Use of Sounder Cloud Products to Improve Imager Cloud Products and Derived Motion Vectors.

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ICWG-2

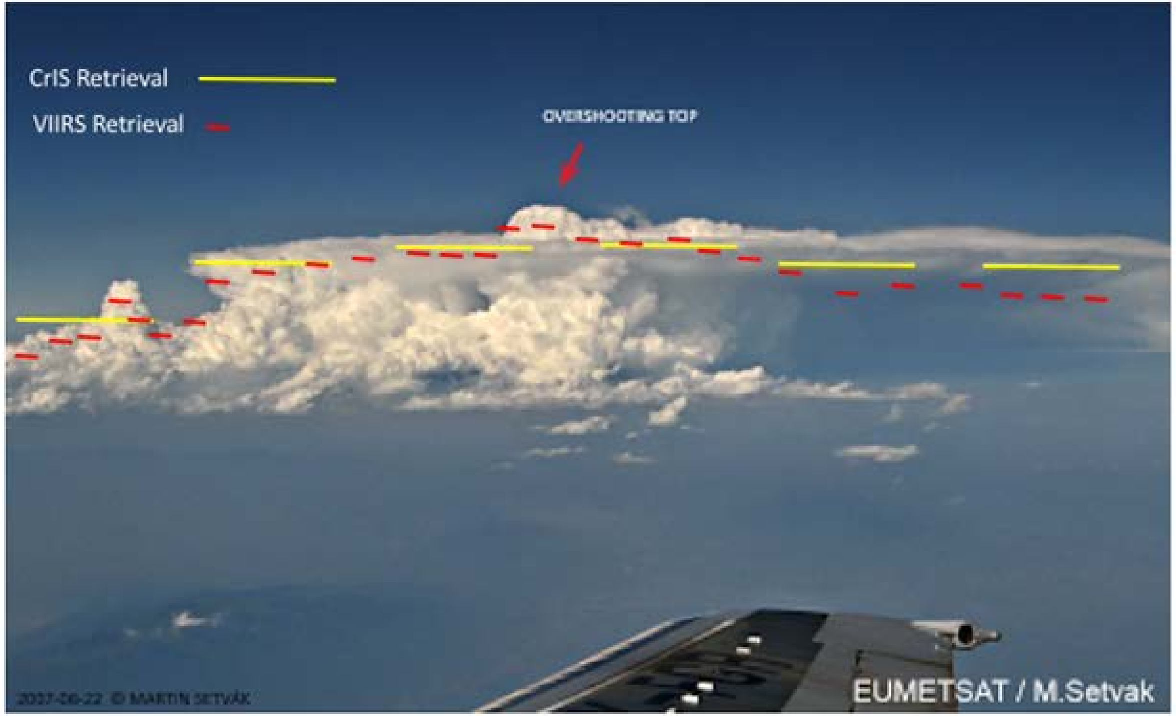
Thanks to Nadia Smith for NUCAPS guidance

Introduction

- **Many studies have used imager and sounder data together.**
- Most (ie. Jun Li, Brian Kahn, Likun Wang, Jim Jung) have all used imager observations to improve sounder cloud or radiance products.
- The “Fusion” concept of E. Weisz et al. is another way to downscale sounder radiance data to the imager spatial resolution (See talks by Brian Baum, Mike Foster).
- **Here we attempt to use the Sounder Products from the NUCAPS system on CrIS to improve the Imager (VIIRS) cloud products.**
- The resolution of the imager is needed for some applications such as on the derivation of cloud drift winds.
- **We focus on Arctic since that is where VIIRS Polar Winds exist.**
- Our focus will expand to global for to support SNPP/N20 Winds.

