Regional Climate Change and Extreme Events

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OUTLINE

Introduction

Intensification of water cycle

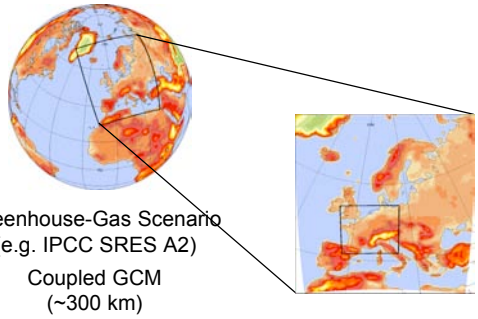
Dry and wet extremes

Summer temperatures

Frequency of windstorms

Focus:
• future climate over Europe •
• primary climatic elements •

Climate Scenarios for Europe



Greenhouse-Gas Scenario
(e.g. IPCC SRES A2)

Coupled GCM
(~300 km)

Atmospheric GCM
(120 km)

IPCC considers 21 AOGCM model simulations

Regional Climate Model (RCM)
(50-25 km)

Over Europe about 20 simulations available

Situation of Europe is exceptional, most other regions must primarily rely on global models.

Associated EU-Projects

Regionalization	1993 - 1995
RACCS	1994 - 1996
MERCURE	1997 - 2001
PRUDENCE	2001 - 2004
ENSEMBLES	2004 - 2009

(EU-Project PRUDENCE, scenario data available at http://www.prudence.dmi)

Role of Extreme Events

Early IPCC-statements (SAR 1996):

"... it can be expected that changes in *hydrological extremes* will be more significant than changes in hydrologic mean conditions"

"In evaluating the societal ramifications of water resource changes, attention must be focused on changes in the *frequency and magnitude of floods and droughts*"

Early IPCC (WG1) coverage of extreme events did not match these claims:

IPCC 1990:	7 pages (of 364)
IPCC 1996:	12 pages (of 572)
IPCC 2007:	**several hundred pages**

"This apparent neglect is not due to a failure to appreciate the importance of extreme events, but rather a result of *well-founded scientific caution*."

(Fowler and Hennessy, 1995)

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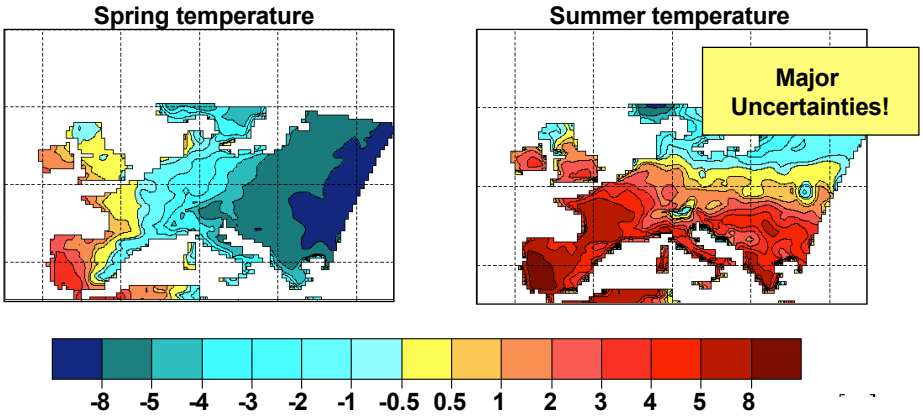
Climate simulations 10 years ago

ECHAM4 (T42, 250 km) => RegCM2 (70 km)

Bias of control run (CTRL-CRU), 5 years



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EU Projects REGIONAL and RACCS (1992-1996); Machenhauer et al. (1998, MPI-Report 275)

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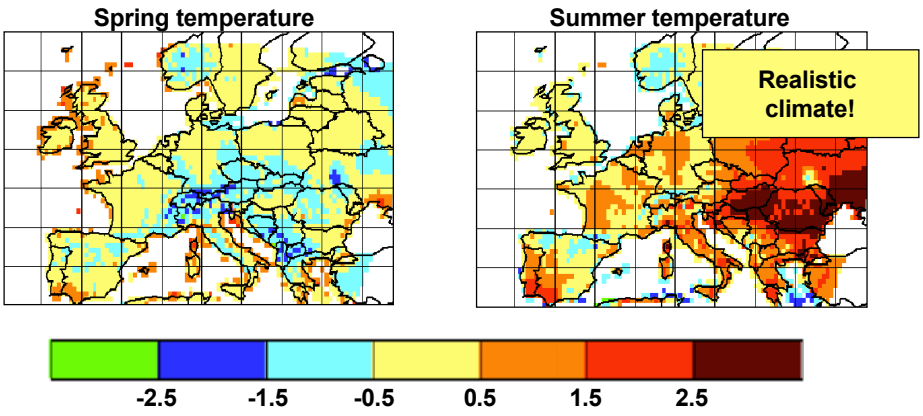
Climate simulations today

HadAM3 (120 km) => PRUDENCE Regional Models (50 km)

Bias of control run (CTRL-CRU), 30 years



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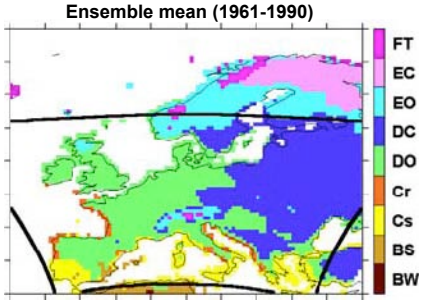
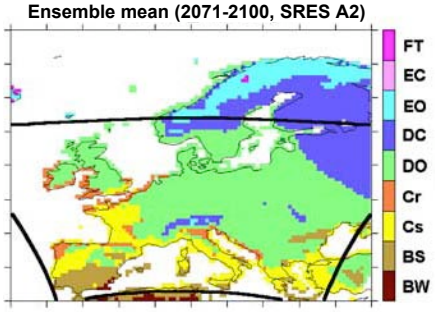
EU Project PRUDENCE (2001-2004). Coordinator: Jens H. Christensen, DMI, Copenhagen

Climate Classification (Köppen-Trewartha)

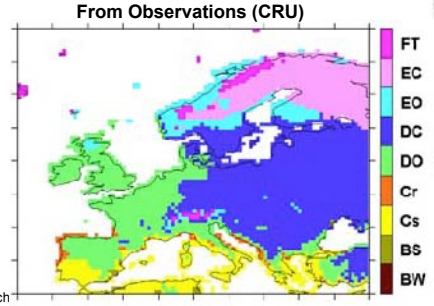
Ensemble mean (1961-1990)



Ensemble mean (2071-2100, SRES A2)



From Observations (CRU)



Tundra
Sub-arctic continental (tayga
Sub-arctic oceanic (needlelea
Temperate continental (need
Temperate oceanic (dense coniferous forests)
Subtropical humid (longleaf trees, pines deciduous forests)
Subtropical summer dry (hardleaved evergreen)
Dry semiarid (steppe)
Dry arid (desert)

Bias is substantially smaller than climate change signal!

(Castro et al. 2007, PRUDENCE)

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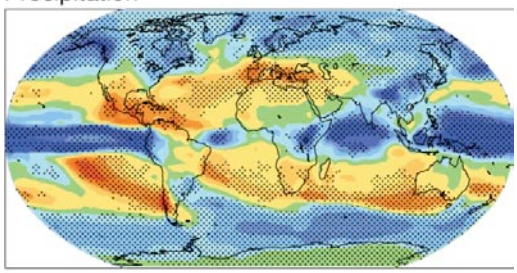
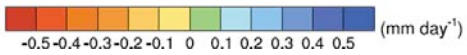
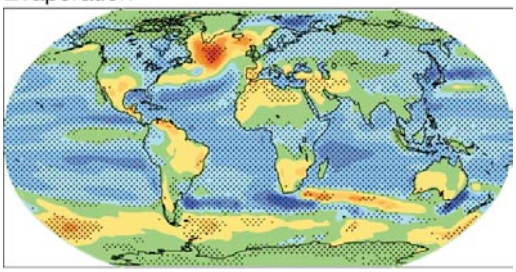
Intensification of the water cycle

