Influence of the Summer Monsoon on Severe Convective Windstorm Development

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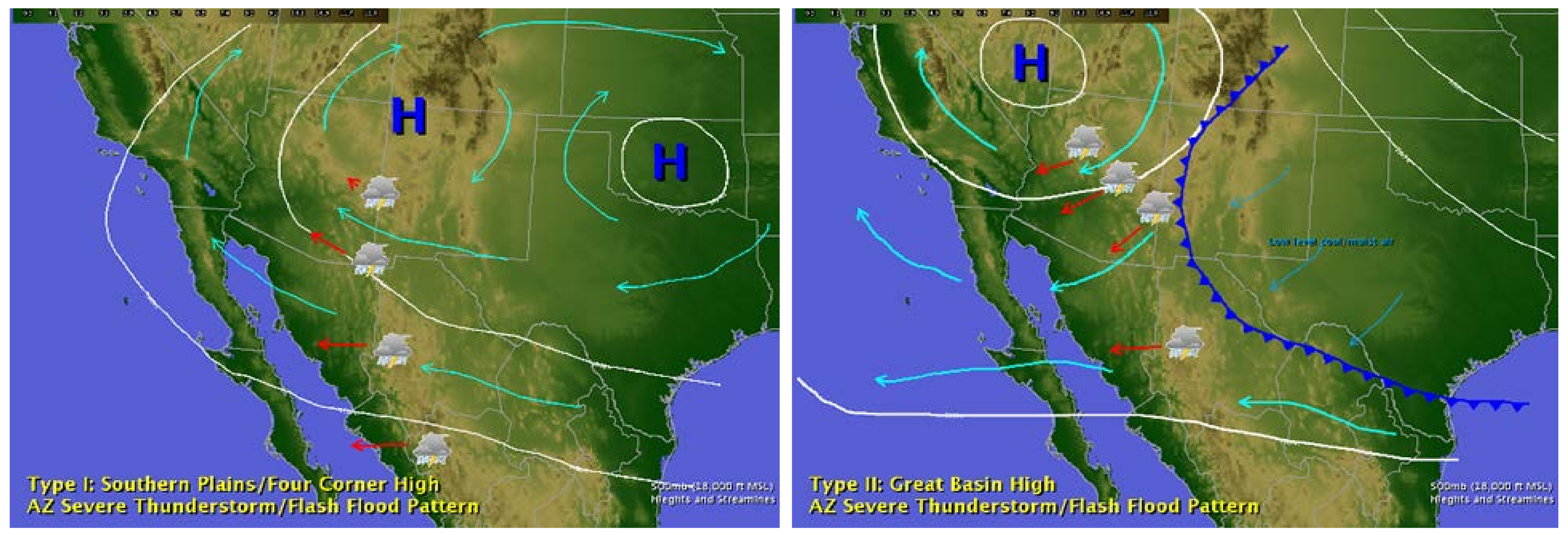
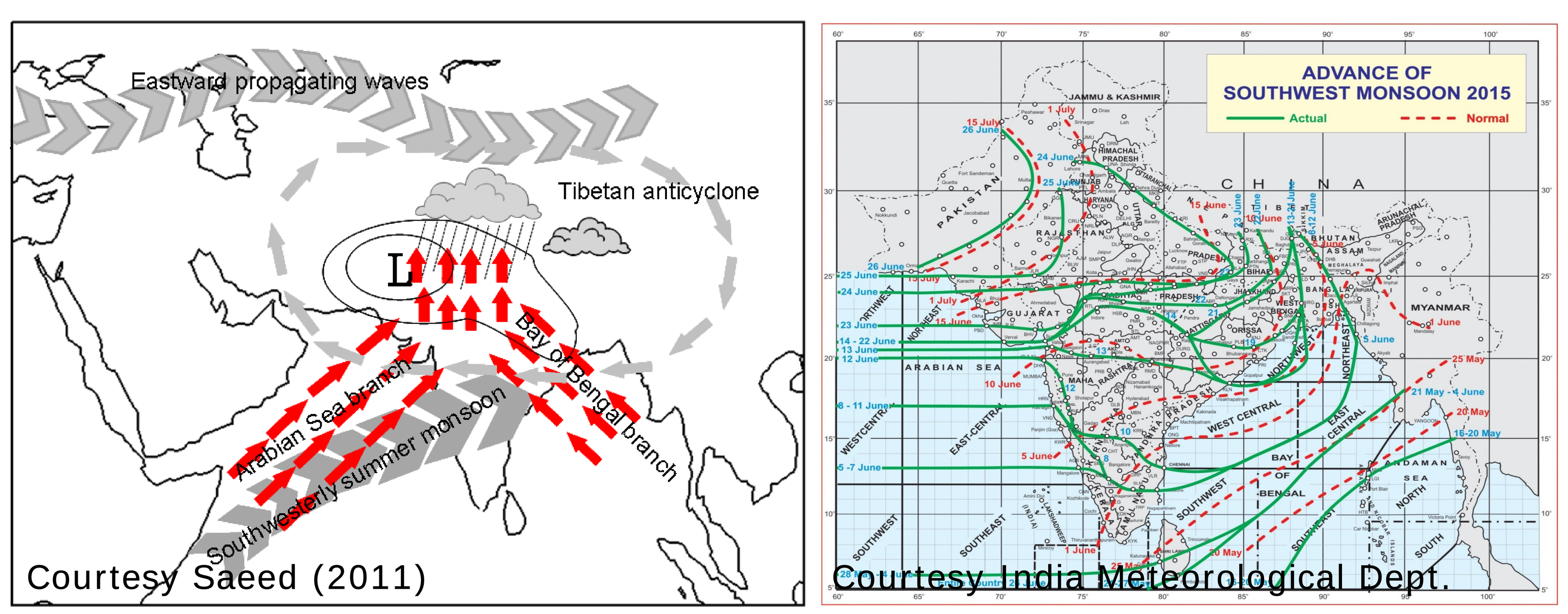
1. INTRODUCTION AND BACKGROUND

