Comparison of SABER OH Measurements to Rocket Photometry Data

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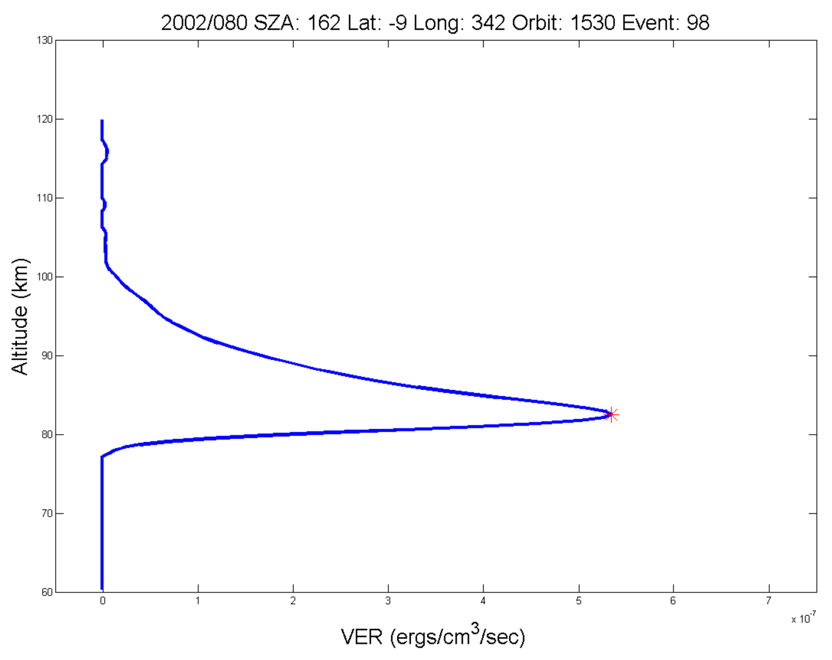
Abstract - In 2002, the Sounding of the Atmosphere using Broadband Emission Radiometry (SABER) instrument aboard the Thermosphere Ionosphere Mesosphere Energetics and Dynamics (TIMED) satellite went online and has since been providing radiometric data concerning the mesosphere and lower thermosphere/ionosphere (MLTI) region of the atmosphere. Researchers at the Utah State University NASA Space Grant Consortium have been tasked with validating measurements of the hydroxyl airglow volume emission rates (VER) taken by SABER. To this end, we compare SABER measurements of the altitude distribution of hydroxyl airglow to measurements taken by photometers aboard rockets launched between 1961 and 1986 that were catalogued in 1988 by Baker and Stair [1]. We select for comparison SABER scans taken near these launch sites at the same time of year, and at similar solar zenith angles. We then plot the selected SABER altitude profiles alongside renormalized rocket photometer profiles. Important considerations for comparison are the mean thickness of emission layers, the mean altitude of their centers, and relative numbers of bifurcated airglow emission layers, which manifest as altitude profiles with two or more peaks.

Background

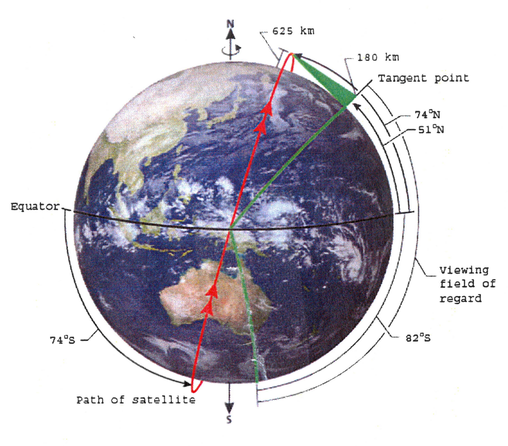
One of the goals of the SABER mission is to provide long-term global measurements of hydroxyl airglow emissions in the mesosphere. The instrument does this by performing limb scans of the atmosphere in infrared spectra, which are then processed off-site to generate altitude profiles. Over the past decade, SABER has scanned millions of airglow altitude distributions, such as the one depicted below, which help provide insight into the Sun-Earth energy balance and atmospheric energy dynamics.



This long time-scale global coverage has enabled application of these data to solar cycle energetics research. However, it also proves useful for data-validation: for any location on Earth, at any time of day, during any time of year, there are dozens of SABER-generated airglow altitude profiles. This unprecedented wealth of information allows matching of archival rocket-borne photometer measurements to corresponding SABER measurements.

