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From: "Bosart, Lance F" <lbosart@ALBANY.EDU>
Subject: **Synopsis of Friday map discussion for 5 April 2013**
Date: 7 April 2013 2:24:43 PM EDT
To: <MAP@listserv.albany.edu>
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Hi Everyone,

Friday map discussion began with a brief review of CONUS weather for March 2013, followed with an examination of recent flooding in the Buenos Aires area of Argentina, and concluded with a brief discussion of transitioning long-lke, lake-effect snow bands from earlier in the week. Alicia Bentley, Jaymes Kenyon, Ross Lazear, Justin Minder and Philippe Papin assisted with the preparation of map discussion materials and/or contributed to the scientific analysis and overviews.

The master map discussion web link can be found here:
http://www.atmos.albany.edu/student/ppapin/mapdisco/20130405/

I. 2012 CONUS daily mean temperature time series (Ryan Maue):

We briefly revisited previous discussions about the dramatic differences in the March 2012 and 2013 climate, most recently in a post by Ryan Maue in late March 2013 (http://www.atmos.albany.edu/student/ppapin/mapdisco/20130405/images/2m_temp.html). A time series of daily surface temperature for the CONUS for 2012 derived from the NCEO CDAS(v2) posted to map by Ryan Maue (http://www.atmos.albany.edu/student/ppapin/mapdisco/20130405/images/2m_temp_map.html) provided the initial focus of map discussion. Distinctive features of this time series include: 1) a ~15 F upward temperature spike over a period of 3-5 days in mid March, 2) a 40-45 day period of quasi constant daily mean temperature despite a rapidly increasing solar elevation angle that followed this upward temperature spike, 3) a smaller upward temperature spike at the very end of June that marked the onset of high summer, 4) a quasi constant period of daily mean temperatures in July and early August, and 5) a resumption of larger variability in daily mean temperatures in early October with the onset of autumn cooling.

Science issues and associated opportunities raised by this time series include: 1) determining whether the observed temperature spike in March was a manifestation of natural variability or an indication of a nonlinear tipping point in the seasonal cycle of climate (e.g., an abrupt poleward shift of the North Pacific subtropical jet in conjunction with MJO-enhanced deep convection) , 2) understanding what physical processes may have contributed to the "flatlined" daily mean temperatures in the latter part of March and April (e.g., did the unusually early onset of spring vegetative growth after a record-breaking warm March contribute to an enhanced evapotranspiration and associated cooling rate?), 3) establishing what physical processes may have contributed to the relatively rapid onset of high summer at the very end of June (e.g., subtropical continental anticyclogenesis at the end of June…..and the "mother-of-all-derechoes" on 29 June….marked the onset of an extended period where much of the CONUS was torched by very high temperatures, prompting the question as to whether the onset of intense and persistent heat so close to the summer solstice was a manifestation of a partial shutdown of the normal summer evapotranspiration process due to the intensification of widespread drought east of the Rockies during mid and late spring).

II. Heavy rains around Buenos Aires, Argentina on 2-3 April 2013:

Media reports of devastating flooding in the Buenos Aires area on 2-3 April (http://www.bbc.co.uk/news/world-latin-america-22023196; http://www.ctvnews.ca/world/torrential-rains-flooding-in-buenos-aires-leaves-at-least-52-dead-1.1223852) prompted a discussion of the synoptic-scale flow configuration that enabled the heavy rains and flooding to occur. More specific information on the rainfall totals (local rainfall maxima of ~400 mm were reported), and the local effects of the associated flooding, can be found from Argentinian weather service sources (http://www-atmo.at.fcen.uba.ar/noticias/noticias_dcao25.pdf; http://www.clarin.com/ciudades/produjo-tormenta_CLAFIL20130404_0001.jpg).

Loops of: 1) 300-200 hPa layer-mean potential vorticity (PV), wind speed and irrotational wind, 500 hPa vertical motion, precipitable water (PW), and SLP (http://www.atmos.albany.edu/student/ppapin/mapdisco/20130405/images/jet_sa.html), 2) dynamic tropopause (DT) potential temperature, winds and 925-850 hPa layer-mean vorticity (http://www.atmos.albany.edu/student/ppapin/mapdisco/20130405/images/dt_theta_sa.html), 3) 200 hPa geopotential heights, vorticity and 1000-850 hPa thickness (http://www.atmos.albany.edu/student/ppapin/mapdisco/20130405/images/200vort_sa.html), 4) 500 hPa geopotential height, relative vorticity, and vertical velocity (http://www.atmos.albany.edu/student/ppapin/mapdisco/20130405/images/500vort_sa.html), 5) PW, 700 hPa geopotential heights and temperatures and winds (toggle down for standardized PW anomalies) (http://www.atmos.albany.edu/student/abentley/mapdisco/20130405/700wind_pw.html), 6) 850 hPa temperatures and winds, and SLP(http://www.atmos.albany.edu/student/ppapin/mapdisco/20130405/images/850temp_sa.html), 7) 925 hPa relative humidity, temperatures and winds (http://www.atmos.albany.edu/student/ppapin/mapdisco/20130405/images/925rh_sa.html), 8) satellite infrared brightness temperatures (http://www.atmos.albany.edu/student/ppapin/mapdisco/20130405/images/ir.html), and 9) soundings from 87576 (SAEZ; Ezeiza Aero) and 87623 (SAZR; Santa Rosa Aero) (http://www.atmos.albany.edu/student/ppapin/mapdisco/20130405/images/skew_t_saez.html; http://www.atmos.albany.edu/student/ppapin/mapdisco/20130405/images/skew_t/SAEZ_3.gif) collectively tell the story of this event.

