2017 International SWAT Conference
Warsaw, Poland

Impacts of climate and land use changes on the water quality of a vineyard-dominated Mediterranean catchment

D. Serpa[1], J.P. Nunes[1, 2], J. Rocha[1], J.J. Keizer [1], N. Abrantes[1]

[1]CESAM – Centre for Environmental and Marine Studies & DAO – Department of Environment and Planning, Universidade de Aveiro, Portugal.

[2]CE3C – Centre for Ecology, Evolution and Environmental Changes, Faculdade de Ciências, Universidade de Lisboa, Portugal.

Background

- **The Mediterranean Basin** has been identified as one of the **most vulnerable regions** to **future climate change**
- **Intense vine culture** have been recognized to cause **high nutrient exports** and **high soil losses**
- **Vine** culture is **highly dependent on agrochemicals** mainly due to the degraded state of Mediterranean vineyard soils and the plant's sensitivity to pests and diseases

Aim

- Evaluate the **impacts of climate and land use changes** on **the surface water quality** of a vine-dominated catchment (São Lourenço)

Specific goals:

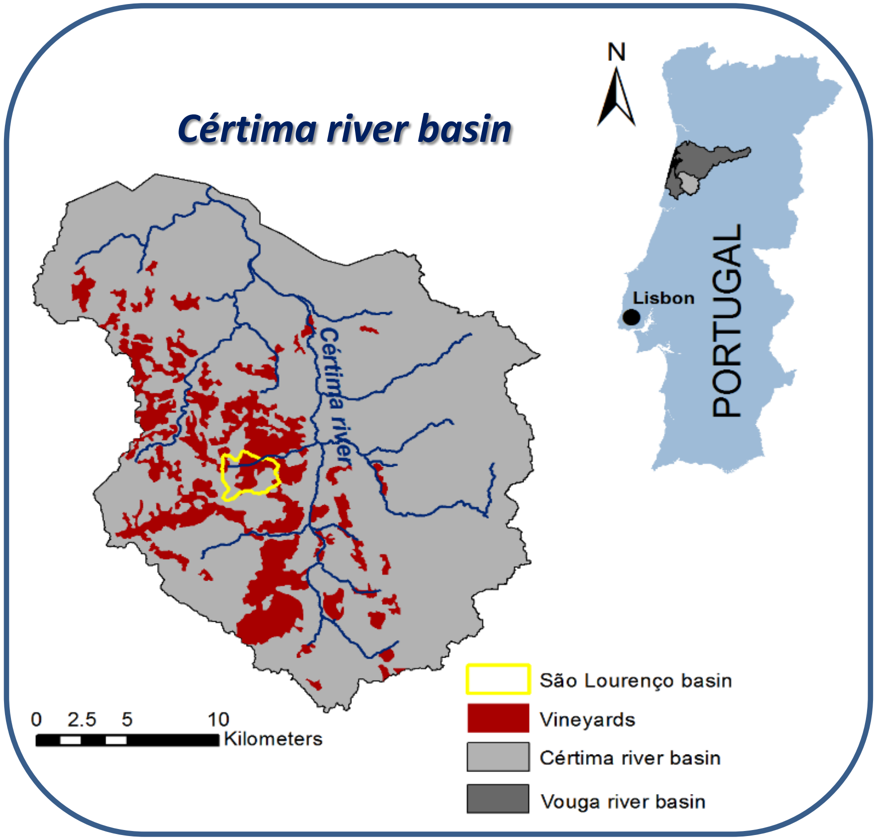
i. **Calibrate and validate the SWAT model** for nutrient (total nitrogen and phosphorus) and pesticide (total copper) exports in the São Lourenço catchment (present conditions)

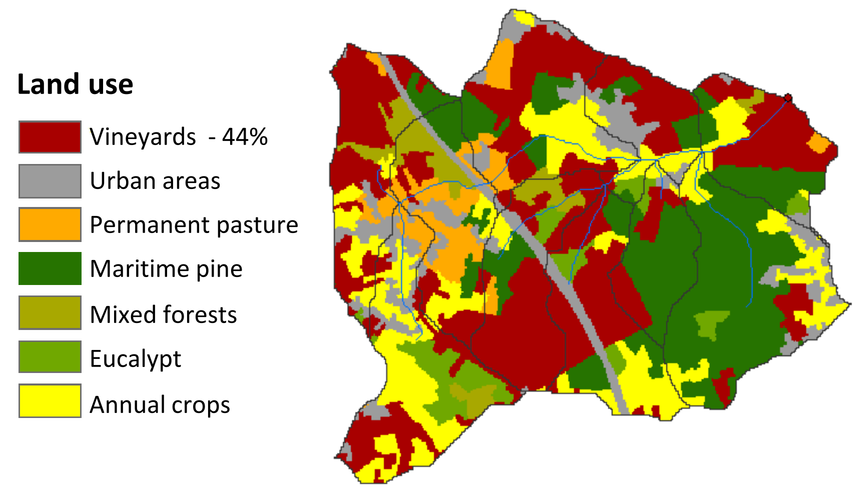
ii. **Simulate the individual effects of climate and land use change** on nutrient and pesticide export under two different gas emission scenarios

