The 9th NOAA Ensemble Users Workshop

中国气象局地球系统数值预报中心
CMA EARTH SYSTEM MODELING AND PREDICTION CENTRE

# Dynamical Seasonal Prediction of the Asian Summer Monsoon in CMA-CPSv3


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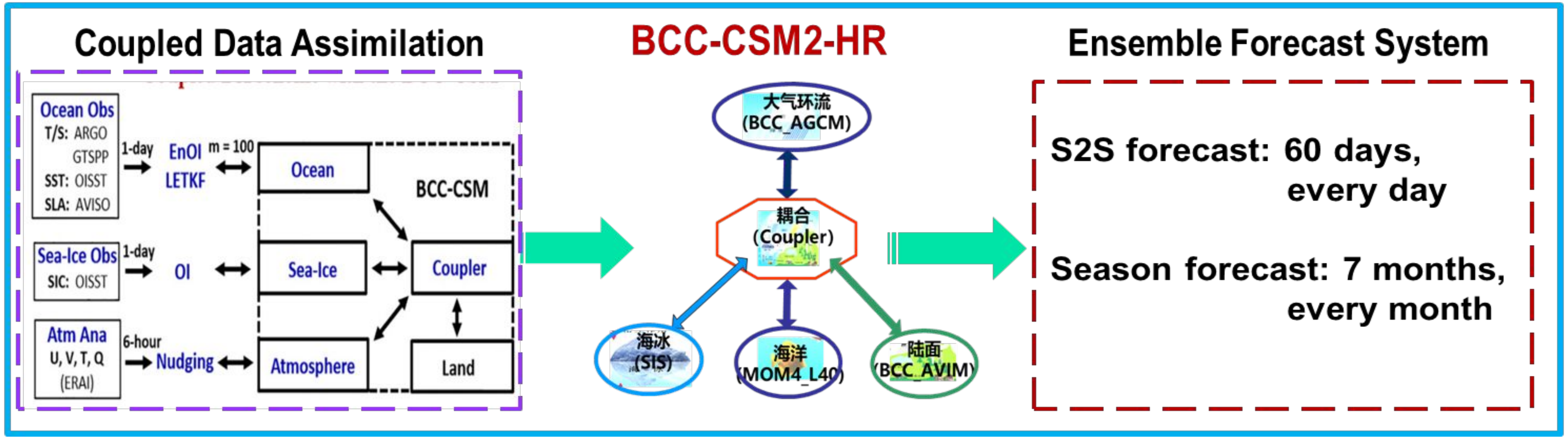
# Content

# Development of CMA Climate Prediction System (CMA-CPS)

| Period | System | Forecast | Models | Status |
|---|---|---|---|---|
| 2016-2021 | CMA-CPSv3 | Subseasonal to seasonal forecast | BCC-CSM2-HR: BCC-AGCM3-HR(T266L56,Top:0.1hPa), BCC_AVIM2(T266), MOM4-L40v3(1/4°), SIS | Takes part in S2S project phase II and in pilot from March 2021 |
| 2005-2015 | CMA-CPSv2 | S2S forecast | BCC_CSM1.2: BCC_AGCM2.3(T106L40), BCC_AVIM1(T106), MOM4-L40(1/3°~30km), SIS(1/3°~30km) | Take part in S2S project phase I in 2015 |
| | | Seasonal forecast | BCC_CSM1.1m: BCC_AGCM2.2(T106L26), BCC_AVIM1(T106), MOM4-L40(1/3°~30km), SIS(1/3°~30km) | Operated in January 2016 |
| | | Extended Range Forecast | BCC_AGCM2 (T106L26) | Operated in June 2014 |
| 1995-2004 | CMA-CPSv1 | Seasonal forecast | BCC_CM1.0 | Real-time ran in March 2005 |
| | | Extended Range Forecast | BCC_AGCM1 (T63L16) | |

# China Meteorological Administration Climate Prediction System version3 （CMA-CPSv3）




| Constituents | CMA-CPSv2 | CMA-CPSv3 |
|---|---|---|
| Atmosphere model | BCC-AGCM2.2<br>(T106L26)<br>Horizontal resolution: ~100km，<br>Vertical： 26 layers with top layer at 2 hPa | BCC-AGCM3.0<br>(T266L56)<br>Horizontal resolution: ~45km，<br>Vertical： 56 layers with top layer at 0.156 hPa |
| Land model | BCC-AVIM1.0<br>Horizontal resolution: ~100km | BCC-AVIM2.0<br>Horizontal resolution: ~45km |
| Ocean model | MOM4-L40<br>Horizontal resolution: 1/3° ~ 1° | MOM5-L50<br>Horizontal resolution: 1/4° x 1/4° |
| Ice model | SISv1<br>Horizontal resolution: 1/3° ~ 1° | SISv2<br>Horizontal resolution: 1/4° x 1/4° |

# Upgrades to Atmosphere model of CMA-CPSv3

| | | CMA-CPSv2 | CMA-CPSv3 |
|---|---|---|---|
| Atmosphere component (BCC-AGCM) | **Resolution** | T106 (~110km), 46 layers with top layer at 1.979hPa and model lid at 1.459 hPa | T266 (~45km), 56 layers with top layer at 0.156 hPa and model lid at 0.092 hPa |
| | **Dynamic core** | Spectral framework described in Wu et al. (2008) | Same as in BCC-CSM2-MR but including spatially variant divergence damping. |
| | **Deep convection** | A modified Wu'2012 scheme described in Wu et al. (2019) | Revised Wu et al. (2019) scheme, including the effects of convective downdraft in neighboring grids. |
| | **Shallow/Middle Tropospheric Moist Convection** | Hack (1994) | Modified Hack (1994) scheme described in Lu et al. (2020b), incorporating a trigger based on lower tropospheric stability. |
| | **Cloud macrophysics** | Diagnosed cloud fraction described in Wu et al. (2019) | Revised Wu et al. (2019) scheme, excluding the special treatment for the marine stratocumulus. |
| | **Cloud microphysics** | Modified scheme of Rasch and Kristj´ansson (1998) by Zhang et al. (2003), but included the aerosol indirect effects in which liquid cloud droplet number concentration is diagnosed using the aerosols masses. | Same as in BCC-CSM2-MR. |
| | **Gravity wave drag** | Gravity wave drag generated by both orography (Mcfarlane 1987) and convection (Beres et al., 2004). | Same as in BCC-CSM2-MR, but using tuned parameters related to model resolutions. |
| | **Surface orographic drag** | No treatment. | The turbulent mountain stress scheme as in Richter et al. (2010). |
| | **Radiative transfer** | Radiative transfer scheme used in CAM3 (Collins et al., 2004), but including the aerosol indirect effects, and the effective radius of the cloud droplet for liquid clouds is diagnosed using liquid cloud droplet number concentration. | Same as in BCC-CSM2-MR. |
| | **Boundary Layer** | Parameterization of Holtslag and Boville (1993), but modified PBL height computation as in Zhang et al. (2014) | The University of Washington Moist Turbulence scheme (Bretherton and Park, 2009) |

## Upgrades:

- **Deep convection:** revised effects of convective downdraft in neighboring grids.
- **Shallow Convection:** incorporating a trigger based on lower tropospheric stability.
- **Cloud macrophsics:** excluding the special treatment for marine stratocumulus.
- **Gravity wave drag:** using tuned parameters related to model resolutions.
- **Boundary layer:** changing to the university of Washington moist turbulence scheme.

# Upgrades to Ocean model of CMP-CPSv3

| | | CMA-CPSv2 | CMA-CPSv3 |
|---|---|---|---|
| Ocean Component (MOM) | Resolution | 1°×1° with a tri-pole grid, but 1/3° latitude between 30°S and 30°N to 1.0° at 60° latitude, 40 layers in vertical | 1/4°×1/4° with a tri-pole grid at north to 60°N, 50 layers in vertical |
| | Tracer advection scheme | MOM4 (Griffies, 2005), Sweby advection scheme (Sweby, 1984) | MOM5 (Griffies, 2012), multi-dimensional piecewise parabolic method |
| | Neutral diffusion scheme | Griffies et al. (1998) with a constant diffusivity of 600 $m^2 s^{-1}$ | None |
| | Surface boundary layer processes | K-profile parameterization (KPP, Large et al., 1994) | Same as in MOM4 |
| | Submesoscale parameterization scheme | None | Fox-Kemper et al. (2008) |
| | shortwave penetration | Morel and Antoine (1994), with the maximum depth of 100m | Manizza et al. (2005), with the maximum depth of 300m |

## Upgrades:

- **Tracer advection scheme:** using the multi-dimensional piecewise parabolic method.
- **Sub-mesoscale parameterization scheme**: introducing Fox-Kemper scheme.
- **Shortwave penetration:** Manizza et al. (2005), with the maximum depth of 300m.

# Upgrades to ice model of CMP-CPSv3

| | | CMA-CPSv2 | CMA-CPSv3 |
|---|---|---|---|
| Sea Ice Component (SIS) | Resolution | Same as in the ocean component, 3 vertical layers including 1 snow cover and 2 ice layers of equal thickness | Same as in the ocean component, 3 vertical layers including 1 snow cover and 2 ice layers of equal thickness |
| | Model physics | SISv1, Elastic-viscous-plastic dynamic processes, Semtner's thermodynamic processes | Same as SISv2 |
| | Snow albedo | 0.80 | 0.85 |
| | Ice albedo | 0.5826 | 0.68 |

## Upgrades:

- **Model physics:** same as SISv2.
- **Snow albedo**: increasing to 0.85.
- **Ice albedo:** increasing to 0.68.

