Developing a NASA cloud algorithm suite for MODIS and VIIRS data record continuity for climate research

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Overview

- Challenge: Direct cloud data record continuity between the S-NPP VIIRS and EOS MODIS imagers is problematic because of the absence or relocation of key spectral channels.
- Approach: Develop common algorithms that can be applied to both the MODIS and VIIRS observations, and thereby provide a long term consistent cloud data set with well characterized uncertainties. An alternated algorithm will be developed that combines VIIRS/CrIS and Aqua MODIS/AIRS to supplement absent VIIRS absorption channels.
- Algorithms/Products: based on combined MODIS and GOES-R Algorithm Working Group (AWG) algorithms and is referred to as MODAWG. The products include:
  - A cloud mask based on MODIS heritage (MOD35)
  - IR products (cloud-top pressure/temperature, emissivity, and phase) based on GOES-R Algorithm Working Group (AWG) algorithms
  - Optical properties (optical thickness, effective radius, water path, and retrieval phase) based on MODIS heritage (MOD06)

MODIS VIIRS Cloud Mask (MVCM)

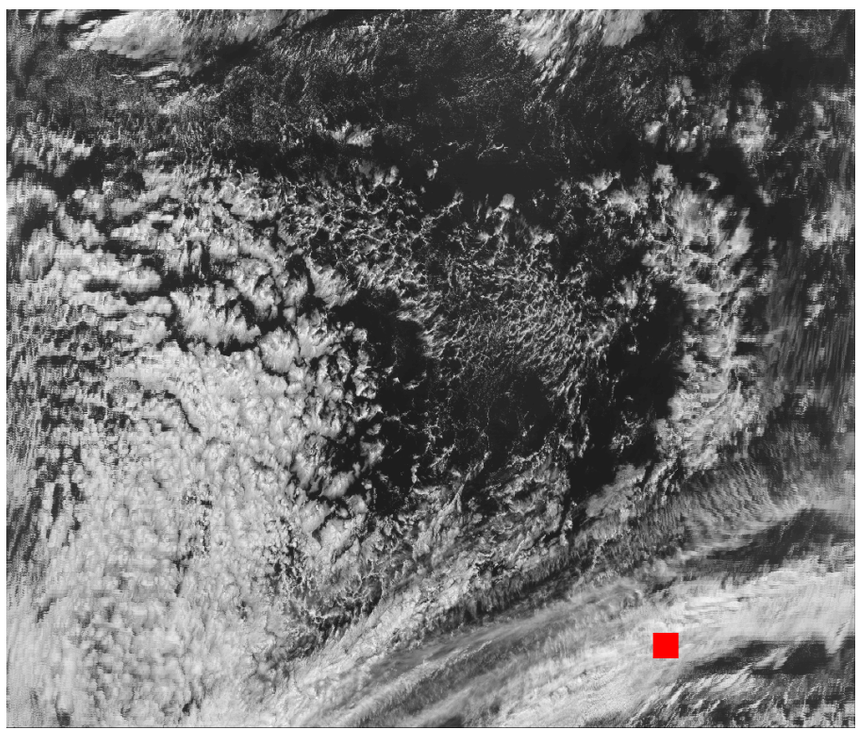
The MODIS-VIIRS Continuity Cloud Mask (MVCM) is designed to provide a mask that can be applied to the common VIIRS and MODIS channel set*, providing consistent detection sensitivity.

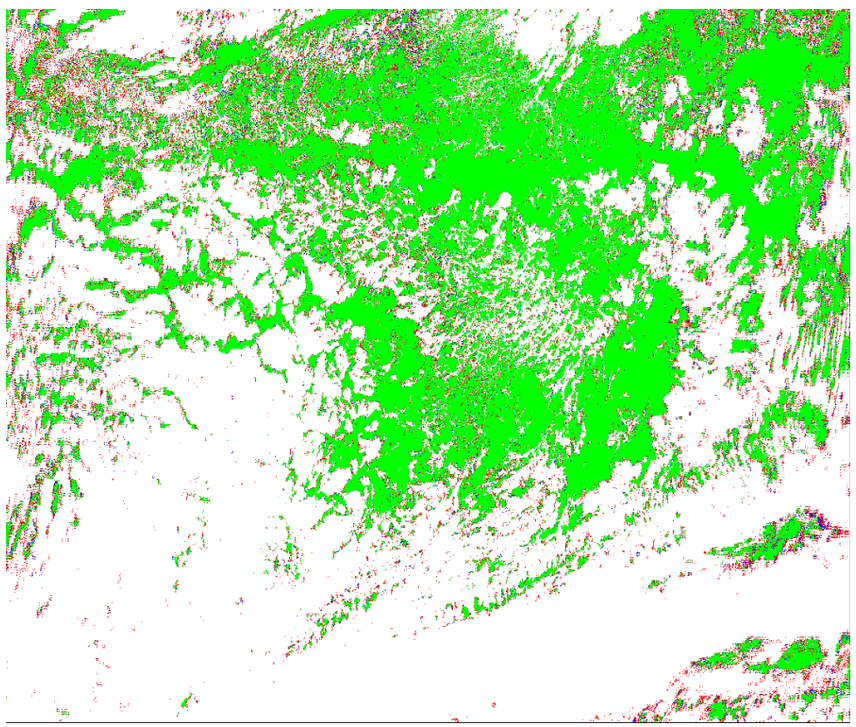
** i.e., when applied to MODIS, the MVCM only uses channels available with VIIRS*

MVCM Examples

Green=confident clear blue=probably clear
red=probably cloudy white=confident cloudy

