

# SMLT Ozone from SOFIE and Other Instruments – Validation and Seasonal Climatology

S.Das<sup>1</sup>, S.M. Bailey<sup>1</sup>, B. Thurairajah<sup>1</sup>, M.E.Hervig<sup>2</sup>, B.T.Marshall<sup>3</sup>

<sup>1</sup>Center for Space Science and Engineering Research, VA, USA

<sup>2</sup>GATS Inc, Driggs, ID, USA

<sup>3</sup>GATS, Inc., Newport News, VA, USA



## 1. Introduction

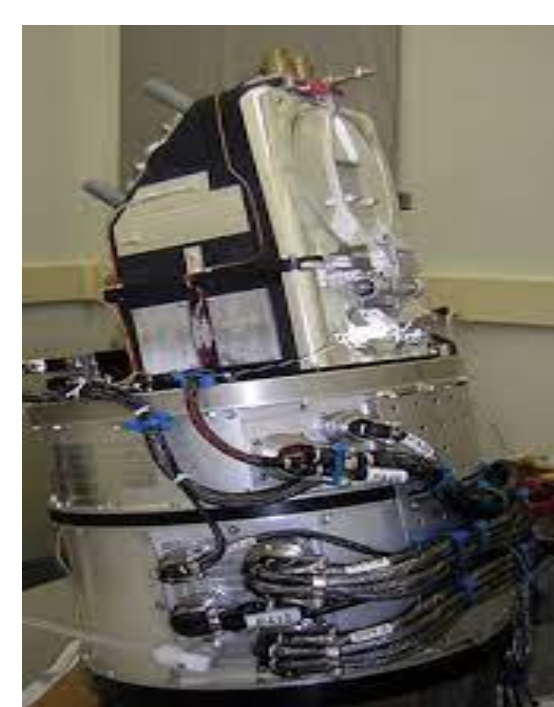
- I. In the atmosphere, ozone (O<sub>3</sub>) is present in the largest amount in the lower stratosphere (~10 – 30 km), and its seasonal variability is attributed to large-scale atmospheric motions.
- II. O<sub>3</sub> secondary maximum layer is present in the upper mesosphere and lower thermosphere (at ~ 90-92 km in the day in mixing ratio). The layer is impacted by transport and molecular diffusion at high latitudes.

## 2. Objectives

- I. Stronger understanding of the O<sub>3</sub> variation in the stratosphere, mesosphere, and lower thermosphere (SMLT) is necessary to quantify the total O<sub>3</sub> column variability.
- II. So far, more work has been done towards understanding nighttime O<sub>3</sub>, thus, necessitating the investigation of daytime O<sub>3</sub>.
- III. This study investigates seasonal O<sub>3</sub> variation in the SMLT from SOFIE and other instruments and analyzes the variation in the secondary O<sub>3</sub> maximum after sudden stratospheric warmings (SSWs).

## 3. Instruments

### ☐ Solar Occultation for Ice Experiment (SOFIE)



Credit: Space Dynamics Laboratory

- Solar Occultation measurements made at Sunrise/Sunset
- FOV = ~ 1.6 km
- Latitude Range = 65°- 85° N/S
- Spectral Range: 0.3 – 5 μm

### ☐ Atmospheric Chemistry Experiment (ACE)



Credit: ABB Bomem

- Solar Occultation measurements made at Sunrise/Sunset
- FOV = ~ 1.25 mrad (circular)
- Latitude Range = ~ 80° N – 80° S
- Spectral Range: 2.2 – 13 μm

