NOAA-20 VIIRS Enterprise Cloud Base Height (CBH) Beta Maturity

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with
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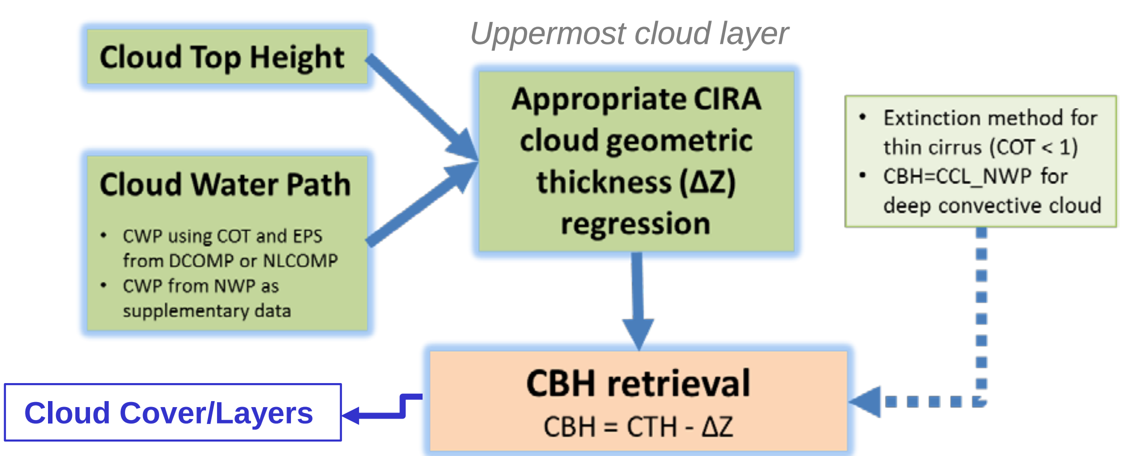
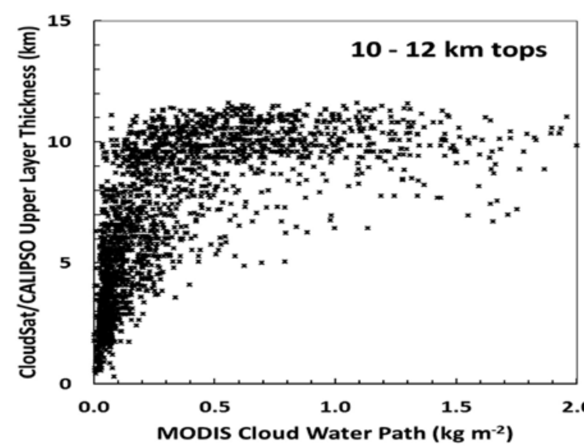
Enterprise Cloud Base Height

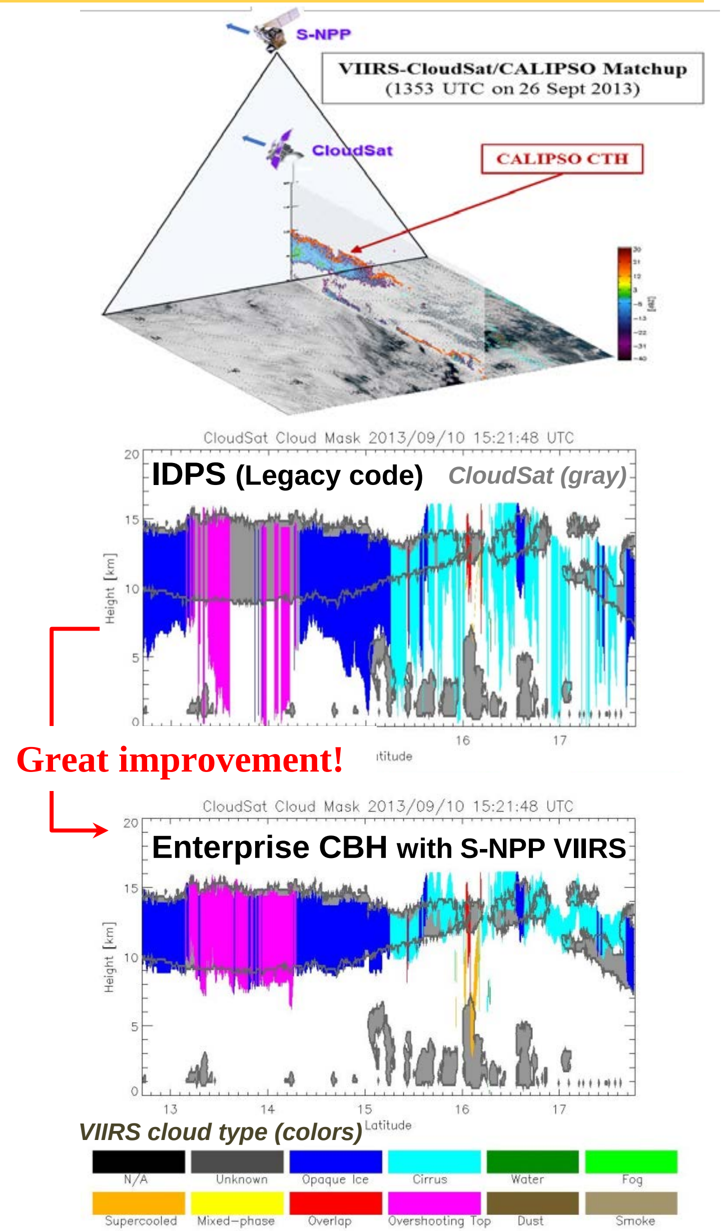
- Estimate the base altitude of the uppermost cloud layer, based upon a statistical relationship drawn between observed cloud geometric thickness (CGT), cloud top height (CTH), and cloud water path (CWP) from A-Train satellite active and passive instruments
- Require CTH and CWP as main input to estimate CGT, and computes CBH by subtracting CGT from CTH
- Additional handling for thin cirrus (extinction method) and deep convection (supplementary NWP data)





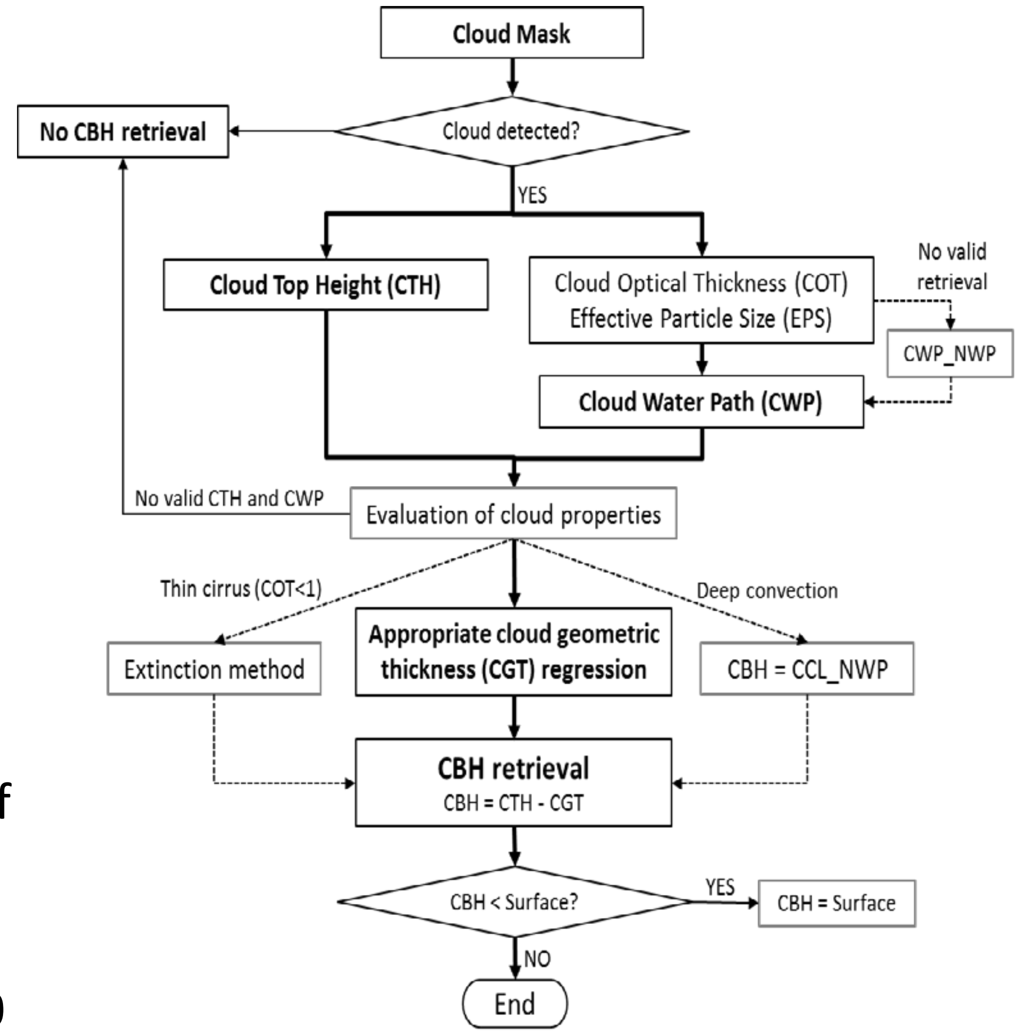
Enterprise Cloud Base Height

- Has been applied to S-NPP VIIRS and intensively validated against CloudSat/CALIPSO, the Enterprise algorithm yields significantly improved performance over the original VIIRS IDPS algorithm, meeting performance reqs
  - *Seaman et al. & Noh et al. (2017 JTECH)*
- Support both polar and geostationary satellite sensors as part of the NOAA Enterprise Cloud Algorithm Suite
- The CBH information is made available to improve the Cloud Cover and Layers product (not in the current DAP)
- Practical relevance to the aviation community, as well as cloud radiative feedbacks in numerical models



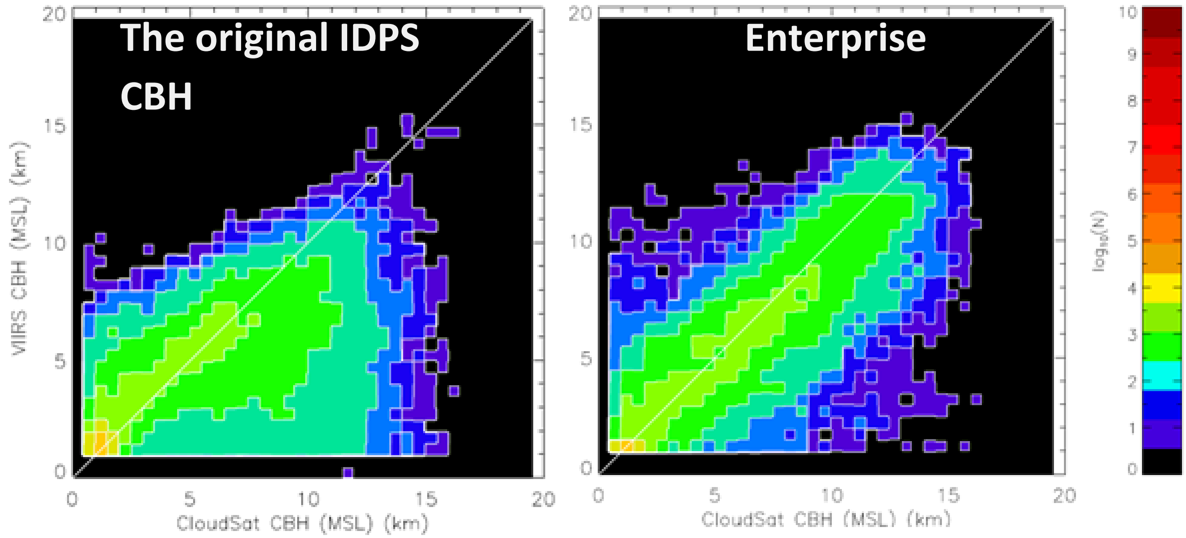
Enterprise Cloud Base Height

- CBH product uncertainty specification: **2 km**
- Valid range: 0-20 km
- The CBH algorithm is inserted downstream of the CTH and cloud optical property retrievals in the cloud processing chain
- False/missed cloud by Cloud Mask will be inherited by CBH
- Errors in upstream retrievals of CTH and CWP directly impact the accuracy of CBH retrievals
- Operationally run for NOAA-20 VIIRS (v1r2)



