Thanksgiving Week 2010 Arctic Outbreak and Storms
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Overview:

Heavy snows, arctic blasts, hurricane force winds, tornadoes and flooding rains highlighted Thanksgiving week 2010, disrupting travel and holiday plans for many across the U.S. The week began with heavy rains along the California and Oregon coasts, with heavy snows across portions of the Sierra, Wasatch, Tetons and Colorado Rockies (Fig. 1). As heavy precipitation continued across the western U.S. into the middle portion of the week, significant precipitation spread through the Midwest into the Northeast (Figs. 2a, b), with heavy amounts reported across the mid Mississippi and Ohio Valleys during the latter portion of the week (Figs. 2c, d). In addition to significant rains, severe weather was reported across the Midwest, including several tornado, damaging wind and hail reports across Illinois and Missouri on 22 November (Fig. 3a) and across the Tennessee and lower Mississippi Valleys on 25 November (Fig. 3b).

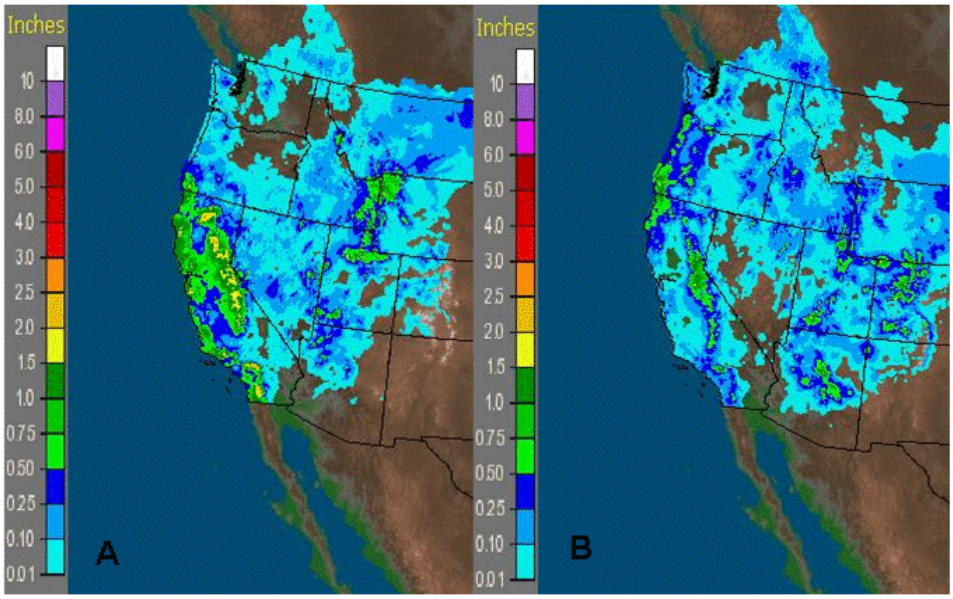

Figure 1: 24-h accumulated precipitation across the western U.S. ending 7 am (EDT) (a) 21 Nov 2010 and (b) 22 Nov 2010 (AHPS).

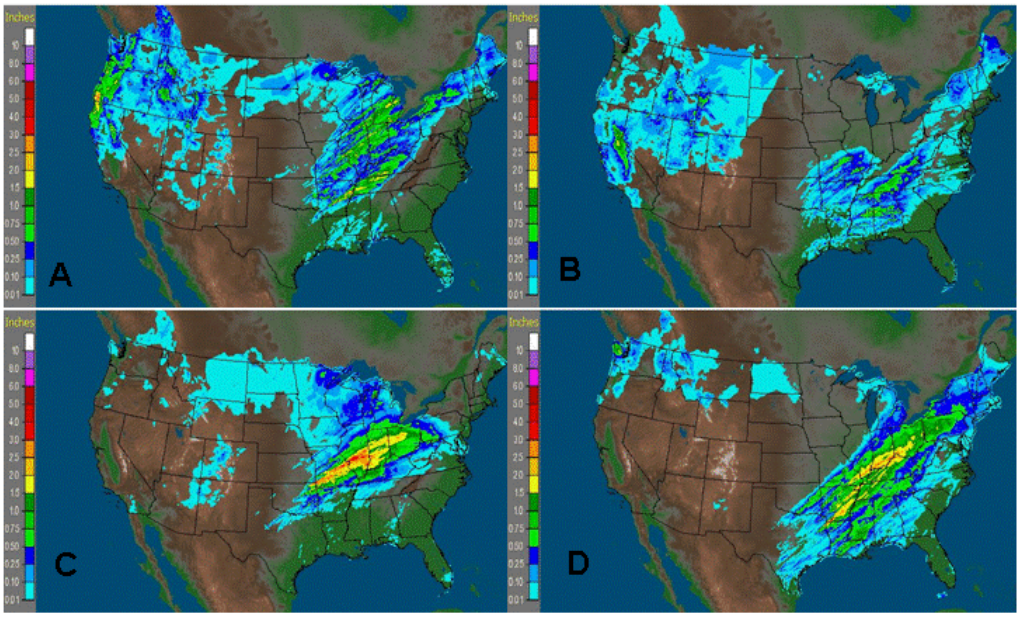

Figure 2: 24-h accumulated precipitation ending 7am EDT (a) 23 Nov 2010 (b) 24 Nov 2010 (c) 26 Nov 2010 and (d) 27 Nov 2010 (AHPS).

