Multispectral Ozone Retrievals for the GEO-CAPE Mission

GEO-CAPE AIR QUALITY SCIENCE WORKING GROUP WORKSHOP
MAY 1 2018

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Publications:

Natraj et al., Atmos. Environ., 2011
Zoogman et al., Atmos. Environ., 2011

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Goals

- Rationale: Measurement requirements in GEO-CAPE STM go beyond current demonstrated capability

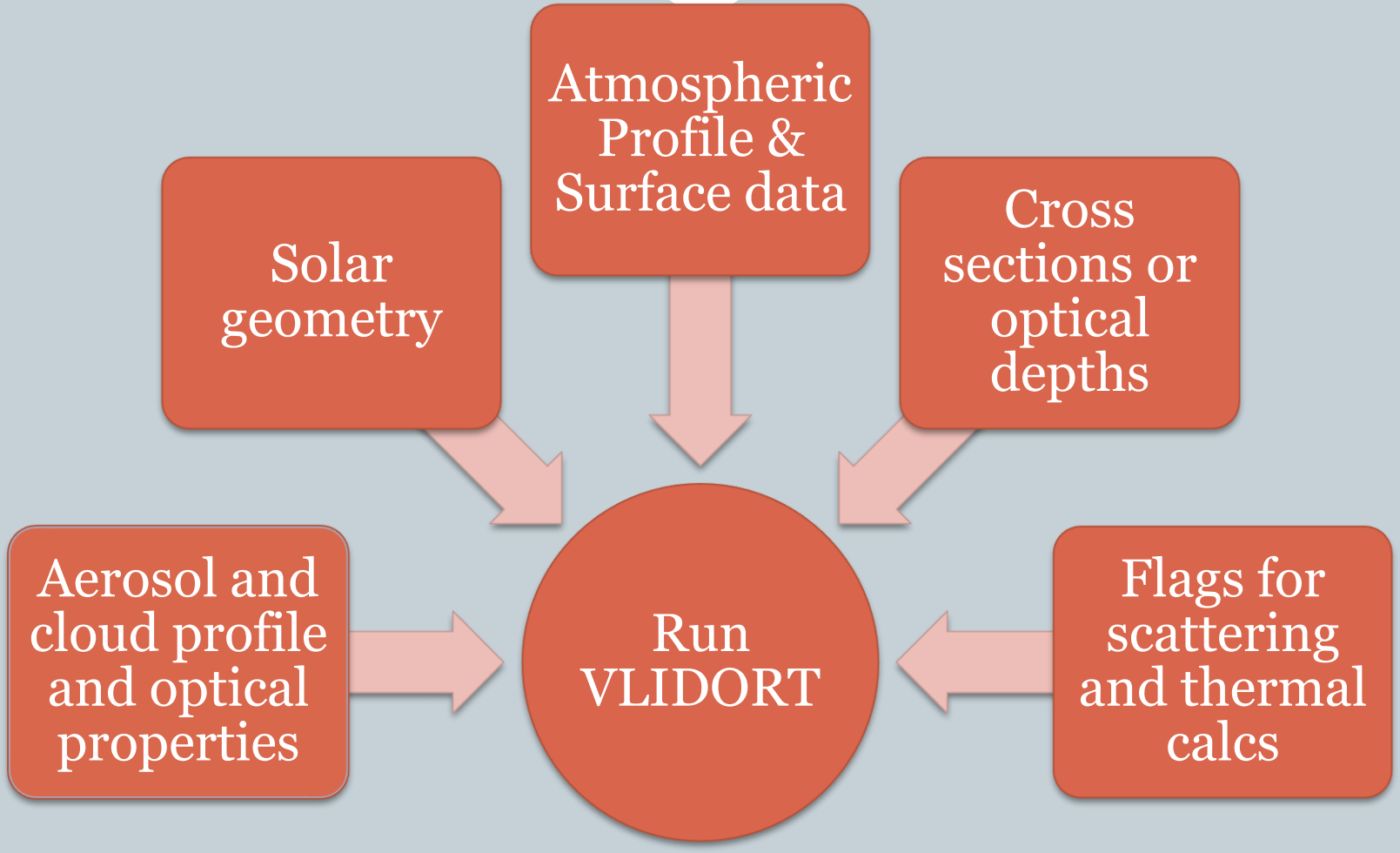
Priority	Science Question	Measurement Objectives	Geophysical Measurements		Measurement Rationale
			Requirement	Value	
Processes	How do atmospheric transport, chemical evolution, and deposition determine tropospheric composition over scales ranging from urban to continental?	2.1 Measure O3, CO, and PM to track pollution transport.	1. Tropospheric vertical spatial resolution: CO and O3	2 pieces of information in the vertical for O3 and CO with sensitivity to the boundary layer	Separate the lower most troposphere from the free troposphere.
			3. Vertical O3 column density,	2.4×10^{16} cm^{-2} typical. 6×10^{15} cm^{-2} precision	
			3. Temporal sampling	hourly for SZA<70	

From GEO-CAPE Science Traceability Matrix (STM)

