Project 771 - TORUS: Towards multi-resolution global climate modeling with ECHAM6-FESOM: Mean climate, climate variability & sensitivity studies

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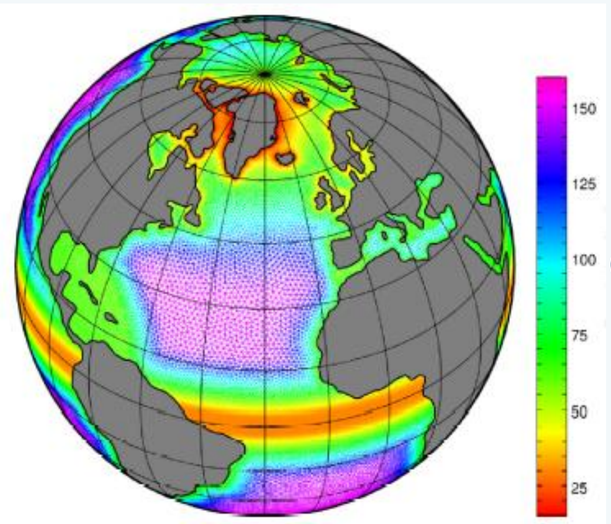
Development of the new coupled climate model ECHAM6-FESOM

FESOM | **ECHAM6**



OASIS3-MCT

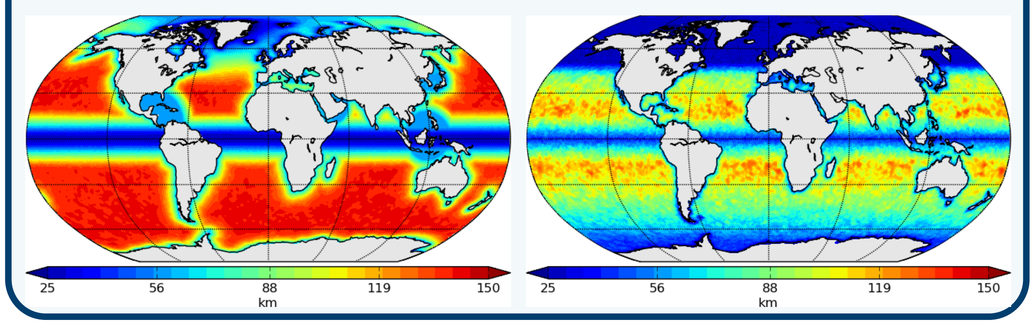
Multi-resolution dynamical core for the sea ice-ocean component
restricting the use of high resolution to dynamically active regions

MiKlip (T63/L47) resolution and configuration
adjustment of the land-sea mask for minimizing flux imbalances

ECHAM6-FESOM - Scientific applications of the new coupled system

- Long integrations & their analyses (Grid **R1**)
- Sensitivity studies w.r.t. a new parameterization of the transfer coefficients over sea ice
- Sensitivity studies on stochastic sea ice parameterizations
- Long integrations with improved resolution over mid- and high-latitudes (Grid **R2**)

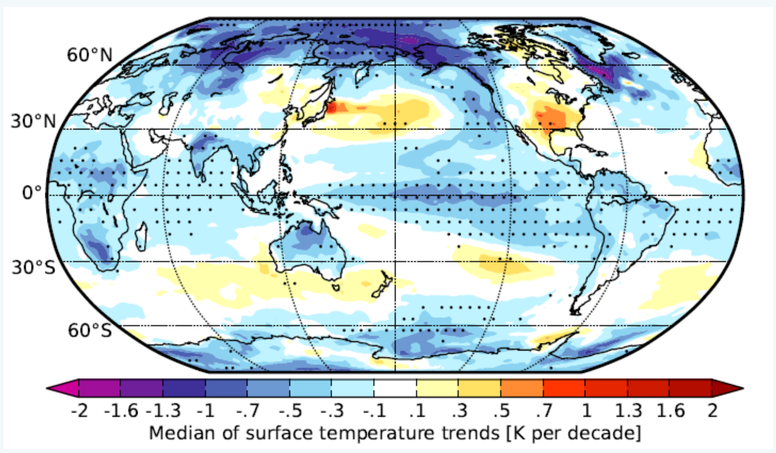
FESOM-Grid R1 | **FESOM-Grid R2**



ECHAM6-FESOM - Simulated variability Hiatus analogues

- **Q:** How often is a hiatus analogue observed in 1000 years of the present-day control run (Grid R1)?
- **A: 12 times, i.e. „once in one hundred years event“**

