Aerosol Retrievals Using Hyperspectral Oxygen A-band Measurements

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Importance of Aerosols I

- Directly impact Earth's radiation budget by scattering and absorbing solar radiation and by interacting with clouds
- Offset some of the radiative forcing from greenhouse gases
- Contribute largest uncertainty to total radiative forcing estimate
- Adversely affect human health

Importance of Aerosols II

- **Aerosol vertical distribution crucial in determining area impacted by them**
  - aerosols transported to the free troposphere or stratosphere will be horizontally transported over a large distance, impacting large regions
  - aerosols confined to the boundary layer are removed quickly by rain.
- **Aerosols and their vertical distribution also impact remote sensing observations by varying photon path length**
  - observations of atmospheric trace gases or surface parameters such as ocean color need to be corrected for aerosol effects

Decadal Survey Designated Observable

TARGETED OBSERVABLE	SCIENCE/APPLICATIONS SUMMARY	CANDIDATE MEASUREMENT APPROACH	Designated	Explorer	Incubation
Aerosols	**Aerosol properties, aerosol vertical profiles, and cloud properties** to understand their direct and indirect effects on climate and air quality	Backscatter lidar and multi-channel/multi-angle/polarization imaging radiometer flown together on the same platform	**X**		

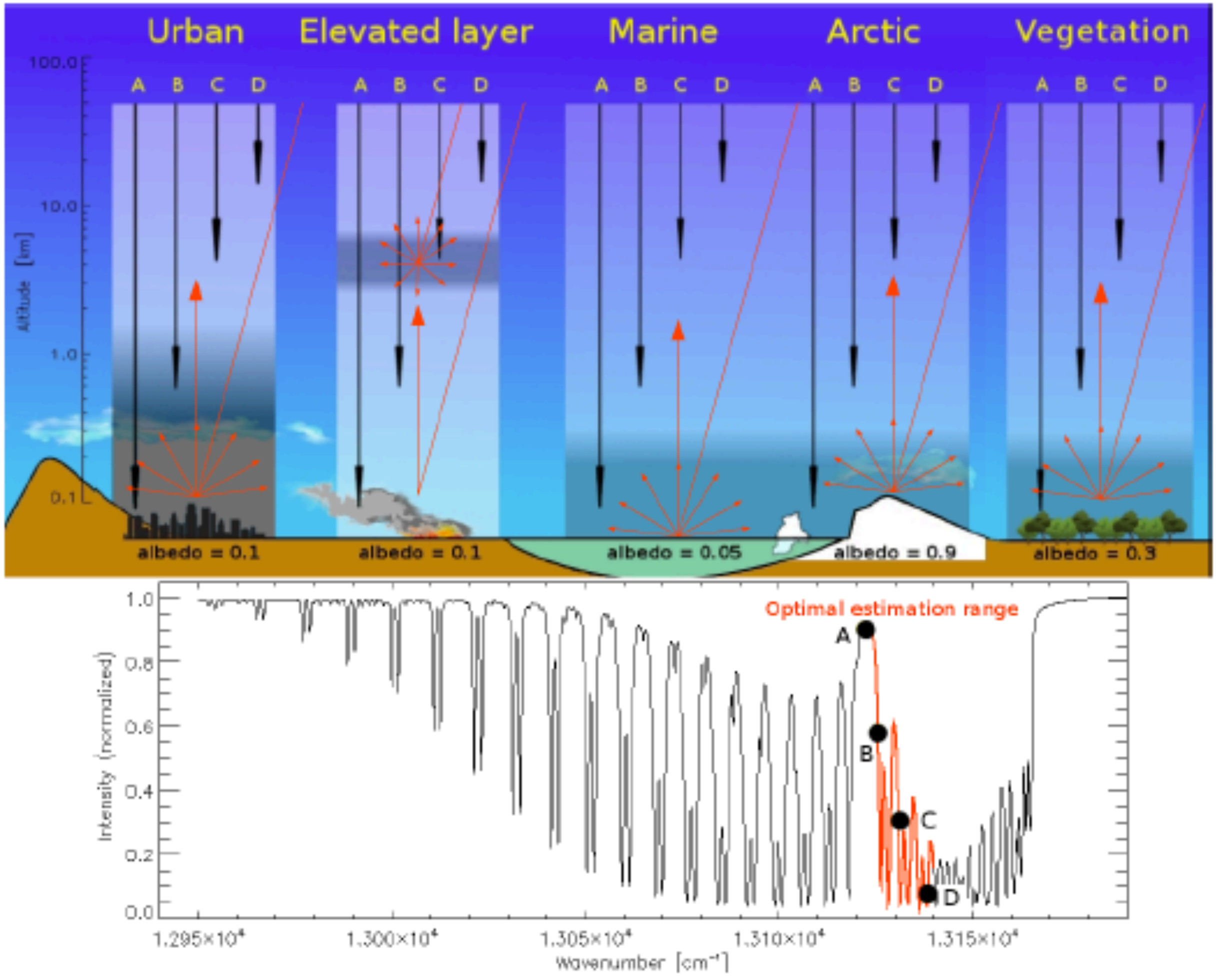
- QUESTION C-2. How can we reduce the uncertainty in the amount of future warming of the Earth as a function of fossil fuel emissions, improve our ability to predict local and regional climate response to natural and anthropogenic forcings, and reduce the uncertainty in global climate sensitivity that drives uncertainty in future economic impacts and mitigation/adaptation strategies?

