www.bsc.es

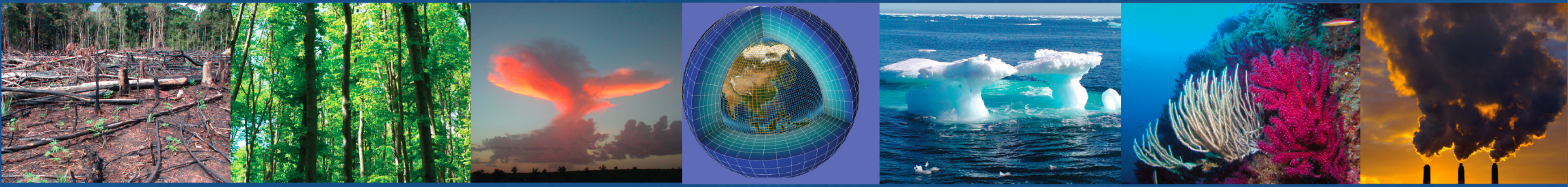
Barcelona Supercomputing Center
Centro Nacional de Supercomputación

EXCELENCIA SEVERO OCHOA

EC-Earth meeting
May 2017, Helsinki

EC-Earth ORCA12-T1279

Laurent Brodeau, BSC / Earth Sciences dept.
(with contributions from O. Tintó and
help from K. Wyser & U. Fladrich)



Context

PRIMAVERA (Horizon 2020)

WP4: *Frontiers of climate modeling*

Objectives

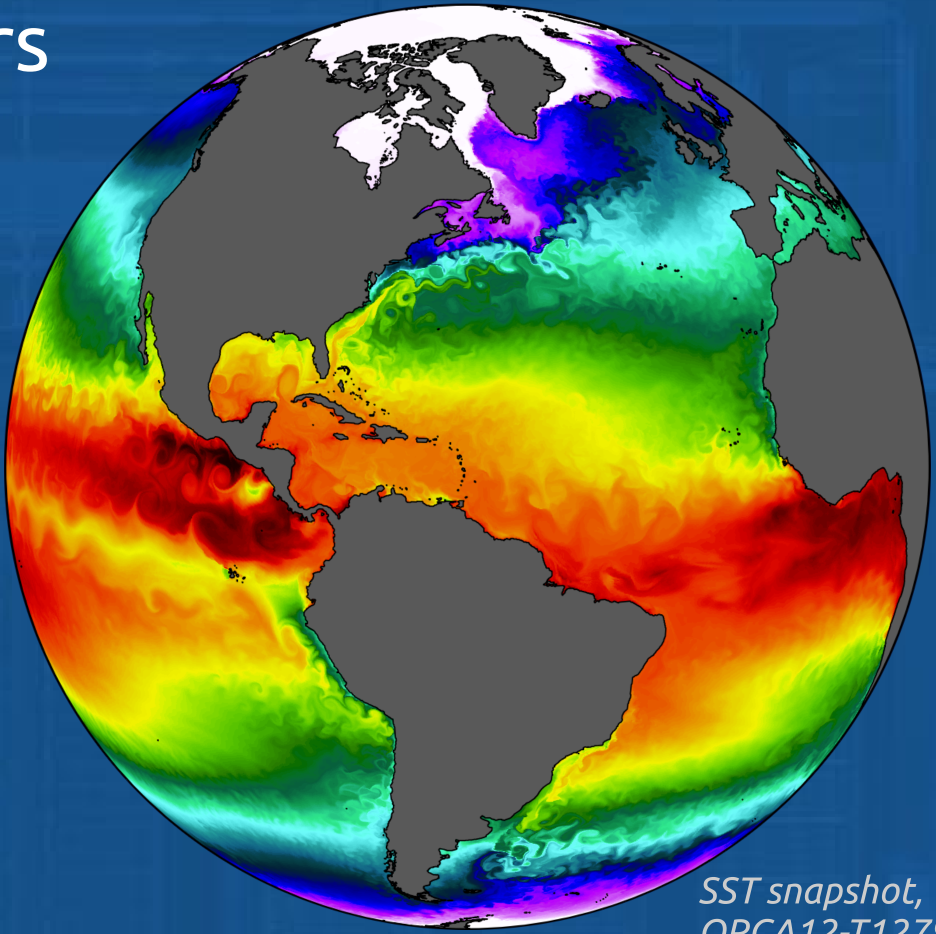
- Develop the next generation of coupled models by exploring the concept of "Beyond simple parameterization" by testing different approaches to the representation of sub-gridscale processes.
- Assess the relative benefits and costs of each approach, and provide recommendations for future development

