NESDIS Enterprise Cloud Products, CLAVR-x, and Future Development

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Clouds, Cloud Ceiling, and Visibility (C&V)

Technical Exchange Meeting

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Goals of this Talk

- Give an overview of the NOAA/NESDIS Enterprise Cloud Products with a focus on the cloud mask
- Show some examples
- Discuss some current development of CLAVR-x derived aviation products

Some Terminology

CLAVR-x - Clouds from AVHRR Extended - The NESDIS operational cloud product processing system for AVHRR and GOES until replaced by the STAR Algorithm Processing Framework (**SAPF**). CLAVR-x continues to be the development system for the NESDIS Cloud Team and provided to **CSPP**. CLAVR-x supports most sensors.

Enterprise Cloud Products - a NESDIS name for the cloud algorithms developed in CLAVR-x and run operationally on VIIRS and GOES-R at NESDIS (transition underway).

PATMOS-x - our reprocessing efforts where we run CLAVR-x over the AVHRR and GOES-I-P records (will be extended to VIIRS and GOES-R). It is an operational CDR at NESDIS (NCEI).

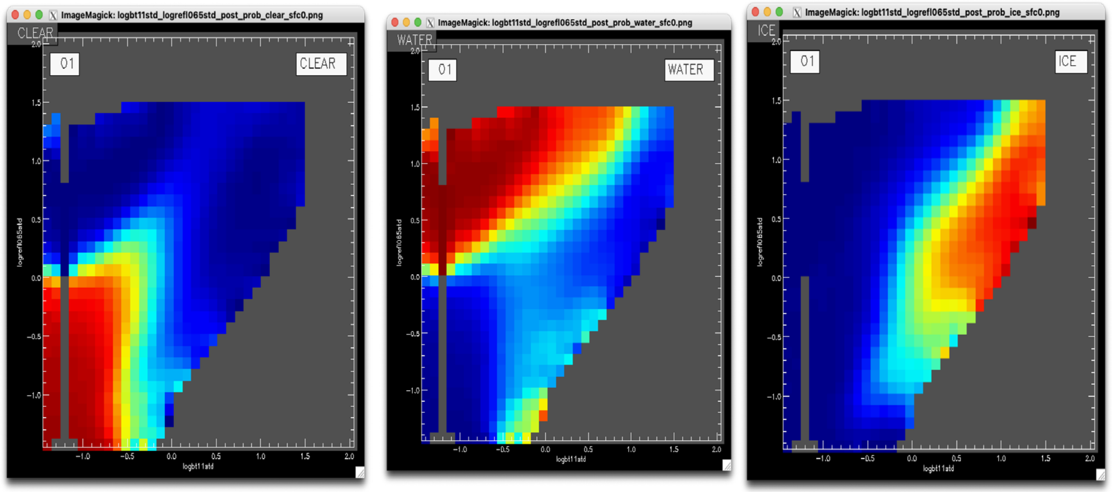
The Enterprise Cloud Mask (ECM)

- ECM is part of the Enterprise L2 software package used by NESDIS.
- Supports GOES-R/ABI, JPSS/VIIRS, HIMAWARI/AHI, MSG/SEVIRI and others
- Trained on the cloud phase product from the NASA CALIPSO/CALIOP Cloud Layer products.
- Fundamental output is probability of a pixel being clear, water cloud or ice cloud.
- Makes a 4-Level mask similar to the NASA MODIS mask
- Makes a cloud phase a cloud type product.

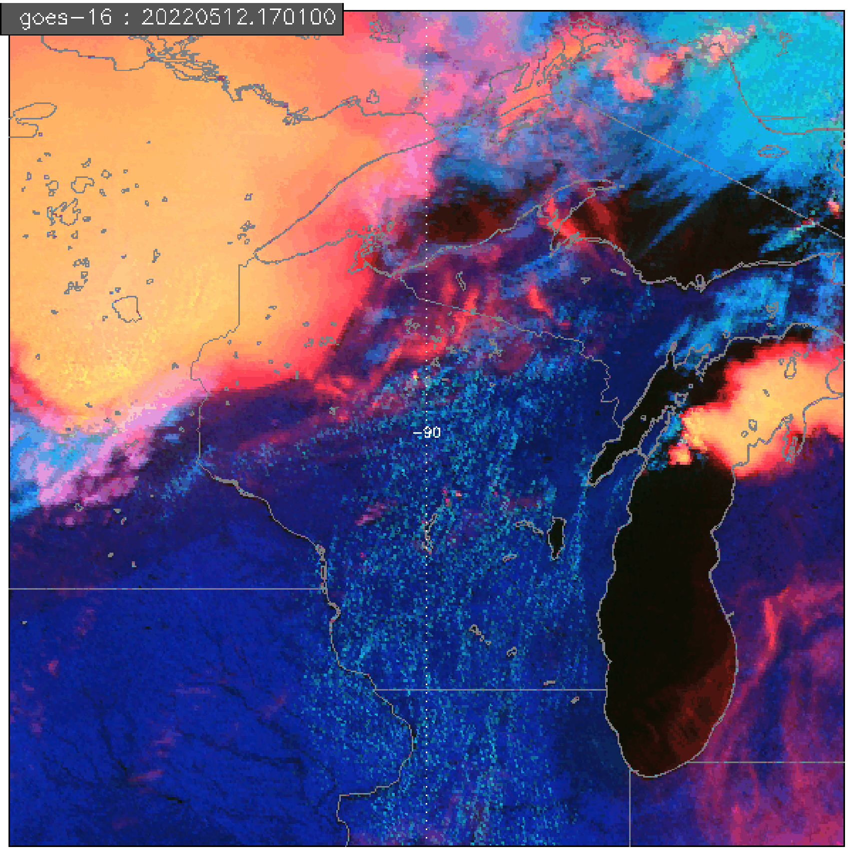
Current approach in operations is Naive Bayesian approach used 1D, 2D, and 3D classifiers optimized for surface type.

New ML/AI methods are being developed at CIMSS and CIRA.

Example 2D Classifier for Clear, Water and Ice

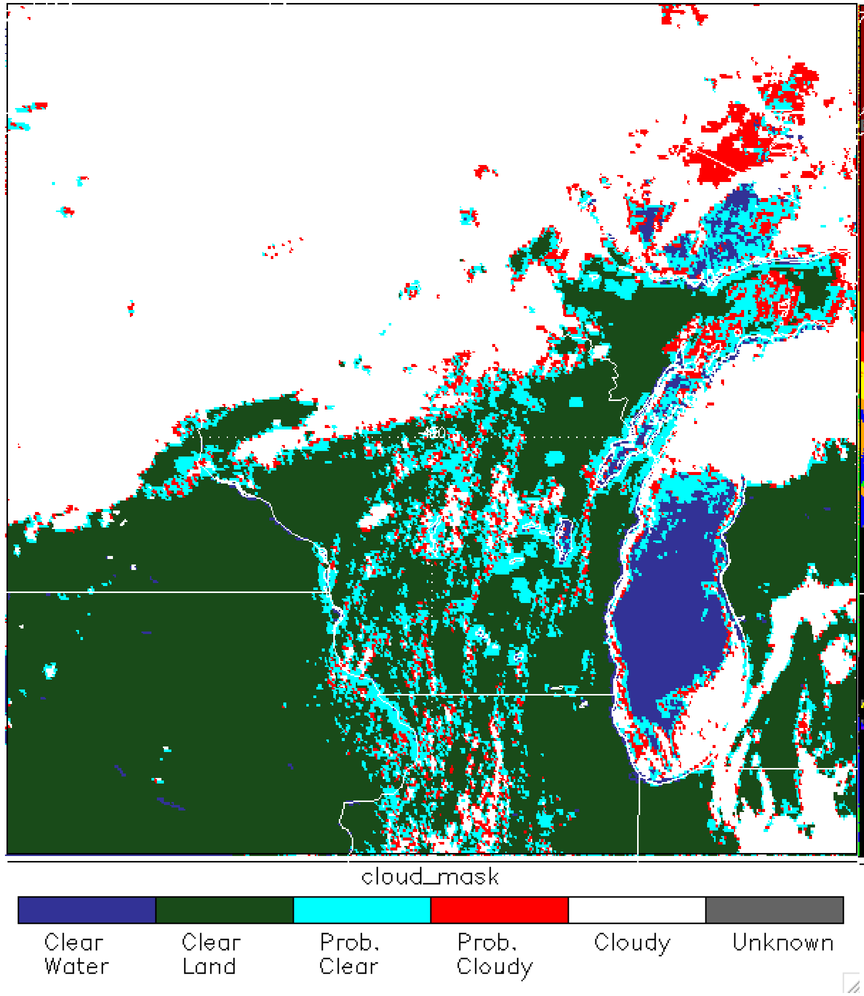


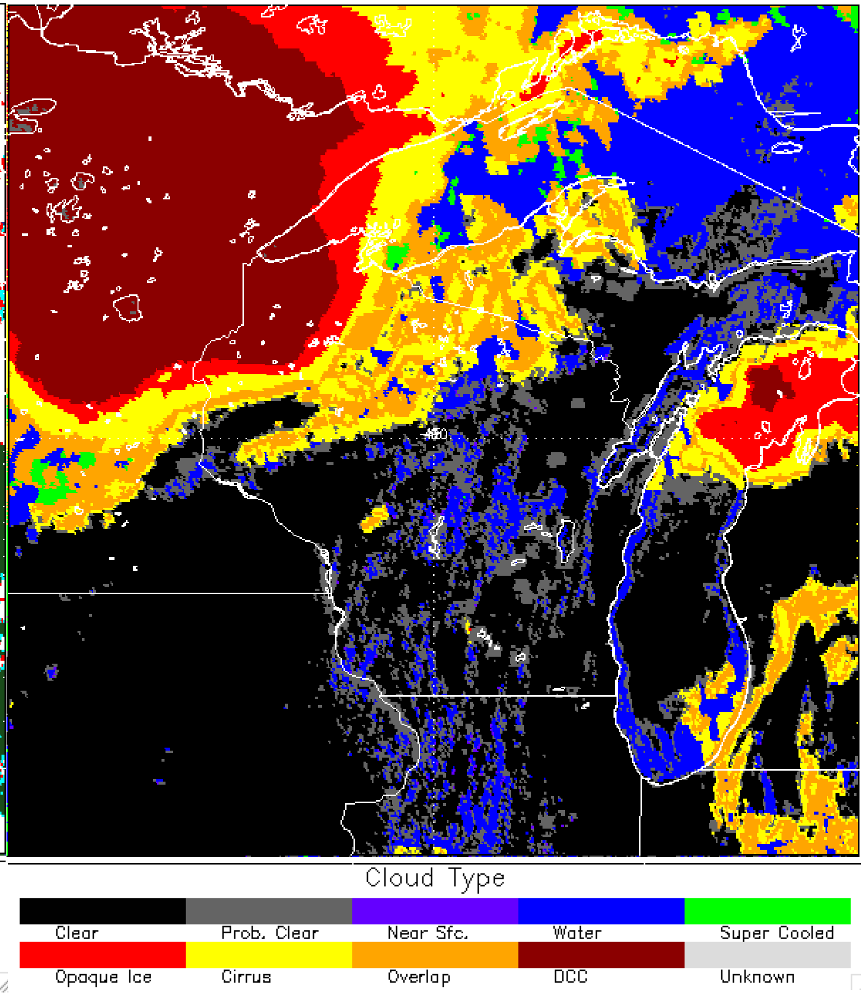
ECM Qualitative Products (Mask and Type)



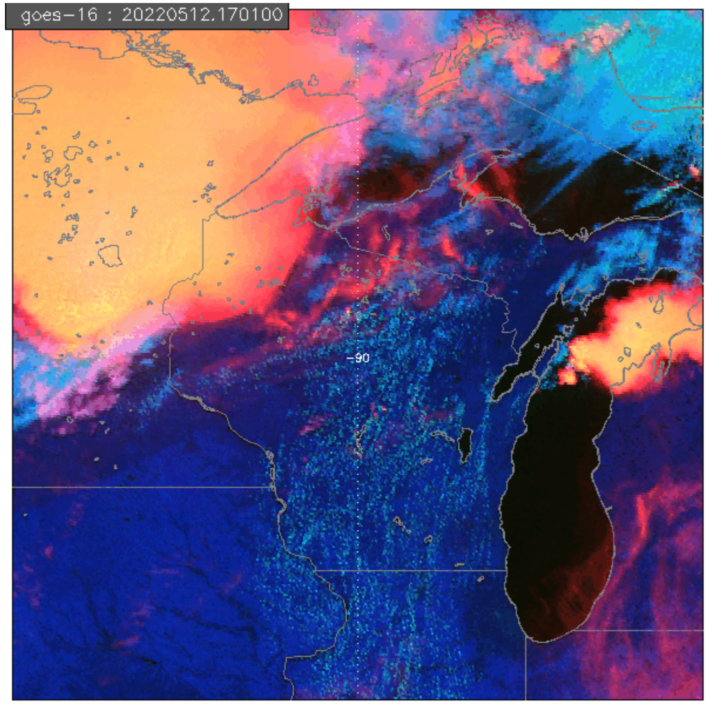
False Color Image

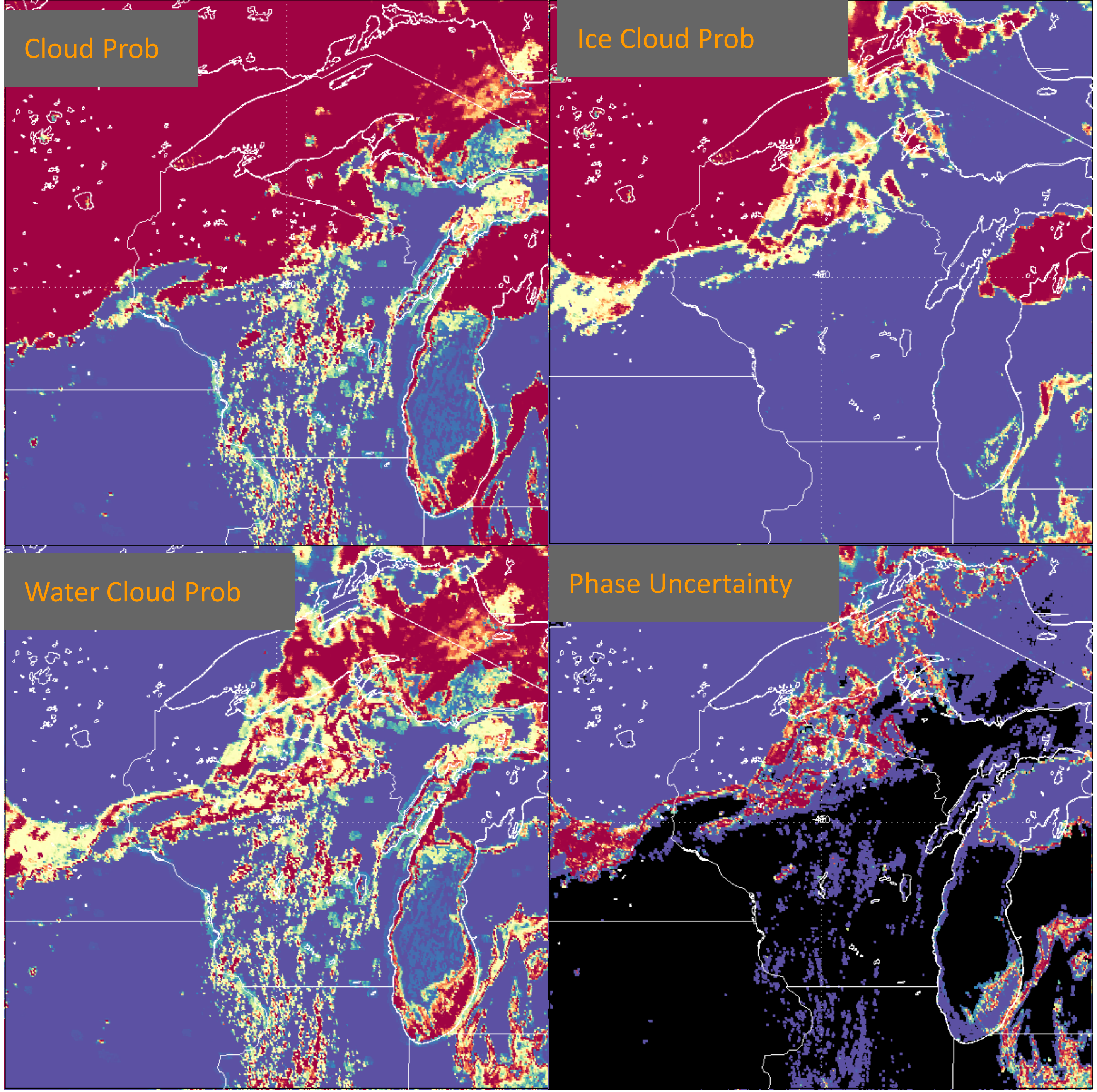
Red=1.38μm, Green = 0.65μm, Blue = 1.60μm



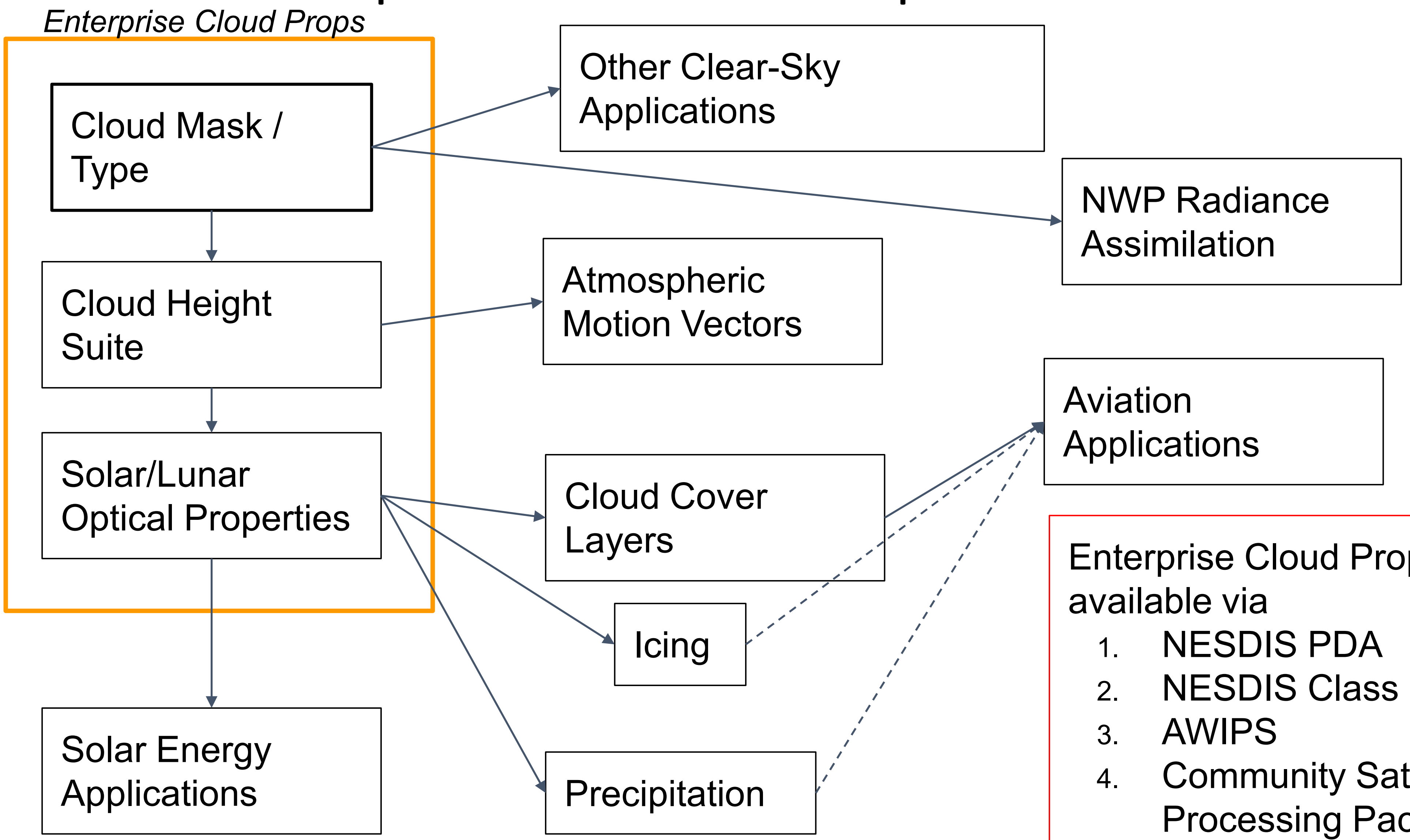


- ECM provides probabilities of 0.0 - 1.0 for clear, water or ice cloud.
- ECM makes a phase uncertainty from 0 - 50%
- These can be used for quantitative glaciation estimates and supercooled water presence (coupled with ACHA Tc).





