Variability of the Seychelles Dome and its possible connection to the Madden-Julian Oscillation

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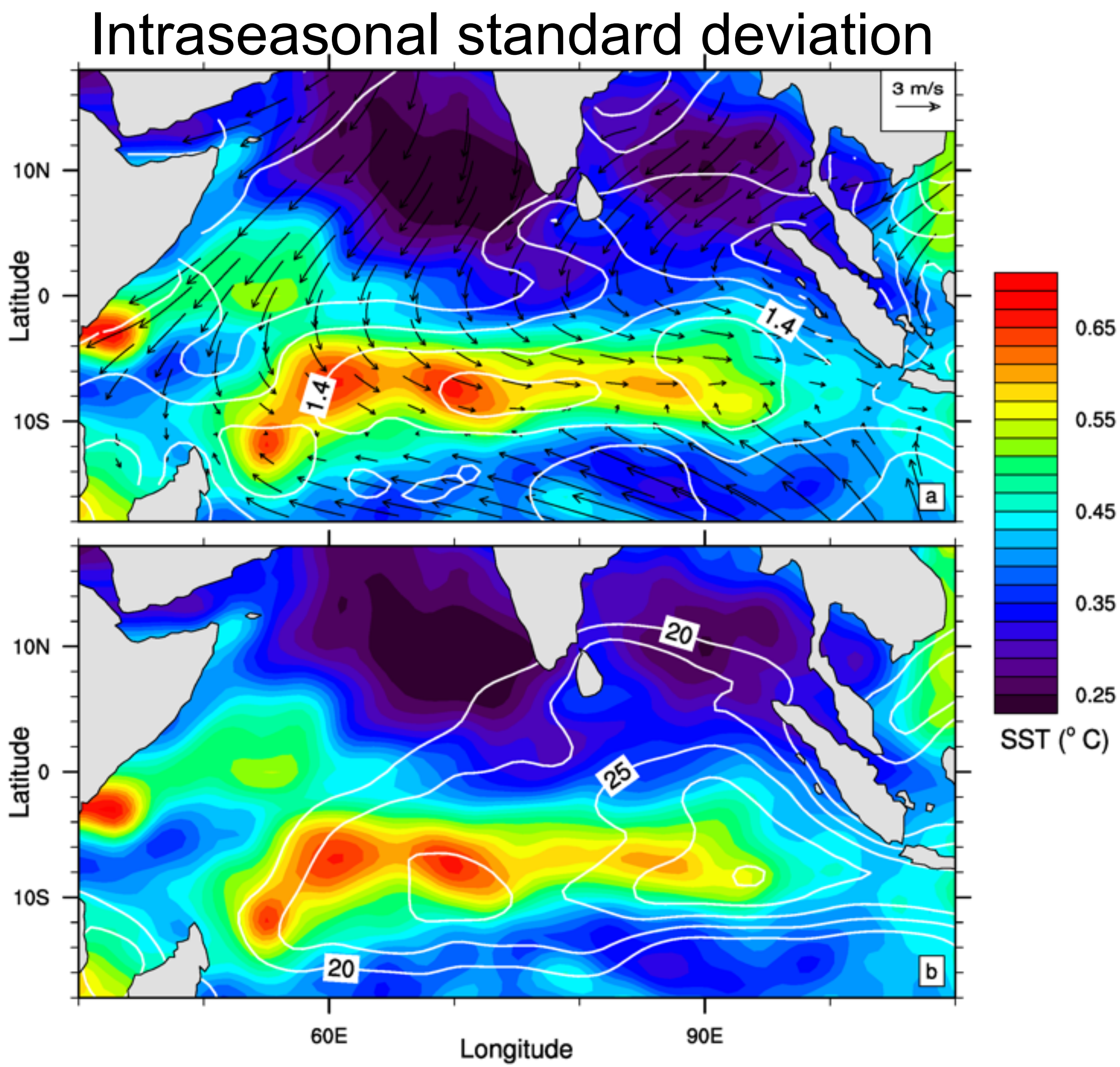
Tozuka et al. (JGR 2010)
Yokoi et al. (J. Clim. 2008, 2012; JPO 2009)

Intraseasonal variations in the Indian Ocean

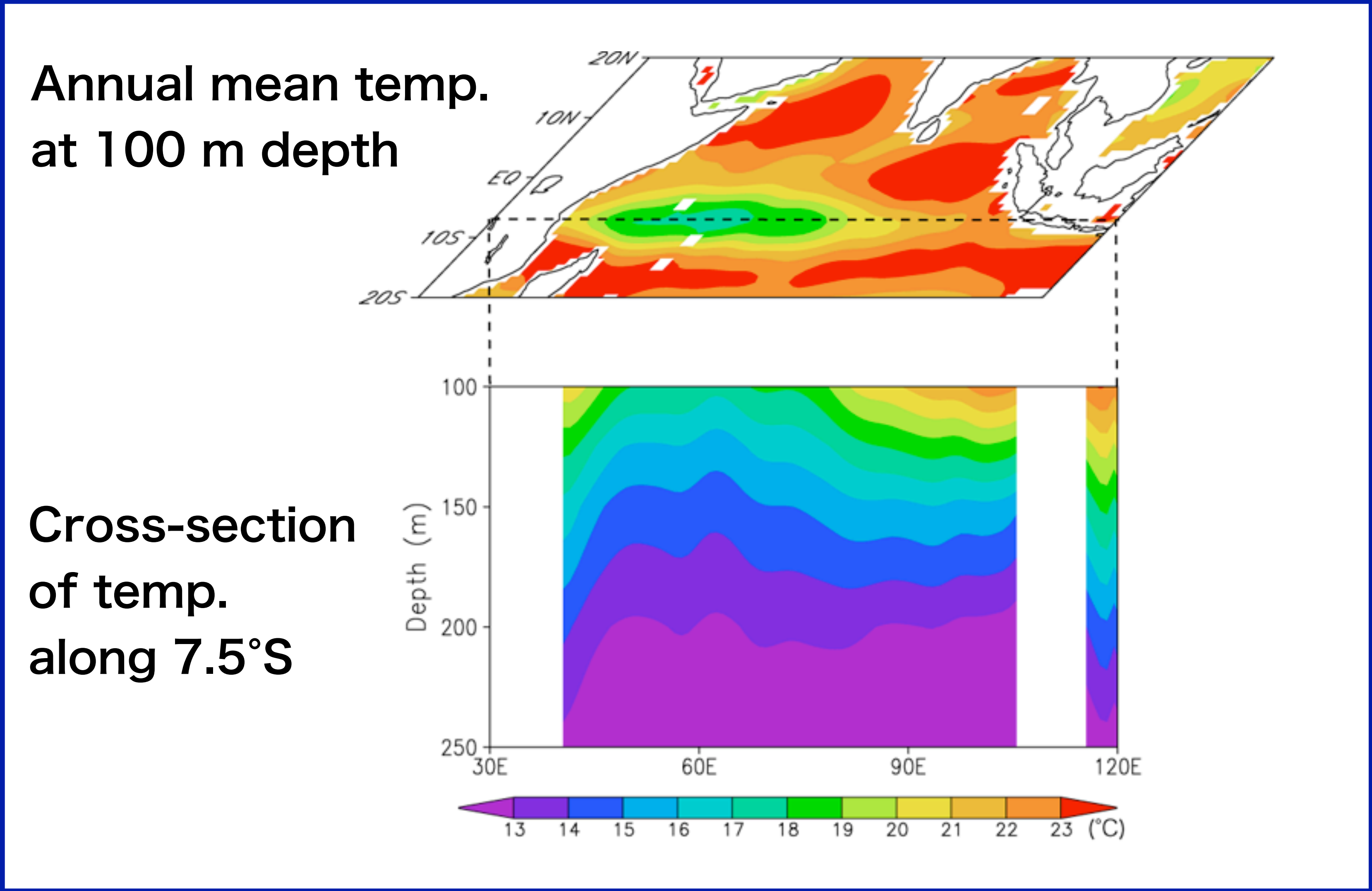
SST (shading) & wind speed (contour)

SST (shading) & OLR (contour)



