GEO-CAPE retrieval simulation subgroup

REPORT TO GEO-CAPE MEETING
SEPTEMBER 2009

GOALS

- This subgroup is focused on using simulations of retrievals and Jacobians to assess the sensitivity (to amounts and vertical distribution) of trace gases of interest to wavelength set used
- The focus of the first effort has been ozone
- The group is comprised of Kelly Chance, Xiong Liu, Thomas Kuruso, Vijay Natraj, Rob Spurr, Joanna Joiner, Ken Pickering, Annmarie Eldering, Susan Kulawik, David Edwards, Helen Worden, Bob Chatfield with support from Ming Luo and Gene Francis

MOTIVATION

- Measurement requirements in GEO-CAPE STM go beyond current demonstrated capability
  - Can the needed vertical sensitivity can be achieved with new combinations of wavelengths?
  - Eventually, what vertical sensitivity is needed to achieve the science goal?

2.1 Measure O3, CO, and PM to track pollution transport.	1. Tropospheric vertical spatial resolution	2 pieces of information in the vertical for O3 with sensitivity to the boundary layer	Separate the lower most troposphere from the free troposphere.
	Ozone : hourly for SZA<70	2.4×10^{16} cm^{-2} typical. 6×10^{15} cm^{-2} precision	Deleted HCHO, and CHOCHO for tracking pollution transport.
2.2 Measure NO2			

Workplan

1) Develop tool to calculate radiances and Jacobians from the ultraviolet to infrared
2) Perform calculations for a finite set of atmospheres
3) Compare Jacobians for species of interest and interferent
4) Use Jacobians in calculations to assess the vertical sensitivity and estimated errors
5) First focus on ozone, can extend to other species

Timeline

- Began telecons in May
- Rob Spurr delivered first version of tool in late July
- In August defined and created output format, worked through issues of input formatting and method to provide infrared optical depths
- Late Aug/ Early Sept – first full set of data generated, begin analysis and ironing out consistent use across groups

1) Tool Development

Rob Spurr provided the critical first set of radiative transfer tools built around VLIDORT. See poster with more details.

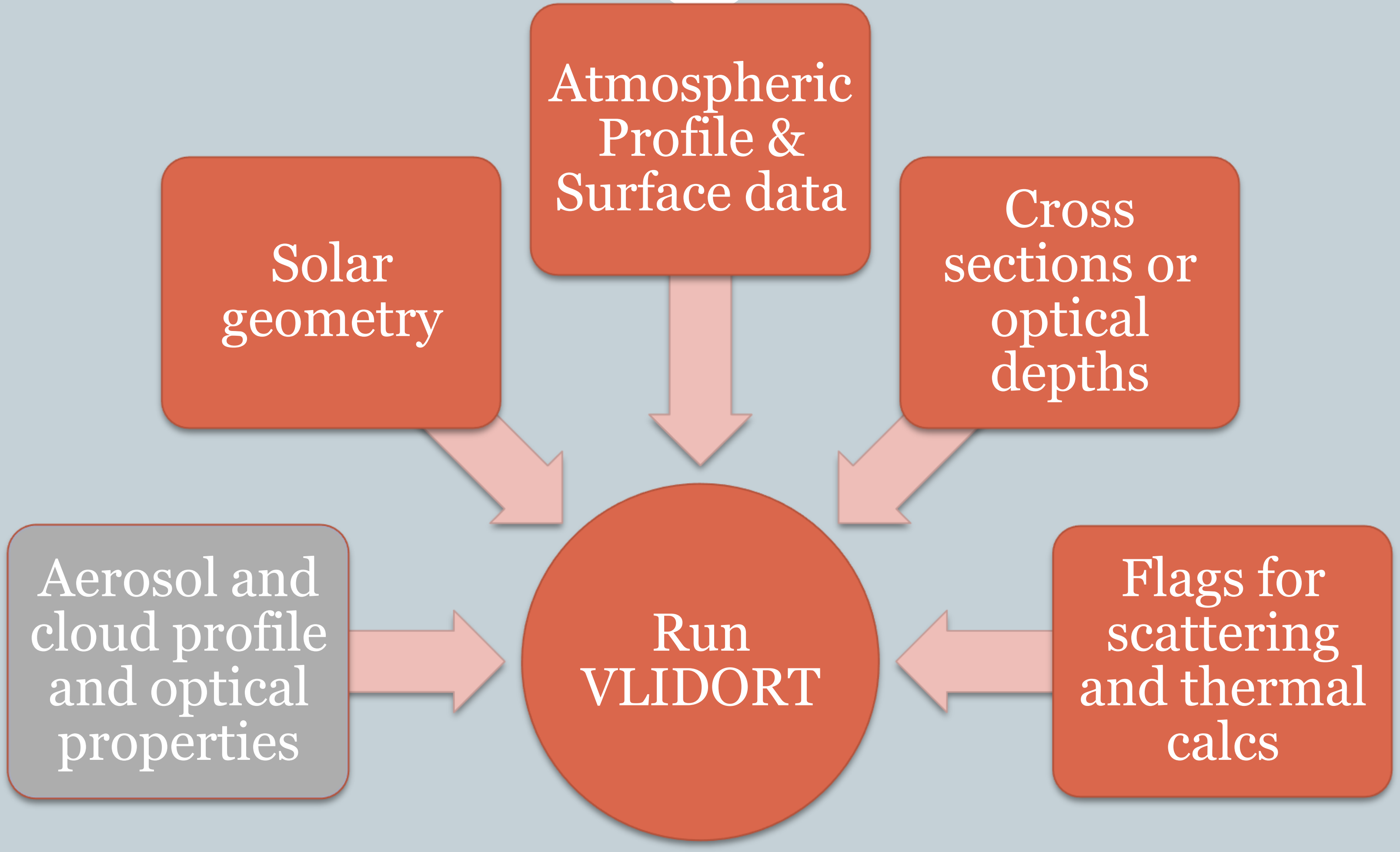
Vijay Natraj has updated the interfaces to read a two of source data (supplied by GSFC and JPL)