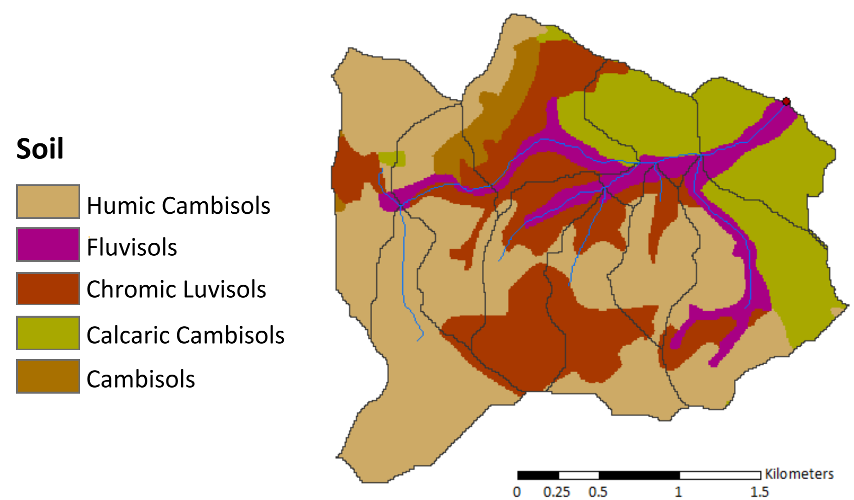
iii. **Simulate the combined effects of climate and land use change** on nutrient and pesticide export under the same emission scenarios

