Polar Vortex Outbreak Air Transport: Observation using Satellite IR Sounder Derived Products 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 (~15 km) better than most global weather and climate models and current operational sounding products. Most recent significant improvement in its quality provides us an opportunity to use SiFSAP sounding data, which will soon be available at NASA DAAC for weather studies and model evaluation. This presentation used SiFSAP together with two model data, i.e. 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 Cold Air Outbreak (CAO) on Jan 29, 2019, and its relationship with polar vortex. In this case study, the changes of temperature (T), water vapor, ozone (O_3), wind fields, geopotential height (GPH) and potential velocity (PV), as well as O_3 from OMPS on SNPP were analyzed and compared.

We found the cold air transport near the surface can be linked with the folding of tropopause, which brought O_3-riched and dry stratospheric air to lower altitudes in the atmosphere. The transport path of cold air from polar to lower latitude can be well mapped from the enhanced O_3, low relative humidity (RH), wind fields and PV contours. The change of surface T has a high correlation (R>0.8) with O_3. Some difference between models and satellite observations of T and RH from the latitude-pressure and longitude-pressure cross-section is found. These results demonstrate the 3-D structures of T, RH and O_3 distribution as derived from CrIS measurements provide some insights of the cold air transport, and have a potential to be used to monitor the 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 CAO across Europe and North America, affecting 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, and brought up to 13 inches (33 cm) of snow in some regions from January 27–29.

- 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 and its Link to Stratosphere