### ☐ Michelson Interferometer for Passive Atmospheric Sounding (MIPAS)



Credit: ESA

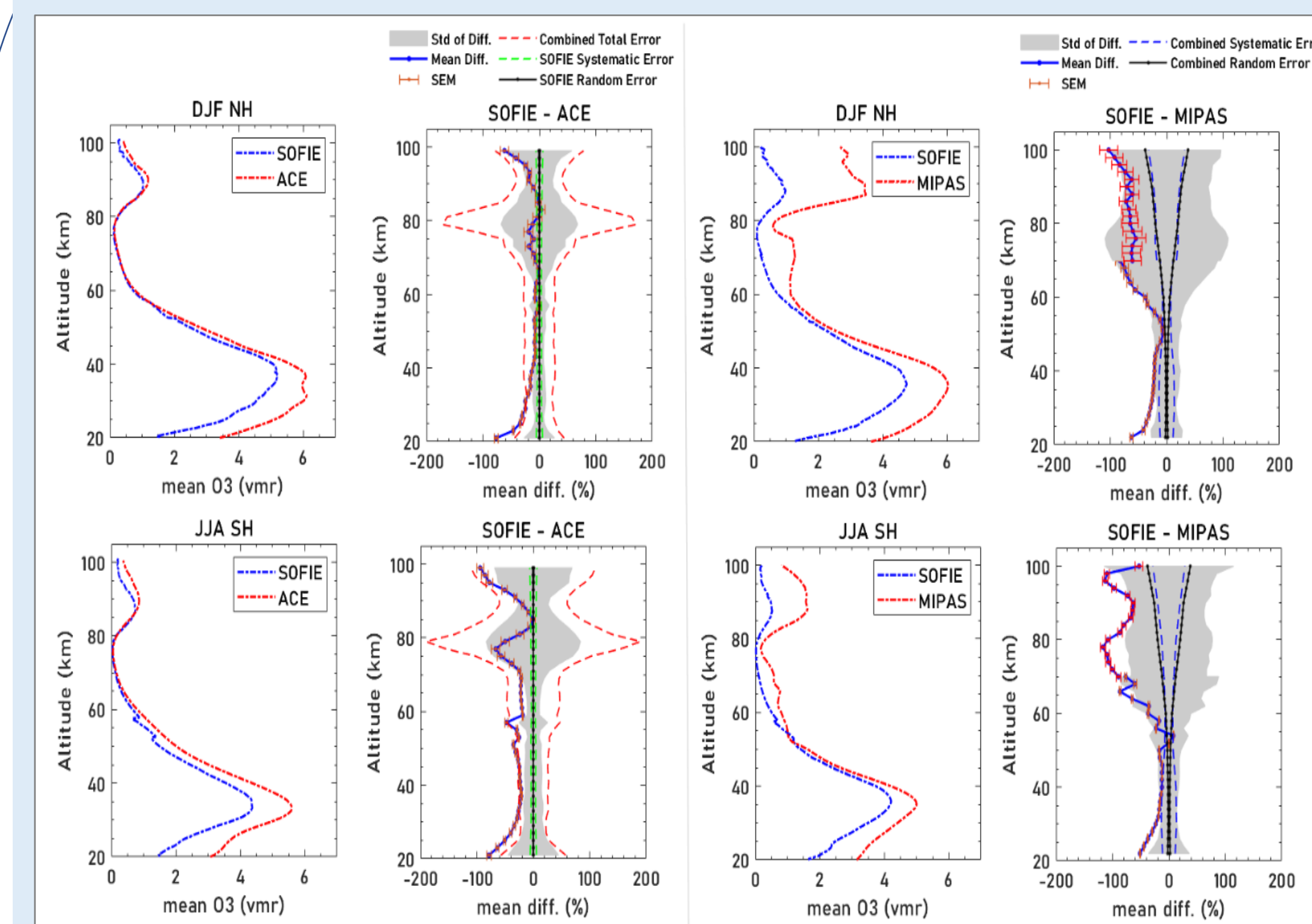
- Day/Night measurements
- FOV = 4-8 km
- Latitude Range = Global
- Spectral Range: 4.15 - 14.6 μm

\* MIPAS has fewer data points above ~ 70 km than below.

## 4. Methodology and Results

- I. Coincidence bins of ± 10° latitude x ± 20° longitude x 2 hours time are used to find coincidences.
- II. ACE measurements are used for 2008-2014 and MIPAS measurements are used for 2008-2011.

