

FUSE Project overview

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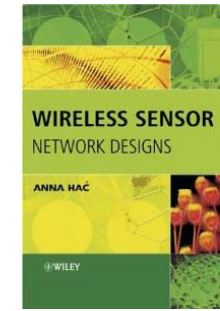
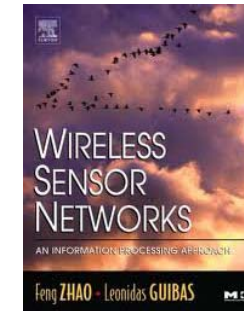
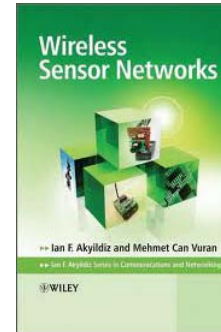
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Floodplain Underground SEnsors - A high-density, wireless, underground sensor network to quantify **floodplain hydro-ecological interactions**

Background

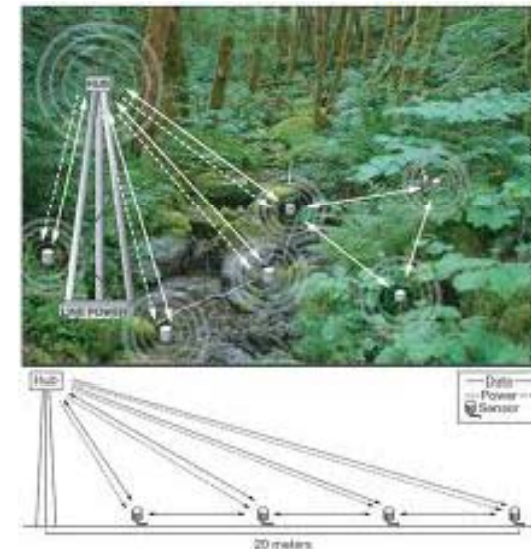
- Natural Environment Research Council (**NERC**) recently recognized major developments in **Wireless Sensor Network (WSN) technology**
- Still **very few sites** where **high density WSNs** have been installed for **environmental research** purposes



- NERC '**Networks of Sensors**' call March 2010, deadline 15 April 2010



- **FUSE** is 1 of 4 projects funded, out of 35 proposals. **£1M, 3-year project** (start-date 1 March 2011)
- **7 Research Institutions, 2 Research Partners**
- FUSE addresses both the **NERC Technologies Theme**, and the **Biodiversity Theme**



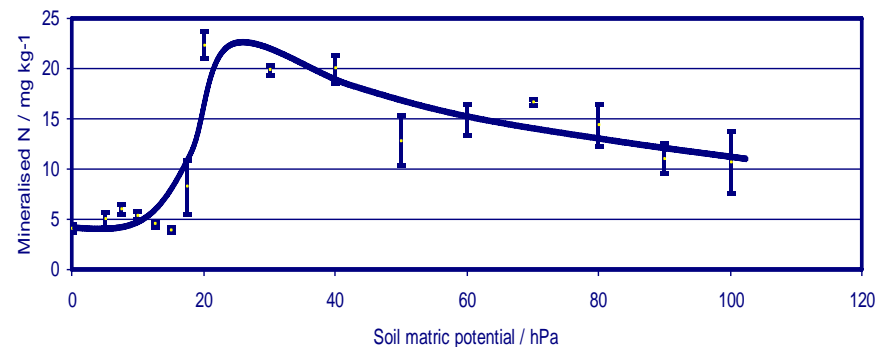
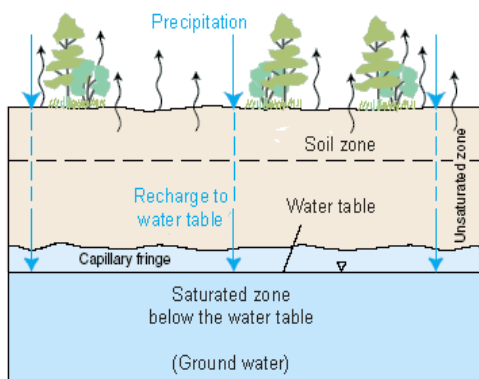
Key science issues 1

- **Floodplains are a valuable resource:**
 - support some of the **most diverse vegetation** in the UK (up to 40 species m⁻²)
 - perform key ecosystem services, such as **flood storage** and **sediment retention**
- **UK now has less than 1500 ha** of this unique habitat remaining and therefore this habitat has been given **protection** under the **European Habitats Directive (92/43/EEC)**



