Hi all,

Friday map discussion for 9 February 2018 focused on an impending major sudden stratospheric warming (SSW) and a classic La Nina snow/ice/rain event from last Wed (7 Feb). A major SSW event is characterized by a reversal of the climatological polar night vortex westerly winds from westerly to easterly at 60 N and 10 hPa. In a major SSW event the climatological polar night vortex at 10 hPa is disrupted and either shifts off the North Pole or splits into two vortices that are displaced equatorward toward higher midlatitudes. Andrea Lang and Hannah Attard lead the discussion of the upcoming SSW event. Links that were used during Friday map discussion can be found here (http://www.atmos.albany.edu/mapdisco/20180209/). Eric Bunker and Tomer Burg assisted with map and helped to lead the discussion of last Wednesday's winter weather event.

1. SSW Event of February 2018:

SSW events occur much more frequently in the NH than in the SH. It is likely that zonal continental-oceanic differences and orographic signatures and middle and high latitudes in the NH favor the generation of long (wave number 1 and 2) Rossby waves in the troposphere that can propagate upward into the stratosphere. High-latitude blocking patterns in the NH are often characterized by Rossby wave number 1 and 2 flow regimes which may be one reason why the NH appears to be more conducive to the occurrence of SSW events than the SH (see Baldwin et al. 2002 http://www.atmosp.physics.utoronto.ca/SPARC/News20/20_Baldwin.html and Thompson et al. 2005; https://journals.ametsoc.org/doi/abs/10.1175/JAS-3321.1 for a discussion of the major SH SSW event of 2002). Long Rossby waves that propagate into the stratosphere dissipate, decelerate the westerly flow, and disrupt the polar night vortex. Rossby wave propagation from the troposphere into the stratosphere seems to be especially favored when the quasi-biennial oscillation (QBO) is in its negative (easterly) phase such as it is now.

A sample of recent references on SSW can be found here: Attard et al. (2016; https://journals.ametsoc.org/doi/abs/10.1175/MWR-D-15-0175.1); Butler and Gerber (2018: https://journals.ametsoc.org/doi/abs/10.1175/JCLI-D-17-0648.1); Horan and Reichler (2017; https://journals.ametsoc.org/doi/abs/10.1175/JCLI-D-17-0257.1 and Xu and Liang (https://journals.ametsoc.org/doi/abs/10.1175/JAS-D-17-0002.1).

Andrea Lang and Hanna Attard noted that the last significant SSW occurred in 2013 under weak La Nina conditions and that this year's significant SSW event will occur under slightly stronger La Nina conditions (see CPC's Oceanic ENSO Index http://origin.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ONI_v5.php). Web pages by Hannah Attard (http://www.atmos.albany.edu/student/hattard/realtime.php) and Andrea Lang (http://www.atmos.albany.edu/facstaff/andrea/maps.html) feature a nice variety of links that can be used to follow stratospheric analyses and forecasts in real time to include stratospheric-tropospheric interaction metrics.

2. Science Questions:

Science Question #1: Why should La Nina conditions should be more favorable for the occurrence of SSW events than El Nino conditions (caveat: we did not have the benefit of a long term correlation analysis between the phase of ENSO the the likelihood of a SSW event during the winter season)?

Science Question #2: Is it more likely that La Nina-like higher latitude circulations are associated with greater poleward- and upward-directed heat fluxes in conjunction with a greater likelihood of occurrence of Rossby wave number 1 and 2 flow regimes with an increased likelihood of a SSW event?

Science Question #3: What physical processes govern whether a Northern Hemisphere SSW event will feature either a ridge over the North Pole with an off-pole vortex or a distinct split of the polar vortex into two separate vortices?

