Detection of Sudden Stratospheric Warming (SSW) Events

Lena Heuscher, Deron Scott, Mark Esplin, Joe Kristl, Kori Moore

Sudden Stratospheric Warming (SSW) Events

- Robust atmospheric phenomena that split/displace the stratospheric polar vortex
- Precede extreme weather regimes in the troposphere
- Most common in the Northern Hemisphere

- Major Events (occur at 10 mb or below) (seen in Fig. 1)
  - Mean temperature increase poleward from 60ºN (≥ 25 K in a week or less)
  - Associated circulation reversal
- Minor Events (occur at any stratospheric level)
  - Mean temperature increase poleward from 60ºN (≥ 25 K in a week or less)

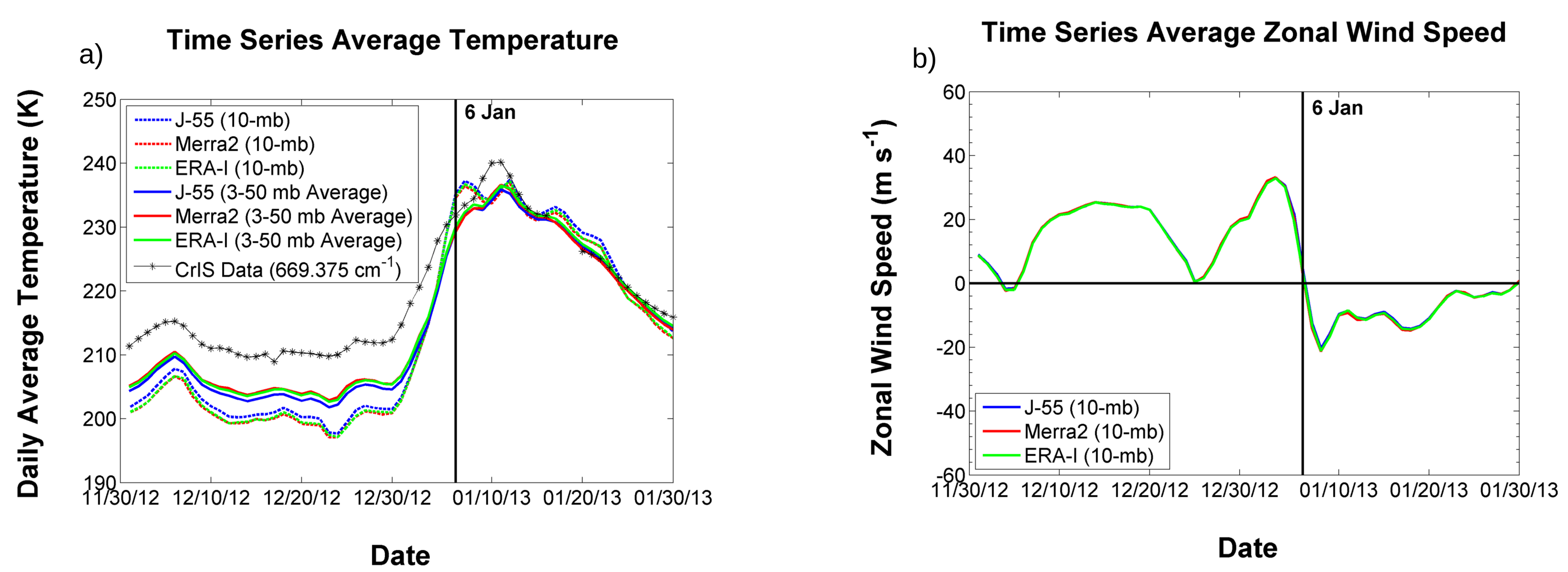


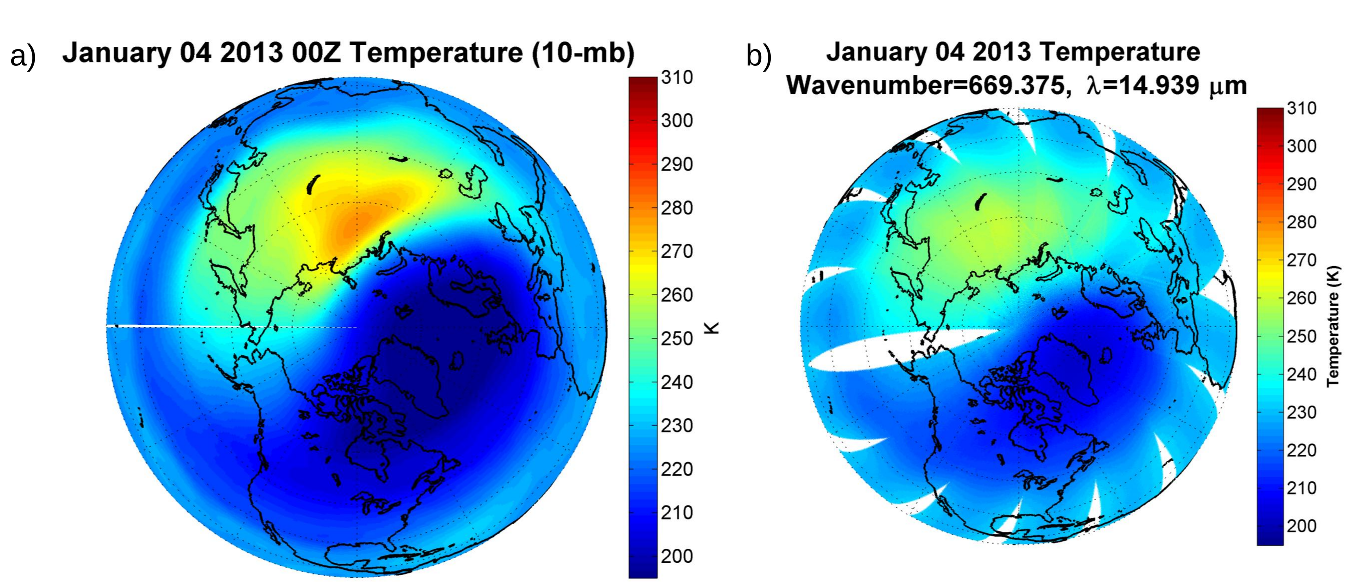
Figure 1: a) Time series average temperature and b) time series average zonal wind speed for December 2012-January 2013 for multiple sources. These figures show that a wind reversal occurred at the same time as a significant temperature increase.

Data

- Reanalysis Data (both 10-mb & 3-50-mb average) → combination of observations and models
  - Japanese 55-year (J-55) – 6 hr. daily; 1.25º longitude x 1.25º latitude grid
  - ERA-Interim (ERA-I) – 6 hr. daily; 0.5º longitude x 0.5º latitude grid
  - Merra2 – 3 hr. daily; 0.625º longitude x 0.5º latitude grid (shown in Fig. 2a)

- Cross-track Infrared Sensor (CrIS) Data
  - Located on Suomi National Polar-orbiting Partnership (S-NPP) satellite
  - Water vapor and temperature profiles of the Earth's atmosphere based on spectral channels that range from 3.92 µm to 15.38 µm
  - Multiple passes/day over polar region; 14 km x 14 km resolution at nadir
  - Brightness temperature (shown in Fig. 2b)

Figure 2: a) Temperatures for Merra2 data on January 4, 2013 at 00Z at the 10-mb height and b) CrIS data for the same day at a wavenumber of 669.375 cm^{-1}. The SSW is evident in both figures.



Merra2 Temperature

CrIS Temperature
Wavenumber = 669.375 cm^{-1}

Detection of SSW Events

Two data points were chosen for the comparison of reanalysis data to CrIS data (Fig. 3). The spectra for the Merra2 data were calculated through MODTRAN and compared to the spectra observed by CrIS at approximately the same time and location (Fig. 4). Five different wavenumbers were chosen and the time series temperature was graphed for each location (Fig. 5). As can be seen in this figure, CrIS data can see the SSW event in each location.

