University of Wisconsin SSEC Development and Support for GEO and LEO Aerosol Retrieval Development

Robert Holz, Min Oo, Willem Marais, Ralph Kuehn, Coda Phillips, Steve Dutcher, Jeff Reid, Andrew Heidinger, Andi Walther, Liam Gumley, Christina Hsu, Rob Levy, Shana Matto, and Rebecca Willett

Observing Capabilities

- With the launch of AHI/ABI we have entered a new era for aerosol (and cloud) observing capabilities with MODIS like observations from Geostationary Orbit

- From LEO we now have VIIRS on S-NPP and NOAA-20

- These new sensors have similar spectral coverage and spatial resolution providing the potential for consistent global aerosol retrievals across the LEO and GEO platforms

- **However there are significant challenges to working with these new data sets which is the focus of this talk**

Challenges: Next Generation Geo-Stationary

- Viewing/scattering geometries for the GEO observations are different from LEO with a much larger range of scattering angles requiring improvements to the radiative transfer

- Cloud masking and cloud shadows

- **The data volume of the new sensors is orders of magnitude larger then the MODIS era and increased support for processing ie NASA GEO-SIPS?**

- These challenges will require substantial effort by the community to effectively leverage the new observational capabilities for operational applications

- **This talk will present the UW SSEC efforts for both algorithm development, processing/visualization support, and data assimilation**

SSEC Projects focused on Aerosols Retrievals

- CSU Multidisciplinary University Research Initiative (MURI) focused development and integration of littoral modeling and retrievals (Min Oo, Steve Miller, Jeff Reid, and Sonia Kreidenweis)
  - UW SSEC funded to develop a geo-stationary aerosol retrieval focused in littoral regions including Asia, India, and Africa
- NRL funded effort to investigate new approaches to extreme aerosol event detection using machine learning (Willem Marais, Rebecca Willett, and Jeff Reid)
- UW Atmospheric SIPS (Liam Gumley, Steve Dutcher, Greg Quinn, and Bruce Flynn)
  - Responsible for processing the NASA cloud and aerosol algorithms for VIIRS on S-NPP and NOAA-20.This includes both the Deep Blue and Dark Target Algorithms (Rob Levy and Christina Hsu)
- UW HSRL Deployments in Singapore, Korea, PISTON (ship), and Manila (Ed Eloranta)
- Geo/Leo product integration and visualization to support the NASA CAMP2eX field experiment (Ralph Kuehn, Coda Phillips, and Jeff Reid)
- Rob Levy’s NASA MEASURES project to produce a DT aerosol product for AHI and ABI (Shana Matto, Paulo Veglio and Min Oo)

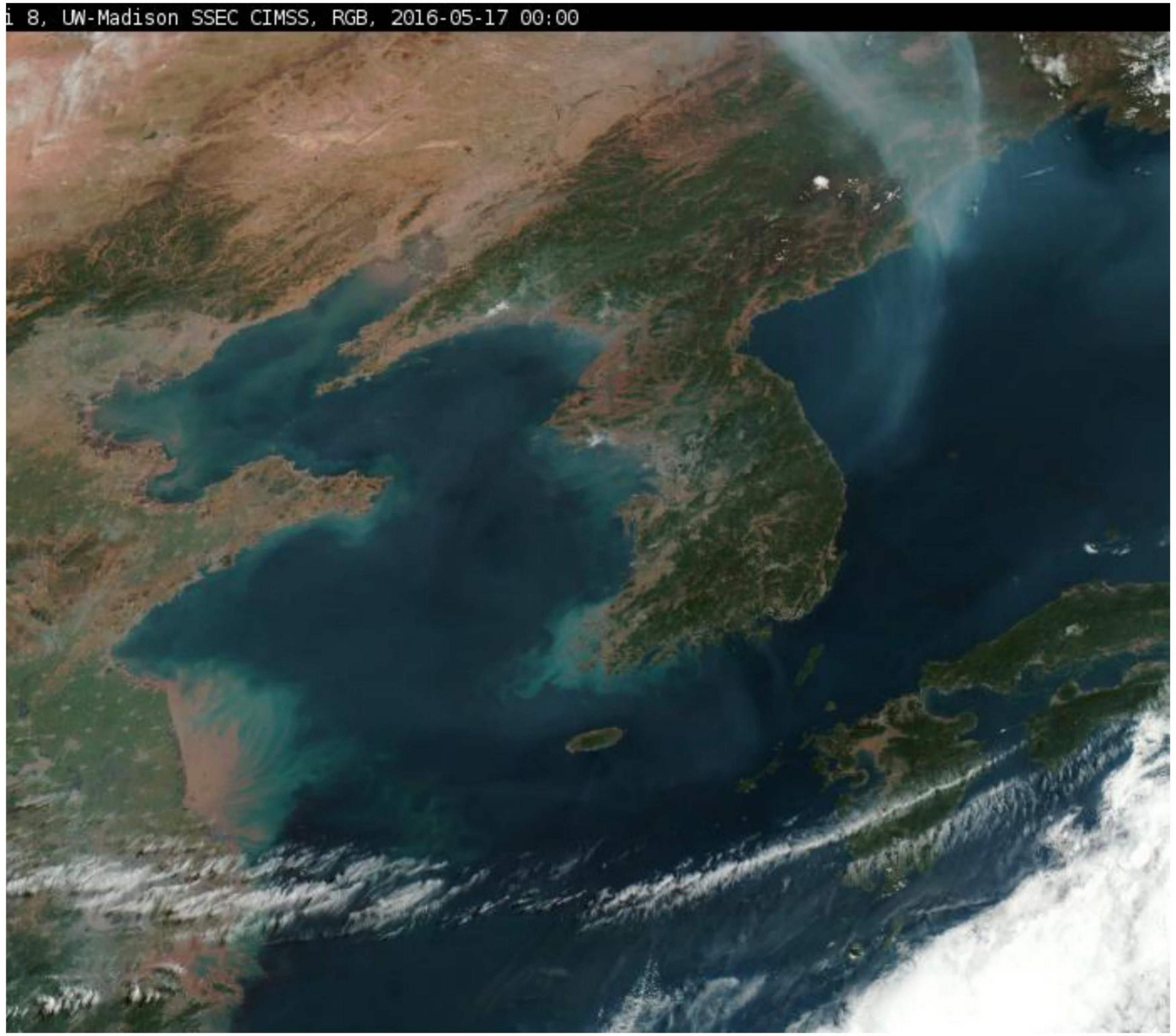
MURI Aerosol Algorithm Development

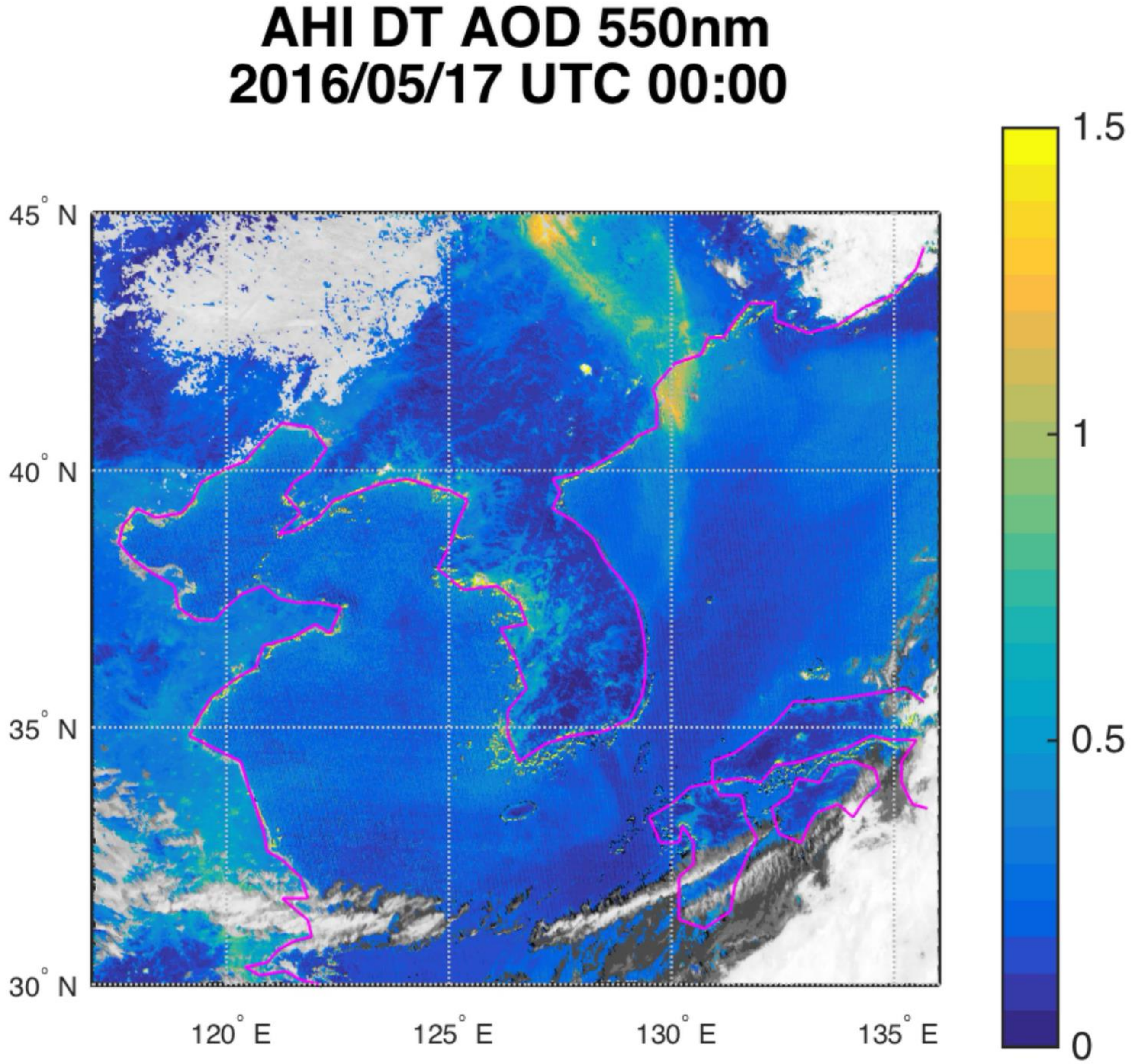
- Develop a next generation geo-stationary aerosol retrieval applied to AHI and ABI observations for land, ocean and littoral zones.

