VIIRS Cloud Product Status

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Outline

1. NDE Status

1. Performance

1. User Feedback

1. Cloud Team’s Role in Alaska Cloud Demo

1. New Activities

NDE Status and Algorithm Maturity

NDE/STAR Cloud Production Status & Delivery

Algorithm	Suomi NPP	NOAA-20
February 2018 DAP August 2017 Science Code delivery **(v1r2)**	**NDE** **Currently in Operations since 1200UTC on 13 August 2018**	**NDE** **Currently in I&T since 28 March, 2018** (Ops after NOAA-20 provisional)
August 2018 DAP February 2018 Science Code delivery (**v2r0**)	**STAR** Systematic production since June, 2018 **NDE** Delivered in Aug 2018 (I&T after NOAA-20 provisional)	**STAR** Systematic production since June, 2018 **NDE** Delivered in Aug 2018 (I&T after NOAA-20 provisional)
Jan/Feb 2019 DAP August 2018 Science Code delivery (**v2r1**)	**Delivery and development in progress** Delivery schedule provided by ASSISTT	**Delivery and development in progress** Delivery schedule provided by ASSISTT

NOAA Enterprise Cloud Maturity

Algorithm	Suomi NPP	NOAA-20
Mask	Prov	Beta
Phase/Type	Prov	
Height	Prov	Beta
Day Opt Prop	Prov	Beta
Night Opt Prop	Prov	
Base	Prov	Beta
CCL	Prov	

NOAA-20 Provisional Reviews to be held in October 2018.

NOAA Enterprise Major Issue Status

- Missing Granules
  - Will be resolved after Aug 2018 DAP is integrated to NDE I&T and Ops string (see previous slides for implementation dates)

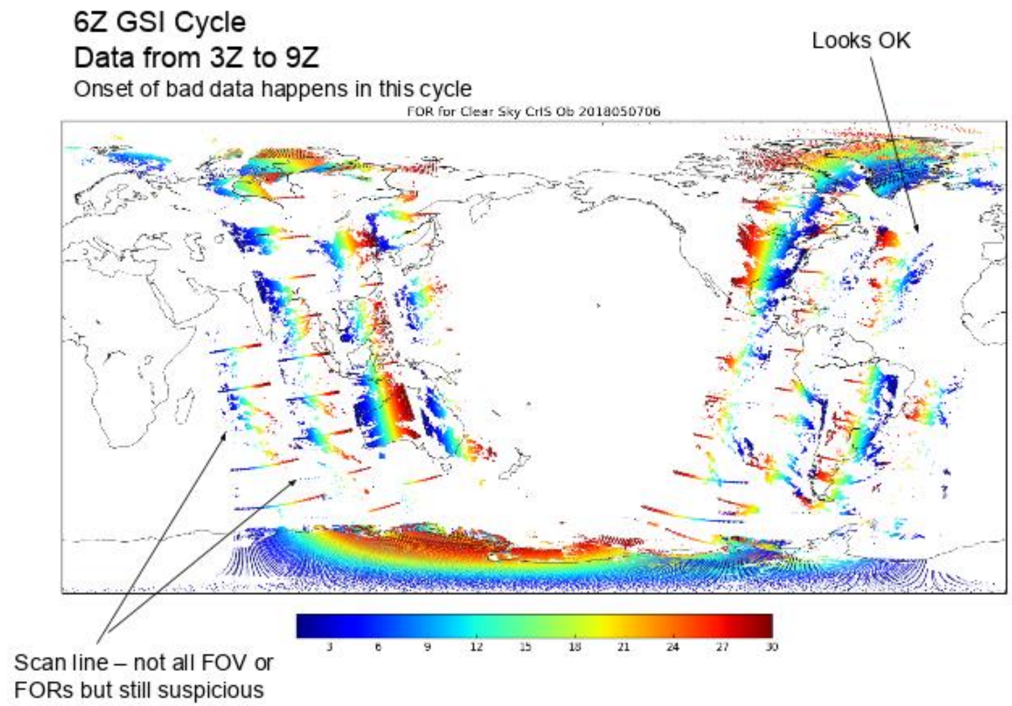
- Corrupted ECM Table
  - Solved.
  - Implemented to I&T string in June 2018 for NOAA-20 and NPP.
  - Implemented in operations for NPP at 12:00 UTC on 13 August 2018.

- M5 Calibration on SNPP

User Feedback

Use of VIIRS Cloud Products by NCEP

- NCEP uses the VIIRS cloud products to detect and characterize clear CrIS FOVs.
- Error detected due to the timeliness of an input file which could be missing. A fix has been identified and OSPO has received the required changes. Currently waiting for implementation for NPP & N20.
- Once data is corrected, NCEP will evaluate the CrIS radiance quality for data assimilation using the VIIRS cloud information.
- Potential to use CrIS/VIIRS information in CrIS radiance bias correction and/or assimilation of cloud information.



Missing files are being interpreted as clear data - NCEP won't use until this fixed.

Other External Users

- ESRL is pulling VIIRS Cloud Products from PDA. Won't go forward in testing until missing granule issue resolved. Goal is assimilation at high latitudes.
- Alaska NWS will receive VIIRS products from CSPP LEO for the Alaska Cloud Demonstration (This Fall/Winter)
- NCEP is also exploring using VIIRS cloud products to improve high-latitude ATMS assimilation.
- NCEP has also expressed interest in VIIRS All-sky Radiance (ASR) similar to the GOES-16 ASR product which uses cloud mask and cloud height.
- Cloud Mask (led by Tom Kopp) continue to poll mask users and response to feedback. Thanks to those that attended breakout on Monday.

