

Impact of Solar Spectral Irradiance Variability on Middle Atmospheric Ozone and Temperature



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I. Abstract:

Ozone and temperature data collected from several instruments was examined for effects from solar spectral variability in the middle atmosphere. Concentration of ozone measurements collected independently at 9.6 μ m and 1.27 μ m from the Sounding of the Atmosphere using Broadband Emission Radiometry (SABER) instrument were compared with one another and analyzed for solar irradiance variability effects in the lower mesosphere. SABER temperature data was compared with that of the Microwave Sounding Unit (MSU) Channel 4 and Advanced Microwave Sounding Unit (AMSU) Channel 9. Temperature comparisons were found to be possible only at 86mbar in the lower stratosphere. The difference between the annual mean temperatures of the instruments was consistently 20K through 10 years of overlapping measurements. MSU and AMSU data was found to have extremely low variability both within each year and through its full record. It showed no QBO or solar cycle effects and varied, on average, 0.06% from its annual mean at solar minimum in 2009. SABER data showed reasonable variability within each year and showed solar cycle and QBO effects. Because of the limitations of comparisons between these two instruments and the variability problems with the MSU and AMSU data set, further comparisons to SABER data would not be particularly useful. Data gathered from the Stratospheric Sounding Unit (SSU) would likely yield more meaningful comparisons to data gathered by SABER.

Ozone measurements at 9.6 μ m and 1.27 μ m were found to be equally populated with values for overlapping pressure level measurements. A constant bias between the measurements of the two channels was found that is higher than would be expected from the documented instrumentation bias of the 9.6 μ m channel. The ozone measurements were found to be significantly affected by solar variability, such that at times of greater UV variability, the difference between the two channel's measurements was greater than it was during times of low solar variability. Further investigation is needed to determine if the photolysis rates used in inferring the ozone measurements at 1.27 μ m are underestimating contributions from solar variability over the solar cycle, particularly, in the oxygen Schumann-Runge Band and the ozone Hartley Band of absorbance. It is plausible that the solar cycle irradiance changes observed by SORCE could bring the 1.27 μ m and 9.6 μ m SABER channels into agreement; however a full reanalysis of the SABER 1.27 μ m data would be required to make this assessment.

III. Temperature Results:

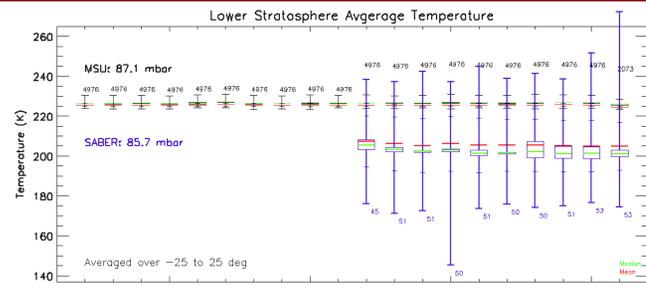


FIGURE 3 – Statistical Comparison of Temperature Data

❖ Consistent separation between the average temperatures of the two data sets is likely due nature of data collection differences

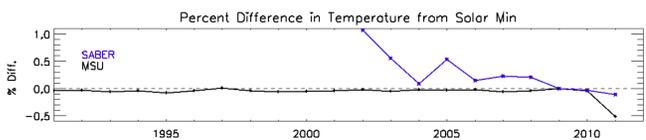


FIGURE 4 – Variation Time Series Comparison

❖ MSU/AMSU data shows no QBO or solar cycle effects and varies on average 0.06% from its annual mean at solar minimum in 2009.

❖ In the SABER data, a more reasonable trend is present approximately every 1.5 to 2 years as well as over the solar cycle.

❖ Meaningful comparisons between MSU/AMSU and SABER temperatures are difficult

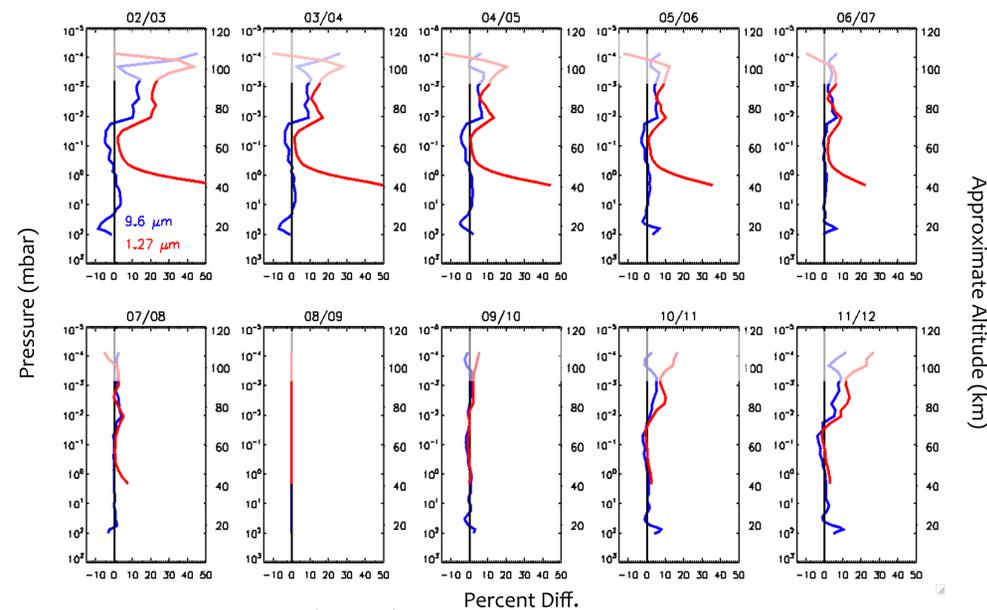
❖ Plausible that the Stratospheric Sounding Unit (SSU) could give more meaningful comparisons to SABER data at this level in the atmosphere.

