

Abbreviations:

MAP:	Mesoscale Alpine Programme
SOP:	Special Observing Period (07.09.99-15.11.99)

4 Solar system planets

4.1 ROSINA, Rosetta ion and neutral gas analysis

Institute: Physikalisches Institut, University of Bern
In cooperation with:
MPAe, Lindau
CESR, Toulouse
TUB, Braunschweig
IPSL, St. Maur
BIRA, Brussels
SWRI, San Antonio
Lockheed, Palo Alto
Univ. Michigan, Ann Arbor

Principal Investigator: H. Balsiger, K. Altwegg

Co-investigators:
P. Bochsler
P. Eberhardt
E. Kopp
P. Wurz

Method: Instrument: neutral and ion mass spectrometers on ESA spacecraft Rosetta

Purpose of research: To determine the global molecular, elemental and isotopic composition and the physical, chemical and morphological character of the nucleus of Comet Wirtanen. This will result in understanding

1. the processes by which the dusty cometary atmosphere and ionosphere are formed,
2. the origin of comets and implications to the origin of the solar system, and
3. the gas environment of asteroids.

Status: We are the PI institution with the responsibility of overall management and testing. Swiss industry is building the sensors with Prodex funding. Currently the Engineering/Qualification Models are partially delivered and undergo qualification tests (vibration, thermal vacuum). Both mass spectrometers appear to achieve the necessary specifications of extremely high mass resolution and sensitivity.

Publications:

1. Balsiger H., Altwegg K. et al. (1998) Rosetta Orbiter Spectrometer for Ion and Neutral Analysis — ROSINA, Adv. Space Res. 21, 1527–1535

4.2 Netlander SEISmometer Operating Electronics SEIS-EL

Institute: Institute of Geophysics ETH Zurich
In cooperation with:
Institut du Physique du Globe, Paris (IPGP)

Principal Investigator: Domenico Giardini, ETH, Switzerland

Method: Development and construction of own instruments:
Development of the seismometer electronics (SEIS-EL) for the Netlander SEISmometer experiment.

Purpose of research: The interior of Mars is today poorly known, in contrary from the Earth interior, for which seismic data have been used for the determination of the interior structure. This is one of the strongest fact motivating the deployment on Mars of a network of very broad band seismometers, in the frame of the 2005 CNES-NASA joint mission. These seismometers will be carried by the Netlanders, a set of 4 landers developed by an european consortium, and are expected to land in mid-2006. Despite a low mass, the seismometers will have a sensitivity comparable to the present Very Broad Band Earth sensors or better than the past Apollo Lunar seismometers. They will record the full range of seismic and gravity signals, from the expected quakes induced by the thermoelastic cooling of the lithosphere, to the possible permanent excitation of the normal modes and tidal gravity perturbations. All these seismic signals will be able to constrain the structure of the Mars mantle, its discontinuities, as well as the state and size of the Martian core.

Status: The project is just before kick-off of phase B, the breadboard development of the Netlander seismometer electronics. The scope of the breadboard development is

- to clarify and finalize the SEIS-EL specifications
- to achieve trade-off on different solutions in order to select the more adapted architecture and technology
- to design the different functions and to build the SEIS-EL breadboard circuit such as to be functionally representative with the final design, including the basic control software.
- to work out a proposal which describes the integration of the breadboard electronics at higher level under the mass, volume and power constraints. The Netlander science and payload kick-off meeting will be held on June 26–27, 2000.
  The Requirements and Statement of work documents are finalized and will be put to tender by ESA within next month. Phase B will last 12 months.

Publications:

1. A.-M. Harri, O. Marsal., P. Lognonné, G.W. Leppelmeier, T. Spohn, K.-H. Glassmeier, F. Angrilli, W.B. Banerdt, J.P. Barriot, J.-L. Bertaux, J.J. Berthelier, S. Calcutt, J.C. Cerisier, D. Crisp, V. Dehant, D. Giardini, R. Jaumann, Y. Langevin, M. Menvielle, G. Musmann, J.P. Pommereau, S. Di Pippo, D. Guerrier, K. Kumpulainen, S. Larsen., A. Mocquet, J. Polkko, J. Runavot, W. Schumacher, T. Siili, J. Simola, J.E. Tillman and the Netlander Team, Network science landers for Mars, Adv. Space Res., 23, 1915-1924, 1999

