

CALIOP trained neural network cloud top pressure and height for imagers

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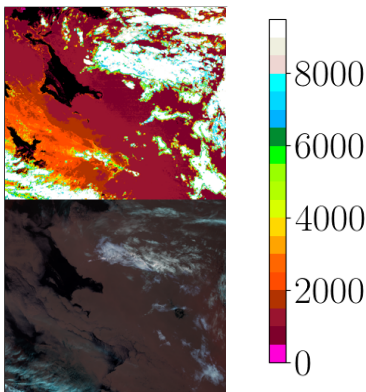
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Presentation at ICWG Madison

NWCSAF PPS Package

- Software for cloud and precipitation products
- Polar orbiting satellites
- Instruments:
 - AVHRR
 - MODIS
 - VIIRS
- Nowcasting & Climate data record production (CLARA-A2)
- Next release December 2018
- CTTH product
 - Cloud top temperature and height (also pressure)

PPS-v2018 CTTH



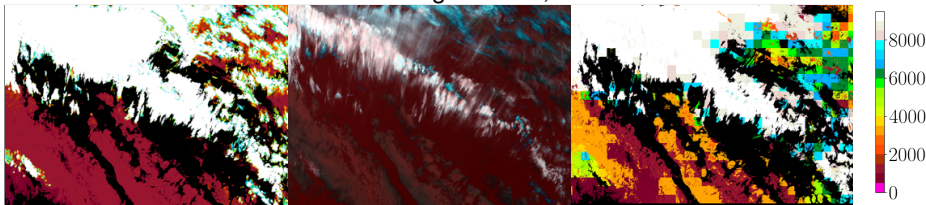
S-NPP 8th March 2015, at 10:57UTC

Neural Network Cloud Top Height

NN-CTTH:

<https://www.atmos-meas-tech.net/11/3177/2018/amt-11-3177-2018.html>

Suomi-NPP 8th August 2015, at 20:25UTC



PPS-v2018 CTTH
(MAE scene:0.9km)

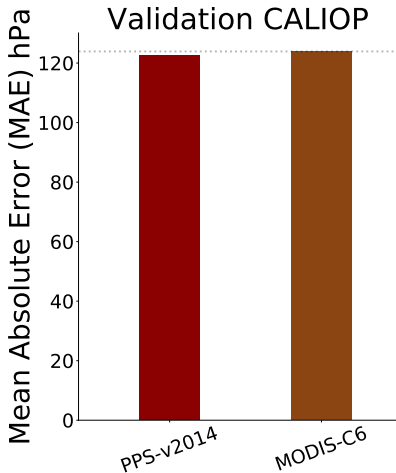
PPS-v2014 CTTH
(MAE scene:1.7km)

- MAE: Mean absolut error compared to CALIOP.

Algorithms for comparison

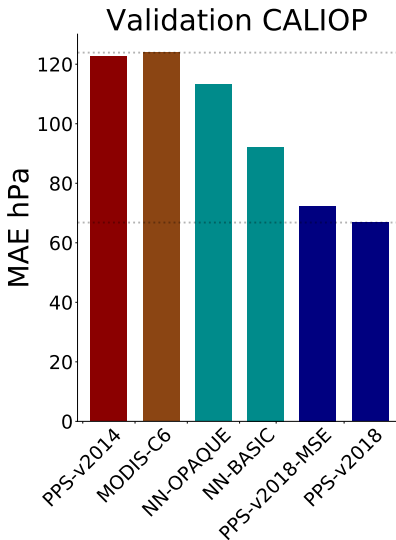
- ESA-CLOUD-CCI and PATMOS-X (end of talk):
 - Optimal estimation
- PPS-v2014 CTTH
 - Spatial information: T_{11} , T_{12} for 32x32 pixels
- MODIS-C6 uses:
 - Spectral information: CO_2 channels at 13 micron
 - Lapse rate
- Validation: CALIOP (V4, 1km) and:
 - 6 days MODIS (Aqua)

! Plot of error: lower bars are better



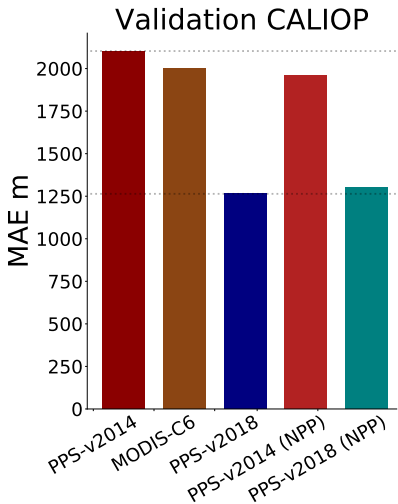
PPS-v2018 CTTH Development

- NN-OPAQUE
 - T_{12}
 - Surface pressure
 - Temperature for 6 pressure levels
- NN-BASIC
 - Including $T_{11} - T_{12}$, which holds information of semi-transparency of cloud
- PPS-v2018-(MSE)
 - Including variables calculated from neighbouring pixels (T_{11}, T_{12})
- PPS-v2018
 - MAE as loss function



