Coupling SWAT and MOHID WATER coastal numerical model

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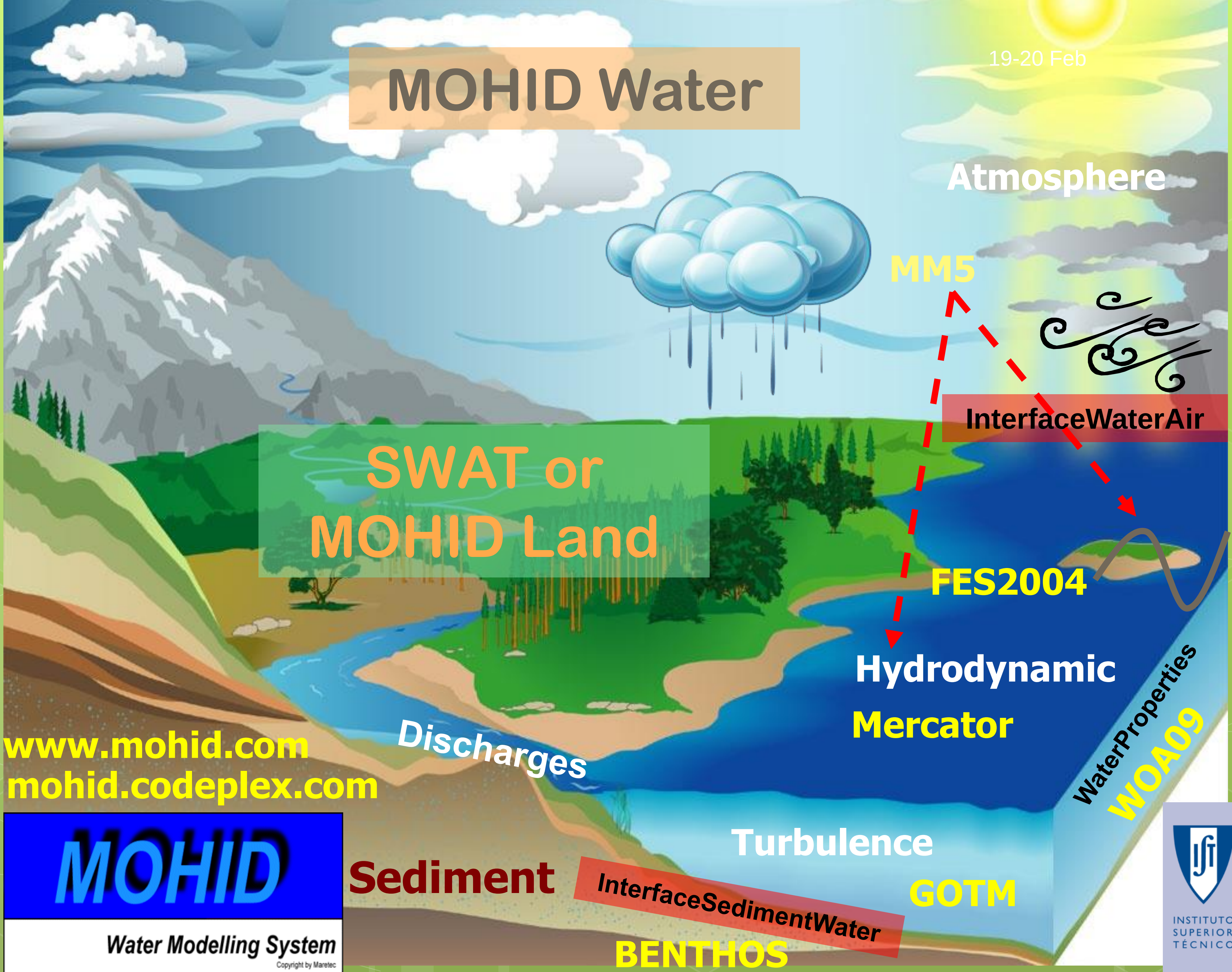
Overview

- Mohid Water
- Vouga in Aveiro – Portugal

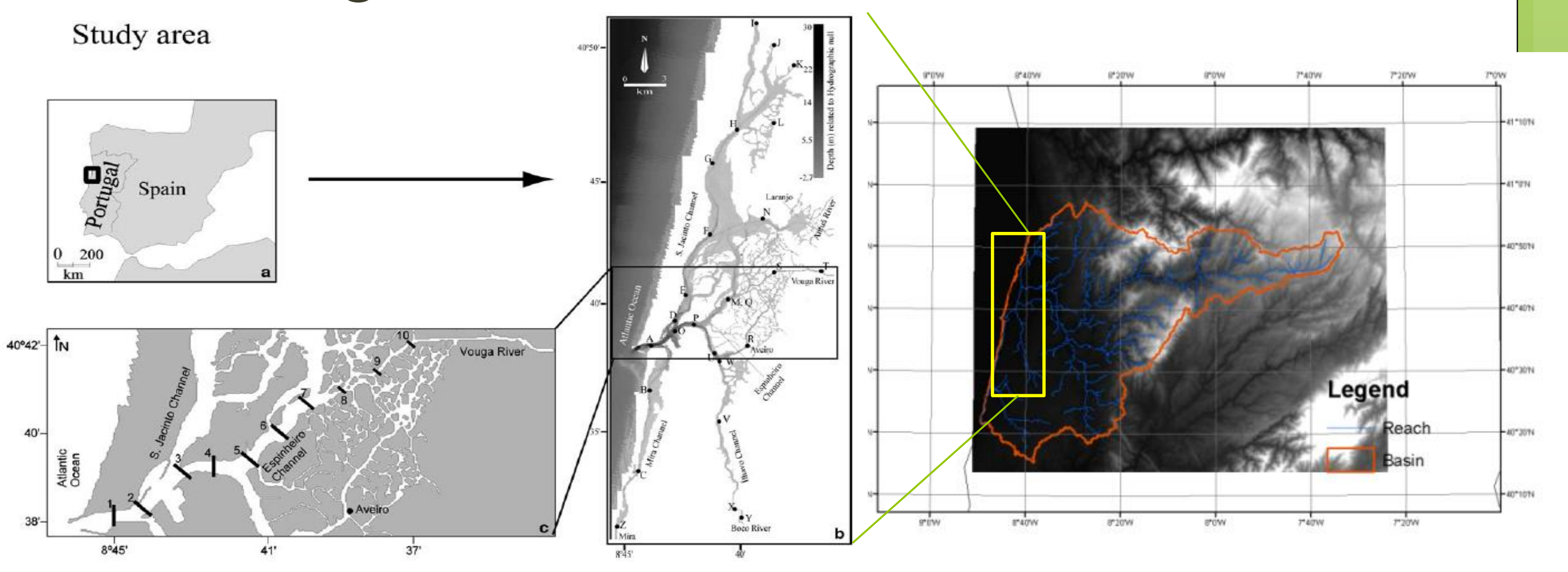
DyEPlume
Estuarine Dynamics and Plume Propagation in the Portuguese Coast
Impacts of Climate Change

- Umbeluzi in Maputo – Mozambique
- Enxoé in Serpa - Portugal


MOHID Water
19-20 Feb
Atmosphere
MM5
InterfaceWaterAir
SWAT or
MOHID Land
FES2004
Hydrodynamic
Mercator
WaterProperties
WOA09
www.mohid.com
mohid.codeplex.com
Discharges
Turbulence
GOTM
Sediment
InterfaceSedimentWater
BENTHOS
MOHID
Water Modelling System
INSTITUTO SUPERIOR TÉCNICO

Vouga

- Vouga watershed is located in central Portugal, extends for an area of approximately 3400 km^2 and discharges into the Ria de Aveiro, a tidal coastal shallow lagoon

