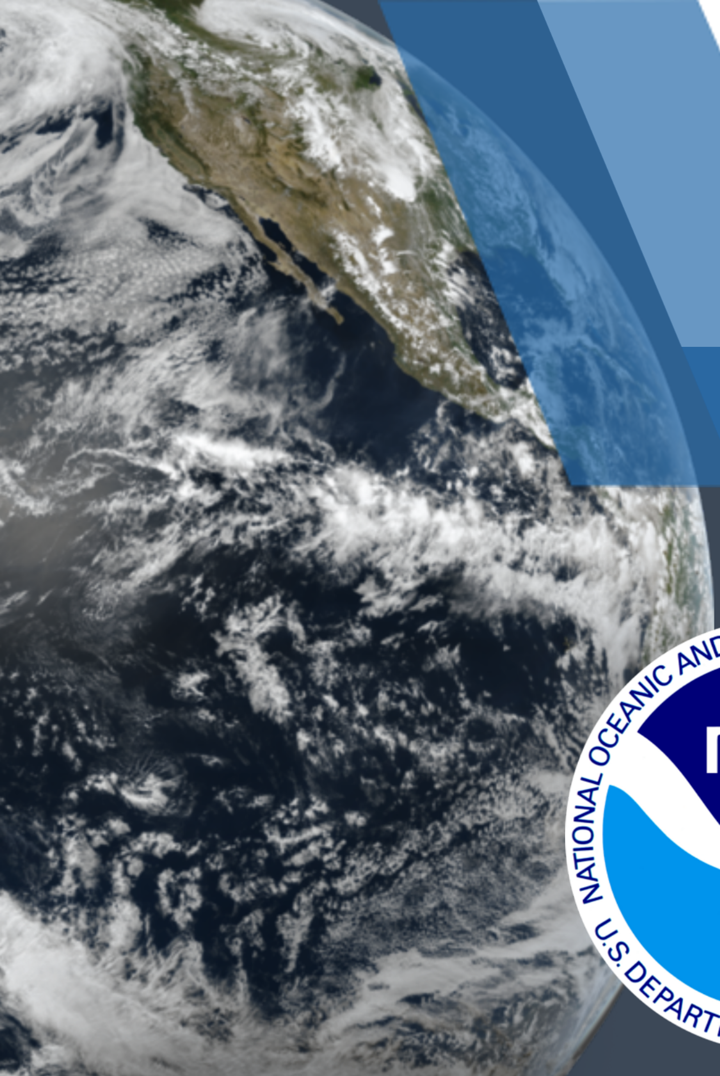


Performance of the NOAA Enterprise Cloud Height Algorithm for AMVs

IWW-15

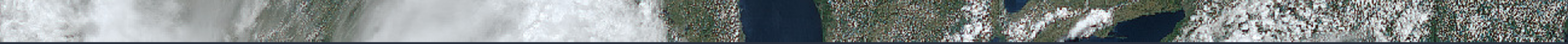
National Environmental Satellite, Data, and Information Service

April 2021

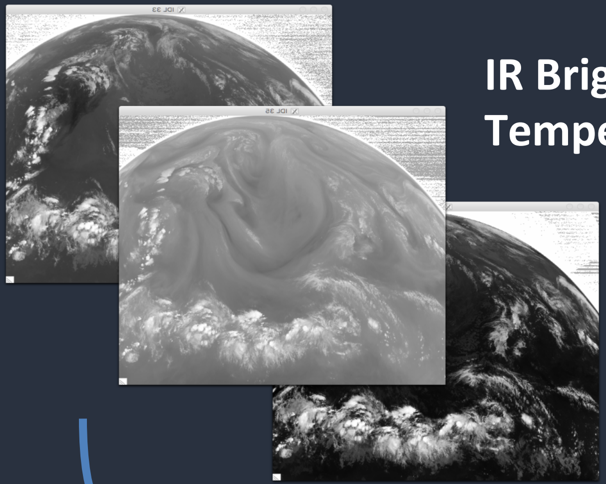
Andrew Heidinger, NESDIS GEO Scientist
Steve Wanzong, Yue Li UW/CIMSS
Charles White, UW/AOS/CIMSS

Outline

- Evolution of the Enterprise Cloud Height Algorithm (ACHA)
- Quantile Neural Network Cloud Top Pressure
- The Mid-Level Issue
- Plans for Height Intercomparison for ICWG

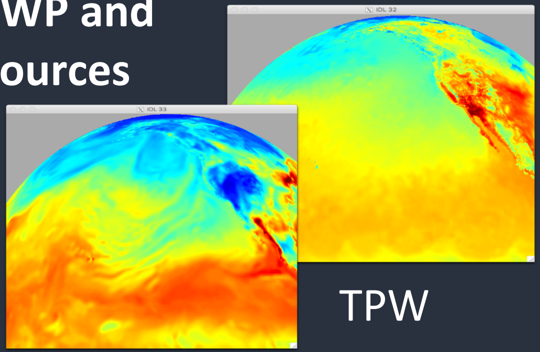


How AWG CLOUD HEIGHT (ACHA) Works



IR Brightness Temperatures

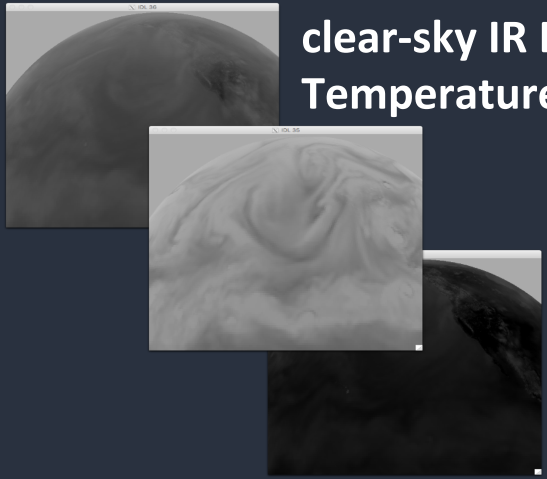
Ancillary Data from NWP and other sources



