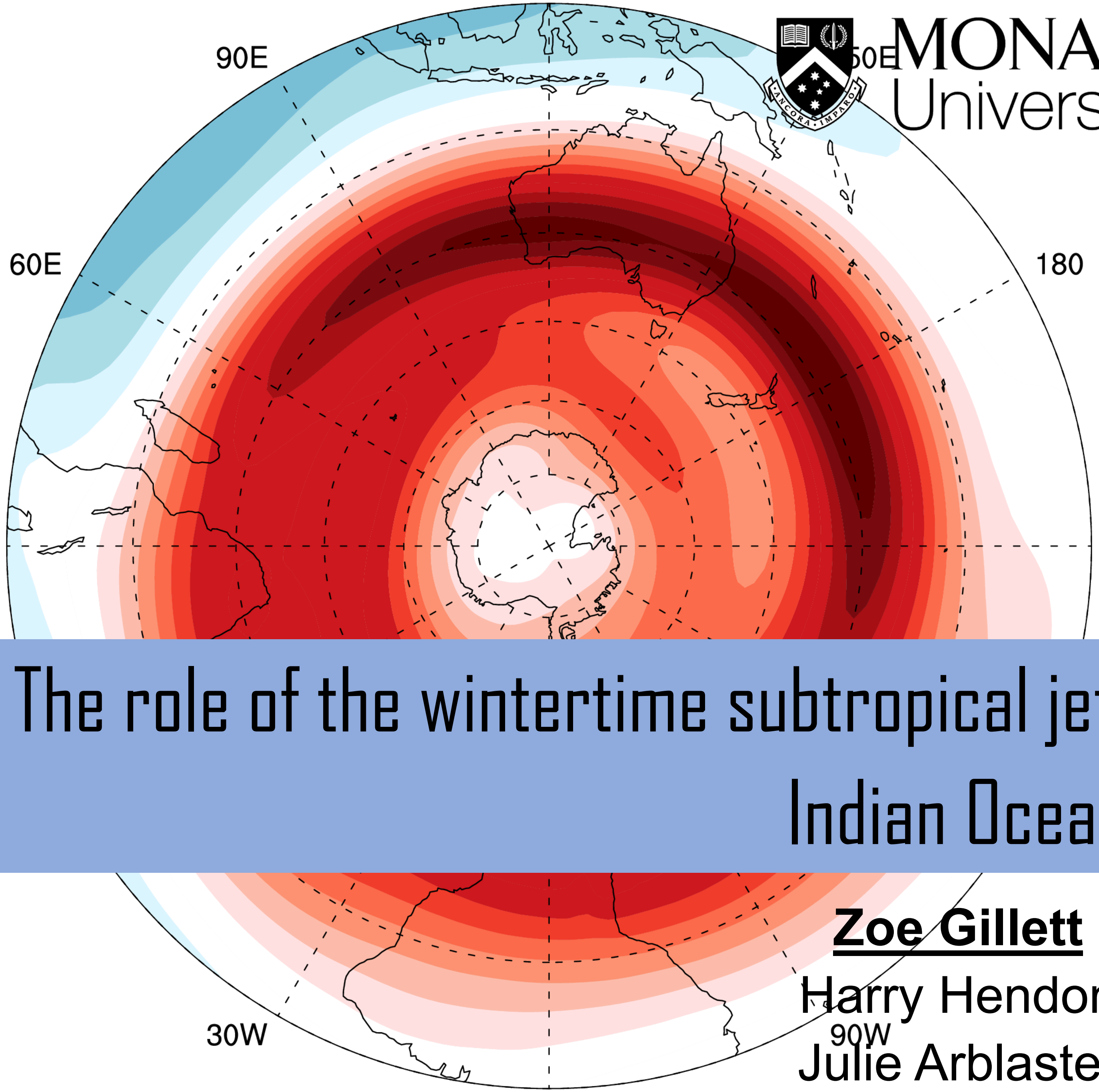

MONASH University

climate extremes
ARC centre of excellence

The role of the wintertime subtropical jet for teleconnections from the Indian Ocean

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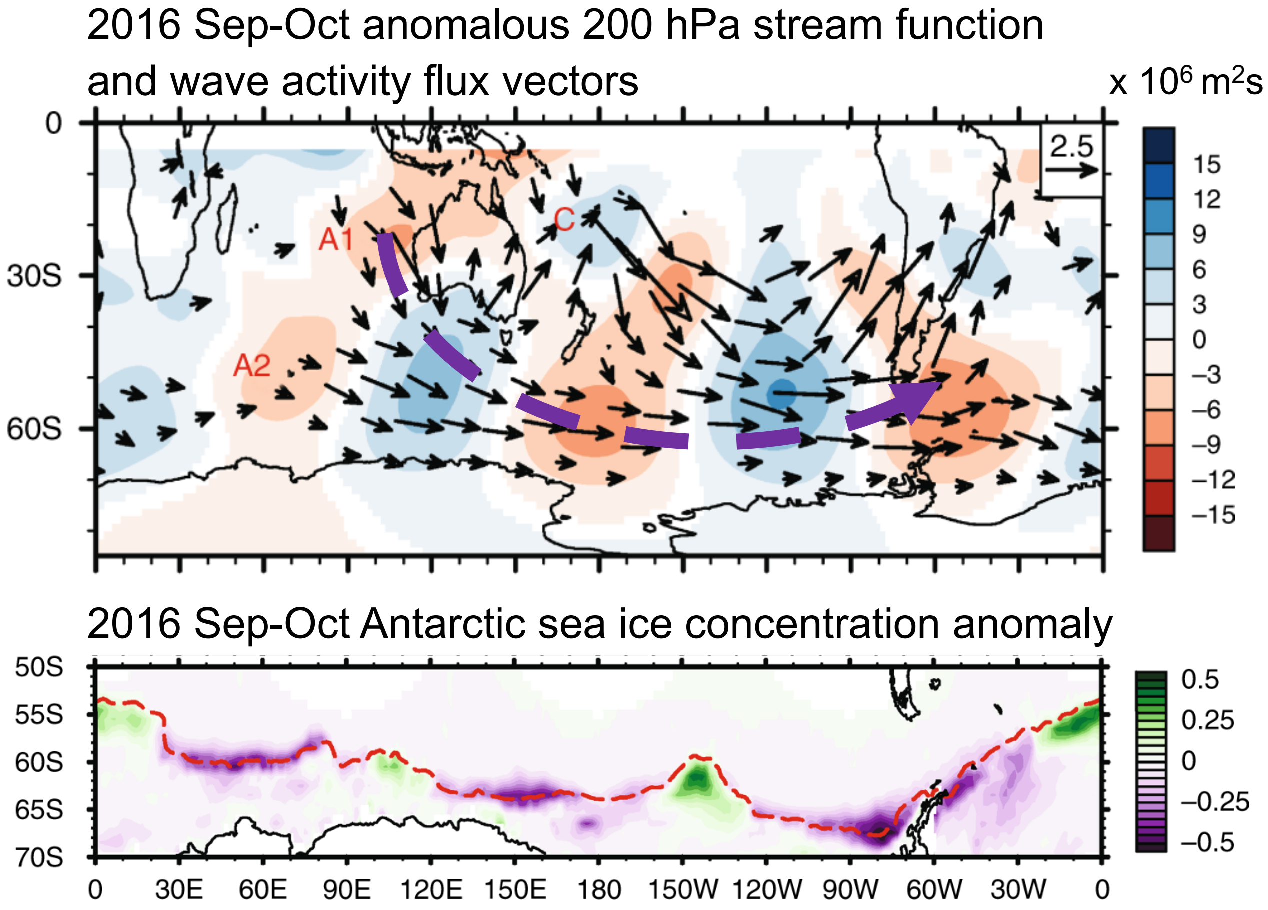
Harry Hendon
Julie Arblaster

Motivation for a better understanding of the IOD teleconnection

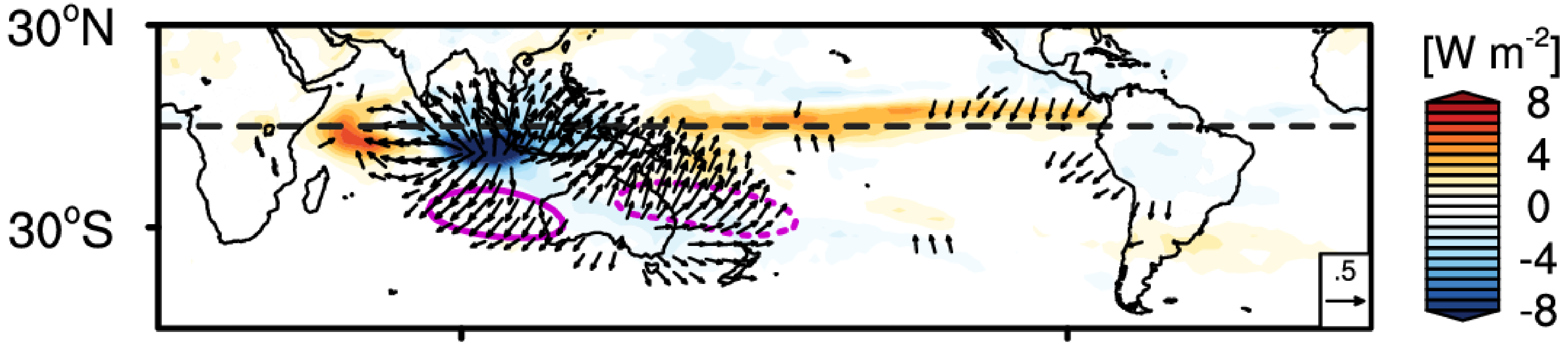
- Record negative IOD contributed to record low Antarctic sea ice extent in spring 2016 (Meehl et al. 2019; Purich & England 2019; Wang et al. 2019)
- Recent absence of negative IOD and La Niña events is the primary reason for the recent southeastern Australian drought (King et al. 2020)
- Extreme positive IOD events have become more frequent and this trend is expected to continue with greenhouse warming (Abram et al. 2020)
- Indian Ocean teleconnections important for Australian spring heat extremes but are poorly simulated because Pacific Ocean teleconnections dominate (McKay et al. 2021)



