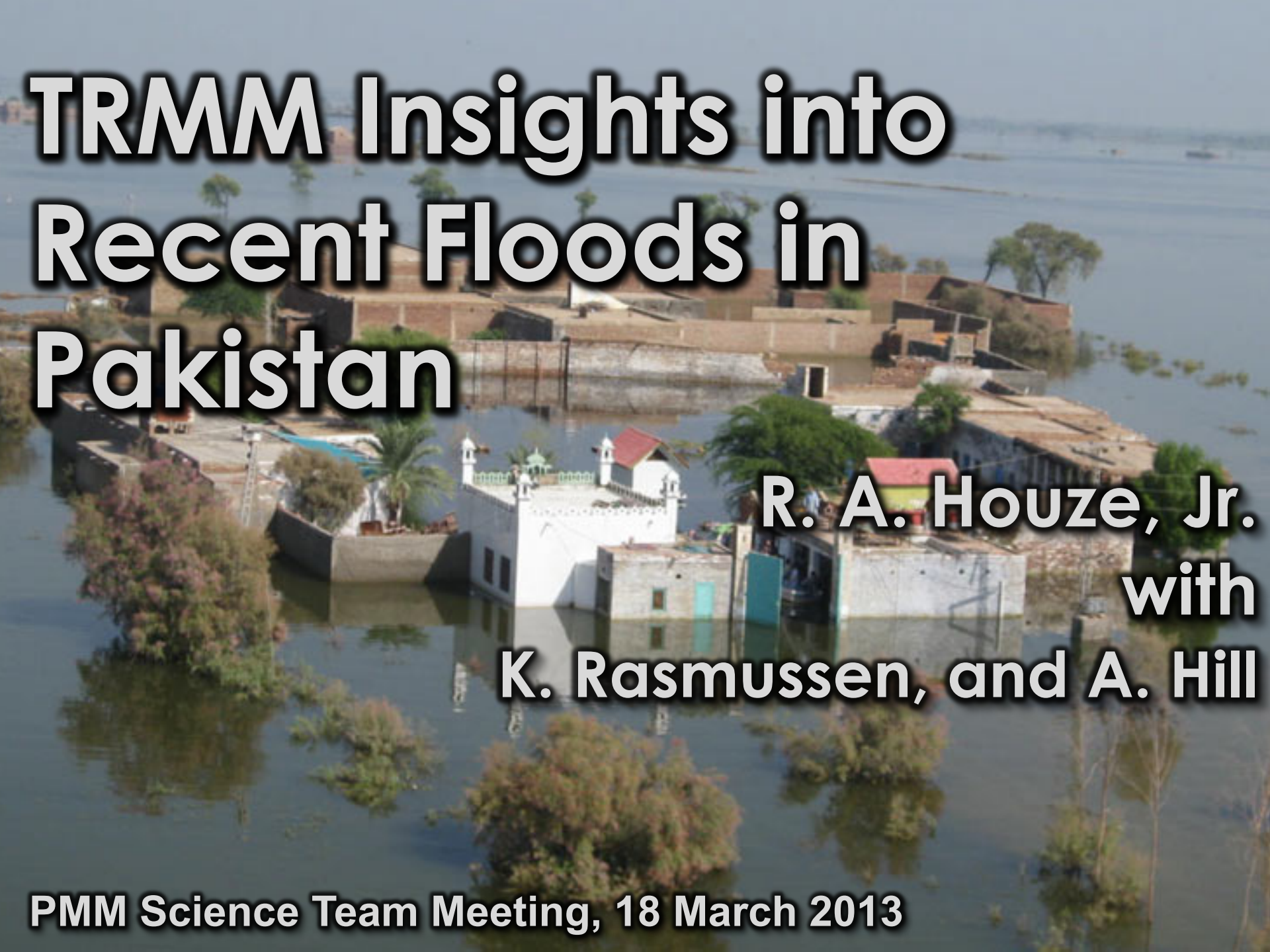


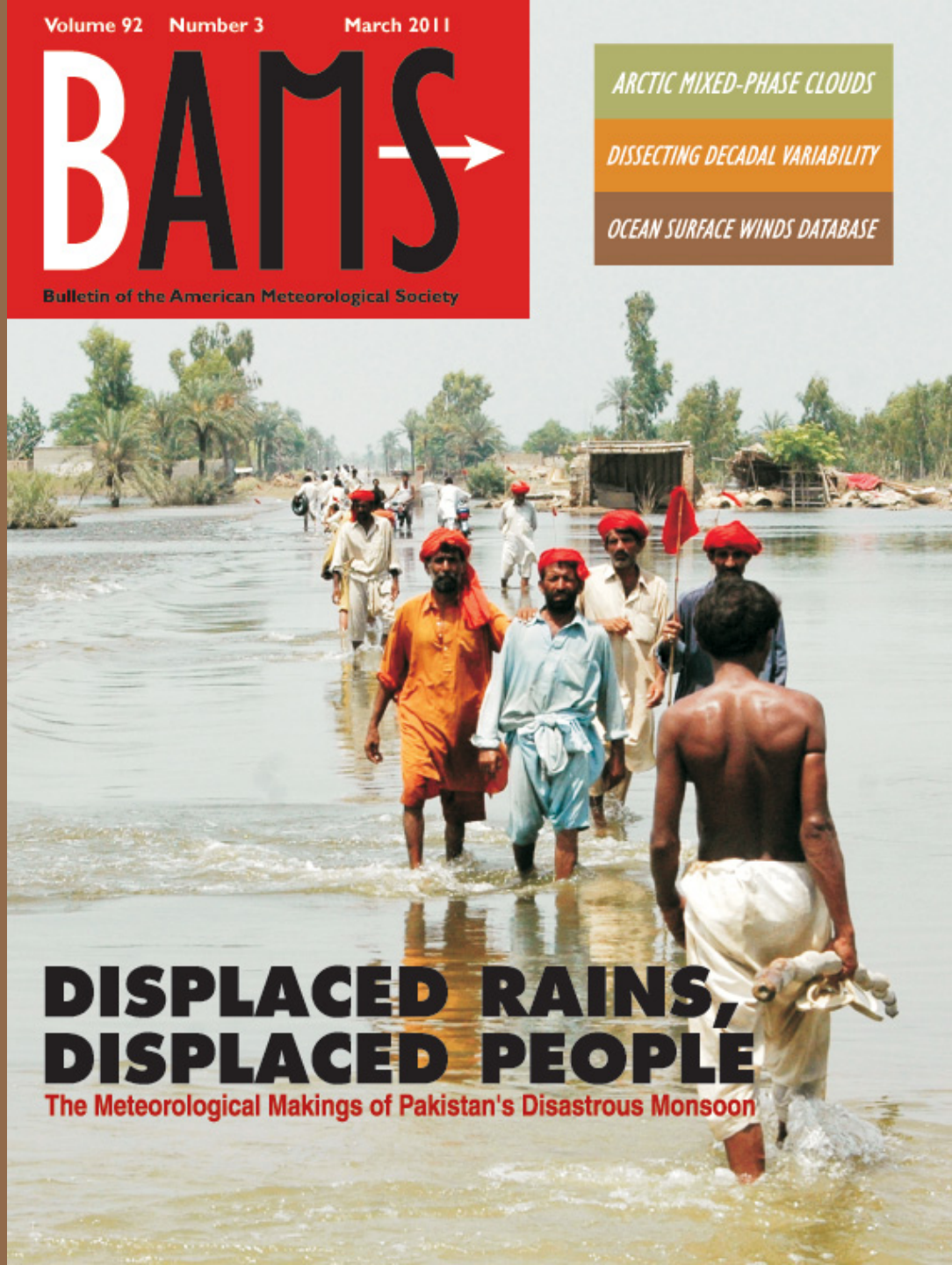
TRMM Insights into Recent Floods in Pakistan

R. A. Houze, Jr.
with
K. Rasmussen, and A. Hill

PMM Science Team Meeting, 18 March 2013


Pakistan 2010
2000 lives, extensive livestock, household, infrastructure & agricultural losses

Article on the 2010 Pakistan floods in BAMS March 2011



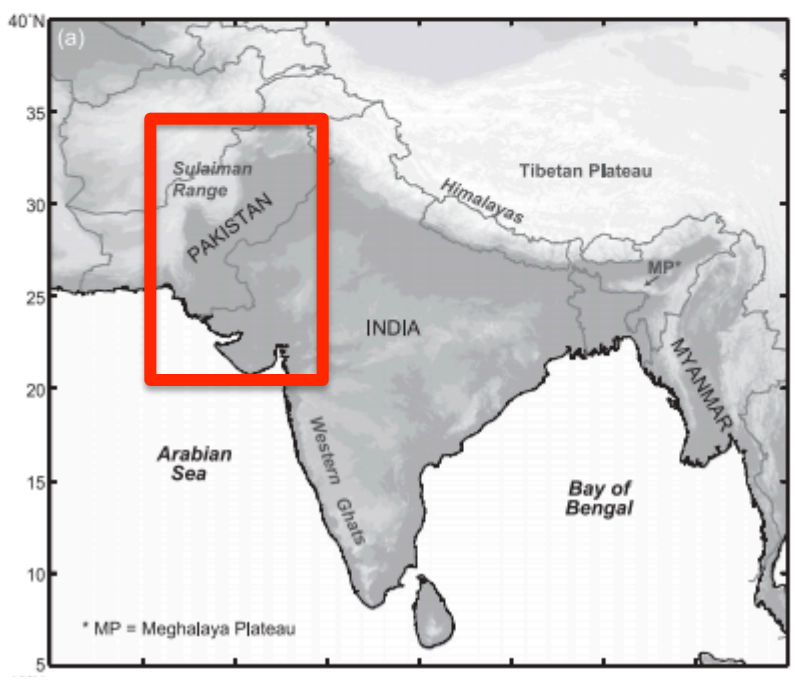
Major floods in Pakistan in last 3 years

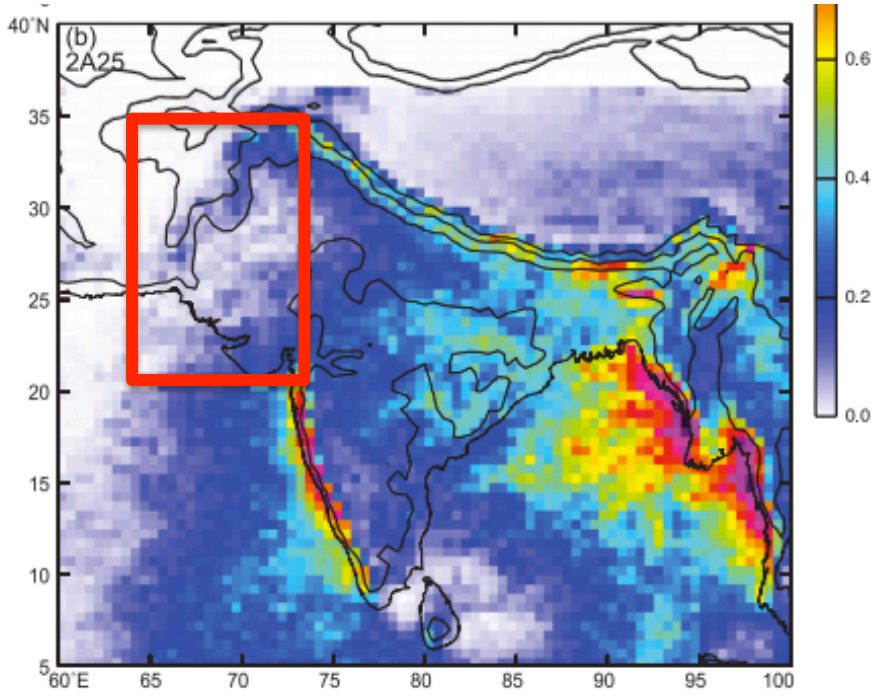
2010—Indus River, 2000+ dead, 20M+ affected

