COPERNICUS · MARINE ENVIRONMENT MONITORING SERVICE

CMEMS
IBERIA-BISCAY-IRELAND
REGIONAL SEAS
MFC

Contract IBI-MFC
Until April 30 2018

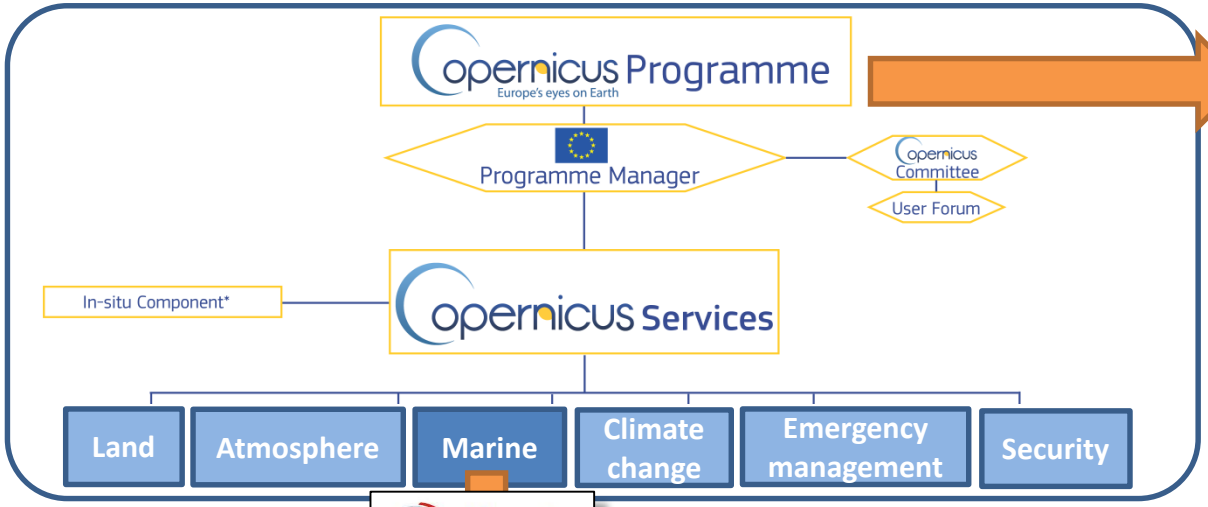
HPC resources for ocean modelling: the IBI Copernicus Marine Service example

R&D Team: M.G. Sotillo, **R. Aznar**, E. Gutknecht, G. Reffray, S. Cailleau, B. Levier, T. Dabrowski, P. Bowyer, L. Aouf, A. Dalphinet, R. Rainaud, J.E. Barrera, C. Toledano, A. Amo-Baladrón, P. Lorente, A. Pascual, E. Alvarez-Fanjul.

CESGA Team: P. Rey, A. Rodríguez, J. Villasuso, A. Feijoo, C. Fernández, A. Gómez, I. López.

COPERNICUS
MARINE ENVIRONMENT MONITORING SERVICE

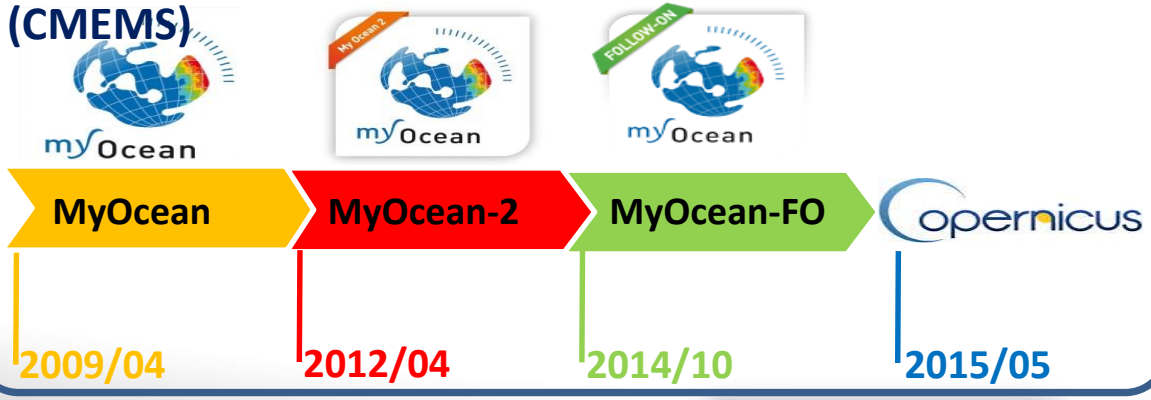
Copernicus: The European Earth Observation Programme



- Environment protection.
- Management of urban areas.
- Forestry.
- Fisheries.
- Health.
- Transport.
- Climate change.
- Sustainable development.
- Civil protection.
- Tourism.

Mercator Ocean
Ocean Forecasters

Copernicus Marine Environment Monitoring Service (CMEMS)



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CMEMS objectives

Oil Spill Combat

Ice Shipping Route

Search & Rescue

Sustainable Aquaculture

Ecosystem-based fisheries management

Marine biology

Coastal Environment

Water Pollution

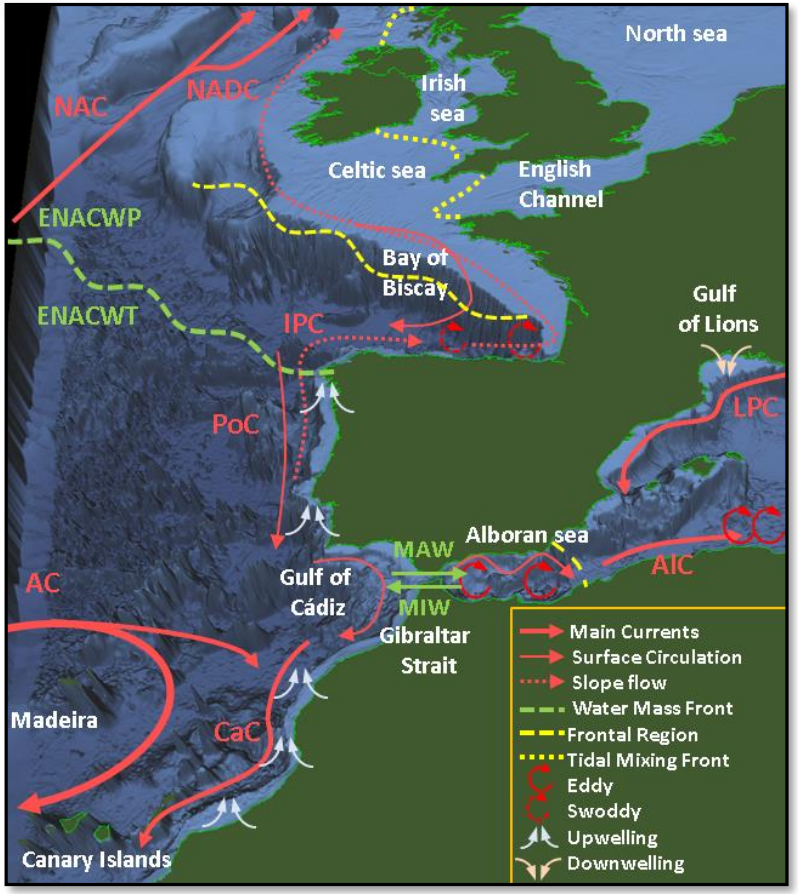
Offshore Energy

Climate Change

Seasonal Forecast

Short & Medium Weather Forecast

CMEMS IBI-MFC: what is IBI?



Modelling

GLO MFC | ARC MFC | BAL MFC | NWS MFC | **IBI MFC** | MED MFC | BS MFC

The IBI (Iberia-Biscay-Ireland) area

Check of physical processes:

- **Eddies**
- **Coastal Upwelling (western African & Iberian coasts)**
- **Gibraltar inflow/outflow**
- **Slope/shelf currents in the Bay of Biscay**

CURRENTS
NAC: North Atlantic Current
NADC: North Atlantic Drift Current
AC: Azores Current
CaC: Canary Current
LPC: Liguro-Provençal Current
AIC: Algerian Current
PoC: Portugal Current
IPC: Iberian Poleward Current

WATER MASSES
ENACWP: Eastern North Atlantic Central Water of sub-Polar origin
ENACWT: Eastern North Atlantic Central Water of sub-Tropical origin
MAW: Modified Atlantic Water
MIW: Mediterranean Intermediate Water

Co-funded by the Horizon 2020 Framework Programme of the European Union

The IBI Consortium

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Contract IBI-MFC
Until April 30 2018

Puertos del Estado
GOBIERNO DE ESPAÑA — MINISTERIO DE FOMENTO

CESGA
Centro de Supercomputación de Galicia

Mercator Ocean
Ocean Forecasters

Marine Institute
Foras na Mara

AEMet
Agencia Estatal de Meteorología
GOBIERNO DE ESPAÑA — MINISTERIO DE AGRICULTURA, ALIMENTACIÓN Y MEDIO AMBIENTE