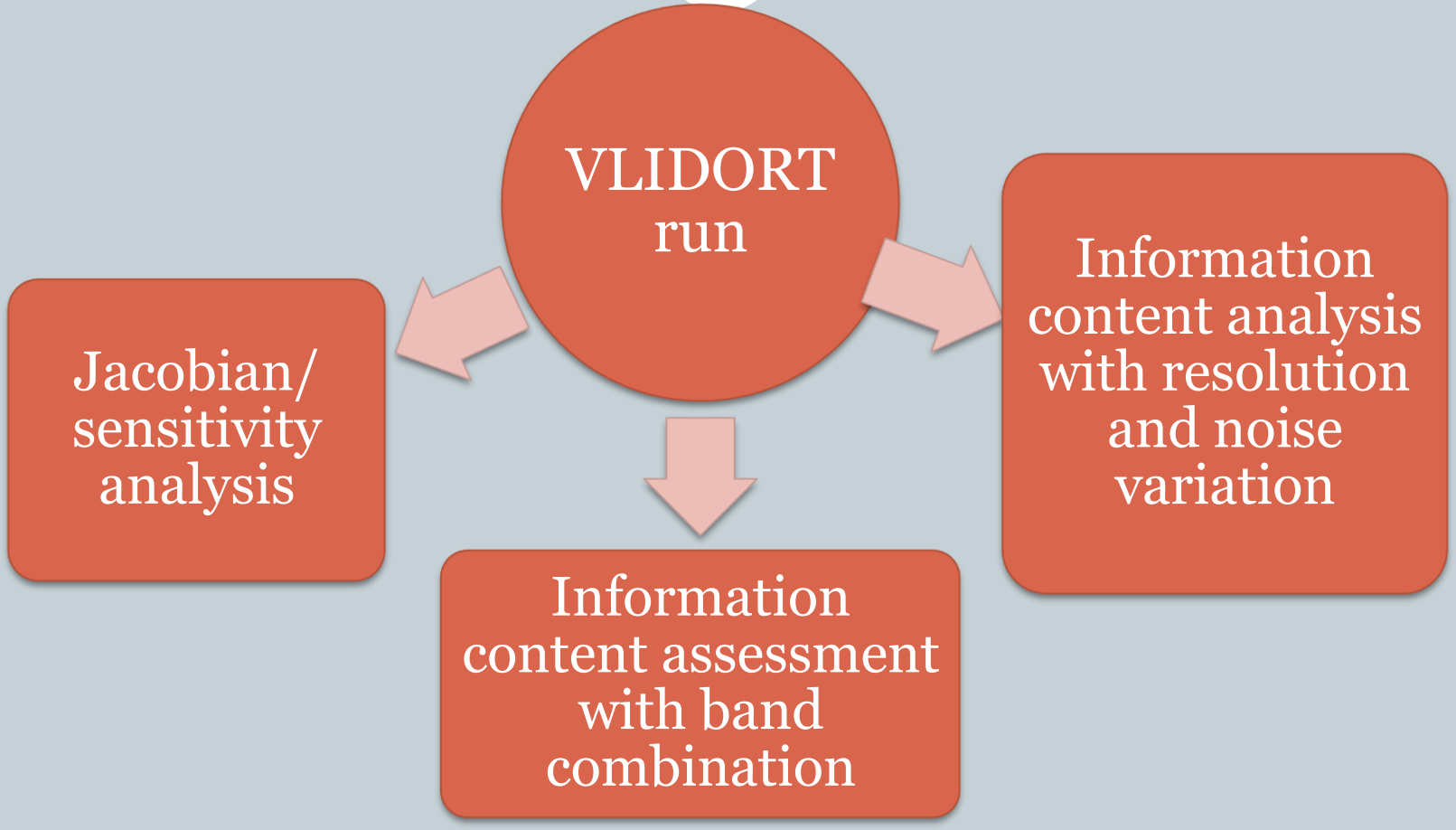
Goals

- Rationale: Measurement requirements in GEO-CAPE STM go beyond current demonstrated capability
- Focus: Assess sensitivity (to amounts and vertical distribution) of trace gas retrievals to wavelength set used
  - Can needed vertical sensitivity be achieved with new combinations of wavelengths?
- Method: Radiative transfer simulations and Jacobian analysis (focus on ozone)

VLIDORT – Part 1



VLIDORT – Part 2



Spectral Regions

	UV/UVQ	VIS	MIR	TIR
Wavelength	290-340 nm	560-620 nm	3035-3055cm^{-1} 2780-2833cm^{-1}	980-1070 cm^{-1}
Spectral Resolution	0.4 nm	0.4 nm	0.18 cm^{-1}	0.1 cm^{-1}
Spectral Interval	0.1 nm	0.1 nm	0.0275 cm^{-1}	0.06 cm^{-1}
Signal to Noise Ratio	3 times of OMI	3 times of OMI	TIMS group 6×6 km^2 10s	3 times of TES

