The Accuracy of Retrieved Cloud Properties Impacted by Systematic Error

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Overview

For this project I looked at the accuracy of cloud optical property retrievals, focusing on the biases induced by an overlying aerosol layer above the cloud.

Measurements -
- Cloud retrievals are made by comparing measured and modeled albedo (upwelling irradiance/downwelling irradiance.)
- Solar Spectral Flux Radiometer (SSFR) is an instrument aboard an airplane that measures.

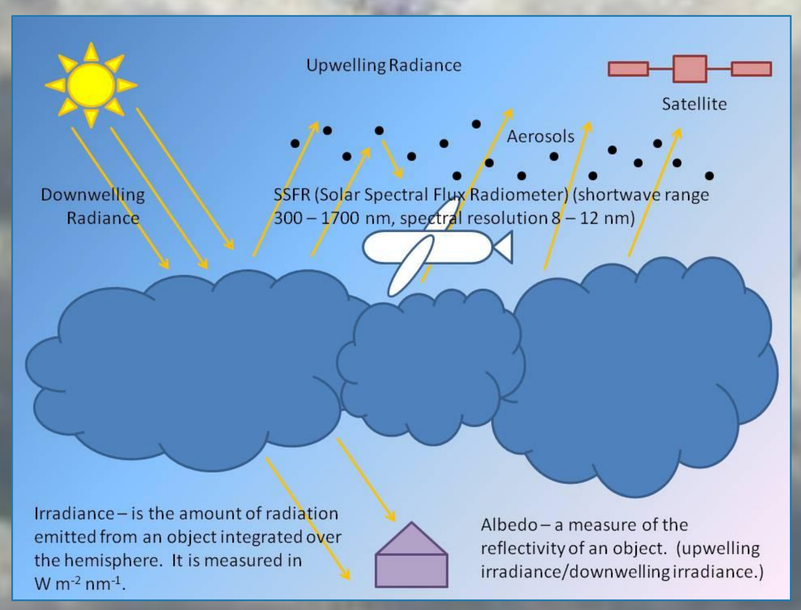
Modeling -
- The forward model takes into account the physics of liquid water absorption to create a look up table of cloud albedo defined by a cloud optical thickness and effective radii pair.
- The forward model does not typically consider sources of systematic error, such as aerosols, which can result in a biased retrieval.

Statistical tool -
- Using a statistical program known as GENRA (Generalized Nonlinear Retrieval Analysis), it was possible to characterize the bias induced by an overlying absorbing aerosol layer above the cloud for different cloud types in an efficient way.
- Future research includes using GENRA to study other biases such as 3D cloud effects.

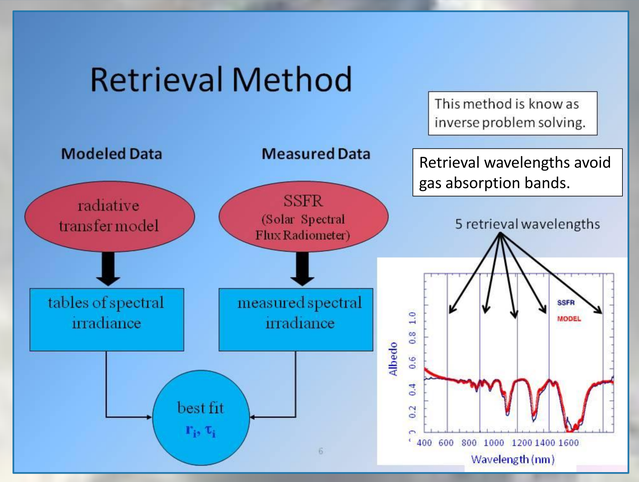
Why Study Clouds?

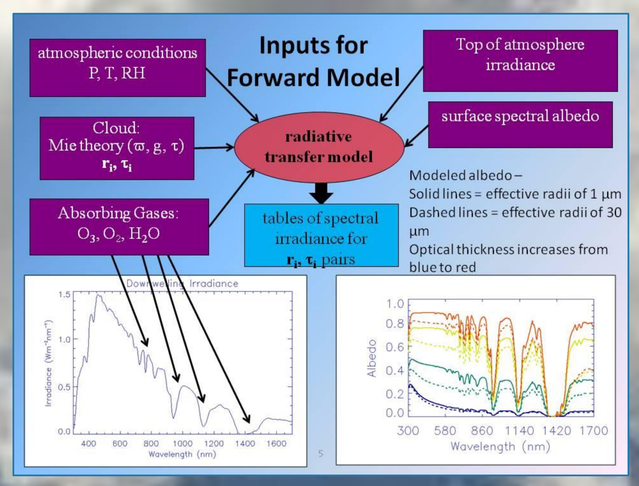
"Knowledge of cloud properties, including their spatial and temporal variability, is needed for understanding and quantifying the role of clouds in climate variability and for modeling clouds and their effects in climate and weather models." (Vukicevic, et al. 2010)

The measured data that I worked with came from the SSFR instrument which is aircraft bound and measures upwelling and downwelling irradiance. We use the albedo for our cloud retrievals.



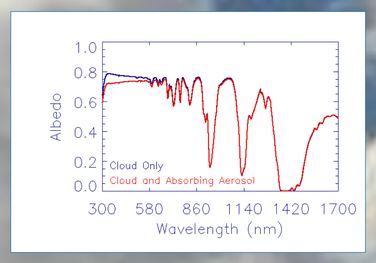
In order to measure clouds we use an inverse problem solving method that compares modeled data with measured to find the optical depth and effective radii pair that matches the irradiance that we have measured.





