Monsoon intra seasonal Rainfall oscillation over Gujarat state 2021.

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Indian summer monsoon which exhibits a wide spectrum of variability on Diurnal, Daily, Seasonal, Inter annual and Decadal time scales over different region/state of the country. Gujarat state is located in the extreme western part of India with Thar Desert in the north-east, Rann of Kutch in the west and the mighty Arabian Sea which envelops the state towards the south and south-west. The bulk of the rainfall activity over this region occurs during the months of July and August under the influence of synoptic scale systems. However during monsoon 2021, major rainfall activity occurred during June and September due to the typical synoptic situations. A study has been taken to analyse the intra seasonal variability of monsoon rainfall and associated characteristics for Indian Summer Monsoon 2021 over Gujarat state for Month of September has been carried out. Also occurrences of heavy rainfall to extremely heavy rainfall due to various synoptic systems formed over land and oceans has been analysed.

Gujarat state has two meteorological subdivisions Gujarat region and Saurashtra-Kutch. During monsoon season 2021, the subdivision Gujarat Region received normal rainfall of about 80cm (-12% departure), subdivision Saurashtra-Kutch received excess rainfall of about 62 cm (24% departure) and Gujarat state as a whole received normal rainfall of about 70 cm rainfall (2% departure).Though Gujarat state received normal rainfall during monsoon 2021 but there is large variation in monthly rainfall over the state. The state received 88 percent rainfall during June(-12 % departures), 60 percent during July(-40% departure), 30 percent during August(-70% departure) and 368 percent during September(268 % departures). From the weekly rainfall district rainfall data analysis it can be seen that over Saurashtra and Kutch region major spell of rain was during month of September (Fig: 3a, 3b).

Due to a few spells of rain during September 2021 the seasonal rainfall of the state became normal (Fig: 3a). This study has been carried out to analyse the variation of intra seasonal rainfall and associated dynamical parameters for the month of September 2021. The time series of daily average rainfall over Gujarat state is shown in the Fig: 2. The data sets used for the study are u and v wind data from ERA5 reanalysis data set with 0.25*0.25 .deg horizontal resolution with vertical levels 1000 to 500 hpa standard levels for the month September 2021 with daily time steps (00UTC, 06UTC, 12UTC and 18UTC) and for area 68 .deg E to 72 .deg E and 20 .deg N to 24 .deg N; daily area averaged rainfall data from Rain gauges, AWS over Gujarat state for the period September 2021.

In this study analysis is being done for the subdivision Saurashtra-Kutch during September 2021 as there was excess rainfall over the subdivision. During the first week of September the subdivision Saurashtra-Kutch received heavy to very Heavy rains (Fig 1a, 3b) with maximum rainfall of 17cm at Junagadh and Kutch districts as monsoon trough was running across Gujarat state.

Due to interaction of Low Pressure Area over southwest Madhya Pradesh & neighbourhood up to 7.6 km above mean sea level and the shear zone along Latitude 20°N between 3.1 km & 5.8 km above mean sea level, the state received heavy rain over Gujarat region and heavy to very heavy rain with isolated extremely heavy rain over Saurashtra-Kutch 2nd week of September (Fig 1a, 3b). The highest rainfall recorded on 9th September was 25 cm in Gir Somnath District. During 13th to 15th September 2021(Fig 1a, 3b) Gujarat state received an active wet spell due to the oscillation of monsoon trough up to Saurashtra coast and interaction with cyclonic circulation over Gujarat region. During the period heavy to very heavy rainfall with extremely heavy rainfall occurred over the state with highest rainfall recoded 52 cm recorded at Rajkot, 47 cm at Junagadh and 41 cm at Jamnagar

on 14th September 2021. On 24th September Gujarat state received a good spell of monsoon rainfall (Fig 1a, 3b) with highest daily rainfall of 19 cm in Jamnagar district due to the cyclonic circulation over West Rajasthan. Last rainfall spell for the month was from 28th to 30th September 2021 (Fig 1a, 3b) due to intensification of Well-Marked Low Pressure Area into a Depression over northeast Arabian Sea & adjoining Kutch due to which highest rainfall recorded was 29 cm in Junagadh district on 30th September 2021.

The ERA5 data is used to compute relative vorticity and hovumuller plot is prepared for lower level(1000-850mb) and higher level(700-500) vorticity for the month September 2021 are shown in the Fig 1b. During the extremely heavy rainfall events, positive vorticity advection is observed at higher level also. Thus vertical advection of positive vorticity up to higher level can be considered as an indicator for extremely heavy rainfall forecast.

