WP4 update

Malcolm Roberts

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Thanks to: Tido Semmler, Kristian Strommen, Malcolm Roberts/Paul Field, Katja Lohmann, Dela Spickermann, Irene Mavilia, Laurent Brodeau

Contributions from:

AWI

Oxford University

Met Office/Leeds

MPI – M

DKRZ

CNR

BSC

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PRIMAVERA

WP4 topics

- Unstructured mesh modelling
- Stochastic physics
- Eddy-resolving ocean coupled modelling
- Next generation aerosol-microphysics

- What are the relative costs and benefits of different approaches?
- *WP4 runs meant to be years 2-3, to offset from WP6*

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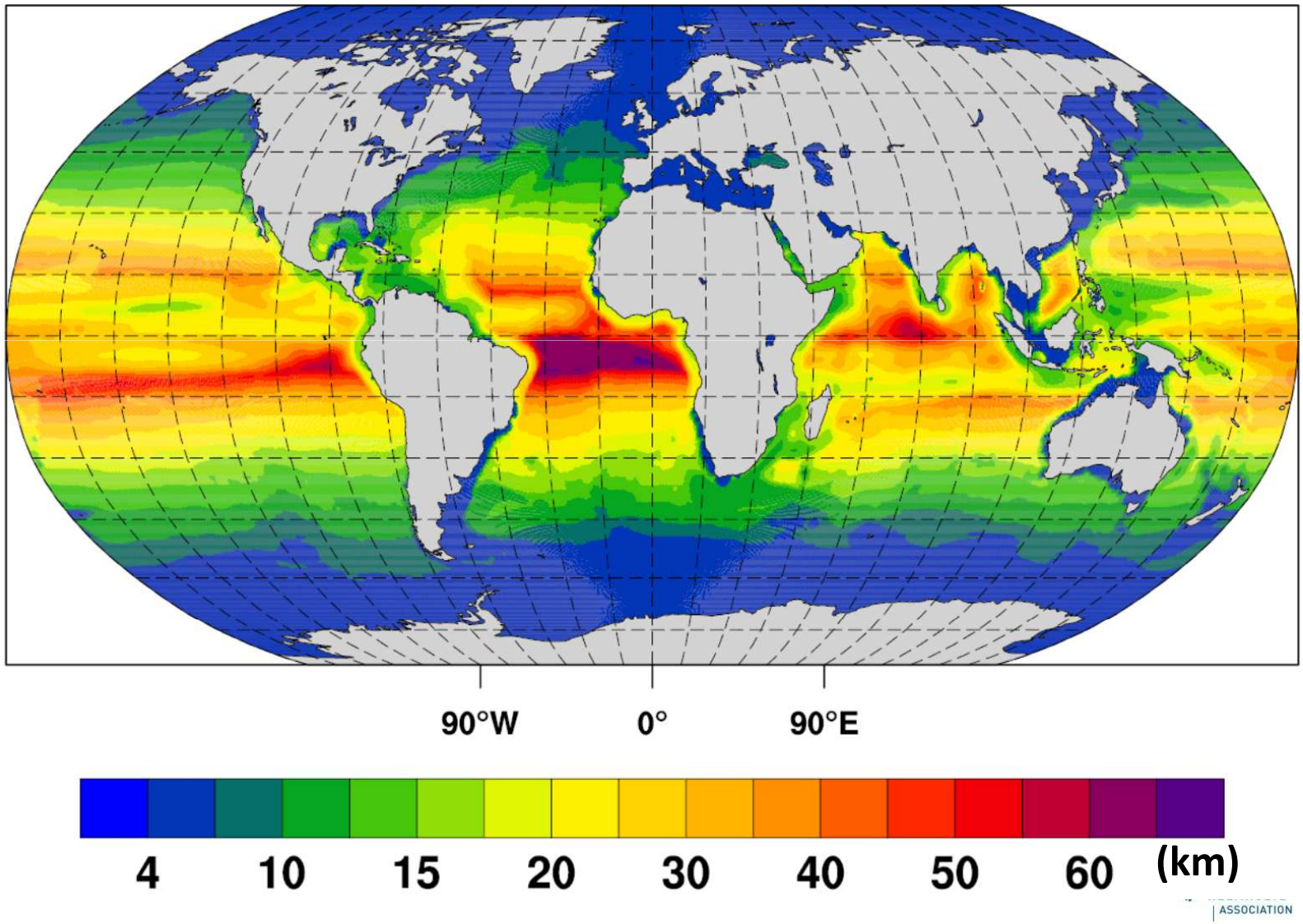
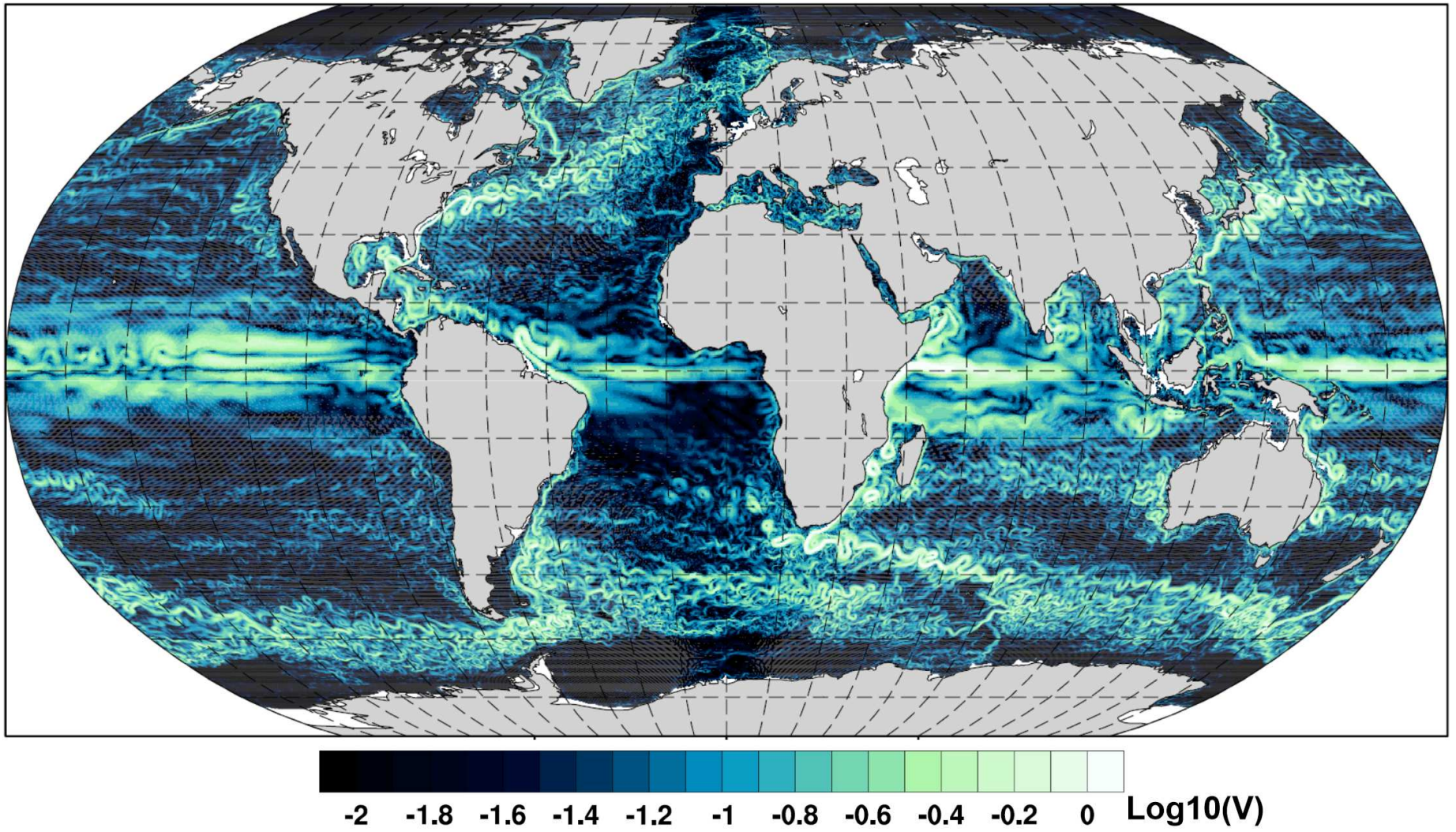
AWI-CM Frontier mesh (5 000 000 surface nodes)

