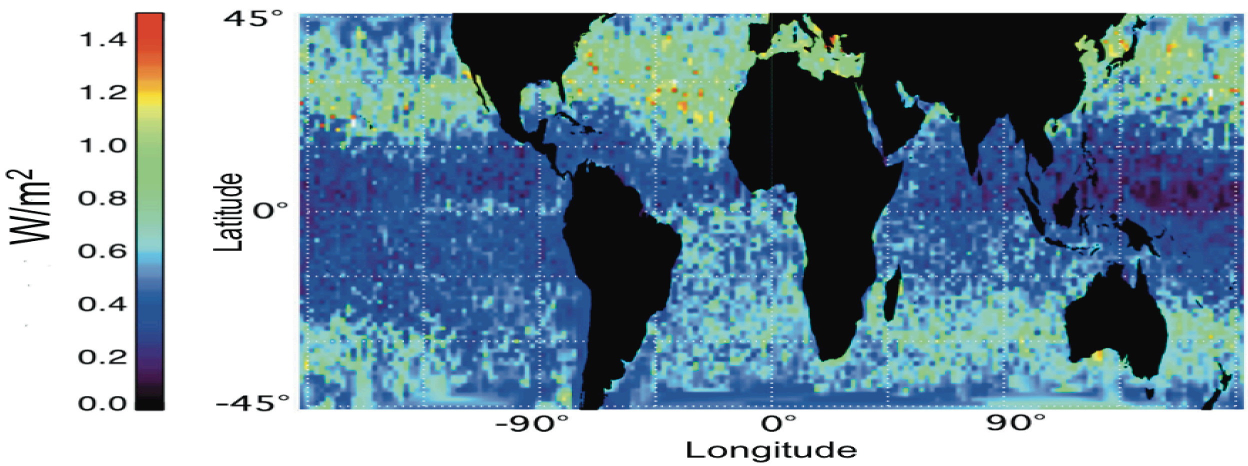
Instantaneous Radiative Forcing with TES Jacobians

H. Worden, NCAR, K. Bowman & S.S. Kulawik, JPL, M. Parrington & D. Jones, U. Toronto

Previous study to compute reduced OLR from upper tropospheric ozone used ensemble Jacobian estimates for clear-sky ocean scenes. (Worden et al., Nature Geoscience, 2008)