- Achievements:
  - Have tool running that can calculate radiance and Jacobians from the ultraviolet to the infrared with VLIDORT as core RT solver
- Still needed:
  - Must implement consistent cloud and aerosol descriptions (optical depth and scattering properties) to include in calcs
  - Need to improve interface to IR optical depths (now calculated with LBLRTM in separate step for each atmosphere)
  - Need better solar angle/ geometry calculation scheme

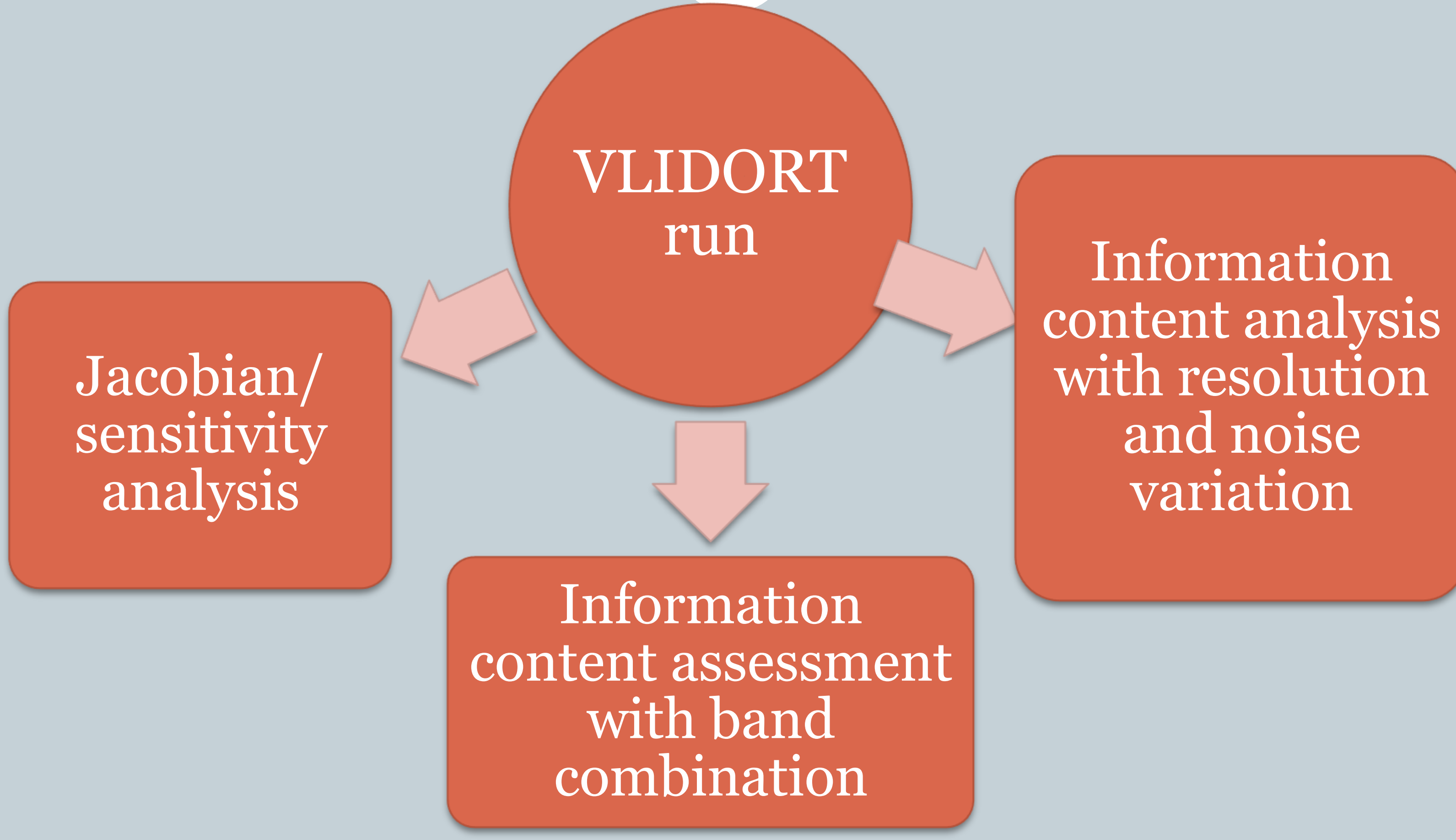
1) Tool Development (cont')

- Still Needed (continued)
  - Independent verification with tools at NCAR, Harvard, and JPL
  - VLIDORT is being updated to calculate the temperature Jacobian in the infrared
  - Need to agree in best high-resolution solar spectrum

TOOL – Part 1


Atmospheric Profile & Surface data
Solar geometry
Cross sections or optical depths
Aerosol and cloud profile and optical properties
Run VLIDORT
Flags for scattering and thermal calcs

TOOL – Part 2


VLIDORT run
Jacobian/ sensitivity analysis
Information content assessment with band combination
Information content analysis with resolution and noise variation

2) Perform calculations

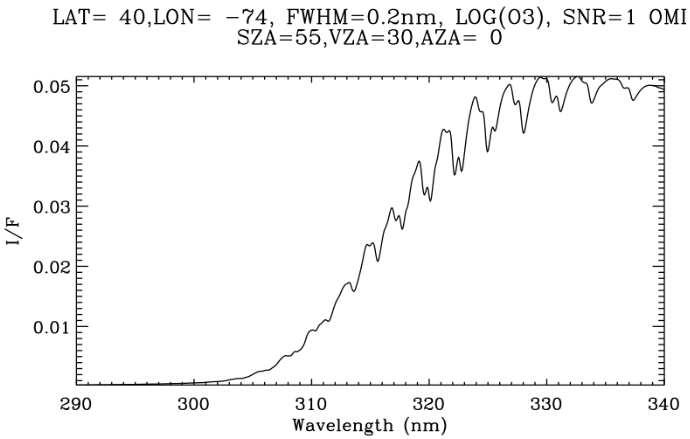
Data files are large, using a ftp site at Harvard/Smithsonian to store data

