

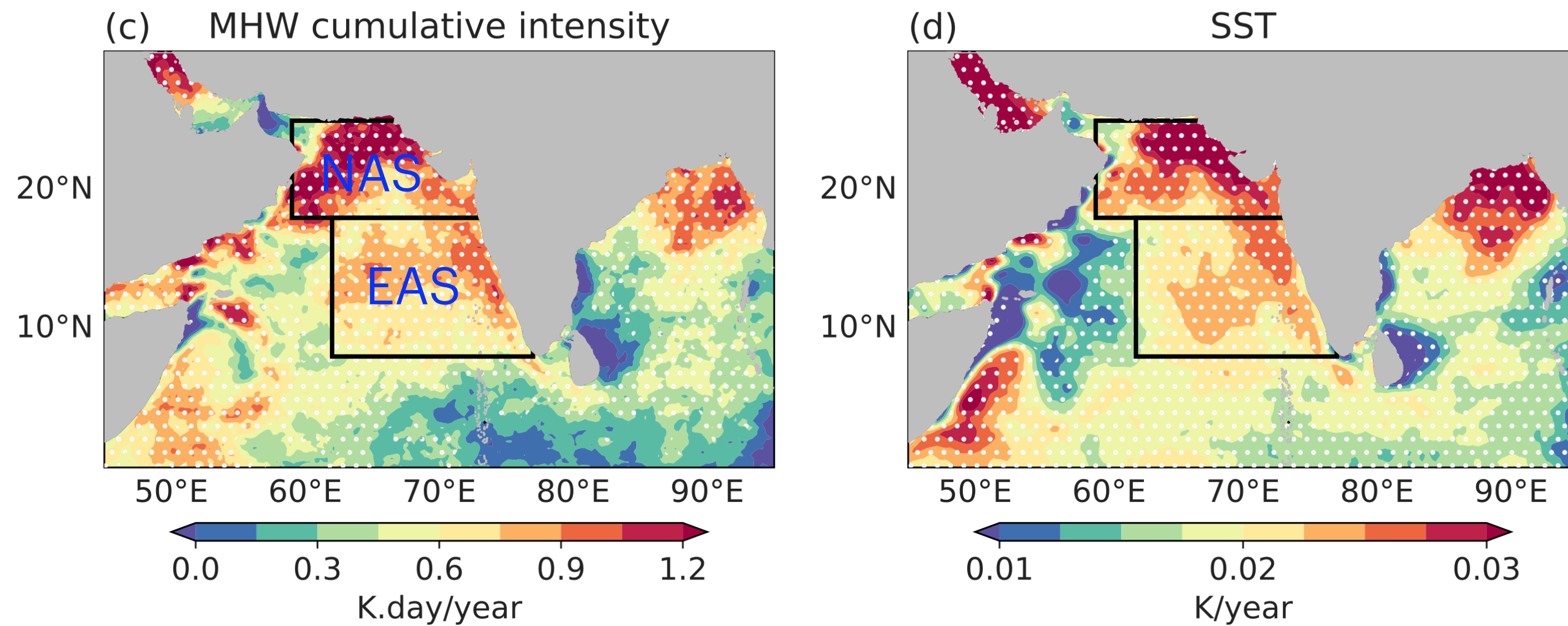
Marine Heatwaves in the Arabian Sea

Drivers and Impacts on Extreme Precipitation in
Southwest India and Pakistan

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Toshiaki Shinoda (Texas A&M U.), Rui Sun (Scripps),
Aneesh Subramanian (U. of Colorado), Mike Alexander (NOAA)

MHWs in the Arabian Sea

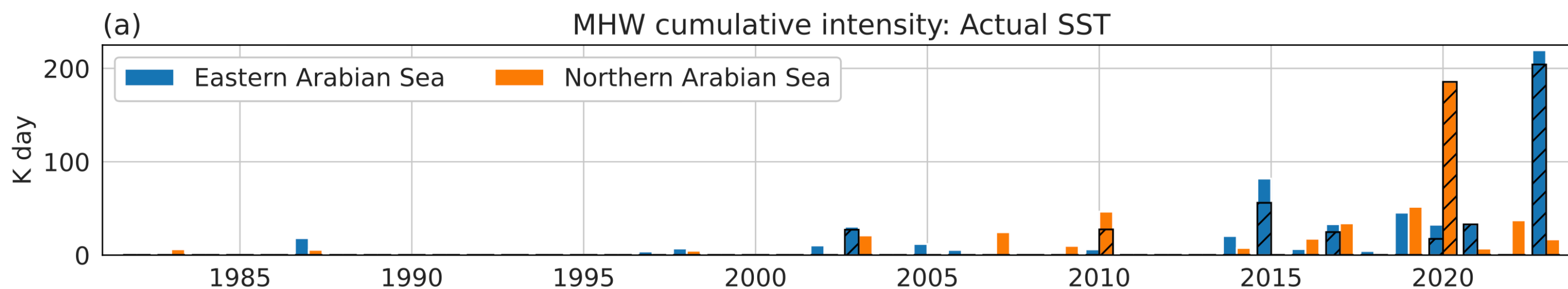
Trend in JJAS MHWs and SST



OISST 1982-2023

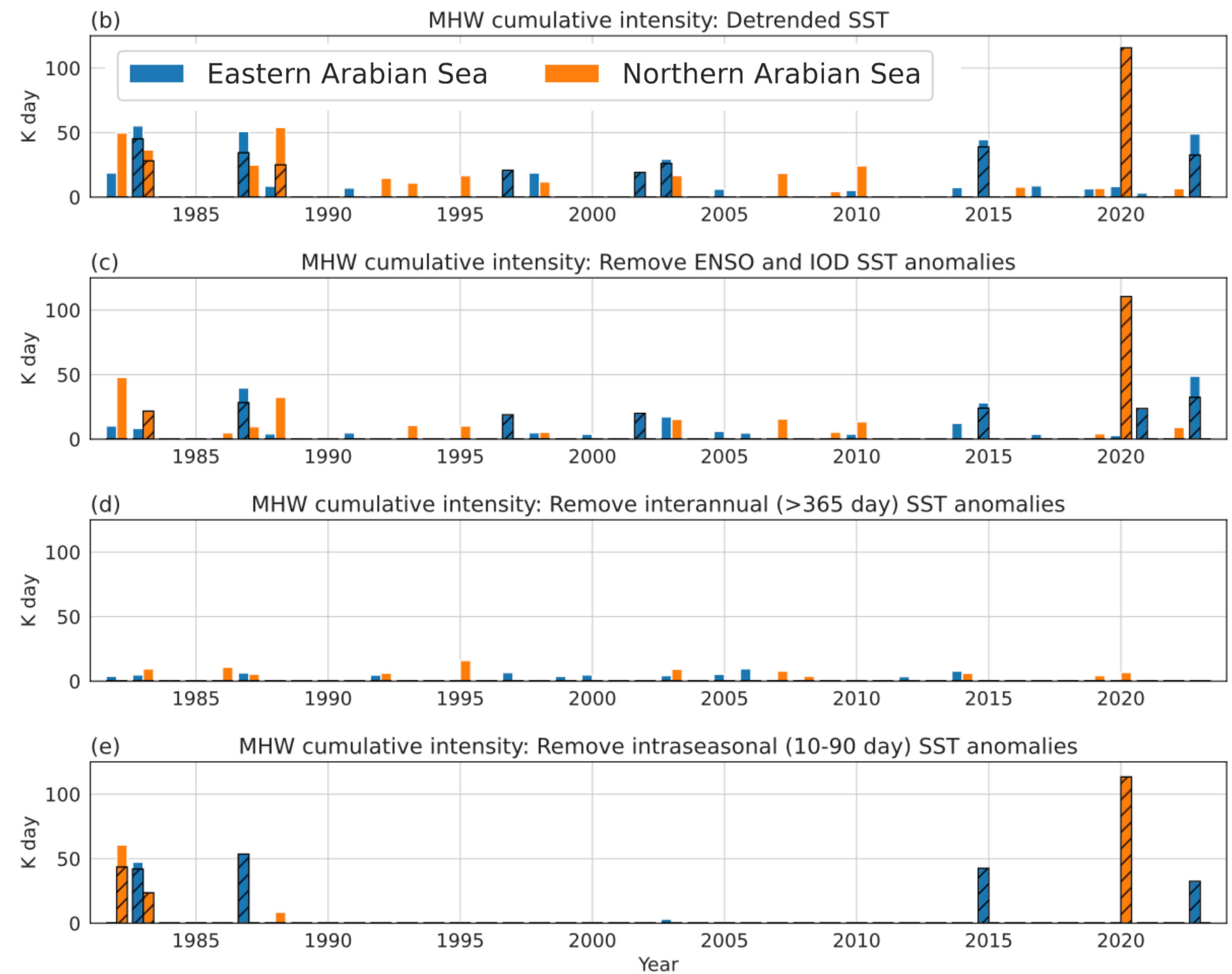
Objectives

- Drivers of Arabian Sea MHWs
- Impacts of MHWs
(precipitation and extreme events)