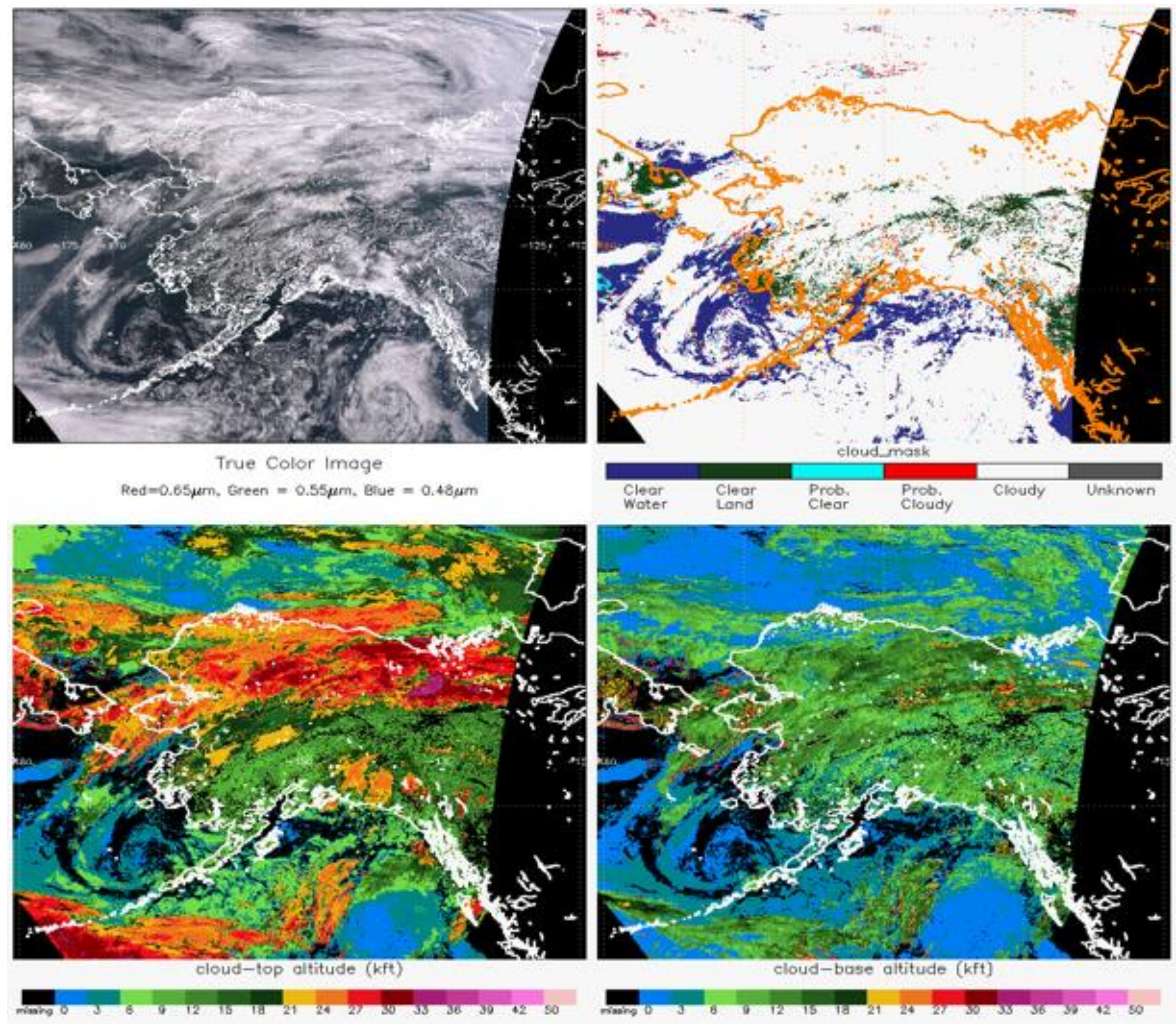
Alaska Cloud Product Demo

- Starting in the Fall 2018, the Cloud Team will support the generation of NOAA Enterprise Cloud Products from VIIRS DB Data from UA Fairbanks / GINA.
- Focus is on Aviation Support and participants will include the Alaska Aviation Weather Unit (AAWU).
- Products distributed into AWIPS and the Web via Polar2Grid.
- Product list will include
  - Cloud Top Altitude
  - Cloud Base Altitude
  - Cloud Cover Layers
  - Supercooled Water Probability
  - Precipitation (maybe)
- Key questions will be
  - Can VIIRS add anything to the model/in-situ existing capabilities?
  - How can we infuse satellite information into existing capabilities?

Cloud Demo Example: Cloud Top and Base Altitude

A day time scene from SNPP between 2248 and 2300 UTC on August 16, 2018 shows

- true color image (top left)
- cloud mask (top right)
- cloud top altitude (bottom left)
- cloud base altitude (bottom right)



Improved VIIRS Cloud Base over High Latitudes using ATMS funded by JPSS-RR (YJ Noh - CIRA)

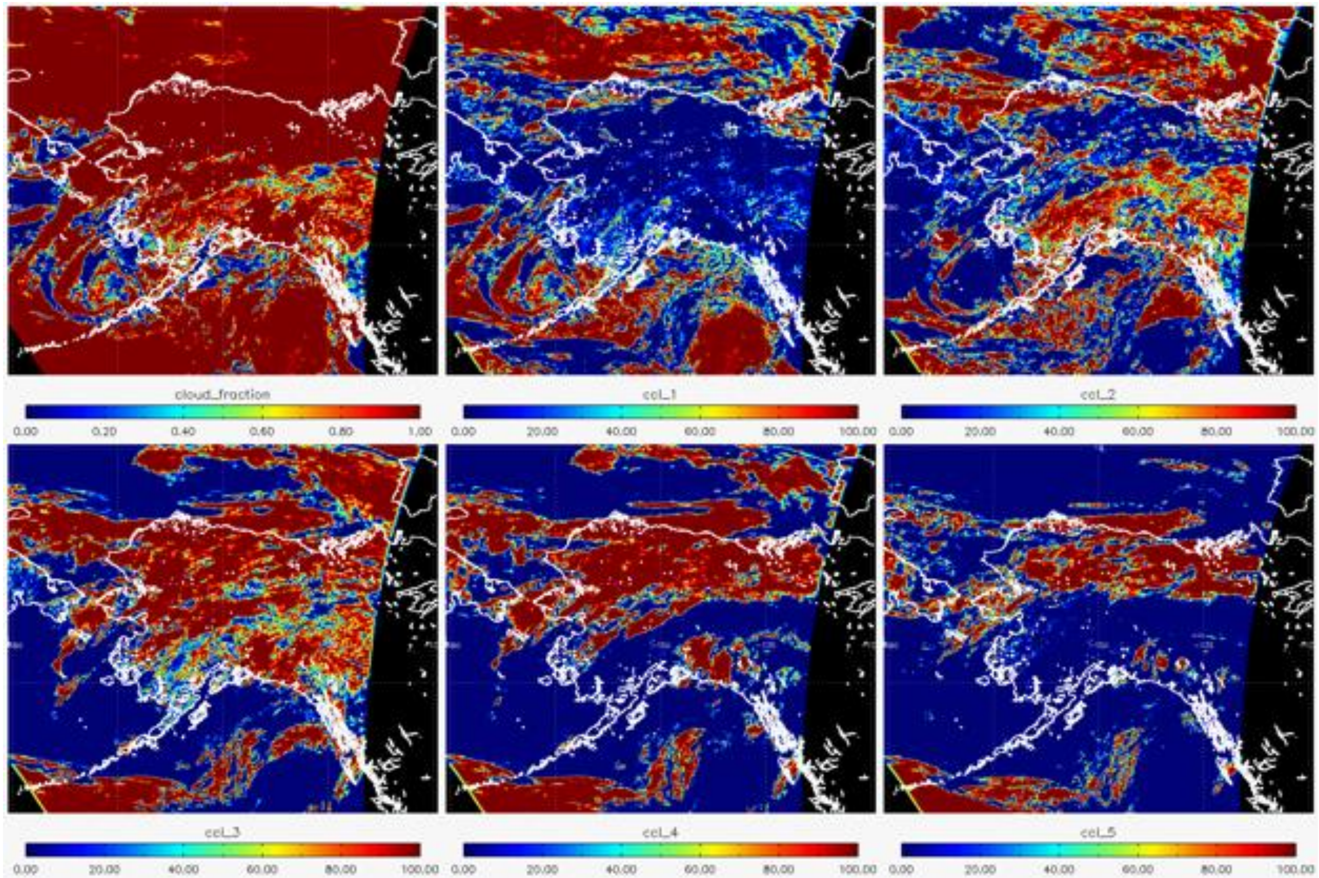
Cloud Demo Example: CCL Cloud Fraction

- Total cloud fraction (top left) and 5 layer cloud fractions indicate clouds are well distributed vertically

- The layer definitions are consistent with NOAT requirement (pressure levels are also supported)

- Layer 1 is the lowest layer and layer 5 is the highest

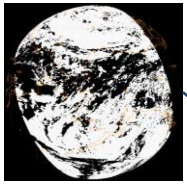
- Both cloud top and cloud base altitudes are used to identify clouds in different layers; other options (top only, top+base+lower level top) are also supported

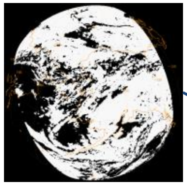


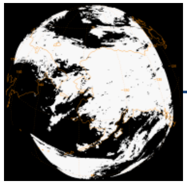
Cloud Demo Example: CCL Cloud Fraction

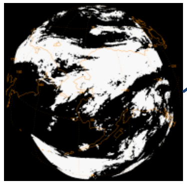
We will “demo” an RGB made from the 5 Cloud Layers defined by Flight Levels in addition to display each layer independently.

