Towards a Seasonal Prediction System using MPI-ESM: Description, Performance, Analysis

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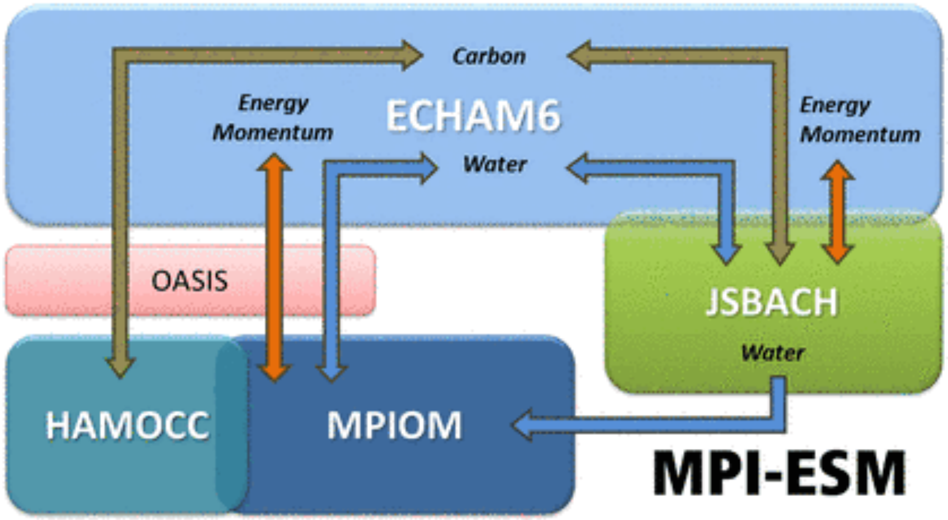
Seasonal forecasting with the MPI-ESM

- MPI-ESM-LR in setup used for CMIP5 and IPCC AR5
- use of the MPI-ESM as a seasonal forecasting system
  - simple initialization: atmosphere / ocean / sea ice nudging and breeding in the ocean for ensemble generation
- planned German contribution (DWD, MPI, Univ. Hamburg) to EUROSIP (ECMWF operational multi-model seasonal forecasting ensemble)

Seasonal forecasting with the MPI-ESM: Model Setup

MPI-ESM: The Earth System Model of the Max-Planck-Institute for Meteorology Hamburg

- ECHAM6 (atmosphere)
  - horizontal T63 (1.9°x1.9°)
  - vertical L47 (47 levels up to 0.01hPa, ~24 levels above 200hPa)
  - land module JSBACH and hydrological discharge model
- MPIOM (ocean) plus sea ice
  - horizontal: 1.5°
  - vertical: 40 levels
  - sea ice model (dynamic / thermodynamic)



Literature on MPI-ESM: Giorgetta et al (2012), Stevens et al (2013), Jungclaus et al (2013), Schmidt et al (2013)

Seasonal forecasting with the MPI-ESM: Initialization

Data assimilation: Full field nudging towards reanalysis data

1. **Atmosphere:** ERA-INTERIM (vorticity, divergence, temperature, surface pressure). Atmospheric temperatures are only nudged above the boundary layer. Relaxation time: 1 day
2. **Ocean:** ECMWF (ORA-S4) ocean (salinity, temperature, no SST nudging). Relaxation time: 10 days
3. **Sea ice:** NSIDC data (sea ice concentration). Effective relaxation time: 10 days

more information on model initialization: Poster 30 S2 P1, J. Baehr et al.

