HARP latest data with comparison to large satellite instruments like ABI, VIIRS and MODIS

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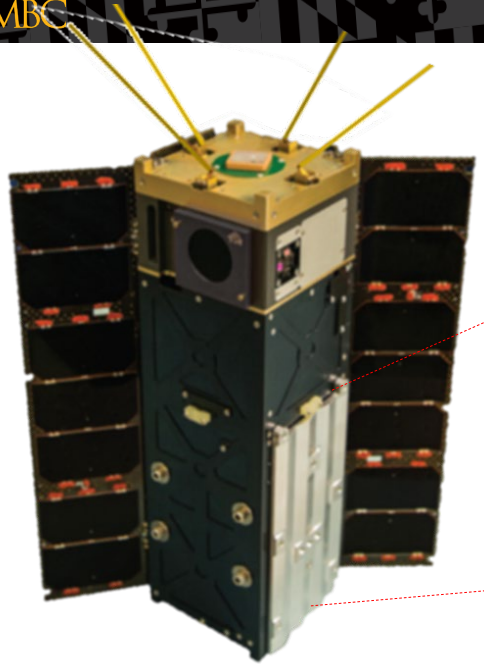
2- University of Lille and GRASP.

martins@umbc.edu

Living Planet Symposium – Bonn 23-27th May 2022

HARP CubeSat

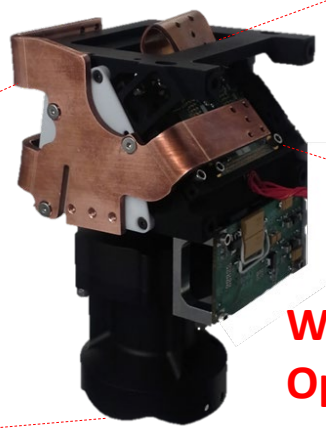
NASA-ESTO InVEST Program



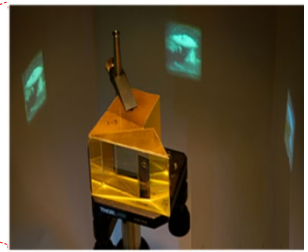
SDL Spacecraft

Launched: Nov 2nd, 2019
ISS Deployment: Feb 19th, 2020
First light: April 15th, 2020

UMBC Sensor

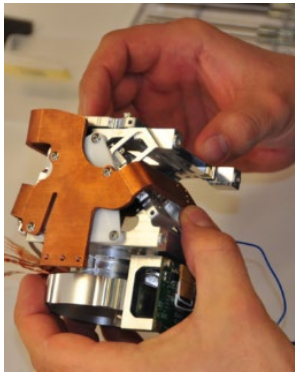


HARP Prism



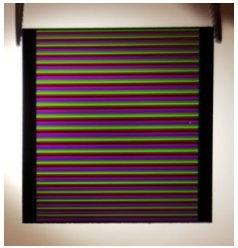
I, Q, U

HARP VNIR Telescope



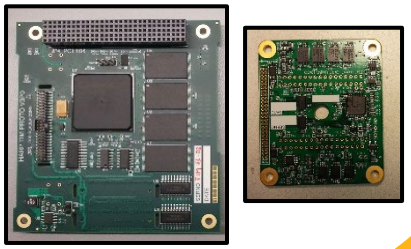
Wide FOV Optics

3U size



HARP Stripe Filter

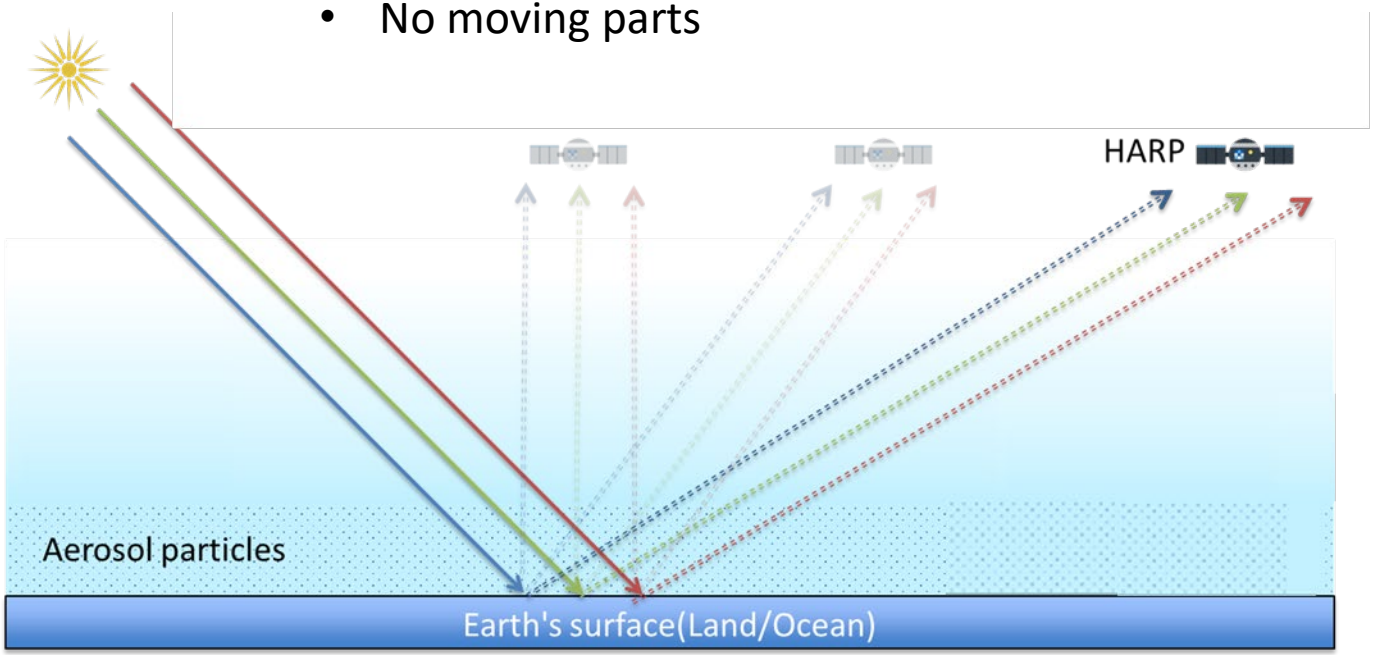
Camera and FPGA Electronics



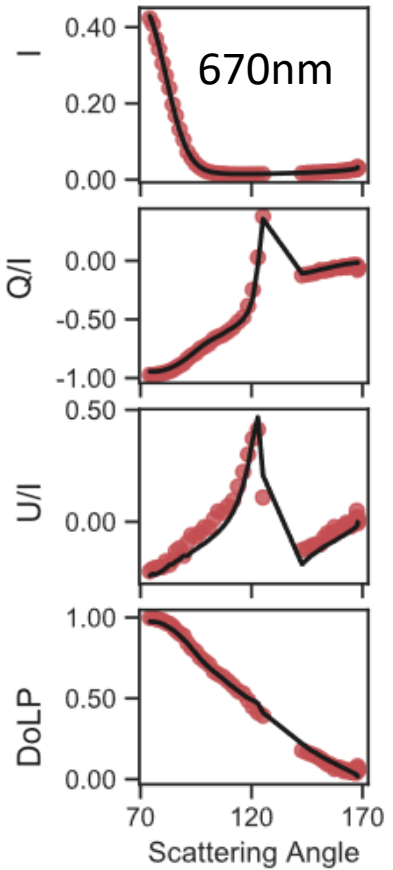
HARP observations

HARP: $(I, Q, U)_{scatt}$ for every pixel:

- Up to 60 viewing angles @670nm
- Up to 20 viewing angles @440, 550 and 870nm
- No moving parts



