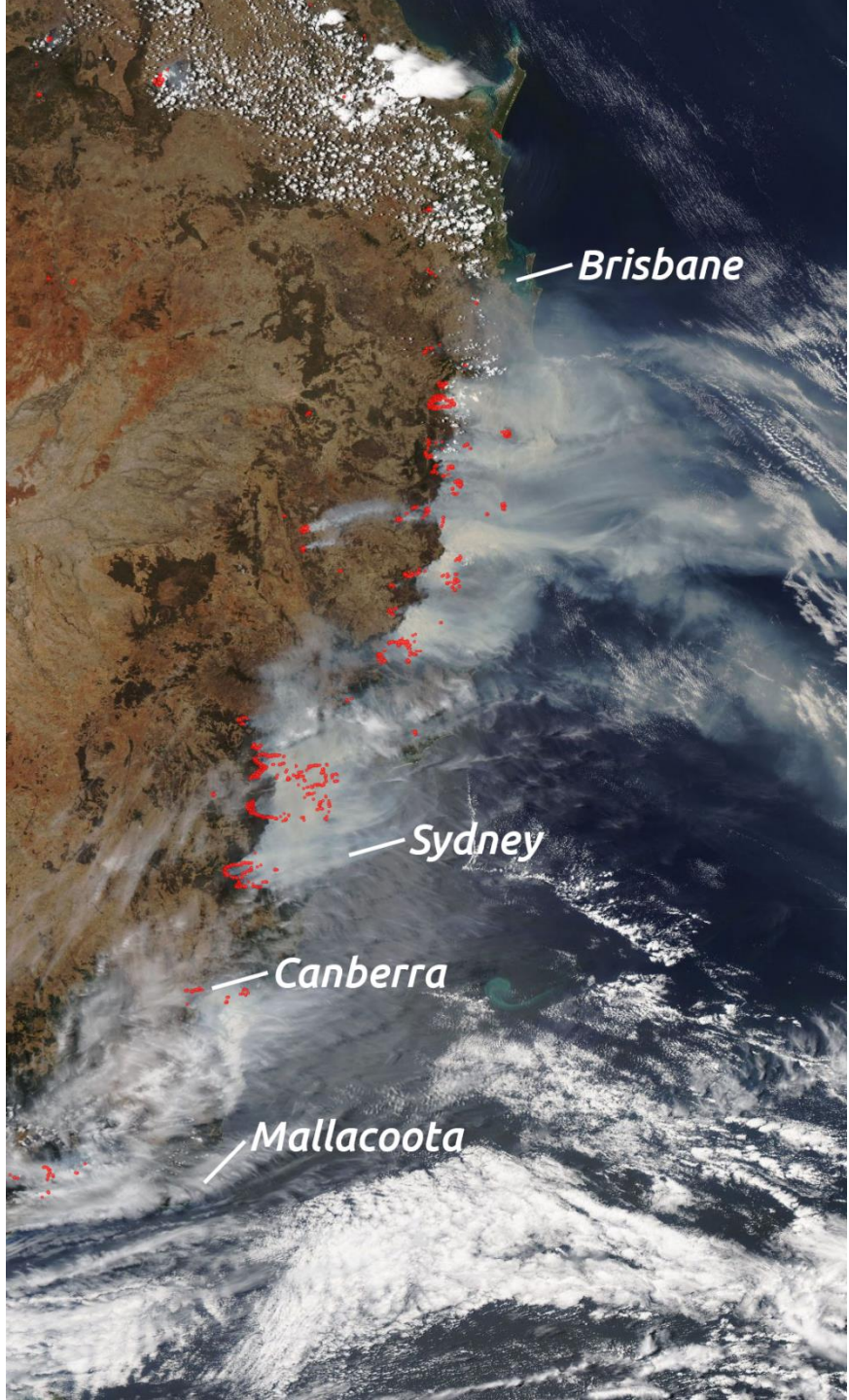
How consistent are satellite retrievals of aerosol properties during the 2019-2020 Australia fire season?

Andrew Sayer (USRA at NASA GSFC), andrew.sayer@nasa.gov
Vijay Natraj (CalTech, JPL), Felix Seidel (CalTech, JPL)

Motivation

- Satellite aerosol products are optimized to provide **good retrievals on a global basis**
- **Extreme events challenge assumptions**, yet **satellite observations of extreme events are needed** for forecasts and model interrogation, e.g. Sep 2019 – Feb 2020 Australian wildfires (image from 7 Dec 2019)
- Beyond AOD, the key aerosol parameters for climate forcing and air quality relate to **size**, **absorption**, and **altitude**
- All algorithms must either **assume** or **retrieve** these and **capabilities depend on sensor and conditions**



Questions

- What information can **an informed data user** (me) obtain about these quantities from satellite products?
- What assumptions or caveats are opaque?
- How **consistent** are they, and can we say anything quantitative about **how good** they are (and if not, what do we need)?
- Are there **practical steps to improve the representation of these events** without sacrificing global performance?
- If not, what would we need to move forward?