Resolution = Max(Min(0.5*Rossby radius, Ocean variability), 4km).

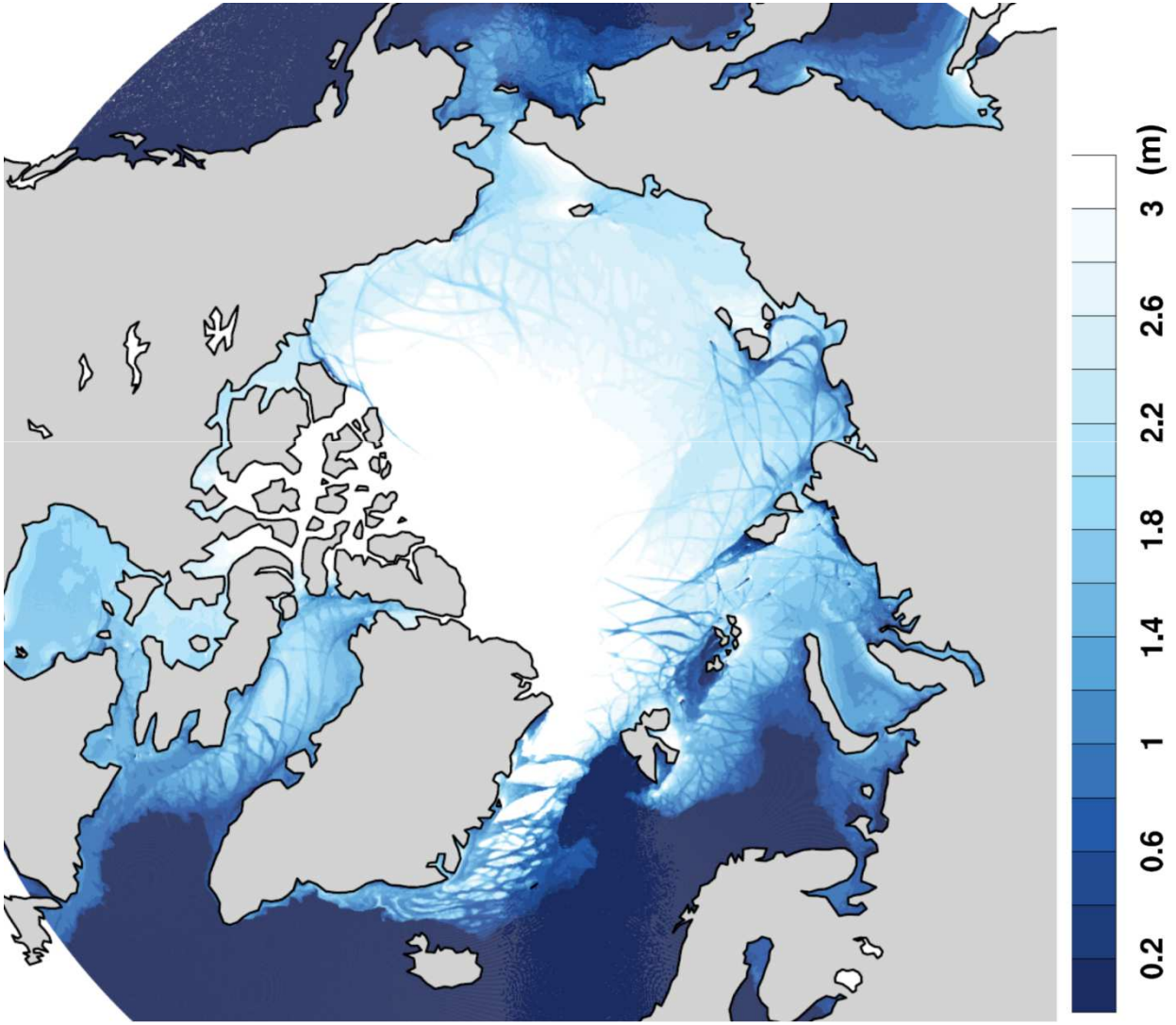
Mean: ca. 0.1 deg.