- Investigate the use of the time dependent information to separate surface from aerosol/cloud features, focused on littoral regions. The algorithm is being integrating into CLAVRx (NOAA cloud algorithm framework)

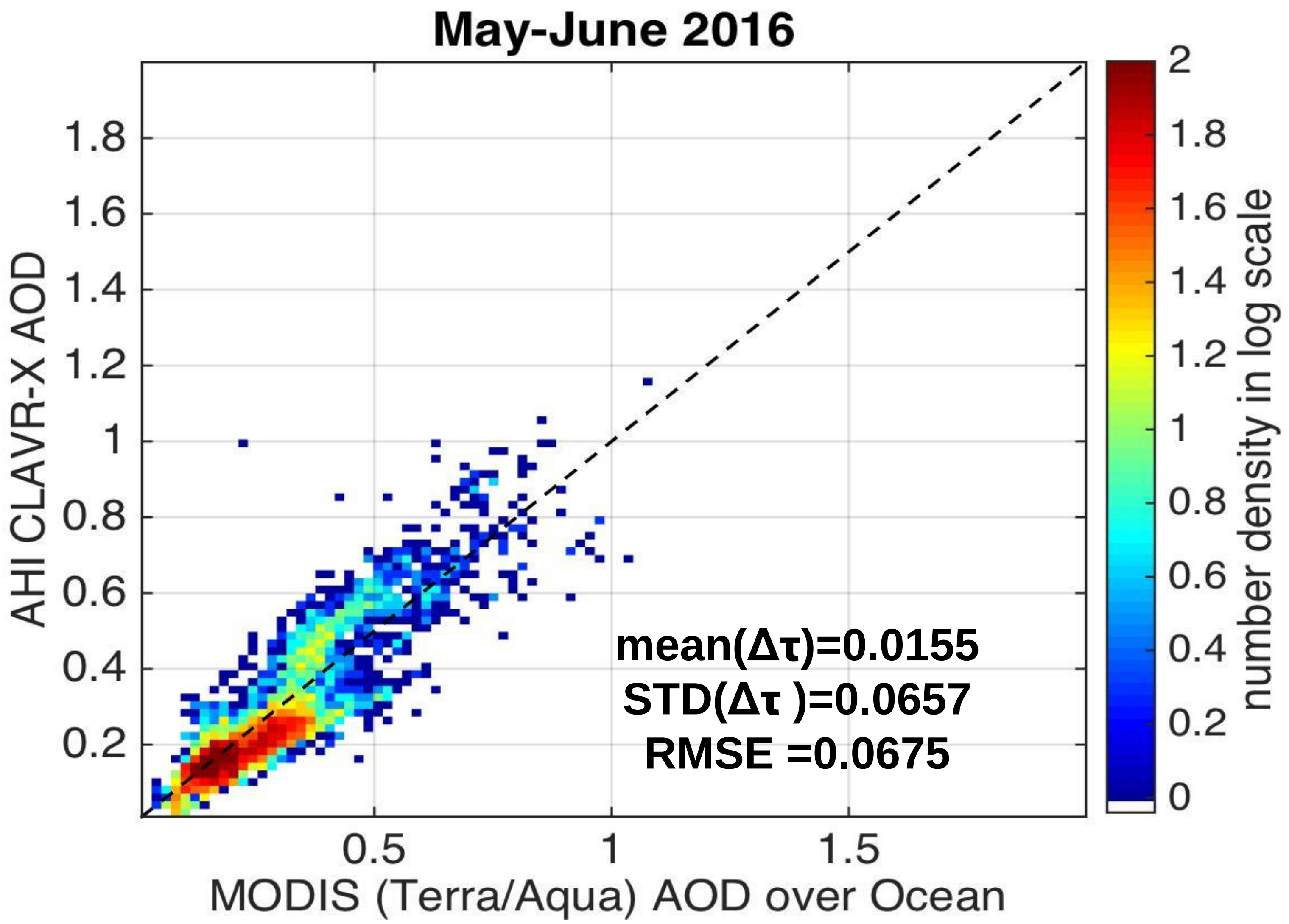
- Investigate the use of geo-stationary aerosol retrievals for data assimilation and modeling components of the MURI

