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Atmospheric circulation, climate and ice sheets

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Albedo

There is a meridional gradient in absorbed solar radiation, with a net deficit at the poles and a net surplus at the equator. This imbalance drives meridional heat transport.

Between 15°N and 15°S oceanic transport dominates, whilst polewards of 30°N/S atmospheric transport dominates.

The gradient in global radiation absorption is due to: (1) geometry (angle of incidence) and (2) non-uniform planetary albedo. Under present climatic conditions two thirds of the meridional heat gradient is due to variations in geometry and one third due to variations in planetary albedo.

Planetary albedo is dependent on surface albedo, atmospheric absorptivity and atmospheric reflectivity. Due to clouds, atmospheric albedo over the oceans in much larger than surface albedo. Similarly, significant loss of Arctic sea ice may have limited climatic impact, due to the high cloud cover, therefore high levels of atmospheric albedo.

East-West Asymmetries in orography and heating: impact on stationary waves and climate

The large orography of the Himalaya and the Rockies has two effects: (1) generation of standing waves which transport energy northwards, and (2) separate the Pacific and Atlantic storm tracks. This effect is particularly important in the winter, with modelling experiments indicating that without the Rockies, Northeast US would be 12-15 °C warmer.

Storminess and Patterns of Climate Variability- basic model for the NAO, NPO and SAM

The temperature gradient between the equator and the poles is strongest in the winter, creating stronger jets. The jets indicate areas with high potential energy and flow instability, storm tracks which transport heat polewards. The interaction of storm tracks and low frequency patterns in those storms created preferred modes of operation, such as NAO, NPO and SAM.

The short term jet events influence the oceans, which operate on longer timescales, creating the longer term variations in NAO, NPO, SAM...

Impact of ice sheets on circulation, storminess and climate during the LGM

During the LGM, the temperatures were colder than today's modern climate, especially in the northern hemisphere and around the North Pole.

The change in temperature was mainly due to the decrease of CO_2 in the southern hemisphere and to a combination of albedo change (large land ice cover), ice sheet orography and CO_2 concentration (small effect) in the northern hemisphere. The insulation changes between the two climates are small.

The ice sheet cover and orography had a large effect on the storminess: it reduced the storminess in the North Atlantic. The Meridional Temperature Gradient was larger than today's, so the jet speed was higher in North Atlantic but the storminess was lower and the atmospheric heat transport was smaller. This phenomenon is similar to what happens today in mid-winter in the North Pacific. Fewer storms are created but their magnitude was constant throughout the year. This is caused by the increase of stability in the atmosphere over China. During the LGM, the orography of the ice sheet reduced the disturbances that perturb the faster and most unstable storms.

The jet in the northern hemisphere could have shifted towards the equator but there is a lack of data to verify this hypothesis and the models are not able to reproduce this effect.

Increased greenhouse gases, circulation and the ice sheets

The increase of greenhouse gases is expected to move the jet towards the pole in the southern hemisphere and intensify the surface winds. It could energize and warm the subsurface water of the ACC (Antarctic Circumpolar Current) and therefore affect the Antarctic ice sheet.

In the northern hemisphere, it is expected to dry the mid latitudes and wet the high latitudes.