UVQ denotes polarized radiation

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	UV/UVQ	VIS	TIR
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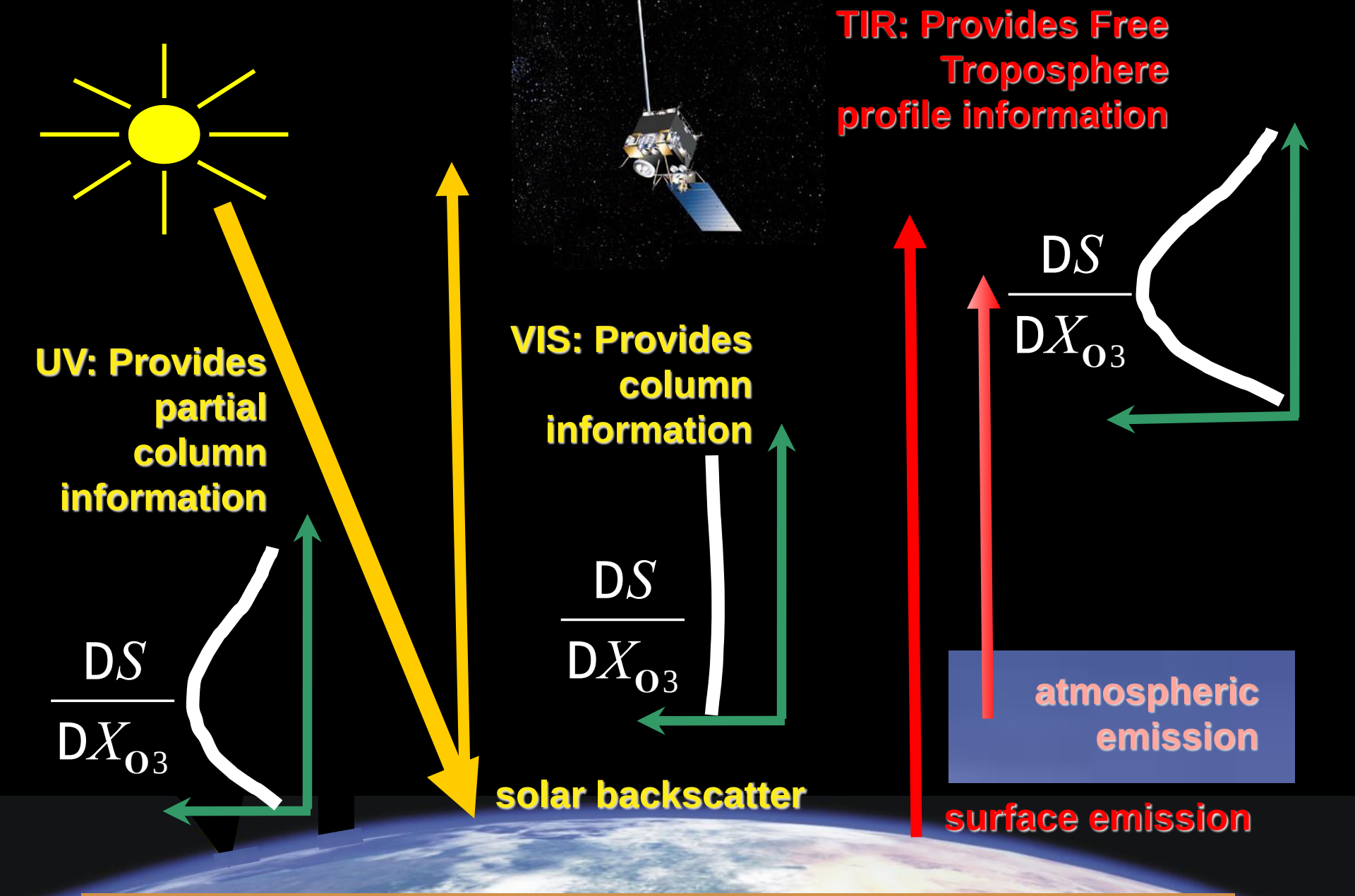
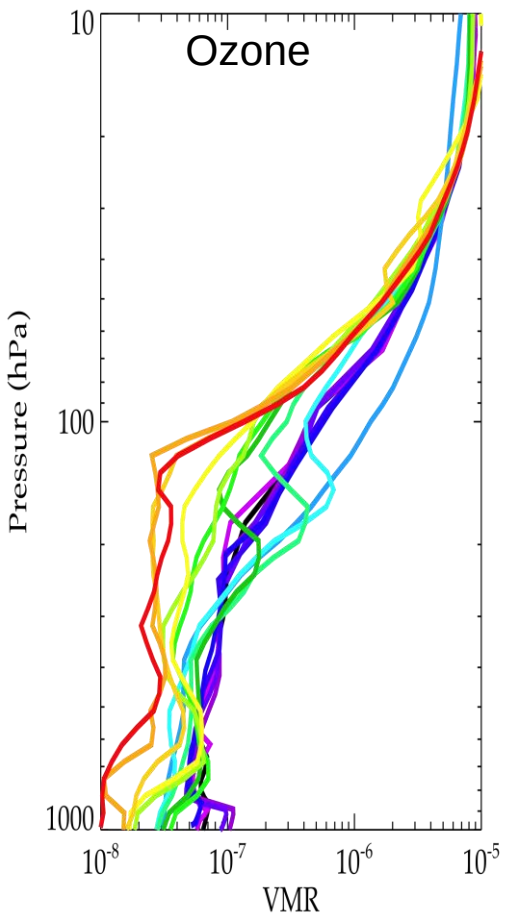
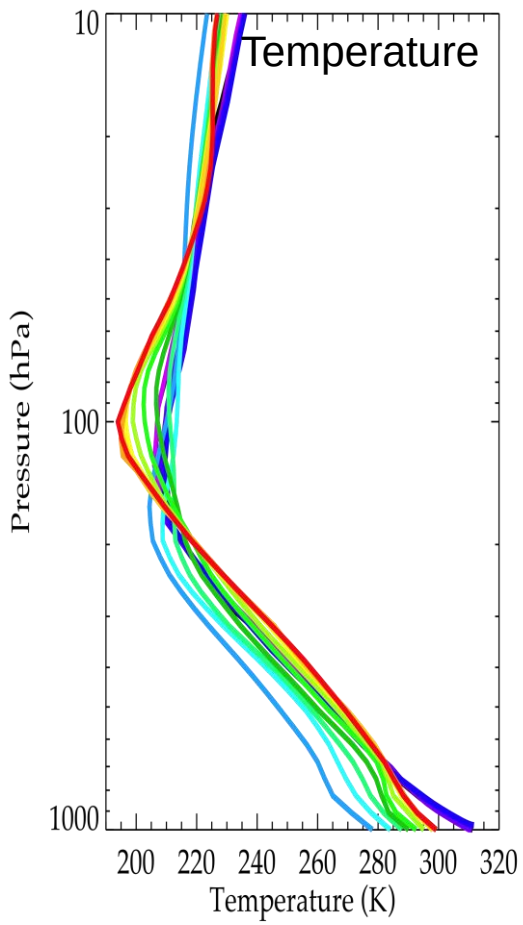


