# NOAA-20 VIIRS Enterprise Cloud Top Height (ACHA) Provisional Maturity

October 2, 2018

**VIIRS Cloud Height Team**

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# Executive Summary

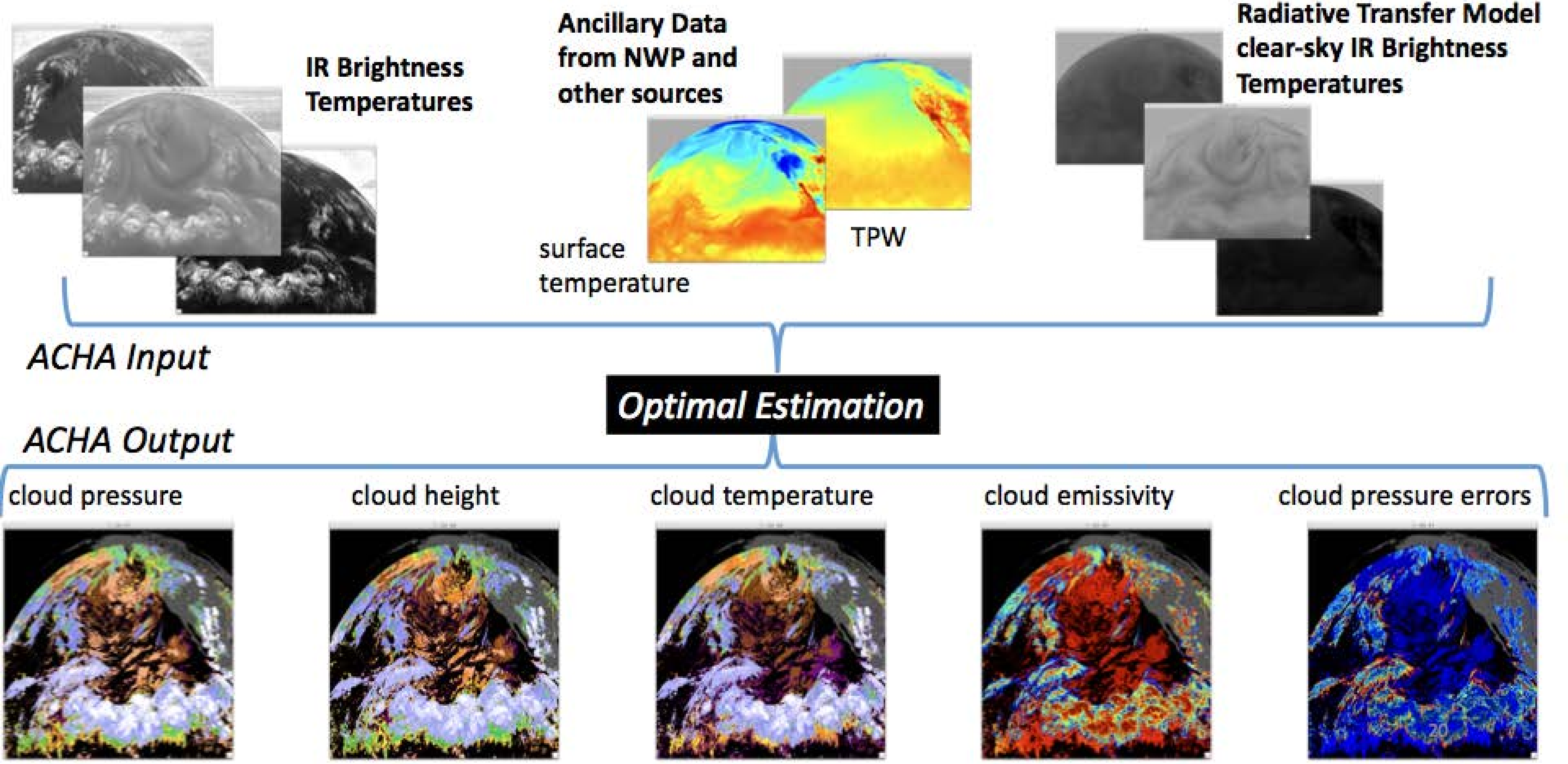
- NDE ACHA cloud top products were evaluated both visually and quantitatively with other products
- Visually inspections reveal issues such as missing granules due to NDE processing and cloud mask problems
- A known issue of unrealistic cloud top height and pressure was fixed within the NDE system with the implementation of v2r0 (currently in I&T)
- Quantitatively assessment against CALIPSO/CALIOP and NASA MODIS indicate for single layer clouds with known phase, all three cloud top products (height, temperature and pressure) meet requirement
- **The cloud team recommends provisional maturity**

# Specs Requirement for Cloud Top Products

- CTT = Cloud-top Temperature
- CTH = Cloud-top Height
- CTP = Cloud-top Pressure

| Attributes | **Requirement (accuracy = precision)** |
|---|---|
| CTT | 6K when $\tau \geq 1$, 12K when $\tau < 1$ |
| CTH | 1km when $\tau \geq 1$, 2km when $\tau < 1$ |
| CTP | 100 hPa when $\tau \geq 1$, 200 hPa when $\tau < 1$ |

# How AWG CLOUD HEIGHT (ACHA) Works



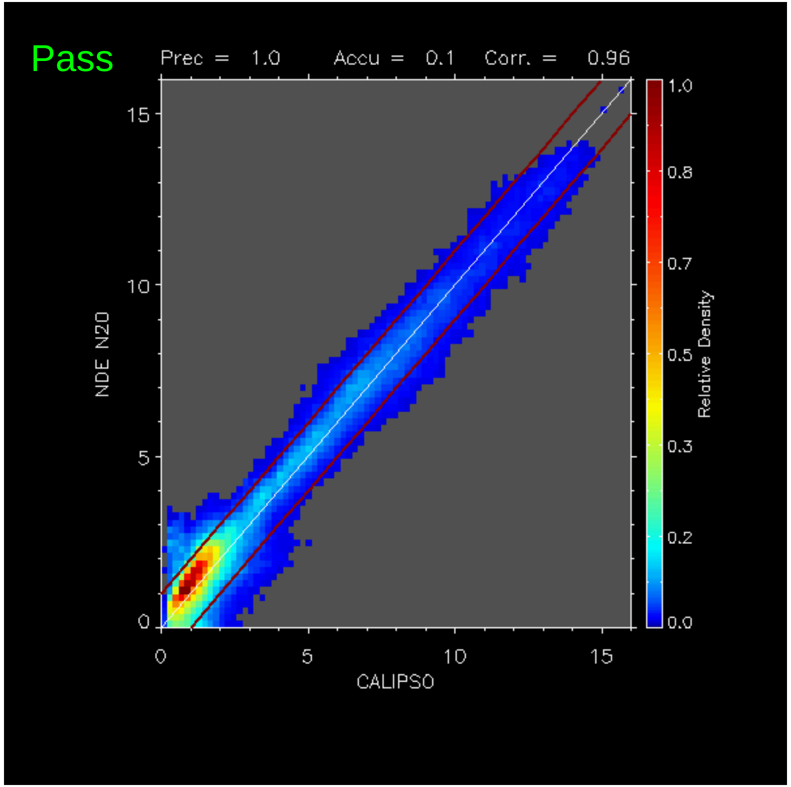
# Unrealistic Height Values

- We are still seeing extreme unreasonable values for cloud height and pressure, for example, CTH > 1,000,000 meters and negative cloud pressure. However, the cloud temperature for those pixels are reasonable.

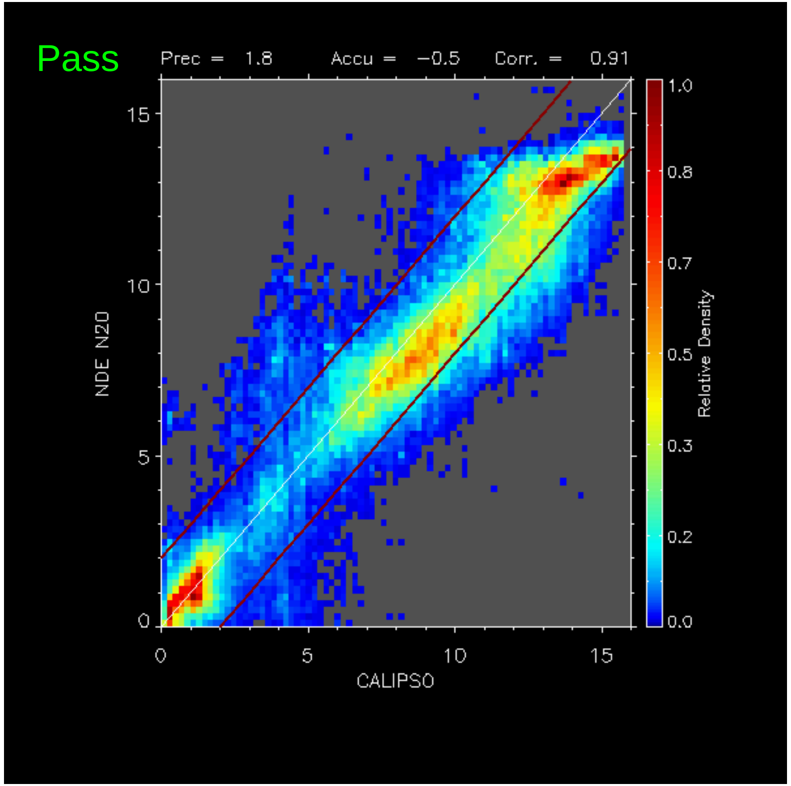
- This is mostly likely due to bad NWP profiles as cloud temperature is retrieved first and height and pressure are derived using NWP profiles.

- A constraint has been added to ACHA (implemented in v2r0) to fix this issue.

# CTH - Phase Matching and Single Layer

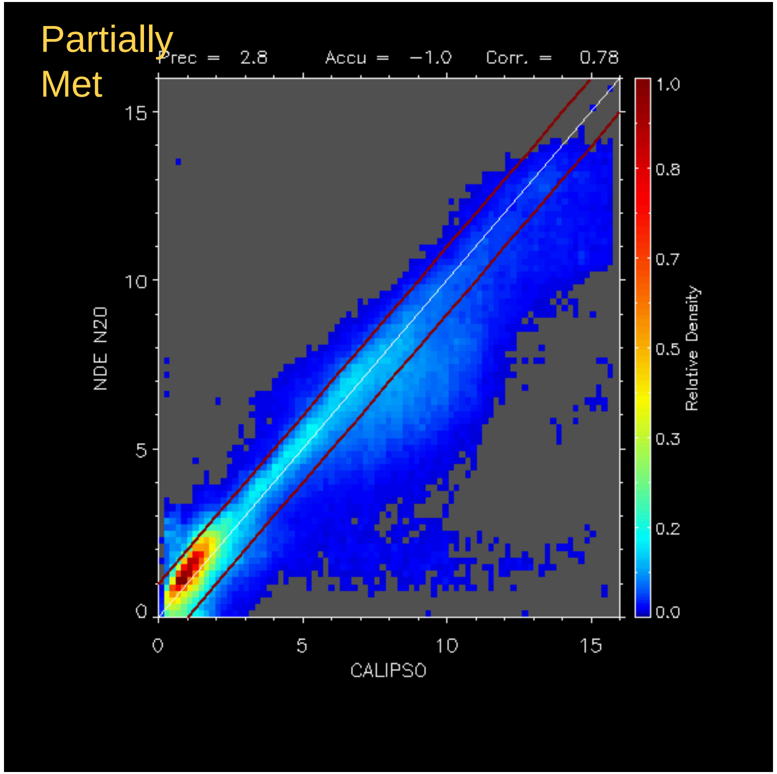



COT >=1

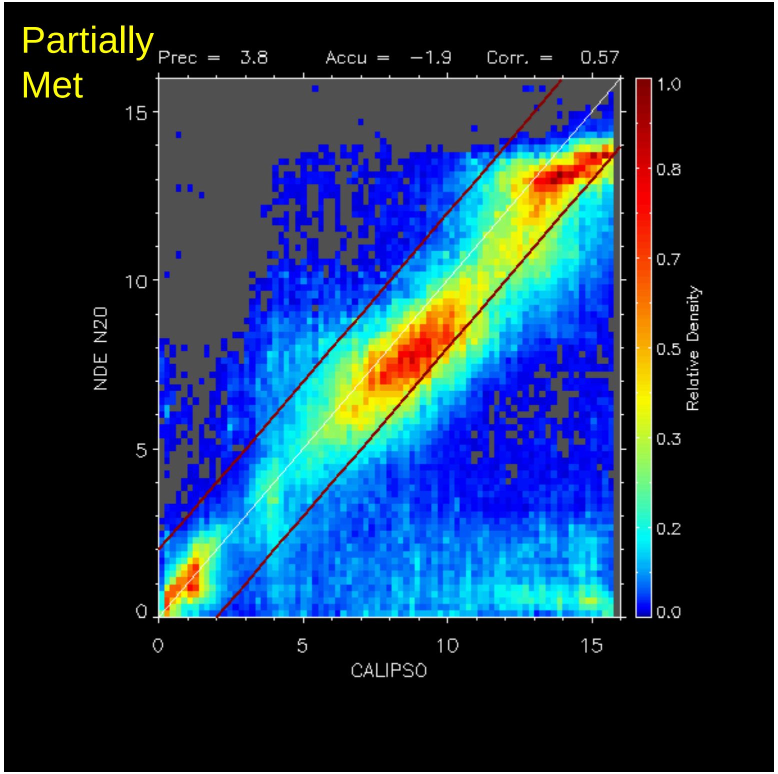



COT < 1

# CTH - no filtering



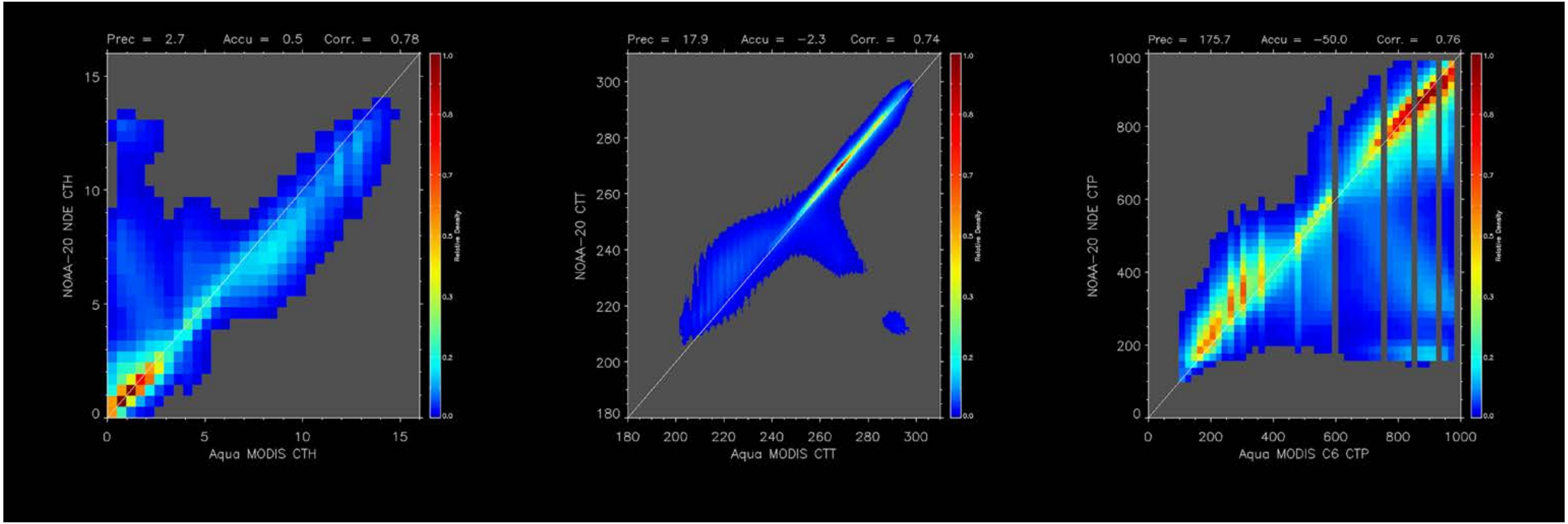

COT >=1



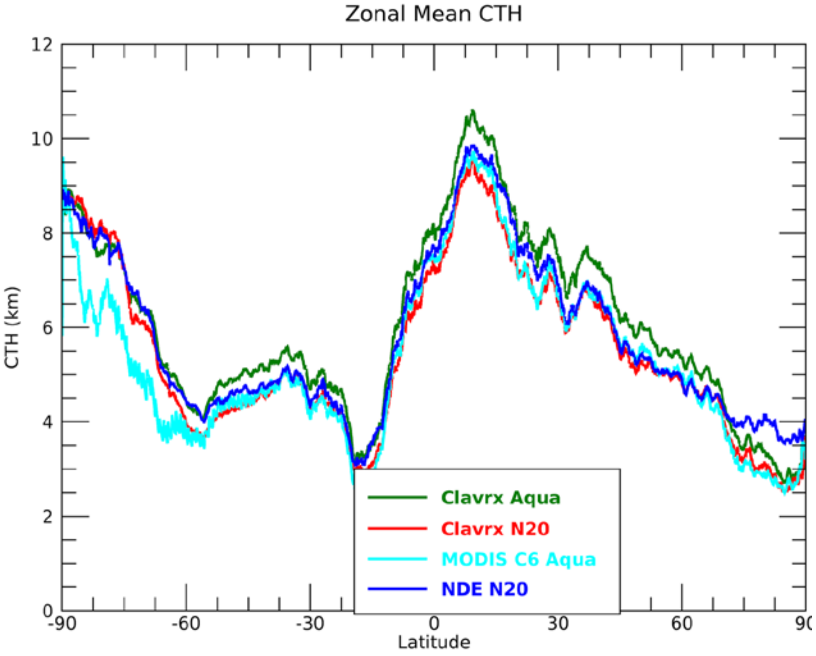

COT < 1

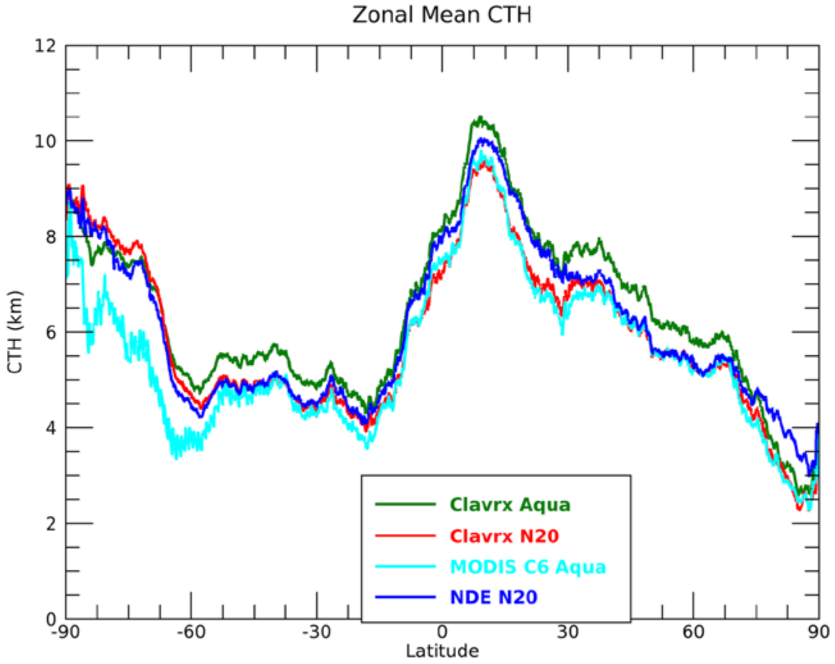
# MODIS Comparison: No Filtering

CTH CTT CTP



# Global Zonal Mean




- Zonal plots computed from 12 days of ACHA products as well as NASA MODIS.
- The zonal mean patterns show reasonably well consistency