Seasonal forecasting with the MPI-ESM: Ensemble generation

Ensemble generation: Breeding

- capture the information about the fastest growing modes in the model related to flow dependent instabilities (Toth and Kalnay, 1997)
- used to generate ensemble spread for free hindcast simulations
- perturbations of ocean only (3D temperature and salinity)

Hindcasts: November and May start dates for 1980 - 2011

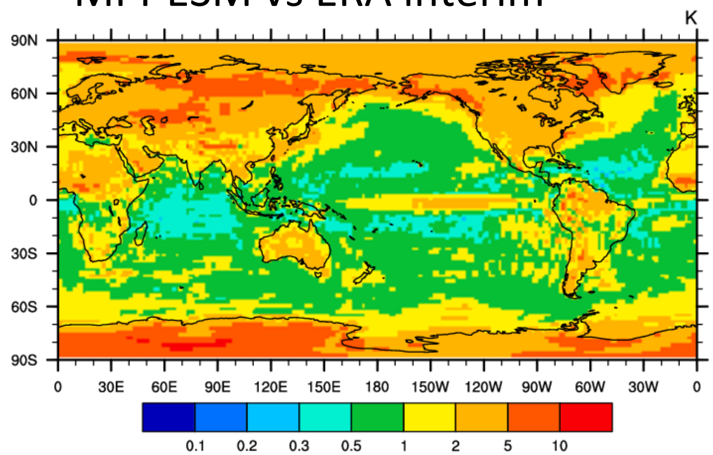
- initialize every November 1 and May 1 with a runtime of 1 year
- 9 ensemble members for each start date

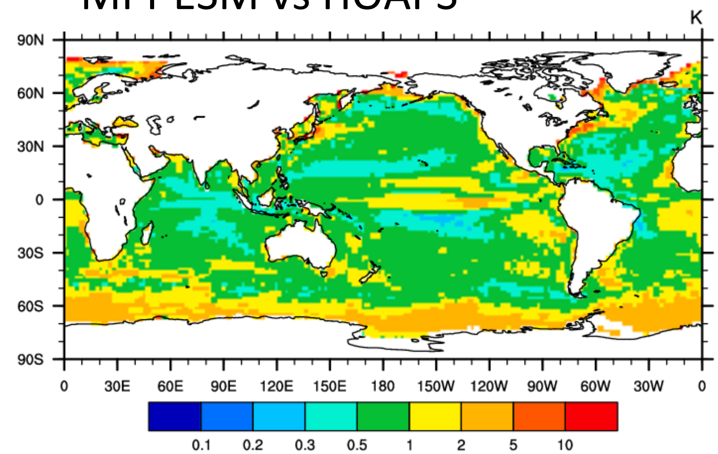
Evaluation of the model skill: RMSE and ACC

2m temperature for DJF:
MPI-ESM vs ERA interim

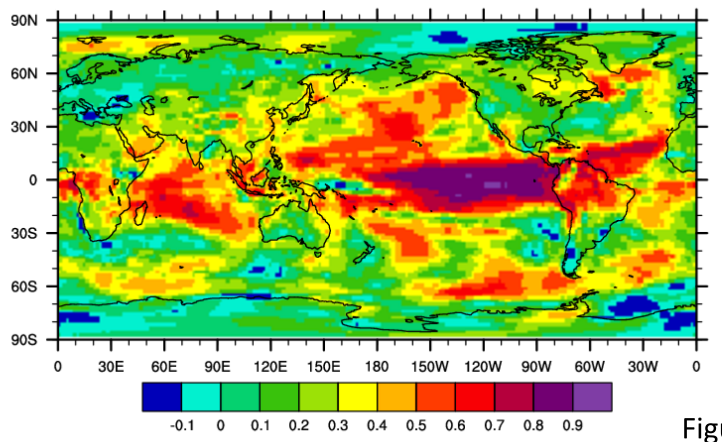
surface temperature for DJF:
MPI-ESM vs HOAPS