Over the contiguous United States (CONUS), development and application of a convective storm downburst prediction algorithm has demonstrated success where convective-storm generated wind is the most prevalent of all severe convective weather types. In addition, tropospheric wind and pressure patterns over North America and southern Asia have been analyzed to study the influence of summer monsoon circulations on severe convective windstorm development.



Summer severe thunderstorm patterns (courtesy NWSFO Tuscon, Arizona).

Over western CONUS, during the summer of 2014, both the "Four Corners High" (Type I) and "Great Basin High" (Type II) monsoon patterns were apparent, and were found to influence the thermodynamic and convective storm environment. Typically, lower- and mid-tropospheric moisture, originating from the tropical Pacific Ocean, Gulf of California, and Gulf of Mexico, respectively, is transported northward and westward over the United States intermountain region where the afternoon boundary layer is deep, well-mixed and unstable. This pattern fosters an "inverted-V" profile favorable for high-based convective storms that produce downbursts.



Schematic diagram showing the major components of the Indian Southwest Monsoon (left), and progression of the Southwest Monsoon over India during May and June 2015 (right).

In contrast to the monsoon evolution over western CONUS, the Indian summer monsoon (ISM) is governed by the development and placement of a monsoon trough over northern India (Rao 1976) between the months of April and September. The development of the ISM typically results in persistent west to southwesterly low-level wind flow over most of India south of the Himalayas that promotes convective storm development and heavy rainfall. Similar to the NAM, the placement and juxtaposition of the lower tropospheric monsoon trough and the mid to upper tropospheric subtropical ridge (Tibetan High) influence the vertical profile of temperature, moisture and wind and the resultant favorability for deep convective storm development and downburst generation. During the month of June 2015, the Southwest Monsoon, with its zonal circulation cell, advanced steadily from southern to northwestern India and had marked effect on the relative strength of convective storm downbursts that occurred over India during June and July 2015.

