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WeSenseIt
Citizen Water Observatories

Tausende Augen auf Wasser und Umwelt

Citizen Science – Gemeinsam forschen und lernen in Hydrologie und Limnologie
Universität Zürich, 11. Juni 2018

Project key figures and consortium

WeSenseIt
Citizen Water Observatories

14 Partners: 4 academic, 8 SME, 2 public bodies
Duration: 4 years (10/2012 – 09/2016)
European Commission FP7 project
Budget: 6.9M€; 5.4M€ EC contribution

- 3 Case studies:
  - Doncaster county, UK
  - Delfland lowlands, NL
  - Bacchiglione river, IT

The University Of Sheffield. · EPFL École Polytechnique Fédérale de Lausanne · Middlesex University London · Sensorscope · k-now managing your knowledge · quinary · Software Mind · UNESCO-IHE Institute for Water Education · HydroLogic Research Delft · Disdro · advanticsys · Starlab Living Science · Doncaster Metropolitan Borough Council

Citizen Observatories (CO) on the rise

CITI-SENSE

CITCLOPS

omniscientis

COBWEB
Citizen Observatory Web

WESENSEIT
CITIZEN WATER OBSERVATORIES

EU FP7 call for Citizen Observatories

Ushahidi

GEO GROUP ON EARTH OBSERVATIONS

eye on earth
CONVENE | CONVERGE | COLLABORATE

Objectives, Requirements and Approaches

Physical and Social Sensors:
Collection of physical (incl. remote sensing) & social data for Citizen Observatories

1. Development of new / innovative sensors incl. cost reduction and dissemination
2. Refining /optimizing existing sensors and heterogeneous sensor networks
3. Information extraction from social networks (crowd sourcing)
4. In-vivo evaluation and testing of physical and social sensors

Beyond floods – and even beyond water…
Drinking water, agriculture (irrigation), industry, hydropower,
natural hazards, (i.e. floods, drought, erosion, water quality…)

Challenges and requirements for a CO

Citizens' Observatory

- **Vision for citizen observatories**: comprehensive, adaptive
- **Physical sensors**: *dynamic, networked, ubiquitous, low cost, easy-to-use* sensors
- **Social sensors**: capturing meaningful data from explicit/implicit social sensing
- **Models**: integration of heterogeneous, noisy data; dynamic calibration of models
- **Mobile App(s)**: 

- **Governance and Communication** : combination of communication mechanisms
- **Stakeholder engagement**: participatory approach; provide added value; manage expectations
- **Case studies**: tailor COs to cultural setting, community needs and priorities
- **E-collaboration platform** for authorities and for citizens
- **Data management infrastructure** to handle heterogeneous data streams

Building the WeSenseIt Citizen Observatory

active participation
largely smart-phone based

minor involvement
CO sensing technology

Project elements:

1. Physical sensors
2. Social sensors
3. Heterogeneous networks
4. Integration
5. Architecture of WSI platform
6. Social dimensions
7. Case studies
8. Demonstrators, Dissemination

Building the WeSenseIt Citizen Observatory

Combination and Integration:

Traditional sensing systems:

static, precise (quality), few sensors, costly, high maintenance (env. influences → errors).

Citizen-supported sensing system:

static/mobile, inexact but quantity! (→ statistics), low-cost, little maintenance.

→ Combine traditional with citizen-based:

→ Sensors for citizens (many, cheap, mobile).

→integrate social media analysis

Social media and networks / crowdsourcing:

- Make sensing infrastructure accessible and affordable (cheap) to the public
- Innovate in sensing technology, also:
- Low-tech, simple solutions for COs
- Complementary to traditional sensors
- Citizen involvement ("human sensor")
- Engagement of citizens & stakeholders, create interest and env. awareness
- New low-cost commercial sensors for the market (SMEs)
- Heterogeneous, distributed sensor networks (physical and social)

WeSenseIt sensor definition: “Data in a server”

Sensor

Interface/logger

Communication/
data transmission

Enclosure
(weather-proof)

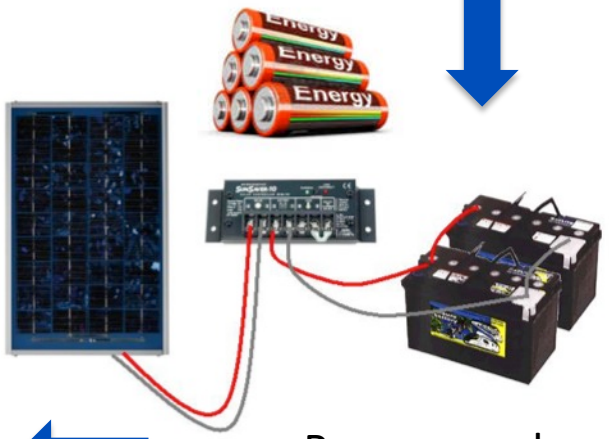
Supports/
Mounting/
Fixation

Cost

Operation/
Maintenance

Installation/
Transport

Permissions/
Authorizations



Power supply
system

(Physical) citizen sensors and low cost interfaces

- **Low cost:** affordable for a majority of citizens (< 50€)

- **Easy to use** by any citizen following easy instructions

- **Build your own** open source design:
  all components easily found in shops and from the Web
  → Citizens can build their own sensors

- **Open source**
  Software and physical designs will be open source
  Citizens may change sensors, add components, etc.

