COUPLING OF WATERSHEDS, ESTUARIES AND REGIONAL SEAS THROUGH NUMERICAL MODELLING FOR WESTERN IBERIA: RIVER DISCHARGE INFLUENCE IN THE NEAR OPEN OCEAN.

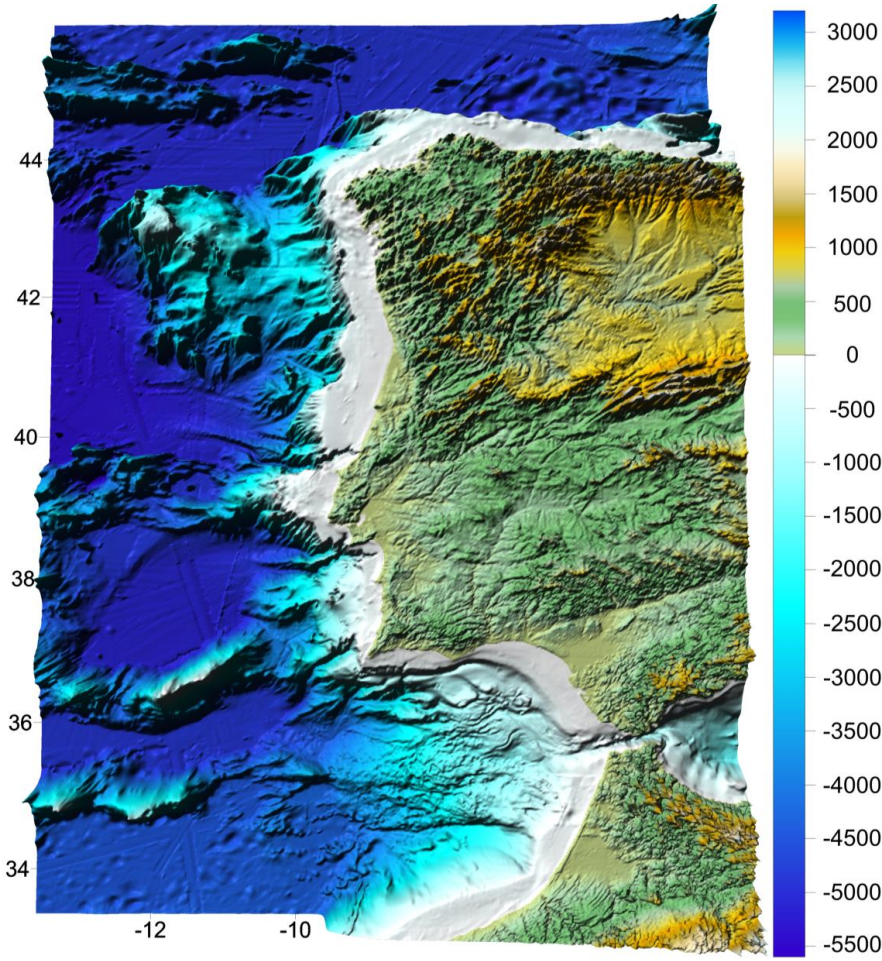
F. J. Campuzano*[1], D. Brito[2], M. Juliano[3], H. De Pablo[1], J. Sobrinho[1], R. Fernandes[2] and R. Neves[1]

campuzanofj.maretec@tecnico.ulisboa.pt

1 MARETEC, IST, Portugal

2 Action Modulers, Portugal

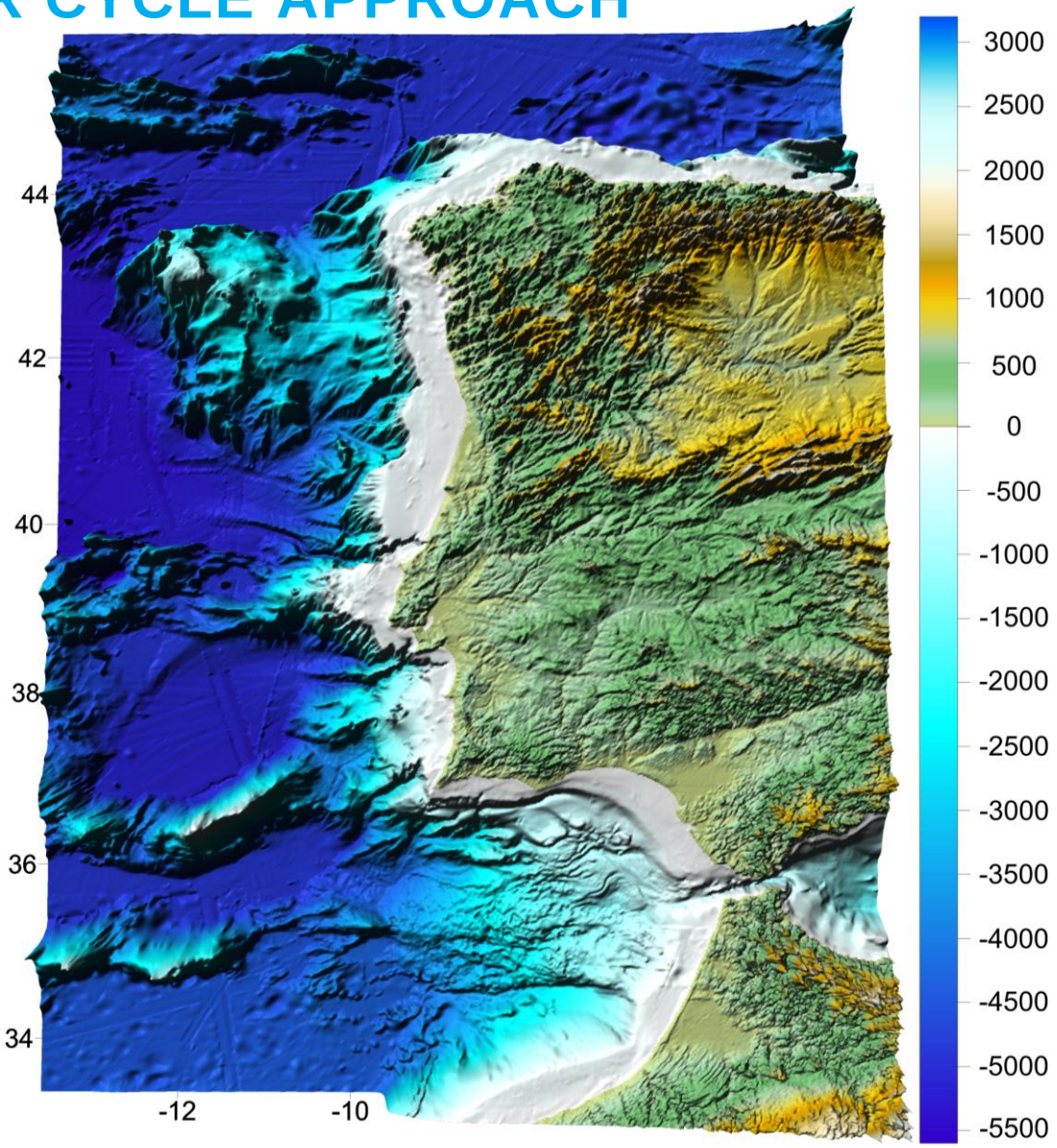
3 University of Azores, Portugal



A PARADIGM SHIFT: INTEGRATED WATER CYCLE APPROACH

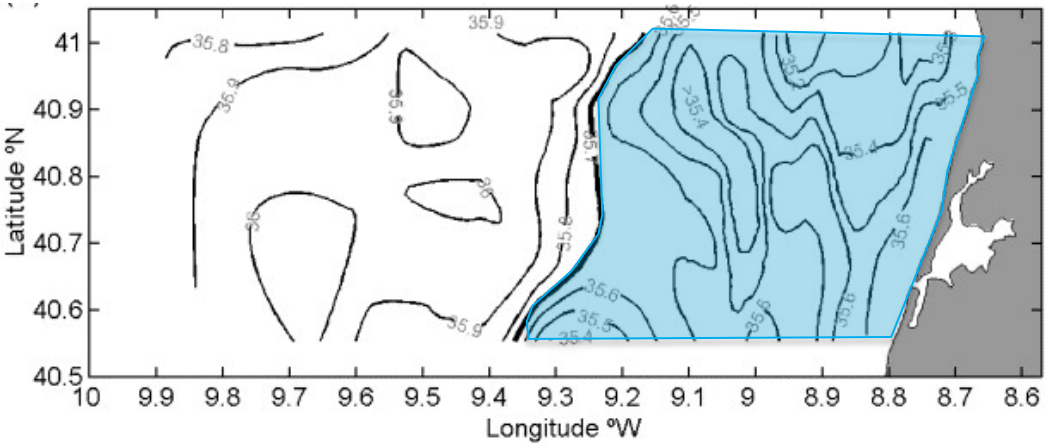
TÉCNICO LISBOA

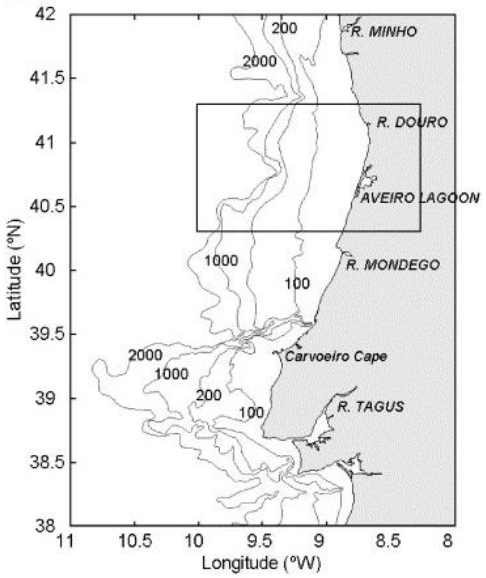
- The main objective of the present research was to develop a methodology and to explore the capacity to improve the thermohaline circulation in regional ocean model applications by a better characterisation of the land-ocean boundary conditions able to represent the salinity features described for the Western Iberia region



WHAT IS THE WESTERN IBERIA BUOYANT PLUME (WIBP)?