surface temperature

TPW

Radiative Transfer Model clear-sky IR Brightness Temperatures

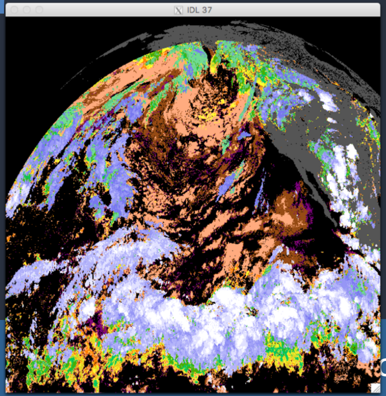


ACHA Input

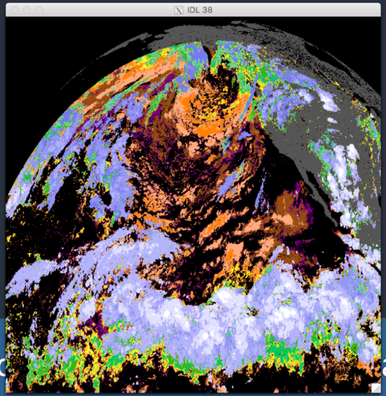
Optimal Estimation

ACHA Output

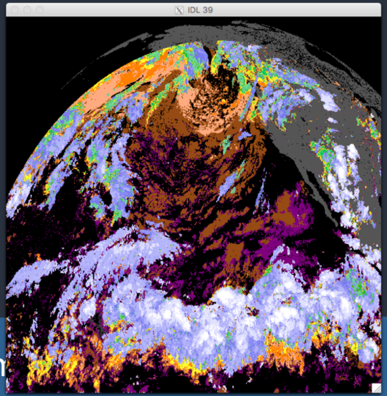
cloud pressure



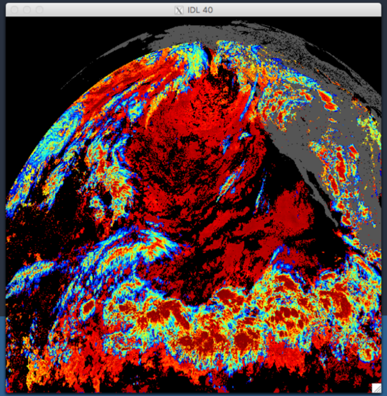
cloud height



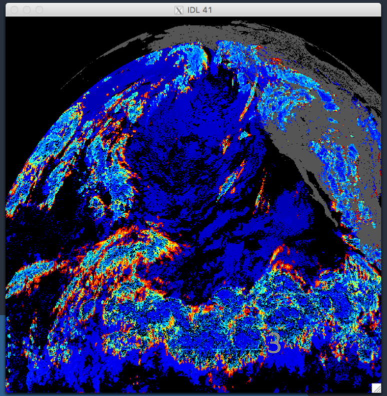
cloud temperature



cloud emissivity



cloud pressure errors



Evolution of ACHA

GOES-R AWG Baseline - 2010

First Guess CALIOP CLIMO + Opaque → ACHA Classic

NOAA Enterprise -2018

First Guess CALIOP CLIMO + Opaque → ACHA Full

NOAA Enterprise Developmental Version -2021

First Guess EYRE+MENZEL → ACHA Classic → ACHA Full

NOAA Enterprise Future Version - 2021+

First Guess Neural Network → ACHA Classic → ACHA Full

ACHA Classic

Tc = Cloud Temperature

Ec = Cloud Emissivity

Reff = Particle Size

ACHA Full

ACHA Classic +

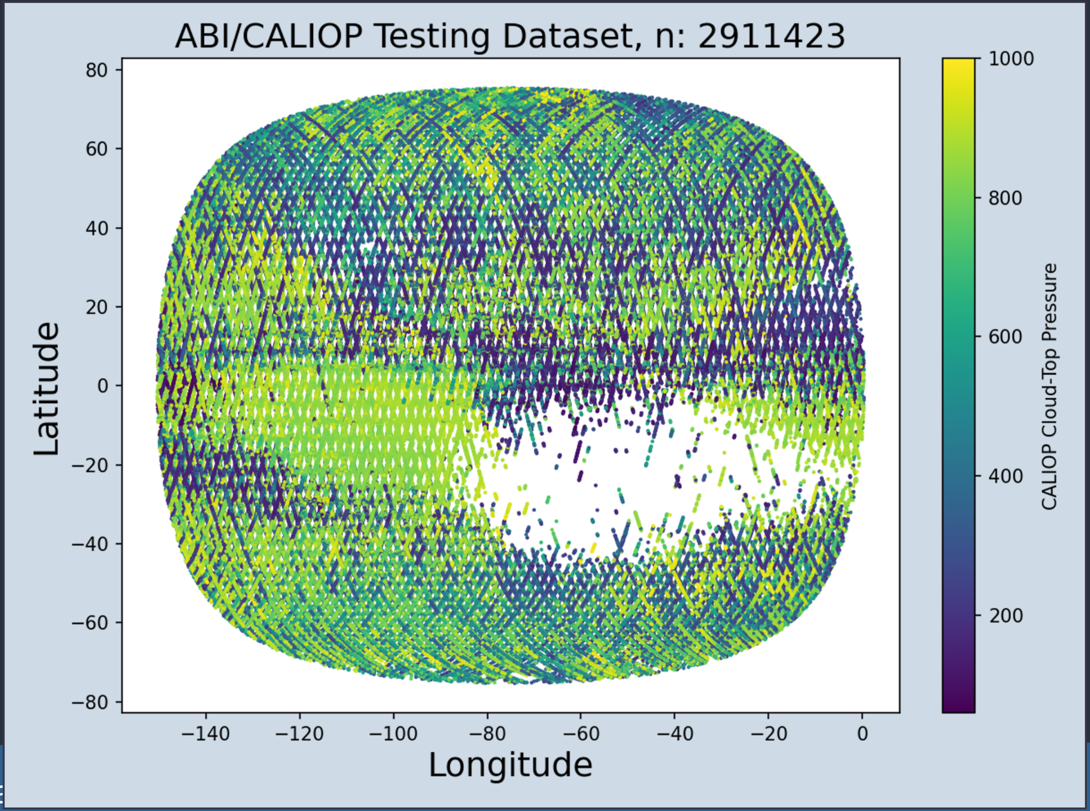
Ice Prob = Probability of ice cloud at cloud top

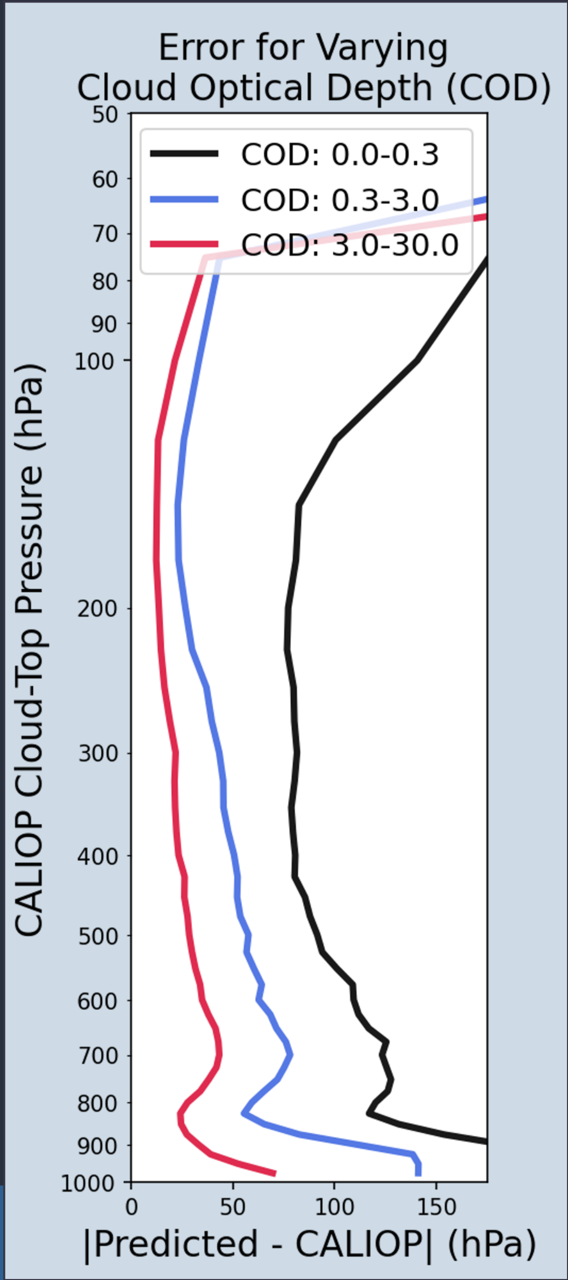
Lower Tc = temperature of lower cloud in a multilayer situation

ABI Neural Network Cloud-Top Pressure Estimation

- Overall approach follows that of **Håkansson et al. 2018** and **Pfreundschuh et al. 2018** (quantile regression neural network) that allows for approximation of uncertainties
- Main difference is **that models are trained specifically to each imager** with CALIOP collocations

- ABI Model validated with 2.9 million collocations with **MAE of 59.0 hPa,** and lower for optically thick clouds
- **Only IR channels used** to reduce issues with range of sun angles in CALIOP data





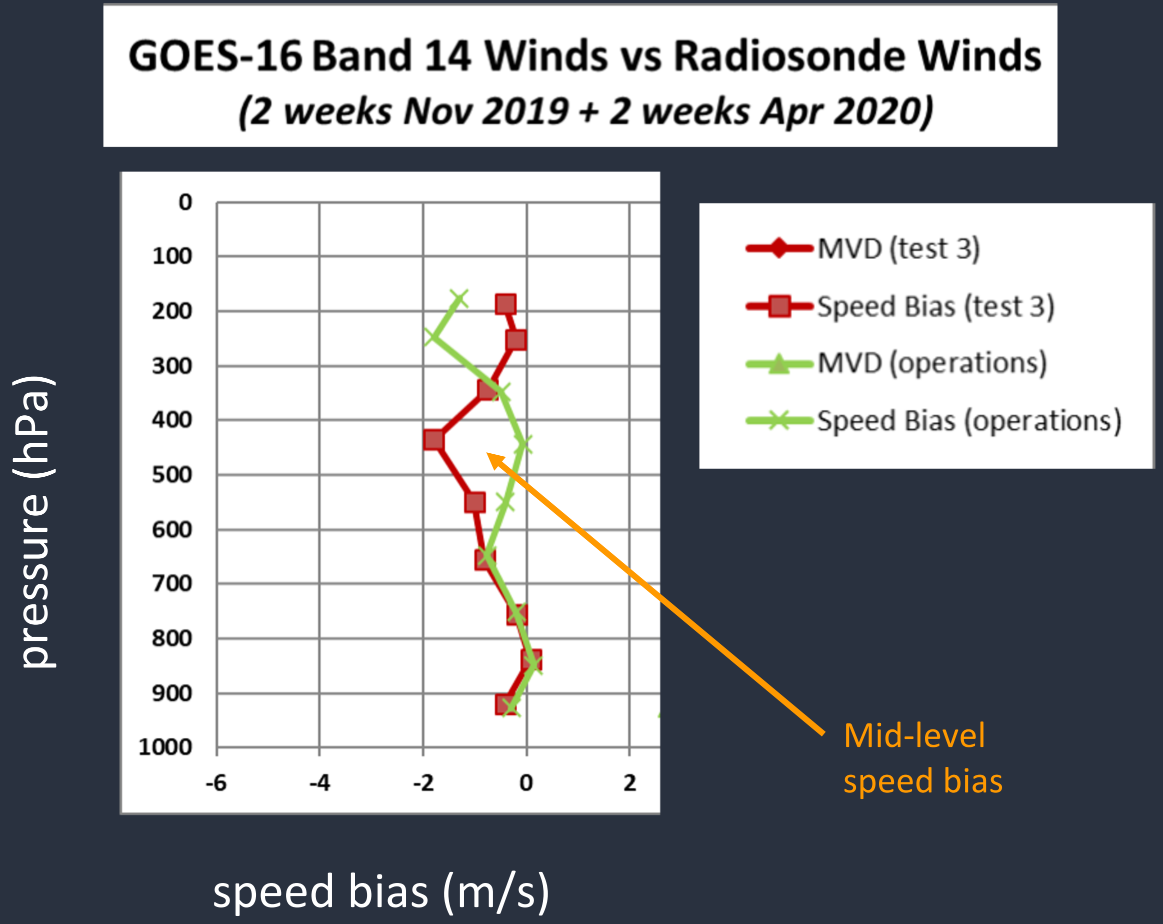
The Mid-Level Issue

- NOAA AMV Team has seen degradation in mid-level speed bias (400-600 hPa) and an improvement in high-levels.