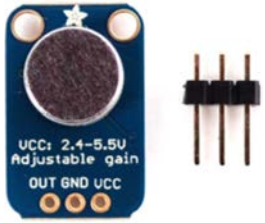
- **Inexpensive platforms and interfaces**
  Based on mobile phones
  and/or low cost micro-controllers (<50€)

Available low cost sensors (examples)

already in any mobile phone

GPRS €25

GPS €20



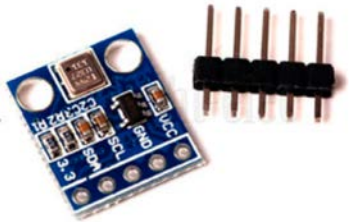
microphone €4

accelerometer €3

bluetooth €3

RFID scanner €3

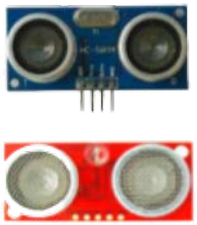
Barometric pressure and temperature €2



Luminosity sensor €5

Rain sensor €2

Distance sensors €3-20



Sensors for Citizen Observatories









water turbidity →

← (liquid) precipitation (amount and intensity)

water pressure →

← incoming solar (shortwave) radiation

flow velocity (water in pipes) →

← air temperature and relative humidity

electric conductivity, EC (salinity) →

← infrared surface temperature

water level (radar) →

← distance to surface (water level, snow depth)

dissolved oxygen (DO) →

← soil water tension (matrix potential, suction)

pH level →

← wind speed and wind direction

oxidation, reduction potential (ORP) →

← soil moisture, temperature, electric conductivity

temperature (air, water, soil) →

← water temperature

water level →





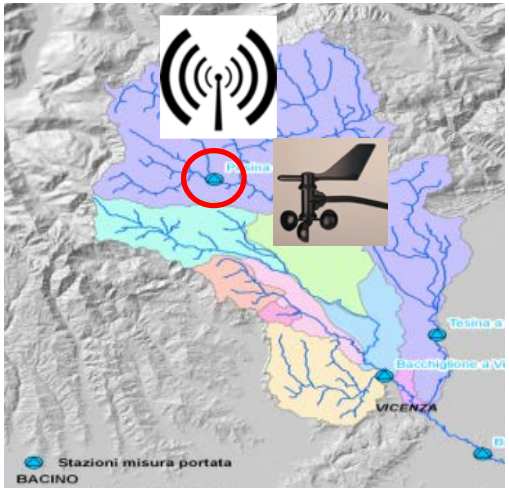





Wireless data transmission and sensor networks

SOAP Web Services API

Mobile network & Internet

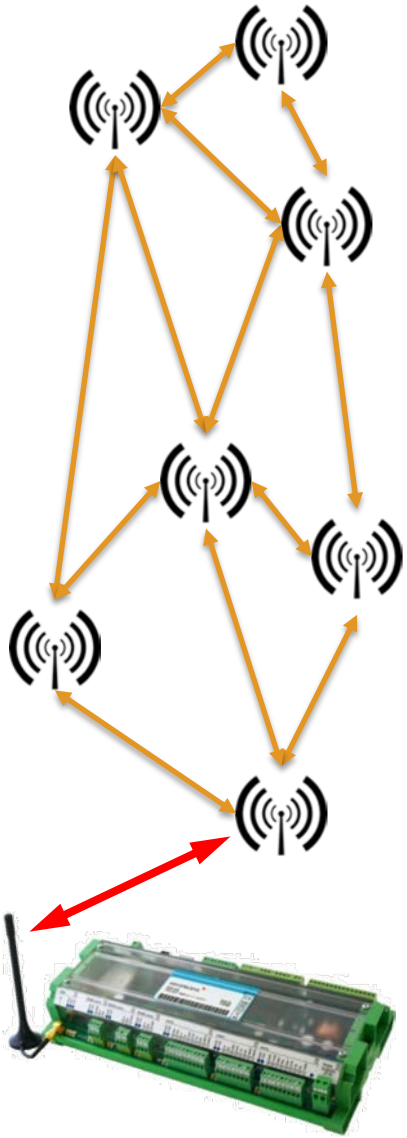


Infrastructure for wireless sensor networks and data transmission / communication

- Sensor interfacing:
  integration of many different sensors

- Modbus controllers for monitoring & remote actuation over hardware
- Analog / digital data loggers
- Mote modules for data transmission

- Self-organizing pathways in networks
- No information gets lost



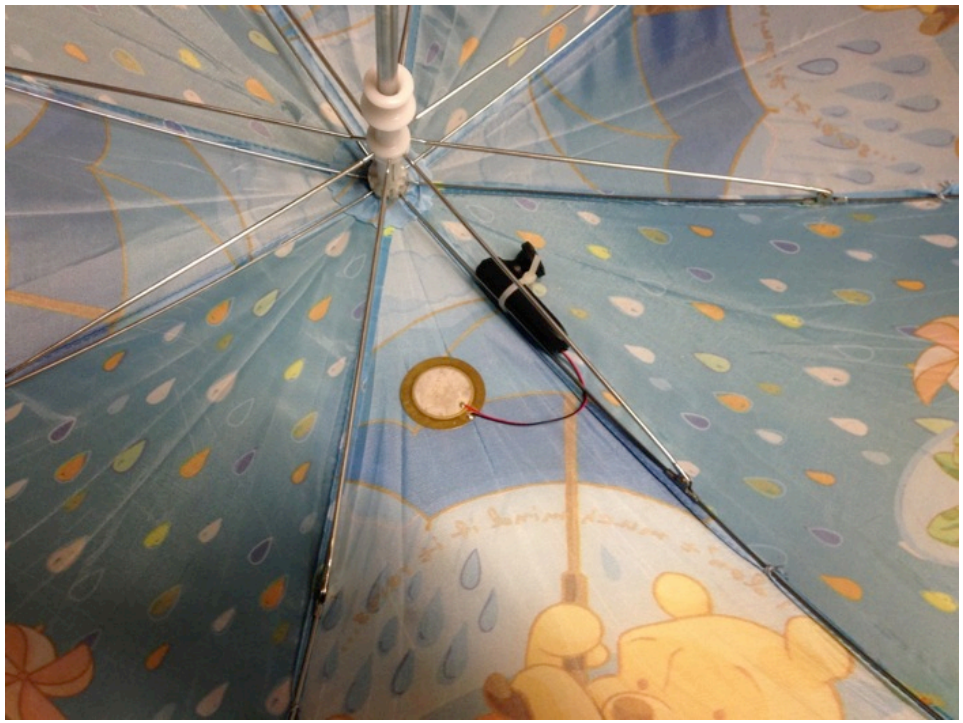
Innovation in Sensing: Acoustic rain gauges

