

ASAP CONUS Cloud Top Height Validation

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CONUS Cloud Top Pressure Overview

- **ASAP cloud products are available hourly from CIMSS, and are derived using single field of view GOES-12 Imager (4 km) and Sounder (10 km) data.**
- **Cloud top pressure is derived using a combined CO₂ Ratio and Infrared Window (11 μm Brightness Temperature lookup table) technique.**
- **Cloud top pressure is not derived using GOES-10 Imager data, because a crucial band for CO₂ slicing (13.4 μm) is not present.**

CO₂ Ratio Technique Overview

- Cloud top pressure is defined as the pressure at which the following ratio difference is minimized:

$$\frac{\text{Observed cloud signal at } \nu_1}{\text{Observed cloud signal at } \nu_2} - \frac{\text{Calculated cloud signal at } \nu_1}{\text{Calculated cloud signal at } \nu_2}$$

Where the Cloud Signal is: $I(\nu) - I_{\text{clr}}(\nu)$

AND ν_1 and ν_2 are spectrally close each other

- This technique eliminates the dependence of retrieved cloud top pressure on cloud emissivity, and thus may be applied to semi-transparent high clouds.
- This technique is not employed if the cloud signal is within 2X the instrument noise level

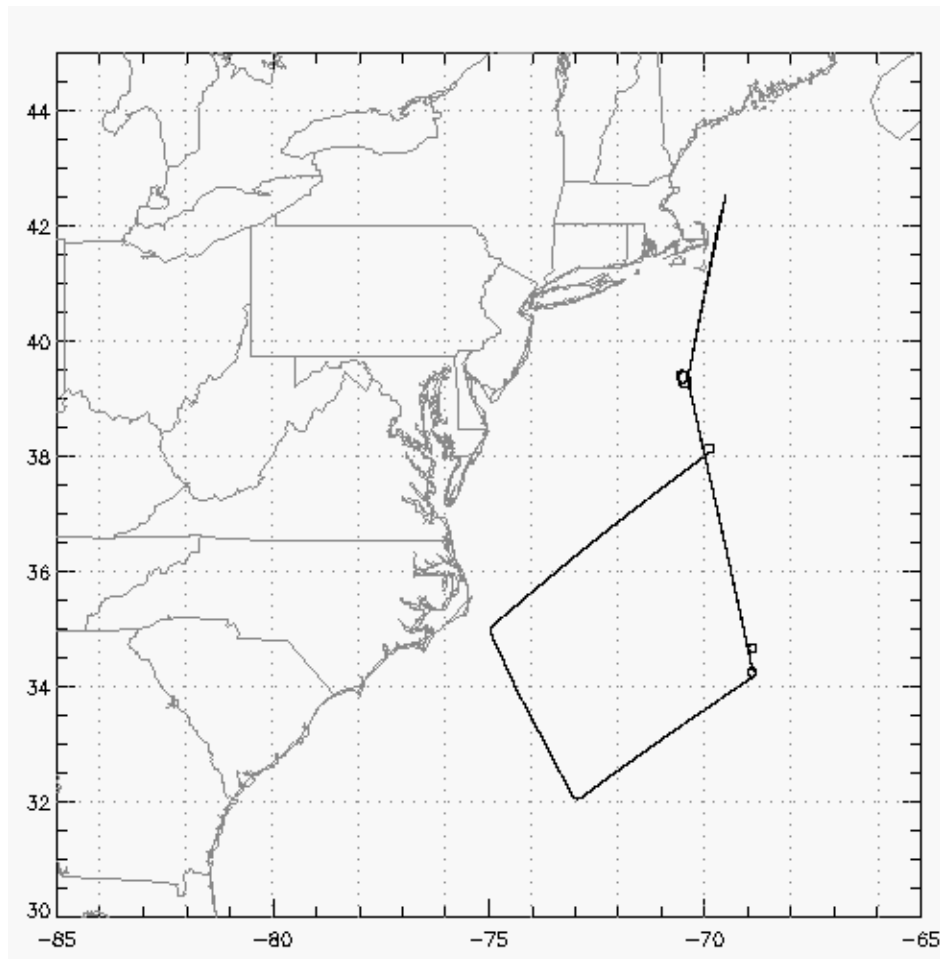
Overview of Comparison

- **Field Campaign:** Atlantic THORPEX Experiment, Bangor ME, 17 Nov – 16 Dec 2003
- **'Truth':** Cloud Physics Lidar (CPL) data from the NASA ER-2 aircraft
- **Comparison data sets:** Cloud top height derived using GOES-12 Imager and GOES-12 Sounder, MODIS, and Scanning – HIS data
- Errors resulting from differences between the spatial resolutions of the satellites and the CPL have been addressed by averaging the CPL data
- Note that the difference in the actual properties measured by the lidar vs. satellite prevents a true 1:1 comparison

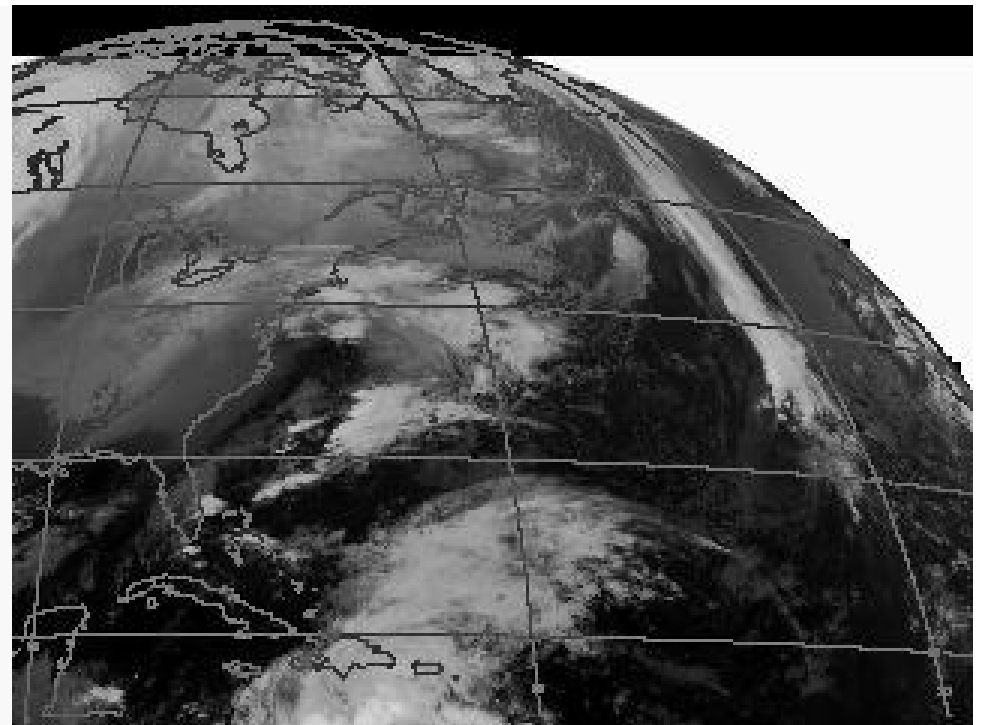
05 December 2003

1515-2145 UTC (1015-1645 EST)