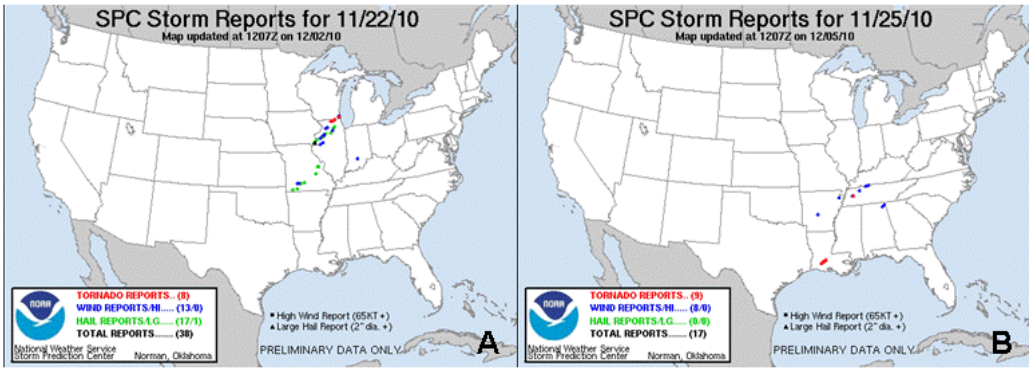

Figure 3: Preliminary severe weather reports showing tornado, hail, and damaging wind reports for (a) 22 Nov 2010 and (b) 25 Nov 2010 (SPC).

Synoptic Pattern:

Two primary upper lows/waves affected the U.S. during the Nov 21-26 period. These will be referred to as "Storm 1" and "Storm 2"

Storm 1 - November 21-23, 2010

The week began with significant rains falling along the greater extent of the southern Oregon and California coasts with heavy snows recorded across the Sierra. This occurred as a deep 500 hPa low shown at 12 UTC on 21 Nov (Fig. 4a) dropped south along the Pacific Northwest coast and moved inland across southern Oregon and northern California. In addition to the orographic lift afforded by the strong onshore flow south of the low, strong vorticity advection was present. California was also positioned in the left

exit region the upper jet (Fig 5) – a region favorable for ascent. Downstream over northwestern Wyoming and southwestern Montana, heavy snowfall occurred in association of the right entrance region of a second upper jet (Fig. 5).