2. MICROBURST WINDSPEED POTENTIAL INDEX

Over both CONUS and India, the Microburst Windspeed Potential Index (MWPI) effectively indicated relative downburst intensity, with a strong correlation between index values and measured downburst-related wind gust speeds, and a high confidence level near 100%. The MWPI formula that accounts for both updraft and downdraft instability in microburst generation is defined as

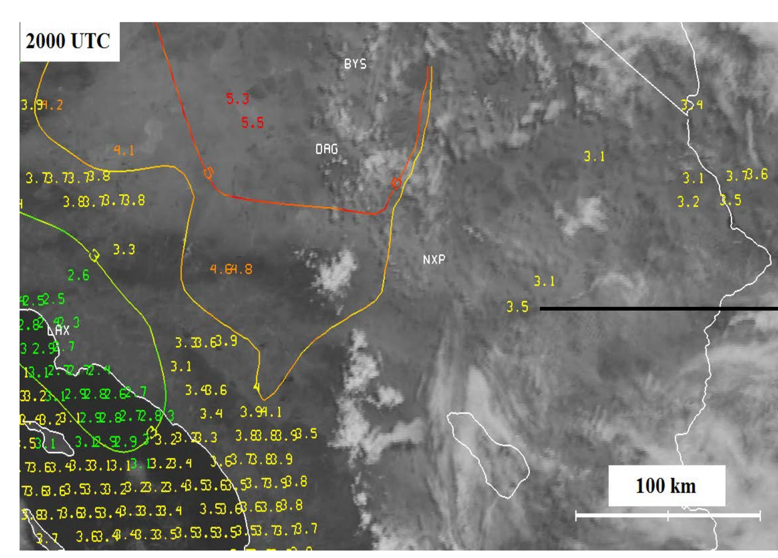
$$MWPI \equiv \{(CAPE/1000\,J\,kg^{-1})\} + \{\Gamma/5°C\,km^{-1} + ((T-T_d)_{850} - (T-T_d)_{670})/5°C\}$$

where Γ is the lapse rate (°K km^{-1}) between the lower boundary level (850 mb) and upper boundary level (670 mb) of a layer of consideration, and the quantity (T–Td) represents the dewpoint depression.

