



TERENO – A new Network of Terrestrial Observatories for Global Change Research

H. Bogaena¹, O. Bens⁶, A. Brauer⁶, E. Borg⁵, P. Dietrich², I. Hajnsek⁵,
H. Kunstmann⁴, E. Priesack³, T. Pütz¹, J.C. Munch², H. Papen⁴, H.P.
Schmid⁴, G. Teutsch², H. Vereecken¹ & S. Zacharias²

¹Agrosphere Institute, Research Center Jülich, FZJ

²Centre for Environmental Research Leipzig-Halle, UFZ

³Institute of Soil Ecology, German Research Center Environment and Health, HMGU

⁴Atmospheric Environmental Research Division, Karlsruhe Institute of Technology, KIT

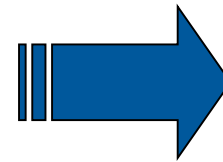
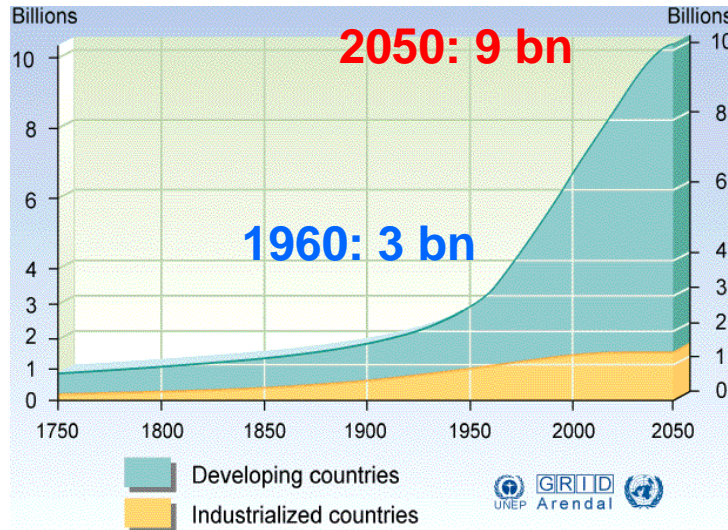
⁵German Aerospace Center, DLR

⁶Helmholtz Centre Potsdam, German Research Centre for Geosciences, Potsdam, GFZ



Facts of Global Change

World population development from 1950 to 2050:



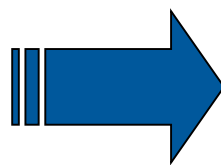
Soil, water, air and vegetation

- Climate change is affecting all compartments of the terrestrial system
- 50% of the global land surface has been changed by human activity; 23 % of the land surface is degraded in quality
- Loss of agricultural land (e.g. in China -3,5 Mio ha since 2002)
- In 2003: 2 % of the agricultural land was lost: Production of rice, corn and wheat -18%
- Worldwide loss of biodiversity
- Decline of water availability (49,000 km³ per year) and water quality
- 1/3 of the earth's annual renewable water may be affected by pollution in 2050 (Gleick et al., 1998) due to waste water



Motivation

- The effects of Global Change on terrestrial systems are regionally differentiated
- Global Change affects all compartments of the terrestrial environment (water, soil, vegetation, atmosphere) with complex feedback mechanisms
- Existing measurement networks are typically focused on specific compartments and research questions
- Long-term hydrological and ecological data are urgently needed for validating terrestrial environmental models
- There is a need for capacity building in the field of terrestrial research by bringing together different research communities



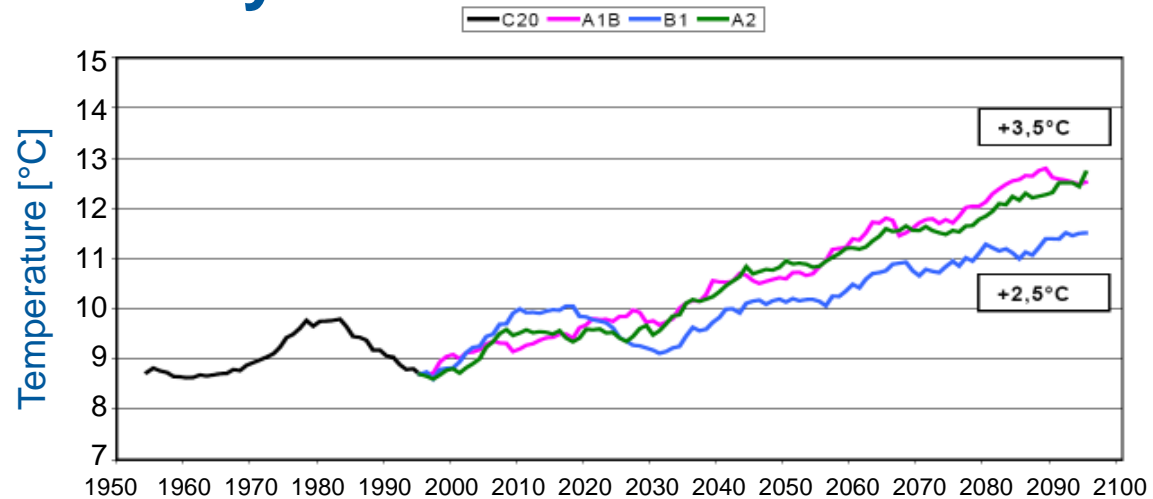
TERENO
TERRESTRIAL ENVIRONMENTAL OBSERVATORIES



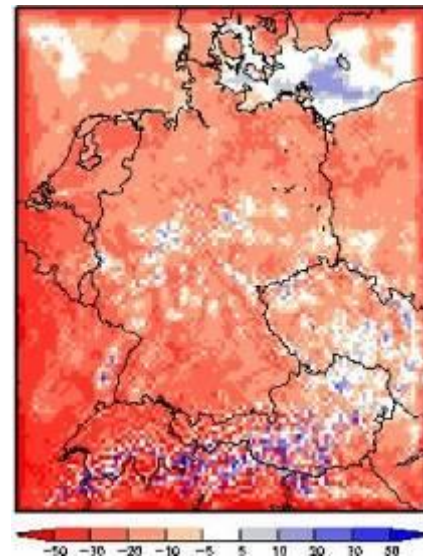
Climate Change in Germany

Climate models are projecting significant climate change in Germany in the next 100 years:

- Increase in temperature (2.5 – 3.5°C)
- Decrease in precipitation (up to 30 %)



Temperature increase in 2100 [°C]

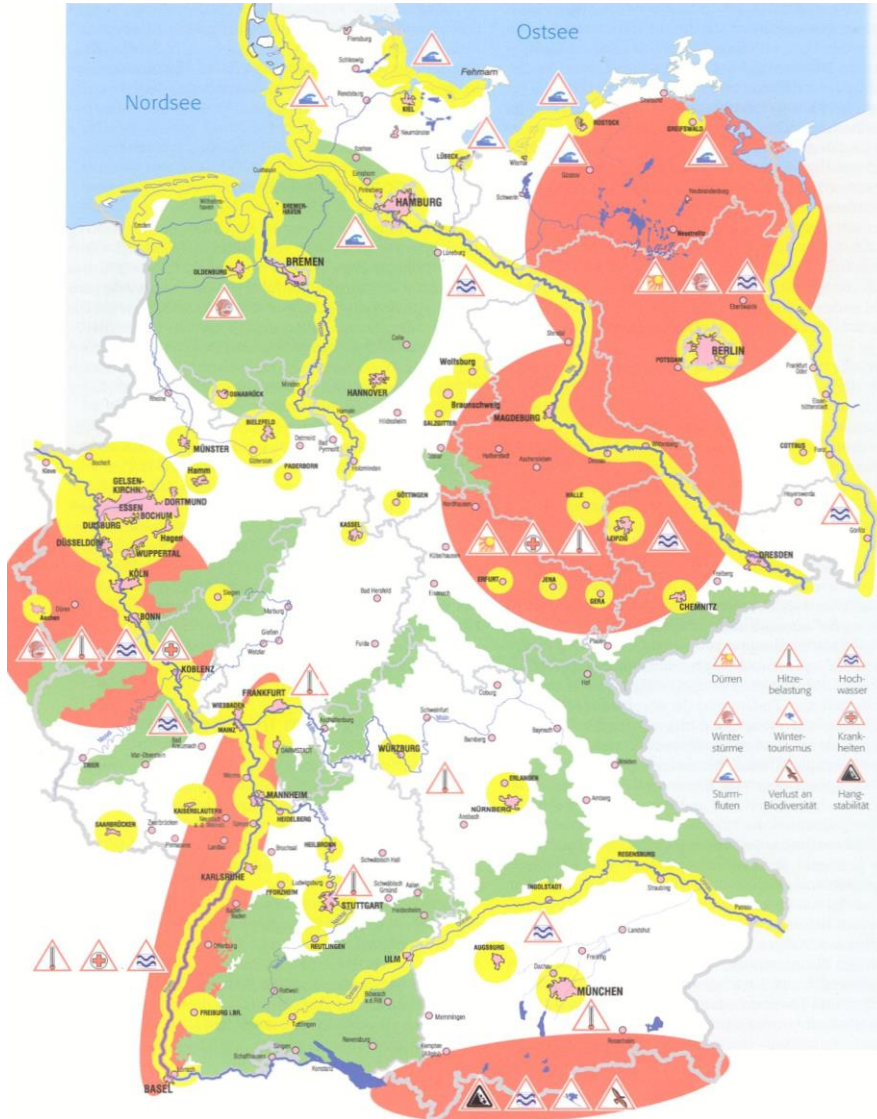



Precipitation decrease in 2100 [mm]

From
Umweltbundesamt
Künftige Klimaänderungen in Deutschland – Regionale
Projektionen für das 21. Jahrhundert
Hintergrundpapier
April 2006, aktualisiert im September 2006



Effects of Climate Change in Germany



 Regions of high vulnerability

- Droughts
- Heat waves
- Floods
- Winter storms
- Loss of biodiversity
- Landslides

From:

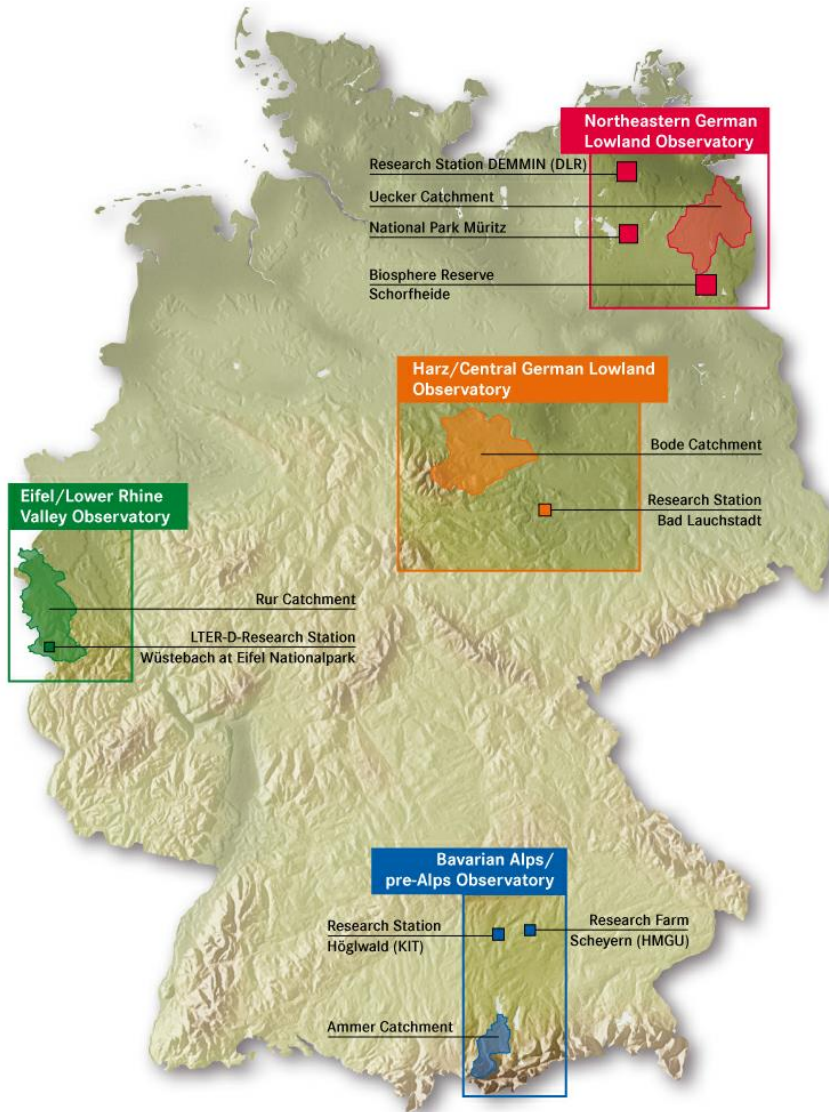
Rüdiger Glaser (2008)

Klimageschichte Mitteleuropas

1200 Jahre Wetter, Klima, Katastrophen



The TERENO Network



- **Northeastern German Lowland Observatory**

Coordination: GFZ

- **Harz / Central German Lowland Observatory**

Coordination: UFZ

- **Eifel / Lower Rhine Valley Observatory**

Coordination: FZJ

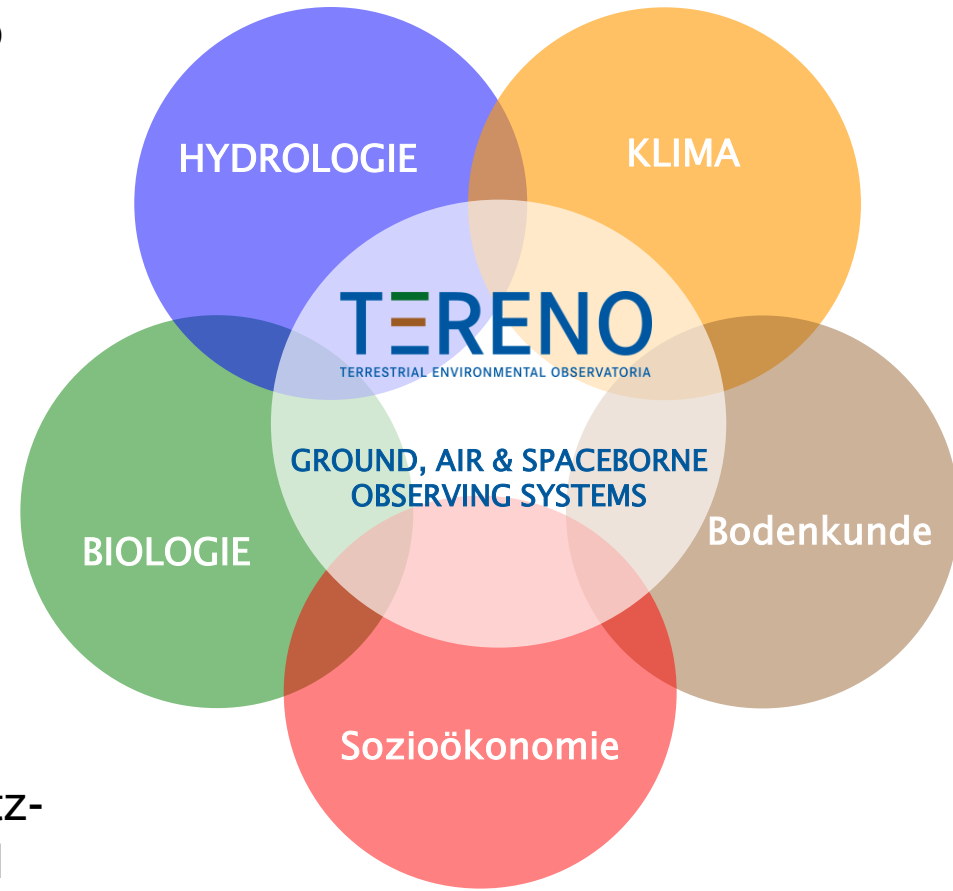
- **Bavarian Alps / pre-Alps Observatory**

