A Severe Southwest Desert Thunderstorm: 19 August 1973

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ABSTRACT

Intense thunderstorms, which frequent the desert Southwest of the United States in the summer months, have been known by several different names: chubasco, haboob, and Sonora storm. Prior to the advent of satellites and radar, the sparsity of observations in the desert Southwest precluded any determination of where these storms developed, as well as information on their areal coverage and life cycle.

A particularly severe and long-lasting thunderstorm occurred 19–20 August 1973. This storm was followed through its life cycle by means of radar, satellite, and surface observations. This particular storm was noteworthy for its very strong winds, locally heavy rain, and the magnitude of the pressure jump associated with it. The converging of two separate mesohighs is believed to be the cause of the very intense storm that moved westward across the Imperial Valley of Southern California.

1. Introduction

On 19 August 1973, an area of severe thunderstorms developed late in the day in the deserts of southwest Arizona and moved westward into Southern California (Fig. 1). This storm was exceptional in several ways. The winds associated with it were some of the strongest on record in the Imperial Valley of Southern California. Also, the life of the storm was unusually long for this particular type. The associated pressure jumps were of extraordinary magnitude at a number of stations in its path. Very heavy rain, particularly for a desert, occurred locally.

This type of storm is not uncommon in the desert southwest and northwestern Mexico. It is known by several different names: chubasco, haboob, and Sonora storm. Several authors: (Bailey, 1966; Blake, 1923; Carpenter, 1973; Idso *et al.*, 1972; Lynch, 1931; Reed, 1937; Taylor, 1954) have recognized their existence in the past, but due primarily to inadequate observational data, little, if any, work has been done on their causes and characteristics. With the advent of regular radar and satellite observations in the past 10 years, a detailed analysis is now possible.

2. Synoptic situation

The radiosonde observations at Tucson and Winslow (Fig. 2), both taken at 0500 MST on 19 August, indicated that the lower levels in eastern Arizona were quite dry, but the humidity increased with elevation to become rather moist above about 600 mb. The K indexes of 24 at Tucson and 25 at Winslow indicate that the atmosphere was not unstable enough to support thunderstorm development from heating in the valleys. With the greater humidities at higher levels, along with vertical totals 29 and 34 at Winslow and Tucson respectively, there is support for the development of thunderstorms over the mountains.

Between 2300 MST 18 August and 0100 MST on the 19th, a low-level surge of moist tropical air moved northward through Yuma, much as shown by Hales (1972a) and Brenner (1974). The dew point at Yuma rose rapidly 14°C (25°F), reaching a level of 25°C (77°F), while the winds increased and became south-southeast at 37 km/h (20 kt). This low-level moisture spread northward past Blythe, Calif., at 0500 MST, with a corresponding dew point rise of 7°C (13°F) in one hour. Thereafter, the pressure gradient weakened and dew points at Needles, Calif., changed little through the day, indicating little further northward movement of the moist low-level surge. At Phoenix, Ariz., the dew point was running 6°C (11°F) higher at 1700 MST on the 19th than at 1700 MST on the 18th, indicating that the low-level moisture spread northeastward during the day, covering all of southwest Arizona by evening.

This surge of moist air made available a layer of increasingly moist tropical air near the surface across southwest Arizona. This quite likely was instrumental in fueling the intense thunderstorm activity that developed in this area later that evening.

The 300 mb chart is used to display the synoptic flow pattern, since below that level the airmass movement during August is quite sluggish, as it was in this case. At 0500 MST 19 August (Fig. 3), a well-defined trough on an east-northeast to west-southwest axis was located just to the south of Arizona. In the following 24 h (Fig. 4), the trough moved northward into Arizona. The cold air advection, noted in eastern

