Potential Reduction of Uncertainty in Passive Microwave Precipitation Retrieval by the Inclusion of Dynamic and Thermodynamic Constraints as part of the Cloud Dynamics and Radiation Database Approach

W. Y. Leung[1], A. Mugnai[3], E. A. Smith[2], G. J. Tripoli[1]

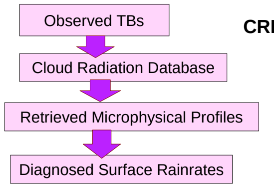
1 Dept. Atmos. Oceanic Sciences, Univ. of Wisconsin, Madison, Wisconsin, USA
2 Goddard Space Flight Center, NASA, Greenbelt, Maryland, USA
3 Istituto di Scienze dell'Atmosfera e del Clima, CNR, Roma, Italy

Contact: Wing Yee Hester Leung
wyleung2@wisc.edu

Type of precipitation retrieval algorithm under study

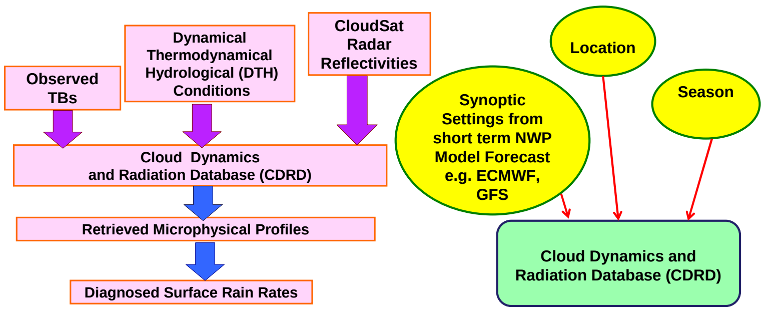
Physically-based, uses Cloud Radiation Databases (CRD's) as basis of relationship between Brightness Temperatures (TBs) & rainrates, and uses Bayesian approach to find microphysical / rainrate profile solutions applied to database subsets.

CRD Approach



Statement of Problem

- The relationship between the simulated microphysical profiles and the simulated multi-spectral TBs are not likely unique.
- Many configurations of liquid and ice hydrometeors in both horizontal and vertical directions can generate an observed set of multispectral TB's.
- During precipitation retrieval, given a set of observed TB's, one can often match with sets of simulated microphysical profiles with strongly different precipitation outcomes.
  - microphysical profiles that do not accurately match with the actual dynamical / thermodynamical state of the atmosphere may contribute to the retrieval solution.
  - This decreases the accuracy of the retrieval results.
- To improve precipitation estimation, additional constraints that could describe the dynamical / thermodynamical state of the atmosphere at the time of retrieval are needed.



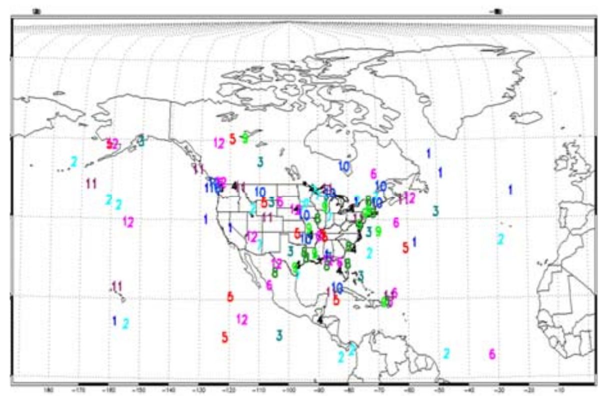
CDRD Approach

Database mining using additional constraints that describe environmental dynamical - thermodynamical - hydrological (DTH) conditions.

Cloud Dynamics and Radiation Database (CDRD)

- **Basic Composition:** Vertical profiles of model simulated of cloud microphysics and associated radiative transfer observable by satellite for a diverse set of cloud types
- **Additional (DTH) Information:** Variables or parameters describing the synoptic weather situation resulting in the simulated profile included in database. Includes *dynamical, theromodynamical, and hydrological* (DTH) descriptors of the synoptic state.
- ***Hypothesis 1:*** *database entries deemed applicable to a given satellite observation can be reduced dramatically by restricting entries to those consistent with the local synoptic situation determined by short term routinely available model predictions*
- ***Hypothesis 2:*** *using a Bayesian physical-statistical retrieval method that combines the satellite observations with DTH information available from short term model prediction and the CDRD can reduce uncertainties in the retrieval of precipitation or other cloud properties*

North America Cloud Dynamics and Radiation Database



120 simulations consisting of 10 for each month of the year, sampling a wide variety of precipitation system types ranging from heavy to light, convective versus stratiform, and liquid to frozen precipitation.
Dates range from Oct 07 to Oct 08
UW-NMS simulations (inner grid: 2km)
RTM 1 – SOI RTM (TBs for each profile)
RTM 2 – MMRS (TBs for each profile)
Radar simulator (Radar reflectivities for each profile)
Dynamical variables at 50km resolution (Global model)

CDRD 50km Dynamics / Thermodynamics Tags

MSLP	Freezing Level	Sfc. Theta Gradient	LFC Height
Surface Temp	Lifted Index	700mb Theta Gradient	LCL Height
**U-Wind	Froude Number	Sfc Theta-E Gradient	Topography Height
**V-Wind	Surface Theta-E	700mb Theta-E Gradient	PBL Height
Latent Heat Term	Surface Brunt Vaisala Frequency	** Q Vector Convergence	Richardson Number in the PBL
V Momentum Flux	Surface Divergence	Vertical Vorticity(700,200hPa)	U Momentum Flux
** Specific Humidity	0-6km Wind Shear	Divergence (700,200hPa)	Height of Maximum Cape
Maximum Cape	Surface Vertical Vorticity	**Vertical Velocity	Surface moisture convergence
Surface Cape	**Temperature	Theta-E minimum	PVA
Kinetic Energy 125 hPa	PV (700,200hPa)	500 and 850 hPa thickness	CIN

** denotes vector - (1000, 925, 850, 700, 500, 250, 200, 150, 100hPa)

Summary

- The Cloud Dynamics and Radiation Database (CDRD) approach, expands the standard CRD approach by including "dynamical / thermodynamical tags", which can be used as independent information describing the synoptic state of the atmosphere during the time of retrieval
- This information is expected to be useful for mining a subset of CRD that contains microphysical profiles that are more associated with the actual atmospheric state.
- CDRD approach has potential for increasing accuracy in the retrieval solution as it reduces retrieval uncertainty by increasing the number of constraints.

Future Research

- Continue to generate more simulations to produce uniform distribution of profiles in North America
- Determine by thorough statistical analysis of North America CDRD profile database, degree to which uncertainty in precipitation estimation can be reduced through use of dynamincal / thermodynamical constraints.
- Ultimate goal is to determine how to optimally apply dynamical / thermodynamical constraints so as to significantly reduce variance in simulated frequency-dependent TB-RR relationships used in passive microwave precipitation retrieval.

References

Mugnai, A., D. Casella, S. Dietrich, F. Di Paola, M. Formenton, P. Sanò, E.A. Smith, A. Mehta, G. J. Tripoli and W.-Y. Leung, 2008: An advanced cloud-radiation database approach for precipitation retrieval from passive-microwave satellite observations over the Mediterranean area". 10th EGU Plinius Conference on Mediterranean Storms.

Acknowledgements

Pete Pokrandt – UW-AOS System Administrator
Funded by NASA Grant Number NNX07AD43G