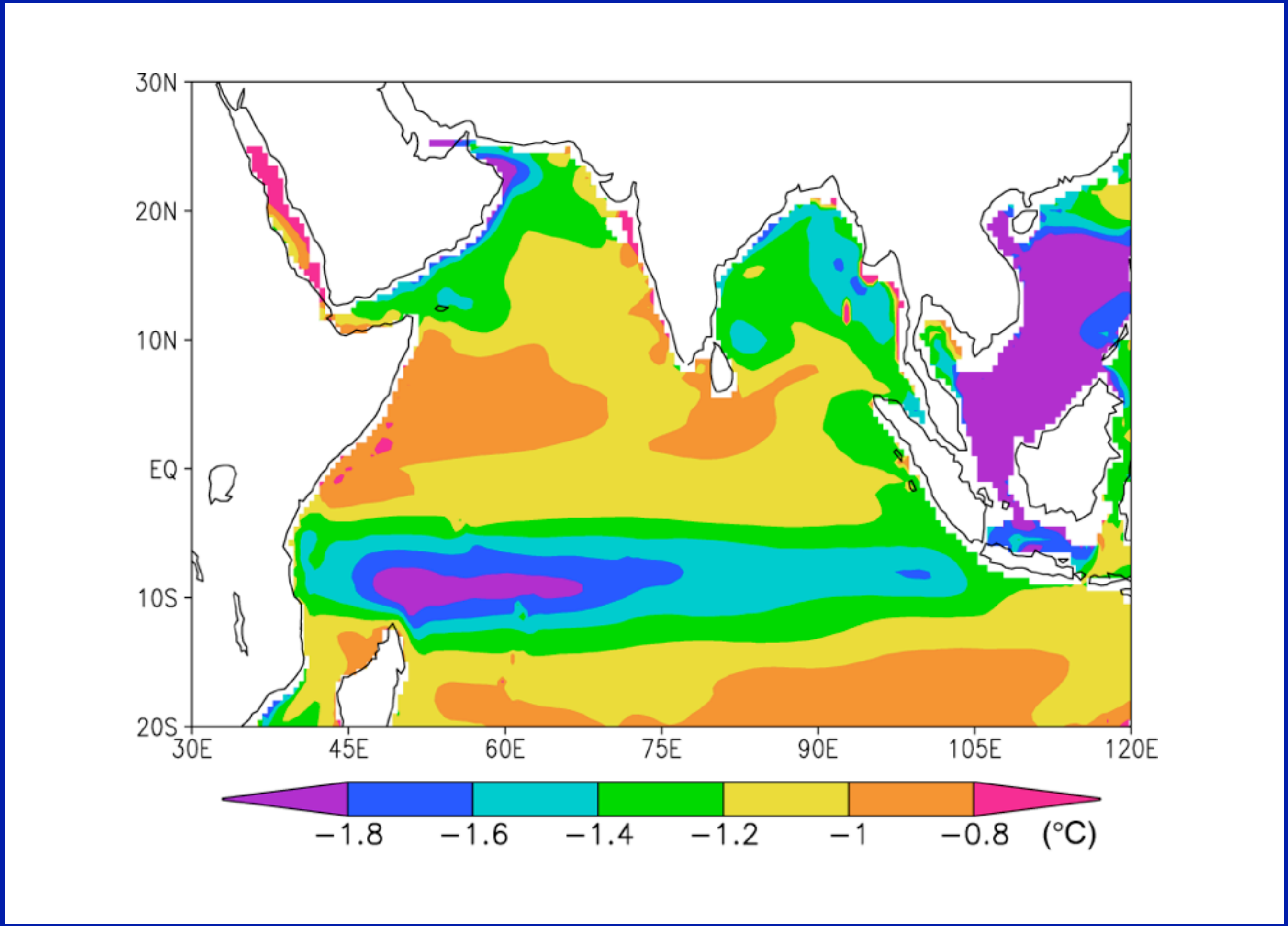
Saji et al. (2006)

Seychelles Dome in the southwestern Indian Ocean



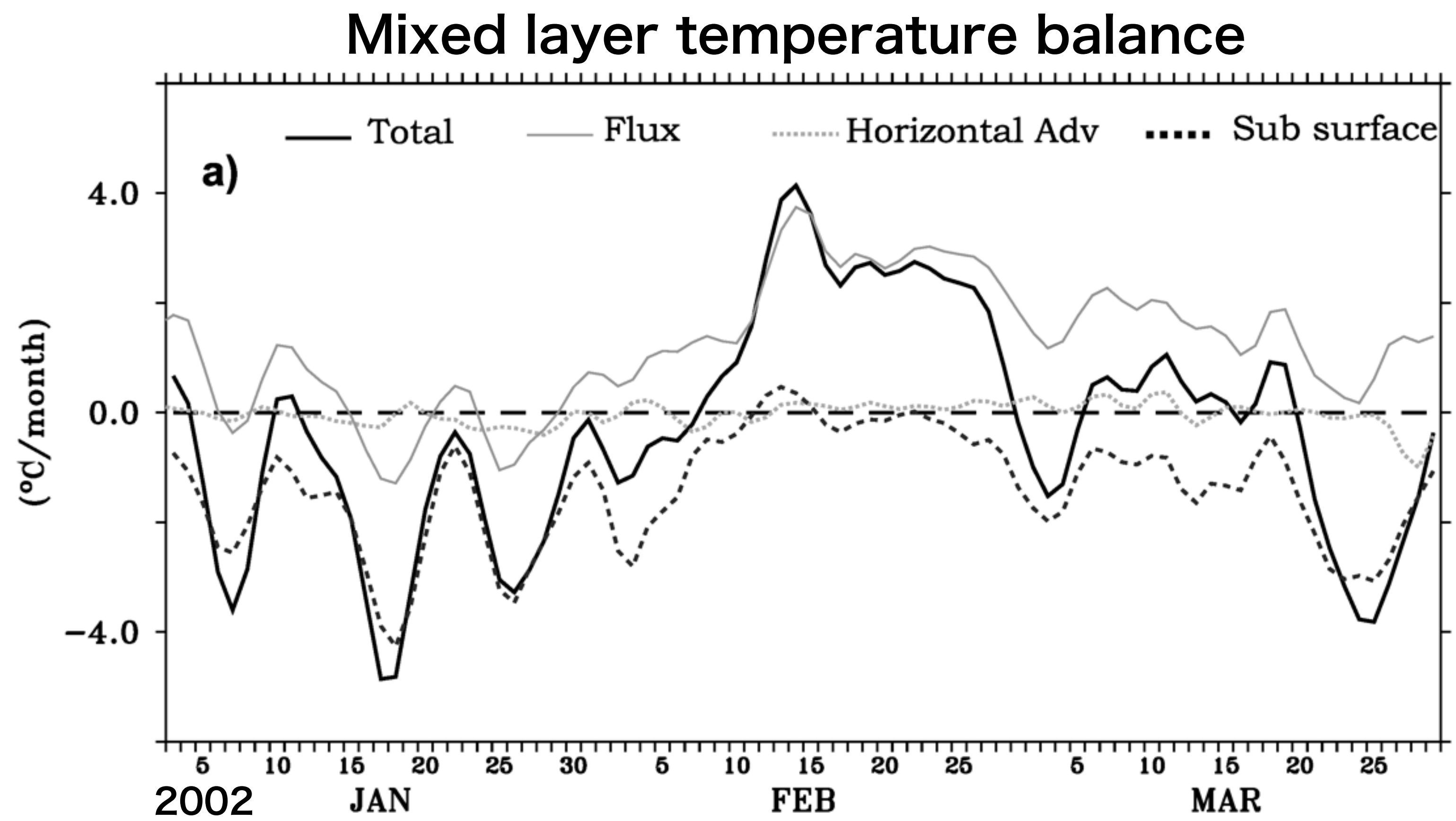
- There is a doming of the thermocline in this region and the water temperature is colder because of upwelling of cold water from below.

Mean temperature difference between the mixed layer and 10 m below its bottom



- Because cold subsurface water is closer to the surface mixed layer, the temperature of entrained water is colder in the SD.
- The SD region has the largest mean temperature difference between the mixed layer and 10 m below its bottom.

Importance of the vertical processes in the cooling events associated with the MJO



Jayakumar and Gnanaseelan (2012)

- Vertical processes are considered to play an important role in the cooling event over the SD region (e.g. Han et al. 2007; Vinayachandran and Saji 2008; Lloyd and Vecchi 2010).

Purpose

It is important to understand the mechanism of variability in the SD to understand the ocean-atmosphere interaction associated with the MJO in the SD region.