Observation x model

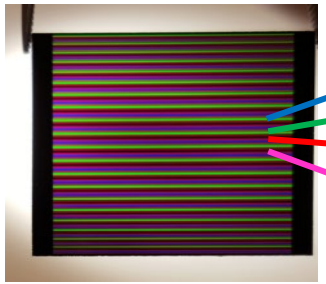


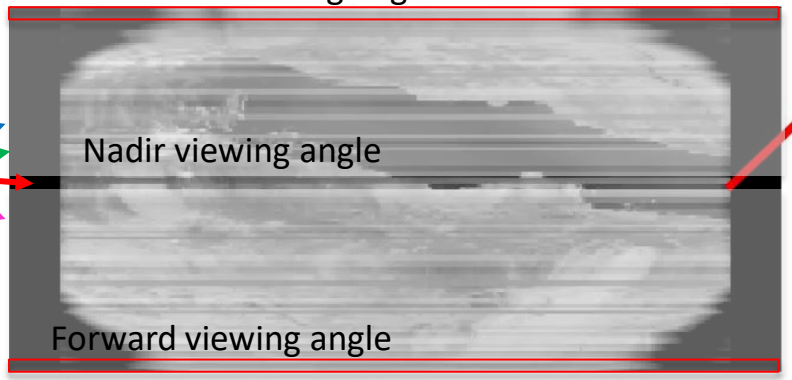
HARP Unique sampling strategy

Push-broom measurements

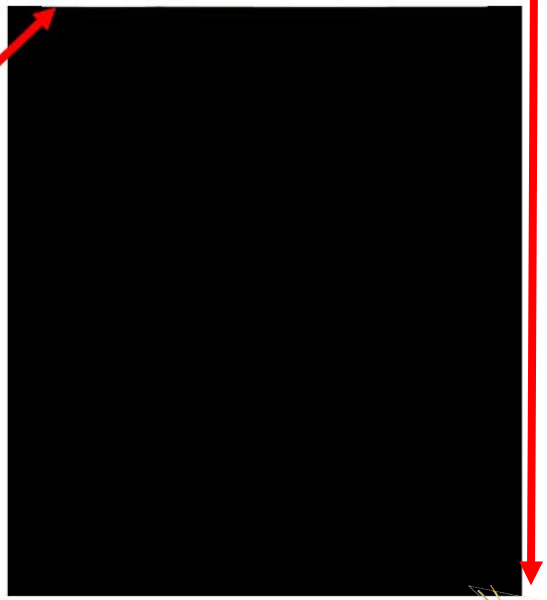
HARP

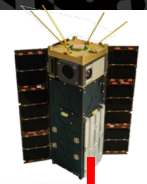
HARP Spectral
"Stripe Filter"

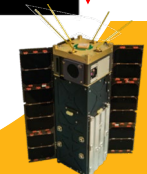




Red nadir pushbroom





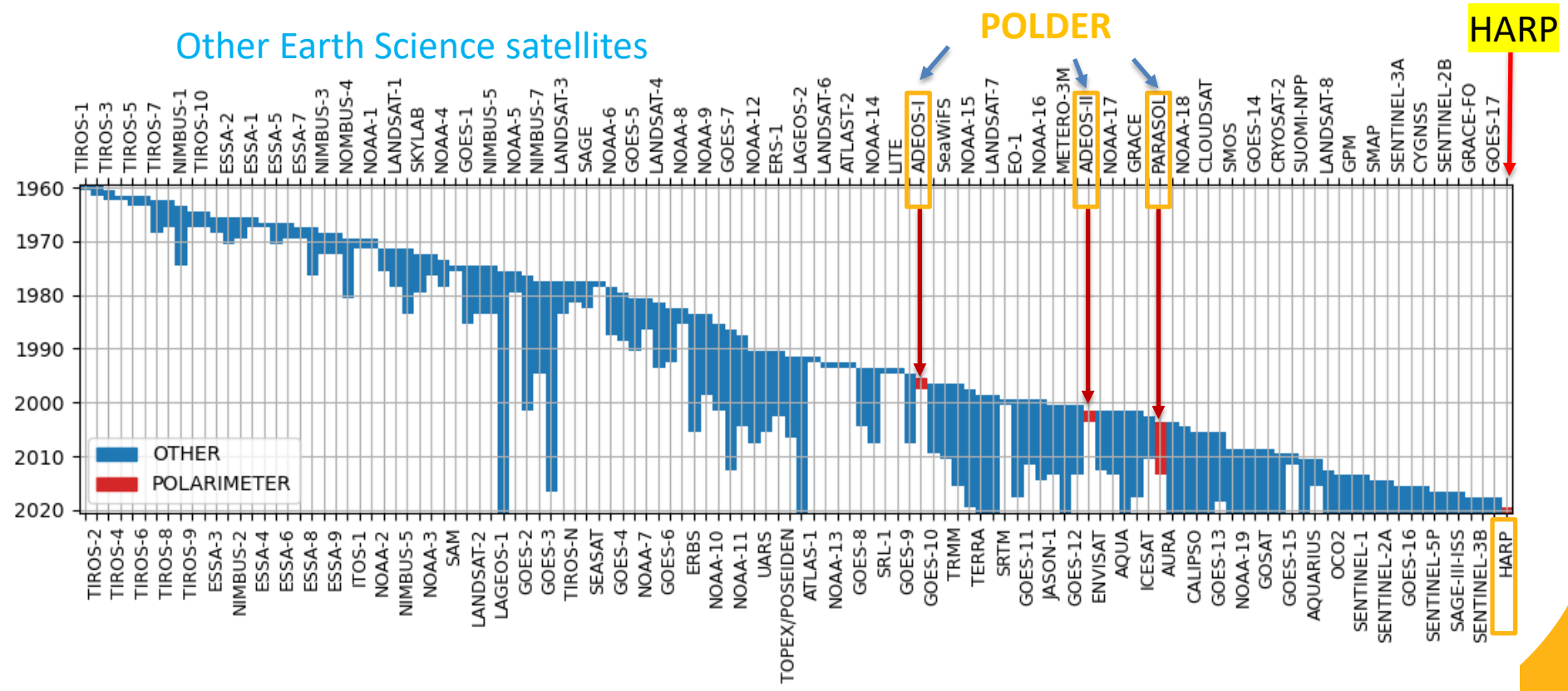


HARP Spectral Channels:

- $440\ nm$
- $550\ nm$
- $670\ nm$
- $870\ nm$

Similar sampling can be done at different wavelengths or different lines in the detector (viewing angles)

HARP – First Hyper-Angular Imaging Polarimeter in Space



Partial list of Current and Planned Earth Observing Polarimeters

Flown or Potentially flown

- HARP CubeSat UMBC/NASA - US
- POSP/HJ-2: China
- SMAC/GFDM-1: China
- PCF/GF-5(02): China
- ScanPol – MSIP: MAO/Ukraine

Planned for Near Future

- GAPMAP – Commercial/France+US
- HARP2: UMBC/NASA - US on PACE mission
- SPEXOne: – SRON/Netherlands on NASA PACE mission
- 3MI: EUMETSAT/EU
- MAIA: JPL-NASA/US
- MAP CO2M: Copernicus/EU
- AOS Polarimeter – NASA/US

