Supplementary Information

Improving Madden–Julian Oscillation Simulation in Atmospheric General Circulation Models by Coupling with Snow–Ice–Thermocline One-dimensional Ocean Model

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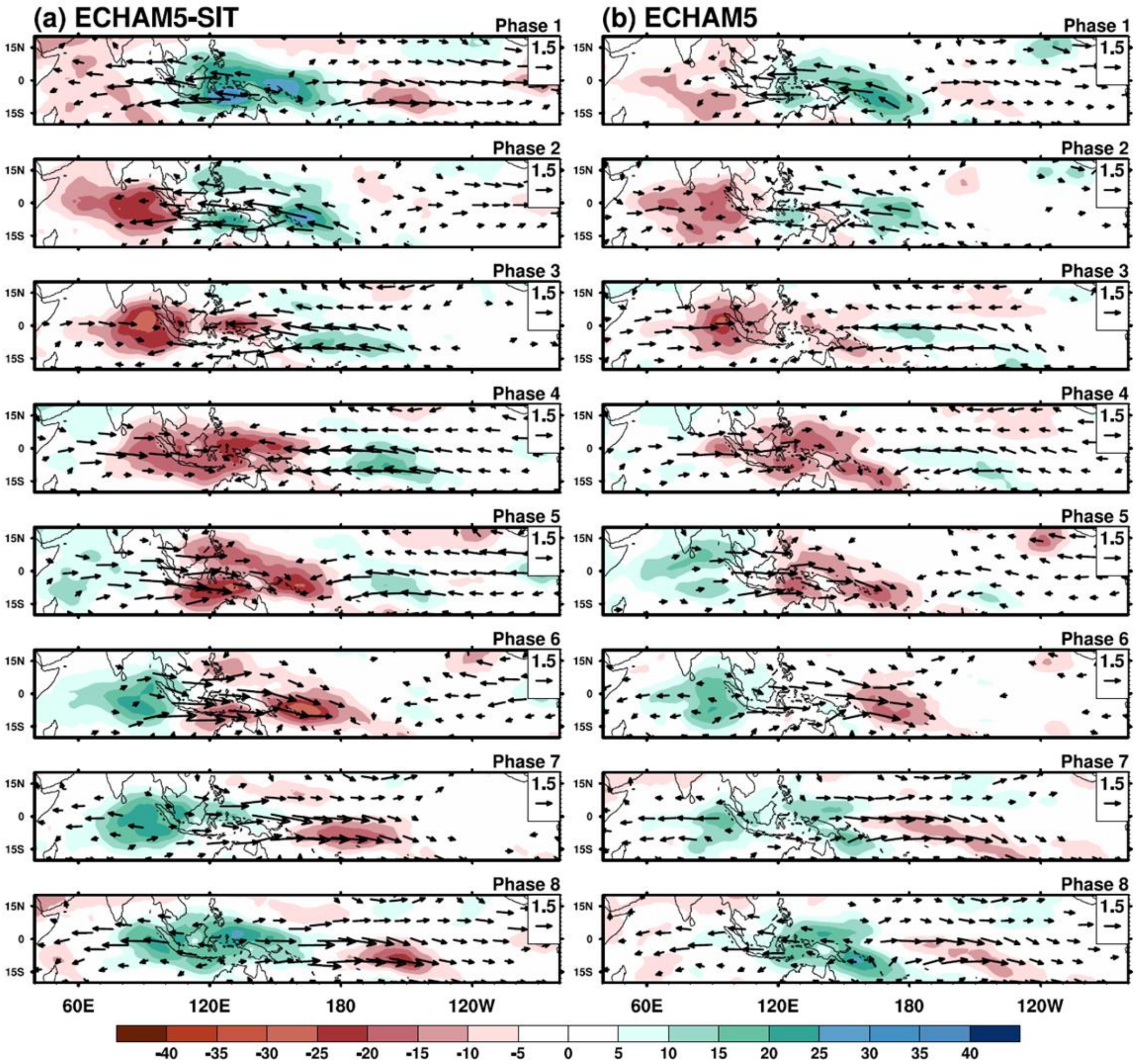

Figure S1. Composite November–April 20–100-day OLR (W m^{-1}; color) and 10-m surface wind anomalies (m s^{-1}; vectors) as a function of the MJO phase in (a) ECHAM5-SIT and (b) ECHAM5. Vectors <0.6 m s^{-1} are not shown. The reference vector in units of m s^{-1} is shown at the bottom right. The number of days used to generate the composite for each phase is shown to the right of each panel.

