Asian Monsoon onset in the present climate and its future projection

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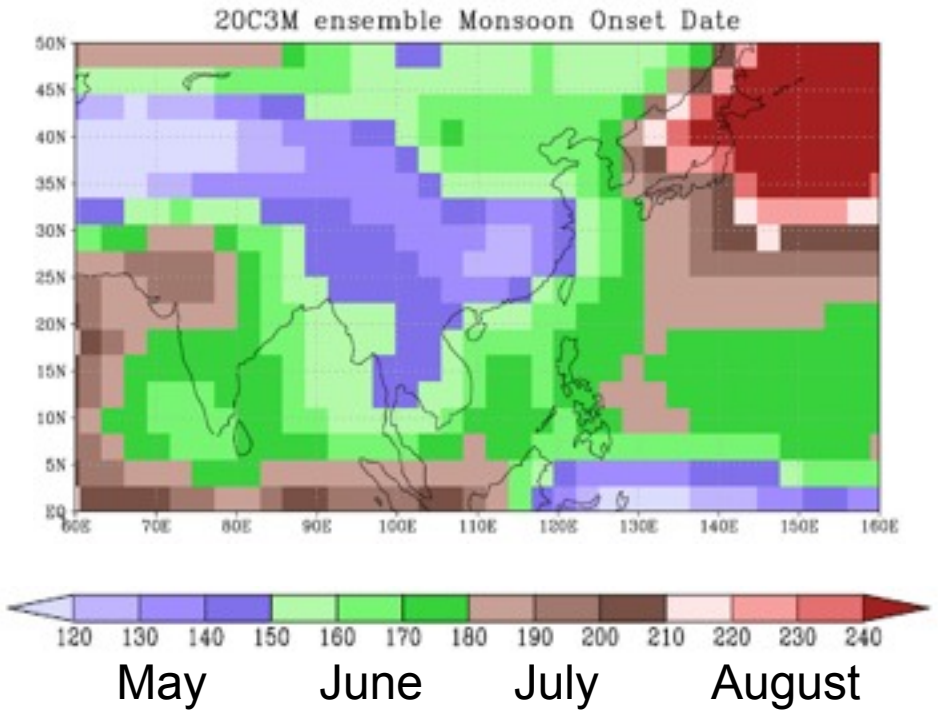
- Background
- Data (obs and model)
- Method (onset)
- Result

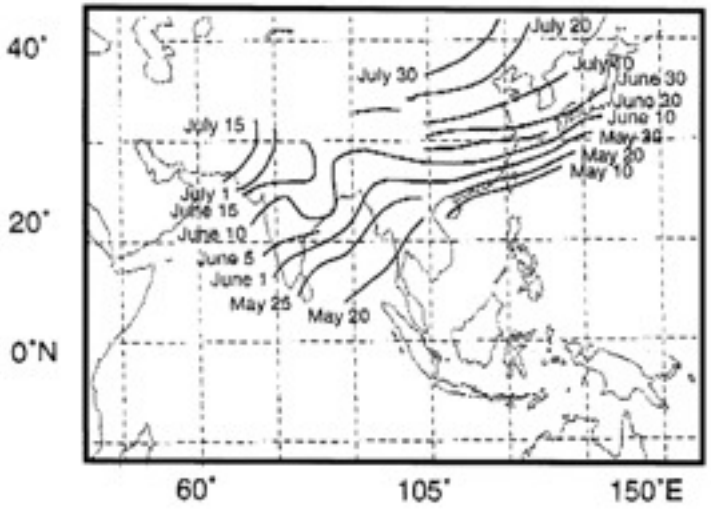


Objectives

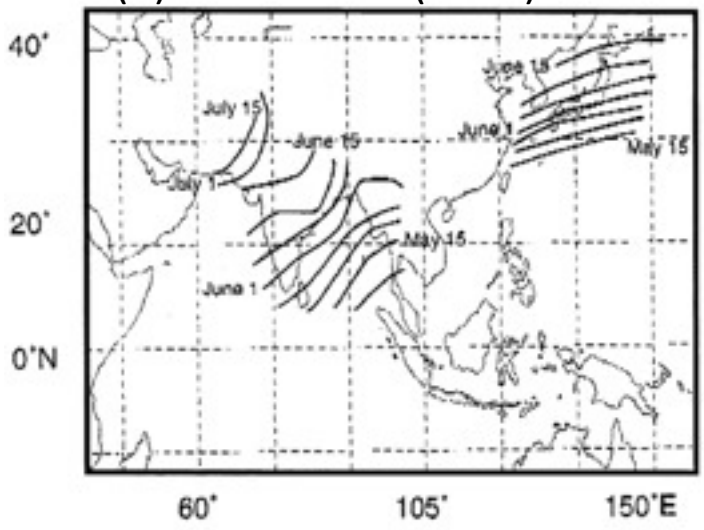
- To examine the modeling capability of more detail temporal and spatial evolution of Asia Monsoon system. (monsoon onset is a good example in this regard)
- The impact of climate change on “monsoon” rainy season onset

How to define Summer monsoon onset?

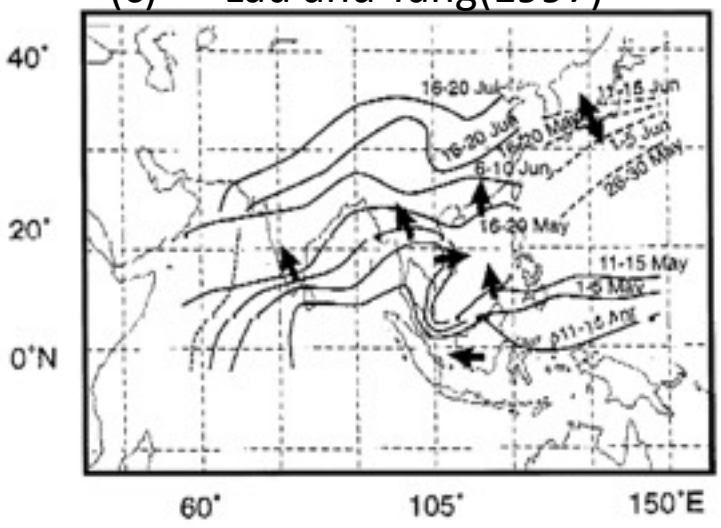
(a) Tao and Chen (1987)



(b) Tanaka(1992)



(c) Lau and Yang(1997)



adapt. from (Wang and Linho, 2002)

Conventional Wisdom:

Migration of stationary front with seasonal transition

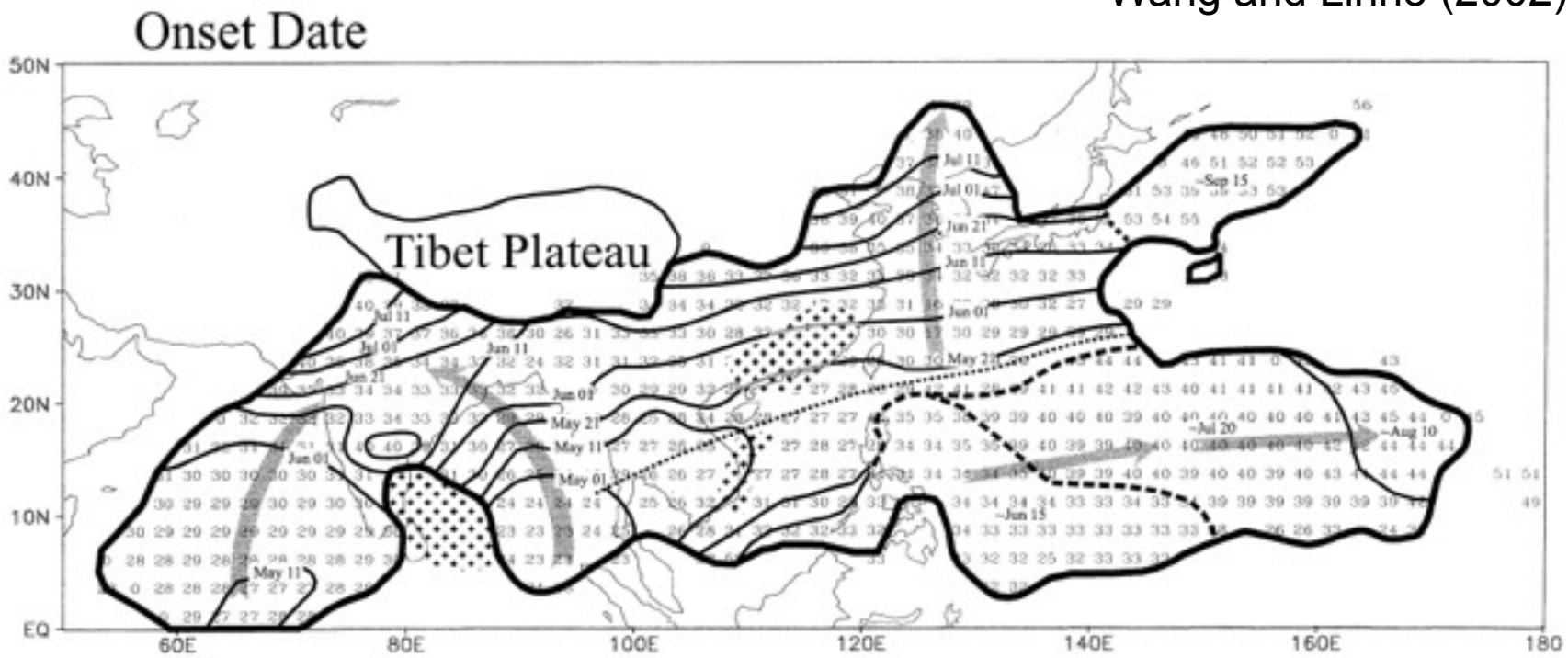
In reality, things can be rather complicated

Earlier studies with different data source already give different results

Onset definitions further diverge the picture

‘Climatological’ Monsoon Rainy Season

Wang and Linho (2002)



Onset pentad “ i ” while $RR_i > 5\ mm\ day^{-1}$ $RR_i = R_i - R_{Jan}$

(1)The first phase begins with the rainfall surges over the South China Sea (SCS) in mid-May, which establishes a planetary-scale monsoon rainband extending from the south Asian marginal seas (the Arabian Sea, the Bay of Bengal, and the SCS) to the subtropical western North Pacific (WNP).

(2)The second phase is the rainband then advances northwestward, initiating the continental Indian rainy season, the Chinese mei-yu, and the Japanese baiu in early to mid-June.

Problems

- Can we really find local “monsoon” rainy season onset that actually has strong year-to-year variability?
- How to deal with spring rainfall, tropical cyclone rainfall? Are they part of Monsoon system that can’t be separated?

Data

- **Observation**

  1. APHRODITE Project (Yatagai et al.)

     High resolution(0.5 degree) gridded precipitation for Asia

     Mainly station based and over land only

     1981~2000 daily precipitation

  2. GPCP 1DD

     Satellite-based precipitation data

     Resolution is 1 degree for Global.

     1997~2007 daily precipitation

- **Models**

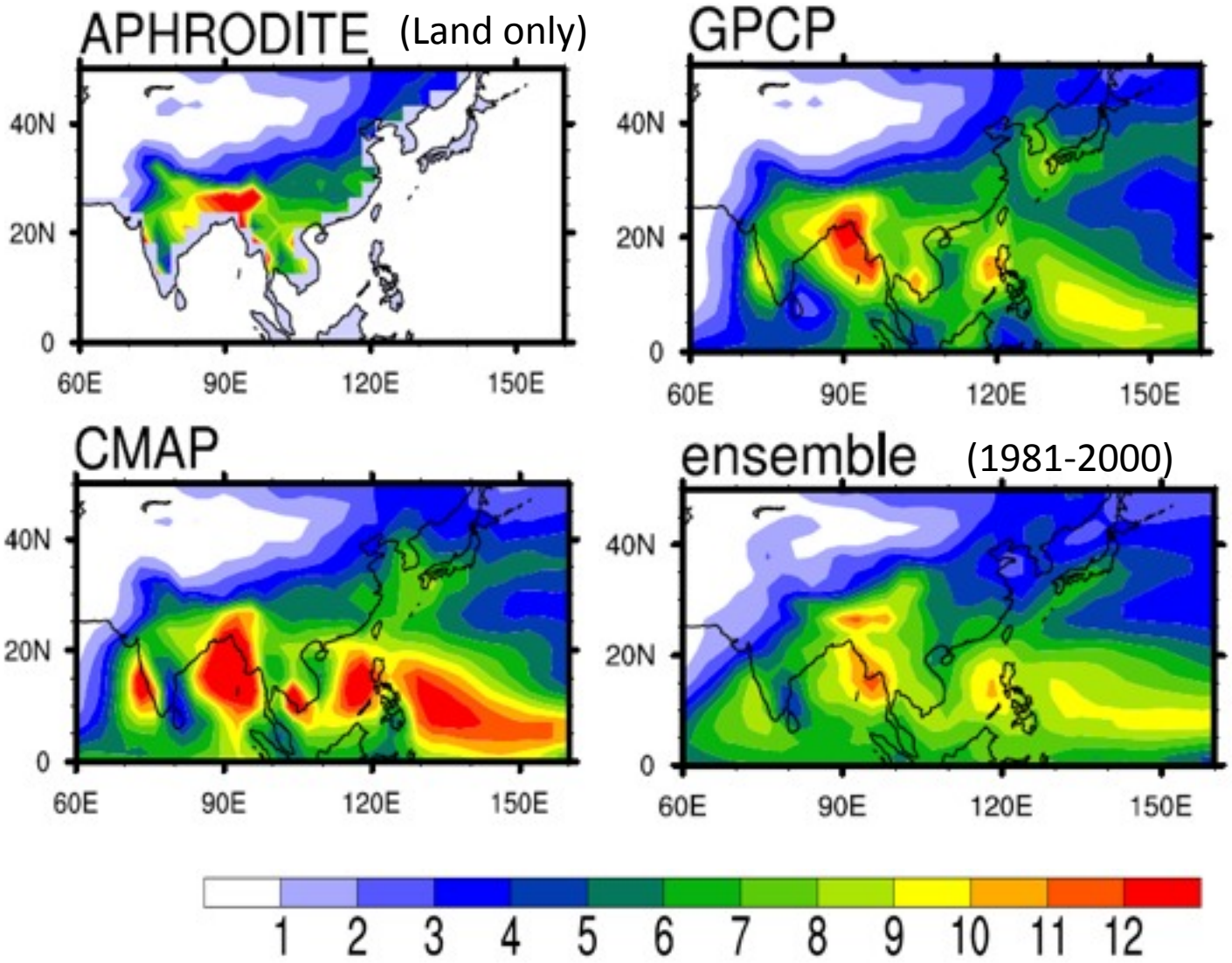
  IPCC AR4 15 models:

  1. 20C3M 1981-2000 daily precipitation
  2. SRES A1B 2081-2100 daily precipitation

IPCC AR4 models list

Model ID	Country	Resolution
1. bccr_bcm2_0	Norway	128*64 (T42)
2. cccma_cgcm3_1_t63	Canada	128*64 (T42)
3. cnrm_cm3	France	128*64 (T42)
4. csiro_mk3_0	Australia	192*96 (T63)
5. csiro_mk3_5	Australia	192*96 (T63)
6. gfdl_cm2_0	America	144*90 (2×2.5)
7. gfdl_cm2_1	America	144*90 (2×2.5)
8. iap_fgoals1_0_g	China	128*60 (~T42)
9. ingv_echam4	Italy	320*160 (T106)
10. miroc3_2_hires	Japan	320*160 (T106)
11. miroc3_2_medres	Japan	128*64 (T42)
12. mpi_echam5	Germany	192*96 (T63)
13. mri_cgcm2_3_2a	Japan	128*64 (T42)
14. ncar_ccsm3_0	America	256*128 (T85)
15. ncar_pcm1	America	128*64 (T42)

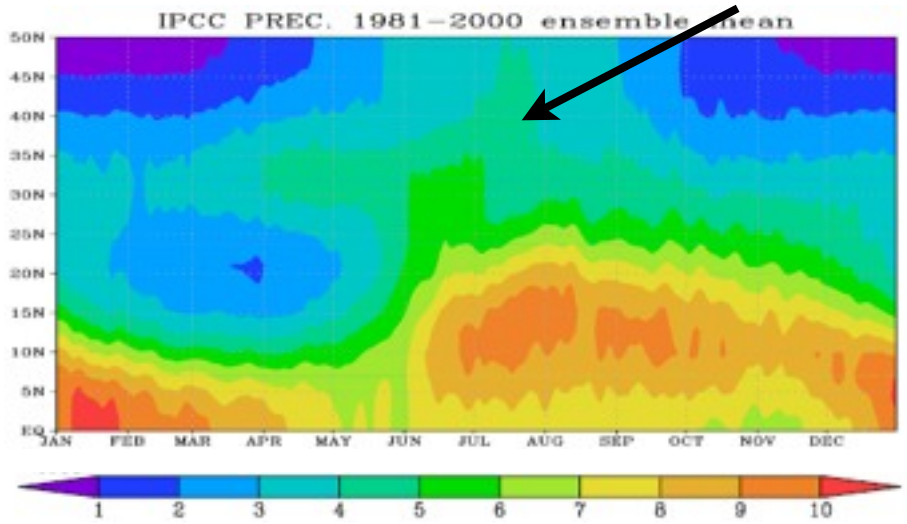
JJA mean precipitation



Reasonably Simulated
(bias over Korea and yellow sea)

Time-latitude section

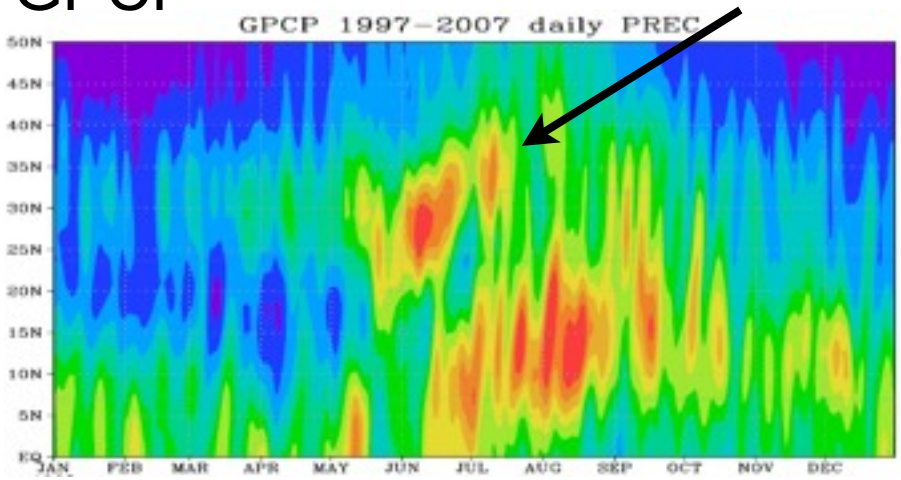
model ensmeble mean



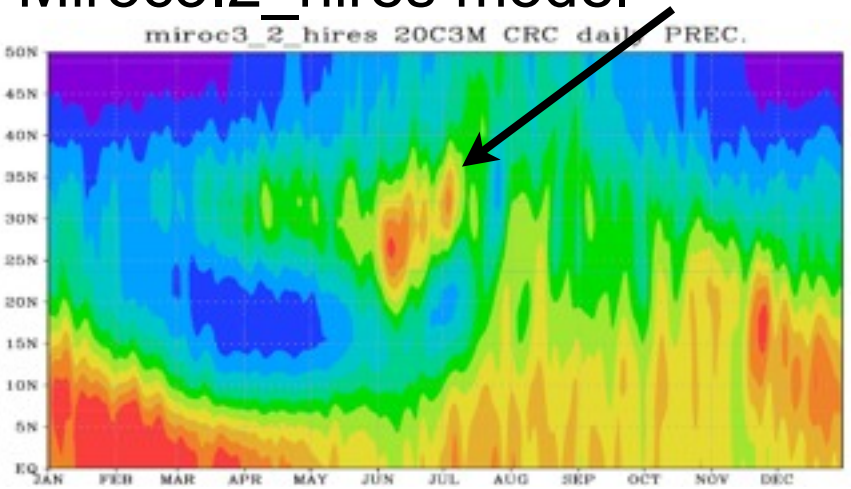
Average over (120-140E)