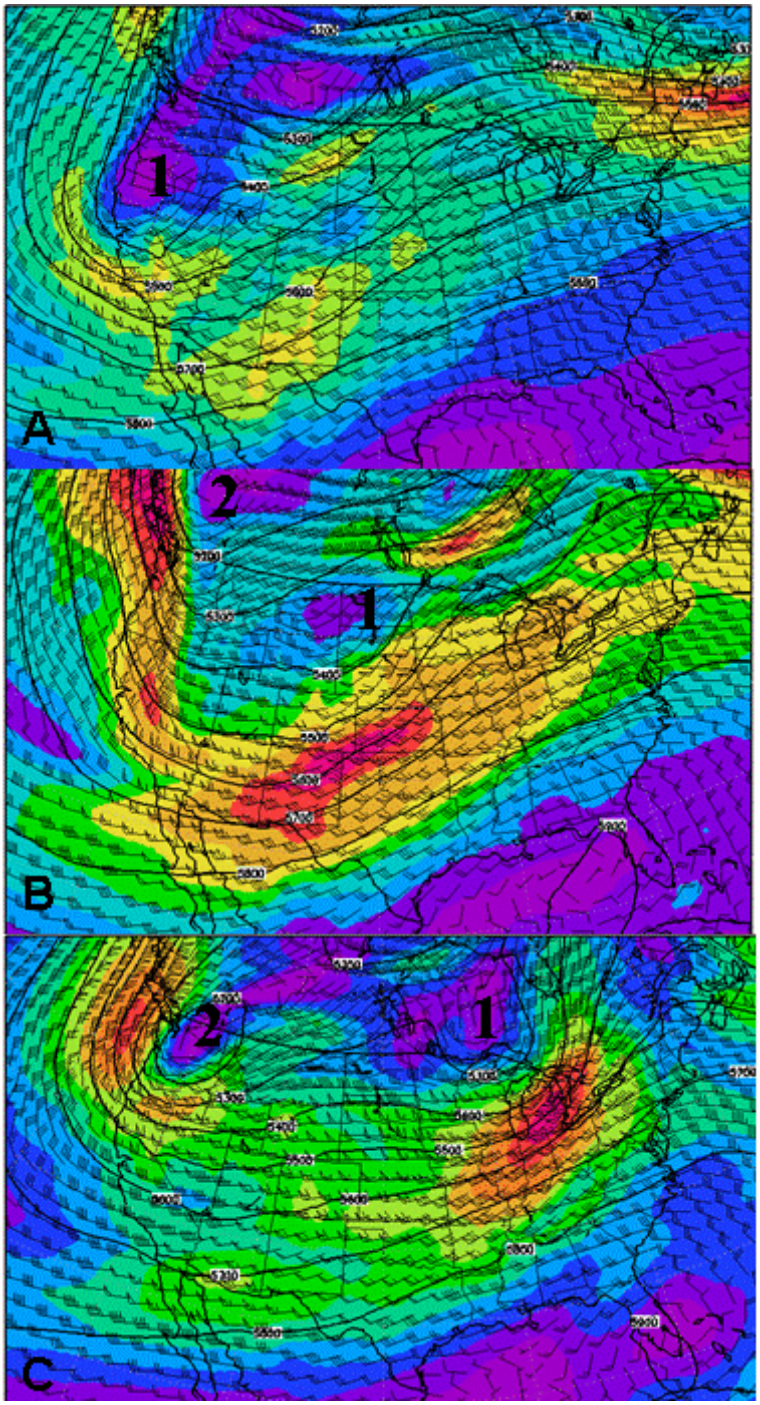

Figure 4: 500 hPa analysis, wind bards, wind speed (shaded) from 12 UTC (a) 21 Nov 2010, (b) 22 Nov 2010 and (c) 23 Nov 2010 (NCDC). The primary shortwaves ("1" and "2") are marked.

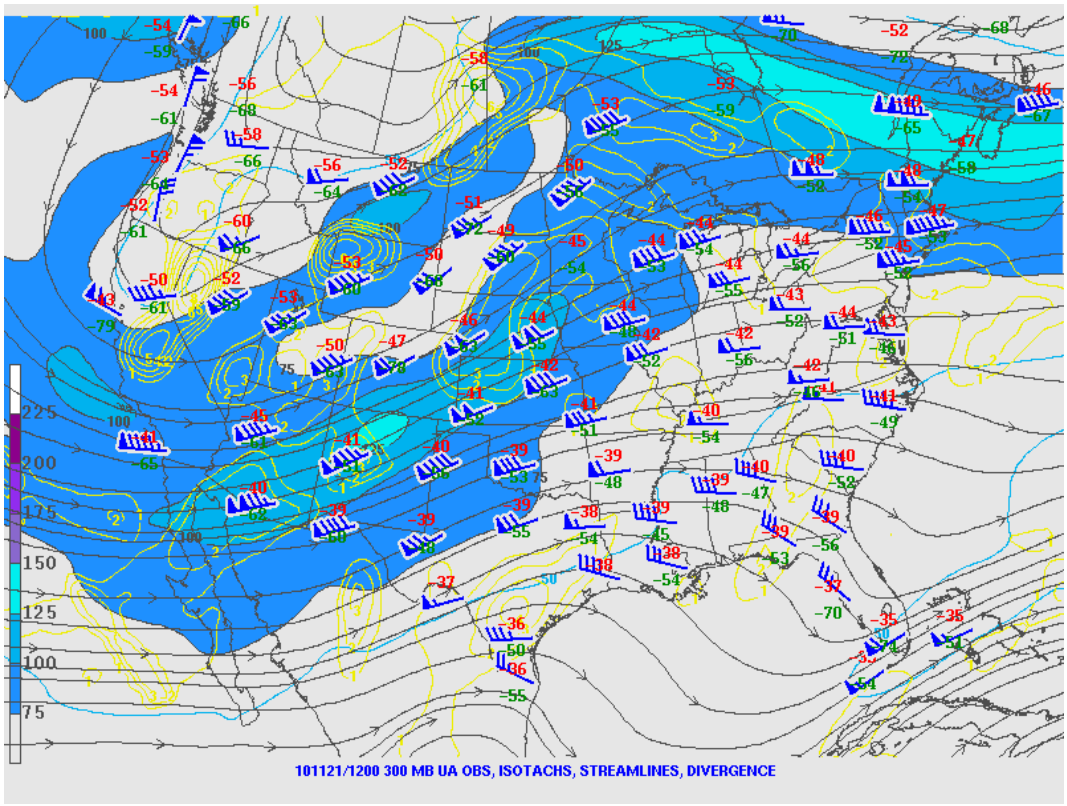

Figure 5: 300 hPa analysis, isotachs, streamlines and divergence from 12 UTC 21 Nov 2010 (SPC).

Meanwhile a second upper system was noted digging south from western Canada into the northern High Plains. This allowed an arctic airmass originally draped over along the northern and central Rockies to push further to the south and extend east behind an area of low pressure developing over the northern Plains (Fig. 6a).