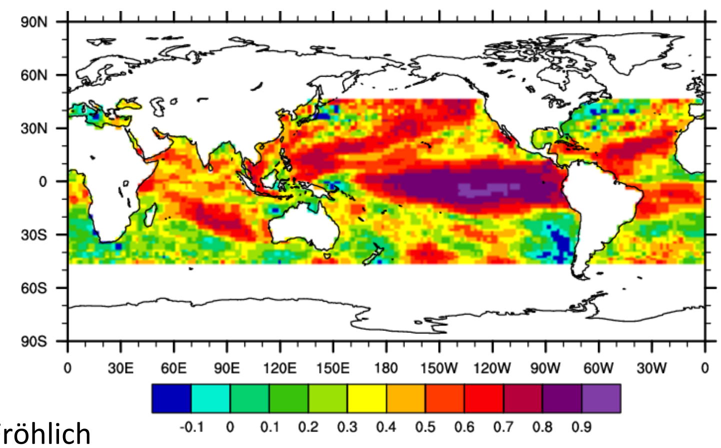
RMSE





ACC

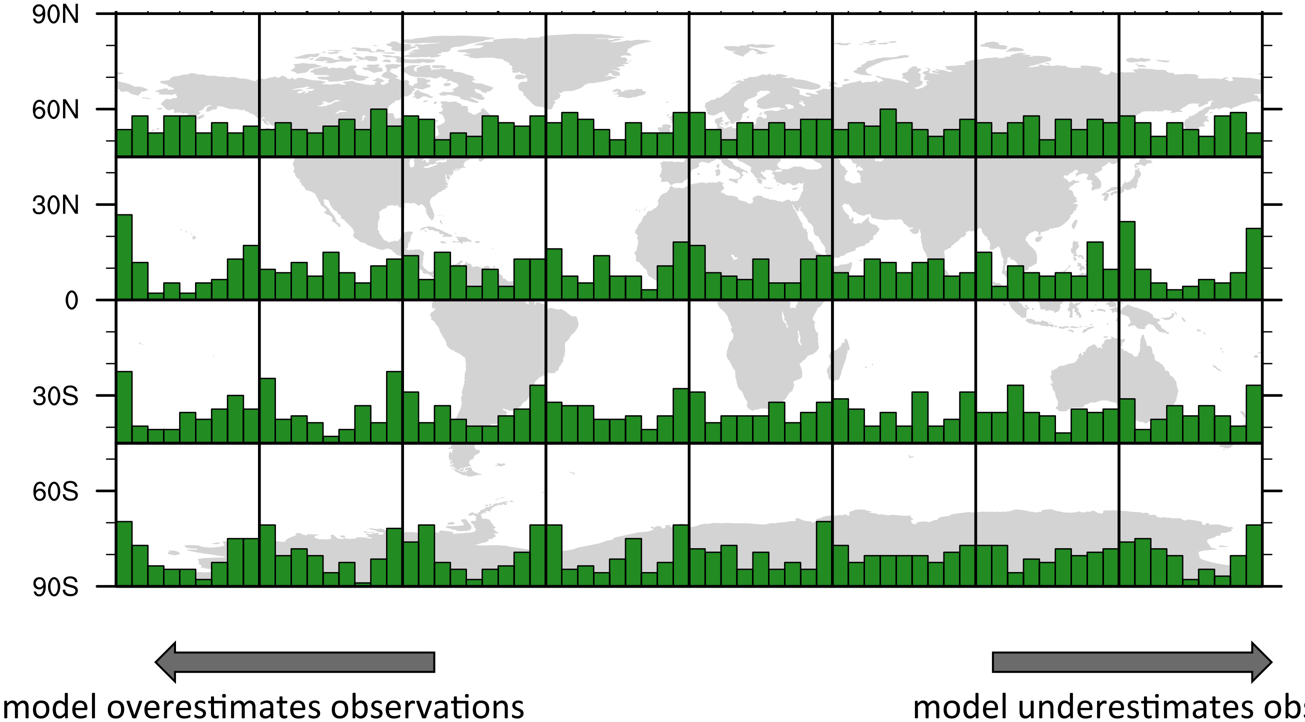




Figures: Kristina Fröhlich