Outline

I. Why down to 15-km scale or less ?

II. Setup and numbers

III. The show



SST snapshot, ORCA12-T1279

I. Why higher horizontal resolution ?

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

Obvious:

Resolve more, rely less on sub-gridscale parameterizations

→ including convection (non-hydrostatic, ≤ 1 km)

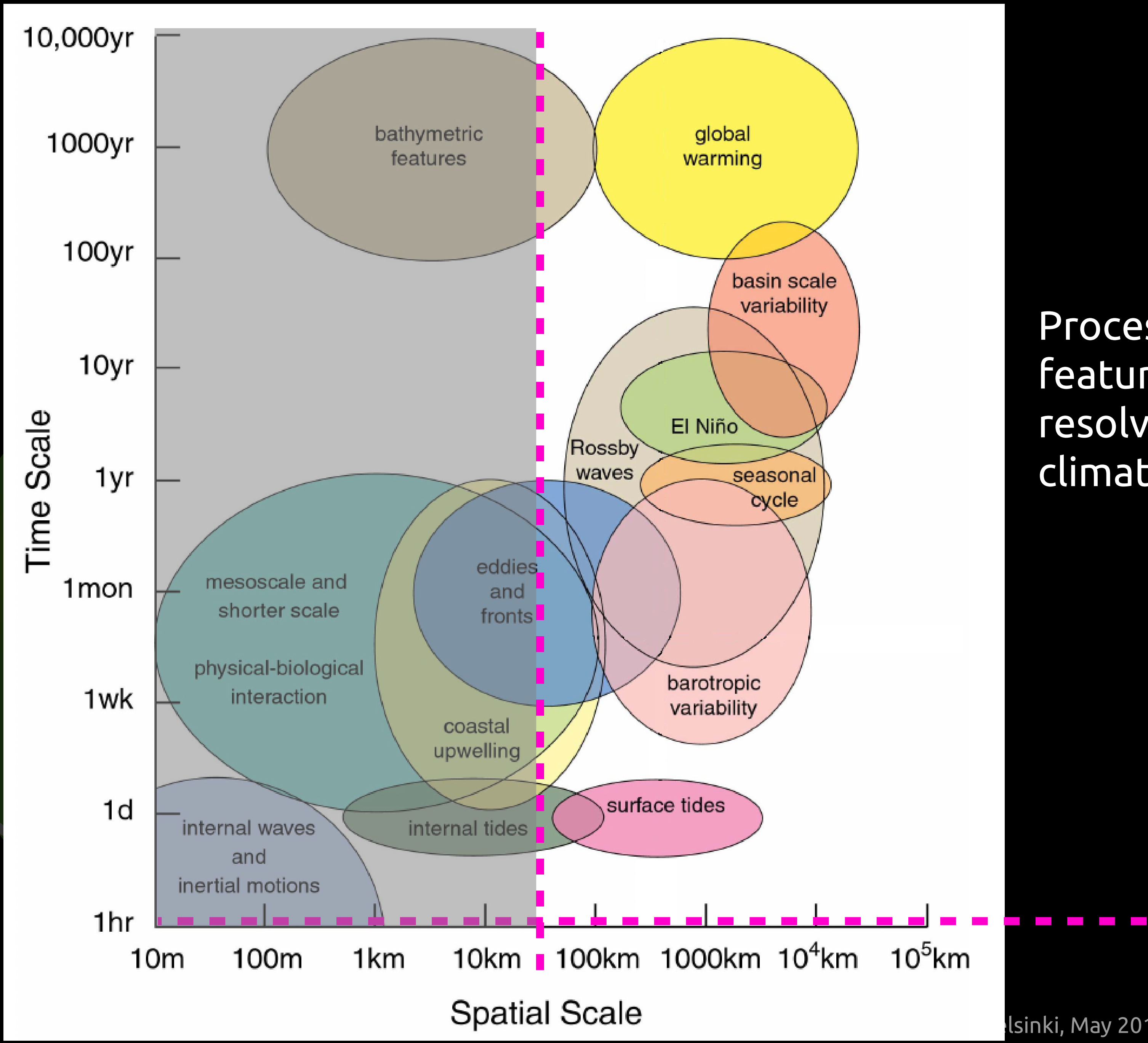
Ocean :

