

Contrasting GCM simulations of Arctic Mixed Phase Boundary Layer Clouds with Observations from a Tethered Balloon Platform

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Abstract

Mixed phase clouds, consisting of ice particles and super cooled liquid droplets, predominantly found in Arctic, are poorly represented in various climate models. A unique tethered balloon campaign carrying 4π radiometer, a cloud particle imager, and a meteorological package on board was conducted in Ny-Ålesund, Norway, located high in the Arctic at 78.91°N , 11.91°E during May-June 2008. The radiometric and cloud observations at 500nm and 800nm were collected during a month long experimental campaign. A state-of-the-art discrete ordinate radiative transfer model was used to estimate optimal cloud optical properties. These optical properties are contrasted with those of the cloud parameterization in the new NOAA-GFDL AM4 model that is presently being used in the Coupled Model Intercomparison Project 6 (CMIP6). The improved simulation of cloud optical properties will aid in understanding cloud radiation feedbacks and better representation of clouds in global climate model.

A11M-2440* Contrasting GCM simulations of Arctic Mixed Phase Boundary Layer Clouds with Observations from a Tethered Balloon Platform

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Motivation/Background

Mixed phase boundary layer clouds are poorly represented in various climate models.

Used the radiometric and cloud observations collected in a unique tethered balloon campaign conducted in Ny-Ålesund, Norway, located high in the Arctic at 78.91°N, 11.91°E during May-June 2008.

The cloud optical properties of mixed phase clouds using tethered balloon measurements are contrasted with cloud optical parameterization in the new NOAA-GFDL AM4 model that is presently being used in the Coupled Model Inter comparison Project 6 (CMIP6).

References
Sikand, M., Koskulics, J., Stamnes, K., Hamre, B., Stamnes, J., and Lawson, R.P. (2013). Estimation of mixed-phase cloud optical depth and position using in-situ radiation and cloud microphysical measurements obtained from a Tethered Balloon Platform, *Journal of Atmospheric Sciences*, 70, 317-329.
Sikand, M., Koskulics, J., Stamnes, K., Hamre, B., Stamnes, J., and Lawson, R.P. (2010). Optical Properties of Mixed Phase Boundary Layer Clouds Observed from a Tethered Balloon Platform in the Arctic, *Journal of Quantitative Spectroscopy and Radiative Transfer*, 111, 1921-1930.

Approach

Discrete Ordinate Radiative Transfer (DISORT) Two stream model simulated the tethered balloon measurements collected at 500 nm wavelength channel having full width at half maximum (FWHM) of approximately 10 nm.

NOAA GFDL AM4 single column model band 8 in the spectral region 20,000 < ν < 22,300 cm⁻¹ is contrasted with DISORT model. The solar irradiance incident at the top of the atmosphere is 101.2186W/m².

The MODTRAN model in the 20,000-22,300 cm⁻¹ spectral range provided the background Rayleigh scattering and absorption. The plane parallel cloud model of 42 layers simulated using DISORT and NOAA GFDL AM4, included top layer of liquid droplets and bottom layer of ice droplets.

The cloud liquid water content and ice water content was parameterized using Slingo’s approximation.

$$LWC \approx 2/3 \rho_w r_{eff} \beta,$$

here ρ_w is a density of water, r_{eff} is an effective radius of liquid droplets and ice particles, β scattering coefficient $\beta = \frac{d\tau}{dz}$, dτ is an optical depth of computational layer and dz is cloud depth.

Conclusion&Future work

Our results show that NOAA GFDL AM4 model fluxes match the fluxes simulated using DISORT and tethered balloon measurements.

By scaling the estimates of liquid water content (LWC) and ice water content (IWC) the absolute error between the two models- DISORT and NOAA GFDL AM4 was reduced.

The absolute error between the two models was further reduced by scaling the single scattering albedo and asymmetry factor of cloud particles in two models.

The future work will involve the simulation of all the 16 vertical profiles of tethered balloon measurements that will aid in understanding the impact of cloud microphysics on the radiation.