- Novel acoustic rain gauge
- No moving parts
- Cheaper than current rain gauges (<100€)
- Several prototypes were operational in the WeSenseIt use cases (UK, NL, IT)

Optical disdrometers (≈10k€)

Innovation in sensing: Rain sensing umbrella

- Acoustic rain sensor integrated in umbrella
- Piezo element attached to umbrella tissue
- Data transmission by Bluetooth to iPhone
- Data push to server by smartphone

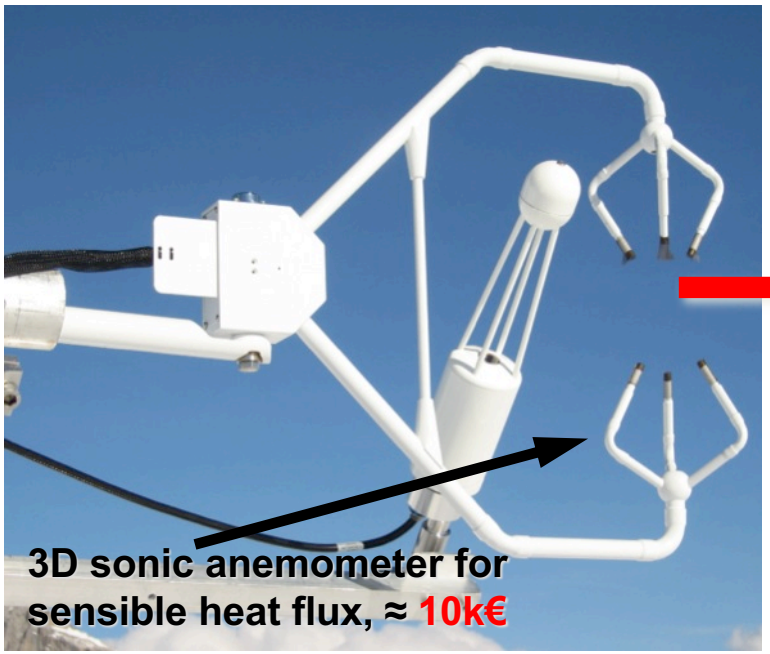


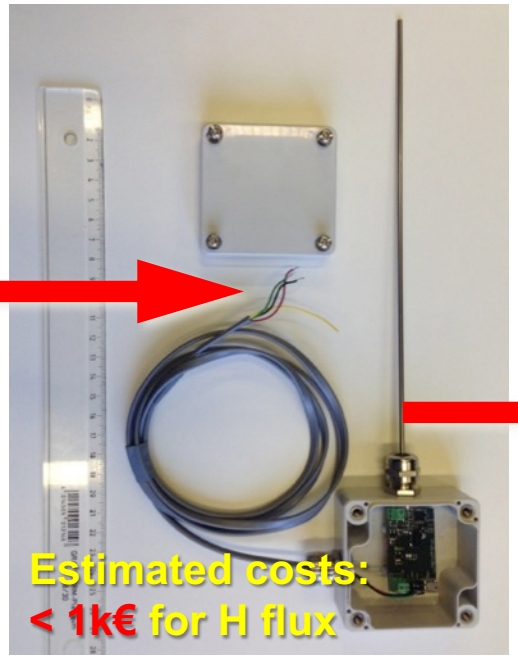
Innovation in sensing: Sensible heat flux

Turbulent heat exchange (convection) between land (water) surface & atmosphere;
Component of surface energy budget. → Evaporation / Water use.

- Sensors for wireless sensor networks & distributed flux measurements
- Sensors order 100€ (State-of-the-art sensible heat flux sensor systems: ≈ 10 k€)

Measurement principle based on free convective scaling – flux variance method



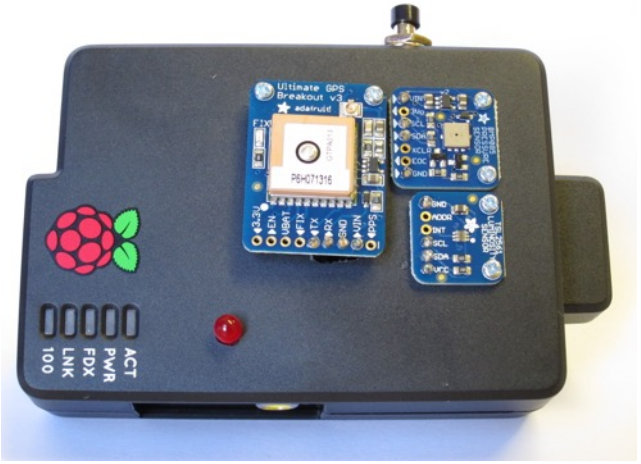


Pi-Box: a new low-cost citizen sensor

(1): estimate water velocity

(2): measure ancillary meteorol. variables, i.e.

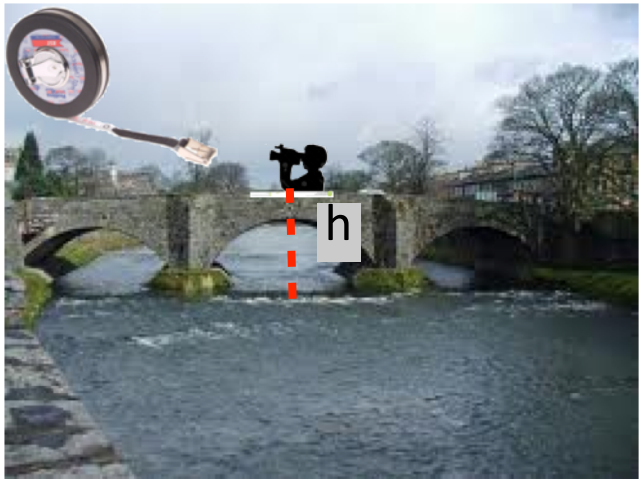
- Luminosity (proxy for cloud cover)
- Air temperature
- Barometric pressure



All information is geo-tagged

(via on-board GPS module)