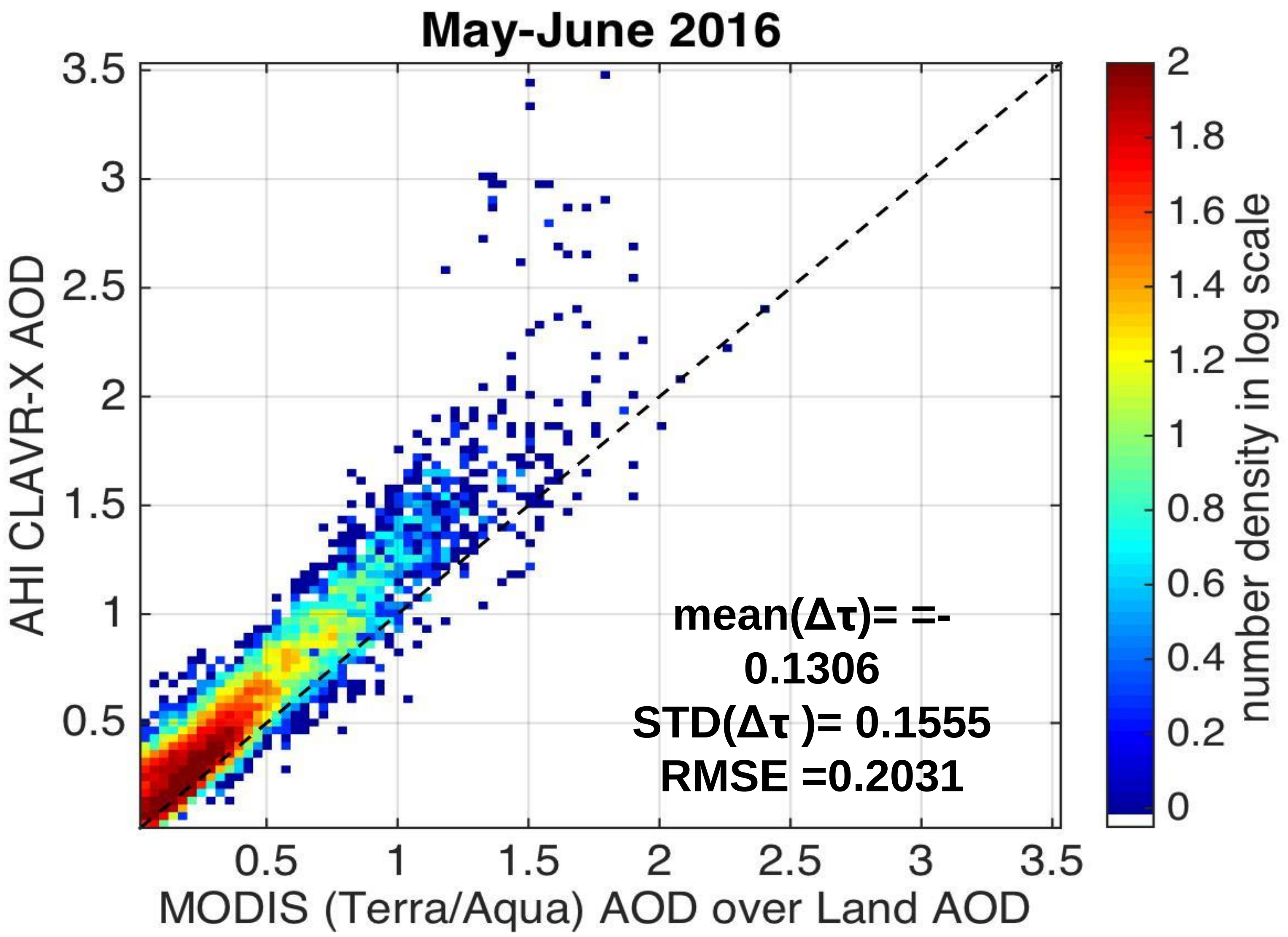
UW MURI AHI AOD





AHI vs MODIS AOD over Korean peninsula during KORUS-AQ

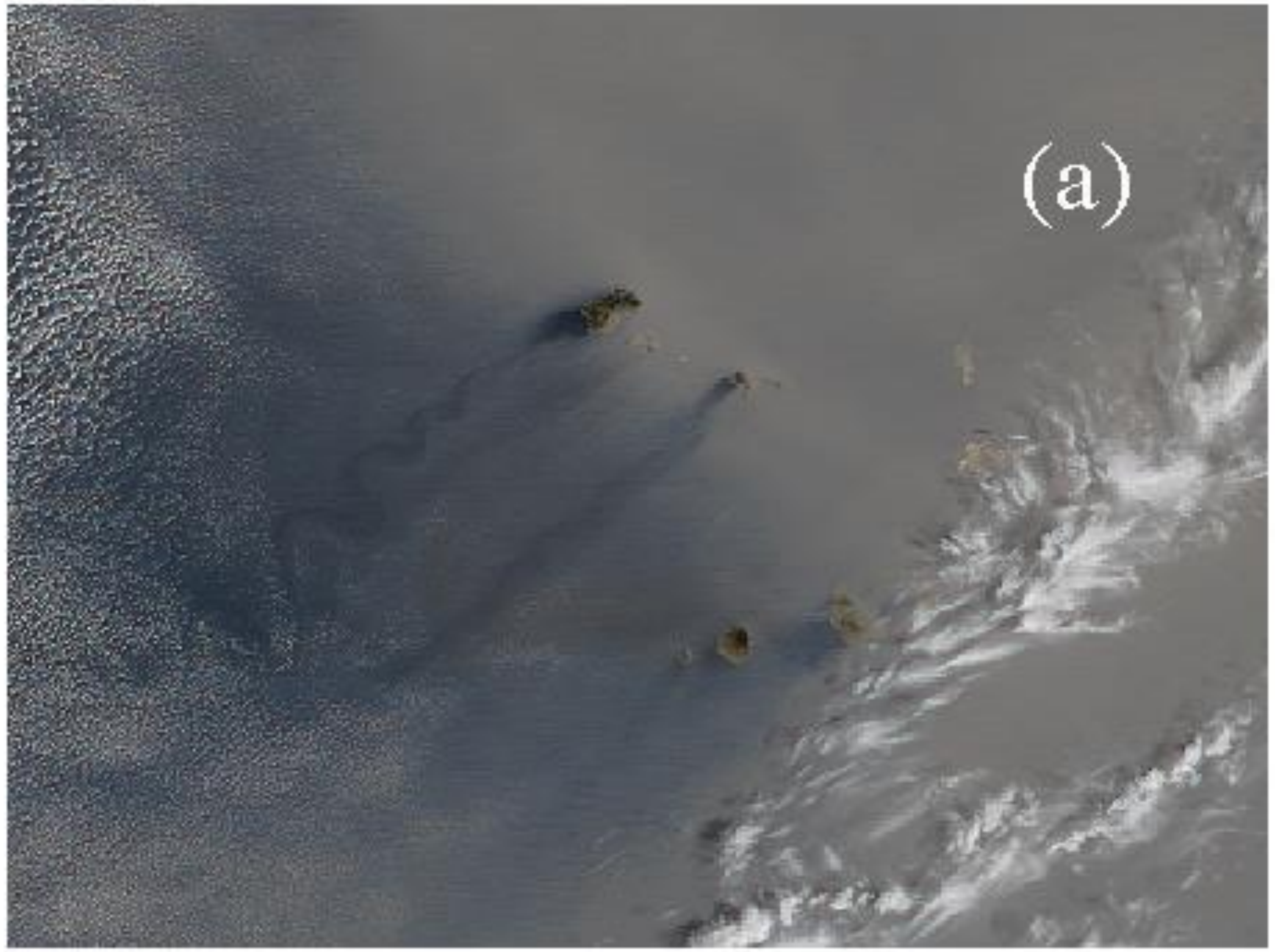




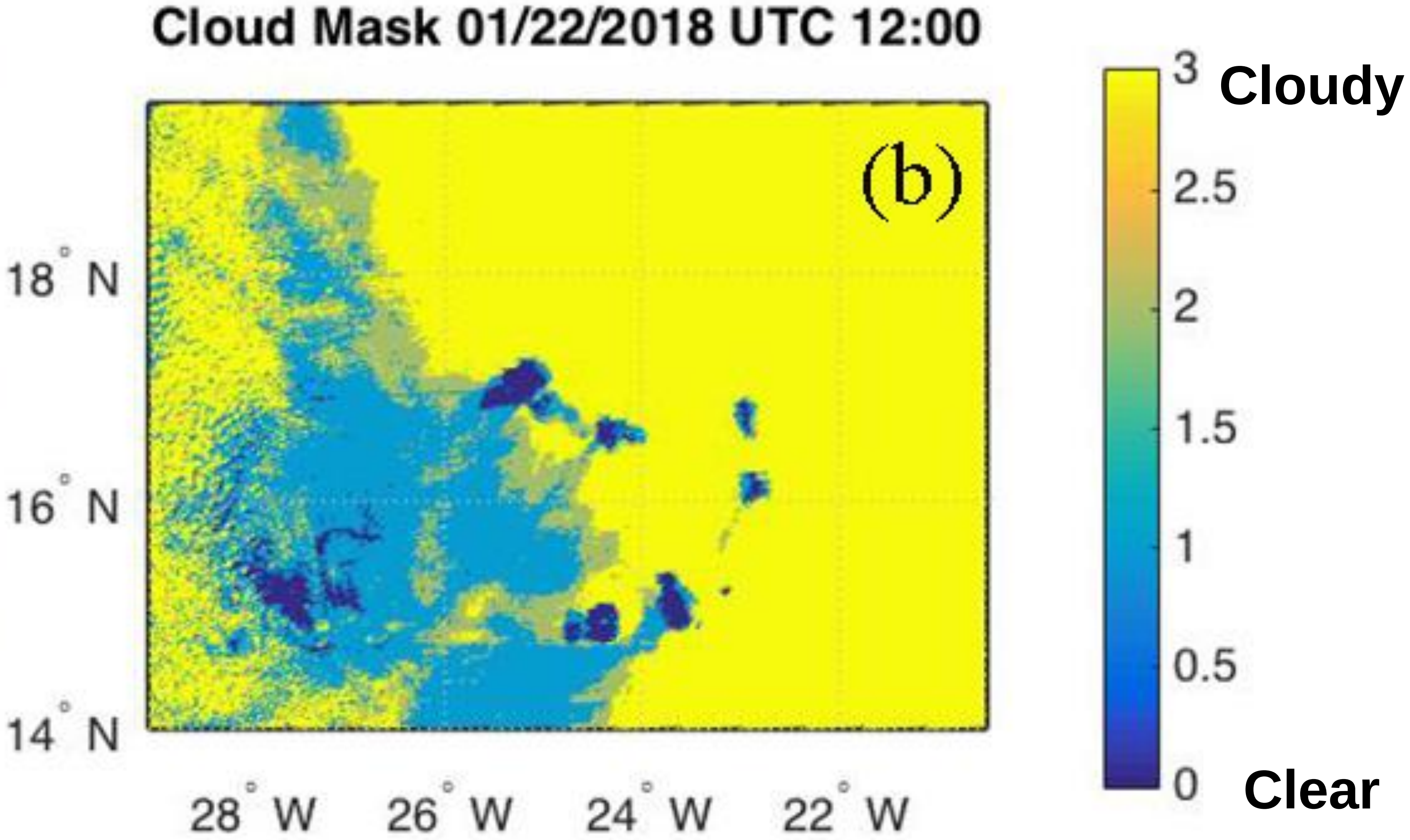
KORUS-AQ: An International Cooperative Air Quality Field Study in Korea (2016)

Saharan dust over Cape Verde islands (ABI January 22 2018)

