Connections Between the Stratosphere and Surface Weather Associated with the Stratospheric Sudden Warming in Early 2018

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Presented by **K. Wargan**

NASA GSFC

Outline

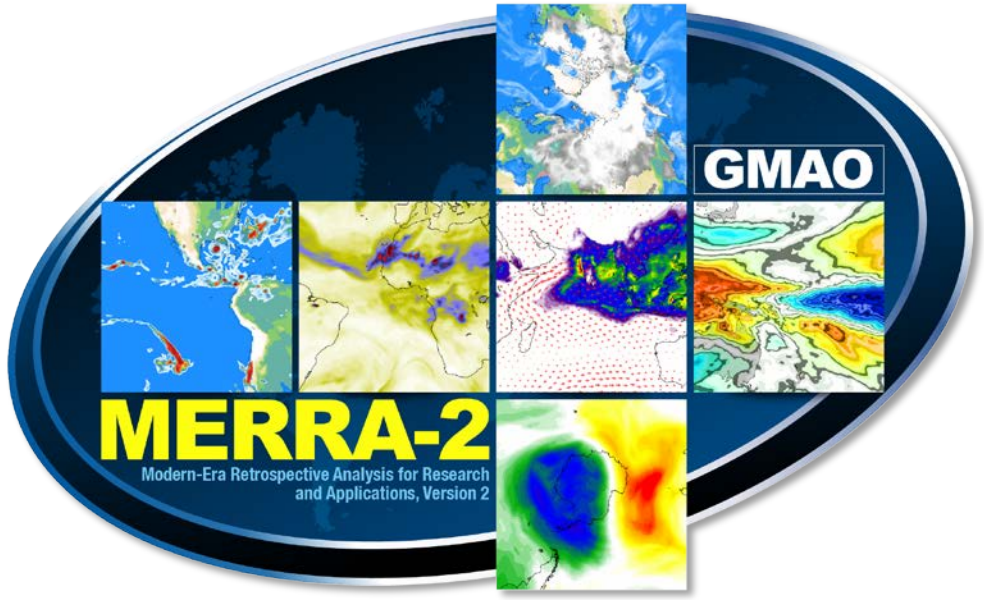
- Stratospheric Vortex Splitting SSW Forecast
- Evolution of the 2018 SSW
- Unusual weather of February 2018 following the SSW
- S2S forecast of the 2019 SSW
- Summary

NASA Global Modeling and Assimilation Office Products

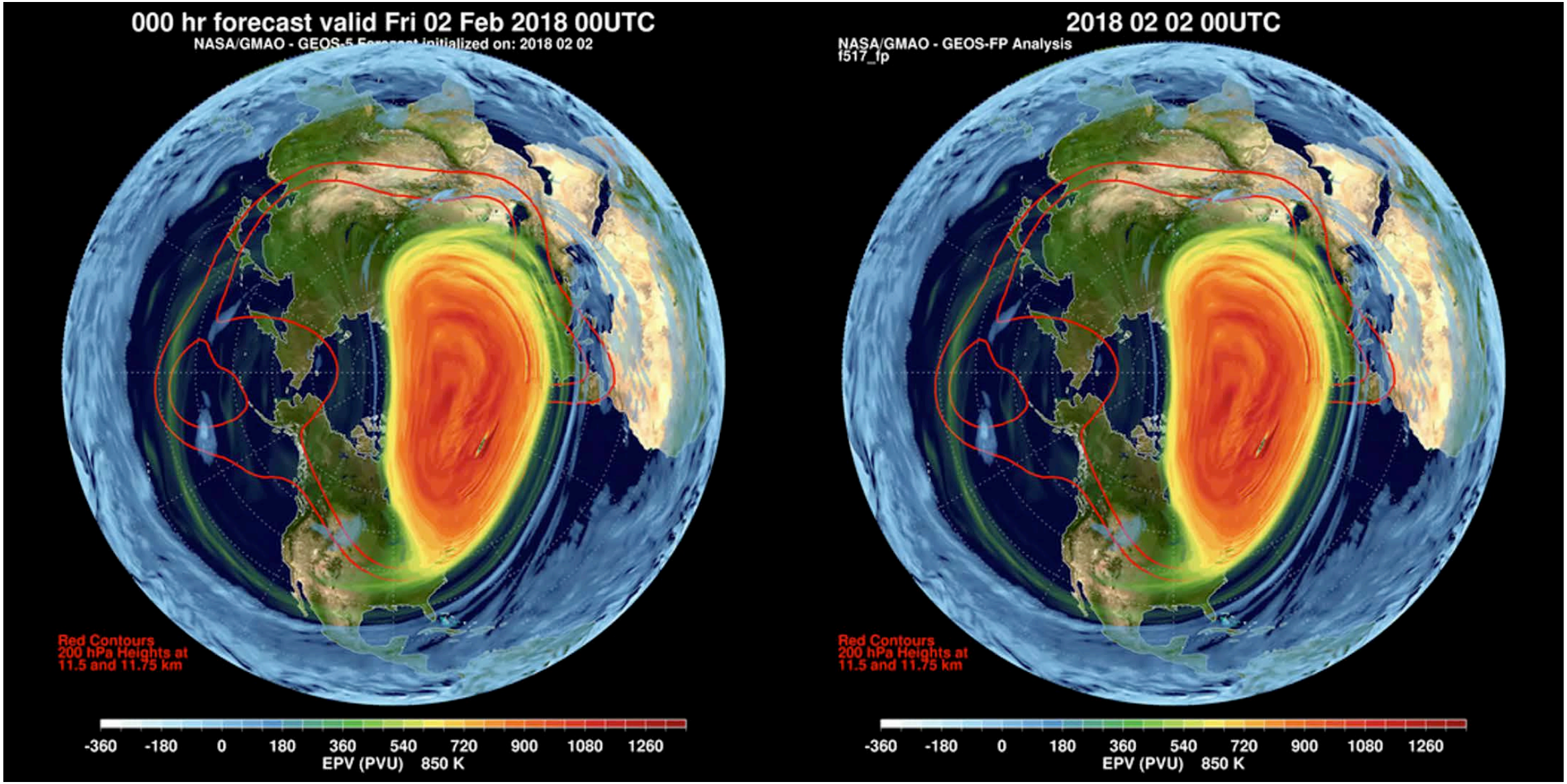
MERRA-2 Data Assimilation System (DAS):
Ongoing 50 km reanalysis starting from 1980.

Forward Processing (**GEOS FP**) System:
Near real time DAS with 12.5 km horizontal resolution and forecasts out to 10 days.

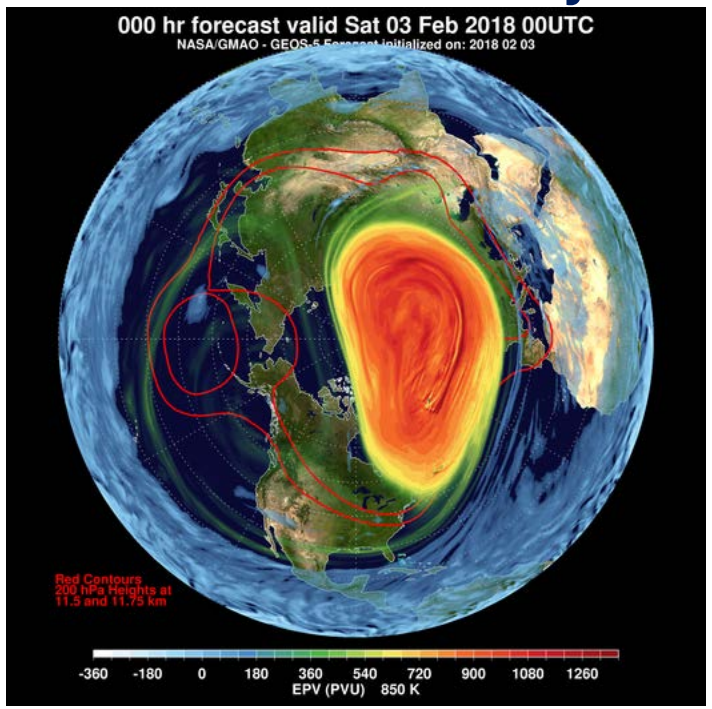
Subseasonal to seasonal (**S2S**) system:
Four-member ensembles, 45-day simulations launched every 5 days



