

The Upper Atmosphere

Homework #1.

At 200 km altitude the the thermospheric atomic oxygen density is $4.0 \times 10^9 \text{ cm}^{-3}$

The atomic oxygen scale height is 50 km.

The Helium Density is $6 \times 10^6 \text{ cm}^{-3}$

The temperature is independent of height above 200 km

What is the mean molecular weight of these two species at 200 km

$$\begin{aligned}\bar{M} &= \frac{M_{He}N_{He} + M_O N_O}{N_{He} + N_O} \\ &= \frac{4 \times 6 \times 10^6 + 16 \times 4 \times 10^9}{6 \times 10^6 + 4 \times 10^9} \approx 16\end{aligned}$$

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What is the mean molecular weight of these two species at 600 km

$$\bar{M} = \frac{M_{He}N_{He} + M_O N_O}{N_{He} + N_O}$$

$$N_{He600} = N_{He200} \exp\left(-\frac{400}{H_{He}}\right) \quad ; \quad N_{O600} = N_{O200} \exp\left(-\frac{400}{H_O}\right)$$

$$H_O = 50 \quad ; \quad H_{He} = H_O \times 4 = 200$$

$$N_{He600} = 6 \times 10^6 \exp(-2) \approx 8 \times 10^5 \quad ; \quad N_{O600} = 4 \times 10^9 \exp(-8) = 1.4 \times 10^6$$

$$\bar{M} = \frac{4 \times 8 \times 10^5 + 16 \times 1.4 \times 10^6}{8 \times 10^5 + 1.4 \times 10^6} \approx \frac{256 \times 10^5}{22 \times 10^5} \approx 11.6$$

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Homework #2.

Go to

http://omniweb.gsfc.nasa.gov/vitmo/msis_vitmo.html

For July 12, 2012 at 15:00 local time and 0° geographic latitude and 180° longitude download an ascii file containing profiles of the following:

The densities of O, O₂, N₂ and He

The neutral Temperature T_n

At altitudes from 0 to 1000 km with a 5 km step size.

Make a list file to import to excel or any other data manipulation and display software of your choice.