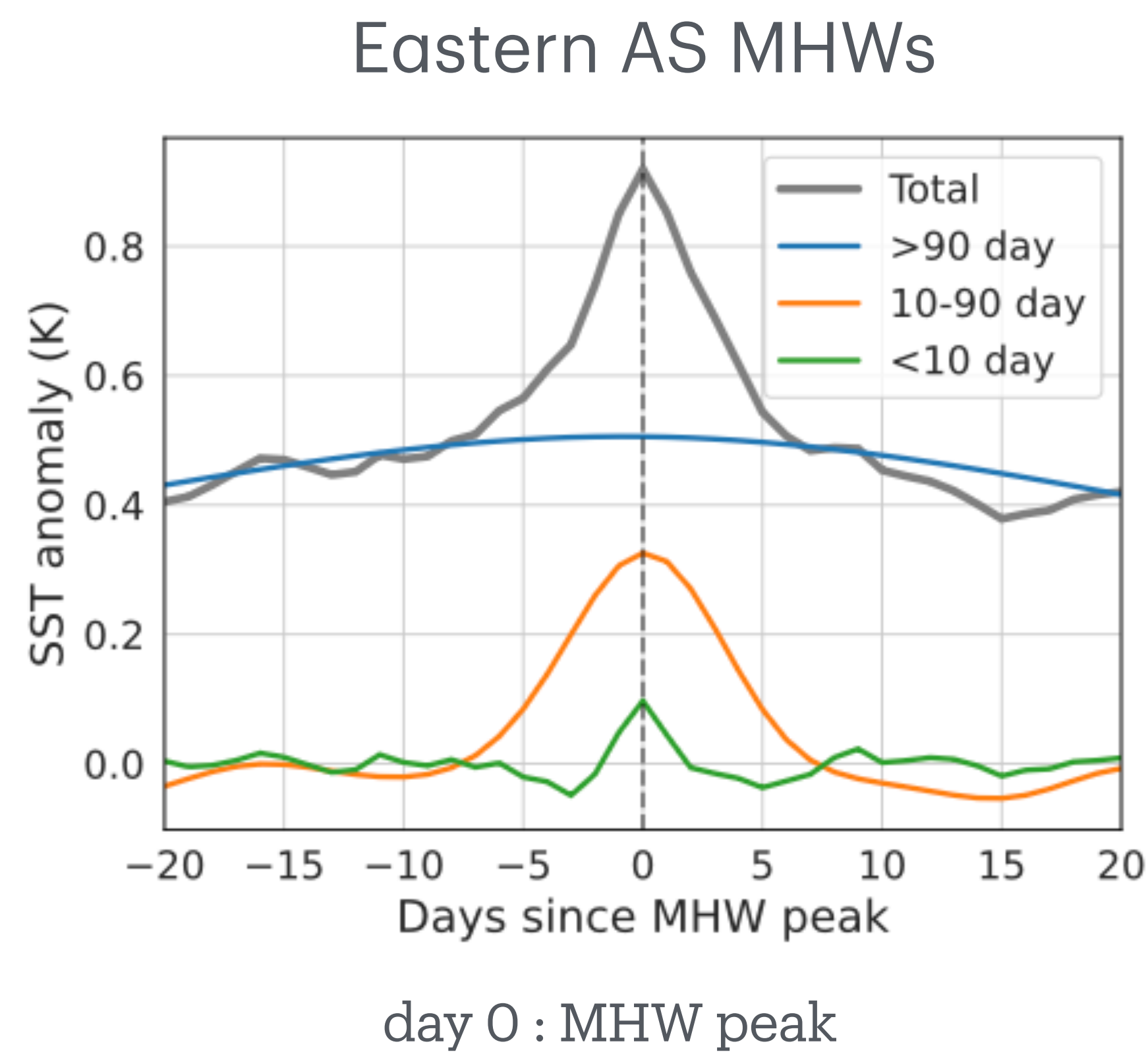


Increasing trend in MHWs

MHWs : Interannual to Intraseasonal Timescales



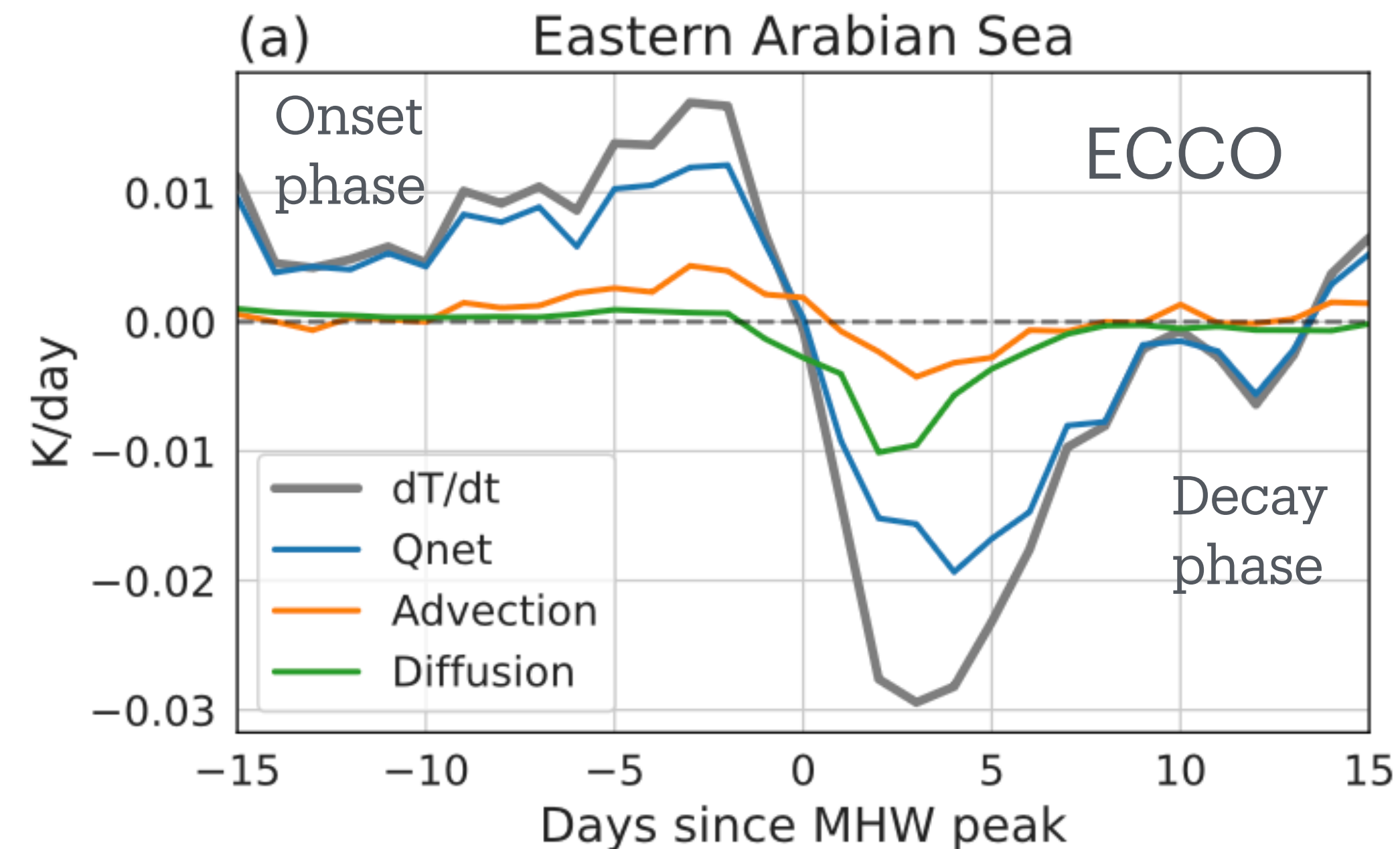
Hatched : longer MHWs (> 20 days)



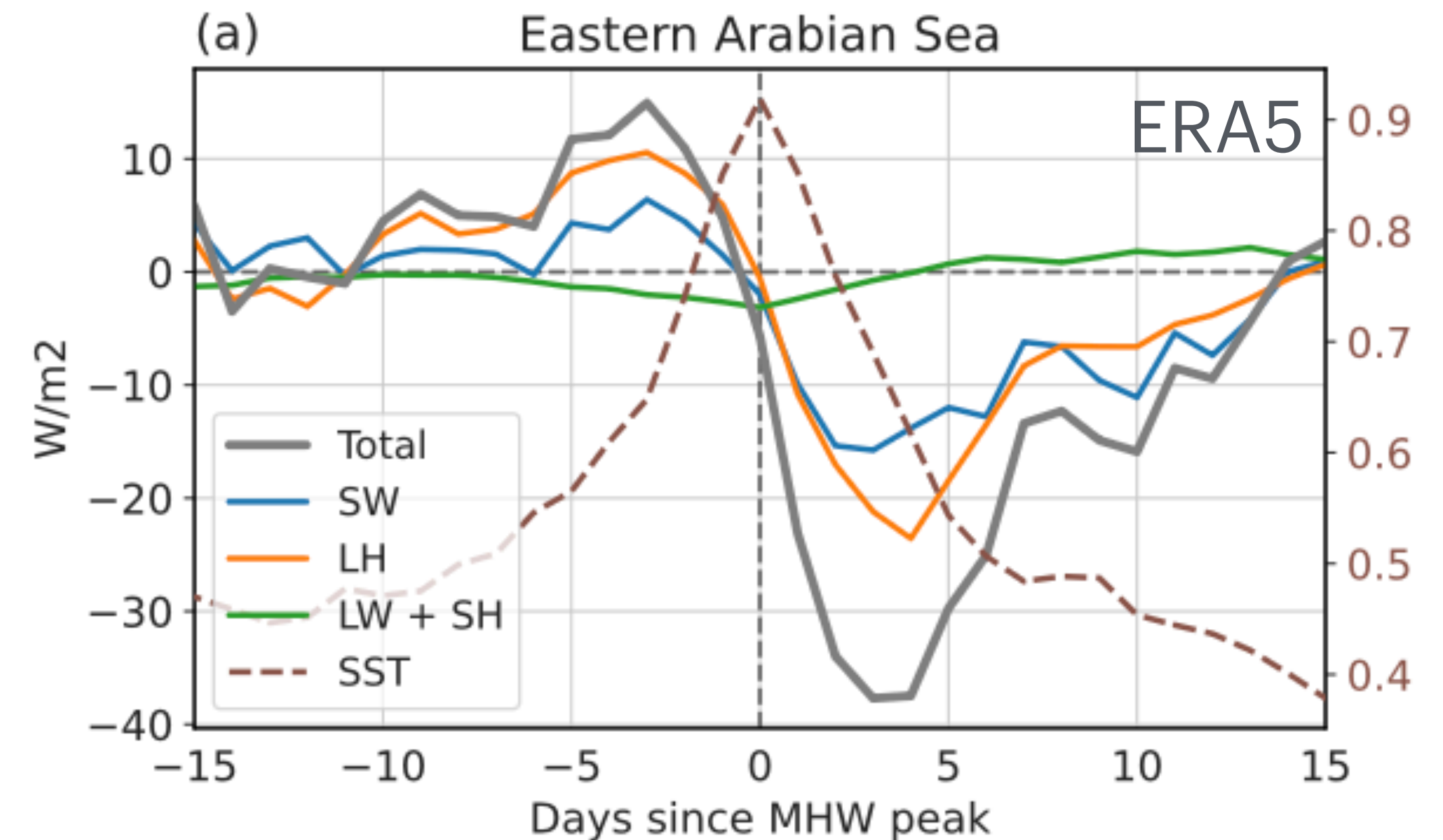
What Drives Individual MHWS?