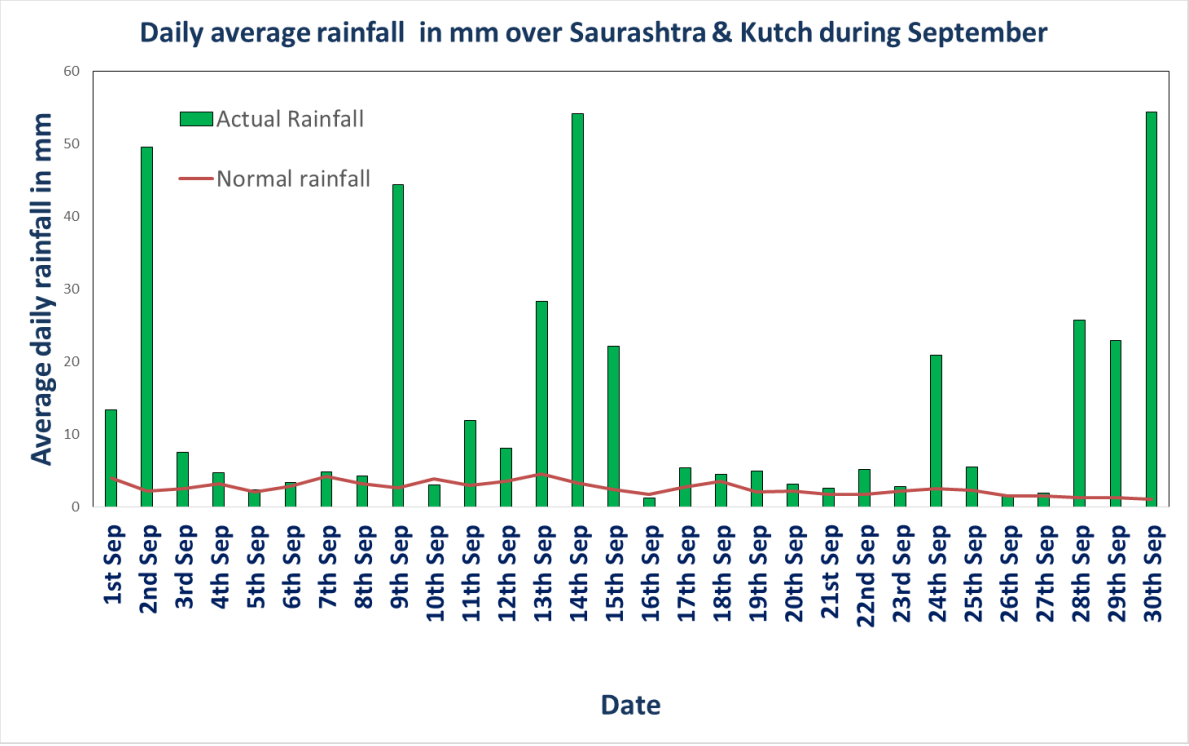

Fig1a: Daily average rainfall in mm over Saurashtra & Kutch during September

