



中国—巴基斯坦地球科学研究中心
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**Emergency Investigation and Assessment Project of
the 2022 Pakistan Flood**

Investigation Briefing

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Analysis of the Causal factors of 2022 Floods in Pakistan: Extremely Strong South Asia Summer Monsoon

Since July this year, heavy rainfalls have struck Pakistan, resulting in widespread flooding, which affected a wide range of areas and had a large impact. The precipitation and its spatial distribution for July and August 2022 compared to historical observations across Pakistan were analyzed based on MSWEP multi-source fusion precipitation data up to August 28, 2022. Figure 1 indicates that a heavy precipitation belt is recorded in Pakistan, mainly in the southern part of the border between Sindh and Balochistan, and in the south and northern Punjab, with maximum precipitation up to 300 mm or more. The average rainfall of areas south of 32°N of Pakistan in July is excessive compared with the average historical period of 1991-2020. Extreme high precipitation is recorded in the central parts of the country, mainly located in the south border between Sindh and Balochistan, the northwest of Balochistan, the south of Punjab, and the areas adjacent to the Arabian Sea in Sindh, etc. The precipitation is greater than 180mm above normal. It can also be seen in Figure 1c that the majority of areas south of 32°N received more than twice as much precipitation as the historical period in July.

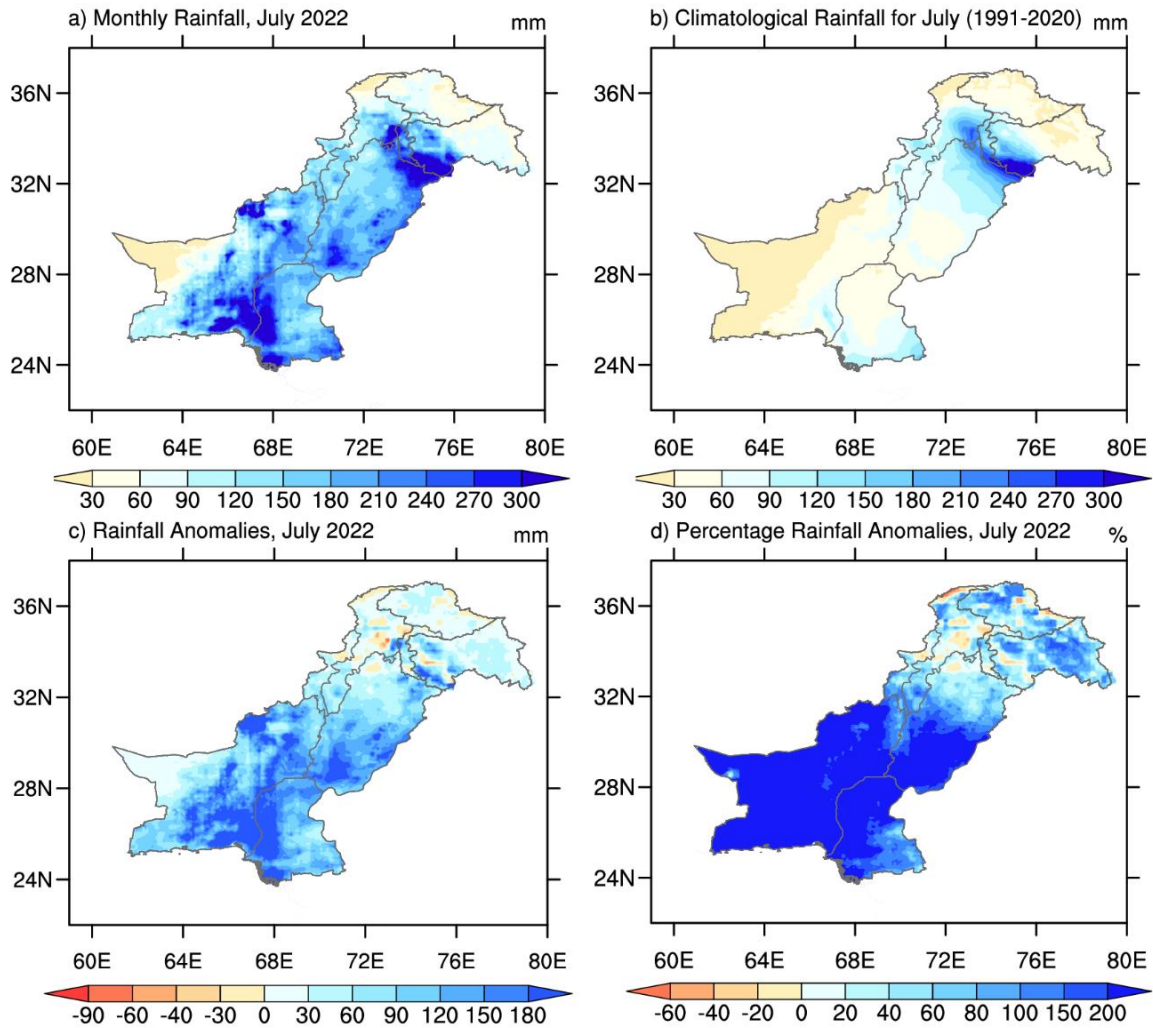


Figure 1: Spatial distribution of monthly precipitation (mm) in Pakistan for July 2022 and its comparison with the historical period: a) Precipitation in July 2022; b) Historical precipitation in July (1991-2020 average); c) Precipitation anomaly in July 2022 compared with the historical period (mm); d) Percentage of precipitation anomaly in July 2022 compared with the historical period (%)