- Baroclinic deformation radius: $R_{ocean} << R_{atmosphere}$
  - → mesoscale eddies small *w.r.t* atmospheric counterparts
  - → re-stratification, etc
- Better bathymetry → improves horizontal circulation
  - → West boundary currents trajectories
- Coastal upwellings and jets (Greenland current)

Atmosphere :

- Keep up with with ocean → (sub-) mesoscale air-sea interactions
- Cyclones, hurricanes
- ...

I. Why higher horizontal resolution ?

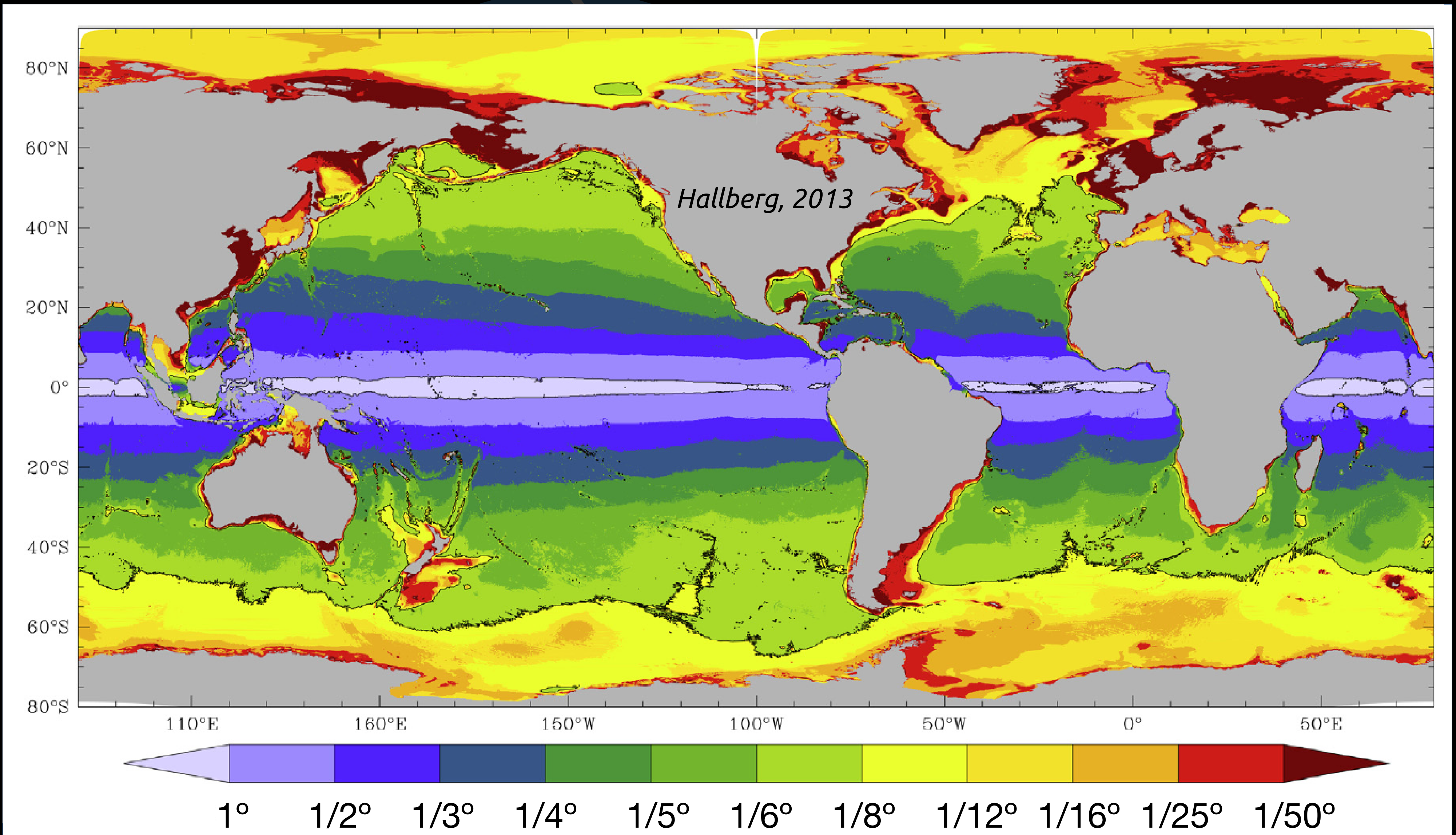


Processes & features explicitly resolved in today's climate models.

I. Why higher horizontal resolution ? Ocean

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