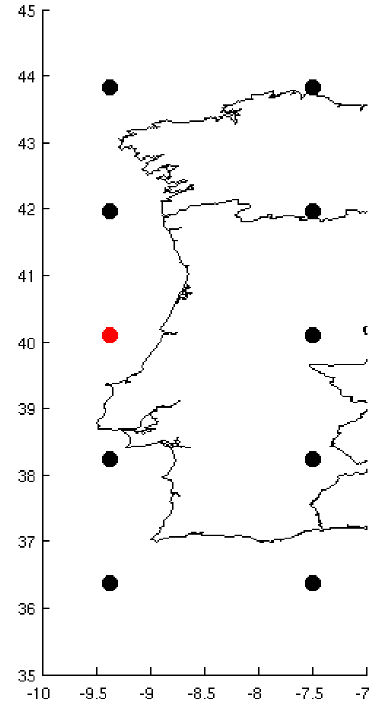


Climate model - ECHAM5

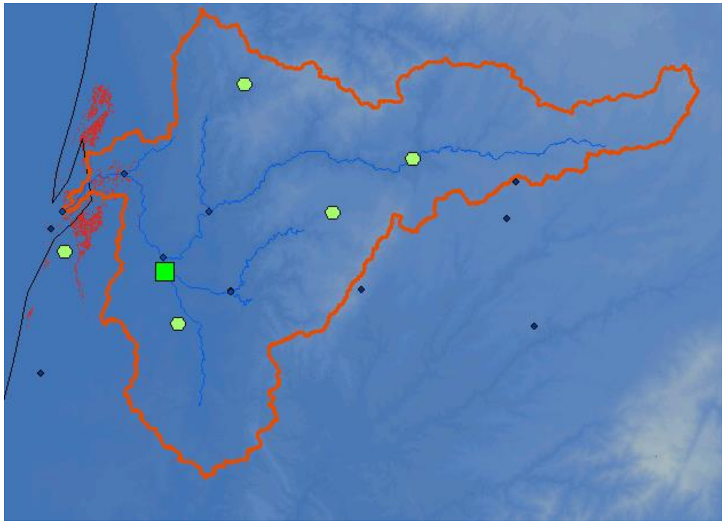
- Results were obtained from simulations of the coupled atmosphere ocean model ECHAM5/MPI-OM, now on referred as ECHAM5.
- This a model that participated in the Intergovernmental Panel on Climate Change – Fourth Assessment Report (IPCC-AR4).
- Results for the period **1971-2000**, which represents the **present** climate, are from the 20th Century Climate
- Results for the climate change **future** scenario, for the period **2071-2100**, are from the SRES-A2 experiment (Roeckner et al., 2006), which implies a continuously increasing greenhouse gases emissions and global population.

Climate model

- Center of the cells of the ECHAM5 modeling Grid. In red the center of the cell where results were obtained for climate scenarios.



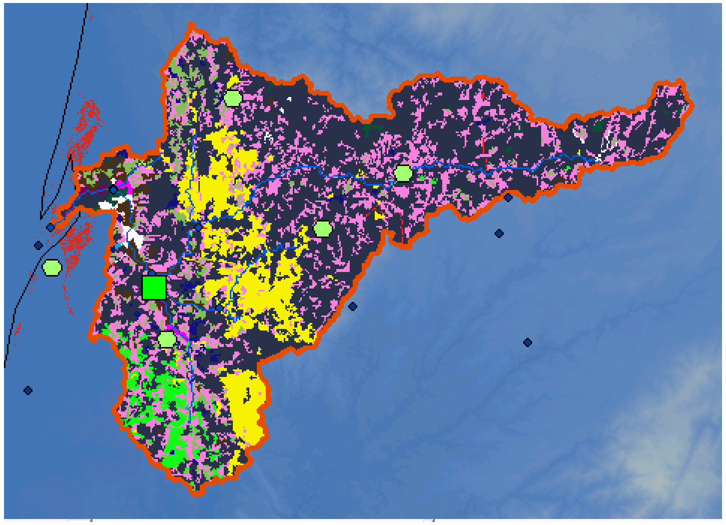
Watershed model - SWAT



- The digital elevation model (DEM) is in a raster format with a grid resolution of 70 m, which has been clipped from the Shuttle Radar Topography Mission (SRTM) DEM data (Hounam & Werner, 1999).

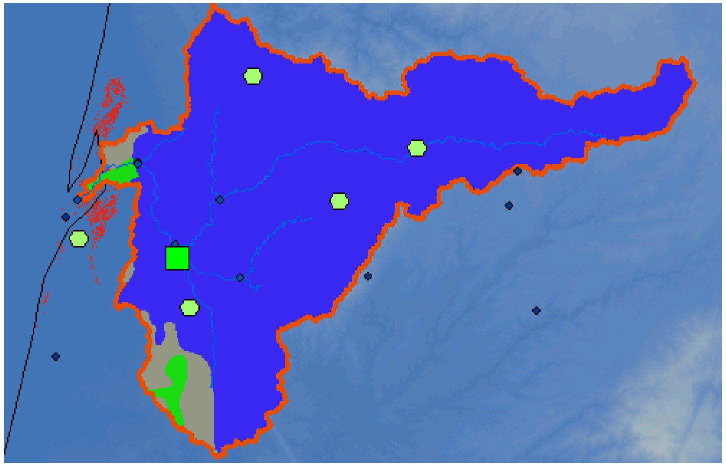
Land Use

- The land use map has been clipped from the CORINE 2000 whose legend is based on the CORINE level 3 legend. The original legend entries were reclassified and, in some cases, aggregated to conform to the land use database present in the SWAT model (the watershed results included 15 land use classes).

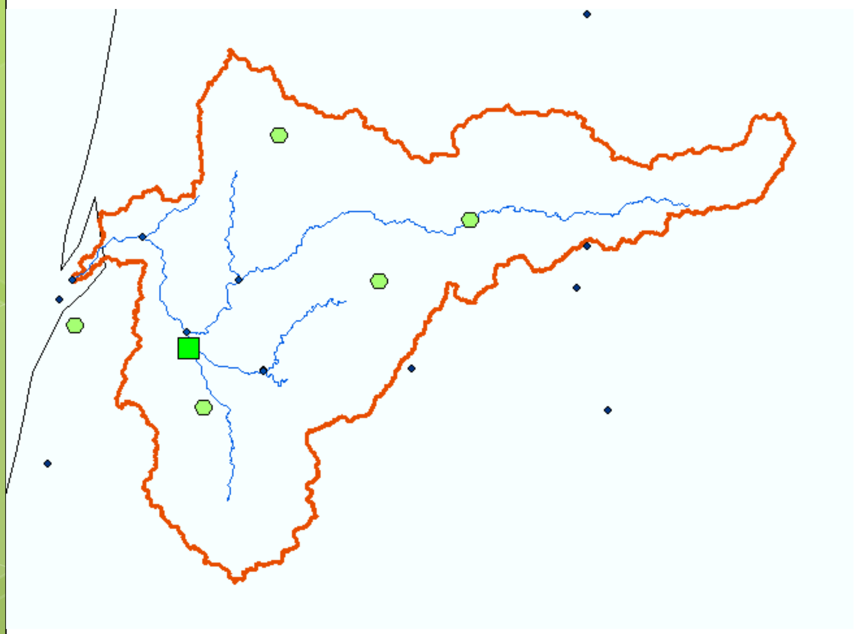


Soil type

- The soil map 1:1 000 000 was gathered from EEA data center in vector form covering the entire Watershed. The physical-chemical parameters needed to fill the SWAT soil database were produced using pedotransfer functions based on texture (Saxton et al., 1986).



Metereology



- Daily precipitation data were obtained for several stations in the area; only those having long near-complete time series were retained. Daily precipitation values from 1931 to 2010 were obtained for 5 stations

Lagoon model - Mohid Water

- In the Ria de Aveiro application elevation at the open boundary is specified from the tidal constituents
- Salinity and water temperature are also imposed at the ocean open boundary and are considered constant.
- At the river boundaries the river flow is imposed and salinity and water temperature are assumed constant.
- The model was used to simulate the horizontal patterns of salinity along the whole lagoon. The model was spun-up for 34 days (about 2 times the general residence time of the lagoon) in order to achieve a steady state solution.

Sensitive Analysis

- SWAT-CUP software was used find the most sensitive parameters to flow. Parameter sensitivities are determined by calculating a multiple regression system, which regresses the Latin hypercube generated parameters against the objective function values. A t-test is then used to identify the relative significance of each parameter. This gives relative sensitivities based on linear approximations and, hence, only provides partial information about the sensitivity of the objective function to model parameters.

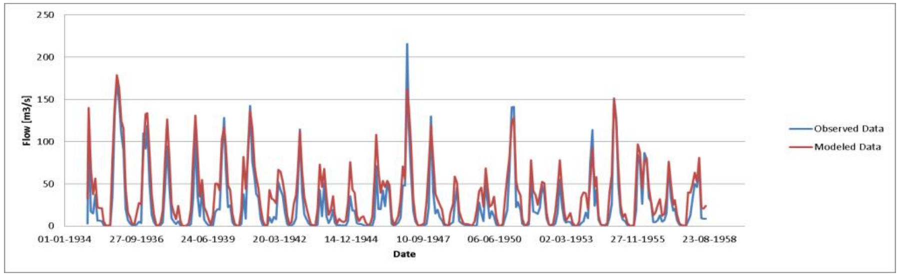
Sensitive Analysis

- t-stat provides a measure of sensitivity (larger in absolute values are more sensitive) p-values determined the significance of the sensitivity. A value close to zero has more significance. The most sensitive parameters are initial SCS curve number (CN2) and Groundwater delay time (GW_DELAY). Normally these are the most sensitive parameters in SWAT model.

