Data Assimilation of Thermosphere Neutral Densities in WAM

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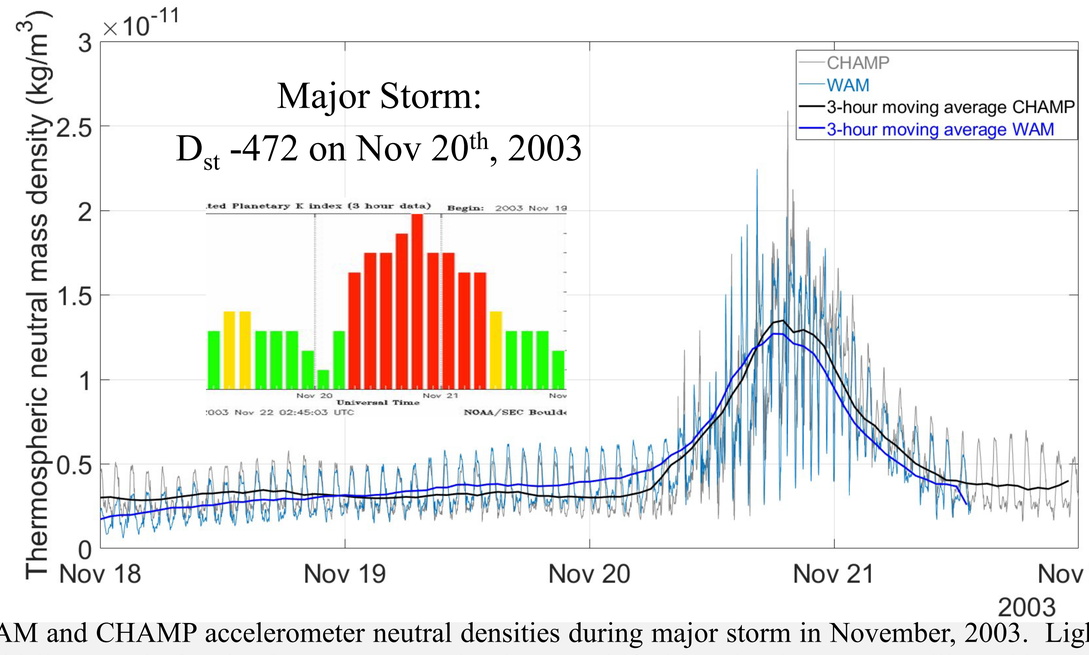
Research Goal

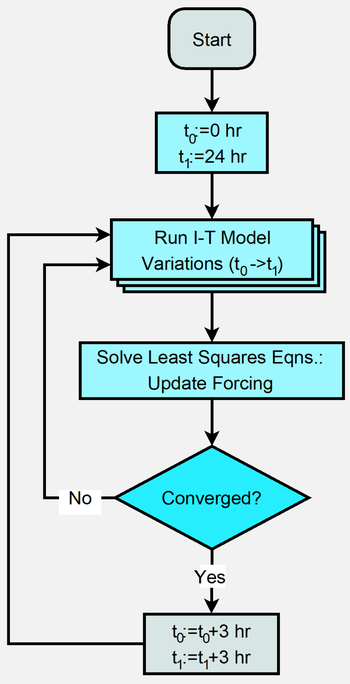
- Improve WAM thermosphere neutral density
- Quantify uncertainties of GUVI neutral density
- Altitudinal, co-located, and simultaneous analysis of GUVI neutral density.

