Aerosol Single Scattering Albedo and Layer Height using VIIRS and OMPS-NM

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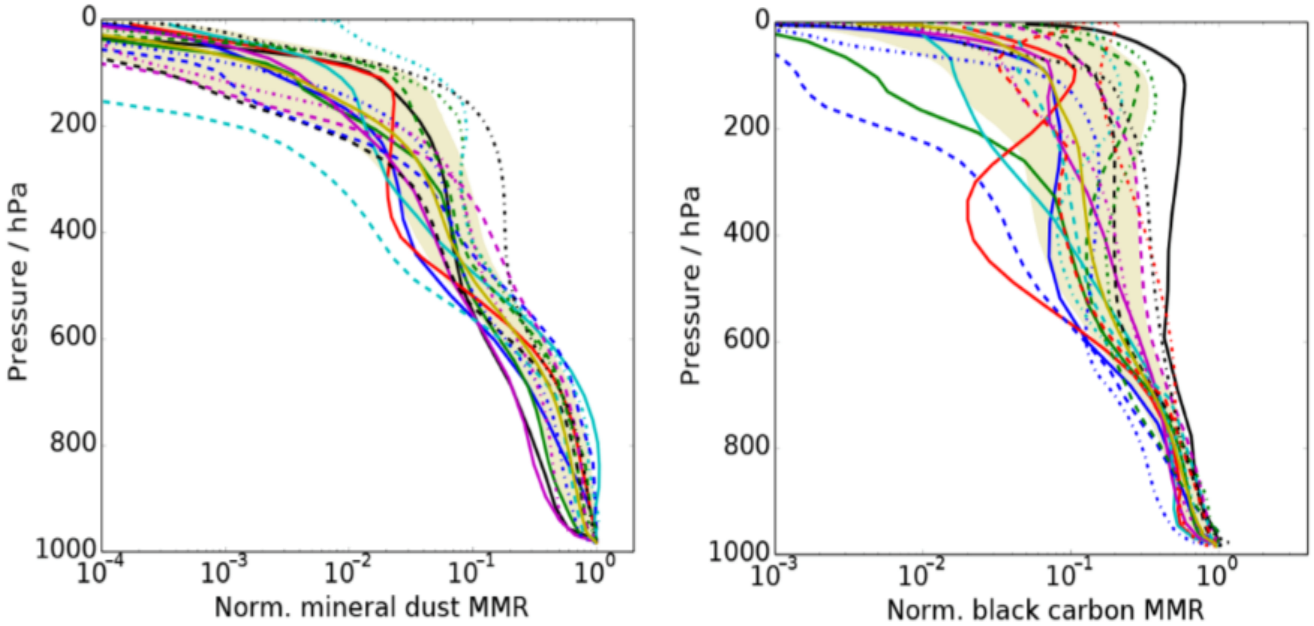
MODIS/VIIRS Science Team Meeting , October 15 –19, 2018, Silver Spring, MD

Motivation: Large Variability in Annual Mean vertical distribution of Absorbing Aerosols in Models

Dust and Smoke Mean Vertical Distribution



Kipling et al., 2016, AeroCom

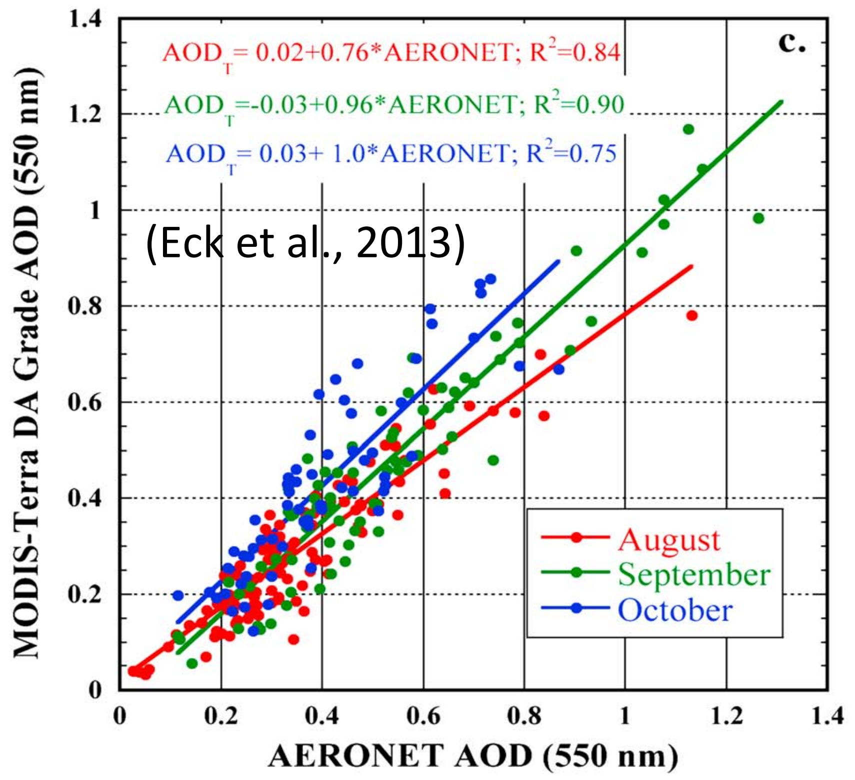
- Aerosol Absorption (AA) is one of the outstanding challenges in aerosol research and climate applications
- Forcing and heating rate computations are critically linked to aerosol single scattering albedo (SSA) and layer height (Z)

There is a need to improve global observations of Aerosol Absorption and Height

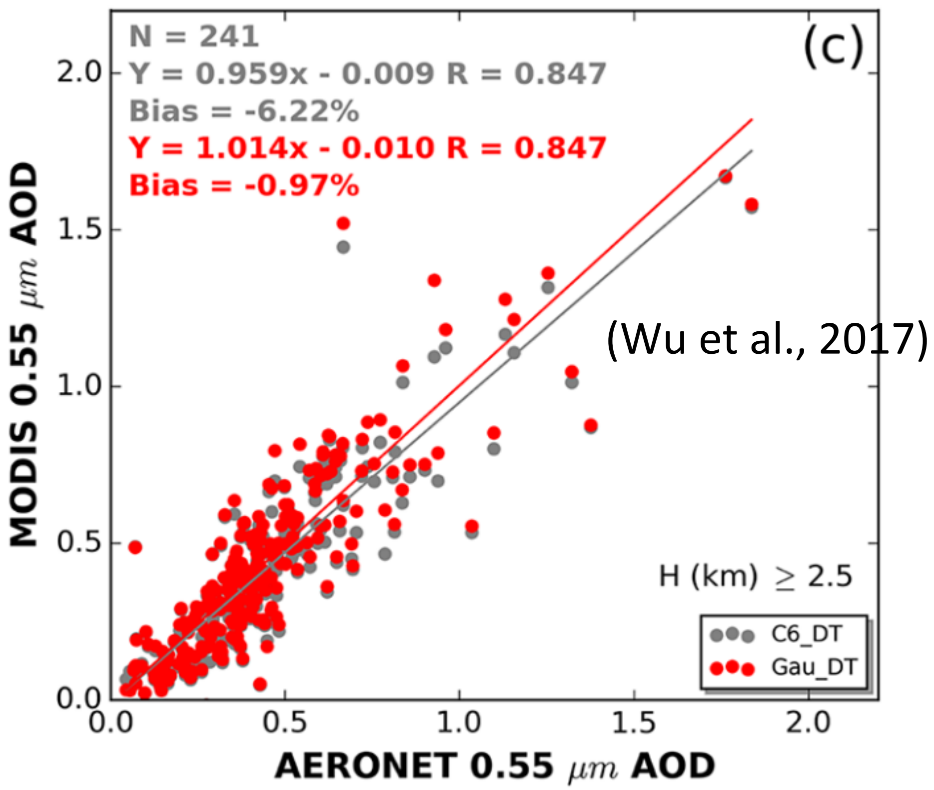
Another Motivation: Better AA information will benefit Current Aerosol Algorithms

Recent Studies Highlight biases in AOD retrievals because lack of aerosol absorption and height information