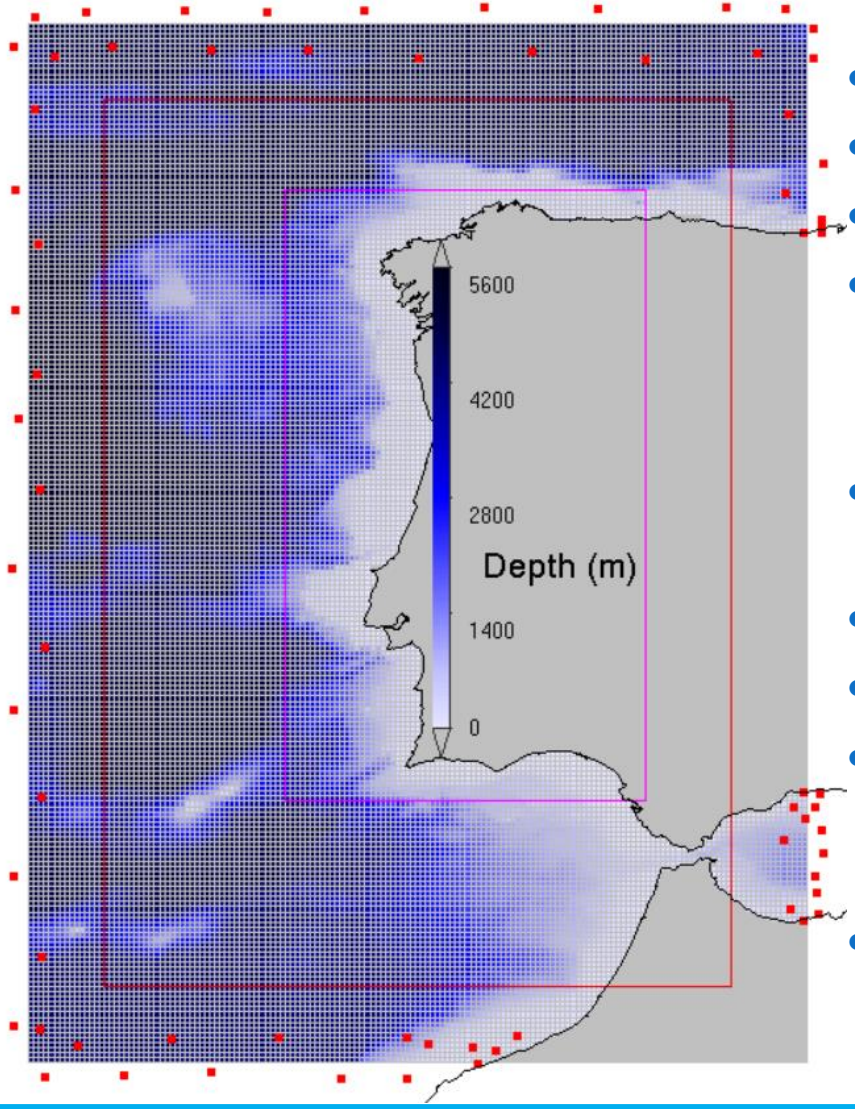
Peliz *et al.* (2002) defined the WIBP as: “the influence of the many terrestrial fresh water sources in the area (Douro, Minho and Mondego, other smaller rivers and the Galician Rias). They originate a low salinity water lens that extends along the coast. Despite the seasonal variation of runoff with significant decrease in summer, this buoyant plume is present all year round”





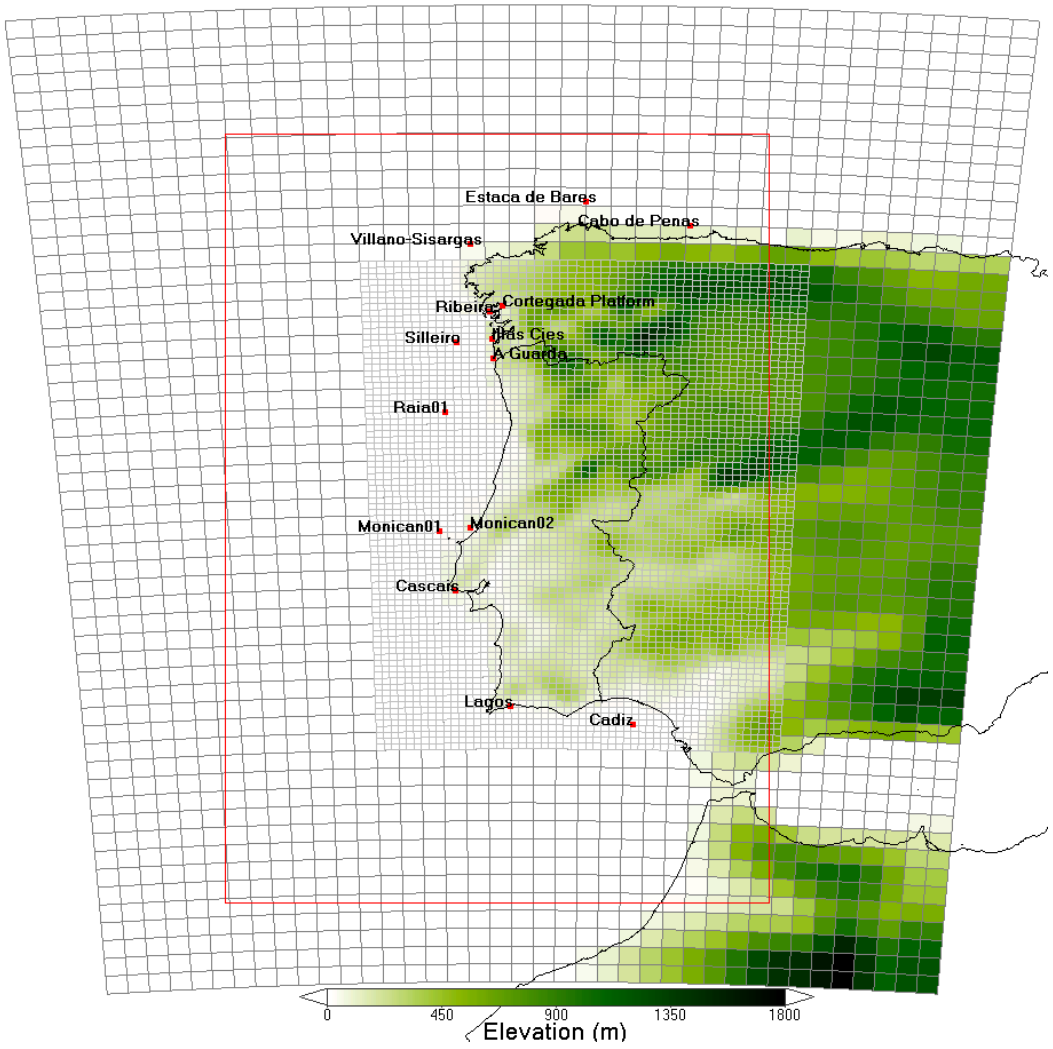
Peliz Á, Rosa TL, Santos AMP, Pissarra JL. Journal of Marine Systems. 2002; 35(1–2): 61-77. DOI: 10.1016/S0924-7963(02)00076-3.

PORTUGUESE COAST OPERATIONAL MODELLING SYSTEM (PCOMS)



- Based on the MOHID model
- Downscalled from Mercator-Océan PSY2V4
- Tides from FES2012
- Two nested domains (0.06° ≈ 6 km):
  - 2D WestIberia domain: 208x155 cells
  - 3D Portugal domain: 177x125 cells
- Hybrid vertical configuration corresponding to 7 Sigma layers on top of 43 Cartesian layers
- Daily run: yesterday, today plus 4-day forecasts
- Weekly run: previous fortnight period
- NPZD biogeochemical model forced by nitrate, phosphate and oxygen 3D climatology fields from World Ocean Atlas 2009 (WOA09).
- Meteorological forcing from MM5 Model application

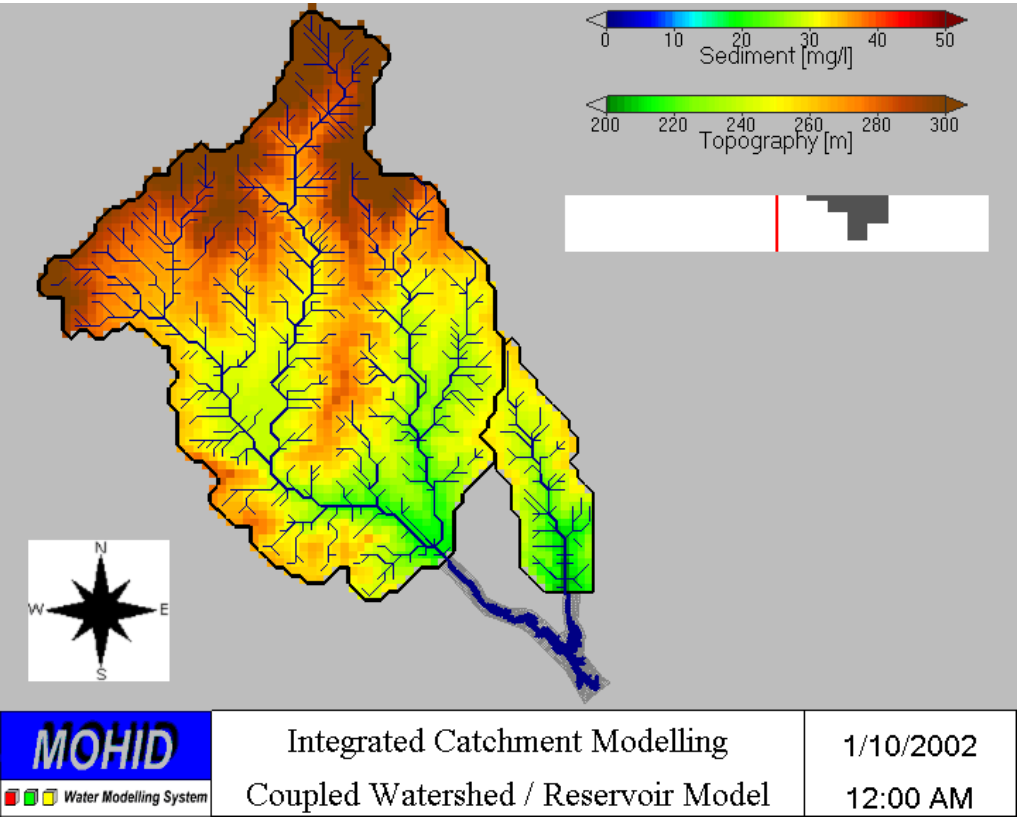
METEOROLOGICAL FORCING

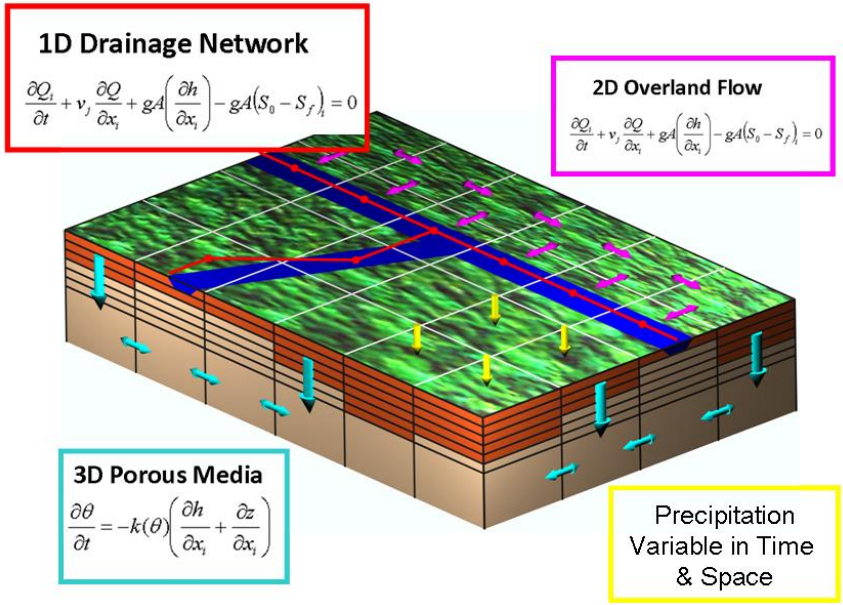


- Based on the MM5 model
- Two nested domains with different horizontal resolution:
  - 27 km domain:
  - 9 km domain:
- MOHID atmosphere and interface water air modules use the following MM5 fields:
  - air temperature,
  - atmospheric pressure,
  - relative humidity,
  - solar radiation,
  - wind velocity X and Y components
  - downward long wave radiation.
- Used for calculating the wind derived upwelling indexes