VII. References

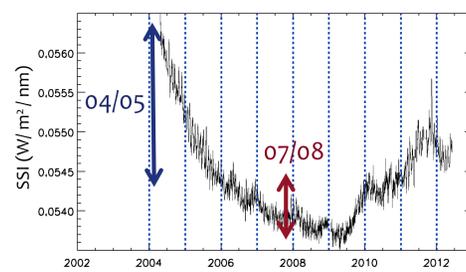
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V. Key Findings

SABER Ozone Comparisons, Biannual % Differences from 08/09 (-25 to 25 deg.)



SSI at Peak Hartley Band (254nm)



❖ Differences in the measurements of ozone at channels 9.6 μ m and 1.27 μ m are affected by the amount of solar variability at that time.

❖ Times of low solar variability, there is greater agreement between ozone measurements that at times of great solar variability.

VI. Extensions & Implications

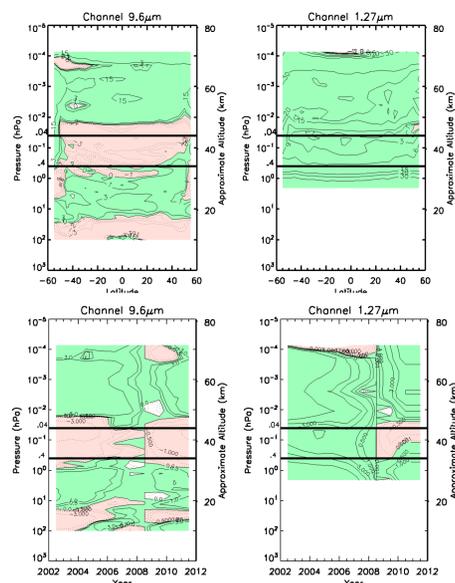


FIGURE 7– Merkel et al 2011 results extended

❖ Modeled SSI variability input used to determine photolysis rates used in inferring 1.27 μ m measurements COULD be underestimating solar variability

❖ Plausible that SORCE data observing SSI could bring SABER channels into agreement

❖ More offline studies on 1.27 μ m data need to be done to determine if a full reanalysis of the SABER 1.27 μ m data could bring channels into agreement

❖ Future research could be done comparing both ozone measurements to independent MLS data

❖ If corrected, it could lend credibility to measurement technique and extend technology in inferring measurements

II. Background:

FIGURE 1 – Natural Production and Destruction of Ozone²

❖ Solar intensity variability affects concentration of ozone as well as temperature in the atmosphere

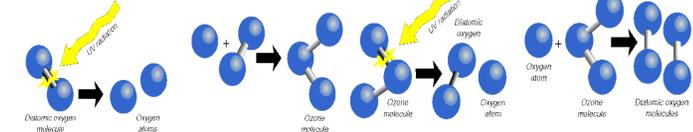


FIGURE 2- Sounding of the Atmosphere using Broadband Emission Radiometry (SABER)⁶

❖ Temperature and ozone measurements reported at 44 different pressures/altitude since 2002

❖ Measures ozone using two independent techniques at different wavelengths

9.6 μ m	1.27 μ m
O ₃ concentration directly measured from emission of ozone molecule	O ₃ concentration inferred from emission of molecular oxygen day glow
Measures from 15-100km	Measures from 50-105km
Day & night measurements	Day measurements

IV. Ozone Results:

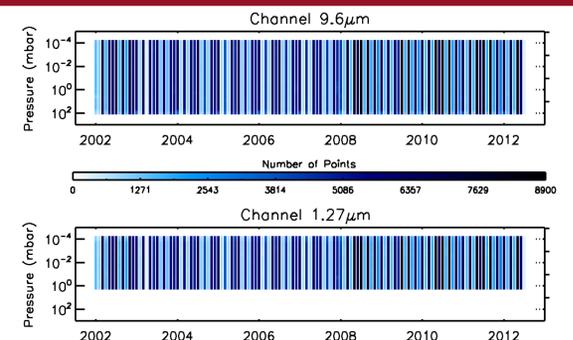


FIGURE 5- Population of Ozone Channels

❖ Channels equally populated throughout all of the levels

❖ 9.6 μ m only 2% more populated with data points

❖ Comparison between the two channels is not limited by the number of data points present.

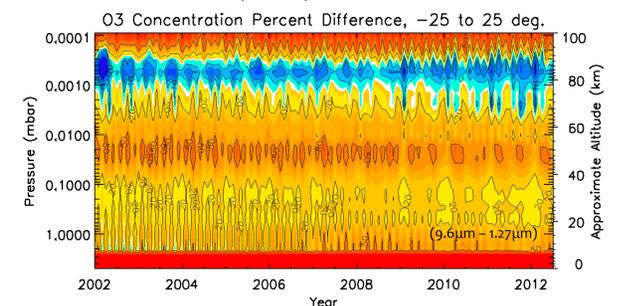


FIGURE 6 – Percentage Difference Between Ozone Channels

❖ 9.6 μ m is known to be 5-7% greater than measurements made by other instruments in the lower mesosphere⁵

❖ The average percent difference in the lower mesosphere is found to be 23.1%.

❖ This is a larger, constant bias than can be accounted for from the known bias in the 9.6 μ m channel.