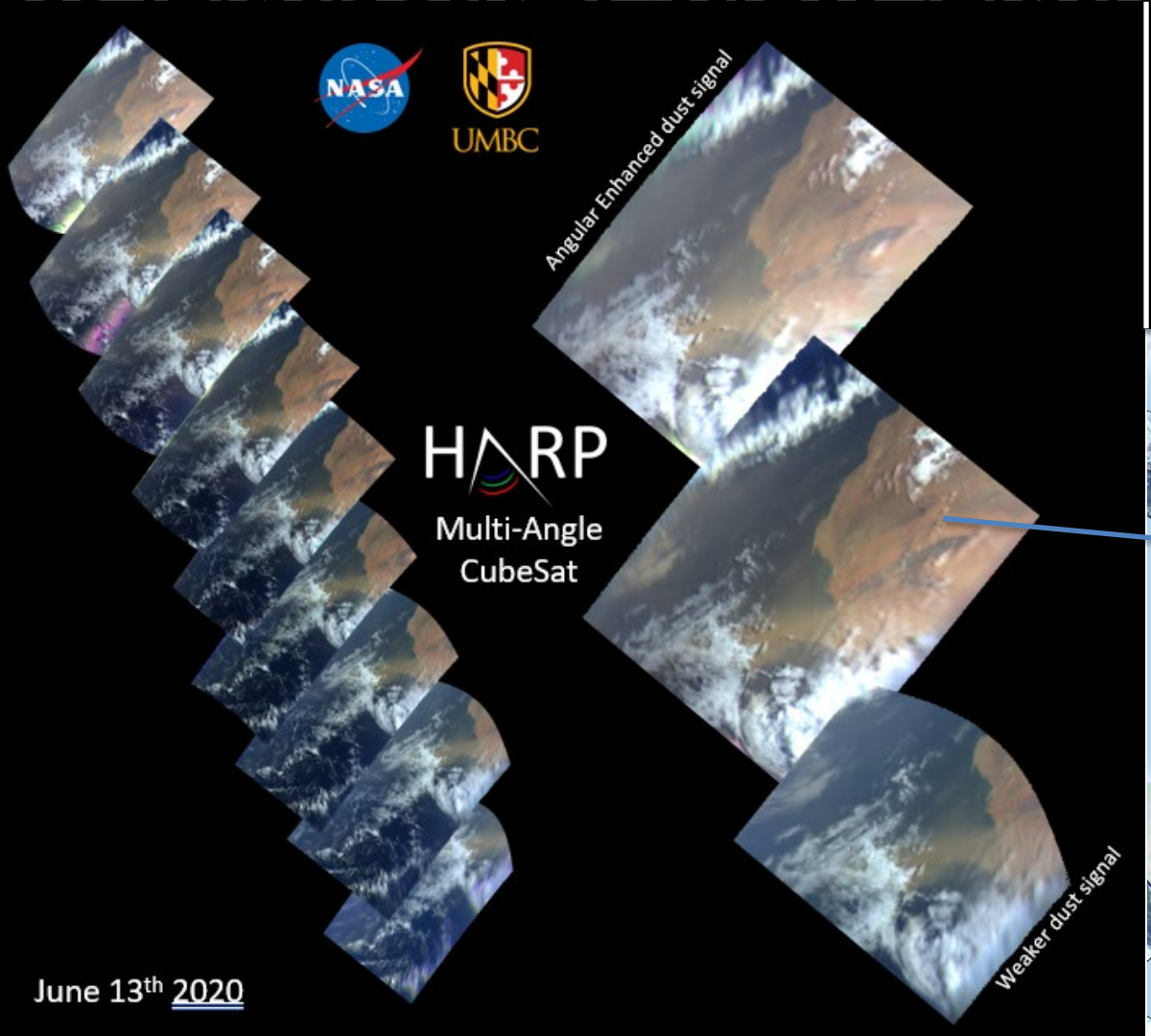
Dubovik et al. 2020

Images collected by HARP CubeSat from 2020-2022

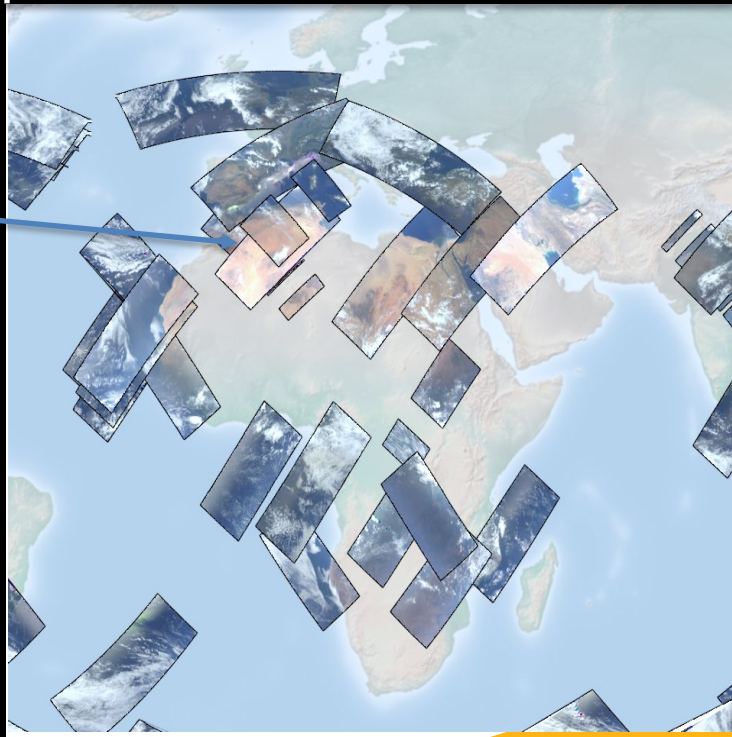
HARP CubeSat Stats:

- 777 Days in orbit
- 12,432 sun sets and rises
- 62 science captures
- 111,600+ images
- 3.4+ Billion pixels