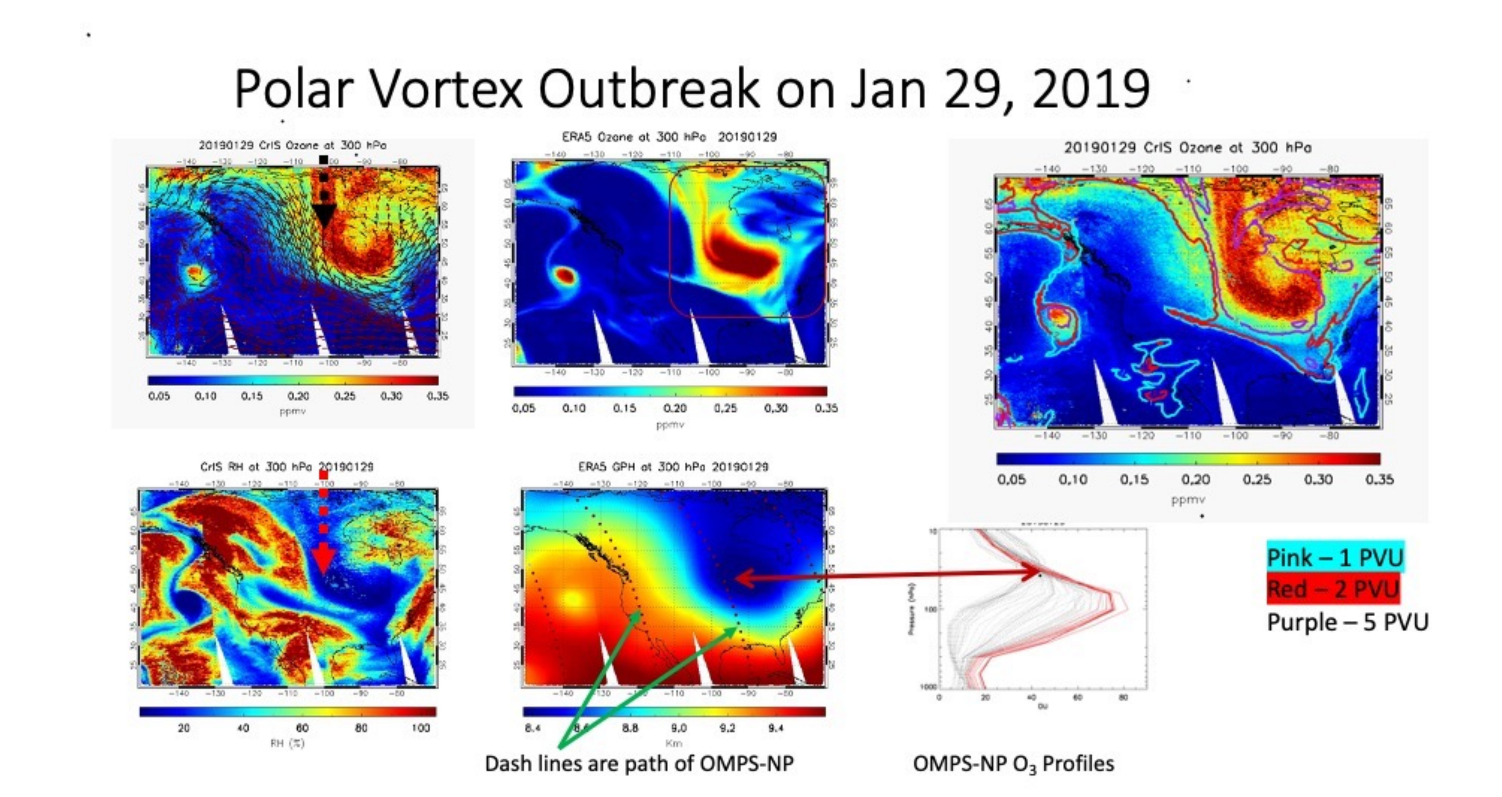

Fig 1. Path of cold and dry air transport is evident from the enhanced zone overlaid with wind field and low relative humidity (RH). The location of enhanced ozone collocated with 5 PVU lines demonstrates its link with stratospheric air.