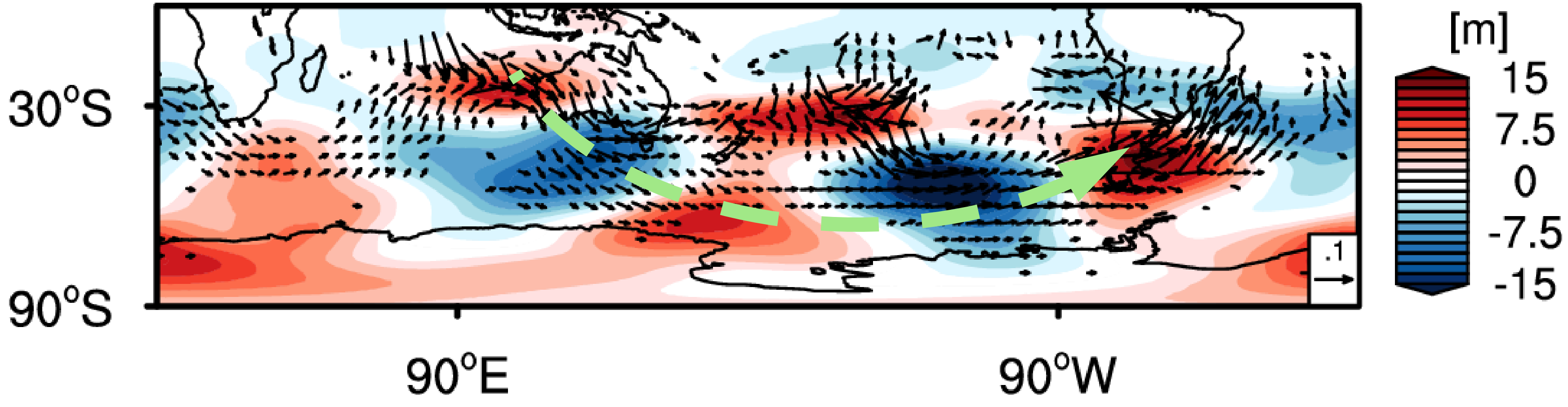
Wang et al. (2019)

Observed IOD teleconnection in winter in JRA-55

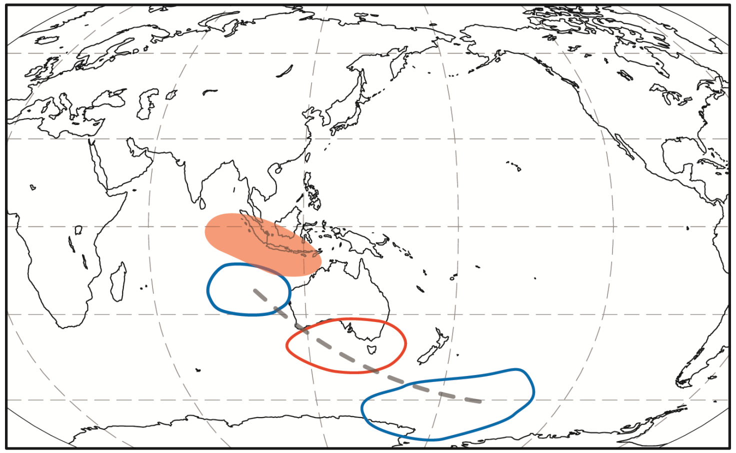
DMI regressed against OLR (shading), 250 hPa divergent wind (vectors), 250 hPa Rossby wave source (contours) in JJA



DMI regressed against Z250 (shading) and 250 hPa wave activity flux (vectors) in JJA

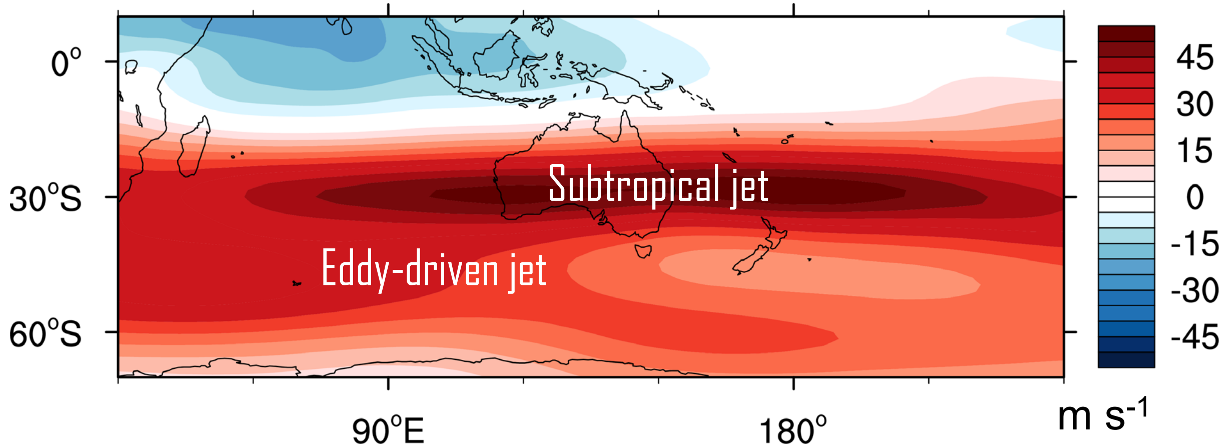


Apparent continuous upper-level Rossby wave train from the eastern Indian Ocean



Cai et al. (2011)

