COUPLING WATERSHEDS, ESTUARIES AND REGIONAL SEAS THROUGH NUMERICAL MODELLING FOR WESTERN IBERIA: REGIONAL SEA SURFACE SALINITY PATTERNS.

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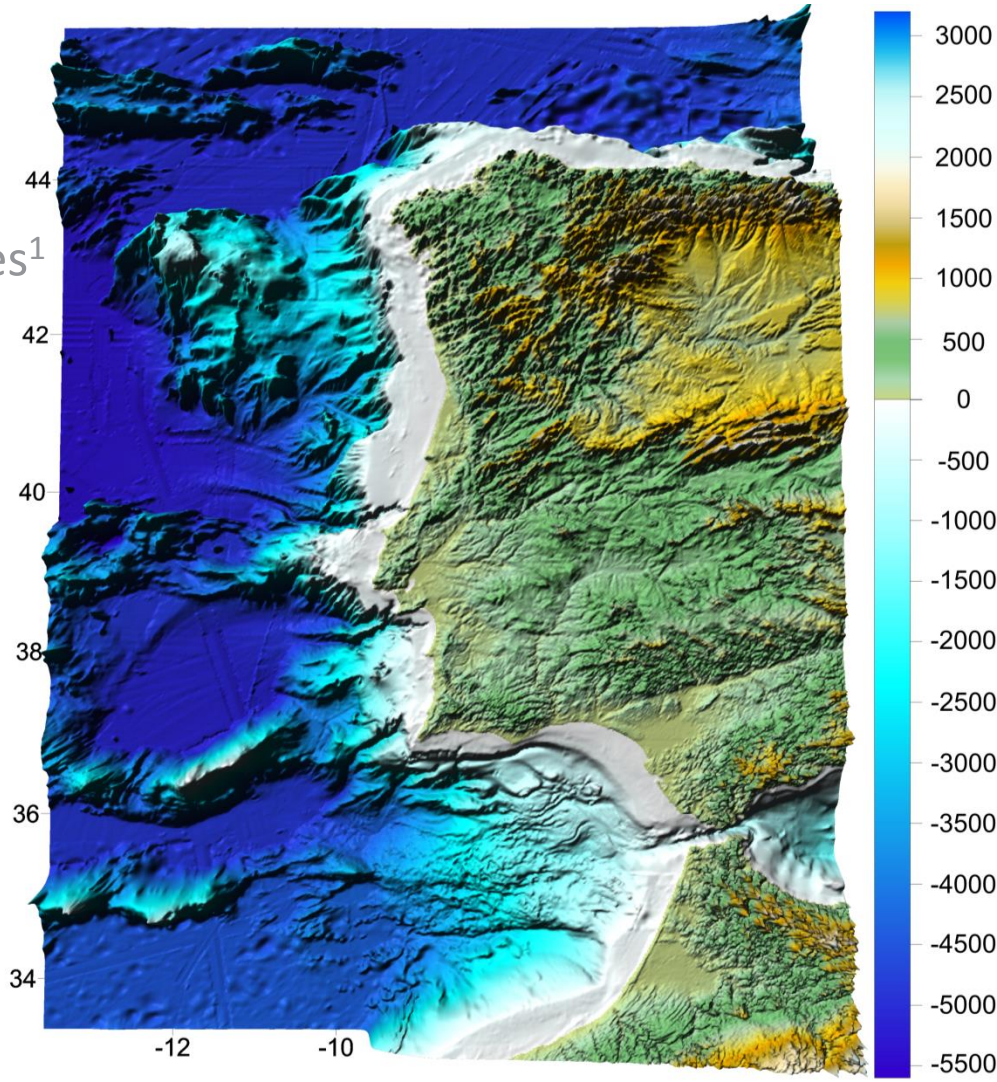
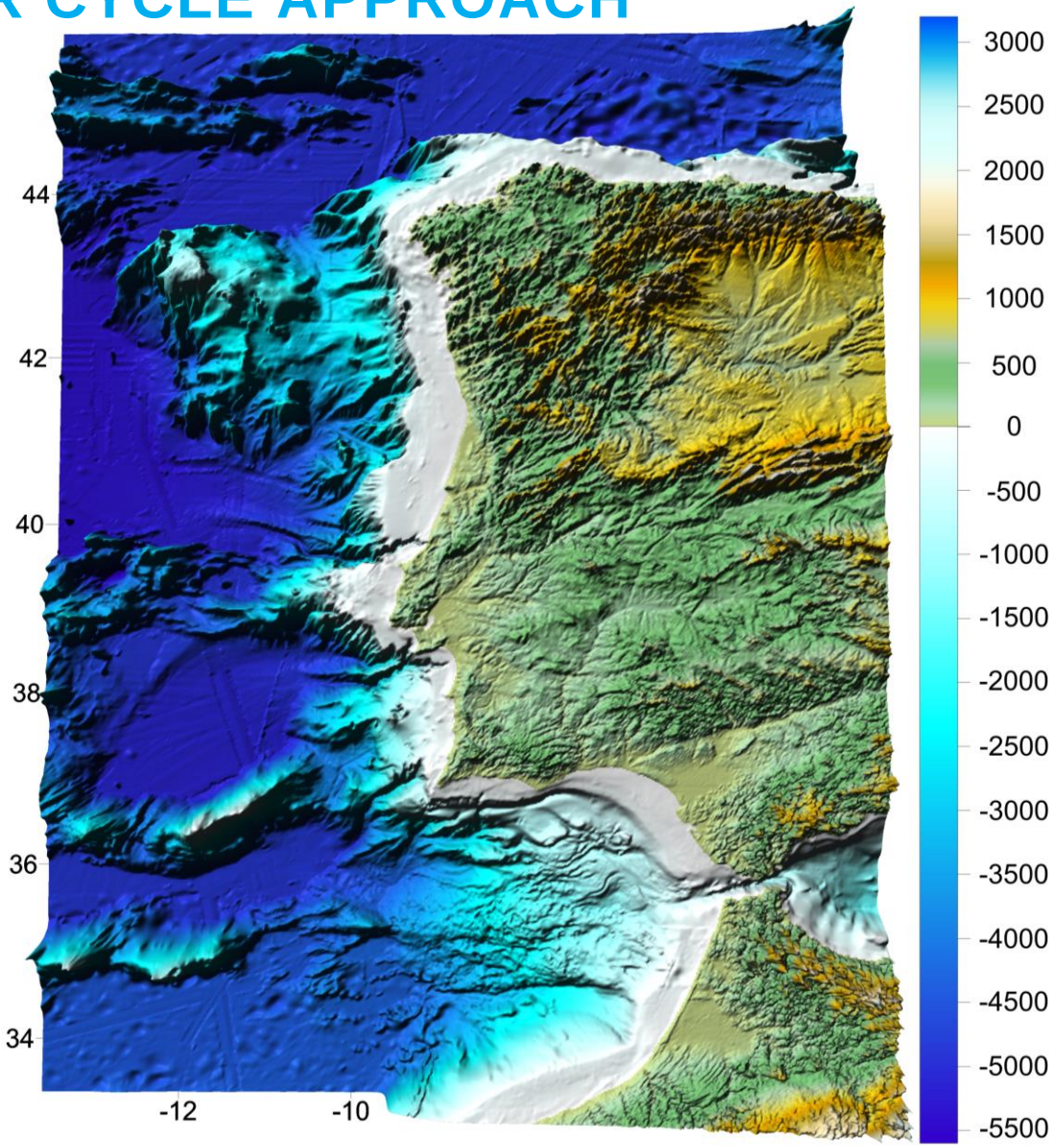


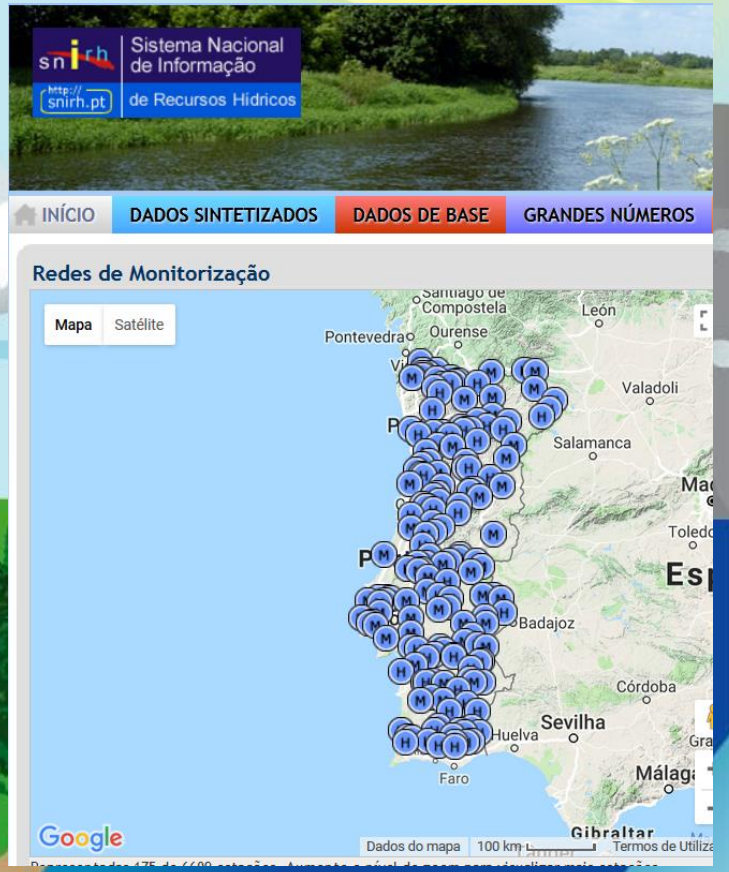
A PARADIGM SHIFT: INTEGRATED WATER CYCLE APPROACH

- 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.

- Main Challenges:
  - To found complete river data near its mouth;
  - How to impose those inputs in regional ocean models;
  - How to validate the results.



