
Dynamics

Basic equations

- Continuity equation

$$\frac{\partial n}{\partial t} = -div(n\vec{u})$$

- Equation of motion

$$\frac{\partial \vec{u}}{\partial t} = -\frac{1}{\rho}\nabla p - \nu_{ni}\vec{u} + \frac{\mu}{\rho}\frac{\partial^2 \vec{u}}{\partial z^2} - 2\vec{\Omega} \times \vec{u}$$

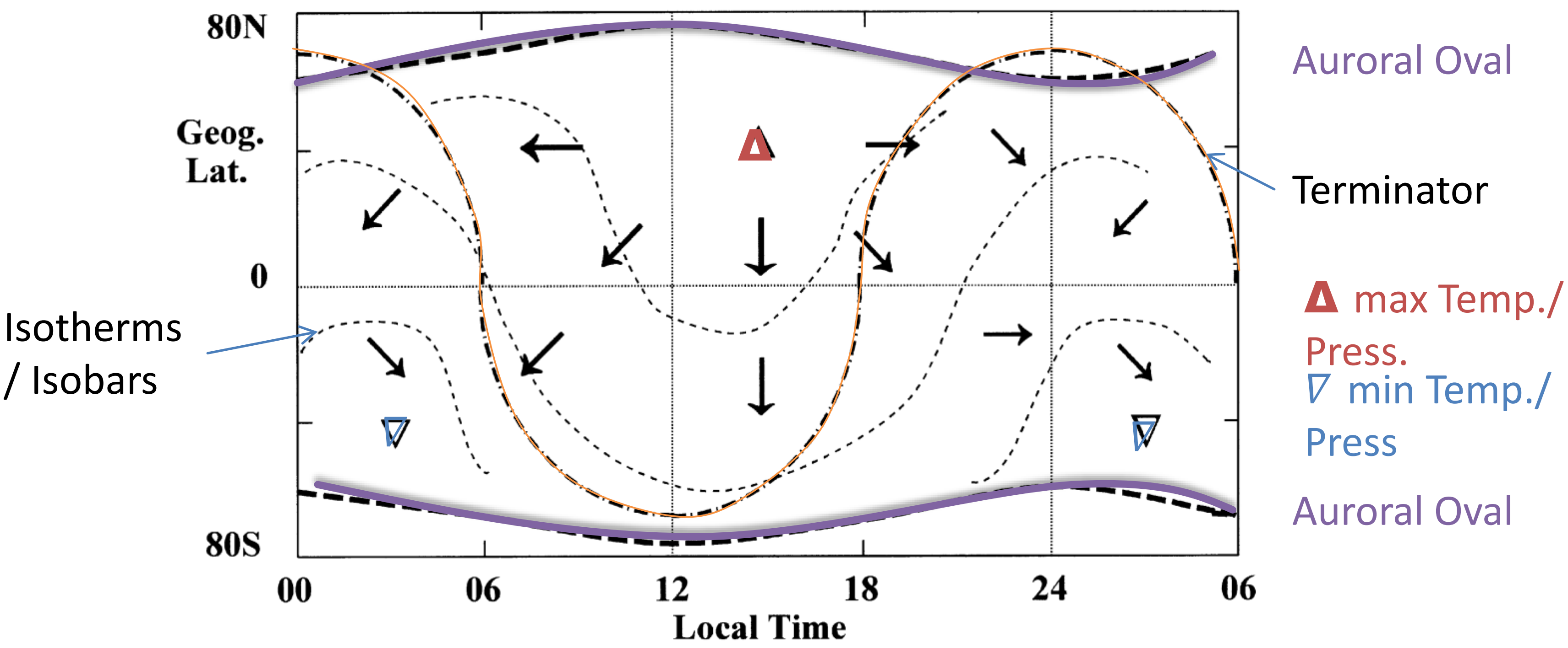
Solar driven circulation

$$\frac{\partial \vec{u}}{\partial t} = \underbrace{-\frac{1}{\rho}\nabla p}_{\text{I}} \underbrace{- \nu_{ni}\vec{u}}_{\text{II}} + \underbrace{\frac{\mu}{\rho}\frac{\partial^2 \vec{u}}{\partial z^2}}_{\text{III}} \underbrace{- 2\vec{\Omega} \times \vec{u}}_{\text{IV}}$$

I. Pressure gradient
II. Neutral-ion collision (ion-drag)
III. Vertical molecular diffusion
IV. Coriolis force

- I ≈ II
- II >> IV
- III: strongly inhibit vertical gradients in the wind field
- IV large in lower ionosphere, small in upper ionosphere