# AMV Validation Statistics (from Daniels/Key)

## NPP VIIRS Winds vs. Radiosondes July 5-29, 2018

| 100_1000mb | 90S – 90N | 25N – 90N | 25S – 25N | 25S – 90S |
|---|---|---|---|---|
| Accuracy | 5.79 | 5.79 | 0.00 | 0.00 |
| Precision | 3.58 | 3.58 | 0.00 | 0.00 |
| Speed Bias | 1.03 | 1.03 | 0.00 | 0.00 |
| Speed | 20.44 | 20.44 | 0.00 | 0.00 |
| Sample | 4668 | 4668 | 0 | 0 |
| **101_400mb** | **90S – 90N** | **25N – 90N** | **25S – 25N** | **25S – 90S** |
| Accuracy | 6.39 | 6.39 | 0.00 | 0.00 |
| Precision | 3.76 | 3.76 | 0.00 | 0.00 |
| Speed Bias | 1.33 | [illegible] | [illegible] | [illegible] |
| Speed | 23.85 | 2[illegible] | [illegible] | [illegible] |
| Sample | 2085 | [illegible] | [illegible] | [illegible] |
| **401_700mb** | **90S – 90N** | **25N[illegible]** | [illegible] | [illegible] |
| Accuracy | 5.42 | [illegible] | [illegible] | [illegible] |
| Precision | 3.40 | [illegible] | [illegible] | [illegible] |
| Speed Bias | 0.81 | [illegible] | [illegible] | [illegible] |
| Speed | 18.95 | 1[illegible] | [illegible] | [illegible] |
| Sample | 2071 | [illegible] | [illegible] | [illegible] |
| **701_1000mb** | **90S – 90N** | **25N[illegible]** | [illegible] | [illegible] |
| Accuracy | 4.81 | [illegible] | [illegible] | [illegible] |
| Precision | 3.13 | [illegible] | [illegible] | [illegible] |
| Speed Bias | 0.66 | [illegible] | [illegible] | [illegible] |
| Speed | 12.56 | 1[illegible] | [illegible] | [illegible] |
| Sample | 512 | [illegible] | [illegible] | [illegible] |

## NOAA-20 VIIRS Winds vs. Radiosondes July 5-29, 2018

| 100_1000mb | 90S – 90N | 25N – 90N | 25S – 25N | 25S – 90S |
|---|---|---|---|---|
| Accuracy | 5.99 | 5.99 | 0.00 | 0.00 |
| Precision | 3.64 | 3.64 | 0.00 | 0.00 |
| Speed Bias | 1.02 | 1.02 | 0.00 | 0.00 |
| Speed | 20.19 | 20.19 | 0.00 | 0.00 |
| Sample | 3860 | 3860 | 0 | 0 |
| **101_400mb** | **90S – 90N** | **25N – 90N** | **25S – 25N** | **25S – 90S** |
| Accuracy | 6.36 | 6.36 | 0.00 | 0.00 |
| Precision | 3.82 | 3.82 | 0.00 | 0.00 |
| [illegible] Bias | 1.23 | 1.23 | 0.00 | 0.00 |
| [illegible] | 23.71 | 23.71 | 0.00 | 0.00 |
| [illegible]e | 2073 | 2073 | 0 | 0 |
| **[illegible]700mb** | **90S – 90N** | **25N – 90N** | **25S – 25N** | **25S – 90S** |
| [illegible]acy | 5.79 | 5.79 | 0.00 | 0.00 |
| [illegible]sion | 3.47 | 3.47 | 0.00 | 0.00 |
| [illegible] Bias | 0.53 | 0.53 | 0.00 | 0.00 |
| [illegible] | 17.93 | 17.93 | 0.00 | 0.00 |
| [illegible]e | 1190 | 1190 | 0 | 0 |
| **[illegible]1000mb** | **90S – 90N** | **25N – 90N** | **25S – 25N** | **25S – 90S** |
| [illegible]acy | 5.10 | 5.10 | 0.00 | 0.00 |
| [illegible]sion | 3.16 | 3.16 | 0.00 | 0.00 |
| [illegible] Bias | 1.28 | 1.28 | 0.00 | 0.00 |
| [illegible] | 12.47 | 12.47 | 0.00 | 0.00 |
| [illegible]e | 597 | 597 | 0 | 0 |

Observed
Accuracy: 5.79-5.99 m/s
Precision: 3.58-3.64 m/s

Requirements:
Accuracy: 7.5 m/s
Precision: 4.2 m/s

NPP VIIRS winds generated at OSPO

NOAA-20 VIIRS winds generated at STAR. Statistics include only VIIRS winds at 12Z. NOAA-20 VIIRS Winds/Raob co-location files being reprocessed for the month of July to include 00Z matchups

# Pathway to Full Maturity

- We expect to apply the same activities to be conducted  for Full Maturity:
  - We continue to gather an archive of golden days where we save SDRs and EDRs spread from June 2018. This collection is ongoing.
  - We hope to continue to engage the teams and continue application-specific analysis.
  - ACHA updates from JPSS-RR (use of CrIS/NUCAPS) will be implemented when possible. These include allowing ACHA to detect multilayer situations.

# Full Briefing

# Outline

- ACHA Status in NDE
- Evaluation of the ACHA
- Provisional Maturity Conclusions
- Path Forward to Full Validation
- Future Plans

# NDE/STAR VIIRS ACHA Production Status

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

# Evaluation Methodology

We have chosen independent sources of cloud height products that provide qualitative and quantitative analysis of the performance.

We also compare to non-NDE generation cloud height data to diagnose NDE-specific issues.

Our Specific Evaluation Methodology applied here:

1. Visual inspection of NDE ACHA against CLAVR-x ACHA

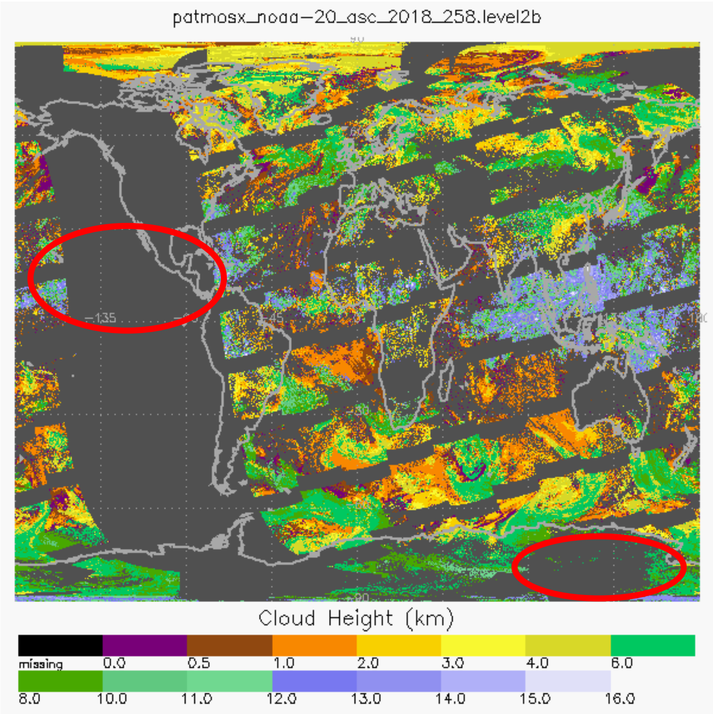
1. Validation against NASA CALIPSO/CALIOP

1. Validation against NASA MODIS MYD06

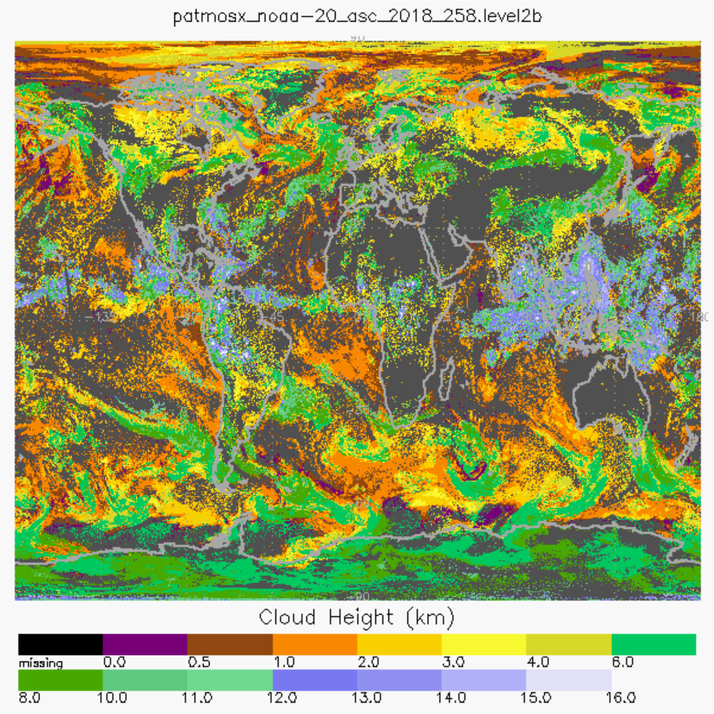
# Visual Comparisons with CLAVR-x ACHA

# Cloud Height Ascending Node

NDE NOAA-20




Clavr-x NOAA-20

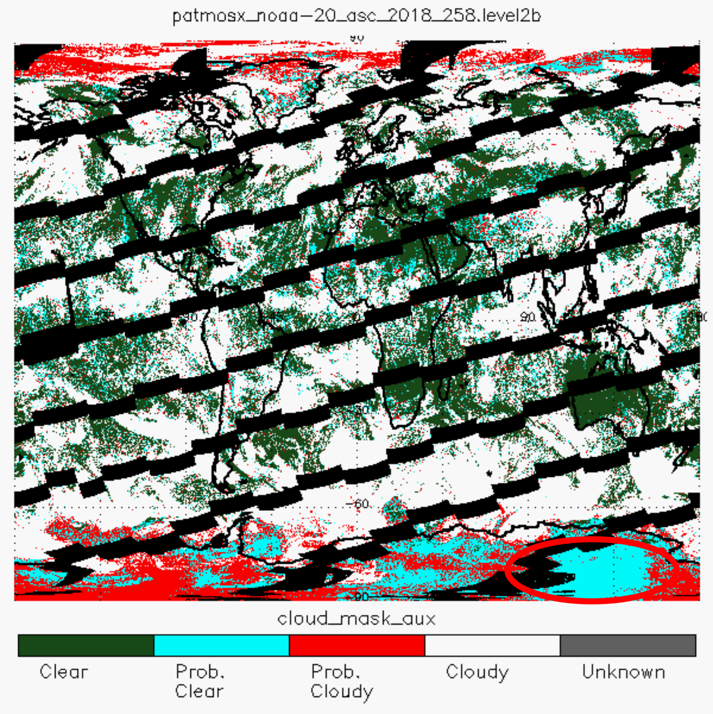


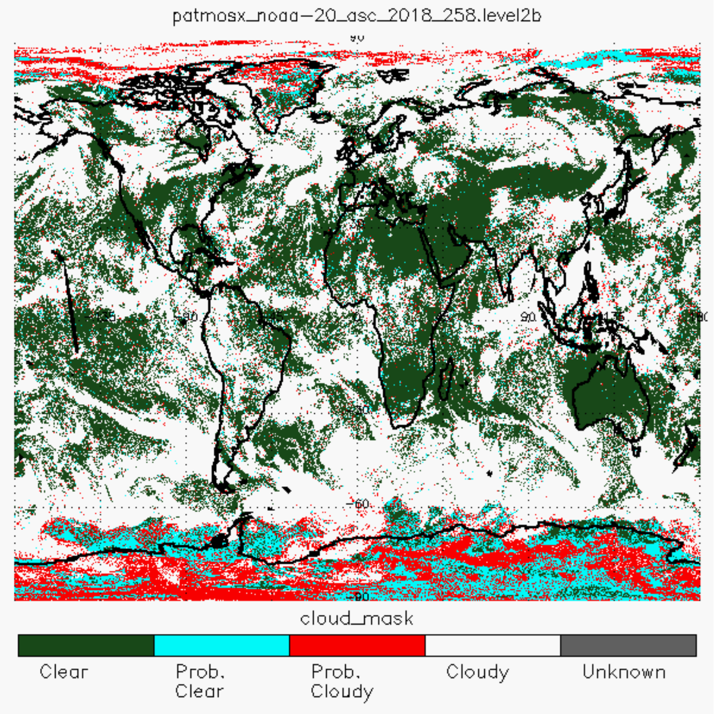

NDE processing issue causes more missing data in ACHA compared to cloud mask.

# Cloud Mask Ascending Node

NDE NOAA-20

Clavr-x NOAA-20




Cloud Mask differences also affect ACHA production.

# Unrealistic Height Values

- We are still seeing extreme unreasonable values for cloud height and pressure, for example, CTH > 1,000,000 meters and negative cloud pressure. However, the cloud temperature for those pixels are reasonable.

- This is mostly likely due to bad NWP profiles as cloud temperature is retrieved first and height and pressure are derived using NWP profiles.

- A constraint has been added to ACHA (implemented in v2r0) to fix this issue.

# Conclusions from Visual Comparisons

| Issue | Comment |
| --- | --- |
| Less retrievals in Polar | This is partially a cloud mask issue |
| Missing granules | This is a PDA issue and will be resolved in the June 2018 DAP (will be in Ops ~end 2018). |
| Bad cloud height and pressure values | Due to bad NWP profiles, this should be fixed in v2r0 |

# Provisional Validation

# Specs Requirement for Cloud Top Products

- CTT = Cloud-top Temperature
- CTH = Cloud-top Height
- CTP = Cloud-top Pressure

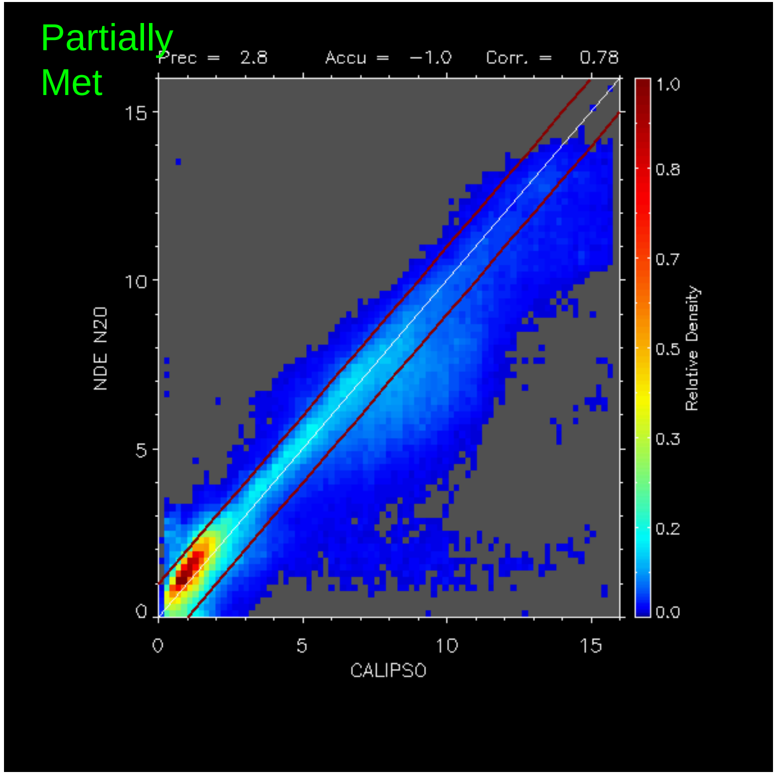
| Attributes | **Requirement (accuracy = precision)** |
|---|---|
| CTT | 6K when $\tau \geq 1$, 12K when $\tau < 1$ |
| CTH | 1km when $\tau \geq 1$, 2km when $\tau < 1$ |
| CTP | 100 hPa when $\tau \geq 1$, 200 hPa when $\tau < 1$ |

# Data Used in this Analysis

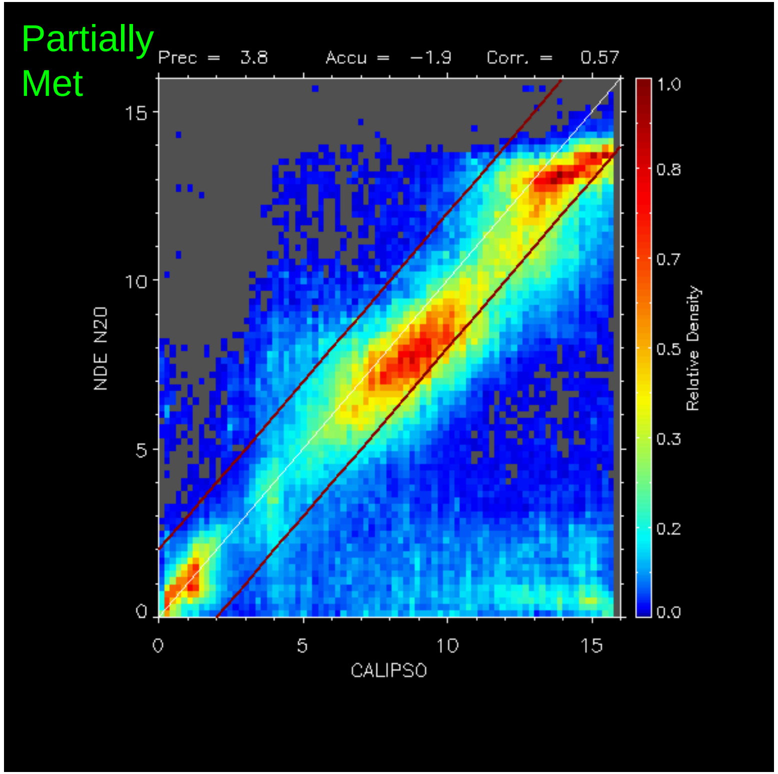
- NOAA-20 NDE v1r2 from 14 days in June and July, 10 days in August and September, 2018
- NOAA-20 CLAVR-x from 14 days in June and July, 10 days in August and September, 2018.
- NASA AQUA/MODIS from 6 days in June and July, 6 days in August and September, 2018.
- NASA CALIPSO from 15 days in June and July, 4 days in August and September, 2018.

