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Supporting Information for

**Substantial Sea Surface Temperature cooling in the Banda Sea associated with the Madden-Julian Oscillation in the boreal winter of 2015**

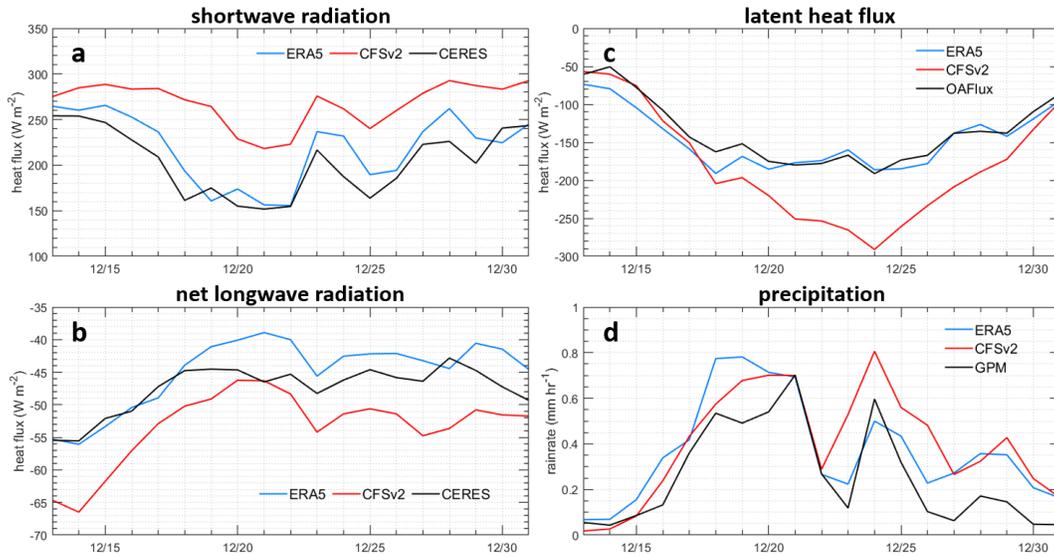
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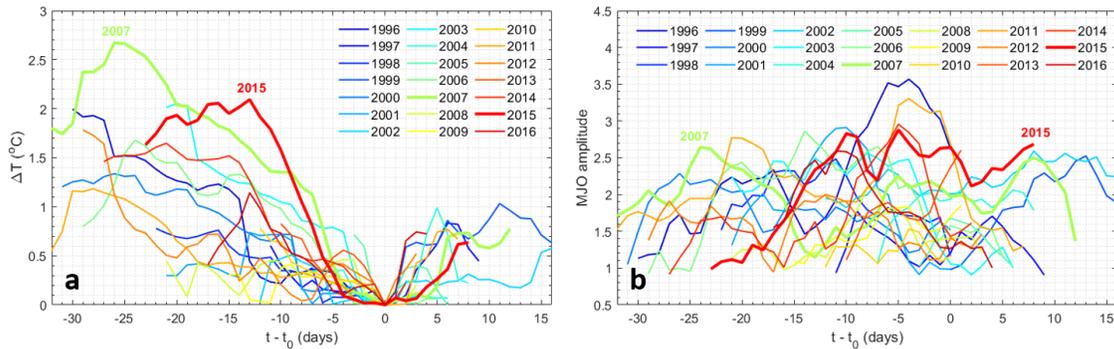
<sup>2</sup>Physical Oceanography Department, Woods Hole Oceanographic Institution.

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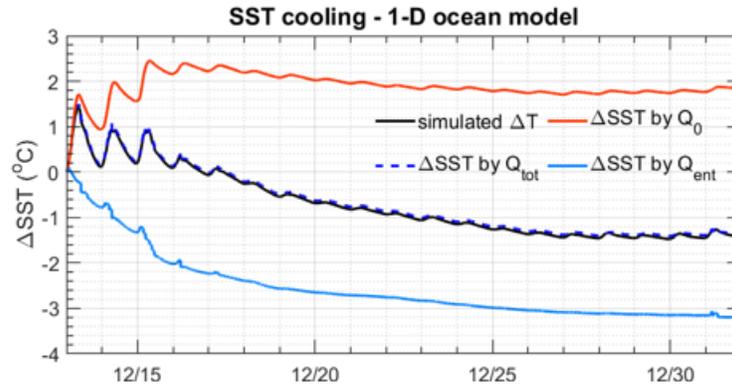
Figures S1 to S7



