Proposed mechanisms driving the annual and semiannual oscillations in the T-I: A TIME-GCM perspective

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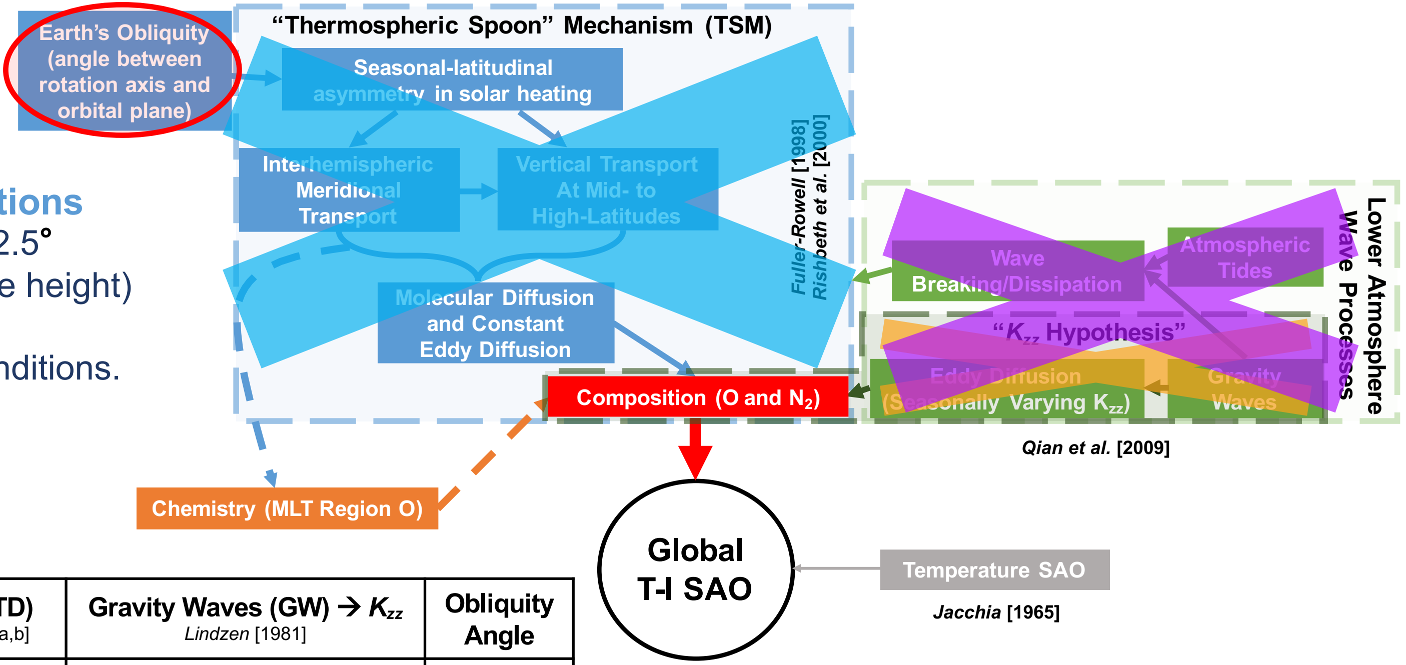
Numerical experiments performed using the NCAR TIME-GCM



