

## **Supplementary Material**

### **Predictability of the Early Summer Surface Air Temperature over Western South Asia**

Irfan Ur Rashid<sup>1</sup>, Muhammad Adnan Abid<sup>\*2,3</sup>, Marisol Osman<sup>4,5</sup>, Fred Kucharski<sup>3</sup>, Moetasim Ashfaq<sup>6</sup>, Antje Weisheimer<sup>2,7</sup>, Mansour Almazroui<sup>8,9</sup>, José Abraham Torres-Alavez<sup>10</sup>,  
Muhammad Afzaal<sup>1</sup>.

1. *Research and Development Division, Pakistan Meteorological Department, Islamabad, Pakistan*
2. *Atmospheric, Oceanic and Planetary Physics (AOPP), Department of Physics, University of Oxford, U.K.*
3. *Earth System Physics, Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, Italy*
4. *Karlsruhe Institute of Technology, Karlsruhe, Germany*
5. *Universidad de Buenos Aires, Facultad de Ciencias Exactas y Naturales, Departamento de Ciencias de la Atmósfera y los Océanos, CONICET – Universidad de Buenos Aires, Centro de Investigaciones del Mar y la Atmósfera (CIMA), CNRS – IRD – CONICET – UBA, Instituto Franco-Argentino para el Estudio del Clima y sus Impactos (IRL 3351 IFAECI), Buenos Aires, Argentina.*
6. *Computational Sciences and Engineering Division, Oak Ridge National Laboratory, Oak Ridge, TN, USA.*
7. *European Centre for Medium-Range Weather Forecasts (ECMWF), Reading, U.K.*
8. *Centre of Excellence for Climate Change Research (CECCR)/Department of Meteorology, King Abdulaziz University, Jeddah, Saudi Arabia.*
9. *Climatic Research Unit, School of Environmental Sciences, University of East Anglia, Norwich, U.K.*
10. *Danish Meteorological Institute, Copenhagen, Denmark.*

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#### **Corresponding Author:**

\*M. Adnan Abid

Email: [adnan.abid@physics.ox.ac.uk](mailto:adnan.abid@physics.ox.ac.uk)

ORCID: <https://orcid.org/0000-0002-7389-7977>

### Supplementary Figure List

**Figure S1: a-d)** Mean surface air temperature (SAT) for NCEP, MERRA-2, CRU and CPC during early summer season (May-June: MJ) respectively; **e-h)** same as of (a-d) but for the standard deviation (STD) of the SAT. Unit is ( $^{\circ}\text{C}$ ).

**Figure S2:** Performance (correlation matrix) of the observational and reanalysis dataset of SAT over WSA in comparison to each other.

**Figure S3: a)** Mean Bias and **b)** RMSE of SAT for SEAS5 against ERA5 during early summer (May-June: MJ) season for the period 1981-2022. Unit is ( $^{\circ}\text{C}$ ).

**Figure S4:** Area-averaged bias of the SEAS5 SAT over the Western South Asia (WSA) region with respect to the ERA5, NCEP, MERRA-2, CRU and CPC. Unit is ( $^{\circ}\text{C}$ ).

