The Accuracy of Retrieved Cloud Properties Impacted by Systematic Error

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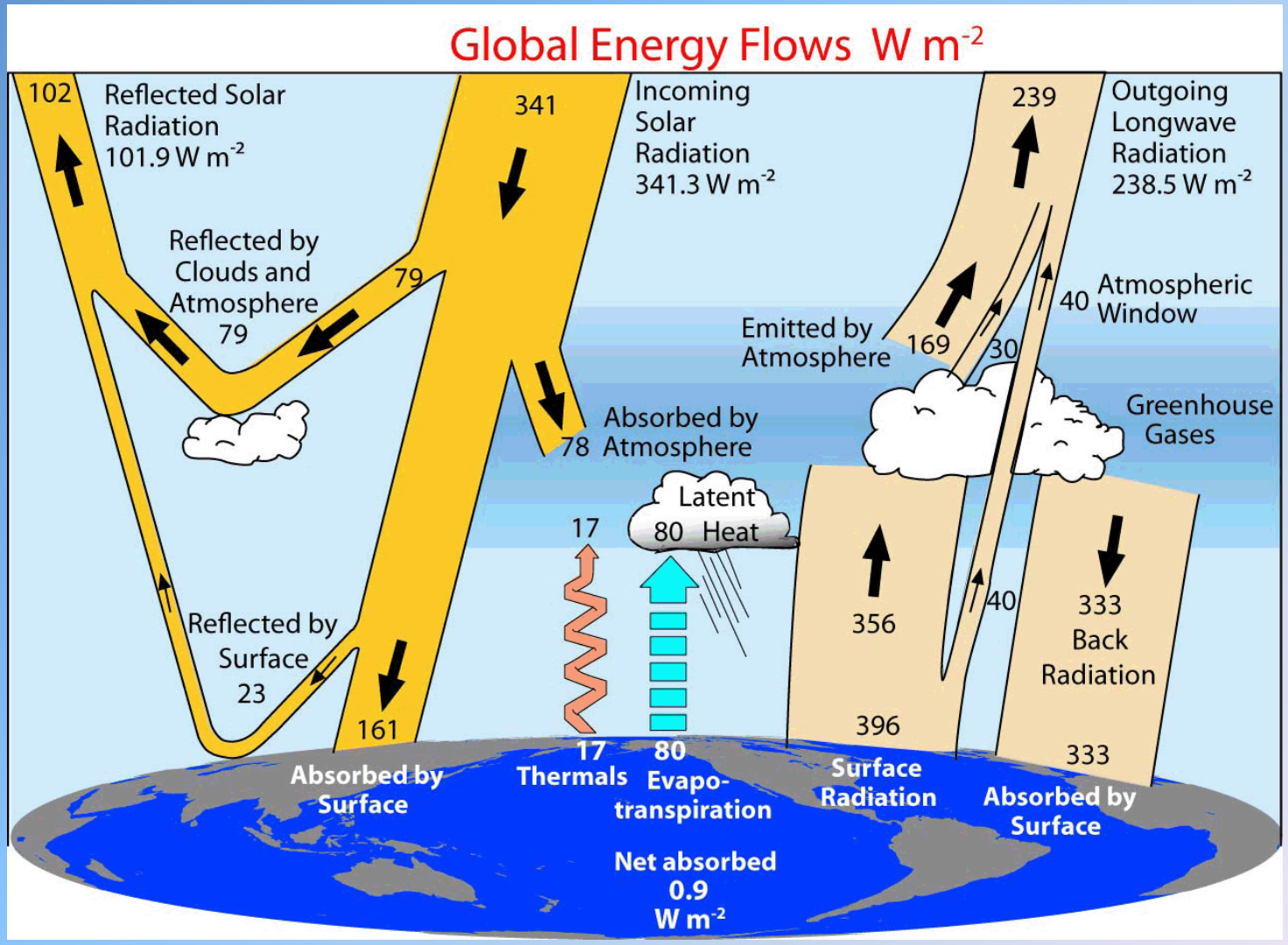
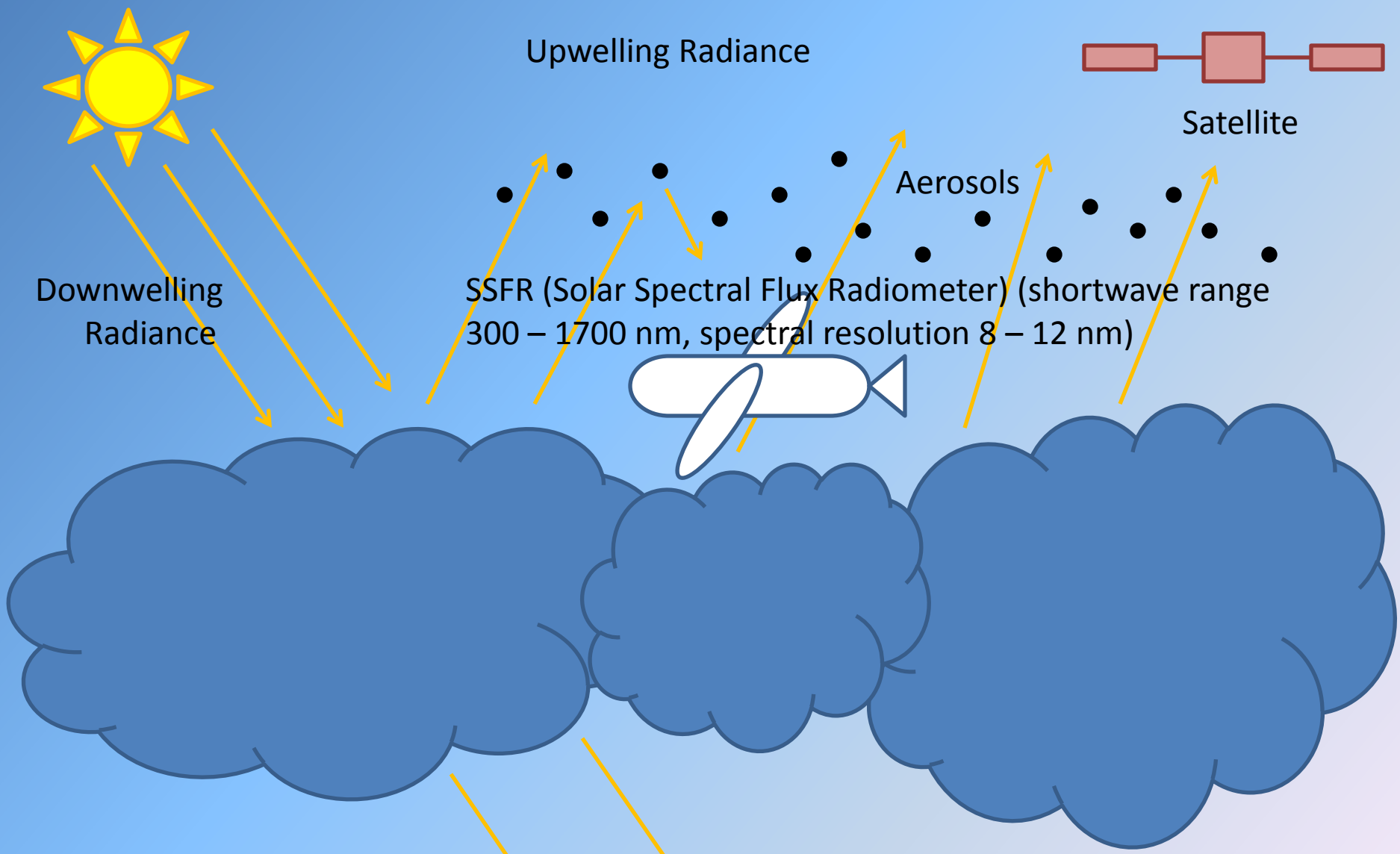
Why Study Clouds?

