Hi all,

Winter weather dominated Friday map discussion for 1 Feb 2019. We discussed a mesoscale snow event that “over performed” in the Denver area on 28 Jan 2019, a moderate snow event in parts of the Northeast on 29 Jan 2019, and an impressive Arctic front-driven long-lived snow squall across parts of the Northeast on 30 Jan 2019. Materials used during map discussion can be found here (http://www.atmos.albany.edu/mapdisco/20190201/).Matt Campbell, Tyler Leicht, Marshall Pfahler, Danny Reese, and Minghao Zhou contributed to map discussion. We greatly appreciate the radar loops and imagery were provided by Morris Weisman, Ed Szoke, and WFO-BOU for the Denver area snow event on 28 Jan.

1. Denver area mesoscale snow event of 28 Jan:

A mesoscale banded snow event impacted the Denver metro area between 0800–1800 UTC on 28 Jan. Maximum snowfall (just under a foot) was reported in the immediate Denver area. The corridor of heaviest tended to coincide with the Denver-Boulder turnpikeduring the morning rush hour with resulting travel difficulties. The forecast challenge for models and humans alike was pinning down the correct location of the heaviest snow and the maximum accumulations. Overall, the storm “over performed” on snowfall amount.See (http://www.atmos.albany.edu/mapdisco/20190201/) for assorted imagery documenting this event.

Assorted loops from Alicia Bentley (http://www.atmos.albany.edu/student/abentley/realtime.html)and Tomer Burg (http://www.atmos.albany.edu/student/tburg/analysis/) show the snow occurred beneath NW flow that was characterized by cold advection and implied subsidence at 700 hPa. The attached DNR sounding from 1200 UTCV 28 Jan, during which time snow was falling, shows the aforementioned NW flow above 700 hPa that capped N/NNE flow in the PBL. A near moist neutral saturated (with respect to ice) lapse rate is present between 650–450 hPa, a situation known to be favorable for banded precipitation.

Papers by Wesley et al. (1995), Davis (1997), Szoke and Shaw (2000), and Schumacher et al. (2010), see the links below, provide observational and theoretical evidence for the existence of banded precipitation structures such as were observed on28 Jan. The forecast challenge, and it is a big one, is determining where the bands will set up, what will be the snowfall rates in the bands, and how long with the bands last. As noted in the WFO-BOU discussion there was considerable forecast uncertainty among the various available mesoscale models (e.g., HRRR, HRRRX, NAM-Nest) as to band location, band duration, snowfall intensity, and snowfall areal coverage.

Science hypothesis: The formation of a “Longmont anticyclone” in conjunction with low NNW flow across the Cheyenne Ridge resulted in the creation of a moist upslope ESE/SE flow directed toward the Front Range beneath a NW flow aloft. The available moisture was further enhanced by a NW-SE oriented weakly positive PW anomaly tail associated with the passage of a predecessor cyclone that was located over Minnesota at 0600 UTC 28 Jan 2019 (http://www.atmos.albany.edu/student/tburg/analysis/loop.php?model=gfs&prod=300wind;700rh;850temp;qpf6;tmp2m;700pwat_std;&curid=5&proj=us&archive=1&run=2019020318). I have attached the relevant PW anomaly image below the DNR sounding image because Tomer Burg's web links from 28 Jan will soon age off.

