MPACT OF EL-NINO ON SUMMER MONSOON RAINFALL OF PAKISTAN

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Abstract:

El-Nino is the dominant mod of inter- annual climate variability on a planetary scale. Its impact is associated worldwide with the displacement of large scale tropical circulation. Several areas of the tropics are directly affected by droughts or wet conditions linked to the occurrence of El-Nino events. This study explores the relationship between El-Nino and Pakistan monsoon rainfall. From the analysis of the data it is evident that El-Nino has a negative effect on summer monsoon (Jul – Sept) rainfall of Pakistan.

Introduction:

El-Nino is defined as a warm current of water initially referred to a weak warm current appearing annually around Christmas time along the coast of Ecuador and Peru and lasting only a few weeks to a month of more. The Southern Oscillation (SO) is global scale sea saw of surface pressure with centers of action around Indonesia, North Australia and south east pacific.

The two phenomena were discovered and studied for decades as separate entities. Now they have been recognized as one and called ENSO. Thus ENSO is another term for El-Nino and scientists use this term to explain the existence of El-Nino better (Bhalme, 1991).

In contrast to El-Nino, La-Nina refers to an anomaly of usually cold sea surface temperatures in the eastern tropical pacific.

El-Nino occurs due to change in the normal pattern of the trade wind circulation. In normal condition (fig1) the trace wind converge near the equator and flow westward toward Indonesia. This steady westward flow creates a warm surface current that moves from east to west along the equator. The result is a “piling up” of a thick layer of warm surface water that produces higher sea levels.

Then for unknown reasons (fig2), the Southern Oscillation occurs, and the normal situation just described changes dramatically. Barometric pressure rises in the Indonesian region, causing the pressure gradient along the equator to weaken or to reverse. As a consequence, the once-steady trade winds diminish and may even change direction. This reversal creates a major change in the equatorial current system, with warm water flowing eastwards. With time, water Temperature in the central and eastern pacific increase and sea level in the region

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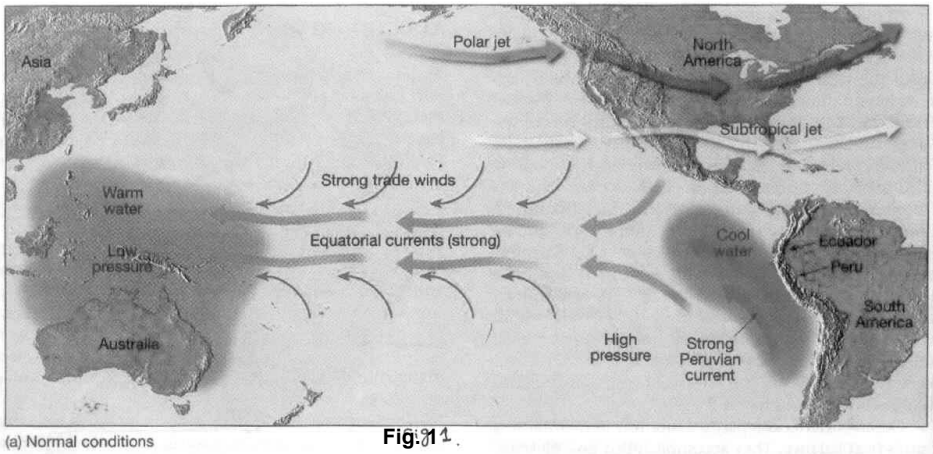
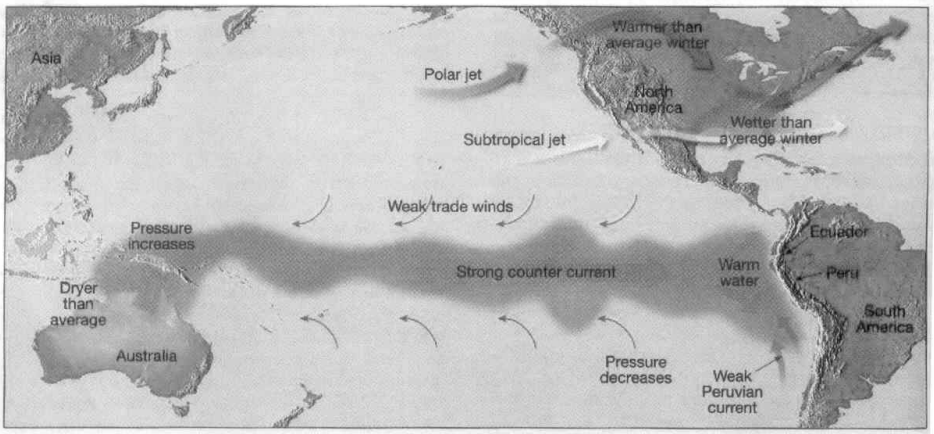
rises. This eastward shift of the warmest surface water marks the onset of El-Nino (Frederick and Edward, 1998, page 179-181).