# Comparison to CALIPSO/CALIOP

# CTH - no filtering

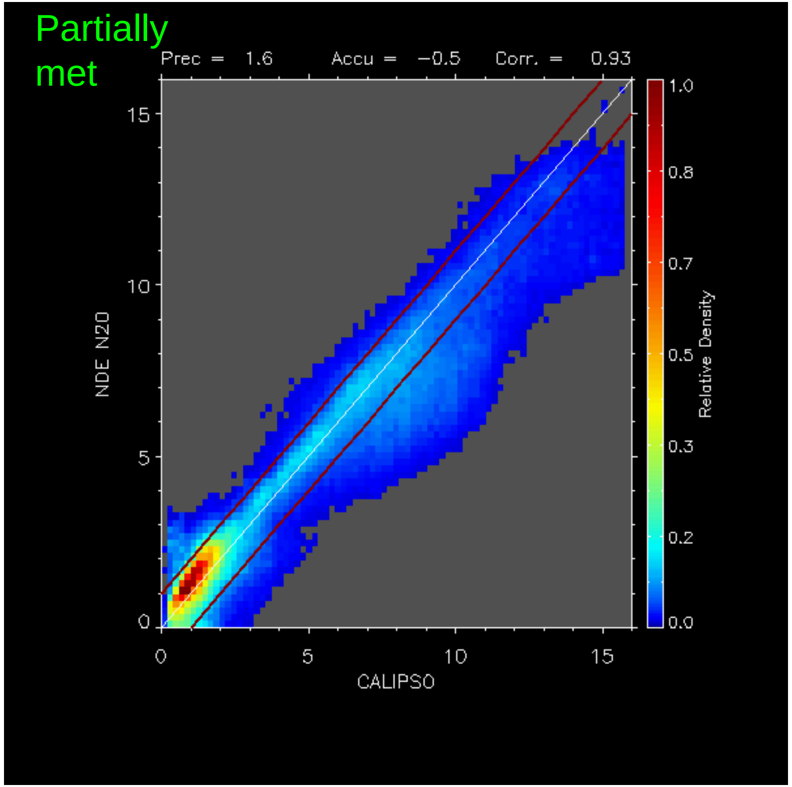



COT >=1

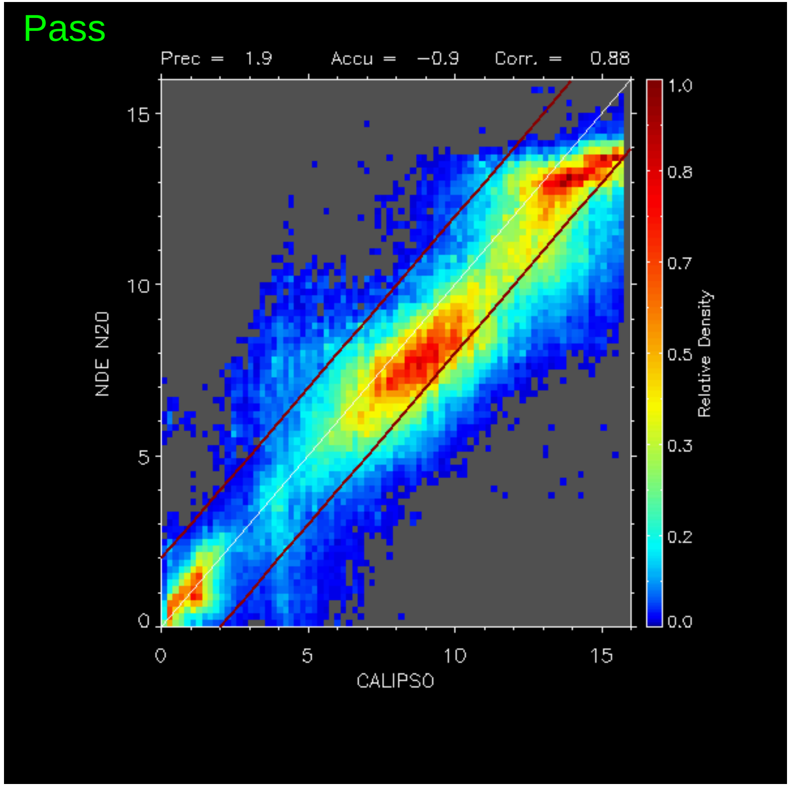



COT < 1

# CTH - Phase Matching

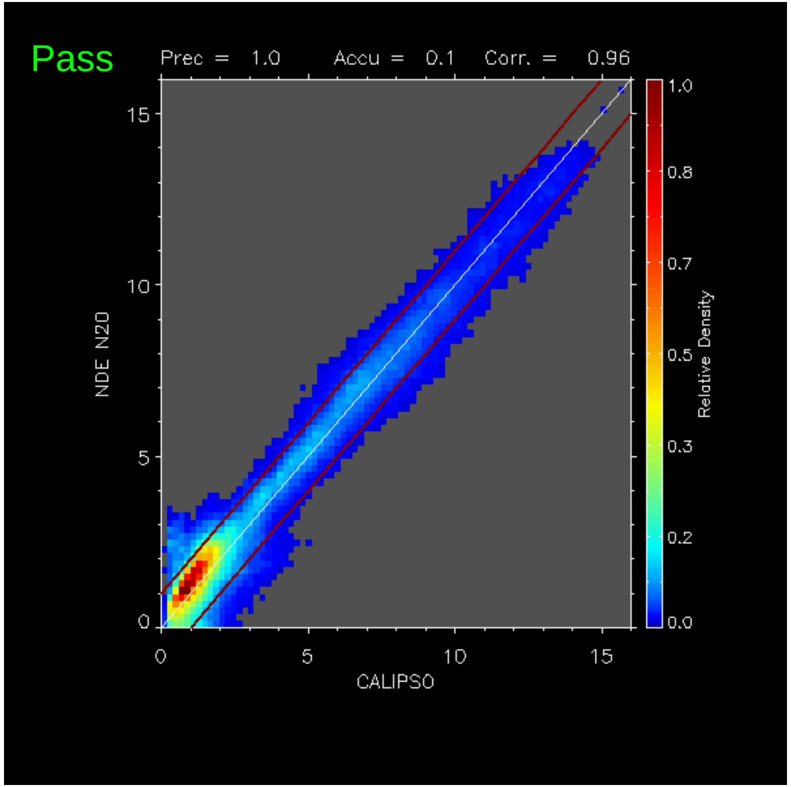



COT >=1

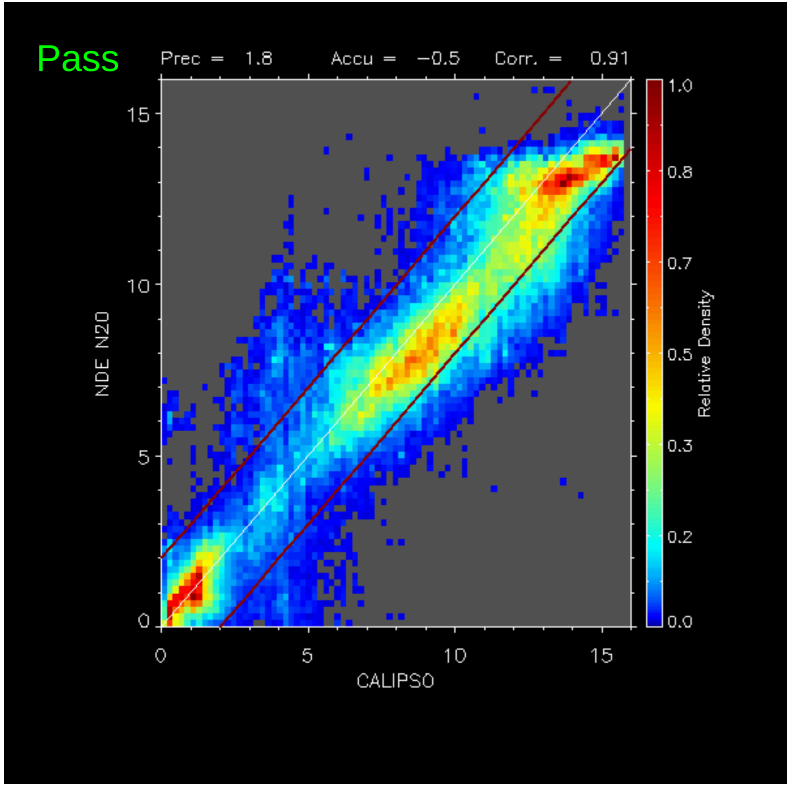



COT < 1

# CTH - Phase Matching and Single Layer

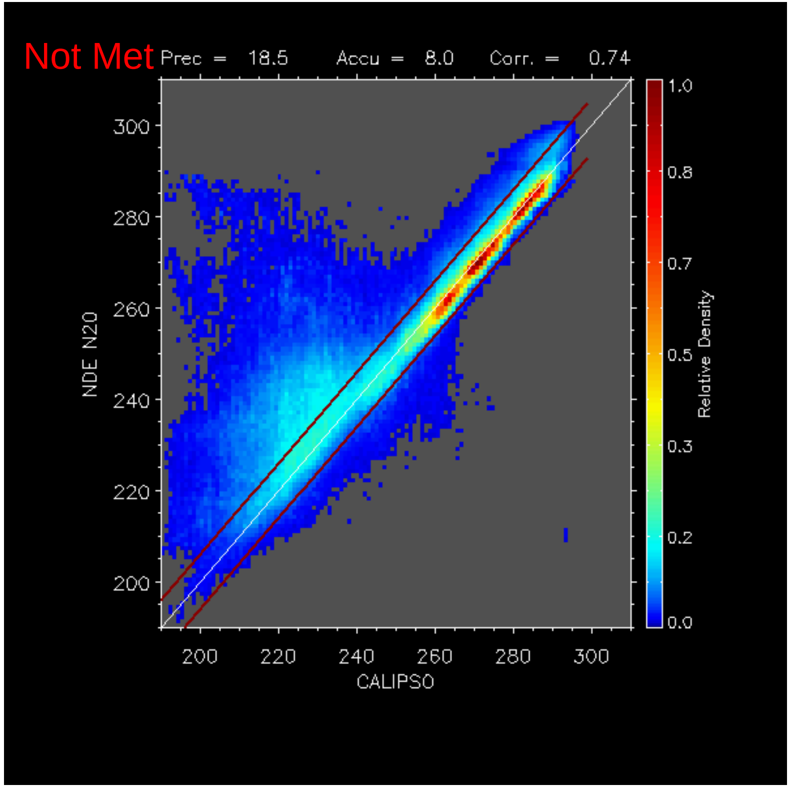



COT >=1

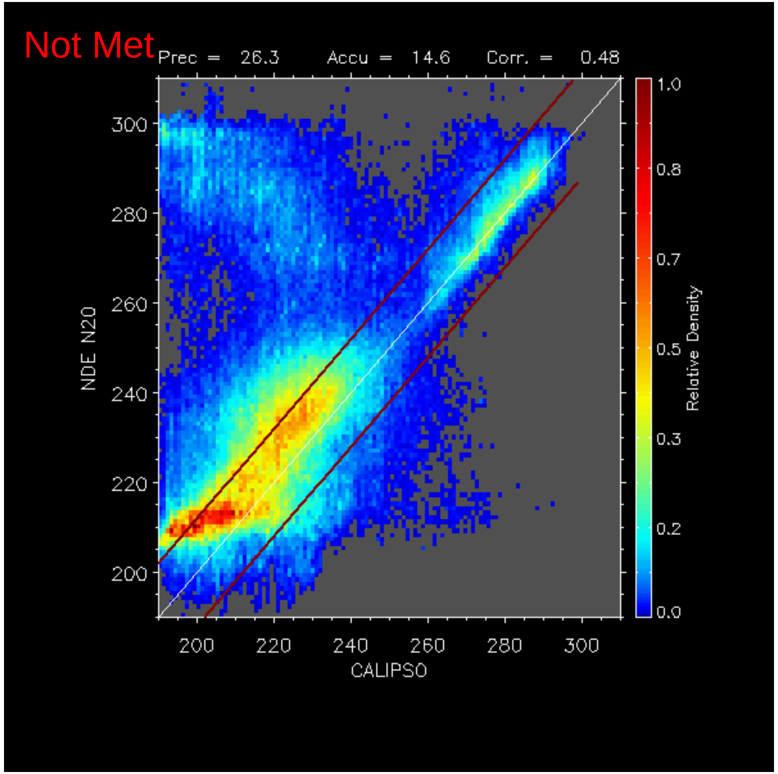



COT < 1

# CTT - no filtering

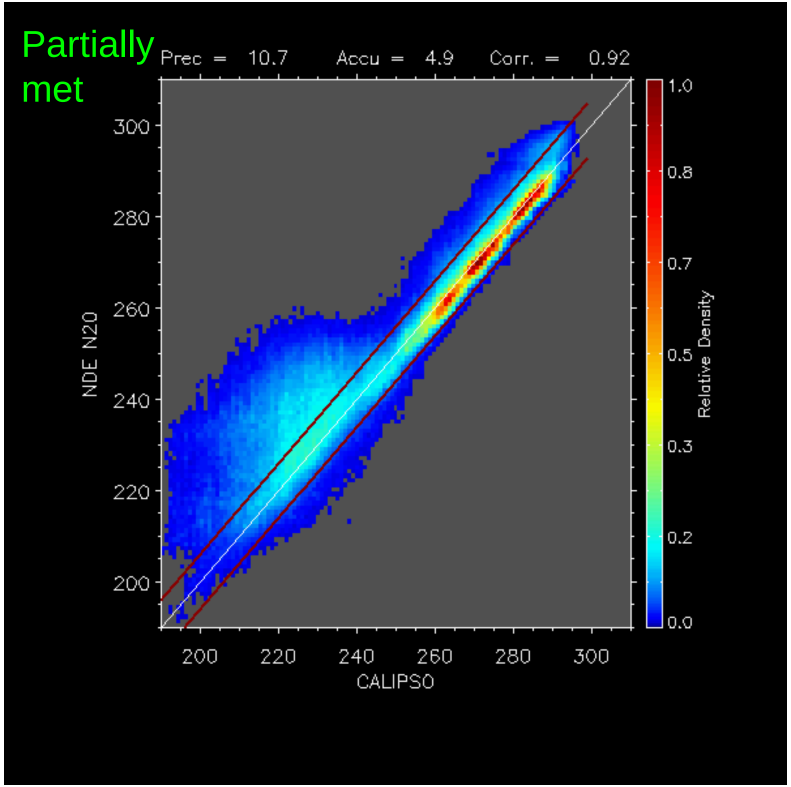



COT >=1

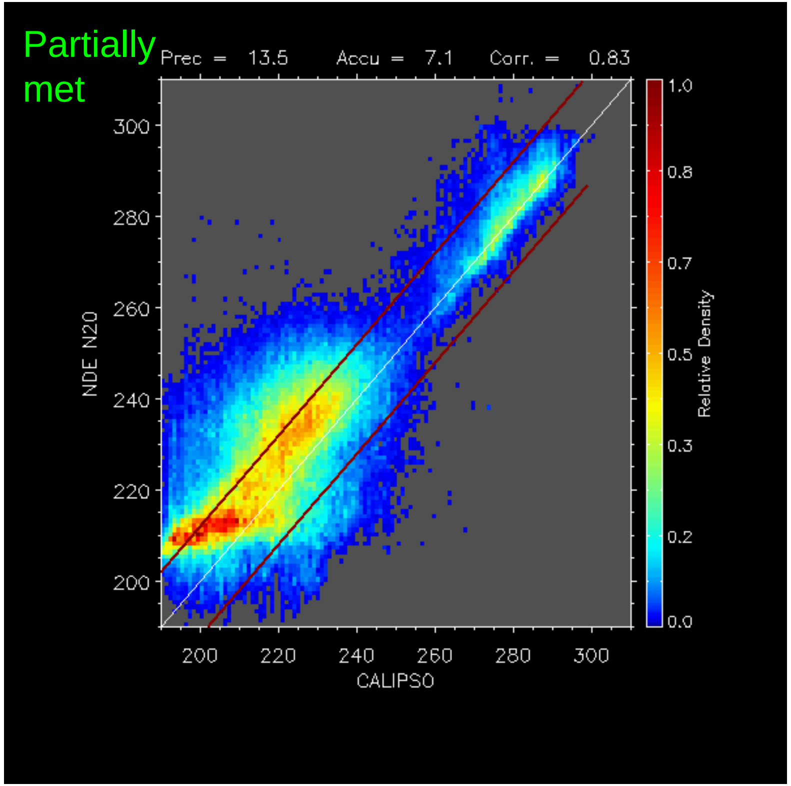



COT < 1

# CTT - Phase matching

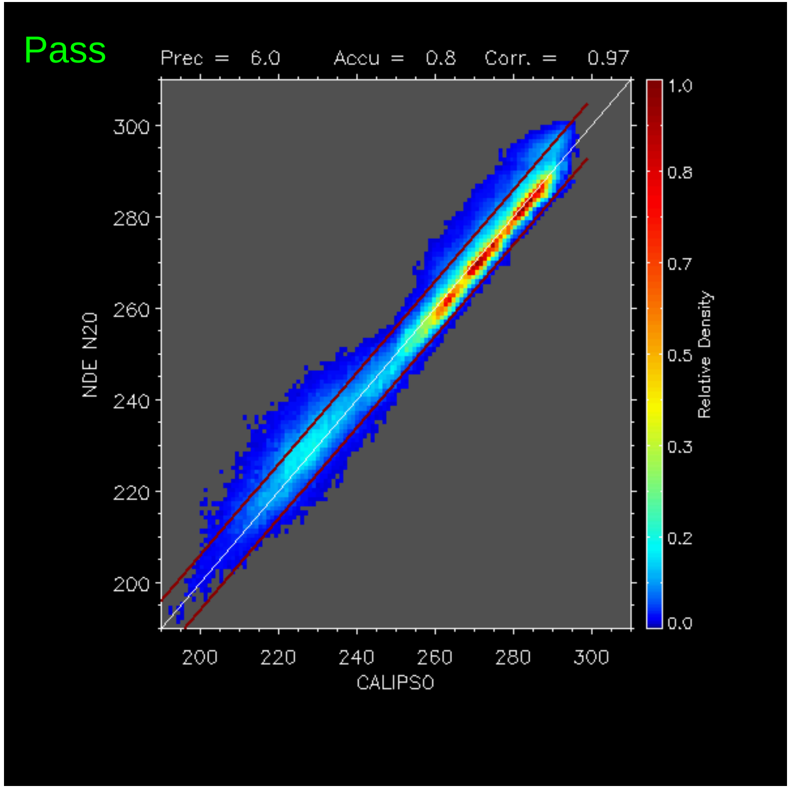



COT >=1

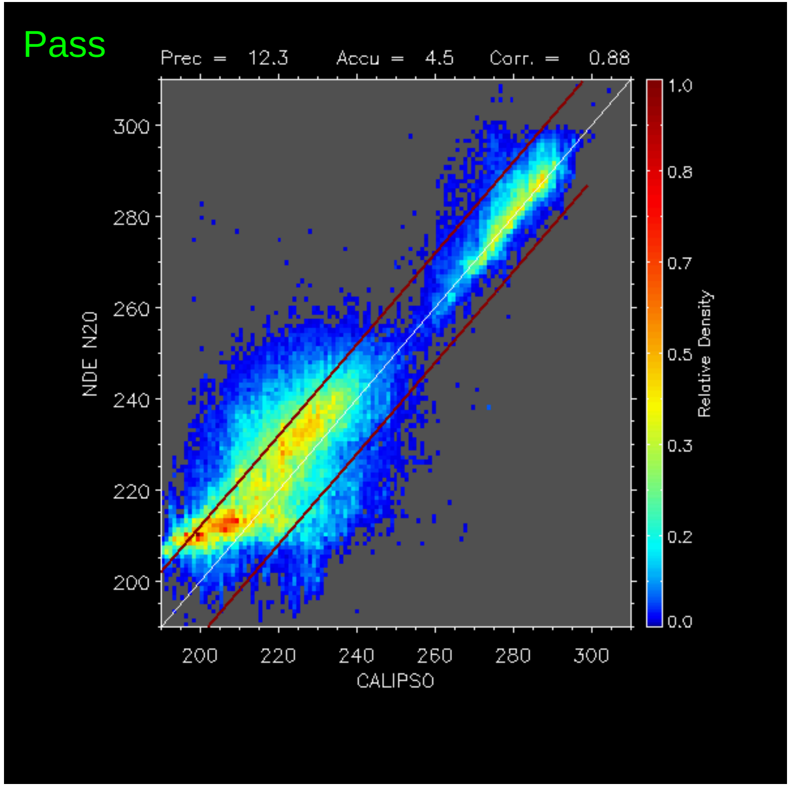



COT < 1