Methodology

Study area



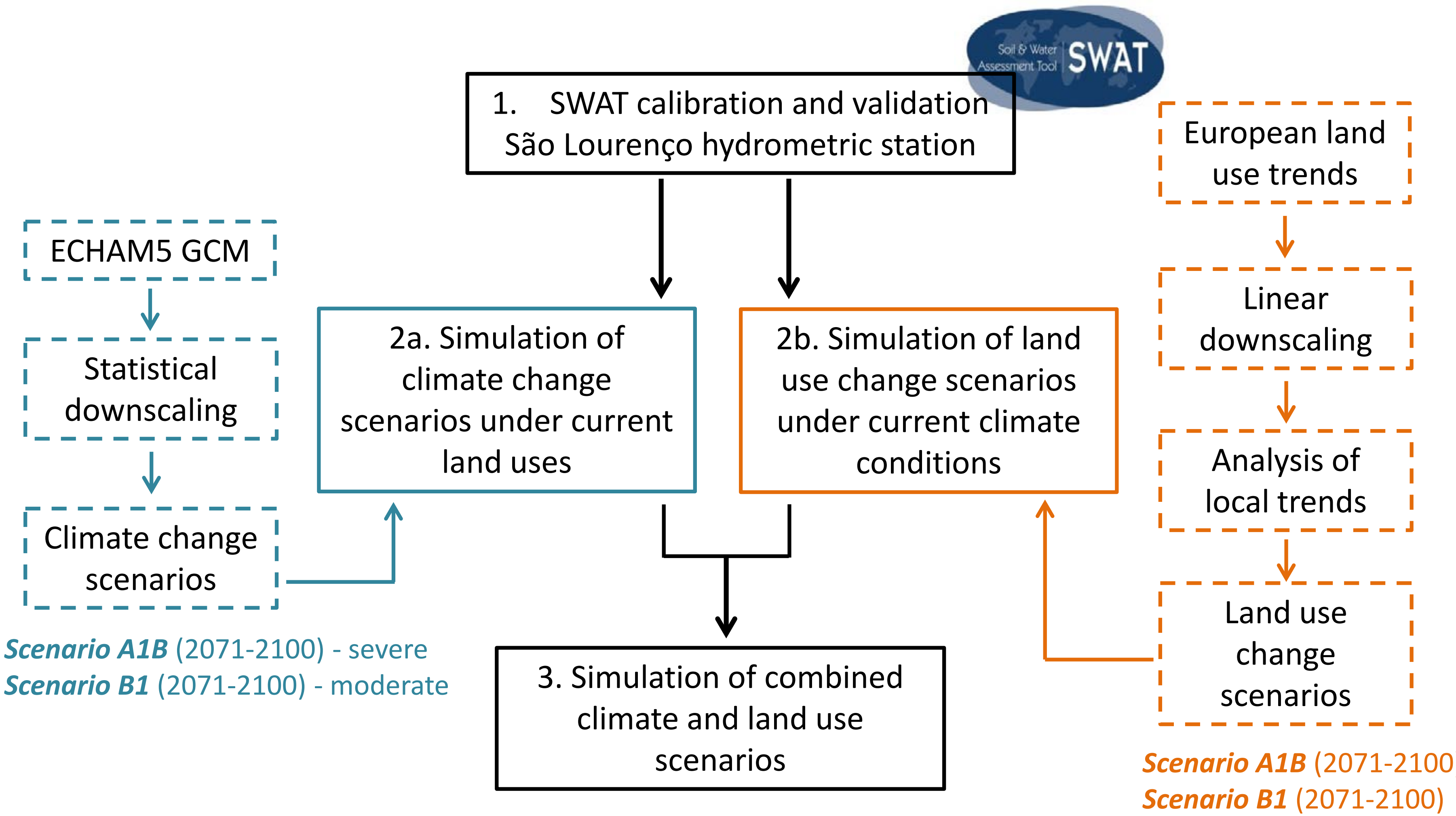




São Lourenço catchment - 6.2 km^2

Methodology

Modelling approach and scenario development



Climate scenarios

Land use scenarios

Results and Discussion

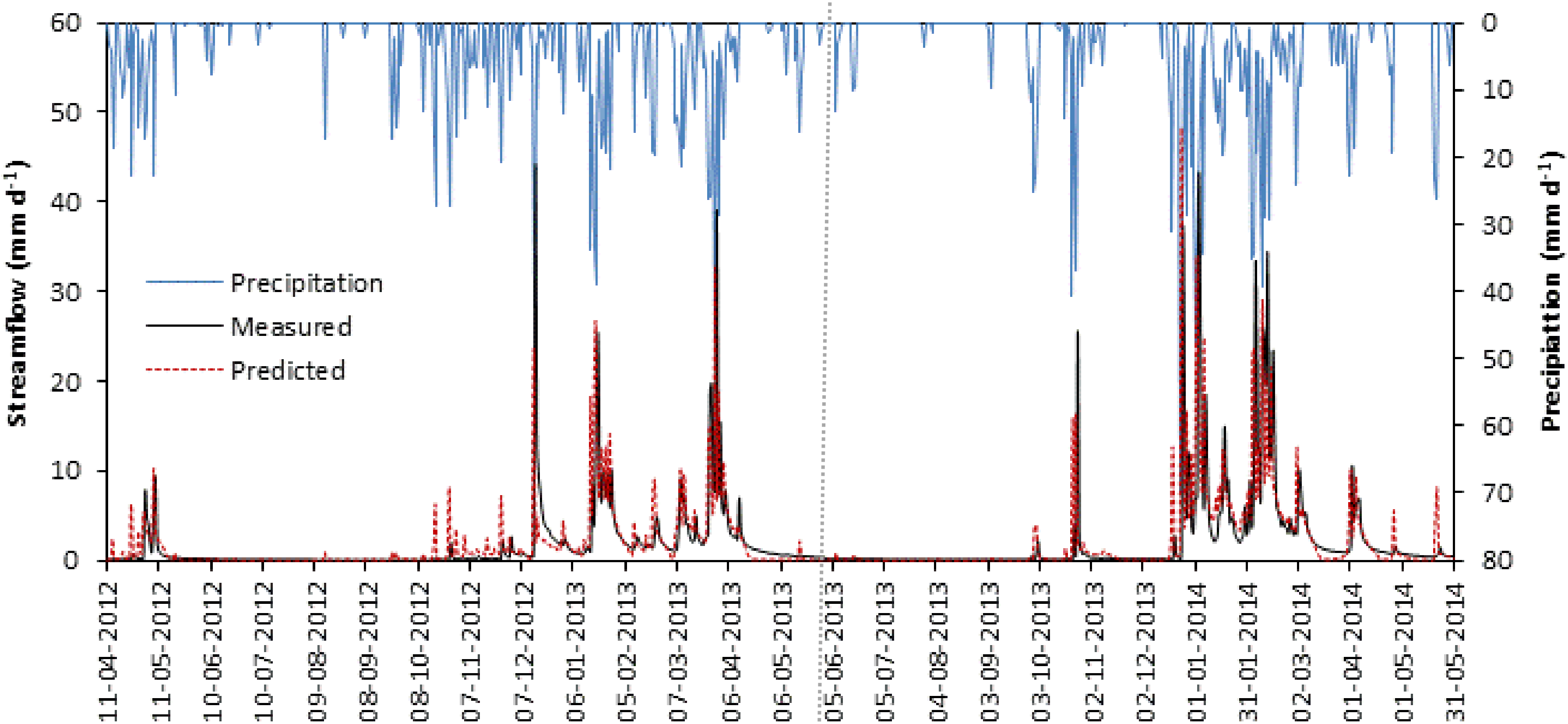
Moriasi et al. (2007) indicators:

NSE – Nash-Sutcliffe coefficient
RSR – Root Mean Square error/ Standard deviation
PBIAS – Percent of bias