Coordination: HMUG und KIT



The TERENO concept

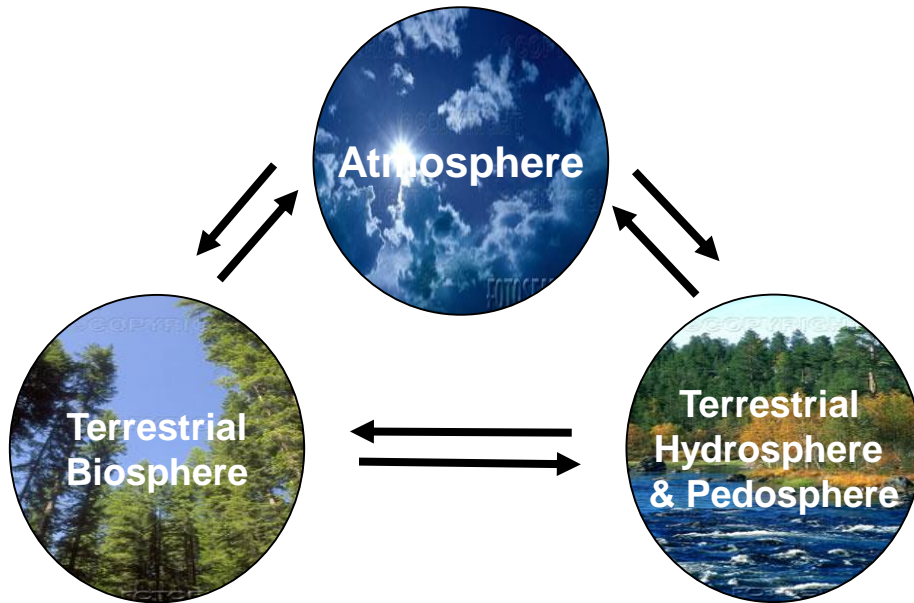
- To bring together scientists from different scientific communities and to integrate disciplines
- To exploit the availability of novel technologies and high performance computer facilities for terrestrial research
- To establish common measurement platforms as the basis for long term data sets
- To combine observation and experimentation
- To foster synergies between Helmholtz-centers and national and international research organizations



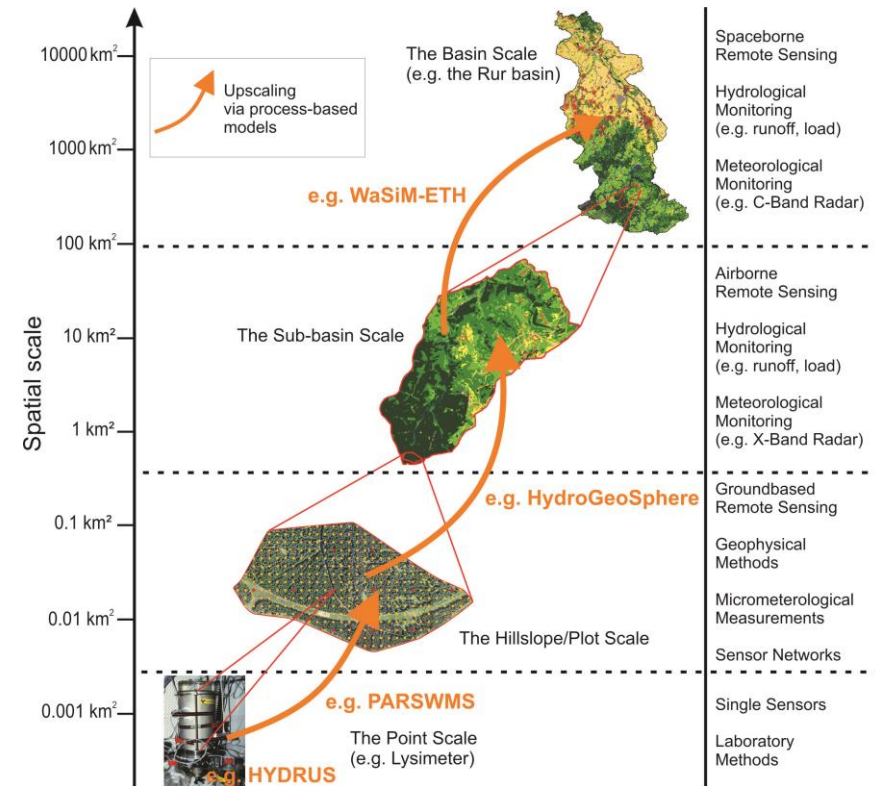


Research Goals

Investigate interactions and feedbacks between different compartments:

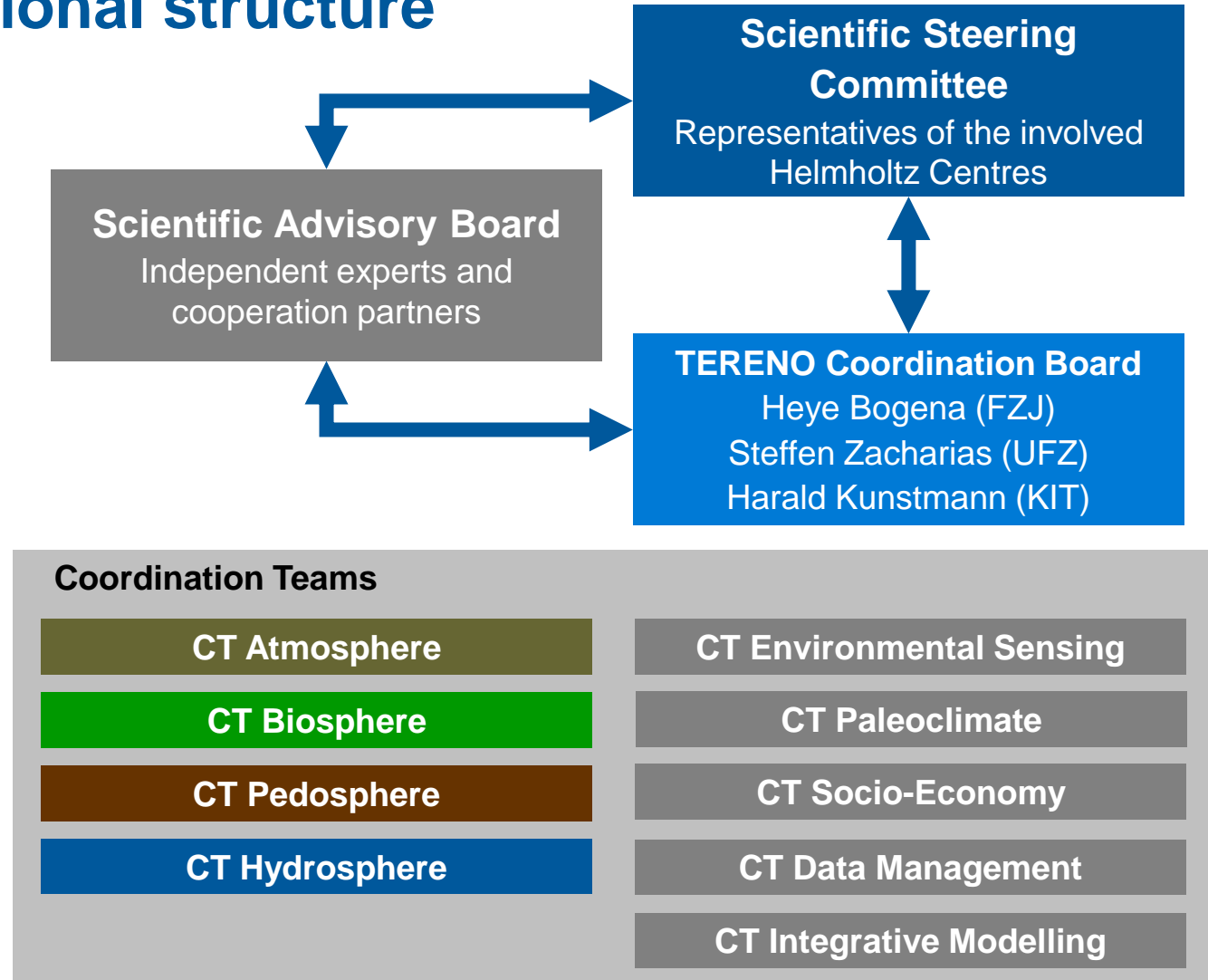


Bridging the gap between measurement, model and management:





Organizational structure





TERENO SoilCan

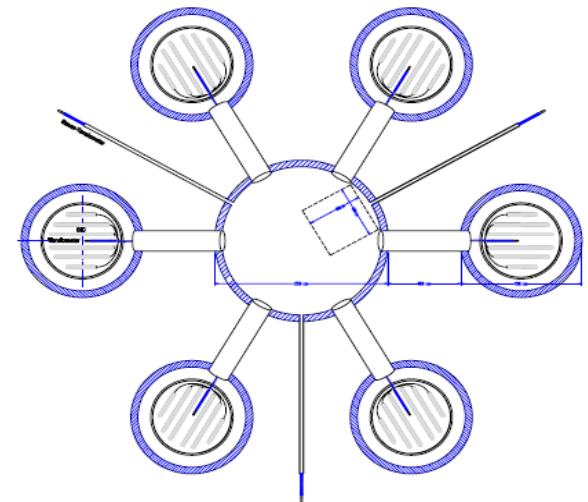
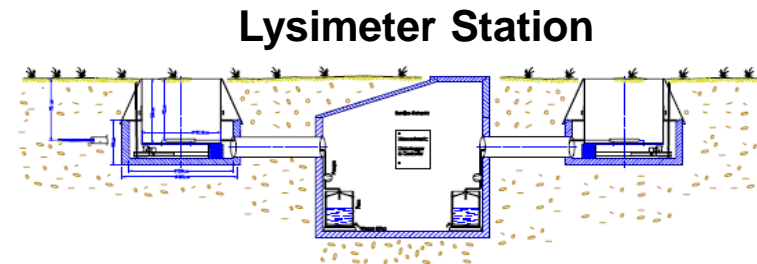
A Large-scale Climate-Feedback-Experiment

Central research question:

How do grassland ecosystems adapt to climate change?

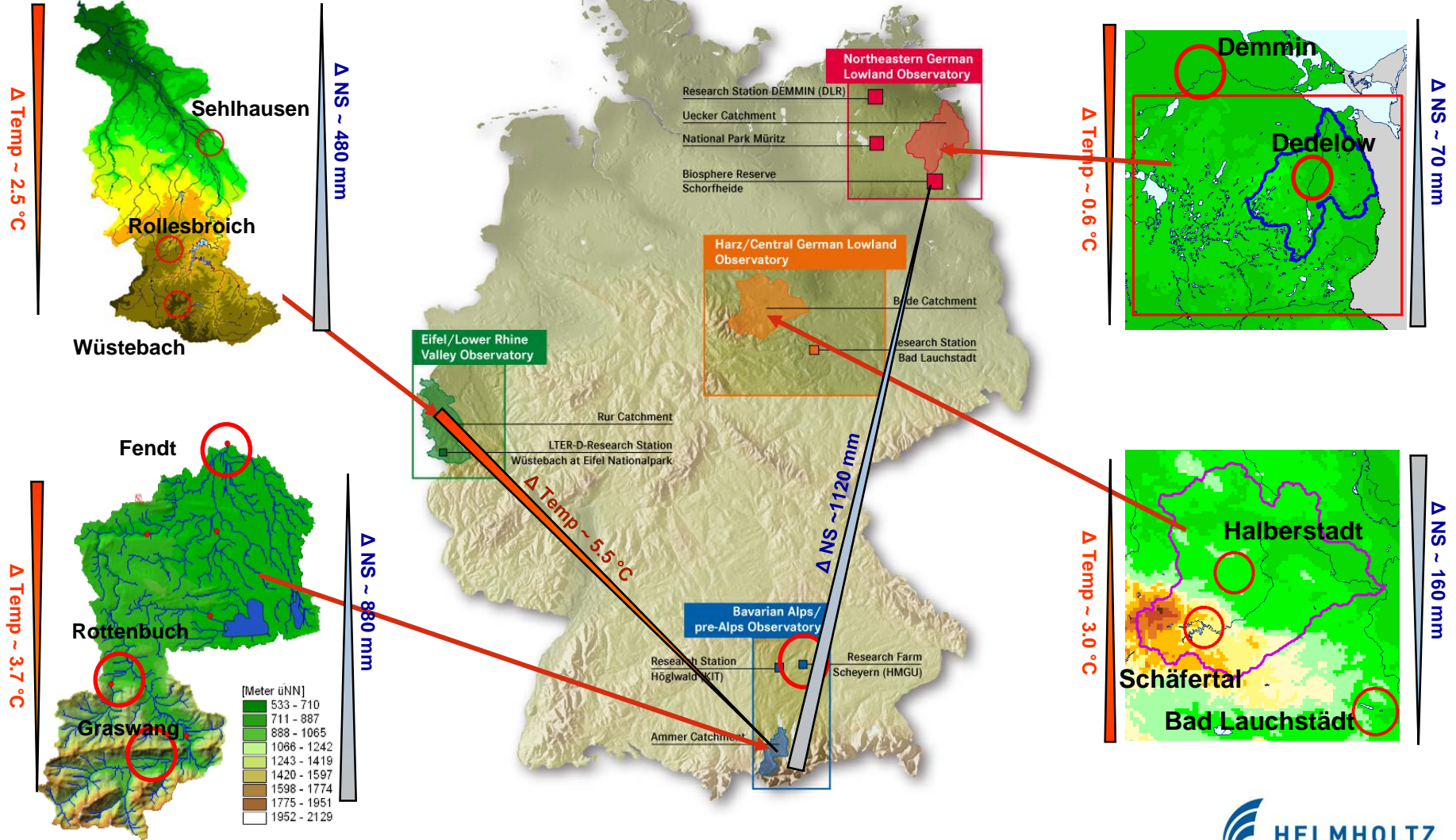
Approach:

- Grassland soil monoliths (lysimeters) transplanted along the natural gradient in temperature and precipitation
- Investigation of Climate Change effects on
 - C/N cycles
 - associated plant and microbial processes/populations/biodiversity
 - terrestrial hydrology
 - water quality





TERENO SoilCan Natural Climate Gradients:

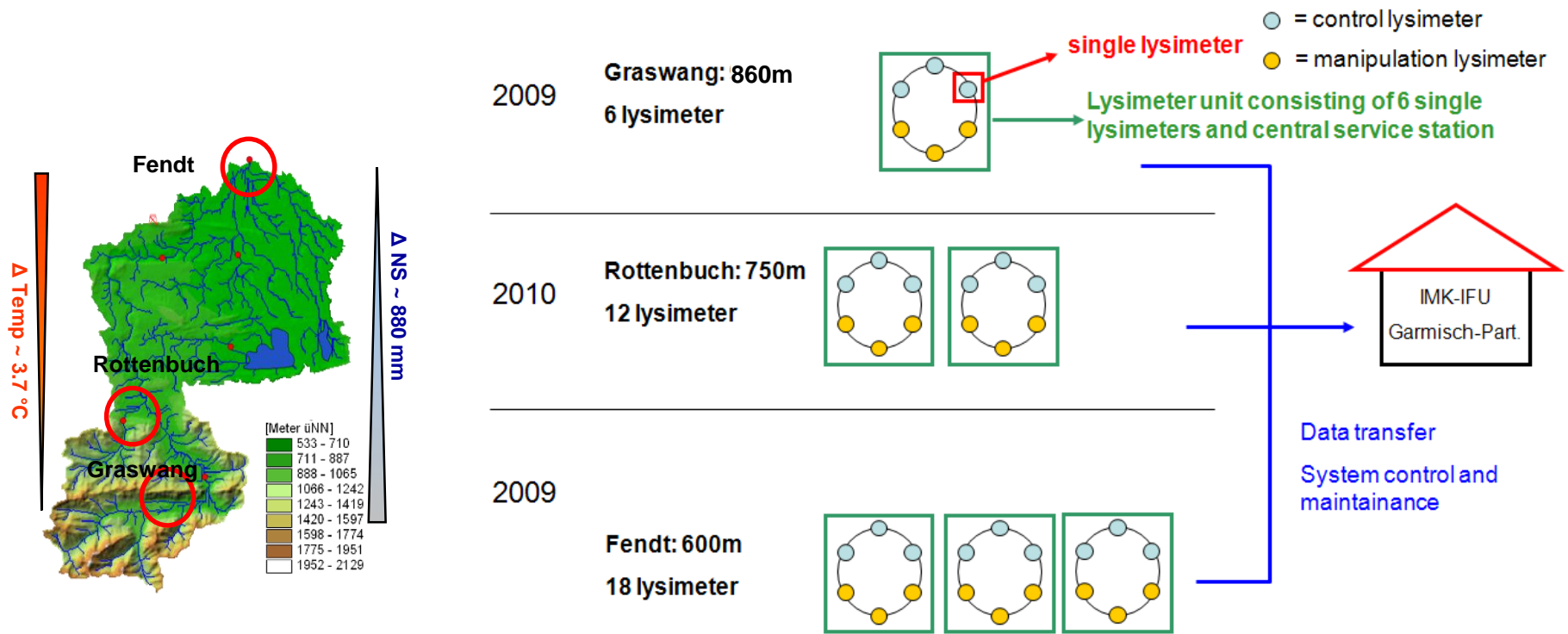




TERENO SoilCan

A Large-scale Climate-Feedback-Experiment

Lysimeter network at the Ammer catchment:





TERENO - ICOS

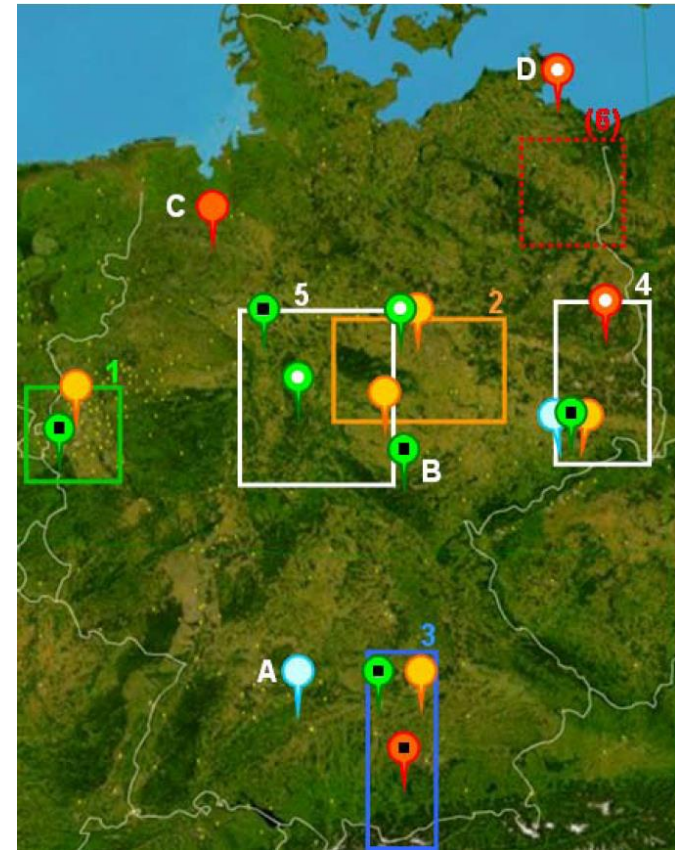


A European infrastructure dedicated to high precision monitoring of greenhouse gas fluxes



- ICOS is part of ESFRI, the European Strategy Forum on Research Infrastructures.
- ESFRI is a strategic instrument to develop the scientific integration of Europe and to strengthen its international outreach.
- ICOS mission: “To provide the long-term observations required to understand the present state and predict future behavior of the global carbon cycle and greenhouse gas emissions.”
- 5 EC-sites at TERENO-prealpine, -Harz, and –Eifel received additional funding from BMBF to expand instrumentation to include fluxes of CH₄ and N₂O and upgrade to ICOS standard
- TERENO is recognized by ICOS-D as primary candidates to receive long-term (staff) funding

German ICOS network:





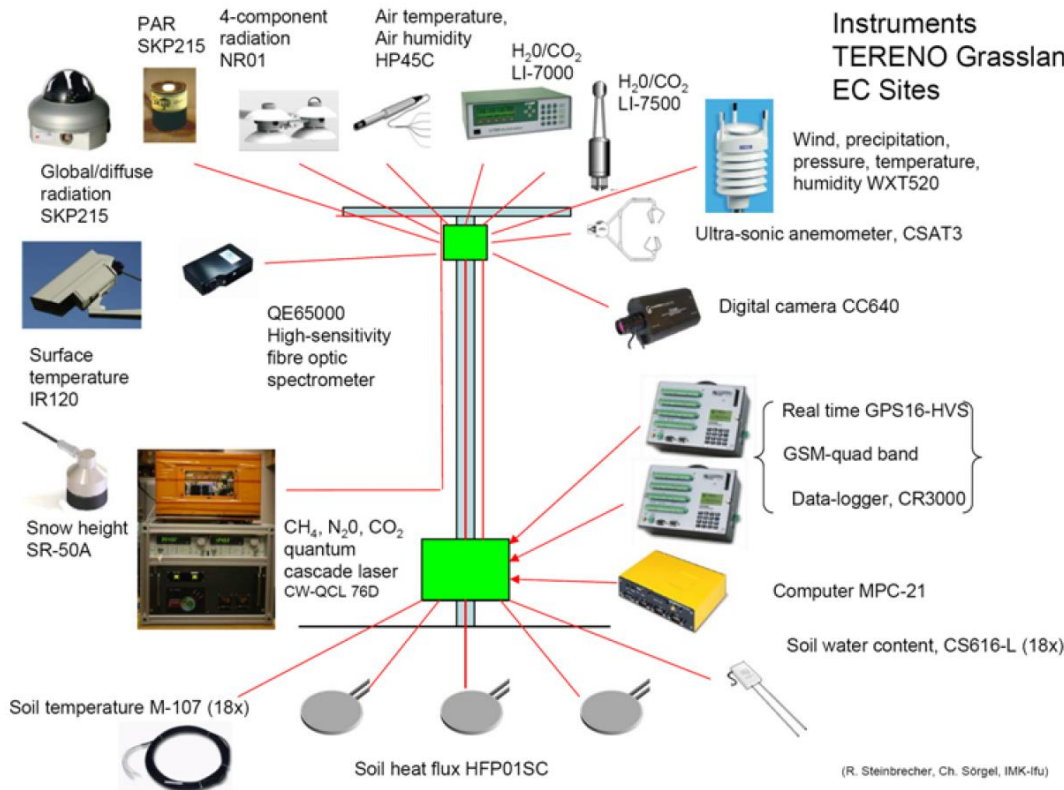
TERENO - ICOS



A European infrastructure dedicated to high precision monitoring of greenhouse gas fluxes



TERENO ICOS instrumentation:

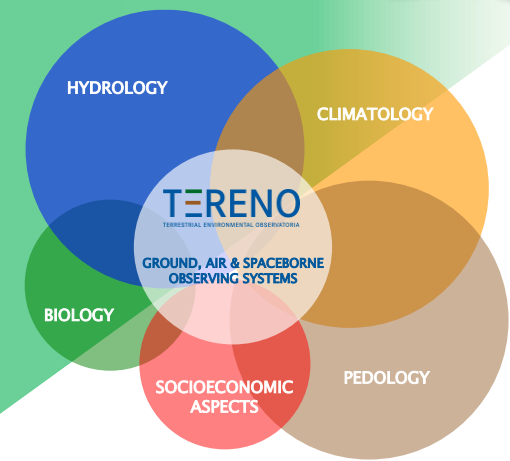
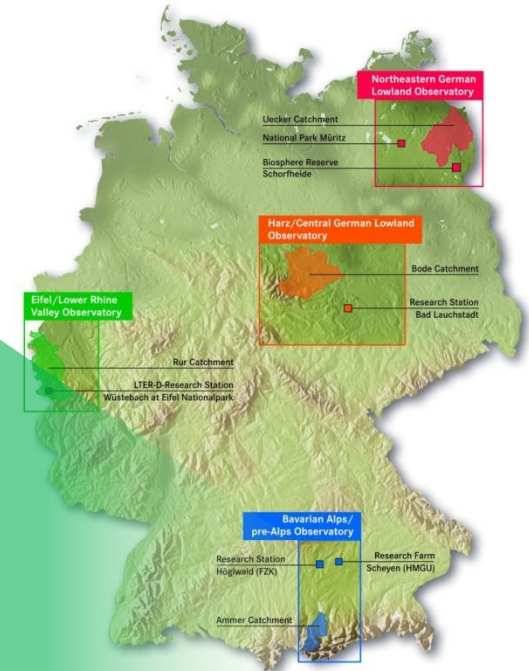
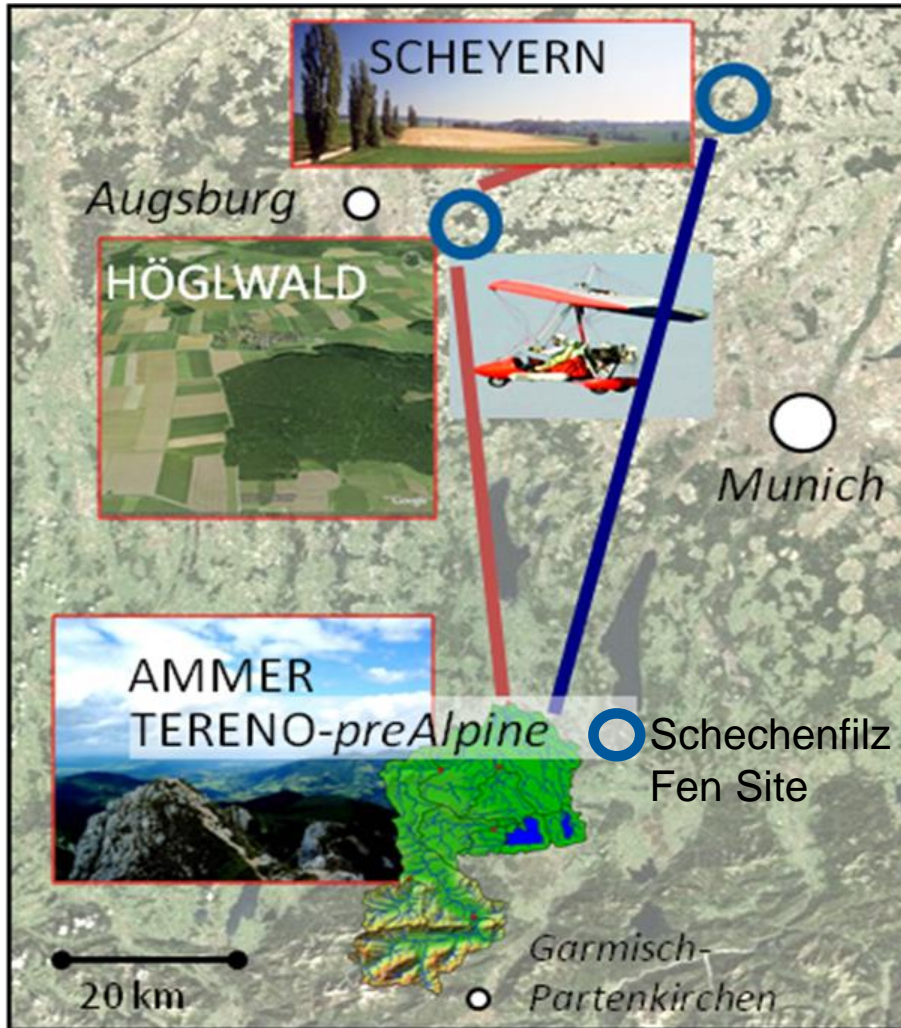


EC-Station at Grasswang:



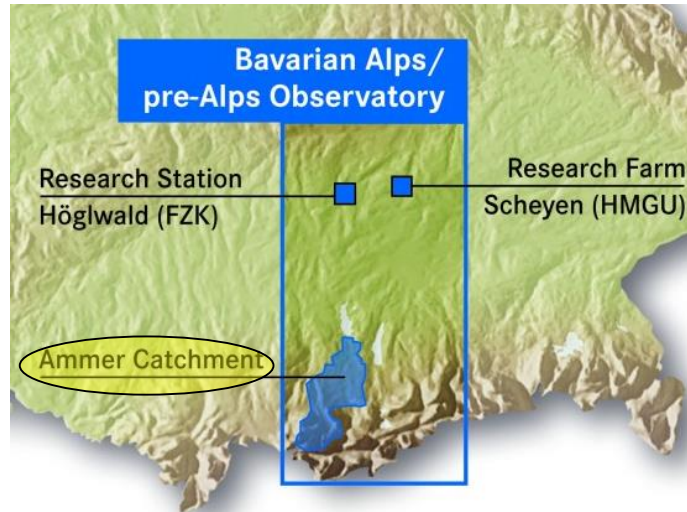


The Bavarian Prealpine Observatory





Ammer Catchment Observatory



- Area: ~710 km² (601 km² above Weilheim)
- Alpine and prealpine landscape with high spatial differentiation in geology and pedology
- Elevations: from 533 m.a.s.l. (Ammersee) to 2185m (Kreuzspitze)
- Two dominant landscape units: the prealpine hill country and moorland and the Swabian-Upper Bavarian foothills of the Alps.
- Dominant geology: lime-alpine zone (south), flysch zone (north)





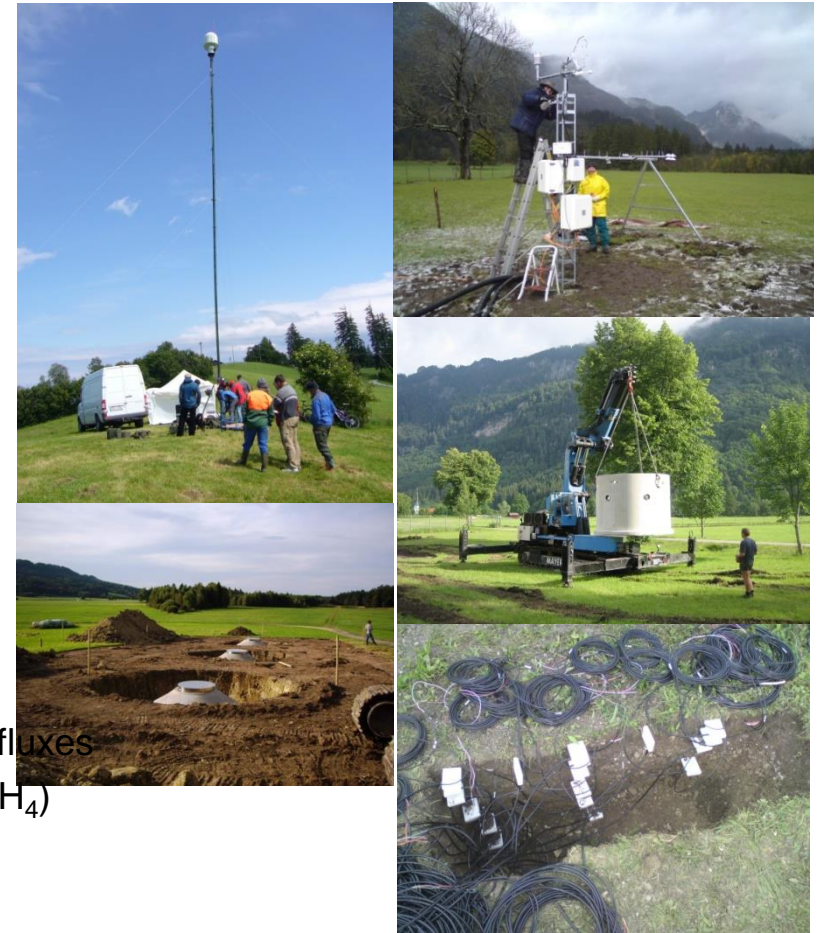
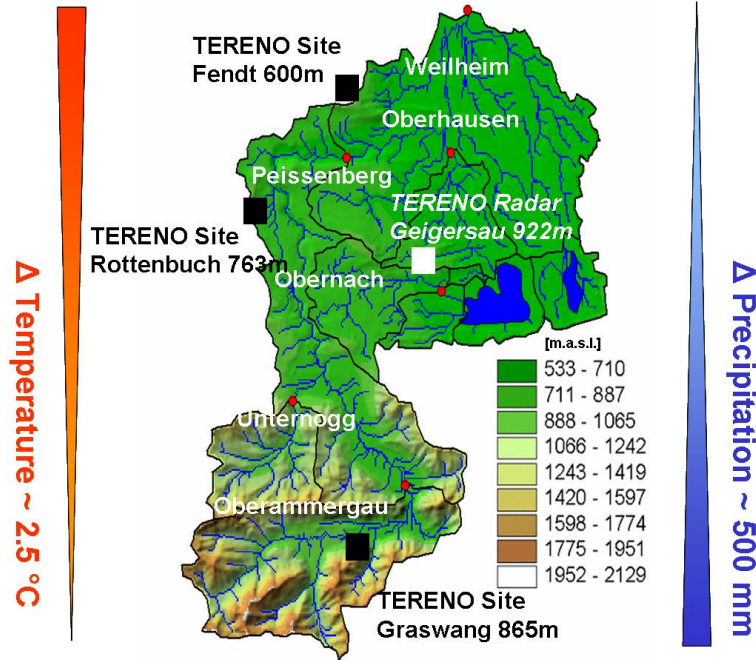
Impact of land use changes on agro-ecosystems

- Adapted and sustainable plant production systems in crop rotations of plants for food, feed and bioenergy
- Optimized energy and trace gas fluxes and balances
- Improved use of soil microbial functions for better plant nutrition and plant protection





TERENO Infrastructure at Ammer catchment



Graswang-, Rottenbuch-, Fendt Sites

3 EC towers: momentum, heat, H₂O, CO₂, N₂O, CH₄ fluxes
 36 Lysimeters: soil water balance, GHG (N₂O, CO₂, CH₄)

Geigersau Site

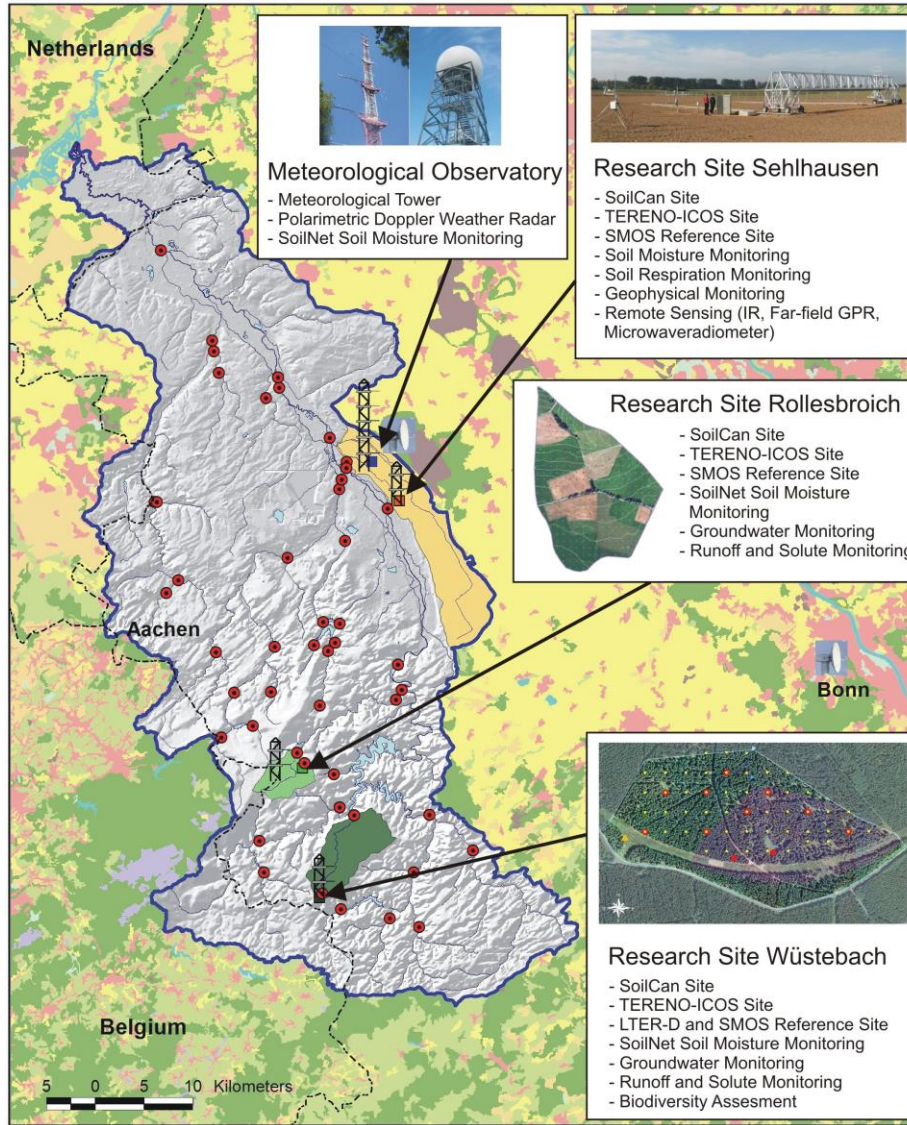
1 X-Band precipitation radar

Additional Sites

3 Climate stations (Mount Hörnle, Forsthaus Unternogg, Uffing)



Eifel / Lower Rhine Valley Observatory

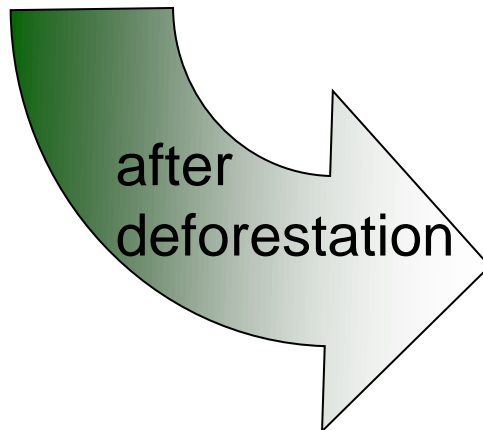
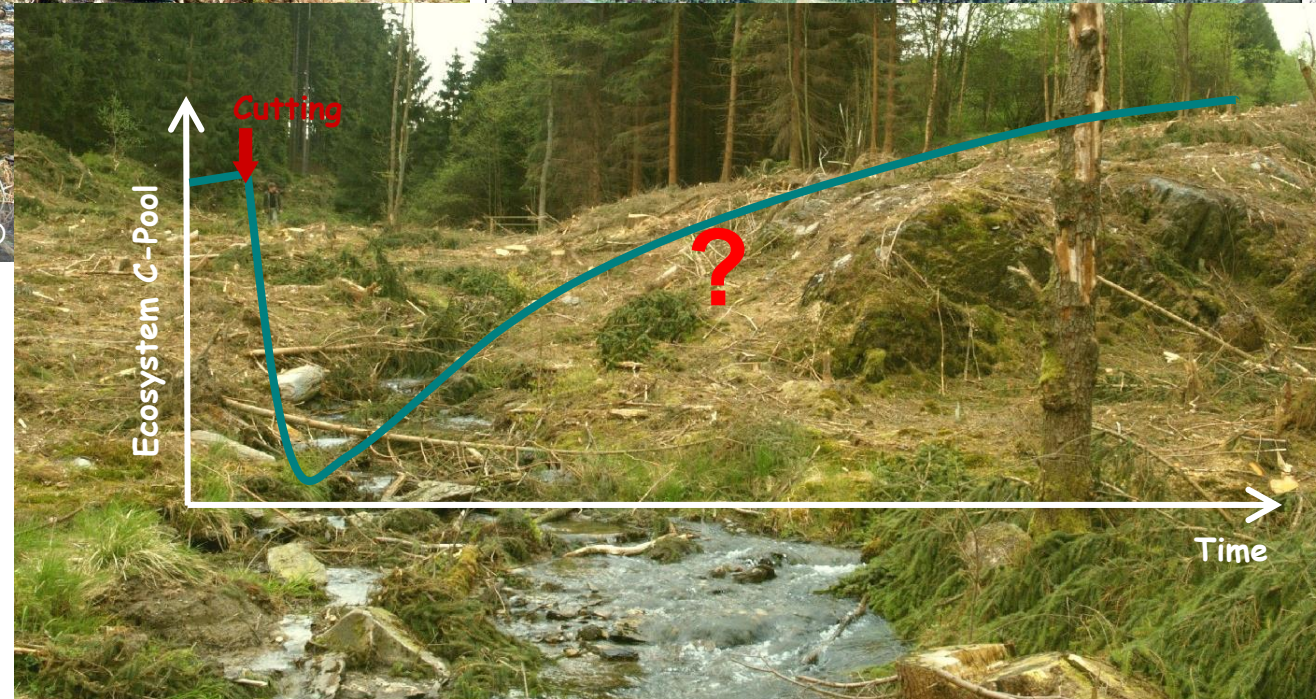
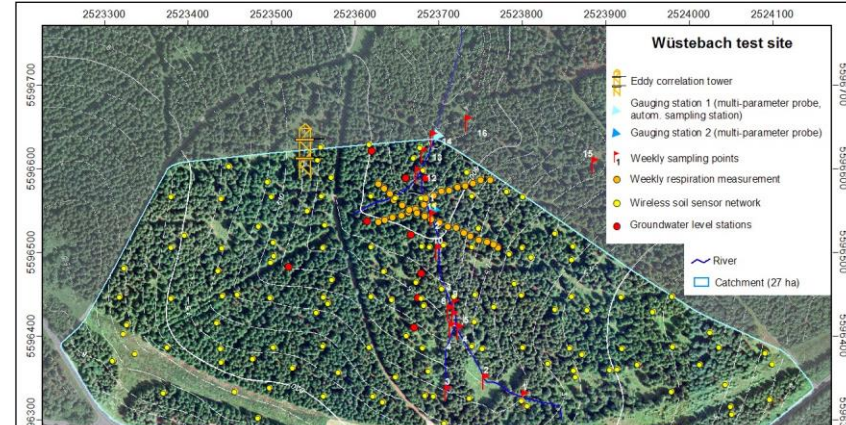


- Rur Hydrological Observatory
- Ellebach Subbasin
- Kall Subbasin
- Erkersruhr Subbasin
- Waterbodies
- Runoff gauging station
- Eddy flux tower
- Weather Radar