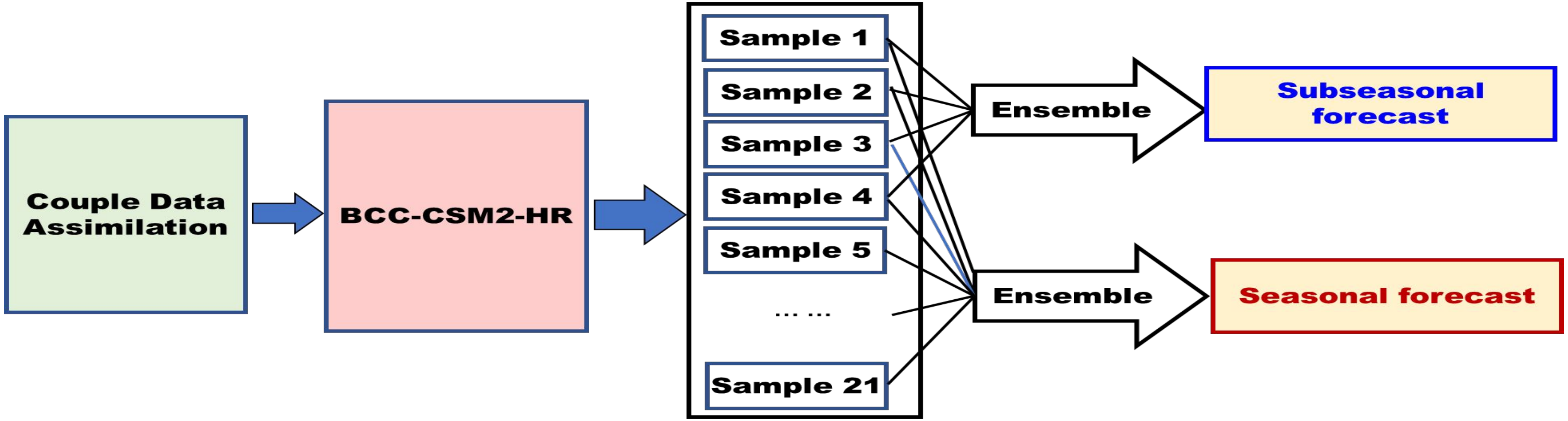
# Ensemble prediction system

### ◆ Sub-seasonal forecast

- Ensemble size: 4 (SPPT)
- Forecast time: 60 days
- Release date: at 7:30 am of every day(real-time),
  Monday and Thursday (re-forecast)
- Re-forecast (on fly) period: the last 15 years

### ◆ Seasonal forecast

- Ensemble size: 21 (SPPT+LAF)
- Forecast time: 7 months
- Release date: the 6th of the month
- Re-forecast period：2001-2020 (20 years)



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# Seasonal forecast of Asian Summer Monsoon in CMA-CPSv3

# Precipitation and Wind of JJA 850hPa

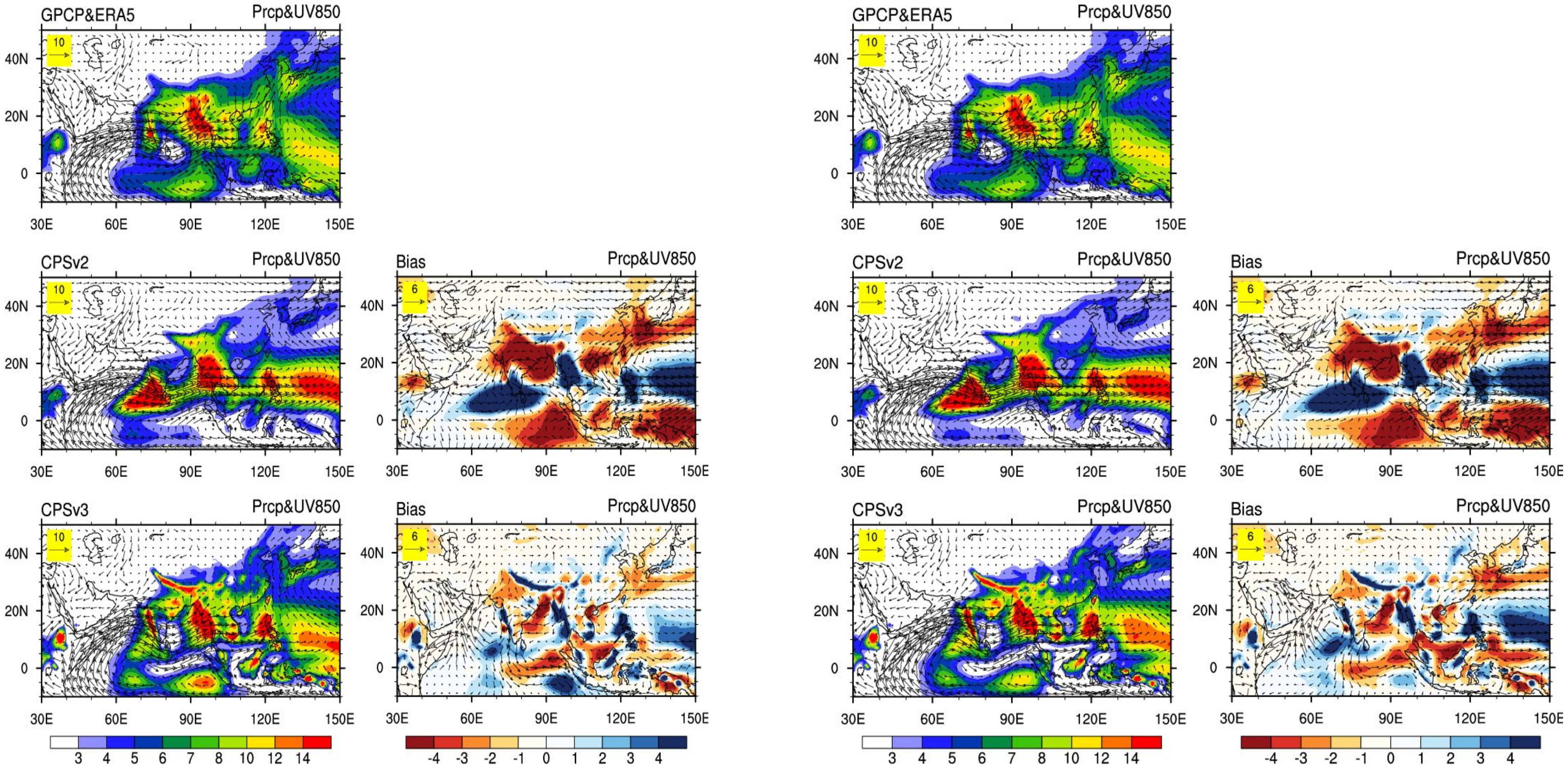
starts in March

starts in May

GPCP

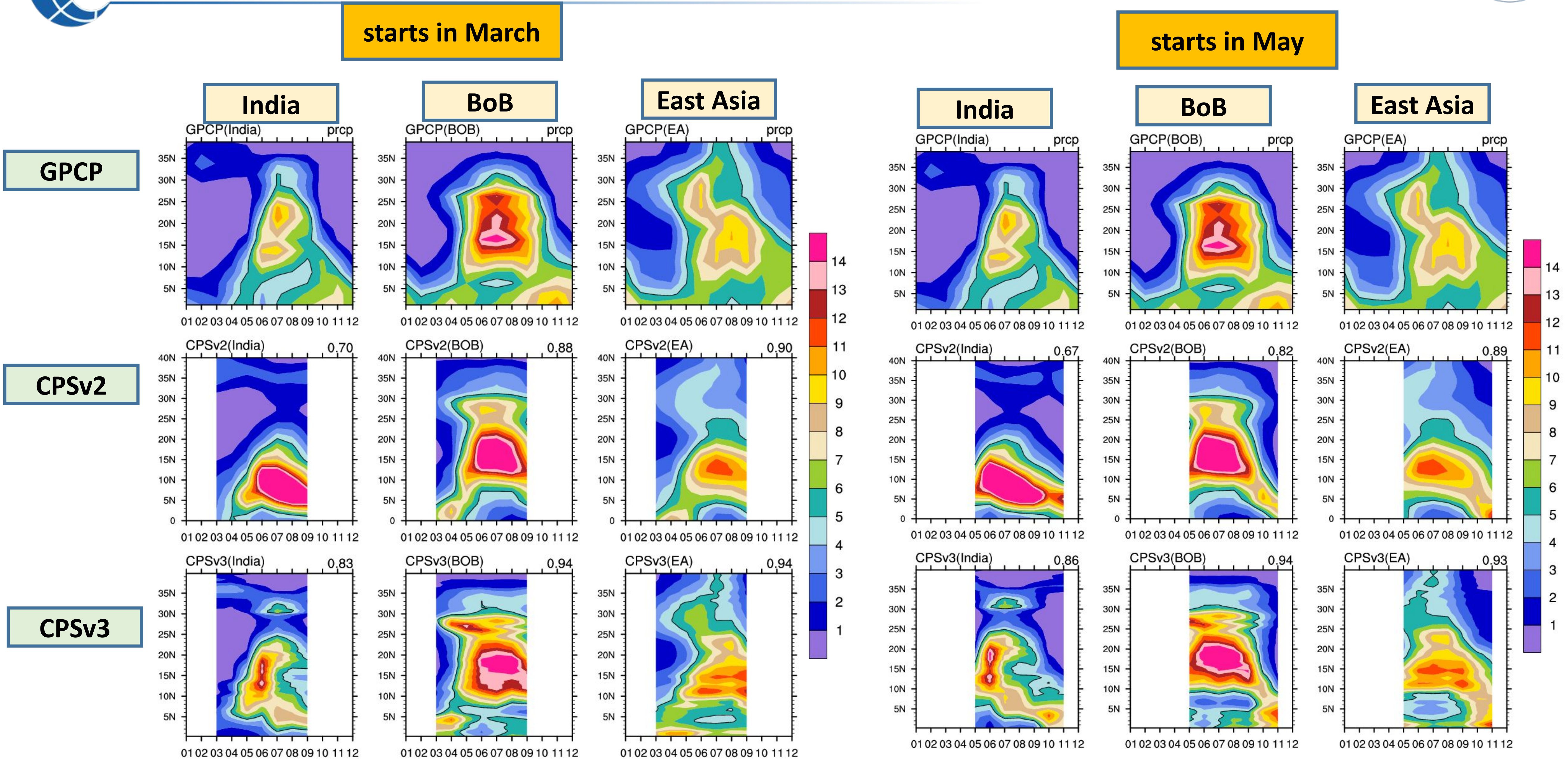
CPSv2

CPSv3




- Bias of summer precipitation over Asian monsoon area obviously decreases in CPSv3.
- The lower-tropospheric level circulation over the western North Pacific is more reasonable.