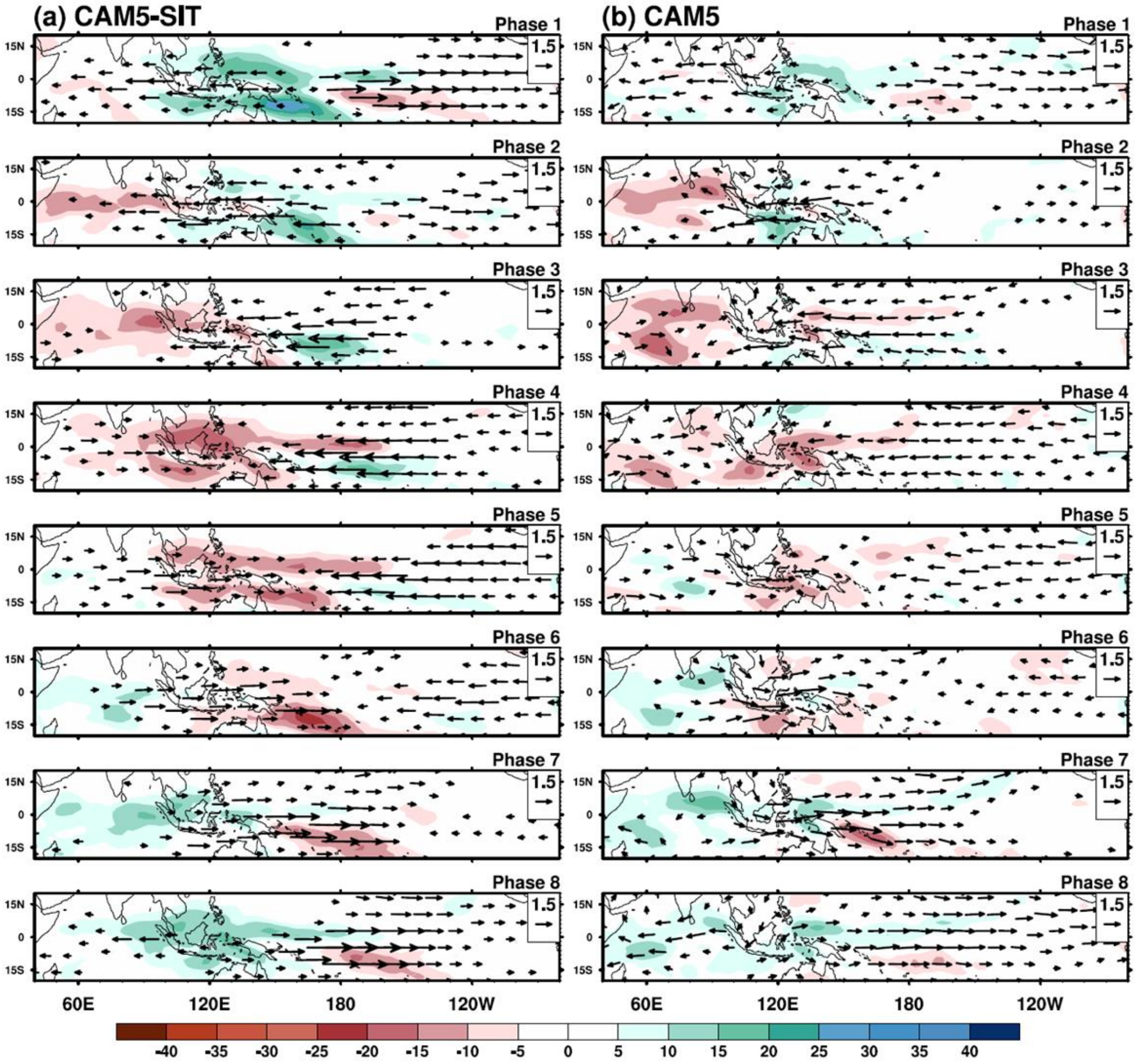

Figure S2. Same as Fig. S1, but in (a) CAM5-SIT and (b) CAM5.