ABI True Color 12:00 UTC



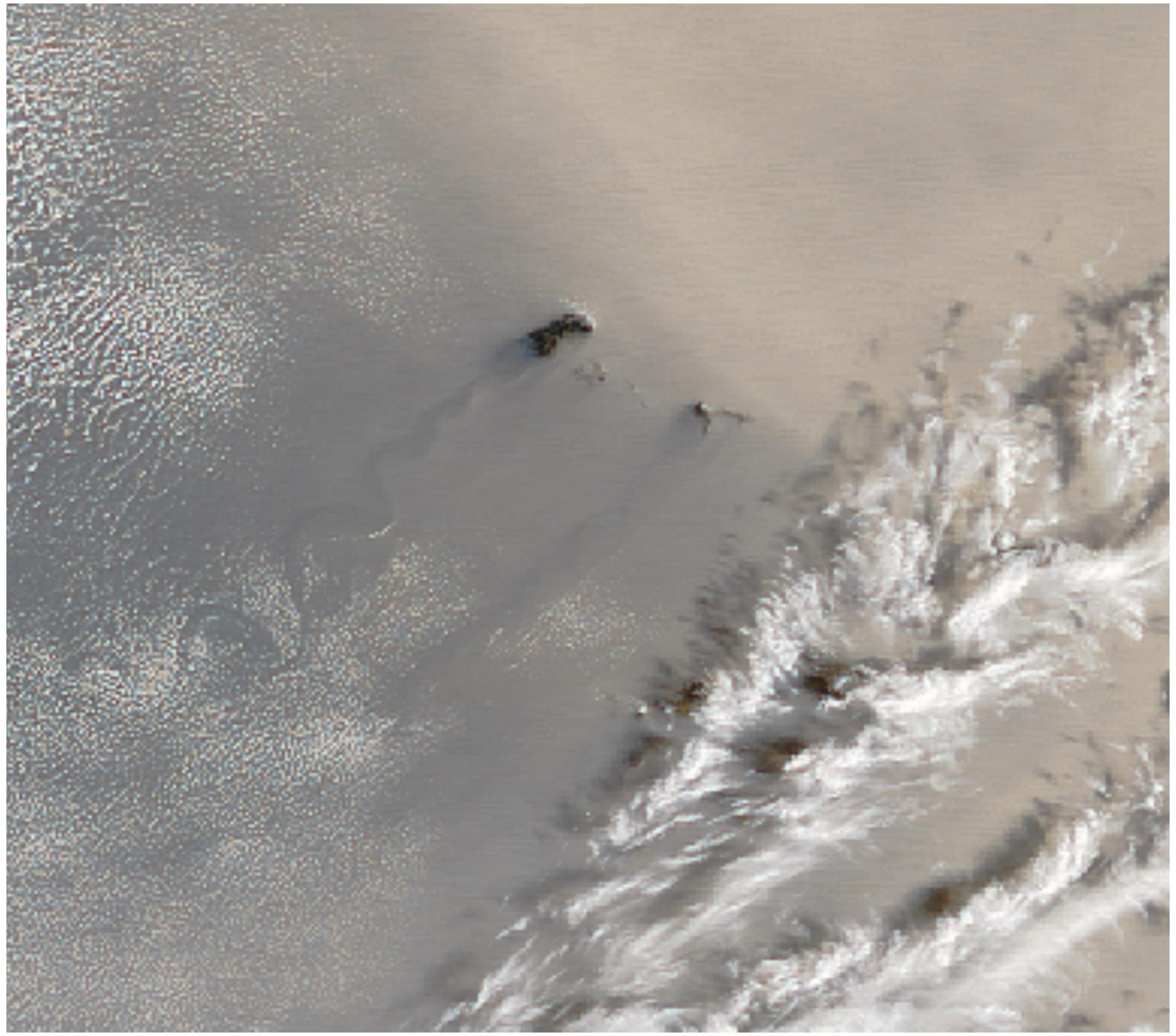
CLAVRx Cloud Mask

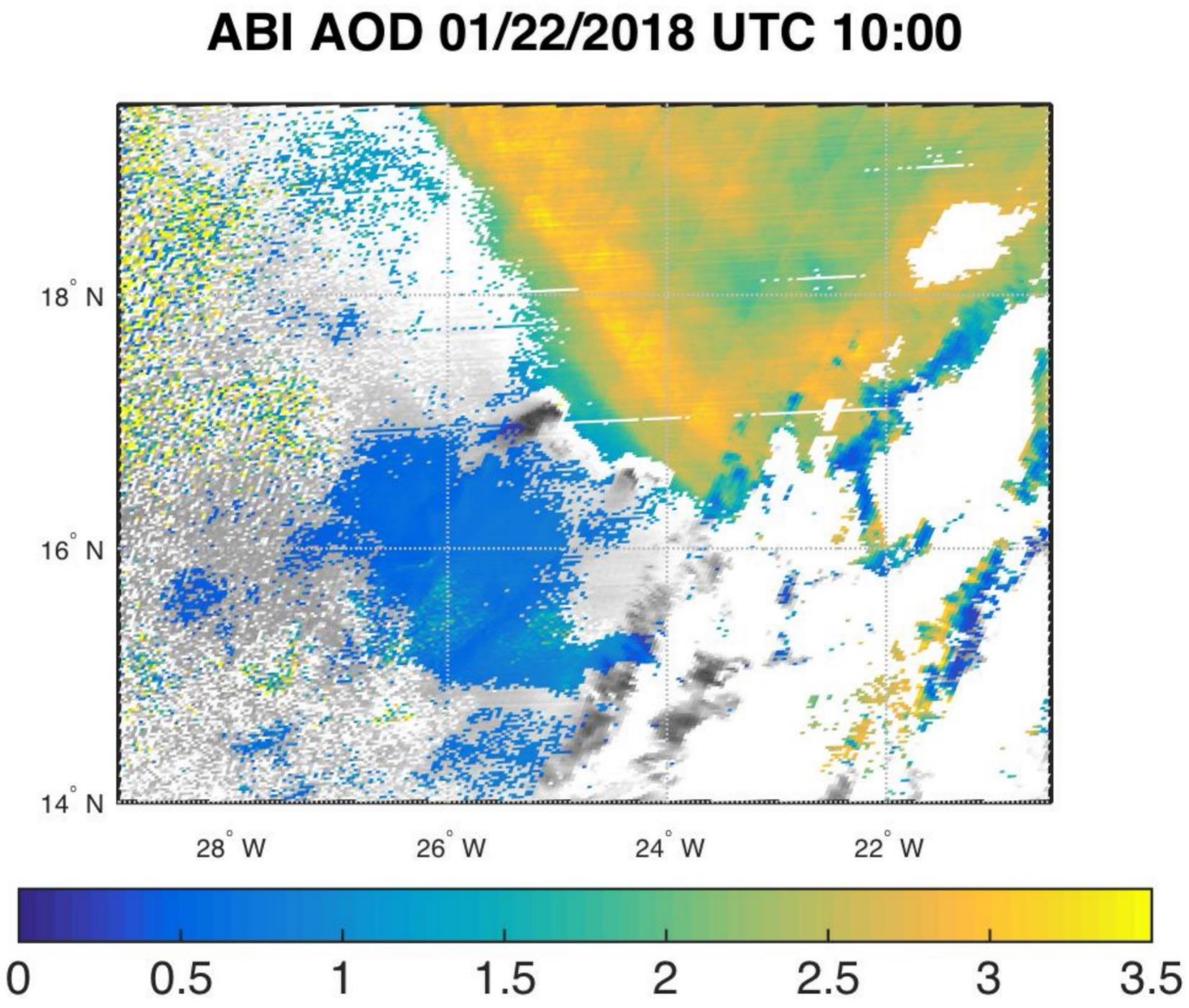


Challenges:

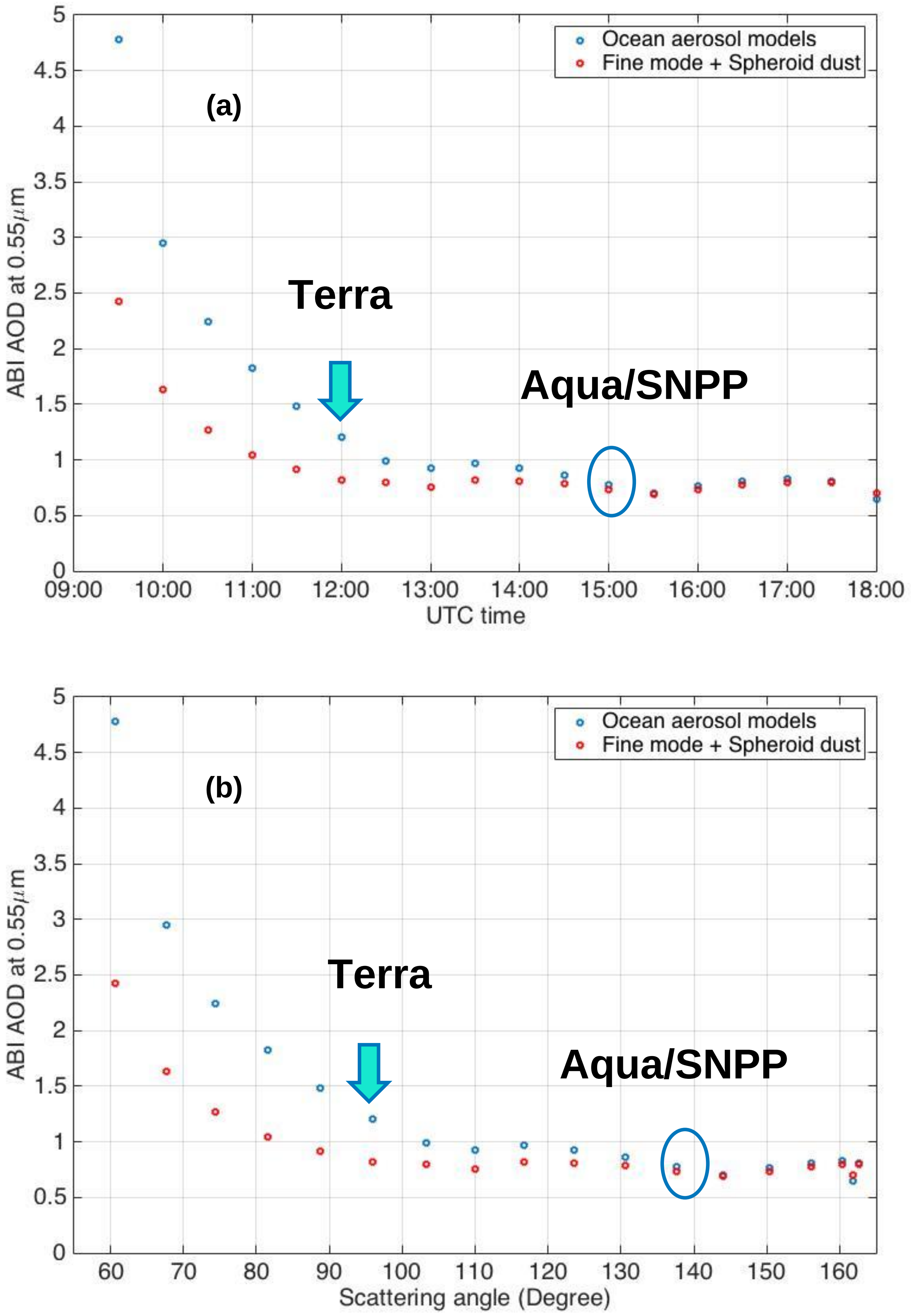
- **Cloud/Aerosol discrimination**
- **ABI Calibration (0.65 channel bias)**
- **GEO is much more demanding on the radiative transfer (particle phase functions compared to LEO)**

MURI ABI AOD (MODIS ocean aerosol model)





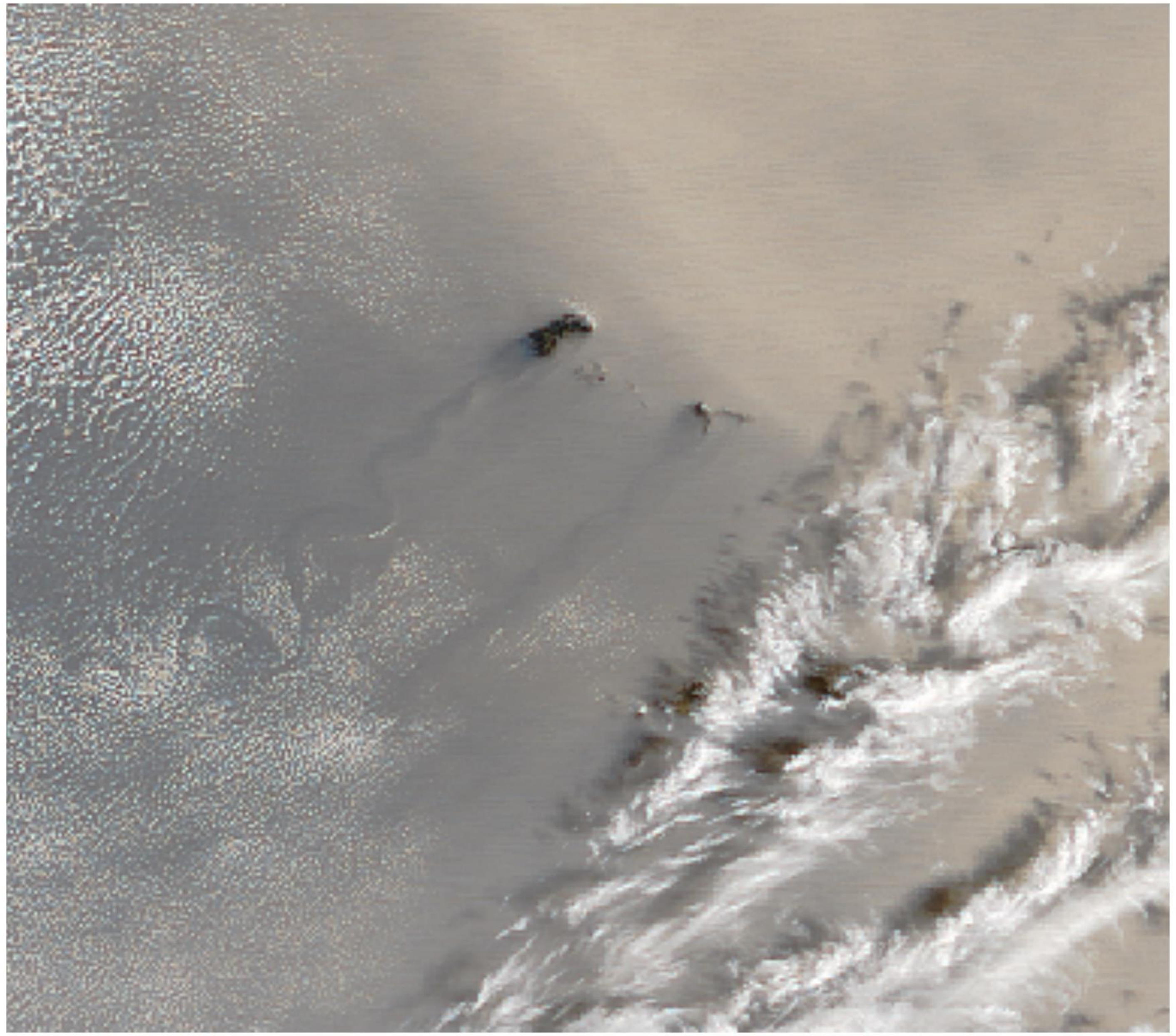
Added BT Cloud mask i.e., BT 3.9,11.2 and 12.3μm