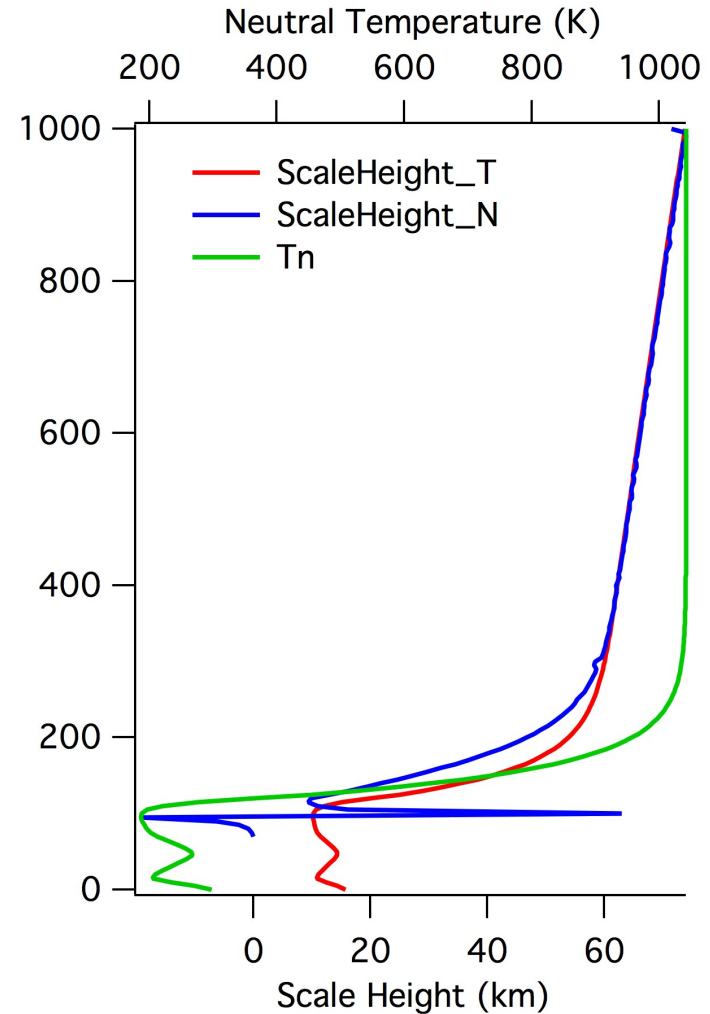
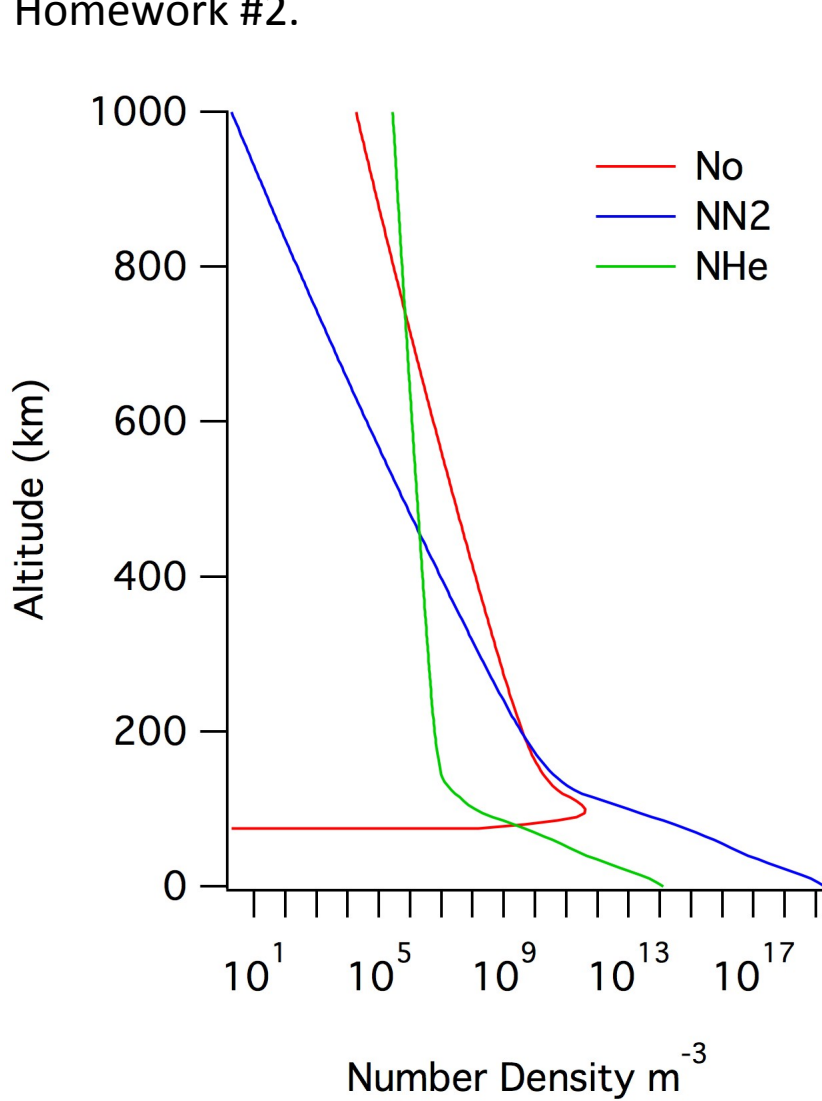
Compute and plot the scale height of atomic oxygen by differentiating the density profile

Compute and plot the scale height of atomic oxygen using the temperature profile.

Comment on any differences you find.

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Homework #2.



They are different if you do not account for altitude dependence of temperature and gravity.

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Homework #3.