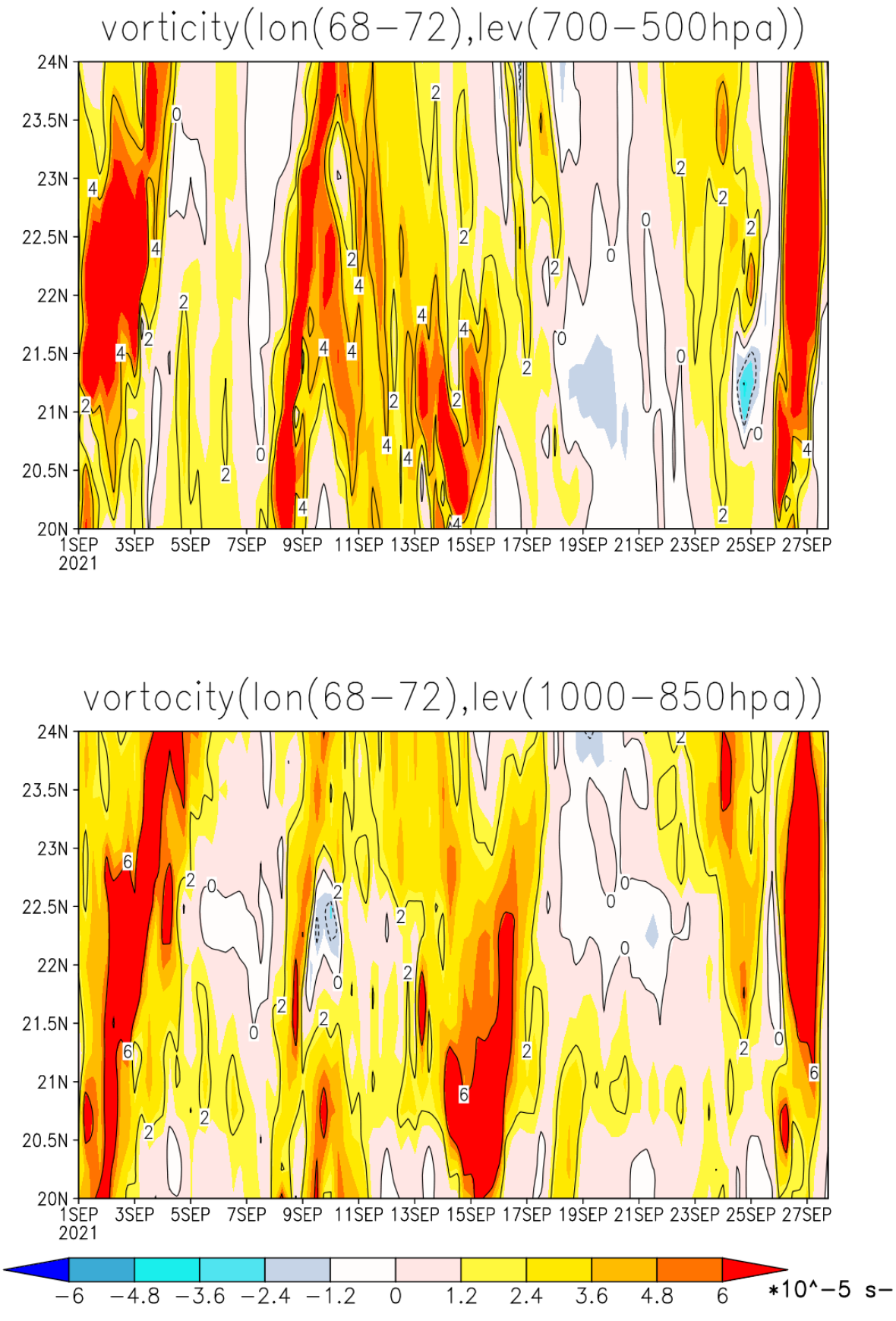

Fig1b: Relative Vorticity Hovumuller plot September 2021

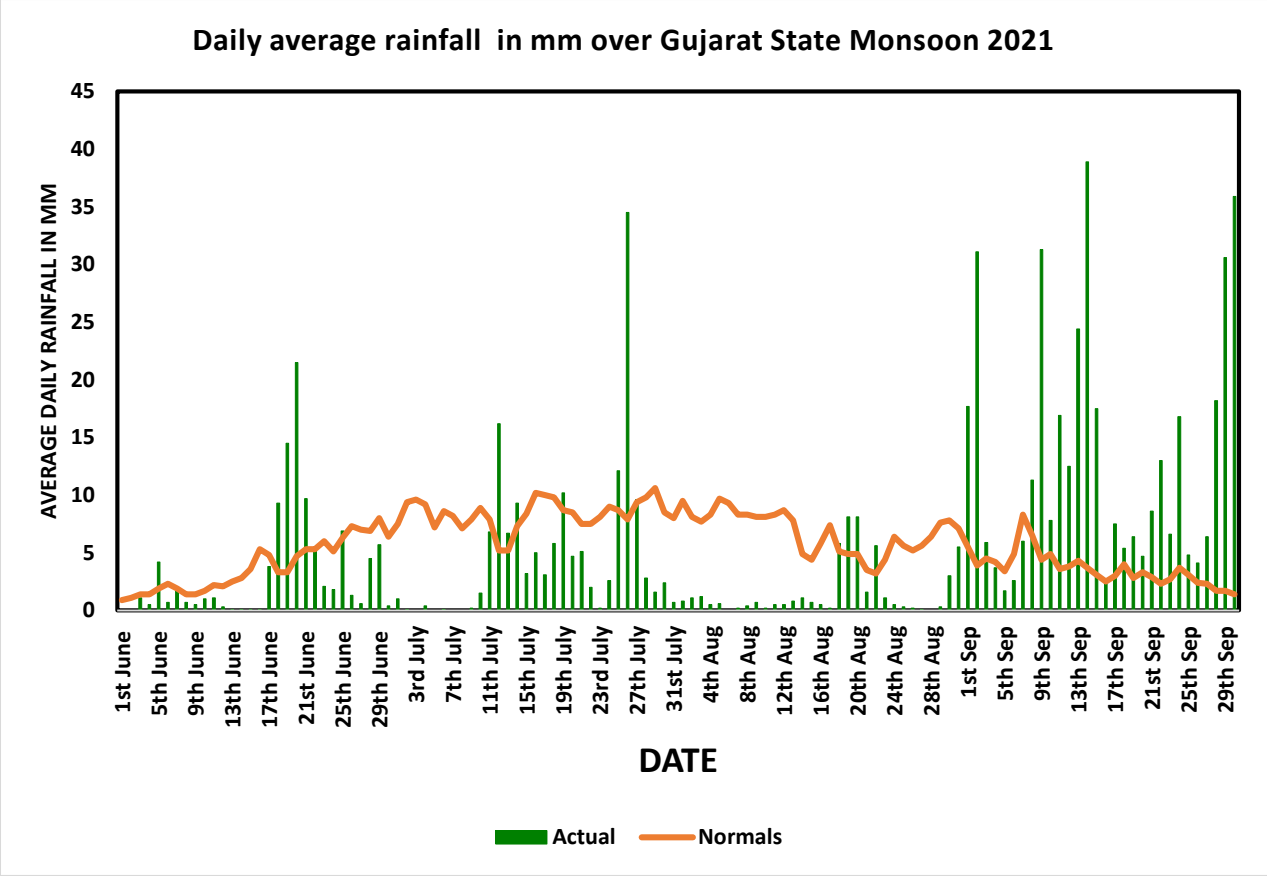

