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Projekt uo0122

Geotechnologien und Erdsystemforschung

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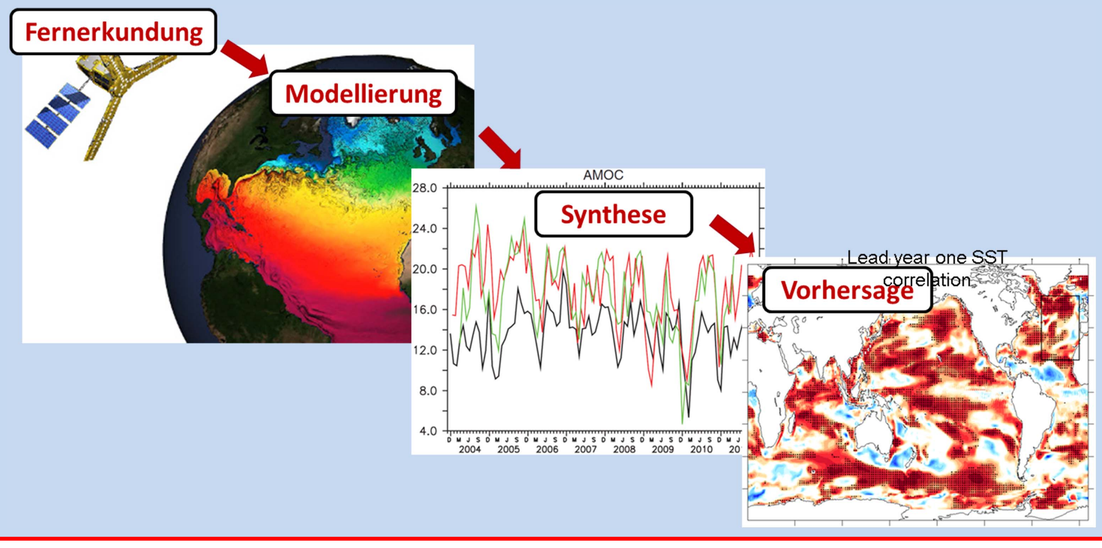
- An essential aspect of the interpretation of remote sensing data is the relation with other sources of information, especially high-resolution numerical simulations of the ocean circulation.
- Along with high-resolution modelling come inverse methods, used in the assimilation of remote sensing data into models (in the form of ocean syntheses), achieving the best possible description of the predominant ocean processes.
- An important application of those syntheses is the initialization of coupled climate model long-term forecasts.

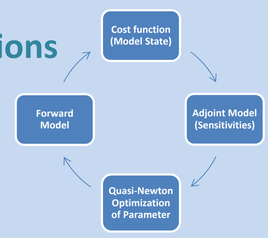


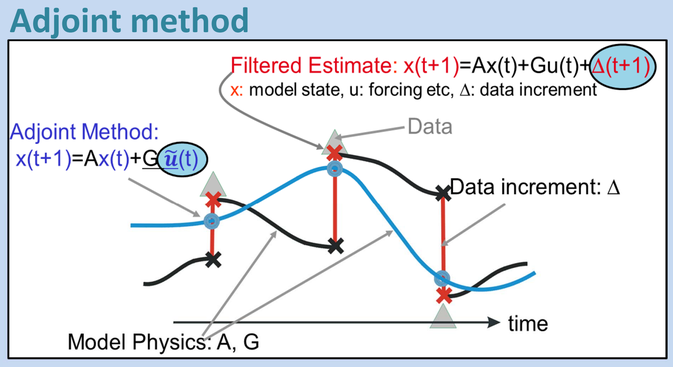
GECCO2 ocean synthesis

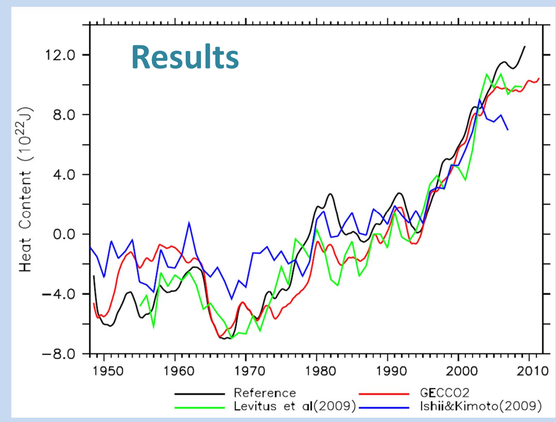
Ocean synthesis data provide initial conditions for decadal predictions