- Part of difference due to smoothing of multi-model ensemble mean
- Weak Meiyu, Beiyu, Changma in general, but can be good in high resolution model (MIROC)

GPCP

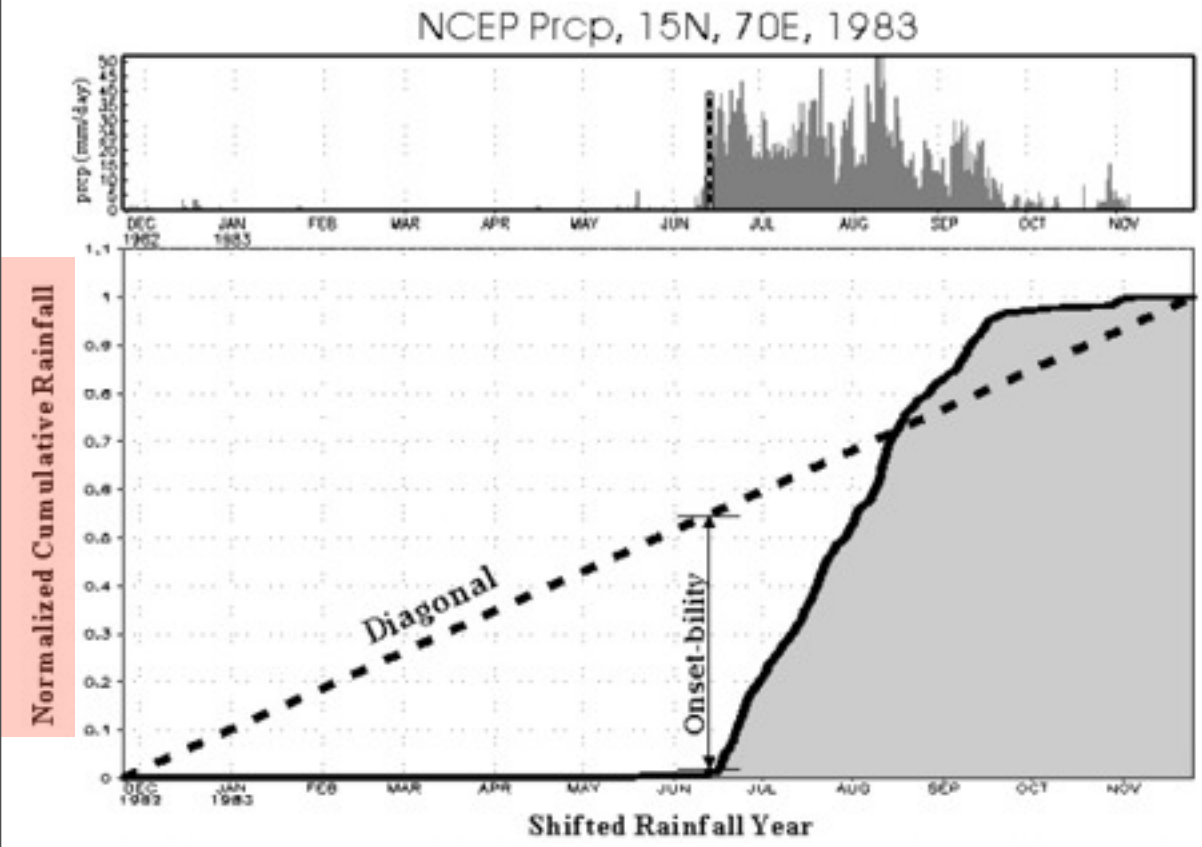


Miroc3.2_hires model



Definition of onset date and onsetability

Follow Linho (2003)

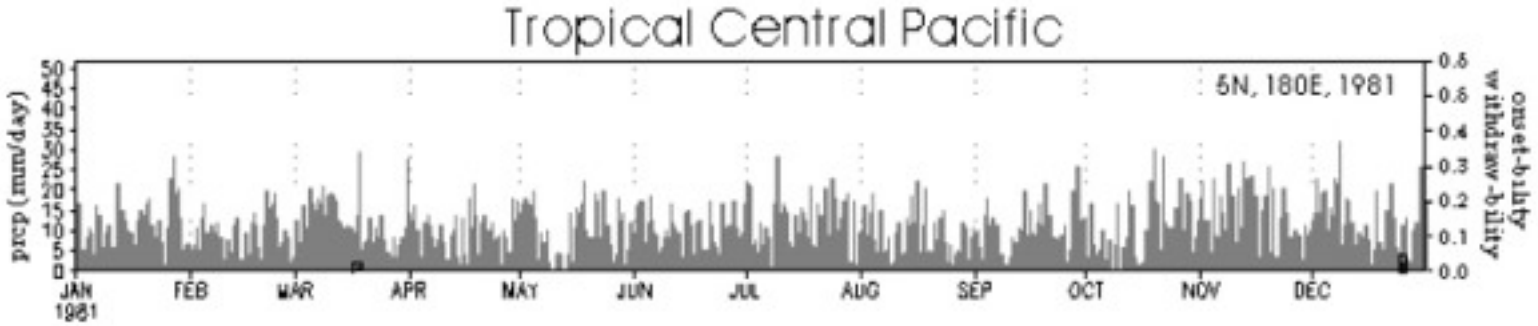


- The cumulated rain curve(CRC), the rain amount integrated from the origin.
- The diagonal refers to an idealized perennial rainfall time series. Hence a typical monsoon climate will deviate from the diagonal and the maximum distance indicates where onset occurs.

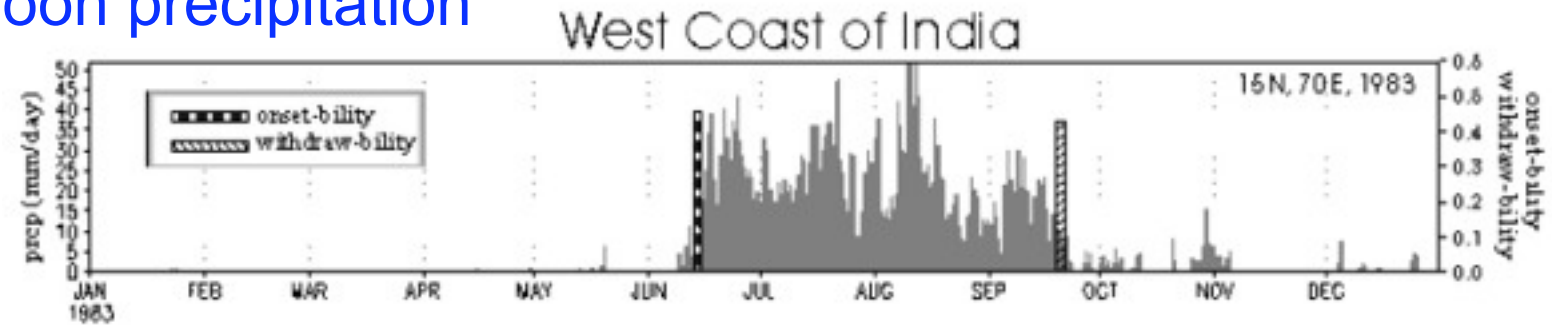
Normalized Cumulative rainfall = CRC / total annual rainfall

