High-resolution ocean modelling at the MPI

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Technical and organizational overview I

- The high-resolution ocean modelling activity at MPI was initiated by the German consortium project STORM, launched in cooperation with CliSAP of University Hamburg, DKRZ and other partners in Germany

- OGCM: MPIOM/TP6ML80 with a tripolar grid, 1/10^{o} (3600X2392 grid points), 80 levels

  - no GM, a 'staggered' 2nd order TVD advection scheme for u,v, T and S, diffusion coefficient proportional to the local isophycnal diffusion and dependent of grid spacing, vertical mixing based on PP + turbulent mixing due to winds, a sea-ice model formulated using viscous-plastic rheology

- AGCM: ECAHM6 T255L95

Technical and organizational overview II

- Simulations performed:

  - an ocean-only run with MPIOM/TP6ML80 forced with 6 hourly NCEP/NCAR reanalysis-1 for the period 1948-2013

  - an AMIP run with ECHAM6/T255L95 forced by the CMIP5 boundary conditions for the period 1976-2008

  - Two runs coupled to ECHAM6/T255L95 (40 yrs, 60 yrs) starting from different initial conditions with hourly coupling

  - an ocean-only run with MPIOM/TP6ML40 forced by the lunisolar tidal potential and climatological winds and with SST and SSS restored to monthly climatology (in cooperation with Malte Müller)

  - a two months ocean-only run forced by the NCEP/NCAR reanalysis, but the 6 hourly winds are replaced by 5-day running averaged winds

Technical and organizational overview III

- Peculiarities for the 65-yr NCEP run: use a process-oriented and dynamic output, rather than the standard uniform output

  - accumulate 3-dimensional second moments on-line and store on monthly basis

  - document the whole simulation by archiving all 3d prognostic variables, all 3d second moments, and some derived variables on monthly basis

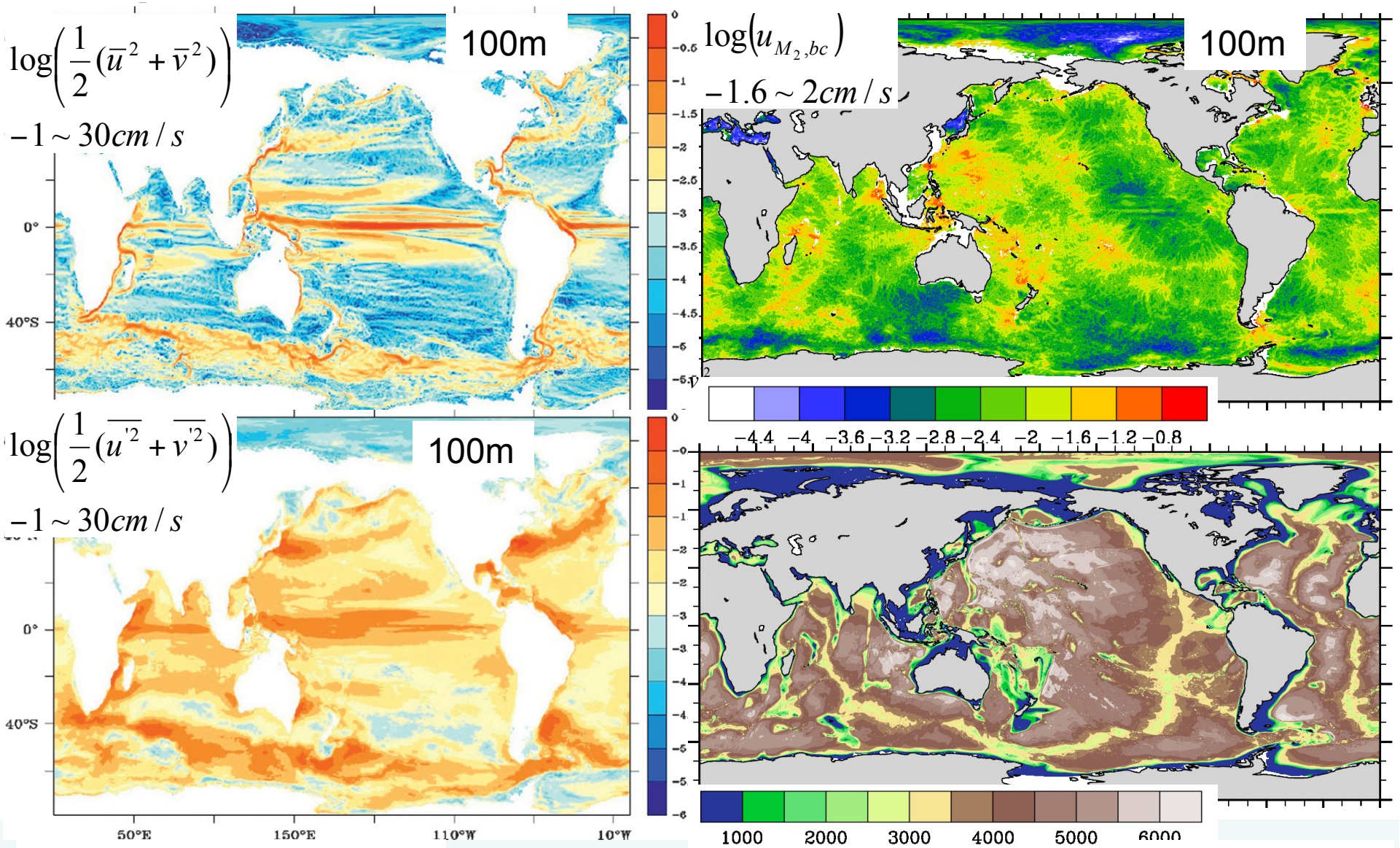
  - document short-term variations using 3d hourly output for all prognostic variables for a period of 6 months and daily output at selected levels throughout the integration