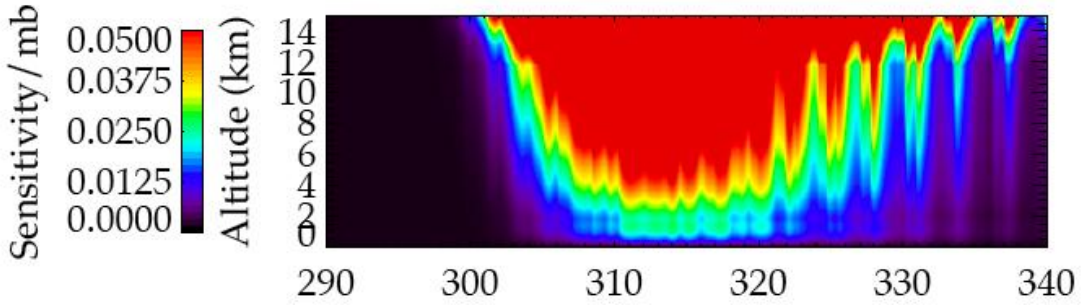
- Achievements:
  - Have radiance and Jacobians for the ultraviolet, visible, infrared and crossover (3.6 micron) for some atmospheres
  - VLIDORT has been used to include polarization in ultraviolet calcs
- Still Needed:
  - Team is working with this dataset, and when we have come to closure, will proceed with calculations for additional atmospheres and report conclusions

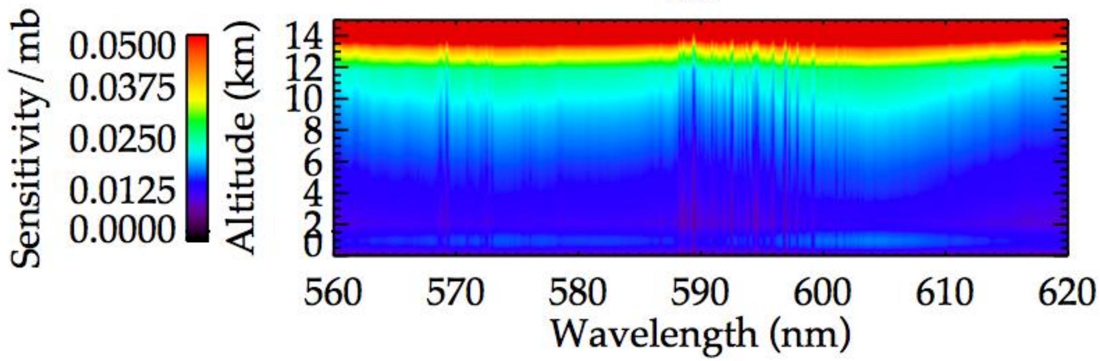
3) Compare Jacobians and Radiances

Vijay is running the VLIDORT tool and makes data availabr to team

Team members (Xiong and Susan, in this case) reviewing data and using in further calcs.