(a) Normal conditions

Fig. 1.



(b) El Niño

Fig. 2.

In El-Nino event sea surface temperatures (SST) is raised at least ones standard deviations above the monthly mean for at least four consecutive months at three or four designated coastal stations.

The event is called strong (W+) when sea surface temperatures (SST) is equal or greater than 4°C than the normal, moderate (W) when SST is 3°C or more than the normal, weak(W-) when SST 2°C or more than is normal. Every three to seven years, an El-Nino event may last for many months, having significant economic and atmospheric consequences worldwide (Moura, 1994).

During an El-Nino, only a small fraction of heat released to the atmosphere is via direct heat flux from a warmer ocean surface. In fact most of the heating result from increase of surface moisture convergence in areas of anomalous warm SST,

which leads to the development of deep convection and the release of latent heat of condensation in mid or upper tropospheric precipitation clouds. Thus to some extent the anomalously warm ocean plays a catalytic role in the hydrological cycle and the thermodynamic mechanisms that force the atmospheric circulation.

Table 1: Cold and Warm Episode of El-Nino by Season

Year	JFM	AMJ	JAS	OND
1976	C	N	N	W-
1982	N	W-	W	W+
1983	W+	W	N	C-
1986	N	N	W-	W
1987	W	W	W+	W
1991	W-	W-	W	W
1992	W+	W+	W-	W-
1993	W-	W	W	W-
1994	N	N	W	W
1997	N	W	W+	W+
1998	W+	W	C-	C
2002	N	W-	W	W

Legend:

N	Normal Temperature	C-	Weak La-Nina
W-	Weak El-Nino	C	Moderate La-Nina
W	Moderate El-Nino	C+	Strong La-Nina
W+	Strong El-Nino		

Preliminary relationship between El-Nino and precipitation in many Regions of the world were noted during the major El-Nino event namely the 1972-1973, 1982-1983 and 1997-1998 events. Because El-Nino is a global event a strong occurrence leads to the nearly simultaneous appearance of large climatic anomalies over many regions around the world. Within the tropics, the eastward shift of thunder storm activity from Indonesia into the central Pacific during warm episodes usually result in abnormally dry conditions over northern Australia, Indonesia and Philippines in both seasons. Drier than normal conditions are also usually observed over south eastern Africa and northern Brazil. During the northern summer season, the Indian monsoon rainfall tends to be less than normal, especially in northwest. Wetter than normal conditions during warm episodes are usually observed along the west coast of tropical South America, and at subtropical latitudes of North America (Gulf Coast) and South America (southern Brazil to central Argentina) (WMO update 1997-1998).

Following El-Nino event were identified during the period 1974-2003.

1976-1977, 1982-1983, 1986-1987, 1991-1992, 1994-1995,1997-1998, 2002-2003.

Data:

Different 21 synoptic observing stations were selected for the period 1974-2003 to study the impact of El-Nino on summer monsoon rainfall of Pakistan (Map 1). The criteria for selection of these stations are that they cover almost whole of Pakistan.