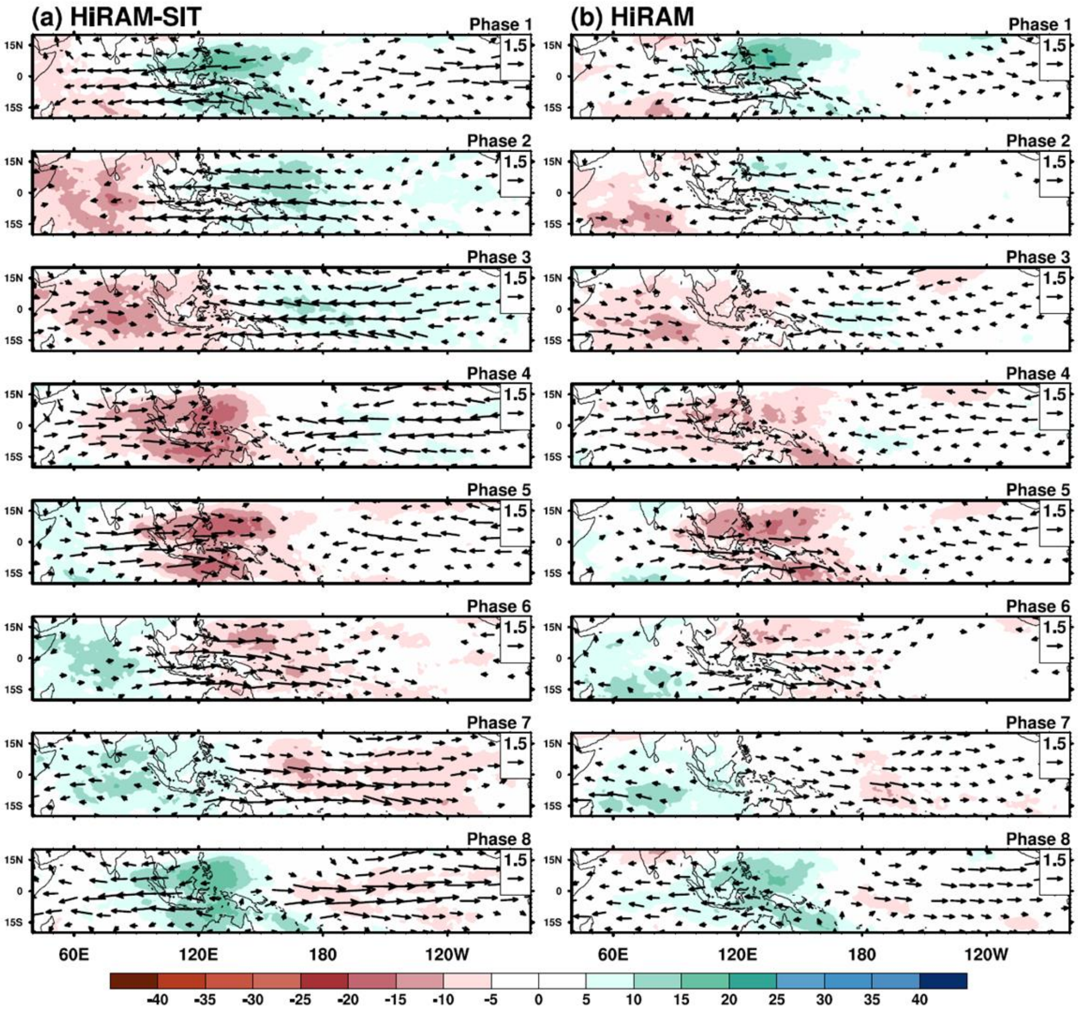

Figure S3. Same as Fig. S1, but in (a) HiRAM-SIT and (b) HiRAM.