METEO FRANCE
Toujours un temps d'avance

IBI-MFC COORDINATION

OPERATION & SERVICE

PHYSICAL

BIOGEOCHEMICAL

WAVES

CROSS-CUTTING

R&D

More than 30 experts in the IBI Team

Co-funded by the Horizon 2020 Framework Programme of the European Union
Copernicus

CMEMS IBI-MFC: Delivered products

IBI Products disseminated to end-users through CMEMS web catalogue:

Near Real Time Forecast (1/36º) (2012-Today)

TEMP, SAL, U, V & SSH

IBI_ANALYSIS_FORECAST_PHYS_005_001
dataset-ibi-analysis-forecast-phys-005-001-**hourly**
dataset-ibi-analysis-forecast-phys-005-001-**daily**

Chl, Fer, NH4, NO3, O2, PO4, Si, Phytoplanckton, Primary production & Euphotic depth

IBI_ANALYSIS_FORECAST_BIO_005_004
dataset-ibi-analysis-forecast-bio-005-004-**daily**

VPED, VHM0_SW1, VTM02, VTM10, VTPK, VMDR, VHM0_SW2, VTM01_SW2, VTM01_SW1, VMDR_SW2, VMDR_SW1, VTM01_WW, VMDR_WW, VHM0_WW, VSDY, VSDX, VHM0

IBI_ANALYSIS_FORECAST_WAV_005_005
dataset-ibi-analysis-forecast-wav-005-005-**hourly**

Multi-year (1/12º) (2002-2014)

TEMP, SAL,U,V & SSH

IBI_REANALYSIS_PHYS_005_002
dataset-ibi-reanalysis-phys-005-002-**hourly**-regulargrid
dataset-ibi-reanalysis-phys-005-002-**daily**-regulargrid
dataset-ibi-reanalysis-phys-005-002-**monthly**-regulargrid
dataset-ibi-reanalysis-phys-005-002-**monthly**-nativegrid

Chl, Fer, NH4, NO3, O2, PO4, Si, Phytoplanckton, Primary production & Euphotic depth

IBI_REANALYSIS_BIO_005_003
dataset-ibi-reanalysis-bio-005-003-**monthly**-regulargrid
dataset-ibi-reanalysis-bio-005-003-**monthly**-nativegrid

VPED, VHM0_SW1, VTM02, VTM10, VTPK, VMDR, VHM0_SW2, VTM01_SW2, VTM01_SW1, VMDR_SW2, VMDR_SW1, VTM01_WW, VMDR_WW, VHM0_WW, VSDY, VSDX, VHM0

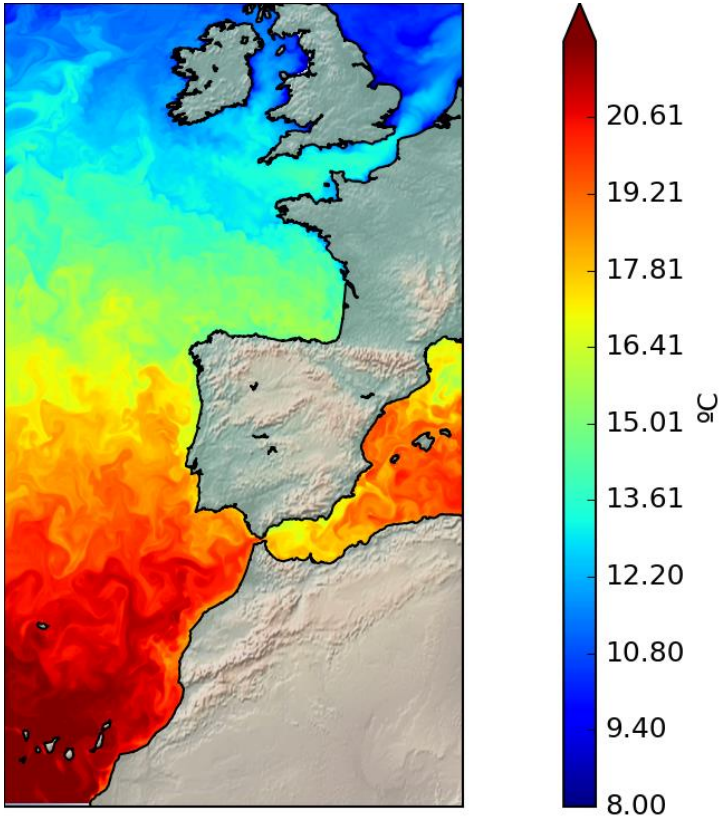
IBI_REANALYSIS_WAV_005_006
dataset-ibi-reanalysis-wav-005-006-**hourly**

Sotillo et al. 2015: The MyOcean IBI Ocean Forecast and Reanalysis Systems: operational products and roadmap to the future Copernicus Service. J of. Op. Oc., Vol. 8 , Iss. 1

Behind the IBI-MFC: PHY component

IBI NEMO v3.6 is a 3D baroclinic model that:

- Solves Navier-Stockes equations in geopotential coordinates under hydrostatic and Boussinesq approximations.
- Solves **high-frequency shelf processes**
- Horizontal Resolution**: 1/36°** (≈ 2 km)
- Vertical Resolution**: 50 z-coord levels**
- IBI Grid size 1093 x 1894 x 50 = **1.035e08 grid points**
- Composite **Bathymetry** from ETOPO 2 & GEBCO
- **Tidal forcing** at OBC & tidal astronomic potential (**11 harmonics** from FES2004 and TPXO7.1 tidal models solutions)
- Run daily **forecast** + 2 weekly **hindcasts** (Mon & Wed) with **spectral nudging** (**Data Assimilation from April 2018**)



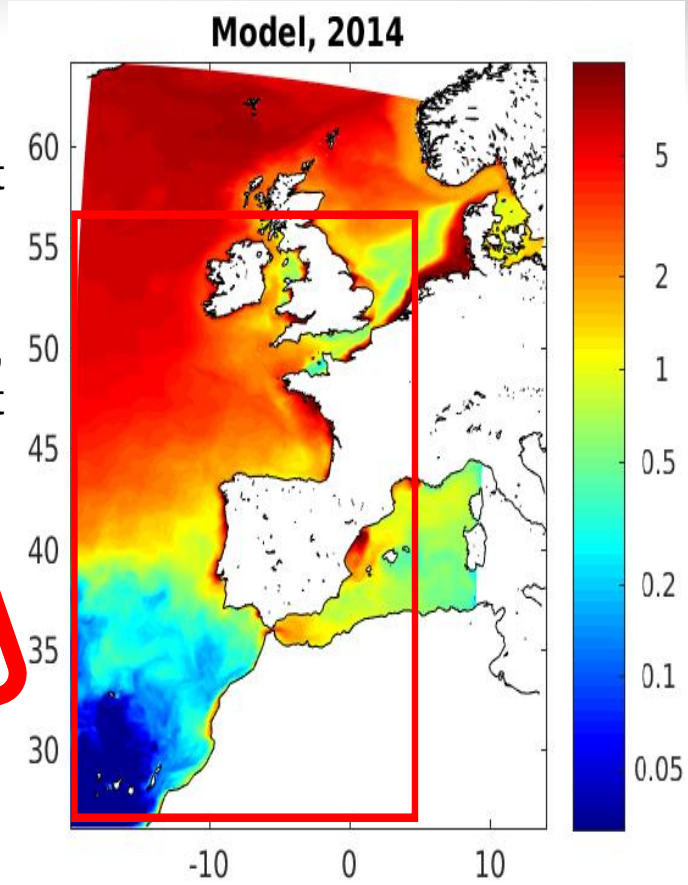
Sea Surface Temperature (23/11/16).
IBI_ANALYSIS_FORECAST_PHYS_005_001

Behind the IBI-MFC: BIO component

- **New IBI-NRT-BIO forecast service** in V3 (April 2017).
- **PISCES model** v3.6
- High resolution (**1/36º - 50lev**) biogeochemical forecast (+7D), updated weekly (on Thu).
- PISCES 3.6 Application:
  - **24 state variables**. Delivers chlorophyll, oxygen, iron, nitrate, ammonium, phosphate, silicate, net primary production and the euphotic zone depth,…

The IBI BIO-Team: Mercator Ocean-Marine Institute-PdE
Sci Development: MO
Qualification: MI & PdE
Transition into operations: MO & PdE
Production & validation: PdE

Since Apr 2017 (V3)



2014 Annual average chlorophyll. IBI_ANALYSIS_FORECAST_BIO_005_004 only delivered for the IBI service domain (in red).

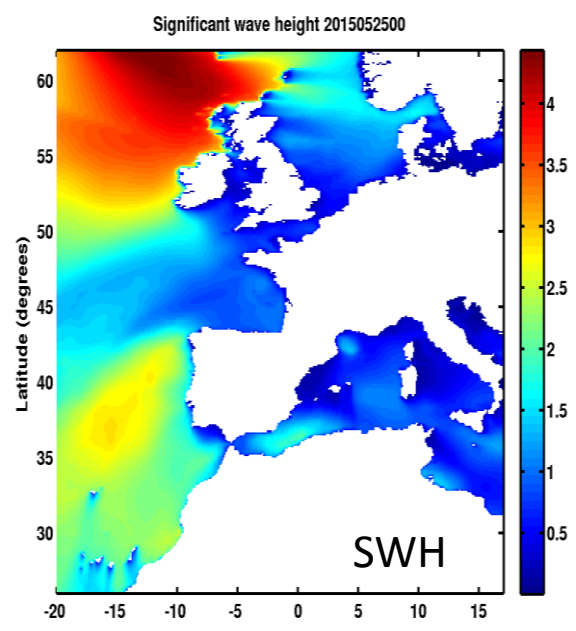
Co-funded by the Horizon 2020 Framework Programme of the European Union