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Results

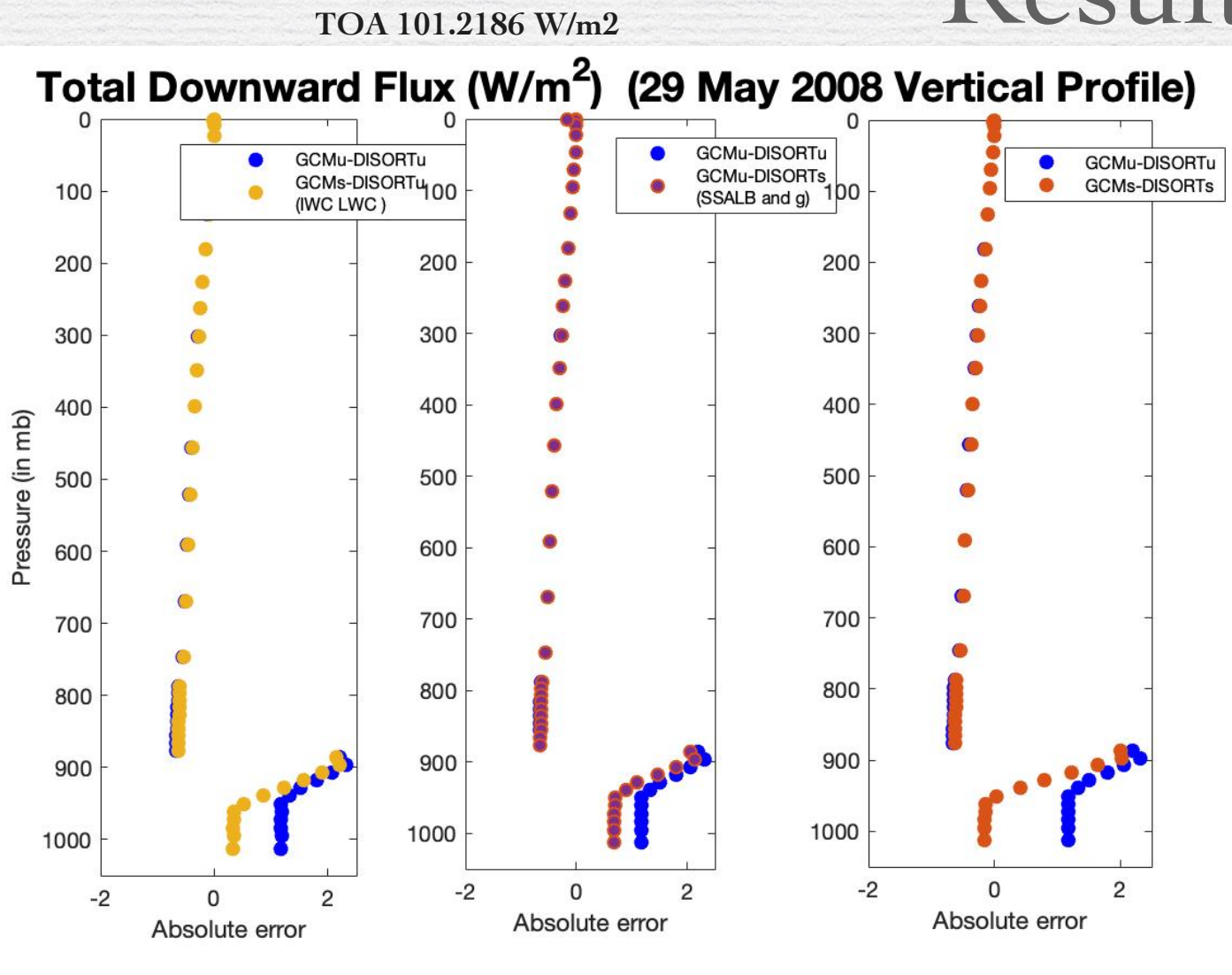


Fig 1: The absolute error in total downward flux simulated in two models – DISORT and NOAA-GFDL AM4 (GCM) using the vertical profile of radiometric and cloud measurements observed on 29 May 2008. “u” stands for unscaled and “s” stands for scaled fluxes. TOA stands for Top of the Atmosphere.

