SALT RIVER SYSTEM
Analysis of daily flow and mean area precipitation (map)

DATA:

Five river gauges contribute data to this analysis. Each gauge has a different period of record, which is noted below:

- Ft Apache, NR, White River (WHTA3)
  Period of record: October 1957 to October 1998 (41 years)
  Daily average values of river flow
  Daily totals of mean area precipitation (MAP) for upper, middle, and lower areas

- Show Low, NR, Carrizo Creek (CRZA3)
  Period of record: July 1967 to October 1998 (21 years)
  Daily average values of river flow
  Daily totals of mean area precipitation for upper and lower areas

- Point of Pines, NR, Black River (BPPA3)
  Period of record: June 1953 to October 1998 (45 years)
  Daily average values of river flow
  Daily totals of mean area precipitation for upper, middle, and lower areas

- Globe, NR, Cherry Creek (CHRA3)
  Period of record: October 1965 to October 1998 (23 years)
  Daily average values of river flow
  Daily totals of mean area precipitation for upper and lower areas

- Roosevelt, NR, Tonto Creek (TNRA3)
  Period of record: December 1940 to October 1998 (58 years)
  Daily average values of river flow
  Daily totals of mean area precipitation for upper, middle, and lower areas

PROCEDURE:

The 20 maximum values of daily flows for each station were identified. A subset of data was extracted for data within four days of the maximum flows to include the two days previous, the day of, and the day following the maximum flow day. The flow and map for each area was plotted sequentially for each of the five rivers (Figure 1 to Figure 5). From these plots, it becomes apparent that some of the maximum flow events are a result of snow melt rather than direct precipitation as the MAP values associated with the flow are small. The snowmelt events will be ignored in subsequent discussion. The remaining maximum flow events are tabulated below (Table 1):

Event	WHTA3	BPPA3	CRZA3	CHRA3	TNRA3
8/29/51					*
1/19/52					21200 (7)
12/26/59					*
12/23/65				3500 (7)	*
10/20/72		11000 (1)	5010 (6)	4000 (4)	
3/2/78	4640 (5)	5740 (5)	5210 (5)	5680 (1)	32200 (3)
12/19/78	7180 (1)	8020 (2)	10900 (1)	5000 (2)	28000 (4)
1/18/79				4000 (4)	24000 (6)
1/30/80					*
2/16/80	4370 (6)	*	6200 (3)	3700 (6)	32600 (2)
10/3/83	6100 (3)	6610 (4)			
12/29/84	3130 (8)	5030 (6)		*	
3/13/85	5130 (4)				
3/2/91	4120 (7)	7190 (3)		*	27200 (5)
1/9/93	7081 (2)		7210 (2)	4170 (3)	36700 (1)
2/23/93			5870 (4)		
2/16/95	3080 (9)	*			19400 (8)

Table 1: Major flood events at the five analyzed gauges. The maximum daily flows are tabulated. In parenthesis is the rank of each flow for the period of record. An * denotes a secondary flood event

The meteorological situation associated with several of these events was established through the historical information of the medium range forecast model (MRF) reanalysis found on the world wide web (www.cdc.noaa.gov/cdc/data.ncep.reanalysis.html). The reanalysis provided a consistent and complete data set albeit model output. The events examined were 12/19/78, 2/16/80, 1/9/93, and 2/16/95. These were chosen qualitatively. Figure 6 shows the 500 mb heights every 12 hours for the 1/9/93 event. Figure 7 shows convective and total precipitation rates for one day during the 2/16/80 event.

To investigate the importance of multiple day precipitation events, a three-day running average was applied to the daily average map taken from each of the areas. The maximum fifty values of the smoothed average map were tabulated.

RESULTS AND CONCLUSIONS:

Fourteen of the seventeen events occurred during astronomical winter. Two were during autumn and one during summer.

Twelve events occurred during or after 1978. This period is a period of generally positive values of the Pacific Decadal Oscillation (PDO) Index shown in Figure 8 (from Mantua, tao.atmos.washington.edu/pdo/). By contrast the earlier portion of the record contains only five events and two of those are secondary events. This period coincides with a generally negative value of the PDO index. A relationship between the PDO climate variability and river flow is suspected.

The four meteorological situations analyzed paint a couple different pictures. Three of the four cases (12/19/78, 1/9/93, and 2/16/95) show features consistent with a major winter extratropical cyclone pushing through the Salt River basin producing synoptic scale precipitation. Figure 6 is typical of these events. At the 500 mb level an eastward moving trough is evident. Typical minimum 500 mb heights over Southern Arizona are 552 dm. The remaining case, 2/16/80, contrasts with the others. The 500 mb flow is largely zonal with only a weak short wave trough passing over Arizona. The minimum 500 mb height is 564 dm. The precipitation in this last case is dominated by convective precipitation whereas the former cases were dominated by synoptic scale precipitation. Figure 7 shows convective and total precipitation for this case.

In general, maximum map values precede maximum daily flow values by one day. However this relationship is far from robust.

For the White River (WHTA3), only five of the highest 50 daily average maps were associated (i.e. within three days of a maximum daily flow value) with a maximum flow event. Of the 50 maximum smoothed daily average maps, 10 were associated with a maximum flow event. Hence we surmise that a maximum flow event is more likely given a multiple day precipitation event than a single day precipitation event.

From a forecasting perspective these results imply that a maximum daily flow event is most likely to occur when:

- It is astronomical winter
- A multiple day precipitation event is occurring
- A large extratropical cyclone is forecast to move over the area
- The PDO index is positive

It is noted that these relationships are general and may not apply to a specific case.

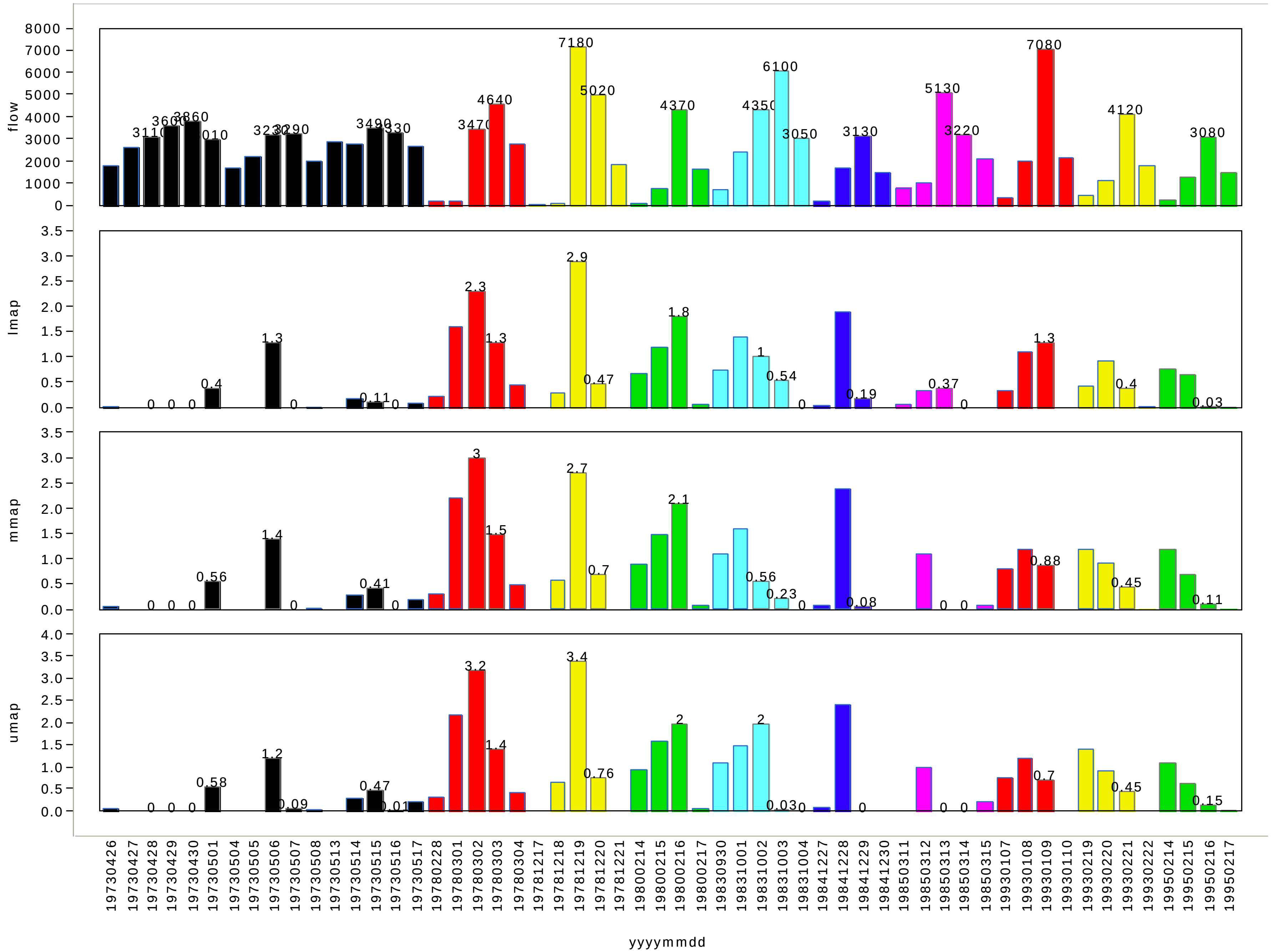

Figure 1: Major flooding events for WHTA3 and associated mean areal precipitation

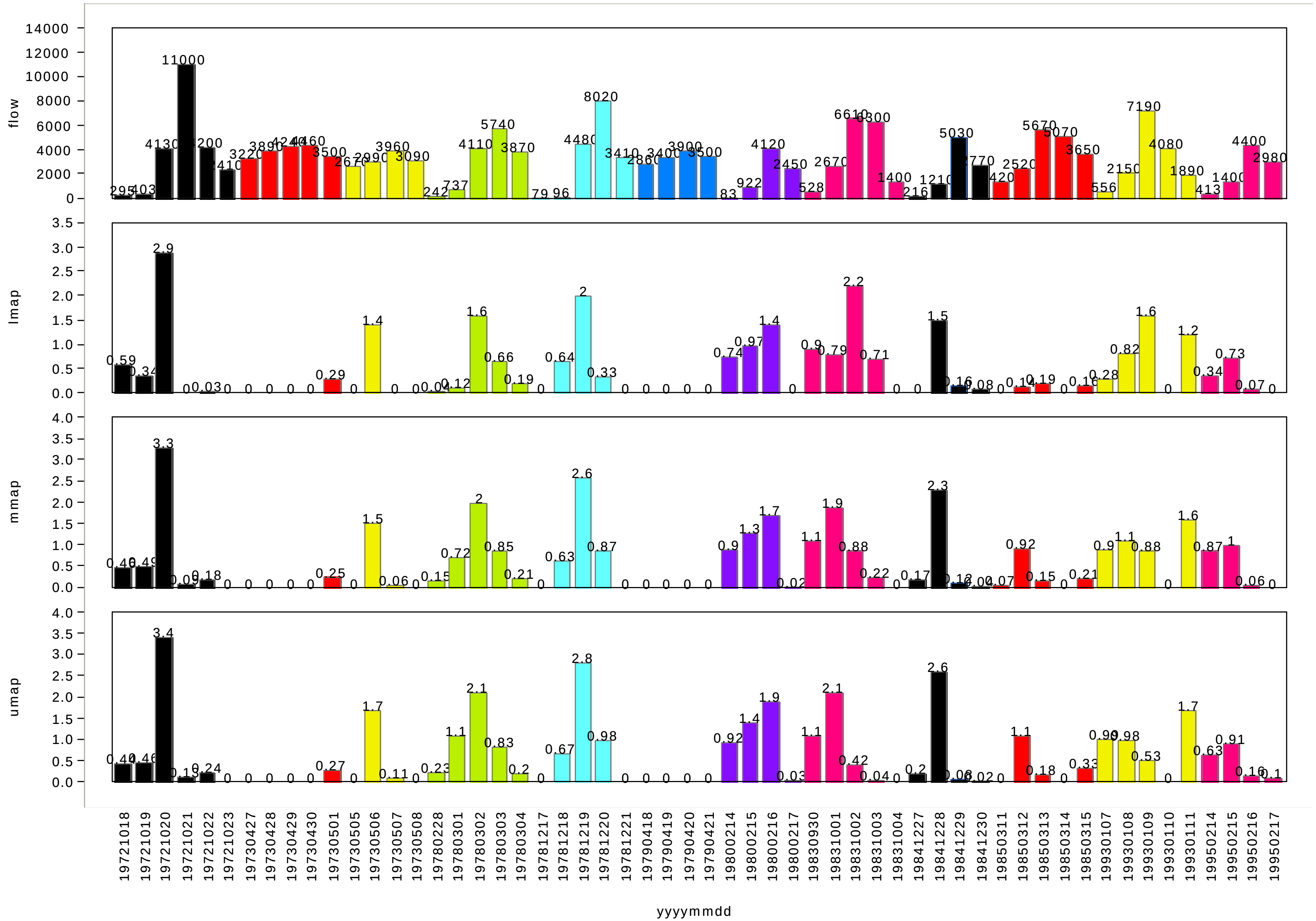

Figure 2: Major flooding events for BPPA3 and associated mean areal precipitation

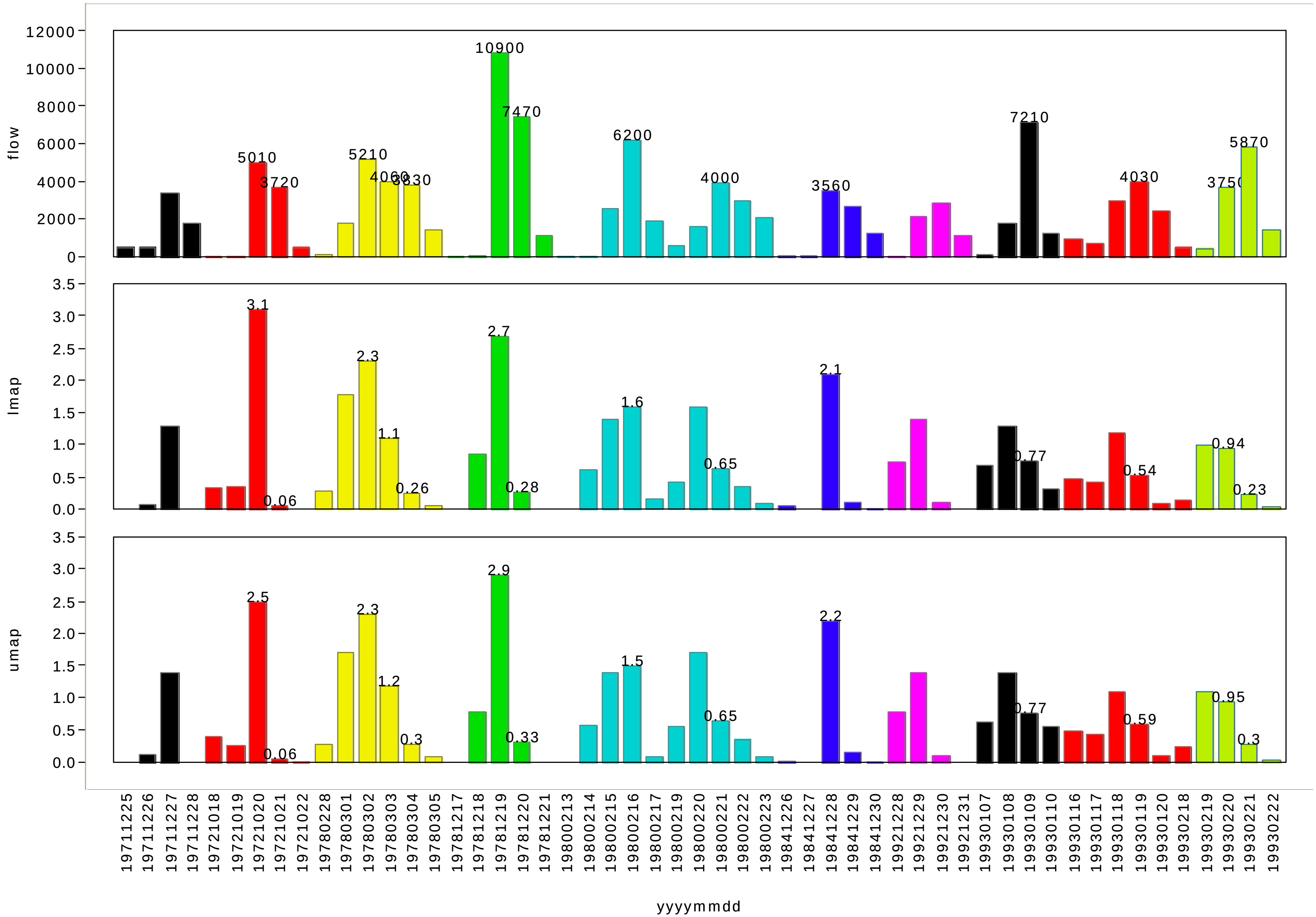

Figure 3: Major flooding events for CRZA3 and associated mean areal precipitation

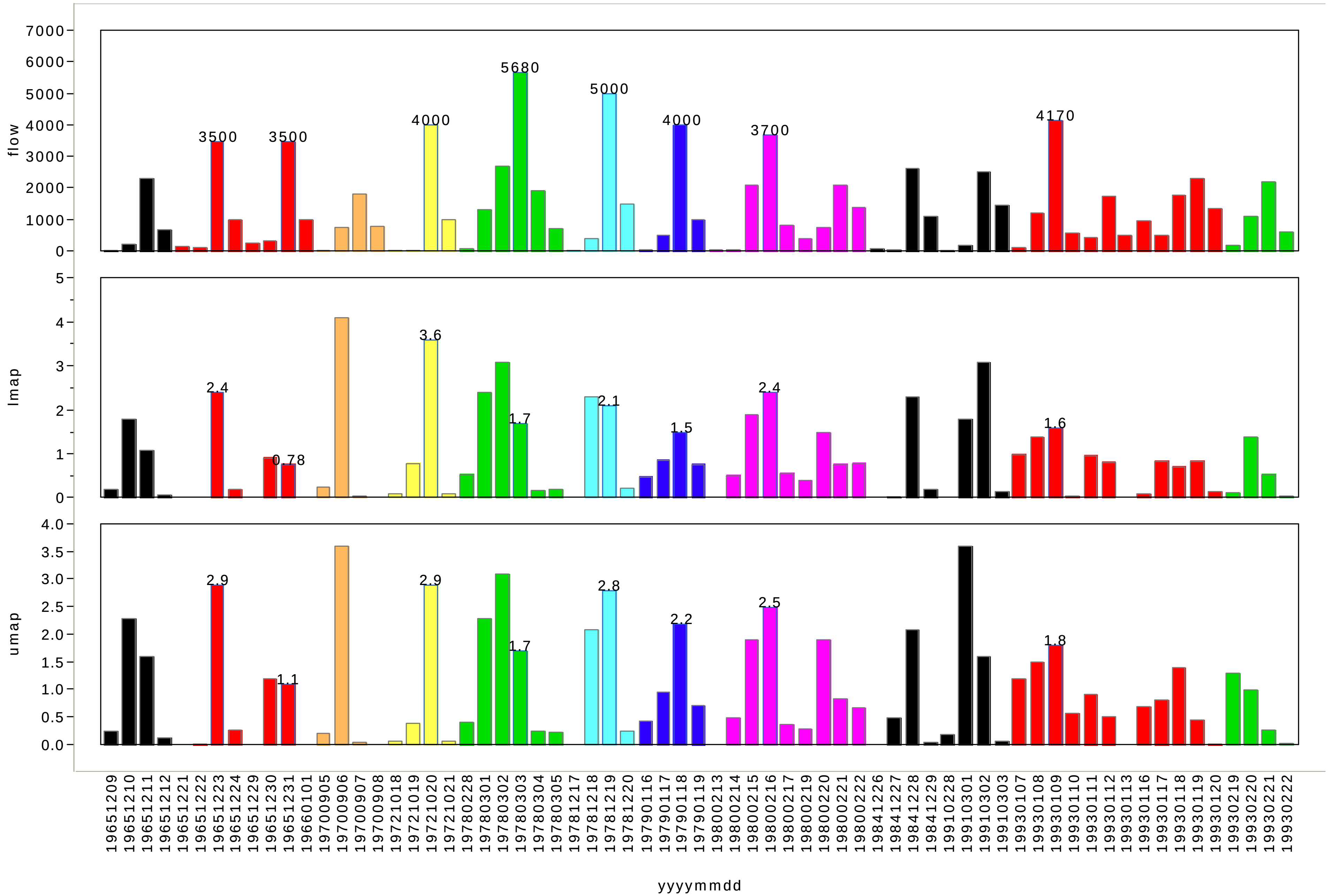

Figure 4: Major flooding events for CHRA3 and associated mean areal precipitation

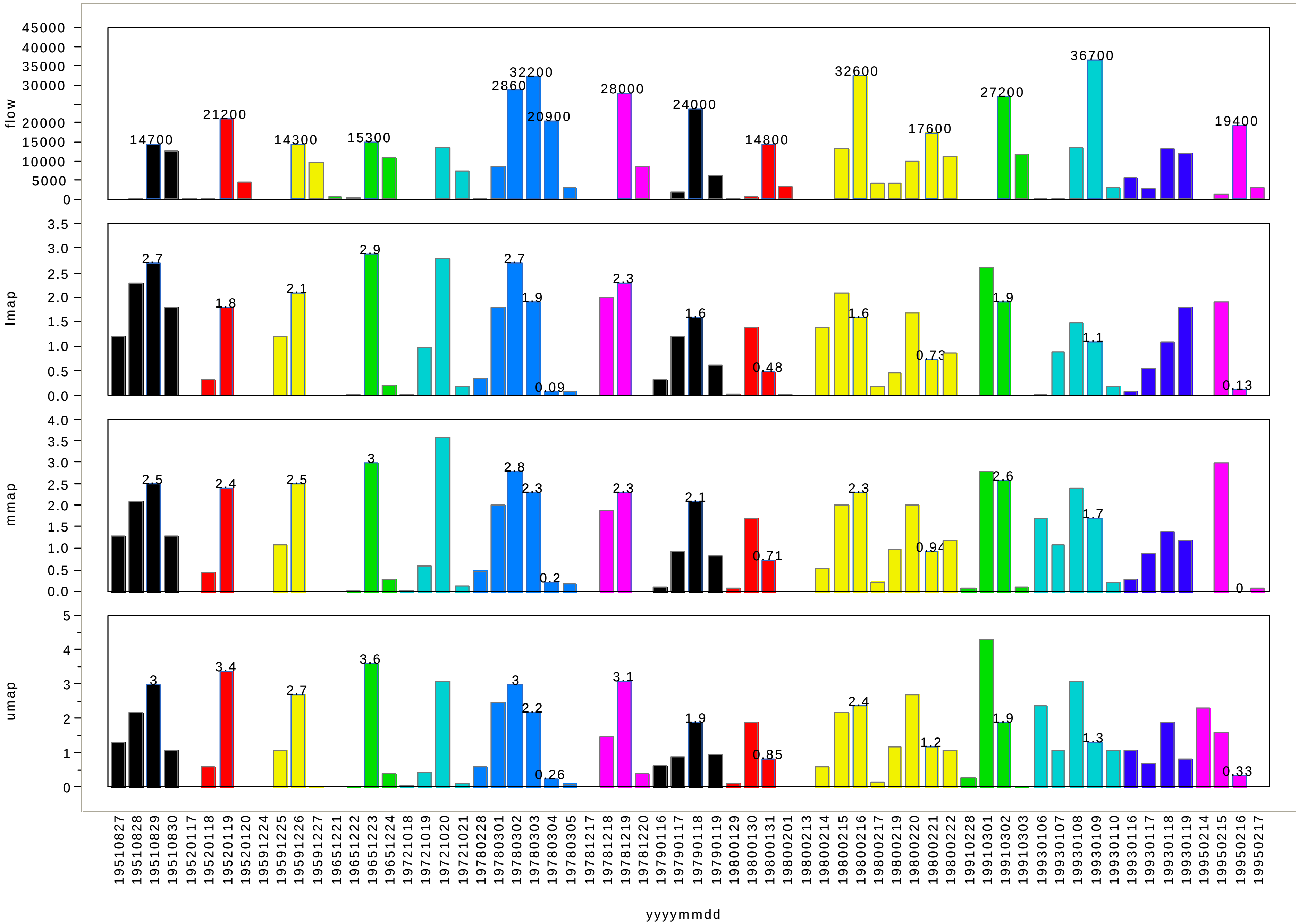

Figure 5: Major flooding events for TNRA3 and associated mean areal precipitation

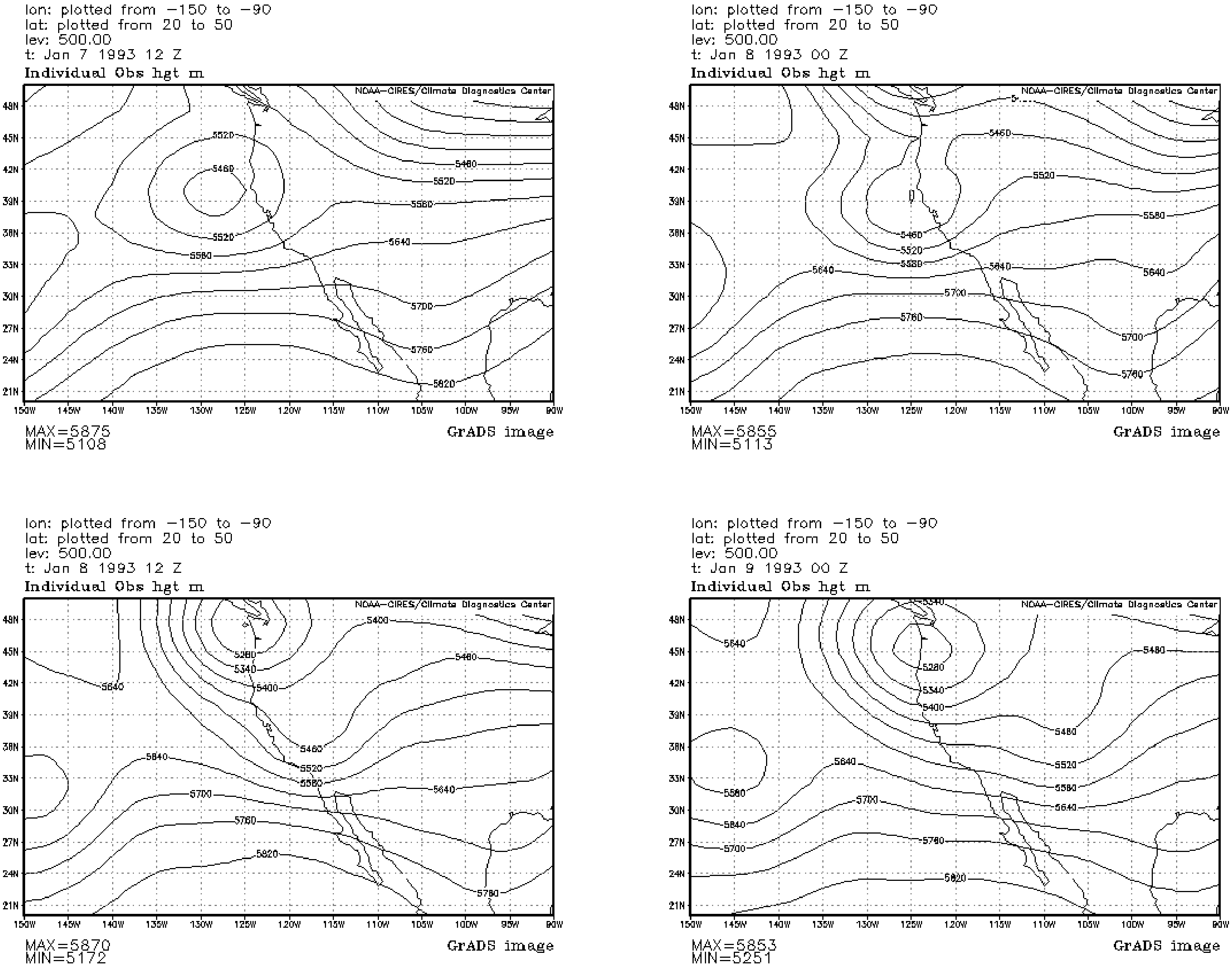

Figure 6: 500 mb heights for 1/9/93 event

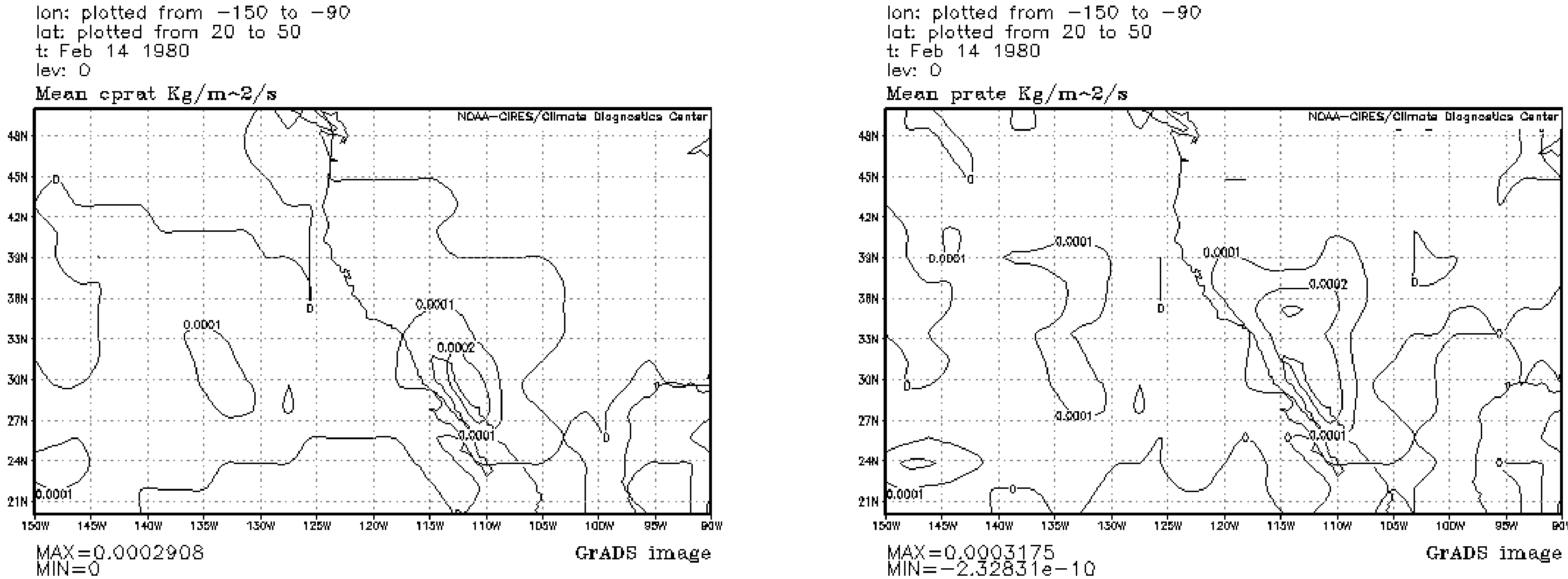

Figure 7: Mean convective (left) and total (right) precipitation rates for the 2/16/80 event

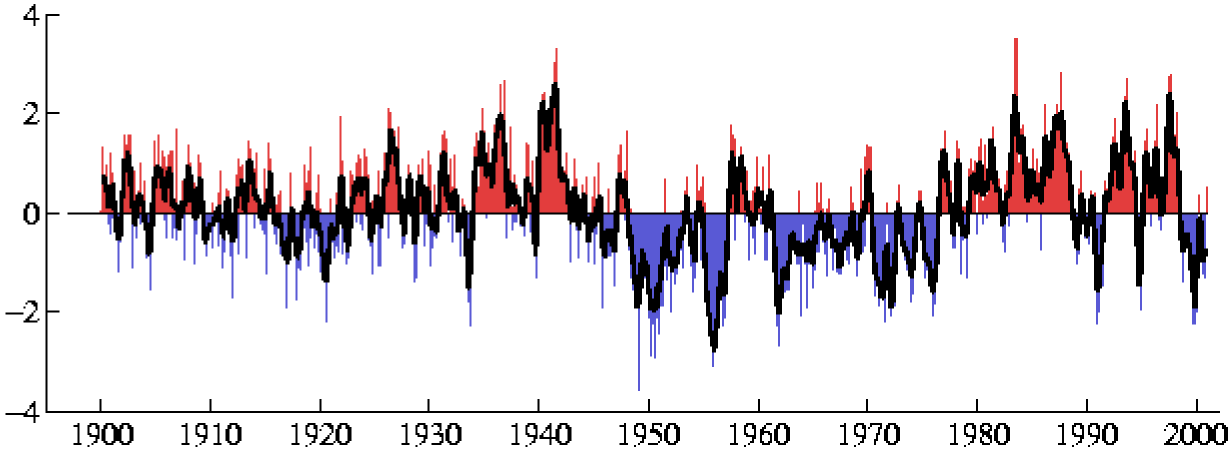

Figure 8: Pacific Decadal Oscillation (PDO) Index