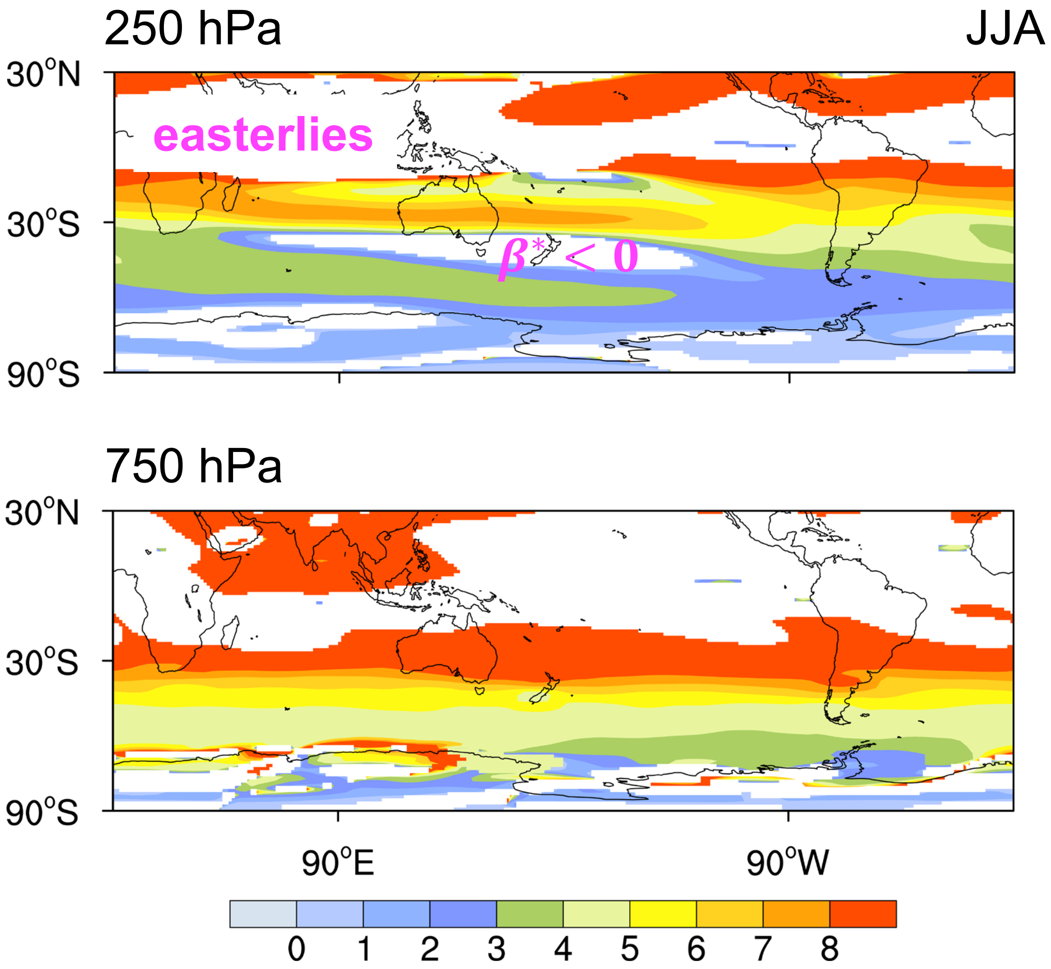
200 hPa zonal wind JJA mean



Total stationary Rossby wavenumber

$$K_s = (\beta^* / \overline{U})^{1/2}$$

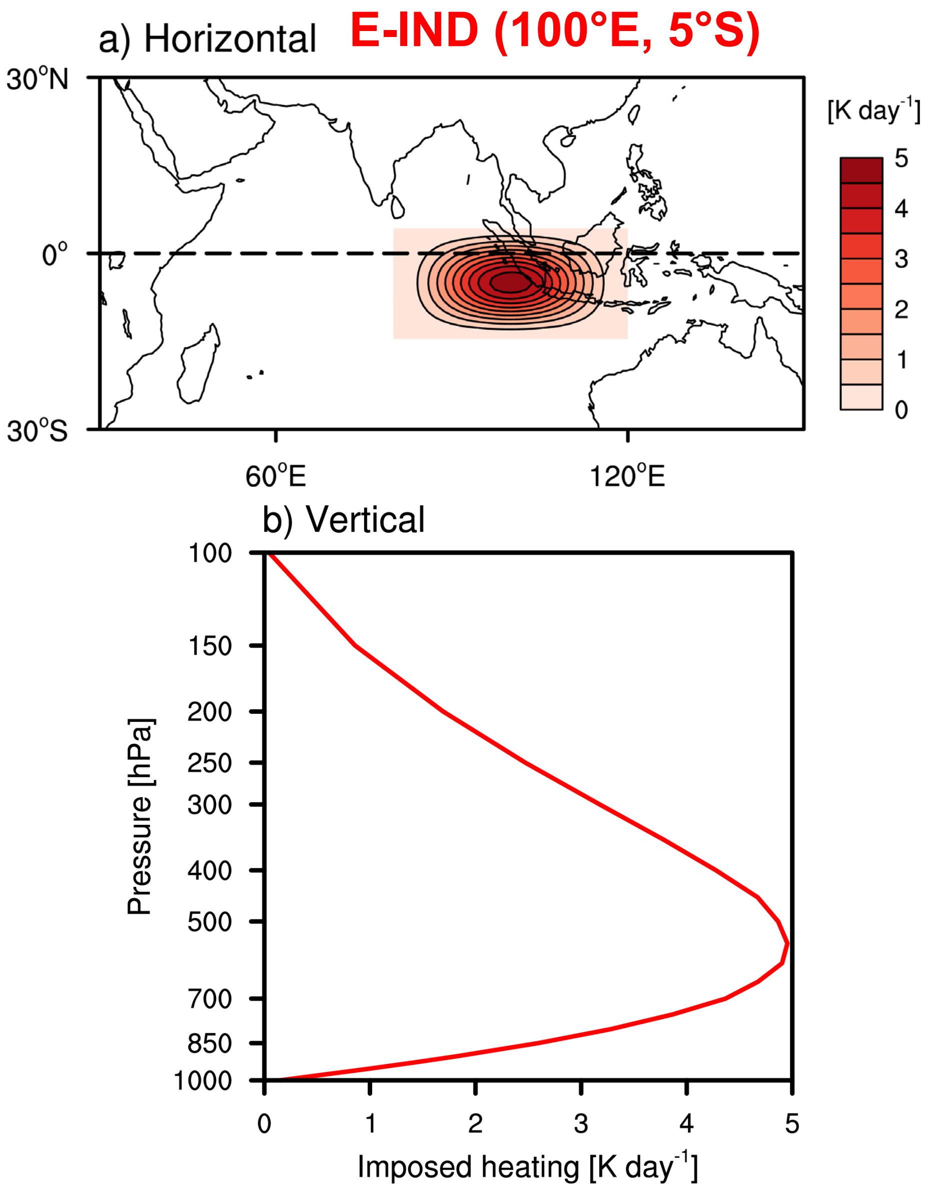
β^* meridional absolute vorticity gradient



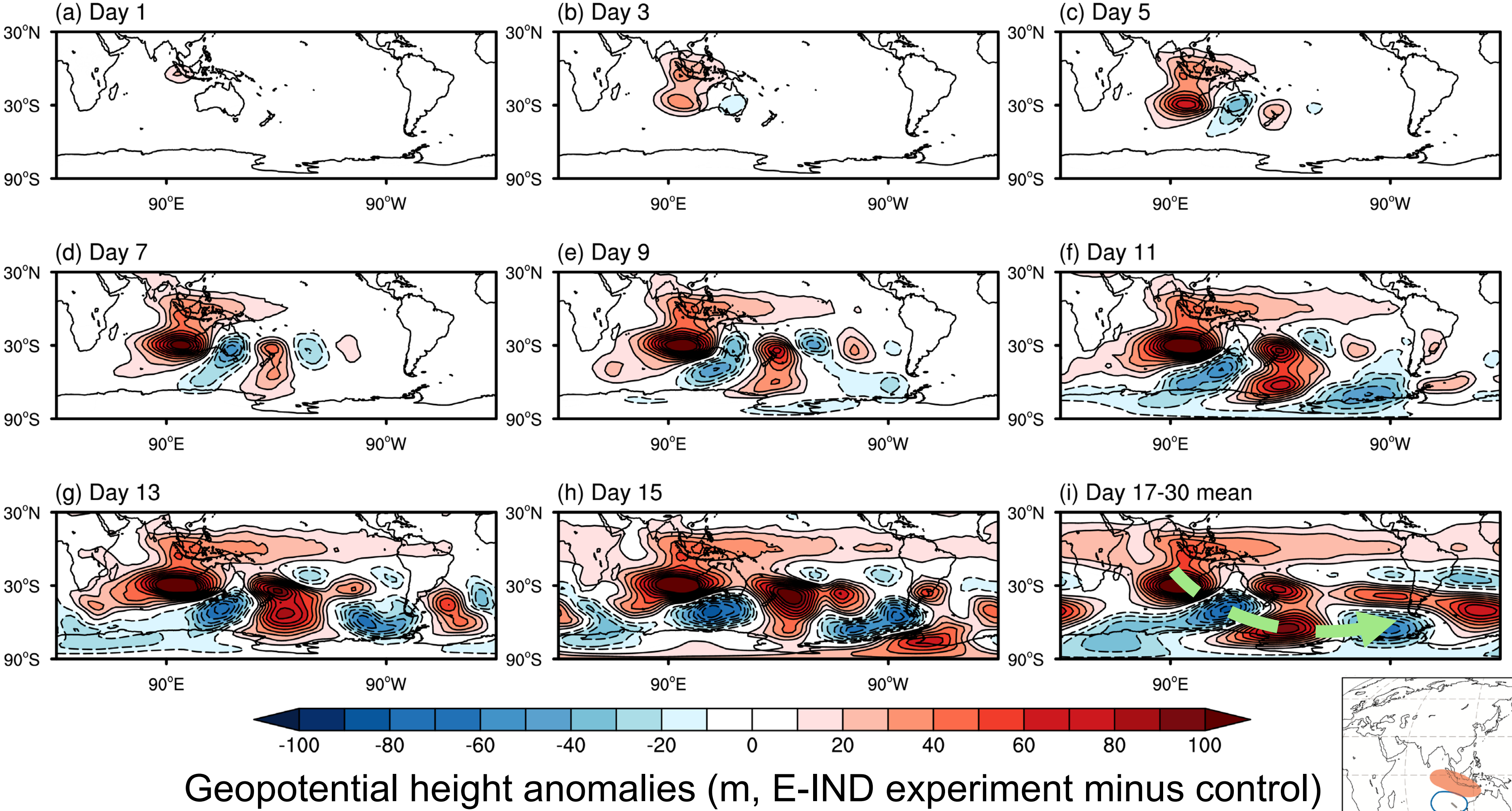
JRA-55

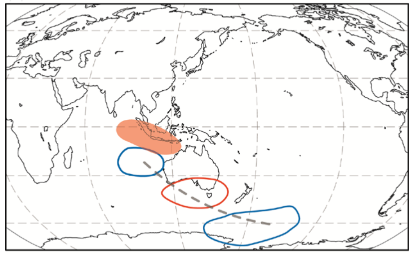
Idealised convective heating experiments

- Directly impose diabatic heating in the Community Atmosphere Model (CAM5)
- ~1° resolution
- Forced by observed present-day SST climatology and year 2000 constant external forcings
- Restart 30 control members with applied heating and run for one month starting on 1 Jun, 1 Jul and 1 Aug (combine to make 90-member ensemble)