SINCE 1985 https://github.com/Mohid-Water-Modelling-System/Mohid



Watershed

MOHID Land

Estuarine Fluxes

Ocean

MOHID Water

www.mohid.com

MOHID

Water Modelling System

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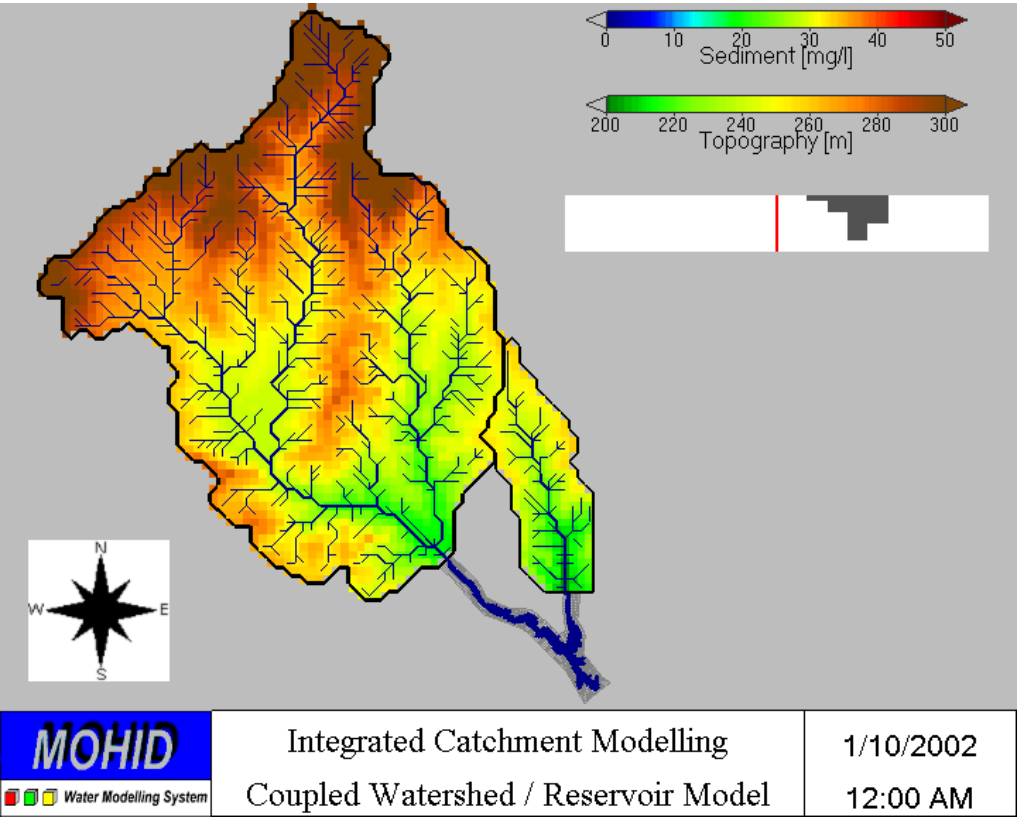
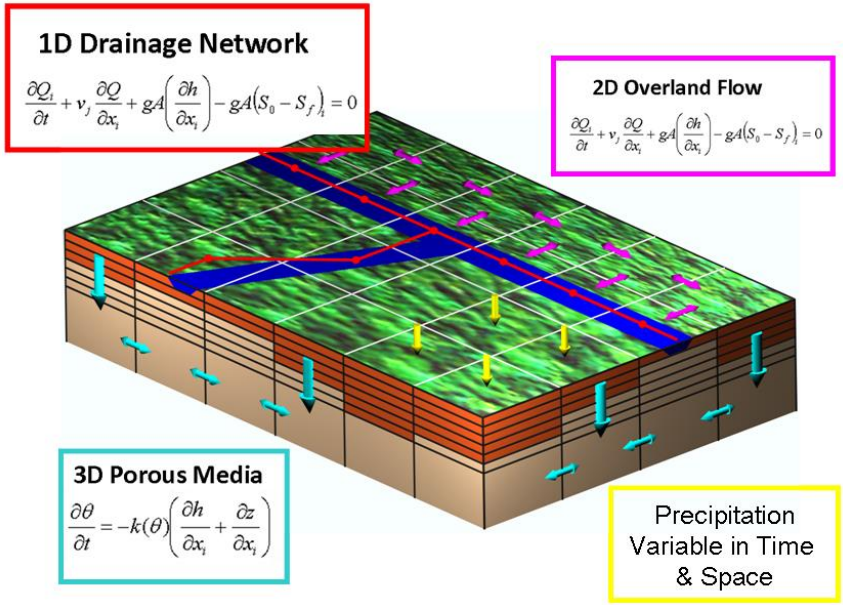
MOHID WATERSHED MODELLING





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

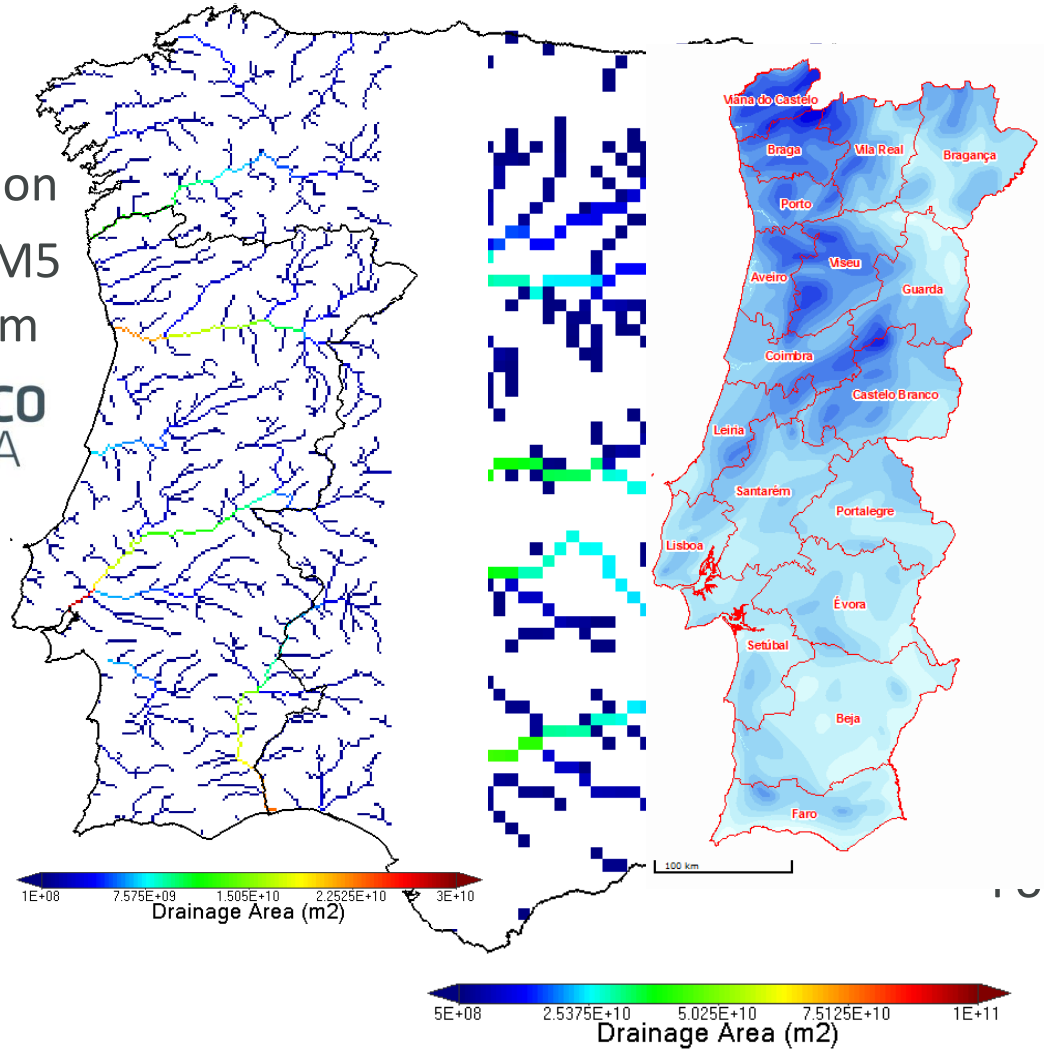
Integrating operational watershed and coastal models for the Iberian Coast: Watershed model implementation – A first approach

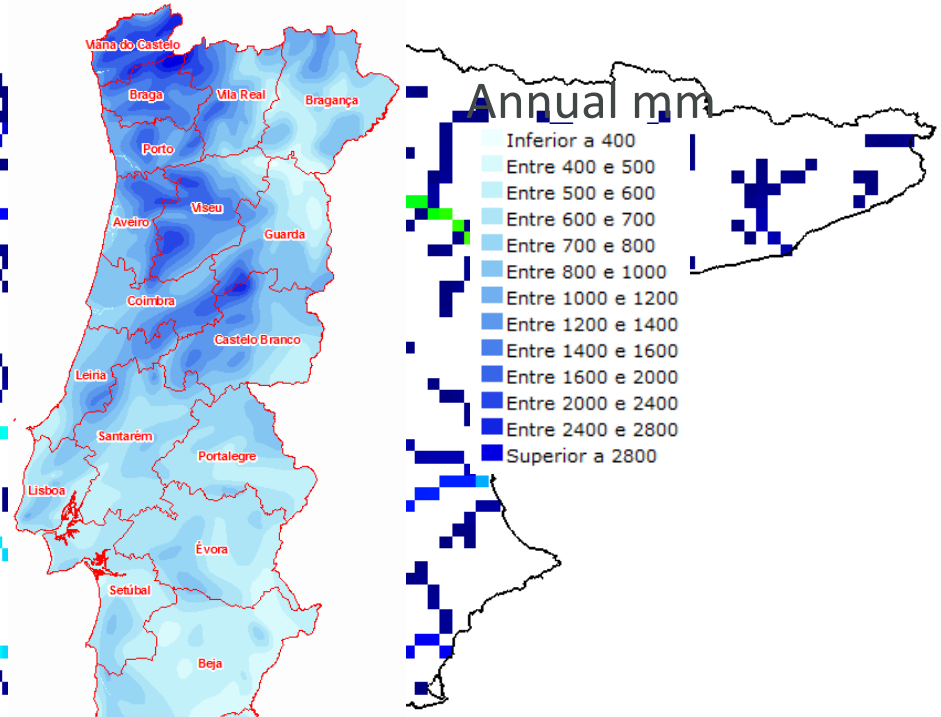
David Brito, F.J. Campuzano, J. Sobrinho, R. Fernandes, R. Neves

