Results from the Canadian CloudSat CALIPSO Validation Project (C3VP)

Environment Canada | Environnement Canada

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http://c3vp.org

Canadian Space Agency | Agence spatiale canadienne

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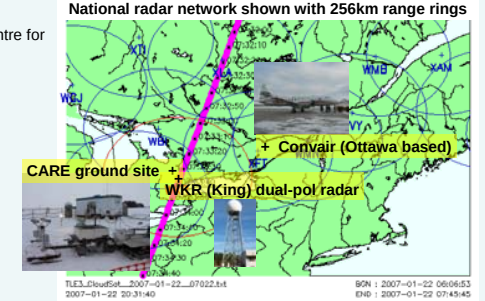
Winter 2006/07 field campaign in the Canadian Great Lakes area

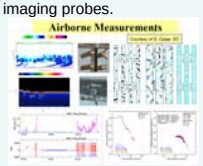
- NRC Convair-580 research aircraft flown under the A-train overpasses in Southern Ontario & Southwest Quebec.
- Enhanced cold season ground-based measurements taken at EC Centre for Atmospheric Research Experiments (CARE).

C3VP flight summary table	Cloud characteristics	#
21 A-train under flights (6 over CARE site)	Stratiform	7
	Lake effect	2
	Precipitating	5
	Boundary layer	4
	Aerosol	2
plus 7 interesting weather flights		

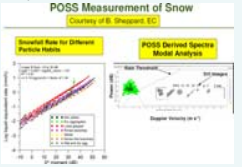
An overpass during C3VP field operations
National radar network shown with 256km range rings



Convair-580 research aircraft instrumentation,
- Ka-band radar and dual-pol lidar.
- bulk microphysics.
- optical imaging probes.



CARE ground instrumentation,
- profiling sensors: W- & X-band radars, dual-pol lidar, and microwave radiometer.
- precipitation sensors: POSS, Parsivel, video distrometers & imagers.



2B-CLDCLASS precipitation occurrence algorithm validation

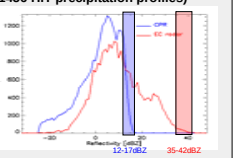
Matched EC King radar & CloudSat footprint to compare their detection of precipitation at ground occurrence (Sep-2006 to Apr-2007).

Verification statistics

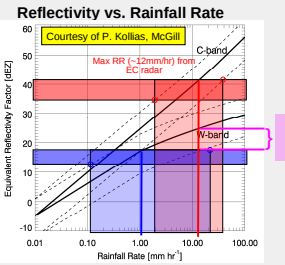
Result	Total	Error characterization	Subtotal
HIT	1456		
FALSE	107	Precipitation threshold	80
		Ground clutter filtering	27
MISS	81	Reflectivity gradients	16
		Attenuation	6
		Ground clutter filtering	59
NEG	4198		

Skill score	Value
critical success index	88.6
Bias (forecast : observation)	1.02
probability of detection	94.7%
false alarm ratio	6.9%

Reflectivity distribution
(1456 HIT precipitation profiles)



Reflectivity vs. Rainfall Rate



T-matrix W-band – CPR measured = 6 dB using M-P

Envelopes of radar reflectivity (dBZ) as function of rainfall rate for a variety of DSD assumptions (Marshall-Palmer as solid curve) at C-band and W-band.

Horizontal boxes represent the reflectivity range of the tail of the above histogram, i.e. 12-17dbZ for CloudSat (horizontal blue box) and 35-42dBZ for C-band (red box). Vertical boxes are their representation in terms of rain rate.

2B-GEOPROF cloud occurrence algorithm validation

Different data sets providing cloud/echo boundary locations,
- 2-D: CALIPSO, airborne radar/lidars, ground radar/lidars.
- 1-D: aircraft in-situ microphysics, wx station cloud obs, upper air sounding, CARE obs.

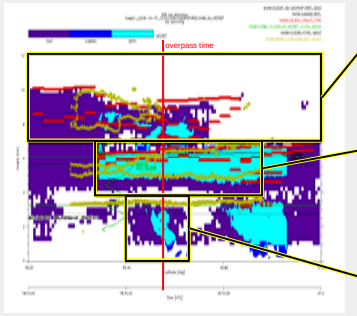
Horizontally homogeneous areas of {HI, MID, LO} cloud layers of each overpass scene were selected for analysis. In mixed phase cases, layers of LIQ and ICE were further handled.