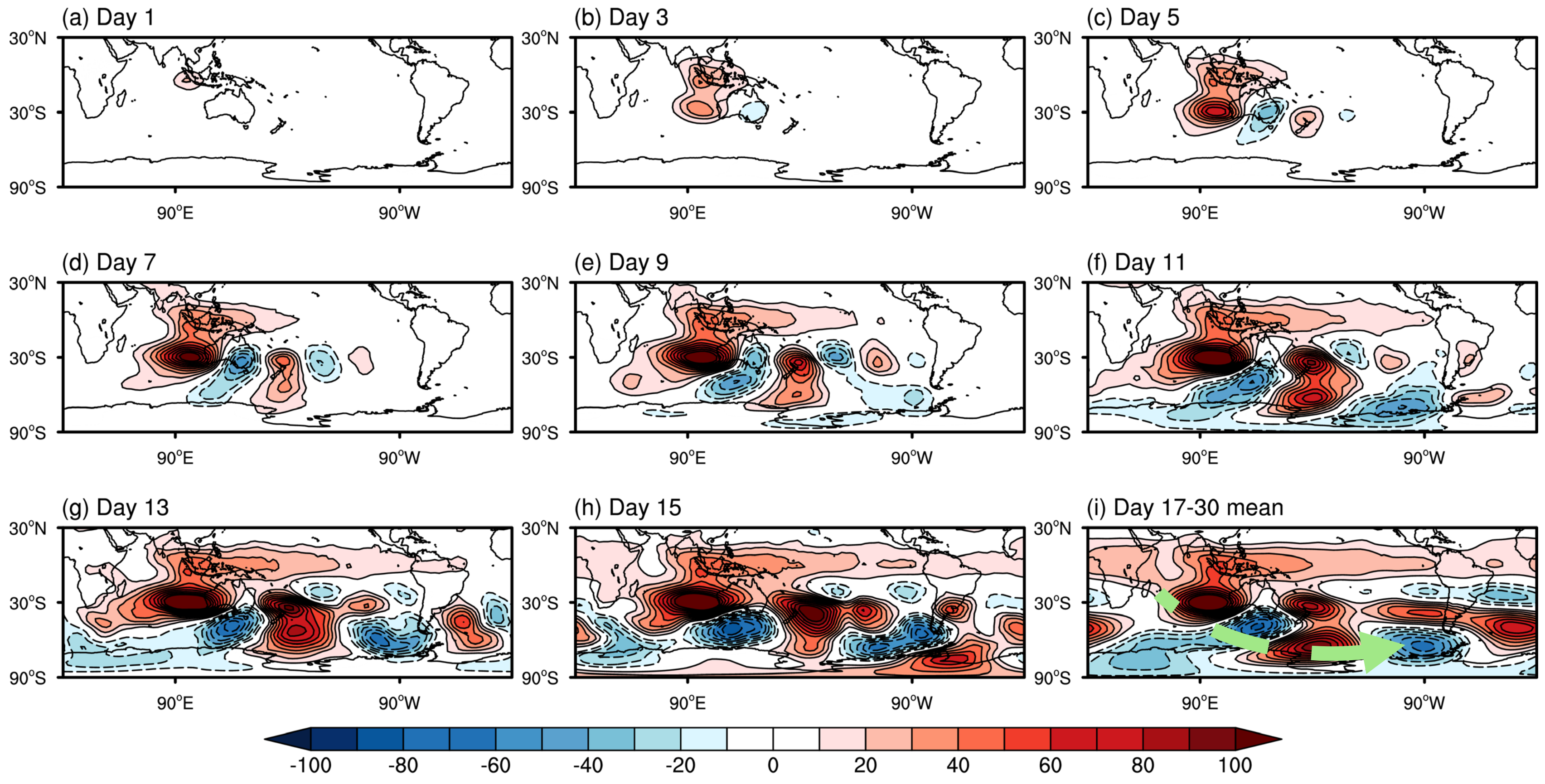


Evolution of the teleconnection from E-IND at 250 hPa

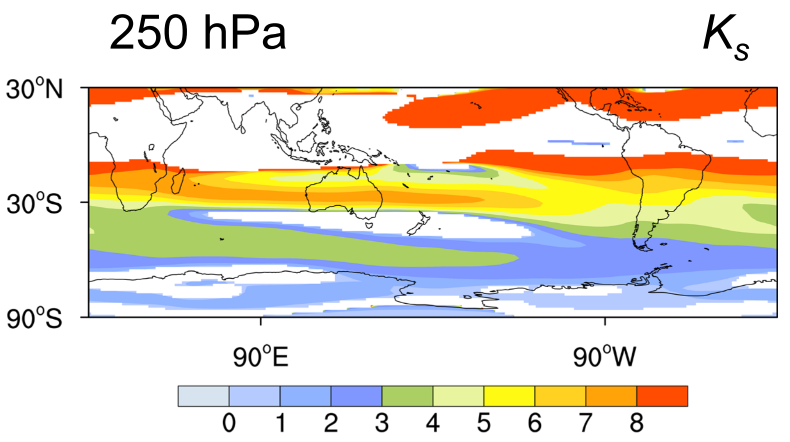




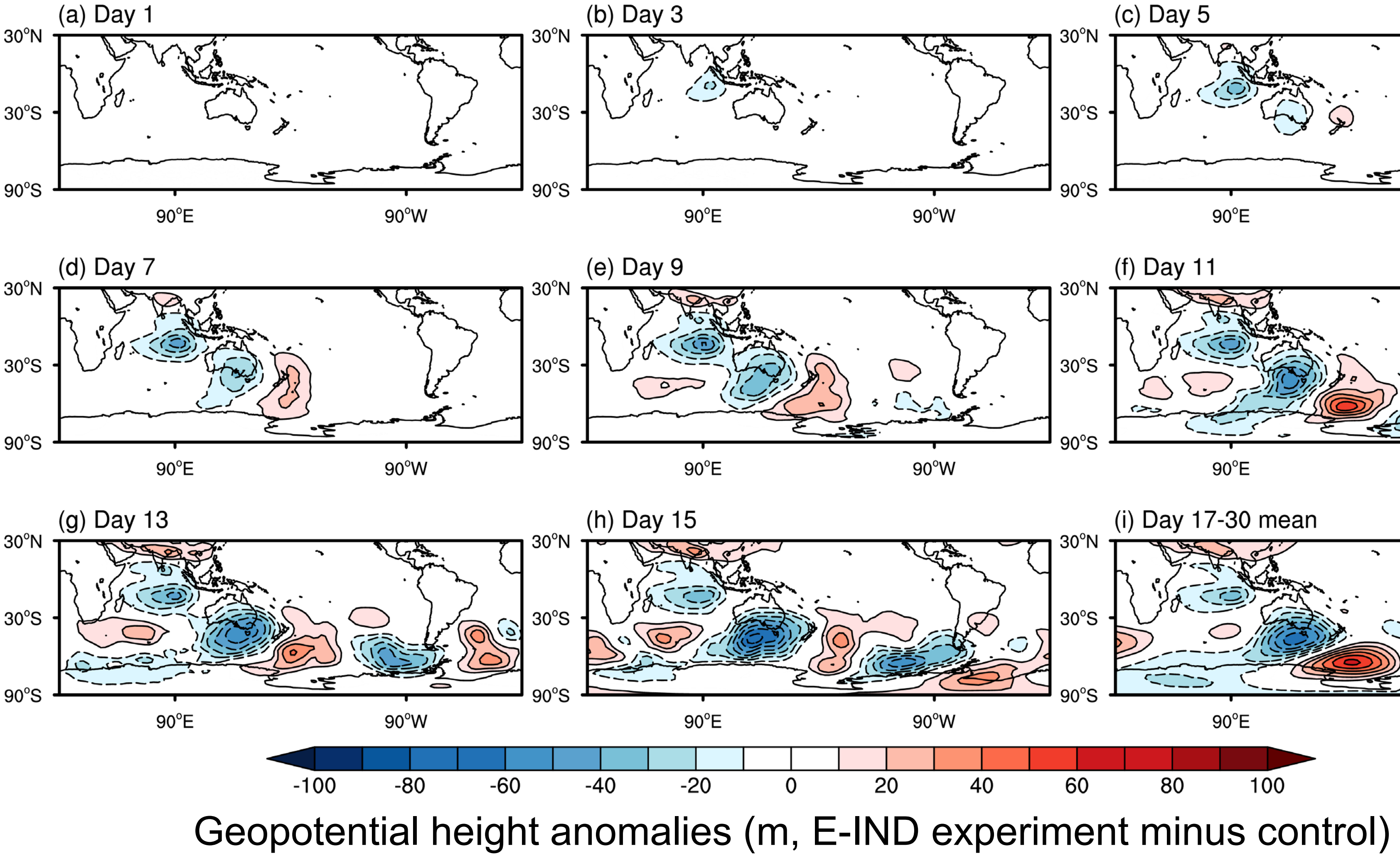
Evolution of the teleconnection from E-IND at 250 hPa

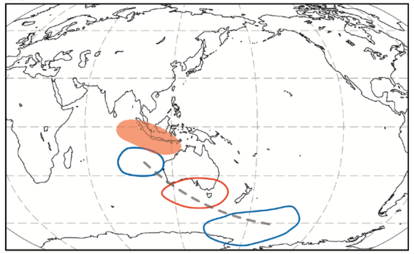


Geopotential height anomalies (m, E-IND experiment minus control)

