Enterprise Cloud Height Status, Progress and Applications

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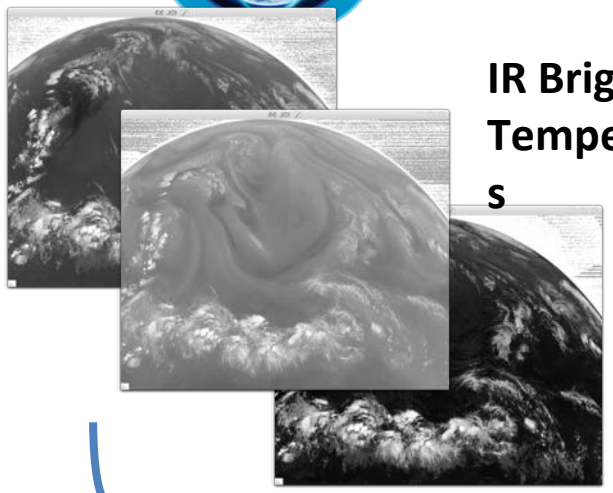
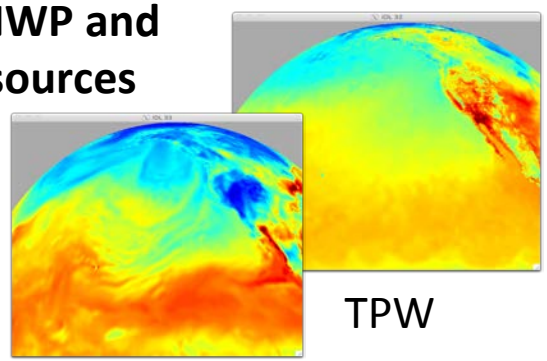
How AWG CLOUD HEIGHT (ACHA) Works



IR Brightness Temperatures

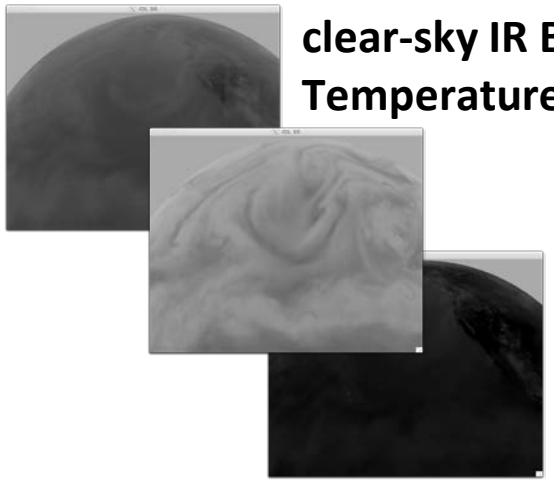
Ancillary Data from NWP and other sources



surface temperature

TPW

Radiative Transfer Model clear-sky IR Brightness Temperatures

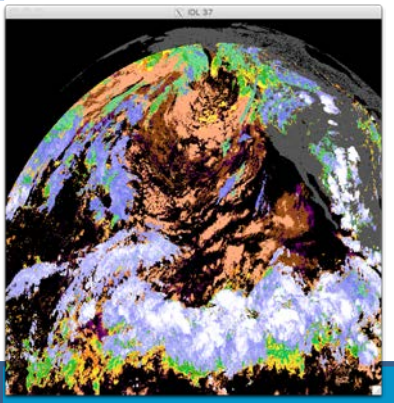


ACHA Input

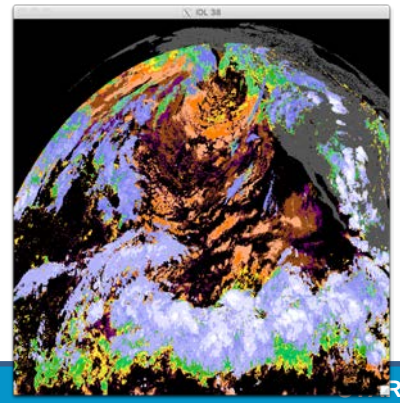
Optimal Estimation

ACHA Output

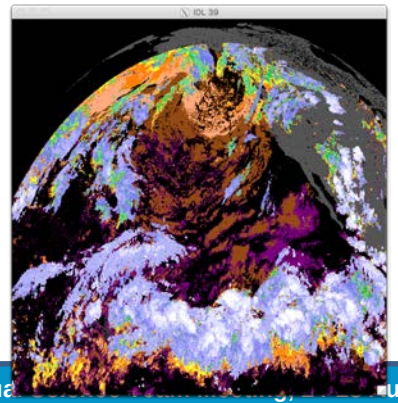
cloud pressure



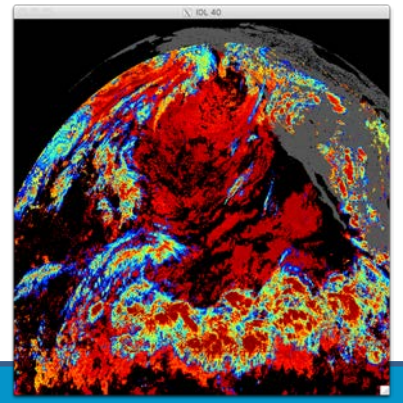
cloud height



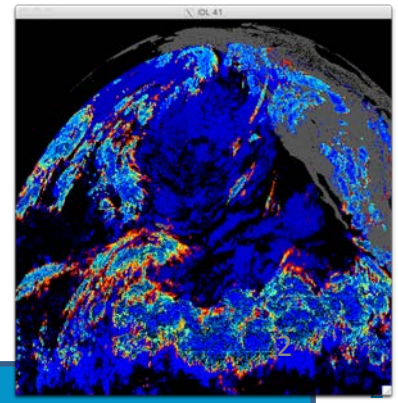
cloud temperature



cloud emissivity



cloud pressure errors



Users of Enterprise Height Products and Software

Software

- Japanese Meteorological Agency (JMA): (ACHA run in their own system).
- Australian Bureau of Meteorology (ABOM): ACHA run for local AMV generation.
- Taiwan Central Weather Bureau: Enterprise algorithms run in CSPP.
- Naval Research Laboratory: ACHA run to support a MURI project.
- CIRA: ACHA part of suite run in CLAVR-x to support solar energy forecasts.
- CSPP: Both LEO and GEO versions.
- NASA NPP MODIS Continuity Project uses ACHA in CLAVR-x in its processing chain.

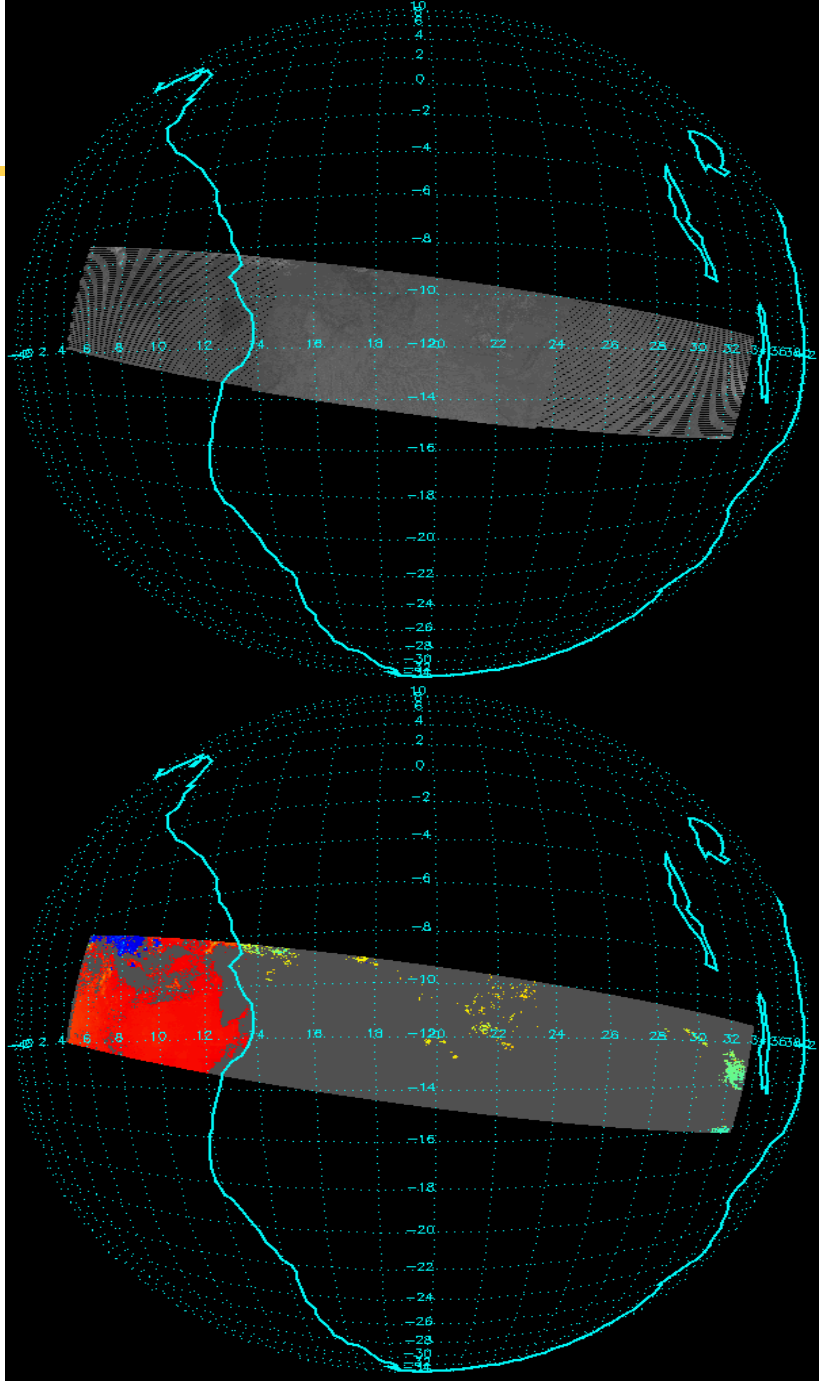
Products

- NWS Aviation Weather Center: ACHA, BASE and CCL from global geos and polar VIIRS.
- Boeing: ACHA from all GEO sensors.
- NESDIS Operations AMVs (GEO and VIIRS).
- NCEP All-sky radiance assimilation stratification (clear and by cloud layers).
- NCEP RTMA (tbd).