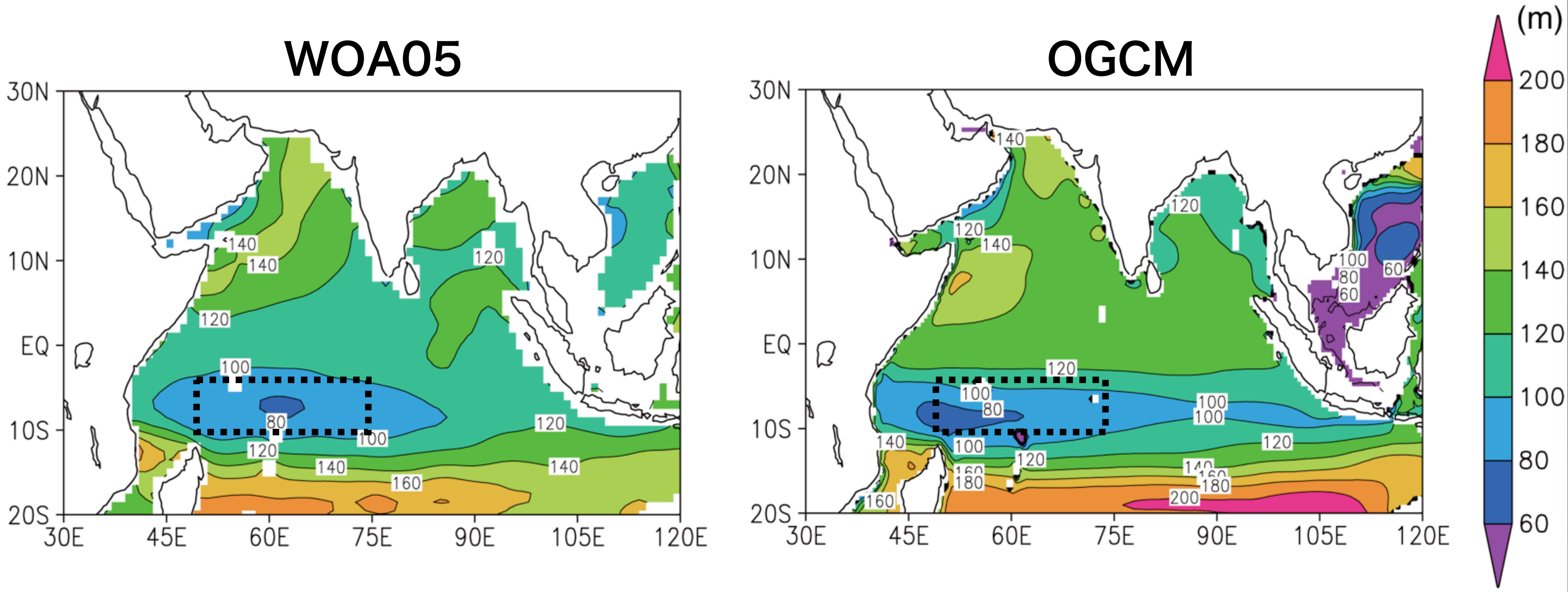
▼

We have investigated the seasonal and interannual variation of the SD quantitatively using OGCM outputs.

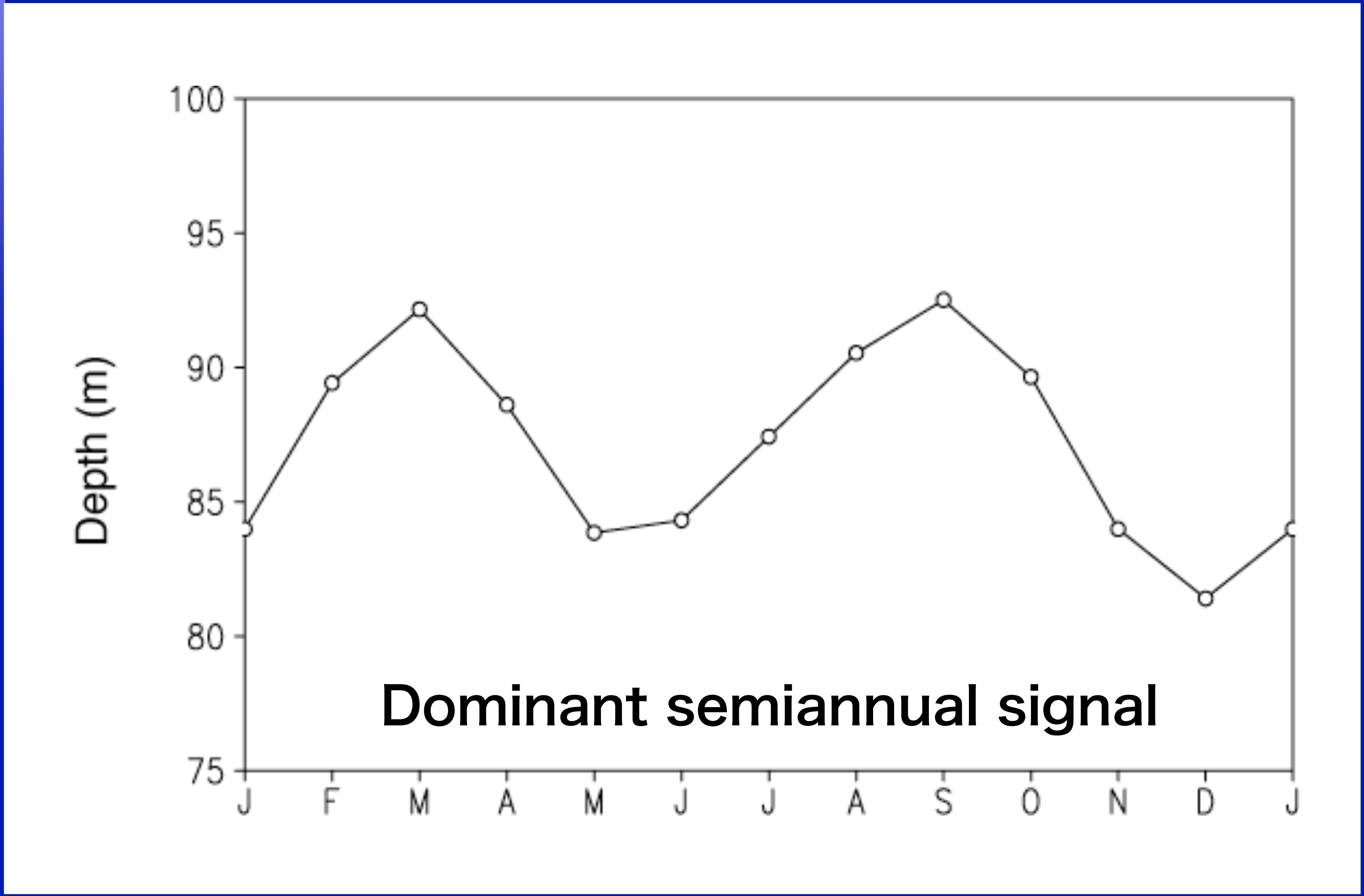
Description of the OGCM

- MOM3.0 (Pacanowski and Griffies 1999)
- Domain: 15°E-70°W, 52°S-30°N
- Horizontal resolution: 0.5° x 0.5°
- 25 vertical levels
- Topography: ETOPO5
- Lateral mixing: Smagorinsky (1963)
- Vertical mixing: Pacanowski and Philander (1981)
- Sponge layer at both meridional boundaries
- Spin up for 20 years by the monthly mean wind stress from the NCEP/NCAR reanalysis data and surface heat flux calculated by bulk formula using the simulated SST and atmospheric variables obtained from the reanalysis data.
- Integrated for 30 more years (1978-2007) by the daily mean data from the NCEP/NCAR reanalysis data.

Annual mean depth of 20°C isotherm (D20)