Pressure and temperature gradients



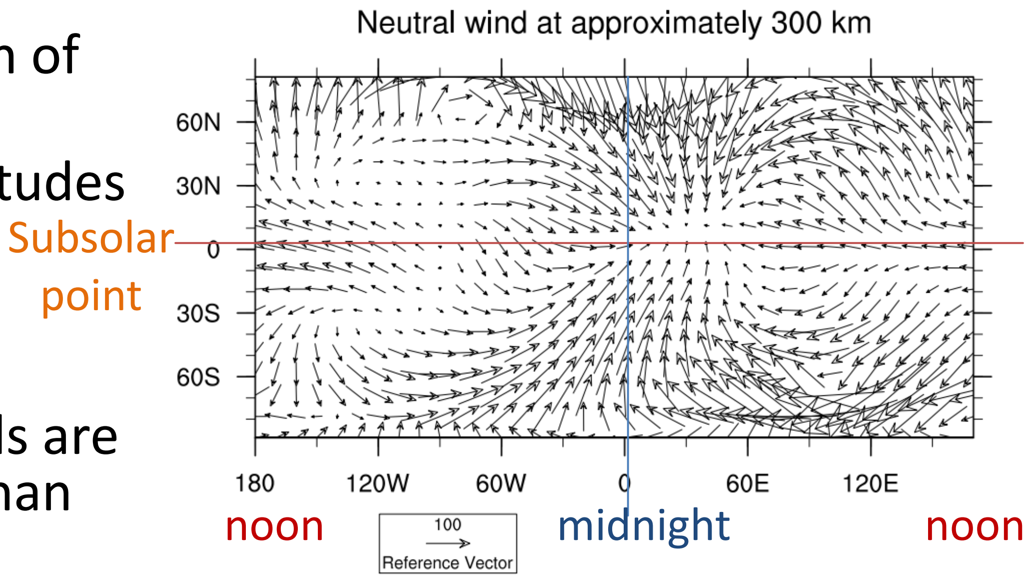
Rishbeth (1998)

Thermosphere winds

<u>300 km winds:</u>

- Mainly driven by diurnal variation in the absorption of solar UV radiation
- Some ion-drag in high latitudes
- Predominantly horizontal winds
- At middle and low latitudes the 300 km winds are generally larger at night than day

TIEGCM, 0 UT for September equinox solar-minimum conditions



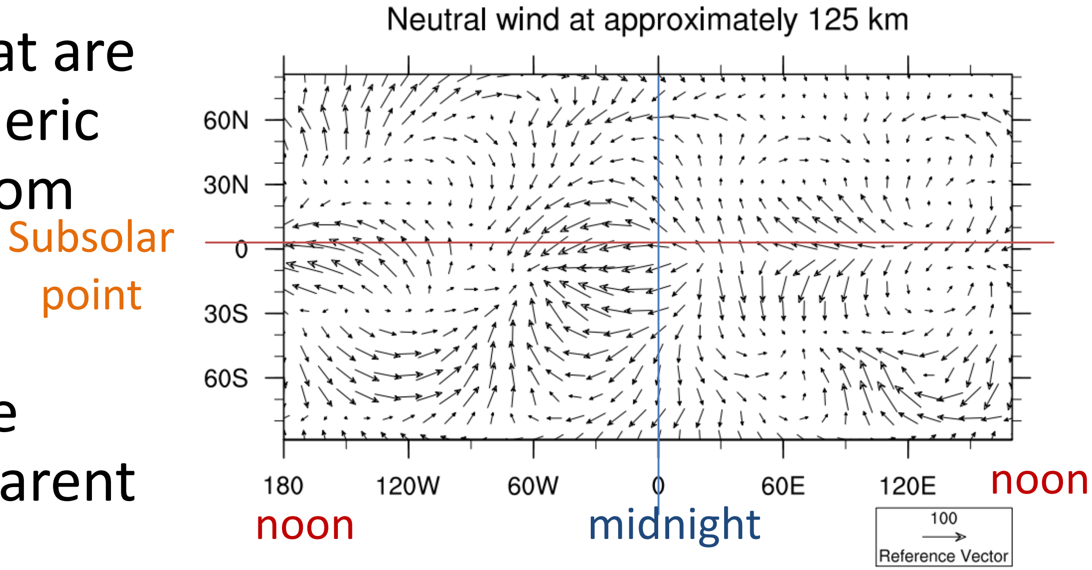
Richmond (1995)

Thermosphere winds

TIEGCM, 0 UT for September equinox solar-minimum conditions

<u>125 km winds</u>

- longitude variations that are dominated by atmospheric tides propagating up from the lower atmosphere
- tendency for the entire wind pattern to migrate westward with the apparent position of the Sun



Richmond (1995)

