

Extreme precipitation events and related weather patterns over Iraq

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Introduction

The extreme precipitation falling in different parts of Iraq are infrequent phenomena with large amounts of precipitation in a short period and whose weather patterns are poorly understood because some of weather stations recorded extreme precipitations exceeding the annual average precipitation ,and produced flash floods in some parts of Iraq causing floods on a large number of villages and farmlands and damaging agricultural crops. The aim of this study is to establish the different weather patterns related with those extreme precipitation events from a synoptic approach.

Methodology & Data

- 1- Daily precipitation records from the Iraqi Meteorological and Seismology Organization form January 2002 until December 2013. Extreme events were found statically at the 90 percentile of the recorded precipitation and were highly correlated with hydrological flooding in some cities of Iraq.
- 2- Atmospheric fields were extracted from the ERA-Interim full resolution daily dataset, available on a $0.75^\circ \times 0.75^\circ$ latitude / longitude mesh were used to analyze the forcing mechanisms of the extreme events. For latent stability we derived SWEAT and K indices. For dynamical forcing we inspected distribution of potential vorticity at 250 hPa and vertical velocity at 700 hPa . Horizontal gradients were derived using centered finite differences. Data were processed and plotted using MATLAB.

Characteristics of the study area Methodology & Data

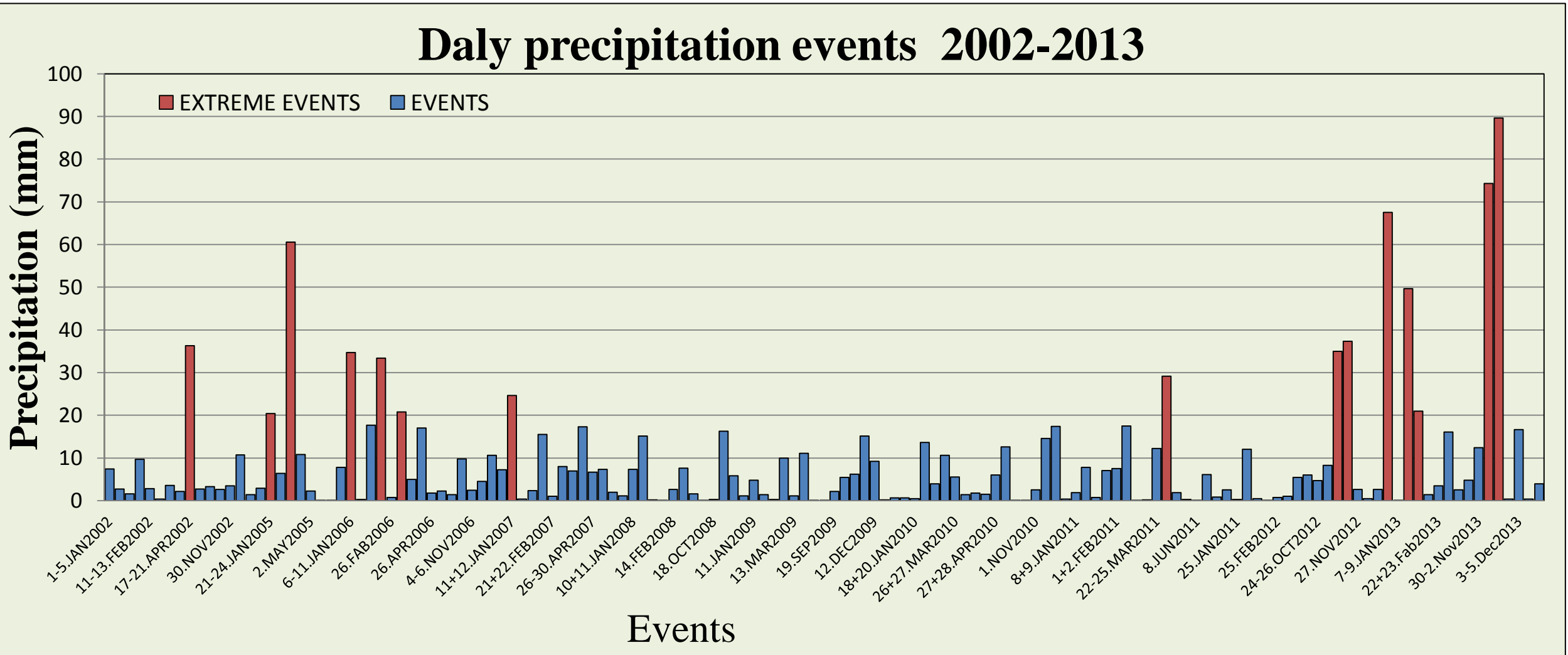
Iraq is a country located in the heart of the Middle East, in south-western Asia, at the NE of the Arabian Peninsula, between 29.5° N - 37.22° N and 38.45° E - 48.45° E. The total area of Iraq is 438,320 km².