Use of Enterprise Cloud Properties



Enterprise Cloud Properties are available via

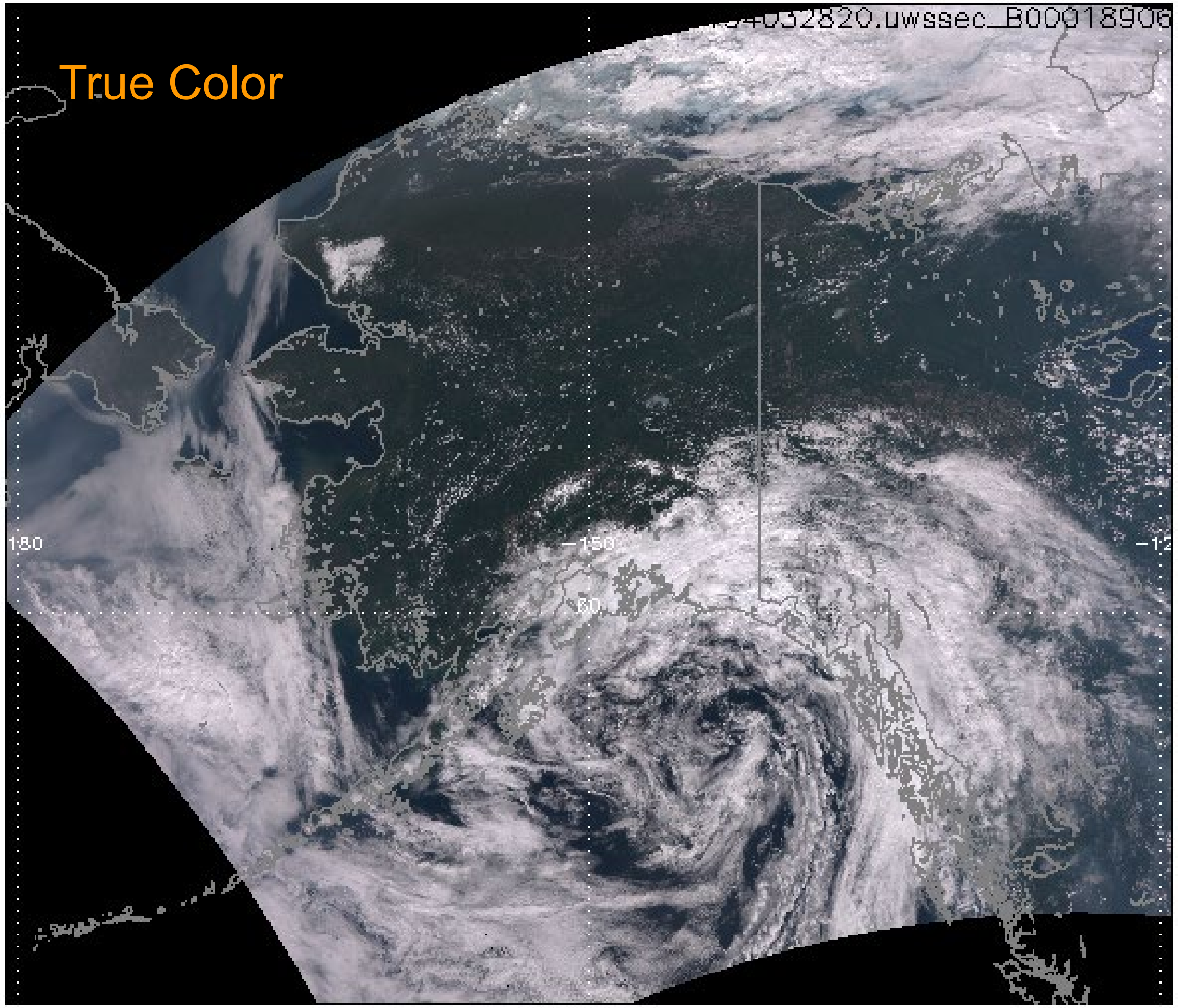
1. NESDIS PDA
2. NESDIS Class
3. AWIPS
4. Community Satellite Processing Package (CSPP)
5. Various non-operational streams

Current CIMSS near-real-time processing

- CLAVR-x and the experimental Enterprise Cloud Products.
- ½ hourly Himawari-8 AHI full disk.
- Hourly GOES-16 ABI full disk.
- Hourly GOES-17 ABI full disk.
- ftp://ftp.ssec.wisc.edu/pub/clavrx/real_time/level2/
- Current work is progressing on making AWIPS2 compatible files.

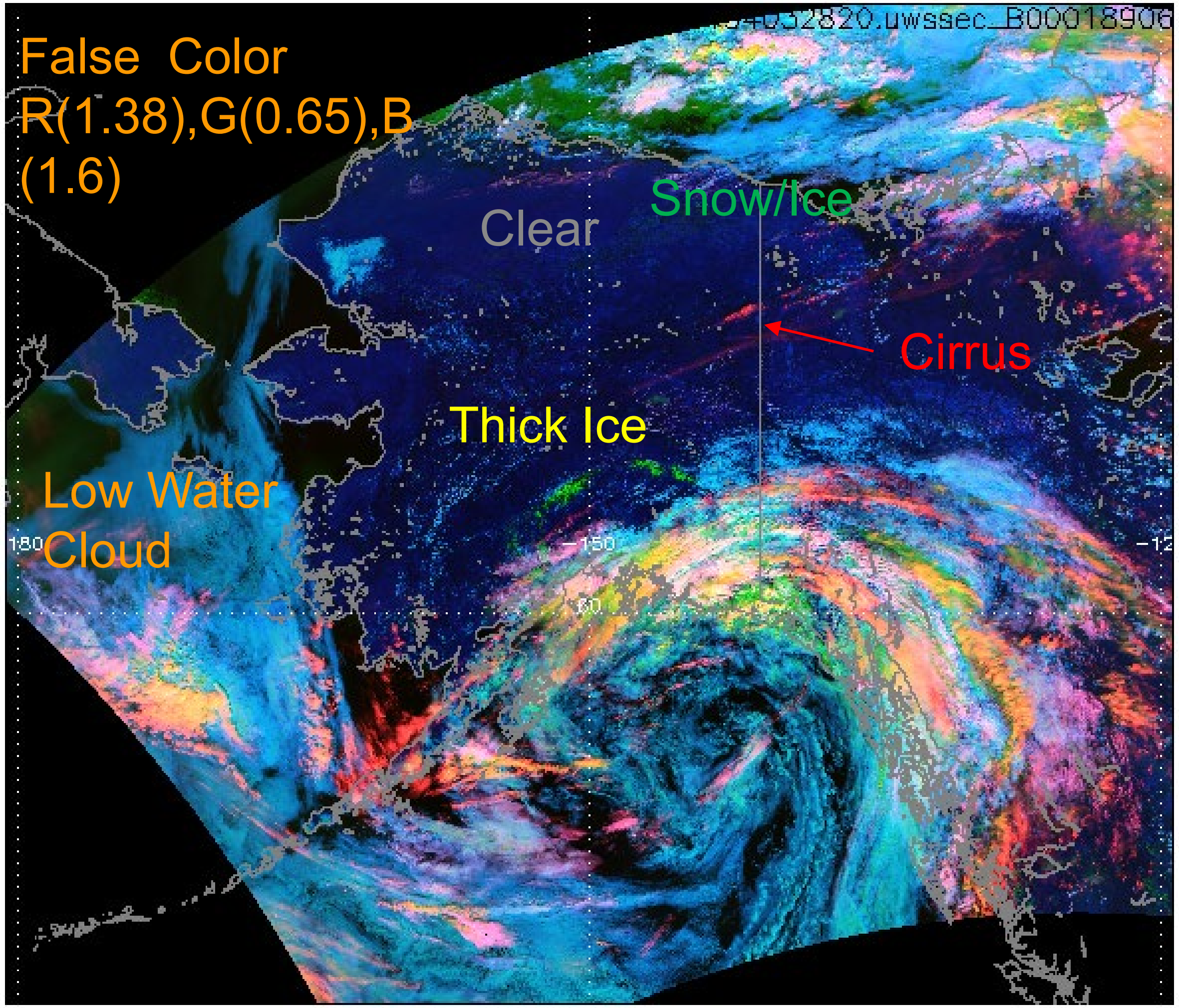
Examples of Enterprise Cloud Products Over Alaska