The order one story of the Buenos Aires flooding event that can be extracted from the above loops is that high-latitude anticyclonic wave breaking (AWB) contributed to the formation of a Rex block over southern South America. Two separate AWB events two days apart formed the poleward portion of the Rex block. A slow-moving cutoff cyclone that crossed the central Andes formed the equatorward portion of the Rex block. A deep trough east of the Rex block over the South Atlantic and a surface anticyclone just east of central Argentina enabled a weak east-west oriented frontal band to persist from the Buenos Aires area eastward into the South Atlantic. Moisture from the South Atlantic was transported westward along this frontal band. Tropical moisture from the Amazon was transported poleward toward Buenos Aires along a lee trough east of the Andes ahead of the aforementioned slow-moving cutoff cyclone. The instability of this tropical air mass was reinforced by cooling aloft ahead of the advancing cutoff cyclone. Lift needed to sustain the region of heavy rainfall and the associated embedded mesoscale convective systems was provided on the synoptic-scale by the advancing cutoff cyclone and its associated negative PV anomaly (SH) and on the mesoscale by warm-air advection along the frontal boundary in the vicinity of Buenos Aires.

A time line of the salient features relevant to the flooding event and key take away points gleaned from the above loops are as follows:

a) AWB over the southeastern Pacific on 30-31 March enabled a NW-SE oriented PV tail (streamer) to become established over southern South America

b) A negative PV anomaly (cyclonic in the SH) fractured from the PV tail along the coast of central Chile by 1200 UTC 31 March (producing chilly weather in Chile)

c) By 0000 UTC 1 April a Rex block was in place over southern South America between 80-70 W in response to the AWB to the south and cutoff cyclone formation to the north

d) A deep trough formed over the southwestern South Atlantic downstream of the Rex block, setting the stage for a confluent jet region to become established near coastal northern Argentina

e) Between 1-3 April the cutoff cyclone slowly crossed the Andes and reached coastal northern Argentina and southern Brazil

f) Cutoff cyclone passage across the Andes was accompanied by a second AWB near the southern tip of South America that reestablished the Rex block by 3 April

g) Surface anticyclogenesis over central Argentina and lee trough development to the north by 1 April was in response to the cutoff cyclone movement and the second AWB event

h) Subsequent surface anticyclone movement from central Argentina into the western South Atlantic established a moderately strong northeasterly flow along the coast to the north

i) This northeasterly flow developed along a low-level baroclinic zone in a deformation zone/front that extended from coastal northeastern Argentina eastward to the west-central South Atlantic

j) This deformation zone/front and associated low-level northeasterly flow was sustained by the surface anticyclone to the south and a deep trough to the east from 1-12 April

k) This sustained low-level northeasterly flow enabled Atlantic moisture to reach coastal northeastern Argentina, Uruguay, and southern Brazil from 1-2 April

l) Lee trough development over northern Argentina and southern Brazil enabled Amazonian tropical moisture (PW ~40 mm; +2-3 sigma) to reach the rain area by 1-2 April

m) Atlantic and Amazonian moisture pooled over northeastern coastal Argentina prior to and during the heavy period (see also SAEZ soundings)

n) Ascent to sustain the heavy rains was produced by warm-air advection along the aforementioned low-level baroclinic zone and ahead of the eastward-moving cutoff cyclone

o) A narrow band of unstable air (CAPE values > 1000 J/kg) in the northerly flow from Amazonia supported embedded convective elements in these ascent regions (see also SAEZ soundings)

p) Cooling aloft ahead of the eastward-moving cutoff cyclone (PV anomaly) may have enhanced CAPE in the northerly Amazonian airstream

q) A weak second front arriving from the southwest may have enhanced low-level convergence in the heavy rain area (see SAZR sounding)