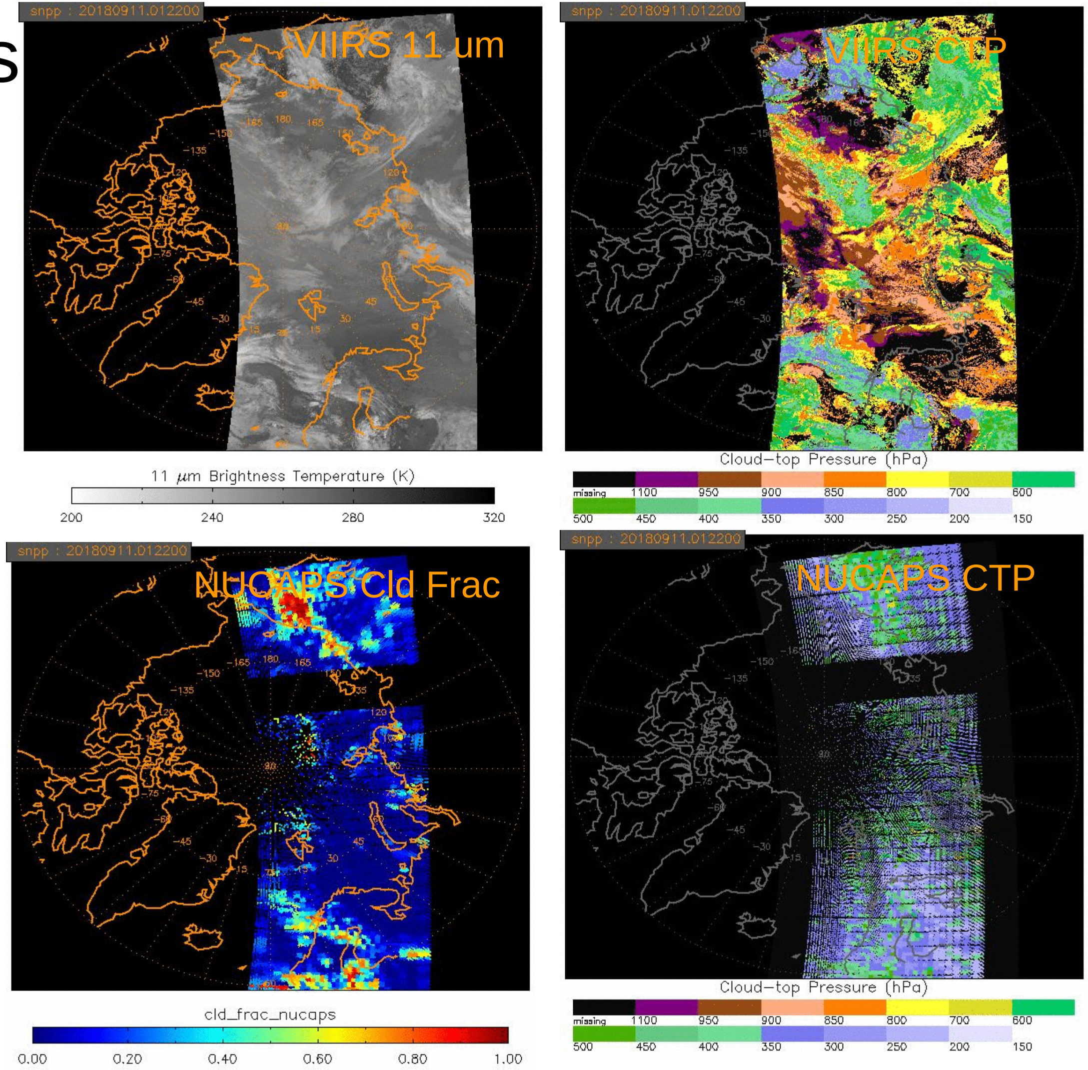
What are We Trying to Do

- CrIS is a hyperspectral IR sounder that makes an accurate cloud height products at coarse spatial resolution.
- VIIRS provides excellent spatial resolution buts its poor IR spectral resolution limits its accuracy for cloud heights for thinner clouds.
- The hypothetical example illustrates our goal
- ***Exploit the Spectral Information of CrIS while maintaining the Spatial Resolution of VIIRS.***



NUCAPS Products

- NUCAPS uses the hyperspectral observations of CrIS to derive cloud pressure and fraction in up to 2 layers.
- We only use the top layer and that is what is shown here.
- NUCAPS often reports of cloud top pressure when the cloud fraction is every small.
- ***At first glance, it is not obvious how to fuse NUCAPS cloud pressures and cloud fractions with VIIRS.***



SNPP Data September 16, 2018

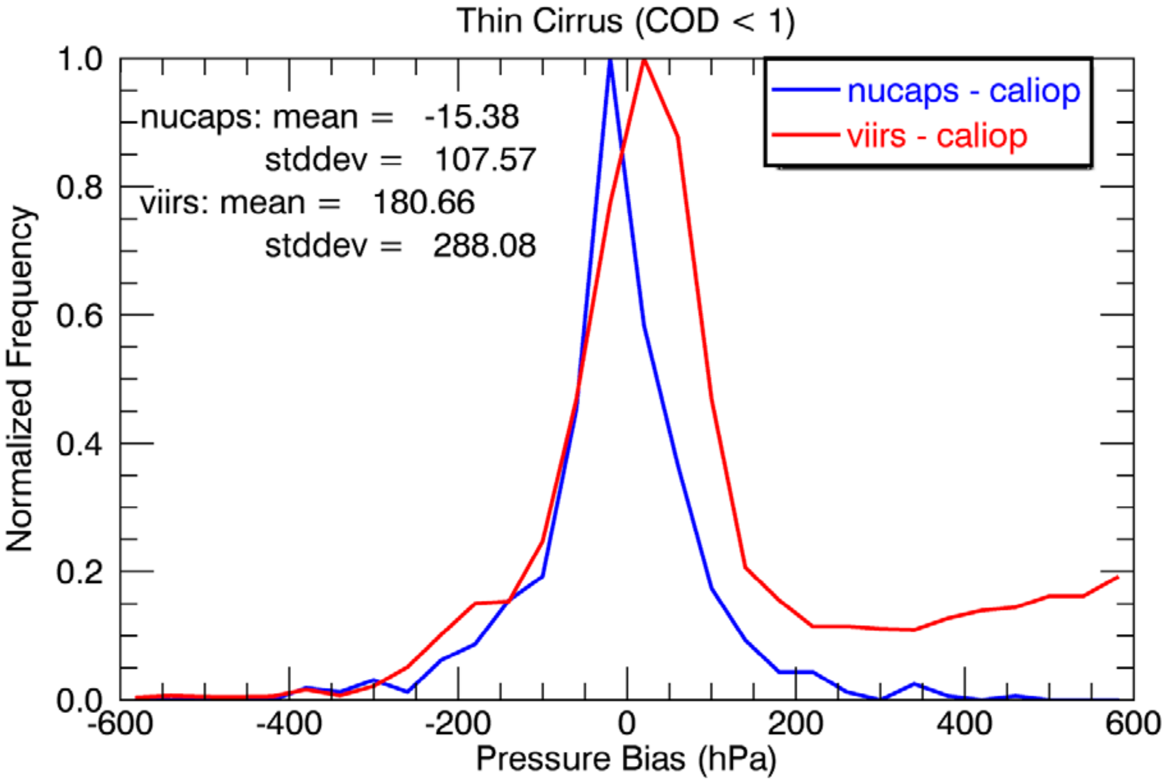
NUCAPS Cloud Pressure Performance

However ...

if one filters the NUCAPS data with cloud fraction > 0.2 and compares to the NASA CALIPSO/CALIOP products, the accuracy of the NUCAPS cloud top pressure is very good and superior to VIIRS.

In addition, the NUCAPS product behaves well for thin cirrus in difficult regions.

NUCAPS offers an ideal data-set to fuse with VIIRS.

