Hi all,

Friday map discussion resumed on 3 Feb with the DAES back at full strength after the AMS annual meeting the previous week. We briefly focused on: (1) the weather-related challenges that some people had getting to Seattle (SEA), (2) the GFS post Ground Hog day "great fantasy snowstorm" that never was, (3) the antecedent flow conditions leading up to a major snowstorm in Portland (PDX), Oregon from 7–11 Jan, and (4) warm frontogenesis in California's San Joaquin Valley and cold-air damming at the north end of the San Joaquin Valley prior to the severe snow and icing event in the Portland (PDX), Oregon. We had hoped to get to a discussion of the California heavy rains of early-to-mid January, but our eyes were bigger than our stomachs. We will get to the California rains during a future map discussion.

Links used during the 3 Feb Friday map discussion can be found here: http://www.atmos.albany.edu/mapdisco/20170203/. Tomer Burg and Kyle Pallozzi assisted with Friday map discussion. Tomer and Kyle conducted a brief current weather discussion to close out Friday map discussion.

1. Seattle travel angst:

People attempting to get to SEA on Sunday 22 Jan encountered fog-related delays at many airports in the Midwest (including Chicago….so what else is new?) and parts of the Middle Atlantic. Travel plans were scrambled. Philippe Papin's travel odyssey can be found here: http://www.atmos.albany.edu/mapdisco/20170203/images/philippe_email.pdf. People scheduled to fly on Southwest to MDW on route to SEA were rerouted instead to MCO where they encountered further delays due to subtropical jet stream (STJ) related severe weather in parts of the Southeast and Florida, and STJ-related heavy rain in southern California.

2. GFS Post-Ground Hog Day "Great Fantasy Snowstorm":

The 324 h deterministic GFS forecast initialized at 0600 UTC 21 Jan 2017 and verifying 1800 UTC 3 Feb 2017 shows a 953 hPa surface cyclone located just north of BOS with a hellacious blizzard in progress in ALB (http://www.atmos.albany.edu/mapdisco/20170203/images/gfs_mslp_pcpn_frzn_us_47.png). The corresponding 6 h deterministic GFS forecast verifying the same time was a tad less exciting (http://www.atmos.albany.edu/mapdisco/20170203/images/gfs_mslp_pcpn_frzn_us_1.png). One-in-a-gazillion shots do not verify….especially when they involve big snow events…..and are about as likely as overcoming a 25-point deficit in the second half of the SuperBowl. I am kicking myself for not saving any of the corresponding 324 h upper-air forecast maps to see how the upper-level flow pattern evolved during the forecast period. For example, was the forecast intense cyclone a result of the phasing of a highly baroclinic northern stream arctic PCV anomaly with a less baroclinic but much more moist southern stream disturbance?

Several possible working hypotheses come to mind. First, the longitudinal position of the Rex block over northern Canada played a major role in determining where and whether an arctic PV anomaly could be ejected into lower latitudes over North America. Second, the forecast extreme cyclone event at 324 h was the result of the phasing of a highly baroclinic northern stream upper-level trough of arctic origin with a very low dynamic tropopause height down to 700 hPa or higher with a less baroclinic but much more moist southern stream subtropical upper-level trough analogous to what has happened in previous extreme cyclone events such as the Cleveland Superbomb of 25–26 January 1978 and the Superstorm of 13–14 March 1993. Third, since Alicia Bentley's loops of standardized 500-hPa geopotential heights and 850-hPa air temperatures show a general absence of negative 500-hPa geopotential height and negative 850-hPa temperature anomalies over most of Canada, indicative of the dominance of Pacific air masses (http://www.atmos.albany.edu/student/abentley/realtime/northamer_500ganom.php and http://www.atmos.albany.edu/student/abentley/realtime/northamer_850tanom.php), can we hypothesize that the presence of Pacific air masses across much of Canada precluded any robust northern stream arctic PV anomaly from reaching the CONUS? Fourth, can we further hypothesize that going forward as the arctic warms at low levels in the atmosphere relative to lower latitudes that extreme phasing events such as described above will become less frequent and less intense due to weaker arctic PV anomalies and a reduced ability for arctic PV anomalies to reach middle latitudes? Have the climate models reached a sufficient resolution that would permit the testing of this hypothesis?

