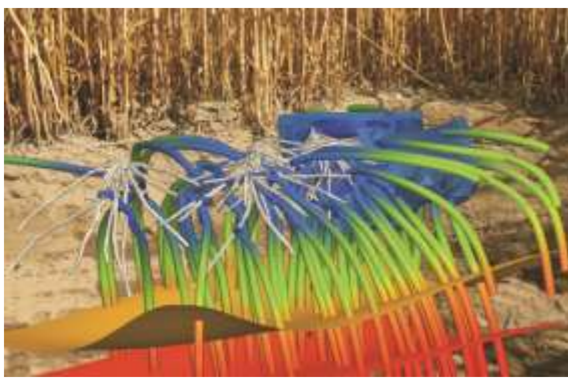
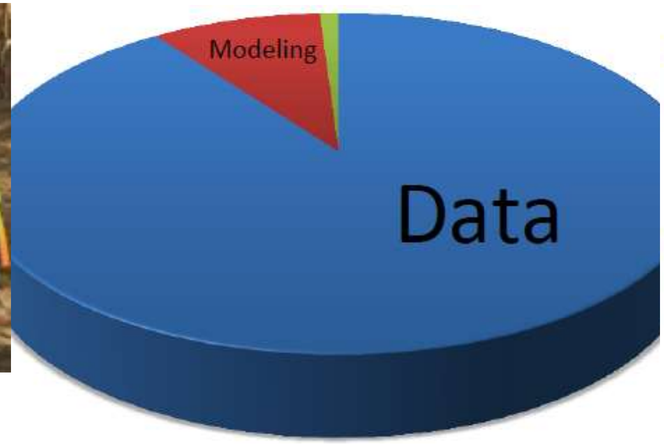
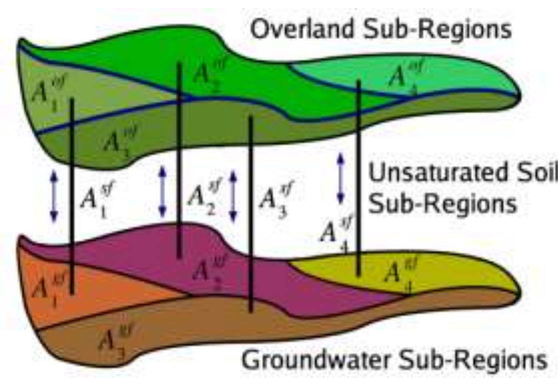
TERENO Workshop:
Data and Modeling Platform
Benchmarking Initiatives
Update of UFZ Activities





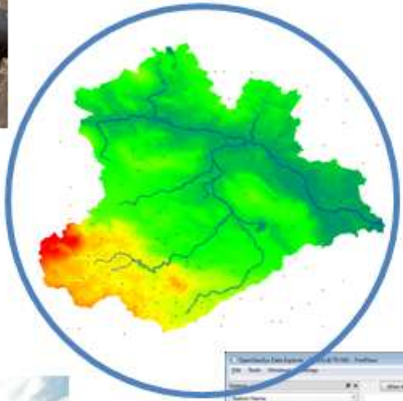


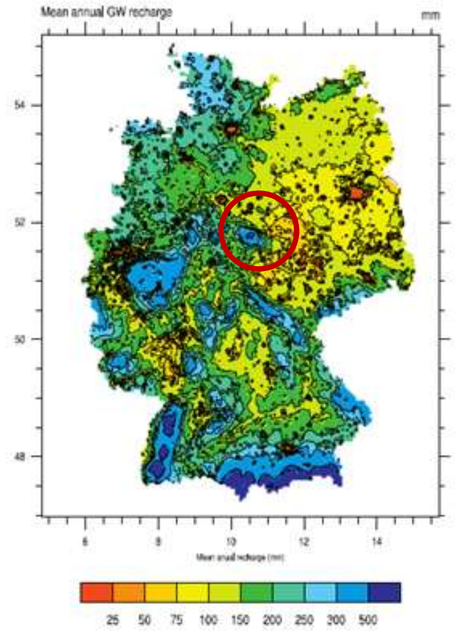
Cross-Sectional-Competence B: Data and Modeling Platform

Topic 6 Concept

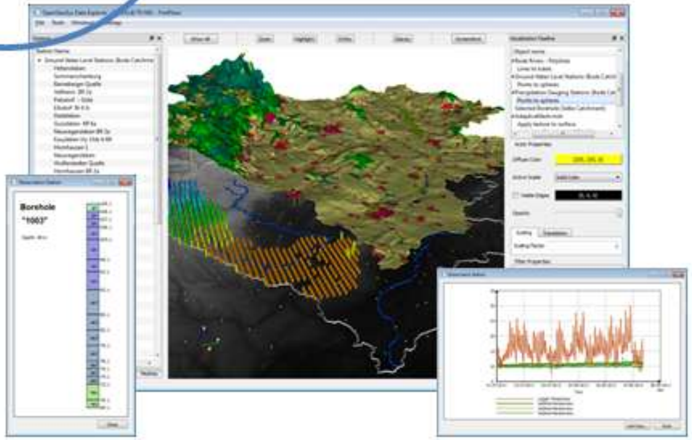
Cluster 2: TERENO-Bode, e.g. Lysimeter network SoilCan

Cluster 1: Measurement and exploration methods





Cluster 3: Exploratory modeling



Cluster 4: Data integration and visualization

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Cross-Sectional-Competence B: Data and Modeling Platform

Developing Continuous Work Flows

Data Work Flow

Data Acquisition
- Measurement
- Monitoring
- Observation

TERENO
TERRESTRIAL ENVIRONMENTAL OBSERVATORIES
TEODOOR

Data Portal
- Access point
- DMS
- Meta data

Data Integration
- Standard formats and protocols
- VTK, OpenSG
- Model preparation

Data Modeling
- Multi-scale
- Uncertainty
- Coupled processes
- Numerical methods
- HPC

Data Visualization
- **TERENO**
- WESS
- IWAS
- INFLUINS
- SUMAR
- GeoEN
- ...

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Benchmarking

Cross-Sectional-Competence B: Data and Modeling Platform
Benchmarking Initiatives – Status-quo

Process-(PDE)-based

Complexity

- HYDROCOIN
- DECOVALEX V
- GEOBENCH
- CO2BENCH
- HM-INTERCOMP
- …

Conceptual models

- DMIP
- MOPEX
- PILPS 1&2
- DMIP I&II (NOAA)
- BALTEX I&II
- GSWP 1&2
- LDAS (NASA)
- …

Scale

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hydrobench - Mozilla Firefox

https://svn.ufz.de/hydrobench

Do you want Firefox to remember the password for "okolditz" on ufz.de?

Discussion Forum

logged in as Olaf Kolditz

Wiki | Timeline | Roadmap | Browse Source

Welcome to the HYDRO BENCH PLATFORM

A community initiative for hydrological benchmarking and model

Hydrological models that incorporate surface-subsurface water interactions use diffe approaches. Accurate and productive code comparison as well as joint model develo of benchmark tests. This benchmark set can be broadly divided into academic and re are often based on laboratory and field experiments. Furthermore, a number of synth evaluate individual processes and model coupling phenomena under idealized conditio large-scale catchments which are linked to their climate zone. We believe that the h within the ongoing model development community effort.

