scarce

UNIVERSIDAD POLITECNICA DE VALENCIA

Distributed hydrological modelling within SCARCE Project: integrating water, sediment, quality and vegetation

CONSOLIDER Ingenio 2010

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Introduction

- **SCARCE Project**:
  - Global change impacts on ***water availably***, ***water quality*** and ***ecosystems*** in Mediterranean environment
  - Means of ***extrapolating*** from the ***available measurements*** in space and time

↓

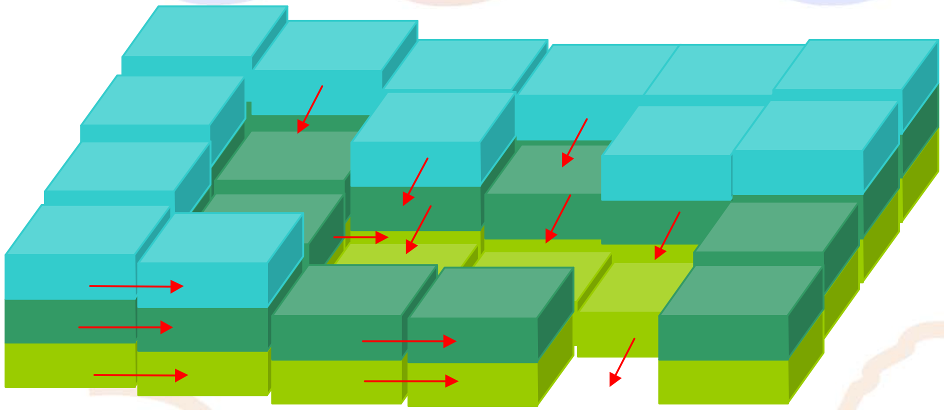
Mathematical models

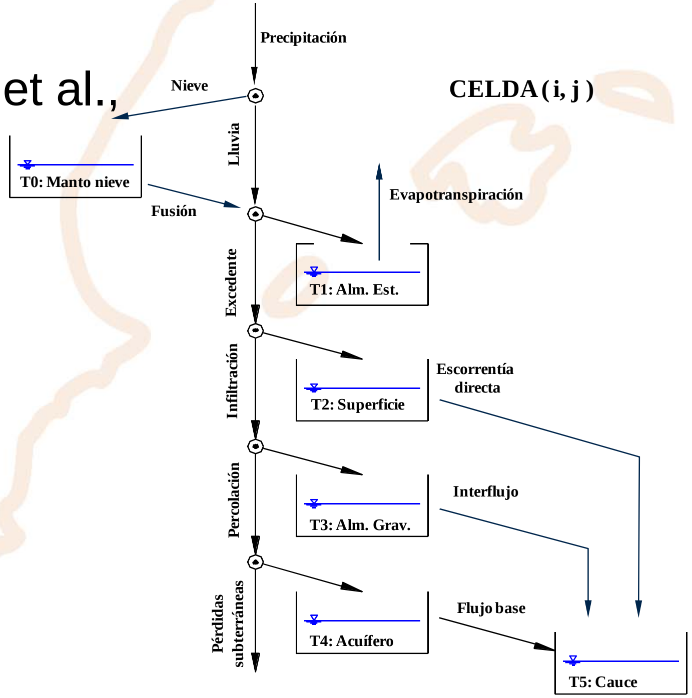
Introduction

- **WATER CYCLE**:
  - Is the ***driving force*** behind everything that happens in the catchment
  - It is well known that any water quality model can only be as good as the water quantity model on which the water quality model is based

TETIS model

- Present TETIS **basin** oriented model:
  - **Distributed** in cells => implicit incorporation of spatial variability
  - **Mesoscale** conceptualization but parameters with **physical** meaning
  - **Global** model
  - Powerful **automatic calibration** (Frances et al., *Journal of Hydrology*, 2007)





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TETIS-SCARCE model

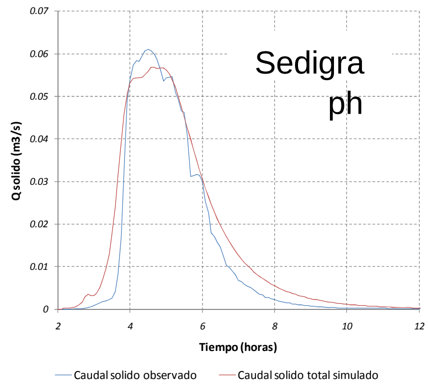
- It will include new **modelling capacities** like:
  - ***Sediment*** production, transport and deposition
  - ***Interactions*** between ***vegetation*** and ***soil moisture*** in semi-arid climates
  - ***Nitrogen*** (N) and ***Phosphorous*** (P) catchment cycles
  - Integration of ***riparian ecosystems***
  - It will ***upscale*** these processes form mesoscale to water body and catchment scales

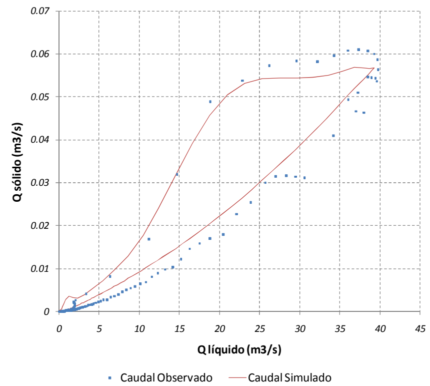
Sediment cycle

- A **sediment yield model** is a useful tool for:
  - Determining ***soil redistribution*** due to environmental changes
  - Location of ***heavy erosion*** and soil ***deposition zones***
  - Assessment of ***land use change*** effect on sediment cycle
  - Estimation of ***soil erosion*** and ***sediment yield*** at different spatial scales

Sediment cycle

- The sediment sub-model coupled to the TETIS model is based on the **CASC2-SED** erosion submodel
  - Balance between ***sediment availability*** and flow ***transport capacity***
  - Hillslope erosion: modified Kilinc and Richardson equation (Julien, 1995)
  - Gully and channel erosion and deposition processes: Engelund and Hansen equation (1967)
- Implemented and tested on Goodwin Creek experimental watershed (USA)
  - Automatic calibration
  - Initial deposits implications





Calibration: NSE = 0.96 on solid discharge
Good fit on hysteresis loop

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Vegetation dynamics

- The ***vegetation*** indeed plays an ***important role*** within the ***water cycle***, in particular in water-controlled ecosystems
  - ***Soil*** and ***climate*** control the ***vegetation dynamic***, while the vegetation modulates the total water balance

Vegetation leaf biomass must be a **state variable** instead of a fixed parameter

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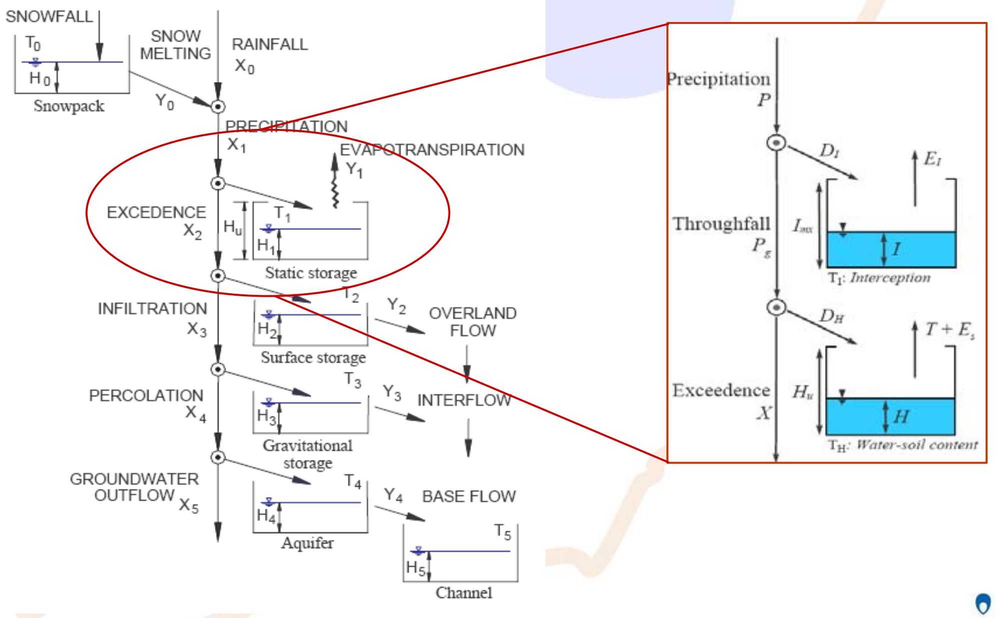
Vegetation dynamics