# Seasonal Evolution of the Monsoon Rainfall



# GPH and Wind of JJA 200hPa

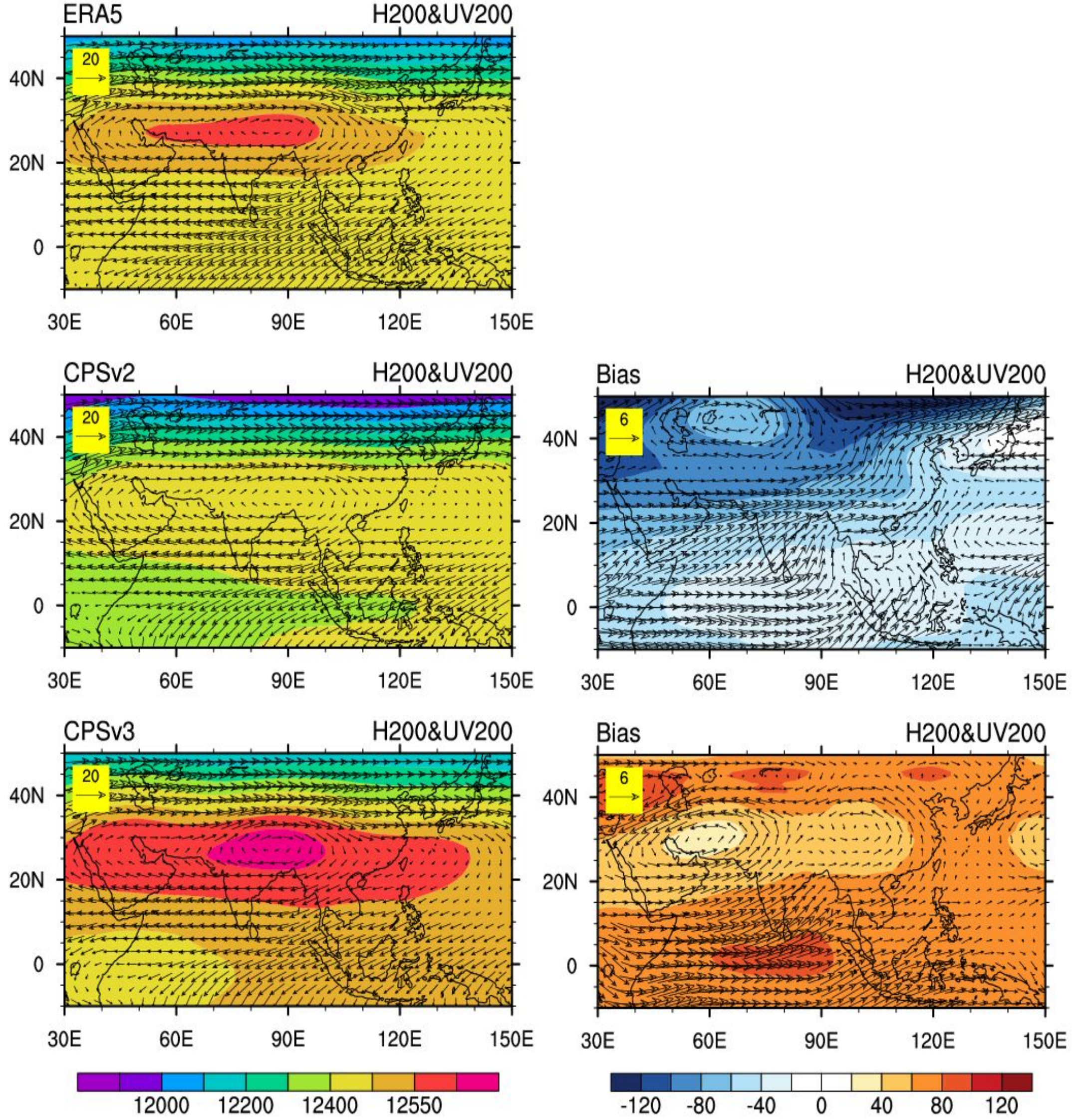
**starts in March**

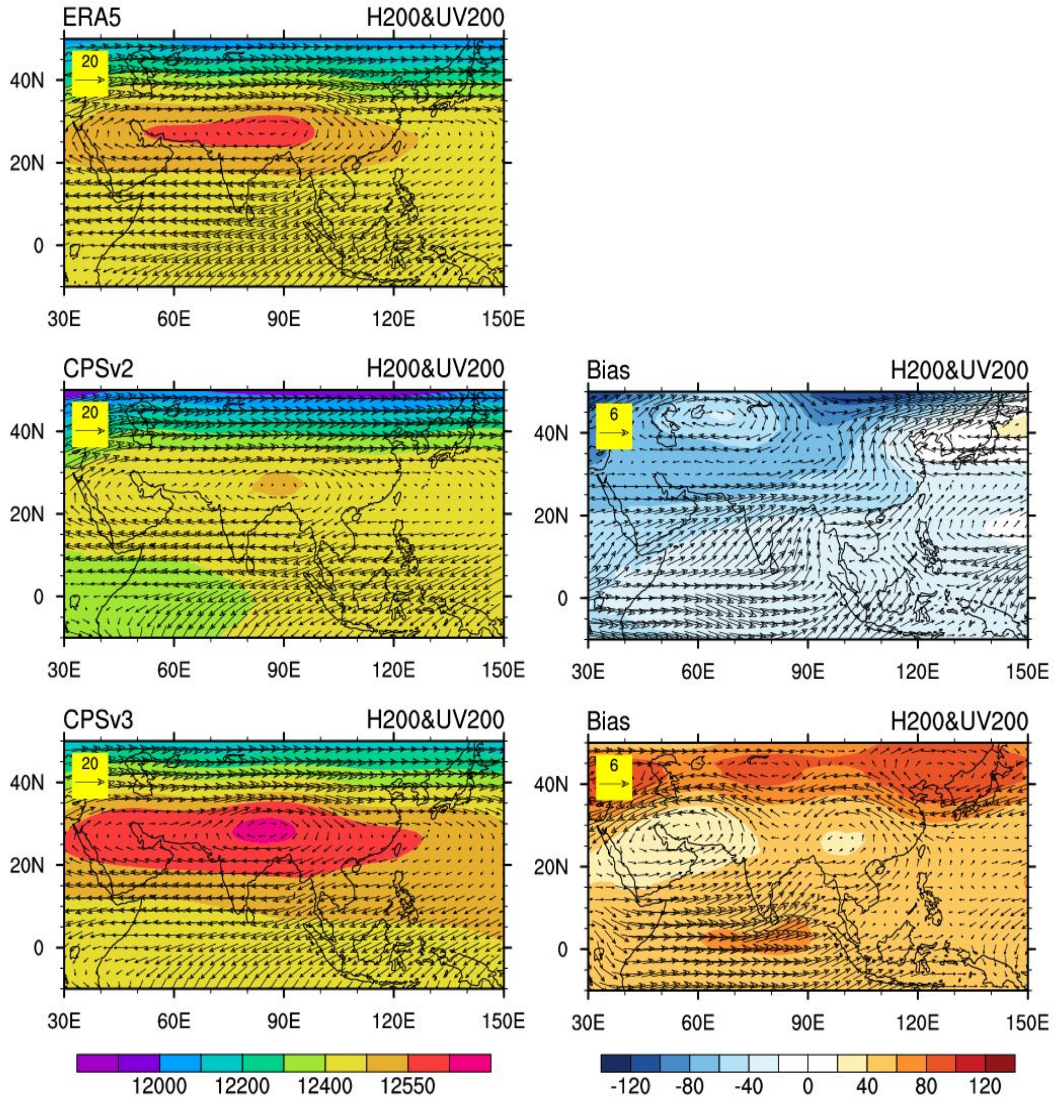
**starts in May**

**ERA5**

**CPSv2**

**CPSv3**



# SST in JJA

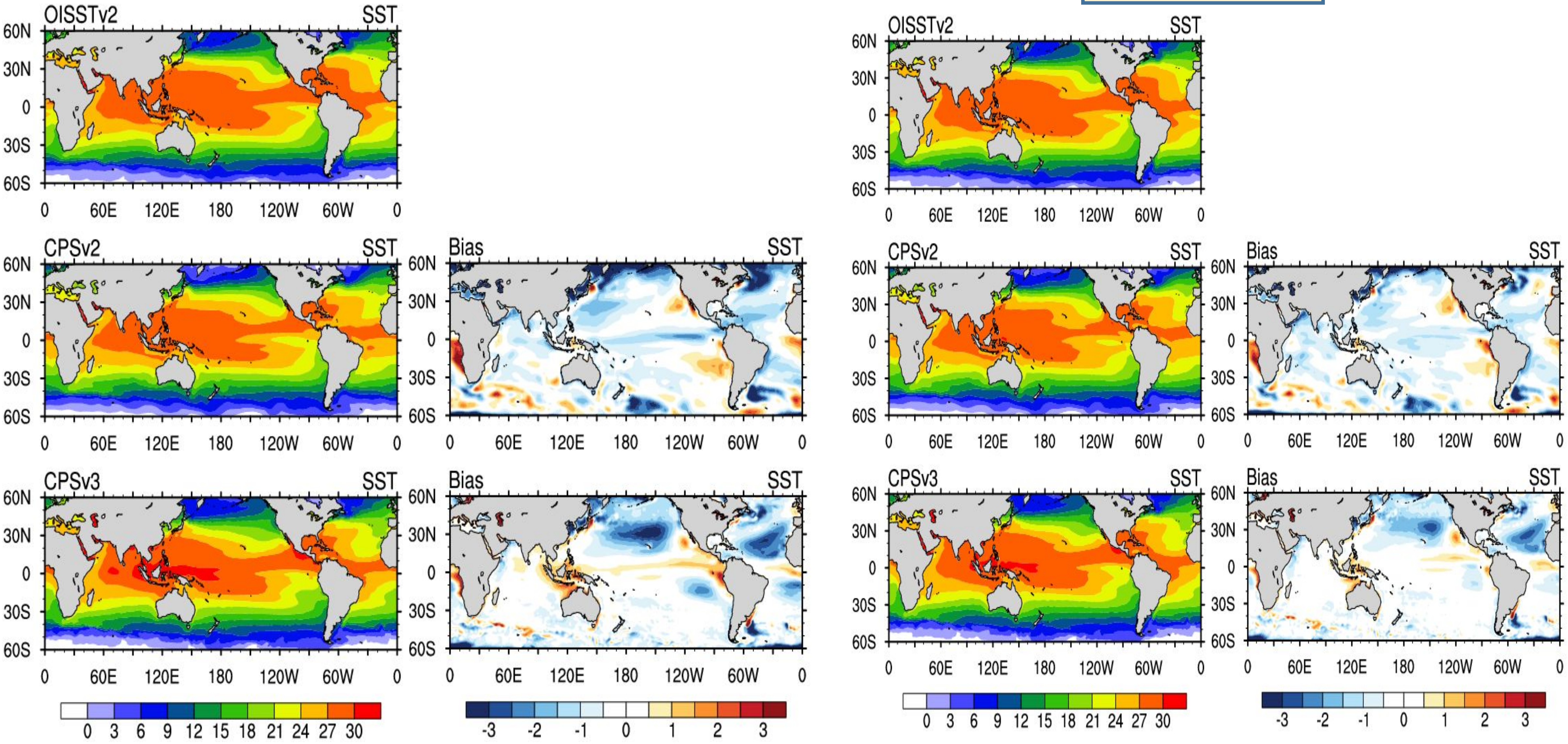
starts in March

starts in May

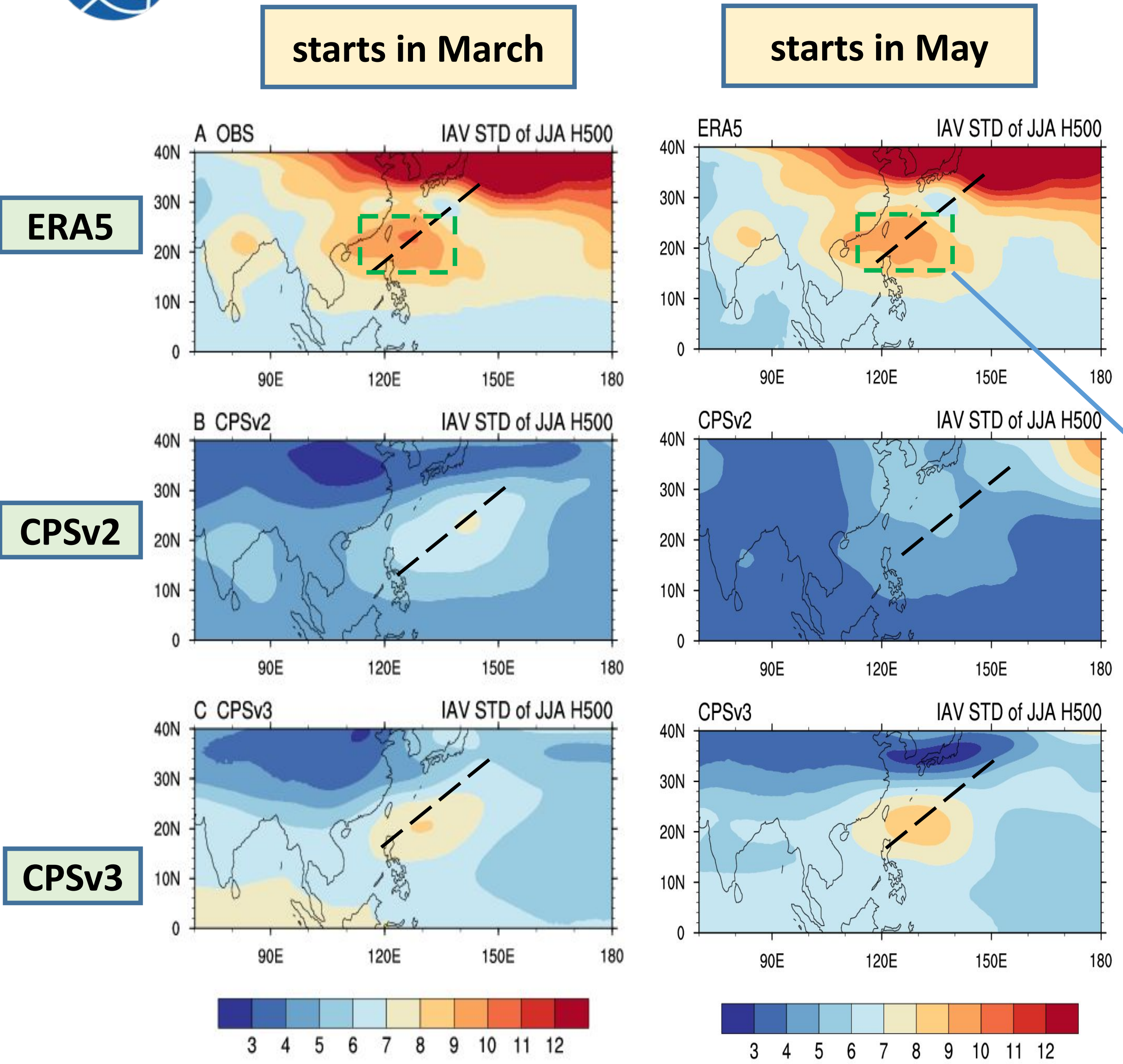