- QUESTION C-5. A. How do changes in aerosols (including their interactions with clouds which constitute the largest uncertainty in total climate forcing) affect Earth's radiation budget and offset the warming due to greenhouse gases? B. How can we better quantify the magnitude and variability of the emissions of natural aerosols, and the anthropogenic aerosol signal that modifies the natural one, so that we can better understand the response of climate to its various forcings?

- QUESTION W-6. What processes determine the long-term variations and trends in air pollution and their subsequent long-term recurring and cumulative impacts on human health, agriculture, and ecosystems?

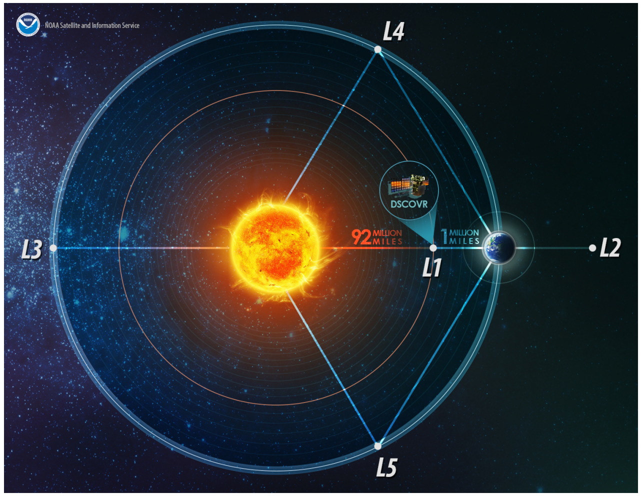
- QUESTION C-3. How large are the variations in the global carbon cycle and what are the associated climate and ecosystem impacts in the context of past and projected anthropogenic carbon emissions?