NASA ER-2 Flight track

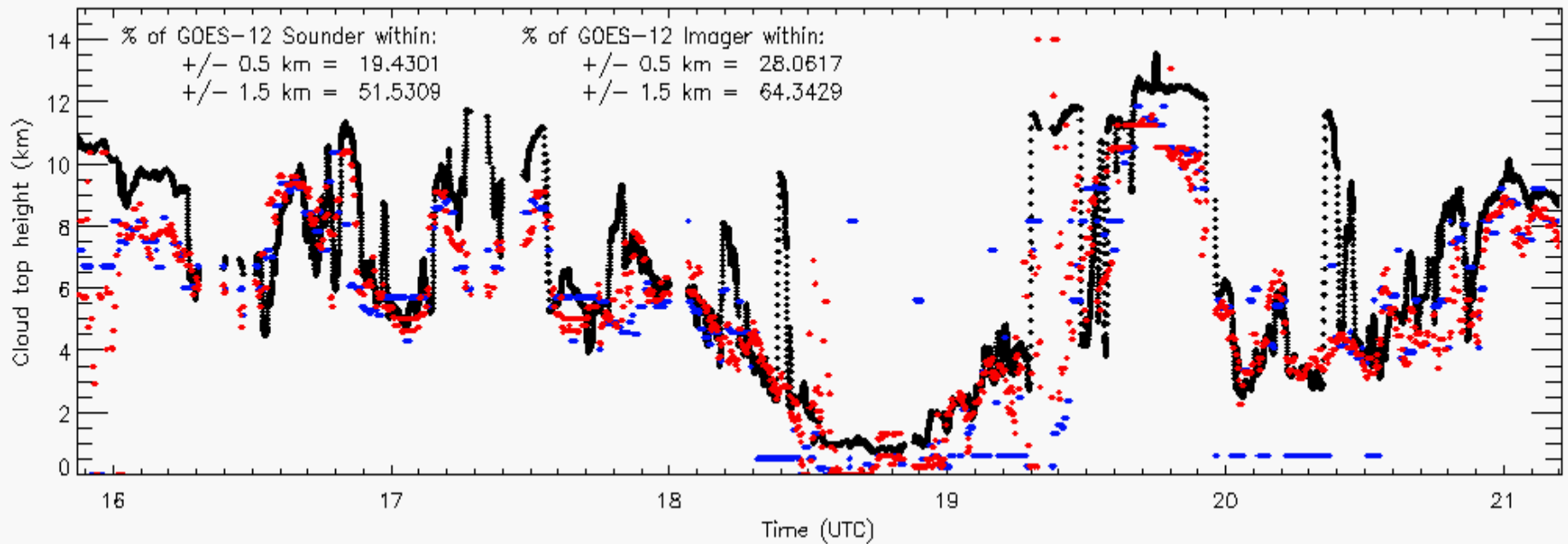


GOES-12 Imager 11 μm BT



The University of North Dakota Citation flew below the ER-2 and released dropsondes.

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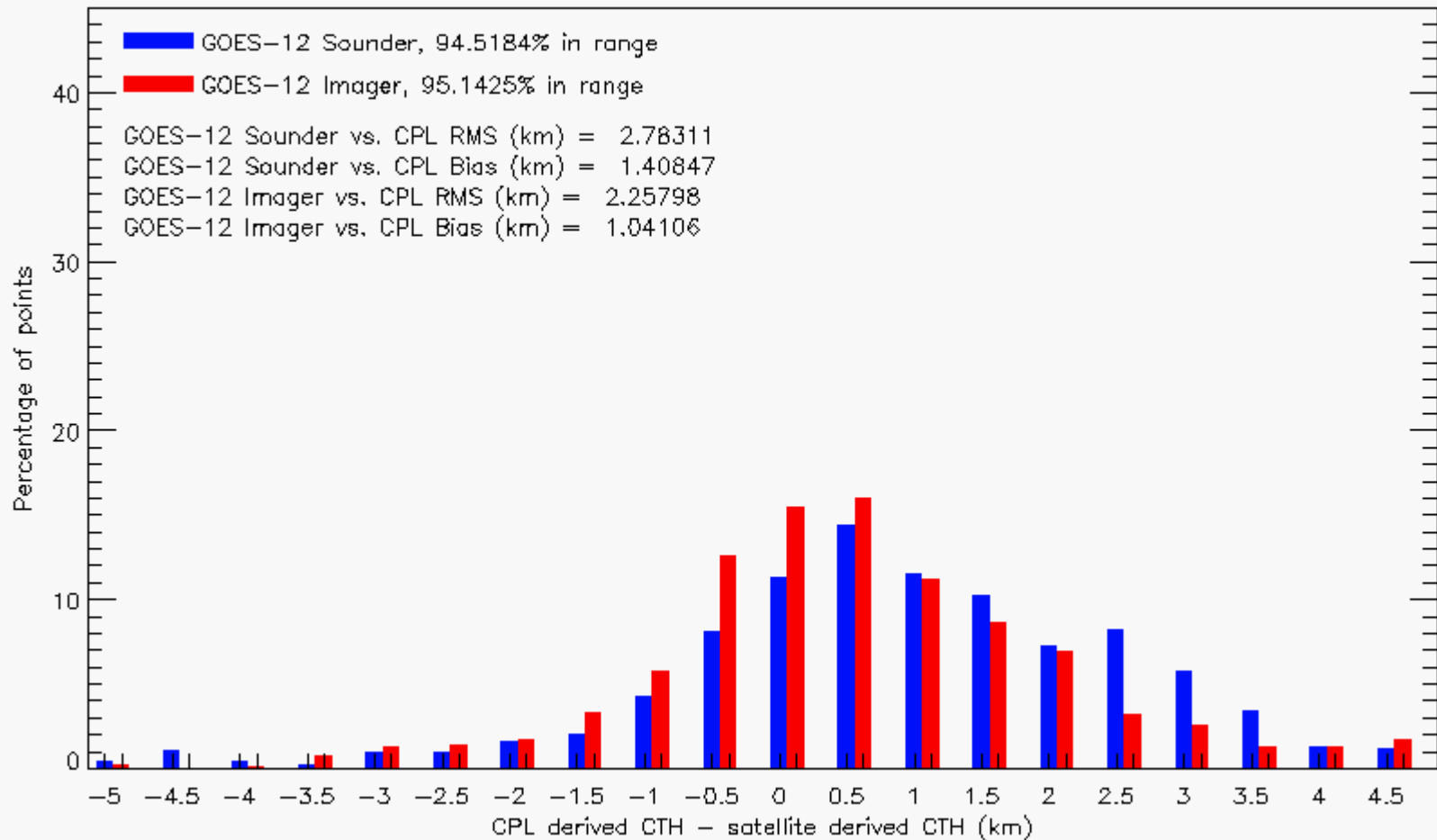