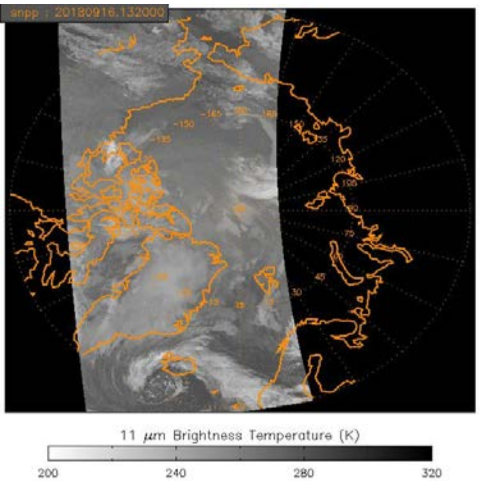


Methodology (*still being developed*)

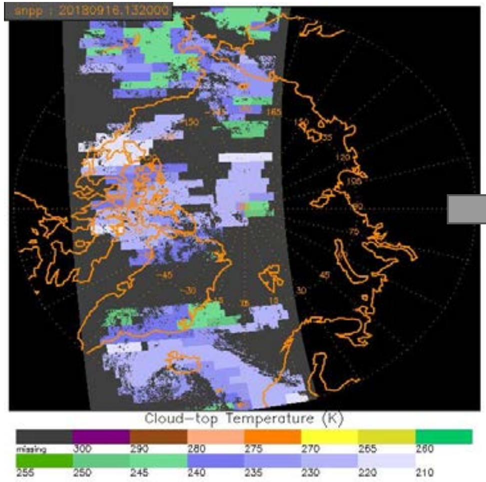
- Colocate the NUCAPS Cloud Pressure and Cloud Fraction to VIIRS using tools from UW/SSEC (Gregg Quinn)
- Throw away values with NUCAPS cloud fraction < 0.2
- Convert NUCAP cloud pressures to cloud temperatures
- Determine ice pixels using VIIRS cloud phase and NUCAP cloud temperatures.
- Spatially spread the NUCAPS ice cloud temperatures to surrounding pixels.
- Use the smoothed NUCAPS ice cloud temperatures as an a-priori constraint in the VIIRS Optimal Estimation (O.E.) cloud height retrieval.

Methodology Example

VIIRS Observations

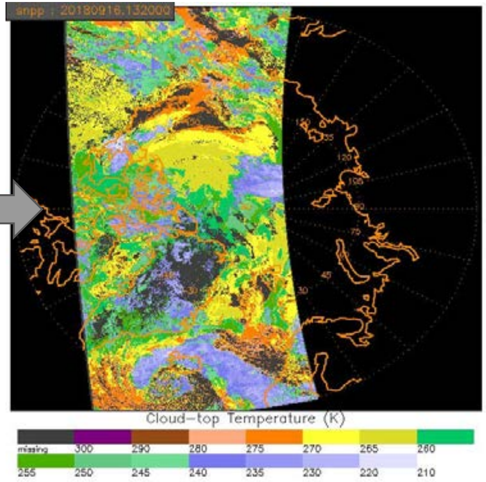


NUCAPS Smoothed Ice Cloud Temperature



NOAA Ent. O.E ACHA (*aka the algorithm*)

VIIRS Cloud Temperature



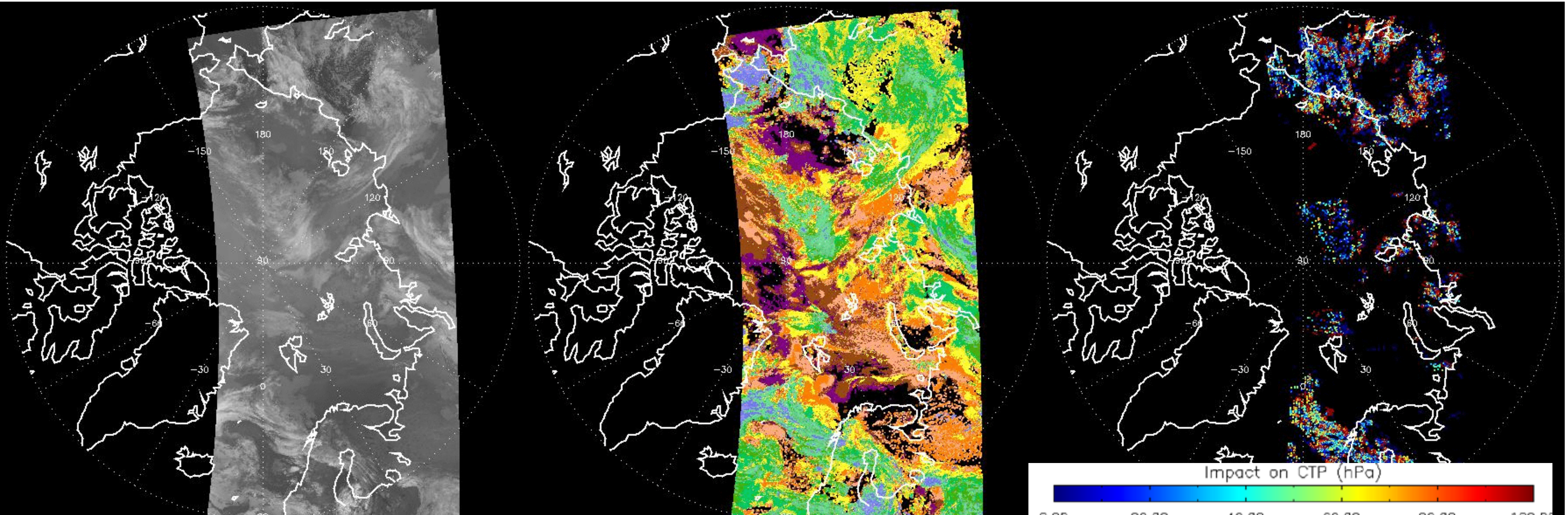
NUCAPS replaces previous ***a-priori*** values from CALIPSO/CALIOP climatology