2011—Sindh region, lower Indus River, 400+ dead, 8M+ affected

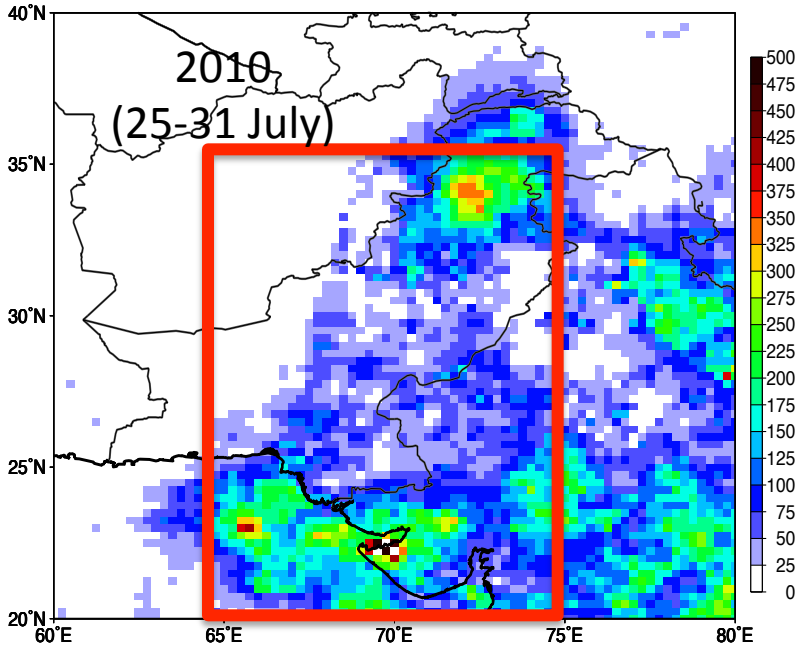
2012—Sindh region, lower Indus River, 450+ dead, 5M+ affected

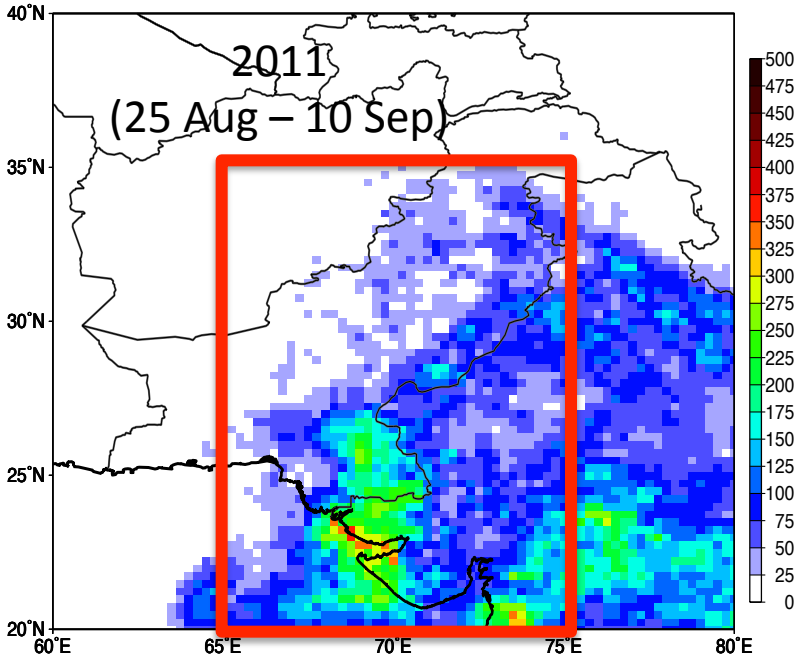
Geography &Rainfall Climatology

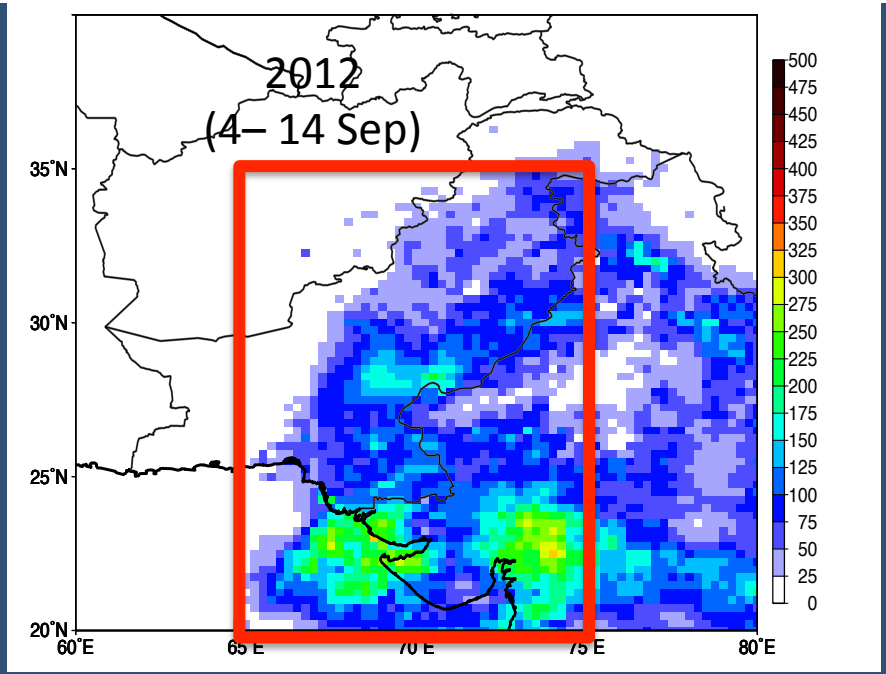




Rainfall in flood episodes mm/h







Radar Identification of Extreme Rainstorms

Identify each contiguous 3D echo object seen on radar

Convective component

Extreme characteristic

Contiguous 3D volume of convective echo > **40 dBZ**

Top height > **10 km**

"Deep convective core"

Horizontal area > **1 000 km²**

"Wide convective core"