In August 2022, Pakistan's maximum precipitation, mainly in Sindh, is recorded, with more than 300mm (Figure 2). Most parts of Sindh Province in Pakistan received more than 180-200mm of precipitation, which is more than twice the average historical precipitation recorded from 1991 to 2020. In the



central region of Baluchistan, precipitation is greater than twice the historical records.

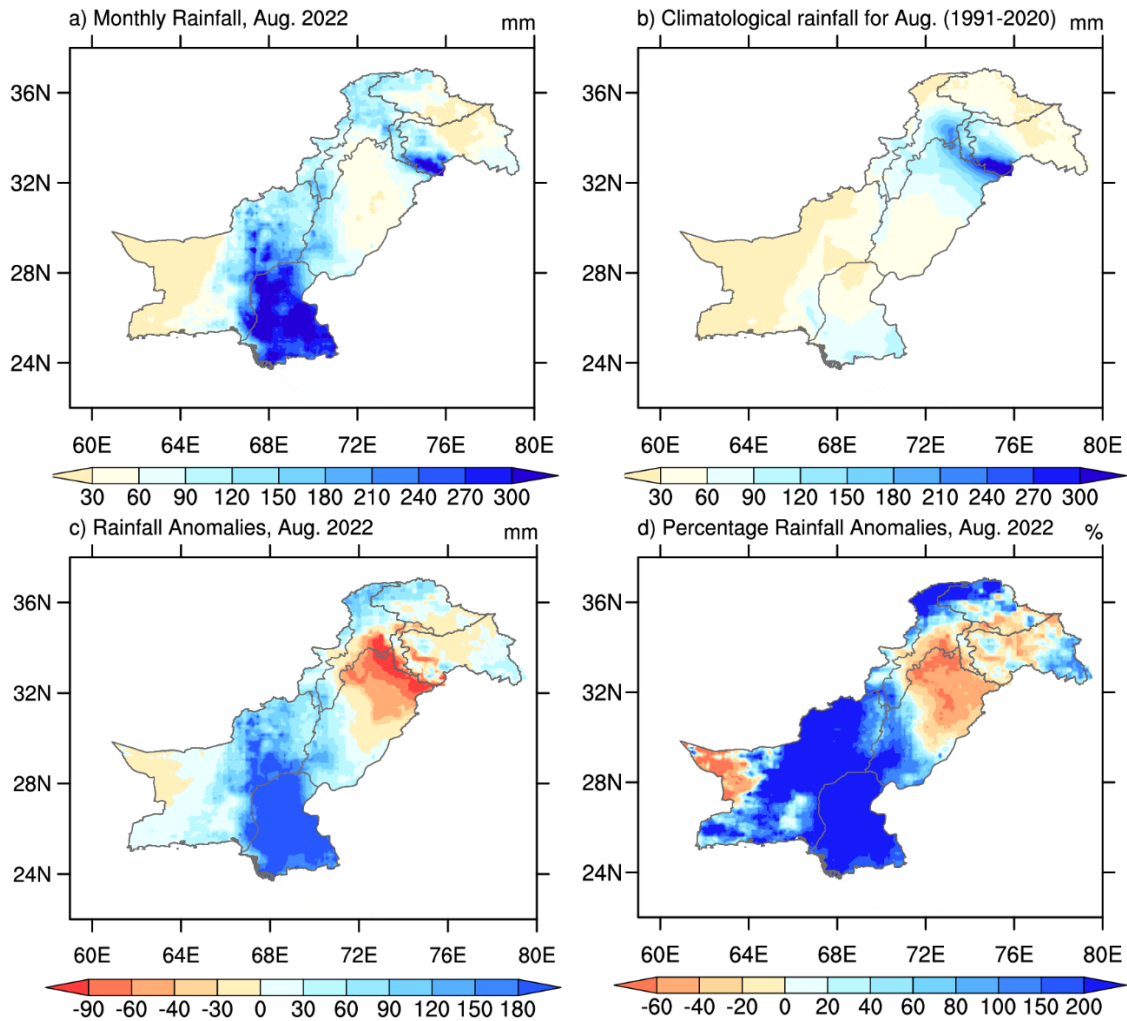


Figure 2: Spatial precipitation distribution (mm) in August 2022 and its comparison with the historical records: a) Precipitation in August 2022; b) Historical precipitation in August (1991-2020 average); c) Precipitation anomaly in August 2022 compared with the historical period (mm); d) Percentage of precipitation anomaly in August 2022 compared with the historical period (%)

In addition, based on the latest ERA5 reanalysis data of the European Center, the Indian summer monsoon index in July and August of 2022 was calculated. And the relationship between the Indian summer monsoon and the



precipitation anomaly in July and August of Pakistan was further analyzed. As shown in Figure 3, the normalized Indian Summer Monsoon Index reached 2.5 in July 2022, which exceeds 2.0 and is the highest record since 1979. In addition, the Indian Summer Monsoon Index in August 2022 continued to be unusually strong, with a magnitude of 1.8. For the first time since 1979, the Indian Summer Monsoon Index in July and August remained unusually strong, and both were above 1.5.