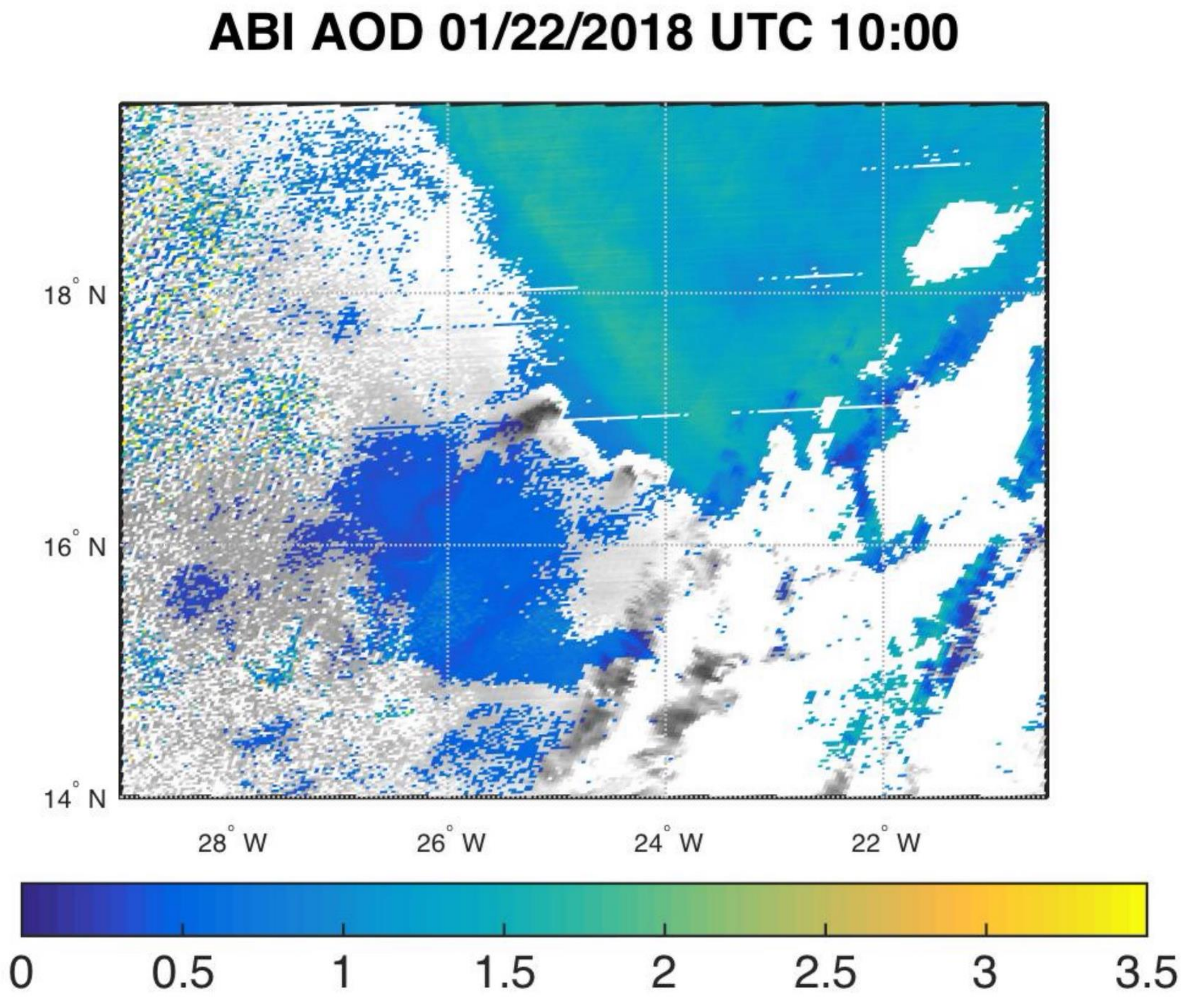


Scattering angle dependent ABI AOD bias for dust

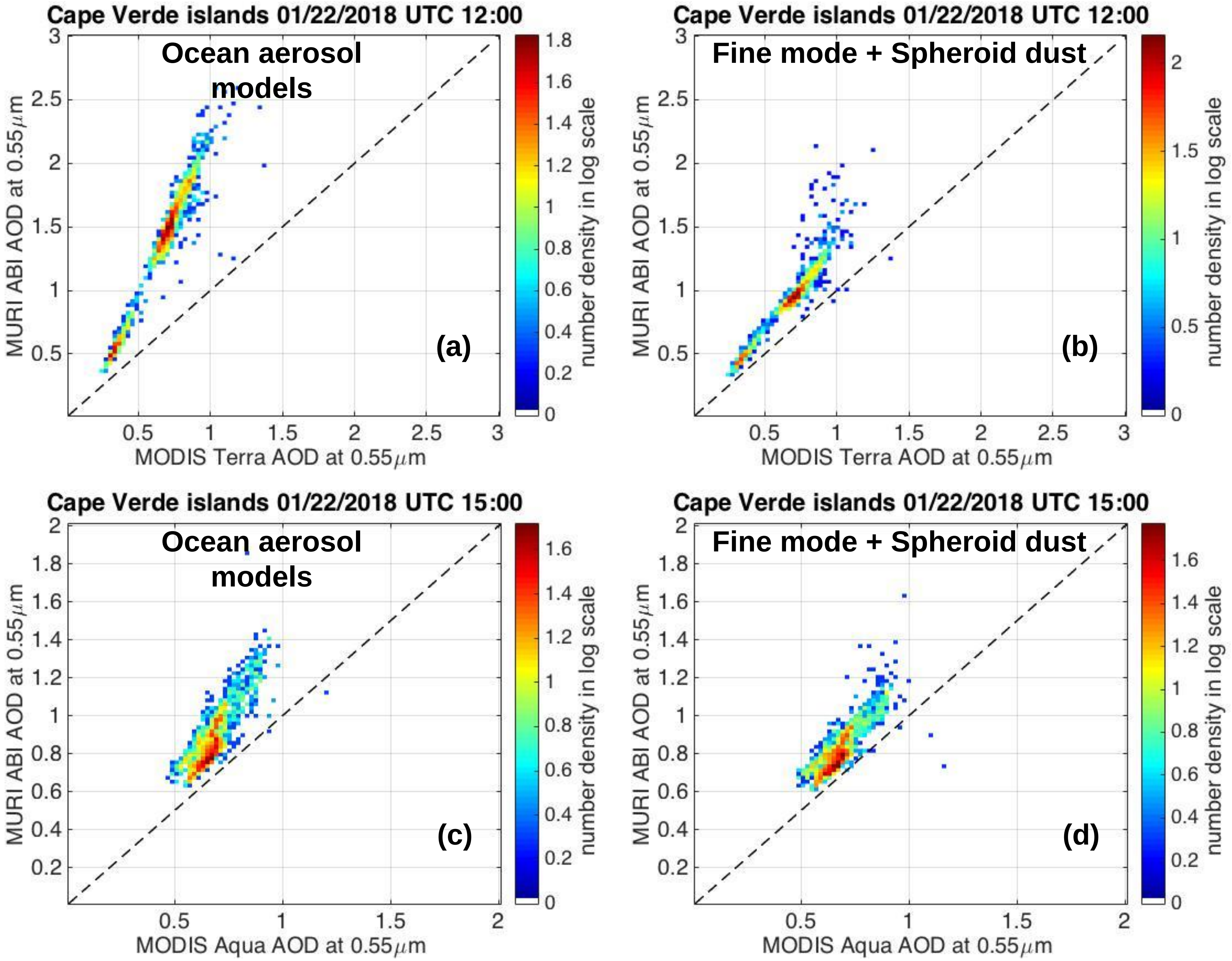
- (a) ABI retrieved AOD using standard ocean aerosol models (blue) and fine mode + spheroid dust models (Texas A&M University) (red) varied with UTC time and (b) corresponding scattering angle.
- MODIS Terra and Aqua pass time to Cape Verde islands are UTC 11:55 (arrow) and 15:00 (oval) respectively.
- ABI scattering angle at UTC 12:00 is ~ 95 ° and UTC 15:00 is ~ 137 °
- Scattering phase function of aerosol models are highly sensitive in (near) forward scattering angles.

New dust model
20% ocean + 80% spheroid dust





Direct comparison ABI vs MODIS AOD



- Fig (a) and (c), retrieved AOD using standard ocean aerosol models
- Fig (b) and (d), retrieved AOD using 20% of a fine mode of 4 fine mode + 80 % of spheroid dust aerosol model