1. WAM neutral density and CHAMP accelerometer

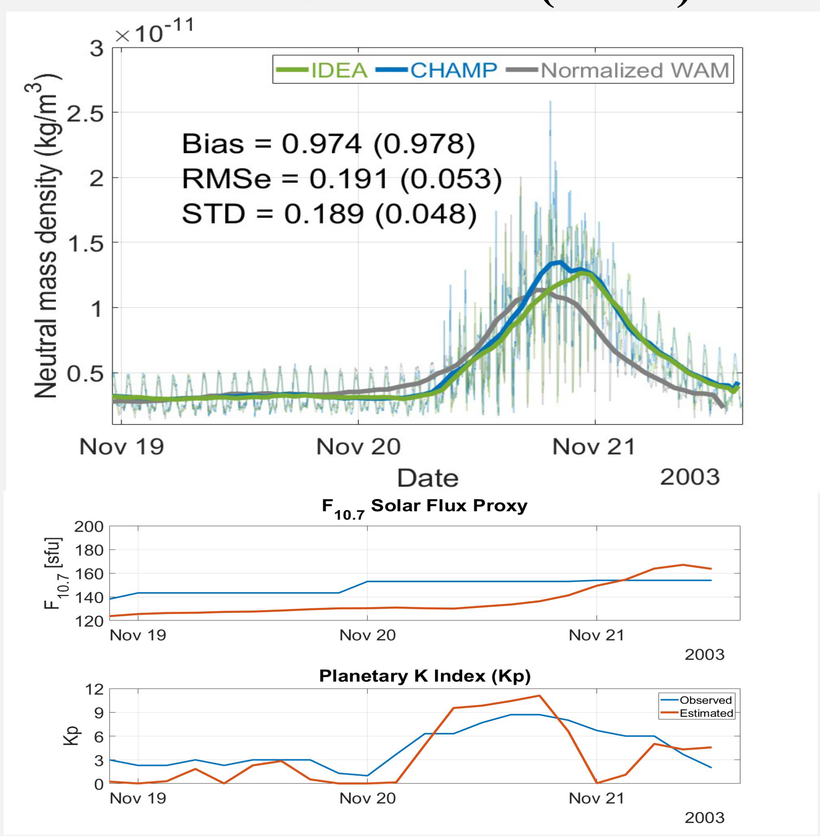


WAM and CHAMP accelerometer neutral densities during major storm in November, 2003. Light blue solid line stands for the free-run WAM density sampled along the CHAMP satellite orbit. Blue and black solid lines represent 3-hour moving average of CHAMP and WAM densities with 1-hour resolution.

2. Iterative Driver Estimation & Assimilation (IDEA): Sutton (2018)

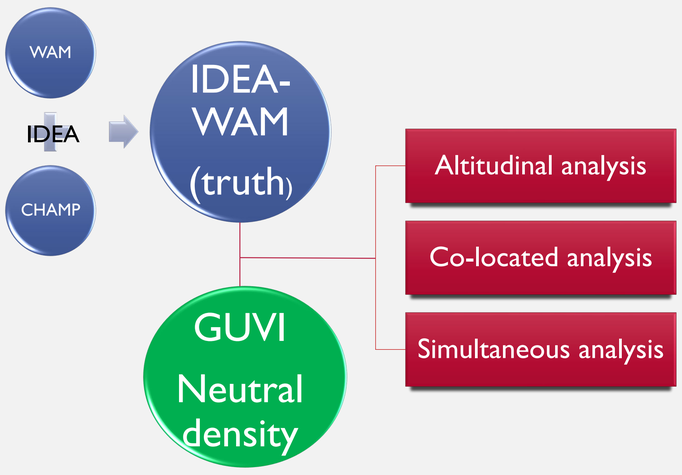


- The IDEA technique is used to improve data/model agreement.
- The IDEA data assimilation technique adjusts Kp and F10.7 inputs to align modeled neutral mass density with the corresponding data.



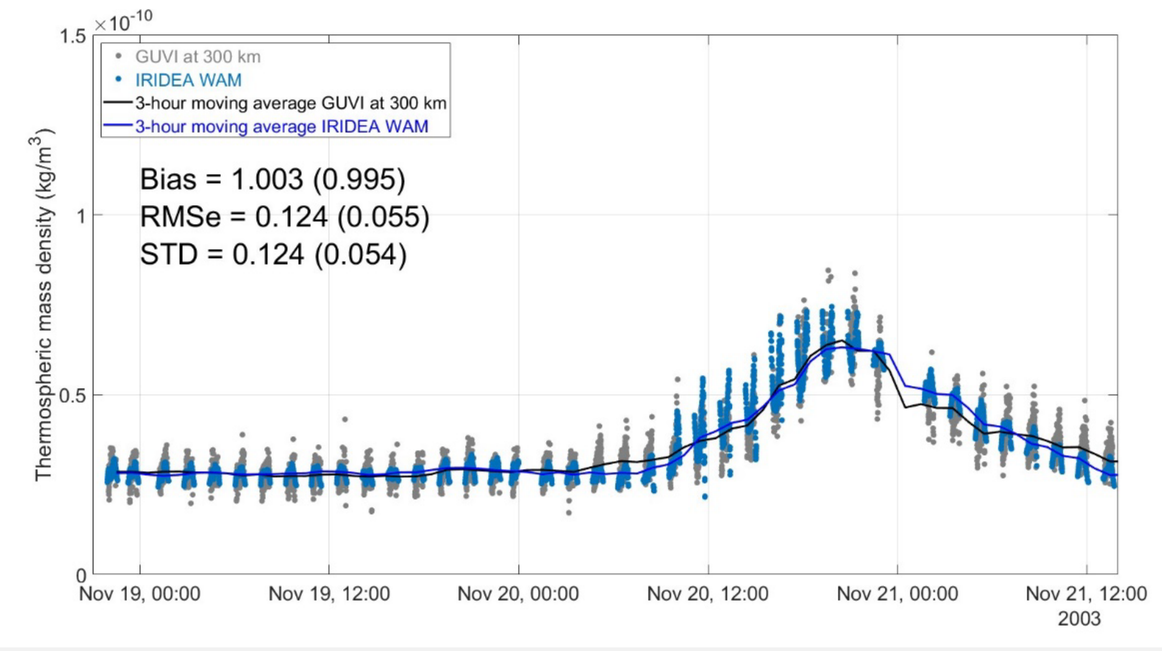
Green line stands for neutral densities assimilated with CHAMP using IDEA technique (IDEA-WAM density). Blue line is CHAMP observations. Grey line represents free-run WAM densities normalized by CHAMP observations on November 19. Bias, RMSe, and STD shown in the figure are calculated using IDEA-WAM and CHAMP densities. The IDEA-estimated solar and geomagnetic indices are those required to drive the model given the uncertainties in the empirical relationships between the indices and the real energy input to the upper atmosphere.