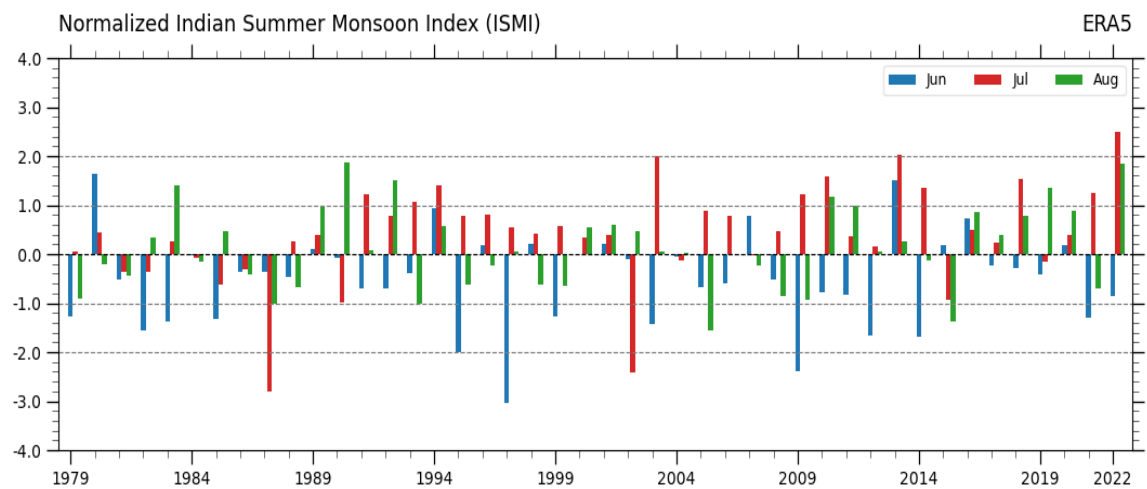


Figure 3: Monthly Indian Summer Monsoon Index for June, July and August from 1979 to 2022

The Indian Summer Monsoon Index was positively correlated with rainfalls in July and August in Pakistan (Fig. 4). Among them, the Indian Summer Monsoon Index in August had a significant positive correlation with the precipitation anomaly in most southern parts of Pakistan ($< 32^{\circ}\text{N}$). The correlation between Indian Summer Monsoon Index and the precipitation anomaly is positive in southern Pakistan in July. The correlation is significant mainly in Baluchistan.

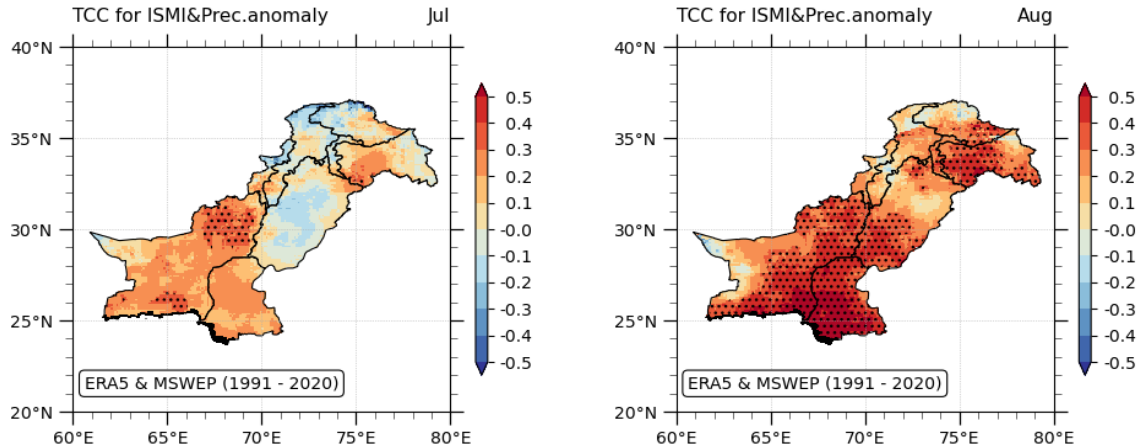


Figure 4: Spatial distribution of Indian Summer Monsoon Index in July and August and precipitation anomaly in Pakistan during 1991-2020, July on the left, August on the right.

In conclusion, the relationship between the historical precipitation and the Indian Summer Monsoon Index shows that the Indian Summer Monsoon in July and August of 2022 was the strongest of the historical period. The intensity was more than twice as strong as usual and continued to be extremely strong in July and August, which led to the extreme flood disaster in southern Pakistan in July and August.

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