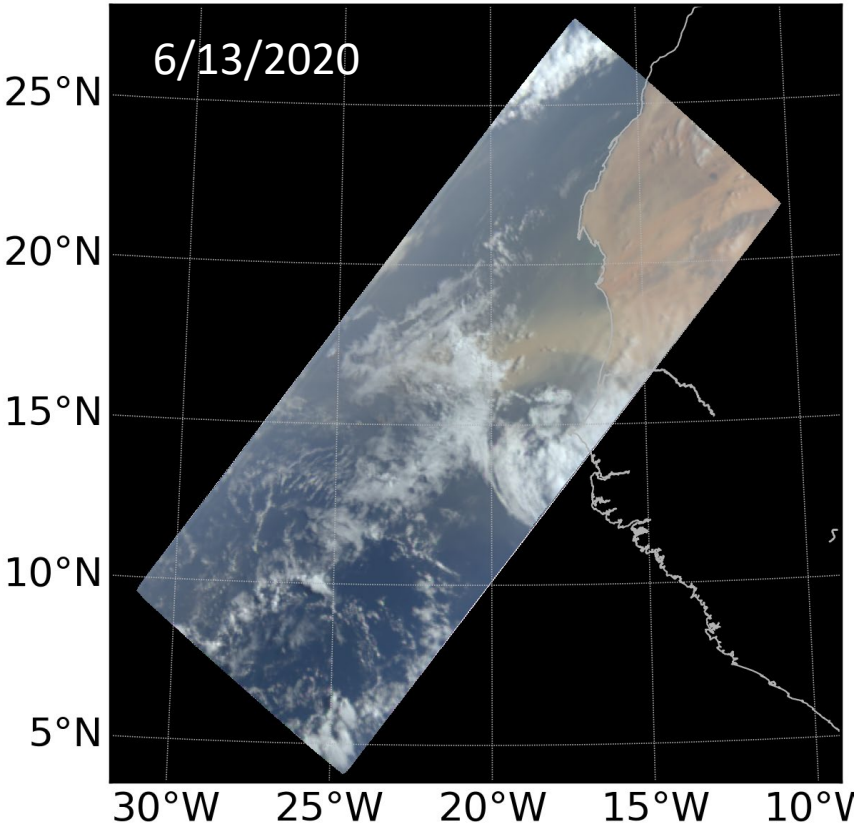
UMBC

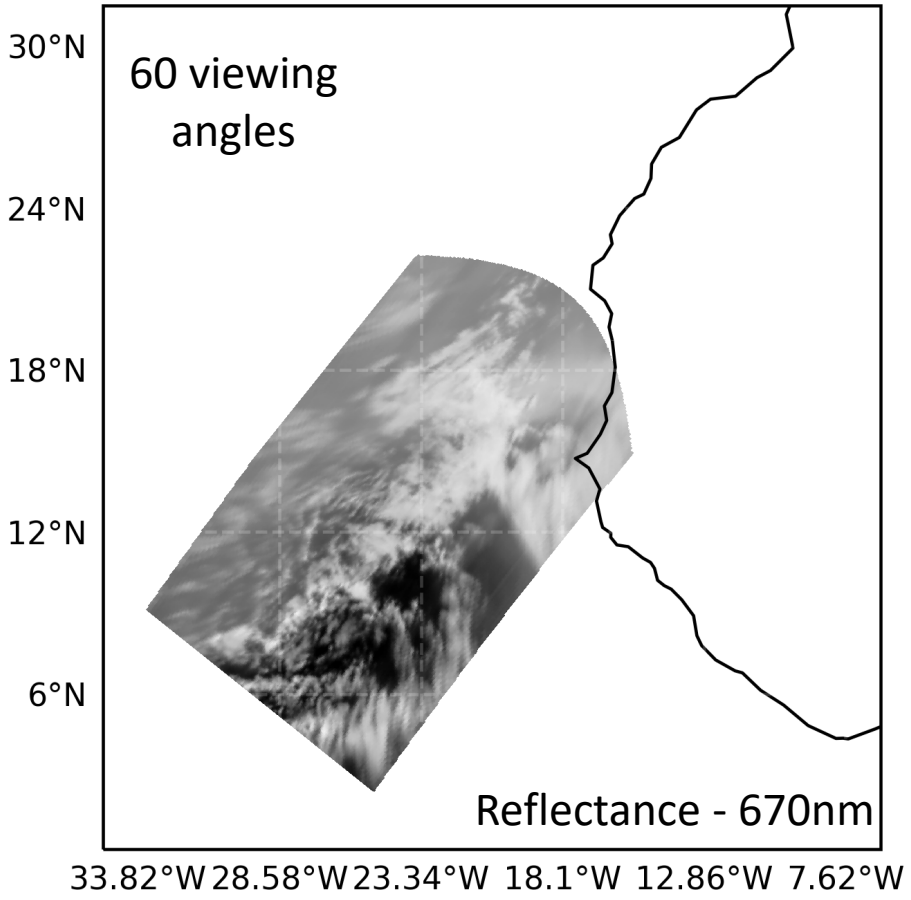


Each Scene has up to 60 different viewing angles over the same location

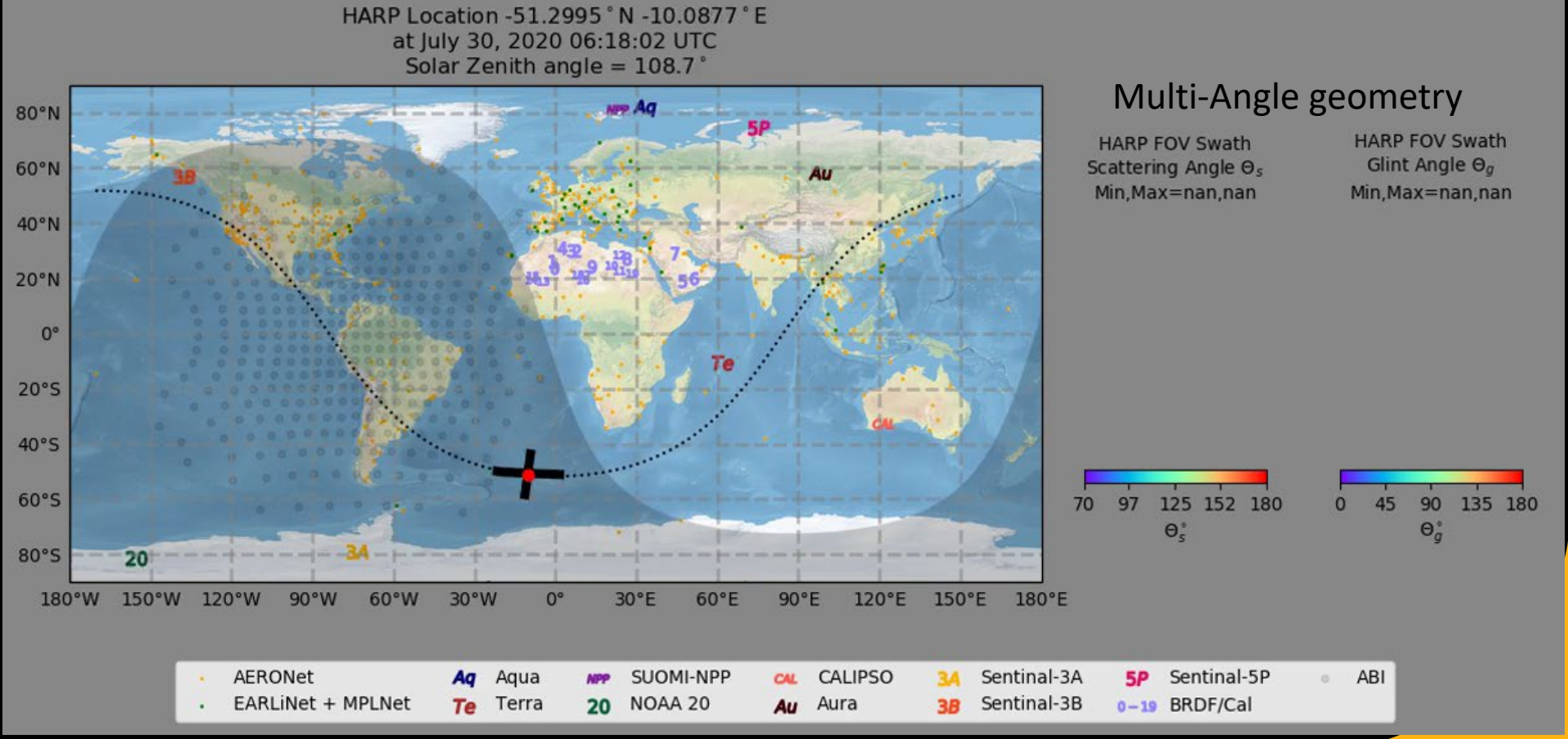


Multi-Angle Intensity of Saharan Dust

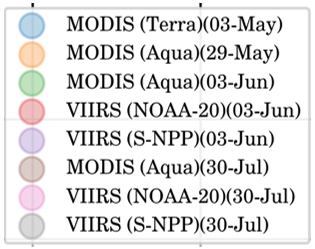


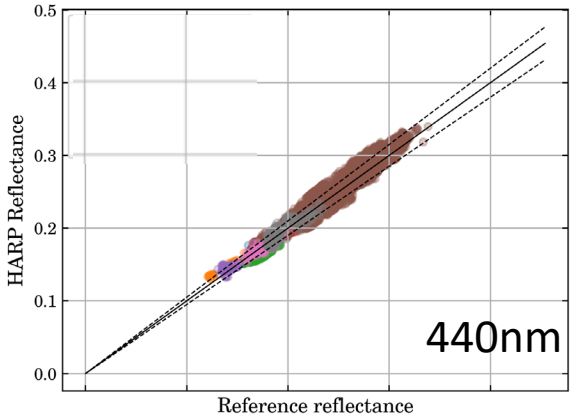


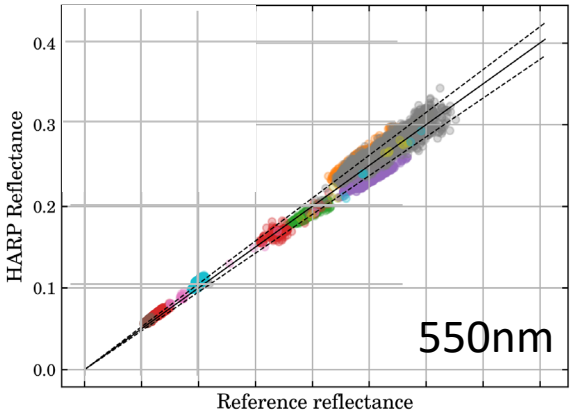
HARP predictive tools x other satellites - Operational

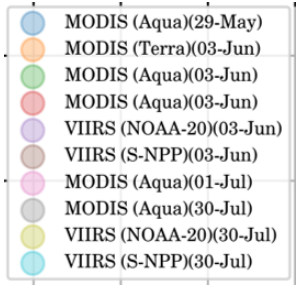


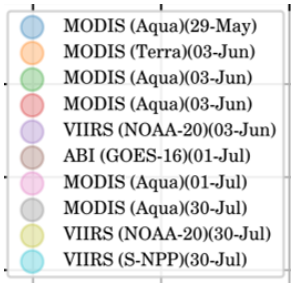
HARP Intercomparisons with other Satellites