EXTREME EVENT: APRIL 2013 FLOODS

MOHID WATERSHED MODELLING





Estuarine, Coastal and Shelf Science
Volume 167, Part A, 20 December 2015, Pages 138–146
Coastal systems under change: tuning assessment and management tools

WATERSHEDS MODELLING SETUP

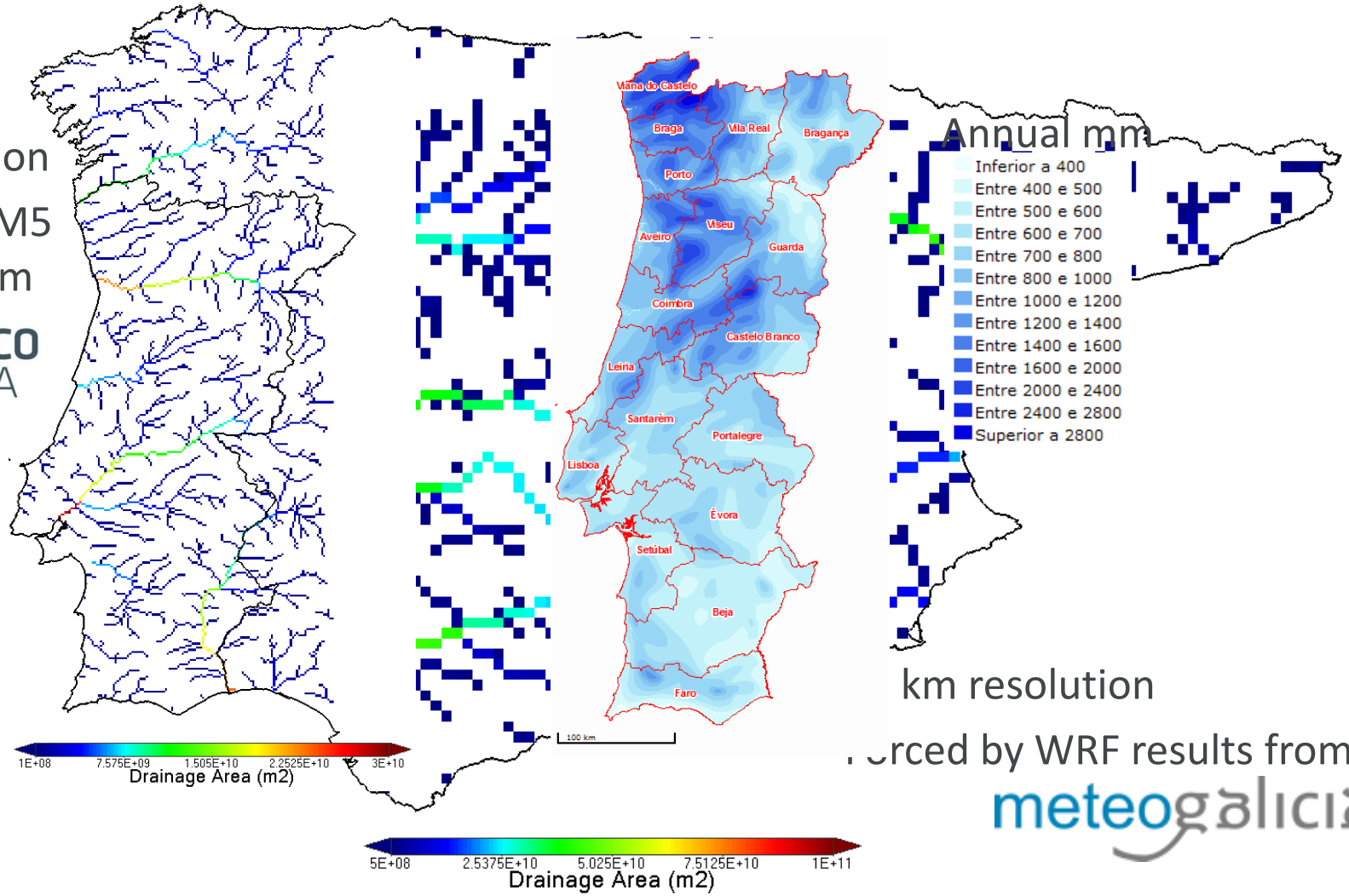
Integrating operational watershed and coastal models for the Iberian Coast: Watershed model implementation – A first approach

David Brito, F.J. Campuzano, J. Sobrinho, R. Fernandes, R. Neves

2 km resolution

Forced by MM5 results from

TÉCNICO LISBOA



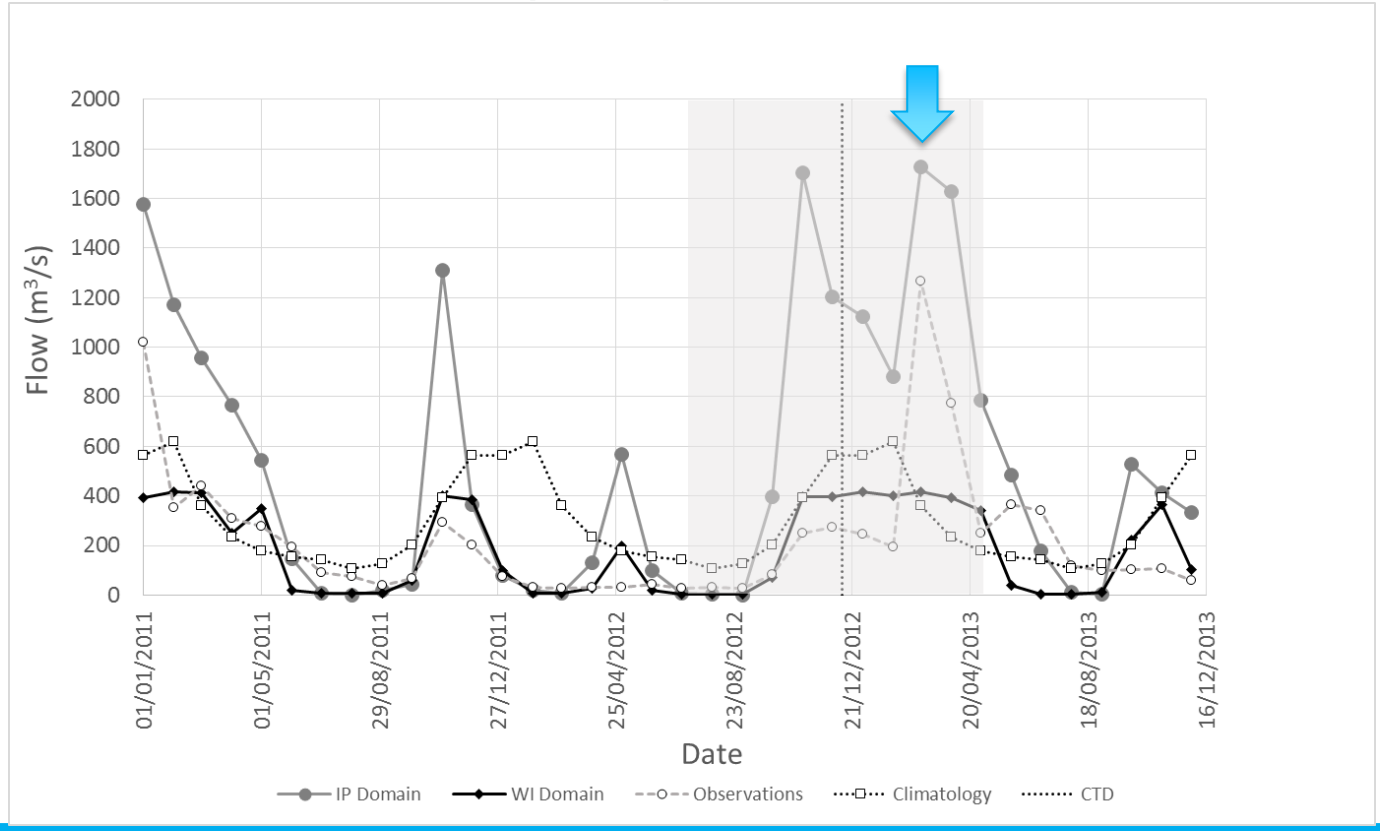
km resolution

Forced by WRF results from

meteogalicia

TAGUS ESTUARY MODELLING SCENARIOS

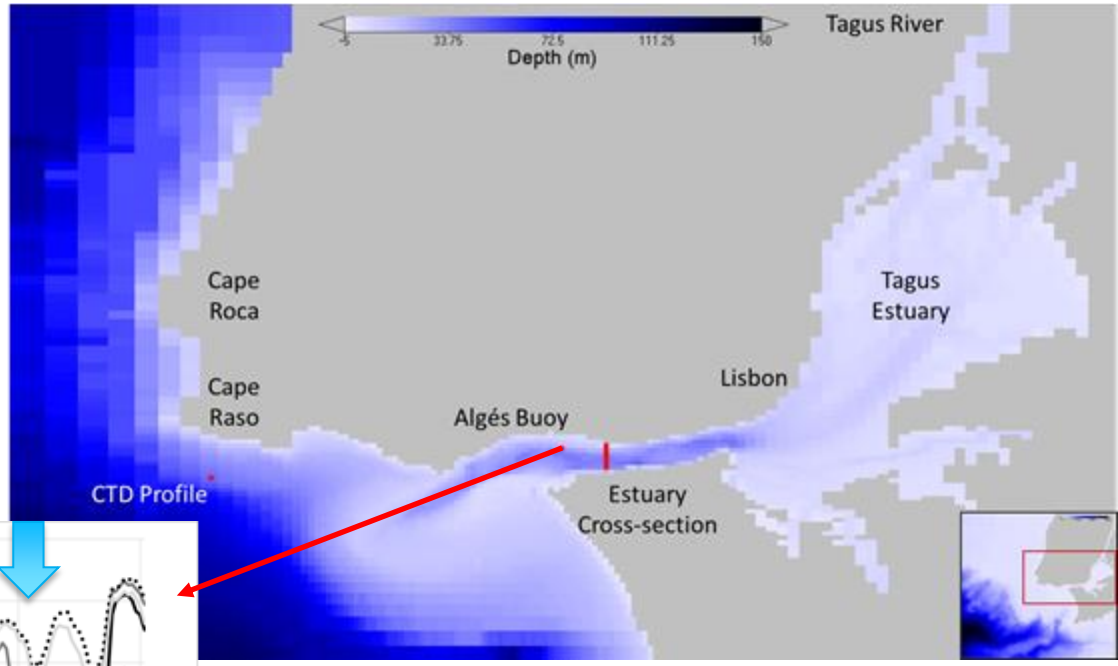
- River Hydrometric Observations (Almourol) (Source: SNIRH-APA)
- River Climatology
- MOHID Land IP (10 km)
- MOHID Land WI (2 km)