Deviations found in SSA assumption



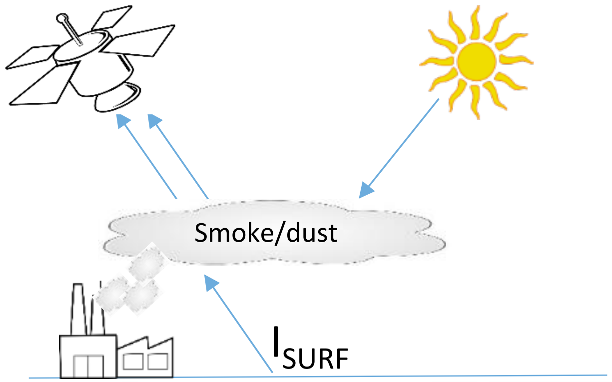
Similarly by a customized aerosol layer



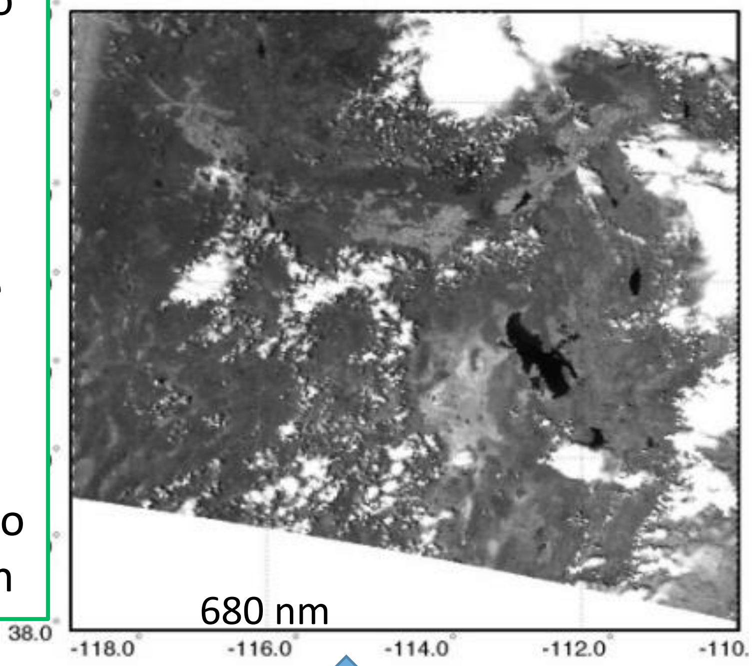
Atmospheric Radiance is distinctively different in the UV

Visible to Near-IR

$I_{TOA} = I_{ATM} + I_{SURF}$



- Surface: difficult to model or assume
- <u>Significant</u> Surface contribution
- <u>Minor</u> Sensitivity to Aerosol absorption



Example from the Cloud Aerosol Imager

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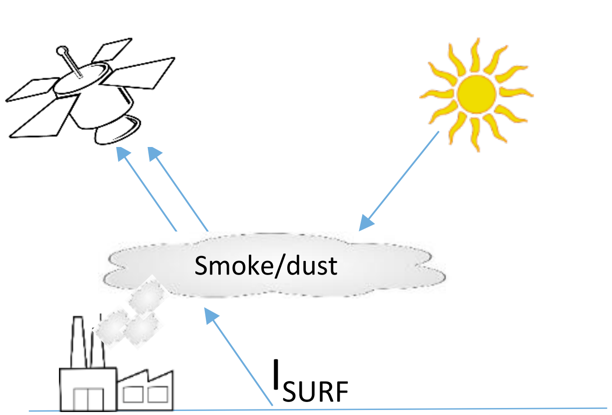

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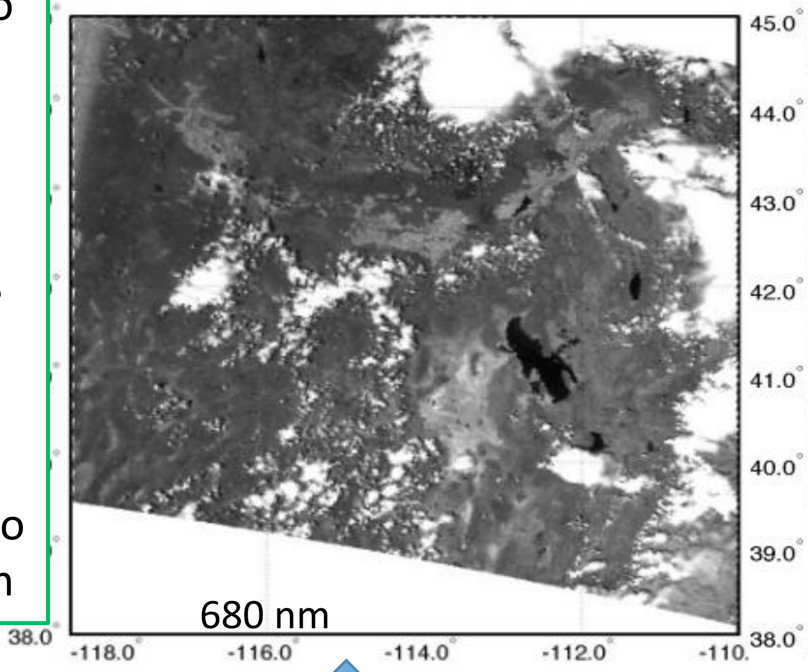
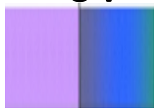
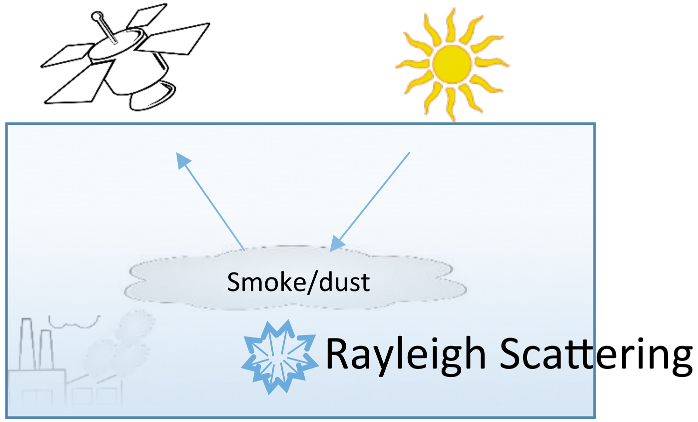


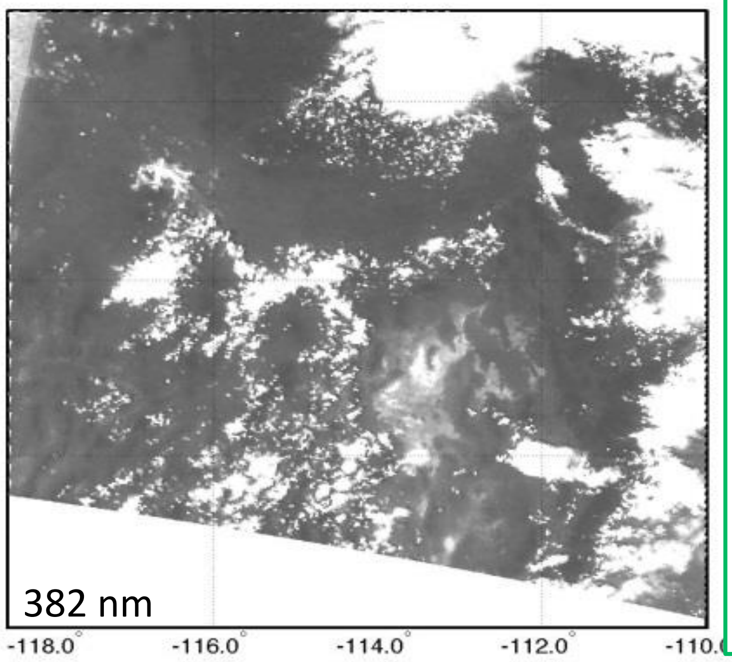
UV



$I_{TOA} = I_{ATM} + \cancel{I_{SURF}}$

$I_{ATM} \sim I_{RAY} + I_{AEROSOL}$





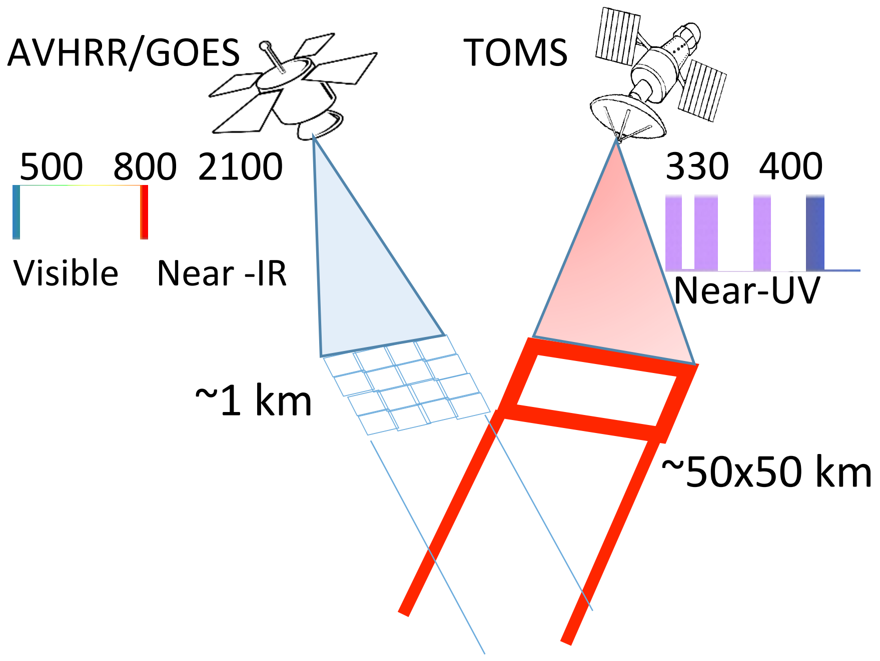
- Atmospheric Signal is dominated by Rayleigh scattering (easy to model)
- Minor Surface contribution
- Significant Sensitivity to Aerosol Absorption