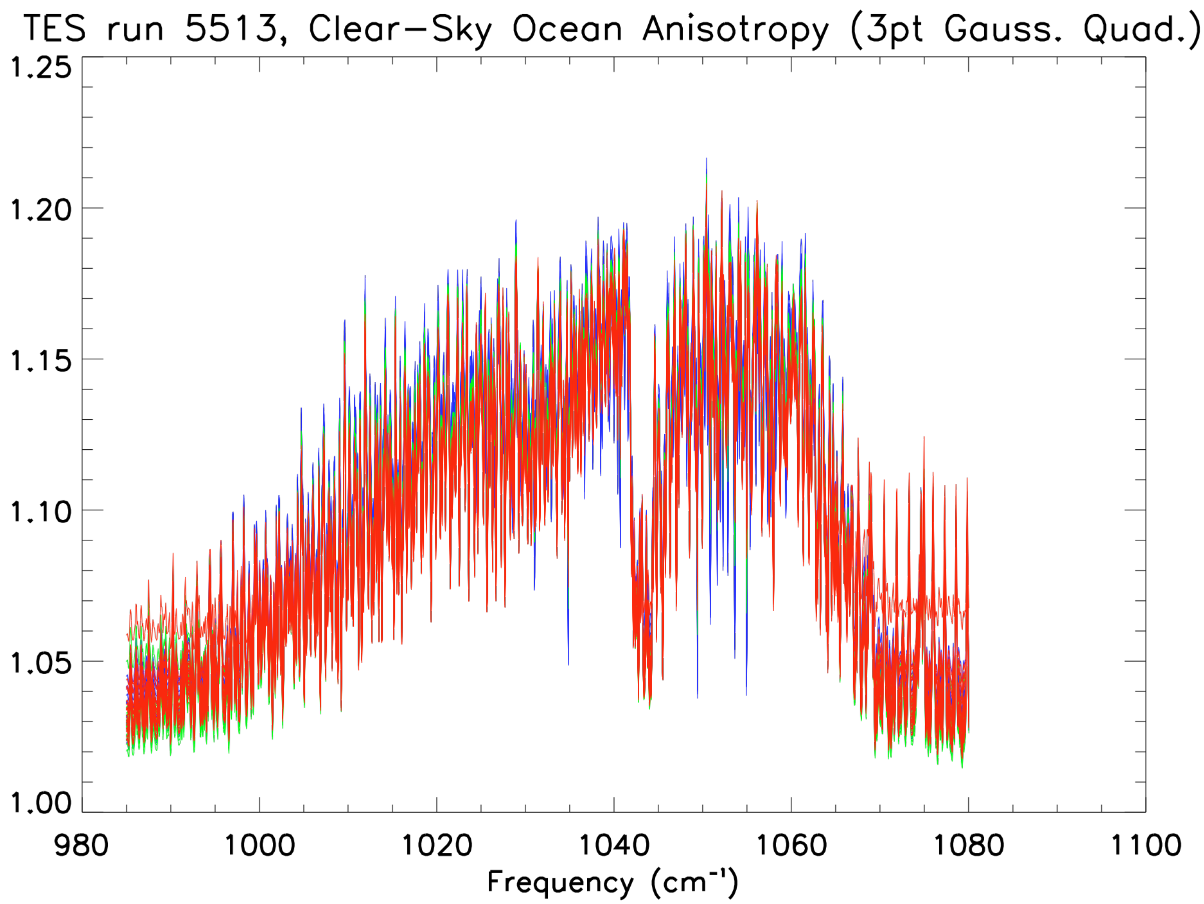


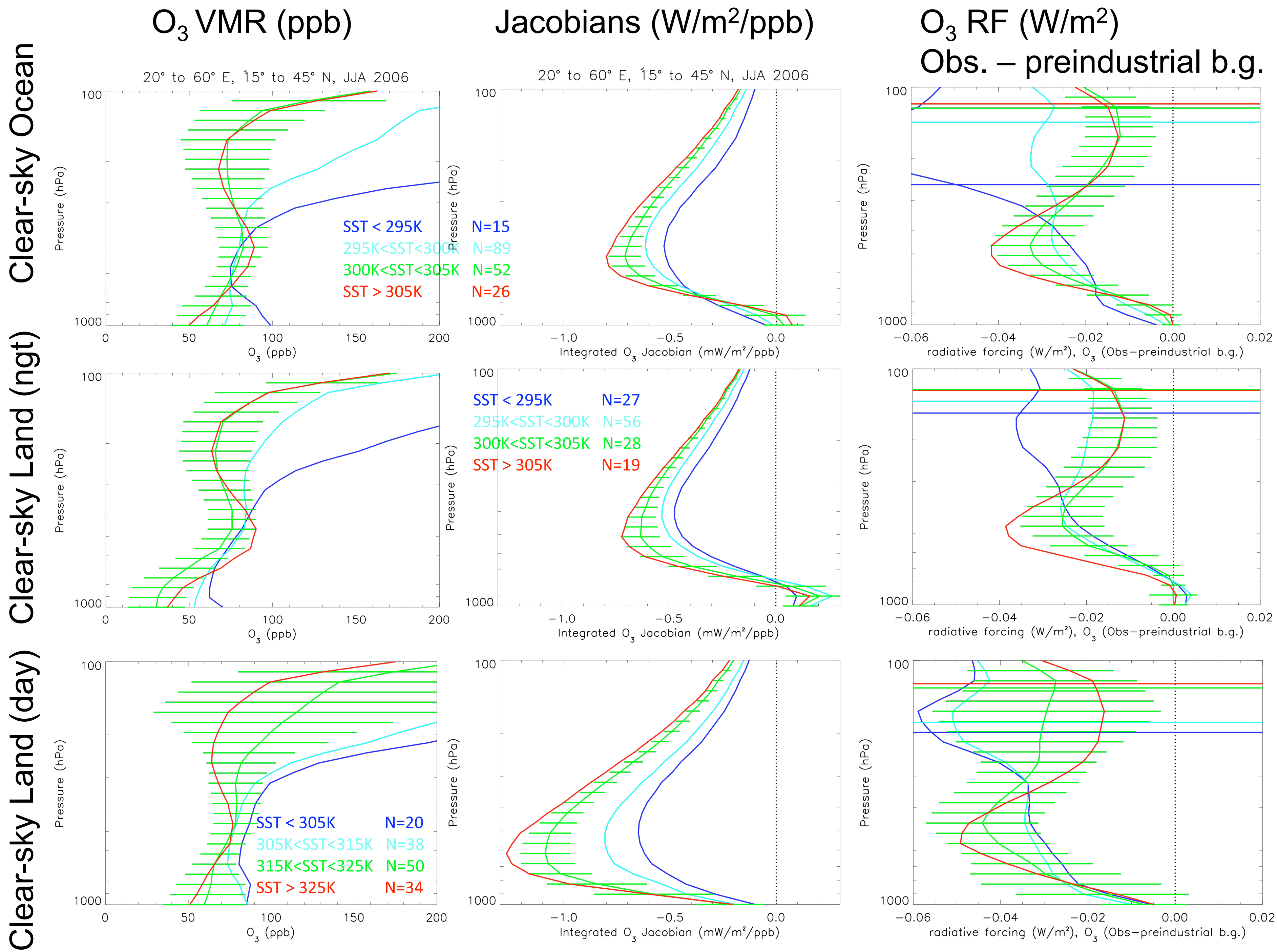
Recent work uses FM Jacobians: d(Radiance)/d(ln VMR) for each retrieval at the convergence iteration, (not saved in normal processing). Initial work with is with ozone (ROSES proposal).

Allows calculation of vertical profiles for instantaneous forcing (W/m^2) and normalized forcing (W/m^2/ppb) for ozone in all observations (land, ocean, clouds).

Flux computation using estimated anisotropy: $$R_\nu = \frac{\pi L_\nu(\theta = 0)}{F_\nu}$$

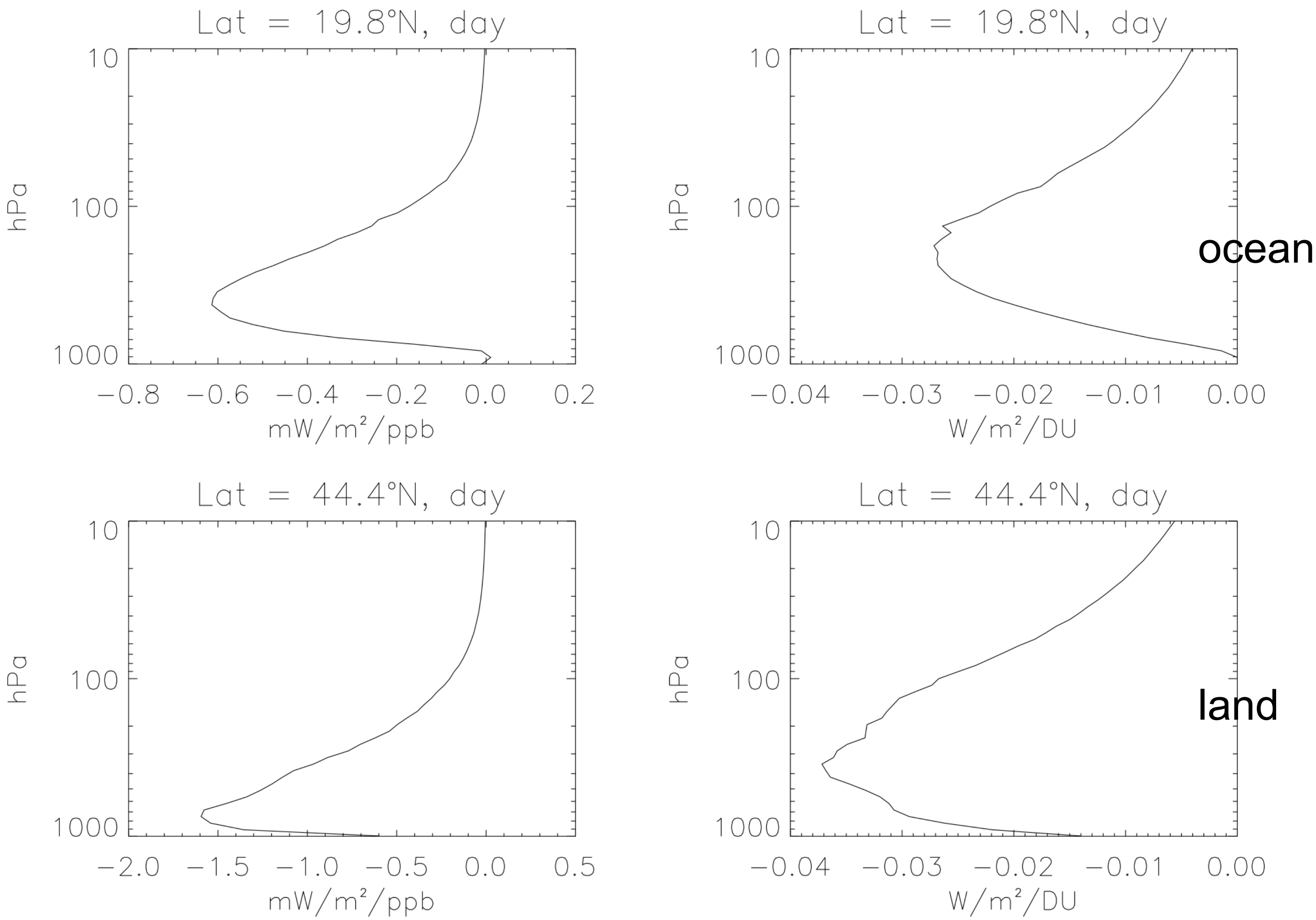
See same frequency behavior as X. Huang et al., JGR, 2008 for AIRS and values are close to CERES for integration over window region (8-12 μm).