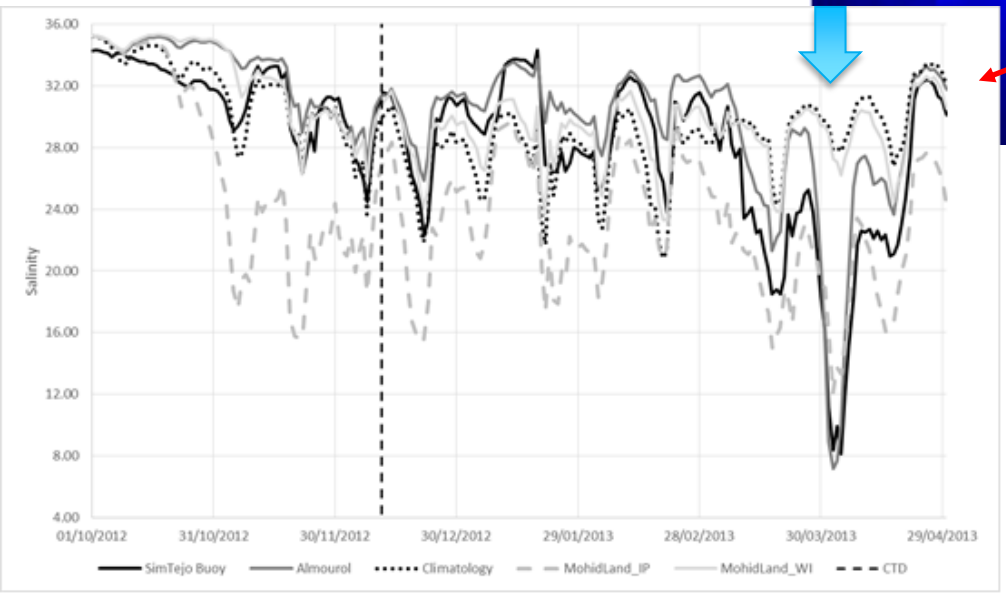


METHOD VALIDATION – ALGES BUOY

- October 2012-April 2013

	R^2	RMSE
Algés Buoy vs Almourol	0.89	2.55
Algés Buoy vs Climatology	0.20	4.71
Algés Buoy vs MohildLand_IP	0.58	5.67
Algés Buoy vs MohildLand_WI	0.40	4.31





Ocean Dynamics
December 2016, Volume 66, Issue 12, pp 1745–1756

Coupling watersheds, estuaries and regional ocean through numerical modelling for Western Iberia: a novel methodology

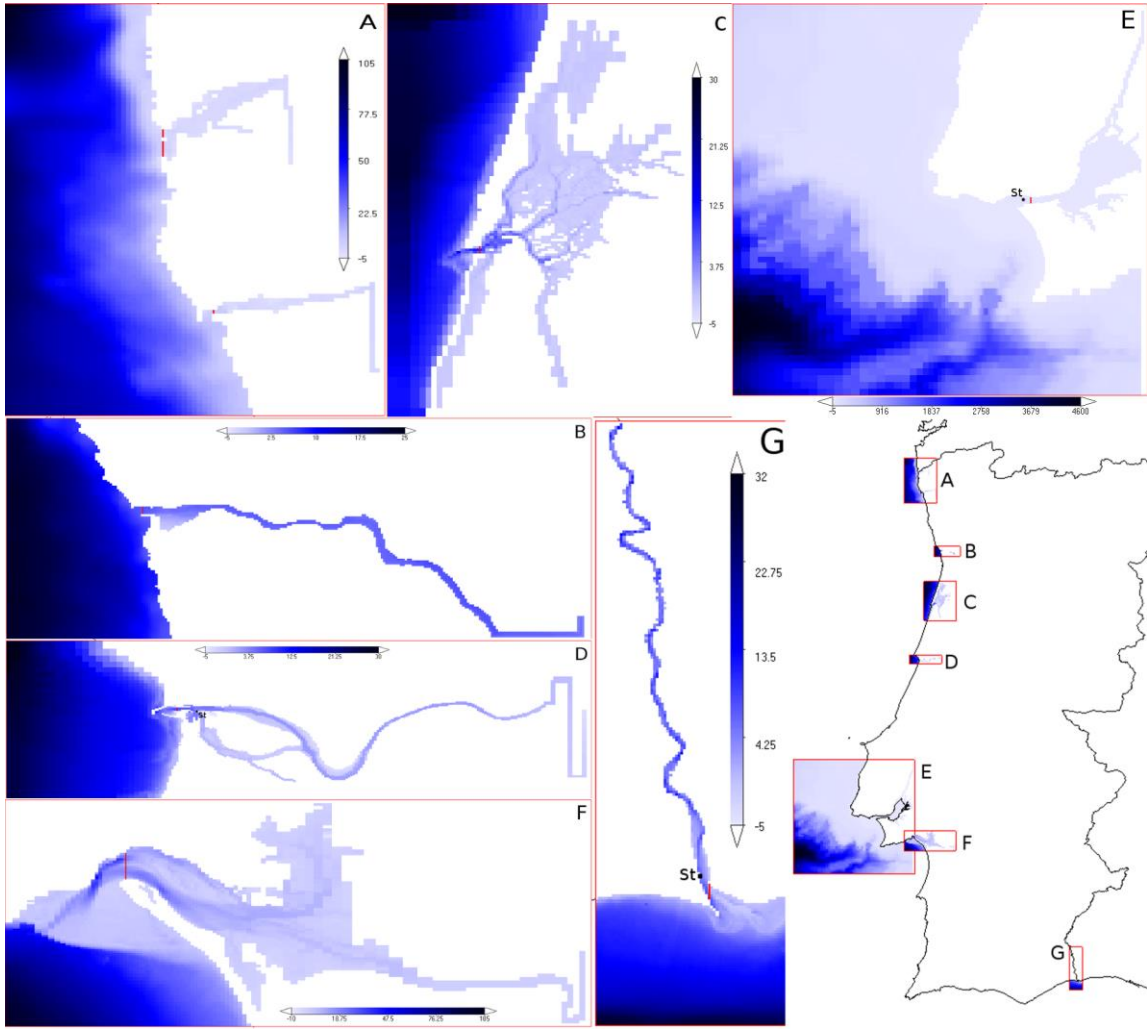
Authors | Authors and affiliations

Francisco Campuzano, David Brito, Manuela Juliano, Rodrigo Fernandes, Hilda de Pablo, Ramiro Neves

Algés Buoy Data provided by SIMTEJO Grupo Águas de Portugal

ESTUARY IMPLEMENTATION

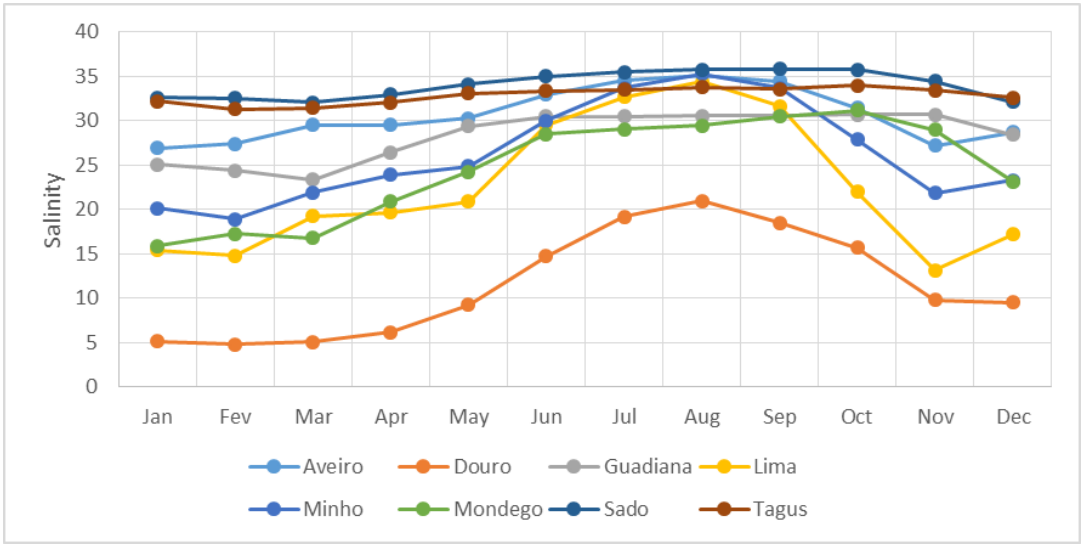
- River flow forcing:
  - A (top): Minho (MOHID Land WI)
  - A (bottom): Lima (MOHID Land WI)
  - B: Douro (SNIRH/APA)
  - C: Aveiro (MOHID Land WI)
  - D: Mondego (SNIRH/APA)
  - E: Tagus (SNIRH/APA)
  - F: Sado (MOHID Land WI)
  - G: Guadiana (SNIRH/APA)
- River temperature provided in all cases by MOHID Land WI.

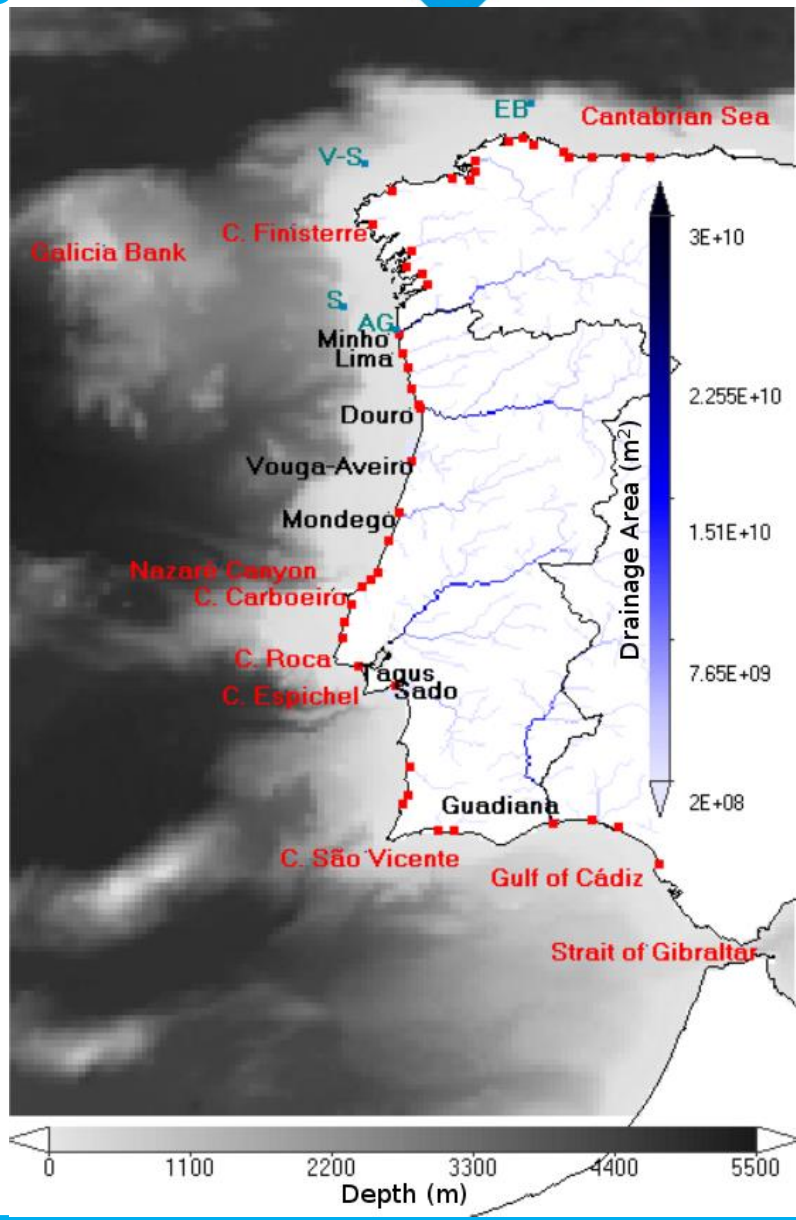


Campuzano FJ, Juliano M, Sobrinho J, de Pablo H, Brito D, Fernandes R, Neves R (accepted). Coupling Watersheds, Estuaries and Regional Oceanography through Numerical Modelling in the Western Iberia: Thermohaline Flux Variability at the Ocean-Estuary Interface. In: Estuary. W. Froneman (Ed), InTech, Rijeka, Croatia. DOI: 10.5772/intechopen.72162.