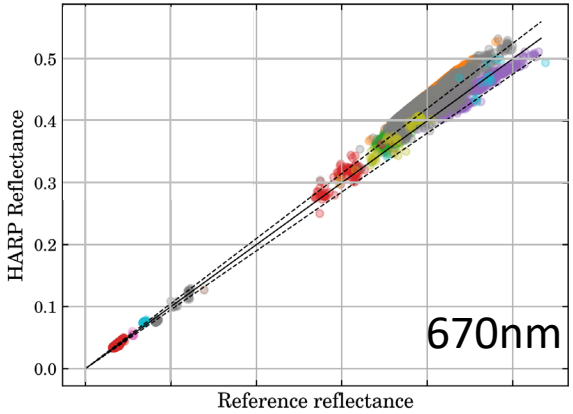


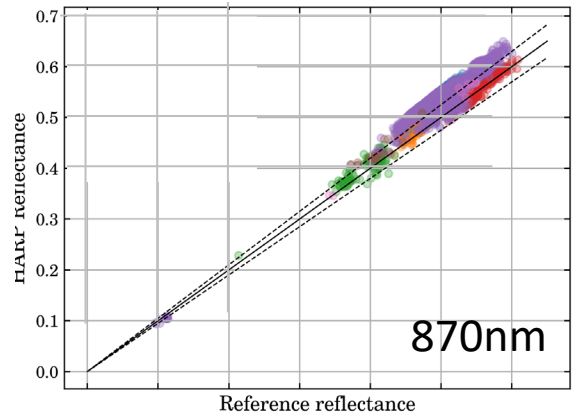


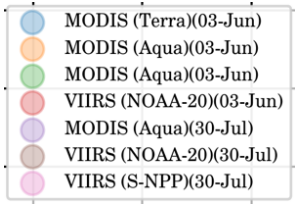






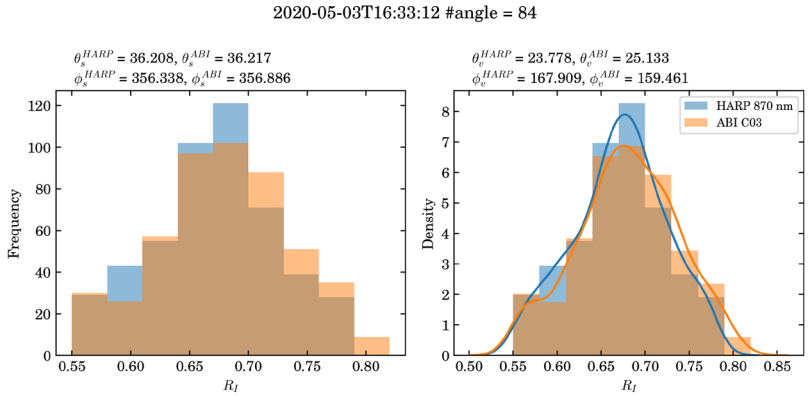


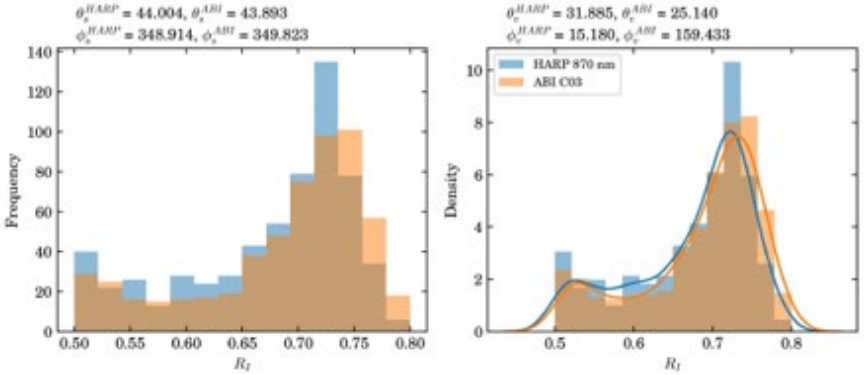




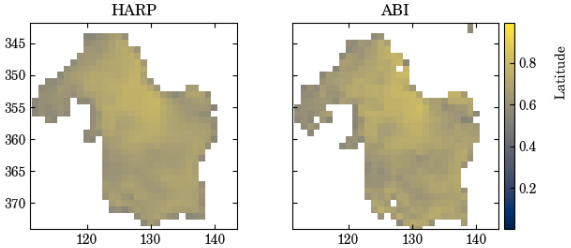
HARP X Geostationary ABI

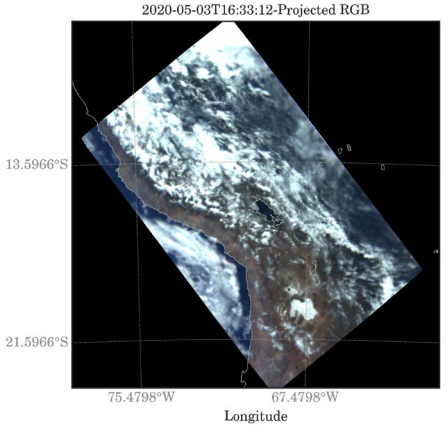
Histogram of the reflectances



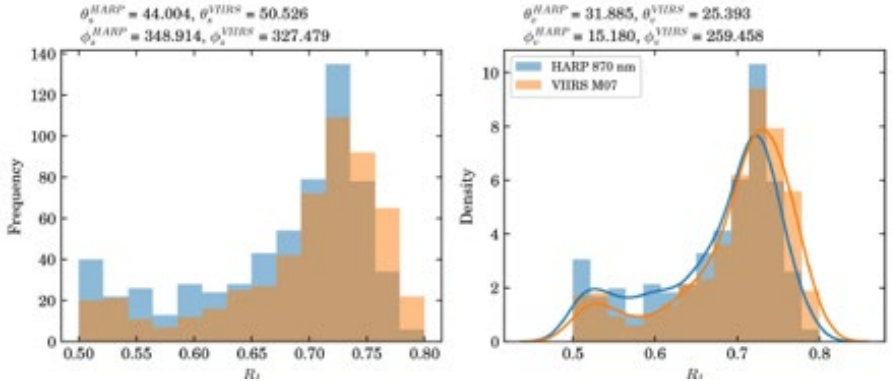


Salar De Uyuni (Bolivia) [ABI data resampled in HARP lat-lon grid]



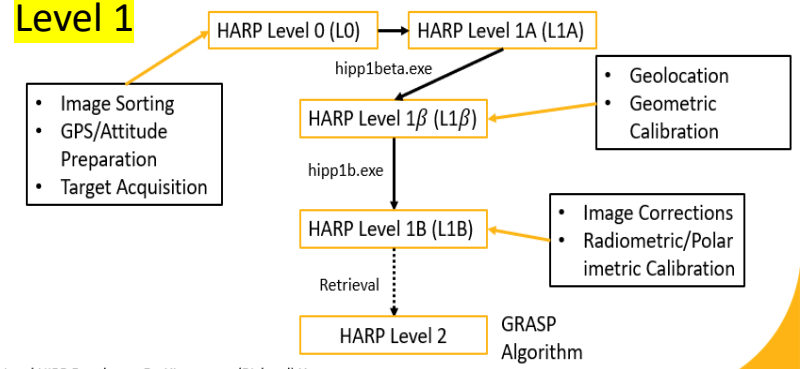


Comparison with VIIRS on S-NPP over the Salr De Uyuni salt flat



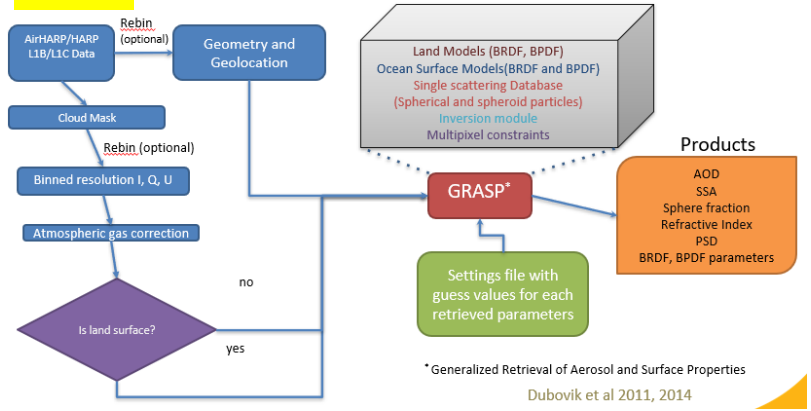
Full Algorithm Development for HARP/HARP2

Level 1



Lead HIPP Developer: Dr. Xiaoguang (Richard) Xu

Level 2

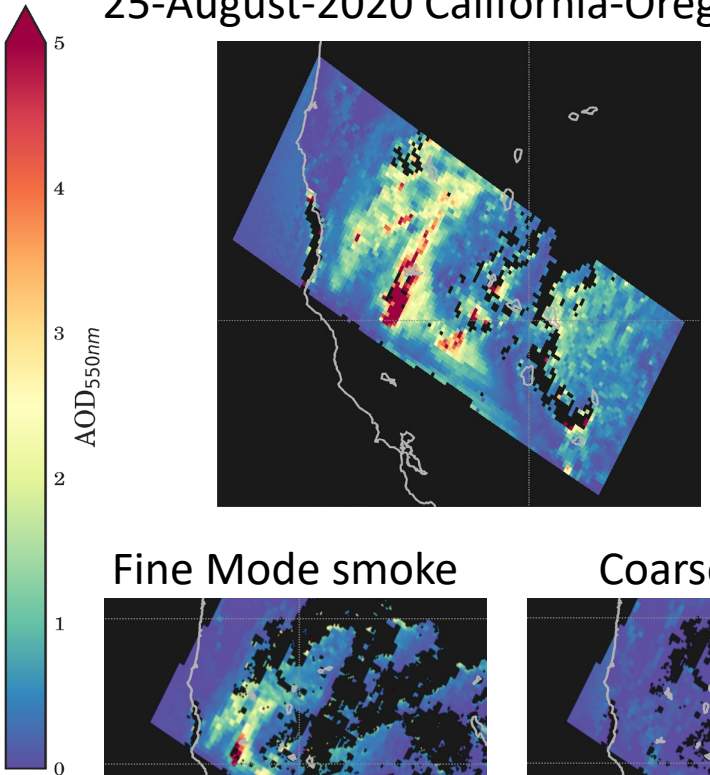


Goals for Multi-Angle Polarization:

- Aerosols
  - Accurate AOD for fine and course mode
  - Aerosol microphysics: particle size and shape
  - Single scattering albedo
  - Real and Imaginary refractive indices
  - Particle phase function
- Clouds
  - Cloud phase
  - Cloud effective radius
  - Cloud effective variance
- Surface
  - BRDF and BPDF retrievals
  - Improved atmospheric correction

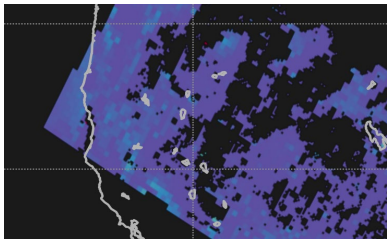
Multiple Cases of Aerosol retrievals around the globe