- The iterative assimilation procedure uses the adjoint method to adjust the initial conditions and atmospheric state to bring a global ocean/sea ice model into consistency with the assimilated data and the prior model-data error weights.
- Assimilation of new data sources, such as GRACE bottom pressure, SMOS ocean salinity and GOCO02 dynamic topography.
- Applications include the understanding of specific processes, of ocean-atmosphere interactions; of the ocean's role the Earth's heat balance and water cycle, of transports across ocean basins and key straits and the estimation of transfer coefficients for unresolved processes.

Köhl, A. (2015). "Evaluation of the GECCO2 ocean synthesis: Transports of volume, heat and freshwater in the Atlantic." Q. J. R. Meteorol. Soc. 141, 166–181.







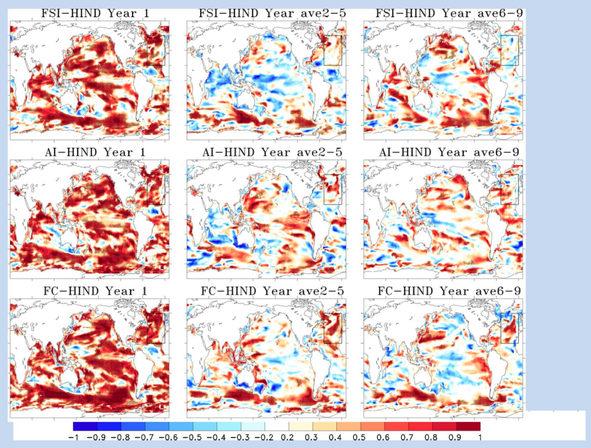
Global mean (0-700m) heat content changes from the reference run and GECCO2 in comparison to the estimates from Levitus et al. (2009) and Ishii and Kimoto (2009).

Initialization of decadal prediction

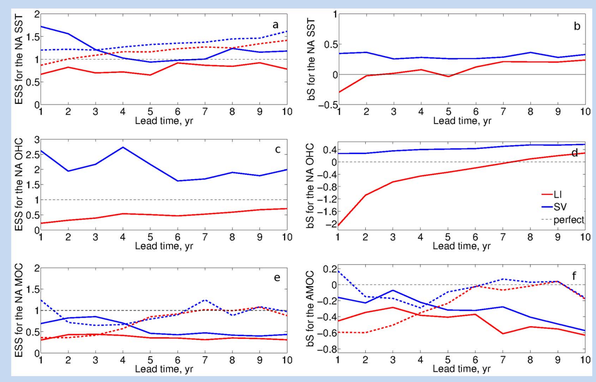
Hindcasts for the evaluation of forecast skill

- Using the UCLA/MITgcm coupled model, three initialization methods for decadal predictions were tested (full state - FSI, anomaly – AI, and full state including heat and fresh water flux correction - FC).
- More realistic representation of the mixed layer depth in full-state initialized and flux-corrected hindcasts resulted in better forecast skill.
- With the MPI-ESM, ensemble generation procedures were tested based on empirical oceanic singular vectors (SVs) and compared with atmospheric lagged initialization. SVs initialized ensembles can overcome the lag of spread in the early years of the predictions.

➢ *Polkova, I., A. Köhl & D. Stammer (2014). "Impact of initialization procedures on the predictive skill of a coupled ocean–atmosphere model." Clim. Dyn. 42, 3151-3169.*



Correlation between detrended GECCO SST and initialized hindcast SST for the first lead year (left column), lead years 2–5 (middle column) and lead years 6–9 (right column). The hatched regions indicate significant skill at the 90% level according to a bootstrap procedure.



