Who moved my spectrum?

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TSIS-1 Hybrid Solar Reference Spectrum

(TSIS-1 HSRS)

- TSIS-1 HSRS is a new reference spectrum for atmospheric radiative transfer and remote sensing applications
- TSIS-1 HSRS spans 0.202 um to 2.73 um and has a spectral resolution of 0.01 nm or better. Uncertainties are 0.3% between 0.4 and 2.365 um and 1.3% at wavelengths outside that range.
- Recently extended to span the ultraviolet to the longwave infrared (115 nm to 200 microns.

Irradiance differences UV to IR

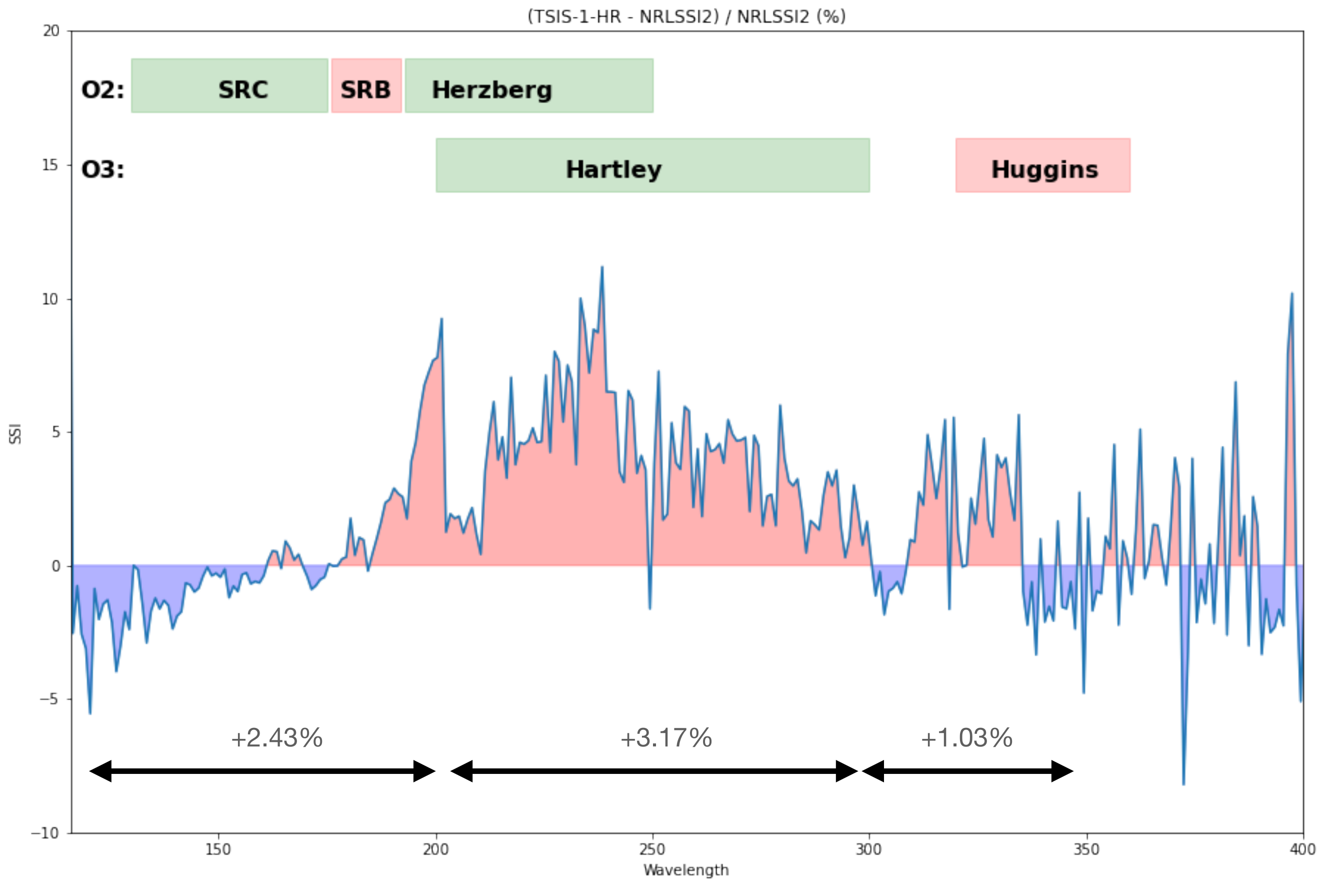
Spectra averaged for Dec 1-7, 2019

Wavelength interval (nm):	115-200	200-300	300-350	350-496	496-985	>985
TSIS-1 (Wm^{-2})	0.095	13.991	38.895	234.74	646.47	421.00
NRLSSI2* (Wm^{-2})	0.092	13.561	38.498	234.60	639.24	428.30
Difference (Wm^{-2})	0.002	0.43	0.397	0.14	7.23	-7.30
Difference (%)	2.43	3.17	1.03	0.06	1.13	-1.70

*The LASP WHI (Woods et al., 2009) is the baseline solar reference spectrum of NRLSSI2

% change in spectral irradiance (116-400 nm)

(TSIS-1-HR - NRLSSI2) / NRLSSI2



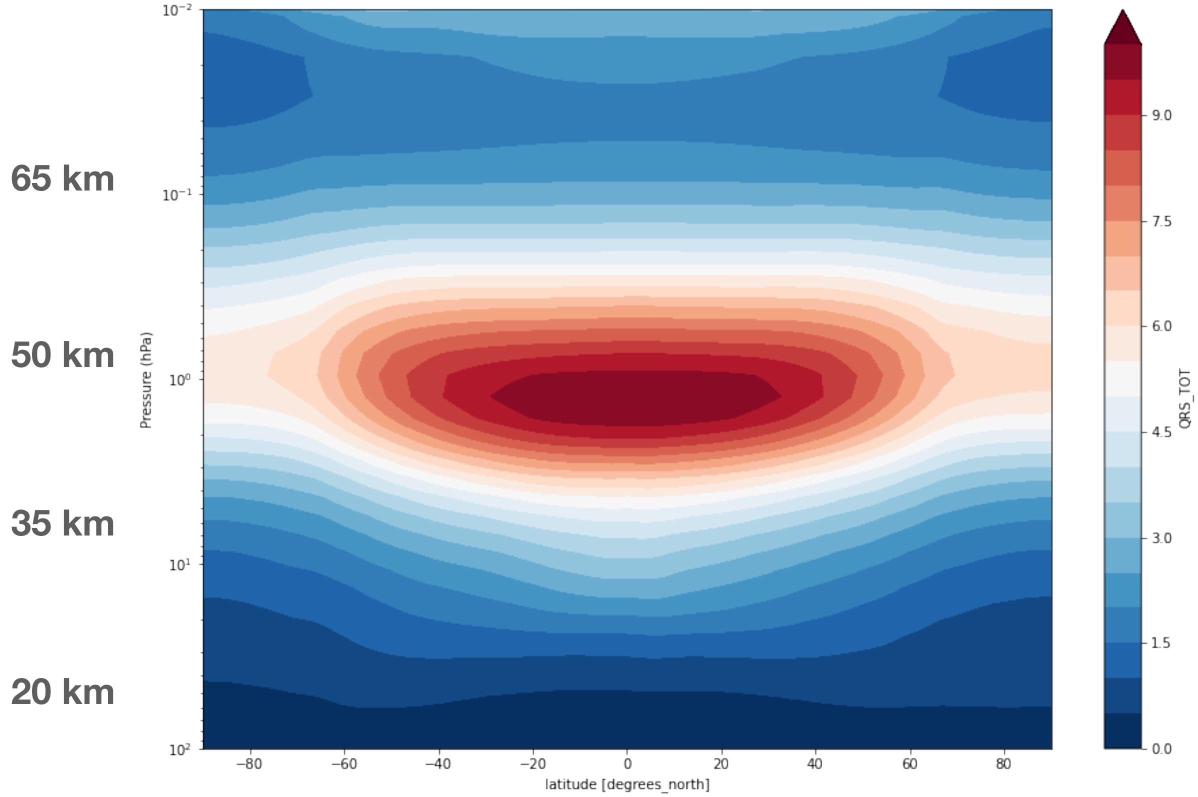
Experimental description

Multi-year climate model simulations

- CESM2 - WACCM6
  - Same model used in IPCC CMIP6
  - Interactive chemistry
  - 0.95° latitude x 1.25° longitude, 71 levels (surface to ~140 km)
  - Fixed greenhouse gas concentrations at the surface (year 2000)
  - Specified climatological sea surface temperatures (climate impacts limited)
- 2 solar minimum SSI experiments (**spectra averaged for Dec 1-7, 2019**)
  - Full Spectrum Extension of the TSIS-1 HSRS reference spectrum
  - NRL-SSI2
- Focus here on annual mean / zonal mean differences averaged over 10 year model integrations

