Response of South and East Asian summer climate to North Atlantic SST anomalies: sensitivity to SST patterns

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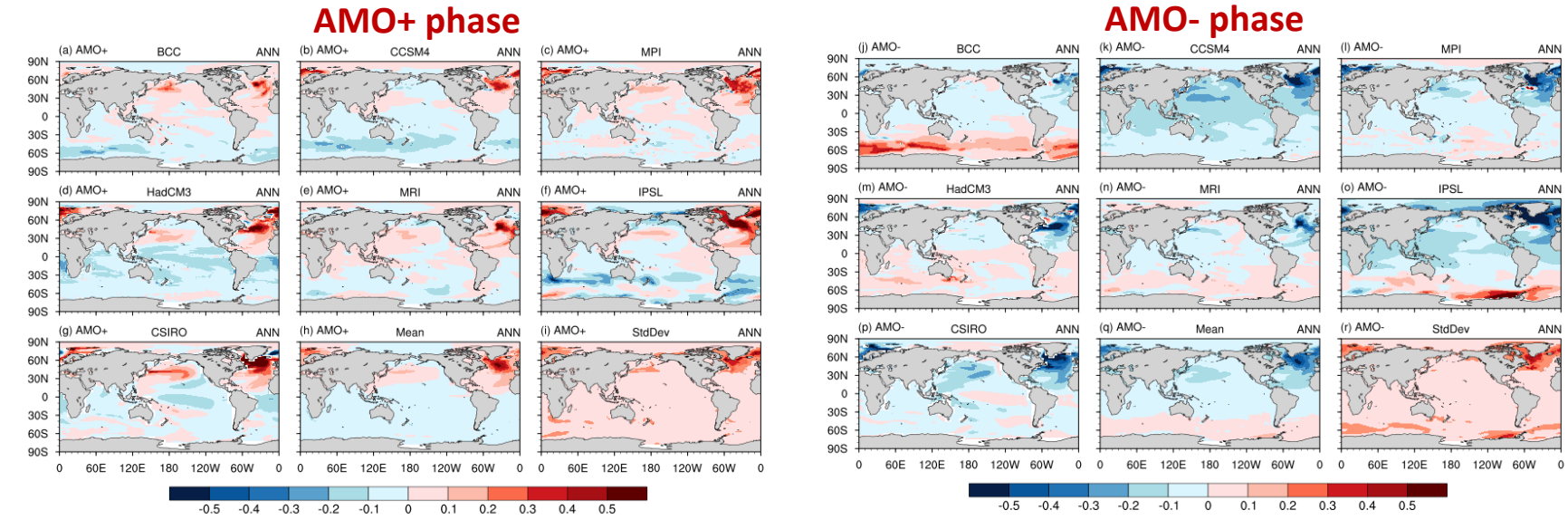
Background:

In a recent study, Ratna et al. (2019) by analysing 7 CMIP5 models highlighted that different coupled GCMs simulate different linkages between Atlantic Multidecadal Oscillation (AMO) and South/East Asia (SEA) climate.

Objective:

We used the AMO SST patterns diagnosed by Ratna et al. (2019) from seven CMIP5 models to force the IGCM4 atmospheric model (Joshi et al. 2015) to understand how the AMO induces the seasonal temperature and precipitation responses over South and East Asia (SEA).



The AMO+ phase is dominated by warm SST in the North Atlantic, but also extending into the Atlantic sector of the Arctic and in the North Pacific.

The AMO- SST pattern shows the opposite sign of the AMO+ in many locations, but with different amplitude in some regions.

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Ratna, S. B., et al (2019), Clim. Past, 15, 1825–1844.

Experimental Design

The IGCM4 (Joshi et al. 2015) is a global spectral primitive equation climate model with a spectral truncation of T42 (having a 128x64 horizontal grid) and 20 layers in the vertical (surface to 50 hPa) denoted as T42L20, which is the standard configuration for studies of the troposphere and climate.