Oxygen A-band and Aerosol Vertical Profiles

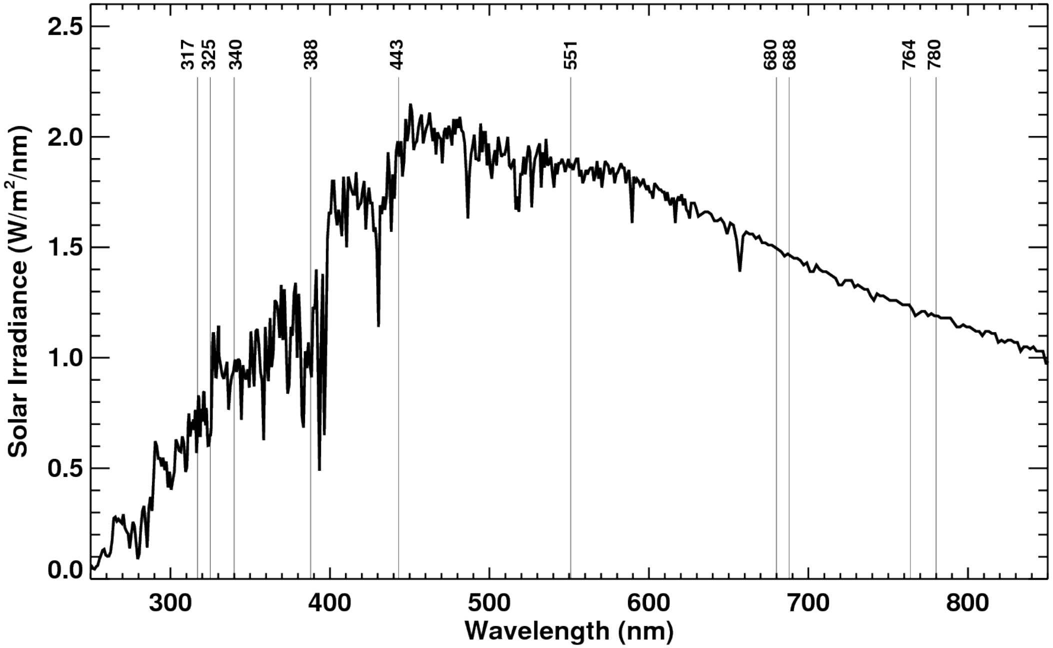


DSCOVR

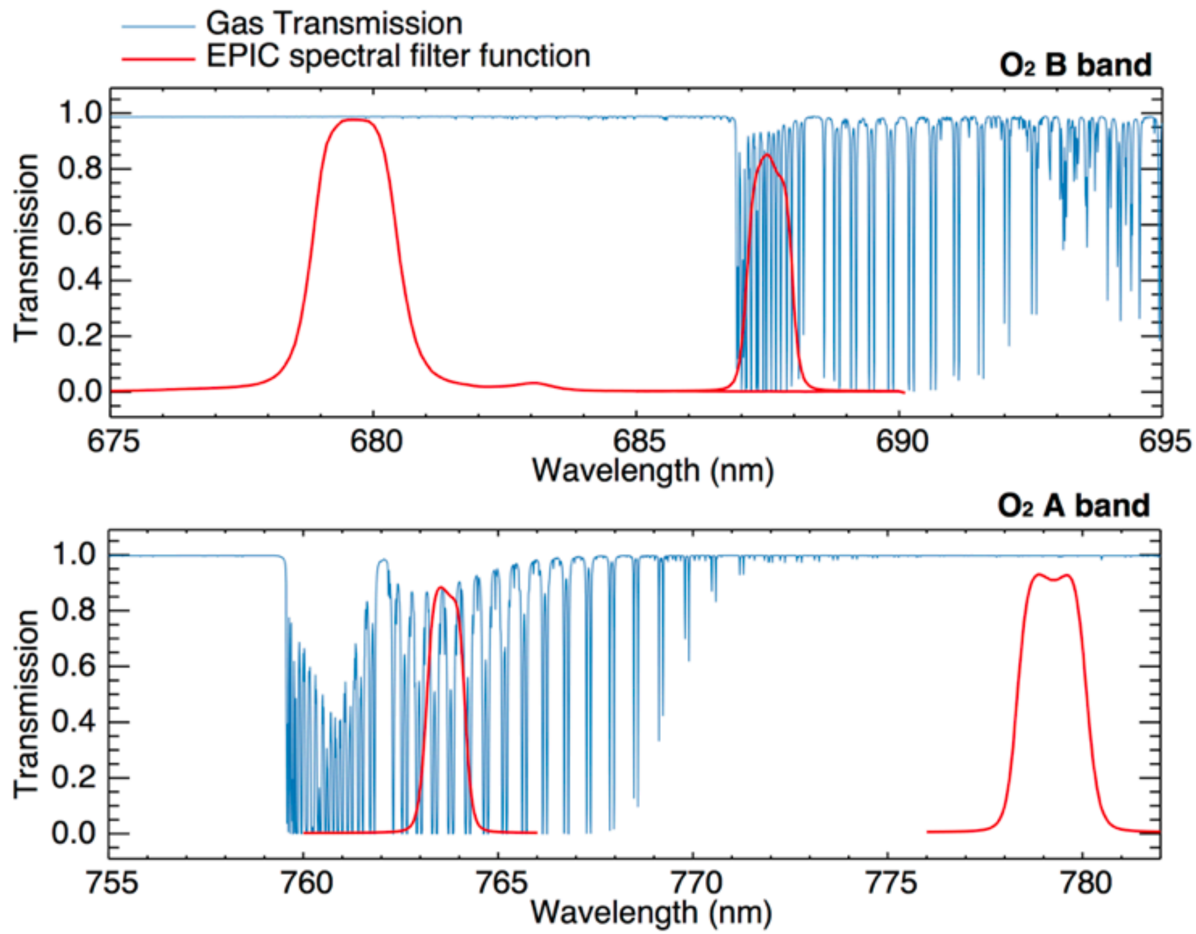
DSCOVR Geometry



EPIC Wavelength Channels



Relevant DSCOVR Measurement Bands



DSCOVR Retrieval Results

GRAPE

	Original	Retrieval (1 channel)	2 channel	3 channel	4 channel
Radius	0.4 micron	0.40 (0.22)	0.40 (0.92)	0.40 (0.13)	0.40 (0.13)
AOD	2	3.94 (96.86)	1.95 (2.31)	2.00 (0.11)	2.04 (2.19)
Height	3 km	1.08 (63.86)	2.84 (5.09)	3.03 (1.14)	2.96 (1.20)

LEVY

	Original	Retrieval (1 channel)	2 channel	3 channel	4 channel
Radius	0.4 micron	-	-	-	-
AOD	2	2.04 (2.21)	2.00 (0.01)	1.99 (0.28)	2.00 (0.03)
Height	3 km	1.72 (42.54)	2.64 (12.15)	3.17 (5.79)	3.08 (2.58)