25-August-2020 California-Oregon Fire

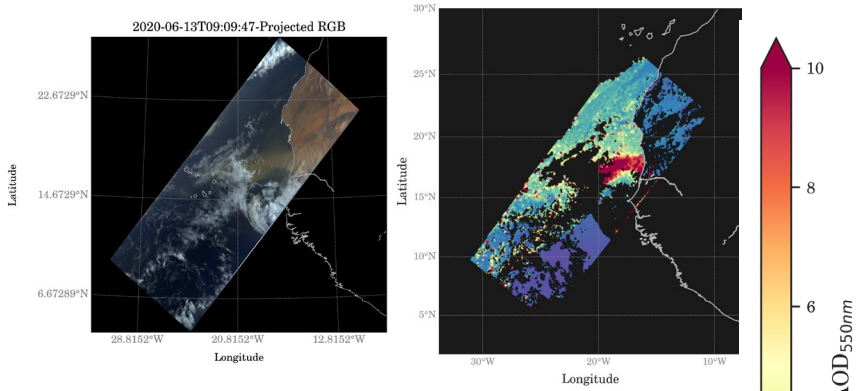


Fine Mode smoke

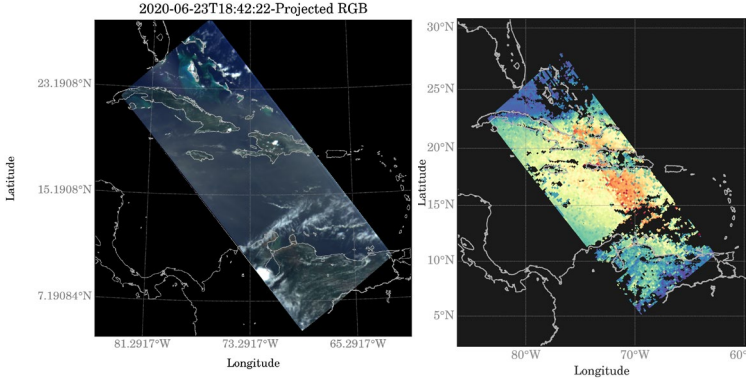
Coarse Mode



Dust leaving the Sahara

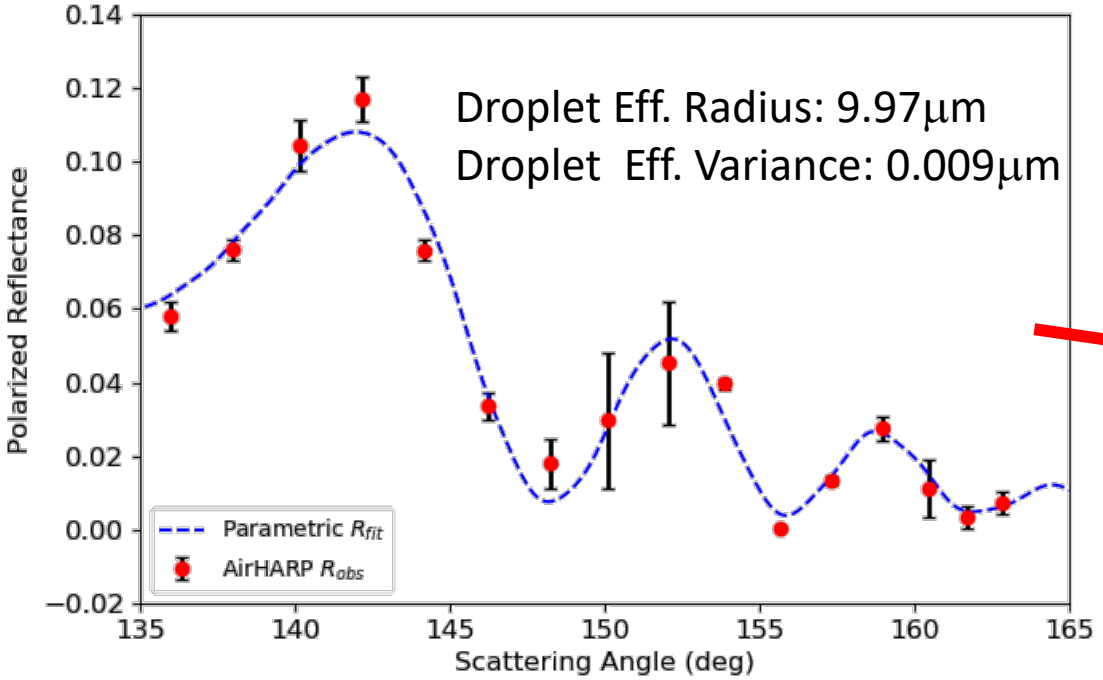


Dust arriving the Americas

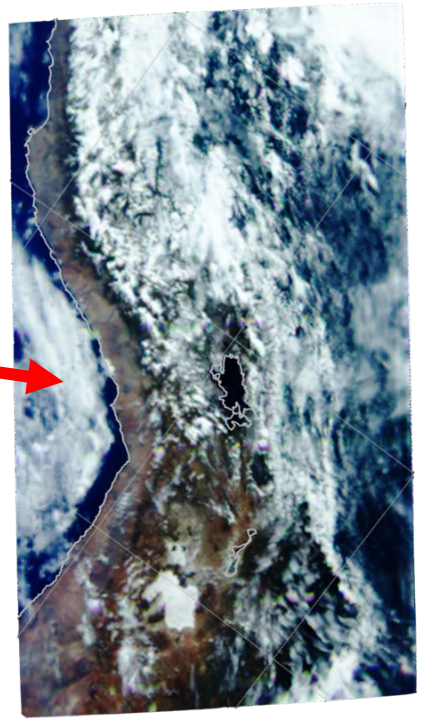


Level-2 Cloud Microphysics Retrieval from Space

HARP CubeSat 670nm (~8.8km^2 resolution)



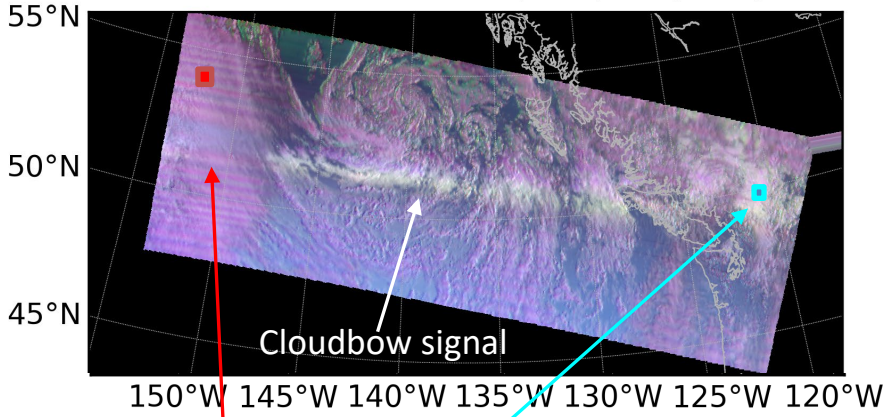
HARP Nadir Pushbroom

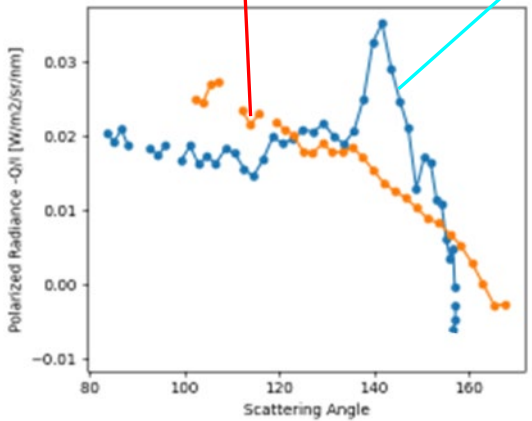


First Ever Hyper-Angular Cloudbow Retrieval from Space

Cloud Phase Retrieval

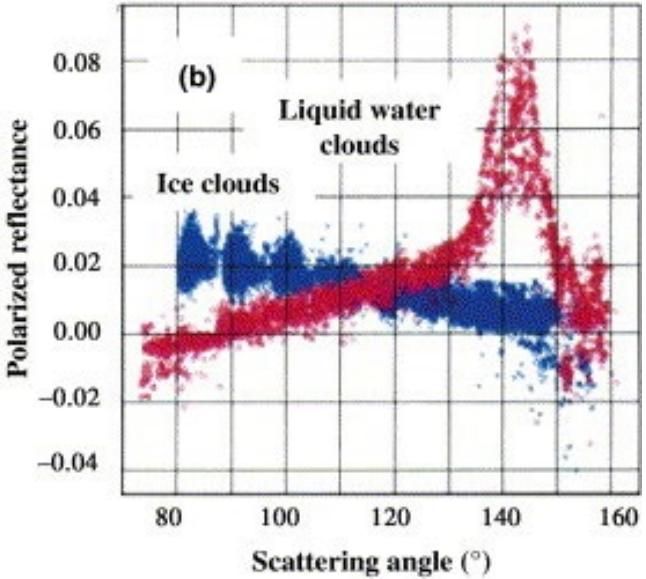
Polarized Radiance (670,550,440)





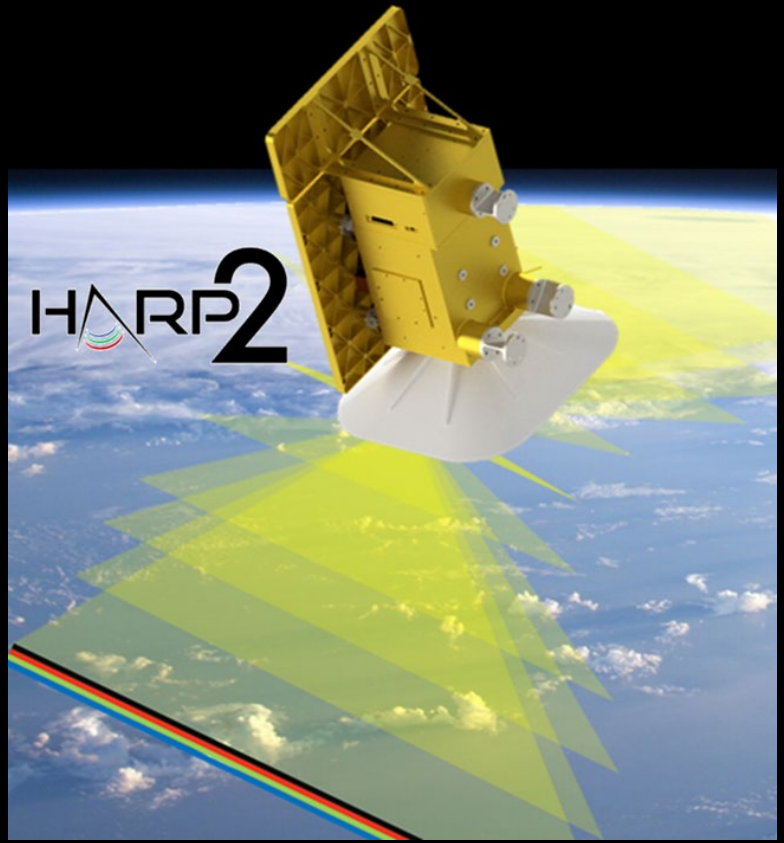
HARP Demonstration on Single Super Pixel