- Scattering angle of MODIS Aqua and Terra **(~ 135° to 145°).**

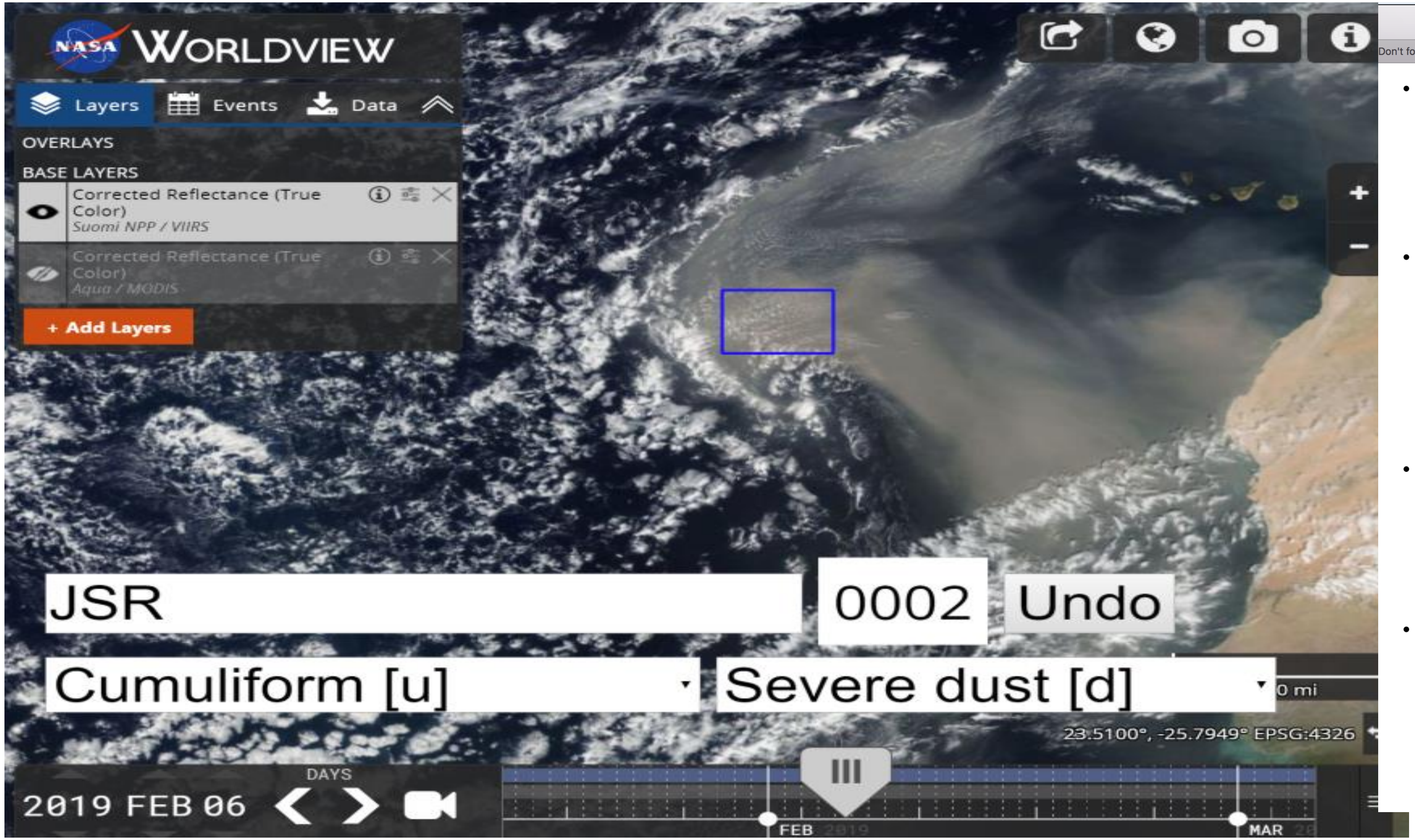
- ABI view zenith angle Cape Verde islands > 65 degree
- ABI scattering angle at UTC 12:00 ~ **95° - 137 °** at 15:00 UTC

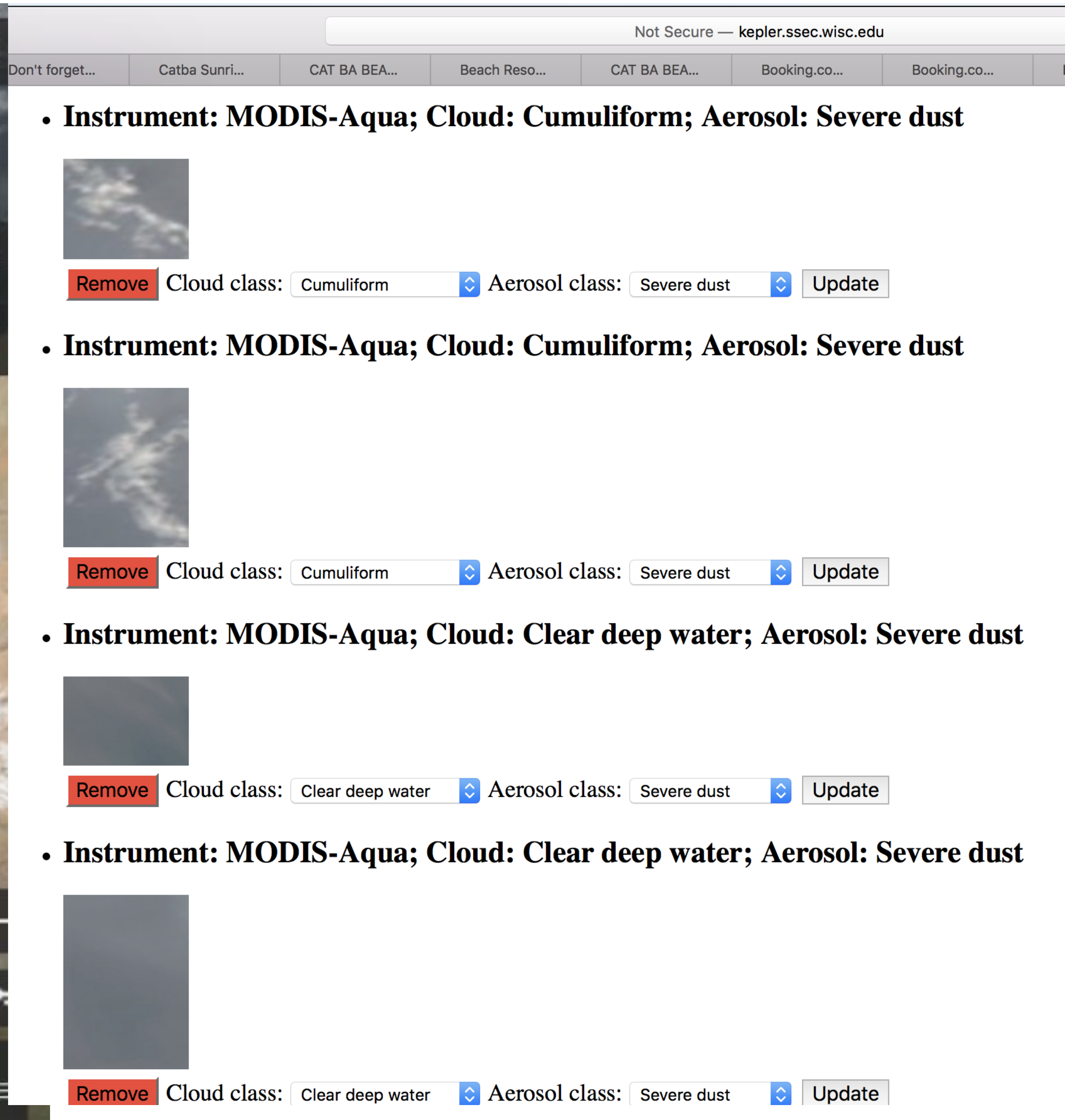
Leverage Spatial Coherence in Satellite Observations to Improve Aerosol/Cloud Classification

- **Goal:** Develop methodologies to identify cloud and aerosols using more powerful spatial texture analysis with the goal of better severe aerosol identification.
- We adopted an off-the-shelf Convolutional Neural Networks (CNN) to extract features from MODIS / VIIRS images.
- The extracted features are classified with a multi-class classifier (multinomial regression method).
- **Challenge**: How do we create a training dataset and optimize the available training data?

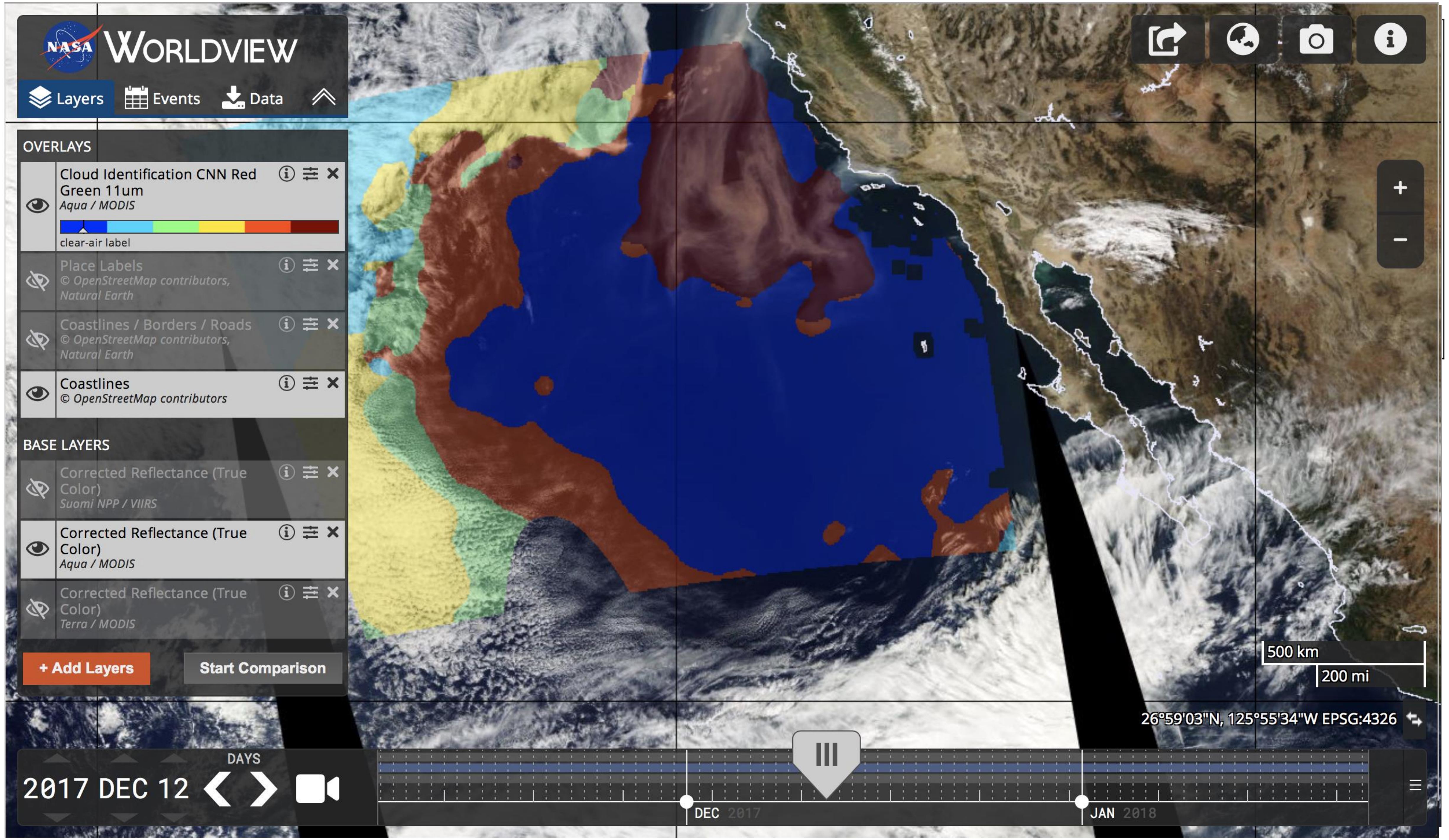
Modified Worldview to facilitate developing a human classification training data set