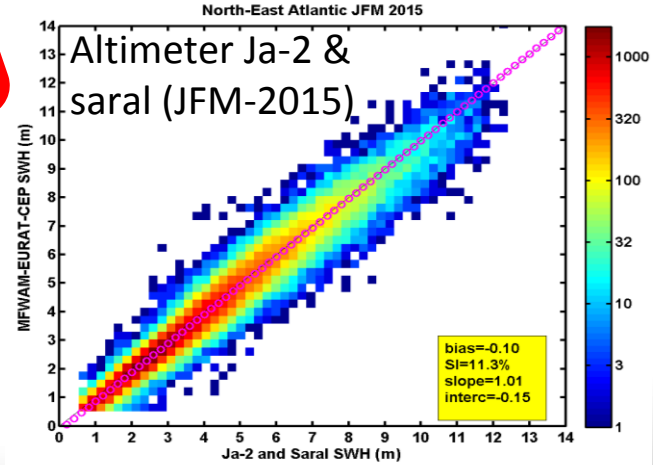
Behind the IBI-MFC: WAV component

- **New IBI-NRT-WAV forecast service** in V3 (April 2017).
- **MFWAM** model code used as base.
- **10Km resolution.**
- Spectral resolution 24 directions and 30 frequencies (start at 0.035Hz).
- Run **twice a day, 5 day** forecast on daily basis**.**
- Product contains the **usual wave variables**, including swell and wind wave separation.
- Additionally, wave inputs for phy-wav coupling: computation of Stoke Drift.

The IBI WAV-Team: MF-AEMET-PdE
Sci Development: MF & AEMET
Qualification: MF, AEMET & PdE
Transition into operations: AEMET & PdE
Production & validation: PdE

Since Apr 2017 (V3)





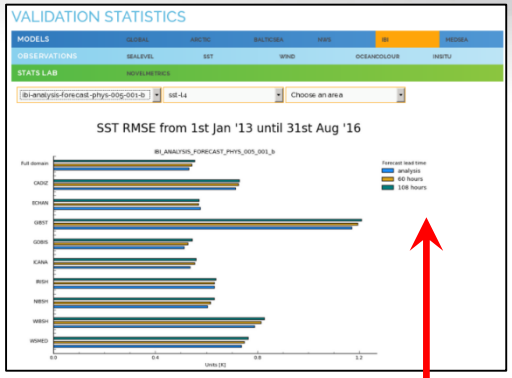
Product Quality: CONTEXT AND GOALS

Operational Ocean Forecasting Systems (OOFSs)

→ Tools to support decision-making

→ Multi-parameter skill assessment: **essential!**

→



1.- QUID (QUality Information Document)

http://marine.copernicus.eu/documents/QUID/CMEMS-IBI-QUID-005-001.pdf

2.- CMEMS validation website (updated on a quarterly basis):

http://marine.copernicus.eu/web/103-validation-statistics.php

3.- Scientific Validation (Projects, Research papers, etc…)

Sotillo et al., 2016: "The MyOcean IBI Ocean Forecast and Reanalysis Systems: Operational products and roadmap to the future Copernicus Service

Aznar et al., 2016: "Strengths and weaknesses of the Copernicus forecasted and reanalyzed solutions for the Iberia-Biscay-Ireland (IBI) waters"

Lorente et al., 2016: «Ocean model skill assessment in the NW Mediterranean using multi-sensor data"

NARVAL

North
Atlantic
Regional
VALidation

Co-funded by the Horizon 2020 Framework Programme of the European Union

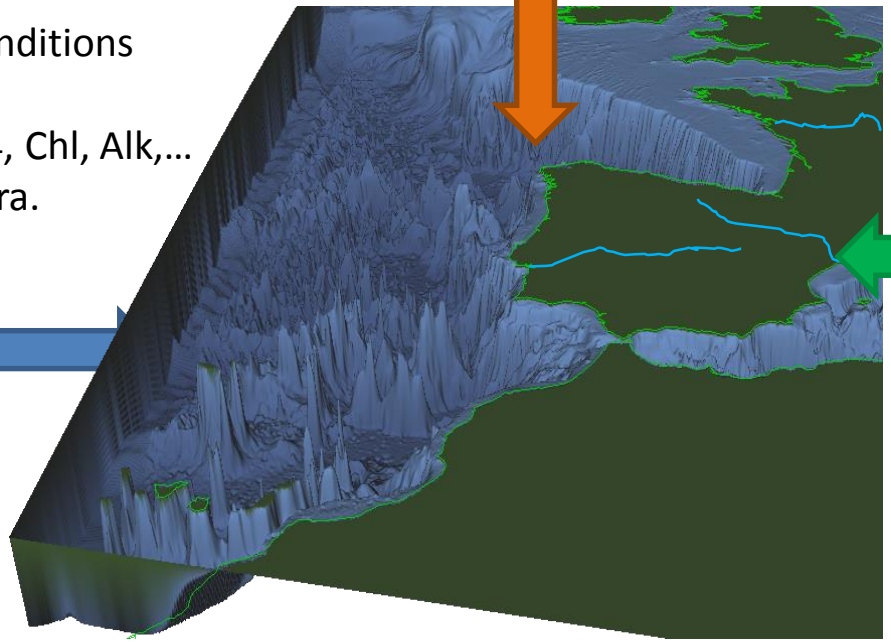
External inputs

3h Atmospheric forcings:
PHY&BIO: T2m, Wind 10m, D2m, Atm. pressure, Solar & Infrared radiations.
WAV: Wind 10m.

ECMWF

Daily Open Boundary Conditions
PHY: SSH, T, S, U, V.
BIO: Si, Fe, PO4, O2, NH4, Chl, Alk,…
WAV: wave energy spectra.

CMEMS
PHY/BIO/WAV
Global models



33 Rivers: discharge

-Observations
-Model
-Climatology

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HPC resources for IBI-MFC

- Use of CESGA Finis Terrae II machine: 328 Tflops, 7712 cores, 44.8 TB RAM, 1.5 PB Disk.
- Noticeable upgrade of operational services at V3: Increase of HPC resources to face IBI V3 upgrade.

	V2	V3	
Nodes (24 cores)	*43*	*51 (44 PHY/BIO + 7 WAV)*	– Increment in the number of nodes (+8)
Output	*24G(PHY)*	*197G(PHY) 61G(BIO) 1G(WAV)*	– Increment in outputs size.
Disk space for run	*224G(PHY)*	*1.8T(PHY)!! 244G(BIO) 1G(WAV)*	– Huge increment in the temporary disk space for PHY run (hourly 3D products).