The daytime E-region consists of equal concentrations of NO^+ and O_2^+ . These species are lost by recombination with reaction rates of $4 \times 10^{-8} \text{ cm}^3 \text{ s}^{-1}$ and $1 \times 10^{-7} \text{ cm}^3 \text{ s}^{-1}$ respectively.

If the total ion concentration is $4 \times 10^4 \text{ cm}^{-3}$ what is the ionization production rate ?

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Homework #3.

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If the total ion concentration is $4 \times 10^4 \text{ cm}^{-3}$ what is the ionization production rate ?

E region is in photochemical equilibrium $P=L$

Loss is due to recombination

$$L = k_1 N_{\text{NO}^+} N_e + k_2 N_{\text{O}_2^+} N_e$$

$$L = k_1 0.5 N_e N_e + k_2 0.5 N_e N_e$$

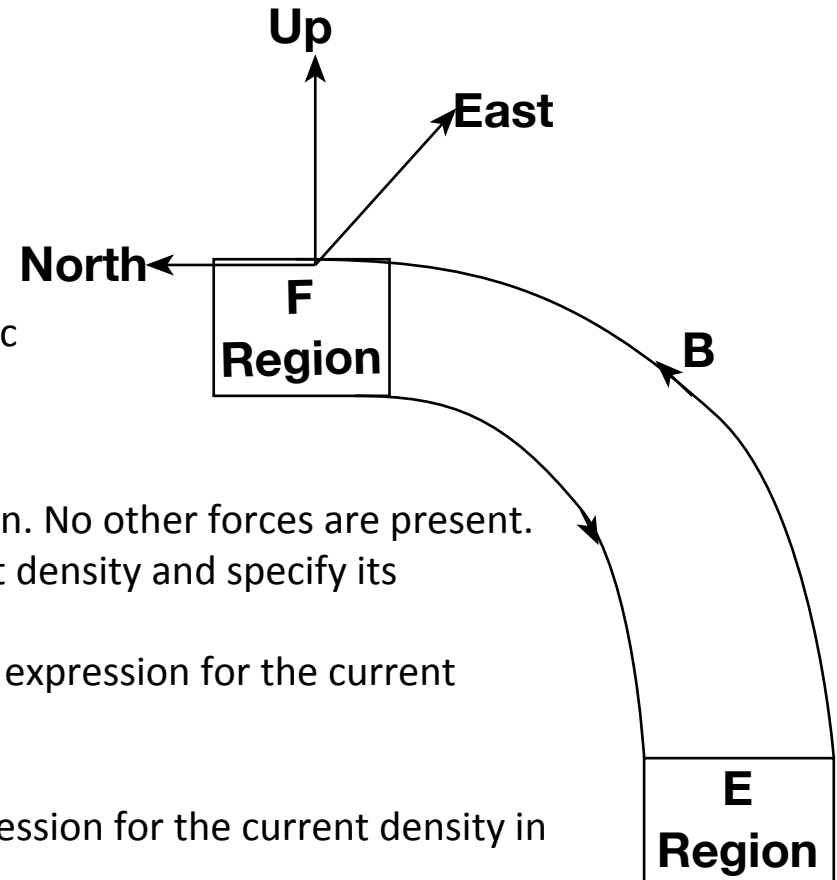
$$L = 4 \times 10^{-8} \times 0.5 N_e N_e + 1 \times 10^{-7} \times 0.5 N_e N_e$$

$$L = 7 \times 10^{-8} \times 16 \times 10^8 = 112 \text{ cm}^{-3} \text{ s}^{-1}$$

Ionosphere-Thermosphere Currents

Homework #4

Consider an F region and E region as uniformly conducting slabs connected by equipotential magnetic field lines as shown in the figure to the right.