Data sets

Processed In progress Downloaded

AERONET direct Sun v3

AERONET SDA v3

AERONET almucantar v3

AERONET hybrid v3

AHI (Himawari 8) v2.1

CALIOP layer, profile v4

MISR v23

MODIS Dark Target (Terra, Aqua) c6.1

MODIS Deep Blue (Terra, Aqua) c6.1

MODIS MAIAC (Terra, Aqua) c6.1

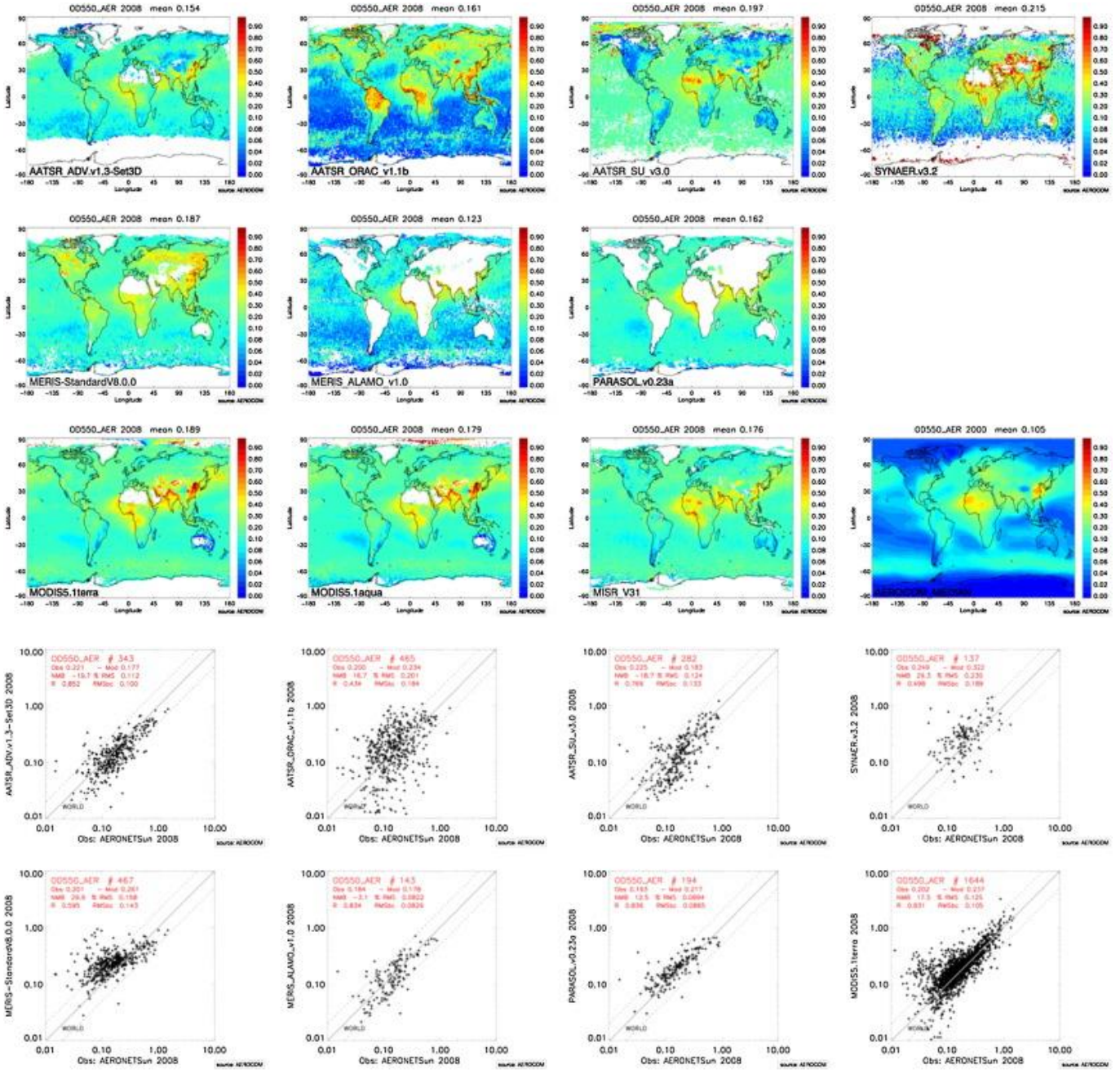
OMI v003

VIIRS Dark Target v001

VIIRS Deep Blue v001

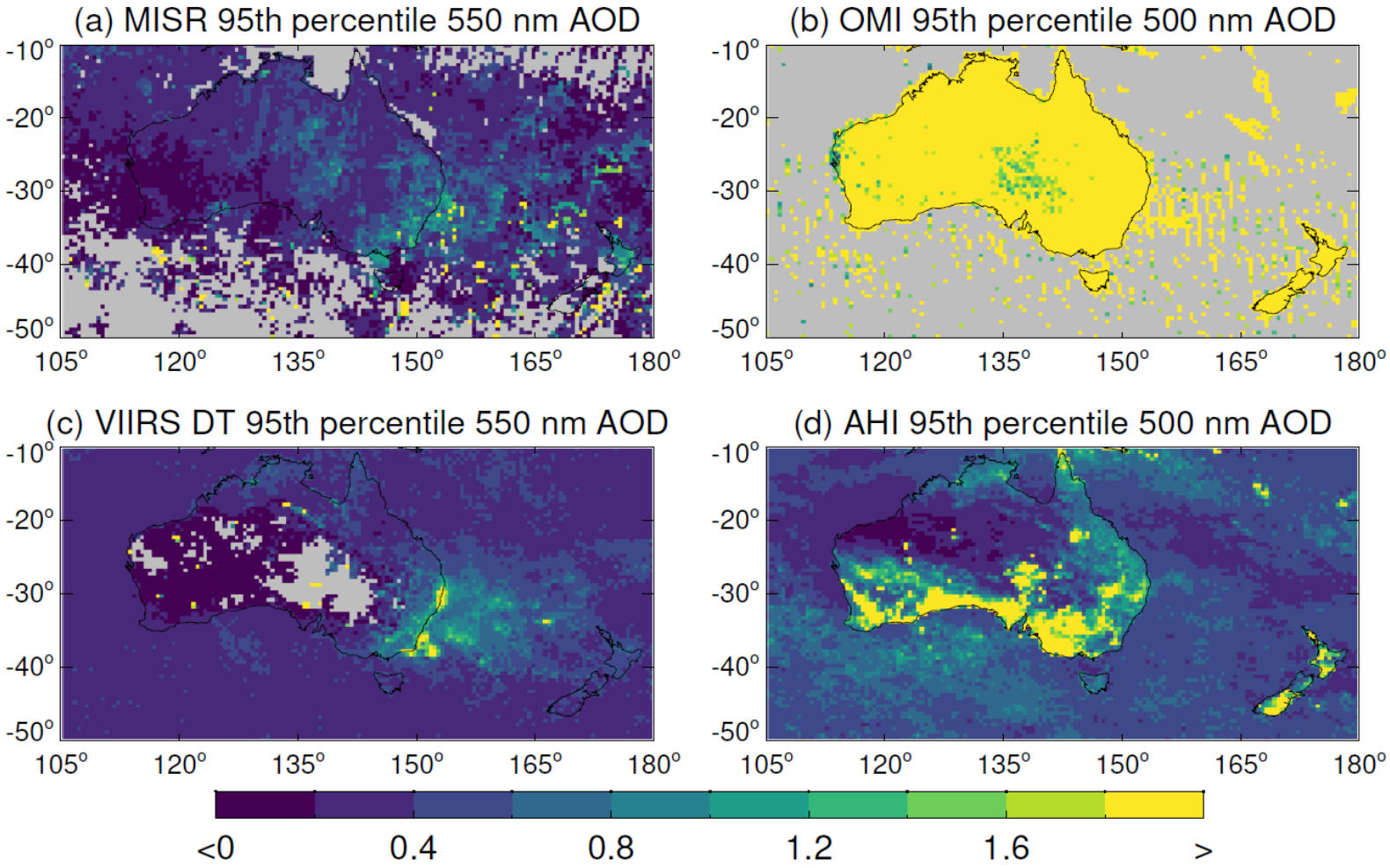
AOD retrievals really do a pretty good job on a global basis

- There is a fair degree of **consistency in spatial and temporal distributions**, and **decent agreement with AERONET**, with no one data set best everywhere
  - Ongoing algorithm refinement continues to improve the results
  - Figures from de Leeuw et al. (2015), https://doi.org/10.1016/j.rse.2013.04.023
  - Don't squint, the details of these panels aren't important to our main point here