Red: GOES-12 Imager
Blue: GOES-12 Sounder
Black: CPL

Strengths: Mid-level clouds, optically thick clouds

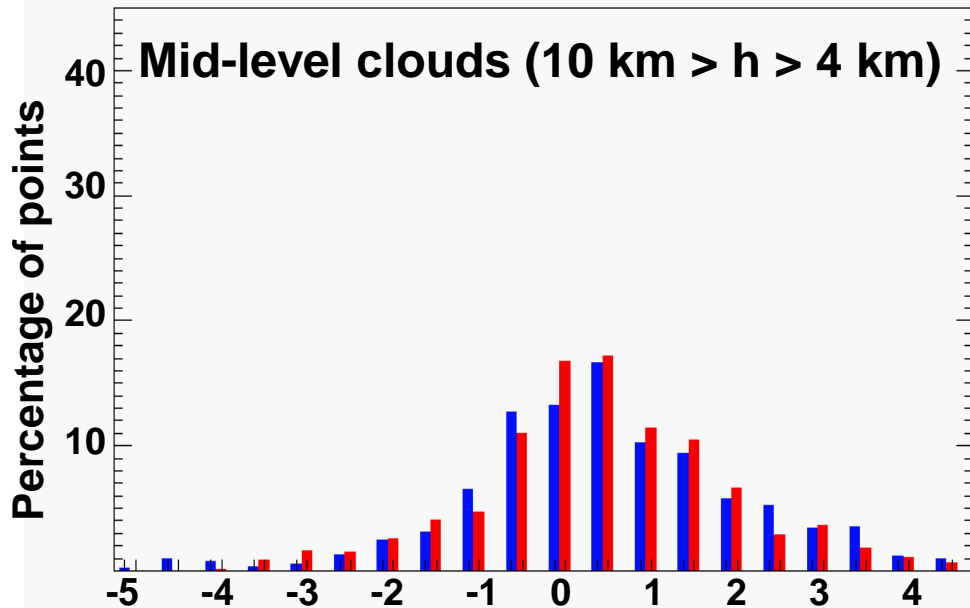
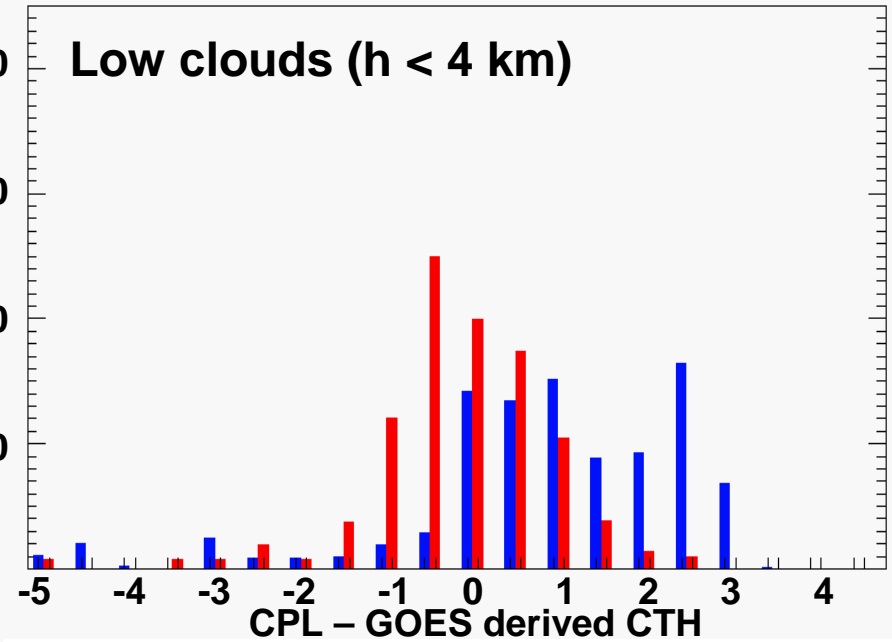
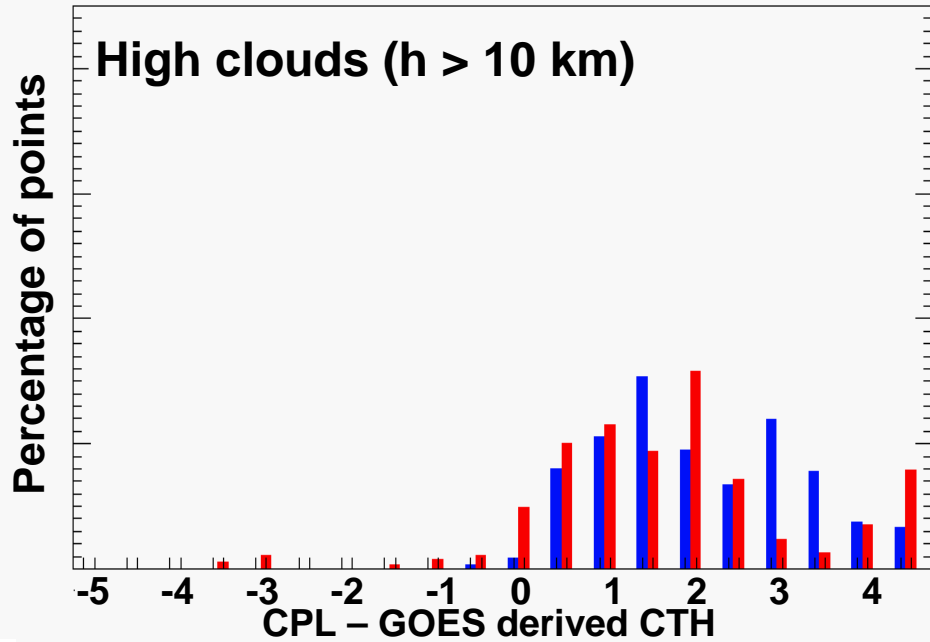
Challenges: High or optically thin clouds, Low/warm clouds

05 December 2003



GOES Imager statistics indicate better agreement with the CPL than do the GOES Sounder statistics. This is to be expected considering the higher spatial resolution of the GOES Imager.

05 December 2003



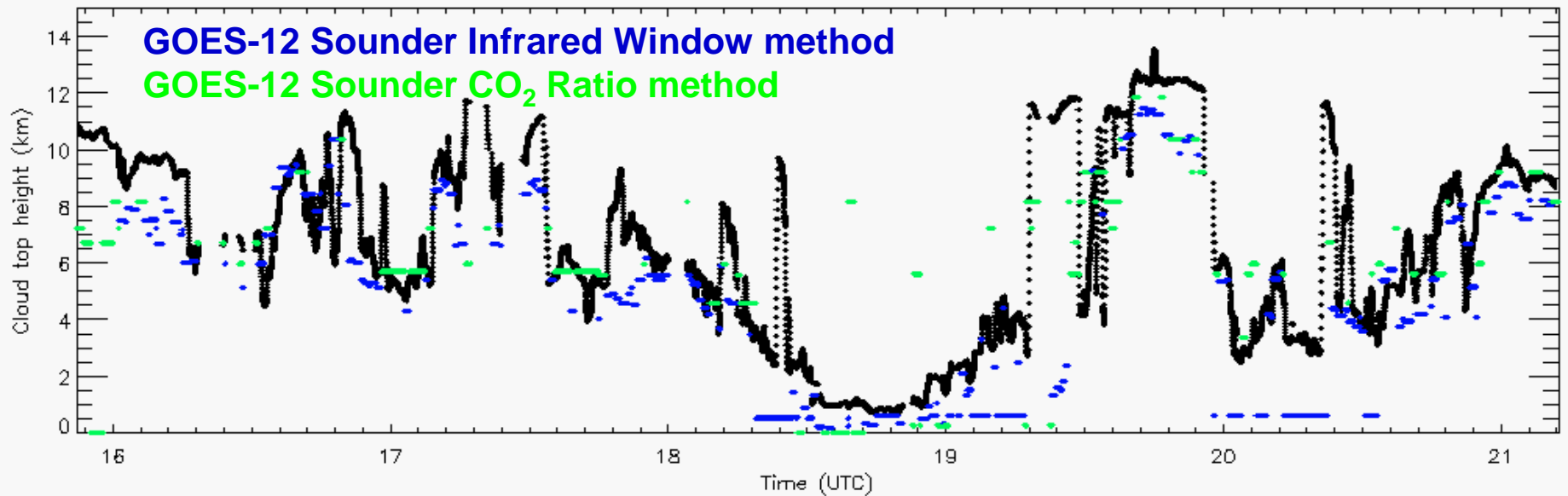
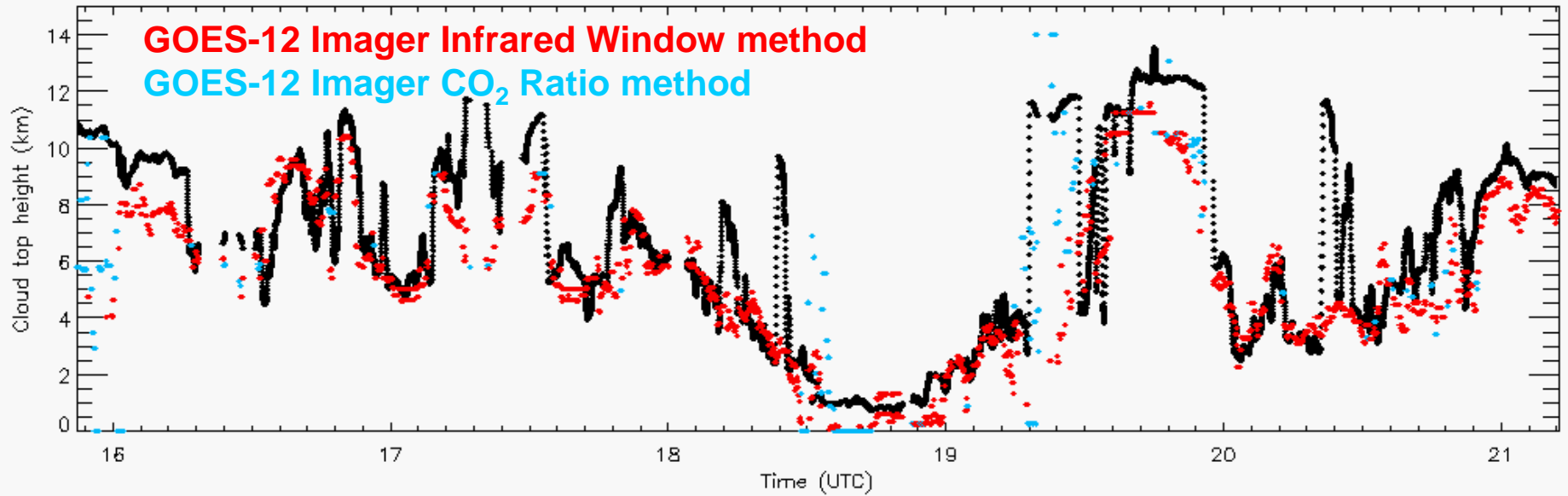
Red: GOES-12 Imager
Blue: GOES-12 Sounder