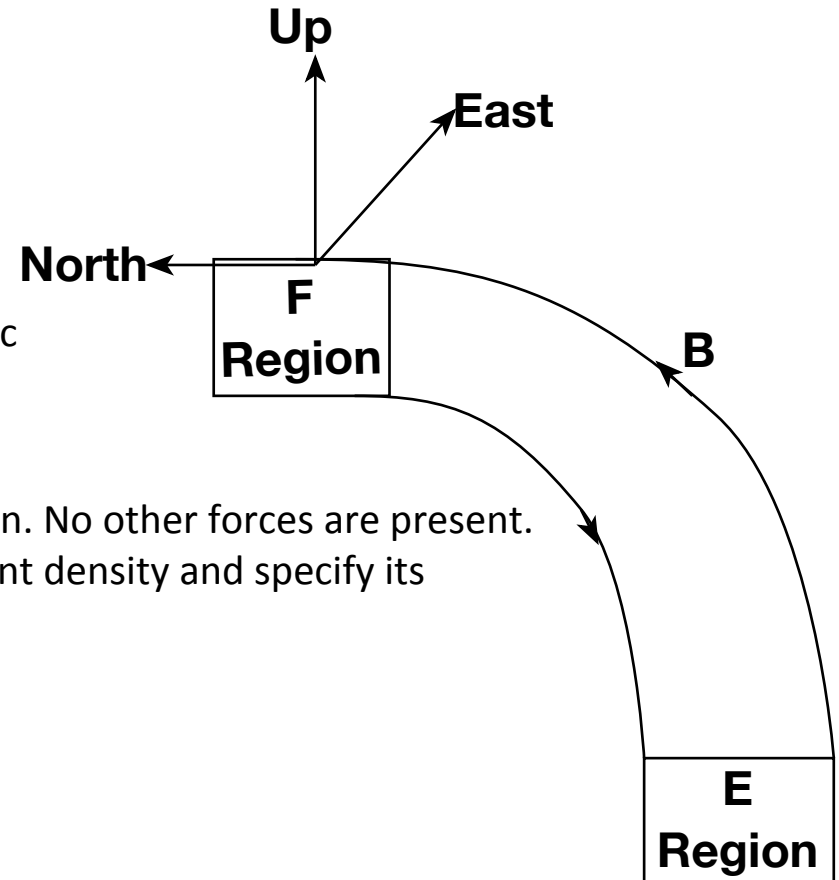
A constant neutral wind blows to the east in the F region. No other forces are present.

- 1) Write an expression for the magnitude of the current density and specify its direction.
- 2) If this current is driven through the E region write an expression for the current density in terms of the electric field in the E region.
Explain your reasoning for the expression you write.
- 3) This electric field maps to the F region; write an expression for the current density in the F-region from this field.
- 4) By equating the total current density in the E and F regions write an expression for the plasma drift in the F region in terms of the neutral wind and the conductivities
- 5) What happens when the E-region conductance is infinite and zero respectively?

Ionosphere-Thermosphere Currents

Homework #4

Consider an F region and E region as uniformly conducting slabs connected by equipotential magnetic field lines as shown in the figure to the right.



A constant neutral wind blows to the east in the F region. No other forces are present.

- 1) Write an expression for the magnitude of the current density and specify its direction.