- A conceptual ***dynamic vegetation sub-model*** is being coupled with the TETIS model
- The **aim** is to represents the ***vegetation response*** and the ***actual leaf biomass influence*** on soil moisture fluctuations, soil water availability and evapotranspiration

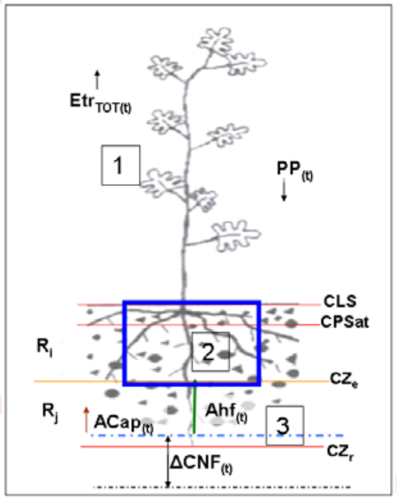


Vegetation dynamics

- **Riparian vegetation** is a key element concerning:
  - ***Retention processes*** (sediment and nutrients)
  - ***Regulation of water temperature*** (shadow effect)
  - ***Controlling low flows*** (reverse flux)
  - ***Fauna habitat*** and its distribution along the river (ecological corridors)

Vegetation dynamics

- Riparian vegetation modelling through ***evapotranspiration index***:
  - Based on the **RibAV** model (Morales and Francés, 2009)
  - In order to obtain the ***most probable vegetation*** functional type in each selected simulation point



RibAV model

Elements:

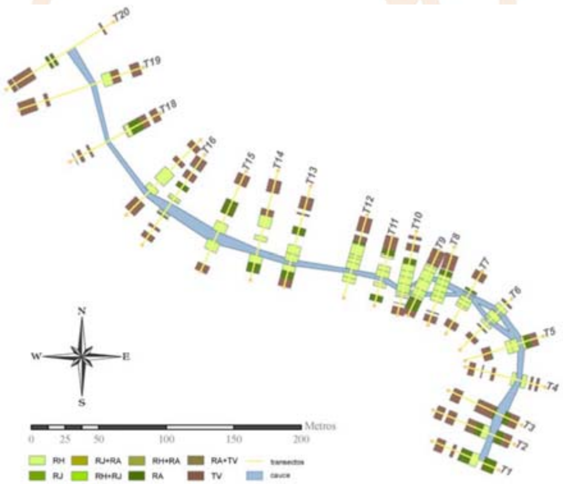
1. Vegetation
2. Static tank-unsaturated zone
3. Saturated zone

Inputs (time series):

