SST-precipitation relationship over the tropical monsoon region, in a changing climate

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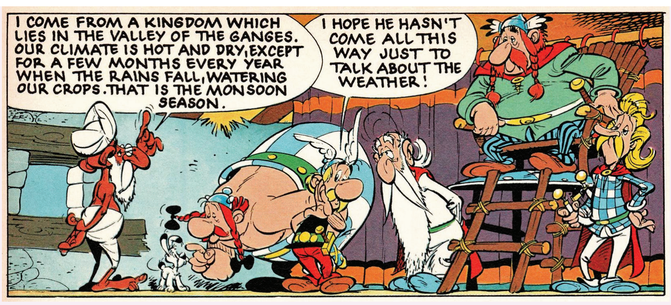
Abstract

It was thought that the monotonous increase of precipitation with respect to sea surface temperature [SST] is limited to an upper threshold of 29°C, over the monsoon basins. The current study finds that there is no upper threshold, and that precipitation continues to increase, even at the highest possible SSTs over the tropical monsoon basins. This helps in **quantifying the SST-precipitation relationship – a 1°C rise in SST corresponds to a 2 mm/day increase in precipitation**. The quantification is useful in understanding the fate of the Asian monsoon in future climate scenarios, with warmer SSTs over the tropical oceans.



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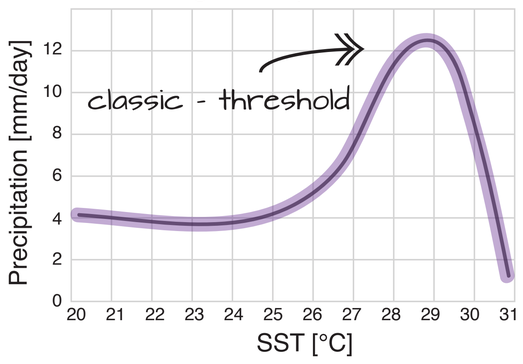
1. Introduction

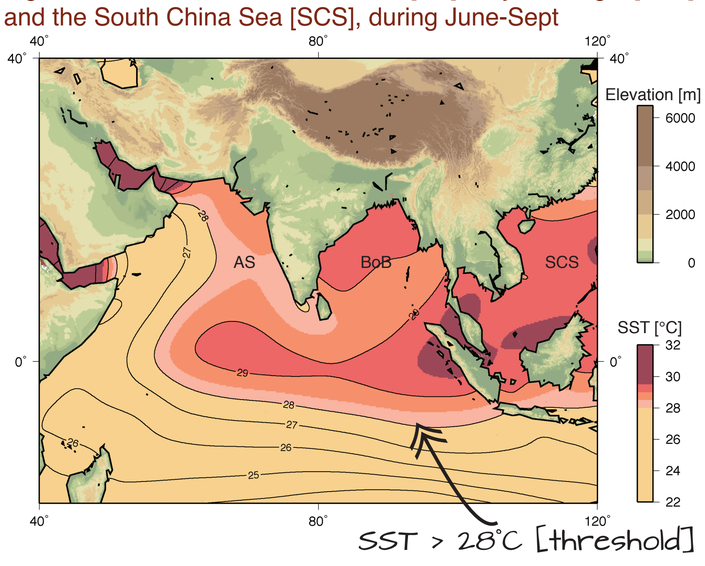
Over the tropical oceans, SST above 26°C are generally accompanied by increased precipitation. However, it has been argued for the last 3 decades that, the increase in precipitation with respect to SST is limited to an upper thershold of 28-29°C, beyond which the relationship fails [1] [Fig.1].

Fig.1. The classic SST - precipitation relationship, as in earlier studies, over the global tropical oceans



- Mean SSTs over the monsoon basins are warmer than the thershold [Fig.2]. Does the classic relationship mean that SSTs do not play an active role on the summer monsoon variability?
- Does increasing SSTs due to a changing climate have any impact on the monsoon precipitation?

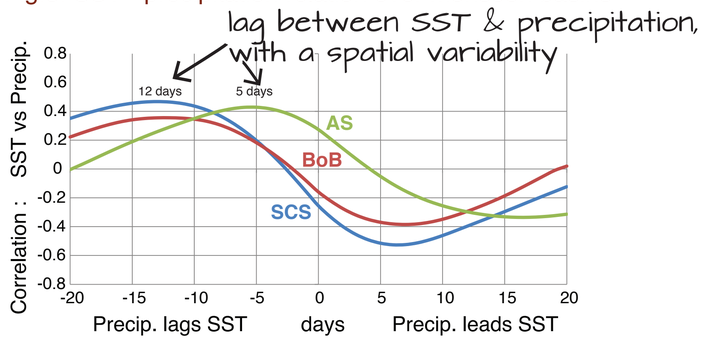
Fig.2. Mean SSTs over Arabian Sea [AS], Bay of Bengal [BoB] and the South China Sea [SCS], during June-Sept



2. Why does SST-precipitation relationship need a revision?

[i] Response of precipitation to SST has a lag. The response is fast over the Arabian Sea, with SST leading precipitation by 5 days, whereas it is slow over the Bay of Bengal and the South China Sea, where SST leads precipitation by 12 days [Fig. 3]. Earlier studies fail to consider this lag and its spatial variability. The spatial variability is due to stronger surface convergence over the Arabian Sea, which results in a faster uplift of the warm moist air, quickening the convective process [2].

