Columbia University in the City of New York

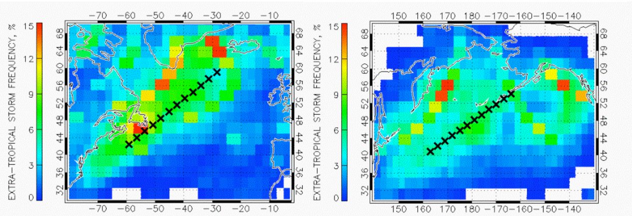
NASA Goddard Institute for Space Studies
New York, N.Y.

Observational constraints on cloud thermodynamic phase in midlatitude storms

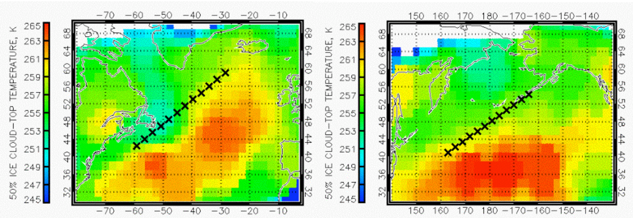
Catherine Naud (Columbia Univ.), Anthony Del Genio (GISS) and Mike Bauer (SGT Inc., NY)

Aim: In order to improve parameterisation of cloud-phase in GCMs we use 2 winters (Dec 2002 to Feb 2004) of AQUA and TERRA MODIS cloud-top temperature and cloud phase selected over the north Pacific and Atlantic oceans. NCEP surface pressure data are analysed to detect and track mid-latitude storms, and vertical velocities are extracted for the area centered on the pressure minimum. Associated precipitation is obtained from the TRMM 3-hourly multi-satellite datatset.

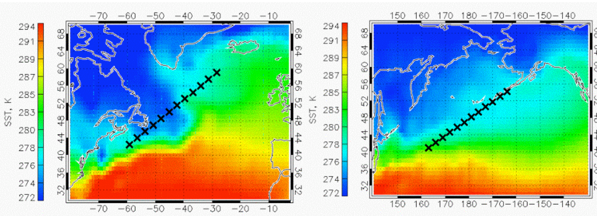
Method:
- Divide each ocean basin into western and eastern parts to check how relation changes with SST and storm phase
- Build histograms of ice fraction (number of ice pixels over ice+water in 2°x2.5° grid cell) as a function of CTT (2K bins) for each ocean and each side of ocean.
- Build composites centered on storm pressure minimum of coincident MODIS CTT, effective radius, precipitation, SST and T50=CTT for ice fraction=water fraction



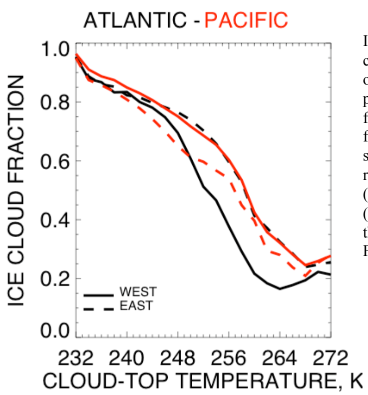
Storm frequency over North Atlantic (left) and North Pacific (right) for winters (DJF) 2002-2003 and 2003-2004 (over time in %)



MODIS T50 distribution for the North Atlantic Ocean (top) and North Pacific Ocean (bottom), from December 2002 to February 2004. The crosses indicate the general direction of the storm tracks. Areas with no phase retrievals (mainly because of the lack of daylight) are shown in white.



NOAA Reynolds sea-surface temperature for the North Atlantic Ocean (top) and North Pacific Ocean (bottom), averaged over December 2002 to February 2004. The crosses indicate the general direction of the storm tracks.



Ice cloud fraction (number of ice clouds detected divided by number of ice and water clouds detected per 2K temperature bins) as a function of cloud-top temperature from MODIS, sampled along ideal storm trajectories divided into two regions: west (solid) and east (dashed) over the Atlantic basin (black) and Pacific basin (red), for the period December 2002-February 2004.