OISST

CPSv2

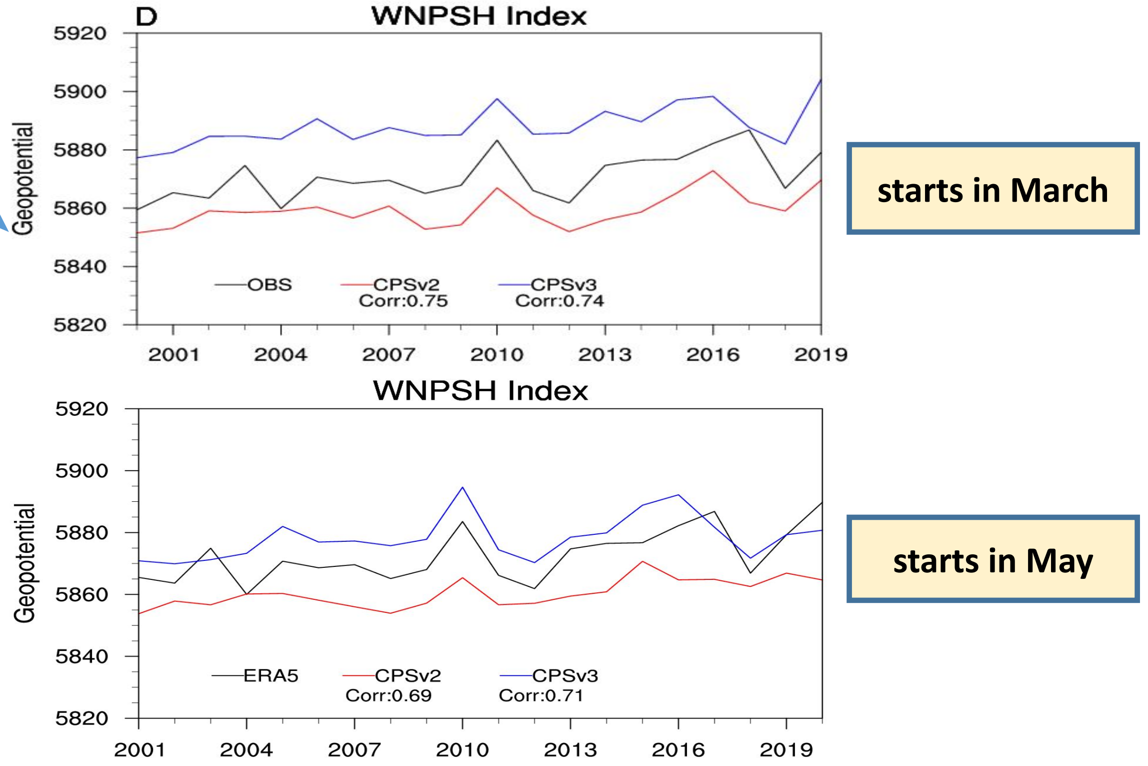
CPSv3



# Inter-annual variability of JJA 500hPa GPH and the Western North Pacific Subtropical High

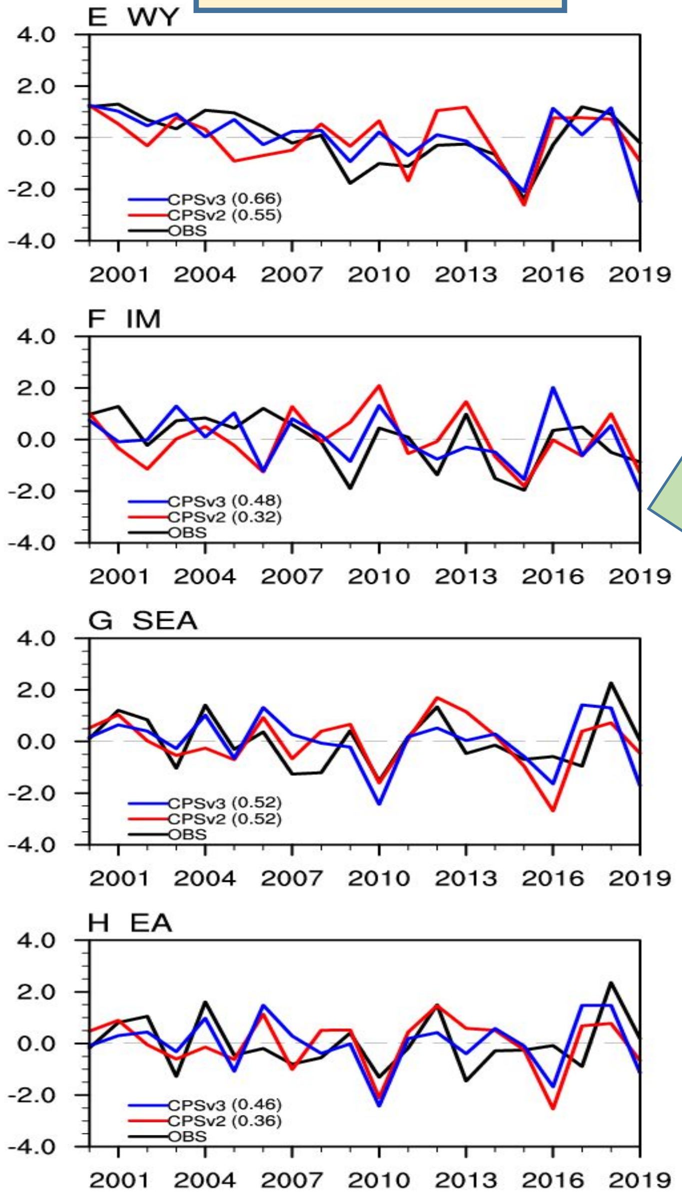



- The correlation of WNPSH in CPSv3 is 0.74, which is highly significant.
- CPSv3 predicts the strengthening tendency of the WNPSH since 2000.