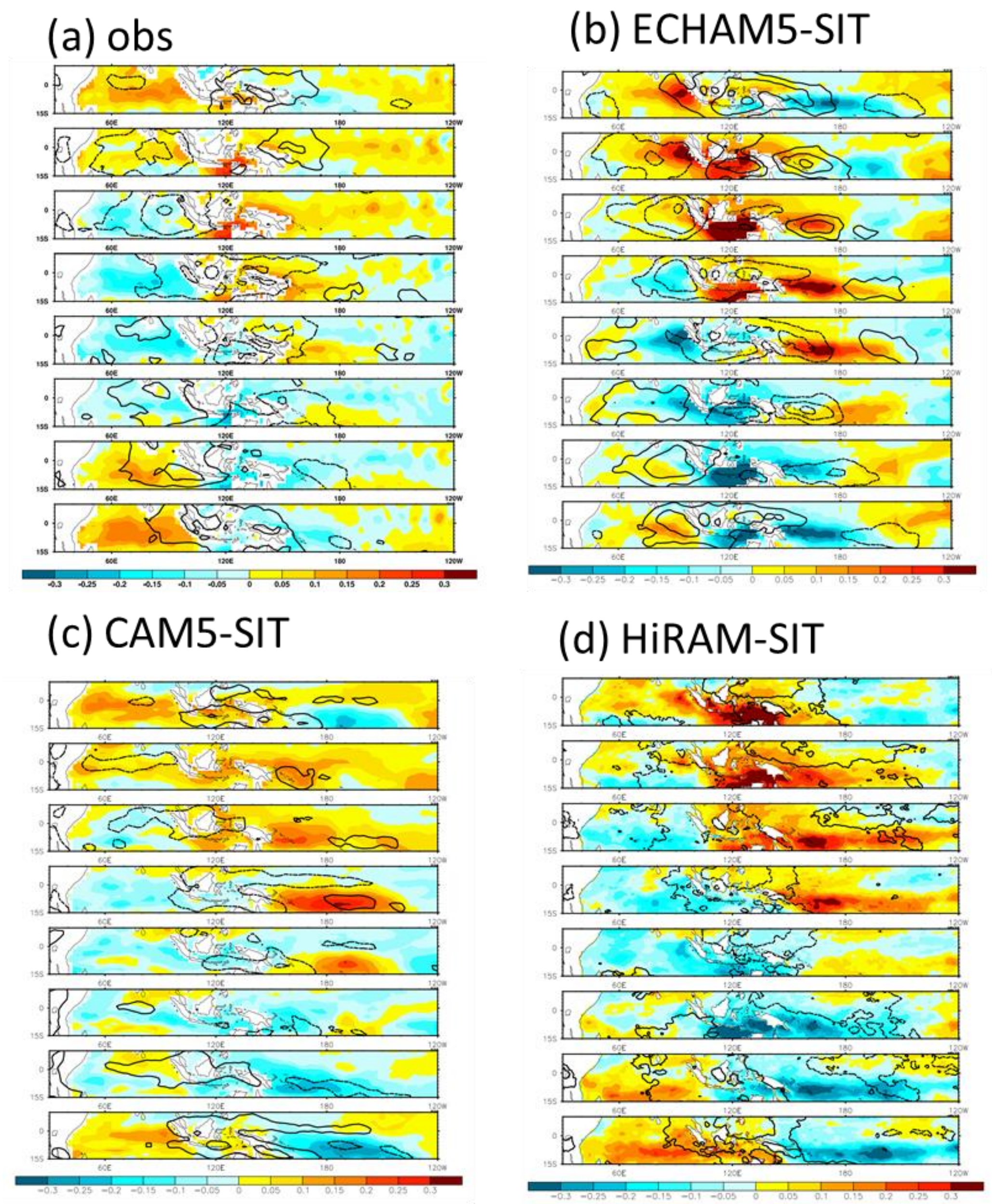

Figure S4. Composite November–April 20–100-day filtering SST (°C; color) and OLR anomalies (W m^{-1}; vectors) as a function of the MJO phase based on (a) observations, (b) ECHAM5-SIT, (c) CAM5-SIT, and (d) HiRAM-SIT.