Mean surface temperature trend pattern for 12 "hiatus analogues"



Virtually all hiatus analogues are associated with a decrease of the El Niño frequency (and a trend towards negative PDO conditions)

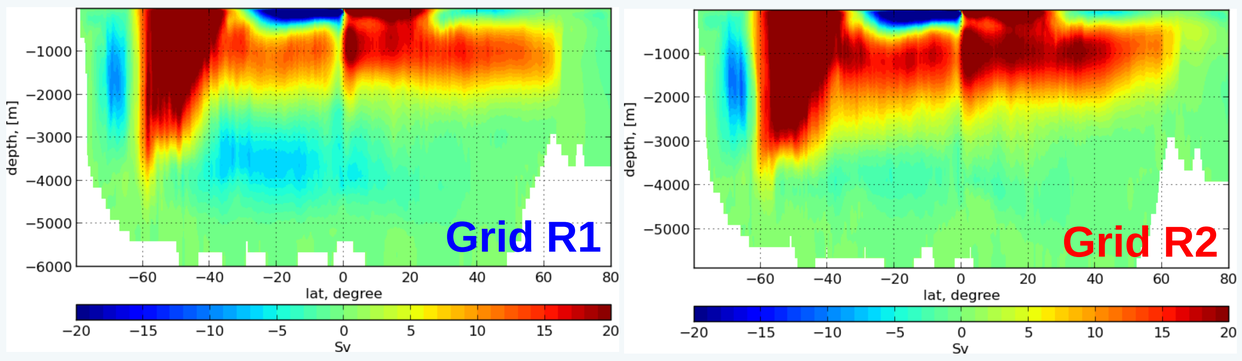
Stippling indicates significant trends with a consensus in sign between at least 11 out of a total of 12 model hiatus realizations

ECHAM6-FESOM captures the mechanisms leading to warming pauses associated with
1) a decreasing PDO-index along with more frequent La Nina events,
2) a vertical redistribution of heat in the ocean.

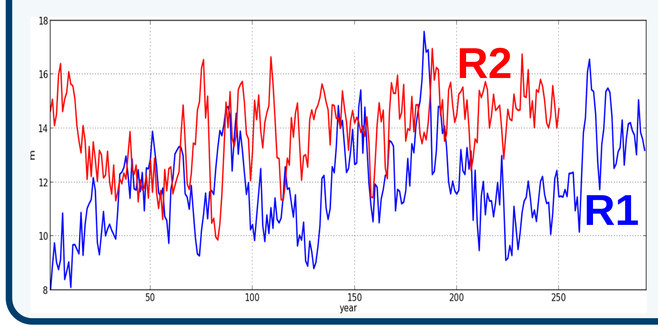
ECHAM6-FESOM - Most recent advance with Grid R2

Strongly reduced Labrador sea bias (no freezing)
Improved AMOC (stronger transports)

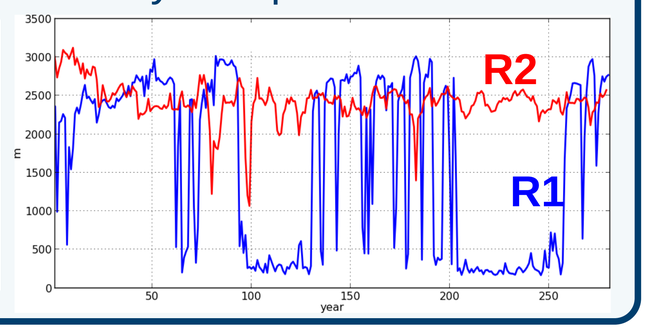
Present-day control runs: Grid R1 vs. Grid R2
Atlantic meridional overturning streamfunction (Sv)