Histograms of CPL -
GOES derived cloud
top height for high,
mid-level, and low
clouds

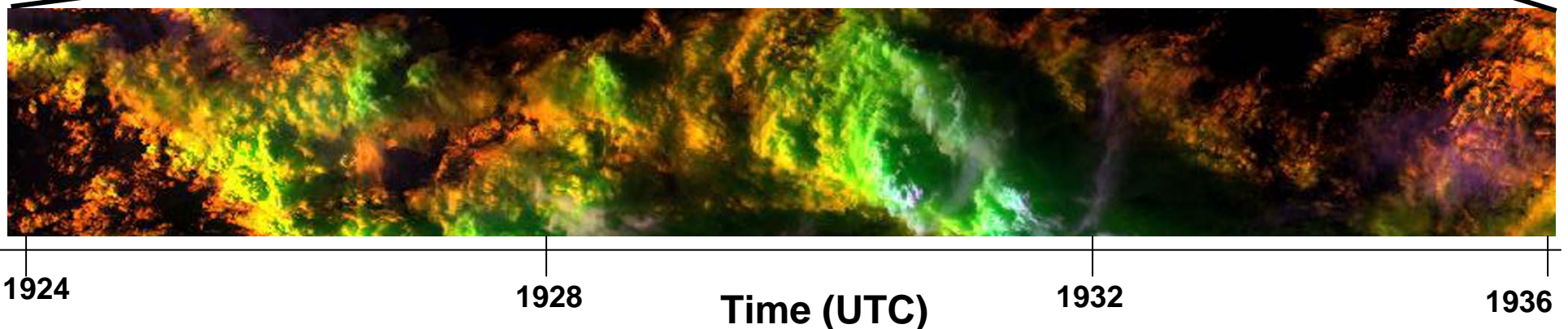
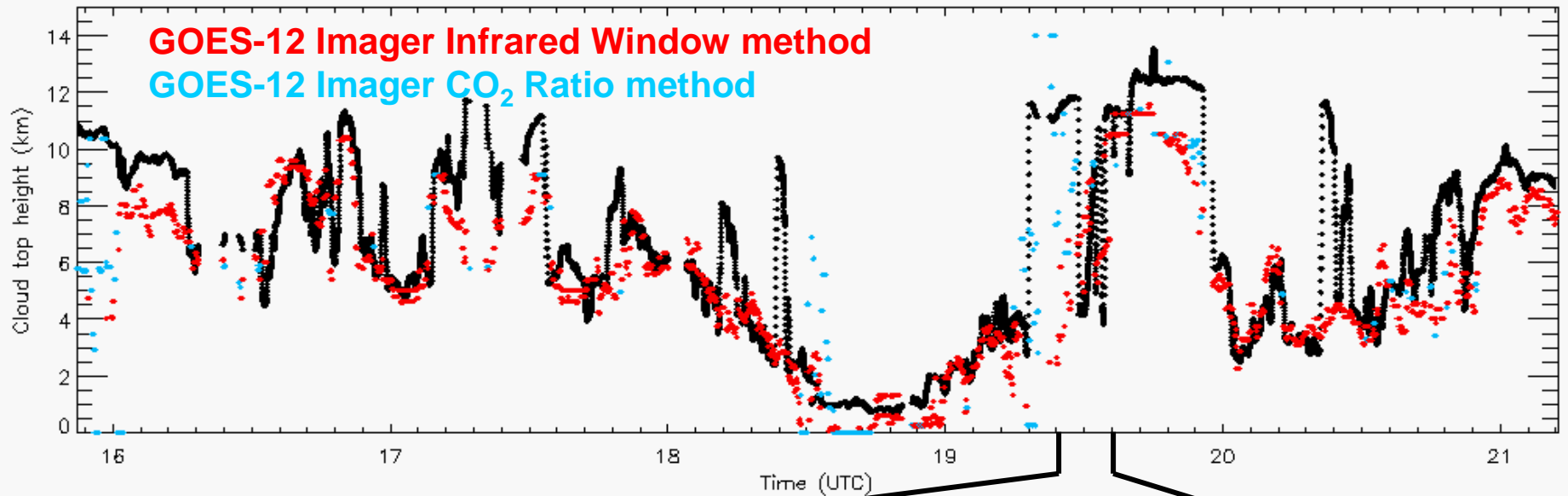
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	High (h > 10 km)	Mid-level (10 km > h > 4 km)	Low (h < 4 km)
Imager vs. CPL RMS	4.10	1.80	1.08
Imager vs. CPL Bias	3.14	0.81	0.09
Sounder vs. CPL RMS	4.85	2.06	2.22
Sounder vs. CPL Bias	3.79	0.90	0.93
Total # of points	2590	9904	4130

