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

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with
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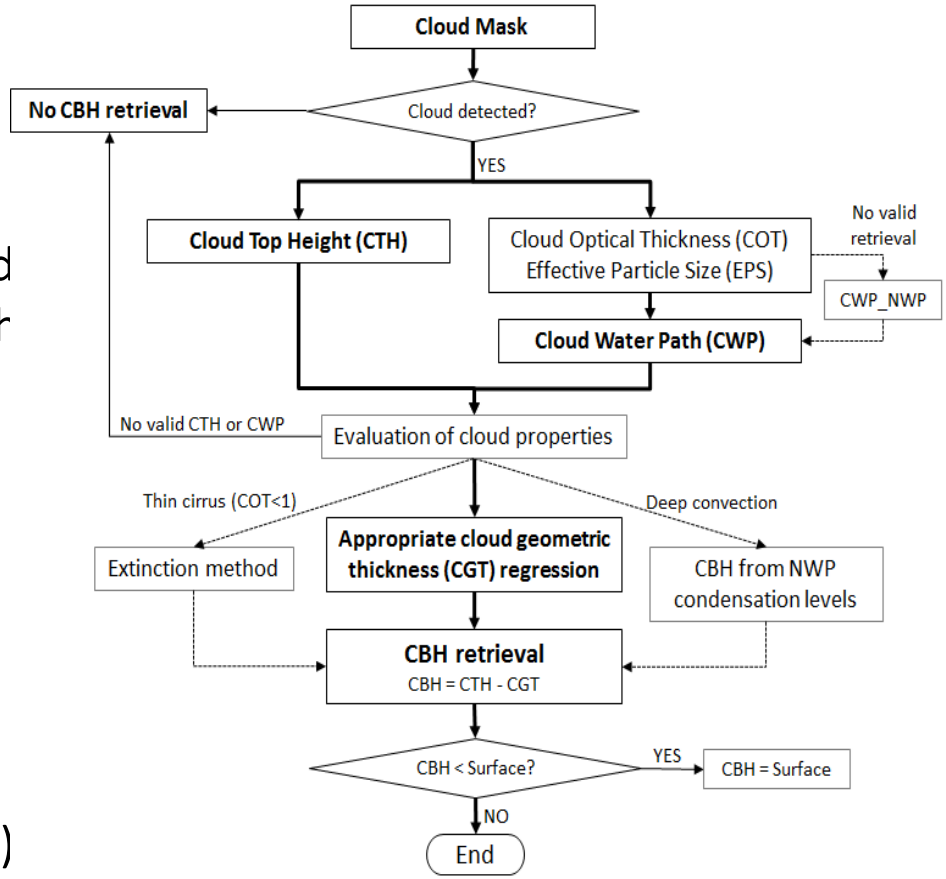
Enterprise Cloud Base Height

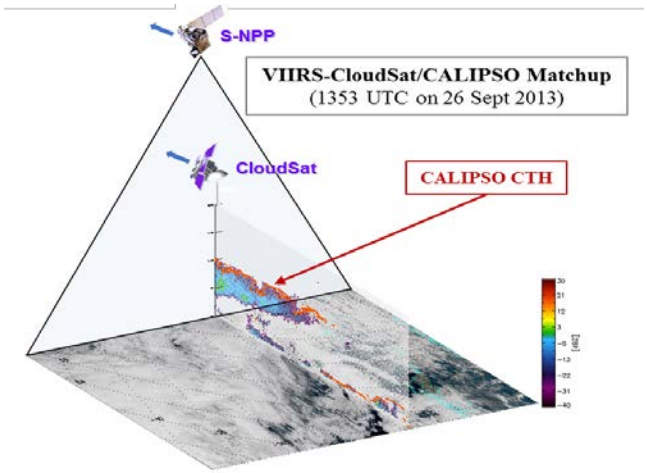
- Estimate the base height of the uppermost cloud layer, based upon statistical relationships trained by cloud geometric thickness (CGT), cloud top height (CTH), and cloud water path (CWP) observations from A-Train satellites
- **Require CTH and CWP as main input to estimate CGT, and computes CBH by subtracting CGT from CTH**
- Additional handling for thin cirrus (extinction method) and deep convection (supplementary NWP data)

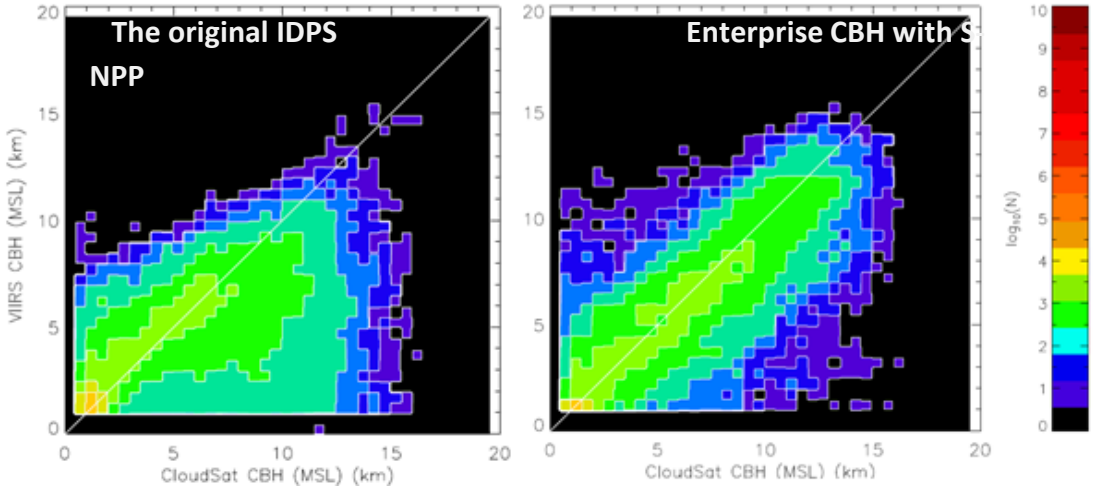


- Errors in upstream retrievals of Cloud Mask, CTH and CWP directly impact the accuracy of CBH retrieval
- **Optimal for single layer clouds**, and may not be 'ceiling' for multi-layered cloudy scenes, comprising uncertainties of the upstream retrievals.