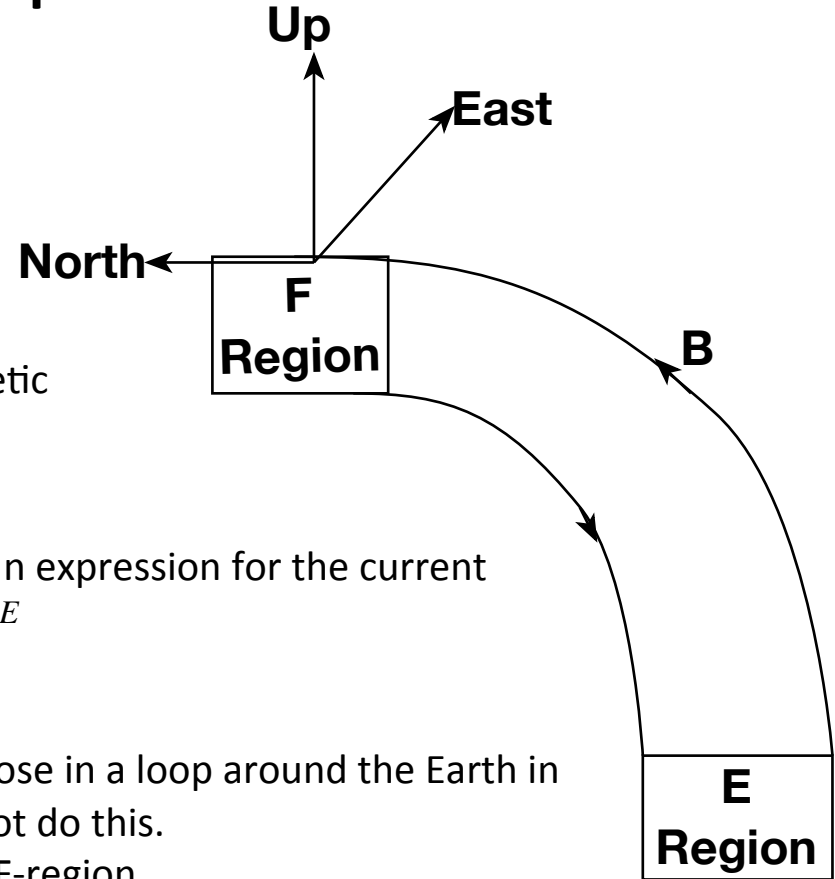
$$J_F = \sum_F^P (U \times B)$$

Current is upward

Ionosphere-Thermosphere Currents

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Consider an F region and E region as uniformly conducting slabs connected by equipotential magnetic field lines as shown in the figure to the right.



2) If this current is driven through the E region write an expression for the current density in terms of the electric field in the E region $J_E = \Sigma_E E$
 Explain your reasoning for the expression you write.

If the current were east-west then it would have to close in a loop around the Earth in the E region. A E-field in the east-west direction cannot do this.
 There is no force to drive an east-west current in the F-region