2 km resolution

Forced by MM5 results from

TÉCNICO LISBOA

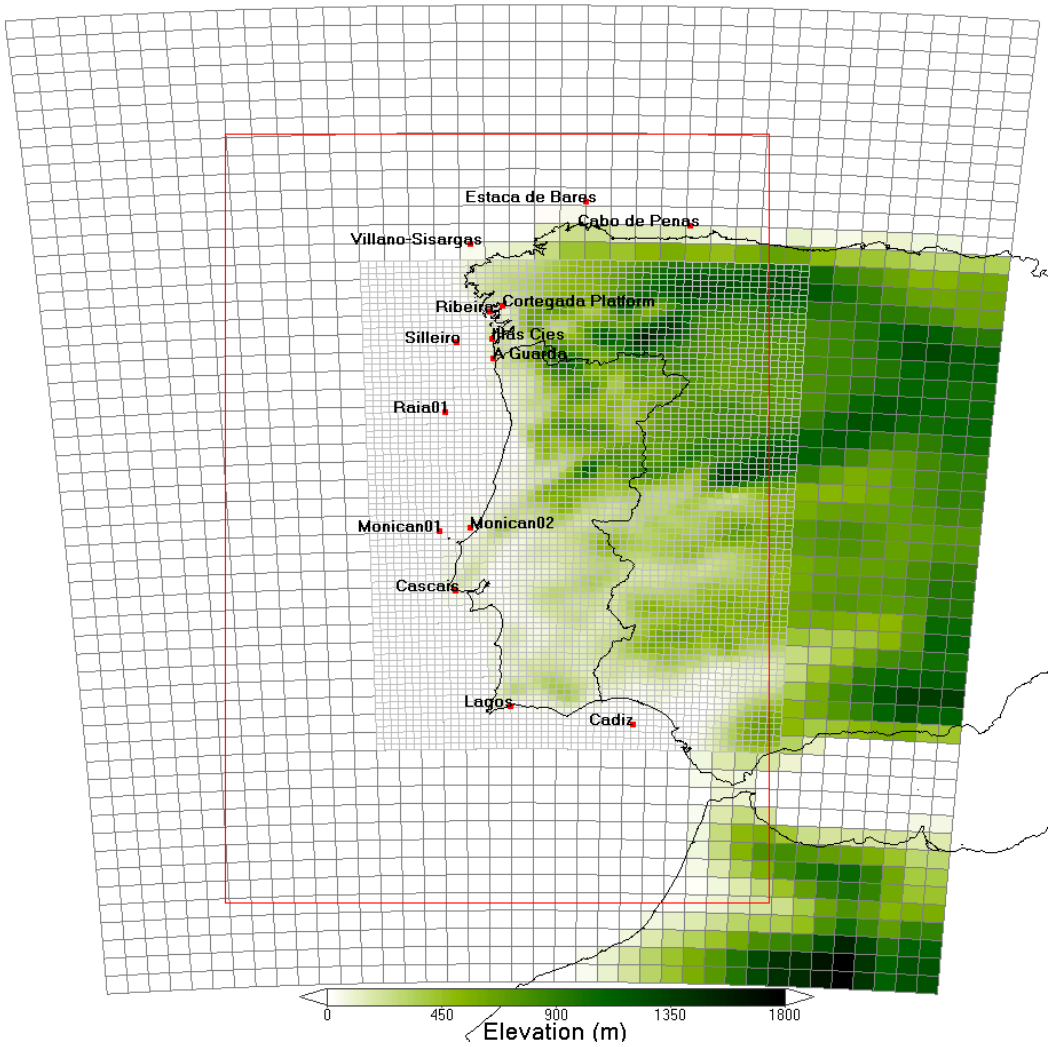




km resolution

Forced by WRF results from meteogalicia

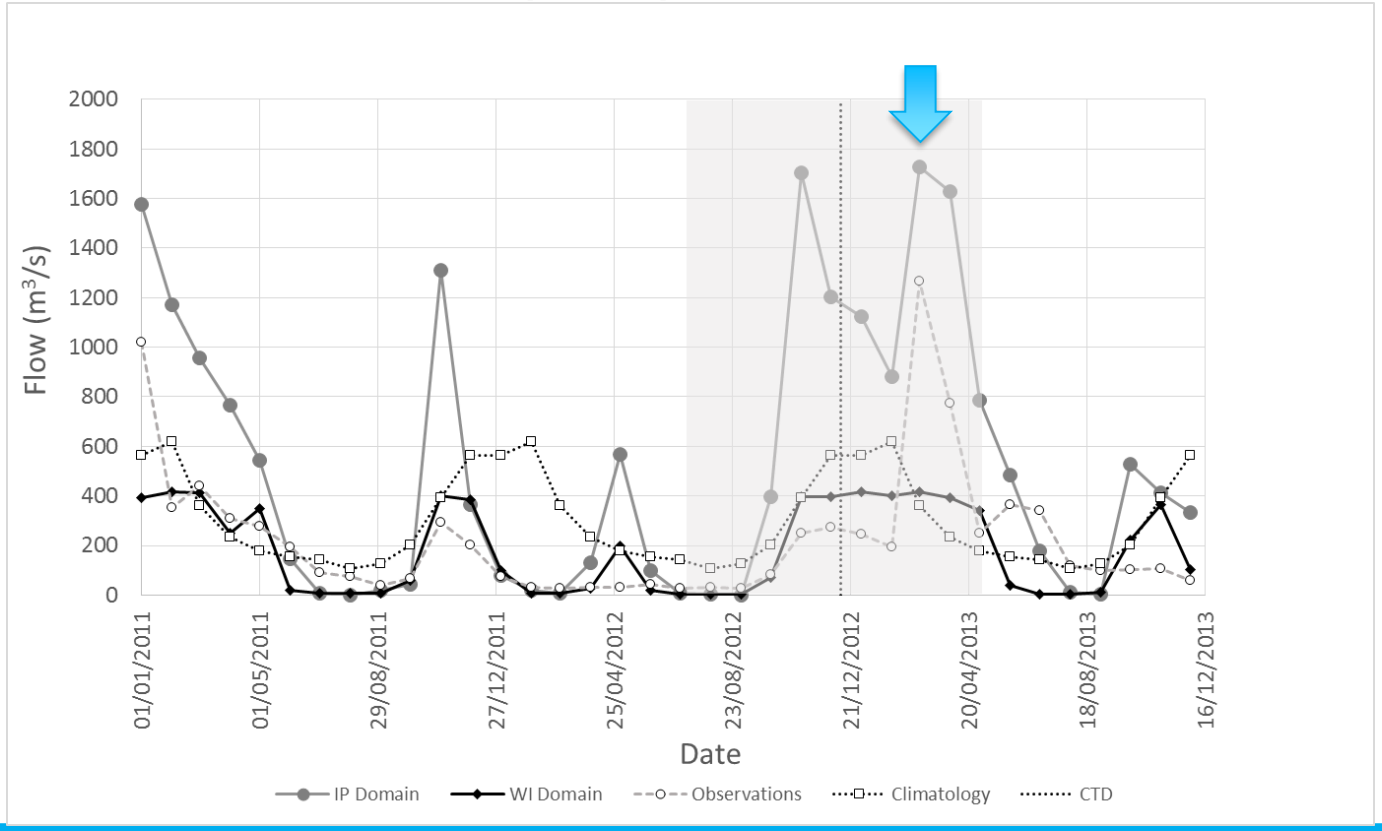
METEOROLOGICAL FORCING



- 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.

TAGUS ESTUARY MODELLING SCENARIOS

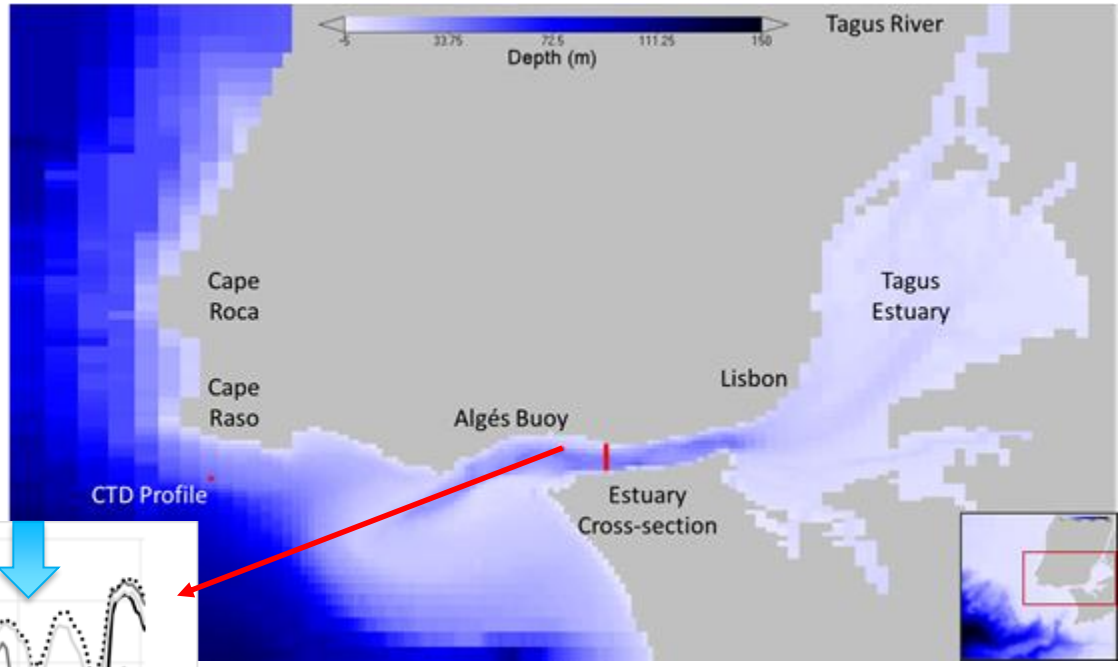
- River Hydrometric Observations (Almourol) (Source: SNIRH-APA)
- River Climatology
- MOHID Land IP (10 km)
- MOHID Land WI (2 km)