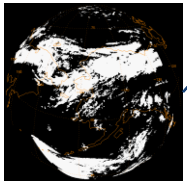
Cloud Layer

1 

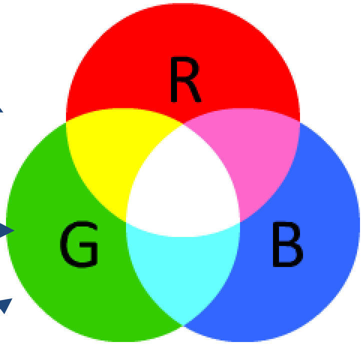
2 

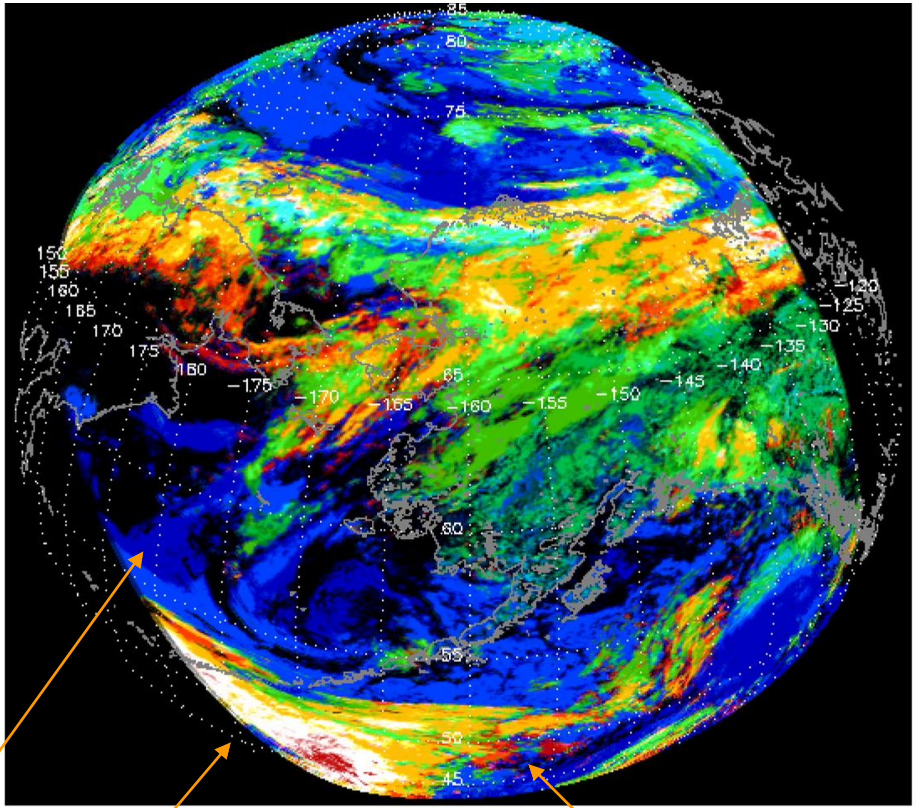
3 

4 

5 

*R = 0.75*FL5 + 0.25 *FL4*
*G = 0.25*FL4 + 0.5*FL3 + 0.25*Fl2*
*B = 0.25*FL2 + 0.75*FL1*





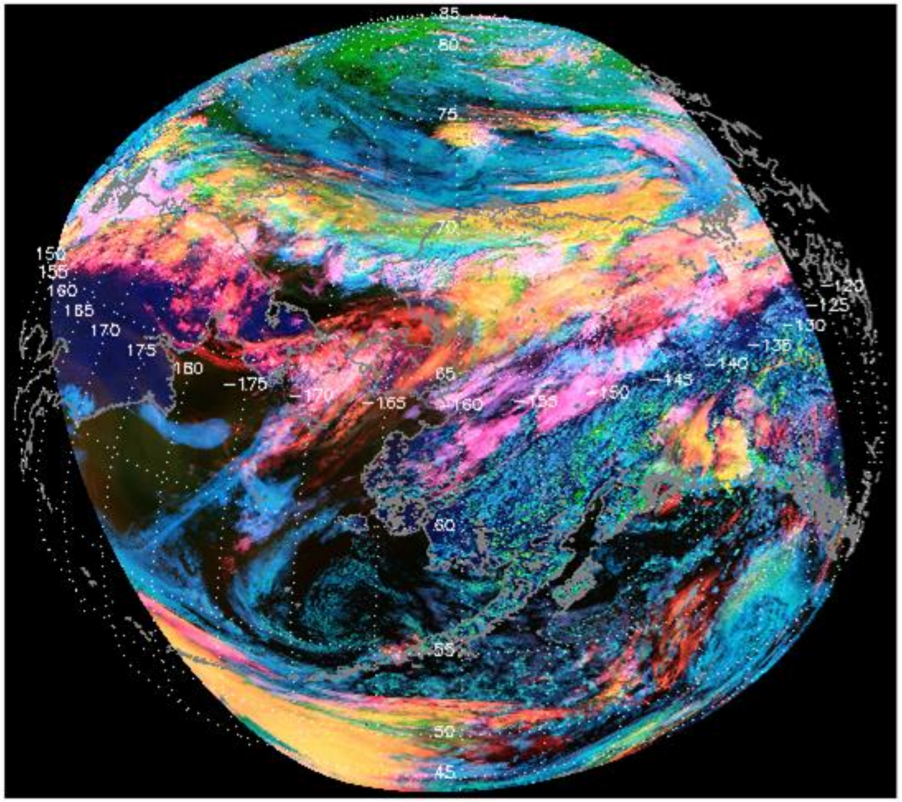
blue = unobscured low cloud

white = cloud in all layers

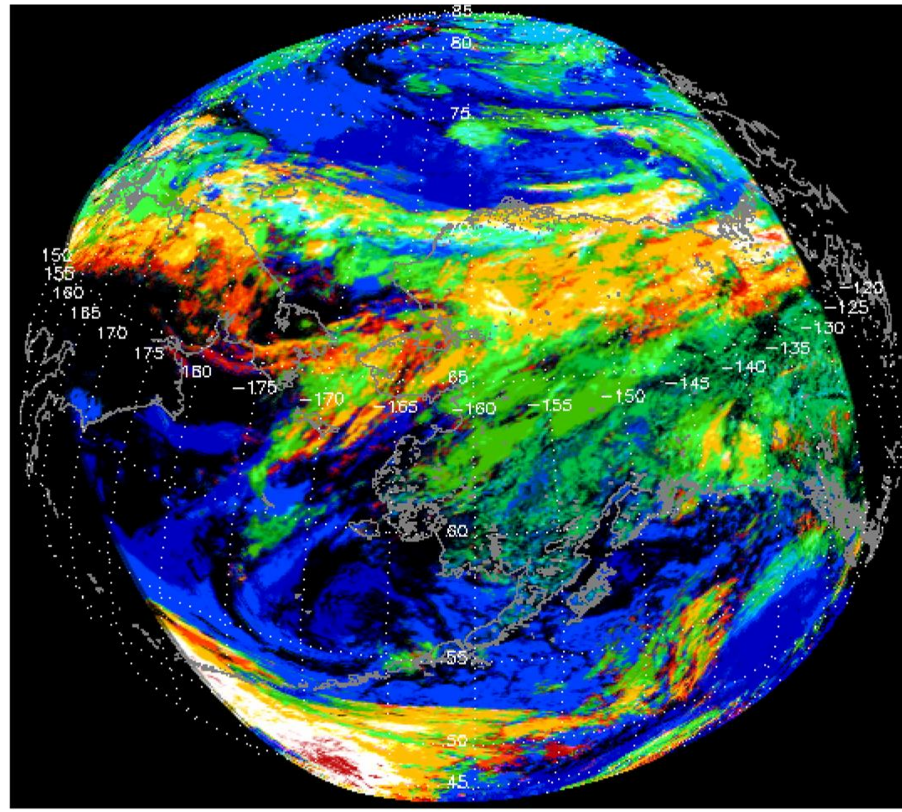
yellow = cloud in high and mid layers

Cloud Demo Example: CCL Cloud Fraction

We can compare this “cloud cover layer” RGB to an RGB using cloud height/phase sensitive channels. We’ll provide both in the Cloud Demo