Scientific issues I:

The mechanical energy cycle of the ocean and the roles of meso-scale eddies and internal waves for the energy pathways

- wind-induced near-inertial waves
- internal tides
- internal waves spontaneously generated by eddying flows

1/10° MPIOM simulation of meso-scale eddies and internal tides

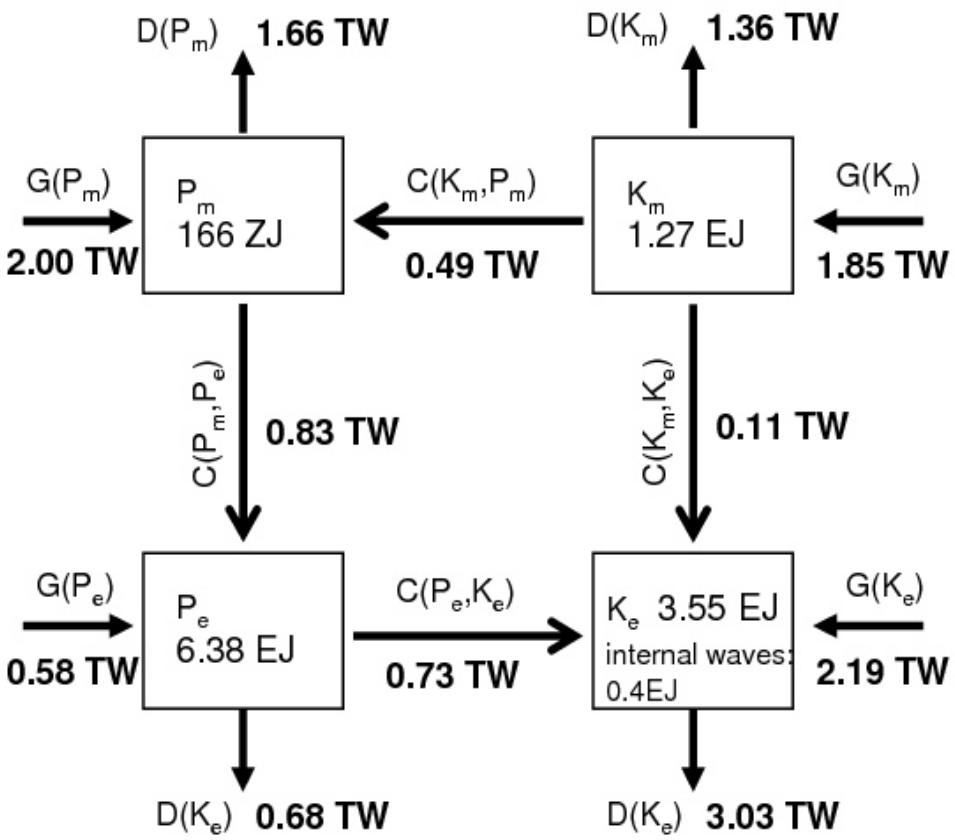


von Storch et al. 2012

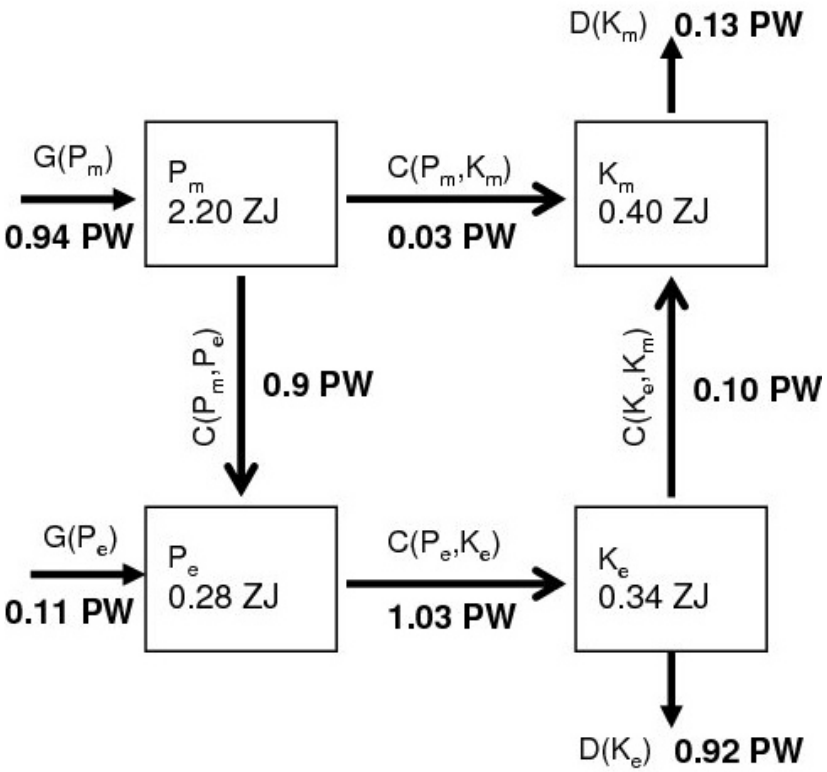
by Zhuhua Li

The Lorenz Energy Cycle

MPIOM Ocean (von Storch et al. 2012)



Atmos (ERA-40) (Li et al. 2007)