Model performance: streamflow

CALIBRATION

VALIDATION



Good performance

NSE = 0.83
RSR = 0.41
PBIAS = 0.44

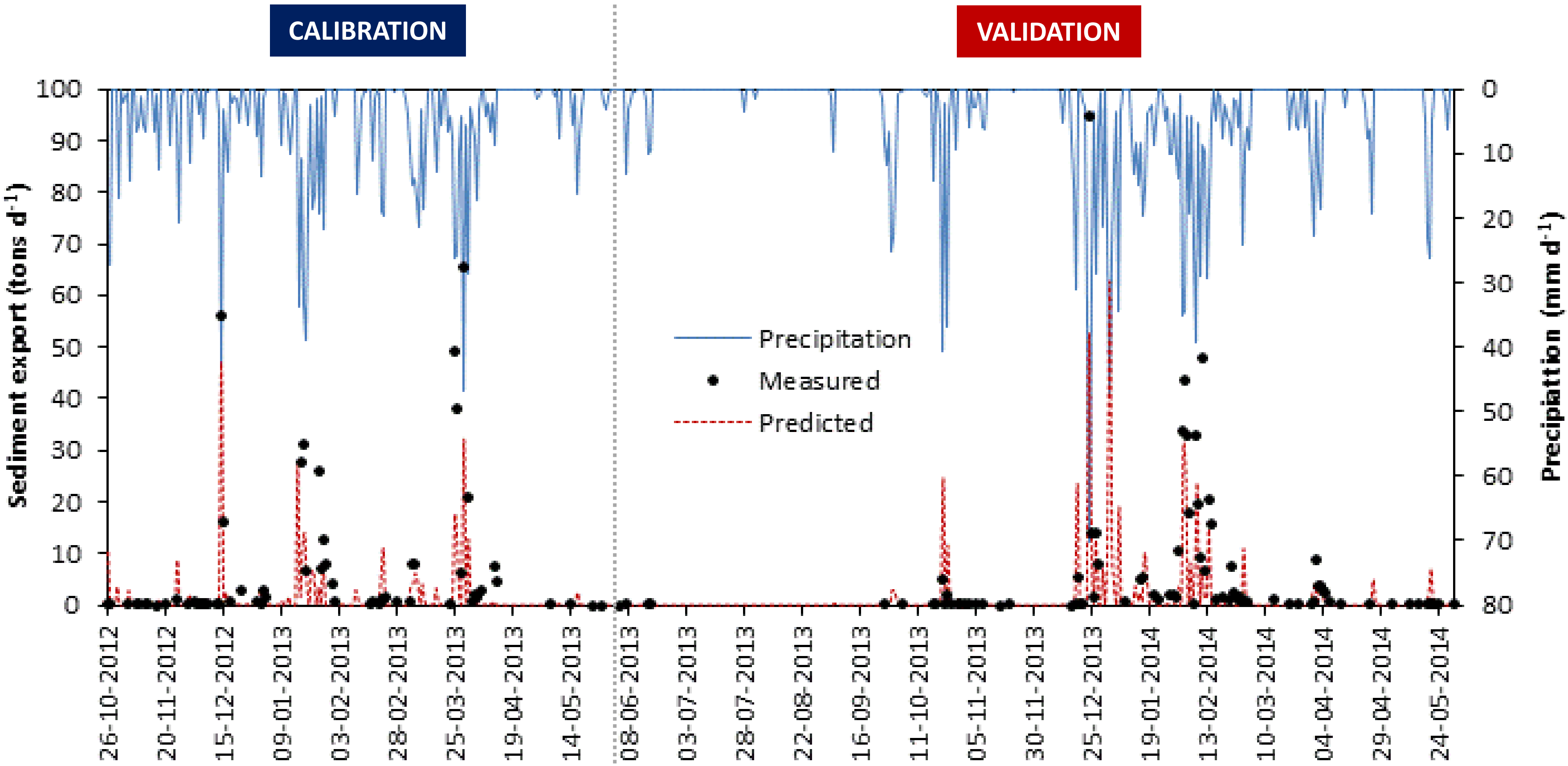
NSE = 0.84
RSR = 0.40
PBIAS = -3.34

Results and Discussion

Moriasi et al. (2007) indicators:

NSE – Nash-Sutcliffe coefficient
RSR – Root Mean Square error/ Standard deviation
PBIAS – Percent of bias

Model performance: sediments



NSE = 0.60
RSR = 0.63
PBIAS = 46.53

NSE = 0.68
RSR = 0.56
PBIAS = 35.94

model underestimation - no continuous measurement of sediment concentrations in the catchment

Satisfactory performance

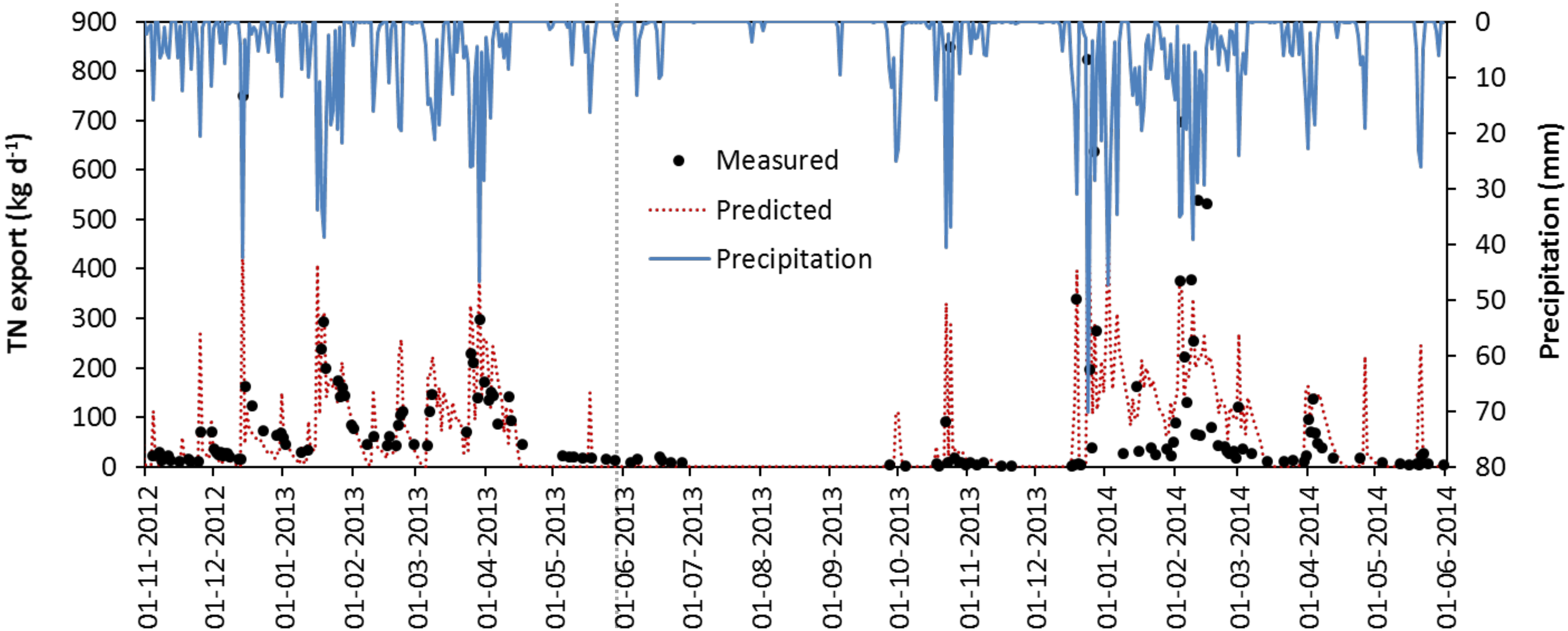
Results and Discussion

Moriasi et al. (2007) indicators:

NSE – Nash-Sutcliffe coefficient
RSR – Root Mean Square error/ Standard deviation
PBIAS – Percent of bias

Model performance: total nitrogen

CALIBRATION | **VALIDATION**



NSE = 0.56
RSR = 0.68
PBIAS = -16.4

NSE = 0.52
RSR = 0.69
PBIAS = -10.0

Satisfactory performance

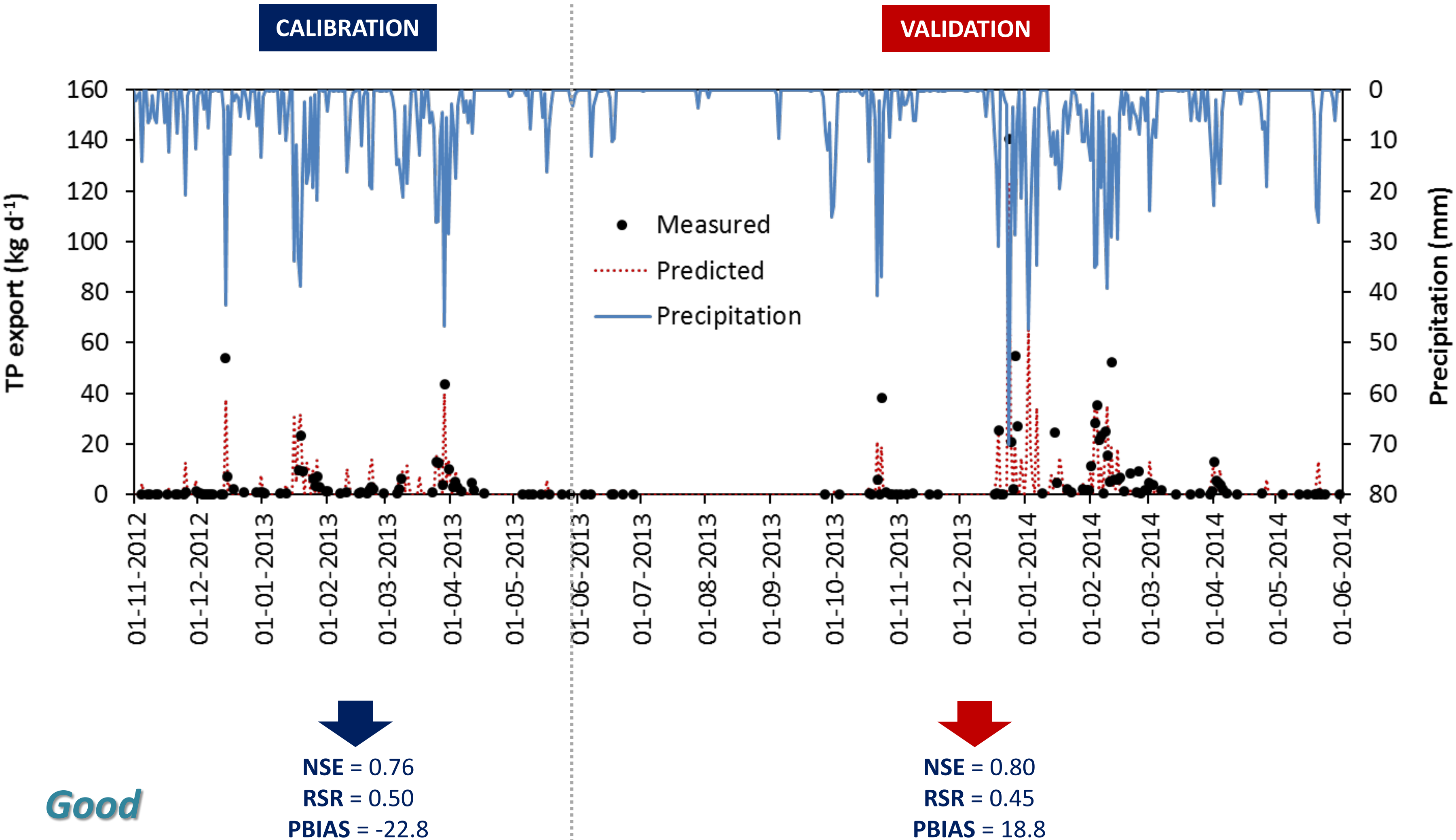
model consistently underestimated the major export peaks – variation of fertilization practices and non-continuous measurements

Results and Discussion

Moriasi et al. (2007) indicators:

NSE – Nash-Sutcliffe coefficient
RSR – Root Mean Square error/ Standard deviation
PBIAS – Percent of bias