PCOMS VERSION WITH RIVERS

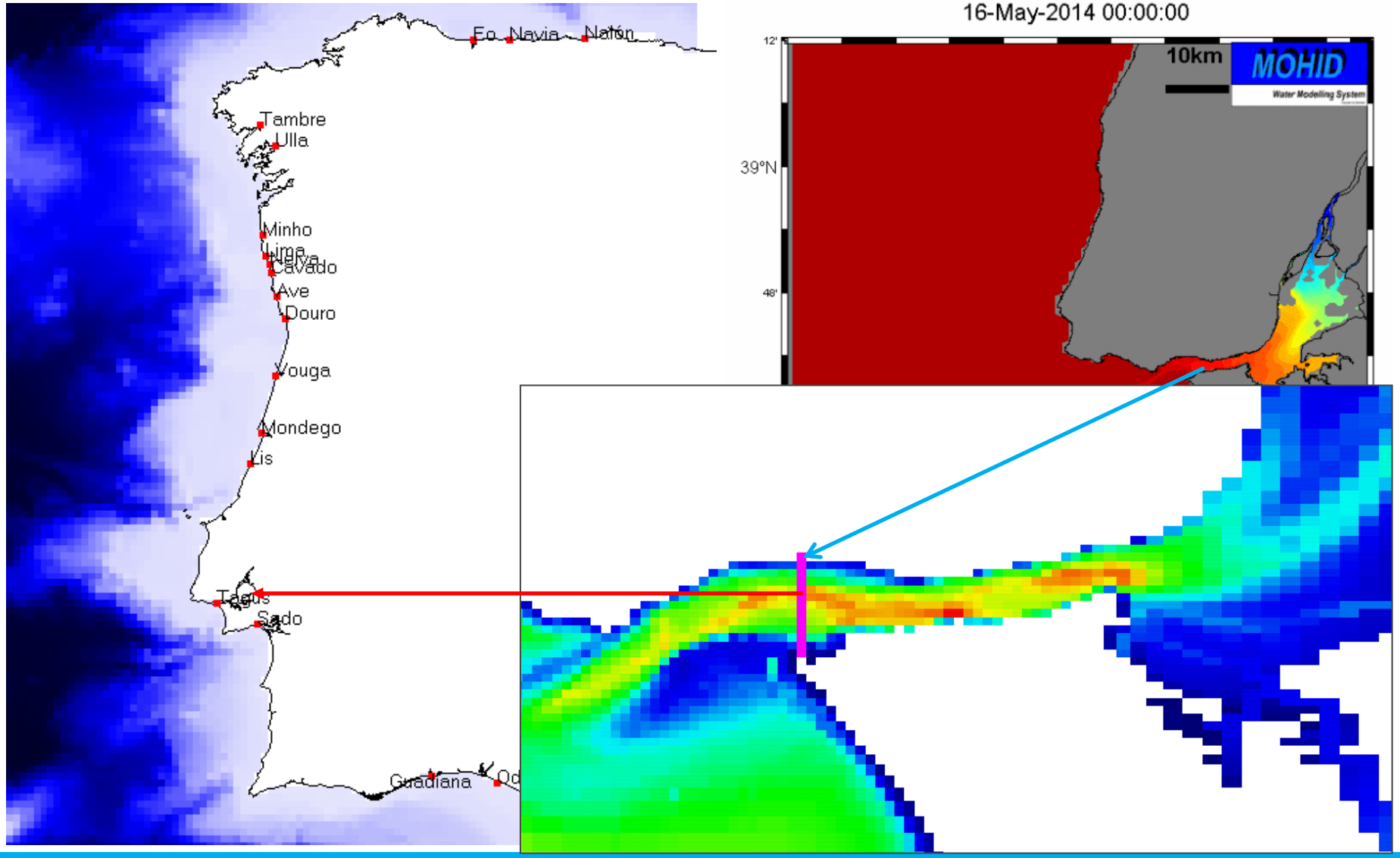
- 44 River discharges:
  - 8 estuarine fluxes
  - 36 direct river discharges with constant salinity value of 32



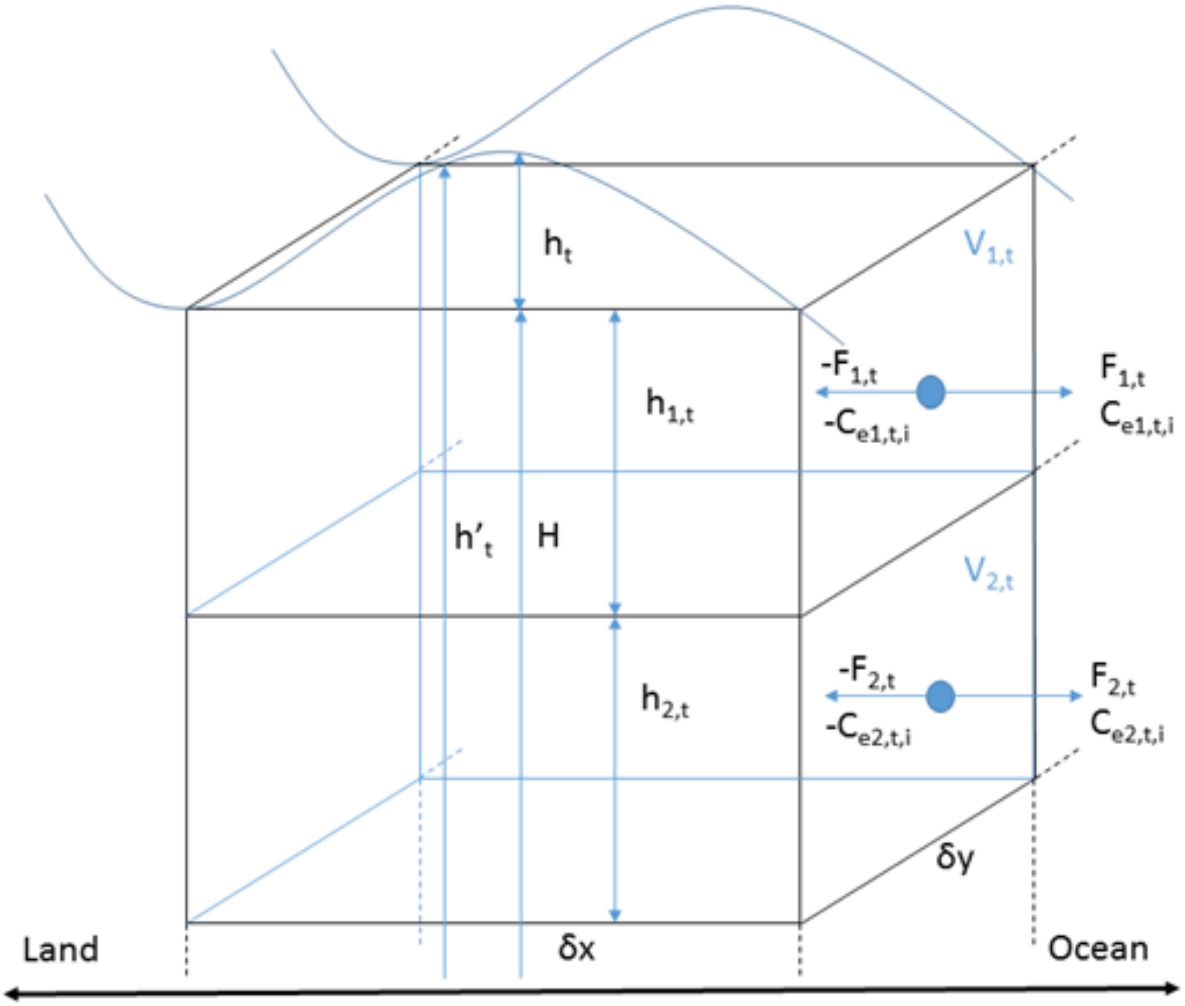


Campuzano FJ, Juliano M, Sobrinho J, de Pablo H, Brito D, Fernandes R, Neves R (2018). Coupling Watersheds, Estuaries and Regional Oceanography through Numerical Modelling in the Western Iberia: Thermohaline Flux Variability at the Ocean-Estuary Interface. In: Estuary. W. Froneman (Ed), InTech, Rijeka, Croatia. DOI: 10.5772/intechopen.72162.