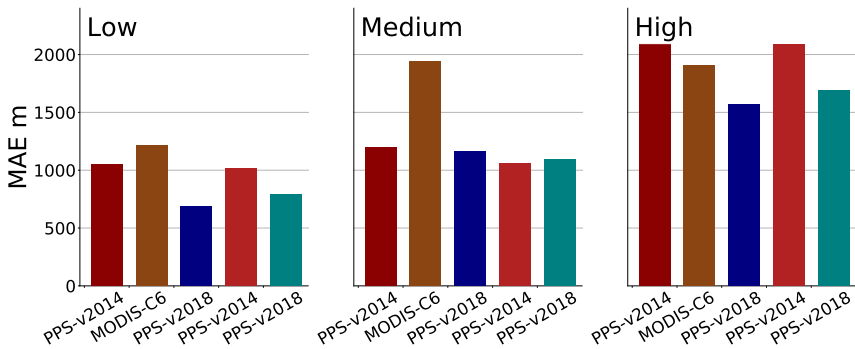
NN-CTTH for VIIRS on Suomi-NPP

- Trained with MODIS 2010
- Applied to VIIRS 2015
- S-NPP VIIRS data: 15 orbits co-located with CALIOP (V4, 1km)
- Robust performance



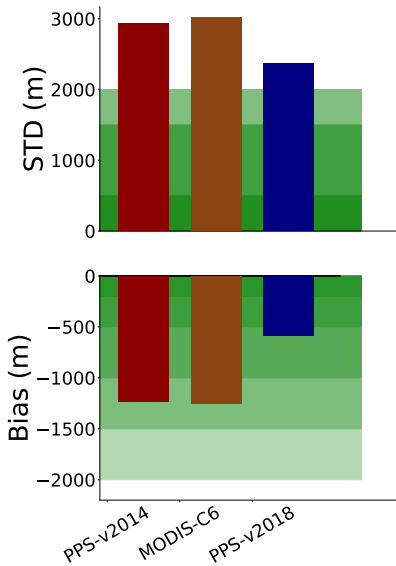
Validation with CloudSat

- Validation with independent truth: CPR radar.
- Neural network good for all cloud classes (low, medium and high).
- PPS-v2014 good for medium level clouds.



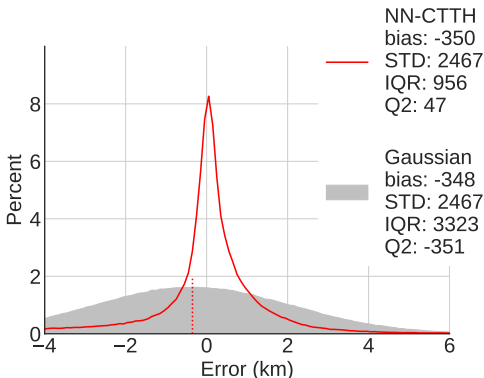
What about bias and STD?

- NWCSAF requirements
- MAE much smaller than MODIS-C6 and PPS-v2014:
 - Expected good performance according to requirements
- STD better for PPS-v2018, but still outside threshold accuracy. Why?
 - 1 Algorithms not good enough?
 - 2 Validation method?
 - Average imager and truth \implies not pixel-level validation
 - Remove thin clouds and cloud edges, how? \implies validation scores valid for part of data
 - 3 Measures not suitable?



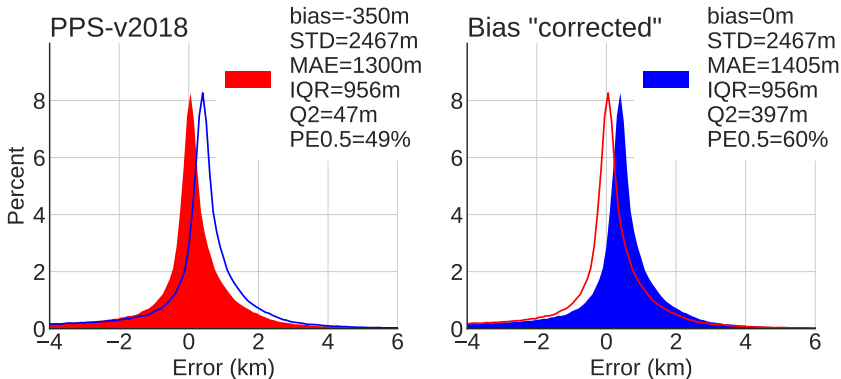
Non-Gaussian error distributions

- NN-CTTH and corresponding Gaussian distribution
 - Same bias & STD
 - Distributions are different
 - ⇒ bias & STD not enough to describe the error distribution!
- Bias: not most common error
- Measures:
 - Q2: Median
 - IQR: Interquartile range Q3-Q1
- Note: some large errors expected due to sensor and FOV differences.