Enterprise Cloud Base Height

- 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 specs (*Seaman et al. & Noh et al., JTECH 2017)*
- The CBH information is made available to improve the Cloud Cover and Layers product (not in the current DAP)
- Support both polar and geostationary satellite sensors as part of the NOAA Enterprise Cloud Algorithm Suite
- Operational for NOAA-20 VIIRS (Beta maturity review in July 2018)





NDE/STAR VIIRS ECM Production Status

Algorithm	Suomi NPP	NOAA-20
February 2018 DAP w/o April patch (missing granules) August 2017 Science Code delivery **(v1r2)**	**NDE** **Currently in Operations since 1200 UTC on 13 August 2018**	**NDE** **I&T from 28 March, 2018 to 28 September**
August 2018 DAP February 2018 Science Code delivery (**v2r0**)	**STAR** Systematic production since June, 2018 **NDE** **I&T on as of 28 September, 2018**	**STAR** Systematic production since June, 2018 **NDE** **I&T on as of 28 September, 2018**
Jan/Feb 2019 DAP August 2018 Science Code delivery (**v2r1**)	**Delivery and development in progress** Delivery schedule provided by ASSISTT	**Delivery and development in progress** Delivery schedule provided by ASSISTT

NDE/STAR CBH Production Status & Delivery

Algorithm	Suomi NPP	NOAA-20
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 Operations since 1200 UTC on 13 August 2018**	**NDE** **I&T from 28 March, 2018 to 28 September**
February 2018 Science Code delivery Minor diagnostic output improvements (**v2r0**)	**STAR** Systematic production since June, 2018 **NDE** **I&T on as of 28 September, 2018**	**STAR** Systematic production since June, 2018 **NDE** **I&T on as of 28 September, 2018**
August 2018 Science Code delivery Minor diagnostic output improvements (**v2r1**)	**Delivery and development in progress** Delivery schedule provided by ASSISTT	**Delivery and development in progress** Delivery schedule provided by ASSISTT

NDE/STAR CBH Production Status & Delivery

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.

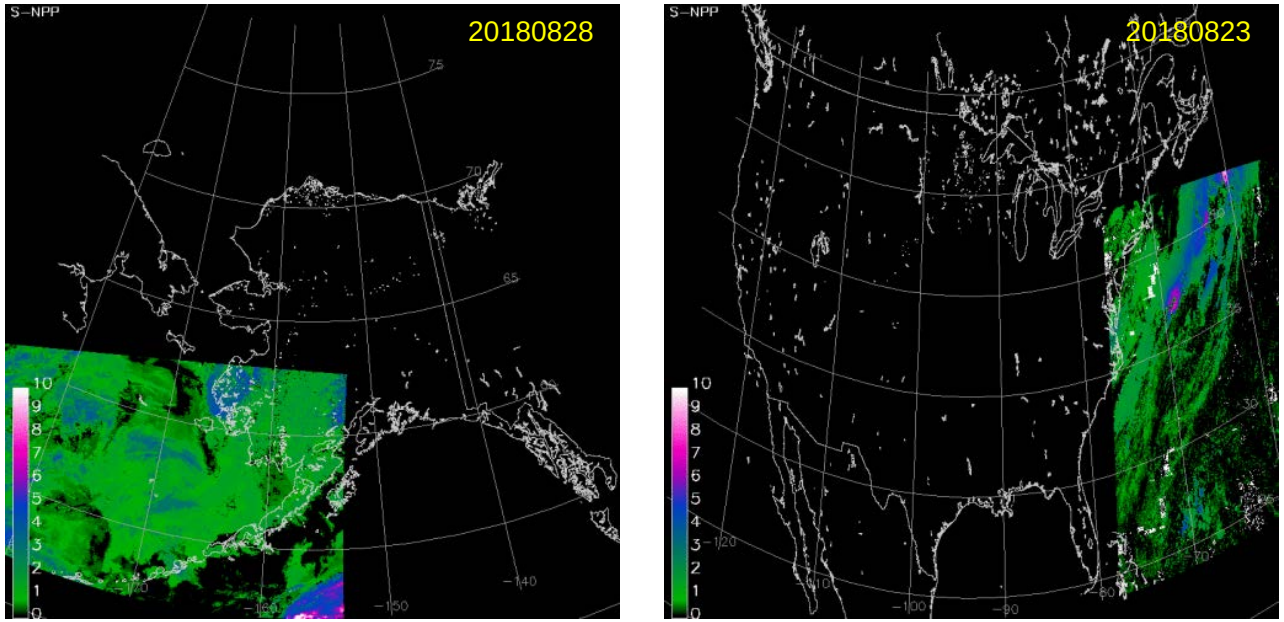
Requirements Cloud Base Height

- 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.