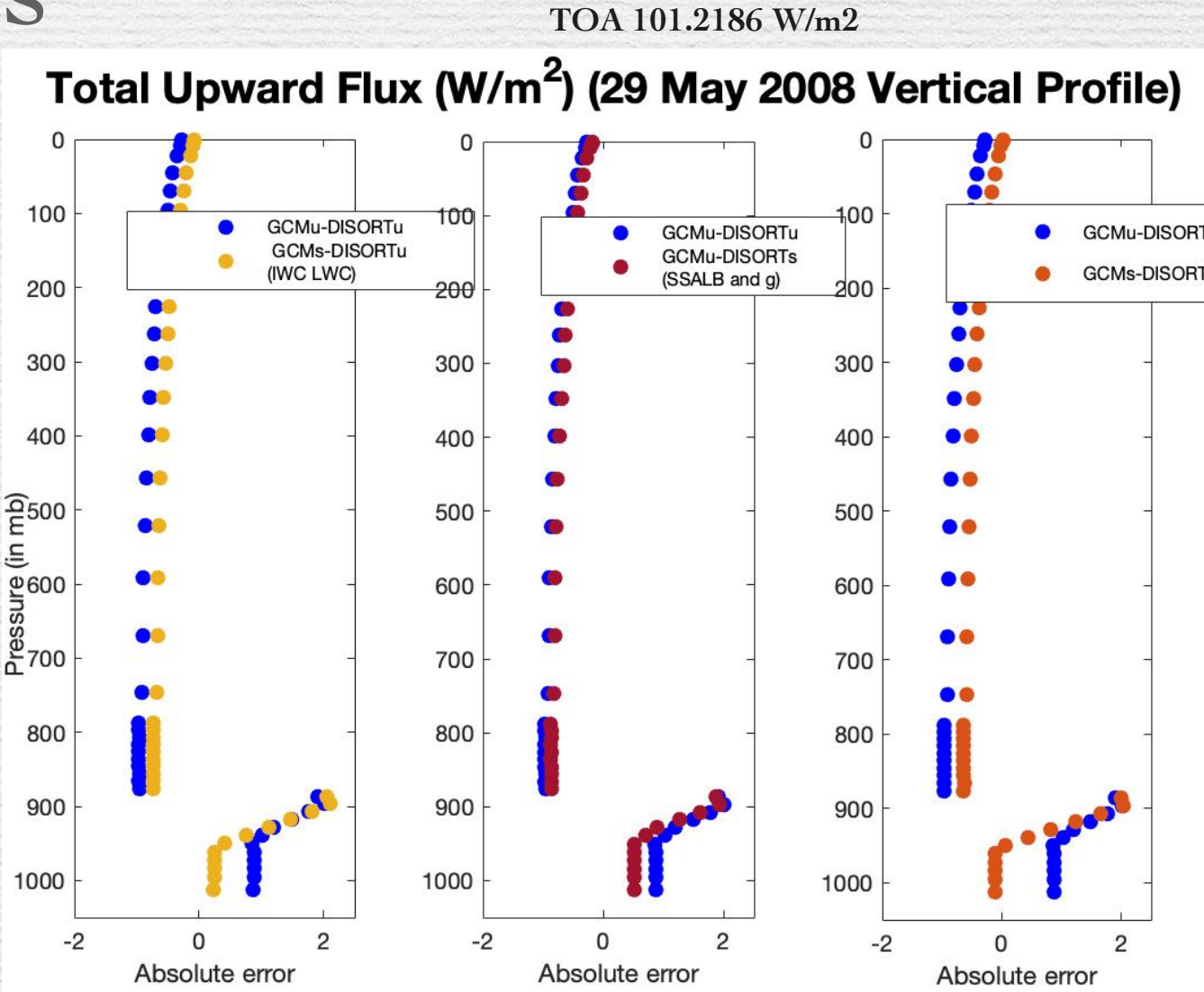


Fig 2: The absolute error in total upward flux simulated in two models – DISORT and NOAA-GFDL AM4 (GCM) using the vertical profile of radiometric and cloud measurements observed on 29 May 2008. “u” stands for unscaled and “s” stands for scaled fluxes. TOA stands for Top of the Atmosphere.

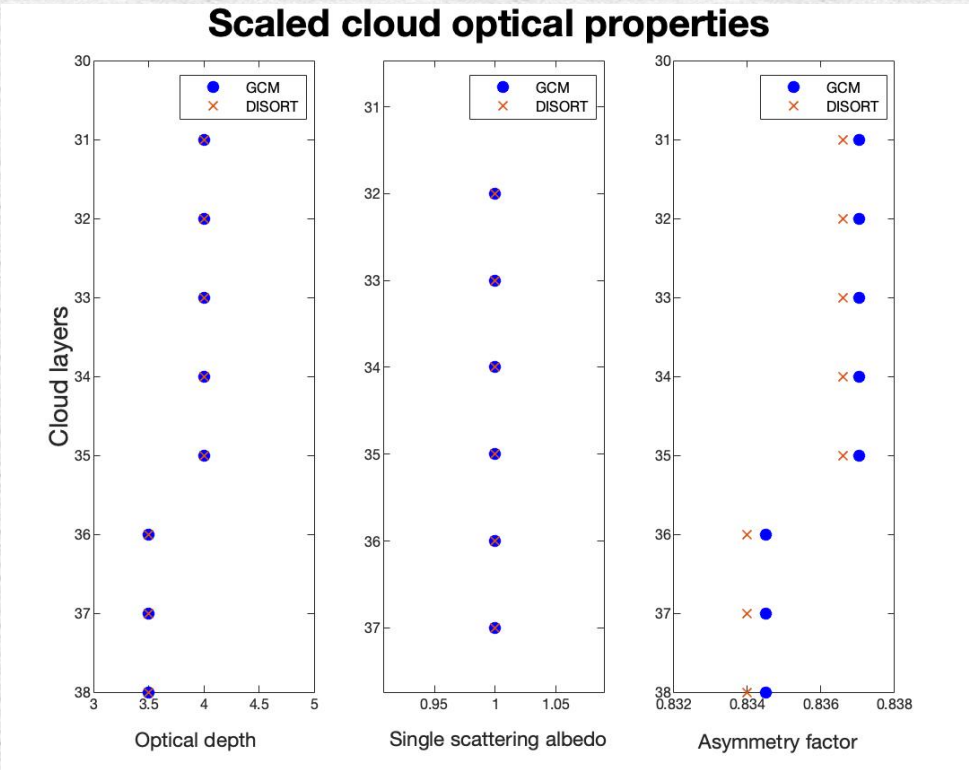


Fig 3: The scaled cloud optical properties that reduced the absolute error in two models- DISORT and NOAA-GFDL AM4 (GCM).