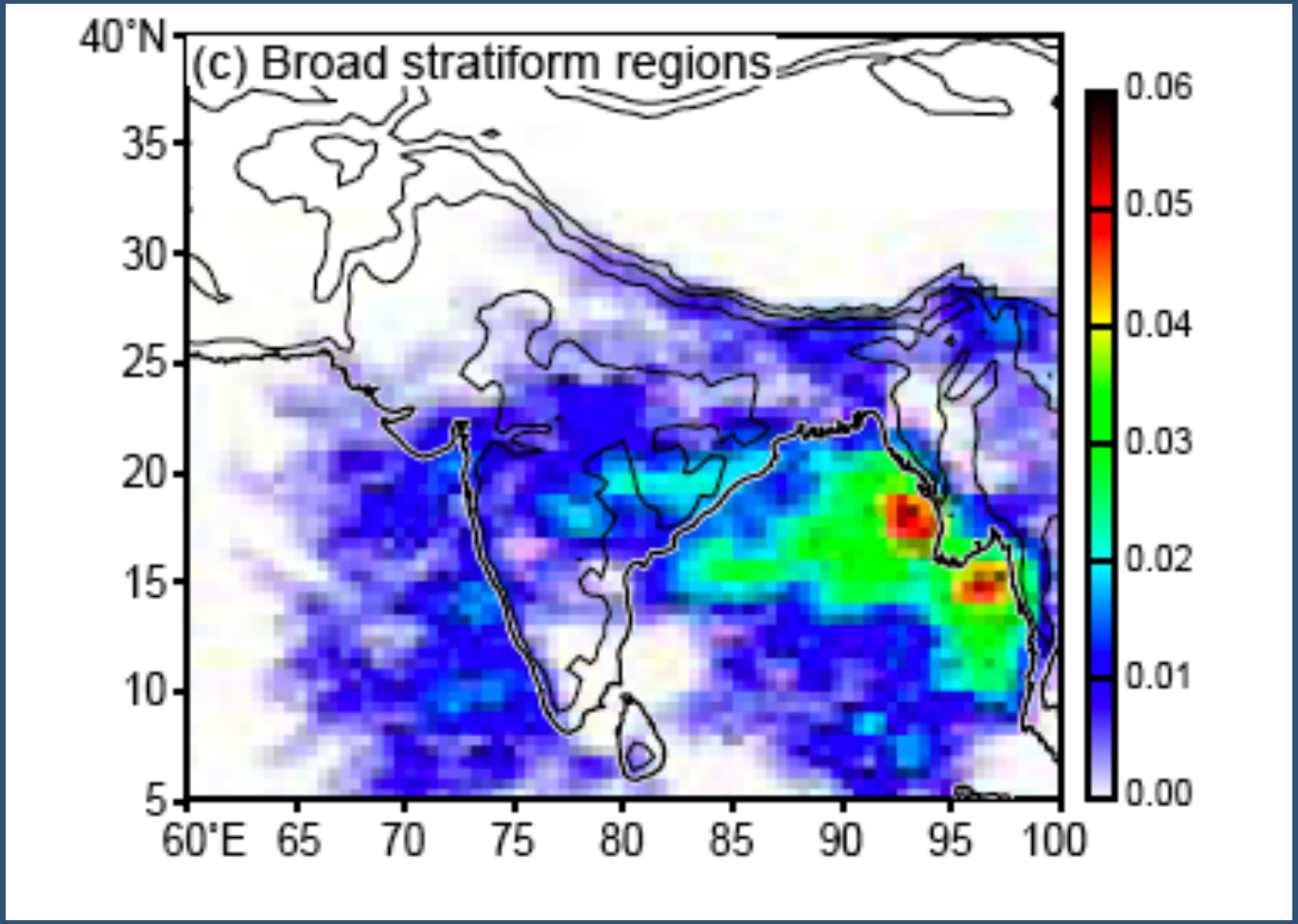
Stratiform component

Extreme characteristic

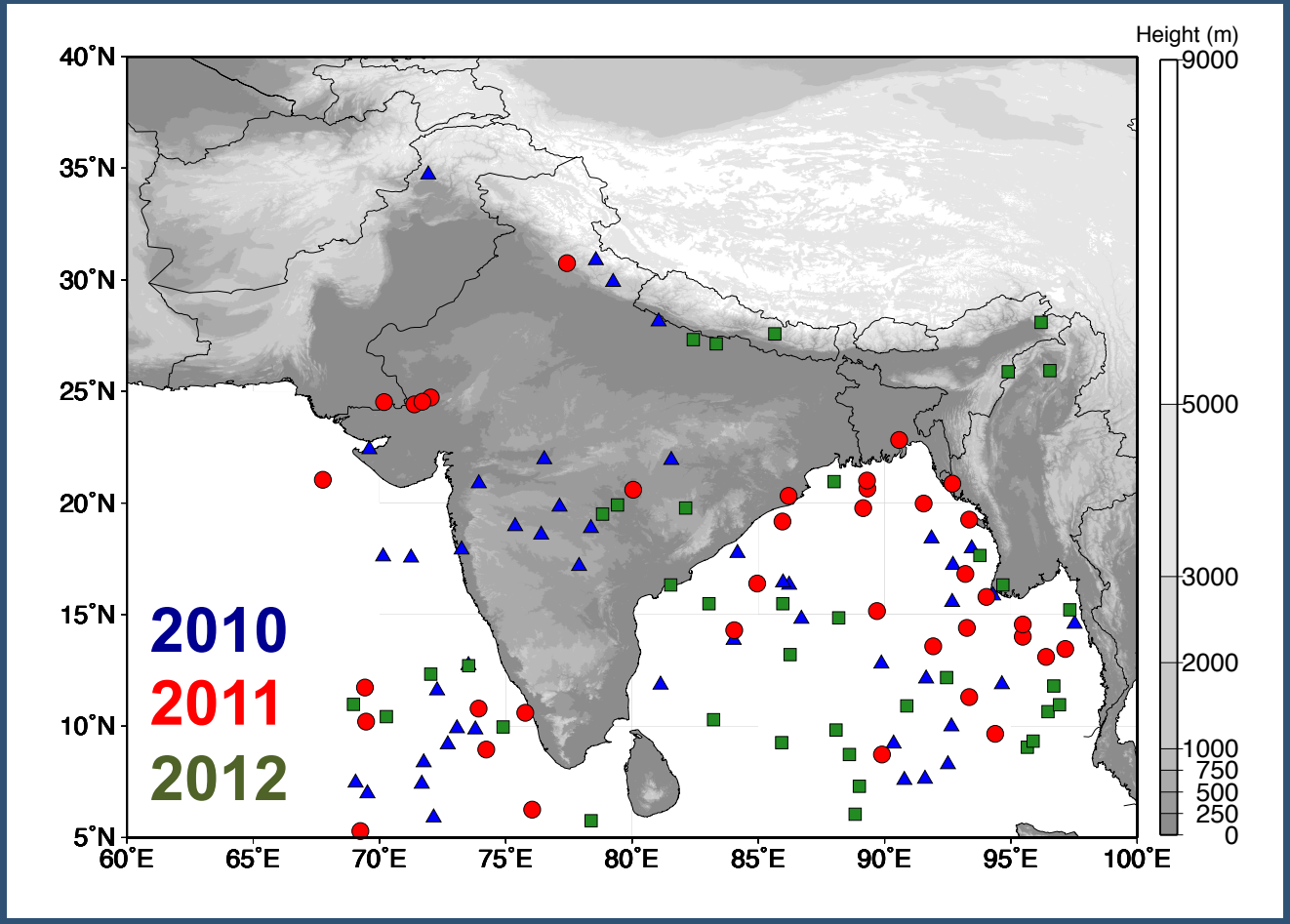
Contiguous stratiform echo with horizontal area > **50 000 km²**

"Broad stratiform region"

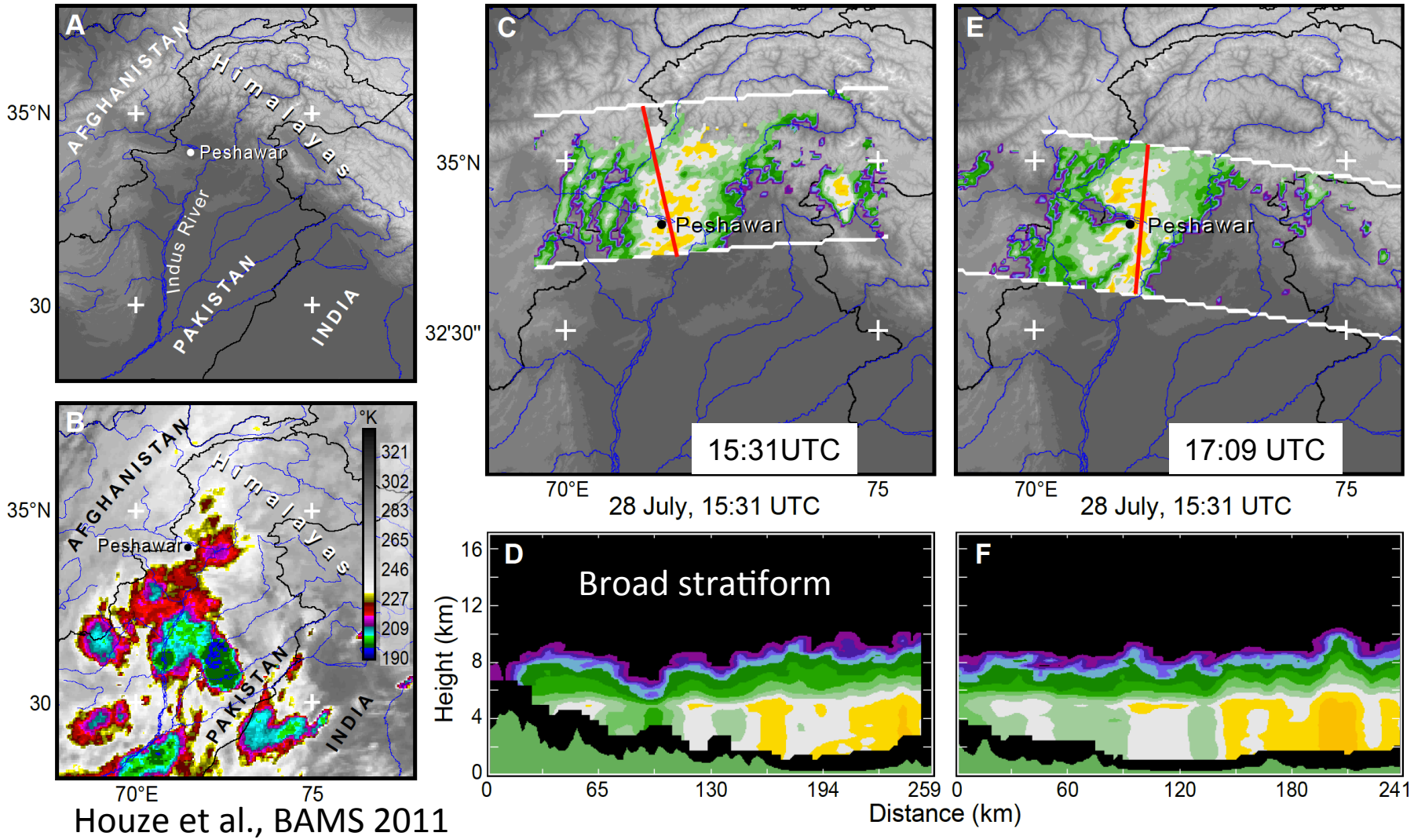
Probability of Broad Stratiform Echo based on multiyear climatolofy of TRMM PR data



Observations of Broad Stratiform Regions During 2010, 2011, & 2012 Flood Episodes



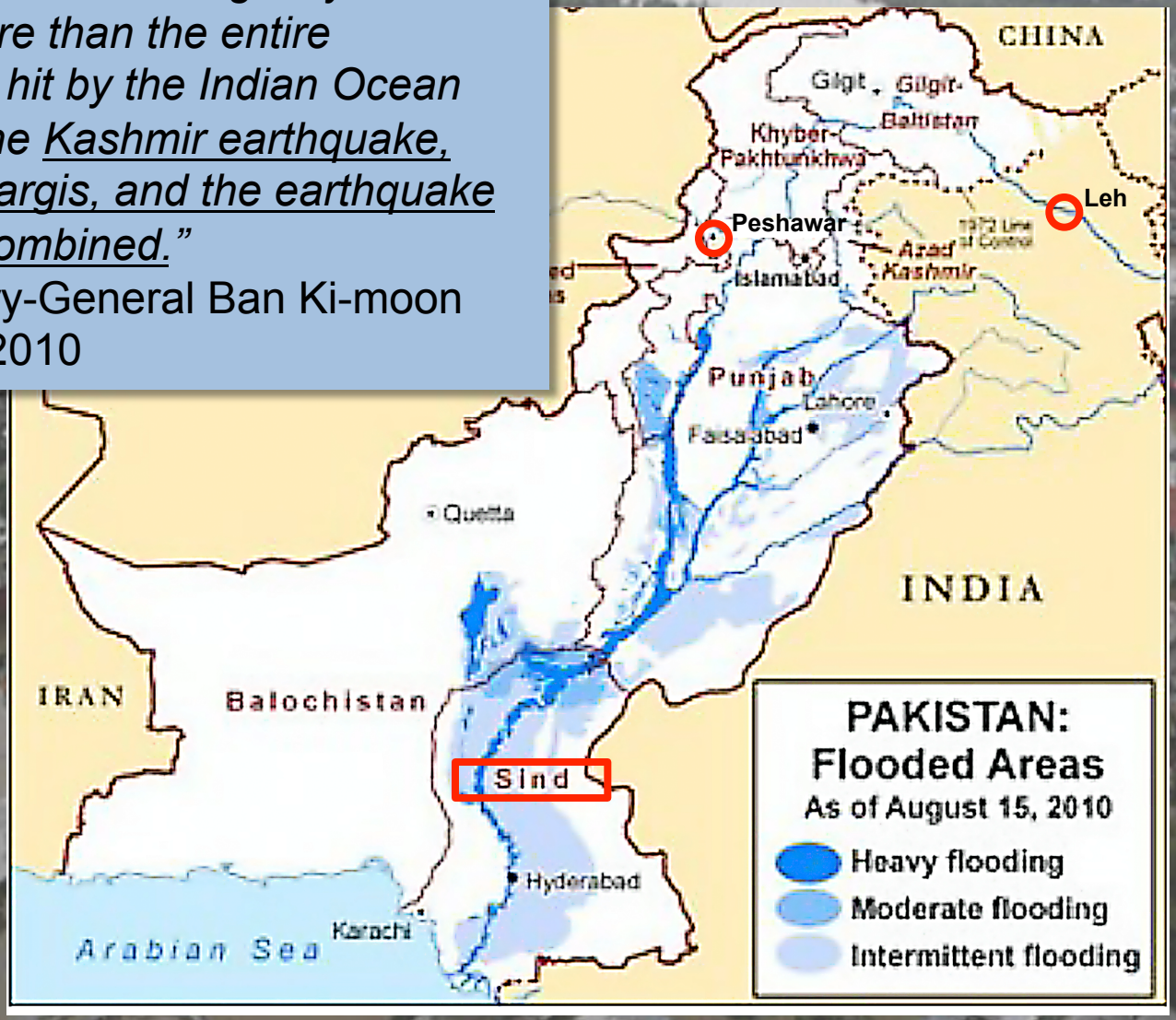
Broad stratiform precipitation over the mountains of Pakistan in 2012