Model performance: total phosphorus



NSE = 0.76
RSR = 0.50
PBIAS = -22.8

NSE = 0.80
RSR = 0.45
PBIAS = 18.8

Good performance

Results and Discussion

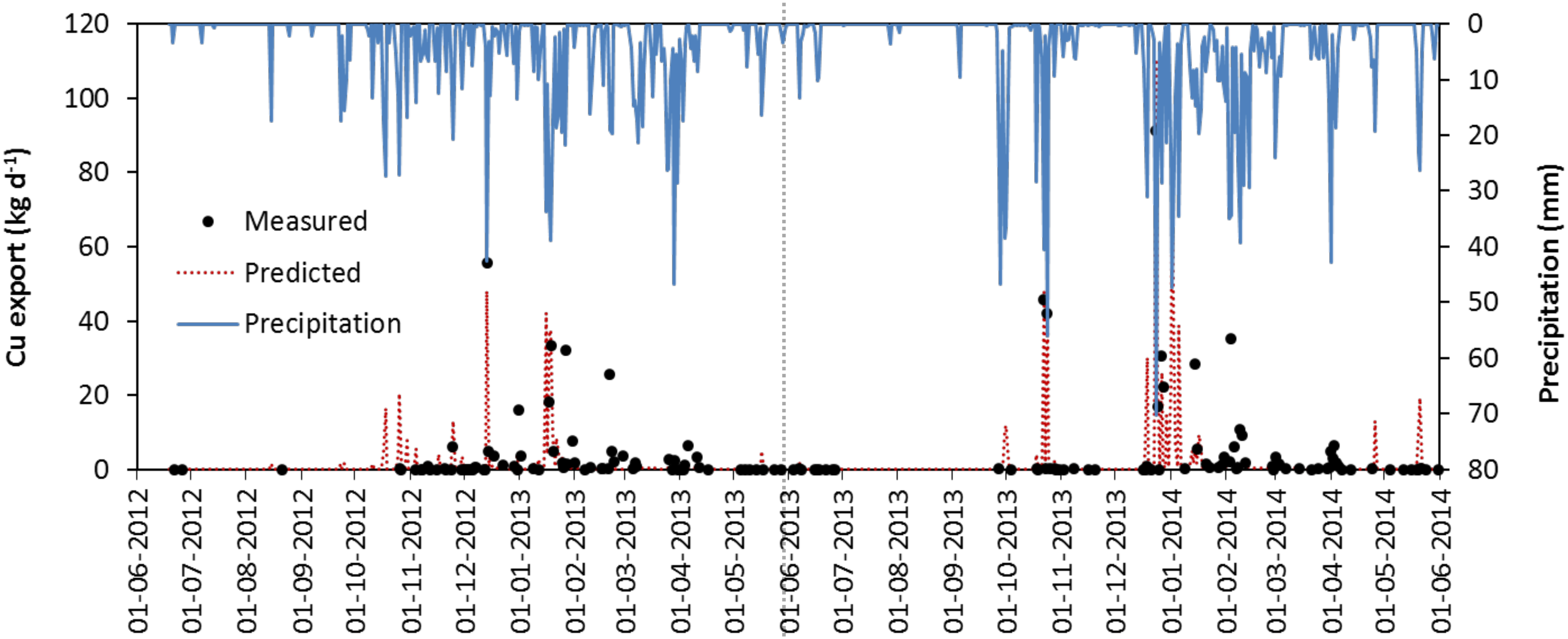
Model performance: total copper

Moriasi et al. (2007) indicators:

NSE – Nash-Sutcliffe coefficient
RSR – Root Mean Square error/ Standard deviation
PBIAS – Percent of bias

CALIBRATION

VALIDATION



NSE = 0.51
RSR = 0.70
PBIAS = 18.9

NSE = 0.70
RSR = 0.55
PBIAS = 6.7

model reasonably reproduced daily exports with some underestimation of peaks - Cu levels were not measured continuously but just at selected water levels during storm hydrograph

Satisfactory performance

Results and Discussion

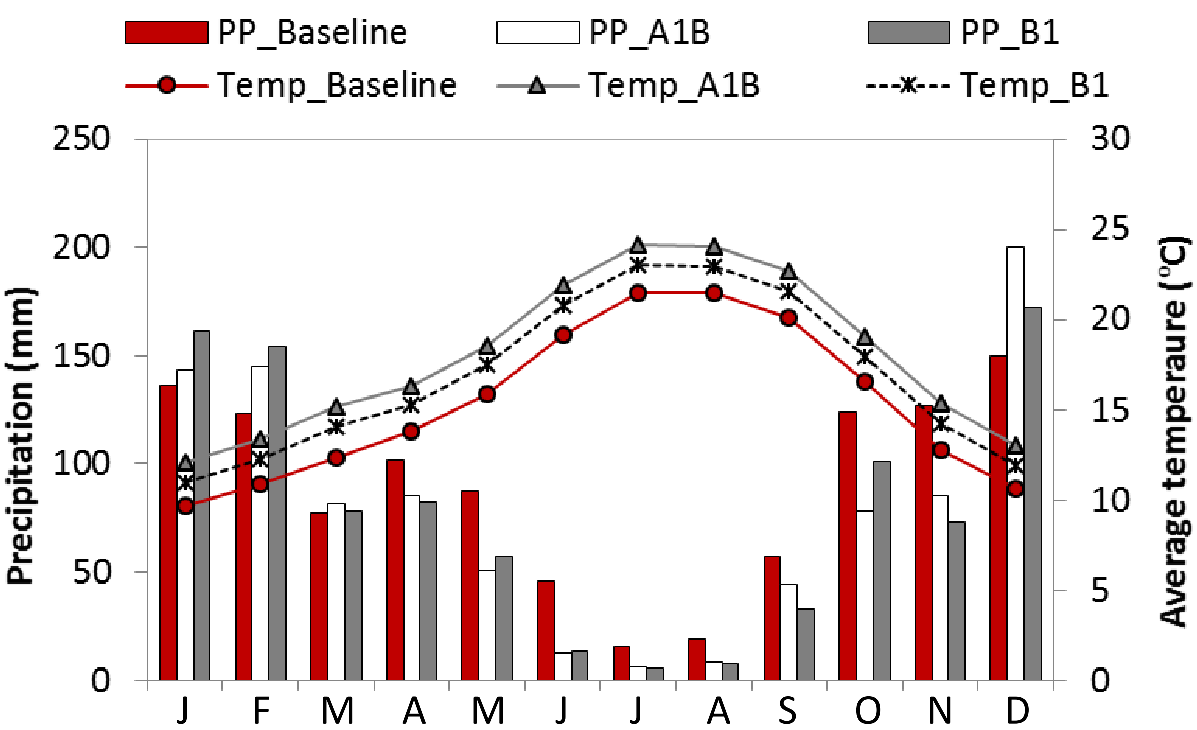
Climate change scenarios

Baseline: 1971-2000

Future *Scenario A1B* (2071-2100) - severe
Future *Scenario B1* (2071-2100) - moderate