Vertical Cross-Sections of Temperature, O_3 and RH

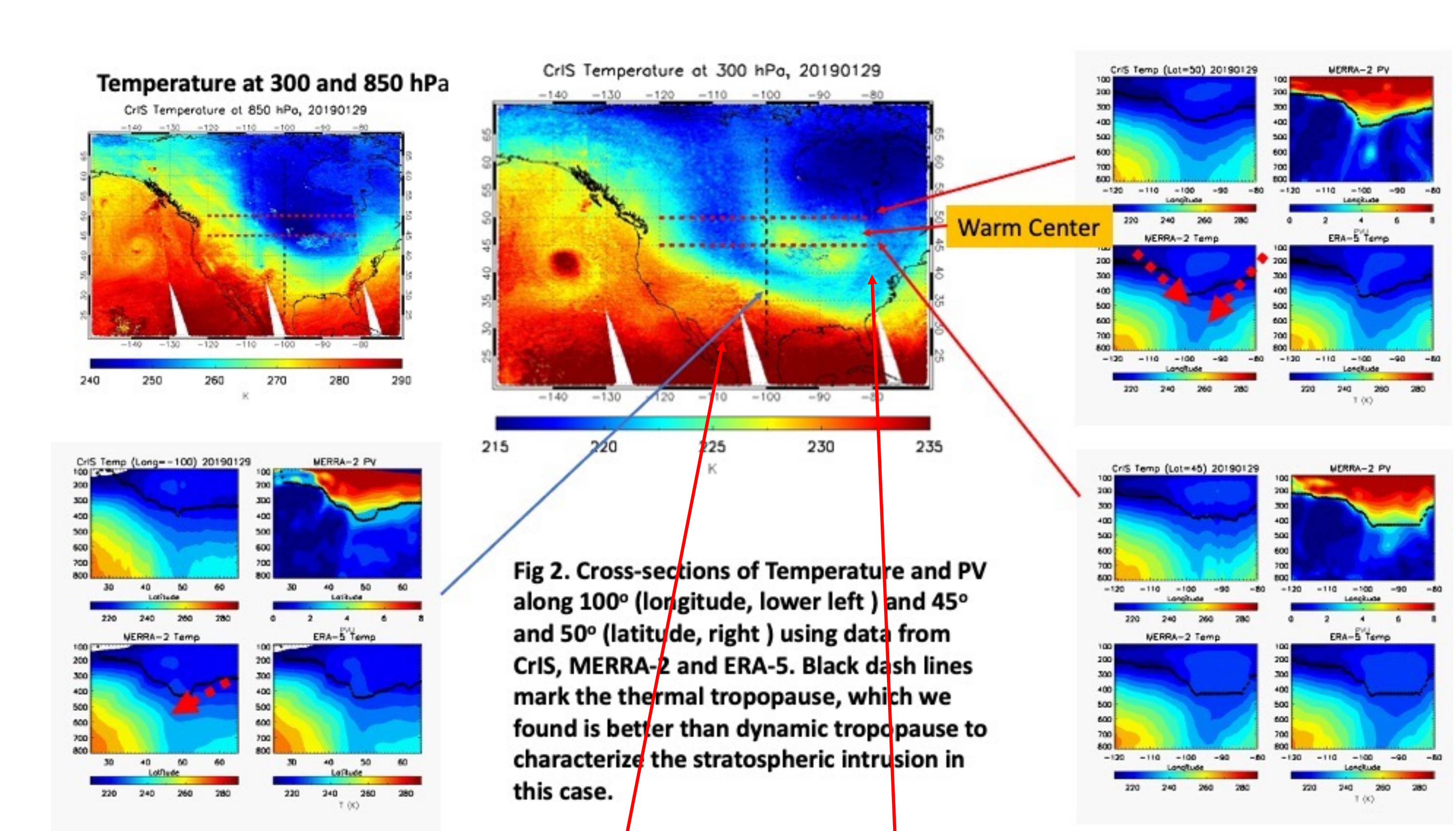

Fig 2. Cross-sections of Temperature and PV along 100° (longitude, lower left) and 45° and 50° (latitude, right) using data from CrIS, MERRA-2 and ERA-5. Black dash lines mark the thermal tropopause, which we found is better than dynamic tropopause to characterize the stratospheric intrusion in this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