A Trac System allows tracking and handling of software issues, enhancements and c Trac|Wiki-System as a platform for a web-based management of hydrologic benchm development, code comparison, data exchange, documentation and discussion. This page" link at the bottom of the page. WikiFormatting will give you a detailed descrip

Academic test cases

Real-world test cases

Software codes

This initiative currently comprises the following hydı

- HydroGeoSphere (HGS)
- OpenGeoSys (OGS), OGS/SWMM, OGS/mHM
- ParFlow

Workshops

In context of this initiative the following internation

- Boulder, Colorado

Leipzig, Germany

Done

TestsAcademic – hydrobench - Mozilla Firefox

https://svn.ufz.de/hydrobench/wiki/TestsAcademic

logged in as Olaf Kolditz | Logout | Preferences | Help/Guide | About Trac

Wiki | Timeline | Roadmap | Browse Source | View Tickets | New Ticket | Search

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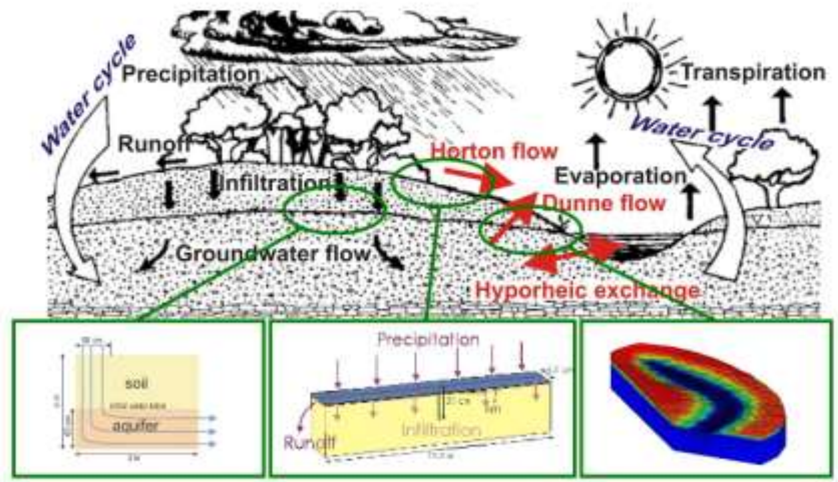
Academic test cases for hydrological coupling



Soil / aquifer coupling: Vauclin et al. (1979)

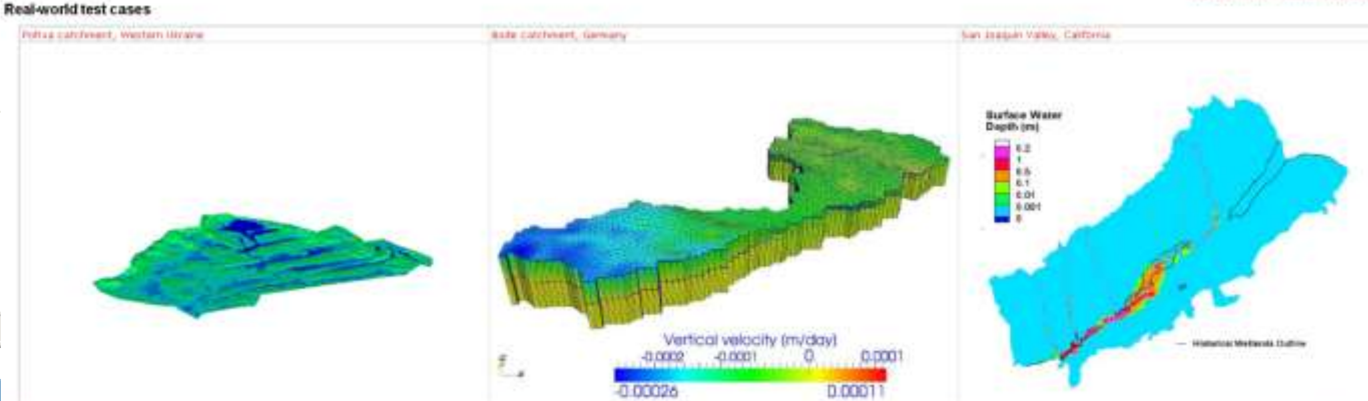
Horton overland flow: Smith & Woolhiser (1971)

Borden site: Abdul & Gillham (1985)

Done

THE HYDRO BENCH

Real-world test cases



Cross-Sectional-Competence B: Data and Modeling Platform

Towards Real-World Benchmarks …

- **TEODOOR: Entry point to observatories, data and models**
- **Development of real-world benchmarks based on the TERENO observatories**
- **Technical issues: data explorer**

Scientific Questions (Bode):

- **How can we quantify fluxes through the hyporeic zone? (e.g. thermal signatures)**
- **How can river discharge described with spatially distributed hydrological models?**
- **How important is hydraulic non-equilibrium to induce preferential flow in different soils ?**
- **How we can quantify instream turnover and structure-functions in aquatic ecosystems?**

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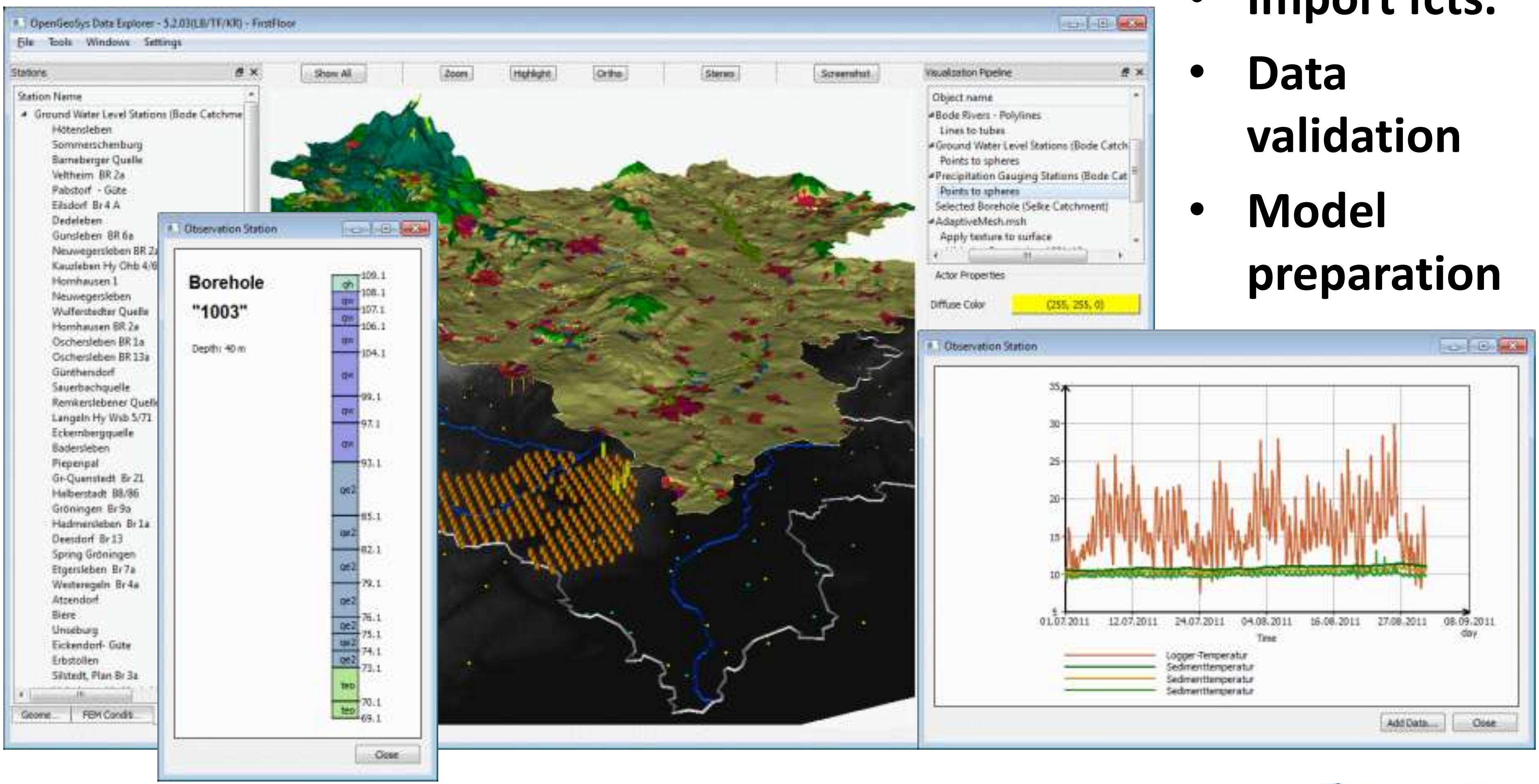
Cross-Sectional-Competence B: Data and Modeling Platform

Data Integration for Benchmark Set-Up



- **Import fcts.**
- **Data validation**
- **Model preparation**

Rink et al. (2011): Visual data integration. *EES*, 65(5)