Evaluation of the model skill: ensemble spread

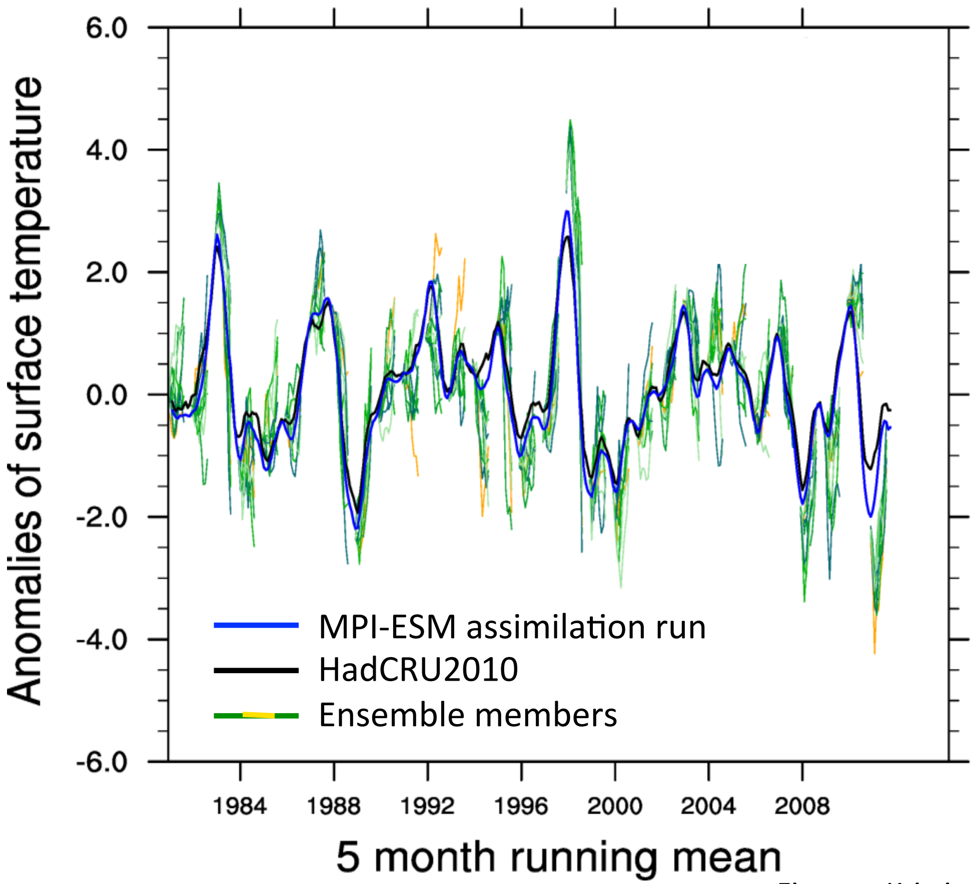
Talagrand of bias corrected
surface temperature for DJF (1982 – 2010)