IDPS vs. Enterprise CBH with S-NPP VIIRS

CloudSat will be added when it's again in operation to further evaluation for NOAA-20



Error statistics of the Enterprise CBHs taken from S-NPP VIIRS-CloudSat matchups for September - October 2013 (95,145 quality-controlled matchup points)

Enterprise CBHs for each cloud type

S-NPP CBH [km] within spec only	Samples (%)	Avg error (bias)	Std of error	RMSE	r^2
IDPS (All)	100	**0.7**	**2.6**	**2.7**	**0.45**
Enterprise (All)	100	**0.3**	**1.7**	**1.7**	**0.79**
Cirrus (thin)	51 (6)	0.3 (-0.5)	1.7 (1.2)	1.7 (1.3)	0.698 (0.775)
Opaque Ice	14	0.3	2.3	2.3	0.515
Water	9	0.2	0.5	0.5	0.688
Supercooled	21	0.3	1.1	1.1	0.688
Overlap	4	0.4	2.1	2.1	0.502
Overshooting	1	0.8	2.8	3.0	0.295

<-Much improved!

"**Within Spec**" evaluation for only clouds where the VIIRS CTH retrieval is within the error specifications: CTH within 1 km of CloudSat CTH if COT $\geq$ 1, or within 2 km if COT < 1

NDE/STAR CBH Production Status & Delivery

Algorithm	Suomi NPP	NOAA-20
April 2017 DAP Initial CBH delivery (**v1r1**)	NDE February 23, 2018	N/A
January 2017 DAP **A smooth transition between CIRA statistical CBH and NWP condensation levels for deep convective clouds and N20 capability** **(v1r2)**	**NDE** **Currently in I&T since 28 March, 2018**	**NDE** **Currently in I&T since 28 March, 2018**
February 2018 Science Code delivery Minor diagnostic output improvements (**v2r0**)	STAR Systematic production since June, 2018 NDE (Estimated Delivery in Aug 2018)	STAR Systematic production since June, 2018 NDE (Estimated Delivery in Aug 2018)

JPSS Data Products Maturity Definition

JPSS/GOES-R Data Product Validation Maturity Stages – COMMON DEFINITIONS (Nominal Mission)

1. Beta

- Product is minimally validated, and may still contain significant identified and unidentified errors.
- Information/data from validation efforts can be used to make initial qualitative or very limited quantitative assessments regarding product fitness-for-purpose.
- Documentation of product performance and identified product performance anomalies, including recommended remediation strategies, exists.

2. Provisional

- Product performance has been demonstrated through analysis of a large, but still limited (i.e., not necessarily globally or seasonally representative) number of independent measurements obtained from selected locations, time periods, or field campaign efforts.
- Product analyses are sufficient for qualitative, and limited quantitative, determination of product fitness-for-purpose.
- Documentation of product performance, testing involving product fixes, identified product performance anomalies, including recommended remediation strategies, exists.
- Product is recommended for potential operational use (user decision) and in scientific publications after consulting product status documents.

3. Validated

- Product performance has been demonstrated over a large and wide range of representative conditions (i.e., global, seasonal).
- Comprehensive documentation of product performance exists that includes all known product anomalies and their recommended remediation strategies for a full range of retrieval conditions and severity level.
- Product analyses are sufficient for full qualitative and quantitative determination of product fitness-for-purpose.
- Product is ready for operational use based on documented validation findings and user feedback.
- Product validation, quality assurance, and algorithm stewardship continue through the lifetime of the instrument.

Requirements Cloud Base Height (1)

- JERD-2428 The algorithm shall produce a cloud height product that has a horizontal cell size of 0.8 km at Nadir.
- JERD-2474 The algorithm shall produce a cloud height product that has a vertical reporting interval of top and base of highest cloud in the column.
- JERD-2475 The algorithm shall produce a cloud height product that has a mapping uncertainty, (3 sigma) of 4 km.

Requirements Cloud Base Height (2)

- JERD-2476 The algorithm shall produce a cloud base height product that has a measurement precision of
  - 2.0 km for COT >=1 and 3.0 km for COT < 1

- JERD-2477 The algorithm shall produce a cloud base height product that has a measurement accuracy of
  - 2.0 km for COT >=1 and 3.0 km for COT < 1

Evaluation Methodology & Data

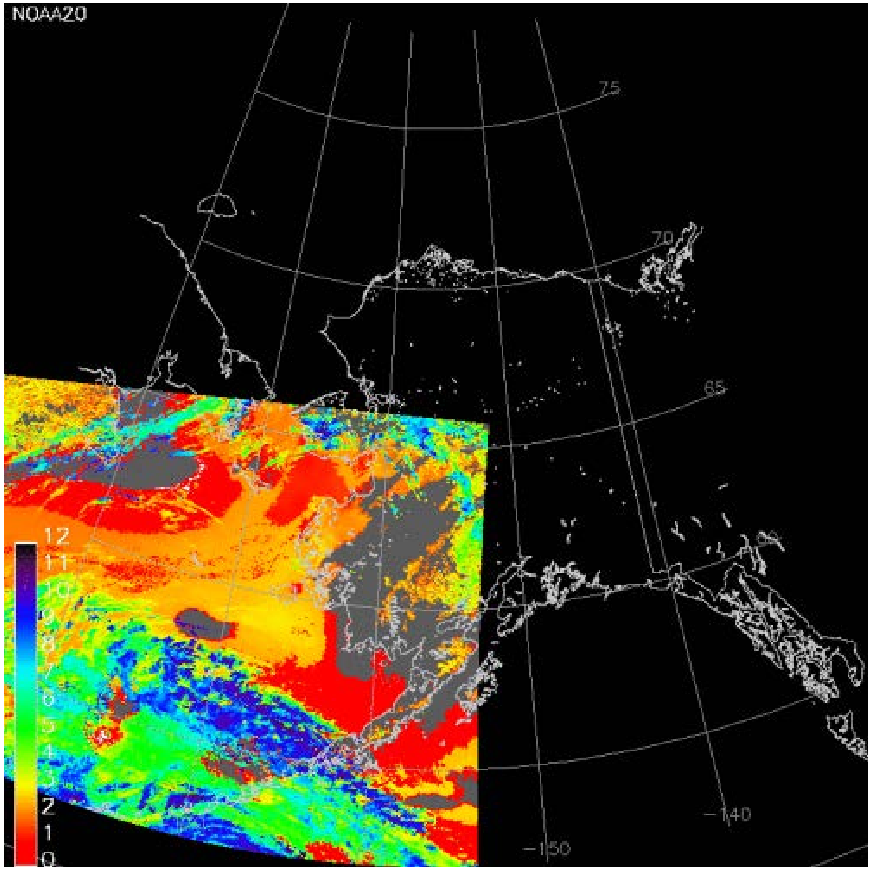
- Selected cases (mid-June to early July 2018, after major update in Cloud Mask and starting the regular v1r2 cloud product data flow on at CIRA)
- Monitoring time series between S-NPP (v1r1) and NOAA-20 (v1r2)
- Examine CBH together with CTH, EPS, and COT Comparison with CLAVR-x output locally run at CIRA
  - CIRA CLAVR-x : GFS, OISST, no snow mask input, no NLCOMP
- Comparison with ARM (U.S. DOE Atmospheric Radiation Measurement) site measurements for selected cases
  - Ceilometer over NSA, Alaska and SGP, Oklahoma

Enterprise v1r2 Integration Results

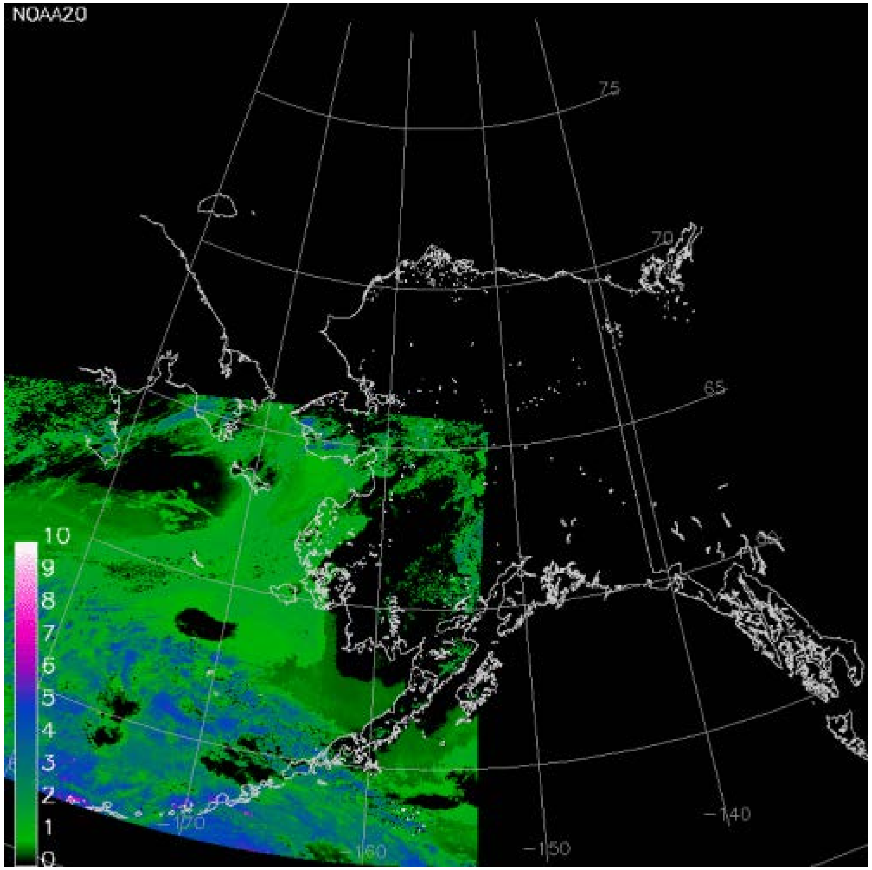
- Monitor CBHs from S-NPP (v1r1), NOAA-20 (v1r2), and CIRA CLAVR-x

Real-time CLAVR-x run at CIRA (**Alaska Domain**)

Cloud Top Height (km)