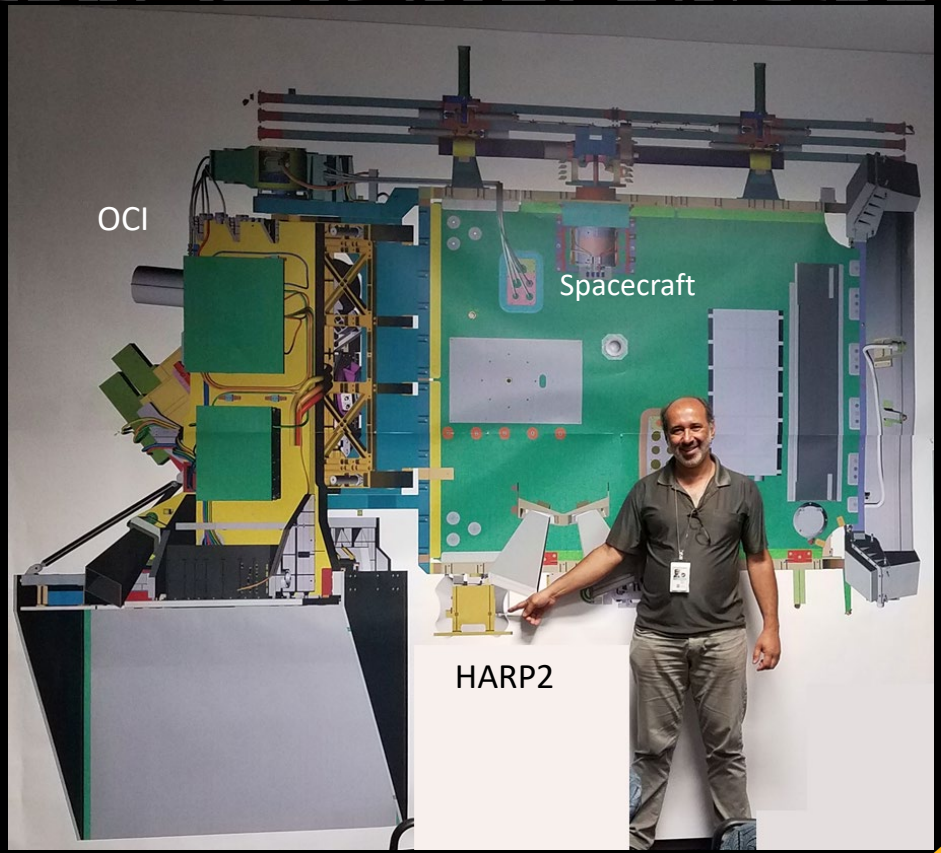
Literature Reference



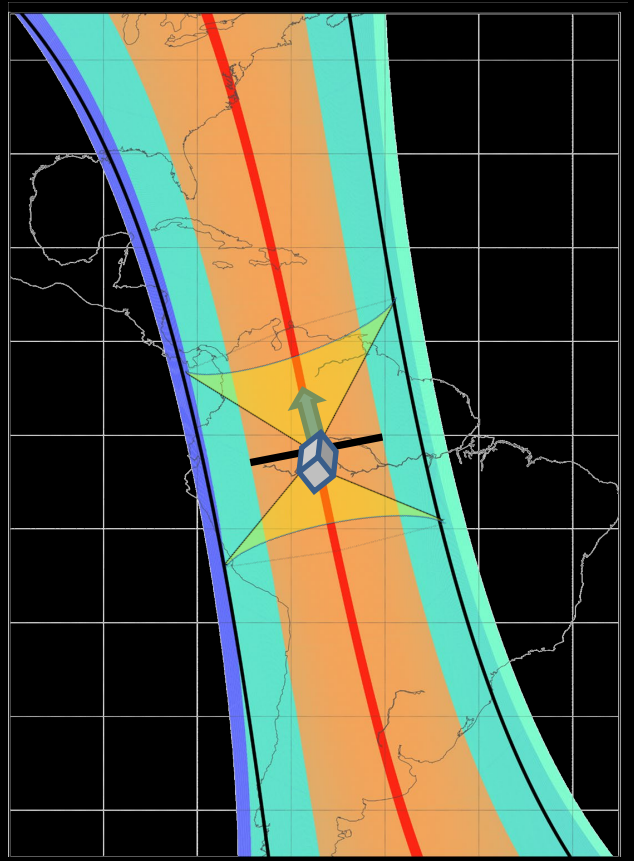
Parol et al. 2004
Goloub et al., 2000

HARP2 – being built for PACE Spacecraft

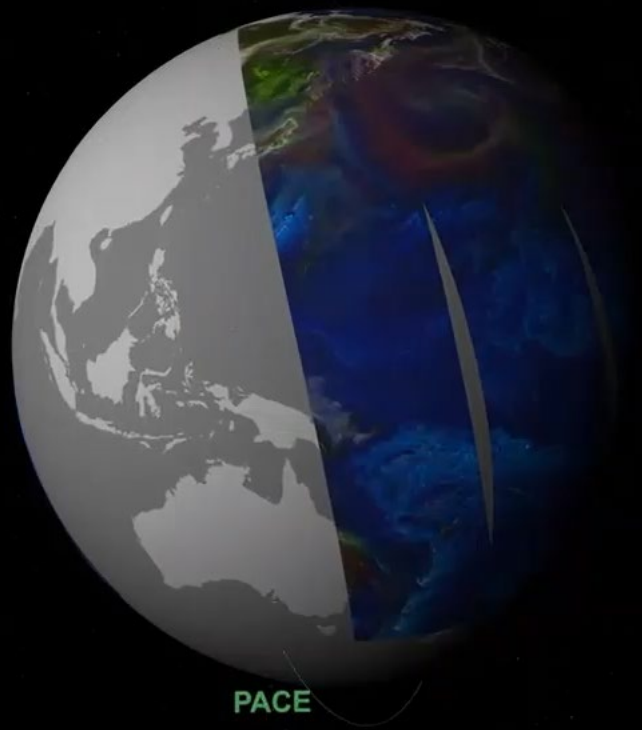




PACE Mission Swath



- **OCI and HARP2:** 2650km
Global coverage in 2 days
- **HARP2 nadir:** 1550km
- **SpexOne**: ~100 km



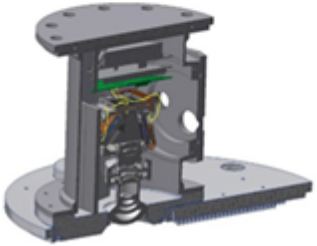
Thank you.

Backup Slides

The HARP Polarimeter Family

Concepts Under Development

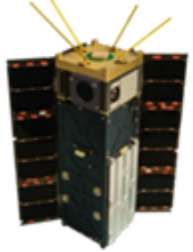
a) Air HARP



Airborne System

- Frequent Ground calibration
- ~40m resolution
- Potential for HARP2 Cal/Val
- Has flown two successful flight campaigns

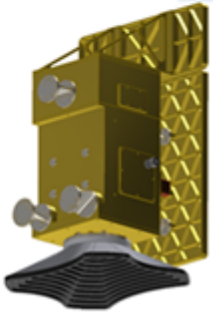
b) HARP CubeSat



Launched to ISS
Nov 2nd, 2019
Deployment
Feb 19th, 2020
First light
April 15th, 2020

- 4 km resolution
- Limited data set: 1 snapshot/day
- No calibrator onboard/only vicarious

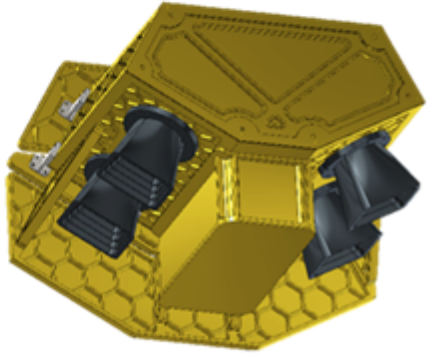
c) HARP2 PACE



Launch: 2022-23

- Improved SNR
- Better calibration features
- ~3 km resolution
- Global coverage in 2 days