Example from the Cloud Aerosol Imager

It's been a long way to achieve UV to near-IR aerosol retrievals

Past missions did not have the right features

80's and 90's : AVHRR/GOES and TOMS



~~Simultaneous~~

~~Spatial Resolution~~

~~UV-Near IR~~

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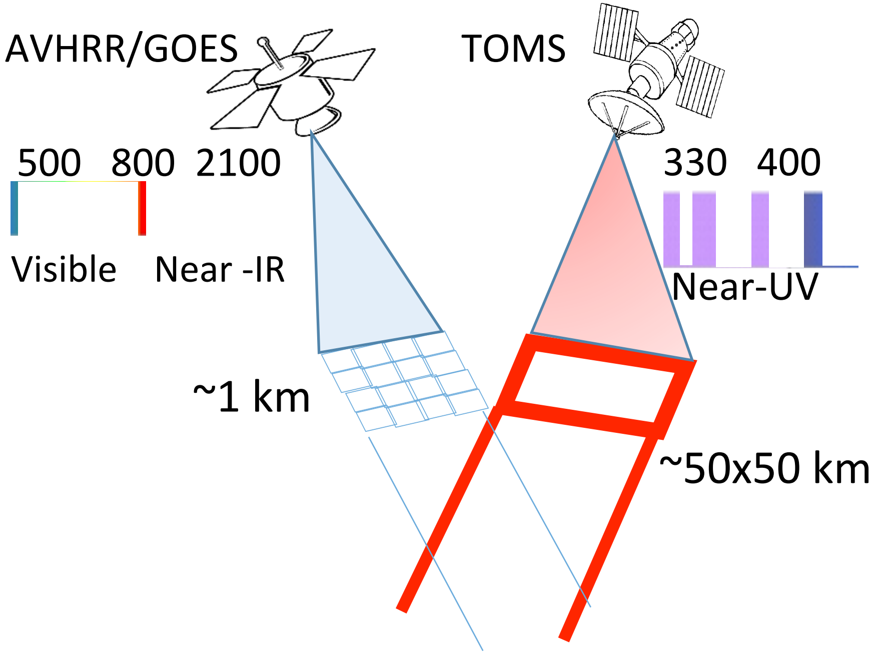

~~Simultaneous~~

~~Spatial Resolution~~

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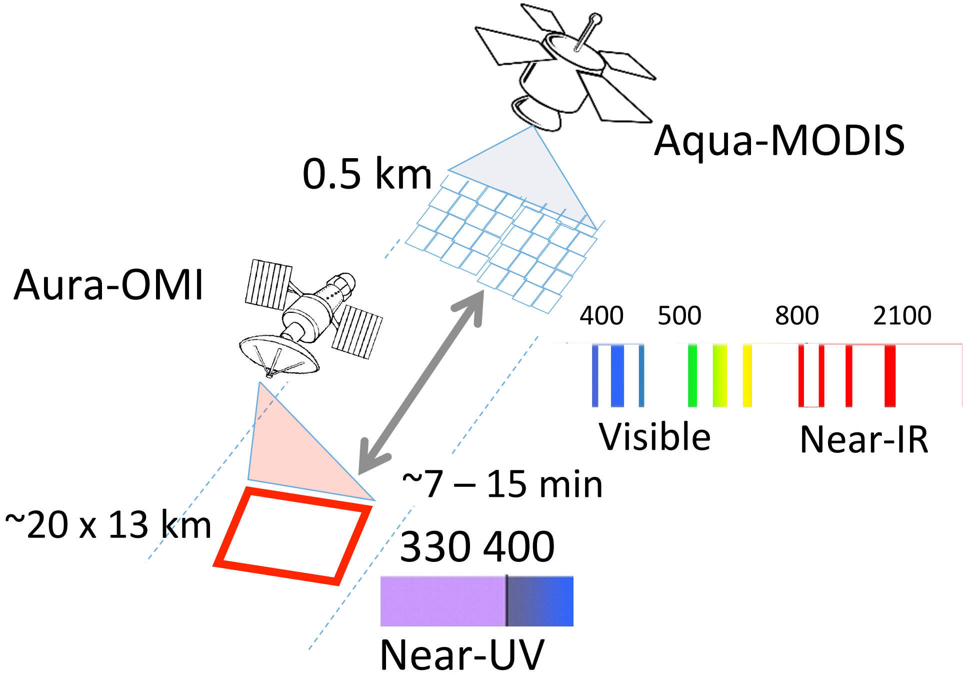
2000’s : Aqua and Aura

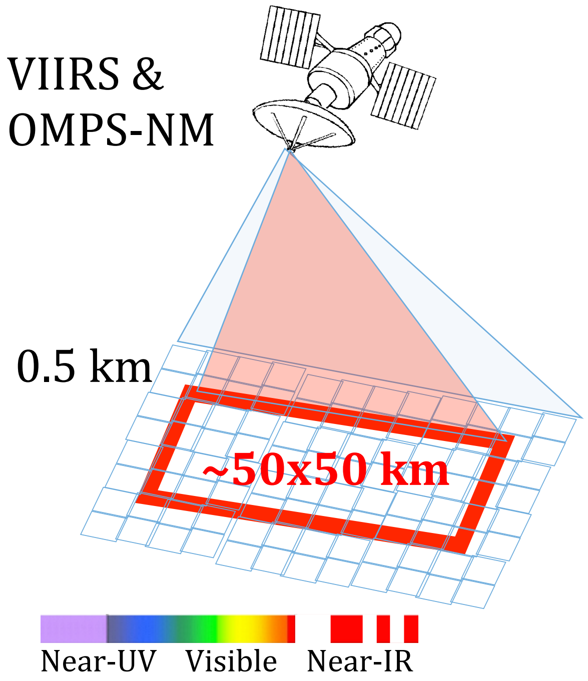


~~Simultaneous~~

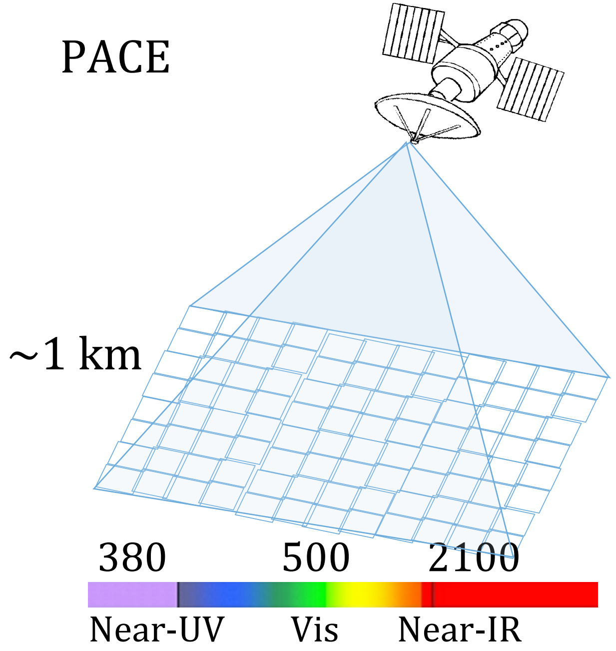
Spatial Resolution

UV-Near IR

The Present is good and the Future bodes very well



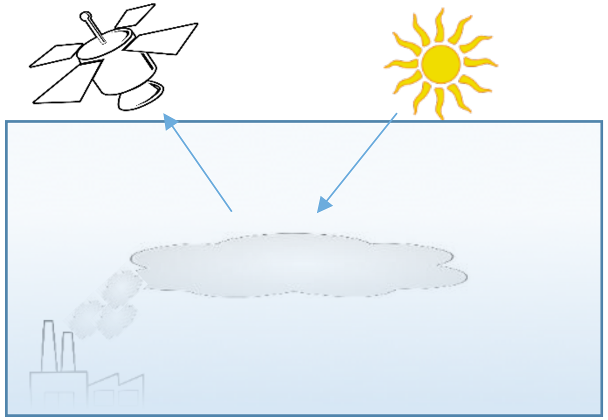
- Simultaneous
- ~~Spatial Resolution~~
- UV-Near IR