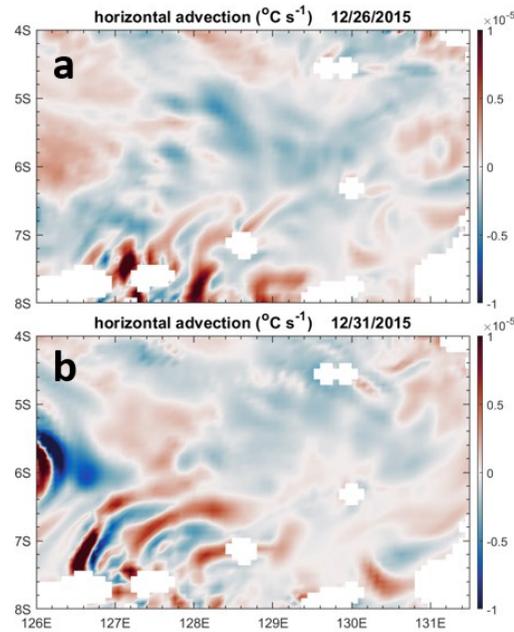
**Figure S1.** Comparison of the Banda Sea basin averaged daily mean (a) shortwave radiation; (b) net longwave radiation; (c) latent heat flux; (d) precipitation over the SST cooling period during Dec. 13-31, 2015. Blue (red) lines are derived from ERA5 (CFSv2) hourly surface fluxes. The black lines in (a) and (b) are computed from CERES hourly data. The black line in (c) represents latent heat flux from OAFlux. The black line in (d) shows GPM precipitation.



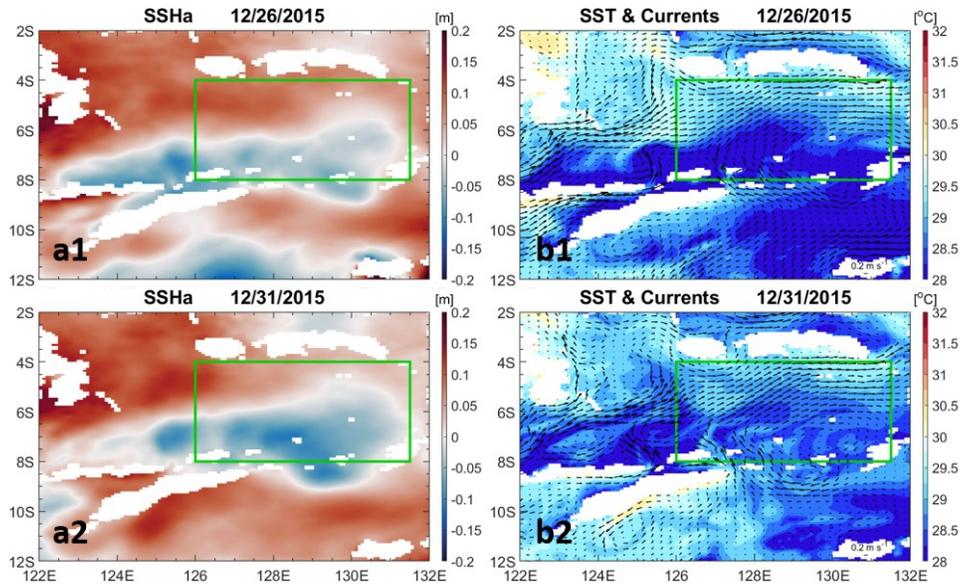
**Figure S2.** Time series of (a) Banda Sea basin-wide SST cooling, (b) RMM amplitude associated with MJO events in extended boreal winter (Oct.-Mar.) of each year from 1996-2016. Time “o” of horizontal axis corresponds to the date when the minimum SST is reached in each cooling event. The SST cooling in (a) is computed with respect to the minimum SST of each event based on the OSTIA SST data. Only MJO events with sufficient large RMM amplitude ( $\geq 0.9$ ) are shown in (b). The 2015 and 2007 events are shown by thick lines.