VIIRS



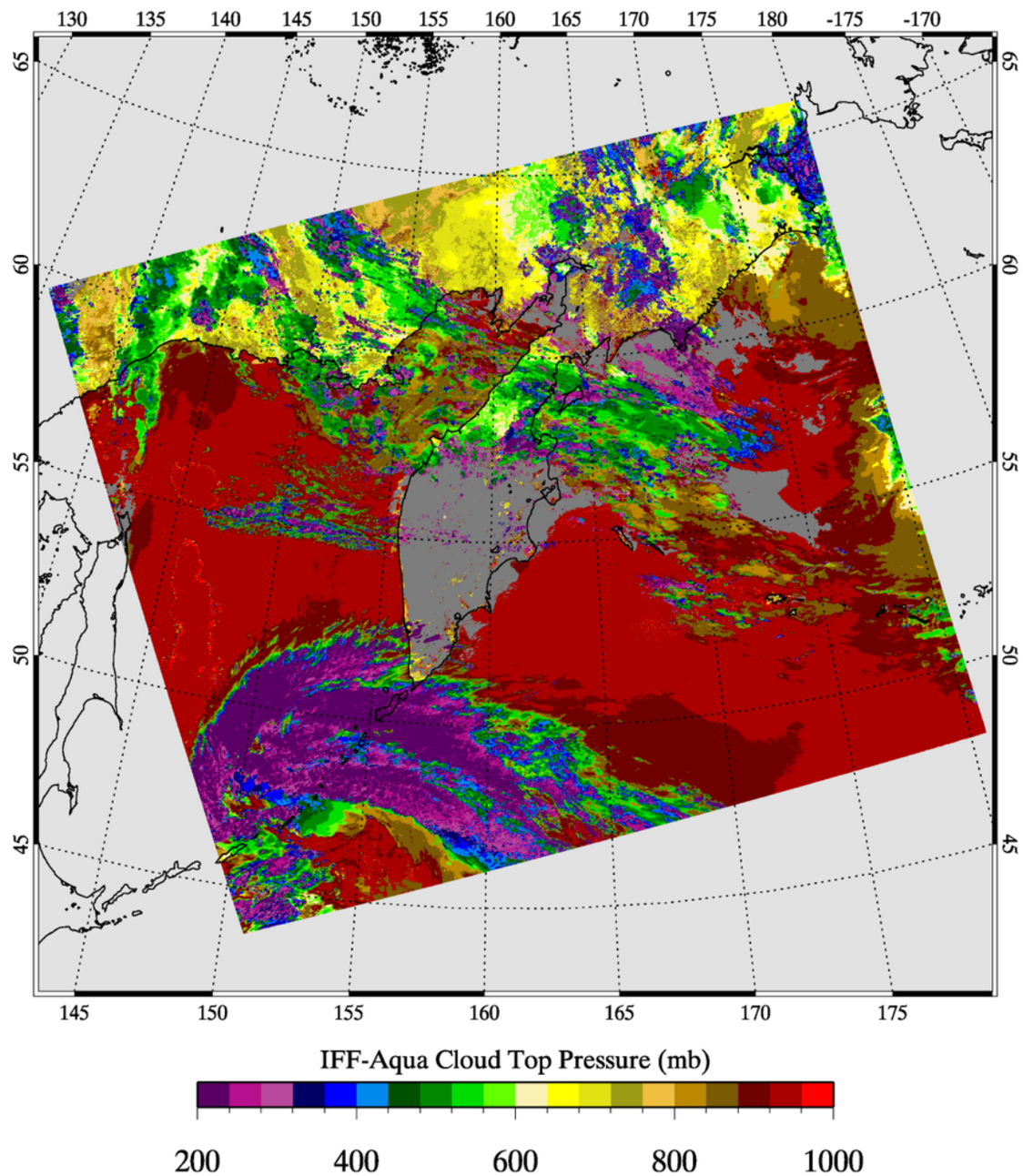


Cloud Top Products

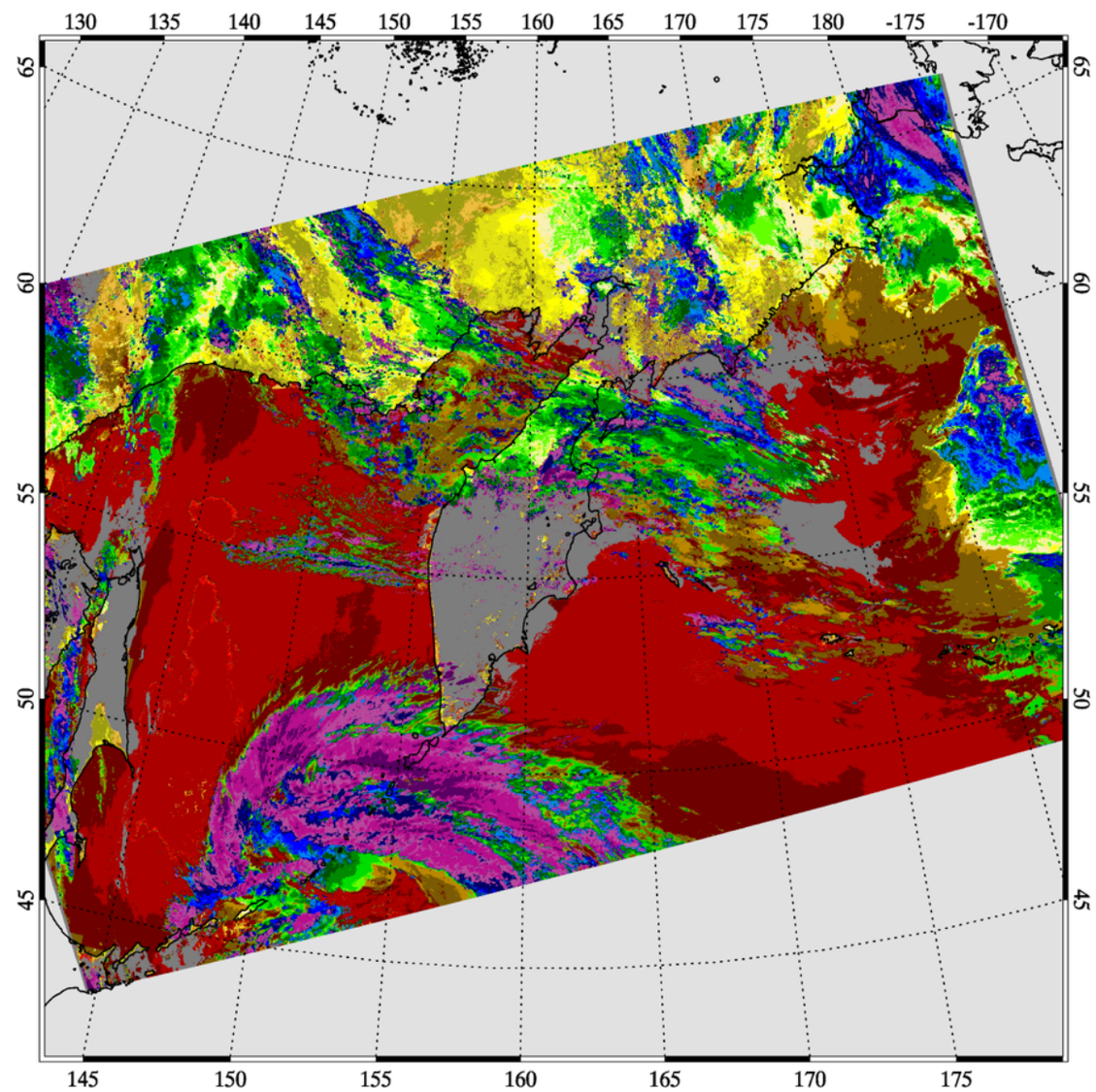
- Challenge: VIIRS lacks absorbing channels (i.e., CO2 Bands)
- Approach: Multiple cloud height products
  - An optimal estimation retrieval developed by Andy Heidinger using the 8.5, 11, and 12 μm channels that provides full imager resolution cloud-top properties.
  - A combined sounder/imager retrieval using sounder (CrIS/AIRS) absorbing channels integrated over the missing MODIS spectral response functions. A MODIS-like CO2 slicing retrieval can then applied at the lower sounder spatial resolution.
  - Use the lower spatial resolution sounder cloud-top retrievals as a first guess for the optimal estimation based approach.