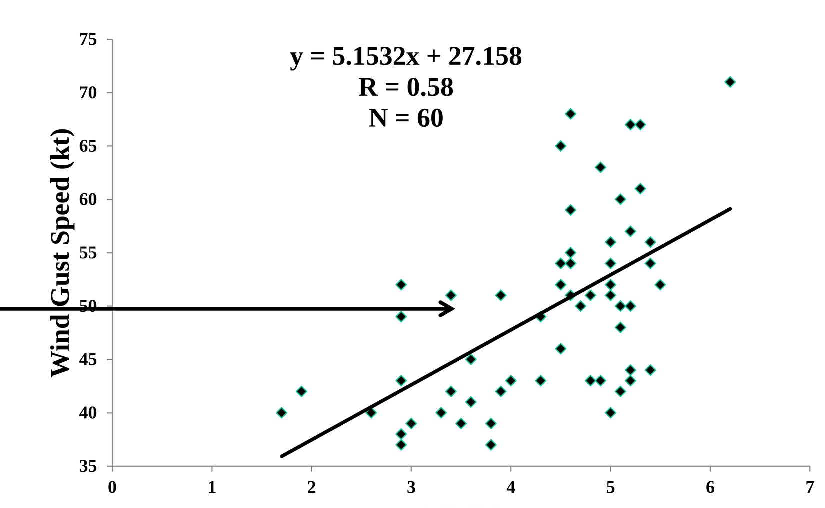
3. CASE STUDIES

18 August 2014 Southern California Downbursts

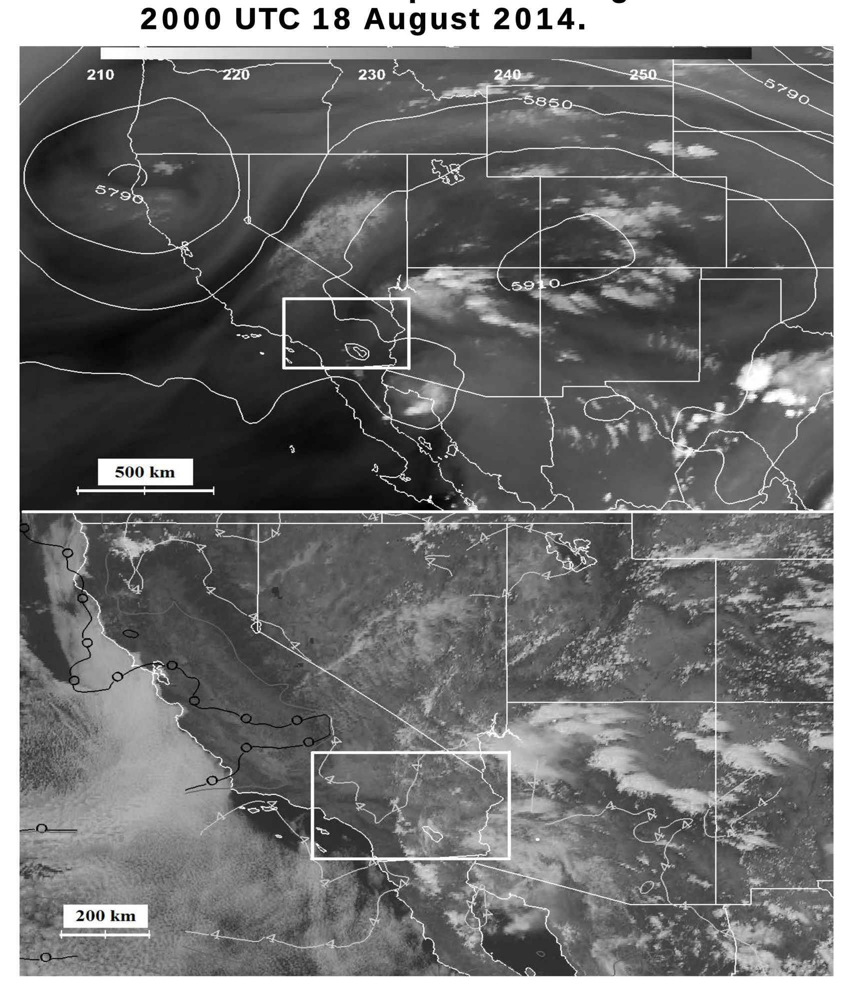
During August 2014, the "Four Corners High" (Type I) pattern was well-established over the western United States. During the afternoon of 18 August 2014, clusters of convective storms developed over the San Bernardino and San Jacinto Mountains of southern California, and remained nearly stationary. The only severe wind event west of the Rocky Mountains recorded by the National Weather Service/Storm Prediction Center on 18 August 2014 occurred at Barstow-Daggett Airport (DAG) with a wind gust of 52 knots at 2215 UTC. Twenty-Nine Palms Landing Field (NXP) recorded a weaker downburst wind gust of 39 knots at 2234 UTC.