- They are pretty to look at!
- “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)

Most importantly clouds effect our climate.





Irradiance – is the amount of radiation emitted from an object integrated over the hemisphere. It is measured in W m^{-2} nm^{-1}.

Albedo – a measure of the reflectivity of an object. (upwelling irradiance/downwelling irradiance.)

Inputs for Forward Model

atmospheric conditions
P, T, RH

Top of atmosphere irradiance

Cloud:
Mie theory (ϖ, g, τ)
$\mathbf{r_i}$, $\boldsymbol{\tau_i}$

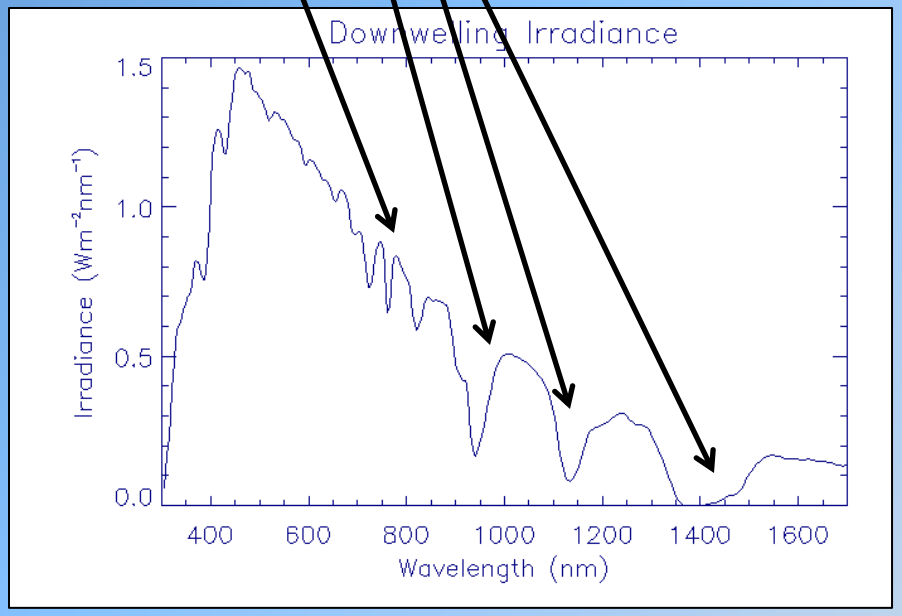
surface spectral albedo

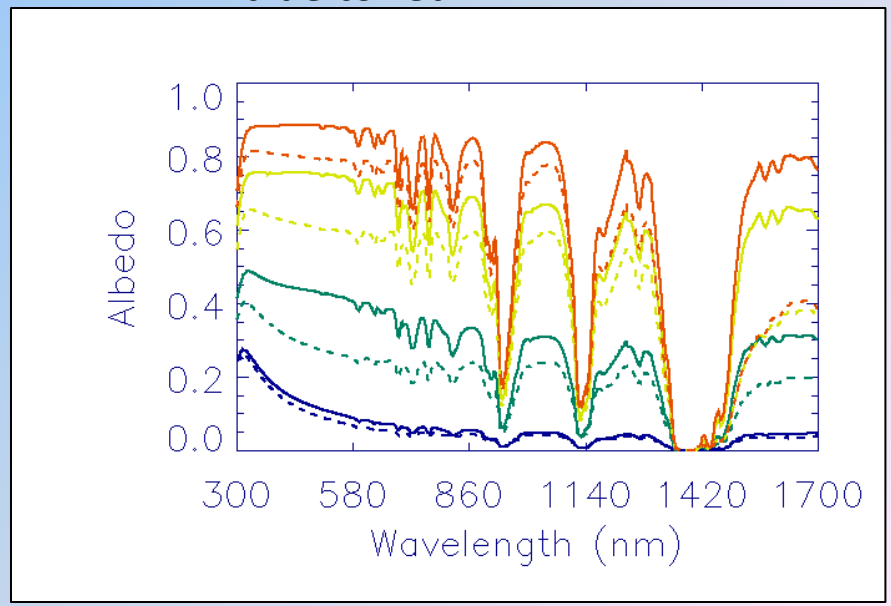
radiative transfer model

Absorbing Gases:
O_3, O_2, H_2O

tables of spectral irradiance for
$\mathbf{r_i}$, $\boldsymbol{\tau_i}$ pairs

Modeled albedo –
Solid lines = effective radii of 1 µm
Dashed lines = effective radii of 30 µm
Optical thickness increases from blue to red





Retrieval Method

This method is know as inverse problem solving.

Modeled Data

Measured Data

radiative transfer model

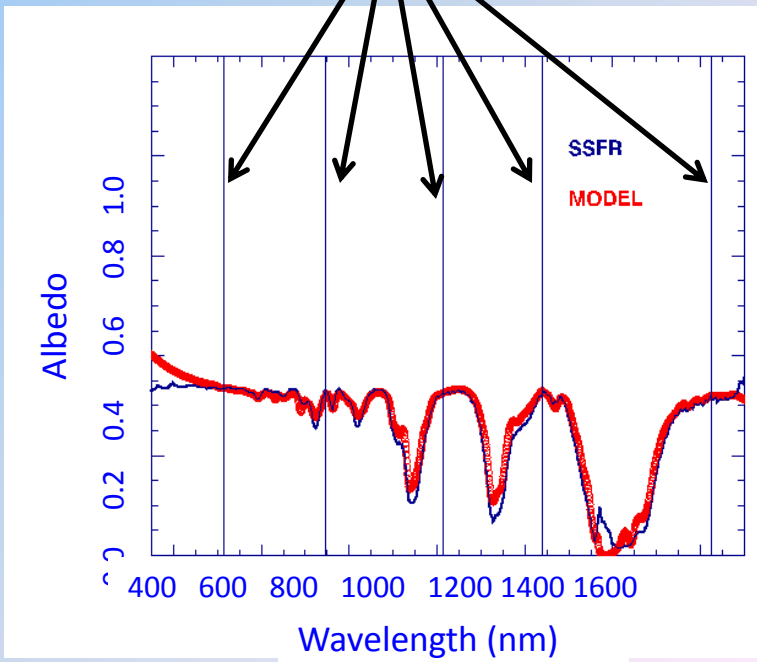
SSFR (Solar Spectral Flux Radiometer)

