Analyzing MERRA-2 ozone uncertainties at high latitudes during Sudden Stratospheric Warming events

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Introduction and motivation

- The influence of Arctic stratospheric Ozone variability on radiative forcing of climate and lower latitude Earth's surface temperature
- High impact dynamical mechanism over mid atmosphere on Arctic ozone
- The altered circulation during SSWs and the associated impact on the transportation of trace gases (de la Cámara et al., 2018)
- MERRA-2 ozone data are expected to have higher uncertainties over the northern high latitudes because of higher dynamic variability in this region (Wargan et al., 2017).
- Unique density of observation at Greenland sector and the opportunity of comparisons

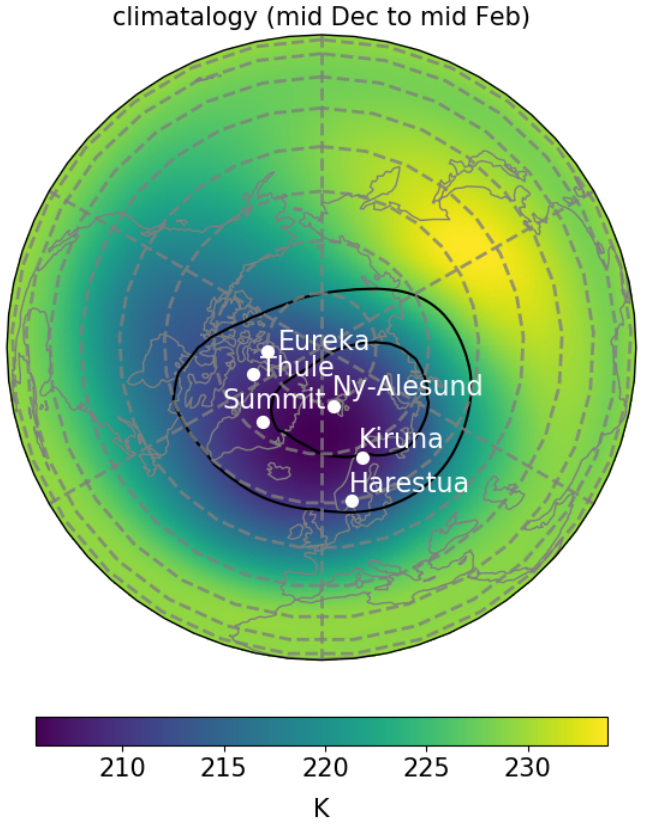
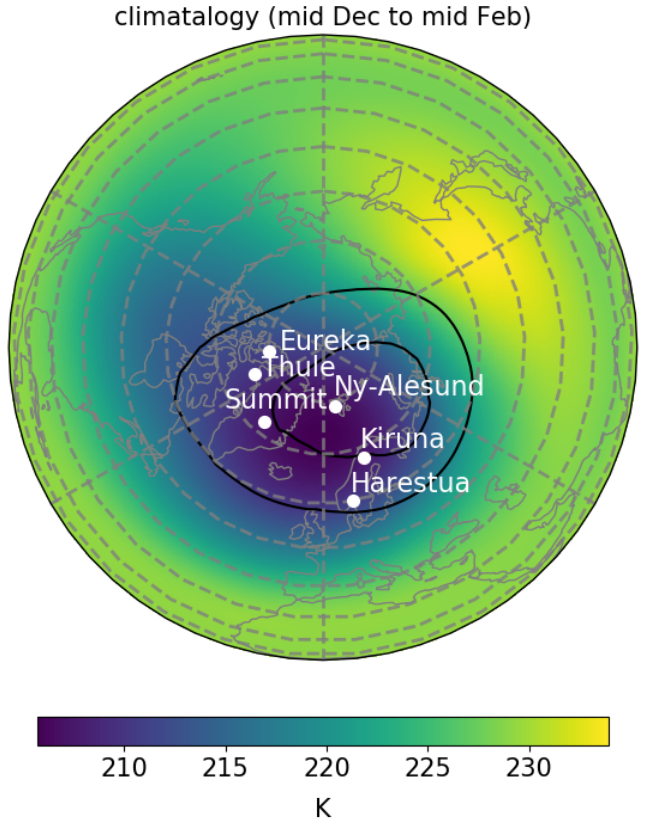


Figure 1. The climatology of temperature at 10 hPa and PV at the potential temperature of 850 k during wintertime (DJF) over the northern hemisphere. The climatology is based on non SSW years from 2004 to 2019. The map coloring shows the average winter temperature. The black contour lines are 60 and 80 PV units (10^5 K m^2 Kg^{-1} s^{-1}). Observational sites are shown in white dots.