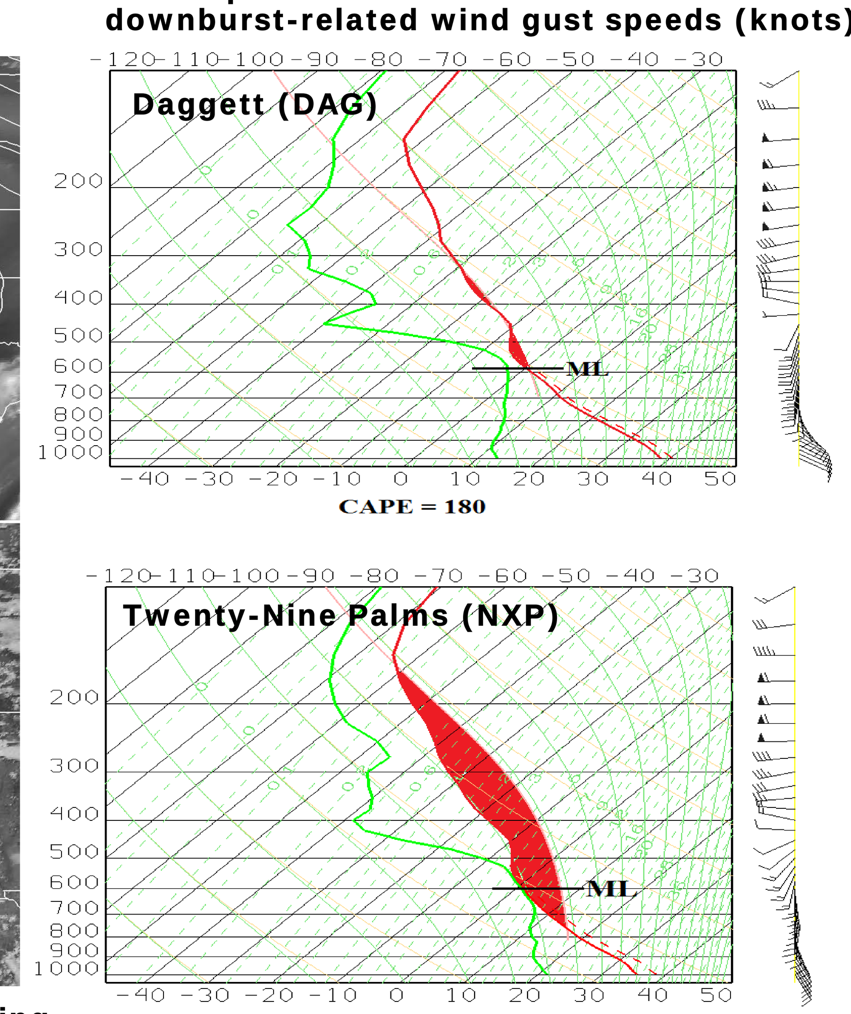
GOES-15 MWPI product image at 2000 UTC 18 August 2014.



Scatterplot of MWPI values vs. measured downburst-related wind gust speeds (knots).

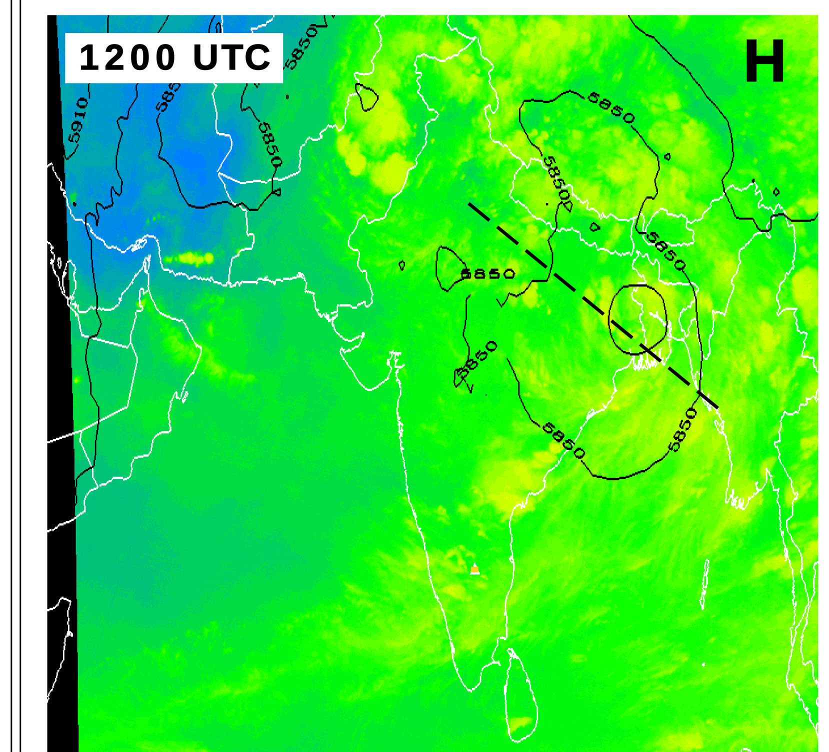


GOES-15 water vapor channel image with overlying 500 mb geopotential height contours (in meters, top) and GOES-15 MWPI product image (bottom) at 2000 UTC 18 August 2014.

