A summary of the heat episodes of June 2017

By
Richard H. Grumm
and
Elissa A. Smith
National Weather Service State College, PA

1. Overview

Over 1800 record high temperatures were set or tied during the month of June 2017 (Fig. 1). Most of these records were set during 2 distinct heat episodes centered on 13 and 21 June 2017 (Fig. 2 & Table 1). The first episode affected the eastern United States and peaked in 13 June 2017 when 124 record high temperature records were set or tied. The second episode affected the southwestern United States spanning the period of 18 to 25 June 2017. During this enduring southwestern heat episode Phoenix, AZ set several record high temperatures and several airports in the southwestern United States had close due to the heat. Phoenix's Sky Harbor Airport delayed or canceled flights to due excessive heat (CNBC 2017).

The issues with the heat were not equal. The operating temperatures of some airplanes are over 126F, and for other aircraft the values are around 120F. Sky Harbor Airport has longer runways to account for the reduced lift due excessively high temperatures. However, temperatures around 120F, about 2F lower than the all-time record of 122F (26 June 1990), were too high for the operations of specific aircraft (CNBC 2017; BBC 2017). Phoenix set 5 daily high temperature records and had the 3rd highest observed temperature of 119F on 20 June 2017.

This paper will document the pattern for the month of June 2017 and examine the conditions associated the two heat episodes of 2017.

2. Methods and Data

The climate forecast system reanalysis data version II were used to reconstruct the pattern. These data were displayed using GrADS. GrADS was used to produce daily images with standardized anomalies and composites for the month and for periods of interest.

The QPF data were derived from the Stage-IV data and displayed in GrADS.

The climate data including daily record highs and counts of records broken by day were obtained from the National Centers for Environmental Information (NCEI) website.

3. The Pattern

i. Pattern for June 2017

The large scale pattern over the United States for June 2017 (Fig. 3) showed a weak 500 hPa ridge over the southwestern United States and over the southwestern Atlantic. The precipitable water (PW) was close to normal over most of the United States but above normal in the Gulf States. The 850 hPa temperatures were above normal under the ridge in the southwestern United States (Fig. 3b).

The total observed precipitation (Fig. 4) over the United States showed little significant precipitation over the southwest. The highest precipitation amounts were focused in the Gulf States near the higher PW values and on the western flanks of the southwestern Atlantic ridge.

ii. Eastern Heat Episode

The composite pattern over the United States from 11 to 14 June (Fig. 5) showed a strong 500 hPa ridge in the east with above normal 850 hPa temperatures from the Midwest, across the Great Lakes into New England. Beneath the strong 500 hPa ridge there was a strong surface anticyclone over the southwestern Atlantic or "*Bermuda High*". The flow about the high brought above normal PW values into the central United States and Gulf Coast.

There were 124 high temperature records set on 13 June (Table 1) which likely occurred on 12 June based on the data collection methods of the National Weather Service COOP program. Thus, the pattern at 0000 UTC 13 June 2017 is shown in Figure 6. These data show the strong ridge and above normal 850 hPa temperatures over the eastern United States.

During the eastern warm episode the flow of moisture over the subtropical ridge brought rain to the upper Midwest and the Gulf States (Fig. 7). The southwestern United States was relatively dry as was the northeastern United States.

iii. Southwestern Heat Wave

The composite pattern over the United States during the peak of the western heat wave (Fig. 8) showed a strong ridge with above normal 500 hPa heights over most of the southwestern United States and eastern Pacific. The 850 hPa temperatures were above normal. There was a split in the upper tropospheric ridge which produced a trough and low heights over the central Gulf of Mexico. At the surface pressure was much below normal in part due to the passage of Tropical storm Cindy (NY Times 2017) through the region on 18-21 June 2017.

The impact of the over pattern and tropical storm Cindy are clearly visible in the total accumulated QPE during the period of 0000 UTC 17 to 0000 UTC 23 June 2017 (Fig. 9). Under the massive southwestern ridge there was little or no significant precipitation.

The composite pattern during the peak of the heat wave is shown in Figure 10. These data show that for over 24 hours there was a closed 5940 m contour over the southwestern United States with +2s above normal heights during this period. The 850 hPa temperatures were well above normal (Fig. 10b) and the region was relatively humid. This was also the period when the afternoon high temperatures affected the flow of aircraft at several cities in the desert southwest.

In addition to the ridge and high temperatures, the circulation associated with tropical storm Cindy was visible in the composite field. Cindy was clearly visible in Figure 11b.

The pattern valid at 0000 UTC 21 June 2017 is shown in Figure 11. These data show the close 5940m contour over the southwestern United States and the above normal 850 hPa temperatures. This was the day when 155 records (Table 1) were set or tied. Most of these records were set in California, Nevada, and Arizona with additional areas of record highs in Utah, Colorado, and New Mexico (Figure 12). In the Phoenix area, five of the top 20 maximum temperature days in the month of June occurred during this particular southwest heat wave (Table 2).

4. Forecasts of the southwestern heat wave

The 42 member NAEFS is used to show forecasts of the southwestern United States heat episode. The 500 hPa height forecasts (Fig. 13) show that from 15 to 20 June the NAEFS consistently forecasts a closed 5940 m contour over the southwestern United States. A pattern associated with a heat wave to include the 5940 m contour was well predicted. Shorter range forecasts also showed the circulation with Cindy in the Gulf of Mexico. Though not shown the 850 and 700 hPa temperatures too were forecast to be above normal.

Just how predictable this ridge was is rather amazing. Forecasts from 9-14 June valid at the same time are shown in Figure 14. These data show a ridge in the southwestern United States in all forecast with the forecasts from 10 June forward forecasting a closed 5940 m contour. There was at least 10 days lead-time for this potential record event.

The shorter range forecasts were sharper with a stronger 500 hPa ridge and larger height anomalies. This is likely due to the combined effects of lower spread and the position of the ridge.

5. Summary

There were two significant heat episodes over the United States during the month of June 2017. Over 1800 record high temperatures were set or tied during the month of June (Figs. 1 & 2). The first shorter lived episode brought record high temperatures the eastern United States from 12-14 June 2107. The second event brought extreme heat and set many record high temperatures in the southwestern United States. This second extensive heat episode affected air travel at several cities due to the effect of the high temperatures on aircraft operations.

The eastern event peaked early in the month and was characterized by a large subtropical ridge and above normal 500 hPa heights over the southwestern United States and western Atlantic (Fig. 3). The 850 hPa temperature anomalies peaked at over +2s above normal over New England under the northern edge of the ridge. The flow around the surface anticyclone brought warm moist air into the central Gulf States and into the MMV where the month of June was wet (Fig. 4).

The southwestern event occurred between the 18th and 25th of June and peaked on the 21st. This event was associated with a strong 500 hPa ridge with a closed 5940m contour over the southwestern United States. Beneath the ridge the low-level temperatures too were anomalously high (Fig. 10). Beneath the ridge many daily record high temperature records were. Phoenix Sky Harbor Airport (Table 2) set of five of the top 20 maximum temperature records during the month of June 2017. This included 5 record high daily maximum temperatures records and the third highest daytime maximum on record. The strong ridge and the closed 5940m contour at 500 hPa were good indicators of a record to near record event.

The 500 hPa forecasts from the NCEP NAEFS show that the southwestern United States heat was very well predicted with at least 10 days of lead-time. The 5940m closed contour was in the NAEFS forecasts from 10 June onward. Clearly, shorter range forecasts had a sharper and more anomalous 500 hPa ridge but the indications of a heat wave were predicted well in advance. Ridges tend to be more predictable and this strong ridge was particularly well predicted. Unlike snowstorms, we may be able to provide better advanced warnings for near record heat events.