- NOAA Cloud Height Team is trying to diagnose this issue but does not see it in its validation.

- Perhaps more data is needed and a standard routine is made available to convert cloud team pressure to AMV target pressures.

From NESDIS AMV Presentation



CALIPSO/CALIOP Comparison GOES-16

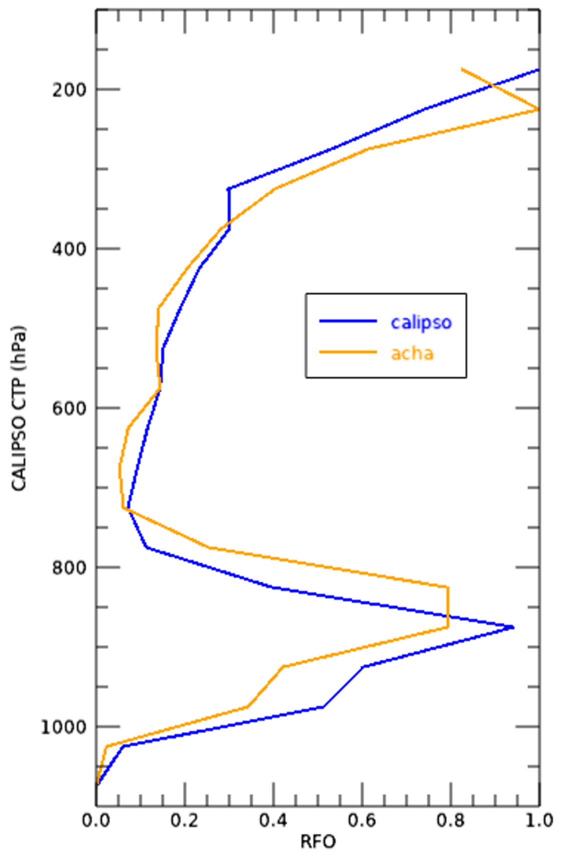
NESDIS Cloud Team performs analysis against CALIOP (left)

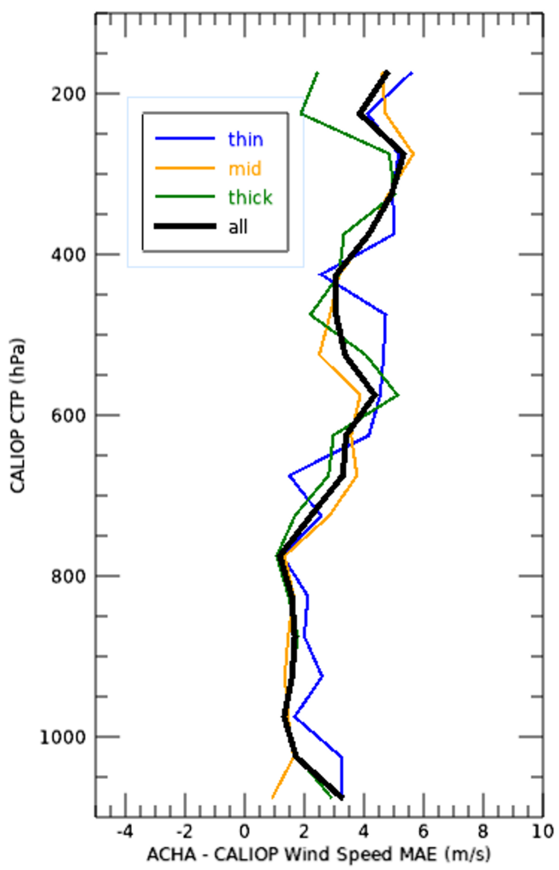
We also use NWP to convert pressure differences into wind speed differences.

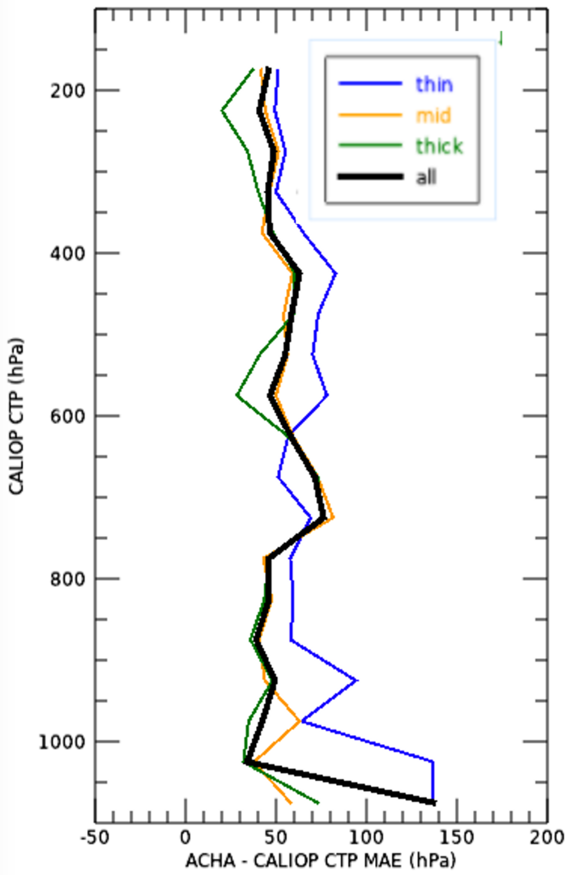
MAE = Mean Absolute Error

mid-level heights are the least in number but our retrievals are similar to CALIOP

We seek guidance from the AMV groups to be able to better see this issue.