Science Question #4: When the polar vortex splits into two vortices during a strong SSW event what determines which longitudes will be favored for the two split vortices to be ejected equatorward and what are the implications for temperature and rainfall anomalies over North America, Europe, and Asia?
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3. La Nina Equatorward Jet-Entrance Precipitation Event of 7 Feb 2018:

The remainder of Friday map discussion focused on the classic cool season La Nina precipitation event of 7 Feb 2018 in the Northeast. Tomer Burg calculated a regional snowfall map for this event based upon NWS/CoCoRaHS/NOHRSC data (http://www.atmos.albany.edu/mapdisco/20180209/images/StormTotalSnowfall.PNG). The biggest forecast challenge was where the transition line from rain to freezing rain to sleet to snow would be located. NWS ALY, to its credit, did not buy into the idea that the precipitation would be all snow in Albany as forecast by the global models (GFS and ECMWF). They (correctly) kept the option open locally that a transition period to sleet and freezing rain would occur with the precipitation changing back to snow before ending based on output from operational higher resolution mesoscale models. A special 1900 UTC 7 Feb sounding from Albany (http://www.atmos.albany.edu/mapdisco/20180209/images/2018020719_ALB.gif) shows the nose of warmer air near 800 hPa in conjunction with strong low-level warm-air advection and 50–80 kt SSW/SW low-level jet during the transition to sleet and freezing rain in the Albany region.

The short-lived downsloping off the northern Catskills and the associated Albany area precipitation hole is evident from radar images prepared by Massey Bartolini and the College of DuPage (see below). Massey's composite loops of base reflectivity, base velocity, correlation coefficient, and differential reflectivity from KENX nicely show how these four different radar scan types can be collectively used to tell a more complete story about the structure and evolution of the precipitation field than any of the single types alone. You can see: (1) the downslope hole develop near the time of the aforementioned 1900 UTC sounding, (2) the evolution of the boundaries separating snow from sleet and freezing rain, and (3) the boundary reflecting changeover from freezing rain and sleet back to snow and the snowbound on the back side of the storm that produced an additional 1–2 inches of snow locally at the end of the storm

For those of you who want and/or need a refresher on how to use dual polarization radar and how to interpret the NEXRAD correlation coefficient and differential reflectivity imagery, the Louisville, KY, office of the NWS has put together a very nice user's guide (https://www.weather.gov/media/lmk/soo/Dual_Pol_Overview.pdf).

Animated radar loops for this event produced by Massey Bartolini and the College of DuPage (http://www.atmos.albany.edu/student/mbartolini/radar/kenx/kenx_20180207_melting_layer_collapse_short.gif; http://www.atmos.albany.edu/student/mbartolini/radar/loop.php?radar=kenx&ehr=138&archive=20180207); http://www.atmos.albany.edu/mapdisco/20180209/images/codnexlab.NEXRAD.ENX.N0Q.20180208.1544.200ani.gif

The above storm snowfall amount image and the corresponding seasonal snowfall to date from NOHRSC (http://www.nohrsc.noaa.gov/snowfall_v2/) show a La Nina signal with the heaviest snowfall concentrated in upslope regions of the High Plains east of the Rockies, across the Great Lakes, and into northern New York and New England. A characteristic La Nina winter signature is frequent equatorward jet-entrance region storminess associated with fairly fast-moving weak-to-moderate surface cyclones in which large-scale ascent is mostly driven by warm-air advection in the equatorward jet-entrance regions as evidenced in GFS loops for this event by Alicia Bentley and Tomer Burg (http://www.atmos.albany.edu/student/abentley/realtime.html and http://www.atmos.albany.edu/student/tburg/analysis/loop.php?model=gfs&prod=1kmrefl&proj=us&archive=0&run=0).

In late January and early February a characteristic La Nina signal became established at a time when a relatively large amplitude MJO moved into phases 6 and 7 (http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/Composites/Temperature/). Coincidence or something to be better understood? MJO phase forecasts from late January 2018 exhibited large variability. The CFSvs had the MJO moving toward phase 8 by early-to-mid February (a phase that tends to be feature below normal temperatures in the eastern U.S.) and continues with this trend (http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/CLIVAR/clivar_wh.shtml). The ECMWF from 11 Feb has the MJO moving into phase 8 as well but with diminished amplitude (http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/CLIVAR/clivar_wh.shtml). The 10 Feb GFS retains the MJO in phase 7 and delays the return of cold to the eastern US (http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/CLIVAR/ncpe.shtml). These model differences beg the question to what extent tropical-midlatitude interactions are, and are not, impacting downstream weather regime evolution over North America.