RGB from Red = 1.38 micron, Green = 0.65 micron and Blue = 1.6 micron

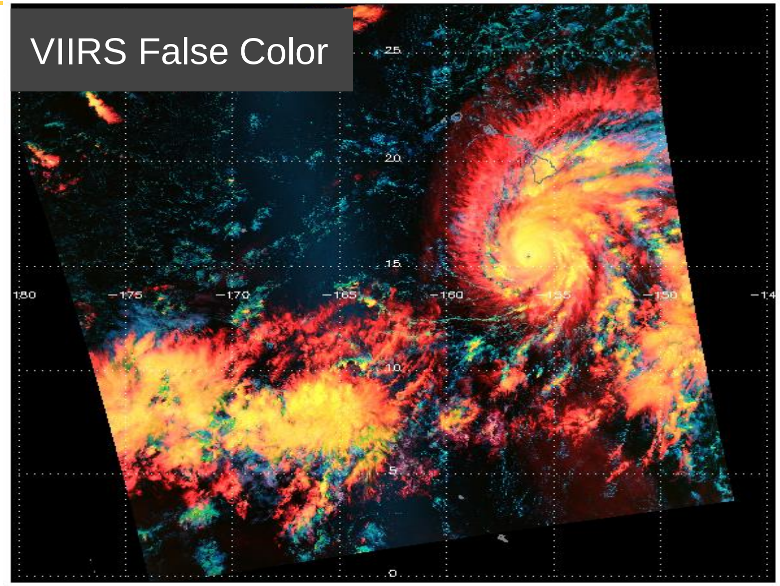


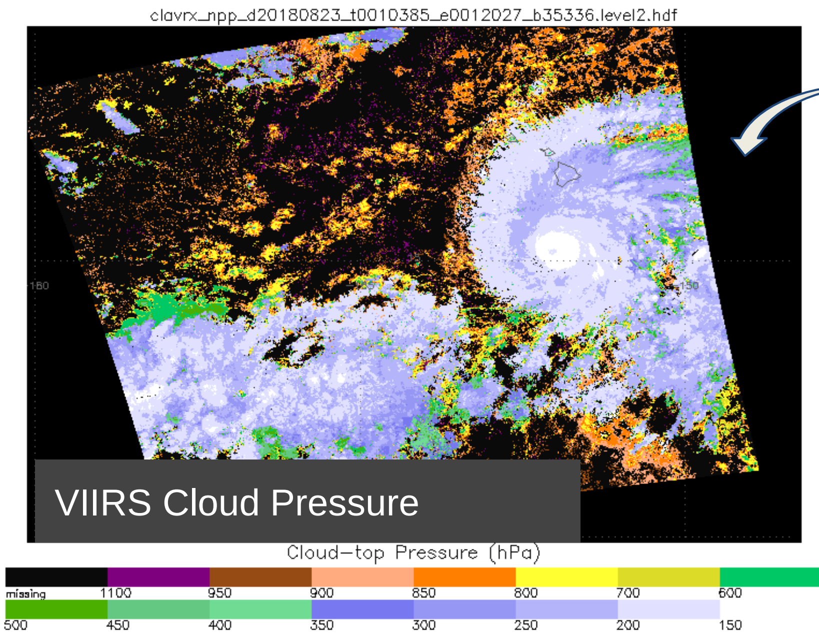
RGB from from the 5 Cloud Layer values.

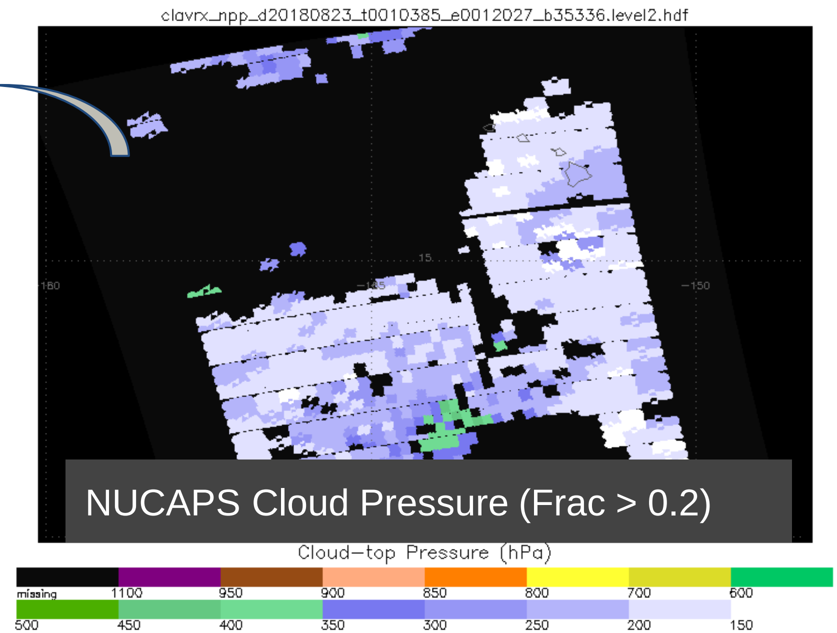
New Activities / Risk Reduction

JPSS RR: Using NUCAPS to Improve VIIRS Cloud Heights

- VIIRS Heights are used in Polar Winds, Aviation Decisions and in Assimilation.
- VIIRS has excellent spatial resolution but poor spectral resolution in the IR.
- CrIS is opposite (low spatial, fine spectral).
- JPSS RR is funding us to use the NUCAPS cloud product to improve the VIIRS products.
- ***Exploit Spectral, Preserve Spatial***

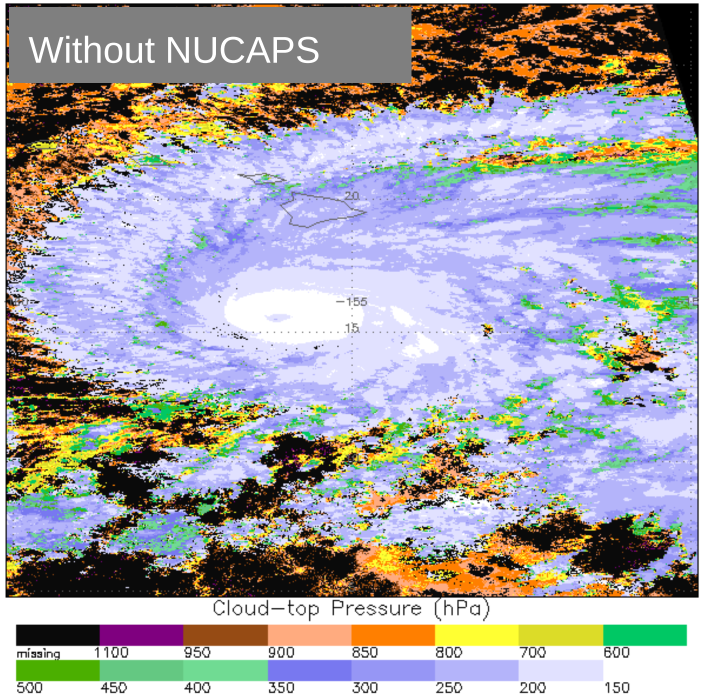






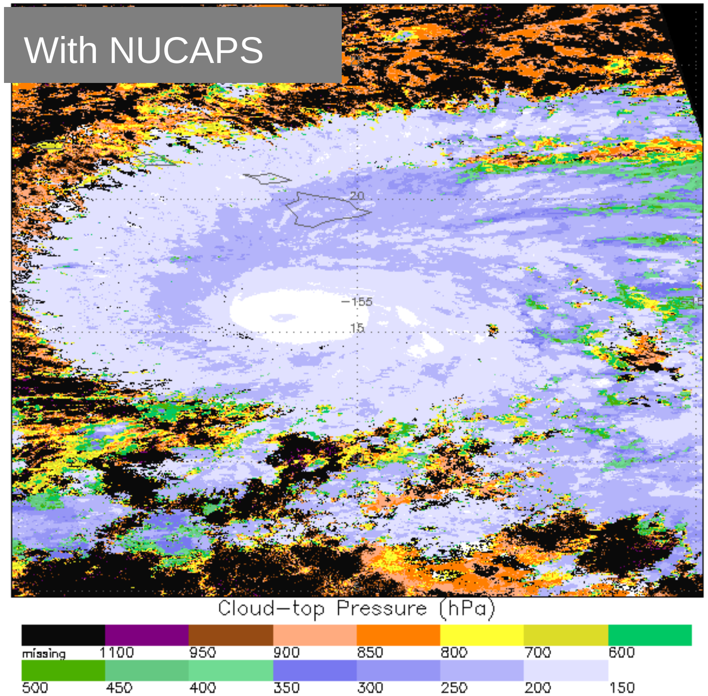
JPSS RR: Using NUCAPS to Improve VIIRS Cloud Heights

- NOAA Enterprise AWG Cloud Height Algorithm (ACHA) uses multiple imager IR bands and an optimal estimation (OE).
- OE can accept constraints from climatology or NWP.
- Here we use the NUCAPS cloud pressures and fractions as a new constraint.
- We colocate NUCAPS Edrs to the VIIRS M-bands using tools from SSEC.
- ***Initial results are promising. Just started.***