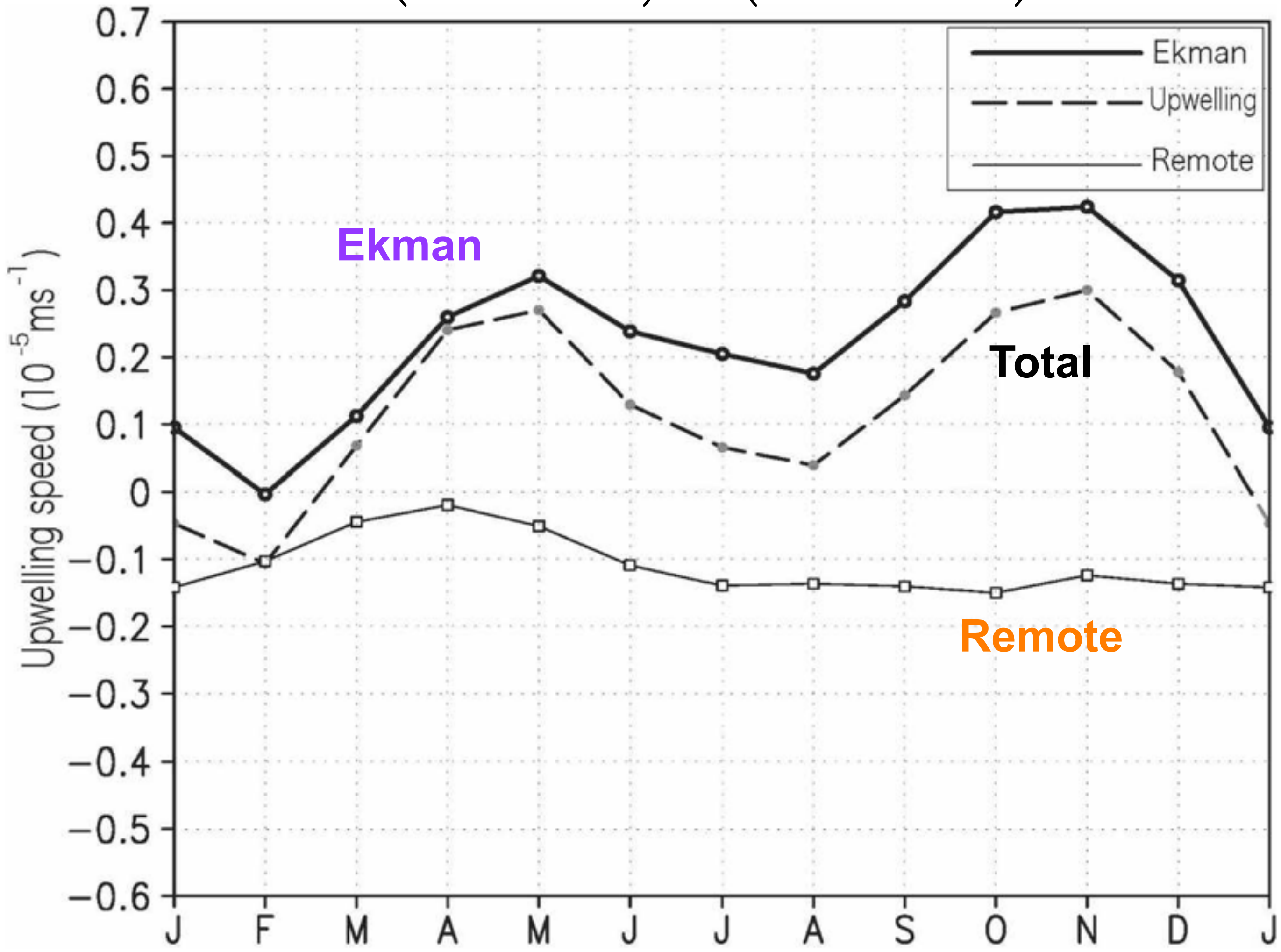


Monthly climatology of D20 in the SD region



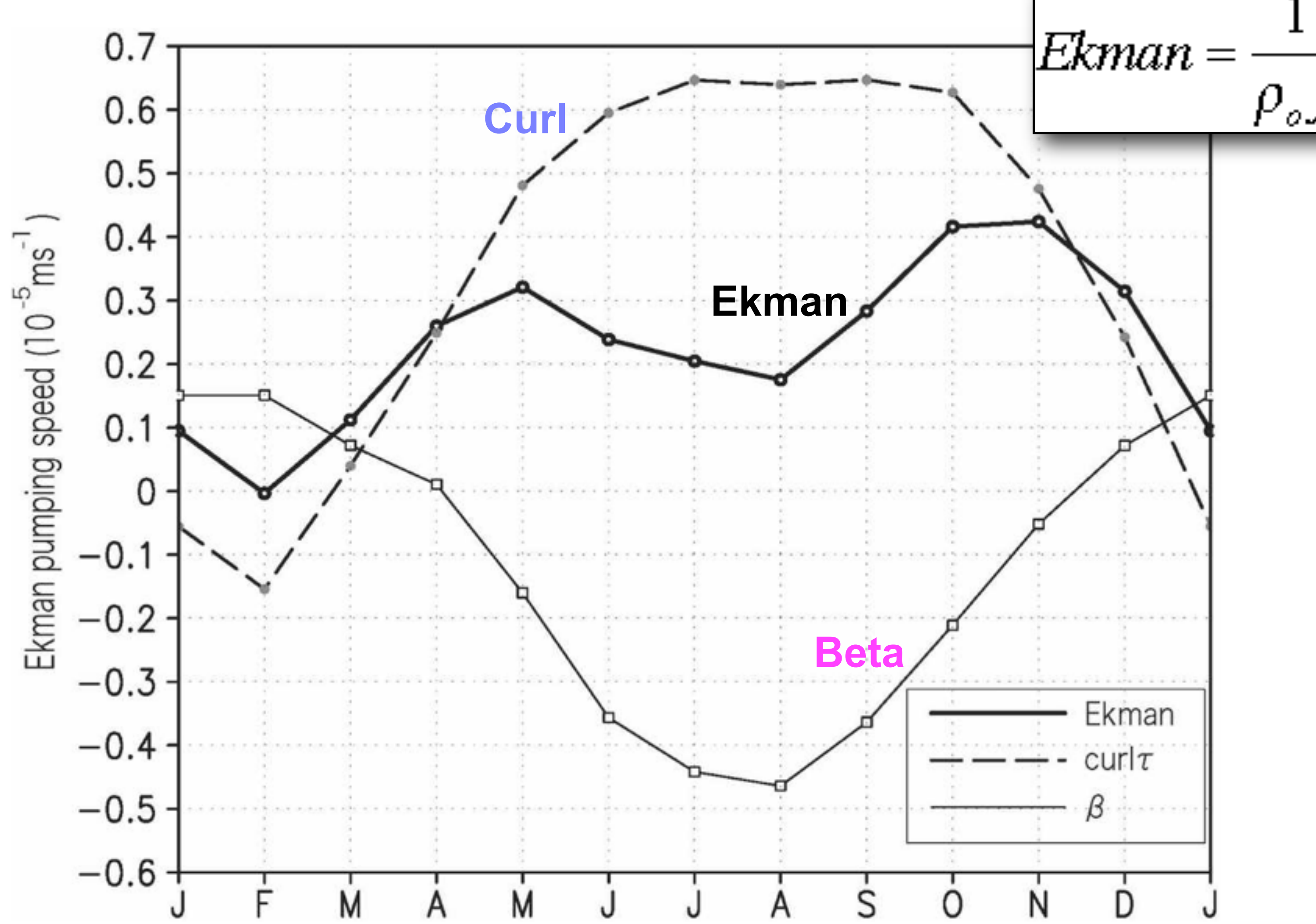
Vertical velocity (50-75°E, 5-10°S)

$$w = (\text{Ekman}) + (\text{Remote})$$



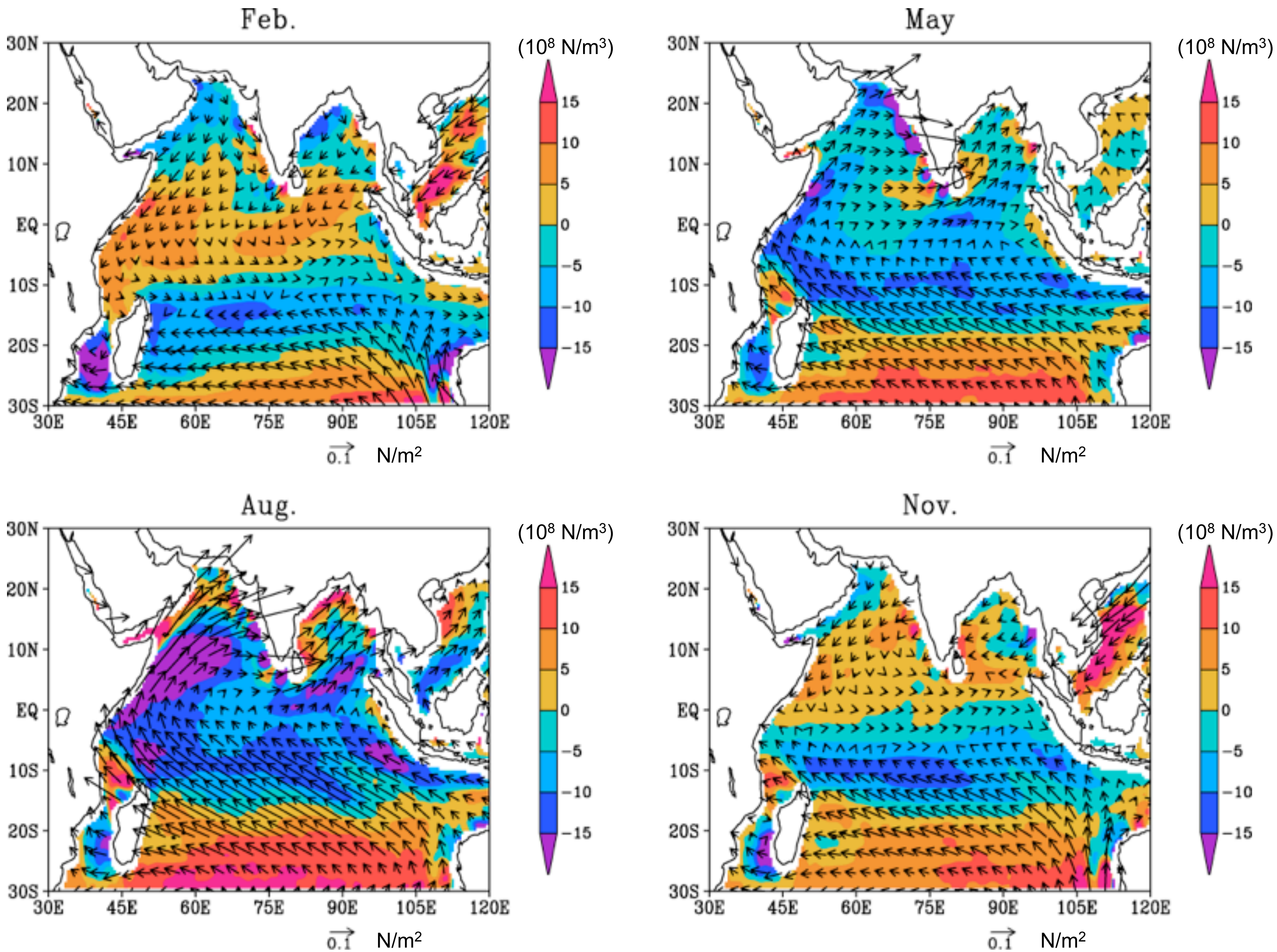
Ekman pumping (50-75°E, 5-10°S)