4. Science Questions:

Science question #1: Is extended cyclone range predictability more limited with fast-moving weak-to-moderate La Nina cyclones that are governed by warm-air advection in the equatorward entrance regions of strong confluent jet streams than it is with classic diffluent flow bomb cyclones (e.g., 4 Jan 2018)?

Science Question #2: Does the stronger and more concentrated cyclonic vorticity advection by the thermal wind associated with negatively tilted diffluent troughs characteristic of bomb cyclones increase the predictability horizon of bomb cyclones relative to ordinary cyclones?

Science Question #3: Do the impacts of tropical-midlatitude interaction as a function of the phase and amplitude of ENSO and the MJO govern the length of the cyclone predictability horizon over North America?

Science Question #4: Is the current anomalously strong ridge over the eastern CONUS and western Atlantic a reflection in part of anomalously warm SST anomalies over much of the western Atlantic (http://www.ospo.noaa.gov/data/sst/anomaly/2018/anomw.2.8.2018.gif)?

Science Question #5: Can the persistent anomalous high-latitude ridge from the Gulf of Alaska to the Arctic Ocean be linked to reduced sea ice in the Bering Sea and reduced sea ice concentration in the Bering Strait (http://nsidc.org/arcticseaicenews/)? NH 300 mean/anomaly height maps from 1 Dec 2017–9 Feb 2018 are below.

Science Question #6: Does the current westward-displaced upper-level ridge over the eastern CONUS reflect a westward displacement of the mid-America trough in response to short wave troughs moving southward east of the Alaskan ridge and carving out the CONUS progressively farther to the west?

Science Question #7: To what extent was the onset of a classic la Nina signature over the central and eastern CONUS by late January 2018 a result of tropical-midlatitude interactions versus midlatitude-polar interactions?

5. Concluding Comment on Current Forecasts:

The current upper-level flow regime over North America looks somewhat like a typical late winter La Nina pattern based upon a persistent and westward-displaced ridge over Alaska, a deepening trough over the western U.S. and a western Atlantic ridge that keeps wanting to amplify and retrograde into the eastern U.S. behind each short-wave trough passage across southern Canada. The passage of strong surface anticyclones behind these Canadian short-wave trough sets up favorable conditions for very wet conditions in the Tennessee and Ohio Valleys, and parts of the interior Southeast and Middle Atlantic States. Freezing rain and icing conditions. The precipitation is primarily driven by warm-air advection in the right equatorward entrance region of a strong jet from the upper Great Lakes to Atlantic Canada. Very warm conditions can develop to the south of frontal boundaries that will struggle to pass south of 35 N over the Southeast under the strong ridge aloft. If this patterns persists there is a risk that early spring growth over the Southeast could advance to the point that a March freeze could cause agricultural problems (think the Georgia peach crop). Skiers in the Pacific Northwest and Northern Rockies should be happy. The Northern Plains will remain frigid. Southern Texas will see 1000–500-hPa thicknesses that will likely exceed 570 dam behind retreating anticyclones and ahead of arriving cold fronts. California should still be mostly dry unless the western U.S. trough can continue retrograding offshore. To be determined.