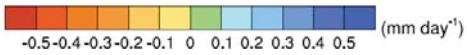
Precipitation





Evaporation





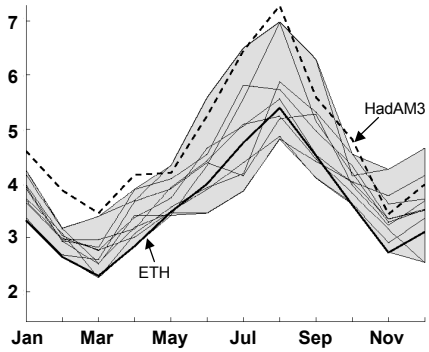
Global mean:
Moisture content: ~6% / K (Clausius Clapeyron)
Precipitation / Evaporation: ~1-2% / K

(IPCC AR4, Chapter 10, SRES A1B)

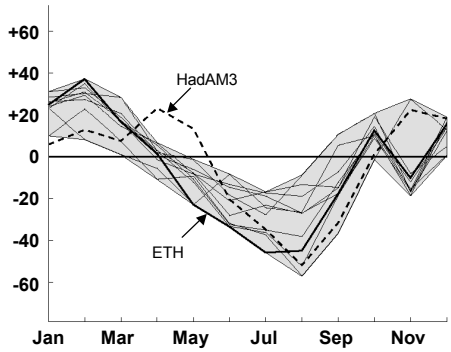
Scenario Alps

2071-2100 versus 1961-1990
Changes in seasonal cycle (2 AGCMs, 9 RCMs)

Temperature [ºC]



Precipitation [%]



(Jacob et al. 2007, SRES A2, PRUDENCE)

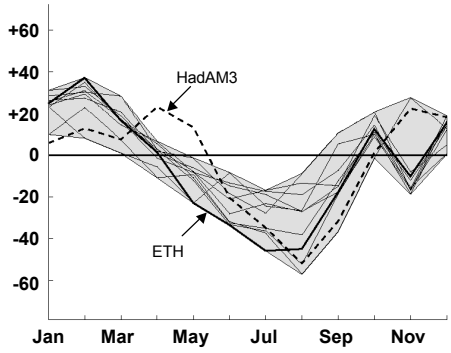
Scenario Alps

2071-2100 versus 1961-1990
Changes in seasonal cycle (2 AGCMs, 9 RCMs)

Note:

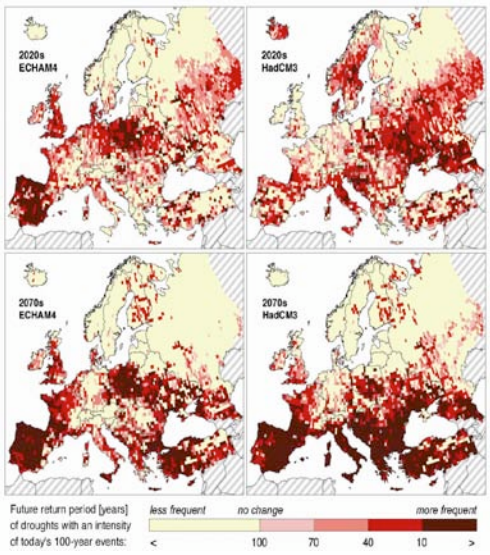
- **Dry signal increases from February to August**
- **N-Alps: Signal out of phase with current climatology. Yearly cycle expected to become less pronounced.**
- **Winter runoff increases likely:**
  - increases in precipitation
  - less snow, more rain
- **Summer soil moisture decreases:**
  - reduction in precipitation,
  - increase in evapotranspiration,
  - decrease in snow melt