- 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

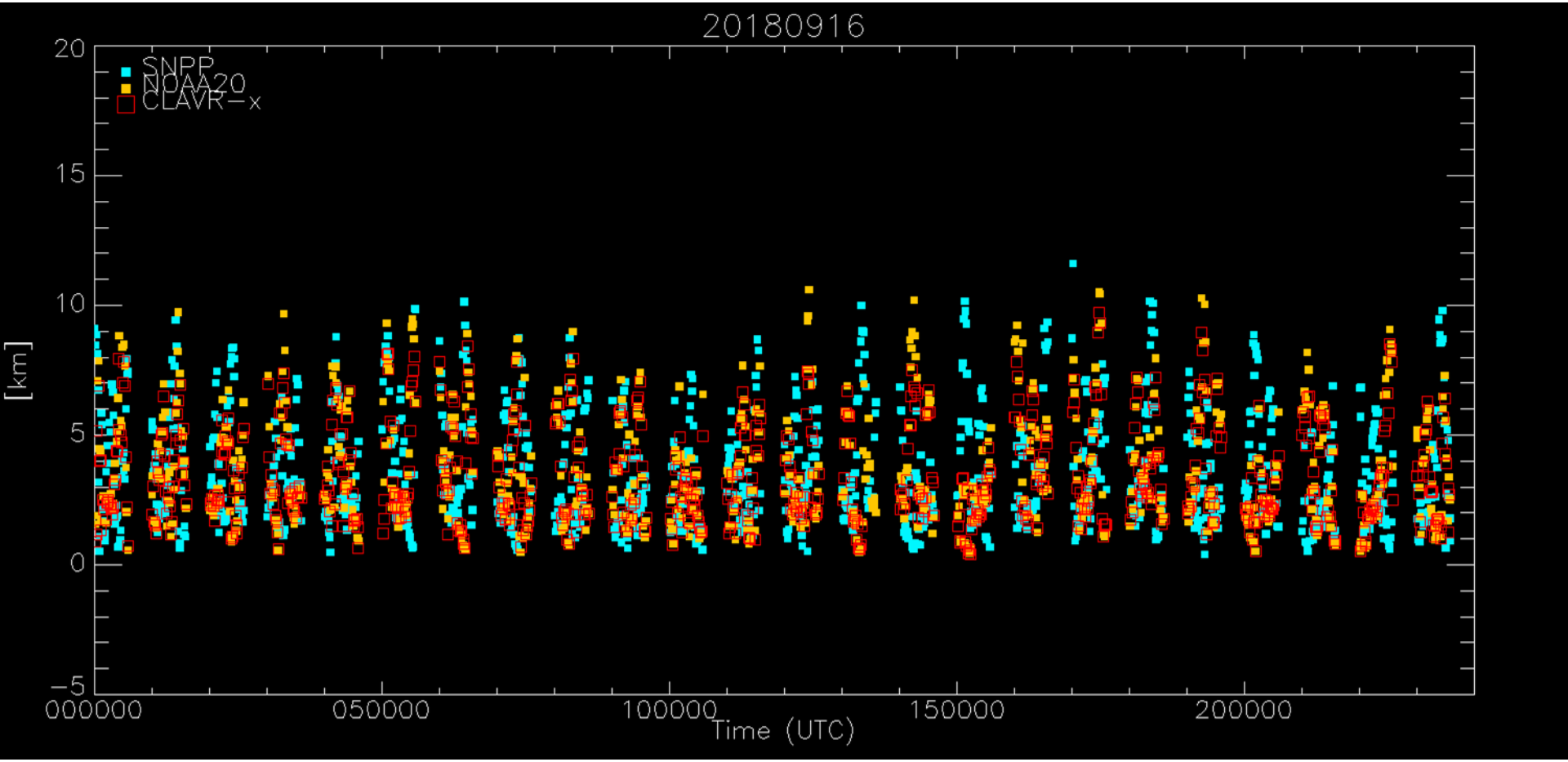
- Monitoring time series to check consistency between S-NPP (v1r1) and NOAA-20 (v1r2) algorithm operations
- Examine CBH (and CGT=CTH-CBH), compared with CIRA's CLAVR-x output
- Case studies (June to Sep 2018) to identify issues for the individual granules
- Comparison with ARM (U.S. DOE Atmospheric Radiation Measurement) site measurements (ceilometer over NSA, AK and SGP, OK) for selected periods



Real-time CLAVR-x run at CIRA (Alaska and CONUS domains): Cloud Geometric Thickness (CTH-CBH, km)

Enterprise v1r2 Integration Results

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



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

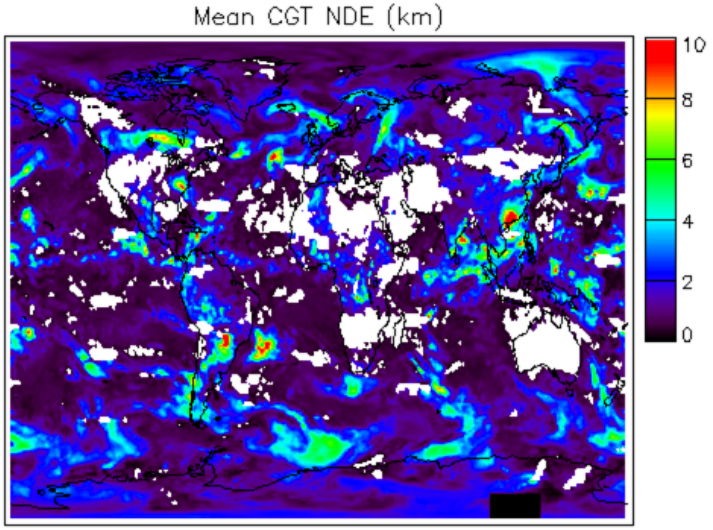
Enterprise v1r2 Integration Results

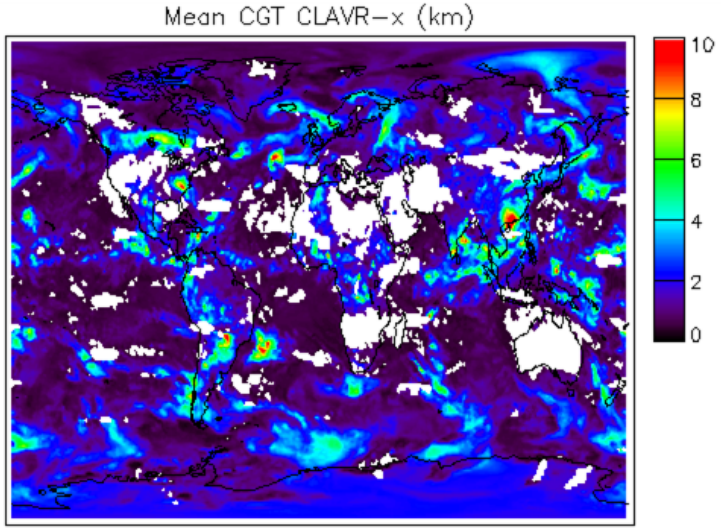
- Compare global CGT and CBH (1ºx1º) from NOAA-20 (v1r2) and CIRA CLAVR-x