Example grids (LinHo, 2003)

Uniform precipitation through the year

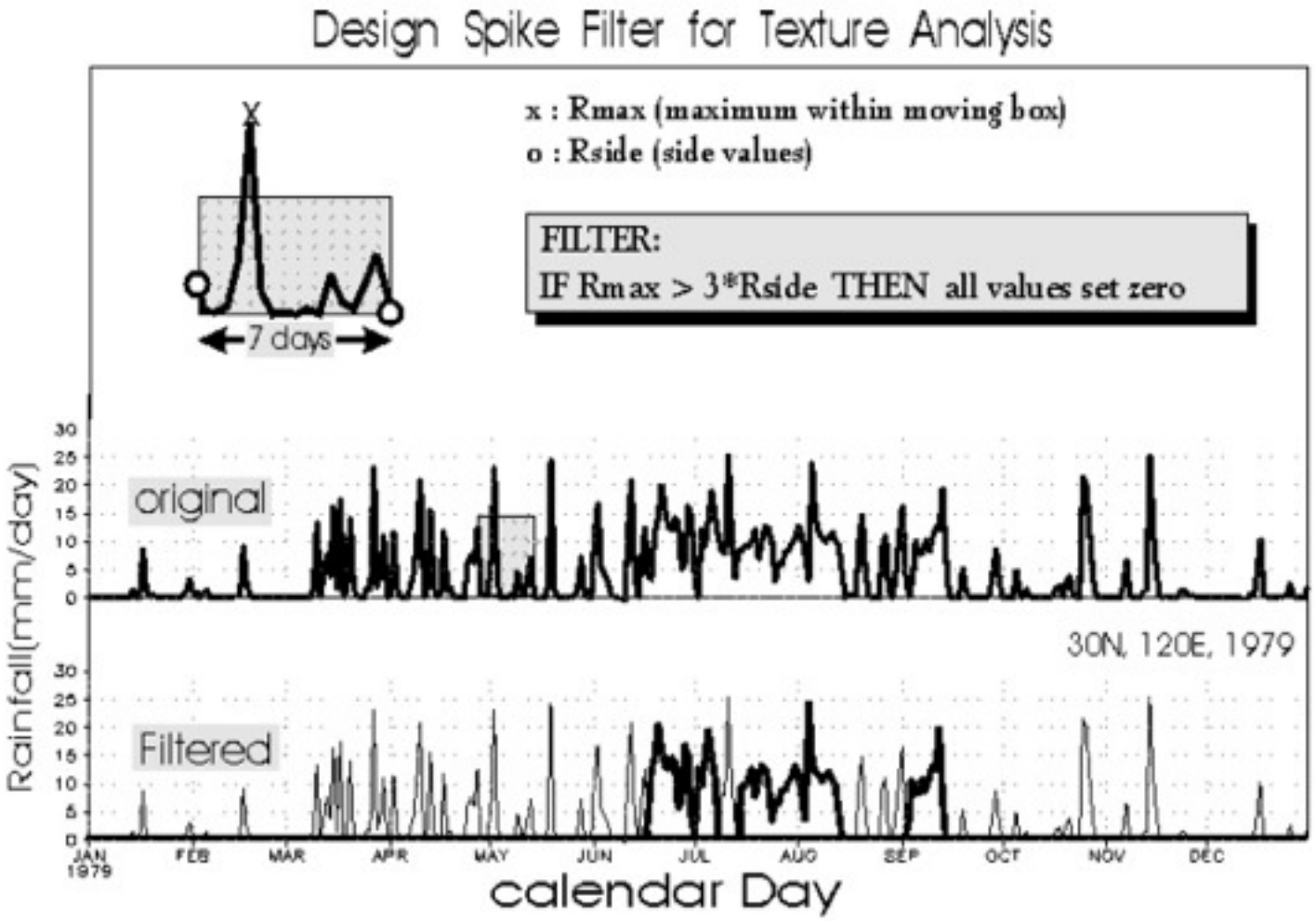


Monsoon precipitation



Data: NCEP reanalysis daily data (1979-1995), 2.5*2.5

Filter out rainfall due to fast moving frontal system

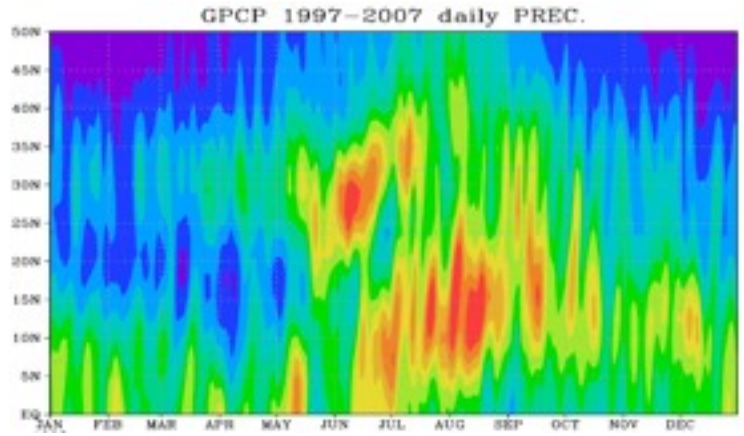


Since each mid-latitude rain event is clearly divided by three- or four-day intervals due to the passage of the baroclinic waves. (LinHo, 2003)

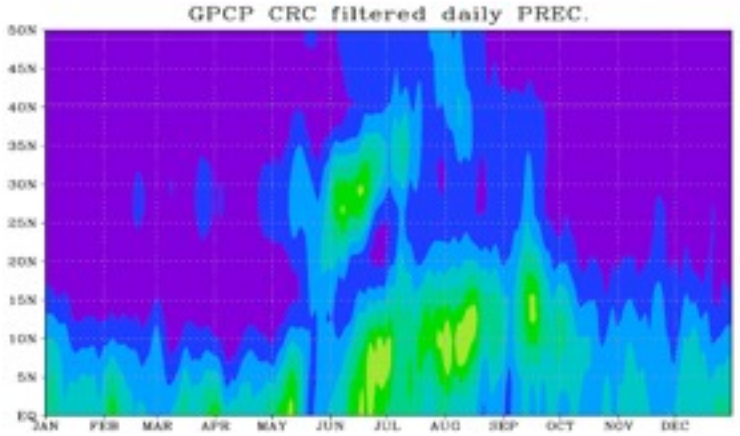
Time-latitude section (after spikes filtered)

120E-140E multi-year daily average(mm day^{-1})