Prediction of the Major Stratospheric Sudden Warming of February 2018

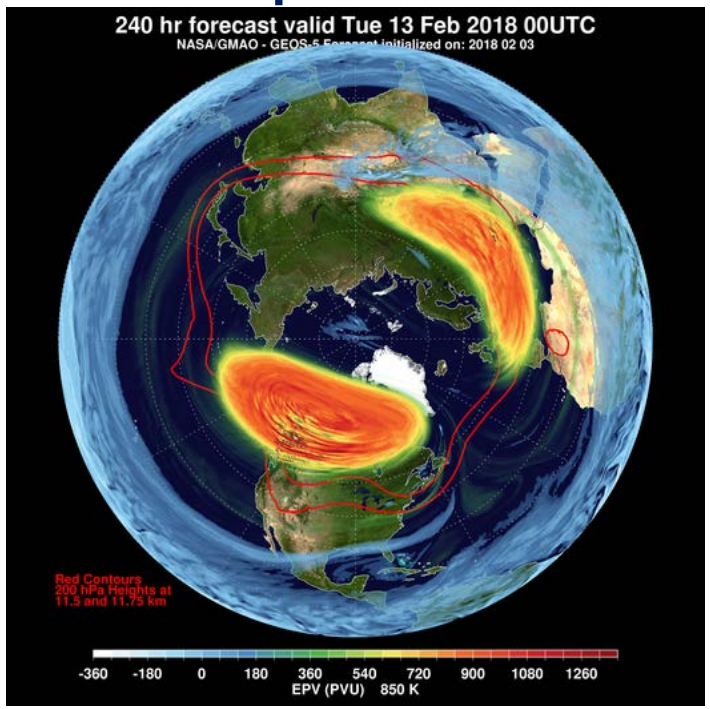

000 hr forecast valid Fri 02 Feb 2018 00UTC
NASA/GMAO - GEOS-5 Forecast initialized on: 2018 02 02
Red Contours
200 hPa Heights at
11.5 and 11.75 km
-360 -180 0 180 360 540 720 900 1080 1260
EPV (PVU) 850 K
2018 02 02 00UTC
NASA/GMAO - GEOS-FP Analysis
f517_fp
Red Contours
200 hPa Heights at
11.5 and 11.75 km
-360 -180 0 180 360 540 720 900 1080 1260
EPV (PVU) 850 K

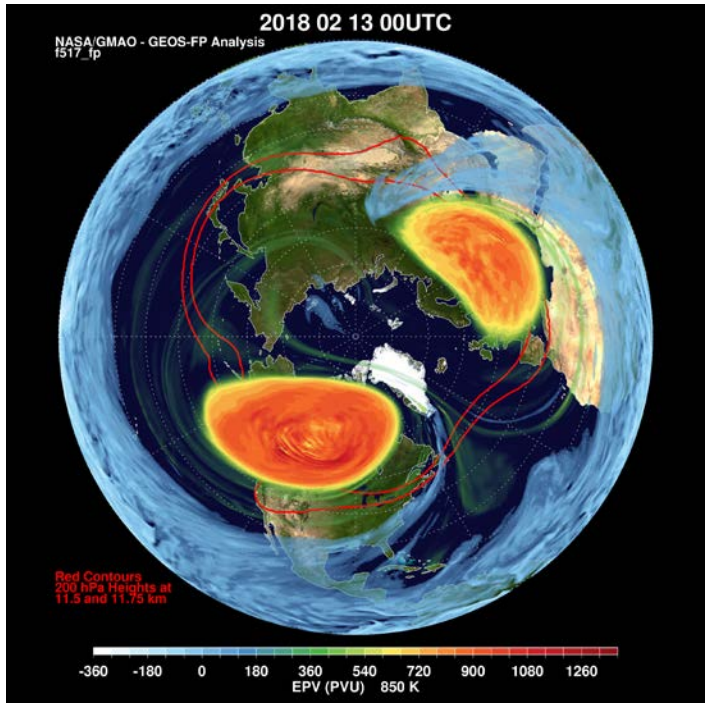
Ertel Potential Vorticity on the 850 K Potential Temperature Surface



10-Day Forecast

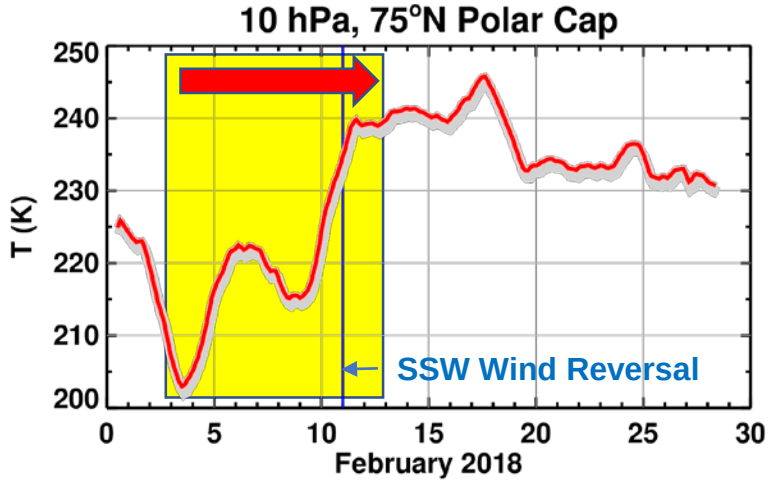
3– 15 Feb





Initial EPV
3 Feb 2018

Large amplitude wave-1 pattern prior to the SSW



Analysis
13 Feb 2018

Excellent 10-day forecast of the vortex split. Part of the vortex moves over North America

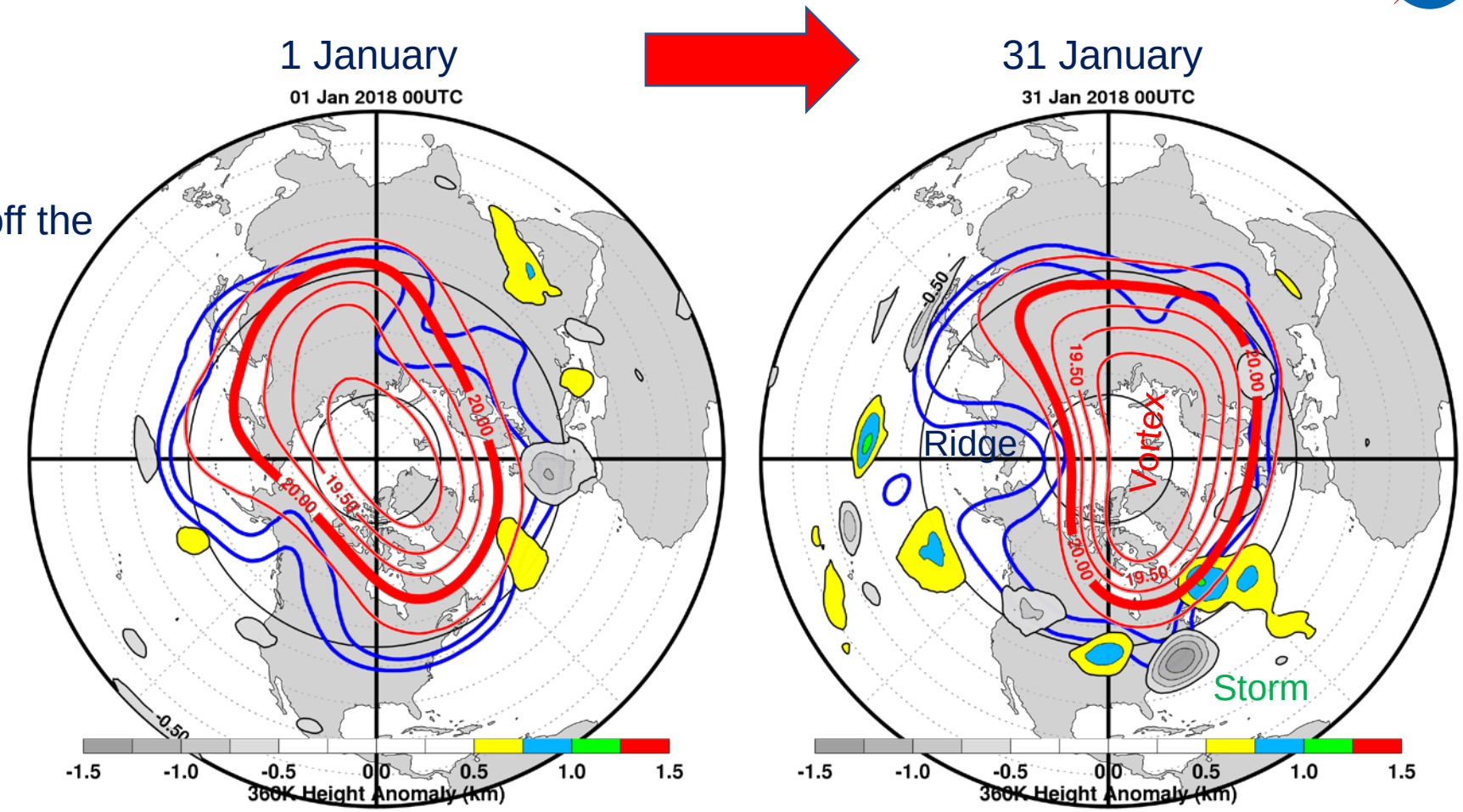
Evolution of the 2018 SSW

January Preconditioning

Polar vortex becomes displaced off the pole during January 2018.