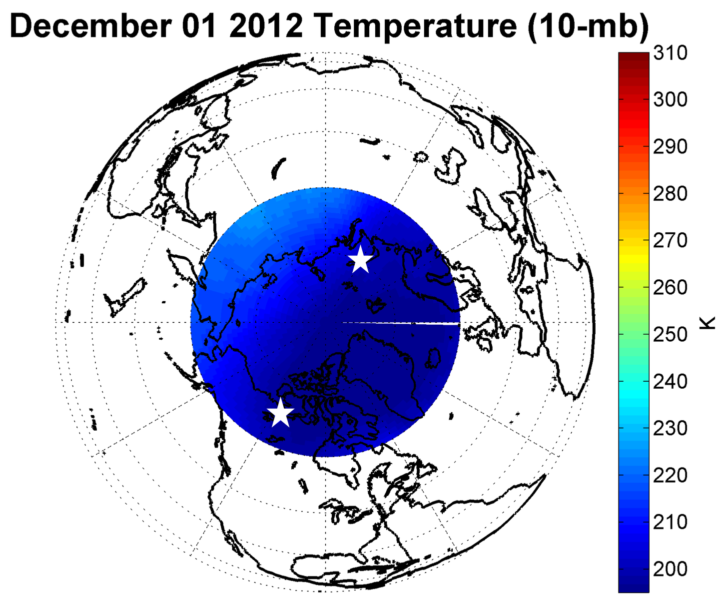


Figure 3: Data point locations for Northern Canada and Northern Russia

Spectra

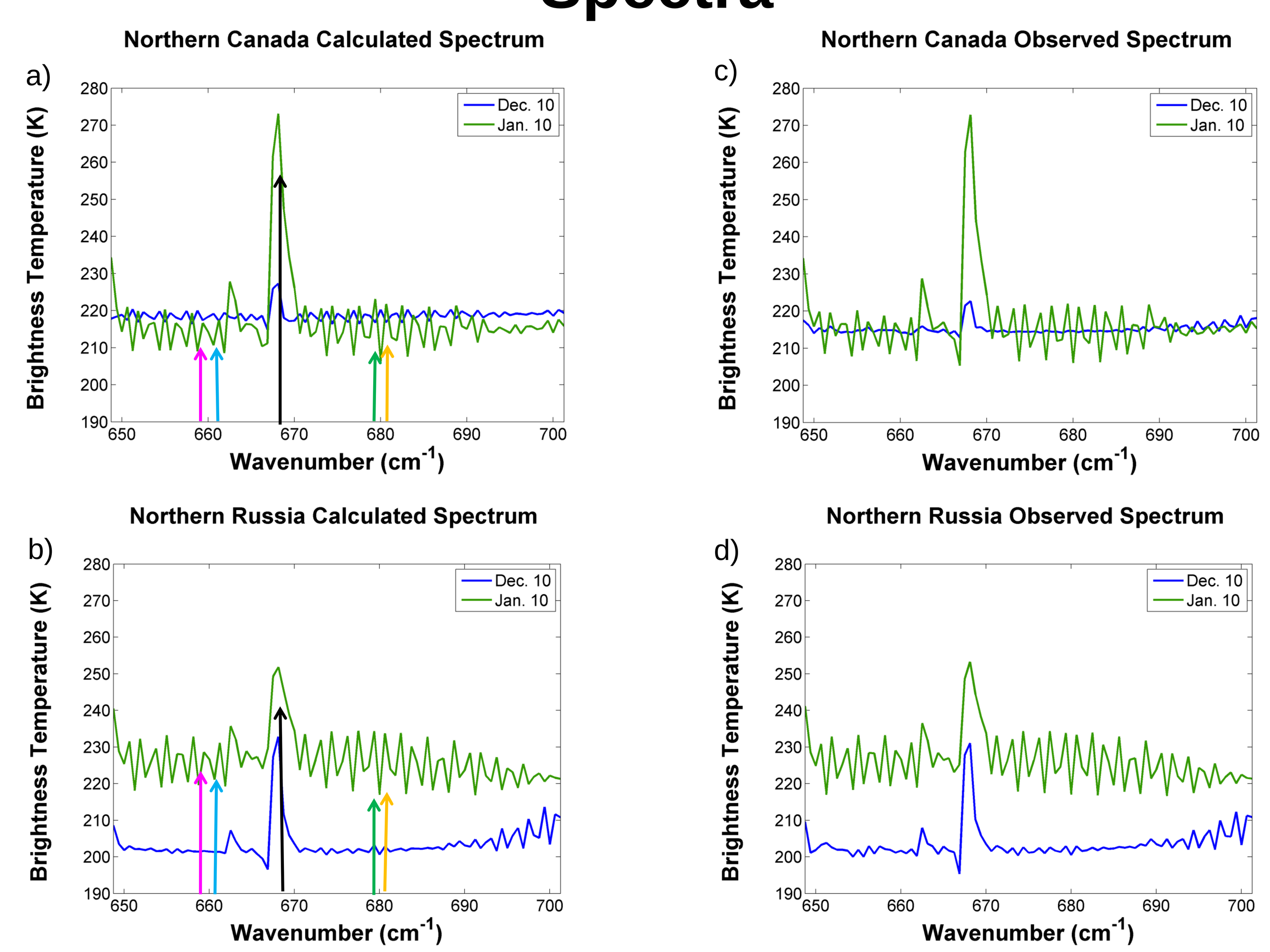


Figure 4: Spectra calculated through MODTRAN from Merra2 profiles in a) Northern Canada and b) Northern Russia. These spectra are compared to spectra observed in the same locations (c) and d) respectively) by CrIS. Wavenumbers used in the analysis include 659.375 cm^{-1}, 661.250 cm^{-1}, 669.375 cm^{-1}, 680.000 cm^{-1}, and 681.250 cm^{-1}.

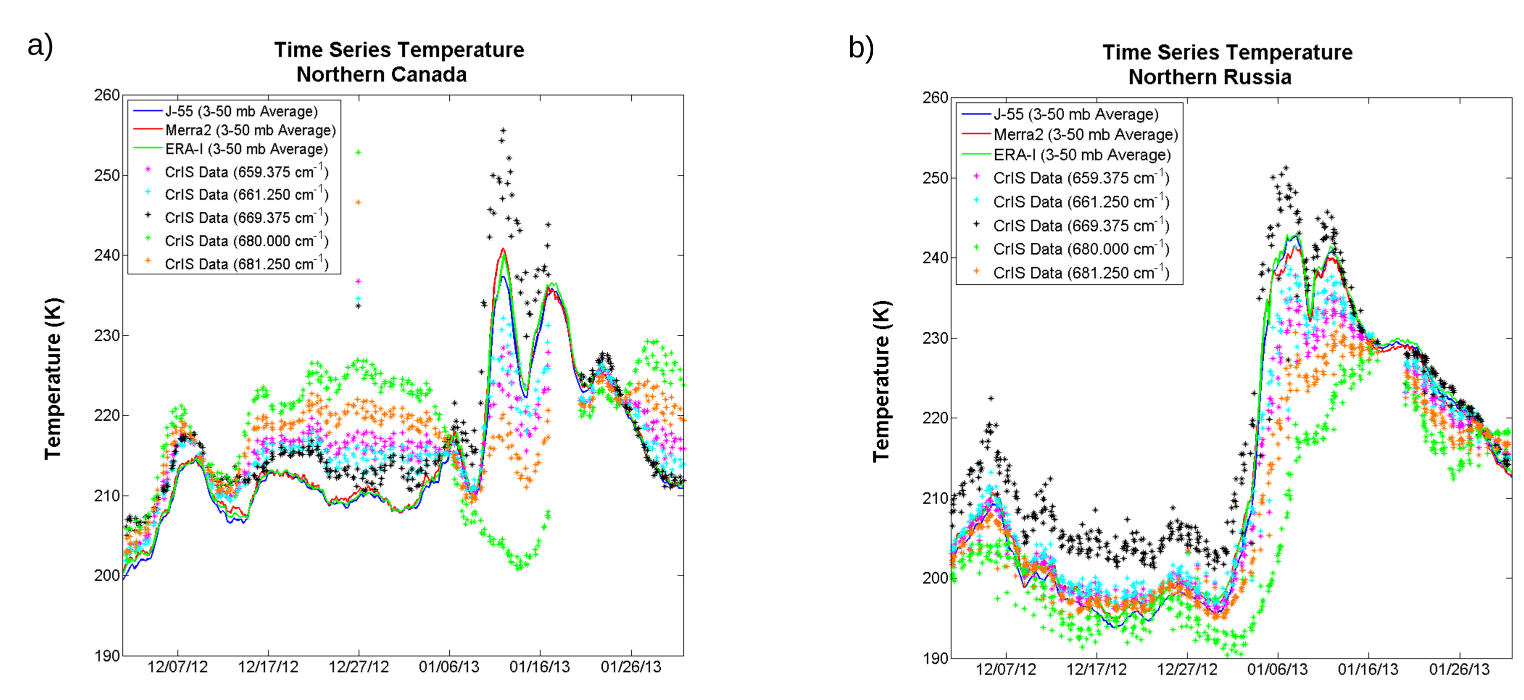


Figure 5: Time series temperature for Northern Canada (a) and Northern Russia (b) for December 2012-January 2013. Included on each graph are the 3-50-mb average for each reanalysis dataset and the five chosen wavenumbers.

Structure of SSW Events

Vertical profiles of the different data sources were compared (Fig. 6) for each location. The CrIS dataset typically had cooler temperatures and ***different*** structure characteristics than the reanalysis profiles.