Methodology:

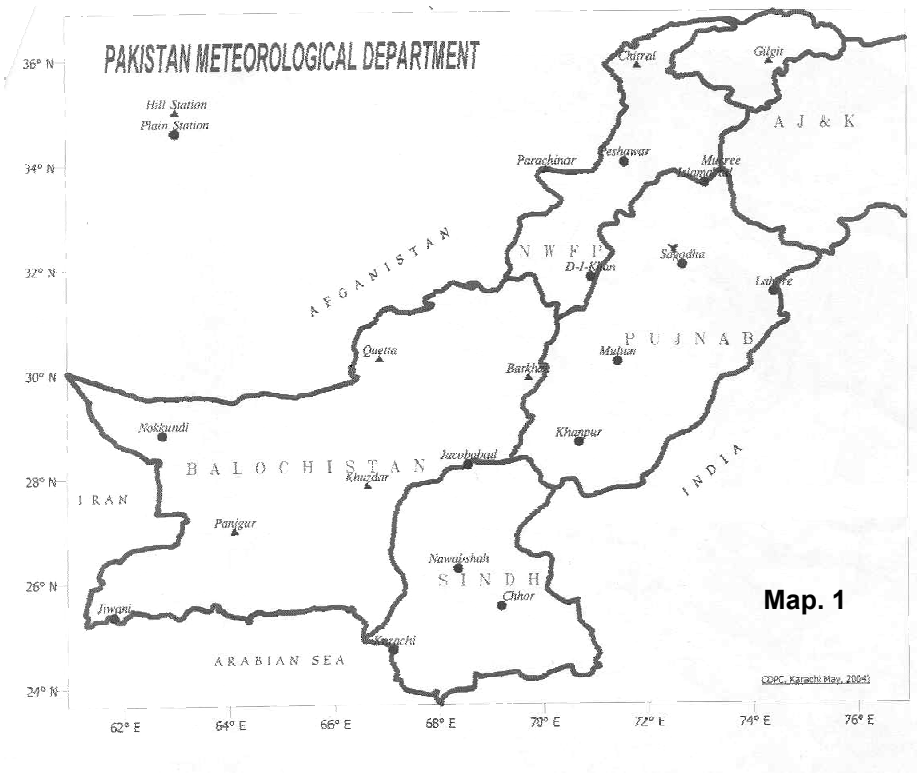
Normalized standard deviation (NSD) versus time have been plotted to find out the relationship between different intensities of El-Nino and rainfall.

$$N.S.D = \frac{R_y - \overline{R}}{\sigma}$$

Where σ is standard deviation of all available data

$\overline{R}$ = Mean rainfall of all available data

R_y = Mean rainfall of particular years.



Map. 1

Discussion:

Table 2:

Year	AMJ Episode	Rainfall
1976	N	Above Normal
1982	W-	Below Normal
1983	W	Above Normal
1986	N	Below Normal
1987	W	Below Normal
1991	W-	Below Normal
1992	W+	Above Normal
1993	W	Below Normal
1994	N	Above Normal
1997	W	Nearly Normal
1998	W	Below Normal
2002	W-	Below Normal