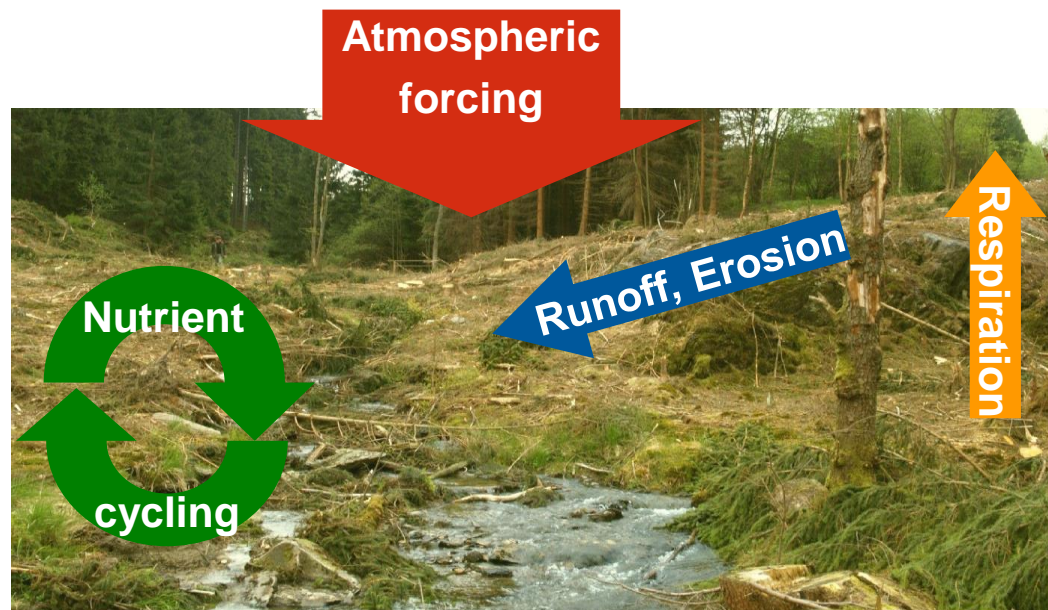
Research station Wüstebach





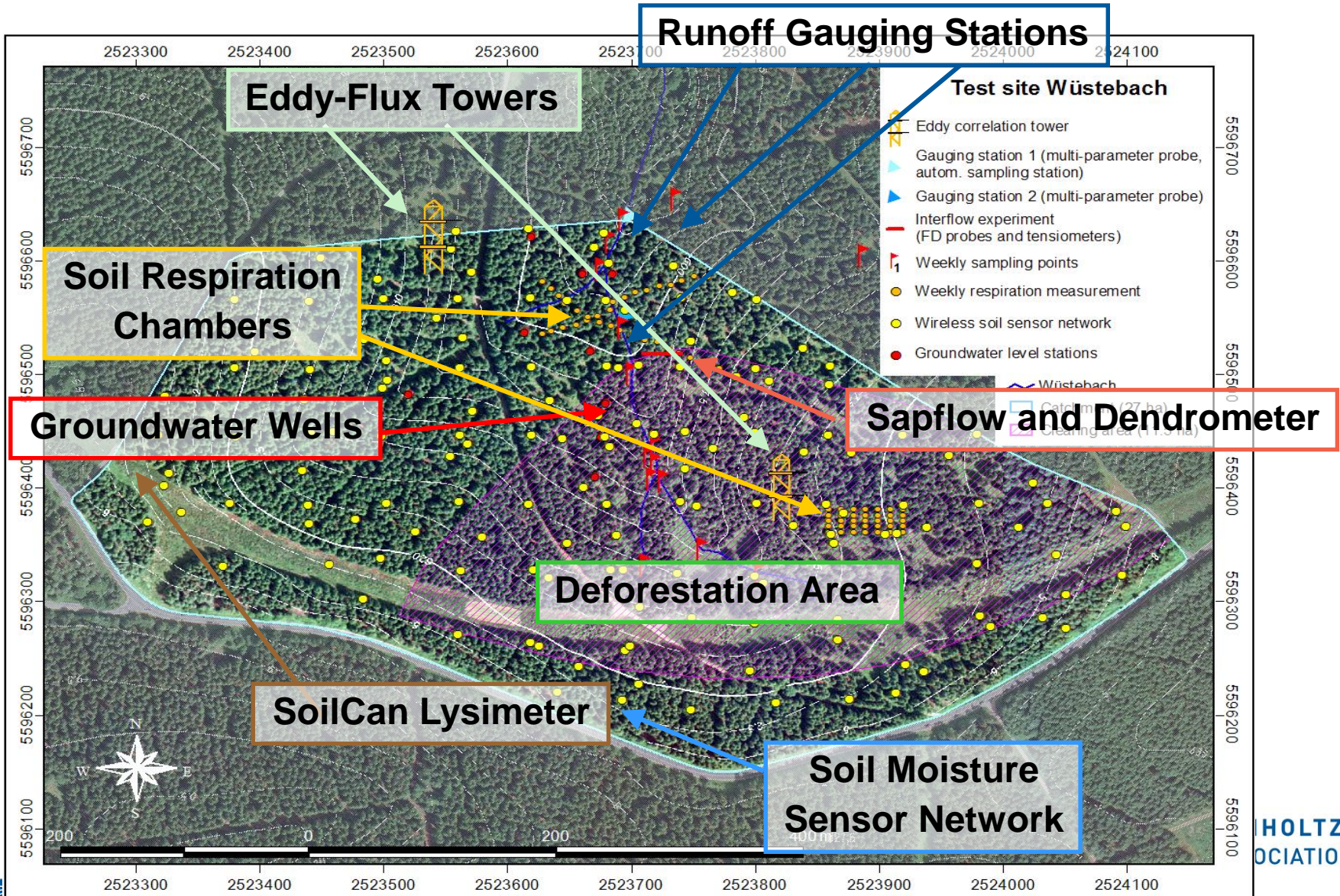
Hypotheses

- Long-term changes of the water balance with reduced water retention capacity, faster efflux with fast increasing and decreasing runoff peaks
- Larger energy-input by direct solar radiation resulting soil warming, enhanced biological activity of the soil and higher conversion rates
- Higher conversion rates of the litter layer, higher losses of the soil C-pools and change in biodiversity



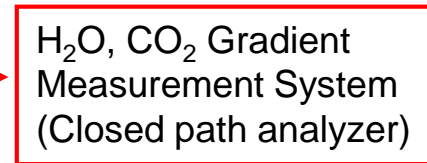
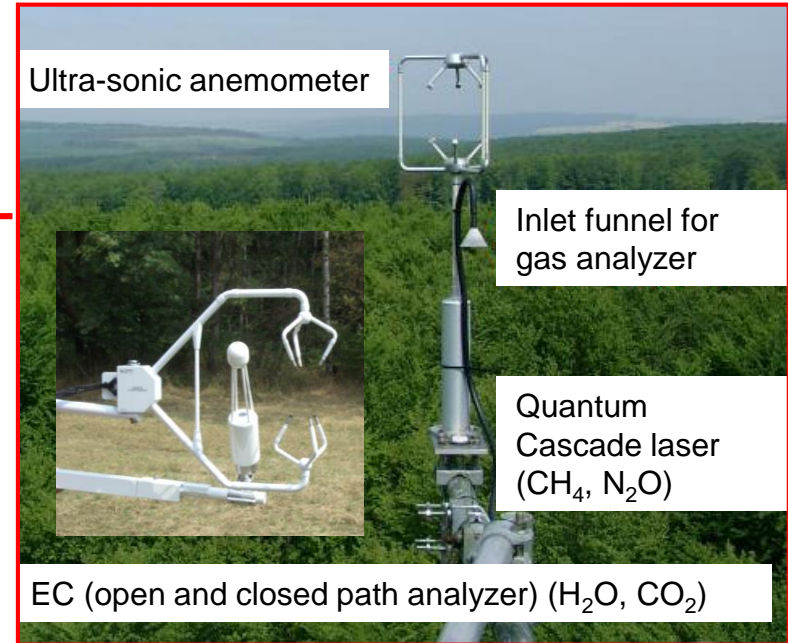
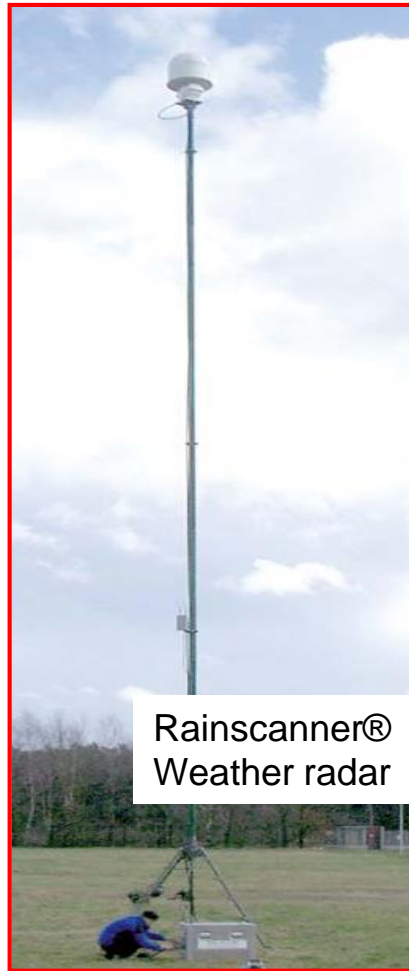


Instrumentation of the Wüstebach research station



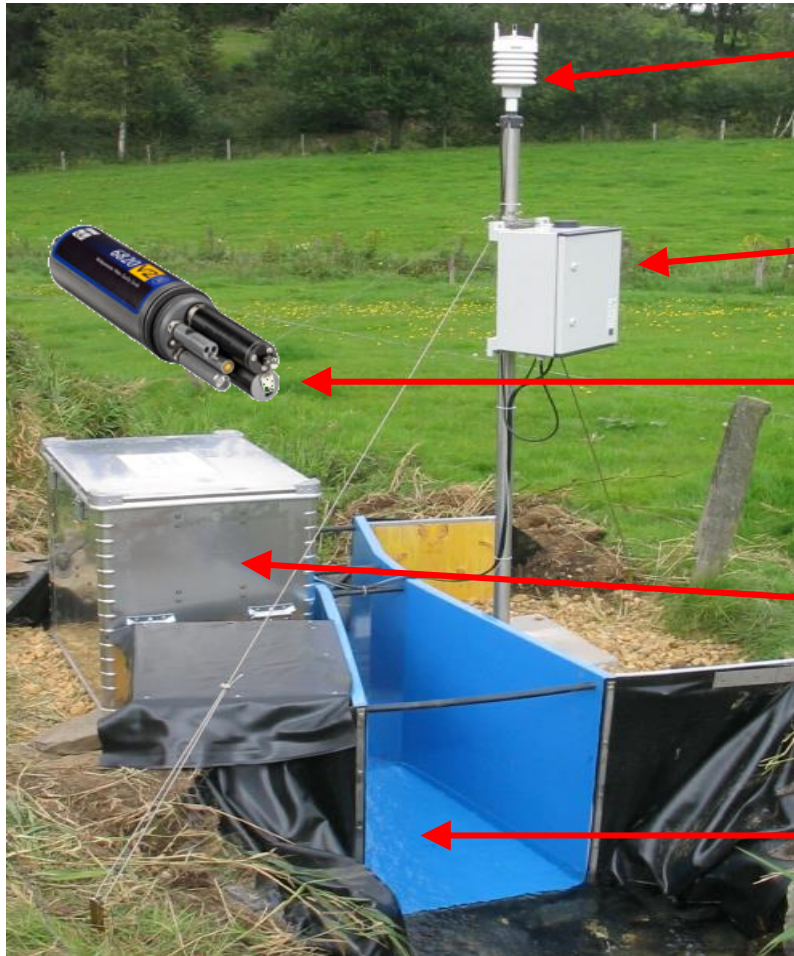


EC-tower at Wüstebach research station





Runoff gauging station at Rollesbroich research station



Meteorological sensor
(rainfall, temperature, air humidity, wind direction, wind velocity)

Data logger with remote transmission

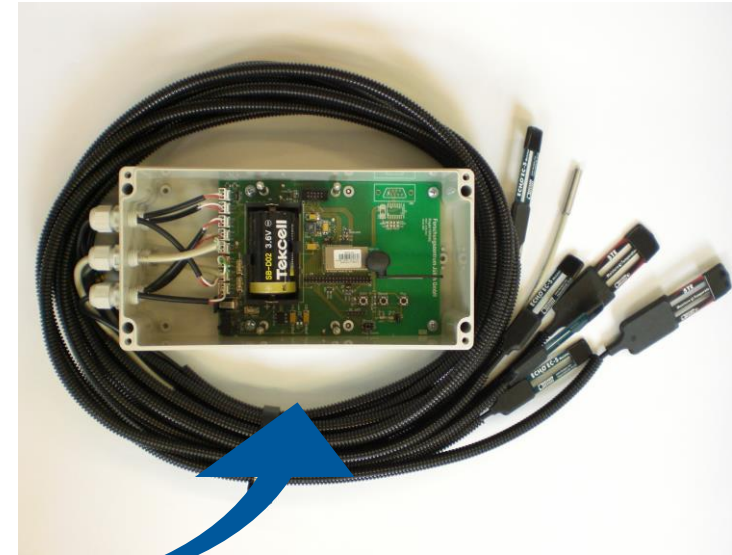
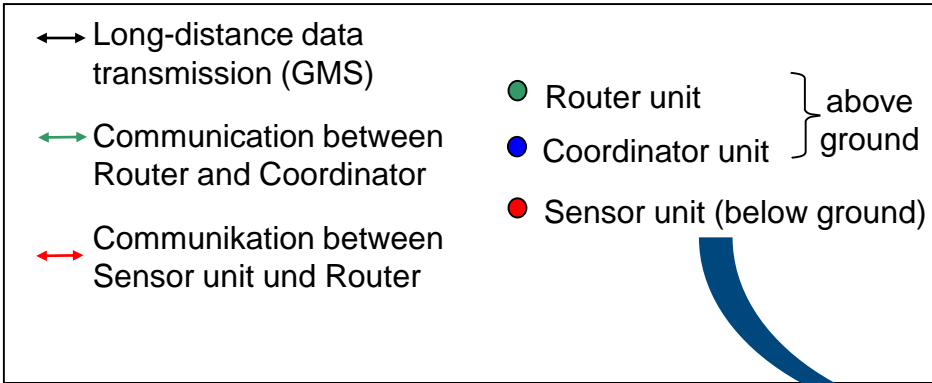
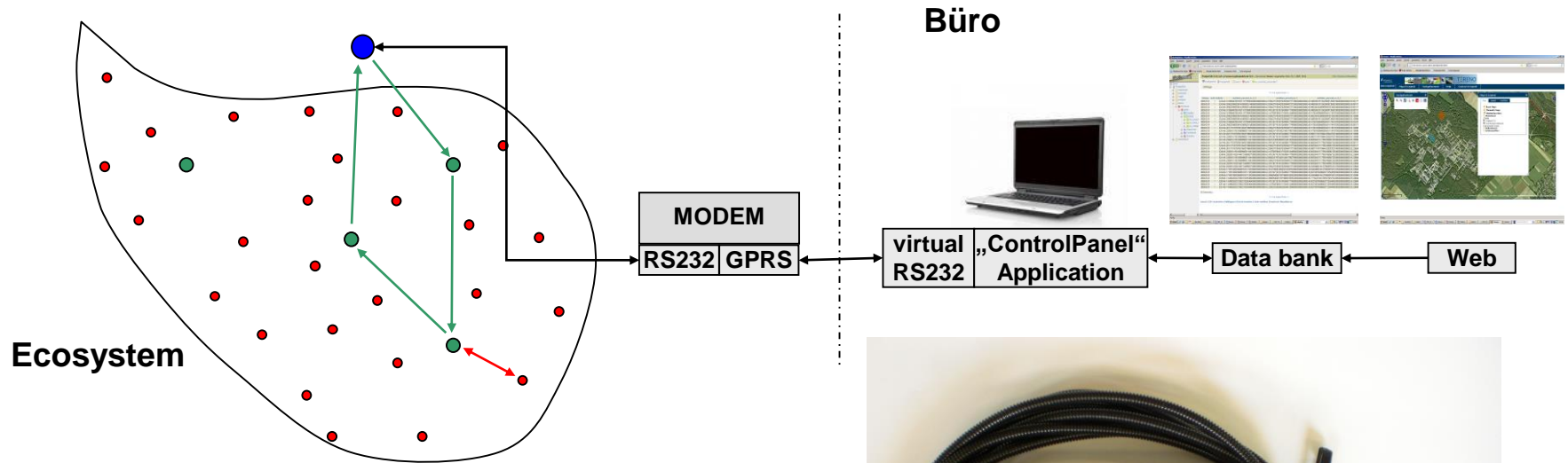
Multi parameter probe
(water temperature, electrical conductivity, pH, nitrate, chloride)