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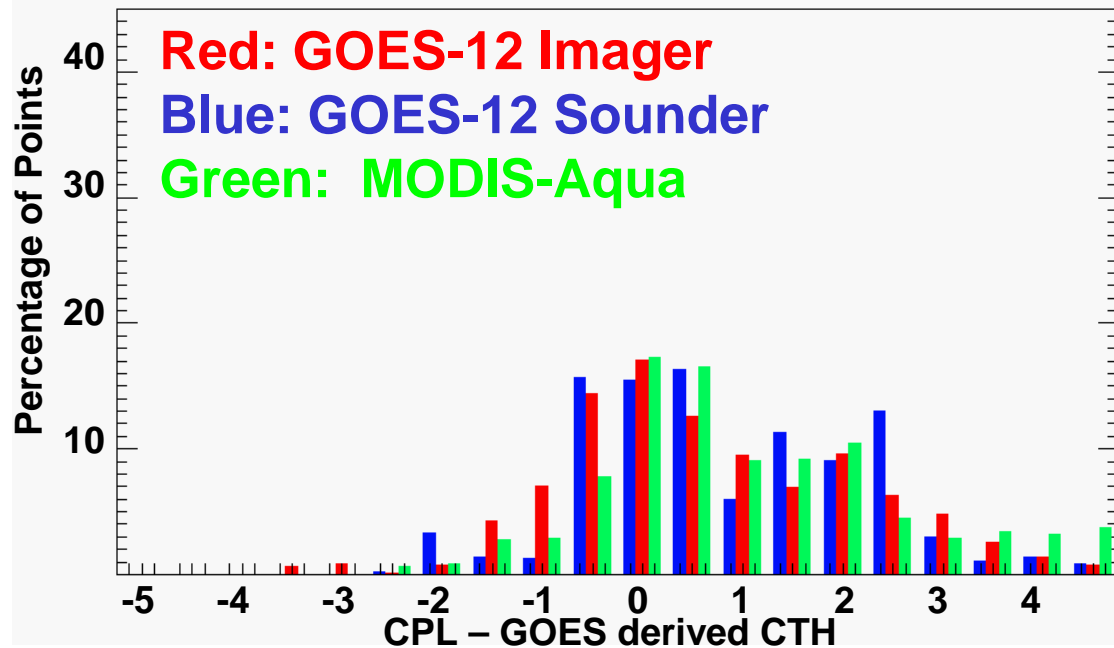
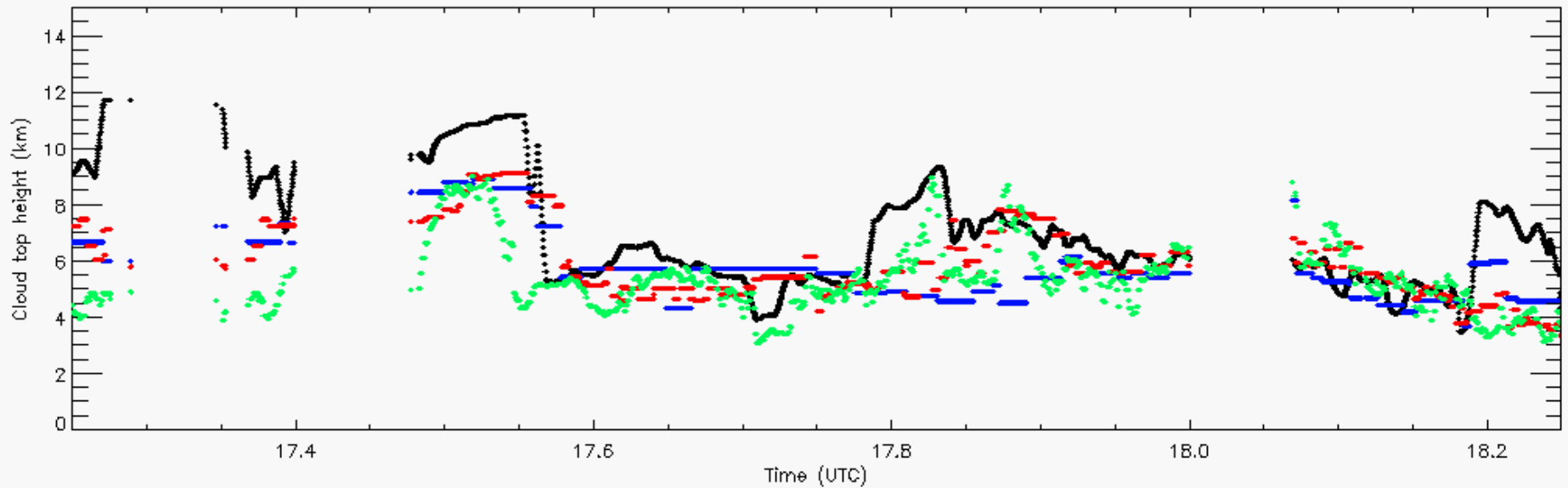


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MAS image displayed with RGB (1.62 μ m, 0.65 μ m, 1.88 μ m)
Courtesy of the AtREC MAS team

05 December 2003

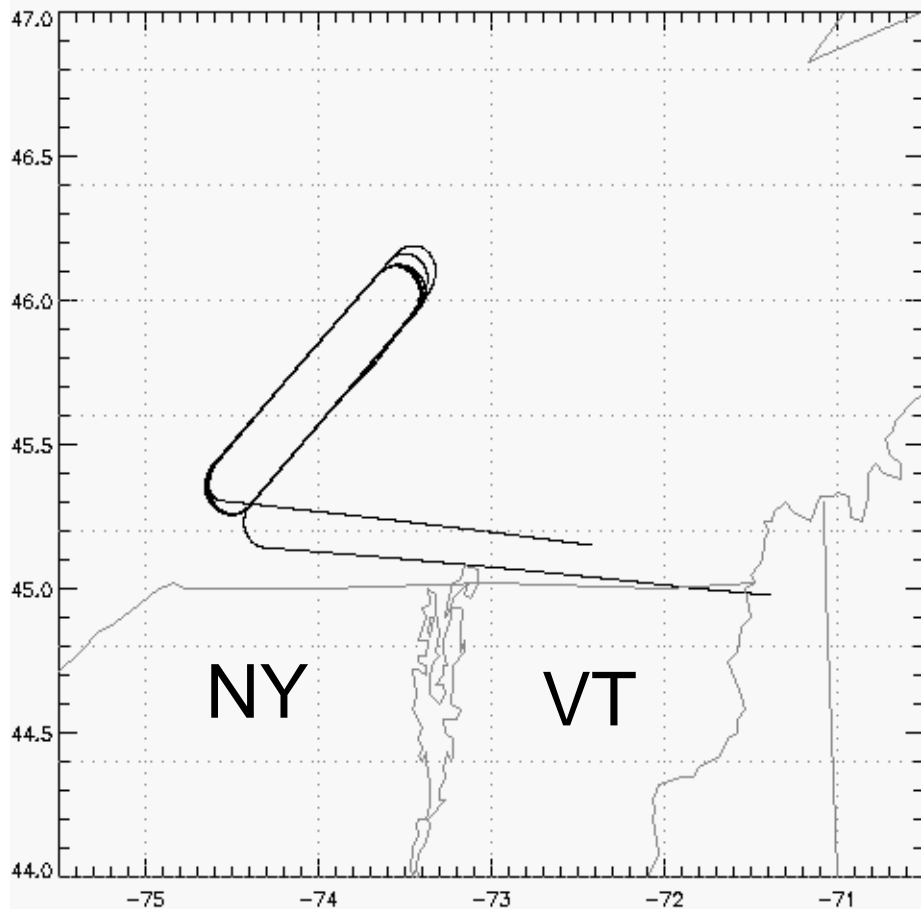


	RMS (km)	Bias (km)
GOES Sounder	1.80	1.14
GOES Imager	1.75	0.93
MODIS	2.34	1.51

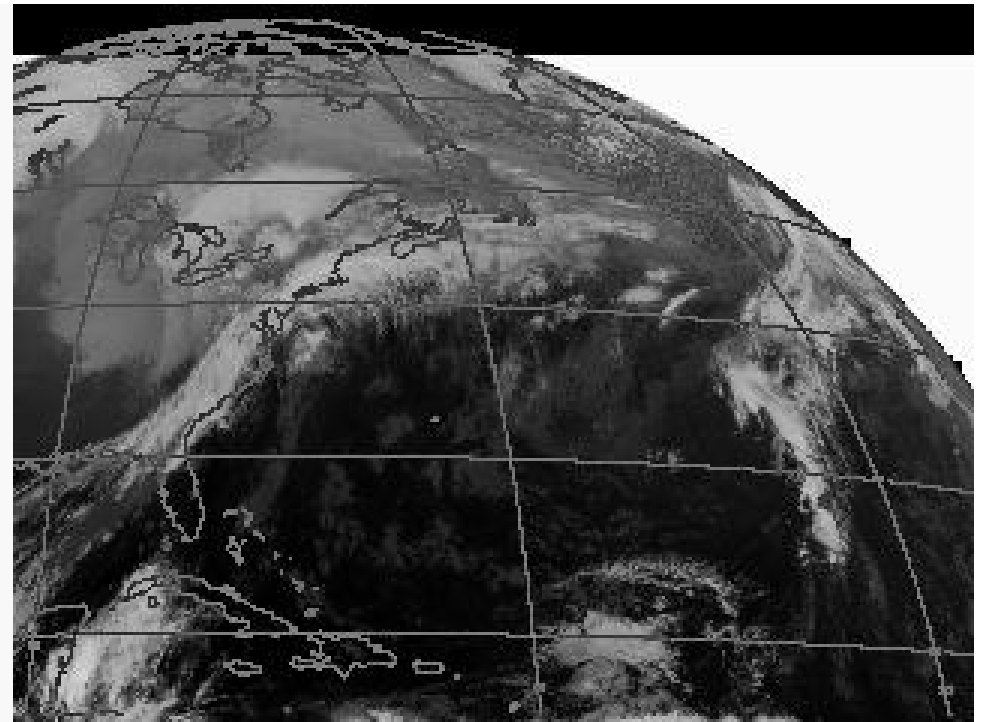
28 November 2003

1530-1930 UTC (1030-1430 EST)