# CTT - Phase matching and single layer

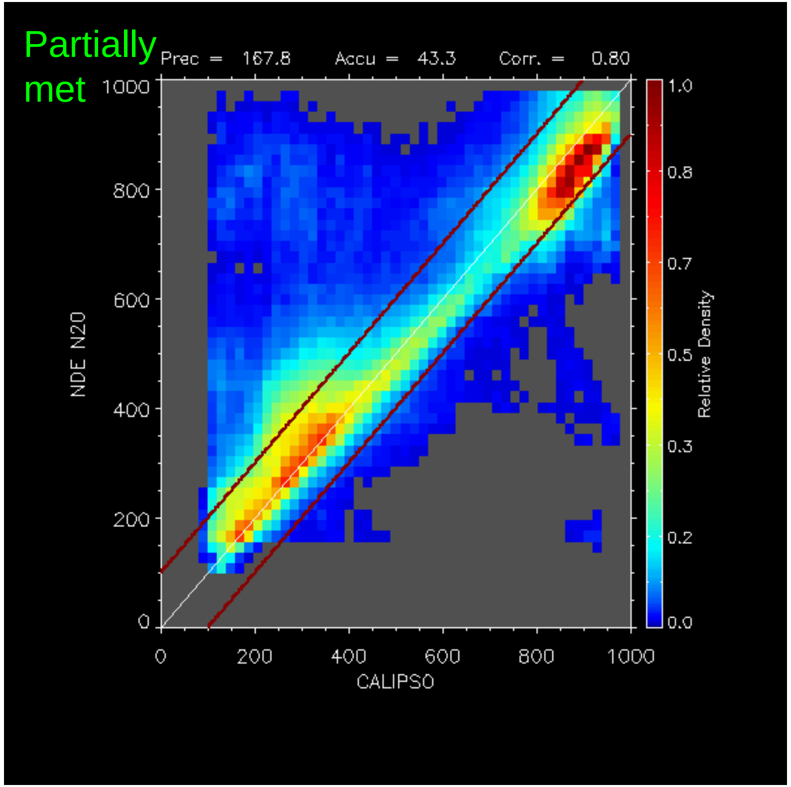



COT >=1

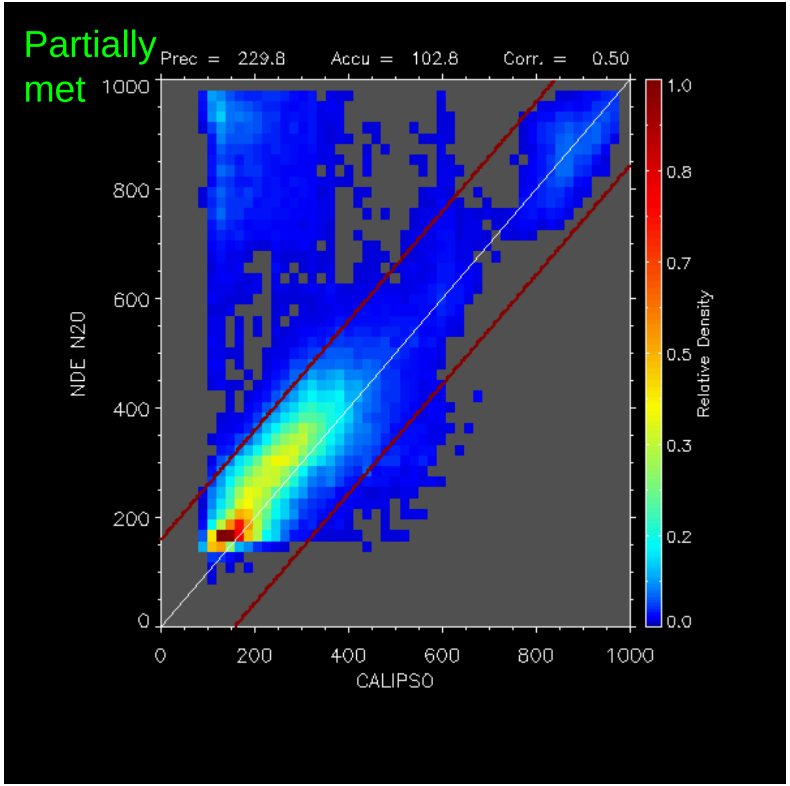



COT < 1

# CTP - no filtering

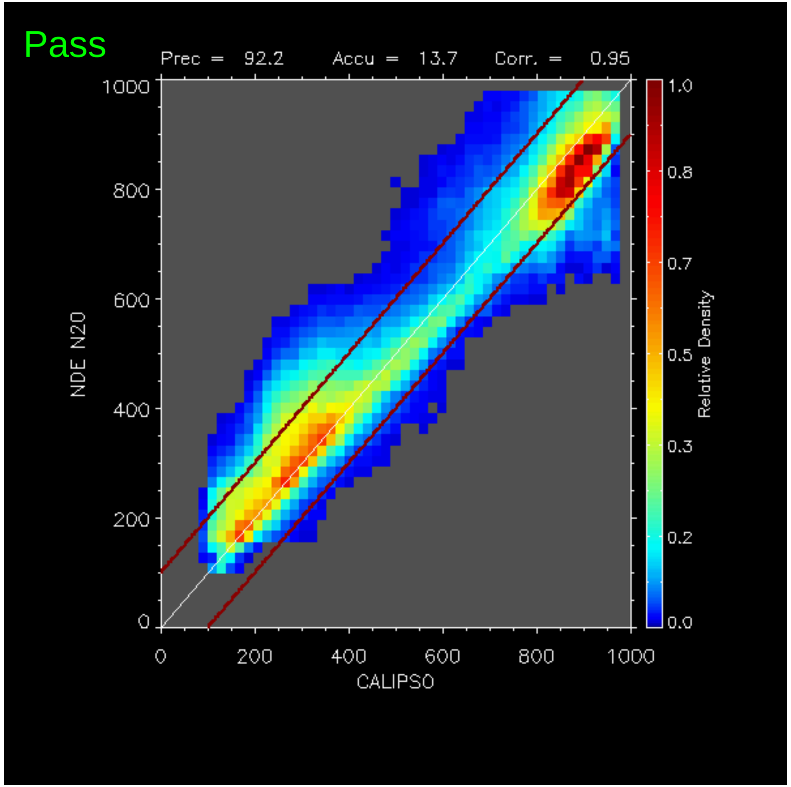



COT >=1

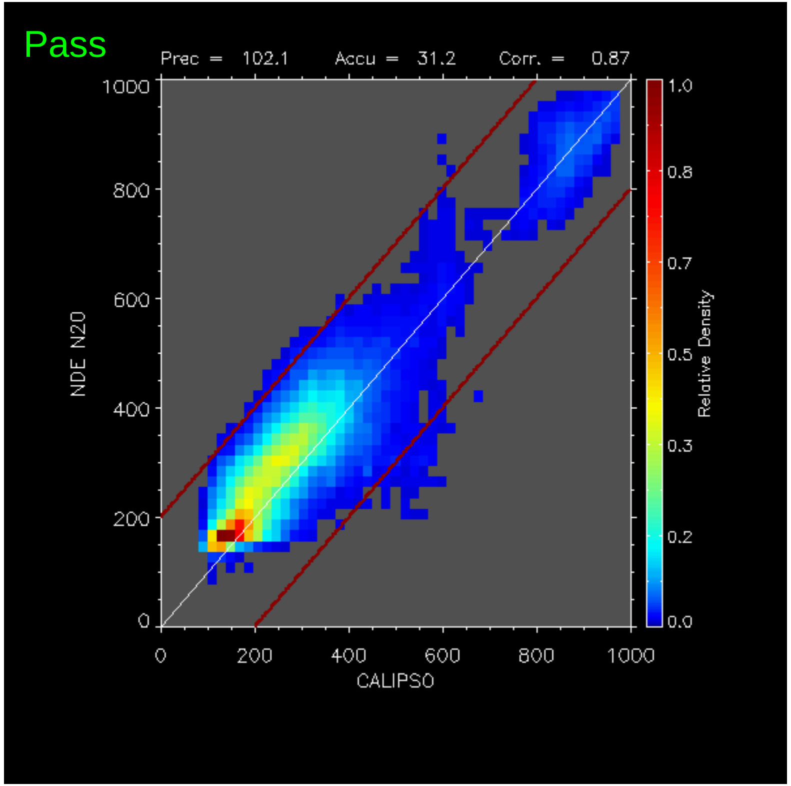



COT < 1

# CTP - Phase matching

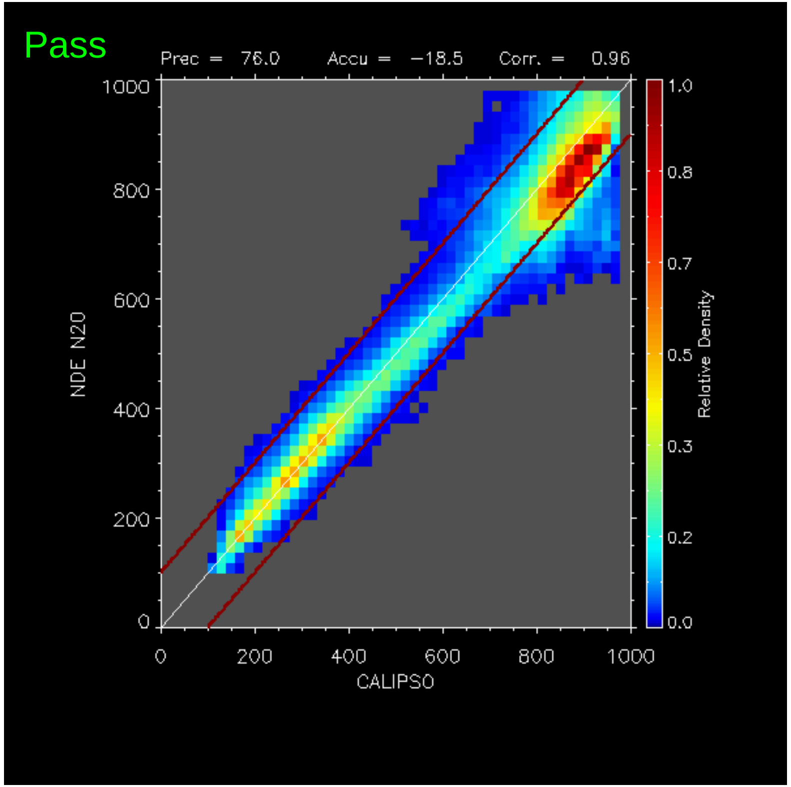



COT >=1

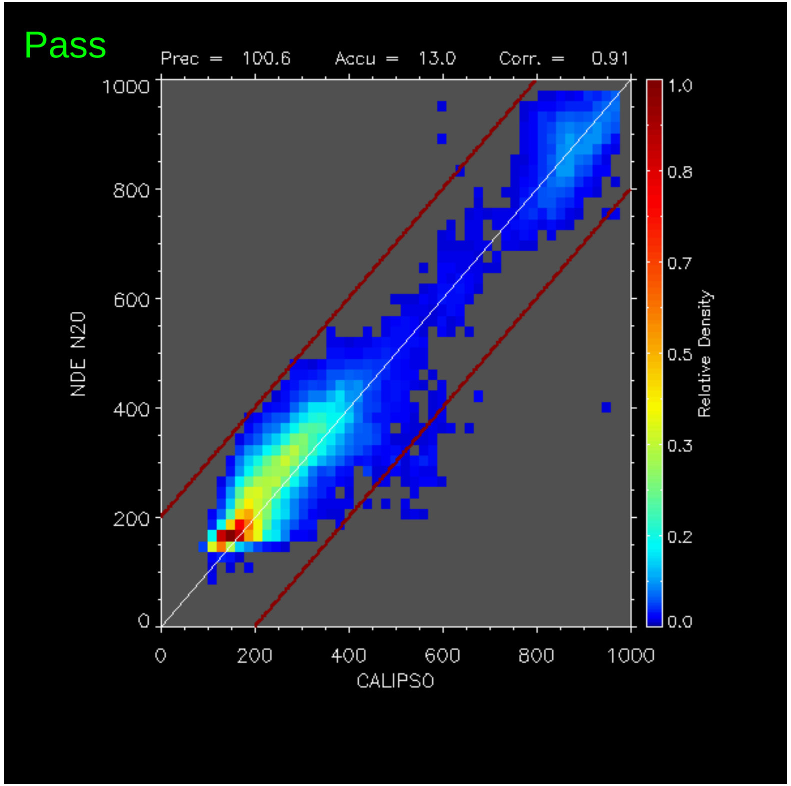



COT < 1

# CTP - Phase matching and single layer

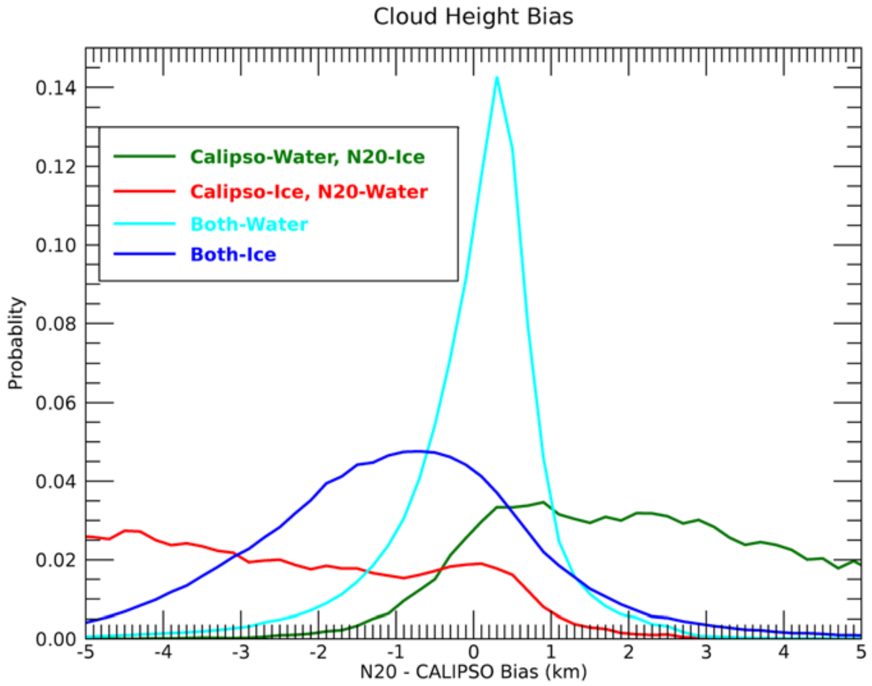



COT >=1




COT < 1

# Impact of Cloud phase on Cloud Top Height




Comparison of phase retrievals between CALIPSO and NDE-N20

| | CALIPSO Water | CALIPSO Ice |
|---|---|---|
| NDE N20 Water | 35% | 13% |
| NDE N20 Ice | 3% | 49% |