Cloud Geometric Thickness



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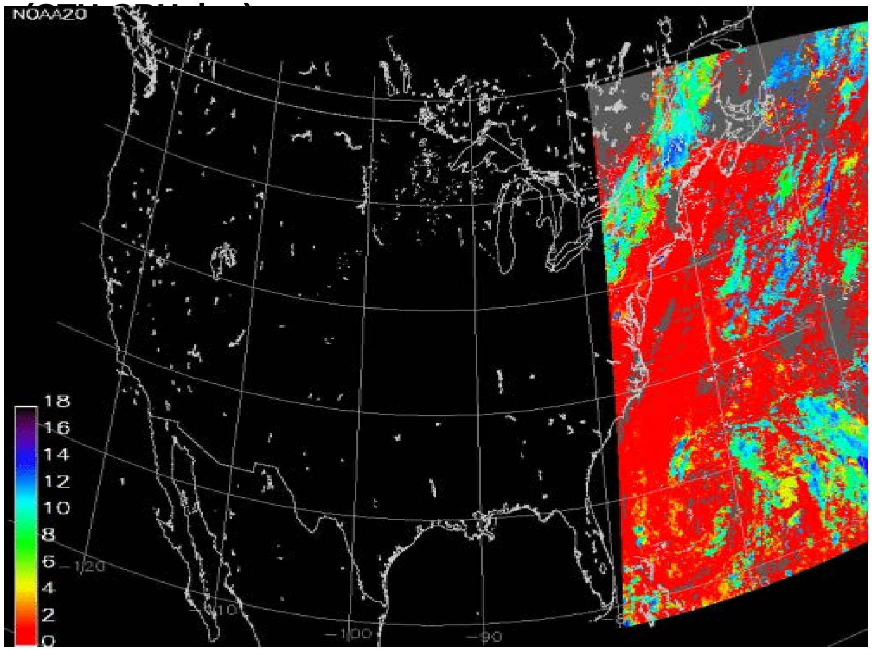
Enterprise v1r2 Integration Results

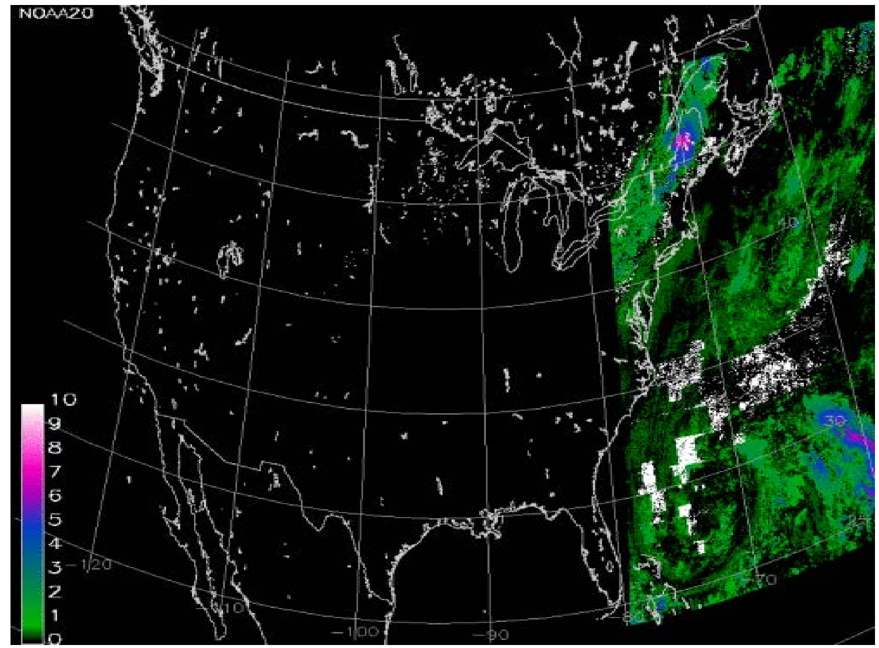
- Monitor CBHs from S-NPP (v1r1), NOAA-20 (v1r2), and CIRA CLAVR-x

Real-time CLAVR-x run at CIRA (**CONUS**)

Cloud Top Height (km)



Cloud Geometric Thickness



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Enterprise v1r2 Integration Results

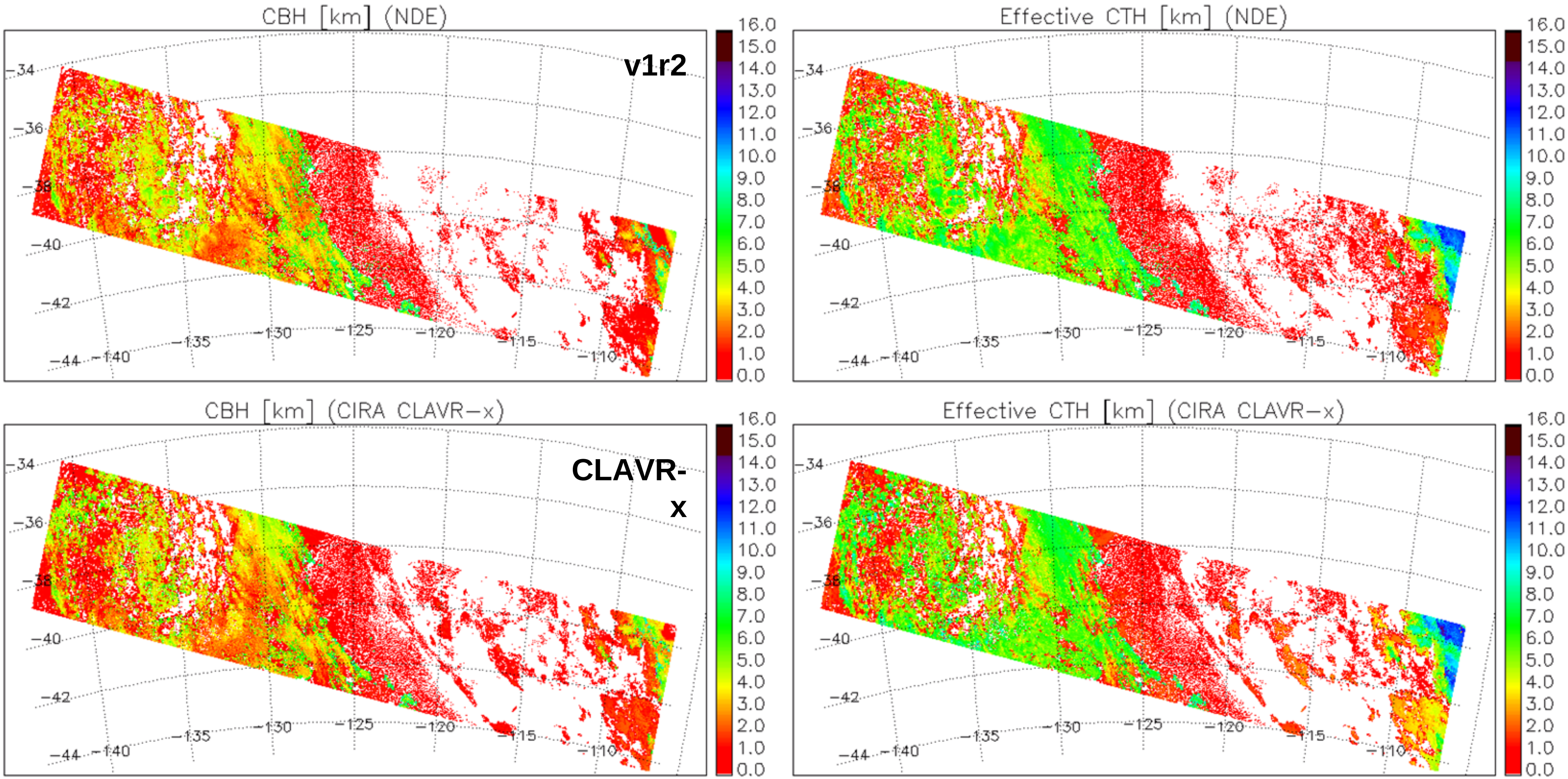
- Monitor CBHs from S-NPP (v1r1), NOAA-20 (v1r2), and CIRA CLAVR-x

Case	No. of granules examined	Valid CTH but invalid CBH (%)	Out of spec (%) compared with CLAVR-x (within 200m CTH range)
13 June 2018	70	2.10	1.47
16 June 2018	525	1.51	1.52
19 June 2018	25	1.54	0.95
03 July 2018	68	2.14	1.70

The CBH algorithm with NOAA-20 VIIRS (v1r2) is working normally as long as the upstream cloud retrievals and supplementary data are valid (CTH, CWP from DCOMP in daytime, NWP at night)

Enterprise v1r2 Integration Results

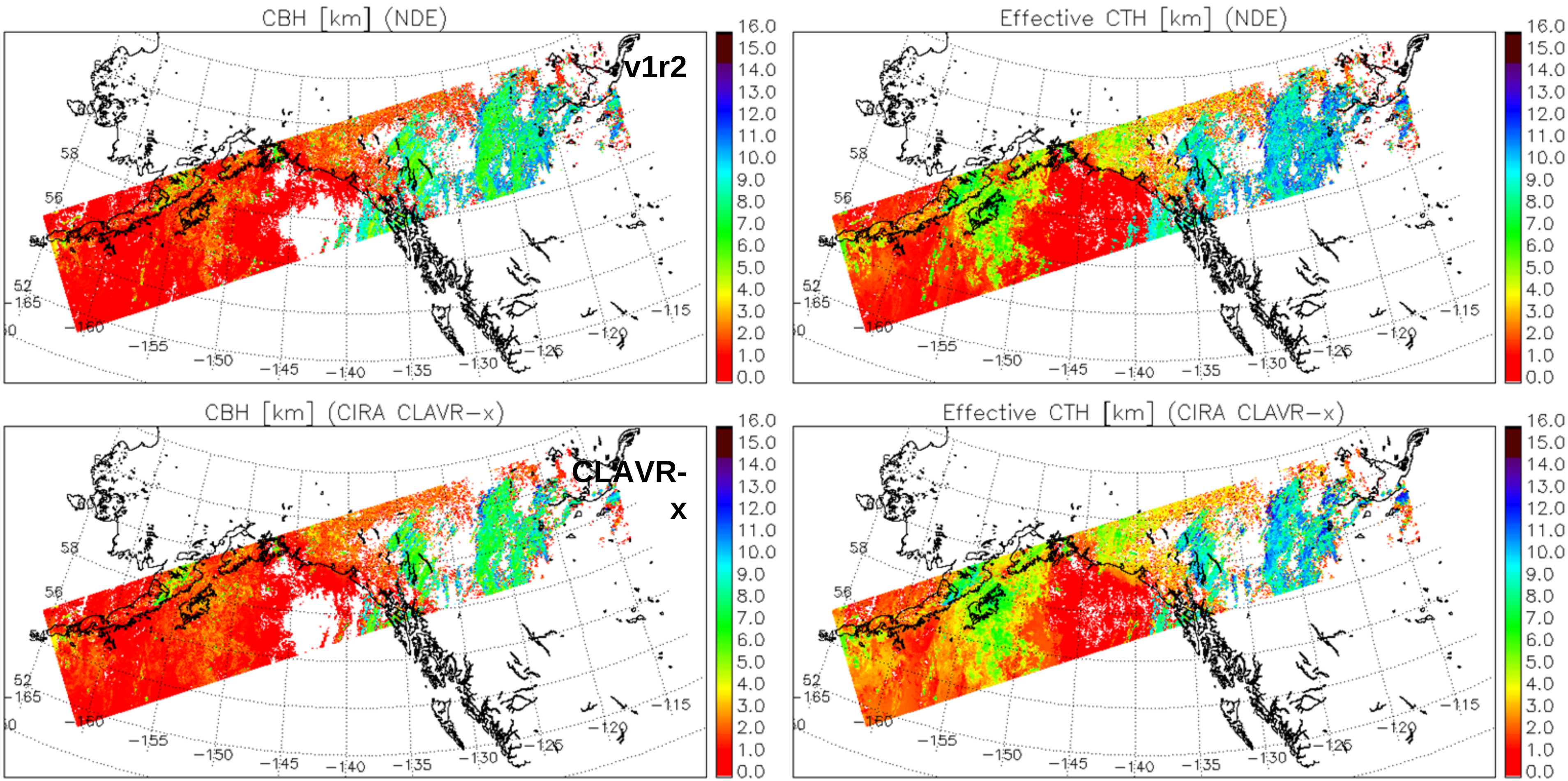
- Visual inspection compared with CIRA CLAVR-x shows general agreement