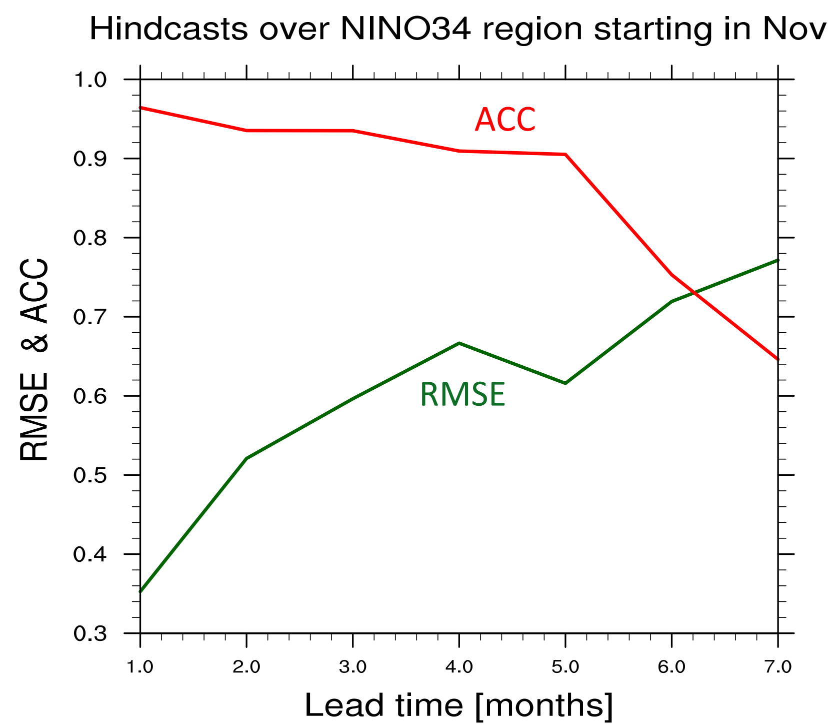


- generally good ensemble spread, especially in Northern Hemisphere
- central Pacific ensemble spread underestimates variability

Figure: Kristina Fröhlich

Evaluation of ENSO predictability: RMSE and ACC





Figures: Kristina Fröhlich

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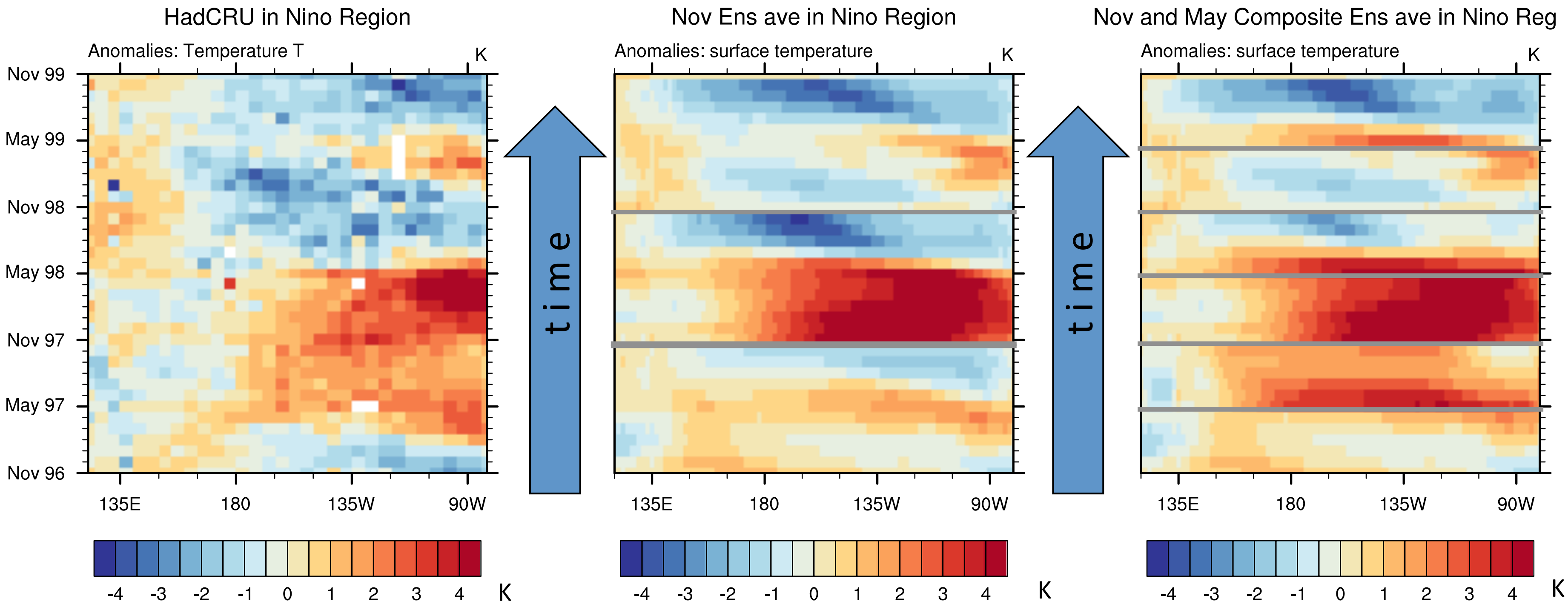
Universität Hamburg
DER FORSCHUNG | DER LEHRE | DER BILDUNG