tables of spectral irradiance

measured spectral irradiance

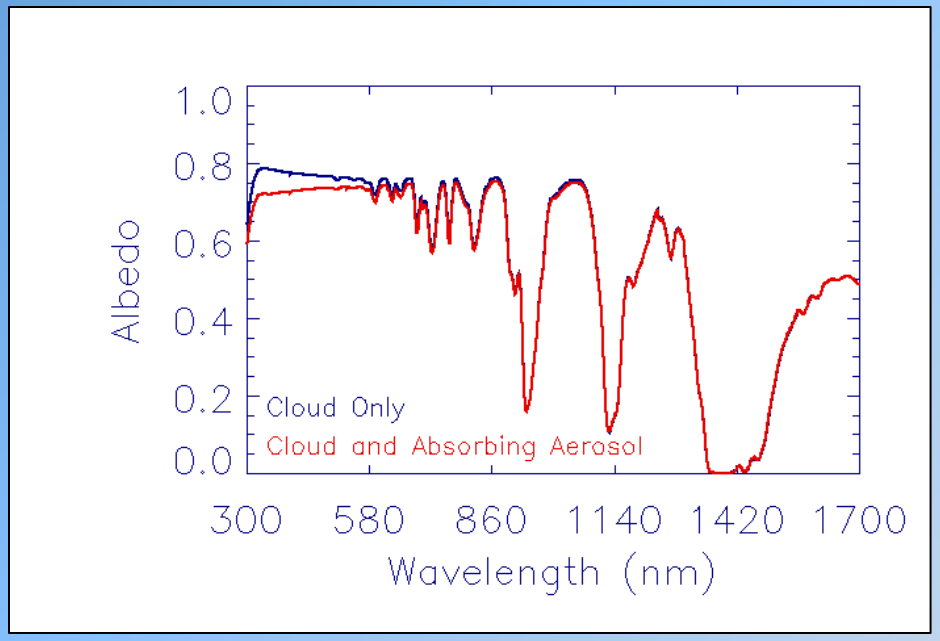
best fit r_i, τ_i

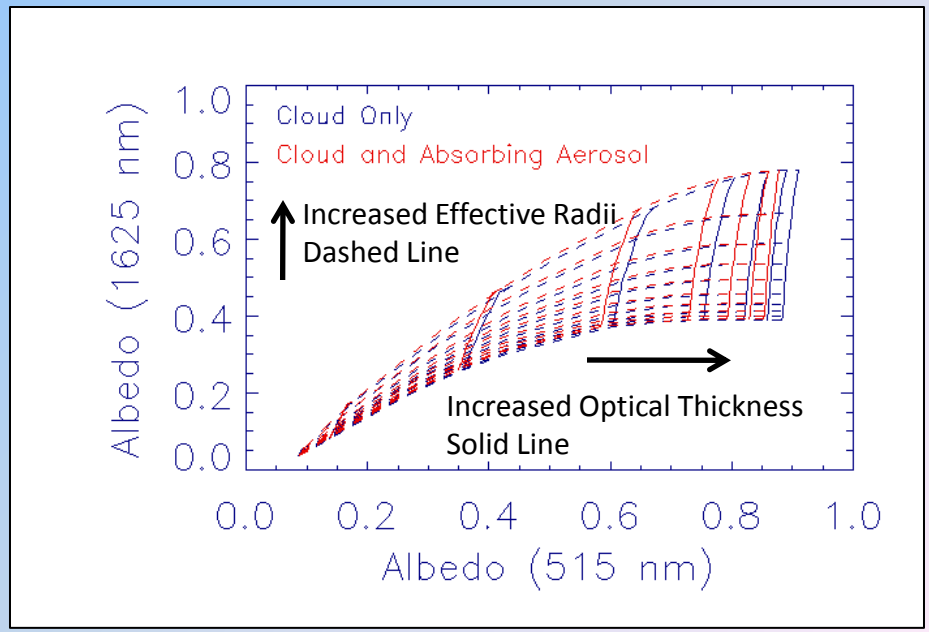
5 retrieval wavelengths



Bias – The Ultimate Enemy

- Overlying absorbing aerosols reduce 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.





GENRA

(Generalized Nonlinear Retrieval Analysis)

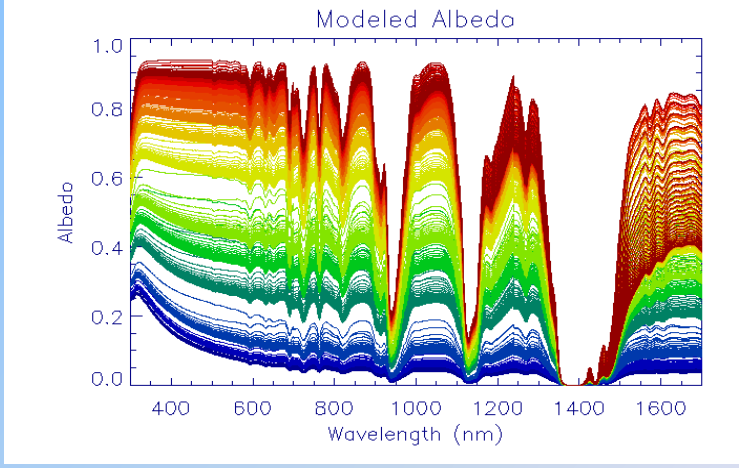
- GENRA is a statistical program that lets us study cloud retrievals from many cloud types with and without systematic error *in an efficient way*.
- GENRA
  - Makes use of the pre-existing look up table.
  - Defines pdfs of measured and modeled albedo.
  - Aerosol impact is treated as a systematic error (shift) in the model pdf.
  - Solution pdf is the expected behavior in retrieved cloud properties.

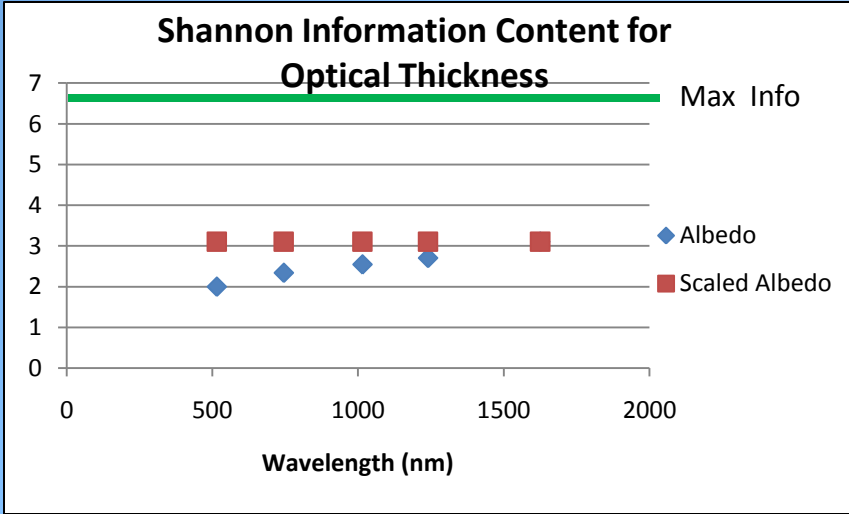
Shannon Information Content

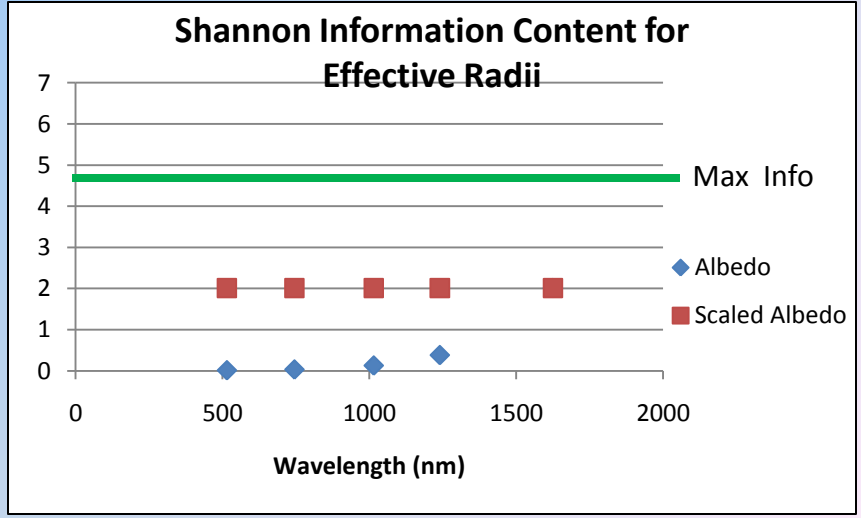
- A formal mathematical theory to quantify the information gained by making a measurement.
- Maximum information content is dependent on resolution of the look up table.
- It’s a scalar.