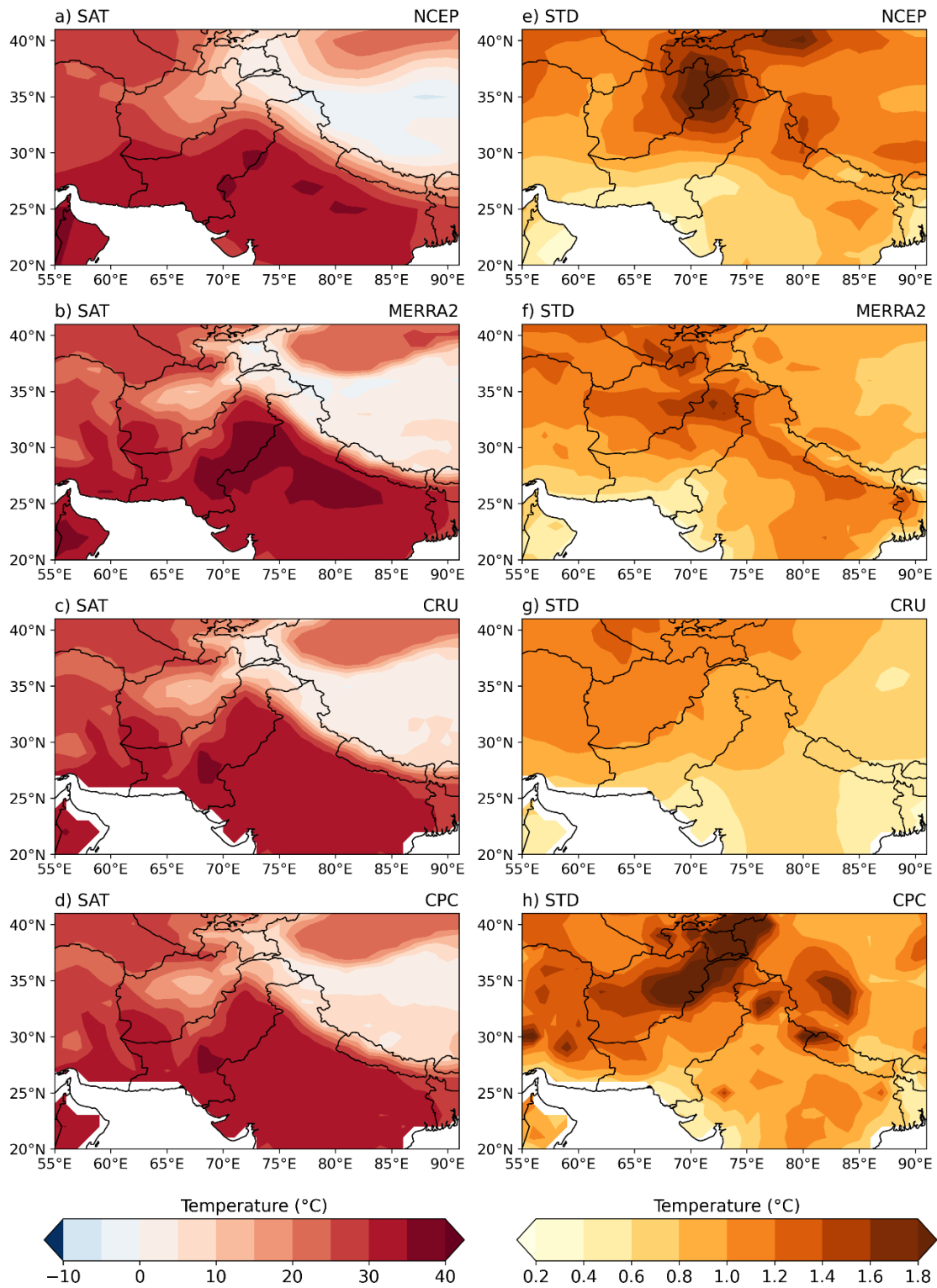
**Figure S5:** ENSO (standardized Niño3.4 Index) forced SAT regression coefficient of SEAS5 ensemble member (blue bars) averaged over WSA compared with the corresponding ERA5 (black line) (for both values are multiplied with -1). Red dashed lines represent the ensemble mean  $\pm$  1-standard deviation. Unit is ( $^{\circ}\text{C}$ ).

**Figure S6: a-c)** ERA5 SAT anomaly ( $^{\circ}\text{C}$ ) composite maps for the warm years (referred as SATI<sub>w</sub>), corresponding 200-hPa geopotential height anomalies (Z200; m) and SST anomalies ( $^{\circ}\text{C}$ ) for the period 1981-2022 respectively; **d-f)** same as (a-c) but for colder temperature composite anomalies (referred as SATI<sub>c</sub>). Warm and Cold temperature years are selected based on  $\pm 1^{\circ}\text{C}$  standard deviation of the ERA5 SATI over WSA region (shown in Table S2).