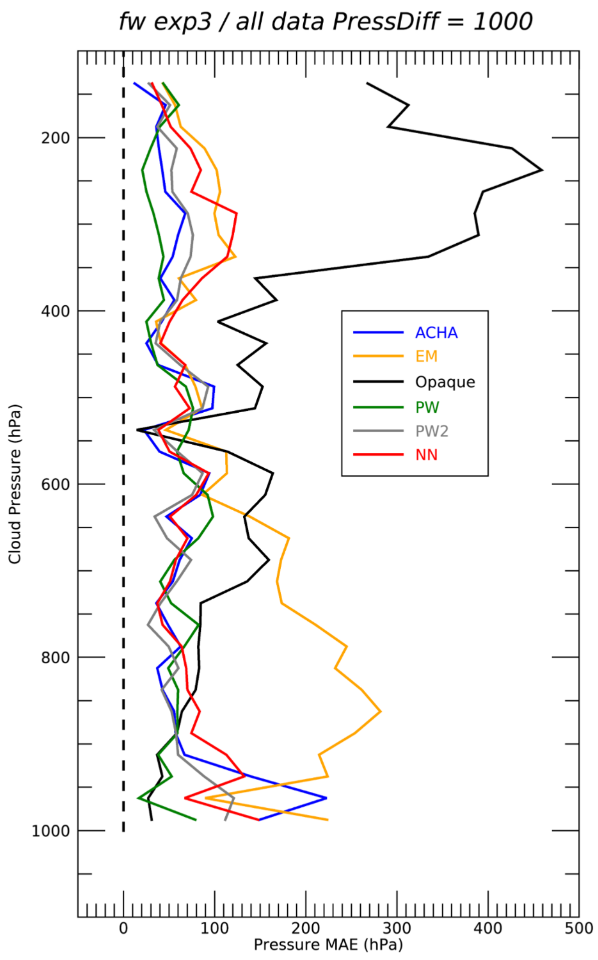




Internal Cloud Working Group

- ICWG continues to have a Topical Group focused on use of cloud properties for the AMV application.
- ICWG has agreed to make GOES-16 October 20, 2019 a "Golden Day" in its next intercomparison.
- We plan to include Aeolus height comparisons for that day and have tools developed.
- We welcome inclusion of Stereo Heights.
- Open to discuss on mid-level issues.
- Plan for virtual mini-conference in May 2021 hosted by EUMETSAT

Thank you!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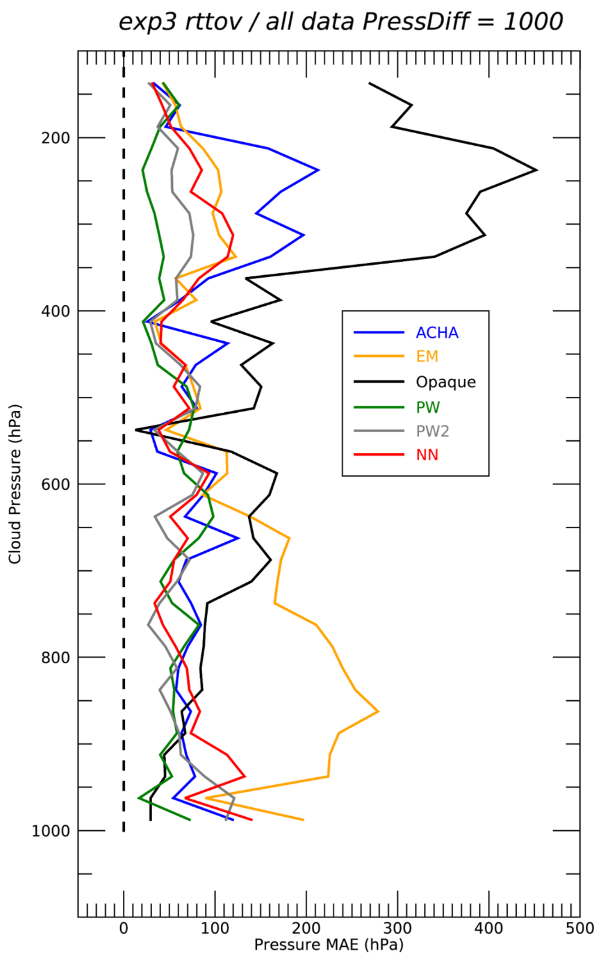
Cloud Pressure (hPa)
Pressure MAE (hPa)
ACHA
EM
Opaque
PW
PW2
NN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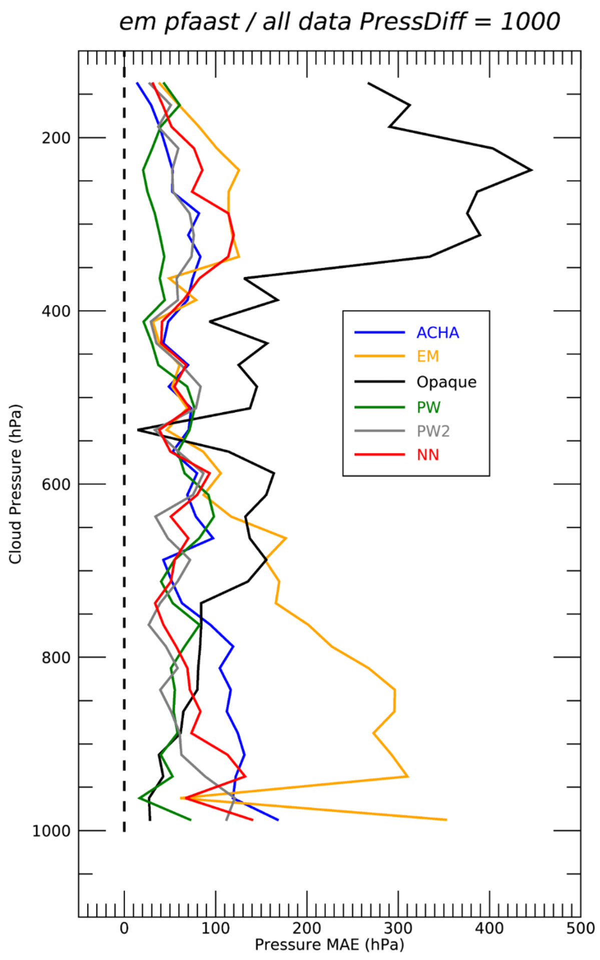
Cloud Pressure (hPa)
Pressure MAE (hPa)
ACHA
EM
Opaque
PW
PW2
NN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Cloud Pressure (hPa)