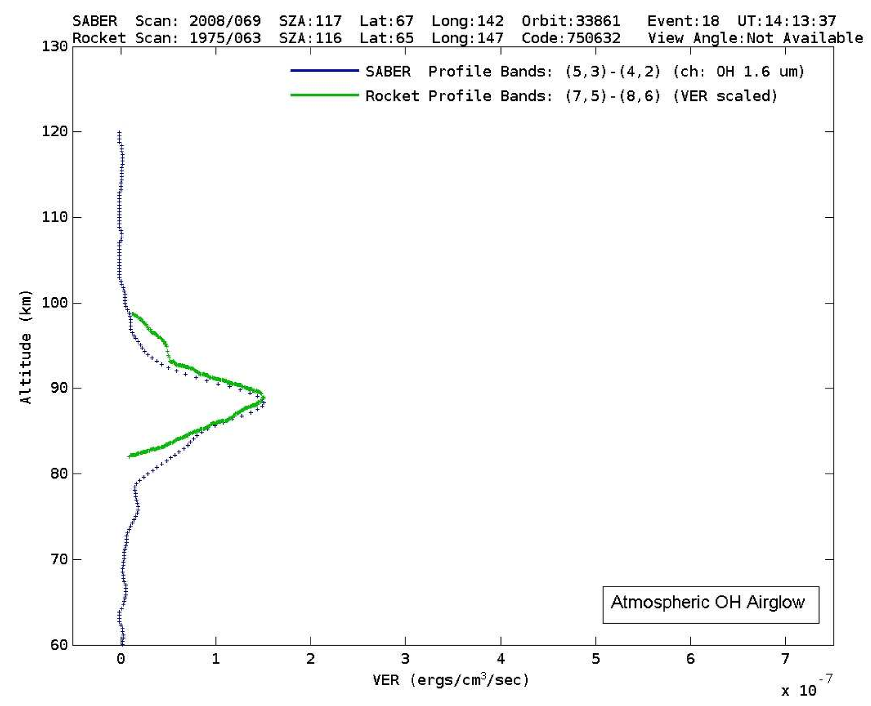
TIMED-SABER Orbit

The TIMED satellite orbits the Earth every half-hour, covering latitudes in the range of 51^o N to 74^o S, or 51^o S to 74^o N, (depending on satellite orientation). SABER scans the atmosphere about once per minute, producing roughly 1500 scans each day.



Matching Measurements

To match each rocket measurement to SABER profiles, we select SABER scans with tangent points within a few degrees latitude and longitude of each rocket's launch site. Greater tolerance is allowed for longitudinal deviations, as global plots suggest longitudinal homogeneity, while, in contrast, indicating appreciable latitudinal sensitivity. We disregard any that are not taken at the same time of year (within a couple of weeks) or time of day (within a few degrees solar zenith angle).



After selection, rocket-borne photometer measurements are renormalized to SABER-measured peak VER, for comparison of relative airglow emission strength altitude distributions. This is done for every band available for each rocket flight, and each match provides two comparison measurements from SABER: one from the the 1.6 micrometer channel (bands OH(5,3;4,2)) and one from the 2.0 micrometer channel (bands OH(9,7;8,6)). This process has generated 2244 profile pairs for comparison, made up of 1130 unique SABER profiles and 29 rocket photometer profiles.