$$Ekman = \frac{1}{\rho_o f} curl\tau + \frac{\beta}{\rho_o f^2}\tau^x$$

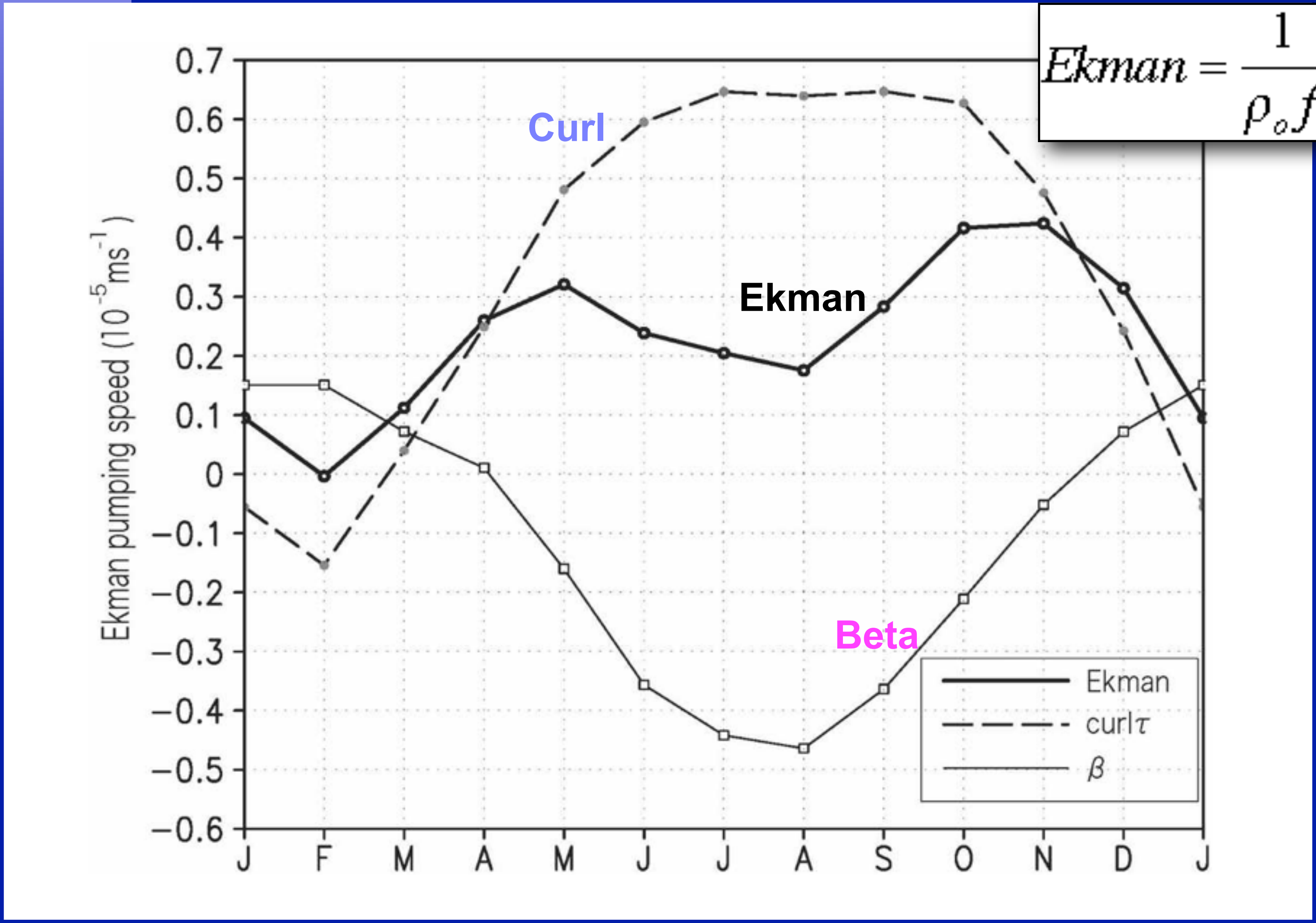


- The beta term causes a strong downwelling in boreal summer and upwelling in boreal winter.

Wind stress and its curl



Ekman pumping (50-75°E, 5-10°S)



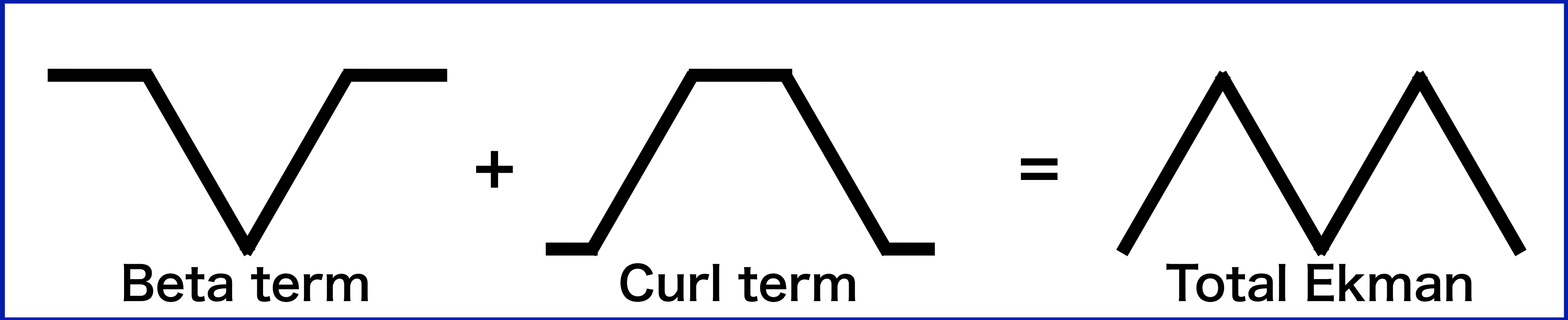
$$Ekman = \frac{1}{\rho_o f} curl\tau + \frac{\beta}{\rho_o f^2}\tau^x$$

- The curl term shows strong upwelling during boreal summer and fall.

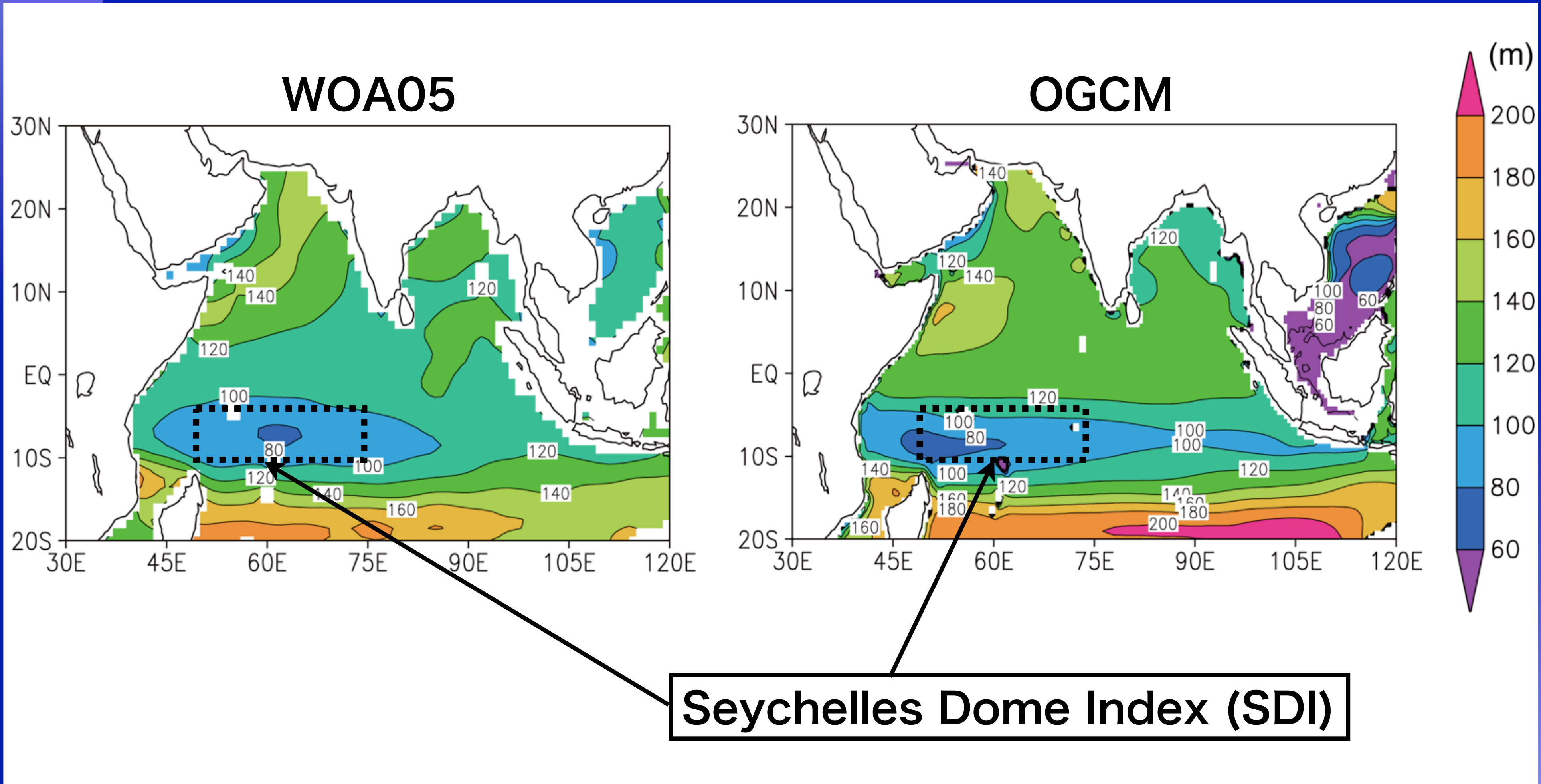
Summary (1): Seasonal variation

Using an OGCM, the seasonal variation of the Seychelles Dome in the southwestern tropical Indian Ocean is investigated.