50m ocean velocity snapshot. Frontier mesh



Sea Ice thickness January snapshot. Frontier mesh.



Oxford University WP4 Status

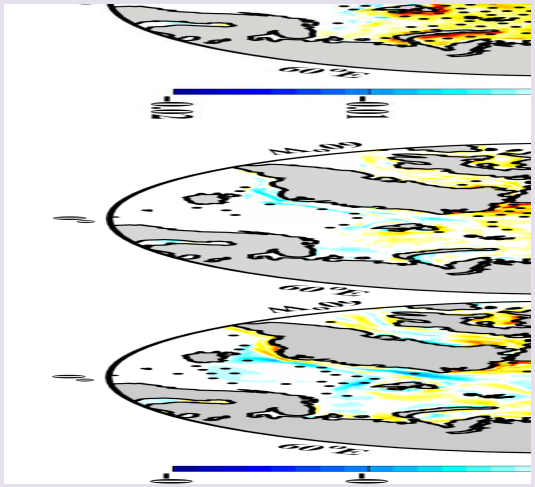
Goal: develop a fully stochastic earth-system model in EC-Earth 3.2

- Land surface: stochastic perturbation of uncertain soil parameters
- NEMO: stochastic eddy and turbulent vertical mixing
- Sea ice: stochastic perturbation of sea ice strength parameter
- Atmosphere: SPPT, 'independent SPPT', SKEBS

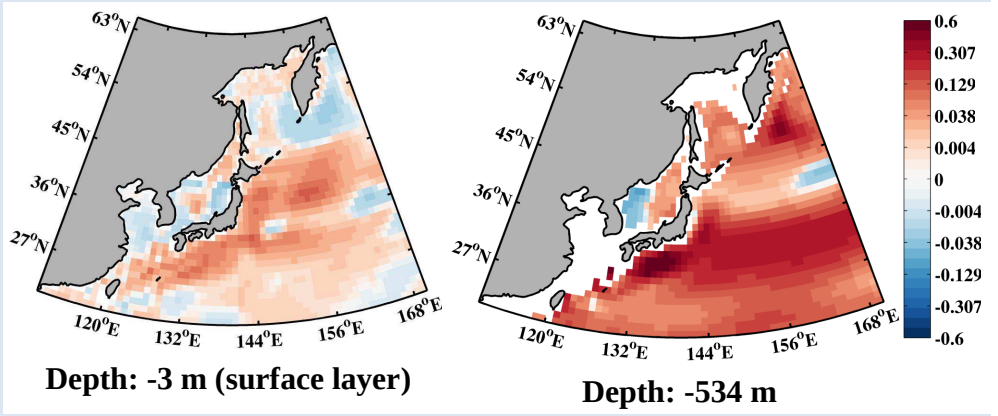
Oxford: H.M.Christensen, D.MacLeod, S. Juricke, K. Strommen, A. Dawson, T. N. Palmer

In collaboration with ISAC CNR: S. Corti, J. von Hardenberg, C. Yang et al.

Known Impacts of new schemes

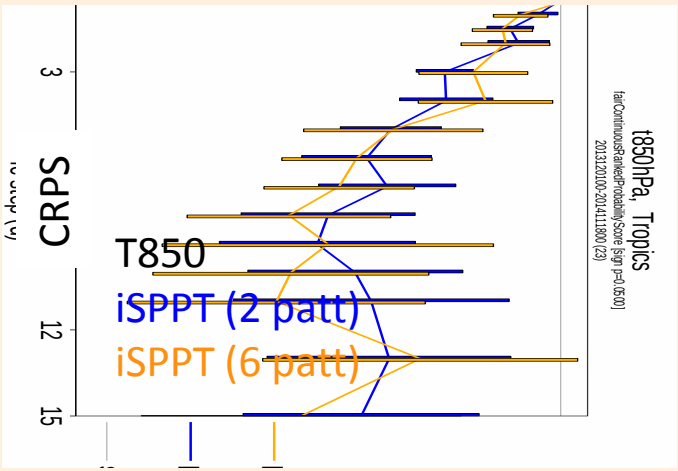


↑ Increase in ensemble spread sea ice thickness (Juricke et al, 2014)