20180613 091315 UTC (Night/Ocean)

Enterprise v1r2 Integration Results

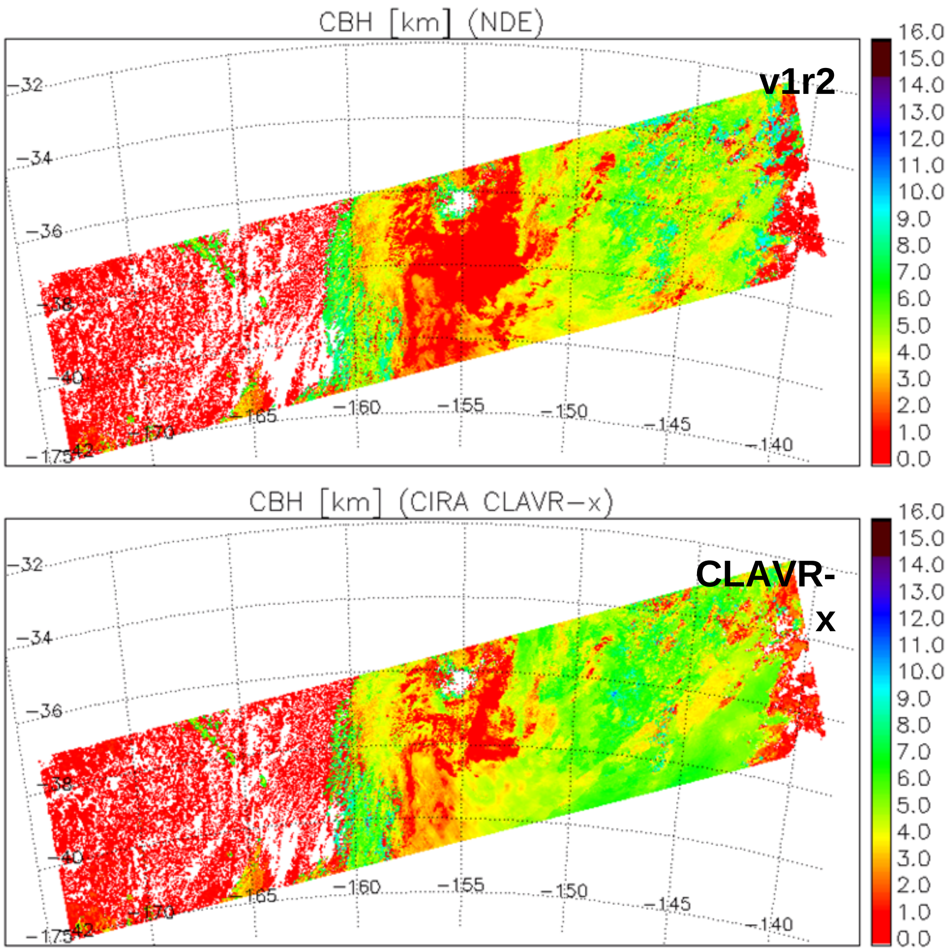
- Visual inspection compared with CIRA CLAVR-x shows general agreement

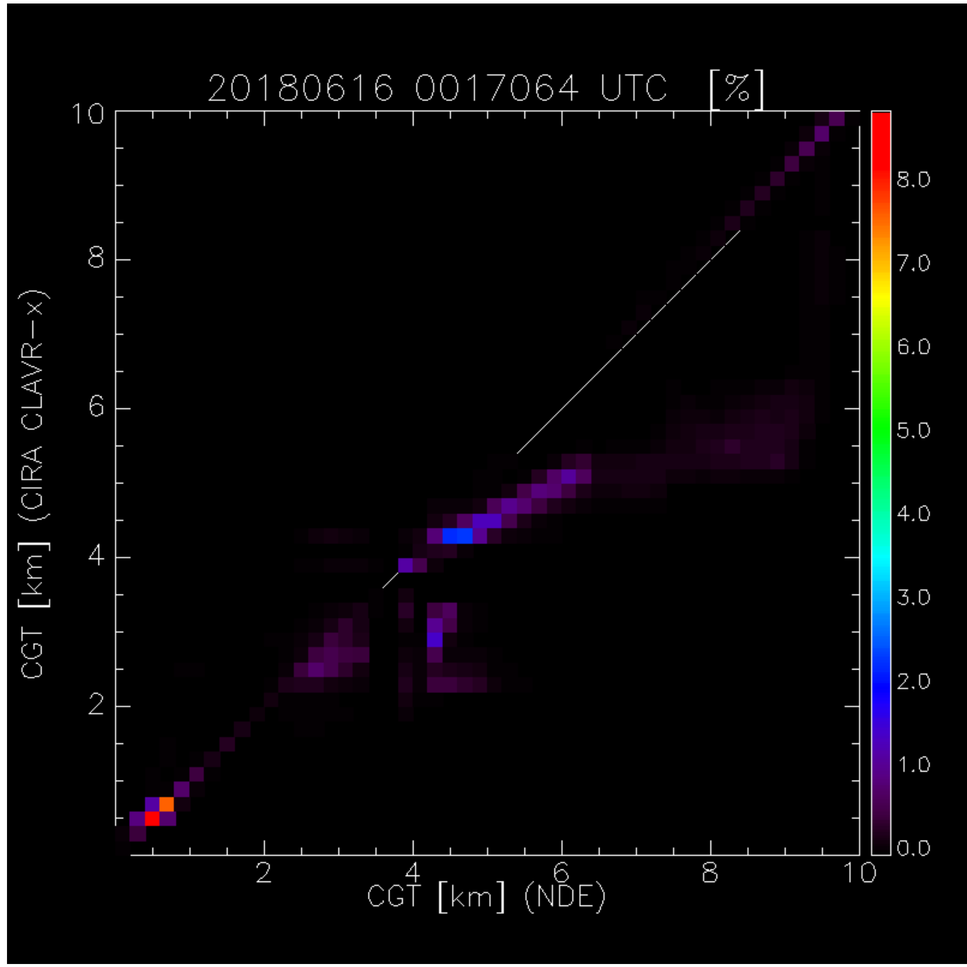


20180619 214726 UTC (Day/Ocean+Land)

Enterprise v1r2 Integration Results

- Visual inspection compared with CIRA CLAVR-x (outliers in twilight granules)





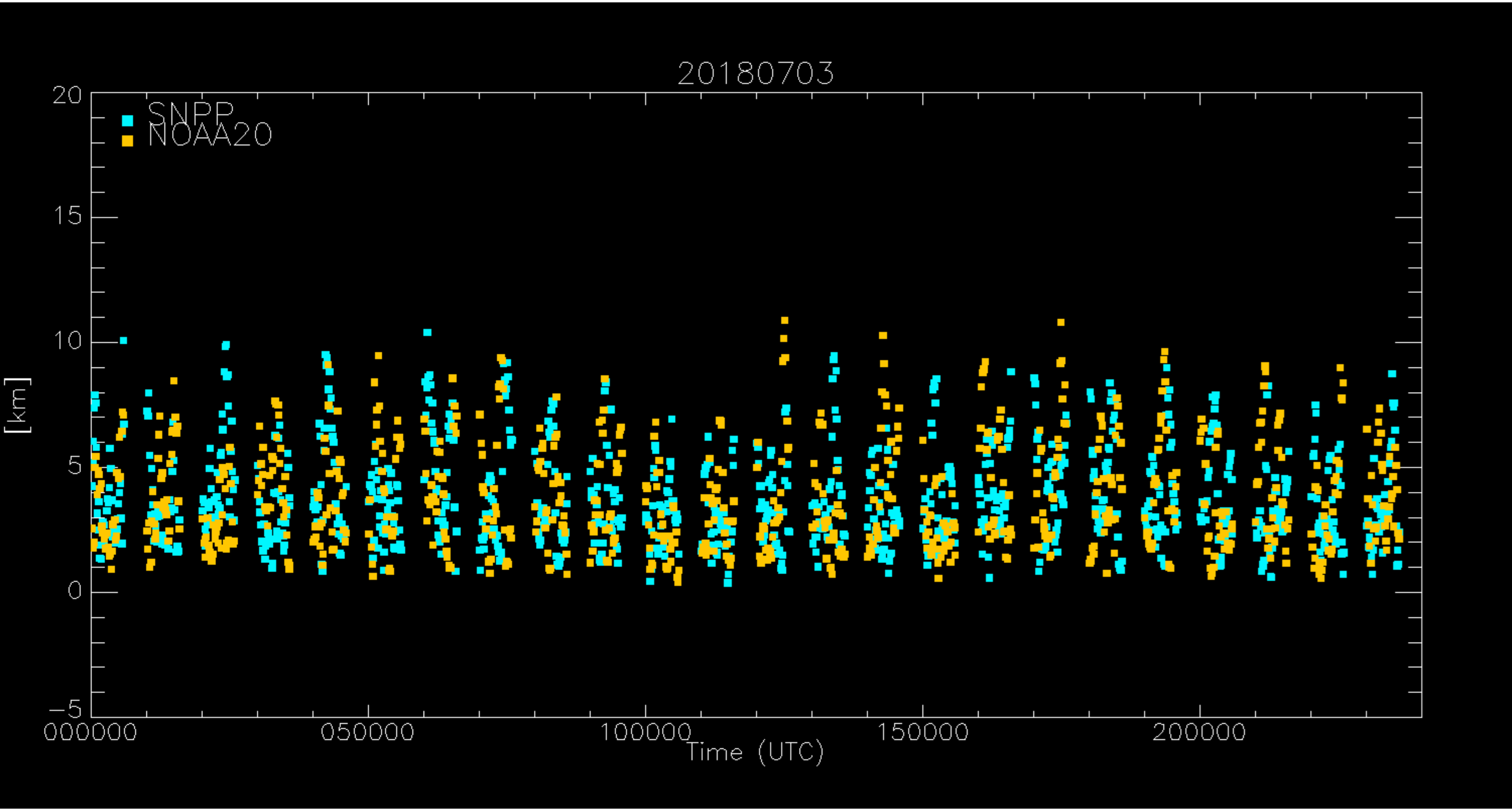
Different NWP conditions or different treatment of the twilight zone?

20180619 214726 UTC (Twilight/Ocean)

CGT comparisons in this evaluation done when CTH differences between NDE and CLAVR-x are less than 200 m.