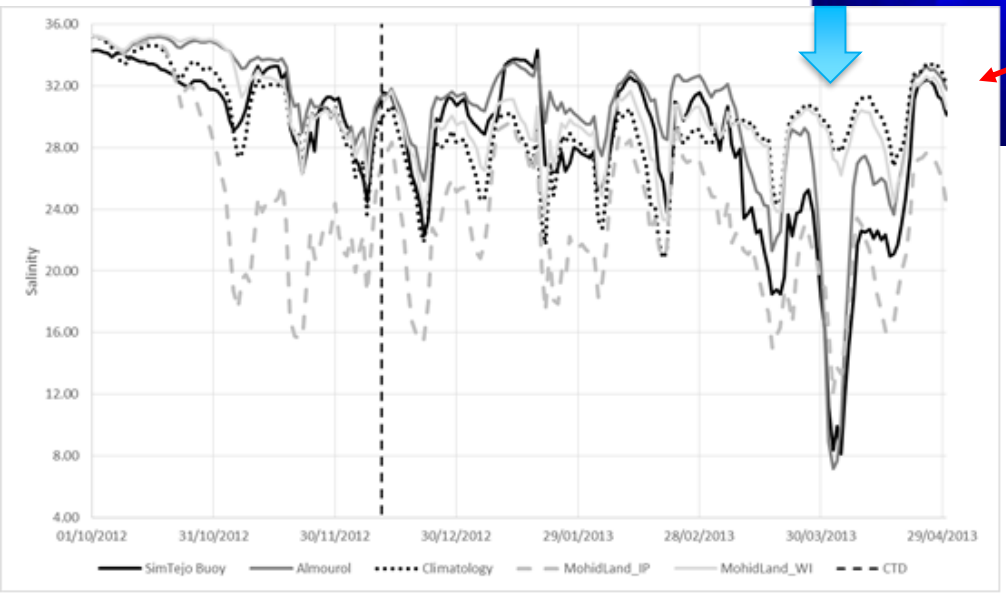


METHOD VALIDATION – ALGES BUOY

- 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

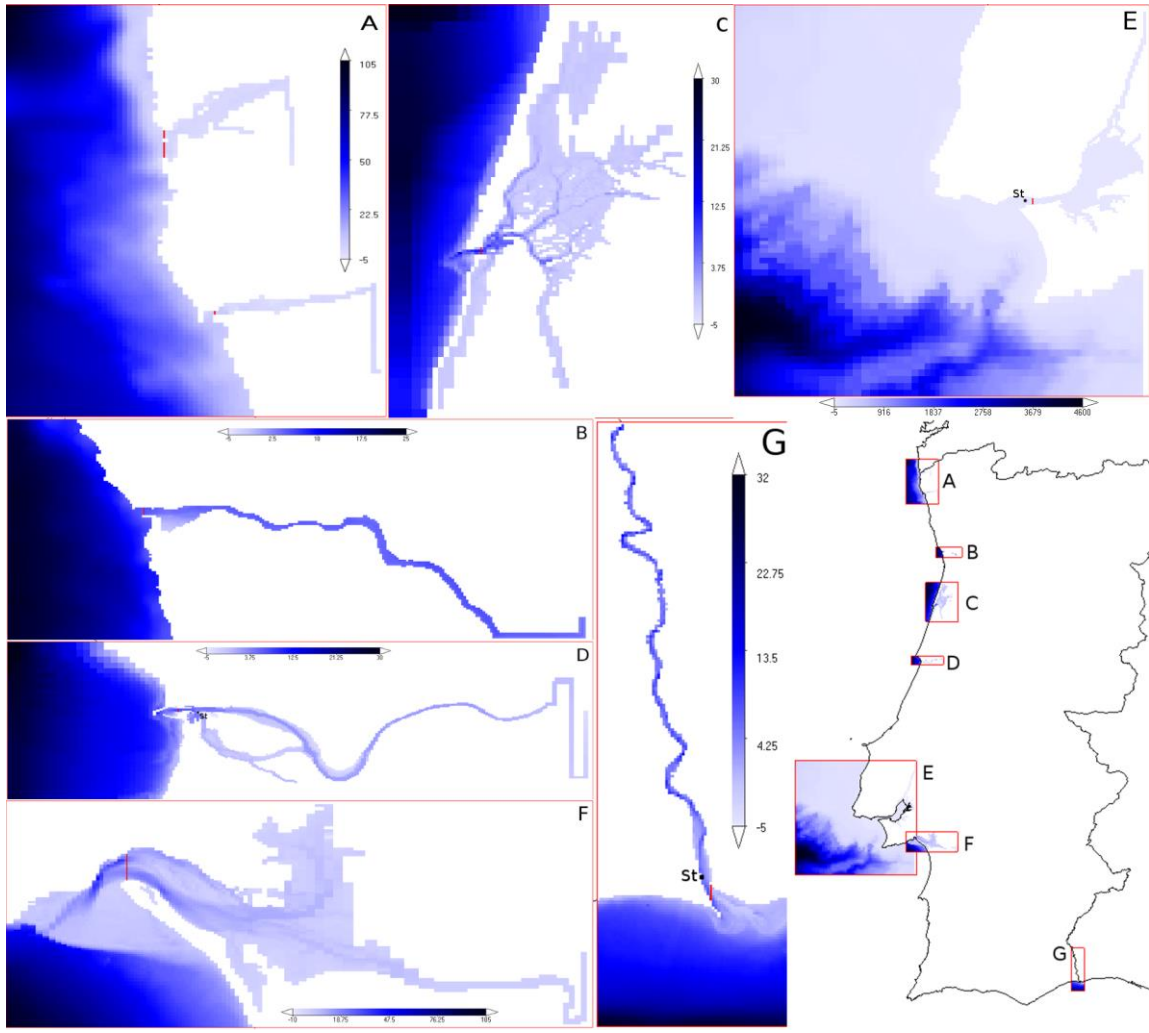
Authors | Authors and affiliations

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

Algés Buoy Data provided by SIMTEJO Grupo Águas de Portugal

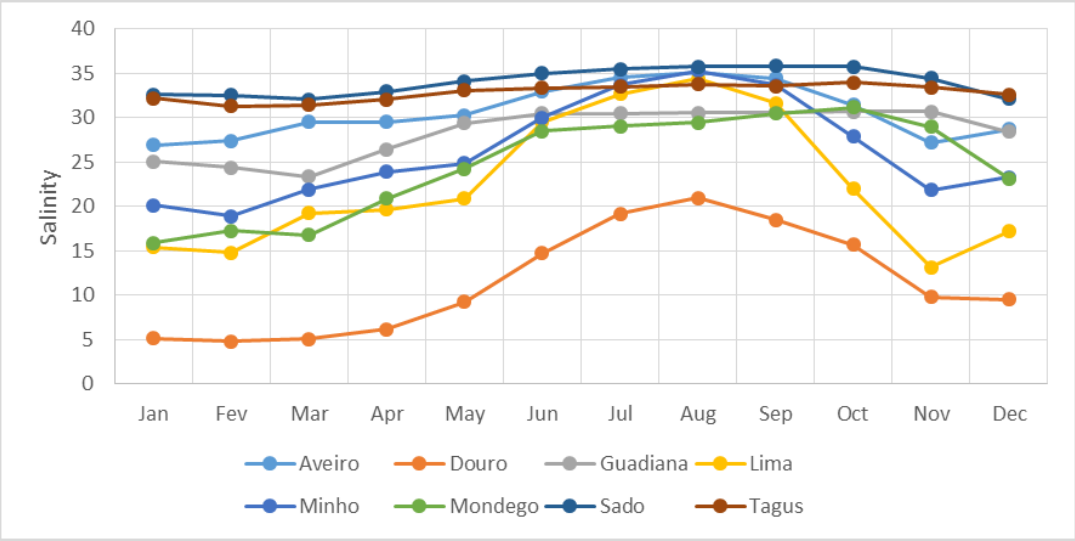
ESTUARY IMPLEMENTATION

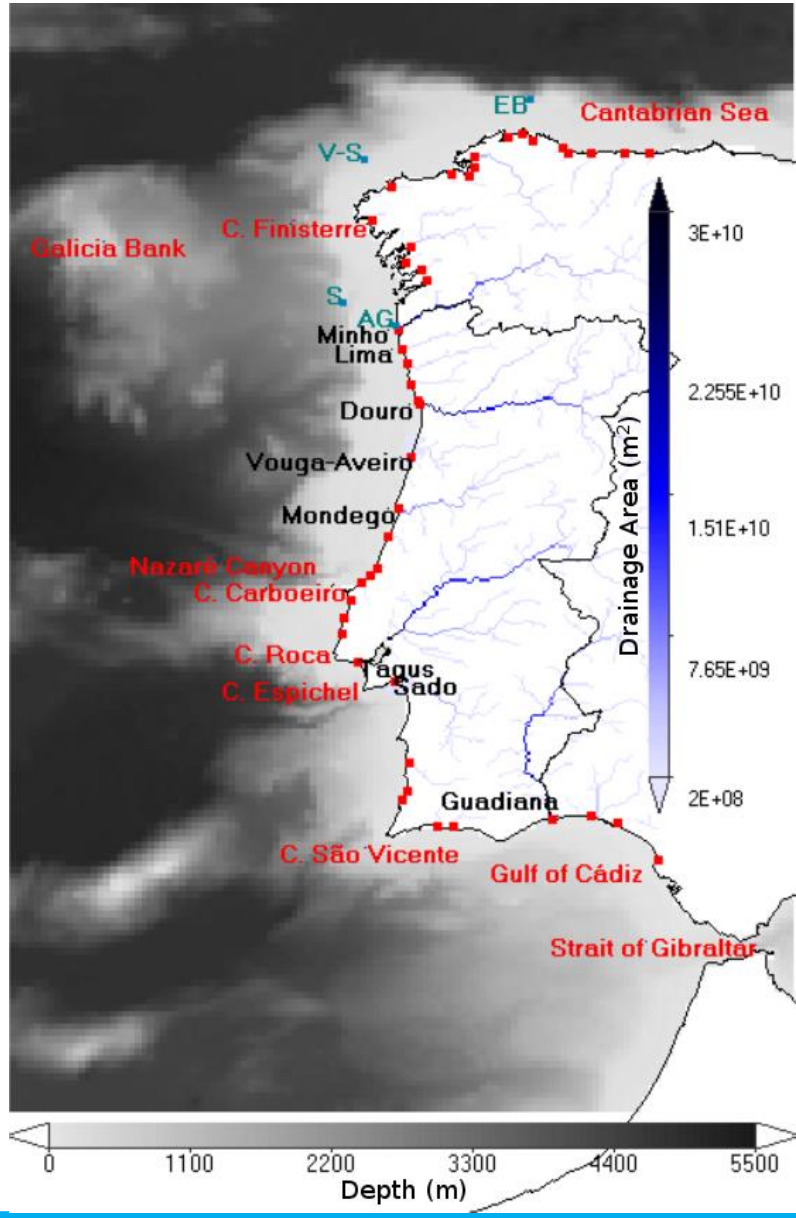
- River flow forcing:
  - A (top): Minho (MOHID Land WI)
  - A (bottom): Lima (MOHID Land WI)
  - B: Douro (SNIRH/APA)
  - C: Aveiro (MOHID Land WI)
  - D: Mondego (SNIRH/APA)
  - E: Tagus (SNIRH/APA)
  - F: Sado (MOHID Land WI)
  - G: Guadiana (SNIRH/APA)
- River temperature provided in all cases by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



PCOMS VERSION WITH RIVERS

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

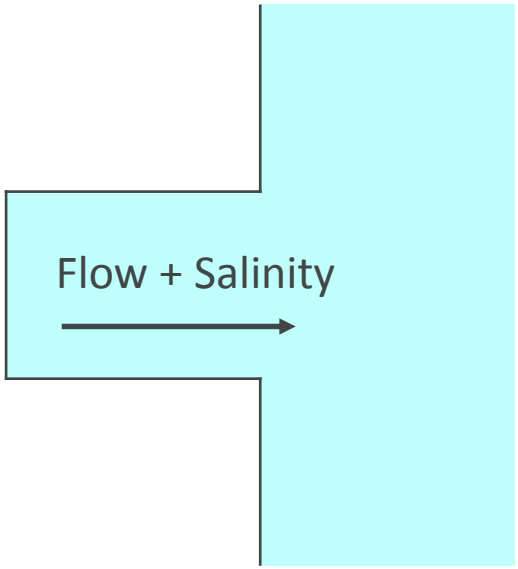


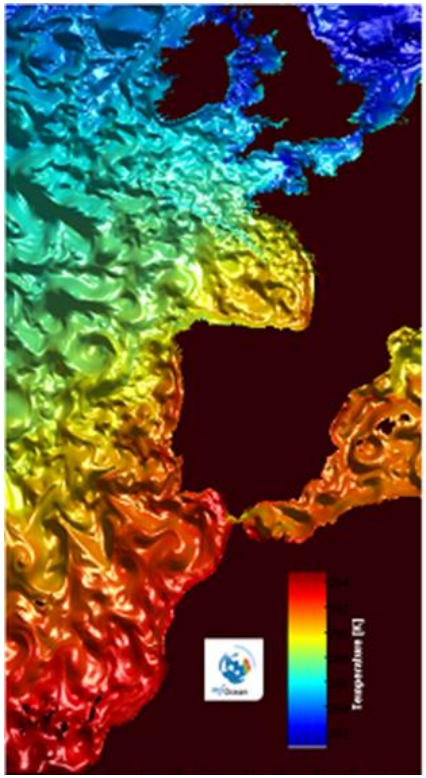


Campuzano FJ, Juliano M, Sobrinho J, de Pablo H, Brito D, Fernandes R, Neves R (2018). Coupling Watersheds, Estuaries and Regional Oceanography through Numerical Modelling in the Western Iberia: Thermohaline Flux Variability at the Ocean-Estuary Interface. In: Estuary. W. Froneman (Ed), InTech, Rijeka,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

