

# HPC y modelado en ciencias del mar: servicios marinos



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# Jornadas usuarios RES 2017

## Ciencias Atmósfera y Océano

### Santiago de Compostela



INSTITUTO  
ESPAÑOL DE  
OCEANOGRAFÍA



Centro de Supercomputación de Galicia

#### Servicios marinos y supercomputación: experiencias y retos futuros

Seminario científico - 27 SEP 2017 - Santiago de Compostela

Esta jornada científica se celebra el 27 de septiembre en Santiago de Compostela, un día antes de la Jornada de Usuarios de la RES, en la que habrá una sesión de interés para los participantes relacionada con las ciencias de la tierra. Está financiada por la Red Española de Supercomputación, el Instituto Español de Oceanografía y la Rede Galega HPC.

#### Organizado por:



Universidad de Vigo



Centro de Supercomputación de Galicia

#### Computación de Altas Prestaciones y Modelización de Ciencias de la Atmósfera y del Océano

Seminario científico - 18 JUL 2017 - Santiago de Compostela

En este seminario científico, que cuenta con el apoyo de la Red Española de Supercomputación, se abordarán diversas cuestiones relacionadas con la simulación del sistema terrestre tanto desde el punto de vista científico como computacional.



Noticias / Más de 50 investigadores expertos en ciencias de la tierra asistieron a la jornada sobre HPC y Modelización en Ciencias de la Atmósfera y del Océano

## Más de 50 investigadores expertos en ciencias de la tierra asistieron a la jornada sobre HPC y Modelización en Ciencias de la Atmósfera y del Océano



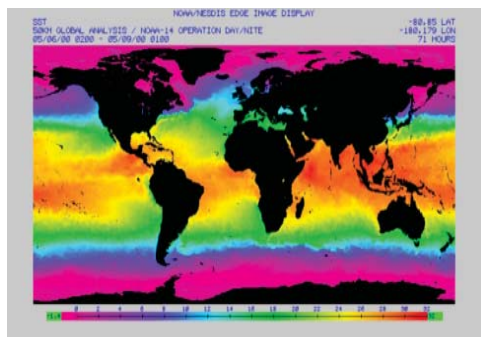
Eventos - 25 JUL 2017

*La jornada científica, que contó con el apoyo de la Red Española de Supercomputación, se celebró como evento paralelo a la Reunión Bienal de la Real Sociedad Española de Física en Santiago de Compostela el pasado 18 de julio.*

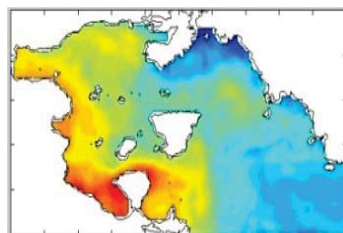
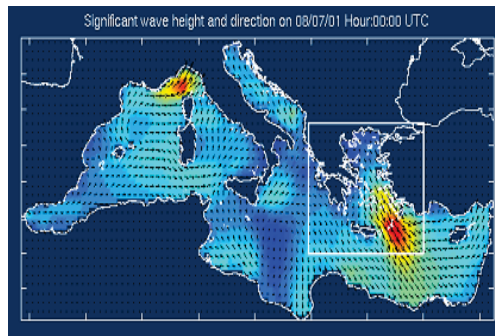
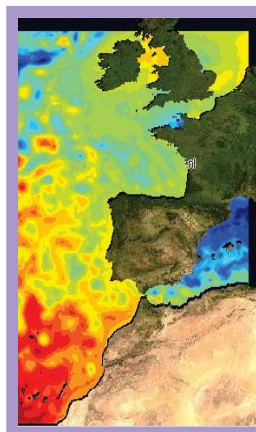
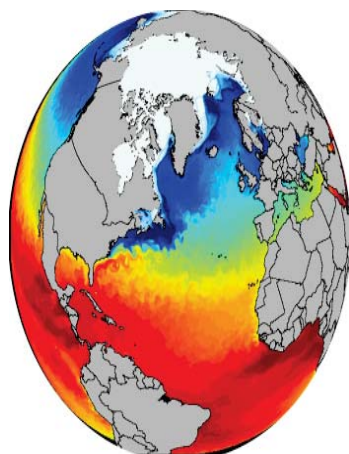
- \* formación transversal para los asistentes (doctorado, etc.)
- \* contacto interdisciplinar para proyectos conjuntos (ajustar proyectos a líneas estratégicas)
- \* aproximación a algunas cuestiones punteras en cada campo
- \* mayor conocimiento de recursos RES (deficiente → ANEP)
- \* artículo revista RSEF

Modelización de  
alaciones del Instituto de  
antiago de Compostela, el  
Reunión Bienal de la Real  
te las mismas fechas en

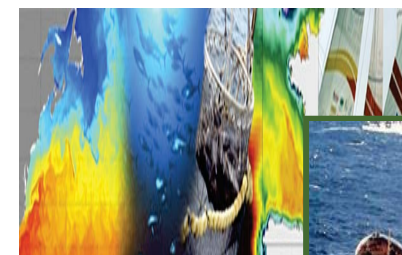
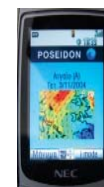
# Observations



# Processing & Modeling



# Services



Operational Oceanography



CEOS

# 6 operational Copernicus Services



Monitoring the State of the Earth System Environment  
...

✓✓  
Copernicus Land Monitoring Service



BSC, UC

Puertos del Estado  
CESGA

✓  
Copernicus Marine Environment Monitoring Service



ECMWF  
Copernicus Climate Change Service



ECMWF  
Copernicus Atmosphere Monitoring Service  
✓



✓  
Copernicus Emergency Management Service  
Mapping Component  
Early Warning Component



✓✓  
Copernicus Security Service

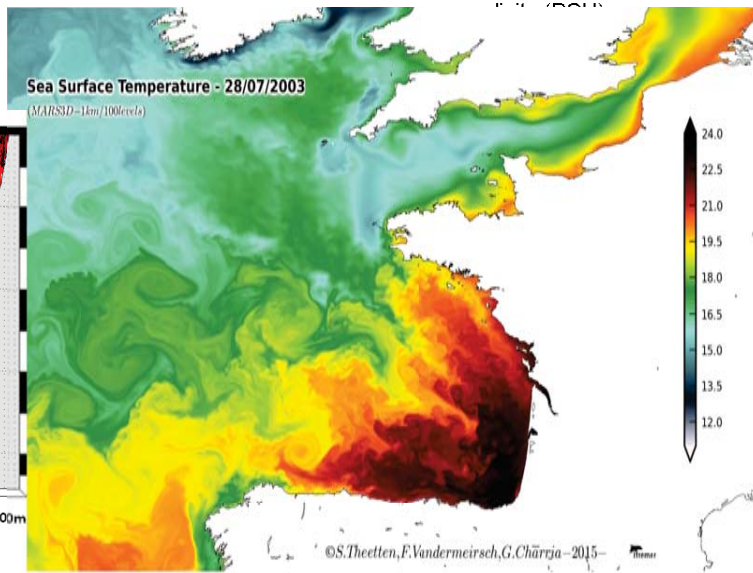
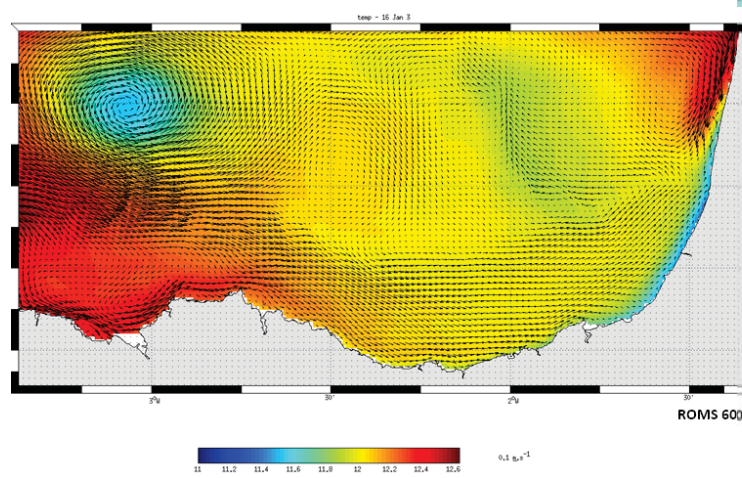
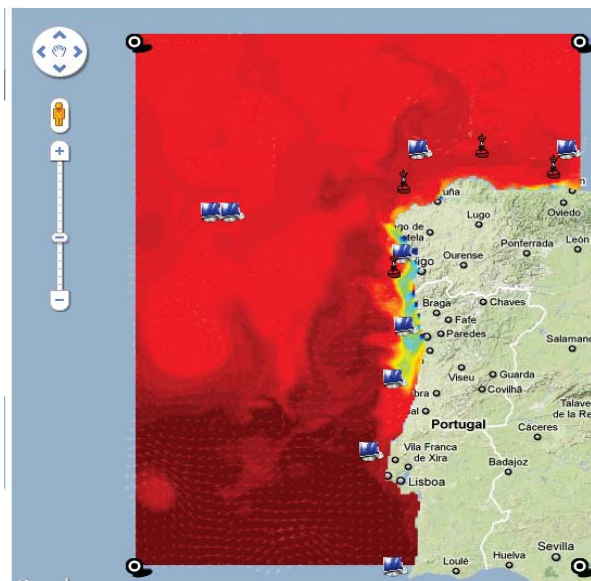
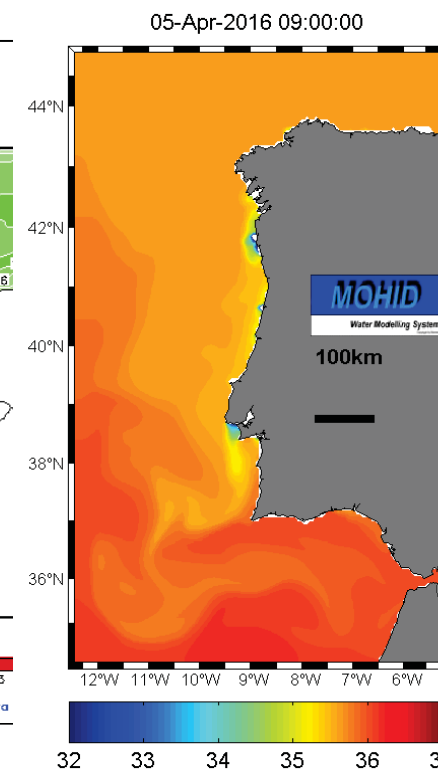
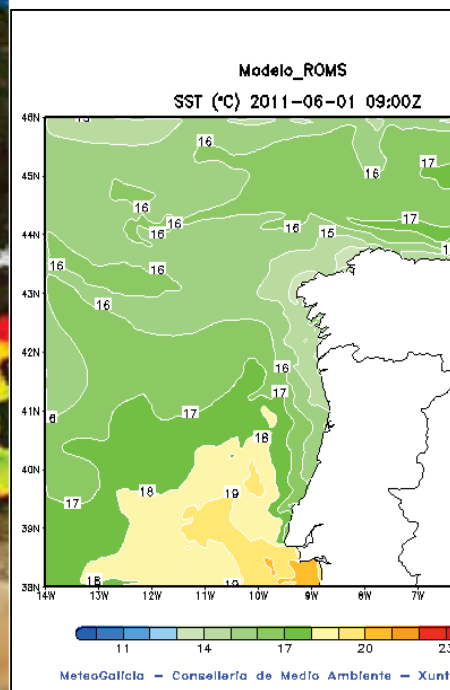
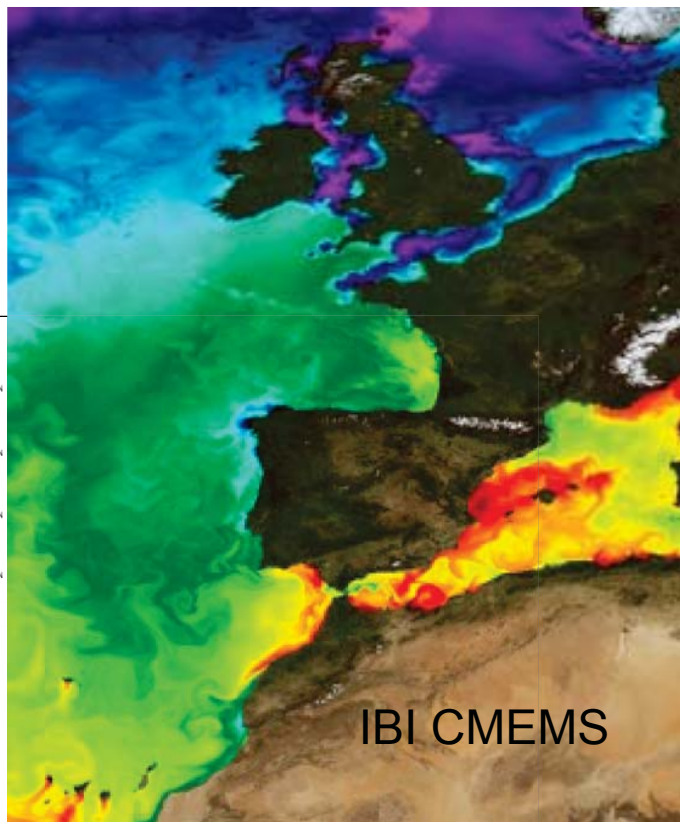
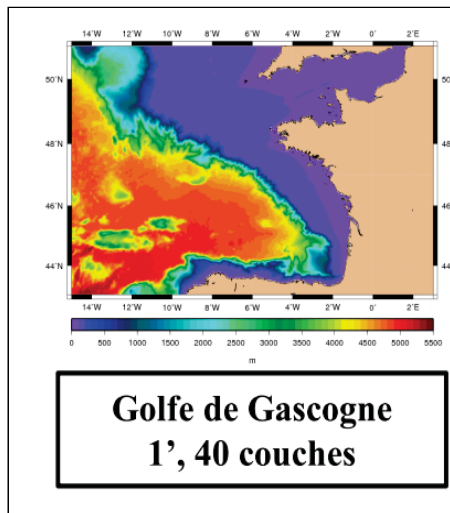