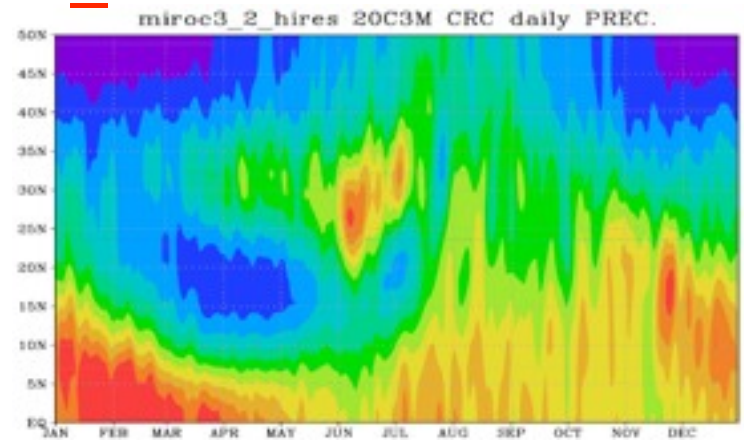
GPCP unfiltered



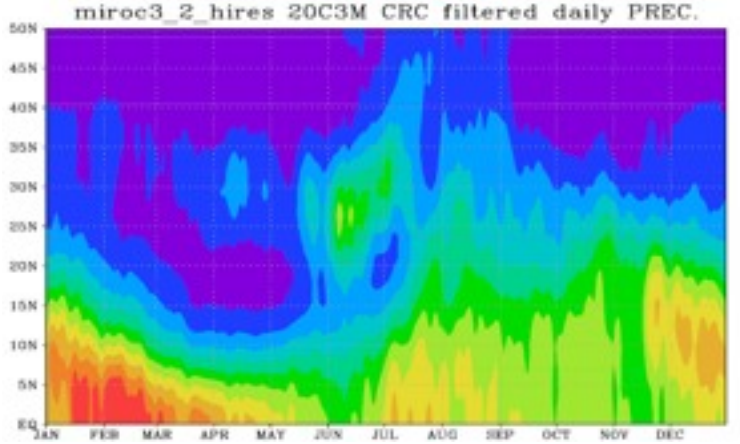
filtered



Miroc3.2_hires unfiltered

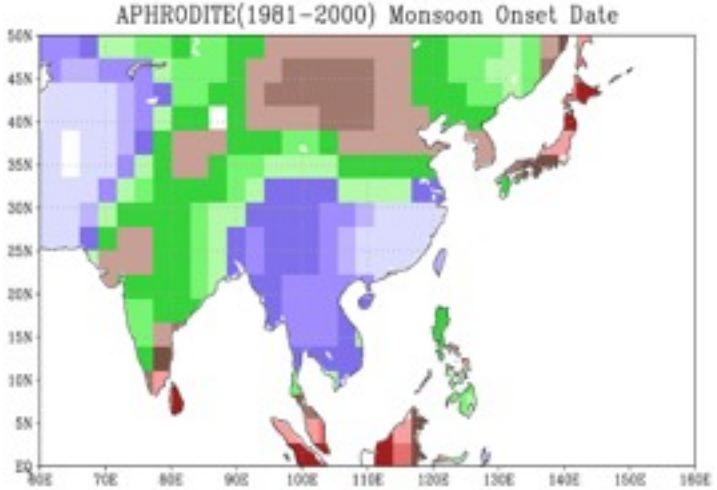


filtered

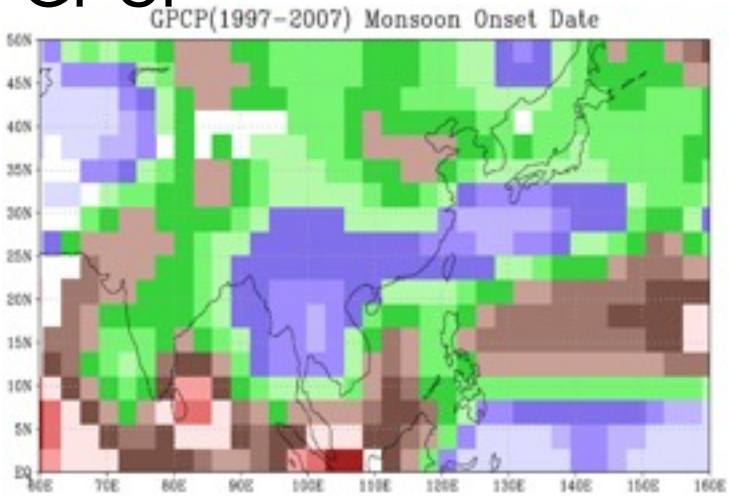


Monsoon onset date

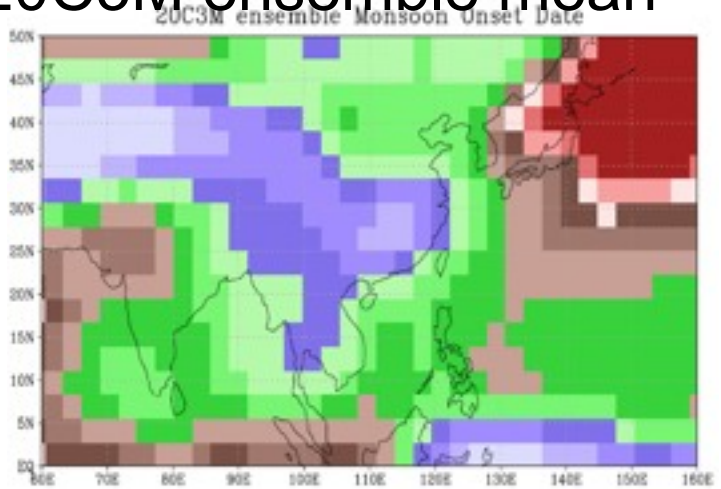
APHRODITE



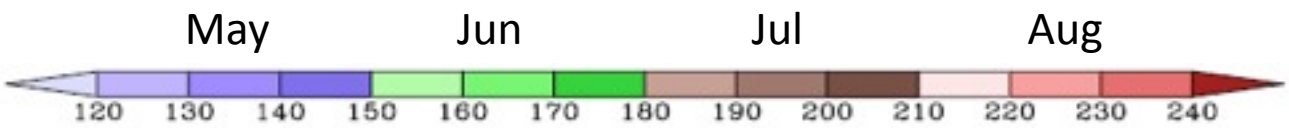
GPCP



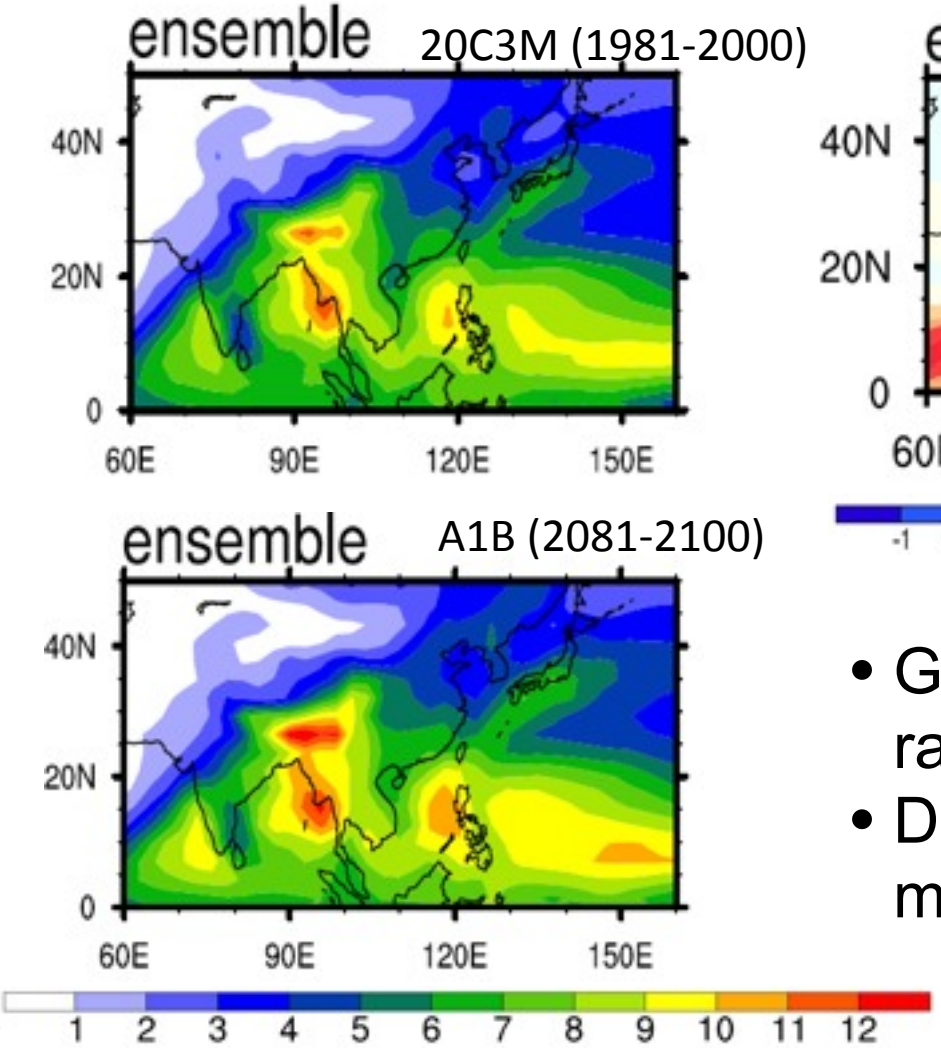
20C3M ensemble mean