Climate of Iraq is similar to that of Mediterranean where Precipitation occurs almost in winter, autumn, spring and disappears in summer.

Precipitation in Iraq is characterized by unorganized spatial and temporal distribution. The annual, seasonal and monthly mean rainfall shows a marked interannual variability. The recorded precipitation amount in the different meteorological stations varies from location to another according to their altitude and the geographical position of meteorological stations.



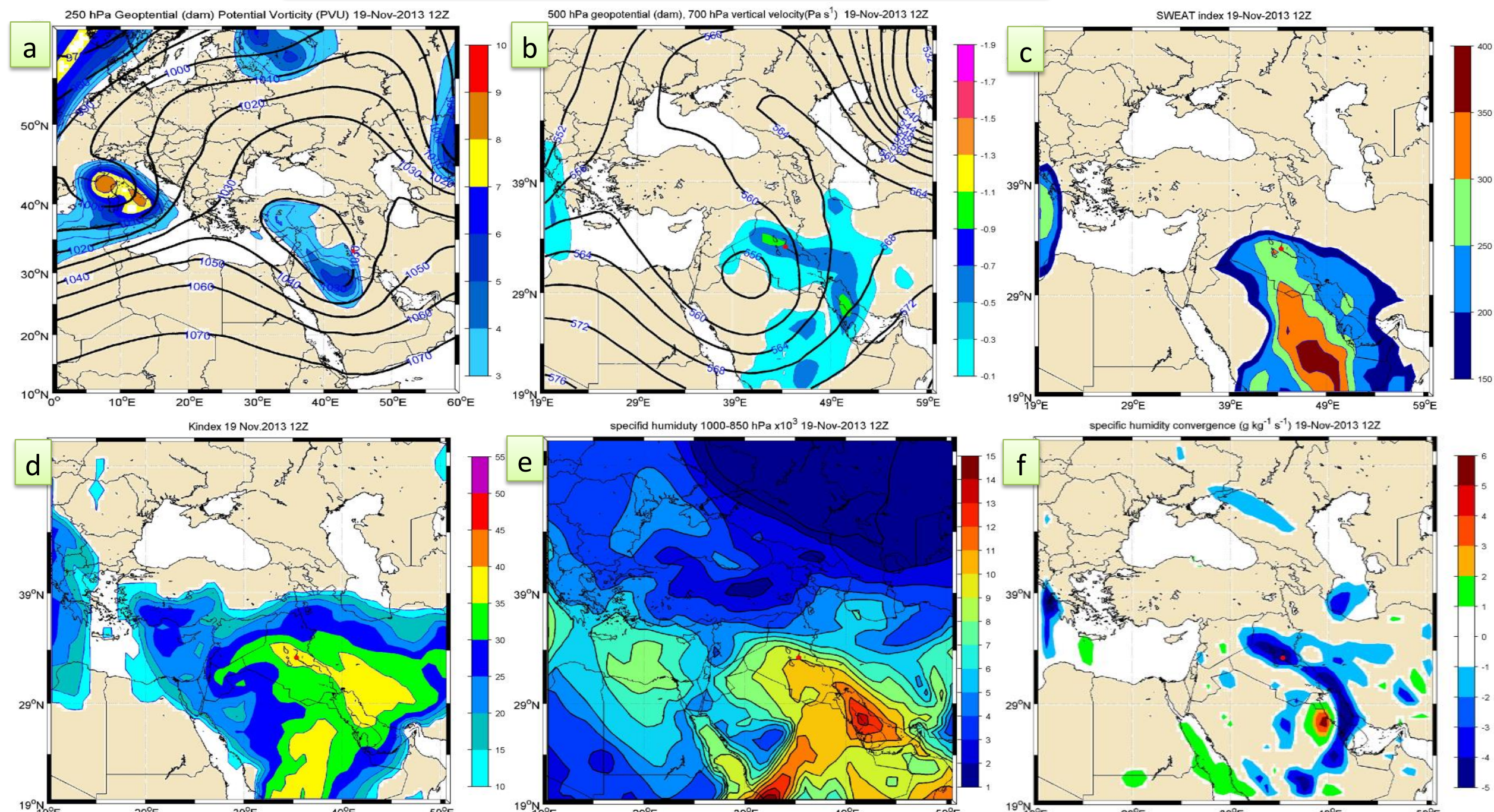
Results



The Extreme precipitation events are found statistically at the 90% percentile of the recorded precipitation. Those events are highly correlated with hydrological flooding in some cities of Iraq. We get fifteen extreme precipitation events. Corresponding synoptic situations indicates that 5 events are related with cut off