PP(t): Precipitation

ET0(t): Potential ET

Q(t): River daily discharges



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Water quality

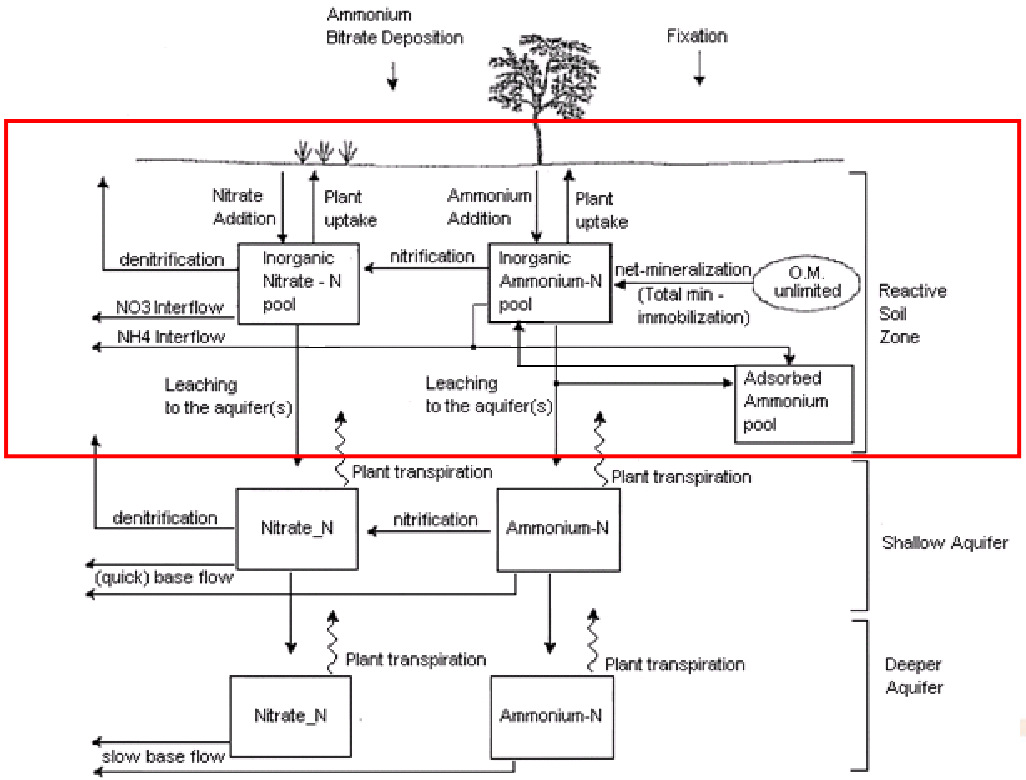
- **Nitrogen** (N) and **Phosphorous** (P) are presents in both terrestrial and aquatic ecosystems and their importance in controlling plant growth and freshwater trophic status is well recognized

- An **N-submodel** to represent the inorganic nitrogen cycle in a catchment has been **already developed**, based on the INCA-N model (Wade et al., 2002) and is being coupled the TETIS model

- The **future work** will be focused on **P export** source areas within a catchment and its **routing** to the stream

Water quality

- Simplified conceptualization of the ***nitrogen cycle***:

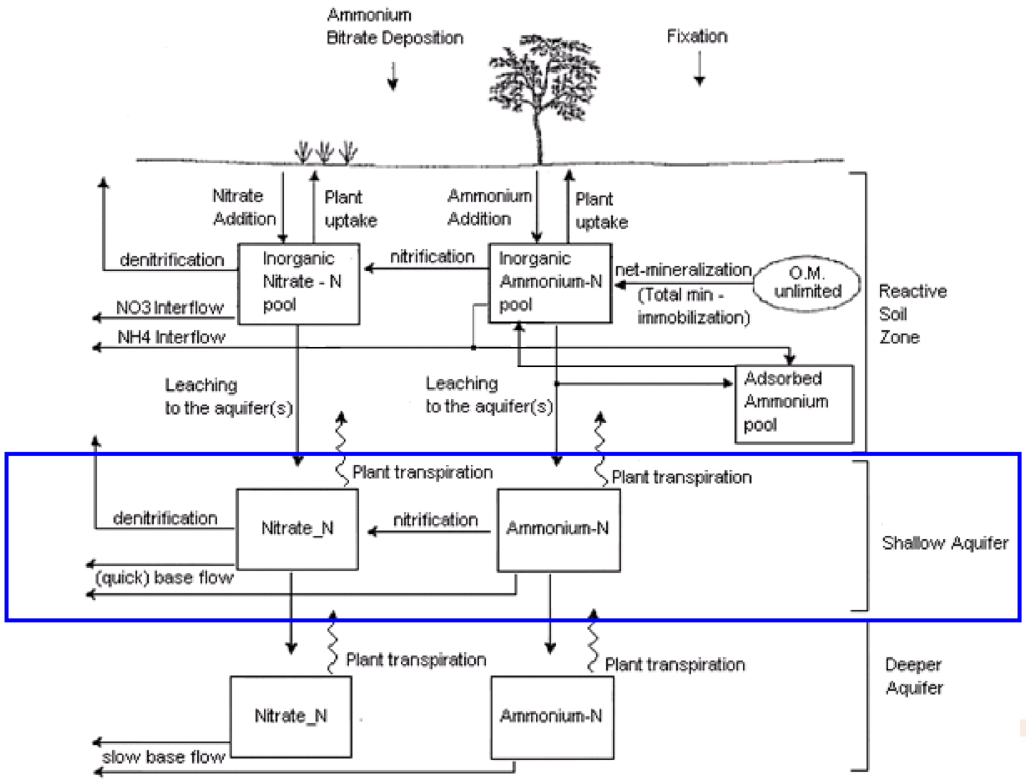


SOIL:

- Mineralization
- Nitrification
- Immobilisation
- Denitrification
- Plant uptake
- Ammonium adsorption/desorption

Water quality

- Simplified conceptualization of the ***nitrogen cycle***:

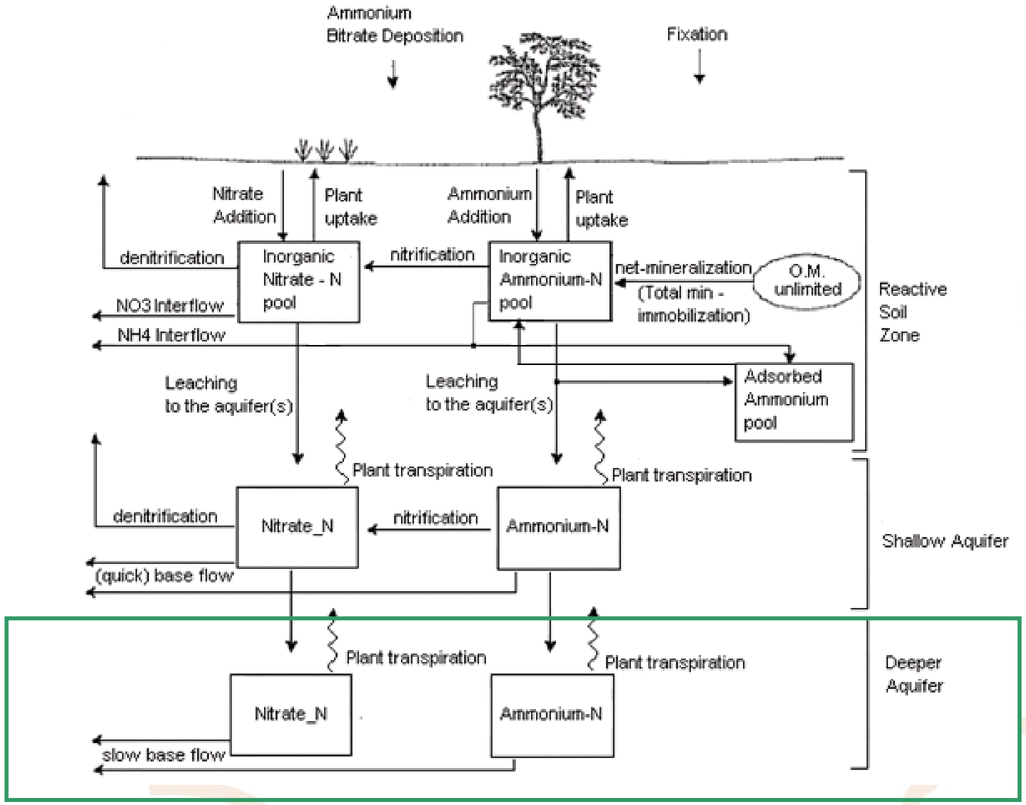


SHALLOW AQUIFER:

- Nitrification
- Denitrification
- Transpiration

Water quality

- Simplified conceptualization of the ***nitrogen cycle***:

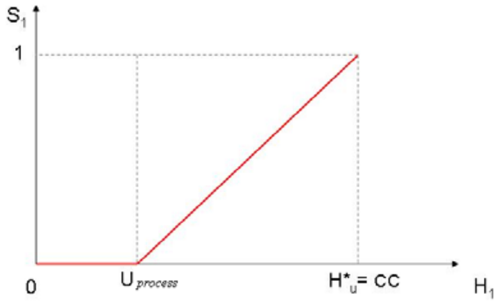


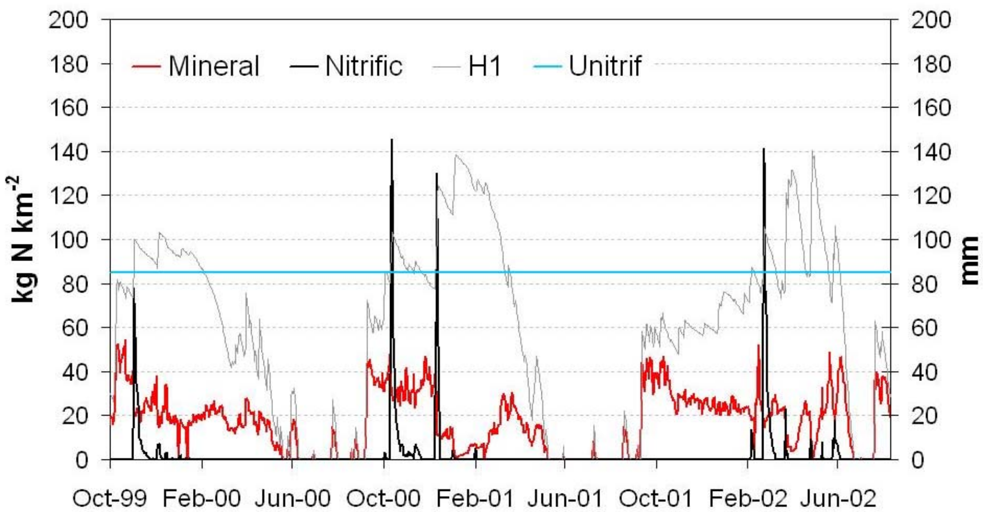
DEEPER AQUIFER:

- Transpiration

Water quality

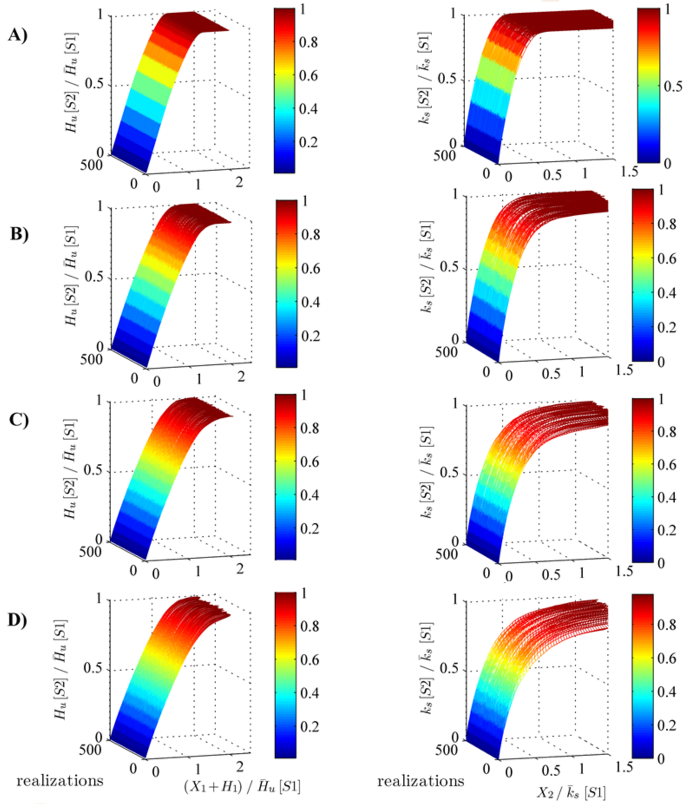
- The model has been thought for ***Mediterranean ecosystems***, which are subjected to **alternate dry** and **humid conditions** that influence the soil microbial activity
- Biological **thresholds** responses to soil moisture