6. Acknowledgements

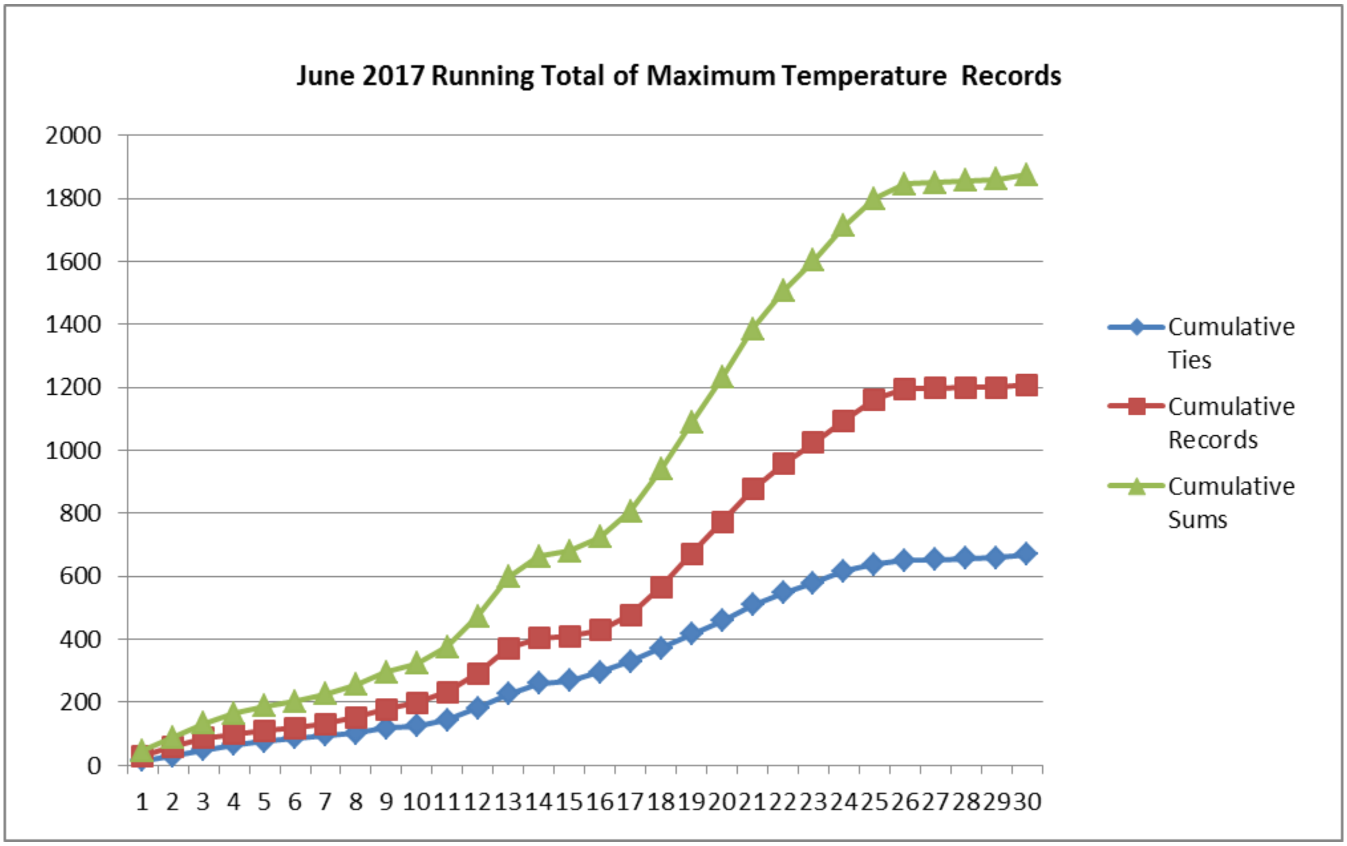

Figure 1.NCEI accumulated daily maximum temperature records from 1 to 30 June 2017. Data include the number of records tied, broken, and the sum of the tied and accumulated records. Please note these data are recorded in the morning and typically reflect the high temperature for the previous day. **Return to text..**

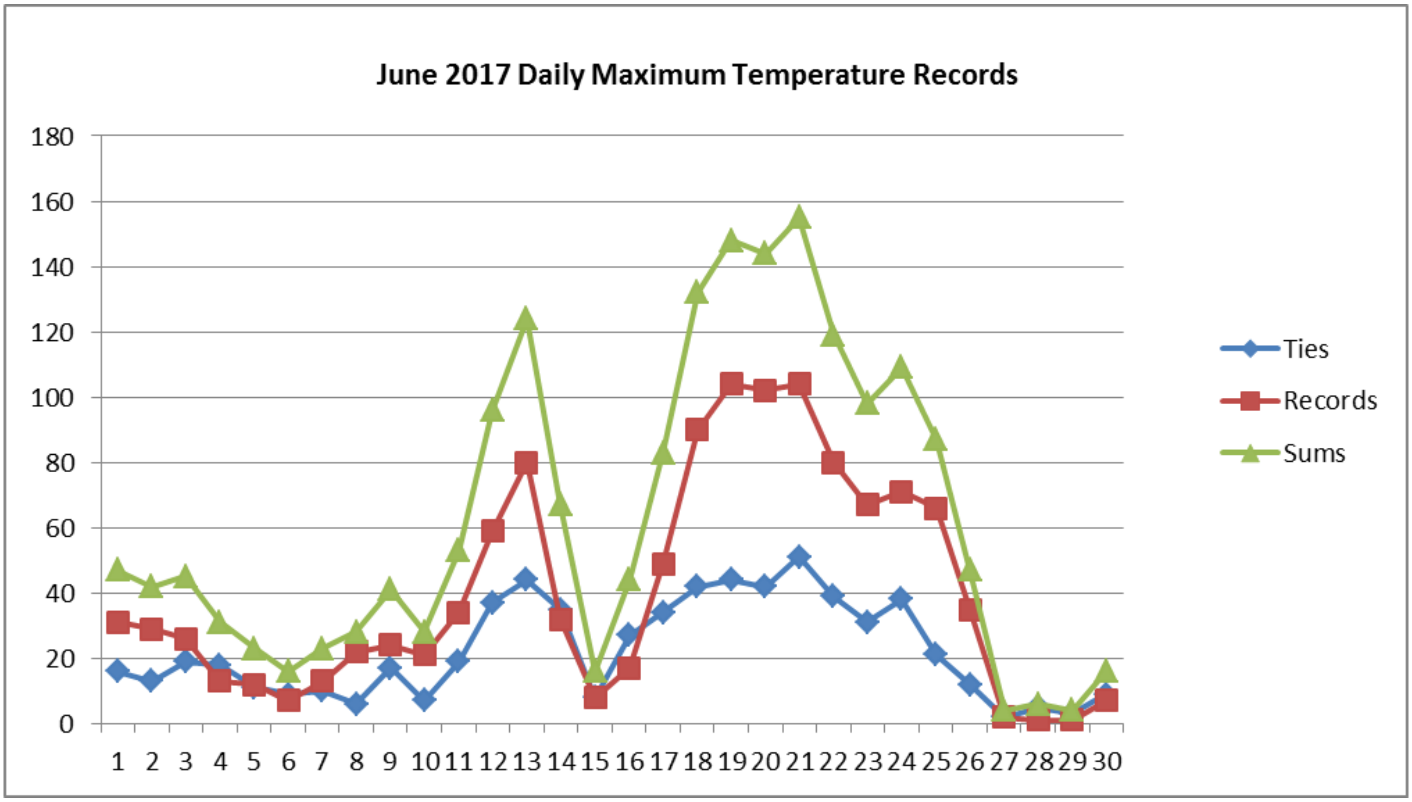

Figure 2. As in Fig. 1 except for the daily values. **Return to text.**

NWS State College Case Examples

Date	Ties	Records	Sums
6/1/2017	16	31	47
6/2/2017	13	29	42
6/3/2017	19	26	45
6/4/2017	18	13	31
6/5/2017	11	12	23
6/6/2017	9	7	16
6/7/2017	10	13	23
6/8/2017	6	22	28
6/9/2017	17	24	41
6/10/2017	7	21	28
6/11/2017	19	34	53
6/12/2017	37	59	96
6/13/2017	44	80	**124**
6/14/2017	35	32	67
6/15/2017	8	8	16
6/16/2017	27	17	44
6/17/2017	34	49	83
6/18/2017	42	90	**132**
6/19/2017	44	104	**148**
6/20/2017	42	102	**144**
6/21/2017	51	104	**155**
6/22/2017	39	80	**119**
6/23/2017	31	67	98
6/24/2017	38	71	109
6/25/2017	21	66	87
6/26/2017	12	35	47
6/27/2017	2	2	4
6/28/2017	5	1	6
6/29/2017	3	1	4
6/30/2017	9	7	16

Table 1. List of NCEI daily maximum high temperature records set or tied from 1 to 30 June 2017. Return to text.