2. P. Lognonné, D. Giardini, B. Banerdt, J. Gagnepain-Beyneix, A.Mocquet, T. Spohn, J.F. Karczewski, P. Schibler, S. Cacho, T. Pike,C. Cavoit, A. Desautez, J. Pinassaud, D. Breuer, M. Campillo, P. Defraigne, V. Dehant, A. Deschamp, J. Hinderer, J.J. Lévéque, J.P. Montagner & J. Oberst, The NetLander Very Broad Band Seismometer, Planet. Space Science, in press, 1999

Abbreviations:

CNES:	Centre Nationale d'études spaciale
ESA:	European Space Agency
IPGP:	Institut du Physique du Globe
SEIS-EL:	seismometer electronics

4.3 Isotopic abundances of noble gases in lunar rocks and soils

Institute: Physikalisches Institut, University of Bern
In cooperation with:
U.S. National Aeronautics and Space Administration

Principal Investigator: O. Eugster, University of Bern

Method: Research based on existing instuments:
Mass spectrometry

Purpose of research: The abundances and isotopic composition of He, Ne, Ar, Kr, and Xe are measured mass spectrometrically in lunar rocks and soils. These investigations are supplemented by determinations of the concentrations of selected elements using neutron activation. The purpose of this work is the study of the detailed history of rocks and soils based on cosmic ray effects, and the determination of the times, durations, and burial dephts during exposure to cosmic irradiation. The elemental and isotopic composition of the noble gases trapped during rock formation or by implantation of solar wind particles are measured.

Status: We determined the noble gas isotopic abundances of five dimict breccias and one cataclastic anorthosite that were collected at the Apollo 16 landing site. These rocks originate from the ejecta blanket of South Ray Crater. Previous studies have shown that this crater formed 2Ma ago. On the basis of cosmic-ray produced nuclei, we found that all six rocks yield the same lunar surface exposure age of 2Ma. Using literature data, we recalculated the exposure ages of additional 16 rocks with suspected South Ray crater origin and obtained an average exposure age of $2.01 \pm 0.10 Ma$. In particular, all nine dimict breccias (a type of rock essentially restricted to the Apollo 16 area consisting of anorthosite and breccia phases) dated until now yield an average ejection age of $2.06 \pm 0.17 Ma$. We conclude that they must originate from the Cayley formation or from bedrock underlying the Cayley plain.

Publications:

1. Eugster O. (1999) Chronology of dimict breccias and the age of South Ray crater at the Apollo 16 site. Meteorit. Planet. Sci. 34, 385-391.

4.4 ASPERA-3/Mars Express: Remote particle sensing of ion populations in Mars' extended atmosphere

Institute: Physikalisches Institut, University of Bern
In cooperation with:
Swedish Space Research Institute, Kiruna, Sweden
(R. Lundin, S. Barabash, J. Gimholt)
Max-Planck-Institut fuer Aeronomie, Lindau, Germany (S. Livi)
Instituto di Fisica dello Spazio Interplanetari, Rome, Italy (S. Orsini)

Principal Investigator: Lundin, Swedish Space Research Institute, Kiruna, Sweden

Co-investigators:

P. Wurz
P. Bochsler
S. Jans
M. Wieser

Method: Development and construction of own instruments:
NPD sensor for the ASPERA-3 instrument on the Mars Express mission

Purpose of research: The general scientific objective of the ASPERA-3 instrument is to study the solar wind & atmosphere interaction and characterize the plasma and neutral gas environment in the near-Mars space through energetic neutral atom (ENA) imaging. The main scientific objectives of the ASPERA-3 instrument are to

1. Determine the instantaneous global distributions of plasma and neutral gas near the planet,

2. Study the atmospheric escape induced by the highly variable solar wind and solar UV irradiation,

3. Investigate the modification of the atmosphere through the solar wind ion bombardment,

4. Investigate the energy deposition from the solar wind to the ionosphere, The Neutral Particle Detector (NPD) provides measurements of the ENA flux, resolving velocity and mass (H and O) of the coming particles with a coarse angular resolution.

the elaboration of signal oriented intelligent

Status: NPD prototype sensor was constructed and tested successfully. Design of flight sensor is under way and will be completed mid April 2000. Construction of the flight sensors will follow with the delivery of the units scheduled for March 2001.