Dataset

- **Ozonesonde** dataset
- Fourier transform infrared spectroscopy (FTIR)
  - **Solar FTIR** Network for the Detection of Atmospheric Composition Change (NDACC)
    - High latitude stations
    - 769 cm^{-1} (13µm) to 5000 cm^{-1} (2µm)
    - 0.0035 cm^{-1} spectral resolution
    - 8 months, excluding polar nights
    - vertical information about ozone
    - winter time measurements
- ***MERRA-2 (***The Modern-Era Retrospective Analysis for Research and Application, version 2)
  - NASA's Global Monitoring and Assimilation Office (GMAO) using GEOS atmospheric data assimilation system
  - Total column ozone from SBUV ,OMI (Ozone Monitoring Instrument),
  - ozone profiles from Aura MLS (Microwave Limb Sounder)



Sudden stratospheric warmings

- SSWs are defined as an abrupt and intense stratospheric temperature increase (up to increases of about 50°C at 10 hPa) that coincides with a reversal of the climatological westerly wind circulation (Scherhag, 1952, Baldwin et al. 2021).

SSWs date	Number of easterly wind days at 10 hPa over 60 N	minimum zonal-mean zonal wind at 10hPa over 60°N (m/s)
21 Jan 2006	26	-26
22 Feb 2008	15	-15
24 Jan 2009	30	-29
6 Jan 2013	22	-13
12 Feb 2018	19	-24
2 Jan 2019	21	-10