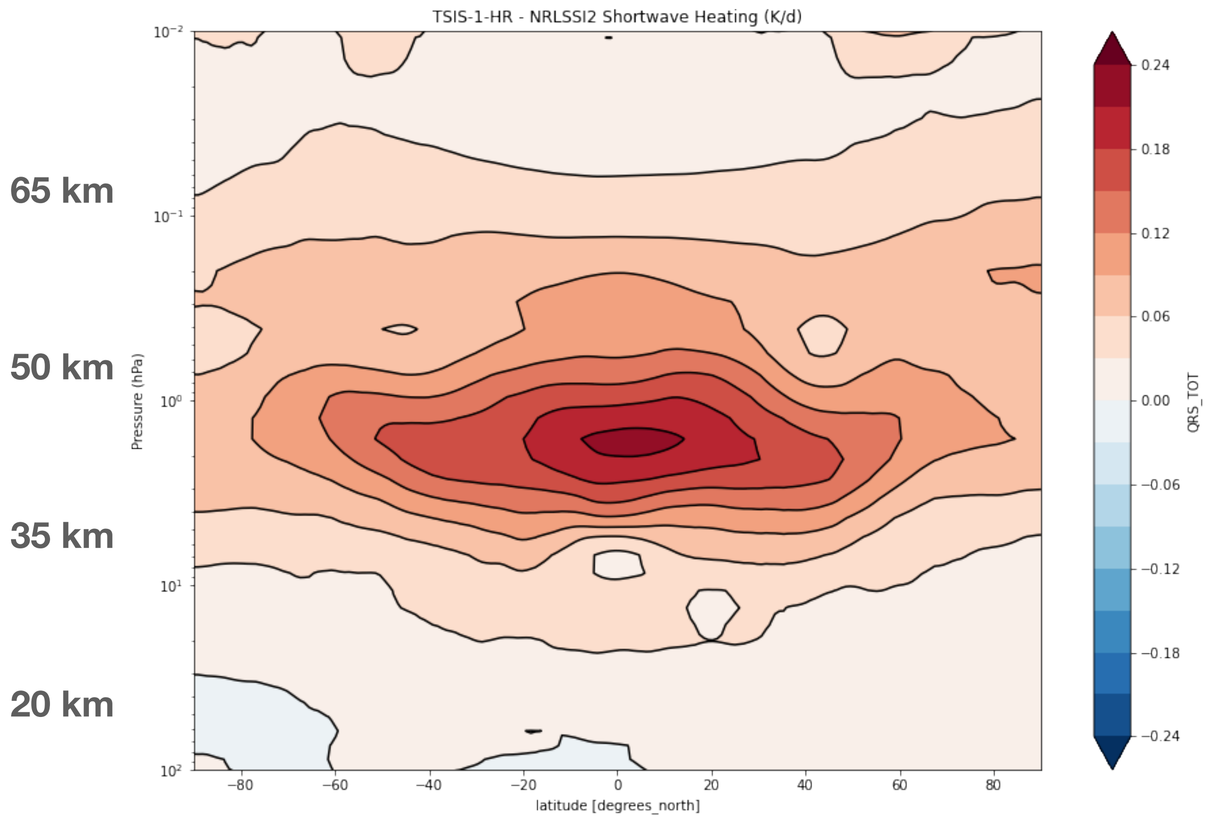
Shortwave heating rate

WACCM & NRLSSI2 (K/day)