Parameter Name	t-Stat	P-Value
v__CH_N2.rte	-0.019	0.985
v__GWQMN.gw	0.199	0.844
r__SOL_BD(1).sol	0.209	0.836
v__ESCO.hru	-0.227	0.822
v__ALPHA_BF.gw	-0.243	0.810
r__SOL_K(1).sol	-0.284	0.778
v__GW_REVAP.gw	0.313	0.757
v__CH_K2.rte	0.395	0.696
r__SOL_AWC(1).sol	0.993	0.330
v__SFTMP.bsn	-1.060	0.299
v__ALPHA_BNK.rte	1.242	0.225
v__GW_DELAY.gw	-2.853	0.008
r__CN2.mgt	3.647	0.001

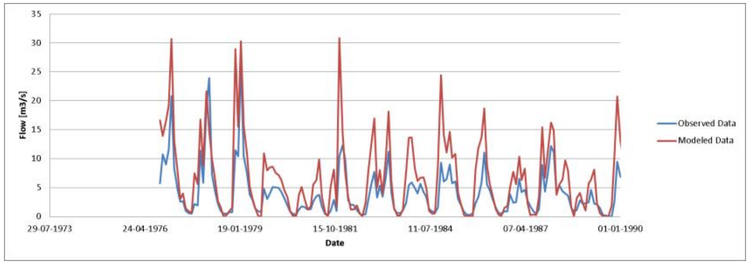
Calibration

Flow gage station	Vouga		Antuã	
	Daily	Monthly	Daily	Monthly
R2 - Pearson Product-Moment Correlation Coefficient [-]	0.60	0.88	-	-
E - Model efficiency (Nash-Sutcliffe) [-]	0.51	0.77	-	-

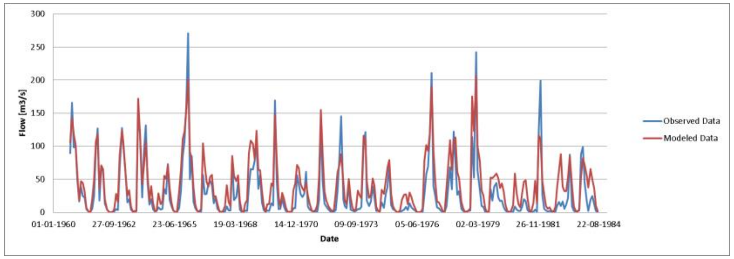


- Following the sensitivity analysis, SWAT monthly calibration was carried out using the data from 1931 to 1960. The results were then assessed based on the visual agreement observed and simulated stream flow plots and the performance statistics generated i.e. R2 and E which are 0.88 and 0.77 respectively

Validation



Flow gage station	Vouga		Antuã	
	Daily	Monthly	Daily	Monthly
R2 - Pearson Product-Moment Correlation Coefficient [-]	0.50	0.82	0.37	0.76
E - Model eficiency (Nash-Sutcliffe) [-]	0.40	0.74	-1.81	-0.05



- Similar results were obtained for validation period which ranges from 1961 through 1990 R2 estimate of 0.82 and E estimate of 0.74

Scenarios

- Three scenarios were analyzed with wavelet analysis. One with calibrated model as described in the calibration validation section. Other two SWAT model scenarios with precipitations from climate model ECHAM5.

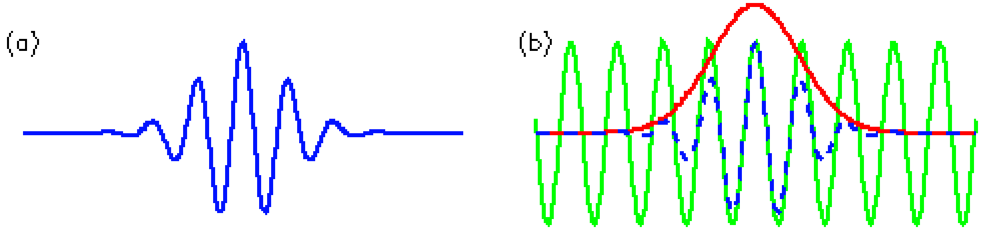
Scenario	Description
A-Cali	measured input precipitation to the catchment model
B-NoCC	precipitation from ECHAM5 model as (with no climate changes) input to catchment model
C-CC	precipitation from ECHAM5 model (considering climate changes) as input to catchment model

Wavelet Analysis

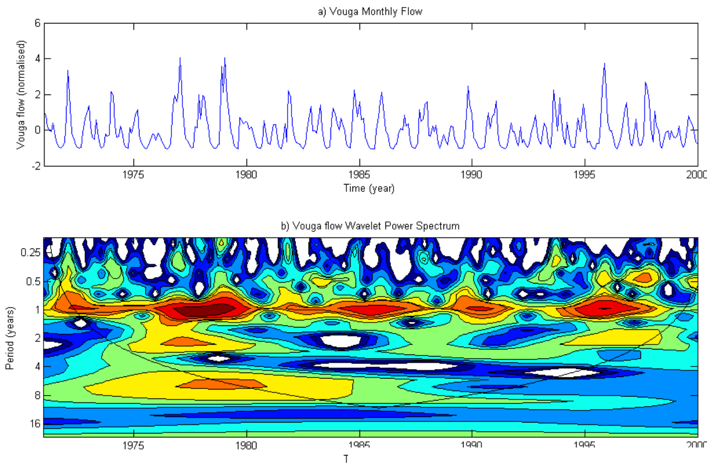
- The time series of Vouga flows for the three scenarios and for the period of 1970-2000 are shown in along with their local wavelet spectra. The future scenarios that were generated for the period of 2070 until 2100 are also presented in the period of 1970-2000 for simplicity in comparing time series.

Wavelet Analysis

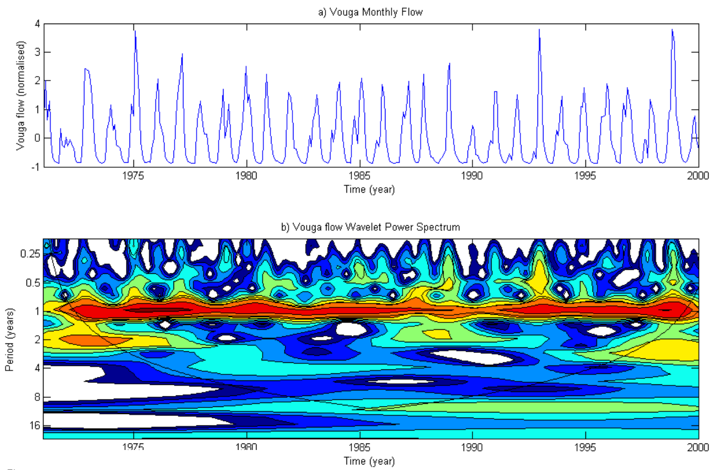
- In Figure a we see an example of a wave "packet", of finite duration and with a specific frequency. This "wavelet" has the advantage of incorporating a wave of a certain period, as well as being finite in extent. In fact, the wavelet shown in Figure a (called the Morlet wavelet) is nothing more than a Sine wave (green curve in Figure b) multiplied by a Gaussian envelope (red curve).