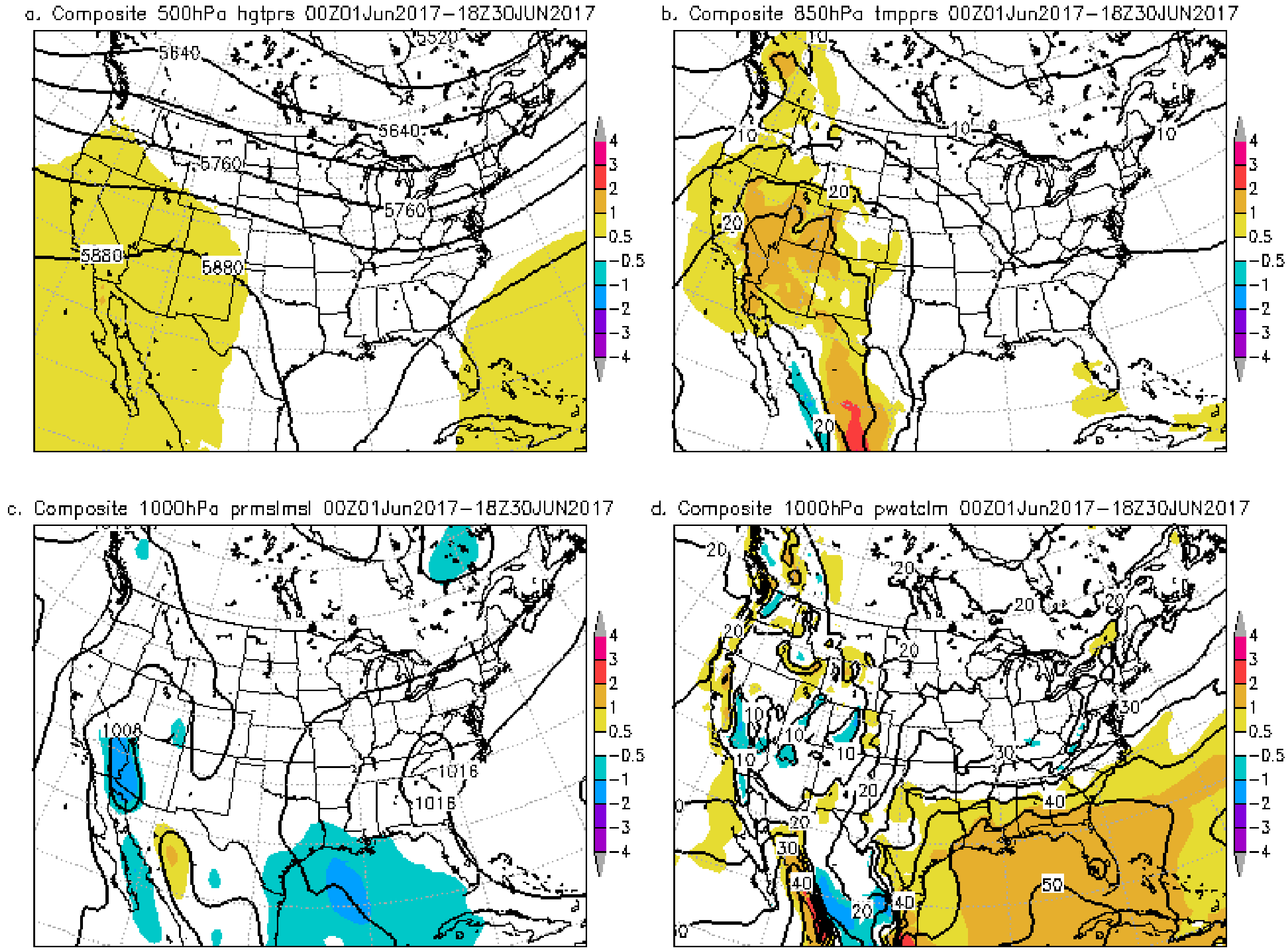

Figure 3. Climate Forecast System Reanalysis showing the composite values and the mean anomalies for the period of 1-30 June 2017. Data include a) 500 hPa heights (m) and anomalies, b) 850 hPa temperatures (C) and anomalies, c) mean sea-level pressure (hPa) and anomalies, and d) precipitable water (mm) and anomalies. **Return to text.**

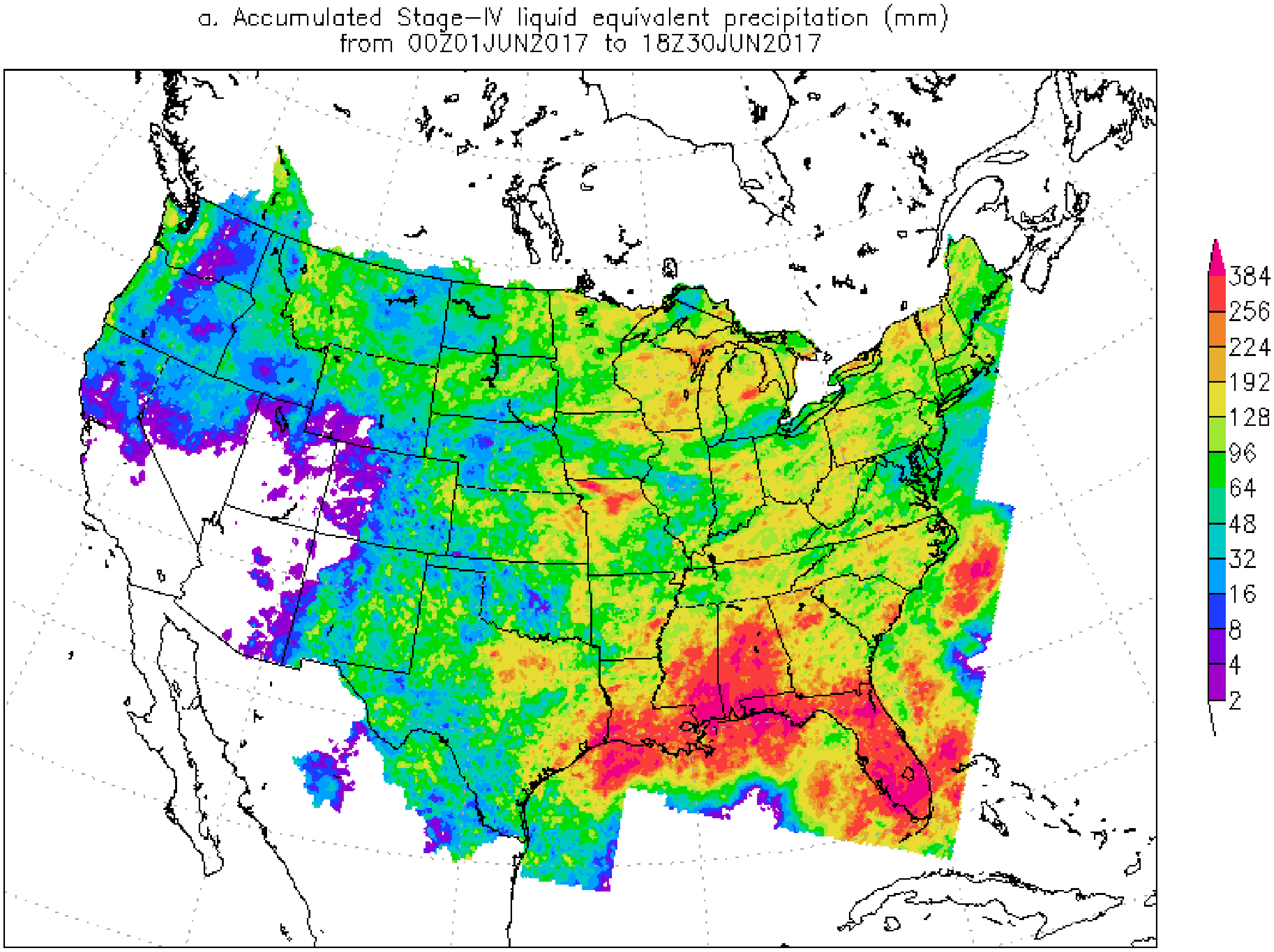

Figure 4. Stage-IV accumulated precipitation over the United States for 1-30 June 2017. Value in mm as in the color bar. **Return to text.**