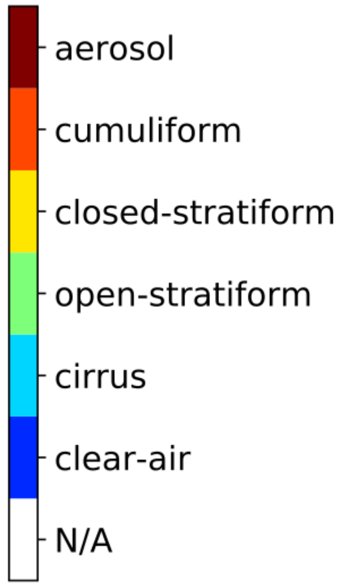
Jeff Reid = 385 boxes = 67,044 patches





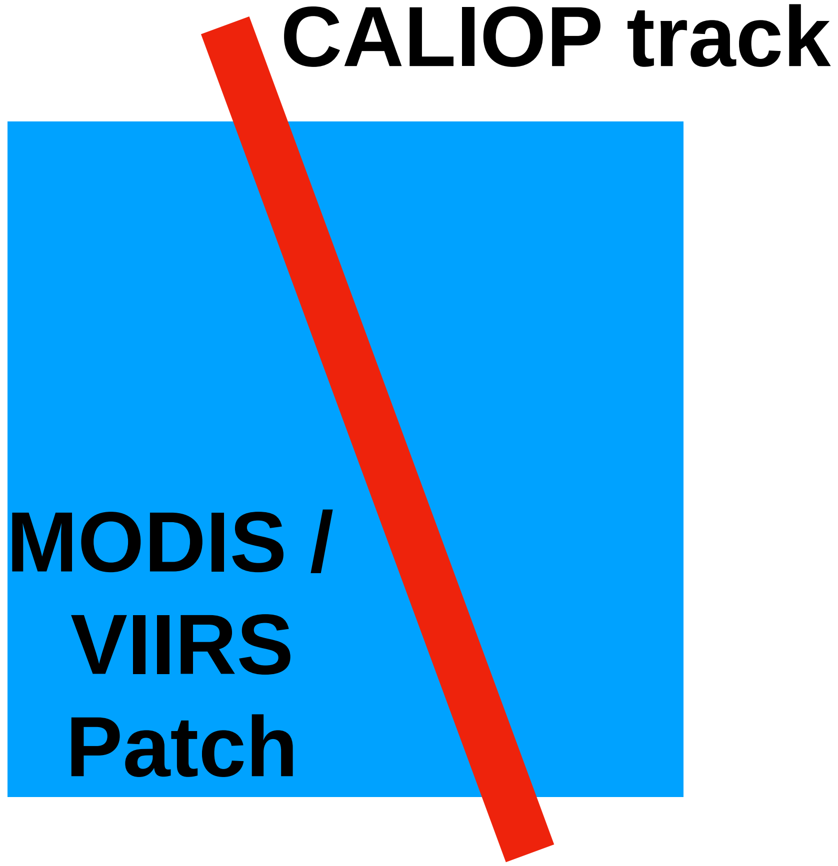
Convolutional Neural Network Classification
MODIS Smoke Case Study Dec 12th 2017

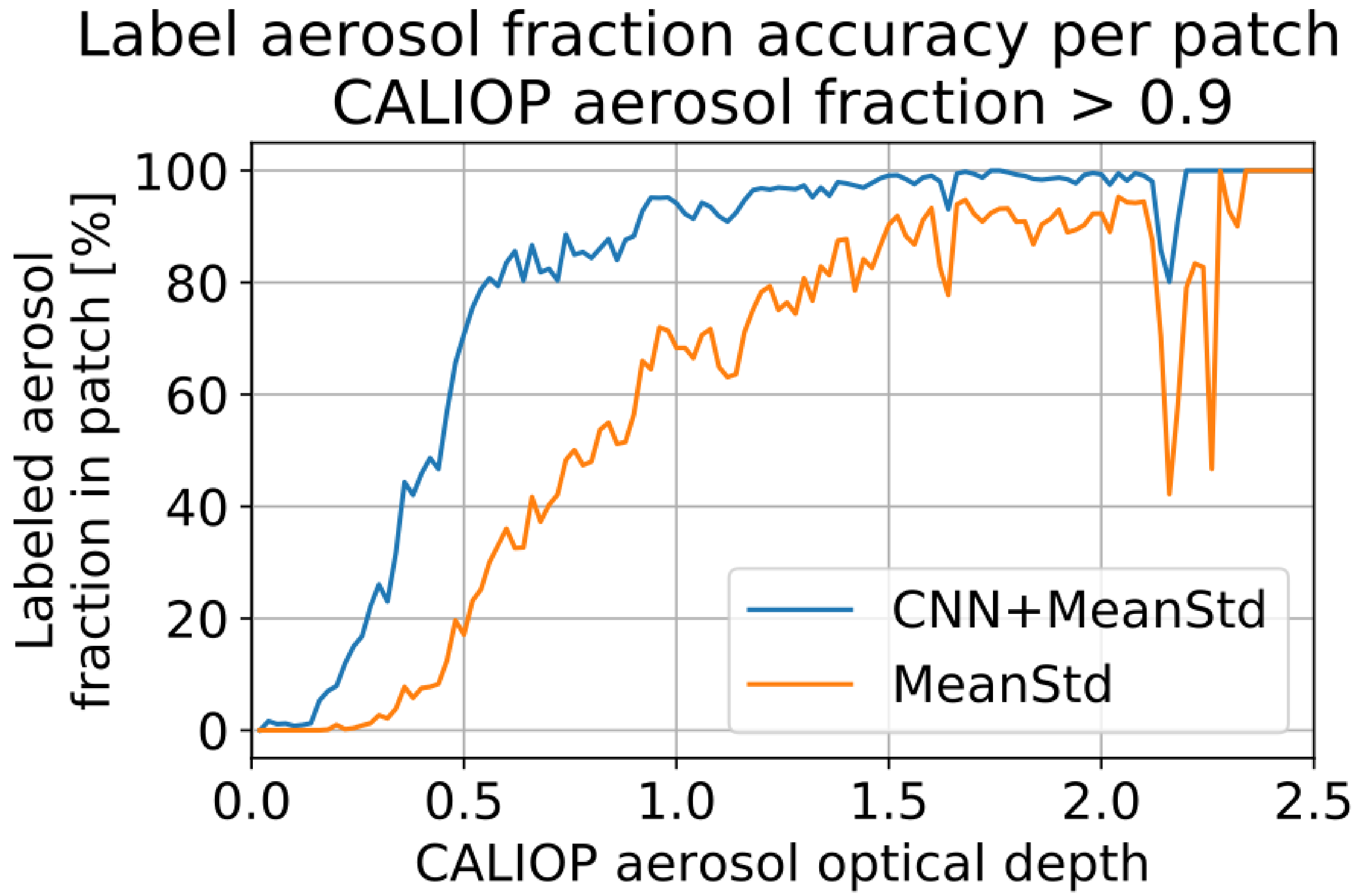




Quantifying aerosol accuracy of CNN approach using collocated CALIPSO observations

- For each aerosol optical depth, what is fraction of the 100 x 100 pixel patch that is labeled as aerosol?
- The CNN approach significantly increases accuracy of aerosol detection for low optical depths.
- **The caveat: CALIOP only observes a fraction of a patch.**





Next Steps ….

- To train a CNN from scratch requires very large training dataset (1.2 million). Is there a way to get away with a smaller training dataset? This could improve aerosol and cloud type identification.

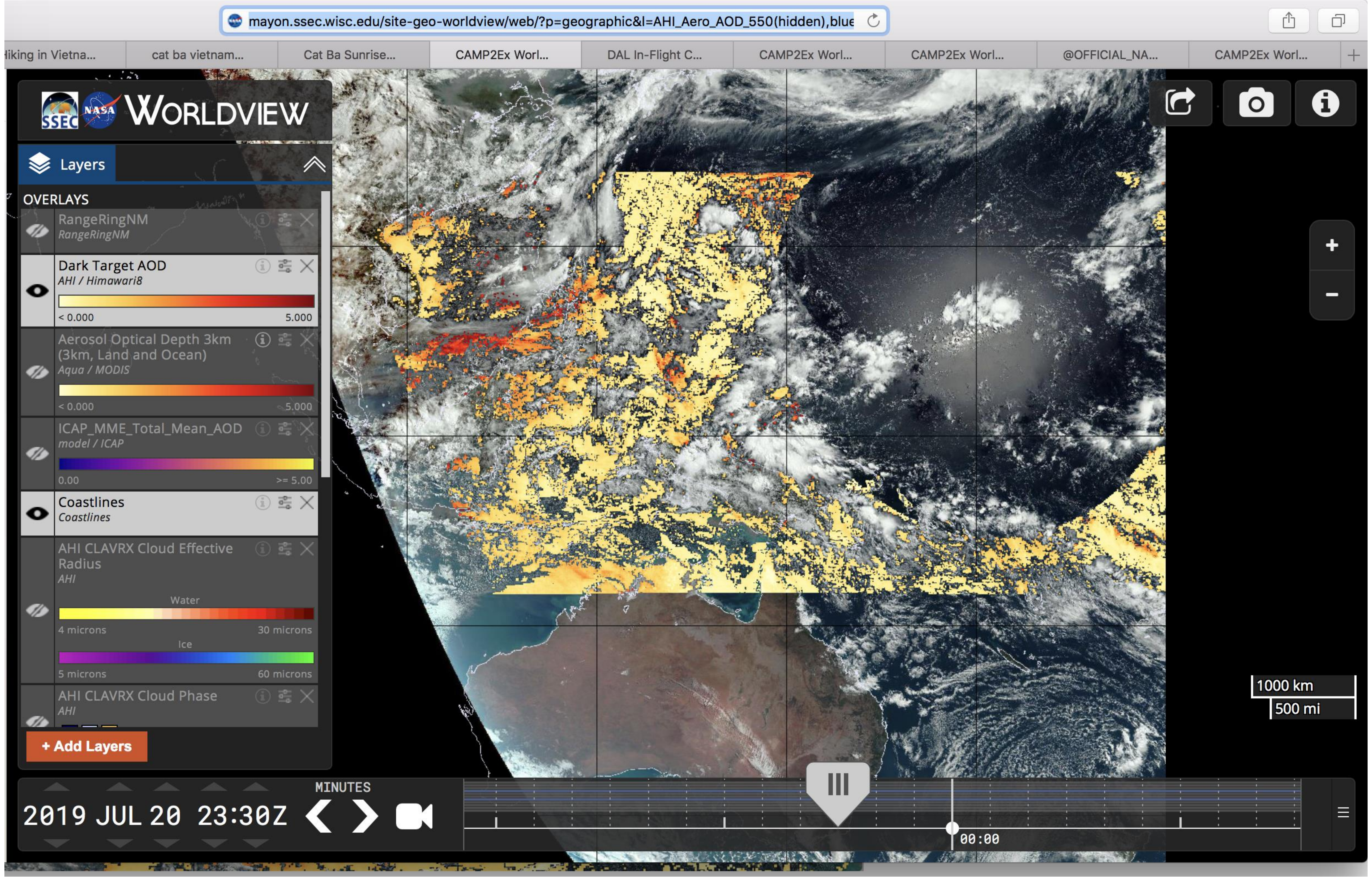
- Adapt methodology for night-time aerosol and cloud type identification.