... cross-cutting Thematic Services





# Forecast models running in IBIROOS area for operational services

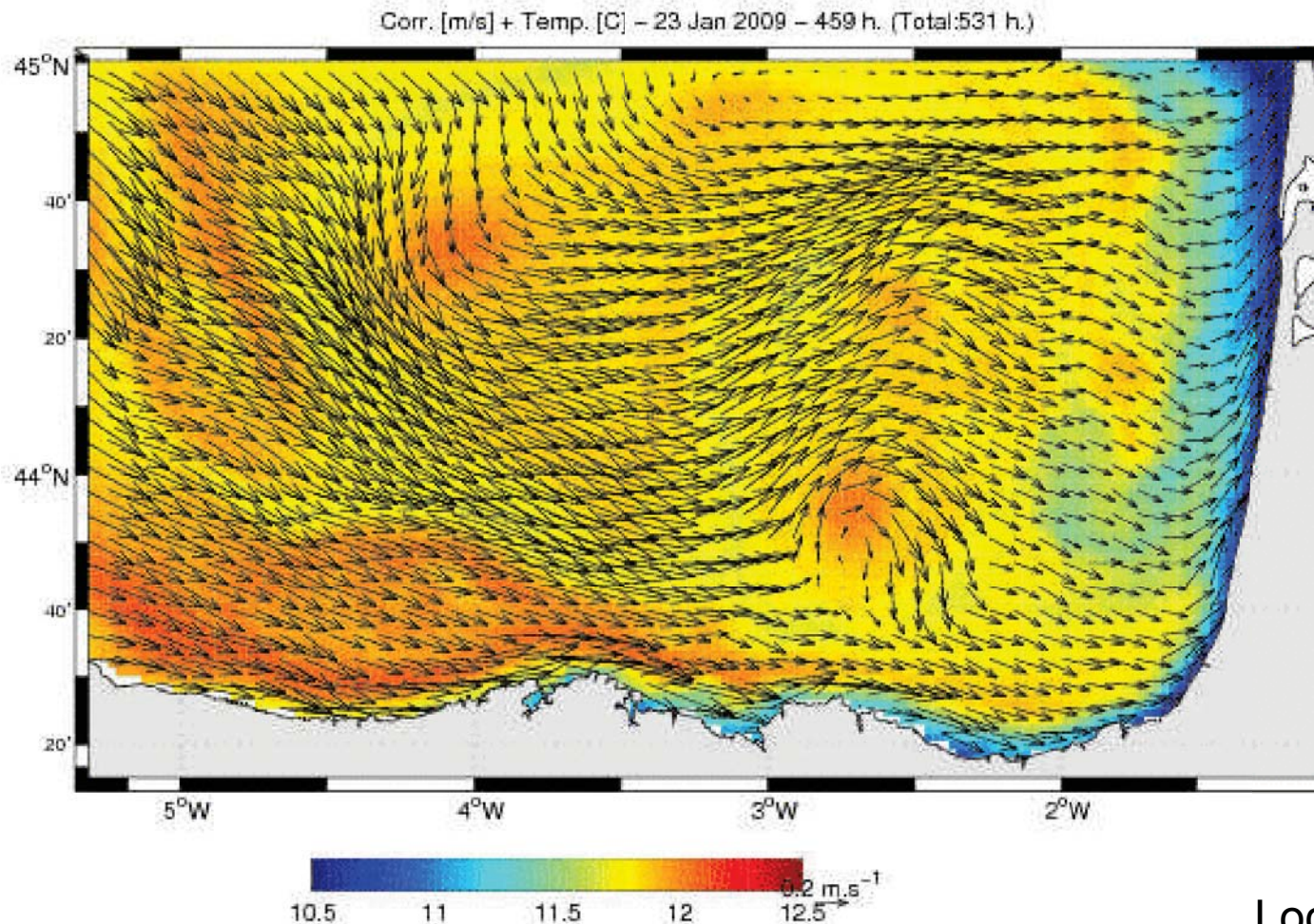




## Numerical models

**AZTI: ROMS (BASQUE COUNTRY AREA)**

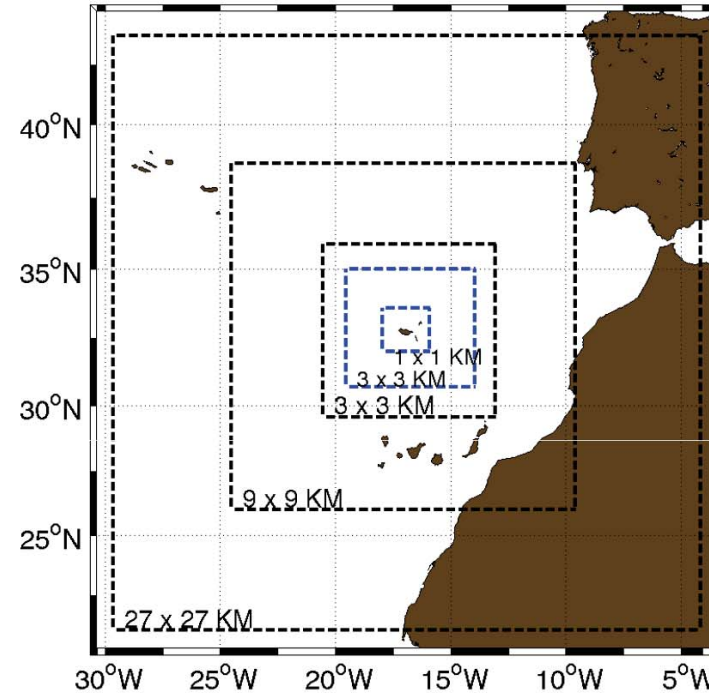
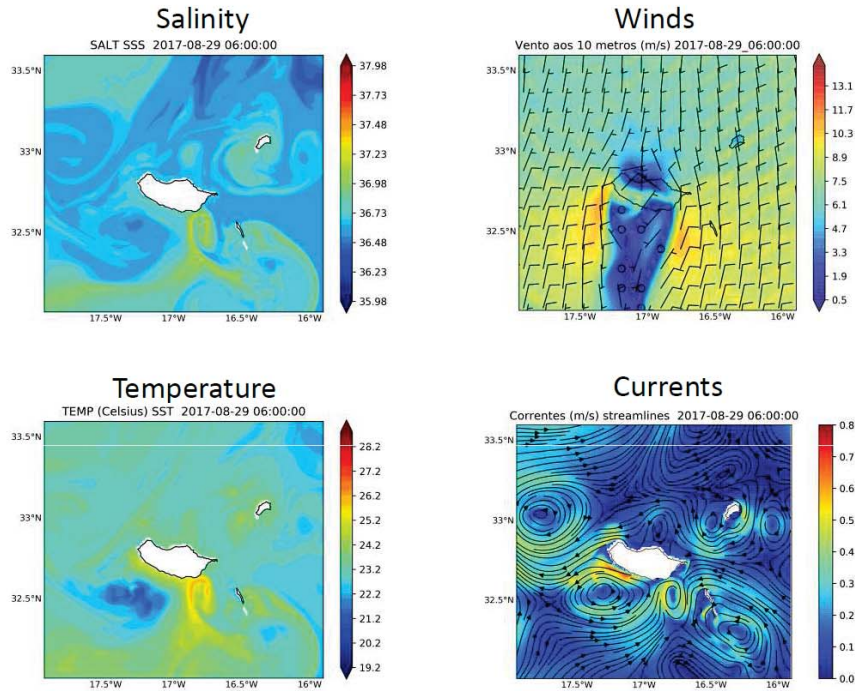
Horizontal resolution:  $1/36^\circ$ ,  $\sim 2.2$  km





# Coupled Forecasting System

COAWST (WRF ↔ ROMS)



## Optimization of bottlenecks:



- More CPUs
- CPUs clock speed
- Model configurations
- Model code
- Others (R/W...)

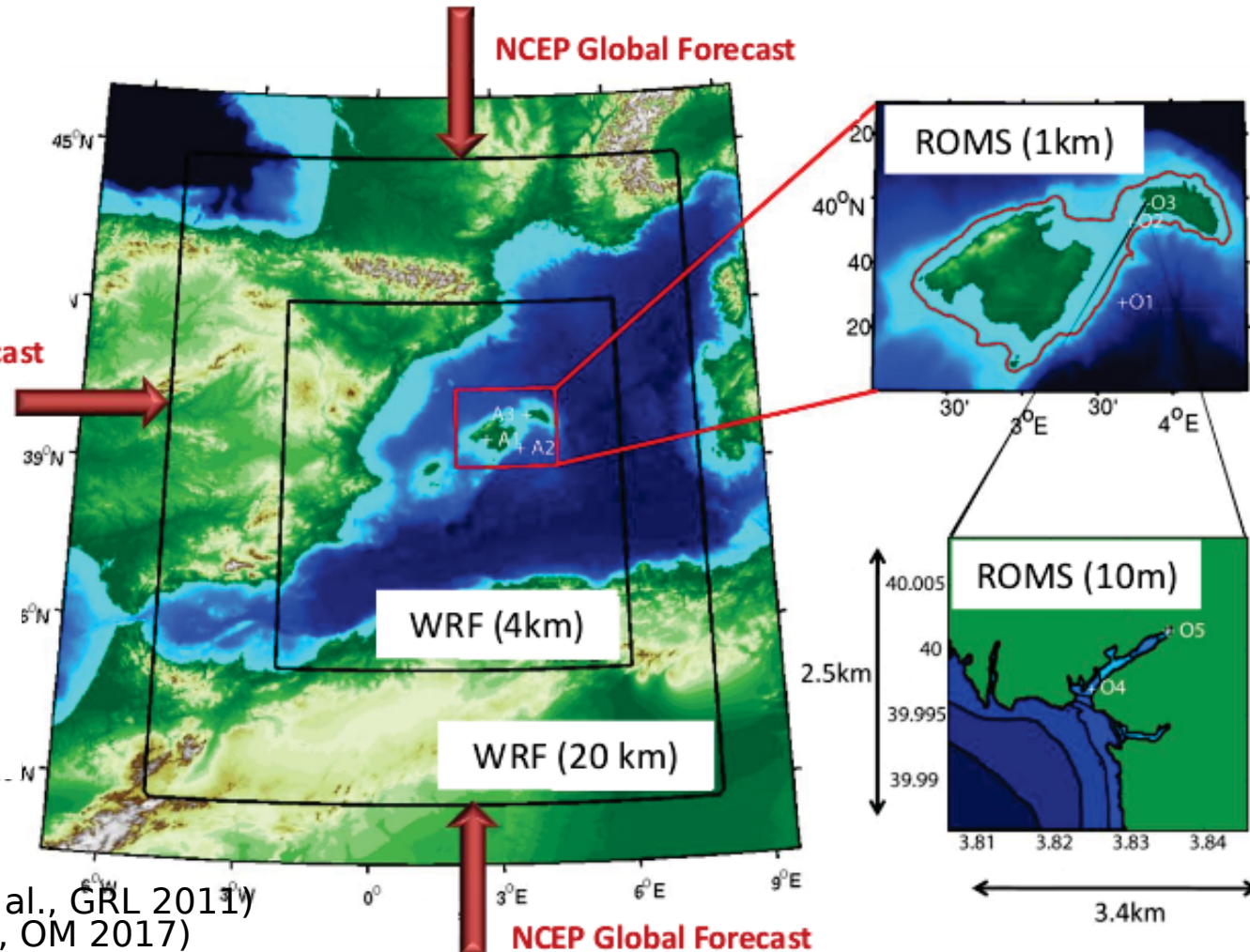


Parallelization with 32 cpus  
Simulation time: 29 hours

Local cluster

# BRIFS - Balearic Rlssaga Forecasting System

Ocean-atmosphere modelling prediction system



Number of gridpoints:

WRF4km ~3.106

ROMS1km ~1.106

ROMS10m ~5.105

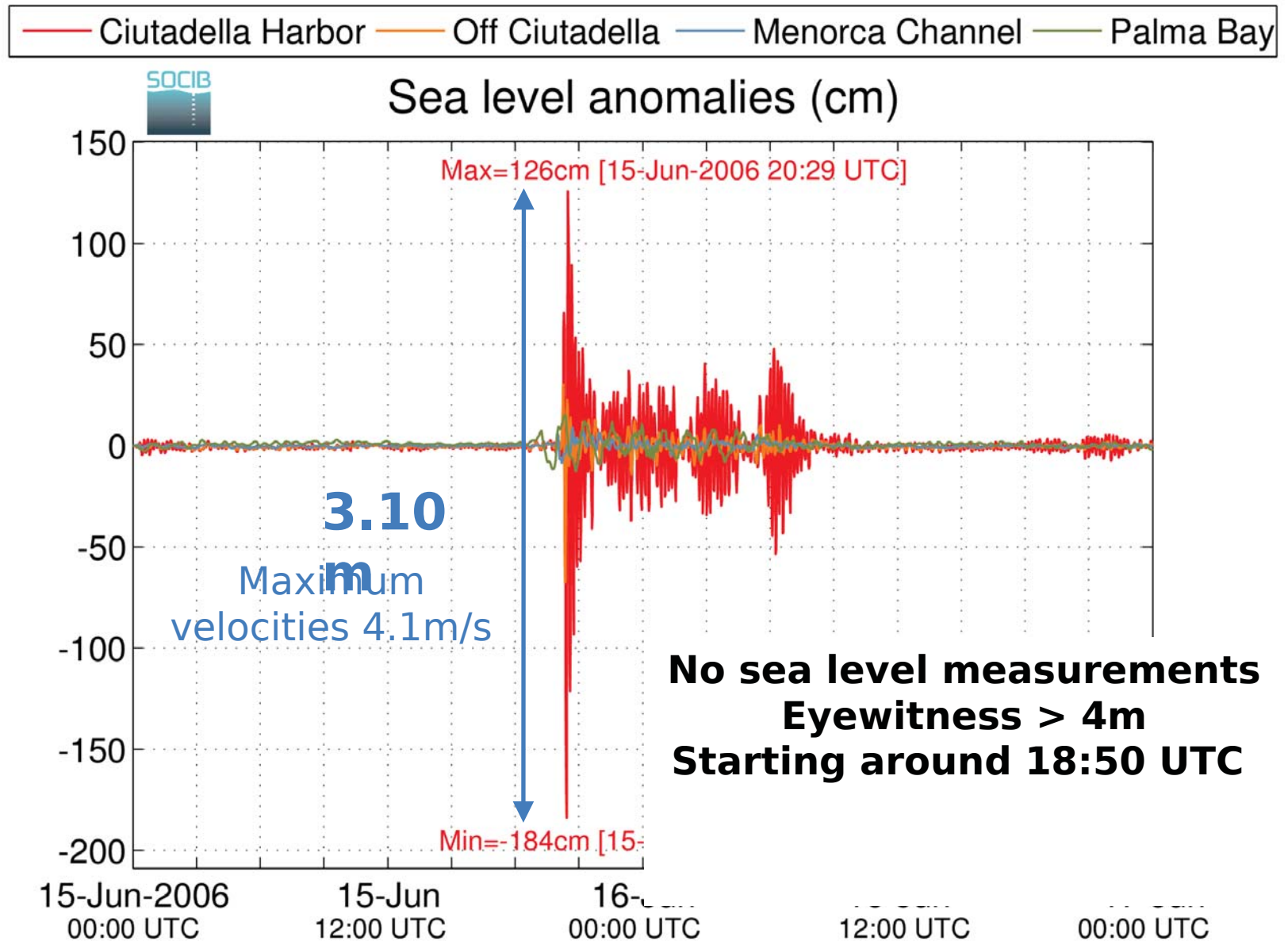
(Renault et al., GRL 2011)  
(Licer et al., OM 2017)

Local cluster



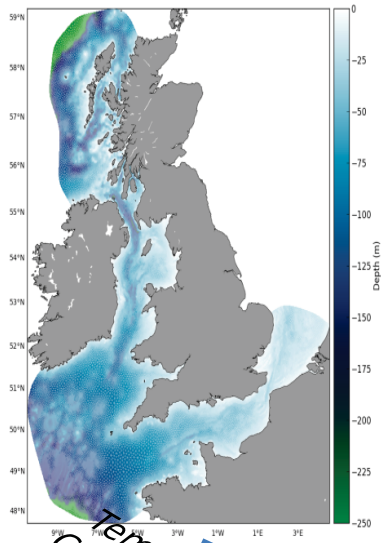
# BRIFS representation of the 15 June 2006 rissaga

ROMS



## Hydrodynamics: FVCOM

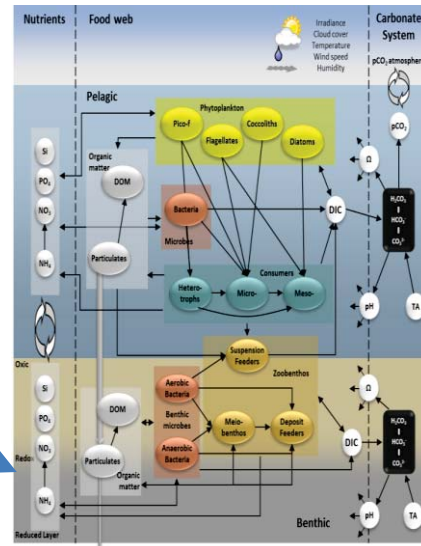
Regional scale, coastal features resolving to 200m, including inter-annual to decadal



Temperature, Salinity, Currents, Light, Vertical mixing

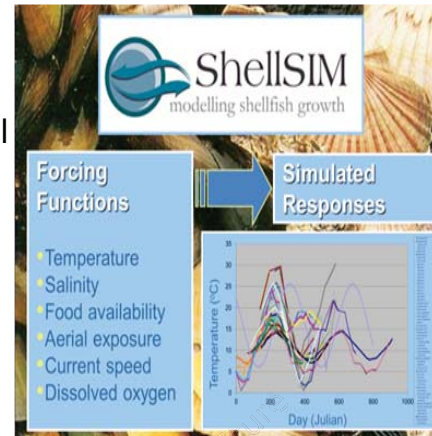
## Ecosystem: ERSEM

Spatial scales of FVCOM, seasonal cycles



## Aquaculture: ShellSIM

Culture practise specific, through full culture cycles, at scales from farm to system



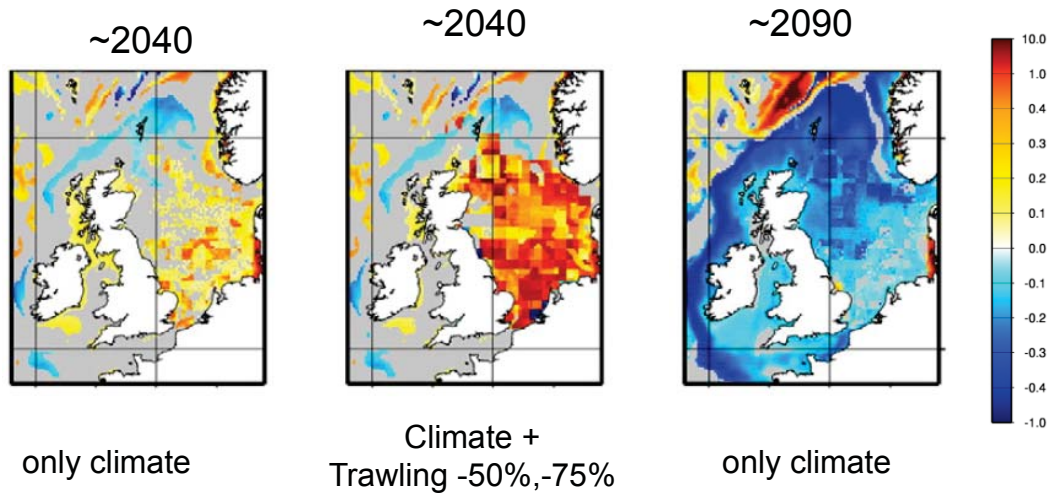
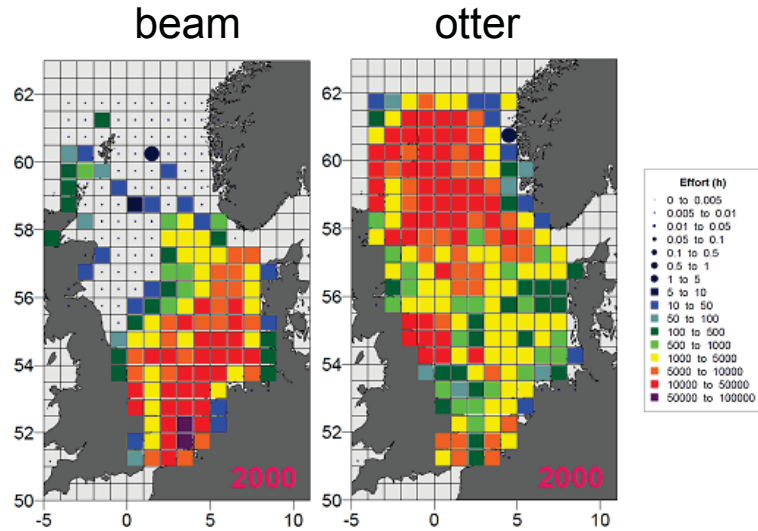
Impacts of shellfish culture  
Chlorophyll, POC, Nutrients

Use combination of high resolution FVCOM-ERSEM model outputs with ShellSIM to investigate potential growth of aquaculture

Has potential applications for aquaculture industry to mitigate potential impacts from expansion of UK and worldwide aquaculture



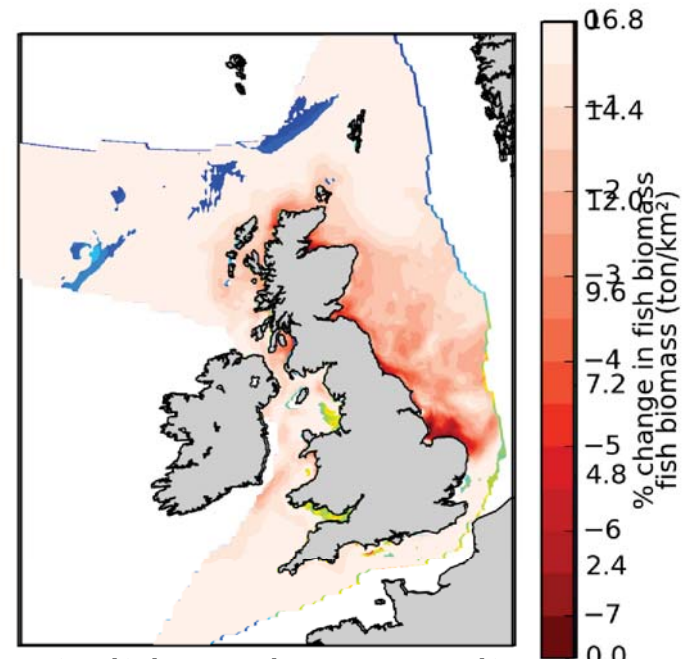
## Fishing effort



Wakelin et al., J. Mar. Sys. 2015

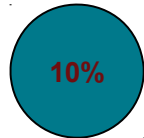
**Table 1**  
Mortality rates (%) on benthic functional types due to trawling [from Allen and Clarke, 2007].

Sediment	Deposit feeders	Filter feeders	Meiobenthos	Aerobic bacteria
<i>Beam trawlers</i>				
Sand	-23	-73	-67	-67
Gravel	-67	-15	-42	-42
<i>Otter trawlers</i>				
Mud	-18	-31	-29	-29
Sand	-23	-4	-15	-15



Mizer, trait-based community size-spectrum ecological model

2000-2007

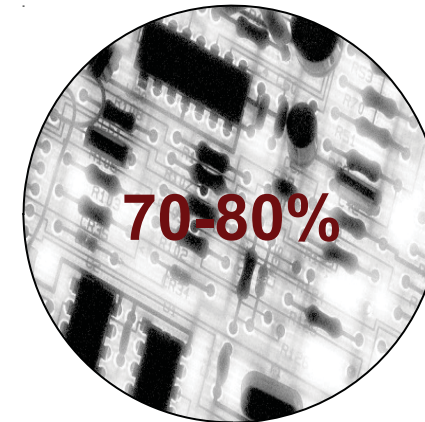


- Model development
- Blue sky research
- 0D and 1D model applications
- Short 3D applications
- Tools development (e.g. 1D Data assimilation)

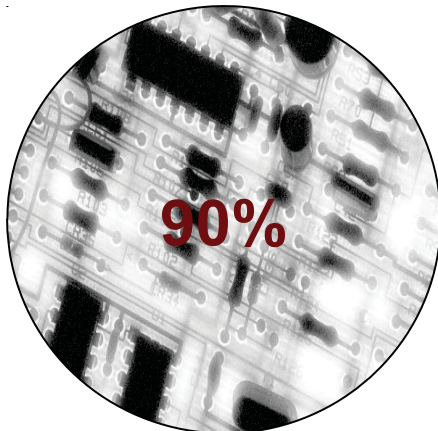
# HECToR Archer

**HPC  
activities**

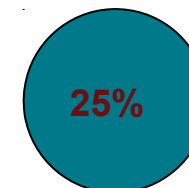
2007-2017



- Applied and directed science
- Climate relevant 3D
- High resolution 3D
- Tools development (e.g. Data assimilation)



**Non-HPC  
activities**



**17 Million core hours in 2017**



Contraseña\*

Iniciar sesión



ELIJE IDIOMA  
ES | GL | EN | PT

## Como está o teu mar?

**Investigadores**

- Visor científico
- Catálogo de datos
- Índice de afloramiento

**Profesionais do mar**

- Visor Autoridades portuarias
- Percebeiros
- Portos e contrarías

**Ocio e deporte**

- Surfteiros
- Náutico
- Praias
- Predicións Surf

**Servizos Técnicos**

- Xestión Costeira
- Desenvolvemento Tecnolóxico
- Modelización
- Outros Servizos

**Tweets** Seguir

**marnaraia** @marnaraia 1h

Lisbon Atlantic Conference 2013. 4-5 decembro, Lisboa. [fem.pt/lac2013/](http://fem.pt/lac2013/)

Abrir

**marnaraia** @marnaraia 19 nov

#marnaraia programa seminario final, #OceanografíaOperacional al servicio de los recursos marinos, 29 novembro 2013 [pico.twitter.com/mBj8WmroX](https://pico.twitter.com/mBj8WmroX)

Twitter a @marnaraia



**Estado das boias**

**Plataforma de Cortegada (Vilagarcía)**

Data (UTC)

28/11/2013 11:53:00

Tª Aire	Tendencia	Tª Auga	Vento
8,7 C		11,9 C	

**Bola de A Guarda (A Guarda)**

Data (UTC)

28/11/2013 11:53:00

Tª Aire	Tendencia	Tª Auga	Vento
9,4 C		12,7 C	

**Bola de Ribeira (Ribeira)**

Data (UTC)

28/11/2013 11:53:00

Predición meteorolóxica

Táboas marítimas

Acceso desde o móbil

Visualización de datos

# Integración



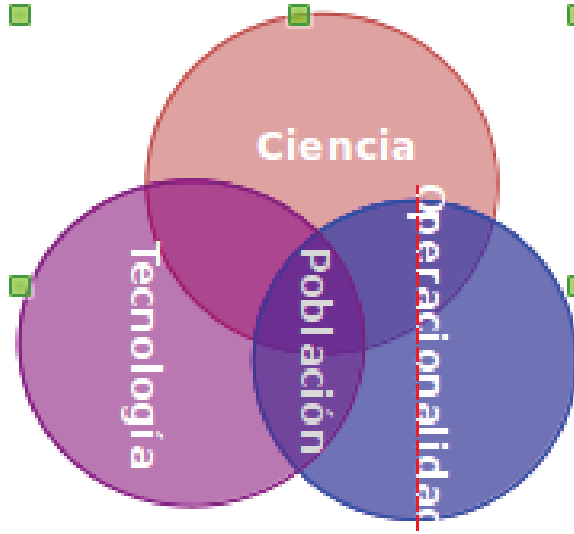
**Observación**



**Modelización  
Numérica  
Atmosfera/Océano**



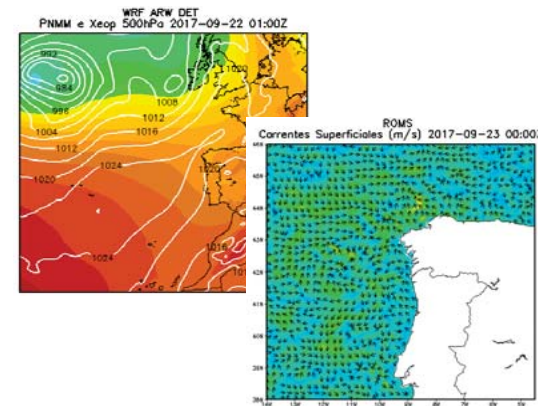
**Implementación  
Operacional**



**Usuarios Finales**



**Distribución**



**Productos y  
Servicios**





# Percegurú: ferramentas para percebeiros



Mapa Inicial Manual informativo

Seleccione...