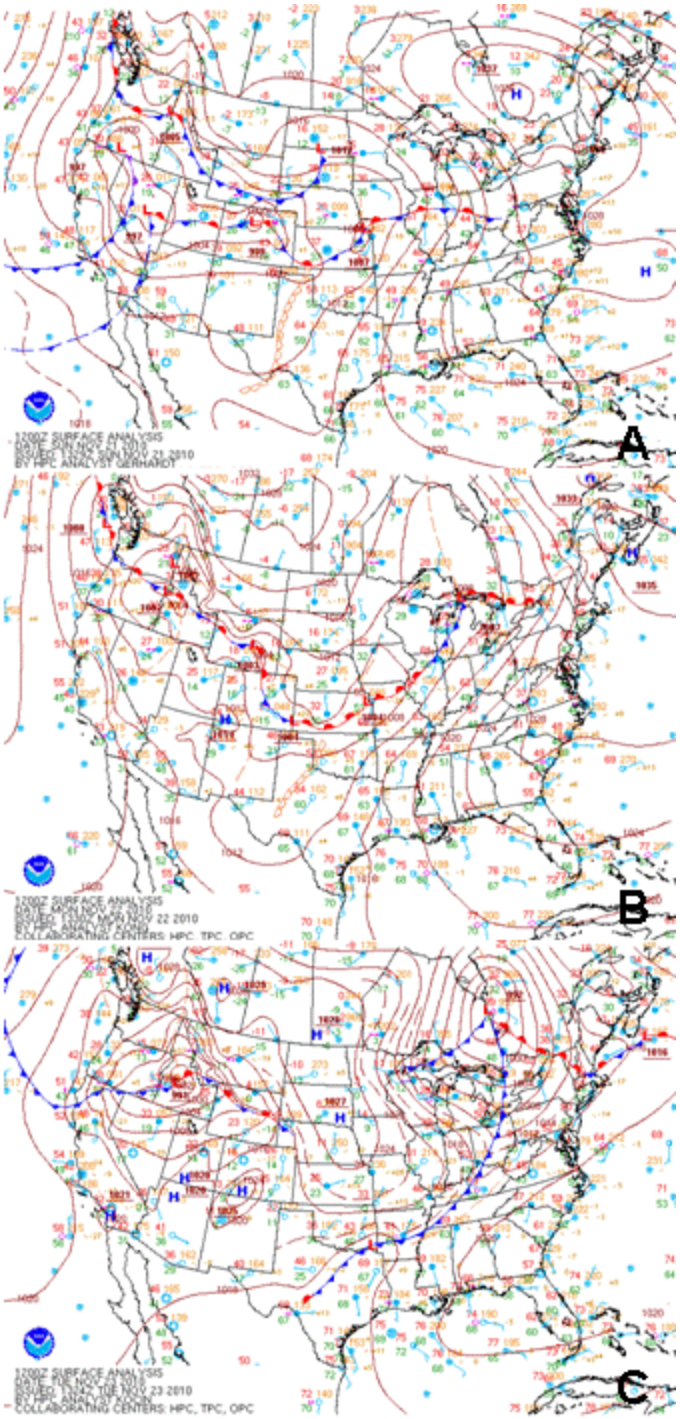

Figure 6: Surface analysis from 12 UTC (a) 21 Nov 2010, (b) 22 Nov 2010 and (c) 23 Nov 2010 (HPC).

Further to the east strong warm air advection across the Northern Plains in the upper Midwest (Fig. 7) contributed to the development of moderate snows across the region during this period.

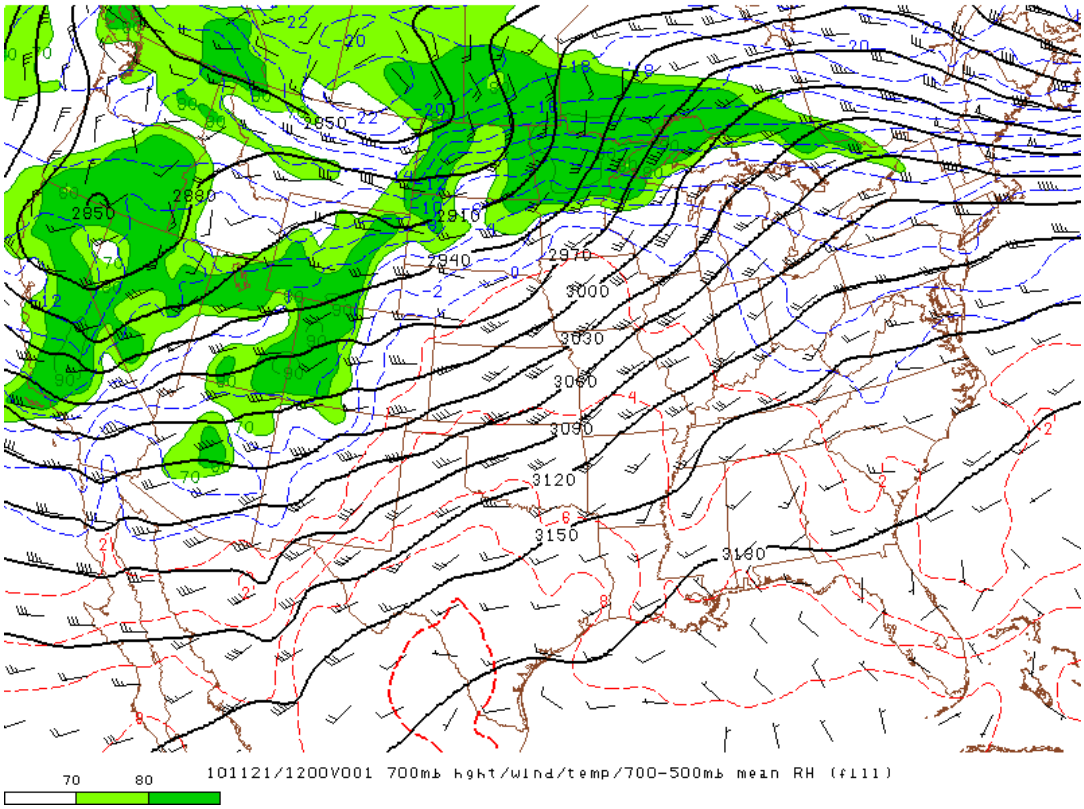

Figure 7: 700 hPa analysis, wind, temperature and 700-500 hPa mean relative humidity (fill) on 12 UTC 21 Nov 2010 (SPC).