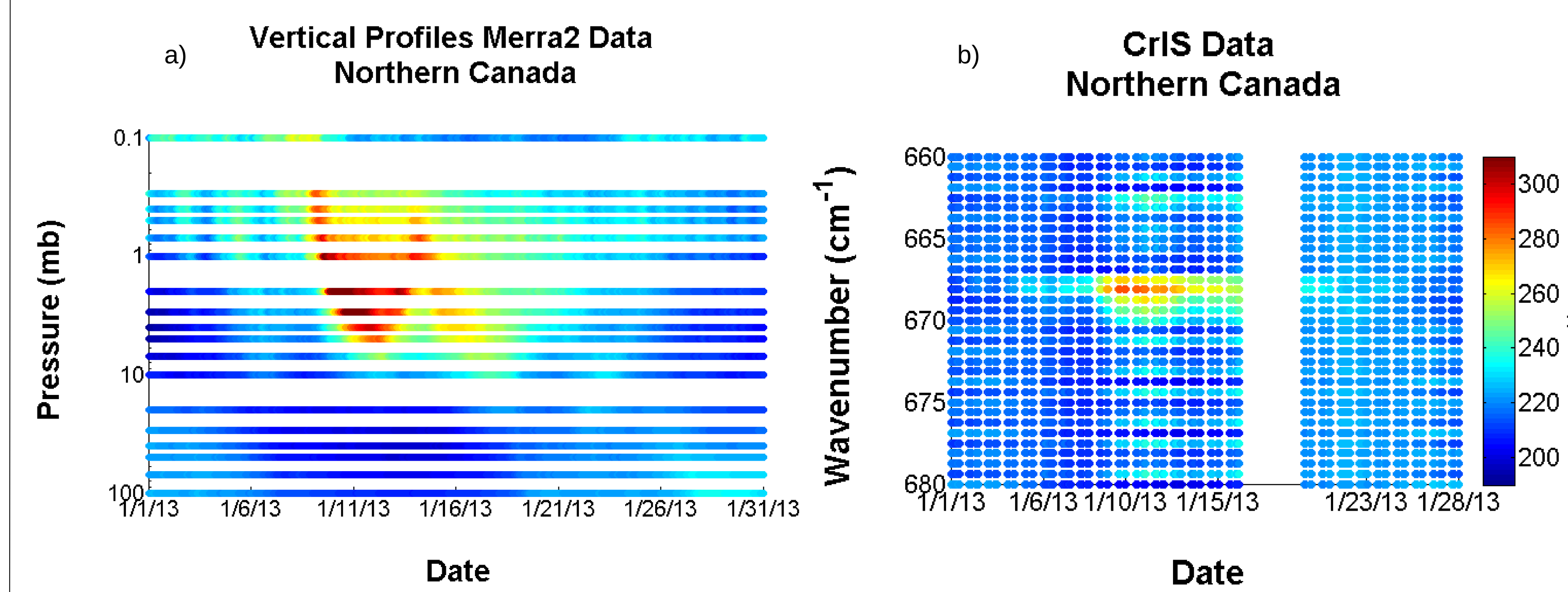


Figure 6: a) Vertical profiles of the Merra2 data and b) the CrIS data for the Northern Canada location.

Conclusions

- The CrIS instrument can be used as a real time detector for SSW events
  - The appropriate wavelength will change depending on location (Reanalysis data is available a minimum of 1 month after event)

- Different structure can be seen with CrIS data than with reanalysis data
  - Looking at a layer of the atmosphere rather than individual levels
  - Finer spatial resolution (14 km x 14 km) and temporal resolution (approx. 90 min.)

- Further analysis and comparison between these datasets could lead to:
  - New information on the formation and propagation of such events
  - Better forecasts of tropospheric weather following these events

References

- Dee, D. P. and Coauthors, 2011: The ERA-Interim reanalysis: configuration and performance of the data assimilation system. *Quart. J. Roy. Meteor. Soc.*, **137**: 553–597. doi:10.1002/qj.828. Accessed 29 June 2016.
- Global Modeling and Assimilation Office (GMAO) (2015), MERRA-2 tavg3_3d_asm_Nv: 3d,3-Hourly,Time-Averaged,Model-Level,Assimilation,Assimilated Meteorological Fields V5.12.4, version 5.12.4, Greenbelt, MD, USA, Goddard Earth Sciences Data and Information Services Center (GES DISC). [Available online at http://dx.doi.org/10.5067/SUOQESM06LPK.] Accessed 18 June 2016
- Japan Meteorological Agency/Japan, 2013: JRA-55: Japanese 55-year Reanalysis, Daily 3-Hourly and 6-Hourly Data. Research Data Archive at the National Center for Atmospheric Research, Computational and Information Systems Laboratory, Boulder, CO. [Available online at http://dx.doi.org/10.5065/D6HH6H41.] Accessed 10 June 2016.
- McInturff, R. M., Ed., 1978: Stratospheric warmings: Synoptic, dynamic and general-circulation aspects. NASA Reference Publ. NASA-RP-1017, 174 pp. [Available online at http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19780010687.pdf.]