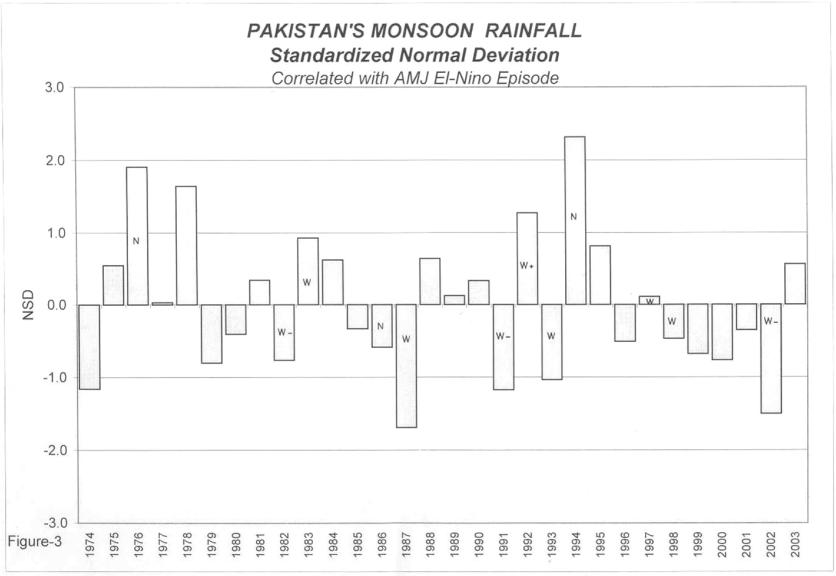


Figure-3

When the NSD is compared with AMJ episode, it is observed that whenever the temperature is above normal, the rainfall is below normal (e.g.1982, 1987, 1991, 1993, 1998 & 2002) and nearly normal in 1997. However variation has been noticed in the years 1983 and 1992 in which rainfall is above normal.

When the temperatures are normal the rainfall is above normal (i.e. 1976 and 1994), except in the year 1986, in which rainfall has been below normal (shown in Fig. 3 Table2)

Table 3: Rainfall Relation with JAS Episode

Year	JAS Episode	Rainfall
1976	N	Above Normal
1982	W	Below Normal
1983	N	Above Normal
1986	W-	Below Normal
1987	W+	Below Normal
1991	W	Below Normal
1992	W-	Above Normal
1993	W	Below Normal
1994	W	Above Normal
1997	W+	Nearly Normal
1998	C-	Below Normal
2002	W	Below Normal

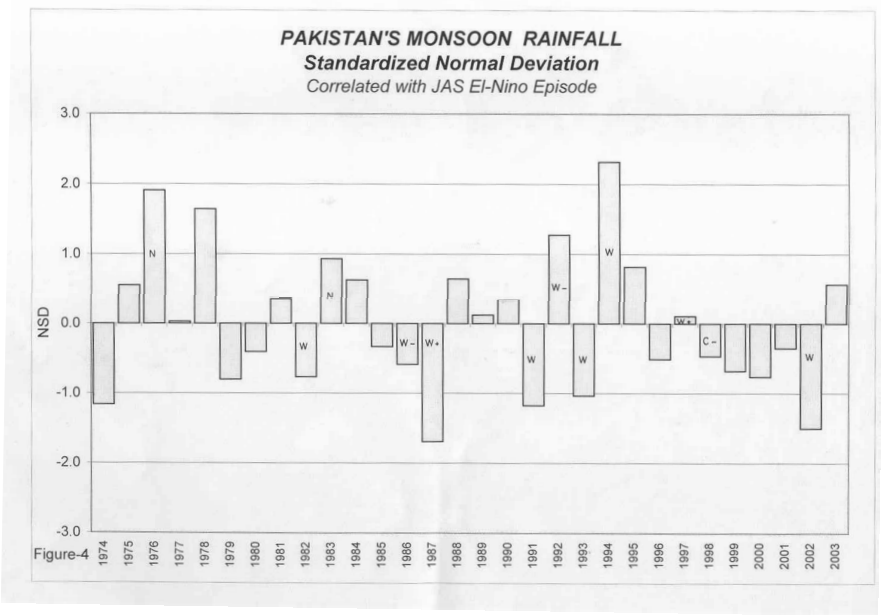


Figure-4

When the NSD is compared with JAS episode, it is observed that whenever the temperatures are above normal the rainfall is below normal (e.g.1982, 1986, 1987, 1991, 1993 & 2002) and nearly normal in the year 1997, while above normal in the year 1992-1994.

When the temperatures are normal the rainfall is above normal (e.g.1976 and 1983), Similar to the AMJ episode.

However variation from this behavior has been observed in the years 1998. When there is slight cooling and the rainfall is below normal.

When the NSD is compared against the combined effect of AMJ and JAS Episodes, it is observed that if the warming is there is the month of AMJ and it continuously increases till JAS. The amount of rainfall is much below normal (e.g.1982, 1987, 1991 & 2002) and nearly normal in the year 1997. If the warming is there in the month of AMJ and it persists in the months of JAS with the same intensity, the rainfall is below normal (e.g. 1993.)

