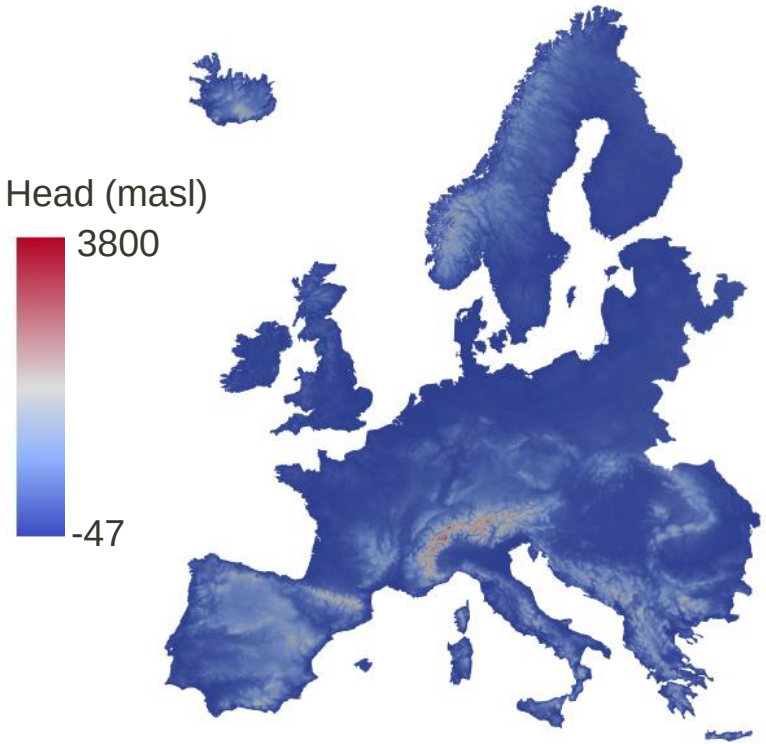


Groundwater head distribution across Europe

# Large scale groundwater modelling in the frame of ViWA project - UFZ

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Speaker Dr. Pujades

23.10.2020

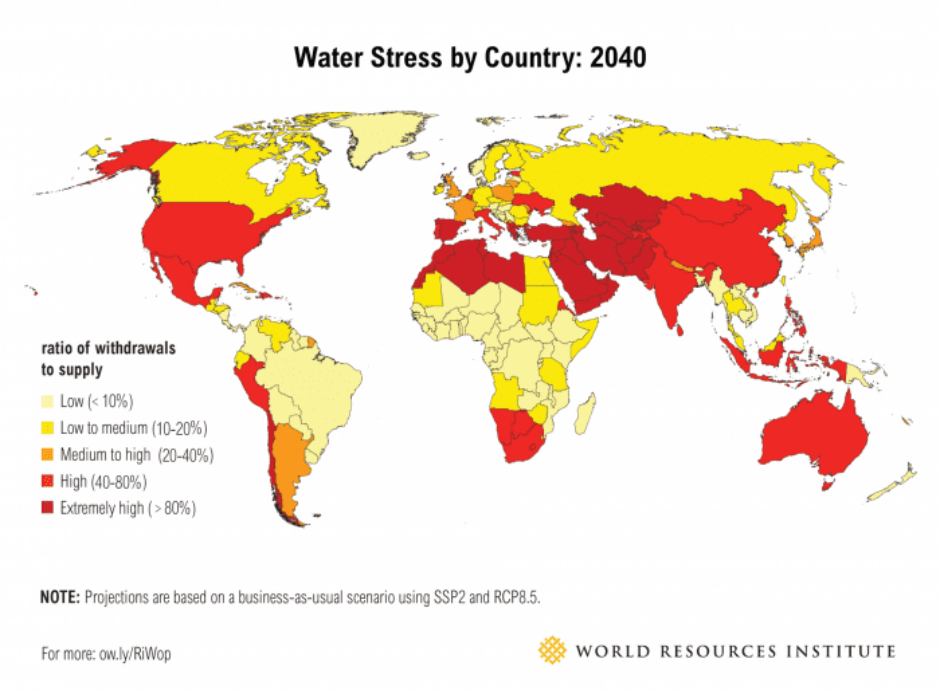
ViWA Virtual Water Values

# Motivation

**Development of regional groundwater models**

WHY?

