

## **Challenges for Earth System Research: Understanding the multi-scale dynamics**

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Challenges for Earth System Research are related to the understanding the multi-scale dynamics of the spatio-temporal system. In polar research, the exploration of data is of course a challenge by its own. Observations on long time scales are sparse and models have their own inherent limitations. Several examples related to the use of data, models and theory are discussed. It is shown that they have the potential for a truly symbiotic relationship.

Data indicate a strong spatial heterogeneity in the oceans, even on time scales covering the last thousands of years. New model results imply that the modulation of atmospheric circulation pattern and oceanic western boundary currents provides a non-trivial response of the system to external forcing. Atlantic multidecadal ocean variability, and its potential links to rapid oceanic changes and the North Atlantic blocking activity are evaluated. A case study indicates an abrupt weakening of the Atlantic Meridional Overturning Circulation during the 1970s, which can be attributed to the Fram Strait sea ice transport and synoptic scale atmospheric blocking. These results have implications for the prediction of rapid ocean changes and indicate that an important part of the atmosphere-ocean dynamics at mid- and high latitudes requires a proper representation of synoptic scale atmospheric blocking, which is a challenge for current coupled climate models.

Finally, examples for over-simplistic views are for past climate information are mentioned. It is concluded that in the field of Earth System Science, basic knowledge and true collaborative problem solving is necessary to make scientists aware of the underlying principles, the limitations and open questions.

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