Flux Closure for Evaluation of Cloud Retrievals

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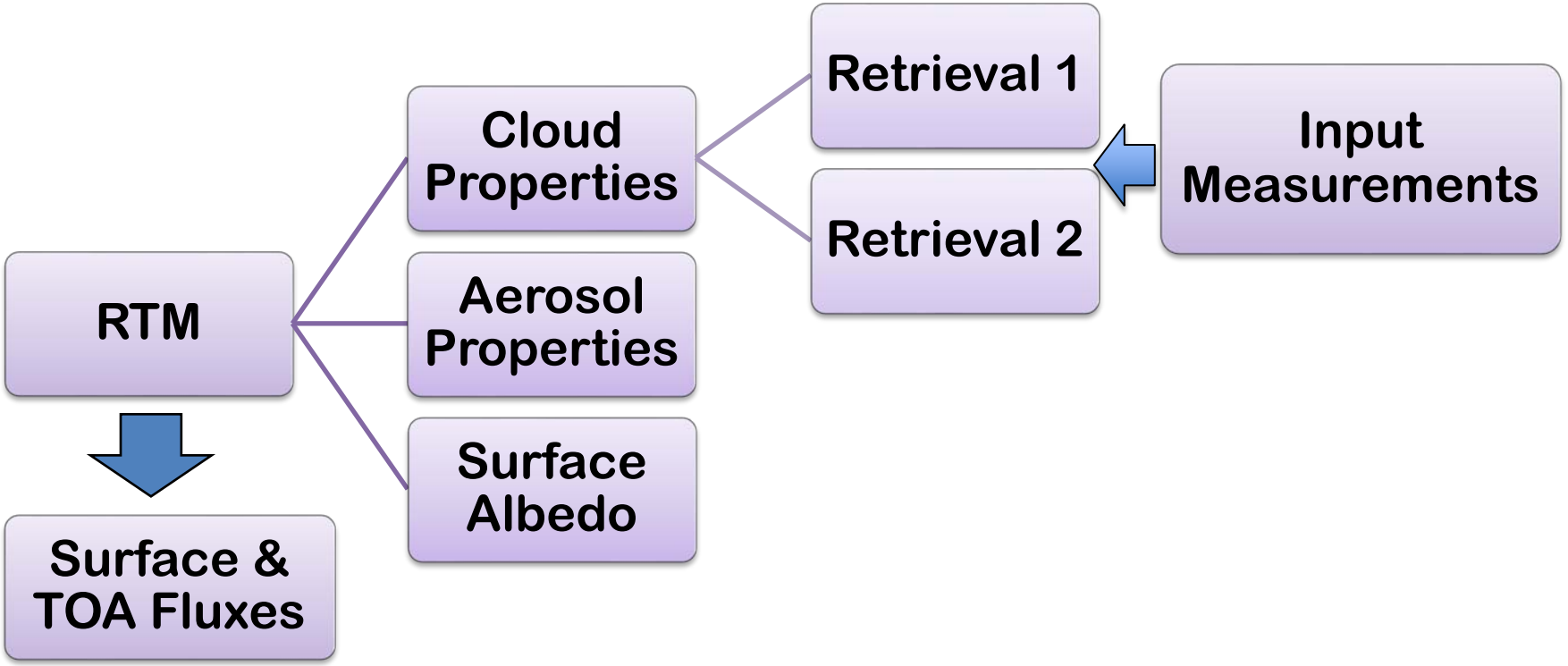
Motivation

- ARM community has multiple cloud retrievals, which often give very different results
- Modelers want to compare their results to ARM retrievals, but do not know which one to use or how to assess uncertainty
- Need a way to compare retrievals and determine:
  - Which retrievals work best under which conditions
  - Uncertainty of retrieved values
- Radiation is one of the important outcomes of a model cloud scheme → Use measured radiative fluxes to evaluate retrievals