Nodes reservation schedule

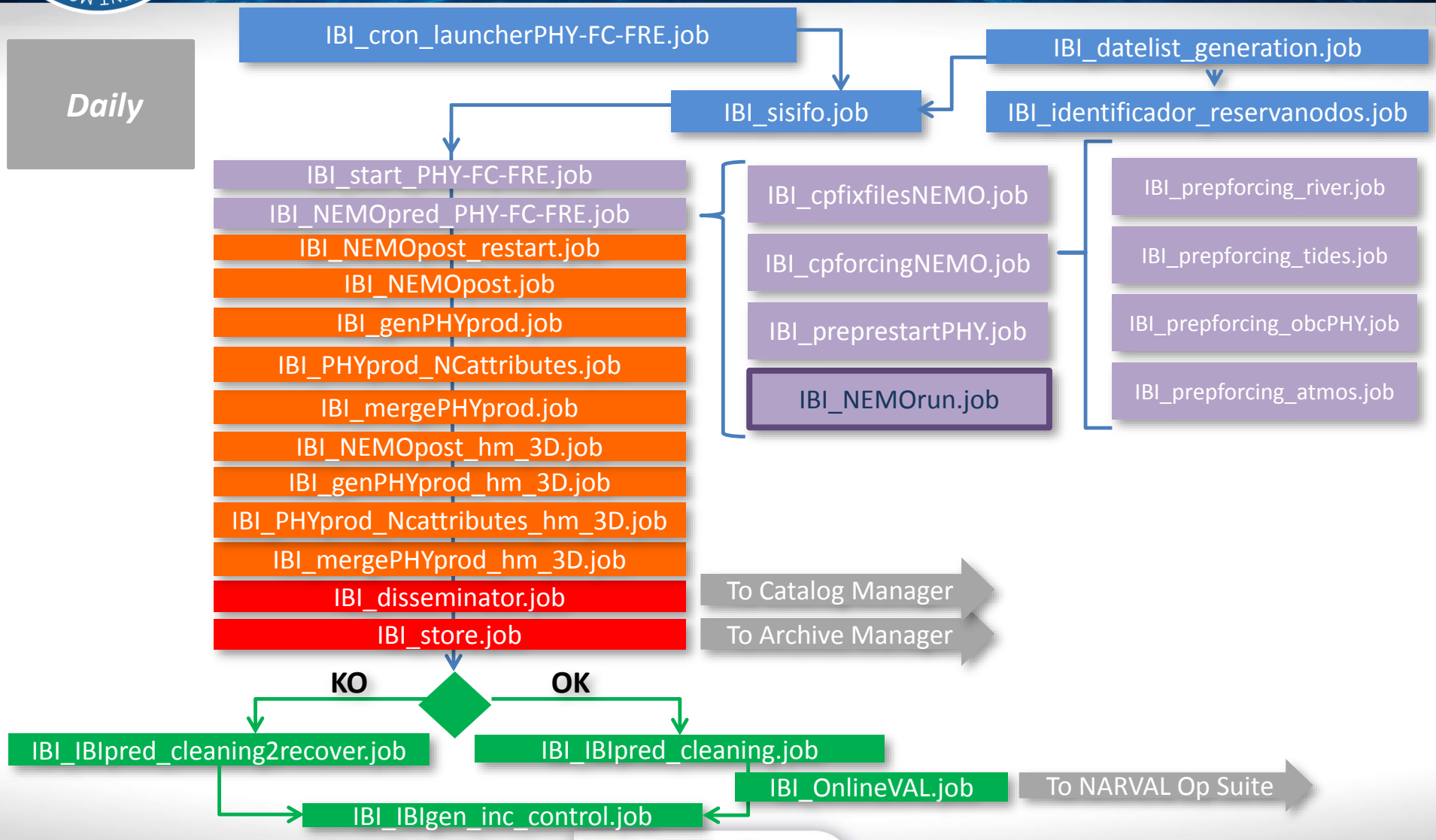
UTC	MON	TUE	WED	THU	FRI	SAT	SUN
0:00							
1:00							
2:00							
3:00	PHY-HC-SAM						
4:00	kill res						
5:00							
6:00							
7:00							
8:00	PHY-FC-FRE	PHY-FC-FRE	PHY-FC-FRE	PHY-FC-FRE	PHY-FC-FRE	PHY-FC-FRE	PHY-FC-FRE
9:00	kill res	kill res	kill res		kill res	kill res	kill res
10:00							
11:00				BIO-FC-FRE			
12:00				kill res			
13:00							
14:00			PHY-HC-SAM				
15:00							
16:00							
17:00							
18:00							
19:00			BIO-HC-SAM				
20:00							
21:00			kill res				
22:00							
23:00							

UTC	MON	TUE	WED	THU	FRI	SAT	SUN
0:00							
1:00							
2:00							
3:00							
4:00							
5:00							
6:00							
7:00							
8:00	WAV-FC-00H	WAV-FC-00H	WAV-FC-00H	WAV-FC-00H	WAV-FC-00H	WAV-FC-00H	WAV-FC-00H
9:00	kill res	kill res	kill res	kill res	kill res	kill res	kill res
10:00							
11:00							
12:00							
13:00							
14:00							
15:00							
16:00							
17:00							
18:00							
19:00							
20:00							
21:00	WAV-FC-12H	WAV-FC-12H	WAV-FC-12H	WAV-FC-12H	WAV-FC-12H	WAV-FC-12H	WAV-FC-12H
22:00	kill res	kill res	kill res	kill res	kill res	kill res	kill res
23:00							

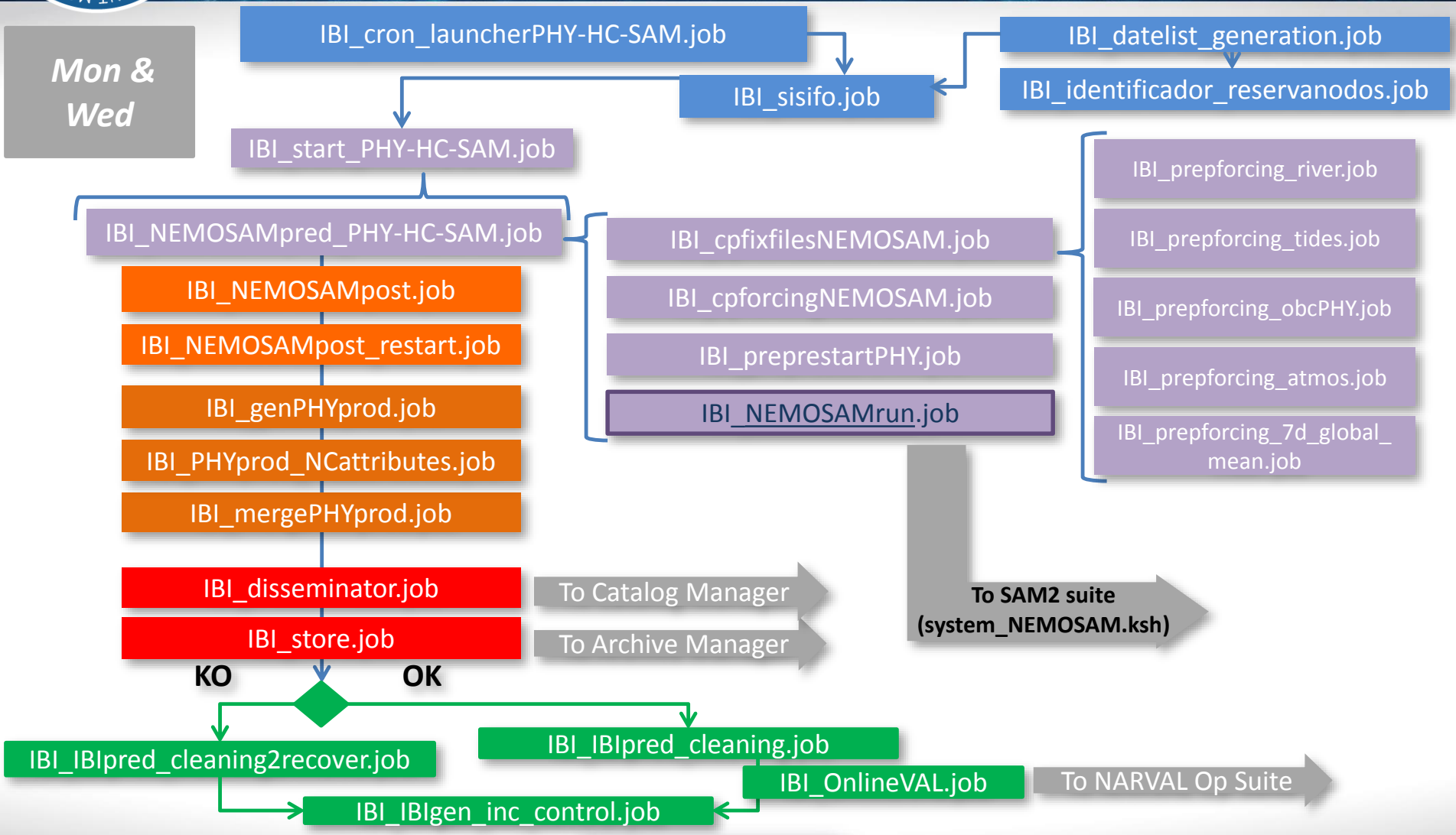
SIMULACIÓN	RESERVA	DURACIÓN APROX.	LANZAMIENTO	FRECUENCIA
PHY-FC-FRE	PHY-FC-FRE	115min	8:00UTC	diaria
PHY-HC-SAM Mon	PHY-HC-SAM	130min	03:00UTC	semanal Mon
PHY-HC-SAM Wed	PHY-HC-SAM	130min	14:00UTC	semanal Wed
BIO-HC-SAM	PHY-HC-SAM	160min	19:30UTC	semanal Wed
BIO-FC-FRE	PHY-FC-FRE	90min	11:30UTC	semanal Thu
WAV-FC-00H	WAV-FC-00H	30min	07:50UTC	diaria
WAV-FC-12H	WAV-FC-12H	30min	21:30UTC	diaria

RESERVA	DÍA SEMANA	HORA INICIO	NUM NODOS	HORA LÍMITE
PHY-FC-FRE	all	07:50UTC	44	L,M,V,S,D: 15:00UTC; X: NO; J: 19:00UTC
PHY-HC-SAM	Mon	02:50UTC	44	-
PHY-HC-SAM	Wed	13:50UTC	44	-
WAV-FC-00H	all	09:50UTC	7	13:00UTC
WAV-FC-12H	all	21:20UTC	7	23:59UTC

Operational suites: PHY forecast



Operational suites: PHY hindcast



Operational suites: pre-processes

ECMWF atmospheric files.