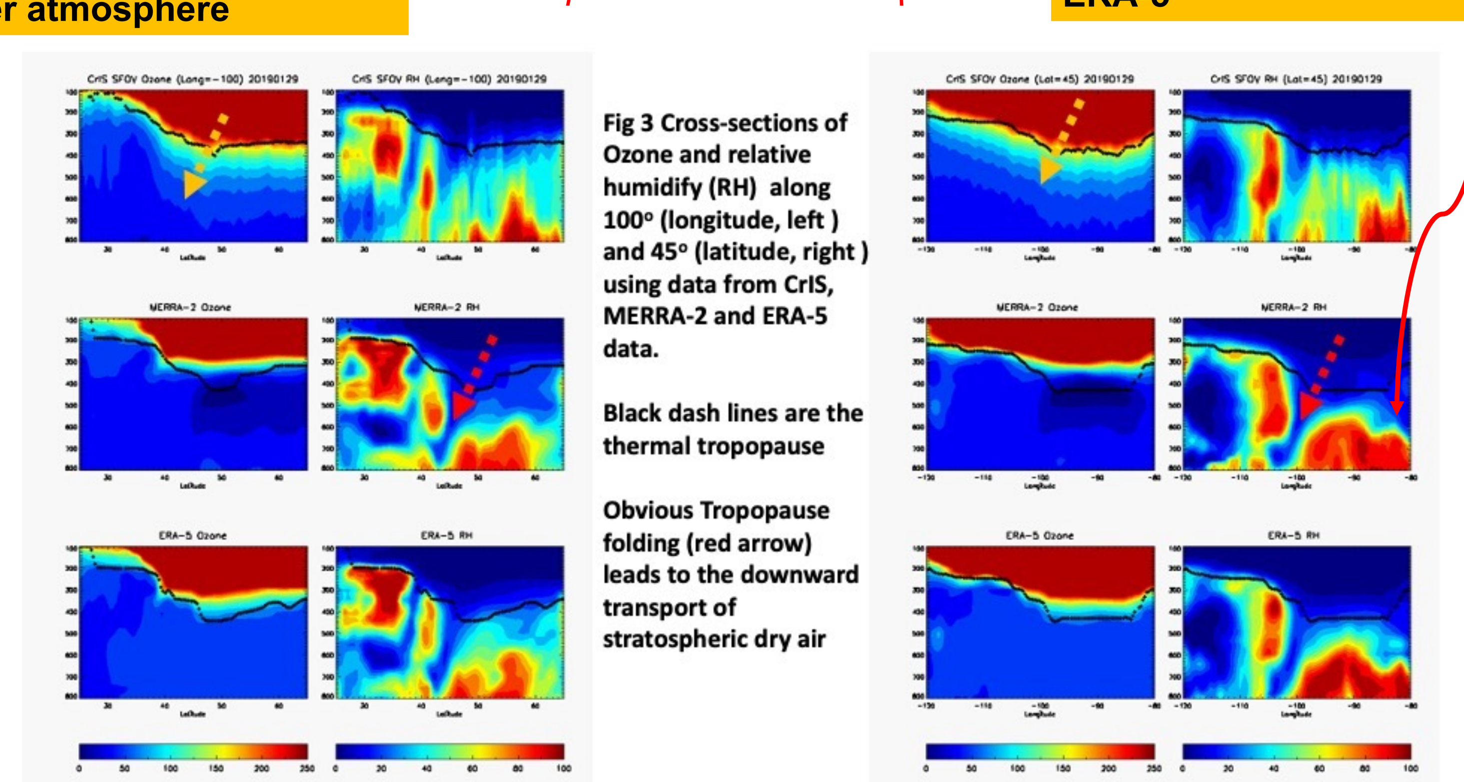

Fig 3 Cross-sections of Ozone and relative humidity (RH) along 100° (longitude, left) and 45° (latitude, right) using data from CrIS, MERRA-2 and ERA-5 data.