(i) Control Experiment

1. CTRL: Climatological SSTs from 20CRv2 (Compo et al. 2011) for the period 1871-1920.

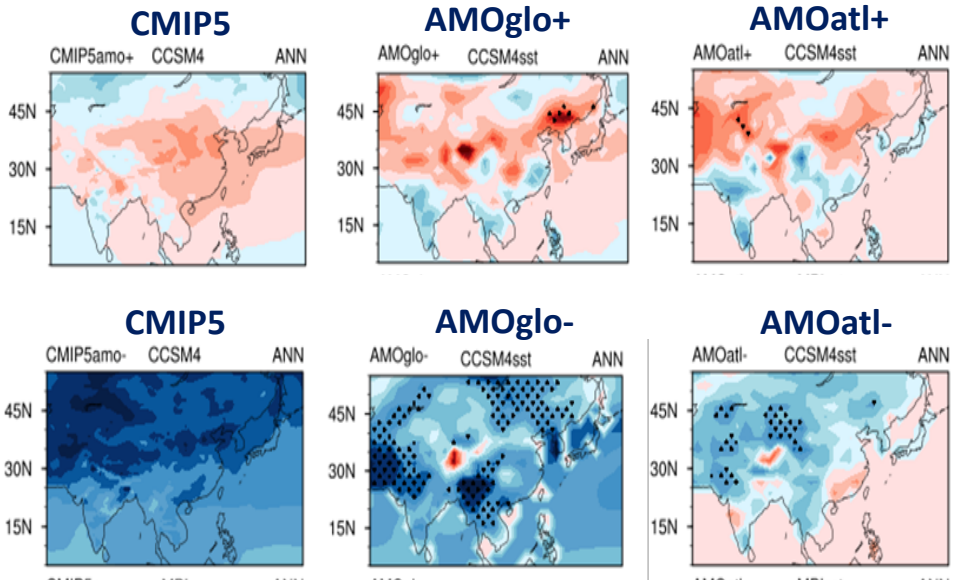
(ii) Perturbed Experiment

1. AMOglo+ ; 20CR SST plus 2 X AMO+ global SSTA
2. AMOglo- ; 20CR SST plus 2 X AMO- global SSTA
3. AMOatl+ ; 20CR SST plus 2 X AMO+ SSTA only over N Atlantic and Arctic
4. AMOatl- ; 20CR SST plus 2 X AMO- SSTA only over N Atlantic and Arctic

Eight sets of experiments (seven individual SSTA patterns and the multi-model mean SSTA) are conducted with each perturbed experiment.

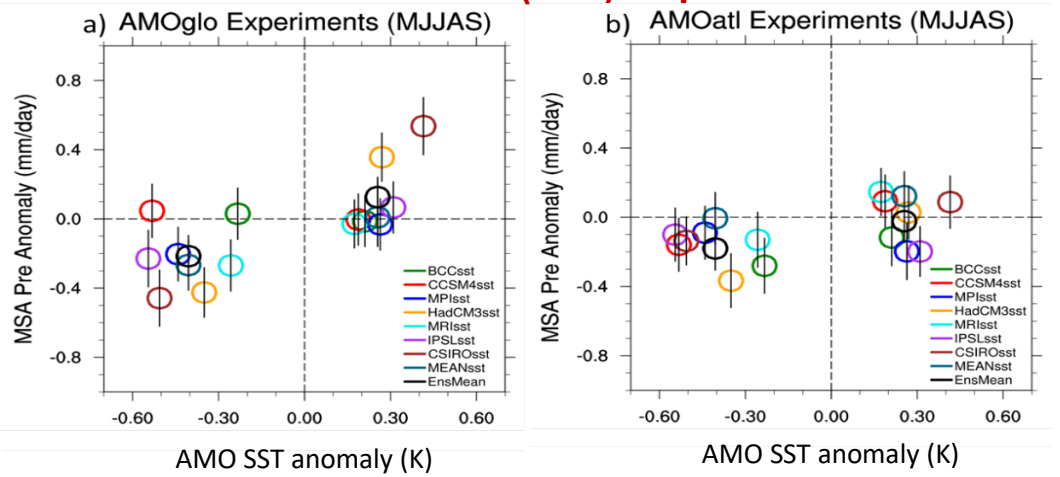
The annual mean surface temperature for the overall SEA region shows positive (negative) anomalies during the warm (cold) phase of AMO in both the CMIP5 composites and SST-forced IGCM4 simulations (e.g. CCSM4sst here).

The analysis from other SST experiments show inter-model variations arise from differences in each models' AMO-related SST pattern and associated dynamical response to the different SST.

