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Research poster: An Overview of progress in NSF EPSCoR project entitled, “Reducing cloud uncertainties in climate models”

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An Overview of Progress in NSF EPSCoR Project entitled, "Reducing Cloud Uncertainties In Climate Models"

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EPSCoR Nevada Infrastructure for Climate Change Science, Education, and Outreach

Motivation/Objective

Problem :

Climate change prediction by the use of Global Climate Models (GCMs) is highly sensitive to cloud feedbacks, which introduce the largest uncertainties in the prediction of climate sensitivity (S) . It was found that 70% of the ensemble variance in the global feedback parameter (λ), where λ = 1/S, was due to two leading factors, the entrainment coefficient and the ice fall velocity.

Hence, characterization of V_f in clouds is critical for accurately estimating climate sensitivity and the earth's radiation budget in general.

General Approach

Better characterization of clouds and accurate representation of V_f in regional and global climate models is possible by:

1. Analysis of new measurements to produce characterizations of the ice particle size distribution (PSD) to parameterize V_f more accurately, based on recent field studies.
2. Using a remote sensing retrieval for better phase discrimination (ice vs. liquid) in clouds
3. Performing long and short range simulations using WRF (Weather Research Forecasting Model).

Short simulations with WRF will determine the direct effect of changes in the cloud microphysics on radiative forcing whereas longer simulations will show the impact of climate feedback effects relative to the standard formulations.

Concept Used For Remote Sensing

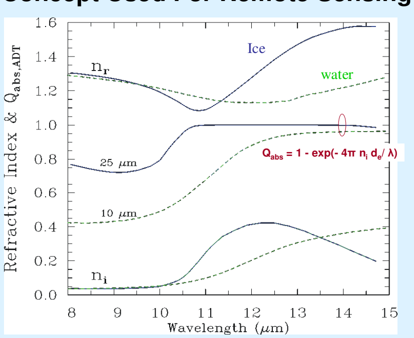


Figure 1. Wavelength dependence of tunneling

The emissivity difference between 12 μm and 11 μm channels enables phase discrimination in clouds and forms the basis of the remote sensing retrieval technique. Based on the emissivity ratio between these channels, the % liquid water content (LWC) in the cloud can be determined.

Project Milestones for the 1st year

1. 4 months – Complete the temperature dependent PSD parameterization for Arctic cirrus.
2. 2 months - Work on completing the framework for the remote sensing technique
3. 5 months - Test and validate the ground based retrieval algorithm that will microphysically characterize Arctic mixed phase and cirrus clouds.
4. 2 months - Work with Dr. Arnott to microphysically interpret FTIR measurements and apply that understanding to the classroom.

Where do I stand ?

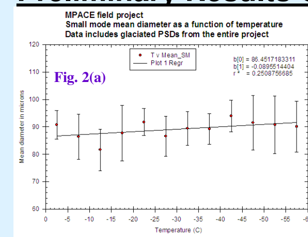
1. A temperature dependent PSD scheme was developed using data from the MPACE field project. This scheme is near completion. We plan on adding data from a more recent field project (ISDAC) to make the present scheme more robust. Results are shown in the adjacent column.
2. A ground based retrieval scheme was developed using AERI radiances in combination with MMCR (Millimeter Cloud Radar) reflectivity measured at the ARM site in Barrow, AK. A case study analysis was also done that showed the presence of liquid water in Arctic ice clouds (see figure 4).

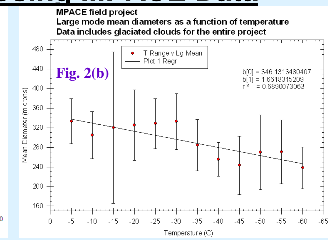
   However, it was realized that this scheme was not reliable because the AERI data used for this retrieval already had preexisting assumptions imposed in regards to particle size. As such, we plan on using satellite remote sensing as described in Mitchell et al. (2009) for cloud phase discrimination and % liquid water calculation.
4. A paper using measurements from a FTIR (Fourier Transform Infra Red) spectrometer aimed at undergraduate students in Atmospheric Sciences was laid out and work is under progress to submit a paper in BAMS.

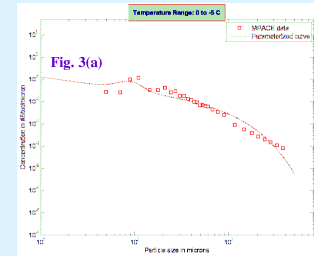
Future Goals

- Work with Dr. Mitchell to resolve problems in the current Arctic PSD scheme to obtain a robust Arctic cloud PSD.
- Work with Dr. Arnott to complete the paper based on FTIR measurements.
- Work with Dr. Mitchell on satellite remote sensing as an alternative to the ground based remote sensing in order to determine the % liquid water in cold (-15 to -35 °C) clouds.
- Incorporate results from improved cloud PSDs to parameterize V_f more accurately in climate models like WRF.
- Perform simulations using WRF to determine the effects of cloud microphysical changes on radiative effects

Preliminary Results Using MPACE Data







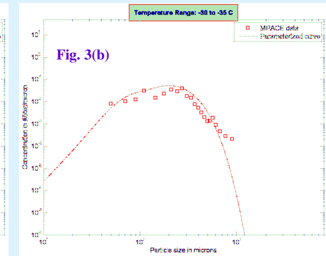


Figure 3(a) and (b) show agreement between parameterized curves and observational data. However, small differences were encountered in two temperature regimes (-40 C to -45 C) and (-15 C to -20 C) which can be resolved with higher order curve fits.

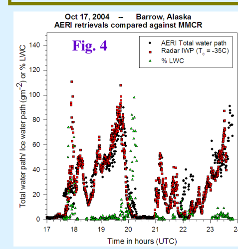
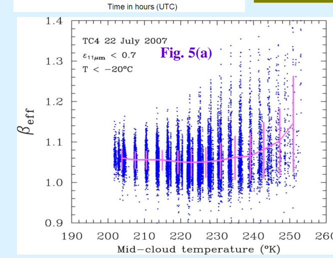
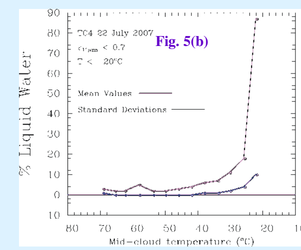


Fig. 4 shows retrieved cloud liquid and ice water path in an Arctic cloud using two methods: radar and passive infrared radiation. These ground-based remote sensing methods will be replaced by a satellite remote sensing method that is more theoretically robust.

Fig. 5(a) and (b) show a case study analysis of anvil cirrus clouds off Costa Rica using the satellite remote sensing technique developed by Dr. Mitchell.





Acknowledgements

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