To Scale or Not to Scale?

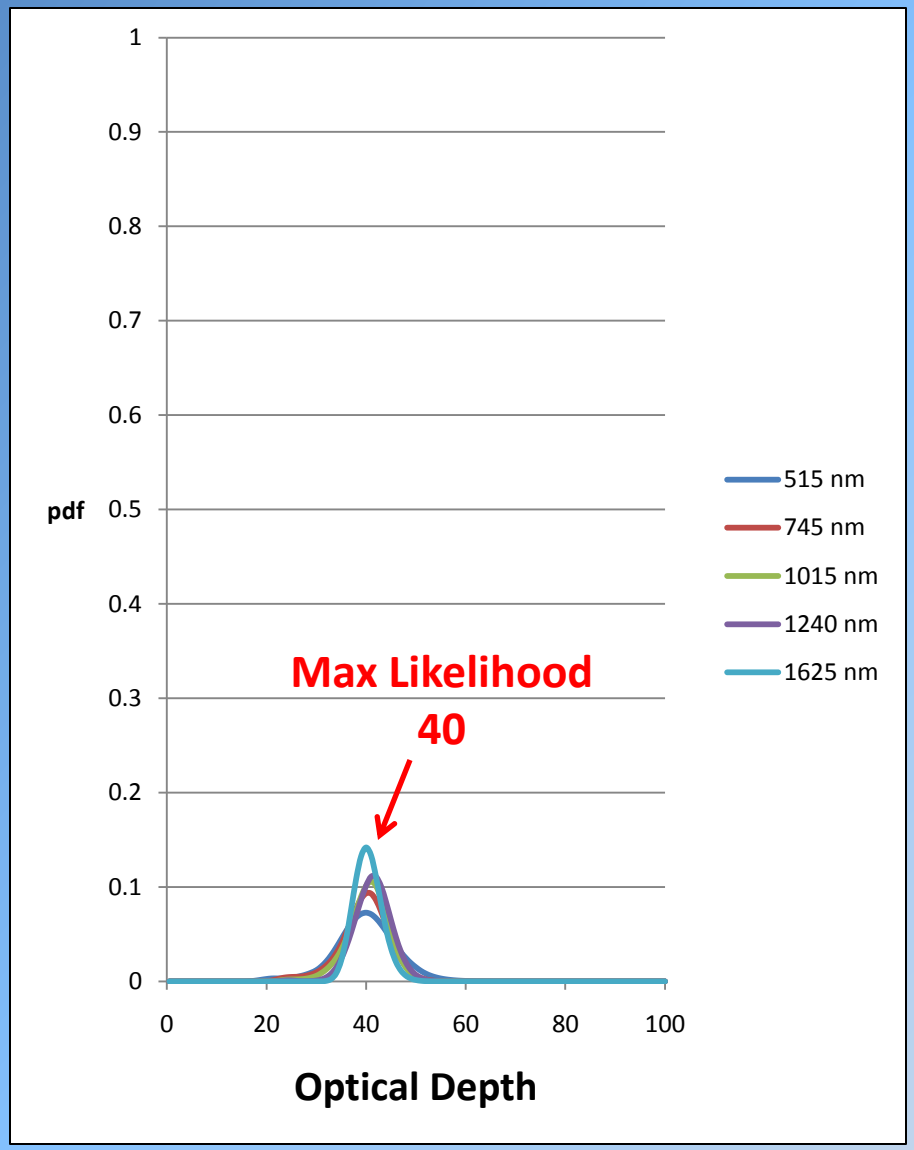
- Scaling comes from the chi square statistic formula that determines the best fit, which is the minimum residual.
- Part one of the formula the absolute difference between measured and modeled albedo, weighted towards shorter wavelengths where there is more information about optical depth.
- The second is the absolute difference between scaled measured and modeled albedo, weighted towards higher wavelengths where there is more information about effective radii.