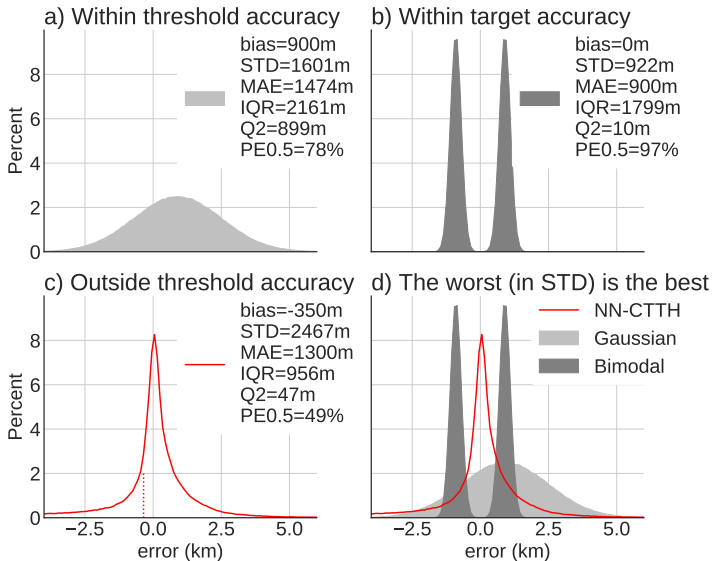


Bias can be misleading

- Bias & STD \Rightarrow blue (bias "corrected") is best
- Median (Q2) & STD \Rightarrow red is best
- PE0.5km = Part of Error larger than 0.5km
- MAE, PE0.5km, and plot show: trust Median!

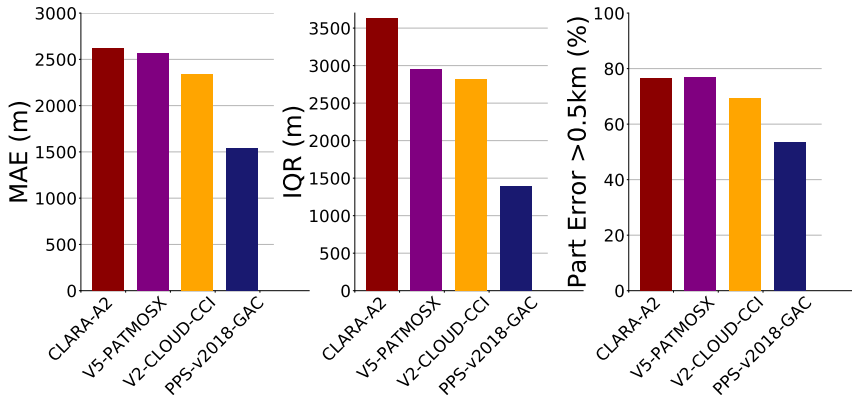


Suitable measures for non-Gaussian error distributions:



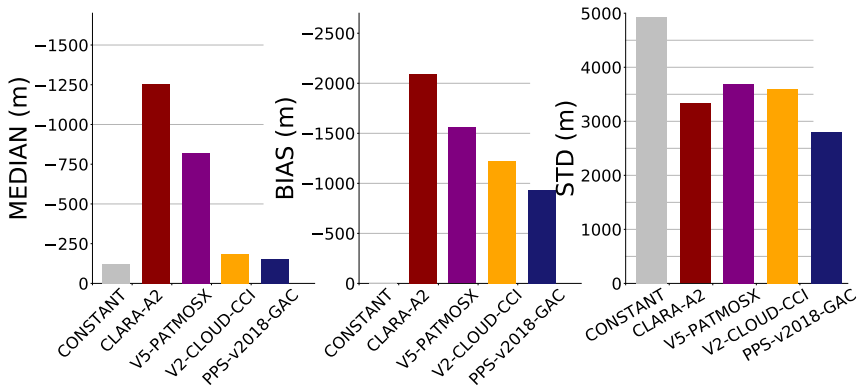
Comparison with several CDRs

- 30 orbits (N=45000) NOAA-18 from 2009 co-located with CALIOP (V4, 5km).
- This PPS-v2018 trained on GAC data.
- Best results for PPS-v2018!