Shortwave heating rate difference

TSIS1 - NRLSSI2



Temperature

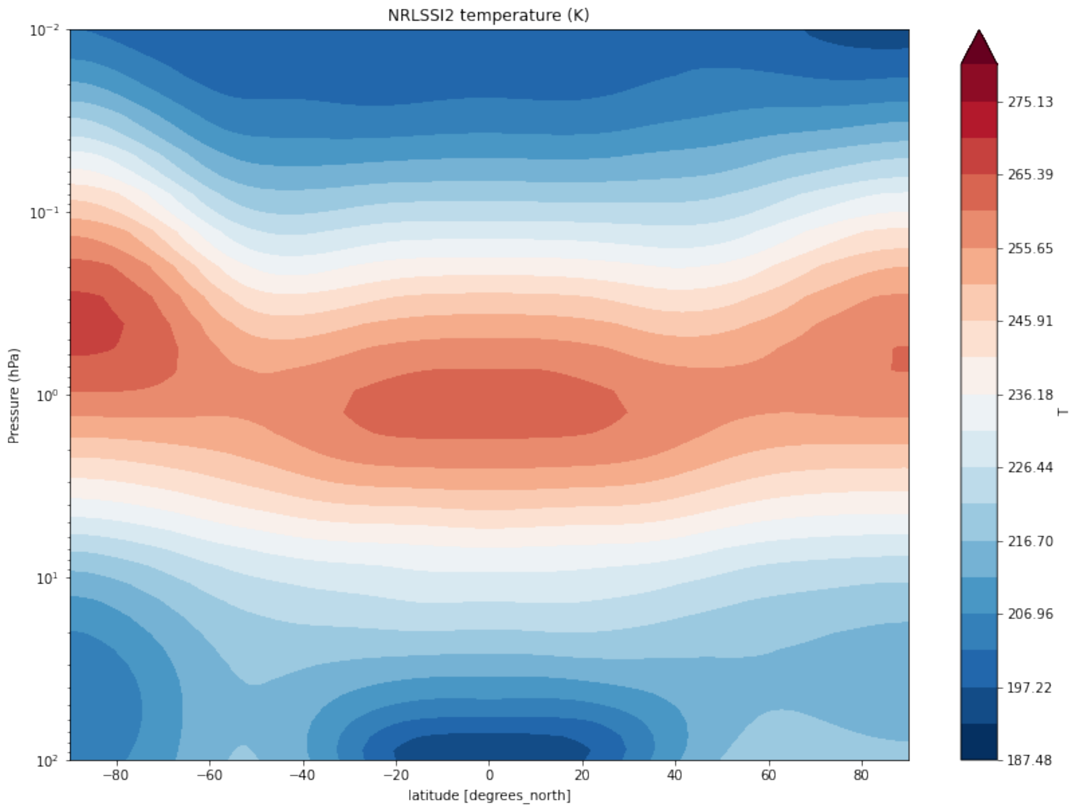
WACCM & NRLSSI2

65 km

50 km

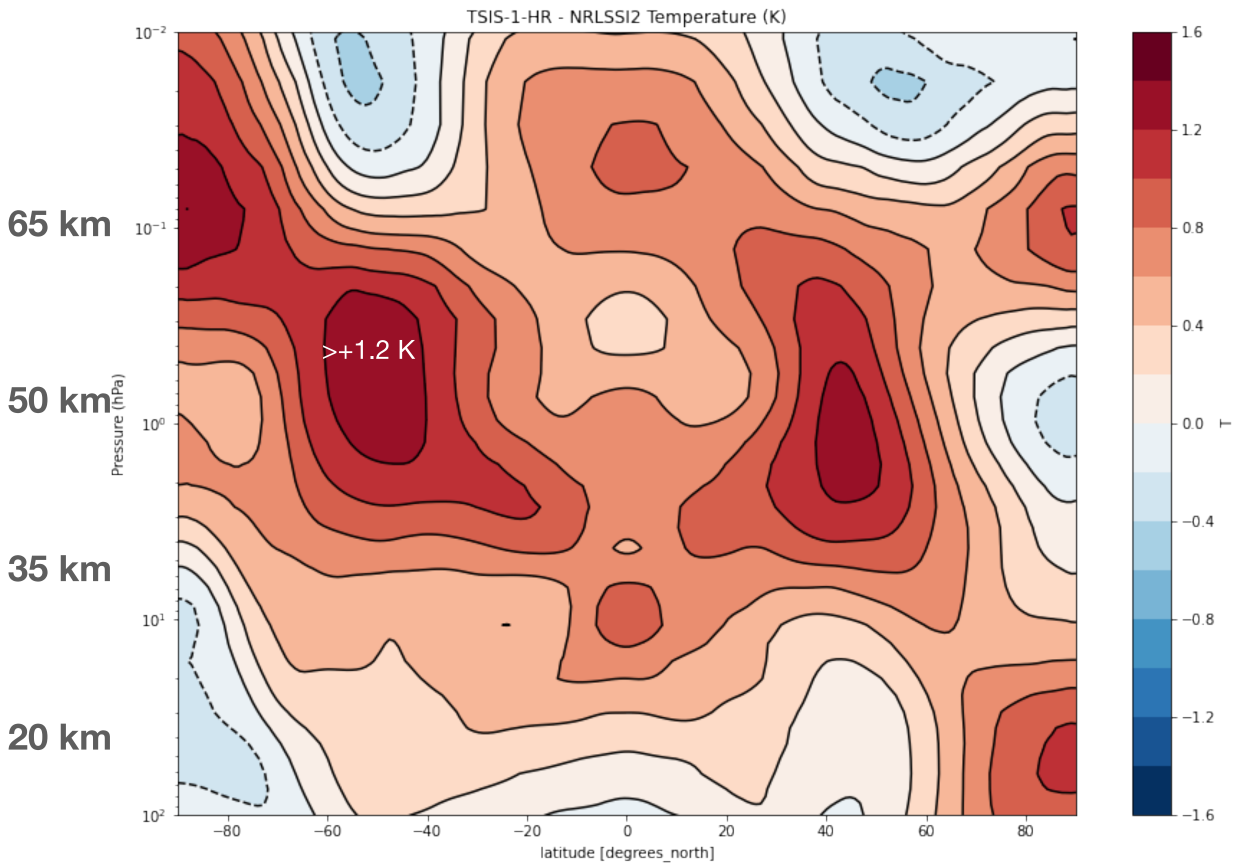
35 km

20 km

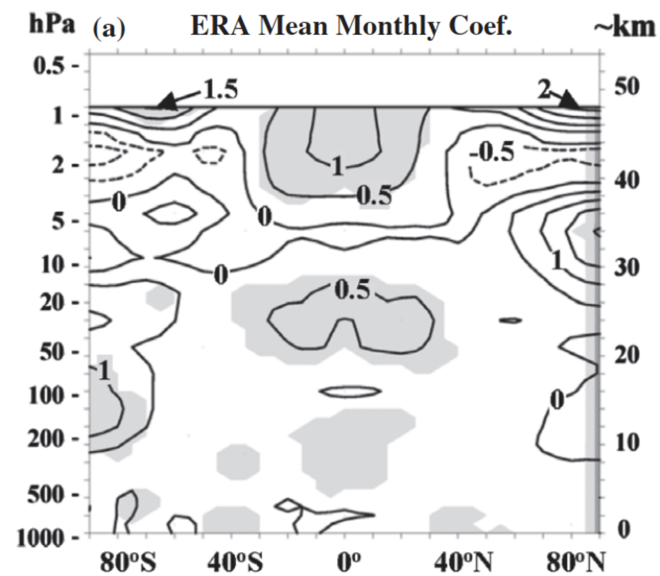


Temperature difference

TSIS1 - NRLSSI2



Comparison with solar-cycle



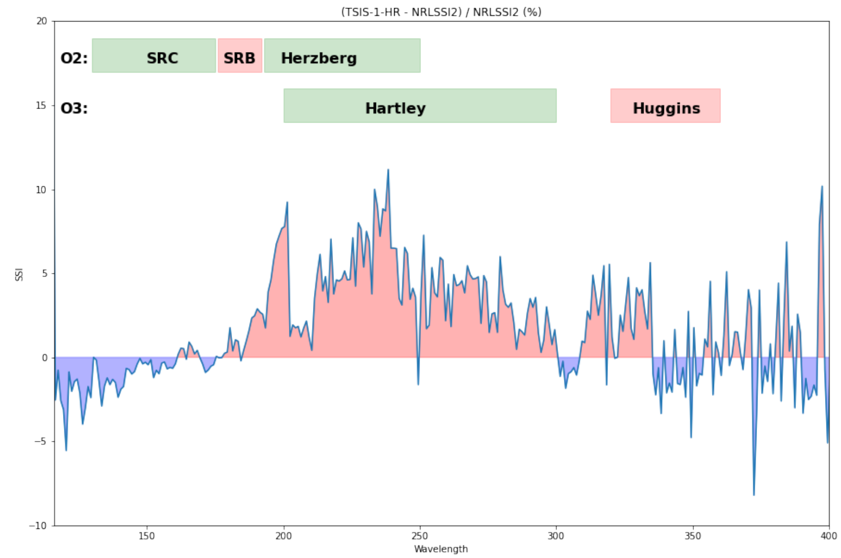
Hood et al., *QJRMS* 2015

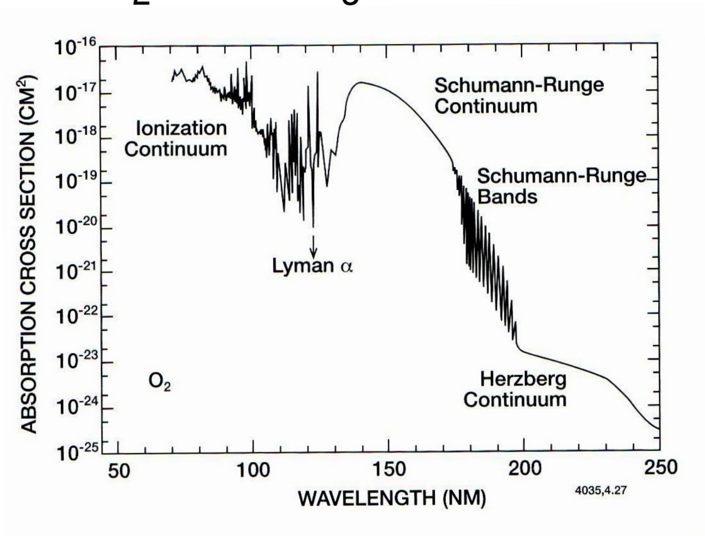
Ox Production

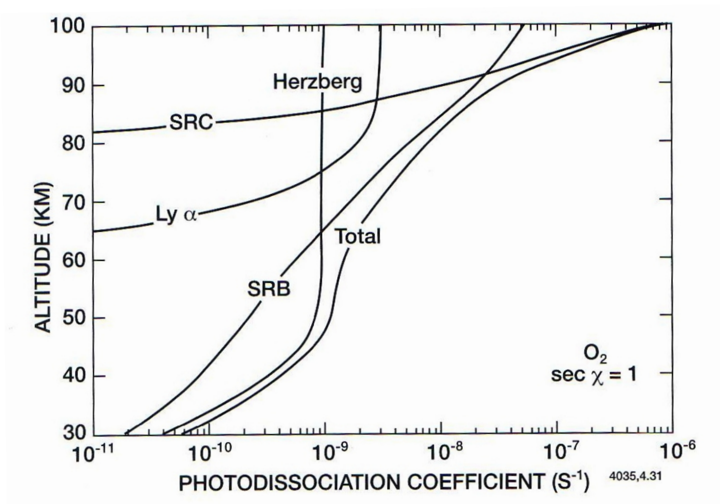
via O_2 photolysis

$$O_2 + h\nu \rightarrow \begin{cases} O + O \\ O + O(^1D) \end{cases} \quad \textbf{(<175 nm)}$$