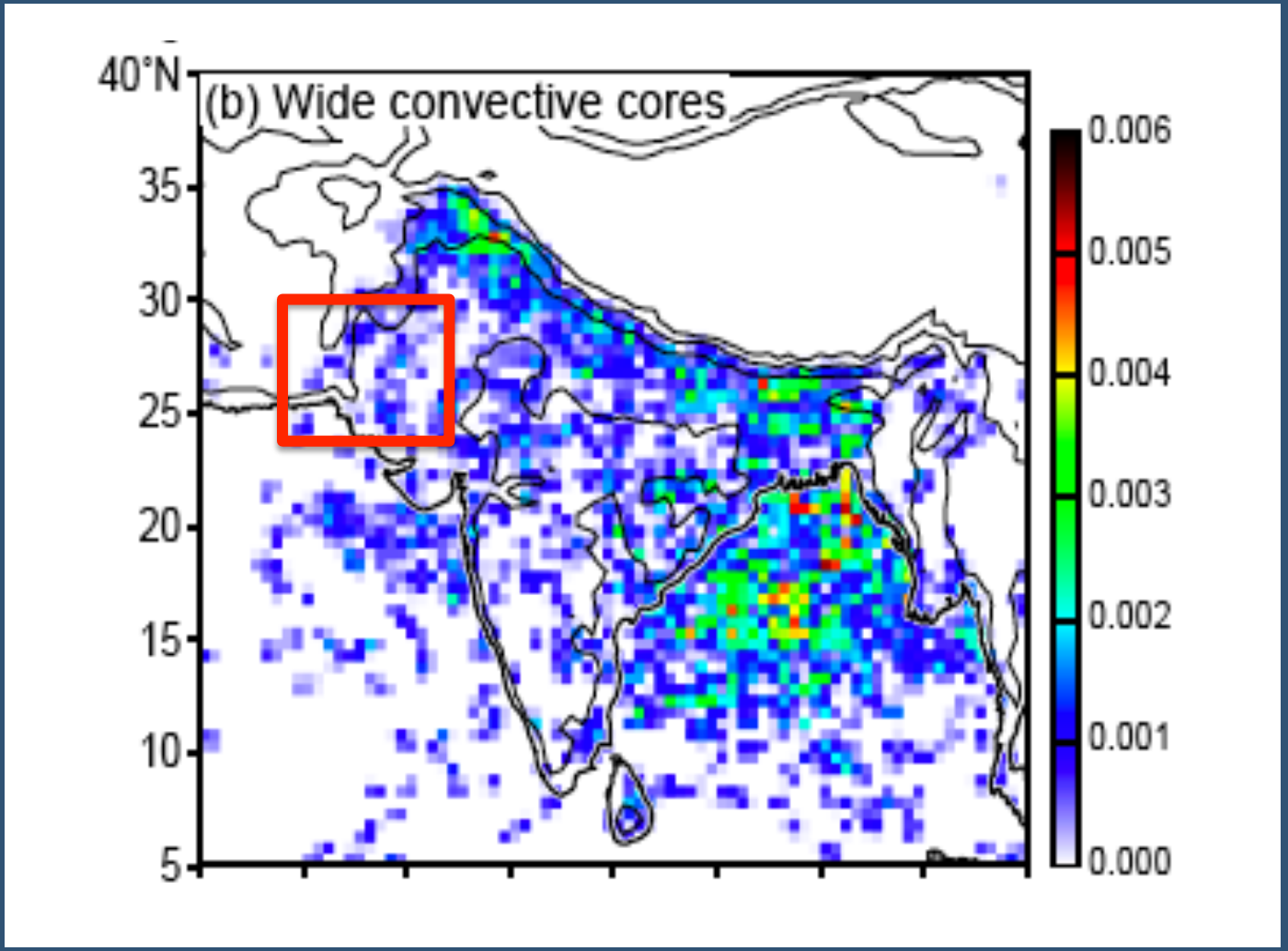
Houze et al., BAMS 2011

"Almost 20 million people need shelter, food and emergency care. That is more than the entire population hit by the Indian Ocean tsunami, the Kashmir earthquake, Cyclone Nargis, and the earthquake in Haiti—combined."

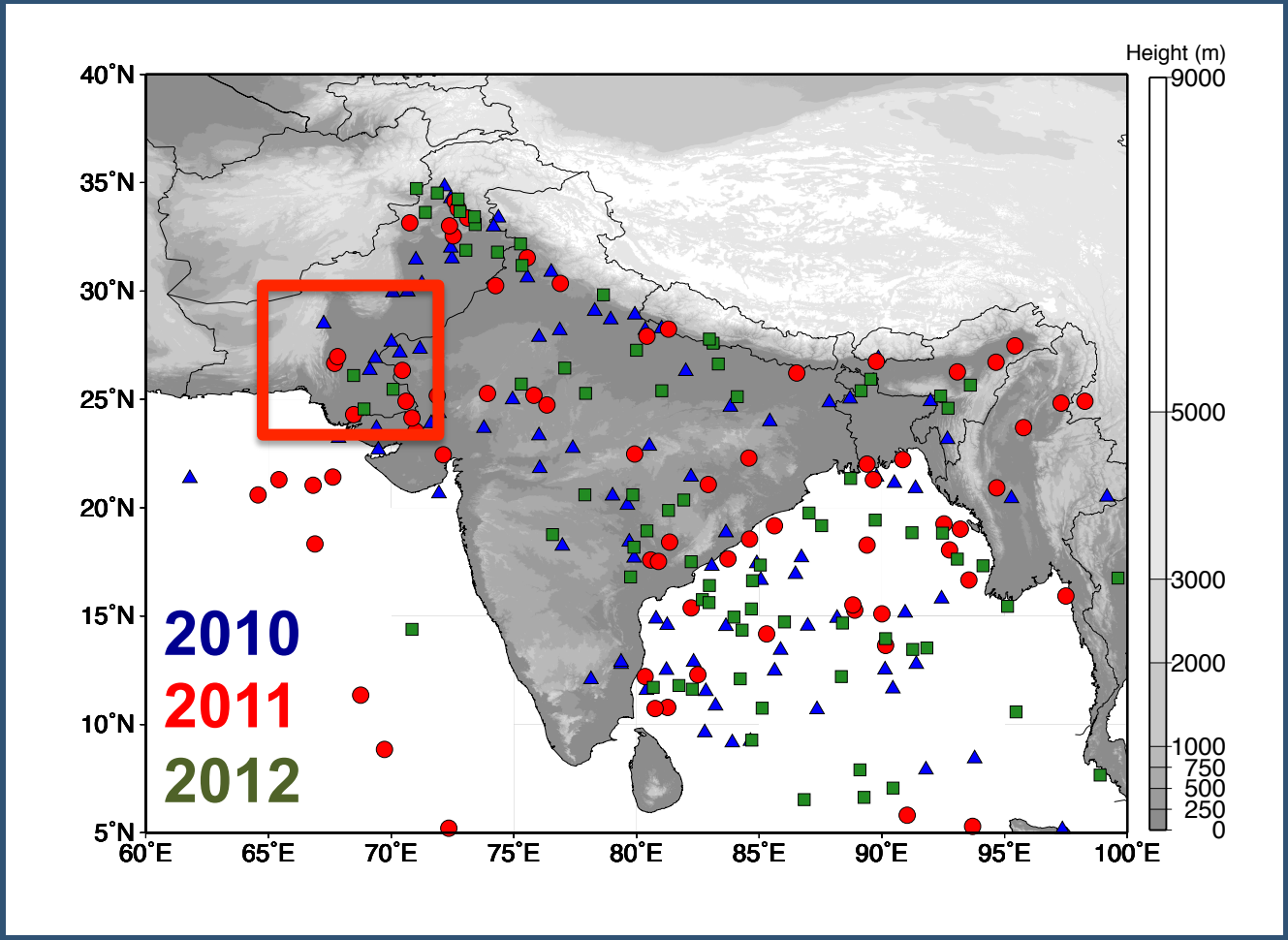
Secretary-General Ban Ki-moon
August 2010



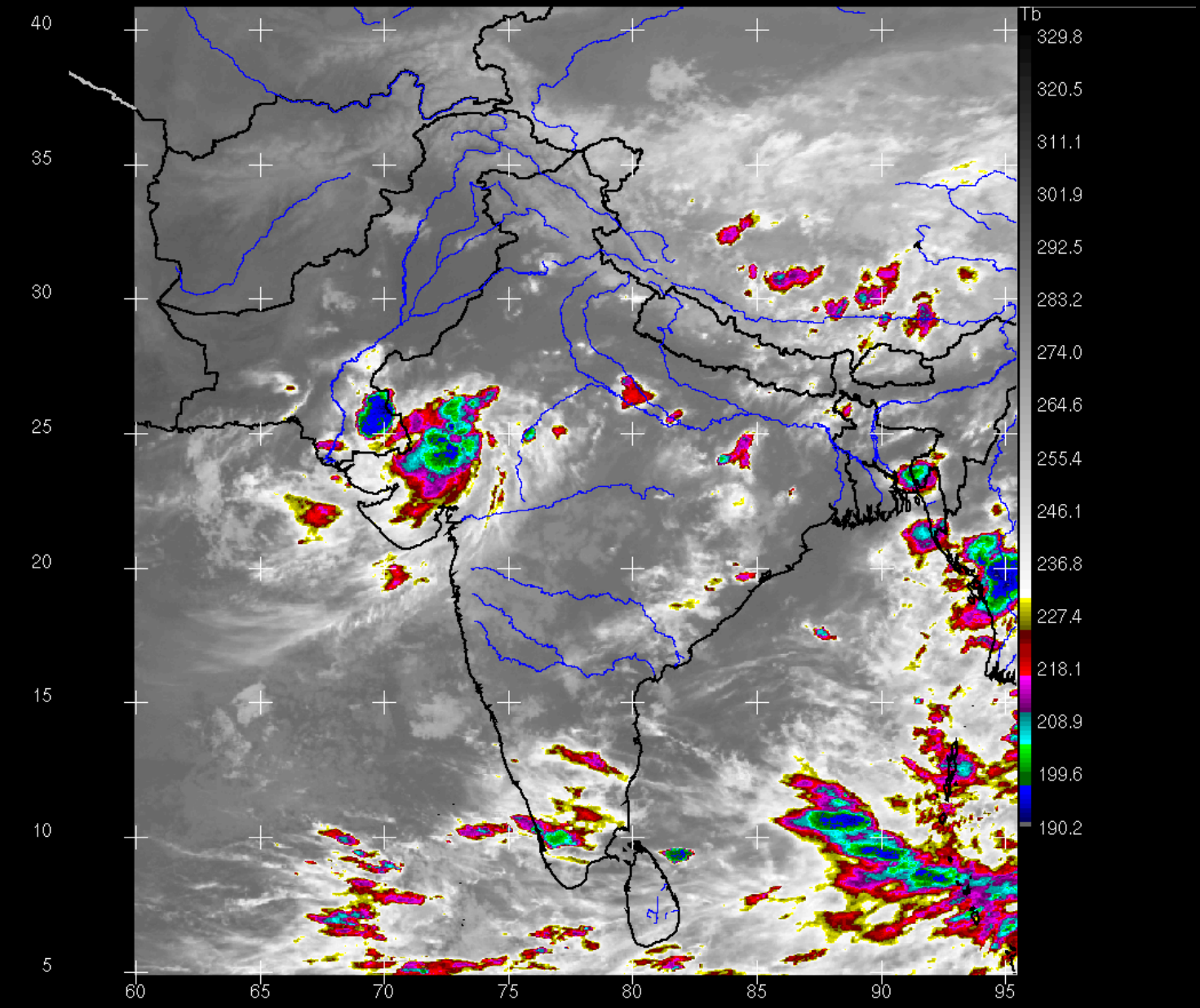
Multiyear TRMM PR Climatology of Wide Convective Echo Cores