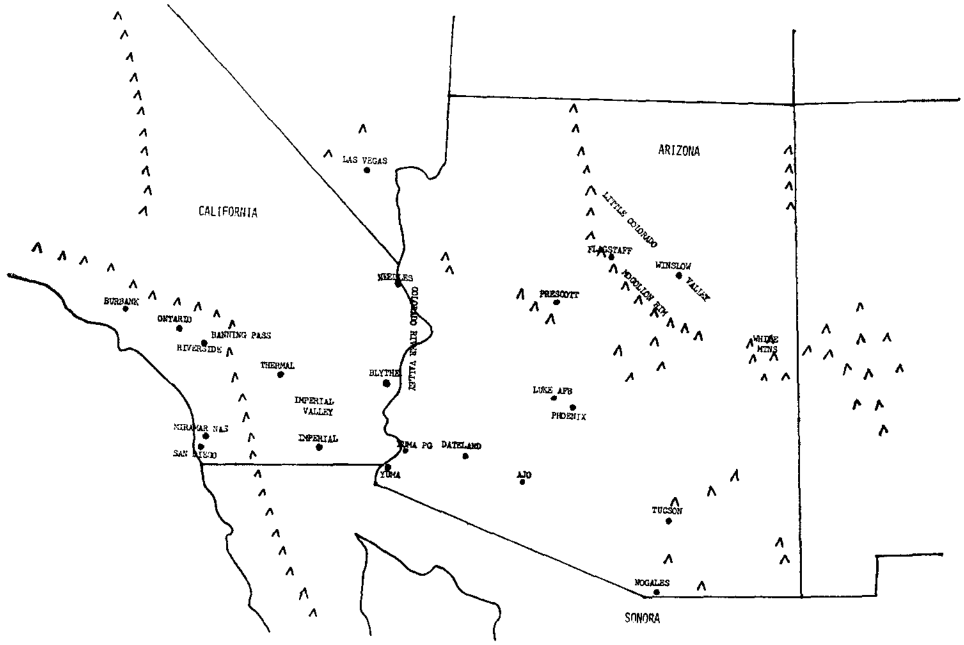

Fig. 1. Map of Arizona and Southern California.

Arizona on the 0500 MST 19 August chart, suggests a possible destabilizing mechanism.

In this particular case, the recurrence of small thunderstorm cells throughout the Imperial Valley and northern Baja California, during the afternoon of the 19th, preceded the severe evening thunderstorms and strongly hinted that some synoptic scale mechanism aided the upward vertical motion. The sharp, high-level, east-west trough across the area was a significant contributor to the intense development.

3. Storm morphology

The ensuing discussion will describe in some detail the synoptic events that led to the development of severe thunderstorms in the Imperial Valleys of South-

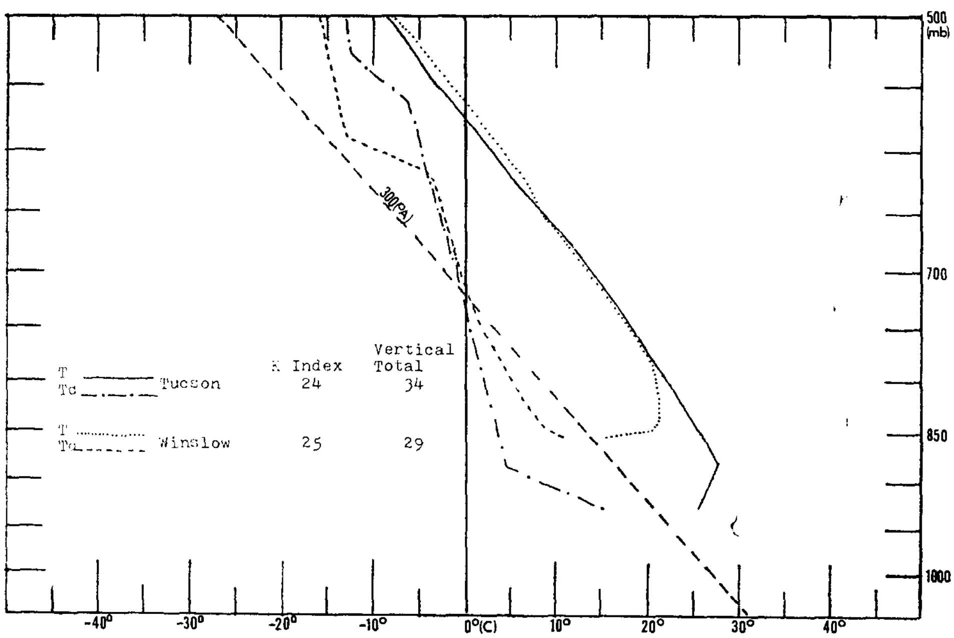

Fig. 2. Radiosonde observations for Tucson and Winslow 1200 GMT (0500 MST) 19 August 1973.