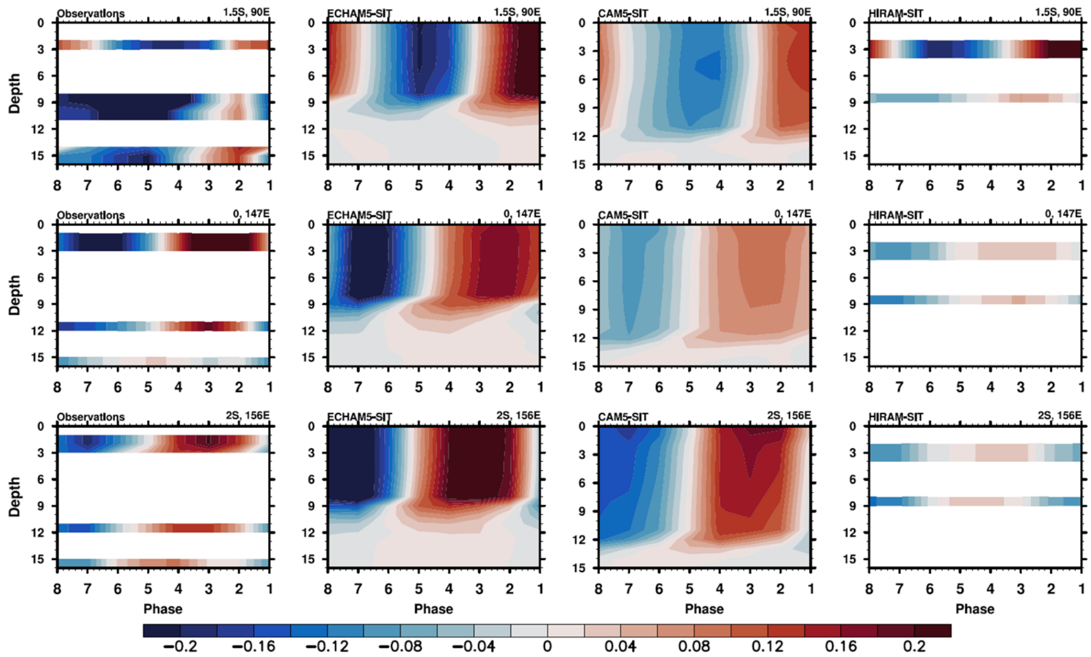

Figure S5. Vertical ocean temperature (°C) profiles with respect to MJO phases for intraseasonal anomalies (i.e., with 20–100-day filtering) in (a) observations and simulations by using the (b–d) coupled and (e–g) uncoupled AGCM. Observations are in suit with data from TAO. Because of storage limitations, only 3 and 10 m water temperatures are presented in the HiRAM-SIT simulation.