OSPO/NDE Operational Status

Enterprise Cloud Algorithms Operational Status

- The NOAA Enterprise Cloud Products (Mask, Phase, Height, Day/Night Optical) became operational on July 7, 2017 and available on PDA.
- Data should be available to public via CLASS on August 23.
- Operational version (v1r1) was that from June 2016.
- Updates delivered January 2017 and August 2017 are not yet running in NDE.

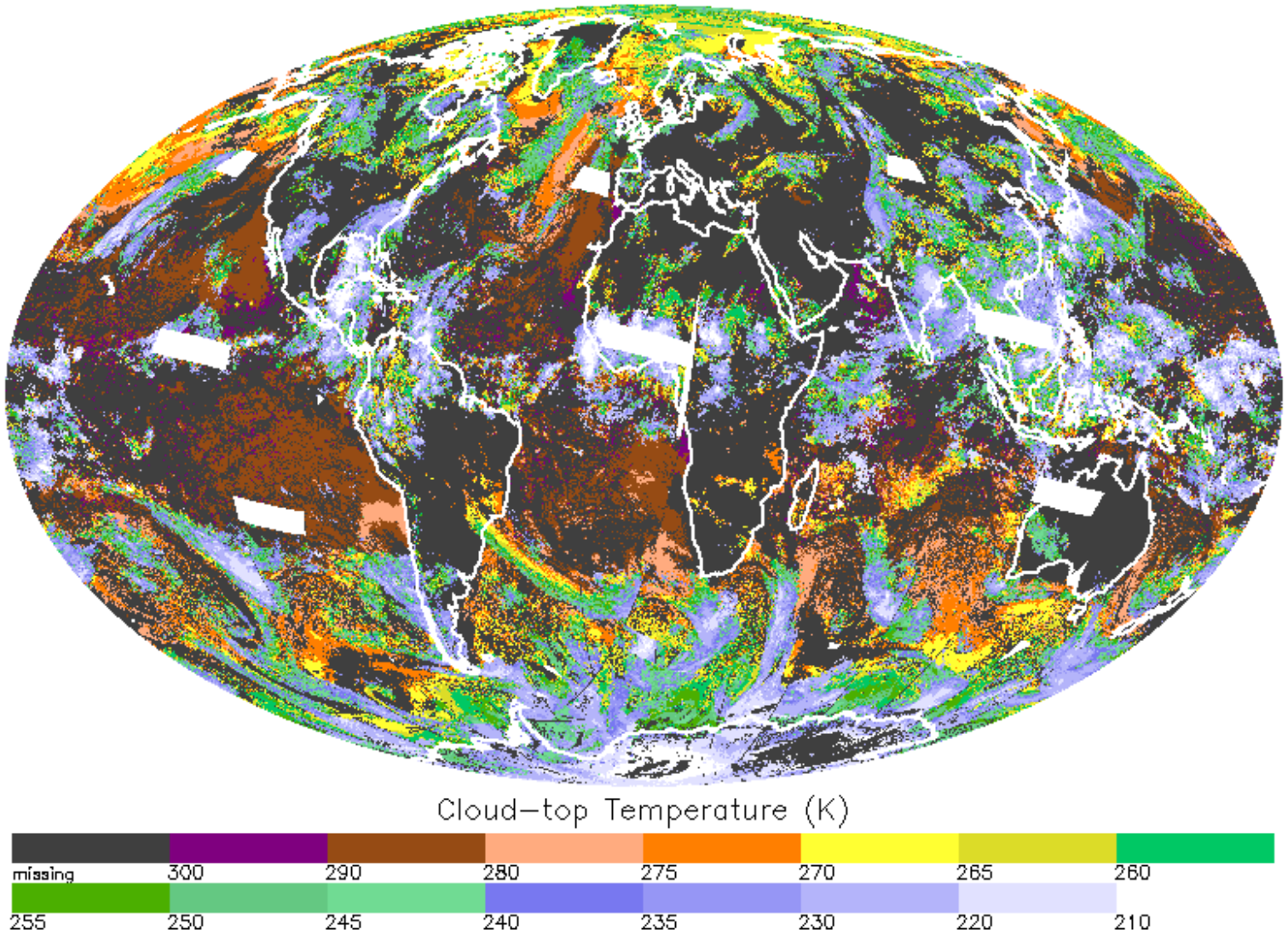


Images show about 8 hours of NDE Enterprise Output. Top image is the 11 micron BT and the bottom image is the NDE operational cloud-top pressure product.

Global Views of NDE Output

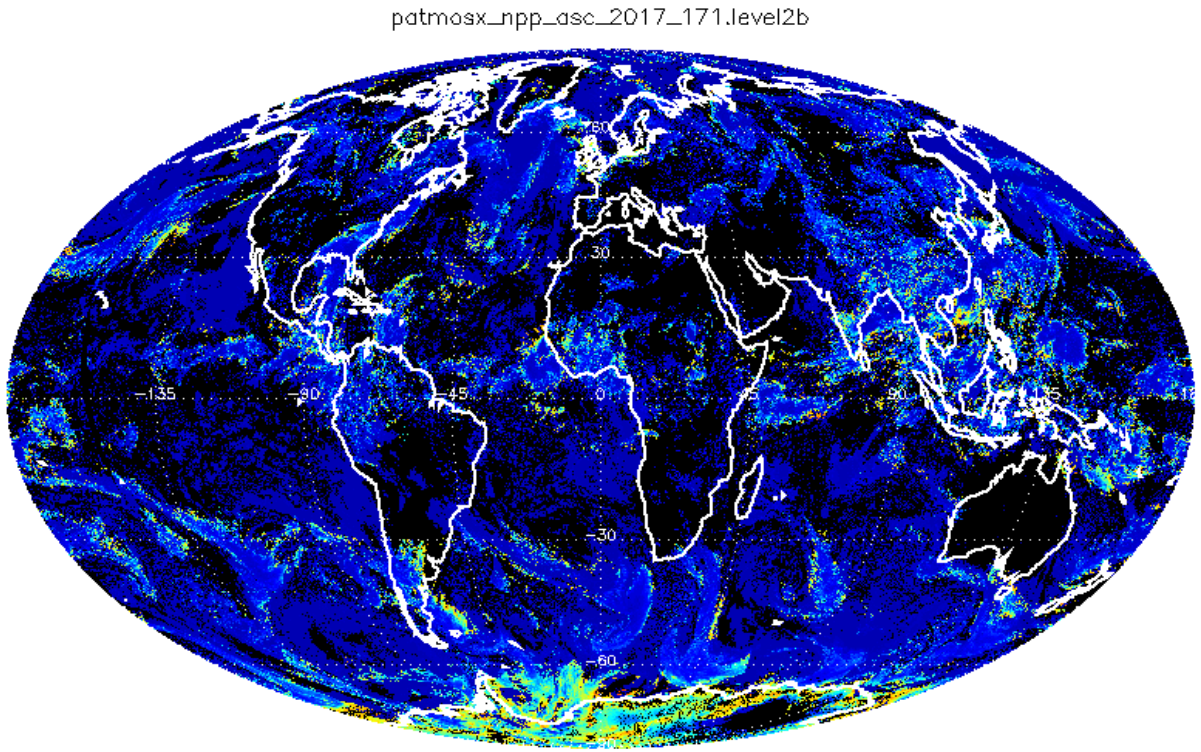
Issues:

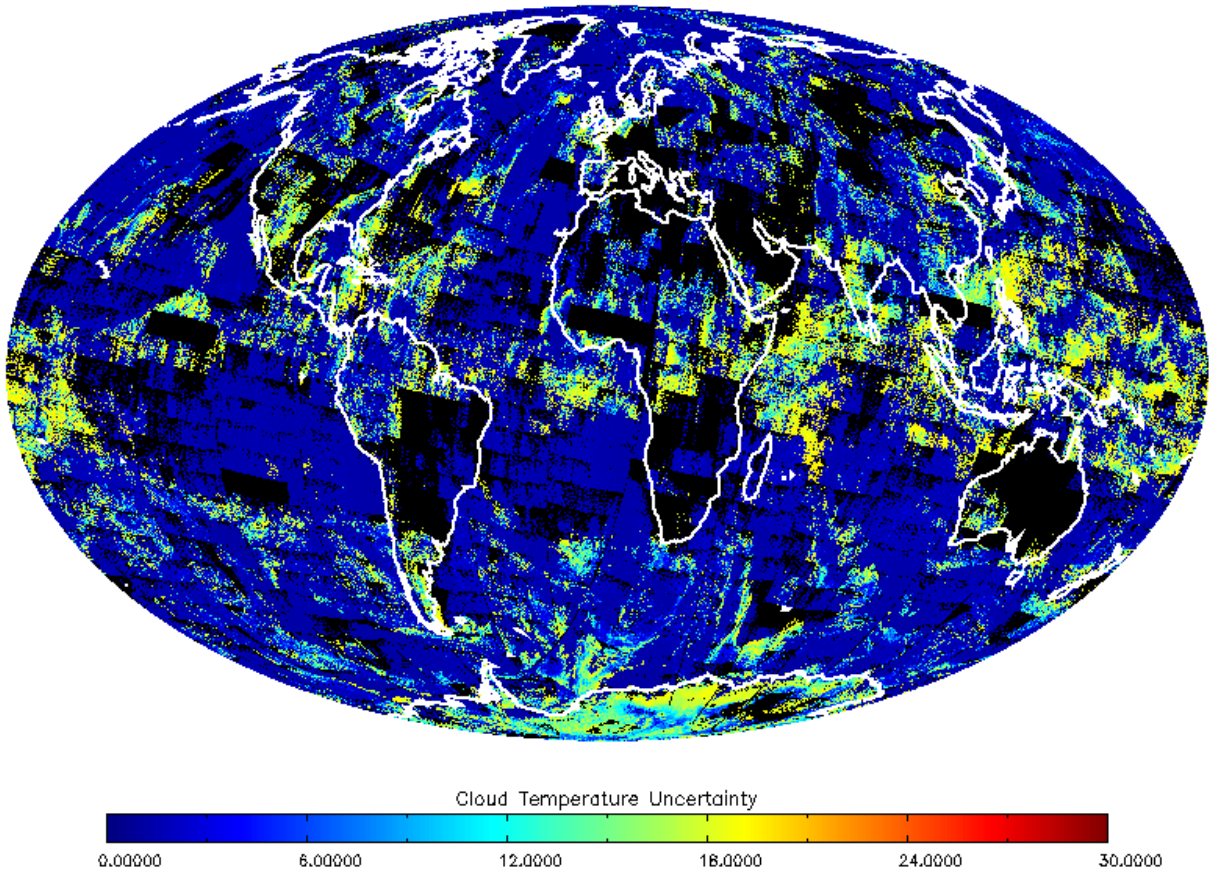
- A few missing granules per day on all days tested.
- Edge of granules are missing. VIIRS maximum zenith angle is larger than maximum supported by CRTM/SAPF



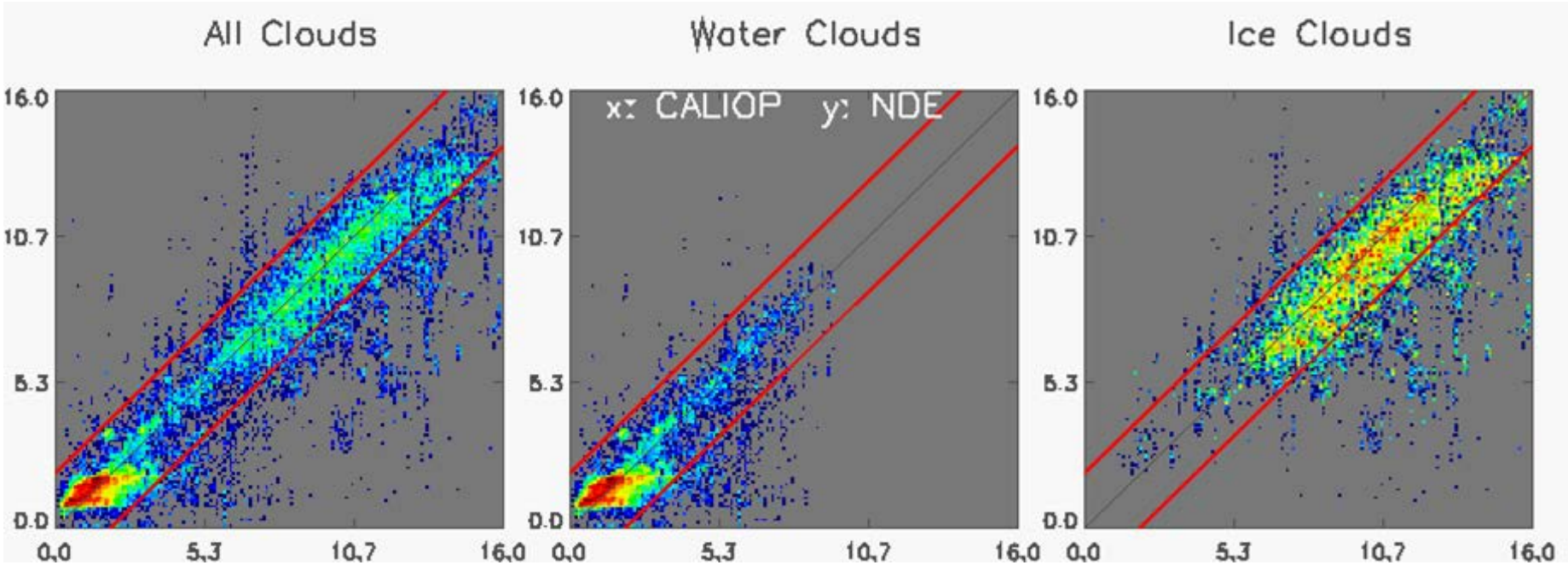
Issues Contd.

Cloud Top Temperature Uncertainty is not correctly written to file.





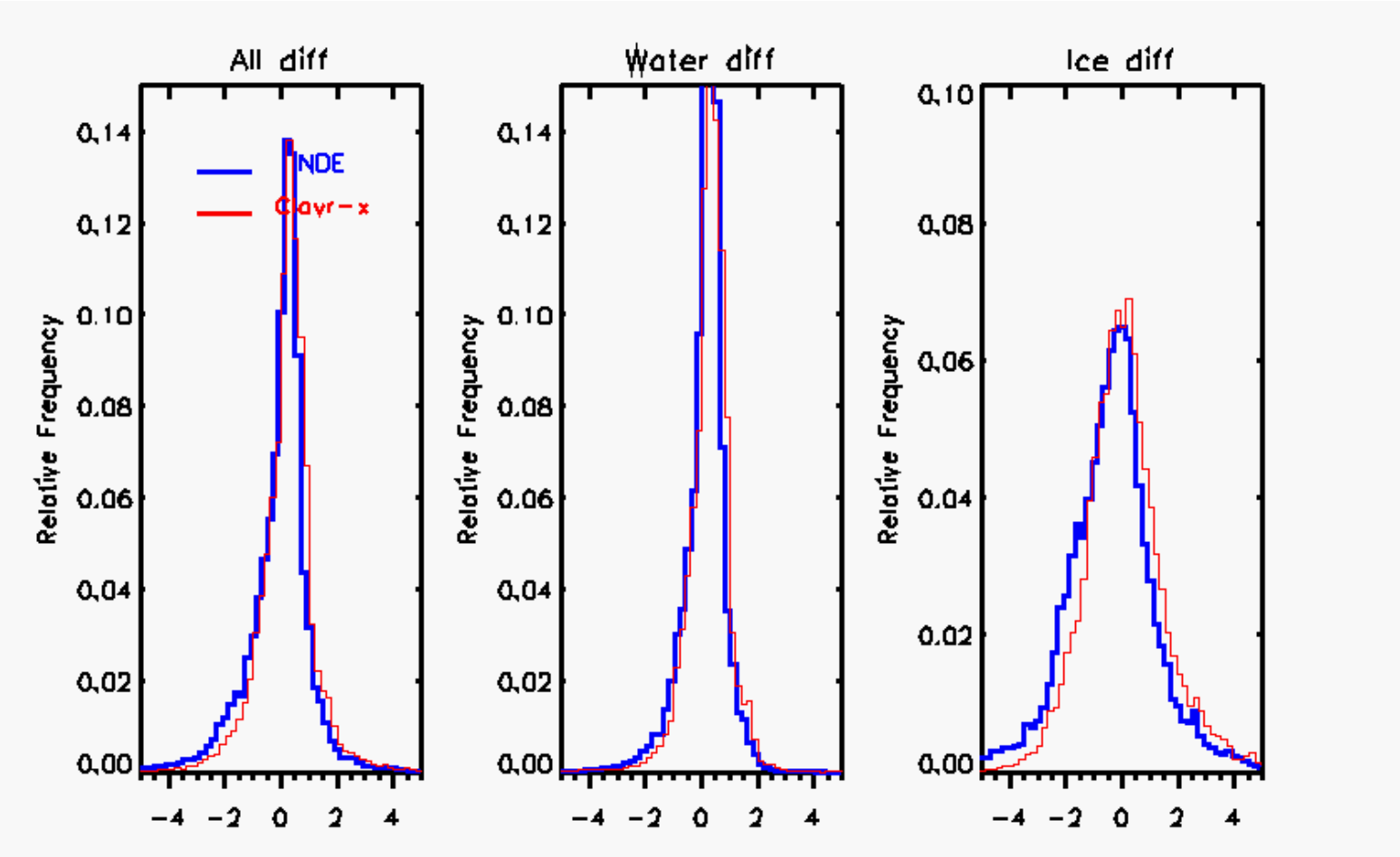
NDE vs Calipso



60◦N-60◦S, Phase matching, single layer						
Type	Bias (km)	StdDev(km)	Corr	Counts	Within Specs-Accuracy	Within Specs-Precision
All clouds	-0.3	1.26	0.96	69060	81.9%	82.3%
Water	-0.02	0.80	0.83	46050	90.7%	90.8%
Ice	-0.87	1.74	0.75	23010	64.5%	65.7%

Histogram Distribution of differences between VIIRS and Calipso

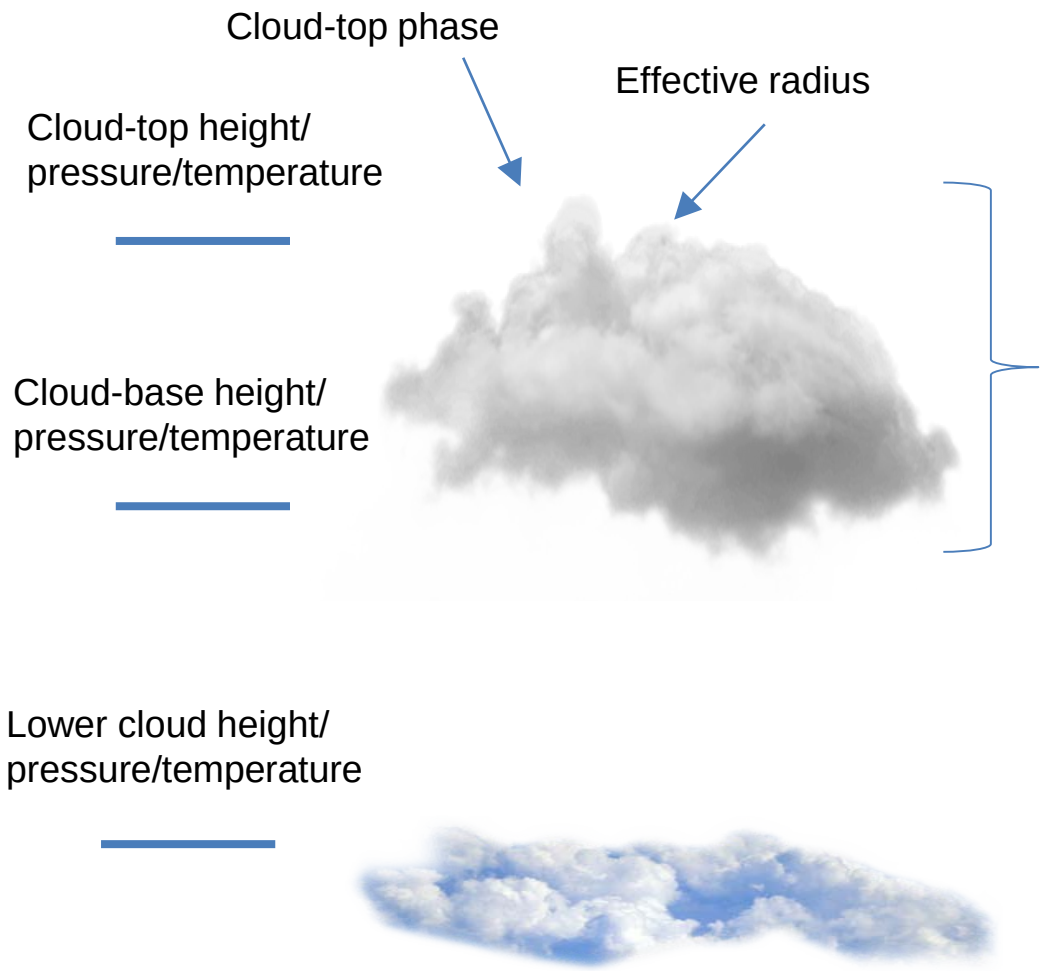
- Phase matching and single layer filtering is applied to 06/20/2017
- Calipso from the same day is collocated and compared
- An independent comparison using current Clavr-x product is provided and shows similar performance
- Current cloud height retrieval indicates a slightly larger estimation, which makes a positive impact compared to NDE (next two slides)



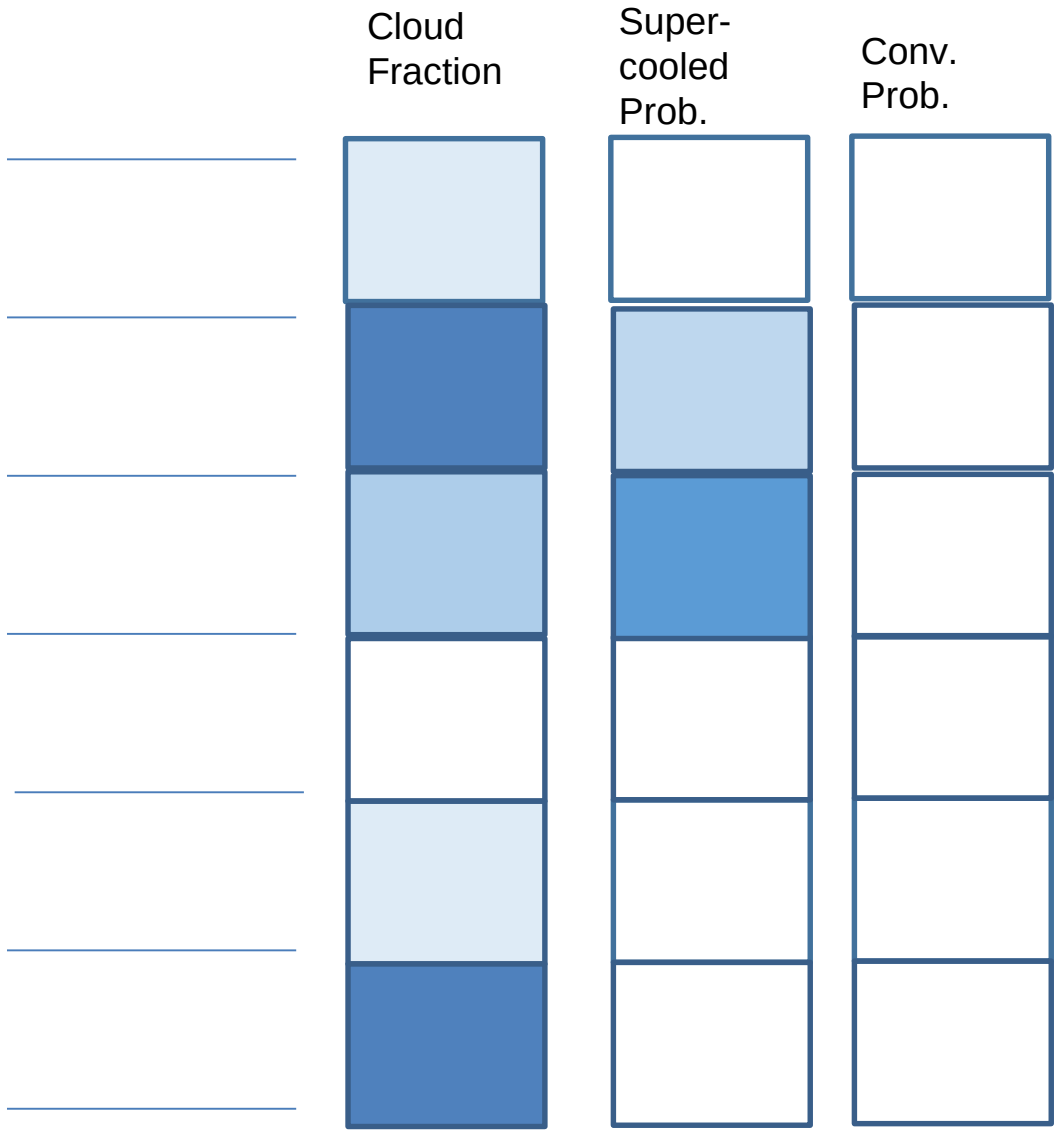
CLOUD COVER LAYERS APPLICATION

Cloud Cover Layers Application

Pixel-level Cloud Products (Mask/Phase/ACHA+Base)