Algorithm Evaluation using Radiative Closure



Example: TWP High Clouds Intercomparison

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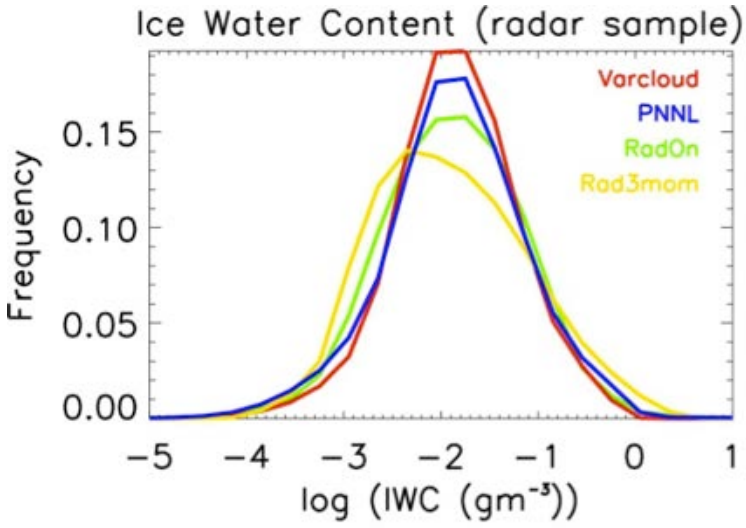
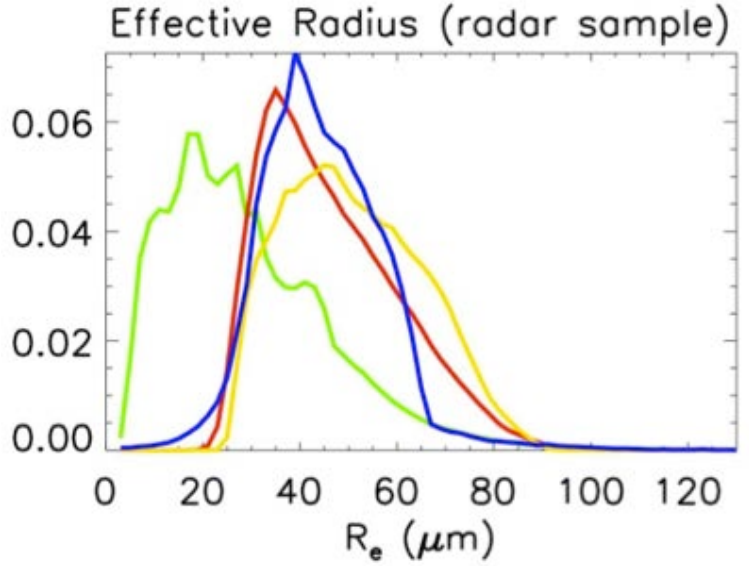
Radar Only	Lidar Only	Lidar+Radar
• Doppler Moments (2) • Variational scheme • Conditional scheme	• Variational scheme • Conditional scheme	• Doppler Moments (2) • Variational scheme • Conditional • scheme