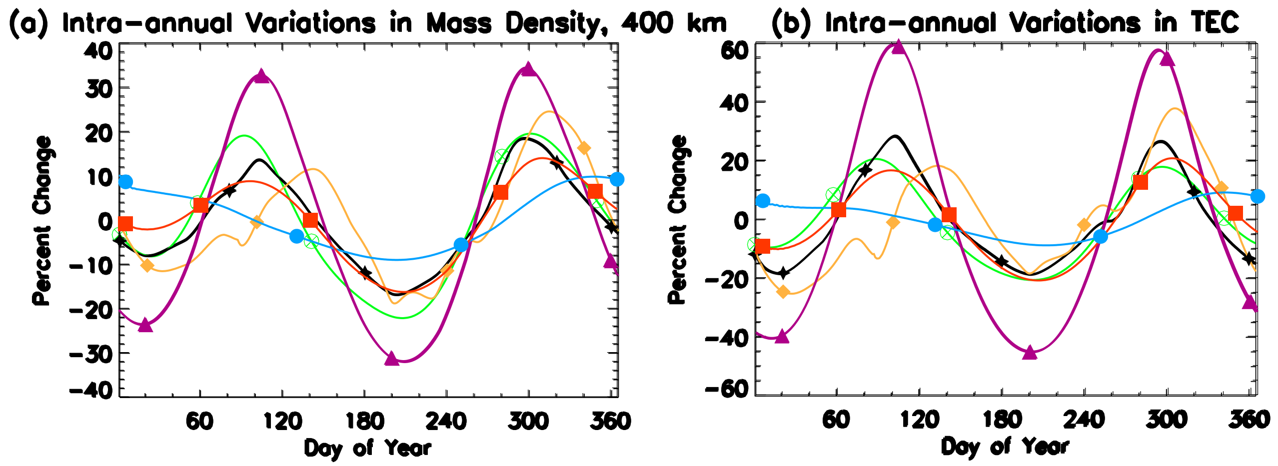
NCAR TIME-GCM[1] Simulations

- Double resolution (2.5° x 2.5° lon x lat, 4 points per scale height)
- $F_{10.7}$ = 110 sfu
- Geomagnetically quiet conditions.

TIME-GCM Simulation	Tidal LBCs (TD) *Zhang et al.* [2010a,b]	Gravity Waves (GW) → K_{zz} *Lindzen* [1981]	Obliquity Angle
Standard, Full Tilt	✓	✓	23.5°

[1] National Center for Atmospheric Research (NCAR) Thermosphere-Ionosphere-Mesosphere-Electrodynamics General Circulation Model (TIME-GCM)

IAVs in Globally Averaged Mass Density and TEC



	Mass Density at 400 km		TEC	
TIME-GCM Simulation/ Observed Climatology	Amplitude (%)	Phase (days)	Amplitude (%)	Phase (days)
Observed Climatology*	15.5	108	15.8	102
Standard, Full Tilt	12.8	114	19.7	106

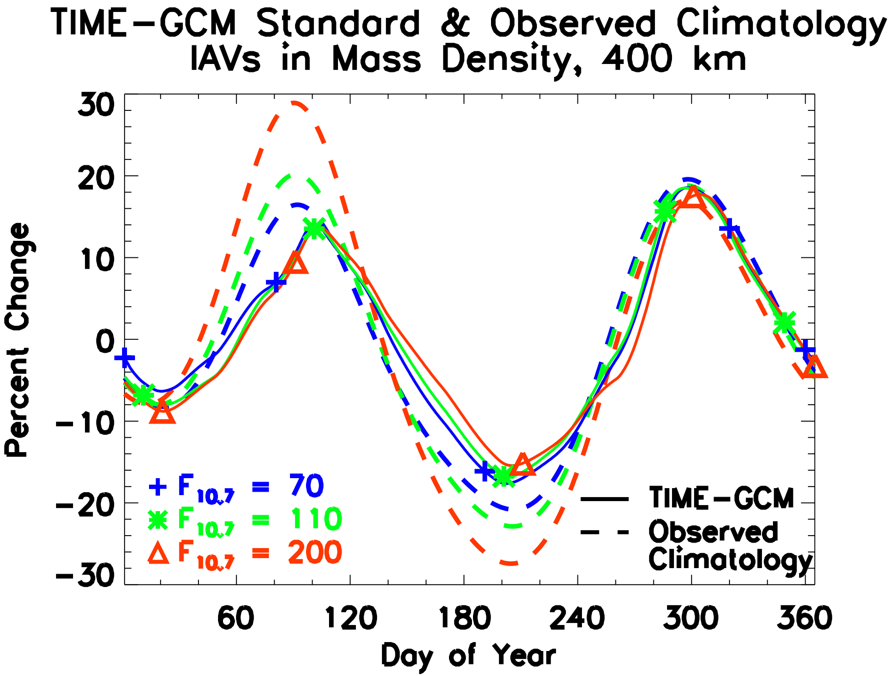
No GWs →
K_{zz} is seasonally-invariant →
T-I SAO is still present