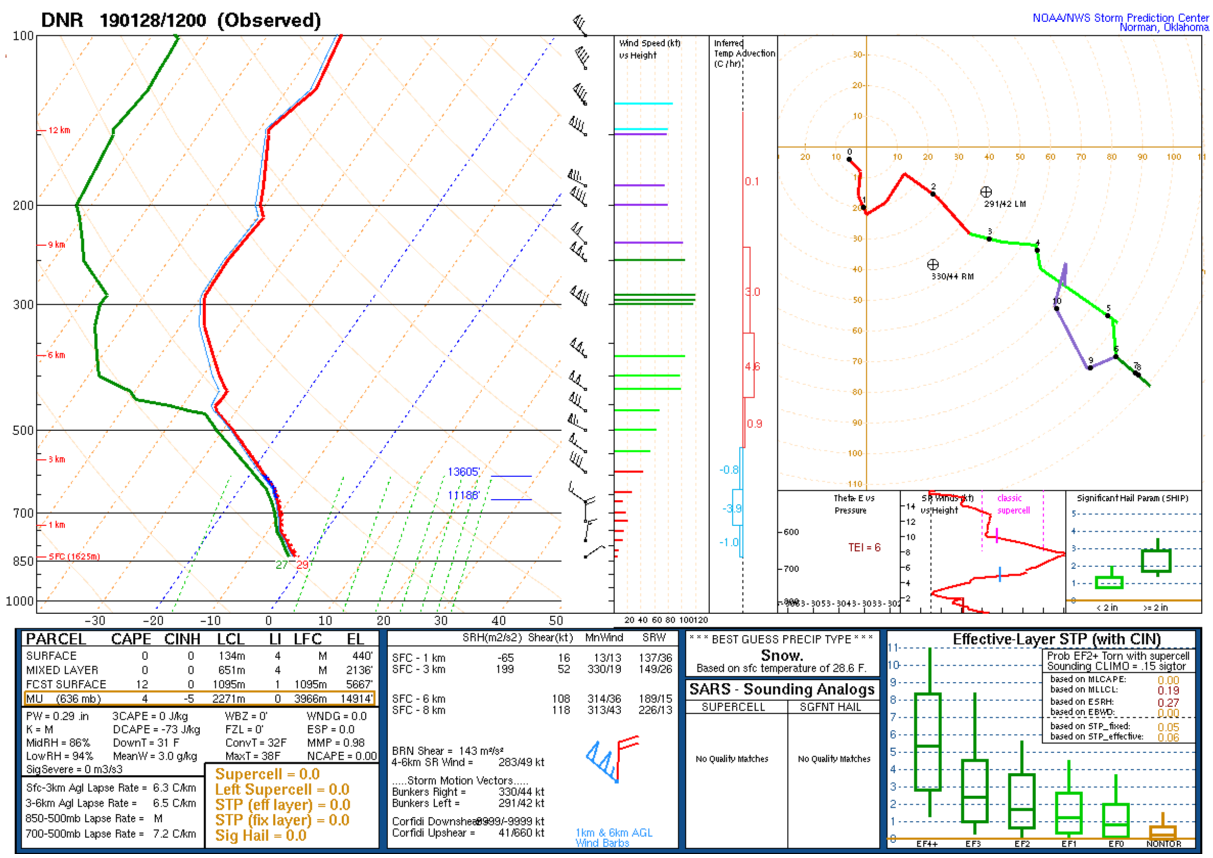
Davis (1997): Mesoscale Anticyclonic Circulations in the Lee of the Central Rocky Mountains (https://journals.ametsoc.org/doi/pdf/10.1175/1520-0493(1997)125<2838:MACITL>2.0.CO;2)