Distance “h” determined with tape measure



Flow calculation with offline annotation

Device intended to be used by flood wardens

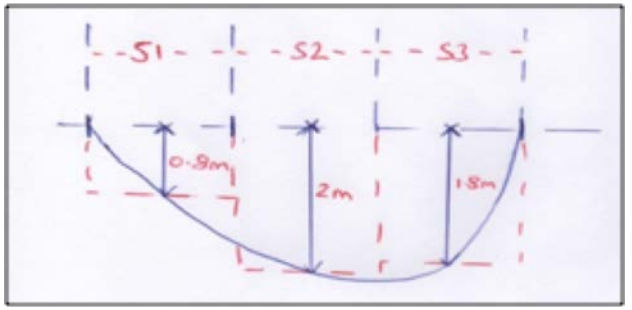
Smart-phone based discharge estimation

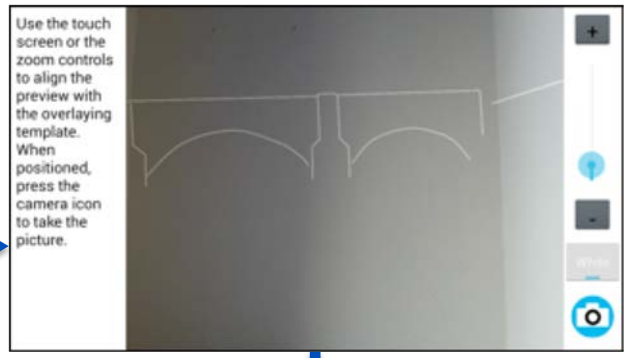
Smartphone-based App (Android):

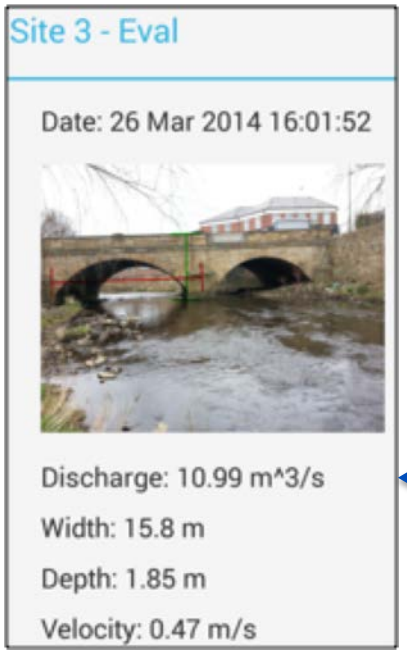
Water level (from App) and annotation

Water surface velocity (from floating object)

→ get (rough) discharge estimate



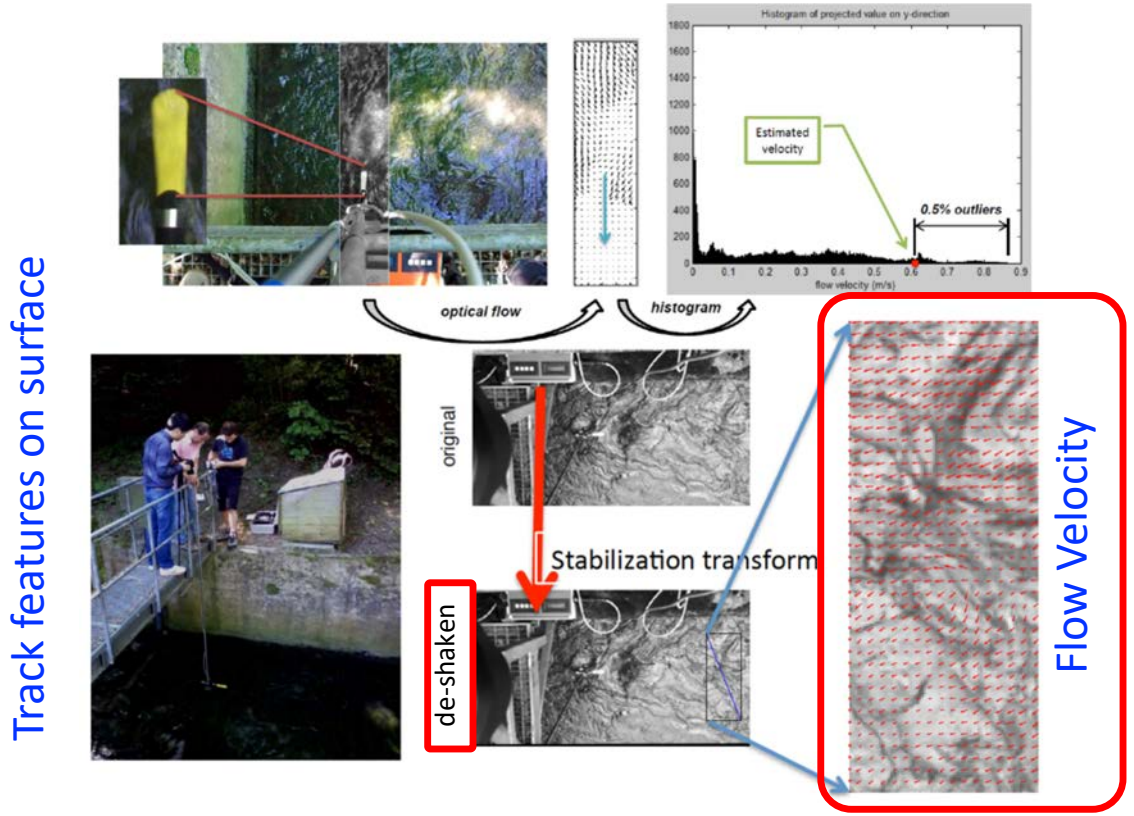




Stream flow velocity from movie clips

Flow velocity at water surface can be measured by analyzing movie clips with (various) optical flow algorithms, given a length reference is present. - Objectives:

- Enable measurements from different perspective angles, for use on smartphones
- Quantify relations with flow and water depth, including uncertainty estimates

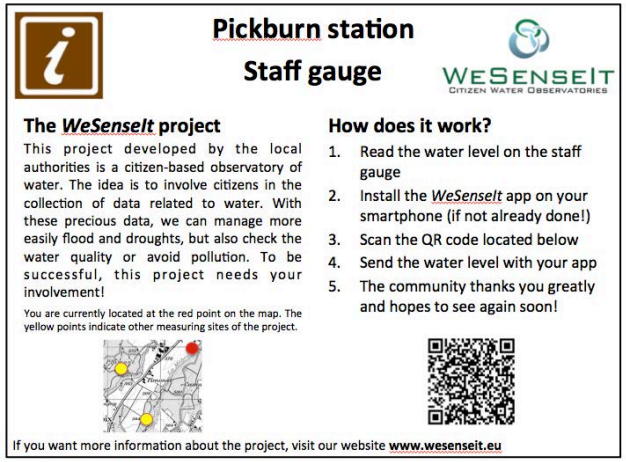


Static sensors and mobile application

QR code based systems

- (Stream) Water level from gauge boards
- Snow depth from graded snow poles

Panels instruct citizens who use their smartphone and the **WeSenseIt App** and send measurements and/or photos.