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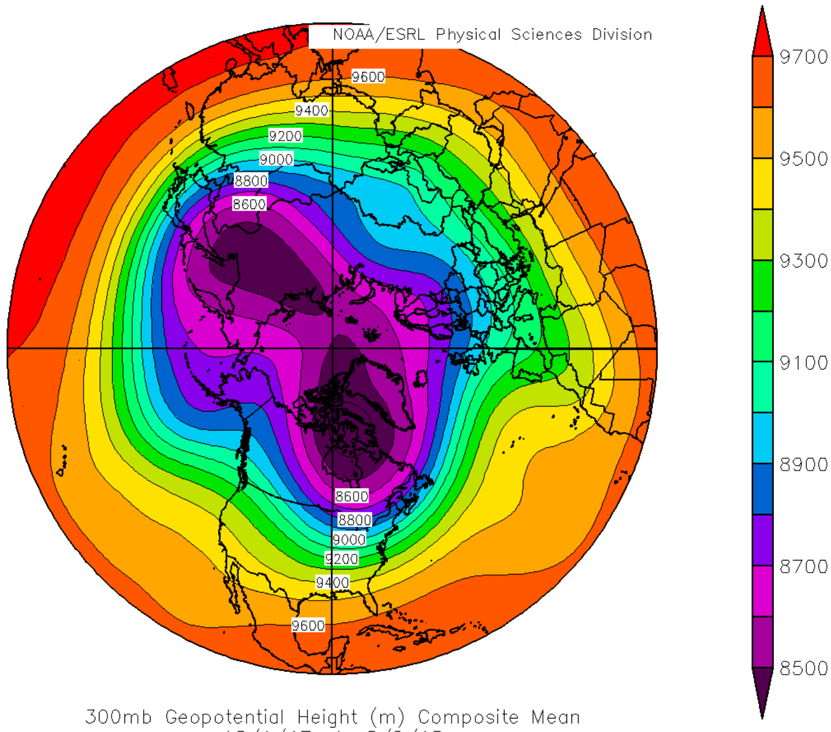
Additional SSW References:

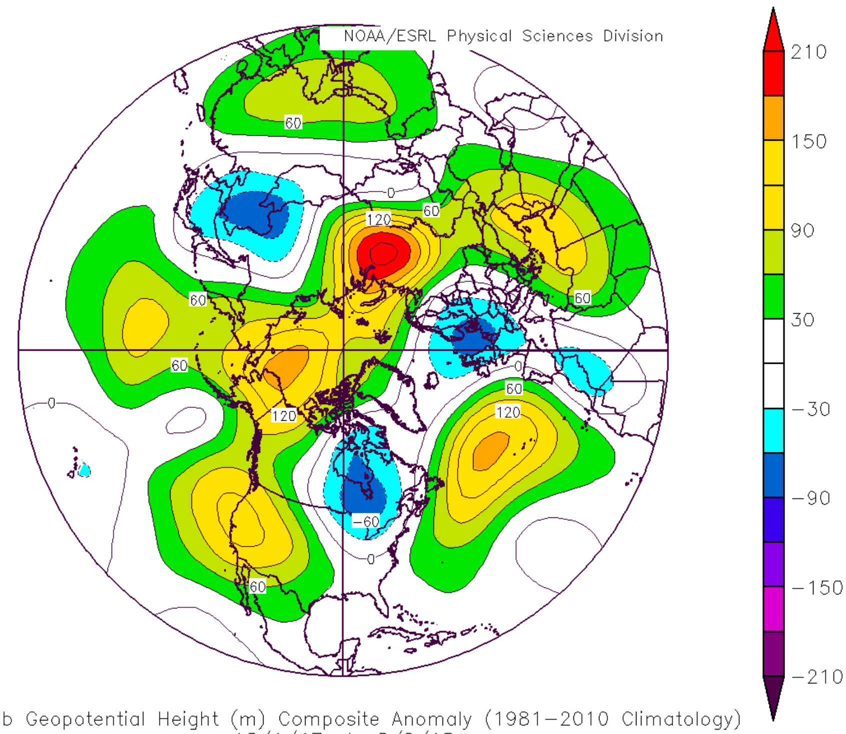
Kidston et al. (2015): Stratospheric influence on tropospheric jet streams, storm tracks and surface weather (https://www.nature.com/articles/ngeo24240

NOAA/ESRL/PSD Sudden Stratospheric Warming Compendium Data Set (https://www.esrl.noaa.gov/csd/groups/csd8/sswcompendium/)

NOAA MAPP S2S Prediction Task Force: https://twitter.com/alopezlang/status/961258756037365760



300mb Geopotential Height (m) Composite Mean
12/1/17 to 2/9/18
NCEP/NCAR Reanalysis



300mb Geopotential Height (m) Composite Anomaly (1981−2010 Climatology)
12/1/17 to 2/9/18

NCEP/NCAR Reanalysis