By 12 UTC 22 November remnant energy from the western U.S. upper low had ejected out into the central and northern plains (Fig 4b). Widespread moderate to locally heavy rains spread across the Midwest. Several reports of severe weather were observed that day across northern Illinois back into Missouri ahead of the associated strong cold front (Fig. 6b).

Storm 2 - November 24-26, 2010

The 500 hPa analysis at that same time showed yet another low developing over British Columbia, dropping south into Washington State a day later (Fig. 4c). This was the beginning of Storm 2 and was associated with a well-developed area of surface low pressure in southern Idaho (Fig 6c). Strong, deeply layered onshore flow ahead of this system fostered moderate to heavy precipitation across the Pacific Northwest into northern California. Two day snowfall totals exceeded three feet across a number of northern Sierra and southern Cascades locations, with Boral Ski Resort near Lake Tahoe topping the list at 78 inches.

The upper low continued further to the east into northern Idaho and western Montana with a deep trough extending down through the Great Basin. At this same time a strong area of surface low pressure moved into western Wyoming, with a well-defined arctic boundary digging through the central Rockies, Great Bain and California. North of the front, subzero Fahrenheit temperatures were noted even in the late afternoon hours over

portions of Montana and northern Wyoming. Blizzard and winter storm warnings were raised across a good portion of the Pacific Northwest, California, the northern and central Great Basin and the northern and central Rockies. Freeze warnings were issued for parts of the interior California valleys.

As blizzard warnings continued across parts of the central Great Basin into the Rockies the following day, winter weather advisories began to extend further to the east across the Northern Plains to the upper Midwest, with freezing rain advisories further to the south across Nebraska. By Wednesday morning, the upper low (2) had tracked further to the east across Montana with the leading edge of the upper trough now reaching out into the high plains (Fig. 8a). At the surface, arctic air continued to spill further to the south through the central Great Basin and Rockies (Fig. 9a). Heavy snows had fallen by this point across portions of the northern Great Basin and Rockies with three day totals of up to three feet reported in the mountains of Idaho. Wind gusts of 70-90 mph had been reported in the Wasatch Range of Utah and San Juan Mountains of western Colorado.

Meanwhile, moderate to heavy rains became a concern across the mid Mississippi into the lower Ohio Valley as a strong low level jet (Fig. 10a) coincident with high precipitable water values (Fig. 10b) developed ahead of the trough from the southern Plains into the mid Mississippi Valley.

