Automatic calibration of a parsimonious ecohydrological model in a sparse basin using the spatio-temporal variation of the NDVI

G.Ruiz-Pérez[1], J. Koch[4,5] , S.Manfreda[2] , K.Caylor[3] and F. Francés[1]

(1): Research Institute of Water and Environmental Engineering. Universitat Politècnica de València. Spain.
(2): School of Engineering, University of Basilicata, Italy.
(3): Department of Civil and Environmental Engineering, Princeton University, USA.
(4):Department of Hydrology, Geological Survey of Denmark and Greenland, Denmark
(5):Department of Geosciences and Natural Resources Management, University of Copenhaguen, Denmark

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Università degli Studi Basilicata

PRINCETON UNIVERSITY

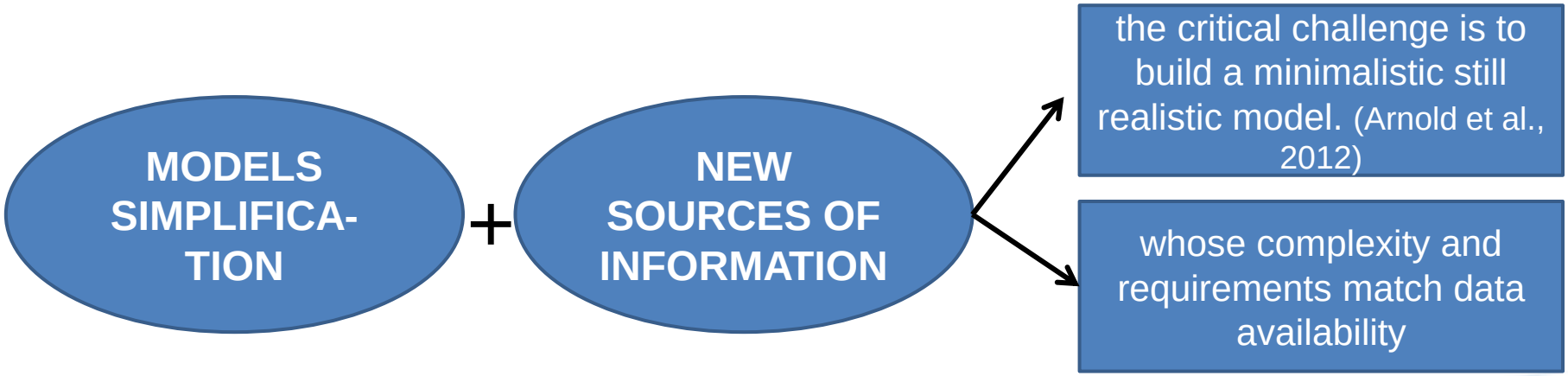
Introduction

- The vegetation plays a key role in a catchment's water balance particularly in semi-arid areas (Laio et al., 2001)

  The ET > 90% of the precipitation (Andersen, 2008)

- The number of hydrological models taking into account the vegetation development has increased substantially