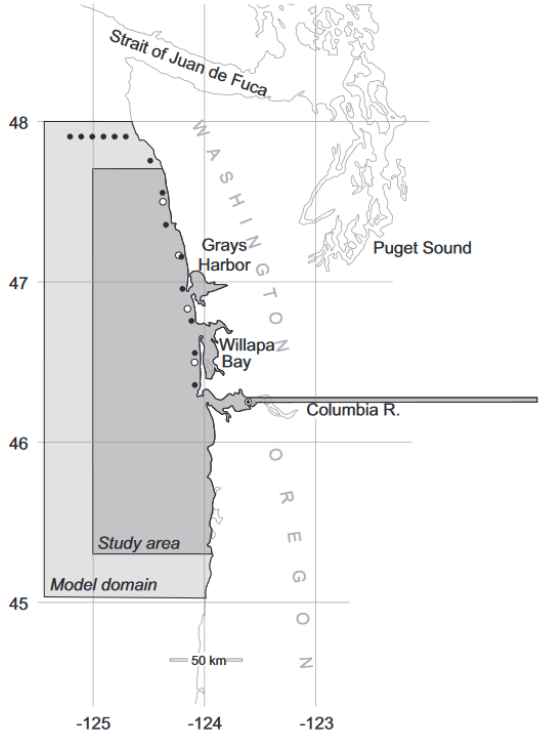
RIVER INPUT METHODS

- Direct Discharge (Flow + constant salinity)
- Initial dilution through single inlet (Flow + constant salinity) such as the Copernicus marine service for the IBI-Region



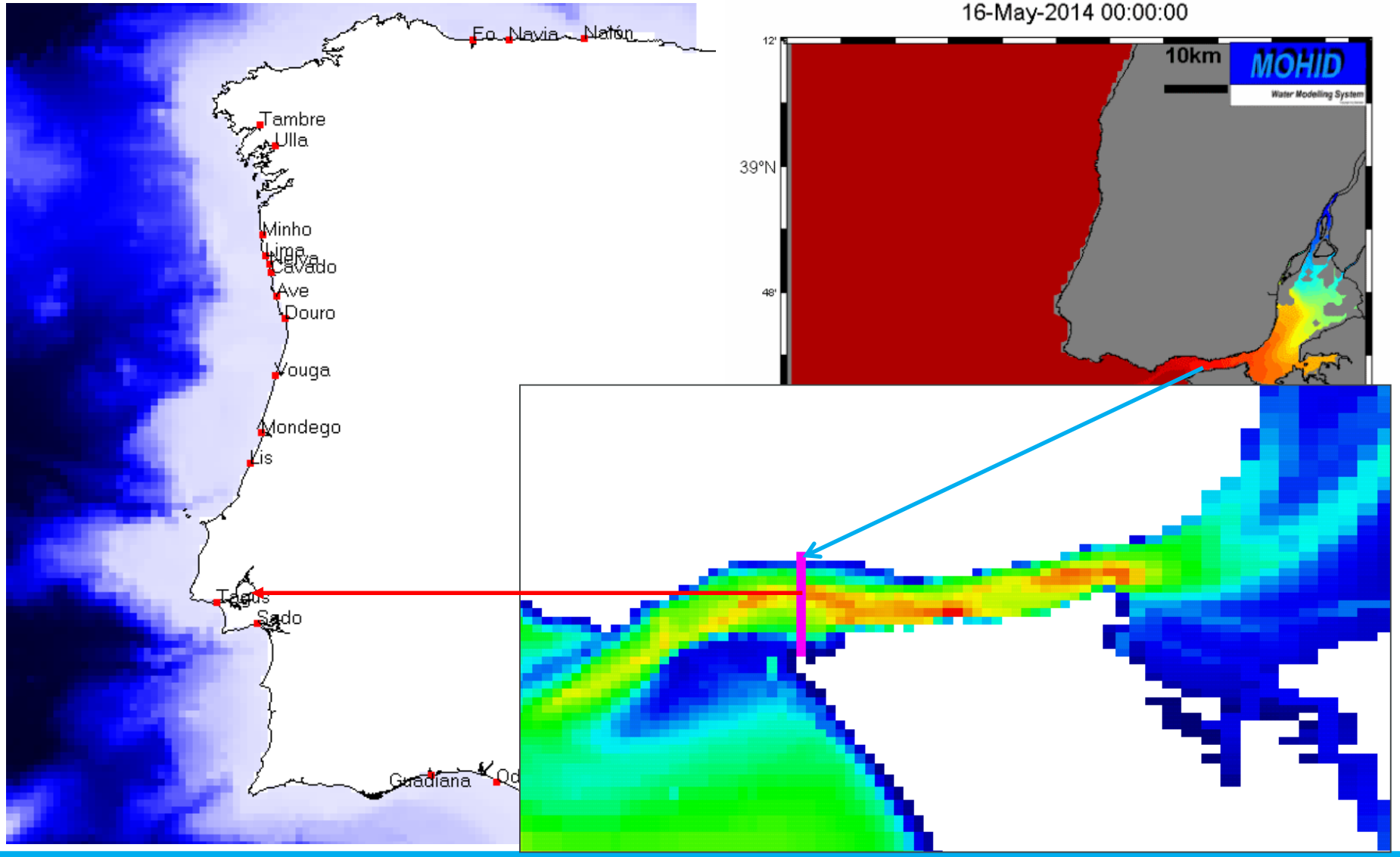


- Integrated estuary to ROFI

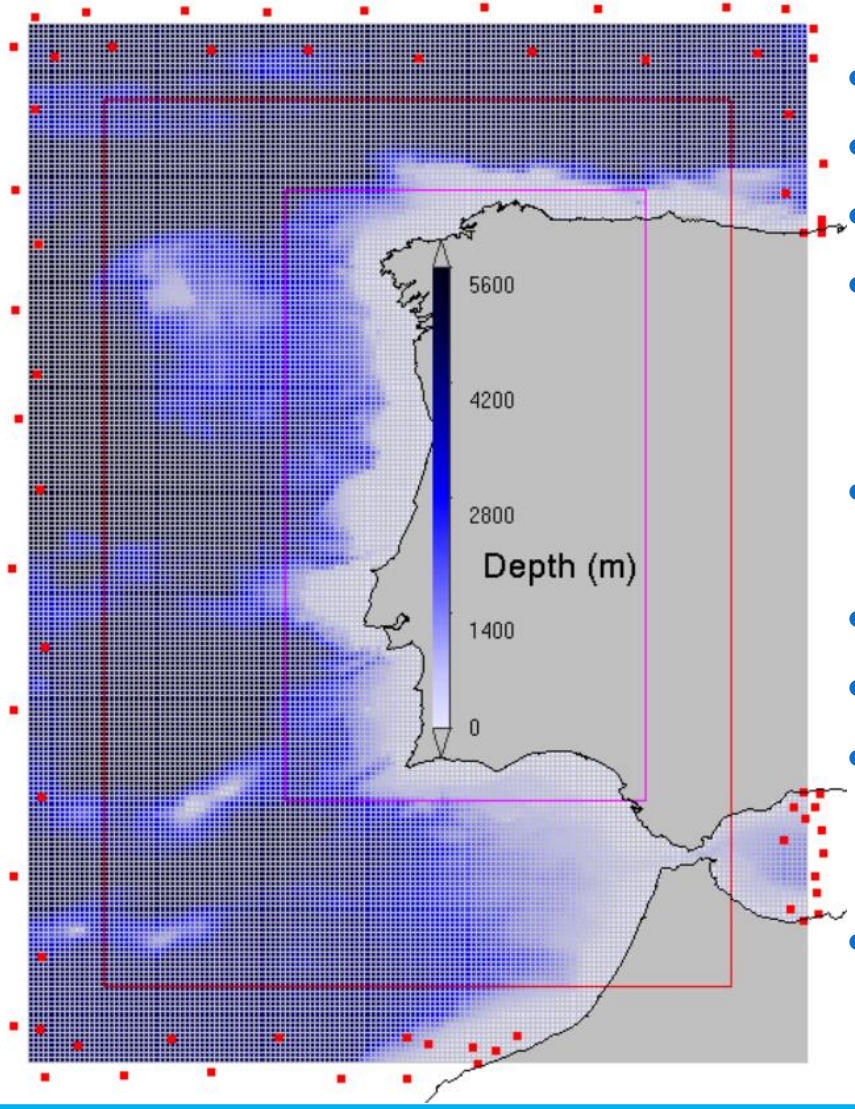


Banas *et al.* 2009
Colorado River

RIVER-ESTUARY-OCEAN COUPLING

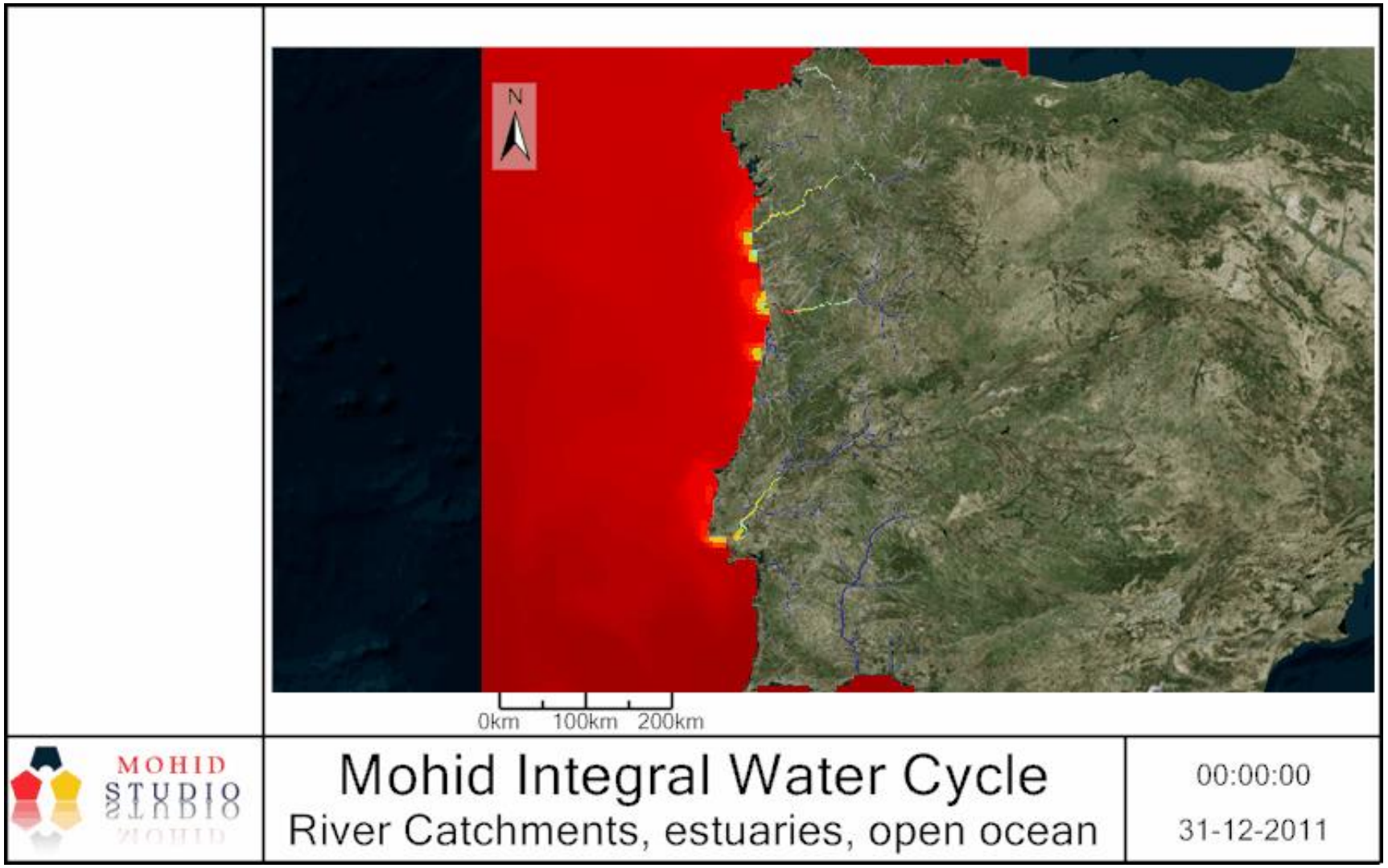


PORTUGUESE COAST OPERATIONAL MODELLING SYSTEM (PCOMS)