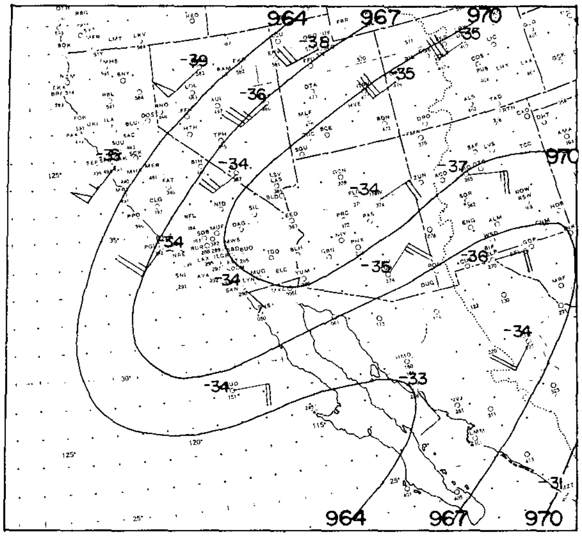

FIG. 3. Three-hundred millibar chart for 1200 GMT (0500 MST) 19 August 1973. Heights are in dekameters and temperatures are in °C.

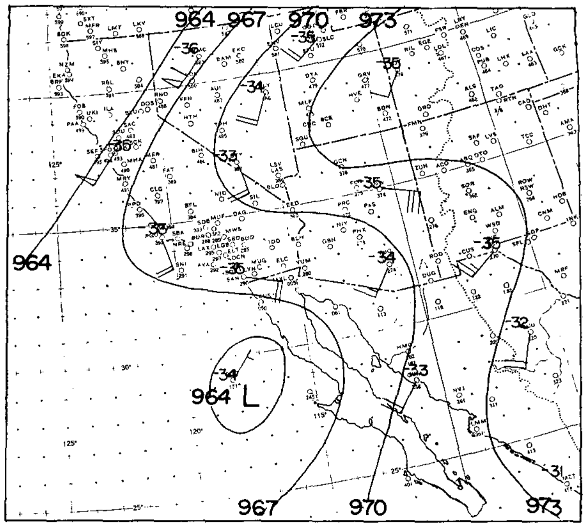

FIG. 4. Same as Fig. 3, except for 1200 GMT (0500 MST) 20 August 1973.

ern California and the desert Southwest valleys of Arizona on the evening of the 19th of August. Initially on the 19th, thunderstorms developed rapidly over the White Mountains of east-central Arizona and moved westward during the afternoon. A separate area of thunderstorms, which also moved westward, developed in the vicinity of Tucson by mid-afternoon. The convergence of the separate pressure surge lines in southwest Arizona, associated with the separate groups of thunderstorms, was the trigger for the intense development that took place during the evening hours.

Purdom (1974) states, "Where a meso high's outer boundary (pressure surge line) intersects another boundary (such as a front, a squall line, or another meso-high) locates a point with a high potential for intense convection. This intersection is quite critical in outbreaks of severe weather, since it locates a favored place for severe thunderstorm development."