3. Antecedent flow conditions leading up to major snowstorm in Portland (PDX), Oregon, 7–11 Jan 2017:

The annual snowfall in PDX is just ~2.8″ (~7 cm). On 10–11 Jan upwards of 10–14″ (25–30 cm) fell in the PDX area. Although forecasters knew that a mix of snow, sleet, freezing rain, and rain was likely in the PDX area, forecast snowfall amounts were consistently and significantly underestimated even up to a few hours before the event started. Not good.

A large-scale North Pacific perspective on antecedent conditions to the PDX snowstorm (and heavy rains in California which will be a topic for a future Friday map discussion) to include MSLP, 6h precipitation, and 850-hPa temperature can be found here (http://www.atmos.albany.edu/student/abentley/test/images/pacific_6hprecip.gif, and for MSLP, 1000–500 hPa thickness and 250-hPa winds can be found here (http://www.atmos.albany.edu/student/abentley/test/images/pacific_mslp.gif), and for 500-hPa geopotential heights, temperatures, winds, relative vorticity, and 600–400 hPa ascent can be found here (http://www.atmos.albany.edu/student/abentley/test/images/pacific_vort.gif). These analyses show that the large-scale flow pattern leading up to the PDX snowstorm on 10–11 Jan was characterized by a high-latitude Rex block with an upper-level anticyclone situated over western Alaska while progressive troughs in the westerlies undercut this block at lower latitudes. One progressive trough embedded in these westerlies interacted with another trough dropping southward and southwestward on the eastern side of the aforementioned Rex block to establish a deep trough offshore of California a few days prior to the PDX snowstorm. Meanwhile, surface anticyclogenesis over southwestern Canada behind progressive trough passages in the downstream northwesterly flow to the east of the northern Rockies in conjunction with cyclogenesis offshore of California and Oregon established a favorable SLP gradient for a westward-directed flow of cold air down the Columbia River Gorge into the Willamette Valley.

Sustained easterly flow down the Columbia River Gorge in winter is a "gorgeous" example of terrain-channeled flow that is favorable for the occurrence of high-impact snow and icing events in the PDX area as has been pointed out by Cliff Mass and others numerous times before. Plots of surface observations over portions of the western CONUS from 0600 UTC 7 Jan to 1200 UTC 9 Jan 2017 illustrate this easterly flow (http://www.atmos.albany.edu/student/tburg/analysis/sfc1701.php). A real-time loop of surface potential temperature prepared by Tomer Burg illustrates a westward-directed surge of surface air with temperatures < 0 C from southeastern Washington down the Columbia River Gorge and into the Willamette Valley (http://www.atmos.albany.edu/student/tburg/analysis/rtma_1701.php). The models may not have been showing this terrain-channeled and westward-directed surge of the 0 C isotherm very clearly, but the observations sure were.

So, why did the official forecasts underestimate the potential for a significant snowfall in the PDX area until the event was imminent? Channeled easterly flow through the Columbia River Gorge is a common occurrence in the cool season. Experienced forecasters know this. That said, experienced forecasters who knew better were reluctant to "overrule" the operational models. At issue is why? Cliff Mass may have put his finger on the problem in a separate email exchange with me about this event when he wrote: "But something else can happen and IS happening this time around. Modelers such as myself and the ESRL HRRR folks can be motivated by forecaster comments to push to rectify model problems. This has happened. I found we could radically improve the Gorge flow forecast/simulations by moving the 2nd order diffusion in WRF from sigma to horizontal surfaces. And get rid of 6th order diffusion. RADICALLY BETTER RESULTS (see attached, slides 12 and 14) (I have appended Cliff's pptx file below). When there was a stable layer, model diffusion was destroying the cold air in or near terrain. I made the change in the UW real time system and HRRR will do so in a few weeks. Communication between forecasters and modelers is not discussed a lot, but it is so very important." To echo Cliff from our long experience with working with forecasters in the COMET and CSTAR programs, O2R is as important as R2O in informing researchers and forecasters alike. I wonder if forecasters "suspended disbelief" and put too much faith in the model solutions which showed a warmer boundary layer and little if any accumulating snow in the lowlands? This question also relates to our earlier discussion about how automation is working its way up the forecast food chain. Over reliance on the models in critical high-impact weather situations, especially when forecasters "suspend disbelief" for whatever reasons, is a problematic strategy going forward in terms of human forecasters potentially succumbing to the ravages of automation.