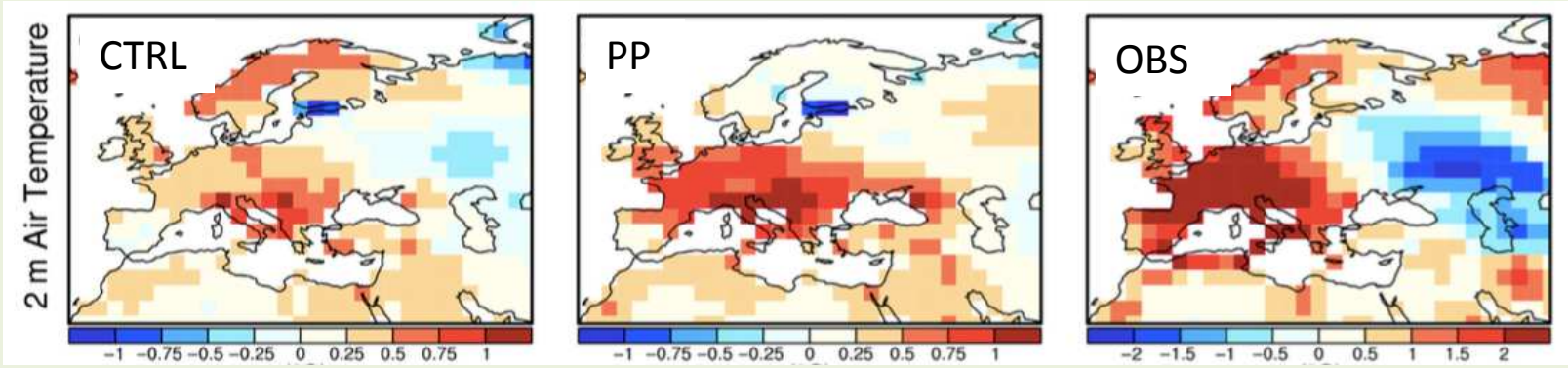
Depth: -3 m (surface layer)

Depth: -534 m



↑ Increase in inter-annual variance in ocean T in Kuroshio (Juricke et al, 2016)

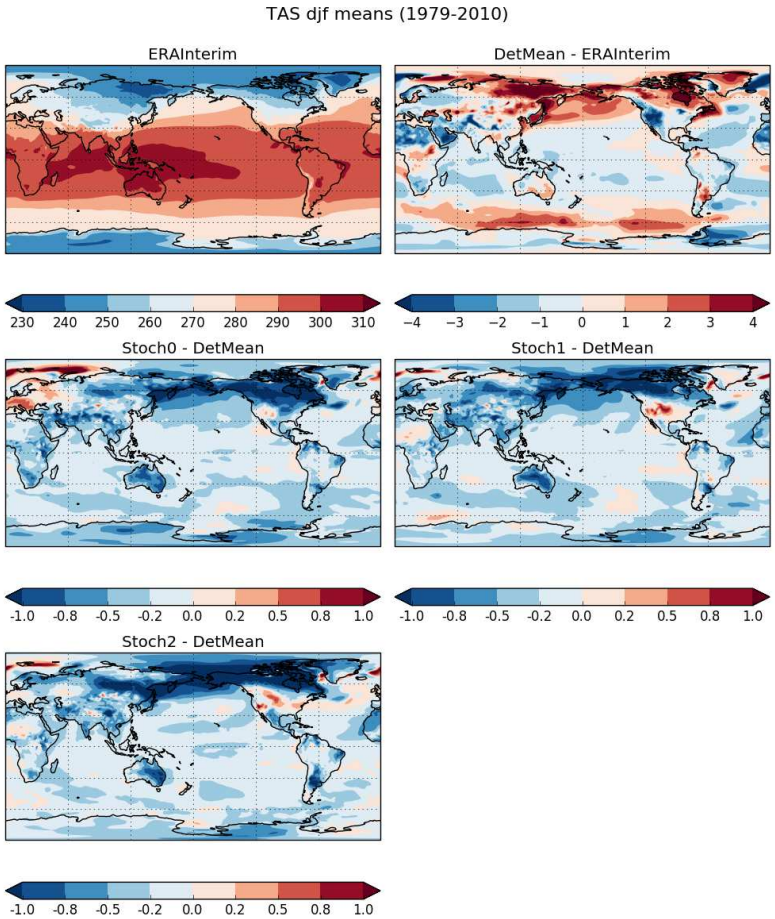
← iSPPT improves CRPS tropical MW forecasts (Christensen et al, in prep)