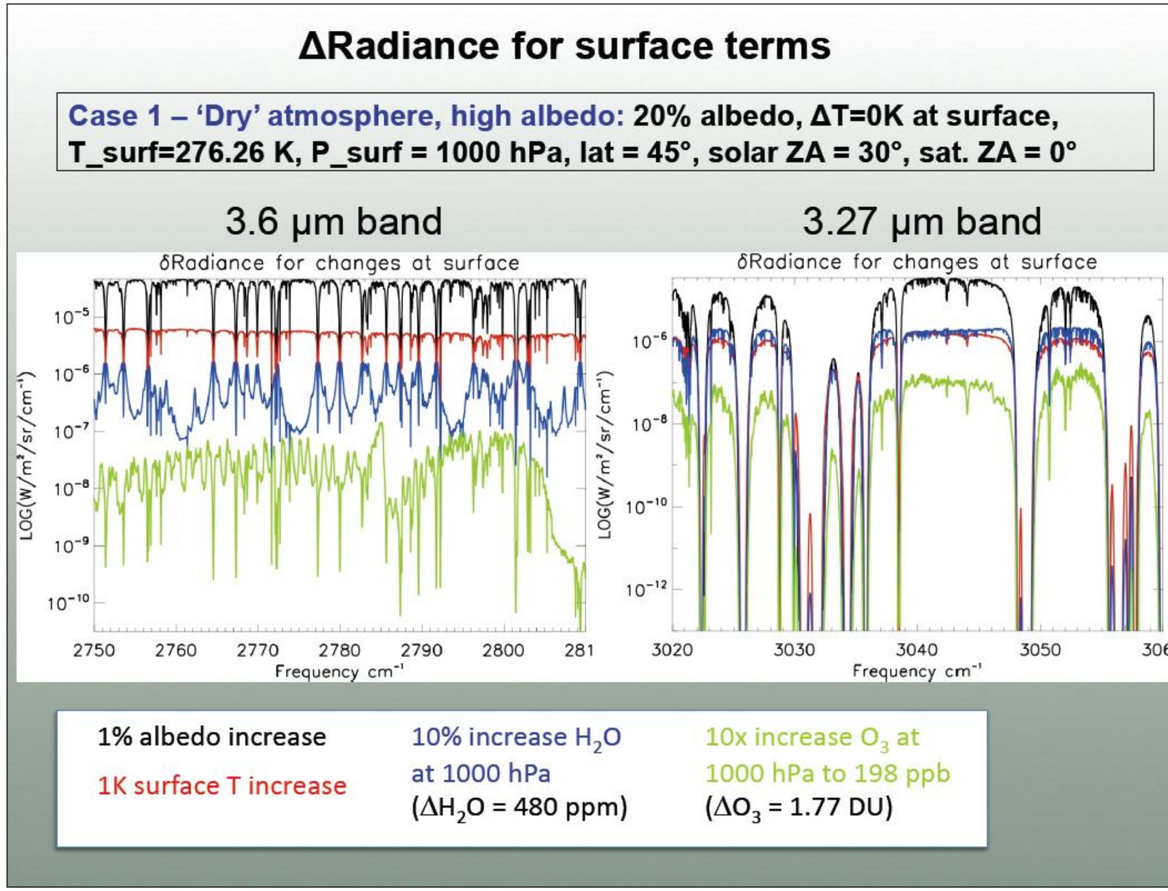






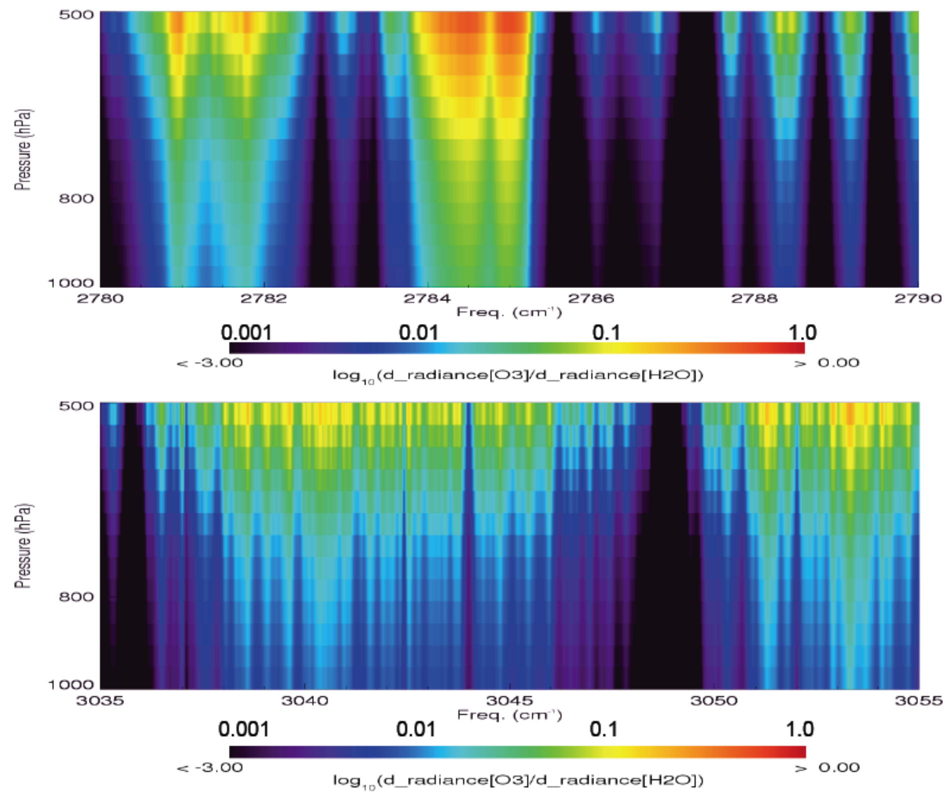
Edwards, Worden et a – sensitivity analysis