NOAA-20 VIIRS July



True Color Image

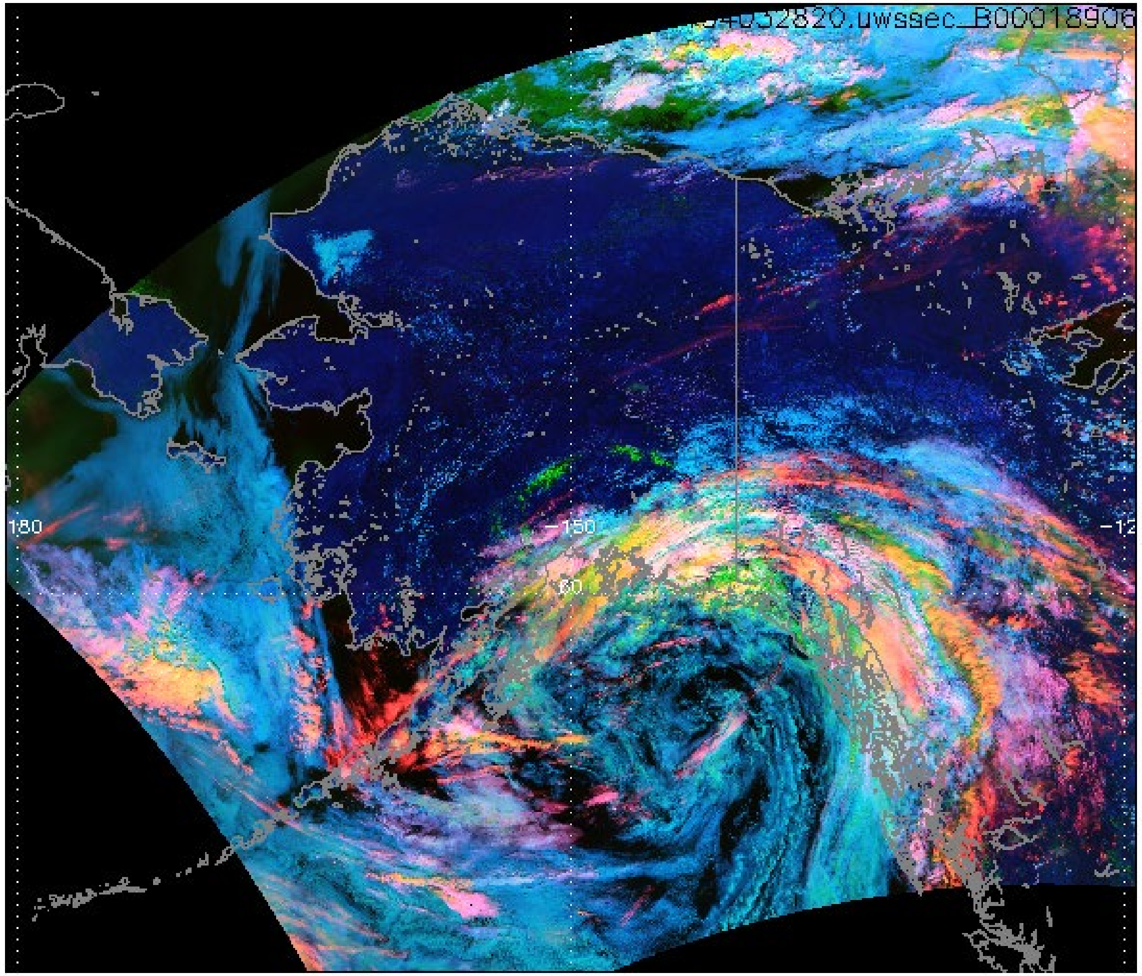
Red=0.65µm, Green = 0.55µm, Blue = 0.48µm



False Color Image

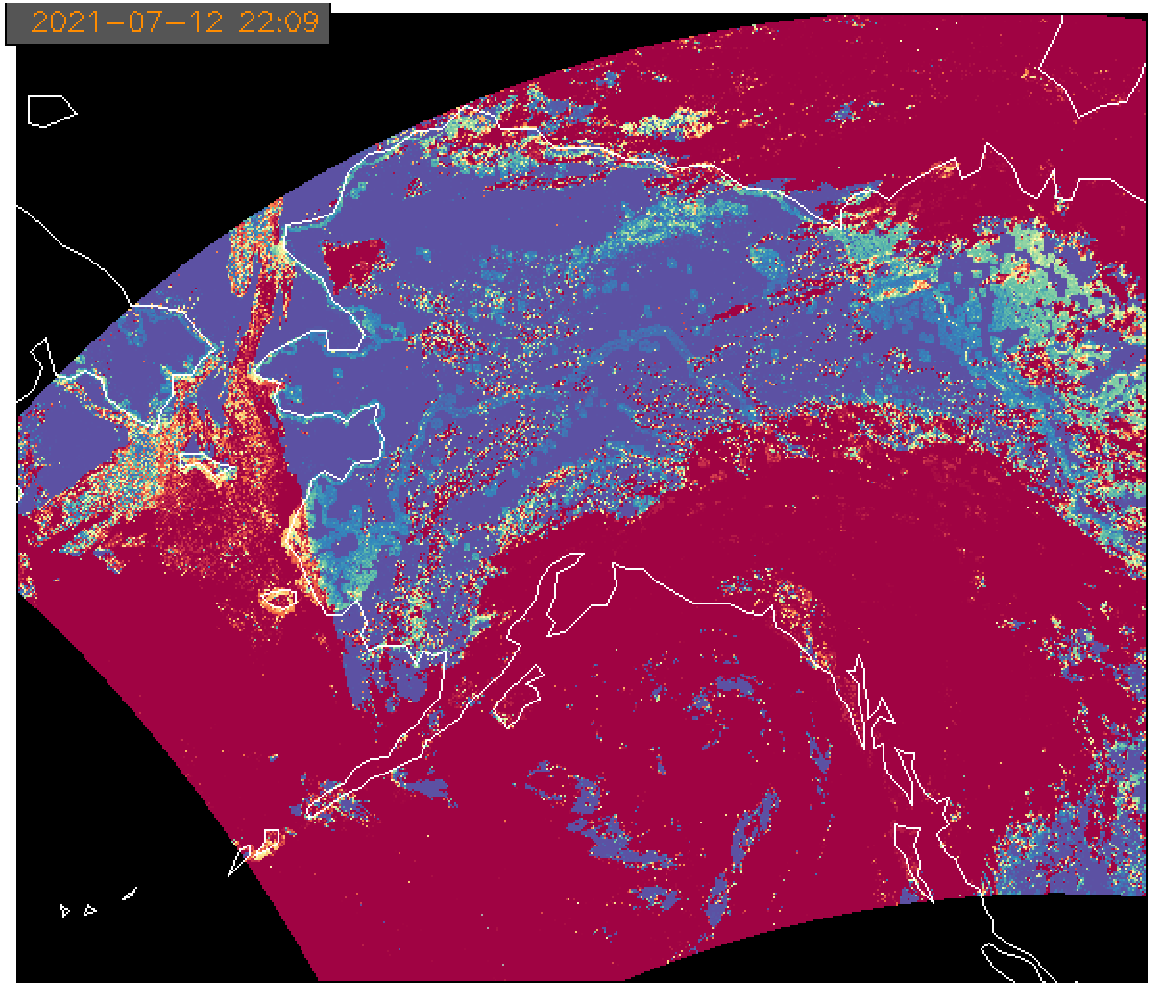
Red=1.38µm, Green = 0.65µm, Blue = 1.60µm

Cloud Probability: 0.0 = Clear, 1.0 = Cloudy

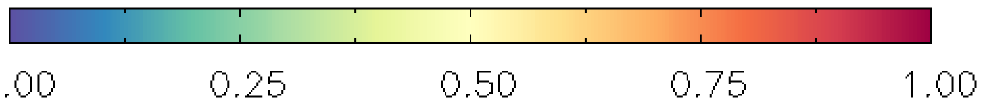


False Color Image

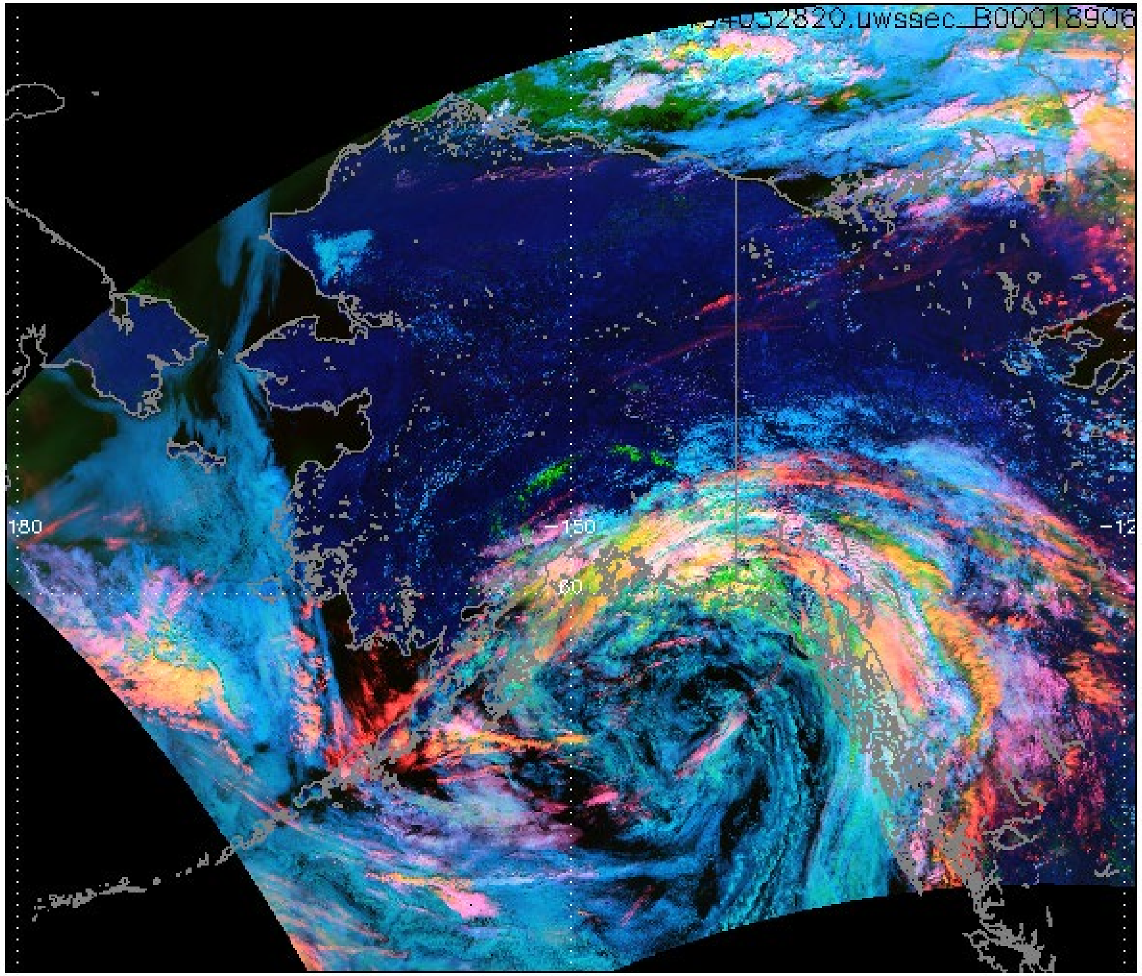
Red=1.38μm, Green = 0.65μm, Blue = 1.60μm



cloud_probability



Cloud Mask : 4-Level Mask - just like MODIS but based on Cloud Prob.