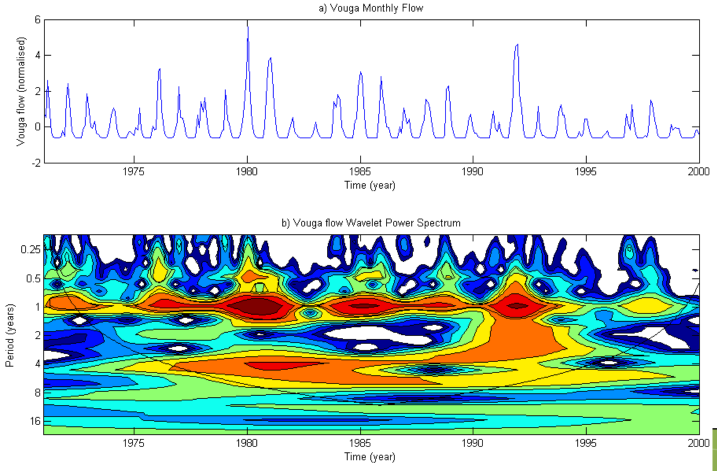
Wavelet Analysis



A



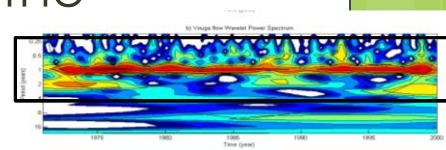
B



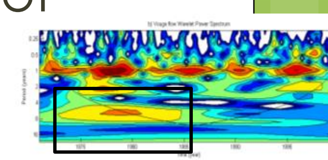
C

Wavelet Analysis

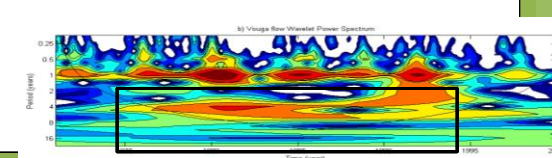
- In all figures is possible to see the high frequency power of 1 year repeated in most of the years. This tendency is more clear in scenario B-NoCC, where the 1 year frequency power is shown though the almost continuum red area in the wavelet spectrum.



- The low-frequency power (between 4 and 8 year) of the flow time series is strongest in in the first set of years in the A-Cali scenario.

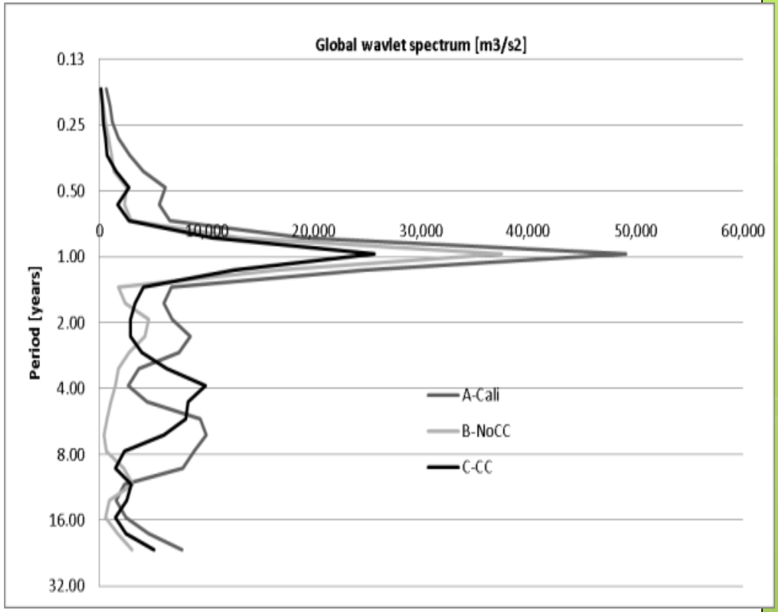


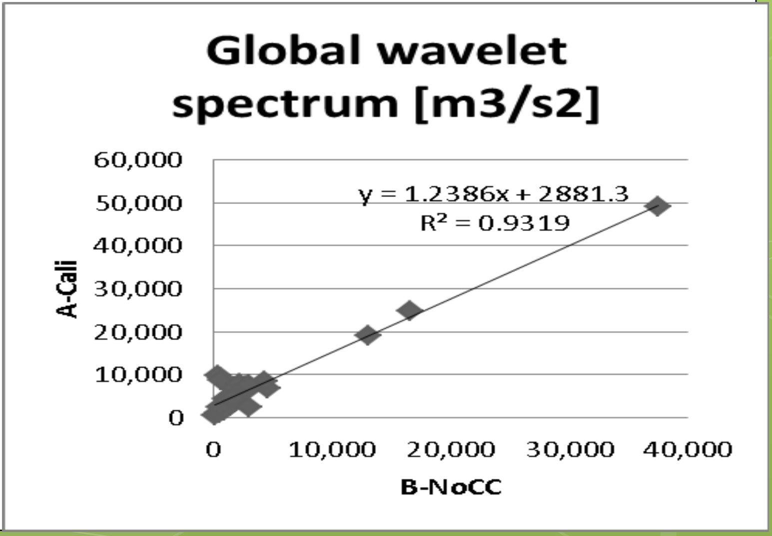
- In scenario C-CC there is a tendency for a low frequency power (between 3 and 5 years) in the middle of time series between 1975 and 1995



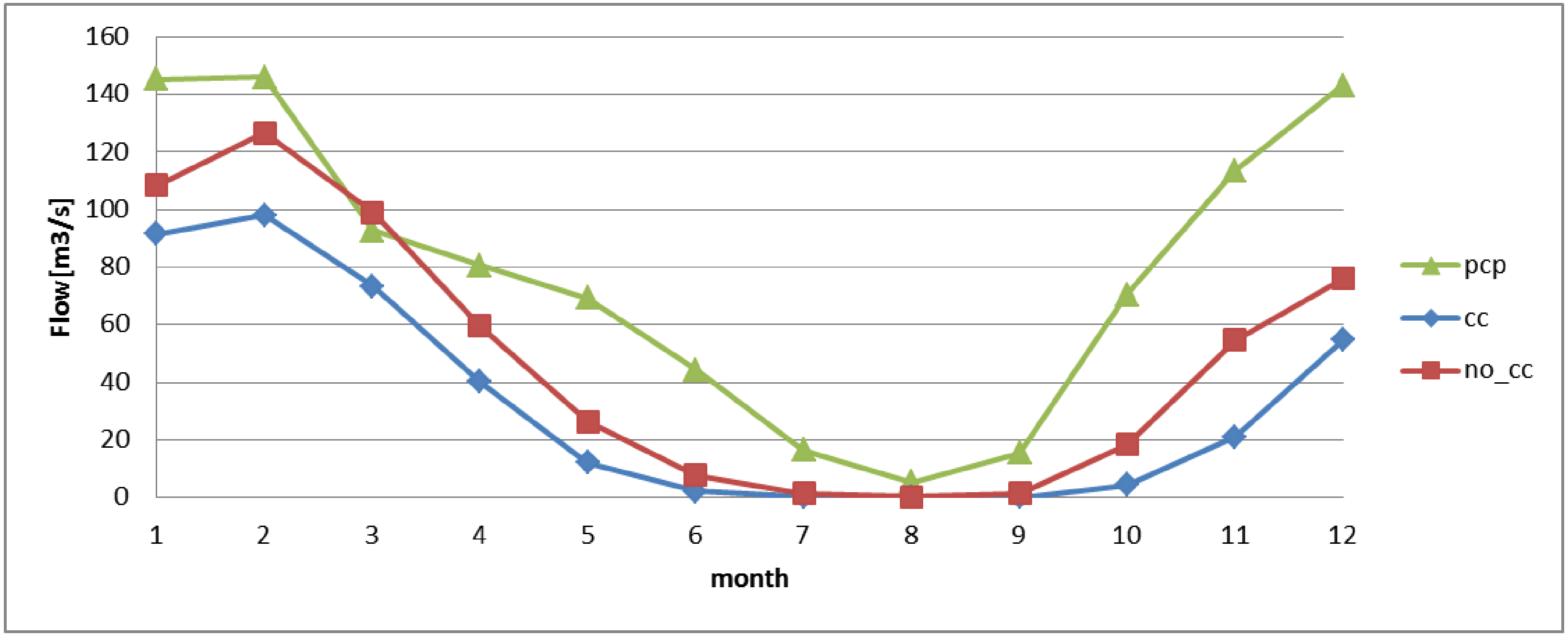
Global wavelet spectrum

- Since the wavelet spectrum presents a large amount of information in one image, it is often desirable to condense this information by averaging the results over a range of scales or times.
- Torrence and Compo (1998) call this the 'global wavelet spectrum'. The result is a graph of variance versus scale, analogous to the Fourier power spectrum, in which localization in time is lost
- The strong power at 1 year periods in the local wavelet spectra appears to decrease with climate change. Climate change also has a clear tendency for higher powers in periods of around four years. It is also possible to see a peack in A-Cali at 7 years and at 4 in the C-CC scenario. This corresponds to the red areas that were described in previous paragraph for the wavelet spectrum.