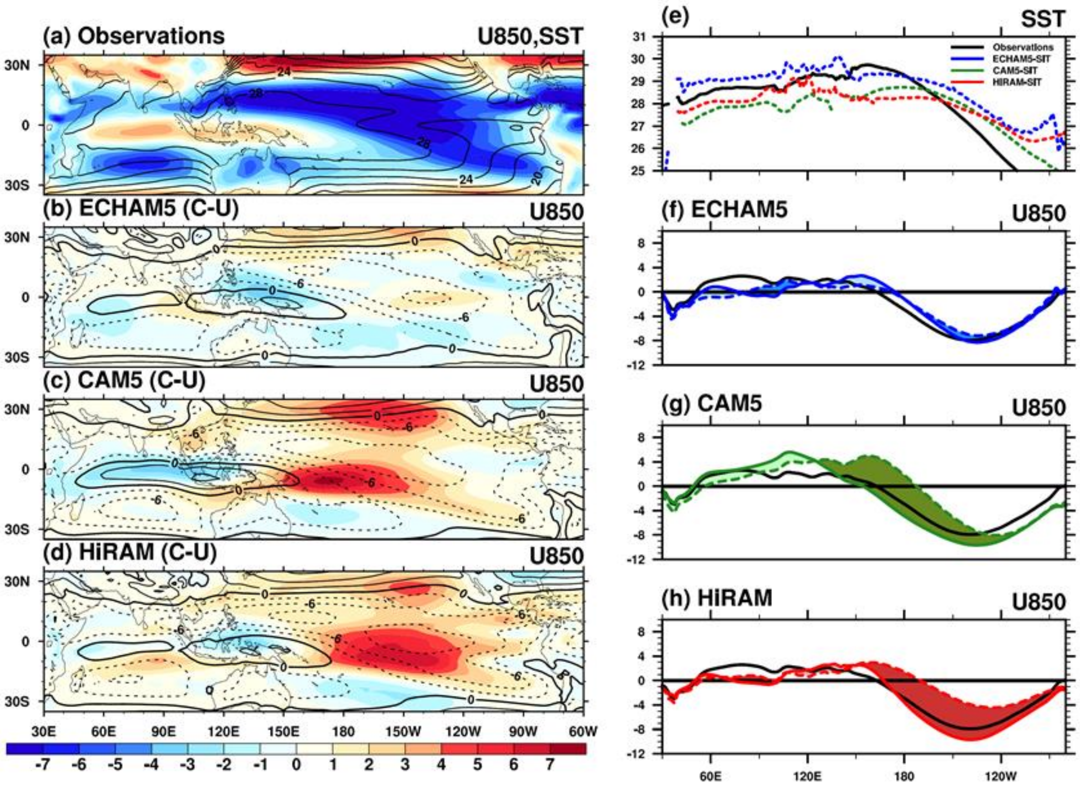

Figure S6. (a) The observational winter (November–April) averaged the mean state in 850 hPa zonal wind (m s^{-1}; shading) and SST (˚C; contours). (b–d) The winter averaged 850 hPa zonal wind difference of coupled and uncoupled simulations (m s^{-1}; shading) and uncoupled 850 hP zonal wind (m s^{-1}; contours) in ECHAM5, CAM5, and HiRAM. (e) The 10°S–EQ averaged winter SST (°C) in observation and simulations. (f–h) The 5°S–EQ averaged winter 850 hPa zonal wind (m s^{-1}) in ECHAM5, CAM5, and HiRAM. The solid line is uncoupled and the dashed line is a coupled model.