Publications:

1. P. Wurz, "Detection of Energetic Neutral Particles," in The Outer Heliosphere&Beyond the Planets, (2000), in press.

2. S. Jans, P. Wurz, R. Schletti, T. Fröhlich, E. Hertzberg, and S. Fuselier, "Negative Ion Production by Surface Ionization Using Aluminium-Nitride Surfaces," J. Appl. Phys. (2000), in press.

3. S. Jans, P. Wurz, R. Schletti, C. Brüning, W. Heiland, J. Quinn, and R. Leuchtner, J. Appl. Phys. (2000), submitted.

Abbreviations:

ASPERA-3:	Analyzer of Space Plasmas and Energetic Atoms
ENA:	Energetic Neutral Atoms
NPD:	Neutral Particle Detector

5 Magnetosphere

5.1 The Low-Energy Neutral Atom Mass Spectrometer for IMAGE

Institute: Physikalisches Institut, University of Bern
In cooperation with:
Goddard Space Flight Center, NASA, Greenbelt, MD, USA (T.E. Moore, F. Herrero)
Lockheed Martin Palo Alto Research Laboratory, CA, USA (S.A. Fuselier)
University of New Hampshire, NH, USA (J. Quinn)

Principal Investigator: J. Burch, PI of IMAGE mission, Southwest Research Institute, TX, USA
Lead Investigator for LENA: T.E. Moore, GSFC/NASA

Co-investigators:
P. Wurz
P. Bochsler
S. Jans
M. Wieser

Method: Research based on existing instuments:
LENA instrument on the IMAGE mission

Purpose of research: Investigation of the global ion outflow from the high-latitude ionosphere, its relationship to auroral features, and its consequences on magnetospheric processes will be investigated by the IMAGE mission. The University of Bern participated in the design of the mass spectrometer (LENA instrument), which simultanously measures mass and energy of the plasma particles with spatial mapping at high time resolution. To obtain 2D images of the plasma volume, emitted neutral atoms from the plasma distribution (by charge exchange with the residual gas) are detected remotely, at a distance of several thousend km. The relevant scale lengths vary from $>$ 10 km (auroral zone) to $>$ 1 Earth radius (outer magnetospheric structure). Furthermore, high temporal resolution is necessary, since magnetopsheric processes are of very transient nature. The time scales vary from minutes for the substorm onset to days for the decay of the ring current.

Status: The IMAGE spacecraft is foreseen to be launched on March 25, 2000.

Publications:
1. A.G. Ghielmetti, E.G. Shelley, S.A. Fuselier, P. Wurz, P. Bochsler, F. Herrero, M.F. Smith, T. Stephen, Mass Spectrograph for Imaging Low Energy Neutral Atoms, Opt. Eng. 33 (1994) 362-370.

2. P. Wurz, M.R. Aellig, P. Bochsler, A.G. Ghielmetti, E.G. Shelley, S.A. Fuselier, F. Herrero, M.F. Smith, T.S. Stephen, Neutral Atom Mass Spectrograph, Opt. Eng. 34 (1995) 2365-2376.

3. T.E. Moore, D. Chornay, M.R. Collier, F.A. Herrero, J. Johnson, M.A. Johnson, J.W. Keller, J.F. Laudadio, J.F. Lobell, K.W. Ogilvie, P. Rozmarynowski, M.F. Smith, S.A. Fuselier, A.G. Ghielmetti, E. Hertzberg, D.C. Hamilton, R. Lundgren, P. Wilson, P. Walpole, T. Stephen, B. VanZyl, P. Wurz, P. Bochsler, and J. Quinn, The low energy neutral atom imager for the IMAGE mission, Space. Sci. Rev., (2000), in press.

Abbreviations:

LENA:	Low Energy Neutral Atom
IMAGE:	Imager for Magnetopause-to-Aurora Global Exploration

6 Microgravity

6.1 ACES Atomic Clock Ensemble in Space

Institute: Observatoire cantonal de Neuchâtel
In cooperation with:
OGMi, ESA, CNES, ENS, LHA, OCA, OP

Principal Investigator: Prof. C. Salomon, ENS

Co-investigators:
Dr L.-G. Bernier, ON
Dr E. Samain, OCA

Method: Development and construction of own instruments:
CH: Space Hydrogen Maser (SHM)
F : Cold Atom Clock (PHARAO)