NASA ER-2 Flight track

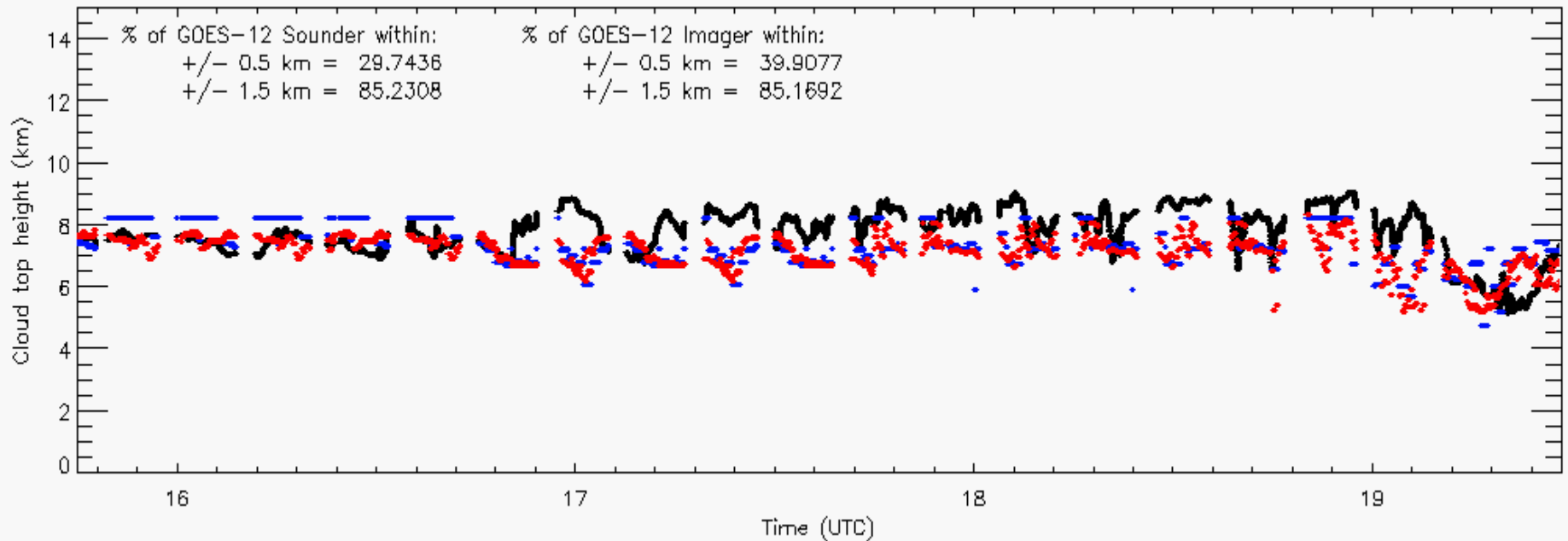


GOES-12 Imager 11 μm BT



The Citation did not accompany the ER-2 on this day, so the 11 UTC radiosonde profile from Manchester, NH was used to convert CTP to CTH.