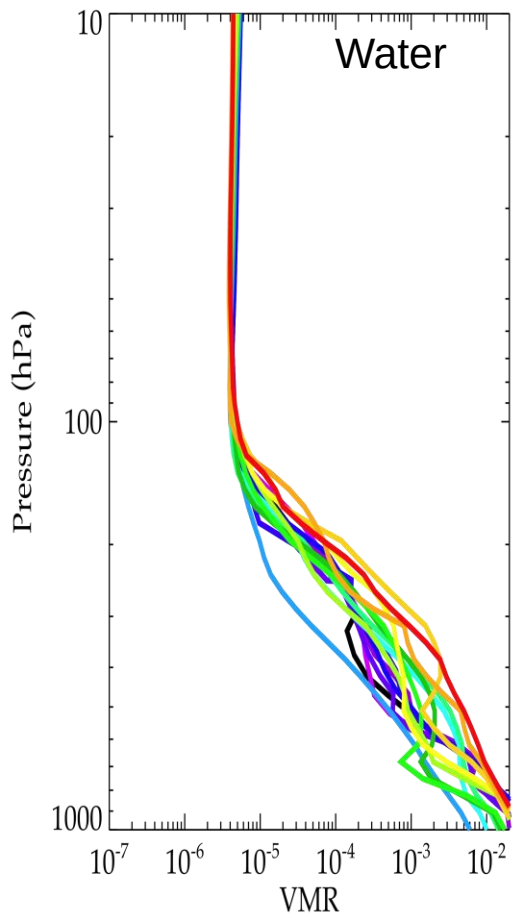
O_3 Multi-Spectral Remote Sensing

Image: NASA

Profile Characteristics



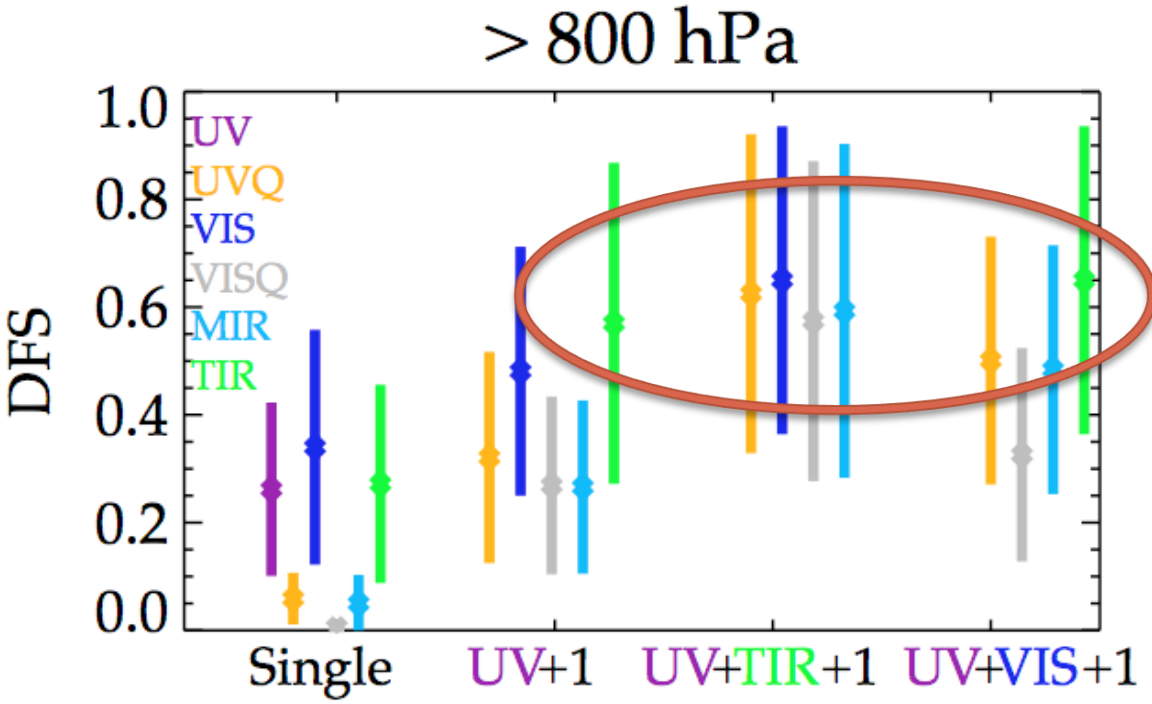




DFS

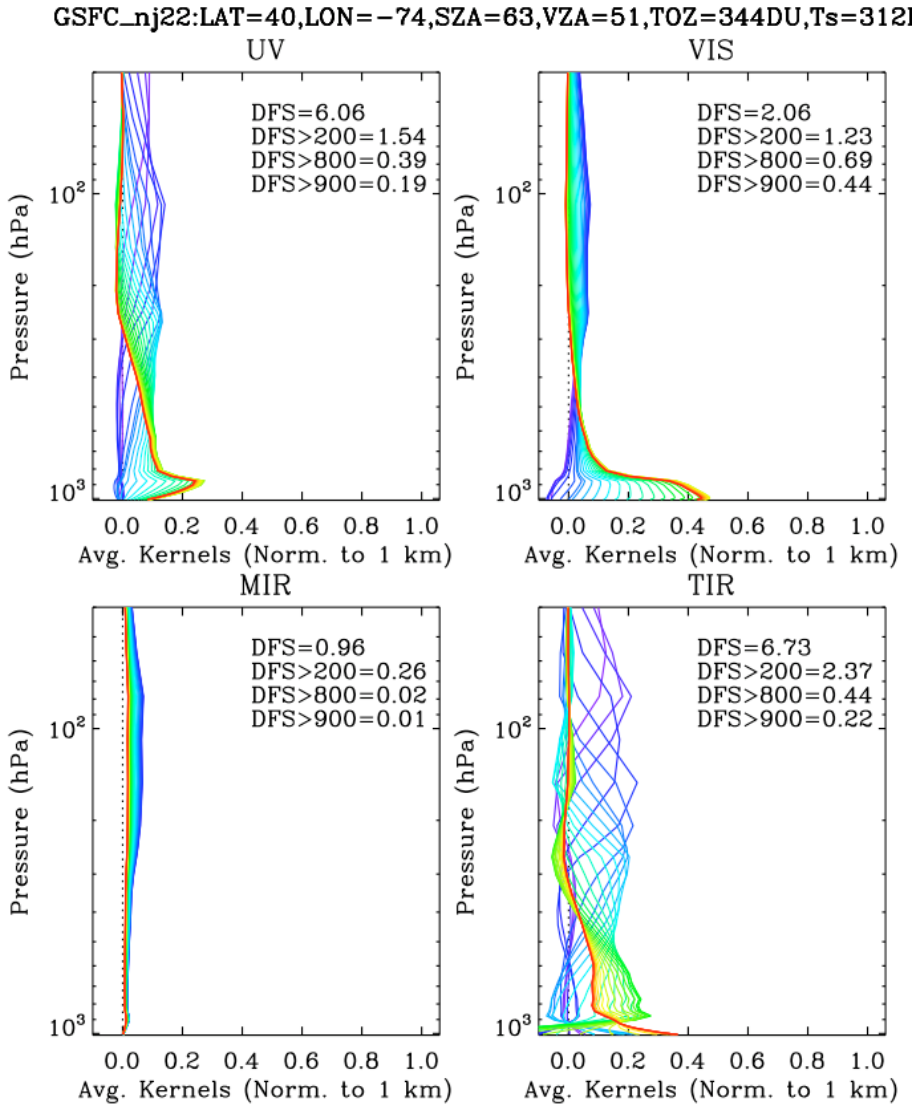
Clearly, there is a group that provides an improvement of sensitivity in the lowest layers

Note: use of Lambertian surface may underestimate power of polarized measurements.