- Based on the MOHID Water 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

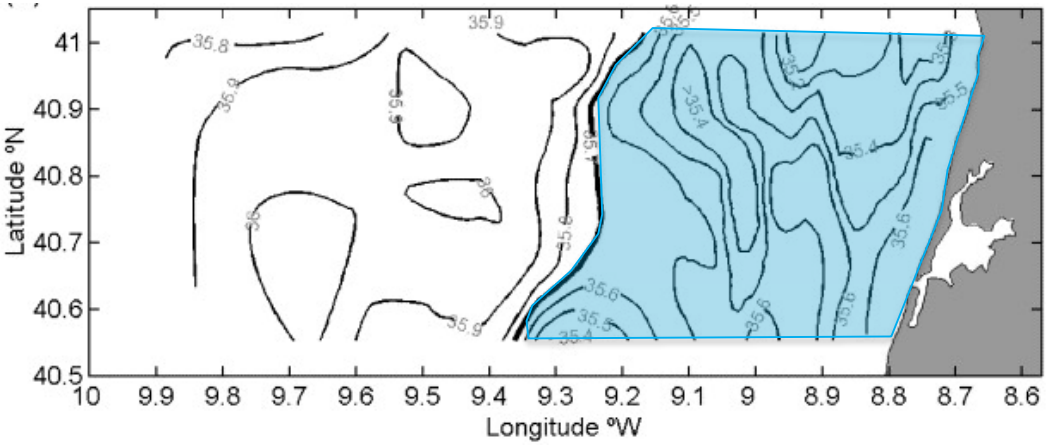
MOHID INTEGRAL WATER CYCLE IN THE PORTUGUESE CONTINENTAL COAST

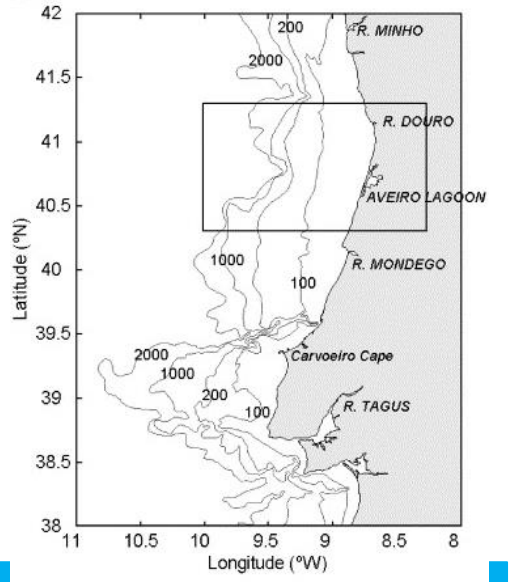


INTEGRATED OCEAN-WATERSHEDS IN MADEIRA ISLAND

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.