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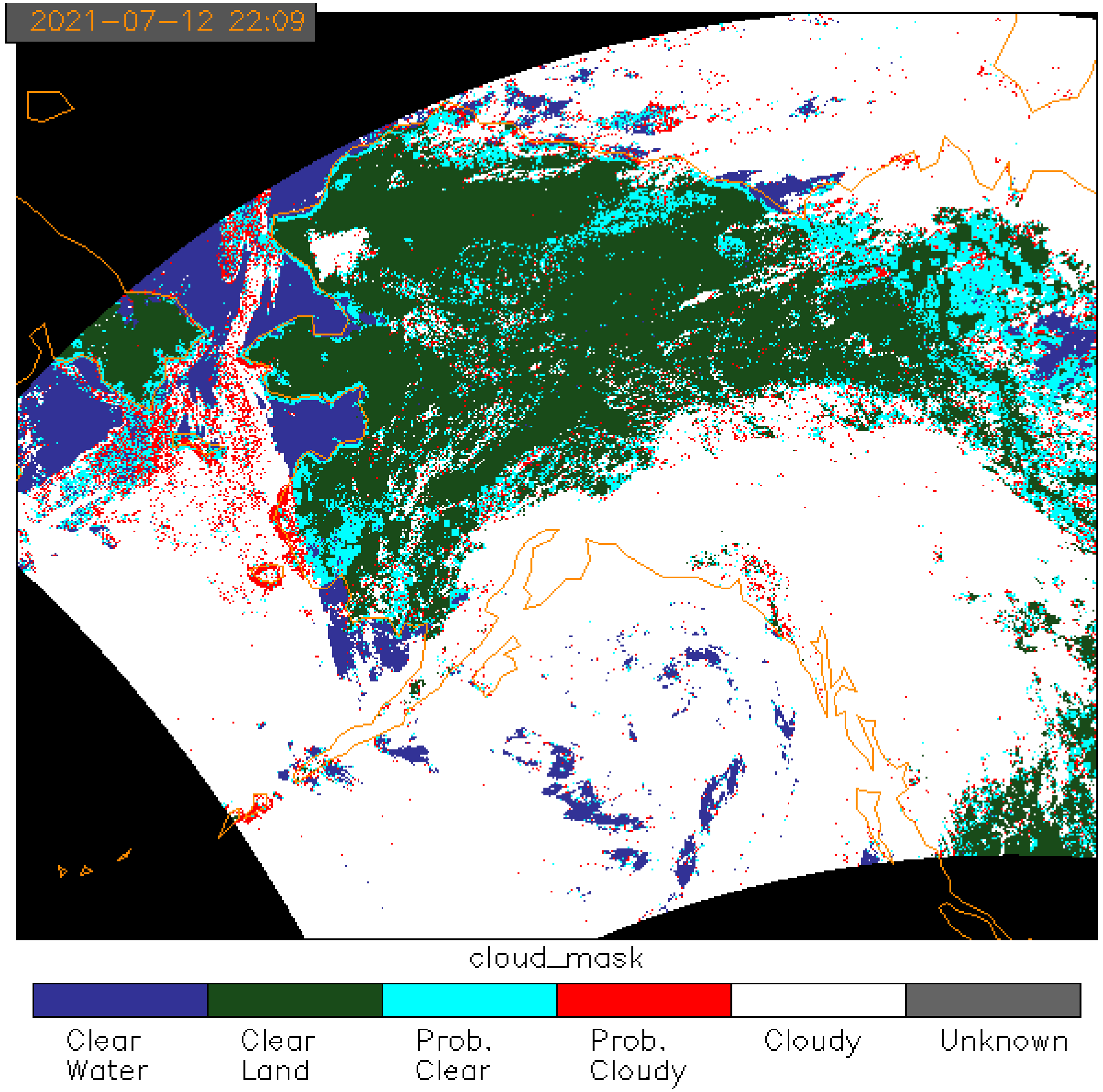
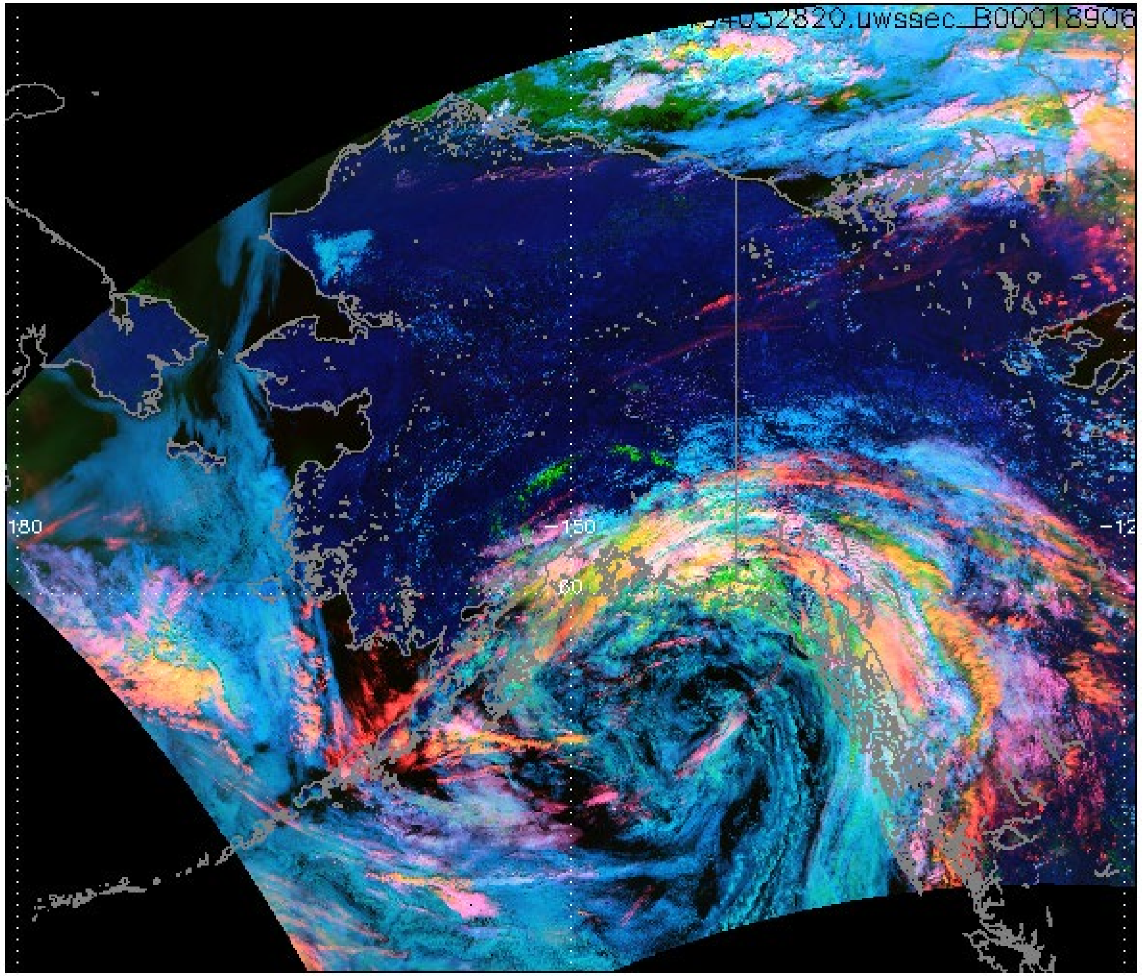