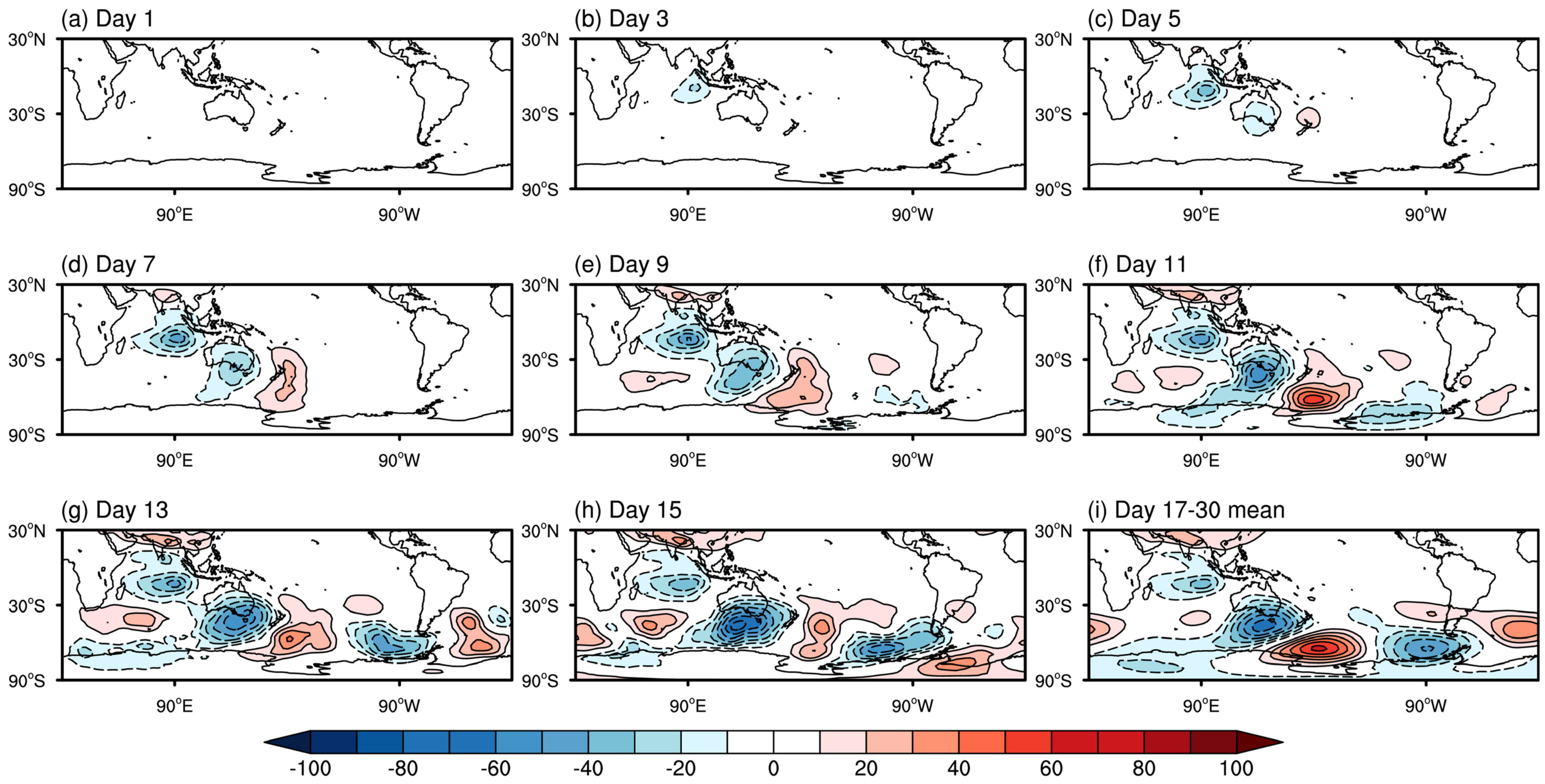


Evolution of the teleconnection from E-IND at 750 hPa

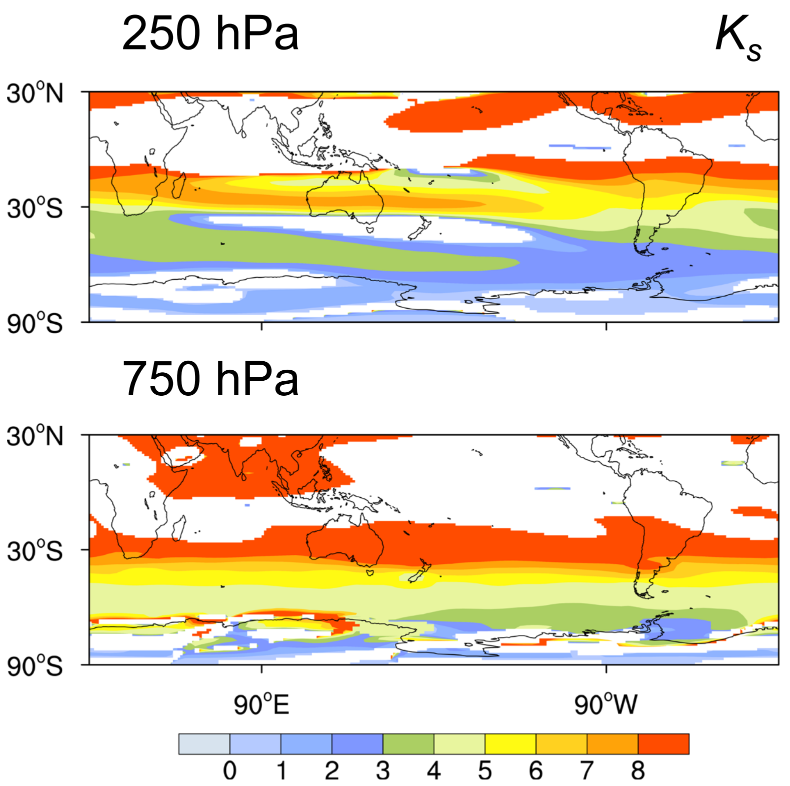




Evolution of the teleconnection from E-IND at 750 hPa

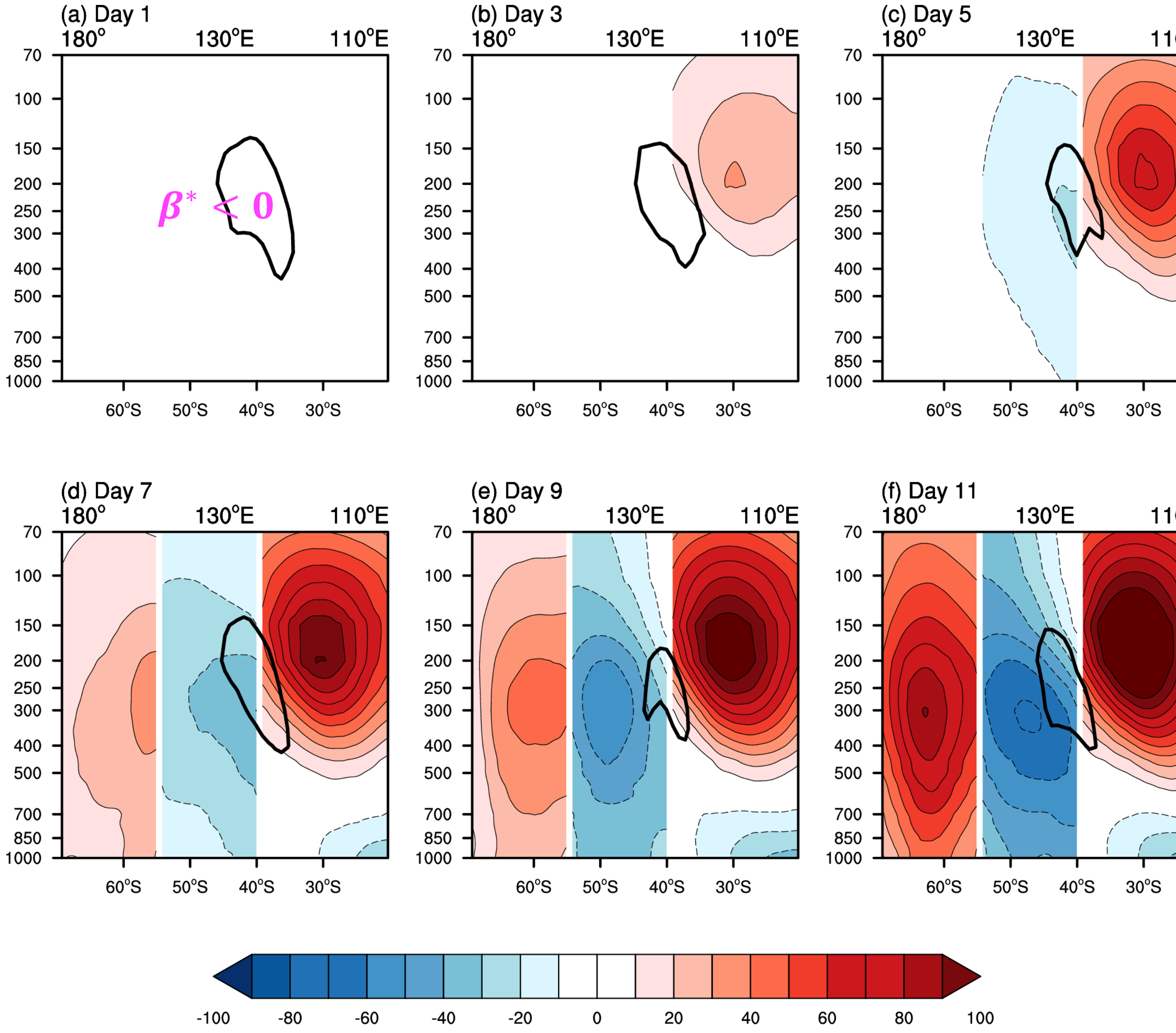


Geopotential height anomalies (m, E-IND experiment minus control)



Following the ray as it moves poleward and eastward

- Maximum anomalies are shifted towards lower levels
- Strong ascent at 400 hPa near region of $\beta^* < 0$ supports development of the equivalent-barotropic structure of poleward wavetrain