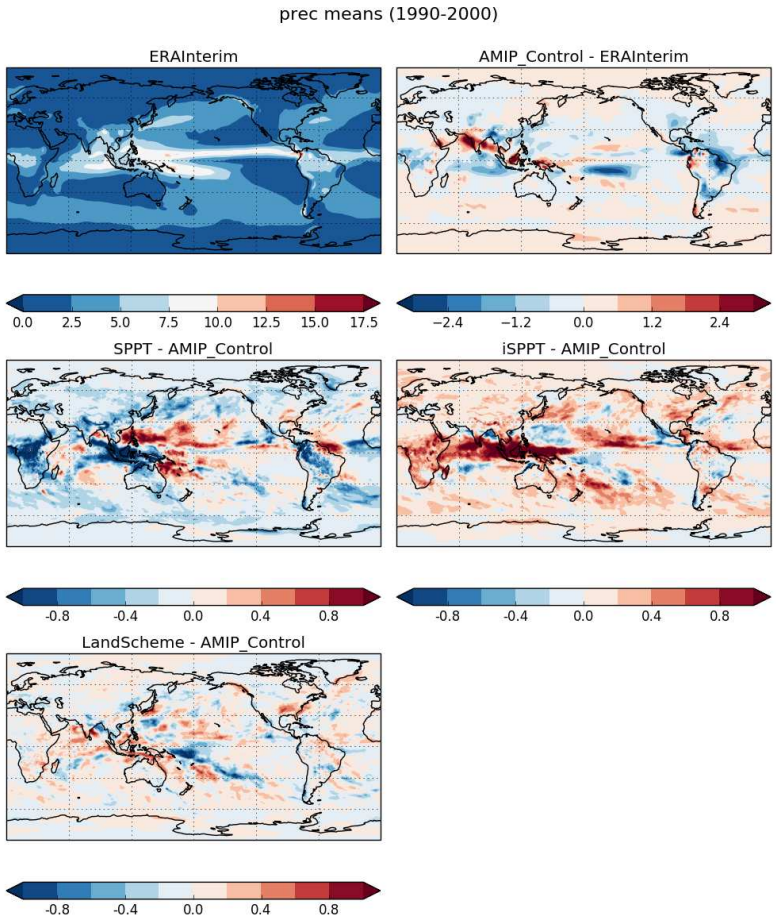
↑ Perturbing land surface parameters improves simulation of 2003 European heatwave (MacLeod et al, 2016)

Recent results and tests

- Reduction in northern hemisphere temperature bias in EC-Earth 3.1 (SPHINX runs)



- First testing of climate with new stochastic schemes in EC-Earth 3.2 (10yr runs).



Current status

- ✓ All three stochastic schemes implemented in EC-Earth 3.2
- ✓ Initial testing has been done: schemes are stable (no blow-up within 10 years) and do not dramatically alter energy balances, though some tuning is still needed

Next goals

- Tuning of the stochastic parametrisations
- Ensemble runs (AMIP style) for more robust testing. Eventually coupled testing.

- Problem: EC-Earth 3.2 is still not fully tuned for coupled runs, so proper testing and final tuning not possible until early 2017!

WP4

CNR National Research Council of Italy

ISAC

✴ We performed a set of ensemble simulations aimed at evaluating the sensitivity of present and future climate to both model resolution and stochastic parameterization:

Truncation	Resolution	# members
T159L91 AMIP	125.2 km	10+10
T255L91 AMIP	78.3 km	10+10
T511L91 AMIP	39.1 km	6+6
T799L91 AMIP	25.0 km	3+3
T1279L91 AMIP	15.7 km	1+1
T255L91 coupled	78.3 km	3+3

CLIMATE SPHINX

Stochastic Physics HIgh resolutioN eXperiments

http://www.to.isac.cnr.it/sphinx

- *Atmospheric-only*: 5 horizontal resolutions (Present day 1979-2008, and Future Scenario 2039-2068 RCP8.5)
- *Coupled*: T255 1850-2100: historical + RCP8.5

UNIVERSITY OF OXFORD

EC EARTH 3

Reference

Paolo Davini, Jost von Hardenberg, Susanna Corti, Hannah M. Christensen, Stephan Juricke, Aneesh Subramanian, Peter A.G. Watson, Antje Weisheimer, and Tim N. Palmer (2106) : ***Climate SPHINX: evaluating the impact of resolution and stochastic physics parameterisations in climate simulations*** – GMD Under review

(1)

WP4

CNR National Research Council of Italy

ISAC

- We are going to test and tune the new version of EC-EARTH (see also WP6)
- We tested the impact of stochastic physics in EC-EARTH 3.1 at different resolutions in AMIP mode

Example:

Niño3.4 variability

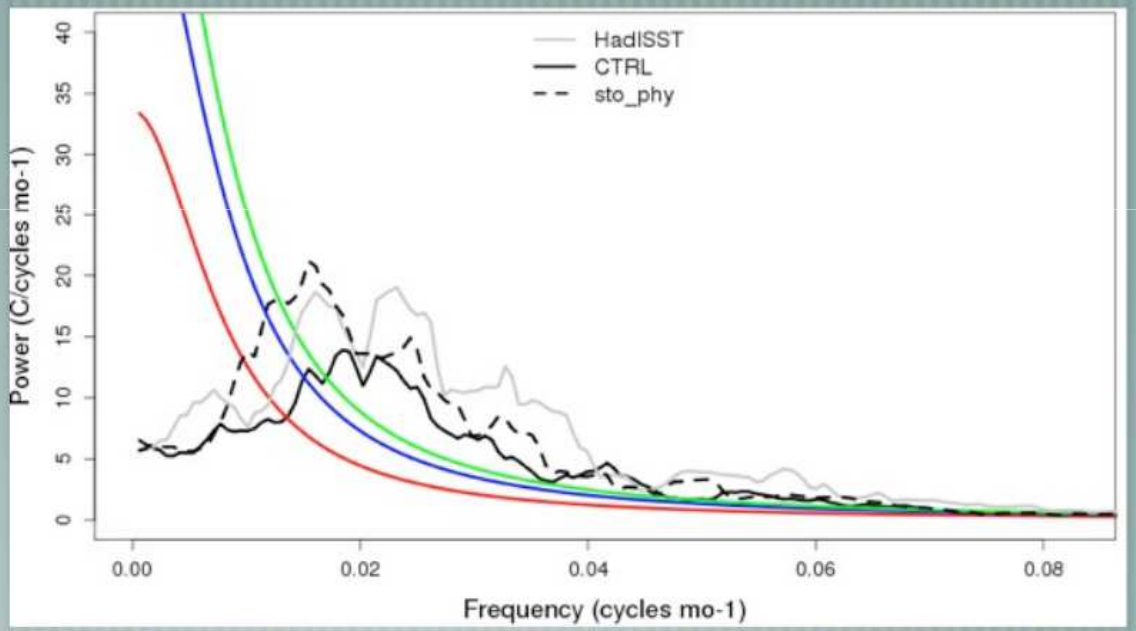


FIG: Power spectrum of Niño3.4 time series: OBS [1850-2010] in gray, coupled simulations [1850-2010] control in black solid line and with stochastic physics in the atmospheric component in black dashed line. For the EC-EARTH simulations the power spectrum has been computed averaging the spectra of the three ensemble members. Also shown are the best fit AR(1) spectrum (red) and its 95% and 99% confidence bounds (blue and green curves respectively). Top axis indicates period in years, while bottom axis indicates the frequency in cycles per month.

Met Office

- Coupled 25km UM – 1/12 NEMO-CICE ocean coupled model running (4.5 years)
  - Present day test run, not yet HighResMIP (HadGEM3 GC3.1) configuration
  - Technical optimisation ongoing, including: XIOS-2, memory
  - Also tests with ocean-sea-ice configuration
  - Over next year, will look at improving efficiency with sea-ice (a limiting factor on speed) via OASIS coupling.
- Global 10km model being set up
  - Use science consistent with GC3.1, but probably with prognostic aerosol to compare with new CASIM aerosol-microphysics package
- Stochastic physics
  - Stochastic scheme as part of standard GC3.1 setup, so will simply run with this switched off
- Aerosol
  - (See 10min madness)
  - CASIM running at N2048 (~5km) aquaplanet for 5 day runs.
  - Experiments carried out to explore the effect of a 100/cc->2000/cc perturbation in ccn for a northern hemisphere channel (30-60N) and an equatorial channel (15S-15N).
  - Comparable experiments carried out with low resolution N96 version of aquaplanet with CASIM but with parametrized convection on. However, parametrized convection is not sensitive to aerosol.

- Work done by:
  - Dan Copsey, Livia Thorpe, Pierre Mathiot, Helene Hewitt, Miroslaw Andrejczuk, Paul Field, (MO)
  - Daniel McCoy (Leeds)

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Results

- Using previous model configuration, completed 20 year 25km – 1/12˚ simulation (compared to 60km – ¼˚)
  - Papers Hewitt et al (2016) – GMD; Roberts et al (2016) – GRL.
  - Main results
    - Aspects of mean state improved:
      - AMOC, dense overflows, northward heat transport
      - Southern Ocean SST warm bias, cold NH SST bias
      - Air-sea interaction slightly improved ¼ to 1/12 degree
        - » 1/12 much better than 1 degree

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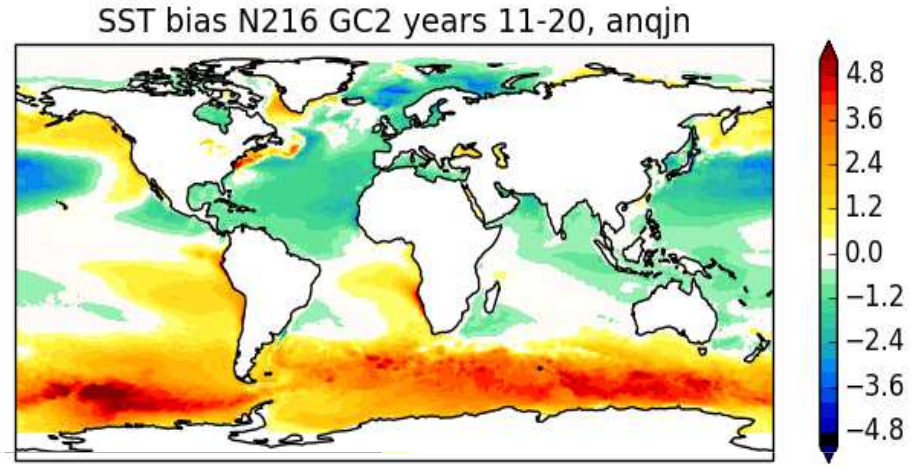
HadGEM3 GC2 configuration, impact of eddy-resolving ocean

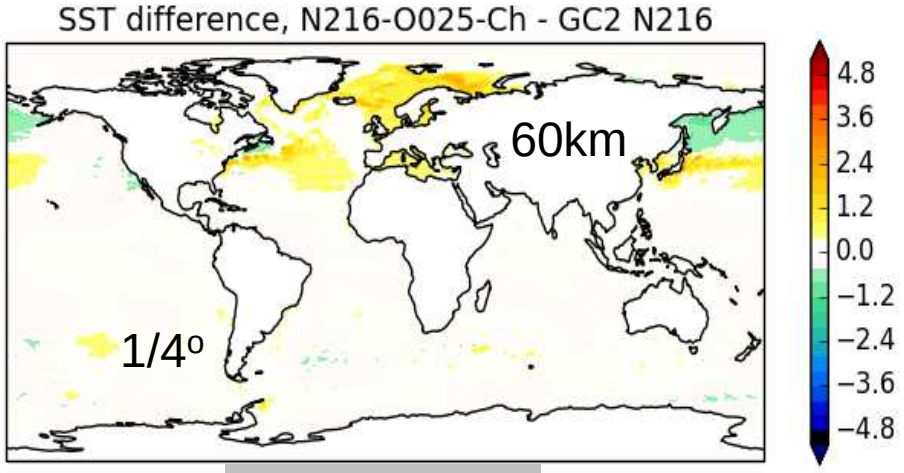
SST bias in N216 GC2, and relative change, over years 11-20