$$O + O_2 + M \rightarrow O_3 + M$$



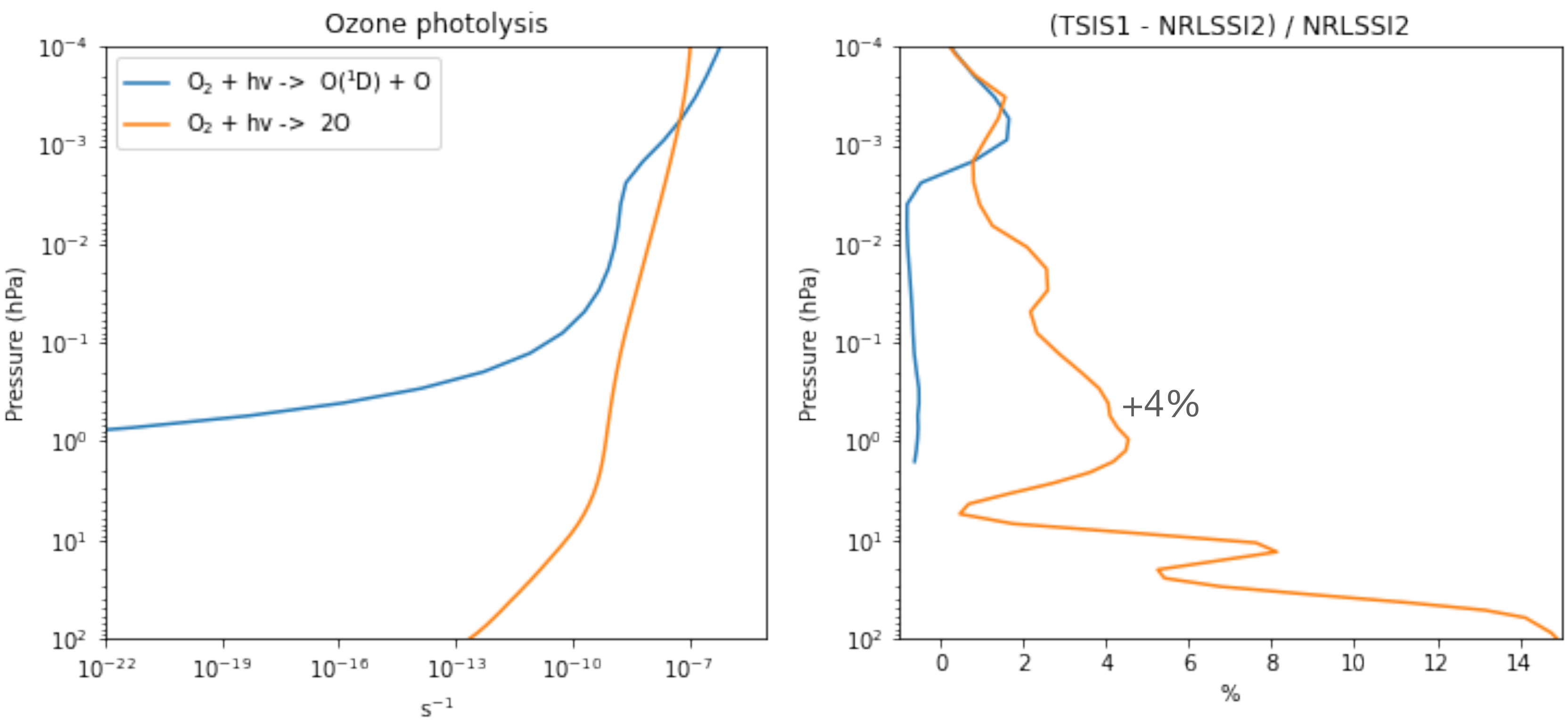




Brasseur and Solomon, Aeronomy of the Middle Atmosphere, 2005

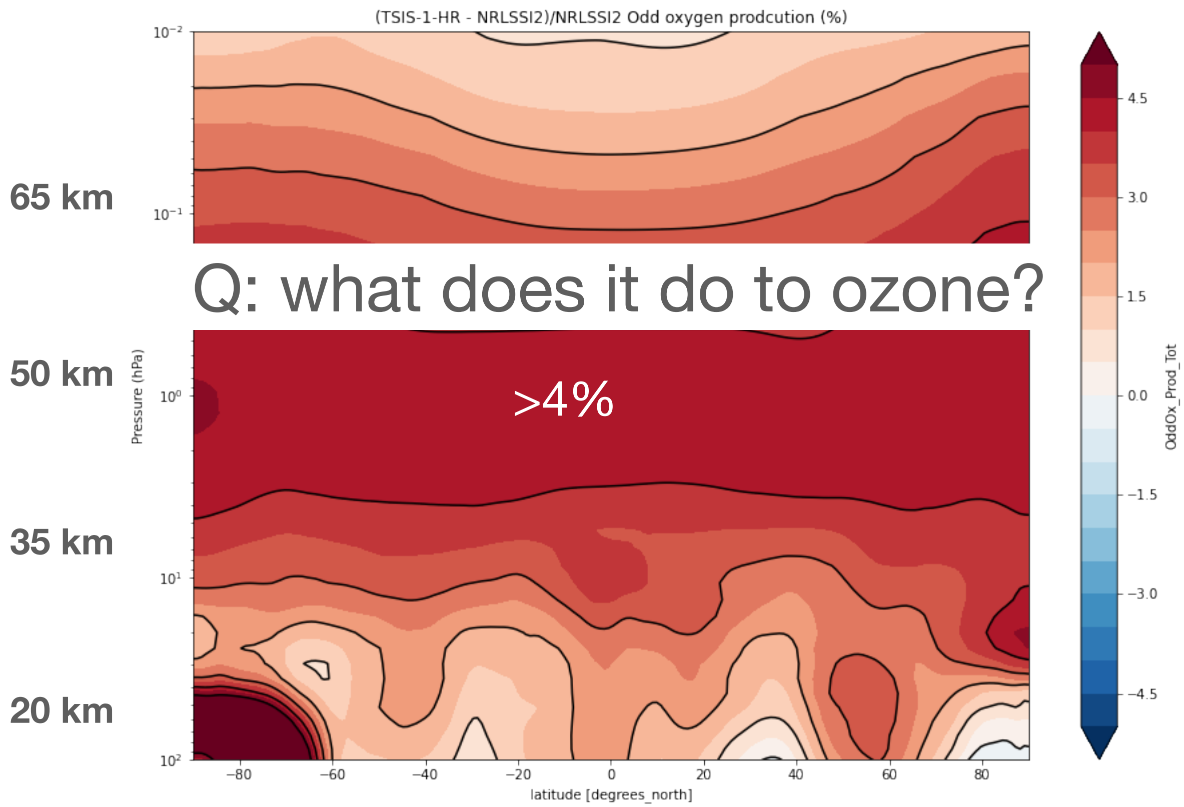
O_2 photolysis rates

Noon, equator, January 16



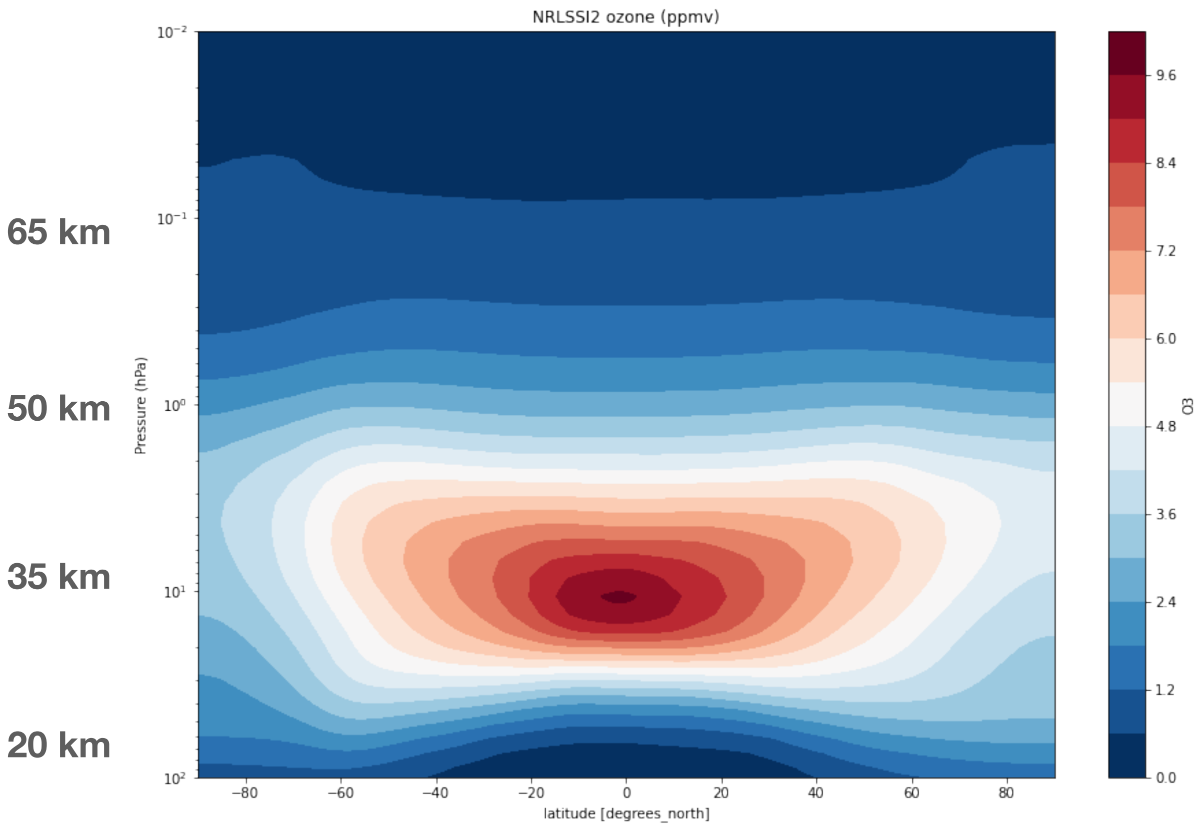