- ***88 files (11x8 days) ➜ 88 jobs.***
- ***Each preprocess job in a different core (88 cores/24 = 4 nodes).***
- ***RH from T dewpoint and T 2m.***
- ***Units changed.***
- ***Total precipitation by adding convective & stratiform.***
- ***Variables renaming.***
- ***Interpolation to 1/12º.***
- ***Vector rotation at higher latitudes.***

Global PHY (and BIO) OBCs and river discharges.

- ***Files renaming.***
- ***Variables separation.***

Preparation of model configuration files:

- ***Namelists for NEMO (and PISCES) models.***
- ***xml files for XIOS IO manager for NEMO (outputs writing frequency, files naming, variables, etc.).***

Operational suites: model run

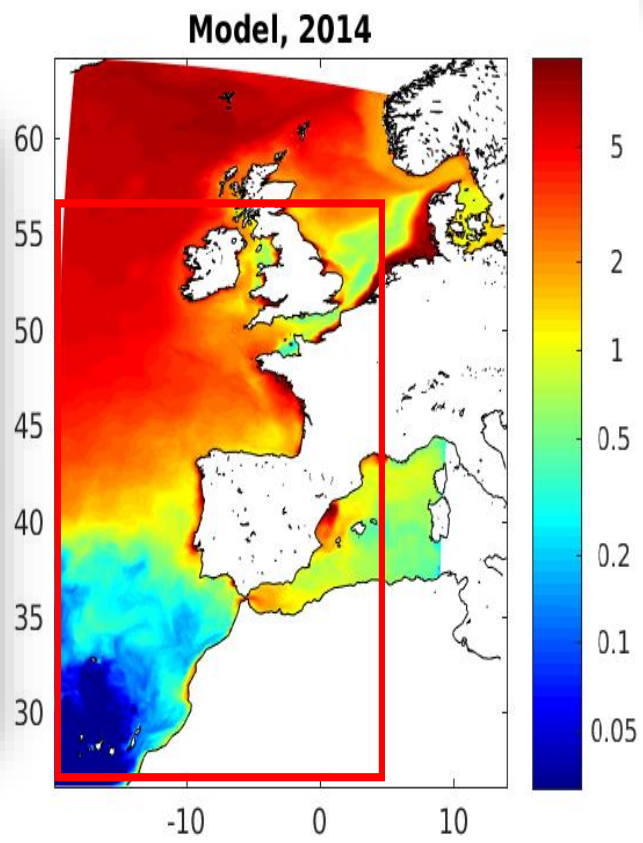
- *Partition in Finis Terrae II (CESGA) for IBI-MFC.*
- *Week schedule for nodes reservation used in OP.*

PHY & BIO:

- *1032 cores.*
  - *43 nodes (24 tasks per node).*
  - *990 cores for model (NEMO or NEMO-PISCES).*
    - *Model domain divided in 30x50 subdomains (510 not modeled since over land).*
  - *42 cores for XIOS IO manager.*

WAV:

- *144 cores.*
  - *6 nodes (24 tasks per node).*



Operational suites: post-processes

PHY & BIO suites

Copying of 990 (one from each processor) IC (restart) files for next launch.

-Splitting variables.
-Converting to short type.
-Defining missing value.

- (18 vars daily + 14 3D hourly) x 6 days = 192 jobs
- Run simultaneously in 108 cores (5 nodes)

- *Interpolating from 1/36º model native grid to 1/36º regular IBI grid.*
- *Modifying netcdf attributes.*

-14 vars x 6 days = 84 jobs
-Run simultaneously in 84 cores (4 nodes)

- *Saving files.*
- *Copying outputs to dissemination machine.*

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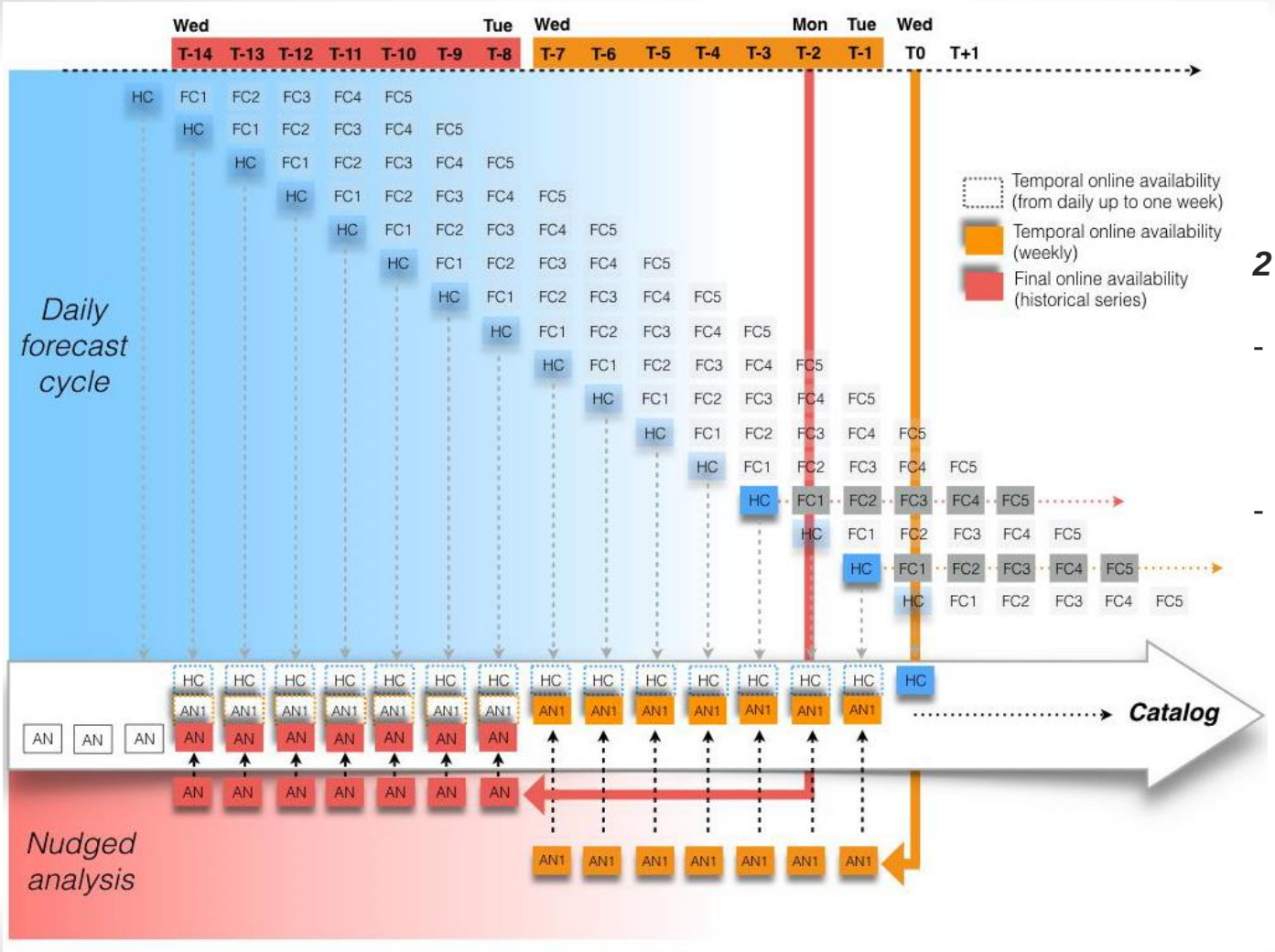
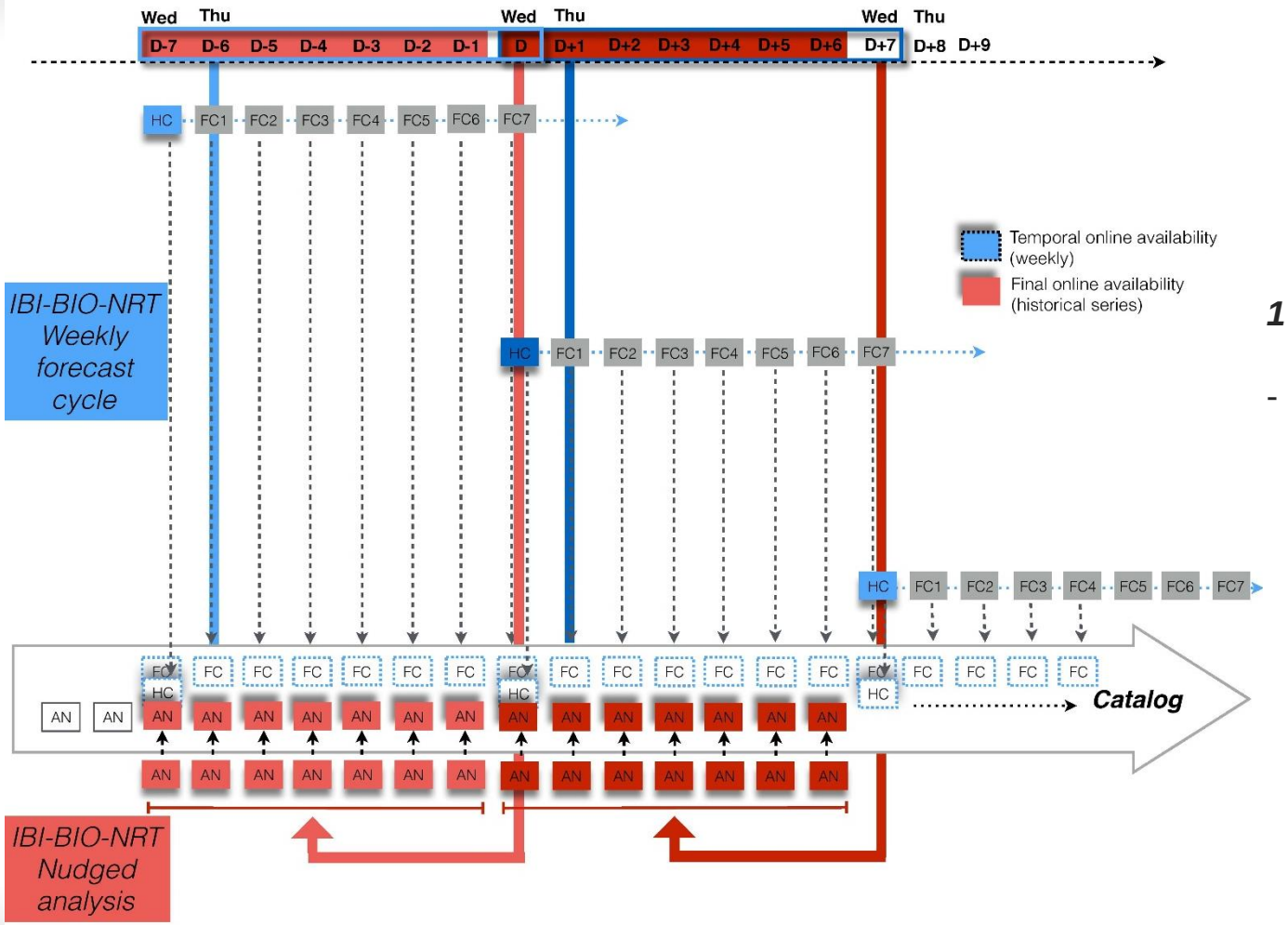
Operational suites: PHY catalogue policy