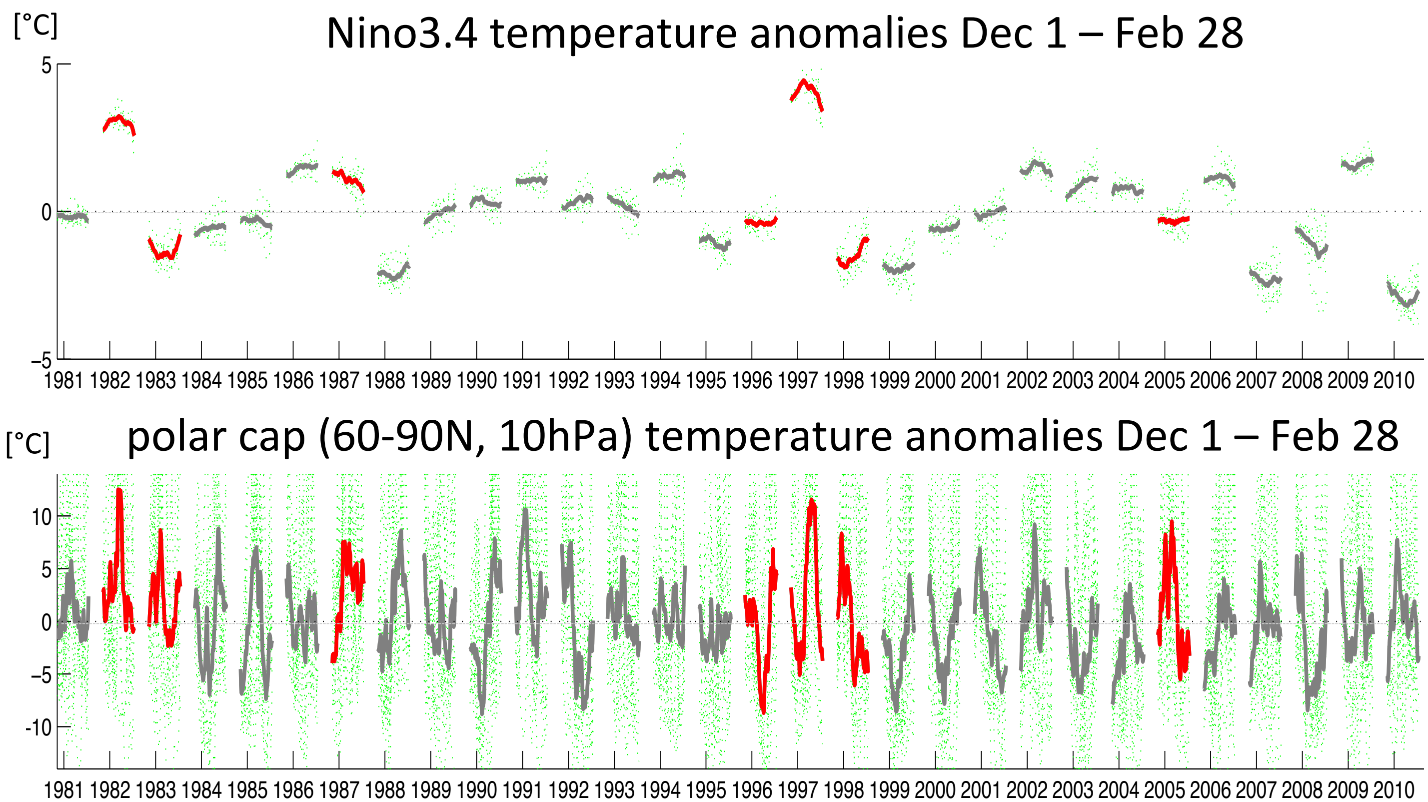
Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Evaluation of ENSO predictability: El Niño 1997/98