Fig.3. SST - precipitation relation over monsoon basins



[ii] Earlier studies utilized monthly data, but daily data is required, because:
(a) the time lag observed is in 'days'
(b) the time lag can be up to 2 weeks - SST change might be in one month but the corresponding change in precipitation might be next month.

[iii] The classic relationship is based on large domains, like the global tropics, or the whole Indian Ocean. Averaging over large domains is not useful, as the monsoon intraseasonal variability over Arabian Sea and Bay of Bengal are at different phases at a time.

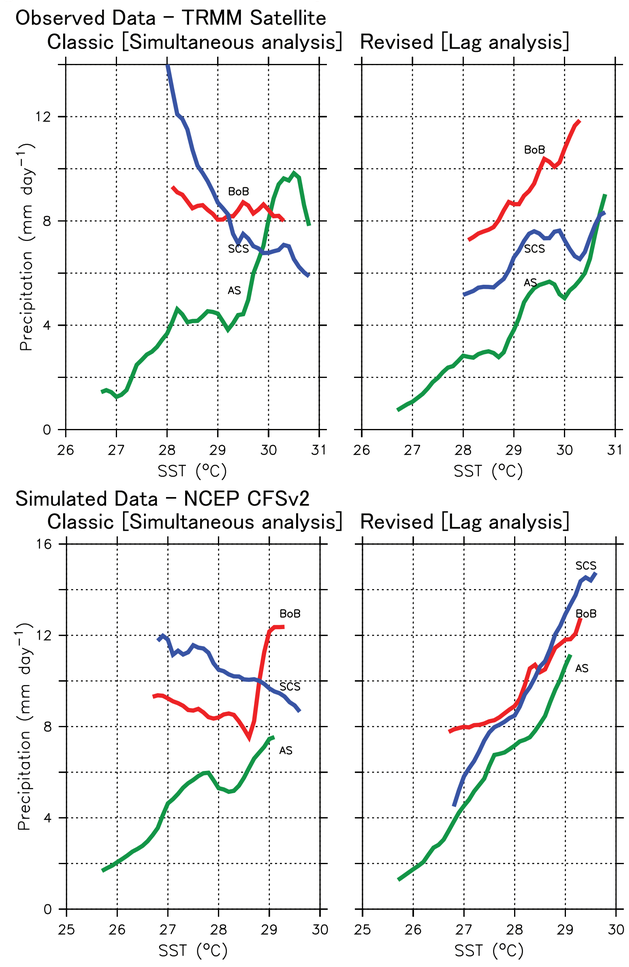
[iv] Simultaneous analysis gives the effect of SST on precipitation and vice-versa, making it difficult to separate them.

- Hence, the lag and its spatial variability is considered in the current study, to revise the SST-precipitation relation

3. Classic v/s Revised SST-precipitation relationship

In the classic analysis without considering the lags, the relation has an upper threshold for Arabian Sea, while it is negative for the Bay of Bengal and the South China Sea. In the revised analysis with lags, precipitation increases with SST, over all the basins.

Fig.4. Classic vs Revised analysis over the monsoon basins



4. New perspective on the SST-precipitation relation [2]

- SST – precipitation relationship has a **spatial variability**, with a **lag** of about
  - 5 days over the Arabian Sea
  - 12 days over the Bay of Bengal and the South China Sea
- The lag analysis gives a **quantifiable**, **linear** SST-precipitation relation [Fig. 5]
  1°C rise in SST -> 2 mm/day in rainfall

Fig.5. The revised SST - precipitation relationship

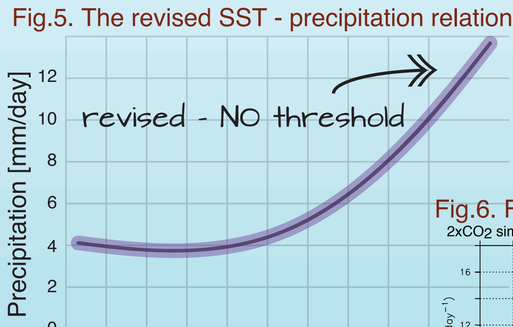
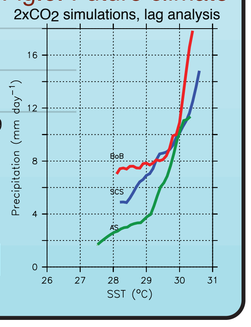


Fig.6. Future climate
2xCO2 simulations, lag analysis



- Relationship **holds for a changing climate** [Fig.6]

References

1. Gadgil et al. *Nature*, 1984
2. M. Roxy, *Climate Dynamics*, 2013