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On the Maintenance and Initiation of the Intraseasonal Oscillation in the NCEP/NCAR and ECMWF Reanalyses and in the GLA and UKMO AMIP Simulations

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Intraseasonal (Madden-Julian) oscillations are a dominant model of tropical variability (Madden and Julian 1971, 1972). Satellite derived outgoing longwave radiation (OLR) and reanalyses from NCEP/NCAR and ECMWF are used as verification data in a study of intraseasonal variability in the Goddard Laboratory for Atmospheres (GLA) and the United Kingdom Meteorological Office (UKMO) atmospheric general circulation models (Sperber et al. 1997). Slingo et al. (1996) indicated that no model was able to capture the dominance of the intraseasonal oscillation (IO) found in the ECMWF/JDP analyses. However, in the case of the GLA and UKMO AMIP integrations, when a clear eastward propagating signal is evident, the period of the oscillation is realistic.Therefore, in order to show the models in their best light, we examine the November-May period during which these models exhibited their strongest <u>and</u> most coherent IO's. 1987/88 from observations and the reanalyses will be compared with 1986/87 from GLA and 1980/81 from UKMO. Case studies are important since specific processes/mechanisms may be evident which might otherwise be obscured by compositing over many years (e.g., Matthews et al. 1996).

During the active phase of the IO, convection migrates from the Indian Ocean to the western/central Pacific Ocean, and into the SPCZ. To demonstrate this, we have calculated an IO index to be used for lagged correlation analysis. This pentad averaged time series is constructed from 20-100 day bandpass filtered 200hPa velocity potential over the region 100^o-140^oE, 10^oN-10^oS from the NCEP/NCAR reanalysis (not shown; the IO index from the ECMWF reanalysis is virtually identical with the NCEP/NCAR IO index [correlation coefficient=0.987]). This region was chosen since this is where the diabatic heating associated with the IO is greatest. This IO index is then correlated with pentad averaged OLR at various time lags, as shown in Fig. 1. Convection first arises over the western Indian Ocean on day -15. Through day 0 the convective envelope matures quickly, dominating the eastern Indian Ocean, the Maritime continent and much of Australia. Subsequently, the extent of the convection decreases, with the strongest enhancement located in the SPCZ. The simulated convection, particularly in the GLA model, is most realistic over the western/central Pacific Ocean and the SPCZ (not shown, see Sperber et al. 1997). However, both models fail to simulate IO related convection over the Indian Ocean and the propagation eastward into the west Pacific.

The maintenance and initiation of the intraseasonal oscillation has also been investigated. Evaporative wind feedback (Emanuel 1987, Neelin et al. 1987) hypothesizes that evaporation to the east of the convection is fundamental for maintaining the eastward migration of the convection. To examine the viability of this hypothesis we have correlated the IO index with 20-100 day bandpass filtered latent heat flux from NCEP/NCAR reanalysis in Fig.1 and ECWMF reanalysis in Fig. 2. Both reanalyses indicate that evaporation is enhanced to the west of the convection, particularly from day -5 onward, with both reanalyses exhibiting virtually identical lag correlation patterns. This result indicates that evaporative wind feedback is not the dominant process by which the eastward propagation of the intraseasonal oscillation is maintained. Correlations of the simulated IO indexes with filtered latent heat flux from the GLA and UKMO integrations are also shown in Fig. 2. In the GLA simulation, enhanced evaporation tends to develop in-place over the west Pacific warm pool, while in the UKMO simulation westward propagation of enhanced evaporation is evident. Thus, the models do not simulate the processes suggested by the reanalyses that occur during the eastward propagation of the IO. While our results suggest a wave-CISK type mechanism (Sperber et al. 1997), the contribution due to frictional convergence (Hendon and Salby 1994) is not apparent.

It is suggested that lack of an interactive ocean may be associated with the models systematic failure to simulate the eastward transition of convection and the latent heat flux from the Indian Ocean into the western Pacific Ocean. Examination of observed SST and its relationship to the active phase of the intraseasonal oscillation suggests that air-sea interaction may be important during the course of the evolution of the IO (e.g. Gutzler et al. 1994; Chen et al. 1996, Lau and Sui 1997). To explore this in more detail, in Fig. 1 we show the correlation of the IO index with filtered observed SST (and skin temperature over land from the ECMWF reanalysis) for the 1987/88 case study. On day -15 convection over the tropical western Indian Ocean occurs over above normal SST. Enhanced warming is also found in the equatorial central Indian Ocean and near Sumatra, which at day -10 is where enhanced convection is the strongest. At day -10 significantly warmer SST spreads south of the Indonesian peninsula near 115°E, 15°S, which is precisely where suppressed convective activity (and presumably enhanced subsidence) occurred during the previous pentad (day -15). Similarly, at day -5 the convection extends eastward over New Guinea and adjacent to northwest Australia, where above normal SST and suppressed convection were found on day -10. This cycle continues on day 0 where convection north of New Guinea is manifested. On day +5 through day +15 convection is found near 170°E, 5-20°S where warm SST anomalies developed previously, subsequent to suppressed convection.

In the vicinity of the enhanced convection, cloud shielding and enhanced latent heat flux serve to cool the local SST, resulting in a zonal gradient of SST with warmer values to the east that may provide the impetus for convection to develop further east. To the west of the convection evaporative cooling dominates, particularly over the Indian Ocean from day 0 through day +10 where below normal SST coincides with the enhanced latent heat flux seen in Fig. 1. As a result the western limit of the convection is eroded. These results suggest that it is the local gradient of SST that is important for the eastward migration of the IO. This cycle of suppressed convection east of the convection, leading to increased SSTs and eastward migration of the convective envelope at subsequent pentads, with conditions in the west that serve to decrease SSTs and convection, is consistent with the conceptual model of Flatau et al. (1997) for maintaining eastward propagation of the intraseasonal oscillation, and observations from the western Pacific Ocean (Zhang 1996, Lau and Sui 1997).