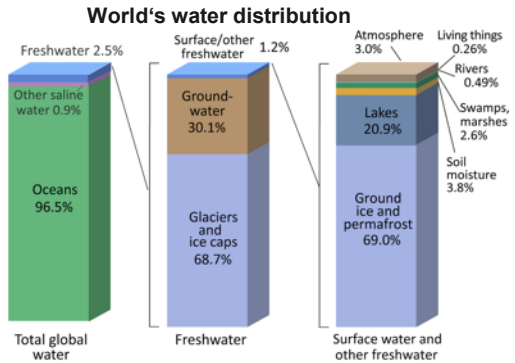
- Stress on groundwater resources is going to increase during the next decades due increasing fresh water demand (drinking water and irrigation water) and changing groundwater recharge.
- Regional groundwater models are needed to predict groundwater storages under climate change and changing water abstraction.



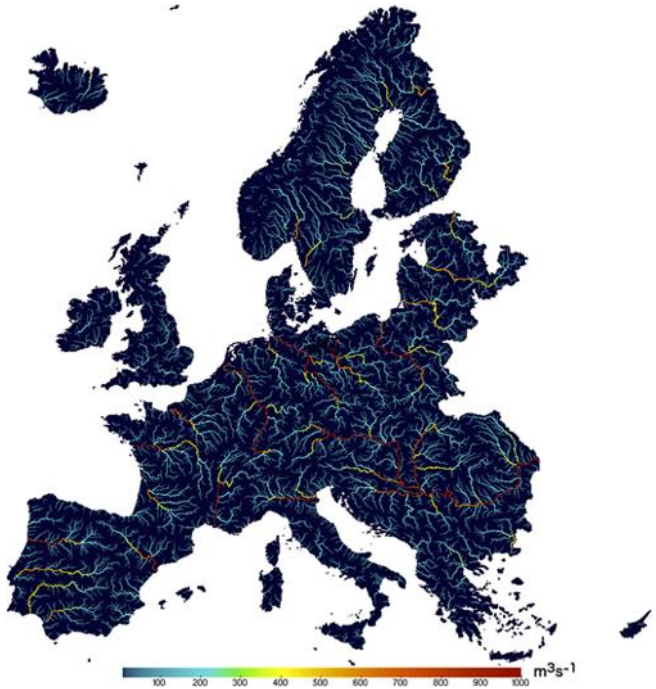

Expected water stress by country in 2040; World Resources Institute

# Large scale groundwater modelling in the frame of ViWA project - UFZ
## Motivation

- Hydrological models simulate realistically the dynamics of surface water resources and groundwater recharge but they do not simulate realistically groundwater storages.
- Groundwater represents more than the 96% of available freshwater resources.




U.S. Geological Survey




Results from mHM hydrological model. Simulated mean daily streamflow from 1950 to 2011. Samaniego et al., 2020

## Motivation and objective

Development of large scale groundwater models is challenging:

- **Lack of observations** to calibrate or validate the results
- **Lack of data** to define the **geometry** of the models
- **Lack of data** to define the **hydrogeological parameters**
- Classical modelling codes are designed to simulate **small scale groundwater models**
- **Coupling** between **hydrological** (surface water) and **hydrogeological** (groundwater) models is complex:
  - Boundary conditions and resolutions (temporal and spatial) are different.

### OBJECTIVE

To develop a methodology to construct at continental or global scales groundwater models which are as simple as possible (but not simpler)!

