NOAA ROSES Semi-Annual Report

Reporting Period: September 2021 – February 2022 (3rd report)

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Project Title: Determination of Exospheric Neutral Hydrogen Density from GOES-R

Executive Summary (1 paragraph max)

The project is well underway and we are accomplishing our milestones. During the past 6 months we have worked on revising and testing the two exospheric models as well as the Monte Carlo model. The GOES 14/15 Lyman-alpha data set as well as a GOES-R ephemeris dataset will be released in the coming months. The team has been meeting monthly for progress updates and technical discussions. Results were presented at the 2021 AGU Fall Meeting (Thiemann) and the SCOSTEP Solar and Terrestrial Physics Symposium (Machol, Riley).

Progress toward FY21 Milestones and Relevant Findings (with any Figs)

1. Cross compare models and define uncertainties.
For the wavelength-dependent model, a solar occultation retrieval pipeline for Hydrogen was developed.Analyzed sensitivity to cross section error. Compared results with prior measurements from TWINS and MSIS model outputs and found relatively good agreement.

For the >3RE model, further optimization was done for the proxy required to extract the atmospheric absorption signal. Revisions included revising the time range for the fit to be symmetric around the absorption dip. Work was also done to determine a refinement for the GOES 13-15 bandpass to solar line conversion during the occulted part of the day. This new calculation requires an approximate fit to the dip shape and the best simple fit for this was determined to be a Gaussian function. A table of Gaussian functions for each day of the year was created to be used in the conversion calculation. The derived densities compare well with other measurements. For GOES-R ephemeris product did detailed error analysis and wrote the Readme.

2. Run Monte Carlo model with test cases.
Research progress for this period include optimizing the Monte Carlo model which is used to determine the line of sight velocity distribution of H atoms in the exosphere. Earlier version of the model took >24 hours to calculate the line of sight velocities along 274 different look directions for every exobase temperature value. The current version of the model takes ~8 hours to do the same. The temperature bins were updated from 100 K to 50 K to generate a bigger library of velocity distributions spanning from 500 K to 1200 K in order to fit the GOES-R observations. The shape of the velocity distribution was also improved from a Gaussian to a Gaussian + Lorentzian profile. This new profile works better to emulate the shape of the velocity distribution function at altitudes <7000 km.

3. Corroborate model results with TWINS results.
Basic comparisons have been made for both models and show good agreement. More robust comparisons need to be made.

4. Combine models to create final automated and robust simple parameterized model to be operationalized. Define model uncertainties.
Model uncertainties are being defined for the wavelength-dependent model. This still needs to be done for the >3RE model.

5. Revise model to use GOES14/15 data and compare with TWINS results from 2011.
Work is still being done to release a new version of the GOES 14/15 data, but an older version of the data is available to use for these comparisons.

6. Work with user community to determine possible model tests and desired data in model output files.
This work remains to be done. The community was engaged via conference presentations: 2021 AGU Fall Meeting (Thiemann) and the SCOSTEP Solar and Terrestrial Physics Symposium (Machol, Riley).

Milestone 3 Optically Thin and Wavelength Integrated Model tested.
In progress.
Milestone 4: Final model and uncertainties defined.
In progress.

Plans for Next Reporting Period

The team will continue to meet monthly to discuss progress and have technical discussions. The team will also start drafting two journal articles on the method and results.

For the atmospheric model, Dolon plans incorporate more GOES-R data in the study, especially compare results from a geomagnetic storm event vs quiet time geocoronal conditions as well as solar max vs solar min conditions to determine if assuming a Maxwellian distribution to determine the LOS velocity profile works for every condition or if a non-thermal population of atoms can be detected in the data.

For Ed's wavelength-dependent model, the retrieval and measurement uncertainty will be precisely characterized. The retrieval will be applied to the broader dataset to characterize the exospheric climatology. A manuscript describing the methods and climatology will be written.

Allyssa plans to complete the development and public release of the reprocessed GOES-14 and -15 Lyman alpha datasets. This will include datasets aggregated at multiple cadences, plots, and documentation. She will also develop and release the reprocessed GOES-14 and -15 30.4 nm datasets, which will also include data aggregated at different cadences, plots, and documentation.

Janet will do further evaluate and optimize the optically thin model including testing a further idea for proxy improvement. The model will be compared with the <3RE model. Preliminary results will be presented at STP-15. A journal article will be started. The GOES 16-17 continuously-updating ephemeris datasets will be released. The contain the ephemeris data in multiple coordinate systems with documentation.