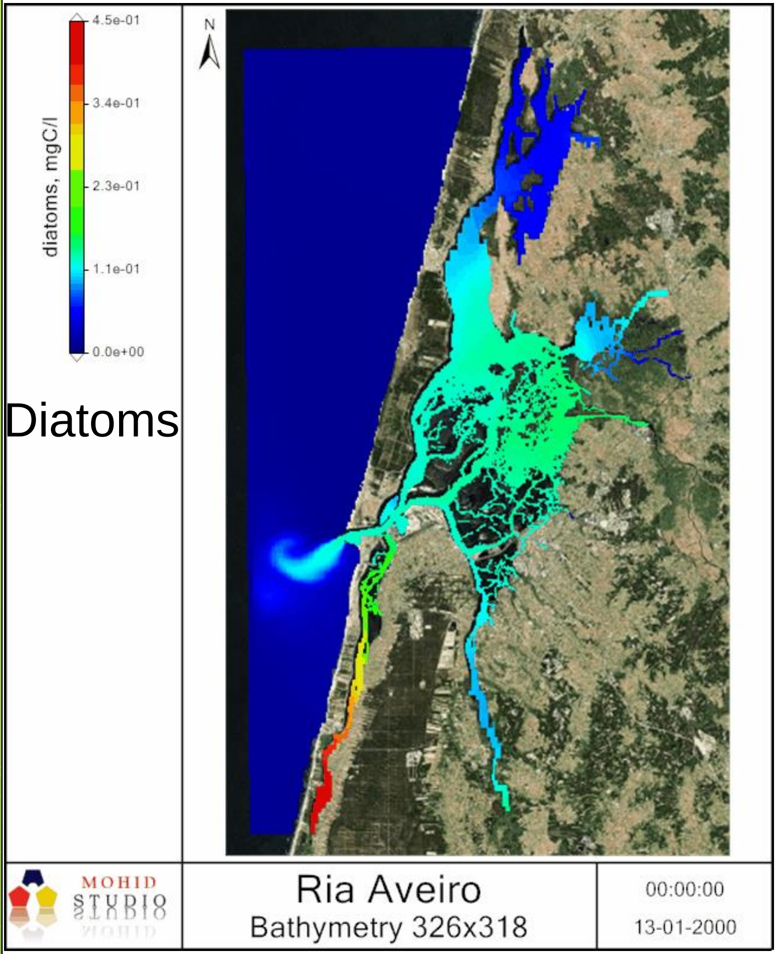


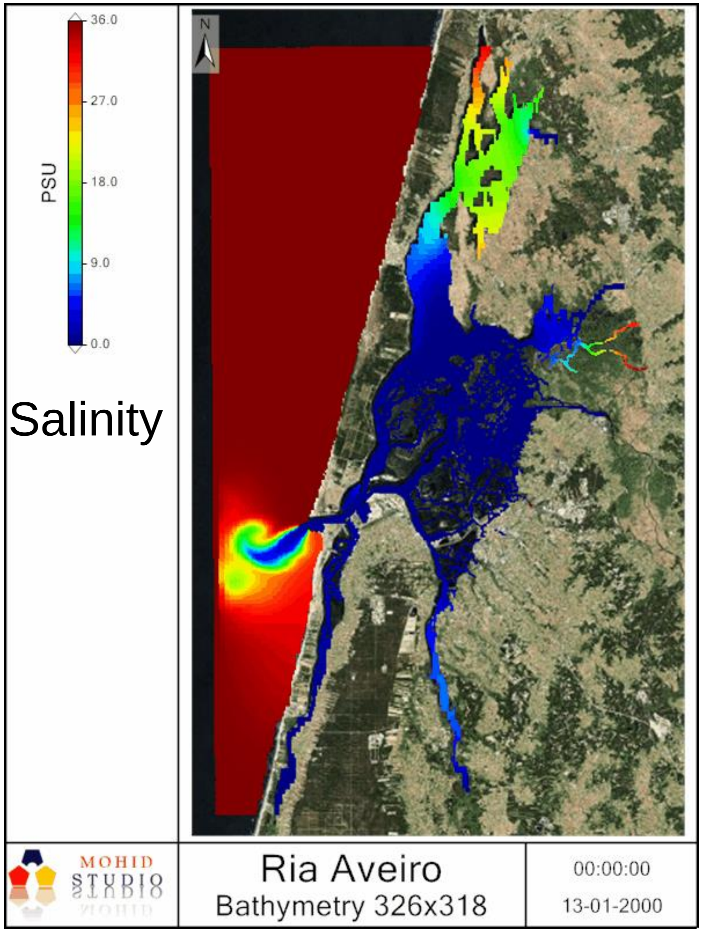
Monthly



160
140
120
100
80
60
40
20
0
Flow [m3/s]
1
2
3
4
5
6
7
8
9
10
11
12
month
pcp
cc
no_cc

MOHID WATER


4.5e-01
3.4e-01
2.3e-01
1.1e-01
0.0e+00
diatoms, mgC/l
N
Diatoms
MOHID STUDIO
Ria Aveiro
Bathymetry 326x318
00:00:00
13-01-2000


36.0
27.0
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9.0
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N
Salinity
MOHID STUDIO
Ria Aveiro
Bathymetry 326x318
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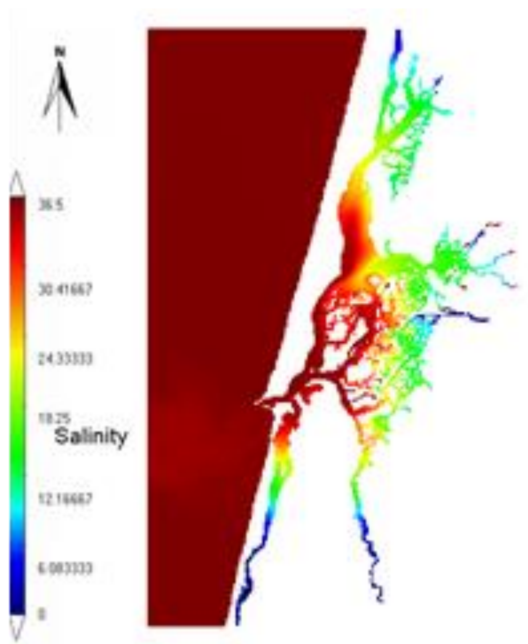
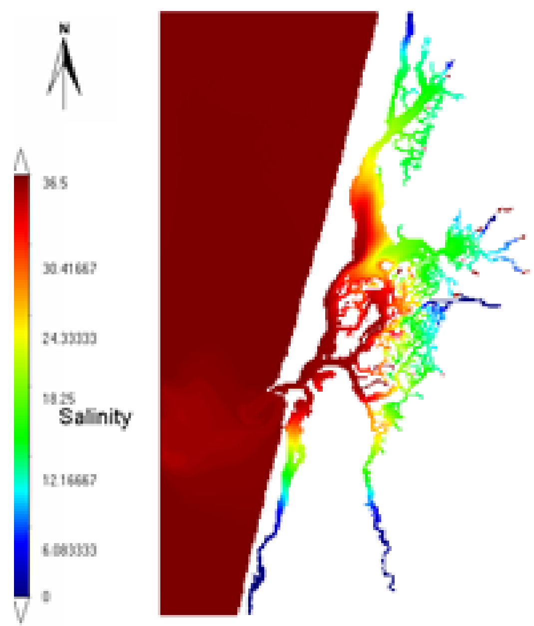
Salinity

