A Changing Thermosphere

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Thermosphere
“Heat Sphere”

• Temperature increases with height

• ~80km to ~600km

• Includes Ionosphere

• Affected by solar radiation

• A Reducing Environment
Thermosphere Cooling?

- Thermosphere thins with height
- Lower density = fewer collisions
- Fewer collisions = less energy radiated back to Earth, and thus cooling
- Density has decreased by 10% in the last 35 years

Increasing amounts of greenhouse gases work in the opposite way in the thermosphere, they radiate heat back to space

- As this happens, thermosphere condenses, each layer moves down, creating smaller differences between the layers
- Example is Venus, extremely hot troposphere and an extremely cold thermosphere
Chemistry

• Three body collisions aren’t common due to low pressures
• Atomic Oxygen = main constituent
• High temperatures drive oxidation reactions in the reverse direction
• Photodissociation of Oxygen
Photodissociation

**Oxygen**
- $\text{O}_2 + \text{hv} \rightarrow \text{O} + \text{O}$
- Gravity separates molecules (Nitrogen at bottom, Oxygen in middle, H and He at top)
- Doesn’t occur at any other part of the atmosphere

**Nitrogen**
- $\text{N}_2 + \text{hv} \rightarrow \text{N} + \text{N}$
- Photodissociation of N2 only occurs at high altitudes
Recombination

**Oxygen**
- $O + O \rightarrow O_2$
- $O + N + [M] \rightarrow NO$
- Cyclical Process

**Nitrogen**
- $N + NO \rightarrow N_2 + O$
- $N + O_2 \rightarrow NO + O$
Thermosphere Reactions

Photodissociation

Photodissociation of Oxygen ($O_2$)

Recombination

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Ionosphere

• Shell of electrons and electrically charged atoms and molecules

• UV, X-Rays, and short wavelengths of solar radiation are ionizing

• Dependent on the sun and its’ solar activity

• Auroras occur here due to solar wind, collisions between ions and atoms become more frequent, causing them to release energy in the visible wavelength
Auroras
Solar Wind

• Solar wind: flux of electrons and protons
• Usually deflected by magnetic field
• During intense sunspot events, flux can reach as low as 150km
• High ion densities increases the conductivity of the atmosphere
• This disrupts power distribution and communication systems.
Effects on Satellites

- Dependent on density of the thermosphere
- Extra heating from solar fluxes causes the outer atmosphere to expand, causing more drag on satellites
- Satellites enter lower regions of the atmosphere, and disintegrate
- Damaging CO2 caused by fossil fuel burning
- Condensing atmosphere causes more space junk to be suspended
Economy

• Satellites orbit in the Thermosphere
• Lower density means less drag by the atmosphere
• Lower fuel costs
• Projected millions of $ of fuel costs saved
SPACE JUNK
It's like dodging bullets up there
Dangers of Space Junk

• 4 million lbs of junk, some traveling at speeds of up to 17,500mph
• Any contact could destroy a satellite or spacecraft
• Usually are pulled down by gravity and disintegrate
• Since the atmosphere is becoming less dense, the junk is suspended for longer periods of time
• “For the first time, junk is the single biggest risk factor to equipment in some orbits” (Fred Guteri, Newsweek)
Conclusion

• Thermospheric cooling

• Our GHG emissions are condensing our upper atmosphere
References

- http://www.sp.ph.ic.ac.uk/~ingo/Reading_material/Rees_Chapters%201_2.pdf
- http://ecjones.org/propag.html
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Questions?