**Figure 1 (a-d).** Statistical moments of coincident O<sub>3</sub> profiles from SOFIE and correlative data sets.



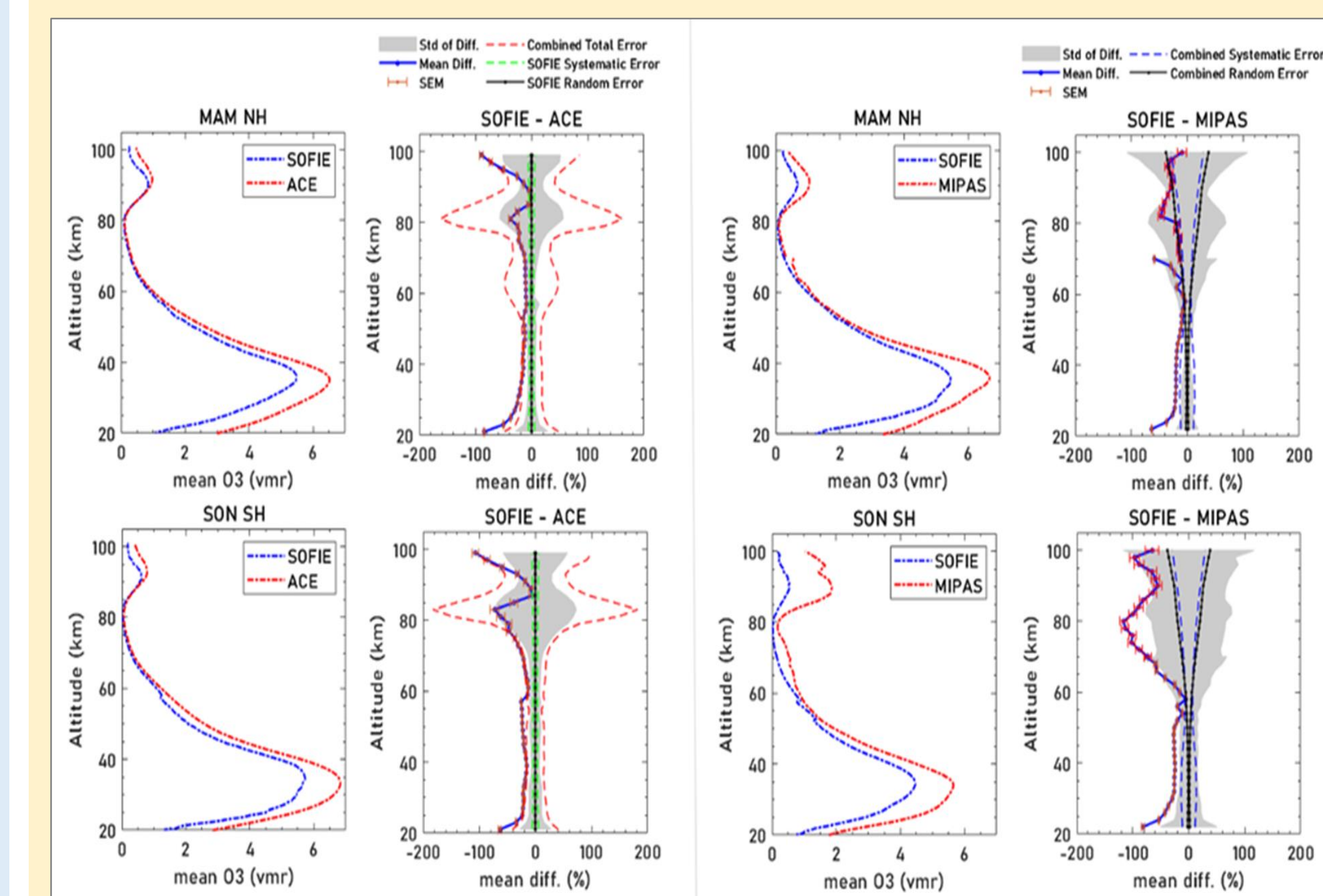
### 1a) Winter

**Stratosphere**  
Lower Photochemical Loss

↓  
**O<sub>3</sub> Accumulation**

**Overall**

- I. SOFIE shows better agreement with ACE than MIPAS in NH and SH.
- II. Lesser STD below 60 km than above for ACE and MIPAS.