Figures: Kristina Fröhlich

Evaluation of the stratosphere: ENSO vs stratospheric variability



— > 6 SSWs/winter in 8 ensemble members

— ensemble mean

- ✓ strong El Nino events ⟺ high polar cap temperatures

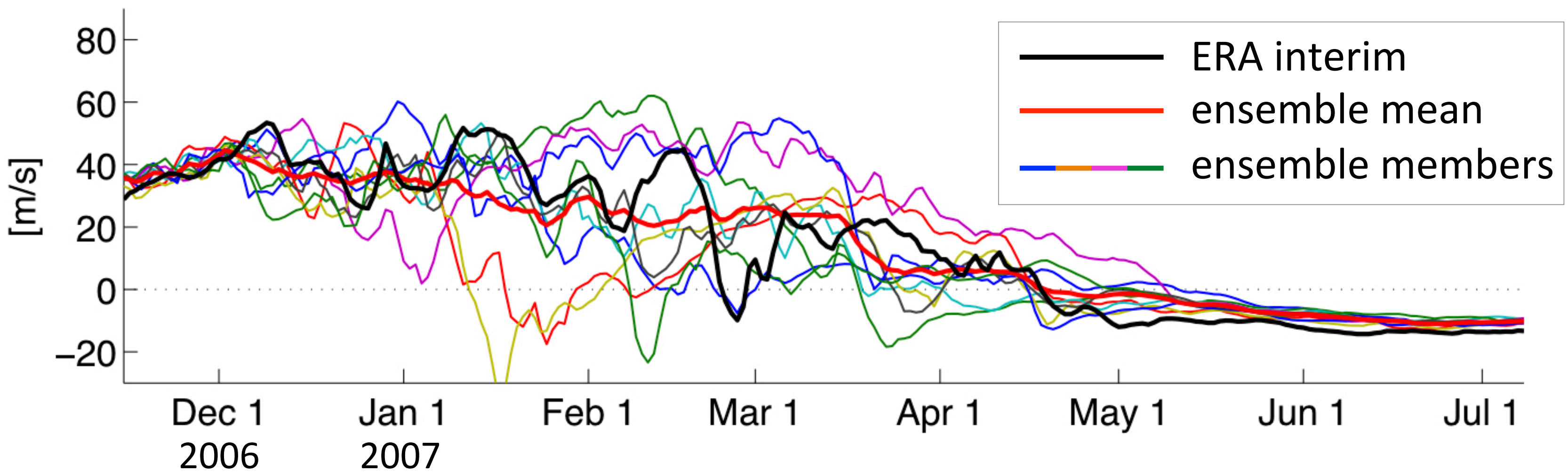
➔ enhanced predictability over Europe?