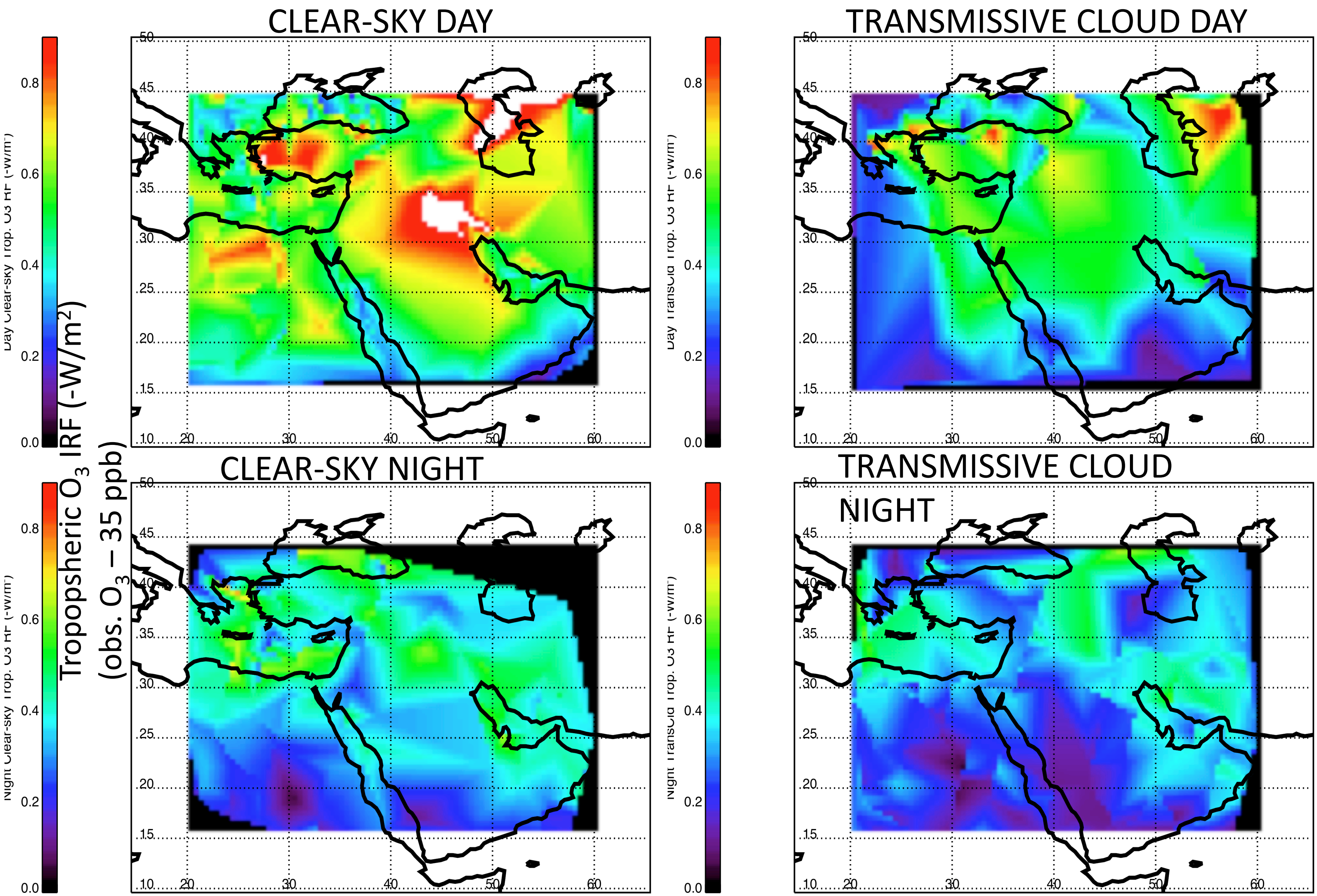




O3 VMR (ppb)
Jacobians (W/m2/ppb)
O3 RF (W/m2)
Obs. – preindustrial b.g.
Clear-sky Ocean
Clear-sky Land (ngt)
Clear-sky Land (day)
20° to 60° E, 15° to 45° N, JJA 2006
Pressure (hPa)
O3 (ppb)
Integrated O3 Jacobian (mW/m²/ppb)
radiative forcing (W/m²), O3 (Obs−preindustrial b.g.)
SST < 295K N=15
295K<SST<300K N=89
300K<SST<305K N=52
SST > 305K N=26
SST < 295K N=27
295K<SST<300K N=56
300K<SST<305K N=28
SST > 305K N=19
SST < 305K N=20
305K<SST<315K N=38
315K<SST<325K N=50
SST > 325K N=34