Observations of Wide Convective Core Echoes During 2010, 2011, & 2012 Flood Episodes

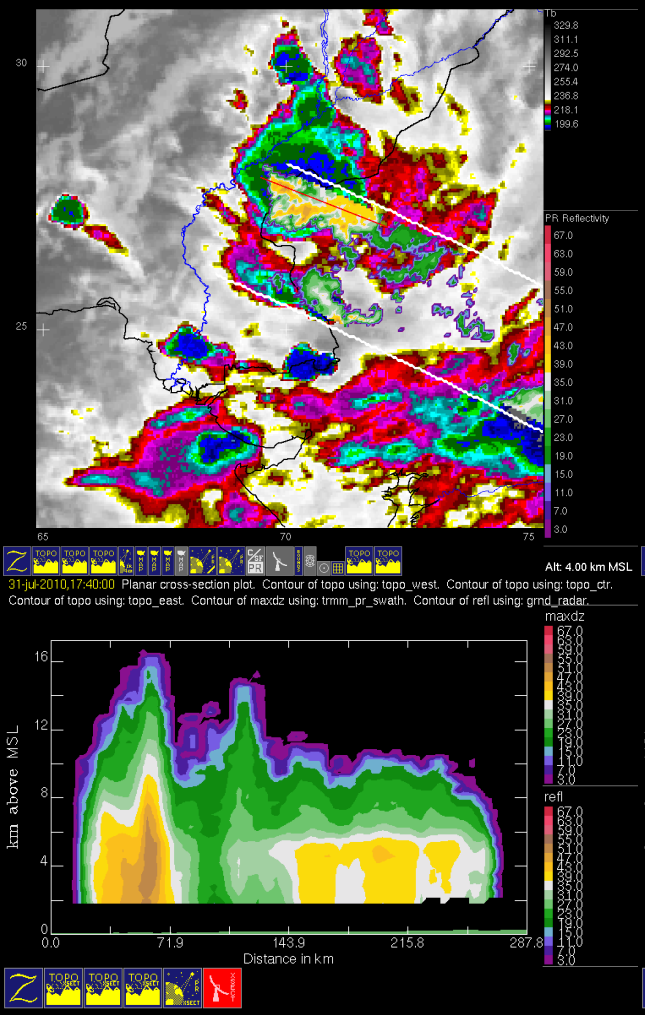


11-sep-2011,16:00:00 elev_west elev plot. elev_ctr elev plot. elev_east elev plot. meteosat5_ir Tb plot. Elev_ncep1 elev contour. Elev_ncep3 elev contour.