- ✓ Simultaneous
- ✓ Spatial Resolution
- ✓ UV-Near IR

Aerosol UV Top-of-atmosphere Radiance is an Unconstrained Retrieval

In the UV, aerosol τ, ω_o and Z modulate the atmospheric path radiance



$I_{TOA} = I_{ATM}(\tau, \omega_o, z)$

Aerosol UV retrievals rely on observations at two bands and the I_{TOA} is modulated by 3 parameters (τ, ω_o, z)

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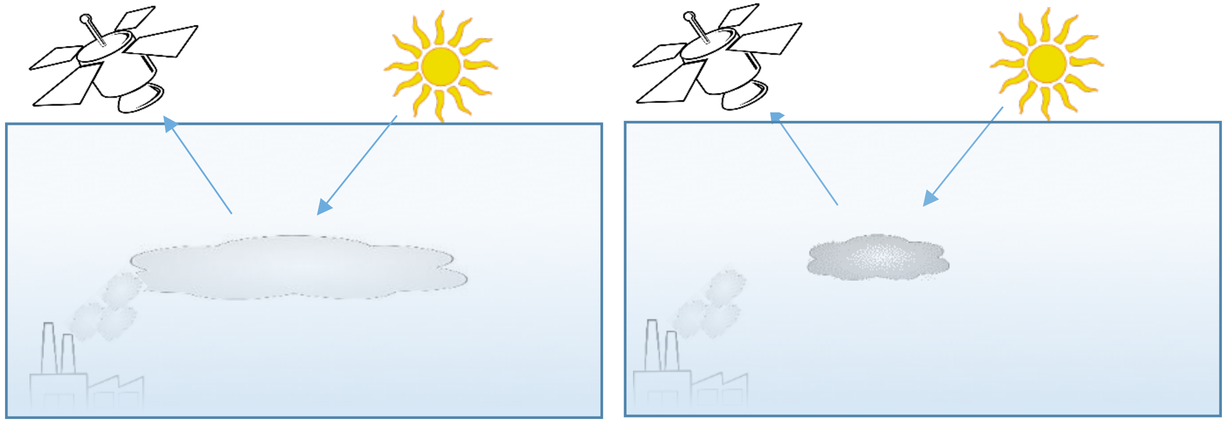

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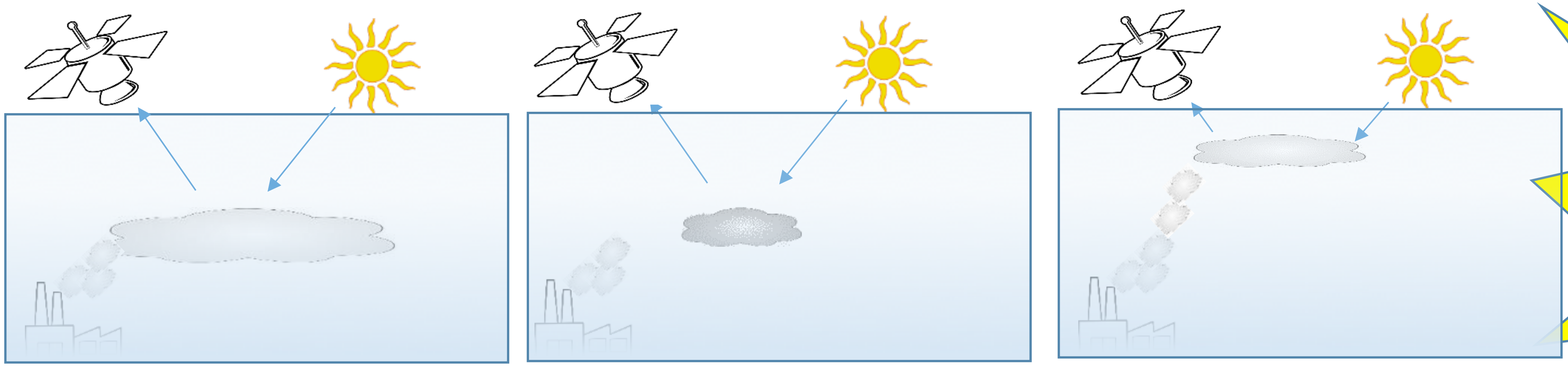

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All these scenarios have same upwelling radiance

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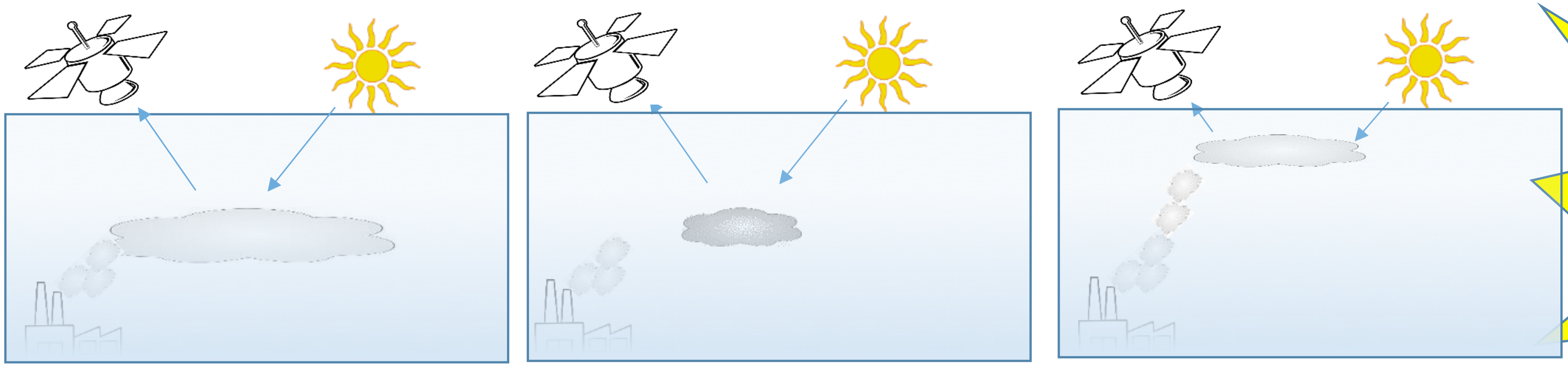

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Aerosol UV retrievals rely on observations at two bands and the I_{TOA} is modulated by 3 parameters (τ, ω_o, z)

Derive Aerosol Optical Depth with a VIS sensor (MODIS/VIIRS) and use it to constrain the UV retrieval (2 obs and 2 unknowns , ω_o and z)