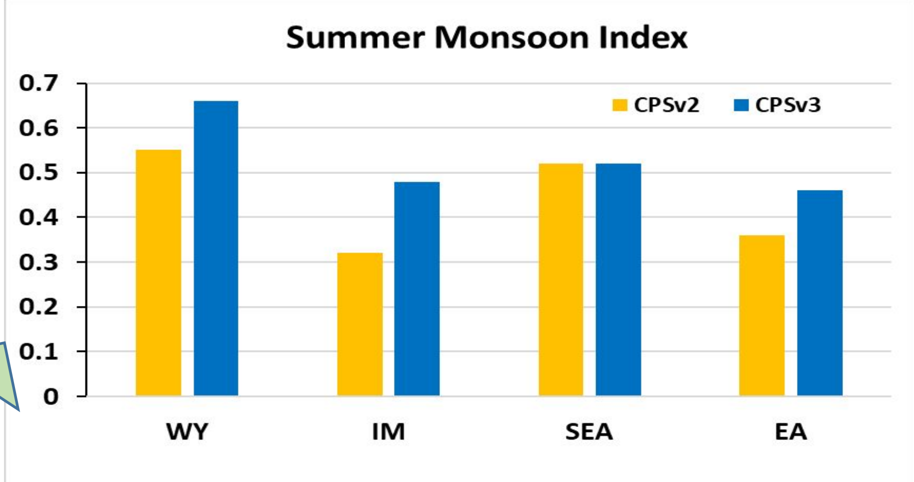


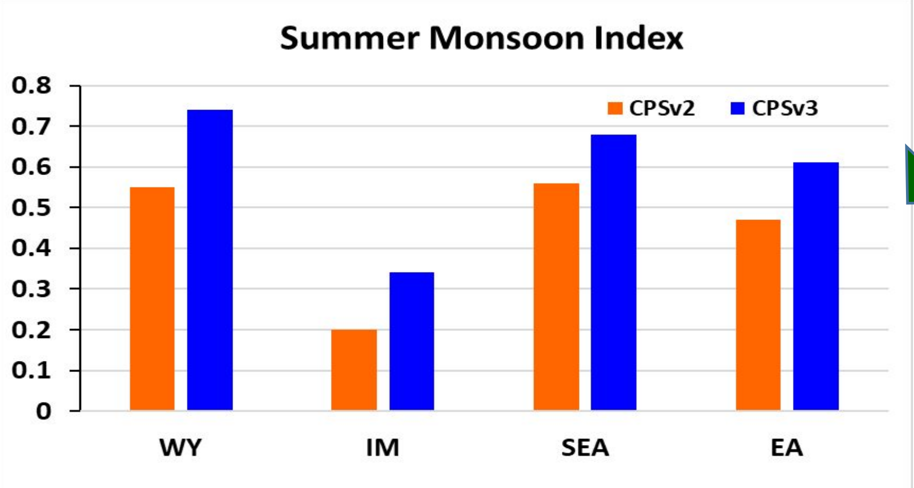
# Asian Summer Monsoon Index

**starts in March**

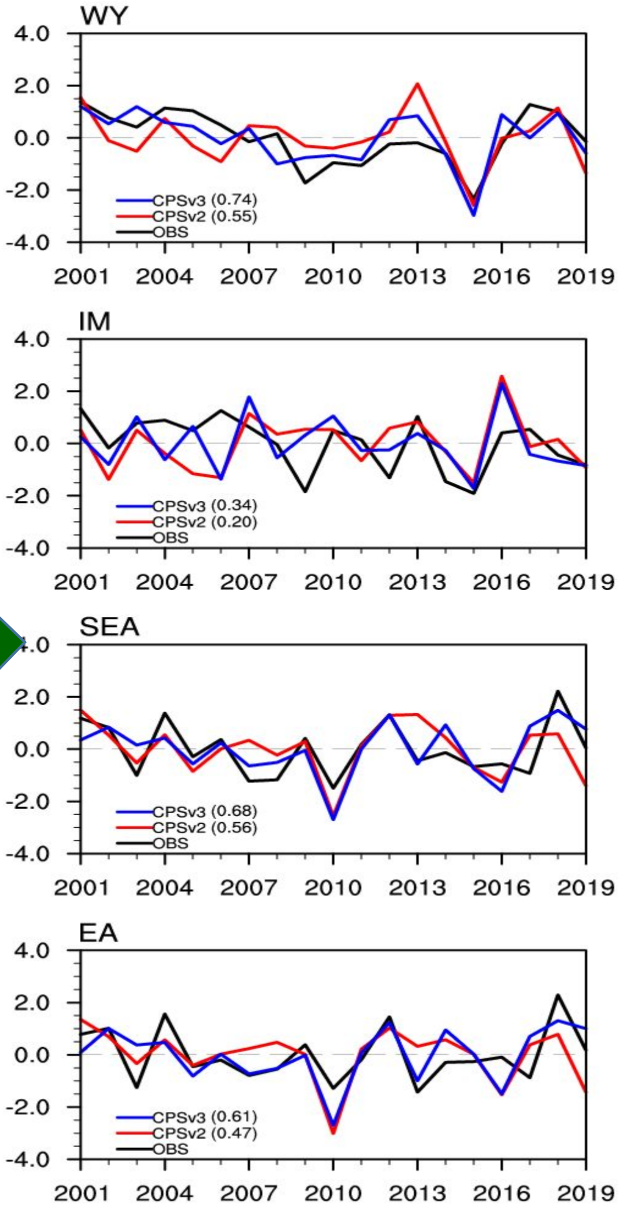



**Correlation of Asian Summer Monsoon Index**



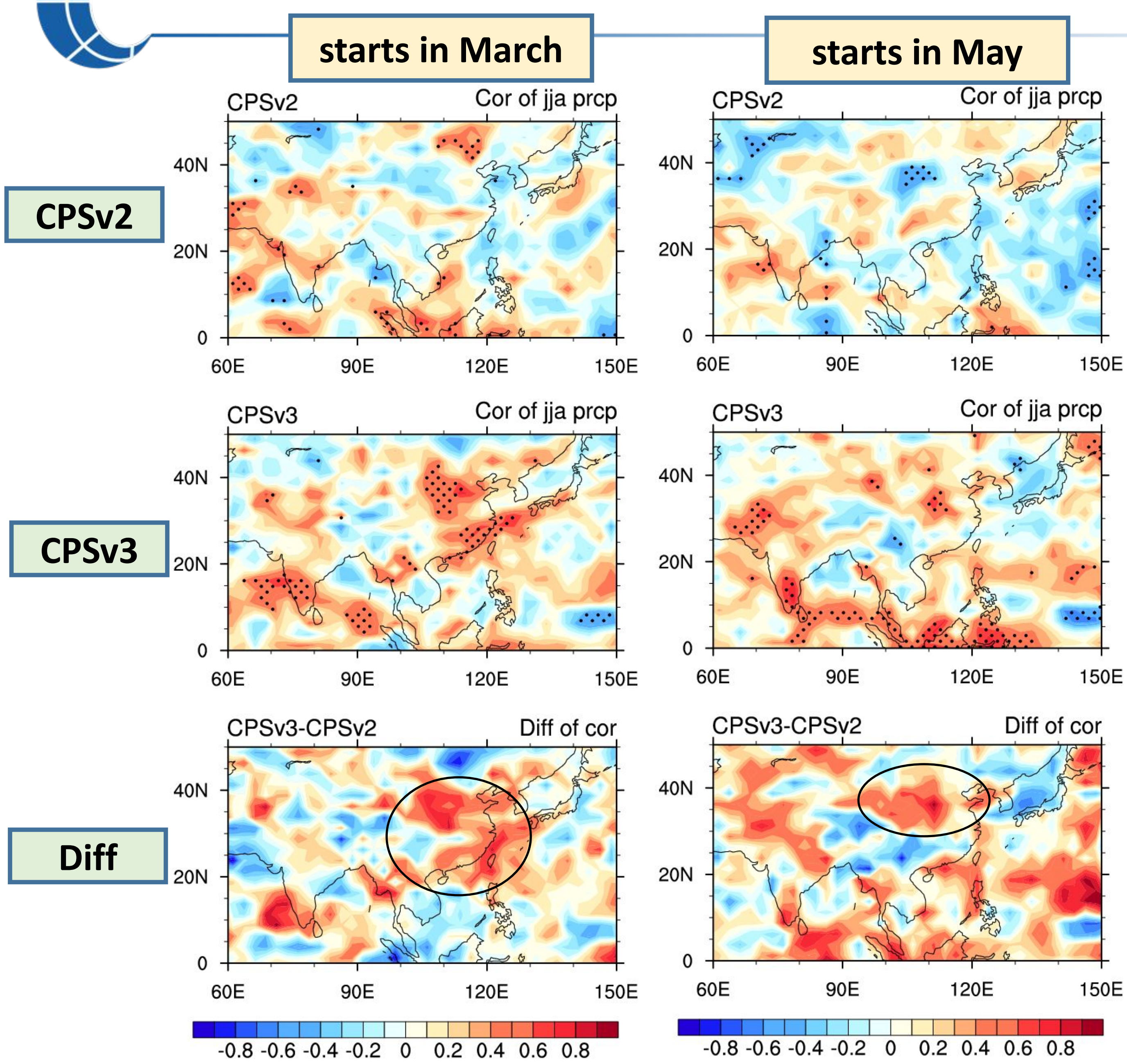




**starts in May**

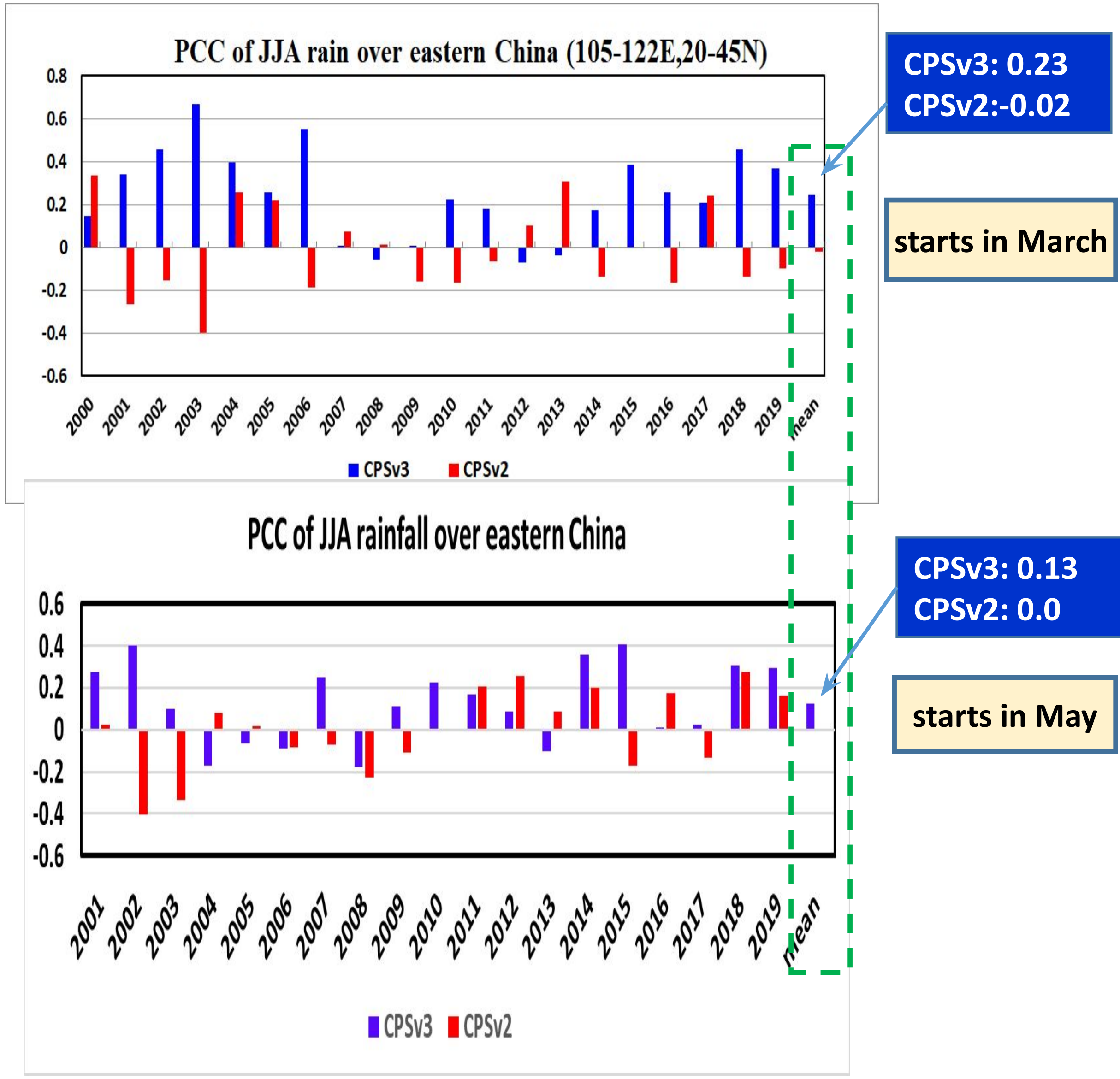



WY: the Webster–Yang monsoon index (Webster and Yang, 1992)
IM: the Indian monsoon index (Parthasarathy et al., 1992)
SEA: the Southeast Asian monsoon index (Wang and Fan, 1999)
EA: the East Asian monsoon index (Zhang et al., 2003)

