MLTS-1

Temporal Variation of Atomic Oxygen in the Upper Mesosphere from SOFIE

S.Das[1] , S.M. Bailey[1] , B. Thurairajah[1] , M.E.Hervig[2], B.T.Marshall [3]

[1]Center for Space Science and Engineering Research, VA, USA
[2]GATS Inc, Driggs, ID, USA
[3]GATS, Inc., Newport News, VA, USA

1. Introduction

I. Atomic oxygen (O) has a long lifetime in the mesopause region (~80-100 km).
II. It varies seasonally and latitudinally due to diffusion, mean circulation, and transport through waves.
III. O is difficult to measure directly due to no vibration or rotation spectra.

2. Objectives

I. Limited attempts at directly measuring O have been made so far.
II. Due to the direct measuring complexity of O, we derive O at high latitudes from satellite instrument ozone (O_3) data.
III. We quantify the seasonal and latitudinal variation of O using derived measurements and model predictions.

3. Methodology

I. O_3 (retrieved at 0.291 µm) from the Solar Occultation for Ice Experiment (SOFIE) instrument is used to derive daytime SOFIE-O at 65°-85° N/S.
II. Using the Chapman mechanism and assuming photochemical equilibrium for O_3,

Production: $O + O_2 + M \rightarrow O_3 + M$
Loss: $O_3 + h\nu \rightarrow O + O_2$

For Daytime O, thus,

$$O_{Daytime} = [J_{O3} \times O_3] / [k_{o\text{-}o2} \times O_2 \times n^2]$$

*where **O**, **O_2**, and **O_3** are the mixing ratios, **$k_{O\text{-}O2}$** = $6\times10^{-34}(300/T)^{2.4}$ is the reaction rate[1], **J_{O3}** = photolysis rate from the TUV model[2], **n** = number density [n = p/(kT), p = pressure, T = temperature, and k = Boltzmann constant].*

III. Using coincident measurements from SABER (Sounding of the Atmosphere using Broadband Emission Radiometry) and the MSIS (Mass Spectrometer and Incoherent Scatter Radar) class models, we compare the SOFIE derived-O measurements in terms of vmr (volume mixing ratio) and ND (number density).

4. Results

Fig . 1a

Fig . 1b

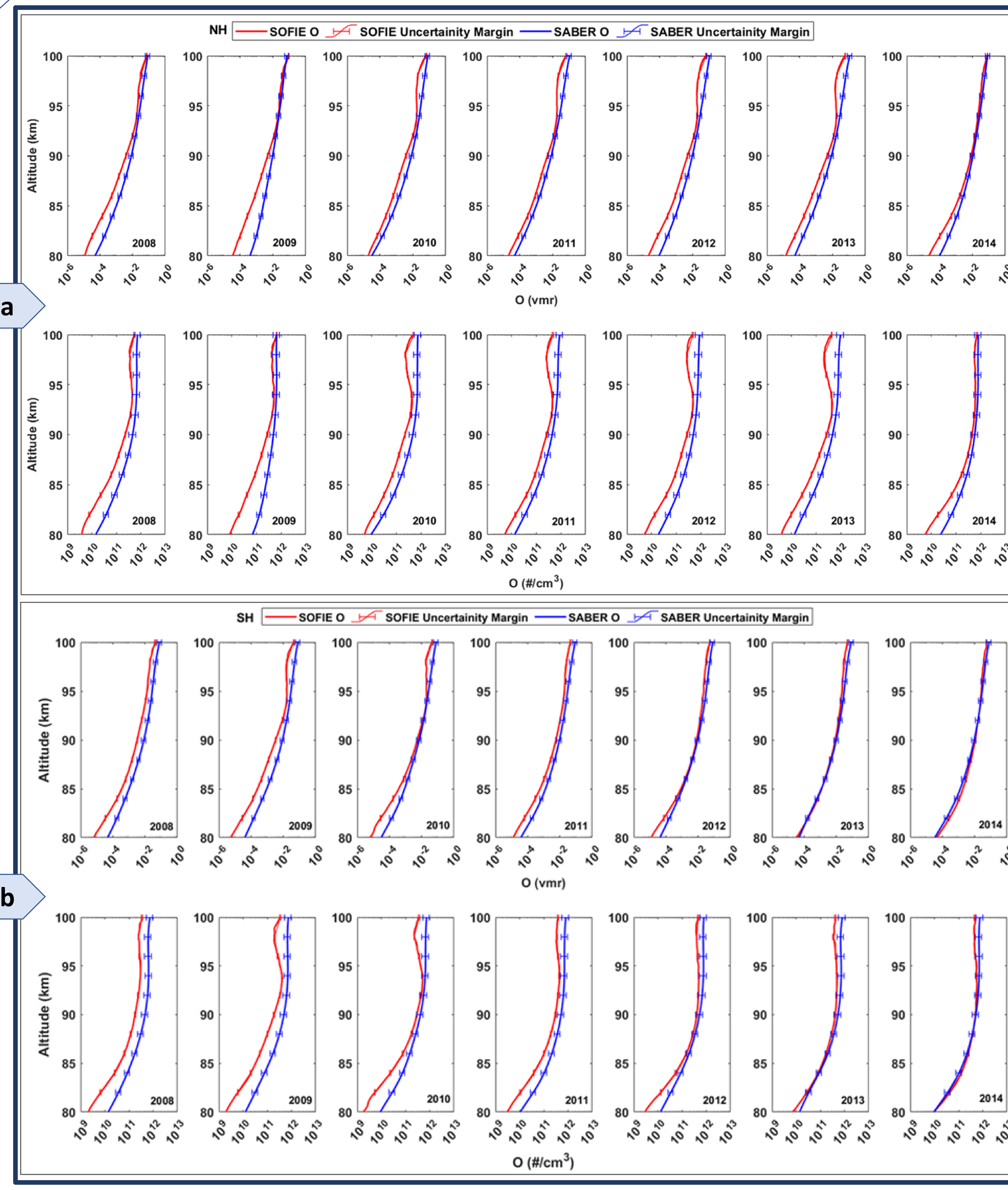

Figure 1. O vmr (top) and ND (#/cm³) (bottom) for a) NH and b) SH.

1a) SOFIE-SABER NH O (vmr and #/cm³)

I. The SABER and SOFIE vmr profiles agree better than the ND.
II. The overall agreement is better at high altitudes.

1b) SOFIE-SABER SH O (vmr and #/cm³)

I. Vmr profiles in the SH agree better than in the NH overall.
II. ND profiles in the SH agree better than in the NH at high altitudes for 2010-2013.
III. Vmr profiles agree better than ND profiles due to differences in SOFIE-SABER T and atmospheric ND measurements.