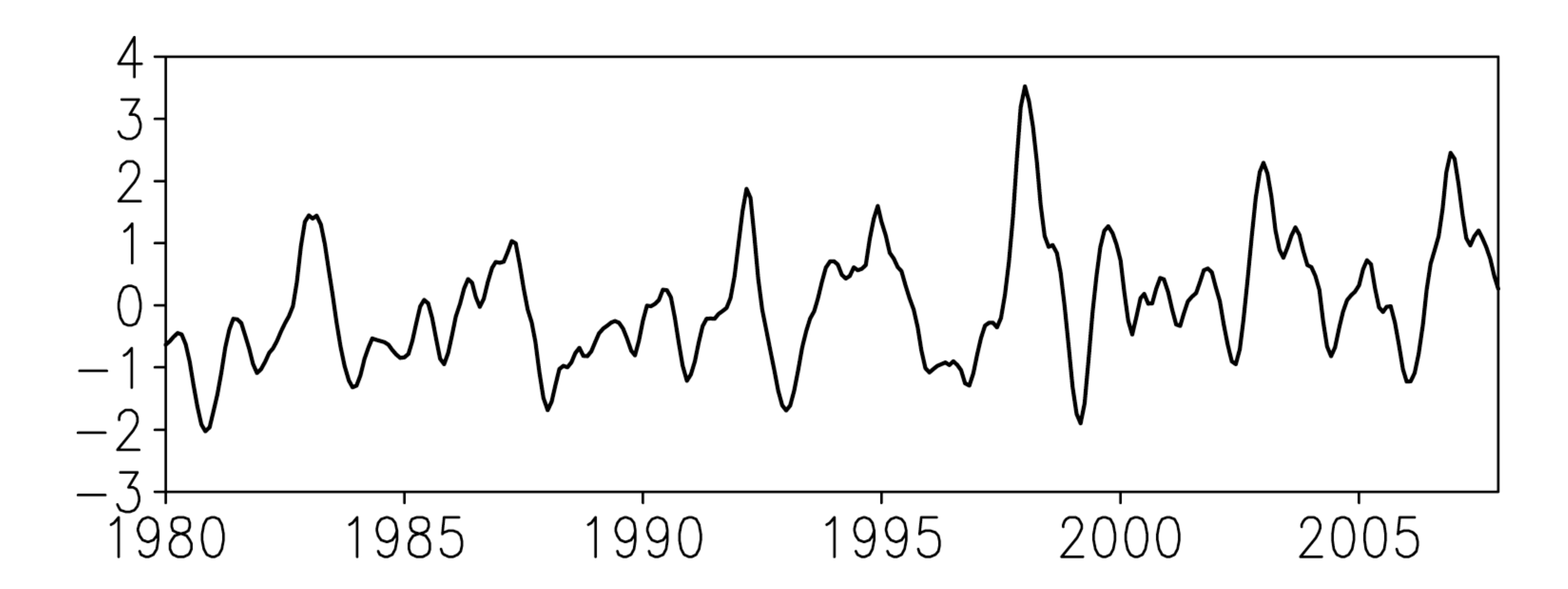
- Its seasonal variation is dominated by a remarkable semiannual cycle resulting from the local Ekman pumping.
- This semiannual nature is explained by different contributions of the beta and curl terms.
  - Beta term: causes strong downwelling during boreal summer and weak upwelling during boreal winter.
  - Curl term: remains almost constant and causes upwelling from Jun. to Oct.



Annual mean depth of 20°C isotherm (D20)

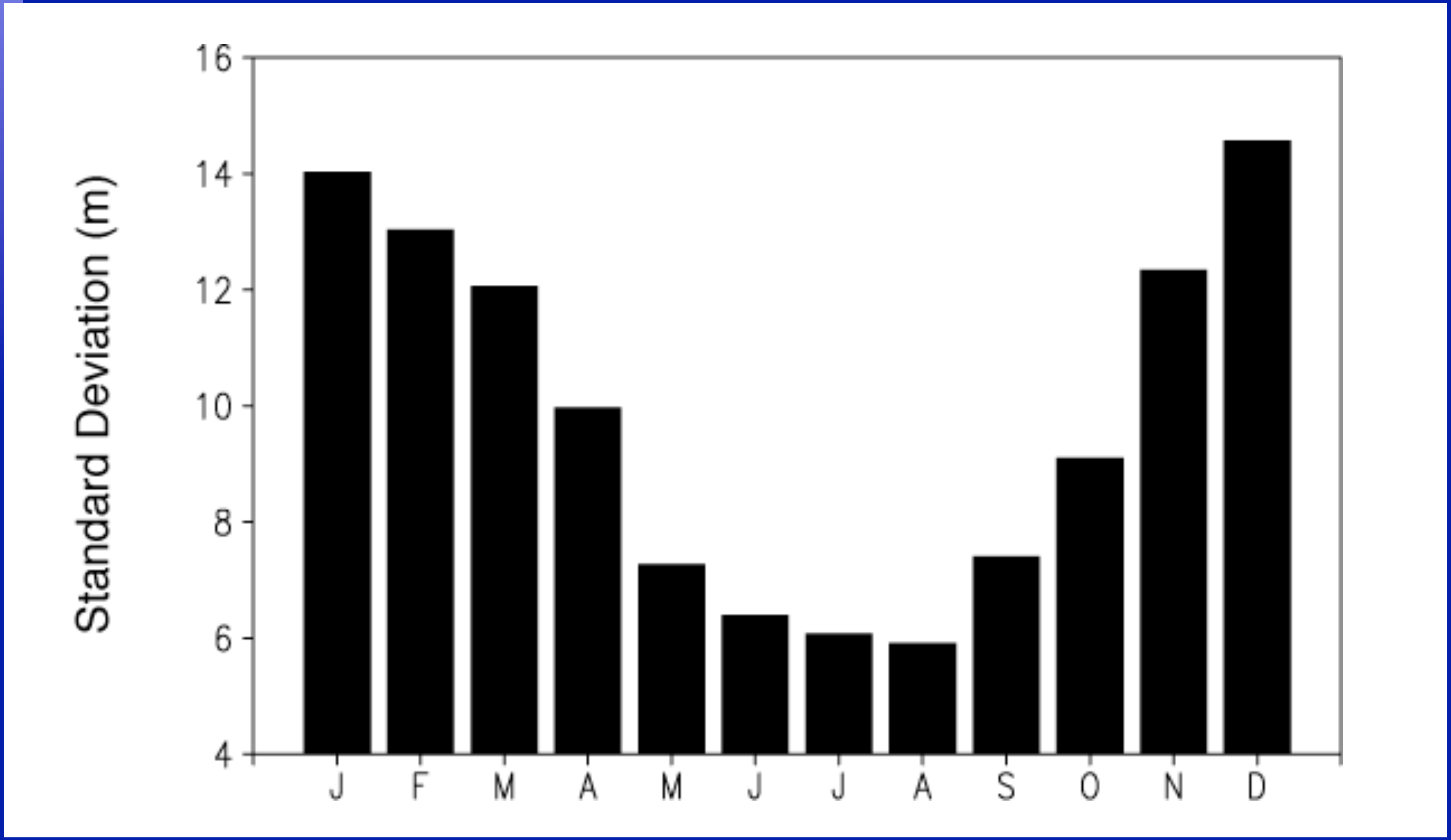


Seychelles Dome Index (SDI)



