Major Stratospheric Sudden Warming (SSW) events significantly disrupt the winter stratospheric circulation. However, SSWs occur over a broad vertical domain that includes not only the stratosphere but also the mesosphere, and in some cases, the troposphere. Here we investigate the recent February 2018 major SSW and associated tropospheric effects to better understand:

1. How far in advance can major SSW events be forecasted?
2. Can knowledge of SSW events improve tropospheric weather, arctic sea ice, and surface forecasts?

**Global Analyses and Forecasts**

NASA Global Modeling and Assimilation Office Products

- **MERRA-2 Data Assimilation System (DAS):** ongoing 50 km reanalyses starting from 1980
- **Forward Processing (GEOS FP) System:** Near real time DAS with 12.5 km horizontal resolution and forecasts out to 10 days
- **Seasonal to Subseasonal (GEOS S2S) System:** Coupled atmosphere ocean forecasts out to 9 months with retrospective

**Forecast of Vortex Splitting Event of February 2018**

- Initial Analysis 3 Feb 2018 00UTC
- 10-Day Forecast 13 Feb 2018 00UTC
- Verifying Analysis 13 Feb 2018 00UTC

The FP 10-day forecasts accurately capture the 1st Wave-2 SSW since 2009.

**Sub-Seasonal Prediction February 2018**

- 20 Day Forecast
  - An ensemble member from an S2S forecast shows a similar pattern to the MERRA-2 Analysis
  - Ensemble Mean (4 members) 20 Day forecast shows stronger wave pattern than the MERRA-2 Climatology

**Vertical Coupling**

- North Pole Geopotential Height
  - r517_fp

Strong anomalies extend from the Stratosphere to the Troposphere after the SSW.

**Tropospheric Response, SSW Plus 40 Days**

The 40-day period after the SSW was characterized by anomalous high pressure over the Norwegian and Barents Seas and low pressure near the Azores. The Arctic high advected cold air down over central Europe, while warm subtropical Atlantic air was transported into the Arctic. The patterns reflect the historical SSW response but differ in magnitude (Smith et al., 2018, J. Clim. https://doi.org/10.1175/JCLI-D-17-0495.1).

**Storm Track Changes in MERRA-2**

- **Left:** Typical day after SSW shows relation between stratospheric circulation and surface conditions, with stratospheric vortex and winds (white), upper tropospheric winds (red), and surface temperature change (GEOSS FP forecast).
- **Right:** In SSW+40 days, the jet stream became more zonal and elongated over North America, leading to enhanced synoptic variability and severe weather over the central US, and more frequent cyclogenesis along the Atlantic seaboard.

**Arctic Changes and Predictability**

- **Barents sea ice extent**
- **MERRA-2 sea ice concentration anomaly March 2018 – March 2017**
- **S2S Version 2 sea ice concentration anomaly March 2018 – March 2017**

Top: The SSW and circulation changes led to an increase in sea ice cover in the Barents Sea in March 2018, while warm conditions and low sea ice cover resulted along the northeast Greenland coast.

Right: GEOS S2S sea-ice forecasts initialized in February 2018 demonstrate a similar, though diminished pattern in sea ice change in March.

**Conclusions**

- The SSW was associated with anomalous conditions that extended to the surface, with particularly enhanced effects in European surface temperatures, North Atlantic sea ice, and the North American jet stream and related storm track.
- Although circulation anomalies are consistent with canonical response patterns, the effects were particularly strong.
- Models accurately predicted SSW in 10-day lead forecasts with some S2S skill out to 20 days. S2S predictability also identified responses in sea ice field.

---

**Science Questions**

1. How far in advance can major SSW events be forecasted?
2. Can knowledge of SSW events improve tropospheric weather, arctic sea ice, and surface forecasts?