Results:

Atlantic East: T50 warmer south and east of pressure minimum

Atlantic West: T50 quite spatially uniform and colder than in East Atlantic

Pacific East: T50 warmer south of the pressure minimum

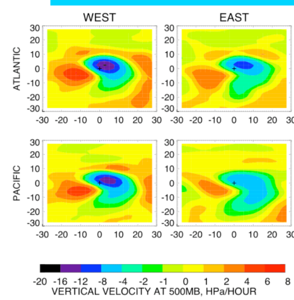
Pacific West: T50 warmer south of the pressure minimum

Differences between Pacific and Atlantic: different SST gradient

Differences between West and East:
- vertical velocity much more vigorous in West Atlantic than other regions=> could lift liquid droplets too quickly for heterogeneous glaciation to occur.
- monthly means of aerosol optical depth and type different.

Conclusion: Dynamics needs to be taken into account in cloud phase parameterization.

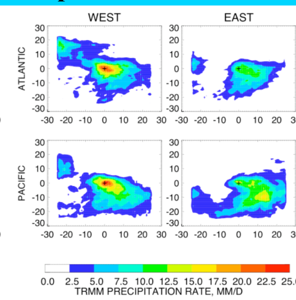
Composites centered on storm sea level pressure minima



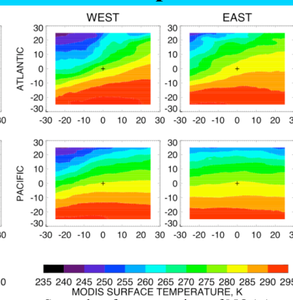
500 hPa pressure vertical velocity (negative upward) obtained from the NCEP-NCAR reanalysis for all storm timesteps, over the Atlantic Ocean (top row) west (left) and east (right) of 50° W and the Pacific Ocean (bottom row), west (left) and east (right) of 177.5°W, for all winter months from December 2002 to February 2004. The + indicates the sea level pressure minimum.

T50= cloud top temperature where ice cloud fraction=water cloud fraction

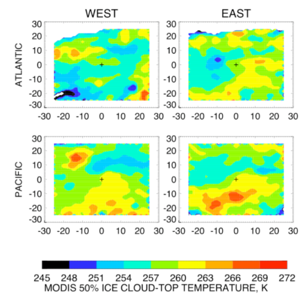
Composite of T50 shows that glaciation occurs at wamer temperatures in the frontal region



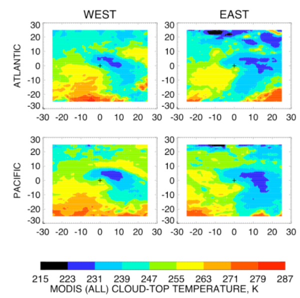
Same but for composites of TRMM precipitation rate.



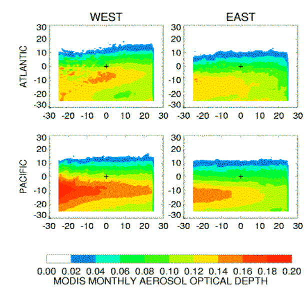
Same, but for composites of NOAA Reynolds SST.



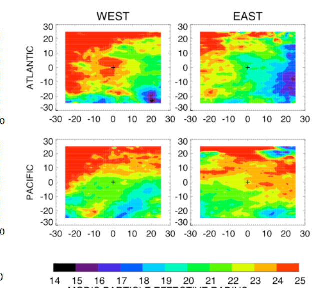
Same but for composites of MODIS T50.



Same but for composites of MODIS cloud-top temperature (for all clouds).



Same but for composites of MODIS monthly mean aerosol optical depth. The color white also refers to the area where no retrievals are available, in the northern portion of each ocean in winter.



Same but for composites of MODIS effective particle size