Confraría: Seleccione unha confraría...

Data: 06/06/2012

Vista Xeral

Lenda

Altura da Onda

- < 2 m
- 2-3 m
- > 3 m

Bancos Percebeiros

Axuda

Datos

Seleccione unha confraría...

Prognóstico día 06/06/2012

Mar de Fondo		
Altura máx. onda (m)	-	-
Dirección	-	-
Periodo (s)	-	-

Mar de Vento		
Vento máximo	-	-
Forza	-	-
Estado da mar	-	-

Temperaturas		
T° máx. aire (°C)	-	-
T° auga (°C)	-	-

Mareas en horario local		
	Hora	m
Baixamar	00:02	0,8
Preamar	06:18	4,4
Baixamar	12:19	1
Preamar	18:38	4,6

Esta predición xérase de forma automática a partir de modelos numéricos e estatísticos de predición meteorolóxica.  
A seguridade é responsabilidade de cada individuo polo que en ningún tipo de accidente poderáselle derivar ningunha clase de responsabilidade ao Intecmar ou aos contidos desta páxina.

Predición realizada o 06/06/2012 ás 9:00.

© 2011 RAIA - Observatorio Océánico da Marxe Ibérica

RAIA INSTITUTO OCEANOGRAFICO  
XUNTA DE GALICIA  
UE FEDER  
Inverdimos en su futuro

intecmar INSTITUTO TECNOLÓXICO PARA O CONTROL DO BIELO MARINO DE GALICIA  
metegalicia  
XUNTA DE GALICIA

<http://ww3.intecmar.org/percebeiros/>

# Predicción: Kite Surf



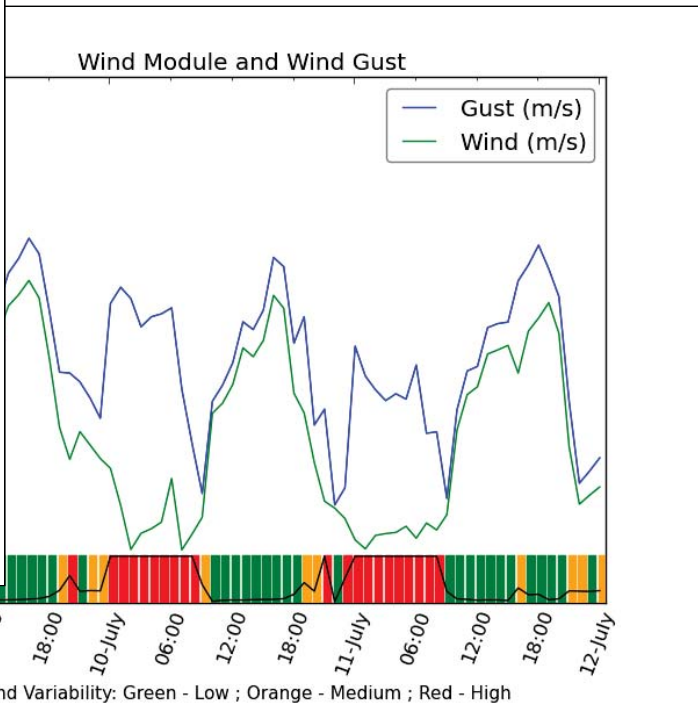
Colaboración  
IH + MeteoGalicia

WRF 1.4 km 11-07-2014 00 UTC	Sex. 11-Jul-2014												Sáb. 12-Jul-2014														
	05h	06h	07h	08h	09h	10h	11h	12h	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	05h	06h	07h	08h	09h	10h	11h	12h	13h
Direção do Vento	[Wind direction icons]																										
Velocidade do Vento (nós)	4	7	10	13	16	19	22	25	28	31	36	41	46	51	56	4	7	10	13	16	19	22	25	28	31	34	37
Rajadas (nós)	9	12	15	18	21	24	27	30	33	36	41	46	51	56	61	9	12	15	18	21	24	27	30	33	36	39	42
Indice turbulência	[Turbulence index icons]																										
Temperatura do ar (°C)	[Temperature values]																										
Nebulosidade (%)	[Cloud cover icons]																										
Precipitação (mm)	[Precipitation icons]																										

WRF 1.4 km 11-07-2014 00 UTC	Sáb. 12-Jul-2014						Dom. 13-Jul-2014																				
	14h	15h	16h	17h	18h	19h	20h	21h	22h	05h	06h	07h	08h	09h	10h	11h	12h	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h
Direção do Vento	[Wind direction icons]																										
Velocidade do Vento (nós)	4	7	10	13	16	19	22	25	28	31	36	41	46	51	56	4	7	10	13	16	19	22	25	28	31	34	37
Rajadas (nós)	9	12	15	18	21	24	27	30	33	36	41	46	51	56	61	9	12	15	18	21	24	27	30	33	36	39	42
Indice turbulência	[Turbulence index icons]																										
Temperatura do ar (°C)	[Temperature values]																										
Nebulosidade (%)	[Cloud cover icons]																										
Precipitação (mm)	[Precipitation icons]																										

Lat: 38.6933 Lon: -9.2036 ☀️ 06:25 - 20:59 🌑



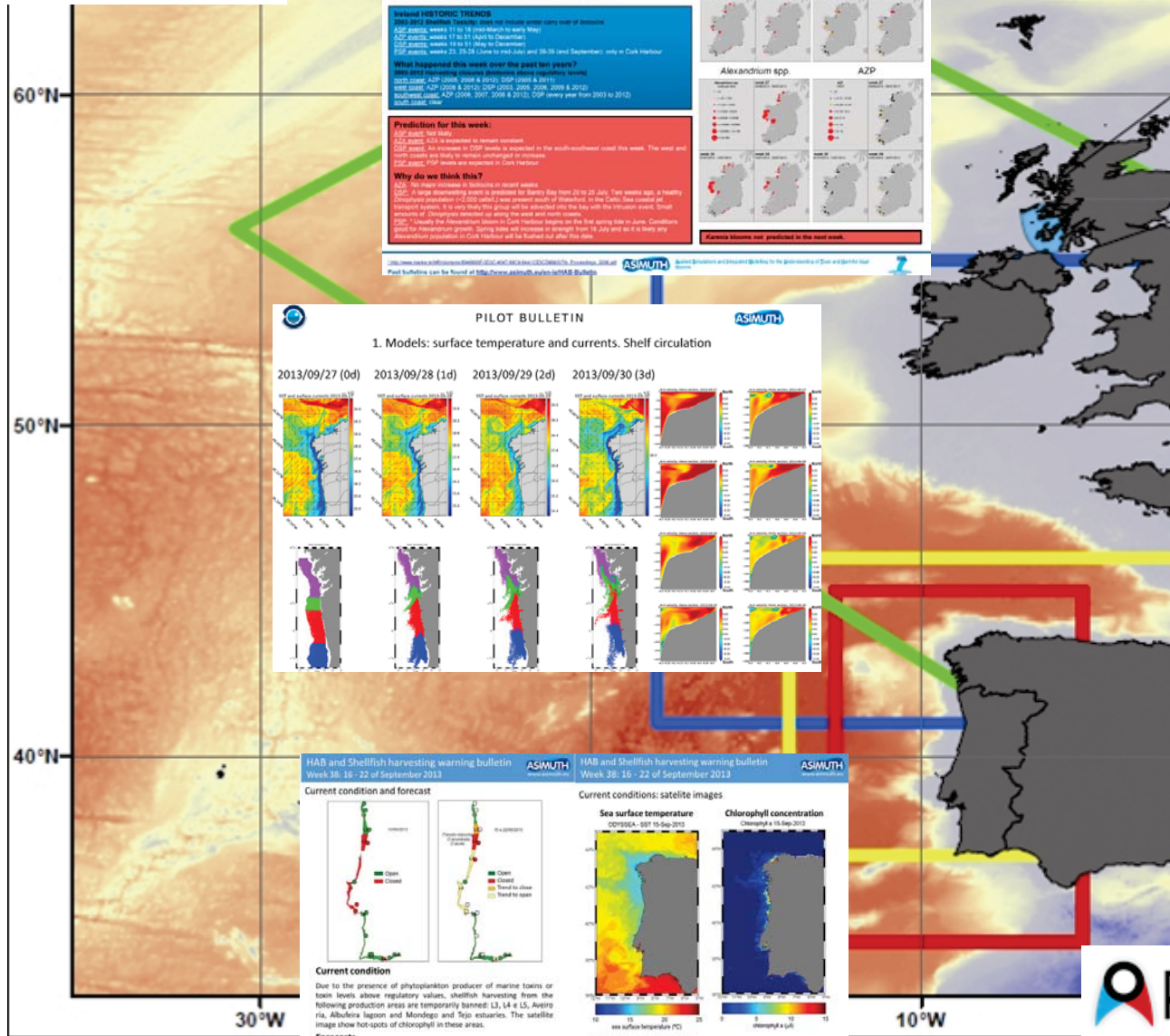
- Playas Gallegas y Portuguesas



XUNTA DE GALICIA

CONSELLERÍA DE MEDIO AMBIENTE  
E ORDENACIÓN DO TERRITORIO





### Pilot HAB Bulletin (status of harmful and toxic algae)

Week 30: 21 - 27 July 2013

**Ireland: Current conditions and Predictions**

**Botanin report (last week)** [whole tissue long-line mussels and oysters]

**ASP toxins:** Yes, maximum on west (0.14 µg/g) east

**AZA toxins:** Yes, maximum on west (0.17 µg/g) and southwest (0.12 µg/g) east

**DSP toxins:** Yes, maximum on west (0.17 µg/g) and southwest (0.12 µg/g) east

**PSP toxins:** No

**HABs report (last week)**

**Dinophysis acuminata:** Yes, blooms off along the western seaboard. Maximum levels on west coast with 'H' concentration for the predominant axis group of yellow cells.

**Alexandrium spp:** Yes, maximum on north coast (>100 cells/L). No levels also present on west and southwest coasts.

**Amoebidium:** Yes, maximum on west coast (10,000 cells/L)

**Karenia mikimotoi:** No blooms; present on south coast (maximum = 200 cells/L)

**Forecast for next week:**

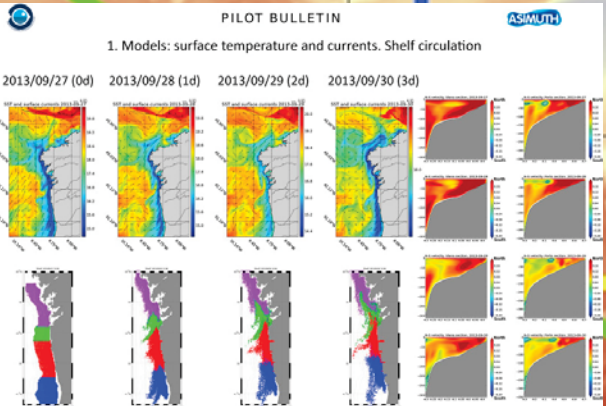
**ASP:** A large downwelling event is predicted for Sunday 29th July to 29th July. Two weeks ago, a healthy environment association (>2,000 cells/L) was present south of Ireland. This could be re-introduced via the transport system. It is very likely this group will be advected into the bay with the transport event. Good transport systems. It is very likely this group will be advected into the bay with the transport event. Good transport systems. It is very likely this group will be advected into the bay with the transport event.

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**Karenia mikimotoi:** No blooms; present on south coast (maximum = 200 cells/L)



### HAB and Shellfish harvesting warning bulletin

Week 38: 16 - 22 of September 2013

**Current condition and forecast**

**Current condition**

Due to the presence of phytoplankton producer of marine toxins or toxin levels above regulatory values, shellfish harvesting from the following production areas are temporarily banned: L3, L4 & L5, Aveiro, Ria, Abulcencis lagoon and Mondego and Tejo estuaries. The satellite image show hot-spots of chlorophyll in these areas.