Initially on the 19th, thunderstorms formed rapidly

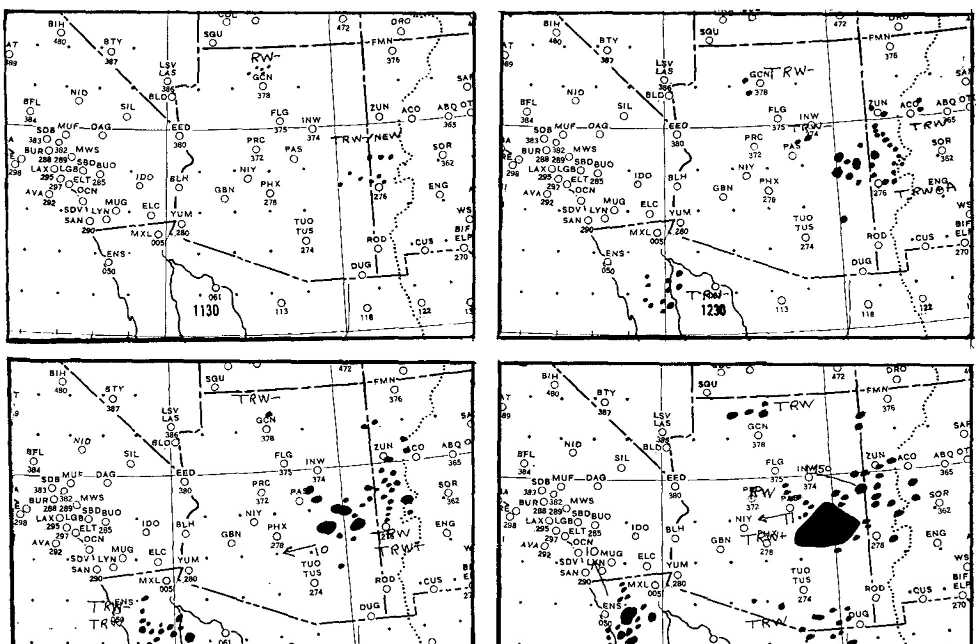

FIG. 5. ARTC radar observations for 1130–1430 MST 19 August 1973.

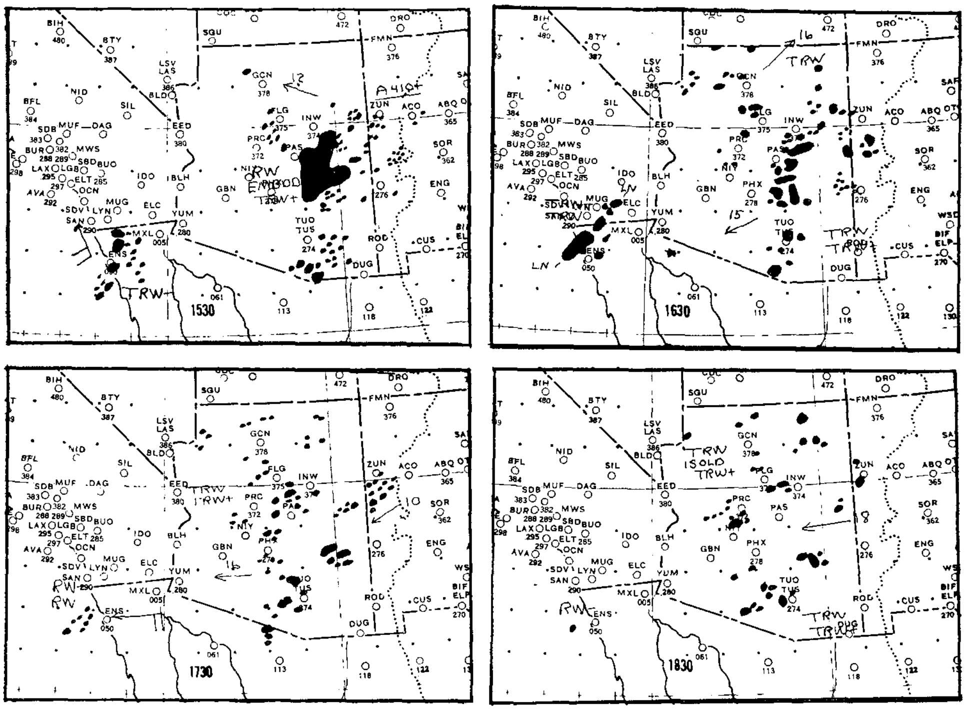

Fig. 6. ARTC radar observations for 1530–1830 MST 19 August 1973.

over the White Mountains of east-central Arizona just before 1200 MST. The trough at 300 mb, as well as the solar insolation, acted as a trigger for these rapidly developing cells. By 1330 MST, large clusters of thunderstorms had formed, as was depicted on the 1330 MST radar chart (Fig. 5). Also, the ATS-3 satellite photograph at 1310 MST (Fig. 9) revealed the large area of development. The next ATS-3 photograph taken