Odd-oxygen production

TSIS1 - NRLSSI2



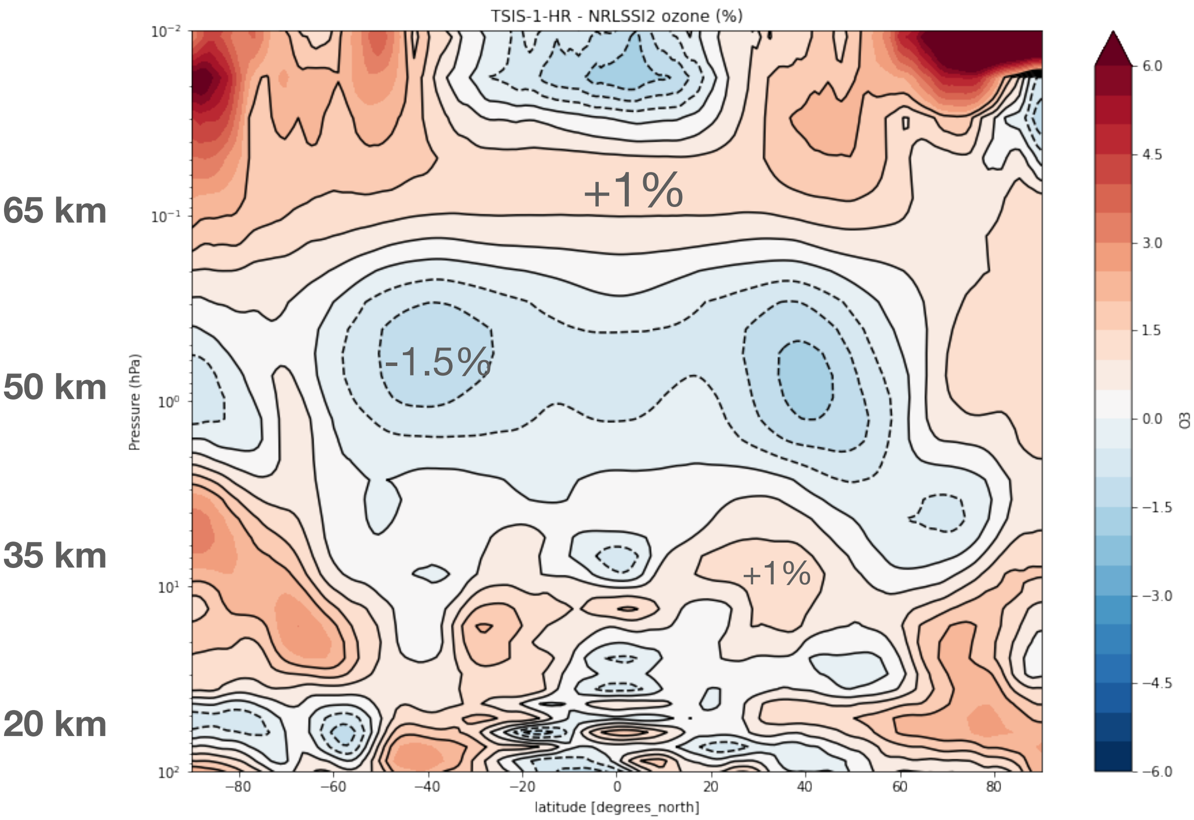
Ozone (ppm)

NRLSSI2



Ozone difference (%)

TSIS1 - NRLSSI2



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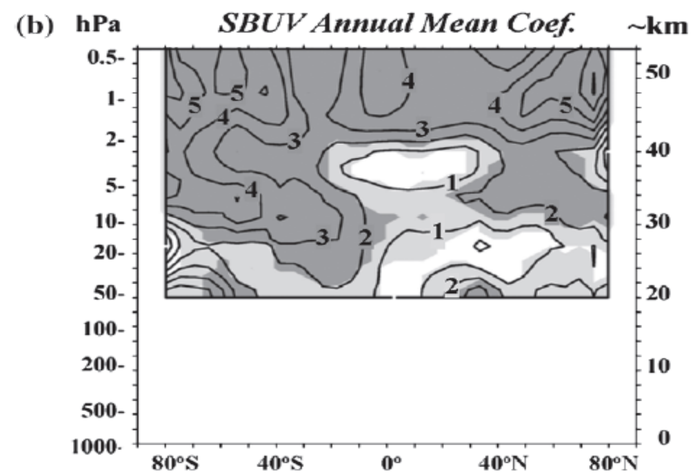
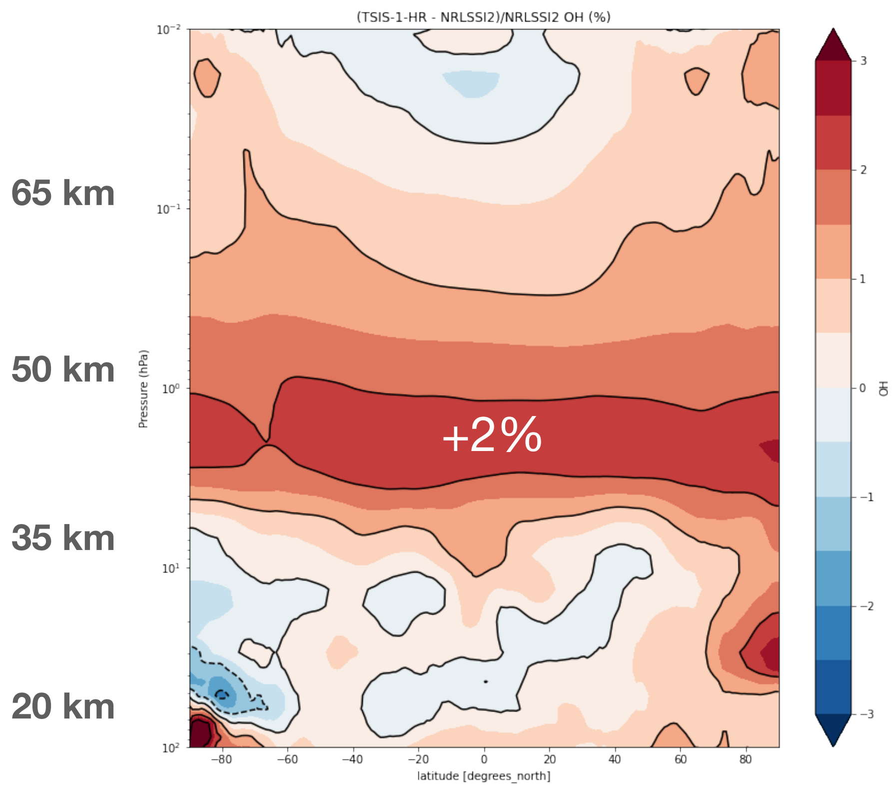