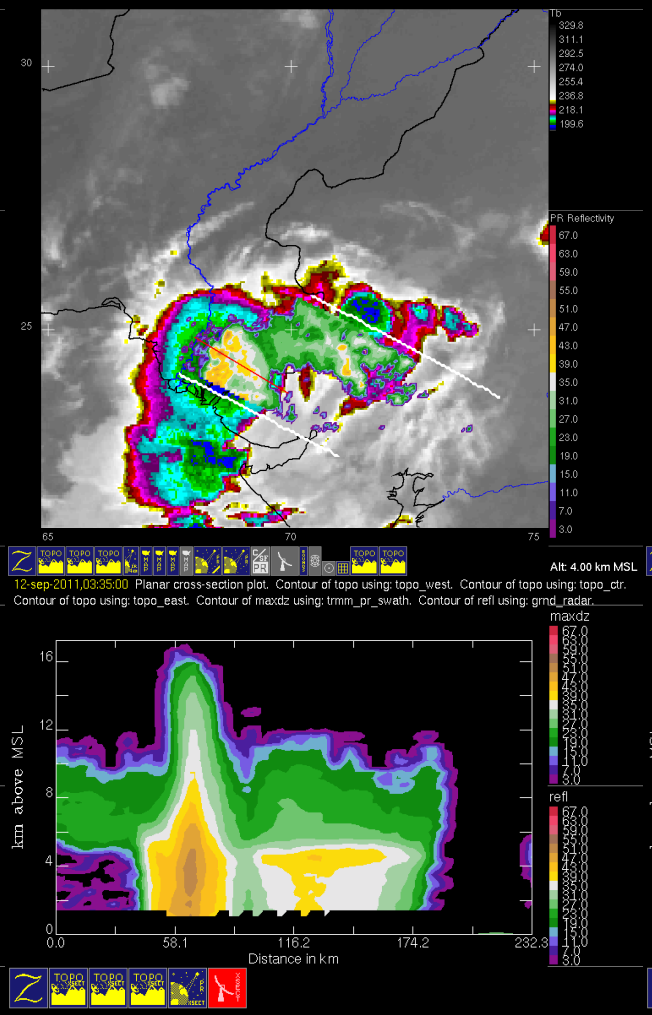


Examples of Storms Producing Floods

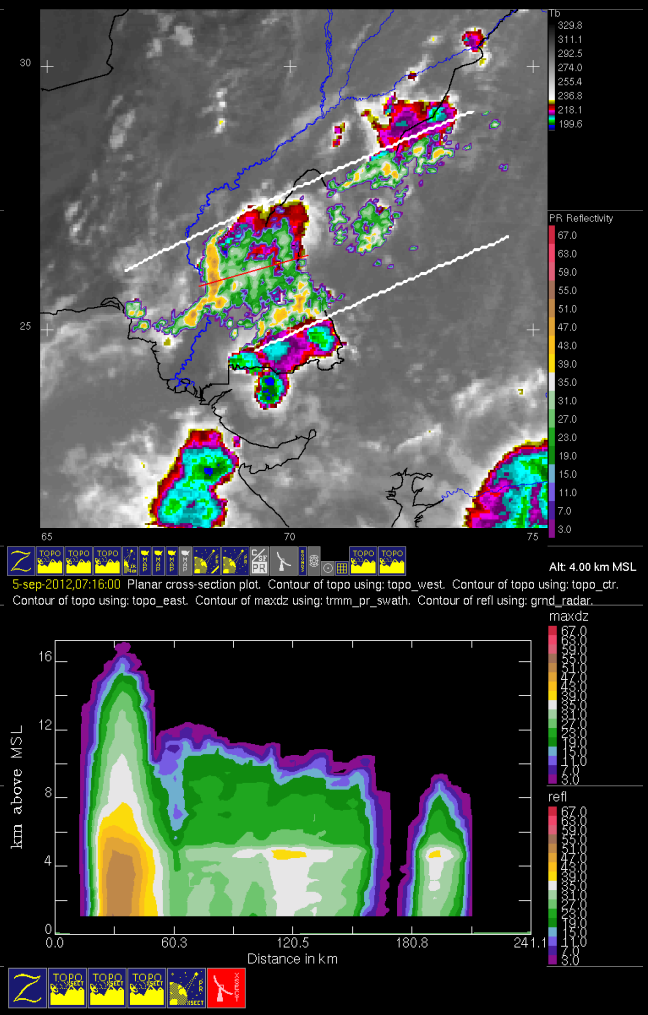
2010



2011



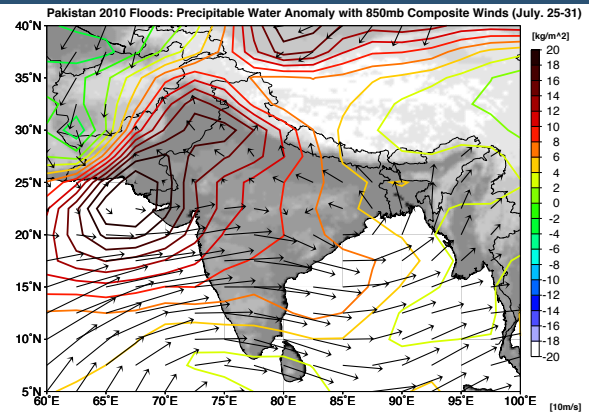
2012

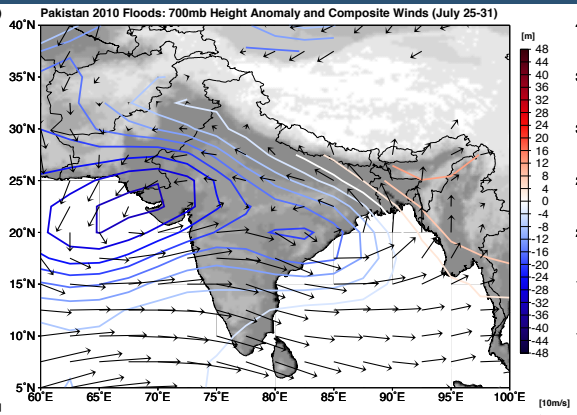


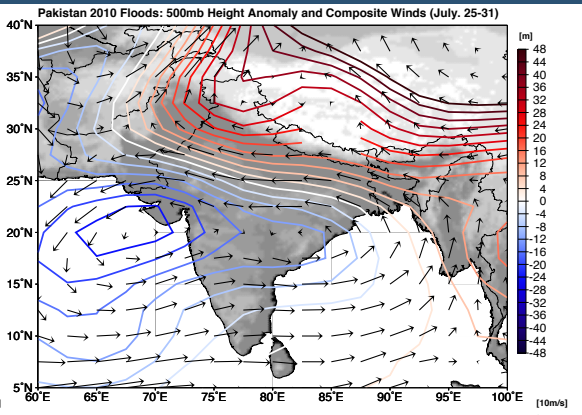
Composites for Flood Periods

850 mb PW Anomaly | **700 mb** Hgt Anomaly | **500 mb** Hgt Anomaly

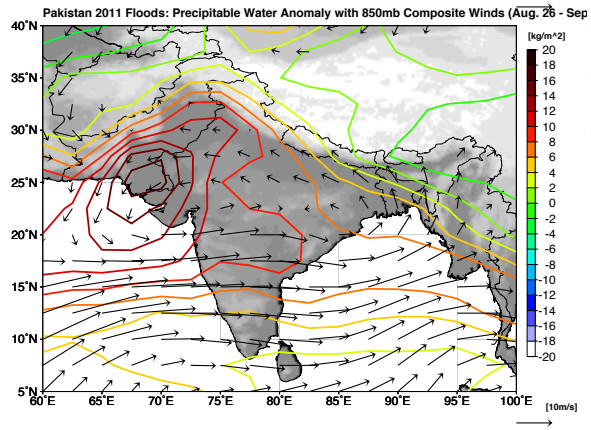
2010

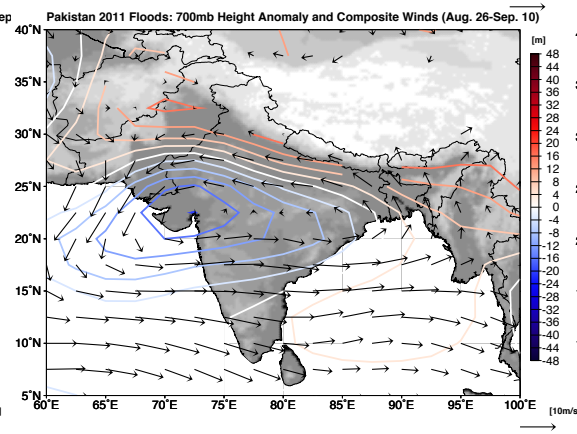


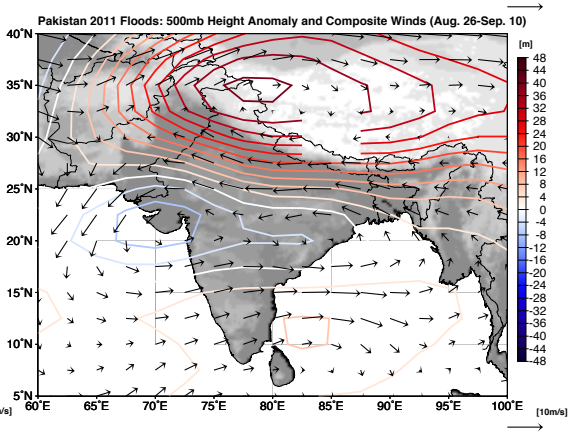




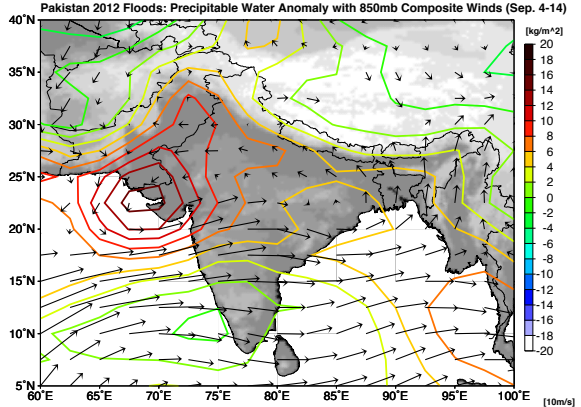
2011

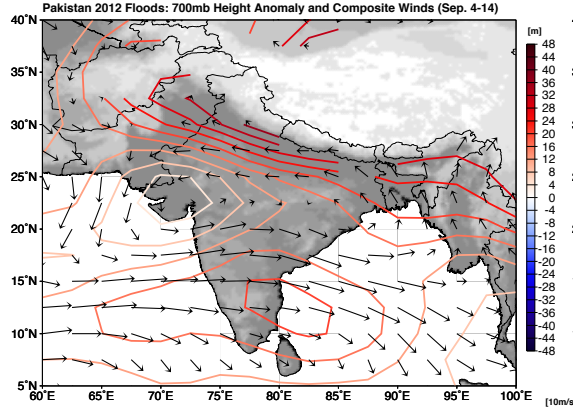


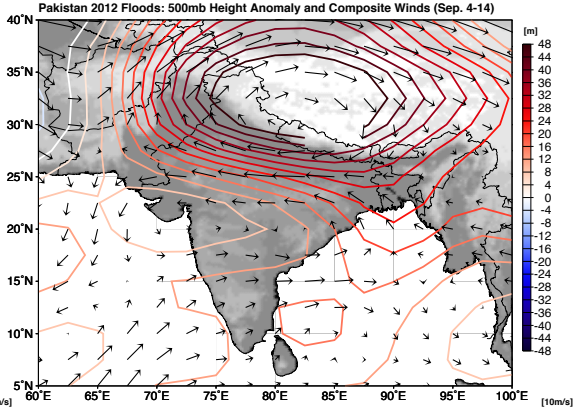




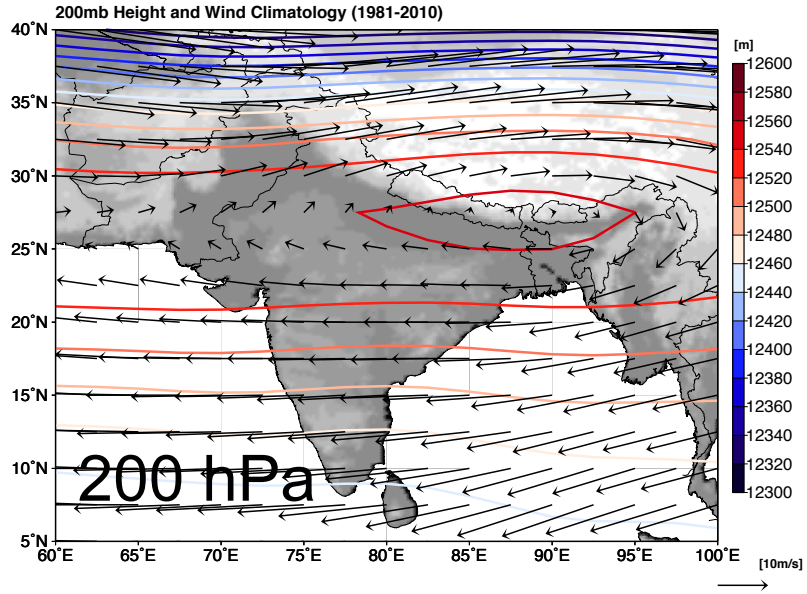
2012

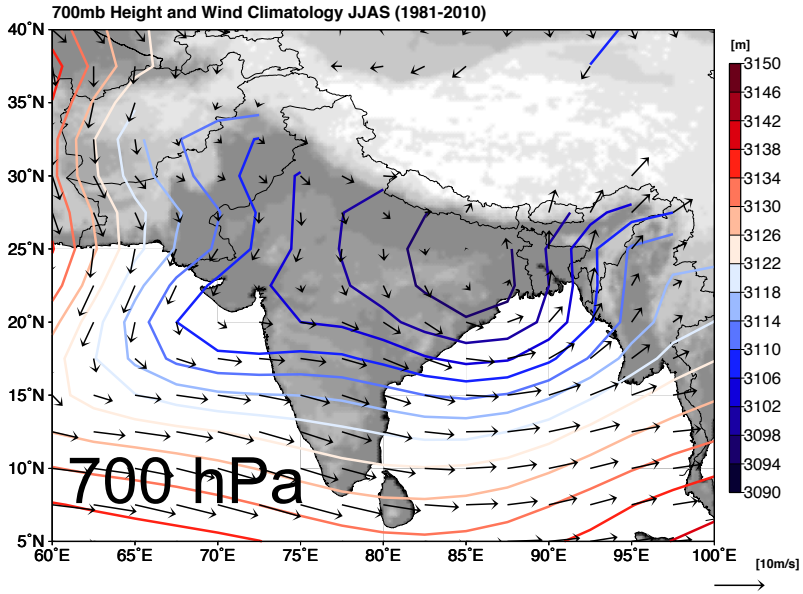


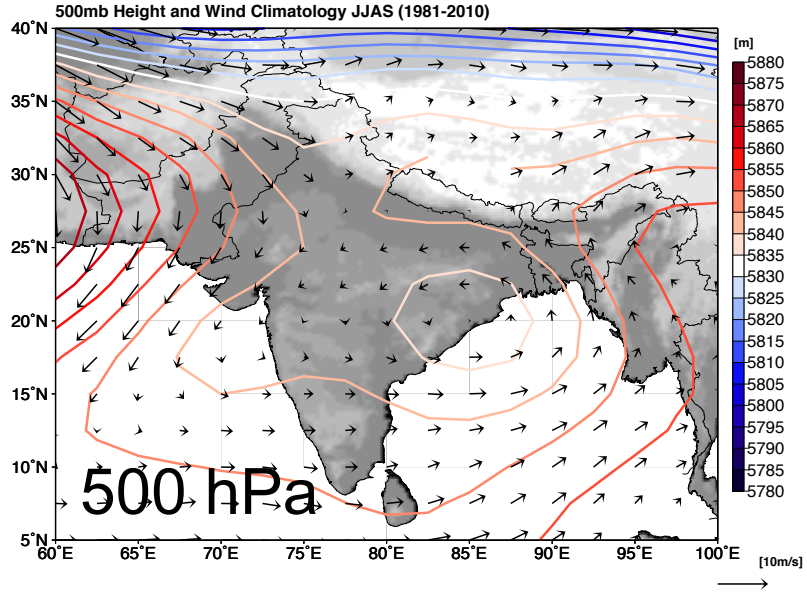


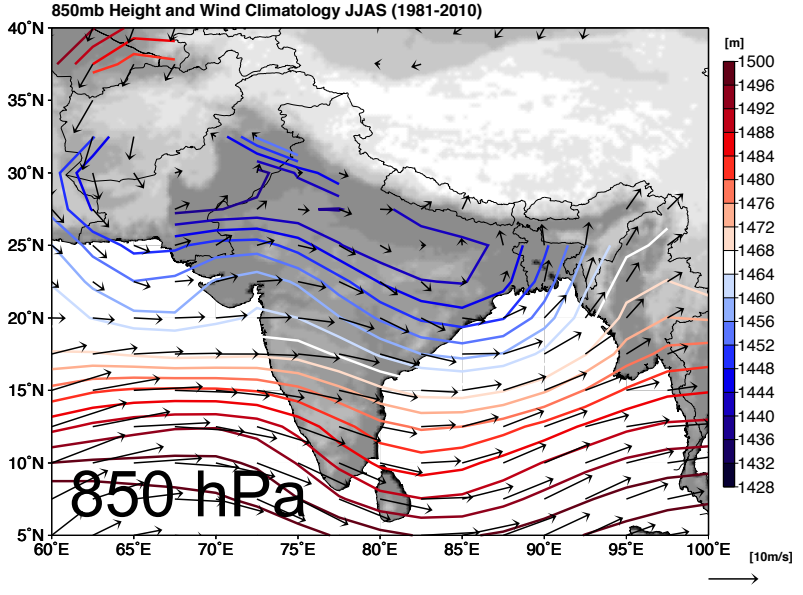


JJAS Climatology 1981-2010

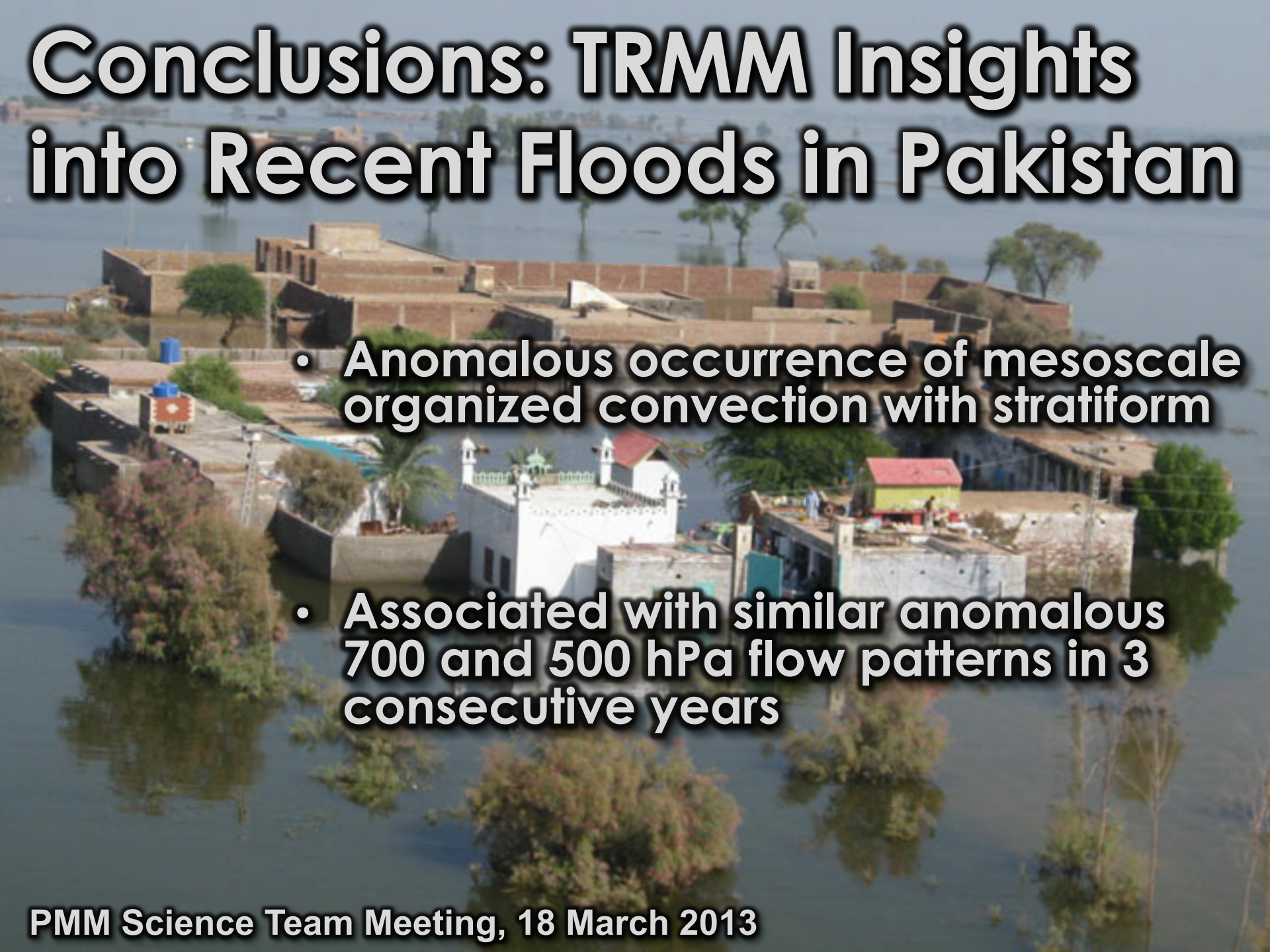








Conclusions: TRMM Insights into Recent Floods in Pakistan



- Anomalous occurrence of mesoscale organized convection with stratiform