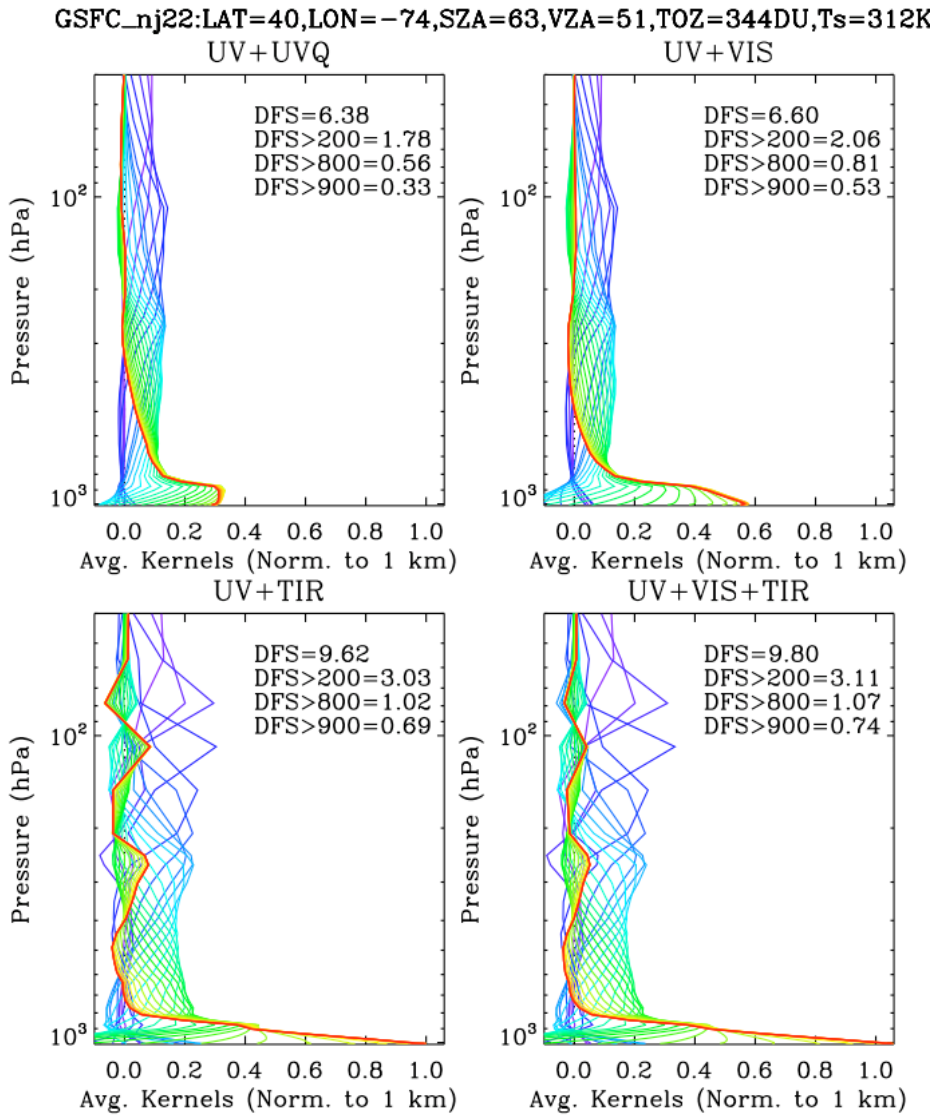
Polluted atmosphere, single band

This profile showed strong sensitivity, it is a polluted atmosphere with an enhanced ozone layer of 80-100 ppbv below 900 hPa