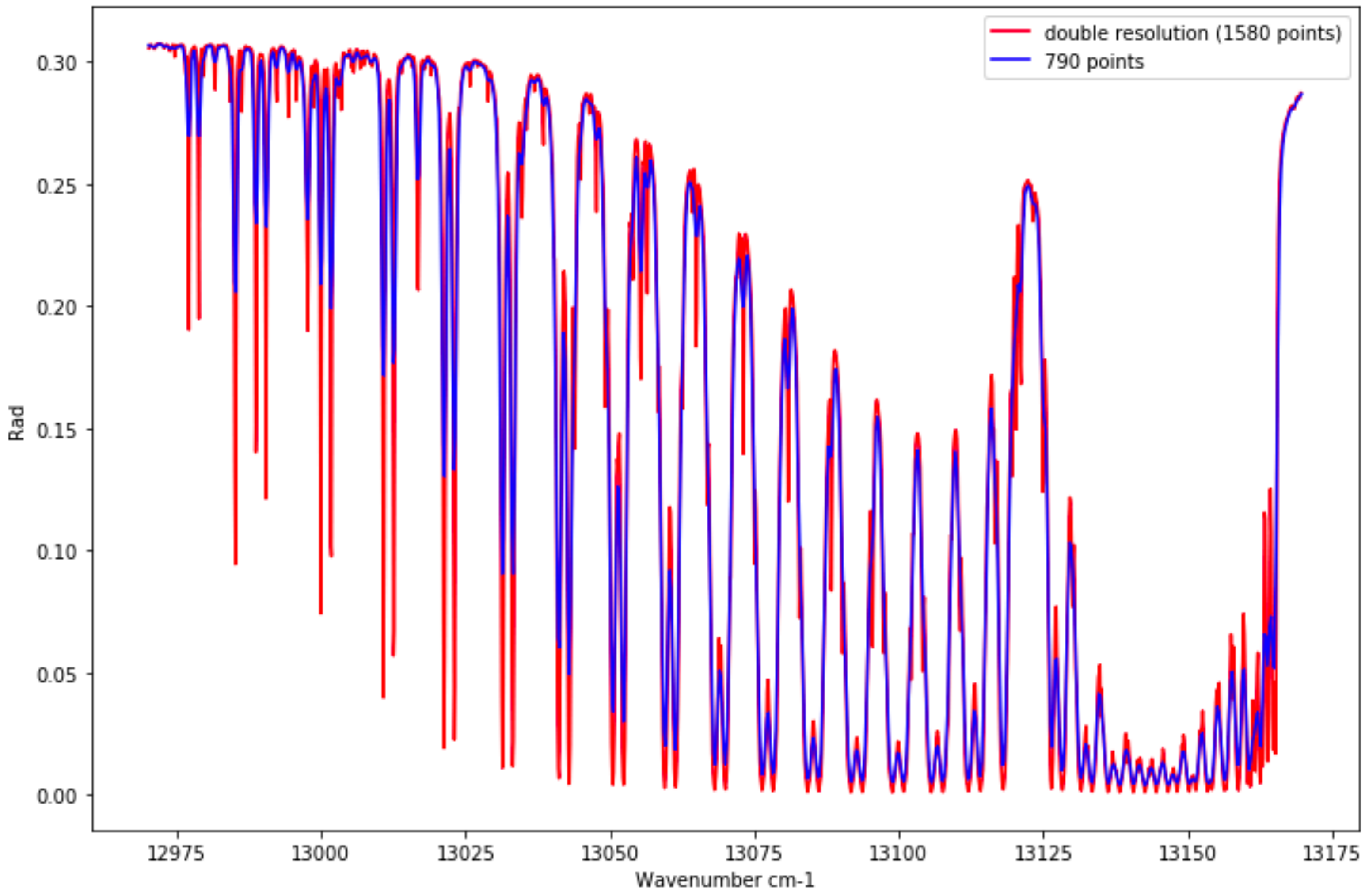
OMI

	Original	Retrieval (1 channel)	2 channel	3 channel	4 channel
Radius	0.4 micron	-	-	-	-
AOD	2	2.04 (1.91)	2.00 (0.01)	1.99 (0.27)	2.00 (0.04)
Height	3 km	1.74 (41.98)	2.70 (10.18)	3.19 (6.25)	3.01 (3.29)

Scenarios for Spectrally Resolved Simulations

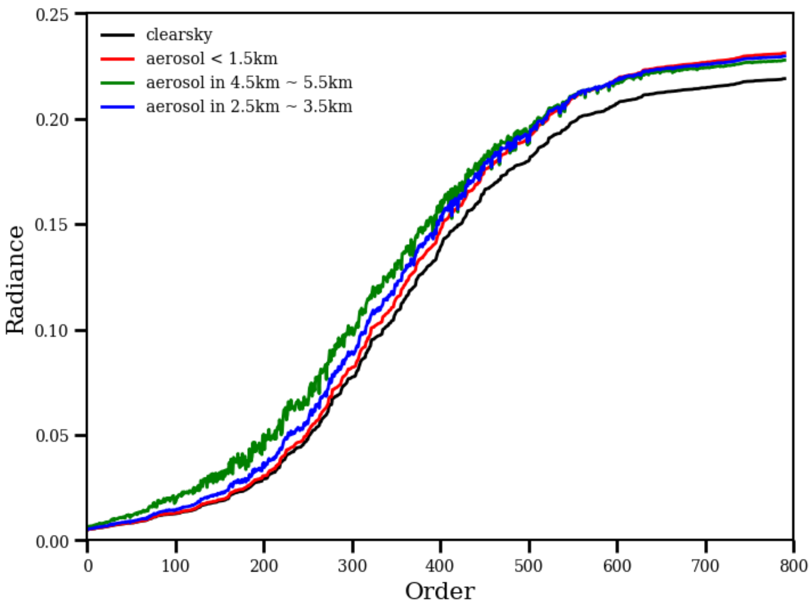
- **Represents OCO-2 target mode measurements over Pasadena, CA**
- **VZA: 10–75°**
- **AOD: 0.01, 0.05, 0.1, 0.2, 0.3**
- **Aerosol types: sulfate (SSA = 0.99); black carbon (SSA = 0.54); mixture (SSA = 0.75)**
- **Aerosol profiles: < 1.5 km, 2.5–3.5 km, 4.5–5.5 km**