**Forecasts**

In areas L2 and L3 there is an increase in the concentration of *Pseudo-nitzschia* spp., including *P. australis*. L2 can be closed. In front of Aveiro, *Dinophysis acuminata* concentration remains high and closures by DSP are maintained. The model indicates that blooms will move offshore and slightly to the south.

Due to the low concentration of *Dinophysis* spp. (DSP producer) the catch and capture of bivalves may be open in the area L8.

**Current conditions: satellite images**

**Sea surface temperature**

Sea surface temperature evidence the upwelling of cold waters along the west coast, well visible in areas L1, L2, L3. On the south coast the sea surface water temperature is higher, but it is within the expectable patterns for this time of year.

**Chlorophyll concentration**

Along the west coast and from areas L1 to L5 there is occurrence of high chlorophyll spots associated with cold water.

### SAMS

**Karenia mikimotoi** abundance in current and preceding 3 weeks within Asimuth project domain in Argyll

**Current status:** *K. mikimotoi* at two sites but densities do not cause concern

**Predictions:** *K. mikimotoi* continues to remain low in magnitude. Now likely to pose little danger to fin fish farming operations.

**Why do we think this:** Whole cell abundance has increased on Colony densities are low. Satellite chlorophyll concentrations does not indicate areas of concern.

**Scotland wide Satellite Chlorophyll**

*K. mikimotoi* is enumerated within samples collected at shellfish monitoring sites. Surface chlorophyll is derived from MyOcean satellite products.



### France: Conditions actuelles et Prédictions

**Rapport de Biotoxicité de la semaine 48 - Synthèse réalisée à partir des bulletins de surveillance hebdomadaires.**

**ASP toxines:** Concentrations > seuil légal (20 µg/L) au large de Concarneau et de deux stations situées dans les rades des coquilles Saint-Jacques. Les concentrations élevées à Concarneau sont observées (voir tableau) et aucune autre mesure n'est encore disponible.

**AZA toxines:** Non

**DSP toxines:** Non

**PSP toxines:** Non

**Rapport sur les concentrations en Algues toxiques**

**Pseudo-nitzschia:** Oui, mais avec des concentrations faibles (<4000 cellules/mL) observées dans la zone de Douarnenez et Concarneau.

**Dinophysis:** No

**Alexandrium:** No

**Karenia mikimotoi:** No

**Prédictions pour la prochaine semaine:**

**ASP:** Oui, Prévisions forte toxicité dans les zones de Concarneau et Douarnenez.

**AZA:** Non

**DSP:** Non

**PSP:** Non

**Pourquoi ces prévisions ?**

Le 22/10/13, un fort épisode de pluie a permis de limiter la période de présence phytoplanktonique dans les zones de surveillance. La situation devrait rester stable jusqu'à fin Mars 2014.

ASP: Les concentrations devraient diminuer fortement pendant les épisodes de pluie particulièrement dans les rades de Concarneau.

**La fréquence d'échantillonnage durant la période hivernale étant réduite, la réalisation de bulletins de prévisions s'arrête à partir de cette semaine.**

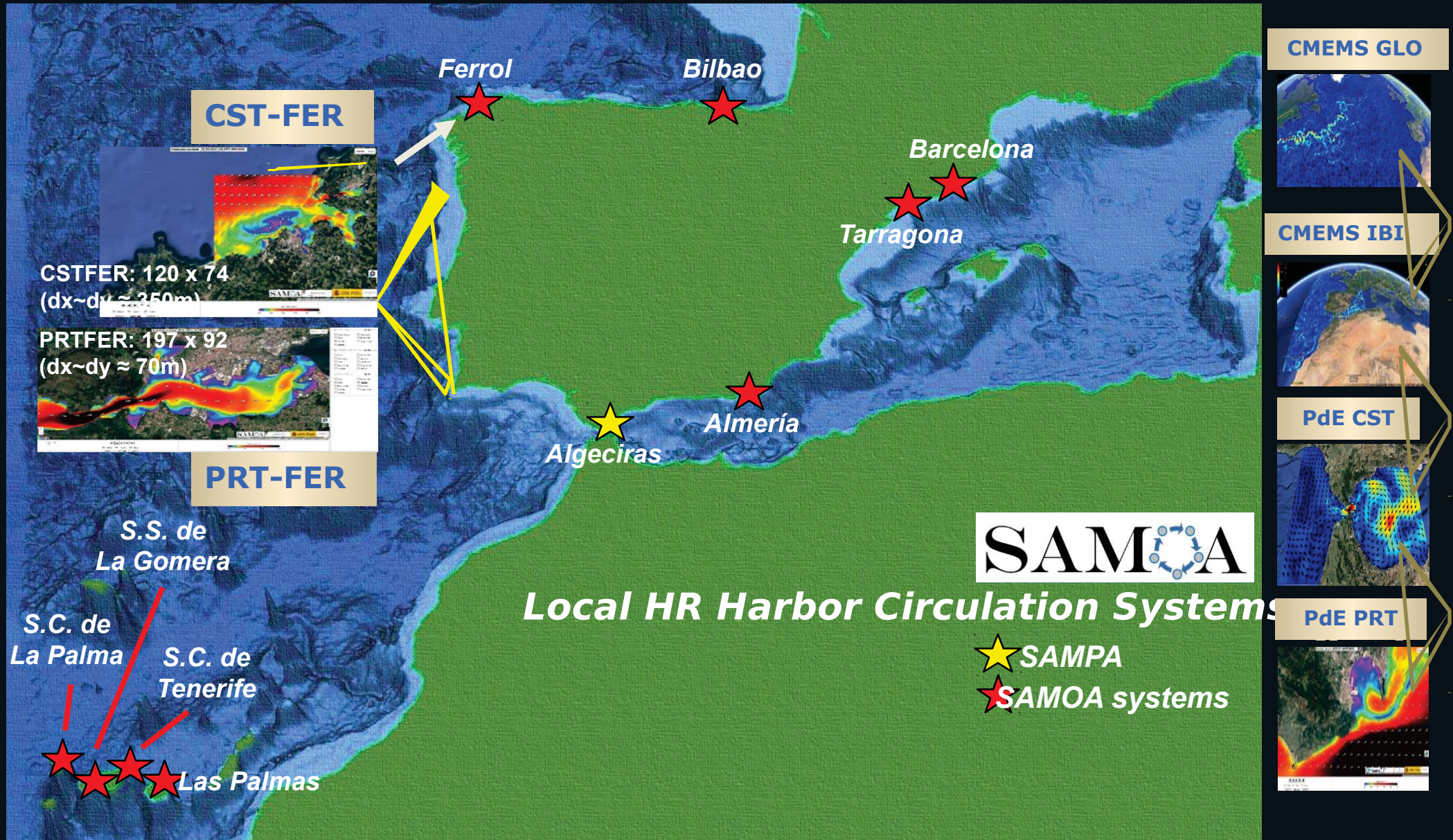
ZONES	Points	Conc. (µg/L)	ASP	AZA	DSP	PSP
Concarneau	CC1	10	10	0	0	0
Concarneau	CC2	10	10	0	0	0
Concarneau	CC3	10	10	0	0	0
Concarneau	CC4	10	10	0	0	0
Concarneau	CC5	10	10	0	0	0
Concarneau	CC6	10	10	0	0	0
Concarneau	CC7	10	10	0	0	0
Concarneau	CC8	10	10	0	0	0
Concarneau	CC9	10	10	0	0	0
Concarneau	CC10	10	10	0	0	0
Concarneau	CC11	10	10	0	0	0
Concarneau	CC12	10	10	0	0	0
Concarneau	CC13	10	10	0	0	0
Concarneau	CC14	10	10	0	0	0
Concarneau	CC15	10	10	0	0	0
Concarneau	CC16	10	10	0	0	0
Concarneau	CC17	10	10	0	0	0
Concarneau	CC18	10	10	0	0	0
Concarneau	CC19	10	10	0	0	0
Concarneau	CC20	10	10	0	0	0
Concarneau	CC21	10	10	0	0	0
Concarneau	CC22	10	10	0	0	0
Concarneau	CC23	10	10	0	0	0
Concarneau	CC24	10	10	0	0	0
Concarneau	CC25	10	10	0	0	0
Concarneau	CC26	10	10	0	0	0
Concarneau	CC27	10	10	0	0	0
Concarneau	CC28	10	10	0	0	0
Concarneau	CC29	10	10	0	0	0
Concarneau	CC30	10	10	0	0	0
Concarneau	CC31	10	10	0	0	0
Concarneau	CC32	10	10	0	0	0
Concarneau	CC33	10	10	0	0	0
Concarneau	CC34	10	10	0	0	0
Concarneau	CC35	10	10	0	0	0
Concarneau	CC36	10	10	0	0	0
Concarneau	CC37	10	10	0	0	0
Concarneau	CC38	10	10	0	0	0
Concarneau	CC39	10	10	0	0	0
Concarneau	CC40	10	10	0	0	0
Concarneau	CC41	10	10	0	0	0
Concarneau	CC42	10	10	0	0	0
Concarneau	CC43	10	10	0	0	0
Concarneau	CC44	10	10	0	0	0
Concarneau	CC45	10	10	0	0	0
Concarneau	CC46	10	10	0	0	0
Concarneau	CC47	10	10	0	0	0
Concarneau	CC48	10	10	0	0	0
Concarneau	CC49	10	10	0	0	0
Concarneau	CC50	10	10	0	0	0
Concarneau	CC51	10	10	0	0	0
Concarneau	CC52	10	10	0	0	0
Concarneau	CC53	10	10	0	0	0
Concarneau	CC54	10	10	0	0	0
Concarneau	CC55	10	10	0	0	0
Concarneau	CC56	10	10	0	0	0
Concarneau	CC57	10	10	0	0	0
Concarneau	CC58	10	10	0	0	0
Concarneau	CC59	10	10	0	0	0
Concarneau	CC60	10	10	0	0	0
Concarneau	CC61	10	10	0	0	0
Concarneau	CC62	10	10	0	0	0
Concarneau	CC63	10	10	0	0	0
Concarneau	CC64	10	10	0	0	0
Concarneau	CC65	10	10	0	0	0
Concarneau	CC66	10	10	0	0	0
Concarneau	CC67	10	10	0	0	0
Concarneau	CC68	10	10	0	0	0
Concarneau	CC69	10	10	0	0	0
Concarneau	CC70	10	10	0	0	0
Concarneau	CC71	10	10	0	0	0
Concarneau	CC72	10	10	0	0	0
Concarneau	CC73	10	10	0	0	0
Concarneau	CC74	10	10	0	0	0
Concarneau	CC75	10	10	0	0	0
Concarneau	CC76	10	10	0	0	0
Concarneau	CC77	10	10	0	0	0
Concarneau	CC78	10	10	0	0	0
Concarneau	CC79	10	10	0	0	0
Concarneau	CC80	10	10	0	0	0
Concarneau	CC81	10	10	0	0	0
Concarneau	CC82	10	10	0	0	0
Concarneau	CC83	10	10	0	0	0
Concarneau	CC84	10	10	0	0	0
Concarneau	CC85	10	10	0	0	0
Concarneau	CC86	10	10	0	0	0
Concarneau	CC87	10	10	0	0	0
Concarneau	CC88	10	10	0	0	0
Concarneau	CC89	10	10	0	0	0
Concarneau	CC90	10	10	0	0	0
Concarneau	CC91	10	10	0	0	0
Concarneau	CC92	10	10	0	0	0
Concarneau	CC93	10	10	0	0	0
Concarneau	CC94	10	10	0	0	0
Concarneau	CC95	10	10	0	0	0
Concarneau	CC96	10	10	0	0	0
Concarneau	CC97	10	10	0	0	0
Concarneau	CC98	10	10	0	0	0
Concarneau	CC99	10	10	0	0	0
Concarneau	CC100	10	10	0	0	0

**Position de la masse d'eau actuelle**

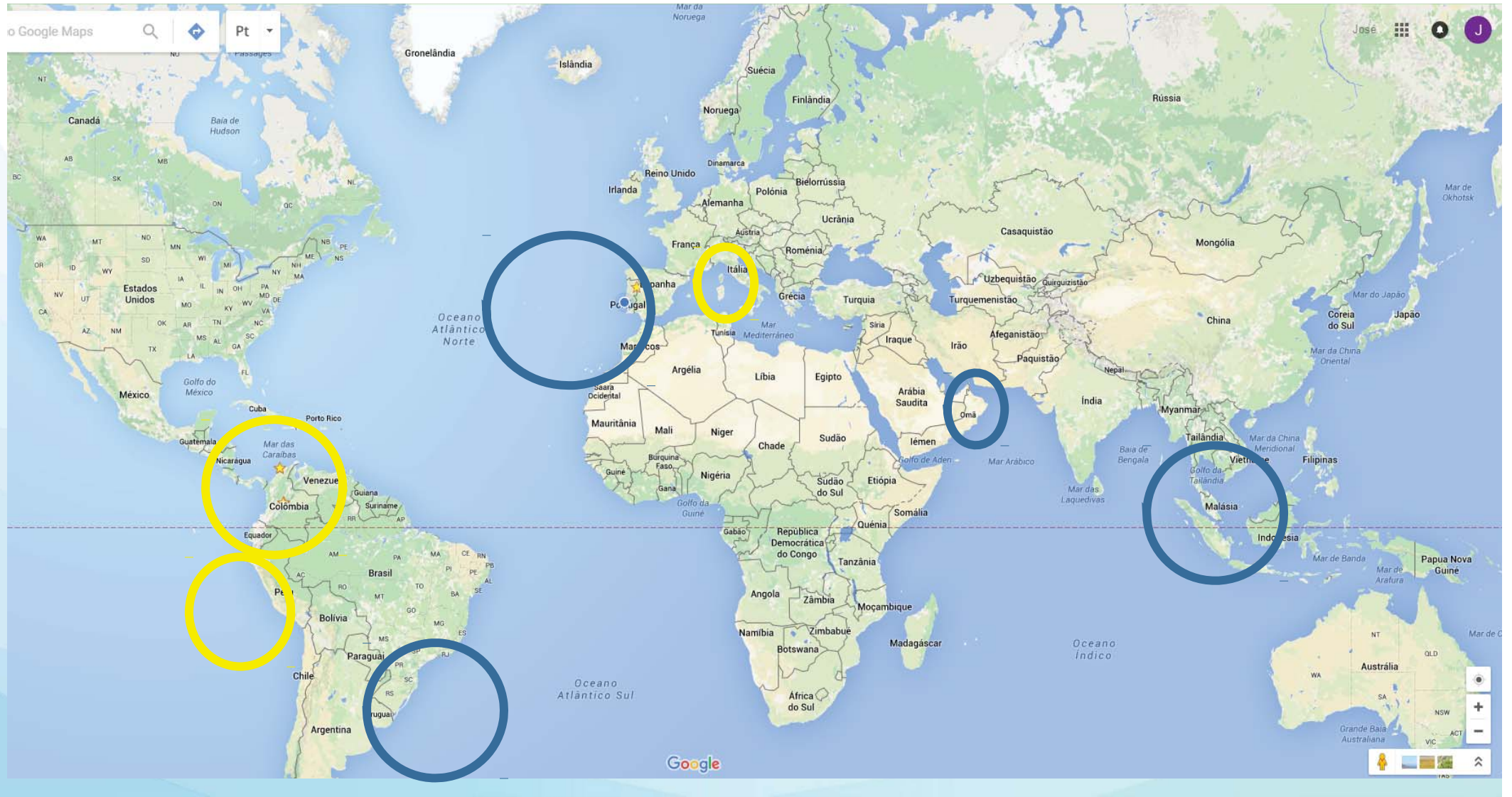
- \* Origine de la masse d'eau (J-15)
- \* Position moyenne de la masse d'eau (J-15 à J)
- \* Position de la masse d'eau dans 3 jours (J+3)



