NEAR REAL-TIME REGIONAL AND GLOBAL 3-D CLOUD PROPERTIES FROM SATELLITES

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SatCORPS Cloud Parameters and Applications

Standard single-layer methods

- Cloud Mask, Phase
- Cloud Optical Depth
- Droplet/crystal effective radius
- Liquid/Ice Water Path
- Cloud Top Temperature, Tcld
- Cloud Top/ Bottom Height
- Overshooting top (OT))
- Icing Potential
- Surface Skin Temperature

New Parameters

- Cloud water content profiles
- Improved IWP/LWP
- Nocturnal IWP
- Aerosol optical depth
- Cloud droplet number density
- HIWC probability
- Surface Radiation
- Multilayer
  - ID, Heights, Optical properties

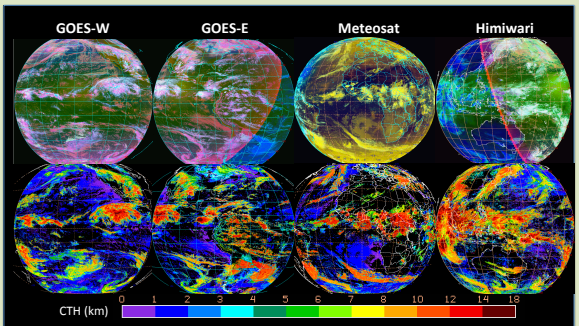
Applications

NASA CERES
- Relate clouds to radiation budget

DOE ARM
- Hi-res radiation and clouds over ARM sites

NASA MAP and GOES-R
- Global, hourly GEO/LEO products for assimilation (COD, Tskin)
- Severe storm assimilation (CWP)
- NAM, RAP Assim (Tcld, Pcld)

NOAA Climate Data Records
- AVHRR analyses since 1980



- Hourly GEO cloud properties computed each hour for each satellite
- 30° longitudinal gap over India (Indian Gap) to be closed with INSAT-3D
- Many other domains and time (15 – 30 min) and space (full res) scales
- Other satellites (AQUA, TERRA, S-NPP, AVHRR)

Incorporating Cloud Vertical Structure to Improve Satellite Retrievals

Satellite Imager Cloud Properties

Some traditional limitations:

- Vertical structure not accounted for
- Only cloud top and integral parameters available
- Large errors possible for thick clouds
- No/poor information on embedded liquid beneath high ice clouds

Solution:

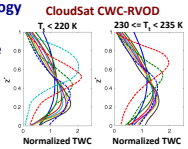
- Incorporate vertical structure information
- Characterize climatologically - translate info to satellite imager data/resolution
- **Thermodynamic phase, cloud water content**
- **Cloud and SLW Probabilities**
- Use CloudSat/CALIPSO/NWP cloud analyses
- Requires satellite TWP parameterization

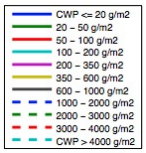
Outcomes:

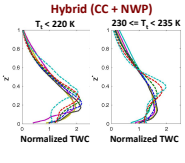
- Improved estimates of IWP and LWP
- Ice and liquid water content profiles (i.e. 4-D cloud properties from GEO)
- Simultanous ice/liquid water retrievals in mixed-phase and overlapping conditions
- Consistent with NWP cloud analyses
- Improved information content and utility for satellite cloud retrievals

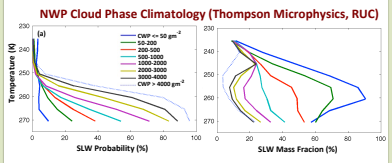
Vertical Structure Climatology

- Over 50 cloud types
- Small subset shown here
- 2C-ICE for cirrus climo
- NWP for thicker clouds (CPR attenuated) and cloud phase
- Hybrid approach best









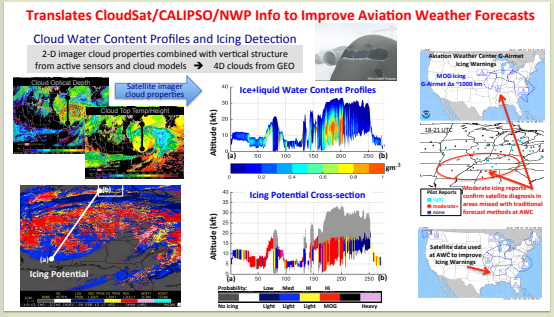
TWC, TWP include all hydrometeors:

- **CloudSat CWC-RVOD: TWC = IWC + LWC**
- **RUC explicit cloud microphysics (5-species)**

TWC = liq + ice + rain + snow + graupel

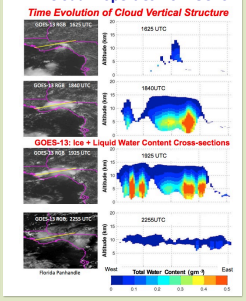
Applications for Satellite Imager Profiling Method Applied to MODIS and GOES Data