2 hindcasts:

- ***a) On Wed (T0): from previous Wed (T-7) to Tue (T-1)***
- ***b) Next Mon: same week as in a) but now with the best global ocean OBCs available.***

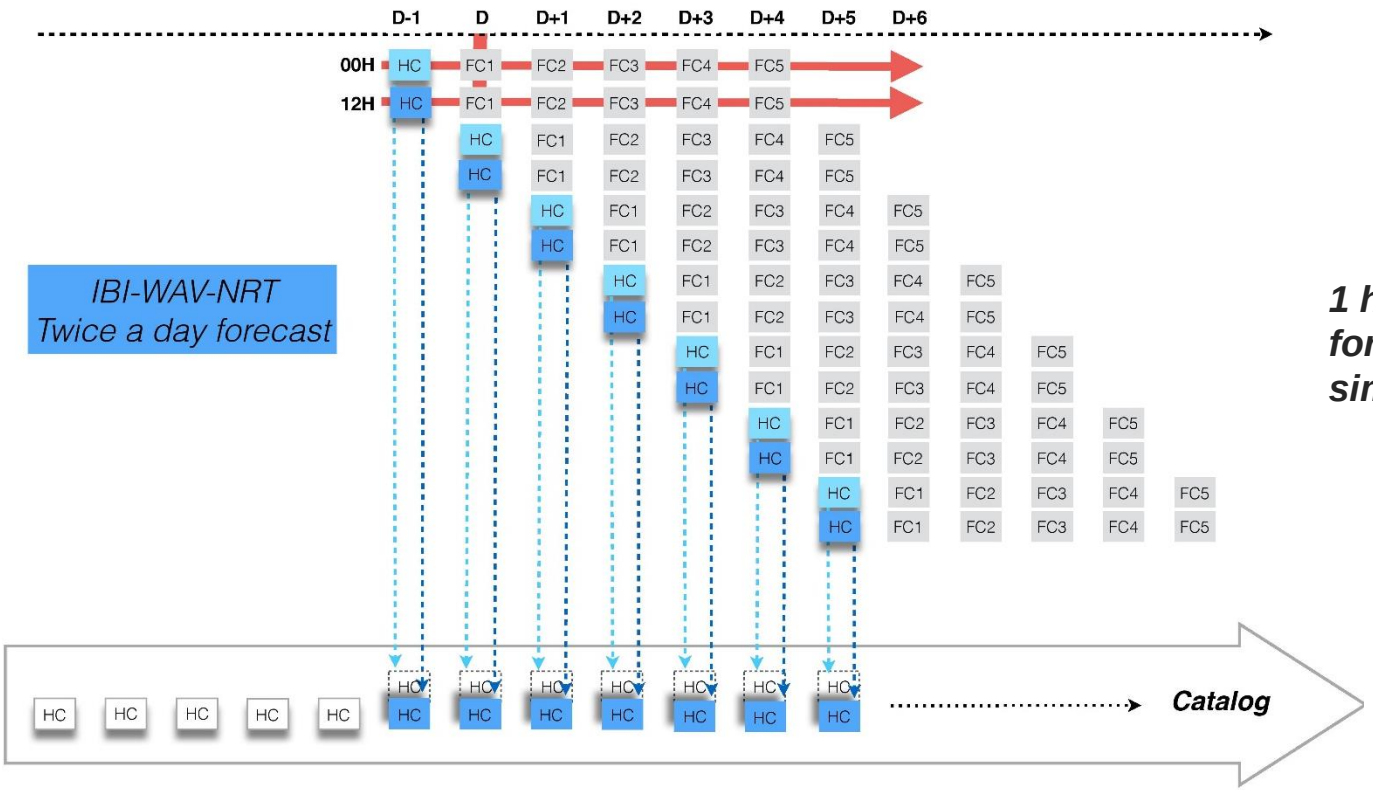
Operational suites: BIO catalogue policy



1 hindcast:

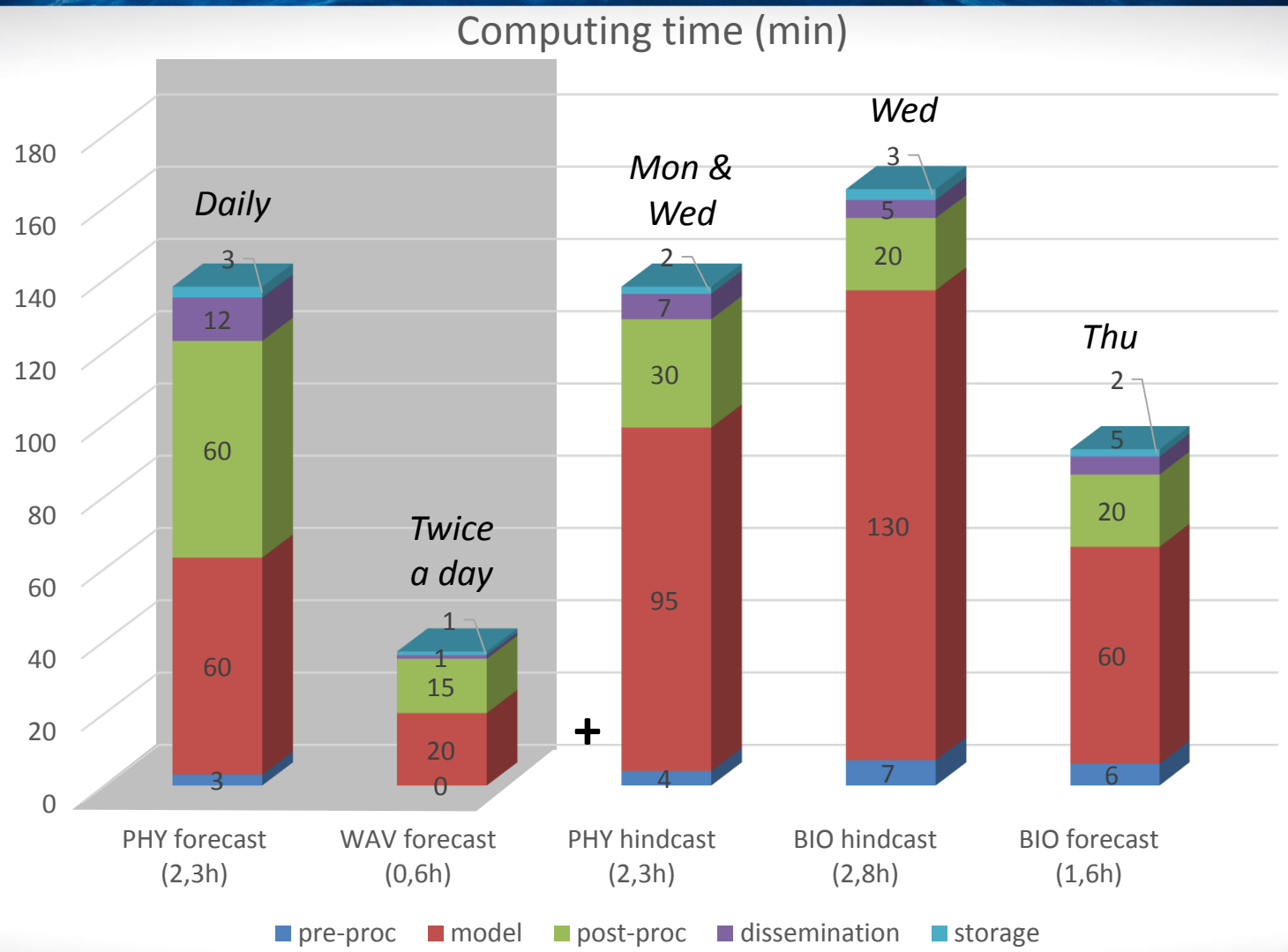
- ***On Wed (T0): from previous Wed (T-7) to Tue (T-1)***

Operational suites: WAV catalogue policy



1 hindcast day from each forecast (1st day of simulation).

