Rethinking the Advance of Asian Summer Monsoon Onset in Recent Decades ---Decadal or Trend Variability?

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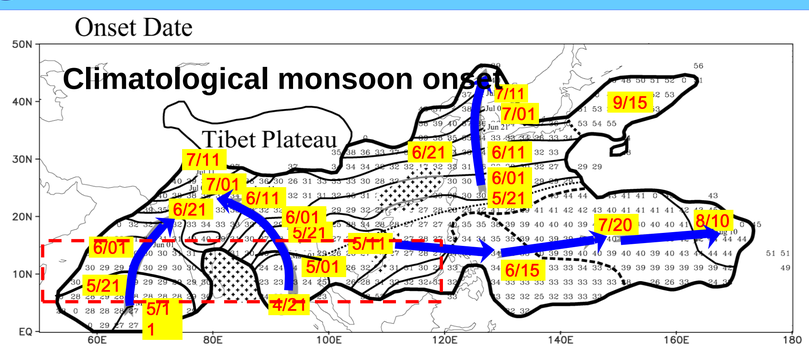
Abstract

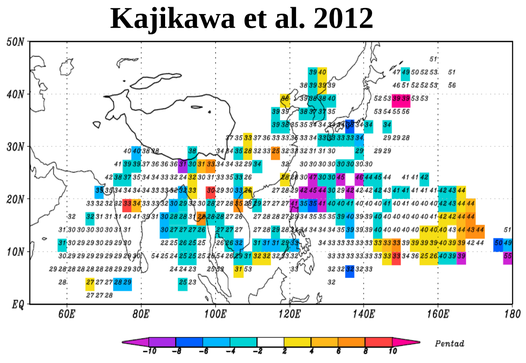
In the last three decades, Asian Summer Monsoon (ASM) onset has remarkably advanced, but the physical mechanisms remain elusive. Since the overall ASM onset occurs in May, we focus on the change of mean fields in May and consider enhanced mean precipitation and monsoon westerly winds as signs of advanced onset. Results show that the advanced ASM onset mainly represents a robust decadal shift in the mid-to-late 1990s, which is attributed to the mean state change in the Pacific basin characterized by a grand La Niña-like pattern. The La Niña-like mean state change controls the ASM onset through the westward propagation of Rossby waves and its interaction with the asymmetric background mean states in the Indian Ocean and western Pacific, which facilitates the amplification of the northern hemispheric perturbations as well as intensified westerly winds. Intriguingly, the abrupt decadal shifts of monsoon onset in the Arabian Sea and Bay of Bengal occur in 1999, in contrast to the South China Sea with decadal shift in 1994. Numerical experiments demonstrate that the advanced monsoon onset in the Arabian Sea and Bay of Bengal is governed by the enhanced zonal sea surface temperature (SST) gradients in the equatorial Pacific, while that in the South China Sea is primarily determined by the abrupt SST warming near the Philippine Sea.