Existing Methodology using MODIS and OMI synergy

Extrapolate MODIS τ to the near-UV

Input

$\tau_{NUV} = f(\tau_{VIS}, \tau_{NIR})$

Outputs

τ_{VIS}, τ_{NIR}

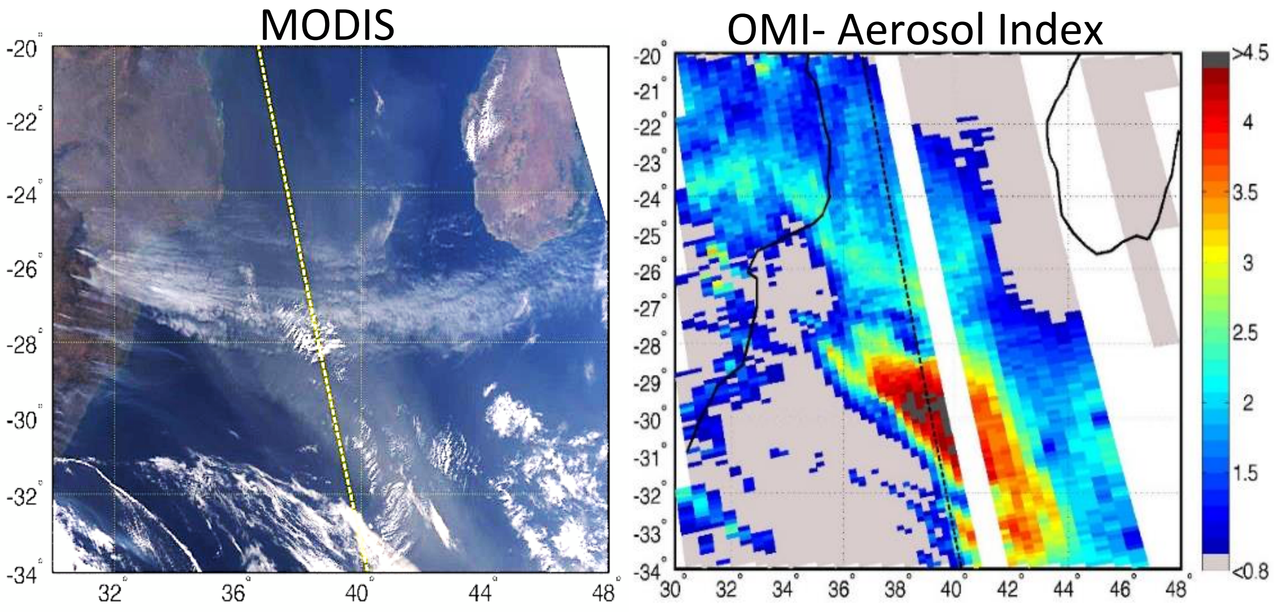
OMI : Derive SSA and Z

Aerosol models w/fix mode conc. & variable SSA

MODIS : Dark Target

Aerosol models w/ variable mode conc. & fixed SSA

Outputs z, τ_{UV}, ω_{UV}



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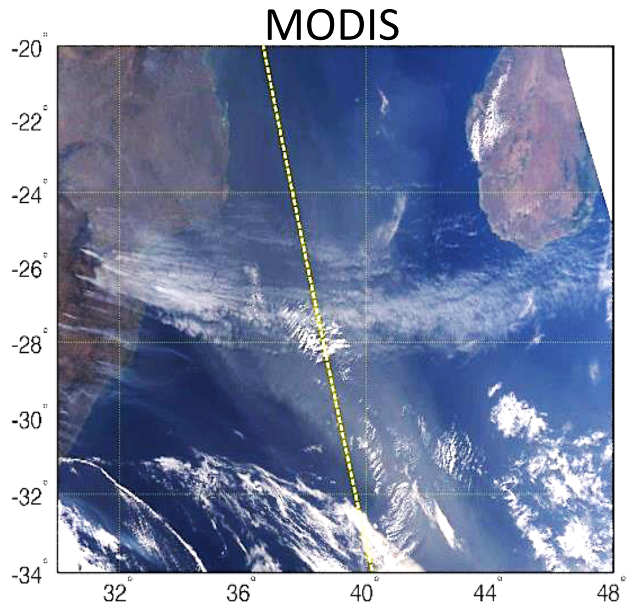
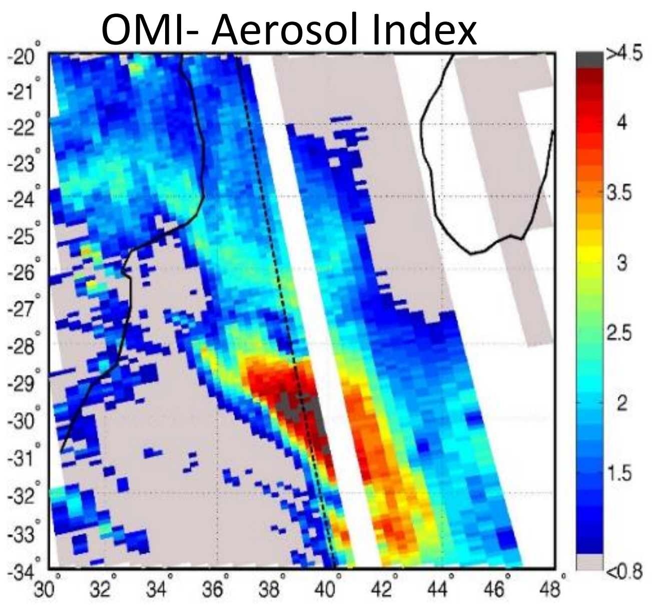
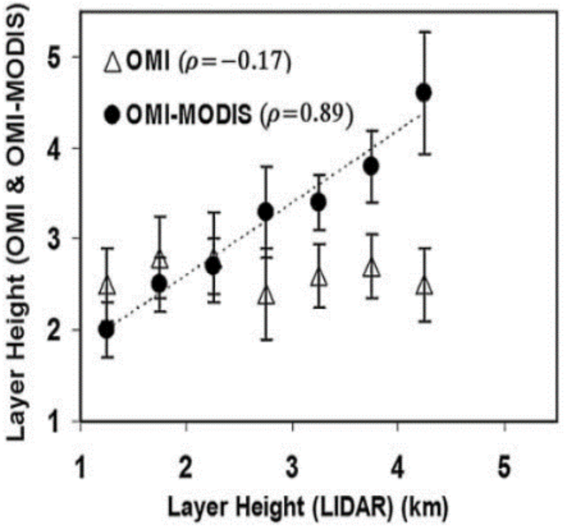
Outputs $z, \tau_{UV}, \omega_{UV}$



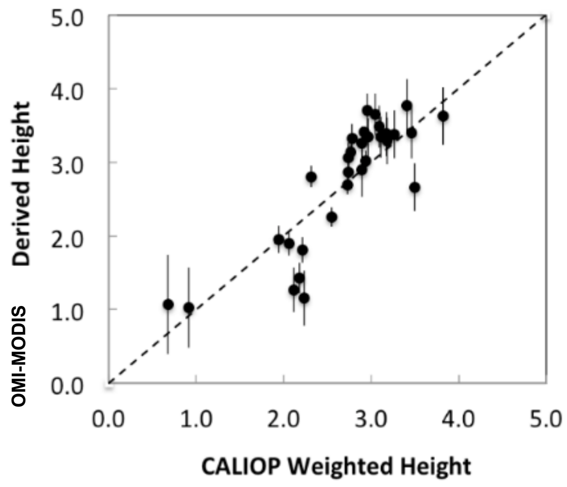




Satheesh et al., ***Improved assessment of aerosol absorption using OMI-MODIS joint retrieval*** (2009)

Gassó and Torres , **The role of cloud contamination, aerosol layer height and aerosol model in the assessment of the OMI near-UV retrievals over the ocean** (2016)

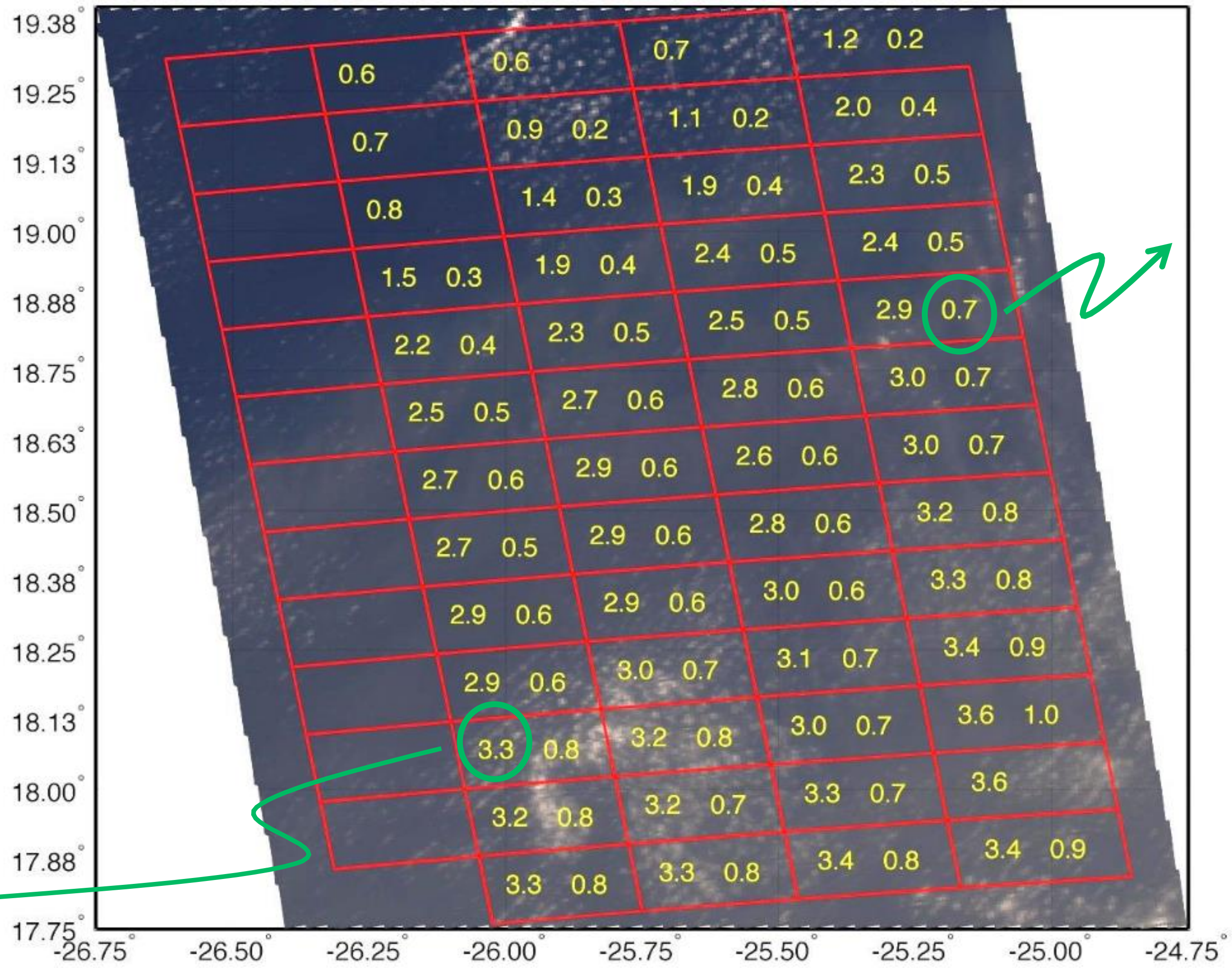
Satisfactory results when compared with Lidar