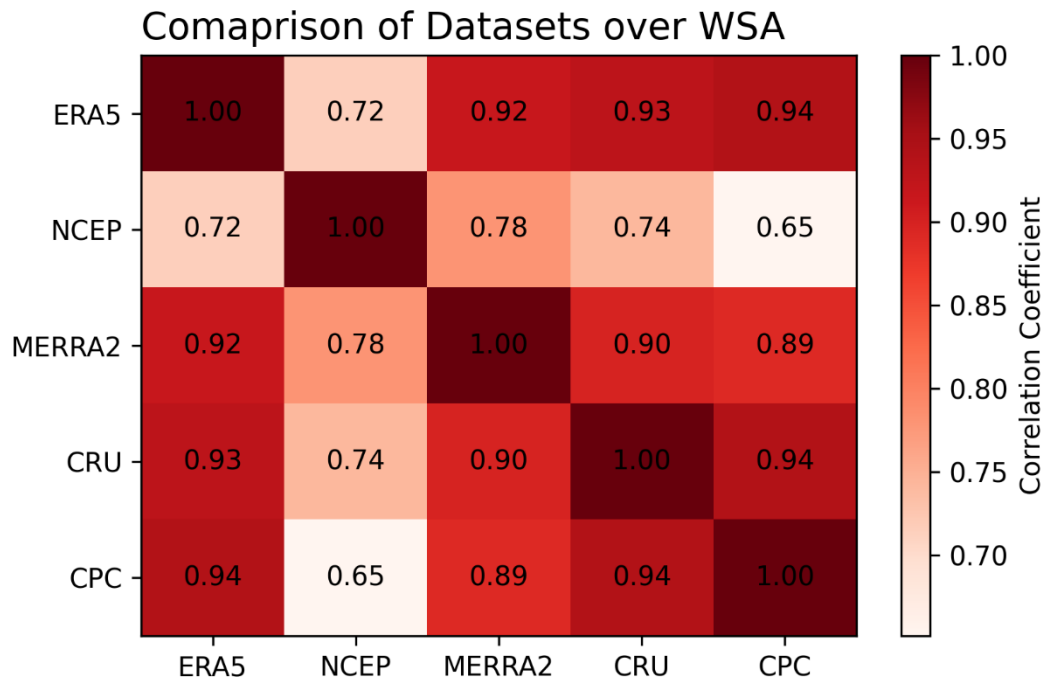
**Figure S7: a-d)** Regression maps of global SST onto the standardized SATI of WSA for CPC, CRU, MERRA-2 and NCEP respectively for the period 1981-2022. Unit is ( $^{\circ}\text{C}$ ).

**Figure S8:** Actual skill of SAT during early summer season (May-June; MJ) based on **a)** NCEP (1981-2022), **b)** MERRA-2 (1981-2022), **c)** CRU (1981-2021) and **d)** CPC (1981-2022) over WSA region.

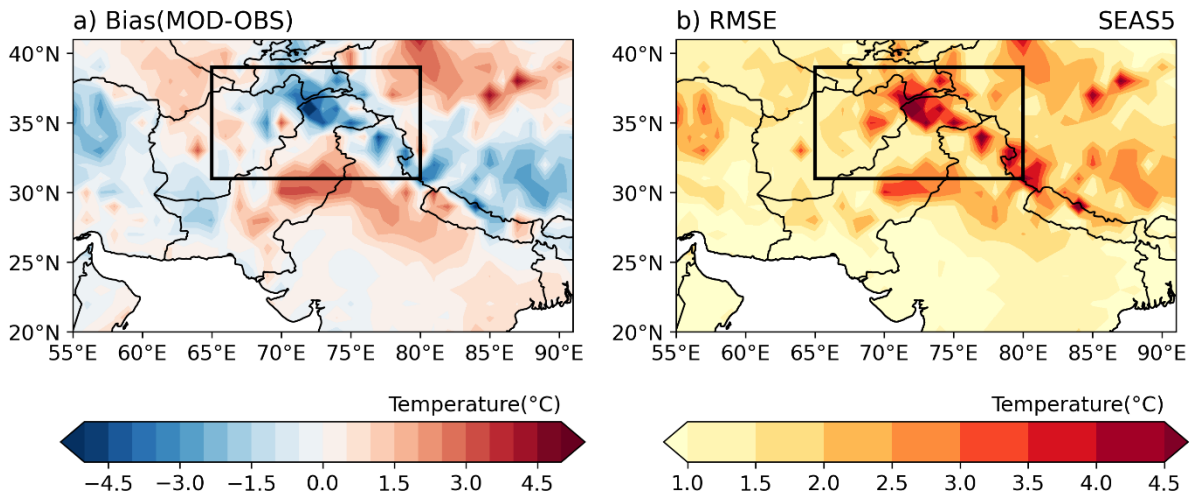
**Figure S9: a-b)** Signal and Noise (Unit is  $^{\circ}\text{C}^2$ ) for El Niño and **c-d)** La Niña years of SAT during early summer season for the period 1981-2022.