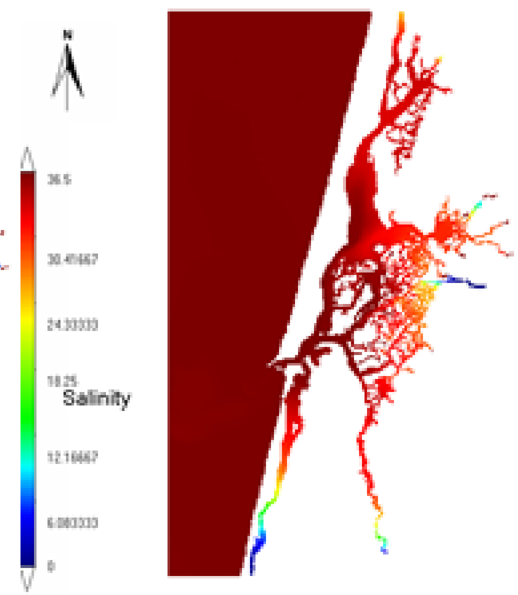
A-Cali



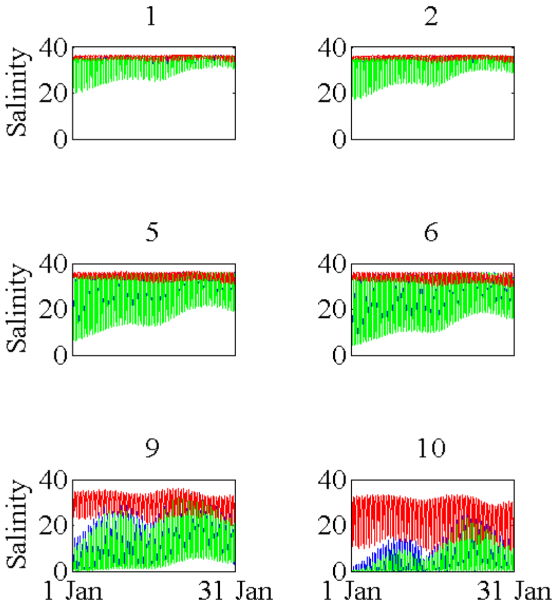
B-NoCC

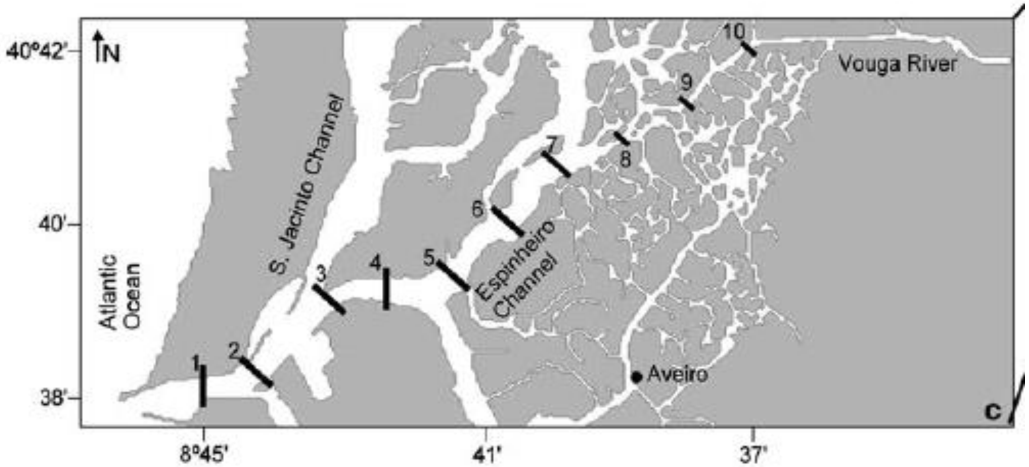


C-CC



Saliniy upstream



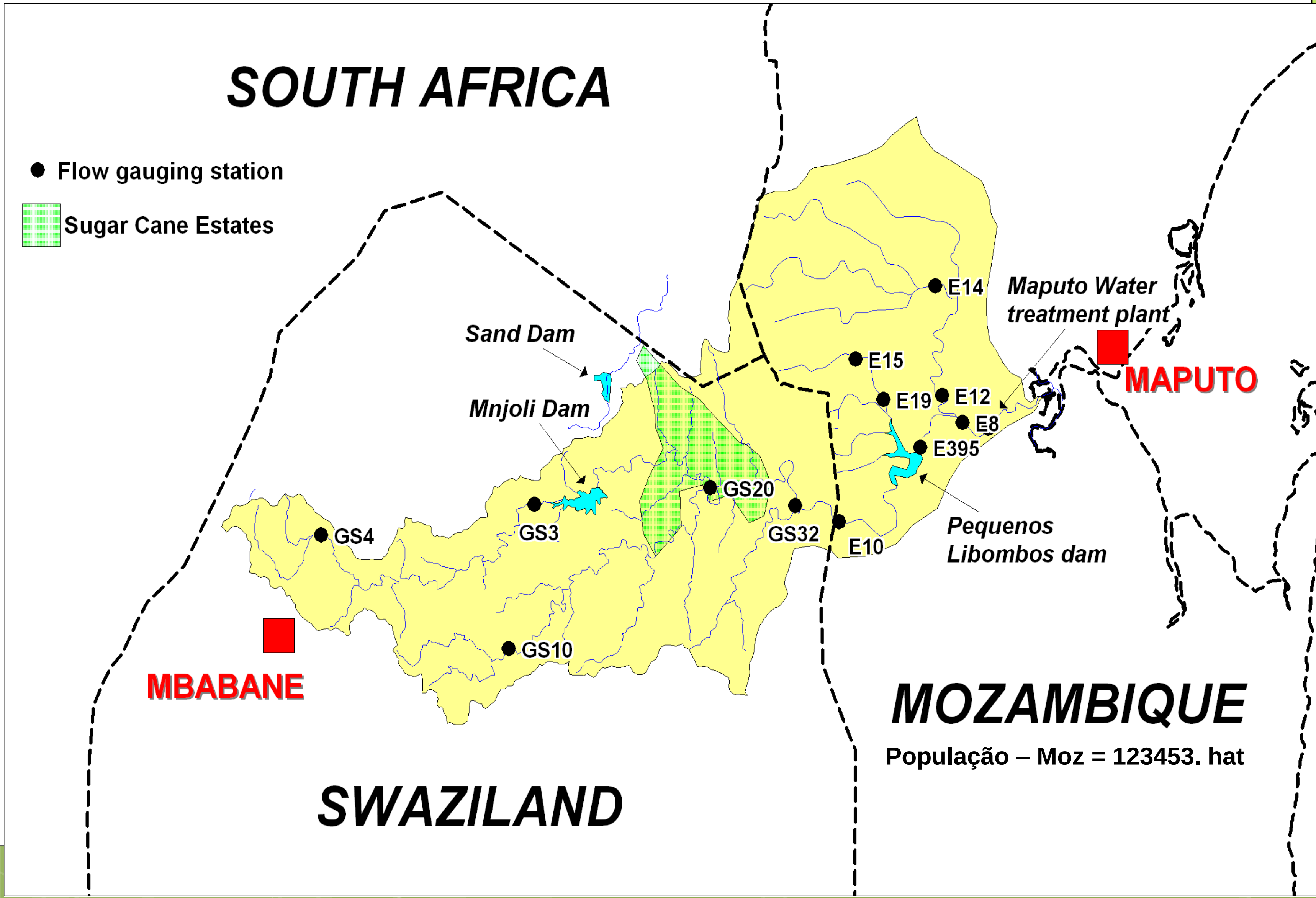


A-Cali
B-NoCC
C-CC

Conclusions

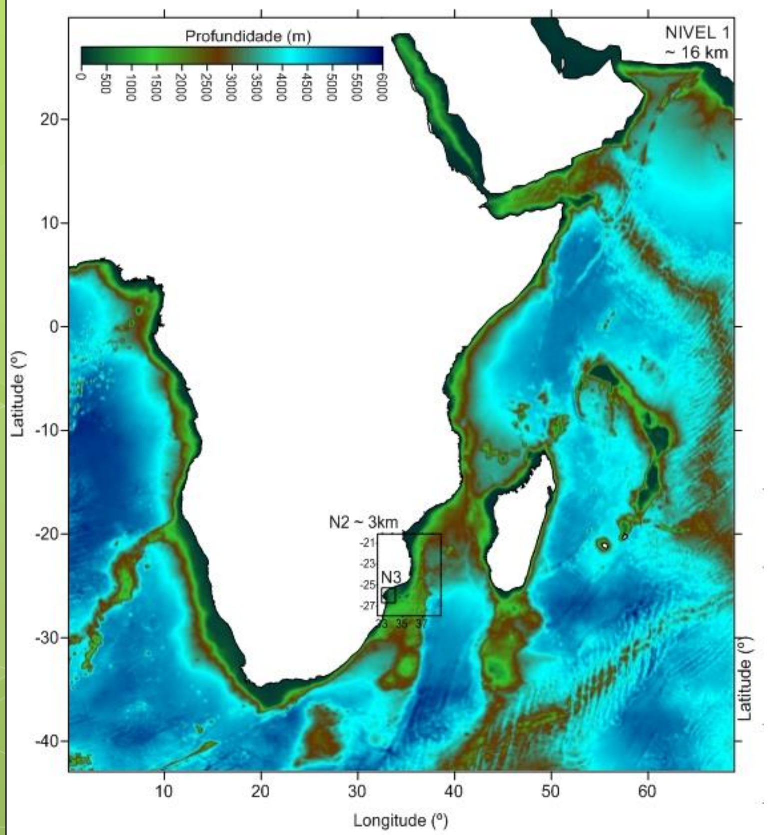
- Results show a general good agreement between the observed and the simulated data as indicated by R2 and E.
- SWAT model results with and without climate change, show an overall decrease on the flows with the climate change scenario.
- In the Espinheiro channel, the salinity is higher along the channel for the climate change scenario. From station 1 near the channel's mouth to station 10 near the channel's head. These values reflect the future low freshwater discharge from the Vouga River computed by SWAT.