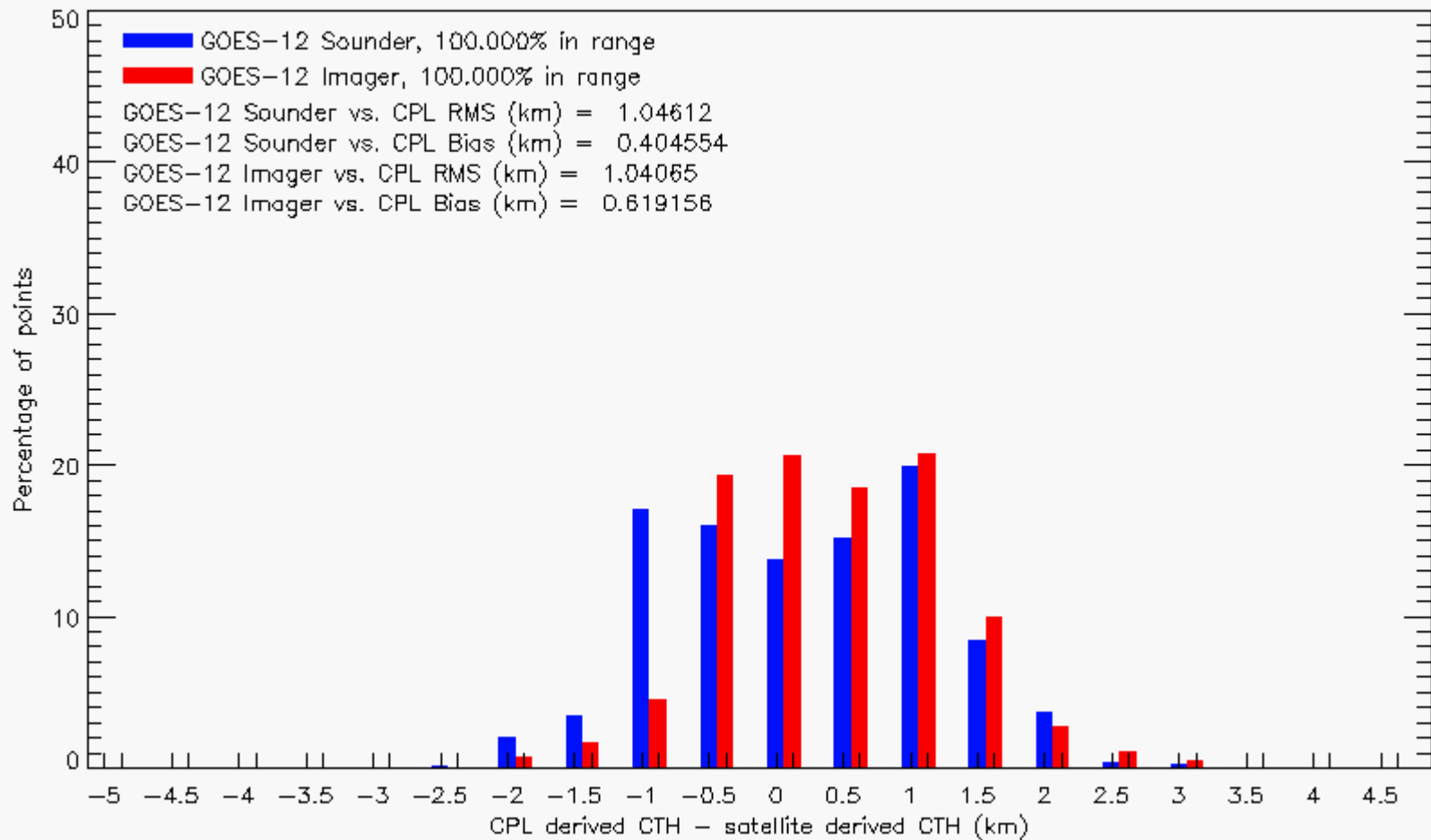
28 November 2003



Red: GOES-12 Imager
Blue: GOES-12 Sounder
Black: CPL

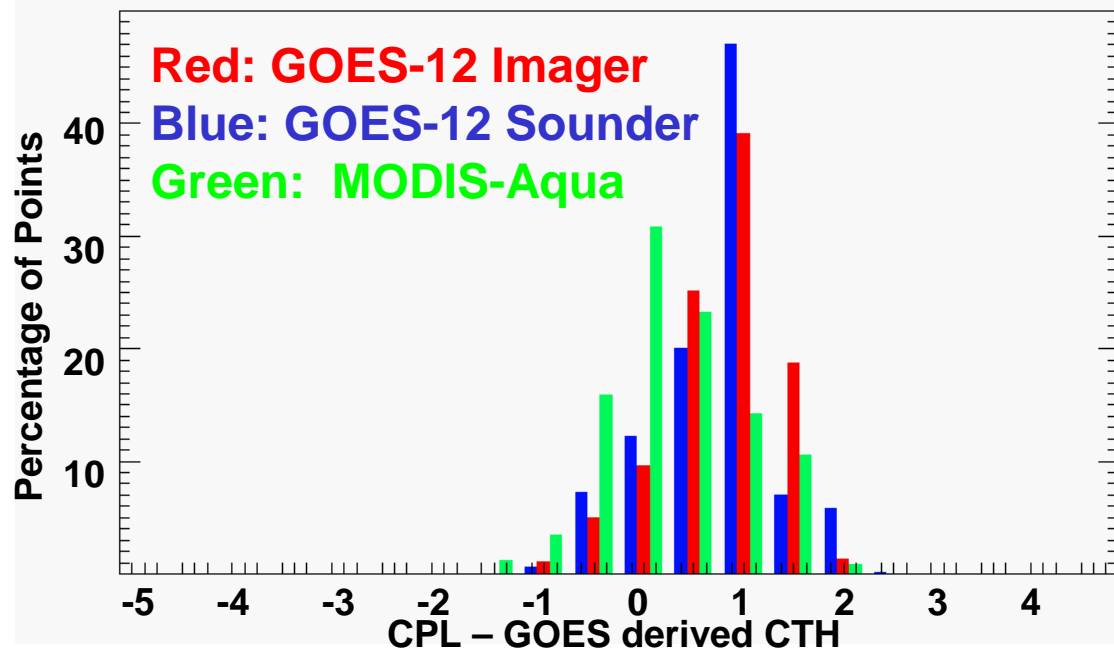
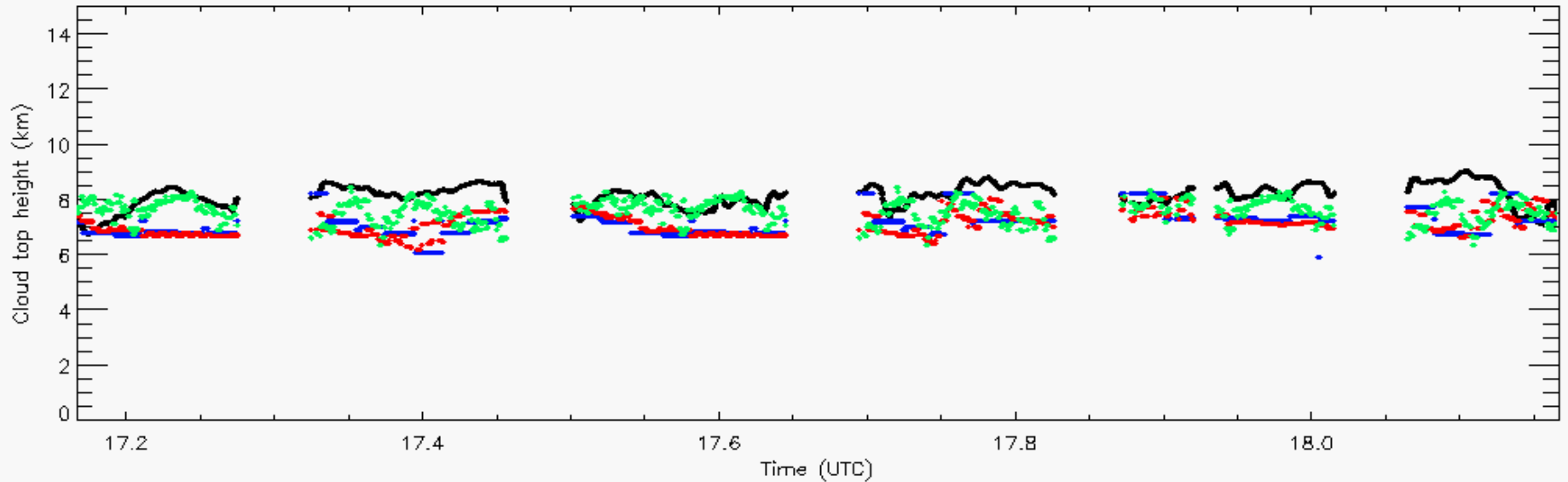
All clouds are considered mid-level and GOES statistics show considerable improvement over the previous case. This strengthens the conclusion that the GOES cloud top height assignment is most reliable for mid-level clouds.

28 November 2003



Again, the GOES Imager is in better agreement with the CPL than is the GOES Sounder. However, both instruments show a significant improvement over the previous case.