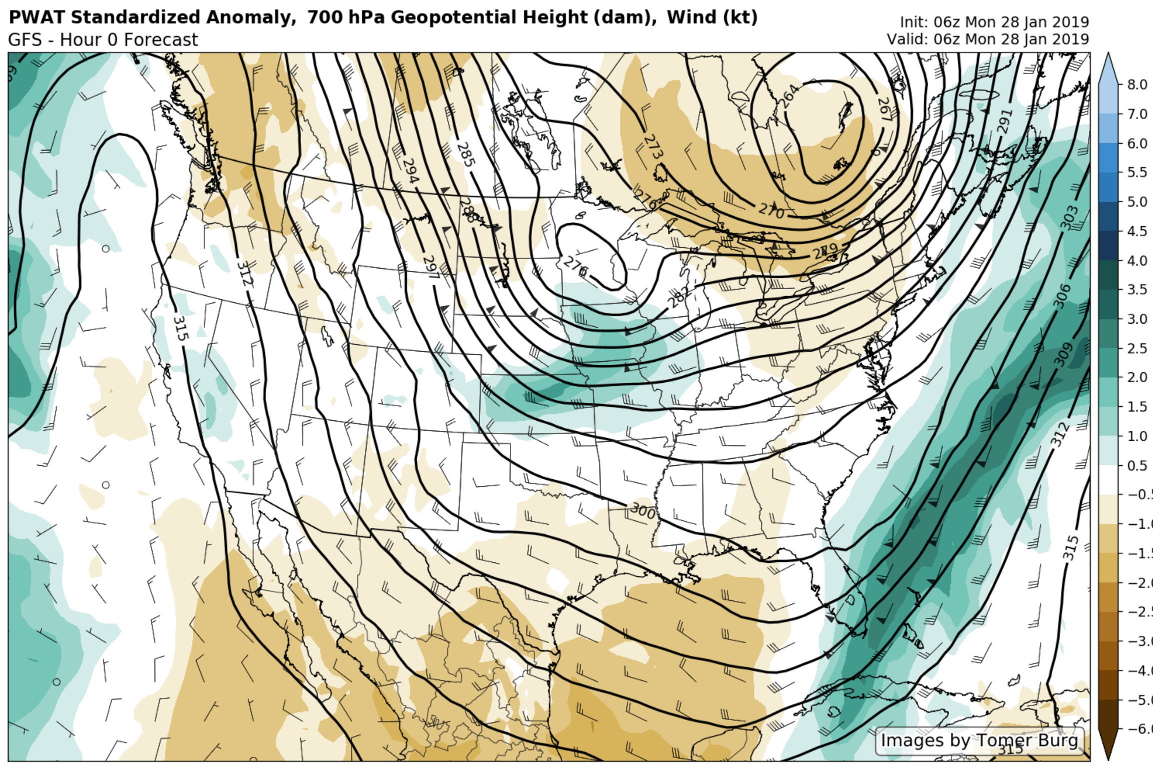
Schumacher et al. (2010): Convective Snowbands Downstream of the Rocky Mountains in an Environment with Conditional, Dry Symmetric, and Inertial Instabilities (https://journals.ametsoc.org/doi/pdf/10.1175/2010MWR3334.1)

Szoke and Shaw (2000): AN EXAMINATION OF THE OPERATIONAL PREDICTABILITY OF MESOSCALE TERRAININDUCED

FEATURES IN EASTERN COLORADO FROM SEVERAL MODELS (Preprint article is appended as a pdf below)

Wesley et al. (1995): Snowfall Associated with a Terrain-Generated Convergence Zone during the Winter Icing and Storms Project (https://journals.ametsoc.org/doi/pdf/10.1175/1520-0493(1995)123<2957:SAWATG>2.0.CO;2)





2. 29 January Northeast Snow Event:

A general light-to-moderate snowfall occurred throughout the region. Snowfall amounts ranged from 4" in the "Albany hole" to upwards to 2–3 times these amounts elsewhere. Downsloping southerly flow kept snowfall totals down in the immediate Capital District. The forecast challenge was the timing of secondary cyclogenesis along an initial mostly NNE-SSW oriented frontal zone as it moved eastward across New York State. The GFS indicated that secondary cyclone formation along this frontal boundary would be delayed until this cyclone had mostly passed the latitude of Albany, resulting in only modest amounts of snow due to a longer period southerly downsloping flow before a wind shift to northerly. The ECMWF showed a more vigorous and earlier developing secondary cyclone with resulting less southerly flow and more northerly flow and higher snowfall amounts in Albany. The atmosphere mostly split the difference with a slight nod to the GFS. The difference between the two model forecasts appeared appeared to be related to trough tilt (more negatively tilted in the ECMWF) and trough equatorward extent (farther south in the ECMWF).

Tyler Leicht presented a trajectory analysis overview of this event. Attached are NOAA HYSPLIT NAM-12 km 120 h backward trajectory analyses ending at 2100 UTC 29 Jan and 0300 UTC 30 Jan for KALB and KISP. For reference purposes, the relevant KISP and KSALB metar observations are also attached below. At KISP, onshore SE flow ahead of an approaching frontal trough at 2100 UTC shifted to westerly behind the frontal trough at 0300 UTC, consistent with the back trajectory analyses. The absence of significant precipitation at KISP during this period is also consistent with a limited net vertical displacement of the air parcels. At KALB, the observed deeper low-level cold air at 2100 and 0300 UTC is consistent with the source region of the trajectories arriving at 500 and 1000 m at both times. Precipitation at KALB during this 6 h period was 0.28”; amounts were suppressed relative to farther north and south by the implied partial southerly flow downsloping associated with air parcels arriving from the south.