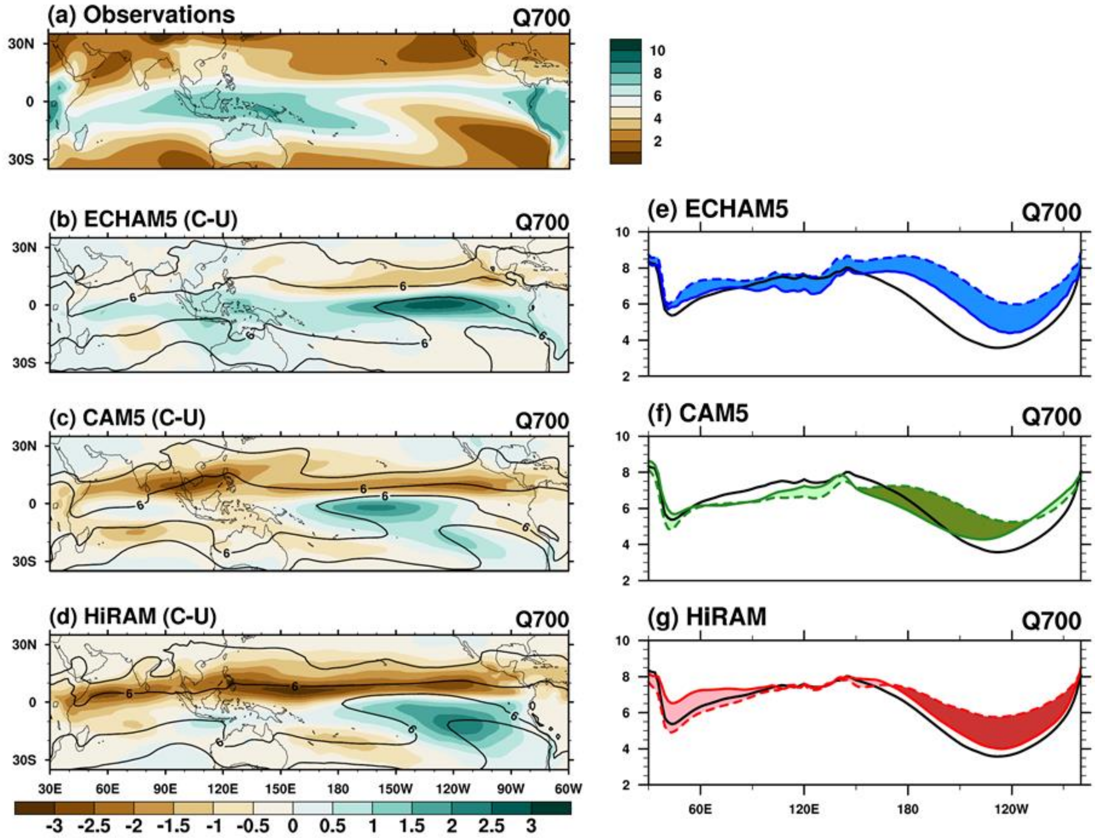

Figure S7. (a) The observational winter (November–April) averaged mean state in specific humidity at 700 hPa (Q700; kg s^{-1}; shading). (b–d) The winter averaged Q700 difference of coupled and uncoupled simulations (mm day^{-1}; shading) and uncoupled Q700 (kg s^{-1}; contours) in ECHAM5, CAM5, and HiRAM. (e–g) The 10°S–EQ averaged winter Q700 (kg s^{-1}) in ECHAM5, CAM5, and HiRAM. The solid and dashed lines indicate uncoupled and coupled models, respectively.