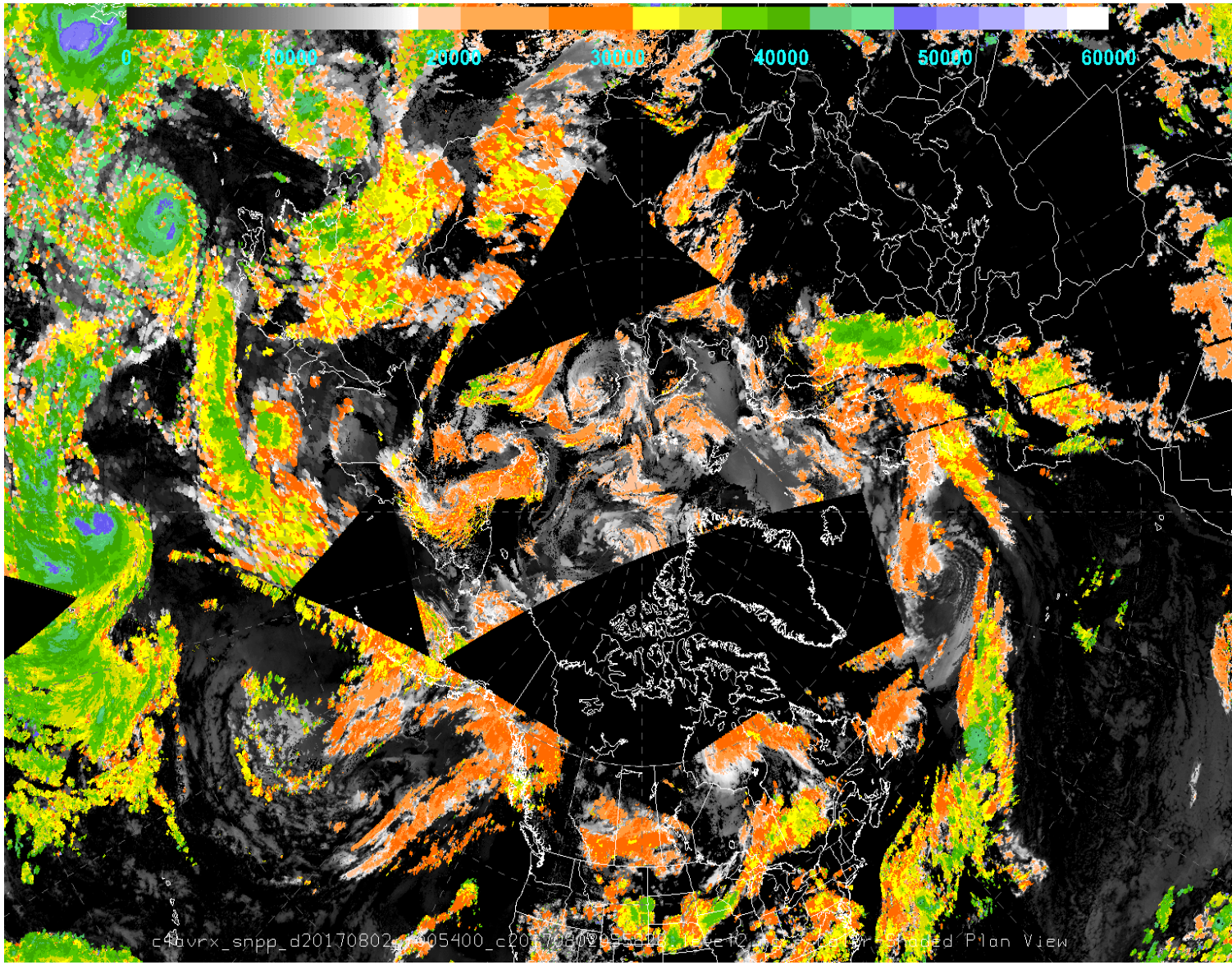


Gridded (10 km) Cloud Cover Layers



Merging VIIRS and GEO for AWC

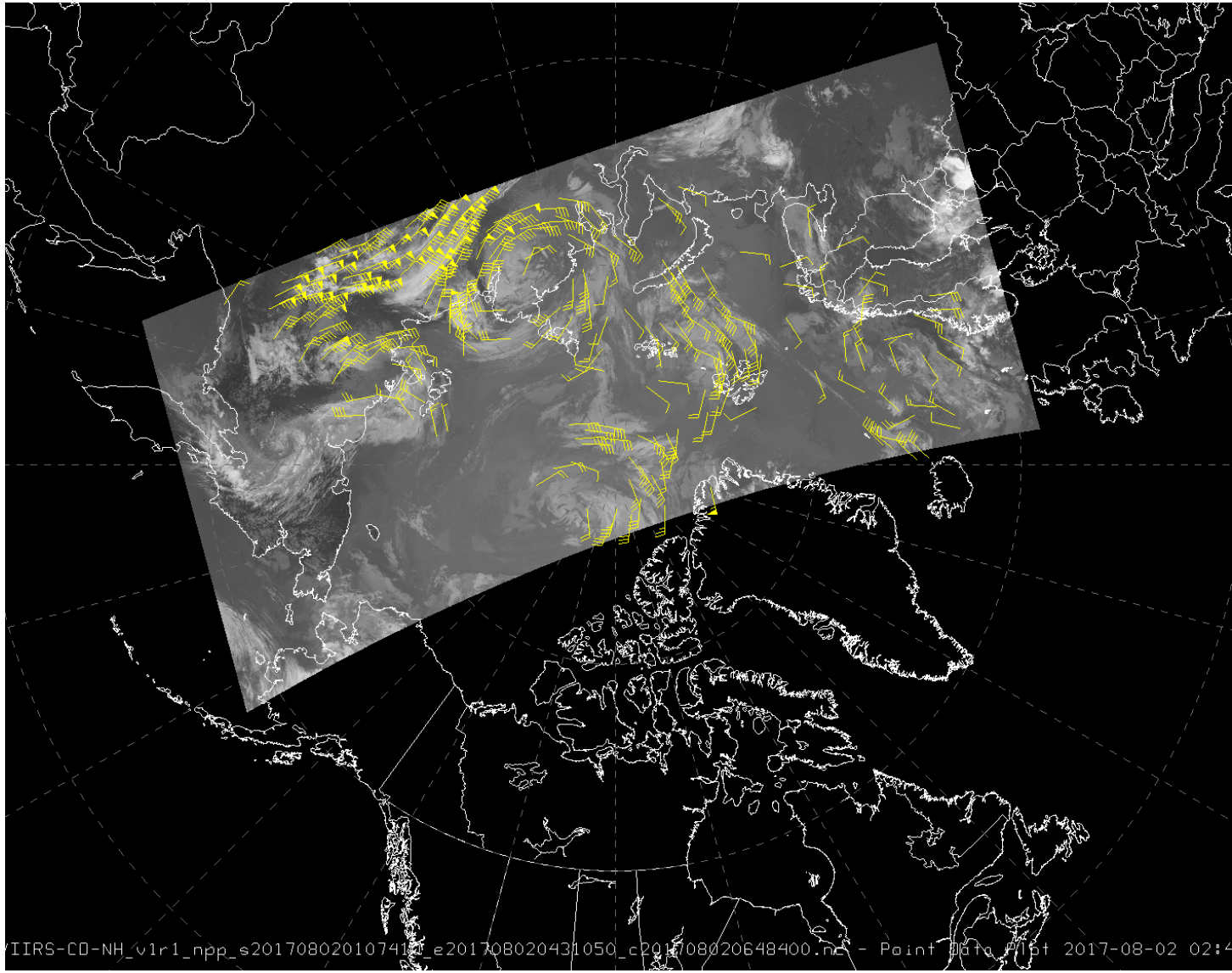
- Image contains one day of cloud-top altitude (ft).
- Arctic data is from SNPP VIIRS
- Non-Arctic data is from the global geostationary constellation.
- Global-geo has been served to NWS AWC since 2014.
- We plan to add VIIRS now that products are operational (see image on right)
- Data will be served to AWC via CIMSS.
- PSDI support will be sought to move all of this in NESDIS ops.
- Products will include the CCL supported under JPSS-RR.



AMV APPLICATION

VIIRS Arctic AMVs for day 2017, August 02

- Initial NWP impact shows mostly neutral to slightly positive NWP impact. Reported by Iliana Genkova at IWW13 in June 2016.
  - –Planned for operational use in the GSI Quarter 3 Fiscal Year 2017.
- All supported sensors use the same AMV software in the Enterprise framework.
  - –Includes both leo and geo sensors.



Enterprise VIIRS AMV RAOB statistics - Arctic

100 - 1000 hPa	All Levels
Accuracy	5.89
Precision	3.48
Speed Bias	0.52
Average Speed	21.79
Sample Size	12784

- Data is from 1 February - 30 June, 2017.
- GOES-R Metrics: 7.5 ms-1 Accuracy; 4.2 ms-1 Precision.
- QI > 80

Enterprise VIIRS AMV RAOB statistics - Antarctic

100 - 1000 hPa	All Levels
Accuracy	6.10
Precision	4.16
Speed Bias	-0.25
Average Speed	15.72
Sample Size	1339

- Data is from 1 February - 30 June, 2017.
- GOES-R Metrics: 7.5 ms-1 Accuracy; 4.2 ms-1 Precision.
- QI > 80

ACHA Algorithm Changes since 2016

Multi-layer Solution

- ACHA always accounted for multi-layer clouds when detected, now temperature of lower layer has been added to the O.E. state vector.
- Very promising performance but varies with spectral content.

Microphysical Models

- Made this a compile-time option and expanded the number of options.
- Analysis has shown this does impact cloud heights appreciably.