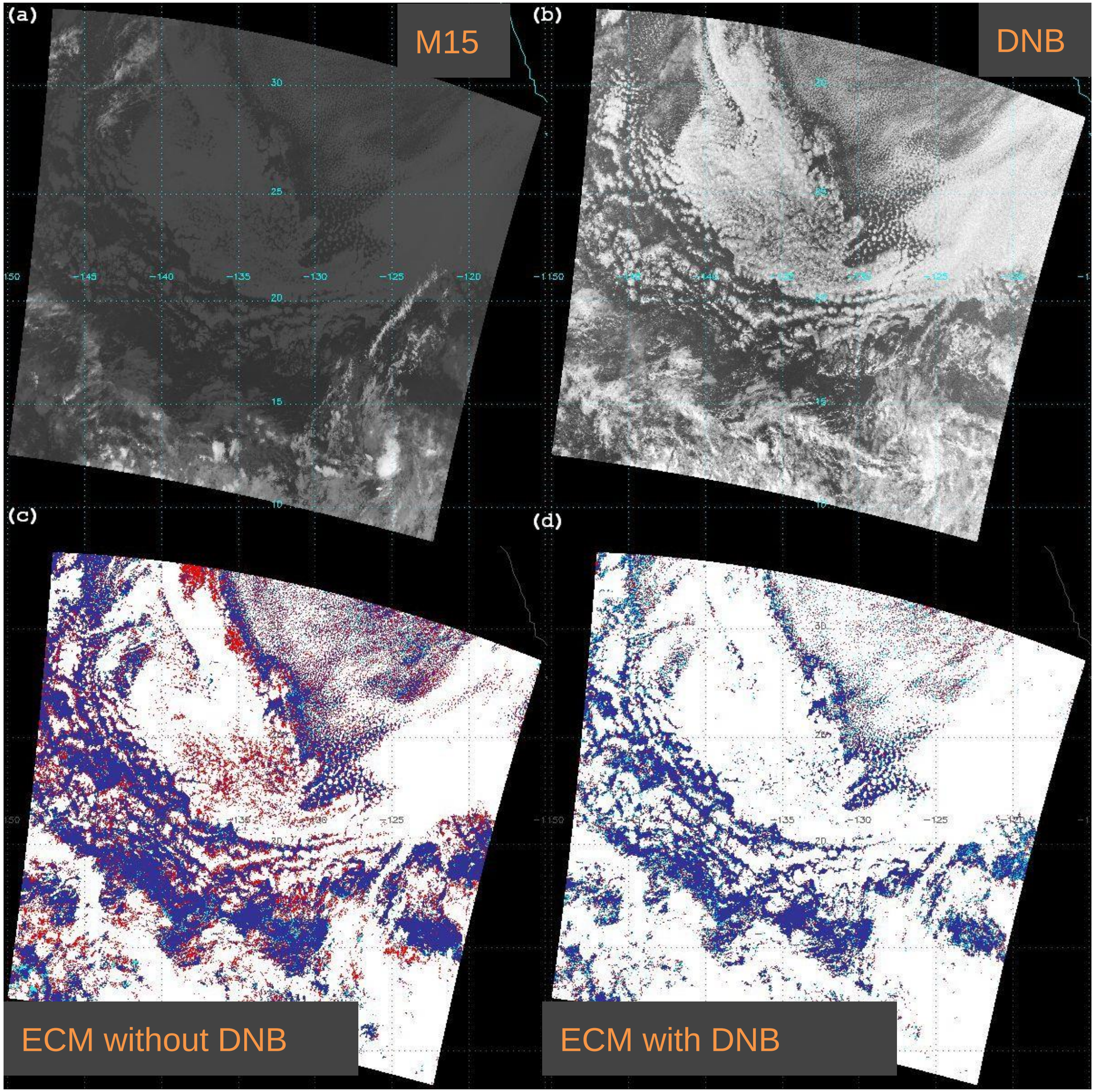
Impact is to

- ***Improve Cirrus Detection***
- ***Raise Cirrus Heights***
- ***Improve performance at cloud edges***



Impact of DNB on ECM

In the cloud mask images, red and cyan pixels are uncertain results.



Example of impact of lunar reflectance on cloud detection.

(a) shows an 11 micron brightness temperature from SNPP over the Pacific Ocean near the USA West Coast.

(b) shows the lunar reflectance for the VIIRS DNB.

(c) shows the NOAA Enterprise 4-level cloud mask without the use of the lunar reflectance.

(d) shows the NOAA Enterprise mask that uses the lunar reflectance.

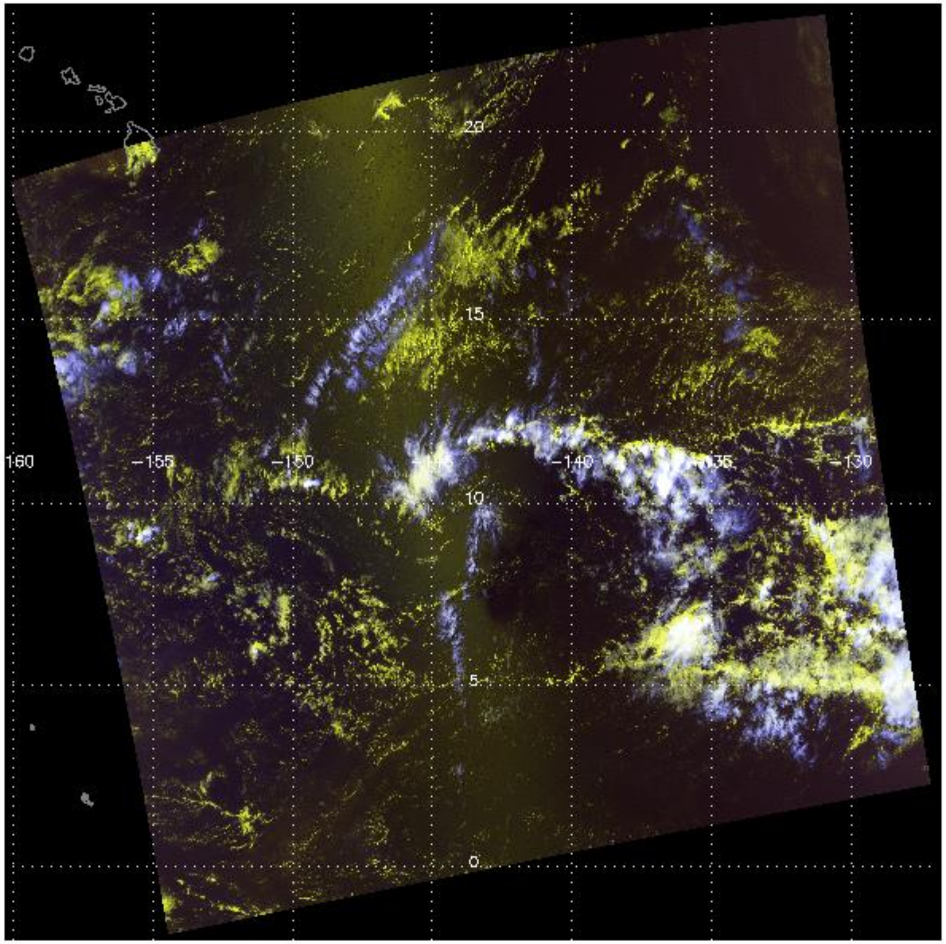
Use of the lunar reflectance greatly reduces the number of uncertain cloud detection results especially in areas of low thin clouds with fine spatial features.