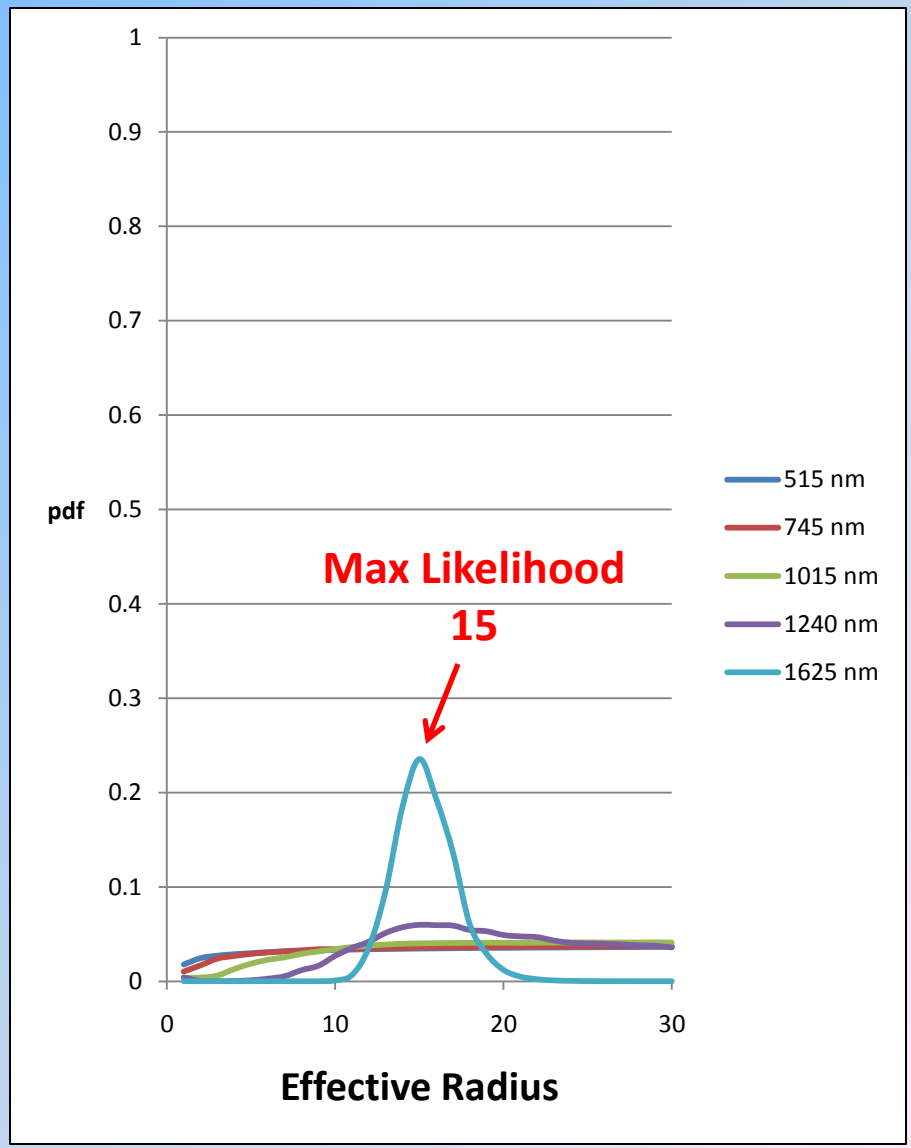






GENRA Output for Case with No Systematic Error
True(tau,re) = (40,15 micron)





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