Enterprise v1r2 Integration Results

- Monitor CBHs from S-NPP (v1r1), NOAA-20 (v1r2), and CIRA CLAVR-x

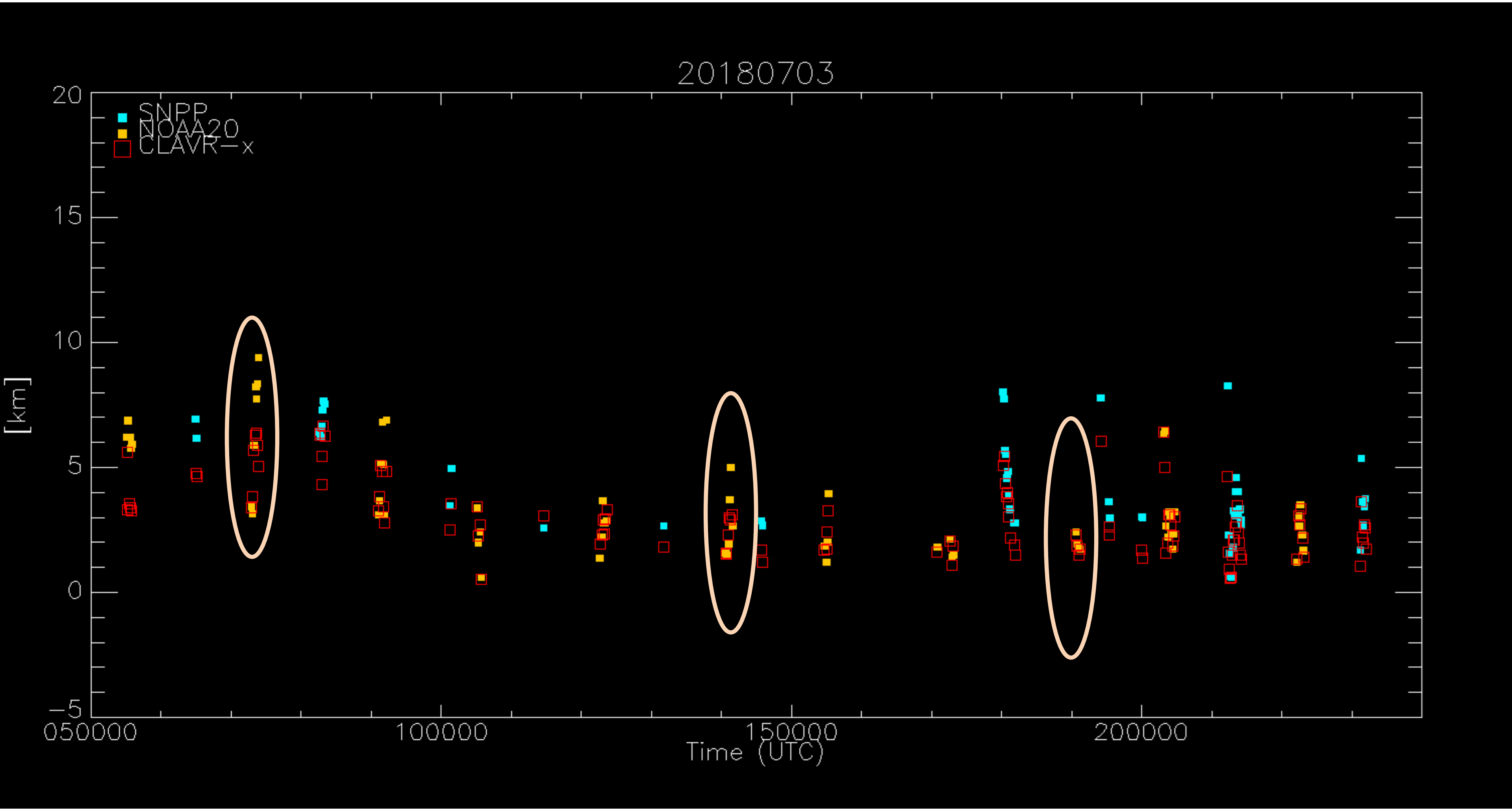


Mean CBH per granule (0-20 km valid pixels only)

Enterprise v1r2 Integration Results

- Monitor CBHs from S-NPP (v1r1), NOAA-20 (v1r2), and CIRA CLAVR-x

Samples (ovals) in the next slides

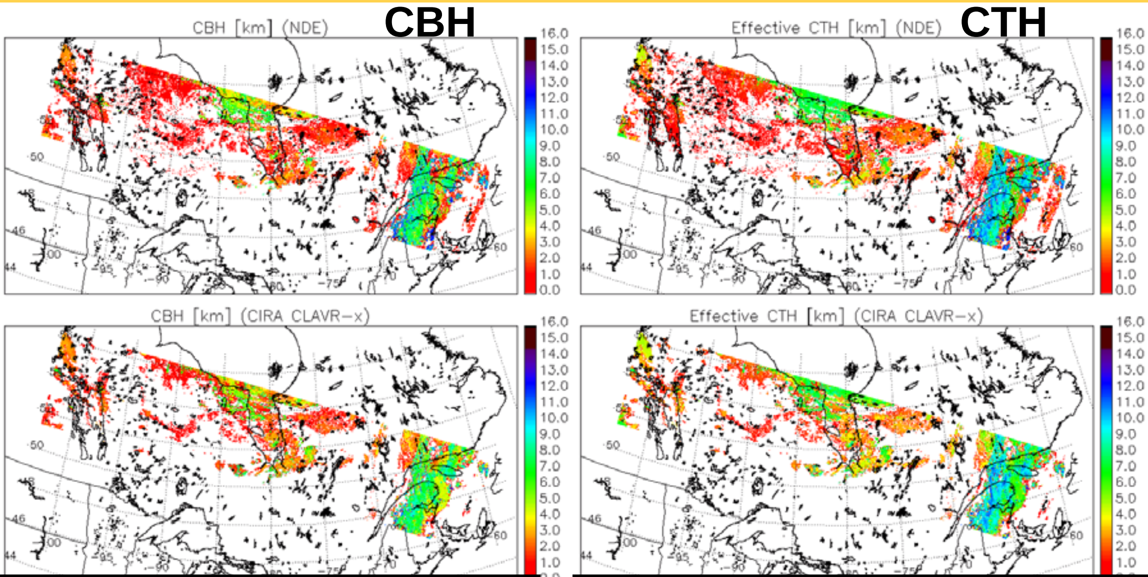


Mean CBH per granule (0-20 km valid pixels only)

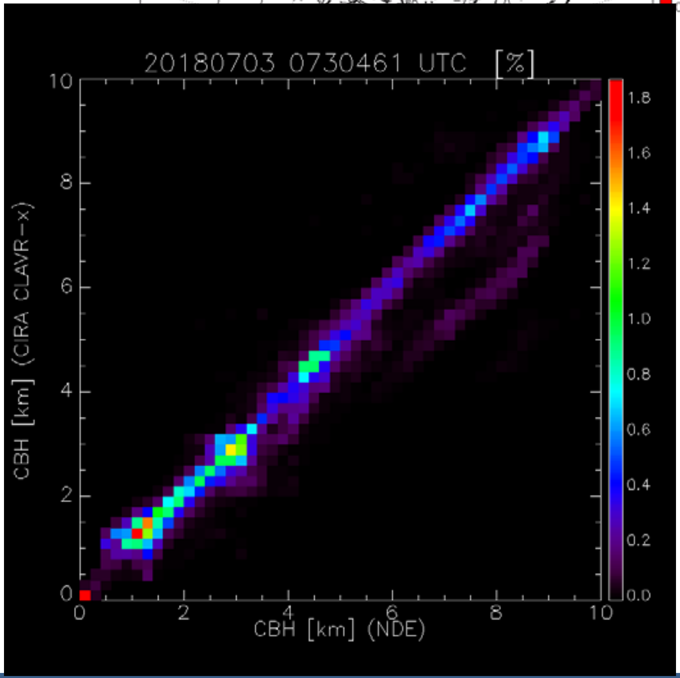
Enterprise v1r2 Integration Results

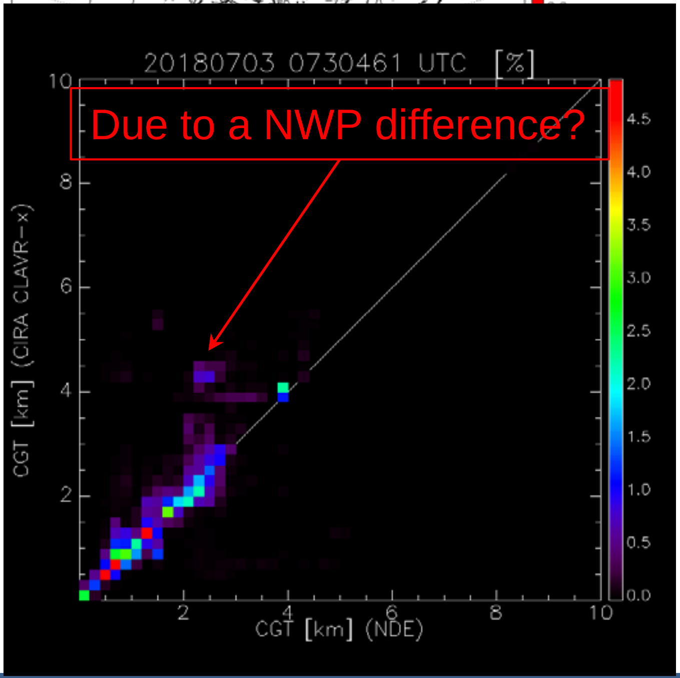
V1R2

CLAVR-x



Nighttime





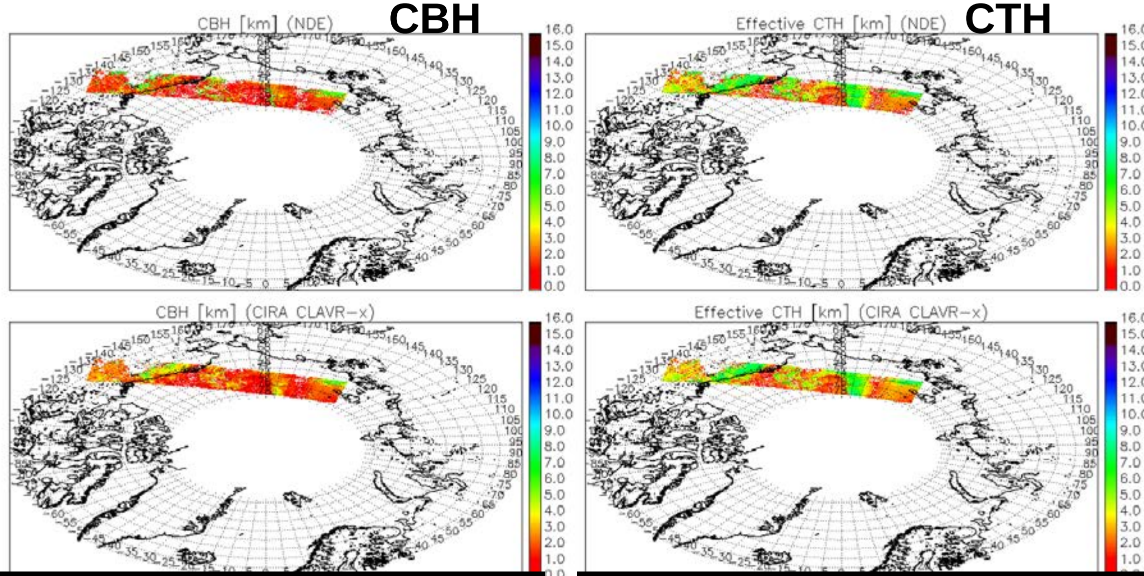
CBH/CGT comparisons in this evaluation are done when CTH differences between NDE and CIRA CLAVR-x are less than 200 m.