Tropospheric Pacific ridge develops during January 2018.

Tropospheric Storms begin to develop off the East Coast of the US.

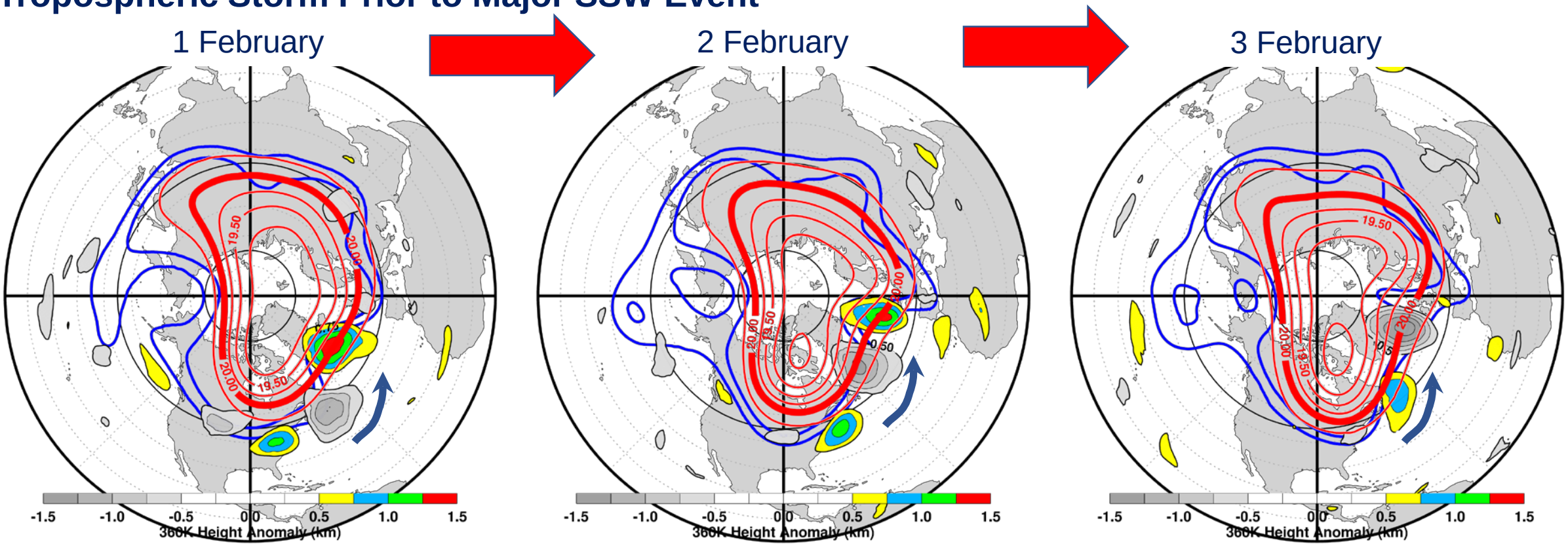


red contours
50 hPa geopotential heights

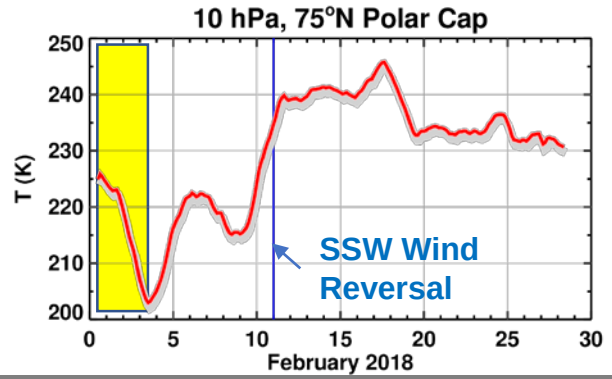
blue contours
200 hPa geopotential heights

filled contours
360 K potential temperature surface height anomalies.

Tropospheric Storm Prior to Major SSW Event



A storm with large upper tropospheric vertical displacements (~2.5 km peak to peak amplitude) moved under the strong winds of the lower stratospheric vortex in early February, disturbing the polar vortex and leading to the major SSW event on 11 February.



SSW 11 February

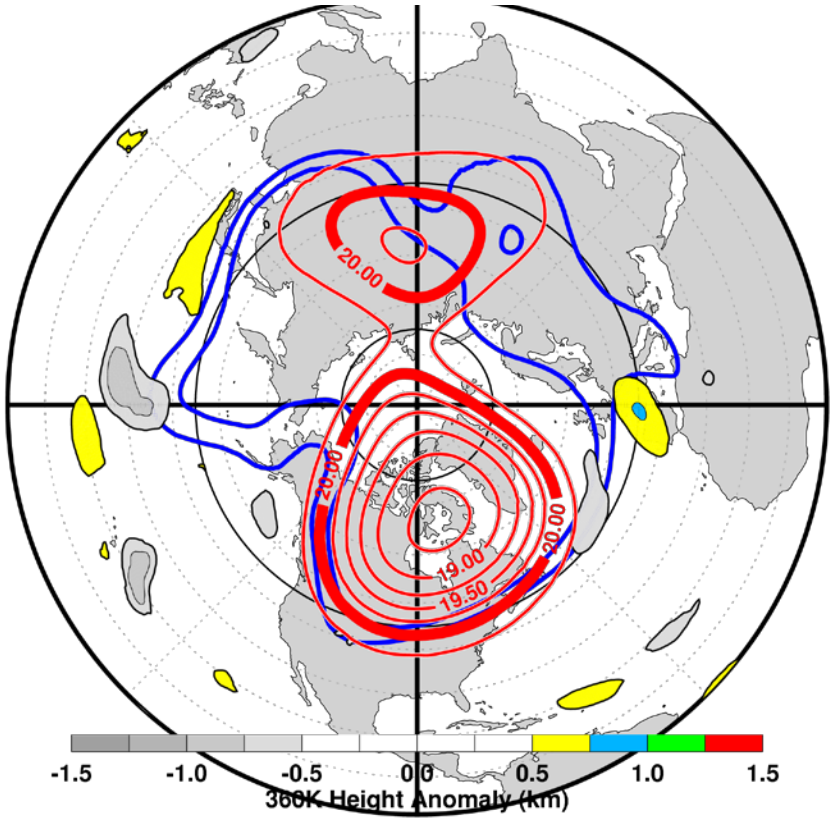
Polar vortex splits with the larger vortex over North America.

Upper troposphere and lower stratosphere jets coincide.

This 11 February pattern continues through 21 February.