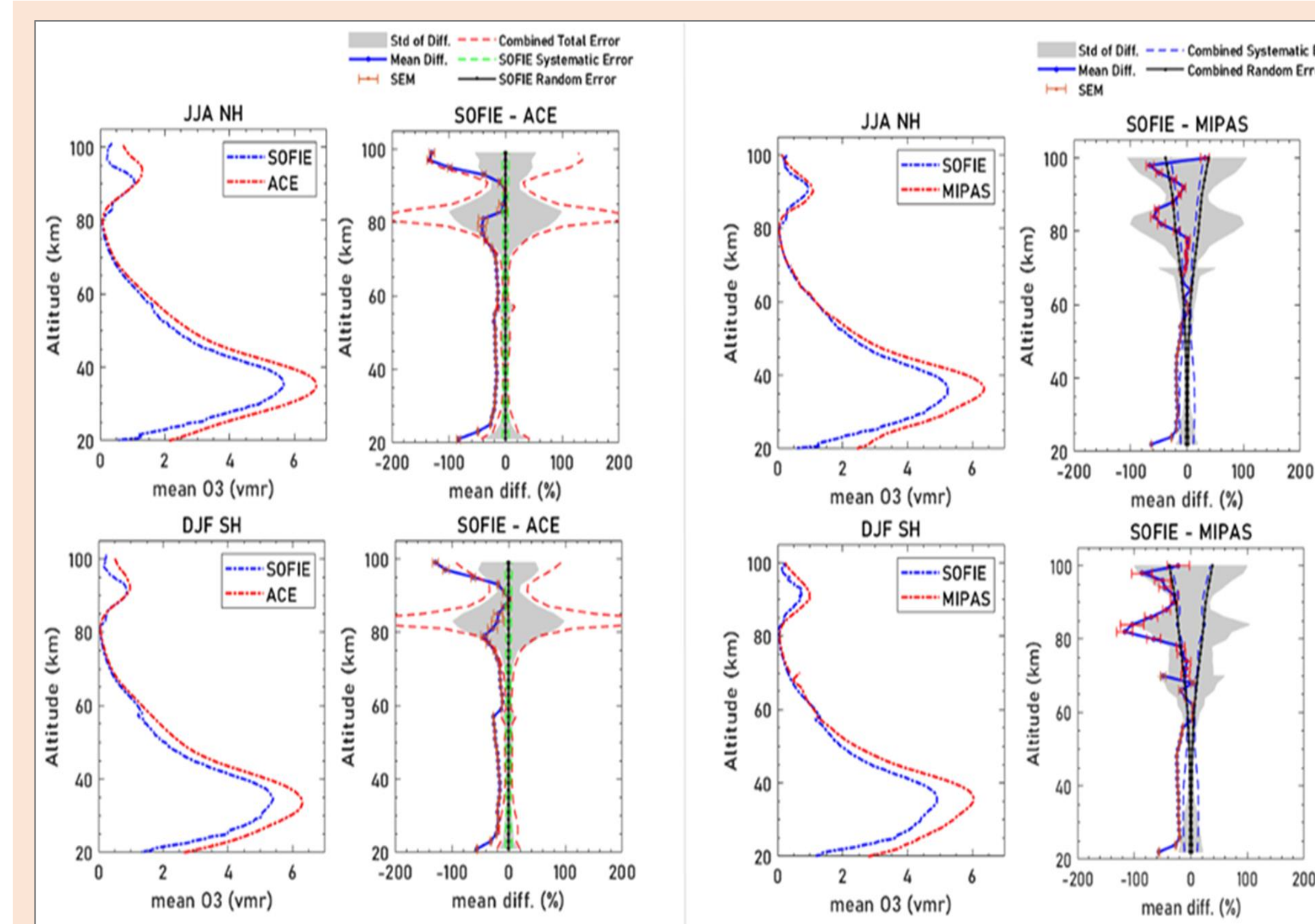
### 1b) Spring

**Stratosphere**  
Wintertime O<sub>3</sub> Accumulation

↓  
**Springtime O<sub>3</sub> Maximum**

**Overall**

- I. SOFIE shows better agreement with ACE than MIPAS in NH and SH.
- II. MIPAS agrees better with SOFIE in the NH than SH