Purpose of research: The Science objectives of ACES/PHARAO are both of fundamental and technical nature. The fundamental aspects deal with the physics of the cold atom clock which, for the first time will operate in conditions which are not accessible on Earth, and with fundamental physics tests (relativity, fundamental constants). The applied aspects are associated on the one side, with a demonstration of new technologies for SHM, PHARAO, T2L2 and MWL and, on the other side, with the vast community of users which, around the globe, will take advantage of the ACES frequency stability. These aspects will become increasingly important with future developments of navigation and positioning systems, new matter wave inertial sensors as will as for fundamental physics tests in solar orbit (SORT). The scientific objectives are:

1. Operate a laser cooled cesium clock in micro-gravity with a relative frequency stability of 7-10 E-14 over a measurement time of one second. Averaged over one day, the stability will reach 2-3 E-16 and over 10 days, 0.7-1 E-16. PHARAO will explore the domain of long interaction times made possible by the reduced gravity and the trade-off between the clock accuracy and stability.

2. Provide, through radio and optical links, the optimised time scale of the combined system SHM-PHARAO, to ground users. The accuracy of this time scale will be 30 picoseconds at one day. Users belong to various areas of applications: Time and Frequency comparisons, covering a large number of laboratories contributing to the realisation of TAI (Temps Atomique International), geodesy, Very Long Baseline Interferometry (VLBI), atmospheric propagation of light pulses and microwave signals.

3. Perform fundamental physics tests. The first test is a new measurement of the red-shift with an accuracy of 3 E-6, a 25-fold improvement over the Gravity Probe A experiment of 1976. The second is a search for a possible anisotropy of the speed of light at a relative sensitivity level of 2 E-10. The third test is a search for a possible time (or space) variation of the fine structure constant alpha, which is one of the fundamental constants of physics.

Status: As of June 2000, the cold atom clock is nearing the end of the design phase, the SHM is in phase A/B (EQM due end 2001)

Publications:

1. ESA document ACE-SM-1000-2-CNS (17.02.2000) (ACES Mission rationale and requirements)
2. ESA document PH-DS.0.161.CNS (PHARAO Synthesis Document)
3. ON document The SHM Hydrogen Atomic Clock for Space applications Development and Test of the PEM Physics Package

Abbreviations:

ENS:	Ecole Normale Supérieure, Paris, F
CNES:	Centre National d'Etudes Spatiales, Toulouse, F
ON:	Observatoire cantonal de Neuchâtel, CH
LHA:	Laboratoire de l'Horloge Atomique, Paris-Orsay, F
OCA:	Observatoire de la Côte d'Azur, Grasse, F
OGMI:	Officine Galileo Milano (Alenia Spazio), I
OP:	Observatoire de Paris, F
SHM:	Space Hydrogen Maser
PHARAO:	Projet d'Horloge A Refroidissement d'Atomes en Orbit
EQM:	Engineering Qualification Model

6.2 Role of the interleukin-2 receptor in signal transduction and gravisensing threshold of T lymphocytes

Institute: Space Biology Group, ETH Zurich
In cooperation with:
ESA/NASA

Principal Investigator: Augusto Cogoli

Co-investigators:
Otfried Müller, University of Bern
Millie Hughes-Fulford, University of California, San Francisco
Proto Pippia, University of Sassari

Method: Development and construction of own instruments:
Biopack developed and manufactured in collaboration with ESA, HTS and Bradford Engineering. Experiment specific hardware developed by ETHZ.
Others: Space Shuttle

Purpose of research: The expression of interleukin-2 receptor (IL-2R) is a key step of T lymphocyte activation.
Nearly total loss of T cell activation in real microgravity was discovered in a Spacelab flight in 1983 and was confirmed later by several experiments in space. Thereby, cells appear to undergo apoptosis. Inhibition of IL-2R expression is probably one of the causes of such loss of activation. It is planned to analyse the pathway of mitogenic signal transduction in T cells in true microgravity as well as at variable g-levels between 0 and 1xg. The work will be supported by ground-based experiments with two new instruments, the random positioning machine (RPM)

and the centrifuge free-fall machine (CFFM).
The objectives of this research project are:

1. to investigate selected critical steps of T cell activation;

2. to test the hypothesis that a failure in the expression of the IL-2 R is causing the loss of activity in microgravity;

3. to identify? windows of sensitivity to gravity during the activation process.

4. to establish thresholds of gravi-sensing in T cells.