Pressure MAE (hPa)
ACHA
EM
Opaque
PW
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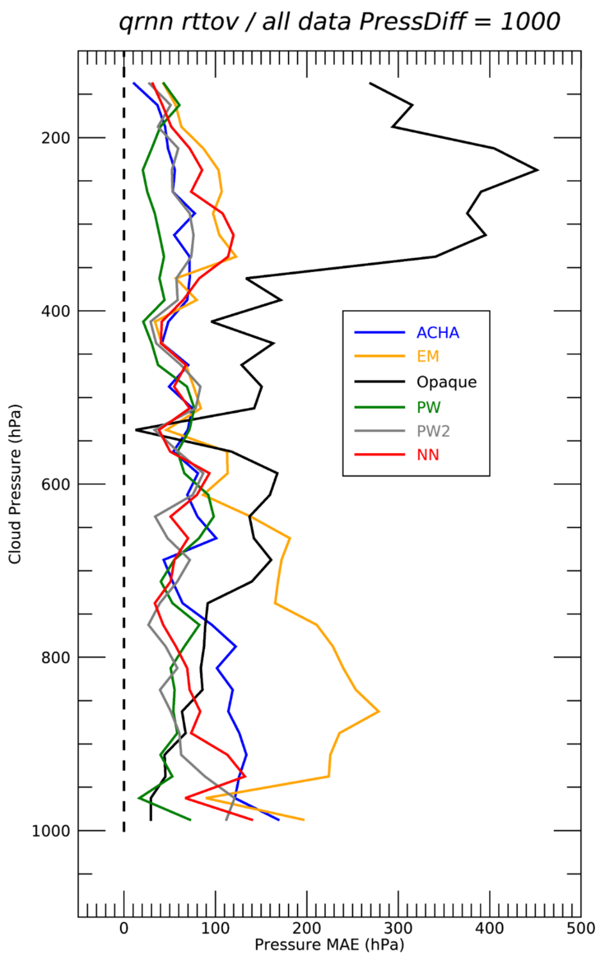
NN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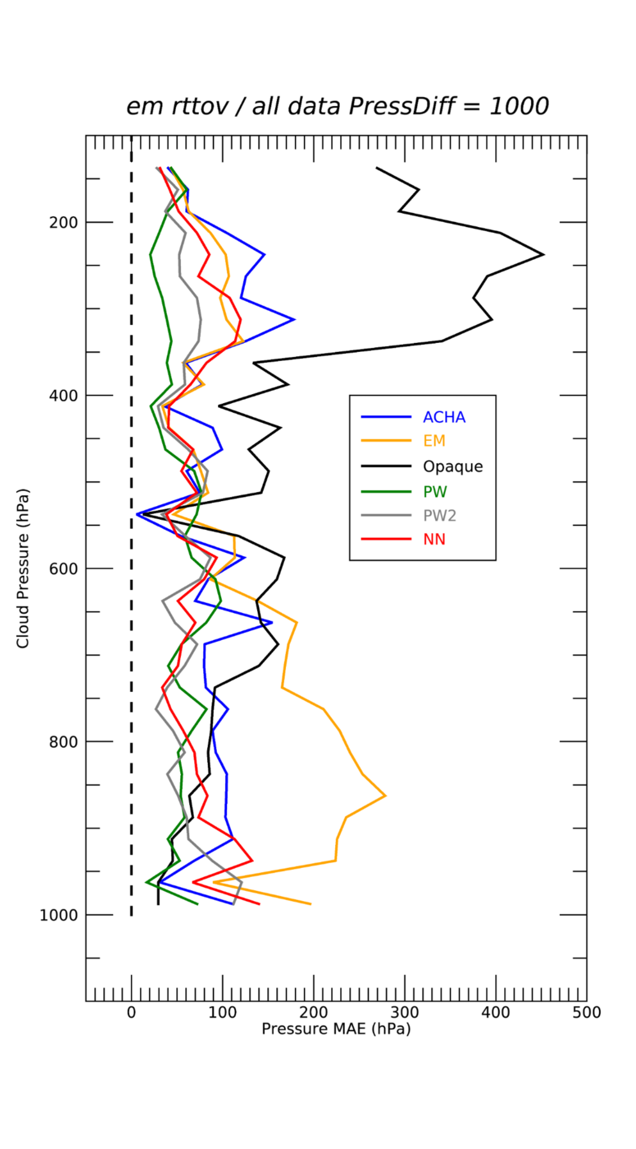
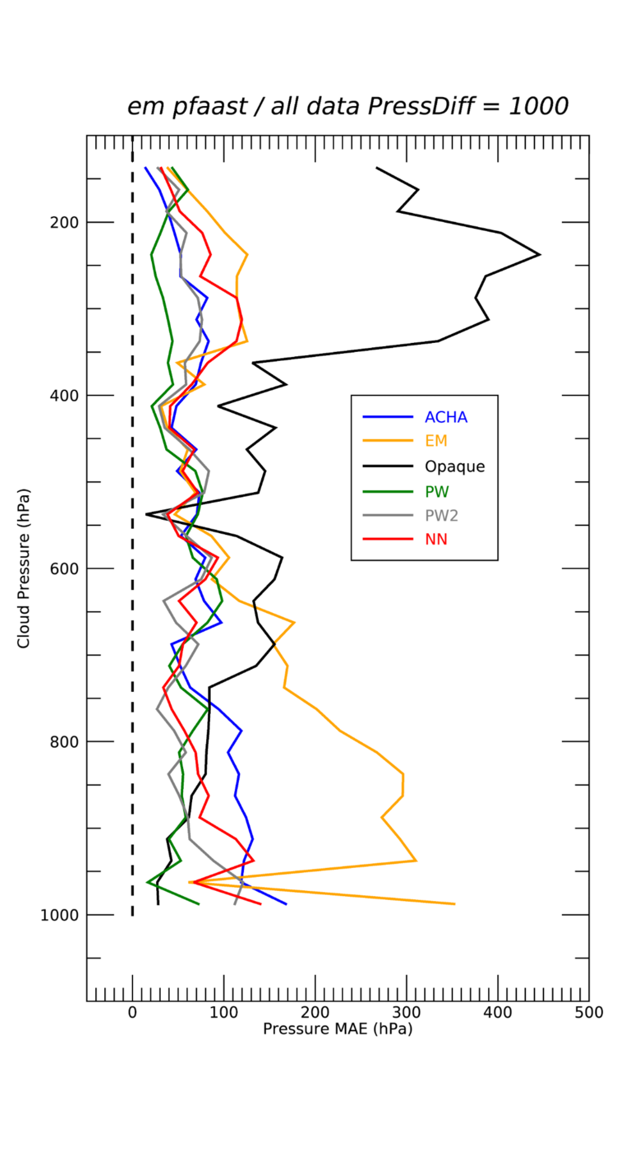
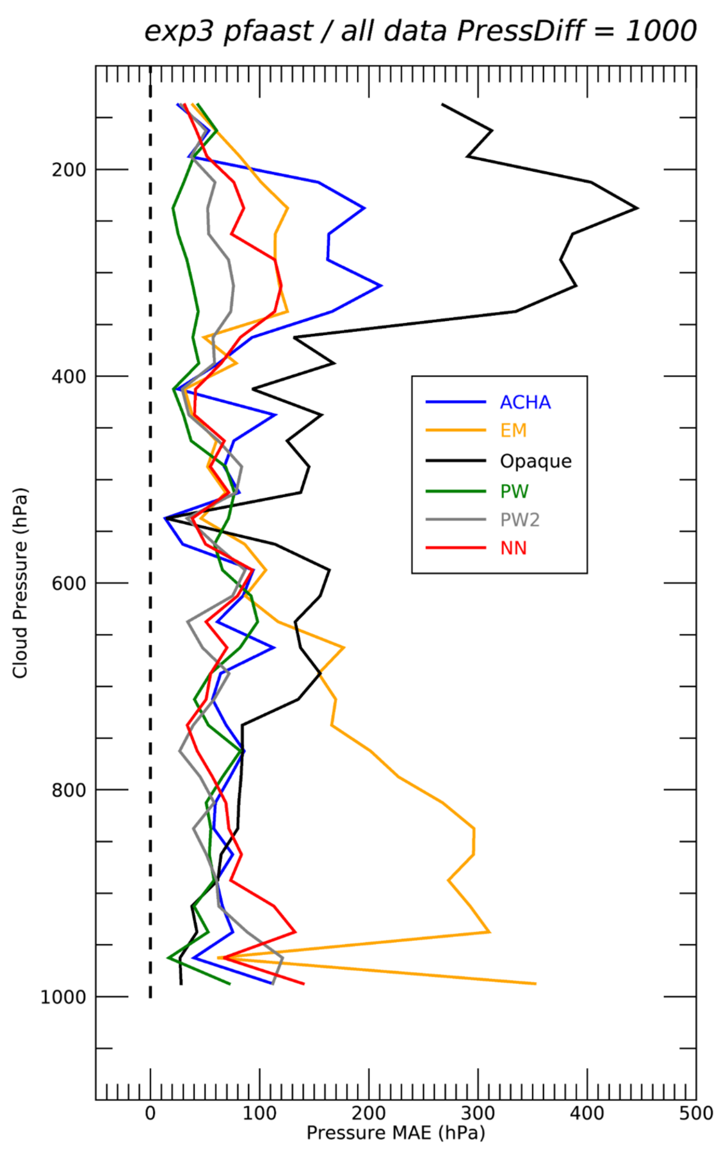
Cloud Pressure (hPa)
Pressure MAE (hPa)
ACHA
EM
Opaque
PW
PW2
NN