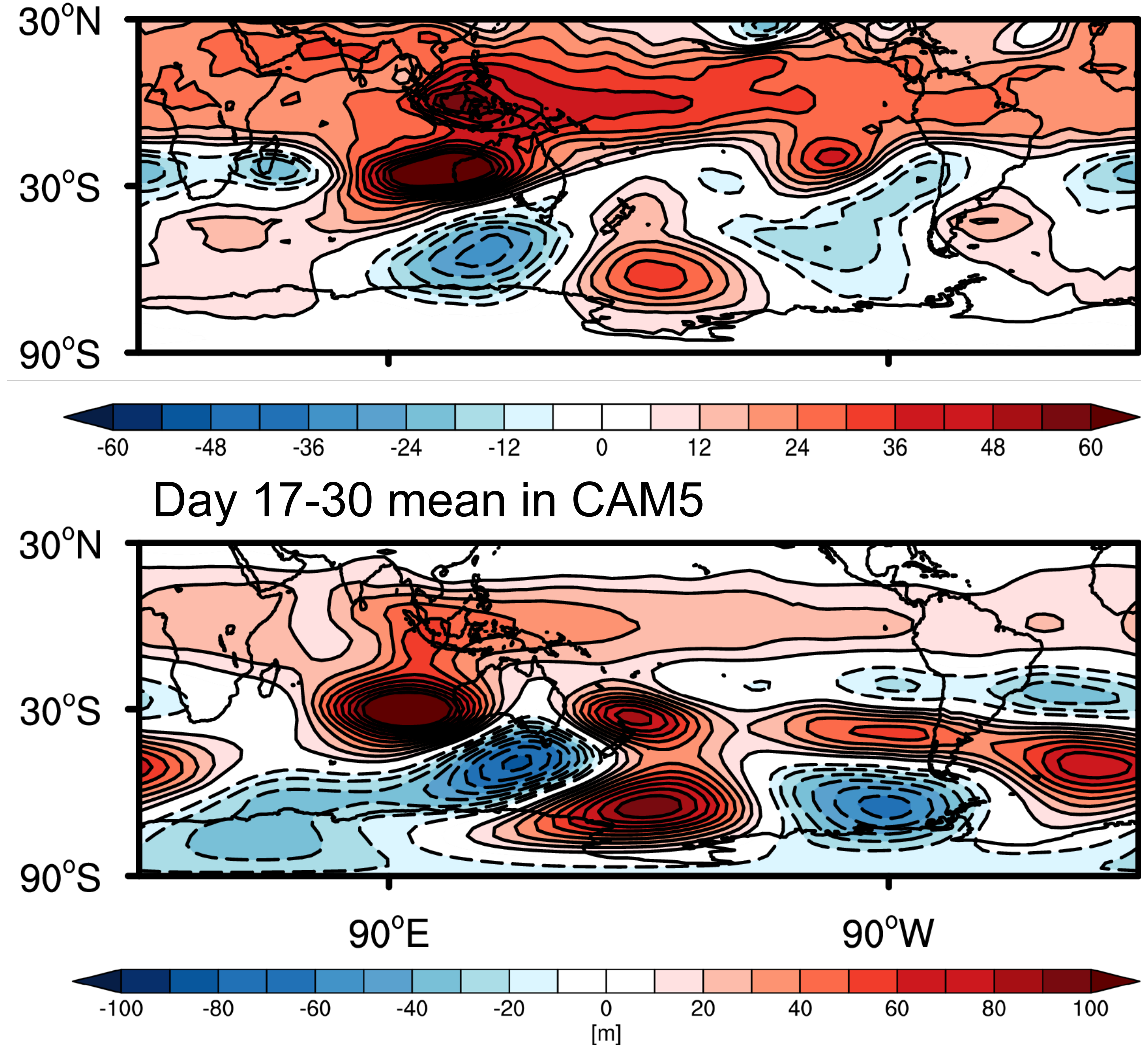


Geopotential height anomalies (shaded), wave activity flux anomalies (vectors), zero contour of β^* averaged over 90-180°E

Comparison with a simple linear GCM

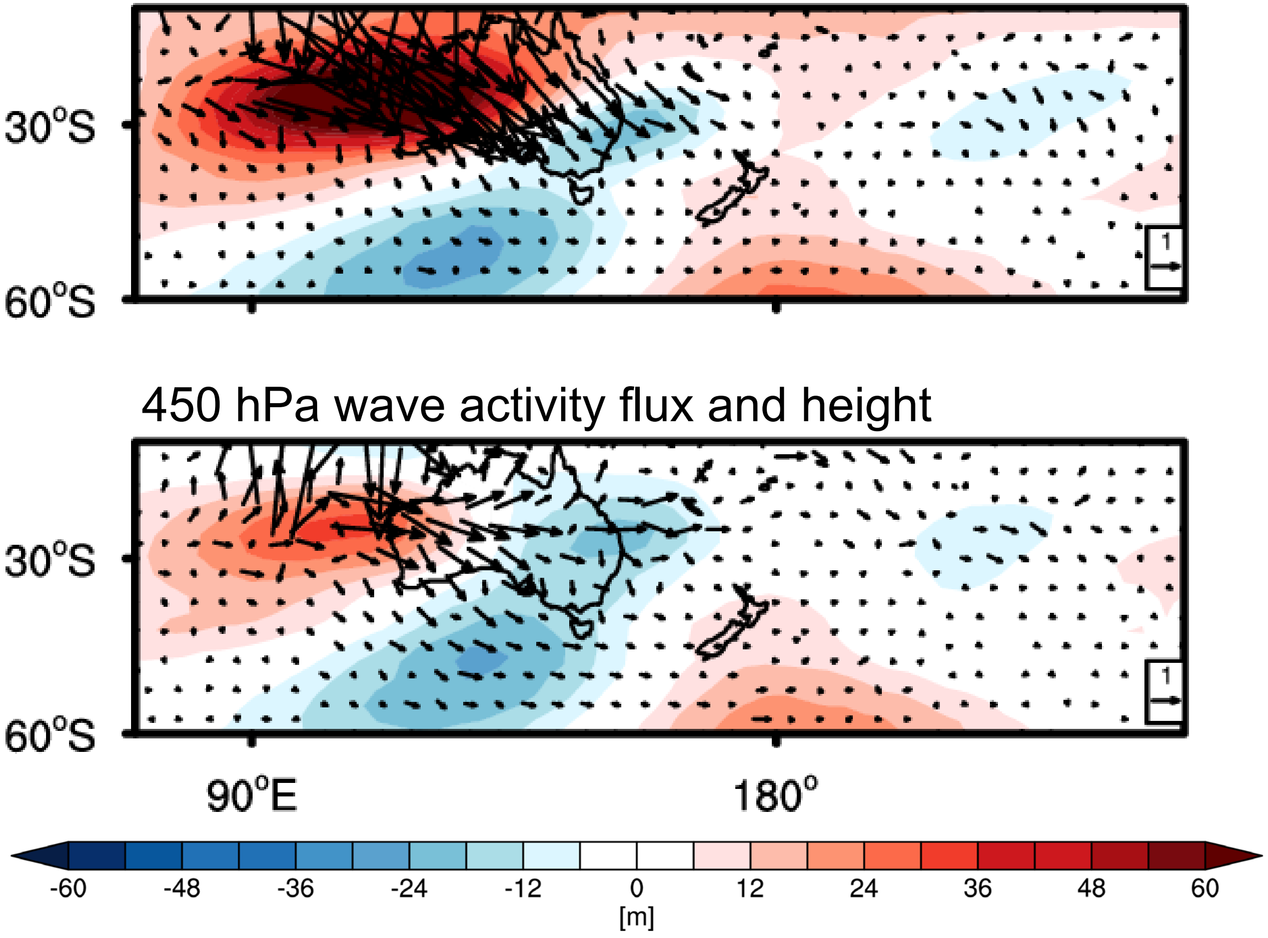
Day 20 in SGCM

Day 17-30 mean in CAM5



250 hPa wave activity flux and height

450 hPa wave activity flux and height



Summary

- Eastern Indian Ocean Rossby wave has two timescales: in the first week, a wave response rapidly propagates eastward along the subtropical jet, while in the second week, a wave with slower group propagation appears in the mid-high latitudes.

- The poleward wavetrain is equivalent-barotropic and it seems to go "underneath" the shallow $\beta^* < 0$ region where Rossby wave propagation should be prohibited.

- Some wave activity may also pass through the shallow $\beta^* < 0$ region.