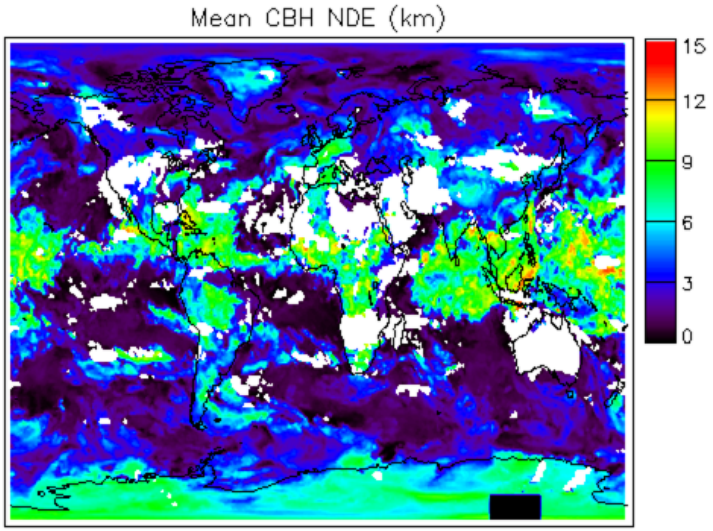
CBH = CTH – CGT

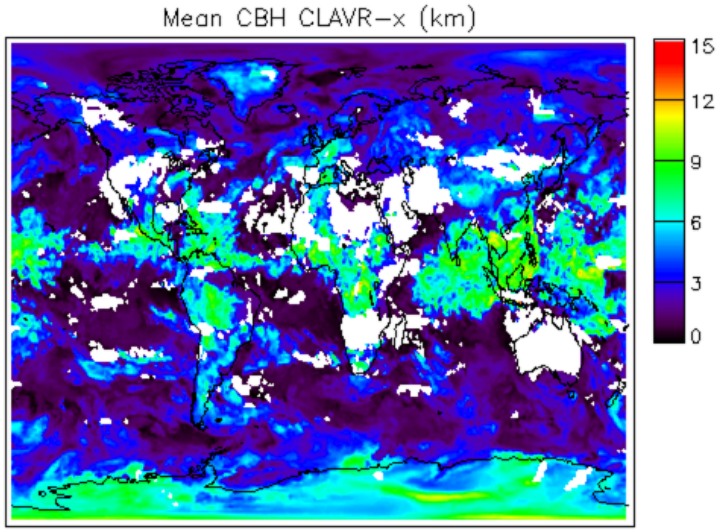
- CBH is highly dependent on CTH
- In general, the main part of the current CBH algorithm (obtaining CGT) is working ok
- Some missing upstream retrievals often found over the central Antarctica region