Budget Analysis

Air-sea flux components



Surface air-sea fluxes dominate

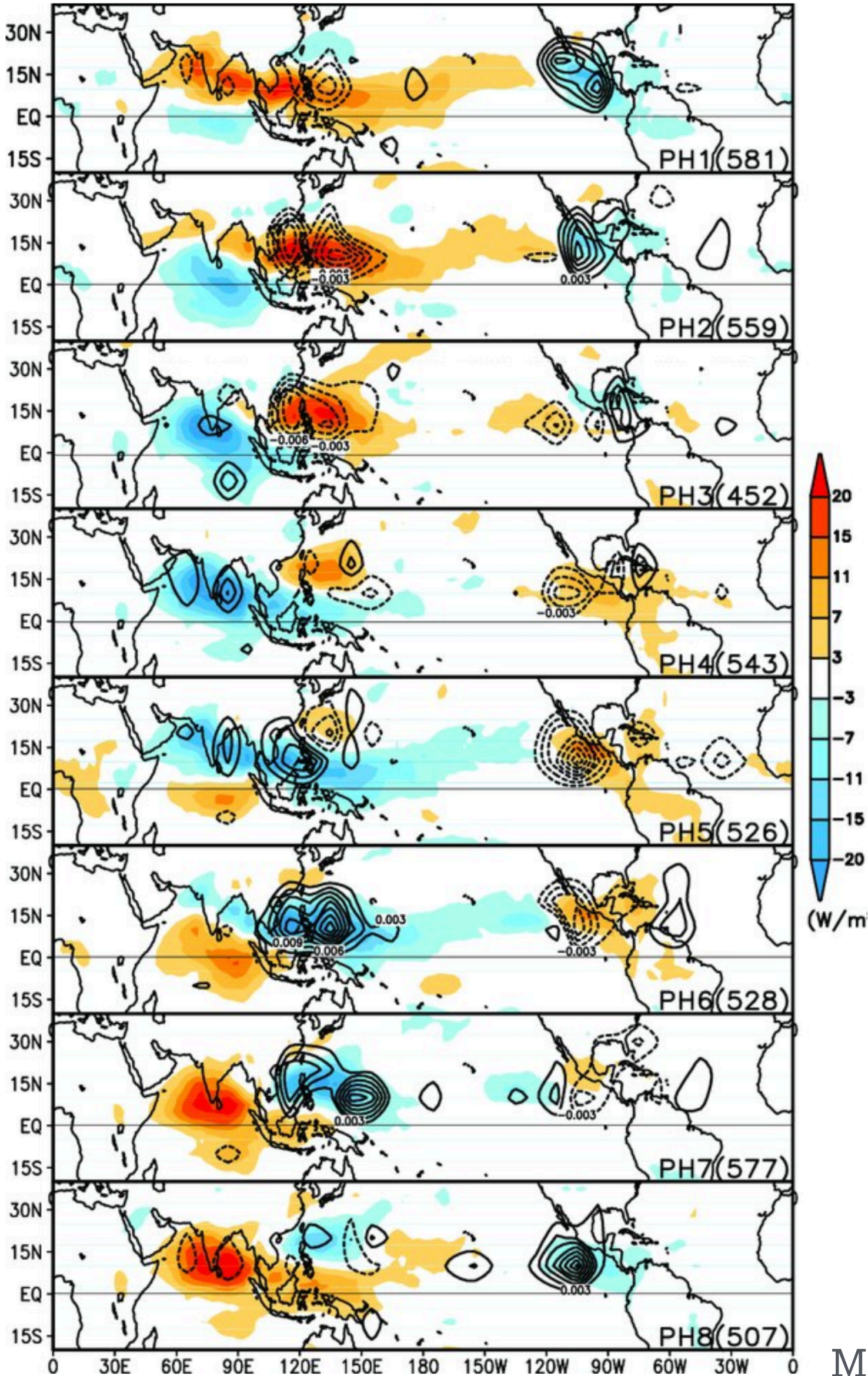


SW and LH contribute almost equally

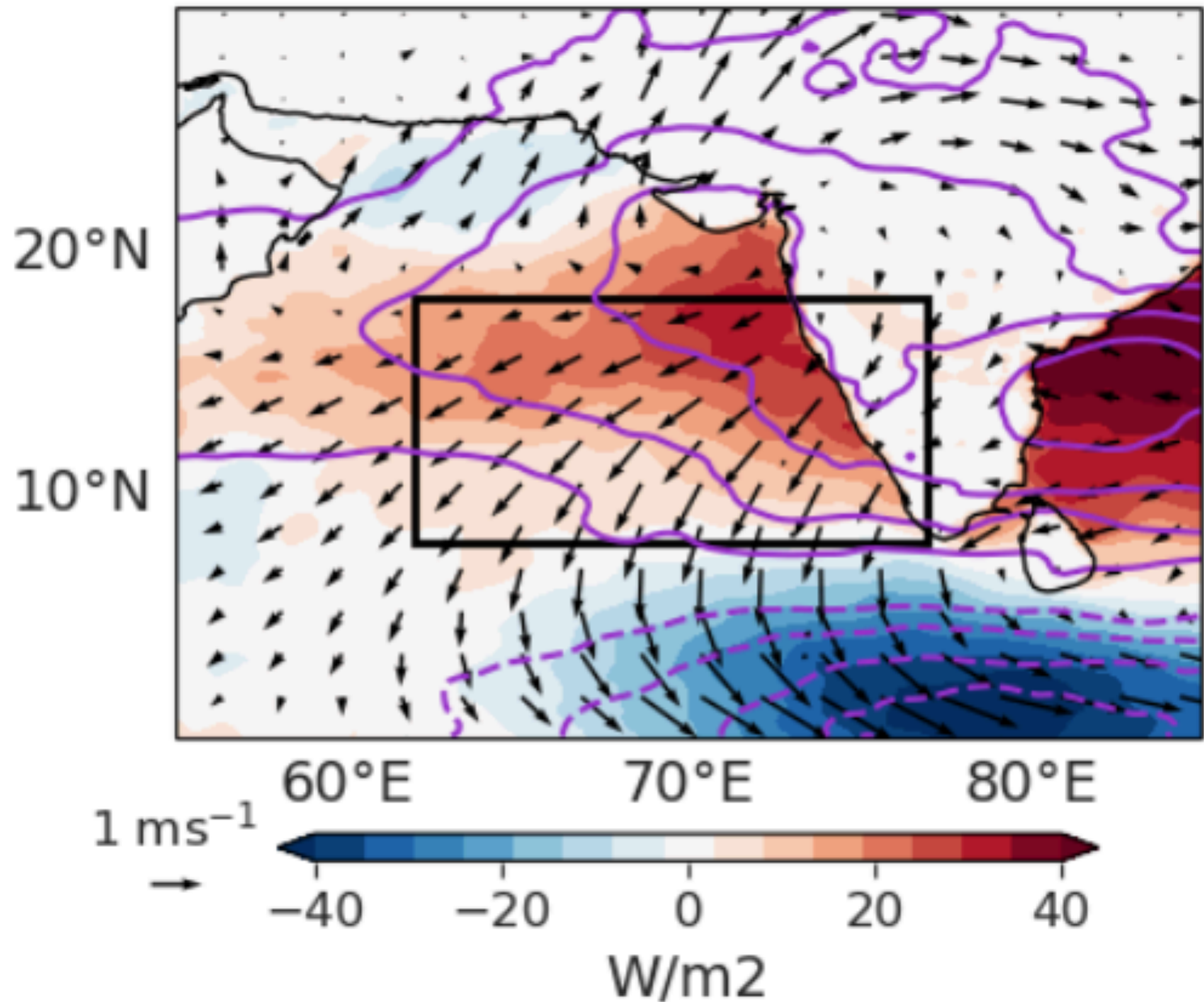
What causes these intraseasonal changes?