Low-cost “automatic” remote visual monitoring

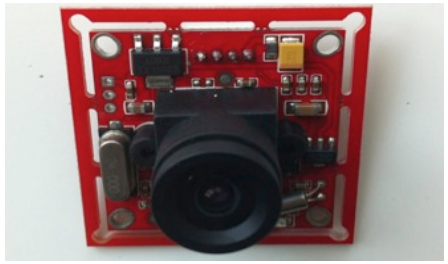
Autonomous GPRS camera module

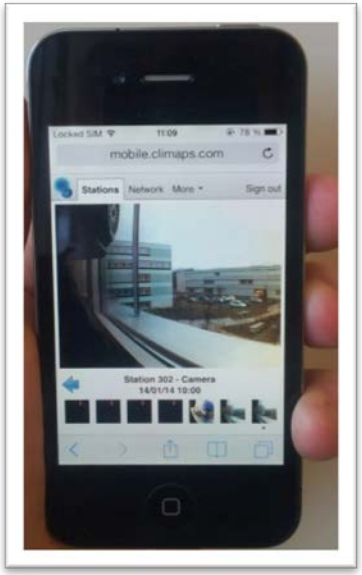
Applications:

- Environ. monitoring, natural hazards
- Autom. event detection.
- Periodical pictures (time series)
- Event-triggered or on-demand pics.
- e.g. “take picture if Rain/24h >50mm”
- Low power, small size, robust

Solutions:

- **New visual sensors**: low-power, small-size, autonomous (CMOS communication device)
- **Smarter “visual systems”:** detect events (water level, natural hazards, water velocity) using image/object recognition





Slide content: Sensorscope

State of the soil

In-situ soil moisture, soil temperature, & electrical conductivity

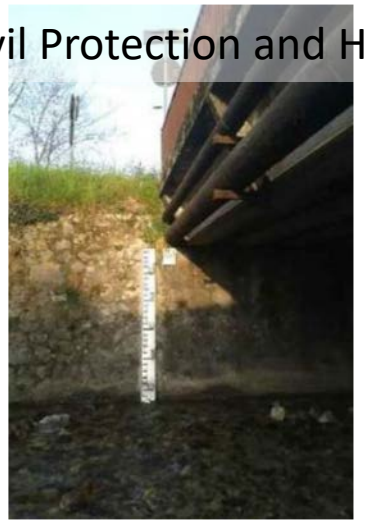
- Smart irrigation probes
- Wireless, autonomous
- Configuration of alarms
- Modular sensor nodes
- Data sent via GPRS/3G

Installation Examples: Use Cases (IT, UK, NL)

Close collaboration with Civil Protection and Hydrological Forecasting

Soil moisture

Water level (Radar)



Water level (gauge board + QR code)

Water pressure

Autonomous or citizen supported measurement stations

Soil moisture, soil temperature

Level, precip., T/RH

Water level

Snow depth

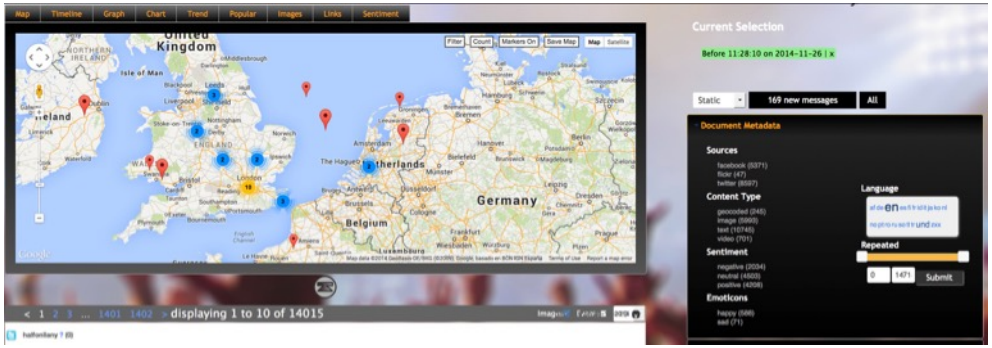
Citizen and Social Sensors

- Screening of social media streams (Facebook, Twitter, Flickr, RSS, etc.).
- Language detection; have multiple use cases (i.e. English, Italian and Dutch).
- Software and tools for crowd sourcing, crowd tracking and event monitoring.
- Extraction of water related (hydrological) information from social data
- Correlation of extracted information with physical sensors → "calibration"
- Error / uncertainty analysis of information from "social sensors"
- Citizen Observatory App/s (for citizens and for authorities)
- Optimization of heterogeneous physical and social sensor and networks

Social Media

Social Media Analysis (opportunistic / social sensing)

- Identify messages highlighting issues; requests of help
- Large scale infrastructure (>10,000 messages/sec)
- Successfully used in emergency control room during social events in 2013 and 2014 in the UK and Italy (Involving over 1,000,000 participants (e.g., Glastonbury Festival)
- Extraction of geo-located water related (hydrological) information from social data