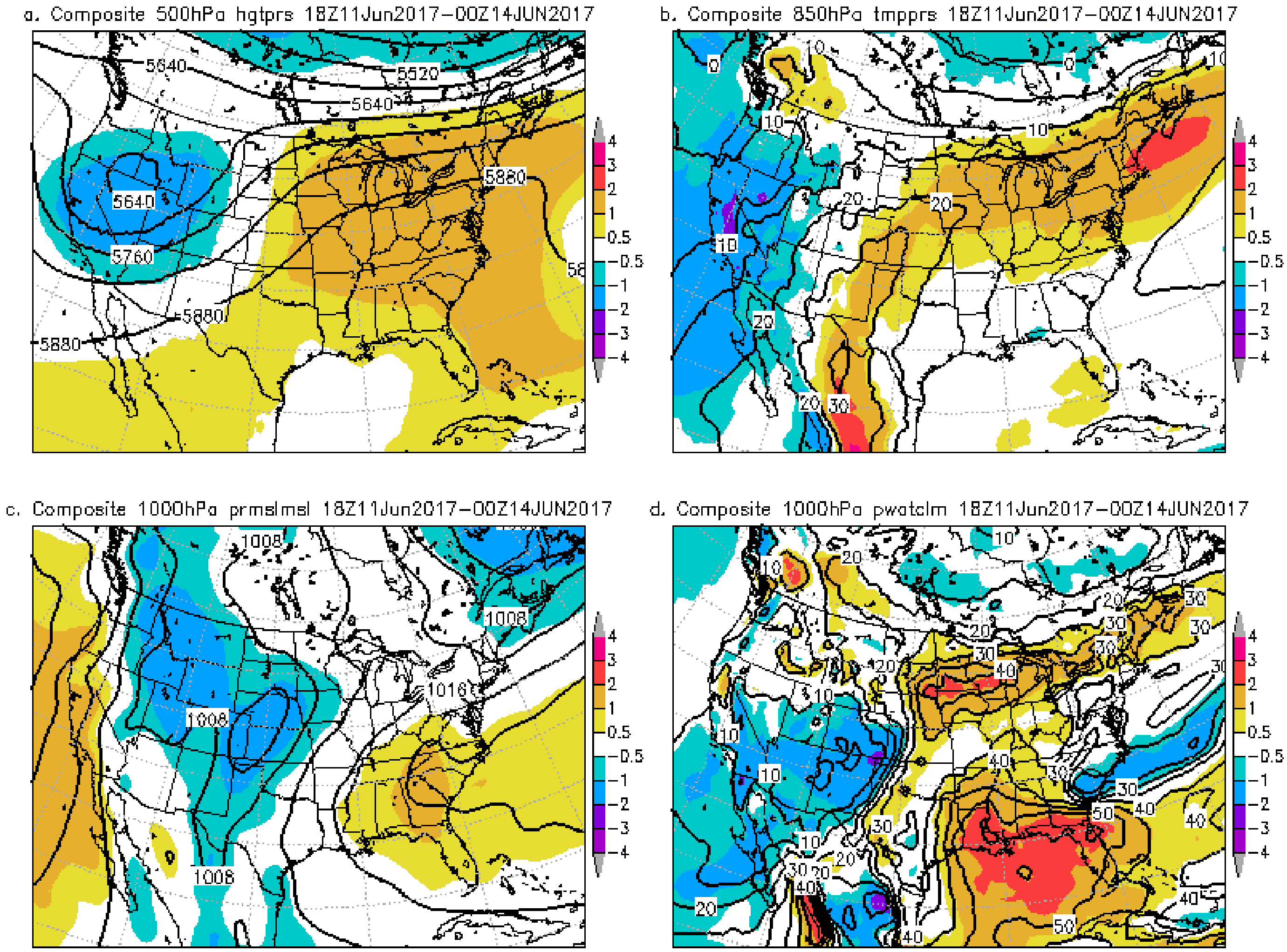

Figure 5. As in Figure 3 except for the period form 1800 UTC 11 to 0000 UTC 14 June 2017. **Return to text**.

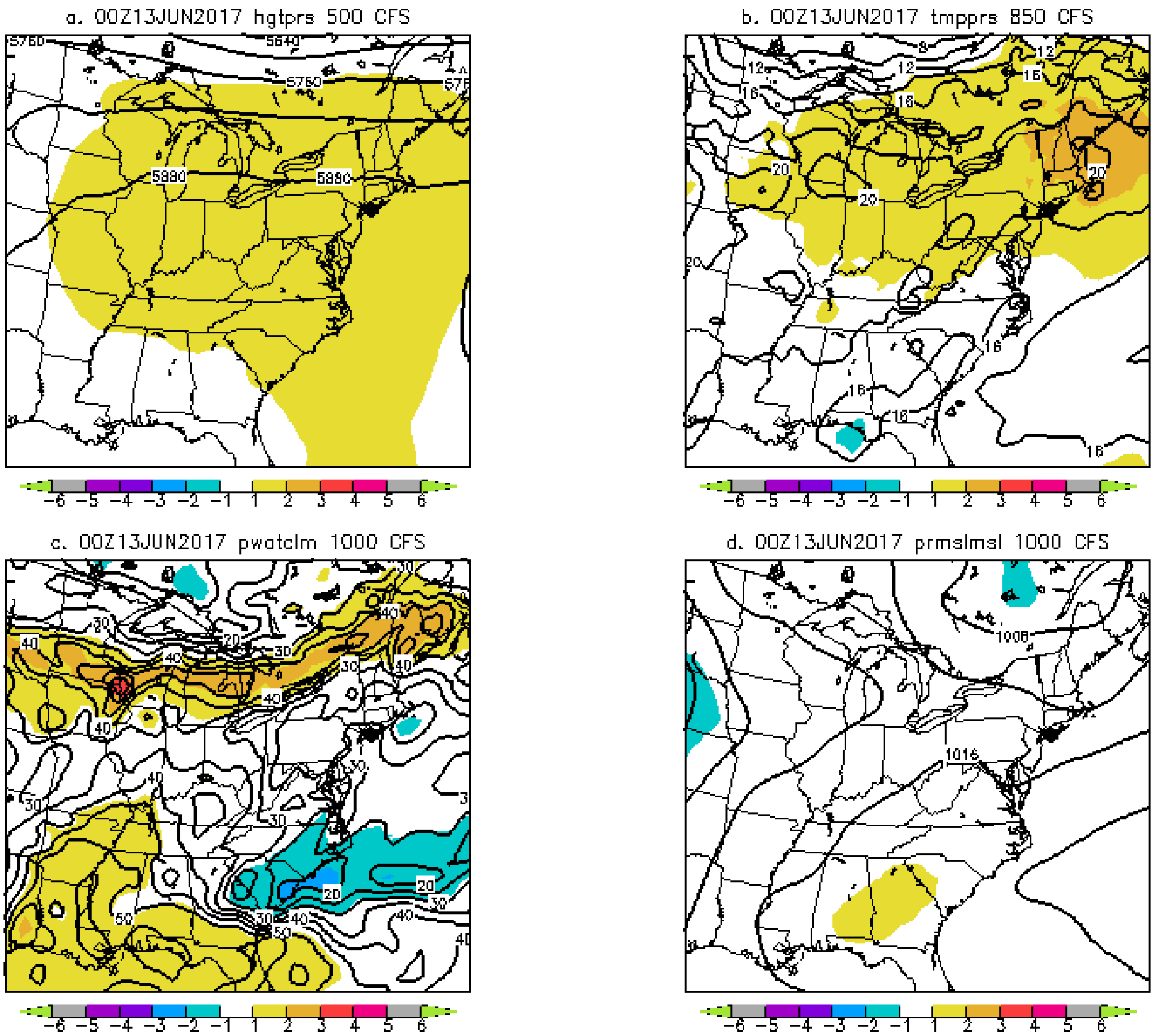

Figure 6. As in Figure 5 except for the daily values at 0000 UTC 13 June 2017 showing the a) 500 hPa heights and anomalies, b) 850 hPa temperatures and anomalies, c) precipitable water and anomalies, and d) mean sea-level pressure and anomalies**. Return to text.**