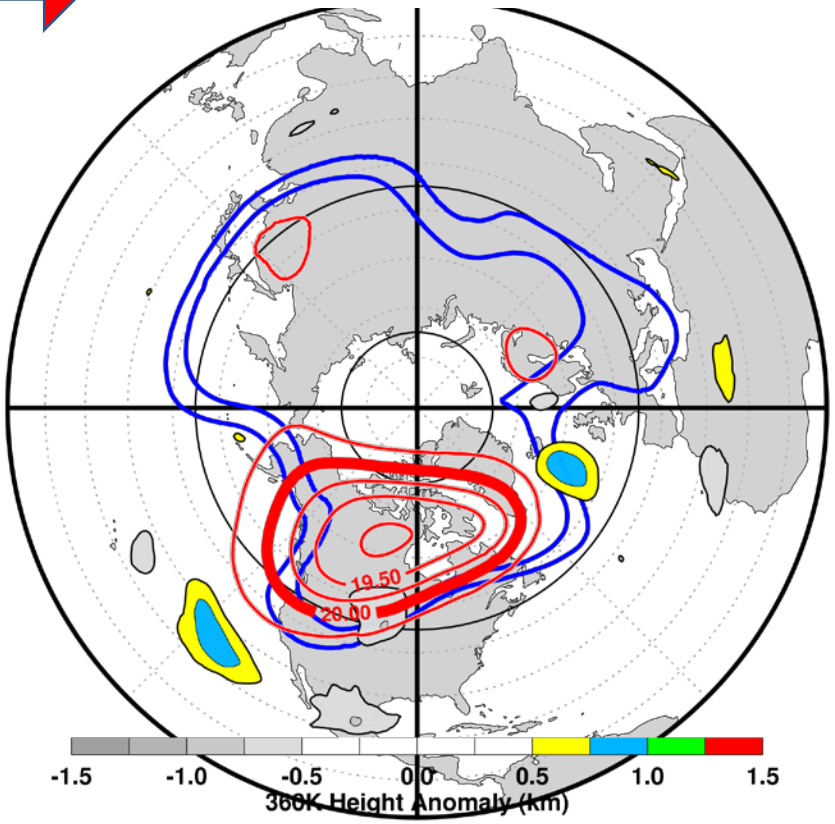
Split Vortex

11 February



Off Pole Vortex

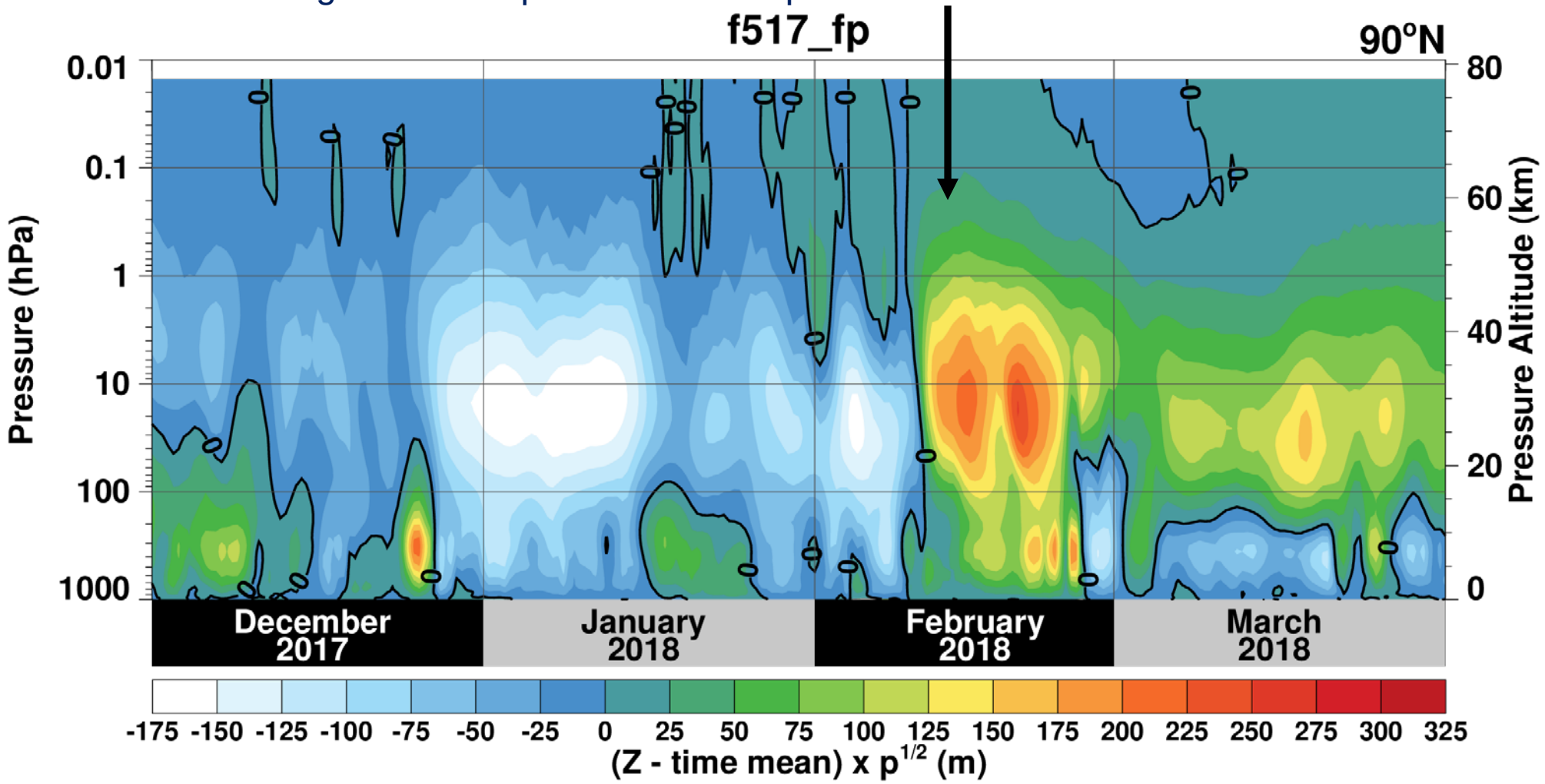
21 February



Changes in Weather following the 2018 SSW

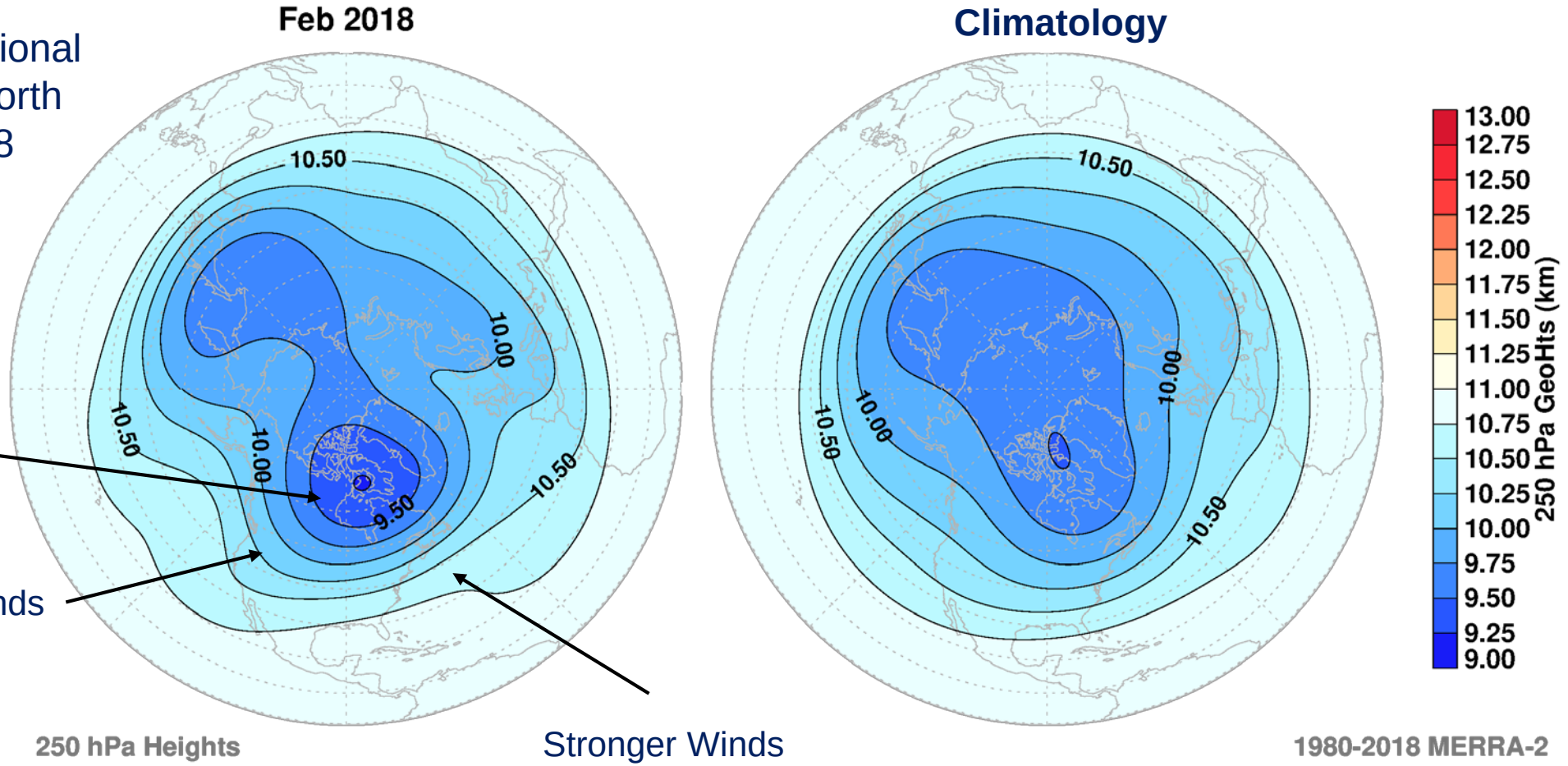
Polar Geopotential Height Anomalies

Heights Increase during the SSW and slowly decrease thereafter throughout the depth of the atmosphere