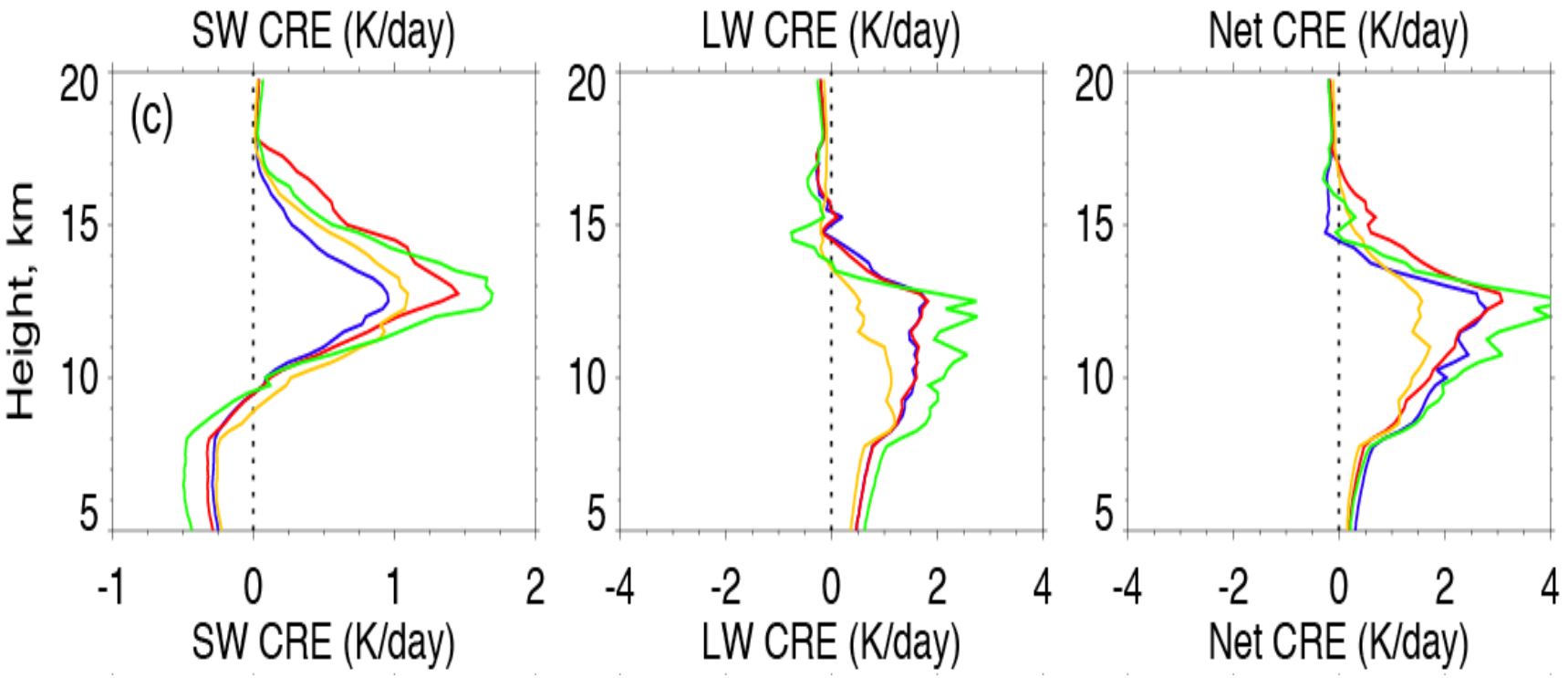
Results for Radar Sample





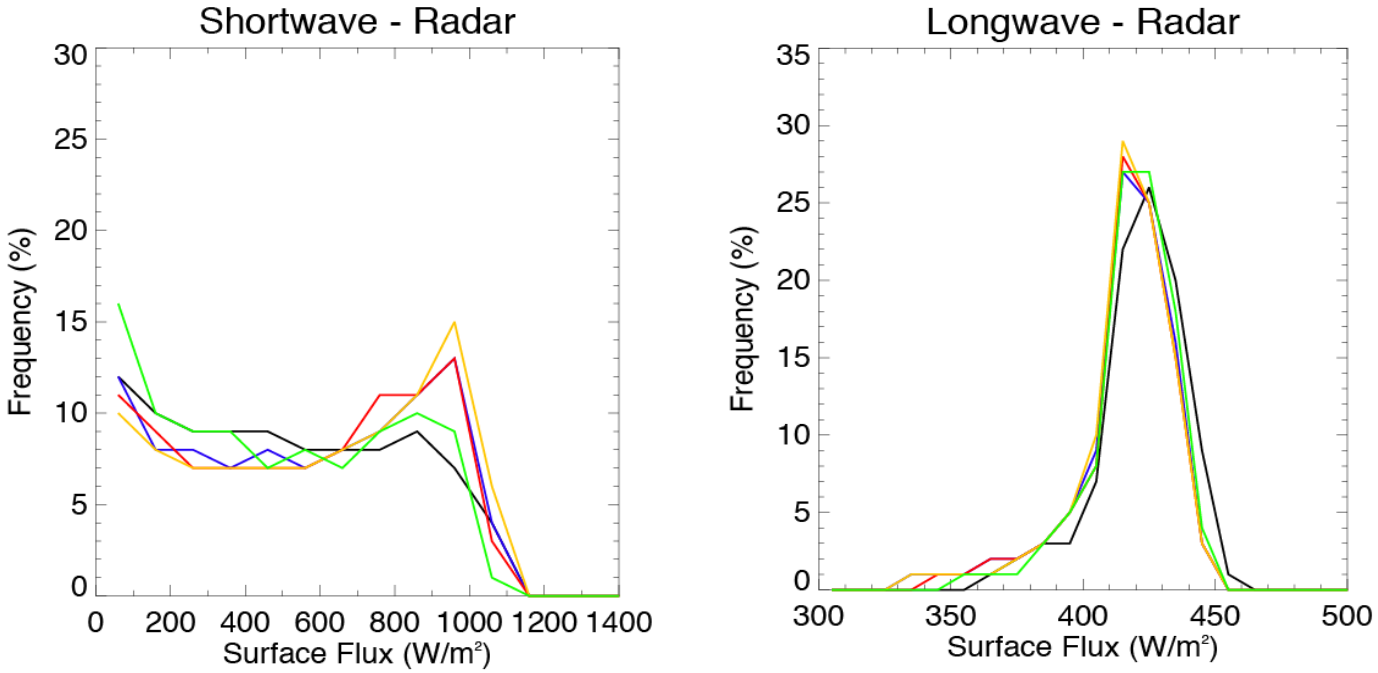
- RadOn (Z-V retrieval) has much smaller Re
- Rad3Mom (Z-V-width) has smallest IWC and largest particle size