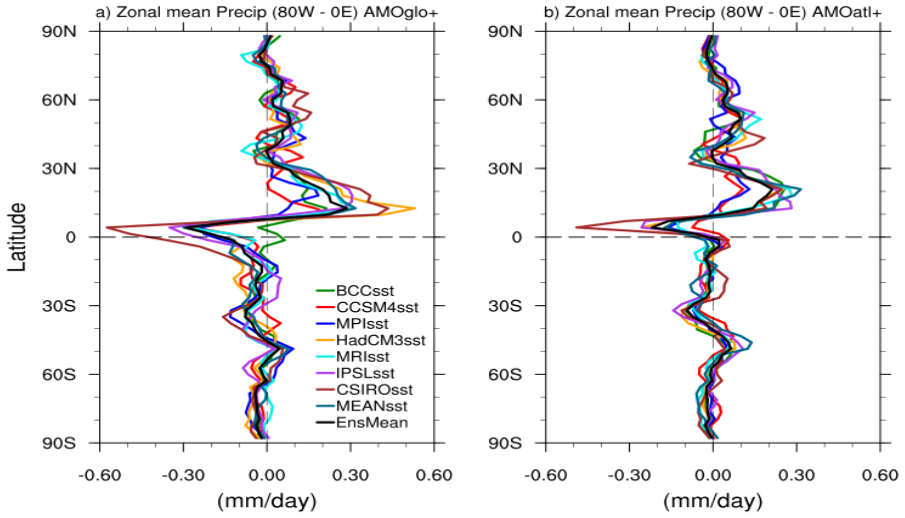


South Asian monsoon (MSA) response to AMO

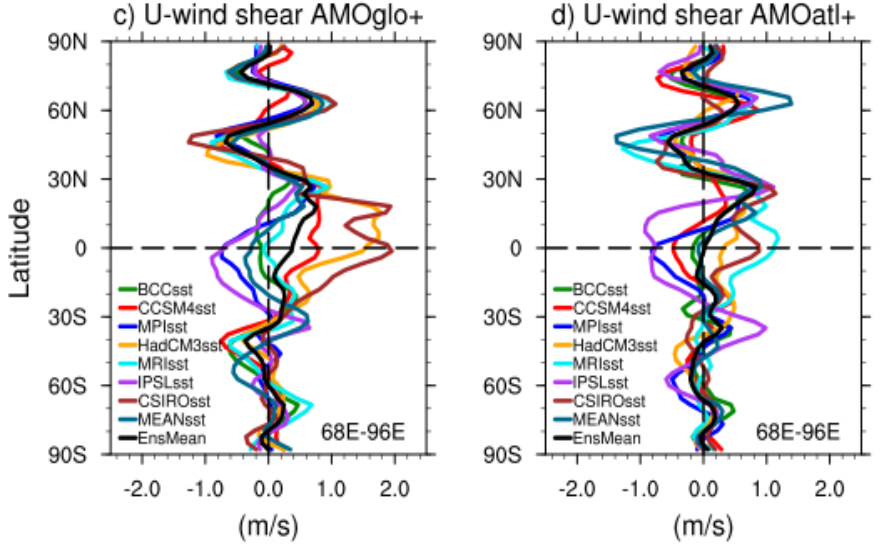
The area averaged SST anomaly indicates that there is greater inter-model spread in the strength of the AMO- SST composites than in the AMO+ composites, though there is no simple relationship between MSA response and strength of the SST forcing.



ITCZ response over Atlantic



vertical zonal wind shear (850 hpa – 200 hPa)



The positive (negative) precipitation anomaly over South Asian monsoon during AMO+ (AMO-) is associated with a northward (southward) shift of the Atlantic ITCZ and strong positive (negative) vertical zonal wind shear anomaly over the Indian subcontinent.