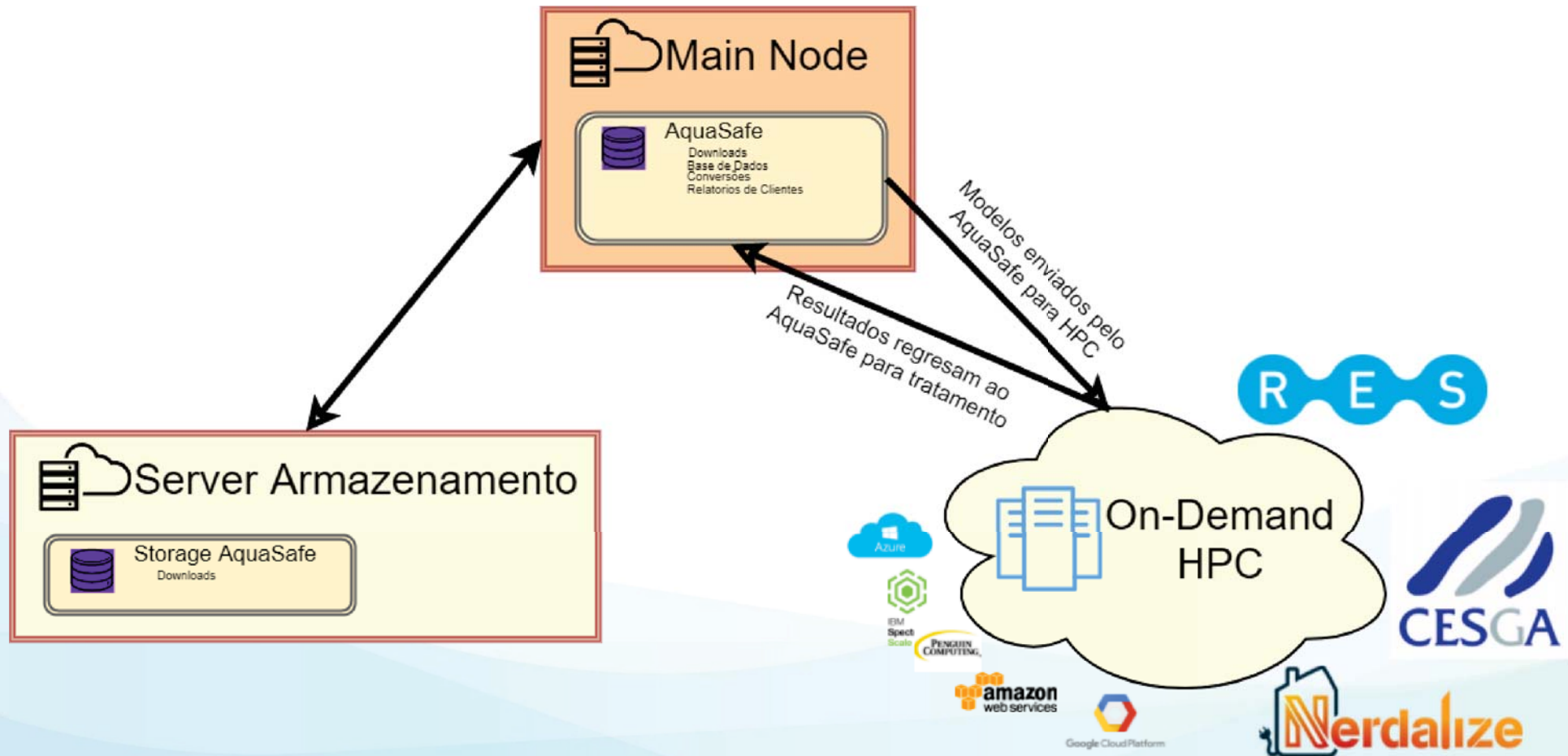
# SAMPA & SAMOA: PdE coastal downscaling capabilities





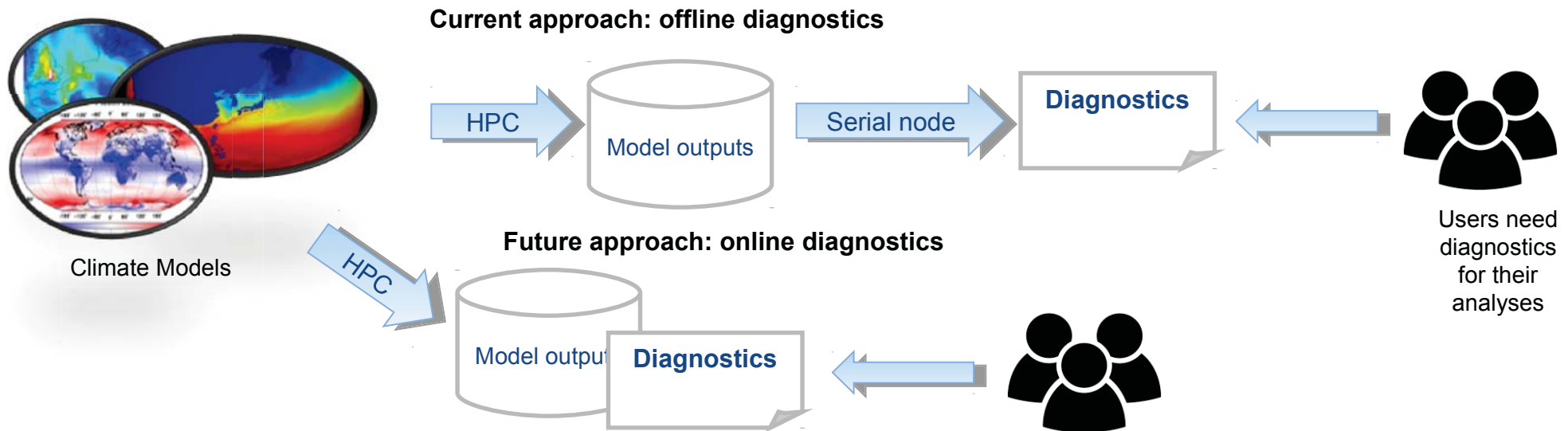


# Retos futuros



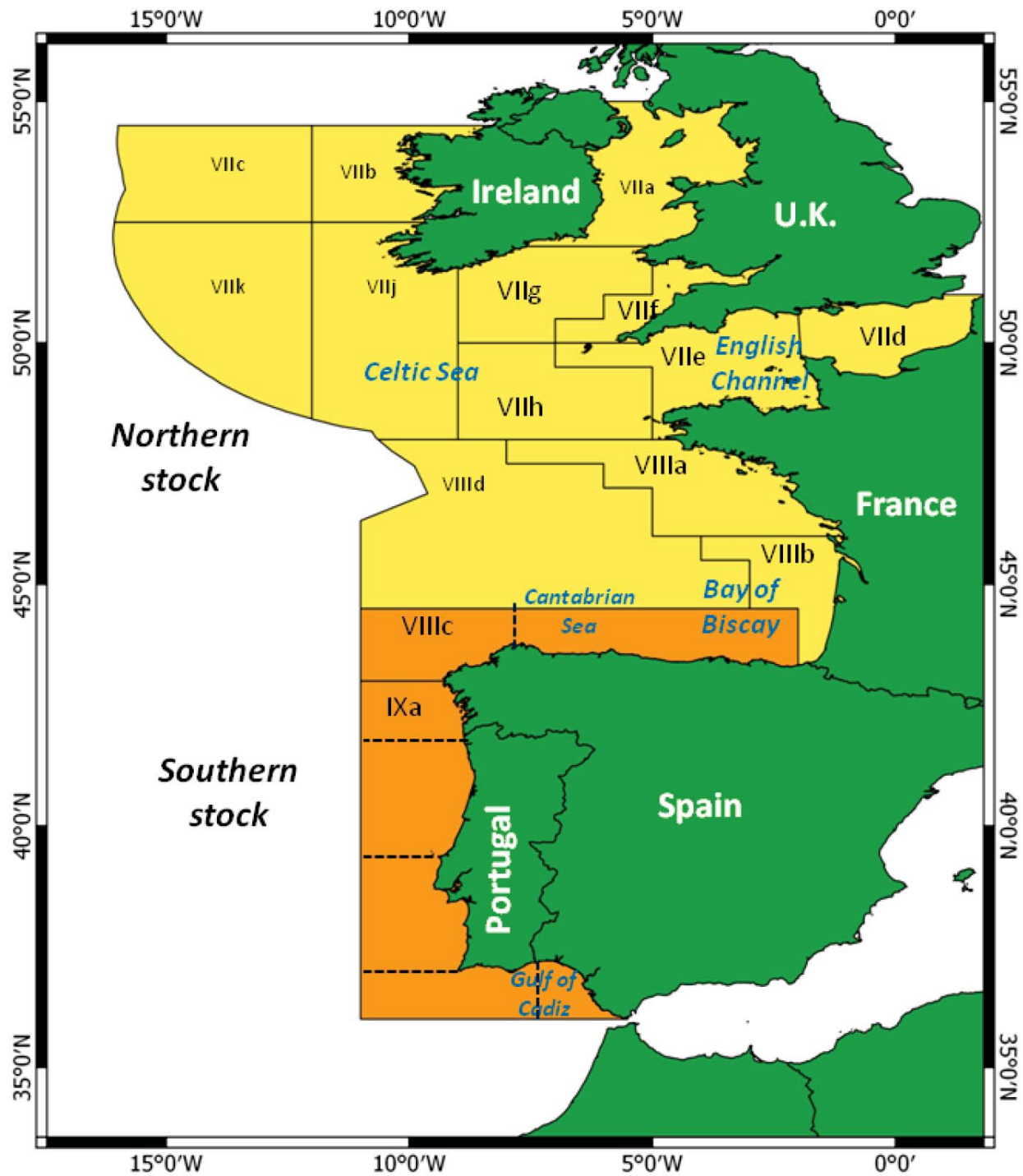
- Utilizar HPC en la operación diaria de simulación de modelos
- Transferir datos de forma eficiente para cada simulación
- Reducir costo operacional





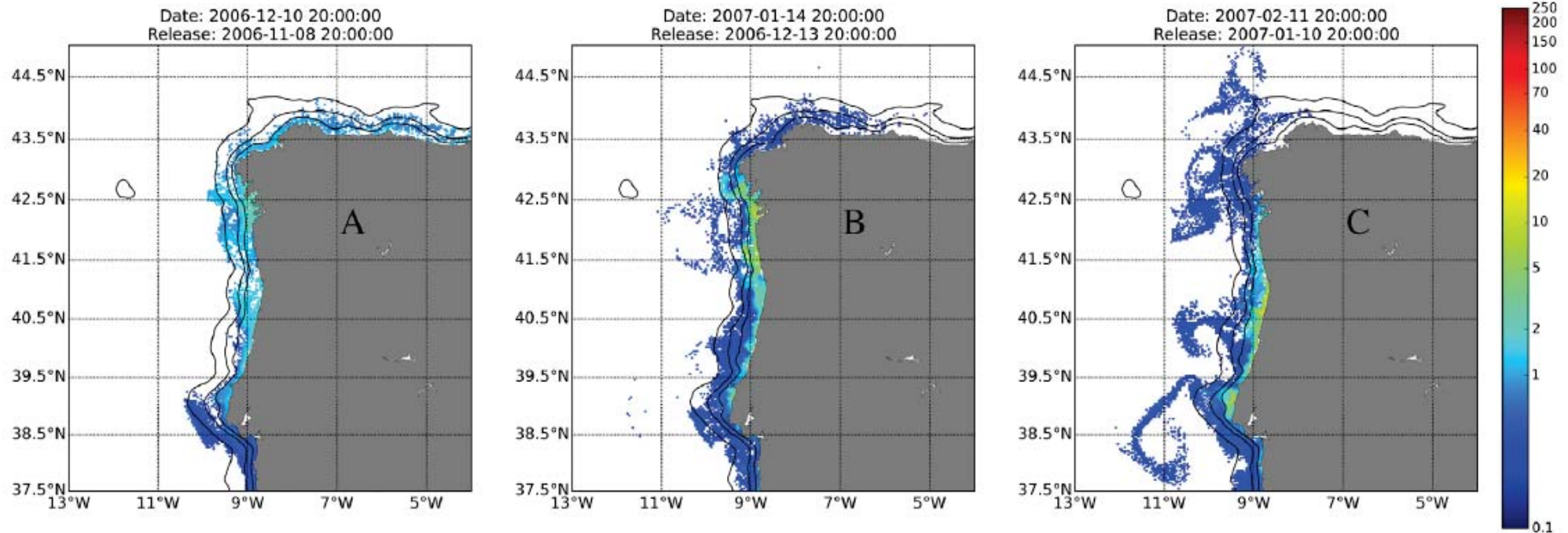
- **Diagnostics computed as Analytics as a Service**
  - Diagnostics online (during model run)
  - Reduced data traffic
  - Diagnostics possible on the computing nodes (using GPUs)
  - New diagnostics (data mining of extremes) possible
  - The user gets the results faster → crucial to adapt to climate change and to develop climate services (public and private)

Map 2: Delimitation of the Northern and Southern sardine stocks





# Supervivencia de larvas de sardina y reclutamiento



**Fig. 14.** Maps showing snapshots of the **zooplankton** distribution (in mg C/m<sup>3</sup>) at the particle positions obtained 29 days (late larvae) after being spawned at the Portuguese coast at the dates indicated in each figure.