Sounder/Imager Fusion

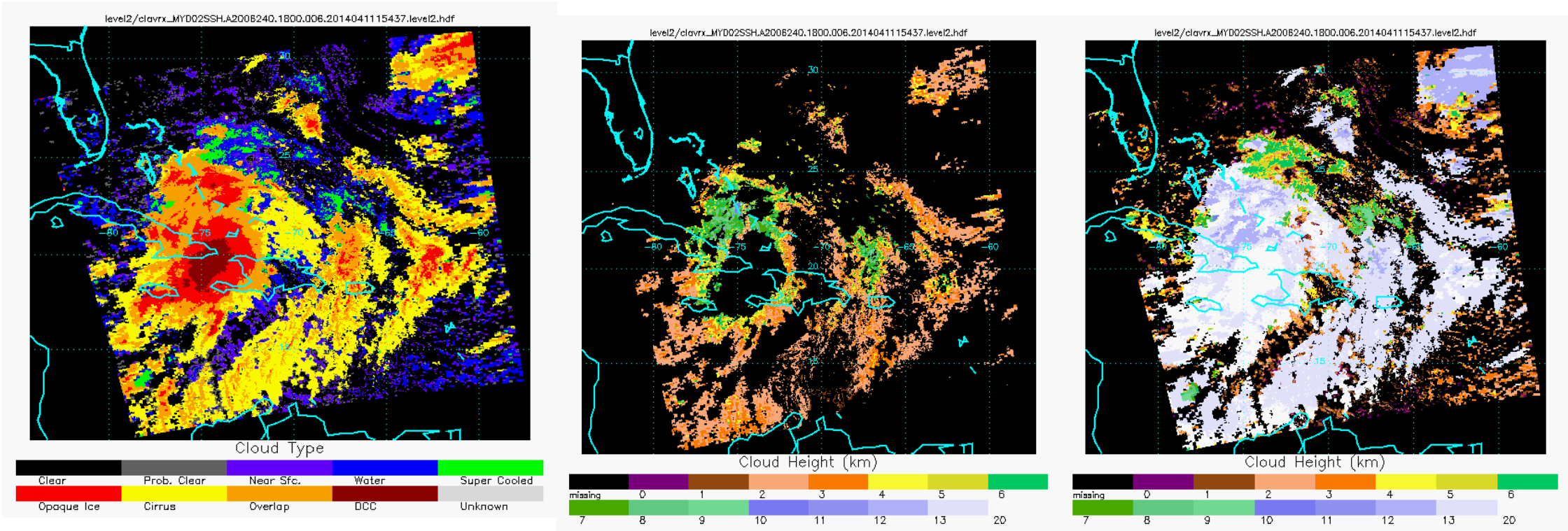
- Finalized use of CrIS data to make CO_2 slicing heights which are used in ACHA O.E.
- Paper drafted and results shown here.
- Studying use of NUCAPS heights and transitioning to operations.

Spectral Channels

- ACHA has always supported many 1,2 or 3 channel combinations. Now we support some 4 and 5 channel combinations. Default for VIIRS remains 8.5, 11 and 12 microns.
- Paper drafted on optimal channel combinations revealed by CALIPSO/CALIOP.

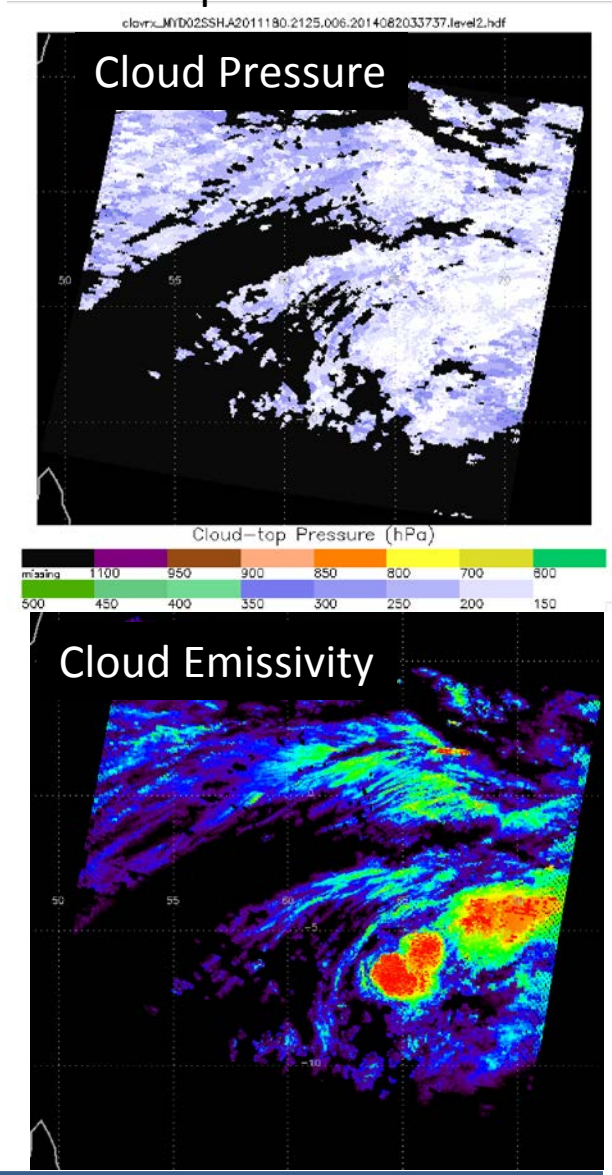
Multi-Layer Cloud Height

- AWG Cloud Height can now directly retrieve height of lower cloud layers.
- It can also determine its own multilayer scenes. (experimental)
- Limited to high thin over low cloud.
- Important for the CCL application and low level AMV targets.