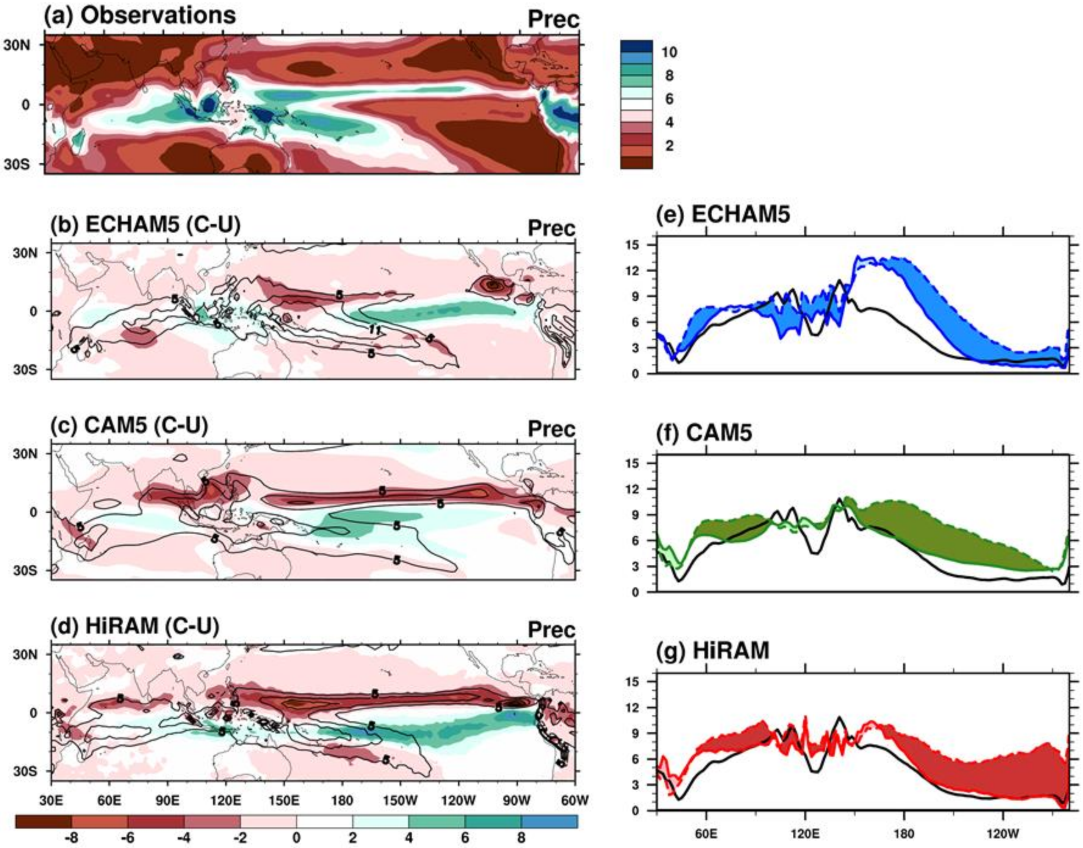

Figure S8. (a) Observational winter (November–April) averaged mean state in precipitation (mm day^{-1}; shading). (b–d) Winter averaged precipitation difference of coupled and uncoupled simulations (mm day^{-1}; shading) and uncoupled precipitation (mm day^{-1}; contours) in ECHAM5, CAM5, and HiRAM. (e–g) The 10°S–EQ averaged winter precipitation (mm day^{-1}) in ECHAM5, CAM5, and HiRAM. The solid and dashed lines indicate uncoupled and coupled models, respectively.

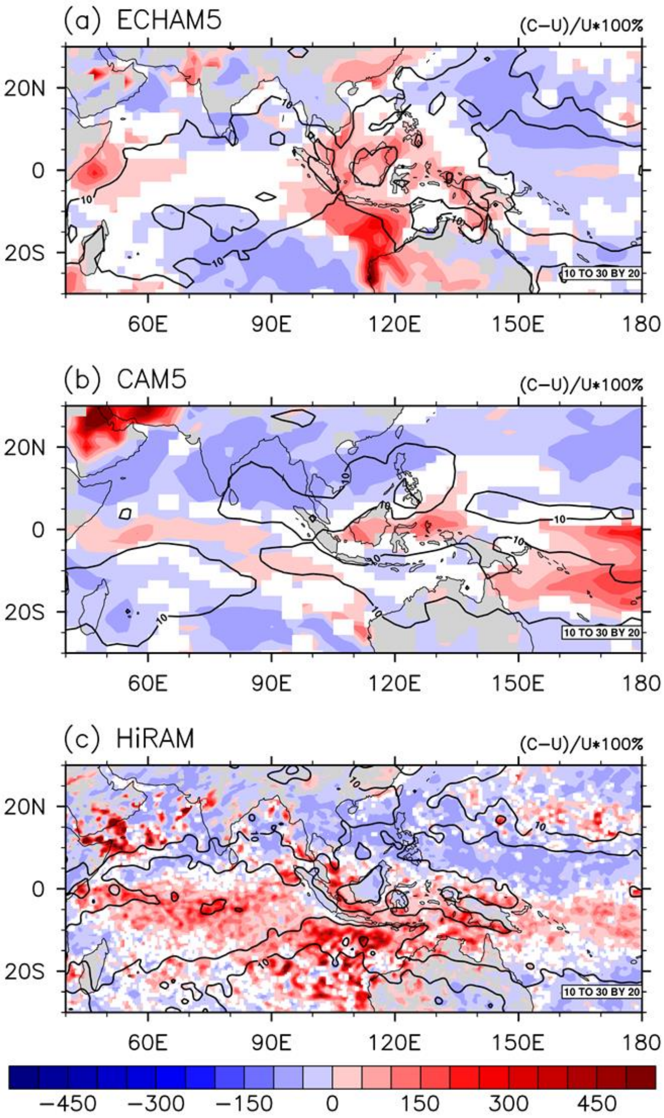

Figure S9. Ratio of the precipitation variance between the coupled and uncoupled models on intraseasonal time scales. The ratio is defined as (coupled – uncoupled) / uncoupled * 100%. The colored areas indicate where the ratio is statistically significant at 1% based on an F test. The contours show the intraseasonal precipitation variance (mm $day^{-1})^2$ in the uncoupled simulation. The 9-point local smoothing is applied in the intraseasonal precipitation variance of HiRAM here (contours only).