Key science issues 2

- **Species composition and plant health** are known to be tightly correlated to the **hydrological regime** and related **temperature** and **nutrient** regime
- **Nitrogen mineralisation rate** has been suggested as a controlling mechanism, which is regulated by both **soil temperature** and **soil oxygen** availability
- Investigate the **variability** (sub-metre to tens of metres; half-hourly to seasonally) by using an **intensity of wireless monitoring** not previously attempted in this environment



Aims of NERC-funded FUSE project

A1. To advance knowledge of the interaction between hydrological regimes and floodplain ecosystems functioning, at a variety of scales, using a combination of **state-of-the-art monitoring** and **modelling** tools;

A2. To test feasibility of using a **high-density *underground* wireless sensor network**, combined with **modelling tools** and **Earth Observation** data, in **ecosystem** research;

A3. To allow **improved environmental management** of these **vulnerable ecosystems** under current and future environmental conditions, through **better process understanding** and tools obtained via A1/A2.



University of
Reading

Institutions & expertise

University of Reading (Soil Research Centre; Anne Verhoef): [Soil physics/chemistry, ecohydrology, plant physiology](#)

University of Reading (School of Systems Engineering; Hugo Mills): [Wireless Sensor Network software, data-base, user-interface \(Web-portal\)](#)

Imperial College (Julie McCann): [WSN technology](#)

Open University (David Gowing, Irina Tatarenko): [Botanical composition, phenology, nutrient analysis](#)

British Geological Survey (Wallingford; David Macdonald): [Groundwater hydrology/chemistry](#)

Rothamsted Research (Ben Marchant): [Geospatial modelling](#)

University of Southampton (John Atkinson): [Novel low cost thick-film sensors](#)

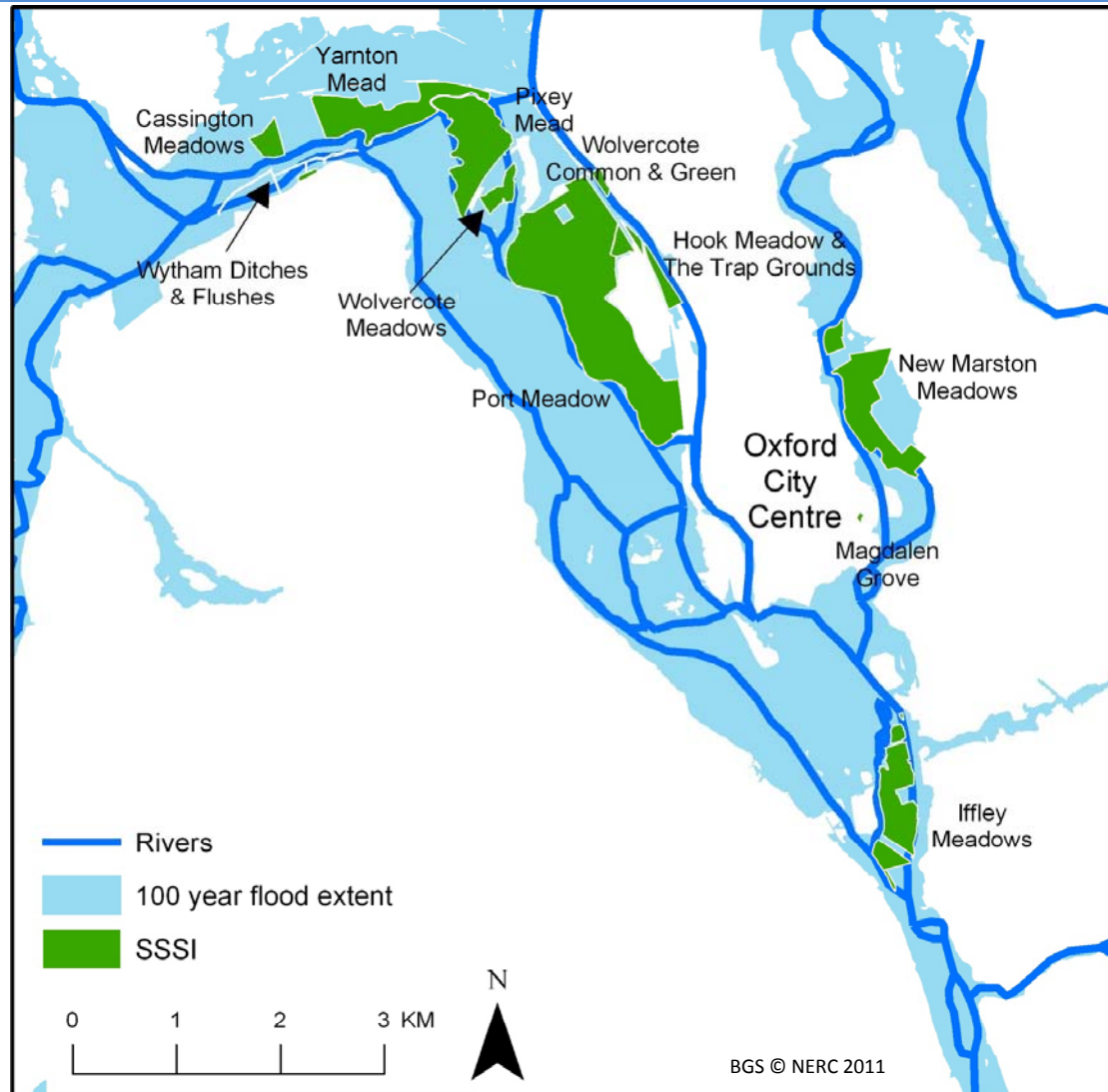
ITC-Enschede, the Netherlands (Christiaan van der Tol): [Remote Sensing and environmental modelling](#)