low causing the highest precipitation (207.3 mm), 3 events related with Rex block (161.9 mm), 2 related with jet streak occurrence (95.3 mm) and 5 events related with trough (169.5 mm). Those weather patterns where identified through 500 hPa and 250 hPa geopotential and velocity field distribution. Five of these events caused flash floods and in particular one of them related with a Rex block was the most dramatic heavy rain even in Iraq in 30 years .

Cut-off low	Rex-block	Jet streak	Trough
22Jan 2005 (20.4 mm)	19 Nov 2013 (89.6 mm)	07 Jan 2006 (34.7 mm)	02Feb2006 (33.4 mm)
12 Jan 2007 (24.6 mm)	23 NOV 2012 (37.3 mm)	10 Mar 2005 (60.6 mm)	18 Apr2002 (36.3mm)
10 Nov 2013(74.3mm)	19 Nov 2012 (35.0mm)		20 Apr2011 (29.1mm)
25 Dec 2012 (67.5mm)			31Jan2013 (21 mm)
2 Apr 2006 (20.8 mm)			28Jan2013 (49.7 mm)

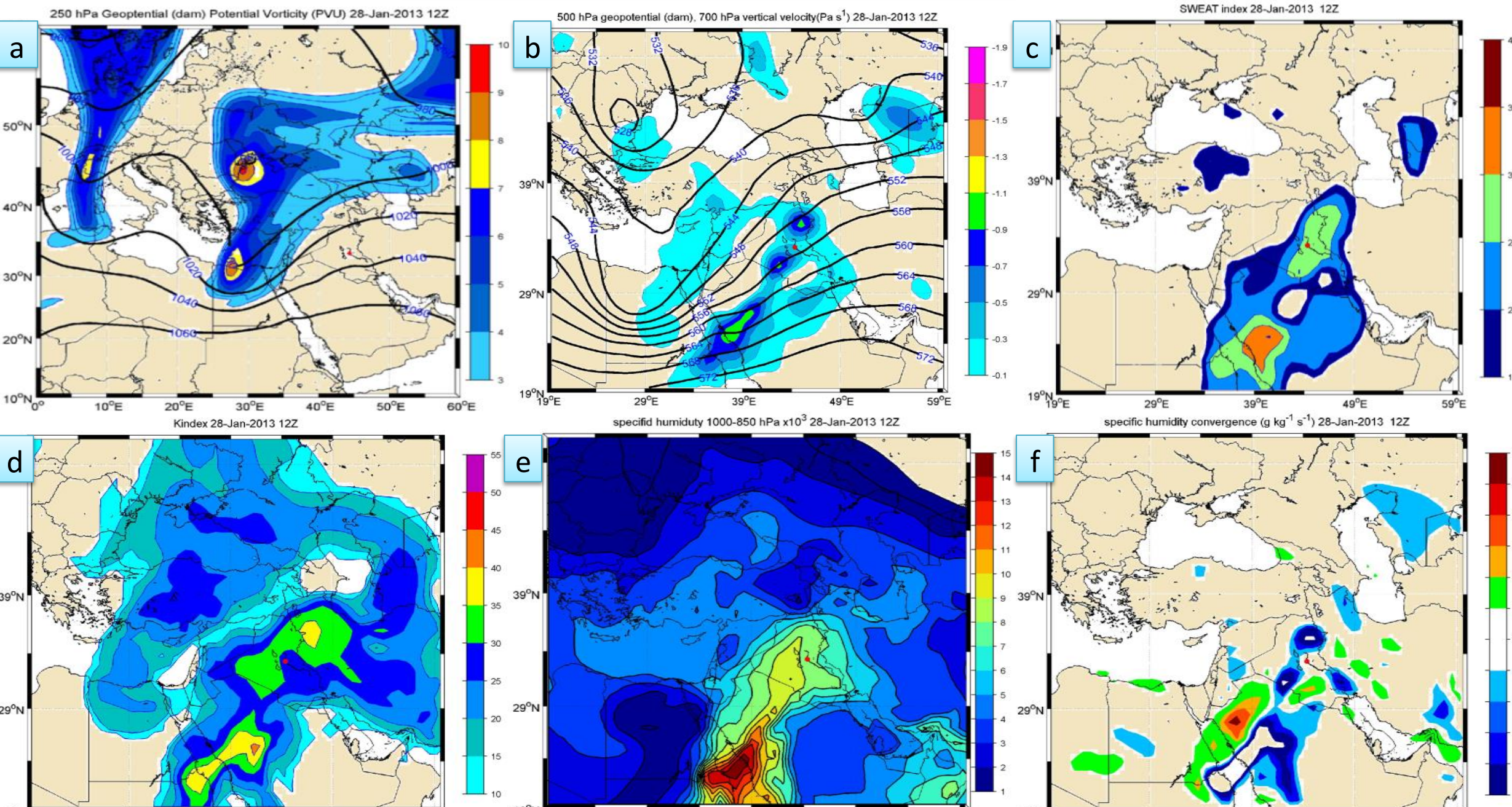
19 Nov.2013 Rex Block (89mm)