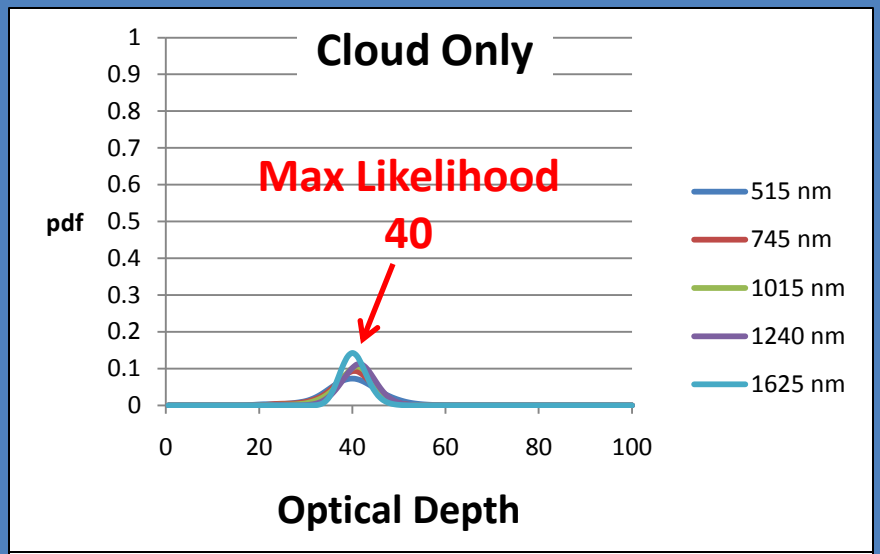
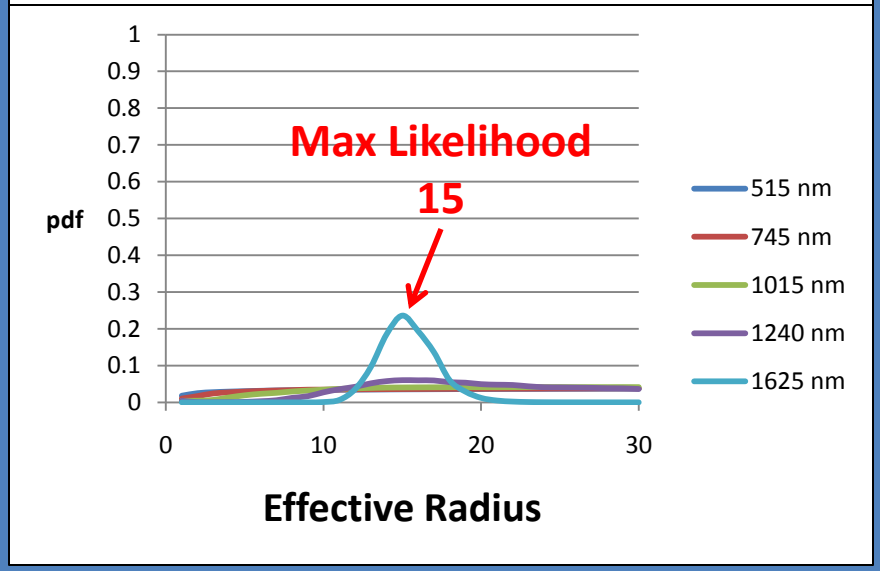
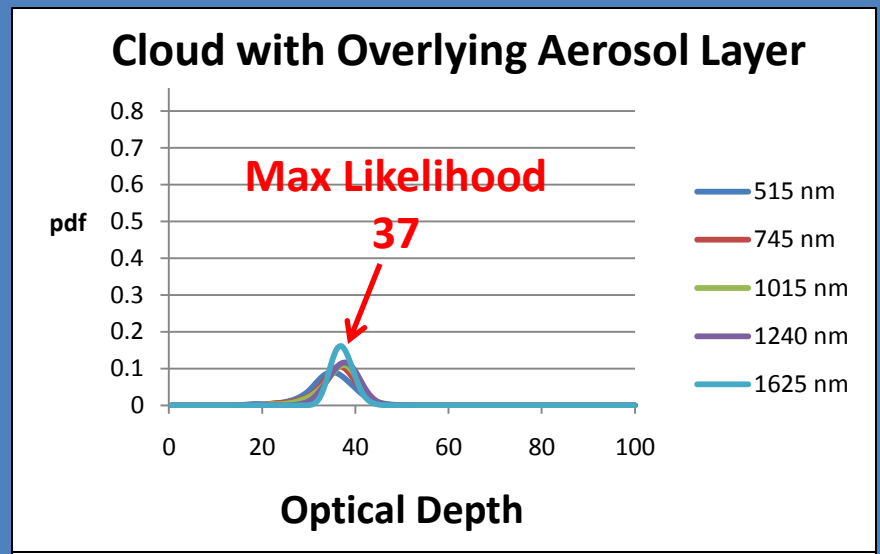
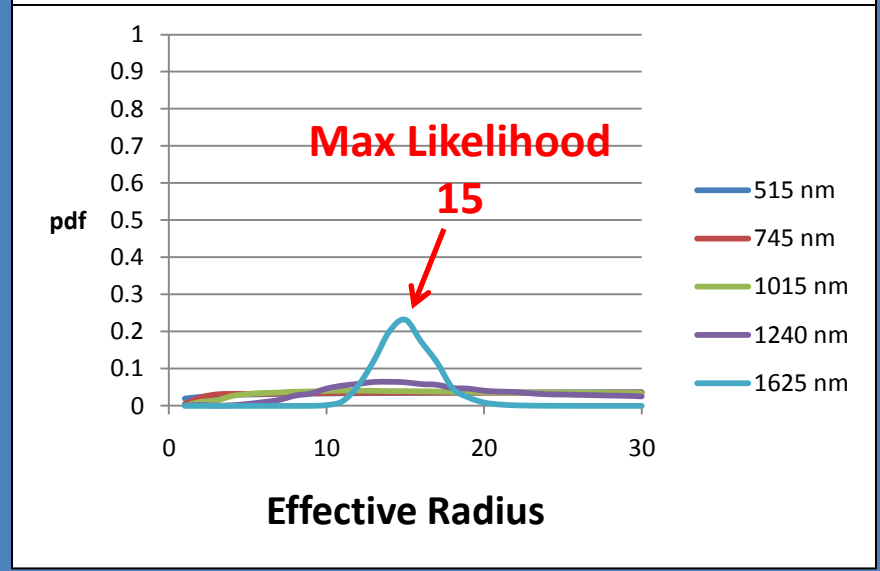