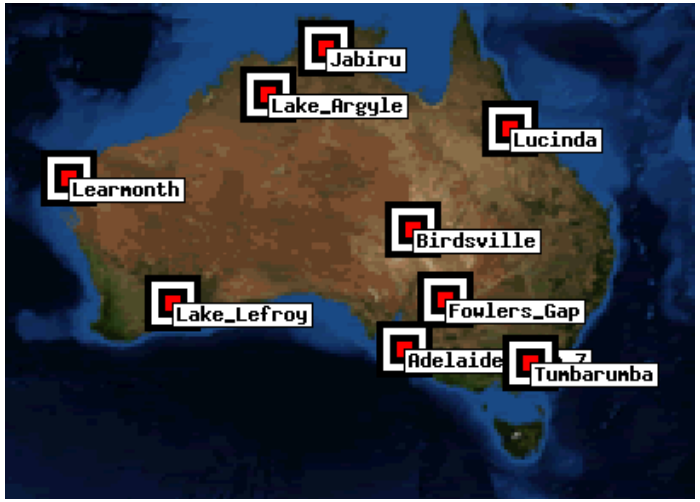


Looking at the 95th percentile AOD should show us peak locations and magnitude

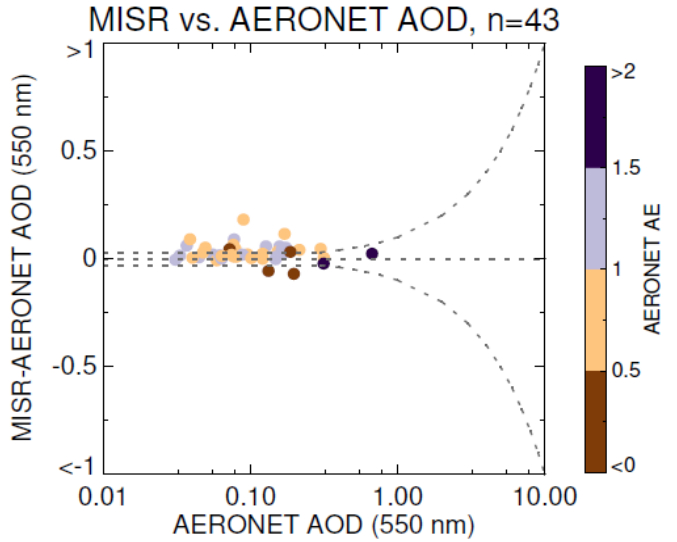
- There are **big differences in the 95th percentile of AOD**, implying **large influences of retrieval assumptions and sampling considerations**
- There are some apparent artefacts as a result
- Australia and surrounding oceans are notoriously challenging
- Require 10+ points from the 6 months of data

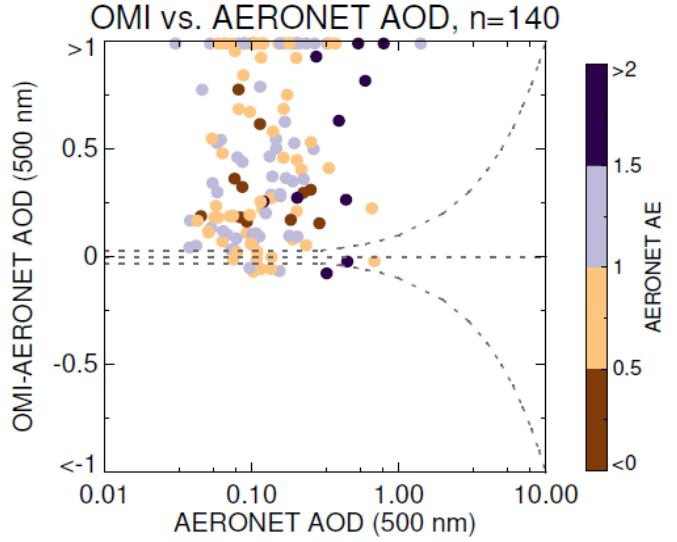


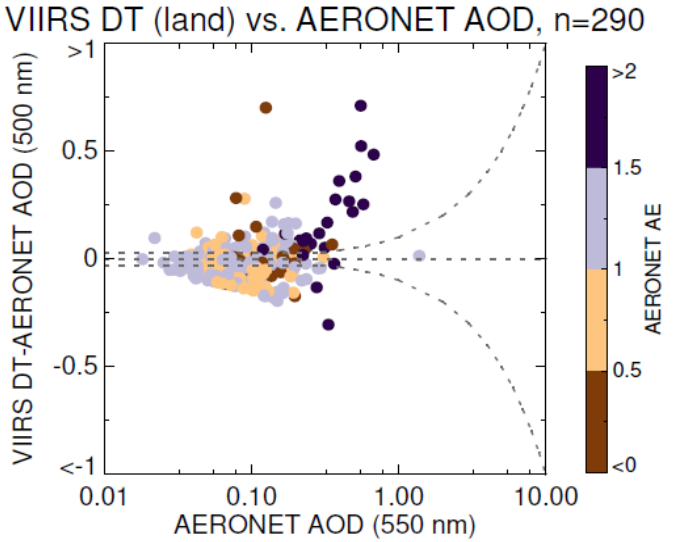
Initial comparisons with AERONET

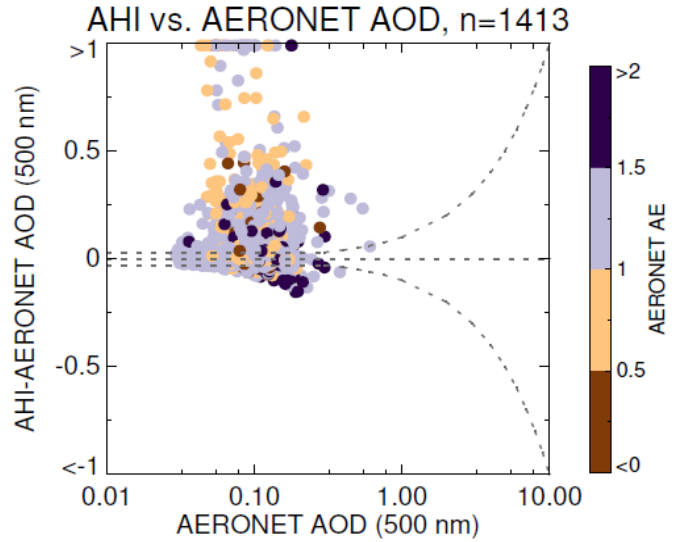


- **Available sites are over land, but much of the smoke traveled over the water** and we know **land/water uncertainties are different**
  - Few matchups with heavy smoke (e.g. AOD>1, high AE)
  - Colour scale is AERONET AE
  - Large variety in data volume