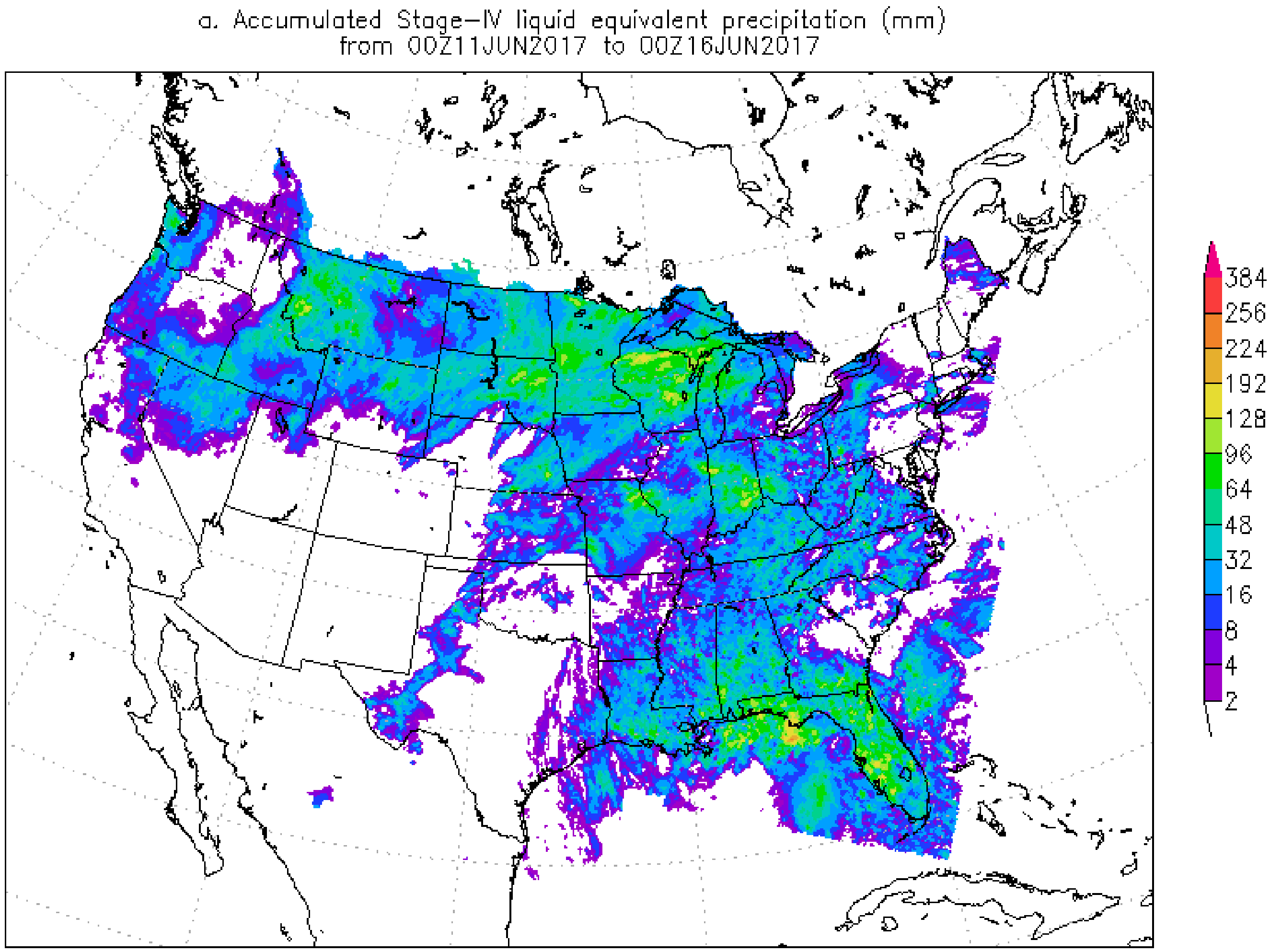

Figure 7. As in Figure 4 except the accumulated QPE during the eastern warm episode. **[Return to text.]()**

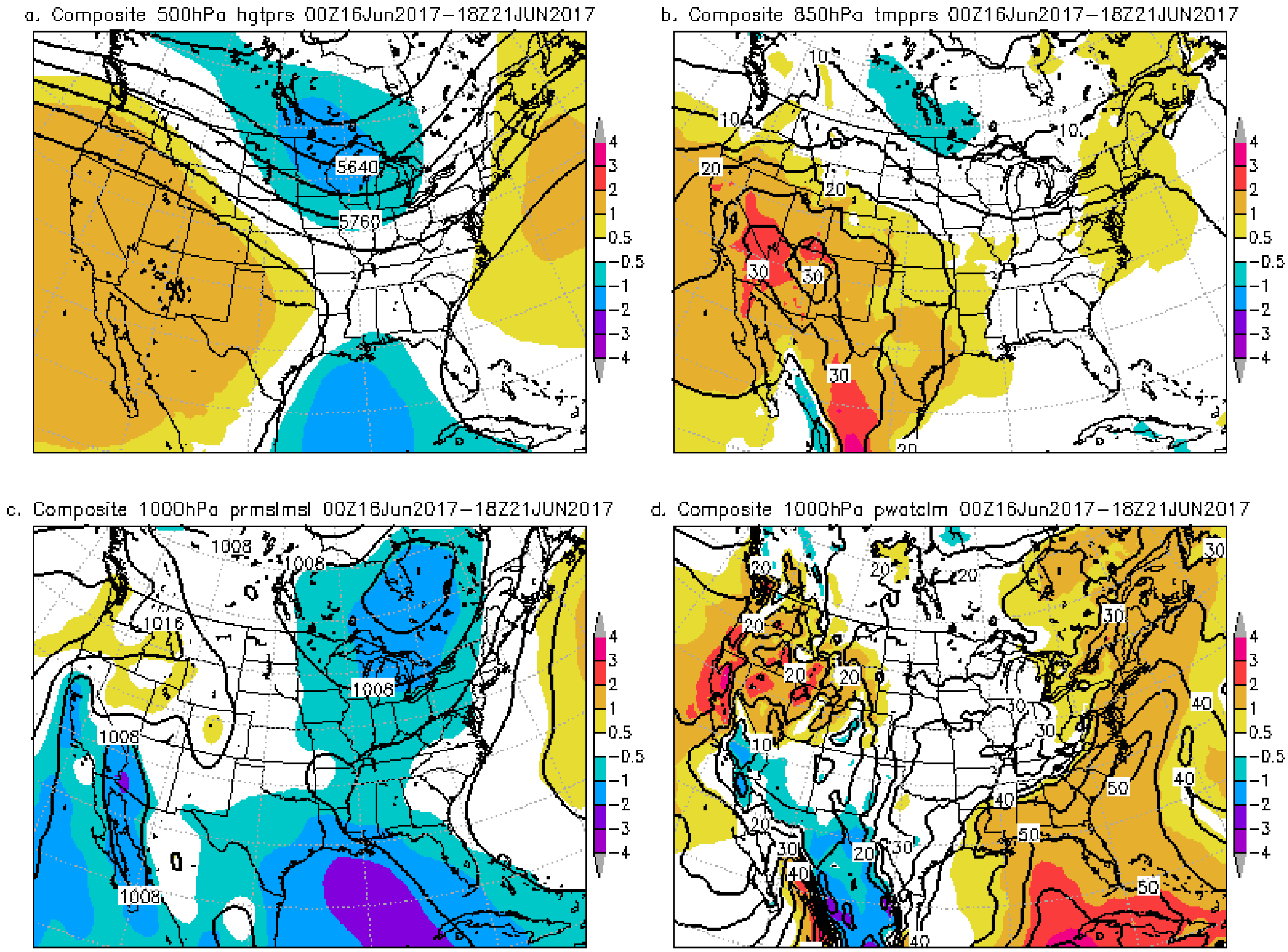

Figure 8. As in Figure 3 except for the period of 0000 UTC 16 to 1800 UTC 21 June 2017. **Return to text.**