- In general, IWC agreement is better than Re

Cloud Radiative Effect Profiles



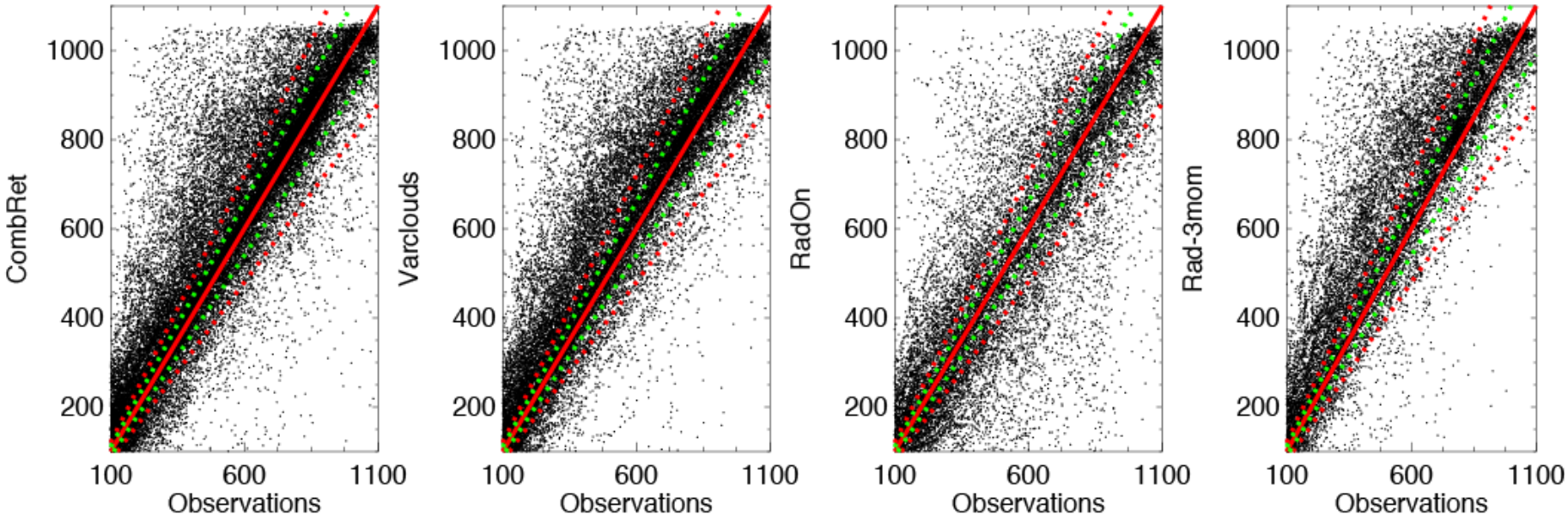
- Differences in cloud properties have large impact on radiative heating profiles