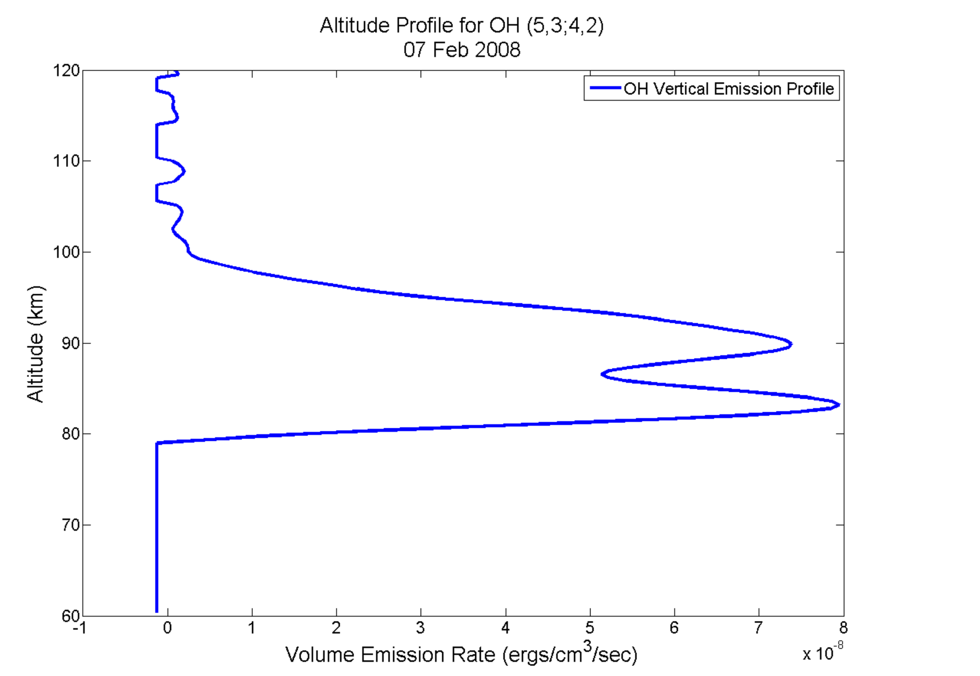
OH Layer Thickness and Altitude

We have compared the average widths and altitudes of matched SABER profiles to working numbers provided by Baker and Stair [1]. A summary table is provided below:

	Mean (km)	Standard Deviation (km)
Rocket Photometer Measured Peak Width (FWHM) [1]	8.6	3.1
Rocket Photometer Measured Peak Altitude [1]	86.8	2.6
SABER 1.6 um Channel Measured Peak Width (FWHM)	7.7	1.5
SABER 1.6 um Channel Measured Peak Altitude	84.3	6.7
SABER 2.0 um Channel Measured Peak Width (FWHM)	9.0	2.1
SABER 2.0 um Channel Measured Peak Altitude	87.7	2.0

OH Layer Bifurcation

A significant portion of SABER profiles, such as the one depicted below, show evidence of bifurcation in the OH layer. This bifurcation is generally attributed to photochemical and dynamical effects in the mesosphere, but could conceivably result from limb geometry in twilight regions.



To validate these results, we examine the prevalence of this phenomenon among SABER and rocket-photometer data sets, as summarized below:

Rocket Measurement Code	Bifurcation Measured by Rocket?	OH 1.6 um Profiles with Bifurcation	OH 2.0 um Profiles with Bifurcation
593101	No	0.00%	0.00%
593102	No	0.00%	0.00%
710392	No	0.00%	0.00%
710393	Yes	0.00%	0.00%
712321	No	9.09%	10.91%
712322	Yes	9.09%	10.91%
720661	No	4.00%	0.00%
720662	No	4.00%	0.00%
732771	No	4.76%	0.00%
732772	No	4.76%	0.00%
732773	No	4.76%	0.00%
750631	Yes	0.00%	0.00%
750632	Yes	0.00%	0.00%
771921	No	5.56%	7.84%
771922	Yes	5.56%	7.84%
771923	No	5.56%	7.84%
771924	No	5.56%	7.84%
813531	Yes	15.00%	20.00%
813532	Yes	15.00%	20.00%
813533	Yes	15.00%	20.00%
652681	No	35.00%	30.00%
692991	No	0.00%	0.00%
720394	Yes	5.88%	2.94%
731061	Yes	4.92%	6.56%
750171*	No	53.66%	28.05%
750601	No	27.59%	N.C.
750661	No	6.32%	5.26%
790571	No	89.29%	N.C.
840411*	No	13.89%	5.56%

We do not find any significant correlation between bifurcation measured by rocket photometers and bifurcation measured by SABER. We note, however, that the distribution of such events is not uniform, hinting at the presence of lurking variables. Understanding the factors that influence this phenomenon is the topic of current research.

Conclusions

Both peak altitude and width show good agreement for the SABER OH channels, and rocket photometers. Both parameters for rocket photometers are bounded by the parameters for the two SABER channels, and are within a standard deviation of each. Variations are therefore easily explainable by sampling variation.The bifurcation data, on the other hand, suggests the presence of unconsidered factors that influence hydroxyl layer bifurcation. The observed distribution has prompted our current investigations into these factors.

References

[1] Baker, D.J. and Stair, A.T. "Rocket Measurements of the Altitude Distributions of the Hydroxyl Airglow". 6th International Symposium on Solar Terrestrial Physics (1988).