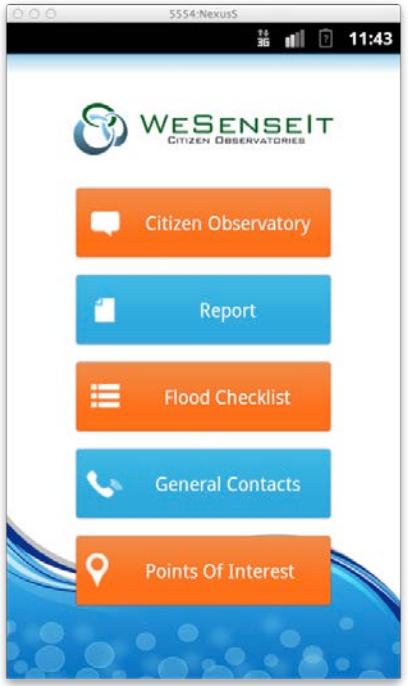
Slide content: N. Ireson, U Sheffield
Huwald et al. |

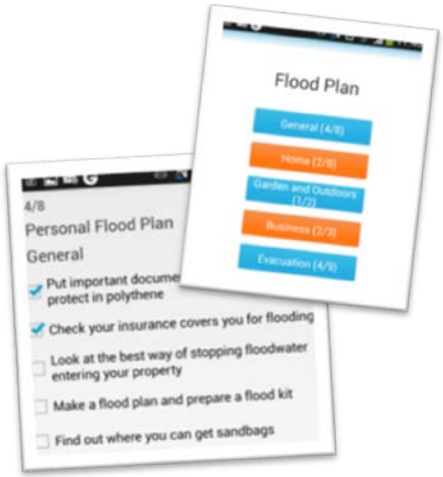
Static sensors and mobile application

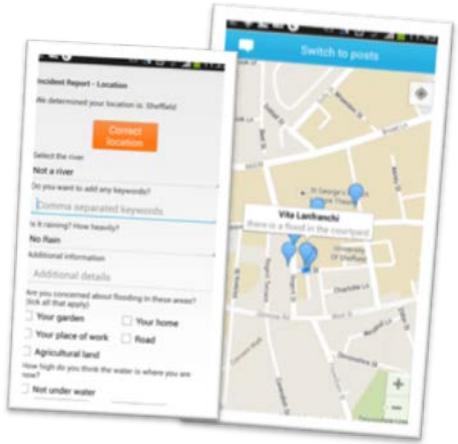
A custom mobile **app** to engage citizens in the Citizen Observatory

- Participatory sensing
- Location-based discussions
- Integrated with Social Media
- **Flood report** submissions
- **Sensor** reading submission
- Direct dialogue between citizens and authorities
- Interactive **flood planning**

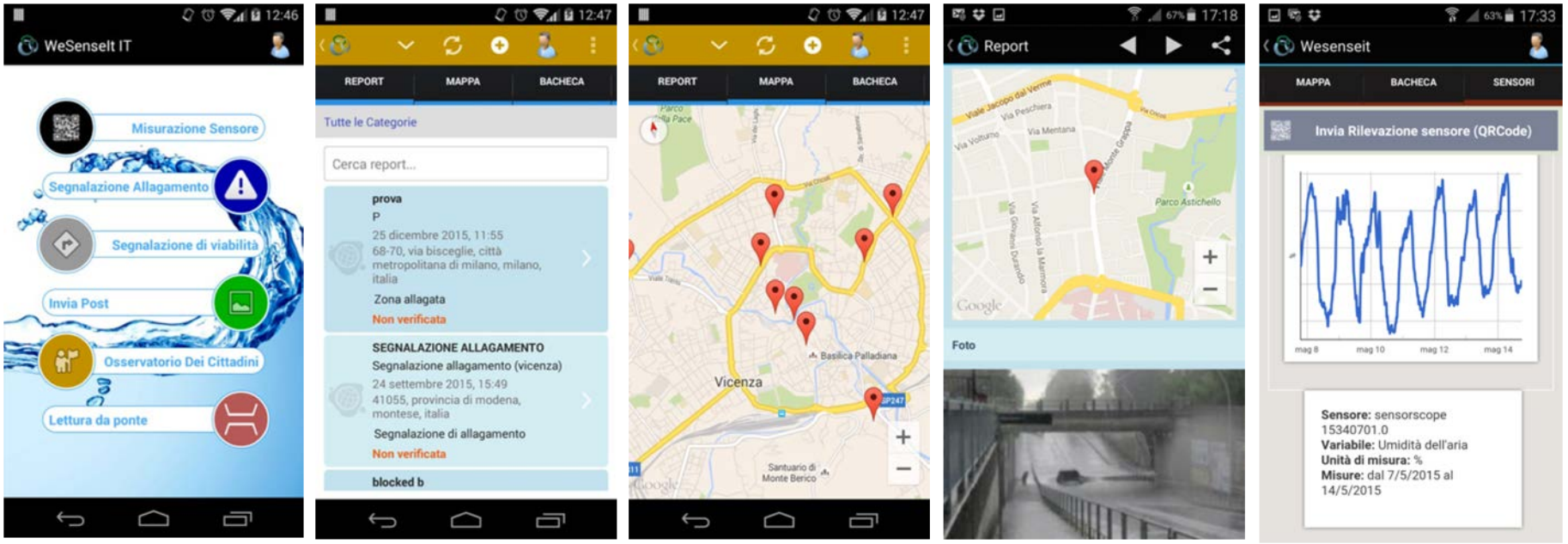
  - App for Italy (Vicenza case study) : http://wesenseit.quinary.it/ushahidi/
  - App for UK (Doncaster case study): http://wesenseit.quinary.it/doncaster/