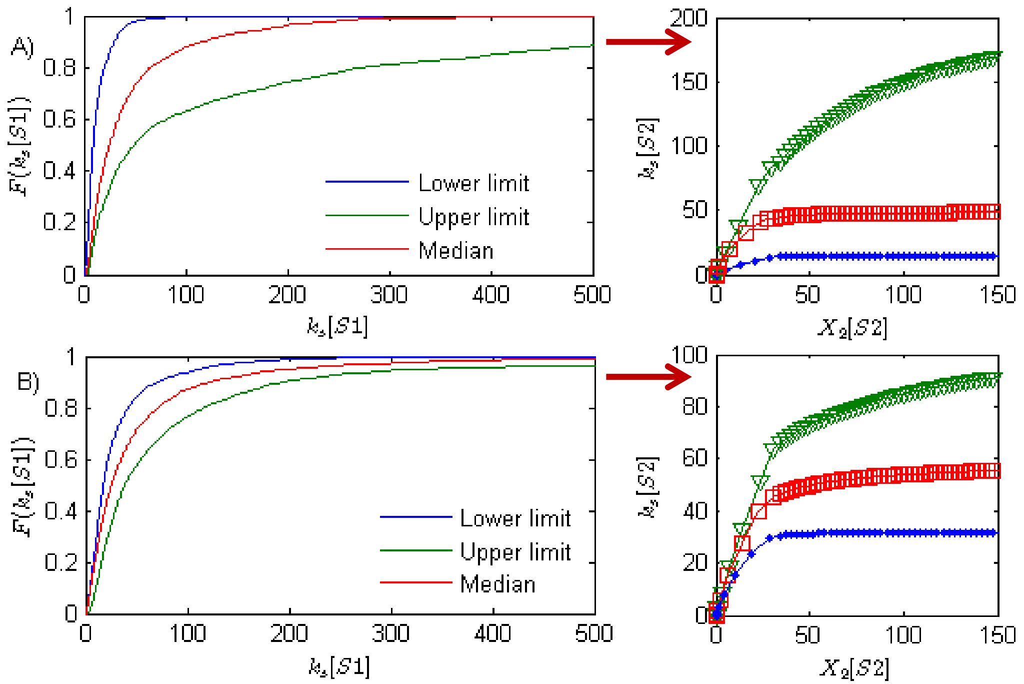
Scaling

- The **spatial scale effect** of two hydrological parameters on the aggregation of infiltration and overland flow production processes has been analysed
  - ➢ According to our aggregation approach, $H_u[S2]$ and $k_s[S2]$ depend on the state variables and spatial variability based on a smaller spatial support S1.
  - ➢ That scaling procedure allows us to deal with ***non-stationary effective parameters*** for DHM (*Francés et al. 2007.)*



Scaling

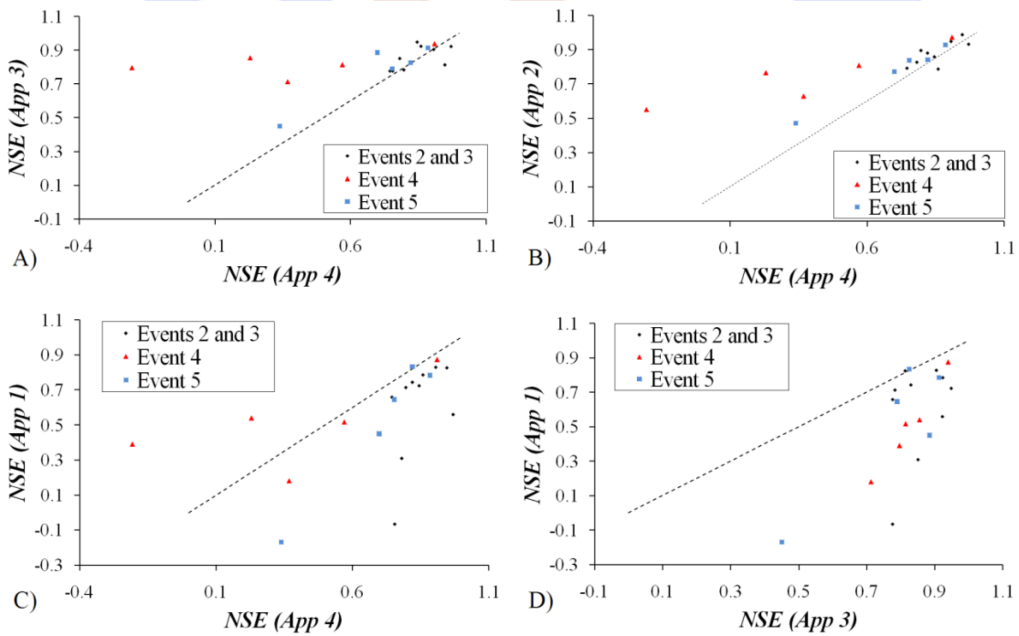
- Propagation of parameter uncertainty (from S1 to S2)
  - The ratio between cell size and correlation length is relevant in the transfer of parameter uncertainty from scale S1 to S2 and the definition of an optimum cell size