Mercator grid resolution required to resolve baroclinic deformation radius with 2 Δx



Atmosphere must be able to respond to (sub)mesoscale SST features.

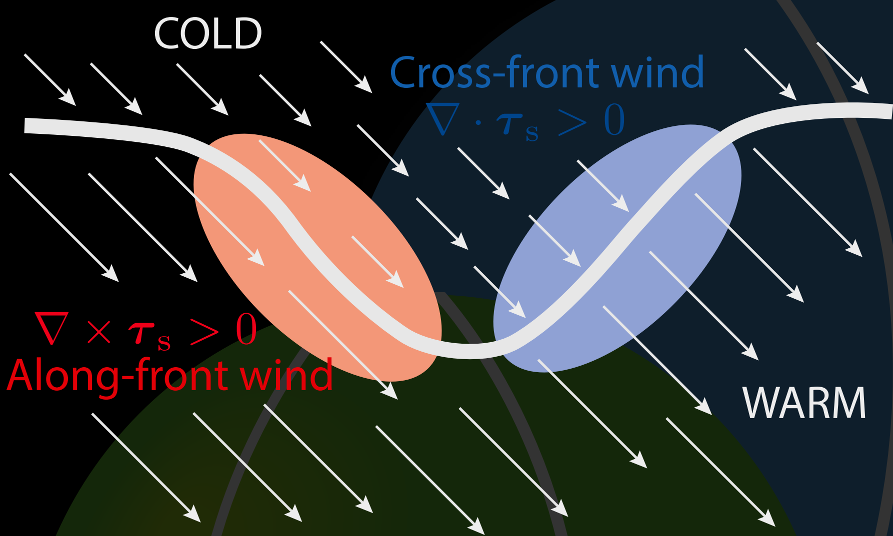


FIG. 1. Schematic of the surface wind stress (arrows) response to a meandering SST front (thick black curve represents an SST isotherm), adapted from Chelton et al. (2004, their Fig. S6). Scatterometer measurements indicate that surface wind stress magnitude and surface wind speed increase over warm SST and decrease over cold SST. Likewise, strong wind stress curl is found in regions with alongfront surface winds (red area), and strong wind stress divergence is found in regions with cross-front surface winds (blue area).