  High parametrical requirement – Data scarcity



Introduction

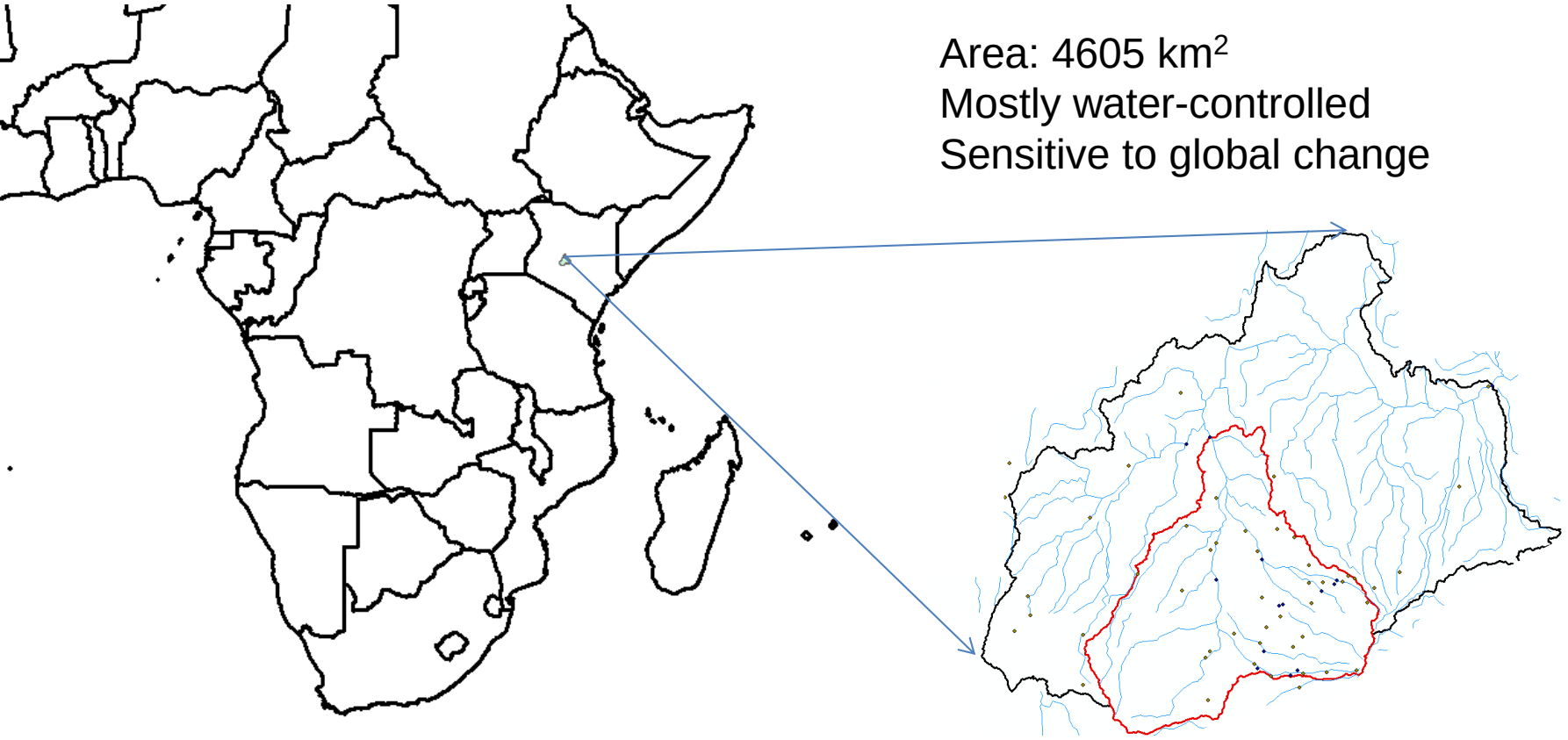
- Applicability of remote sensing data
  - Models forced by remote sensing data
  - Proxy of some parameters
  - Calibration and validation → challenging task
- Bibliographic survey of the Web of Knowledge:

Satellite | Calibration | Implementation | Modelling | Ecohydrology

  - Lumped or semi-distributed models: 76.5%
  - Distributed models: 23.5% → multi-objective approach (1 excepction)