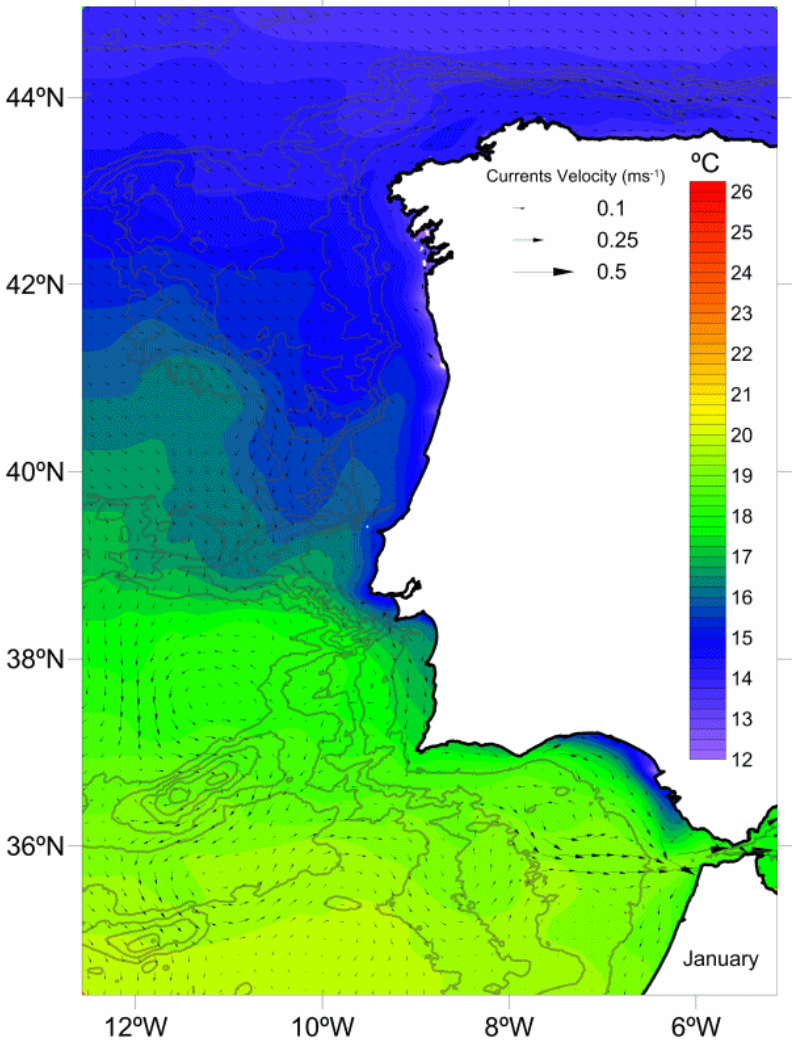
MONTHLY CLIMATOLOGY 2011-2015 PERIOD

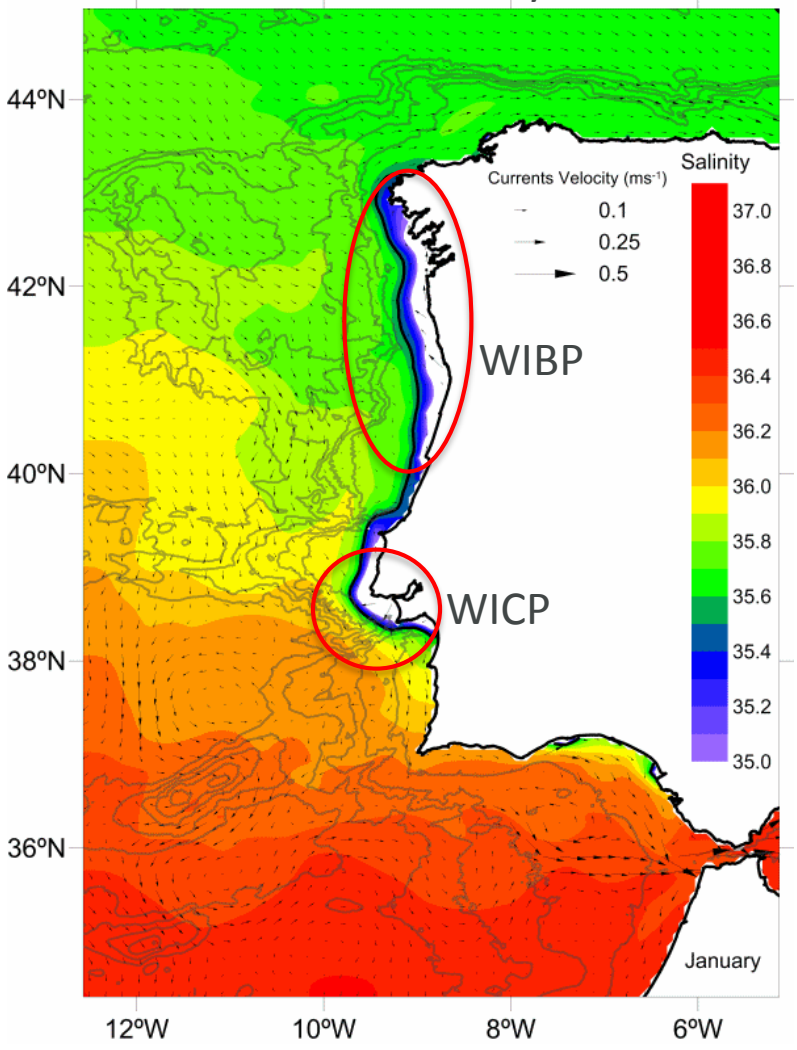
WIBP = Western Iberia Buoyant Plume

WICP = Western Iberia Central Plume

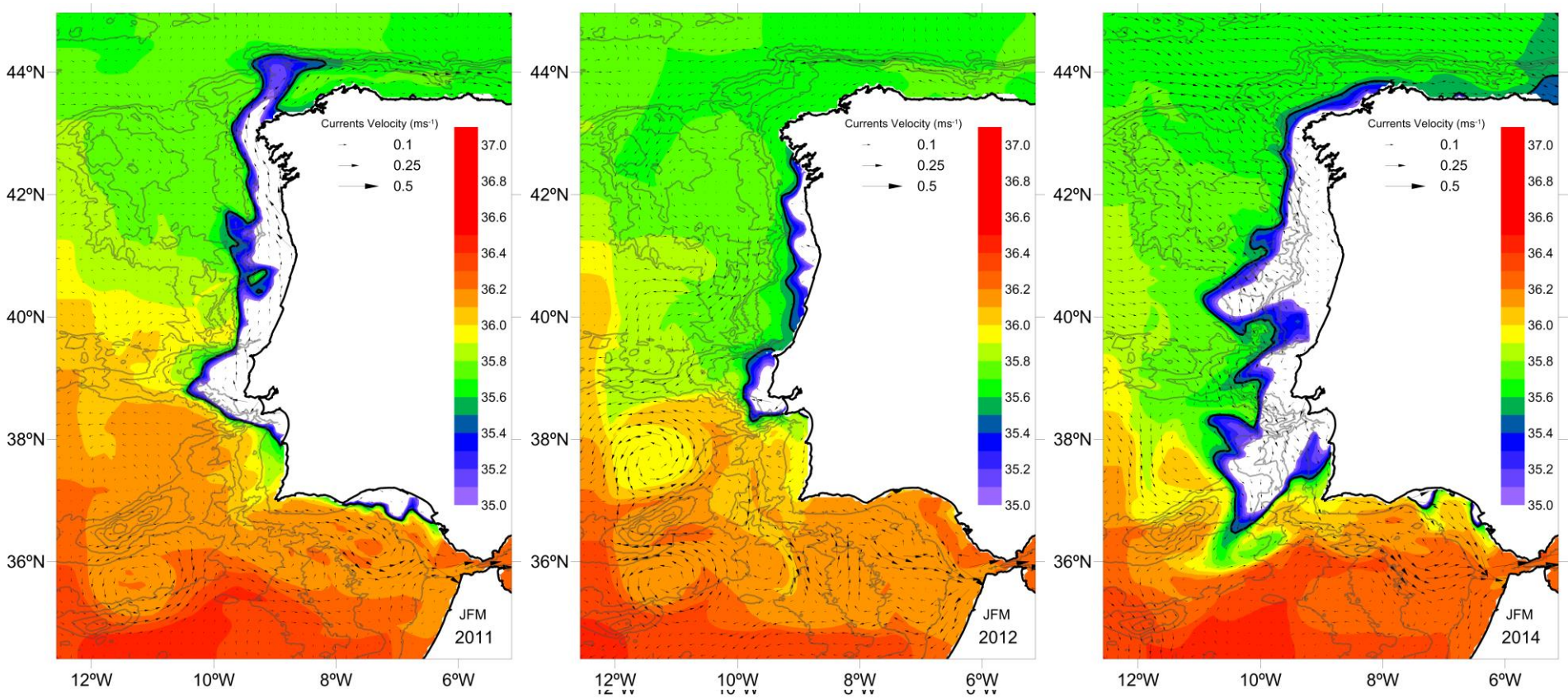
White values indicate salinity below 35

Dark line contours salinity 35.5

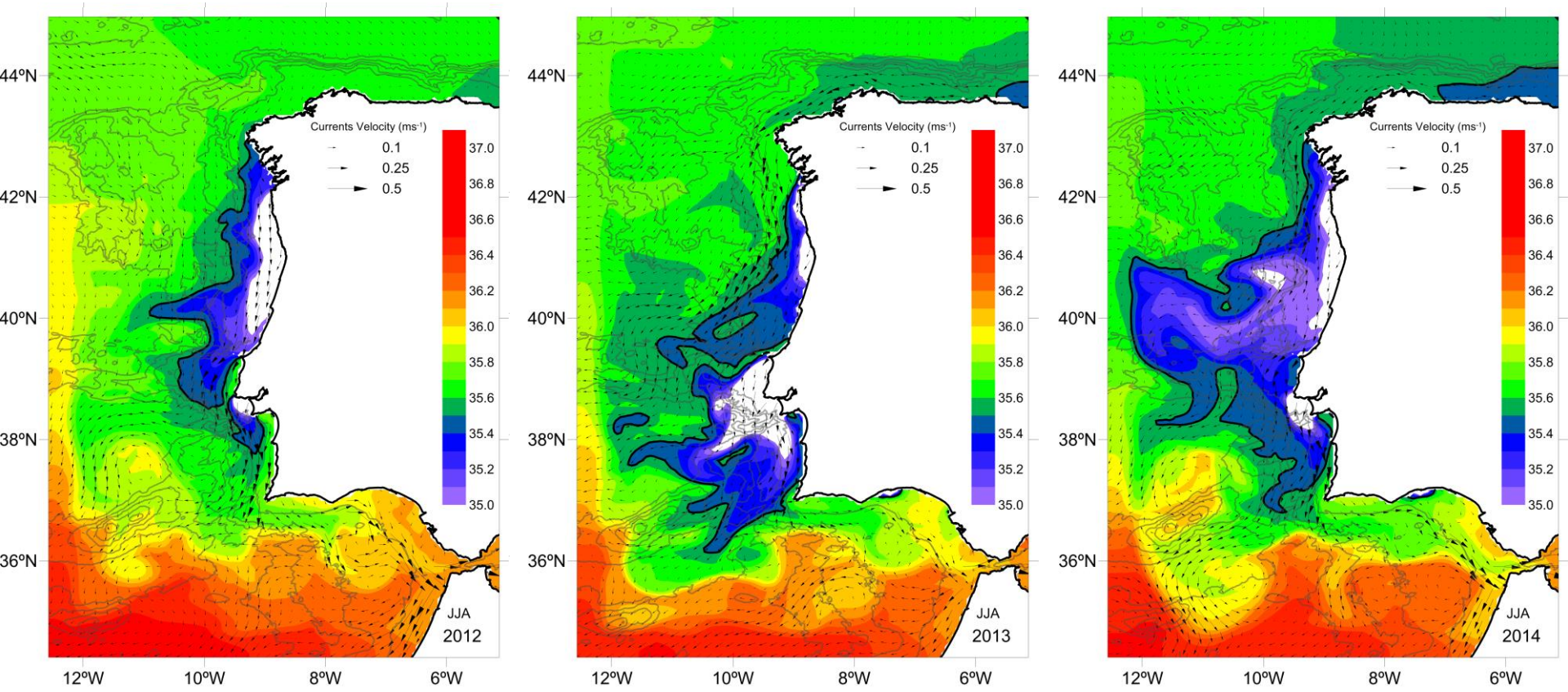




MEAN AND P05 SALINITY FOR RAINY SEASON (JFM)



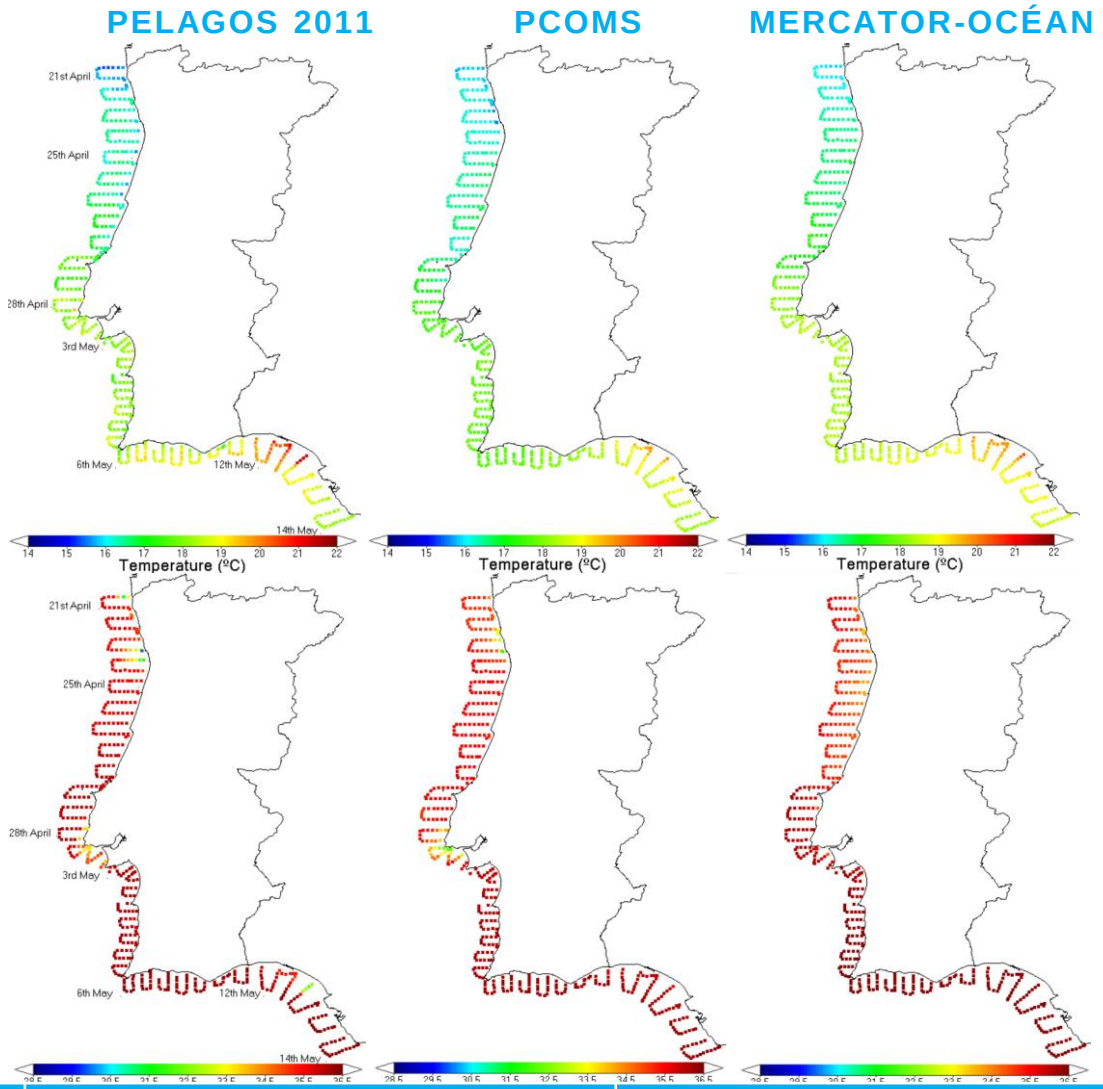
MEAN AND P05 SALINITY FOR DRY SEASON (JJA)



PELAGOS 2011 CRUISE

Data provided by M. M. Angélico and P. Oliveira from

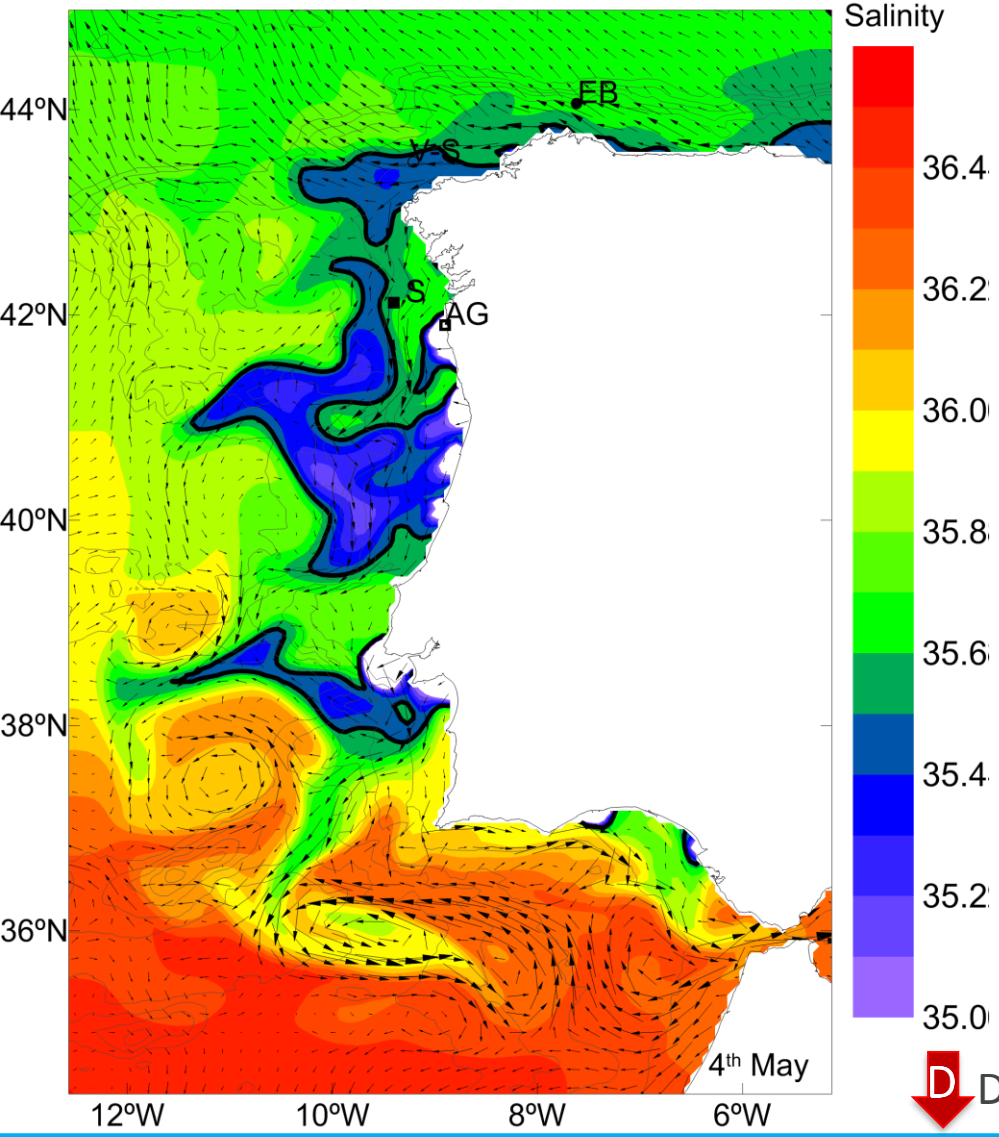
IPMA
Instituto Português do Mar e da Atmosfera