Kilpatrick et al. 2016, Chelton et al. 2004

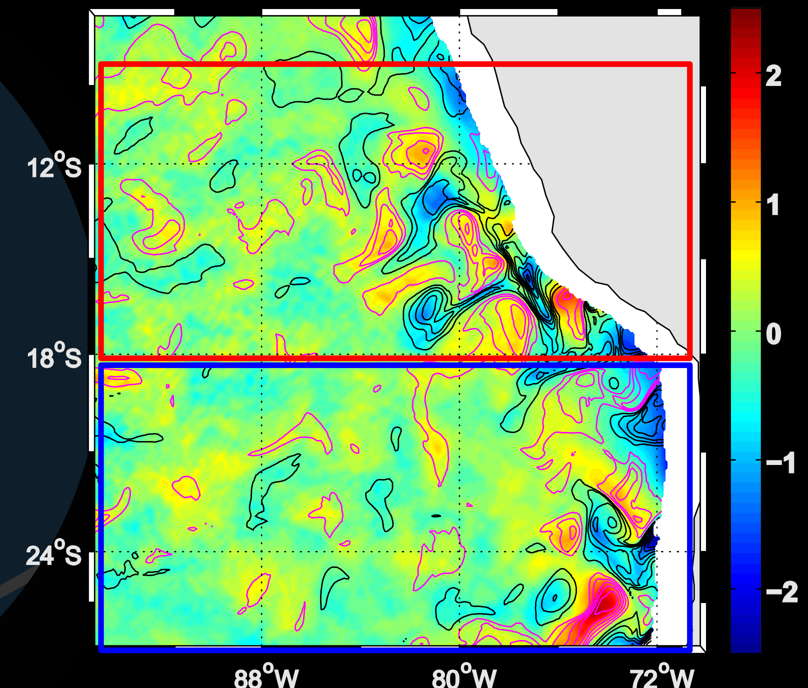
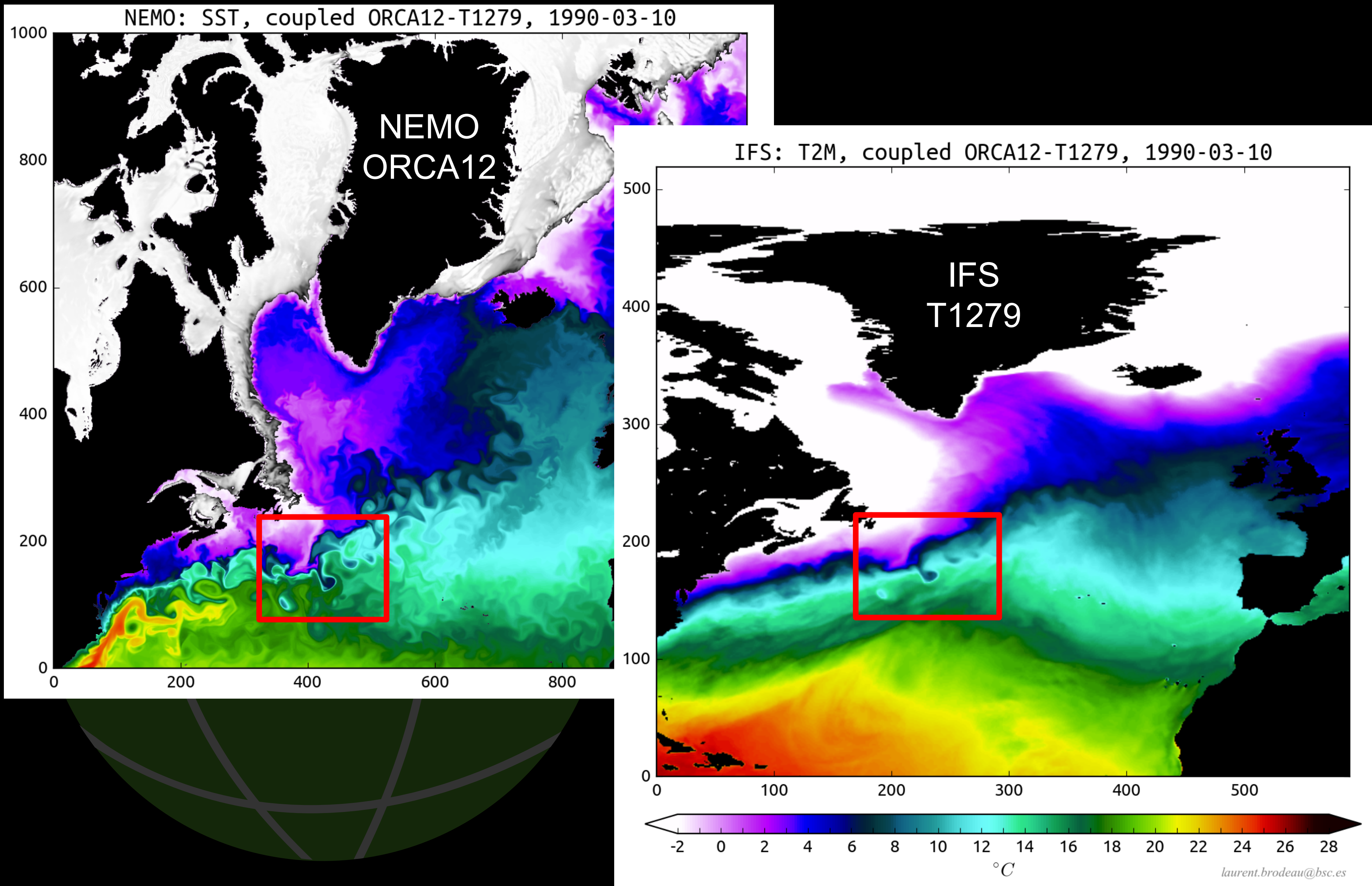


