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## February 2011: A Month of Below Average Temperatures, A Record Cold Snap, and a Sharp Frontal Passage with Snow

## Overview of the Weather and Detail Diagnosis for Feb 25<sup>th</sup>-27<sup>th</sup>

Daily surface weather observations for TUS, valid at 5 pm MST, were recorded for the 28 days of February 2011. The reports were then plotted using the surface station model (Fig. 1). These data were also graphed as time series (Fig 2a and 2b). The station models and time series reveal that daily temperatures at Tucson during February 2011 ran mostly below the 30-year mean values (thin red line in Fig. 2a), with 11 days more than 5°F below normal but only 4 days more than 5°F above normal. The beginning of the month was marked by an extreme cold snap that set record low MAX (38°F) and MIN (18°F) temperatures for the Feb 3<sup>rd</sup>, which was followed by near-record warmth on Feb 15 (82°F MAX) before dropping to mostly below normal temperatures the last nine days of the month (Feb 20-Feb28).

Feb 26-28 is a three-day period that stands out because of the large day-to-day changes. The temperature dropped from 67°F on 2/26 to more than 20°F below norm (49°F) on 2/27, only to warm abruptly to 70°F on 2/28. The wind on 2/26 was sustained to 20 knots from the SSW instead of the more typical afternoon wind of NW at 10 knots that was observed on the adjacent days. SLP dropped 8 mb to 1003.3 mb on 2/27, the lowest value recorded during the entire month, then rose 15 mb by 2/28. TUS also received 0.21" of precipitation during the calendar day of Feb 27. The three days of change warranted closer examination.

Figure 3 shows the composite surface-satellite-radar map for 6:30 am MST (1330 UTC) for 27 FEB 2011, which is about midway between 5 pm MST observations of the 2/26 and 2/27. The surface analysis shows a 996 mb cyclone over N. Arizona. The map also reveals a cold front

extending southward from the cyclone and that passed through SE Arizona during the early morning hours of 2/27. Satellite imagery shows an elongated band of clouds flanking the cold front, and radar reflectivity suggests that precipitation was falling over Tucson at 6:30 am MST. In fact, the hourly surface reports show that snow occurred just before sunrise on the 2/27. (See https://www.wunderground.com/history/airport/KTUS/2011/2/27/DailyHistory.html?HideSpecis=1)

The 500 mb analysis for 1200 UTC 27 FEB 2011 (Fig. 4) shows a deep, cold-core, closedlow centered over the Lower Colorado River Valley. Tucson is situated to the east of the upperlevel low, in a region with a strong temperature gradient and brisk SW flow that is conducive to forcing upward motion. Indeed, the 300 mb analysis for same time (Fig. 5) shows Tucson is underneath an area of strong upper-level divergence (the thin, yellow contours). Temperatures in the midst of the 500 mb low are below -35°C, much colder than the -15°C to -20°C values that typify the 500 mb conditions during late February. It is now clear why the 27 FEB surface temperatures were so low as the coldest air passed over TUS at that time.

Abrupt cooling, a wind shift from SW to NW, a steady pressure fall followed by an abrupt pressure rise, abnormal cold and even light snow. *Such a sequence of observations is the classic signature of a strong cold front from the Pacific Ocean passing through SE Arizona*. Indeed, it was the combination of a sharp cold front, a bitter cold 500 mb low and upper-tropospheric divergence that produced the snowy conditions at TUS.

## References

Ahrens, C.D., 2015: Essentials of Meteorology, An Invitation to the Atmosphere. Seventh edition. *Brooks-Cole.* 525 pp. Mullen, S.L., 2011: Lectures notes for ATMO 1701.

Sources for weather maps. http://www.mmm.ucar.edu/imagearchive/ http://www.spc.noaa.gov/obswx/maps/ http://www.wunderground.com/history/

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| 27 3.10           | 5             | Daily surface o | observations for Tu  | icson Airport, valid | 5:00 pm MST, for     | February 2011.     |
| Feb 27            | Feb 28        |                 |                      |                      |                      |                    |





Figure 2: Time series of 0000 UTC observations at TUS for the period 1 FEB 2011 TO 28 FEB 2011. Upper panel: Temperature (red, °F). Dew point (blue, °F). Average MAX temperature for the date (thin red, °F). Precipitation (green, inches). Lower panel: SLP (red, mb). Wind speed (violet, knots).



45 55 150 145 220 240 250 dB2(winter) Figure 3: Composite surface-satellite-radar map , valid 1330 UTC 27 FEB 2011. Source <u>http://www.mmm.ucar.edu/imagearchive/</u>



Figure 4: 500 mb heights (solid, every 60 m) and isotherms (red, every 2 °F), valid 1200 UTC 27 FEB 2011. Source :

http://www.spc.noaa.gov/cgi-bin-spc/getuadata.pl?MyDate1=110227&Time1=12&MyDate2=&Time2=12&align=V&Levels=500



Figure 5: 300 mb streamlines (solid), isotachs (shading) and divergence (yellow), valid 1200 UTC 27 FEB 2011. Source: