An Investigation of Atmospheric Model Biases Due to Thin Ice Clouds during Polar Night

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Introduction

The formation and the evolution of cold temperature anomalies in the polar atmosphere is a challenging process hard to predict well enough to insure reliability of medium range forecast in the high and mid latitudes during winter. Atmospheric models are notoriously deficient in simulating the role of clouds in forcing large scale circulation. One of the central processes involved is the treatment of radiation and microphysics in ubiquitous thin ice clouds (TIC) (Grenier et al, 2009) forming during the Arctic night. Using observation data from ground site at PEARL and concurring satellite data from the A-Train, we are starting to investigate biases found in GEM through the data assimilation scheme used for weather forecasts. A particular emphasis is put on the correlation with thin ice cloud types, microphysics, precipitation and radiation.

The synoptic winter circulation is largely driven by latent heat release in the tropics and IR cooling at High Latitudes. Thin polar clouds strongly modulate atmospheric cooling from the whole body of optically thin clouds, that are also poorly treated in models.

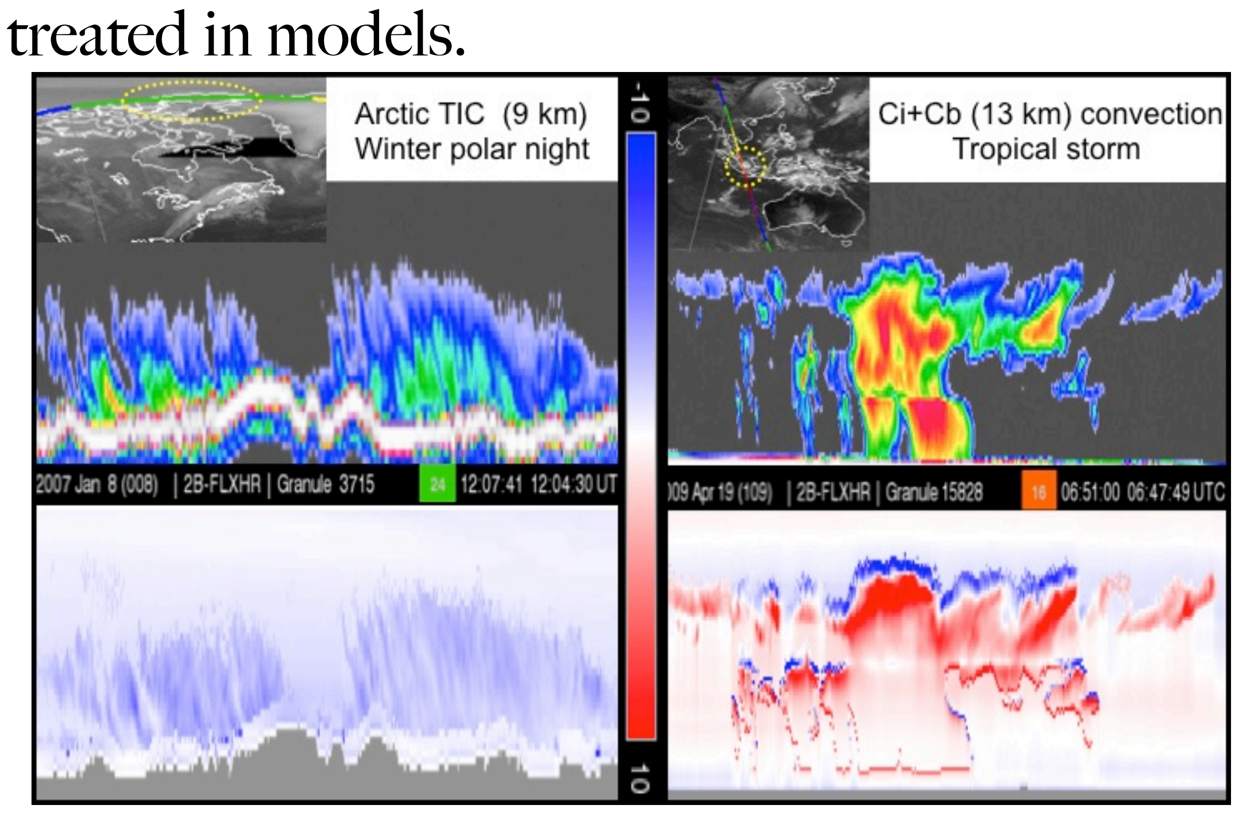

Figure 1: During the polar night, TIC effectively cool everywhere, unlike in warm latitudes where clouds generally cool at the top only and warm from below due to upwelling radiation from the solar heated surface.

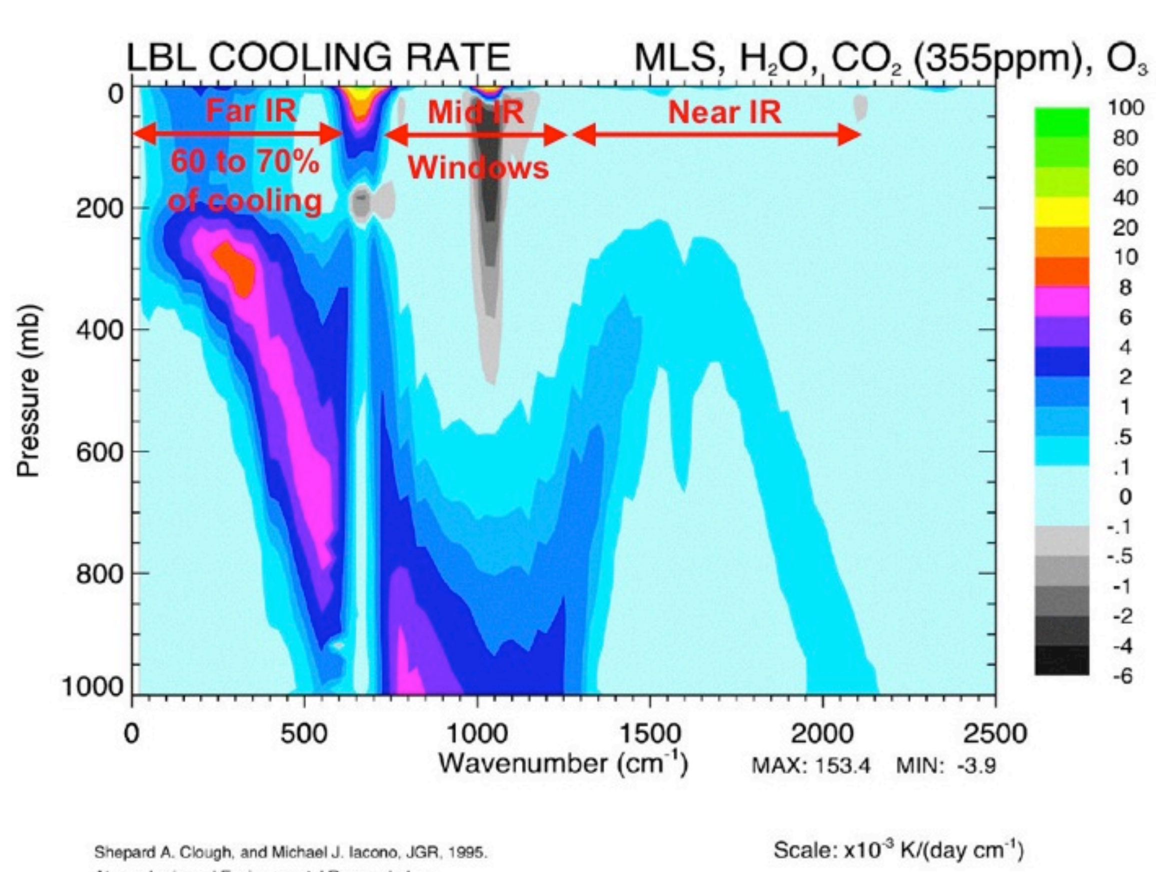

Figure 2: Spectral cooling rates systematically show that most radiative lose are from the far IR range where TIC are also very effective radiators of atmospheric heat to space.

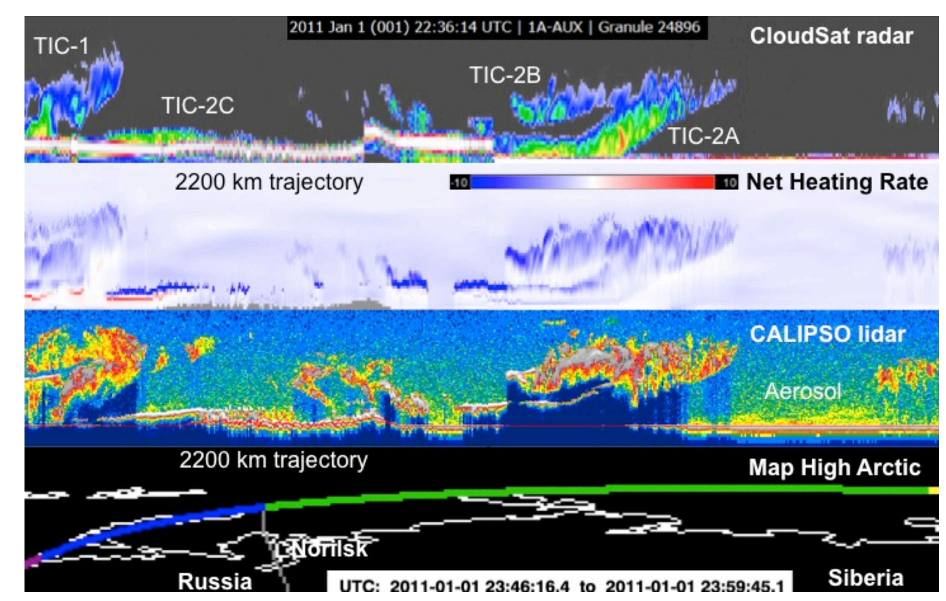

Figure 3: Heating rate from sample orbit (bottom) by CloudSat (top) and CALIPSO (lidar) demonstrating the large scale effects of polar TIC.

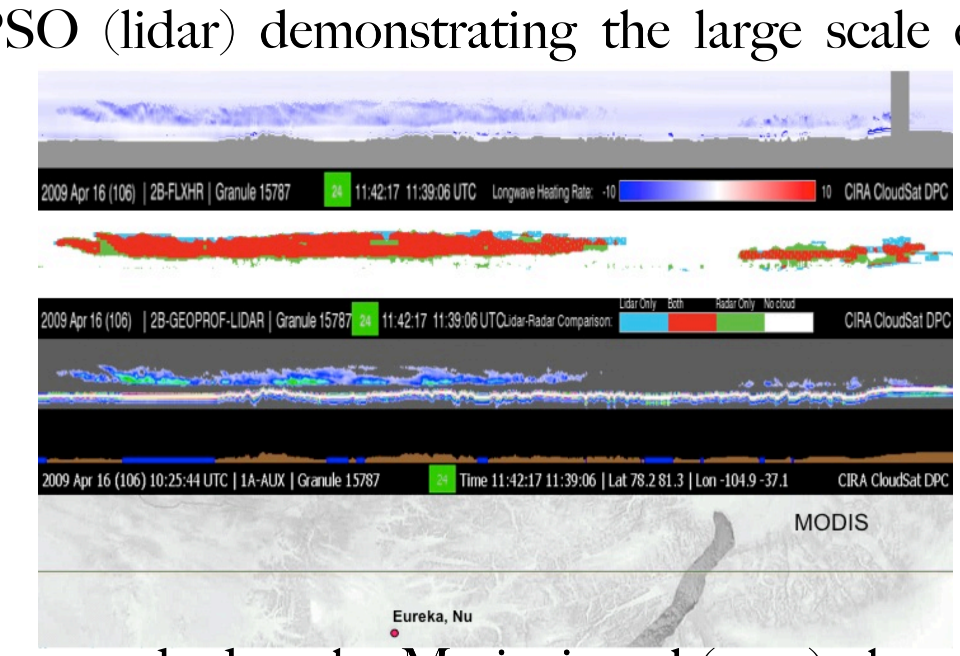

Figure 4: Case study done by Mariani et al (2012) observed by A-Train satellites. Shown top-down are heating rate, CloudSat-CALIPSO mask, CloudSat radar echoes and nearby Eureka orbital passage on April 16, 2009 at 11:42.

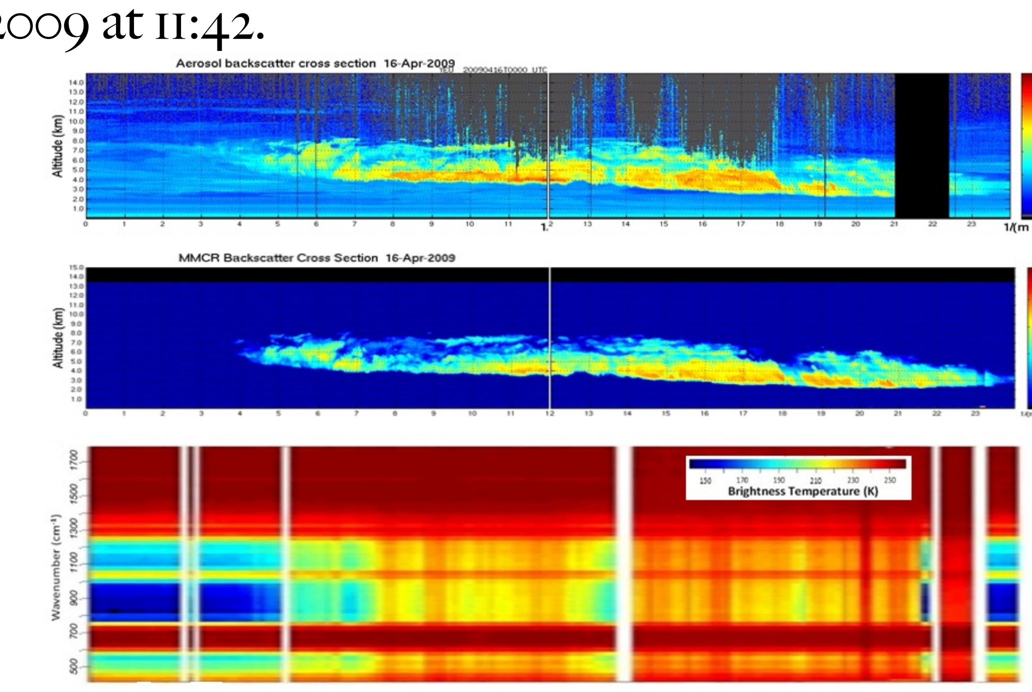

Figure 5: Same case as in Figure 4, but observed from PEARL by Mariani et al (2012). Shown top-down are time series (2019/4/16) for upward looking lidar, MSR radar and E-AERI spectral radiance. Strong modulations due to clouds are seen in the mid and far IR ranges.

Objectives

Using EC data assimilation scheme, we are investigating the atmospheric GEM model biases in TIC regions associated to cloud radiative forcing. Secondly, PEARL high quality data can be use to investigate the improvement of inserting high quality data in the forecast stream.

References

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