Natural England (Rebecca Tibbetts): [Project partner](#)

Environment Agency (Mark Whiteman): [Project partner](#)



Study site for FUSE project 1

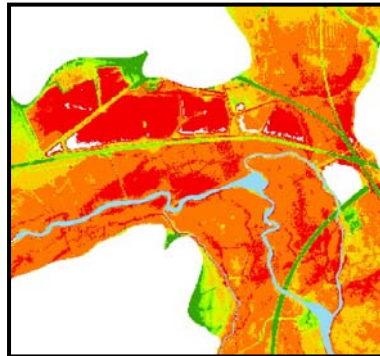


FMP Workshop Oxford Meads 26th May 2011

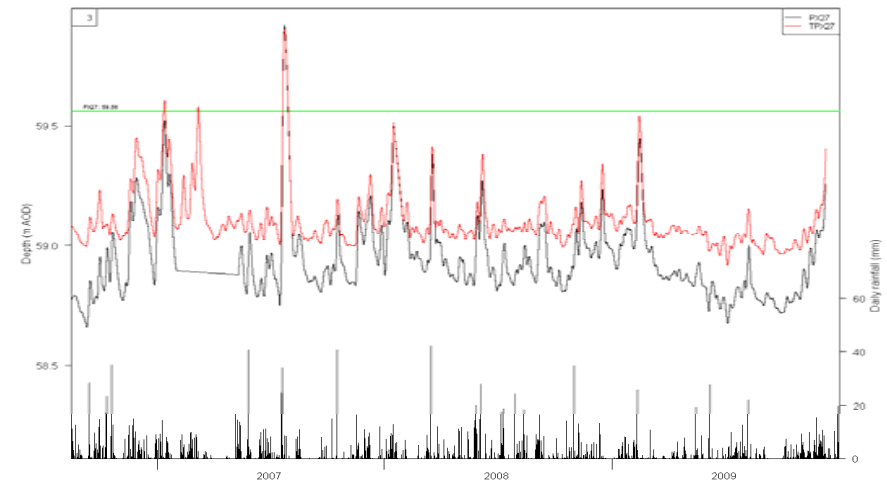
Information available

- LIDAR topography
- Botanical surveys
- Soil surveys
- Geology
- Soil and aquifer parameters
- Plant-soil-water studies
- GW and surface water levels
- GW and river models