Automatic sampling system

Venturi-Gauging Weir
(water level, drainage volume)

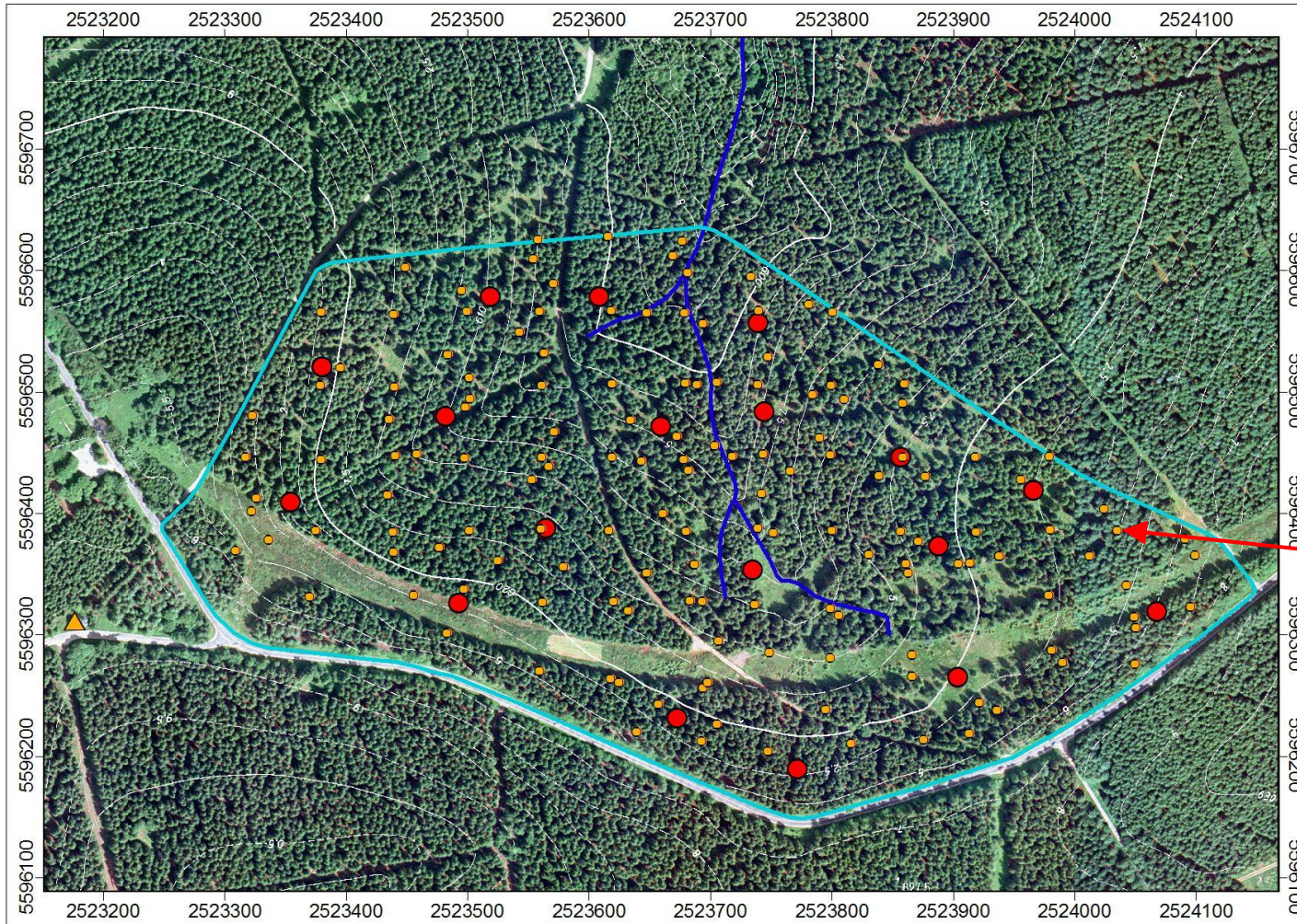


Wireless soil moisture sensor network SoilNet

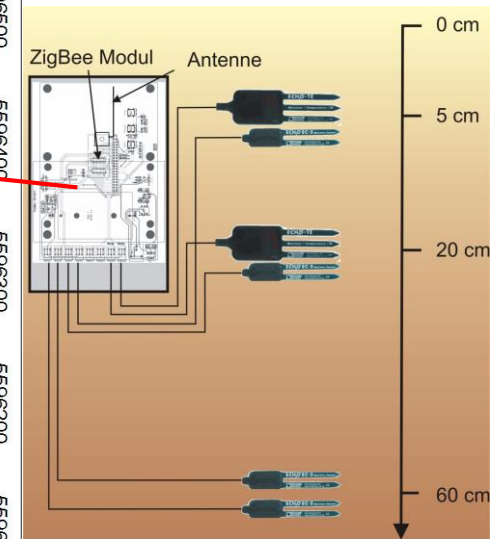




SoilNet instrumentation at Wüstebach research



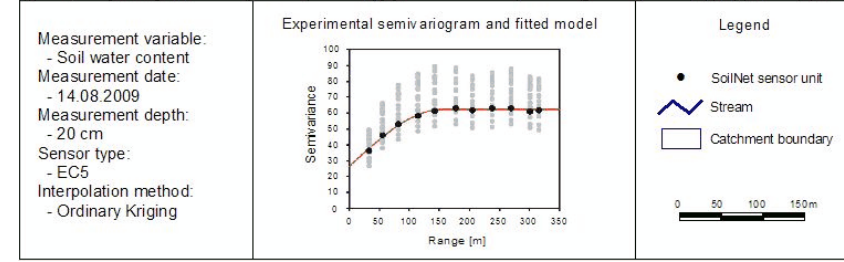
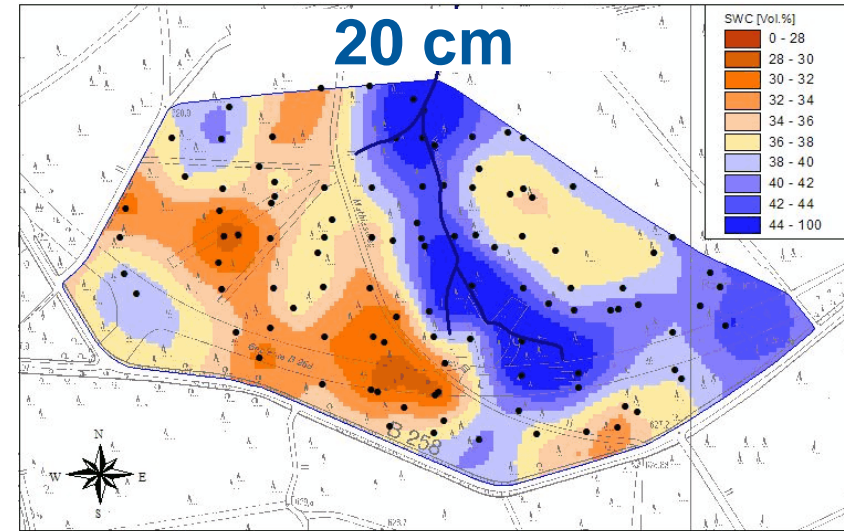
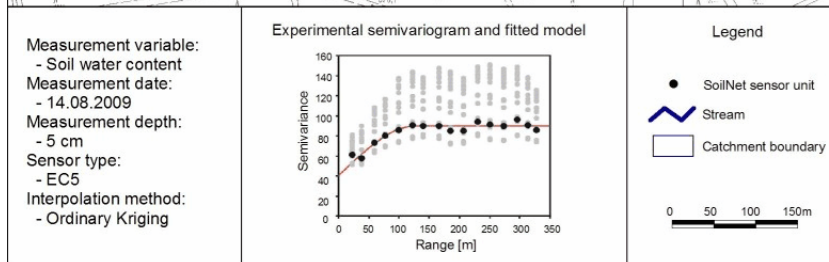
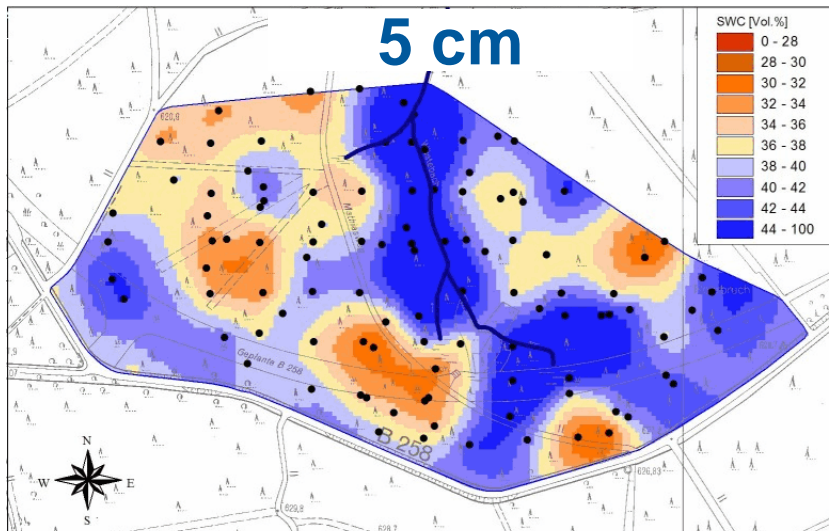
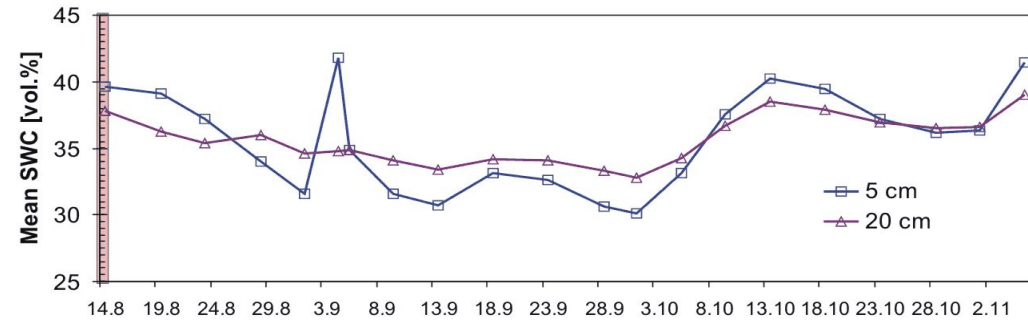
- 150 Sensor units
- 18 Router units
- 900 Soil water content sensors
- 300 Temperature sensors





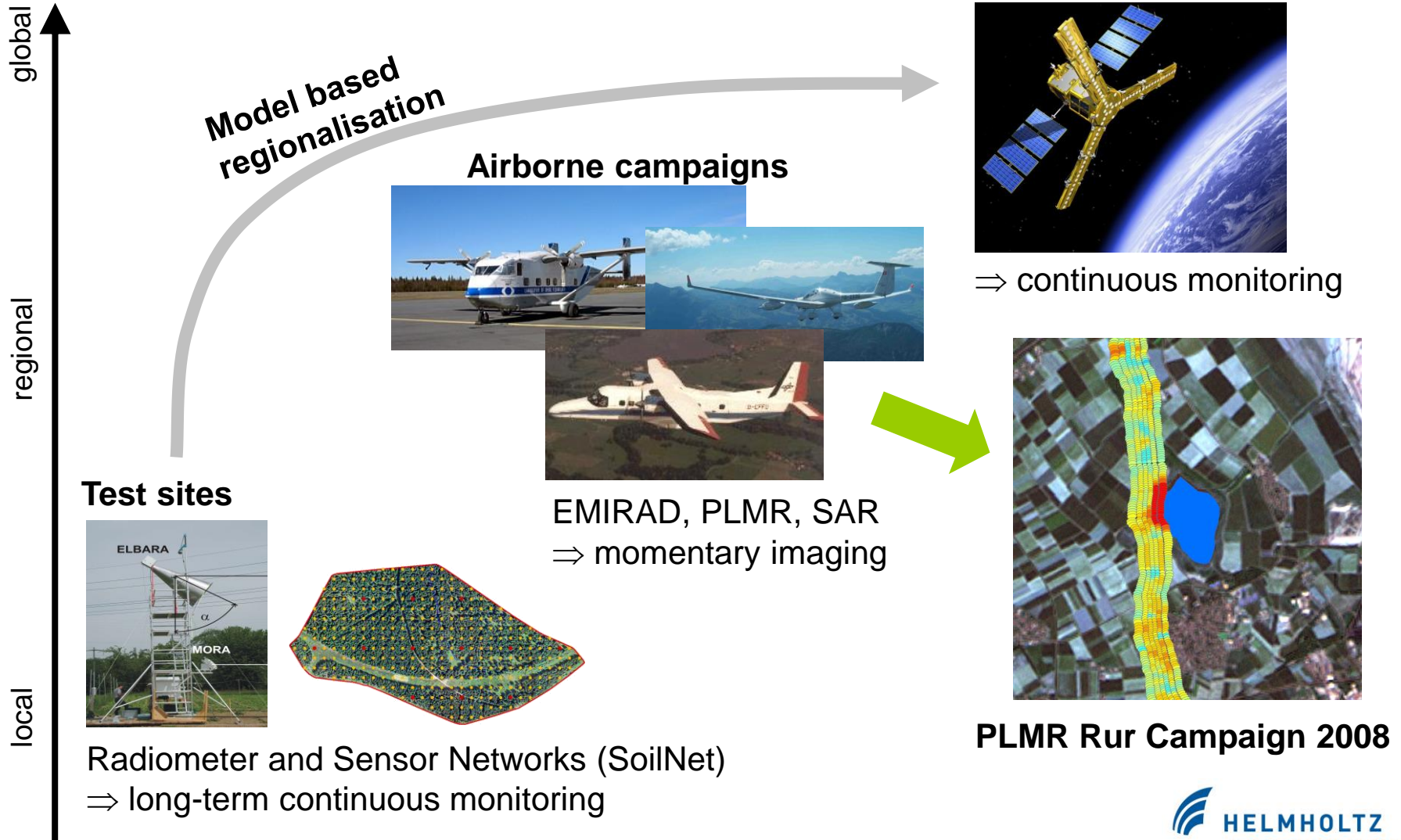
Time series of soil moisture pattern

Mean soil water contents from August to November 2009:





From the local to the regional Scale...