The main experimental approach will consist of the activation of cultures of purified peripheral blood lymphocytes with T cell mitogens in real and simulated microgravity. The specific IL-2R mRNA will be quantitatively determined with the reverse transcriptase-polymerase chain reaction (RT-PCR) technology, the insertion of IL-2R in the membrane will be visualised by immunofluorescence and its secretion in the supernatant will be measured by immunoassay. Apoptosis will determined by flow cytometry.
Signal transduction will be further analysed by determining the early expression of the oncogenes c-myc and c-fos.? Windows of sensitivity to microgravity will be determined by interruptions of the incubation at 1xg with short incubations at 0xg. Finally, by using a variable-g centrifuge, if available, it is planned to identify a gravi-sensing threshold between 0 and 1xg.

Status: Biopack Phase A, Phase B completed, Phase C/D to start April 2000.
Experiment specific hardware completed.
Experimental protocol defined.
Preparatory control tests: T lymphocyte purification protocol completed; T cell activation protocol completed; Genetic expression protocol in progress, to be completed by September 2000; Esperiment Sequence Test to be carried out in Spetember 2000.

Publications:

1. Walther I, Pippia P, Meloni MA, Turrini F, Mannu F, Cogoli A (1998) Simulated microgravity inhibits the genetic expression of interleukin-2 and its receptor in mitogen-activated T lymphocytes, FEBS letters, 436, 115– 118.

2. Schwarzenberg M, Pippia P, Meloni MA, G. Cossu, M. Cogoli-Greuter, A. Cogoli (1999) Signal transduction in T lymphocytes - A comparison of the data from space, the free fall machine and the random positioning machine. Adv. Space Res. 24, 793– 800.

3. Walther I, Cogoli A, Pippia P, Meloni MA, Cossu G, Cogoli M, Schwarzenberg M, Turrini F, Mannu F (1999) Human immune cells as space travelers. Eur. J. Med. Res. 4, 361–363.

Abbreviations:

RT-PCR: Recerser transcriptase - polymerase chain reaction

6.3 Modular space bioreactor for medically relevant organ-like structures

Institute: Space Biology Group, ETH Zurich
In cooperation with:
Sulzer Medica, Winterhur

Principal Investigator: Augusto Cogoli, ETHZ

Co-investigators:
Saverio Ambesi, Udine
Augustinus Bader, Hannover
Peter Bruckner, Münster
Werner Müller, Winterthur
Ralph Pörtner, Hamburg
Isabelle Walther, Zürich

Method: Development and construction of own instruments:
Modular space bioreactor
Rocket
Others: Space Shuttle, International Space Station

Purpose of research: The production of artificial tissues and organ-like structures is one of the most innovative and timely technologies. The understanding of the molecular and biological mechanisms regulating the growth and survival of such structures is a necessary prerequisite for medical applications. It is believed that microgravity may contribute in two aspects to progress in this field. First, as shown in other systems, microgravity is a useful tool to investigate important biological events at the cellular and molecular levels (e.g. signal transduction, genetic expression and cell proliferation) from a new and non-invasive (i.e. avoiding inhibitors or other biochemical agents) standpoint. Second, low-g conditions may favor both the mass production of cells by obtaining higher cell densities per unit culture volume on one side, and smooth cell-cell aggregation and tree-dimension organogenesis in the absence of the disturbing pull of the force of gravity or of damaging shear forces due to agitation on the other side. One of the purposes of this proposal is to involve leading pharmaceutical and medical companies.
The objectives:

1. Development of procedures of in vitro organogenesis of pancreatic islets, thyroid tissue, liver, vessel, and cartilage.

2. To select those engineered tissues that could take advantage of being continuously cultured under controlled conditions in microgravity. This will allow to better understand and to improve earth-bound bioprocesses as well as to develop innovative bioengineering in space.

3. To define the requirements of the instrumentation (bioreactor) needed for this purpose. Preferentially a closed system under continuous monitoring, i.e. automatic, capable to sustain the production of organ-like structures that can be implanted into an organism in which they develop to fully functional tissues or organs. A useful frame could be the biotechnology mammalian tissue culture facility, BMTC, of ESA.

4. To set up procedures for the production of implants for medical applications

The relevant issue behind the present proposal, is the variety of normal, differentiated mammalian and human in vitro biological systems available within the project. Such collaborative effort will give access to the most sophisticated and biotechnologically relevant in vitro cultured systems presently available. Those cultures, all within the long-term expertise of the proposers, will be used to validate both the theoretical approaches and the practical implementations to the bioreactor prototype(s) during its development.
The phases:

1. Developmental phase: Organ- or tissue-like structures are developed from single cells, applying conditions of microgravity.