996 NOAA-20 VIIRS granules (16 Sep 2018)







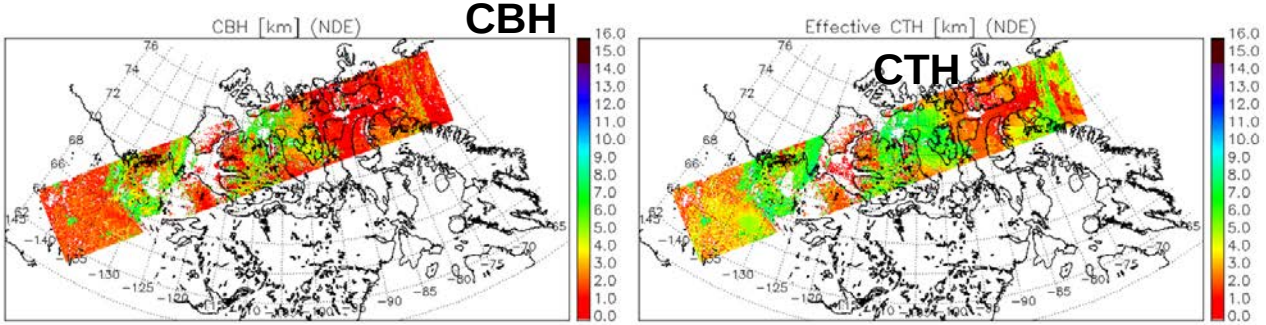


Enterprise v1r2 Integration Results

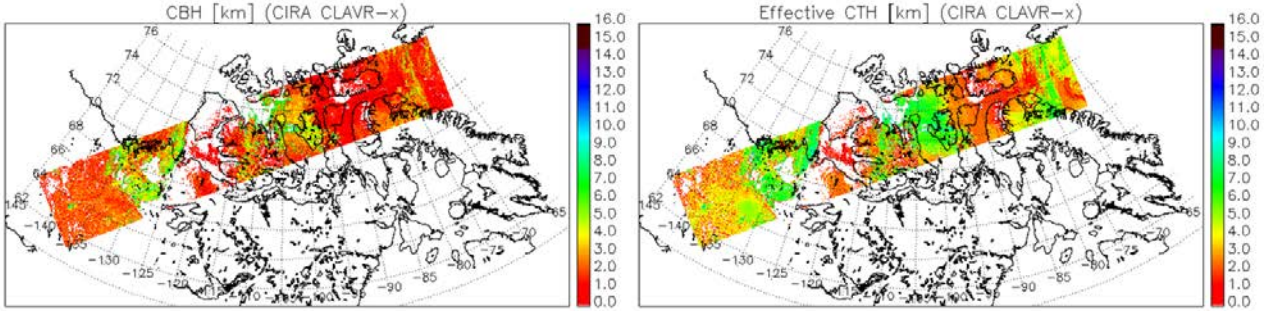
CBH

CTH

V1R2

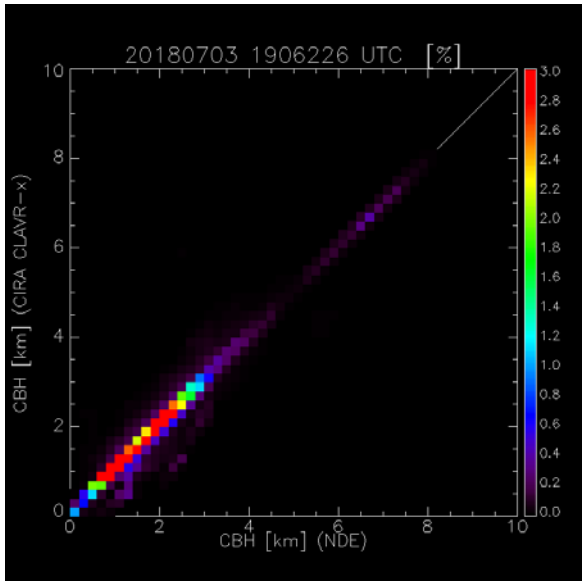


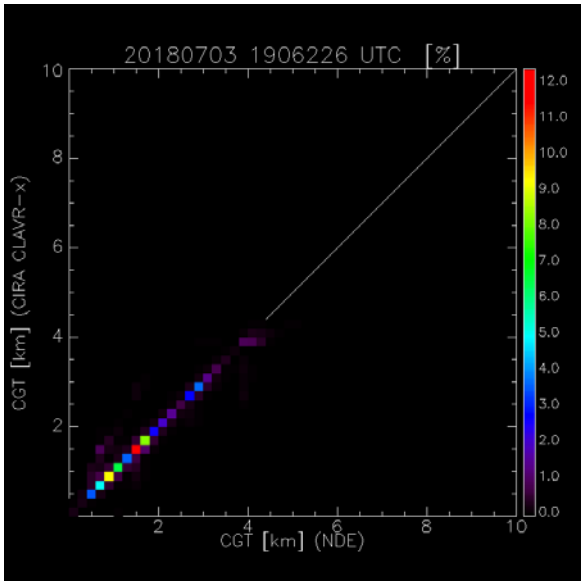
CLAVR-x



Day

Generally in a good agreement





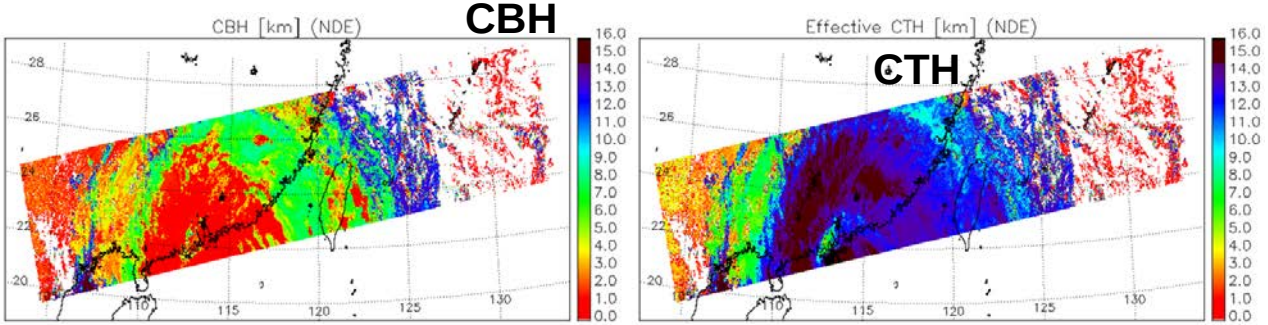
CBH and CGT comparisons in this evaluation are done when CTH differences between NDE and CIRA CLAVR-x are less than 200 m.