Impact of NUCAPS on VIIRS Heights

VIIRS Observations

VIIRS Cloud Pressure Using NUCAPS as a Prior

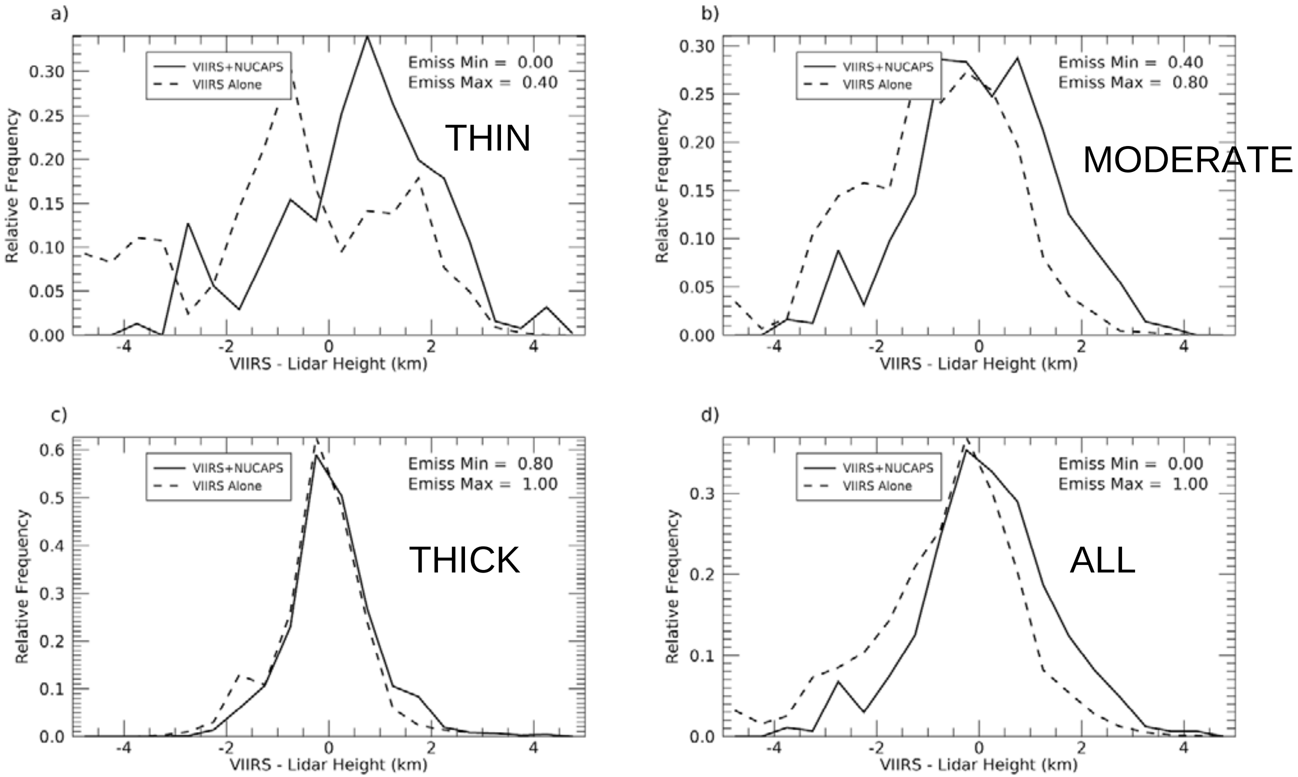
Difference in VIIRS Cloud Pressure Using NUCAPs Prior



CALIPSO/CALIOP Inferred Impact

- CALIPSO/CALIOP provides a direct measure of cloud height.
- If we adjust for IR weighting functions, we should have little bias.
- We expect the NUCAPS data to have big impact for thin clouds.
- We expect little impact for thick clouds.
- This what we see so we are confident NUCAPS moves VIIRS in the right direction.

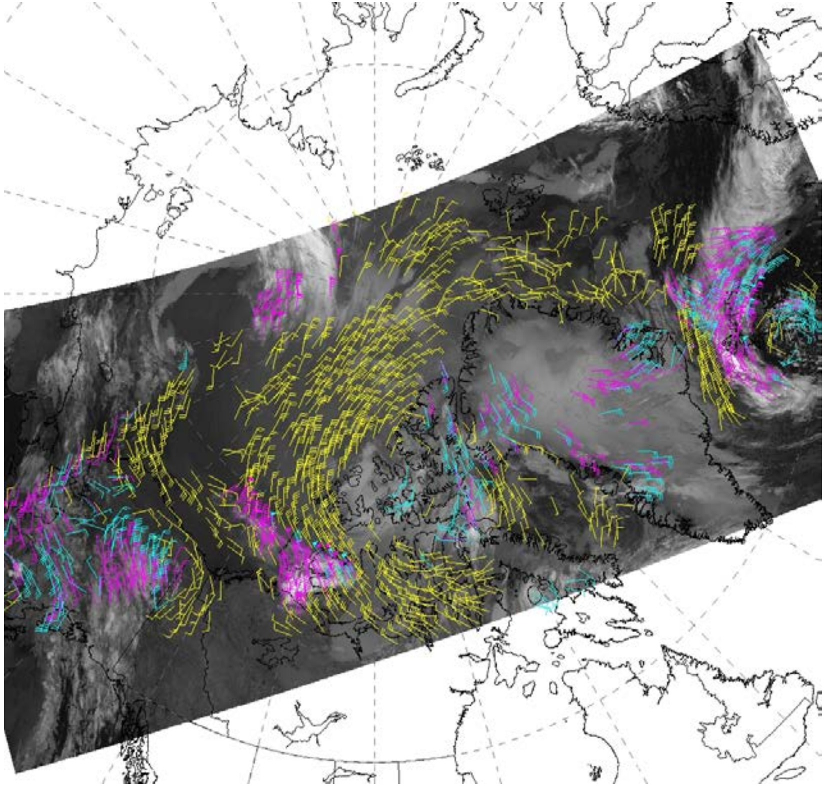
CALIPSO/SNPP Co-locations in the Arctic for September 11, 2018