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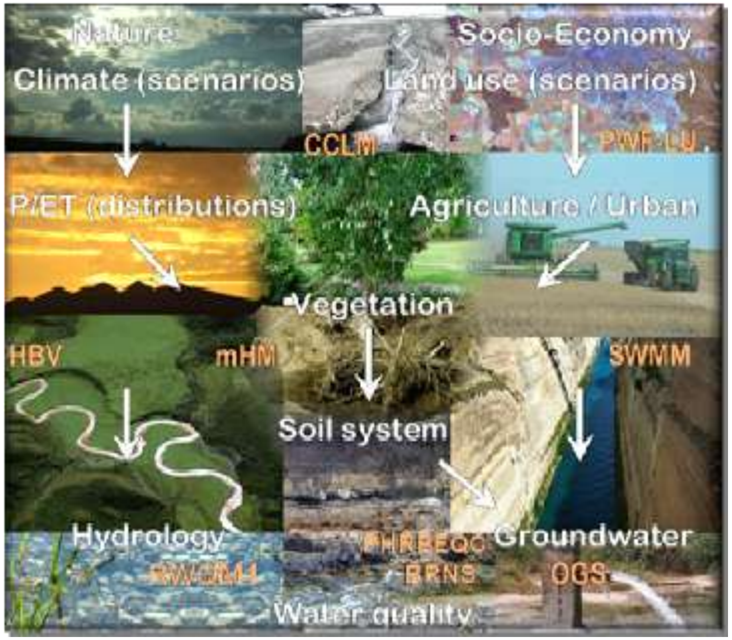
UFZ News

Cross-Sectional-Competence B: Data and Modeling Platform

Modeling Platform

WRR Editors' Choice Award 2011

Luis Samaniego, Rohini Kumar, and Sabine Attinger, "Multiscale parameter regionalization of a grid-based hydrologic model at the mesoscale" (doi:10.1029/2008WR007327).



IWAS

Integrated Water Resources Management under different hydrological, climatic and socio-economic conditions (22)

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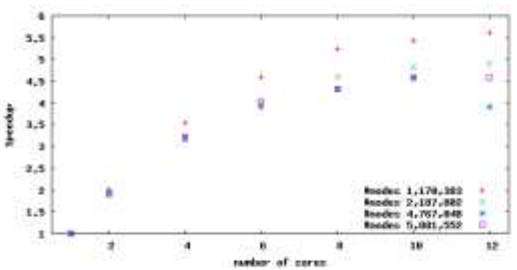
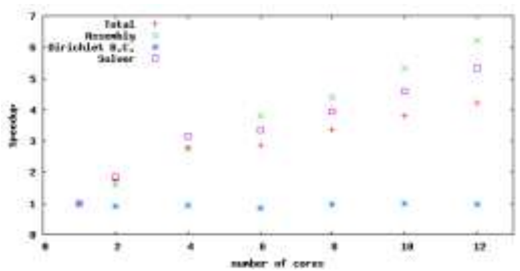
Cross-Sectional-Competence B: Data and Modeling Platform
High Performance Computing: *HSL „Terrestrial Systems“*

OpenMP
(shared)

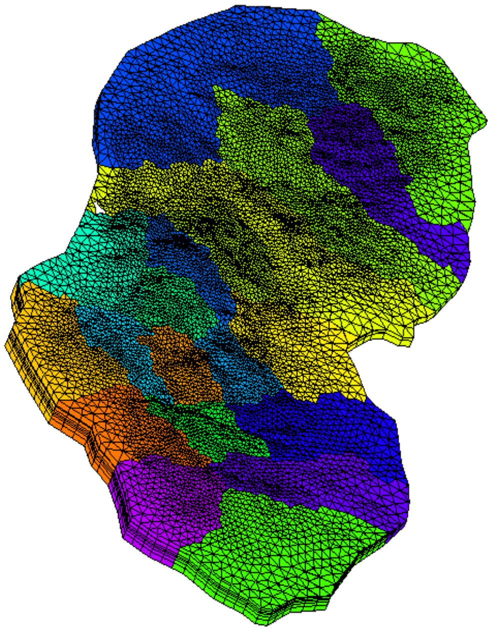




Small machines
12 CPUs

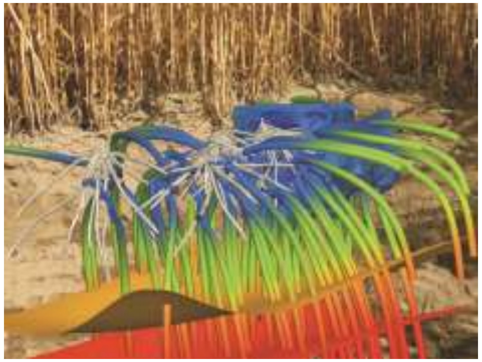
Kalbacher et al. (2011) *VZJ*
Fischer, Watanabe et al. (2012) *HIC*

MPI
(distributed)



Domain
Decomposition
10^3 CPUs

OpenMP#MPI
(hybrid)



- Roots: OpenMP
- Soil: MPI

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Cross-Sectional-Competence B: Data and Modeling Platform

Data Visualization: *TESSIN VISLab*

Geological model of Schleswig-Holstein, mobile *VISLab* facility available

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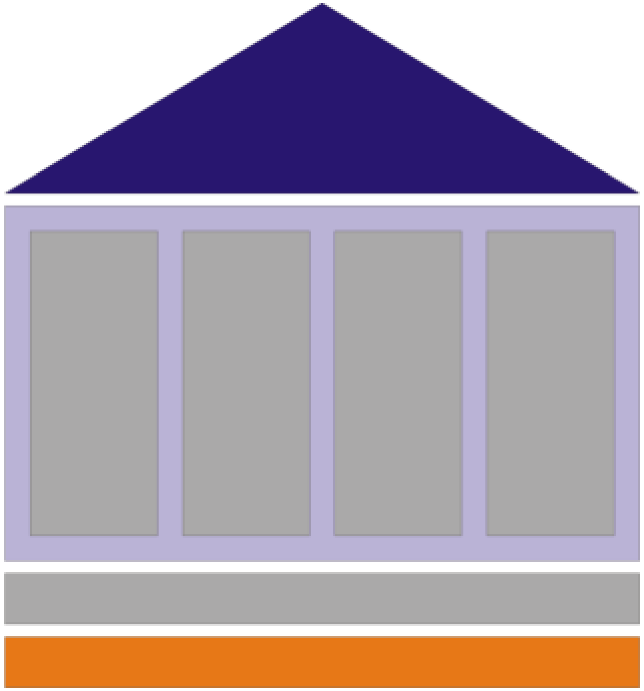
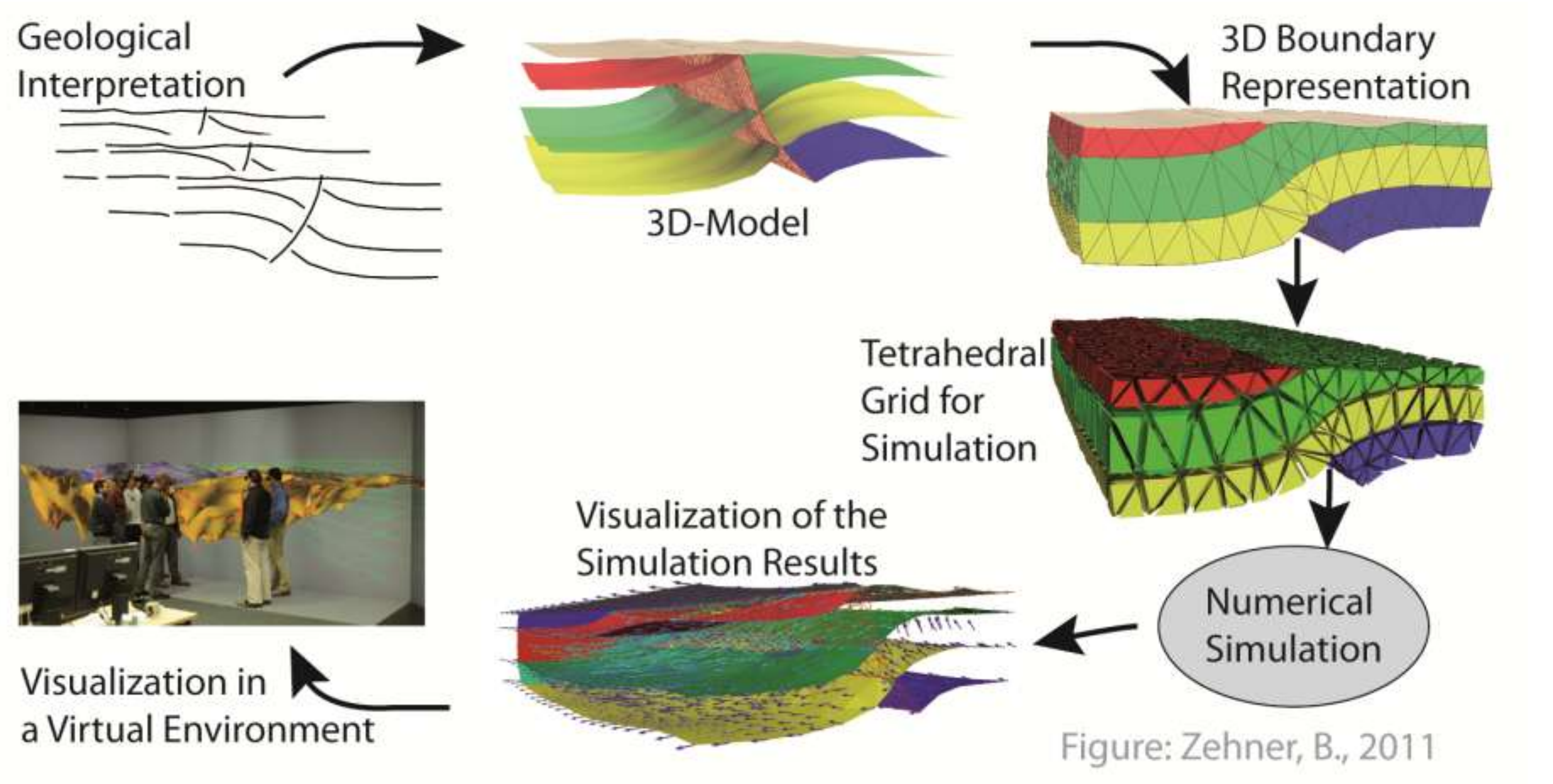
Cross-Sectional-Competence B: Data and Modeling Platform