KISP 300256Z 26006KT 10SM -RA FEW011 BKN025 OVC032 03/03 A2980 RMK AO2 WSHFT 0143 SLP090 P0003 60012 T00330028 55001

KISP 300203Z 24012G22KT 9SM -RA FEW011 BKN023 OVC029 05/04 A2980 RMK AO2 WSHFT 0143 P0000 T00500039

KISP 300156Z 23016G22KT 7SM -RA FEW011 BKN023 OVC029 06/04 A2979 RMK AO2 WSHFT 0142 SLP088 P0007 T00560039

KISP 300140Z 18013G19KT 8SM -RA BKN029 OVC033 06/04 A2978 RMK AO2 P0004 T00560044

KISP 300056Z 16011G15KT 8SM -RA FEW028 OVC042 06/05 A2979 RMK AO2 SLP089 P0002 T00610050

KISP 292356Z 14010KT 10SM -RA FEW021 OVC039 06/04 A2980 RMK AO2 SLP092 P0000 60000 T00610044 10061 20039 58013 $

KISP 292256Z 17007KT 10SM -RA FEW016 OVC043 06/03 A2982 RMK AO2 RAB31 SLP097 P0000 T00560033 $

KISP 292156Z 12011G18KT 10SM SCT017 OVC055 05/03 A2984 RMK AO2 SLP105 T00500033 $

KISP 292153Z 12013G18KT 10SM SCT017 OVC050 05/03 A2984 RMK AO2 $

KISP 292056Z 12014KT 10SM FEW008 BKN017 OVC050 05/03 A2986 RMK AO2 SLP110 T00500028 56022 $

KALB 300251Z 18004KT 3/4SM R01/P6000FT -SN BR OVC014 M02/M04 A2979 RMK AO2 TWR VIS 1 SLP090 P0004 60013 T10171039 56019

KALB 300151Z 14008KT 3/4SM R01/P6000FT -SN VV014 M02/M04 A2980 RMK AO2 TWR VIS 1 SLP094 P0004 T10171044

KALB 300124Z 14008G14KT 3/4SM R01/P6000FT -SN VV010 M02/M04 A2980 RMK AO2 TWR VIS 1 P0003 T10171044

KALB 300051Z 12006KT 3/4SM R01/5000V6000FT -SN VV009 M03/M06 A2982 RMK AO2 TWR VIS 1 SLP101 P0005 T10331061

KALB 292351Z COR 00000KT 3/4SM R01/5500VP6000FT -SN VV011 M04/M07 A2984 RMK AO2 TWR VIS 1 SLP111 SNINCR 1/5 4/005 P0005 60015 T10441072 11028 21061 56002

KALB 292317Z 05004KT 3/4SM R01/5500VP6000FT -SN BR VV011 M05/M07 A2985 RMK AO2 TWR VIS 1 P0002 T10501072

KALB 292251Z 00000KT 3/4SM R01/P6000FT -SN BR OVC009 M05/M07 A2985 RMK AO2 TWR VIS 1 SLP112 P0005 T10501072

KALB 292228Z 03003KT 3/4SM R01/4500V5500FT -SN VV009 M05/M08 A2985 RMK AO2 TWR VIS 1 P0003 T10501078

KALB 292154Z 02003KT 1SM R01/4500VP6000FT -SN BR BKN012 OVC015 M06/M08 A2984 RMK AO2 P0000 T10561078

KALB 292151Z 03003KT 3/4SM R01/4500VP6000FT -SN BR FEW008 SCT012 OVC015 M06/M08 A2984 RMK AO2 TWR VIS 1 SLP110 P0003 T10561078

KALB 292118Z 34004KT 3/4SM R01/4000FT -SN SCT008 OVC012 M06/M08 A2985 RMK AO2 TWR VIS 1 P0001 T10561083

KALB 292051Z 33005KT 3/4SM R01/4000V5000FT -SN BKN008 OVC016 M06/M09 A2985 RMK AO2 TWR VIS 1 SLP112 P0002 60002 T10561089 56019

Science hypothesis: Uncertainties in the prediction of upper-level trough tilt and depth can have a disproportionate impact on the timing and location of East Coast secondary cyclogenesis due to terrain-flow interactions west, over, and east of the Appalachians with a corresponding disproportionate effect on sensible weather.