However, OMI and MODIS overlaps are not quite adequate for a systematic retrieval approach

Both, time difference (cloud formation) and viewing geometry are an impediment for a systematic UV to Near-IR retrieval

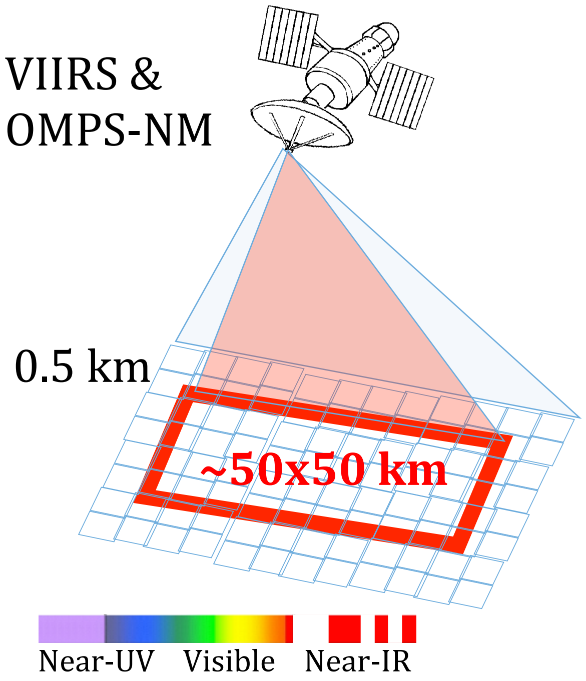
MODIS image with OMI grid overlap

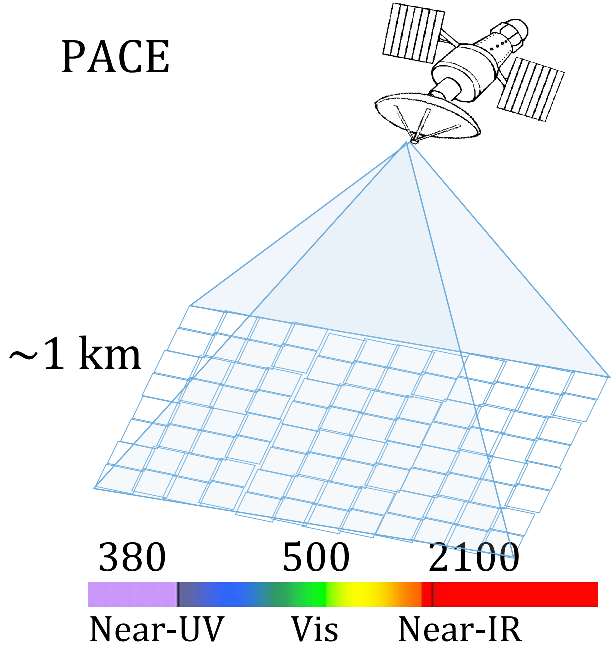


OMI AOD retrieved (right)

Yellow numbers in grid : Aerosol Index (left)

OMPS-NM High Resolution mode and VIIRS are an improvement





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UV-Near IR

✓ Simultaneous
✓ Spatial Resolution
✓ UV-Near IR

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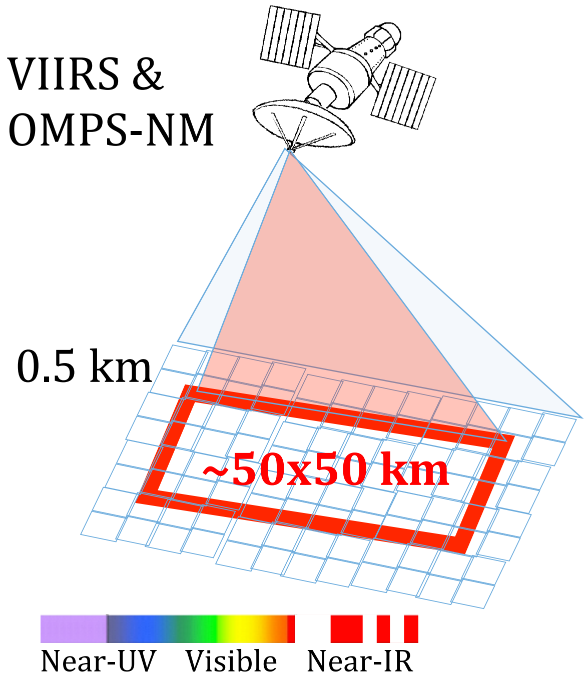

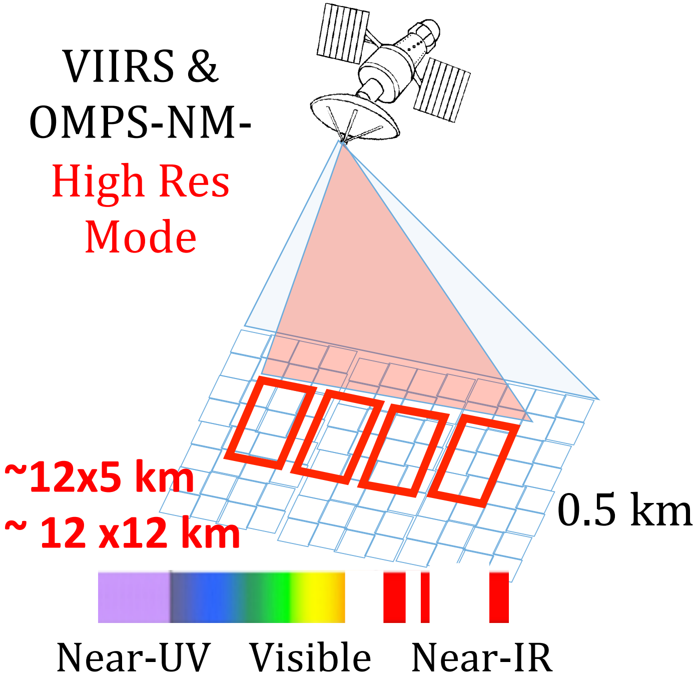

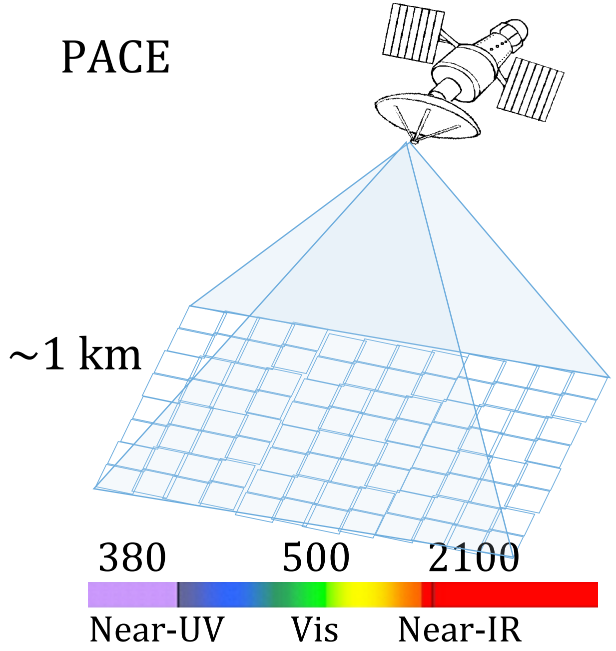

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Spatial Resolution
UV-Near IR