Environmental Sensing with Multi-Sensors

Example of an airborne campaign:

Campaign Preparation:

- Flight planning
- Testsite location

Campaign Execution:

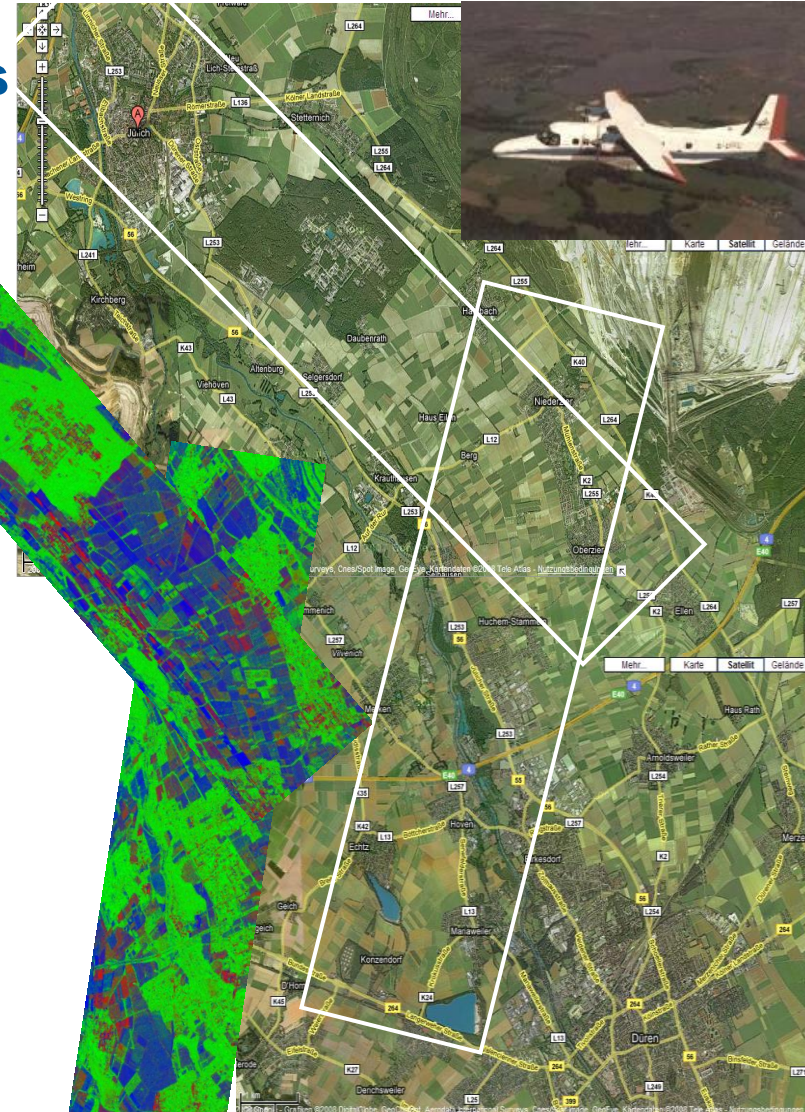
- Calibration instrument
- Measurement campaign

Data Processing:

- Flight position processing (DGPS)
- Raw data processing

Parameter Estimation:

- Algorithms for environ. parameter estimation
- Validation with ground measurements



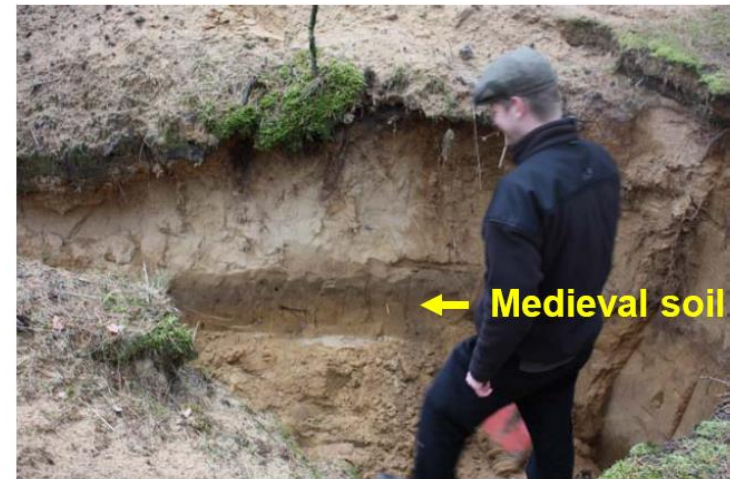
SAR Data from the SARTEO campaign 2008 over the Rur catchment



Northeastern Lowland Observatory



landuse: from intensive agriculture to natural park (quasi-natural)

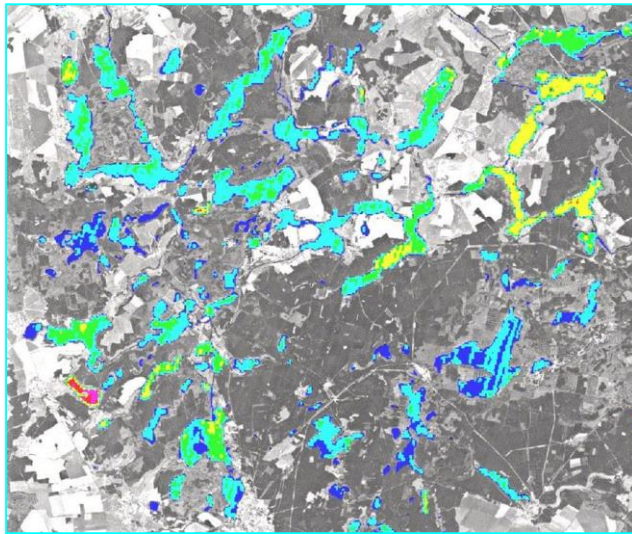




Combination of process observations with geoarchives

- Region impacts of Global Change on near-natural terrestrial ecosystems and landscape in space and time
- Integrated system analysis of climate- and landscape development/process understanding
- Combination of real-time process observations (e.g. soil moisture, hydrology, vegetation) and evaluation of geoarchives (seaborne, colluvials, peats, soils)

Remote Sensing



Field observation

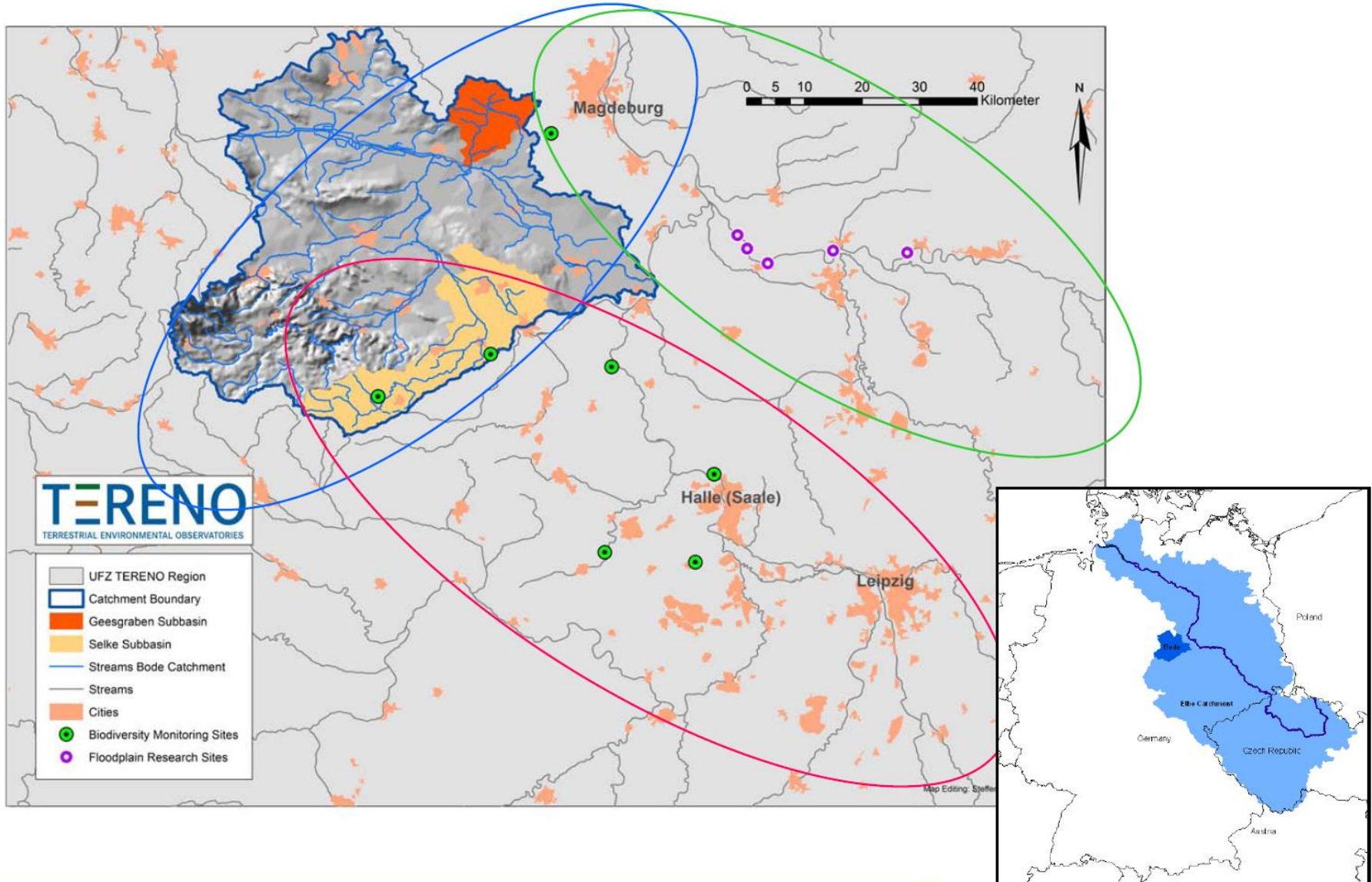


Geoarchive





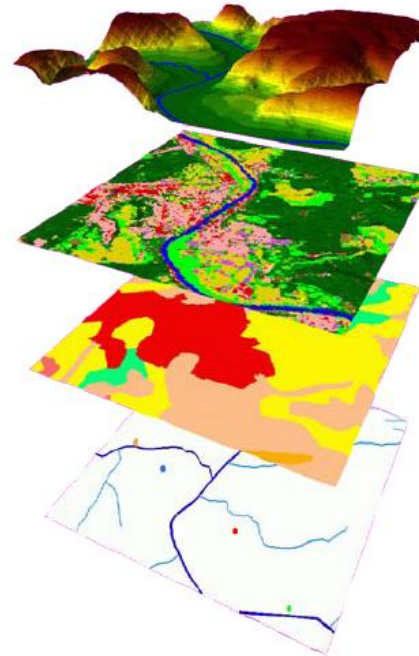
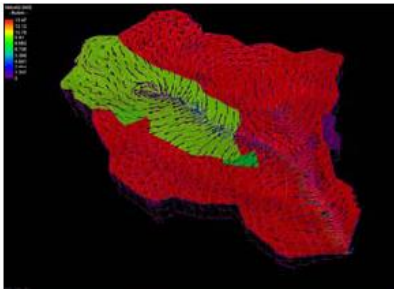
Harz/Central German Lowland Observatory





Conceptual approach

Example: Solute Flux management at catchment scale



Process studies in high intensity measurement areas

- small subcatchments
- groundwater transects
- Stream mapping locations

Identification of dominant processes and development of effective descriptions guided by the structure of the system

Stochastic representation of biochemical transformations (streamline approach)

Estimation of residence time distributions for mesoscale catchments via pedotransfer functions and geophysical proxies

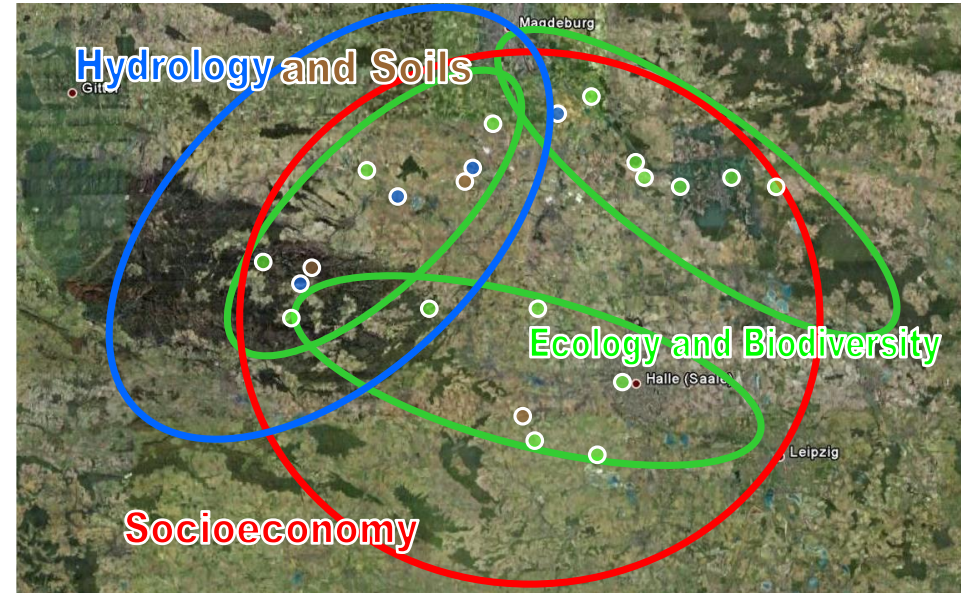
Process-oriented transport simulations based on distributed hydrological model



Integrating different disciplines in TERENO

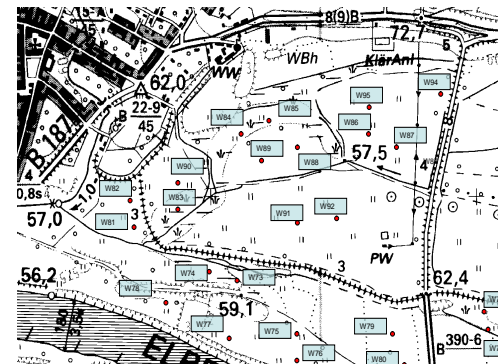
E.g. Floodplain habitats - Assessment targets