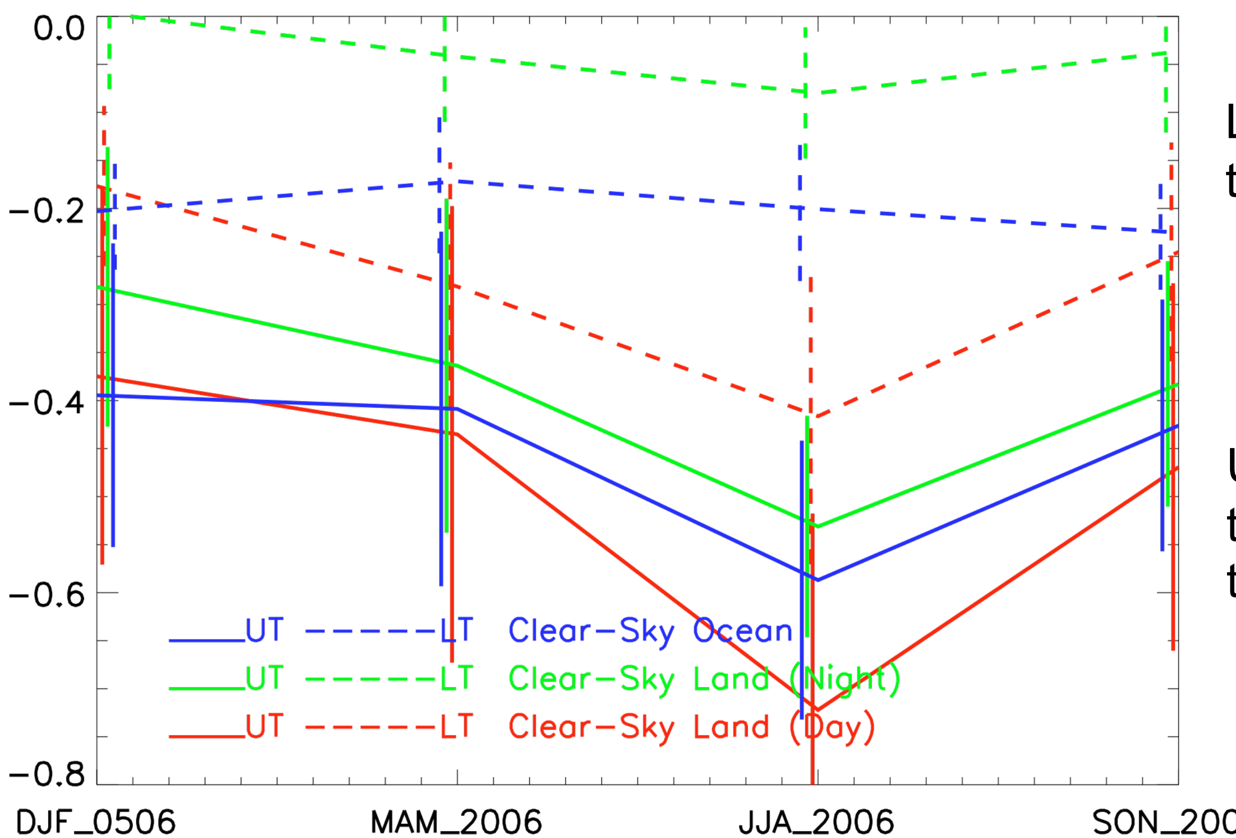
Examples of VMR vs. Column Jacobians




CLEAR-SKY DAY
TRANSMISSIVE CLOUD DAY
CLEAR-SKY NIGHT
TRANSMISSIVE CLOUD
NIGHT
Tropospheric O3 IRF (-W/m2)
(obs. O3 – 35 ppb)
0.0
0.2
0.4