N216 = 60km, N512 = 25km atmosphere; O025 = 1/4˚, O12 = 1/12˚ ocean

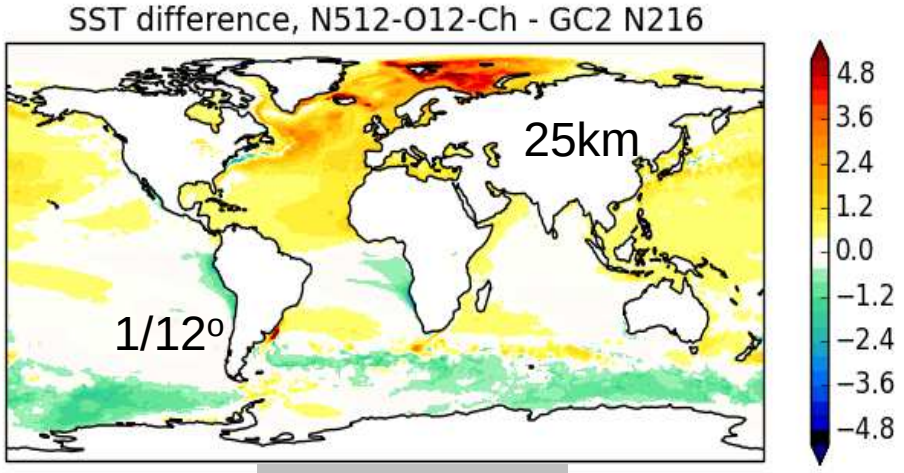


Impact of increasing the ocean model resolution from ¼ degree to 1/12 degree:

Significant warming in the North Atlantic due to increased overturning and heat transport