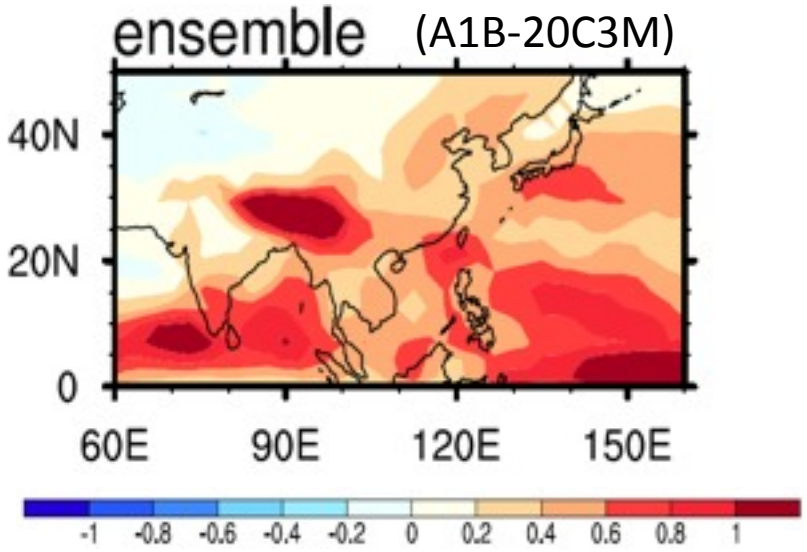


- Differences between APHRODITE and GPCP (over southern China, Taiwan, Korea, Japan)
- Is the spring rainfall the start of rainy season for part of East Asia?



Projected Change in JJA mean precipitation

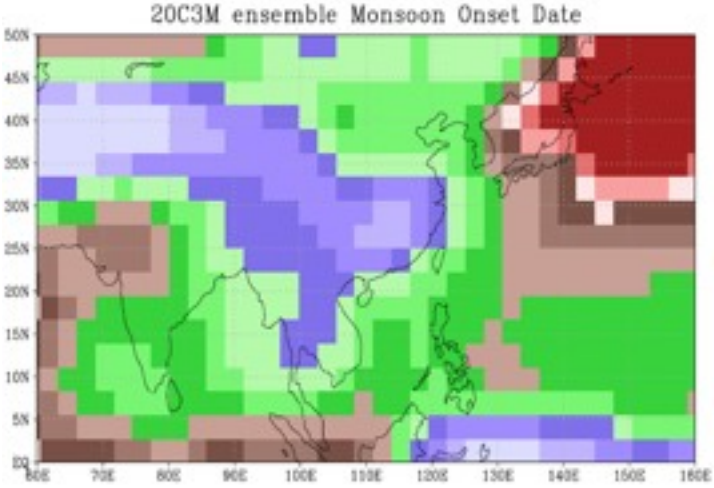




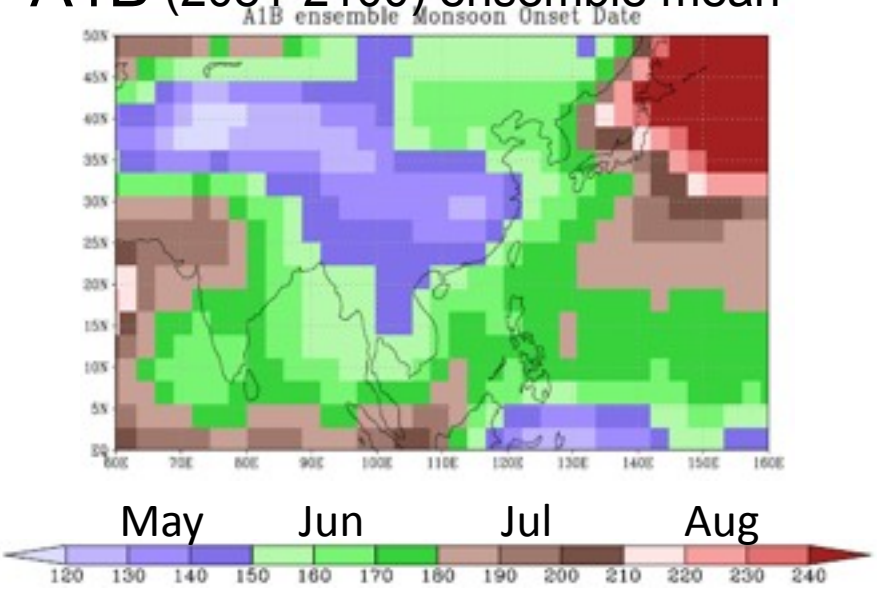
- General increase in summer rainfall
- Does that mean lengthen the monsoon rainfall or intensify?