The Lorenz Energy Cycle

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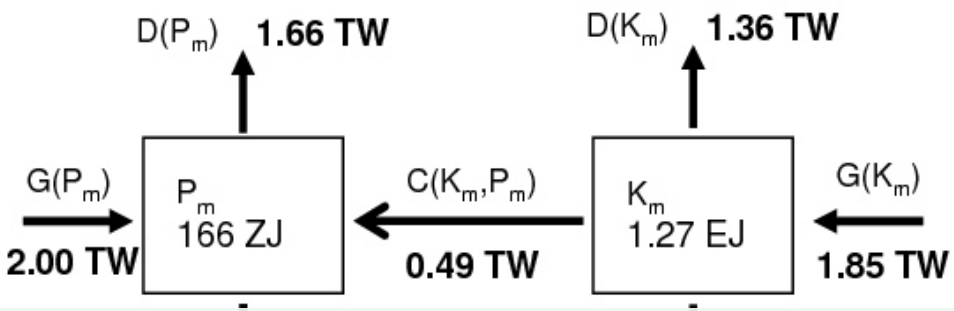
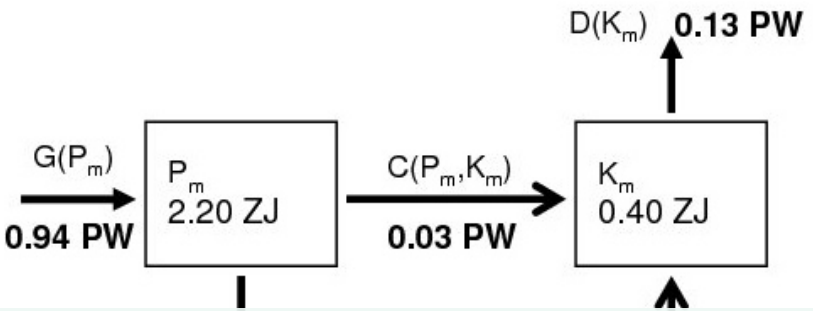


an ocean without eddies

Atmos (ERA-40) (Li et al. 2007)



an atmosphere without synoptic variability

The Lorenz Energy Cycle

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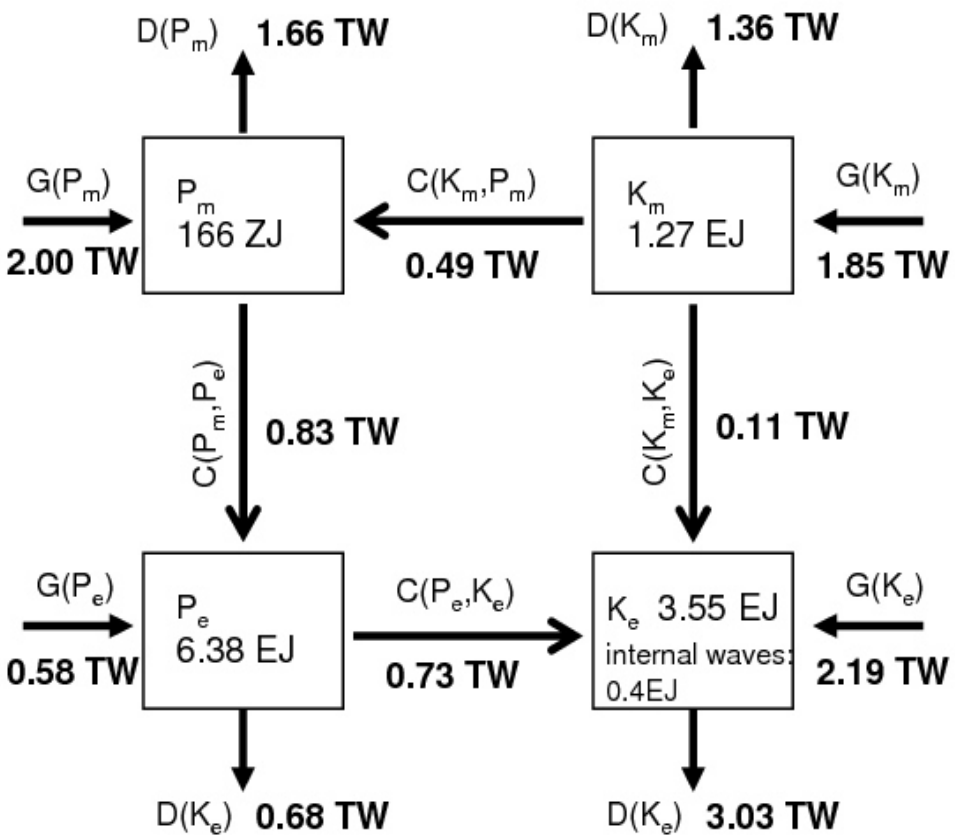