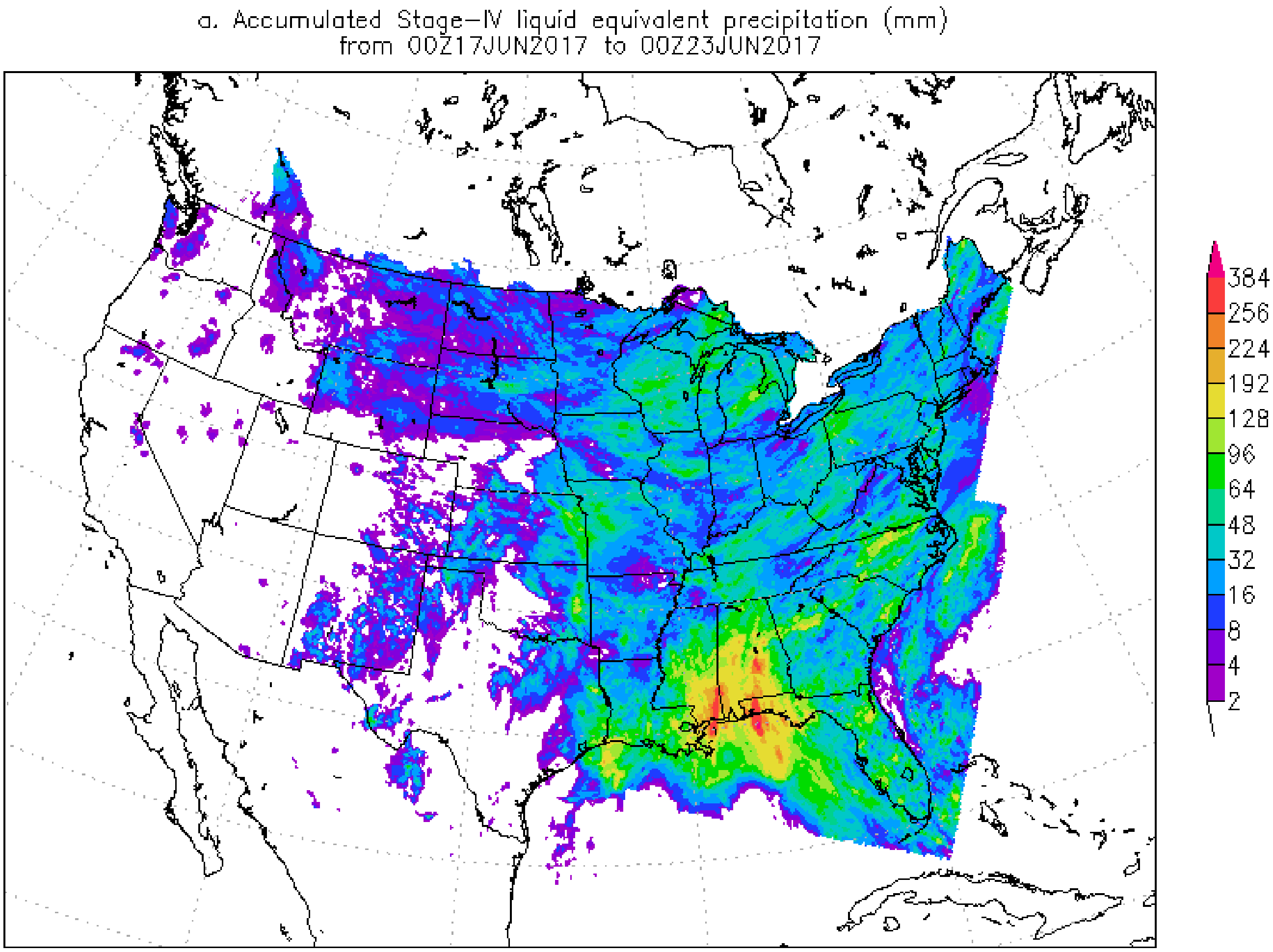

Figure 9. Stage-IV accumulated precipitation, mostly due to Tropical Storm Cindy, for 17-23 June 2017. Value in mm as in the color bar.
Return to text.

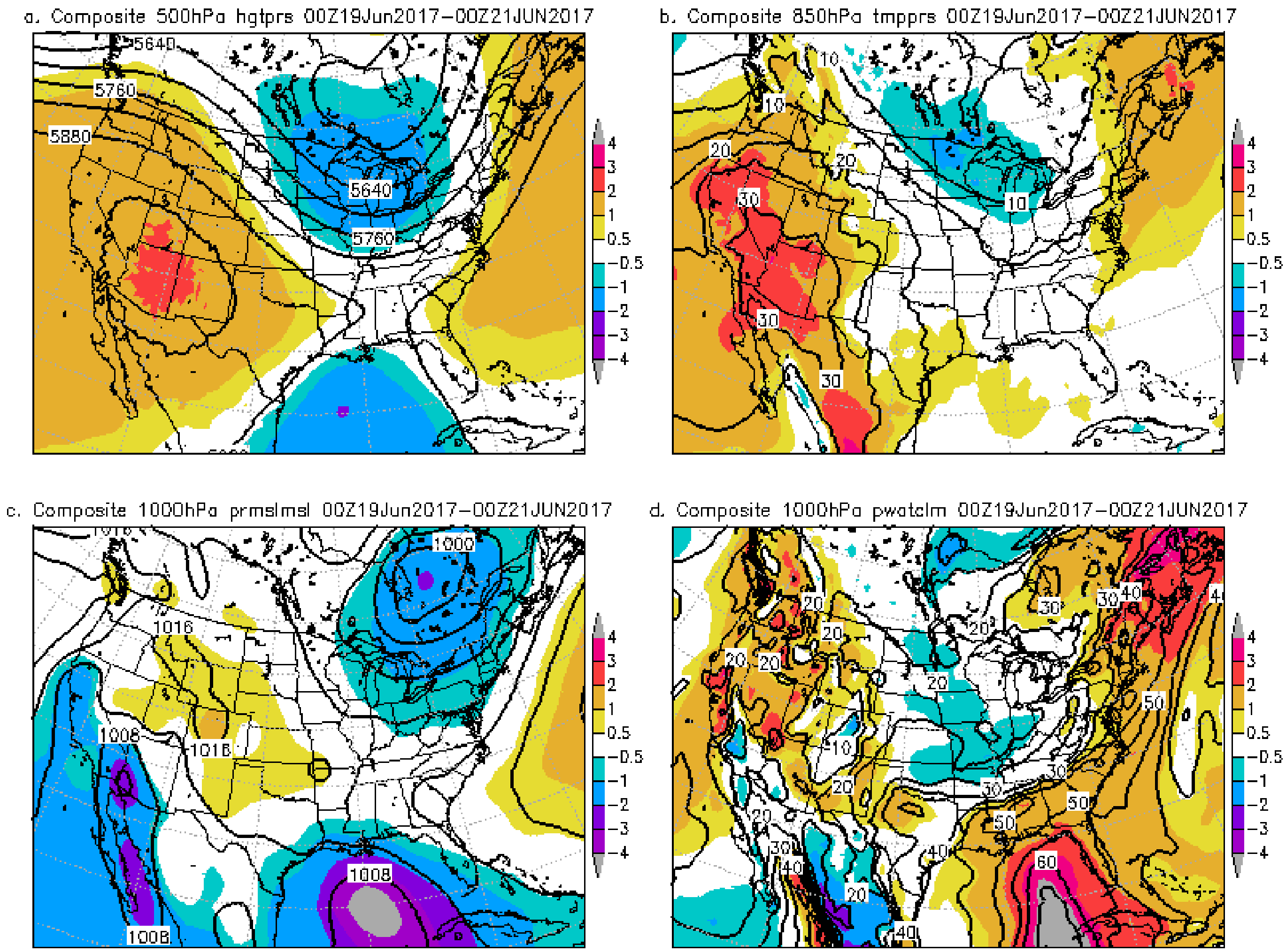

Figure 10. As in Figure 9 except for the period from 0000 UTC 19-21 June 2017. **Return to text.**