- ✓ Simultaneous
- ✓ Spatial Resolution
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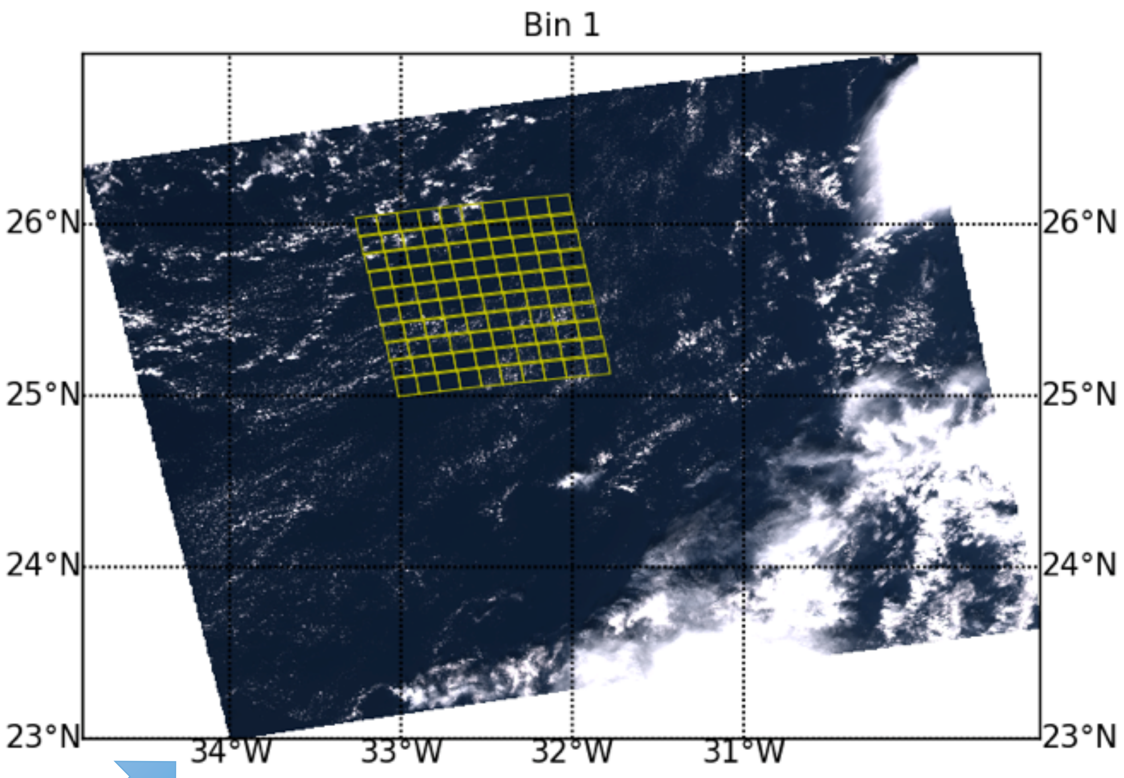
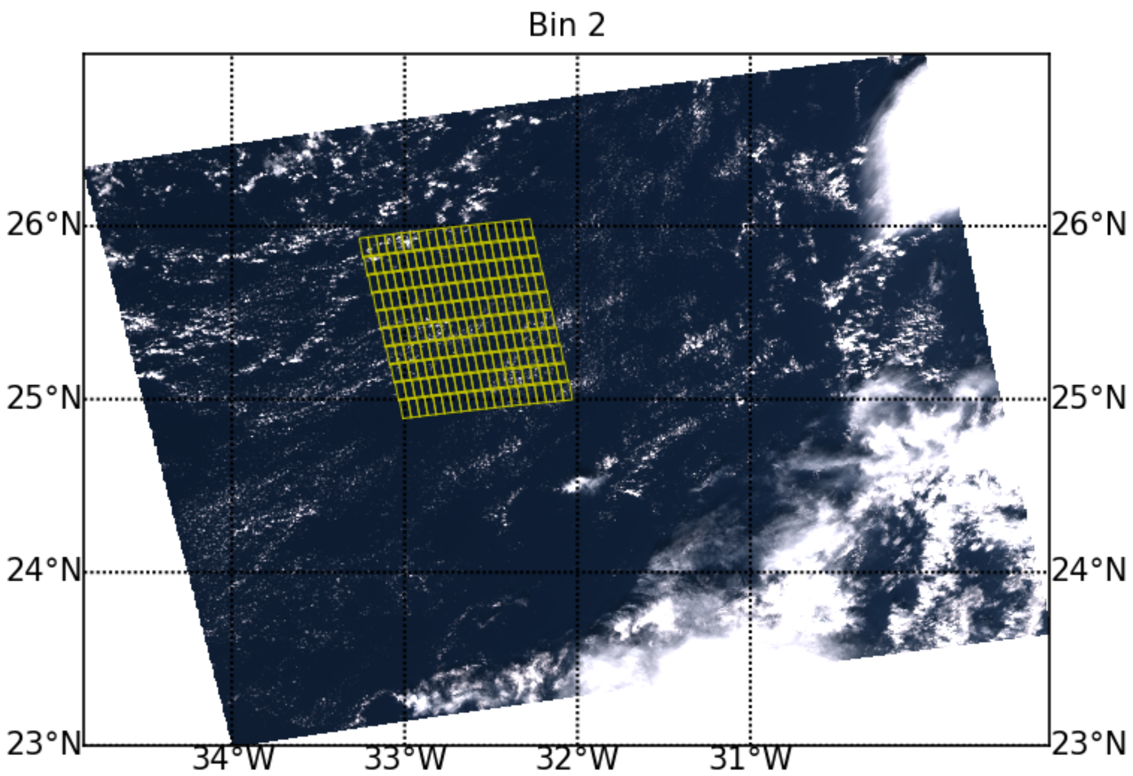
OMPS-NM has two High Resolution Modes



- ~4000 orbits spanning 4 years (1 day / week)
- "High" res ~ 12 x 12 km , similar to OMI
- "Super high" res ~12 x 5 km , Better than OMI!!



~ 12 x 12 km

~ 12 x 5 km

A Synergetic UV to Near-IR Algorithm: Fusion Dark Target – OMAERUV approach

Extrapolate MODIS τ to the near-UV

Input: $\tau_{NUV} = f(\tau_{VIS}, \tau_{NIR})$

OMPS : Derive SSA and Z

Aerosol models w/fix mode conc. & variable SSA

Outputs: z, ω_{UV}

Outputs: τ_{VIS}, τ_{NIR}

VIIRS: Dark Target

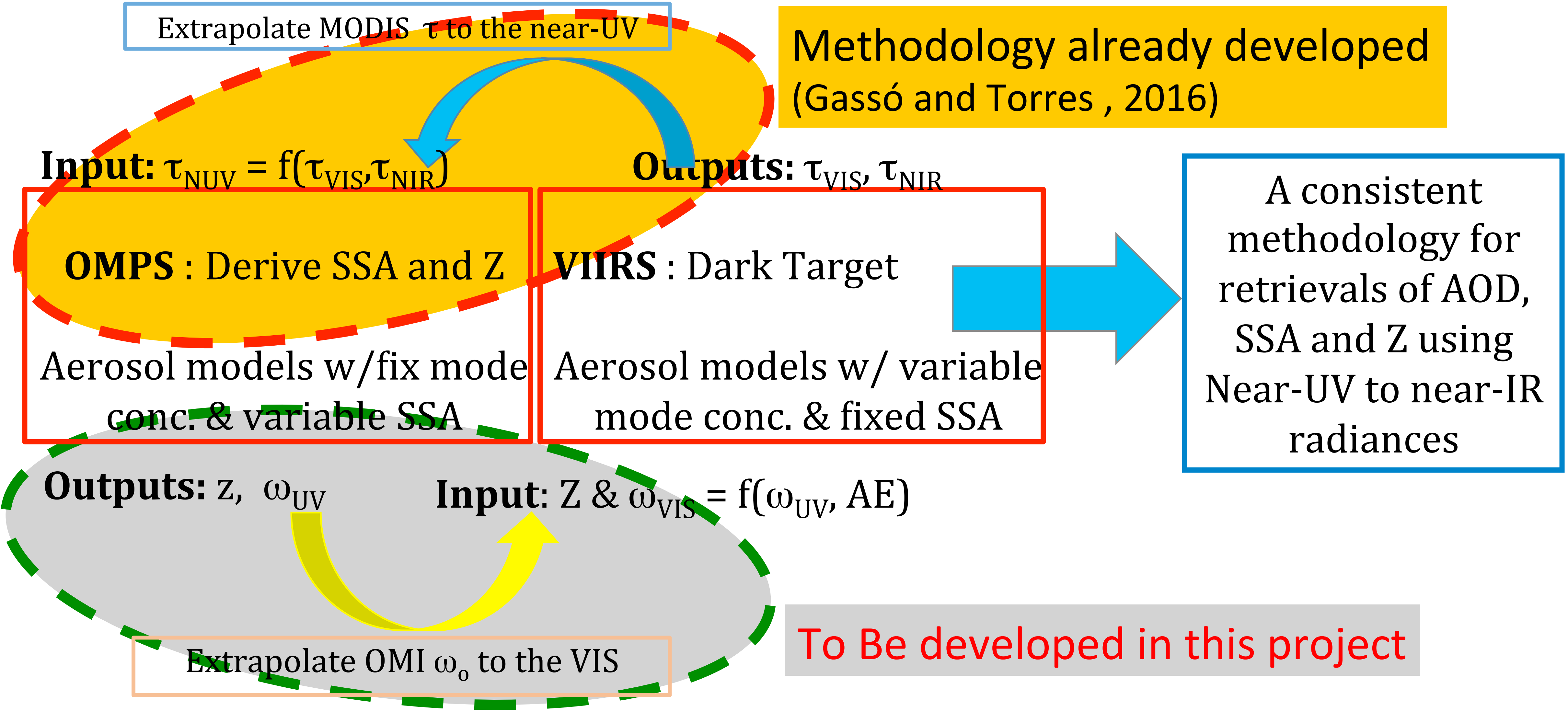
Aerosol models w/ variable mode conc. & fixed SSA