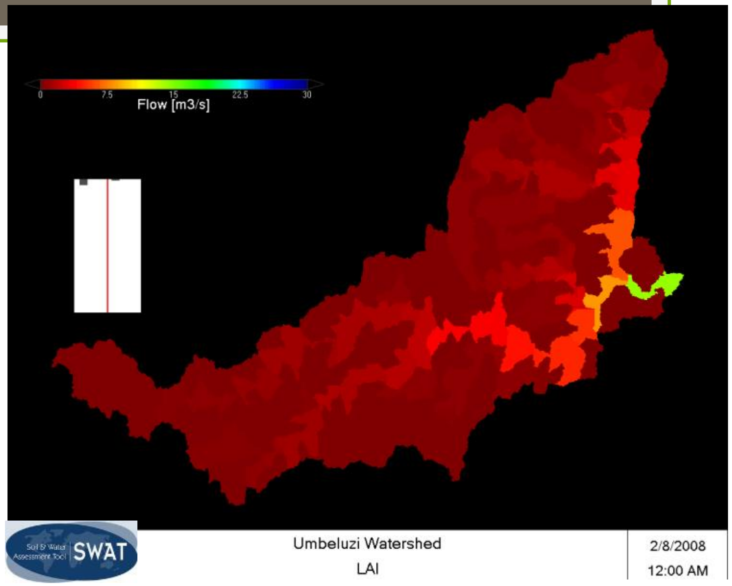
Umbeluzi - Mozambique

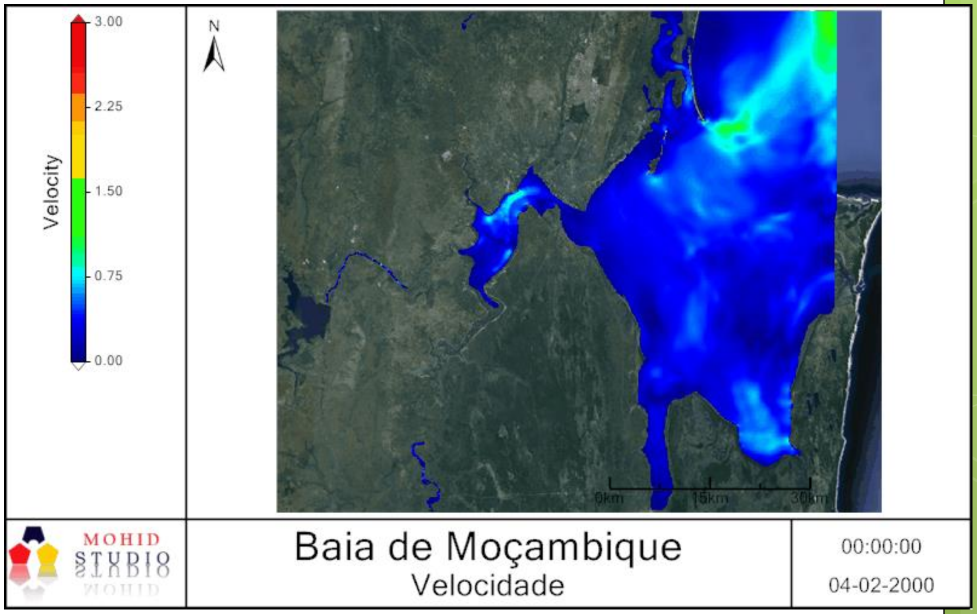


Land Use

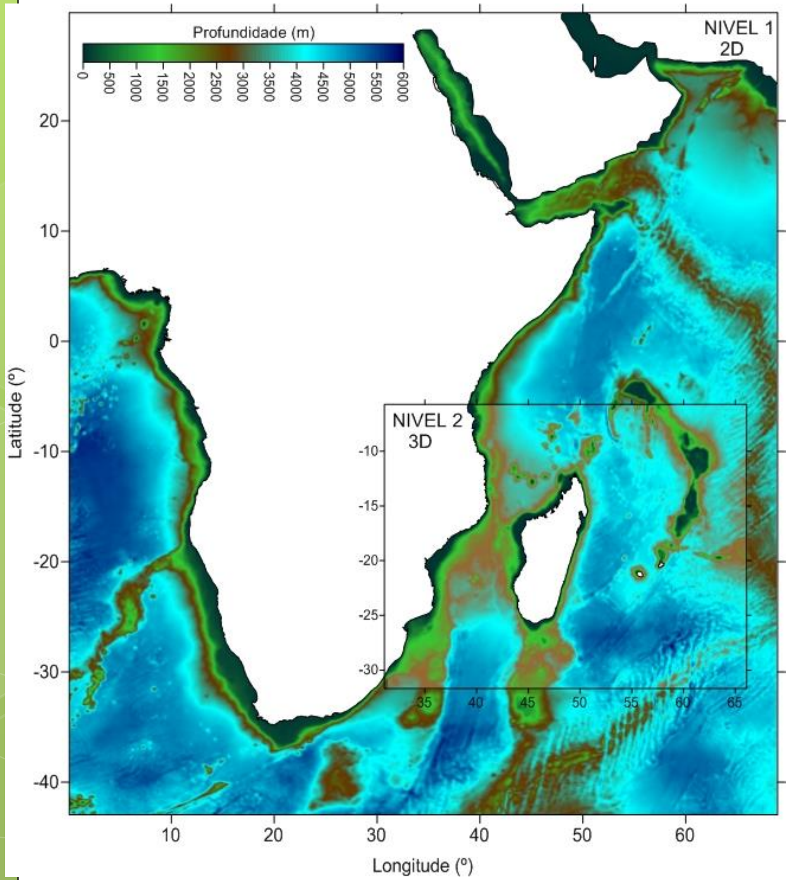
Maputo Estuary



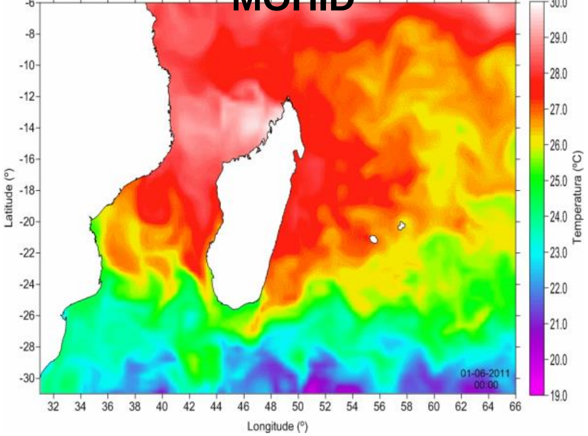




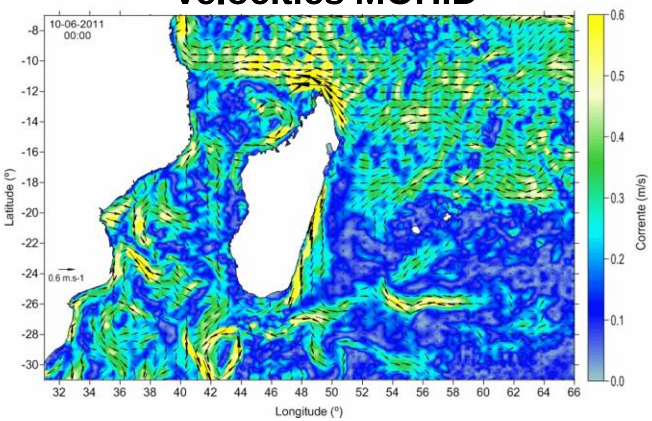
Indian ocean model



Temperature MOHID



Velocities MOHID



Enxoé – South of Portugal

Montado

December

May