Fig2: Daily average rainfall in mm over Gujarat State

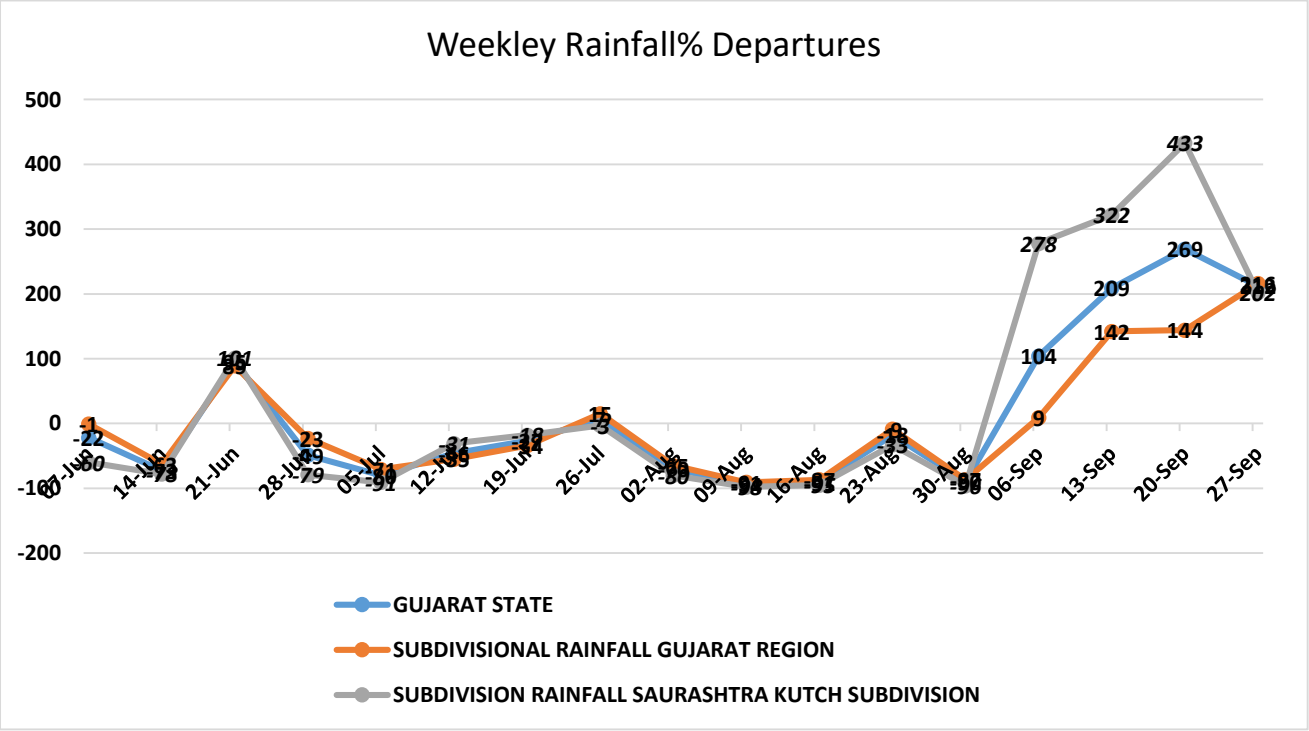

Fig3a: Weekly percentage departures of