Fine



Cross-Sectional-Competence B: Data and Modeling Platform

Work Flow Example



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Physics-based

Complexity

- **HYDROCOIN**
- **DECOVALEX**
- **HM-INTERCOMP**
- **GEOBENCH**
- **CO2BENCH**

Conceptual models

- **DMIP**

(Distributed Model
Intercomparison Proj

- **MOPEX**

(Model Parameter
Estimation Experimen

Scale

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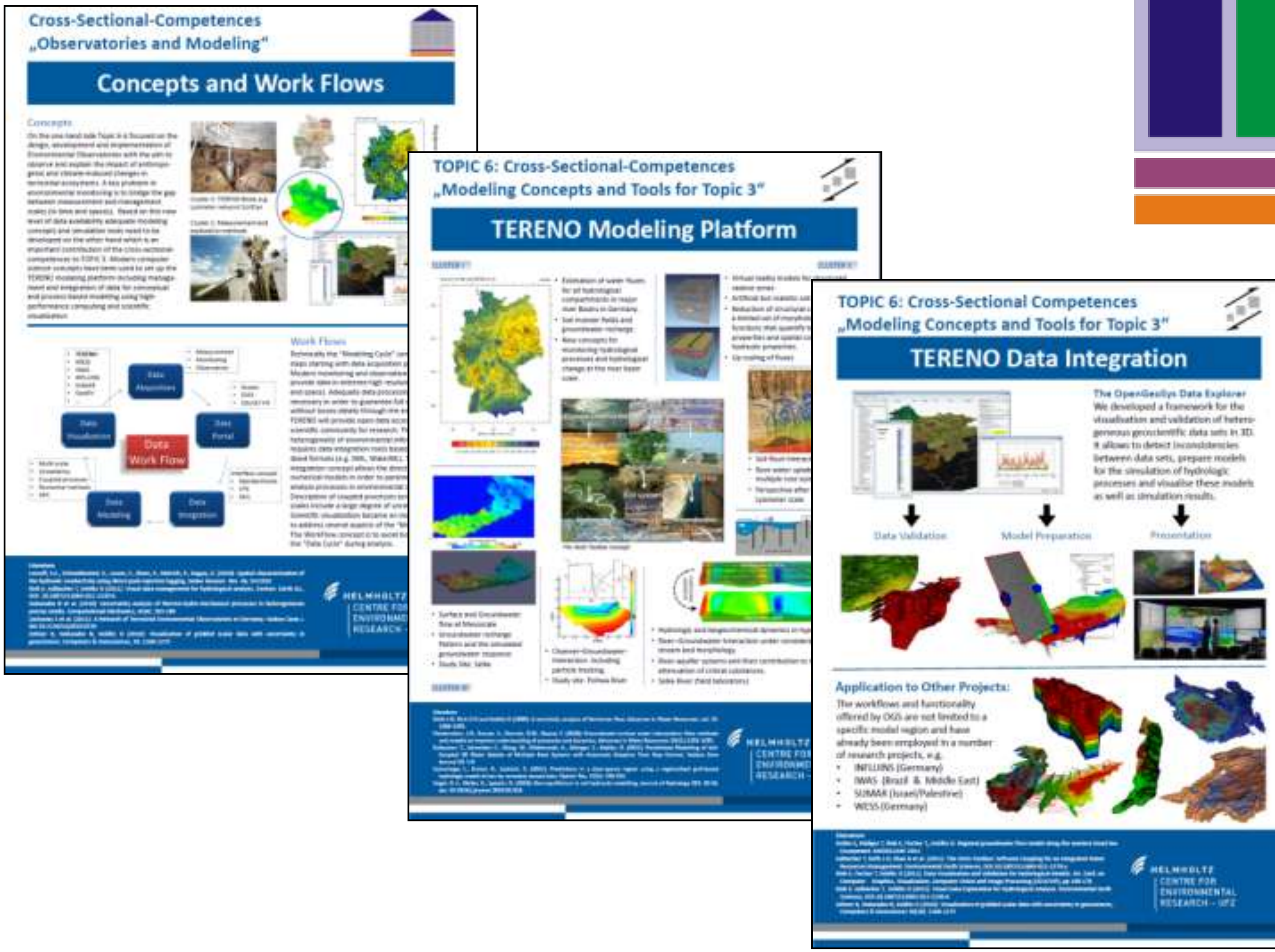
Cross-Sectional-Competences & Clusters
Poster Session (more details)



- CSCs
- Clusters
- Linking
  CSC#Cluster

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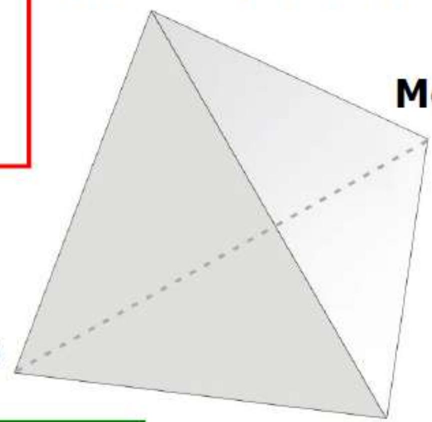
Cross-Sectional-Competence B: Data and Modeling Platform
Coupling Concepts



Heat transport

$$c\rho \frac{\partial T}{\partial t} = -\nabla(-K\nabla T + \sum_\beta h_\beta \vec{F}_\beta) + q$$

Deformation

$$\nabla \vec{\sigma} - \rho \vec{g} = 0$$

$$\nabla \cdot \left(\sigma - (S^l p^l + S^g p^g)\mathbf{I} - \beta_T \Delta T \mathbf{I}\right) + \rho \mathbf{g} = 0$$

Fluid flow

$$\frac{\partial}{\partial t} \int_{V_n} M^\kappa dV_n = \int_{\Gamma_n} \vec{F}^\kappa \vec{n} d\Gamma_n + \int_{V_n} q^\kappa dV_n$$

$$M^\kappa = \Phi \sum_\beta \rho_\beta S_\beta X^\kappa_\beta$$

$$\vec{F}^\kappa_\beta = -\rho_\beta \frac{\vec{k} k_{r\beta}}{\mu_\beta} (\nabla P_\beta - \rho_\beta \vec{g})$$

$$\sum_\beta S_\beta = 1$$

Reactive transport

$$\vec{F^\kappa} = \sum_\beta \left(X^\kappa_\beta \vec{F_\beta} + \rho_\beta \vec{D^\kappa_\beta} \nabla X^\kappa_\beta \right)$$