- Soil, hydrology, matter fluxes
- Organisms groups
 - Vegetation primary producers
 - Carabides as predators important indicators for land use intensity and hydrology quality
 - Molluscs important indicators for hydrology and connectivity
 - Mosquitoes possible disease vectors
 - Amphibians highly mobile, sensitive to landscape context
- Habitat mapping by remote sensing and fieldwork



Example: Floodplain Testsite Roßlauer Oberluch

Stratified random study design (monitoring plots covering flood channels, semi-natural wet grassland and mesophilic grassland)



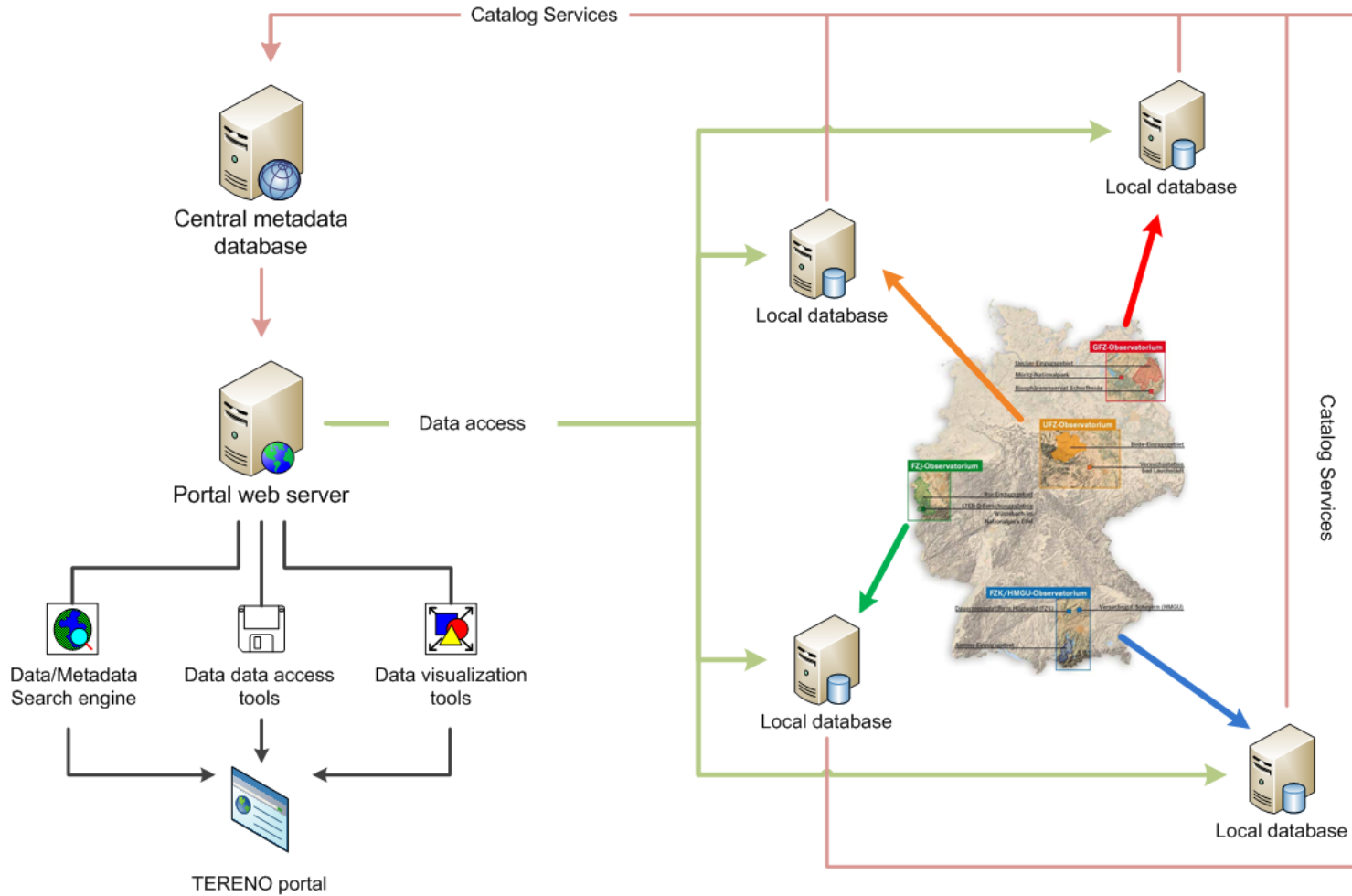


TERENO Data management

- Data storage and archiving
- Intellectual property rights and TERENO data policy
- Control of data utilization within TERENO and data dissemination to third parties
- Implementation of a web based data bank and data visualization tool for the presentation of research results
- Simple data allocation to a broad scientific community

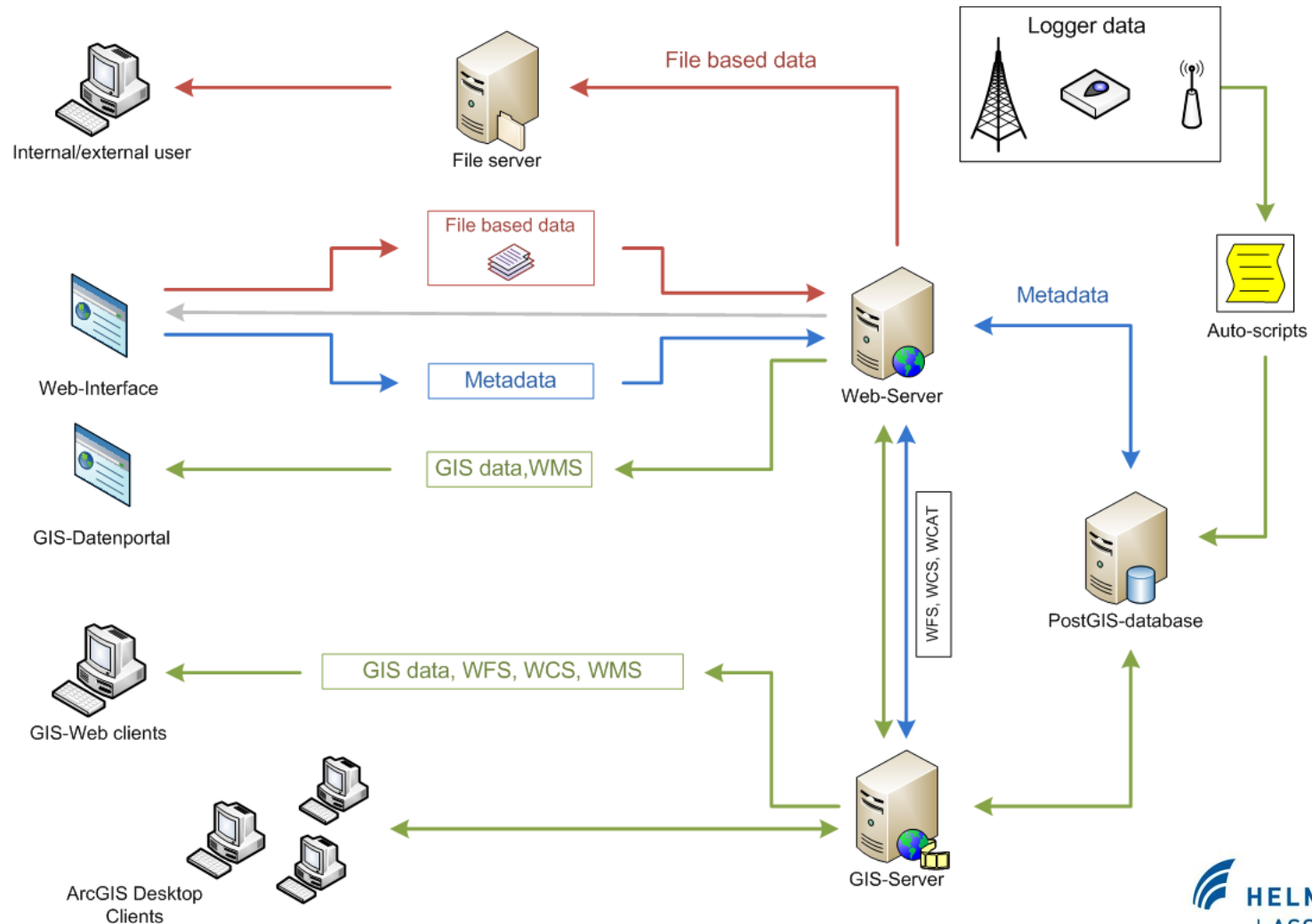


TERENO management concept





Locale TERENO Data bank structure





Pilot projects

Three pilot projects already established to develop and test:

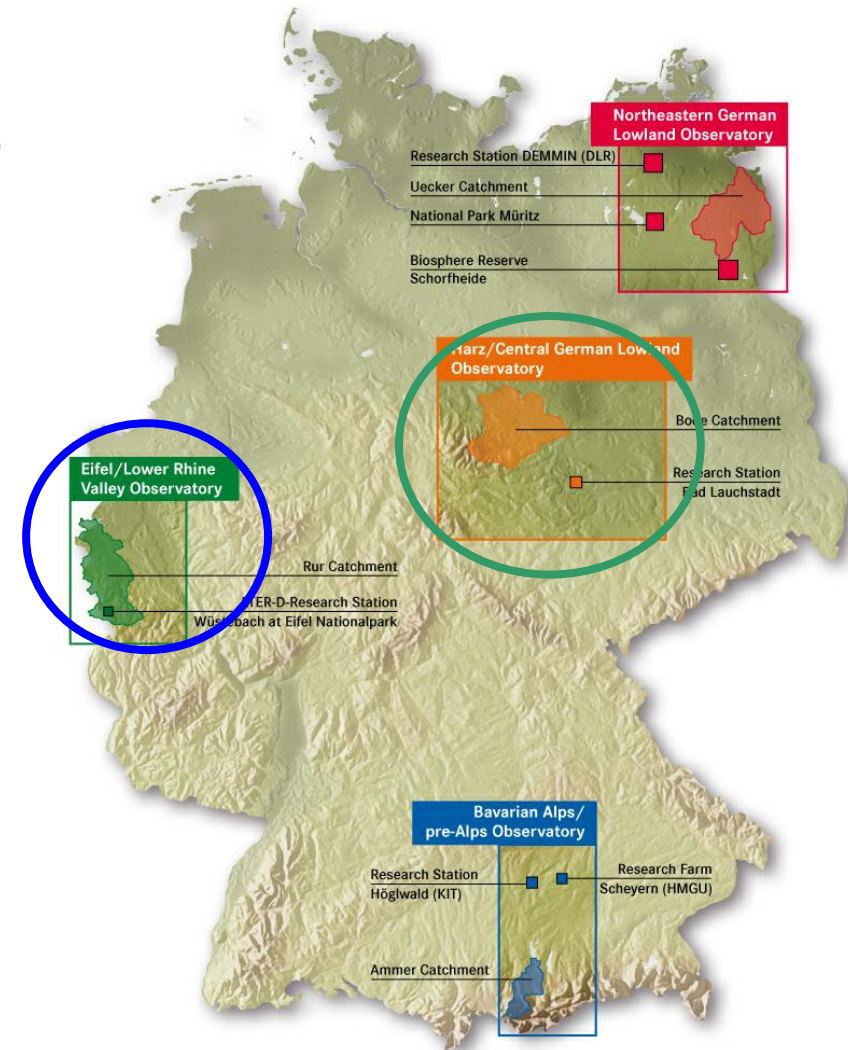
- Local data infrastructure for meteorological, hydrological and pedological data

(FZJ – Eifel / Lower Rhine Valley Observatory)

- Local data infrastructure for biodiversity data

(UFZ – Harz / Central German Lowland Observatory)

- Data communication and data exchange (all observatories, coordination FZJ)



TERENO Data portal

TERENO - Dataportal

Navigationtools

Maps & Legend

- Base Maps
- Thematic Maps
- Monitoring Sites
 - Wüstebach
 - Runoff Gauging Station
 - SoilNet Router
 - SoilNet Topology
 - SoilNet Sensor Nodes
 - Groundwater Wells
 - Climate Station
 - Soil Moisture Network
 - Wuestebach Catchment
 - Interpolated Values
 - FZJ Testsite
 - Rollesbroich
 - Schöneseiffen

TERENO - Dataportal

Please select your field of investigation:
Wüstebach

Please select an attribute for raster interpolation:
moisture_percent_ec_5_1

Please select interpolation method:
IDW

Please select aggregation method:
Averaged value

Please select grid resolution [m]:
2

Please select the time period to visualize:
Start: 16-10-2009 14:00
End: 16-7-2009 16:00

... create raster

TERENO - Dataportal

Please select gauging station:
Wuestebach

Please select type of precipitation: acc. precip.

Please select attribute for rendering your chart:
discharge [l/sec]

Please select the time period to visualize:
Start: 16-1-2009 14:00
End: 16-7-2009 16:00

Graph visualisation: width(px): 600 height(px): 400

NAME	COLOR	LINE WIDTH	DASHED?	MIN Y-AXIS	MAX Y-AXIS
lsec	Black	1.2	<input type="checkbox"/>		
us	Red	1.2	<input type="checkbox"/>		

... create graph

Übertrage Daten von tereno.icg.kfa-juelich.de...



TERENO Vision and Challenge

Prediction of terrestrial processes

**Multi-scale Observation
using non-invasive
technologies**

SMOS



SAR



Weather-Radar



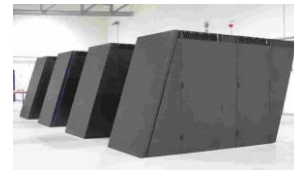
Radio-meter



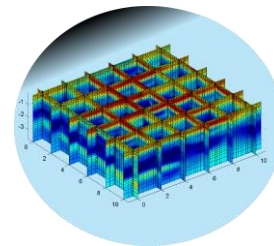
EM



**Data Fusion
Upscaling**



Super Computing



**Data management
Visualization**



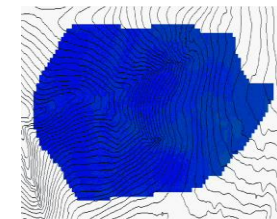
**Data assimilation
Coupled Modeling**

Terrestrial Processes

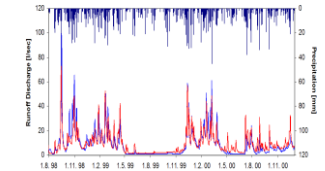
Evapotranspiration



Soil moisture



Runoff





Thanks a lot for your attention!

For further information please visit our homepage:
www.tereno.net