2. Optimization: The process is optimized to produce constructs that develop to functional organs / tissues after implantation in mammals.

3. Industrial application: The results of phase B are taken to produce implants for organ / tissue regeneration for medical applications.

Phases A to C are started with the de novo articular cartilage tissue.
The applications oriented aspects of the research program:
Industrial parties interested in the development of tissues or organs, e.g. skin or liver, thyroid glands, etc., may join the topical team proposed in parallel as well as and this MAP project.
Patents covering the principles of phases A to C may be licensed by industrial parties for the development of specific tissue and organ applications.
Possible areas of application: implants, test systems for product development, e.g. pharmaceuticals, testing for quality control.
The team does not intend to manufacture a space-qualified instrument, but rather define - based on experiments and tests with models - the requirements of a bioreactor for medically relevant organ-like structures to be integrated in the International Space Station.

Status: MAP contract with ESA to be finalized in April 2000.
Preparation for Flight on sounding rocket MASER 9 in Nov. 2001 in progress.
Hardware design in progress.
Adaptation of earth-bound culture device for the growth of cartilage from single chondrocyte cells to MASER hardware in progress.

Publications:

1. Walther, I., van der Schoot B. H., Jeanneret S., Arquint P., de Rooij N. F., Gass V., Bechler B., Lorenzi G. and Cogoli A.: Development of a miniature bioreactor for continuous culture in a space laboratory. J. Biotechnol. 38, (1994), 21-32

2. Walther, I., Bechler, B., Müller, O., Hunzinger E., and Cogoli, A.: Cultivation of Saccharomyces cerevisiae in a bioreactor in microgravity. J. Biotechnol. 47, (1996) 113-127.

3. Walther I., van der Schoot B., Boillat M., Müller O., and Cogoli A.: Microtechnology in space bioreactors. Chimia (1999), 53 (3), 75-80.-

Abbreviations:

MAP:	Microgravity application programme
BMTC:	Biotechnology mammalian cell culture facility

6.4 Signal transduction and genetic expression in T lymphocytes in microgravity

Institute: Space Biology Group, ETH Zurich
In cooperation with:
ESA

Principal Investigator: Marianne Cogoli-Greuter

Co-investigators:
Augusto Cogoli, ETH Zürich
Proto Pippia, University of Sassari (Italy)

Method: Development and construction of own instruments:
LIDIA: automated experiment chambers in collaboration with Fokker Space
Rocket

Purpose of research:

Introduction
Several experiments performed since 1983 under different gravity conditions have revealed dramatic gravitational effects on the in vitro activation of human T lymphocytes by the mitogen concanavalin A (Con A). The most striking observation is that the activation of free-floating lymphocytes is nearly nil in microgravity. From the results obtained so far it appears that microgravity has a selective effect on the secretion and genetic expression of different cell-specific products by monocytes (IL-1 and tumour necrosis factor) and T cells (interleukin-2, interleukin-2 receptors, and interferon-gamma), respectively.
Sounding rockets have proven to be a useful tool to clarify several aspects of the T lymphocyte activation in microgravity.

Scientific objectives
The mechanism of the mitogenic activation of human lymphocytes is very complex and not yet completely understood. The objective of our experiments is to understand the mechanisms underlying the changes observed in microgravity as well as in hypergravity. Thereby, the main question is whether the effects on the cell are direct or indirect. In addition, microgravity is used as a tool to clarify some aspects of this mechanism.
To test the two hypotheses we have carried out several experiments in sounding rockets, in the clinostat and in the centrifuge. The experimental evidence, in particular the changes observed in the structure of the cytoskeleton, speaks in favor of a direct effect of gravity on lymphocyte activation.
A direct effect does not necessarily arise from a single event, but may rather be the consequence of many little changes amplifying each other. This is best described by the theory of bifurcations applied to systems evolving irreversibly far from thermodynamic equilibrium. Indeed, the activation of lymphocytes is based on a complicated and still unclear sequence of irreversible events lasting more than 48 hours. It is known that lymphocyte activation is going the inositol-lipid path involving activation of PIP2 phosphodiesterase and C-kinase. Two signals activating the two enzymes are required. The activation signals trigger the expression of several proteins which were classified by Crabtree into three categories: immediate, i.e. expressed within the first 15-30 min, early, expressed within 30 min and 48 hours, and late, expressed between 2 and 14 days after reception of the activation signal.