4. Warm frontogenesis and cold-air damming in California's San Joaquin Valley:

A common perception, perhaps incorrect, is that strong warm frontogenesis occurrences in California are very rare. Strong warm frontogenesis was observed in the central San Joaquin Valley in conjunction with the very heavy rains that fell across central and northern California between 7–9 January 2017 (same period when favorable conditions were developing farther north for the above-described PDX snow event). Loops of western CONUS plots of surface observations at 2 h intervals from 0600 UTC 7 Jan to 1200 UTC 9 Jan 2017 (source: NCAR-RAL) can be found here: http://www.atmos.albany.edu/student/tburg/analysis/sfc1701.php. Warm frontogenesis is first apparent near Stockton (SCK), CA, at 1000 UTC 7 Jan as evidenced by northerly (southerly) flow to the north (south) of SCK. Warm frontogenesis occurs where a flow of mild and moist Pacific air ahead of an offshore cyclone moves inland through the San Francisco Bay region and encounters ambient cooler air in portions of the central San Joaquin Valley. By 1800 UTC 7 Jan, southerly wind components have reached as far north as Beale AFB (BAB) and Oroville (OVE) in the northern part of the San Joaquin Valley. Farther north, Redding (RDD) and Red Bluff (RBL) have northerly wind components and are ~12–14 F cooler than stations with southerly wind components farther south. At 0200 UTC 8 Jan, Chico (CIC) reports a north wind and a temperature of 39 F while BAB to the south reports a temperature of 57 F. The 18 F (10 C) temperature difference is pretty impressive for this part of CA. After 0800 UTC, BAB reverts briefly back to a northerly wind component as the temperature decreases to 48 F before shooting back up to 57 F at 1000 UTC as southerly winds return. By 2200 UTC 8 Jan, RDD and RBL have warmed considerably as southerly wind components have developed and only Trinity Center (KO86) at the extreme northern end of the San Joaquin Valley is still in the cooler air.

Travis Wilson, Rob Fovell's former Ph.D. student at UCLA and now with the NWS, and I liked to discuss winter weather situations where RDD would report accumulating snow with a north wind while RBL < 50 km to the south would report rain with a south wind in conjunction with cold-air damming at the northern end of the San Joaquin Valley. Cold-air damming in the northern San Joaquin Valley differs from more common cold-air damming east of mountain barriers like the Rockies and Appalachians. A low-level southerly airflow impinging on the Siskiyous at the northern end of the San Joaquin Valley can lead to adiabatic cooling when a southerly airstream is forced upward toward the Siskiyous. This orographically forced upward motion enables a mass of cooler air to build up along the southern flanks of the Siskiyous. As this mass of cooler air grows it enables surface pressures to rise at locations at the northern end of the San Joaquin Valley relative to locations farther south. Cold-air damming at the northern end of the San Joaquin Valley can result if the aforementioned lifting is strong enough and lasts long enough to allow a surface-based layer of cooling to become deep enough to reverse the direction of mesoscale SLP gradient at the northern end of the San Joaquin Valley.

To my knowledge, this variant on cold-air damming has only been discussed in the gray literature and not in the refereed literature (I am prepared to be wrong as usual, so please enlighten me if otherwise) and is ripe for further investigation. I thank Travis Wilson for several very interesting discussions of this type of cold-air damming event. He deserves credit for what I have mentioned above. I also can't help but wonder whether a similar type of cold-air damming can occur at the northern end of the San Joaquin Valley in conjunction with occasional but rare thunderstorms over the Siskiyous as cold pool-produced air drains into the northern end of the San Joaquin Valley. Given adequate surface convergence at the leading edge of the mountain-produced cool pool and a decent 0–6 km shear profile as a result of 10–15 kt SSE up-valley flow beneath 20–25 kt WSW flow aloft, could severe weather be triggered on very rare occasions in summer in the RDD/RBL to CIC area?

5. California heavy rains of early-to-mid January 2017:

We ran out of time. To be discussed during a future Friday map discussion.

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