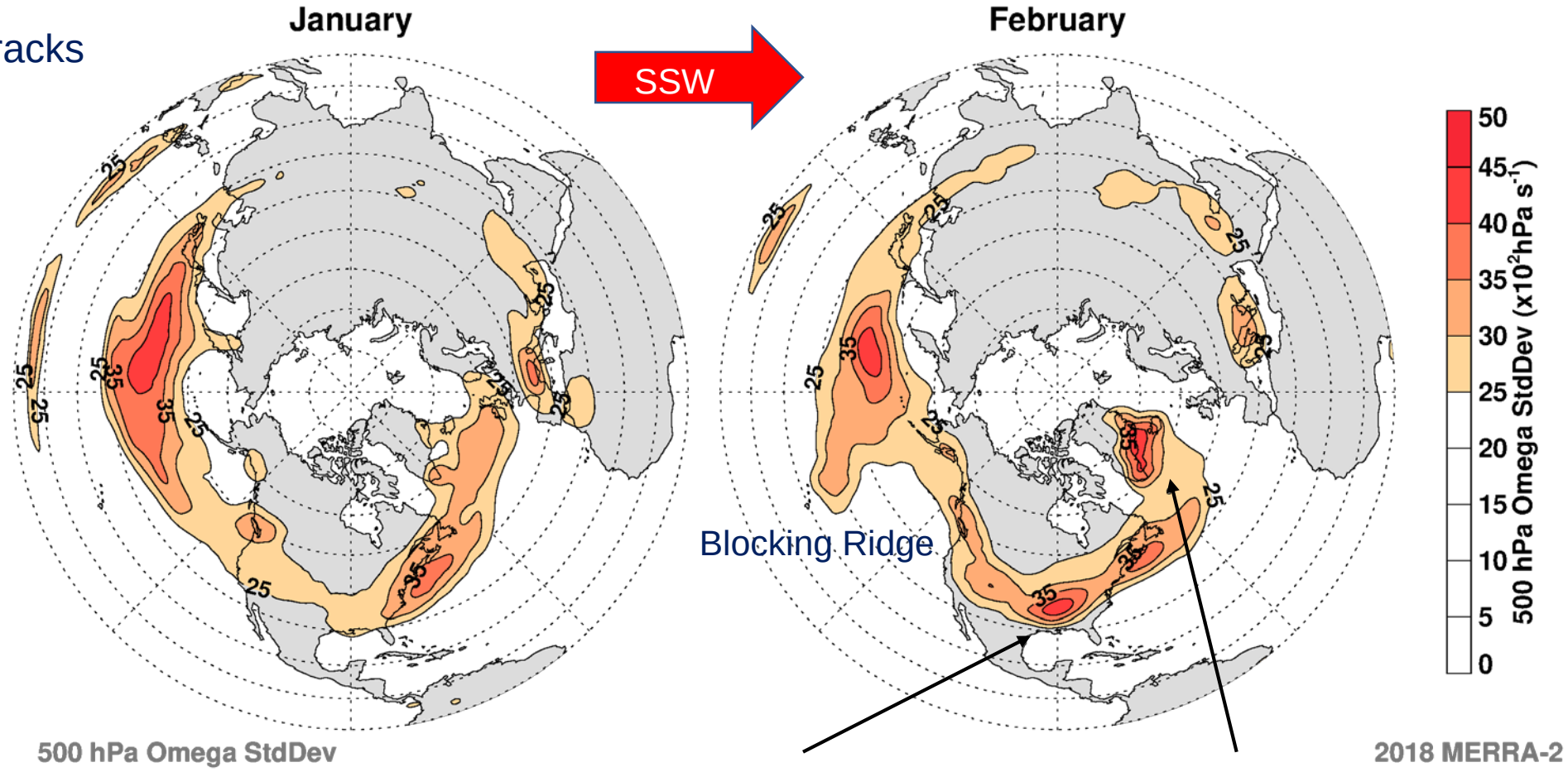
250 hPa Geopotential Heights from MERRA-2 Monthly Averages

Stronger and more meridional winds were found over North America in February 2018 than in the climatology.



500 hPa Omega Standard Deviation

The tropospheric storm tracks changed after the SSW.