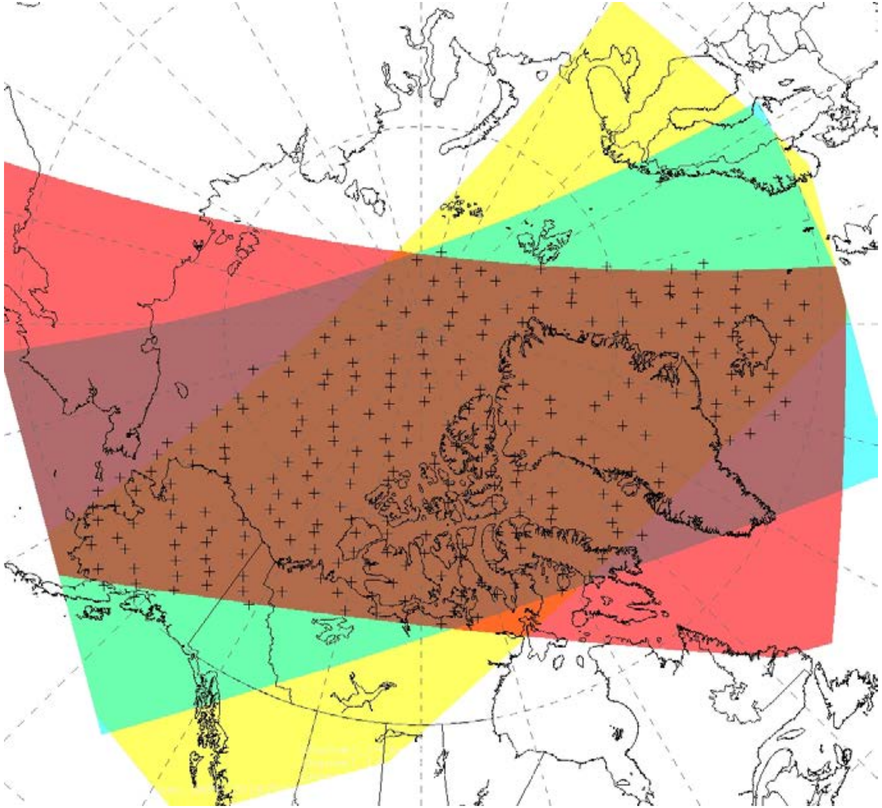
NOAA Polar Winds

VIIRS Polar Winds are derived by tracking clouds features in the VIIRS longwave infrared channel (M15).

- Wind speed, direction, and height are determined throughout the troposphere, poleward of approximately 65 degrees latitude in cloudy areas only.
- Wind information is generated in both the Arctic and Antarctic regions.
- The algorithm utilizes the Enterprise cloud mask, phase, height, and winds software.

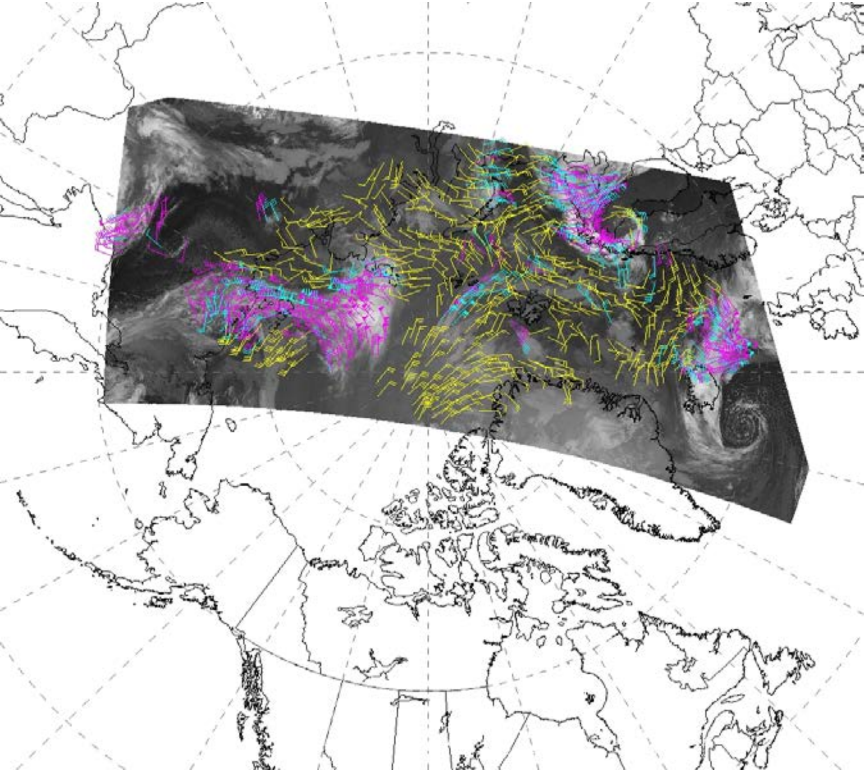


NOAA Polar Winds



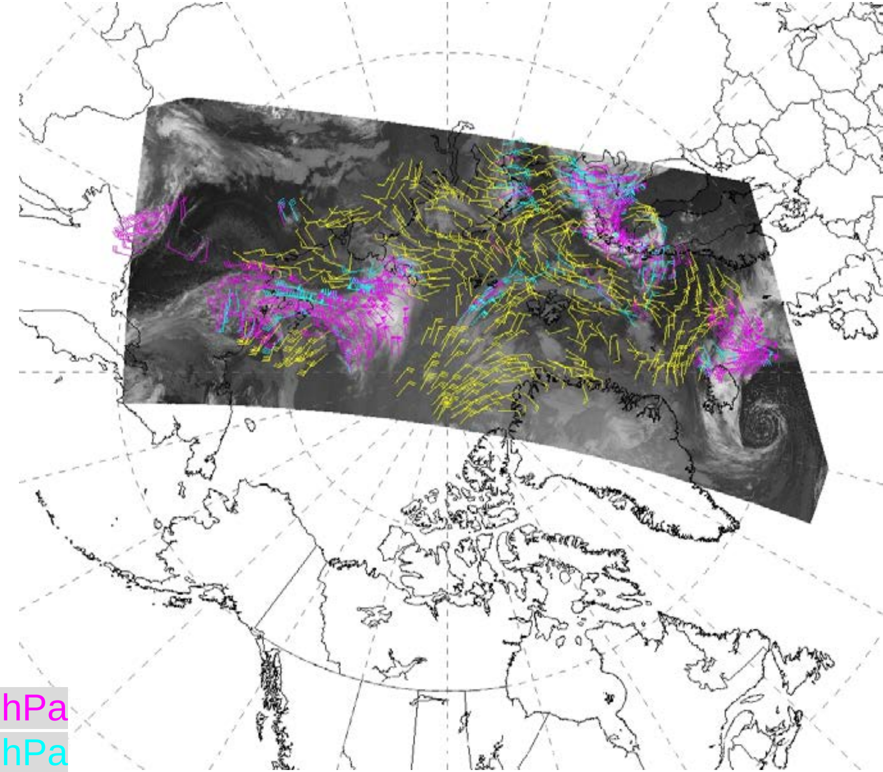
- Image triplet is used.
  - September 19, 2018
- Time steps approximately 101 minutes apart.
  - 1125 + 1306 + 1147 UTC
- Each pass contains 12-13 VIIRS granules.
- Brown region is the overlap between all 3 images.
- Plus signs are the AMV locations.

