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

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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).

Cloud Top Height

Cloud Water Path

Appropriate CIRA cloud geometric thickness ($\Delta Z$) regression

CBH retrieval

CBH = CTH - $\Delta Z$
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
• 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

The original IDPS CBH

Enterprise

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

<table>
<thead>
<tr>
<th>S-NPP CBH [km] within spec only</th>
<th>Samples (%)</th>
<th>Avg error (bias)</th>
<th>Std of error</th>
<th>RMSE</th>
<th>r²</th>
</tr>
</thead>
<tbody>
<tr>
<td>IDPS (All)</td>
<td>100</td>
<td>0.7</td>
<td>2.6</td>
<td>2.7</td>
<td>0.45</td>
</tr>
<tr>
<td>Enterprise (All)</td>
<td>100</td>
<td>0.3</td>
<td>1.7</td>
<td>1.7</td>
<td>0.79</td>
</tr>
</tbody>
</table>

Enterprise CBHs for each cloud type

<table>
<thead>
<tr>
<th></th>
<th>Samples (%)</th>
<th>Avg error (bias)</th>
<th>Std of error</th>
<th>RMSE</th>
<th>r²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cirrus (thin)</td>
<td>51</td>
<td>0.3</td>
<td>1.7</td>
<td>1.7</td>
<td>0.698</td>
</tr>
<tr>
<td>Opaque Ice</td>
<td>14</td>
<td>0.3</td>
<td>2.3</td>
<td>2.3</td>
<td>0.515</td>
</tr>
<tr>
<td>Water</td>
<td>9</td>
<td>0.2</td>
<td>0.5</td>
<td>0.5</td>
<td>0.688</td>
</tr>
<tr>
<td>Supercooled</td>
<td>21</td>
<td>0.3</td>
<td>1.1</td>
<td>1.1</td>
<td>0.688</td>
</tr>
<tr>
<td>Overlap</td>
<td>4</td>
<td>0.4</td>
<td>2.1</td>
<td>2.1</td>
<td>0.502</td>
</tr>
<tr>
<td>Overshooting</td>
<td>1</td>
<td>0.8</td>
<td>2.8</td>
<td>3.0</td>
<td>0.295</td>
</tr>
</tbody>
</table>

“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 ≥ 1, or within 2 km if COT < 1

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

<Much improved!>
<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Suomi NPP</th>
<th>NOAA-20</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 2017 DAP</td>
<td>NDE February 23, 2018</td>
<td>N/A</td>
</tr>
<tr>
<td>Initial CBH delivery <em>(v1r1)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>January 2017 DAP</td>
<td>NDE Currently in I&amp;T since 28 March, 2018</td>
<td>NDE Currently in I&amp;T since 28 March, 2018</td>
</tr>
<tr>
<td>*A smooth transition between CIRA statistical CBH and NWP condensation levels for deep convective clouds and N20 capability <em>(v1r2)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>February 2018 Science Code delivery</td>
<td>STAR Systematic production since June, 2018</td>
<td>STAR Systematic production since June, 2018</td>
</tr>
<tr>
<td>Minor diagnostic output improvements <em>(v2r0)</em></td>
<td>NDE <em>(Estimated Delivery in Aug 2018)</em></td>
<td>NDE <em>(Estimated Delivery in Aug 2018)</em></td>
</tr>
</tbody>
</table>
### JPSS Data Products Maturity Definition

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

<table>
<thead>
<tr>
<th>Stage</th>
<th>Definition</th>
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</thead>
</table>
| **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.
- 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
• 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

20180703
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

20180703
Enterprise v1r2 Integration Results

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

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

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
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?

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

Due to a NWP difference?

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

V1R2

CLAVR-x

CBH

CTH

Twilight

CWP transition difference?
Enterprise v1r2 Integration Results

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

Mean CBH per granule (0-20 km valid pixels only)
Enterprise v1r2 Integration Results

V1R2

CLAVR-x

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

V1R2

CLAVR-x

Twilight

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**

Daytime granules generally in a good agreement in an accurate CTH range, but in these noted areas, CWP discrepancy from DCOMP?
• 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’
• The CIRA and CIMSS teams continue to support the STAR ASSIST 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.