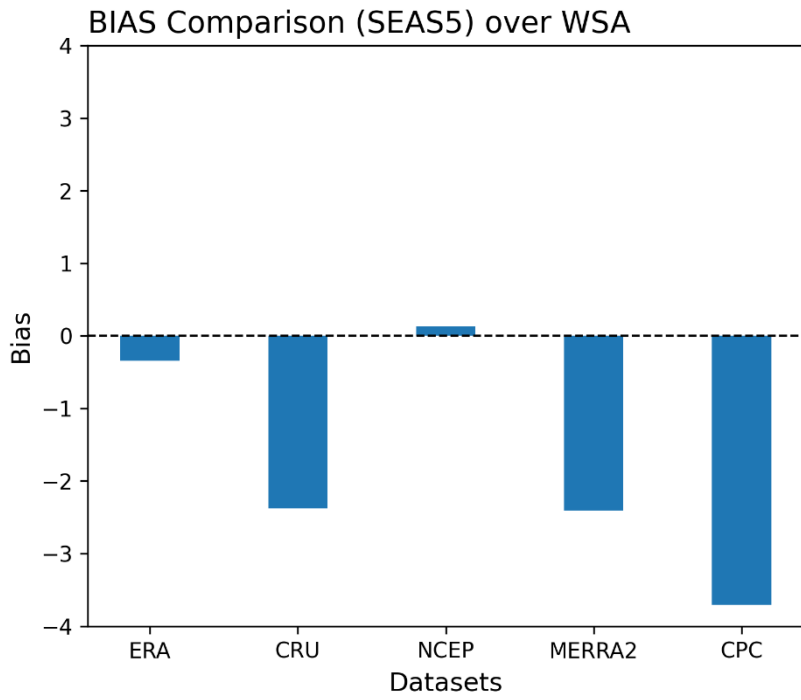
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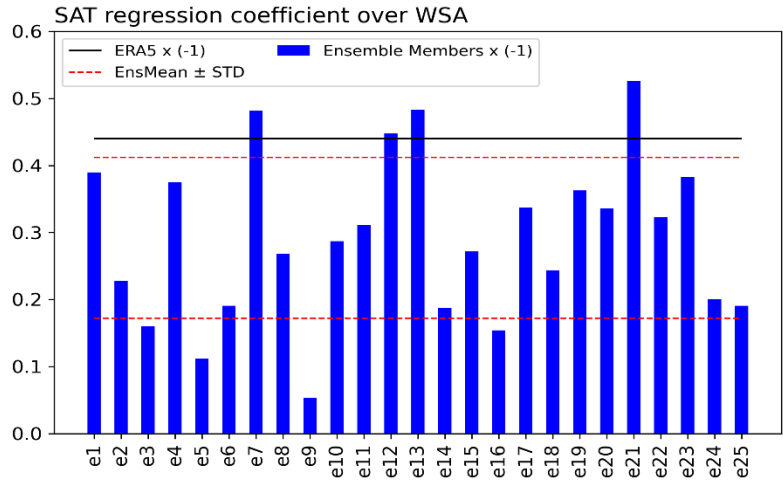
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