# Conclusions from CALIPSO Comparisons

- ACHA NDE NOAA-20 performs well comparing to CALIPSO
- ACHA NDE NOAA-20 performs similarly to CLAVR-x

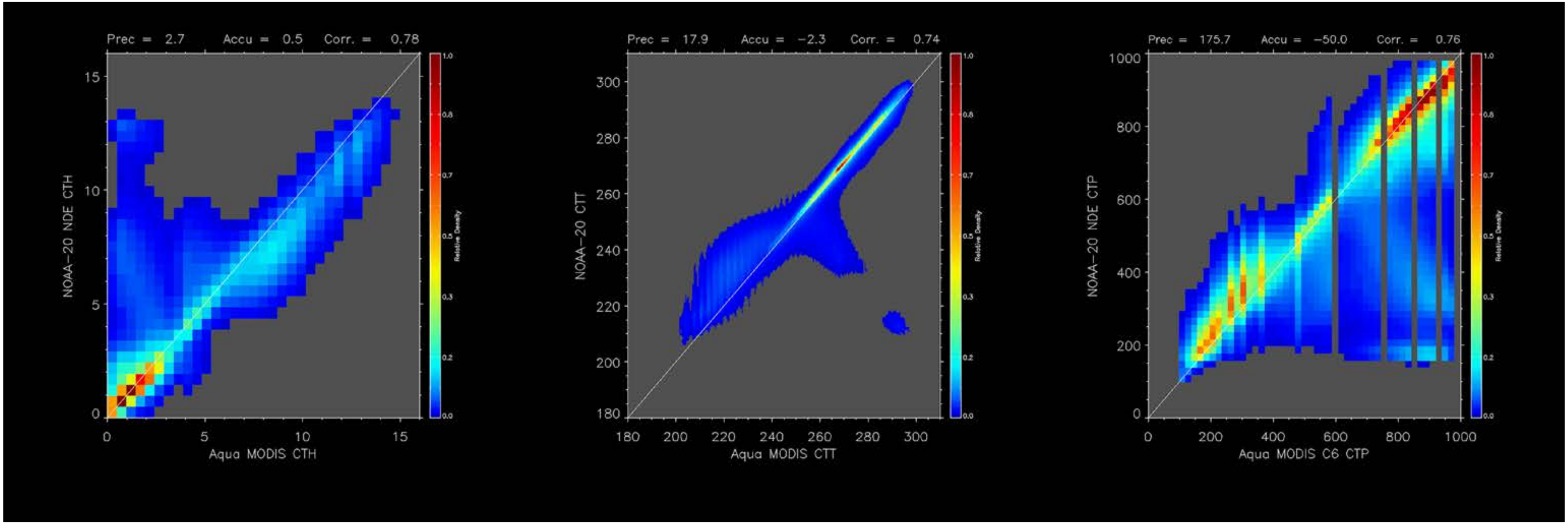
# Comparison to AQUA/MODIS

# Data and Methods

- 12 days of matchup files between NOAA-20 and Aqua MODIS from June to September 2018 were used
- ACHA NDE NOAA-20 were compared to NASA MODIS
- ACHA values from all VIIRS footprints within a MODIS footprint were averaged to compare to MODIS

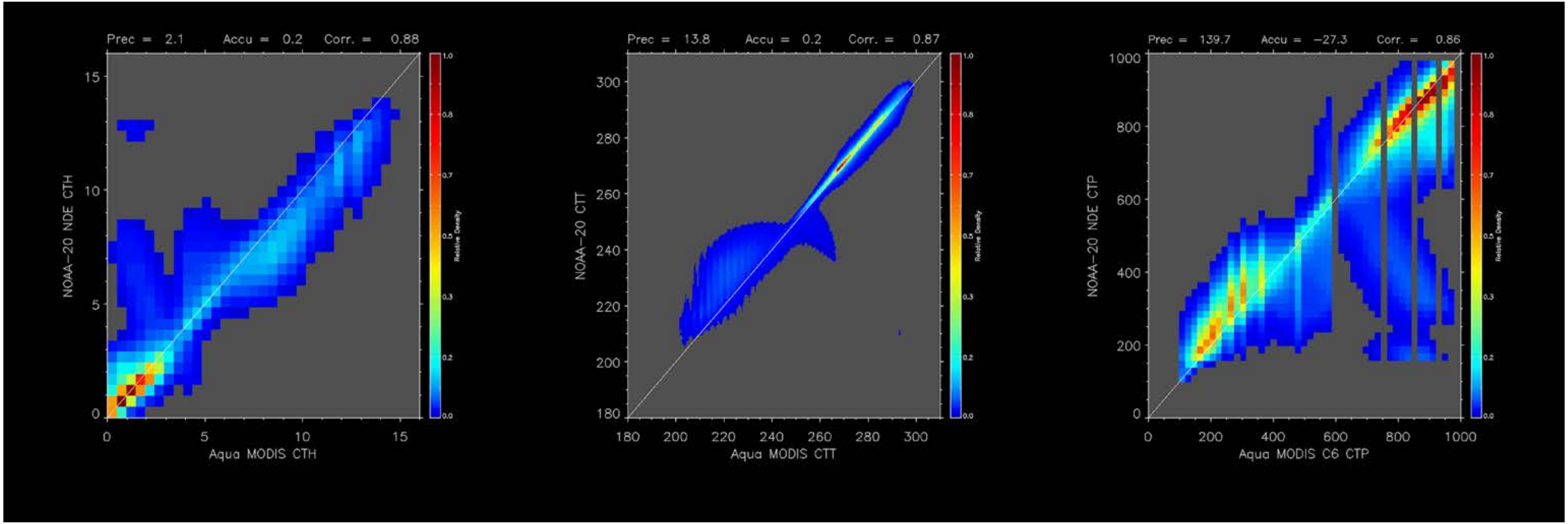
# MODIS Comparison: No Filtering

CTH | CTT | CTP



# MODIS Comparison: Phase-Matched

CTH CTT CTP



# Evaluation Against NASA MODIS - No filtering

| | | Against MODIS C6 | Against Caliop | Meet Specs - against MODIS | Meet Specs - against Caliop |
|---|---|---|---|---|---|
| CTH | Bias | 0.5 | -1.2 | 55.4% | 55.7% |
| | Std Dev | 2.7 | 3.1 | 49.6% | 39.0% |
| CTT | Bias | -2.3 | 9.7 | 57.7% | 53.9% |
| | Std Dev | 17.9 | 21.0 | 54.4% | 31.9% |
| CTP | Bias | -50.0 | 58.9 | 57.7% | 71.2% |
| | Std Dev | 175.7 | 187.9 | 54.4% | 65.6% |

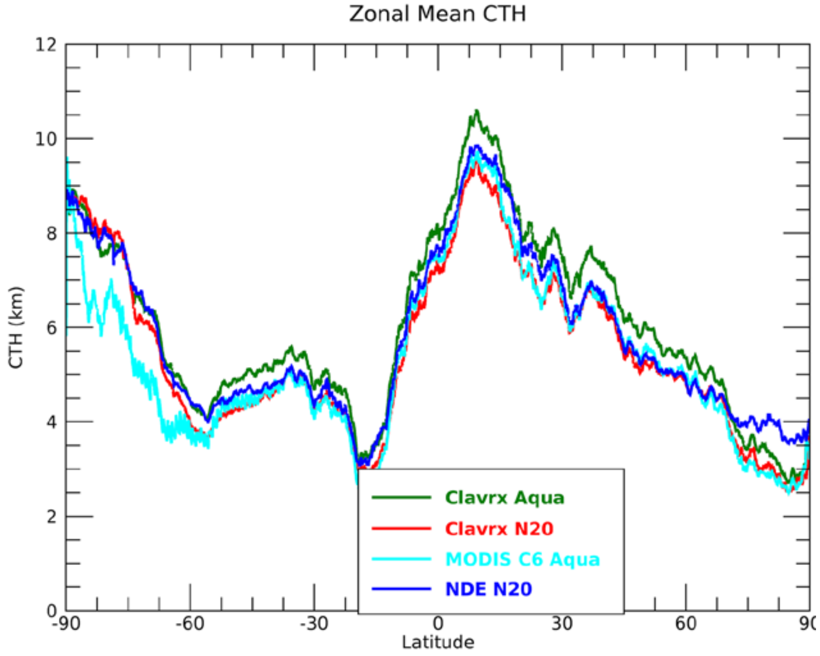
Statics against Caliop are included for comparison purpose

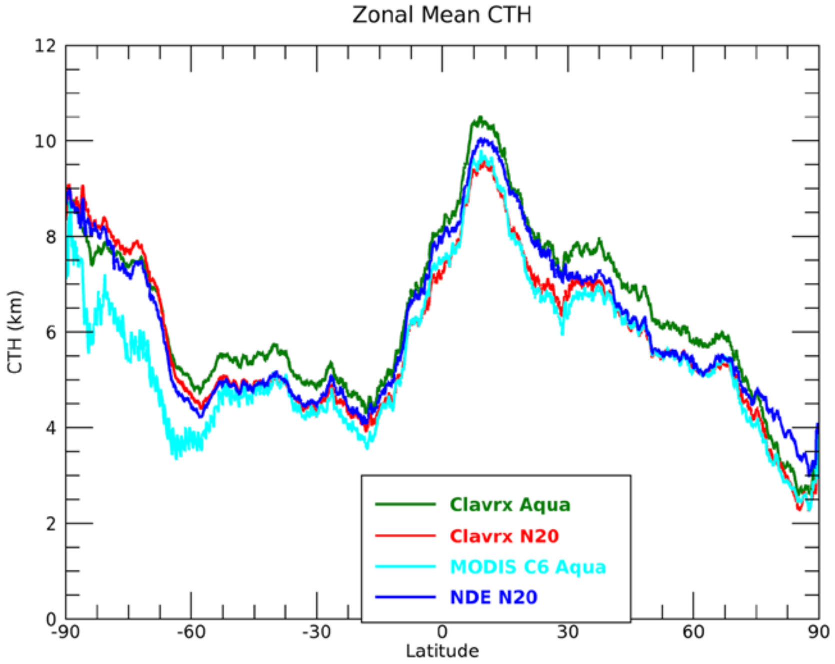
# Evaluation Against NASA MODIS - Phase matched

| | | Against MODIS C6 | Against Caliop | Meet Specs - against MODIS | Meet Specs - against Caliop |
|---|---|---|---|---|---|
| CTH | Bias | 0.2 | -0.6 | 60.6% | 63.9% |
| | Std Dev | 2.1 | 1.7 | 59.0% | 58.6% |
| CTT | Bias | 0.2 | 5.4 | 62.4% | 62.0% |
| | Std Dev | 13.8 | 11.5 | 62.6% | 49.9% |
| CTP | Bias | -27.3 | 18.2 | 62.4% | 81.8% |
| | Std Dev | 139.7 | 95.1 | 62.6% | 82.0% |

Statics against Caliop are included for comparison purpose

# Global Zonal Mean




- Zonal plots computed from 12 days of ACHA products as well as NASA MODIS.
- The zonal mean patterns show reasonably well consistency

# Conclusions from MODIS Comparisons

- ACHA NDE NOAA-20 performs well comparing to NASA MODIS.
- The specs shows the performances against NASA MODIS are comparable to that against CALIPSO/CALIOP.

# AMV Application

# AMV Validation Statistics (from Daniels/Key)

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| Precision | 3.76 | 3.76 | 0.00 | 0.00 |
| Speed Bias | 1.33 | [illegible] | [illegible] | [illegible] |
| Speed | 23.85 | 2[illegible] | [illegible] | [illegible] |
| Sample | 2085 | [illegible] | [illegible] | [illegible] |
| **401_700mb** | **90S – 90N** | **25N[illegible]** | [illegible] | [illegible] |
| Accuracy | 5.42 | [illegible] | [illegible] | [illegible] |
| Precision | 3.40 | [illegible] | [illegible] | [illegible] |
| Speed Bias | 0.81 | [illegible] | [illegible] | [illegible] |
| Speed | 18.95 | 1[illegible] | [illegible] | [illegible] |
| Sample | 2071 | [illegible] | [illegible] | [illegible] |
| **701_1000mb** | **90S – 90N** | **25N[illegible]** | [illegible] | [illegible] |
| Accuracy | 4.81 | [illegible] | [illegible] | [illegible] |
| Precision | 3.13 | [illegible] | [illegible] | [illegible] |
| Speed Bias | 0.66 | [illegible] | [illegible] | [illegible] |
| Speed | 12.56 | 1[illegible] | [illegible] | [illegible] |
| Sample | 512 | [illegible] | [illegible] | [illegible] |

## NOAA-20 VIIRS Winds vs. Radiosondes July 5-29, 2018

| 100_1000mb | 90S – 90N | 25N – 90N | 25S – 25N | 25S – 90S |
|---|---|---|---|---|
| Accuracy | 5.99 | 5.99 | 0.00 | 0.00 |
| Precision | 3.64 | 3.64 | 0.00 | 0.00 |
| Speed Bias | 1.02 | 1.02 | 0.00 | 0.00 |
| Speed | 20.19 | 20.19 | 0.00 | 0.00 |
| Sample | 3860 | 3860 | 0 | 0 |
| **101_400mb** | **90S – 90N** | **25N – 90N** | **25S – 25N** | **25S – 90S** |
| Accuracy | 6.36 | 6.36 | 0.00 | 0.00 |
| Pr[illegible]ision | 3.82 | 3.82 | 0.00 | 0.00 |
| [illegible] Bias | 1.23 | 1.23 | 0.00 | 0.00 |
| [illegible] | 23.71 | 23.71 | 0.00 | 0.00 |
| [illegible]e | 2073 | 2073 | 0 | 0 |
| **[illegible]700mb** | **90S – 90N** | **25N – 90N** | **25S – 25N** | **25S – 90S** |
| [illegible]acy | 5.79 | 5.79 | 0.00 | 0.00 |
| [illegible]sion | 3.47 | 3.47 | 0.00 | 0.00 |
| [illegible] Bias | 0.53 | 0.53 | 0.00 | 0.00 |
| [illegible] | 17.93 | 17.93 | 0.00 | 0.00 |
| [illegible]e | 1190 | 1190 | 0 | 0 |
| **[illegible]1000mb** | **90S – 90N** | **25N – 90N** | **25S – 25N** | **25S – 90S** |
| [illegible]acy | 5.10 | 5.10 | 0.00 | 0.00 |
| [illegible]sion | 3.16 | 3.16 | 0.00 | 0.00 |
| [illegible] Bias | 1.28 | 1.28 | 0.00 | 0.00 |
| [illegible] | 12.47 | 12.47 | 0.00 | 0.00 |
| [illegible]e | 597 | 597 | 0 | 0 |

Observed
Accuracy: 5.79-5.99 m/s
Precision: 3.58-3.64 m/s

Requirements:
Accuracy: 7.5 m/s
Precision: 4.2 m/s

NPP VIIRS winds generated at OSPO

NOAA-20 VIIRS winds generated at STAR. Statistics include only VIIRS winds at 12Z. NOAA-20 VIIRS Winds/Raob co-location files being reprocessed for the month of July to include 00Z matchups

# Provisional Maturity Conclusions

# Provisional Maturity Conclusions

- ACHA meets all specs for single-layer clouds of known phase for tau > 1.
- Accuracy spec is always met and precision spec is partially met for all other clouds except for unfiltered cloud top temperature.
- The unrealistic values for cloud height and pressure, but not for cloud temperature were found during beta
  - This was **FIXED** within the NDE system with the implementation of v2r0 (currently in I&T)
- ACHA appears to perform well enough for the AMV's to meet spec and we continue to try and optimize ACHA for that application.
- **The Cloud Team recommends Provisional Maturity at this time.**

# Pathway to Full Validation

# Pathway to Full Maturity

- We expect to apply the same activities to be conducted  for Full Maturity:
  - We continue to gather an archive of golden days where we save SDRs and EDRs spread from June 2018. This collection is ongoing.
  - We hope to continue to engage the teams and continue application-specific analysis.
  - ACHA updates from JPSS-RR will be implemented when possible.

# Risks for Full Validation

Currently outstanding issues, unless fixed by handover, may prevent declaration of Full Validation Maturity:

- **NDE processing issues (Moderate)**
  - Missing granules in NDE processing
    - Currently being addressed in June 2018 DAP delivery. Expected operations in late 2018

# Future Plans

# Future Plans of ACHA

- We will work with Phase team and explore methods that allow ACHA to try a different phase value when ACHA retrievals fail.
- We will continue to expand the ACHA multi-layer capability but VIIRS provides limited spectral information for this.
- If successful, our JPSS PG RR project should develop a capability to leverage off NUCAPS to improve the VIIRS height performance.