Ensemble Spread Skill (ESS, left) and beta-score (bS, right) for North Atlantic SST (a,b), OHC (c,d) and AMOC at 25◦N (solid) and 48◦N (dashed) (e,f). Atmospheric lagged initialization (LI) results are in blue and oceanic perturbations (SV) results in red. Verification data: Reynolds SST (Reynolds et al. 2007), NODC OHC (Levitus et al. 2009) and AMOC from assimilation run.

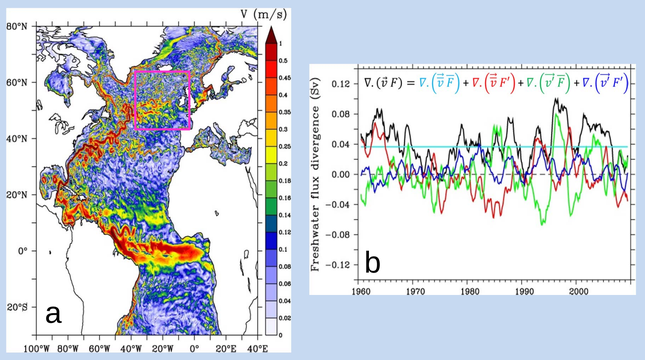
High-resolution modelling

Realistic model configurations to study the Atlantic and Arctic Oceans

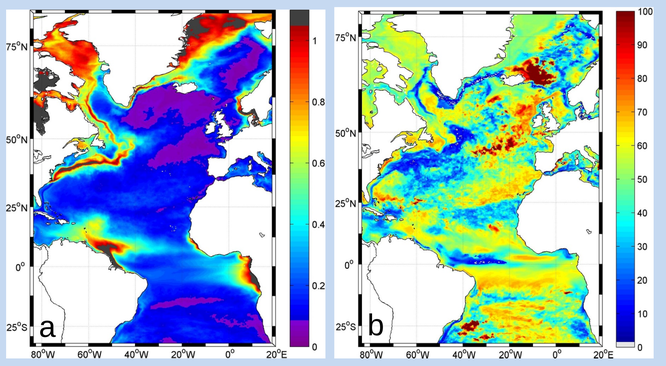
A hierarchy of model resolutions (32, 16, 8 and 4 km) is used to study:

- Variability of Arctic-Atlantic exchanges of volume and freshwater;
- Dense water overflow processes and their impact on the north Atlantic overturning circulation;
- Spatial and temporal scales of upper ocean variability (salinity and sea level);
- Role of eddies in the volume, heat and freshwater subtropical-subpolar gyres exchange;
- Ocean kinetic and potential energy budgets.

➢ *Köhl, A. & N. Serra (2014). "Causes of decadal changes of the freshwater content in the Arctic Ocean". J. Clim., 27, 3461-3475.*
➢ *Serra, N., R. Käse, A. Köhl, D. Stammer & D. Quadfasel (2010). "On the low-frequency phase relation between the Denmark Strait and the Faroe-Bank Channel overflows". Tellus, 62A, 530-550.*
➢ *Sena-Martins, M., N. Serra & D. Stammer (2015). "Spatial and temporal scales of sea surface salinity variability in the Atlantic Ocean". J. Geophys. Res., 120, 4306-4323.*



(a) Instantaneous surface velocity in a 8-km resolution integration. (b) Decomposition of the horizontal freshwater flux divergence in the northeastern north Atlantic (see box) into contributions due to mean and fluctuating velocity and salinity.