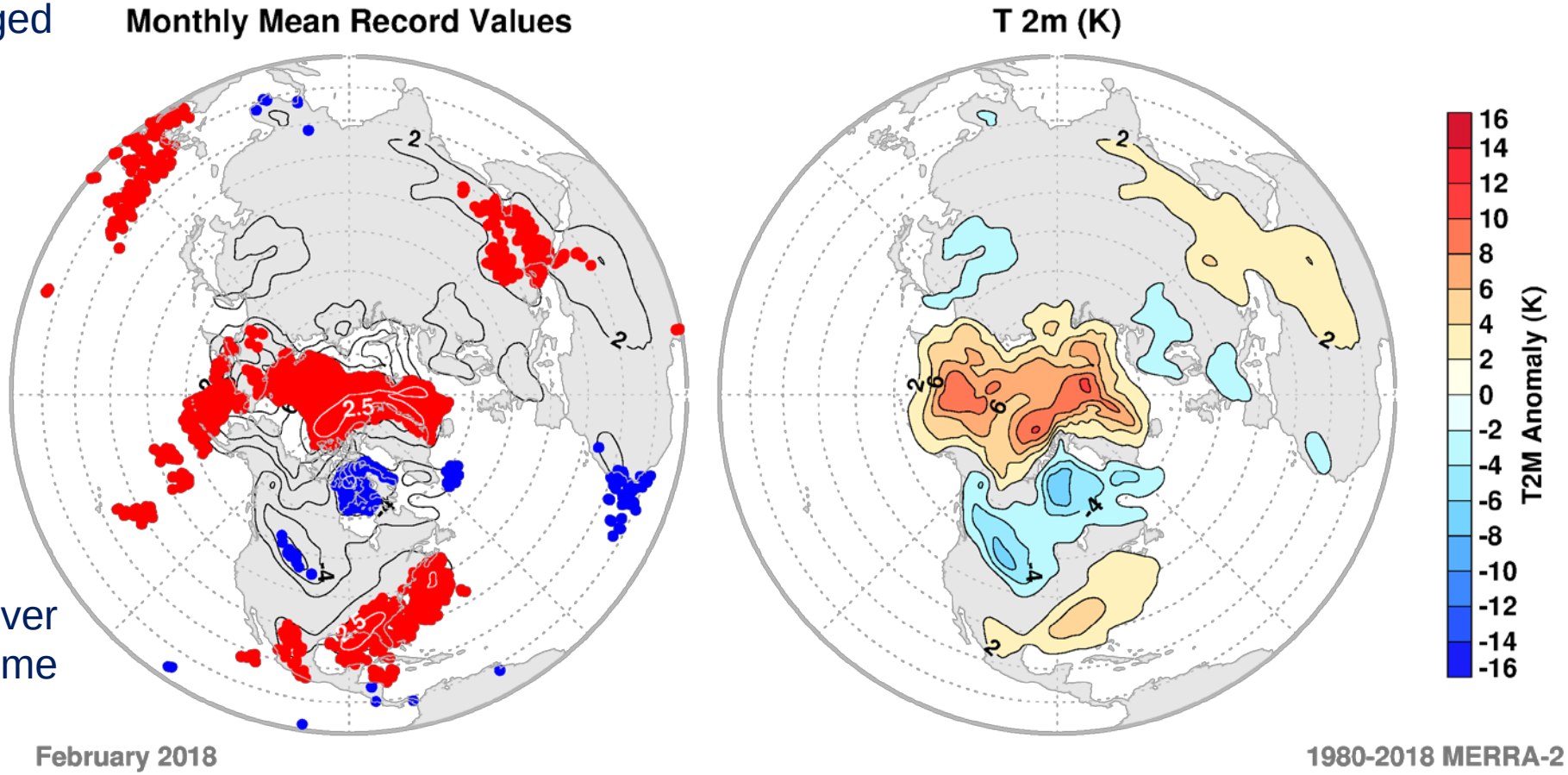


Surface Temperatures from MERRA-2 Monthly Averages

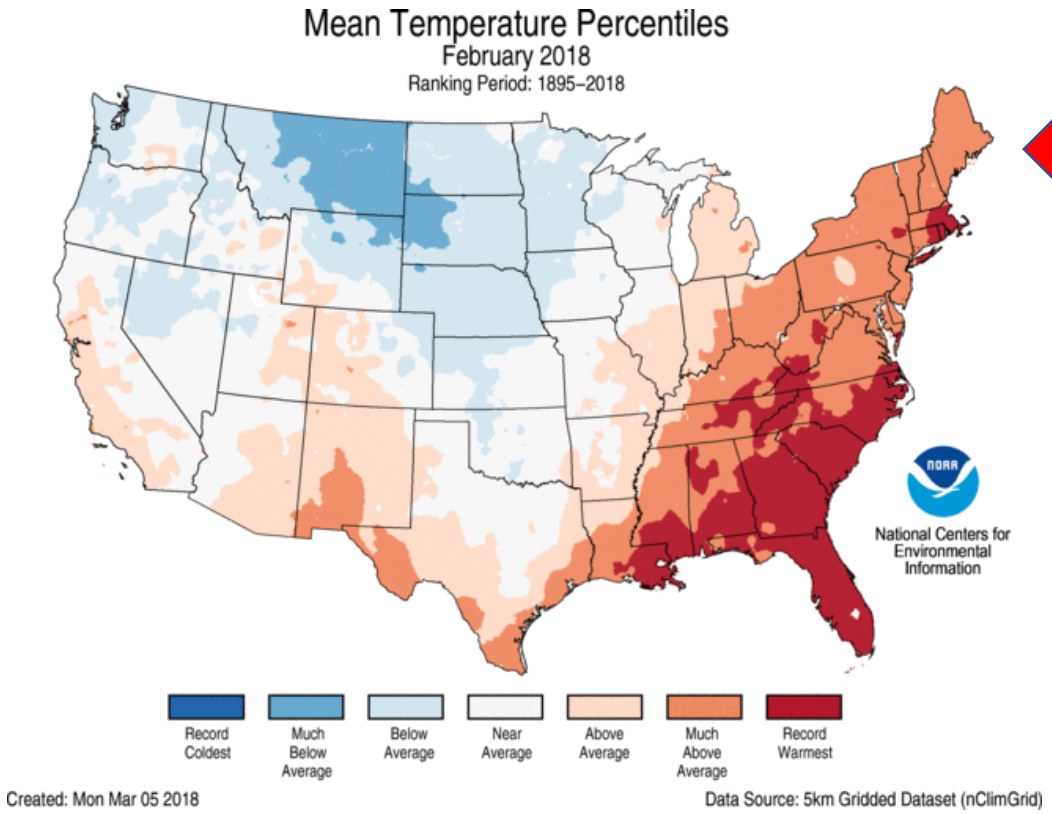
North Pole surges above freezing in the dead of winter, stunning scientists
Washington Post 26 Feb 2018

February 2018 monthly averaged 2 meter temperatures were highest in the 1980-2018 MERRA-2 record (red circles) over the SE US and polar regions.

Colder than average regions over much of Canada along with some record cold (blue circles)



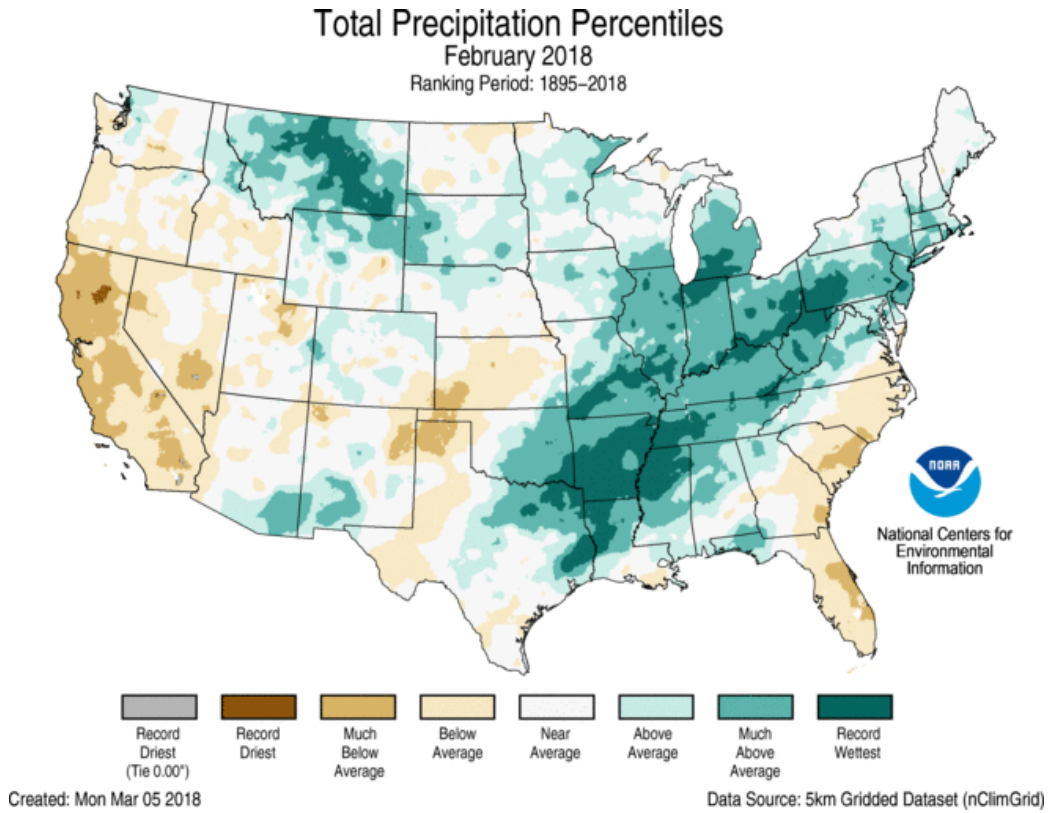
White Contours: 2.5 Sigma



In addition to Washington, DC, the entire East Coast experienced warm to record warm temperatures during February 2018

Precipitation records were also set over the eastern half of the US during February 2018.

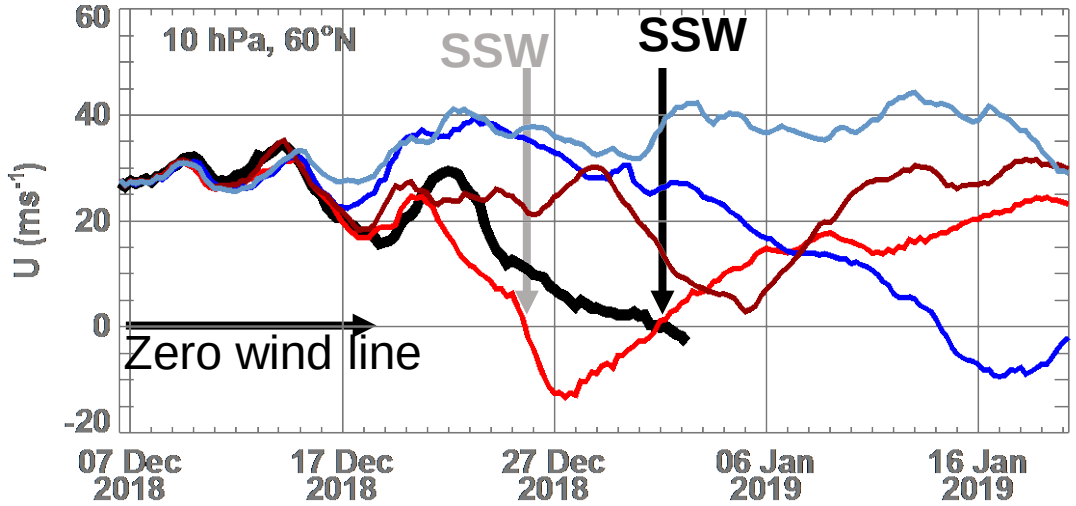
This is not a typical response!
[*Butler et al., 2017*]