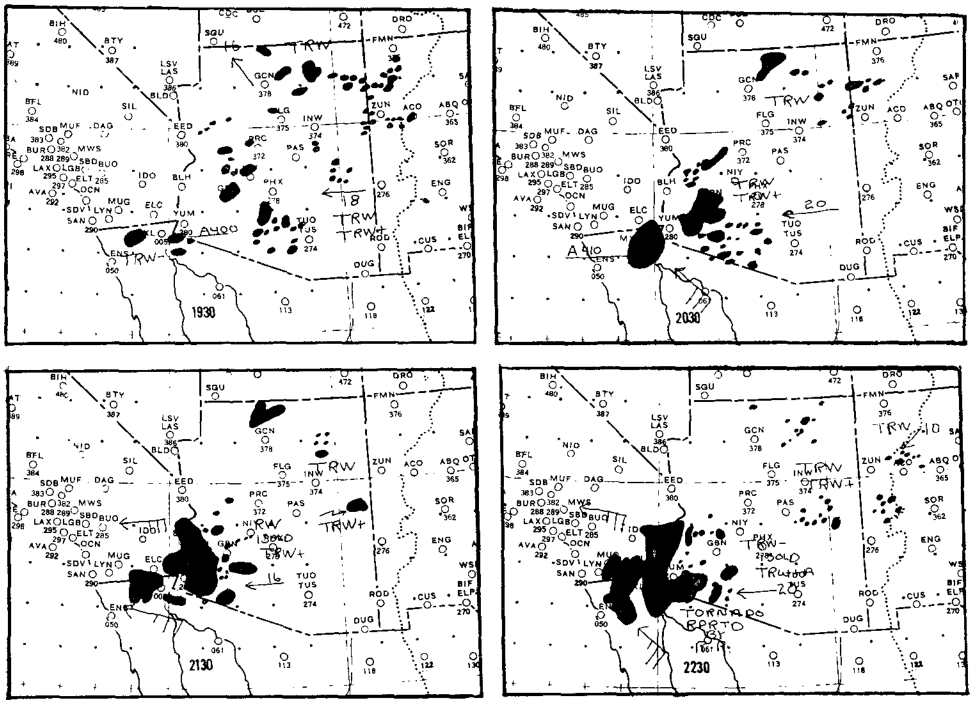

Fig. 7. ARTC radar observations for 1930–2330 MST 19 August 1973.

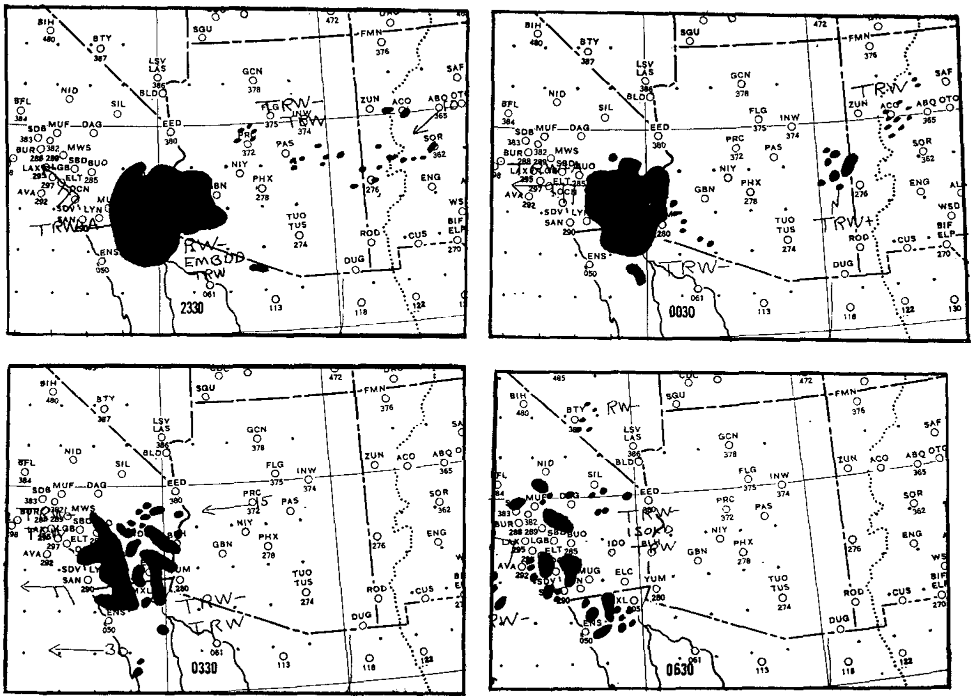

FIG. 8. ARTC radar observations for 2330 MST 19 August 1973 and 0030, 0330, 0630 MST 20 August 1973.

at 1405 MST (Fig. 10) and the 1430 MST radar chart (Fig. 5) show a rapid increase in size of the thunderstorm area around the White Mountains. Thunderstorms were beginning along the Sonora-Arizona border on the 1405 MST ATS-3 photograph, with the 1430 MST radar chart also showing this development.

