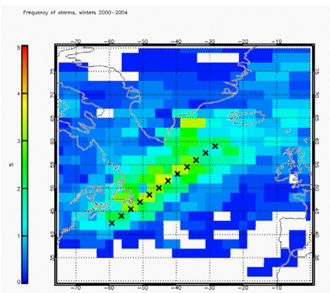
Goddard Institute for Space Studies
New York, N.Y.

Study of the relationship between ice phase and cloud-top temperature with MODIS data

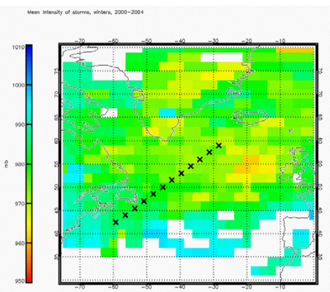
Catherine Naud and Anthony Del Genio, GISS, NY

Abstract: Cloud feedback in GCM climate change simulations is sensitive to predictions of cloud phase because of the different microphysical and radiative properties of liquid and ice. Usually the liquid-ice transition is parameterized as a simple function of temperature, but ice occurrence in clouds is known to depend on the underlying dynamics of the cloud system. We are using MODIS data to gain insights into this behaviour that might serve as a guide to improved parameterizations. Cloud top temperatures were obtained from 5-min level 2 MODIS TERRA and AQUA day-time granules, along with SWIR phase for all available winters (Dec-Jan-Feb) from the start of the missions until February 2004. Cloudy pixels in each granules were selected over the northern parts of the Atlantic and Pacific oceans in the area covered by the storm tracks and aggregated in 2x2.5° grid boxes. For each grid box, all pixels identified as ice only and ice or water are selected and sorted into temperature bins defined every 2K from 200 to 300K. Histograms can then be obtained that give the fraction of ice cloud pixels over the total number of ice and water cloud pixels in a given temperature range. The grid boxes are further aggregated along the best estimate of the storm track trajectory obtained from a contemporary NCEP reanalysis storm track atlas (Chandler and Jonas, 1999) and divided into a west, central and east region. The storm trajectories are chosen so that the storm frequency of occurrence does not vary much over the trajectory. However, we find that both mean intensity (central pressure) and severity (peak intensity) increase along the track.

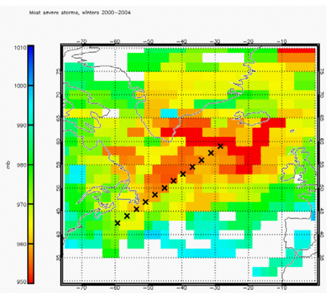
Atlantic ocean



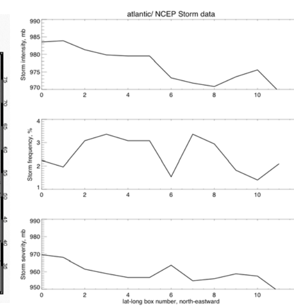
NCEP storm frequency (%) for all winters from December 2000 to February 2004.



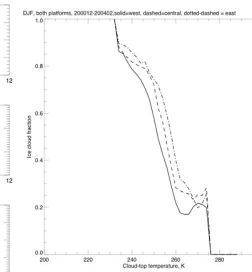
NCEP storm mean intensity (mb) for all winters from December 2000 to February 2004.



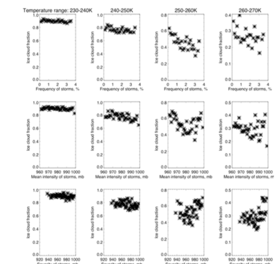
NCEP storm severity (mb) for all winters from December 2000 to February 2004.



Variations along the estimated storm mean trajectory of storm frequency (top), mean intensity (centre) and severity (bottom) as the storms move eastward.

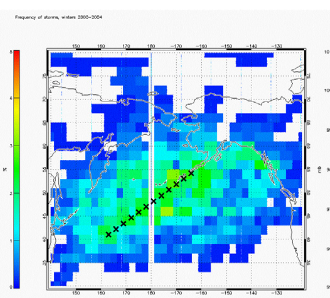


MODIS ice cloud fraction versus cloud-top temperature for all months and both platforms accumulated in the western (solid), central (dashed) and eastern (dot-dash) portions of the storm track.There are at least 10,000 pixels in each 2K temperature range.

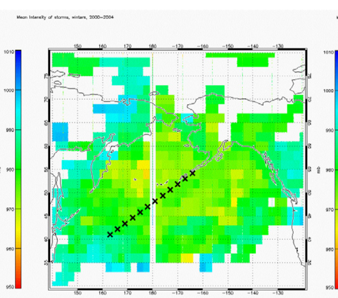


For 4 different temperature ranges, ice cloud fraction versus storm frequency (top), mean intensity (central) and severity (bottom). The ranges are: 230-240K (column 1), 240-250K (column 2), 250-260K (column 3) and 260-270K (column 4).

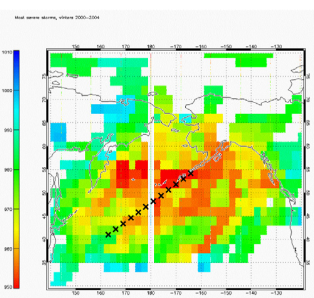
Pacific Ocean



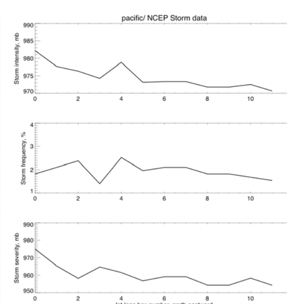
NCEP storm frequency (%) for all winters from December 2000 to February 2004.



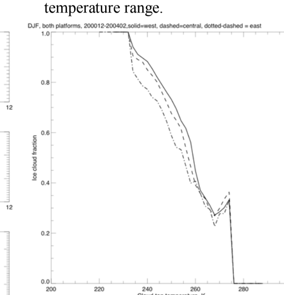
NCEP storm mean intensity (mb) for all winters from December 2000 to February 2004.



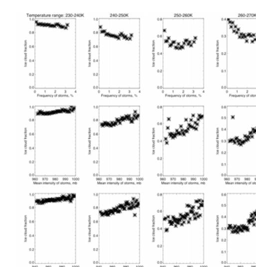
NCEP storm severity (mb) for all winters from December 2000 to February 2004.



Variations along the estimated storm mean trajectory of storm frequency (top), mean intensity (centre) and severity (bottom) as the storms move eastward.



MODIS ice cloud fraction versus cloud-top temperature for all months and both platforms accumulated in the western (solid), central (dashed) and eastern (dot-dash) portions of the storm track.There are at least 10,000 pixels in each 2K temperature range.



For 4 different temperature ranges, ice cloud fraction versus storm frequency (top), mean intensity (central) and severity (bottom). The ranges are: 230-240K (column 1), 240-250K (column 2), 250-260K (column 3) and 260-270K (column 4).

Preliminary Conclusion:

Over the Atlantic storm track region, we found that as the clouds move eastward, the ice cloud fraction at a given temperature tends to increase, implying that heterogeneous freezing becomes more important as the storms travel eastward. Furthermore, there is a correlation between ice cloud fraction and storm intensity, at least for storms with a large enough intensity (pressure < 980mb). As storm intensity increases, ice cloud fraction increases, suggesting a dynamic control.

However, over the Pacific ocean, the behaviour is inverted: the ice cloud fraction decreases as storms move eastward and is anticorrelated with storm intensity, suggesting another influence, perhaps varying aerosol concentration.