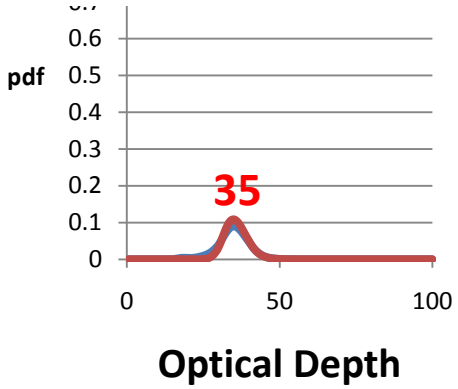


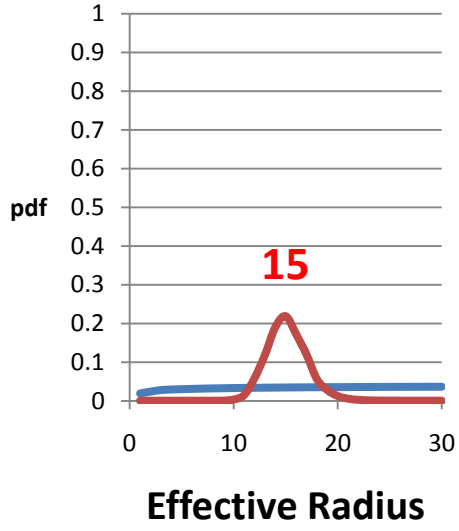




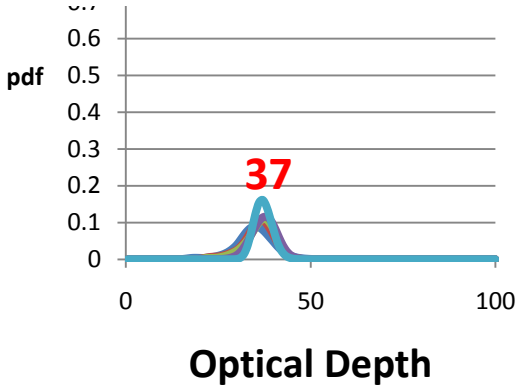
GENRA Output for Case with Systematic Error Using Different Retrieval Wavelengths
True(tau,re) = (40,15 micron)

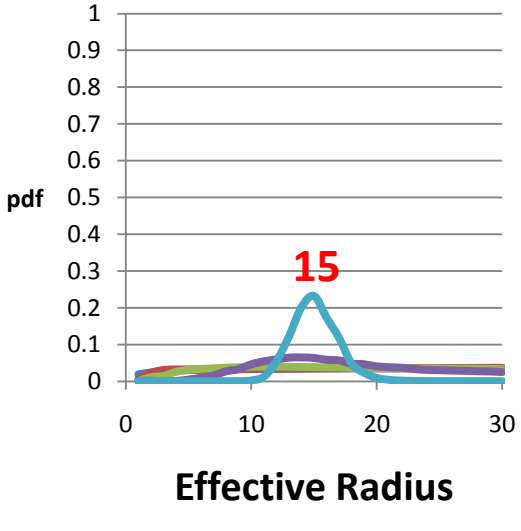
2-wavelength retrieval (e.g. satellite)