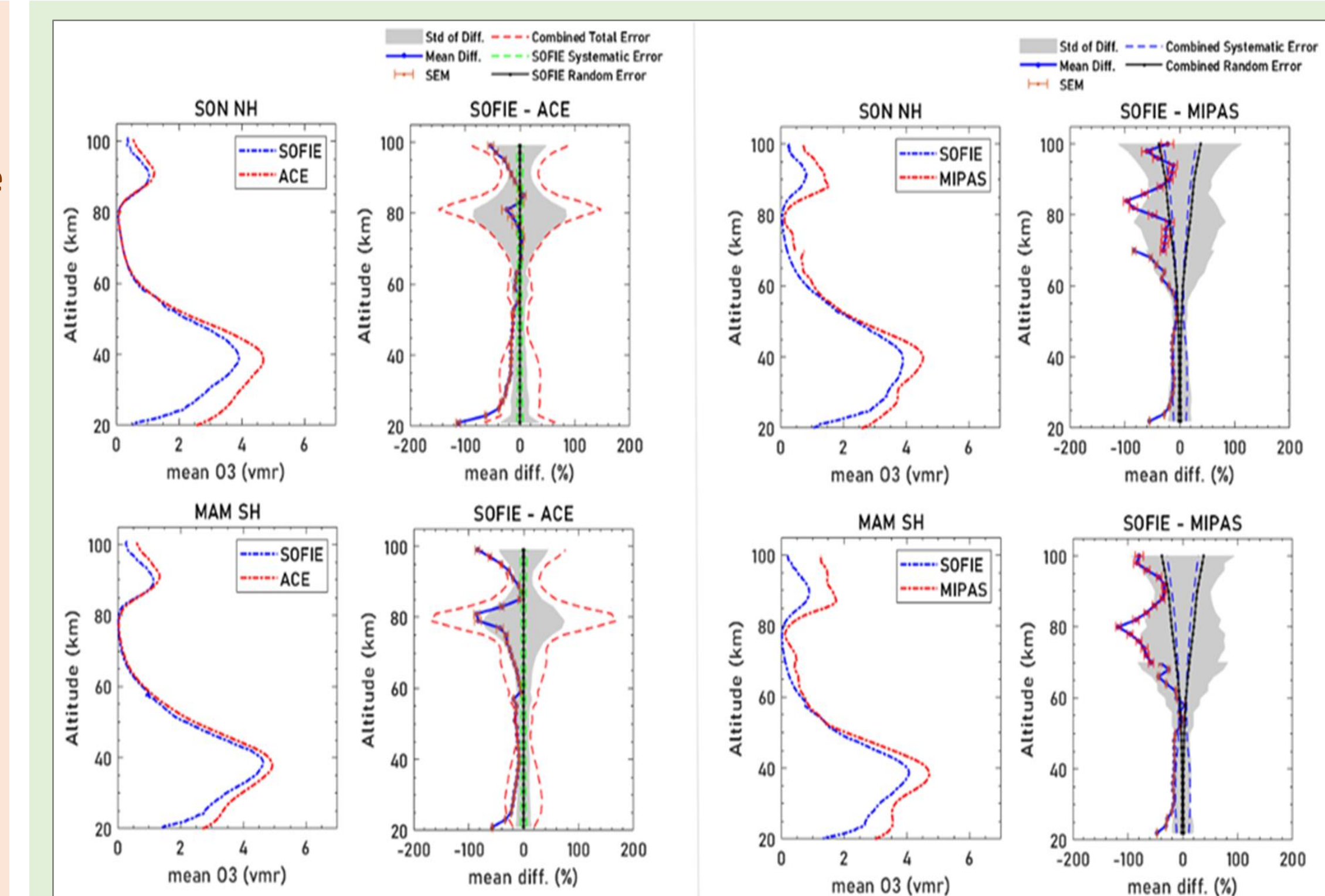
### 1c) Summer

**Stratosphere**  
Effective Summertime Photochemistry

↓  
**Persistent O<sub>3</sub> Loss**

**Overall**

- I. MIPAS (NH and SH) above ~ 90 km agrees better with SOFIE than ACE.
- II. MIPAS agrees better with SOFIE in the NH than SH.