Translates CloudSat/CALIPSO/NWP Info to Improve Aviation Weather Forecasts



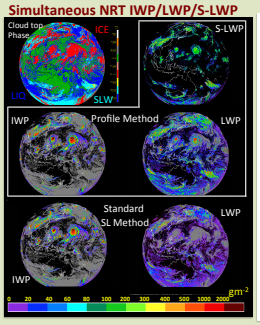
Aviation Weather Applications

4-D Cloud Properties from GOES

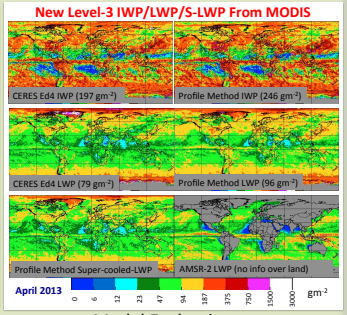


Data Assimilation (?)

Simultaneous NRT IWP/LWP/S-LWP



New Level-3 IWP/LWP/S-LWP From MODIS

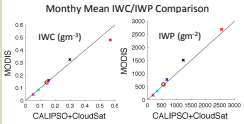


Model Evaluation

MODIS IWC/IWP Validation with CERES C3M

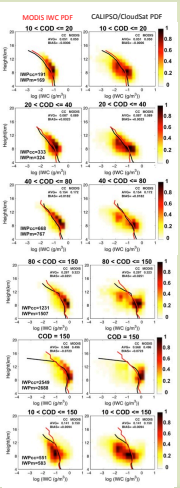
April 2010 (20-55°N and 65-150°W)

- Matched CALIPSO IWC (version3), CloudSat CWC-RO, CERES MODIS Ed4 cloud properties at 1km resolution
- Comparisons made for all ice clouds and stratified by COD
- Above 253K level (avoids mixed phase, CPR attenuation)



- High sensitivity of CALIPSO responsible for large differences at high altitude
- MODIS CTH, CBH errors also contribute to differences
- MODIS PDF narrower (climatological approach doesn't capture extremes)
- Overall, excellent agreement in monthly means as a function of altitude and over a wide range of COD

MODIS IWC/IWP (Profiling Method) consistent with CALIPSO/CloudSat



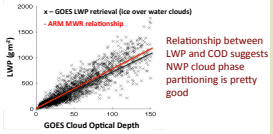
Verification

- IWC/IWP compared to CloudSat/ CALIPSO retrievals and in-situ data
- LWC/LWP validated with ARM data and aircraft icing intensity PIREPS
- Current method developed/tested over CONUS
- Method can be applied to any cloud type (low clouds not validated)
- Needs to be tested/refined for global application and more extreme conditions (HIWC)

GOES LWP Validation

CONUS, Jan-Mar, 2013

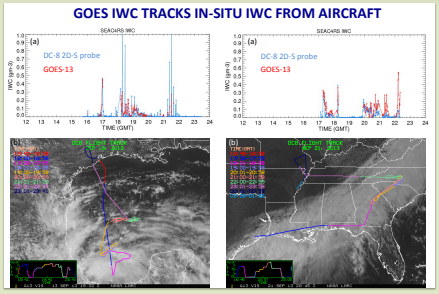
Estimates in known icing conditions (PIREPS)



Relationship between LWP and COD suggests NWP cloud phase partitioning is pretty good

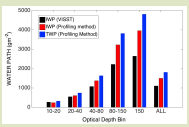
GOES LWP (Profiling Method) consistent with MWR estimates

GOES IWC TRACKS IN-SITU IWC FROM AIRCRAFT

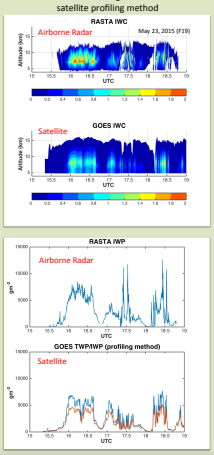


Profiling Method used to Test and Refine IWP Parameterizations

COD BIN	GOES V1S3T IWP	GOES Profile method IWP	GOES Profile method TWP	V1S3T BIAS (IWP) %	V1S3T BIAS (TWP) %	N
10-20	260	234	321	11%	-19%	62515
20-40	539	604	741	-11%	-27%	74047
40-80	1070	1368	1632	-22%	-34%	47192
80-150	2220	3228	3815	-38%	-42%	25905
150	2640	3960	4809	-33%	-45%	42893
ALL	1098	1494	1810	-27%	-39%	252552



Comparison with standard IWP parameterization applied in NASA LaRC algorithm (assumes vertically homogeneous clouds)

IWC retrievals (deep convection)

Airborne radar being used to refine satellite profiling method