São Lourenço

- **12% reduction** in annual rainfall
- **19% increase** in winter rainfall
- **Temperature increase**
  - Scenario A1B = **2.2°C**
  - Scenario B1 = **1.1°C**



Results and Discussion

Land use change scenarios

LAND USE	AREA (%) Baseline	A1B	B1
Vineyards	43.9	**37.1**	43.9
Maritime pine	26.5	26.5	**31.2**
Corn	12.1	**23.9**	**17.8**
Potato	2.8	0.0	0.0
Pasture	2.8	0.0	0.0
Urban area	4.6	4.6	4.6
Permanent pasture	3.0	0.0	0.0
Eucalypt	2.7	**7.9**	2.7
Mixed forests	1.5	0.0	0.0

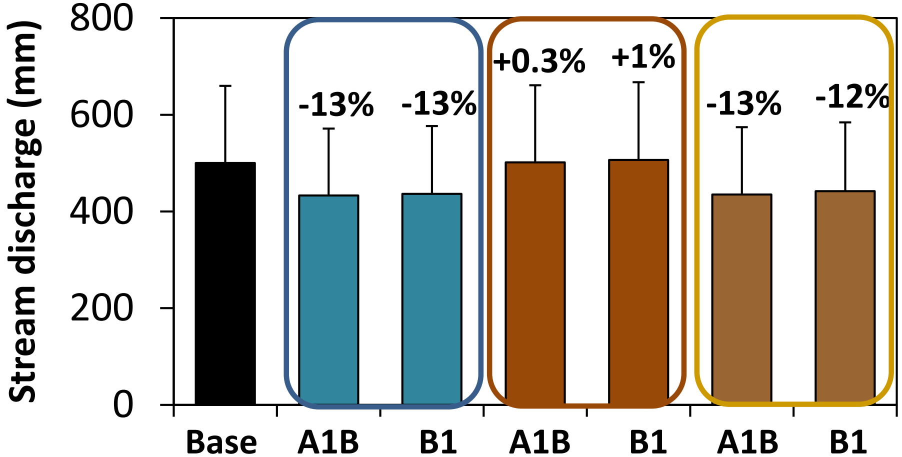
- **Less subsistence agriculture** (potatoes, pasture, small vineyards)
- **More corn** (for biofuel)
- **More forests** (eucalypt or pine)

future land use scenarios predict a replacement of traditional agricultural crops such as potato, pastures and small vineyards by corn (for biofuel production) and commercial forests

existing permanent pastures and mixed forests would be replaced by more economically valuable eucalypt plantations in scenario A1B , and by more sustainable maritime pine forests in scenario B1

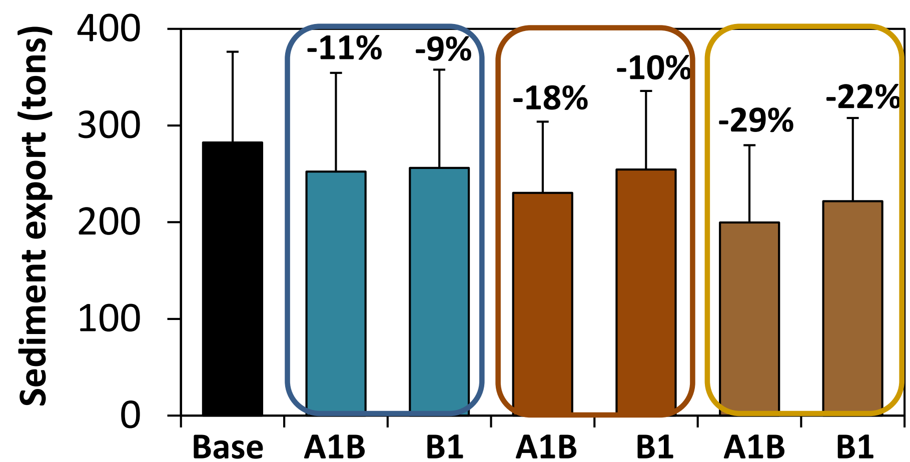
Results and Discussion

Scenarios analysis - individual effects and combined effects



- **Reduction in precipitation** as a result of climate changes is likely to **reduce streamflow**
- **Increase in irrigated crops** (e.g. corn) **adds water** to the system
- **Combined scenarios** had off-setting effects on stream discharge