On MASER 9 we plan to study the expression of immediate genes in purified T lymphocytes activated with Con A and CD28. The timeline of the expression of the immediate genes following mitogenic activation in T lymphocytes, shows, that several genes are expressed within few minutes. One of these immediate genes is c-fos proto-oncogene.

Status: The hardware for the automatic performance of this experiment (LIDIA 3) was developed in close collaboration with Fokker Space B.V. LIDIA was designed to satisfy the special requirements for this experiment with cells in suspension, i.e. not only addition of liquids to the cells but exchange of liquids in the cell culture chamber. Two former versions (LIDIA 1 and 2) proved not to be suitable for this type of experiments. The crucial problem for the use of LIDIA 1 with cells in suspension (i.e. lymphocytes) turned out to be the filters placed at both ends of the sample chamber in order to confine the cells during the exchange of liquids. The experiment originally planned for a flight on MASER 7 was therefore postponed for a flight on MASER 9. A redesign (LIDIA 2) did not really improve the situation.
In LIDIA 3 the design was changed. Furthermore a filter membrane was found suitable for the requirements of the experiment. Tests with the engineering model of LIDIA 3 showed that the present design is feasible for the performance of the experiment.
The scientific aspects of the experiment (performance, analysis) have been elaborated within the last year.

Publications:

1. Walther I, Pippia P, Meloni MA, Turrini F, Mannu F, Cogoli A (1998) Simulated microgravity inhibits the genetic expression of interleukin-2 and its receptor in mitogen-activated T lymphocytes, FEBS letters, 436, 115-118.

2. Cogoli A and Cogoli-Greuter M (1997) Activation and proliferation of lymphocytes and other mammalian cells in microgravity. In: Advances in Space Biology and Medicine, S. Bonting ed.. JAI Press inc. Vol. 6, pp. 33-79

3. Cogoli-Greuter M., Spano A., Sciola L., Pippia P. and Cogoli A. (1998) Influence of microgravity on mitogen binding, motility and cytoskeleton patterns of T lymphocytes and Jurkat cells. Experiments on sounding rockets.

4. Japanese Journal of Aerospace Medicine 35:27-39

Abbreviations:

LIDIA: Liquid Dispenser Assembly

6.5 Yeast cells: Stress under microgravity

Institute: Space Biology Group ETH-Technopark
In cooperation with:
ESA

Principal Investigator: Isabelle Walther

Co-investigators:
Augusto Cogoli
Otfried Mueller

Method: Development and construction of own instruments:
Others: Shuttle

Purpose of research: This project has for first objective to investigate the capacity of the cells to correctly respond to stress factors in microgravity. Two different stress conditions will be investigated: osmotic and temperature shocks; the first involves a transmembrane protein sensor (osmosensing), the second implicates only intracellular reactions. The response will be analysed, when possible, at several levels: gene expression, ultrastructural changes and end point. Due to the importance of cytoskeleton proteins in the organisation of the cell structure and their possible role in the alteration of cells' reaction in space, the reorganisation of the actin protein after an osmotic shock will be especially investigated.
To allow the experiments to be repeated after different cultivation times but with cells growing in a steady-state, a small automated chemostat will be developed. This bioreactor will fit in Type II/E containers allowing it to be installed on the reference centrifuge on-board.
The experiment is based on the cultivation of yeast cells in a continuous bioreactor for several days. Cells will be withdrawn at defined time and stressed by adjunction of a salt solution or by a rapid warming to 37-39řC. The treated samples will be fixed or frozen. All analyses concerning the stress response will be performed post-flight.

Status: This experiment will fly aboard the STS-107 Shuttle flight early next year. The bioreactor, used fort the delivery of the freshly-grown cells, is based on a bioreactor previously developed but with a cultivation chamber enlarged to a volume of 7 ml. The cells will be stressed in especially developed investigation chambers with heating capacity, and injection possibility. The project is currently in the phase C/D. An engineering-qualification model is on the point to be delivered for biological testing.
Due to the storage conditions of space flights, specially adapted biological methods have been worked out to keep the cells for long term storage in fixative solution.