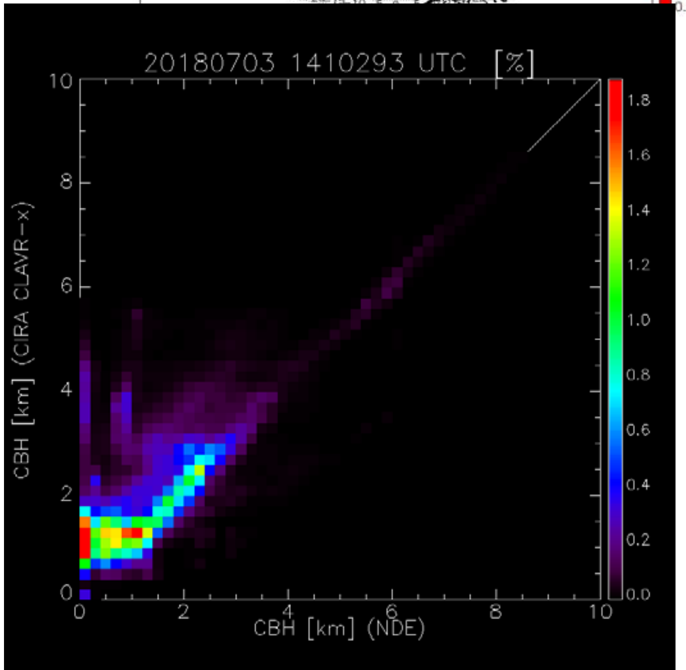
Enterprise v1r2 Integration Results

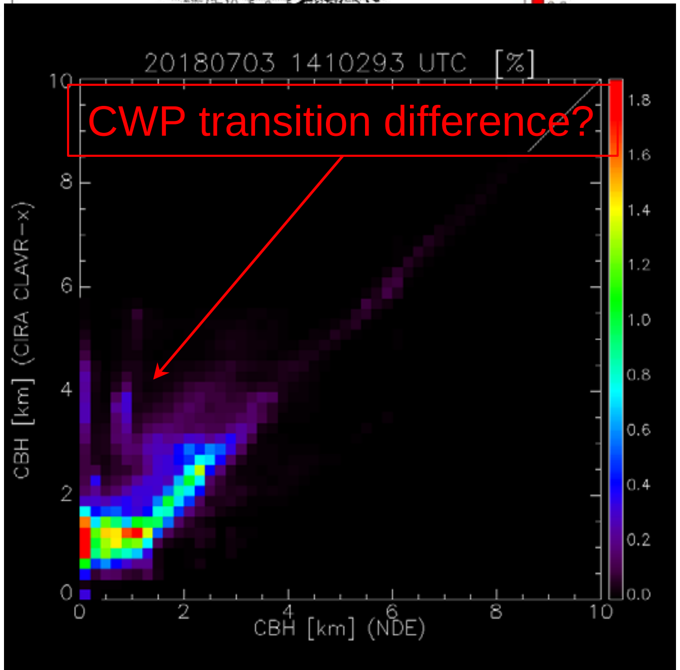
Twilight

V1R2

CLAVR-x





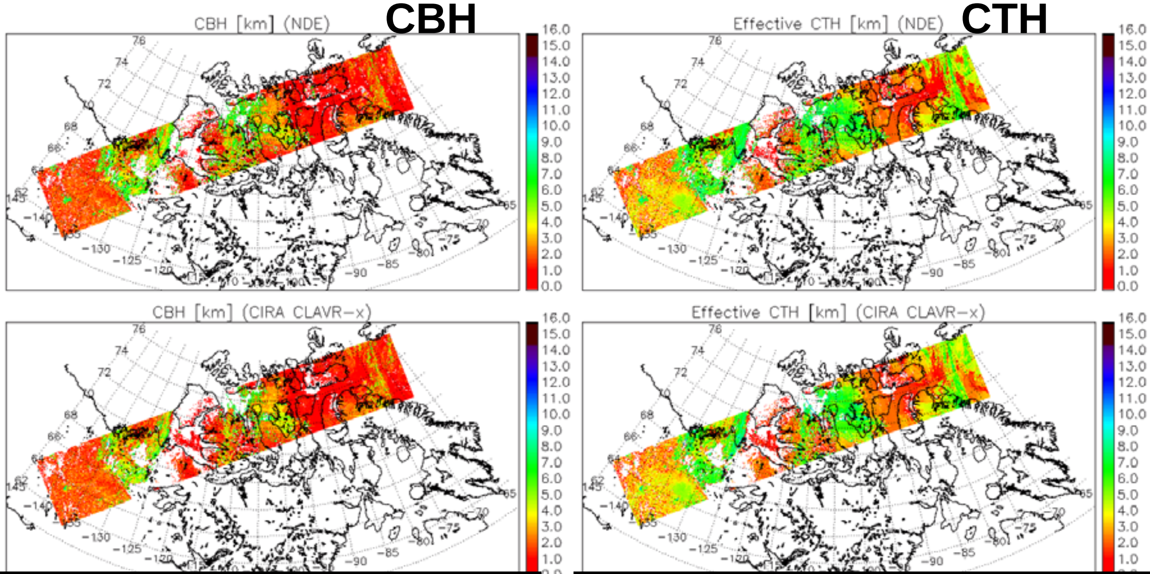


Enterprise v1r2 Integration Results

CBH CTH

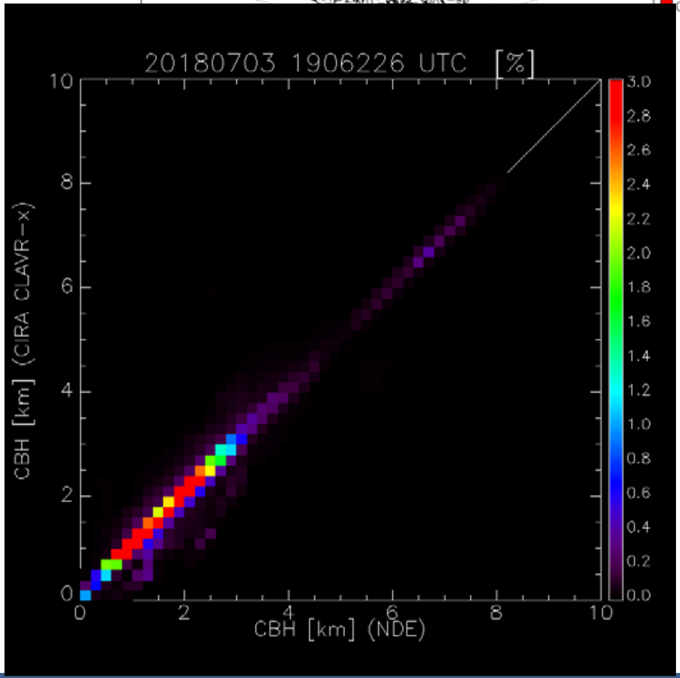
V1R2

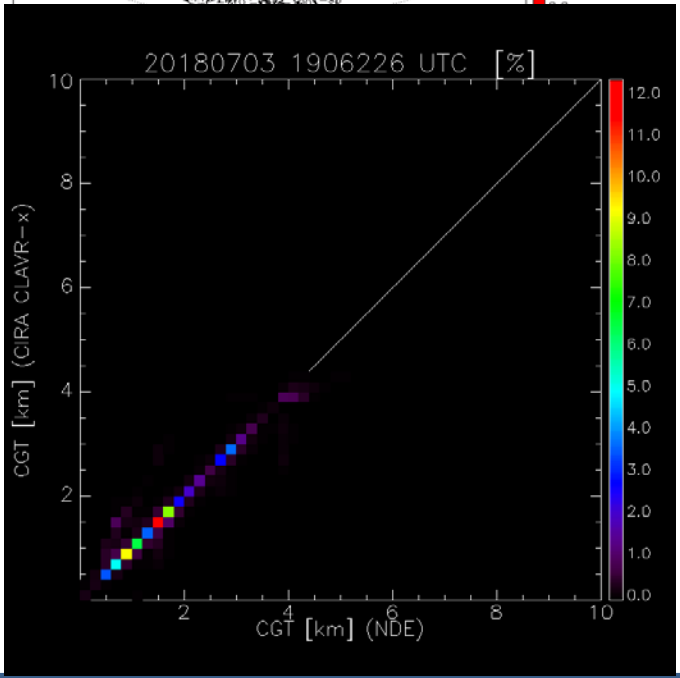
CLAVR-x



Daytime

Generally in a good agreement despite DCOMP EPS/COT differences

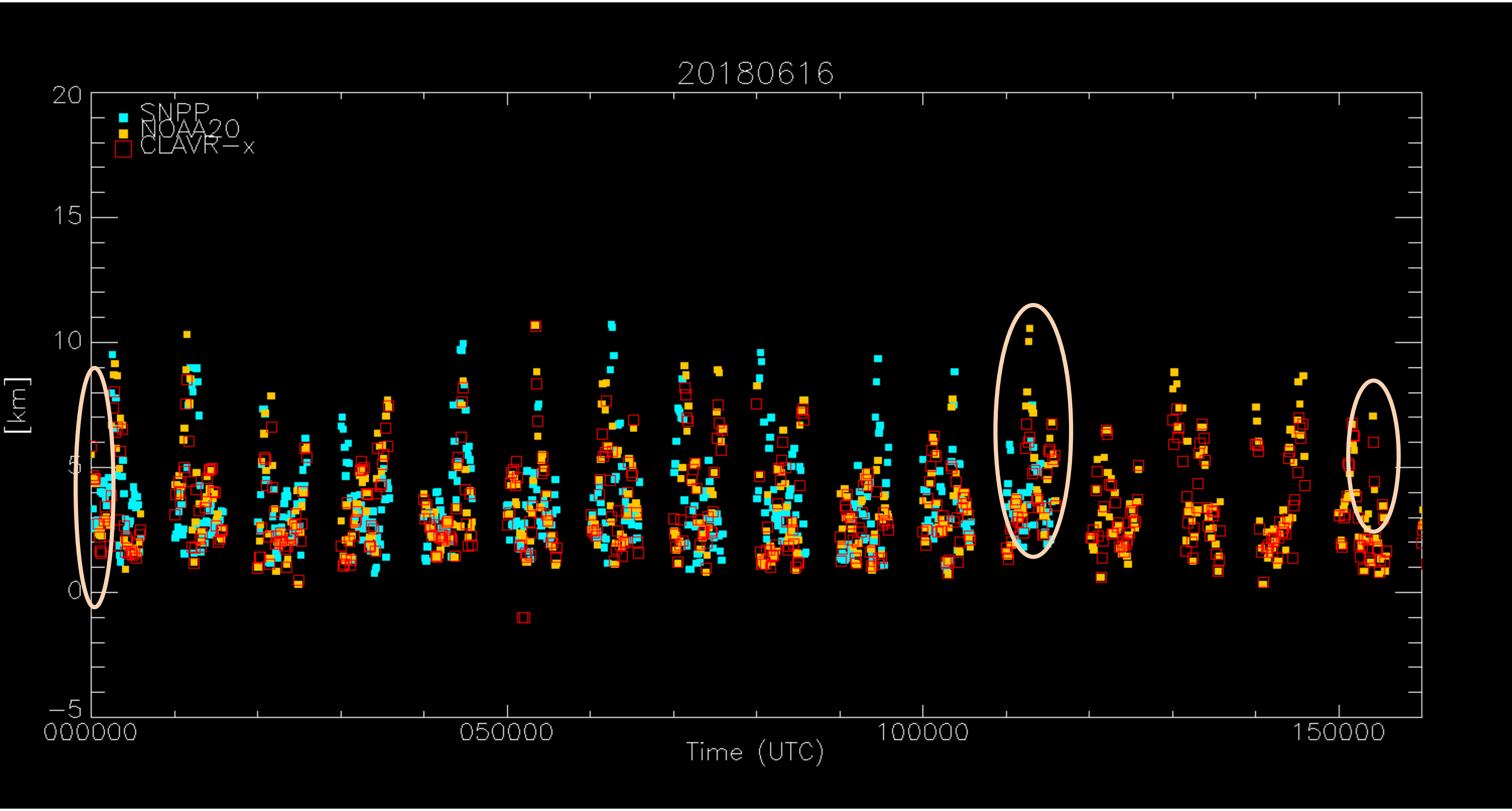




Enterprise v1r2 Integration Results