Use of I-Bands in ECM

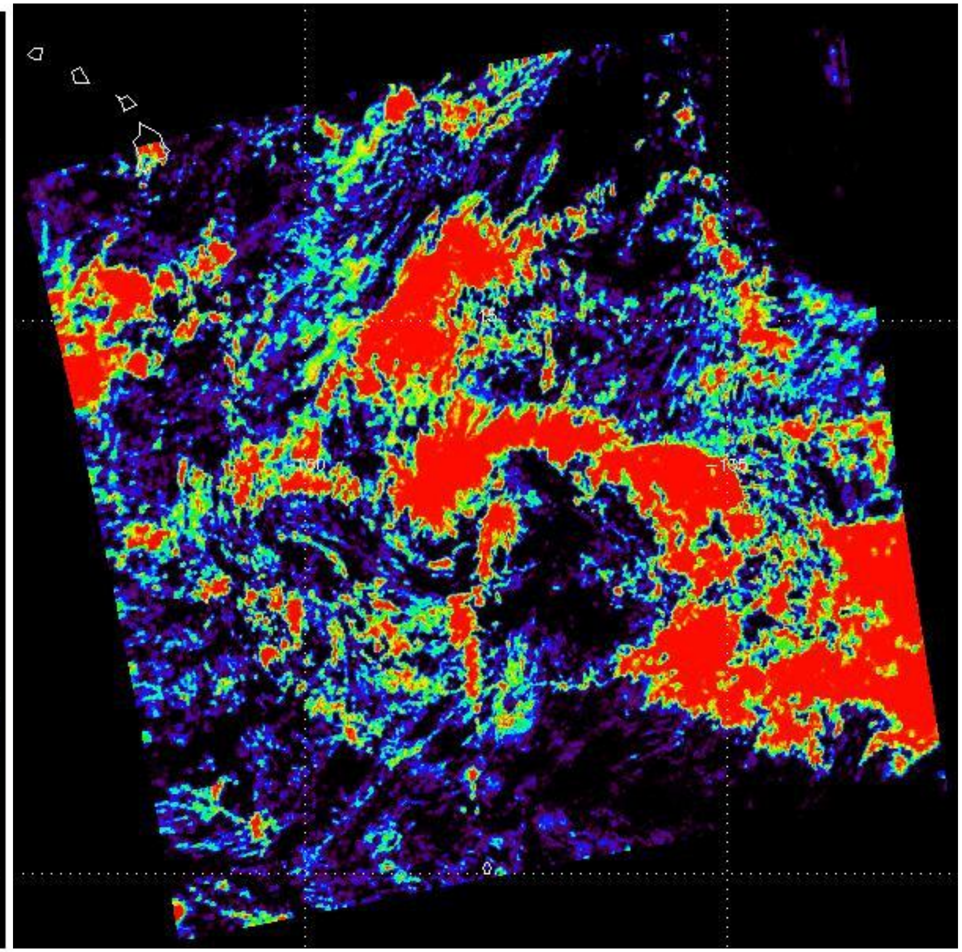
We can run the ECM using the min and max values of the analogous I-bands for relevant channels. This can greatly impact the yield of the cloud detection and benefit users.

The images show animations of 3 images. The first uses the darkest/warmest I-band, the second uses the nominal M-band s and the third uses brightest/coldest I-bands..

False Color from 0.65, 0.86 and 11 micron

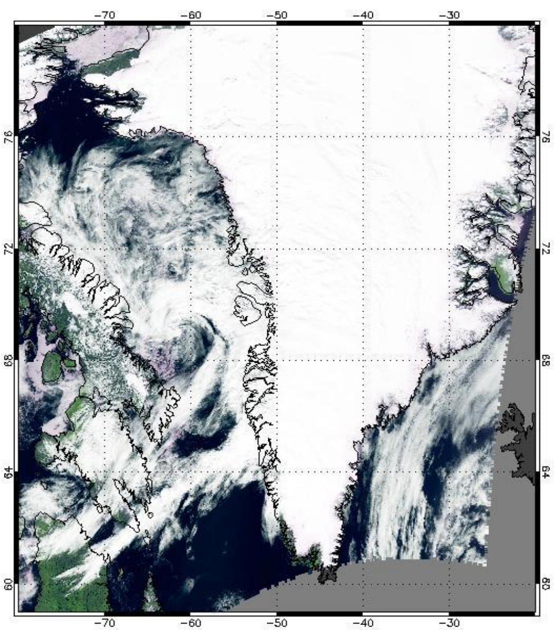


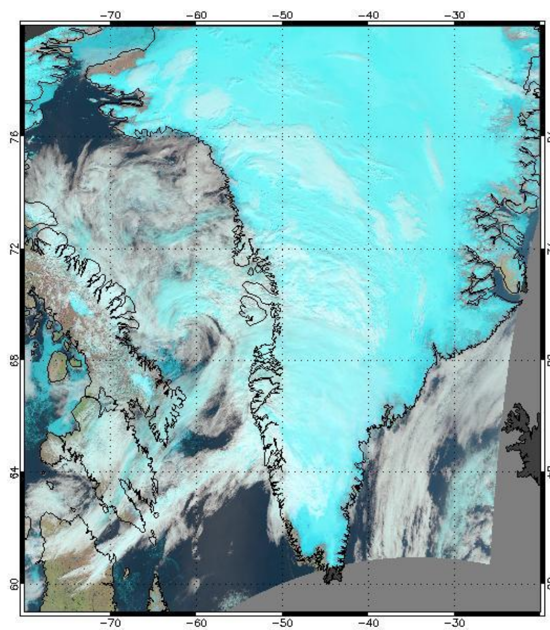
Total Cloud Fraction from CCL

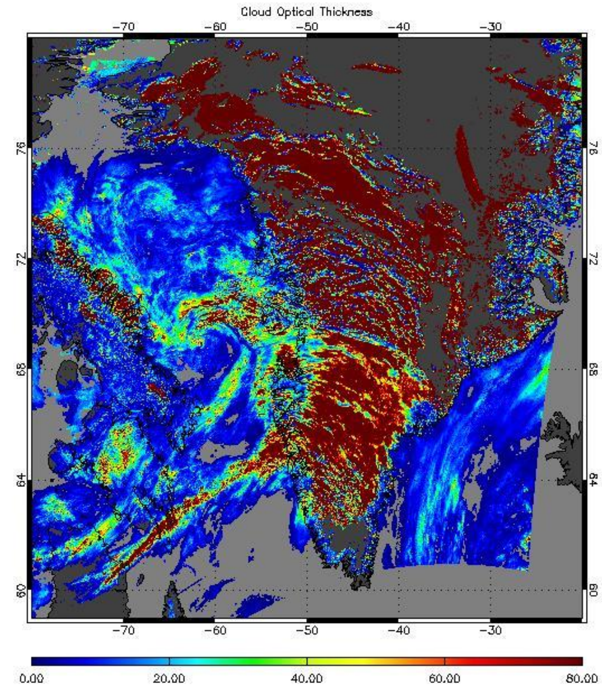


Improvements over snow and sea-ice surfaces

- Standard all-surface DCOMP runs on 0.6/2.2 micron channel combination.
- Bright snow surface made COD retrieval impossible for thin and medium thin clouds. The information depth of the algorithm is very low.







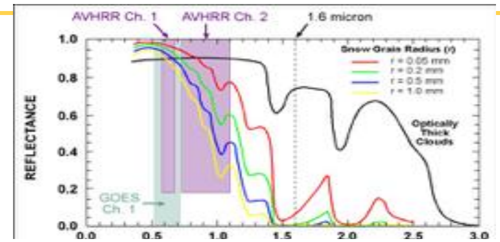
RGB [M5,M6,M11,M12] Clouds and snow surface are not distinguishable

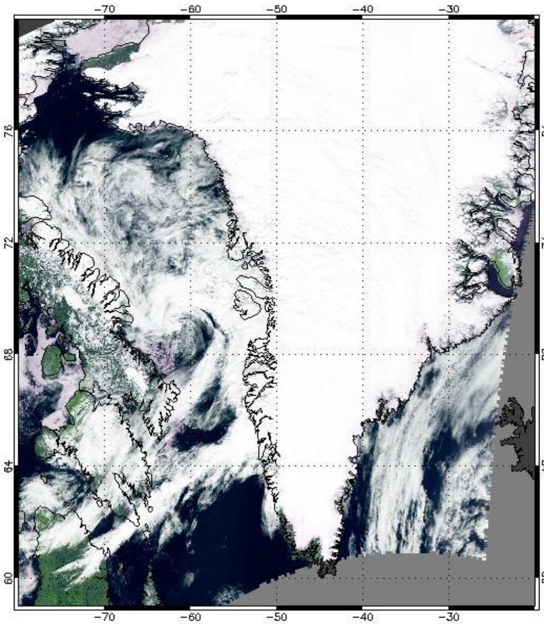
Enhanced RGB [M10,M6,M5]. illustrates how 1.6 micron channel [M10] helps separating clouds and surface.

Cloud Optical Thickness from M5/M11 (0.6/2.2 microns) approach over snow has shown unrealistic high values.