Fig. 2 Surface wind stress (WS) mesoscale anomalies (*colored*, 10^{-2}Nm^{-2}). Sea surface temperature (SST) anomalies (*contours*, °C): *black* (*magenta*) *lines* indicate negative (positive, respectively) anomalies, contour interval is 0.25 °C. Fields are from the CPLM simulation and are time-averaged over July 2007. The 150 km nearshore zone, where the anomalies are dominated by orographic effects, is removed. Anomalies are computed using a gaussian smoothing filter as described in Sect. 2.3.2. *Red box* indicates the Peru region and the *blue box* indicates the Chile region

Oerder et al. 2015

I. Why higher horizontal resolution ? Atmosphere

Barcelona Supercomputing Center
Centro Nacional de Supercomputación



Outline

I. Why down to 15-km scale or less ?

II. Setup and numbers

III. The show

II. EC-Earth 3.2 ORCA12-T1279

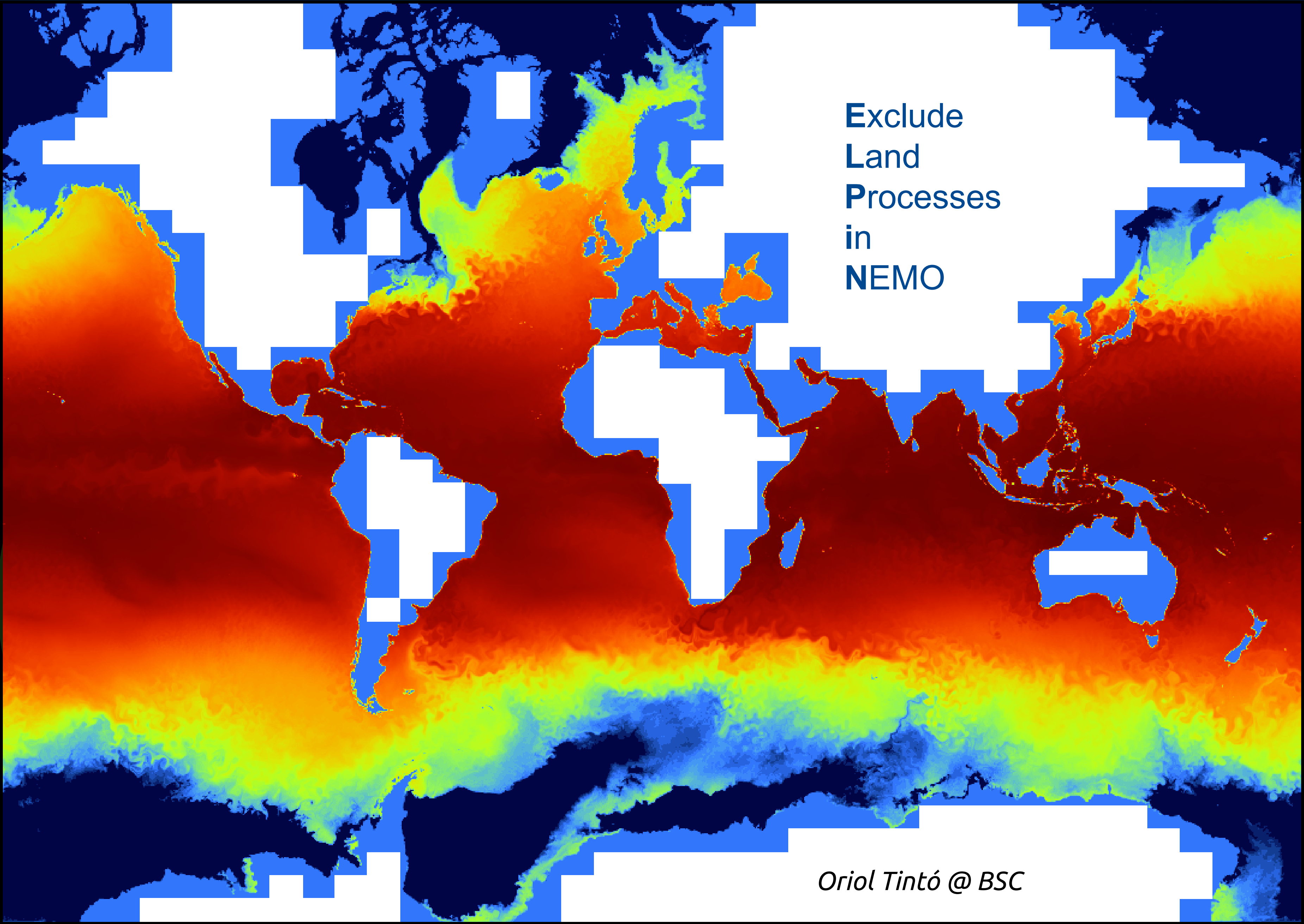
Component	Domain	Δt	# cores
NEMO 3.6 **LIM 3** (sea-ice) XIOS 2	**ORCA12 L75** (~ 15 km)	6 min. 12 min.	**54 × 36 → 1449** (495 land proc. saved) 32