RIVER-ESTUARY-OCEAN COUPLING

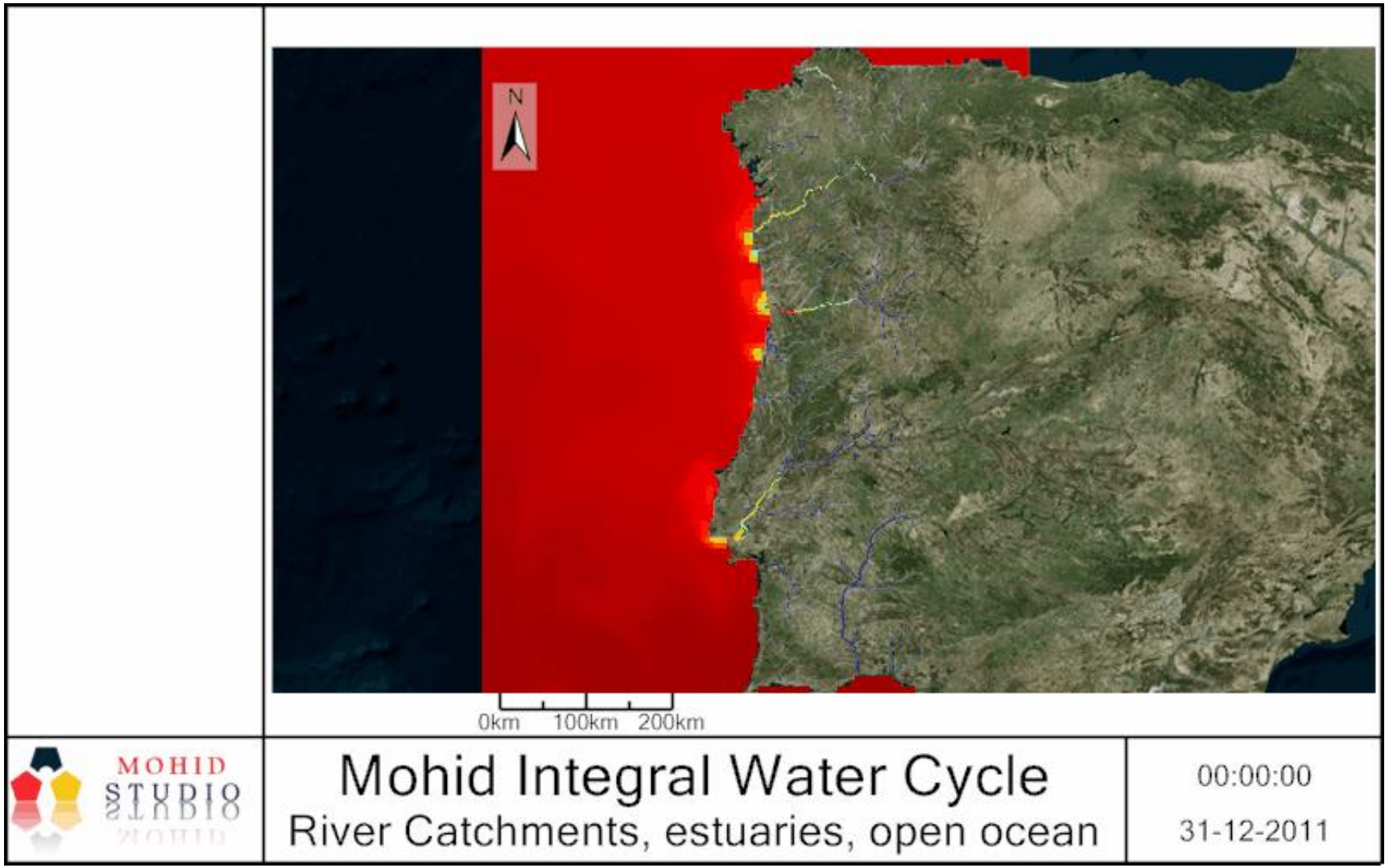


FLUXES CALCULATION



- Flow calculated for every cell at the cross-section both in the horizontal and vertical direction
- Fluxes imposed in the receiving cell at the corresponding vertical layer.

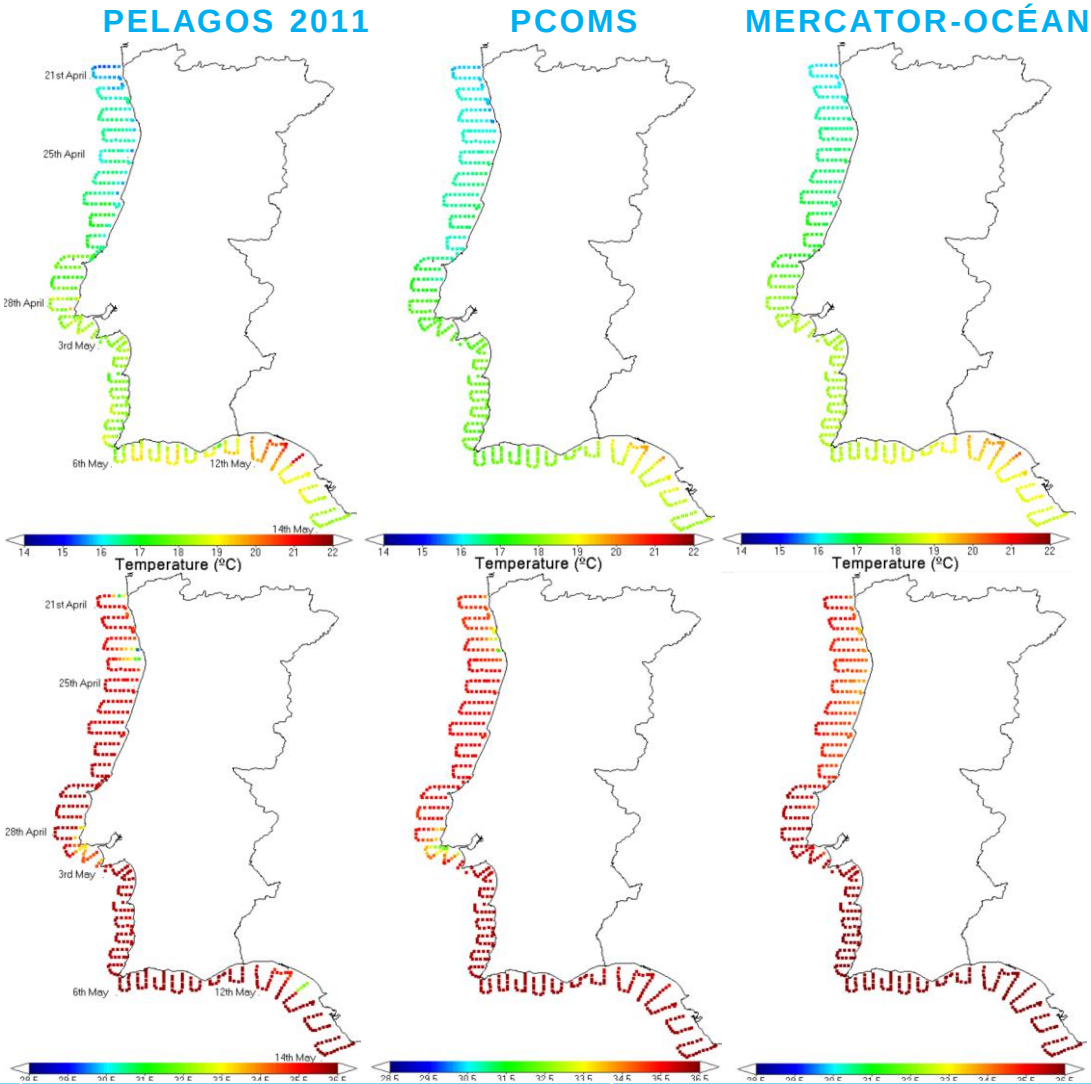
MOHID INTEGRAL WATER CYCLE IN THE PORTUGUESE CONTINENTAL COAST



INTEGRATED OCEAN-WATERSHEDS IN MADEIRA ISLAND

PELAGOS 2011 CRUISE

Data provided by M. M. Angélico and P. Oliveira from IPMA Instituto Português do Mar e da Atmosfera



	Temperature (ºC) (N=466)				Salinity (N= 466)			
	Mean (Min.-Max.)	R^2	Bias	RMSE	Mean (Min.-Max.)	R^2	Bias	RMSE
PCOMS	17.34 (15.49-19.90)	0.87	-0.44	0.66	35.66 (31.86-36.36)	0.38	-0.14	0.67
MERCATOR	17.83 (15.87-20.38)	0.89	0.05	0.42	35.87 (33.88-36.43)	0.17	0.08	0.77
PELAGOS11	17.78 (15.25-21.40)	-	-	-	35.80 (29.90-36.43)	-	-	-