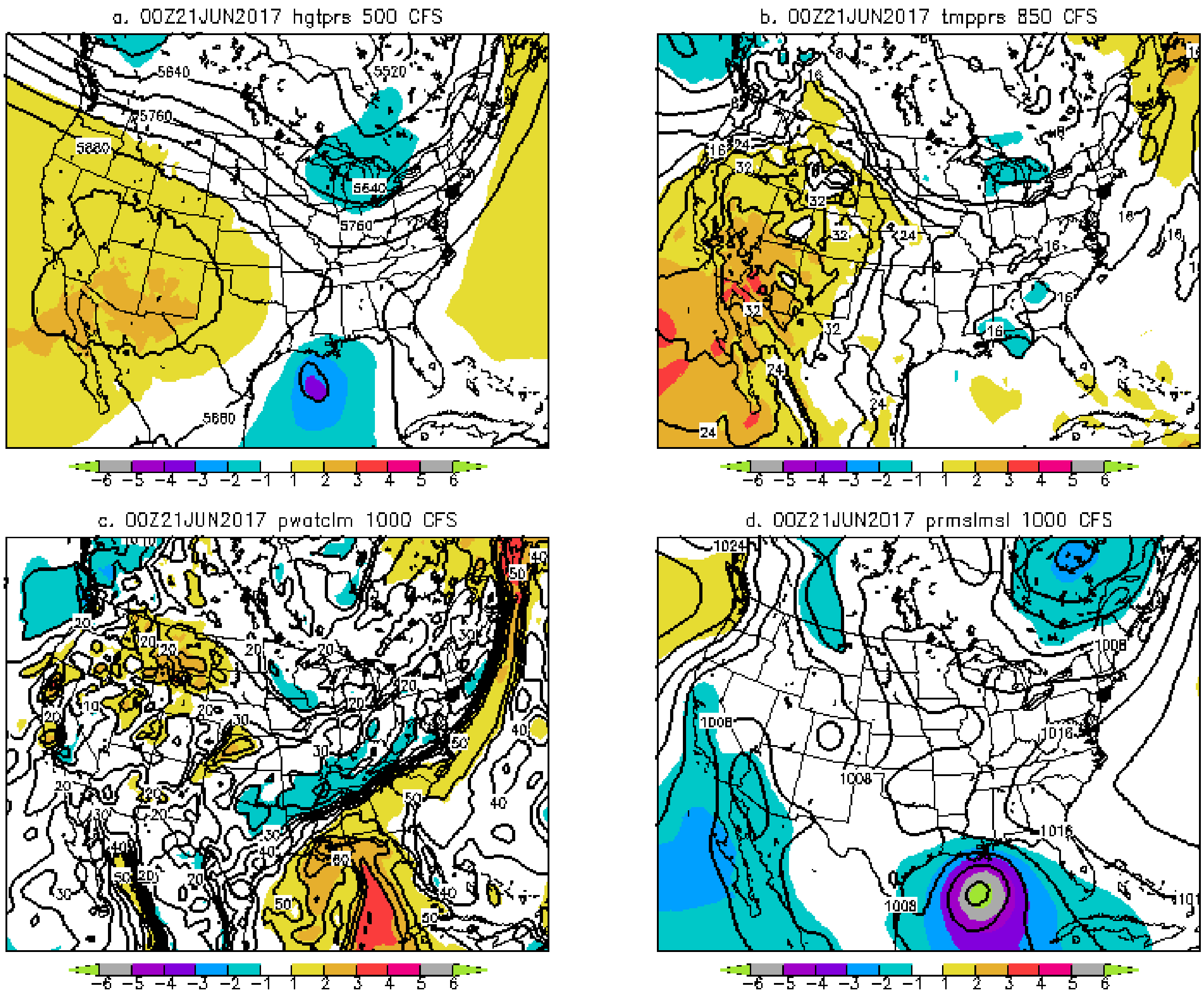

Figure 11. As in Figure 6 except valid at 0000 UTC 21 June 2017. **[Return to text.]**

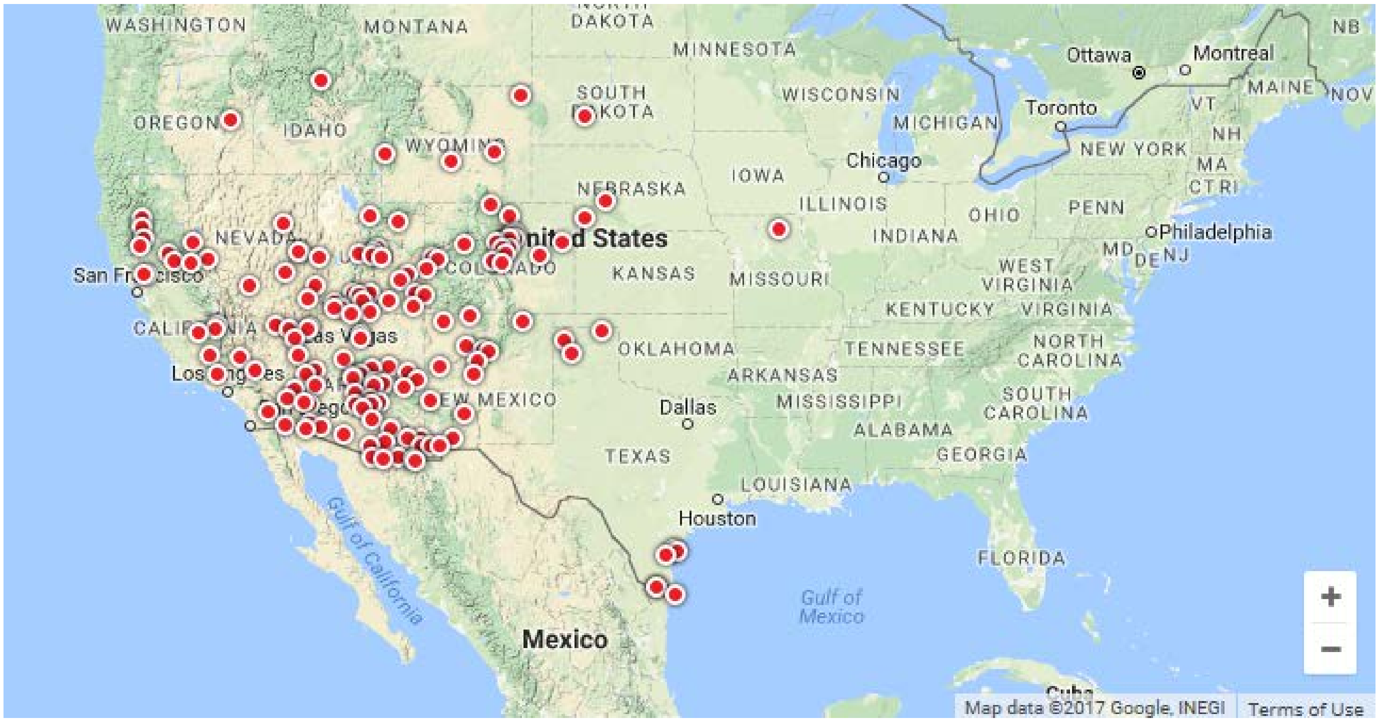

Figure 12. Locations of records that were either tied or set for June 20th, 2017. [Return to text](#).

Rank	Value (°F)	Ending Date
1	122	6/26/1990
2	120	6/25/1990
3	119	6/20/2017
-	119	6/29/2013
5	118	6/19/2017
-	118	6/19/2016
-	118	6/28/1990
-	118	6/27/1990
-	118	6/24/1929
10	117	6/21/2017
-	117	6/29/1994
-	117	6/28/1979
13	116	6/25/2017
-	116	6/24/2017
-	116	6/20/2016
-	116	6/28/2013
-	116	6/28/1994
-	116	6/26/1994
-	116	6/25/1994
-	116	6/24/1994

Table 2. Top 20 Maximum 1-Day Mean Max Temperature Days for Phoenix Area, AZ in the month of June. Return to text.