SPATIO-TEMPORAL DATA

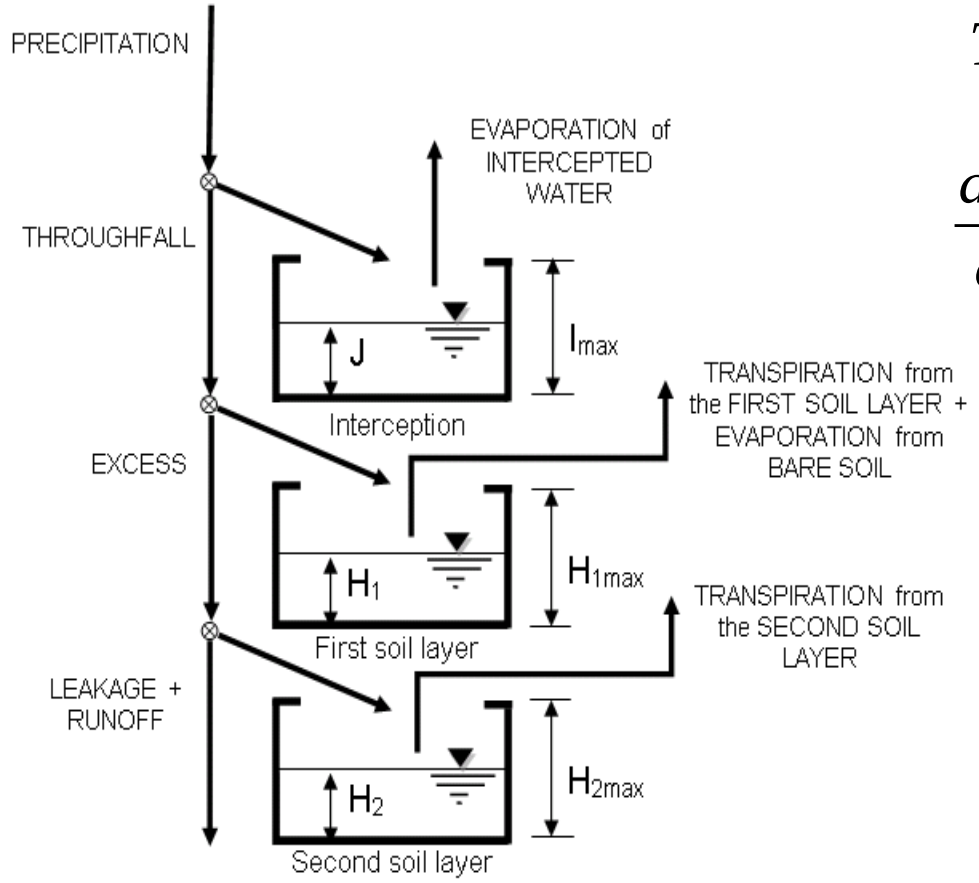
Study area and data



Area: 4605 km^2
Mostly water-controlled
Sensitive to global change

Rainfall: 1950-2003
Temperatures: 1950-Nowadays
Observed discharge: 1980-2002
NDVI: 2000-Nowadays (MODIS products)

ECO-TETIS Model



$$T_1 = ET_o \cdot f_t \cdot \min\left(LAI, 1\right) \cdot \beta_t\left(H_1\right) \cdot r_1$$

$$\frac{dB_l}{dt} = \left(LUE \cdot \varepsilon \cdot APAR - \mathrm{Re}\right) \cdot \varphi_l - \kappa_l \cdot B_l$$

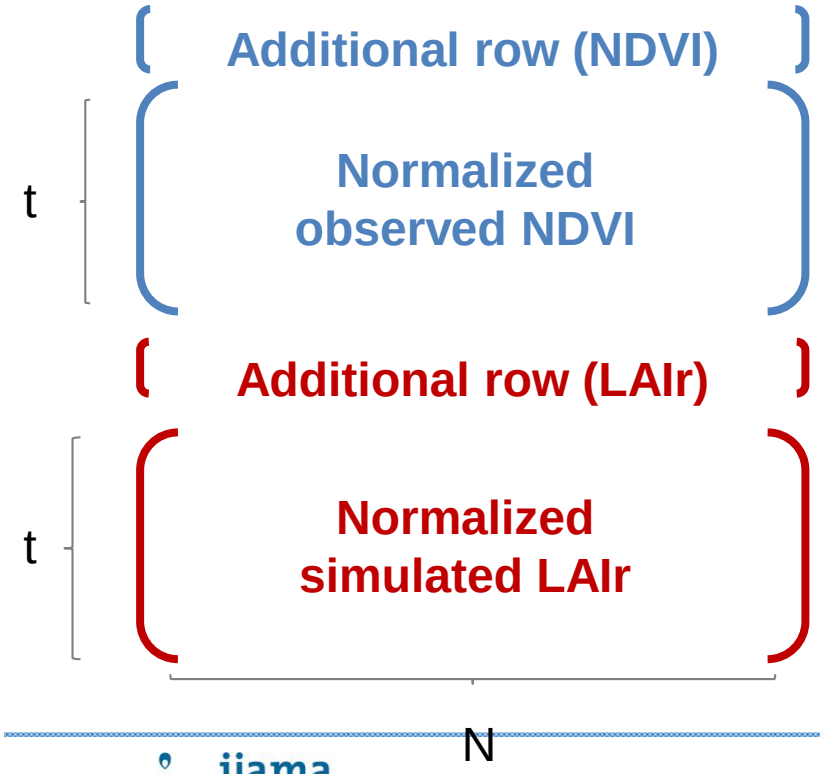
$$LAI = B \cdot SLA \cdot f_t$$

ε depends on:

- Water Stress => connection with hydrological model
- Temperature

ECO-TETIS calibration

- Automatic calibration using EOF analysis
- Minimize the difference between the loadings
- Always according to the explained variance