- Case A: Cell size smaller then the correlation length. The prediction interval is wide and that uncertainty is transferred to ks[S2]
- Case B: Cell size bigger than correlation length. The uncertainty is smaller, the prediction interval is narrow.

Scaling

- The importance of sub-grid heterogeneities representation of soil parameters within a distributed hydrological modeling framework (TETIS) was tested



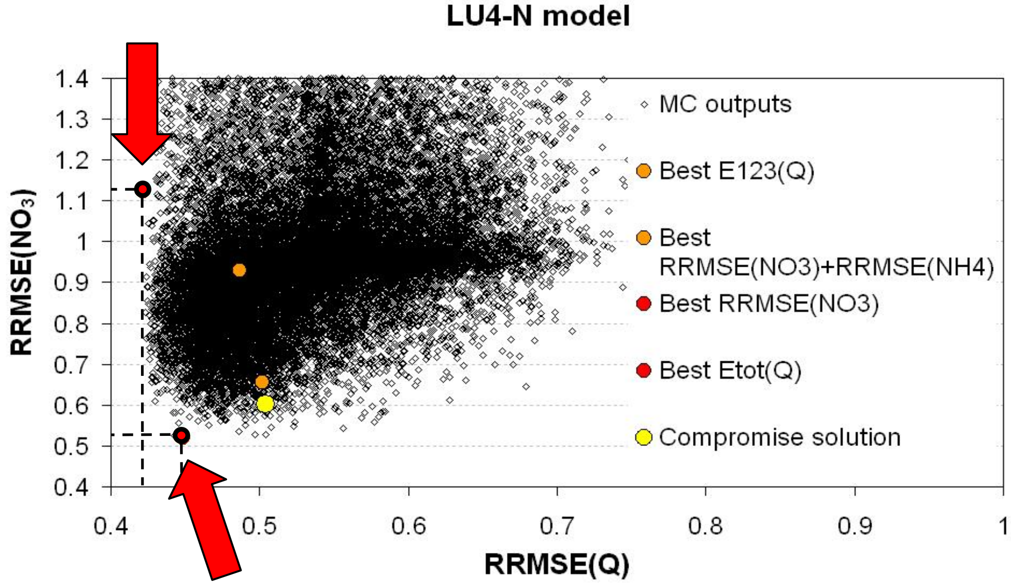
➢ The use of non-stationary effective parameters let us to obtain a more robust model than using stationary effective parameters. (in the sense of better performance of runoff simulations for low magnitude rainfall events)

Synergies and conclusion

- All the **ecological** and **hydrological processes interact** strongly in landscape, yet these processes are often studied separately
    - **Sediment** can carry **nutrients** and pesticides that degrade water quality
    - Trapping/retention effect that **vegetation** may exert on runoff and **sediment** transport
    - **Nutrients** availability is indeed a key factor for **plant growth**
- Ecological interactions can have profound effects and management implications at larger watershed and catchment scale

Synergies and conclusion

- Medici et al. (2010) highlighted that:
  - Stream **nitrate** and **ammonium concentrations** may help to constrain rainfall-runoff parameters
  - Hydrology and water quality simultaneous calibration leads to **reduce** dramatically the number of **equally good parameters** sets



Synergies and conclusion

- **TETIS-SCARCE** will try to take advantage from:
  - The ***knowledge*** provided ***different type of data*** and observed state variables, in order to better constrain model parameters and obtain ***more robust estimations***
  - **Simultaneous calibration** strategy (McIntyre et al., 2005)

Thank you for your attention!

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