Depth to GW



Thickness of alluvium



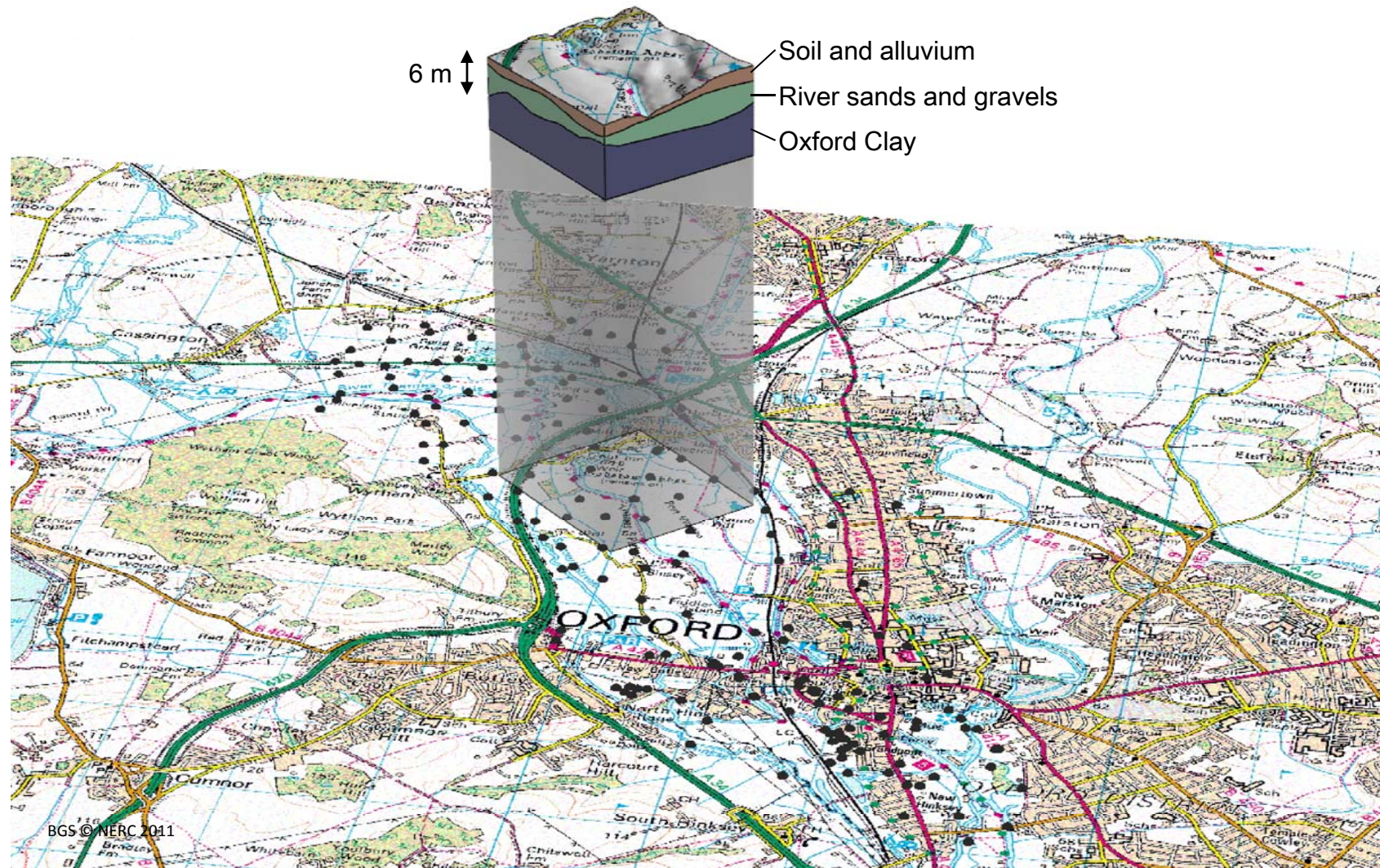
Previous studies at the site

- Impact of quarrying on Meads
- Impact of upstream abstraction from River Thames
 - Thames Water Drought Permit
 - Requirements of Habitats Directive
- Oxford Flood Risk Management Study
- MAFF/IH study: Water regime of river meadows
- Various botanical studies

<i>Variable</i>	<i>2006</i>	<i>2007</i>	<i>2008</i>	<i>2009</i>	<i>Time</i>	<i>Time*Block</i>
Species number	23.5	26.1	20.5	21.5	<0.001	<0.001
Ellenberg F	6.02	6.00	6.33	6.30	<0.001	<0.001
Ellenberg N	4.66	4.75	4.76	4.69	<0.001	<0.001



Floodplain Geology



FMP Workshop Oxford Meads 26th May 2011

Sensors to be installed and linked to WSN

Soil/alluvium/gravel aquifer:

- **Soil moisture content:** dielectric constant sensors
- **Soil temperatures:** thermistors
- **Groundwater levels and temperatures:** pressure transducers & thermistors
- Novel, low-cost **thick film physico-chemical sensors**



Atmosphere (UoR)

- Net radiation
- Air temperature & humidity
- Wind speed
- Rainfall



WUSN

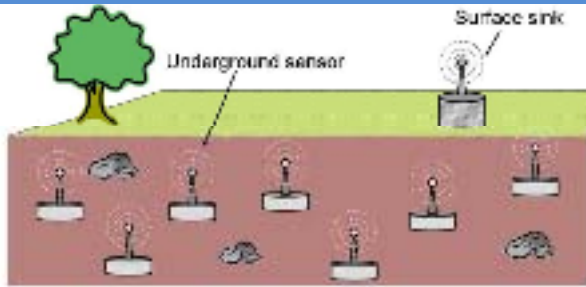


Fig. 4. Underground topology.