Enterprise v1r2 Integration Results

CBH

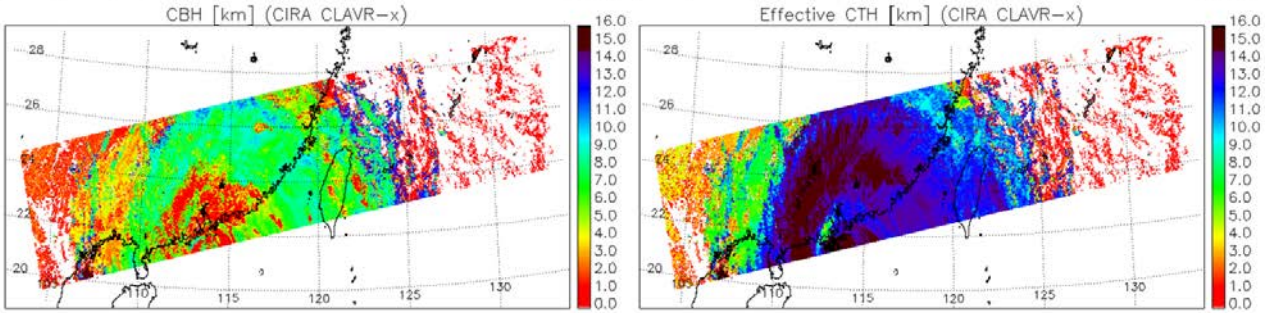
CTH

V1R2

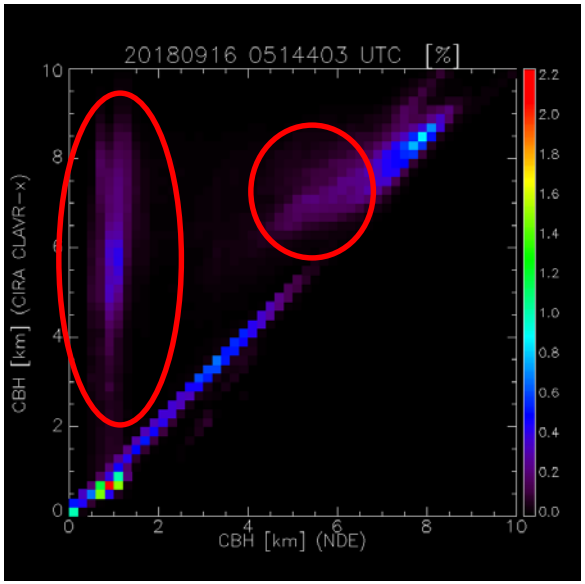


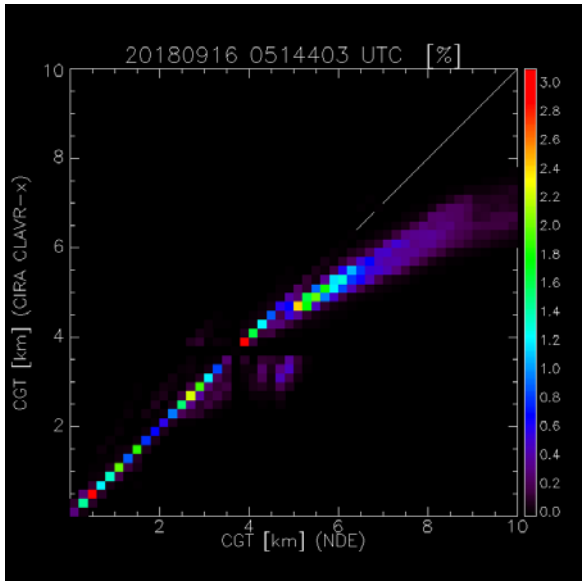
Day

CLAVR-x



Discrepancy in deep convection due to DCOMP differences (CWP threshold ≥ 1.0 kg/m² to apply NWP data)





CBH and 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

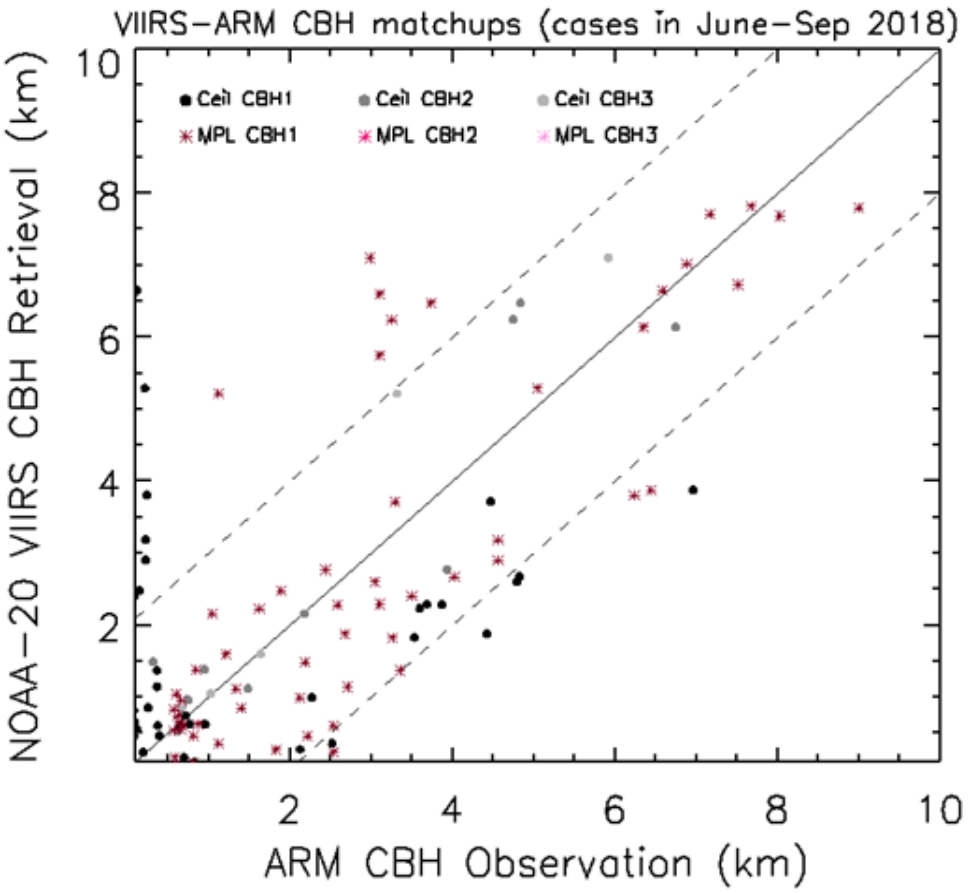
- Compare CBHs from NOAA-20 (v1r2) with CIRA's CLAVR-x output

Case	No. of granules examined	Valid CTH but Invalid CBH (%)	Out of spec (%) compared with CLAVR-x (within 200m CTH range)
Jun 2018	620	1.57	1.49
Jul 2018	194	1.30	2.20
Aug 2018	64	1.00	0.64
Sep 2018	855	1.74	1.83

- 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)
- "Invalid CBH" pixels with valid CTH values: primarily due to no CWP input
- "Out of spec" pixels (difference $\geq$ 2 km) need further investigation through evaluation against observations, including potential improvement on nighttime performance and multi-layered clouds

CBH performance against ARM measurements

- Ongoing evaluation efforts using ground ceilometer and lidar data from ARM sites
  - Blue squares: VIIRS CBHs (NOAA-20 v1r2)
  - Black/gray circles: ceilometer
  - Brown/red asterisks: lidar
- Examine individual cases and multi-months
- Continue more quantitative assessment for precip (surface obs) and multi-layered cloud cases (CALIPSO data)



ARM NSA **64 matchup cases** within 2-km CTH error range (VIIRS and ARM ground lidar - MPL)