3. Experiment



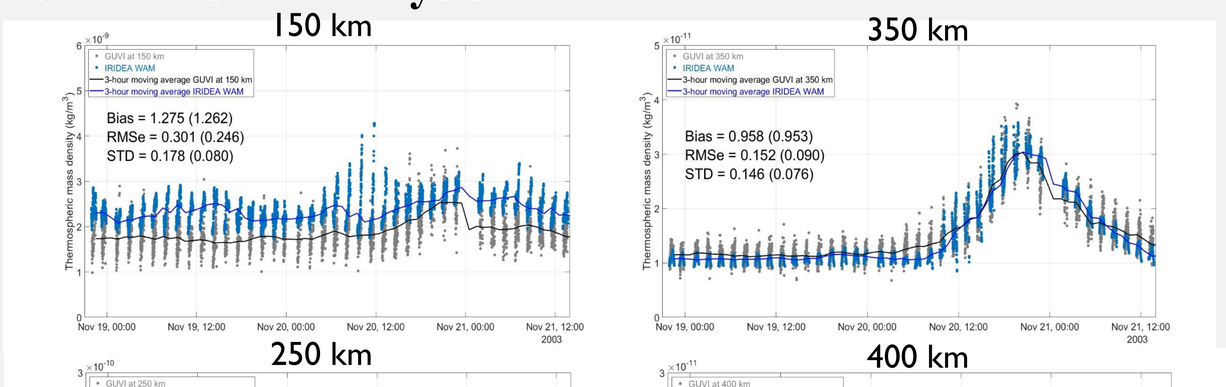
A possible real-time data source is available from an instrument similar to the TIMED-GUVI observations. This part of the study is designed to evaluate the usefulness of this data-stream in the IDEA data assimilation scheme to improve the WAM neutral thermospheric density. IDEA-WAM is generated by the combination of WAM and CHAMP neutral densities, to serve as the 3-D truth density structure, which can be used to quantify the uncertainties of GUVI neutral density profiles and to perform altitudinal, co-located, and simultaneous analyses.

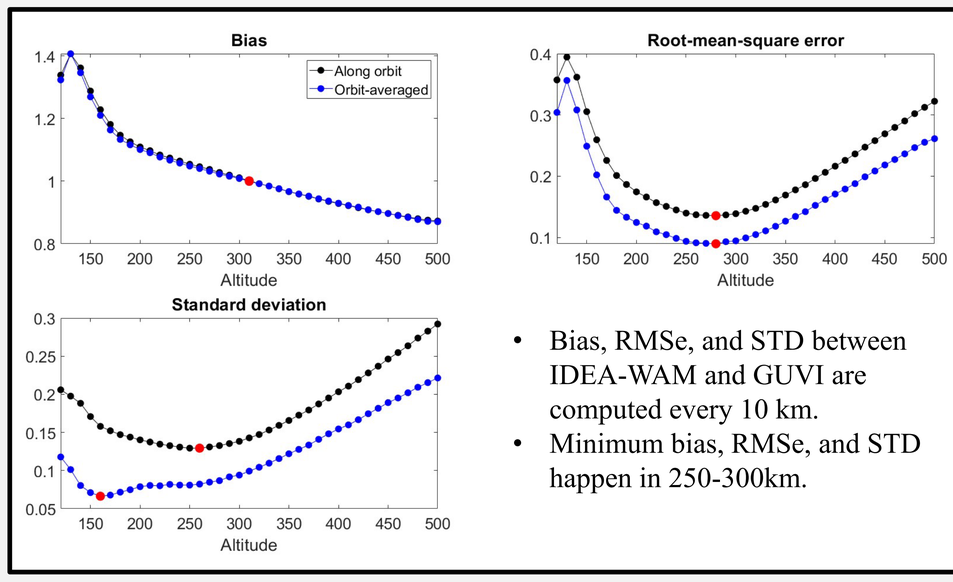
4. IDEA-WAM vs GUVI neutral density



The good agreement between IDEA-WAM and GUVI shows that GUVI density measurements are accurate at 300km. GUVI densities at around 00UT on November 21 are determined as outliers and discarded. GUVI densities are much more deviated than IDEA-WAM, which shows that further quality control of GUVI data is needed before feeding into WAM.

5. Altitudinal analysis





- Bias, RMSe, and STD between IDEA-WAM and GUVI are computed every 10 km.
- Minimum bias, RMSe, and STD happen in 250-300km.

Results and Future Work

- Assimilation of neutral density data with the IDEA technique can be used to quantify GUVI neutral density.
- GUVI neutral density yields minimum bias, RMSe, and STD in 250-300km altitude, which can be employed to improve the WAM neutral density and validate the related limb scan measurement.

Acknowledgements

The authors gratefully acknowledge support from the National Science Foundation's Space Weather with Quantification of Uncertainties program under grant number AGS 2028032

Reference

Sutton, E. K. (2018). A new method of physics-based data assimilation for the quiet and disturbed thermosphere. *Space Weather*, *16*, 736–753. https://doi.org/10.1002/2017SW001785