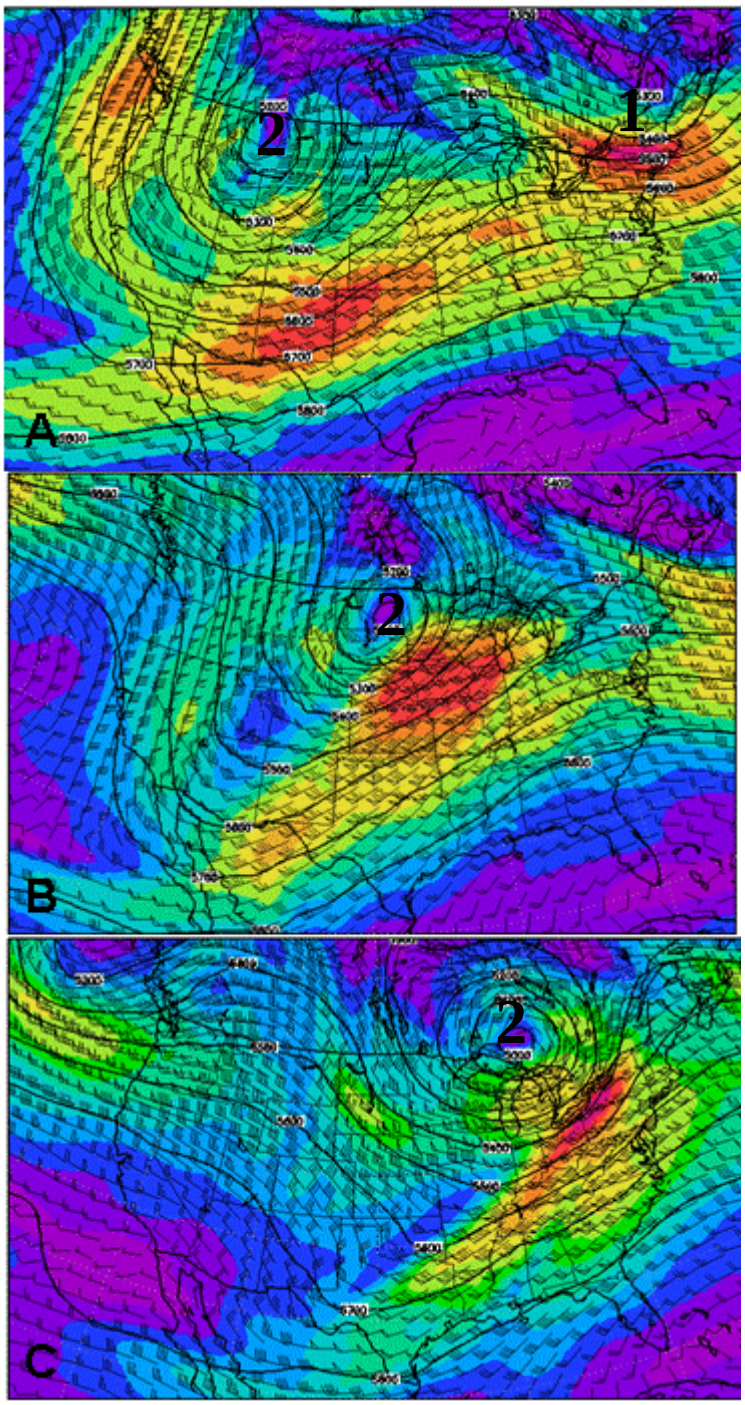

Figure 8: 500 hPa analysis, wind bards, wind speed (shaded) from 12 UTC on (a) 24 Nov 2010, (b) 25 Nov 2010 and (c) 26 Nov 2010 (NCDC). The primary shortwaves ("1" and "2") are marked.

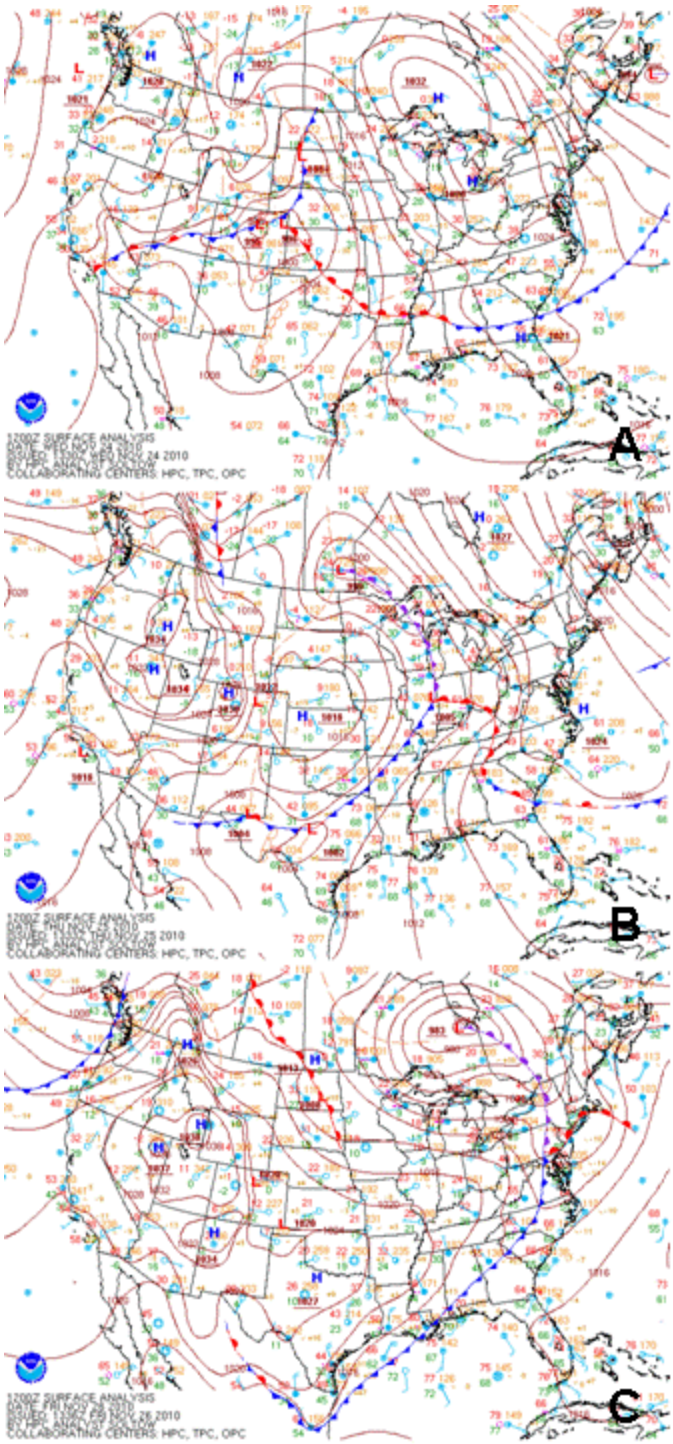

Figure 9: Surface analysis from 12 UTC on (a) 24 Nov 2010, (b) 25 Nov 2010 and (c) 26 Nov 2010 (HPC).