MHW Onset Phase

BSISO composites (OLR)

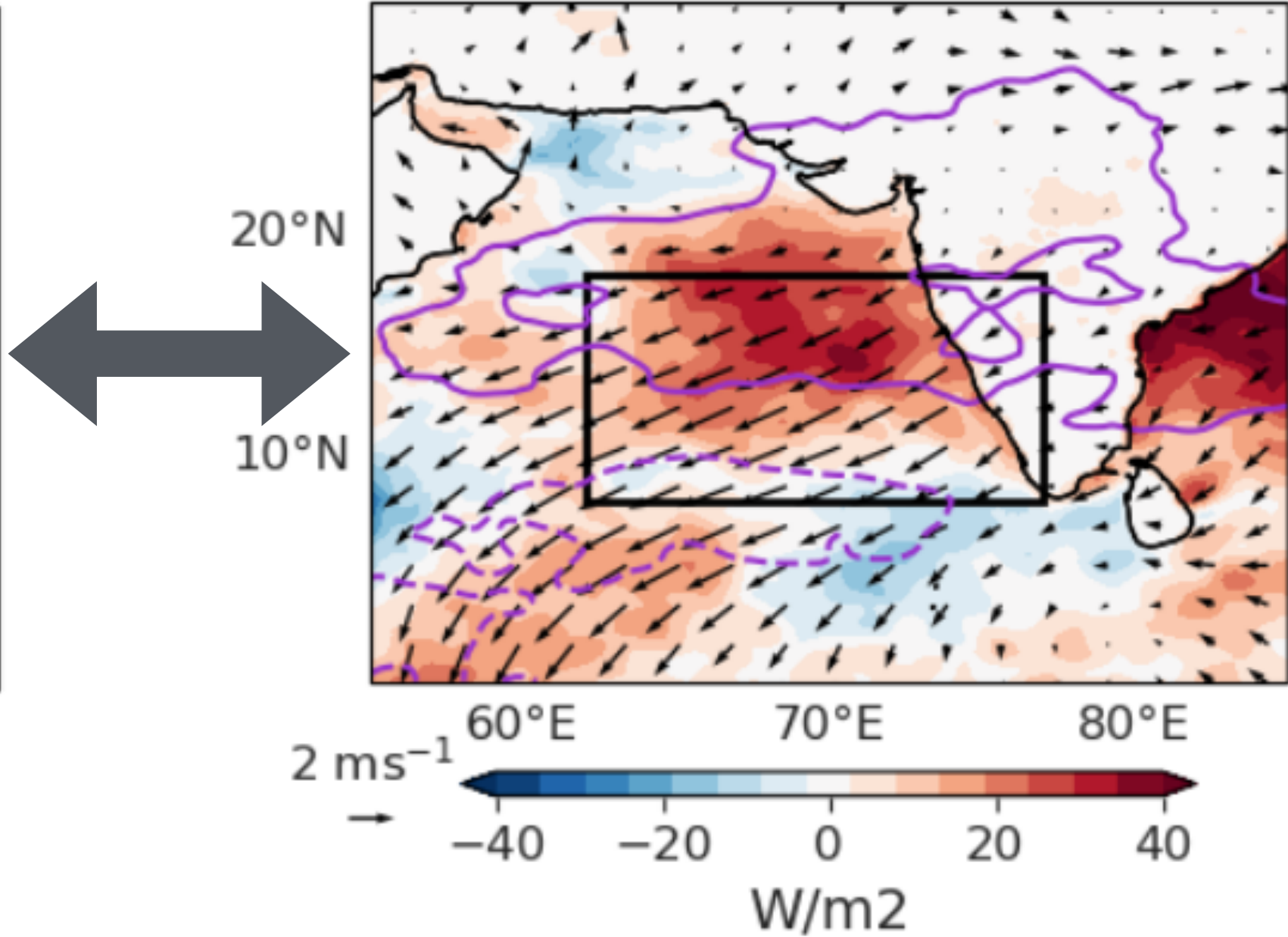


BSISO conditions favoring
E. Arabian Sea warming



- Qnet (ERA5): color
- Sfc. winds (CCMP): black vectors
- OLR (ERA5): purple contours