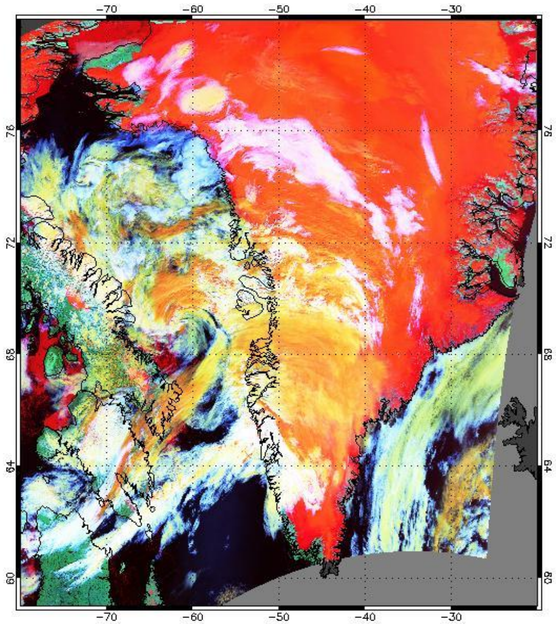
Improvements over snow and sea-ice surfaces

- Recently included approach in CLAVR-x applies 1.6/3.75 channel combination [M10/M12]. [Platnick 2001]
- Advantage: 1.6 micron channel snow reflectivity is very low
- Figure right shows typical reflectance functions for clouds(black) and different snow types

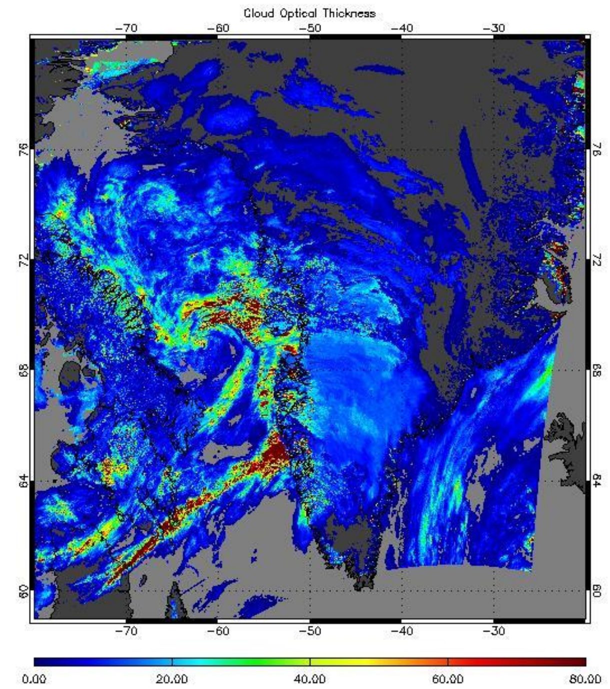




RGB [M5,M6,M15,M16]. Clouds and snow surface are indistinguishable if using only visible channels.



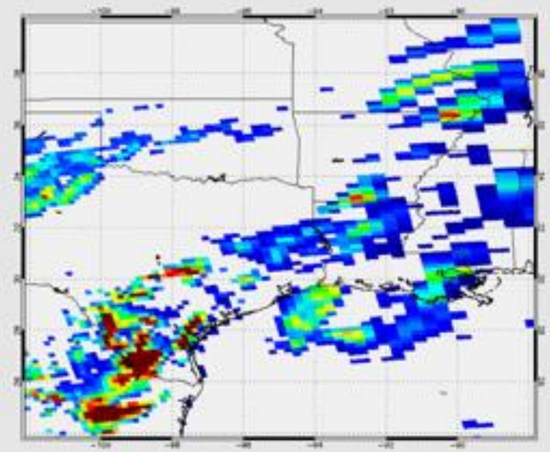
A “Snow” RGB employs channels M6(r),M10(g) M12(b)]. Snow surface appears red, clouds are white/yellish

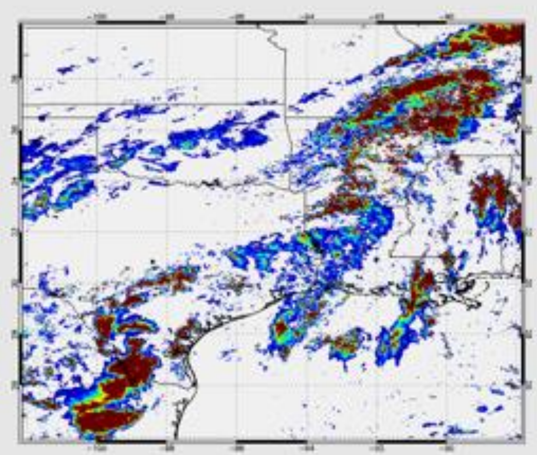


Cloud Optical Thickness images over snow show more realistic values if retrieved with 1.6 channel

Hybrid Cloud and Precipitation from VIIRS and ATMS

- **Microwave-based** (MW) rain rate retrievals such as MIRS retrieval applied to ATMS, are based on a physical approach.
- Spatial resolution is low, as well as accuracy over land.
- DCOMP and NLCOMP includes rain detection and rain rate retrieval from a **VIS/NIR approach** from VIIRS based on trained coefficients. Training linked cloud parameters COD, REF and Cloud Water path with truth data from NEXRAD.
- A **hybrid approach** uses MIRS/ATMS rain rate to adjust quantitative rain rates during processing. The method uses a factor to weight MW rain rates from ATMS, preserves the sub-pixel texture, corrects COD saturation effects for thick clouds.
- This effort enables us to analyze ATMS **sub-pixel precipitation** on a VIIRS grid.
- Advantages: Combining physically-based MW rain rates with high (VIIRS) **spatial resolution from VIIRS** cloud products. It retrieves rain detection and rate also **over land**.


ATMS Rain Rate


VIIRS Rain Rate after ATMS adjustment

Conclusions

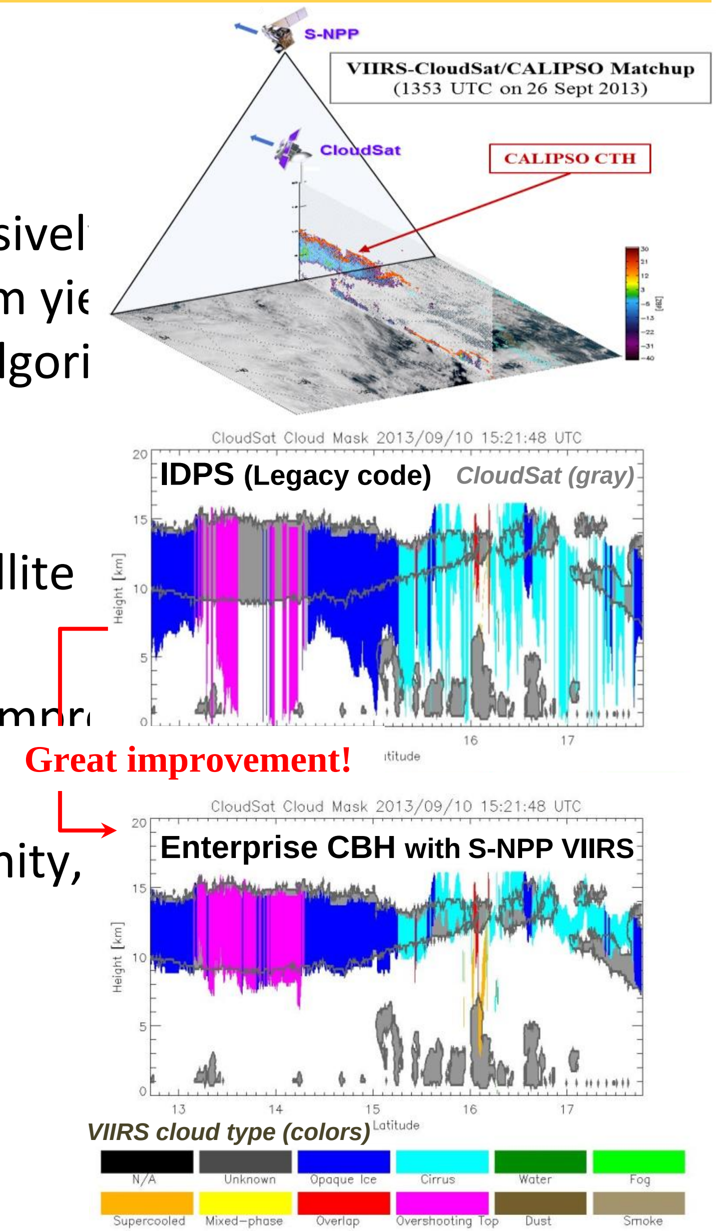
- Usage of VIIRS Cloud Products by NCEP/ESRL is hindered by data production artifacts.
- Performance of these algorithms is good and we expect the resolution of these issues will allow NCEP/ESRL to begin using VIIRS.
- Blending or fusion with other sensors (CrIS and ATMS) offers opportunities for improved JPSS cloud products and some of this work is actively funded by JPSS-RR.
- NOAA Enterprise Cloud algorithms have been developed to benefit from the DNB and I-bands and these offer additional opportunities for improvements.

Thank You

Extra Material Follows

Enterprise Cloud Base Height

- Has been applied to S-NPP VIIRS and intensivel CloudSat/CALIPSO, the Enterprise algorithm yie performance over the original VIIRS IDPS algori reqs
  - *Seaman et al. & Noh et al. (2017 JTECH)*
- Support both polar and geostationary satellite NOAA Enterprise Cloud Algorithm Suite
- The CBH information is made available to impr Layers product (not in the current DAP)
- Practical relevance to the aviation community, feedbacks in numerical models

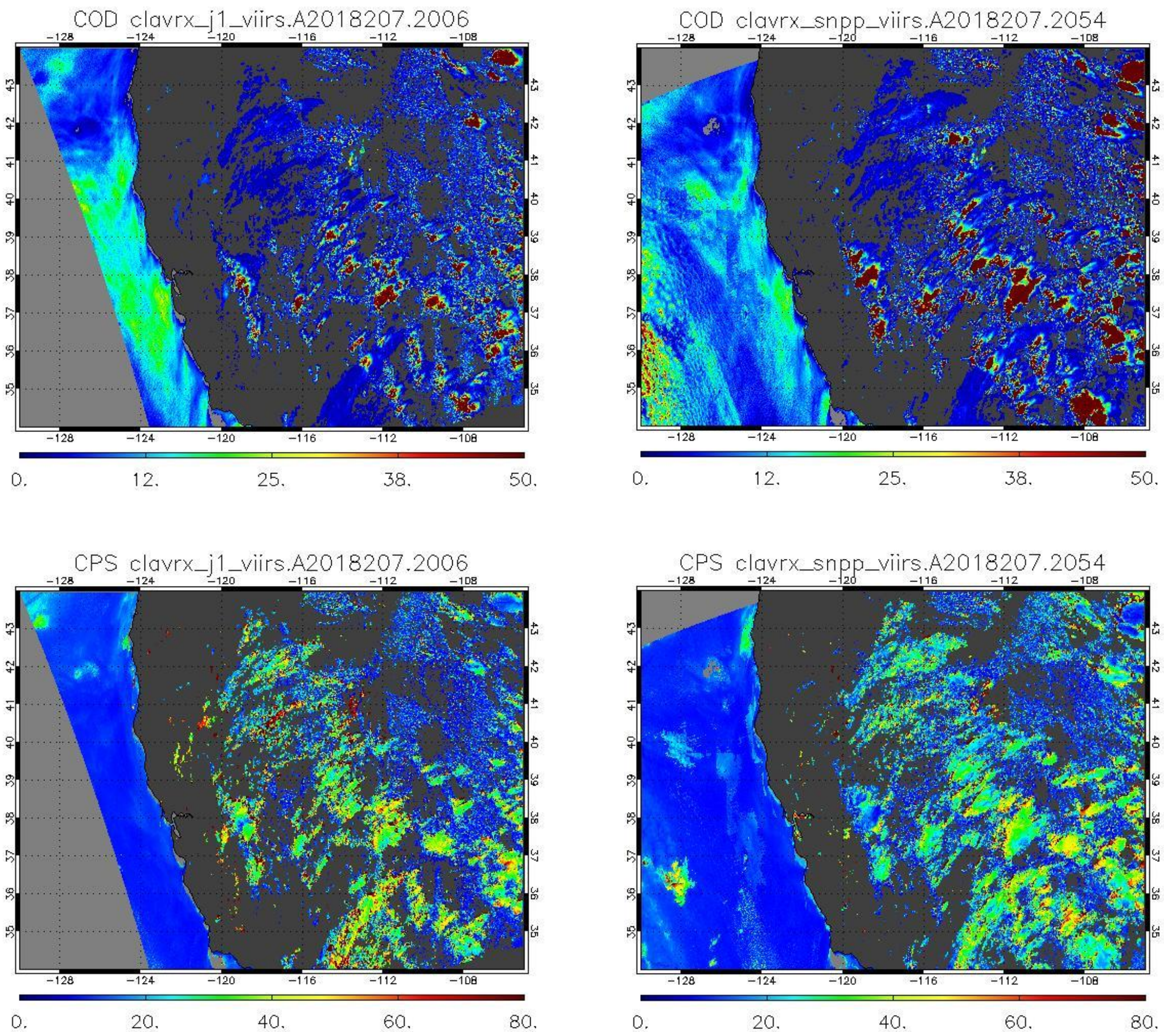


Cloud Optical Properties from SNPP and NOAA-20

NOAA-20 (aka JPSS-1) operates about 50 minutes ahead of Suomi NPP.

This constellation allows more studies of cloud diurnal developments from polar-orbiting satellites.

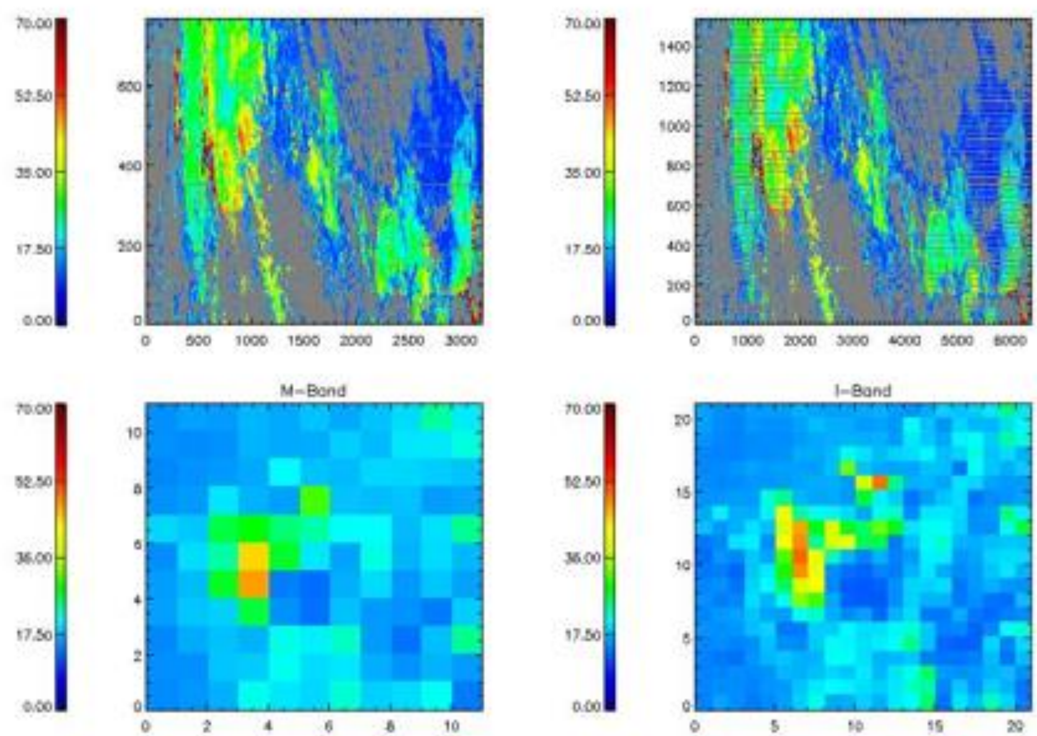
Images show an example of California coast from 26 July 2018 20:06 UTC (NOAA-20) and 20:54 UTC (S-NPP) for Cloud Optical Thickness and Cloud Particle Size.



DCOMP on I-band

Official NOAA Cloud Optical Products are retrieved on M-Band grid on a 2km x 2km grid.
We currently include an I-band DCOMP version to CLAVR-x.
Advantages: Higher spatial resolution allows us to use sub-pixel information, and to detect extreme values.
Potential use cases: Detecting convective cores and small-scale cloud particle size dynamics to predict the genesis of severe convective events.

Cloud Effective Radius



DCOMP on I-band

Official NOAA Cloud Optical Products are retrieved on M-Band grid on a 2km x 2km grid.
We currently include an I-band DCOMP version to CLAVR-x from I1/I3 channel combination.
Advantages: Higher spatial resolution allows us to use sub-pixel information, and to detect extreme values.
Potential use cases: **Detecting convective cores** and small-scale cloud particle size dynamics to predict the **genesis of severe convective events**.

Cloud Optical Thickness