Time series of the AMOC maximum at 45ºN



Annual Labrador Sea mixed layer depth maximum



ECHAM6-FESOM – Sensitivity studies

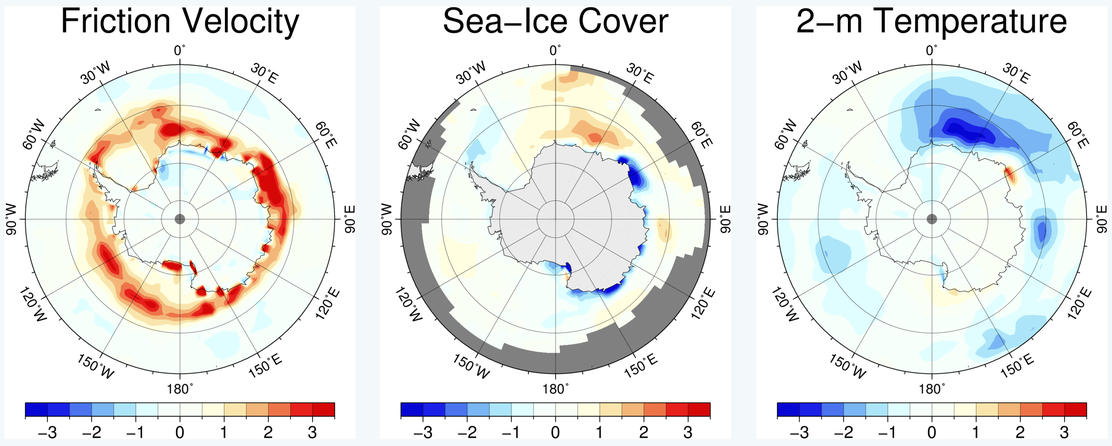
(1) on the transfer coefficients over sea ice

Ensemble Sensitivity Experiments

default = 10 runs with ECHAM's default parameterization (Grid R1, 20 yrs present-day conditions).

new-v3 = 10 corresponding runs with the new parameterization of the transfer coefficients over sea ice by Lüpkes & Gryanik (2015).

Normalized difference new-v3 minus default (JJA)



The new parameterization is accompanied by higher surface drag with positive effect on simulated sea ice and 2m-temperature

(2) on stochastic sea ice parameterizations

Ensemble Sensitivity Experiments

Idealized one-year ensemble forecasts

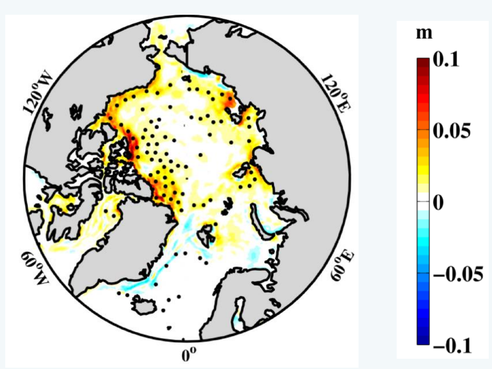
INI = 10-member ensembles, atmospheric initial perturbations only

STOINI = As INI but with additional stochastic ice strength perturbations

Difference STOINI minus INI

Ensemble standard deviation of ice thickness averaged for days 11 to 30

Start dates: 1st January



On short lead times, stochastic sea ice strength perturbations in coupled model forecasts generates ensemble spread of sea ice thickness (central Arctic, north of Greenland, in the CAA)

DKRZ Resources

2015
Blizzard CPU time (CPUh) 382676
GPFS work (GB) 3929
HPSS arch (GB) 12044

2014
Blizzard CPU time (CPUh) 1056755
GPFS work (GB) 5250
HPSS arch (GB) 33661

DKRZ Support and cooperation

- Performance measurement trainings
- Visualization tools (ParaView) and servers
- Library development (cdi, yaxt)
- Data archive
- Model optimization and support
- Help desk availability

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References
Juricke et al. (2014): Potential sea ice predictability and the role of stochastic sea ice strength perturbations. Geophys. Res. Lett., 41, 8396–8403, doi:10.1002/2014GL062081.
Sidorenko et al. (2015): Towards multi-resolution global climate modeling with ECHAM6-FESOM: Part I: model formulation and mean climate. Clim. Dyn., 44, 757–780, doi:10.1007/s00382-014-2290-6.
Rackow et al. (2015): Towards multi-resolution global climate modeling with ECHAM6-FESOM: Part II: climate variability. Clim. Dyn., submitted.

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