# Backup Material

# STAR ECM Cal/Val Team

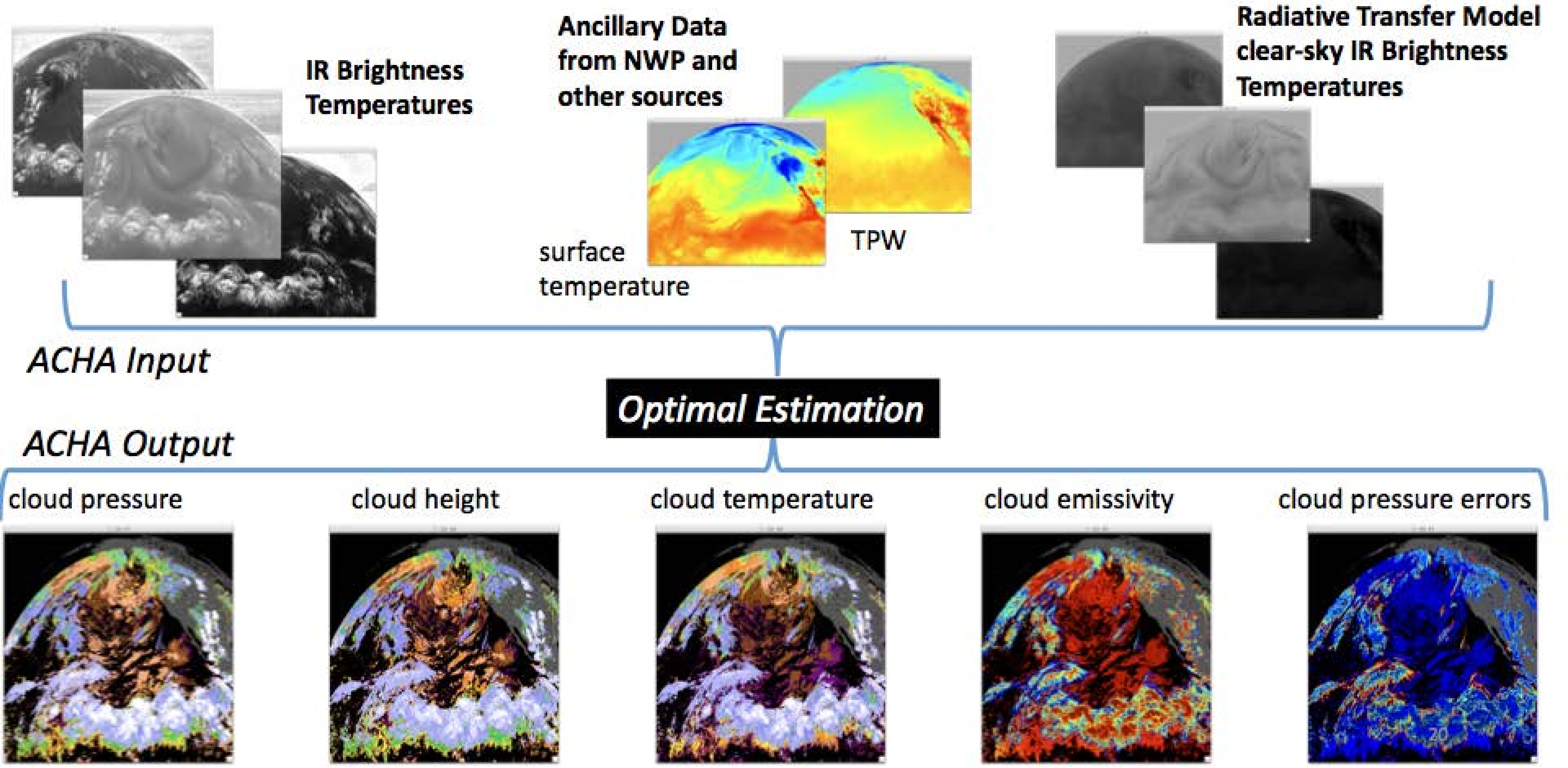
| Name | Organization | Major Task |
| --- | --- | --- |
| Andrew Heidinger | NESDIS/STAR | Cloud Team Lead |
| Yue Li | CIMSS | Algorithm development, verification |
| William Straka | CIMSS | ASSISTT integration |
| Steve Wanzong | CIMSS | Algorithm development |
| Shuang Qiu | OSPO | Product Area Lead |

# Enterprise Cloud Height Review

# Enterprise Cloud Height

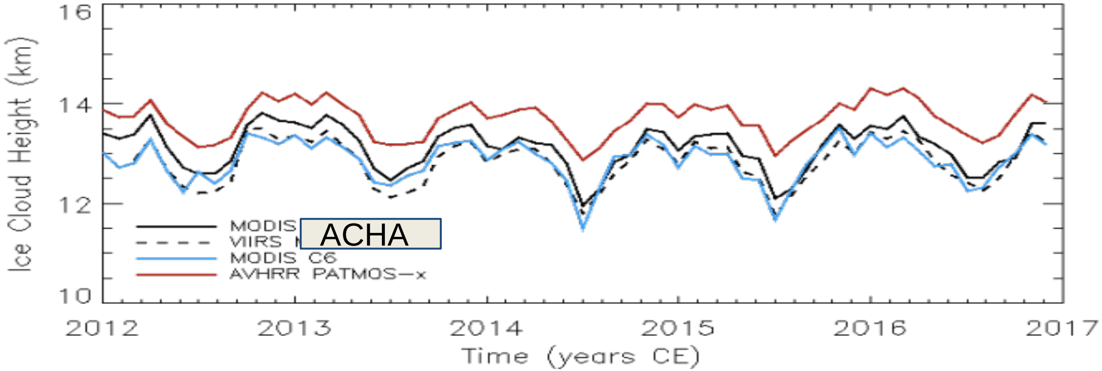
- ACHA estimates cloud top height using a combination of infrared channels.
- Supports many sensors and it’s part of the NOAA Enterprise Algorithm Suite.
- It is based on a 1-D var optimal estimation approach.
- The primary outputs are cloud top height, temperature and pressure.
- The demand for one algorithm to serve many sensors drove the ACHA development.

# How AWG CLOUD HEIGHT (ACHA) Works



# ACHA Heritage

- ACHA has run for years on AVHRR, GOES in OSPO and other sensors in STAR.
- PATMOS-x is a NOAA Climate Program that uses NOAA Enterprise algorithms to make climate records.
- The figure below show the NOAA Enterprise applied to Brazil for the entire AQUA/MODIS record.
- Shows the nice stability in spatial and temporal variation.



# ACHA Channels

- ACHA uses three IR channels for VIIRS
  - M14
  - M15
  - M16

- ACHA also supports other channels combinations, a.k.a. modes. For VIIRS, M15 and M16 only is also supported.

| | | Band No. | Driving EDR(s) | Spectral Range (um) | Horiz Sample Interval (km) (track x Scan) Nadir | End of Scan |
|---|---|---|---|---|---|---|
| Reflective Bands | VisNIR | M1 | Ocean Color Aerosol | 0.402 - 0.422 | 0.742 x 0.259 | 1.60 x 1.58 |
| Reflective Bands | VisNIR | M2 | Ocean Color Aerosol | 0.436 - 0.454 | 0.742 x 0.259 | 1.60 x 1.58 |
| Reflective Bands | VisNIR | M3 | Ocean Color Aerosol | 0.478 - 0.498 | 0.742 x 0.259 | 1.60 x 1.58 |
| Reflective Bands | VisNIR | M4 | Ocean Color Aerosol | 0.545 - 0.565 | 0.742 x 0.259 | 1.60 x 1.58 |
| Reflective Bands | VisNIR | I1 | Imagery EDR | 0.600 - 0.680 | 0.371 x 0.387 | 0.80 x 0.789 |
| Reflective Bands | VisNIR | M5 | Ocean Color Aerosol | 0.662 - 0.682 | 0.742 x 0.259 | 1.60 x 1.58 |
| Reflective Bands | VisNIR | M6 | Atmosph. Correct. | 0.739 - 0.754 | 0.742 x 0.776 | 1.60 x 1.58 |
| Reflective Bands | VisNIR | I2 | NDVI | 0.846 - 0.885 | 0.371 x 0.387 | 0.80 x 0.789 |
| Reflective Bands | VisNIR | M7 | Ocean Color Aerosol | 0.846 - 0.885 | 0.742 x 0.259 | 1.60 x 1.58 |
| Reflective Bands | S/MWIR | M8 | Cloud Particle Size | 1.230 - 1.250 | 0.742 x 0.776 | 1.60 x 1.58 |
| Reflective Bands | S/MWIR | M9 | Cirrius/Cloud Cover | 1.371 - 1.386 | 0.742 x 0.776 | 1.60 x 1.58 |
| Reflective Bands | S/MWIR | I3 | Binary Snow Map | 1.580 - 1.640 | 0.371 x 0.387 | 0.80 x 0.789 |
| Reflective Bands | S/MWIR | M10 | Snow Fraction | 1.580 - 1.640 | 0.742 x 0.776 | 1.60 x 1.58 |
| Reflective Bands | S/MWIR | M11 | Clouds | 2.225 - 2.275 | 0.742 x 0.776 | 1.60 x 1.58 |
| Emissive Bands | S/MWIR | I4 | Imagery Clouds | 3.550 - 3.930 | 0.371 x 0.387 | 0.80 x 0.789 |
| Emissive Bands | S/MWIR | M12 | SST | 3.660 - 3.840 | 0.742 x 0.776 | 1.60 x 1.58 |
| Emissive Bands | S/MWIR | M13 | SST Fires | 3.973 - 4.128 | 0.742 x 0.259 | 1.60 x 1.58 |
| Emissive Bands | LWIR | M14 | Cloud Top Properties | 8.400 - 8.700 | 0.742 x 0.776 | 1.60 x 1.58 |
| Emissive Bands | LWIR | M15 | SST | 10.263 - 11.263 | 0.742 x 0.776 | 1.60 x 1.58 |
| Emissive Bands | LWIR | I5 | Cloud Imagery | 10.500 - 12.400 | 0.371 x 0.387 | 0.80 x 0.789 |
| Emissive Bands | LWIR | M16 | SST | 11.538 - 12.488 | 0.742 x 0.776 | 1.60 x 1.58 |

# How to Use the Enterprise Cloud Height

- The fundamental output of ACHA is cloud top temperature
- Cloud top height and pressure are derived using NWP profiles
- Due to the nature of IR radiative transfer, the retrieved cloud top height are typically lower than the true top height

# Users of ACHA

- Downstream Enterprise Algorithms, including DCOMP, NCOMP and cloud base algorithms
- VIIRS Polar Winds.
- NUCAPS
- ESRL
- Potentially External ACHA Users: NWP data assimilation teams

# JPSS Data Products Maturity Definition

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

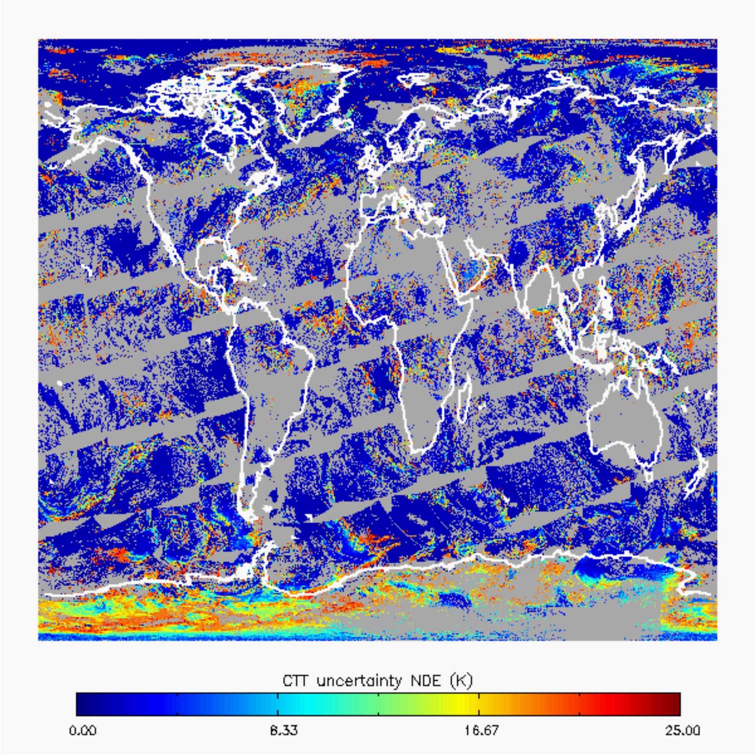
## 1. Beta
- Product is minimally validated, and may still contain significant identified and unidentified errors.
- Information/data from validation efforts can be used to make initial qualitative or very limited quantitative assessments regarding product fitness-for-purpose.
- Documentation of product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

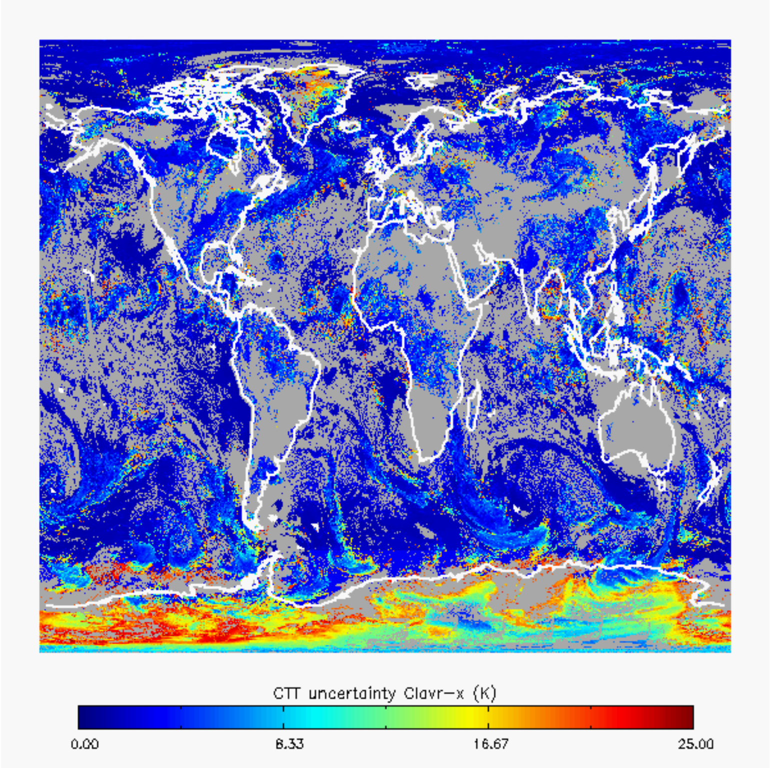
## 3. Validated
- Product performance has been demonstrated over a large and wide range of representative conditions (i.e., global, seasonal).
- Comprehensive documentation of product performance exists that includes all known product anomalies and their recommended remediation strategies for a full 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.

# Cloud Temp Uncertainty Ascending Node

NDE NOAA-20



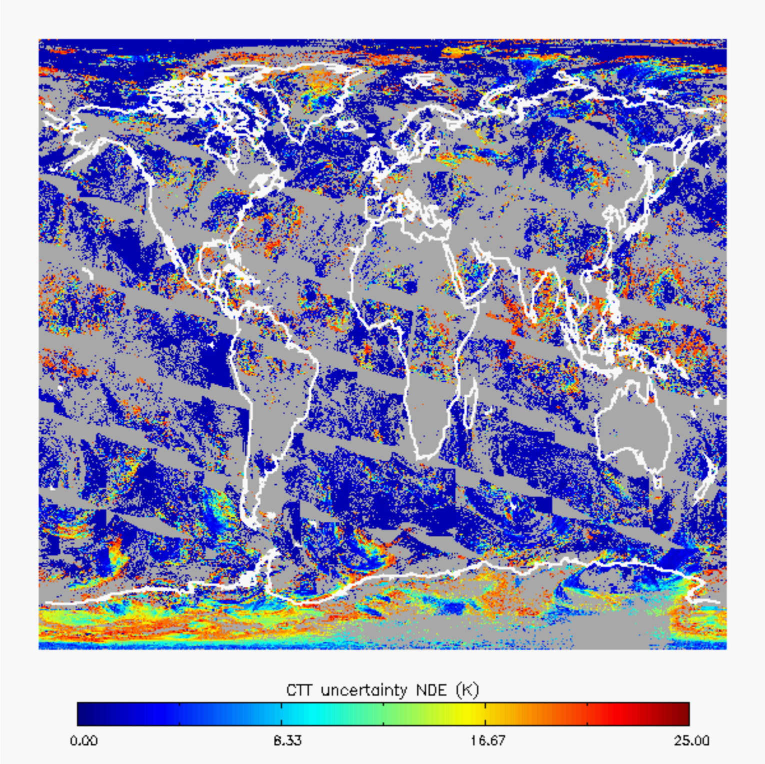

Clavr-x NOAA-20



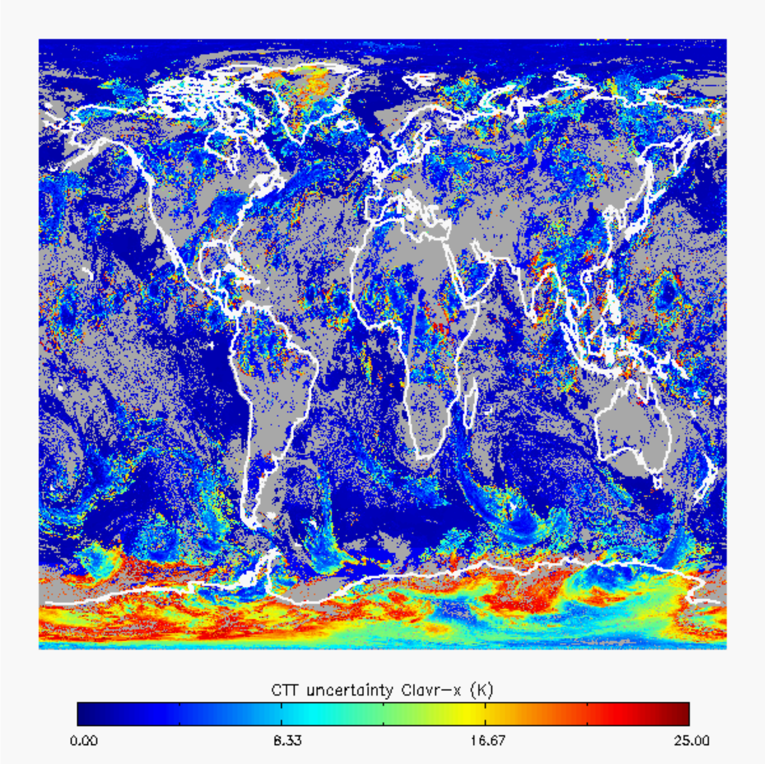

Cloud top retrieval uncertainty is used by the AMV team. However, missing data in NDE affect visual assessment of the uncertainty values, thought it appears at tropics NDE values are larger than expected.