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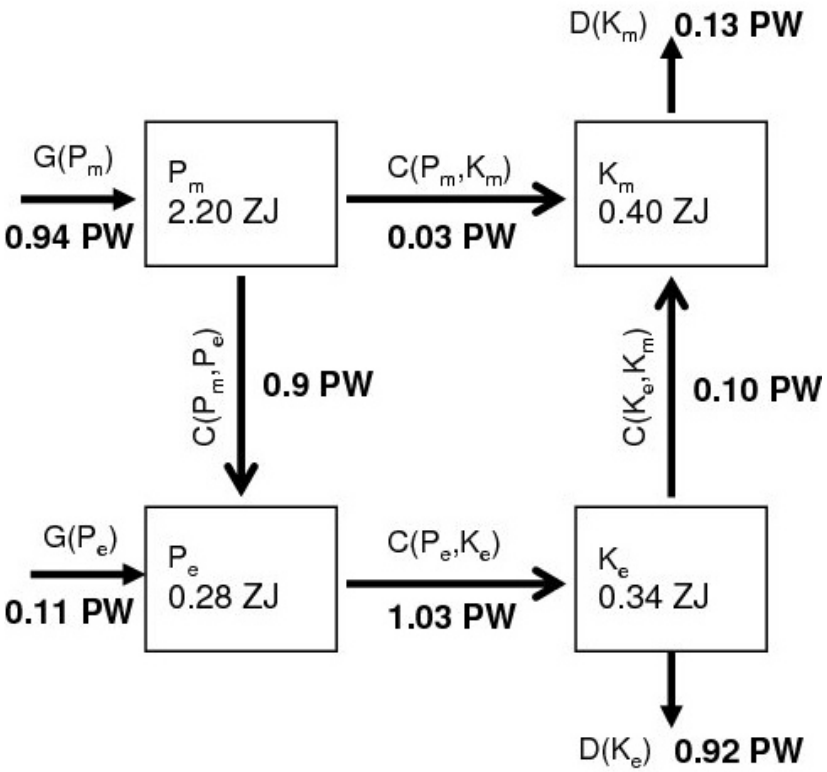

The Lorenz Energy Cycle

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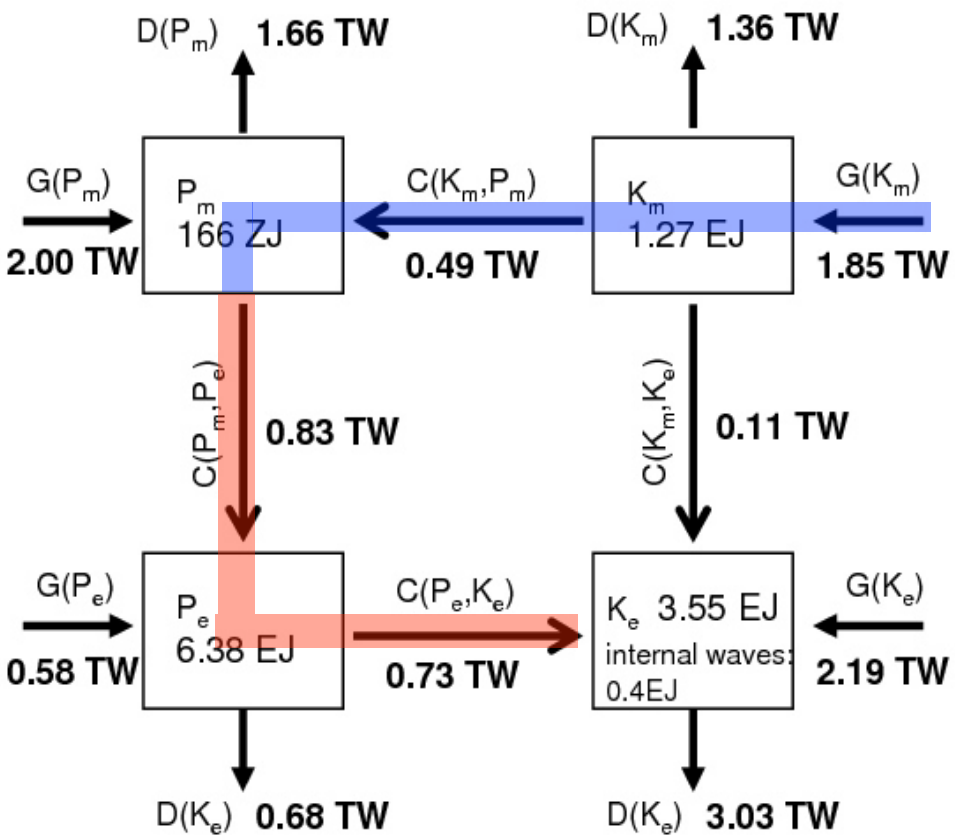