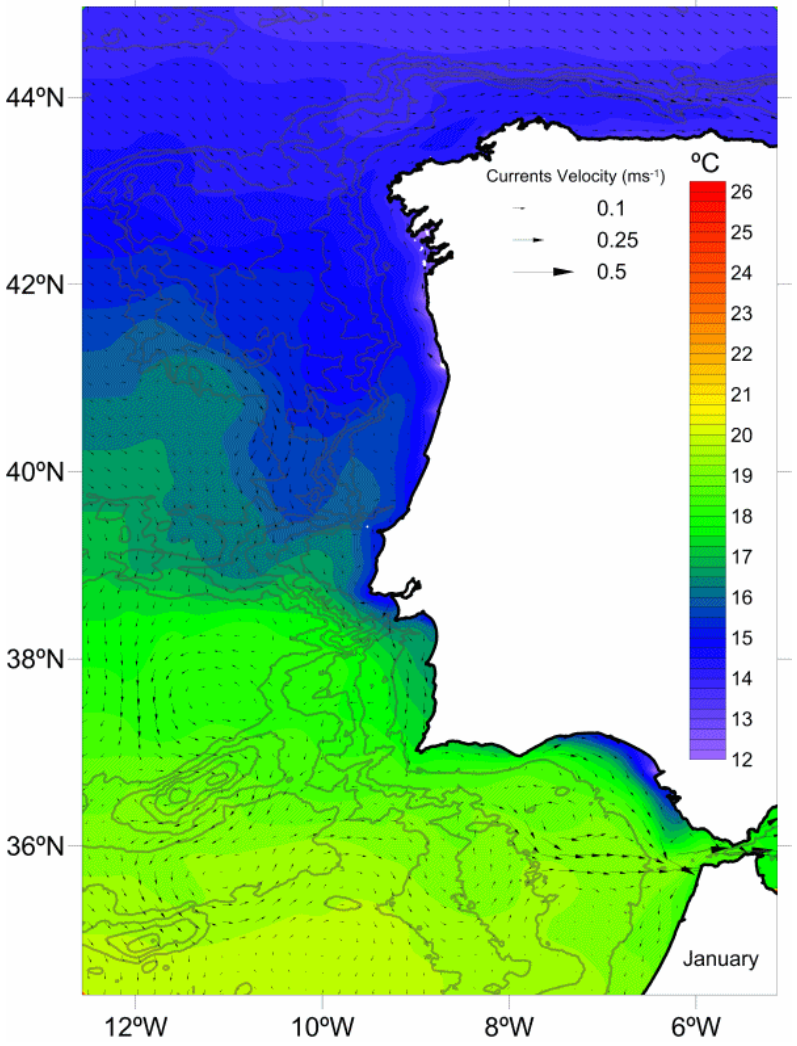
MONTHLY CLIMATOLOGY 2011-2015 PERIOD

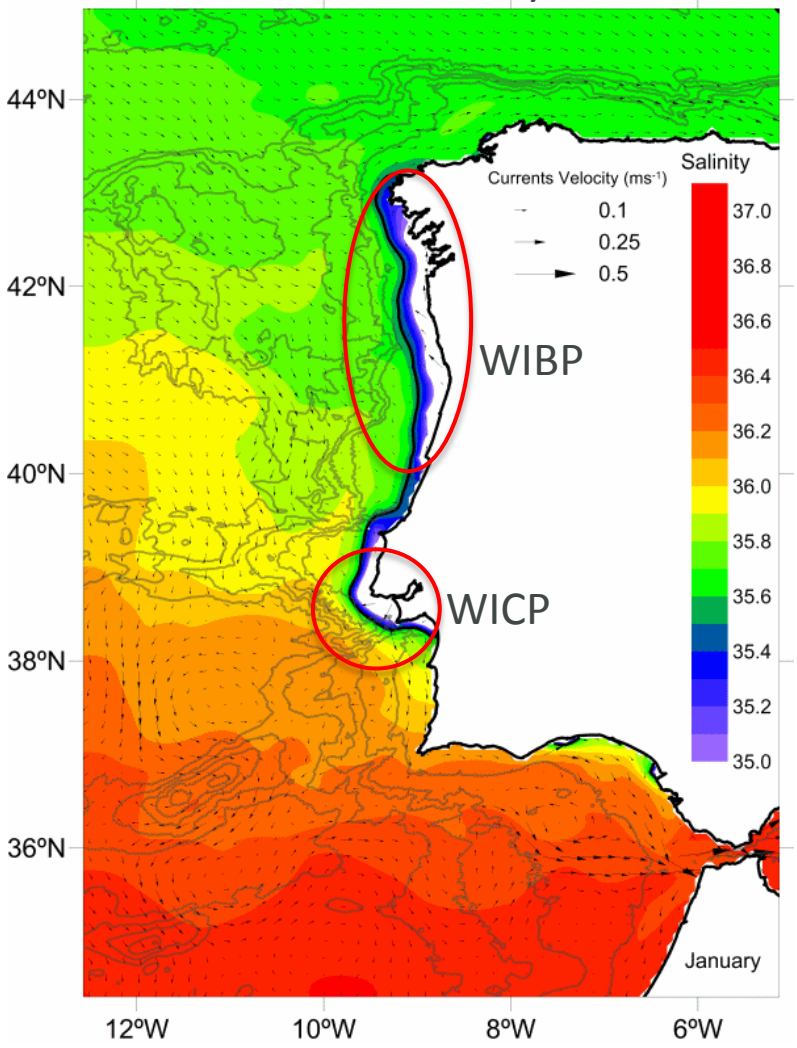
WIBP = Western Iberia Buoyant Plume

WICP = Western Iberia Central Plume

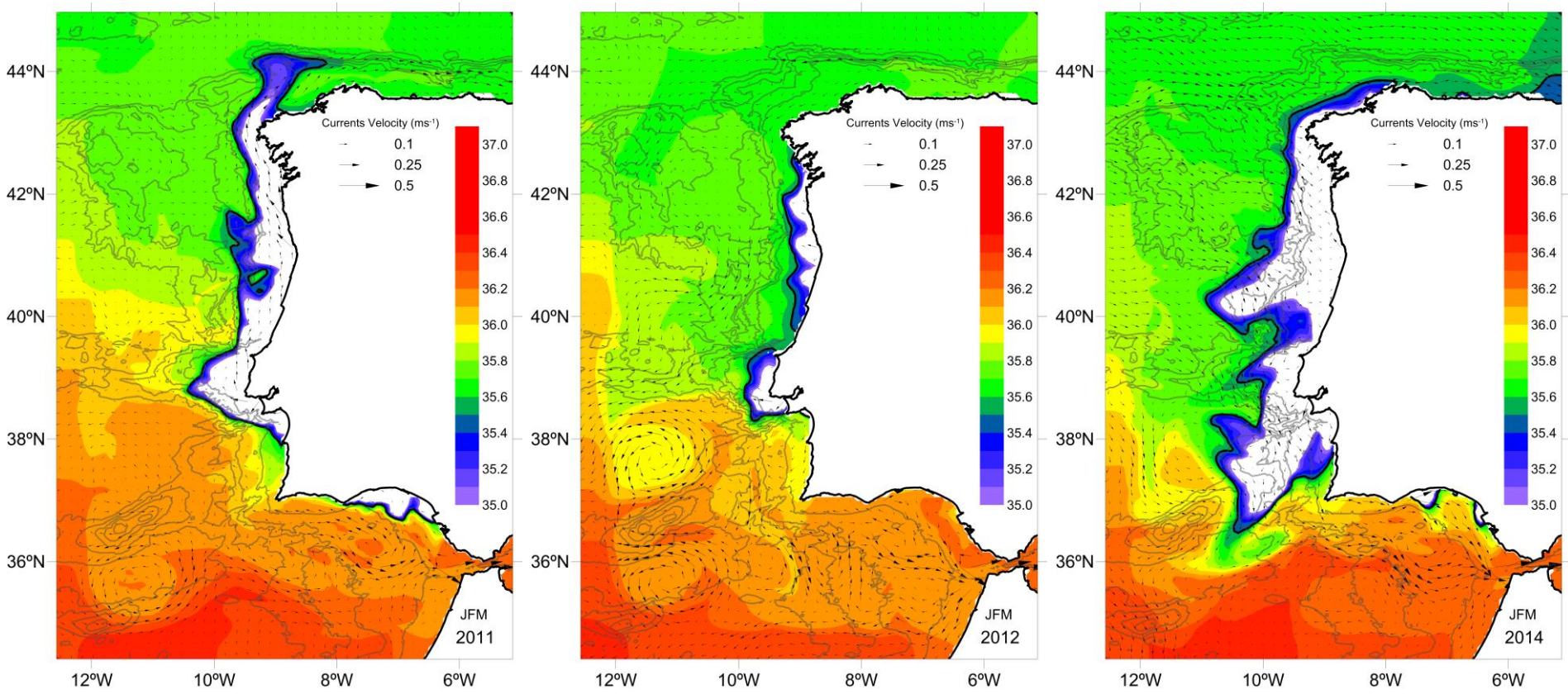
White values indicate salinity below 35

Dark line contours salinity 35.5

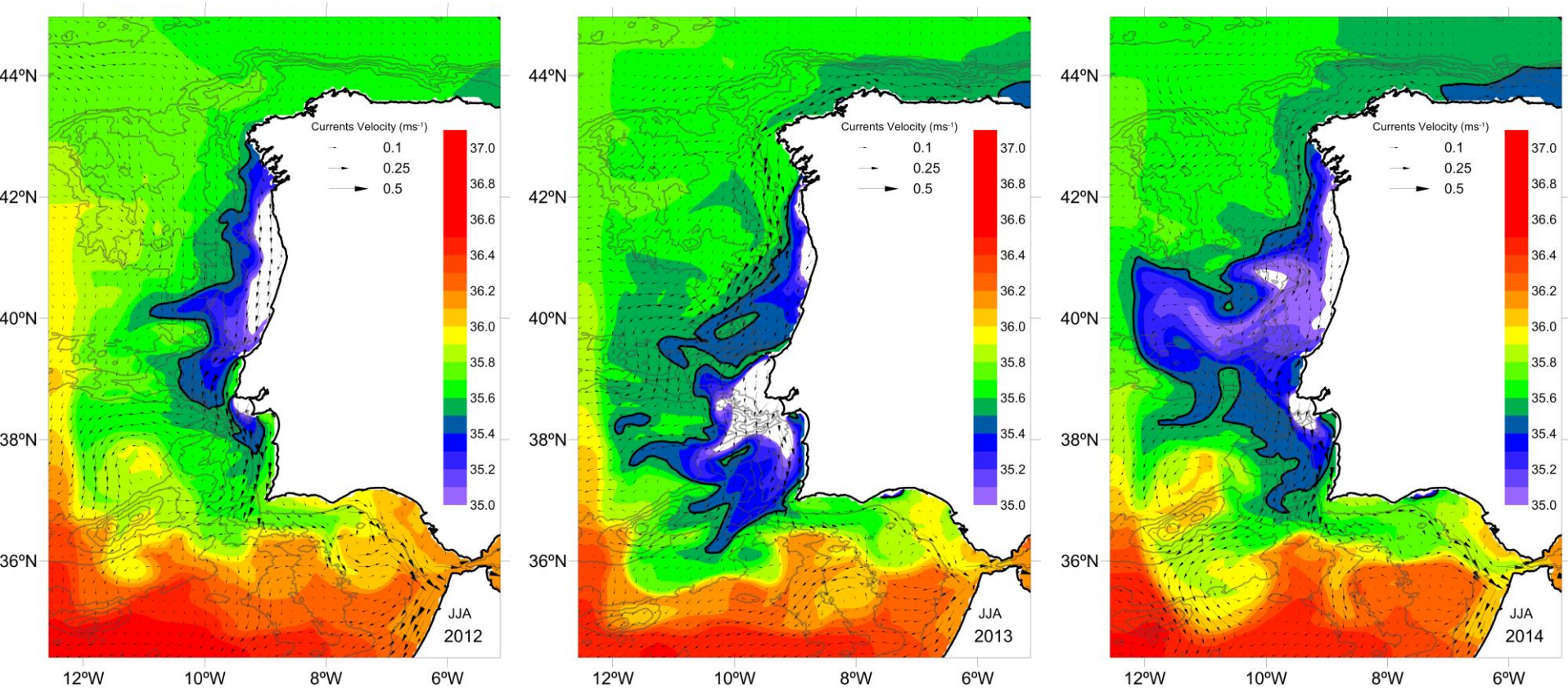




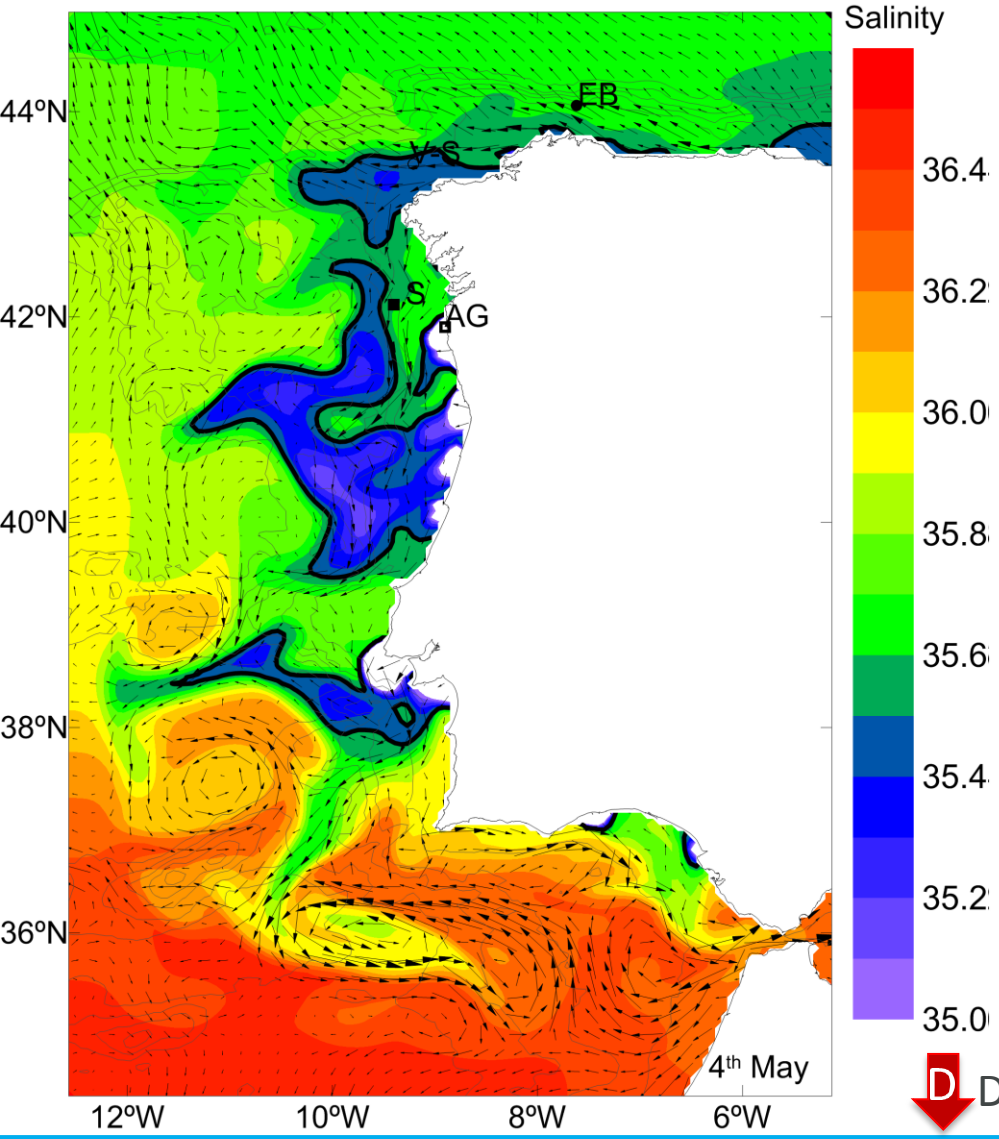
MEAN AND P05 SALINITY FOR RAINY SEASON (JFM)

