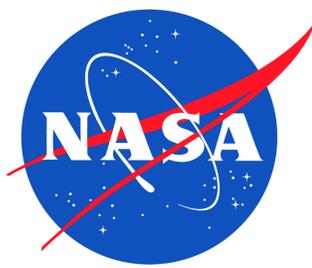


Polar Vortex Outbreak Air Transport: Observation using Satellite IR Sounder Derived Ozone Product and Comparison with Model (*Poster #A15L-1810*)



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Abstract

The Single Field of View (SFOV) Sounder Atmospheric Products (SiFSAP) derived from Cross-track Infrared Sounder (CrIS) on SNPP have a spatial resolution (~14.5 km) better than most global weather and climate models. Most recent significant improvement in the quality of these products enables us to use these high-resolution observation-based sounding data for weather studies and model evaluation. This study used these SFOV products, together with the model data from NASA's Modern-Era Retrospective Analysis for Research and Applications Version-2 (MERRA-2) and the fifth-generation ECMWF reanalysis (ERA5) data, to study the dynamic transport associated with polar vortex outbreak.

The variation of temperature, water vapor, ozone and their correlation in both horizontal and vertical directions, following the strong polar vortex outbreak on Jan. 29, 2019, from CrIS and model are analyzed and compared. Observation of ozone (O₃) from OMPS on SNPP, wind fields, geopotential height (GPH) and potential velocity (PV) are also used in these analysis.

It was found the link of the cold air outbreak near the surface with the stratospheric intrusion, based on the transport of O₃-riched polar air accompanying the polar vortex breakup to lower latitude and lower atmosphere, and the transport path of O₃ agreeing well with the path of polar cold air (illustrated using the retrieved RH, wind fields and GPH). Some difference between model and satellite observation were also illustrated. These results demonstrate the 3-D structure of water vapor and O₃ distribution as derived from CrIS measurements provides some insights of the cold air transport, and can be used to track the dynamic transport of polar cold air following the outbreak of polar vortex.

Introduction

- A polar vortex is a large-scale low-pressure system, which spins counterclockwise in the stratospheres over the north and south poles, and is unusually persistent during winter and spring. Breakup of the northern polar vortex will lead to the transport of cold and dry air masses to mid-latitude regions, which may cause snow storms or cold air break (CAO) across Europe and North America, and affect a large region of the midlatitudes during the winter months. The strength of the northern hemisphere polar vortex is generally recognized as an important element for coupling between the stratosphere and troposphere during winter and spring (e.g., Kidston et al., 2015).
- On Jan 28-31, 2019 the frozen Arctic winds brought record-low temperatures across much of the US midwest. Temperatures in Chicago dropped to a low of around -30°C on Jan 30, 2019, killed at least 22 people, brought up to 13 inches (33 cm) of snow in some regions from January 27-29. Data on Jan 29, 2019 is presented here.

- Satellite Data used:
 - SiFSAP from CrIS on SNPP with a resolution of ~ 15 km;
 - Ozone Mapping and Profiler Suite (OMPS) on SNPP;
- Model Data used: MERRA-2, ERA-5;

Transport of Polar Cold Air

Polar Vortex Outbreak on Jan 29, 2019

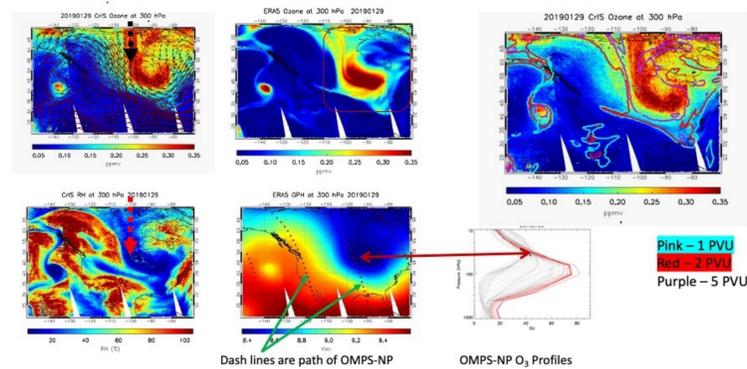


Fig 1. Path of cold and dry air transport is evident from the enhanced zone overlaid with wind field and low relative humidity (RH). The location of enhanced ozone collocated with 5 PVU lines demonstrates its link with stratospheric air.