A Day of Arctic AMVs from September 16, 2018



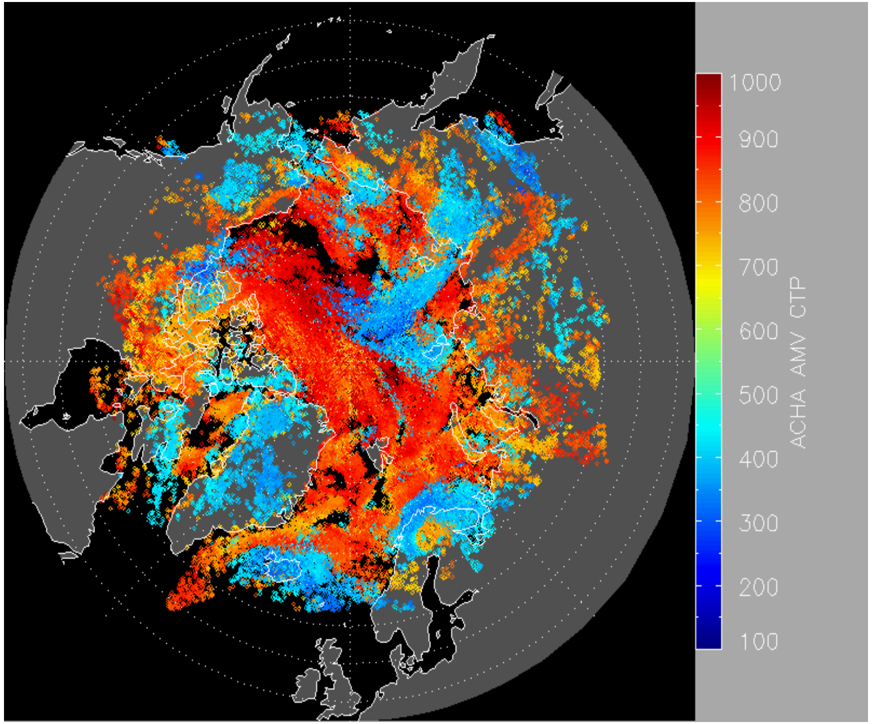
NO NUCAPS

100 - 400 hPa
400 - 700 hPa
> 700 hPa

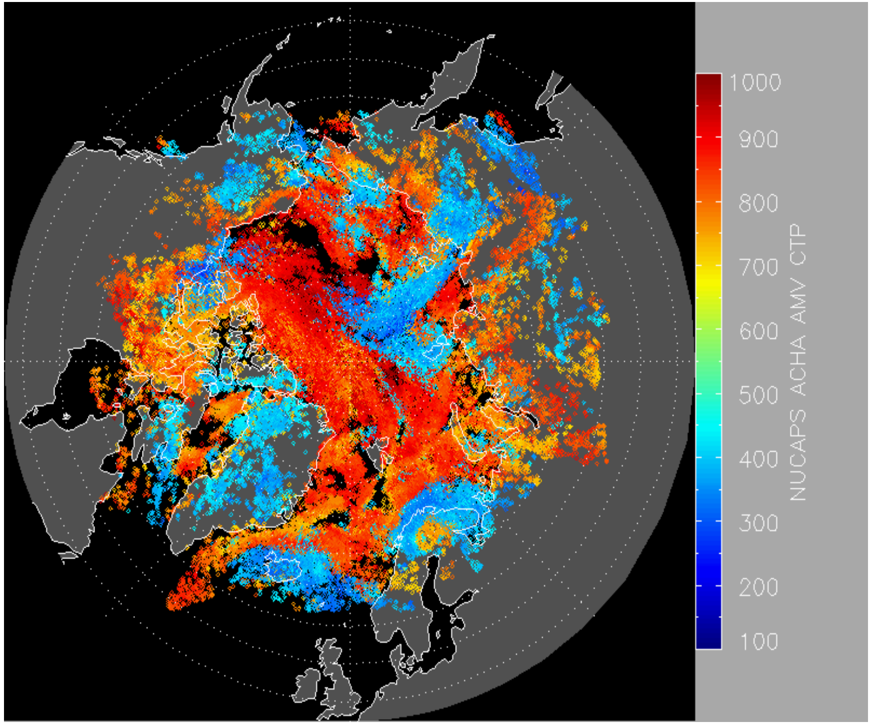


WITH NUCAPS

AMV CTPs from September 16, 2018



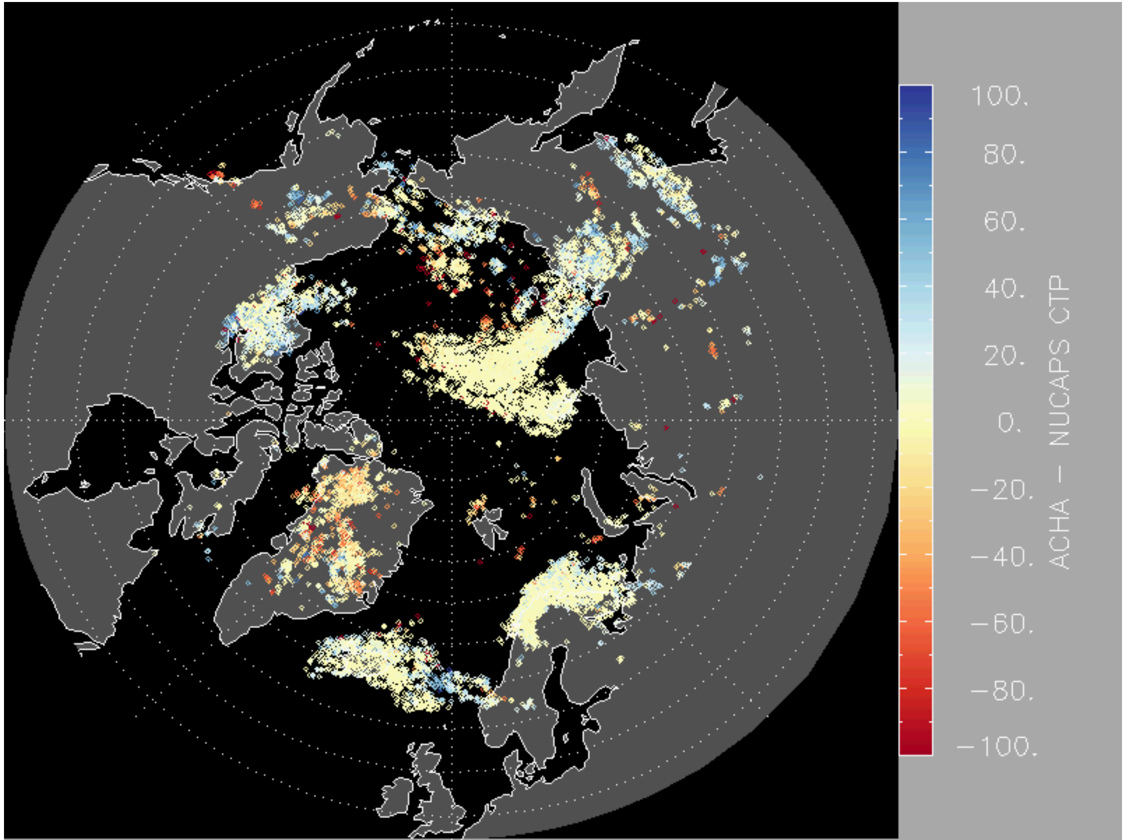
NO NUCAPS