28 November 2003

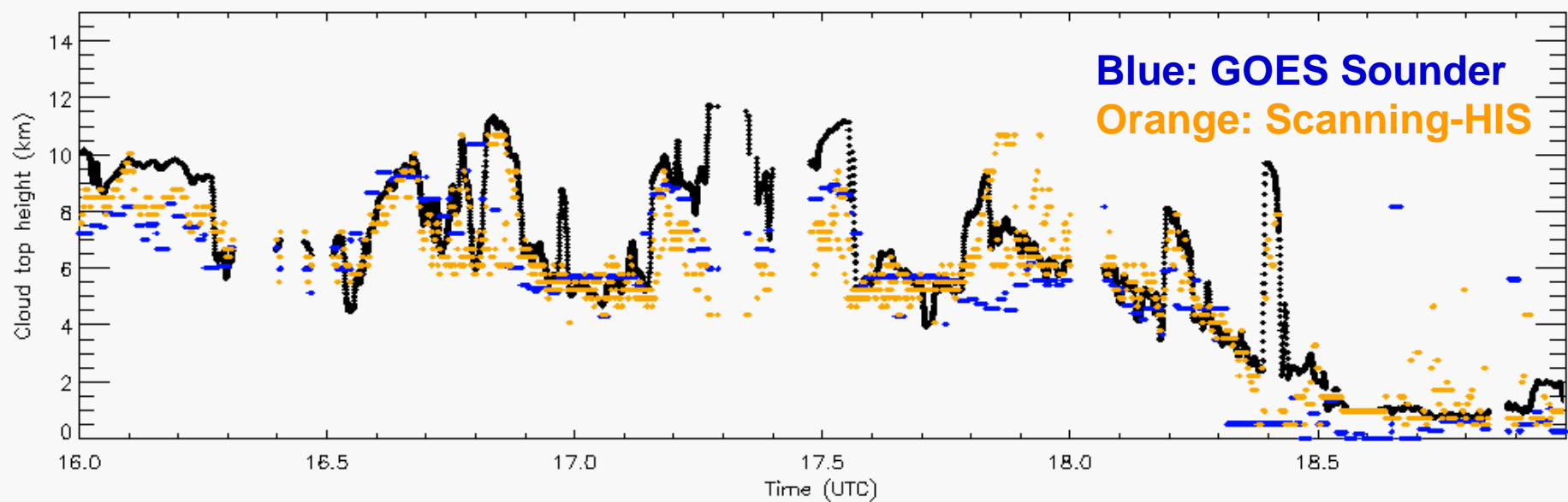
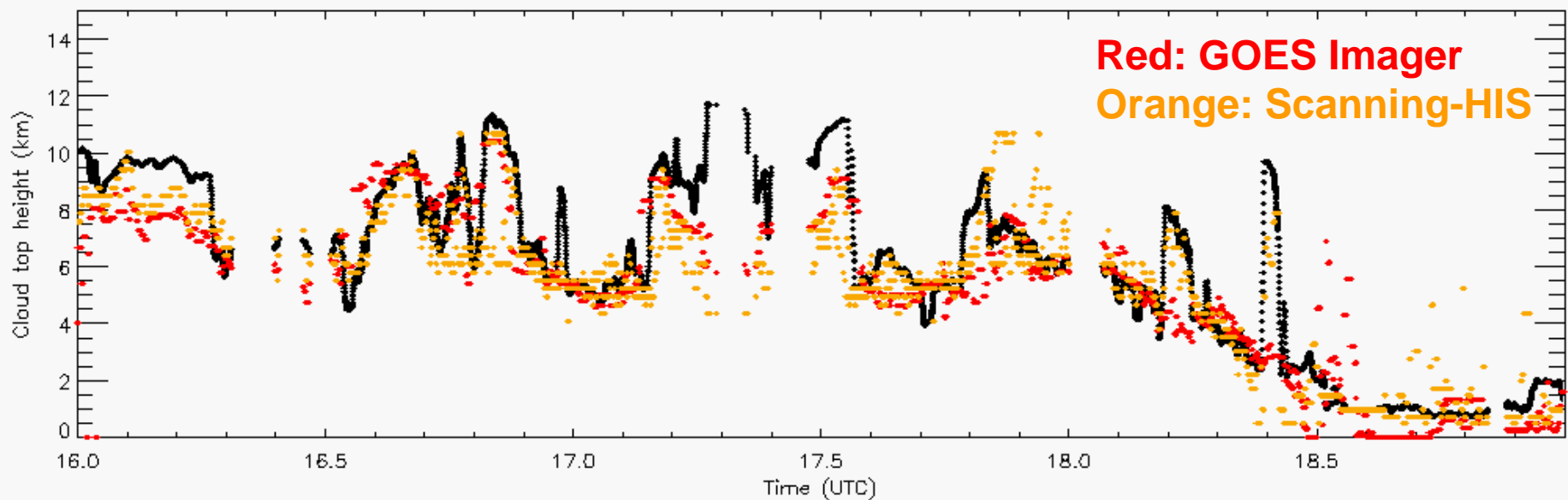


	RMS (km)	Bias (km)
GOES Sounder	1.18	1.01
GOES Imager	1.19	1.05
MODIS	0.87	0.55

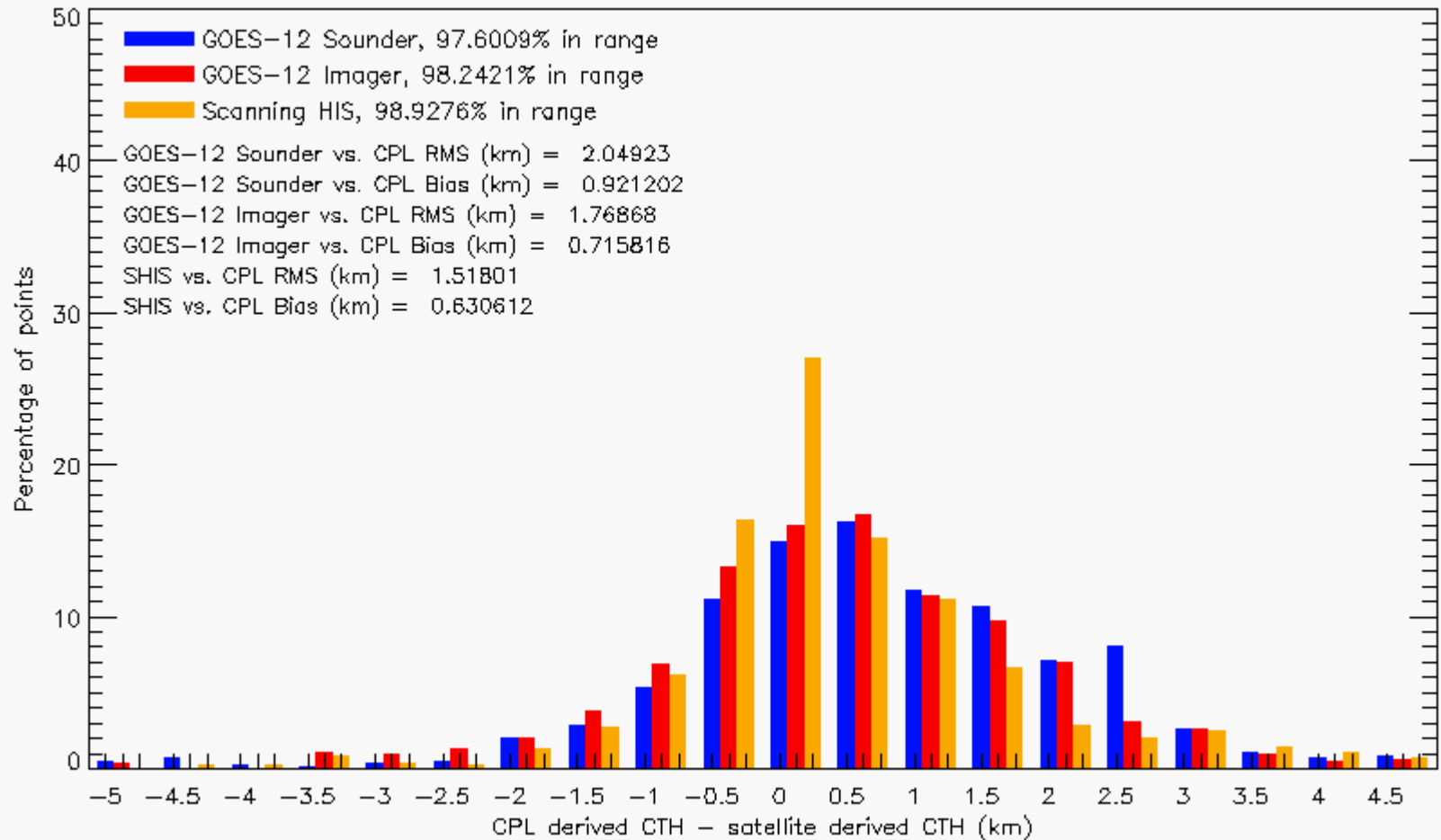
Comparisons to SHIS data

- **ASAP Phase II will include research and development in preparation for future space-borne hyperspectral satellite instruments**
- **During the AtREC experiment, a Scanning High-resolution Interferometer Sounder (SHIS) instrument flew on the NASA ER-2**
- **The SHIS measures emitted thermal radiation at high spectral resolution between 3.3 and 18 μm , at a spatial resolution of 2 km at nadir.**
- **Cloud top height algorithm is an experimental algorithm using exclusively the CO₂ Ratio technique.**

05 December 2003



05 December 2003



Differences exist between the SHIS and planned space-borne hyperspectral instruments. However, preliminary results are encouraging for the future of satellite hyperspectral technology.

Conclusions

- **Results from these 2 case studies show that the GOES Imager provides better agreement with the CPL than does the GOES Sounder.**
 - Probably due to the improved spatial resolution of the GOES Imager, which allows it to identify some smaller scale features that the CPL would also identify.
- **Considering the differences between the different products presented, the satellite data shows reasonable and encouraging agreement with the CPL measurements of cloud top height.**
 - Differences in spatial and temporal resolution, as well as the actual quantities being measured (e.g. Radiative vs. Physical cloud boundaries)
- **Preliminary looks at hyperspectral technology are encouraging, and further studies are necessary to examine the utility of these instruments.**