Precipitation [%]



(Jacob et al. 2007, SRES A2, PRUDENCE)

Droughts



Change in drought occurrence according to two GCMs

IPCC AR4, WG2, Lehner et al., 2005:

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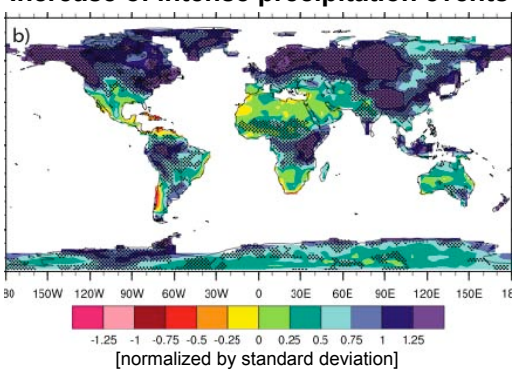
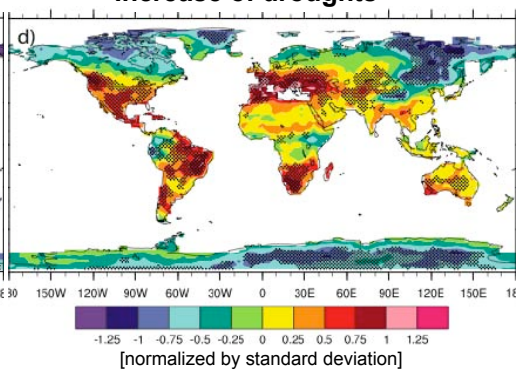
Increase of (moist and dry) extremes

Increase of intense precipitation events



[normalized by standard deviation]

Increase of droughts



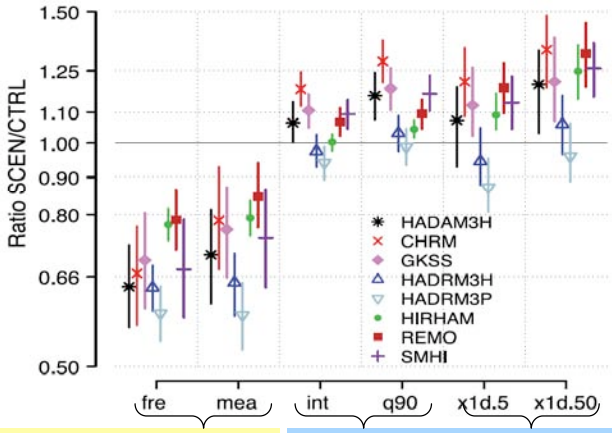
[normalized by standard deviation]

Intense precipitation (droughts) become more common, even in many regions with reduced (increased) precipitation!

In many regions, BOTH moist AND dry extremes increase!

(IPCC AR4, Chapter 10, SRES A1B)

Summer precipitation in Central Europe



Results from PRUDENCE models

Significant in all models considered	Decrease in frequency and amount	Increase in intensity	Increase in heavy events	Significant in some but not all models.

(IPCC AR4, Chapter 11, SRES A2, PRUDENCE, Frei et al. 2006)

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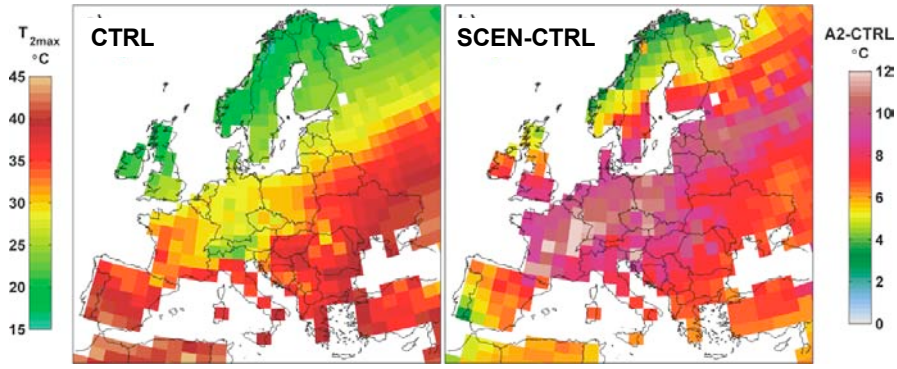
Heatwaves and hot summer days