Please see poster for more details of this work



Water is strong interferent in 3.6μm region

Best case 'Dry' atmosphere Detectability scenario: ΔR [for ΔO_3 of 20 ppbv] / ΔR [for ΔH_2O of 10%] changes from surface to 500 hPa

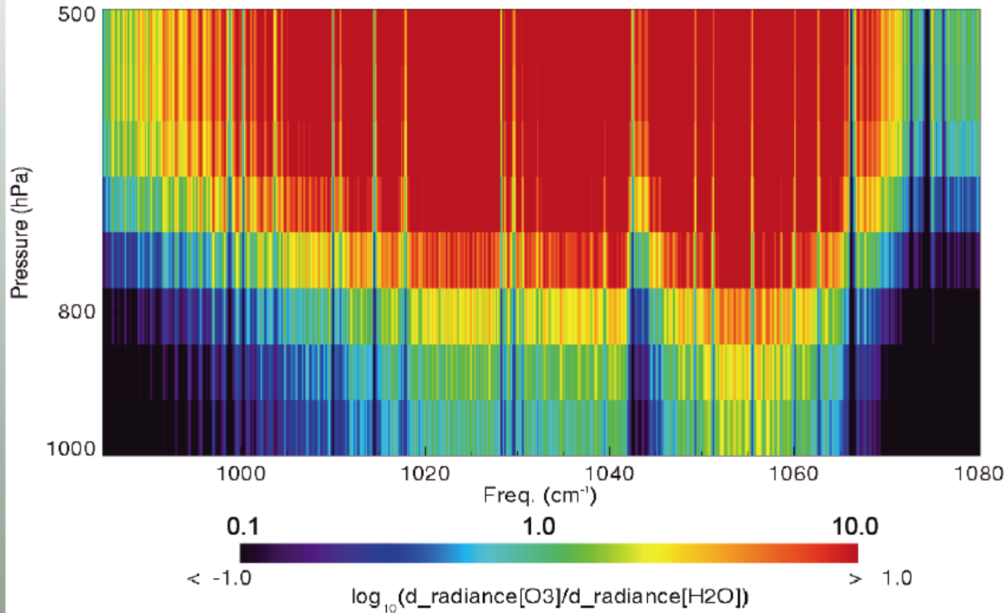


- The Detectability measure does not reach unity in either spectral region
- Ozone Jacobians & Detectability also both decrease toward the surface as a result of H_2O absorption
- Near-surface sensitivity is the main motivation for the NIR measurement