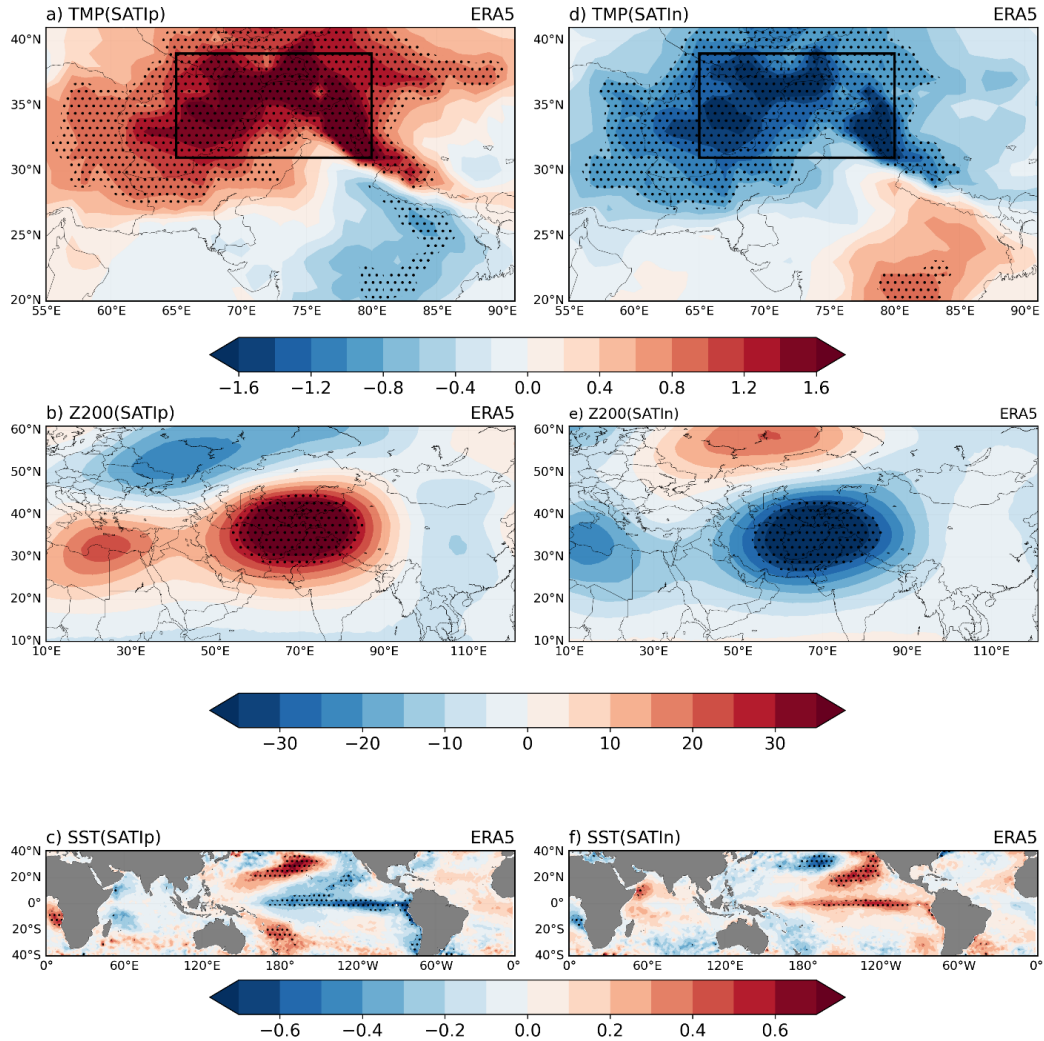
**Figure S3: a) Mean Bias and b) RMSE of SAT for SEAS5 against ERA5 during early summer (May-June: MJ) season for the period 1981-2022. Unit is (°C).**