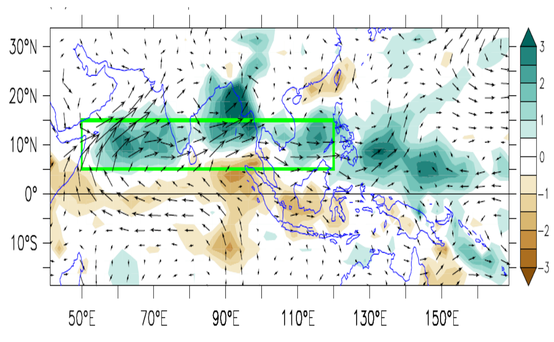
Background and Motivation



Wang and LinHo 2002

Kajikawa et al. 2012





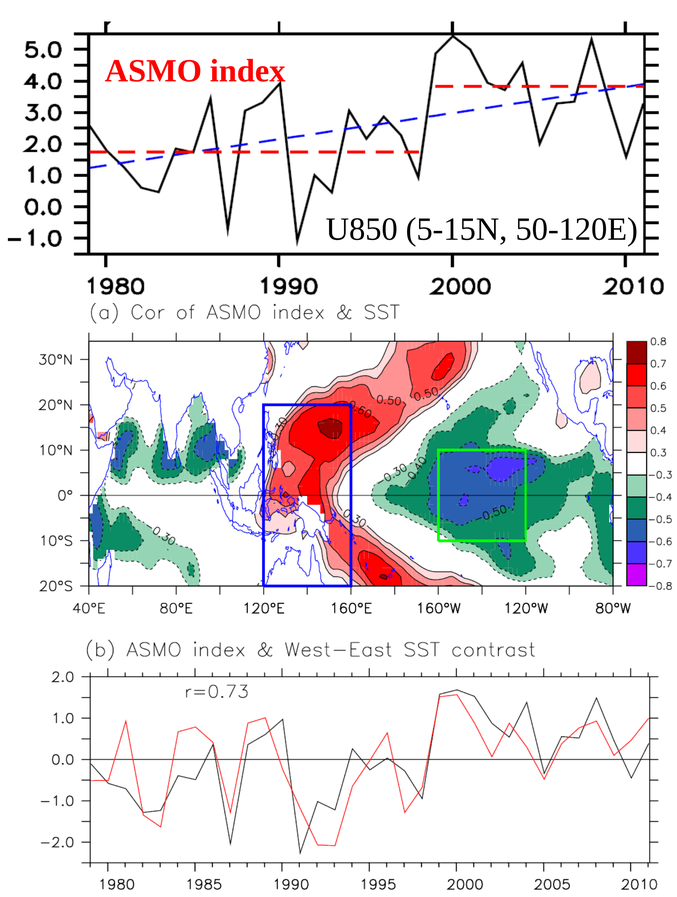
Advanced Asian Summer Monsoon Onset

Mean State Change of May (trend in recent 33 years)

Questions:

1) How to measure the Asian Summer Monsoon Onset(ASMO)?
2) What causes the advance of ASMO in recent decades?
3) Does this reflect a decadal or a trend variability?

ASMO index and its relationship with SST

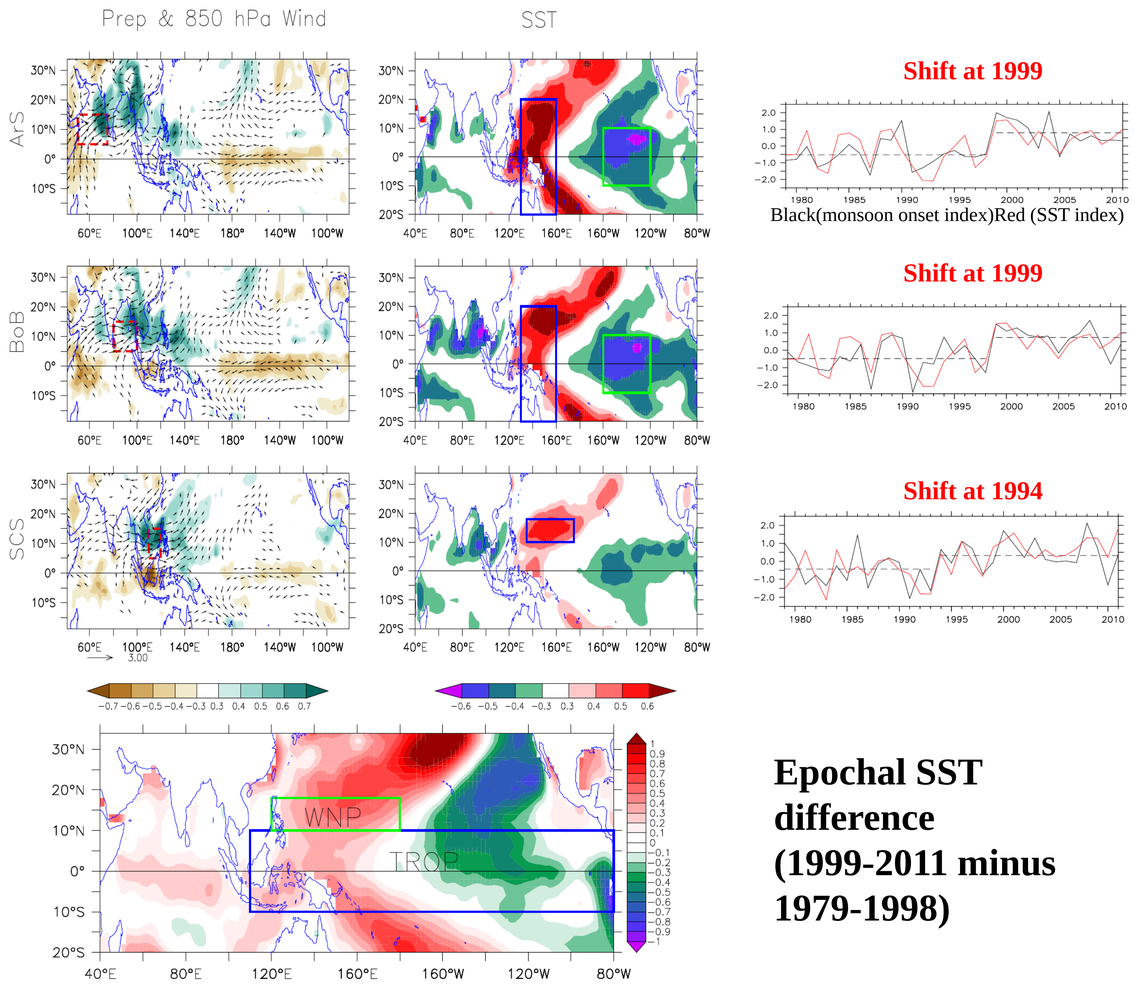


Trend or decadal shift?

Question:
1)Does the equatorial SST gradient in the Pacific basin govern the ASMO?

2) Are there some differences of ASMO in ArS, BoB, and SCS?