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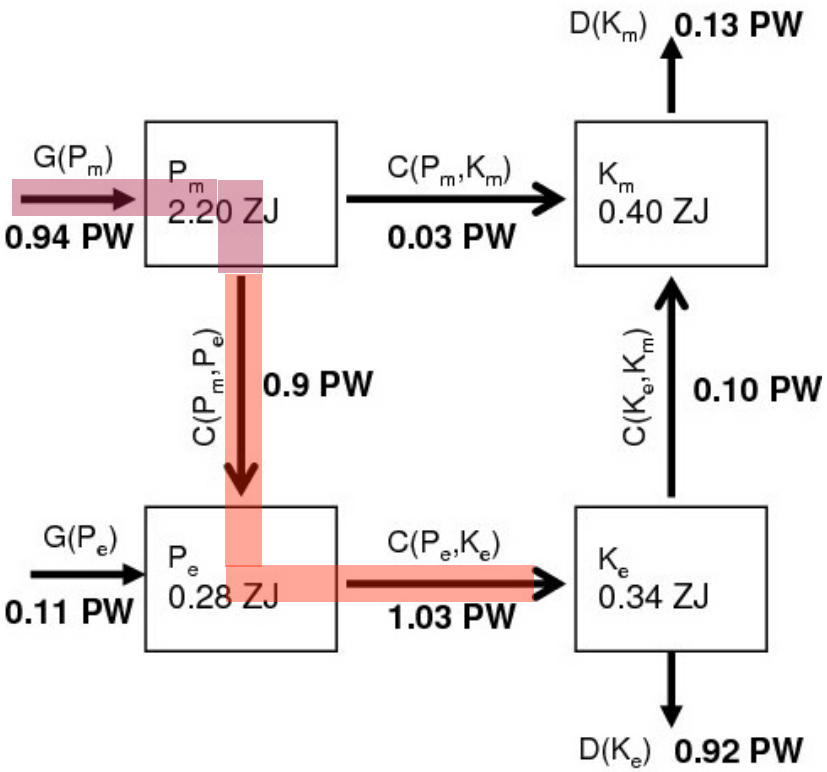


- a global baroclinic pathway transferring of about 0.8 TW in the ocean
- significant conversion from K_m to P_m, so that the baroclinic pathway is fueled by winds rather than by differentially heating only as in the atmosphere

Scientific issues II:

parameterization of meso-scale eddies:
deterministic versus stochastic scheme

The deterministic paradigm

$$\frac{\partial b}{\partial t} + \nabla \cdot \mathbf{F} = q, \qquad \mathbf{F} = \mathbf{v}b = \overline{\mathbf{v}}\,\overline{b} + (\mathbf{v}b)'$$

