TERENO
A network of terrestrial environmental observatories in Germany

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Motivation for TERENO: Global Change

- Land degradation and loss of agricultural land
- Loss of biodiversity
- Decline of water quantity and quality
- Climate change
- Loss of ecosystem functions

World population development from 1950 to 2050:

- 1960: 3 bn
- 2050: 9 bn

Soil, water, air and vegetation
Climate Change in Germany


Network of TERENO Observatories
Budget: ~20 Mio. €
Start: 2008
TERENO – The concept

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

There is a need for capacity building in the field of terrestrial research by bringing together different research communities. 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. The concept of integrating different disciplines and communities is illustrated by the figure.
Multi-scale and multi-compartment Monitoring Concept

Multiscale-nested monitoring observatories are fundamental for the evaluation and assessment of dominant processes and their representative elementary areas. Densely monitored test sites are the testbeds where new "effective" models are to be benchmarked. Observation of fluxes at various scales (redundancy) will allow understanding the intricacies of the nonlinear hierarchical scaling procedures required to link them. Holistic models so developed would, in turn, help to design new cost efficient and optimal monitoring concepts for the larger scale.
A Network of soil moisture and EC-sensors (Wireless sensing, cosmic ray probes and ground-based remote sensing +.....)

Eddy-Covariance system

Soil moisture sensing network

Cosmic Ray Probes

Ground-based remote sensing
TERENO Cosmic-ray Soil Moisture Observing System

(Planned) implementation of up to 20 Cosmic Ray Moisture Probes within the TERENO Observatories Eiffel/Lower Rhine Valley and Harz/Central German Lowland

- Embedded in international community effort towards an global CRS observing system

Location of COSMOS Probes

COSMOS: the COsmic-ray Soil Moisture Observing System

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Network of cosmic-ray soil moisture probes
Soil moisture sensor network Wüstebach

150 Sensor units
18 Router units
900 Soil moisture sensors
300 Temperature sensors

>30 Mio. SWC measurements per year since 2008!
Lysimeter-Network TERENO SoilCan

- Δ Temp ~0.6 °C
- Δ Temp ~2.5 °C
- Δ Temp ~3.0 °C
- Δ Temp ~3.7 °C
- Δ Temp ~5.5 °C
- Δ Temp ~7.0 °C
- Δ Temp ~14.0 °C

- Δ NS ~480 mm
- Δ NS ~880 mm
- Δ NS ~1200 mm
- Δ NS ~1600 mm
- Δ NS ~4800 mm

- Sauerbach
- Rollesbroich
- Wüstebach
- Fendt
- Rottenbuch
- Graswang
- Sehlhausen
- Schäfertal
- Bad Lauchstädt
- Demmin
- Dedelow
- Scheyern
- Harz/Central German Lowland Observatory
- Eifel/Lower Rhine Valley Observatory
- Bavarian Alps/Pre-Alps Observatory
- Northeastern German Lowland Observatory
- Ucker Catchment
- National Park Müritz
- Biosphere Reserve Schorfheide
- Lysimeter Network TERENO SoilCan

- Research Station DEMMIN (DLR)
- Research Station BAD LAUCHSTÄTDT
- Research Station ROTTENBUCH
- Research Station EIERFELD (IPK)
- Research Farm SCHUELBACH (HMSU)
TERENO - ICOS

• 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 TERENO sites obtained additional funding to meet demands of ICOS standards

• TERENO is partner in ICOS-D
ICOS-D Ecosystem Network

Cluster 1
Cluster 2
Cluster 3
Cluster 4
Cluster 5
6 CZOs established within TERENO

- Ellebach CZO
- Kall CZO
- Erkensruhr CZO
- Scheyern/Schnatterbach CZO
- Fuerstensee CZO
- Selke CZO
Integrating TERENO, CZO and LTER sites in Germany: eLTER
Remote Sensing Cal/Val activities (e.g. soil moisture)

- Test sites
  - Radiometer and Sensor Networks (SoilNet) ⇒ long-term continuous monitoring
  - EMIRAD, PLMR, F-SAR ⇒ momentary imaging
- Airborne campaigns
- Model based regionalisation
- Satellites (e.g. SMOS, SMAP) ⇒ continuous monitoring
  - PLMR Rur Campaign 2008

Local, regional, global
Passive and active radiometry using a combined F-SAR/PLMR2 platform

Measurement results of the flight campaign April 17th 2013

F-SAR backscatter  PLMR2 brightness temperature in H-pol  Land cover by RapidEye

Integrated modelling of terrestrial processes across scales from groundwater into the atmosphere.
TERENO data portal – Free data access

- [www.tereno.net](http://www.tereno.net)

TEODOOR Data Portal provides Free Data Access (hourly data)

Online stations:
- Runoff gauging stations
- Sensor networks
- Climate stations
- Cosmic-ray stations
- Weather radar
Today we’ve heard a lot about the complexity of terrestrial-hydrological systems. Despite this complexity, the terrestrial-hydrological component in most process-based climate and biosphere models is typically represented in a very conceptual and often rudimentary way. Disparity of scales requires new technologies and integrative methodologies for multi-scale observation.

Prediction of terrestrial processes at larger scales is hampered by a lack of upscaling/downscaling approaches. Validation of terrestrial models requires long-term multi-compartment data sets. Using observations by non-invasive and novel technologies at multiple scales, we want to contribute to answering the question: How to bridge scale and information gaps in terrestrial systems? This measuring concept combines techniques and methods for different spatial and temporal granularities.

Starting from spaceborne techniques, airborne measurement techniques (hyperspectrum imagery, radar techniques, optical sensors using drones) are an important part of the concept.