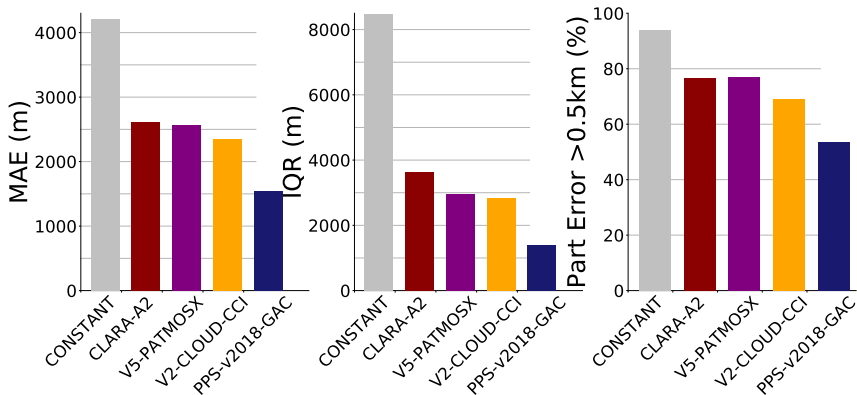
Comparison with several CDRs

- Best results for PPS-2018, also for the *non-suitable* measures bias and STD.
- CONSTANT method: height = 7477m everywhere.



Comparison with several CDRs

- MAE, IQR and PE0.5km correctly detects CONSTANT method as bad.



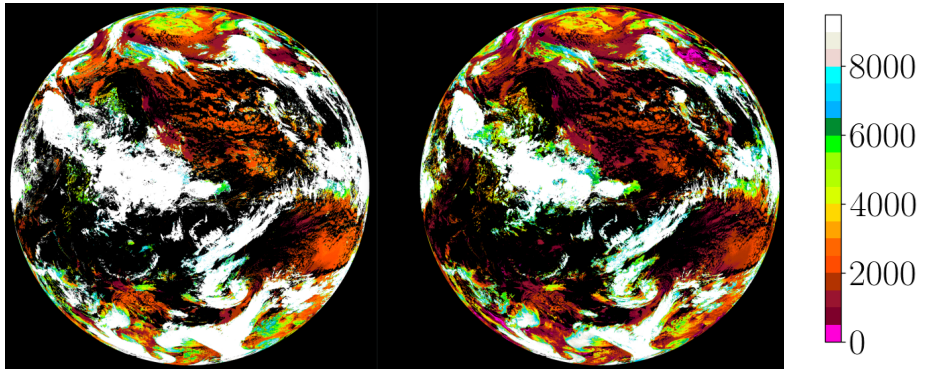
Error estimates

Upper and lower threshold with quantile regression
neural networks, Simon Pfreunds Schuh et al. (2018):

<https://www.atmos-meas-tech.net/11/4627/2018/amt-11-4627-2018.html>

Upper limit

Lower limit



- Method not restricted to AVHRR/MODIS/VIIRS although PPS-software package is.

Future and Summary

Future without CALIOP:

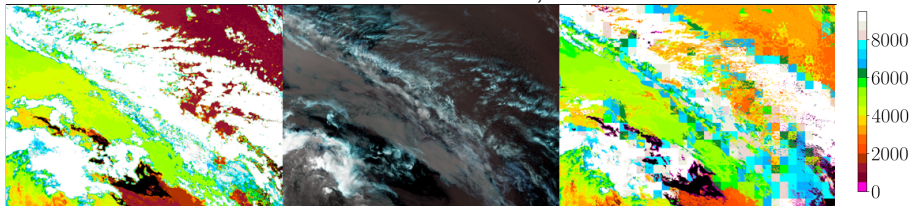
- Neural network training requires a truth
- After CALIPSO comes EarthCARE, but then ...
- Current NN-CTTH can be trained on historic IMAGER/CALIOP data
- But for newer channels or other retrievals?

Summary:

- 1 NN-CTTH performs well:
 - validated with CALIOP and CPR (Cloudsat)
 - for sensors MODIS, VIIRS and AVHRR
 - compared to PPS-v2014, MODIS-C6, PATMOS-X, ESA-CLOUD-CCI and CLARA-A2
- 2 The retrieval errors are **NOT** well described by Bias and STD.
- 3 MAE, IQR, PE0.5km and Median give important information of the errors.

Thank you for listening!

Suomi-NPP 8th March 2015, at 10:58UTC



PPS-v2018 CTTH
(MAE:1.4km)

PPS-v2014 CTTH
(MAE:3.1km)