The current must flow equatorward in the E region

$$J_E = \Sigma_E^P E$$

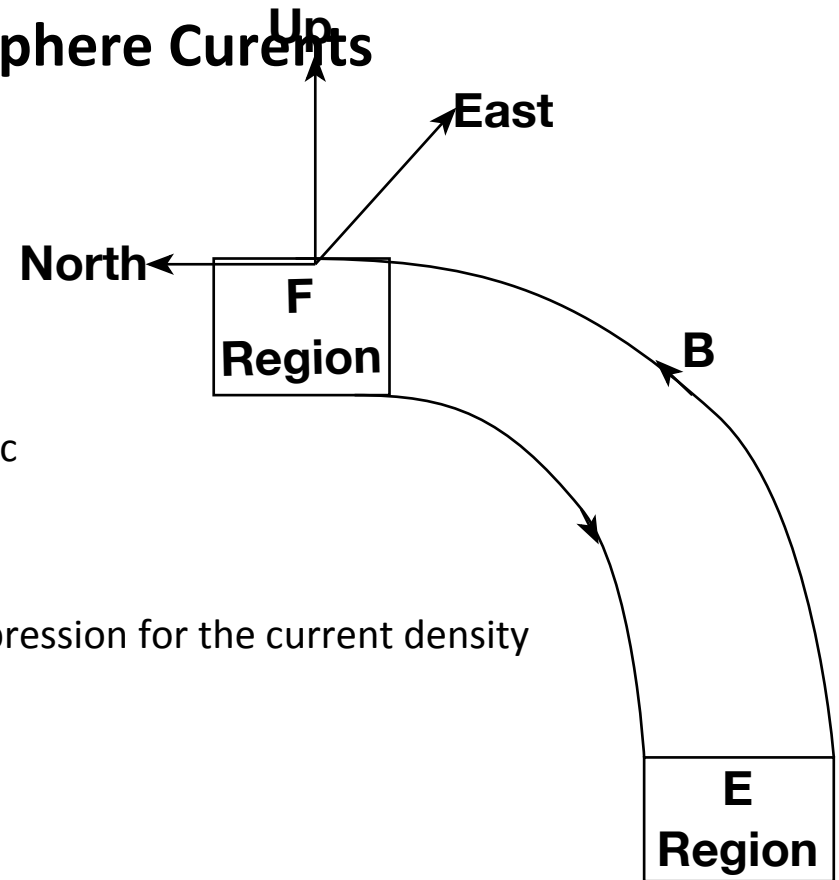
Ionosphere-Thermosphere Currents

Homework #4

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3) This electric field maps to the F region; write an expression for the current density in the F-region from this field.

This current is directed vertically downward

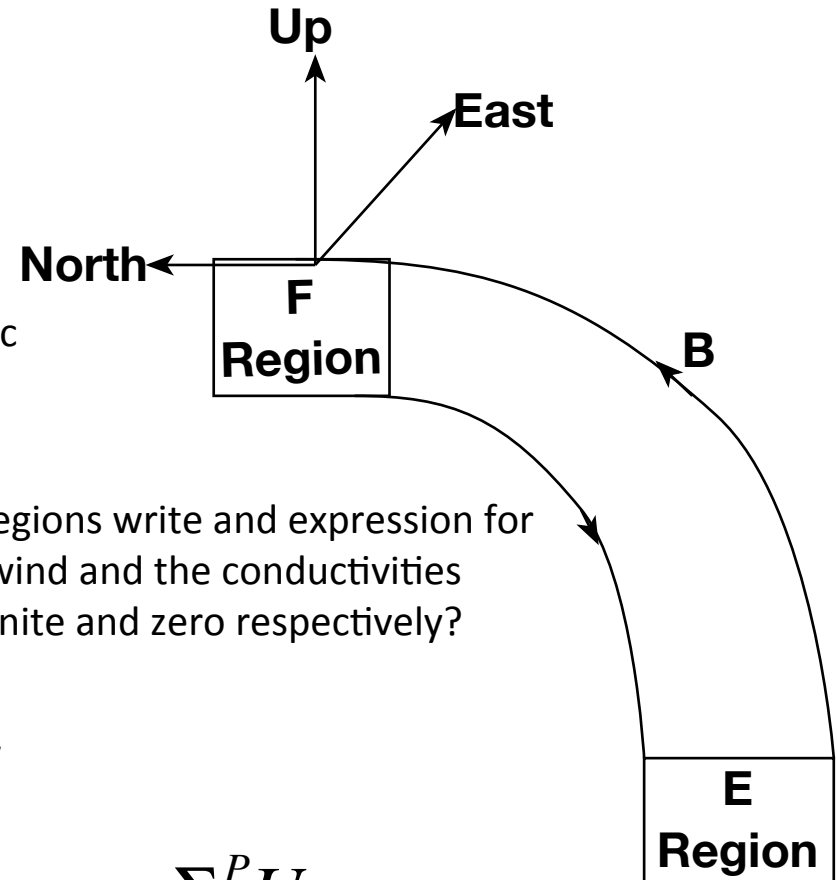


$$J_F = \sum_F^P (UB) - \sum_F^P E$$

Ionosphere-Thermosphere Currents

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- 4) By equating the total current density in the E and F regions write an expression for the plasma drift in the F region in terms of the neutral wind and the conductivities
 5) What happens when the E-region conductance is infinite and zero respectively?

$$J_F = \sum_F^P UB - \sum_F^P E = J_E = \sum_E^P E$$

$$E = \frac{\sum_F^P UB}{\sum_F^P + \sum_E^P} \quad ; \quad V_P = \frac{E}{B} \Rightarrow V_P = \frac{\sum_F^P U}{\sum_F^P + \sum_E^P}$$