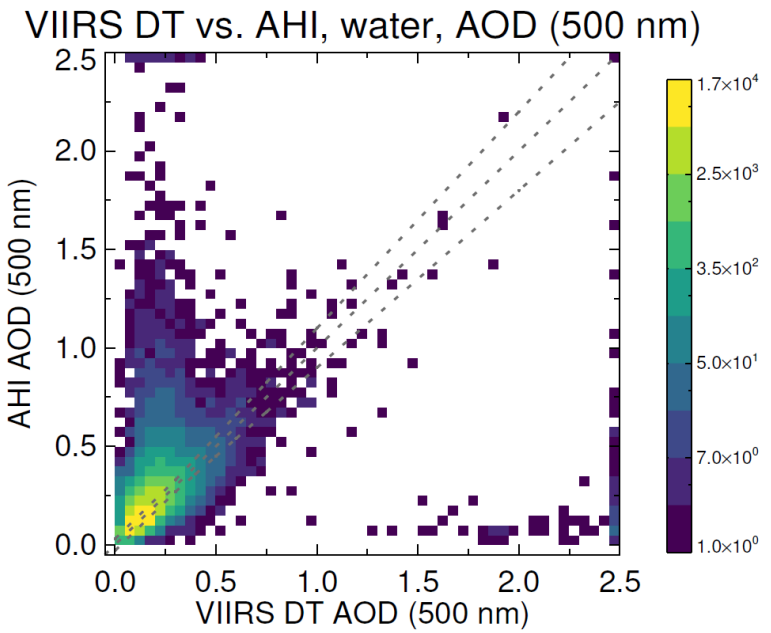


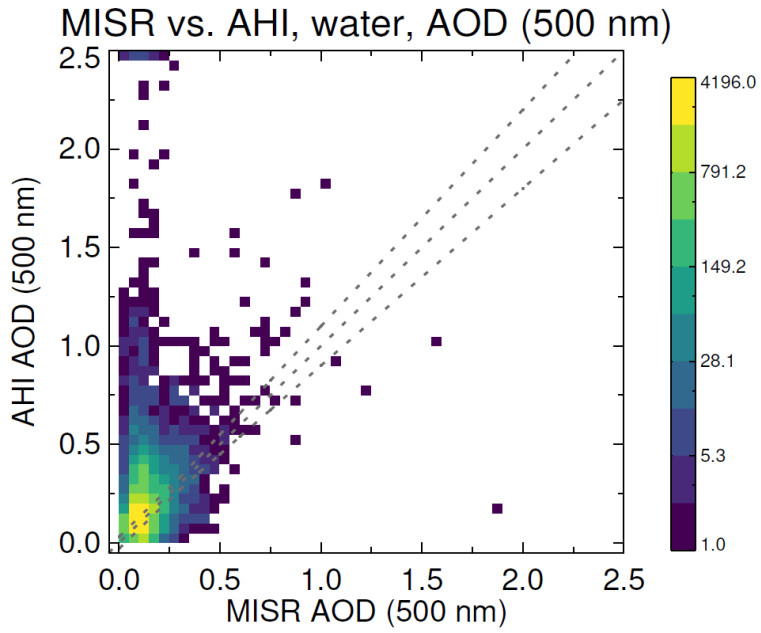


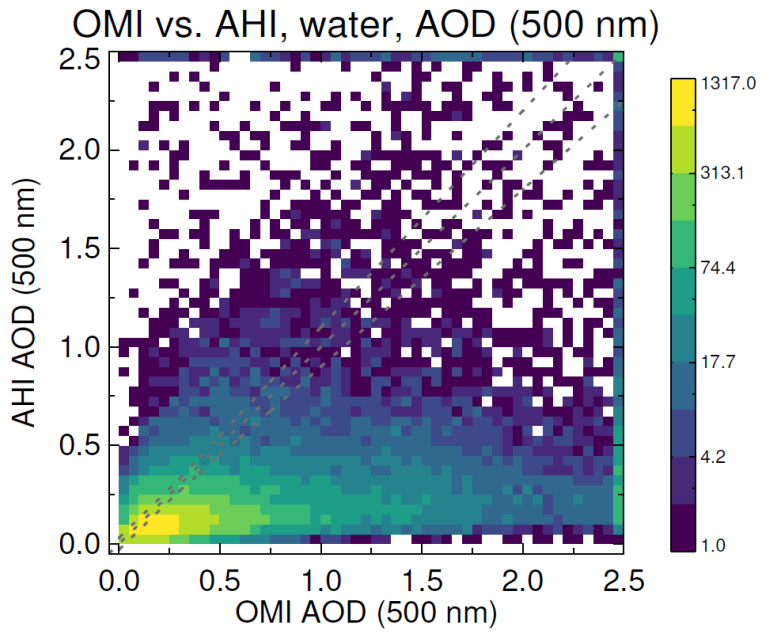


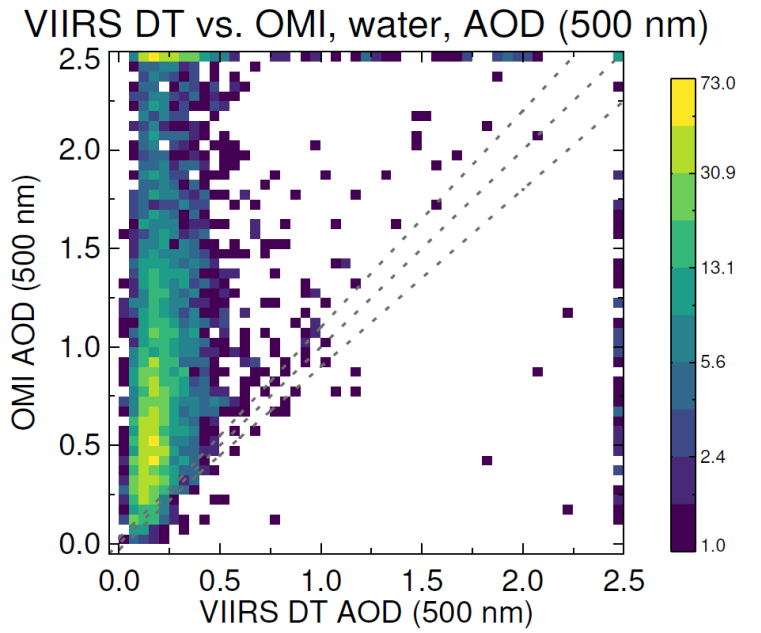
Initial comparisons of collocated AOD over water

- Generally, **there is good agreement in baseline AOD** but **retrievals diverge when AOD is high**.
- All data shown at 500 nm and truncated at AOD=2.5