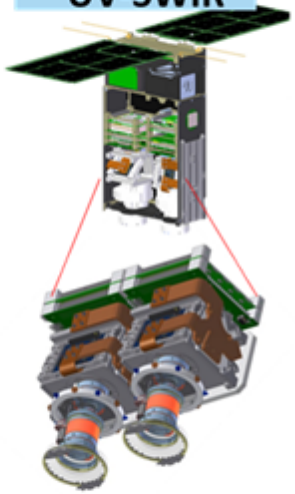
d) Mega-HARP UV-SWIR



New Concept

- Extended Wavelength range (UV to SWIR wavelengths)
- Improved SNR
- Full calibration features
- ~0.5km resolution

e) ASTEC 6U UV-SWIR



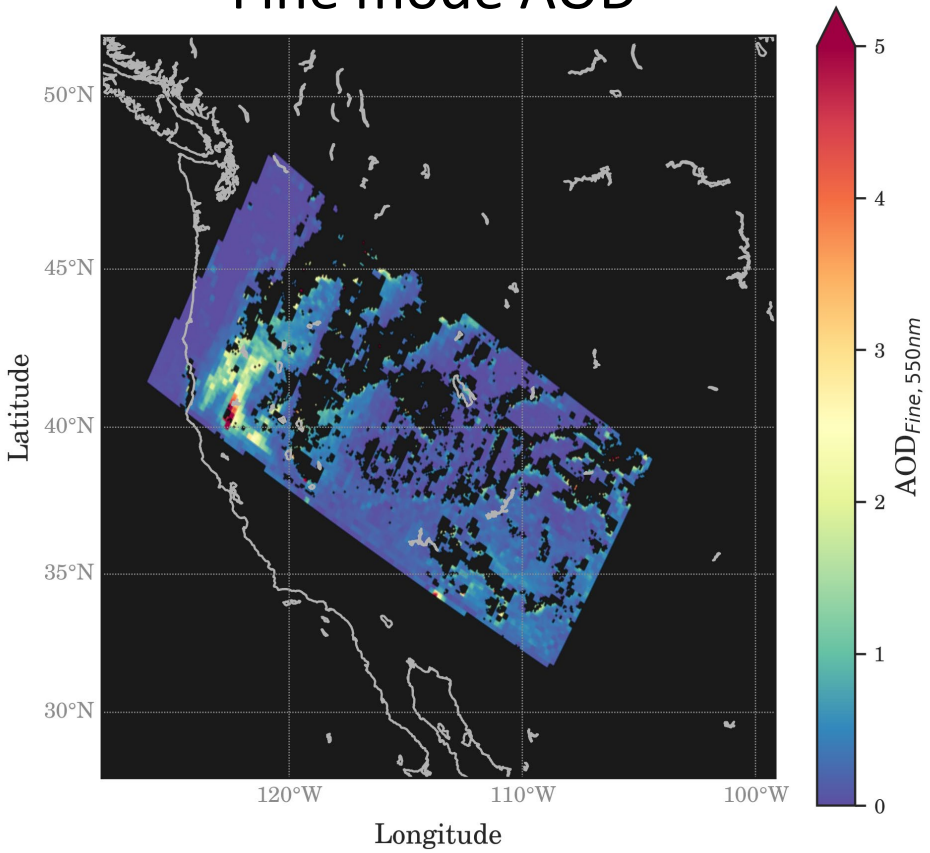
ASTEC Polarimeter concept for SmallSat constellation

- UV-SWIR polarimeter
- Wide FOV/Global coverage

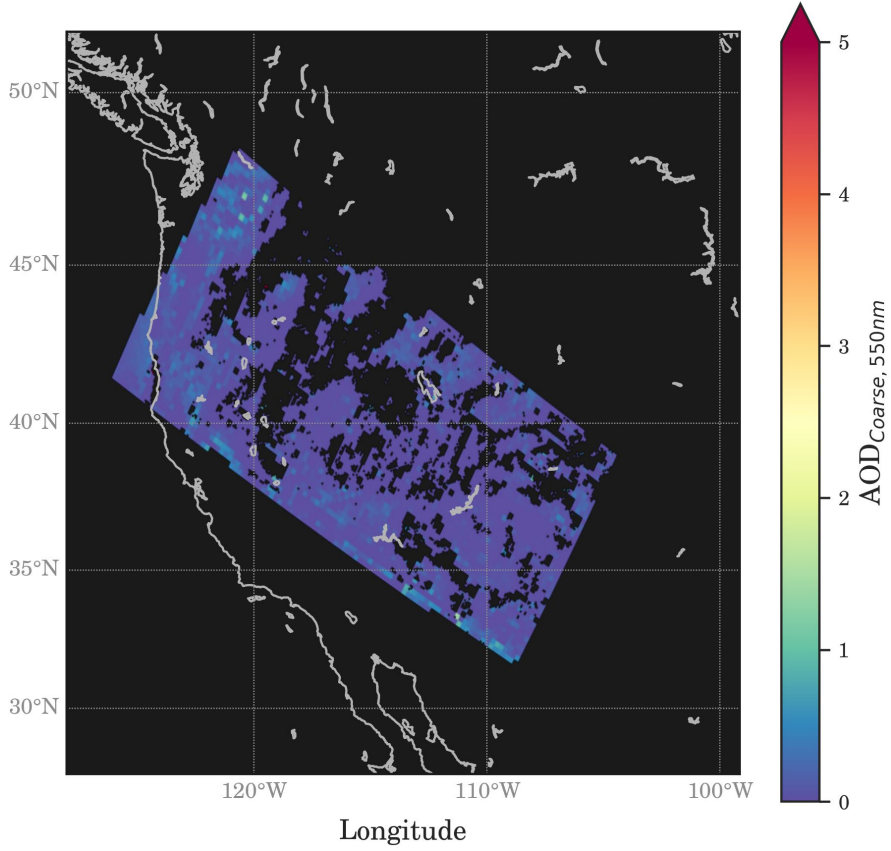
Current Projects

25-August-2020 California-Oregon Fire

Fine mode AOD

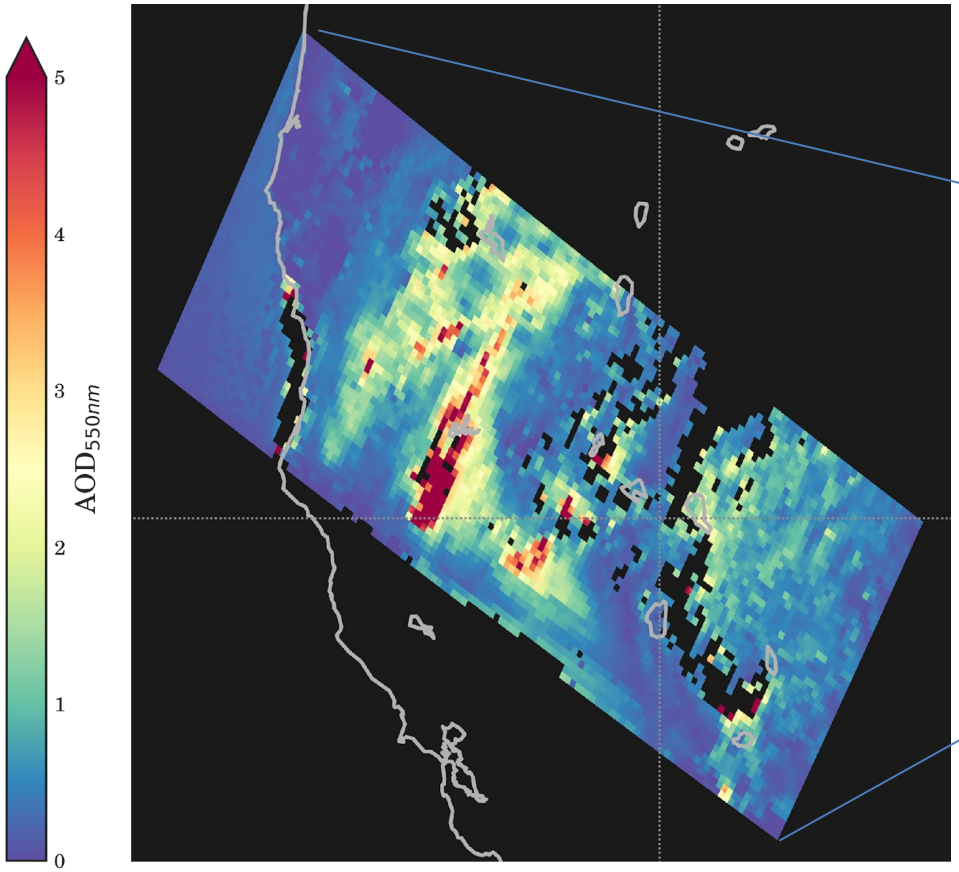


Coarse mode AOD



6.6 km resolution AOD retrievals

25-August-2020 California-Oregon Fire



3.3 km resolution AOD retrievals