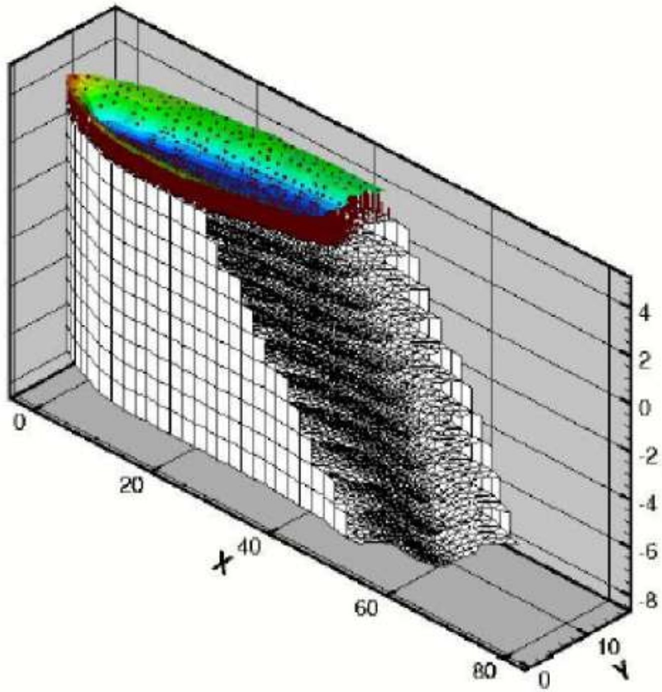
$$ln(K_{P,T}) = \frac{\triangle G^0_{P,T}}{RT}$$

$$K_j = \frac{a_w^{\nu_{wj}} \prod_i (\gamma_i C_i)^{\nu_{i,j}} \prod_m (a_m)^{\nu_{mj}} \prod_g (f_g)^{\nu_{gj}}}{\gamma_j C_j}$$

Coupling Concepts

Compartment Approach

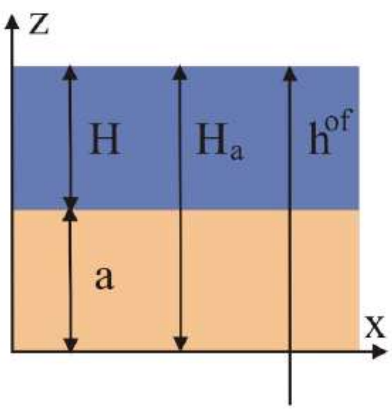
H^3 Problem



Diffusive wave surface flow

$$\phi_a \frac{\partial H_a}{\partial t} + \overline{\nabla} \cdot \mathbf{q}^{\mathbf{of}} = q_s^{of} \qquad 0 \le \phi_a \le 1$$

$$\mathbf{q}^{\mathbf{of}} = -\frac{CH^{l+1}}{S_s^{\,1-j}} \overline{\nabla} h^{of}$$



Richards flow in soil

$$\phi \frac{\partial S}{\partial t} + \nabla \cdot \mathbf{q}^{\mathbf{sf}} = q_s^{sf}$$

$$\mathbf{q}^{\mathbf{sf}} = -k_r \mathbf{K} \nabla (\Psi + z)$$

Groundwater flow in aquifer

$$\phi \frac{\partial h^{gf}}{\partial t} + \nabla \cdot \mathbf{q}^{\mathbf{gf}} = q_s^{gf}$$

$$\mathbf{q}^{\mathbf{gf}} = -\mathbf{K} \nabla h^{gf}$$

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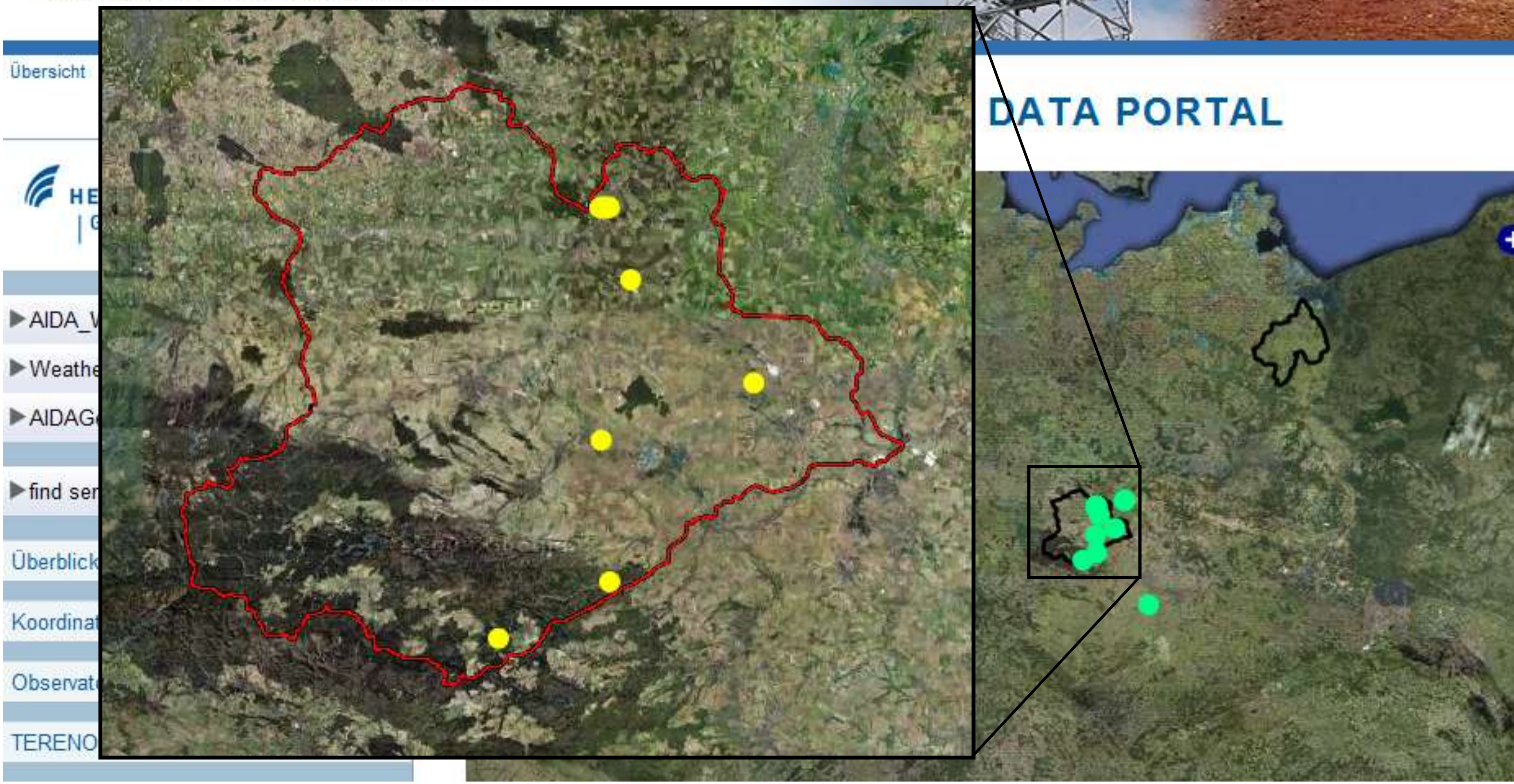
TERRESTRIAL ENVIRONMENTAL OBSERVATORIES