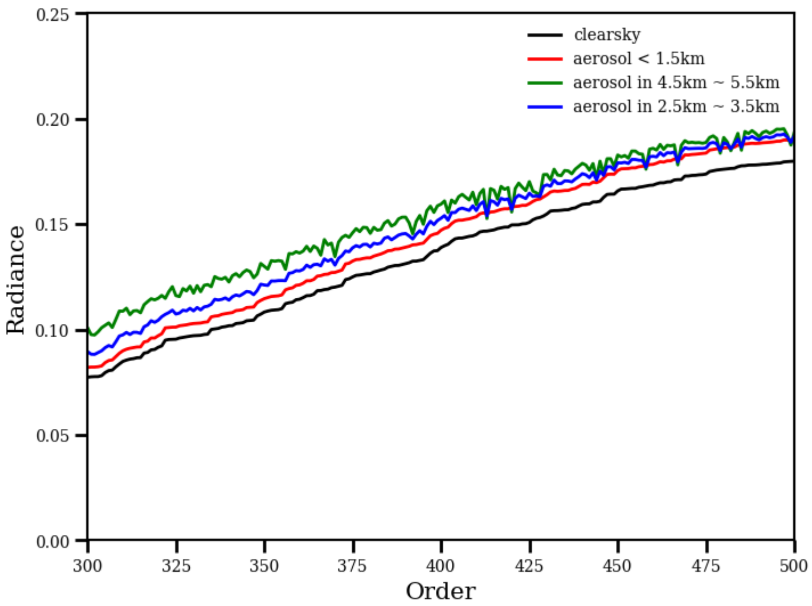
Spectra



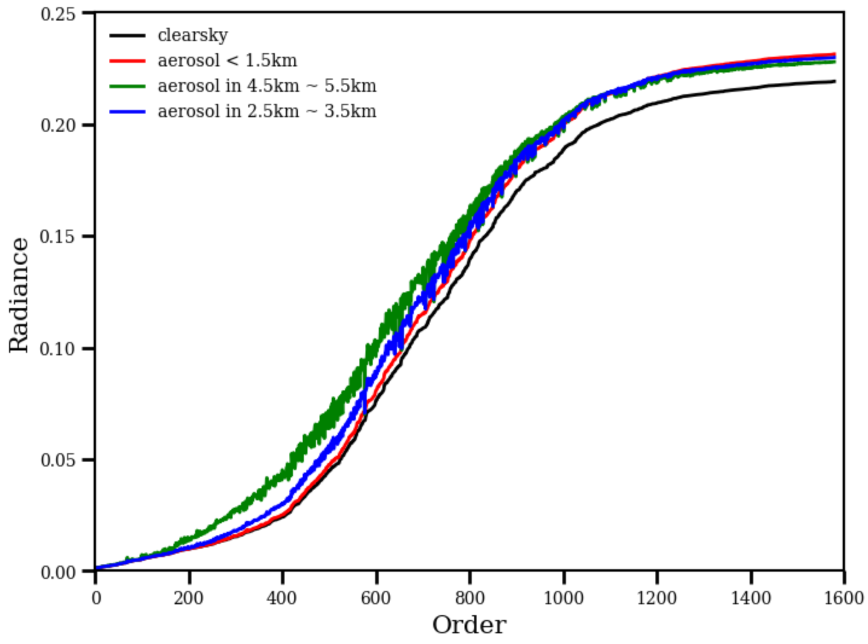
double resolution (1580 points)
790 points
Rad
0.30
0.25
0.20
0.15
0.10
0.05
0.00
12975
13000
13025
13050
13075
13100
13125
13150
13175
Wavenumber cm-1