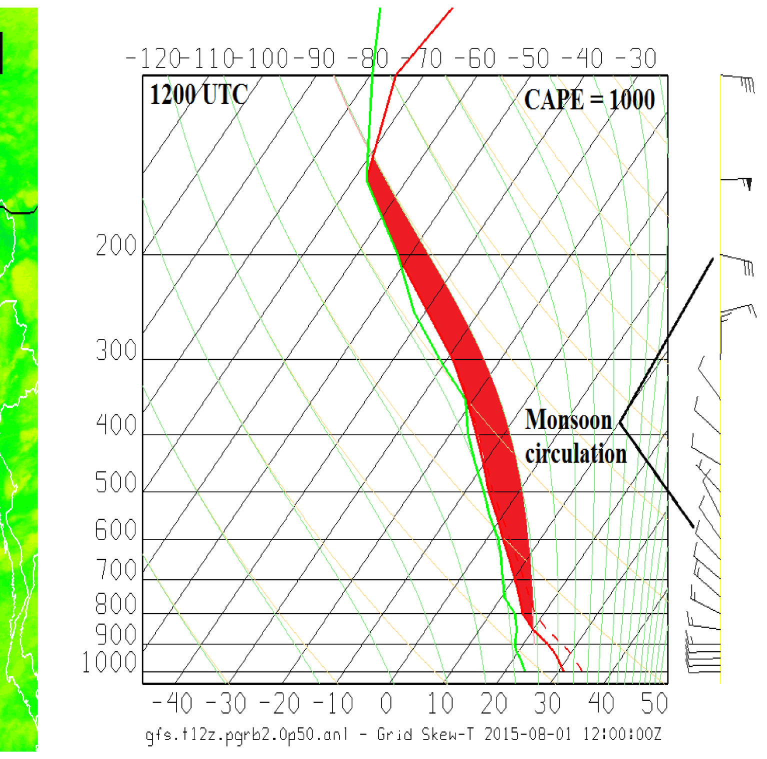


RAP model-derived sounding thermodynamic profiles at 2000 UTC (top) and at 2100 UTC (bottom) 18 August 2014.