Cloud Type : Not standard Met Types, Thick/Thin + Ice/Water + Sc



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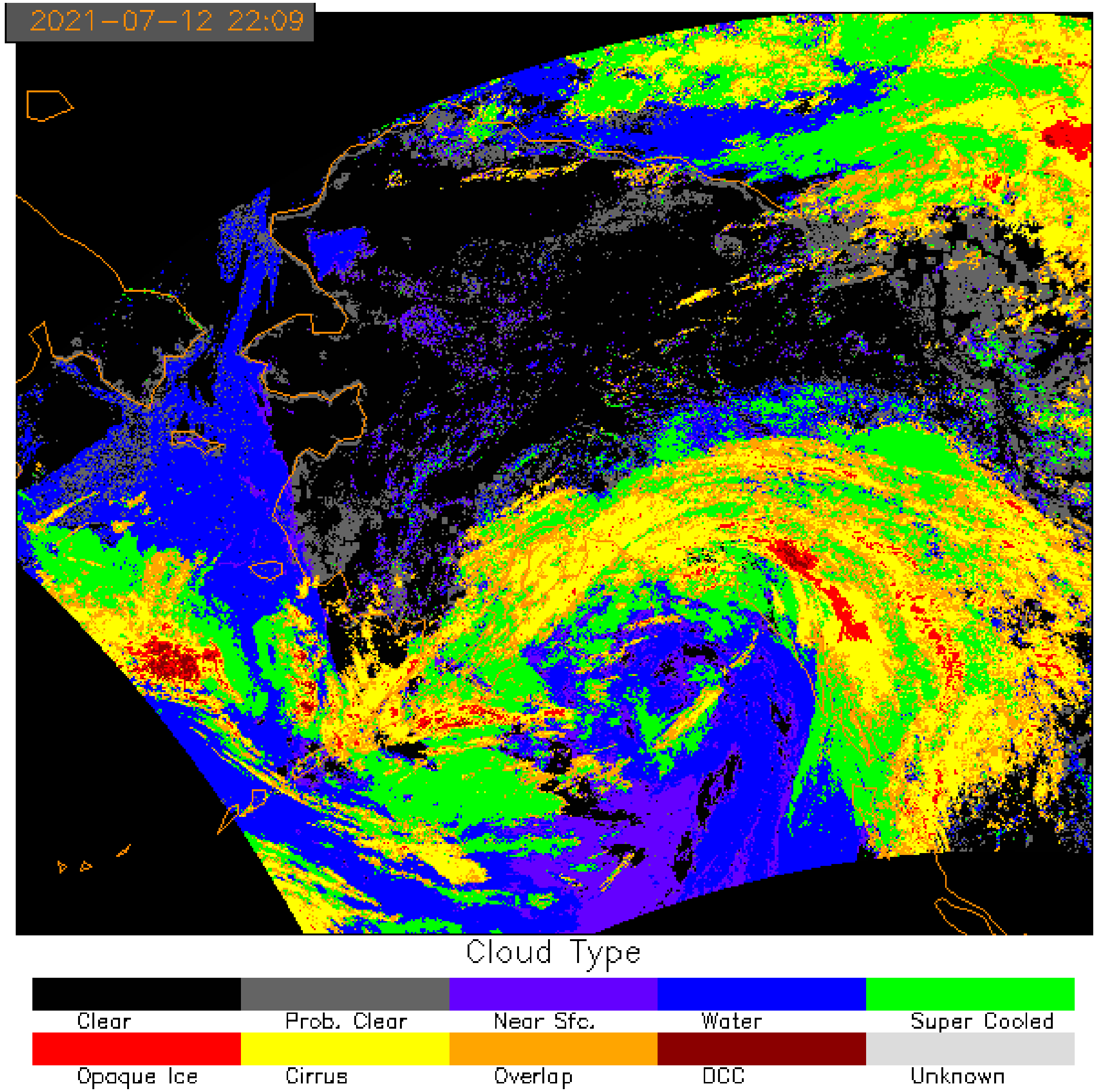
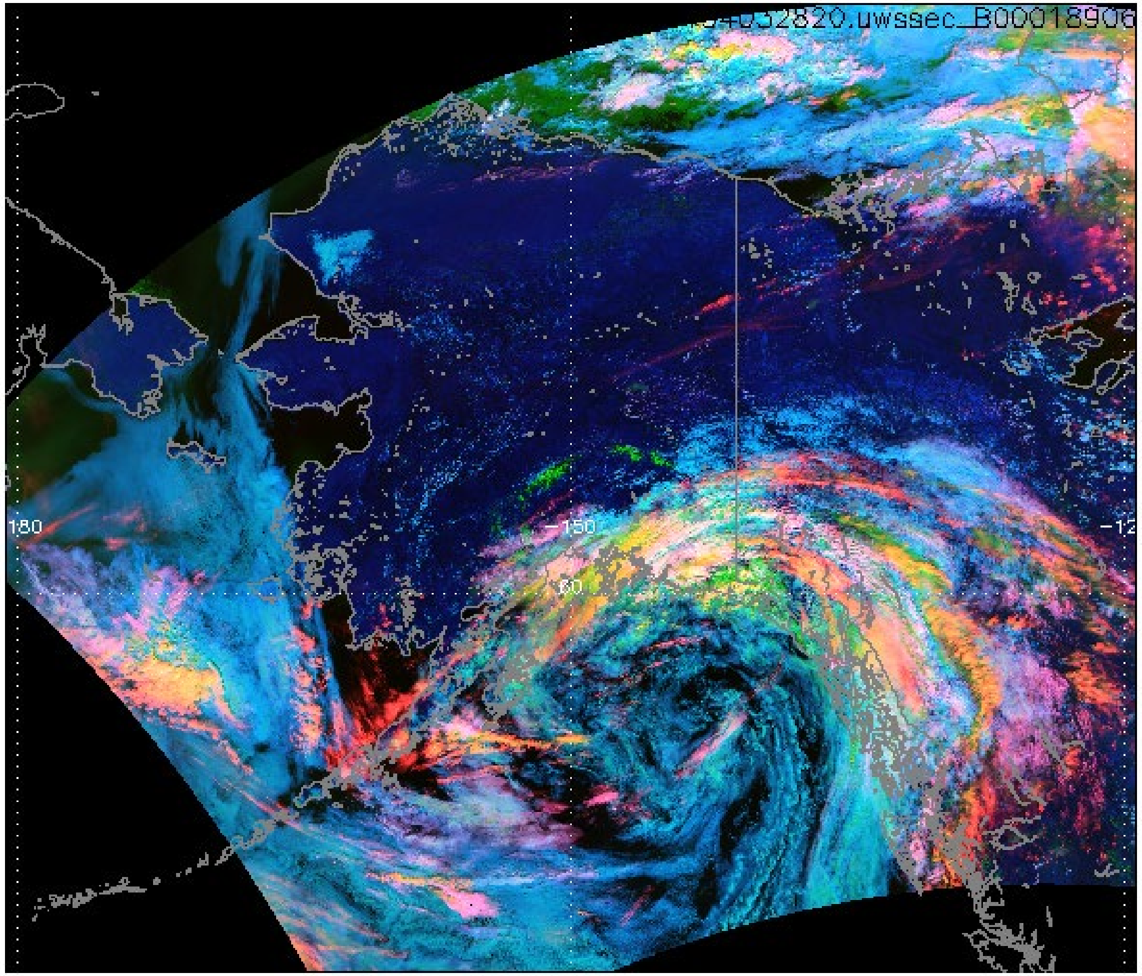