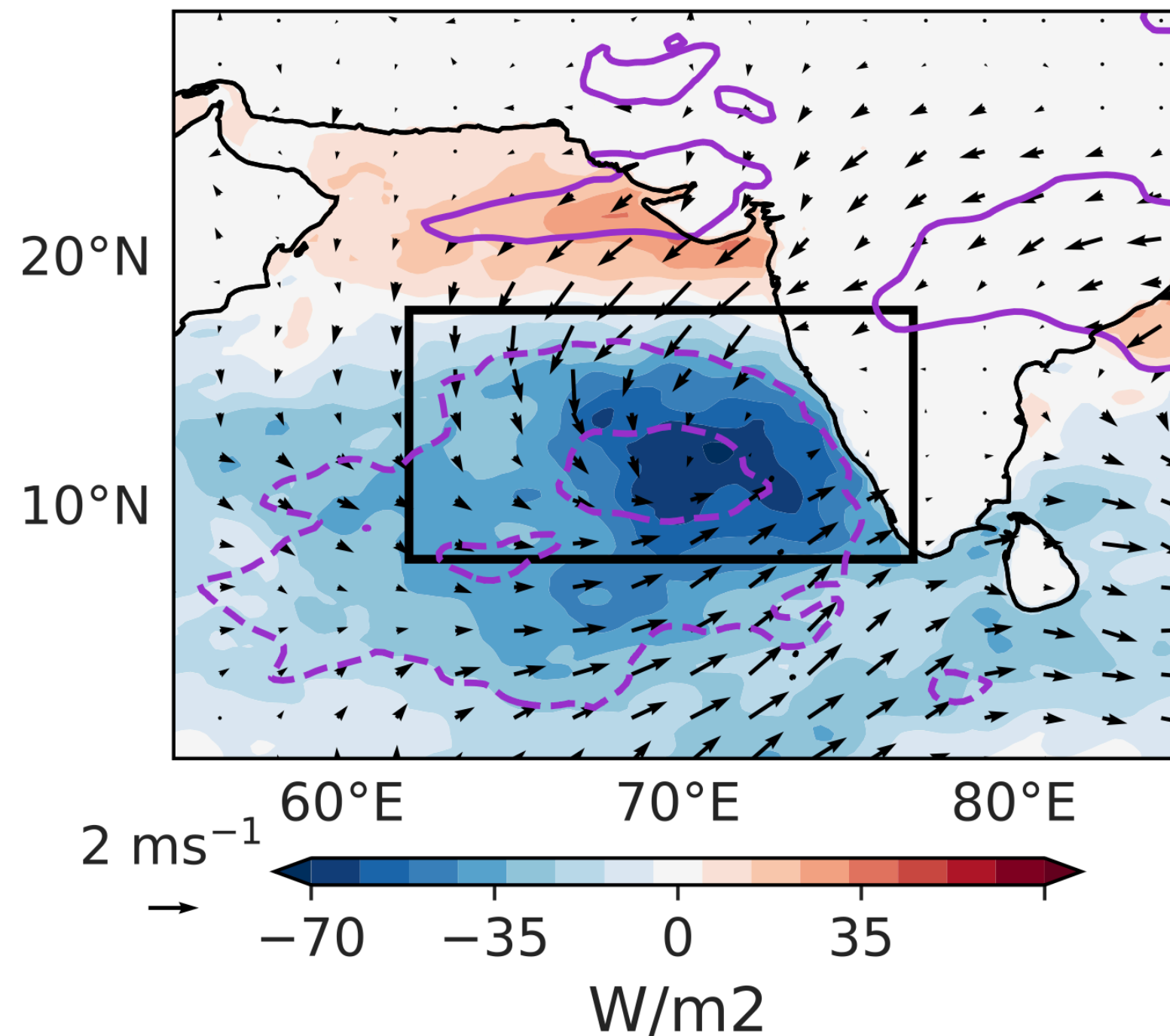
during MHW onset



Suppressed convection phase of BSISO can trigger MHWs

MHW Decay Phase

(d) MHW peak: 2 days



Qnet (ERA5): color

Sfc. winds (CCMP): black vectors

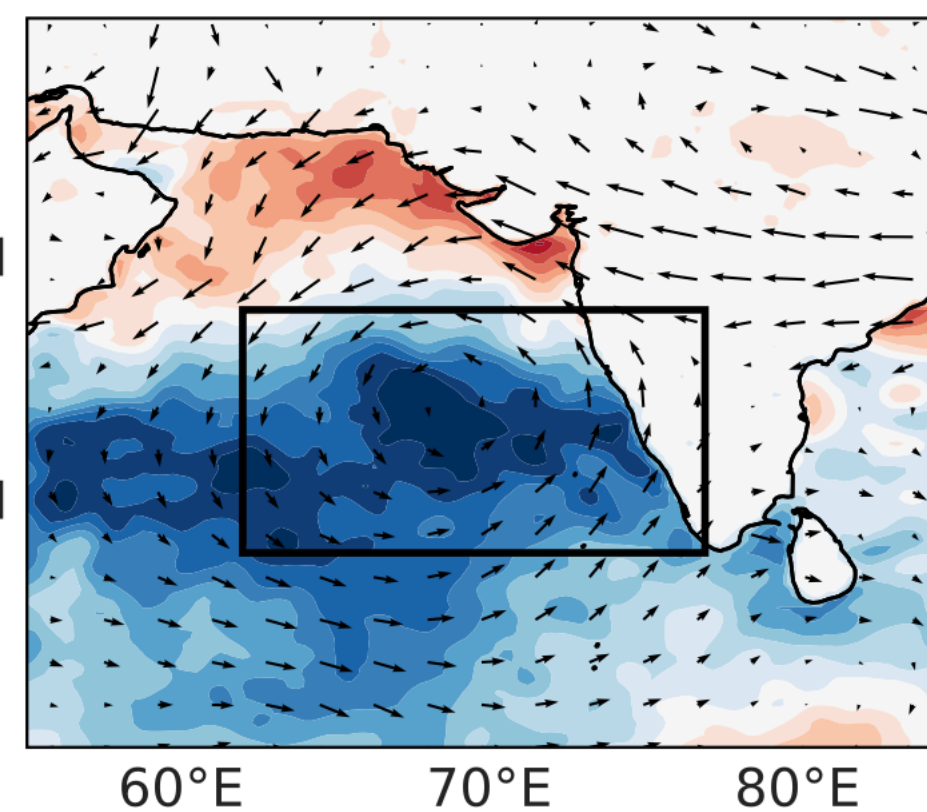
OLR (ERA5): purple contours

days 1 to 5

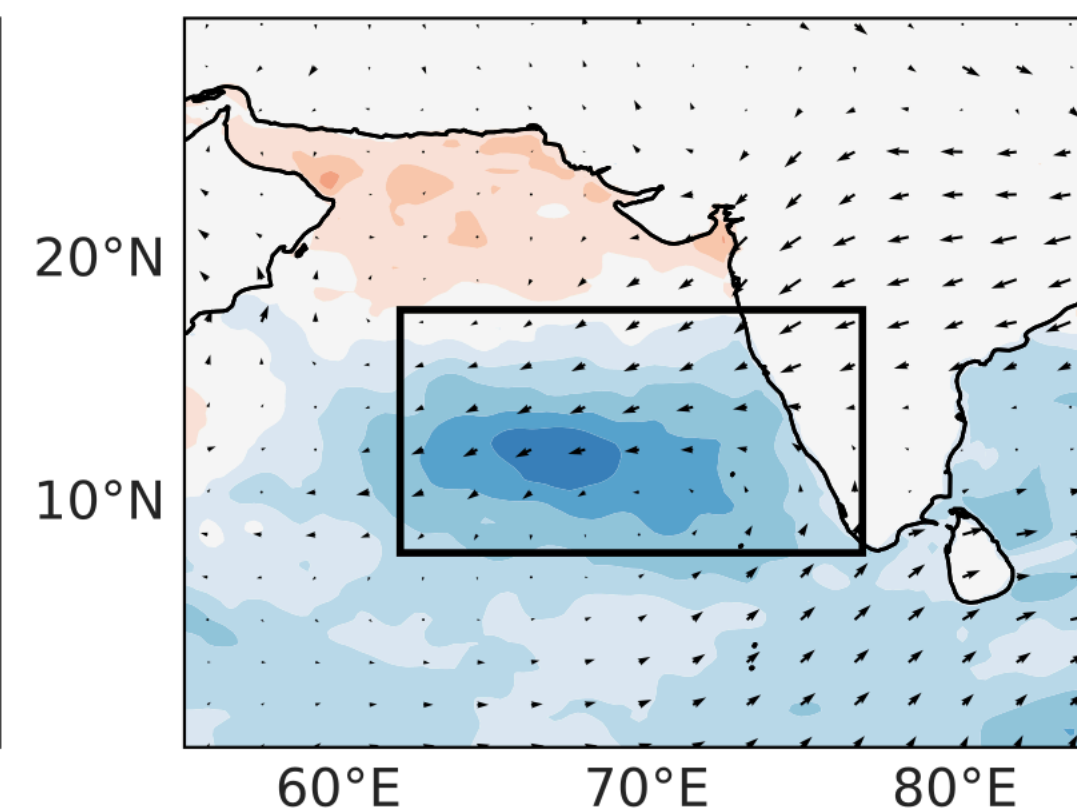
Cyclonic anomaly develops in response to warm SST anomalies

Is cyclonic anomaly due to MHW or BSISO?

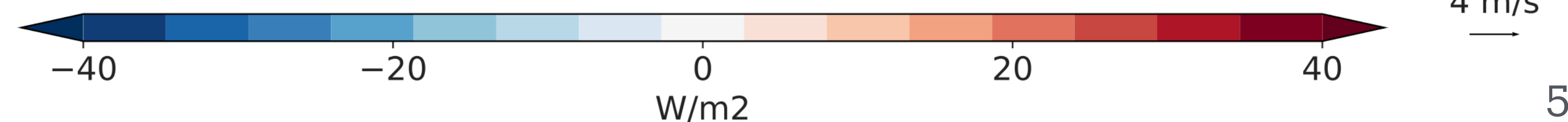
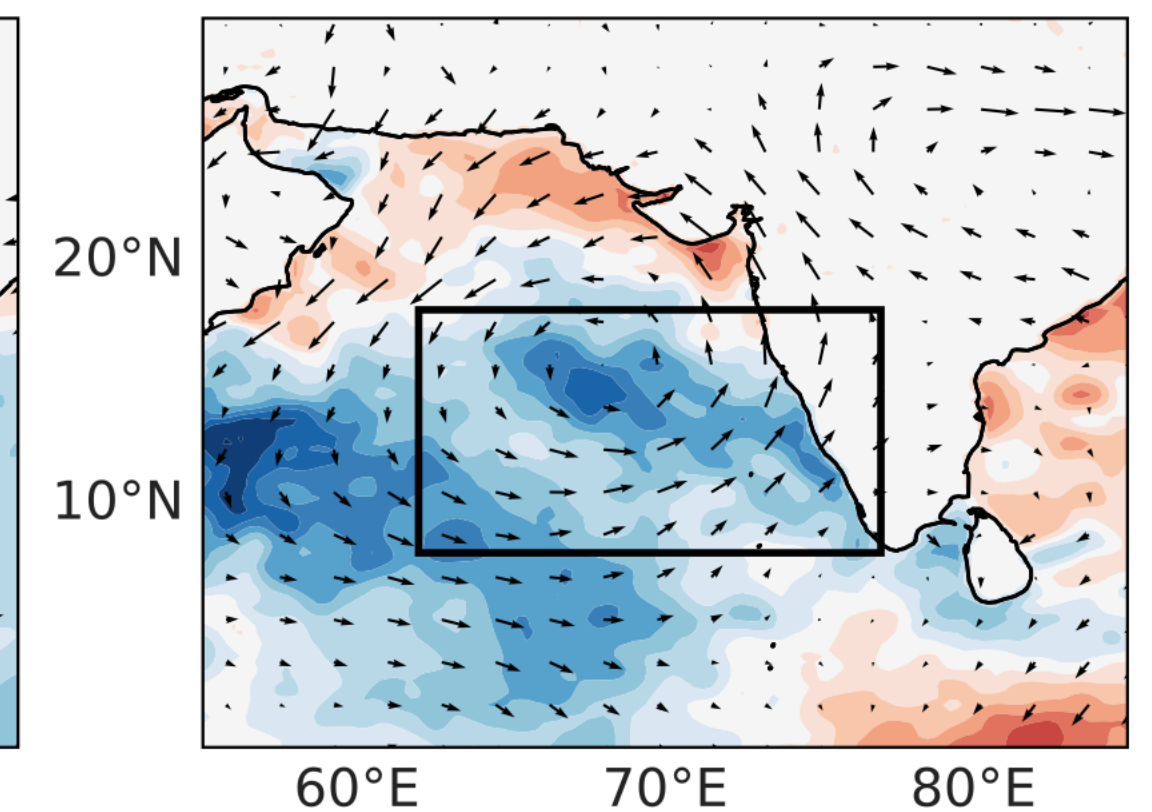
BSISO with MHW