Fig . 2

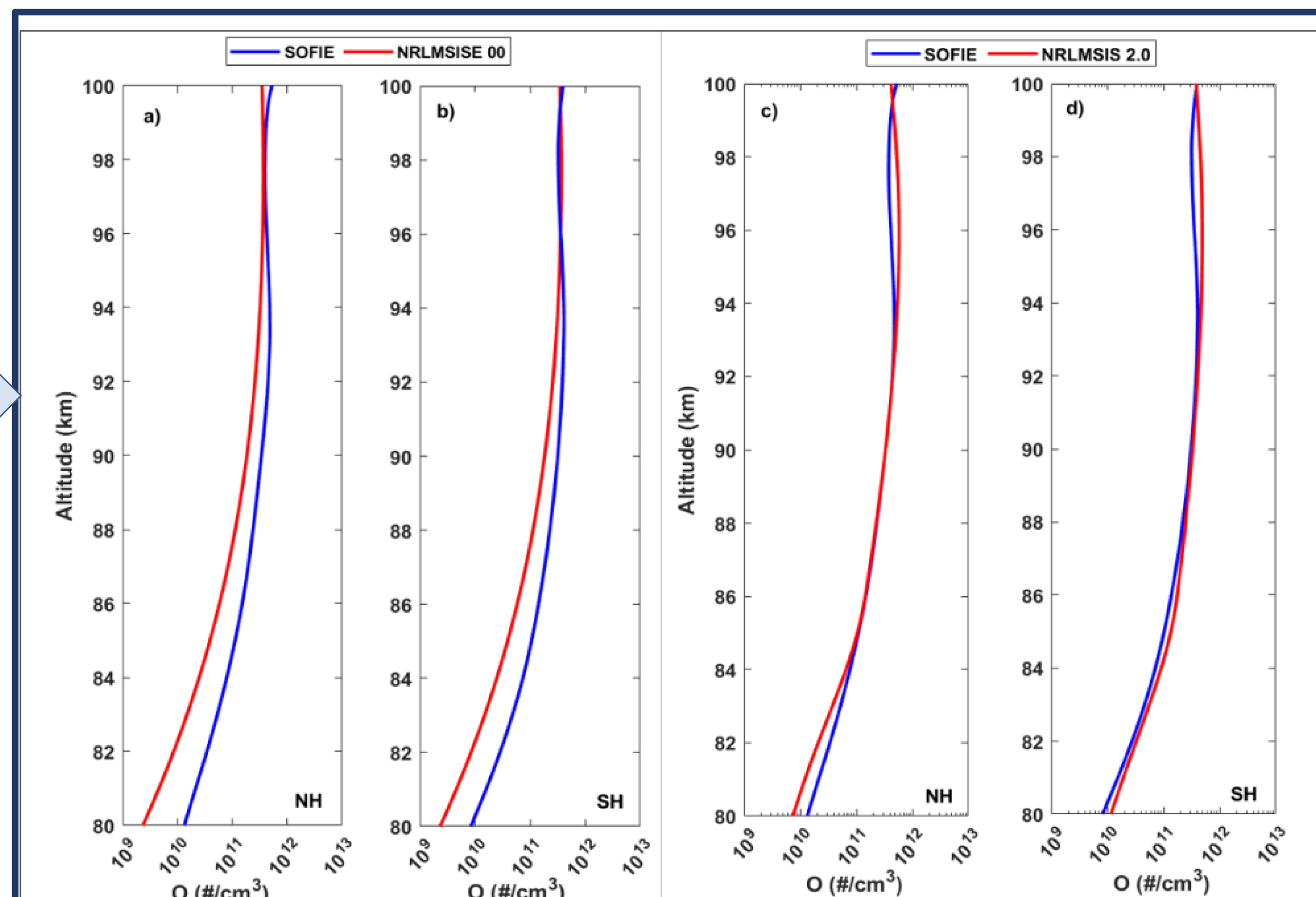

Figure 2. O ND (#/cm³) for a) NH, b) SH for MSISE-00 and c) NH, d) SH for MSIS 2.0 averaged during 2008-2014.

2) SOFIE-MSIS models' O (#/cm³)

I. SOFIE and MSISE-00 (1a and 1b) agree well above ~ 90 km but show significant differences below.
II. Inclusion of satellite measurements and other improvements in MSIS 2.0 (1c and 1d) lead to better agreement with SOFIE between 80 and 100 km.

3) SOFIE O Seasonal Variation

I. O is transported in high amounts from the mesopause region during winters (Dec-Jan-Feb in NH, Jun-Jul-Aug in SH).
II. The NH average is affected by the strong transport events of 2009 and 2013.

Figure 3. O vmr contour plot (top) NH and (bottom) SH averaged during 2008-2014.