Thermal infrared ozone stronger than water

Compare with Detectability in the TIR

ΔR [for ΔO_3 of 20 ppbv] / ΔR [for ΔH_2O of 10%] changes from surface to 500 hPa



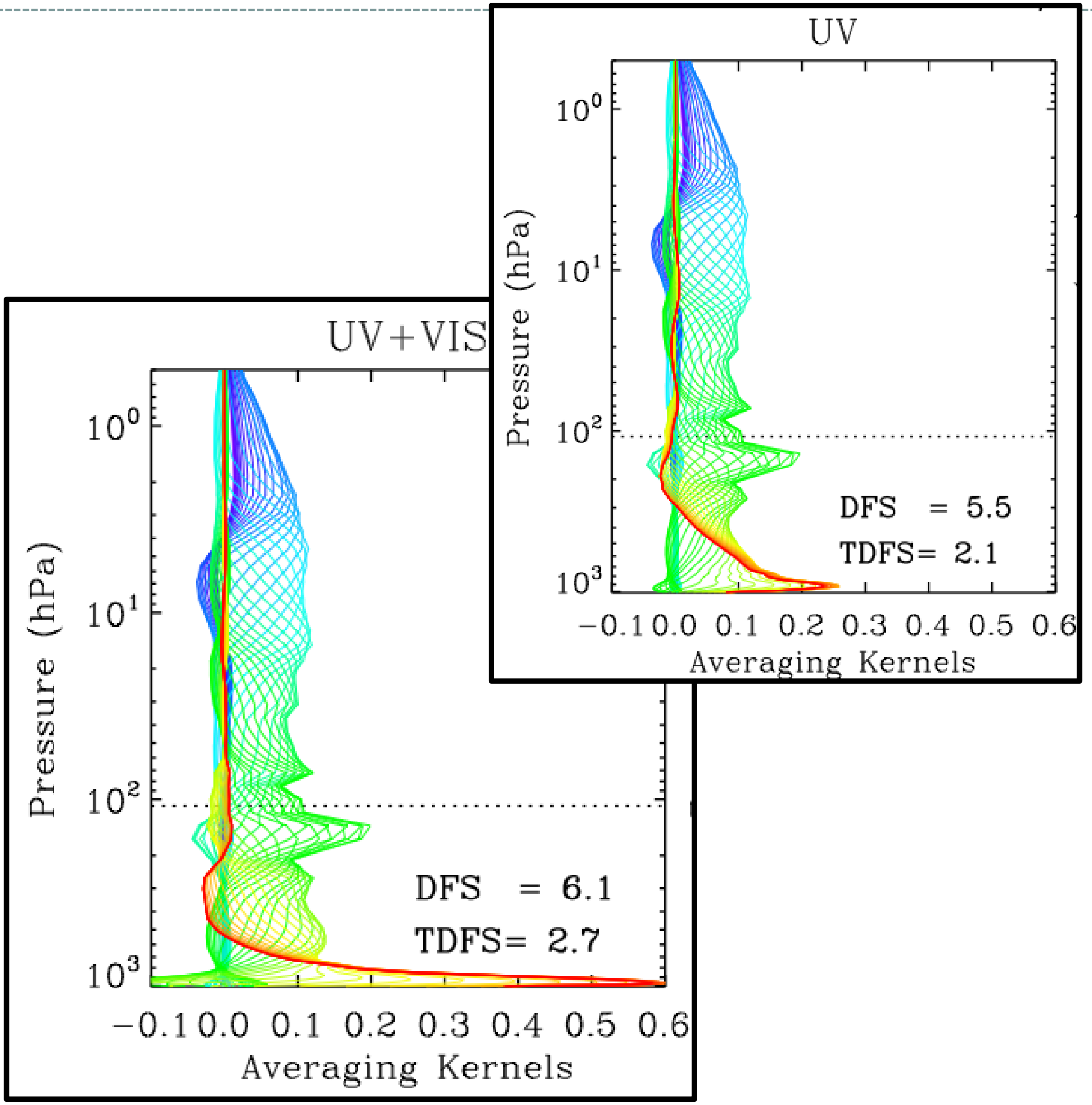
NOTE: Different scale for TIR

TIR O_3 and H_2O Jacobians are from TES with 0.1 cm^{-1} resolution, cloud-free case at 65°N, Aug 2006, surface T = 295 K, H2O vmr = 1.3E-2, thermal contrast = 8.7K

4) Averaging Kernals and information content

Using agreed upon set of constraints and noise calculation, averaging kernals and error estimates can be calculated. (plots cortesy of Xiong Liu).

Also see posters and presentations on other work – Eldering, Edwards, Zoogman/Jacobs



5) Next Steps

See poster by Kelly Chance on extension to additional species

Also, Dave Edwards poster on CO

- Ozone is a critical species –want to quantify the options for sensing low into the troposphere
- Estimate sensitivity in a joint retrieval (O3, H2O, Tatm)
- Integrate lidar/sonde data in analysis
- Most critical advance of this work is improvement of the aerosol and cloud interferents in calcs
- Should also examine benefits for So2 and CH4

FY10 plans

Completion Schedule:

1) End of October
2) End of December
3) End of January
4) End of February
5) End of February
6) End of April
7) End of June
8) End of Sept

1) Complete first set of calculations for range of atmospheres
2) Perform sensitivity studies and linearized retrievals including interferents
3) Update tool with consistent cloud and aerosol treatment
4) Write report of first results
5) Complete calcs with clouds/aerosols
6) Complete updated linearized retrievals and sensitivity
7) Manuscript for peer reviewed journal on ozone analysis
8) Extend to additional species