## Methodology - codes

### Groundwater model

OpenGeoSys

GIS2FEM

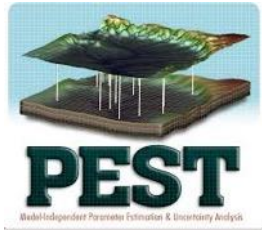
### Groundwater recharge

Danube


Europe

mHM

### Calibration / Validation



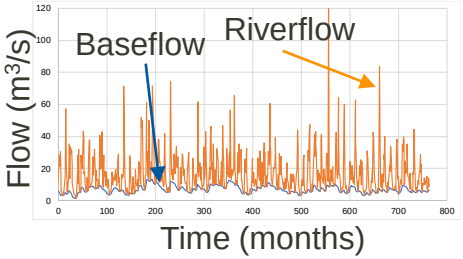

ParaView

# Methodology – characteristics of the model

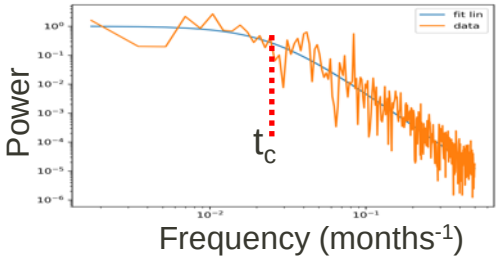
- **Spatial resolution**:
  - 2D model; Thickness (third dimension) is incorporated through the transmissivity.
  - Size of the elements
    - Danube: 500m
    - Europe:1000m
- **Temporal resolution**:
  - Danube: Steady state and transient state with monthly time steps
  - Europe: Steady state
- **Boundary conditions (BC)**:
  - Lakes, rivers, springs and sea: Dirichlet BC
  - Groundwater recharge: Prescribed flow at the top of the model

# Methodology - parametrization

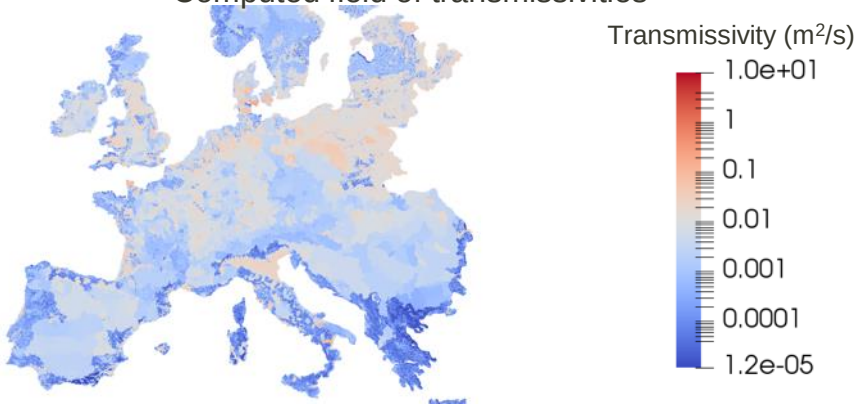
Baseflow separation




Example of spectral analysis




Computed field of transmissivities




**NEW: Regional Transmissivity (*T*) is obtained from spectral analyses of the baseflow**:

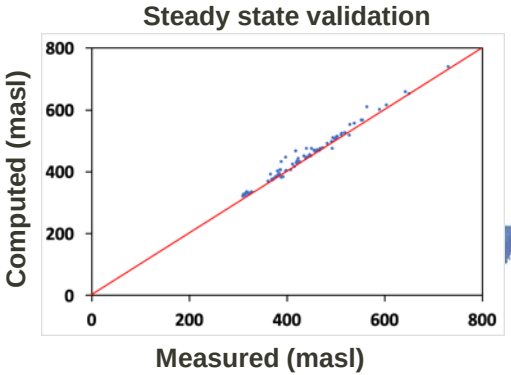
- Selection of gauging stations (enough data)
- Baseflow is computed
- Power spectrum of the baseflow is calculated
- The inflection point is the characteristic time of the materials located upstream the gauging station.