OASIS MCT	10 days to generate remapping weights ORCA12 – T1279 (sequential jobs)	Coupling 12 min.	
IFS cy36r4	**T1279L91 L91** (~ 15km)	6 min.	**1040**
			Total: **2521**

→ 7h15m for 1 month of simulation on MareNostrum3@BSC

Cost: ~220 000 core·hour / simulated year

II. EC-Earth 3.2 ORCA12-T1279

Barcelona Supercomputing Center
Centro Nacional de Supercomputación



II. EC-Earth 3.2: cost of the atmosphere

EC-Earth 3.2 setup	Cost of atmosphere / total computational cost
ORCA**1**.L75 **– T159L62 (125km)**	55%
ORCA**1**.L75 **– T255L91 (80km)** [CMIP6]	65%
ORCA**12**.L75 **– T255L91 (80km)**	7%
ORCA**12**.L75 **– T1279L91 (16km)**	**42%** 😳

II. EC-Earth 3.2: output data

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

For 1 year of simulation…

- **NEMO-ORCA12 L75** (packed into netcdf4!):
  1 2D field @ 1day freq → 11 GiB
  1 3D field @ 1month freq → 16 GiB

  Number of 2D fields to save (daily): 20 (SST, SSS, SSU, SSV, SSH, MLD, …)
  Number of 3D fields to save (monthly): 4 (T, S, U, V)

  20×11GiB + 4×16GiB → **~300GB / year**

- **IFS T1279 L91:**
  (6-hourly freq)