If the warming is there is the month of AMJ and it starts decreasing in the months of JAS. The amount of rainfall is above normal (e.g.1983 & 1992).

If there is no warming in the month of AMJ i.e. temperatures are normal and warming start in the month of JAS, the rainfall is slightly below normal (e.g. 1986).

If there is no warming in the month of AMJ i.e. temperature are normal and they remain normal in the month of JAS. The rainfall is above normal (e.g. 1976) (shown in Fig 4, Table 3).

Table.4: Rainfall Relation with AMJ and JAS Combined Episode.

Year	AMJ Episode	JAS Episode	Rainfall	Temperature
1976	N	N	Above Normal	Normal
1982	W-	W	Below Normal	Increasing
1983	W	N	Above Normal	Decreasing
1986	N	W-	Below Normal	Increasing
1987	W	W+	Below Normal	Increasing
1991	W-	W	Below Normal	Increasing
1992	W+	W-	Above Normal	Decreasing
1993	W	W	Below Normal	Constant
1994	N	W	Above Normal	Increasing
1997	W	W+	Nearly Normal	Increasing
1998	W	C-	Below Normal	Decreasing
2002	W-	W	Below Normal	Increasing

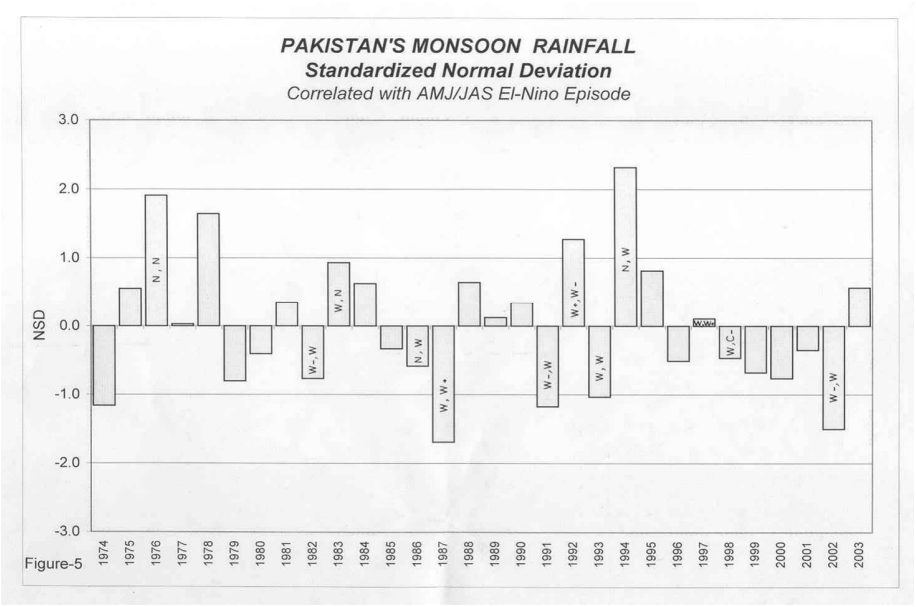


Figure-5

However variation from this behavior has been observed during the years 1994 in which temp is normal in AMJ and increasing in JAS the rainfall is above normal whereas in 1998 temperature has been above normal in AMJ and because slightly cold in JAS then the rainfall is below normal.(shown in Fig 5 ,Table 4)

Conclusion:

From the above results it may be concluded that as El-Nino year if there is warming in the month of AMJ and it increases in the month of JAS or it persists or even warming start in the month of JAS. The monsoon rainfall will be in deficit.

If there is no warming in the months AMJ and JAS i.e. the temperatures are normal or even warming is there in the month of AMJ and it starts decreasing in the month of JAS, the monsoon rainfall will be above normal.

In short it can be said that in an El-Nino year if there is warming in AMJ are even it is normal and it is likely to continue or increase in JAS then there is likely hood that monsoon rainfall over Pakistan will be in deficit.

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