➔ Valid CBHs against lidar (within 2 km) = 85.94 %

➔ Valid CBHs against ceilometer = 68.75 %

Provisional Maturity Conclusions

- **The NDE Enterprise CBH algorithm with NOAA-20 VIIRS (v1r2) is working nominally without serious issues** (valid day/night operations), as long as the upstream cloud retrievals and supplementary data are valid (Cloud Mask, CTH, CWP from DCOMP in daytime, NWP at night)
- Invalid CBH pixels (despite valid CTH) account for ~1.60 % of 1733 granules in this evaluation. The primary cause is invalid CWP (either from DCOMP or NWP)
- 'Out-of-spec' CBHs with >2 km difference compared to CIRA CLAVR-x (~1.71% in valid pixels that CTH is in an accurate range (200 m) between v1r2 and CLAVR-x)
- Discrepancies often found in twilight and some daytime zones: possibly due to different DCOMP and NWP versions in NDE and CIRA's CLAVR-x
- Often missing CBHs over the central Antarctica: missing upstream input
- Will continue further investigation on the identified issues
- **Recommend 'Provisional maturity'**

Pathway to Validated

- The CIRA and CIMSS teams continue to support the STAR ASSISTT for its correct operation and long-term monitoring within the operational frame.
- Continue validation over an extended period
  - Intercomparison between NOAA-20, S-NPP, and CLAVR-x (separate evals for Day/Night/Terminator)
  - Use ARM ground-based measurements
  - Employ CALIPSO and CloudSat upon data availability
  - Utilize new quality flags to examine each subroutine in the algorithm
- Continue improvement of the algorithm implementation and science codes for the identified issues
- Add evaluation of CCL products when the CBH component will be included in the next DAP round.