By 1530 MST (Fig. 6), radar indicated that an arc-shaped mass of thunderstorms was moving westward, both north and south of the Mogollon Rim. This rapid growth of cells into a large mass, and accompanying movement away from the mountains by mid-afternoon, was not typical of summertime airmass-type thunderstorms in Arizona, as shown by Hales (1972b). As a rule, the cells remain rather small through the afternoon and are confined to the higher terrain until late afternoon or early evening.

The thunderstorms decreased rapidly as they moved downslope toward the desert valleys (Fig. 1). However, a well-defined pressure surge persisted. Winslow reported a peak wind gust of 82 km/h (44 kt) from the southeast at 1628 MST, with a pressure rise of 3 mb (.09 inch) in less than an hour, though no rain or

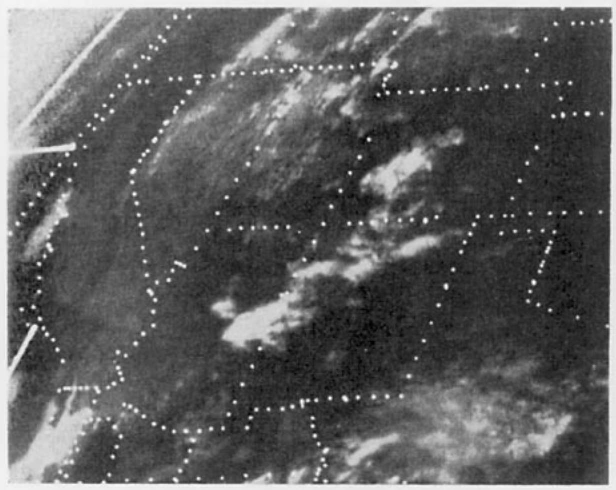

FIG. 9. ATS satellite photograph taken at 2010 GMT (1310 MST) 19 August 1973.

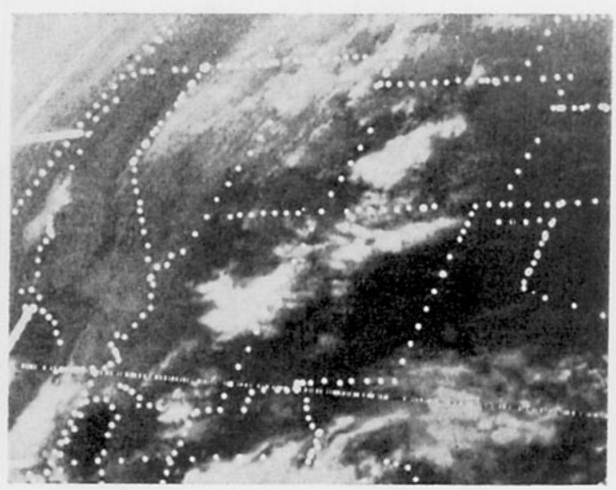

FIG. 10. ATS satellite photograph taken at 2105 GMT (1405 MST) 19 August 1973.

thunder was observed. Peak gusts of 52 km/h (28 kt) at 1828 MST and 56 km/h (30 kt) at 1800 MST were reported at Flagstaff and Prescott respectively. The pressure rise at both of these stations was only of the order of a few hundredths of an inch. Hail did accompany a thundershower at Flagstaff, however.

As the cells moved off the higher elevations into the desert valleys east of Phoenix, they decreased in number and intensity rather rapidly, the large mass of cells disappearing altogether. This very likely was the result of the downslope flow into the deserts which caused the drying of the airmass.

The cold air outflow (pressure jump line) reached Phoenix shortly after 1700 MST. The line was marked by gusty northeast winds to 65 km/h (35 kt) and dust. The arrival of the pressure jump is shown on the Phoenix pressure trace (Fig. 12) with a rise of 2 mb (.05 inch). Attesting to the downslope motion, the dew point dropped 5°C (9°F) after the arrival of the cooler air.

The pressure jump passed Luke Air Force Base (32 km west of Phoenix) about 20 min later, with again a rise of just 2 mb (.05 inch). The peak wind gust was NE at 78 km/h (42 kt), with visibility briefly down to 1.4 km ($\frac{7}{8}$ mi) in blowing dust. Again the dew point dropped—this time some 4°C (7°F).

On the 1730 MST radar chart (Fig. 6), echoes over the desert valleys near Phoenix were widely scattered, whereas an organized cluster of larger cells was moving westward from the Tucson and Nogales areas.

The thunderstorms in the Tucson area apparently intensified as they moved west, as the 1730 MST radar chart suggests. Also, Tucson reported a 3 mb (.09 inch) pressure rise between 1800 MST and 2000 MST, after the passage of the thunderstorm over the station. Peak winds of 58 km/h (31 kt) from the west at 1824 MST supported the intensification west of Tucson.

The area bounded by Tucson to Phoenix to Yuma has no observation stations; therefore, some of the following ideas are based on the author's experience and knowledge of the area.

As the active pressure surge moved WSW from Phoenix, it quite likely intersected the developing pressure surge moving west from Tucson. This would induce strong convergence at the intersection, which would have been located in the Ajo area about 2000 MST, much as Purdom (1974) has shown. Also, a low-level moisture source was available in this area, as discussed previously.

The NOAA-2 2019 MST infrared photograph (Fig. 11) shows a tremendous mass of cumulonimbus located in southwest Arizona, with a line of thunderstorms extending northward from the large circular cloud area, and then arcing eastward across northern Arizona into New Mexico. This arcing line of cumulonimbus and cumulonimbus debris was quite likely associated with the original pressure surge line that moved through central Arizona, while the circular mass of thunderstorms was at the intersection of the two pressure surge lines.

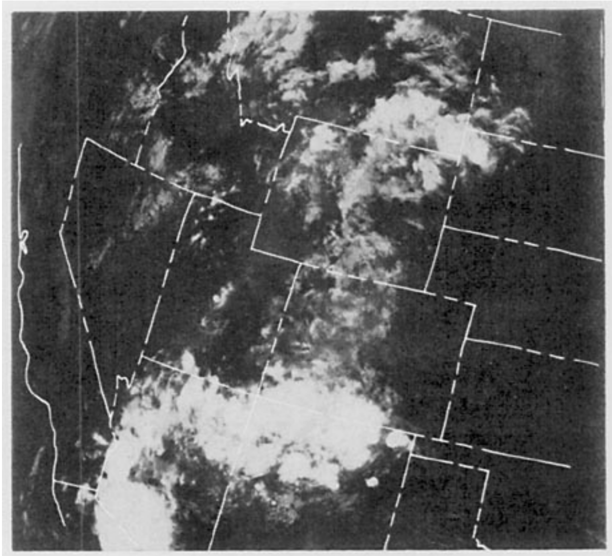

FIG. 11. NOAA-2 IR night satellite photograph taken at 0319 GMT 20 August 1973 (2019 MST 19 August 1973).

Between 1930 MST and 2130 MST (Fig. 7), a rapid intensification and increase in areal coverage occurred in the Yuma area.

A severe wind and dust storm accompanied the pressure surge through Yuma at 2140 MST. The peak all-time, one-minute wind speed was established with east winds of 97 km/h (52 kt), and gusts were recorded up to 113 km/h (61 kt). Further attesting to the severity of the storm was the large pressure jump of 7 mb (.22 inch) in 12 min (Fig. 12). The magnitude of this jump was comparable to the most severe pressure jumps that occur in the Midwest. The Yuma Proving Grounds, located about 22 km north-northeast of the Yuma Airport, also reported peak winds in excess of 97 km/h (52 kt) attesting to the extent of the storm. The pressure at Yuma Proving Grounds showed a jump of 9 mb (.27 inch) in an hour.

At 2200 MST, a pressure jump occurred at Blythe, though no thunder was heard and only sprinkles of rain fell. The Blythe pressure trace (Fig. 12) shows a very pronounced pressure rise of 6 mb (.19 inch) in about an hour.

The severe storm continued westward passing through Imperial, Calif., at 2258 MST, with peak wind gusts of 108 km/h (58 kt) from the east at 2302 MST, and a temperature drop of 13°C (23°F) in one hour. The pressure jump was not as great as at Yuma (Fig. 12), but still about 5 mb (.16 inch) in 20 min.

The radar still indicated at 2330 MST (Fig. 8) a large area of thunderstorms, strongest in the forward portion. There was a gradual decrease in intensity and areal extent from 0030 MST through 0630 MST on

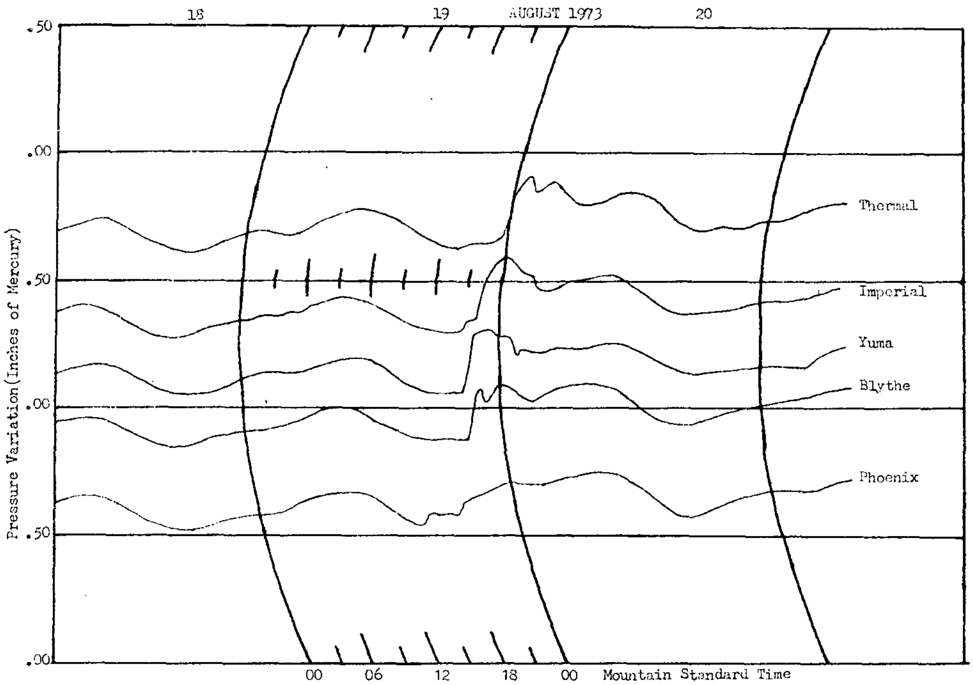

FIG. 12. Pressure traces for Phoenix, Blythe, Yuma, Imperial, and Thermal from 18–20 August 1973. Pressure variation is in inches of mercury (1 in. Hg = 33.9 mb).

the 20th, with most activity remaining east of the southern California coastal mountains.

At 2335 MST, the storm moved into Thermal, Calif. The peak wind was not observed due to a complete power failure, but the pressure (Fig. 12) showed a rise of at least 5 mb (.16 inch) in less than half an hour. There was only a trace of rain with the storm passage.

The pressure surge moved somewhat weaker up the Colorado River Valley, with Needles noting SSW winds to 71 km/h (38 kt) at 0100 MST.

The coastal mountains effectively blocked the westward push of the pressure surge into the San Diego area, though a thunderstorm was reported at 0100 MST at the Miramar Naval Air Station. Banning Pass allowed the penetration of the pressure surge into the intermediate valleys as far west as Burbank.

Riverside, Calif., had restricted visibility to 4 km ($2\frac{1}{2}$ mi) in blowing dust at 0200 MST, with peak wind gusts to 48 km/h (26 kt) from the southeast. Shortly thereafter, Ontario reported visibility of 10 km (6 mi) in blowing dust, with wind gusts to 56 km/h (30 kt).

The last observable evidence of the pressure surge originally associated with the severe thunderstorms was reported at Burbank, with a one-minute wind speed of 34 km/h (18 kt), at 0300 MST from the southeast. While the northward push of the pressure surge weakly reached Las Vegas, Nev., at 0500 MST with a south-southwest wind gusting to 29 km/h (10 kt), it was accompanied by a dew point rise of 8°C (14°F) in one hour.

4. Conclusion

Although rainfall measurements were scarce, the 79 mm (3.10 inch) at Dateland Whitewing Ranch and 26 mm (1.00 inch) at Ajo attested to the intensity of the storm. The Dateland Whitewing Ranch measurement was approximately equal to the total rainfall expected in one year. Quite likely higher rainfall amounts occurred, but they went unrecorded.

A tornado was reported near Yuma about 2230 MST; however, the damage that occurred with this storm from Ajo to Thermal was almost all attributed to the very strong, straight-line winds.

While this storm was intense and long-lived, there are several such storms that occur each summer in the desert Southwest that are of comparable intensity. They play havoc because of the sudden onset of zero visibilities in blowing dust and sand, frequently after dark.

The role played by the convergence of the two meso-thunderstorm systems in causing the severe development is quite obvious in this case and needs to be investigated further.

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