$$t_c = S(2L)^2/T$$

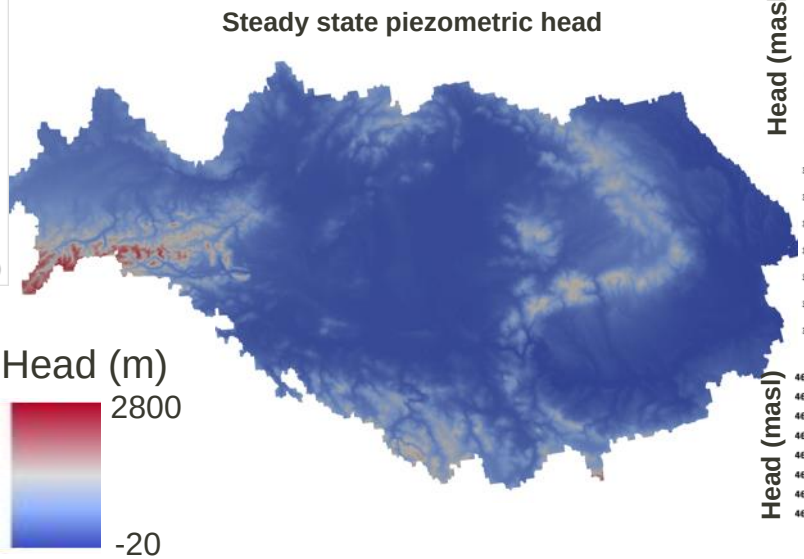
- *S* is obtained from Gleeson et al., 2014, L is estimated by drainage density

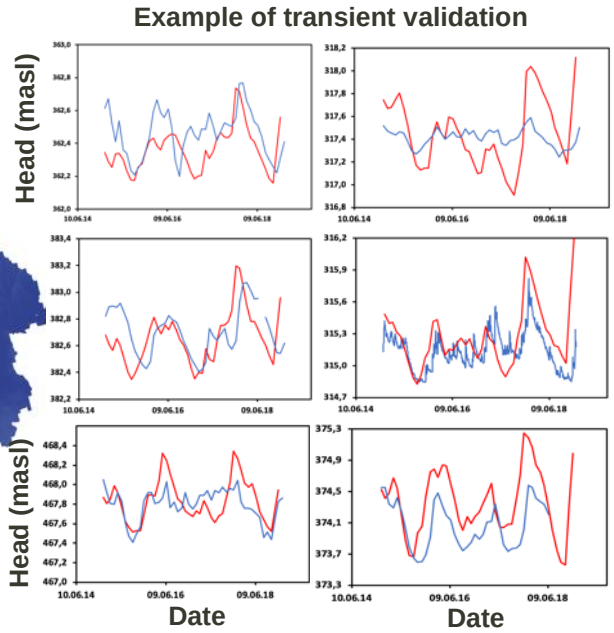
# Large scale groundwater modelling in the frame of ViWA project - UFZ