Hood et al., *QJRMS* 2015

OH % change

TSIS1 - NRLSSI2



HOx catalytic ozone loss

$OH + O_3 \rightarrow HO_2 + O_2$

$HO_2 + O \rightarrow OH + O_2$

Net: $O_3 + O \rightarrow 2\ O_2$

Enhanced OH production

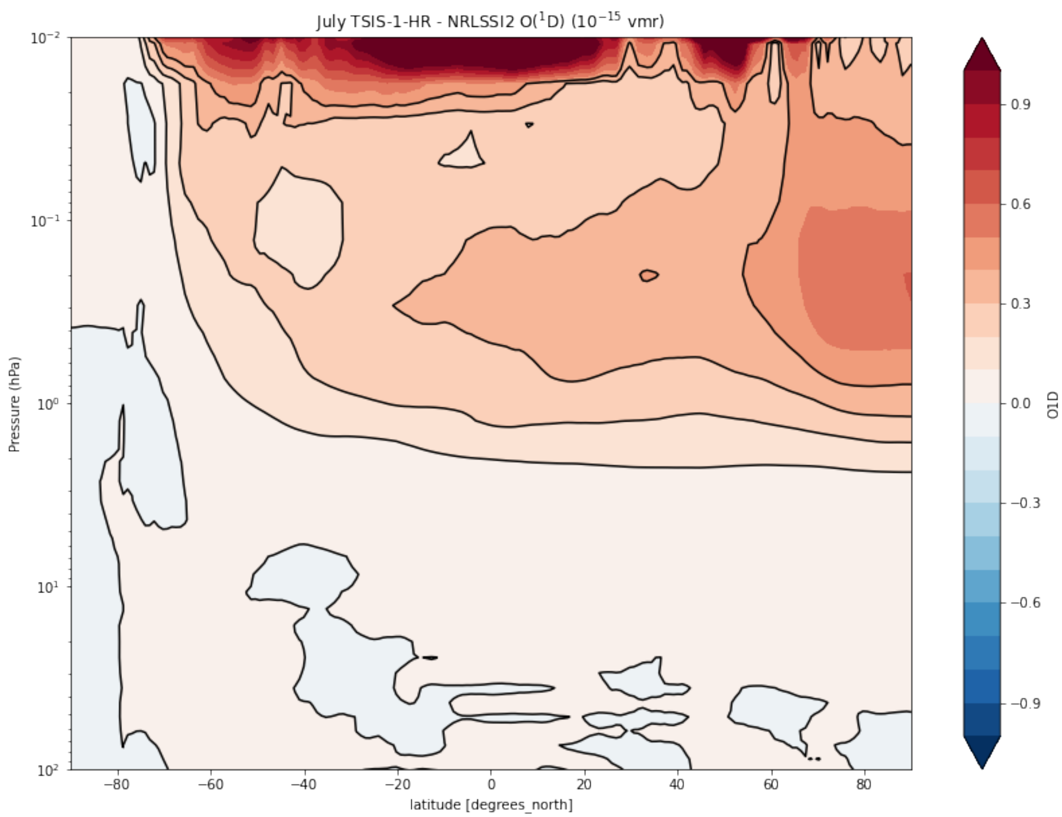
TSIS1 - NRLSSI2 O(¹D) Difference

65 km

50 km

35 km

20 km



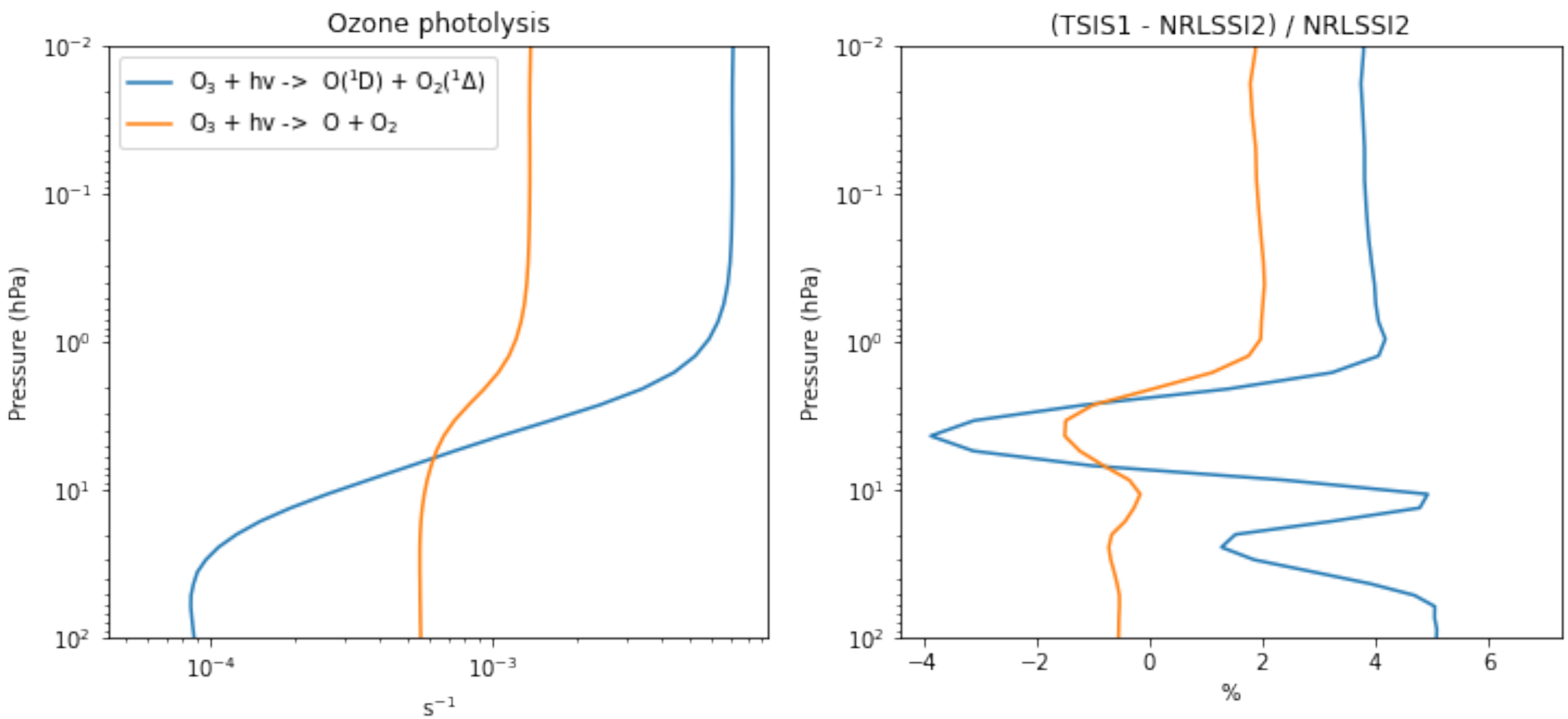
$$H_2O + O(^1D) \rightarrow 2\ OH$$

Ozone photolysis

Enhanced flux in Hartley band

$O_3 + hv \rightarrow O(^1D) + O_2$, 90% < 305 nm

$O_3 + hv \rightarrow O(^3P) + O_2$, 10% < 305 nm



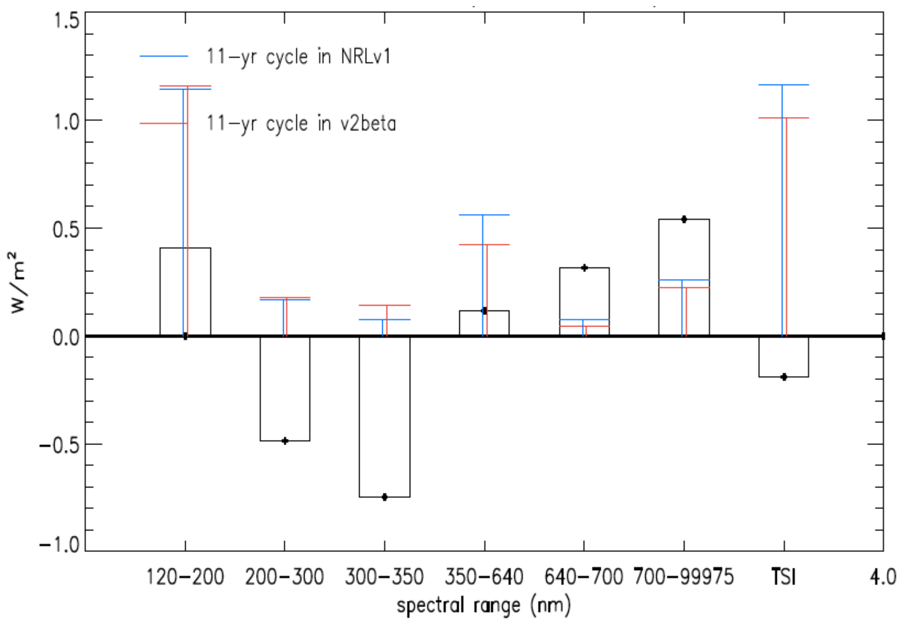
Summary for the middle atmosphere

- Shortwave heating and temperatures increase throughout the middle atmosphere
- Production of odd-oxygen increases from O_2 photolysis in Herzberg and Schumann-Runge bands
- Ozone increases in the middle mesosphere and lower stratosphere but decreases at the stratopause
- Decrease due to higher OH at the stratopause due to enhancements in O(1D) (and it's reaction with water vapor) produced from higher ozone photolysis in the Hartley band

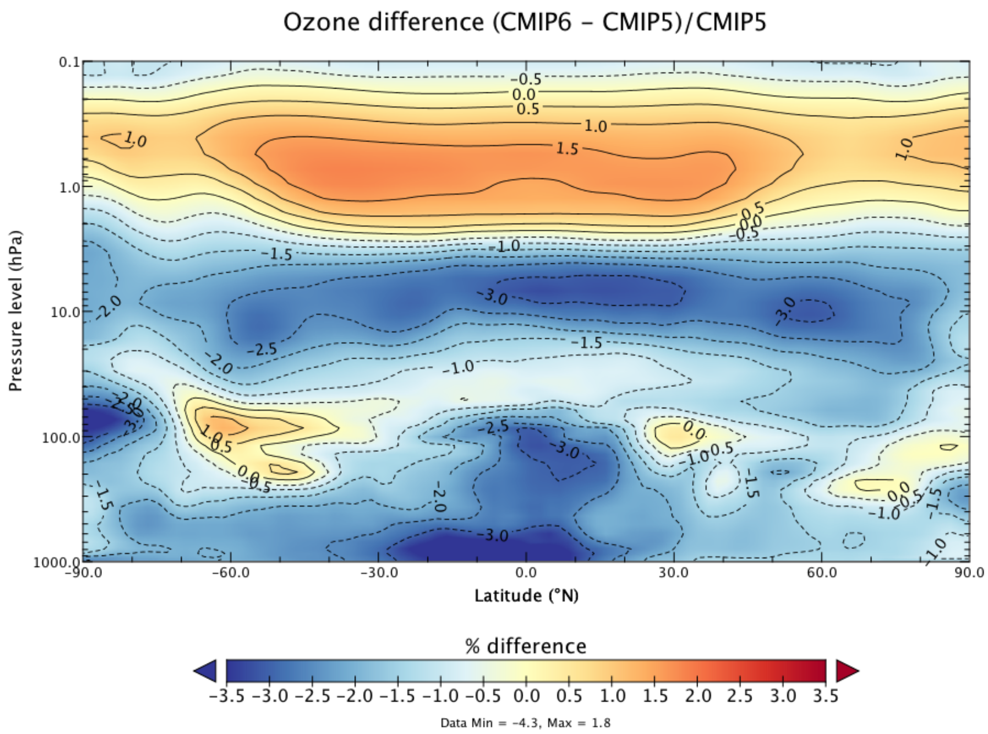
Back to the future?