STEP 1: Concatenate observed and simulated matrices

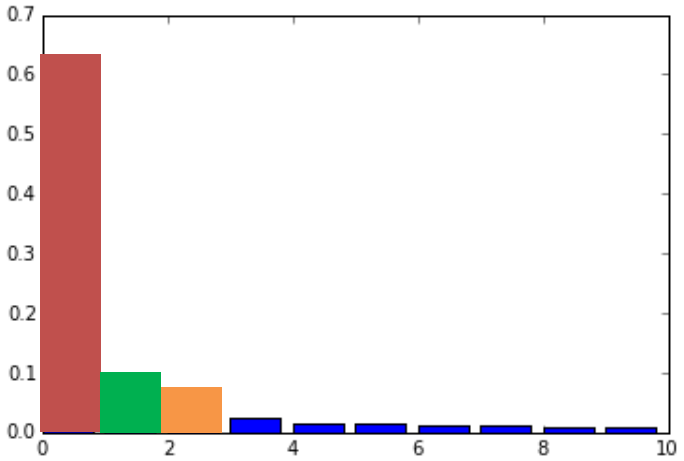
Addition of a row wich takes into account the spatial gradient

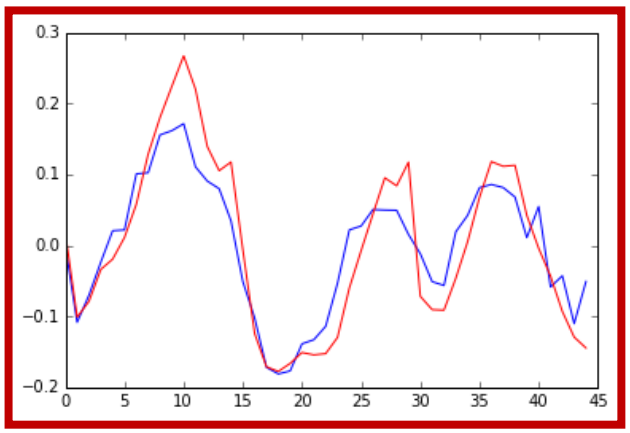
STEP 2: Minimizing loadings differences according to the explained variance

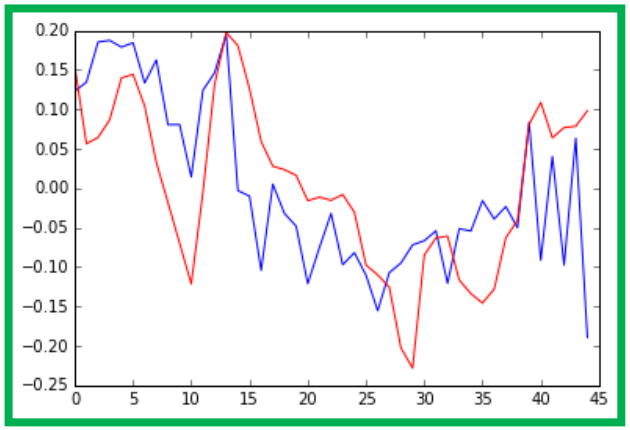
ECO-TETIS calibration

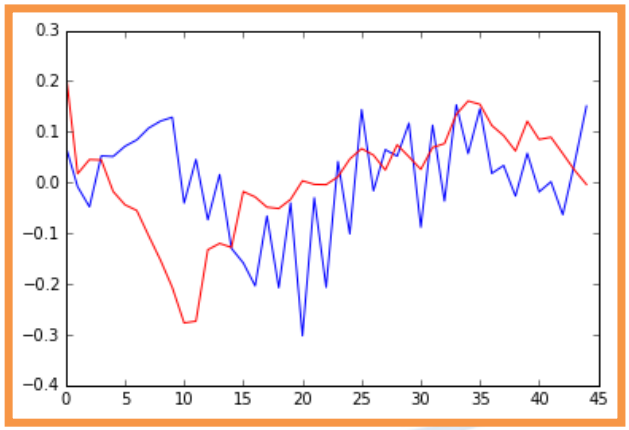
- Calibration process:
  - Python package
  - Objective function:

$$Error = \sum_{i=1}^{n} \left| w_i * (load_i^{SIM} - load_i^{OBS}) \right|$$



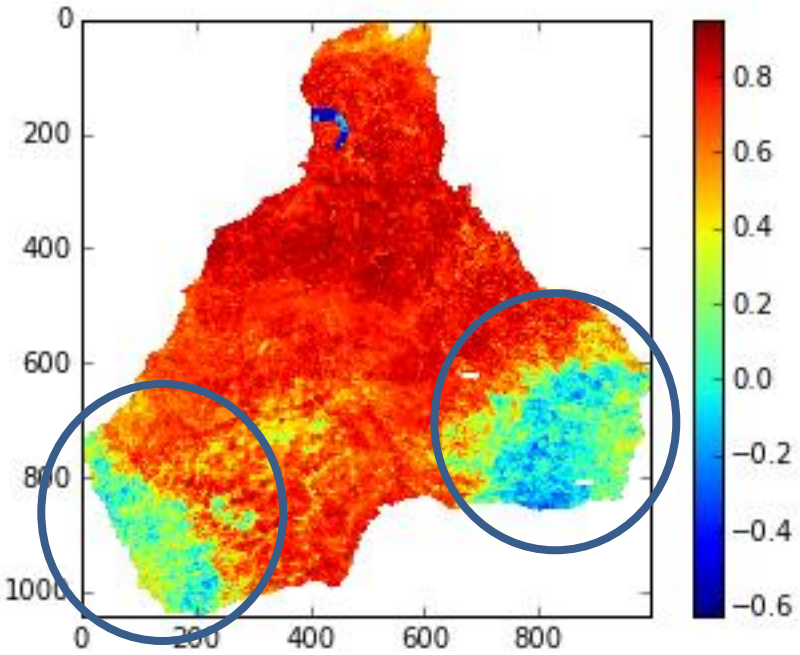




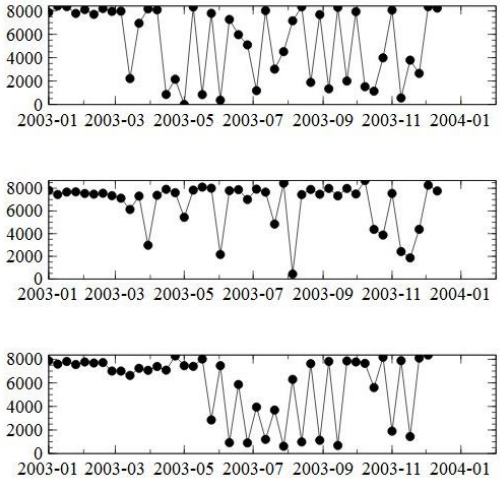


ECO-TETIS calibration

- Results→ Temporal correlation in each pixel

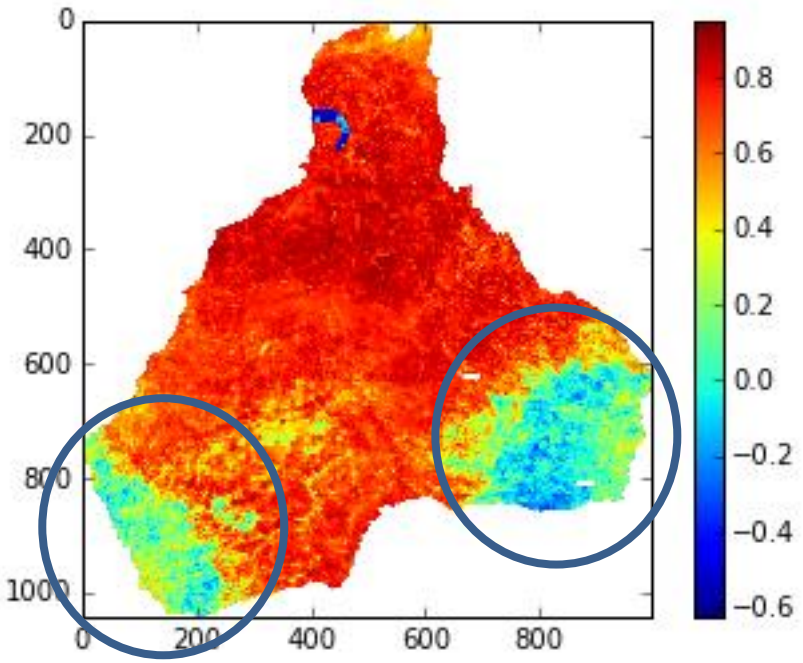


Realistic observed NDVI? Oscillations between 0.8 to 0.2 (even 0.0) just in a week

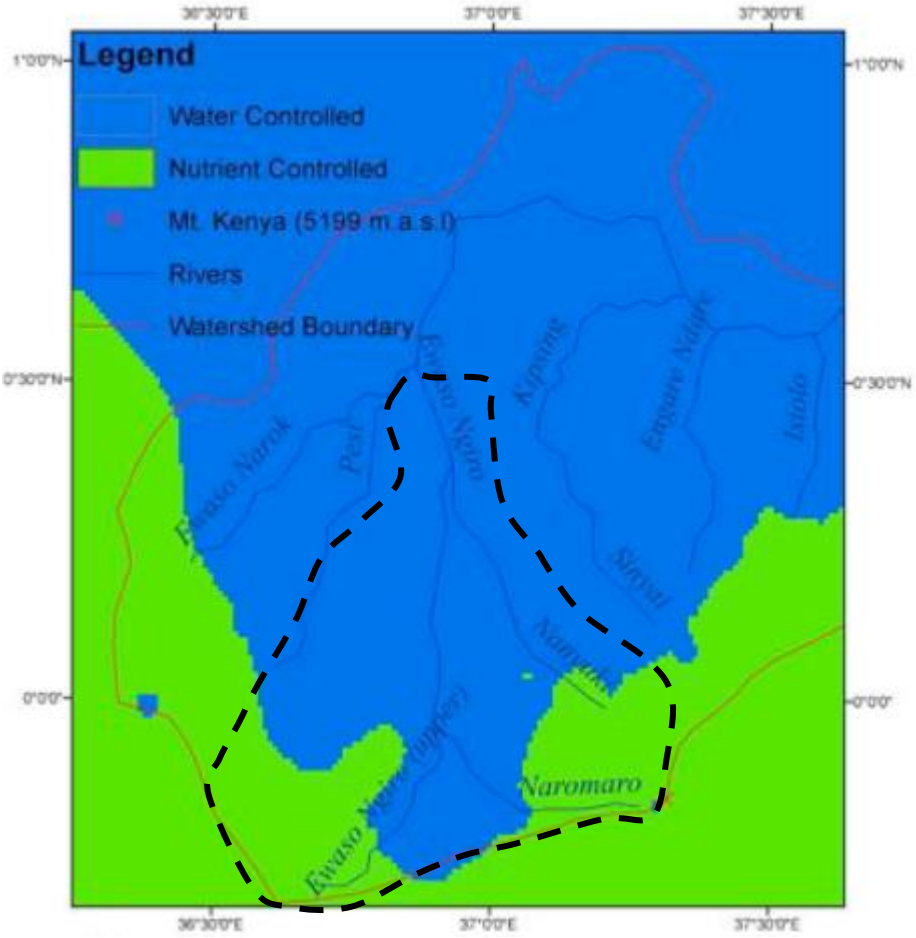


ECO-TETIS calibration

- Why?

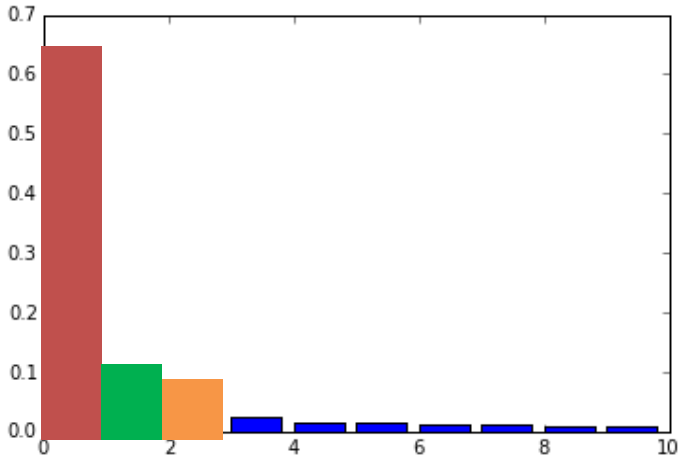


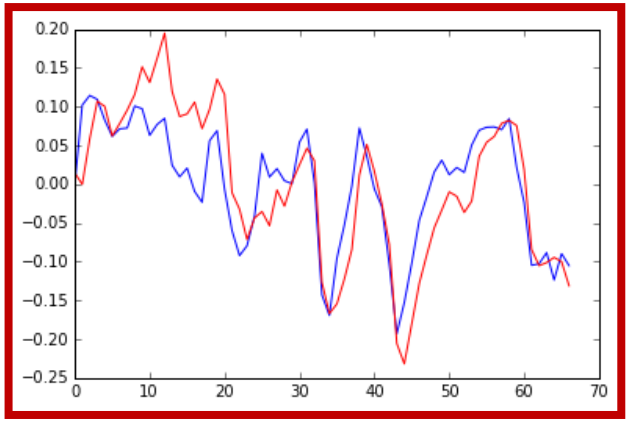
According to a previous work→ No water-controlled areas