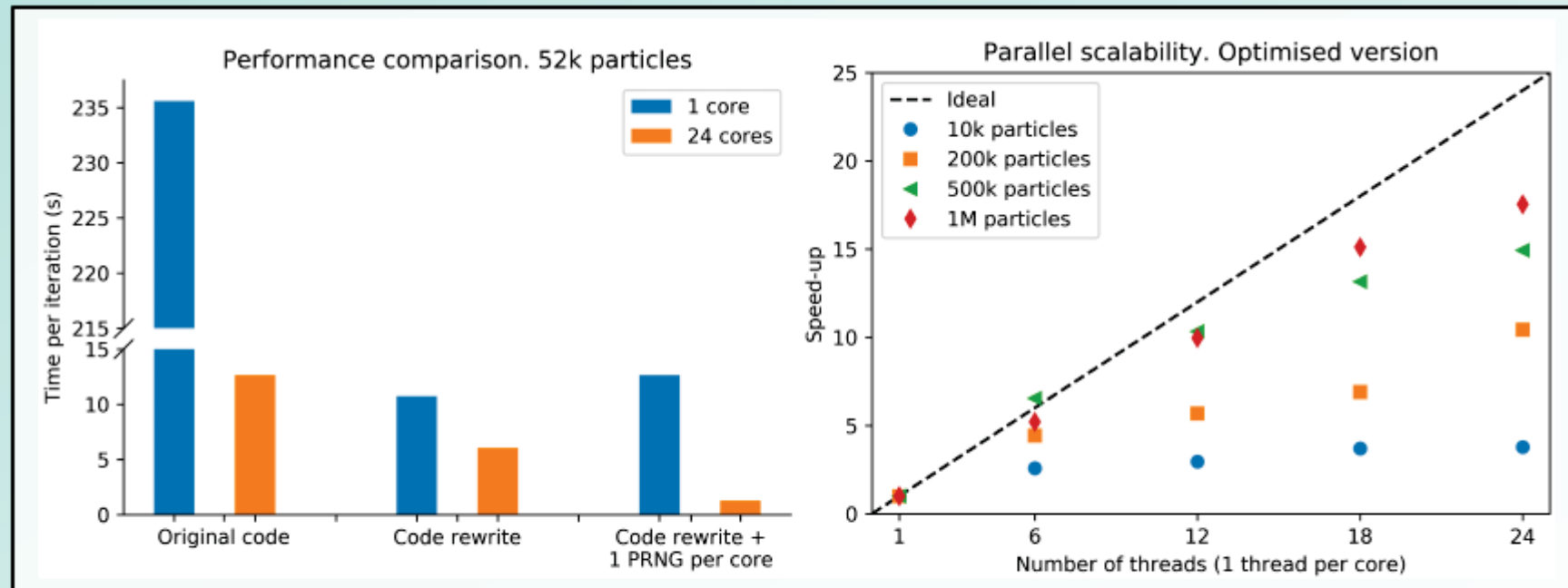
2007

Zooplankton distribution (model) at the position of late sardine larvae (29 days after spawning)

García-García & Ruiz-Villarreal, A biophysical model for simulating early life stages of sardine in the Iberian Atlantic stock, Fisheries Research, 2016

# Off-line lagrangian particle tracking: Efficient implementation of a Vertical Dispersion algorithm

Ignacio Vidal-Franco<sup>(1)</sup>, Manuel Ruiz-Villarreal<sup>(2)</sup>, Andrés Gómez-Tato<sup>(3)</sup>



Finisterrae II cluster: 2x Intel(R) Xeon(R) CPU E5-2680 v3 @ 2.50GHz

Java Hotspot 64 bit Server VM, 1.8.0\_121-b13

Optimization of the numerics of the offline Lagrangian model (vertical diffusion)

Optimization of the code for running in Finisterrae II:

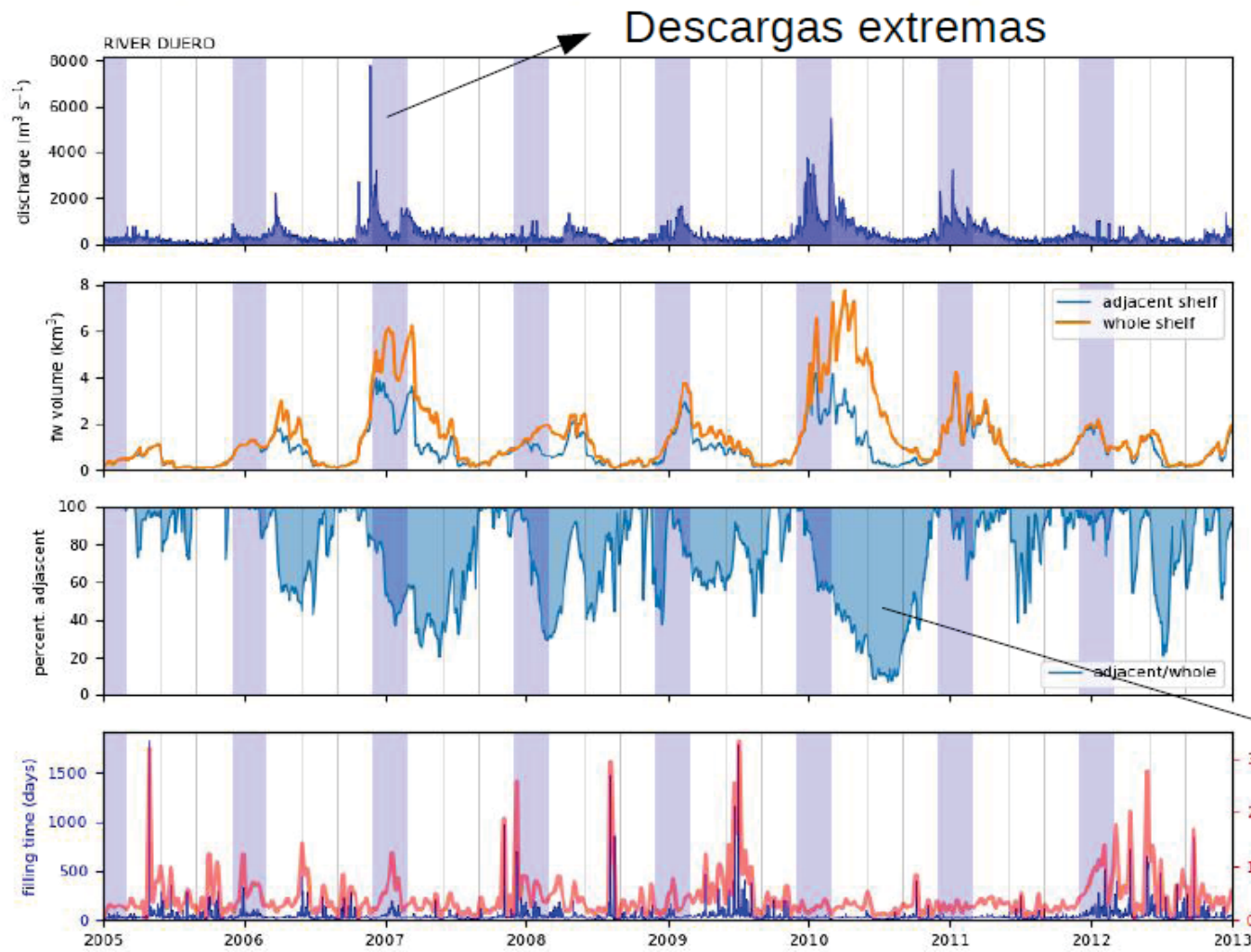
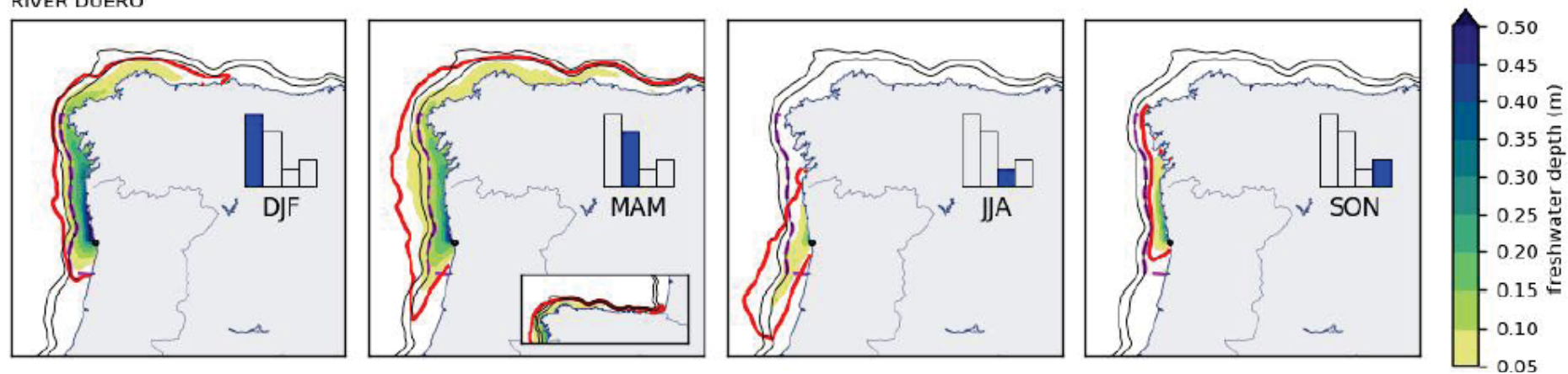
more particles, more frequency of release, more years  
THEREFORE  
simulations more representative of interannual variability sardine recruitment

Rede Galega de Tecnoloxías

Cloud e Big Data para







Transporte alongshore  
quase total da pluma

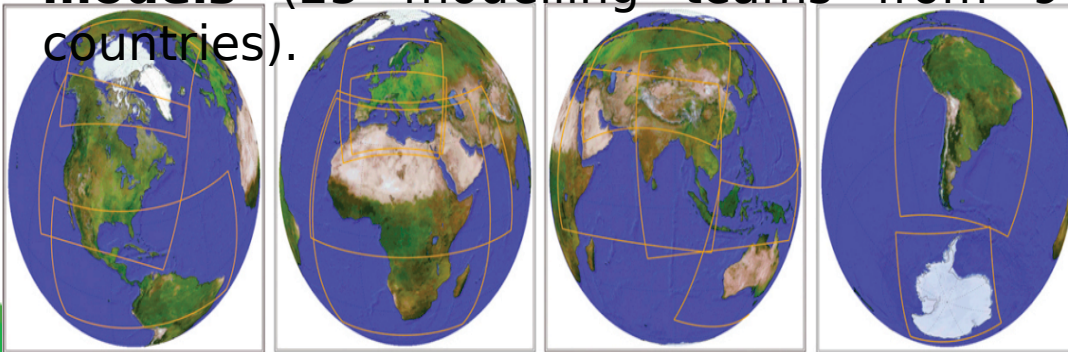
Decadal simulation run at CESGA

# Joining efforts, the multimodel initiatives



The Coordinated Regional Downscaling Experiment (**CORDEX**) is a project of the World Climate Research Program.

**MedCORDEX** is one of the 14 regional domains. It has been proposed as the follow-up of previous and existing initiatives and is supported by HyMEX and MedCLIVAR. At present it is the **largest effort in terms of regional coupled models** (23 modelling teams from 9 countries).



