Suggested "Standard" Model Simulations for Comparison

- First look at the ***"climatological" global* T-I AO and SAO** produced by the models ***"out-of-the-box" for a continuous yearlong simulation***.
  1) External Forcing
     i. ***Constant moderate solar conditions*** (model dependent, done in NCAR TGCMs using F10.7)
     ii. ***Constant quiet geomagnetic conditions*** (e.g., Kp =1 to eliminate IAVs in geomagnetic activity)
     iii. ***Include model wave forcing*** including planetary waves, tides, gravity waves including model's native gravity wave parameterization (if applicable).

  2) Output fields needed directly from model or calculated in post-processing should be saved in 3D or 4D with preferably and 1 hr cadence:
     i. Temperature, Mass and Electron Density
     ii. Composition: O, O_2, N_2, He, O/N_2, O^+
     iii. Neutral Winds: U, V, W, ω
     iv. E x B drifts: U, V, W
     v. Ionosphere: N_mF_2, h_mF_2, TEC
     vi. Other: K_{zz}, K_T, variables to calculate molecular diffusion coefficients

Metrics for calculating Intra-annual Variations → AO and SAO amplitudes

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$\overline{y}(\theta, z, t)$ = zonal and diurnal average quantity

$\overline{y}(\theta, z)_t$ = zonal and annual average quantity

$$\Delta y(\theta, z, t) = \frac{\overline{y}(\theta, z, t) - \overline{y}(\theta, z)_t}{\overline{y}(\theta, z)_t}$$

= Intra-annual variation in a zonal and diurnal average quantity relative to their ***local (latitude-dependent) annual averages***

$\left\langle y(z, t) \right\rangle$ = global (cosine-weighted) and diurnal average quantity $= y_g(z, t)$

$\left\langle y(z) \right\rangle_t$ = global (cosine-weighted) and annual average quantity $= y_{g,t}(z)$

$$\Delta y_g(z, t) = \frac{y_g(z, t) - y_{g,t}(z)}{y_{g,t}(z)}$$

= Intra-annual variation in a global and diurnal average quantity relative to their ***global annual averages***

$$\Delta y(\theta, z, t) = \frac{\overline{y}(\theta, z, t) - y_{g,t}(z)}{y_{g,t}(z)}$$

= Intra-annual variation in a zonal and diurnal average quantity relative to their ***global annual averages***

Metrics for determining the combined dynamical, chemical, and diffusive forcing of the T-I AO and SAO

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- **Parameters derived to explain species vertical distribution relative to diffusive equilibrium:**
  1. Hydrostatic contribution (gravitational contribution)
  2. Ideal gas law contribution (temperature contribution)
  3. Dynamics
  4. Chemistry

$$m_i^{eff} = \overline{m}\left[\frac{d(\ln n_i)}{d(\ln p)} + \frac{d(\ln T)}{d(\ln p)}\right]$$ ***= Effective mass***

$$\Sigma[\overline{y}(\theta, z, t)] = \int_{z_1}^{z_2} [\overline{y}(\theta, z, t)]dz$$ ***= Column species density***

(see *Jones et al. [2018]* for a description)

$$P = 28 \ln[O] - 16 \ln[N_2] + 12 \ln T$$ ***= P-Parameter*** (see *Rishbeth et al. [1987]* for a description)

$$\frac{1}{H^*_{\rho i}} = -\frac{1}{\rho_i}\frac{\partial \rho_i}{\partial z}$$

Actual density scale height of species i

$$\frac{1}{H_{\rho i}} = \frac{1}{H_{Pi}} + \frac{1}{H_{mi}} + \frac{1}{H_{Ti}}$$

Density scale height of species i in diffusive equilibrium

$$\frac{1}{H_{\rho}} = \frac{1}{H_{P}} + \frac{1}{H_{m}} + \frac{1}{H_{T}}$$

Total mass density scale height in diffusive equilibrium

$$\frac{1}{H_T} = \frac{1}{T}\frac{\partial T}{\partial z} \qquad \frac{1}{H_m} = -\frac{1}{m}\frac{\partial m}{\partial z} \qquad H_{Pi} = \frac{kT}{m_i g}$$

(see *Thayer et al. [2012]* and *Liu et al. [2014]* for a description)

Suggested Metrics to be Calculated from Model Simulations

- ***Global Mass Density IAVs at 250, 400, and 550 km (GAMDM Altitudes)***
  i. AO and SAO Amplitudes

- ***N_mF_2 and TEC IAVs***
  i. AO and SAO Amplitudes

- ***O, N_2, and O_2, Temperature, K_{zz}, Mass Density, Electron Density → 4D Distributions***

- ***For models with high LBCs (TIE-GCM and GITM)***
  i. Lower Boundary Conditions
     a) Momentum
     b) Mass/Constituents
     c) Energy
     d) Eddy Diffusion