- Collocation is 0.5 degree spatial, 30 min temporal, so MISR only overlaps with AHI from this set of sensors



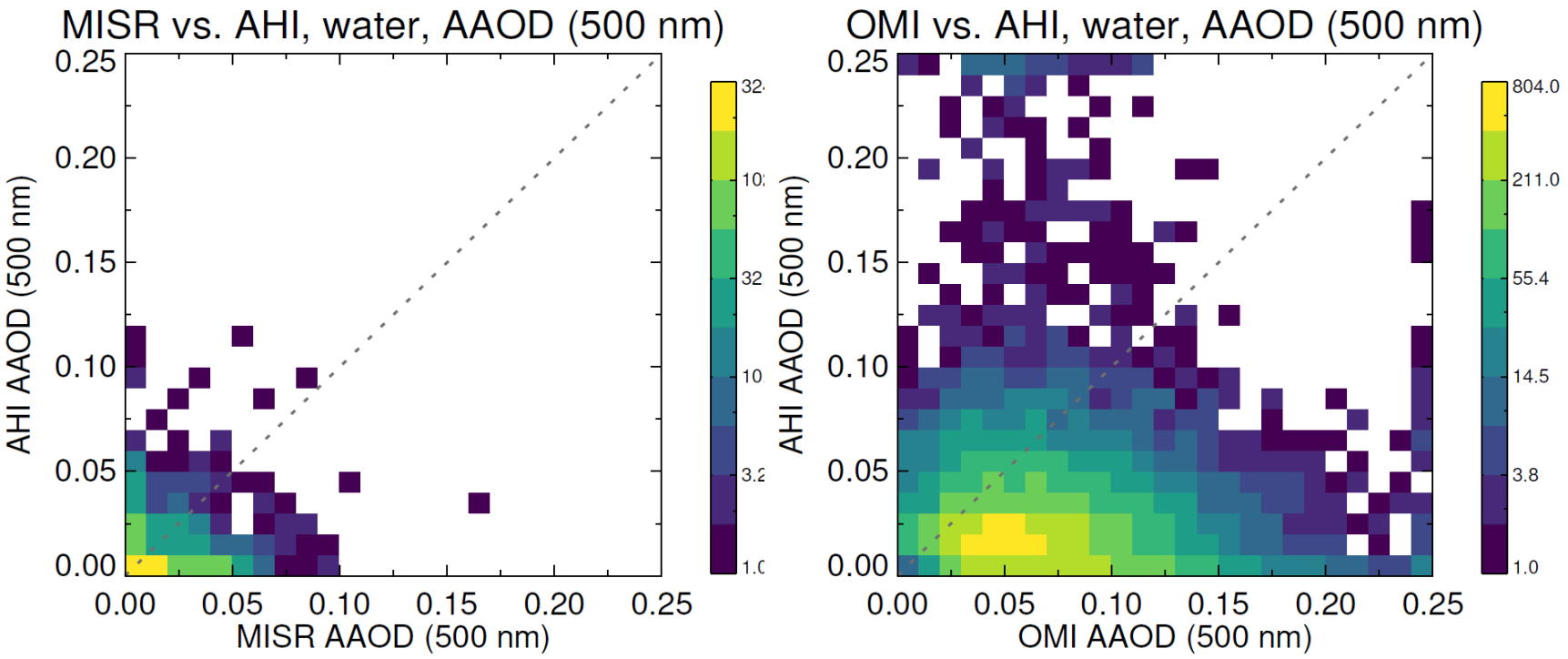






Initial comparisons of collocated AAOD

- **Only a few products provide the means to calculate AAOD** (retrieved or derived), and **there is not much agreement**
  - Filtered with threshold of 500 nm AOD >0.2 to exclude clean background points
  - Data truncated at AAOD=0.25
  - Similar land/water tendencies (not shown)