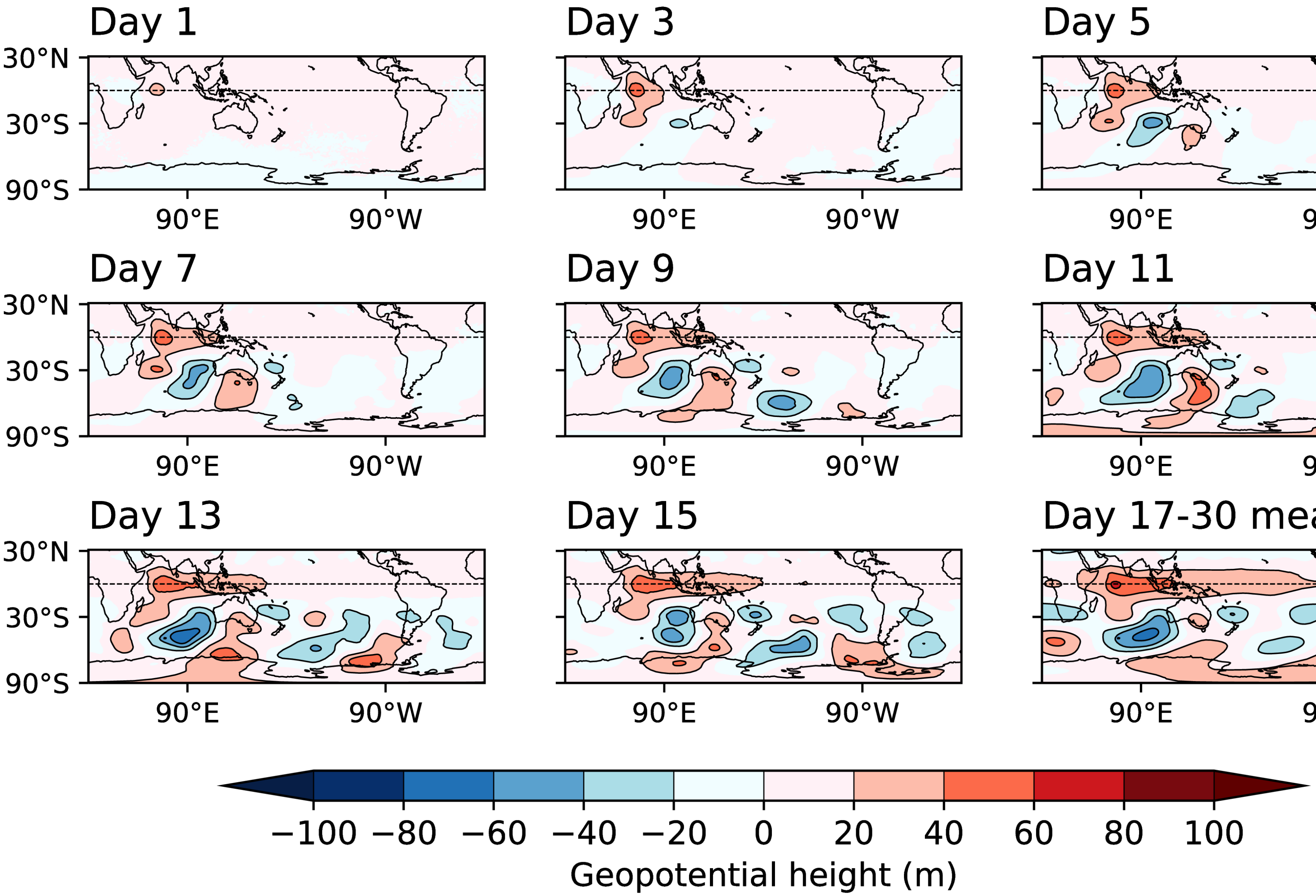
- Transient eddy forcing of the mean flow also reinforces the wave train at mid-high latitudes to the south of Australia but it is not required for wave propagation based on similarity between CAM5 results and a similar heating experiment in a simple linear GCM.

- Representation of the teleconnection depends highly on model mean state.

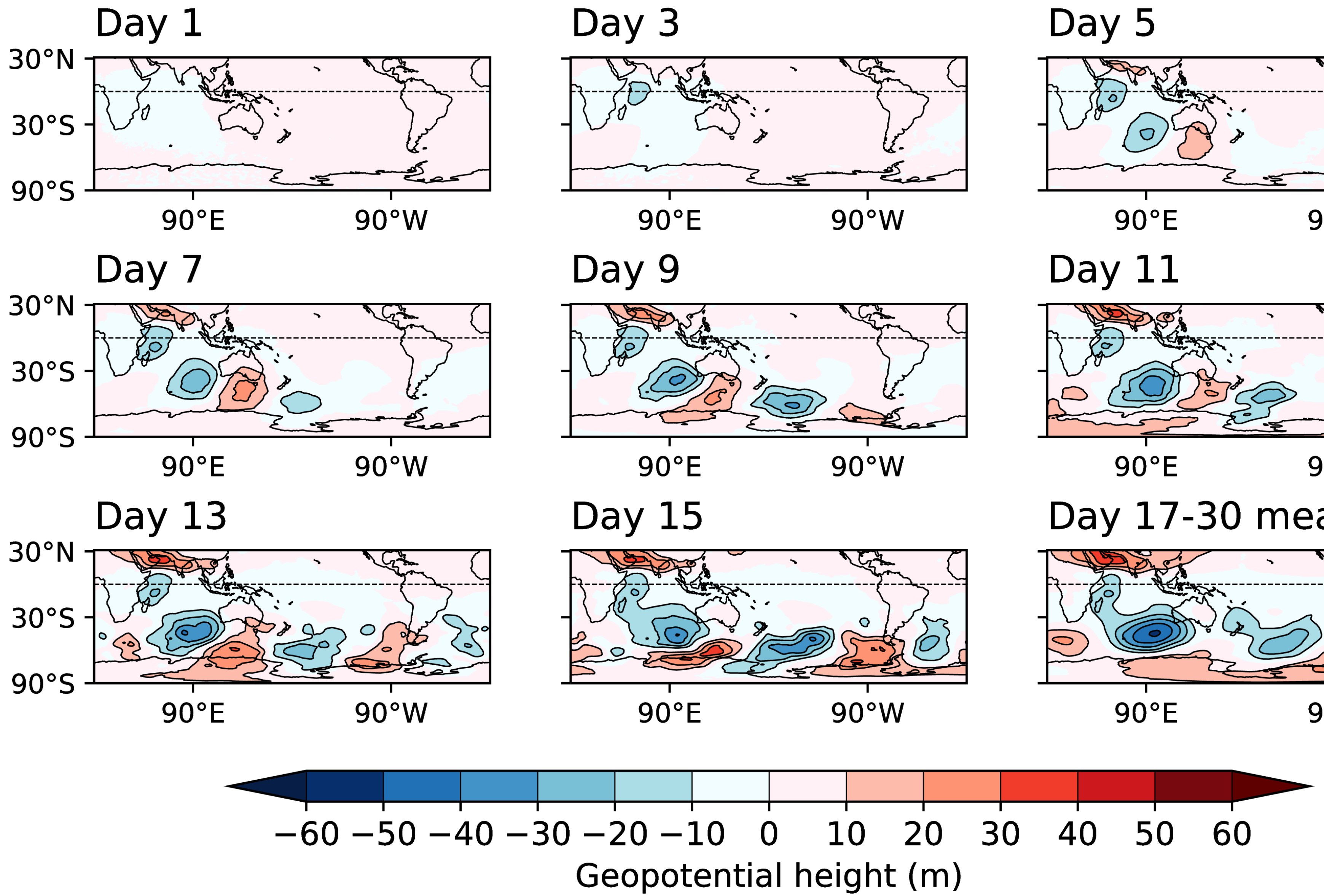
Additional slides

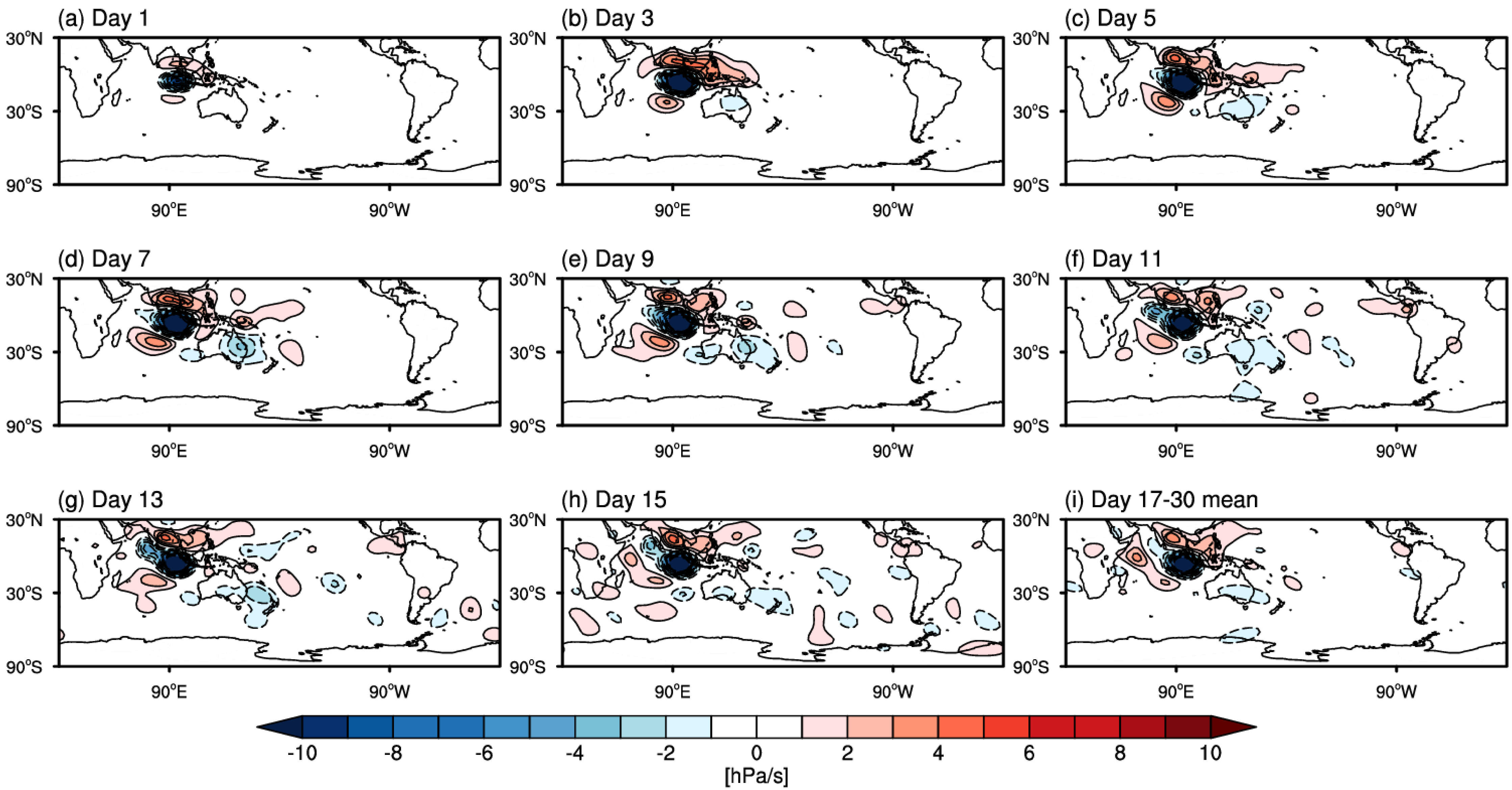
Teleconnection from western Indian Ocean heating at 200 hPa