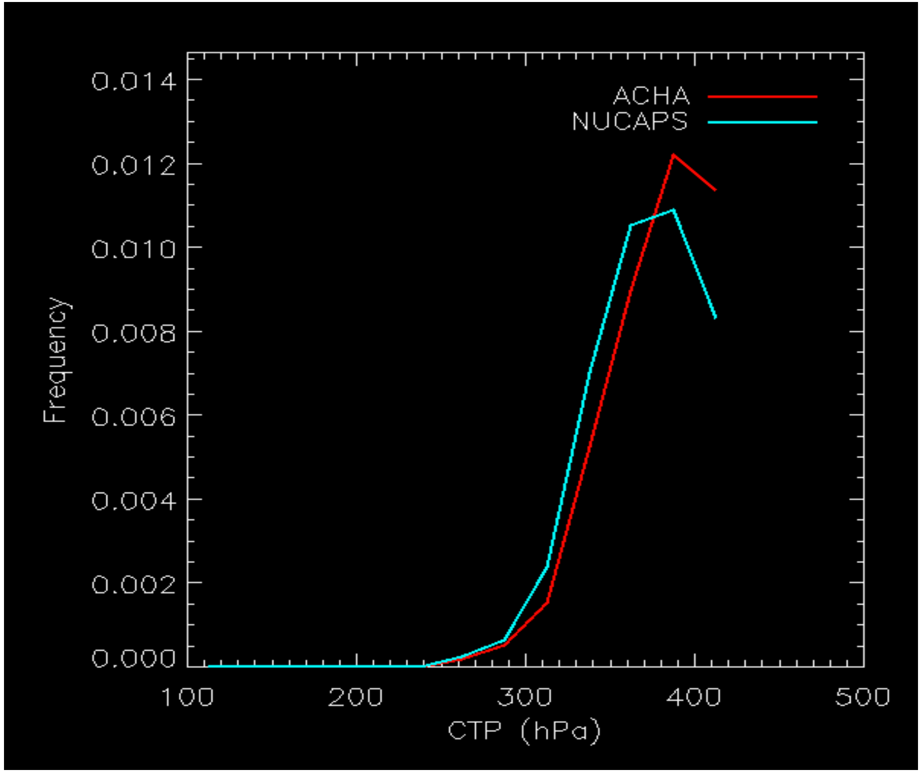
WITH NUCAPS

ACHA - NUCAPS AMV CTP (upper levels)

- ACHA - NUCAPS for all data on September 16, 2018.
- For clarity, only the differences in the 100 - 400 hPa range are shown.
- The negative outliers still need to be investigated as we expected mostly positive differences.