VIIRS CTH IFF Example

Example MODIS MODAWG CTP



Example MODAWG IFF CTP

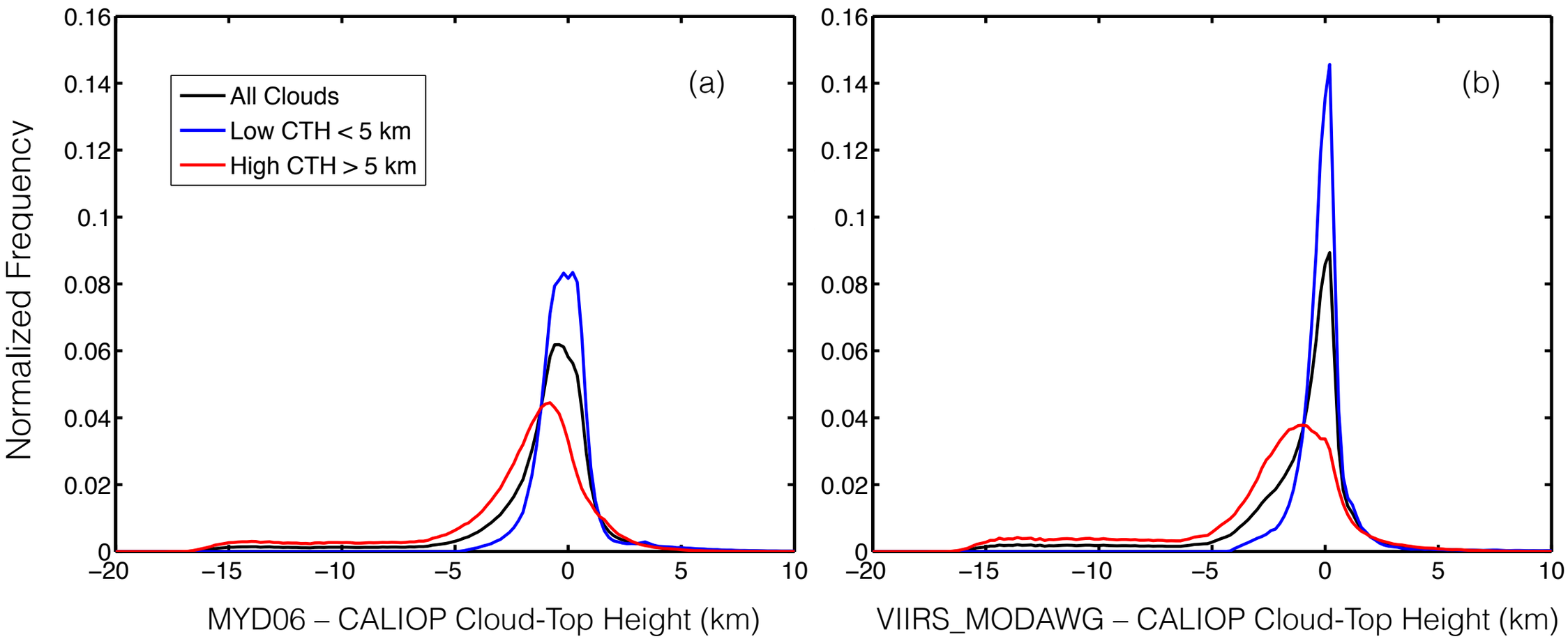


Global Collocated CALIOP CTH Statistics

- Derived from Atmospheric SIPS processing of a year of MODAWG test products 2012 - 2013