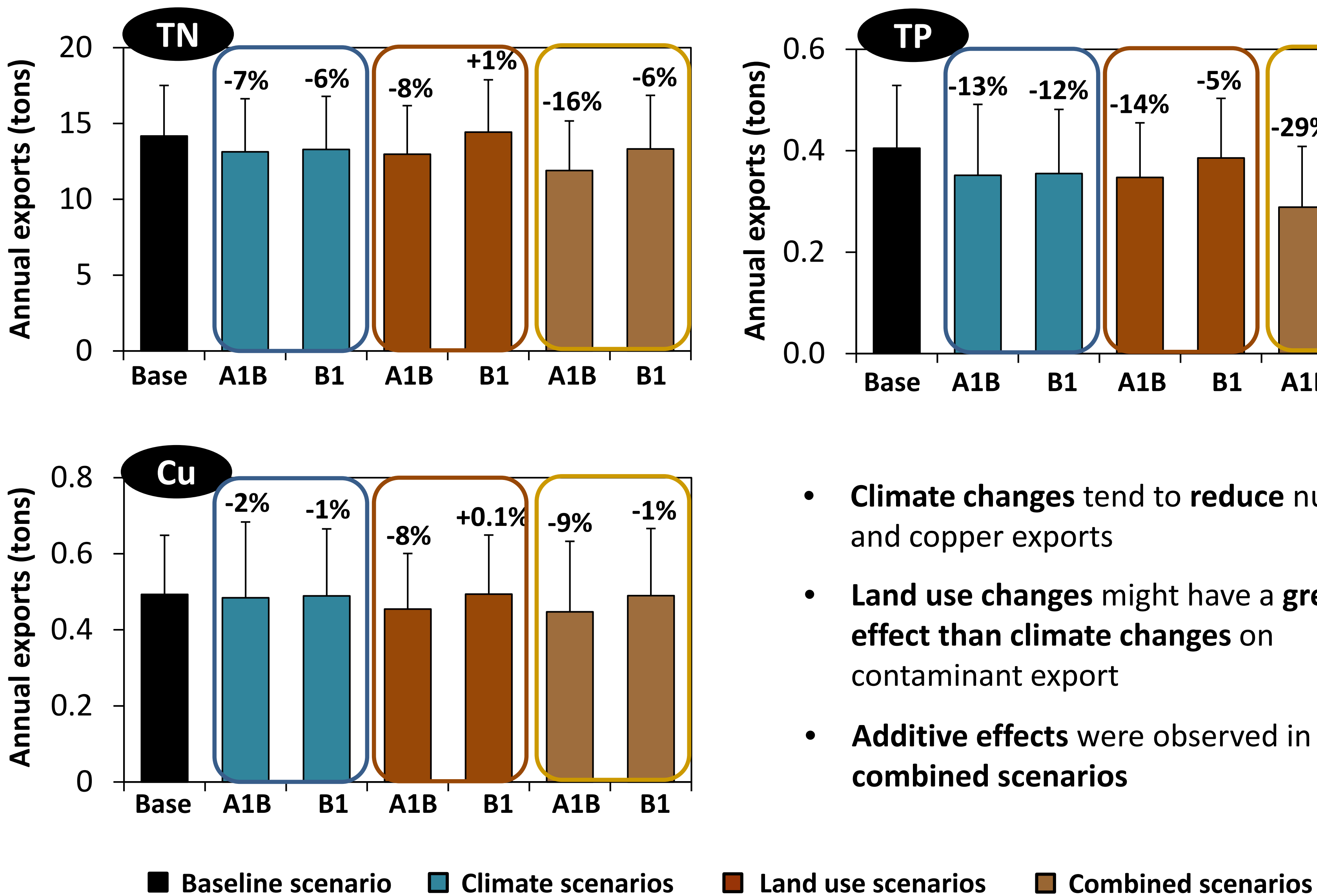
- **Decrease** in precipitation **reduces** soil erosion
- **Cultivation of more soil protective crops** (e.g. eucalypt and pine) **reduces** soil erosion
- **Climate and land use changes** have **cumulative effects** on soil erosion



■ Baseline scenario ■ Climate scenarios ■ Land use scenarios ■ Combined scenarios

Results and Discussion

Scenarios analysis - individual effects and combined effects



- **Climate changes** tend to **reduce** nutrient and copper exports
- **Land use changes** might have a **greater effect than climate changes** on contaminant export
- **Additive effects** were observed in the **combined scenarios**

Conclusions

- **Climate changes** have a more pronounced effect **on water yields than land use changes.**

- **Land use changes** have a marked effect **on sediment and contaminant export,** which reinforces the importance of land management for minimizing the effects of climate changes on water and soil resources.

- **Land use practices that can mitigate** the impacts of **climate changes** on viticulture-impacted basins include**:** maintenance of **vegetation with permanent cover**, **reduction of tillage** operations, **adjusted fertilizer** management, **proactive pesticide use**.

Future work

- **Upscale the model for the Cértima catchment**, to evaluate the future chemical and ecological status of this water body, which is presently one of the most polluted in Portugal.

Acknowledgements

COMPETE 2020
PROGRAMA OPERACIONAL COMPETITIVIDADE E INTERNACIONALIZAÇÃO

PORTUGAL 2020

UNIÃO EUROPEIA
Fundo Europeu de Desenvolvimento Regional

FCT Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

CESAM
Centre for Environmental and Marine Studies
www.cesam.ua.pt

Earth Surface Processes Team

ITAQUA Project (PTDC/AACAMB/112438/2009)

ERLAND Project (PTDC/AAC-AMB/100520/2008)

More info on...

Environmental Pollution 224 (2017) 454–465

ELSEVIER

Contents lists available at ScienceDirect

Environmental Pollution

journal homepage: www.elsevier.com/locate/envpol

Impacts of climate and land use changes on the water quality of a small Mediterranean catchment with intensive viticulture☆

CrossMark

D. Serpa*, J.P. Nunes, J.J. Keizer, N. Abrantes

CESAM & Department of Environment and Planning, University of Aveiro, Campus de Santiago, 3810-193 Aveiro, Portugal