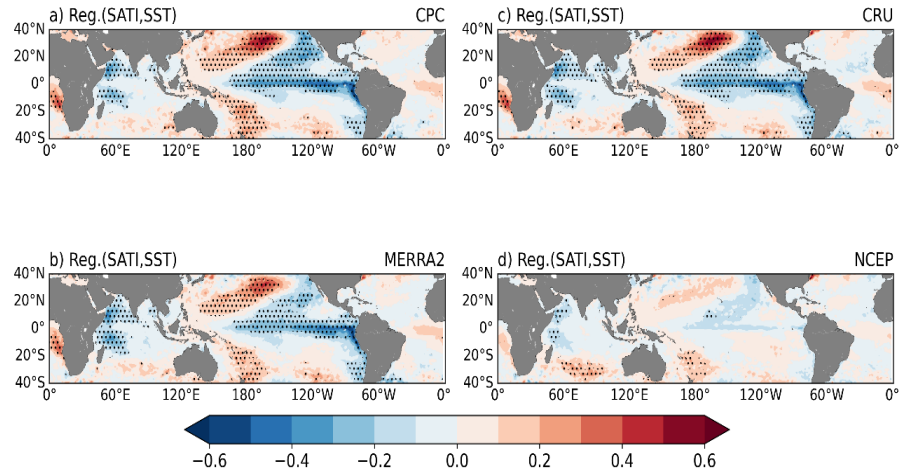
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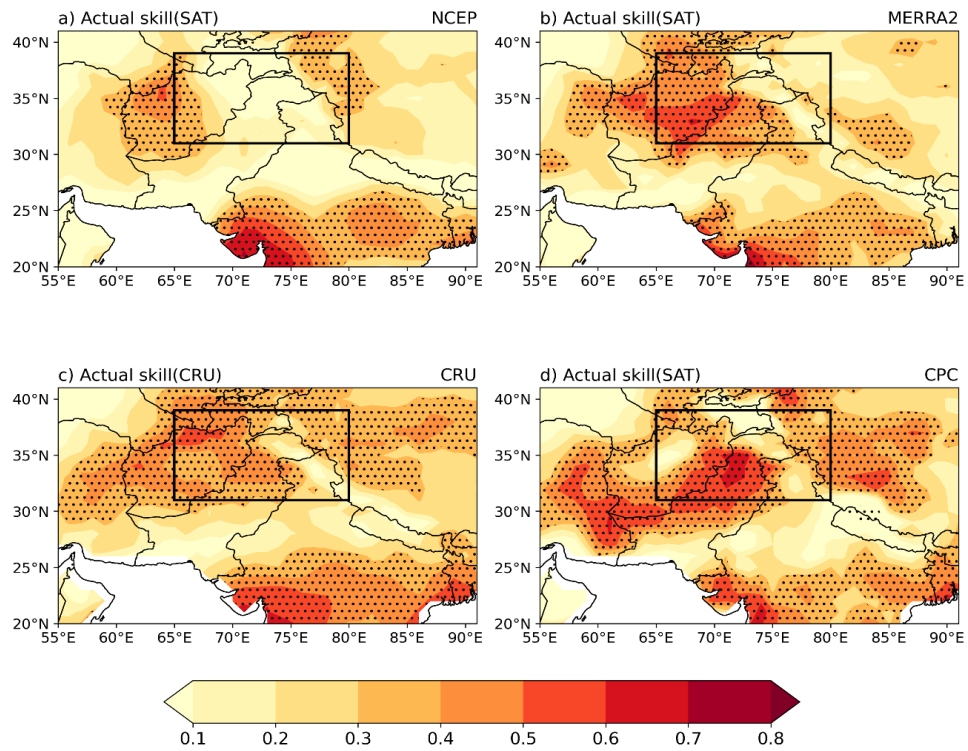
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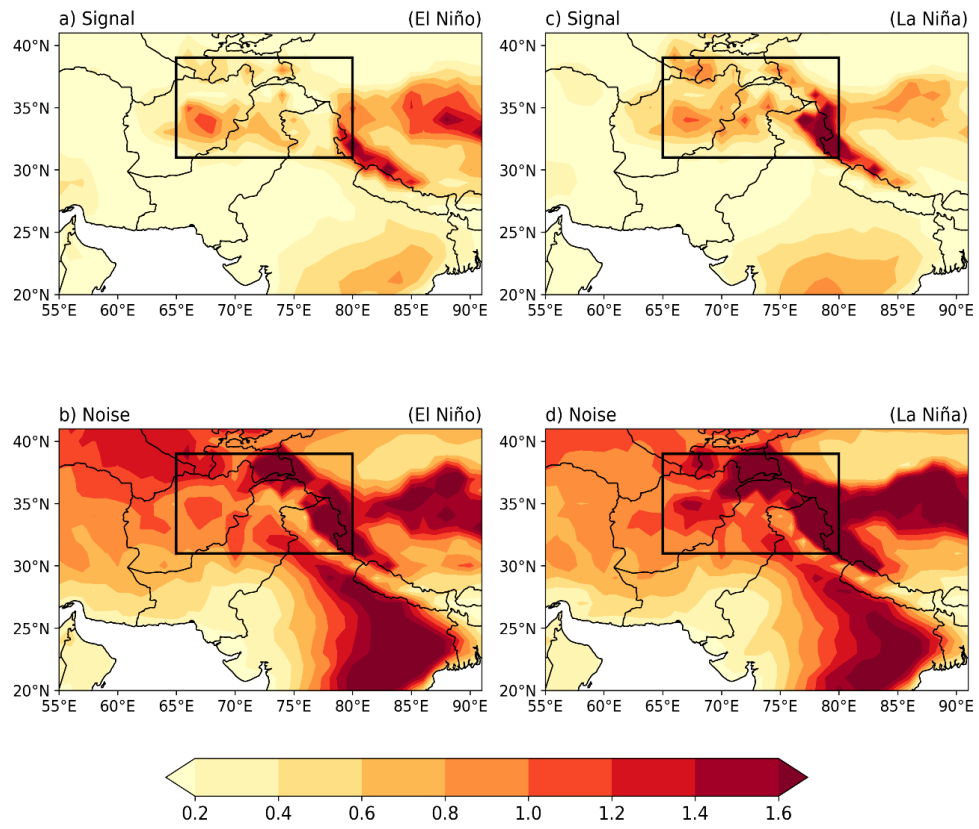
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**Figure S9: a-b) Signal and Noise (Unit is  $^{\circ}\text{C}^2$ ) for El Niño and c-d) La Niña years of SAT during early summer season for the period 1981-2022.**