## Validation - Danube



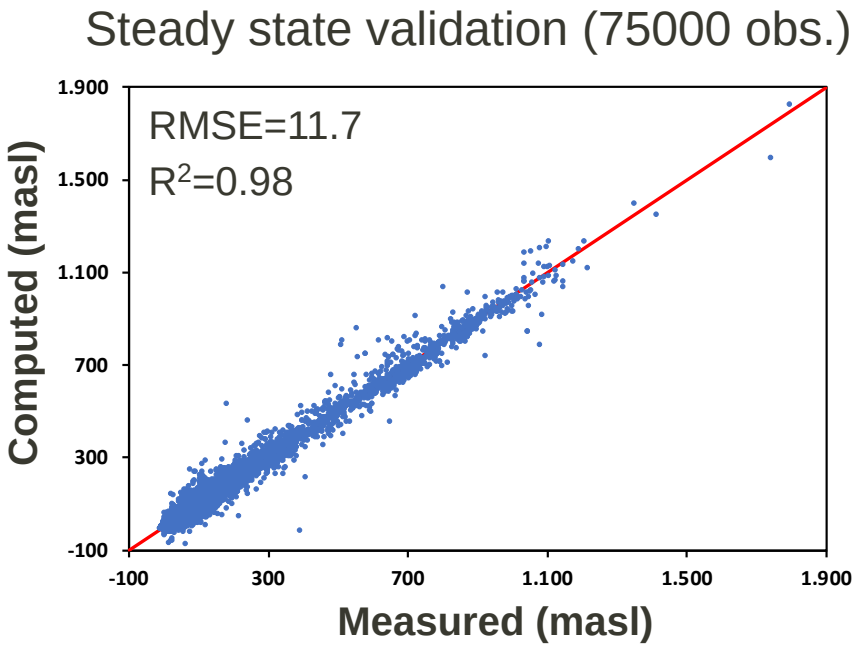

| Regression statistics | |
|---|---|
| Multiple R | 0.99 |
| R Square | 0.98 |
| Standard Error | 10.5 |
| Observations | 96 |



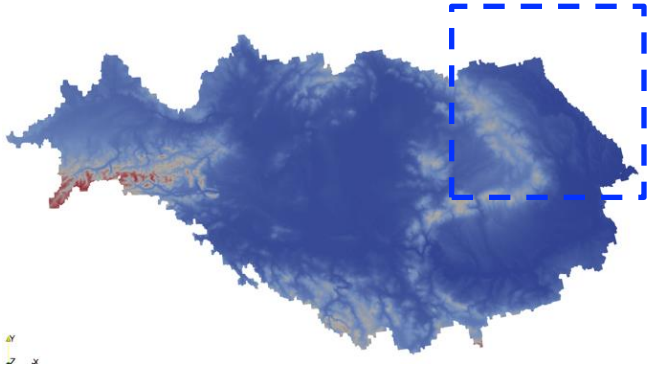



# Large scale groundwater modelling in the frame of ViWA project - UFZ

## Validation - Europe

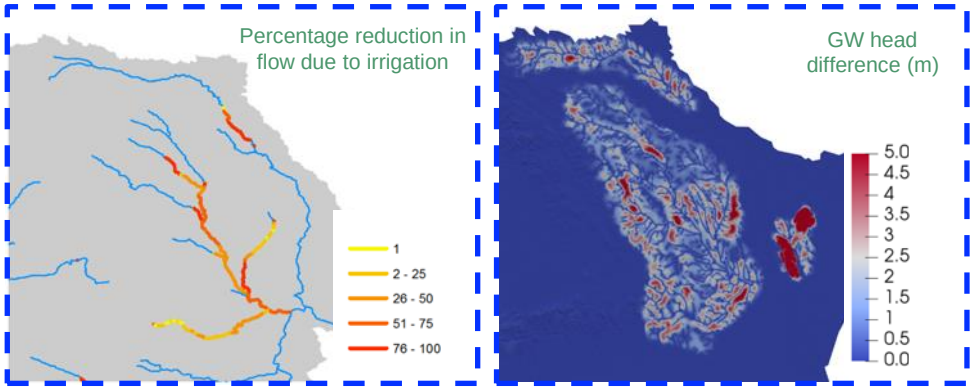
# Large scale groundwater modelling in the frame of ViWA project - UFZ
## Application - Danube



In combination with hydrological models, the groundwater models can be used to predict the **groundwater response to different forcing**:

- abstraction (irrigation) scenarios from PROMET
- Groundwater recharge scenarios derived from hydrological projections.

**Impact of an irrigation scenario in groundwater**



# Conclusions

- A unique method (based on spectral analysis of the base flow) has been established to robustly infer regional groundwater parameters (other models use parameters from global databases)
- The coupling between a groundwater (OpenGeoSys) and a hydrological model (PROMET and mHM) allows to force the groundwater model with realistic groundwater recharge fields
- The developed methodology delivers model results that match the shallow regional groundwater dynamics very well.
- This kind of models are useful to predict the groundwater response to different forcing (abstraction scenarios, groundwater recharge scenarios) and manage water use at regional scales.

# Thanks for your attention

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