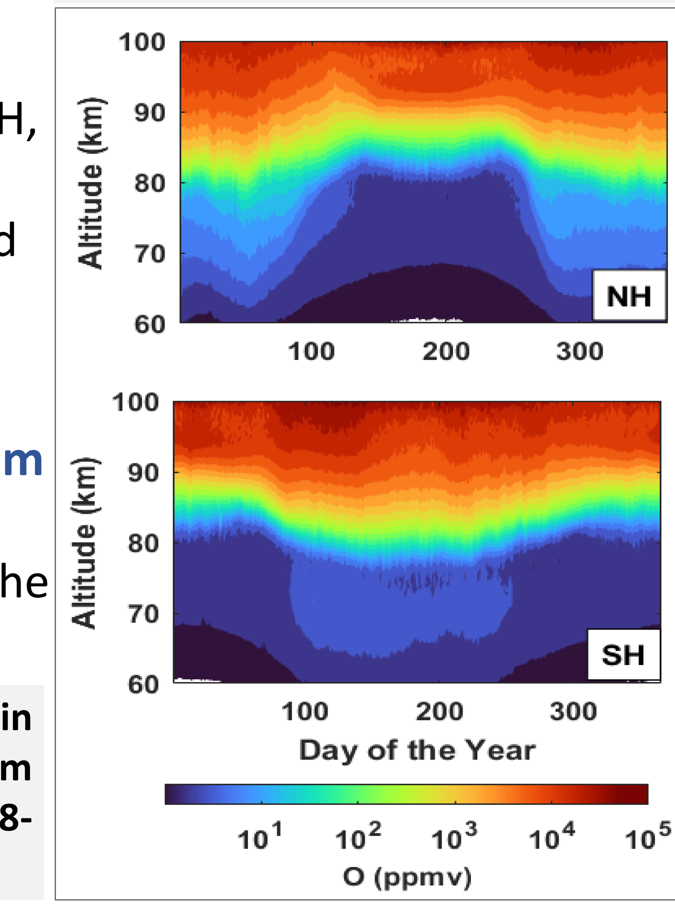

Fig. 3

4) O Maximum and Minimum

I. O wintertime maximum occurs at ~ 84 km and in the summertime at ~ 94 km.

Figure 4. O variation at 84 km in the a) NH and c) SH, and at 94 km in the b) NH and d) SH for 2008-2014 averaged over 65°-85° .