BSISO without MHW



with - without MHW

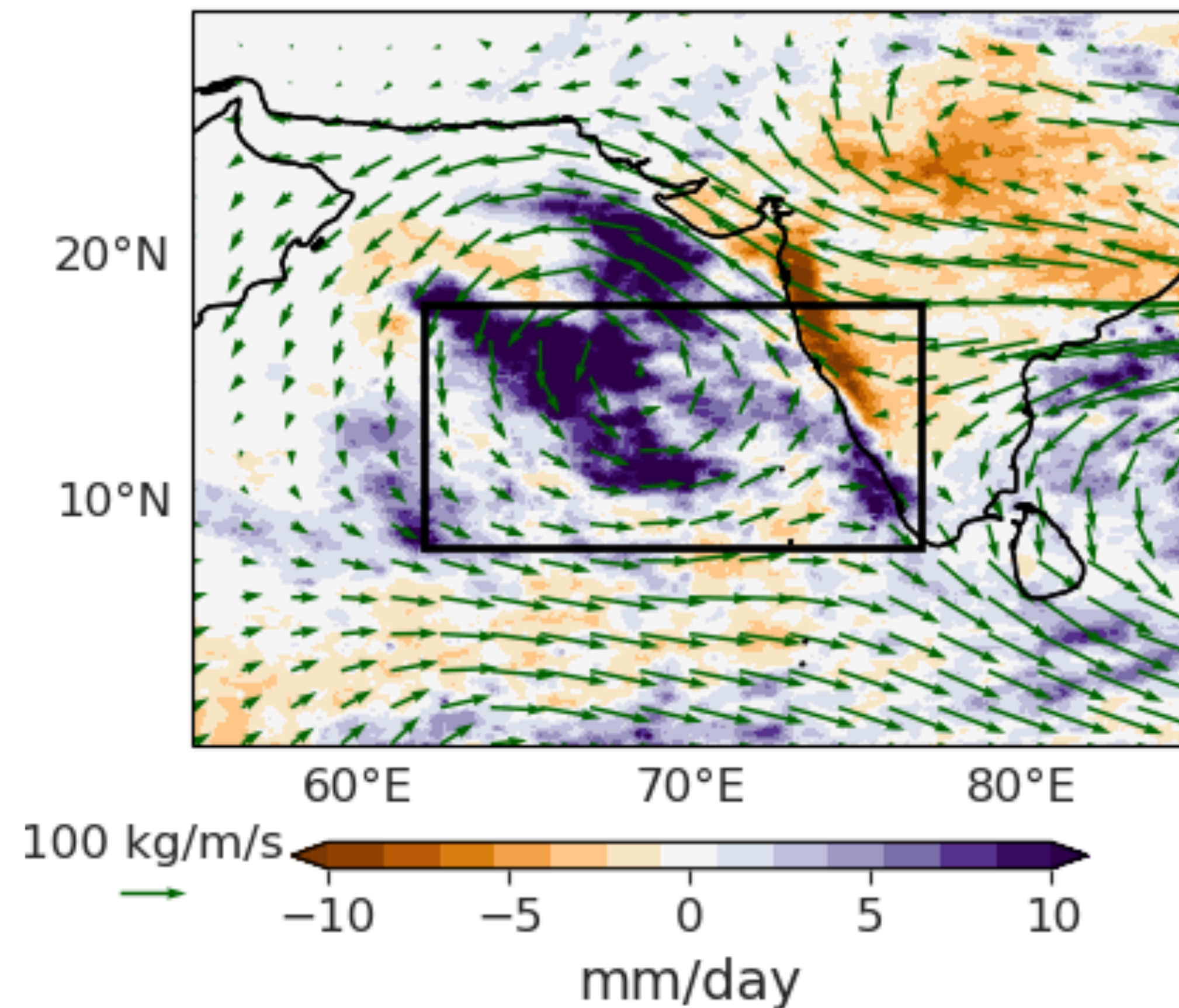


Impacts of Arabian Sea MHWs

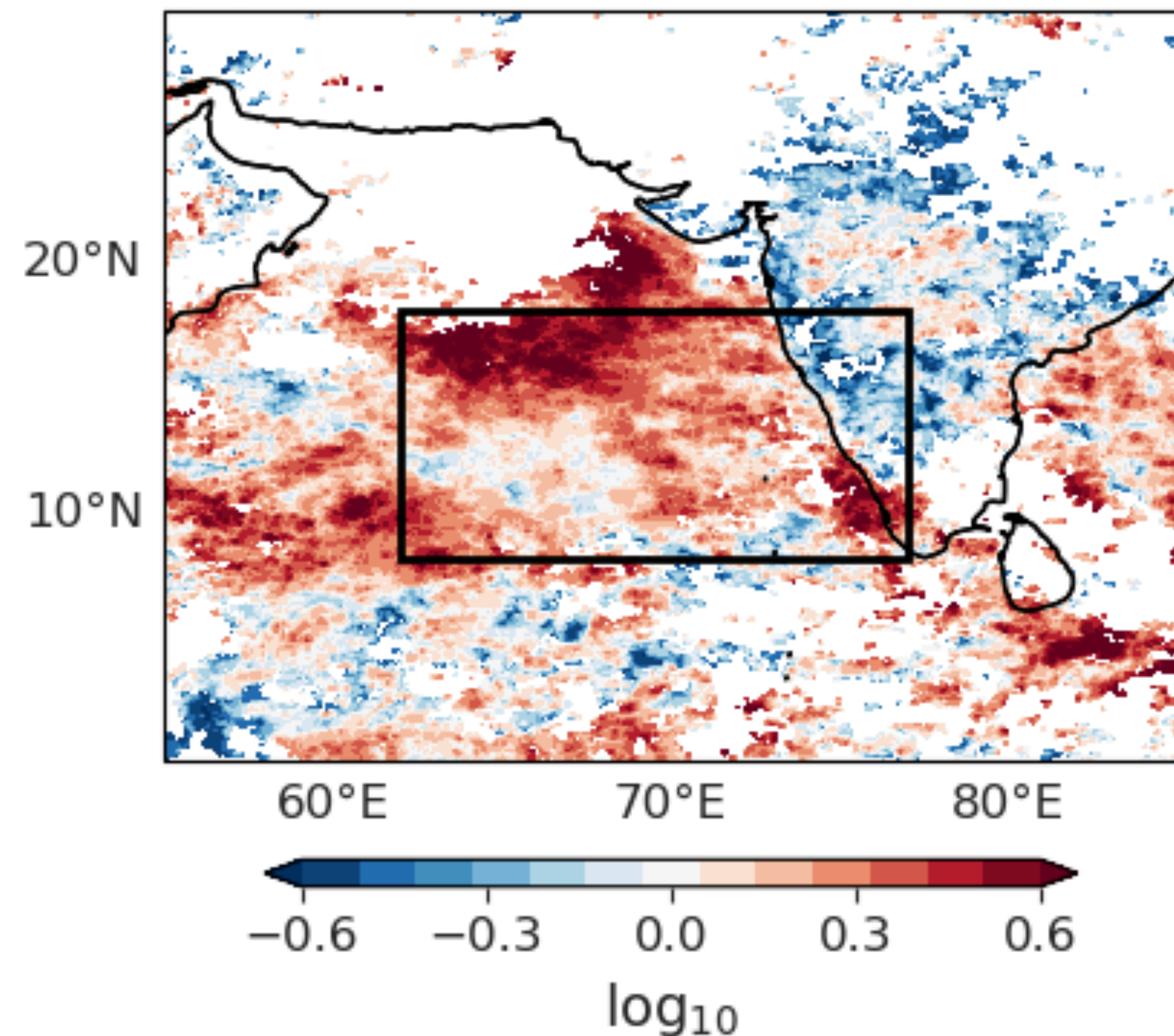
Impacts on Precipitation : Eastern Arabian Sea

BSISO_with MHW - BSISO_without MHW

Precipitation (color) and
moisture flux (green vectors)



Risk of P95 days for BSISO with MHW /
for BSISO without MHW



Case Study of a MHW

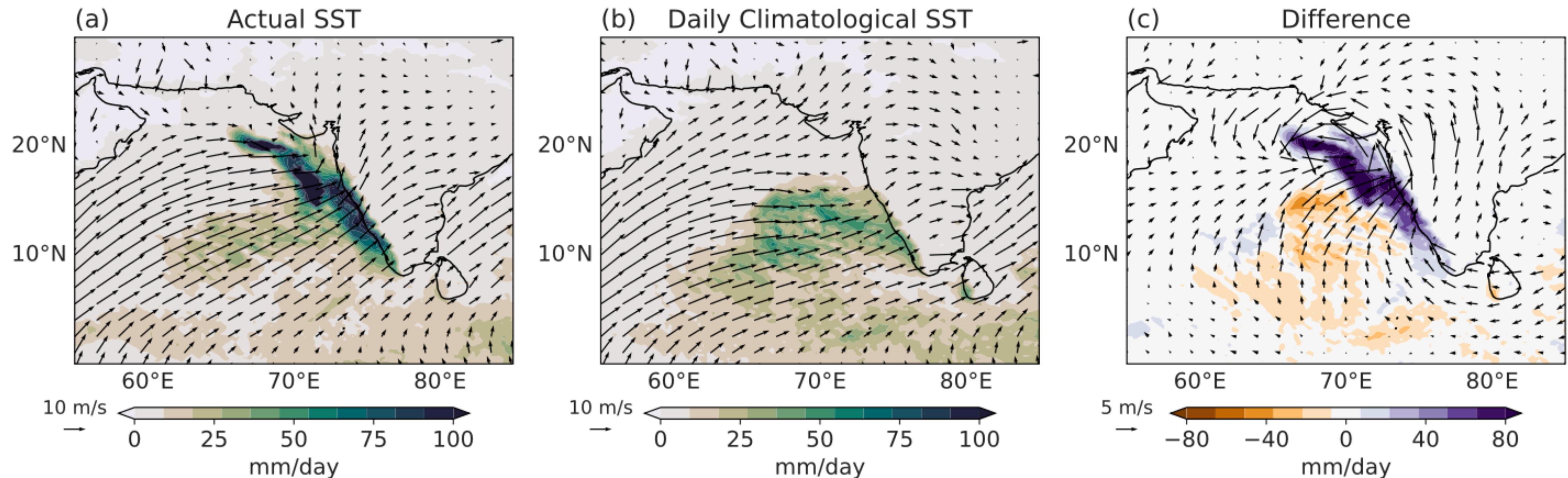
WRF Model Simulations

MHW began on June 1, 2014

Reached its peak on June 8, 2014

WRF model initialized on June 5, 2014

Averaged over days 1-5 following the MHW peak



Cyclonic winds only with warm SST anomalies

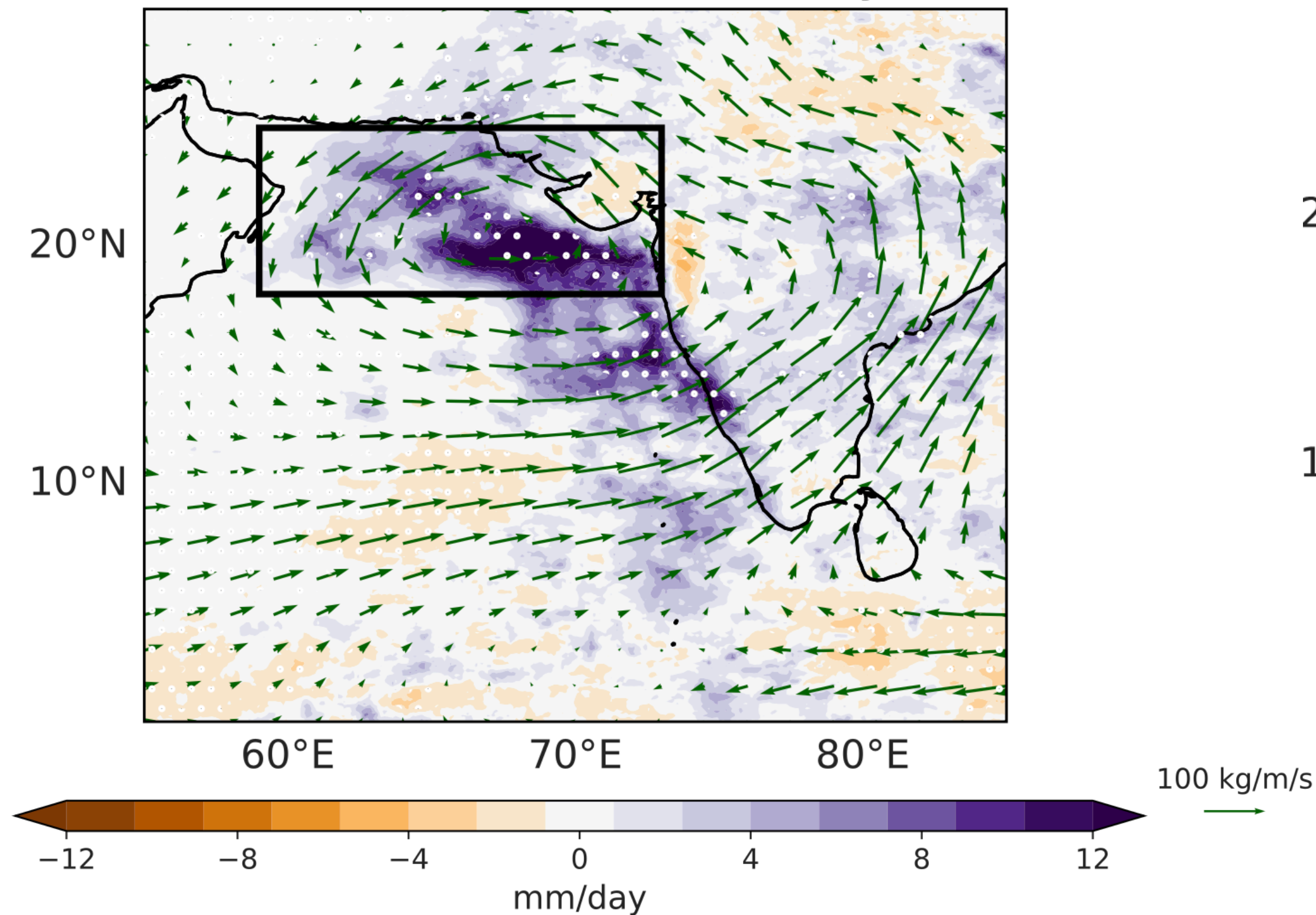
Precipitation (color)