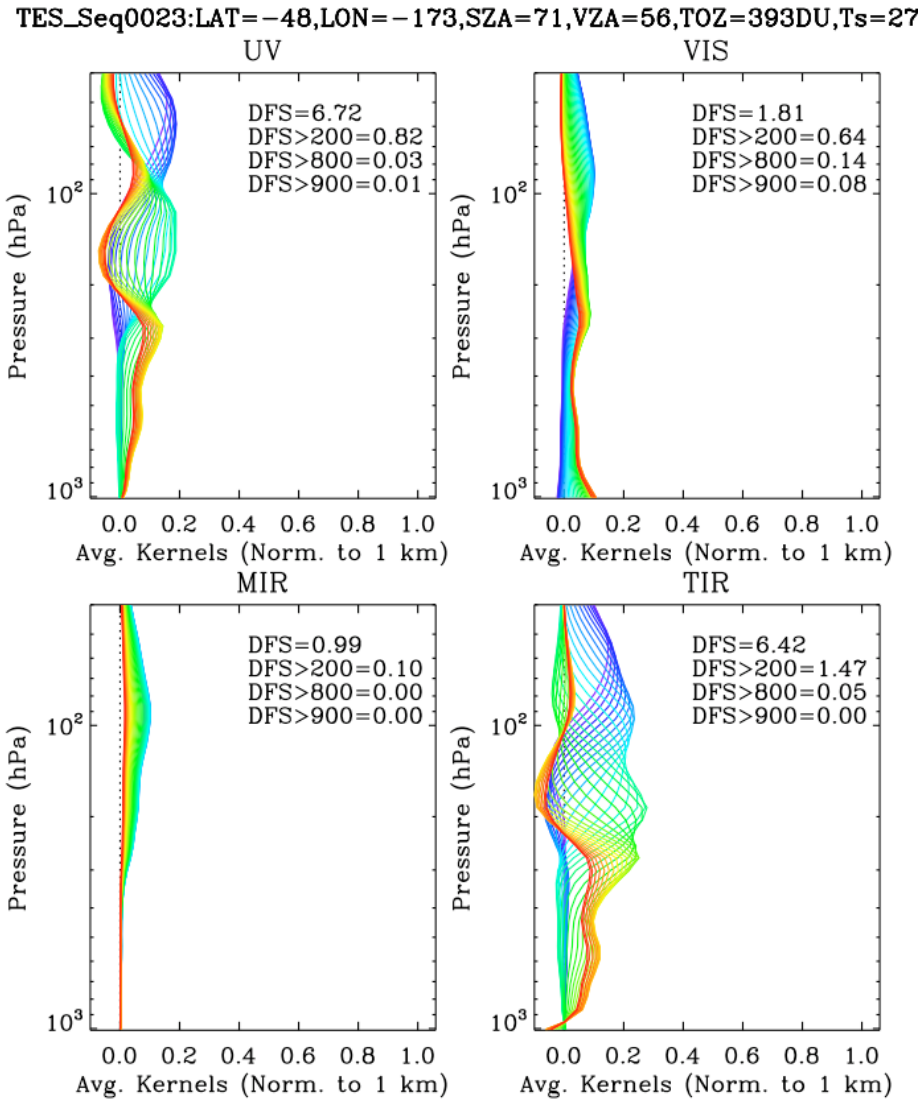
Polluted atmosphere, joint bands

Use of TIR really lets you separate lower layers above and beyond UV+VIS



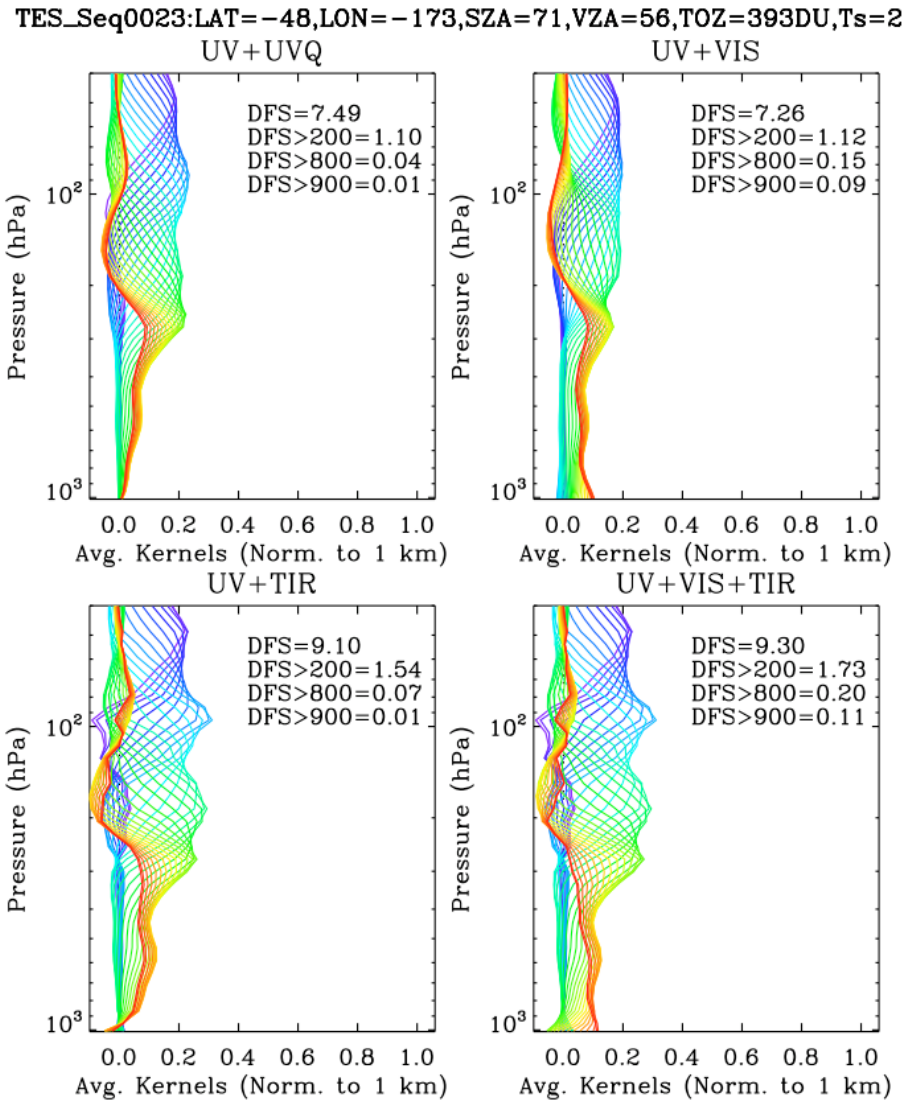
Nominal atmosphere, single bands

This atmosphere features high sza, low temperature and thermal contrast, small a priori variability (clean).