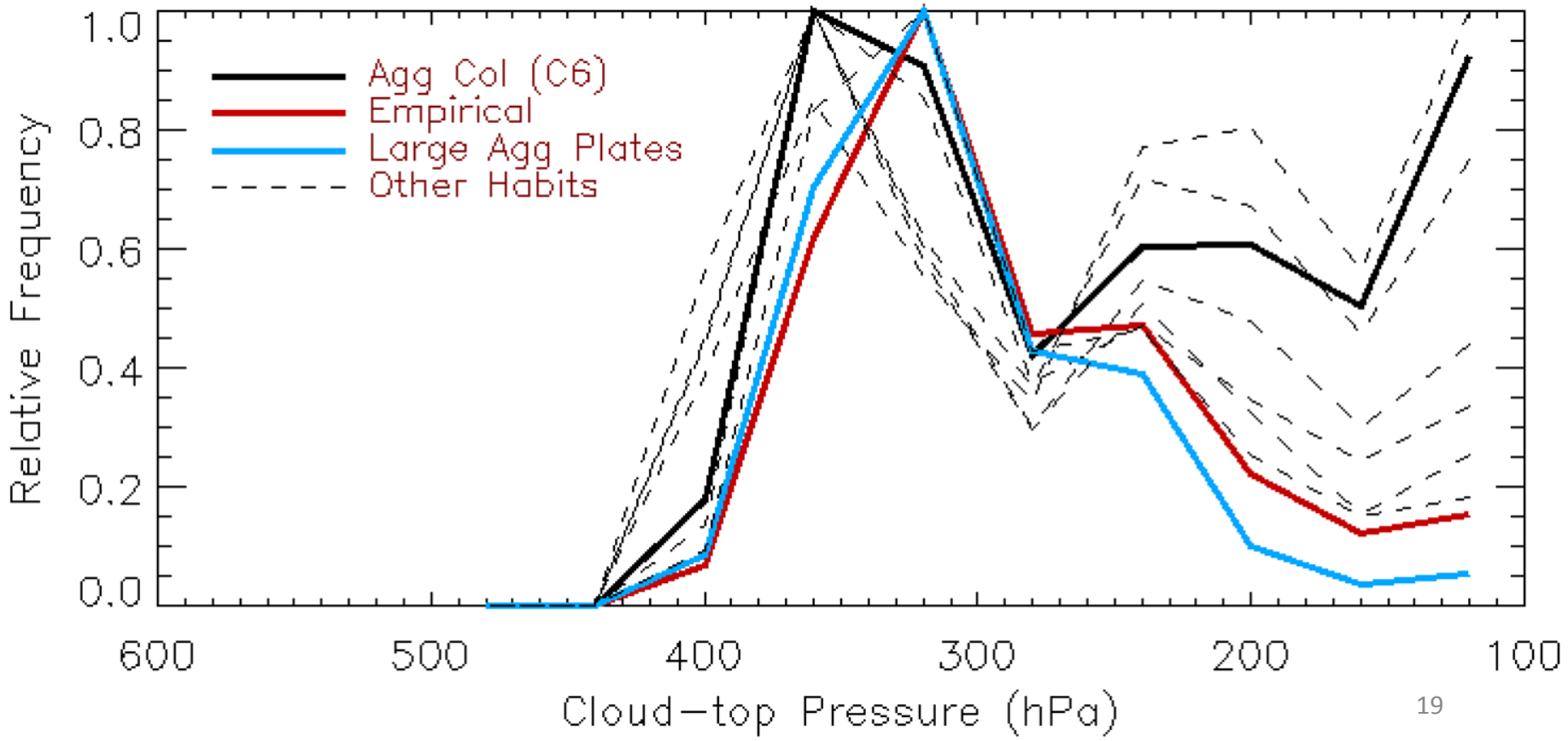


Impact of Ice Crystal Habit Choice on Cloud Height

Example VIIRS Scene

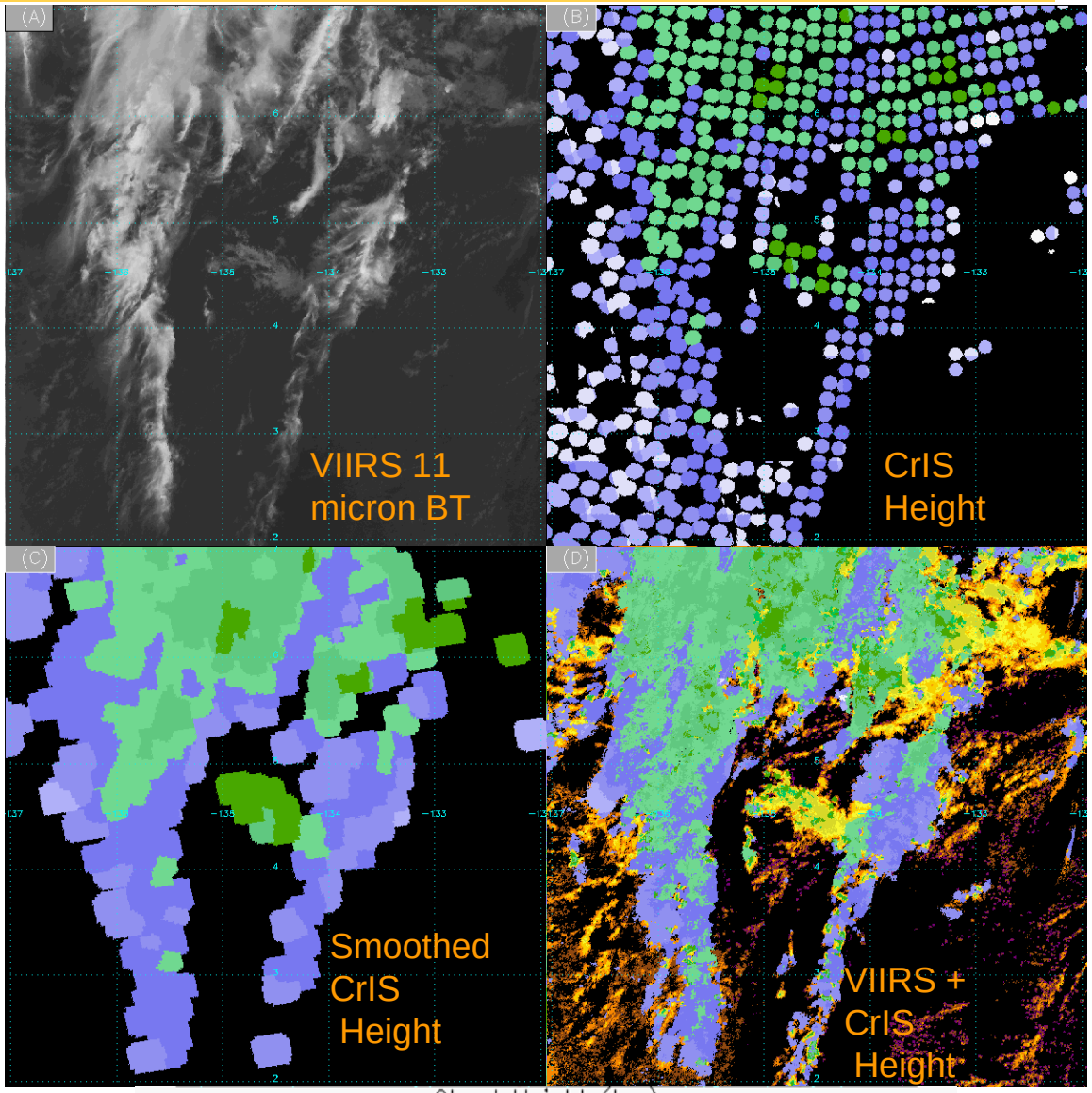


- MODAWG uses the Aggregate Column Habit as did MODIS C6
- This was chosen to improve VIS and IR consistency in optical depth
- The images below show the cloud-top pressures predicted **solely based on a direct inversion using the 8.5, 11, 12 µm channels and each habit.**
- Unfortunately, Agg Col solutions often go very high and are not optimal.
- The Empirical model is based on spectral consistency between 8.5-11-12 µm



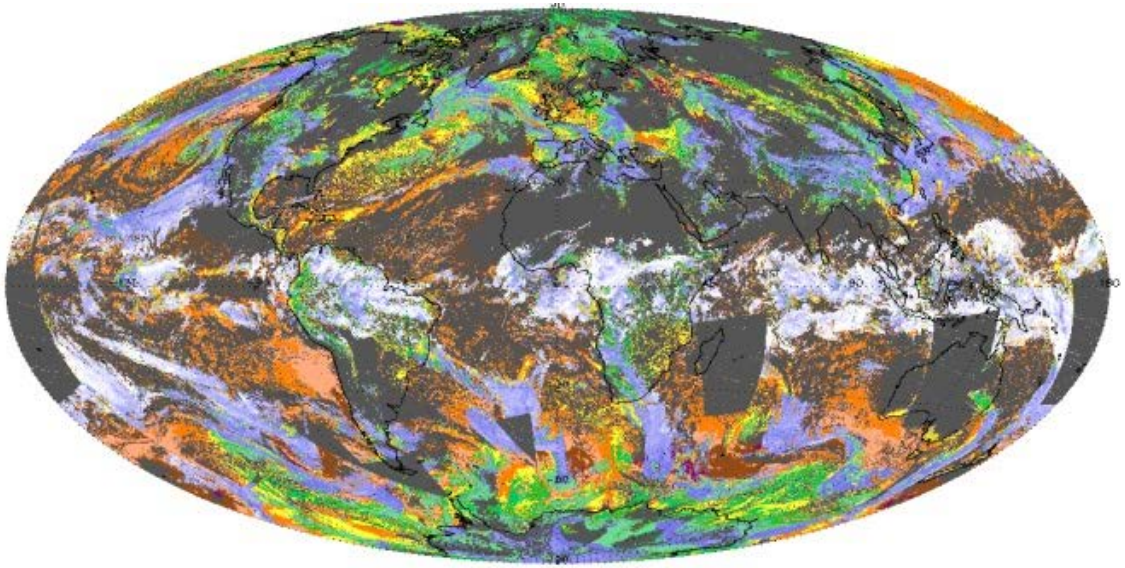
Imager/Sounder Merge

- VIIRS lacks IR bands in CO_2 or H_2O absorption bands that are present on GOES-16 and MODIS.
- Leveraging from the ***NASA SNPP MODIS Continuity Project***, we developed a methodology to merge with CriS to improve performance.
- Currently, we make MODIS CO_2 bands from CrIS and run a MODIS-ish CO_2 slicing. (top right)
- These sounder heights for ice clouds are spatially smoothed (lower left)
- The smoothed sounder heights are added as a new constraint to the ACHA IR Optimal Estimation.
- Benefits
  - ***Utilizes sounder spectral information***
  - ***Preserves imager spatial resolution***
- Applications
  - Polar Winds (need high spatial for tracking)
  - Radiance Assim - better cloud stratification
  - Climate - better cloud depiction - consistency with MODIS/GOES-16
- Future
  - Submit publication
  - Explore using NUCAPS as the sounder height source.
  - Look again at VIIRS pixel level CrIS Bands (Fusion)