$$\overline{\mathbf{v}}\,\overline{b} + \overline{\mathbf{v}'b'}$$

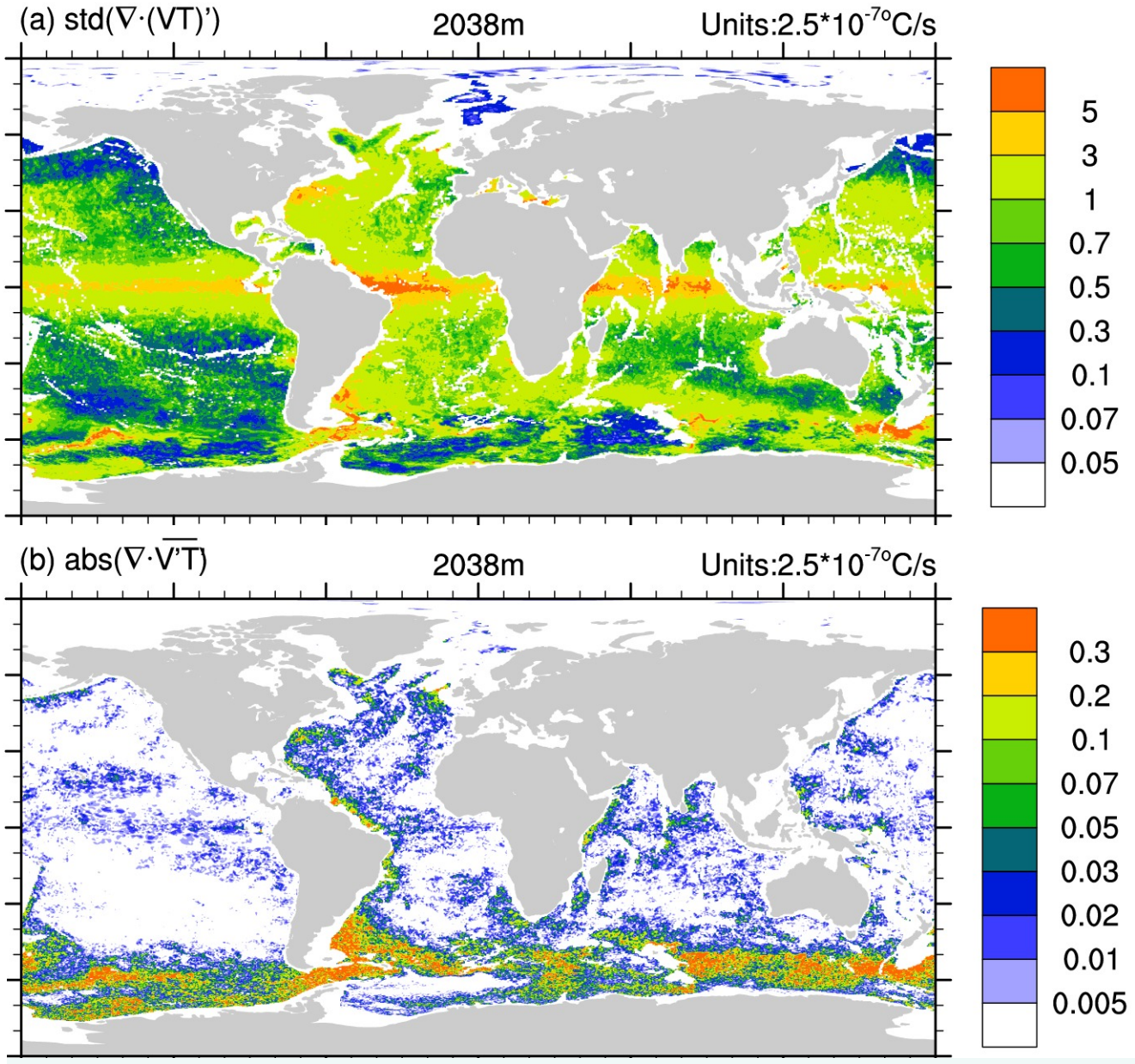
resolved

parameterized in form of a deterministic scheme

Eddy heat flux at 2038 m:

typical magnitude of the fluctuating eddy forcing

magnitude of the mean eddy forcing

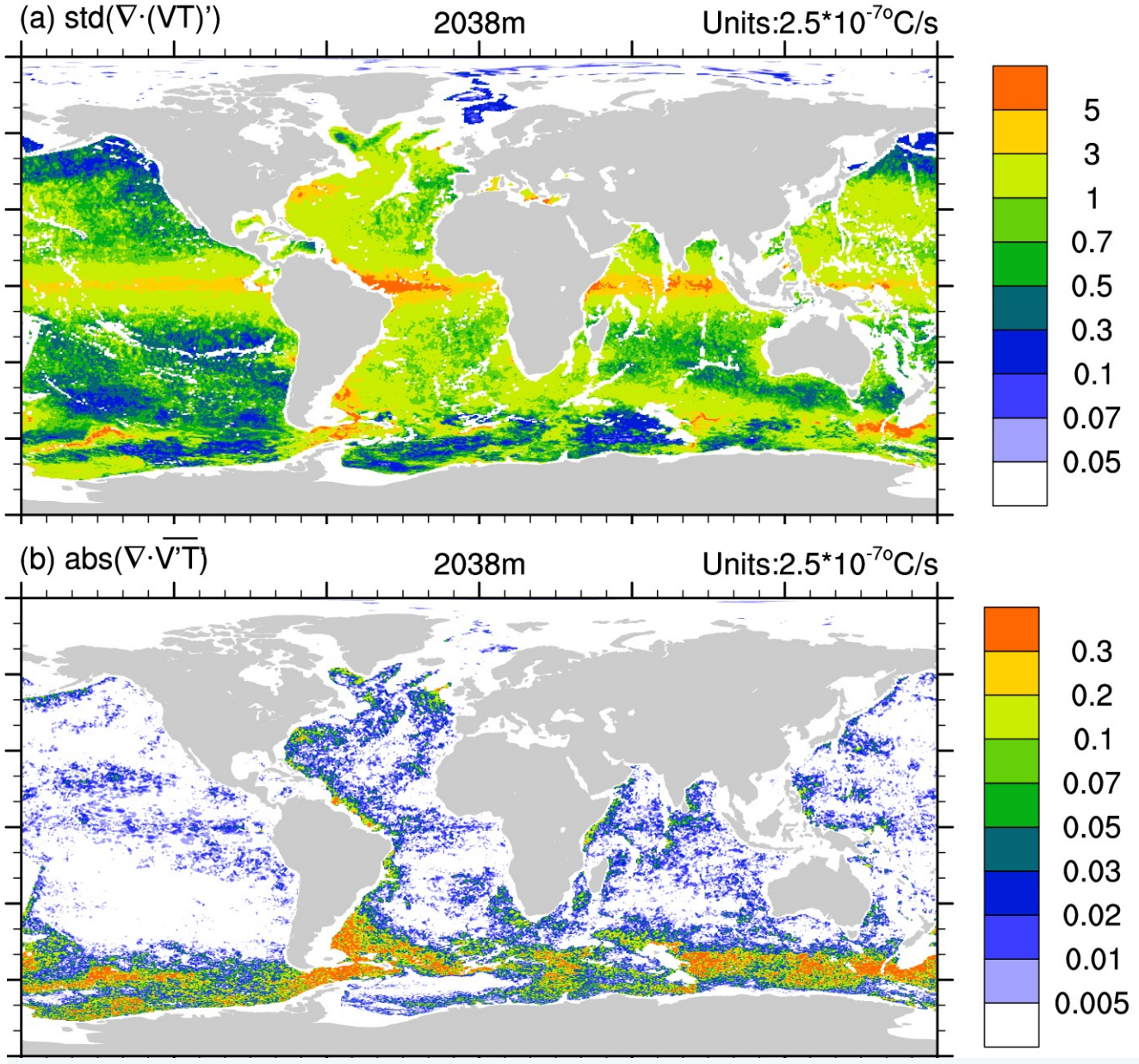


Li & von Storch, 2013

Eddy heat flux at 2038 m: fluctuating forcing is about one order of magnitude or more larger than the mean forcing

typical magnitude of the fluctuating eddy forcing

magnitude of the mean eddy forcing



Li & von Storch, 2013

Scientific issues III:

Impact of meso-scale eddies on the stability and sensitivity of AMOC

- high-resolution coupled modelling needs to be further matured

- a further increase in high-performance computing capacity is most welcome

Thanks!