- Associated with similar anomalous 700 and 500 hPa flow patterns in 3 consecutive years


End
Acknowledgements: NASA Grants
NNX10AH70G, NNX11AL65H, and NNX13AG71G
PMM Science Team Meeting, 18 March 2013

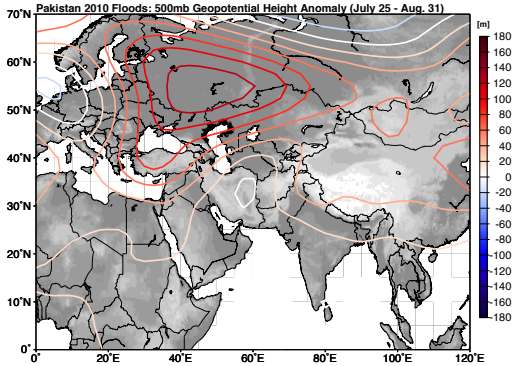
Extra slides

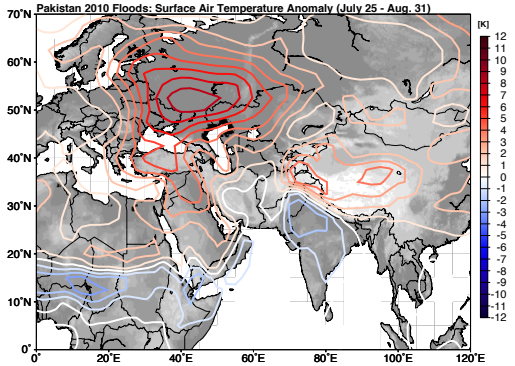
Blocking Pattern

500 hgt anom

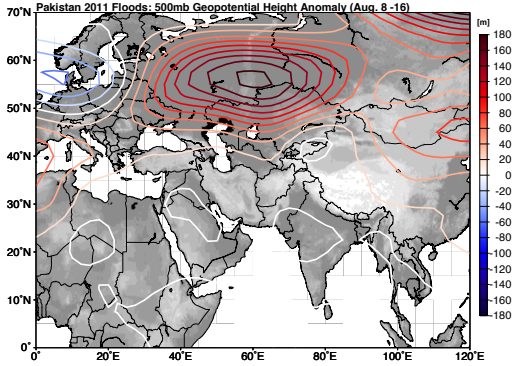
Surf. T anom

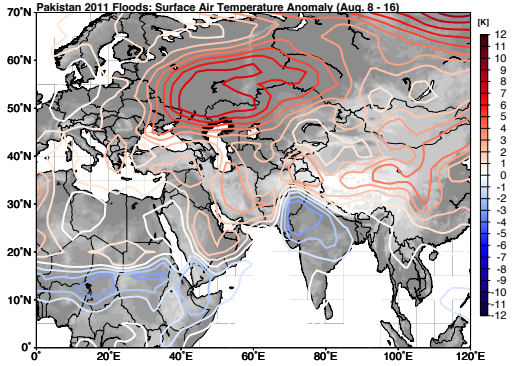
2010



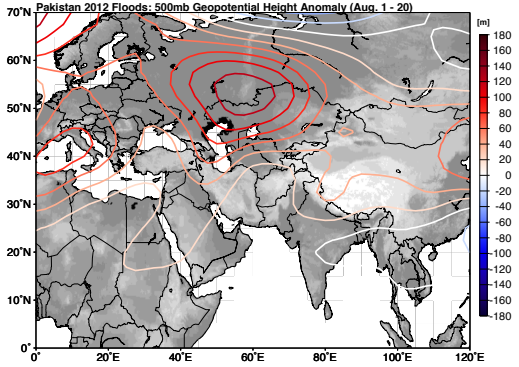


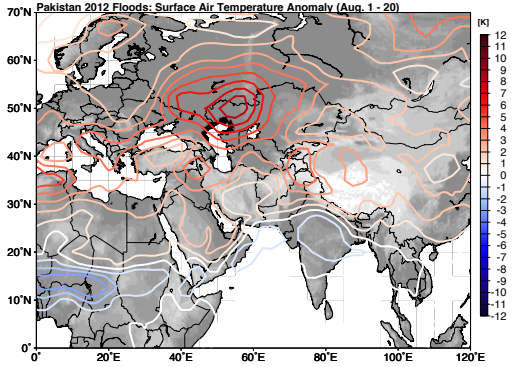
2011





2012





Periods vary in length but all surpass the 5 day minimum length to classify as “blocking” pattern

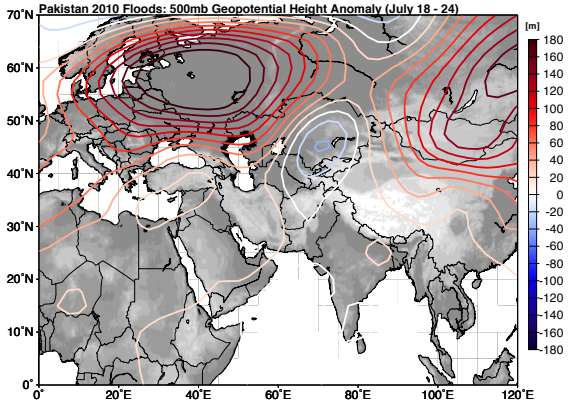
Periods:

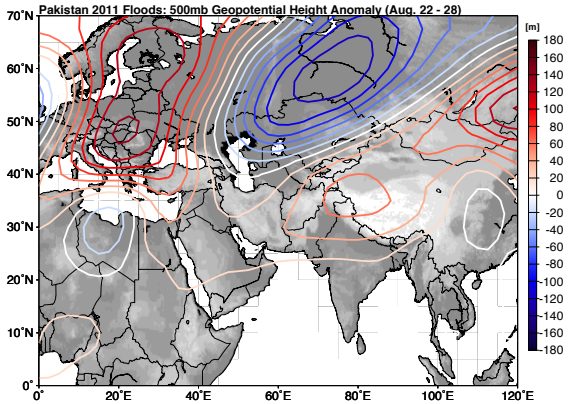
July 25th – Aug. 31st 2010

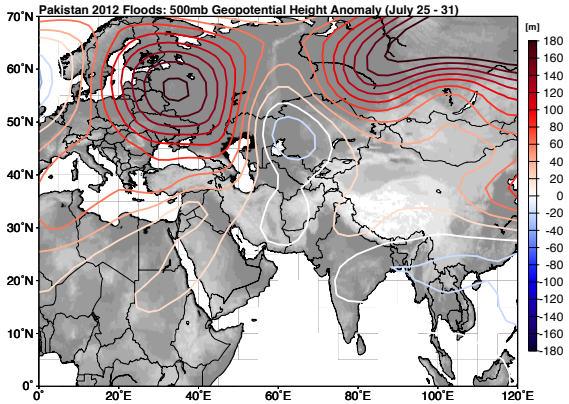
Aug. 8-16th 2011

Aug. 1-20th 2012

Rossby Wave Train







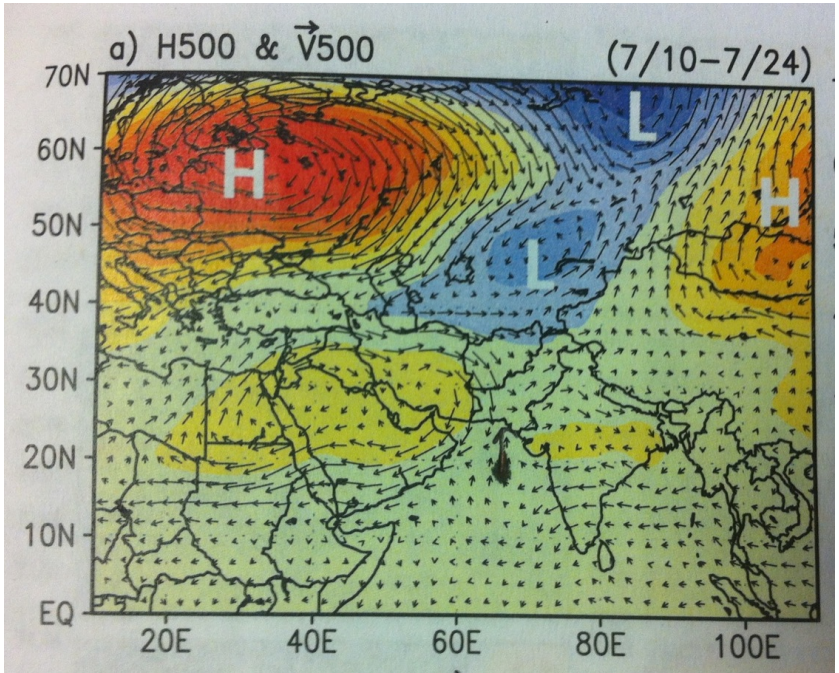
Onset periods of significiant flooding indicate this Rossby Wave Train (Lau and Kim 2012) that precede flooding events in ALL THREE YEARS