No Waves but Half Tilt →
TSM weaker →
T-I SAO weaker

No Waves and Tilt →
No TSM →
Very Small T-I SAO

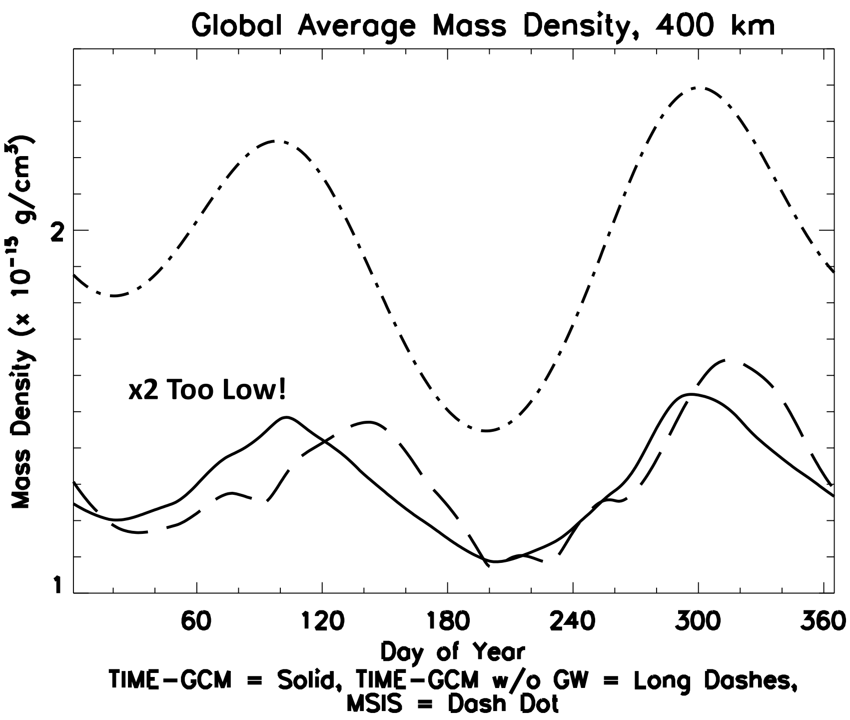
*from *Emmert et al.* [2015,2017]

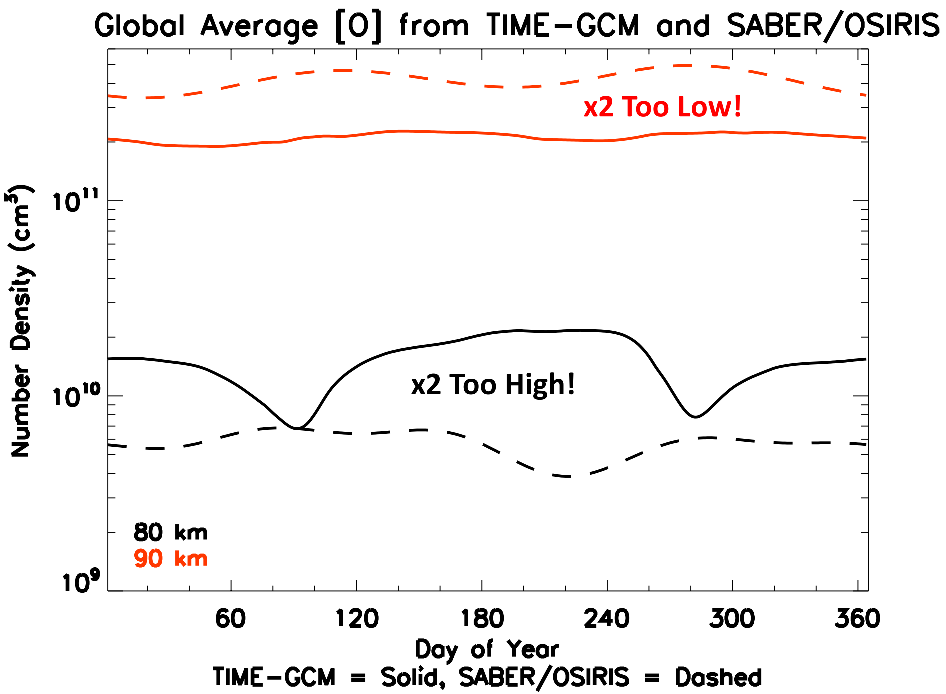
Solar Cycle Variability in SAO Amplitude



TIME-GCM does not reproduce the solar cycle variability in SAO amplitude.