Cloud Top Pressure



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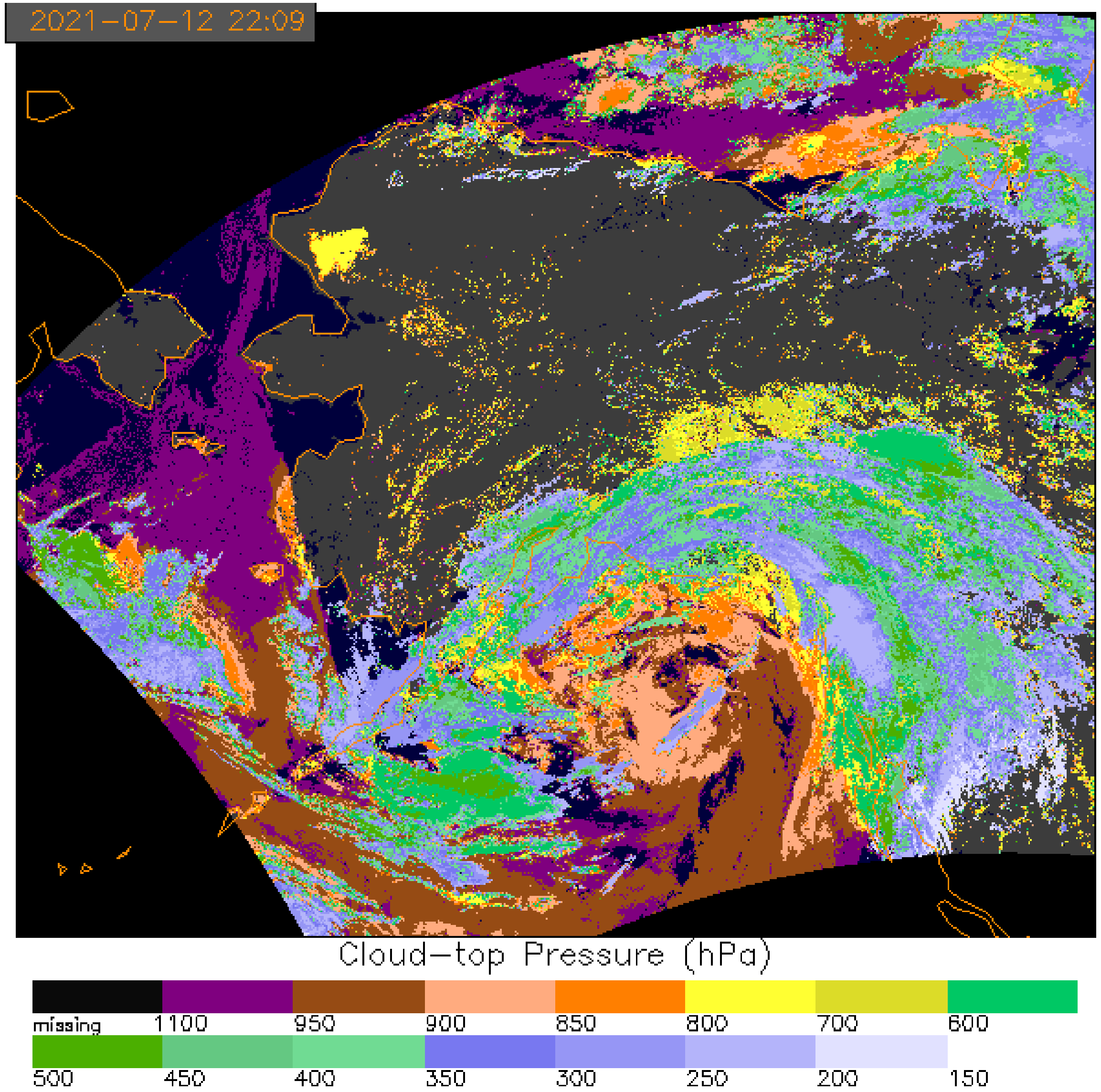
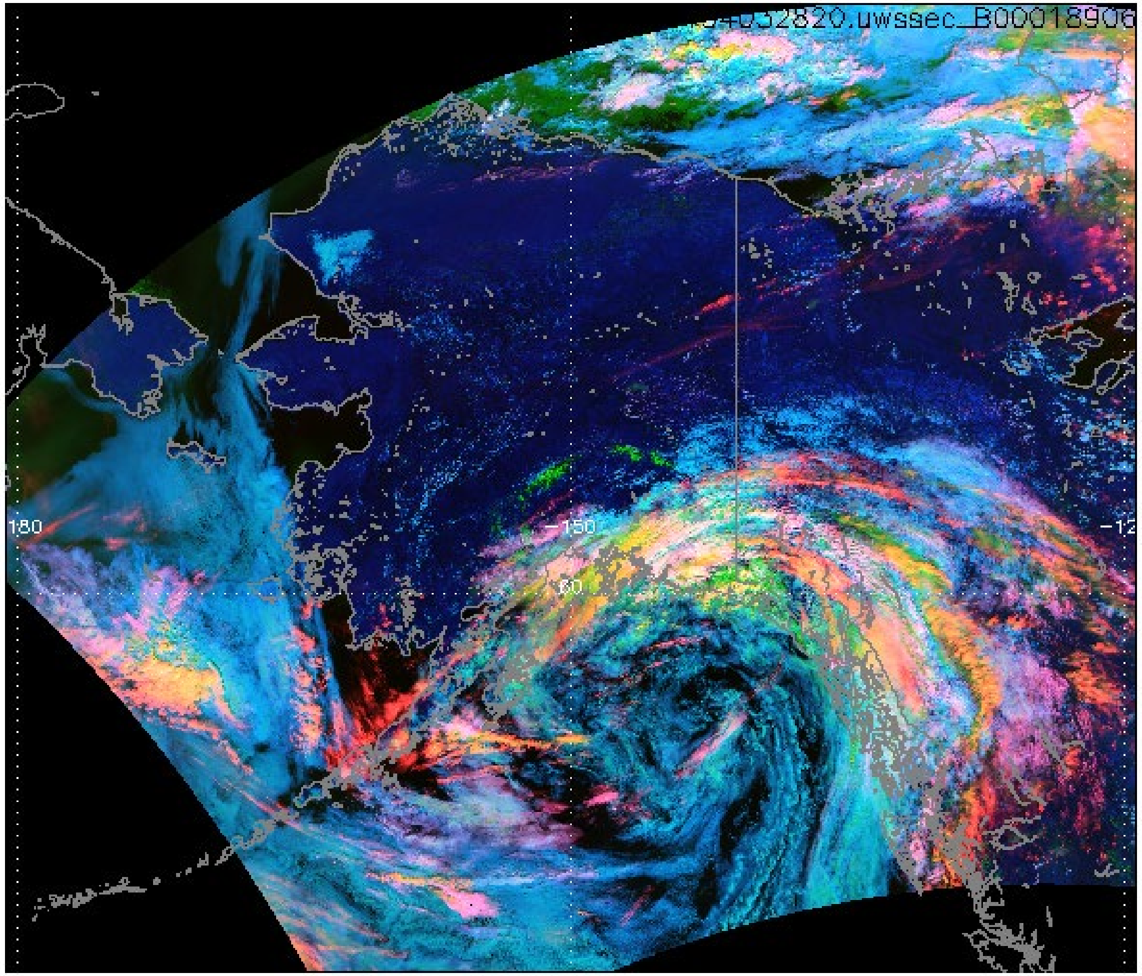


Cloud Optical Depth: A measure of cloud thickness



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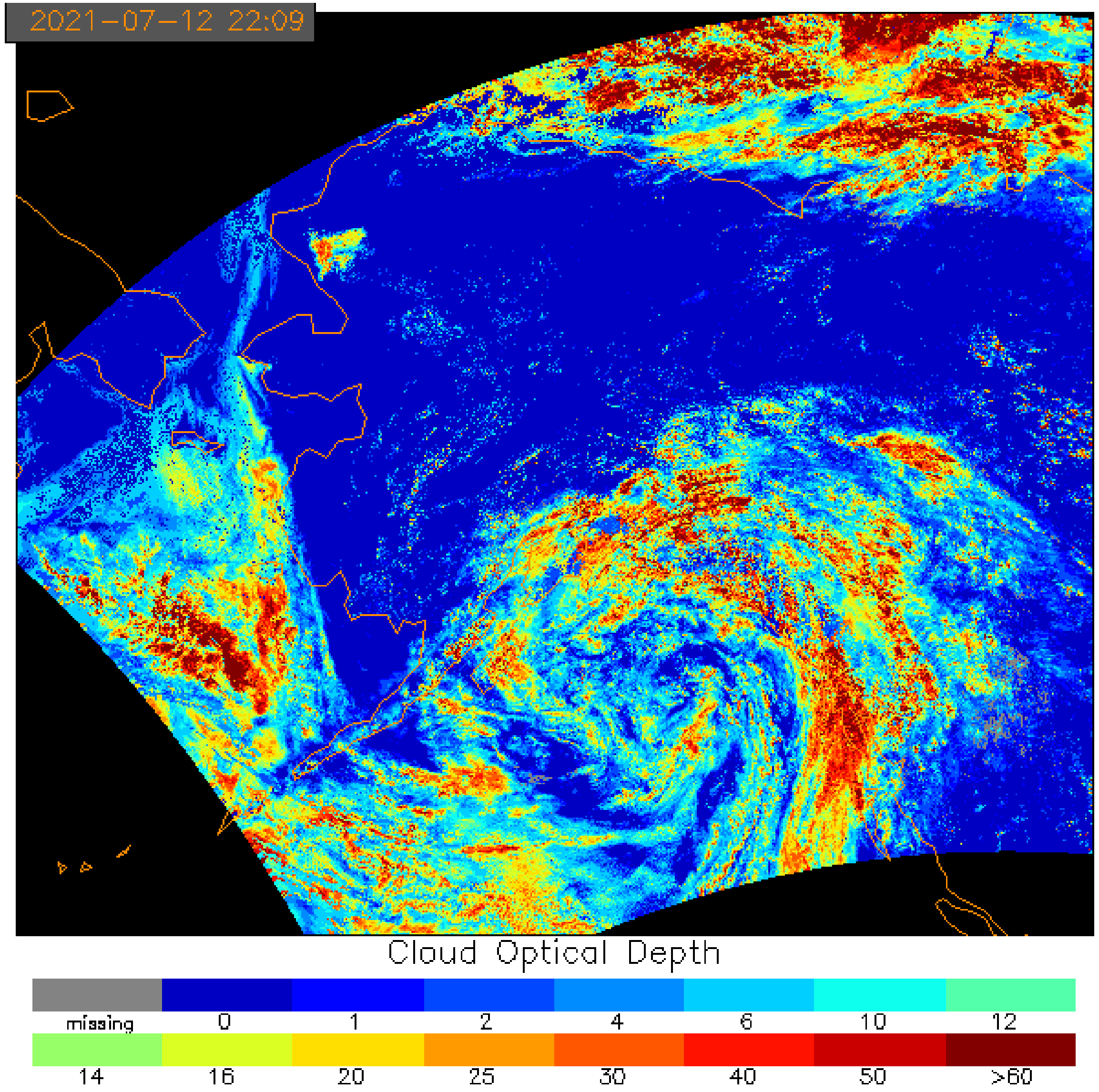

Current/Future CLAVR-x Development

- Recent product development has shifted to using core CLAVR-x cloud products as input to ML/AI models

CLAVR-x Level 2 products

↓

Trained ML/AI Model

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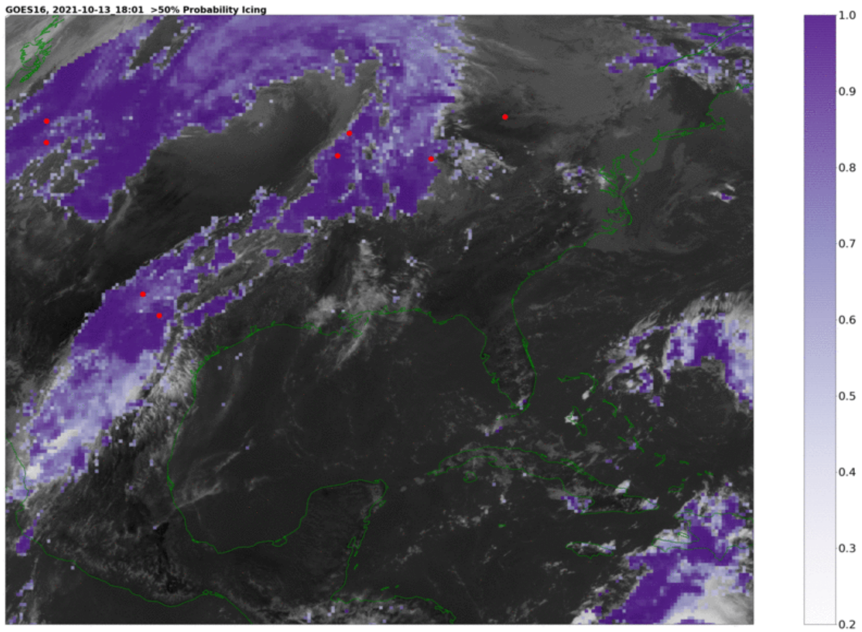
Derived Products