Mid-Res AO



Hi-Res AO

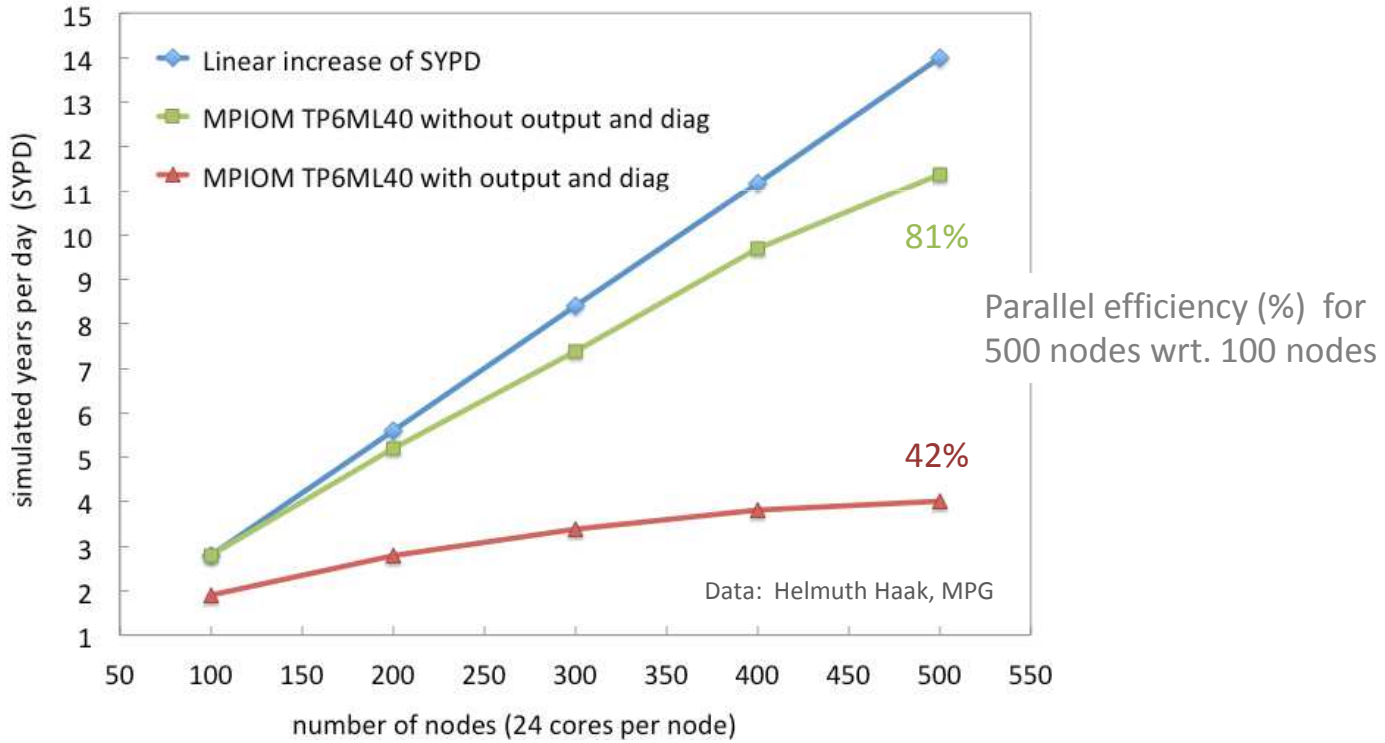
Hewitt et al., 2016, GMD

Met Office

WP4: Frontier simulations at MPI-M

- **Frontier configuration: T255/TP6M (~ 50 km in atmosphere, ~ 10 km in ocean)**
- **Problem: Substantial weakening of MOC, in contrast to T63/TP6M and similarly to T255/TP04 (WP6 high-resolution configuration)**
- **We believe, MOC decrease in frontier configuration is caused by too weak winds in T255 atmosphere component (as shown for WP6 high-resolution configuration by Dian Putrasahan on Tuesday)**
- **Future plan: Port tuning experience from WP6 high-resolution configuration (once successful) to WP4 frontier configuration**
- **Frontier simulation (tests) mainly in 2018 given WP6/WP5 simulation load in 2017**

- **DKRZ team:** Jörg Behrens, Irina Fast, Dela Spickermann, Joachim Biercamp (PI)
- **Current activities within WP4:** Optimisation of computational performance of MPIOM
- **Motivation:** Throughput and scaling of eddy resolving ocean model MPIOM TP6ML40 (i.e. 1/10° with latitudinal refinement in SH, 40 vertical layers) is strongly limited by missing parallel output and online diagnostic calculations (MOC, global means etc).



Parallel efficiency (%) for 500 nodes wrt. 100 nodes

⇨ Implementation of a parallel asynchronous output in MPIOM using CDI-PIO has been started at DKRZ.

WP4 progress @ BSC

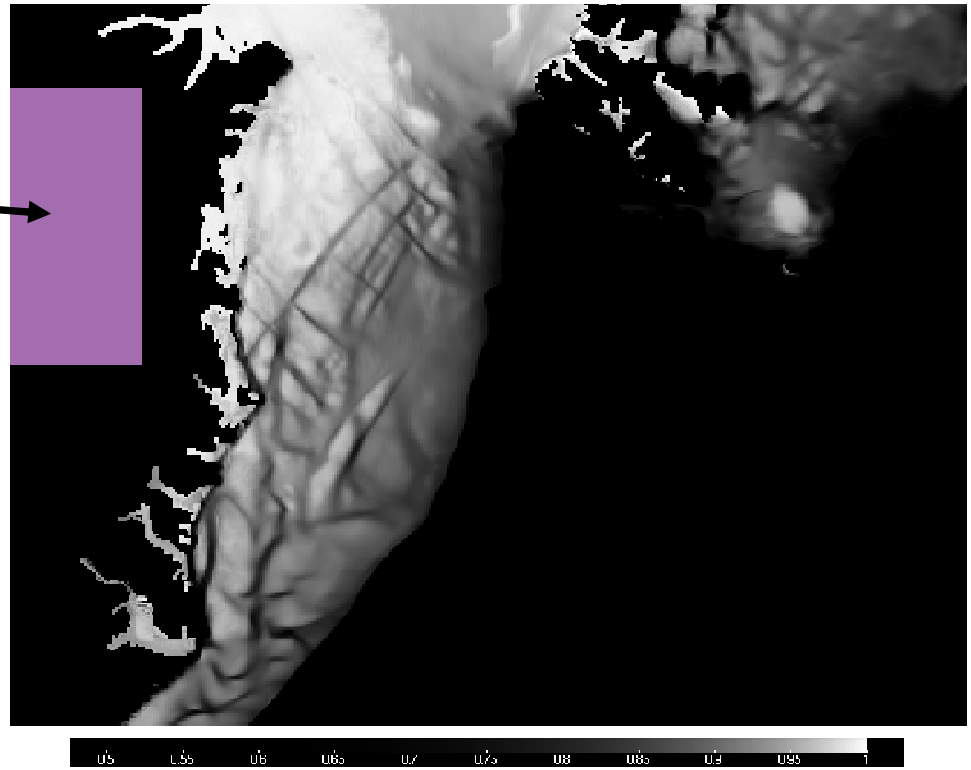
Barcelona Supercomputing Center
Centro Nacional de Supercomputación

Laurent Brodeau, laurent.brodeau@bsc.es

Setting up EC-Earth 3.2 at ultra-high resolution:
[NEMO:ORCA12.L75-LIM3] / [OASIS-MCT] / [IFS:T1279.L137]

NEMO version 3.6 – LIM3 – XIOS2
IFS cycle 36r4

”saved” land processors domain



Daily sea-ice concentration, east of Greenland, LIM3/ORCA12, early April
Are these realistically-looking cracks here for the good reason?

WP4 progress @ BSC

Laurent Brodeau, laurent.brodeau@bsc.es

Recently:

IFS:T1279.L137 successfully run 1 year (E. Tourigny)

NEMO: Obtaining stable and “realistic” ocean circulation with ORCA12.L75-LIM3 in ocean-only forced mode / year 1989 (hindcast) / careful namelist tuning

- Assessed horizontal processor decomposition / performance
- Cold start from T and S (WOA 2013)
- 10 initial days with dt = 60s
- Production with dt = 360s
- Forced with DFS5.2 (DRAKKAR Forcing Set)
- Surface salinity restoring
- Monolithic file output with XIOS2
  - → restarts for year 1990

Now:

Coupling setup for OASIS, optimization of communication in namelist & preparation of configuration fields (grids, masks, weights, restarts, etc).

Soon:

Launch in coupled mode!