- Major challenge ahead: Adapt methodology for land-based aerosol and cloud type identification

- Apply to Geo-stationary and leverage the temporal dimension ….

Geo-Worldview

[worldview](#)

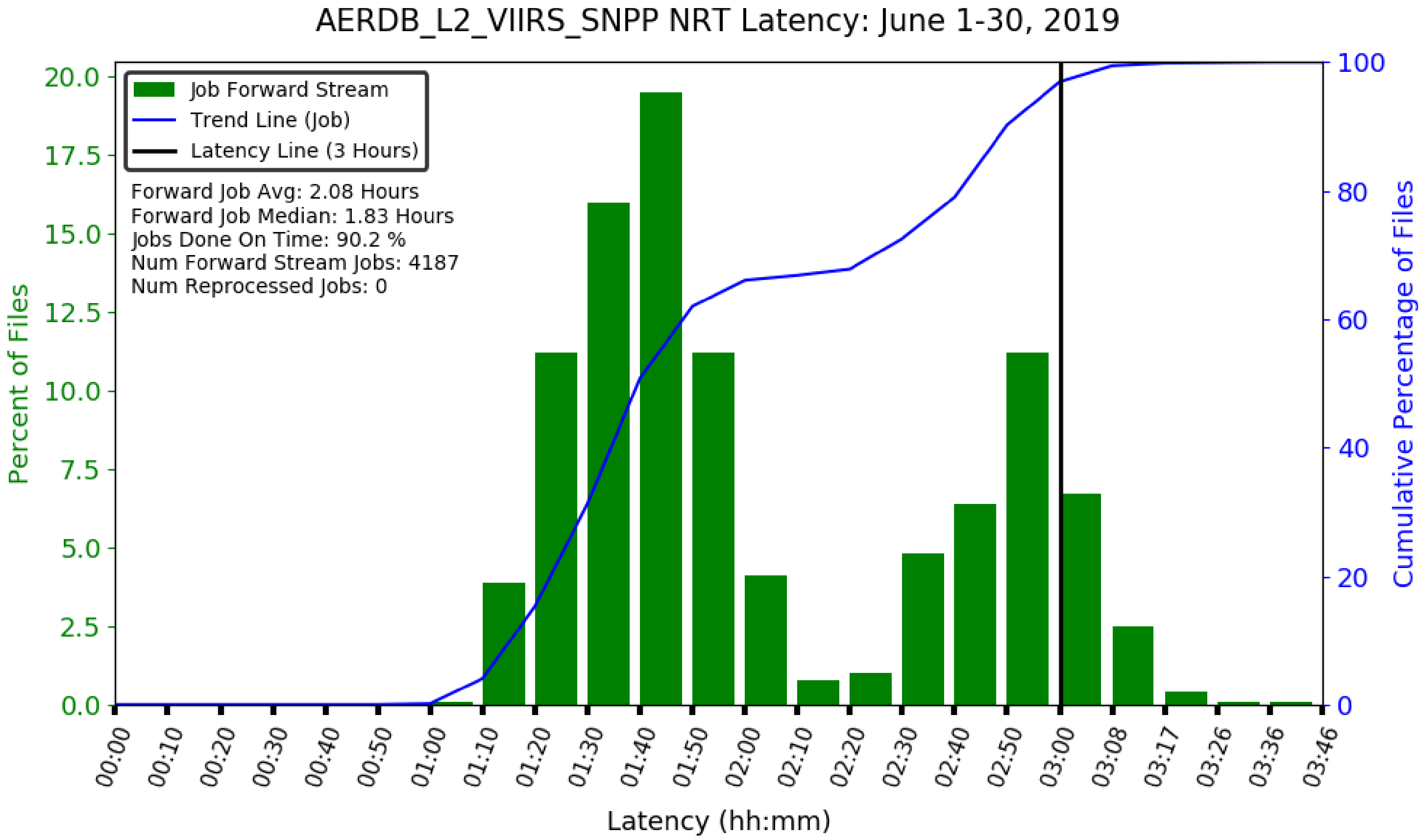


- Working with the worldview team worldview was modified to support AHI (10 min) data
- The ”beta” version of worldview is running at SSEC (mayon.ssec.wisc.edu) to support the NASA CAMP2eX field campaign
- AHI products are generated at SSEC/AWS including:
- CLAVRx cloud products
- AHI true color and false color imagerys
- Working with Rob Levy we recently started generating the DT processing in near real time
- Modeling products

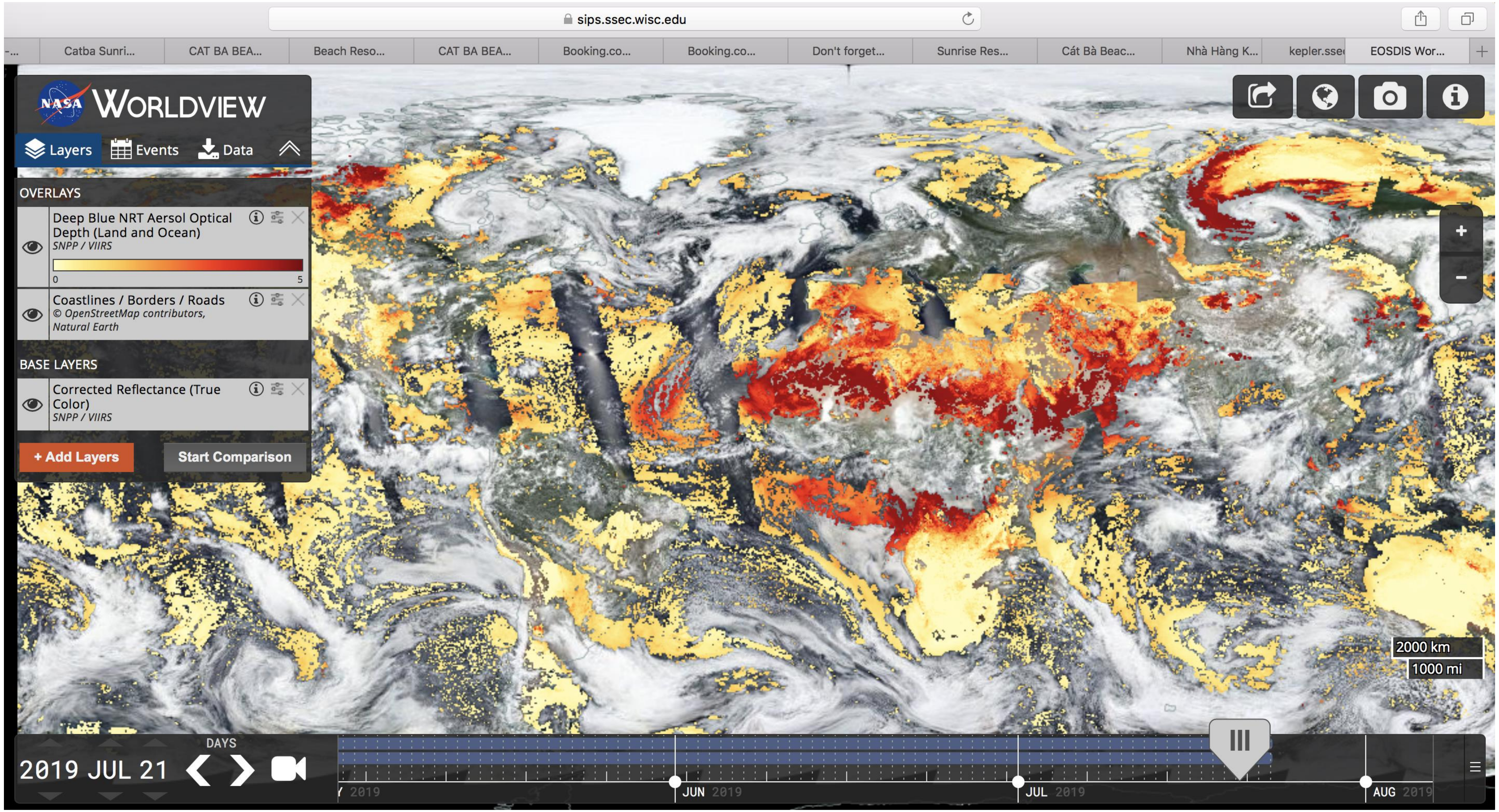
UW Atmospheric-SIPS (LEO)

- Supports science team algorithm development and testing
  - **Collocation and intercalibration for both LEO and GEO sensors**
- Aerosol and cloud VIIRS product processing for NASA including Deep Blue and Dark Target
- Near Real Time Processing
- Products are transferred to the NASA LAADS/LANCE data centers for public distribution
- Supporting limited GEO development for NASA teams

NRT Latency for S-NPP Deep Blue



VIIRS DB Products in worldview



UW HSRL Deployments to Asia

- HSRL deployments to Asia
  - KORUS-AQ Seoul S. Korea (2 years of continuous observations
  - Manila Observatory in the Philippines in support of CAMP2eX (December 2018 – present)
  - Two ONR ship deployments (Summer 2018 and August 2019)
- All data available at: http://hsrl.ssec.wisc.edu

Manila July 21 2019