Collocated CALIOP vs MODAWG CTH

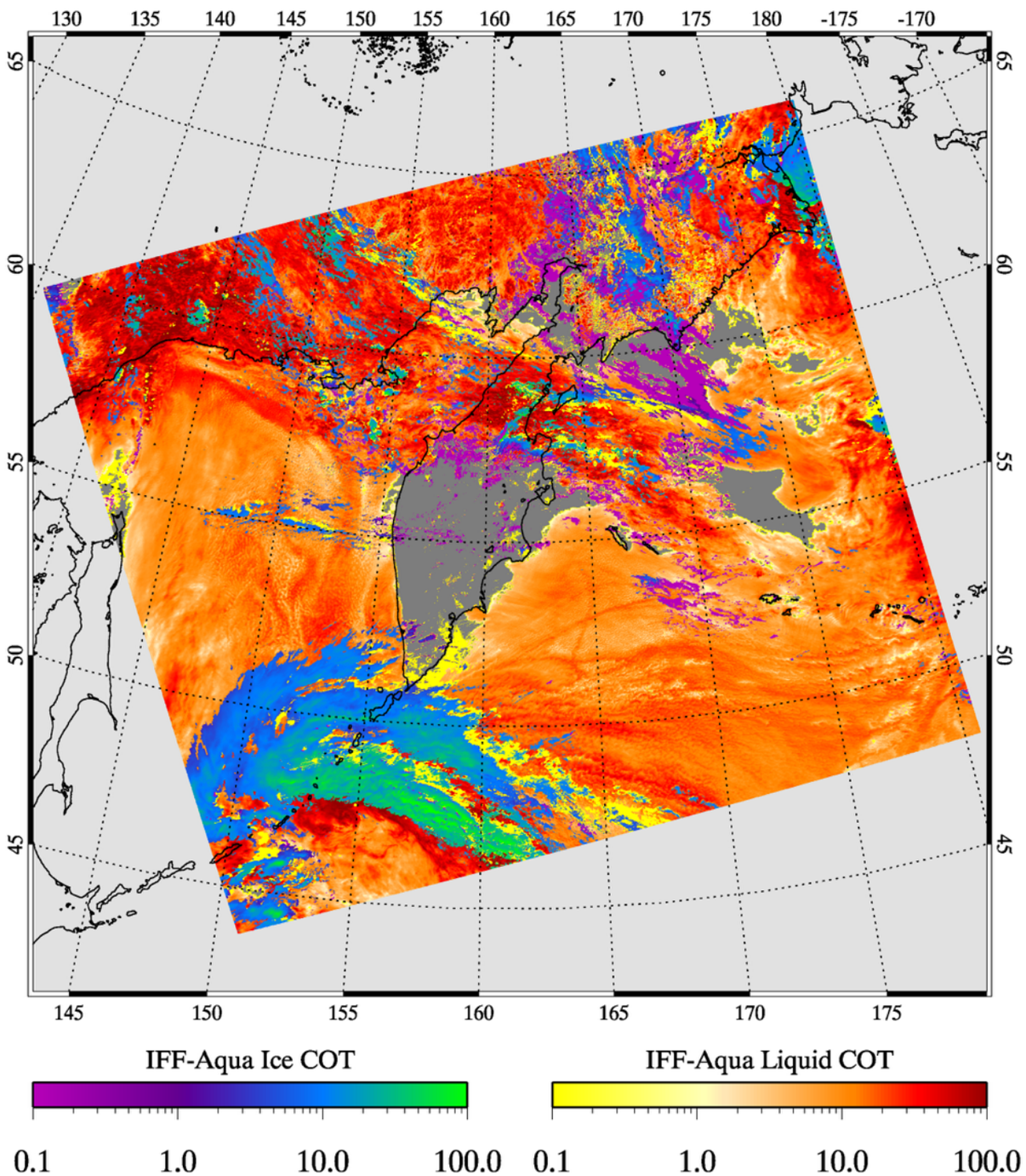
MODIS C6 MODAWG VIIRS



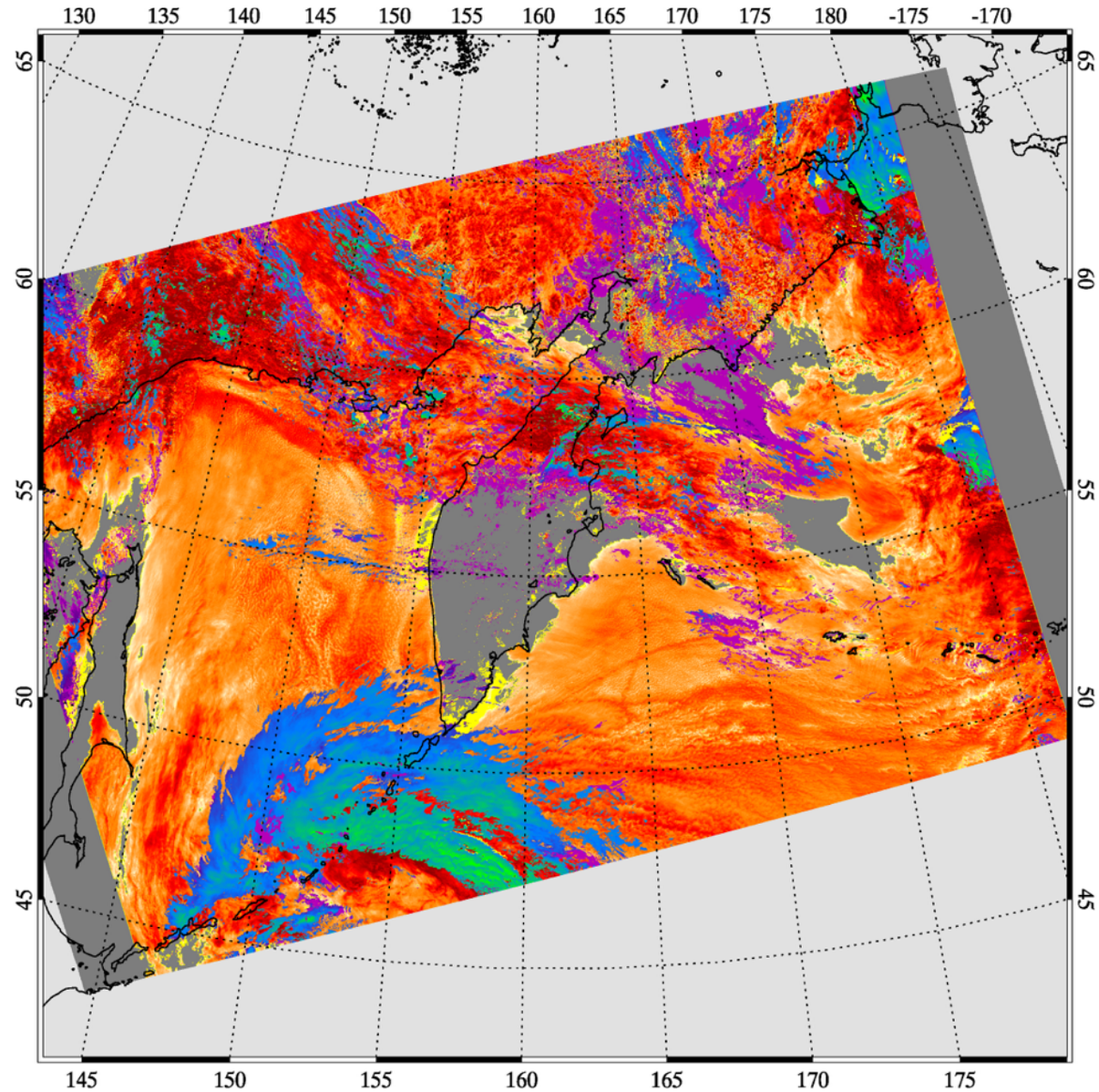
Optical Properties

- Approach:
  - Separate two-channel optical and microphysical retrieval algorithms applied to six visible through midwave-infrared channels, along with several IR channels and the cloud mask and cloud-top datasets.
  - Uses identical cloud radiative models, radiative transfer code, retrieval solution logic, pixel-level uncertainty algorithm, etc.
  - Identical use of ancillary data sets (e.g., spectral surface albedo/emissivity, snow/ice maps, sea ice maps, model clear-sky analyses, etc.)
  - Identical quality assurance (QA) bit structure
- Challenges:
  - VIIRS 2.25 μm vs. MODIS 2.13 μm channel: shift in the location of this key SWIR channel used for microphysical retrievals reverses the relative absorption between liquid and ice phase particles.
  - Depends on cloud mask and cloud-top retrieval quality for 3.7 μm emission calculations and above-cloud atmospheric corrections.

