Resent-From: <jkenyon@ALBANY.EDU>
From: "Bosart, Lance F" <lbosart@ALBANY.EDU>
Subject: **Synopsis of Friday map discussion for 15 March 2013**
Date: 18 March 2013 12:15:10 PM EDT
To: <MAP@listserv.albany.edu>
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Hi Everyone,

Friday map discussion for 15 March 2013 opened with a comparison of the Northern Hemisphere (NH) flow patterns for 1-12 March 2011-2013….to illustrate the especially large variability in the NH flow patterns that can occur at this time of the year from one year to the next…..shifted into a discussion of sudden stratospheric warming (SSW) events and the phase of the Arctic Oscillation (AO), and concluded with a discussion of the ongoing blocking pattern over the North Atlantic (and extended period of negative AO values), the associated North Atlantic storm tracks/European cold, and tropospheric-stratospheric linkages. Master link: http://www.atmos.albany.edu/student/ppapin/mapdisco/20130315/. Alicia Bentley and Philippe Papin created numerous loops and links in support of map discussion.

I. NH Flow Pattern Anomalies for 1-12 March 2011-2013:

The NH mean and anomaly 850/200 hPa geopotential heights, 850 hPa temperatures, and the NH anomaly precipitable water (PW) patterns for 1-12 March 2011-2013 can be found at: http://www.atmos.albany.edu/student/ppapin/mapdisco/20130315/images/compaire.html (on your keyboard use the left-right arrows to go backward/forward in time for a given type of image and the up-down arrows to scan all of the available images at a given time). A comparison of these images reveals that large interannual variability was pervasive during the first part of March 2011-2013. For example, anomalous (and record-breaking) warmth was found over most of the CONUS during 1-12 March 2012 while much of northern Canada, Alaska, northern Eurasia, and northern Africa experienced anomalously cold conditions. This NH 850 hPa temperature anomaly pattern reversed during 1-12 March 2013 with Alaska, Asia, eastern Canada and North Africa becoming anomalously warm while the CONUS cooled to near normal (below normal in the Southeast). The near-absence of tornadoes over the CONUS through 15 March 2013 over the CONUS reflects the frequent incursions of cold air into the Southeast behind multiple trough passages and an anomalously strong and equatorward-shifted subtropical jet (STJ) over the North Atlantic. Additional relevant loops (that also include GFS forecasts from 1200 UTC 15 Mar 2013) can be found here: http://www.atmos.albany.edu/student/ppapin/mapdisco/20130315/, http://www.atmos.albany.edu/student/ppapin/mapdisco/20130315/images/200vort.html, http://www.atmos.albany.edu/student/ppapin/mapdisco/20130315/images/dt_theta.html, http://www.atmos.albany.edu/student/ppapin/mapdisco/20130315/images/500vort.html, http://www.atmos.albany.edu/student/ppapin/mapdisco/20130315/images/850temp.html. Four times daily loops of NH infrared brightness temperatures for 0000 UTC 1 March-1800 UTC 13 March can be found here: http://www.atmos.albany.edu/student/ppapin/mapdisco/20130315/images/ir_nh.html.

II. Sudden Stratospheric Warming Events and Tropospheric-Stratospheric Interaction:

The segue into North Atlantic blocking prompted a discussion of stratospheric-tropospheric interaction, SSWs, and possible associative relationships between SSW events and the phase of the AO. With the exception of the early January and late January/early February 2013 periods the AO has been in the negative phase since late November. Likewise, the tropospheric polar vortex was anomalously weak during much of this period, consistent with the observed extensive negative phase of the AO. In the stratosphere, the polar vortex was also anomalously weak between late December and mid-February in conjunction with what appears to be a moderate/strong SSW event that developed above 1.0 hPa shortly after 1 January, expanded downward to near 200 hPa by mid-January, and weakened downward from above 1.0 hPa toward the end of January (http://www.cpc.ncep.noaa.gov/products/stratosphere/strat-trop/gif_files/time_pres_HGT_ANOM_JFM_NH_2013.gif). By mid-March, an anomalously strong stratospheric polar vortex had re-established itself above 70 hPa. Below 100 hPa, however, the polar vortex has remained anomalously weak through mid-March, consistent with the continuing negative phase of the AO.

In early winter, poleward tropospheric fluxes of heat and momentum extended well into the stratosphere (upward Eliassen-Palm (EP) flux). The resulting upward-propagating EP flux convergence in the stratosphere was associated with an increase in stratospheric wave activity and consequently a decrease in the strength of the stratospheric zonal westerly flow that is a characteristic of a strong polar-night vortex. The associated reduced high-latitude zonal westerly shear (and onset of zonal easterly shear in major SSW events) between the upper troposphere and the stratosphere in turn shuts down further upward heat and momentum fluxes from the troposphere to the stratosphere. Once the stratosphere becomes better "insulated" from tropospheric energy fluxes when anomalous zonal easterly shear is present the stratospheric polar night vortex can slowly re-establish itself in conjunction with continuing radiative cooling before the return of the sun as appears to have happened in the first part of March 2013. A comparison of the GDAS-CPC JFM-2013 time series of zonal wind and anomalous zonal from 1000-0.4 hPa (http://www.cpc.ncep.noaa.gov/products/stratosphere/strat-trop/gif_files/time_pres_UGRD_MEAN_JFM_NH_2013.gif; http://www.cpc.ncep.noaa.gov/products/stratosphere/strat-trop/gif_files/time_pres_UGRD_ANOM_JFM_NH_2013.gif) shows that the stratosphere above 200 hPa was characterized by zonal wind easterly shear for much of January. Zonal wind westerly shear developed above 10 hPa by late January as the polar vortex began to reform slowly. By early March, zone westerly shear was re-established down to ~50 hPa (the delayed/slow restart of the polar night vortex in the lower stratosphere may reflect the rapid decrease in strong radiational cooling with the return of the sun to the NH and/or continuing upward energy fluxes from the troposphere). Upward energy fluxes from the troposphere to the stratosphere are favored when the stratospheric polar vortex is characterized by anomalously strong zonal westerly flow (anomalous westerly shear).

III. North Atlantic blocking and the Arctic Oscillation:

The last part of map discussion built upon the aforementioned SSW event and focused on atmospheric blocking over the North Atlantic and its relationship with the continuing negative phase of the AO. High-latitude anticyclonic wave breaking (AWB) episodes occurred over the northeastern Atlantic on 28 Feb-1 Mar, 3-4 Mar, and 5-6 Mar in conjunction with an ongoing parade of coastal storms near and offshore of the east coast of North America. Each of these AWB events reinforced high-latitude surface anticyclones (central pressure > 1050 hPa) located over and east of Greenland. A persistent northerly flow east of these anticyclones enabled very cold Arctic air to seep equatorward to south of 40 N over the central Atlantic. Western and southwestern Europe remained relatively mild to the south of the AWB region. Repeated northerly flow accompanying southward-moving troughs over west-central Russia east of the AWB region allowed very cold Arctic air to overspread much of northern Russia. Discontinuous retrogression of the major high-latitude trough and ridge features followed between 10-17 Mar as further high-latitude AWB events occurred over the northwestern Atlantic and Greenland on 10-11 Mar and 14-17 Mar (the rich complexity of these AWB events is readily apparent in Heather Archambault's NH wave guide analysis based on the distribution of 250 hPa PV and superimposed 250 hPa meridional wind anomalies (http://www.atmos.albany.edu/student/heathera/mer_wind/nhem/1_to_15_mar13.html)). As the high-latitude blocking anticyclones moved westward in conjunction with discontinuous retrogression, western Europe turned much colder as anomalous easterly flow extended westward to the UK and the eastern Atlantic. At the same time, southern Europe became stormy as a strong STJ extended eastward across the North Atlantic to northwestern Africa. Eastward-moving disturbances embedded in this STJ brought periods of significant unsettled weather to northern Africa and the Mediterranean region.

IV. Science Issues:

The time may be ripe to take a more holistic view of the synoptic-dyanmic meteorology associated with SSW events in order to identify possible different pathways that can govern the structure and evolution of a SSW event. SSW events are relatively infrequent. Andrea Lang estimated that ~20 well-documented SSWs have occurred in the modern satellite data era (1979 to present). Although many years will have at least one SSW event, other years may have none or (rarely) two events. A comprehensive study of SSW events in the historical data record from a synoptic-dynamic perspective to help establish possible different SSW triggering mechanisms (e.g, the recurvature and high-latitude extratropical transition of Supertyphoon Dale in mid-to-late Oct 1996 triggered a breakdown of the early polar night vortex in Nov) for polar night vortex breakdown would likely be insightful. The synoptic-dyanmic perspective would need to be balanced against the slower-acting radiative cooling perspective to help address questions as to the maximum number of possible SSW events that can occur (2?) in one NH cool season and the latest that a SSW event could occur during winter and still allow for the recovery of the polar night vortex.

The GDAS/CPC-derived observed and ensemble-forecast AO time series from late Nov to present (http://www.cpc.ncep.noaa.gov/products/precip/CWlink/daily_ao_index/ao.sprd2.gif) shows instances when the observed AO time series derived from 1000 hPa geopotential height analyses falls outside the envelope of GFS ensemble AO solutions derived from 7-day forecasts of the 1000 hPa geopotential height field (e.g., near 20 Dec, 20 Jan, 4 Mar and 14 Mar) (http://www.cpc.ncep.noaa.gov/products/precip/CWlink/daily_ao_index/ao.sprd2.gif

)(CPC AO calculation methodology can be found here: http://www.cpc.ncep.noaa.gov/products/precip/CWlink/daily_ao_index/history/method.shtml). In each of these four AO envelope exceedance cases the AO was < -2. Carefully crafted predictability studies centered around these (and other) forecast AO envelope exceedance cases may shed some light of some of the important synoptic-dynamic processes that may be operative when the 7-day AO forecasts are underdispersive (caveat: care would need to be taken to separate regional from hemispheric constraints on predictability).

Finally, as noted by Brian Hoskins during the summer 2012 NCAR-ASP colloquium on the weather-climate interface, forecasting atmospheric blocking remains a challenge to existing global forecast models. The events of Feb-Mar 2013 over the North Atlantic suggest that further progress in understanding atmospheric blocking might be made by taking a more holistic approach to the problem. By holistic I mean that research should be devoted to understanding the bulk upscale (cumulative) effects of multiple synoptic events on the rearrangement and reconfiguration of the large-scale NH flow pattern (e.g., multiple AWB events which can reinforce and strengthen high-latitude ridges; multiple oceanic cyclogenesis events along similar pathways which can concentrate poleward heat, momentum, moisture, vorticity, and PV fluxes along longitudinally confined corridors; cold air outbreaks between the multiple oceanic cyclogenesis events which can contribute both to atmospheric destabilization in conjunction with oceanic sensible and latent heat fluxes below and cooling aloft in the wake of predecessor cyclones and precursor warm-air advection, deep ascent, and low-level vorticity/PV generation ahead of subsequent cyclones).

V. References:

A sampling of recent references (not meant to be comprehensive) of possible relevance follows:

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