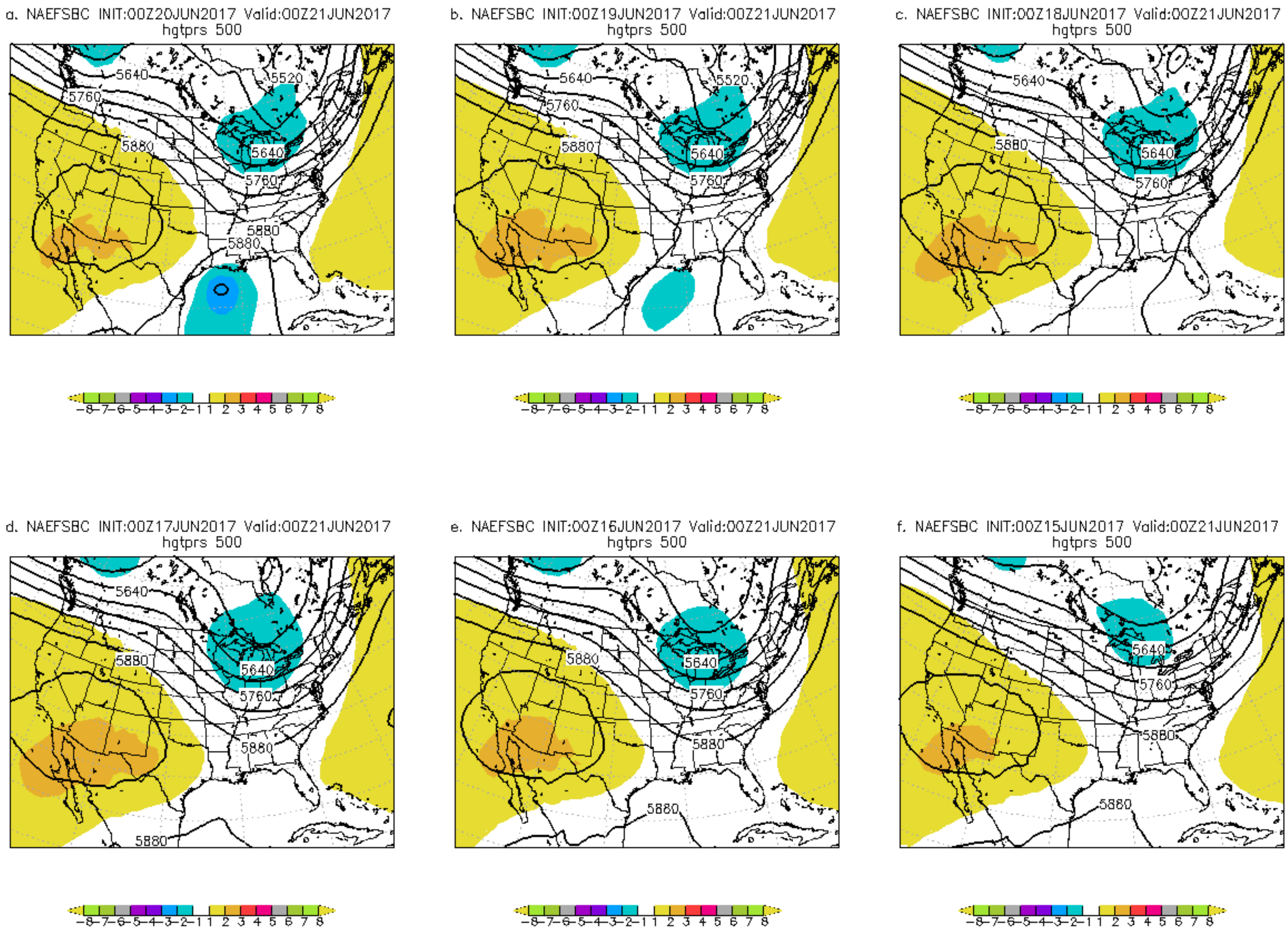

Figure 13. NCEP NAEFS forecasts valid at 0000 UTC 21 June showing 500 hPa heights and height anomalies from forecasts initialized every 24 hours from 0000 UTC a)20 June through f) 15 June 2017. [**Return to text.**]

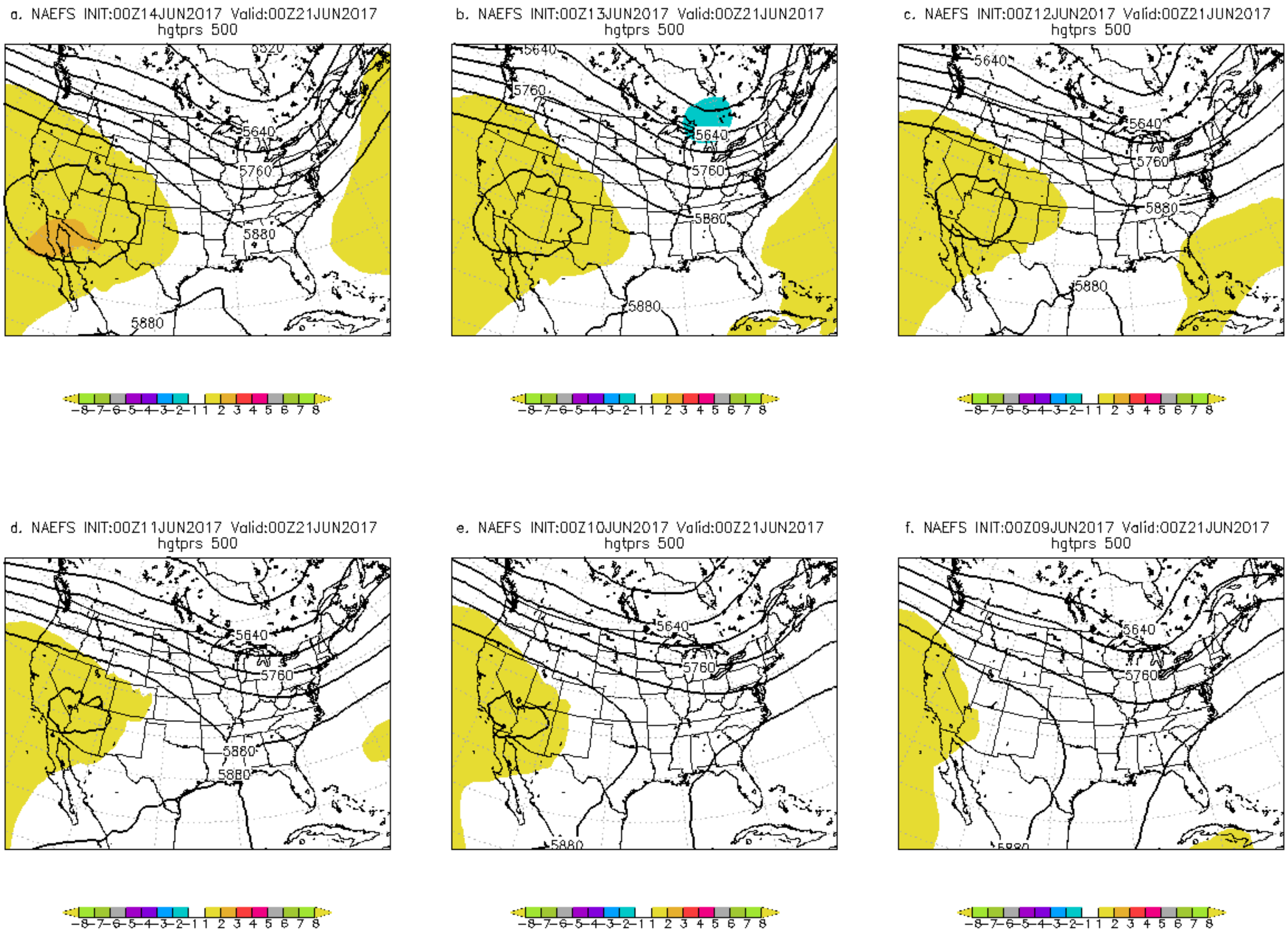

Figure 14. As in Figure 13 except forecasts initialized from a) 14 June to 9 June 2017**[. Return to text.]**