MASK | ACHA | PHASE | DCOMP | NLCOMP | BASE | MURI | CCL

Cloud Binary Mask	Aerosol Optical Thickness MURI	Rain probability from VIS/NIR	Surface Temperature	Fire mask
Cloud Top Height	Aerosol Fine Mode MURI	Rain rate from VIS/NIR	Cloud Base Temperature	Smoke mask
Cloud Top Pressure	Aerosol Coarse Mode MURI	Rain rate VIIRS/ATMS	Cloud Base Pressure	Cloud Shadow Mask
Cloud Top Temperature	Aerosol Fine/Coarse Mode Ratio MURI	Convection cloud probability	Cloud Base Height	NDVI
Cloud Phase	Solar insolation	Super-cooled Cloud Probability	Outgoing Longwave Radiance	Glint Zenith Angle
Cloud Optical Thickness	Solar insolation diffuse	Cloud Phase IR	Inversion Flag	Glint Mask
Cloud Effective Radius 1.6	Cloud Transmission	Cloud Type IR	Visible Reflectance from Lunar Irradiance	Cloud Shadow
Cloud Effective Radius 2.2	Cloud Albedo	Cloud Height H2O	Cloud Temperature Opaque	Cloud Optical Thickness IR cirrus
Cloud Effective Radius 3.7	Cloud Spherical Albedo	Cloud Height Opaque	Cloud Top Emissivity	Cloud Effective Radius IR cirrus
Nighttime Cloud Optical Thickness	Cloud Fraction	Cloud Layer	Cloud Top Beta	Cloud Droplet Number Concentration
Nighttime Cloud Effective Radius	Cloud Fraction High	Aerosol Optical Thickness AVHRR	Cloud Height Sounder	Cloud Geometrical Thickness
Cloud Probability	Cloud Fraction Middle	Cloud Fraction Low	Cloud Temperature Second Layer	Cloud Water Path

Daytime/Nighttime Aircraft Icing Predictor



Data Engineering:

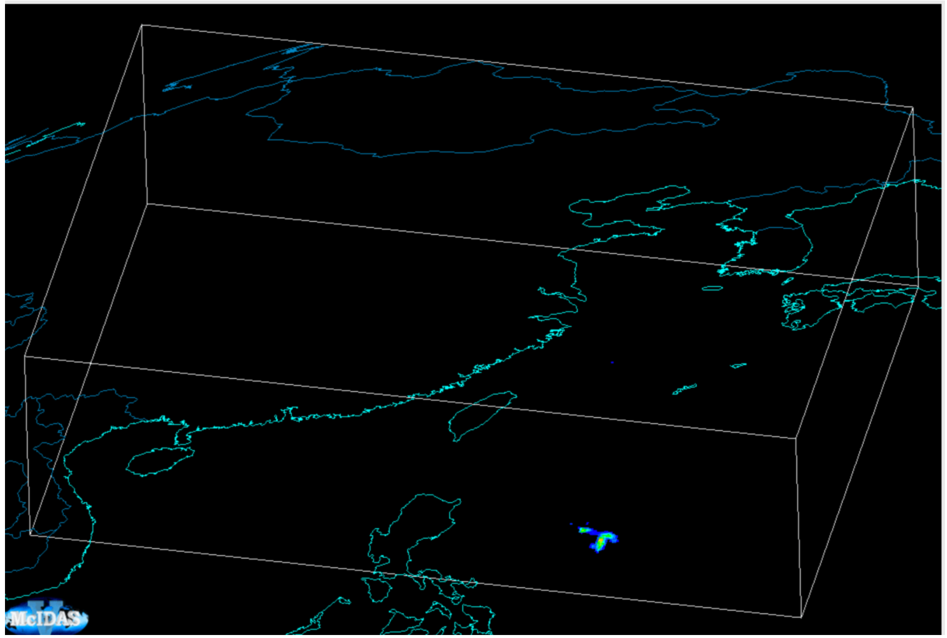
- Training data: ABI channels and CLAVR-x cloud products. CONUS, 2018-01-01 to 2020-01-01, 2km, 10min resolution. Approximately 70,000 samples.
- Truth data: Quality controlled PIREP data obtained from the Iowa Mesonet archive.

Features:

- Generates cloud icing probability for five discrete flight levels
- Prediction for day, night, or mixed scenes with default 'AUTO' mode
- Implemented as a Fully Convolutional Network (FCN)
- Support for GOES-16, GOES-17, Suomi NPP, NOAA-20, Himawari-08/09

Current development:

- Support for arbitrary sized input array
- Support for Lunar cloud optical properties (NLCOMP)

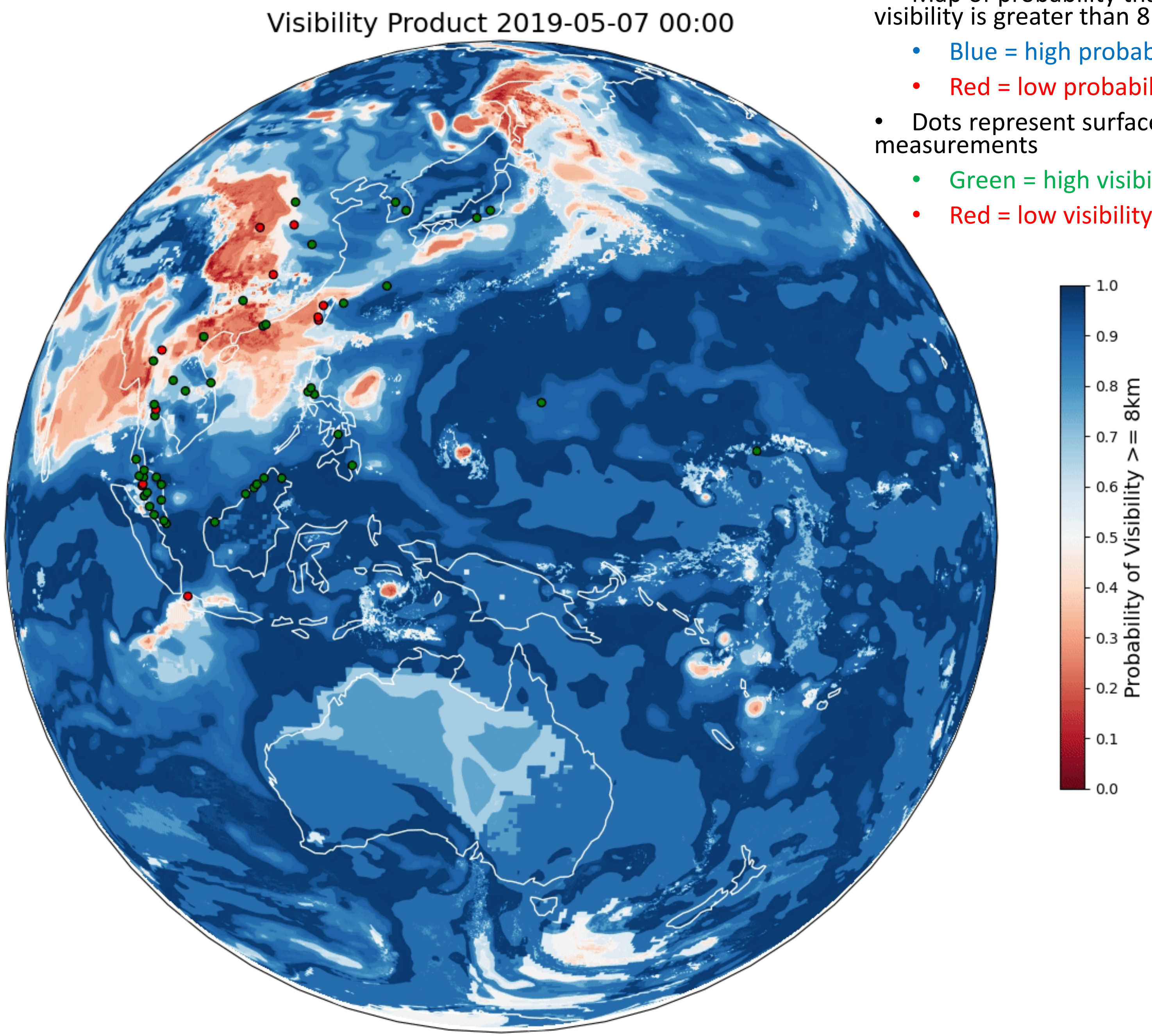


Near Surface Visibility

Training data:
- 6 months of Himawari-8 data matched with quality-controlled surface station visibility measurements

Input parameters:
- Himawari-8 imager channels
- CLAVR-x cloud products
- Aerosol Optical Depth (AOD)
- Relative Humidity (RH)
- Rain Mask

Output parameters:
- Probability of visibility above or below a given threshold (currently 8km)
- Visibility estimate (km)
- Information on most important input variable



- Map of probability that visibility is greater than 8 km
  - Blue = high probability
  - Red = low probability
- Dots represent surface station measurements
  - Green = high visibility
  - Red = low visibility

Conclusions

- NESDIS Enterprise Cloud Products are available from ABI and VIIRS and made by NESDIS operationally and other sources including GINA.
- CLAVR-x is the development system for these products and supports the generation of an expanded set of cloud products from many different satellites/sensors
- Algorithms are evolving with AI and we are always looking for opportunities to optimize them for applications and engage with users.

Backup slides

What does CLAVR-x provide

All Underlined product algorithms are adopted as NOAA's operational algorithm for VIIRS on SNPP/NOAA and ABI on GOES-16/17

- Cloud Mask: A Naive Bayesian approach.
- Cloud Type/Phase: Based on spectral tests.
- Cloud Top Temperature/Height/Pressure (ACHA): An optimal estimation based approach.
- Daytime Cloud Optical and Microphysical Properties (DCOMP): An optimal estimation based approach.
- Nighttime Lunar Cloud Optical and Microphysical Properties (NLCOMP): Utilize lunar reflectance and a lunar reflectance model.
- Cloud Base Height: A statistically based approach.
- Cloud Cover Layer (CCL): Compute cloud fraction at various flight levels and resolution using cloud mask and ACHA products.
- And many more ...