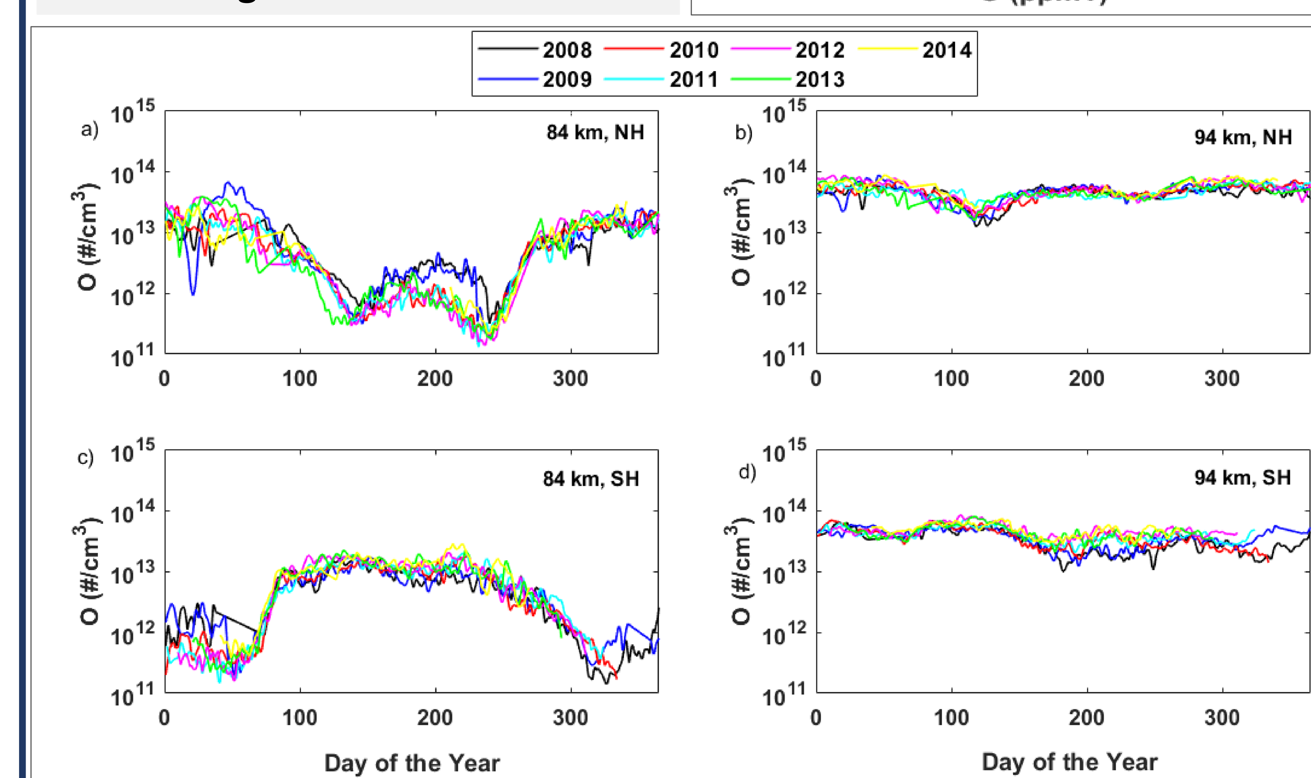

Fig. 4

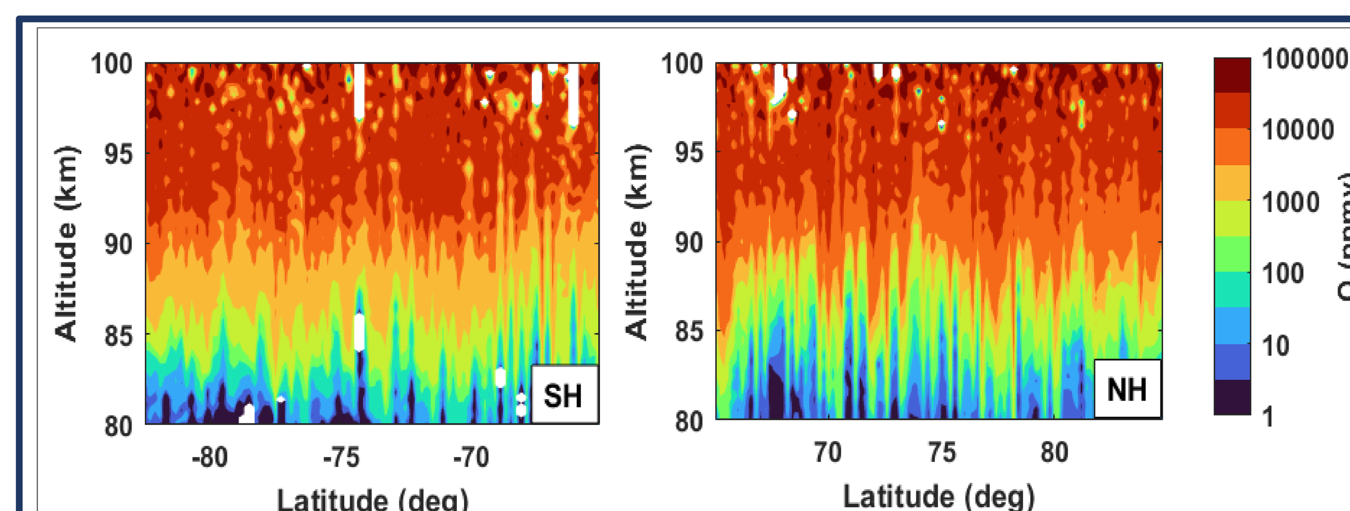

Fig.5

Figure 5. Contour images of latitude vs. altitude of mean O averaged over 2008-2014 for 65°-85° in the (left panel) SH and (right panel) NH.

5) O Latitudinal Variation

I. O varies by several orders of magnitude in the mesopause, with a stronger presence in the NH at high altitudes.

5. Conclusions

I. SOFIE and SABER vmr profiles agree well above ~ 85 km and, overall, show better agreement in the SH.
II. SOFIE shows excellent agreement with MSISE 2.0 overall.
III. O shows wintertime descent to lower altitudes. It attains wintertime and summertime maximum at ~ 84 km and ~ 94 km, respectively.
IV. O at high attitude NH is larger and better distributed than in the SH.

References

1. Sander, S. P., et al. (2006), Chemical kinetics and photochemical data for use in stratospheric modeling, Evaluation 15, JPL Publ., 06-2, 523 pp
2. Madronich, S., and S. Flocke (1998), The role of solar radiation in atmospheric chemistry, inHandbook of Environmental Chemistry, edited by P. Boule, pp. 1–26, Springer, Heidelberg, Germany.

Author Contact:
saswad1@vt.edu