**Proof**



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**TITLE:** Northern Hemisphere Wintertime Regional Trends

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**ABSTRACT BODY:** The amplified Arctic near-surface air temperature is one of the important features of climate change in recent decades. While there is attribution of the polar warming to human influence, winter-spring warming over northern areas of the Eurasia and the cooling of eastern Canada and southern Greenland during the 1980s and 1990s is argued to be largely associated with internal variability such as the positive phase of the Arctic Oscillation/North Atlantic Oscillation (AO/NAO). Although over the past 5-6 years the NAO is in more neutral state, some modeling studies suggest that the anthropogenic forcings, including the increased greenhouse gases and stratospheric ozone loss, may cause a higher frequency of the NAO positive phase.

In addition to the amplified high latitude temperature increase, the global warming resulting from anthropogenic emissions of greenhouse gases may be linked with the effects of fluctuations of atmospheric circulation systems on precipitation distributions. The recent severe snow storms in the northwestern Europe, which is believed to be forced by the low NAO index conditions by the large extent, highlight the effect of natural fluctuations in atmospheric circulation systems on precipitation distribution. Using the GISS climate model with both anthropogenic (time-varying well-mixed greenhouse gases, ozone, tropospheric aerosols, stratospheric water vapor from methane oxidation, a parameterized indirect effect of aerosols on clouds, soot effect on snow and ice albedos, and land use changes) and natural forcings (changing volcanic aerosols, solar irradiance, and Earth orbital parameters), it is shown that human-induced increases in greenhouse gases in the last three decades of the 20th century, as well as anthropogenically forced scenarios for the twenty first century, have contributed to higher year-to year variability of the simulated NAO index reflected in fluctuations of atmospheric circulation systems, which in turn leads to the intensification/deficiency of precipitation in the different regions of the Northern Hemisphere.

The model simulations produce a strengthened meridional pressure gradient over the North Atlantic during the last few decades of the twenties century, as well as in the projected twenty-first century warming scenarios. The NAO index exhibits a tendency towards the positive phase and enhancement of its intensity. The anomalously hot temperatures and heavy precipitation over Northern Europe, western Siberia, south-eastern America and northern Alaska are caused by positive NAO regime, while the negative NAO phase causes the extreme cold conditions over the northern Europe and increasing frequency of frozen precipitation over southern regions in Europe.

Many proxy indicators in paleoclimate variability reconstructions and different studies of past, present and future high-risk events with global and regional models indicate that Europe will face major changes in extreme events, such as heat waves, heavy winter precipitation, extreme wind storms. RCP8.5 scenario with the strongest greenhouse warming presents cooling over major continental areas under the negative NAO phase that confirms enhanced variability and intensity of climate variability under extreme warming conditions.

**CURRENT SECTION/FOCUS GROUP:** Global Environmental Change (GC)

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