July 18-24th 2010

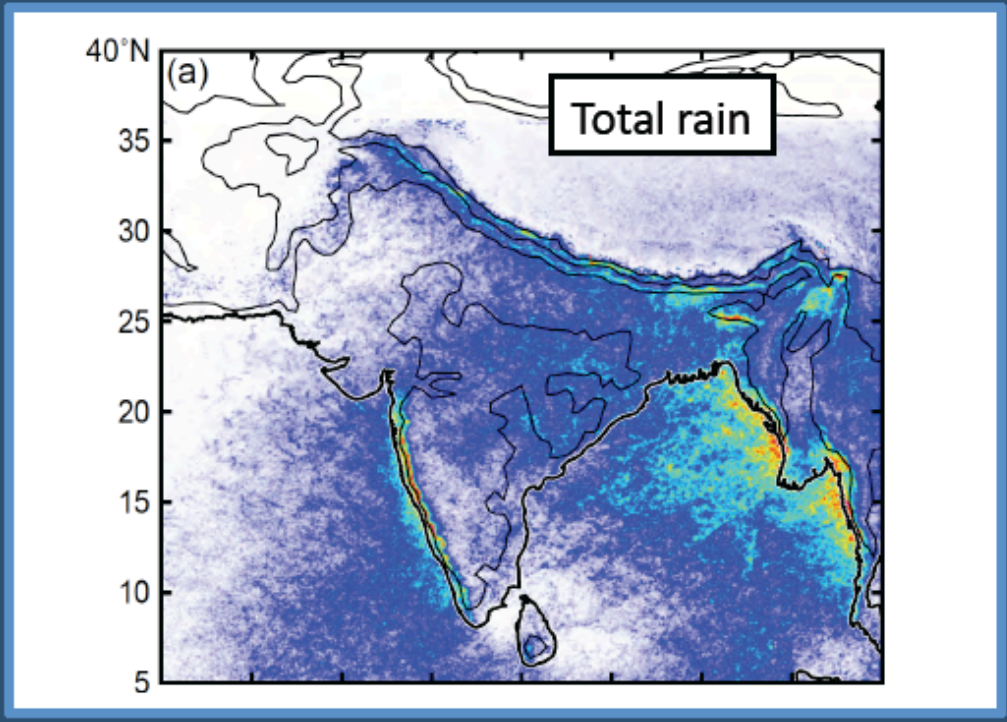
Aug 22-28th 2011

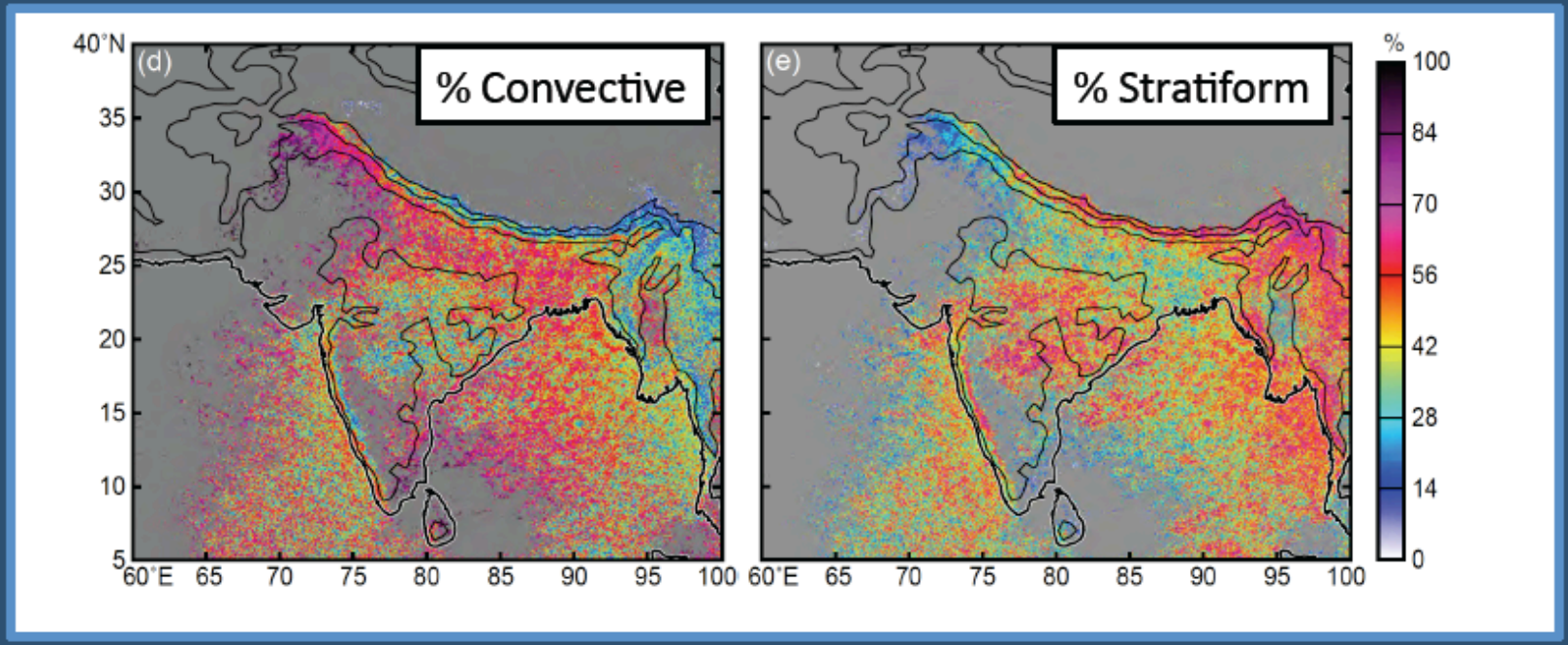
July 25-31st 2012

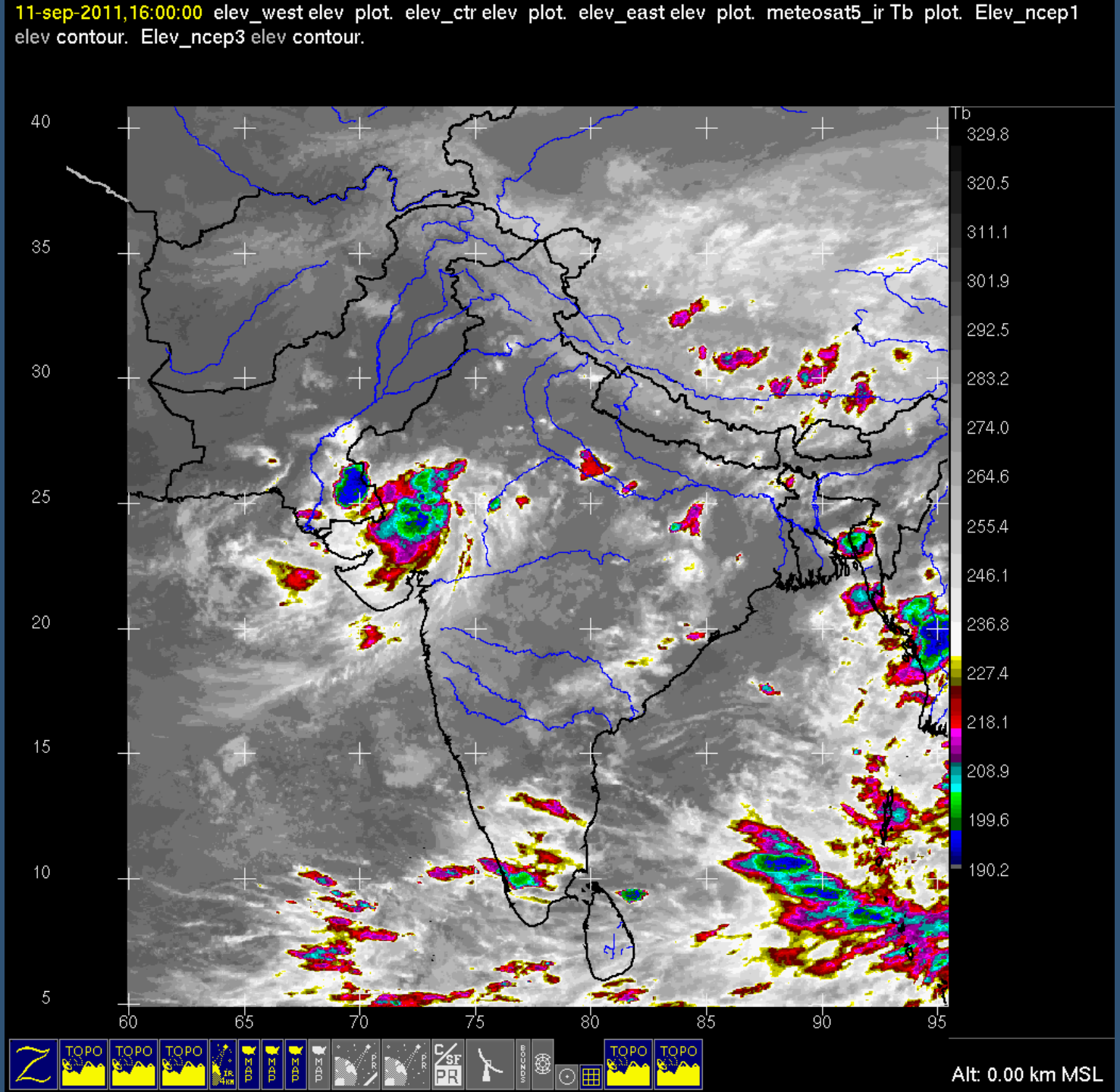
anomalies



Climatology of TRMM PR Rainfall






11-sep-2011,16:00:00 elev_west elev plot. elev_ctr elev plot. elev_east elev plot. meteosat5_ir Tb plot. Elev_ncep1 elev contour. Elev_ncep3 elev contour.
Tb
329.8
320.5
311.1
301.9
292.5
283.2
274.0
264.6
255.4
246.1
236.8
227.4
218.1
208.9
199.6
190.2
40
35
30
25
20
15
10
5
60
65
70
75
80
85
90
95
TOPO
TOPO
TOPO
TOPO
TOPO
Alt: 0.00 km MSL