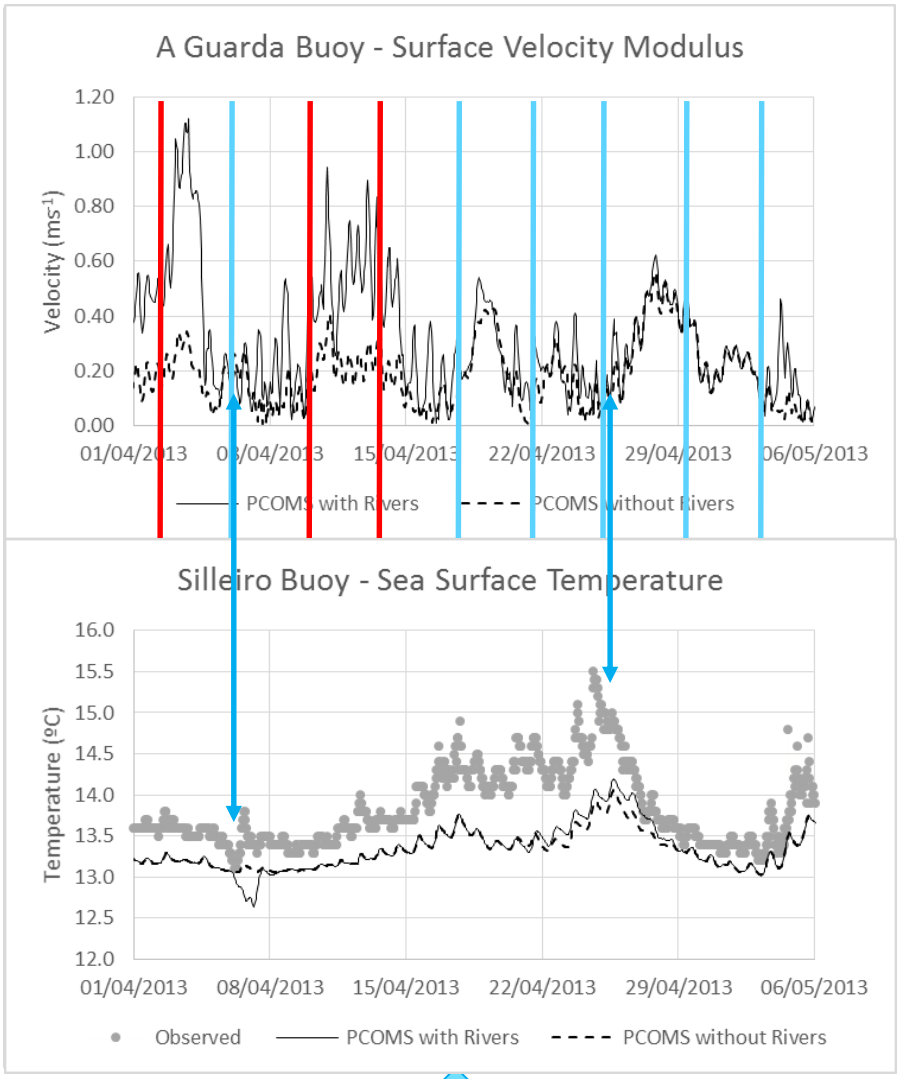


	Temperature (ºC) (N=466)				Salinity (N= 466)			
	Mean (Min.-Max.)	R^2	Bias	RMSE	Mean (Min.-Max.)	R^2	Bias	RMSE
PCOMS	17.34 (15.49-19.90)	0.87	-0.44	0.66	35.66 (31.86-36.36)	0.38	-0.14	0.67
MERCATOR	17.83 (15.87-20.38)	0.89	0.05	0.42	35.87 (33.88-36.43)	0.17	0.08	0.77
PELAGOS11	17.78 (15.25-21.40)	-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

EXTREME EVENT: APRIL 2013 FLOODS

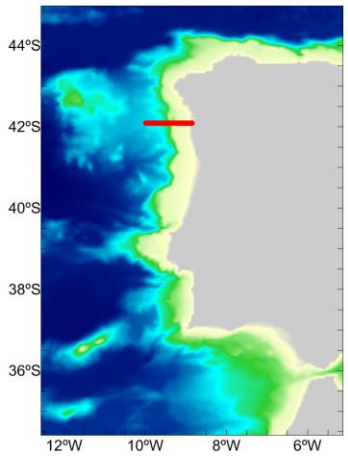
PCOMS - EXTREME EVENT SIMULATION

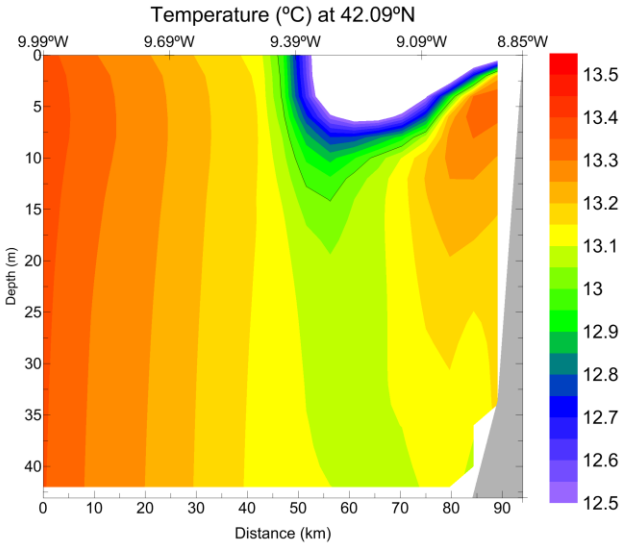


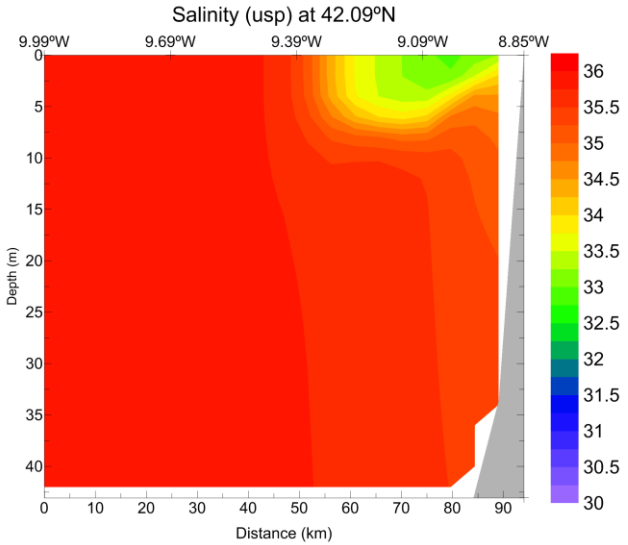


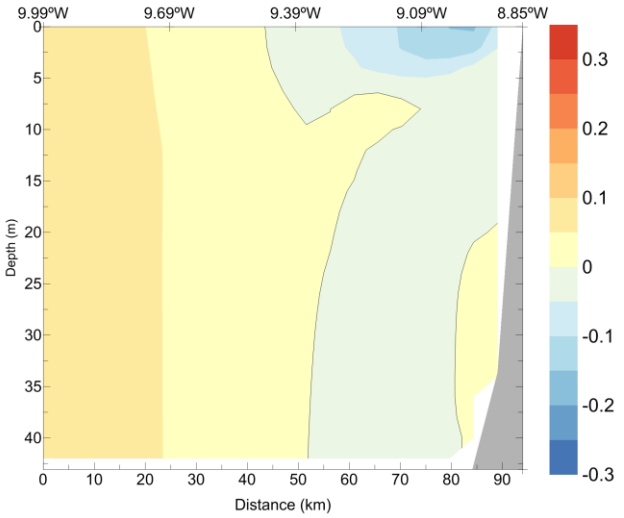
D Downwelling Conditions U Upwelling Conditions

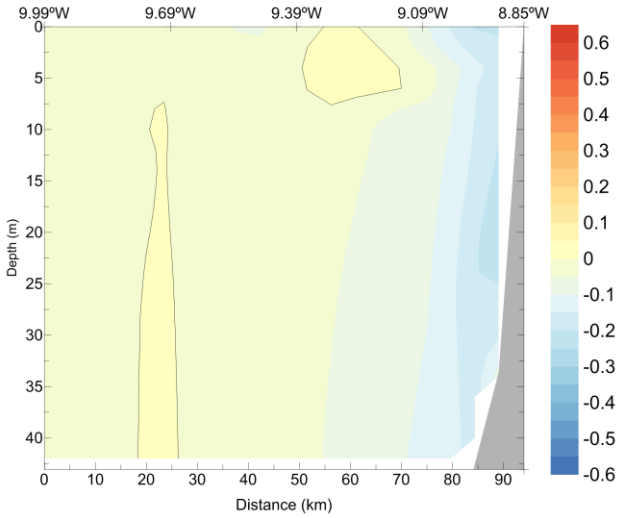
CROSS-SECTION EVOLUTION AT SILLEIRO BUOY











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.
- Numerical modelling is currently the only tool able to represent and estimate the temporal and spatial scale of the WIBP and other estuarine plumes.
- This set of tools improve significantly salinity fields and aid to the delimitation of region of fresh water influence and salinity fronts which are relevant to fisheries management.
- The 5th percentile allow to evaluate the area influenced by the river discharges including the highly dynamic outer reaches.
- The developed methodology is generic and could be set for any region using open source data and models.

Historic Flooding in Coimbra (Portugal)

Muito obrigado pela vossa atenção!

Muchas gracias por su atención!

Thank you very much for your attention!

- 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. http://wiki.mohid.com

- 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