Projected change in monsoon onset date

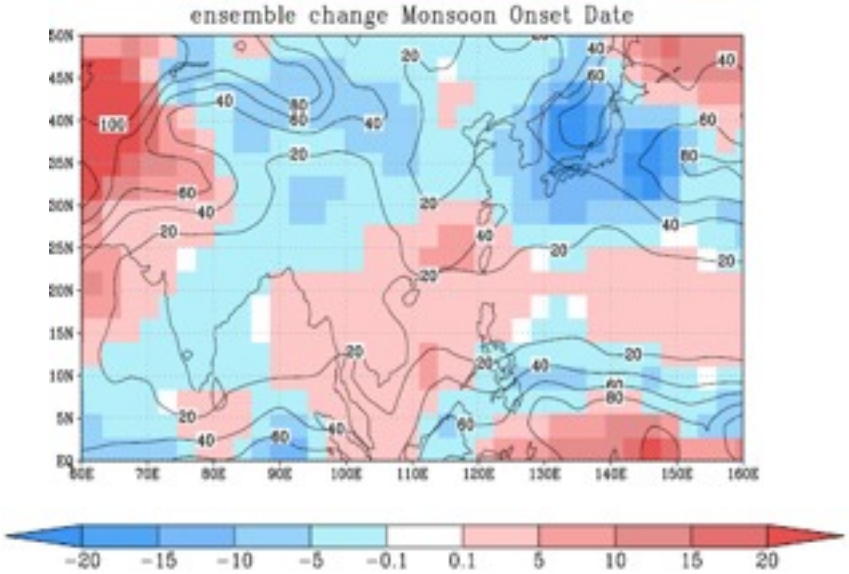
20C3M (1981-2000) ensemble mean



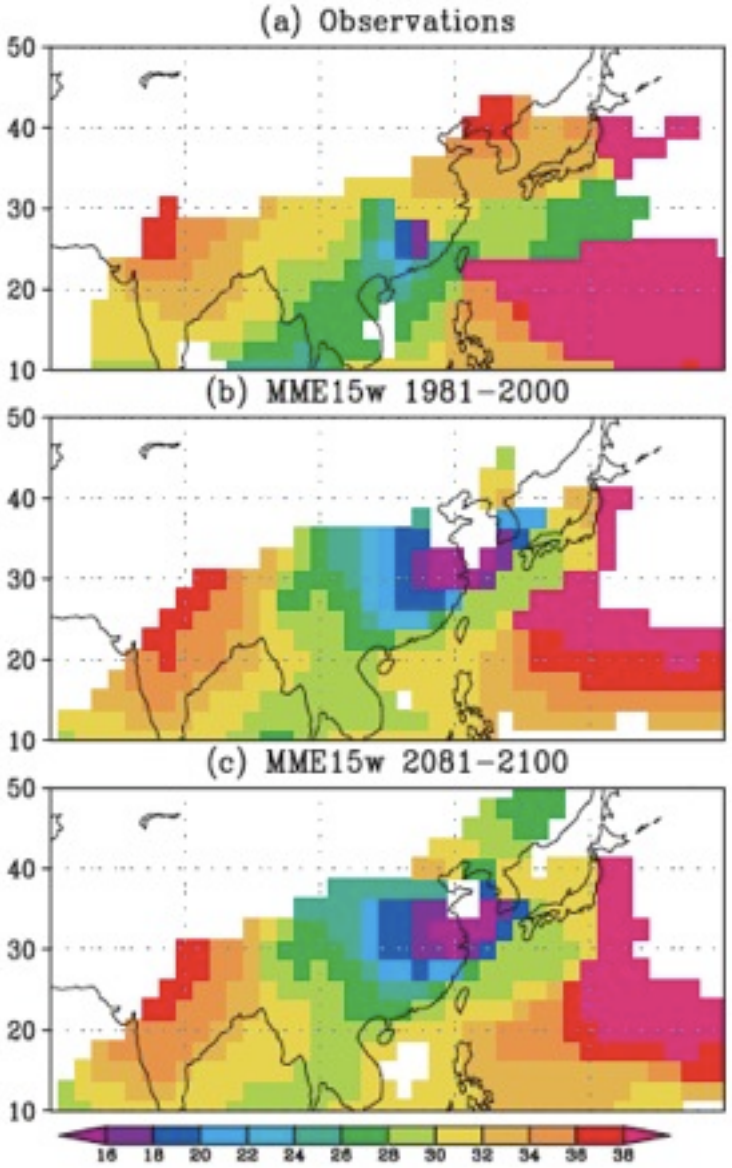
A1B (2081-2100) ensemble mean



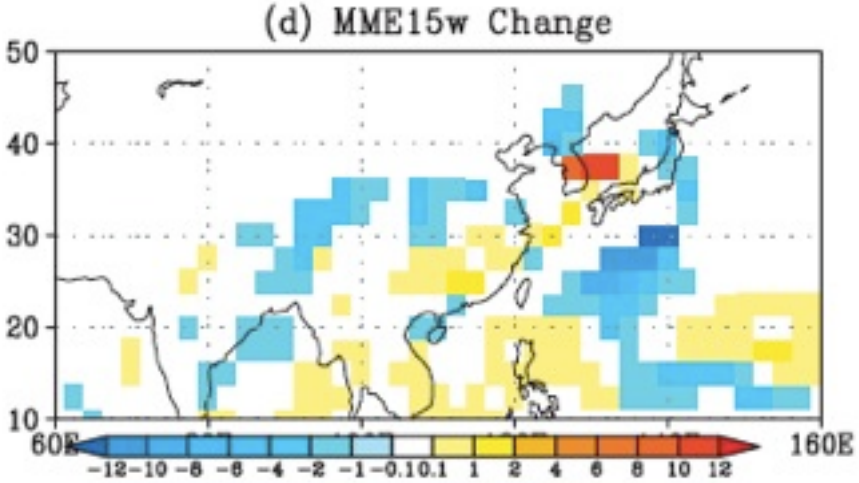
A1B-20C3M ensemble mean



- Earlier onset over Korea and Japan
- Slightly delayed of onset over Southeast China, Taiwan and Indochina peninsula



Kitoh and Uchiyama (2006)



Different definition of onset?

Monsoon onset date change (A1B-20C3M)