Change in 95th percentiles of Tmax
2071-2100 versus 1961-1990, Scenario A2, HadAM3H

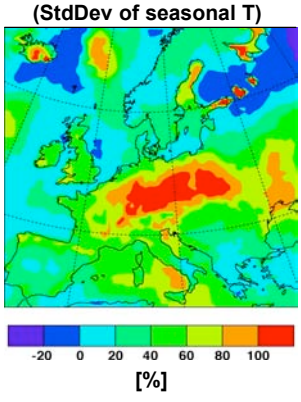


In Central Europe and for most models, T_{max} increases stronger than T_{mean}

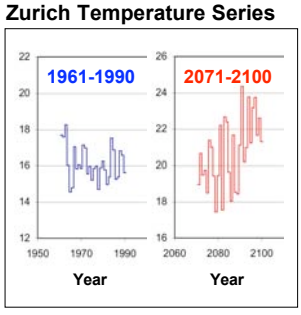
(IPCC AR4, Chapter 11, SRES A2, PRUDENCE, Kjellstrom et al. 2007)

Summer Temperature Variability

Change in Variability Δσ/σ
(StdDev of seasonal T)



Zurich Temperature Series



Signal present in a wide range of models
Weisheimer and Palmer, 2005; Scherrer et al. 2005, 2007; Rowell 2005; Giorgi and Bi 2005; Clark et al. 2006; Seneviratne et al. 2006; Vidale et al. 2007; Lenderink et al. 2007; Kjellstrom et al. 2007

Uncertainty due to importance of moist model physics

Trends in observational data detected
Della Marta 2007
(no IPCC stamp yet)

(IPCC AR4, Chapter 10 and 11, SRES A2, PRUDENCE, Schär et al. 2004)

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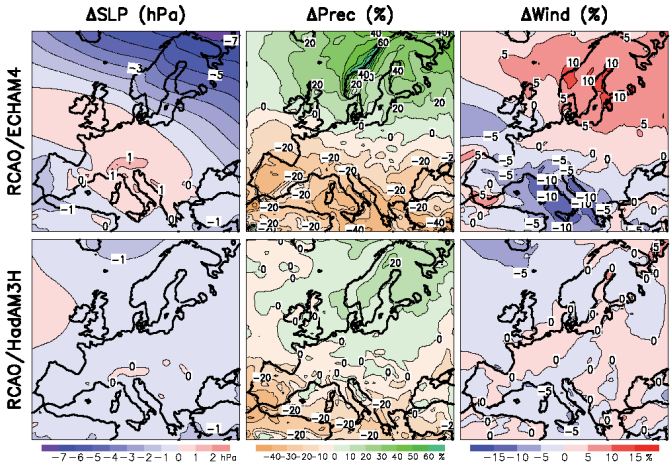
Wind storms

Annual mean simulated changes, 2 global models



Note:

- **Differences in circulation are very pronounced**
- **Nevertheless, qualitatively the two precipitation signals agree**
- **But circulation uncertainties imply pronounced uncertainties in wind scenarios**

(IPCC SRES A4, Chapter 11, Rummukainen et al. 2004)

Summary & Outlook

Major progress since last IPCC Assessment, more reliable and refined information

For the first time, WG1 of IPCC made a major effort to address extremes

Wishlist for AR5:
- **reduce circulation uncertainties in scenarios**
- **strengthen assessment of extremes and make a step towards natural hazards.**