Publications:

1. Walther, I., van der Schoot B. H., Jeanneret S., Arquint P., de Rooij N. F., Gass V., Bechler B., Lorenzi G. and Cogoli A.: Development of a miniature bioreactor for continuous culture in a space laboratory. J. Biotechnol. 38, (1994), 21-32

2. Walther, I., Bechler, B., Müller, O., Hunzinger E., and Cogoli, A.: Cultivation of Saccharomyces cerevisiae in a bioreactor in microgravity. J. Biotechnol. 47, (1996) 113-127.

3. Walther I., van der Schoot B., Boillat M., Müller O., and Cogoli A.: Microtechnology in space bioreactors. Chimia (1999), 53 (3), 75-80.

Abbreviations:

ESA: European Space Agnecy

7 Material Science

7.1 Proton Irradiation Facility PIF

Institute: Paul Scherrer Institut PSI / Laboratory for Astrophysics LAP
In cooperation with:
ESA ESTEC

Principal Investigator: Dr. W. Hajdas

Co-investigators:
R. Harboe-Sorensen

Method: Others: Radiation hardness tests of devices for space applications

Purpose of research: The proton environment in space, particularly at low altitudes in the trapped radiation belts and during solar events can have a detrimental effect on semiconductor components and other materials used in spacecraft. The progress towards higher scale integration and using of components off the shelf only exacerbates the problem. The malfunctioning of the semiconductor in space is essentially caused by either heavy ion or proton induced nuclear reactions in which highly ionizing heavy particles are produced. The space radiation environment consists predominantly of energetic protons and electrons. Protons are one of the principal sources of single event upsets SEU and single event latch-ups SEL in semiconductor memories and processors. Electrons are mainly responsible for total dose effects TDE while heavy ions form a small but very forceful fraction of space radiation environment. Because the proton spectrum in space extends up to several hundred MeV, the laboratory simulations require a high energy accelerator.
The Proton Irradiation Facility PIF was built in the PSI Nucleon Area under a contract with the European Space Agency ESA. It has been designed in a user friendly manner for a wide range of applications in materials science, solid state physics and applied nuclear physics. The main task of the facility is terrestrial proton testing of components and materials for spacecraft and studying of radiation effects on electronics, devices materials and men. The facility can generate realistic proton spectra encountered by the spacecraft at any possible orbit. It provides genuine information on irradiation hazards caused by proton environment in space and enables projects to take them into consideration in the design stage. The facility, designed in a user friendly manner, is available for general use. It can be easily adapted to individual requirements of experimenters.

Status: The Proton Irradiation Facility obtained a status of the ESA Centre of Excellence. In general, it operates in a shift mode. There are 240 beam hours a year reserved for European Space Agency activities and the same amount for other users like industry, research institutes and universities. In 1999, the facility was used for 35 different experiments conducted by 16 groups of researchers. All tests were performed using 25 beam blocks and resulted in almost 50 days with protons on target. Experiments are conducted using two test areas: one for low energy tests - up to 71 MeV, and the other for high energy tests - up to 300 MeV. Recently, PSI started a new project to construct new cyclotron and facilities for biomedical purposes - proton spot scan therapy. The PIF is also included in its experimental part and it will obtain a dedicated test area. Among many benefits there will be a gain in the beam time and flexibility as well as advancements in conducting versatile experiments using wide range of energies and

intensities of the proton beam.

Publications:

1. "Components Testing for HESSI Satellite Aspects Modules"
   W.Hajdas et al., 1999 IEEE Radiation Effects Data Workshop, Norfolk 1999, p. 92

2. "Radiation Effects Testing Facility in PSI Low Energy OPTIS Area"
   W.Hajdas et al., 1998 IEEE Radiation Effects Data Workshop, Newport Beach 1998, p. 152

3. "The Proton Irradiation Facility at the Paul Scherrer Institute"
   W.Hajdas et al., Nucl. Inst. and Meth. B113(1996)54

Abbreviations:

PIF:	Proton Irradiation Facility
PSI:	Paul Scherrer Institut
LAP:	Laboratory for Astrophysics
ESA:	European Space Agency
ESTEC:	European Space Research and Technology Centre
SEE:	Single Event Effect
SEU:	Single Event Upset
SEL:	Single Event Latch-up
TDE:	Total Dose Effects
IEEE:	Institute of Electrical and Electronics Engineers
HESSI:	High Energy Solar Spectroscopic Imager
OPTIS:	Ophtalmologic Proton Therapy Installation Switzerland