Surface Flux Closure Results (Radar Samples)



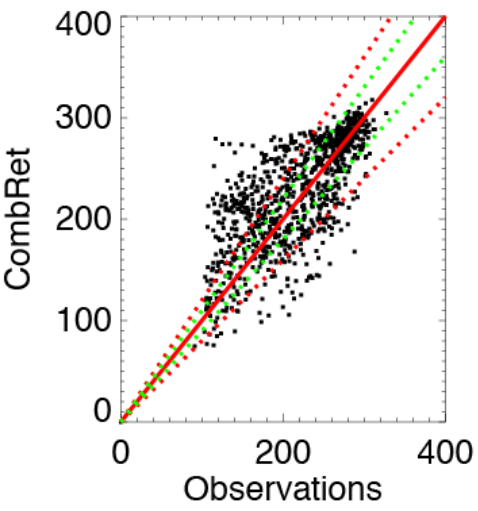
- RadOn best reproduces overall distribution of observed SW surface fluxes
- LW surface fluxes not useful for distinguishing between retrievals for optically thick ice clouds

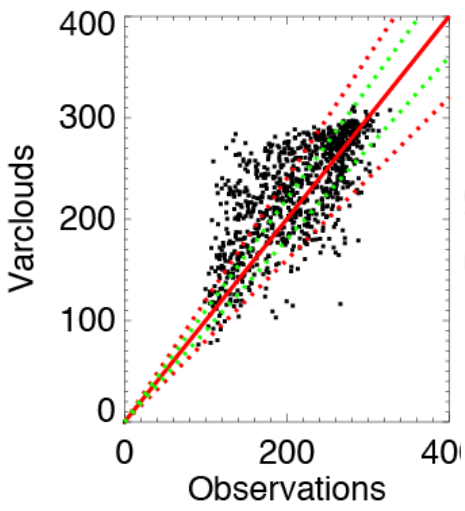
Shortwave Surface Flux

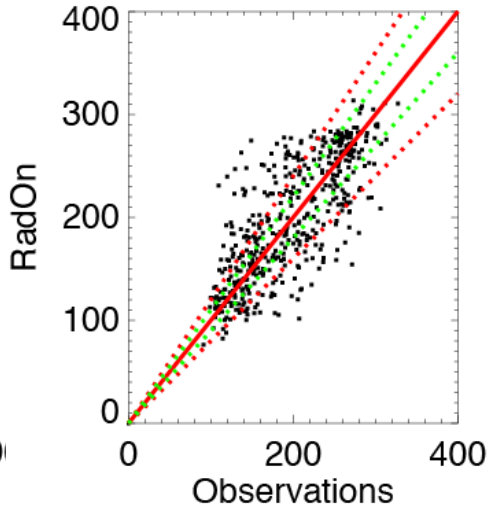


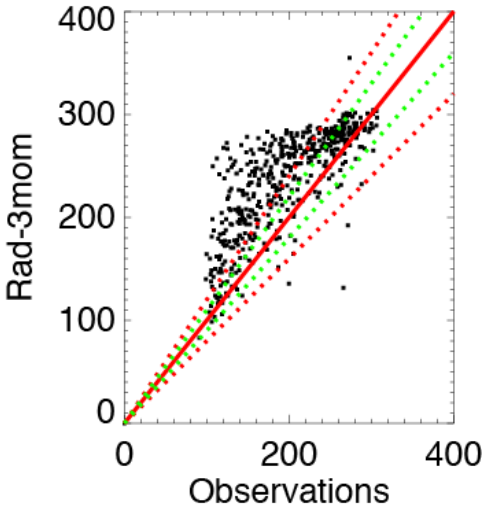
Retrieval	# Points	R2	< 10%	< 20%
CombRet	8222	0.90	**38.5**	**58.5**
Varclouds	8454	**0.91**	38.1	57.9
Rad3mom	8541	0.87	34.0	54.0
RadOn	7649	**0.91**	35.9	55.9

Longwave TOA Fluxes









Retrieval	R2	< 10%	< 20%
CombRet	0.74	**48.2**	94.7
Varclouds	0.72	43.1	93.3
Rad3mom	0.77	33.2	87.2
RadOn	0.77	42.3	**96.3**

Lessons Learned

- Importance of common dataset
  - Makes evaluation of retrieval physics easier by removing other aspects (averaging, cloud masks, phase determination, etc)
  - These are important to understand, but they confuse the results
- Fluxes may not be enough to constrain some aspects of retrievals (e.g. LW surface fluxes)
- On average, simple-regression relationship did as well at matching observed fluxes as Z-V algorithm
- Particle size is more uncertain than IWC in retrievals
- Radiative transfer model has assumptions about mass/dimension that may not be consistent with retrieval

BBHRP Status

- Over the past year, the radiative transfer calculation (BBHRP) has been separated from the specification of input datasets (RIPBE)
- Multiple years (2002-2007) of RIPBE and BBHRP 1-min files have been produced at SGP
- Initial version of BBHRP-Average file created
- Still need to:
  - Add TOA fluxes to BBHRP-average file
  - Add precipitation and mixed phase flags to RIPBE
  - Create RIPBE-Average file

BBHRP-ACRED Plans

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- Use RIPBE code to create gridded input data
  - ACRED cloud file will replace Microbase
  - Other surface/aerosol/atm inputs will stay same
- Run BBHRP on RIPBE-ACRED datasets
  - Create 1-min and 30-min averages
- Compare calculated fluxes to observed surface and TOA fluxes to evaluate retrievals

Potential Issues

- Input Data Sets Used in Retrievals
  - Reflectivity (ARSCL, CloudNet, other?)
    - Attenuation correction?
  - Liquid Water Path (MWRRET, mwrlos, other?)
- Cloud Detection
  - Radar, Lidar, or Radar + lidar ?
  - Cloud Masks (reflectivity thresholds, SNR, averaging)
  - Cloud boundaries
- Cloud Classification
  - Definition, detection, treatment of mixed-phase
  - Some retrievals only work for specific cloud types
    - Do we fill in “missing” clouds? Or only analyze given cloud type?

Potential Issues (2)

- Precipitation
  - Detection and treatment of precipitation
- Optical properties for ice clouds
  - Consistency between retrieval and RT model
- Time Resolution
  - Average or sub-sample cloud properties?
- 3D Radiative Transfer
  - Only use homogenous cases?
- Flux Closure is not sufficient by itself to constrain retrieval uncertainty

Discussion

- What is the overall goal?
  - Identify a “best” retrieval?
  - Identify the best retrieval for each condition?
  - Assess the uncertainty in broadband flux for the given retrieval?
- Should we move toward common input datasets and common cloud classification?
  - If so, which ones?