Initial take-aways

- We are doing a good job using individual sensors for global processing
- In the short term to go further **maybe we need multi-sensor (at level 1) retrievals** or **special processing with different assumptions for these events**
- From data sets looked at so far:
  - Some **desired info is missing, populated inconsistently, or not easily accessible** (OMI is best in that regard and also has a nice explicit “type” identification)
  - In maps and collocated data **the AOD and AAOD peaks from the smoke are not captured consistently**
  - **Geostationary AHI data has excellent sampling** but needs quality filtering (sorry- rerunning with that now)
- This a work in progress and we welcome discussion with algorithm teams

Extras for discussion

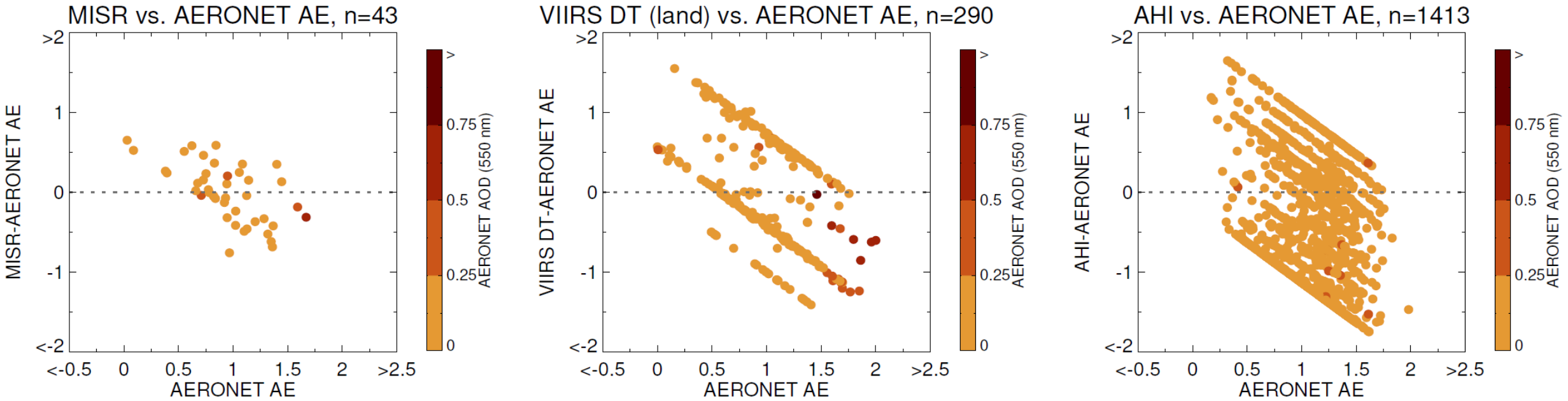
What is (and isn't) in the data?

Key

Available | Partial | Not directly

Data set	Midvisible AOD	Fine/coarse partition	SSA	Aerosol height	Notes
Himawari 8 AHI					• Data at 500 nm • 10 minute sampling cadence is nice
OMI					• Data at 500 nm • No FMF but provides dust, smoke, sulfate type • Over-water coverage limited
MISR					• Provides blue to nIR • SSA, mixture info missing if no mixture fit well • Overall AE, but no FMF direct analogue
VIIRS DT (land)					• Provides blue to red • Fine "model" fraction not fine "mode" fraction, plus missing in low AOD • Unphysical negative retrievals which cluster
VIIRS DT (water)					• Provides blue to swIR • No SSA or info about best (only average) solution
VIIRS DB (land)					• Provides blue to red • Overall AE, but no FMF • SSA not consistently populated

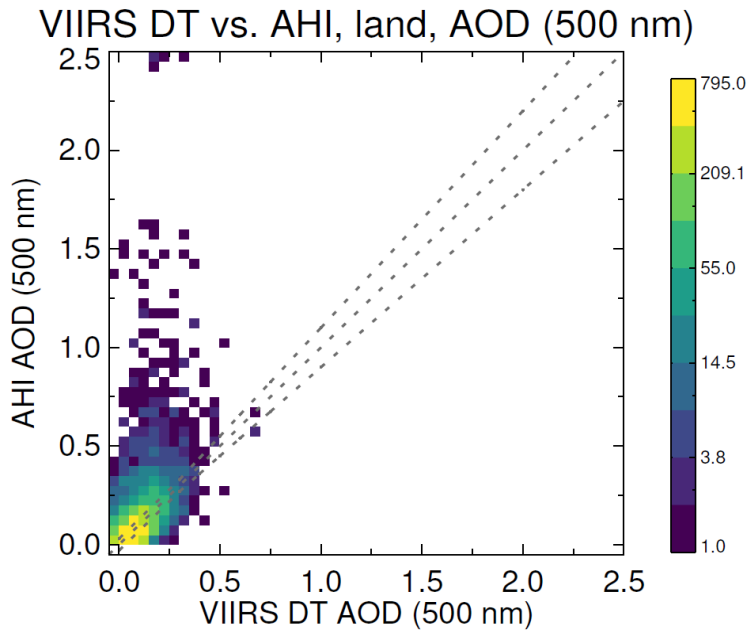
Known limited satellite AE skill over land