## The MedCORDEX initiative

[www.medcordex.eu](http://www.medcordex.eu)

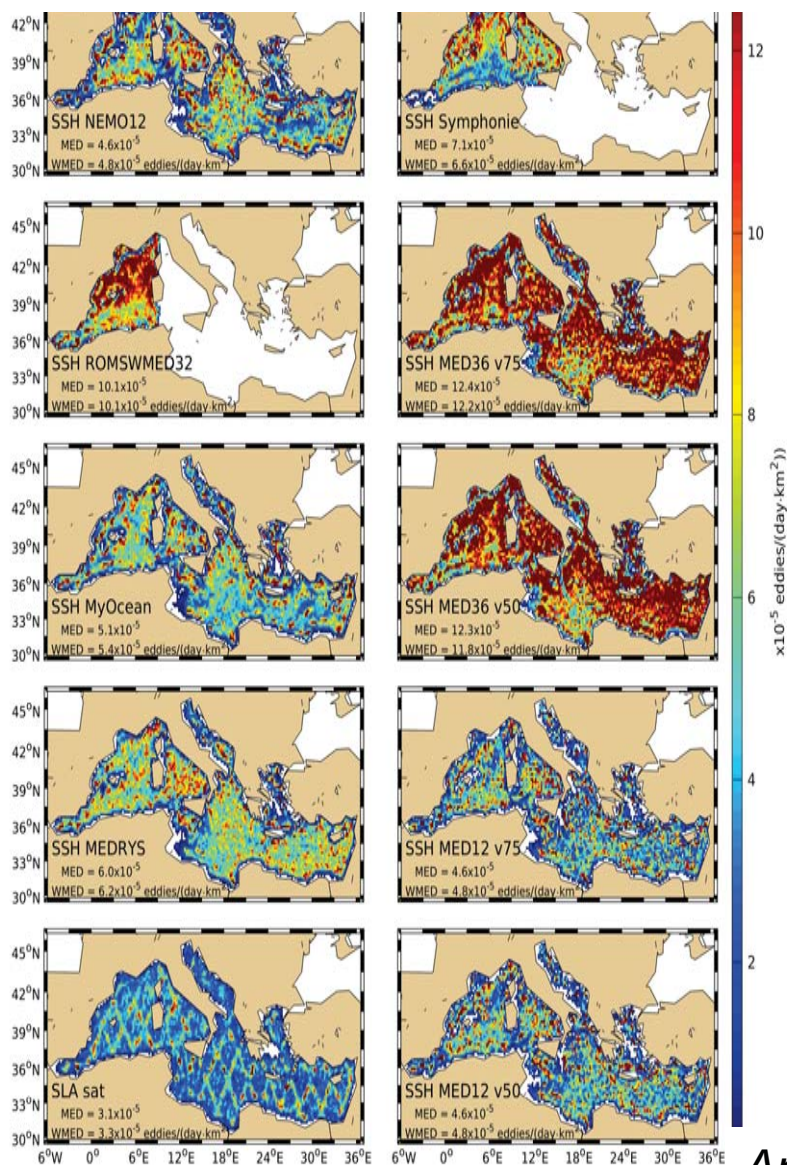
*Ruti et al., BAMS, 2015*





# Results : *Eddy field statistics*

*Density of eddies in an ensemble of models  
(eddies/(day km<sup>2</sup>))*



The analysis of the ensemble of climate models highlights the impact of model resolution, differences on model physics and more important, the strong limitations of observational estimates

Amores and Jordà ,  
2017

# HPC in MedCORDEX

All activities of MedCORDEX teams rely on HPC resources, although with different approaches. Some teams can use their own HPC resources (e.g. MétéoFrance), others use small clusters for small applications while rely on PRACE/RES for the demanding experiments. *This may pose problems to ensure results for certain projects with rigid deadlines !* Experiments require intensive use for a limited period of time (ie. few but demanding experiments)

## An example, the ENEA experience

### Cluster USED

2 sockets with 8 cores Intel E5-2670 2.6 GHz 64 GB/RAM (4 GB per core)  
 One interface IB QDR 40 Gb/s  
 Two interfaces GbE

### Resources needed

MITgcm 1/12° Ocean forced model.  
 312 cores - 5 years/day  
 MITgcm 1/12° Atmosphere/Ocean coupled model.  
 252 cores - 1 years/day  
 MITgcm very high resolution for the Turkish Straits Systems  
 252 cores 1.5 month/day  
*Climate runs require o(100 yrs) runs (0.2 - 1. Millions of core hours per exp.)*

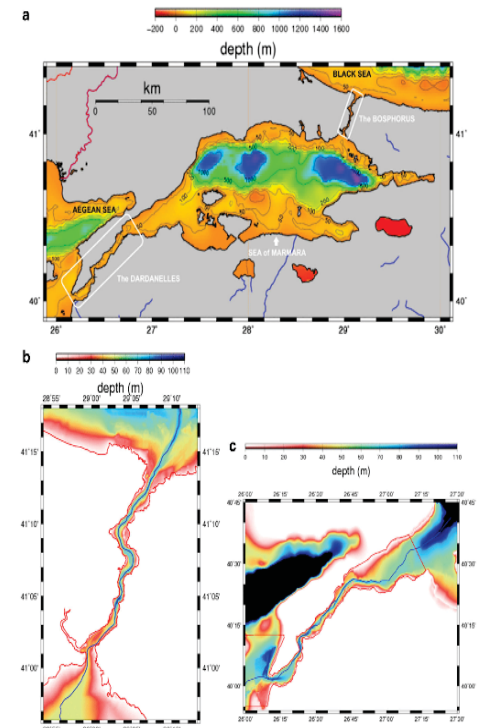


Fig. 1 Location and bottom topography maps for a Turkish Straits System (TSS) including b Dardanelles and c Bosphorus Straits. The blue line denotes the flowway along the strait channels

*Sannino et al.,  
 2017*



# Future challenges on HPC from the MedCORDEX perspective

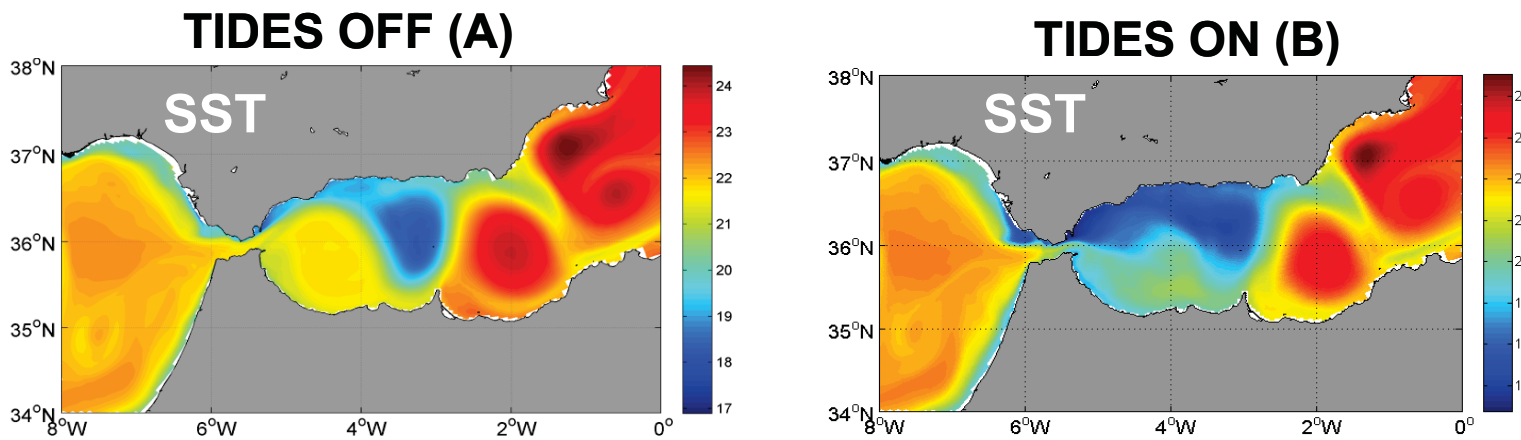


The MedCORDEX community has discussed several times about the next challenges on HPC. Future improvements in computing speed are not a pressing priority (*need more research time to really take advantage of it!*). Conversely, storage and the processing of huge amounts of data start to be a serious concern. Local storage usually necessary.

Also, it is worth noting that in MedCORDEX there are no code developers that could design computational solutions to optimize the problems. Problems consolidating know-how to exploit/optimize HPC applications (*the publish-or-perish Damocles' sword*)

**Shared or Cloud computing, are there a real alternative for climate simulations?**

## Small-scale proc. Problems to climate models



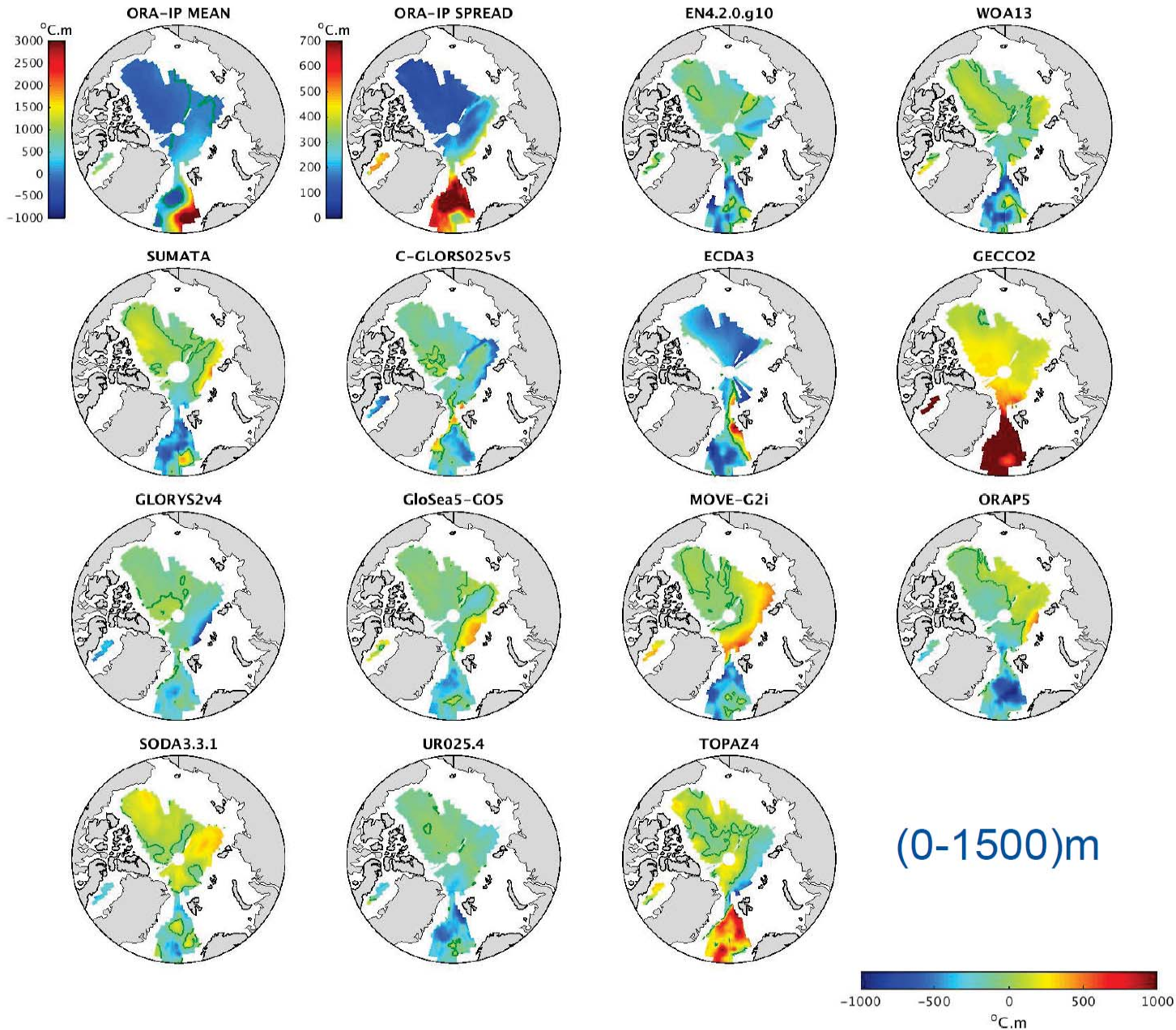
- Shortcomings of regional **climate** models due to **low resolution** and lack of **relevant forcing**

- Present **computer power** unable to **explicitly resolve** these processes in climate projections

- Need for clever **parameterization** until reaching sufficient computer power



# Ocean reanalysis



Never Fuckar talk  
ORA-IP  
Intensive use of HPC  
Data assimilation

- ✓ **Recursos de cálculo:** Hacen uso de las reservas.
  - ✓ Las reservas se hacen con 1 semana de antelación.
  - ✓ Se hacen por más tiempo del inicialmente necesario por si hubiese algún problema.
  - ✓ Diferentes operativas => Diferentes reservas.
- ✓ **Almacenamiento:** Este tipo de operativas necesitan bastante espacio y dado que es imposible asignarles el espacio que necesitarían para almacenar todo el histórico de datos, hay que implementar una política de backup a cinta y/o disco.
- ✓ **Diseminación:** Necesidad de dar acceso a los datos obtenidos a sus usuarios: Thredds, Motu, FTP, ... Uso de los recursos de Cloud.
- ✓ **Monitorización:** Podemos seguir el estado de la operativa



# HPC y servicios marinos

- Comunidad española (y portuguesa) muy activa en el desarrollo de servicios marinos y en iniciativas de simulaciones climáticas y reanálisis. Participación en consorcios europeos Fp7, H2020, Interreg, Copernicus e iniciativas internacionales MedCordex, ORA-IP, EuroGOOS
- Uso de clúster local para servicios basados en predicción. Necesidad más recursos para algunas aplicaciones y retos computacionales.
- Predicciones en HPC requieren reserva. CESGA mantiene predicciones Copernicus marino, MeteoGalicia
- Simulaciones de periodos largos requieren HPC. Pero no sólo cálculo, también almacenamiento. Necesidad de recursos dedicados para ejecutar simulaciones cumpliendo plazos.
- Soporte a usuarios: experiencias CESGA, BSC, Rede Galega HPC
- Mejoras en el workflow: experiencias BSC Copernicus, Aquasafe HIDROMOD, ecFLOW, Python dash.
- PyMES en servicios marinos

# Instituto Español de Oceanografía Fundado en 1914



Odón de Buén  
Fundador del IEO



1916: Red de plancton en una campaña oceanográfica  
en el navío de la Armada Hernán Cortés

*“Los cambios de las variables oceánicas obedecen leyes y siguen ciclos que deben comprenderse, **resulta necesario pues reunir datos por un periodo largo de tiempo** como un medio para predecir el tiempo en el mar en beneficio de marinos y pescadores”*