Smoothing method

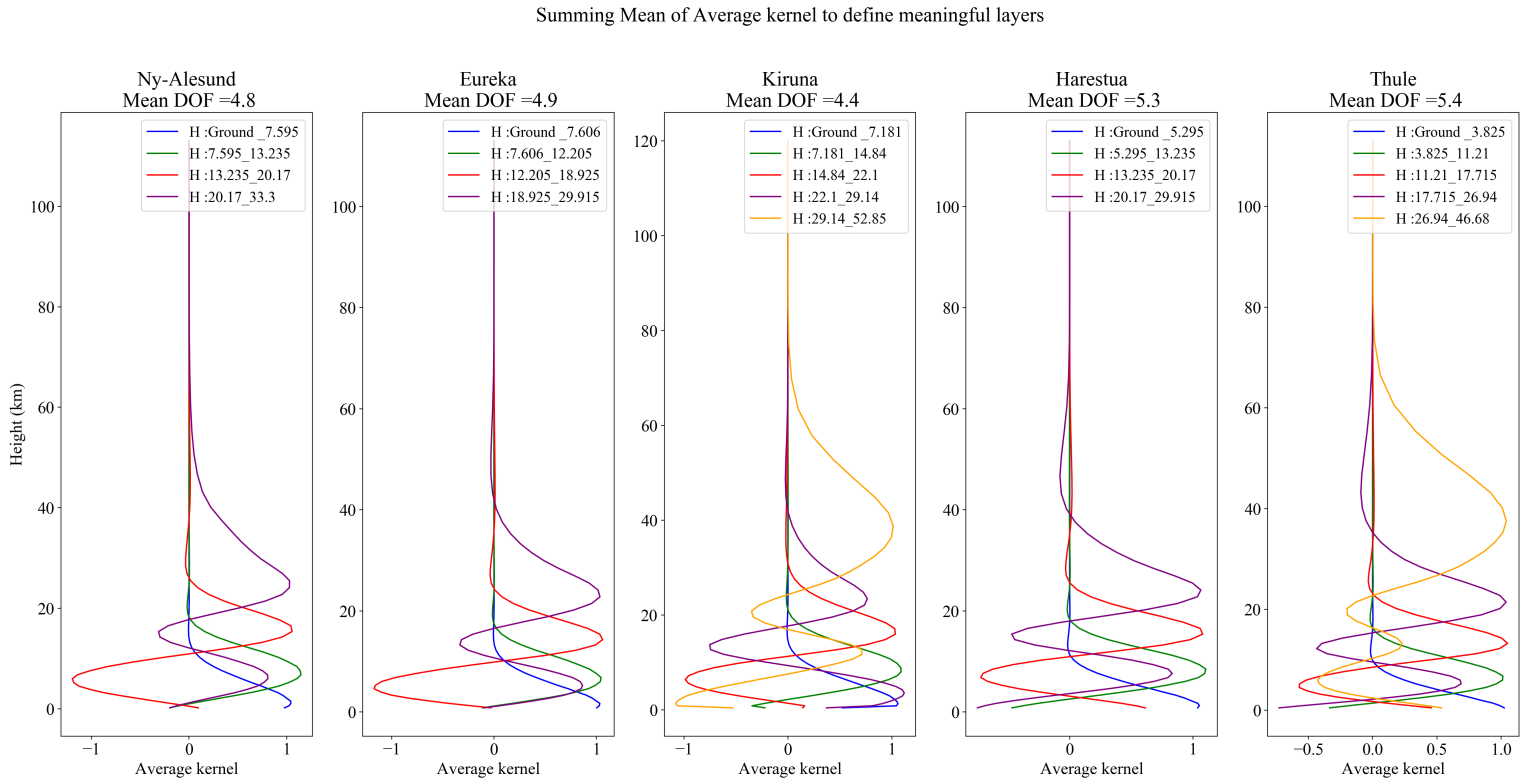
$$x_s = x_a + A\,(x_h - x_a)$$

x_s =the final smoothed profile,

x_h= model estimated profile,

X_a =a priori of the retrieval

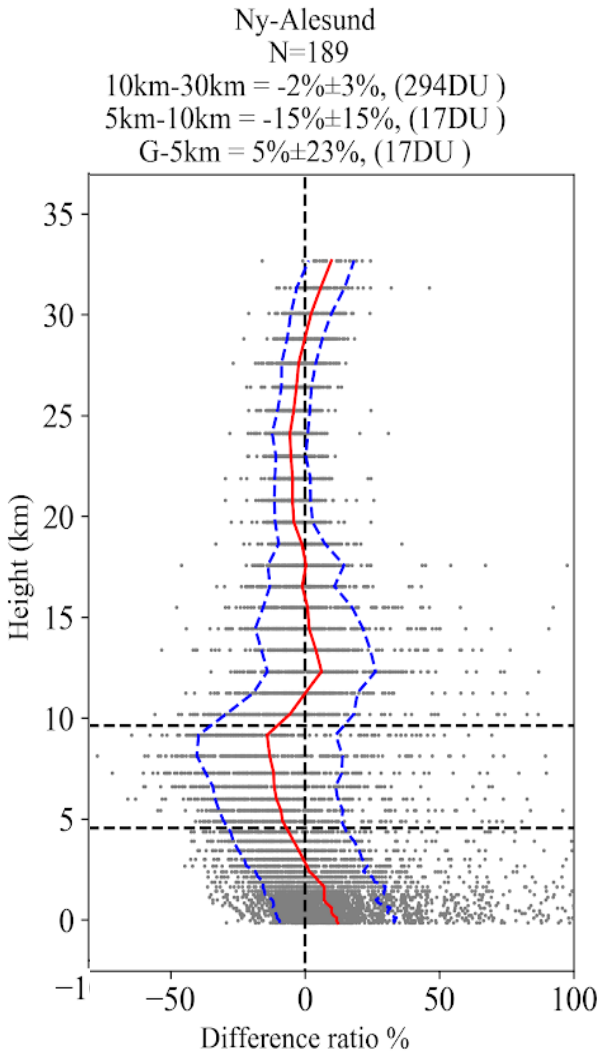
A=averaging kernel of the retrieval



Comparison of MERRA-2 and observations

Comparison to Ozonesondes

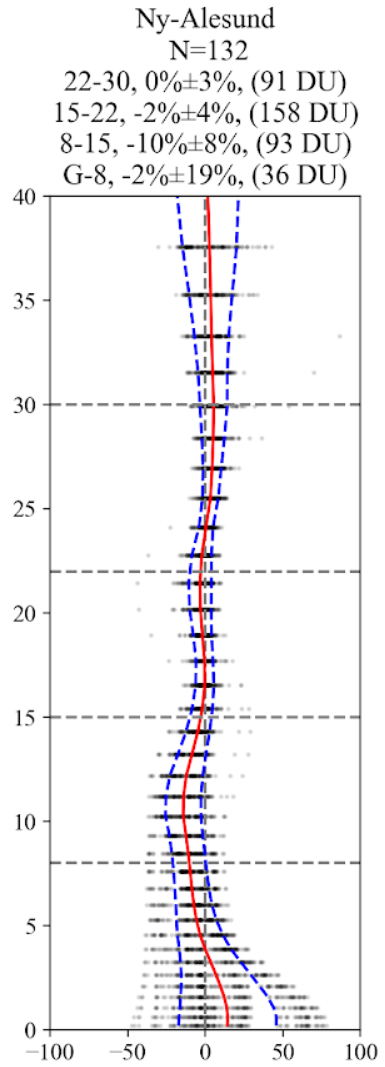
Difference ratio of ozonesonde and MERRA-2 at each layer in three stations from Dec 1st to May 1st for six year of SSWs. Difference ratio is the subtraction of ozonesonde from MERRA-2 ozone dataset divided by ozonesonde for each layer .



Comparison to FTIR (Fourier transform infrared)

Using average kernels (smoothing method) to create comparable profile.

Difference ratio of FTIR retrieved ozone from MERRA2. For each layer in each station mean ± standard deviation of NDACC retrieved ozone is subtracted from MERRA-2 and divided by retrieved value.



The mean and standard deviation of ratio difference for each layer is shown by the red and blue lines.

Conclusions

- The importance of having independent observations to assess model performances
- High agreement of MERRA-2 with observation at mid stratosphere (2%±5%) during SSWs
- Higher uncertainties of MERRA-2 at lower stratosphere and troposphere
- Great motivation to use MERRA-2 dataset to analyze the impact of SSWs on ozone variability in mid stratosphere over high latitude.
    - **Shima Bahramvash Shams**, Von P. Walden, James W Hannigan, William J. Randel, Irina V. Petropavlovskikh Amy H. Butler, Alvaro de la Cámara: **Analyzing ozone variations and uncertainties at high latitudes during Sudden Stratospheric Warming events using MERRA-2** (2021, in prep)

Question
Comments