S2S: forecasting the 2019 SSW

S2S 45-Day Forecast

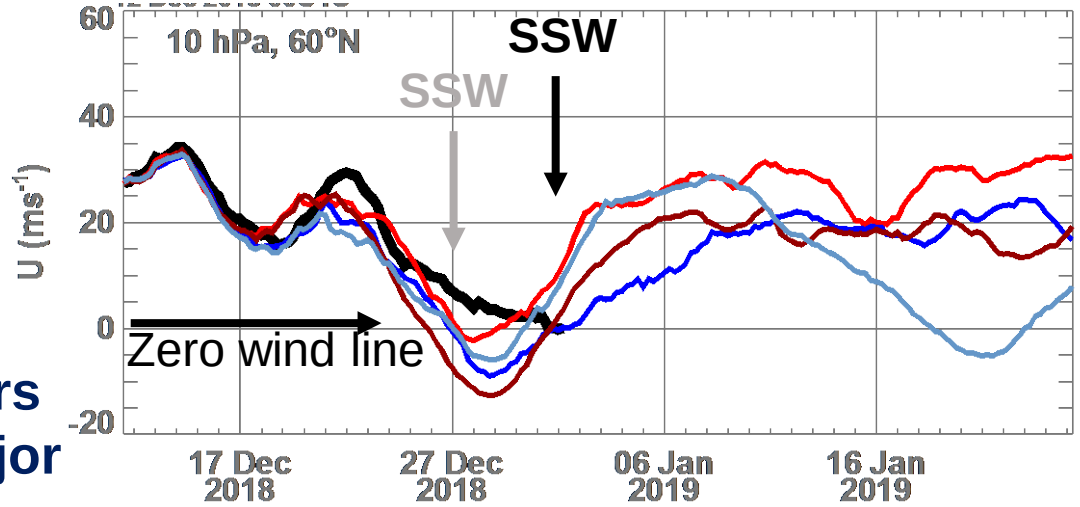
Initialized
7 Dec 2018



Only one ensemble member was predicting a major SSW near the end of December 2018.

This is close to a 19-day forecast of the SSW.
Note the large amount of variability in the ensemble members in this case.

Initialized
12 Dec 2018



The polar vortex experienced strong disruption above 10 hPa and below 30 hPa, however, the SSW unexpectedly lagged at 10 hPa, 60ºN.

Result: the forecasted wind reversal at 10 hPa was early by ~5-6 days.

All members show a major SSW

Summary

The polar vortex splitting SSW event was realistically represented in the near-real-time FP **10-day forecast**.

The polar vortex moved off center of the pole during January 2018 (**preconditioning**).

An early February **storm off the east coast of the US** experienced significant upper troposphere development as it moved under the polar vortex winds, disturbing the lower stratospheric polar vortex and initiating the 11 February SSW event.

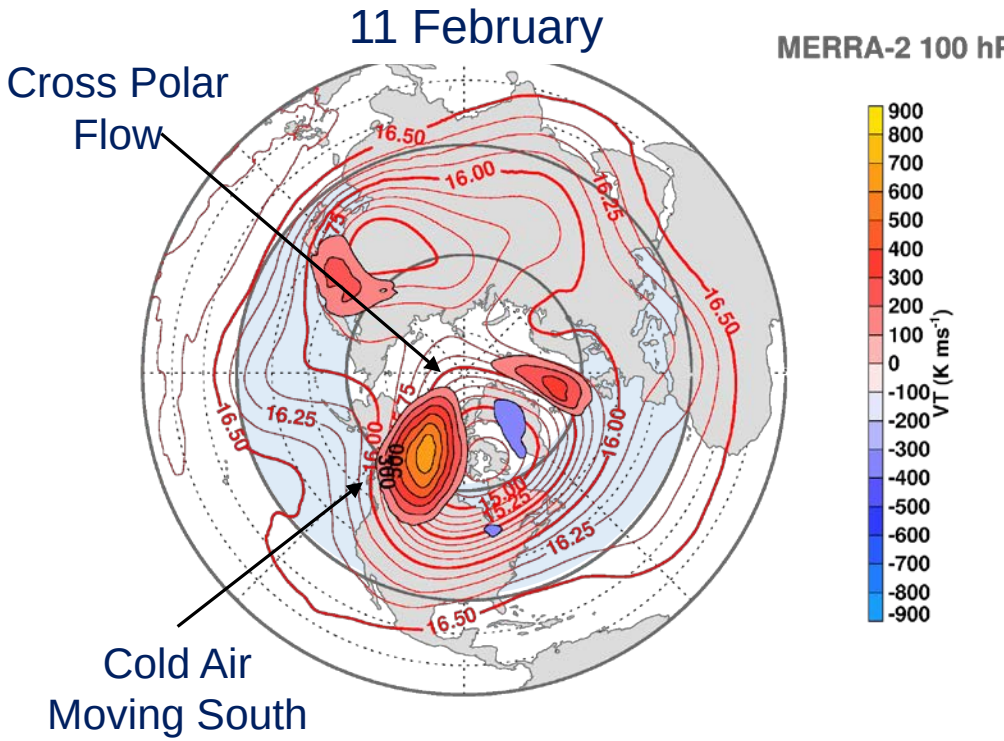
The SSW was associated with coupled global circulation changes in both the stratosphere and troposphere that produced regions of **record warmth and precipitation** over the US.

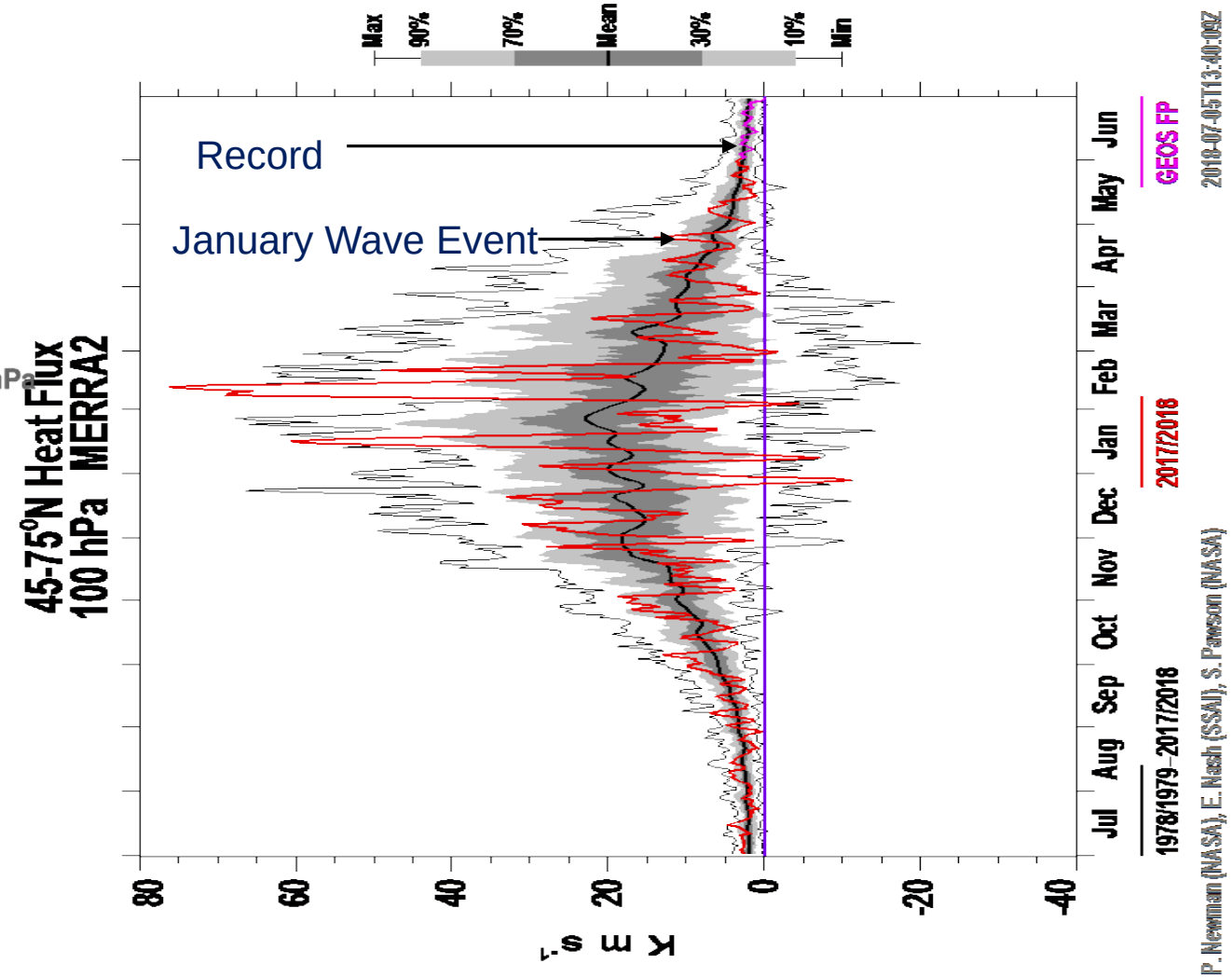
The S2S forecast initialized 12 December predicted a major SSW with a **two-week lead**; the 10-hPa wind reversal occurred several days later than forecasted.