### 1d) Fall

**Stratosphere**  
Persistent Summertime O<sub>3</sub> Loss

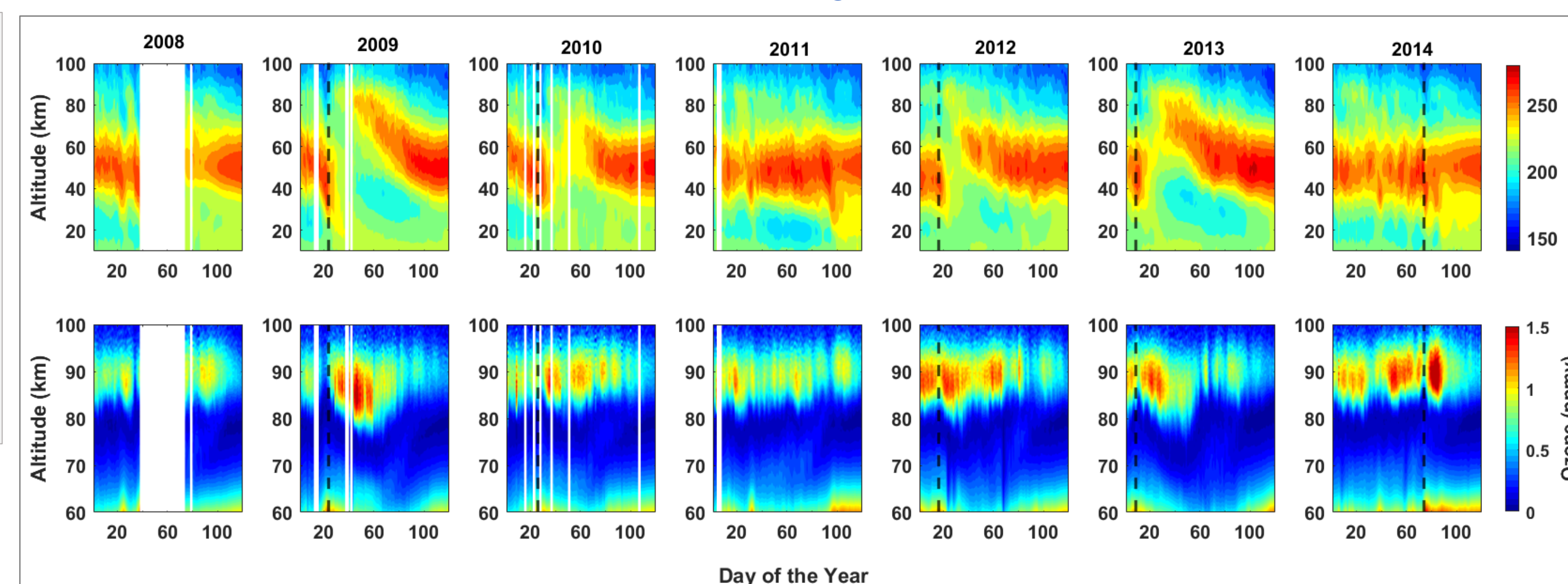
↓  
**O<sub>3</sub> Minimum in Late Fall**

**Overall**

- I. ACE agrees better with SOFIE in the NH than SH, particularly above ~ 80 km.
- II. MIPAS agrees with SOFIE comparably in the NH and SH.

## Secondary O<sub>3</sub> Maximum During Sudden Stratospheric Warming

**Figure 2. (Top)** SOFIE temperature and **(Bottom)** O<sub>3</sub> from 2008-2014. Dashed black lines indicate the SSW date (zonal mean zonal wind reversal date for 2014).



- I. SSW events occurred in 2009, 2010, 2012, and 2013.
- II. Temperature measurements indicate elevated stratopause up to several kilometers above the usual climatological height.
- III. O<sub>3</sub> measurements indicate the decrease in the secondary O<sub>3</sub> maximum with increasing temperature.

## 5. Conclusions

- I. SOFIE shows good quantitative agreement (Mean % Difference (Uncertainties)) except at 20 km, 80 km and 100 km.

Data Set	~ 20 km	30 km	40 km	50 km	60 km	70 km	80 km	90 km	100 km
SOFIE and others (NH and SH)	-57.86 (25.01)	-20.39 (12.26)	-16.56 (11.28)	-14.77 (12.50)	-14.91 (24.15)	-31.50 (34.01)	-57.68 (69.72)	-25.28 (37.86)	-70.19 (83.97)

- II. Typically, SOFIE measurements < Correlative Data Set.
- III. Strong SSWs were observed in 2009 and 2013, and moderate SSWs in 2010 and 2012.
- IV. SOFIE results demonstrate O<sub>3</sub> seasonal variability and the utility of the SOFIE O<sub>3</sub> data product.

**Author Contact:**  
saswad1@vt.edu