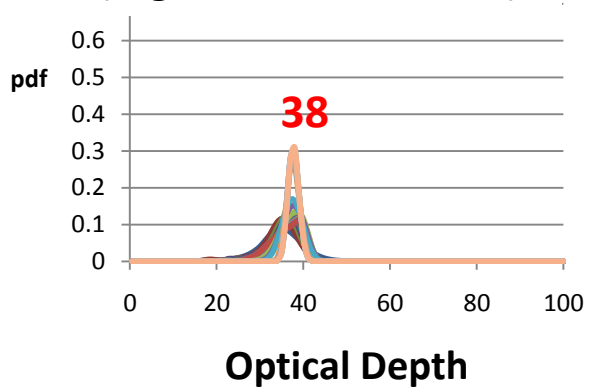


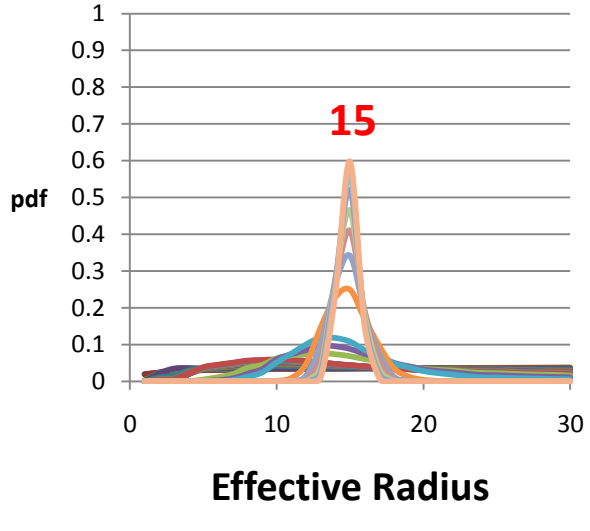
5-wavelength retrieval (e.g. SSFR)



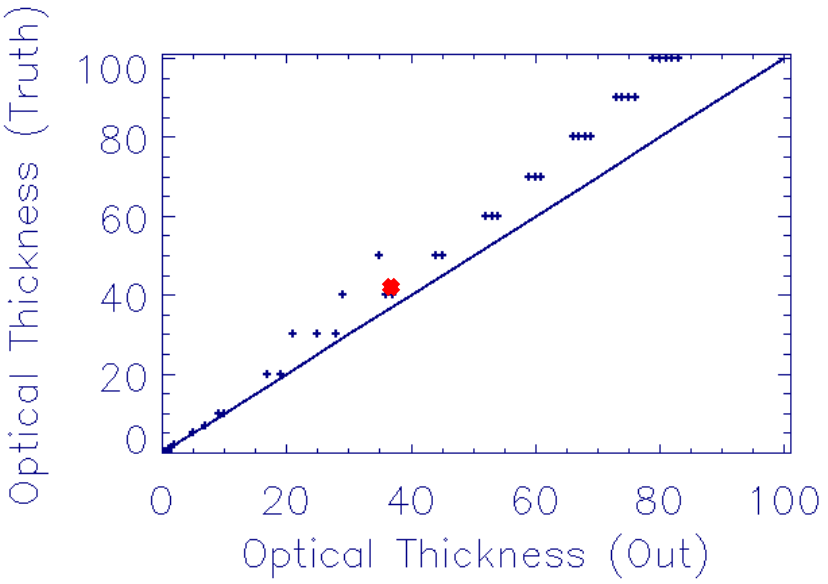


24-wavelength retrieval (e.g. future retrievals)

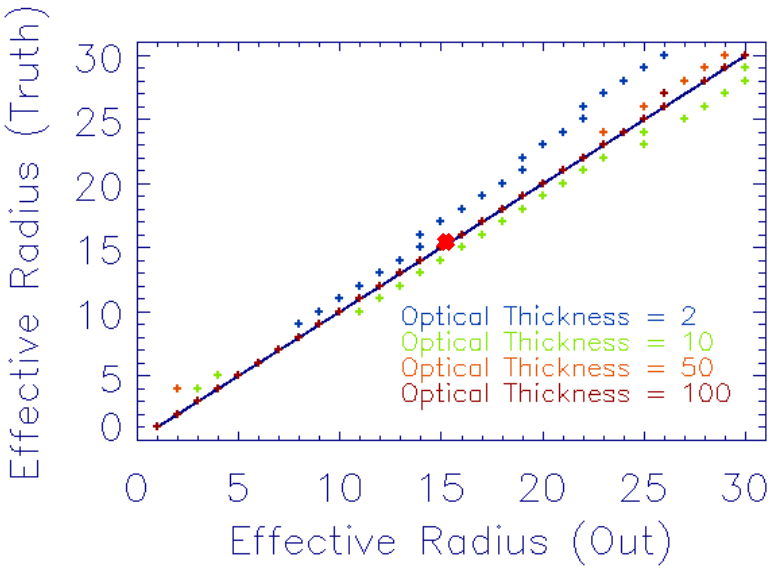




Characterizing the Entire Look up Table



3000 (tau,re) pairs were characterized in 4 hours on the Cynewulf cluster using GENRA.



Future Research

- Look at other factors that may cause bias in cloud retrievals such as:
  - Absorbing aerosol mixed within a cloud
  - 3D cloud effects
- GENRA can be used for characterizing any retrieval statistic and to compare retrievals from different instruments.


Questions?