- Monitor CBHs from S-NPP (v1r1), NOAA-20 (v1r2), and CIRA CLAVR-x

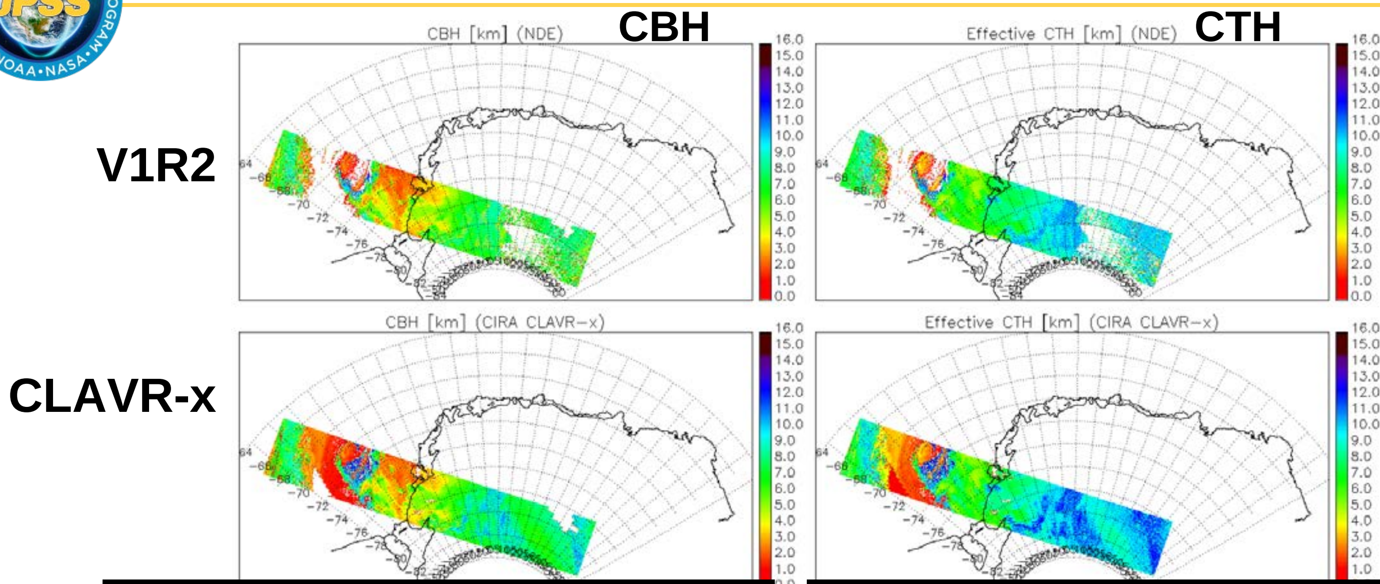
Samples (ovals) in the next slides

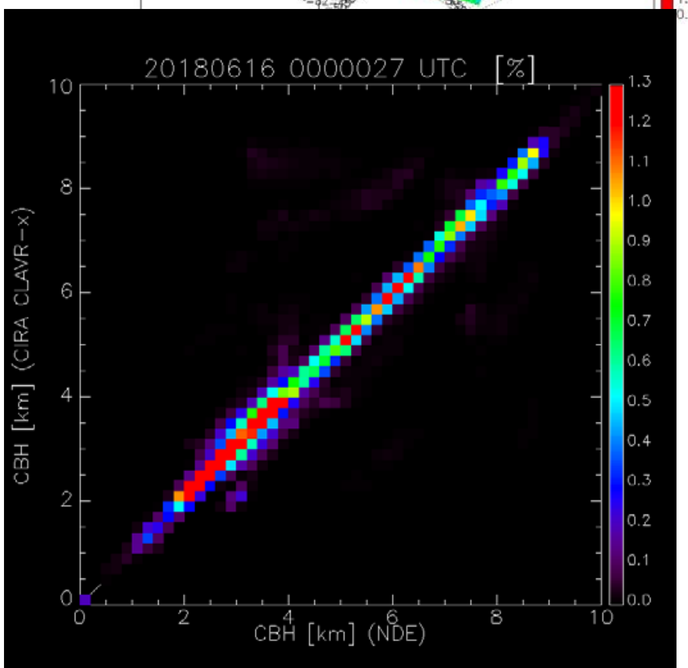


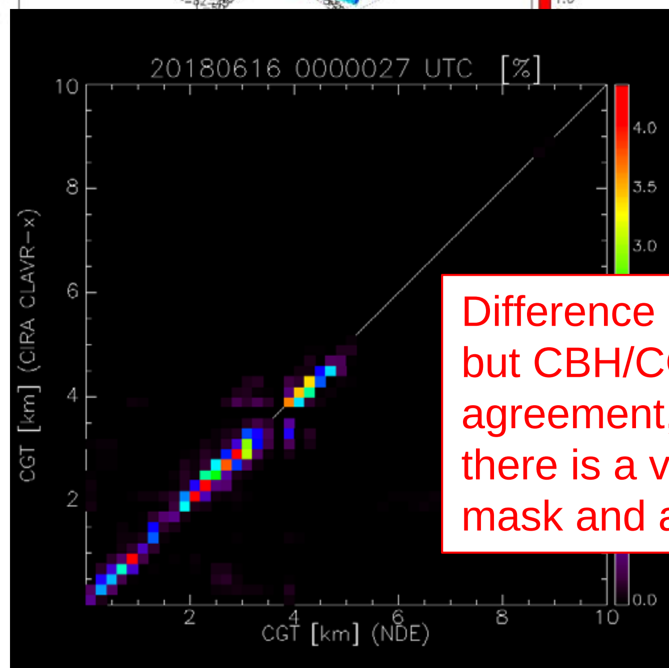
Mean CBH per granule (0-20 km valid pixels only)

Enterprise v1r2 Integration Results

Nighttime (Antarctic)





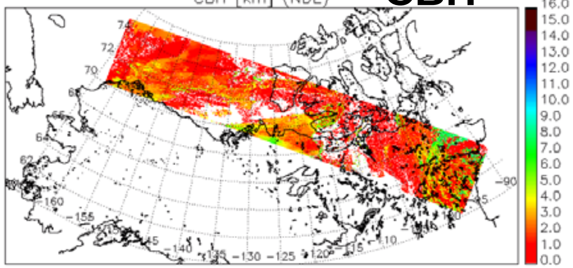


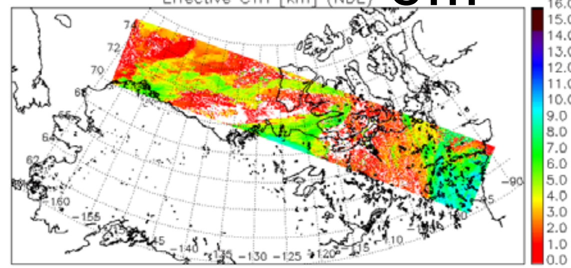
Difference in visualization but CBH/CGT in a good agreement, so long as there is a valid cloud mask and accurate CTH

