Thermospheric Expansion - CEDAR Notes:

Go ahead and make comments here!

2) What gaps in understanding must be filled to enable predictive simulations?

Liying Qian (Overview Talk)1) What are the goals of predicting thermospheric expansion?

Eric Sutton (Overview Talk)

Satellite drag accuracy study: DOD perspective

Three major requirements: Reentry prediction, collision avoidance, accurate pointing requirement

Hejduk and Snow, 2018, SW: SD is the dominant error for predicting the position of low perigee satellites. The higher the altitude, the larger the density uncertainty.

VMAG estimation every 100 km. SD error threshold need to meet SSA requirement at 70% level or 95% level. Extremely challenging for solar maximum!

Latitudinal difference of density anomaly is not available. 72 hour prediction difficult because of error propagation.

Ballistic coefficient is highly dependent upon environmental parameters. What is a realistic goal? Inputs to the model are important but we don't have them. Some physics in the model is missing even with perfect input. Initial state is important too.

Model upper boundary is around 600 km. Need exosphere model for higher altitudes. Ion upflow/outflow important for changing high altitude exosphere. Need to think about the coupling between ionosphere and thermosphere.

SD force determined by multiple parameters. The most important is mass density.

Temporal and spatial variations:

annual/semi annual variations depend on latitudes, longitudes and species. Yue et al., to be submitted.

Need to find out the latitudes where the large mass density errors occur and not orbit-averaged. It should also be storm-phase dependent. High latitude at the initial phase and then later mid/low latitudes due to energy propagation. Complicated by both internal and external forcing working at the same time.

How important is the chemistry specification in the model? Fundamental parameters, such as Ionization and absorption parameters, need to be revisited. Should reach community consensus on important parameterizations in the model. JPL standard?

1958 solar cycle:(from Allen)

Unusual features of the 1957-1958 solar maximum.

EUV activity was greater than that in any subsequent solar cycle. Thus any attempt to model a future solar cycle like this one will run into the problem that we are extrapolating from subsequent data and assuming that it will produce a reasonable description of expansion during extreme EUV conditions, this is not necessarily a reasonable assumption.

There are unusual observations from ionosondes in the period between 1958 (when we had a great expansion in the number of ionosondes from a handful – I have not written any of this material up yet and would appreciate the opportunity to do so, some of this is hearsay, rather than a detailed analysis at this point). First, the middle latitude, middle of the day, summer NmF2 does not seem to change much between 1958 and 1961, suggesting saturation. However, there is a very large decrease in NmF2 in the middle of the day from 1958 to 1961, suggesting that there may have been a “super” winter anomaly in 1958. Second, the large winter anomaly led to a large feeding of NmF2 into the southern polar cap (there are no suitable data in the north, so that must remain unknown). This may have led to an enhanced tongue of ionization and boundary blobs in the south.

1982: DE-2 data simultaneous plasma and neutral measurements

Jeff Thayer (Overview - MI Coupling and Joule Heating)

High-latitude energy input: poynting flux is a proxy of incoming energy. Let et al. 2008: CIR storms impact. Long lasting. High occurrence rate. CIR and CME storms are different in terms of their impact on thermosphere.

Density scale height vs pressure

Compressed thermosphere leads to a greater % change in density even with the same energy input.

Prolss, 2011

Interplay among diffusion, mixing and eddy diffusion.

3) What modeling advances are needed for prediction?

Hanli Liu (Overview - Whole Atmosphere Perspective)

WACCM-X: Liu, H. X. 2005, Liu et al. 2018, Liu, J. 2018.

2008 June EIA has a peak in COSMIS in the NH but all models predict peak in the SH.

NmF2 underestimated in the equator and mid latitudes.

Chuck Bardeen highlight science on March 17, 2013 storm

AMIE driven WACCM-X and TIEGCM of March 17, 2015 storm

Large eddy diffusion coefficient, TEC decrease.

Pedatella and Liu, 2018: internal atmosphere variability has big effect storm-time TEC.

Need to characterize the atmosphere state (initial and boundary conditions)

Aaron Ridley (Overview - Energy from Above)

High-latitude drivers and measurements needed:

Effect of average energy is important. Need global measurements of auroral incoming energy flux and average energy. Thermosphere is extremely undersampled.

Drivers and responses should be at the same location. Precipitating particle energy spectrum is needed. Cubesphere grid can help solve singularity and pole issues. Adaptive mesh refinement would be a great improvement. Tracking features in the model instead of averaging over grid would be helpful.

Model improvement needed:

Eddy diffusion and gravity wave dissipation

Winds are difficult to model

Need Aaron's slide!

4) What observations are necessary to provide the basis for understanding and modeling?

Tomoko (Data Assimilation Overview)

Model uncertainty: forced dissipative dynamical system highly dependent on details of the external forcing and internal dissipation processes.

Thermosphere mass density and composition can be assimilated but more difficult than ionosphere. Coupled ionosphere-thermosphere assimilation help to infer neutral states from ionosphere observations.

5) What instrumentation is necessary to provide those observations?

Mark Conde (Overview)

Heating

Wind changes

Composition perturbations

Bistatic SDI, FPI arrays, Close-spaced SDIs, geophysical inverse reconstruction of winds at different altitudes

Lots of small scale E-region wind features

Small-scale features in F-region wind are important and has global effect.

Brian Harding (FPIs)

Can measure O density and temperature profiles twice a day from the ground, during sunset and sunrise

Ground based optics have limitations and advantages.

Ruth (for Dave Fritz) - Enabling technologies (CubeSats)

DWTS: doppler wind and temperature sounder ~17-200km

Need to track perturbations coming from the troposphere and stratosphere

NO can be sensed > 90km and below 50 km.CO2 below 110km.

It can produce T and CT winds between 25-250 km, day+night. AT wind > 90 km, <50 km, day+night