3. Arctic front snow squall of 30 Jan 2019:

Danny Reese described a spectacular Arctic front snow squall occurred in the Albany area shortly after 2000 UTC on Wed 30 Jan. Lots of UAlbany students and faculty (including yours truly) went outside to experience the event. We were not disappointed! Visibility at the height of the snow squall was probably no more than 10–15 m. Peak winds during the squall in the 35–45 kt range provided a mesmerizing perspective from being enveloped in gazillions of swirling, wind-blown flakes up close and personal. See Danny Reese's video (https://www.youtube.com/watch?v=-HPj_cH7tHI), the University Mohawk Tower video (https://www.youtube.com/watch?v=3Vjq-cvIl1w) ,and a State College video (https://www.youtube.com/watch?v=3Vjq-cvIl1w). A radar loop of the this event obtained from the UCAR image archive (http://www2.mmm.ucar.edu/imagearchive/) shows that the snow squall originated over central PA at the leading edge of the Arctic front (choose 30 Jan 2019; choose radar imagery; choose New England in the UCAR image archive). Note that the apparent weakening over eastern PA was likely not a result of the band weakening, but rather due to its shallow nature and movement into an area of poorer radar coverage. Beam height in this area was around 2-3 km, shortly below the tropopause.

The Arctic front snow squall formed at the leading edge of the advancing tropopause polar vortex (TPV) that was responsible for the recent Arctic cold in much of the Midwest and parts of the Northeast as evidenced by Alicia Bentley's dynamic tropopause(DT) loop (http://www.atmos.albany.edu/student/abentley/realtime/standard.php?domain=conus&variable=dt_2pvu). Note the band of maximum layer-mean 925–850-hPa relative vorticity associated with the snow band across central Pennsylvania and New York immediately at the leading edge of the TPV. This positive PV advection is driving the ascent associated with the Arctic snow squall. Evidence for this ascent case be found in 3-km NAM forecast soundings from model runs initialized at 1200 and 1800 UTC and valid at 1900 and 2000 UTC at a point near Albany, NY, just ahead of the Arctic front (http://www.atmos.albany.edu/mapdisco/20190201/images/AlbanySnowSquall.pdf).

The above forecast soundings indicate a tow DT height (~600 hPa) associated with the TPV, a steep surface-based lapse rate to the DT, an ascent maximum near 800 hPa in the dendritic growth zone, more than 100 J/kg of MUCAPE/SBCAPE, DCAPE values between 40–140 J/kg, SRH values > 100 m**2/s**2, and surface to 500-hPa shear values > 75 kt. If this were summertime, everyone would have been heading out the door to go storm chasing. The surface-based steep lapse is a result of the cold, low DT in the absence of any surface heating. A surface-based steep lapse rate to ~600 hPa at Albany would be remarkable for July, let alone late January. Visually, several of us saw a shelf cloud pass overhead at the leading edge of the serious S+ whiteout conditions. An Albany radar (KENX) base reflectivity loop showed that the leading edge of the Arctic front bowed down the Mohawk Valley toward Albany. This behavior is consistent with the observed shelf cloud and convectively driven cold pool surges down the Mohawk Valley that are frequently observed during the summer. The only thing missing from this Arctic front snow squall was thunder and lightning.

Science hypothesis: Northerly flow TPVs associated with low DT heights that move quickly from Arctic source regions to middle latitudes can generate intense short-lived snow squalls at the leading edge of the Arctic air that havemany attributes of warm season mid-latitude squall lines minus thunder and lightning due to the absence of mixed phase microphysics.

Lance