0.6
0.8
10
15
20
25
30
35
40
45
50
20
30
40
50
60

Seasonal dependence of O_3 IRF for clear-sky scenes lower and upper troposphere, 15-45°N, 20-60°E

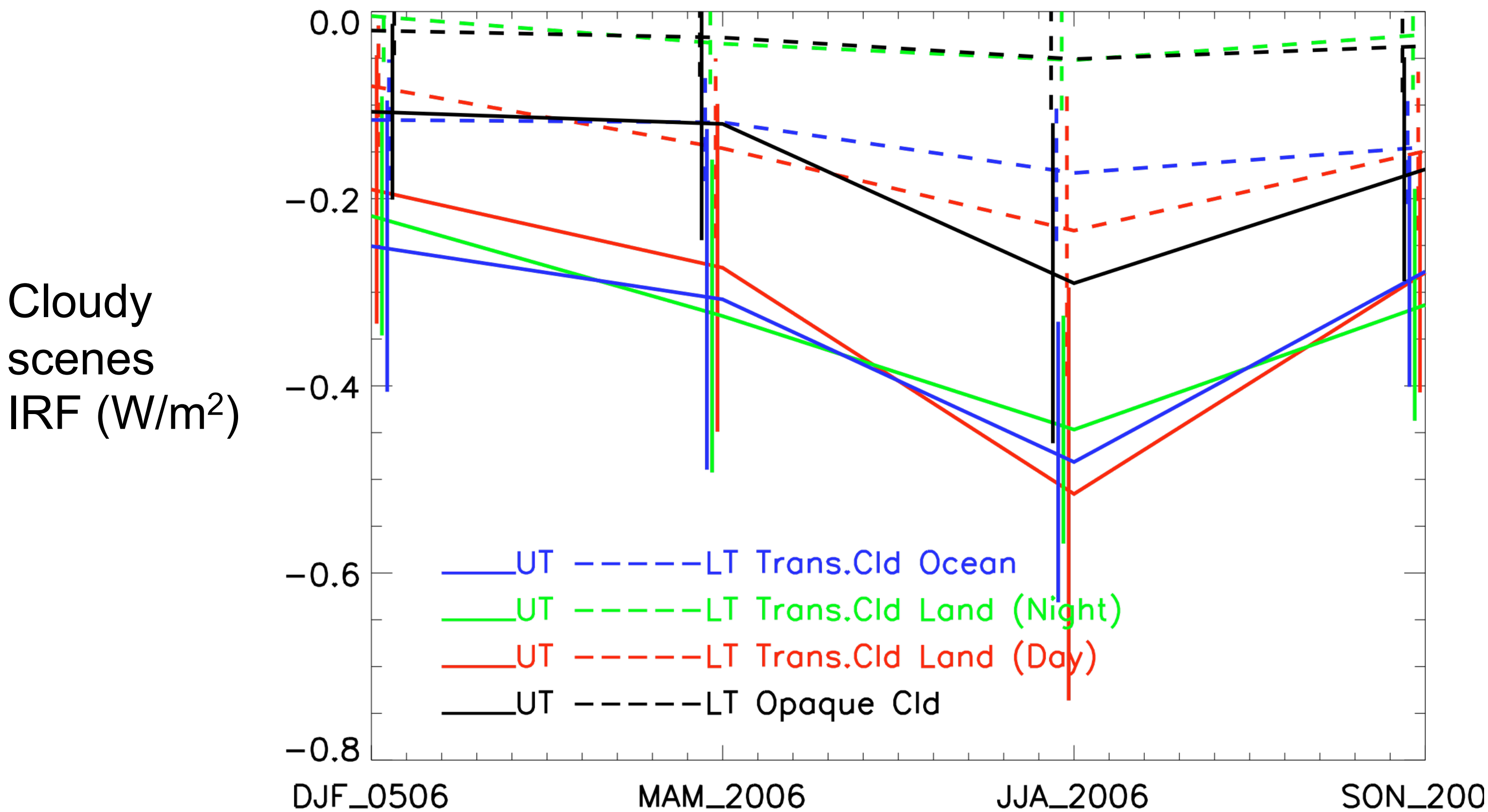
Clear-sky scenes IRF (W/m^2)