# Cloud Temp Uncertainty Descending Node

NDE NOAA-20




Clavr-x NOAA-20

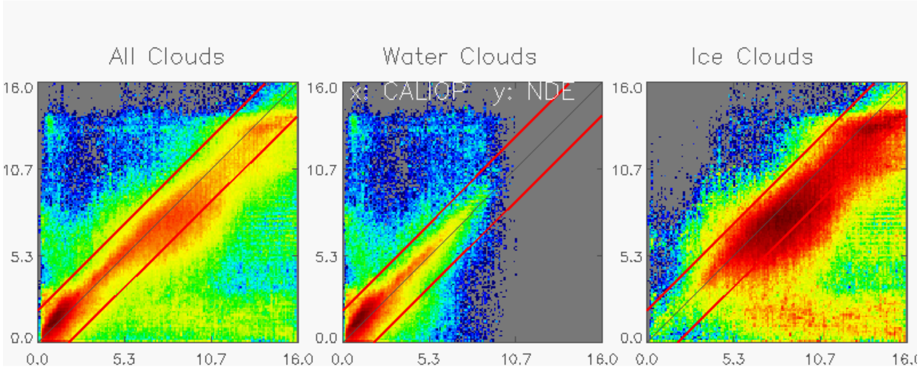


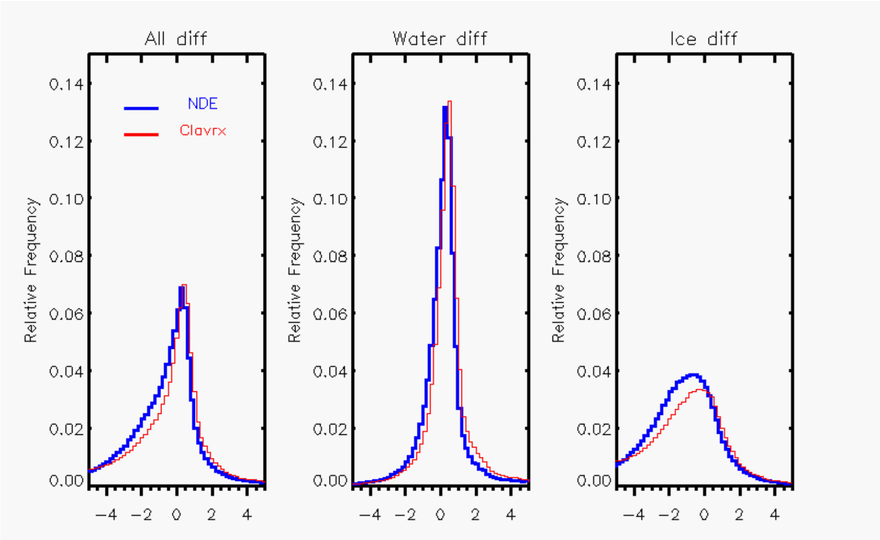
# Quantitative Assessment against CALIPSO

- Data: 19 days of ACHA data from NDE and CLAVR-x in 2018
- Combined five and one km matchup files with Calipso
- Additional filtering including phase matching and single layer were implemented to account for different phase algorithms between Calipso and NDE

# No Filtering - CTH

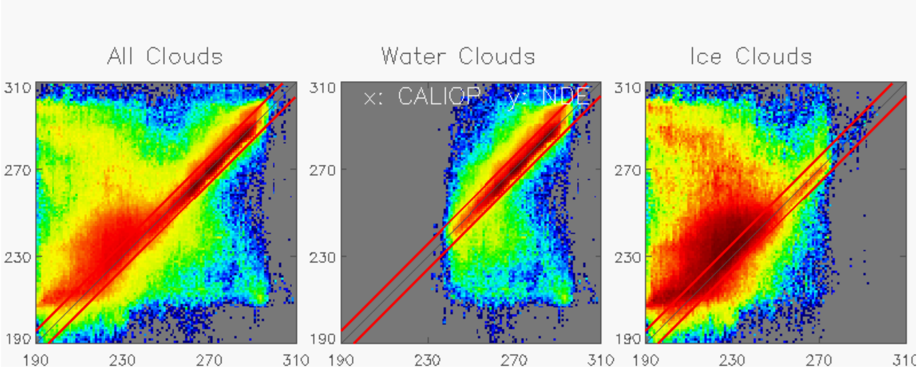
| | Unit (km) | NDE | Clavrx | Meet Specs-NDE | Meet Specs -Clavrx |
|---|---|---|---|---|---|
| All Clouds | Bias | -1.2 | -1.5 | 55.6% | 52.3% |
| | Std Dev | 3.1 | 3.6 | 39.0% | 27.9% |
| Water Clouds | Bias | 0.3 | 0.5 | 76.5% | 73.5% |
| | Std Dev | 1.7 | 1.4 | 75.4% | 75.4% |
| Ice Clouds | Bias | -2.2 | -2.7 | 42.7% | 39.1% |
| | Std Dev | 3.4 | 4.0 | 39.0% | 25.7% |

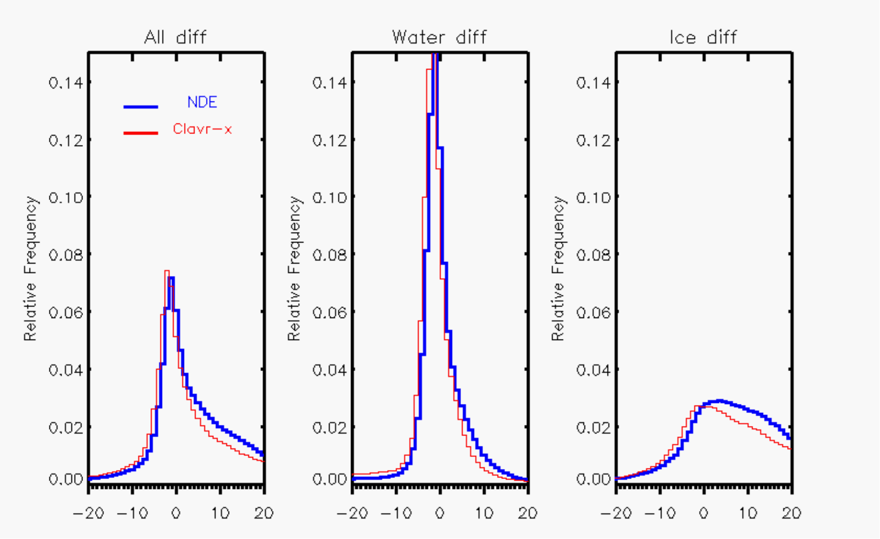


# No Filtering - CTT

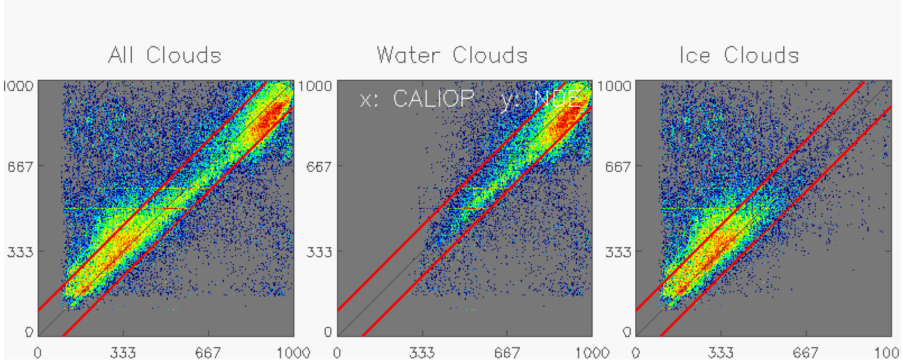
| | Unit (K) | NDE | Clavrx | Meet Specs-NDE | Meet Specs -Clavrx |
|---|---|---|---|---|---|
| All Clouds | Bias | 9.7 | 11.0 | 53.9% | 54.5% |
| | Std Dev | 21.0 | 23.8 | 31.9% | 22.7% |
| Water Clouds | Bias | -1.2 | -2.1 | 81.2% | 83.7% |
| | Std Dev | 10.4 | 8.0 | 79.6% | 82.5% |
| Ice Clouds | Bias | 16.3 | 19.0 | 37.5% | 36.9% |
| | Std Dev | 22.9 | 26.5 | 32.3% | 21.8% |

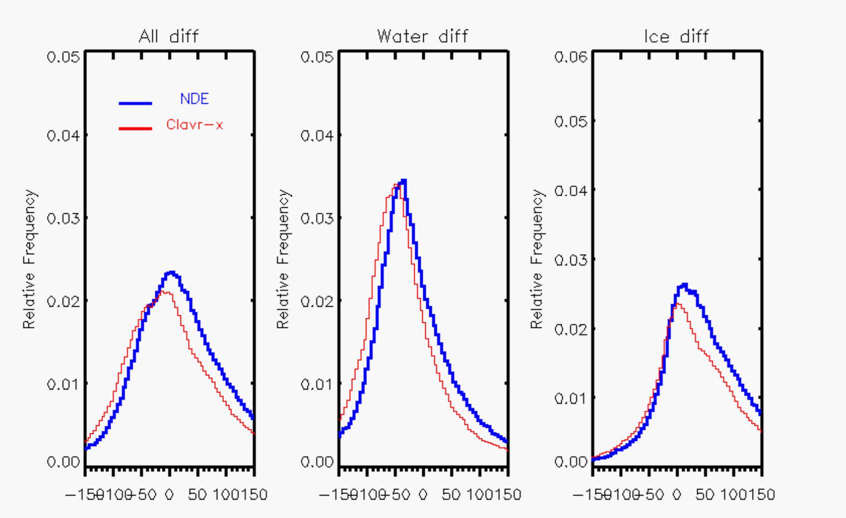


# No Filtering - CTP

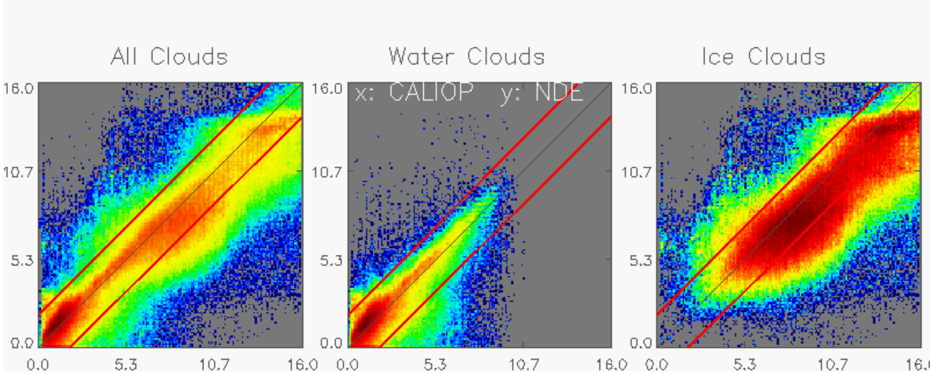
| | Unit (hPa) | NDE | Clavrx | Meet Specs-NDE | Meet Specs -Clavrx |
|---|---|---|---|---|---|
| All Clouds | Bias | 58.9 | 75.0 | 71.2% | 64.6% |
| | Std Dev | 187.9 | 225.7 | 65.6% | 50.0% |
| Water Clouds | Bias | -32.5 | -52.1 | 77.3% | 72.9% |
| | Std Dev | 126.9 | 116.7 | 78.1% | 78.0% |
| Ice Clouds | Bias | 113.1 | 151.0 | 67.5% | 60.0% |
| | Std Dev | 197.0 | 240.6 | 61.5% | 41.1% |

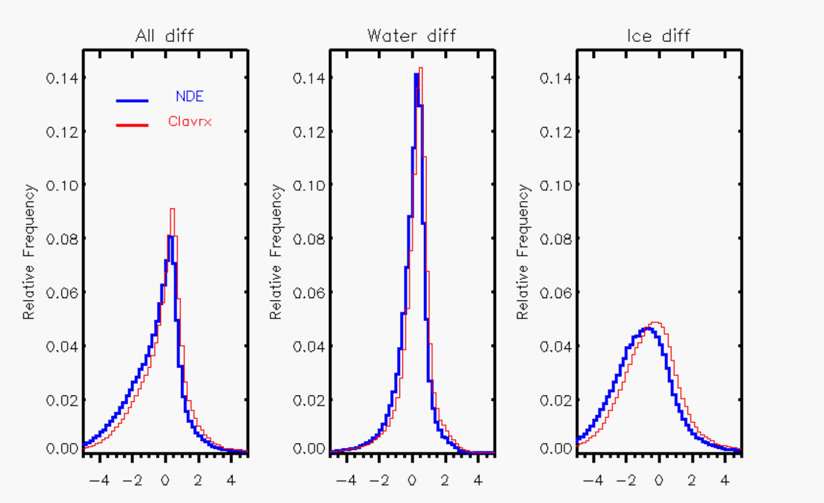


# Phase Matched - CTH

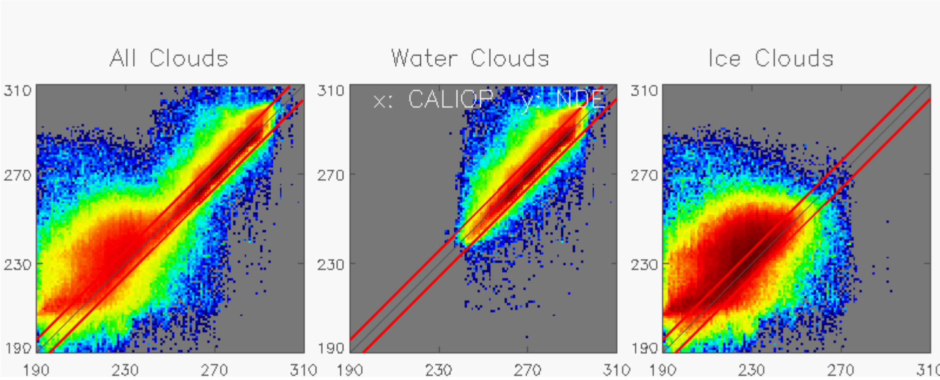
| | Unit (km) | NDE | Clavrx | Meet Specs-NDE | Meet Specs -Clavrx |
|---|---|---|---|---|---|
| All Clouds | Bias | -0.6 | -0.1 | 63.9% | 67.1% |
| | Std Dev | 1.7 | 1.6 | 58.6% | 65.8% |
| Water Clouds | Bias | -0.01 | 0.2 | 81.2% | 79.0% |
| | Std Dev | 1.0 | 1.0 | 81.2% | 81.1% |
| Ice Clouds | Bias | -1.0 | -0.5 | 51.3% | 56.8% |
| | Std Dev | 1.9 | 1.8 | 54.8% | 57.1% |

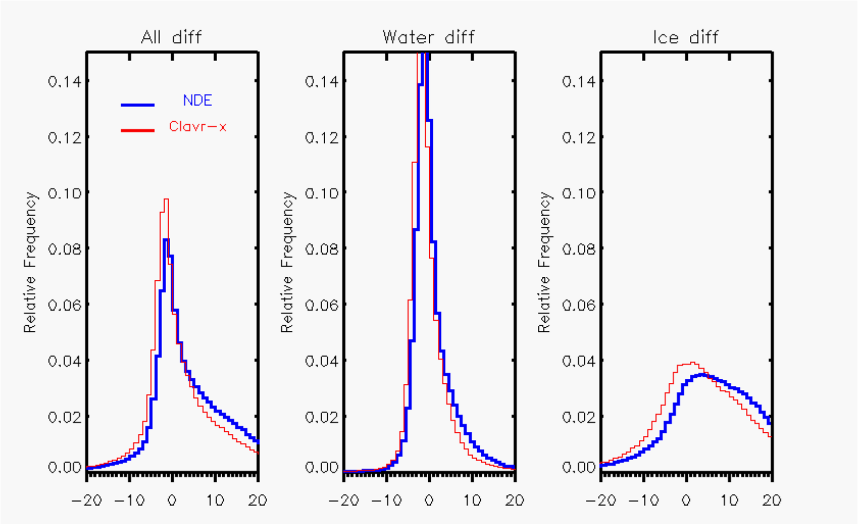


# Phase Matched - CTT

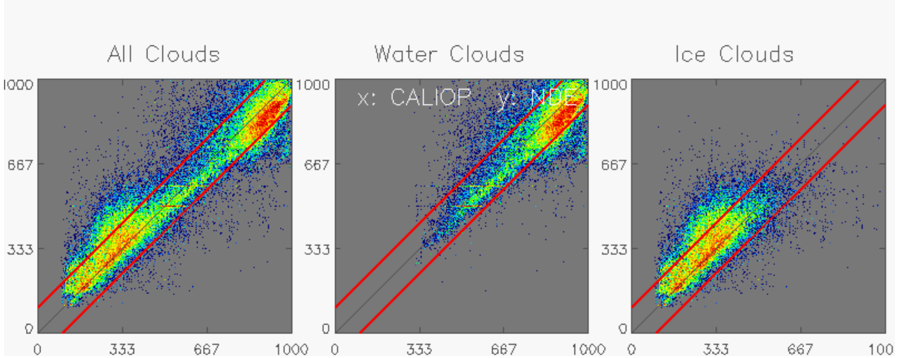
| | Unit (K) | NDE | Clavrx | Meet Specs-NDE | Meet Specs -Clavrx |
|---|---|---|---|---|---|
| All Clouds | Bias | 5.4 | 2.4 | 62.0% | 70.5% |
| | Std Dev | 11.5 | 10.0 | 49.9% | 66.6% |
| Water Clouds | Bias | 0.8 | -0.5 | 86.6% | 90.5% |
| | Std Dev | 5.4 | 4.8 | 87.0% | 90.5% |
| Ice Clouds | Bias | 8.7 | 4.8 | 44.7% | 53.3% |
| | Std Dev | 13.4 | 12.4 | 48.4% | 52.1% |