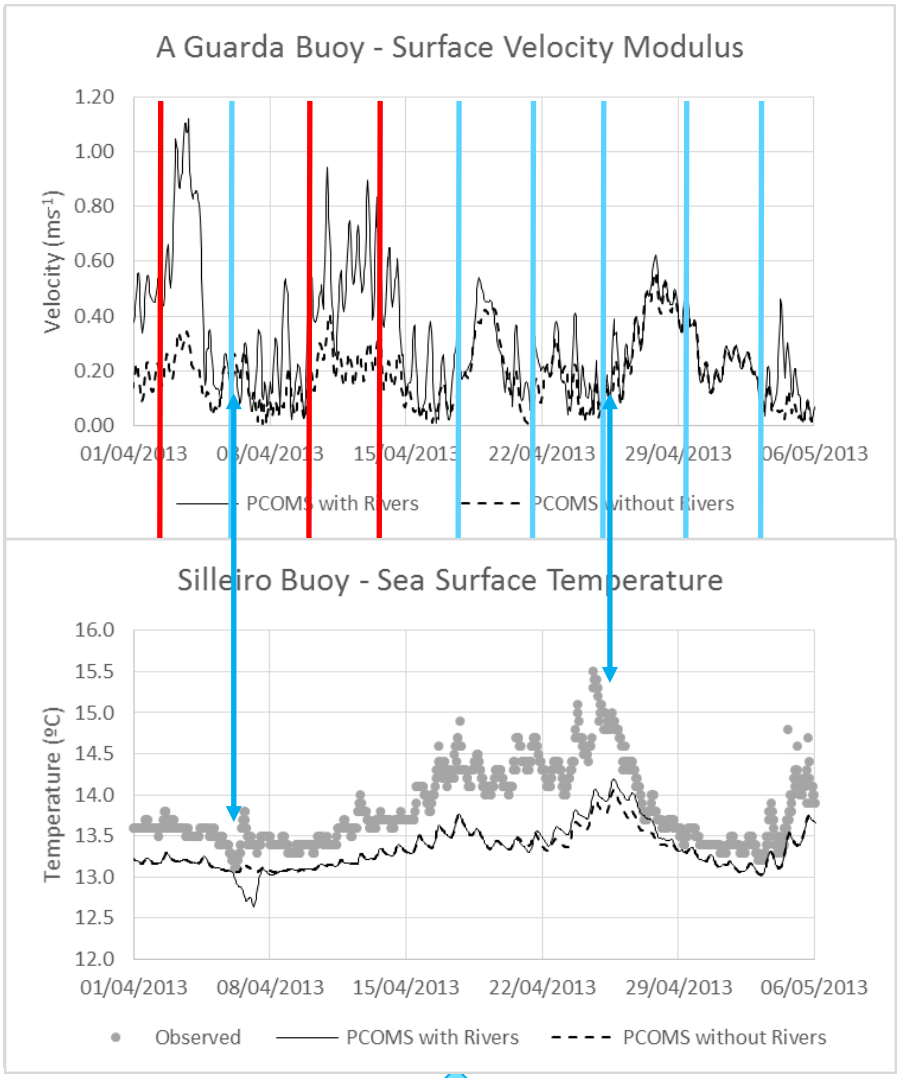


MEAN AND P05 SALINITY FOR DRY SEASON (JJA)



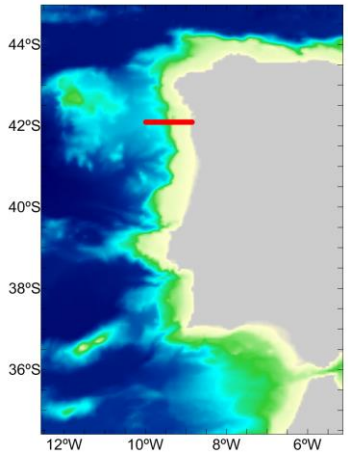
PCOMS - EXTREME EVENT SIMULATION

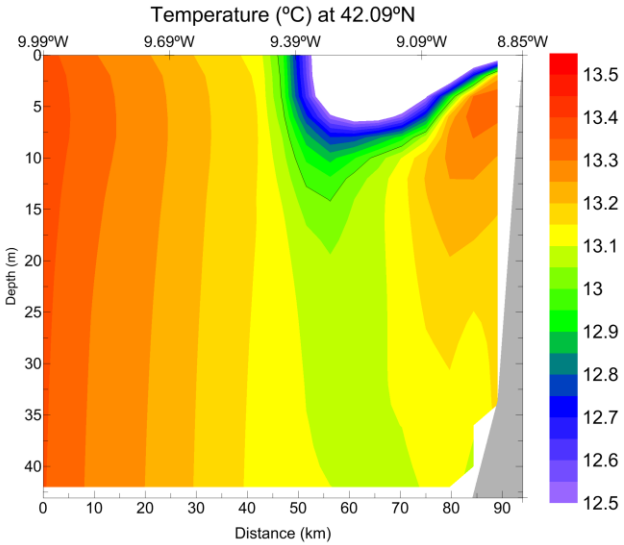


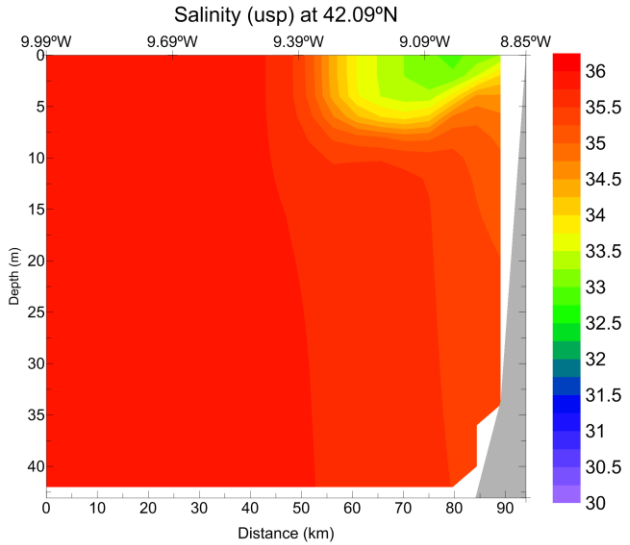


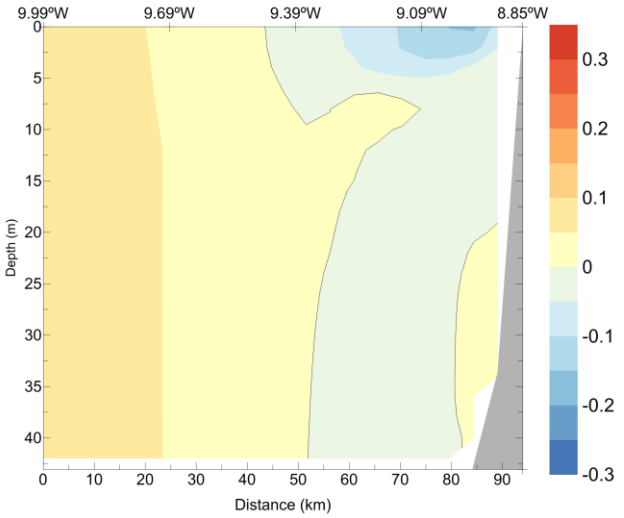
D Downwelling Conditions U Upwelling Conditions

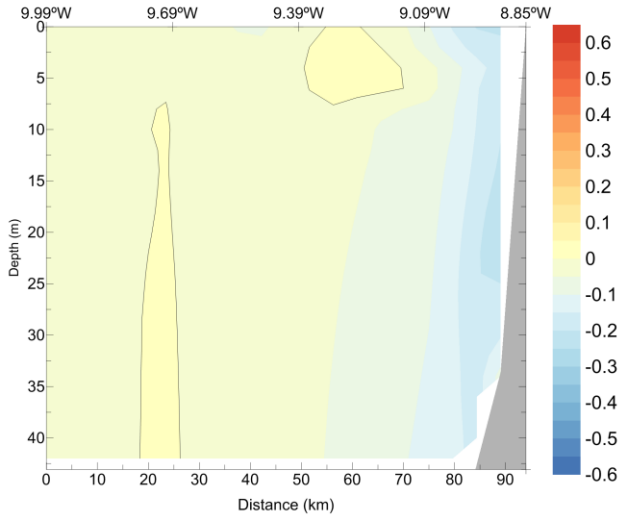
CROSS-SECTION EVOLUTION AT SILLEIRO BUOY











THESIS MAIN CONCLUSIONS:

- A novel methodology for calculating the overall inputs to the coastal area, simulate its evolution in the estuary continuum and inserting the volume and properties dynamics in a regional model was developed and tested successfully.
- The present methodology is able to complete temporally, spatially and cover the data gaps provided by monitoring equipment and field surveys in fresh water, estuarine and ocean environment to produce forecasts.
- This set of tools would be very valuable for understanding nutrient budgets, paths and fate. Also to study the formation of fronts which are relevant to fisheries management.
- The developed methodology is generic and could be set for any region using open source data and models.
- This methodology could aid in decision making at several levels: ecological, hydropower stations, managing watersheds, disaster and risk management, etc..

FUTURE CHALLENGES

- Complete the publication of the information collected in this thesis;
- Increase atmosphere and circulation model resolutions;
- Couple biogeochemical module to all the estuarine model applications;
- Include the human management along the watershed by implementing the dams´ simulation in the watershed domain;
- Improve the characterisation of the direct river discharges;
- Study the importance of estuaries as nutrient filters and the influence of their outputs in the near ocean primary production;

- More info in Campuzano F (2018). Coupling watersheds, estuaries and regional seas through numerical modelling for Western Iberia. PhD Thesis, Instituto Superior Técnico, Universidade de Lisboa, Portugal.
- The author would like also to thank to the initiatives and institutions that contributed to this research by sharing their observations:
  - CMEMS
  - APA
  - IH
  - IPMA
  - SIMTEJO
  - PdE
  - IEO

Historic Flooding in Coimbra (Portugal)