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On the transient atmospheric response to an impulsive sea-ice forcing

Paolo Ruggieri (1), Fred Kucharski (2), Roberto Buizza (3), Maarten H. P. Ambaum (4), and Guido Visconti (5)

(1) Department of Physical and Chemical Sciences and CETEMPS, University of L'Aquila, L'Aquila, Italy (paolo.ruggieri@aquila.infn.it), (2) Abdus-Salam International Centre for Theoretical Physics, Trieste, Italy (kucharsk@ictp.it), (3) European Centre for Medium-Range Weather Forecasts, Reading, United Kingdom, (roberto.buizza@ecmwf.int), (4) Department of Meteorology, University of Reading, UK (m.h.p.ambaum@reading.ac.uk), (5) University of L'Aquila, Department of Physical and Chemical Sciences, L'Aquila, Italy (guido.visconti@aquila.infn.it)

The rapid decline of sea-ice cover in the Arctic has instilled great interest in the atmospheric community. One of the aspects that is debated with lack of consensus is whether sea-ice concentration variability has an important feedback on the atmospheric circulation, and to which extent the latter can lead to upstream variations in mid-latitude weather.

The tropospheric response to sea-ice concentration reduction is analysed with a simplified Atmospheric General Circulation Model provided by the Abdus Salam International Centre for Theoretical Physics. Hundred winters are simulated starting from an ensemble of initial conditions, both with a climatological and a reduced sea-ice cover in the Barents and Kara seas. In order to separate a fast, linear response from a slower, indirect response, sea-ice in the second experiment is removed for two weeks, and then relaxed towards a climatological value within one month. This experiment is compared to a control run, and is analysed in terms of the atmospheric response to the (sea-ice induced) shallow heat source.

Two key steps are discussed: the transition from a shallow, local response to a barotropic, larger-scale response, and the impact of the latter on the upper-tropospheric, zonally asymmetric circulation. Tropospheric, low-level eddy heat fluxes are shown to be associated with the indirect tropospheric response. On the other hand, anomalous heat fluxes in the lower stratosphere suggest that early winter sea-ice variations can enhance the troposphere-stratosphere coupling. The 100 hPa eddy heat fluxes are linked to anomalies of potential vorticity through a quantitative, dynamical relation, revealing a weakening of the lower-stratospheric circulation consistent with tropospheric forcing.

This study aims to provide a quantitative description of the dynamical response to the surface heating associated to a sea-ice reduction, and presents a possible explanation of the link between sea-ice variability in the Barents and Kara seas and the circulation over the North Atlantic sector.