Beastie wireless sensing nodes

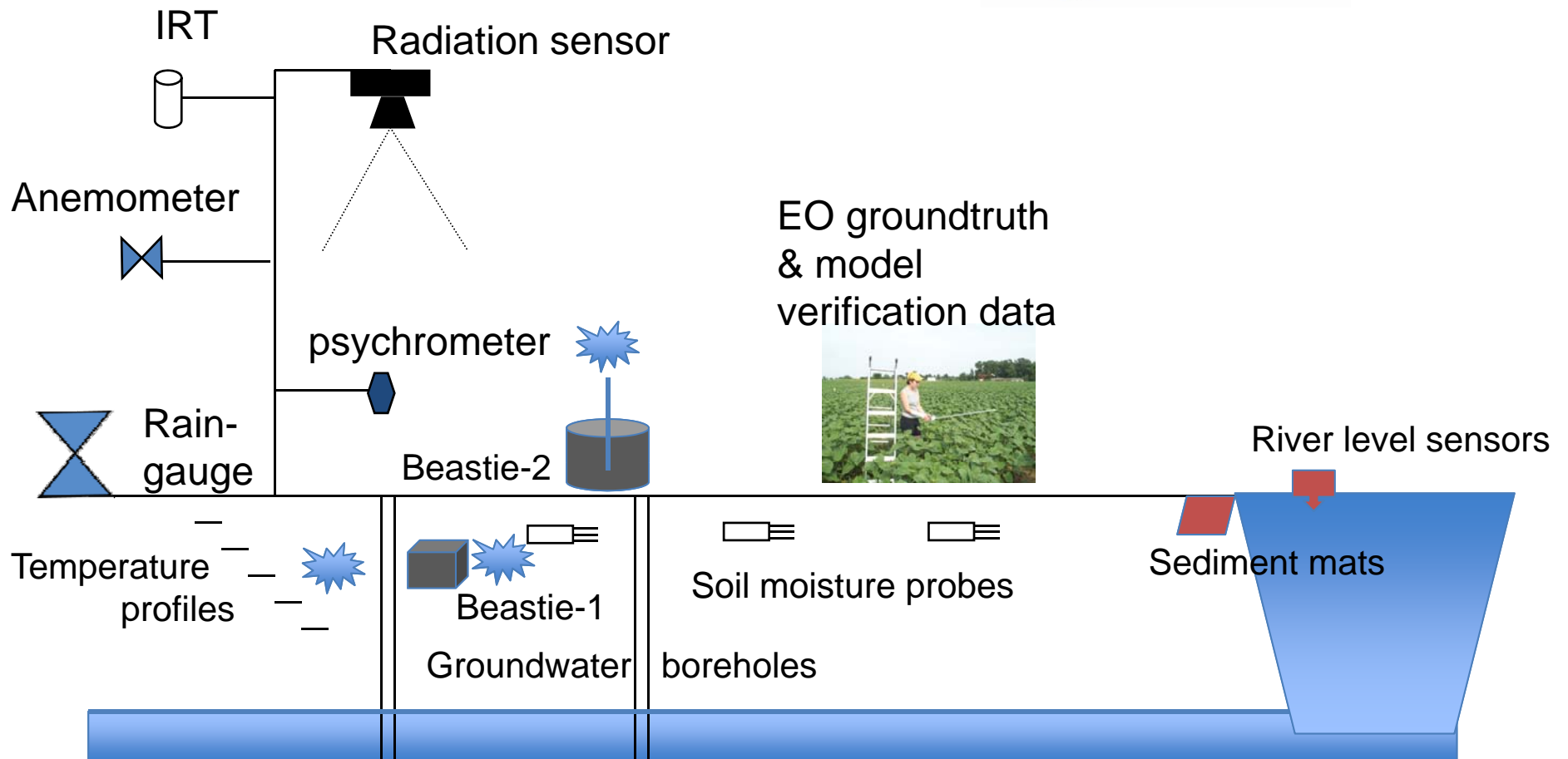


- Water-proofing (IP68)
- Sensors
 - Expected depth – single or multi sensors
 - Sensing radius, energy used, data rates
 - Sensor interference
- Antenna implications
- Effect of **soil type & moisture content on radio propagation and signal attenuation** of the Beastie nodes.