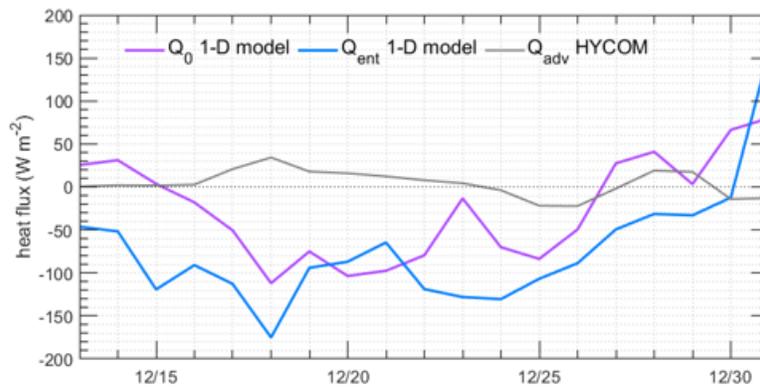
**Figure S3.** SST cooling produced only by vertical mixing (light blue line) and only by surface heat flux (red line), computed by integrating initial SST forward in time using only the entrainment heat flux  $Q_{ent}$  and the surface heat flux  $Q_0$ , respectively. The dark blue dashed line shows the combined total SST cooling. The black line indicates the simulated SST cooling by 1-D ocean model.



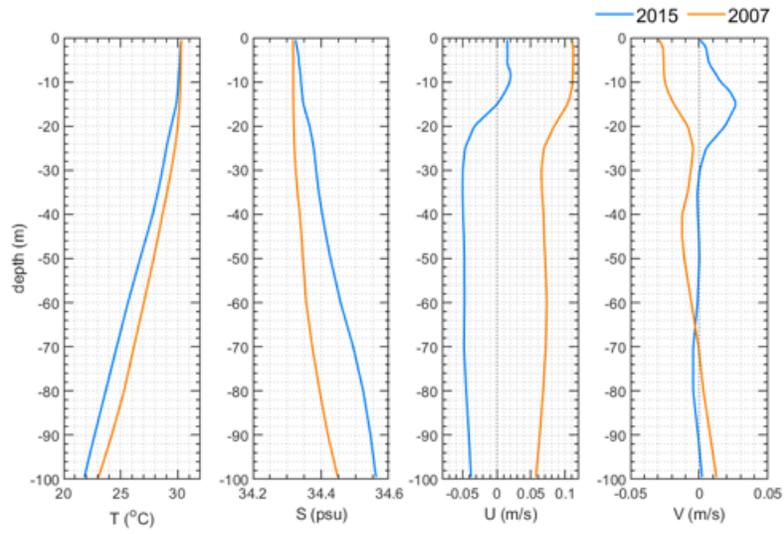
**Figure S4.** Contour plots of horizontal heat advection averaged over mixed layer on (a) Dec. 26; (b) Dec. 31 in the Banda Sea. The results are estimated based on the outputs from HYCOM reanalysis.



**Figure S5.** Contour plots of SSH anomaly on (a1) Dec. 26; (a2) Dec. 31 in the area of 122°E-132°E, 12°S-2°S. The Banda Sea is shown by the box area bounded by the green lines. In (a1-a2), SSH anomaly is computed as the difference between the SSH on the plotting date and the SSH on Dec. 1, 2015, which is in the MJO suppressed phase. (b1-b2) are the same as (a1-a2) except for SST (shading with a contour interval of 0.25°C) and surface currents averaged over upper 30 m (arrows). All the data are computed based on the outputs of HYCOM reanalysis.



**Figure S6.** Time series of Banda Sea basin-wide net surface heat flux  $Q_0$  (purple line), entrainment heat flux  $Q_{ent}$  (blue line), and heat flux produced by horizontal advection  $Q_{adv}$  (gray line) during the SST cooling period associated with the 2015 boreal winter MJO. Note that  $Q_0$  and  $Q_{ent}$  are from 1-D ocean model simulation.  $Q_{adv}$  is estimated based on the outputs of HYCOM reanalysis. The dotted line indicates zero heat flux.



**Figure S7.** Vertical profiles of (a) temperature; (b) salinity; (c) zonal velocity; (d) meridional velocity on Dec. 13 from HYCOM reanalysis. Vertical profiles of 2015 (2007) are indicated by the blue (orange) lines.