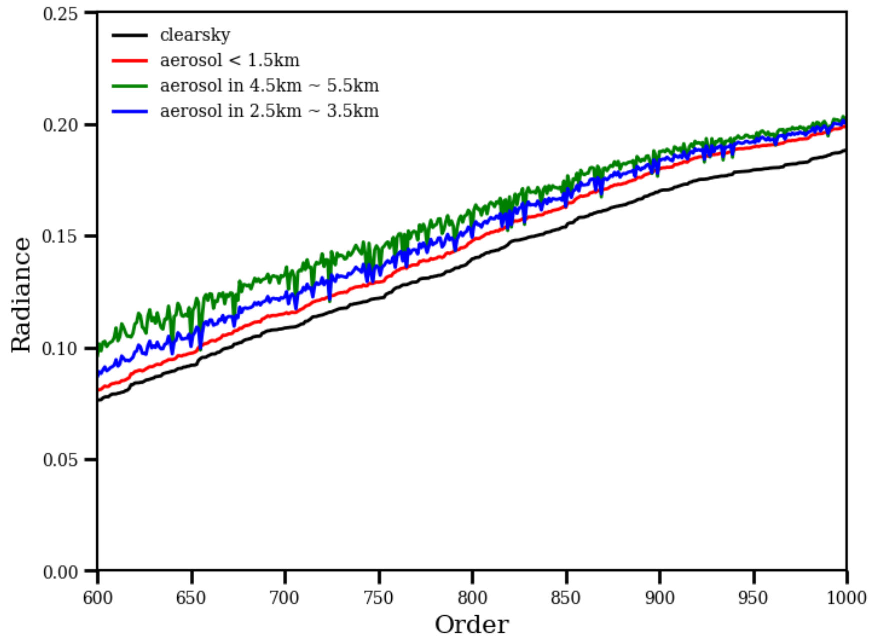
Spectral Sorting



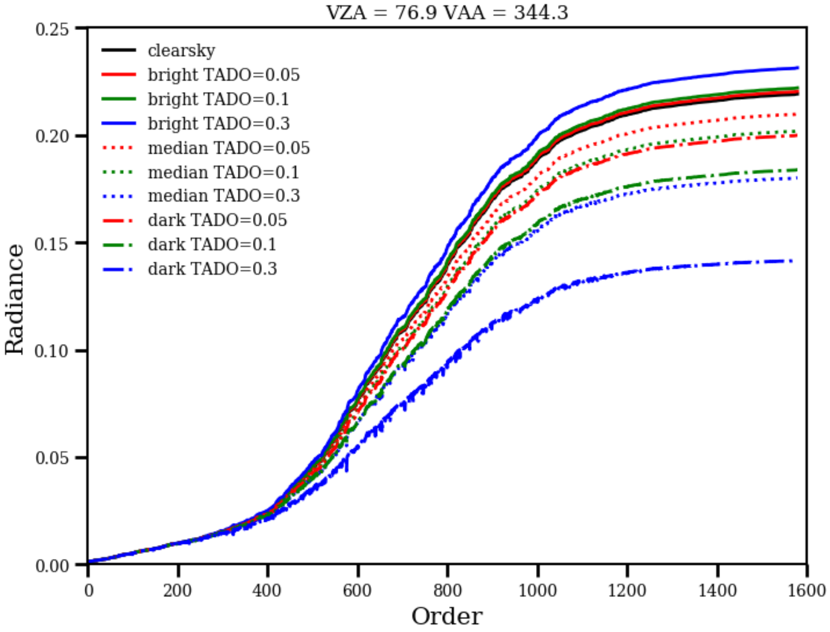


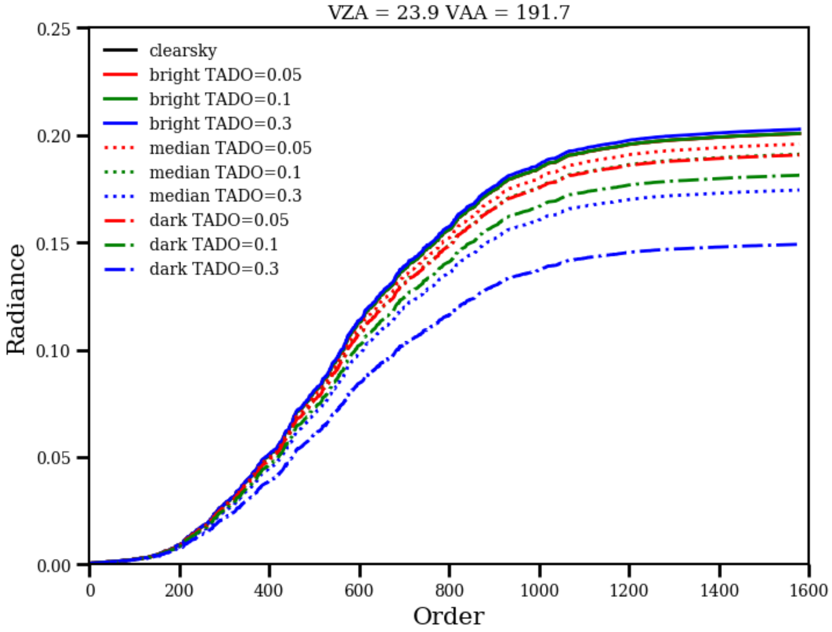
Impact of Spectral Resolution



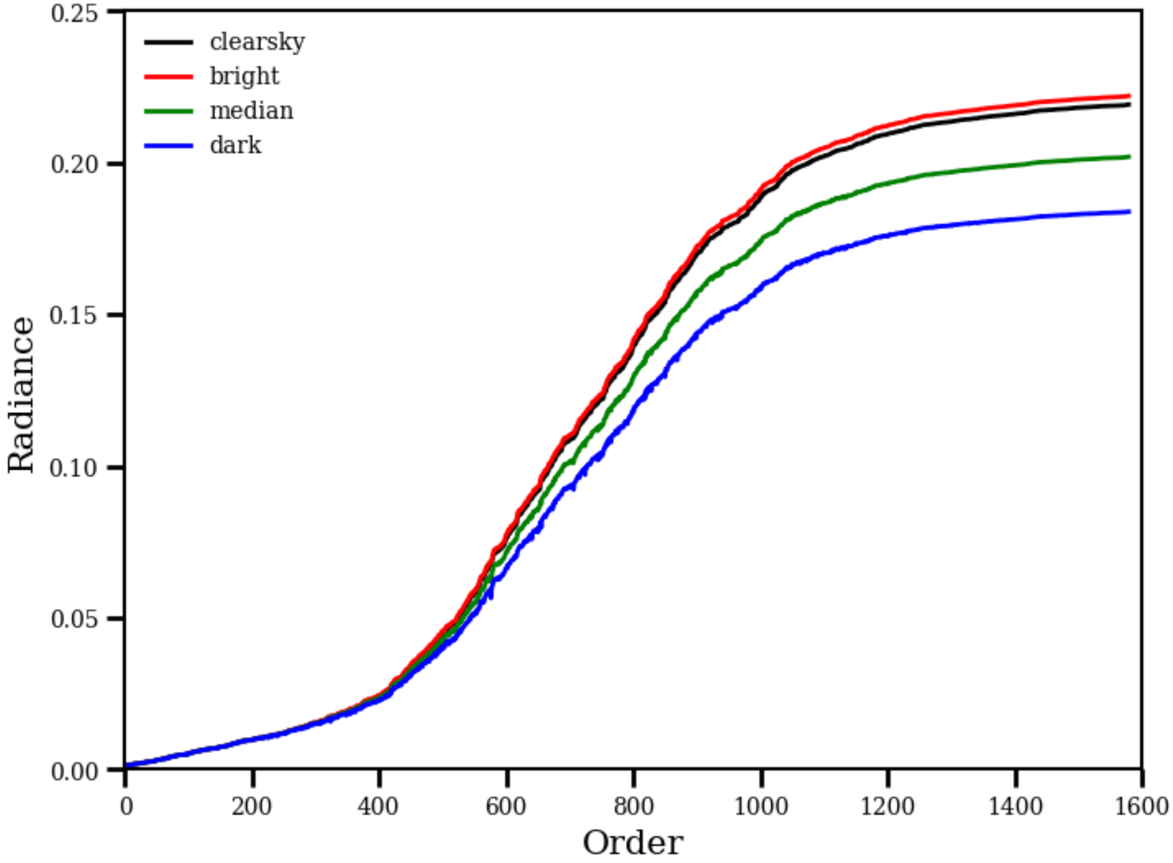


Impact of Multiple Angles





Large Angles



Conclusions

- **Multiple angles provide composition information (phase function)**
- **Resolving spectral features provides profile information, especially at high zenith angles**
- **Profile retrievals (should be) improved at higher spectral resolution**
- **High resolution retrievals distinguish between boundary layer and elevated aerosols**

Next Steps

- Spectral resolution vs SNR trade-off
- More complex aerosol profiles
- Coupling with multi-wavelength measurements
- Include polarization effects
- Use real data

Acknowledgments

- NASA ESUSPI

- JPL R&TD