Vertical winds

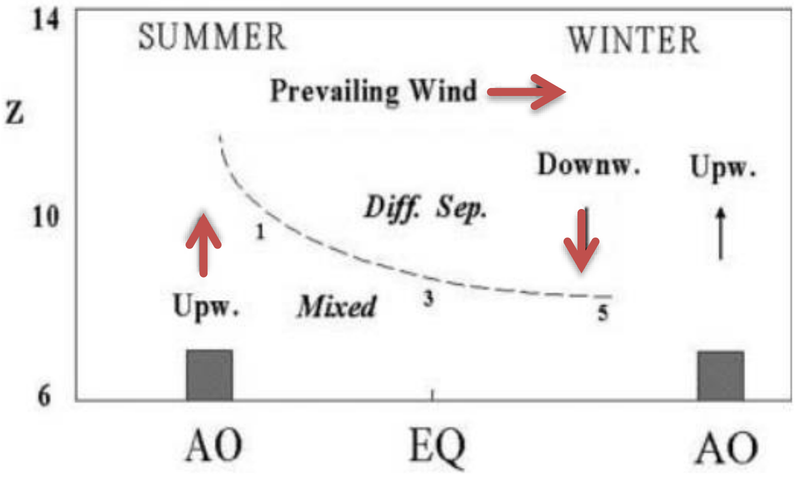
- $U_z = W_B + W_D = \left(\frac{\partial h}{\partial t}\right)_p - \frac{1}{\rho g}$
- Barometric motion W_B and divergence velocity W_D
- Barometric motion (positive or negative W_B) changes the [O/N_2] ratio and the mean molar mass at a fixed height, but not at a fixed pressure-level,
- Upwelling "positive W_D" decreases the [O/N_2] ratio and increases the mean molar mass,
- Downwelling "negative W_D" increases the [O/N_2] ratio and decreases the mean molar mass.

- Dickinson and Geisler (1968) showed that vertical winds play an important role in determining the amplitude and phase of the temperature response with respect to EUV heating

Rishbeth (1998)

Molecular mass transfer

- The composition changes, produced by vertical motions, are propagated horizontally by the global wind system
- Low O/N2 ratio in mid-latitudes in summer
- High O/N2 ratio in winter



Rishbeth et al. (2000)

Atmospheric waves

- Waves often represent an important mechanism for transporting energy and momentum from one point to another in an atmosphere
- Gravity waves, tides, planetary waves
- Many of the above waves are capable of propagating or penetrating to higher altitudes where they undergo dissipation and deposit heat and momentum into the mean flow.

Modelled temperature tides

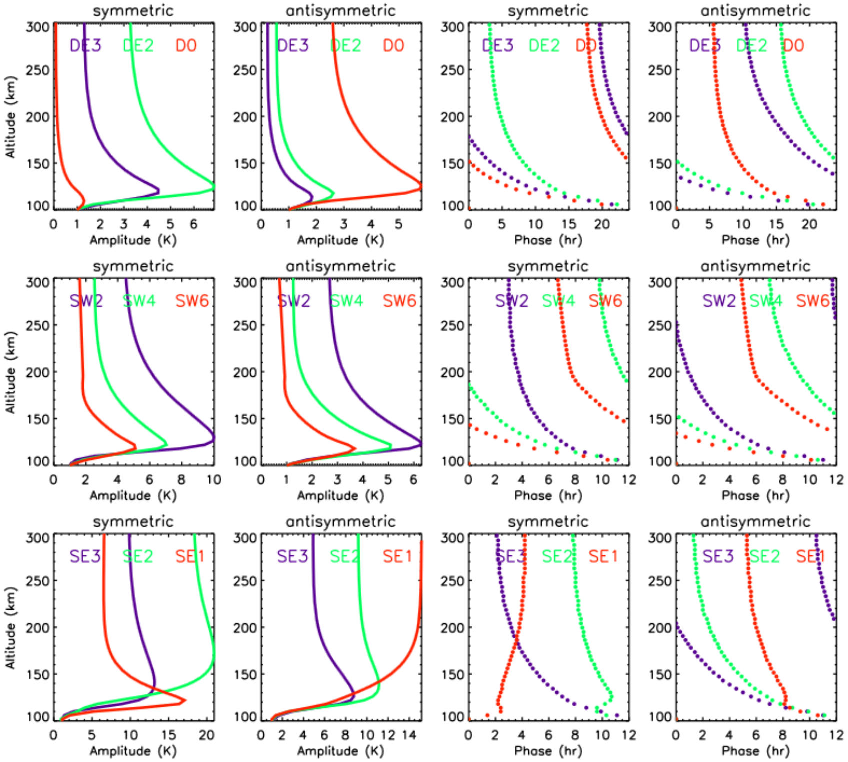


Figure 1 Amplitude and phase vertical structures. HME temperature amplitude and phase vertical structures of the various non-migrating diurnal and semidiurnal tidal components considered in this study.

Forbes et al. (2014)