Input: Z & $\omega_{VIS} = f(\omega_{UV}, AE)$

A consistent methodology for retrievals of AOD, SSA and Z using Near-UV to near-IR radiances

Extrapolate OMI ω_o to the VIS

A Synergetic UV to Near-IR Algorithm: Fusion Dark Target – OMAERUV approach



Expected Outcome and Summary

- Global Maps of SSA and Z from combined OMPS-NM and VIIRS
- Unified Methodology for Aerosol retrievals of AOD, SSA and Z from the UV to Near IR

Misc

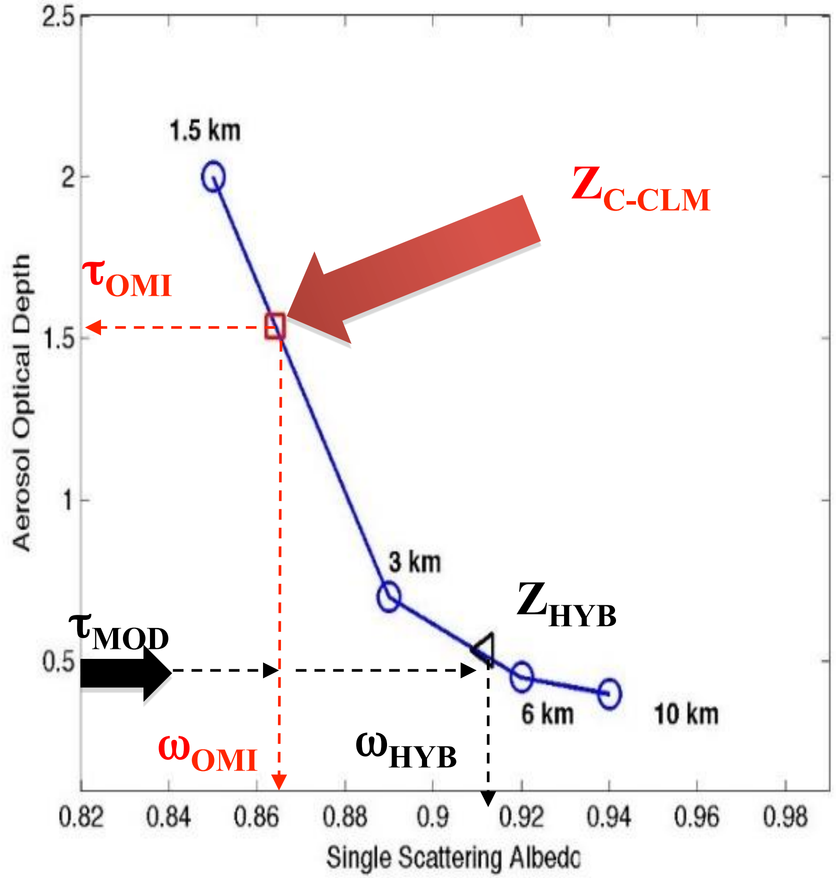
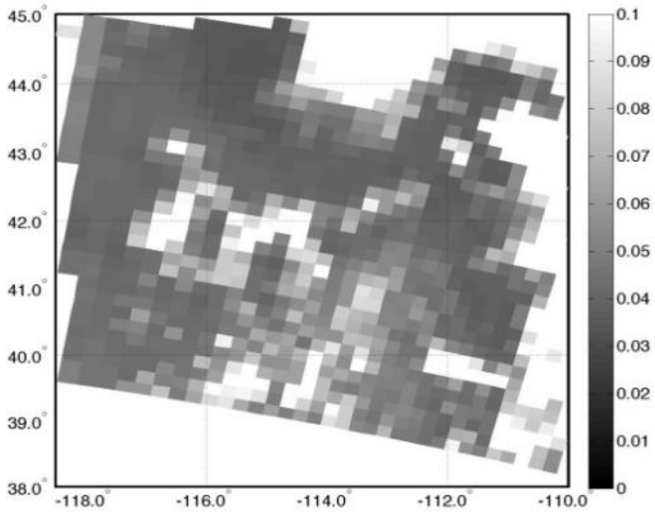


Figure 3: Illustration of the standard (or operational, *Torres et al., 2013*) and hybrid (Satheesh et al., 2009) retrieval schemes. The standard algorithm computes the pair of AOD and SSA at five assumed aerosol heights for the pixel's viewing geometry (blue solid lines and circles). In a prior step, it selected an aerosol model and surface albedo used in the computation. Each triplet (Z, SSA and AOD) has a corresponding upwelling radiance matching the observed radiance by OMI. To select the final (or retrieved) AOD and SSA for the pixel, the operational algorithm uses a climatological height (Z_{c-clm}, red arrow and red dashed lines). The hybrid method uses a VIS AOD (extrapolated to 388nm) as entry point (black arrow and black dashed lines) to determine the Z and SSA using the triplets from the lookup table.

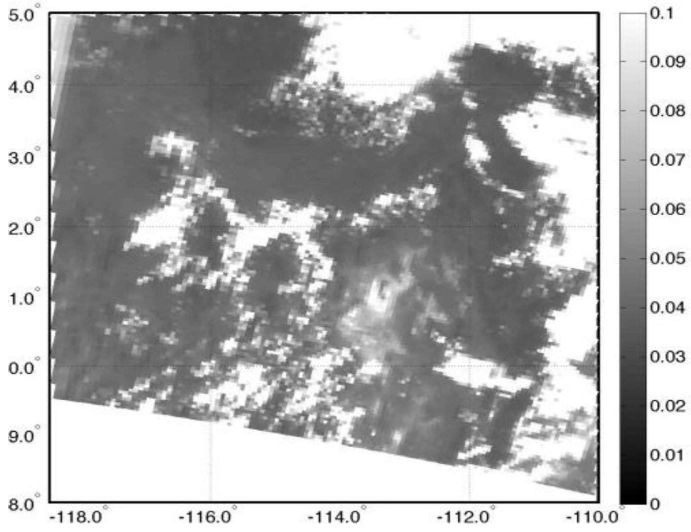
Spatial resolution in near UV sensors has been improving steadily

TOMS, OMPS



40-60 km x 40-60km

OMI

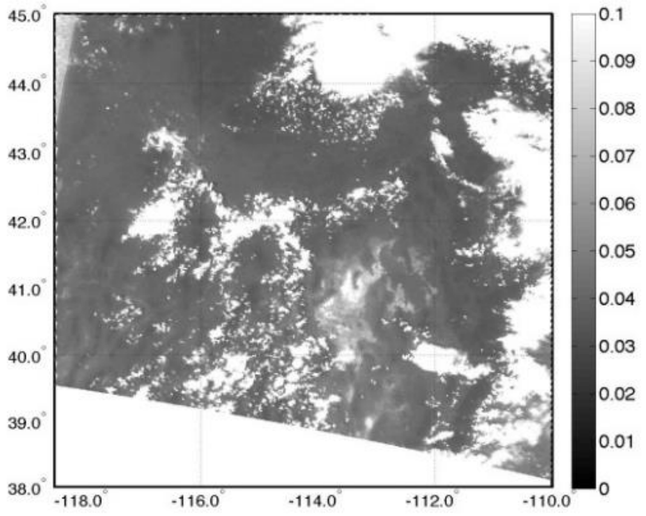


20 km x 13km

TEMPO,
OMPS (JPS1)
TropOMI

3-10 km x 3-10 km

CAI-2, PACE, ACE?



0.5 -1 km x 0.5 - 1km

1970s-1990s — 2000s — 2017 > — 2020s>

Example of UV Radiances aggregated at different pixel size over the Nevada Desert (from CAI Band 1)