Conclusions

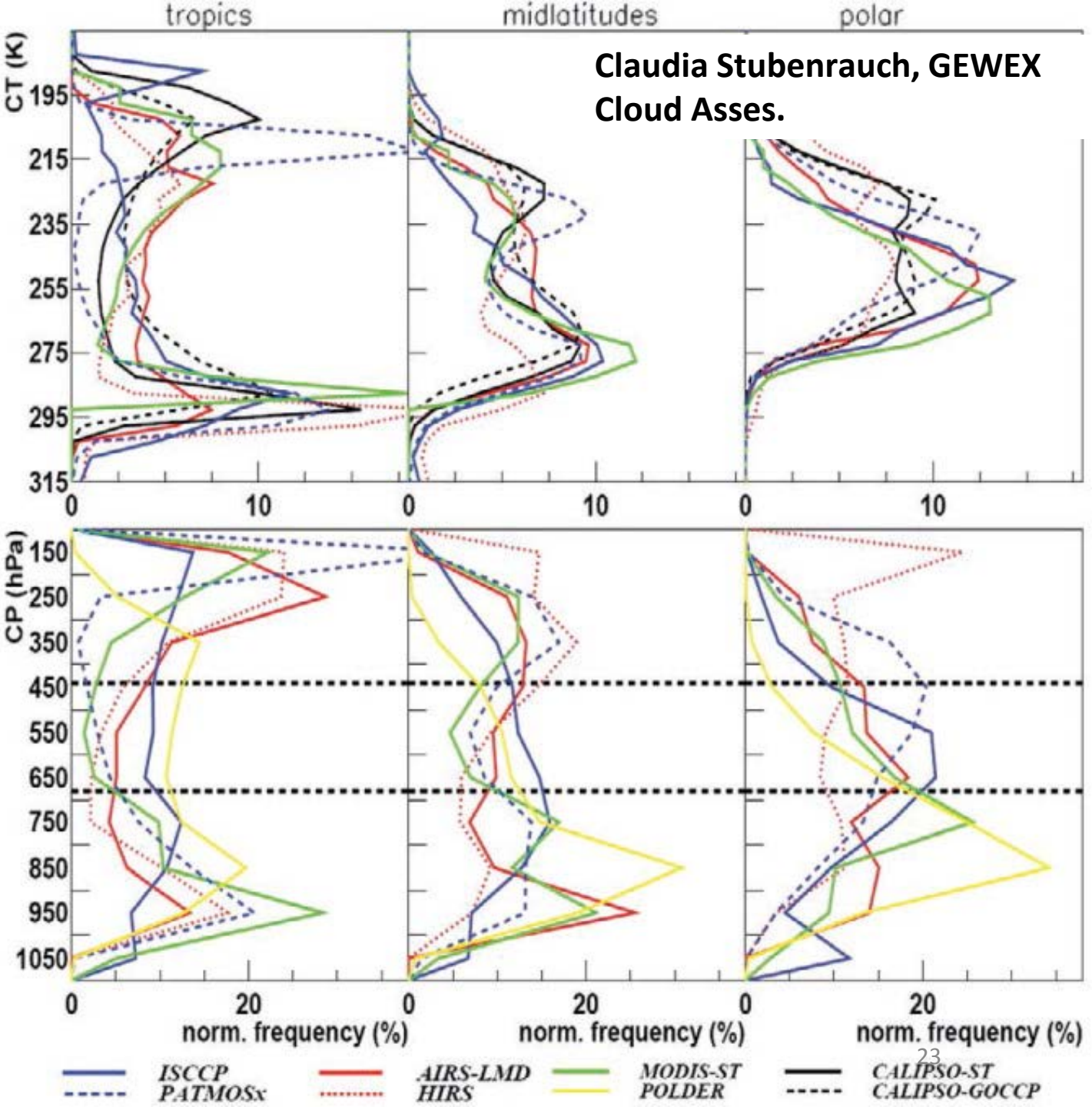
- ACHA is operational now in NDE.
- Performance seems as expected with a few lingering issues.
- We hope CCL from VIIRS can join global-geo CCL for AWC.
- ACHA's use in AMV application appears to be successful.
- We hope the use of ACHA for VIIRS/CrIS All-sky Radiance Assimilation is also successful.
- Several algorithm developments are ongoing and hold promise for improved performance.



The End, Thank You!

Challenge of Cloud Height Consistency

- Image shows cloud top temperature (top) and cloud pressure (bottom) from GEWEX Cloud Assessment.
- **Variation among sensors and groups is large.**
- Sensors with IR abs channels can use slicing or sorting techniques.
- Sensors with only IR window channels rely on microphysical techniques which are more problematic.



Additional AMV Stats

Enterprise VIIRS AMV RAOB statistics - Arctic

101 - 400 hPa	Upper Levels
Accuracy	6.38
Precision	3.58
Speed Bias	0.51
Average Speed	26.94
Sample Size	5528

- Data is from 1 February - 30 June, 2017.
- GOES-R Metrics: 7.5 ms-1 Accuracy; 4.2 ms-1 Precision.
- QI > 80

Enterprise VIIRS AMV RAOB statistics - Arctic

401 - 700 hPa	Middle Levels
Accuracy	5.72
Precision	3.30
Speed Bias	0.59
Average Speed	20.03
Sample Size	5525

- Data is from 1 February - 30 June, 2017.
- GOES-R Metrics: 7.5 ms-1 Accuracy; 4.2 ms-1 Precision.
- QI > 80

Enterprise VIIRS AMV RAOB statistics - Arctic

701 - 1000 hPa	Lower Levels
Accuracy	4.87
Precision	3.40
Speed Bias	0.28
Average Speed	10.97
Sample Size	1731

- Data is from 1 February - 30 June, 2017.
- GOES-R Metrics: 7.5 ms-1 Accuracy; 4.2 ms-1 Precision.
- QI > 80

Enterprise VIIRS AMV RAOB statistics - Antarctic

101 - 400 hPa	Upper Levels
Accuracy	6.55
Precision	3.61
Speed Bias	-0.70
Average Speed	19.13
Sample Size	597

- Data is from 1 February - 30 June, 2017.
- GOES-R Metrics: 7.5 ms-1 Accuracy; 4.2 ms-1 Precision.
- QI > 80

Enterprise VIIRS AMV RAOB statistics - Antarctic

401 - 700 hPa	Middle Levels
Accuracy	5.76
Precision	4.64
Speed Bias	-0.09
Average Speed	13.39
Sample Size	656

- Data is from 1 February - 30 June, 2017.
- GOES-R Metrics: 7.5 ms-1 Accuracy; 4.2 ms-1 Precision.
- QI > 80

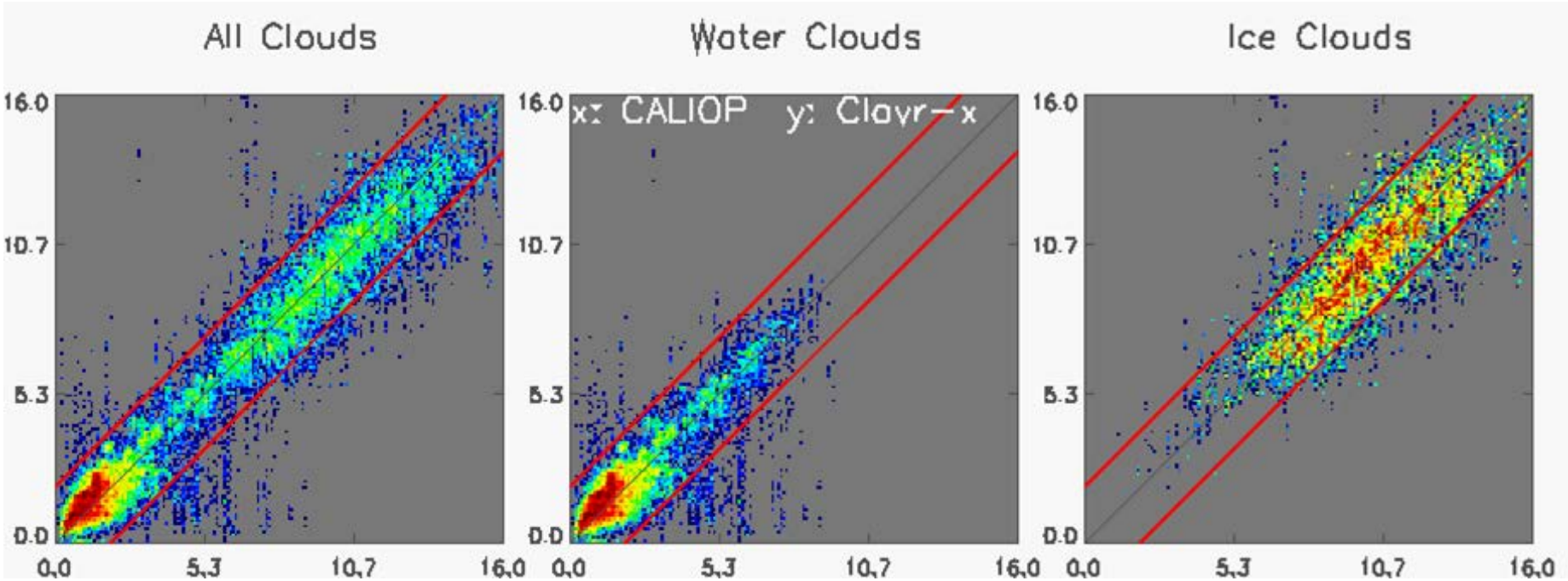
Enterprise VIIRS AMV RAOB statistics - Antarctic

701 - 1000 hPa	Lower Levels
Accuracy	5.58
Precision	3.46
Speed Bias	1.60
Average Speed	9.82
Sample Size	86

- Data is from 1 February - 30 June, 2017.
- GOES-R Metrics: 7.5 ms-1 Accuracy; 4.2 ms-1 Precision.
- QI > 80

Additional CALIPSO Stats

CLAVR-x vs Calipso



60◦N-60◦S, Phase matching, single layer						
Type	Bias (km)	StdDev(km)	Corr	Counts	Within Specs-Accuracy	Within Specs-Precision
All clouds	0.07	0.96	0.97	71997	85.0%	85.2%
Water	0.18	0.77	0.85	51539	91.0%	91.0%
Ice	-0.2	1.3	0.85	20458	70.0%	70.3%

NDE vs Calipso, No phase matching

Type	Bias (km)	StdDev(km)	Corr	Within Specs-Accuracy	Within Specs-Precision
All	-1.25	2.91	0.77	56.5%	34.4%
Tropics	-1.77	3.48	0.79	55.9%	29.6%
Poles	-0.65	2.48	0.61	54.8%	42.0%
Midlat	-1.09	2.70	0.72	56.5%	37.4%
Single Layer	-0.18	2.22	0.84	75.0%	74.3%
Single Layer - thin	-0.85	2.87	0.66	57.1%	66.0%
Single Layer - thick	0.04	0.94	0.96	82.3%	82.4%
Multi layer	-1.84	2.11	0.71	24.8%	47.8%

- Correct phase identification is critical for ACHA retrieval
- ACHA performs equally well in different latitude regions, including the Poles
- ACHA performs significantly better under single layer situation than multilayer
- We can now retrieve multilayer cloud height (up to two layers), which is promising to improve general ACHA performance