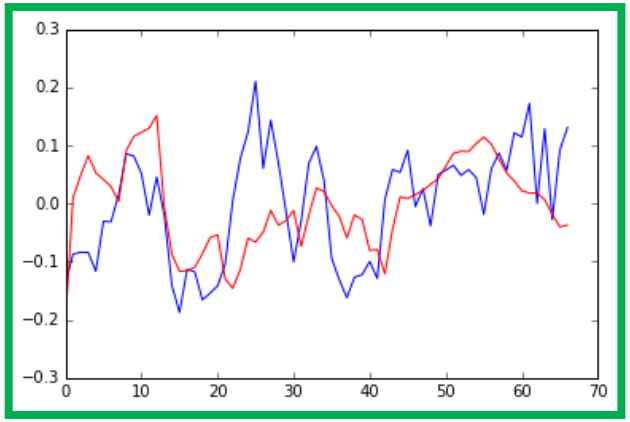


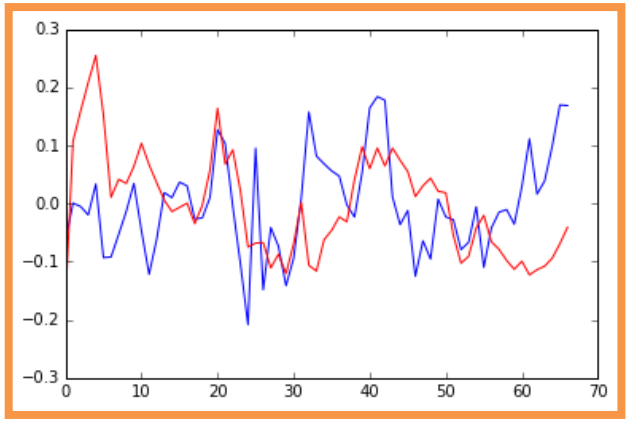
ECO-TETIS validation

- Years 2000, 2001 and 2002
  - Vegetation
    - Loadings comparison
    - Temporal Pearson correlation maps in each year