Data Portal for access to data from all centres

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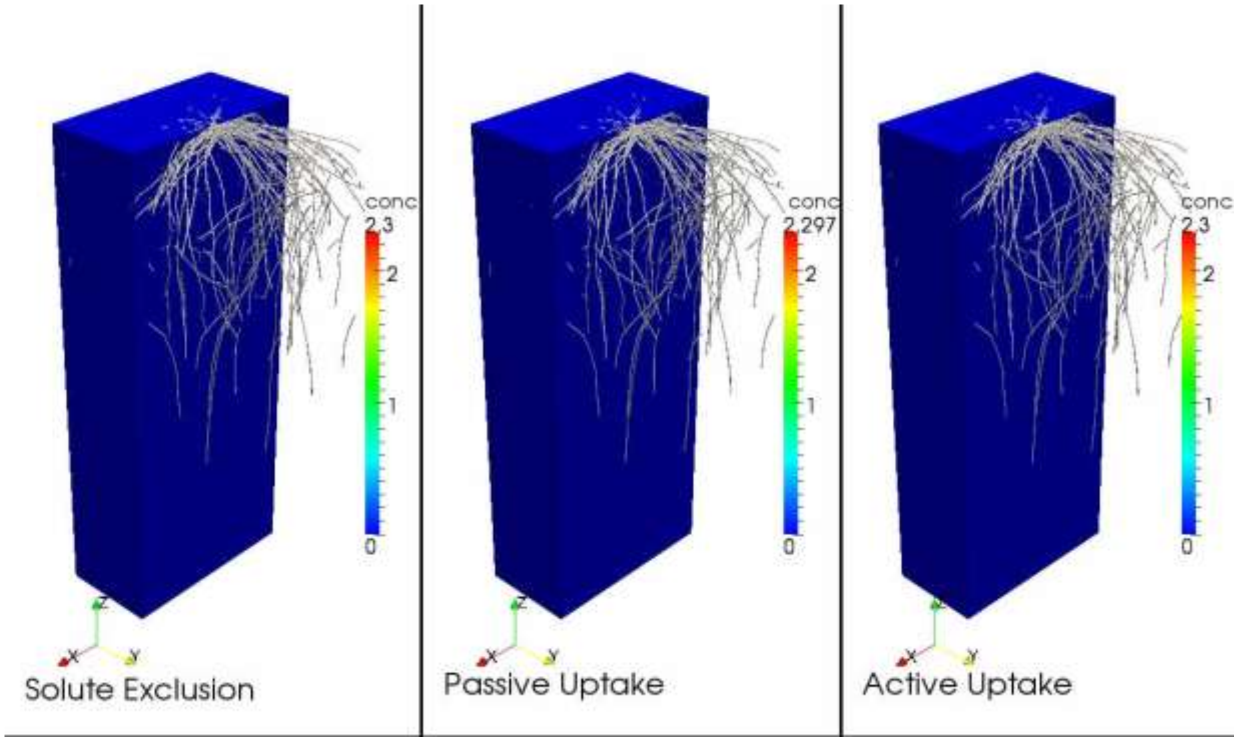
TEODOOR

CT Modelling: development of coupled process models

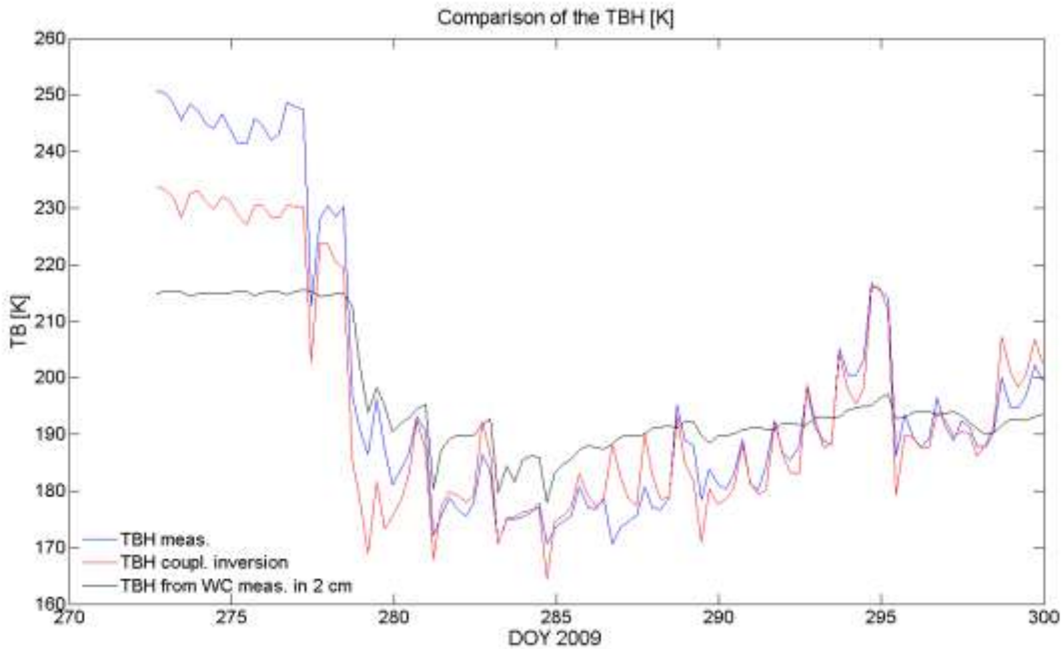
Soil-plant models that couple water flow and transport processes in soils and plants.



Current work: Include feedbacks between root development and soil environmental conditions.

CT Modelling: development of coupled process models

Models that couple heat, vapor and liquid water fluxes in soils with models that simulate remote sensing data (e.g. radiative transfer models for passive and active radar)

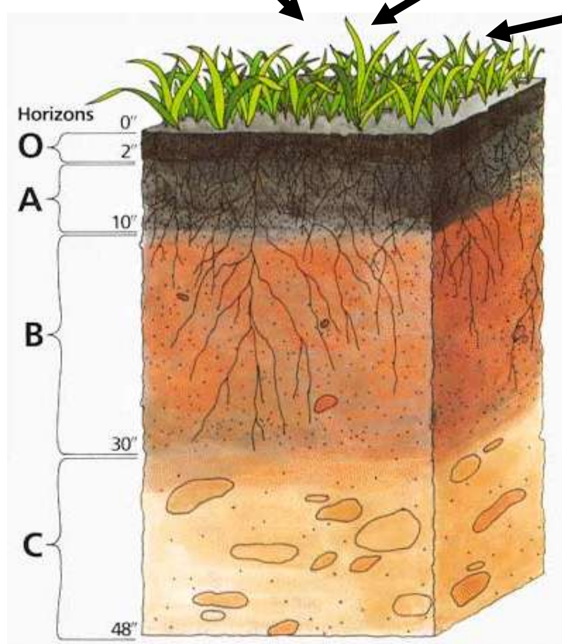


Particle Filter to estimate soil hydraulic parameters from SMOS

Measuring a soil volume:

Surface to 5 cm depth

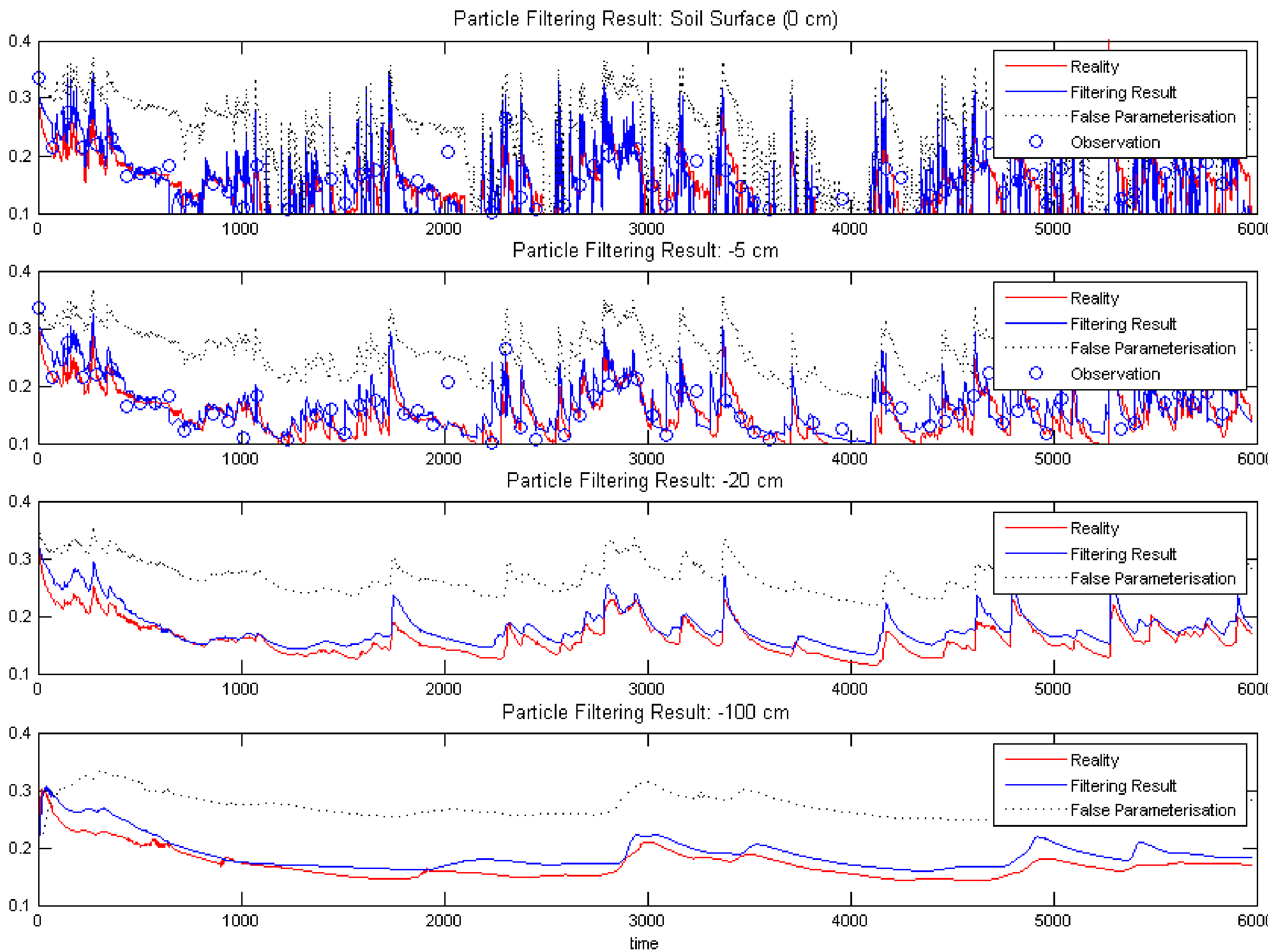
⇒ Assimilation



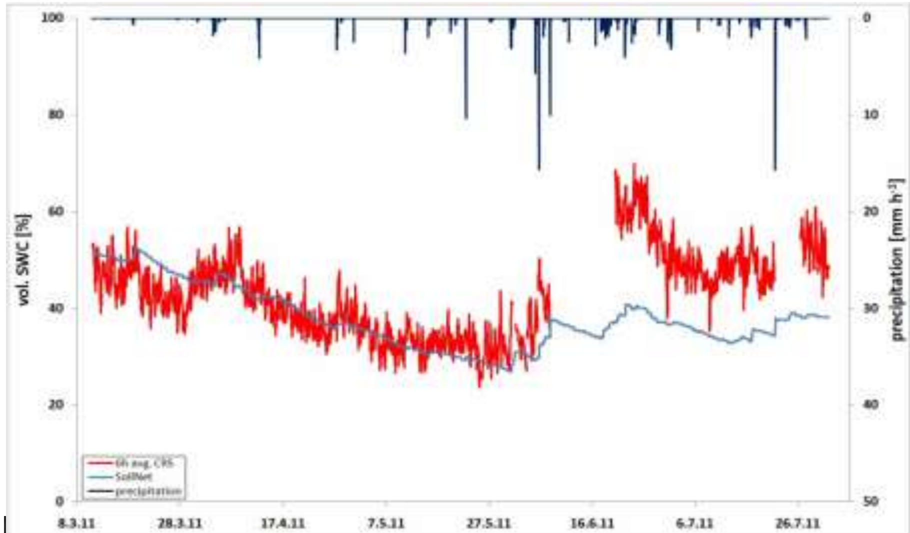
Top soil moisture measurements with microwave radiometry in L-Band (1 - 2,6 GHz)

- groundbased (ELBARA)
- airborne (PLMR, EMIRAD)
- spaceborne (SMOS, ALOS)

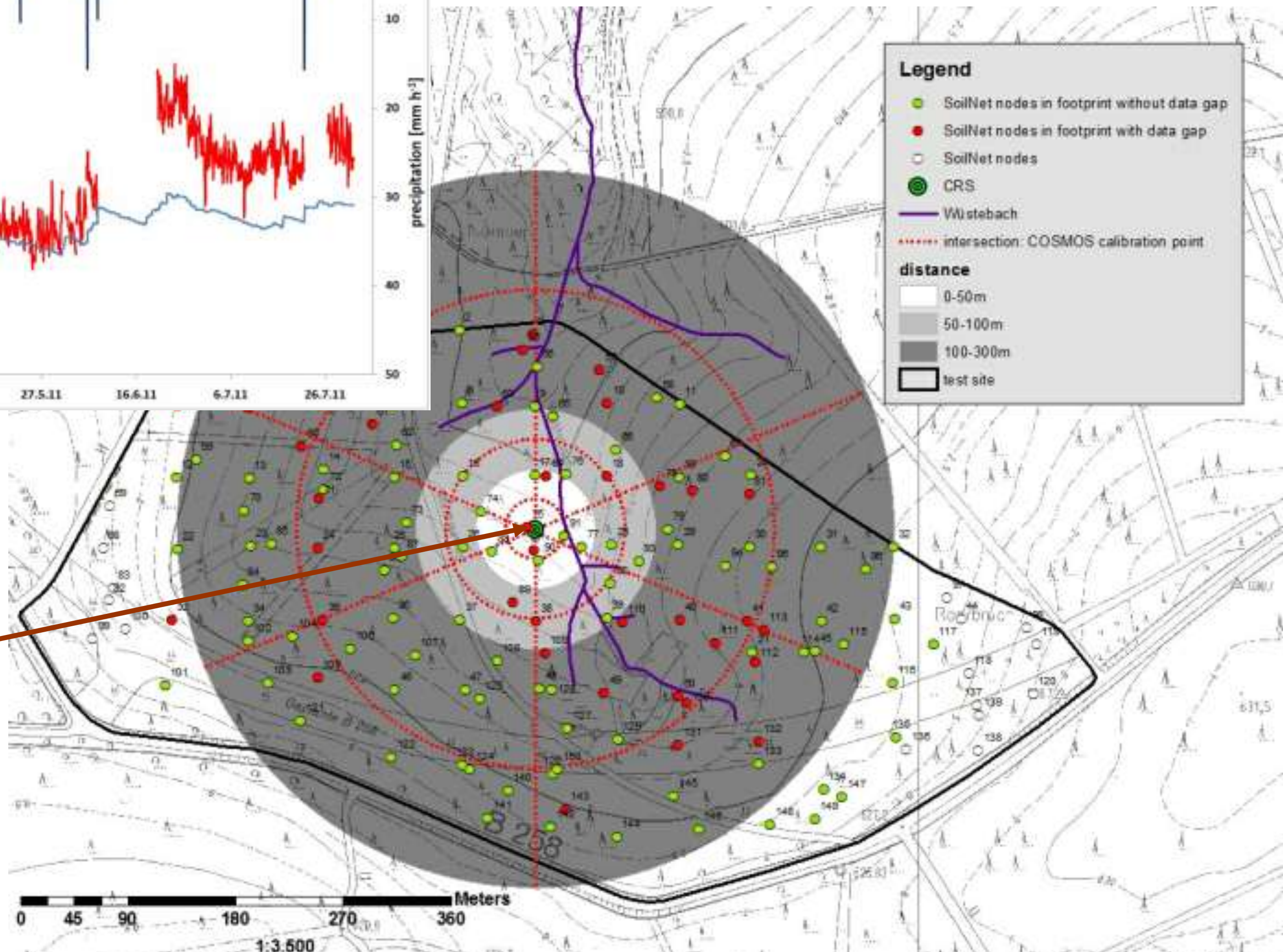
Particle Filter to estimate soil hydraulic parameters from SMOS