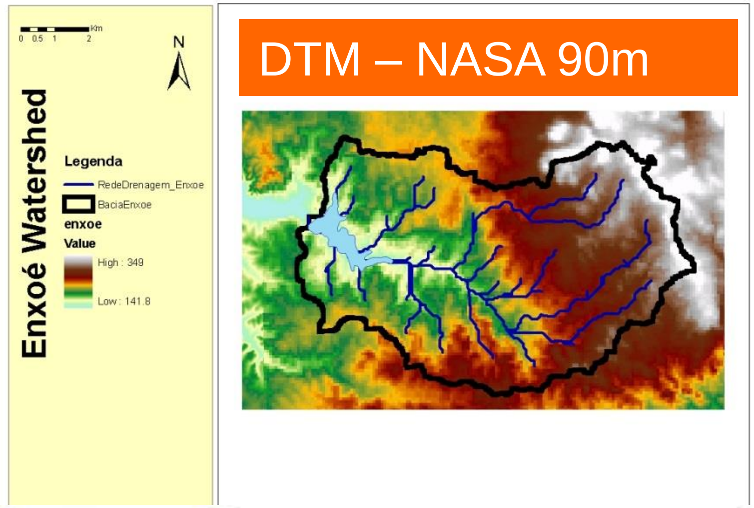
October

Olive

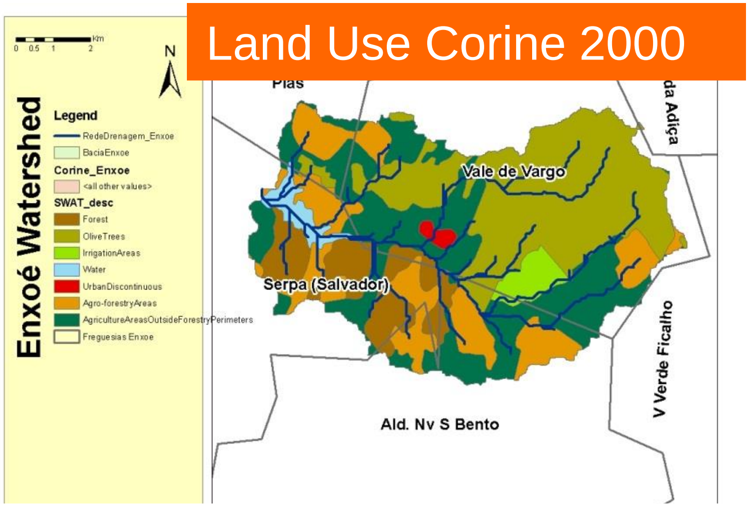
Small Farms

Enxoé watershed – 60 Km2

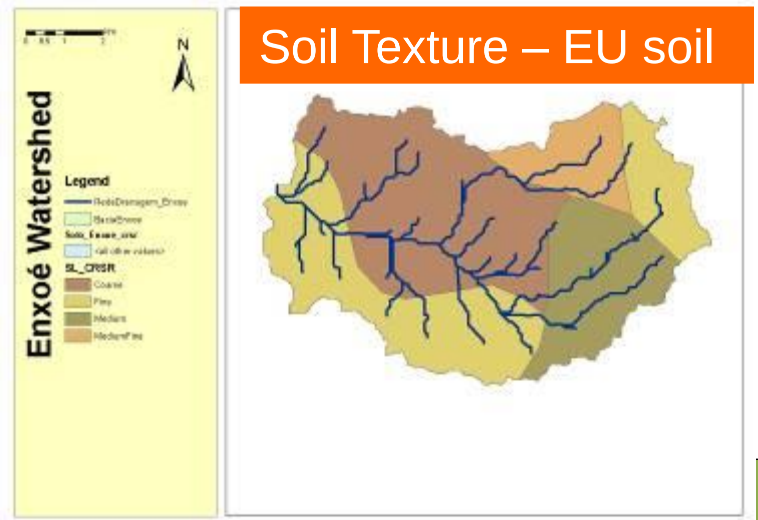
DTM – NASA 90m



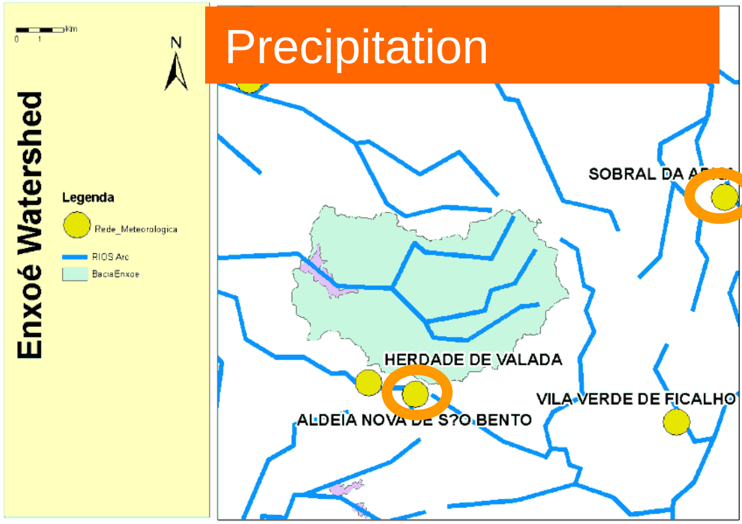
Land Use Corine 2000



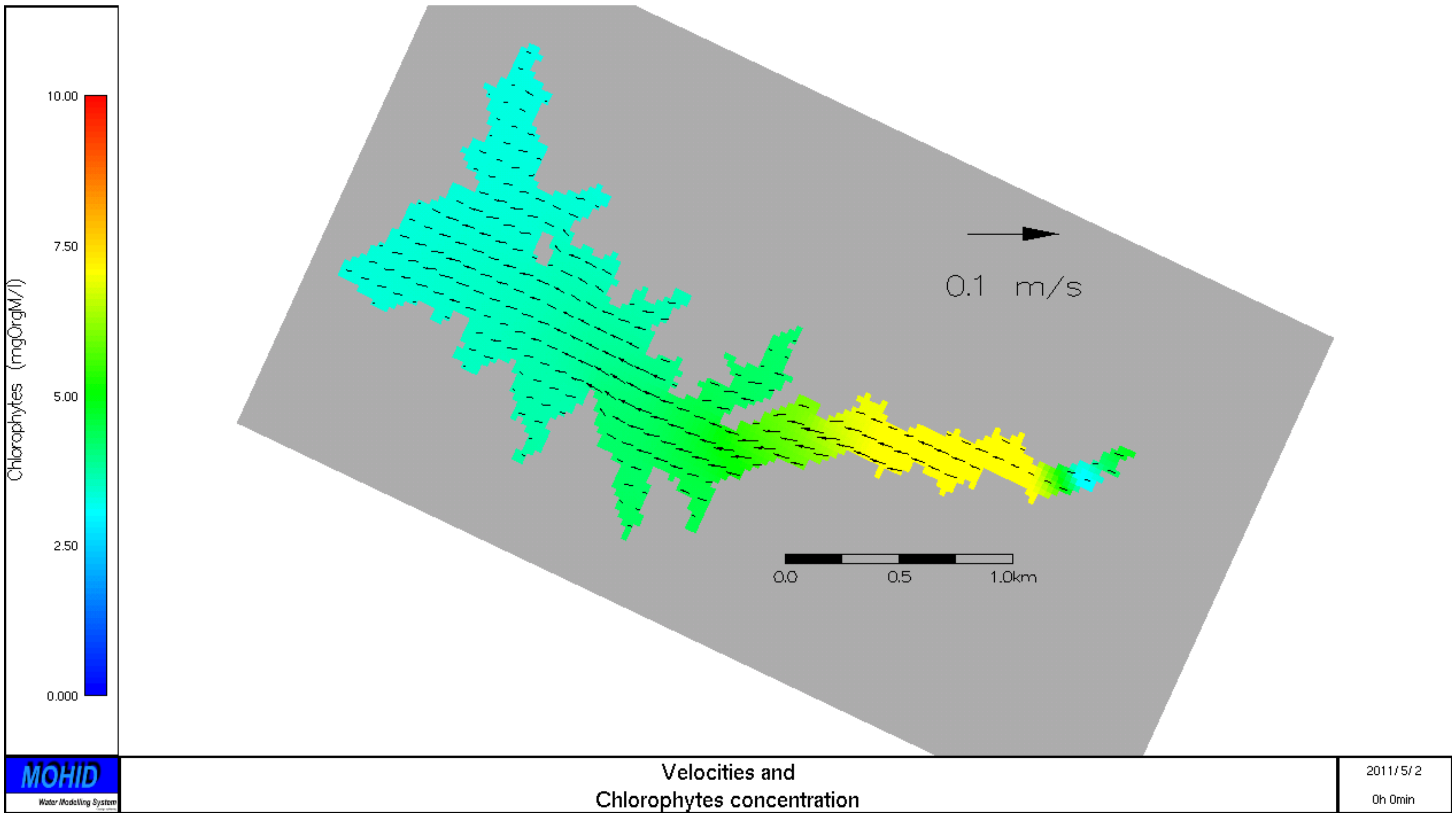
Soil Texture – EU soil



Precipitation



Enxoé reservoir simulation



Enxoé reservoir simulation