Using and browsing the CO Mobile App and Platform



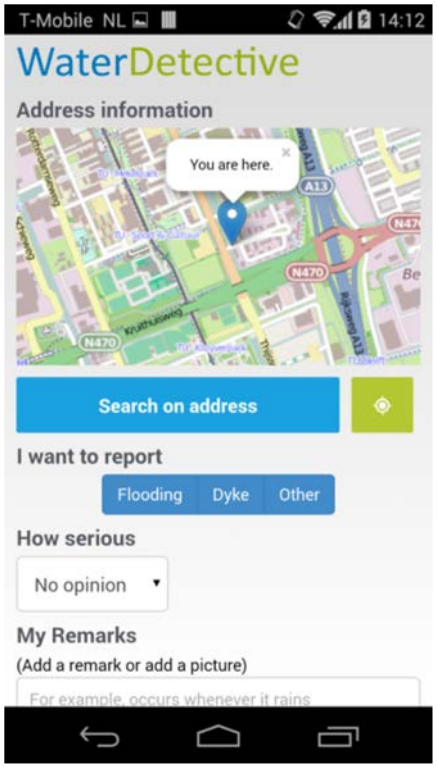
- Citizens can easily send reports and pictures (flood reports, road condition, QR code readings, incident reports, community behavior, etc.)
- Reports are geo-located by GPS service. If the GPS is not active, tap on a map
- Reports can be browsed and filtered and visualized on a map
- Sensors can be visualized in a map, and sensors reading plotted in a graph

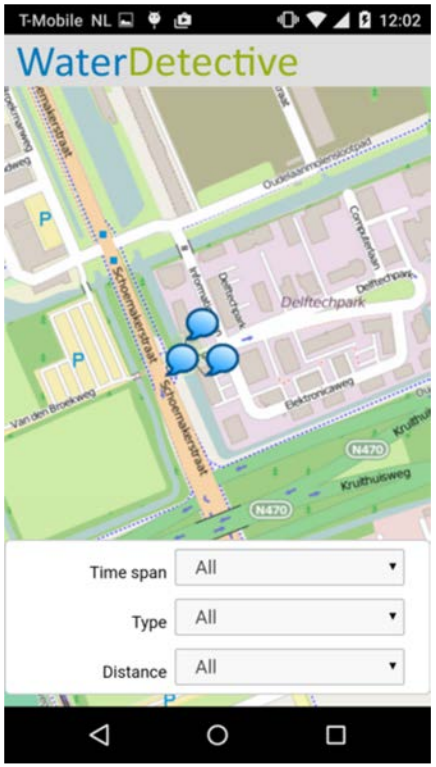
Water Detective

HydroLogic

Water Detective

Mobile App to report events





- Take pictures and categorize report type
- Submitted reports visualized on a map
- Users can vote on each others reports
- Administrator portal for authorities:
- Authorities can send direct feedback to users via push notifications
- Push notifications directly to users to alert of upcoming events;
- Different event types can be superposed with additional layers of geographical information for decision making (e.g. rainfall);

Slide content: D. Galvo, HydroLogic

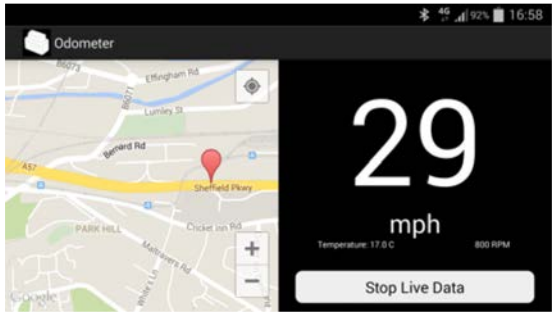
Monitoring citizen behavior

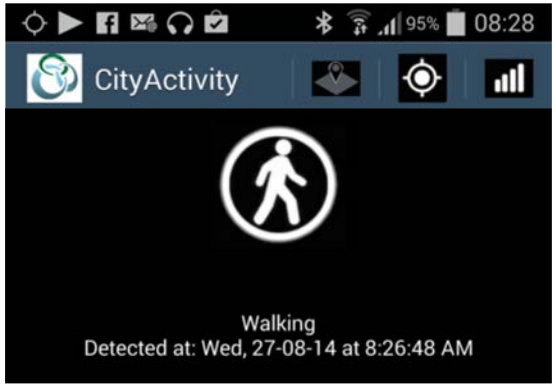
Monitoring cars and/or individuals

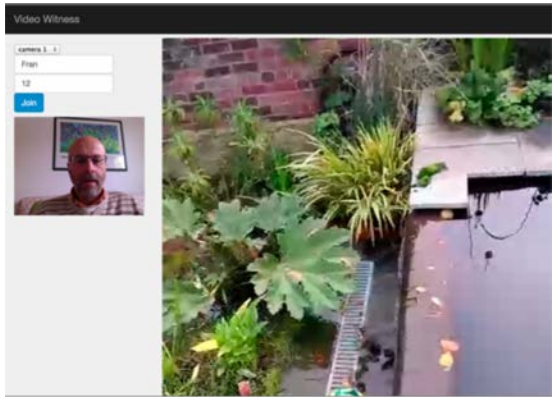
(e.g. for civil protection):

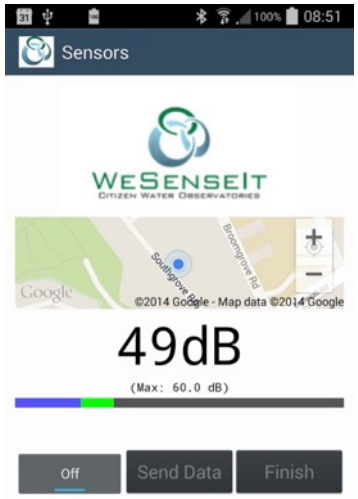
- On-board diagnostics (OBD) and Activity monitor
- Speed measuring from curb
- Bluetooth and wireless counting
- Face counting in crowds