Vertical Distribution of Temperature, Ozone and RH

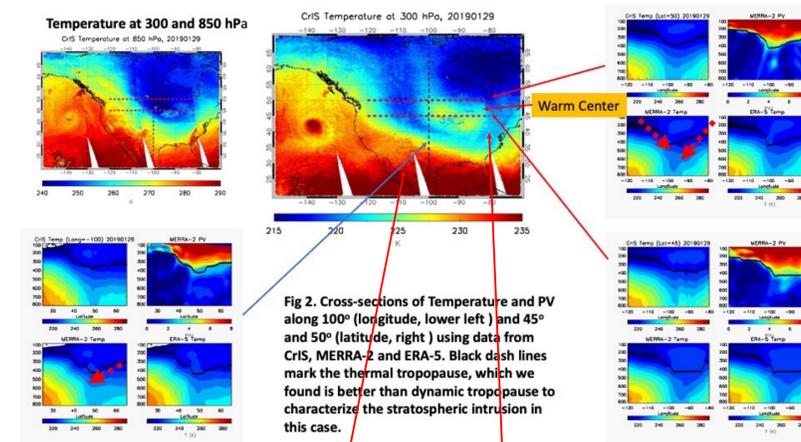


Fig 2. Cross-sections of Temperature and PV along 100° (longitude, lower left) and 45° and 50° (latitude, right) using data from CrIS, MERRA-2 and ERA-5. Black dash lines mark the thermal tropopause, which we found is better than dynamic tropopause to characterize the stratospheric intrusion in this case.

Dash line arrows mark the folding of tropopause and the transport of stratospheric cold/dry air to lower atmosphere

Under tropopause, there is a thicker dry layer in MERRA-2 than SiFSAP and ERA-5

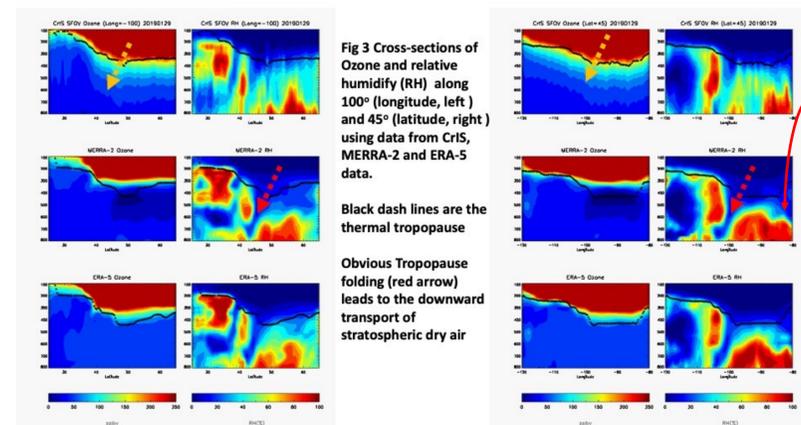


Fig 3 Cross-sections of Ozone and relative humidity (RH) along 100° (longitude, left) and 45° (latitude, right) using data from CrIS, MERRA-2 and ERA-5 data.

Black dash lines are the thermal tropopause

Obvious Tropopause folding (red arrow) leads to the downward transport of stratospheric dry air

Total Ozone

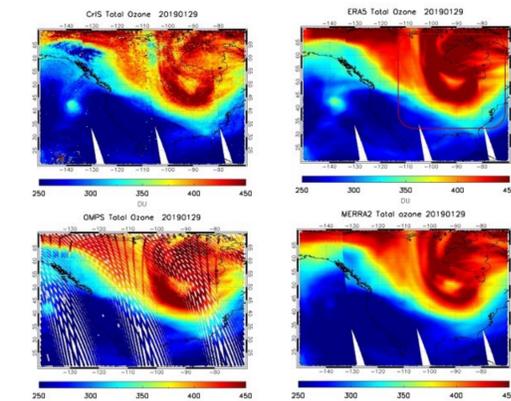


Fig 4 Total ozone from CrIS agrees well with OMPS measurement and model simulated data from ERA-5 and MERRA-2. It is also evident that CrIS SFOV product has a better spatial resolution than OMPS.

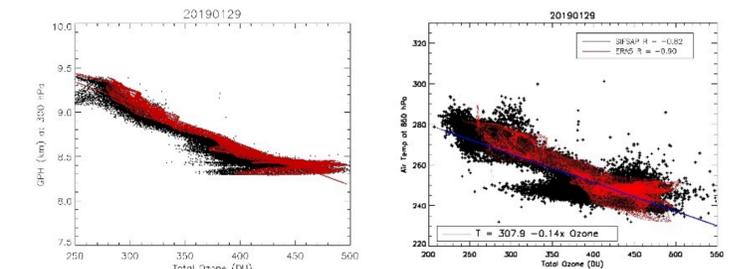


Fig 5 The correlation coefficient between total ozone with GPH at 300 hPa (left, from ERA-5) and temperature at 850 hPa using SiFSAP (black) and ERA-5 data (red) respectively (using data in the box).

Summary and Conclusions

- The blast of cold air on Jan 29, 2019 across the US Midwest was well captured from the ozone and RH at 300 hPa and total ozone, and the correlation between the total ozone and air temperature at 850 hPa or GPH is > 0.8-0.9.
- The link of the cold air near the surface with the stratospheric intrusion is evident from the cross-sections of temperature, water vapor, ozone and PV.
- Above the center with the coldest air at 850 hPa, there is a warm center of air at 300 hPa, where ozone is enhanced and is associated with tropopause folds.
- It seems the thermal tropopause is better than the dynamic tropopause to be used in characterizing the tropopause variation.
- Total ozone from SiFSAP agree well with total ozone from OMPS and model data, and potentially they can be used to track the polar vortex outbreak.

References

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