Representations of layer TOP & BOT are subjectively chosen to construct a GEOSIM of the CloudSat overpass scene.

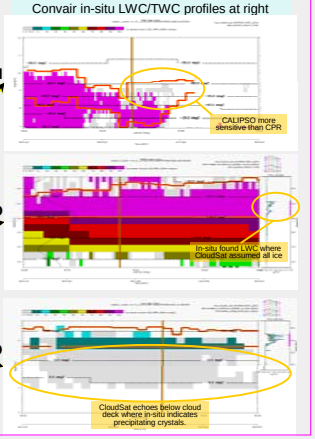
Statistical analysis of GEOSIM vs. 2B-GEOPROF cloud/echo TOP & BOT performed.

Single case example:
2006-Oct-31

GEODET visualization
Cloud boundaries as seen by various sensors

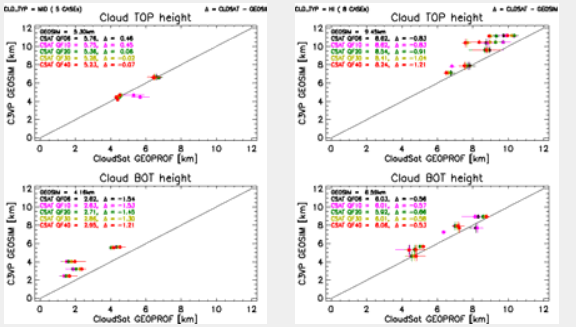


Validating GEOSIM layer in red
CloudSat ice fraction & model temps overlaid.
Convair in-situ LWC/TWC profiles at right



All combined GEOPROF vs. GEOSIM C3VP cases
Case means and spreads shown by point and whiskers respectively.
Further stratified by GEOPROF quality flag (QF).

MID layer | **HI layer**



2B-GEOPROF vs. GEOSIM results

CPR Layer	TOP	BOT	CPR thickness bias
HI	Too low (-0.83km), due to CPR sensitivity	Too low (-0.56km), due to vertical resolution and virga (interlayer echoes)	Thinner, -0.22km
MID	Good (0.06km), after removal of Convair artifact (QF20)	Too low (-1.54km), mostly due to virga	Thicker, +1.49km at QF20
LO	Good (0.06km)	Generally OK, but too high in 4 of 11 cases (+0.44km) due to ground clutter removal	Thinner, -0.33km in those 4 GC cases

Summary

- The C3VP 2006-07 field campaign successfully collected 105 flight hours of in-situ data and from CARE enhanced ground measurements captured a full fall/winter season (67 precipitation events).
- Good flight planning focused on satellite validation: above cloud top at overpass time, immediately followed by a profiling descent. At times, the Convair itself was found as an artifact within the CloudSat scene.
- Validating 2B-GEOCLASS precipitation occurrence product,
  - Plus: no overall bias, good handling of attenuation
  - Minus: ground clutter, need some threshold tuning for hi IWC
- Validating 2B-GEOPROF cloud/echo occurrence product,
  - HI cloud layers: too thin due to CPR sensitivity
  - MID cloud layers: too thick by 1.5km mostly due to virga
  - LO cloud layers: shallow bases in the winter typically lost in the ground clutter

Future work

- Support continued CloudSat precipitation algorithm development,
  - Compare reflectivity histograms (CFADs) of the C3VP@CARE radars {WKR, VertiX, JPL W-band}.
  - Solid particle habit characterization and climatology of Canadian latitudes from C3VP precip sensors @ CARE & Eureka.
  - To apply matching/validation analysis on 2C-PRECIP product and other national networks {POSS, all radars, wx station obs}.
- Quantitative LWC/IWC profiles comparison with aircraft in-situ and profiling radiometer data for vertical resolution features.
- Explore, why CPR reflectivities in precipitation, all <17dBZ, so low?

CloudSat/CALIPSO Science Team Meeting, Madison, Wisconsin, U.S., July 28-31, 2009.