STORM – Development of a high resolution climate model

Dr. Jin-Song von Storch, group leader in the department „The Ocean in the Earth System“ at Max Planck Institute for Meteorology (MPI-M), and her colleagues at MPI-M and the University Hamburg have accomplished for the first time an estimate of the Lorenz energy cycle for the world ocean with an eddy resolving model within the STORM project. Such an estimate has not been possible with the state-of-the-art ocean models and enables more detailed studies on the sensitivity and stability of the Atlantic Meridional Overturning Circulation and more precise representations of the climate and changes in climate.

One challenge in climate research is to examine how the global energy cycles function in the atmosphere and ocean. Scientists try to simulate the circulation systems with climate models. Through improved understanding and increased computational power, these models have been constantly improved over time. Ocean currents and estimates of the energy transfer via the Atlantic Meridional Overturning Circulation (AMOC) were previously analyzed using coupled atmosphere-ocean models with the oceanic model having a relatively low resolution. The ocean circulation can be simulated more realistically using high-resolution models. Such models enable the representation of small-scale eddies in the ocean and thus enable possible better estimates of the sensitivity and stability for the Atlantic Meridional Overturning Circulation and also more precise statements about the global climate.

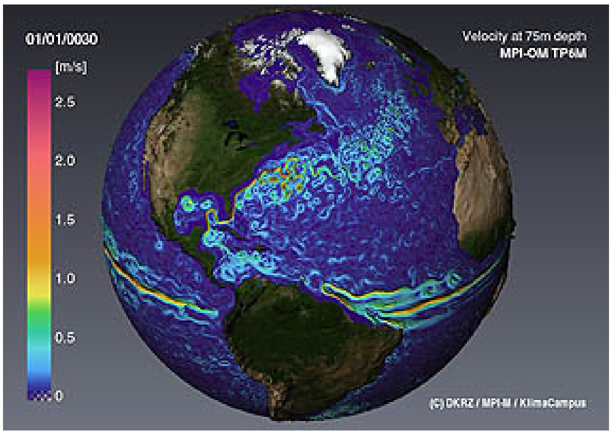

Figure: The visualization of the velocity at 75 m depth clearly shows the structure of the most important currents in the Northern Atlantic. In the gallery of the German Climate Computing Center (DKRZ) you can also see an animated version of this figure.

In the consortium project STORM, Jin-Song von Storch and her colleagues have made a first estimate of the energy cycle for the world ocean with the high-resolution climate model MPIOM/TP6ML80. This has been hardly possible or even impossible because the observational data are sparse for the ocean and the previous low-resolution ocean models were unable to provide the necessary information.

For the atmosphere, the energy cycle can be determined relatively well, since the atmospheric eddies have much larger scales, so that current models and extensive observational data provide sufficient information. An estimate of the energy cycle in the ocean is important to understand how the circulation works. Dr. von Storch and her group demonstrate that the energy cycle of the ocean differs significantly from that of the atmosphere. Although the atmosphere is a heat engine that converts thermal energy (heat) into mechanical energy (wind) between the warm areas of tropical latitudes (source) and colder regions at higher latitudes (sink), the ocean is more like a windmill, that converts wind power into rotational energy of small eddies, or even a refrigerator that uses the wind energy to produce temperature differences in the ocean (von Storch et al., 2012).

The STORM simulations for the ocean are currently being analyzed by different research groups. After the uncoupled simulation for the atmosphere has been successfully carried out, coupled simulations are now being tested. The following climate change experiments will be used to investigate the role of small-scale processes in climate sensitivity.

The model STORM:

The atmosphere and ocean models used within the STORM project are based on the latest version of the ECHAM atmosphere model and the MPIOM ocean model. The mean horizontal resolution of the atmosphere model is approximately 40 km (768 x 384 grid cells on a Gaussian Grid). With 95 vertical levels, the model grid has total 59 Million grid cells.

In order to allow a proper simulation of mesoscale ocean eddies, the ocean model, MPIOM TP6M, uses a setup with even much higher spatial resolution. With a horizontal grid spacing of 10 km, yielding 3602 x 2394 grid cells per layer, and 80 vertical layers, the model equations need to be solved for 690 Million grid cells. A curvilinear tripolar grid was chosen to achieve an essentially homogenous grid.

The project STORM:

STORM is a consortium project initiated by ten German climate research institutes. It aims at developing a climate model at the highest possible spatial resolution and performing simulations with improved representation of small-scale processes in the atmosphere and the ocean. The STORM project is jointly led by Dr. Jin-Song von Storch (MPI-M) and Prof. Dr. Detlef Stammer (Institute of Oceanography, University of Hamburg) in the Excellence Cluster CliSAP.

What are goals of the STORM project? In addition to study the impact of high resolution on climate sensitivity, the simulation results from STORM serve as a basis for further applications using regional models with even finer resolutions, and furthermore can be used for studying the variability and change in various climatic parameters, such as the changes in extremes, the intensity and frequency of storm-related floods, upwelling in coastal areas, their past variability and the influence of anthropogenic climate change, as well as their connection to the corresponding large-scale events.

Project:
https://verc.enes.org/storm

Paper:
von Storch, J.-S., C. Eden, I. Fast, H. Haak, D. Hérnandez-Deckers, E. Maier-Reimer, J. Marotzke and D. Stammer, 2012: An Estimate of Lorenz Energy Cycle for the World Ocean Based on the STORM/NCEP Simulation; Journal of Physical Oceanography 2012 ; e-View doi: http://dx.doi.org/10.1175/JPO-D-12-079.1 .

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