Acknowledgments: Amy Butler

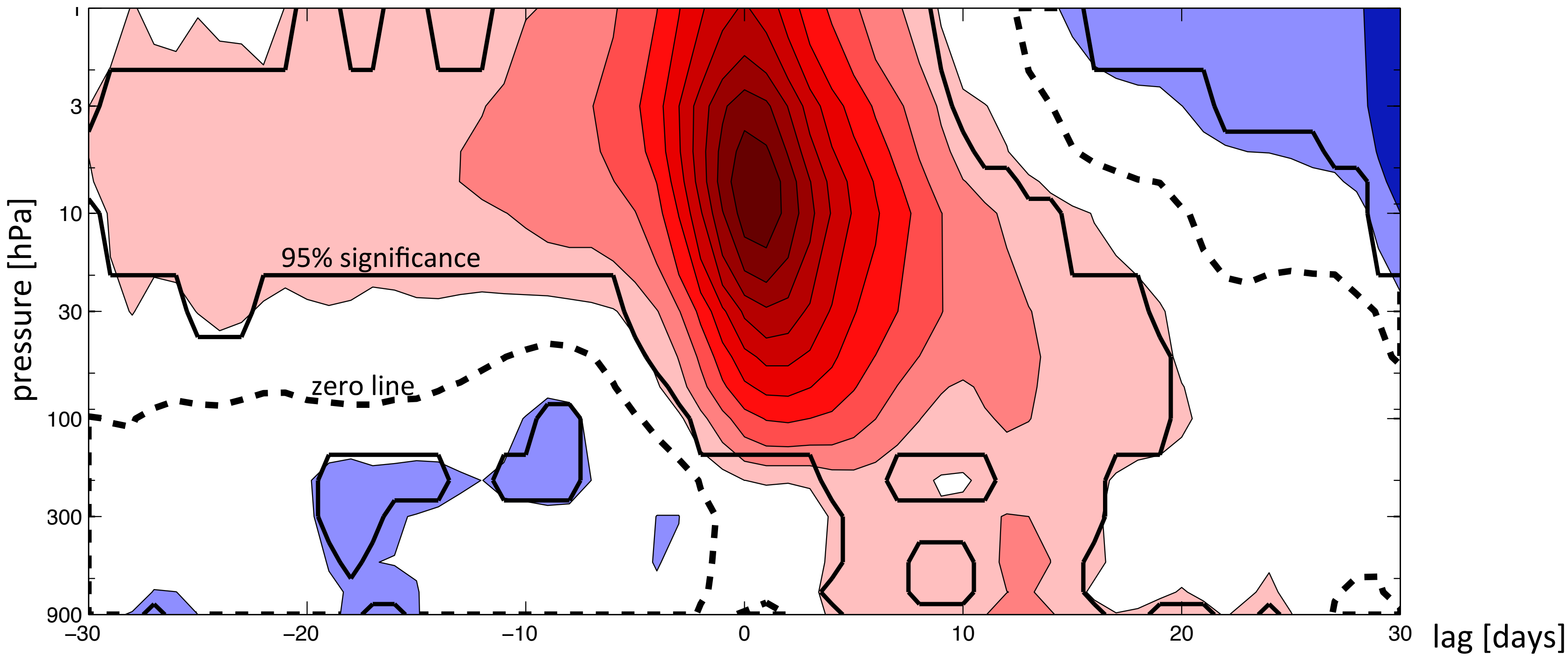
Evaluation of the stratosphere: Stratospheric variability and predictability

- ✓ variability well reproduced
- ✓ ensemble spread encompasses natural variability
- x predictability of specific events

zonal mean zonal wind at 60°N / 10hPa for winter 2006/2007



Evaluation of the stratosphere: Stratospheric sudden warmings



Composite of 67 of the stratospheric sudden warmings btw 1981- 2010

✓ downward coupling

x precursor structure

Level-by-level EOF/PCs,
cp. Baldwin & Dunkerton (2001)
Acknowledgments: Edwin Gerber

Summary and Conclusions

- the MPI-ESM can be successfully initialized as a seasonal prediction model using breeding for ensemble generation and nudging for data assimilation
- atmosphere is well reproduced by ensemble in terms of its mean state and variability

Ongoing and future work

- operational work: setting up the system at ECMWF within the EUROSIP framework
- research: predictability of
  - ENSO
  - MJO
  - ocean heat content
  - stratosphere / stratosphere – troposphere coupling

Literature

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