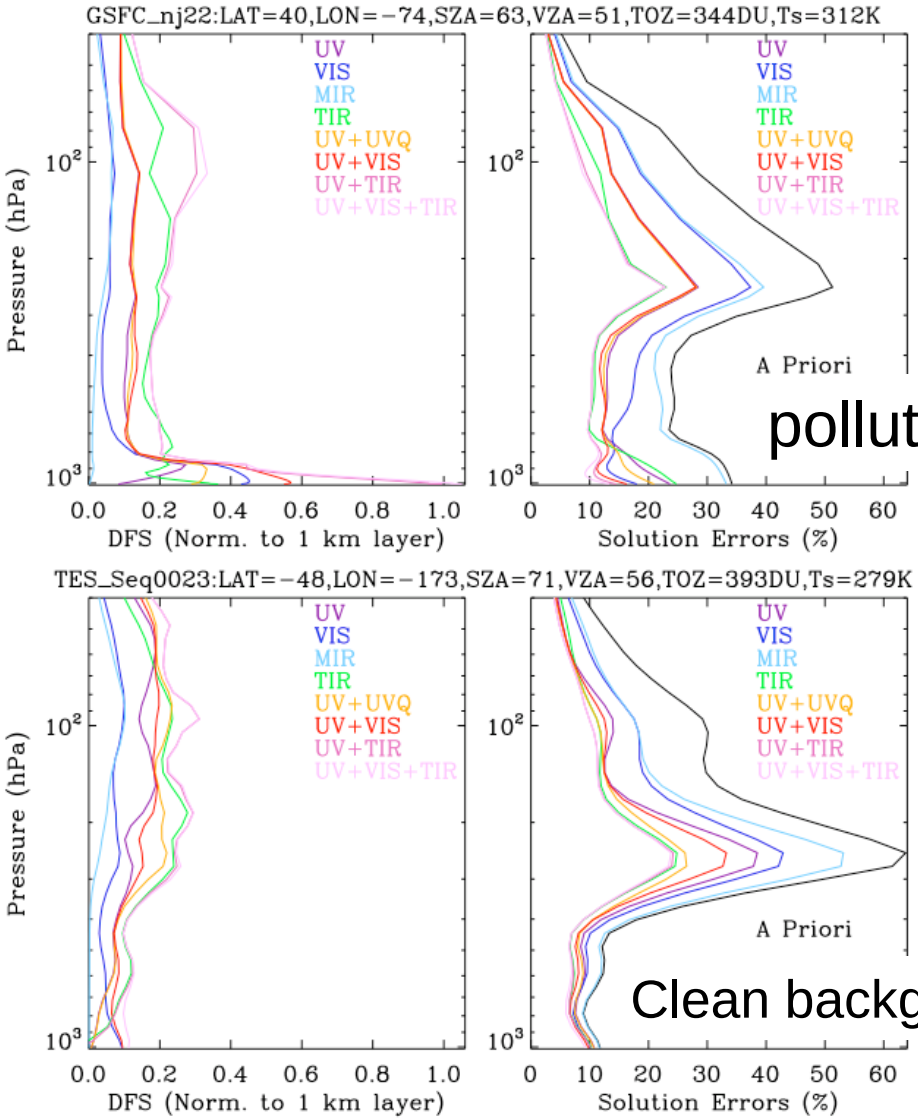


Nominal atmosphere, joint bands

Less dramatic change, but there is increased sensitivity in lower layers



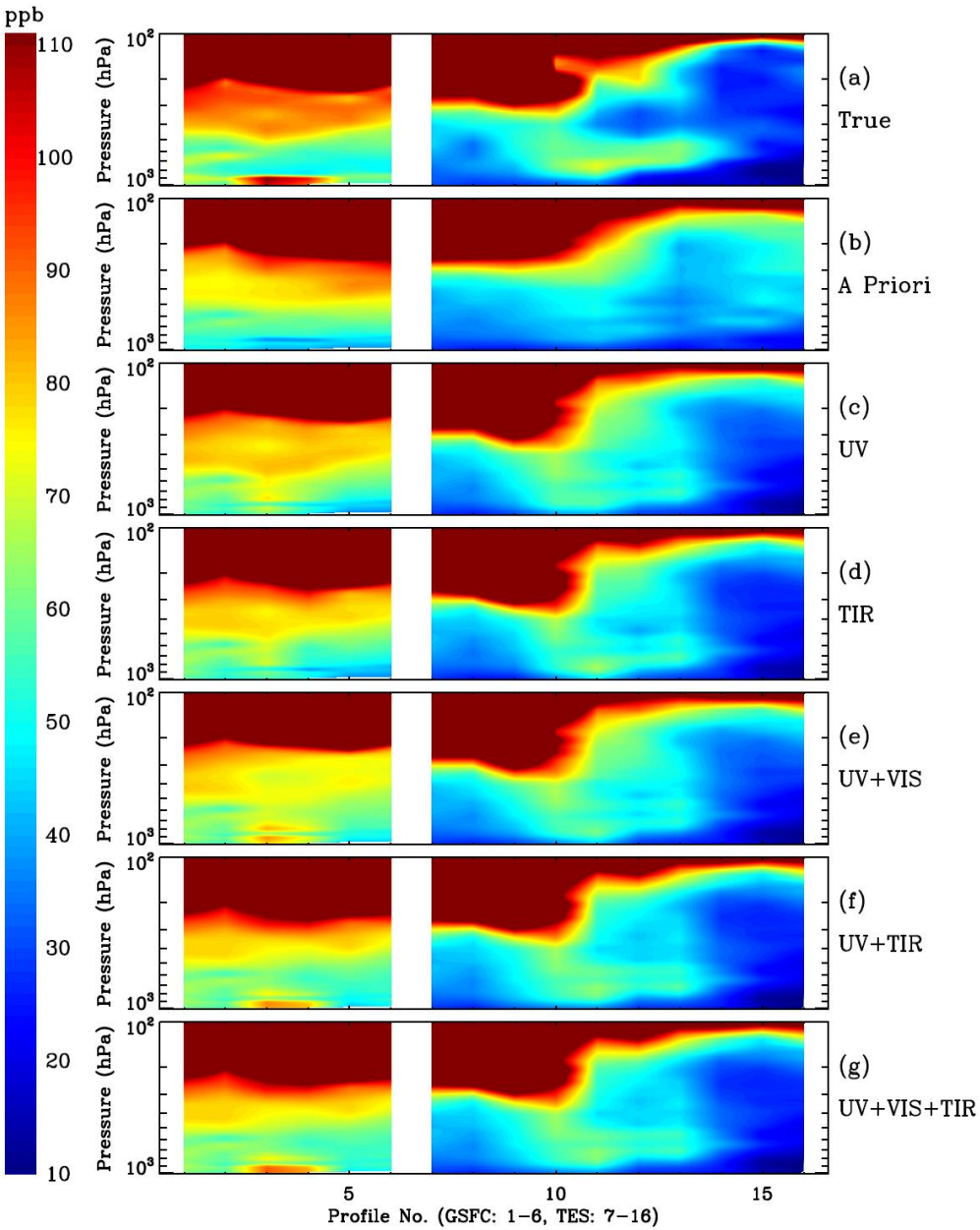
Reduction in Errors



polluted

Clean background

Another Perspective

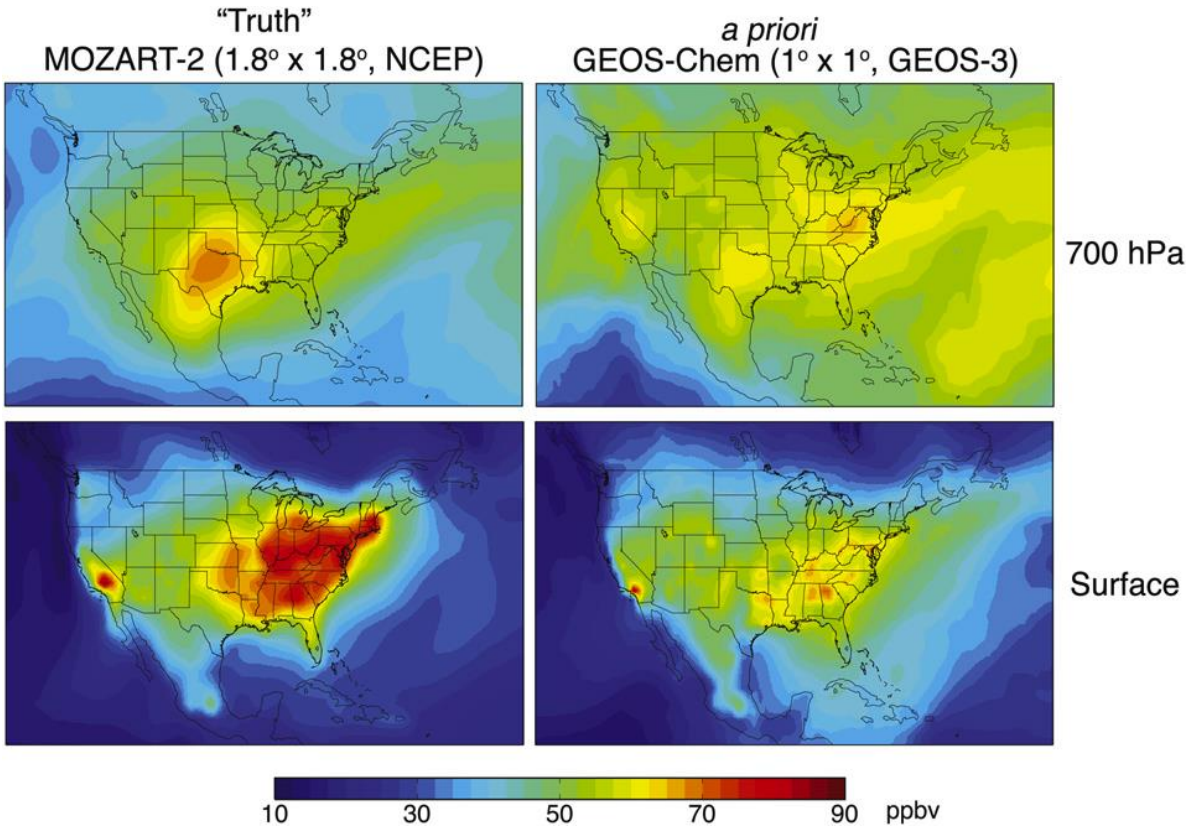


MDA8 Ozone Concentrations

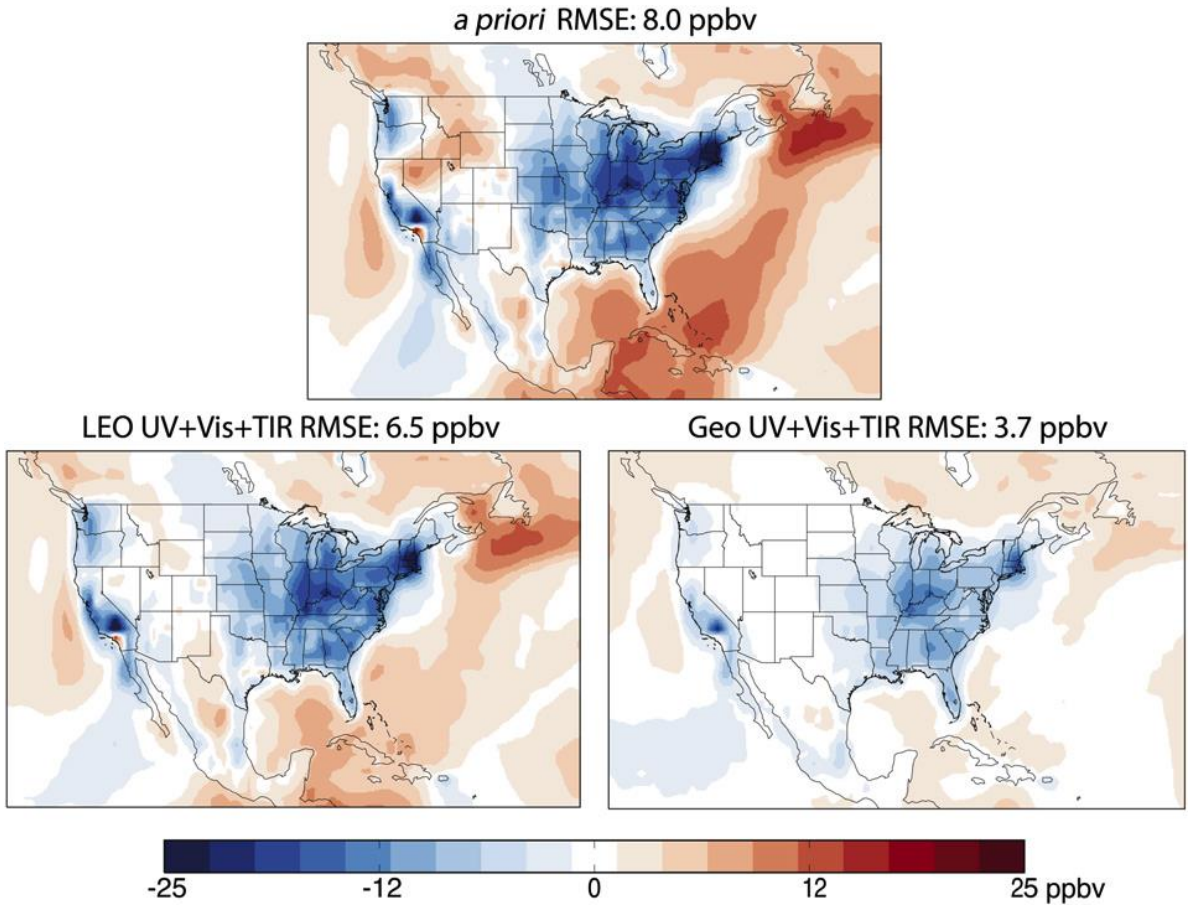
Simple OSSE

Two averaging kernels (high and low sensitivity)

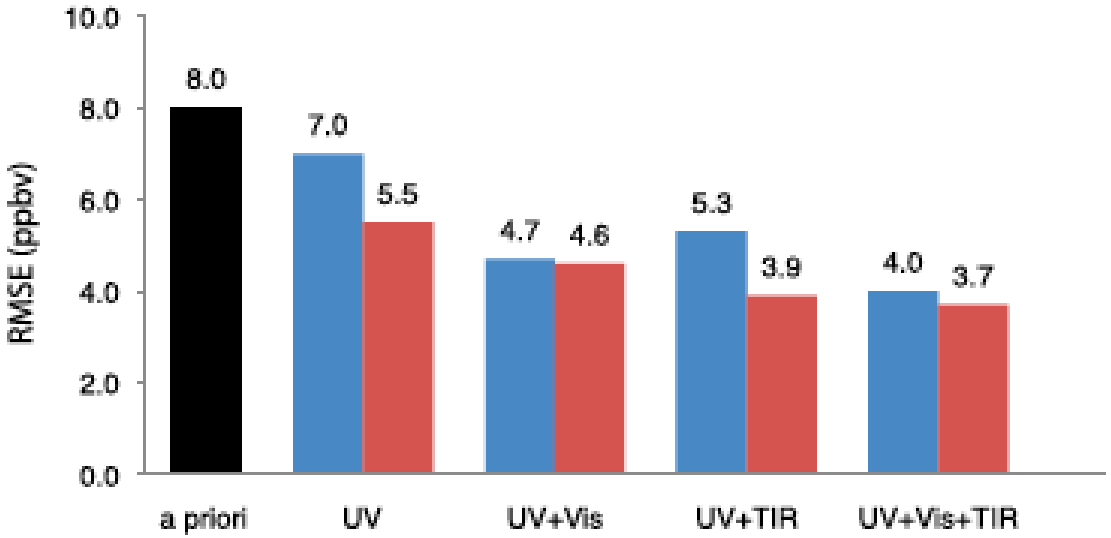
Coarse model



Surface Ozone Bias



RMSE of MDA8 Ozone



Conclusions

- Multi-spectral retrievals (UV+VIS, UV+TIR, UV+VIS+TIR) improve sensitivity to the variability in near-surface O_3 by a factor of 2-2.7 over those from UV or TIR alone.
- Multi-spectral retrievals provide the largest benefit when there is enhanced O_3 near the surface.
- Combining all 3 wavelengths (UV+VIS+TIR) provides the greatest sensitivity below 850 hPa, with a 36% improvement over UV+VIS and a 17% improvement over UV+TIR.
- Zoogman's OSSE results consistent with Natraj et al. analysis.

Further Thoughts

- VLIDORT too slow
- Convolve cross sections to TEMPO spectral resolution
- Use 2S-ESS model
  - Exact single scattering
  - Two-stream multiple scattering
- Speed-up of > 200
- Relevant for TEMPO