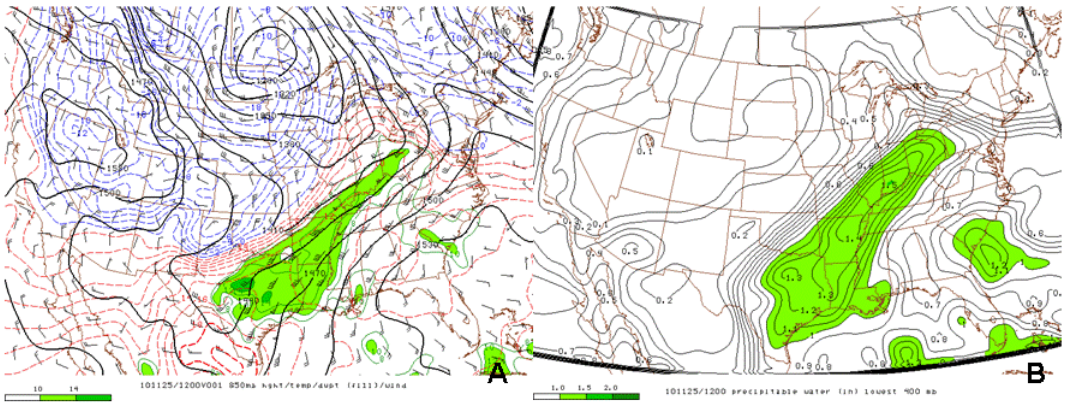

Figure 10: 850 hPa analysis, temperature, dewpoint (fill) and wind (a) and precipitable water (inches) through lowest 400 hPa (b) on 12 UTC 24 Nov 2010 (SPC).

By the evening of 24 November (Thanksgiving Eve), flash flood and flood watches had been issued across the Ohio Valley as strong low level flow and moisture transport continued through the day, driving a plume of deep moisture further into the Ohio Valley Surface dewpoints in the 60s were observed to the south of a warm front extending from the mid Mississippi into the Tennessee valleys. At this point upper trough #2 was centered across the Rockies and High Plains. Showers and thunderstorms were noted developing along the associated arctic boundary and a preceding dryline as it pushed into the mid Mississippi Valley and down into the Southern Plains. In addition to the significant rains, winter weather remained a concern with winter weather advisories and winter storm warnings encompassing the northern states from Montana to the upper Midwest, where strong mid to upper level dynamics, including left exit region upper jet dynamics helped to prolong the precipitation (Fig. 11).

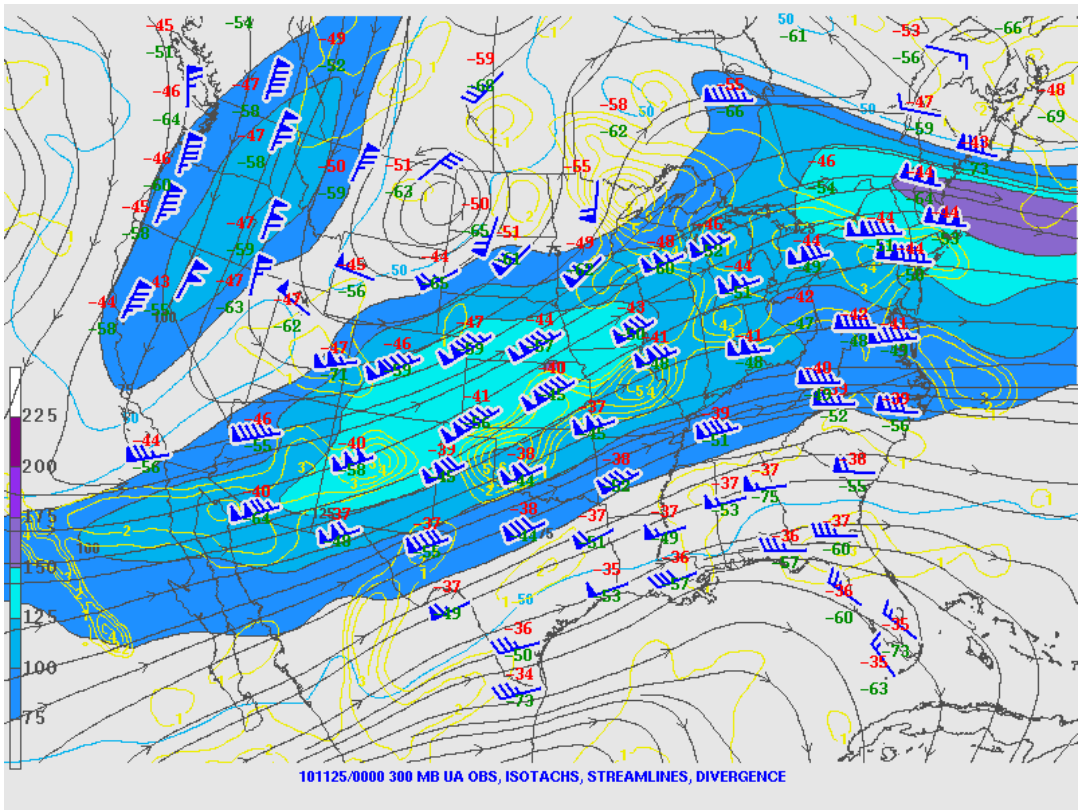

Figure 11: 300 hPa analysis, isotachs, streamlines and divergence from 12 UTC on 25 Nov 2010 (SPC).

The weather on Thanksgiving Day 2010 (25 November) remained unsettled across a large portion of the U. S., with flash flood and flood watches, warnings and advisories issued for the mid Mississippi and Ohio valleys. Three to four inches of rain along with several reports of severe weather were observed in a 24-hour period ending at 8 a.m. along a northeast-southwest band stretching across southern Illinois into central Missouri. Winter weather continued to extend its reach across the northern U. S., with blizzard warnings in Montana, and a combination of winter weather advisories and winter storm warnings extending from Montana to the Northeast and northern Mid Atlantic states. A mixture of rain, sleet and freezing rain was observed spreading ahead of the warm front lifting through the Ohio Valley (Fig 9b). In addition to showers and thunderstorms, winter weather was observed over parts of the Southern Plains, lower Mississippi and Tennessee valleys.

