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Decadal-Scale Variability in Coupled AOGCM Simulations

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Coupled atmosphere-ocean general circulation models, driven with realistic natural (solar variability, latitudinally dependent volcanic aerosol) and anthropogenic forcings (greenhouse gases, sulphate aerosol, time-varying land-use changes) exhibit variability on interannual to decadal time scales. Such variability is sensitive to the treatment of non-linear feedbacks, such as the temperature dependence of snow albedo. Also the parameterization of processes, such as the inclusion of melt ponds on sea ice, can substantially modify the ice-albedo feedback and thus exert strong influence on mid-latitude climate variability on interannual to multidecadal time scales by modulating the strength and position of mid-latitude storm tracks and the redistribution of tropospheric energy fluxes on a hemispheric scale.

We show results from such a set of experiments covering the period 1500 to 2100. Independent of parameterization, strong warming and an increase of the positive phase of the North Atlantic Oscillation is simulated after 1850. However, high latitude temperatures are strongly dependent on the treatment of snow and ice albedo. Even though the modified parameterizations result in present-day temperatures below those for the standard parameterization, arctic warming is considerably faster and sea ice retreat is much stronger from 2030 on when the changes in the ice-albedo feedback take over.

Cool conditions, e.g. during the Late Maunder Minimum, are accompanied by a decrease in geopotential gradient between low and high latitudes and a decrease of the North Atlantic Oscillation, favouring positive sea-ice anomalies east of Greenland and around Iceland which act on decadal time scales. For the changed parameterization of snow and sea ice during these periods, we find an increase of blocking patterns over

Western Europe, especially in autumn, which contribute to the advection of cold air.