AMV CTP histograms



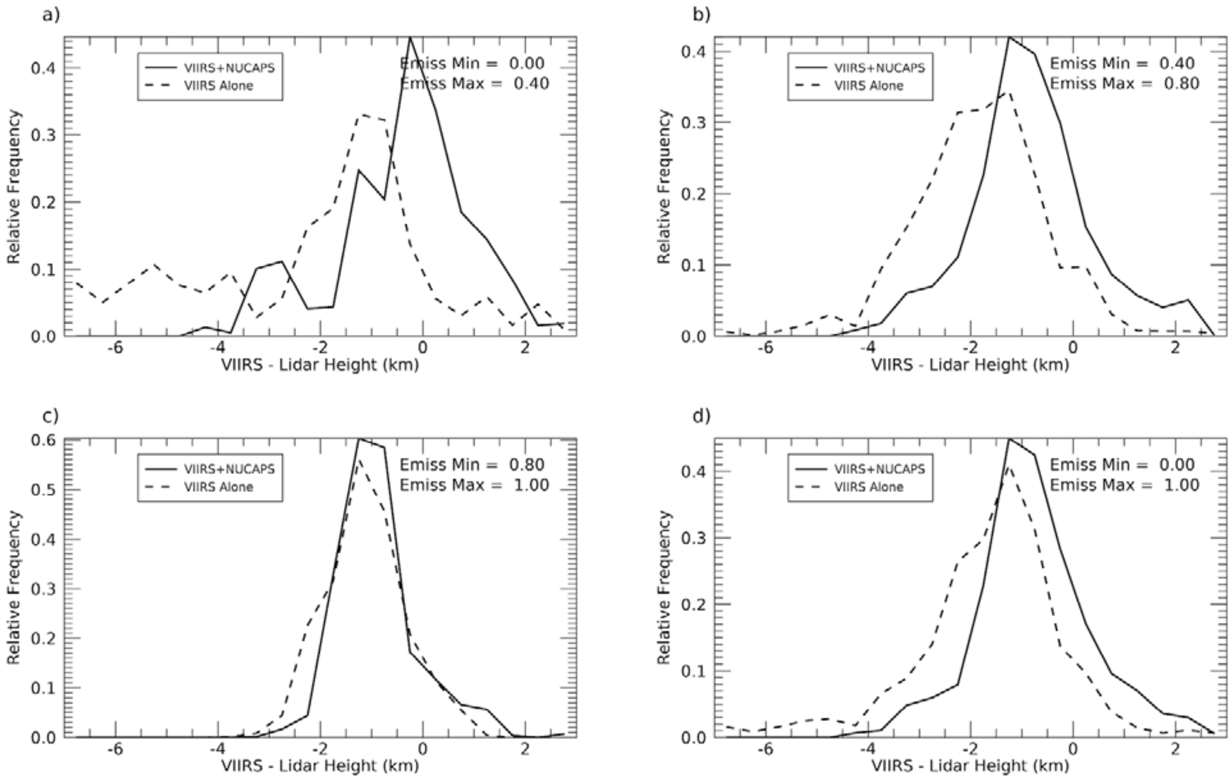
- Histograms of upper level (100 - 400 hPa) AMV CTPs for September 16, 2018.
- The NUCAPS AMVs have been shifted higher in the atmosphere as expected.
- More data sets and RAOB validation is needed.

Conclusions

- NUCAPS provides a beneficial constraint on cloud height to the NOAA Enterprise O.E. Cloud Height Algorithm (ACHA).
- We focused on the Arctic because our need is great there and the NOAA Polar AMVs provide a relevant application.
- The process works and we do see improved heights (via CALIPSO) and impacts on the AMVs.
- We expect bigger impacts in the Tropics where cirrus are pervasive and we hope will impact the SNPP/NOAA-20 AMVs.
- Need a larger sample of AMV datasets to compare to CALIPSO and RAOBs.
- We will finalize our methodology this year and we thank the JPSS-RR project.

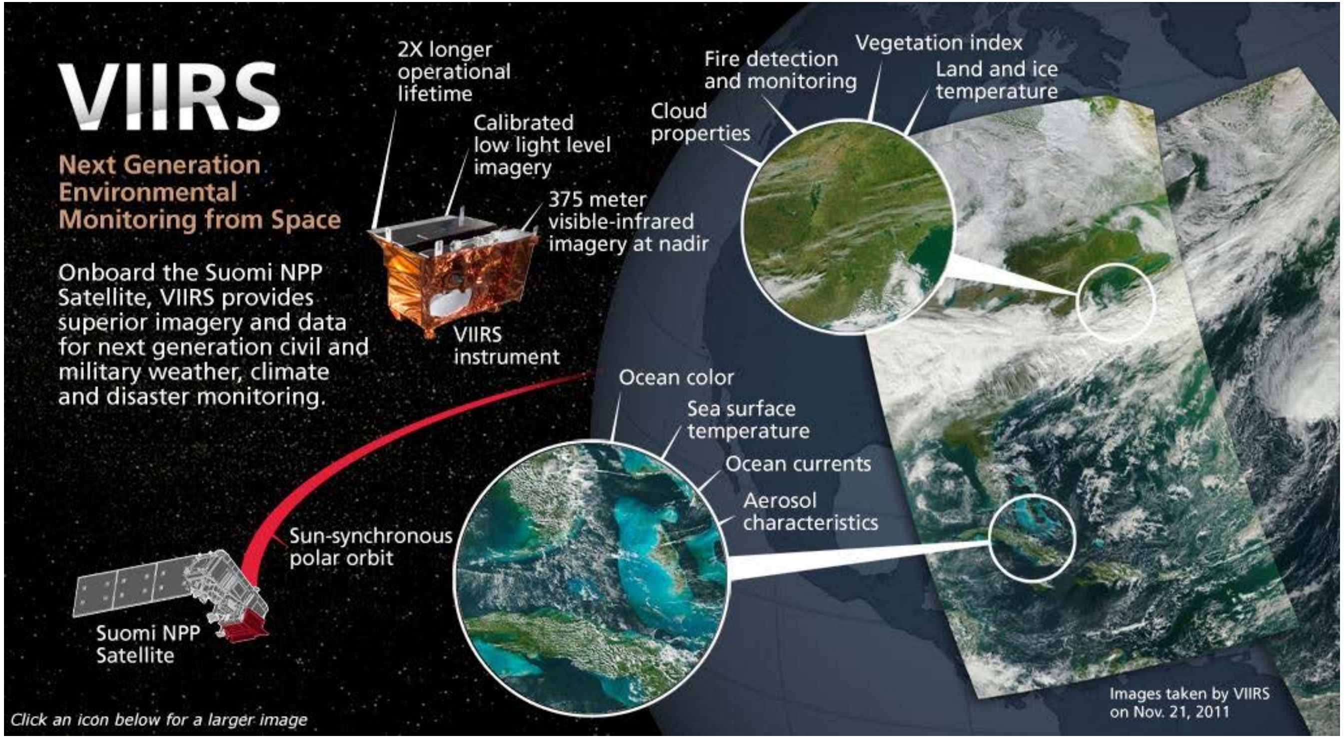
Extra slides

Performance against uncorrected CALIOP



VIIRS Instrument

16 M-bands (750m); 5 I-Bands (375m); 1 DNB Band (750m)



Copied from Raytheon Website

CrIS Operational Concept