### **Supplementary Tables**

**Table S1:** Detail of observational and reanalysis datasets used in the study.

**Table S2:** The positive and negative phase of SAT based on the ERA5 SATI referred as SATI<sub>p</sub> and SATI<sub>n</sub> respectively. Positive and negative years are defined based on  $\pm 1$ -standard deviation of SATI. (\*) indicate the years which correspond to the El Niño and La Niña during SATI<sub>n</sub> and SATI<sub>p</sub>

**Table S1:** Detail of observational and reanalysis datasets used in the study.

<b>Observational / reanalysis datasets</b>	<b>Horizontal Resolution (lat x lon)</b>	<b>Period</b>	<b>References</b>	<b>Data types</b>
Fifth generation European Re-Analysis (ERA5)	0.25° x 0.25°	1981-2022	(Hersbach <i>et al.</i> , 2020)	reanalysis
National Centre for Environmental Prediction (NCEP)/National Centre for Atmospheric Research (NCAR)	2.5° x 2.5°	1981-2022	(Kalnay <i>et al.</i> , 1996)	reanalysis
Climate Research Unit (CRU v4.04)	0.5° x 0.5°	1981-2021	(Harris <i>et al.</i> , 2020)	observational
Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA-2)	0.5° x 0.625°	1981-2022	(Gelaro <i>et al.</i> , 2017)	reanalysis
Climate Prediction Center (CPC)	0.5° x 0.5°	1981-2022	<a href="https://psl.noaa.gov/data/gridded/data.cpc.globaltemp.html">https://psl.noaa.gov/data/gridded/data.cpc.globaltemp.html</a>	observational

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<b>SAT Phases</b>	<b>Years</b>
<b>SATI<sub>p</sub> (9)</b>	1984*, 1988*, 1990, 2000*, 2001, 2006, 2008*, 2011, 2016
<b>SATI<sub>n</sub> (10)</b>	1987*, 1989, 1991*, 1992*, 1996, 1997*, 2003, 2005, 2009, 2019*