LT=surface to 500 hPa

UT=500 hPa to chem. tropopause

Seasonal dependence of O_3 IRF for cloudy scenes lower and upper troposphere, 15-45°N, 20-60°E



- Opaque = cloud OD > 1.386 (transmission < 25%)
- Transmissive = 0.1 < cloud OD < 1.386 (transmission from 90% to 25%)
- Clear-sky = cloud OD < 0.1 (transmission > 90%)

Multimodel Comparisons with TES Ozone: means, variability and instantaneous radiative forcing

Collaboration with:
Drew Shindell, GISS model
Larry Horowitz, GFDL and Dylan Jones, U. Toronto (AM2-chem)
Kevin Bowman & Adetutu Aghedo, JPL (running ECHAM5)
J.F. Lamarque, NOAA and Bill Collins, LBL (CAM-chem)

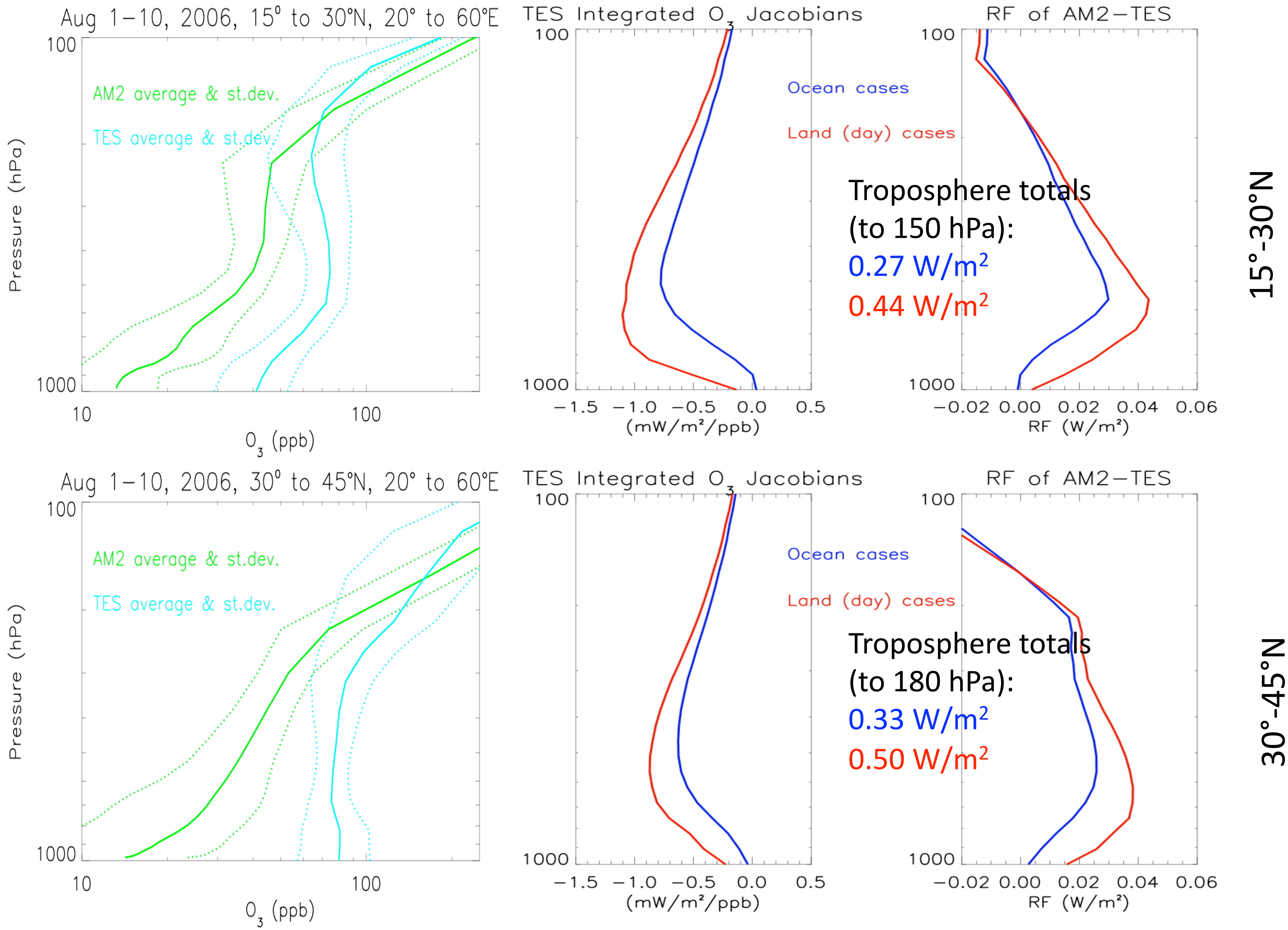
Questions:

•Will focus on support of AC&C activity 4: Future scenarios (D. Shindell lead)
•How well do Chemistry-climate models represent ozone and its instantaneous radiative forcing under all-sky conditions?
•What is the radiative coupling between ozone, water vapor, and clouds?
•Does tropospheric ozone have any effect on local dynamics?

Technical steps:

•What are the appropriate time scales to compare TES and GCMs?
  •Start with August 2006 (3hr sampling) for initial comparisons of clear-sky ozone and IRF output for small region 20°-60°E, 15°-45°N
•All-sky comparisons – Aug. 2006, test monthly mean
•Move to global comparisons and over the Aura time frame
•Investigate IASI ozone IRF product

Radiative forcing due to AM2-TES O3 difference



Conclusions and future directions

- TES can provide the spectrally resolved outgoing longwave radiation (OLR), the atmospheric state that produced the OLR, and the sensitivity of OLR to that state under all-sky conditions, which are fundamental climate quantities.
- Through its high spectral resolution, TES OLR sensitivity can help characterize the radiative coupling within the atmospheric state, .e.g, clouds and ozone
- These OLR products from O3 to atmospheric state variables, e.g., water vapor, can be produced for all observation types (clouds, ocean, land)
- TES spectra and Jacobians, (e.g. CO2, H2O and O3) can be used to study requirements on spectral resolution for CLARREO, which will need to characterize the radiative response of the hydrological cycle to anthropogenic forcing.
- The radiative forcing of ozone on dynamics can be characterized through extension to heating and cooling rates products

Seasonal dependence of O_3-band average anisotropy