Schematic of observations



Earth Observation



Manual sampling



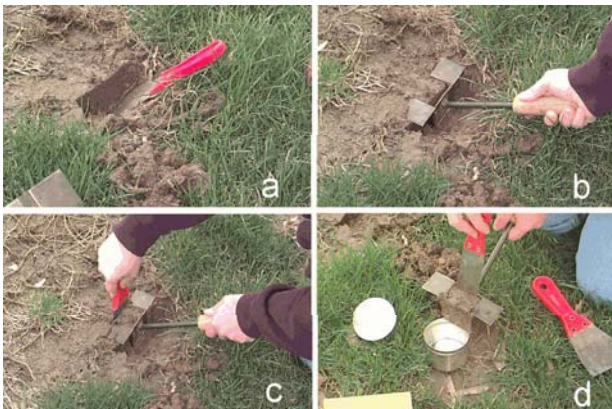
Plant-related:

- Botanical composition
- Phenology
- Cover of dominant species
- Nutrient analysis (hay N & P content)
- Stomatal conductance →



Soil physical parameters:

- Water retention curve
- Hydraulic conductivity
- Bulk density



BGS © NERC 2011

Groundwater-related:

- Nutrients in GW
- Aquifer physical parameters
 - Specific yield
 - Permeability



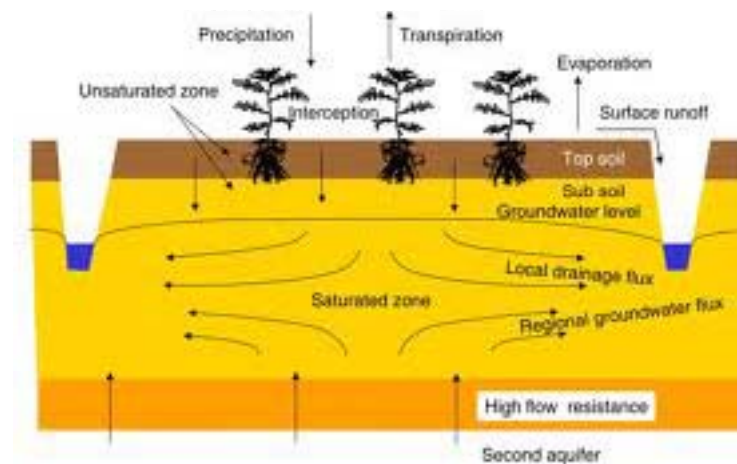
Modelling framework

Various models

- Soil-Vegetation-Atmosphere-Transfer (**SVAT**) modelling coupled with **EO** data
- Groundwater modelling (BGS)
- Geospatial modelling (RR)

Should lead to **more generic tools** for

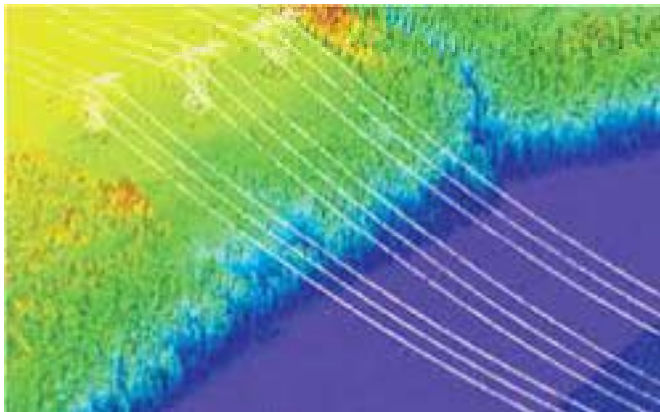
- Environmental **research**
- Environmental **management**



SCOPE-model

SCOPE is a Soil Vegetation Atmosphere Transfer (**SVAT**) model that supports direct interpretation of **EO** data (Van der Tol et al., 2009). See <http://scope.itc.nl/>

- Allows for integration of **underground and above-ground** key biophysical and chemical **processes**;
- It will be **extended with a multi-layer below-ground model component**.



Ongoing & future work

- Collating **reports/data**
- Employing **post-docs**
- Talking to **stakeholders**
- Starting to **instrument** the site
- **WUSN testing** late summer/autumn
- **Modelling work**
- Next year **fully working system**