em rttov / all data PressDiff = 1000
Cloud Pressure (hPa)
Pressure MAE (hPa)
ACHA
EM
Opaque
PW
PW2
NN
200
400
600
800
1000
0
100
200
300
400
500


em pfaast / all data PressDiff = 1000
Cloud Pressure (hPa)
Pressure MAE (hPa)
ACHA
EM
Opaque
PW
PW2
NN
200
400
600
800
1000
0
100
200
300
400
500


exp3 pfaast / all data PressDiff = 1000
Cloud Pressure (hPa)
200
400
600
800
1000
0
100
200
300
400
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Pressure MAE (hPa)
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PW2
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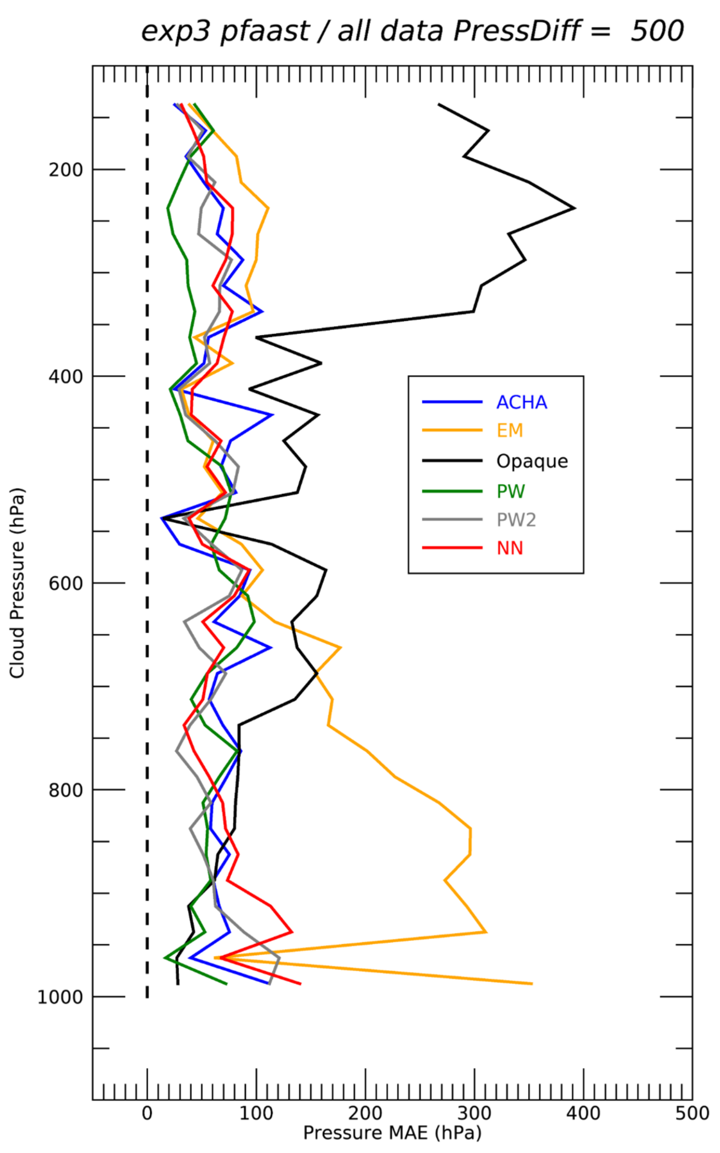
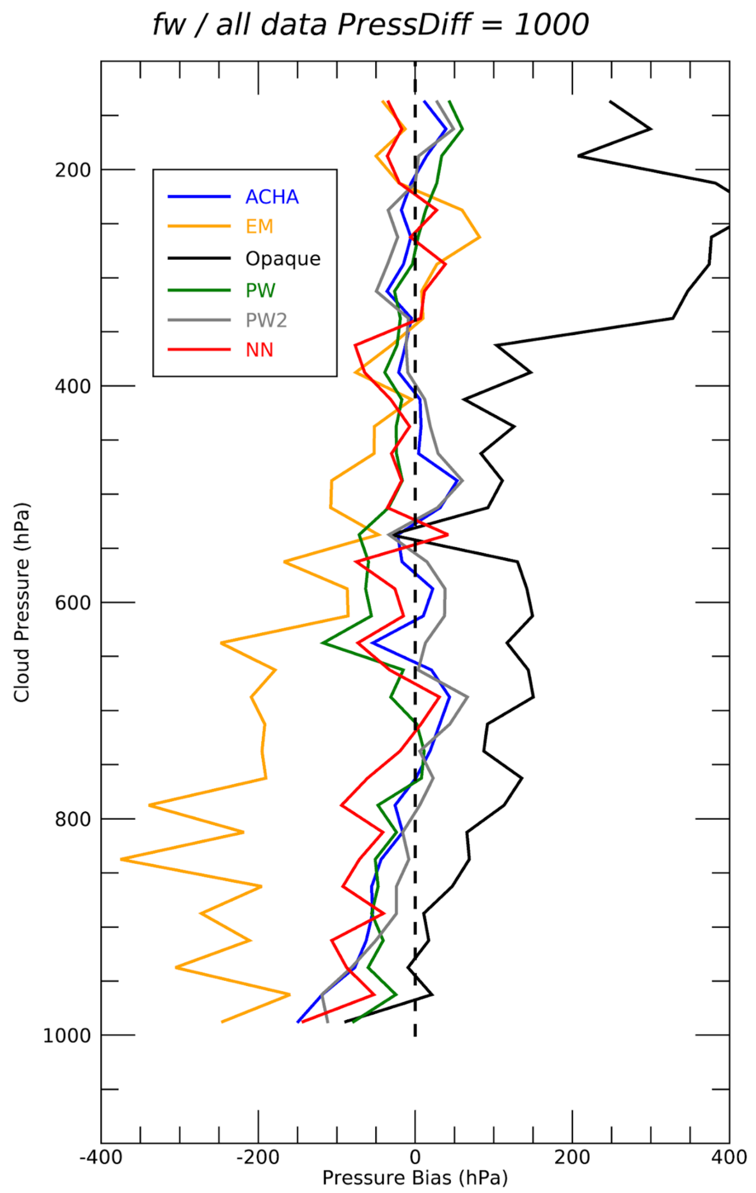

exp3 pfaast / all data PressDiff = 500
Cloud Pressure (hPa)
200
400
600
800
1000
0
100
200
300
400
500
Pressure MAE (hPa)
ACHA
EM
Opaque
PW
PW2
NN

NOAA Enterprise Cloud Height

- ECH is aware of the mid-level speed bias in the current operational code.
- ECH is having trouble isolating the cause and seeing issue.
- New versions of ACHA are being developed that use better prior information (EM = Eyre Menzel (1989) and NN = Quantile Neural Network (Chuck White Phd Student).
- These could augment the current use of opaque and caliop derived climatologies.
- Image on right shows new GOES-16 ACHA and operational versions (PW and PW1) for a 00Z 10/20/2020 Raob Comparison.
- We recommend adoption of standard raob analysis to help cloud height producers understand these issues.



Evolution of ACHA

First Guess
CALIPSO CLIMO
EYRE+MENZEL
Neural Network

ACHA Classic
(Tc, Ec, Reff)

ACHA Full
(Tc, Ec, Reff, Ice Prob, Lower Tc)

Evolution of ACHA

Tc = Cloud Temperature
Ec = Cloud Emissivity
Reff = Particle Size
Ice Prob = Probability of ice cloud
Lower Tc = temperature of lower cloud in a multilayer situation

GOES-R AWG Baseline - 2010	First Guess CALIPSO CLIMO + Opaque →	ACHA Classic (Tc, Ec, Reff)	
NOAA Enterprise -2018	First Guess CALIPSO CLIMO + Opaque →	ACHA Full (Tc, Ec, Reff, Ice Prob, Lower Tc)	
NOAA Enterprise Developmental Version -2021	First Guess EYRE+MENZEL →	ACHA Classic (Tc, Ec, Reff) →	ACHA Full (Tc, Ec, Reff, Ice Prob, Lower Tc)
NOAA Enterprise Future Version - 2021+	First Guess Neural Network →	ACHA Classic (Tc, Ec, Reff) →	ACHA Full (Tc, Ec, Reff, Ice Prob, Lower Tc)

Neural Networks + VIIRS/CrIS Fusion Channels

- VIIRS has only 3 IR channels unaffected by solar radiation VIIRS/CrIS Fusion channels (Weisz et al. 2017) are MODIS-like channels created from interpolated CrIS observations
- We experimented with including these channels in a QRNN model for estimating cloud-top pressure from VIIRS
- Imager/Sounder Fusion can improve the characterization of cloud-top pressure, particularly for upper and mid-level optically-thin cloud cover

Evaluation for 3 mil. VIIRS/CALIOP collocations:
QRNN MAE: **73.1 hPa**
QRNN + 9 Fusion Channels MAE**: 63.7 hPa**