By Friday morning, conditions finally began to settle across much of the U.S.; however winter weather advisories still remained in effect across parts of the Northeast and Tennessee Valley and flood watches remained over portions of the Ohio Valley, where four day storm totals had exceeded four inches across a large portion of southern Illinois into southern Indiana. The upper low had tracked north of the upper Great Lakes (Fig. 8c), with its associated surface low analyzed well north of the Canadian border southwest of James Bay (Fig. 9c).

Mesoscale Pattern:

The training storms and associated flooding were a key impact of storm 2 from the mid Mississippi into the lower Ohio valleys during the overnight hours of 24-25 November. A computation of the "upwind propagation" vectors - a method developed by Corfidi et al. (1996) to forecast mesoscale convective systems (or more specifically mesoscale beta element - MBE) movement – showed weak vectors across southwestern Missouri through southern Illinois (Fig. 12). The upwind propagation vector is considered the sum of the mean flow through the cloud-bearing layer and the propagation component. The magnitude and direction of the propagation component is assumed to be equal and opposite to that of the low-level jet. This weak upwind propagation likely contributed to the heavy rains noted across portions of the mid Mississippi into the lower Ohio valleys during this period.

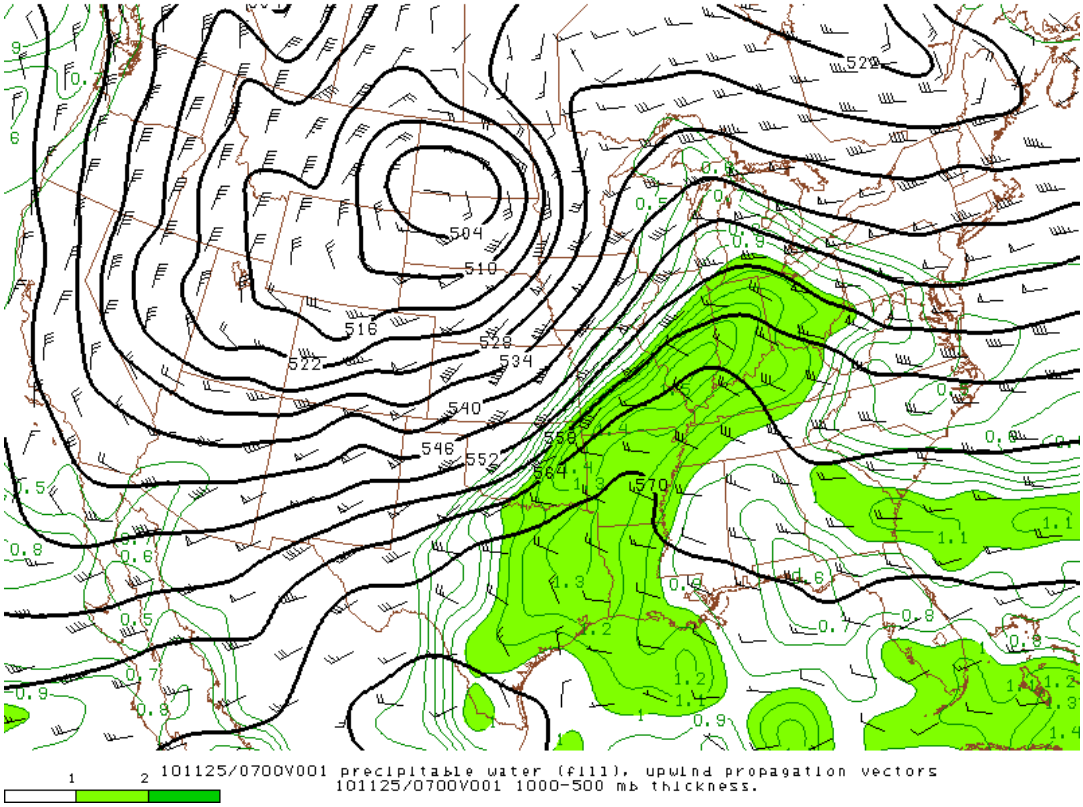

Figure 12: Precipitable water (fill), upwind propagation vectors, 1000-500 hPa thickness (thick solid) on 07 UTC 25 Nov 2010 (SPC).

Conclusion:

Two storms progressed across the country during the Nov 20-26 period, causing a prolonged period of active weather. The first storm was associated with a shortwave trough that dropped into a deep longwave upper level trough centered over the western U.S., and ejected eastward out of the trough across the Northern Plains into the upper Midwest causing several weather impacts. The initial system was quickly followed by the amplification and eastward propagation of the longwave across the western and central

U.S. leading to a second storm and further widespread unsettled weather across the country during the holiday week. This unsettled pattern disrupted travel plans for many. Weak upwind propagation through the cloud bearing layer is believed to have likely contributed to the heavy rains that were reported across the mid Mississippi into the lower Ohio Valleys 24-25 November.

References:

Corfidi, S. F., J. H. Merritt and J. M. Fritsch, 1996: Predicting the movement of mesoscale convective complexes. Wea. Forecasting,11, 41-46.