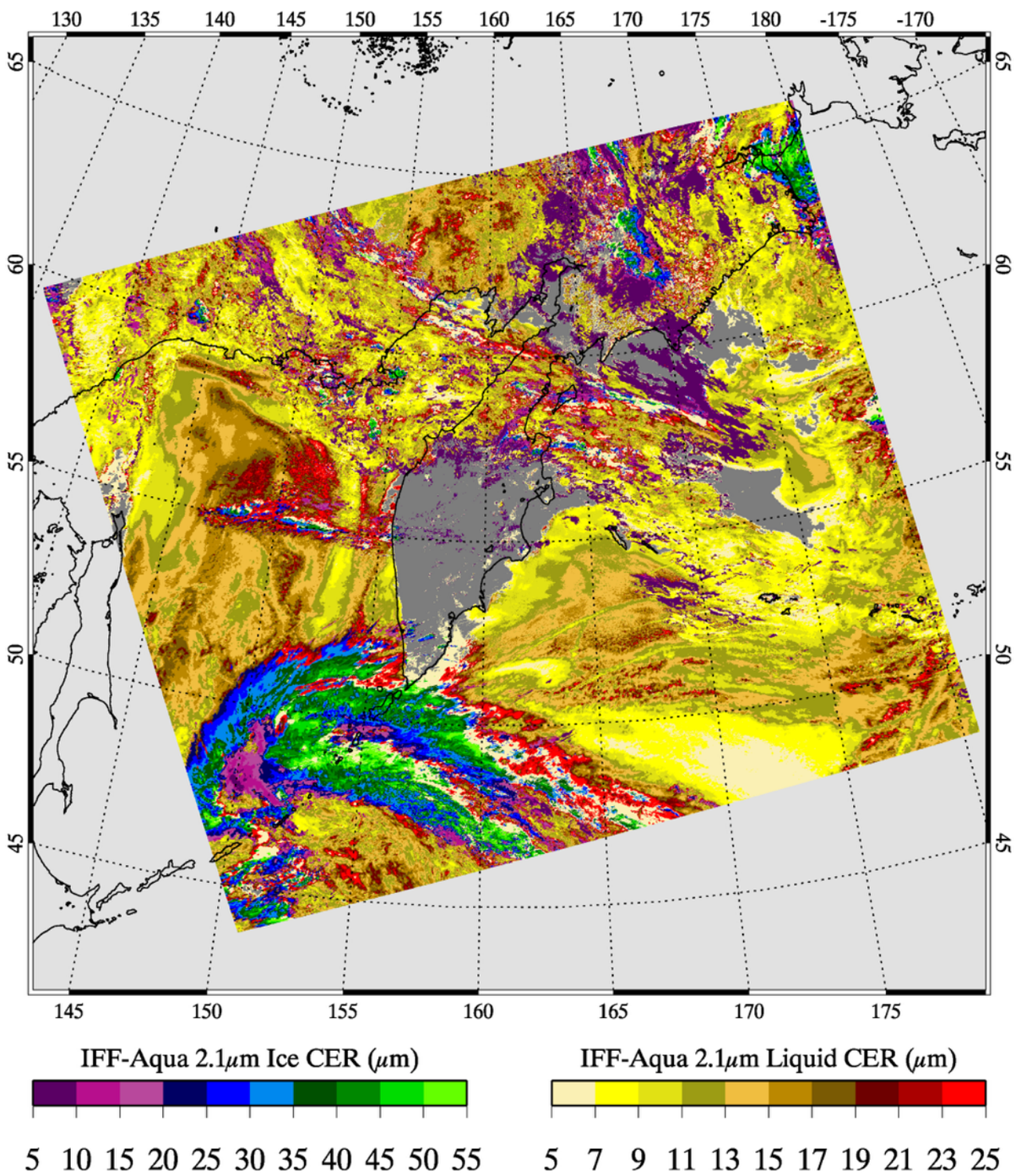
MODIS MODWAG COT Retrievals



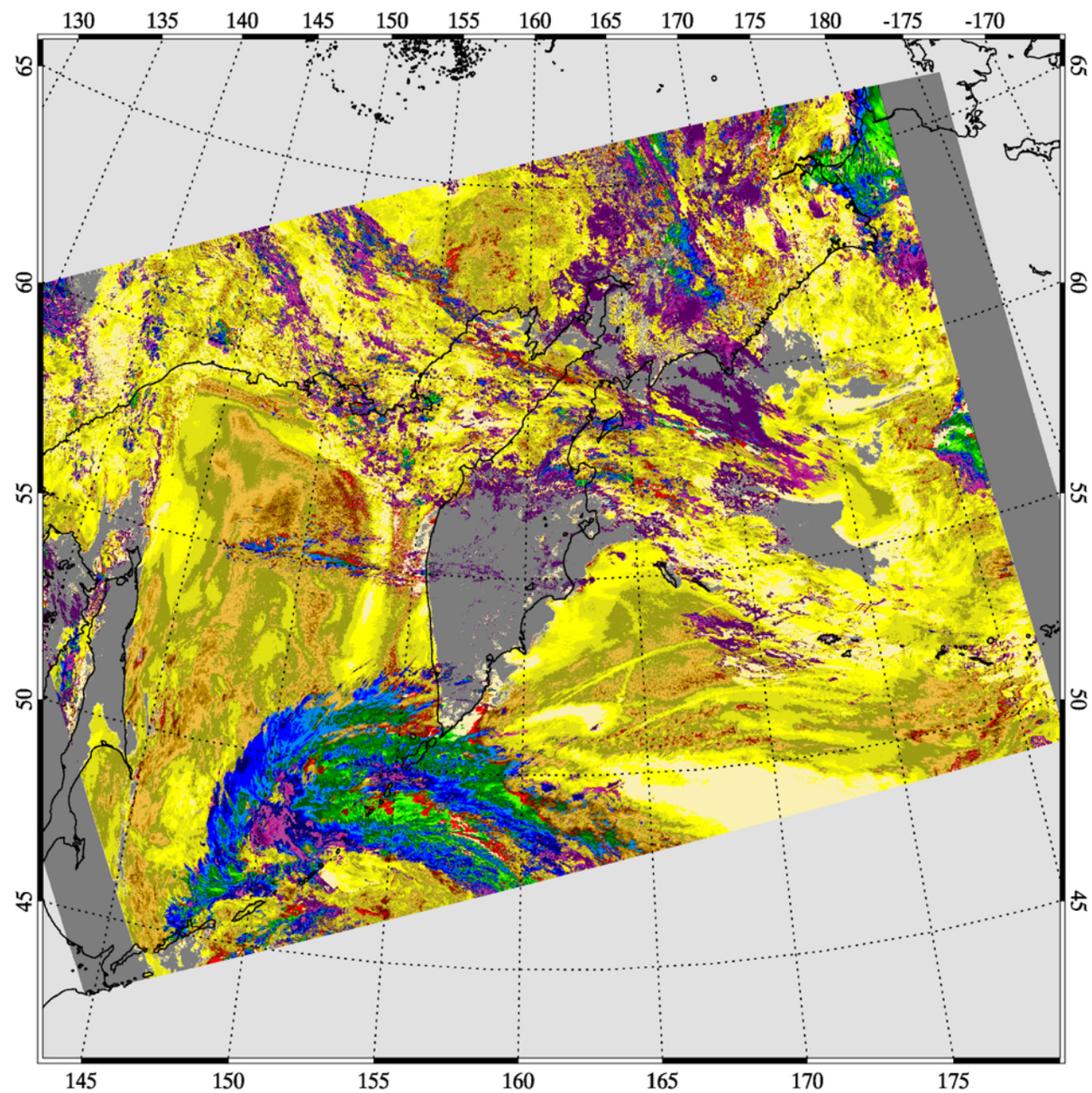
VIIRS MODAWG COT Retrievals



Example MODIS C6 Effective Radius

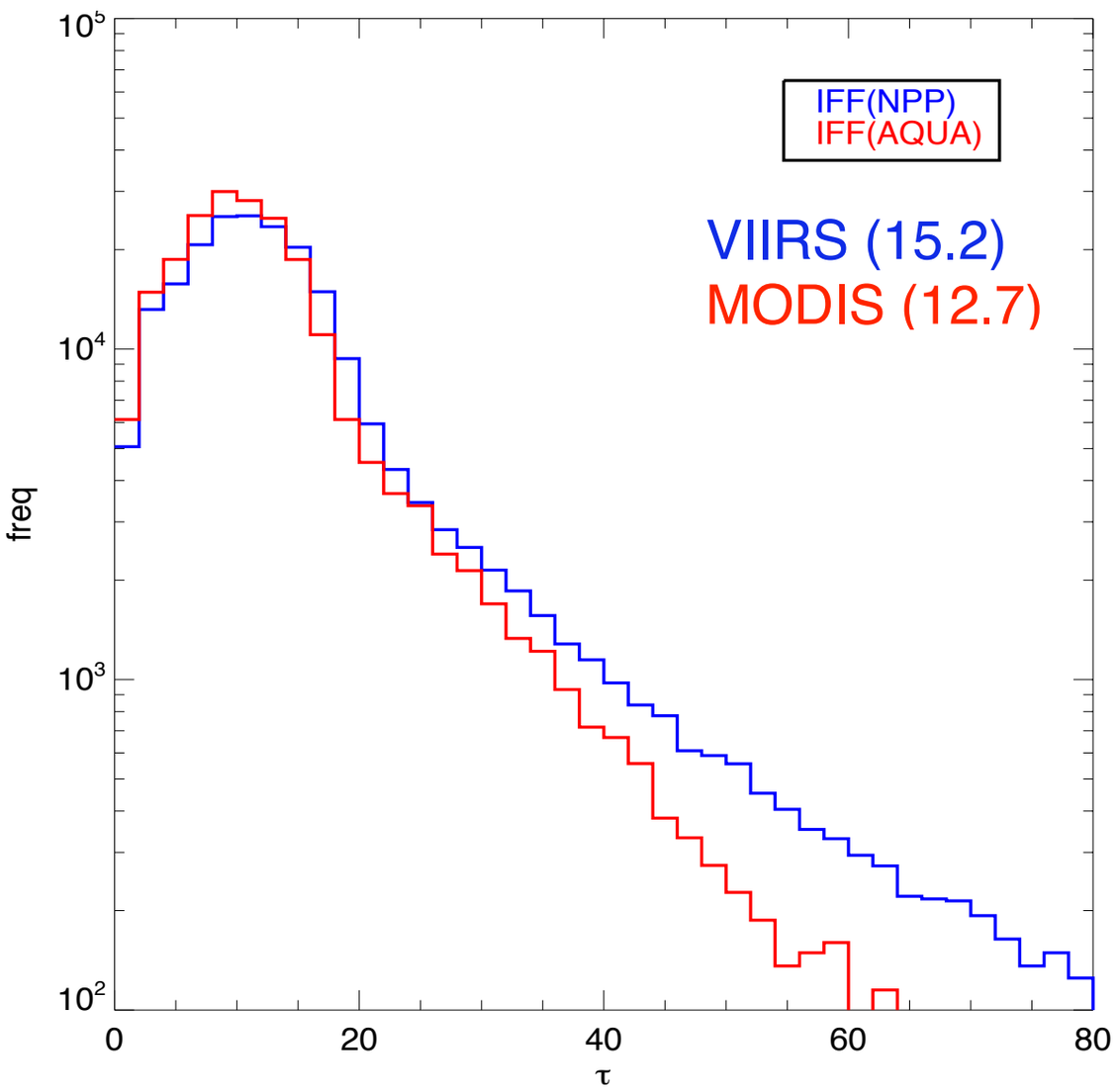


Example MODAWG IFF Effective Radius

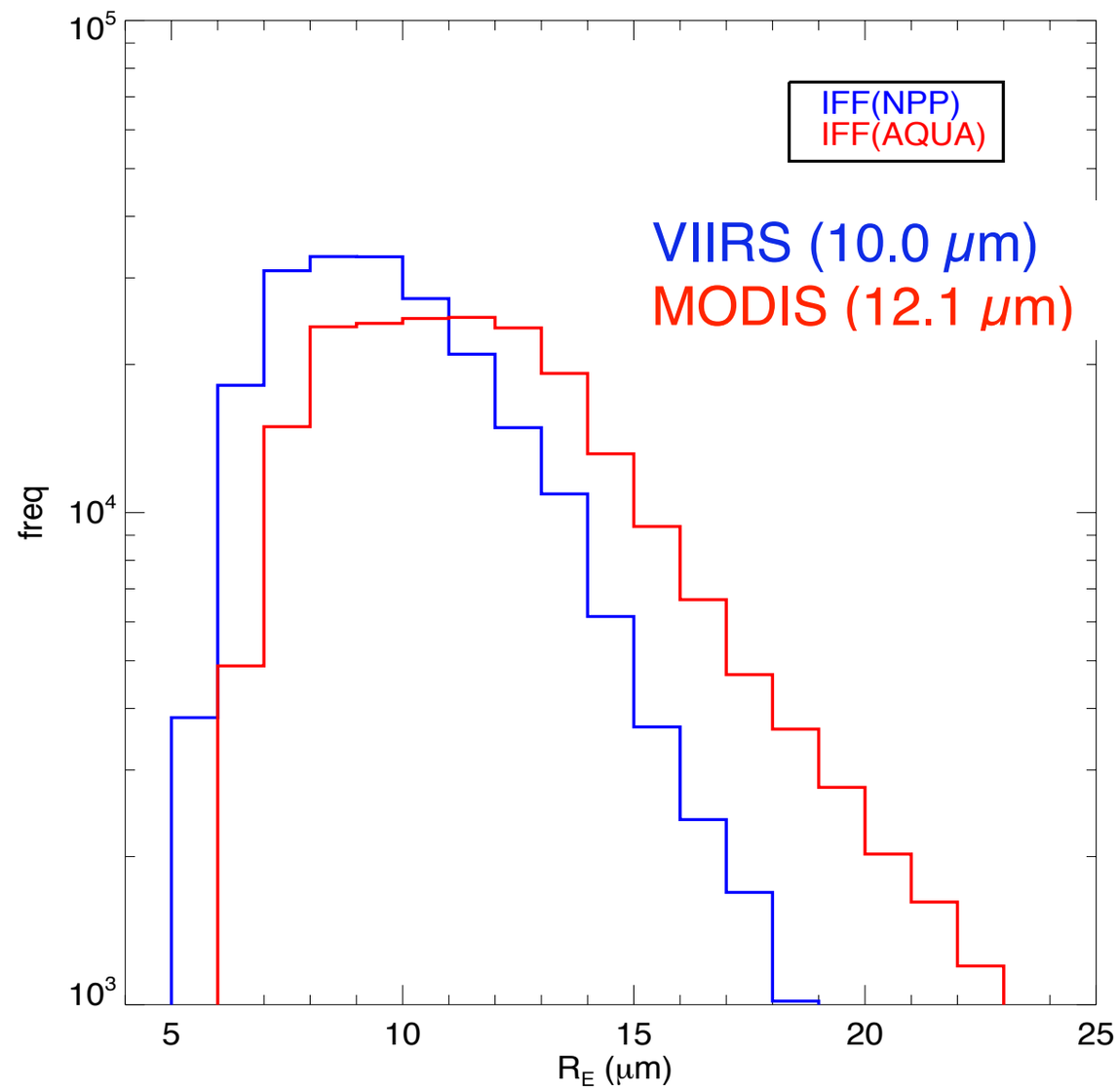


Histograms of the OT and Effective Radius for the sample granule

Optical Thickness

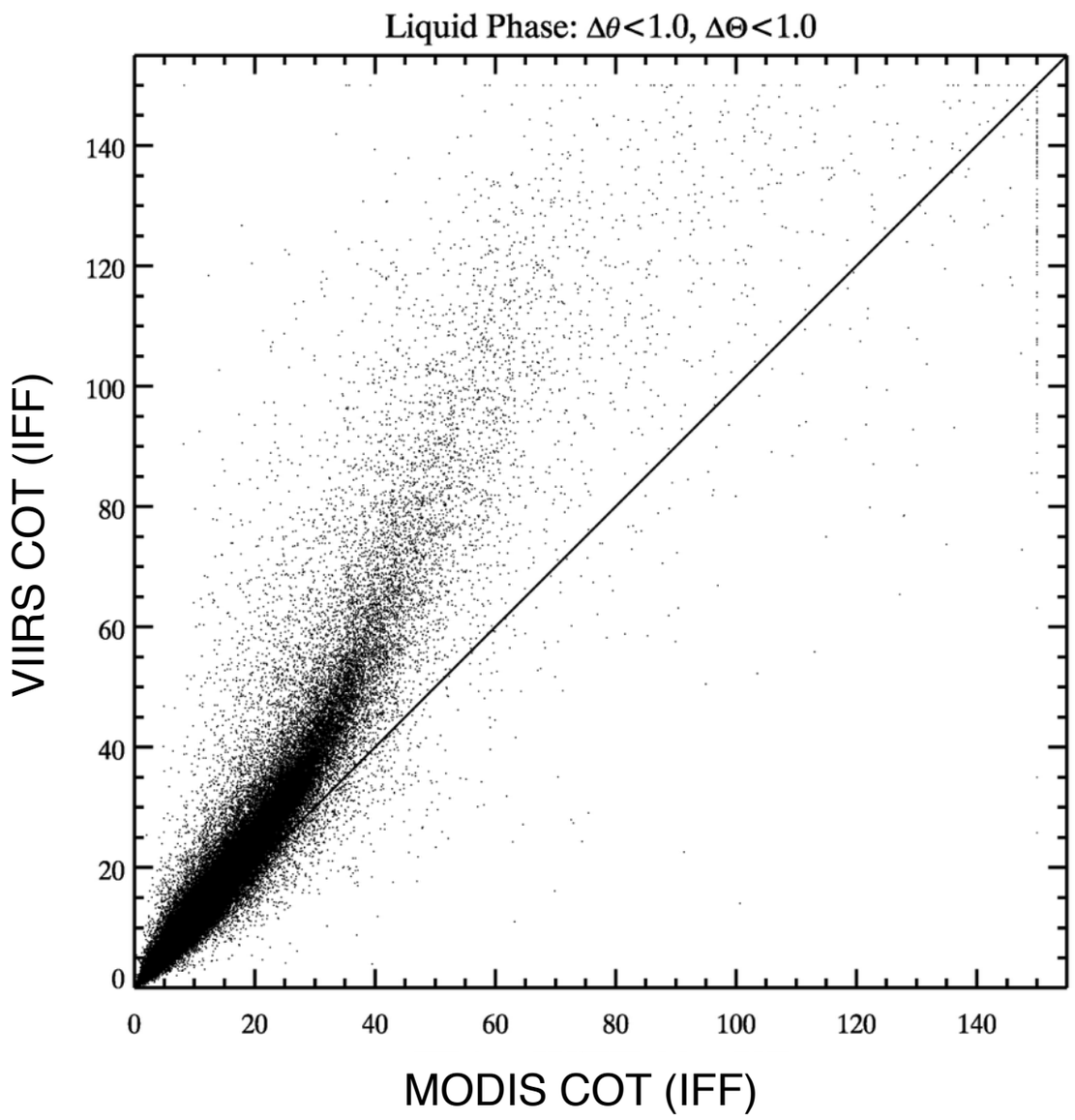


Effective Radius

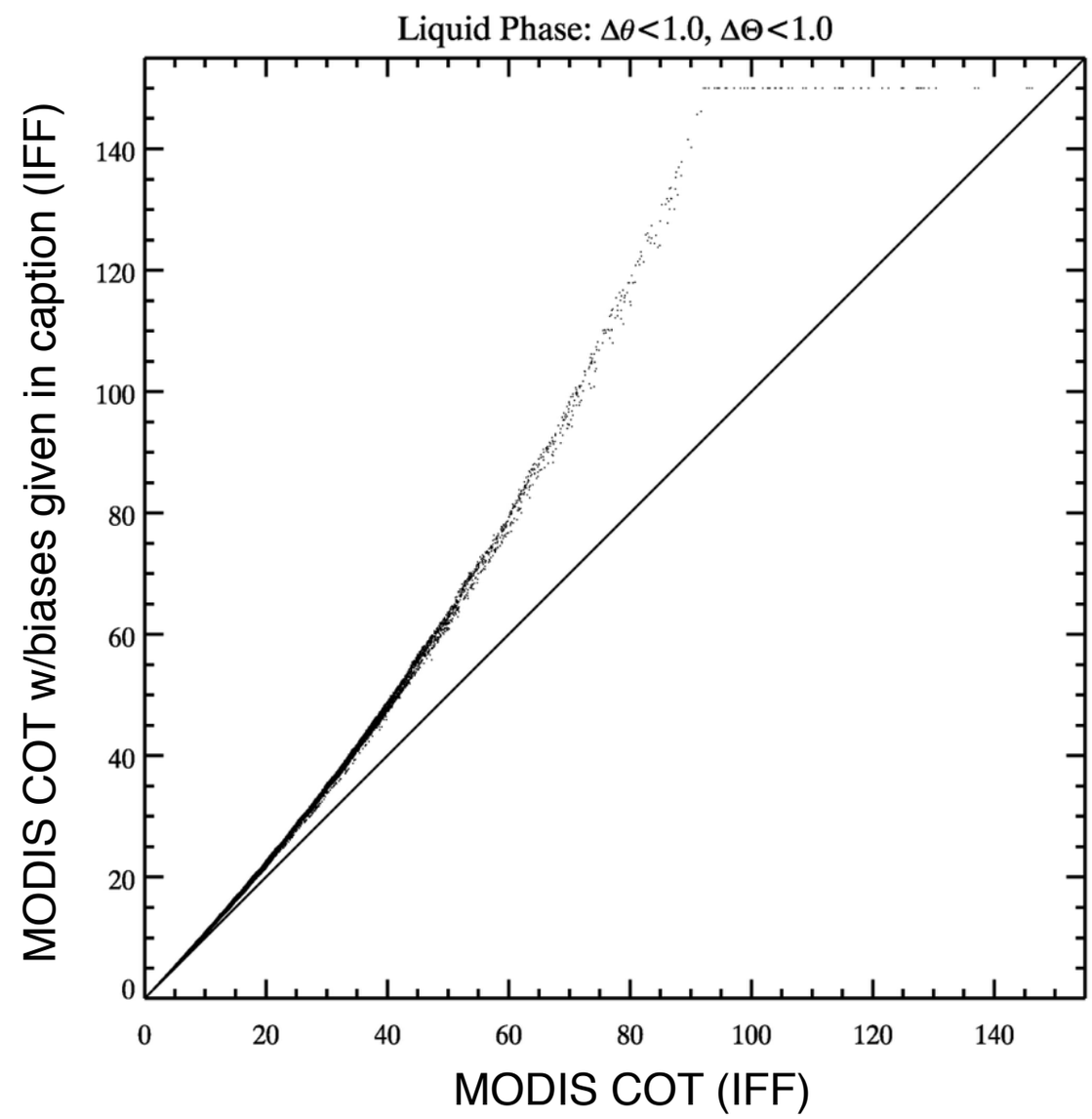


Liquid Water COT Comparisons for Example Granule

MODIS C6 vs VIIRS MODAWG



MODIS C6 vs Simulated 3% Bias



Summary

- NASA has funded, and is in the process of developing, a suite of S-NPP algorithms that will allow for continuity with EOS observations.
    - The ultimate goal is to provide NASA and the scientific community with products that bridge the EOS and S-NPP observational record and provide consistent performance for climate studies.
- **Instrument calibration (uncertainties) is crucial for this effort**
- Algorithm continuity (including forward models, ancillary data, pixel filtering, etc.) is required for data record continuity. Instrument measurement/information continuity alone is not sufficient.
- Due to the absence of key absorbing channels, the cloud product suite will leverage both imager (VIIRS/MODIS) and sounder (CrIS/AIRS) capabilities.
- The products will be tested and processed at the NASA Atmospheric SIPS located at UW SSEC. Following NASA ATBD reviews, the products will be delivered to a NASA data center for public distribution.