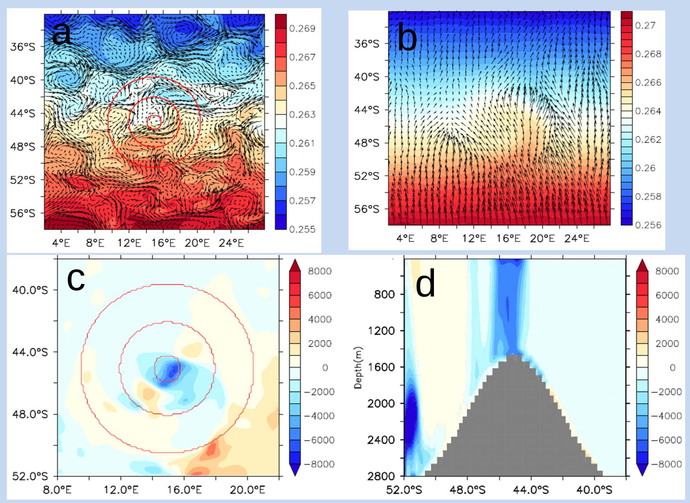
(a) Sea surface salinity standard deviation (in g/kg) in a 4-km resolution simulation and (b) respective temporal decorrelation scales (in days).

Process modelling

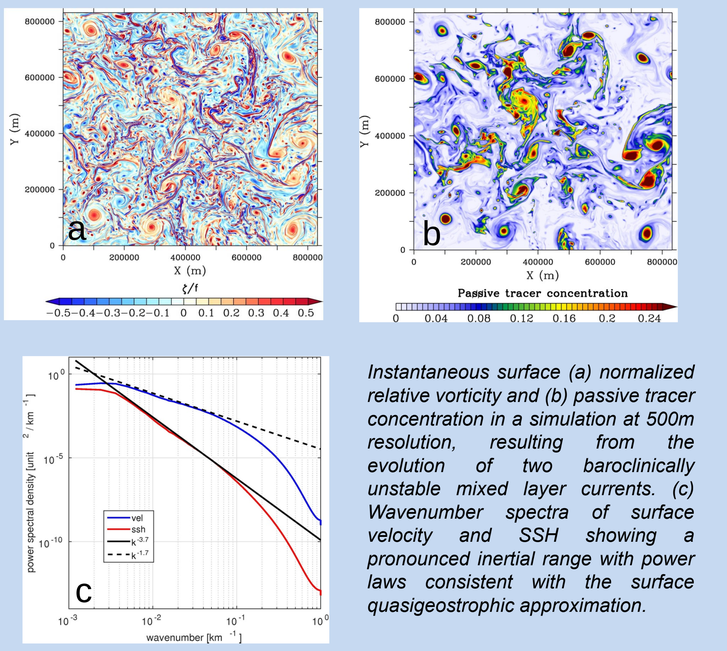
Idealized models for studying mixing and stirring processes

- A process model configuration is used to study the effect of topography on horizontal mixing, to support the interpretation of the mixing estimates from the inverse method.
- Layer thickness advection can be interpreted in terms of eddy–topography interaction.
- Idealized mixed layer tracer stirring experiments are used to study the energy and enstrophy transfer between the ocean mesoscale and the submesoscale.

➢ *Liu, C., A. Köhl & D. Stammer (2012). "Adjoint-based estimation of eddy-induced tracer mixing parameters in the global ocean." J. Phys. Oceanogr. 42.7, 1186-1206.*
➢ *Liu, C., A. Köhl & D. Stammer (2014). "Interpreting layer thickness advection in terms of eddy–topography interaction." Ocean Modelling 81, 65-77.*



(a) Instantaneous buoyancy and velocity over isobaths of 2800, 2200 and 1600 m. (b) 10-year average of divergent buoyancy fluxes and 10-year mean buoyancy (colour, m s^{-2}). (c,d) Layer thickness advection coefficient k_{gmskew} (colour, m^2 s^{-1}) diagnosed from the divergent buoyancy flux($k_{gmskew} = -|\nabla_h \bar{b}|^{-2}(\mathbf{u}_h' b' - \mathbf{u}_h' b'^{rot}) \cdot \nabla \bar{b}$).



Instantaneous surface (a) normalized relative vorticity and (b) passive tracer concentration in a simulation at 500m resolution, resulting from the evolution of two baroclinically unstable mixed layer currents. (c) Wavenumber spectra of surface velocity and SSH showing a pronounced inertial range with power laws consistent with the surface quasigeostrophic approximation.