HPC resources for IBI-MFC



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HPC resources for IBI-MFC: dissemination

How to download CMEMS products?

- ***Register at marine.copernicus.eu.***
- ***3 options:***
  - ***Subsetter (HTTP protocol, subset the files).***
  - ***Direct Get File (HTTP protocol, save file as is).***
  - ***CMEMS FTP (standard FTP protocol, save file as is).***

Virtual machines

test-puertos2.cesga.es

- ***For new products dissemination testing (i.e., 3D hourly products).***
- ***Same as OP machine.***

puertos2.cesga.es

- ***For operational suite.***
- ***MOTU (Web Server).***
- ***THREDDS (for PdE use).***
- ***M-FTP (CMEMS FTP server)***

puertos.cesga.es

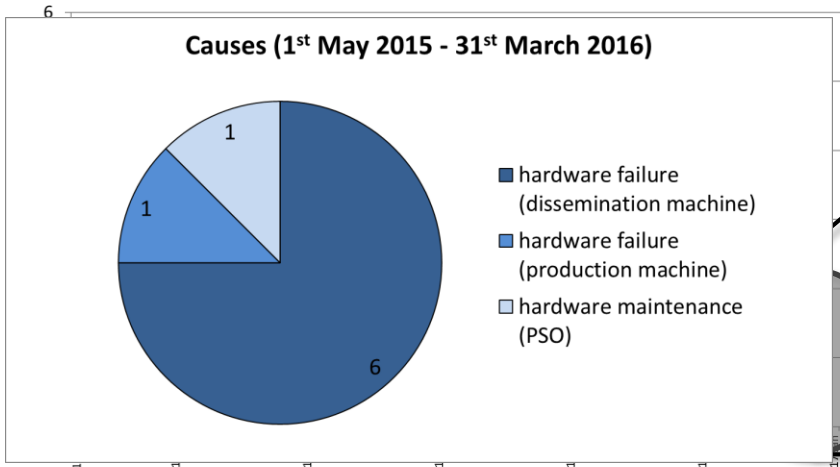
- ***For double dissemination (1 month) when a new version is updated.***

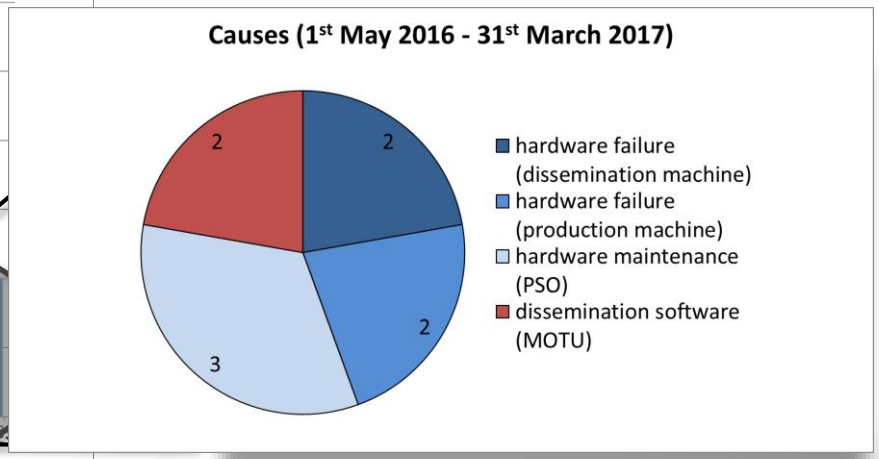
IBI-MFC systems performance

Incidents/Problems/PSO

Status of the period (from 1/5/2016 to 31/03/2017)

	How many have been raised?	How long did they take? [mean in days]	How many are still open?
Incidents	6	1	0
Problems	0	0	0
Planned Service Outages	3	1 (<8h)	0





IBI-MFC systems performance

Products

Status of the period (1/5/2016 to 31/03/2017)

Availability: % Availability of download mechanisms (HTTP/FTP)	Timeliness: %Products ready for download	How many questions from users	Are some of your products distributed by another service?
SUB-DGF/WMS/MFTP 99.83/99.92/99.95	98.81	4	No

- Questions from users related to:

✓ Problems with data download (metadata info through subsetter interface).

✓ Request of variables not distributed.

✓ Problem with postprocessed data (BIO)

IBI MFC Monitoring Tools: Availability of servers & Timeliness of products

– Monitoring IBI PU/DU server & Services (01-05-2016 to 31-04-2017)

"Intelligent" Check Frequency: time freq varies to avoid server saturation
(Server/services 3min; Data storage avail 0.5h; System load 3min)

IBI Diss machine availability
(puertos.cesga.es)

Host State Breakdowns:

State	Type / Reason	Time	% Total Time	% Known Time
UP	Unscheduled	333d 23h 54m 50s	99.999%	99.999%
	Scheduled	0d 0h 0m 0s	0.000%	0.000%
	Total	333d 23h 54m 50s	99.999%	99.999%
DOWN	Unscheduled	0d 0h 5m 10s	0.001%	0.001%
	Scheduled	0d 0h 0m 0s	0.000%	0.000%
	Total	0d 0h 5m 10s	0.001%	0.001%
UNREACHABLE	Unscheduled	0d 0h 0m 0s	0.000%	0.000%
	Scheduled	0d 0h 0m 0s	0.000%	0.000%
	Total	0d 0h 0m 0s	0.000%	0.000%
Undetermined	Nagios Not Running	0d 0h 0m 0s	0.000%	
	Insufficient Data	0d 0h 0m 0s	0.000%	
	Total	0d 0h 0m 0s	0.000%	
All	Total	334d 0h 0m 0s	100.000%	100.000%

NAGIOS checks:

-httpd

-thredds

-misgw

-system load

-data storage

-data availability,...

State Breakdowns For Host Services:

Service	% Time OK	% Time Warning	% Time Unknown	% Time Critical	% Time Undetermined
/	99.953% (99.953%)	0.000% (0.000%)	0.000% (0.000%)	0.047% (0.047%)	0.000%
/data	99.497% (99.497%)	0.000% (0.000%)	0.000% (0.000%)	0.503% (0.503%)	0.000%
LOAD	99.338% (99.338%)	0.024% (0.024%)	0.000% (0.000%)	0.638% (0.638%)	0.000%
httpd	99.918% (99.918%)	0.000% (0.000%)	0.000% (0.000%)	0.082% (0.082%)	0.000%
misgw	99.826% (99.826%)	0.000% (0.000%)	0.000% (0.000%)	0.174% (0.174%)	0.000%
thredds	99.897% (99.897%)	0.000% (0.000%)	0.000% (0.000%)	0.103% (0.103%)	0.000%
Average	99.738% (99.738%)	0.004% (0.004%)	0.000% (0.000%)	0.258% (0.258%)	0.000%