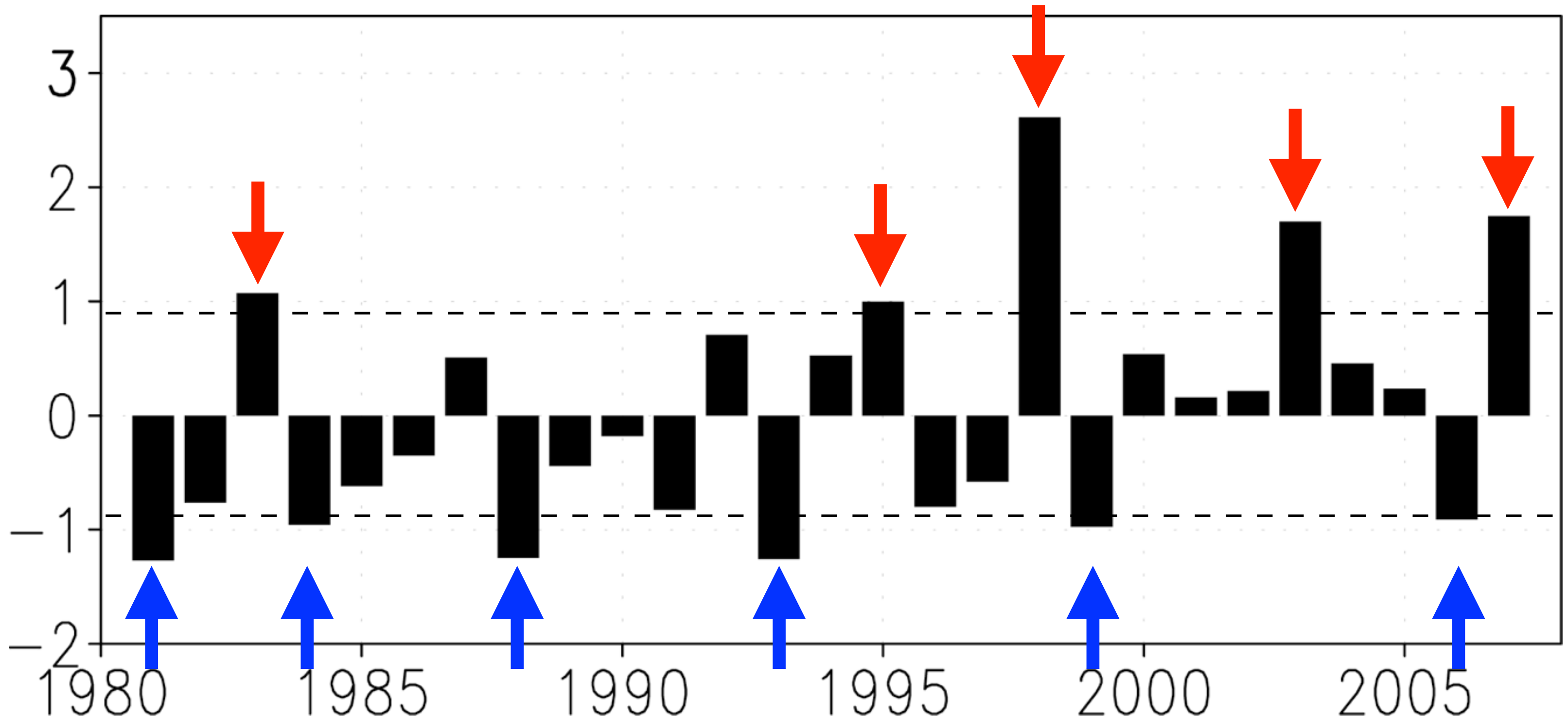
- OGCM SDI vs. SODA SDI (1980-2007)=0.73
- OGCM SDI vs. AVISO SSHA SDI (1993-2007)=0.80

Standard deviation of SDI in each month



The interannual variations of the SD are seasonally locked to boreal winter.

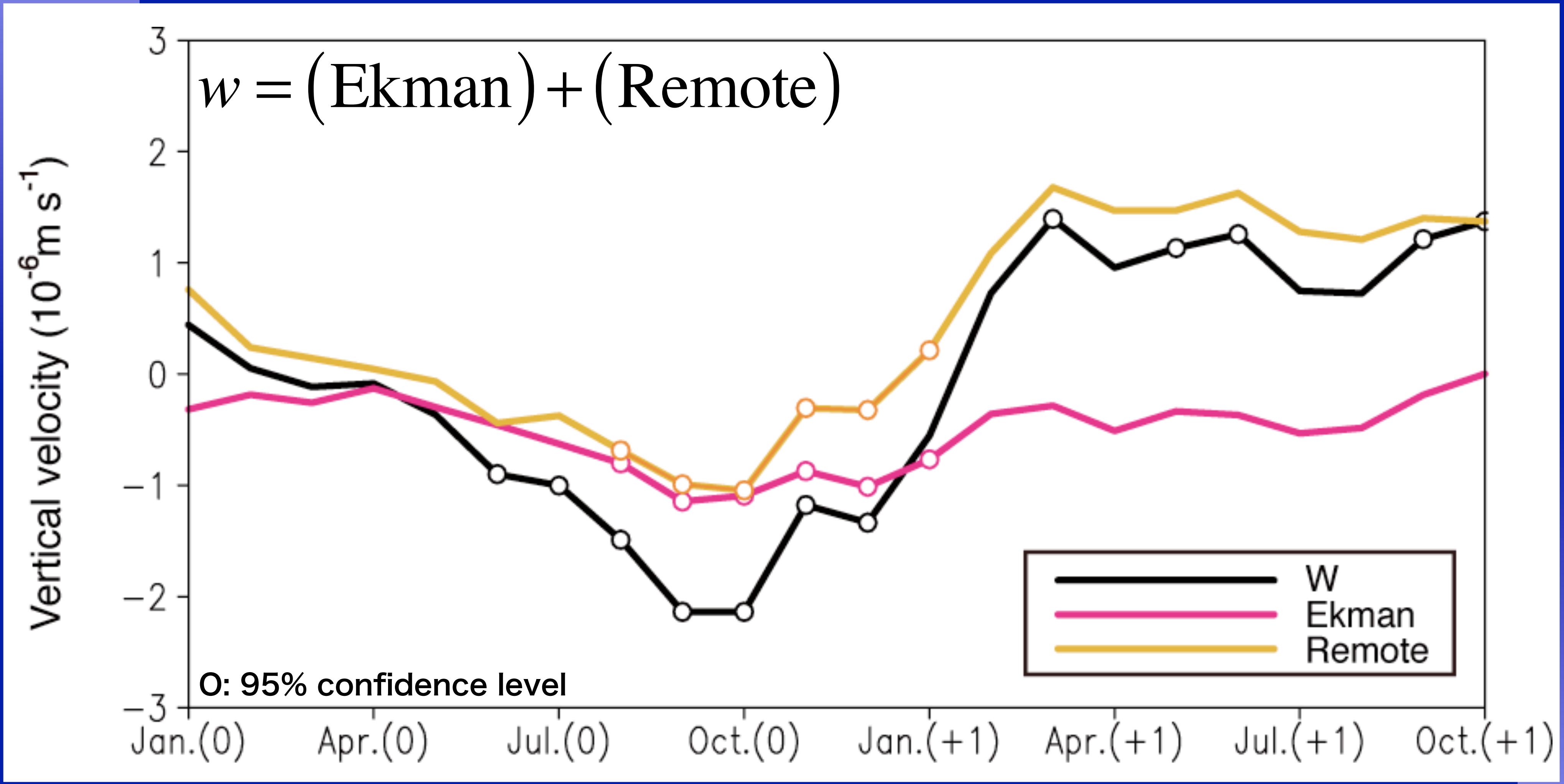
SDI in Dec.-Jan.-Feb.



Anomalous years in which the SDI in boreal winter is above or below 0.9 standard deviation are selected to identify:

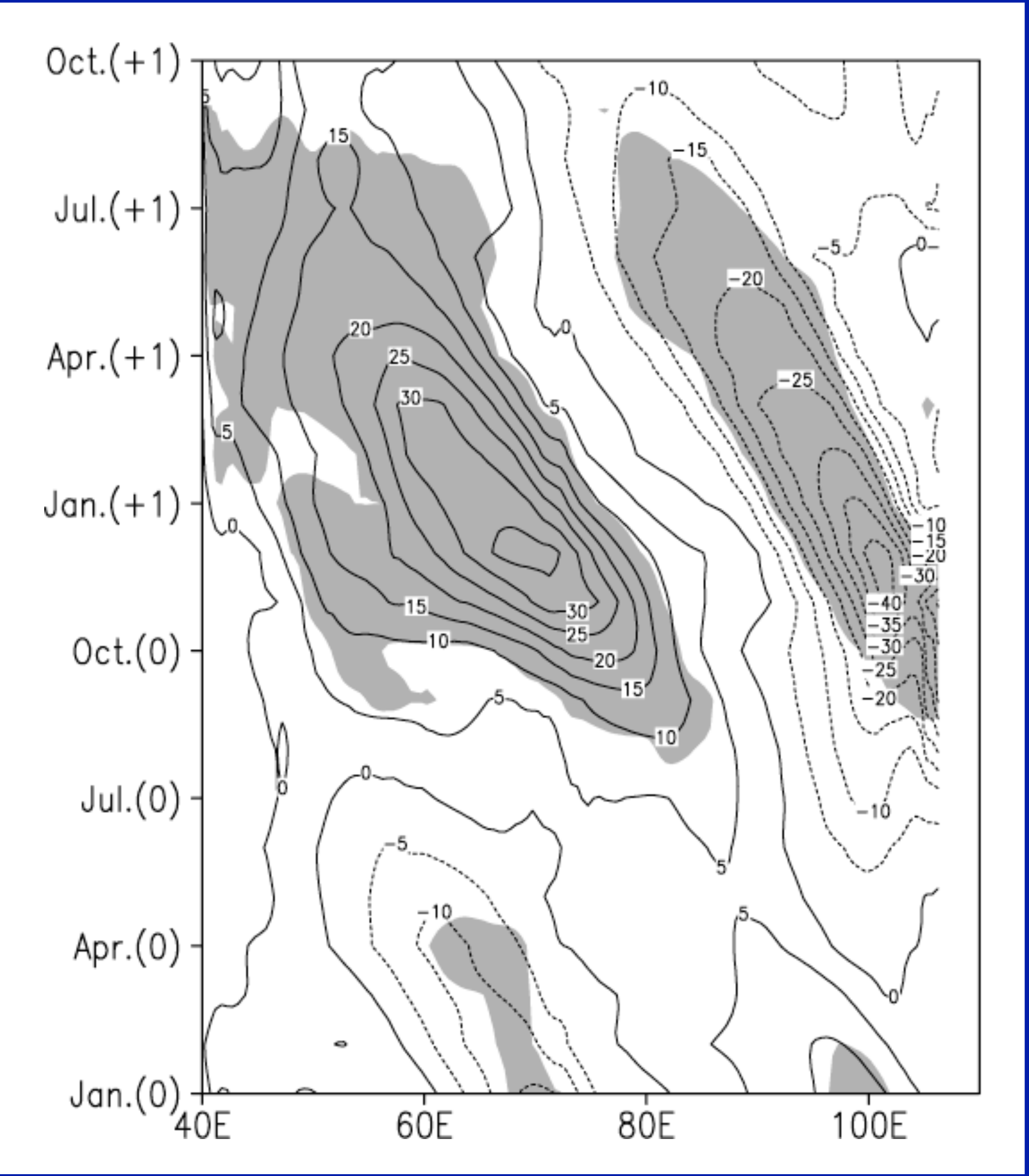
- Weak SD: 1982-83, 1994-95, 1997-98, 2002-03, 2006-07
- Strong SD: 1980-81, 1983-84, 1987-88, 1992-93, 1998-99, 2005-06

Vertical velocity anomaly (weak SD years)



- The local Ekman pumping anomalies play an important role in the interannual variation in addition to the Rossby waves as suggested by past studies.

Time-longitude diagram of D20 anomaly along 7.5°S (weak SD years)

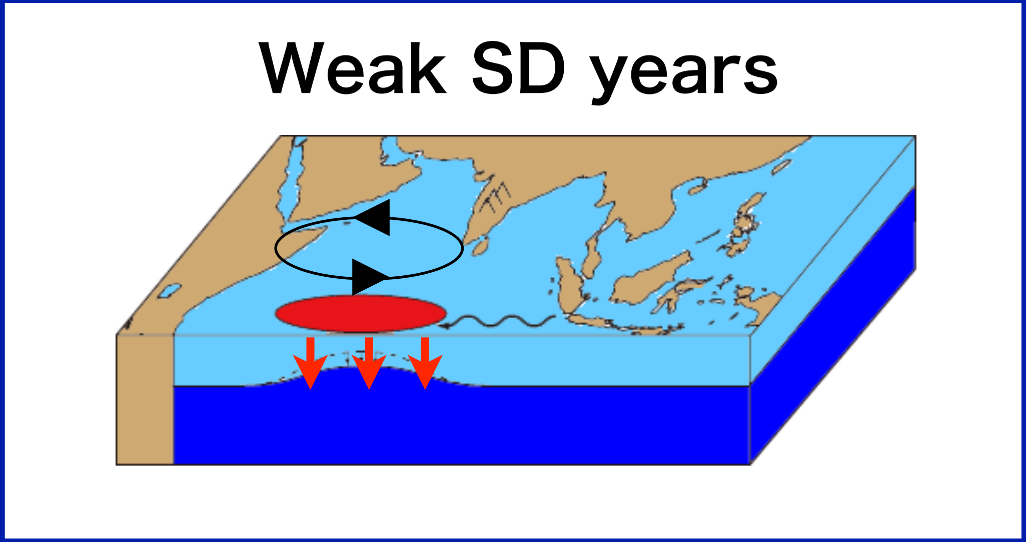


Shading: above 95% confidence level

Summary (2): Interannual Variations

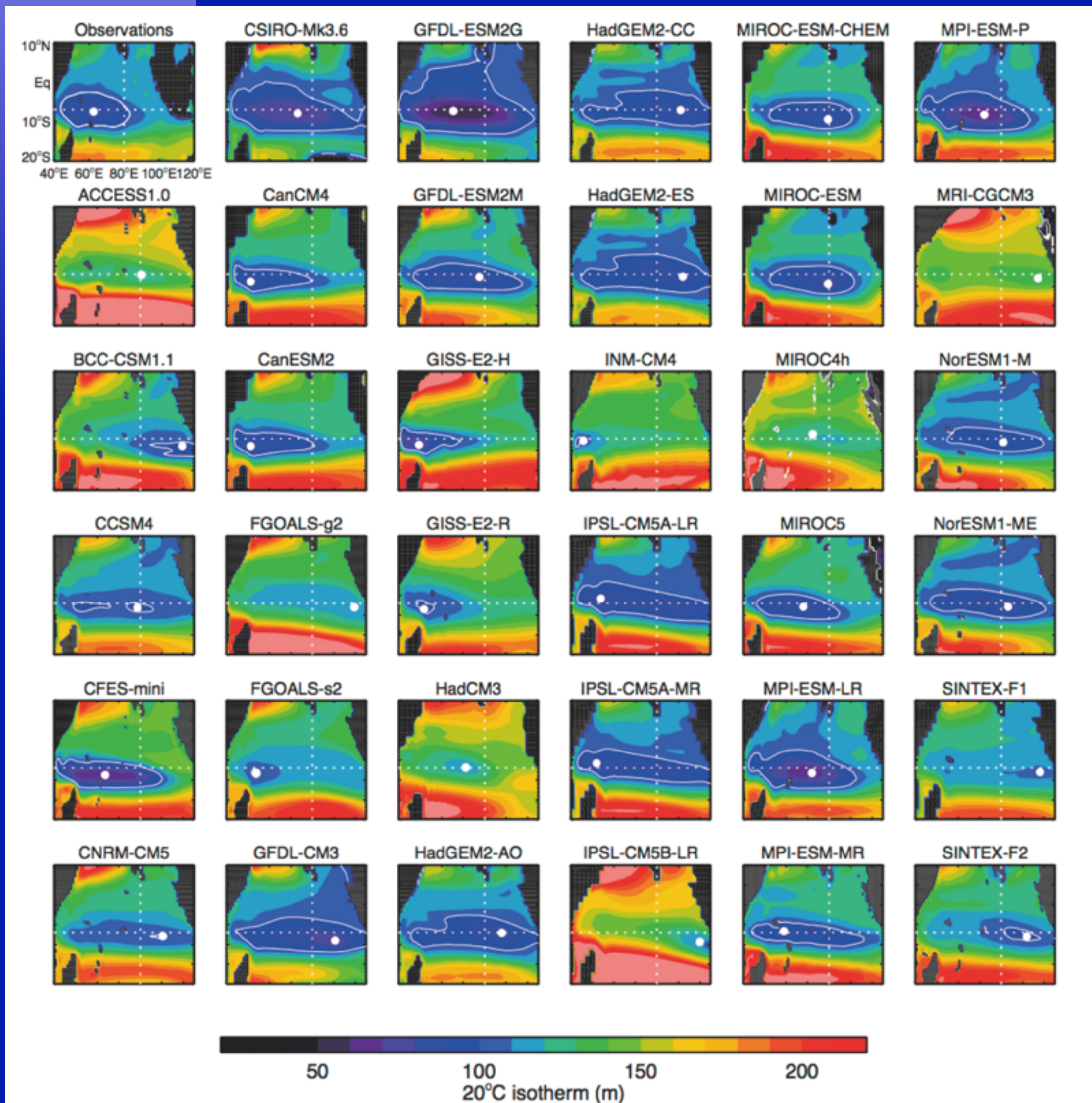
Using outputs from an OGCM, we have investigated the mechanism of the interannual variations of the SD.

- The SD becomes anomalously weak (strong) as a result of anomalous local Ekman downwelling (upwelling) and arrival of downwelling (upwelling) Rossby waves.



SD in coupled GCMs

Annual mean D20



Nagura et al. (2012, JGR)

To better understand the ocean-atmosphere interactions associated with the MJO in the SD region, we need a realistic CGCM, but simulation of the SD is considered a difficult task.

OS41B-1716
"Longitudinal Biases in the Seychelles Dome Simulated by 34 Ocean-Atmosphere Coupled General Circulation Models"
M. Nagura, W. Sasaki, T. Tozuka, J. Luo, S. K. Behera, and T. Yamagata