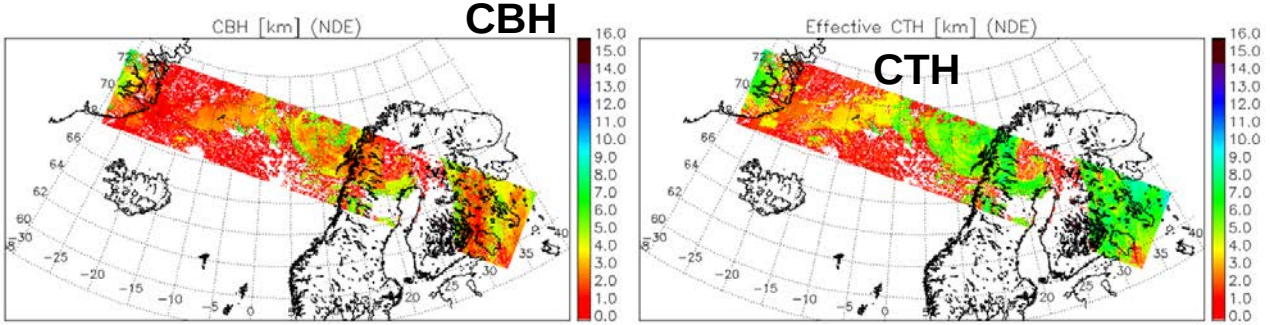
BACKUP

Enterprise v1r2 Integration Results

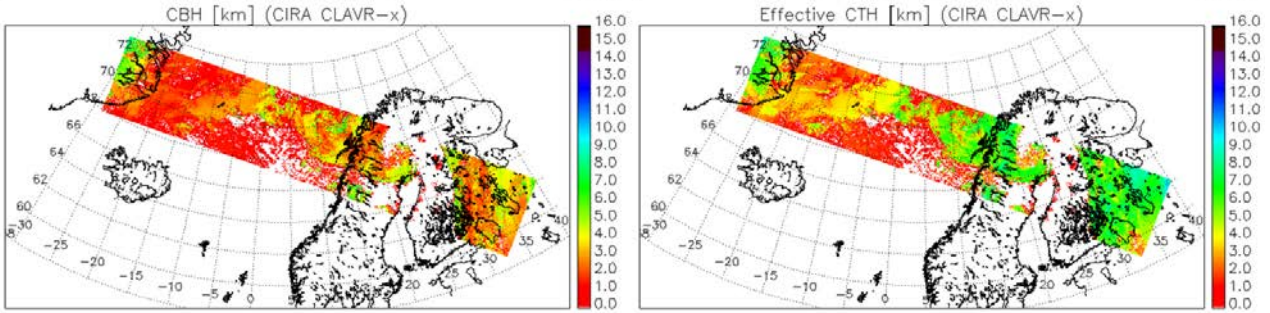
CBH

CTH

V1R2

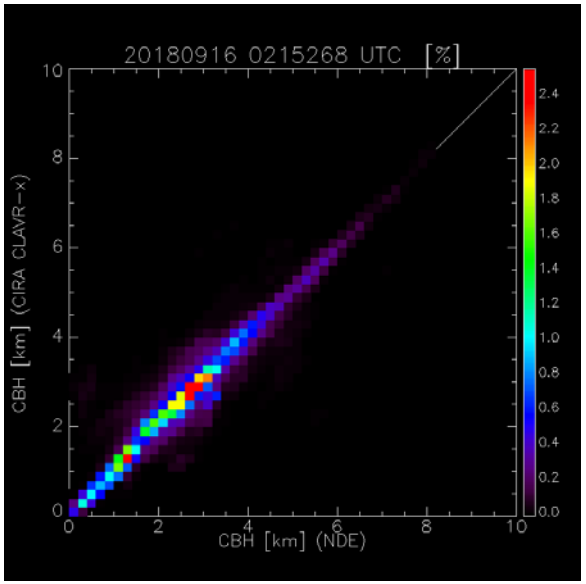


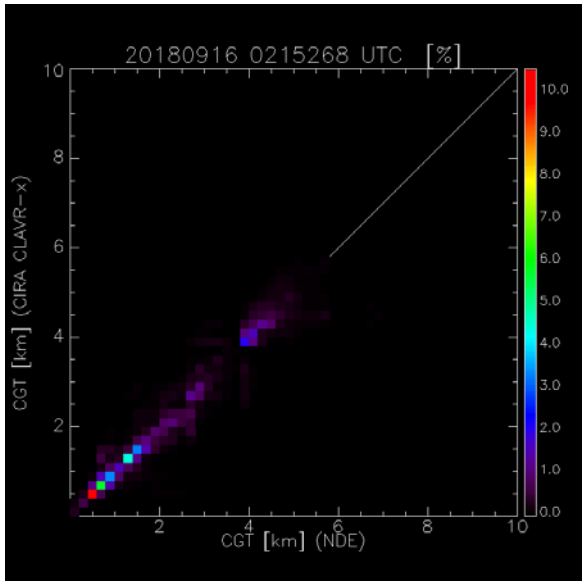
CLAVR-x



Night

Generally in a good agreement





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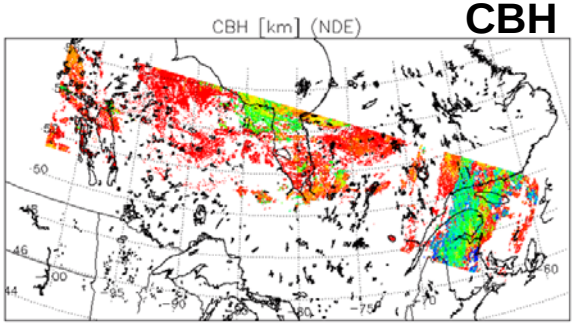
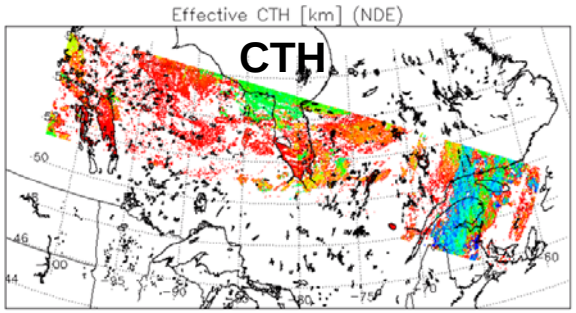
CBH

CTH

V1R2





Night

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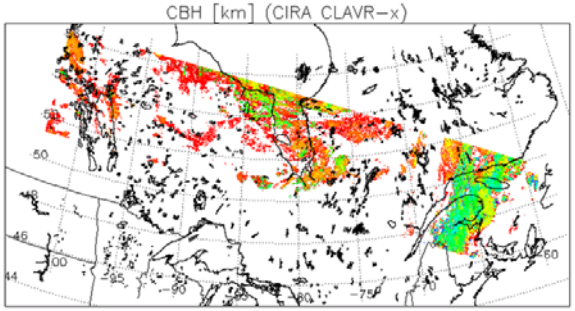
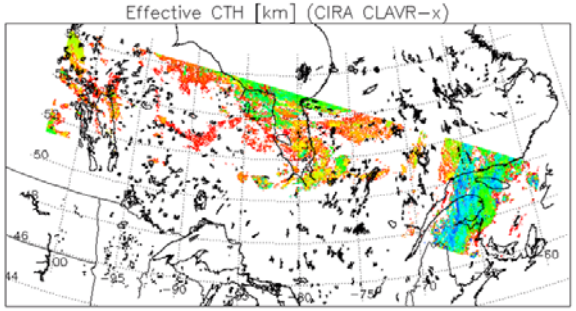
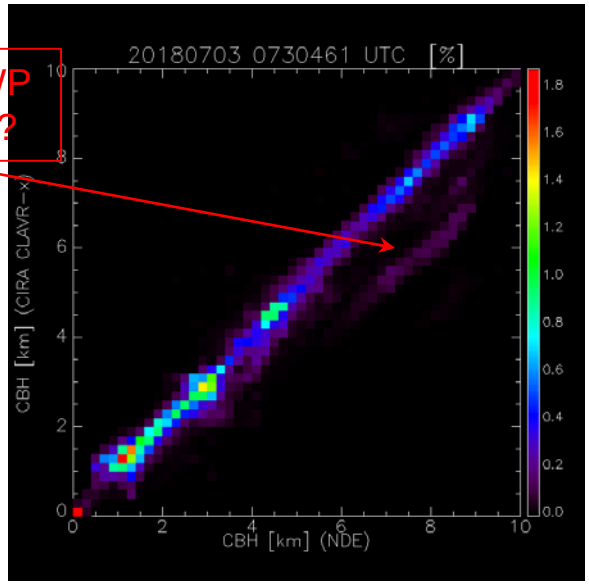
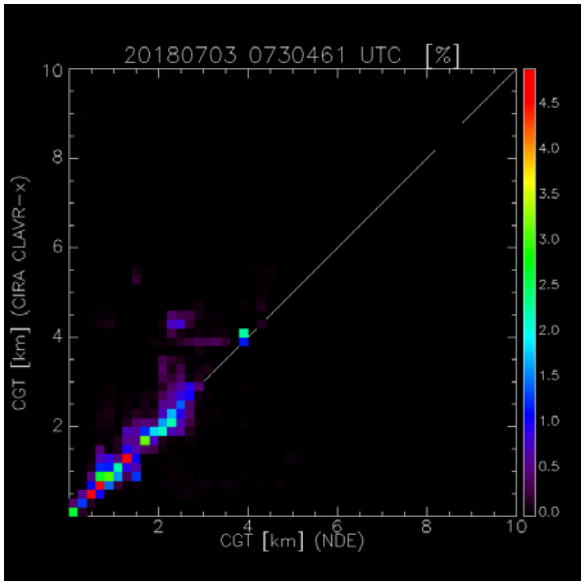




Due to NWP differences?





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CBH performance against ARM measurements

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