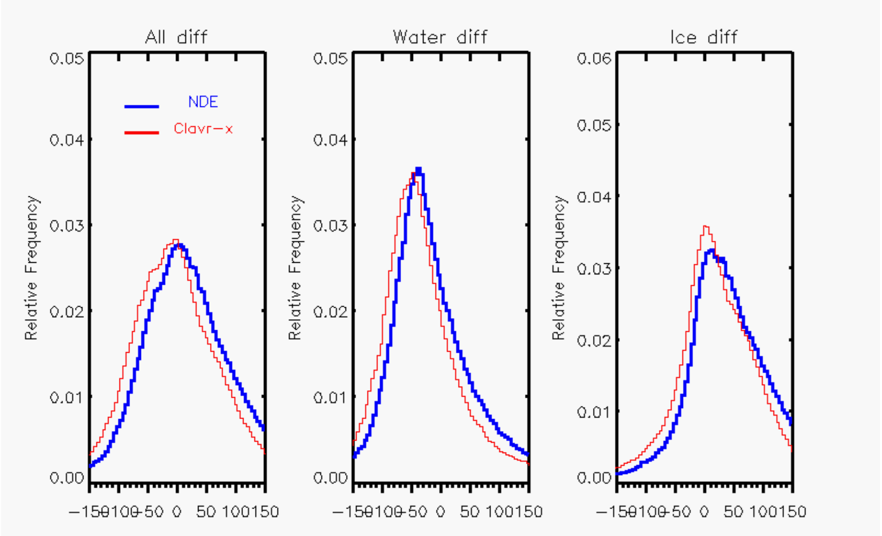


# Phase Matched - CTP

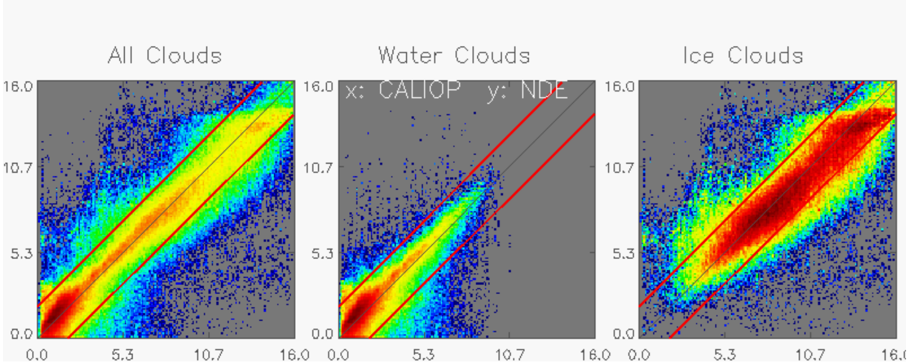
| | Unit (hPa) | NDE | Clavrx | Meet Specs-NDE | Meet Specs -Clavrx |
|---|---|---|---|---|---|
| All Clouds | Bias | 18.2 | -10.0 | 81.8% | 82.6% |
| | Std Dev | 95.1 | 92.5 | 82.0% | 82.9% |
| Water Clouds | Bias | -12.9 | -34.3 | 81.4% | 77.4% |
| | Std Dev | 94.1 | 95.8 | 82.3% | 82.1% |
| Ice Clouds | Bias | 39.9 | 10.5 | 82.0% | 87.0% |
| | Std Dev | 89.7 | 84.4 | 86.9% | 88.0% |

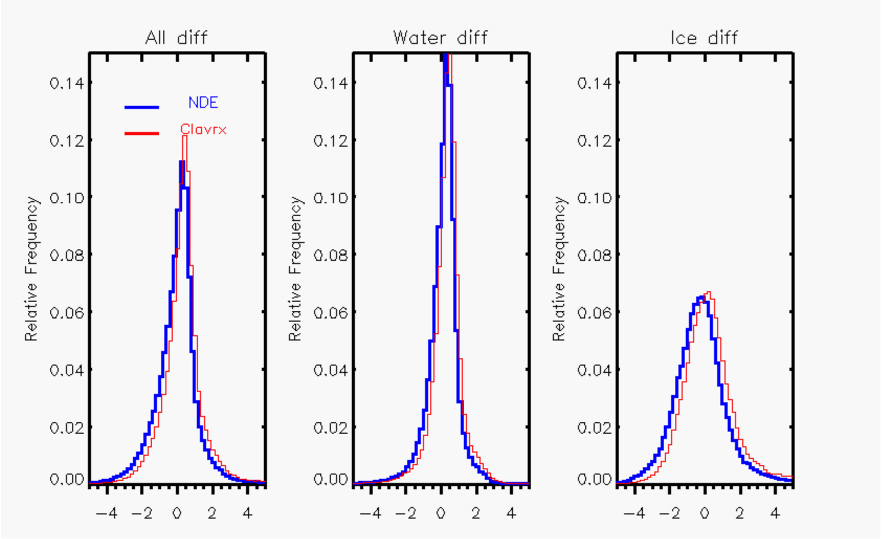


# Phase Matched and Single Layer - CTH

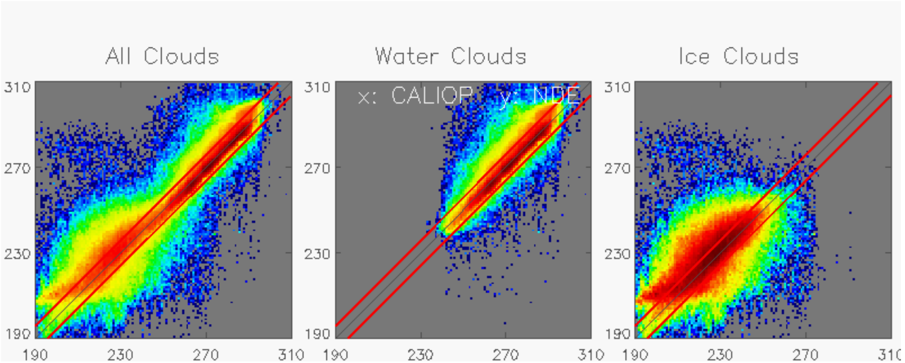
| | Unit (km) | NDE | Clavrx | Meet Specs-NDE | Meet Specs-Clavrx |
|---|---|---|---|---|---|
| All Clouds | Bias | -0.04 | 0.3 | 77.9% | 76.6% |
| | Std Dev | 1.3 | 1.2 | 77.9% | 78.5% |
| Water Clouds | Bias | 0.1 | 0.3 | 83.7% | 81.0% |
| | Std Dev | 0.9 | 0.9 | 84.0% | 84.1% |
| Ice Clouds | Bias | -0.2 | 0.2 | 69.6% | 69.1% |
| | Std Dev | 1.6 | 1.5 | 70.1% | 69.2% |

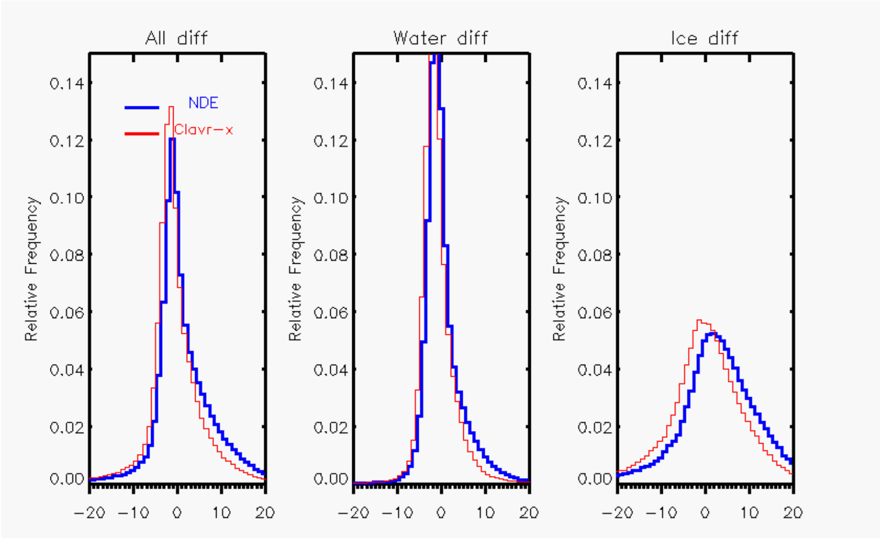


# Phase Matched and Single Layer - CTT

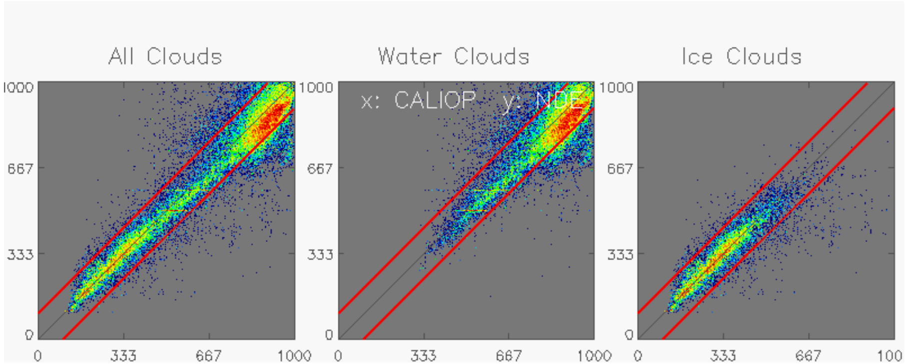
| | Unit (K) | NDE | Clavrx | Meet Specs-NDE | Meet Specs -Clavrx |
|---|---|---|---|---|---|
| All Clouds | Bias | 1.6 | -0.6 | 78.2% | 83.4% |
| | Std Dev | 8.0 | 6.7 | 78.9% | 83.4% |
| Water Clouds | Bias | 0.4 | -0.9 | 88.4% | 92.3% |
| | Std Dev | 4.9 | 4.2 | 88.7% | 92.3% |
| Ice Clouds | Bias | 3.4 | -0.05 | 63.7% | 68.6% |
| | Std Dev | 10.7 | 9.4 | 66.6% | 68.6% |

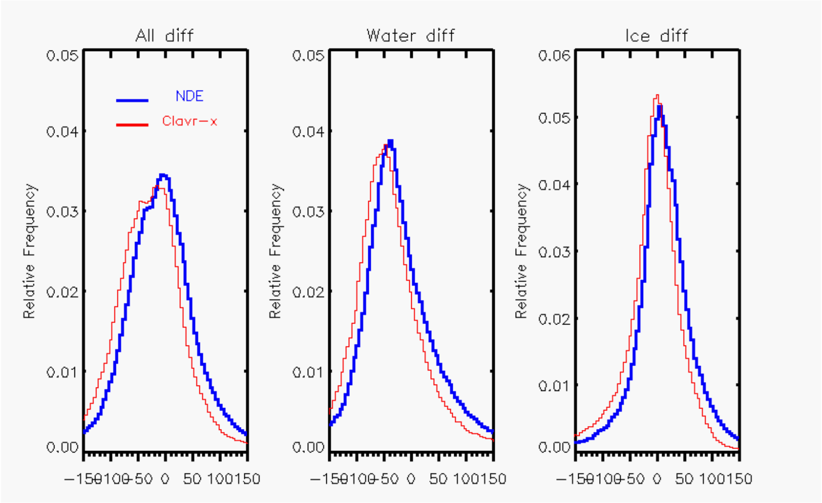


# Phase Matched and Single Layer - CTP

| | Unit (hPa) | NDE | Clavrx | Meet Specs-NDE | Meet Specs -Clavrx |
|---|---|---|---|---|---|
| All Clouds | Bias | -11.5 | -36.3 | 87.7% | 83.9% |
| | Std Dev | 83.1 | 83.9 | 88.4% | 88.0% |
| Water Clouds | Bias | -23.1 | -46.0 | 83.0% | 78.5% |
| | Std Dev | 85.0 | 85.0 | 84.7% | 84.8% |
| Ice Clouds | Bias | 4.73 | -20.1 | 94.2% | 92.7% |
| | Std Dev | 77.4 | 80.0 | 94.3% | 93.7% |



# Evaluation of Arctic Cloud Top height

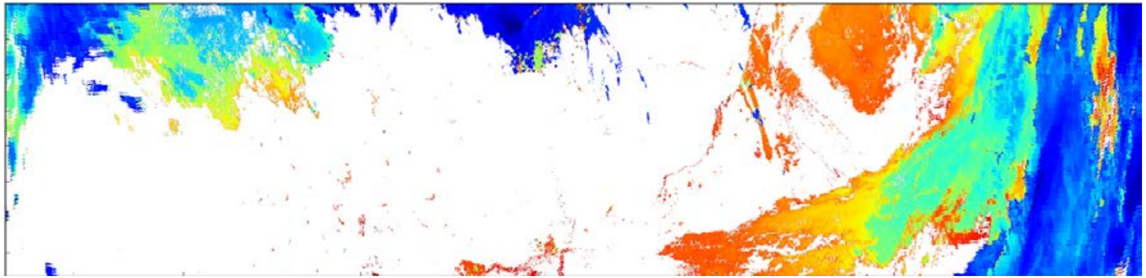
| | Unit (km) | NDE - Global | NDE - Arctic | Meet Specs- Global | Meet Specs -Arctic |
|---|---|---|---|---|---|
| No filter | Bias | -1.2 | -0.9 | 55.6% | 52.3% |
| | Std Dev | 3.1 | 2.3 | 39.0% | 40.3% |
| Phase matched | Bias | -0.6 | -0.5 | 63.9% | 61.3% |
| | Std Dev | 1.7 | 1.5 | 58.6% | 57.2% |
| Phase matched single layer | Bias | -0.04 | 0.19 | 77.9% | 74.1% |
| | Std Dev | 1.3 | 1.11 | 77.9% | 74.6% |

# ACHA v1r2 Integration Results

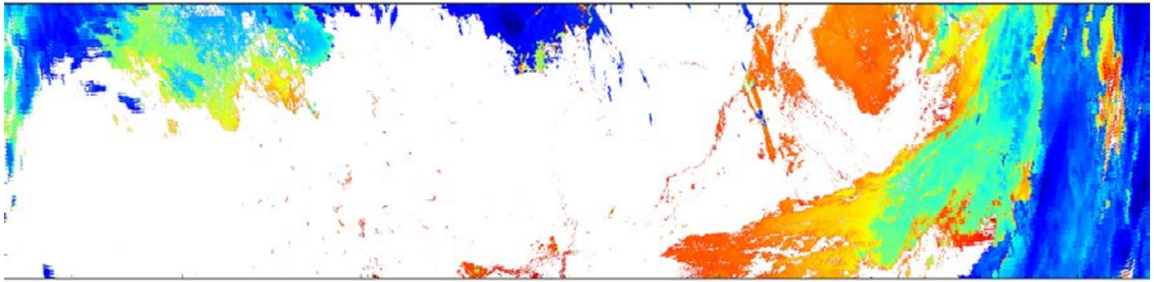
- Analysis was performed using GLANCE (which is used for algorithm integration verification) with an epsilon of 0 (i.e. a perfect match).
  - Small differences are to be expected due to slight run to run rounding differences.

- Due an issue discovered in ECM beta, which was fixed within NDE in mid-June, a verification test was performed using that data being run at NDE against locally run SAPF data to ensure that the code was integrated and being run correctly. The four scenes that were compared were chosen due to them being the NDE validation "golden" granules
  - 0045Z on 8 April, 2018 (NOAA-20)
  - 0749Z on 8 April, 2018 (NOAA-20) - **shown**
  - 1743Z on 16 Dec, 2016 (SNPP)
  - 0659Z on 8 April 2018 (NOAA-20)

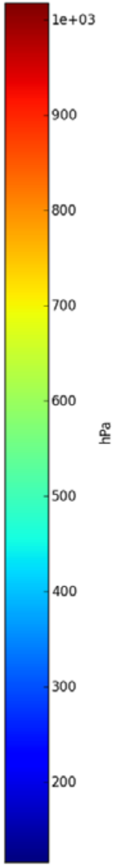
# ACHA v1r2 Integration Results (CTP)



CIMSS SAPF



NDE SAPF



# ACHA (CTP) v1r2 Integration Results

- Correlation between NDE and CIMSS SAPF run :  0.996
- Mean difference : -0.01910
- Other products and scenes show similar results
- As mentioned previously, it is expected that there will be differences due to machine and run to run differences, and minor differences (as seen) are as expected.

# Backup Material - Requirements

# JPSS Data Products Maturity Definition

| JPSS/GOES-R Data Product Validation Maturity Stages – COMMON DEFINITIONS (Nominal Mission) |
|---|
| **1. Beta**<br>o Product is minimally validated, and may still contain significant identified and unidentified errors.<br>o Information/data from validation efforts can be used to make initial qualitative or very limited quantitative assessments regarding product fitness-for-purpose.<br>o Documentation of product performance and identified product performance anomalies, including recommended remediation strategies, exists. |
| **2. Provisional**<br>o 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.<br>o Product analyses are sufficient for qualitative, and limited quantitative, determination of product fitness-for-purpose.<br>o Documentation of product performance, testing involving product fixes, identified product performance anomalies, including recommended remediation strategies, exists.<br>o Product is recommended for potential operational use (user decision) and in scientific publications after consulting product status documents. |
| **3. Validated**<br>o Product performance has been demonstrated over a large and wide range of representative conditions (i.e., global, seasonal).<br>o 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.<br>o Product analyses are sufficient for full qualitative and quantitative determination of product fitness-for-purpose.<br>o Product is ready for operational use based on documented validation findings and user feedback.<br>o Product validation, quality assurance, and algorithm stewardship continue through the lifetime of the instrument. |

# Requirements Cloud Top 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 Top Height (2)

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

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

# Requirements Cloud Top Pressure (1)

- JERD-2428 The algorithm shall produce a cloud top pressure product that has a horizontal cell size of 0.8 km at Nadir.
- JERD-2492 The algorithm shall produce a cloud top pressure product that has a vertical reporting interval of tops of up to four layers.
- JERD-2493 The algorithm shall produce a cloud top pressure product that has a mapping uncertainty, (3 sigma) of 4 km.

# Requirements Cloud Top Pressure (2)

- JERD-2494 The algorithm shall produce a cloud top pressure product that has a measurement precision of
  - 100hPa for COT >=1 and 200hPa for COT < 1

- JERD-2495 The algorithm shall produce a cloud top pressureproduct that has a measurement accuracy of
  - 100hPa for COT >=1 and 200hPa for COT < 1

# Requirements Cloud Top Temperature (1)

- JERD-2434 The algorithm shall produce a cloud top temperature product that has a horizontal cell size of 0.8 km at Nadir.
- JERD-2496 The algorithm shall produce a cloud top temperature product that has a vertical reporting interval of tops of up to four layers.
- JERD-2497 The algorithm shall produce a cloud top temperature product that has a mapping uncertainty, (3 sigma) of 4 km.

# Requirements Cloud Top Temperature (2)

- JERD-2498 The algorithm shall produce a cloud top temperature product that has a measurement precision of
  - 6K for COT >=1 and 12K for COT < 1

- JERD-2499 The algorithm shall produce a cloud top temperature product that has a measurement accuracy of
  - 6K for COT >=1 and 12K for COT < 1