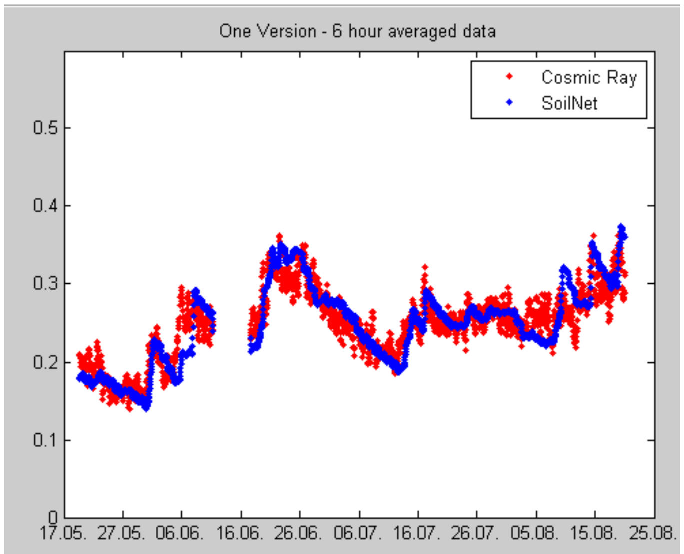
Development of measurement operator for cosmic ray data

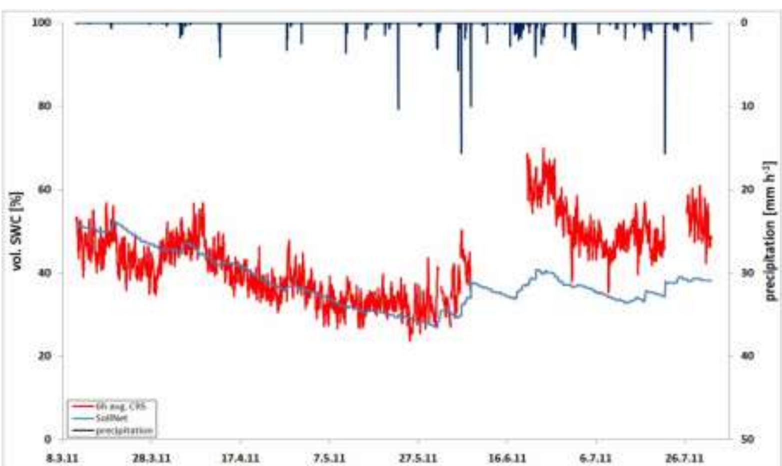


Example: TERENO test site Wüstebach



Development of measurement operator for cosmic ray data

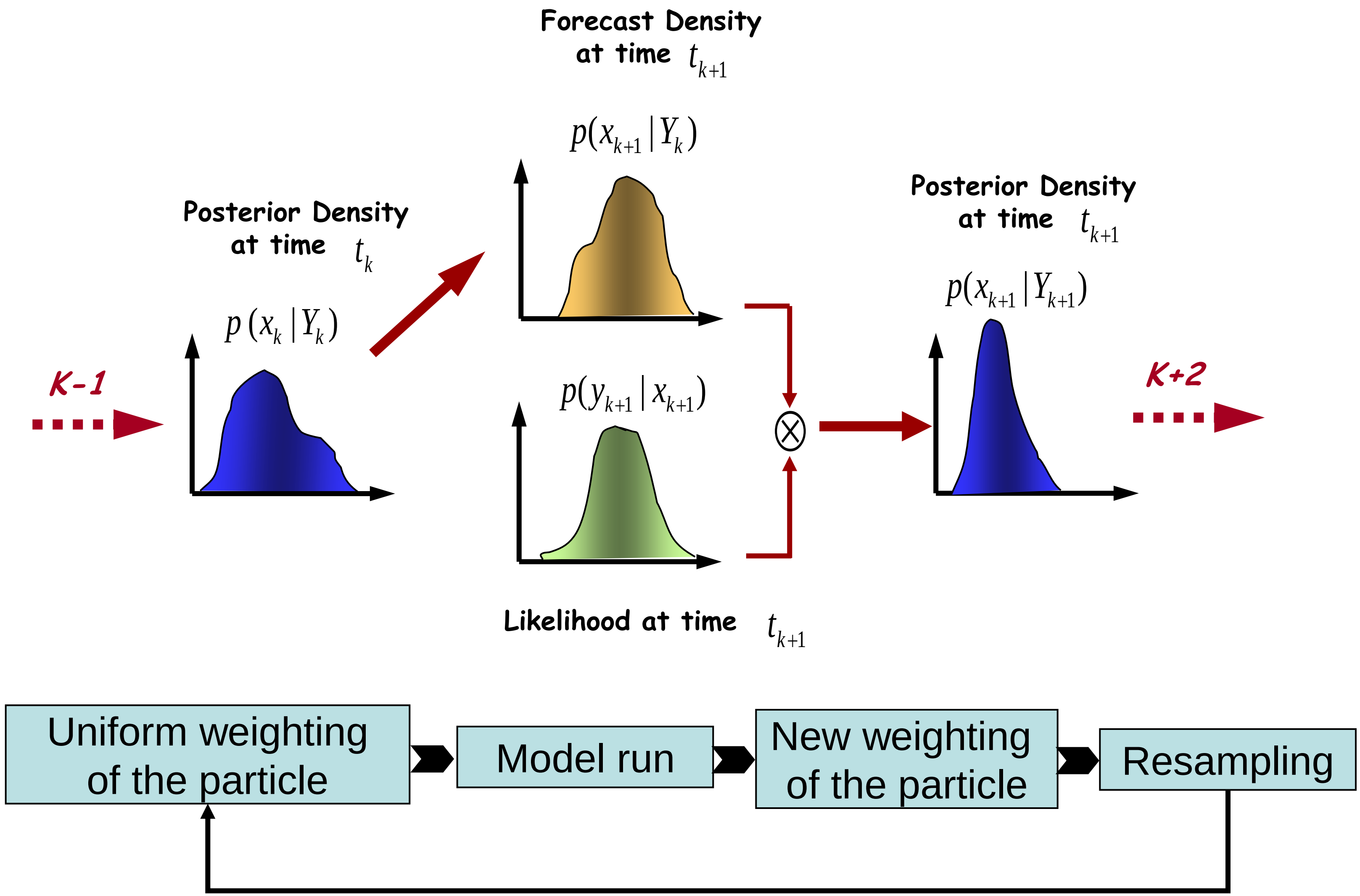




TERENO TERRESTRIAL ENVIRONMENTAL OBSERVATORIES

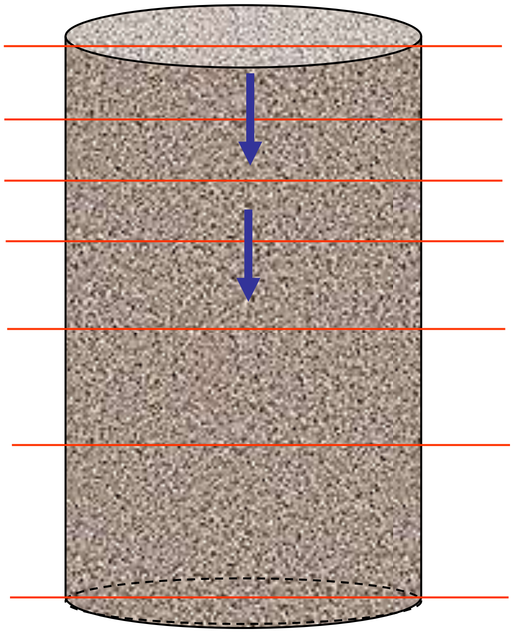
JÜLICH FORSCHUNGSZENTRUM

Particle Filter to estimate soil hydraulic parameters from SMOS



Particle Filter to estimate soil hydraulic parameters from SMOS

- 1-D physical finite elements model
- Solves Richards equation numerically
- Soil hydraulic properties are parameterised using the Mualem-van Genuchten model
- 1 hour temporal resolution
- Homogeneous soils (clay, loam, silt, loamy sand)



$$\frac{\partial \theta}{\partial t} = \frac{\partial}{\partial z}\left[k(h)\left(\frac{\partial h}{\partial z} - 1\right)\right] - Q$$

Development of measurement operator for cosmic ray data

- Non-linear measurement operator to be used in sequential DA
- This measurement operator determines link between neutron counts (NC) and soil moisture contents taking into account:
  - NC-contribution as function of distance to sensor
  - NC-contribution as function of depth (influence SM-content)
  - Air pressure and solar activity variations
  - Soil moisture heterogeneity within footprint
  - Measurement uncertainties
- Daily assimilation (together with other data) in CLM for updating SM