Mesospheric composition issues manifesting in the Upper TI

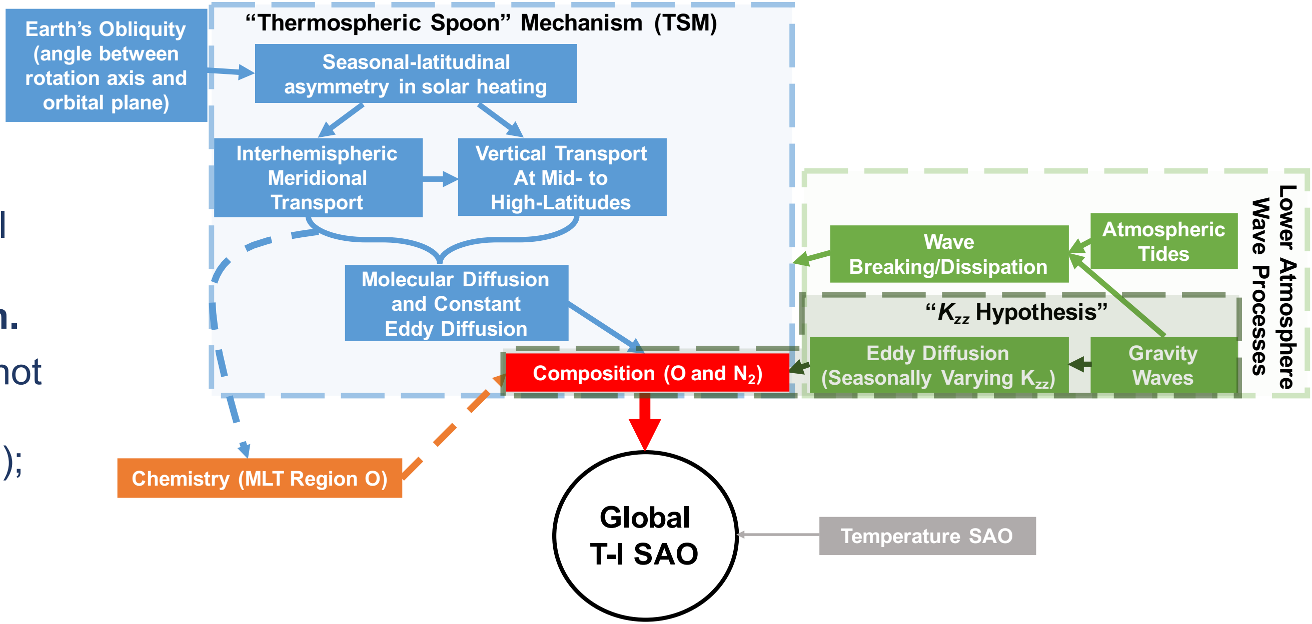




Throughout upper mesosphere TIME-GCM [O] is factor of ~2 different than SABER/OSIRIS.

Summary

- Earth's obliquity drives the global T-I SAO through seasonally varying large-scale advection of neutral thermospheric constituents, **i.e., the thermospheric spoon.**
- Seasonal variations in K_{zz} are not the primary driver of the global T-I SAO (*Jones Jr. et al.* [2017]); rather, tidal and gravity wave dissipation act to damp the obliquity-generated T-I SAO.



- The TIME-GCM does not reproduce the solar cycle variability associated with the T-I SAO amplitude.
- TIME-GCM simulations produce T-I AO amplitudes that are too small.
- [O] values in the TIME-GCM are off by a factor of ~2 in the MLT region → these then get mapped to the T-I and could be affecting the T-I IAVs.

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