Researchers can predict Atlantic Meridional Overturning Circulation

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Climate scientists around Dr. Daniela Matei and Prof. Dr. Jochem Marotzke from the Max Planck Institute for Meteorology and Prof. Dr. Johanna Baehr from Hamburg University have now shown for the first time that the strength of the Atlantic Meridional Overturning Circulation at 26.5 °N can be skillfully predicted for up to four years. Their results have been recently published in *Science*.

The Atlantic Meridional Overturning Circulation (AMOC) - colloquially known as "Gulf Stream" - transports warm surface waters into the high latitudes, where they cool, sink and return southwards at depth as cold North Atlantic Deep Water. Variations in AMOC can significantly affect the northward ocean heat transport and therefore the European and North Atlantic climate. Through its influence on sea surface temperature (SST), AMOC can further impact climate phenomena such as Sahel droughts or the frequency of Atlantic hurricanes. Therefore, it is of outmost importance to be able to predict these climate variations on a time horizon from years to decades. Multi-year climate predictions have so far been limited to predicting surface temperature variations and hurricane frequency, but have not addressed the prediction of any dynamical quantity such as the AMOC.

In the near term (inter-annual to decadal timescales), climate variations are influenced by both anthropogenic forcing and natural variability. This is why the near-term climate prediction models must be started (“initialized”) from the present state of the ocean.

The skill of any prediction system is assessed retrospectively, by performing the so-called “hindcast” or “retrospective forecast” and comparing them with observations. In the present study, ensemble hindcasts have been performed starting in January of each year between 2004 and 2007. The AMOC strength in the hindcasts closely follows the observations for up to four years.

The results of the coupled atmosphere-ocean-model ECHAM5/MPI-OM of the MPI-M have been evaluated against the only continuous available observations of the AMOC over the period April 2004 to March 2009. The AMOC observations were and will be performed in the RAPID-MOC project.

The good agreement between the hindcasts and the observations has motivated Dr. Daniela Matei and her colleagues to also produce AMOC forecasts (more details on the method in the original publication). An ensemble of nine forecasts spanning 10 years has been constructed for each of the Januaries from 2008 to 2011. For all start years the ensemble mean forecasts until 2014 indicate a generally stable AMOC. However, the forecast initialized in January 2010 shows a pronounced minimum in March 2010. This brief minimum was induced by an extremely negative NAO (North Atlantic Oscillation) during the winter 2009/2010.

According to the findings of the working group, the AMOC predictive skill arises predominantly from the basin-wide upper-mid-ocean geostrophic transport. The results of the study demonstrate that the skill of climate prediction arises not only from the large ocean thermal inertia, but also from the long timescales of internal ocean dynamics.

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More information: Multiyear Prediction of Monthly Mean Atlantic Meridional Overturning Circulation at 26.5°N, *Science*, 6 January 2012: Vol. 335 no. 6064 pp. 76-79. DOI: 10.1126/science.1210299

ABSTRACT

Attempts to predict changes in Atlantic Meridional Overturning Circulation (AMOC) have yielded little success to date. Here, we demonstrate predictability for monthly mean AMOC strength at 26.5°N for up to 4 years in advance. This AMOC predictive skill arises predominantly from the basin-wide upper-mid-ocean geostrophic transport, which in turn can be predicted because we have skill in predicting the upper-ocean zonal density difference. Ensemble forecasts initialized between January 2008 and January 2011 indicate a stable AMOC at 26.5°N until at least 2014, despite a brief wind-induced weakening in 2010. Because AMOC influences many aspects of climate, our results establish AMOC as an important potential carrier of climate predictability.

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