Black dash lines are the thermal tropopause

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

Total O_3 and Correlations

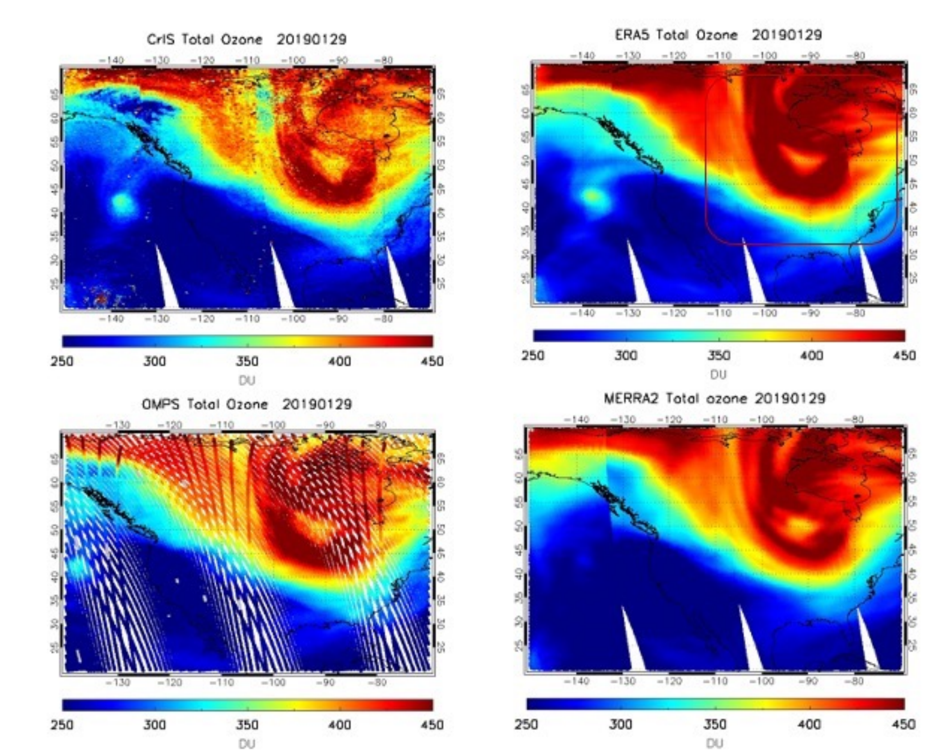

Fig 4 Total ozone from CrIS agrees well with OMPS measurement and model simulated data from ERA-5 and MERRA-2. It is also evident that CrIS SFOV product has a better spatial resolution than OMPS.

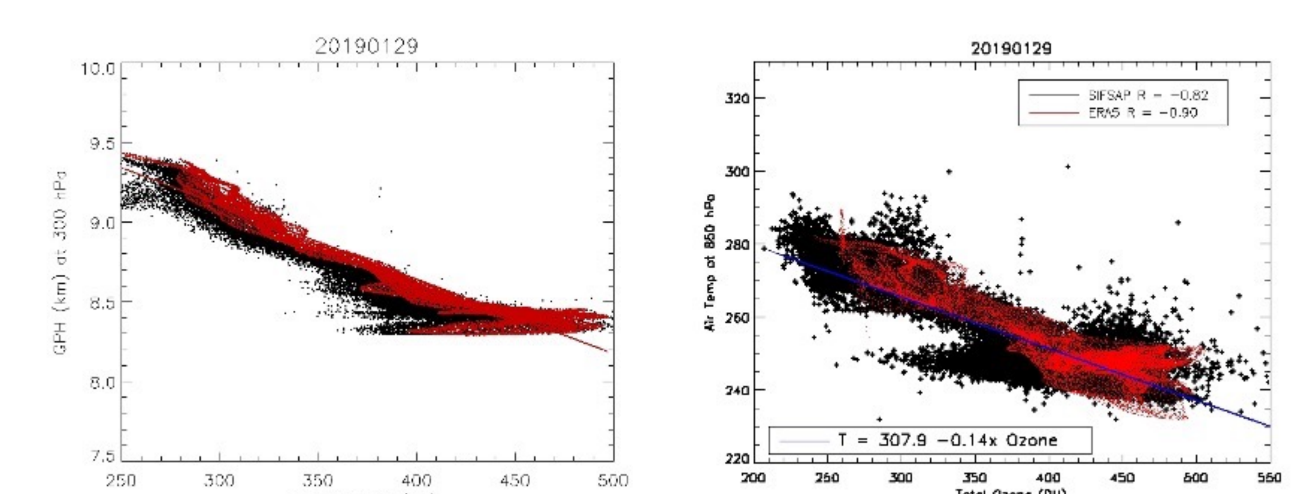

Fig 5 The correlation coefficient between total ozone with GPH at 300 hpa (left, from ERA-5) and temperature at 850 hPa using SIFSAP (black) and ERA-5 data (red) respectively (using data in the box).

Summary and Conclusions

1. **The path of the blast of cold air on Jan 29, 2019 across the US Midwest was well captured from O_3 and RH at 300 hPa and total O_3, and the correlation between the total ozone and air temperature at 850 hPa or GPH is more than 0.8-0.9.**
2. **Corresponding to the center with the coldest air at 850 hPa, an interesting warm center at 300 hPa is found.**
3. **The thermal tropopause is better than the dynamic tropopause to characterize the downward transport of stratospheric air.**
4. **A good agreement of the total O_3 from SiFSAP and total O_3 from OMPS and model data, which can be used to monitor the exchange of stratosphere/troposphere air.**
5. **This study provides an observational evidence to link the CAO with the stratospheric intrusion, highlighting the impact of stratosphere to tropospheric weather system.**

References

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