Figures from Boulder Solar Day, 4 April 2017, HAO

Revised SSI for CMIP6

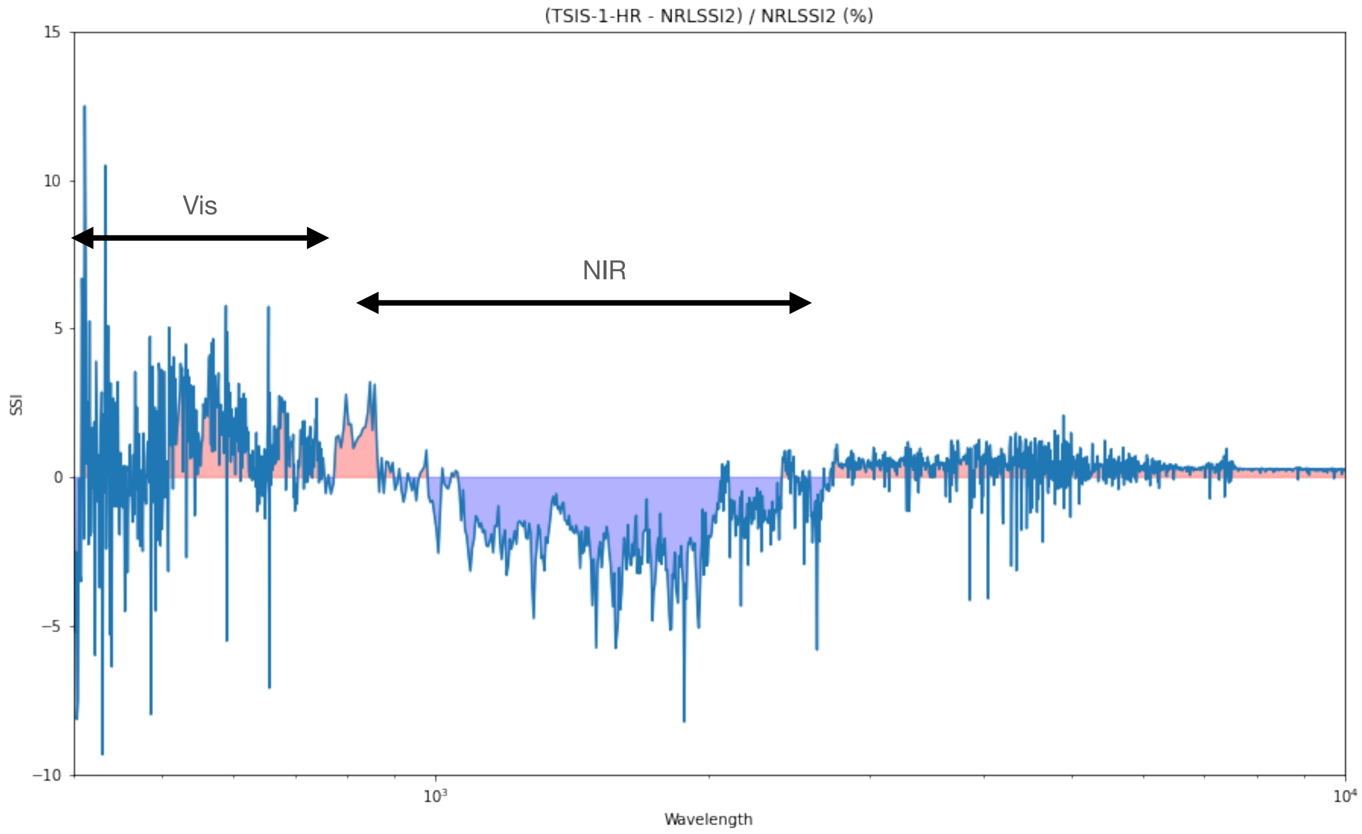


Study with Gabriel Chiodo



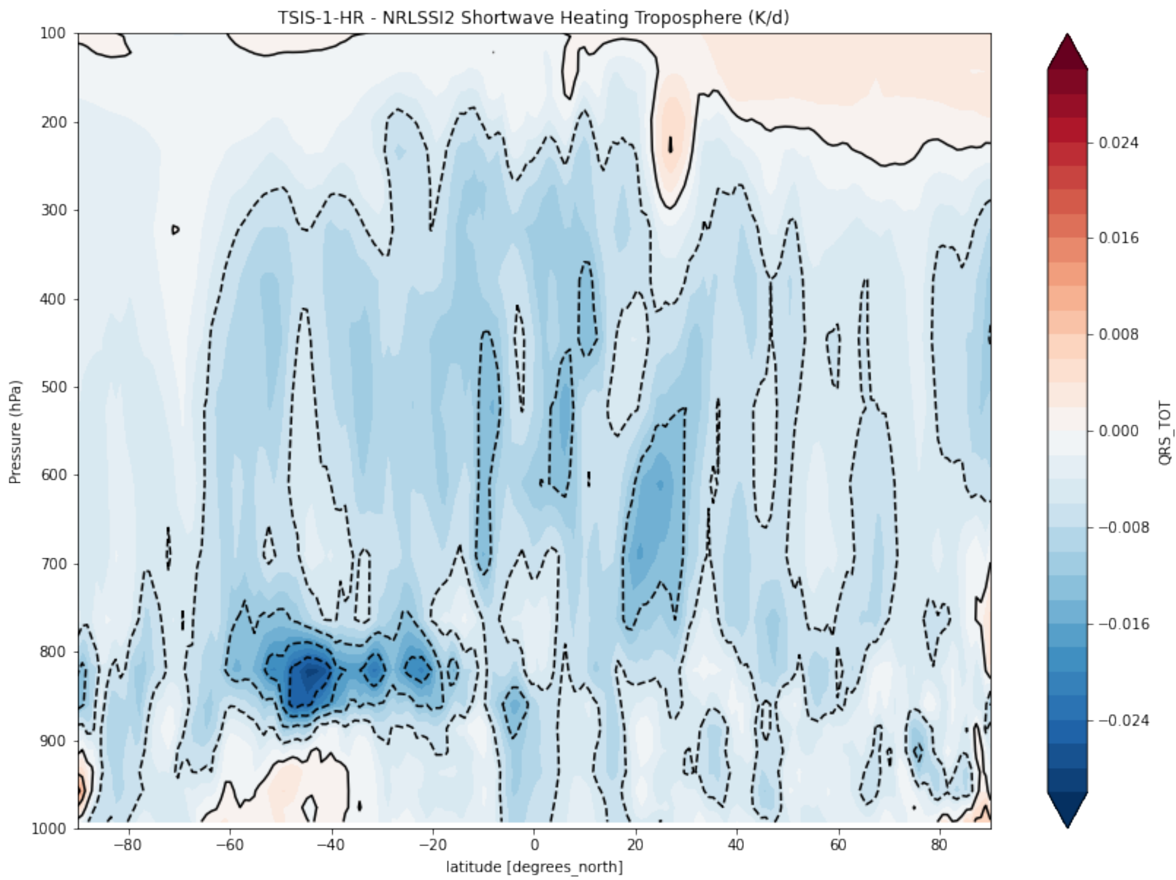
Tropospheric effects

% changes in the visible to infrared



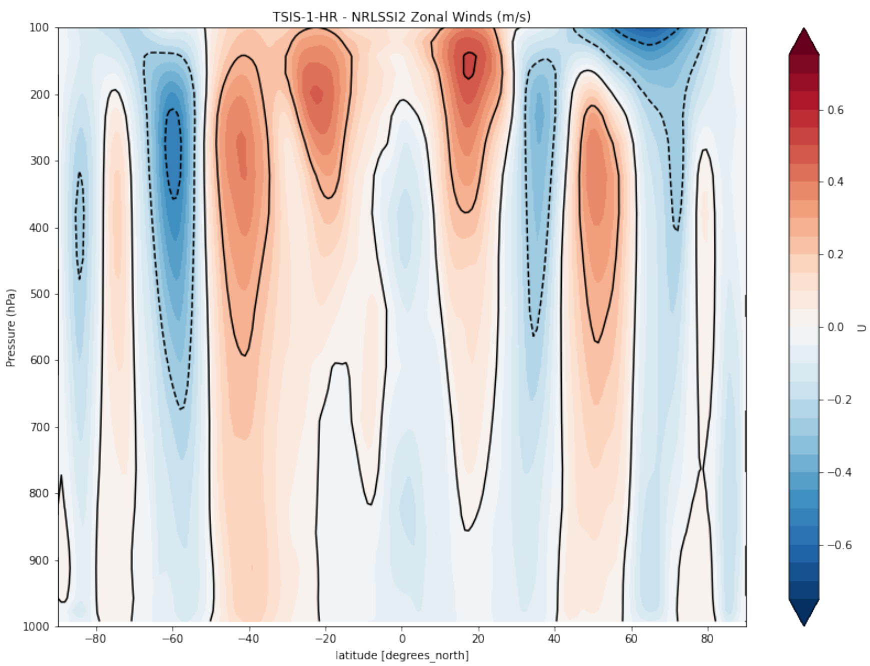
Tropospheric shortwave heating rate differences

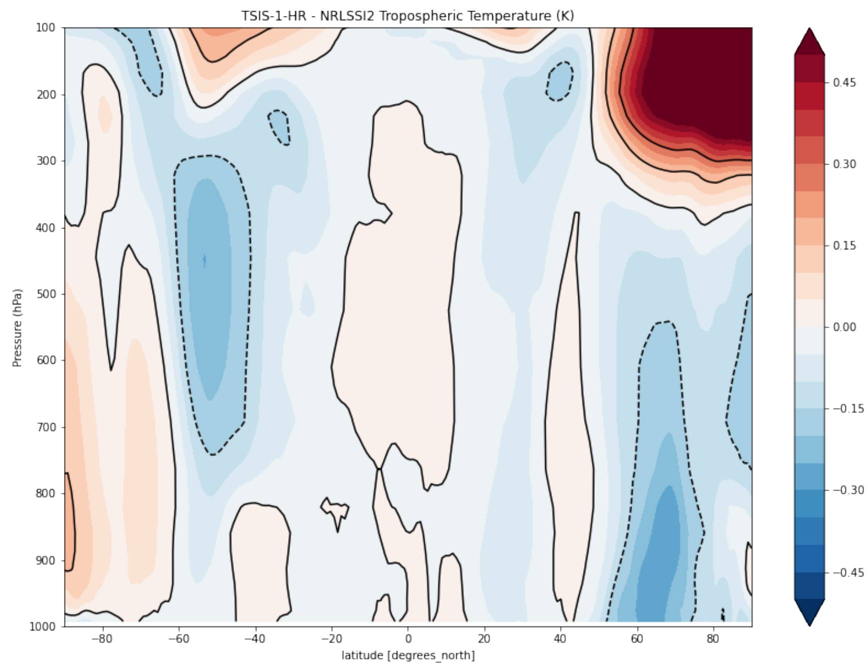
TSIS1 - NRLSSI2



Zonal wind and temperature differences

>10 years with interactive ocean needed to determine if this is robust





SCOSTEP-PRESTO

Pillar 3

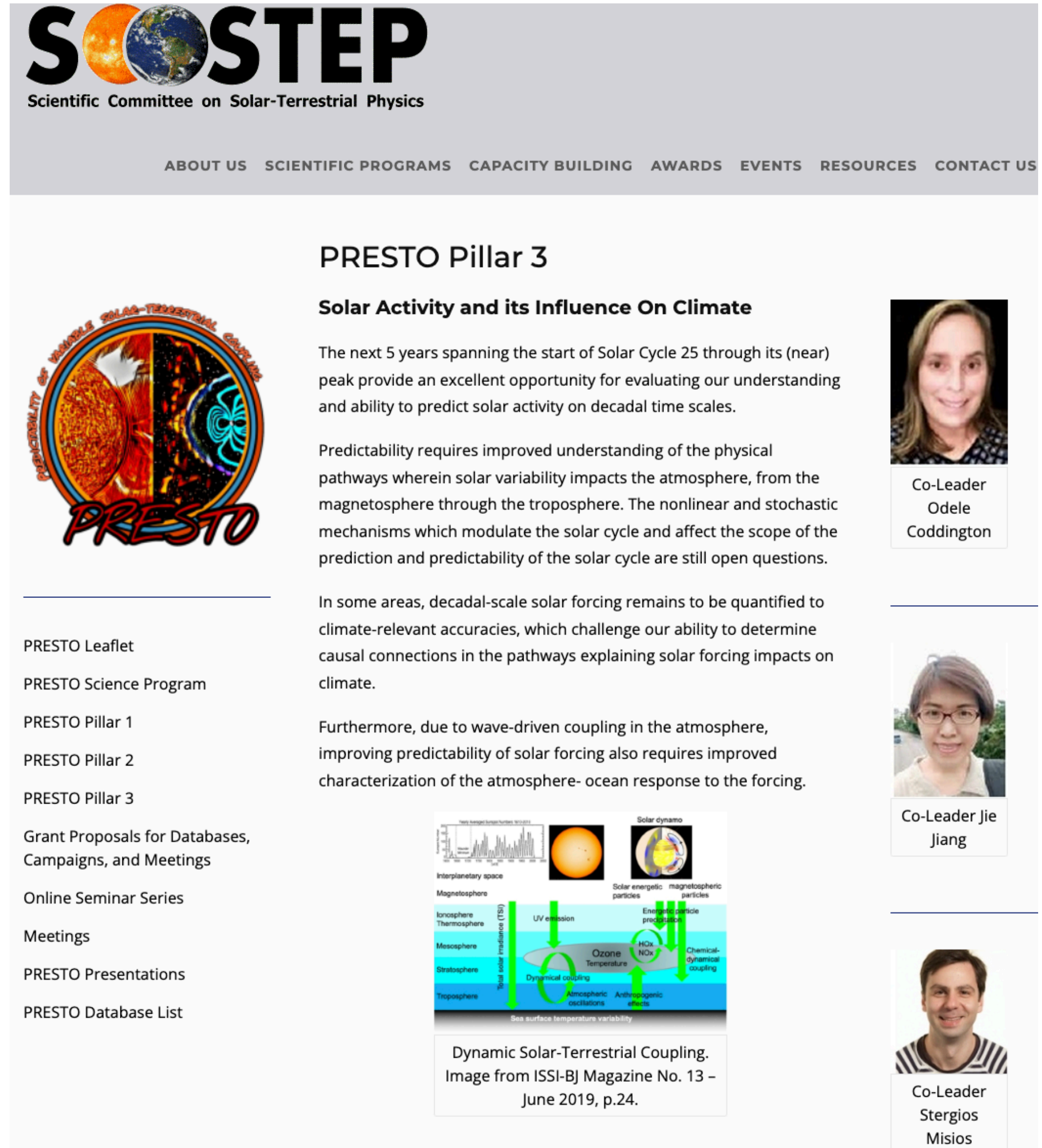
Solar activity and its influence on climate
https://scostep.org/pillar-3/

SPARC SOLARIS-HEPPA

Towards CMIP7 solar forcing recommendations

Working group meeting 15-17 June 2022 in Bergen

https://solarisheppa.geomar.de/bergen2020



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PRESTO Pillar 3

Solar Activity and its Influence On Climate

The next 5 years spanning the start of Solar Cycle 25 through its (near) peak provide an excellent opportunity for evaluating our understanding and ability to predict solar activity on decadal time scales.

Predictability requires improved understanding of the physical pathways wherein solar variability impacts the atmosphere, from the magnetosphere through the troposphere. The nonlinear and stochastic mechanisms which modulate the solar cycle and affect the scope of the prediction and predictability of the solar cycle are still open questions.

In some areas, decadal-scale solar forcing remains to be quantified to climate-relevant accuracies, which challenge our ability to determine causal connections in the pathways explaining solar forcing impacts on climate.

Furthermore, due to wave-driven coupling in the atmosphere, improving predictability of solar forcing also requires improved characterization of the atmosphere- ocean response to the forcing.

Dynamic Solar-Terrestrial Coupling. Image from ISSI-BJ Magazine No. 13 – June 2019, p.24.

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- PRESTO Pillar 3
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- Online Seminar Series
- Meetings
- PRESTO Presentations
- PRESTO Database List

Co-Leader Odele Coddington

Co-Leader Jie Jiang

Co-Leader Stergios Misios

Thank you

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