Enterprise v1r2 Integration Results

CBH **CTH**

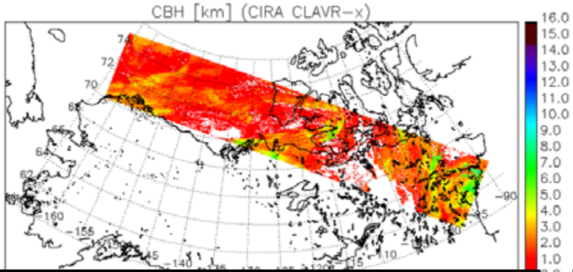
V1R2

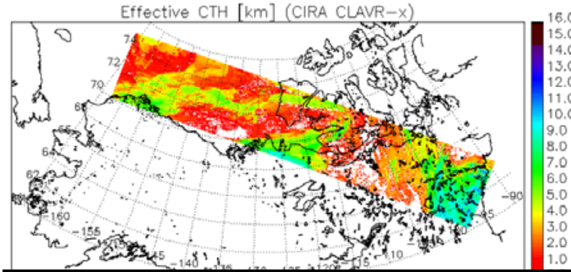


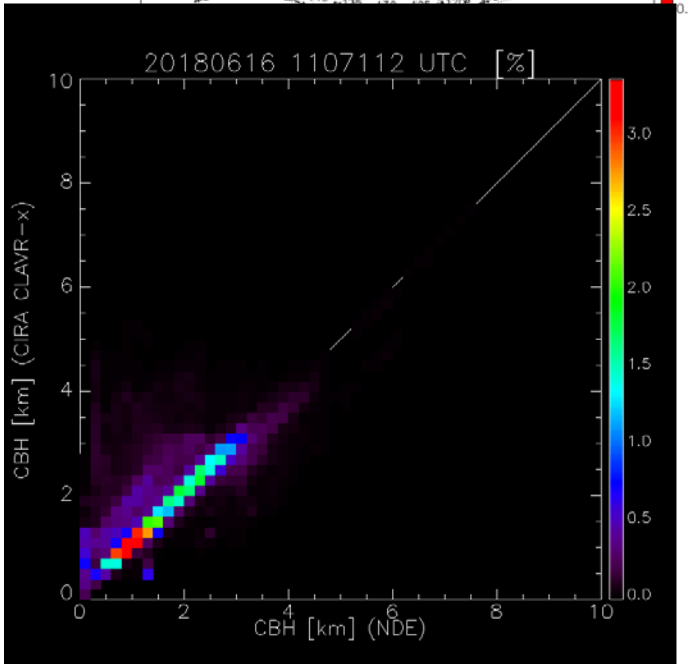


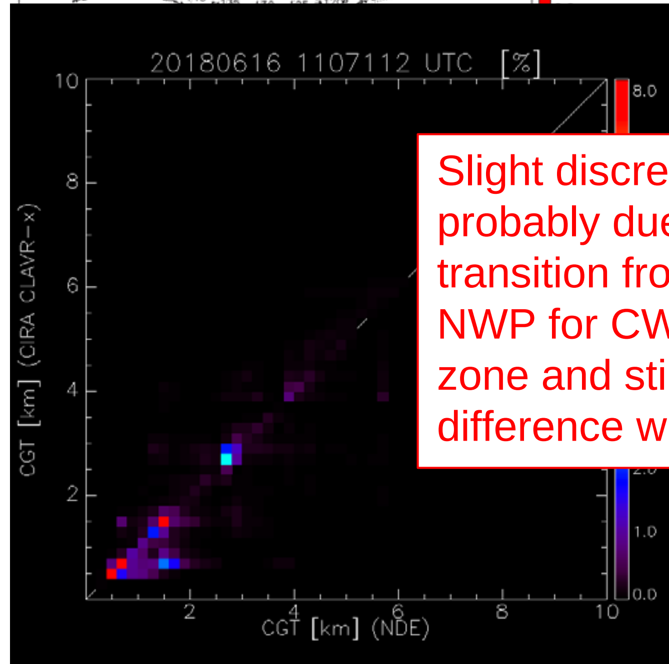
Twilight

CLAVR-x









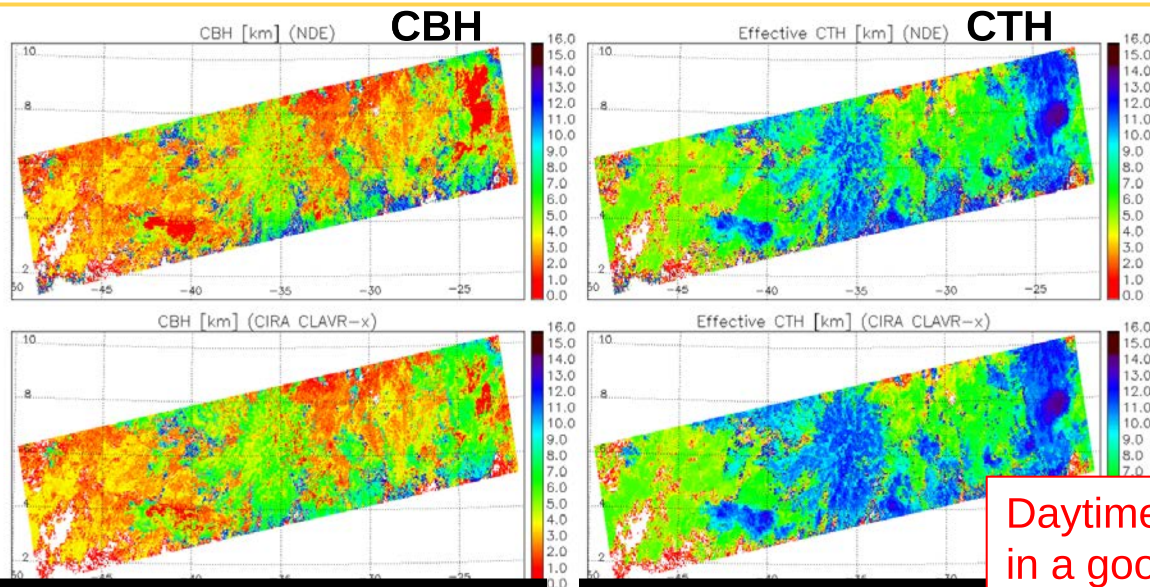
Slight discrepancy probably due to a transition from DCOMP to NWP for CWP in a twilight zone and still a CTH difference within 200 m

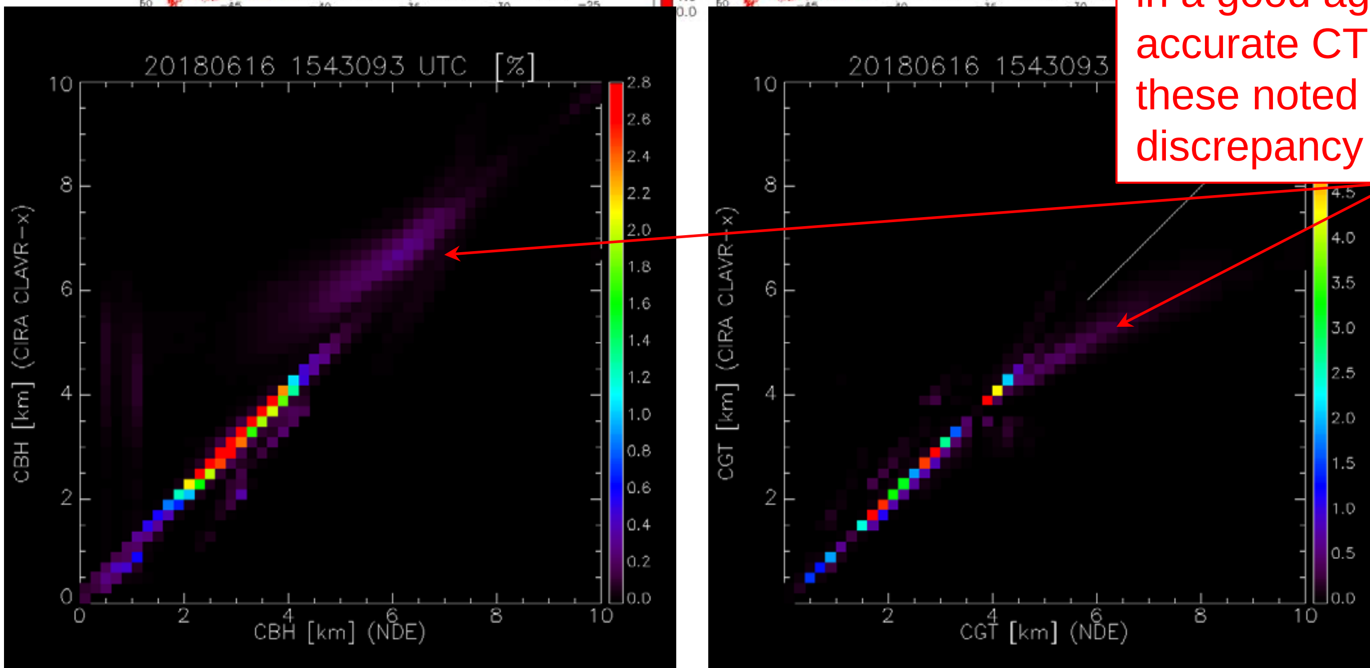
Enterprise v1r2 Integration Results

Daytime

V1R2

CLAVR-x

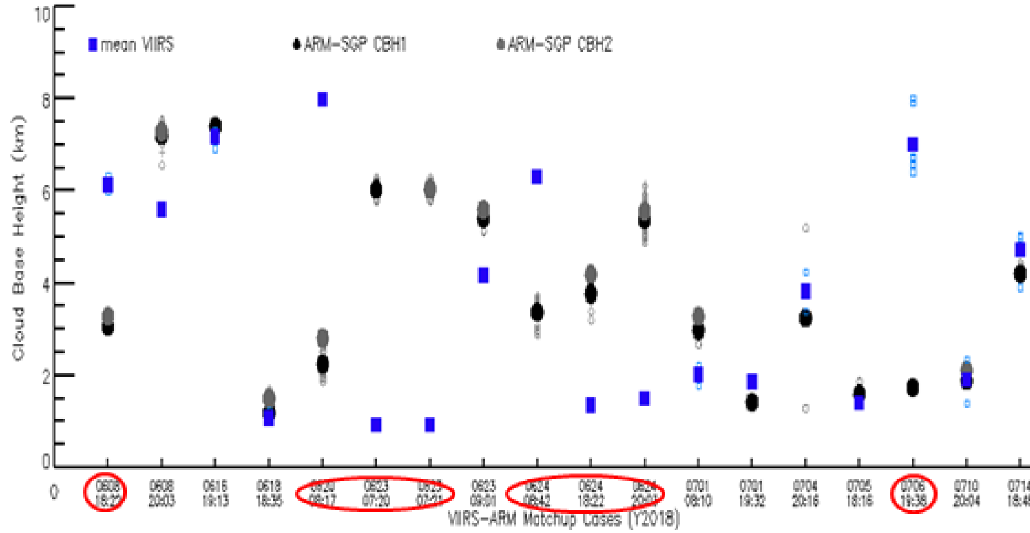


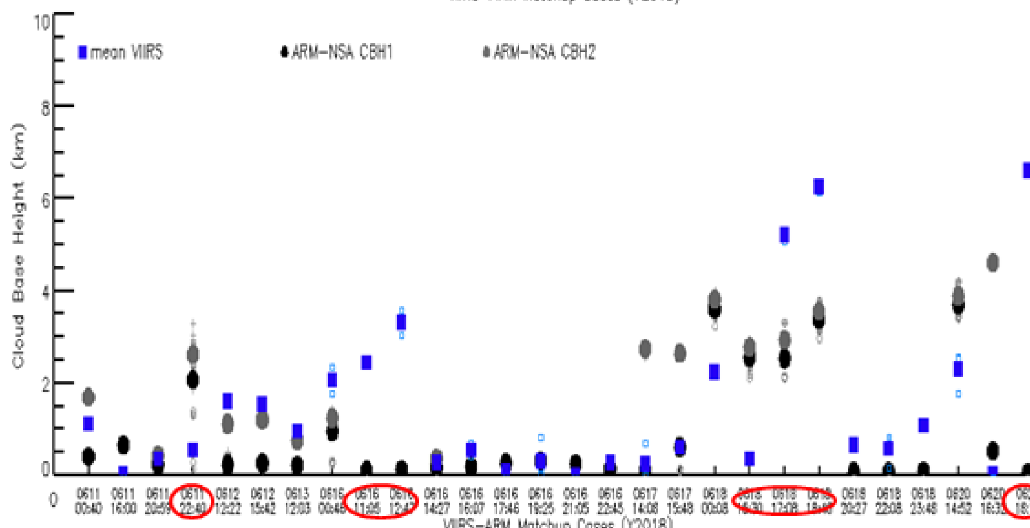


Daytime granules generally in a good agreement in an accurate CTH range, but in these noted areas, CWP discrepancy from DCOMP?

CBH performance against ARM measurements

- Ongoing evaluation efforts using ARM ceilometer data from SGP and NSA sites
  - Blue squares: VIIRS CBHs (NOAA-20 v1r2)
  - Black and gray circles: ARM ceilometer CBHs
- CBHs which need further investigation circled in red
- ARM lidar and CALIPSO data will be added for more quantitative assessment, including multi-layered cloud cases





Beta Maturity Conclusions

- **The NDE Enterprise CBH algorithm with NOAA-20 VIIRS (v1r2) is working nominally without serious issues**, as long as the upstream cloud retrievals and supplementary data are valid (CTH, CWP from DCOMP in daytime, NWP at night)
- Valid nighttime operation at this time
- Invalid CBH pixels (despite valid CTH) account for ~1.82 % of the selected 688 granules in this evaluation. The primary cause is invalid CWP (either from DCOMP or NWP, CBH_QF=1), which needs further investigation
- Slight discrepancies are often found in twilight zones, which could be caused by different cloud optical properties-NWP treatment in NDE and CIRA's local version of CLAVR-x
- Need more quantitative assessment on the 'out-of-spec' CBHs with >2 km difference compared to CIRA CLAVR-x (~1.41% in valid pixels that CTH is in an accurate range (200 m) between v1r2 and CLAVR-x for 688 granules)
- **Recommend 'Beta maturity'**

Pathway to Provisional

- The CIRA and CIMSS teams continue to support the STAR ASSISTT for its correct operation and long-term monitoring within the operational frame.
- Ongoing efforts for validation over an extended period (multiple months until September).
  - Inter-comparison using NOAA-20, S-NPP, and CLAVR-x
  - Use CALIPSO and ARM ground-based measurements for more cases (CloudSat will be added when it's again in operation for further evaluation)
- Additional evaluation of CCL products when the CBH component is included in the next DAP round.