Science issues and opportunities originating from this heavy rain event appear to be related to: 1) quantifying the extent of synoptic-scale and mesoscale circulation interactions during what appears to be a relatively rare case of Rex block formation over southern South America (need to establish the frequency of Rex block formation in this region), 2) establishing how two consecutive AWB events near the southern tip of South America drove surface anticyclogenesis over the South Atlantic and created a weak low-level baroclinic zone that served as focus for moisture convergence, frontogenesis and deep ascent, 3) determining how the second AWB event created conditions favorable for the continuation of a lee trough to the east of the Andes that helped to sustain the associated poleward transport of Amazonian moisture toward the rain area, and 4) elucidating to what extent a second northward-moving weak cold front associated with the second AWB event may contributed to the focusing of low-level convergence and warm-air advection in the heavy rain area. Any research effort on this case should also examine the role that large-scale circulations in the tropics and subtropics may have played in setting up the antecedent conditions for heavy rainfall. Victor Torres remarked during map discussion that instances of Rex block formation over southern South America may be related to episodes of above normal SSTs over the southeastern Pacific (present in this case) which would tend to favor ridge development and AWB in the upper troposphere immediately west of southern South America. Whether the currently amplifying MJO in the Indian Ocean-Indonesia region can be related to the amplifying Rossby Wave trains over the South Pacific Ocan since very late march remains to be determined.

III. Transitioning lake effect snow bands over eastern New York from 1-3 April 2013:

Map discussion concluded with a brief look at transitioning lake-effect snowbands that were observed over interior eastern New York downwind of Lake Ontario from the afternoon of 1 April to the morning of 3 Apr. A sequence of Buffalo (BUF) and Albany (ALB) soundings beginning at 0000 UTC 1 April (http://www.atmos.albany.edu/student/ppapin/mapdisco/20130405/images/skew_t_buf.html; http://www.atmos.albany.edu/student/ppapin/mapdisco/20130405/images/skew_t_alb.html) shows the west to east transition to cold advection behind a cold front between 0000 UTC 1-2 April. Scattered cellular convective elements developed over western and central New York during the afternoon. The big picture radar perspective can be seen from the NCAR/UCAR image archive link (http://www.atmos.albany.edu/student/ppapin/mapdisco/20130405/images/ne_radar.html). A local radar perspective from KENX can be viewed here (http://www.atmos.albany.edu/student/jkenyon/ATM401-501/cases/01-Apr-13/loop.html). Between 0000-1200 UTC 2 April, cold advection relaxed as winds became unidirectional in the lower troposphere and long-axis, lake effect snow bands developed downwind (east) of Lake Ontario. During the day on 2 April, the few individual snow bands transitioned into numerous low-top "popcorn-looking" cellular convective cells. This precipitation mode transition occurred in conjunction with a well-mixed boundary layer and small amounts of surface-based CAPE (~50 J/kg) and repeated itself the next day. Residents of many Capital District communities awoke to snowfall accumulations, depending on your location, of 0.5-1.5" on two consecutive mornings (2-3 Apr). As might be expected, forecasting the occurrence and locations of these snowbnads proved to be challenging.

The science opportunity with this case comes from a relatively "clean" synoptic-scale frontal passage that was associated with a minimal amount of synoptic-cale lift and precipitation. Long-axis, lake effect snowbands developed overnight after strong daytime heating ceased. Heat fluxes from Lake Ontario into an unusually cold air mass that was being advocated eastward along the long axis of the lake acted to destabilize the overlying cold air mass over and immediately downwind of the lake overnight. The resulting air mass instability (the only overnight heating show in town) and the associated ascent from thermally direct circulations driven by nocturnal land breeze convergence near the lake shores was concentrated over and downwind of Lake Ontario and resulted in the formation of long-axis, lake-effect snowbands. During the day, when diurnal heating was widespread over the land (strong early April sun) long-axis, lake-effect snowbands could no longer be maintained due to too much "ascent competition" from widespread diurnally driven strong insolation and the lake bands transitioned to widespread low-top cellular popcorn convection. The ALB/BUF soundings cited above depict 150-200 hPa deep, surface-based near dry adiabatic lapse rates across New York state that are characteristic of diurnally driven and strongly heated air masses. The KENX radar loops also showed that many of the observed low-top popcorn convective elements over higher terrain weakened and dissipated as they moved off the higher elevations into the Hudson, Mohawk and Champlain Valleys. How much of the observed weakening and dissipation of these convective elements can be attributed to strong downslope flow and adiabatic warming versus sinking and warming over the valleys in conjunction with local and regional diurnally driven circulations (ascent over higher terrain, descent over the valley cores) remains to be determined. This lake-effect snowband event is ripe for a WRF modeling study.

Lance