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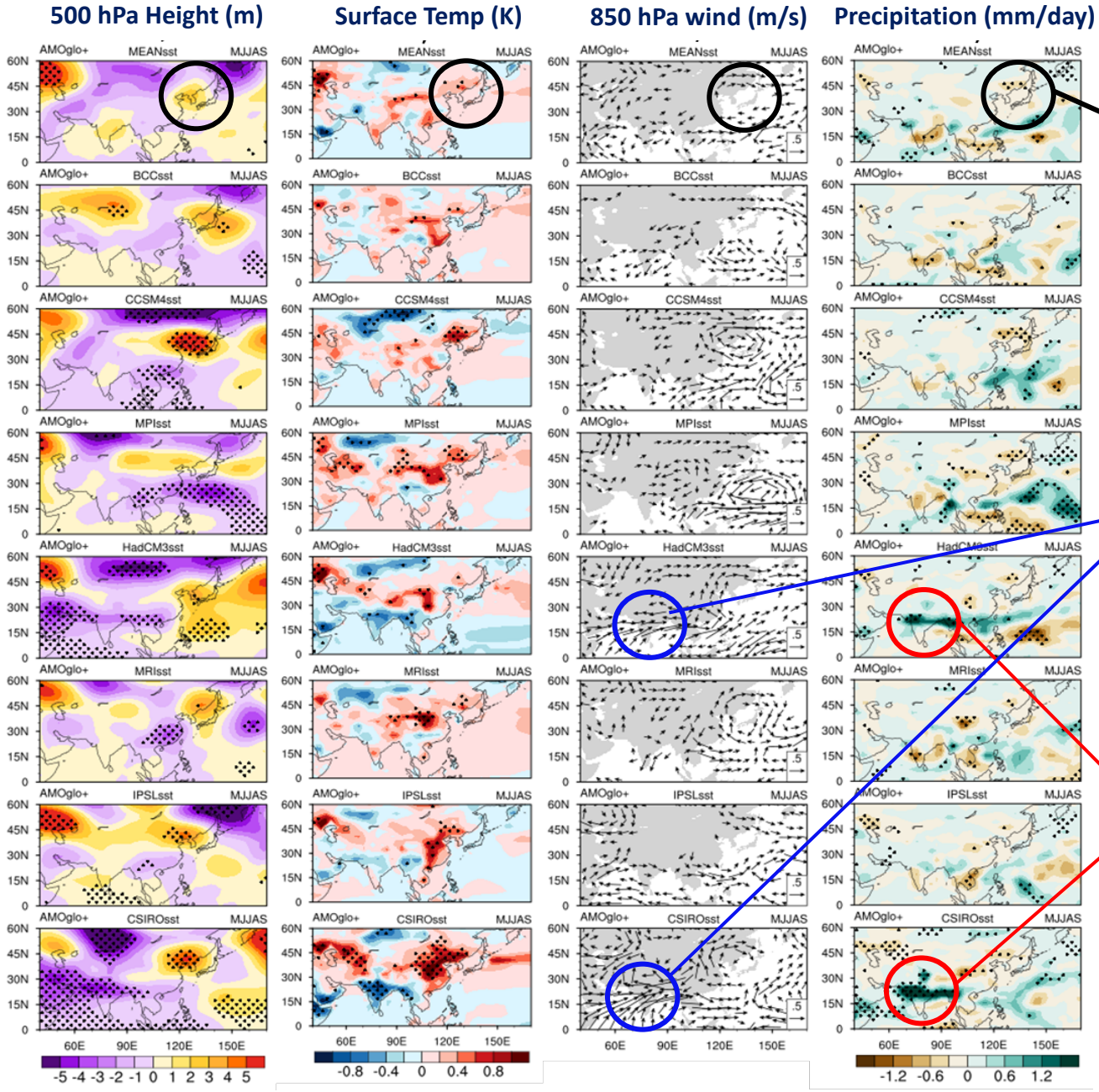
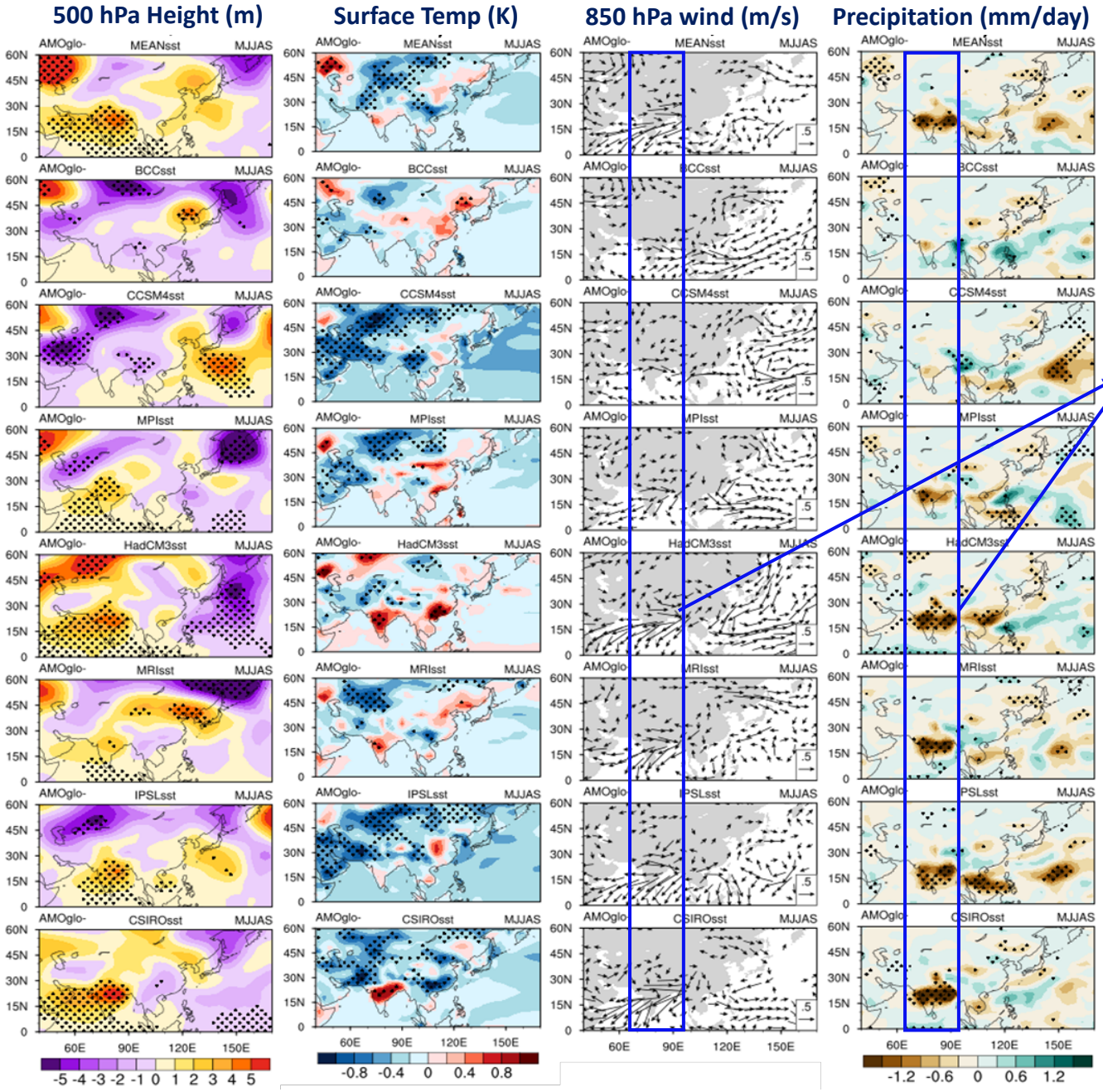
Response of SEA summer (MJJAS) climate to AMOglo+



Response of SEA summer (MJJAS) climate to AMOglo-



Negative precipitation anomaly over Indian region associated with anomalous northeasterly wind.

Summary

- The surface temperature for the overall SEA region shows positive (negative) anomalies during the warm (cold) phase of AMO. IGCM4 produces this anomalies over the SEA region that are similar to those simulated by CMIP5 models.

- A Rossby wave train originates in the North Atlantic during the warm phase of AMO and propagates eastward, leading to a potential connection between the North Atlantic SST and the Asian climate. The mid-latitude Rossby wave train is less robust in response to the cool phase of the AMO. Cooling over Asia seems to be simply linked to a NH-wide cooling both over the ocean and land.

- In response to AMO- SST patterns, IGCM4 simulates a southward shift of the Atlantic ITCZ linked to low level anomalous easterlies extend across North Africa and into the South Asian monsoon. This reduces the moisture transport to South Asia which, alongside a reduction in vertical wind shear in the Indian Ocean region, leads to drying of the South Asian monsoon. This mechanism is less clear for the positive AMO phase although there is a northward shift of the Atlantic ITCZ only with two SST patterns.

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