MFTP Service Up → /

WMS Service Up → httpd

MISGW Service Up (SUB/DGF) → misgw

IBI-MFC systems performance: Monitoring tool

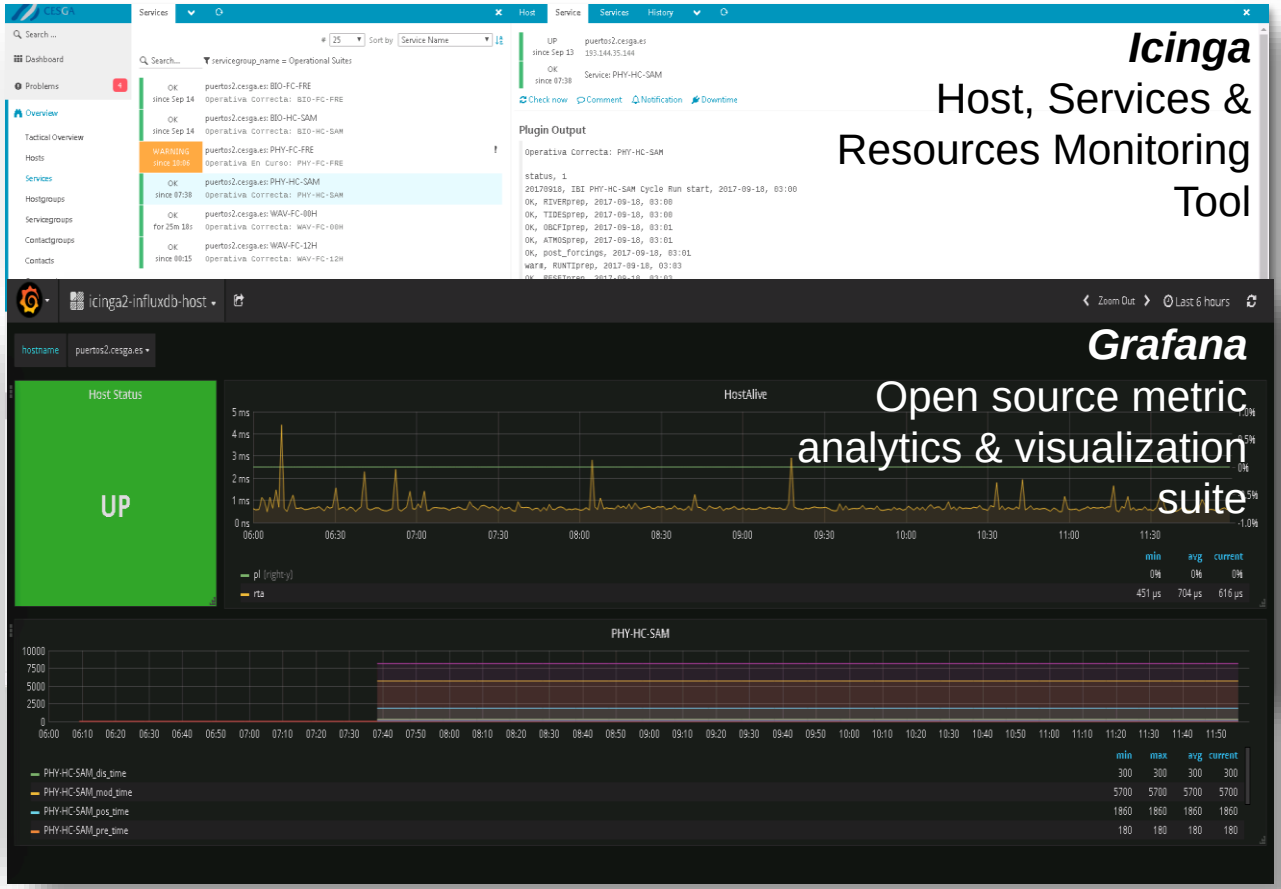
New monitoring tool IBI-(Con)Trol

From NAGIOS to IBI-Trol. Much-needed dashboard to compile IBI monitoring metrics and performance indicators.

Need to control:

- Diss. machine load & availability.
- Services up (MFTP, WMS, MISGW, THREDDS)
- Storage capability.
- Status of 6 different simulations.
- Availability of inputs (BCs, rivers, atm forcings, DA)

& validation sources.



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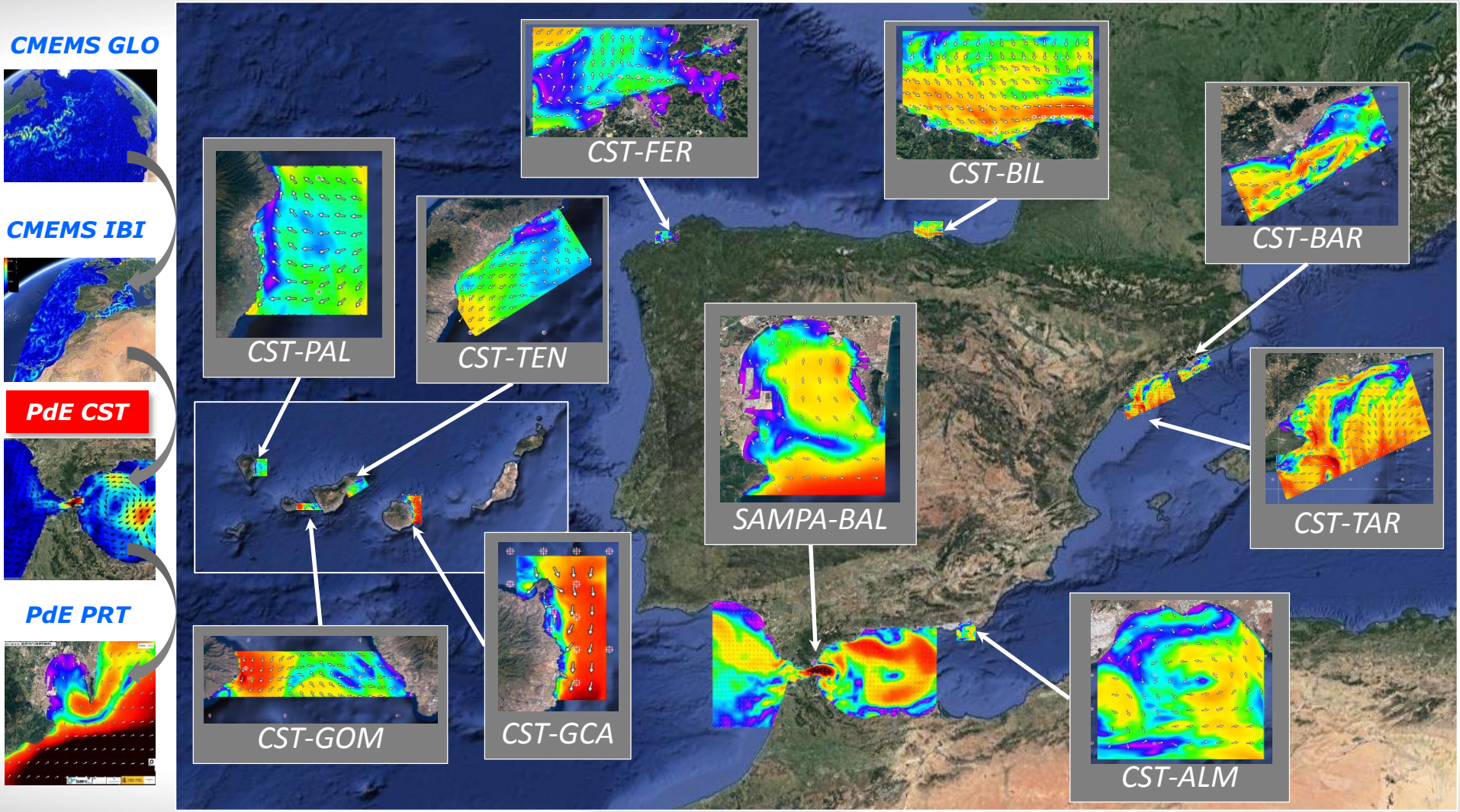
SAMPA & SAMOA: PdE coastal downscaling capabilities



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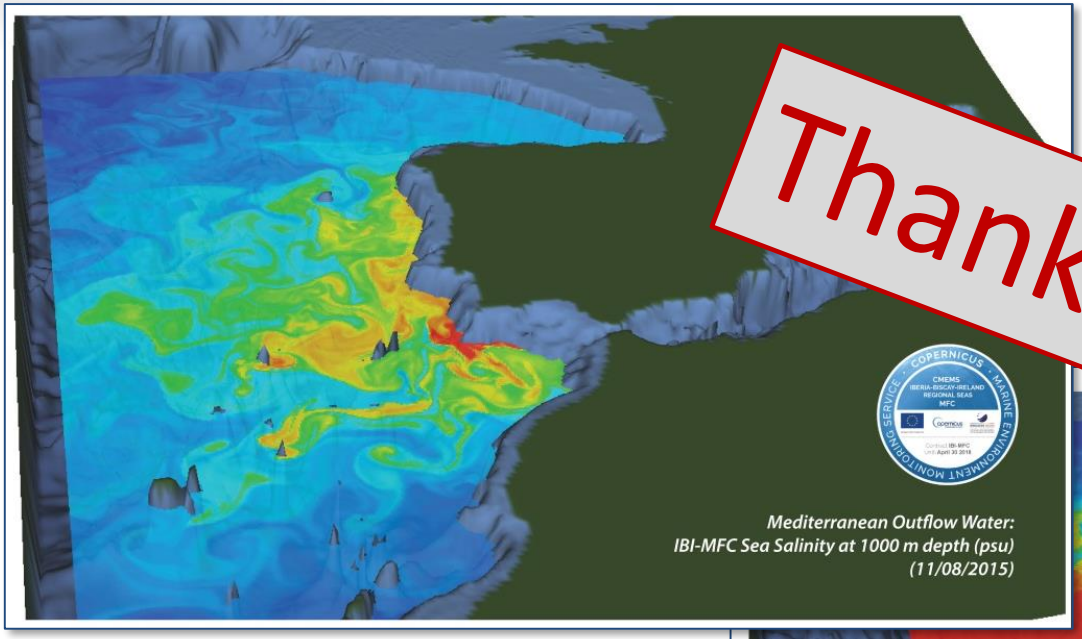
The IBI-MFC Team



Thank you!