rainfall from long period average

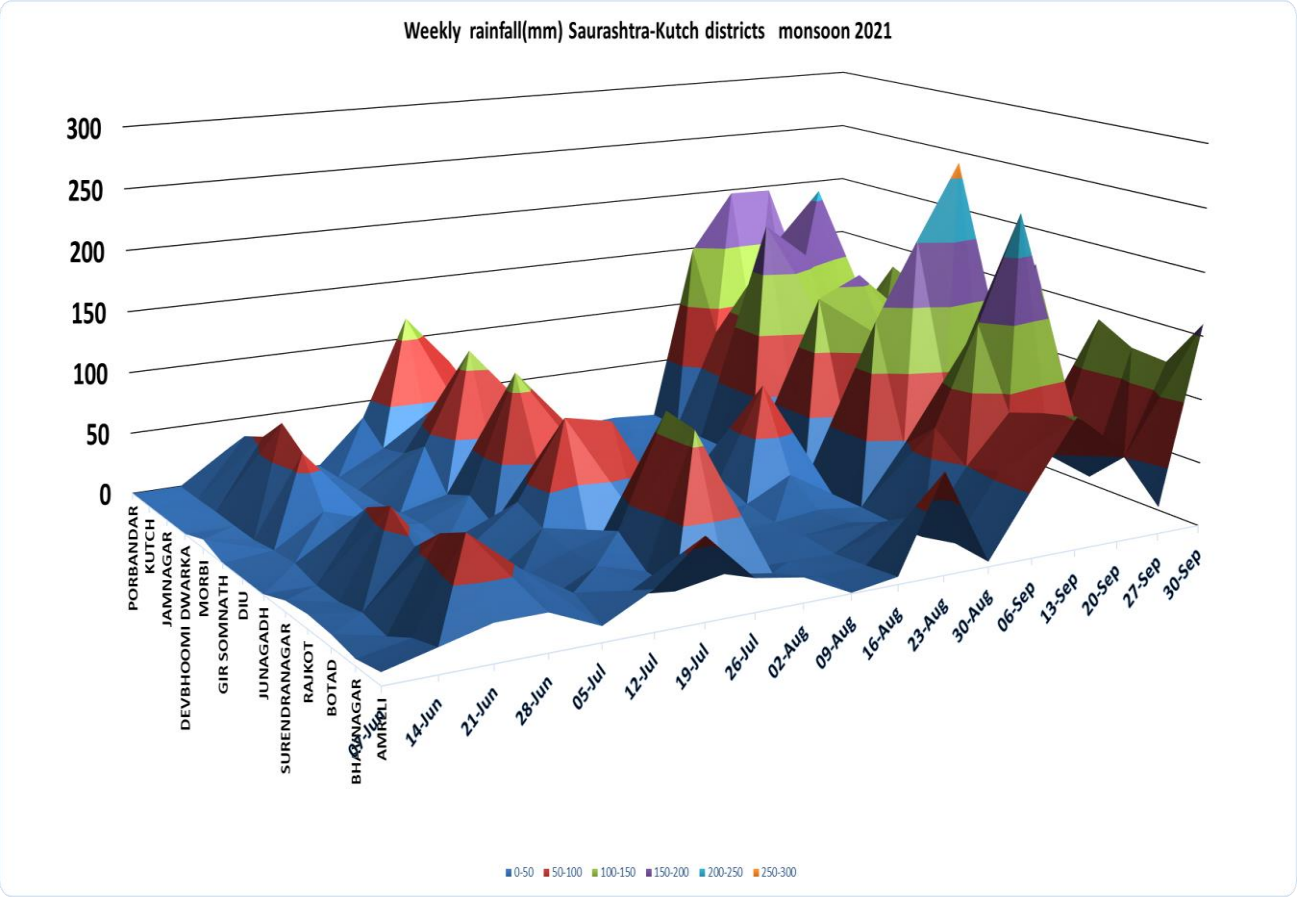

Fig3b: Weekly rainfall (mm) over districts of Saurash-Kutch