Direct propagation across the STJ to higher latitudes

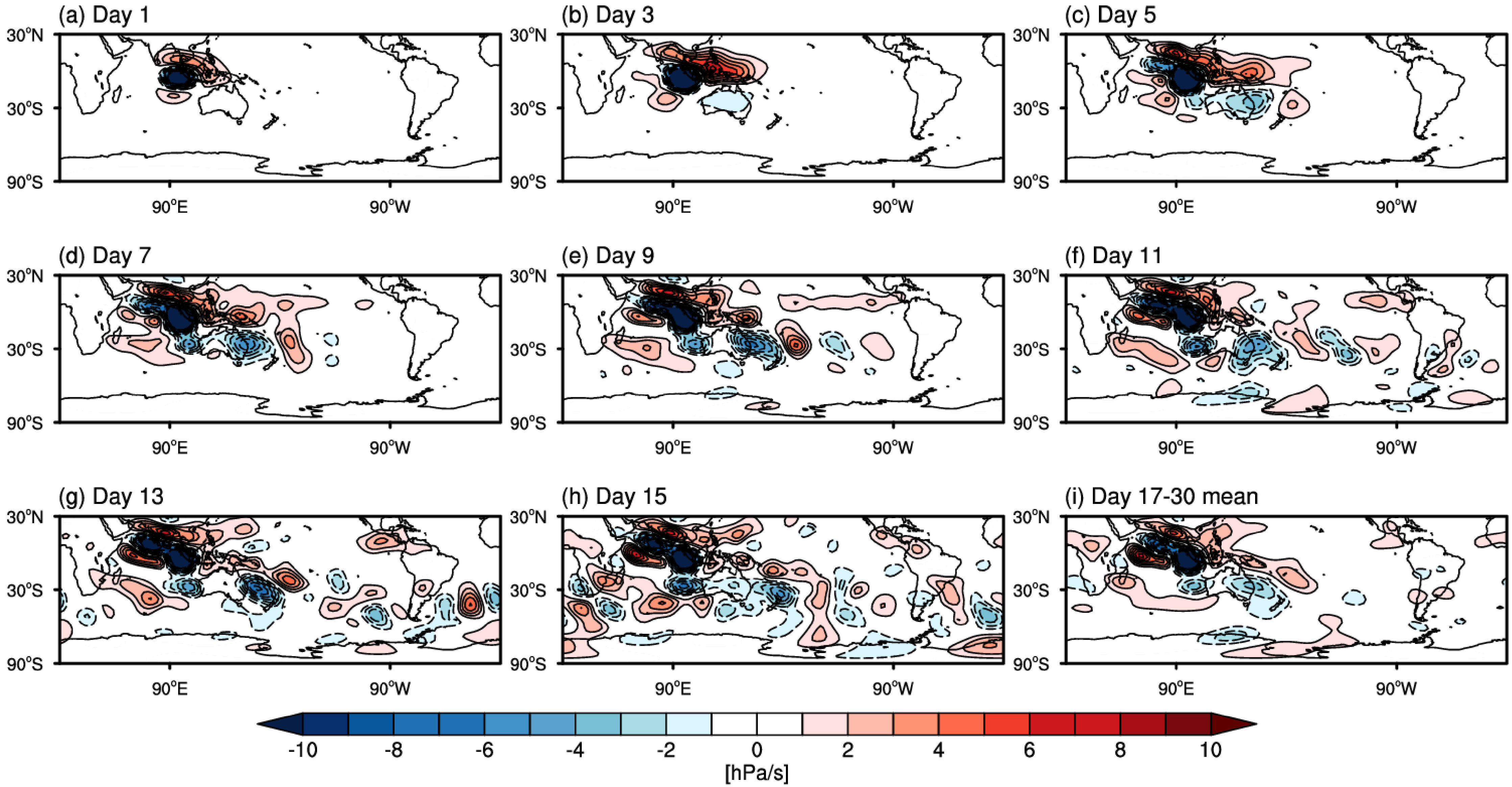


Teleconnection from western Indian Ocean heating at 700 hPa



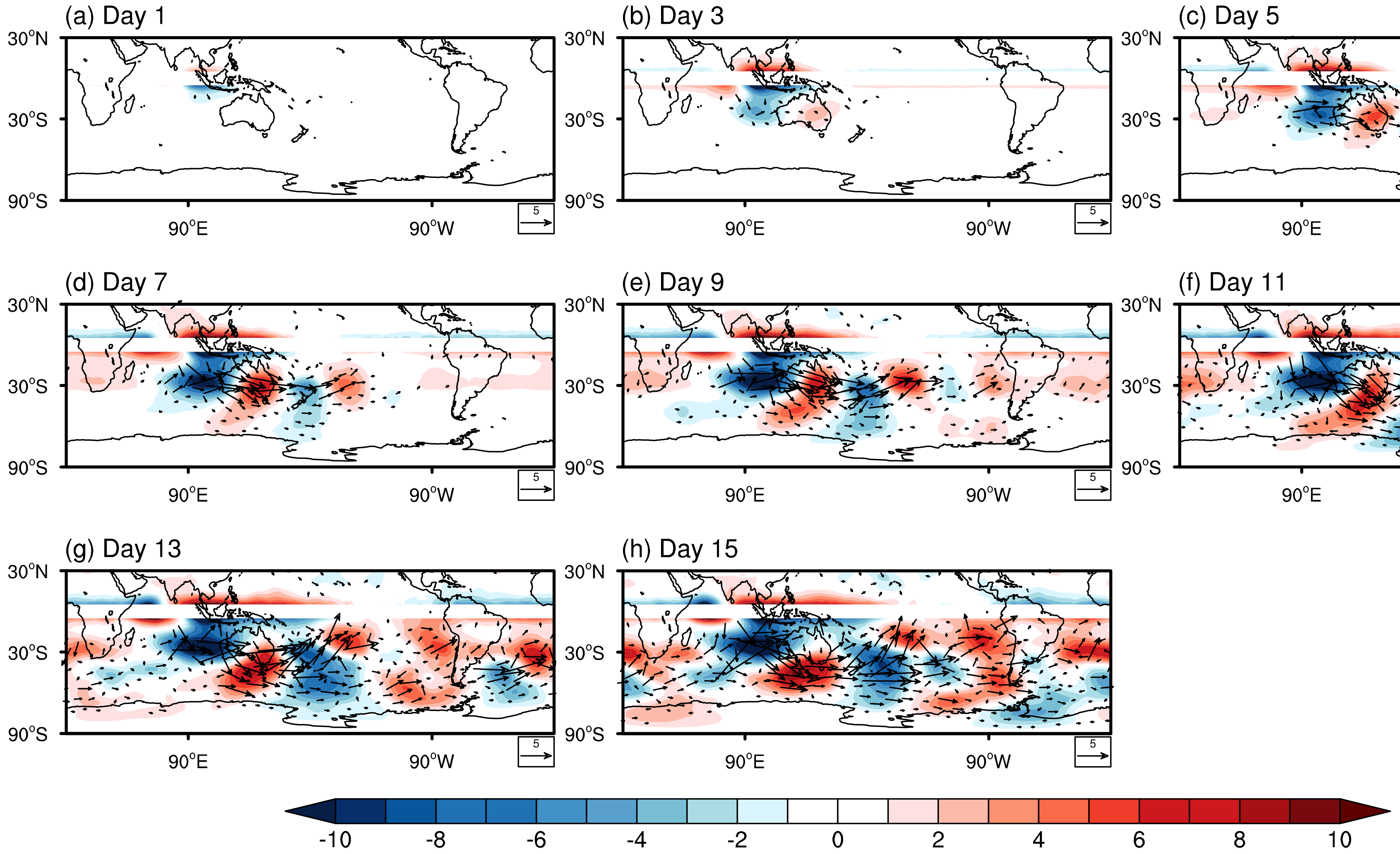


Evolution of the 200 hPa **omega** anomalies (East Indian Ocean heating experiment – control).



Evolution of the 400 hPa **omega** anomalies (East Indian Ocean heating experiment – control).

250 hPa WAF, PSI in E-IND experiment



450 WAF, PSI in E-IND experiment