Surface winds (vectors)

MHWs and Precipitation

Northern Arabian Sea

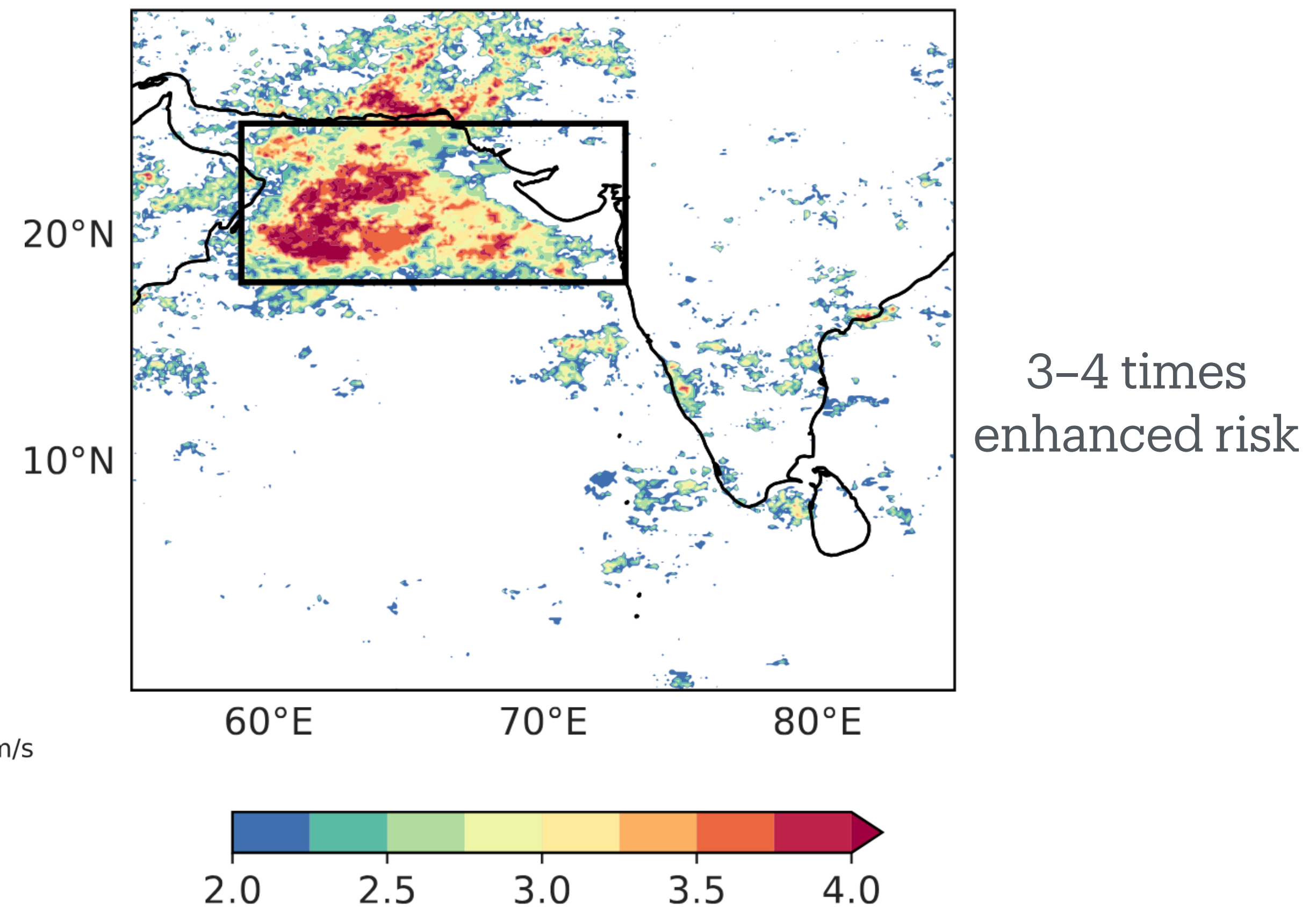
(e) Northern: P (MHW decay)



Precipitation (IMERG): color

Vertically integrated moisture flux (ERA5): green vectors

Risk of P95 days with MHW / without MHW



MHW and 2022 Pakistan Floods

The New York Times

Pakistan Hit by Deadly Floods of ‘Epic Proportions’

More than 1,000 have died since mid-June from flooding that a senior official called a “climate-induced humanitarian disaster.”