1 August 2015 Bangalore, India Downburst

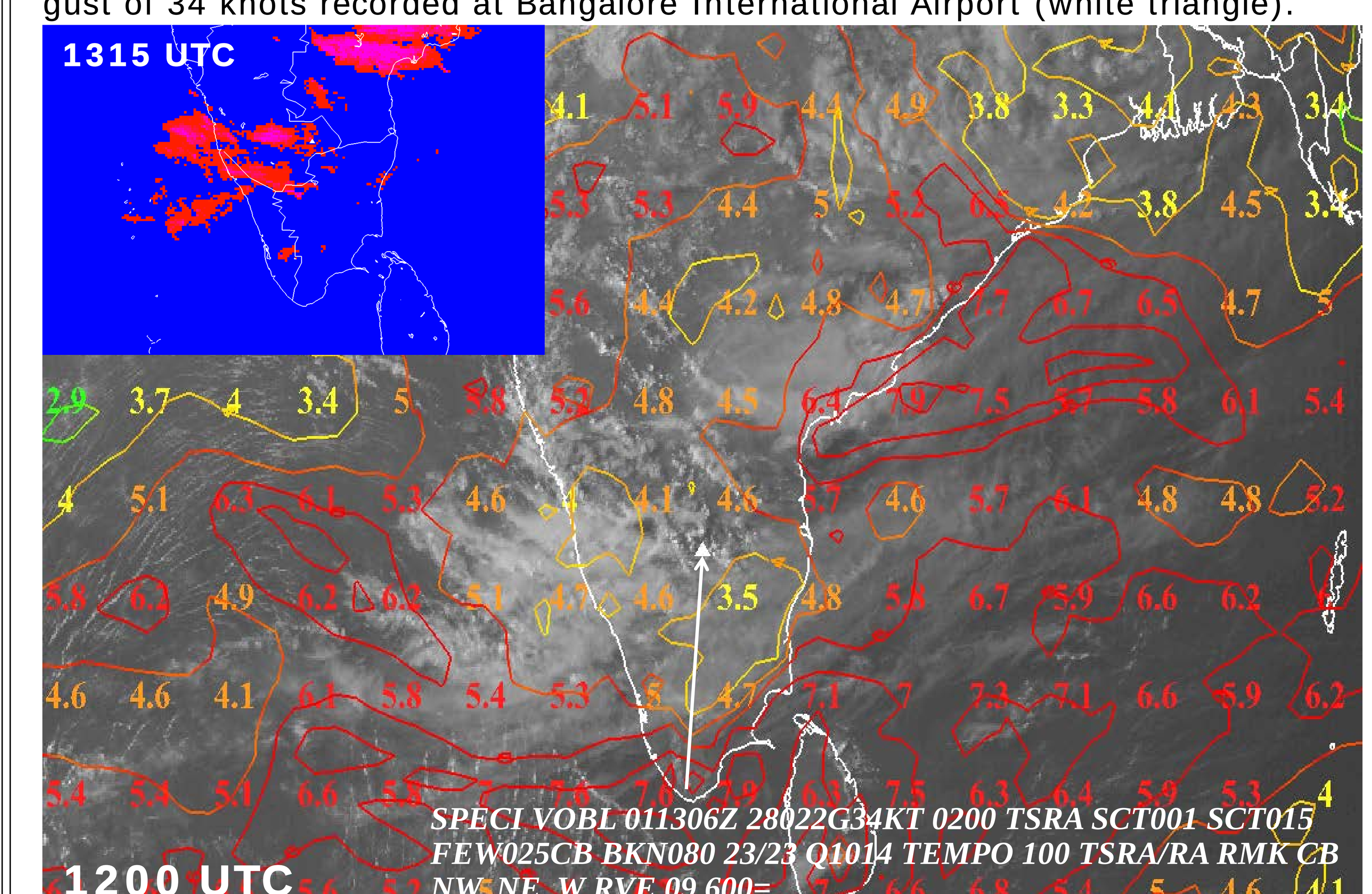


METEOSAT-7 WV image with overlying GFS model 500 mb height contours (meters) .



GFS model-derived sounding profile at Bangalore, India.

During the afternoon of 1 August 2015, clusters of thunderstorms developed over the coastal region and the Western Ghats of Karnataka and then tracked east and southeastward. By early evening, near 1305 UTC, a thunderstorm that developed along an outflow boundary produced a strong downburst with a wind gust of 34 knots recorded at Bangalore International Airport (white triangle).



GFS MWPI overlying METEOSAT-7 VIS image at 1200 UTC 1 August 2015 with KALPANA-1 VHR WV-IR brightness temperature difference at 1315 UTC (inset).

4. REFERENCES

Adams, D. K. and A. C. Comrie, 1997. The North American Monsoon. *Bull. Amer. Meteor. Soc.*, 78, 2197–2213.

Maddox, R., D. McCollum, and K. Howard, 1995: Large-scale patterns associated with severe summertime thunderstorms over central Arizona. *Wea. Forecasting*, 10, 763–778.

Pryor, K. L., 2014: Downburst prediction applications of meteorological geostationary satellites. *Proc. SPIE Conf. on Remote Sensing of the Atmosphere, Clouds, and Precipitation V*, Beijing, China, doi:10.1117/12.2069283.

Pryor, K. L., 2015: Progress and Developments of Downburst Prediction Applications of GOES. *Wea. Forecasting*, 30, 1182–1200.

Rao, Y. P., 1976: *Southwest Monsoon*. India Meteorological Dept., New Delhi, 379 pp.

Saeed, S., 2011: Relative contribution of the mid-latitude circumglobal wave train to the South Asian summer monsoon. Reports on Earth System Science 106/2011, Max Planck Institute for Meteorology, 108 pp.

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