# TCC of JJA precipitation




## PCC of JJA rainfall over eastern China



# TCC of JJA temperature at 2 meter

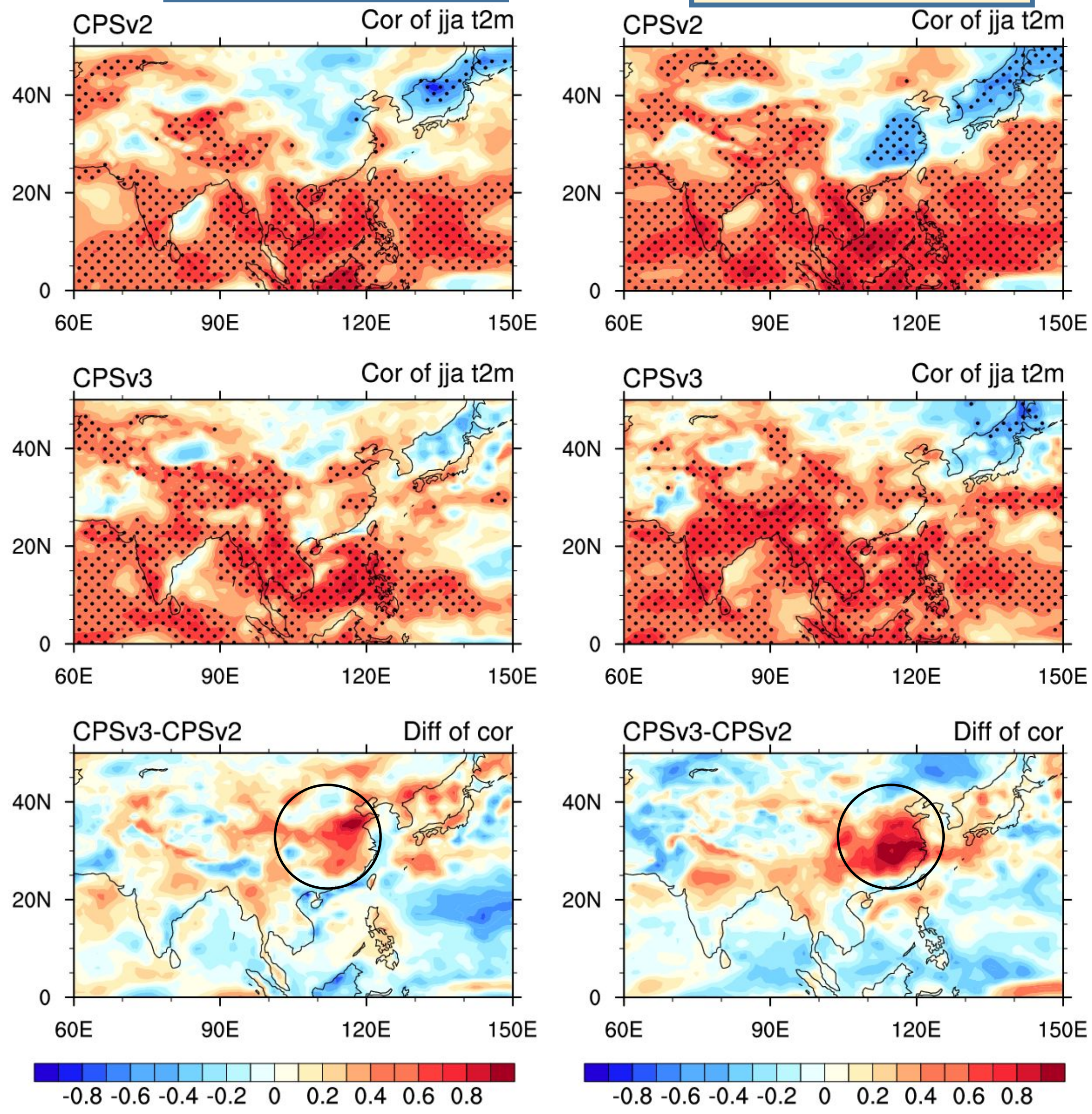
starts in March

starts in May

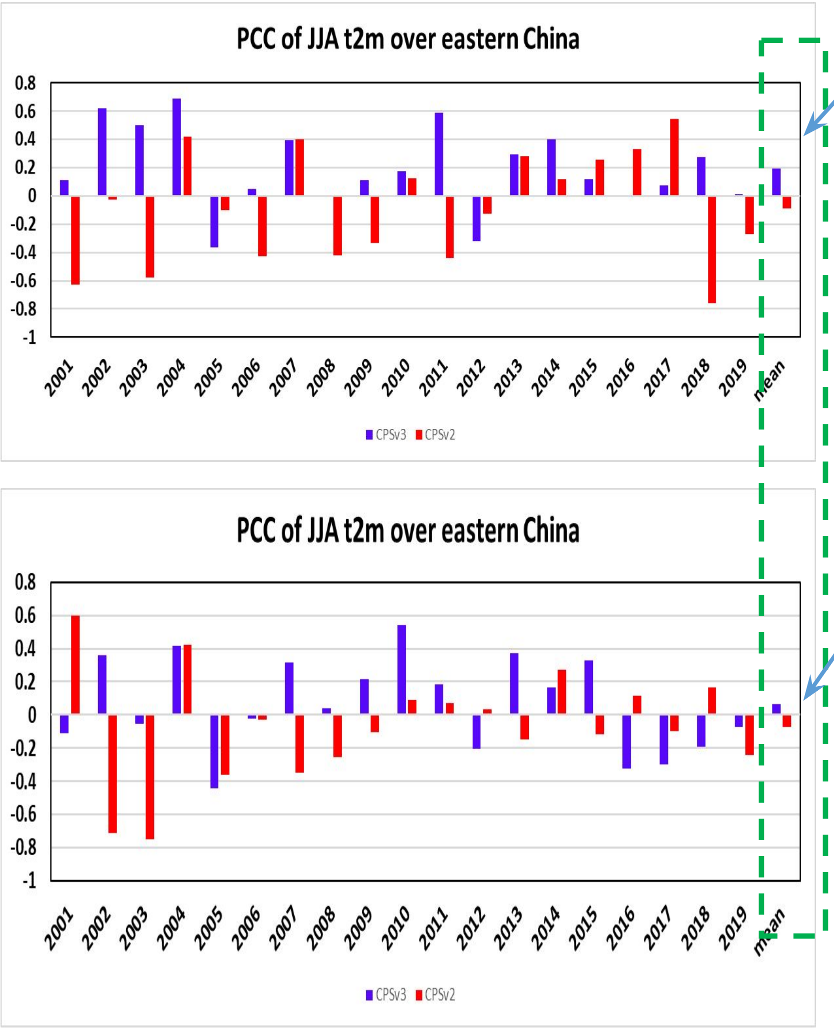
CPSv2

CPSv3

Diff




PCC of JJA t2m over eastern China



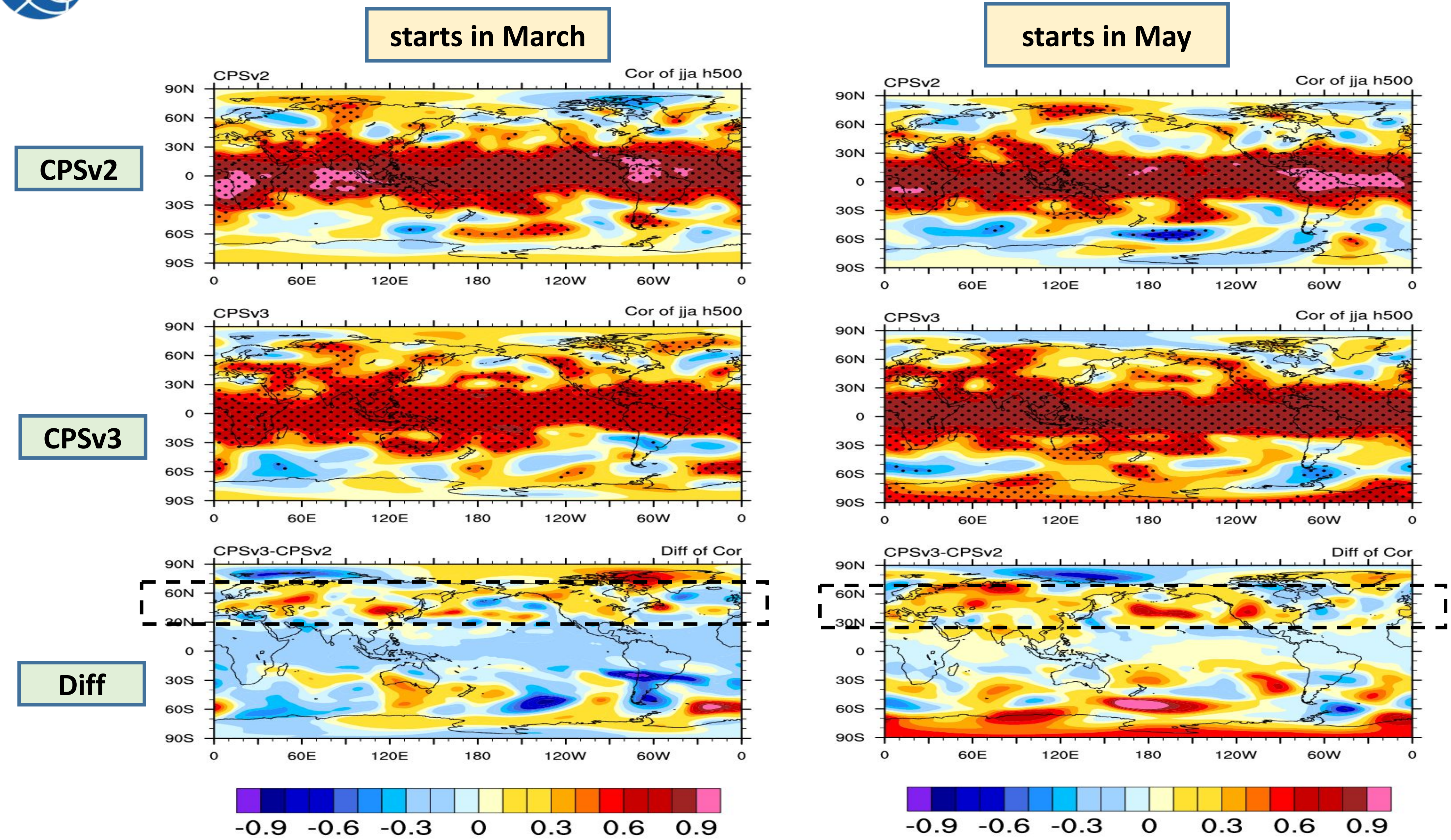

CPSv3: 0.20
CPSv2:-0.09

starts in March

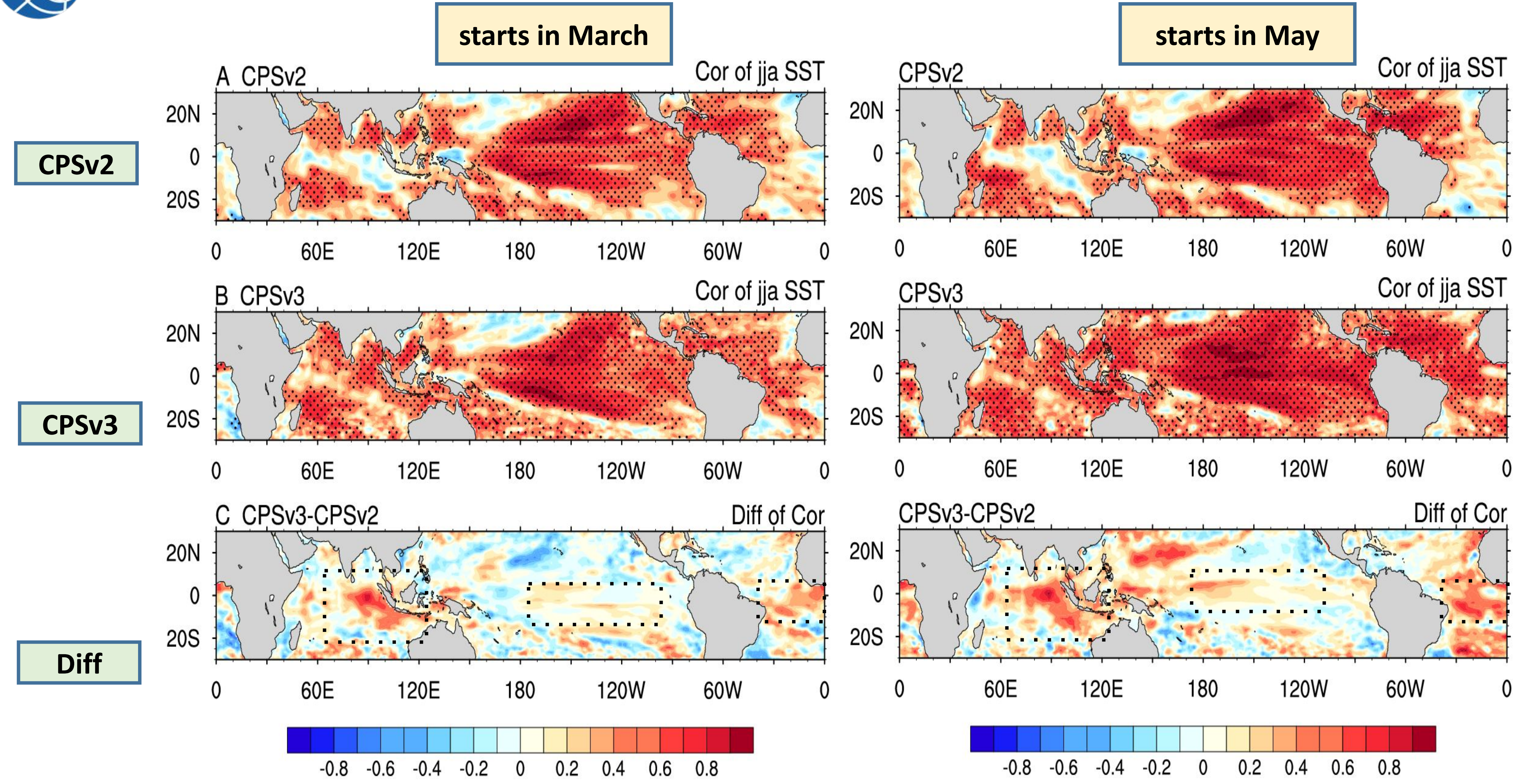
CPSv3: 0.06
CPSv2:-0.07

starts in May

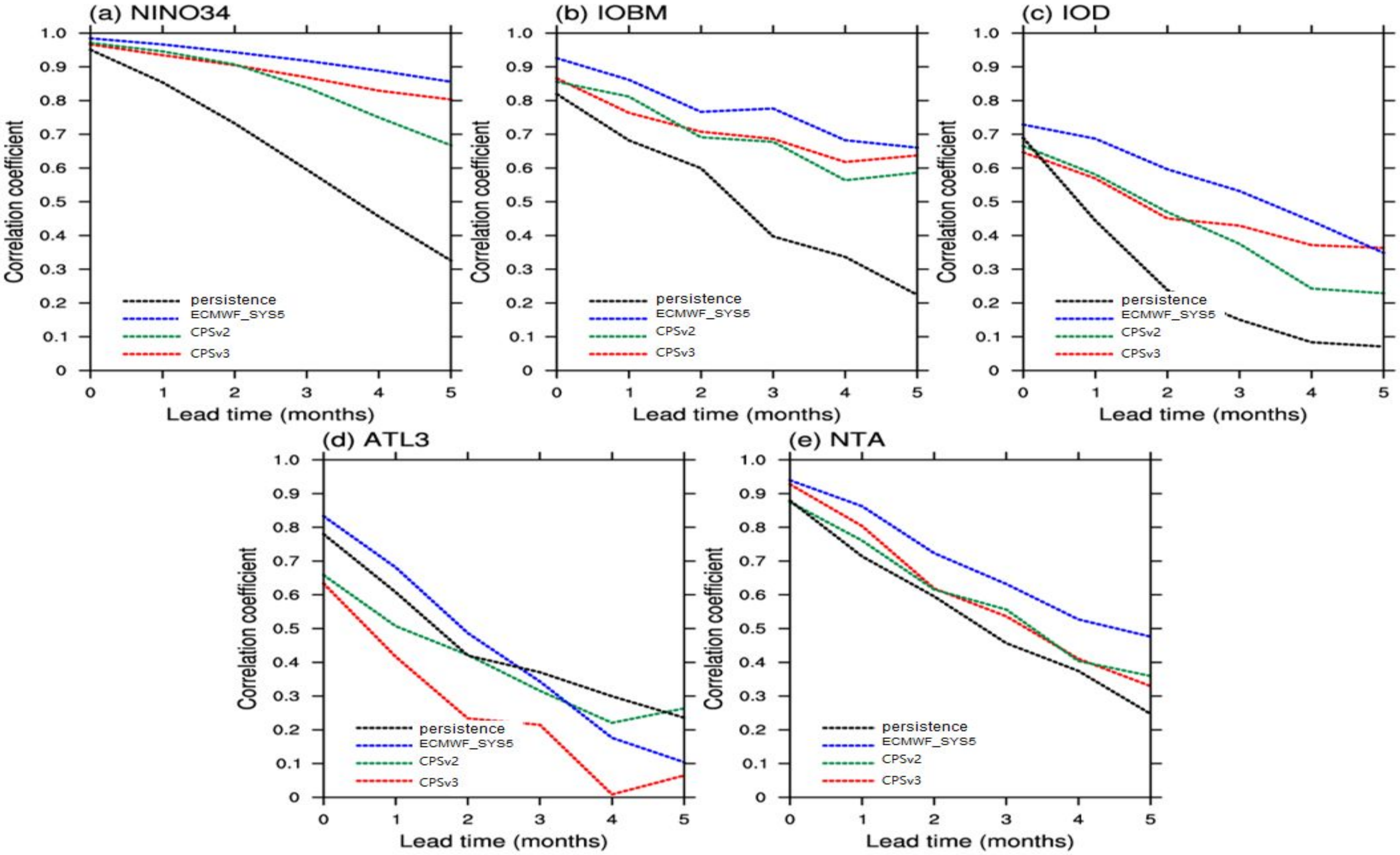
# TCC of JJA 500hPa GPH



# TCC of JJA SST



# ENSO and other Tropical SST indices

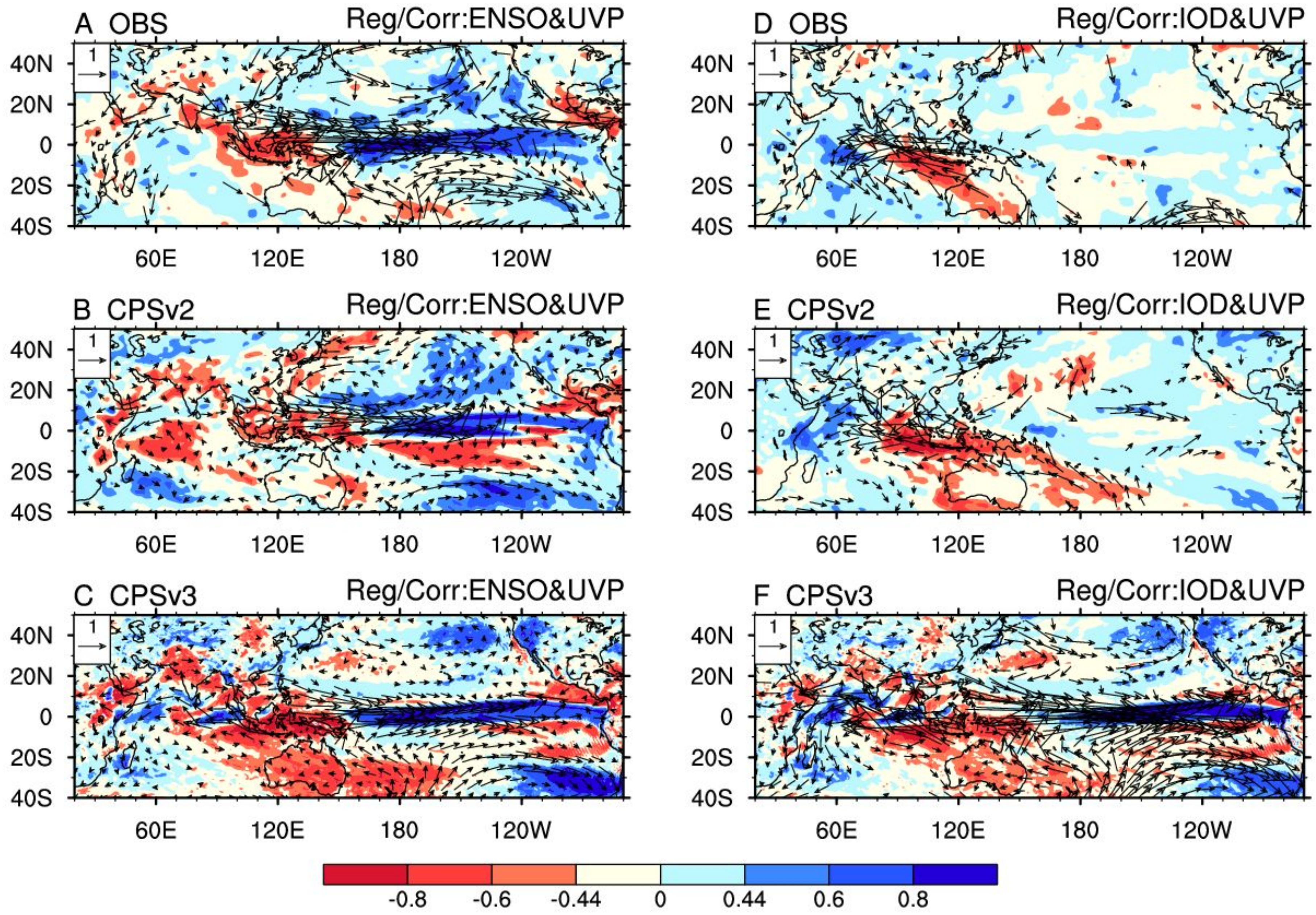


# Air-sea interaction

OBS

CPSv2

CPSv3



# Conclusion

- CPSv3 can well predict many major features of the ASM, including the intensity and locations of the heavy rainfall centers, lower- and higher-level monsoon flows, anticyclonic circulation over the western North Pacific, and monsoon onset.
- Large-scale South Asian summer monsoon and the Southeast Asian summer monsoon are more realistically predicted than the Indian summer monsoon.
- The interannual variation of the WNPSH, which greatly impacts the East Asian summer precipitation, is skillfully predicted in CPSv3.

# Conclusion

- The tropical Pacific SST and tropical Indian Ocean SST indices and their associated anomalies of rainfall and circulation can be predicted 3 months in advance.
- Compared with CPSv2, the prediction skill of the summer precipitation over Asia is significantly improved in CPSv3, especially over eastern China. The benefits may be from the CPSv3 performs well in predicting SST anomalies in the tropical Pacific and the relationships of the Asian monsoon circulation and precipitation to the SST anomalies can be well simulated.

# Thank you for your attention ！