(a) The weather pattern related with precipitation event that happened in 19th November 2013 was related with the low of a rex block. It is characterized by positive anomaly of potential vorticity (PV) from the stratosphere reservoir. It is expected that PV advection will forced vertical upward motion ahead the anomaly where Baghdad is located (red point). (b) Related with this it was also observed a strong divergence of the horizontal flow field at 250 hPa (not shown) which may be a sign of ascending air as indicated by vertical velocity distribution at 700 hPa.(c) and (d) Latent instability was also high with SWEAT and k-index of 300 and 35 respectively over Baghdad that indicates a great potential for severe weather. (e) and (f) There was a quiet large source of humidity from Persian Gulf and Red sea, and a strong humidity convergence .

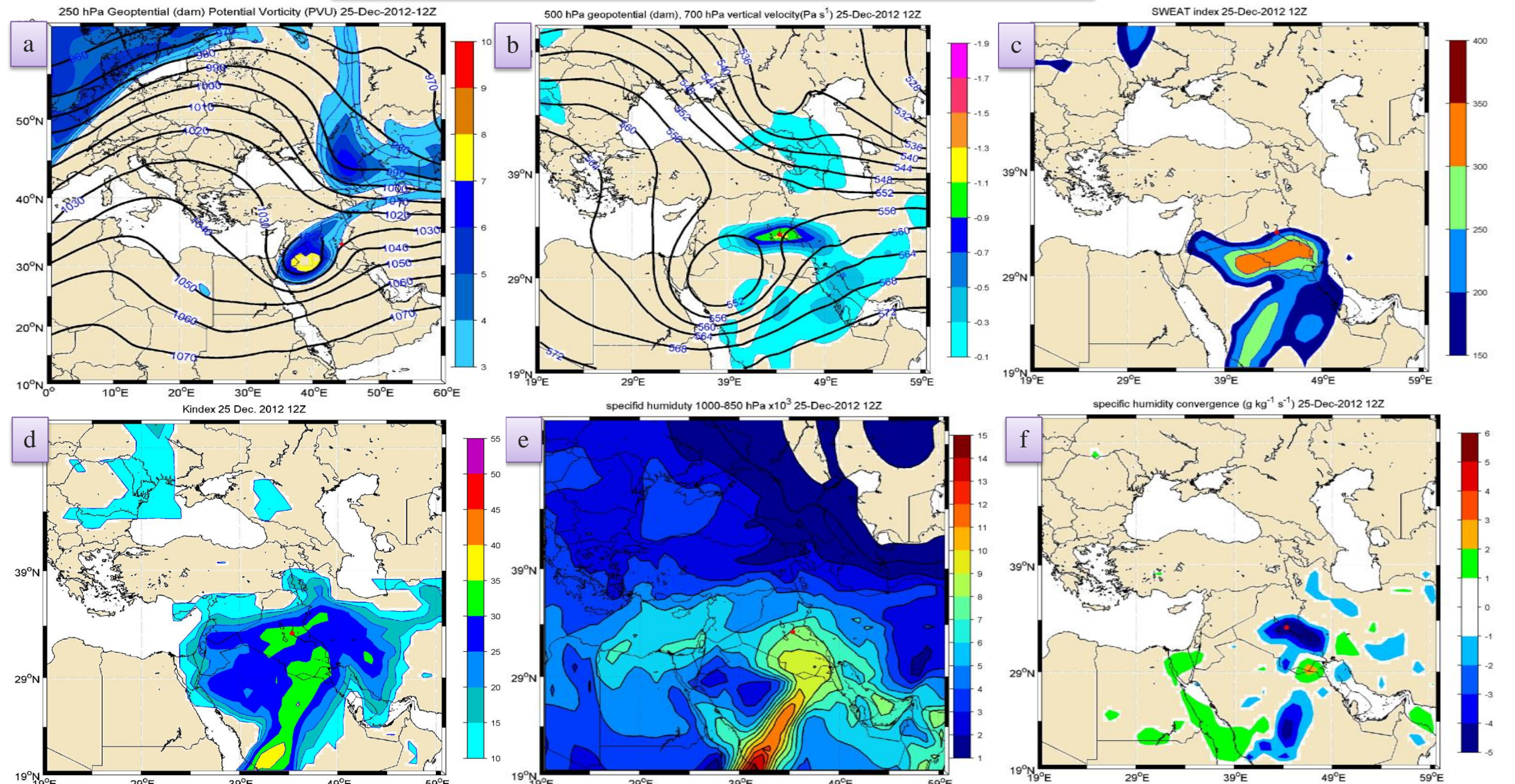


28 Jan.2013 Trough (47.3mm)



This case related with a trough in the upper and middle level,(a) at 250 hPa it is related with Anomaly of potential vorticity, whose caused ascending air and as 500 hPa it is located just west of Iraq. The vertical velocity(b) shows very large values in addition latent stability as (c) and (d) indicate by SWEAT and K-index of 266 and 28.6 respectively indicates low stability thus a potential for severe weather. As the case of cut-off low and rex block there is advection of humidity form Red sea but the additional source of humidity from Persian Gulf do not take place in this event as in (e) and (f) .