backup

Record Strong 100 hPa Heat Flux (1980-2018, MERRA-2)

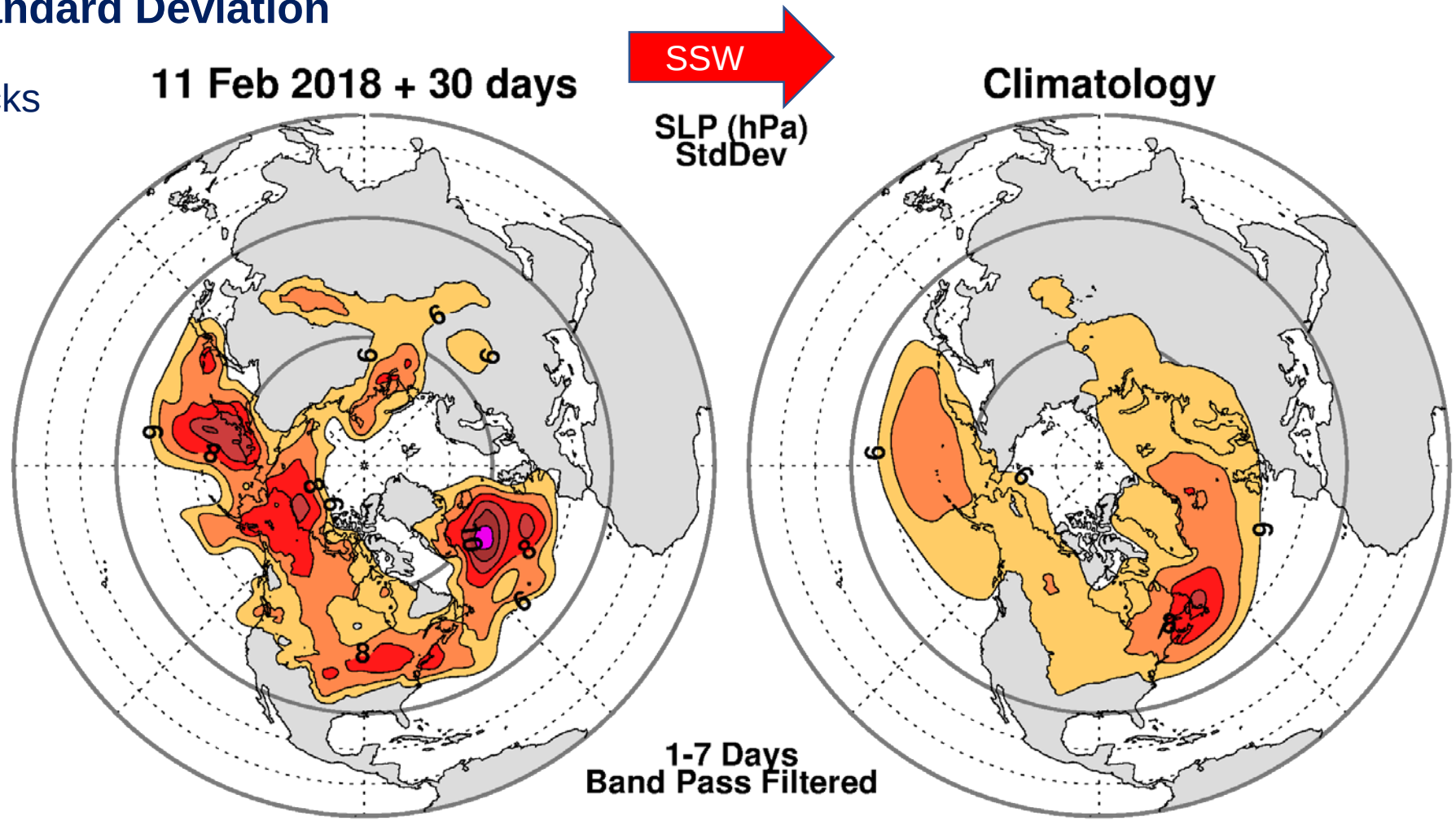
Record heat flux for the NH winter.
76.16 K ms^{-1}
11 February 2018.

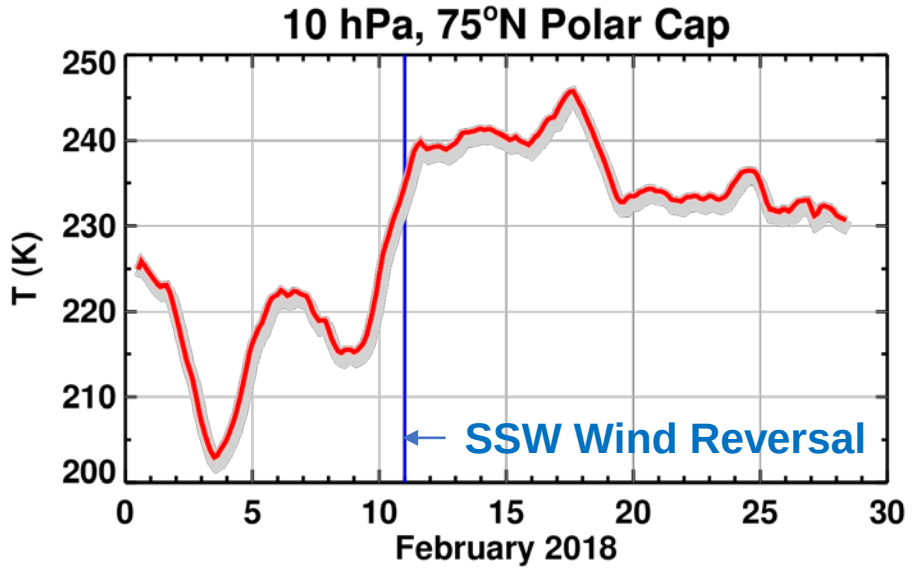


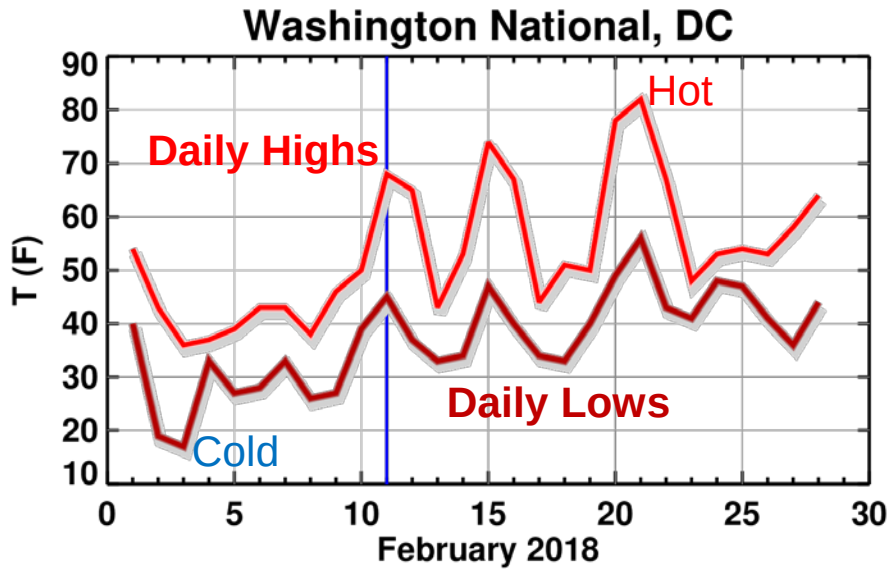


Sea Level Pressure Standard Deviation

The tropospheric storm tracks changed after the SSW.







Stratospheric polar temperatures warmed during the early February 2018 major Stratospheric Sudden Warming.

At the same time the DC region experienced the first of three strong warm events.

21 February 2018 Station Records
- Earliest high temperature in the 80s
- Highest low temperature for date