Features of ASMO in ArS, BoB, SCS

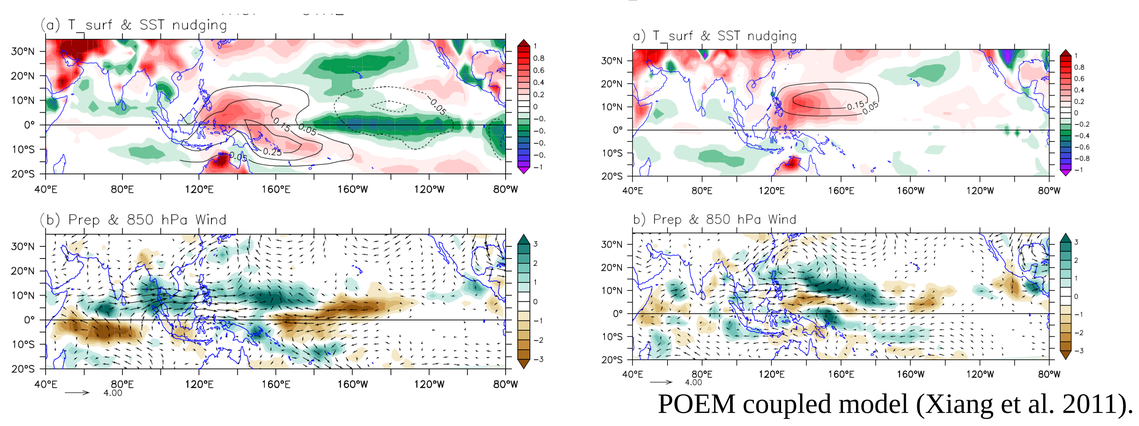


Epochal SST difference (1999-2011 minus 1979-1998)

What causes the different behaviors of ASMO in ArS, BoB, SCS?

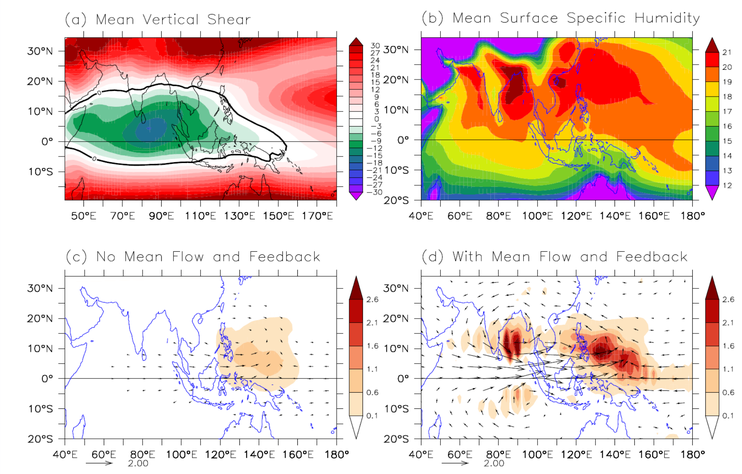
Mechanism for the Advanced ASMO

1) Pacific-induced advanced ASMO in a coupled model -- POEM



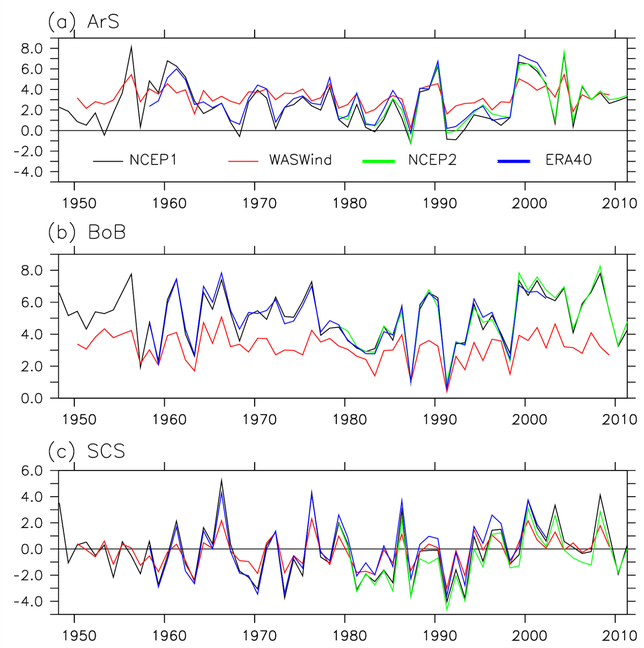
POEM coupled model (Xiang et al. 2011).

2) Role of asymmetric mean states in the advanced ASMO



In May, asymmetric mean vertical shear and moisture are essential in driving the in the amplification of the northern hemispheric perturbations as well as intensified westerly monsoon flow!

Nature of the recent advance of ASMO



Conclusion:

1)With the aid of the **asymmetric background state** (vertical shear and moisture), **the advanced ASMO is dominantly controlled by the Pacific mean state change which is characterized by a La Nina-like pattern**.

2)The recent advance of ASMO mainly represents **a decadal variability**, with the decadal shift at 1999 for ArS and BoB, and 1994 for SCS.