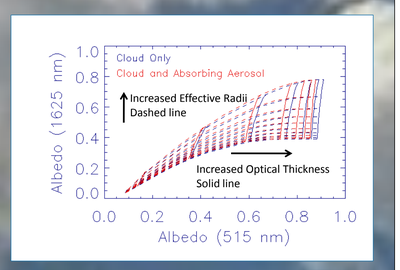
Bias – The Ultimate Enemy

- Overlying absorbing aerosols reduce cloud albedo.
- These aerosols bias the cloud retrieval giving us inaccurate information about the cloud, which could be confused with the indirect aerosol effect.
- Aerosol 1st Indirect Effect – when aerosols physically change cloud microphysical properties and therefore change its albedo.



Here you can see that an aerosol changes the albedo, which would change the optical properties retrieved, giving us a biased view of the cloud.

This graph shows a snap shot of a 2 wavelength retrieval for many cloud types. As the lines become orthogonal they become independent so that one property can have bias when the other does not.



Tools for Characterizing Cloud Retrievals

GENRA
(Generalized Nonlinear Retrieval Analysis)

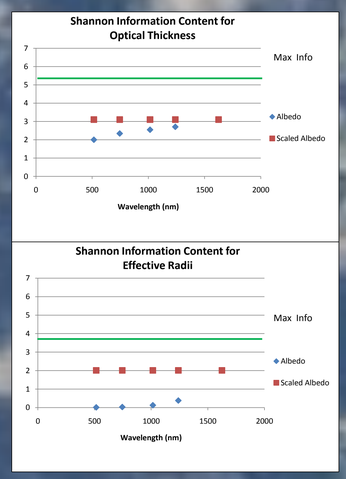
GENRA is a statistical program that lets us study cloud retrievals from many cloud types with and without systematic error *in an efficient way*.

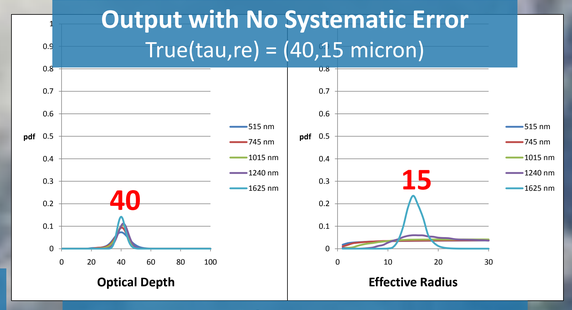
PDFs

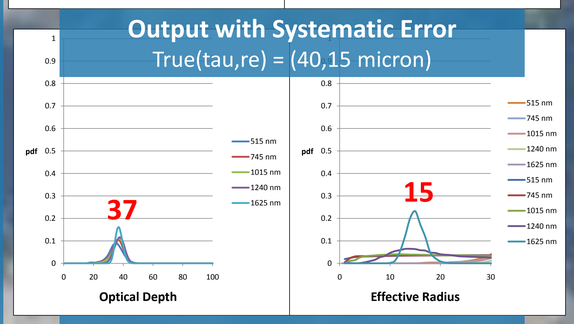
- Makes use of the pre-existing look up table.
- Defines pdfs of measured and modeled albedo.
- Aerosol impact is treated as a systematic error (shift) in the model pdf.
- Solution pdf is the expected behavior in retrieved cloud properties.

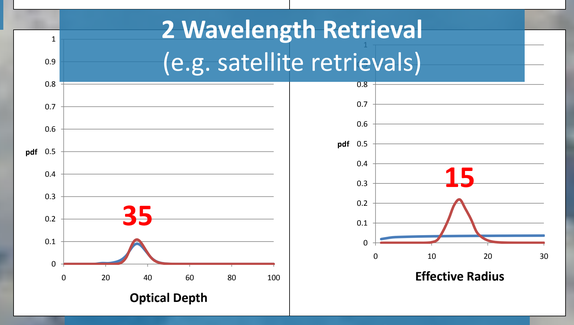
Shannon Information Content

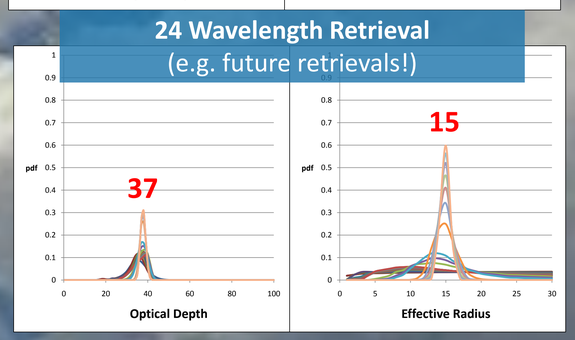
- A formal mathematical theory to quantify the information gained by making a measurement.
- It's a scalar.
- Maximum information content is dependent on resolution of the look up table.





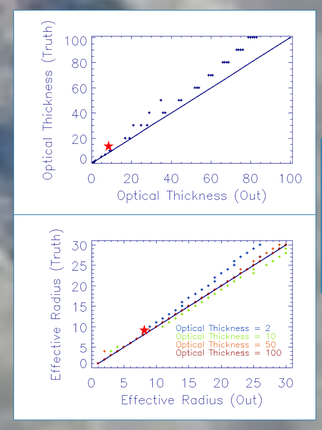






Results

By looking at the Shannon Information Content for the output from the albedo and comparing it to the output from the scaled albedo we see that no new information is gained.



The red stars are points taken from actual SSFR data when aerosols were present. (Coddington, et al. 2010)

We were able to characterize the bias induced by aerosol over all cloud types and found that retrievals of thicker clouds have a large, low bias of optical depth and thin clouds have a large low bias of effective radii.