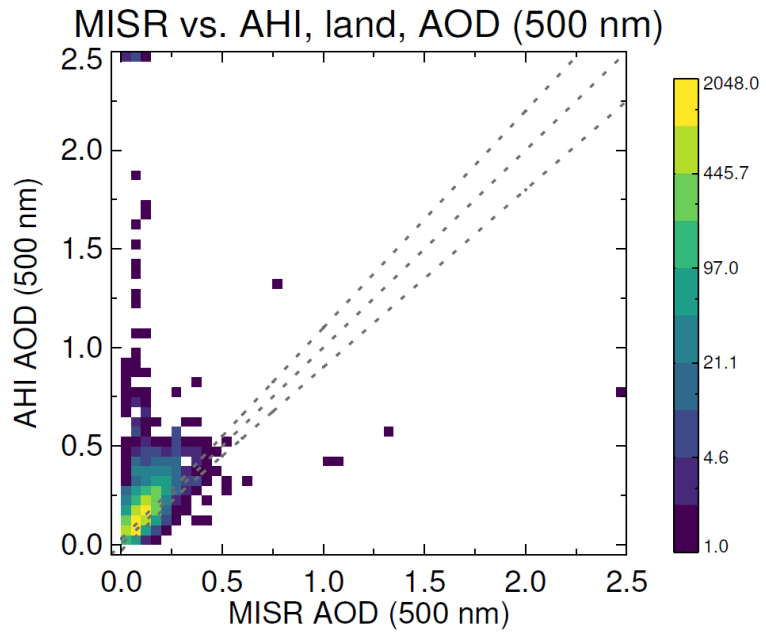


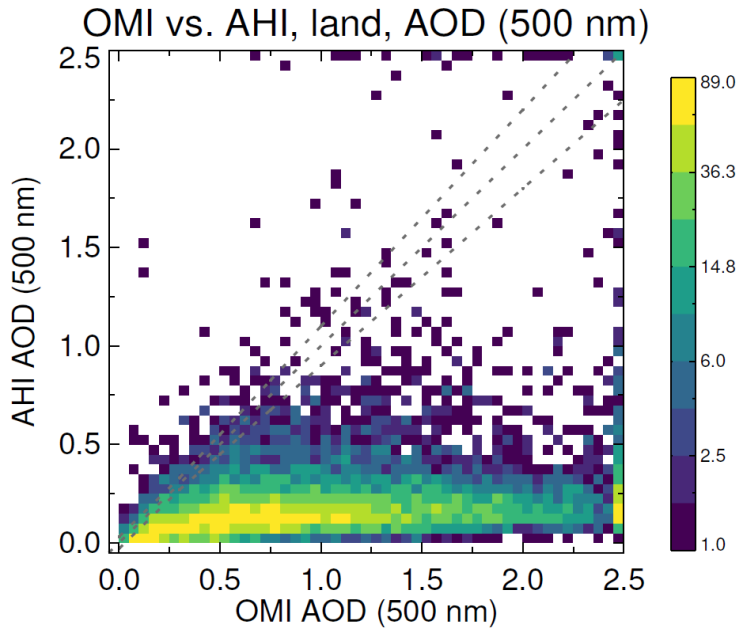
- Downward tilts imply **diminished range in satellite compared to AERONET**
- **Streaks** in VIIRS DT and AHI **imply preferential retrieval of certain values**
- AERONET AE also has non-negligible uncertainty when AOD is low
- Colour scale is AERONET AOD at 550 nm

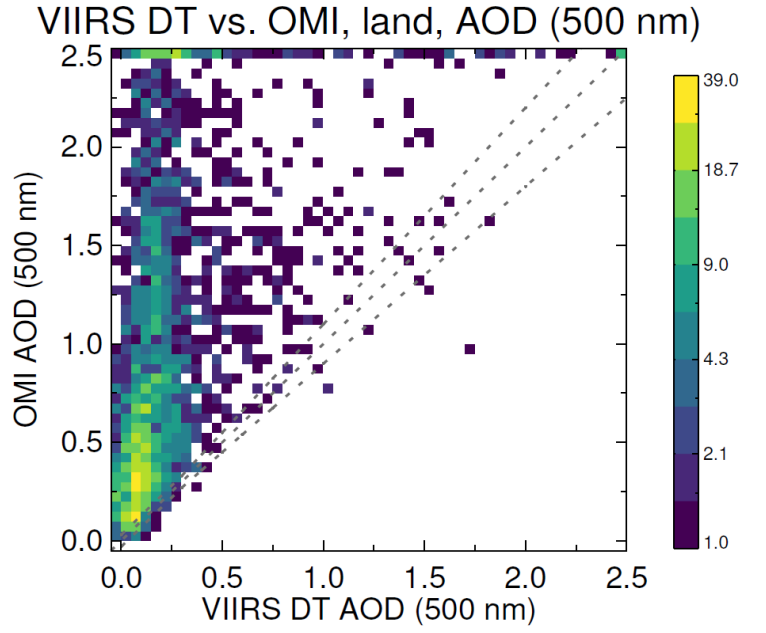
Initial comparisons of collocated AOD over land

- **As over water, baseline is often similar but retrievals diverge when AOD is high**
- All data shown at 500 nm and truncated at AOD=2.5









Initial comparisons of collocated fine mode AOD

- Few products provide the ability to calculate fine mode AOD
- Again, **baseline values are reasonably similar** but **there is divergence when AOD is high**