Turning any phone into a camera for control room



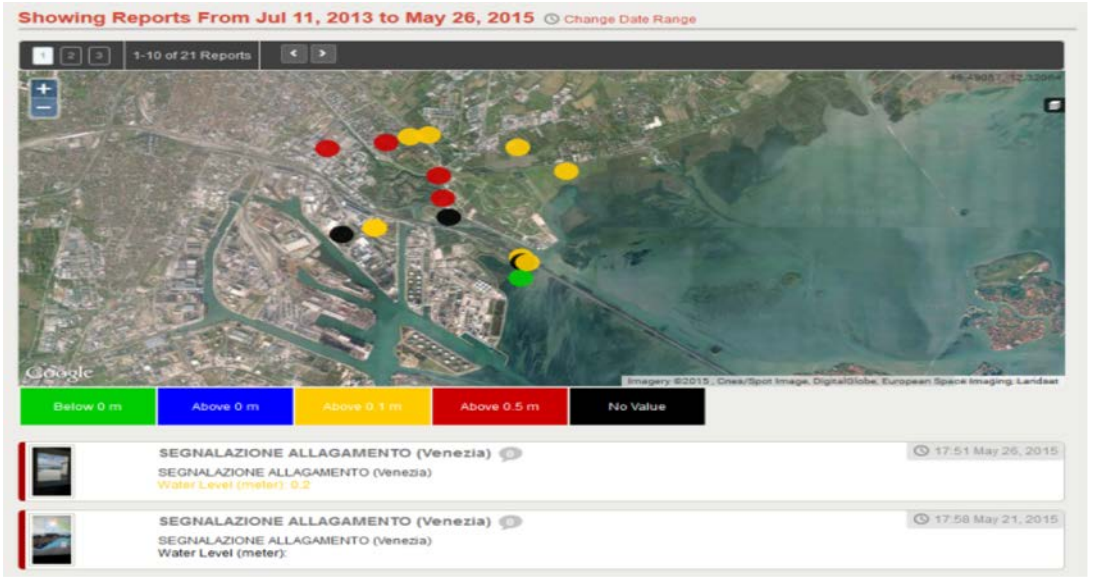


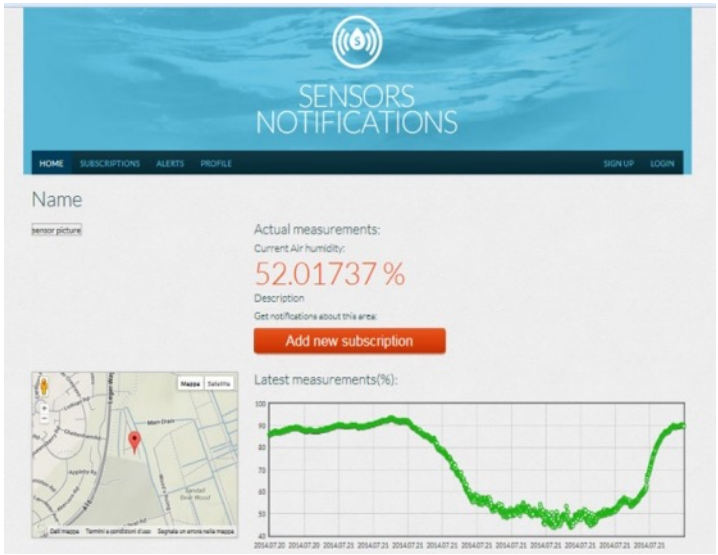


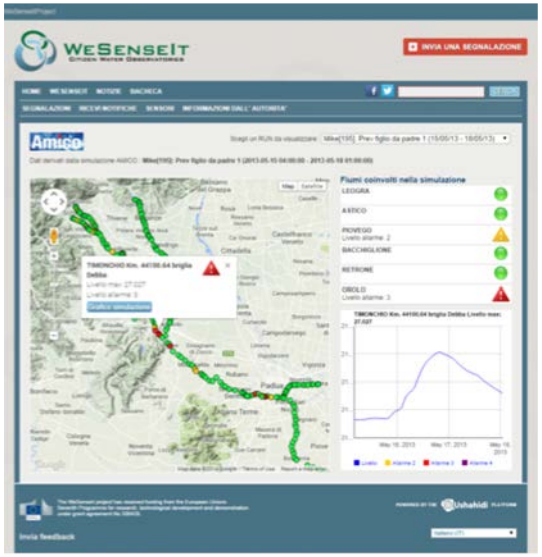


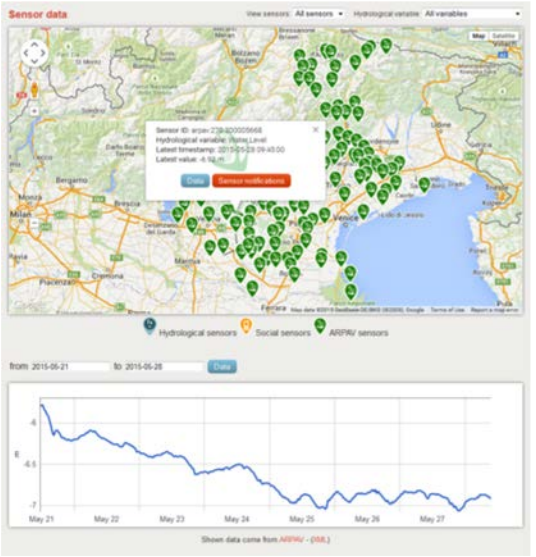
E-collaboration platform for citizens and author.

- Send and share reports
- Search for contents
- Report alerts
- Sensors viewer
- Notifications
- Warnings (from authorities)
- AMICO warning alerts
- Links to relevant authorities
- Disaster and crisis management









Slide content: Quinary etal.
Huwald et al. | © WeSenseIt Consortium

Summary

- Sensing equipment for COs is very diverse
- CO sensors complement (not replace) standard instruments
- COs promote and favor technical innovation and inspiration
- Cost reduction of sensors enables spatial coverage
- Low-cost equipment has proven useful and quite reliable
- Large potential further developing citizen-based monitoring
- Success depends on acceptance and participation of citizens
- Quality of citizen collected data may be good but not reliable as expert data
- Social science components in CO indispensable
- Risk: dispersion as a result of 100s of uncoordinated efforts (Apps)

Results: Case studies

Delfland (NL)

Initiative: External, Researchers

Most valued result:

"Nice to have more information but no need for exchange of knowledge".

Limited uptake from both authorities and citizens' side.

Vicenza (IT)

Initiative: Authorities, water authority

Most valued result:

Faster and easier communication towards and alignment between different groups

wesenseit.quinary.it/ushahidi/main

Doncaster (UK)

Initiative: Authorities, Council

Most valued result:

More intense collaboration with already familiar citizen groups

wesenseit.quinary.it/doncaster/main

WeSenseIt
Citizen Water Observatories

Thank you for your attention !

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