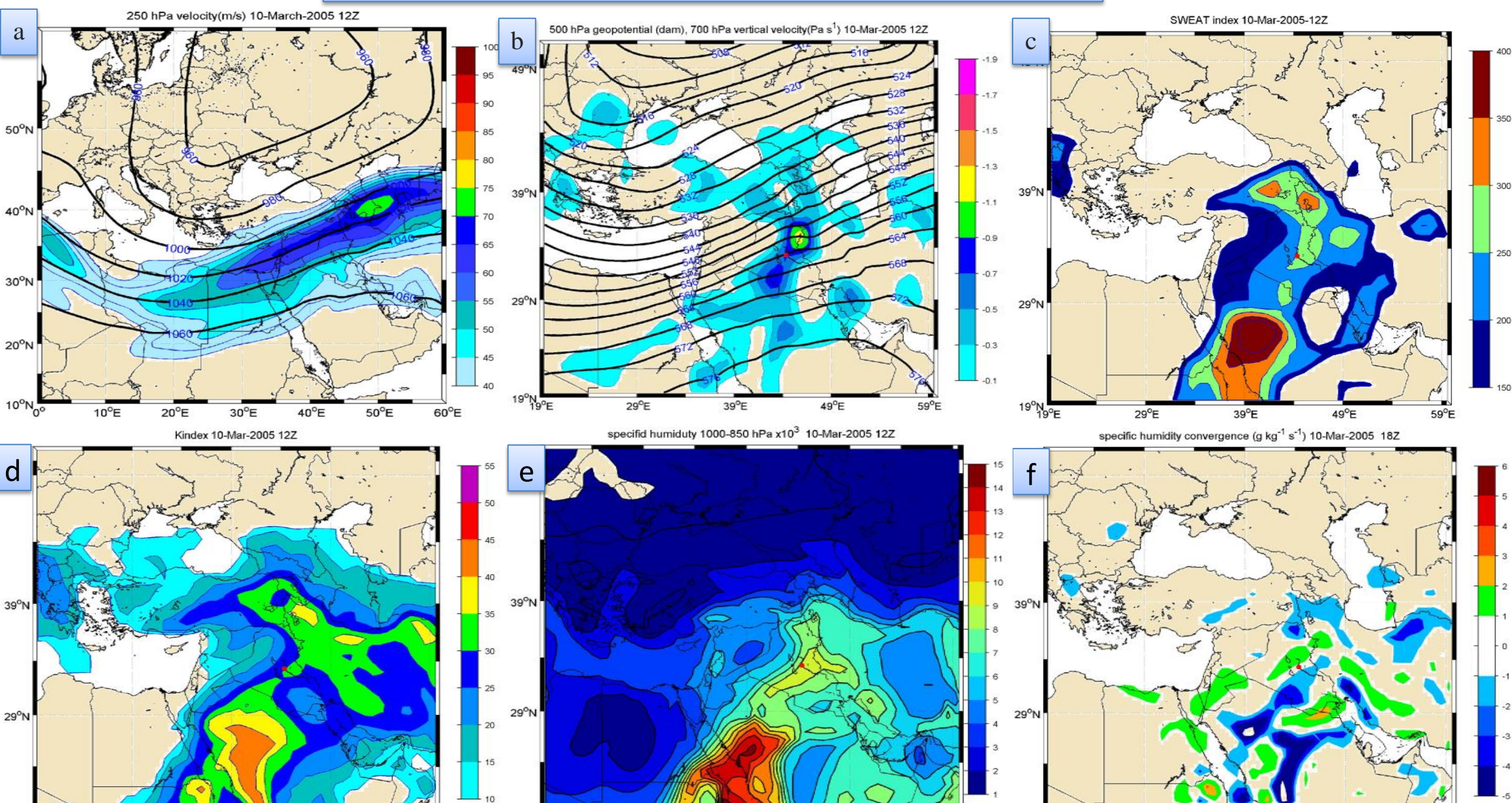
25 Dec.2012 cut-off (67.5mm)



The weather pattern related with the extreme precipitation on 25 Dec.2012 was similar to rex block but we have a cut-off low shown in the 250 hPa by a positive potential vorticity anomaly (a) and in 500 hPa (b) by closed of geopotential isolines anti-clockwise circling. The latent stability in (c) and (d) was higher than in the rex block as indicated by SWEAT and k-index of 165 and 30.21 respectively over Baghdad. However dynamical forcing as indicated by vertical omega velocities was much higher than in the rex-block case . Advection of humidity (e) and (f) from Red Sea was not so high as in the rex block case.



10 Mar.2005 Jet streak (34.1mm)



(a) This case related with jet streak as show in wind speed in 250 hPa. (b) The vertical velocity in the south part of the entrance region of the jet streak and it was high indicating strong dynamical forcing. (c) and (d) Latent stability was also low SWEAT and k-index of 250 and 29.21 respectively over Baghdad that indicates a great potential for severe weather so latent stability also played an important role to produce this severe weather. (e) And (f)The source of humidity is from red sea but convergences of humidity was low than in other cases.

Conclusions

- Weathers patterns related with extreme precipitation events in Iraq were related with middle and upper troposphere perturbations instead of mid latitude lows of Mediterranean origin as previous studies suggested.
- We identified four different weather pattern related with extreme precipitations: rex block, cut-off low, jet streak and trough.
- Both low latent stability and dynamical forcing played an important role, however there is a tendency of dynamical forcing to dominate.
- We observe that a necessary condition for extreme precipitation events is an advection of humidity from the Red Sea and Persian Gulf at lower levels instead of an advection from the Mediterranean.
- Extreme events has increased last years after a severe drought period that hit Iraq.

References

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