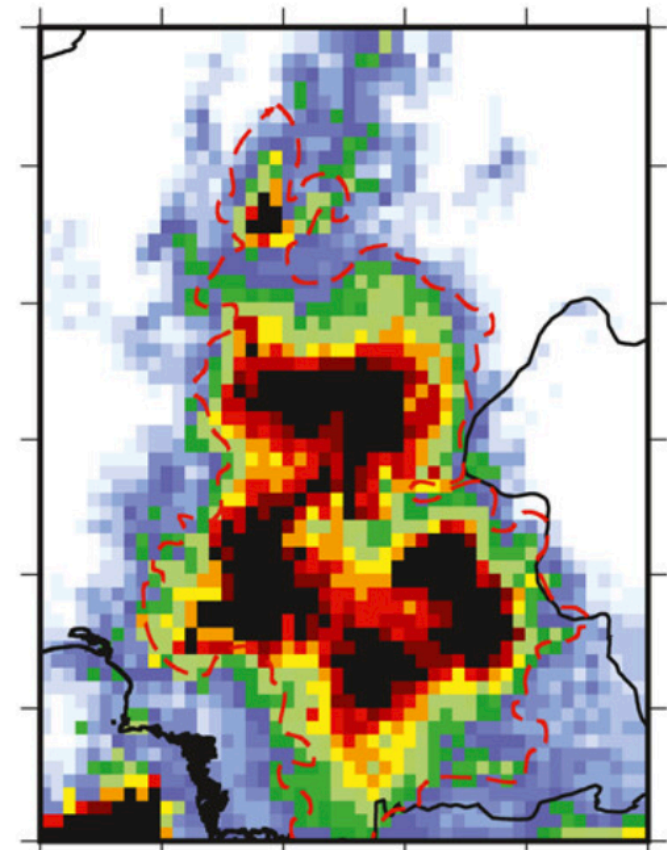


By Austin Ramzy

Aug. 28, 2022

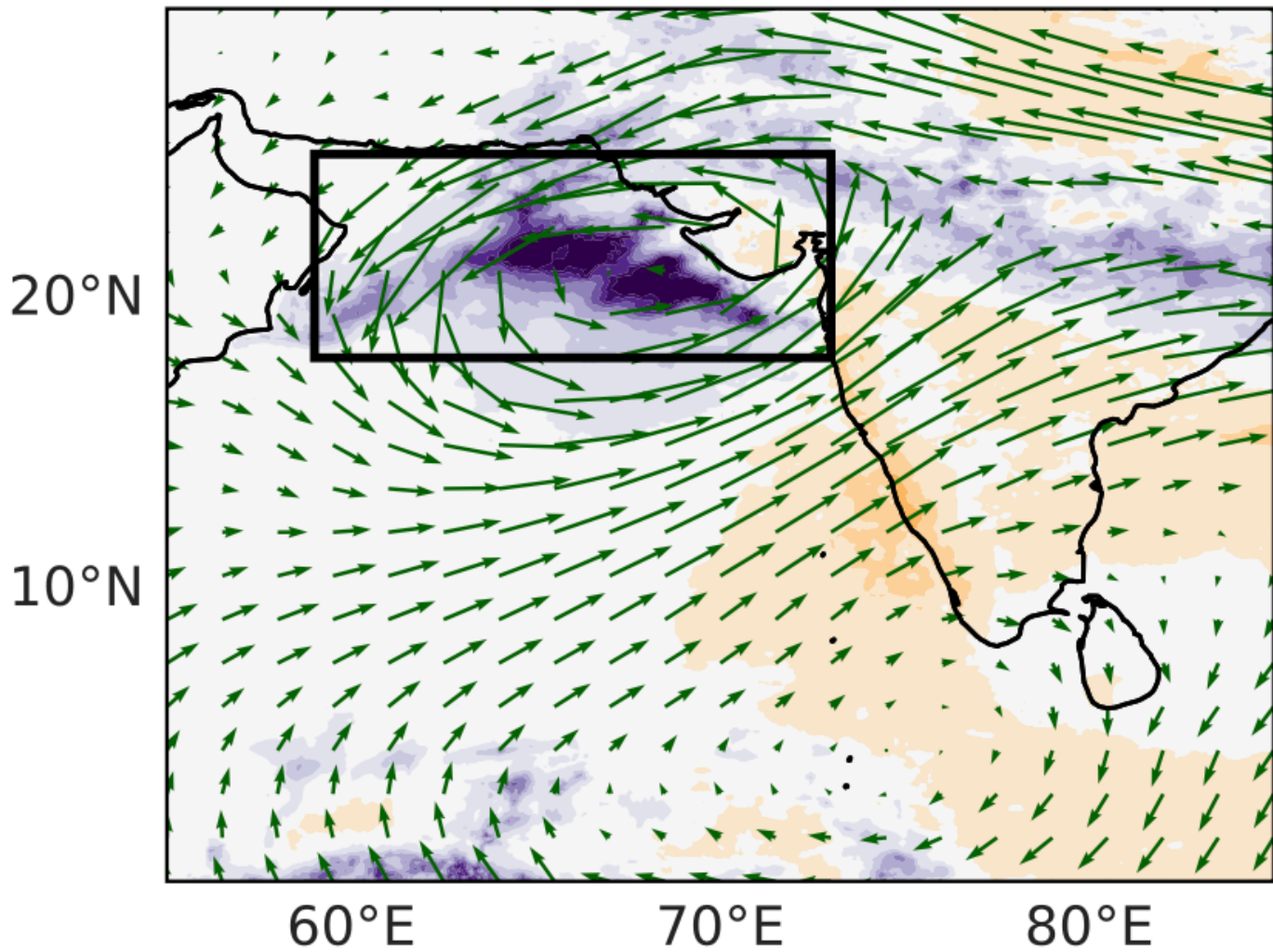
MHW reached its peak on Aug 8, 2022

15-day (10–24 Aug)

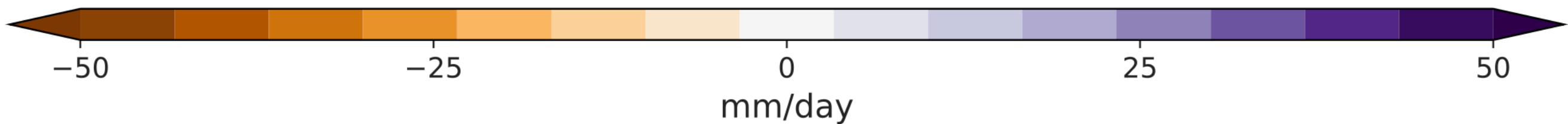
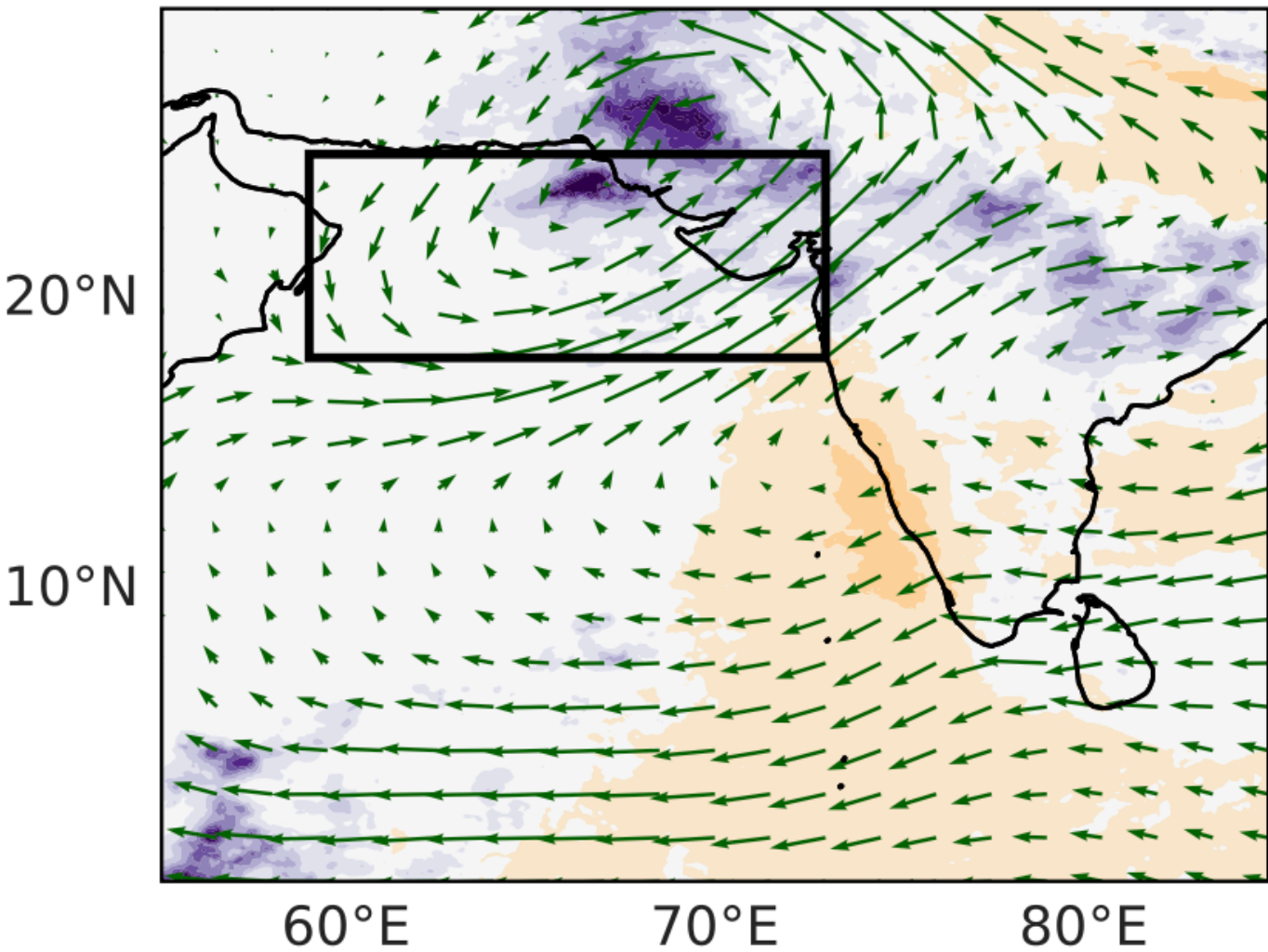


Nanditha et al. 2023

(b) Aug 9-13 (days 1 to 5)



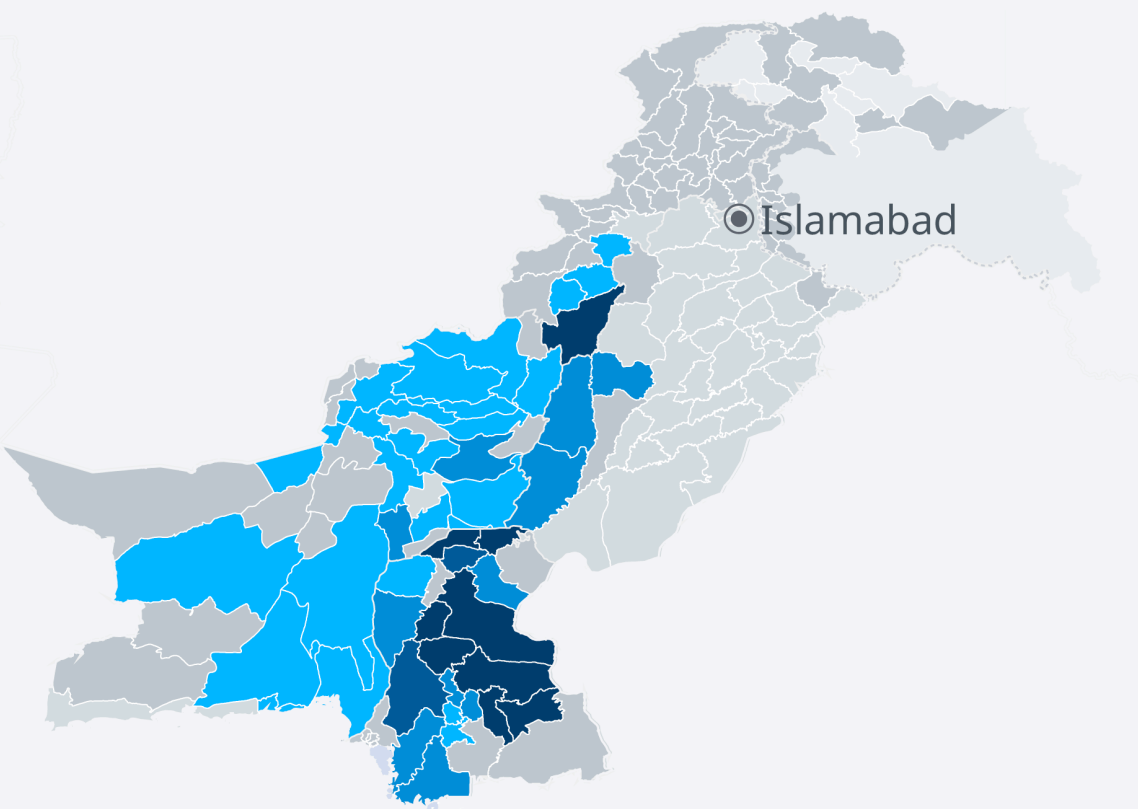
(c) Aug 14-18 (days 6 to 10)



500 kg/m/s

Monsoon floods in Pakistan

Houses damaged in 2022 by district (by thousands)



Source: OCHA | as of September 2022

Summary

Drivers of Arabian Sea MHWs

- Modulated by both interannual and intraseasonal timescales.
- Driven by air-sea fluxes influenced by BSISOs.

Impacts of MHWs

- Eastern Arabian Sea MHWs: Meridional contrast in precipitation and extreme events along the Western Ghats.
- Northern Arabian Sea MHWs: Intense precipitation over northwestern India and Pakistan.