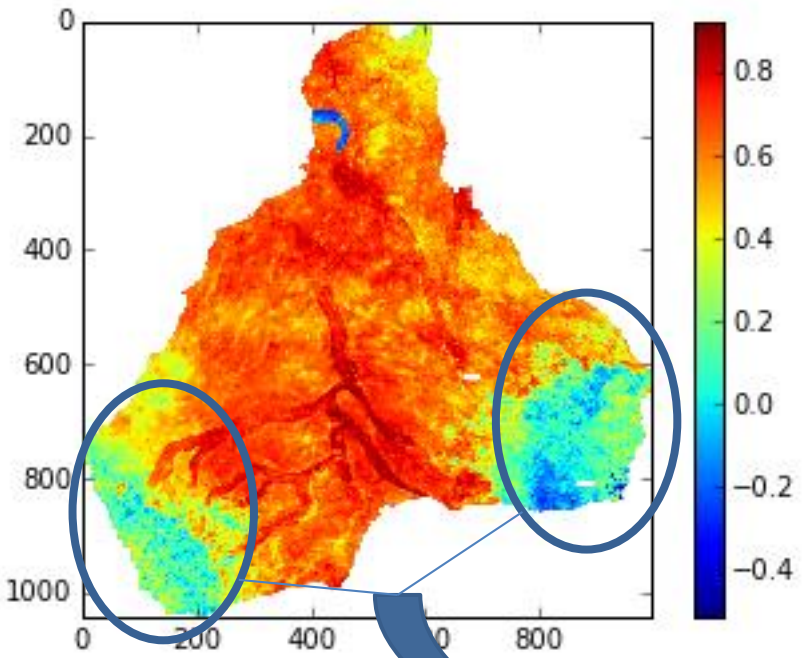






ECO-TETIS validation

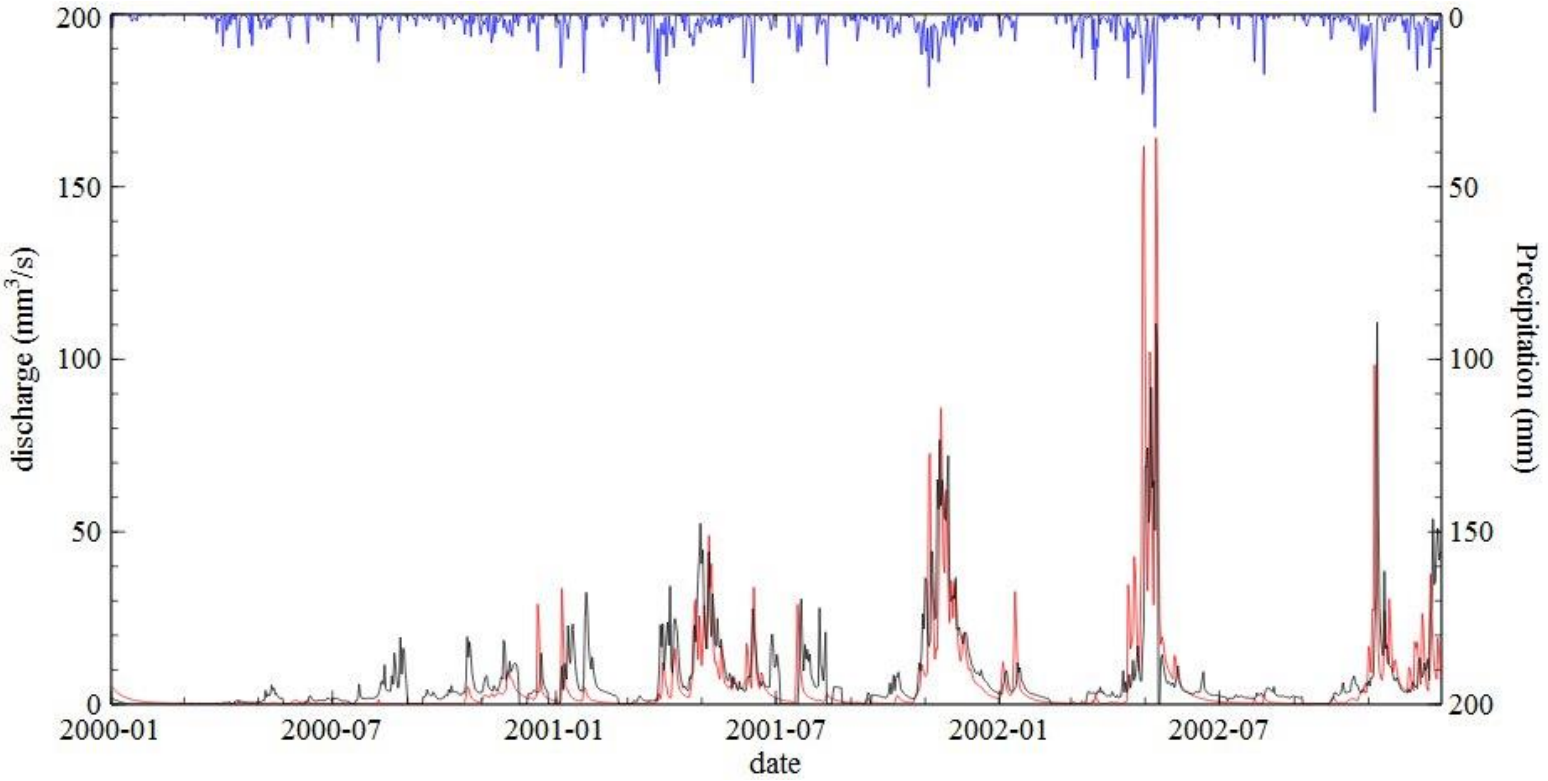
- Years 2000, 2001 and 2002
  - Vegetation
    - Loadings comparison
    - Temporal Pearson correlation maps



Expected
bad results
(even worse)

ECO-TETIS validation

- Years 2000, 2001 and 2002
  - Water
    - Comparison between observed and simulated discharge



Conclusions

- Simple models together to remote sensing data could be a potential alternative in un-gauging basins
- Some limitations:
  - Related to the model (nutrient-limited areas)
  - Related to the satellite data (clouds and others)
- The proposed methodology is an innovative option in order to include spatio-temporal data
- More statistics and methodologies must be proposed and analyzed if we want to use spatio-temporal data

Thanks for your attention

Guiomar Ruiz-Pérez (guruipr@cam.upv.es)

Research Group of Hydrological and Environmental Modelling

lluvia.dihma.upv.es

Research Institute of Water and Environmental Engineering

iiama.upv.es

Universitat Politècnica de València

This work has been funded by the Spanish Ministry of Economy and Competitiveness through the research project INTEGRA (ref. CGL 2011-28776-C02). The MODIS data were obtained through USGS/Earth Resources Observation and Science (EROS) center (https://lpdaac.usgs.gov/data_access). The meteorological data were provided by the Spanish National Weather Agency (AEMET).