  1.2 TB / year (SH files ~4/5 of the total, GG files ~1/5)

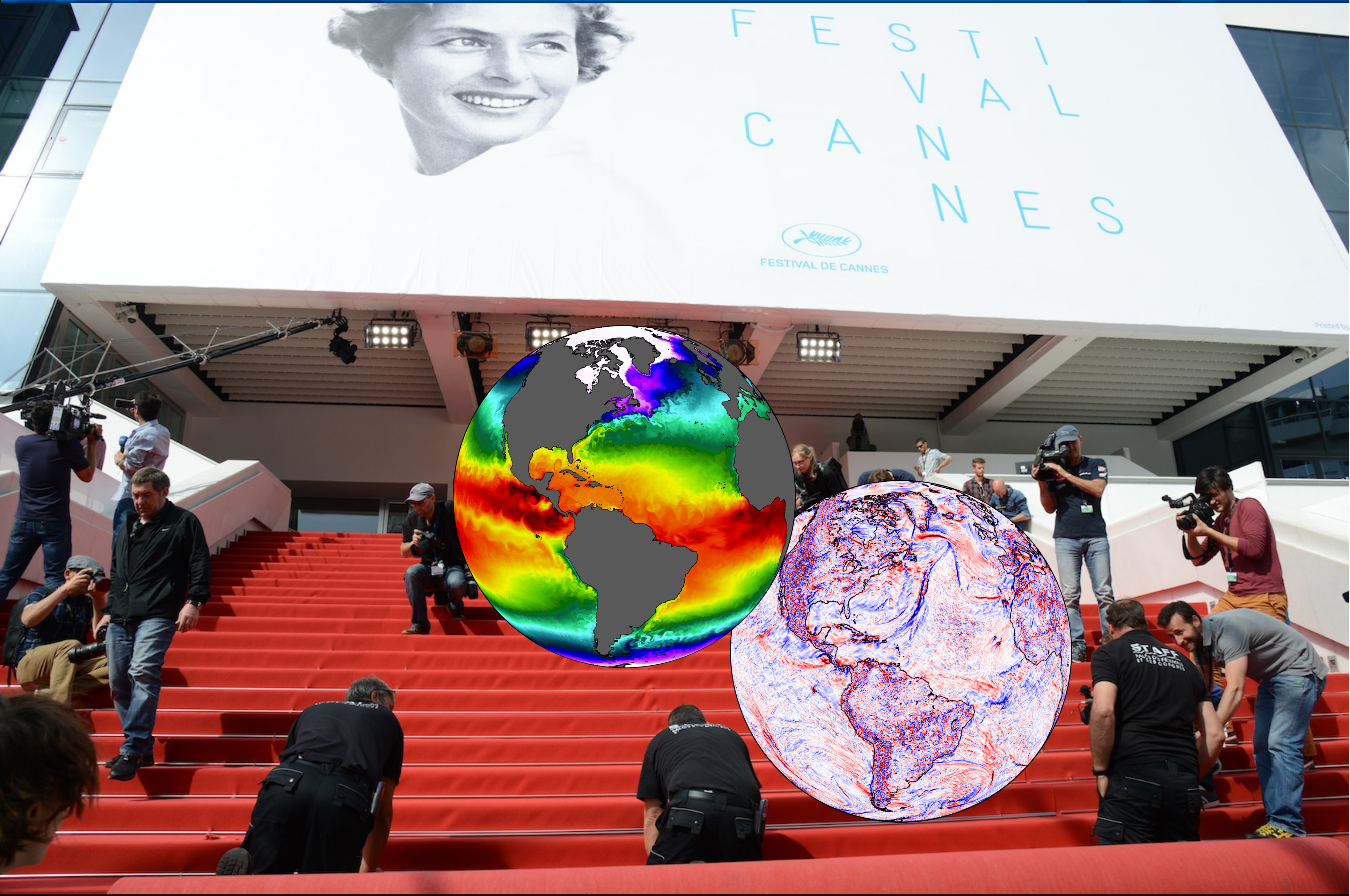
TOTAL: ~ 1.5 TiB / simulated year

Outline

I. Why down to 15-km scale or less ?

II. Setup and numbers

III. The show


FESTI
VAL
CAN
NES
FESTIVAL DE CANNES
STAFF

Outlook

Priorities :

- Improve scalability and target the efficient use of at least 5000 cores
- Define strategy for data output and storage (online output coarsening)

  (storage capacity growth does not follow CPU growth!)
- Strategy for data analysis!
- A few decades of simulation and some real science!

Climate scientists

Computer scientists


Thank you!
0.5
0.55
0.6
0.65
0.7
0.75
0.8
0.85
0.9
0.95
1