Although Slingo et al. (1996) discuss reasons for the poor simulation of IO variability, the overall lack of skill exhibited by the models suggests that the IO may have to be treated as a coupled ocean-atmosphere mode. It is anticipated that additional insight will be gained from further analysis of data from the TOGA-COARE IOP during which several strong intraseasonal oscillations occurred. However, the dearth of in situ observations over the Indian Ocean is particularly troubling, especially given the models shortcomings over this domain. Extending the TOGA-TAO array into the Indian Ocean would be beneficial for understanding the ocean-atmosphere interactions over this region, and for the study of transitions between the Indian Ocean and western Pacific.

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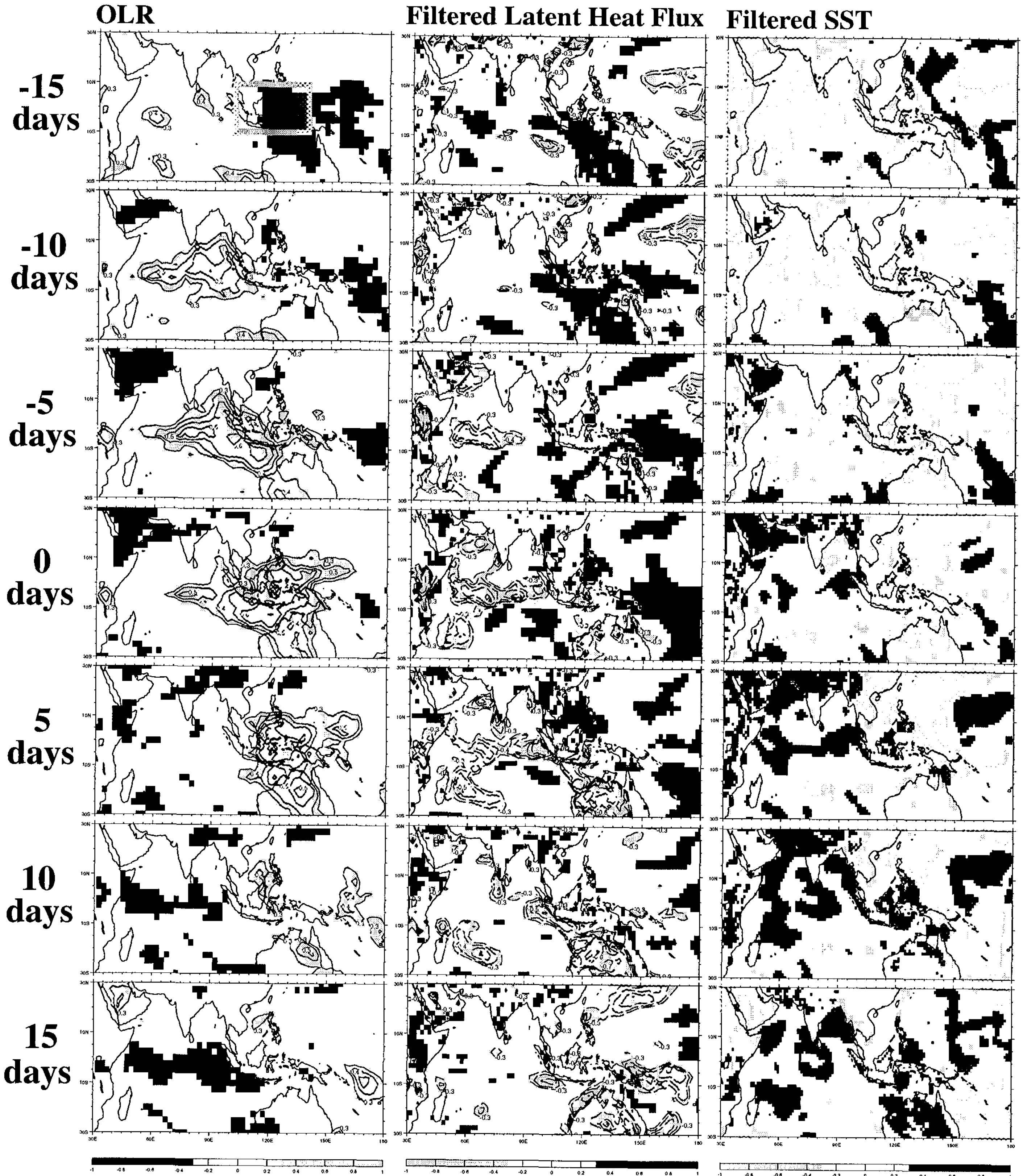

Fig. 1. Correlations of the IO index with NOAA OLR, filtered NCEP/NCAR reanalysis latent heat flux, filtered observed SST (and surface skin temperature over land from the ECMWF reanalysis) for the case study period of November 1987-May 1988. Correlations significant at ≥95% confidence level are shown. Grey shading indicates enhanced convection, enhanced latent heat flux, and above normal SST in each column respectively. Correlation coefficient contours are plotted for enhanced convection and enhanced latent heat flux beginning at |0.3|, at an increment of |0.1|. The box in the upper left panel is the region from which the IO index was obtained.

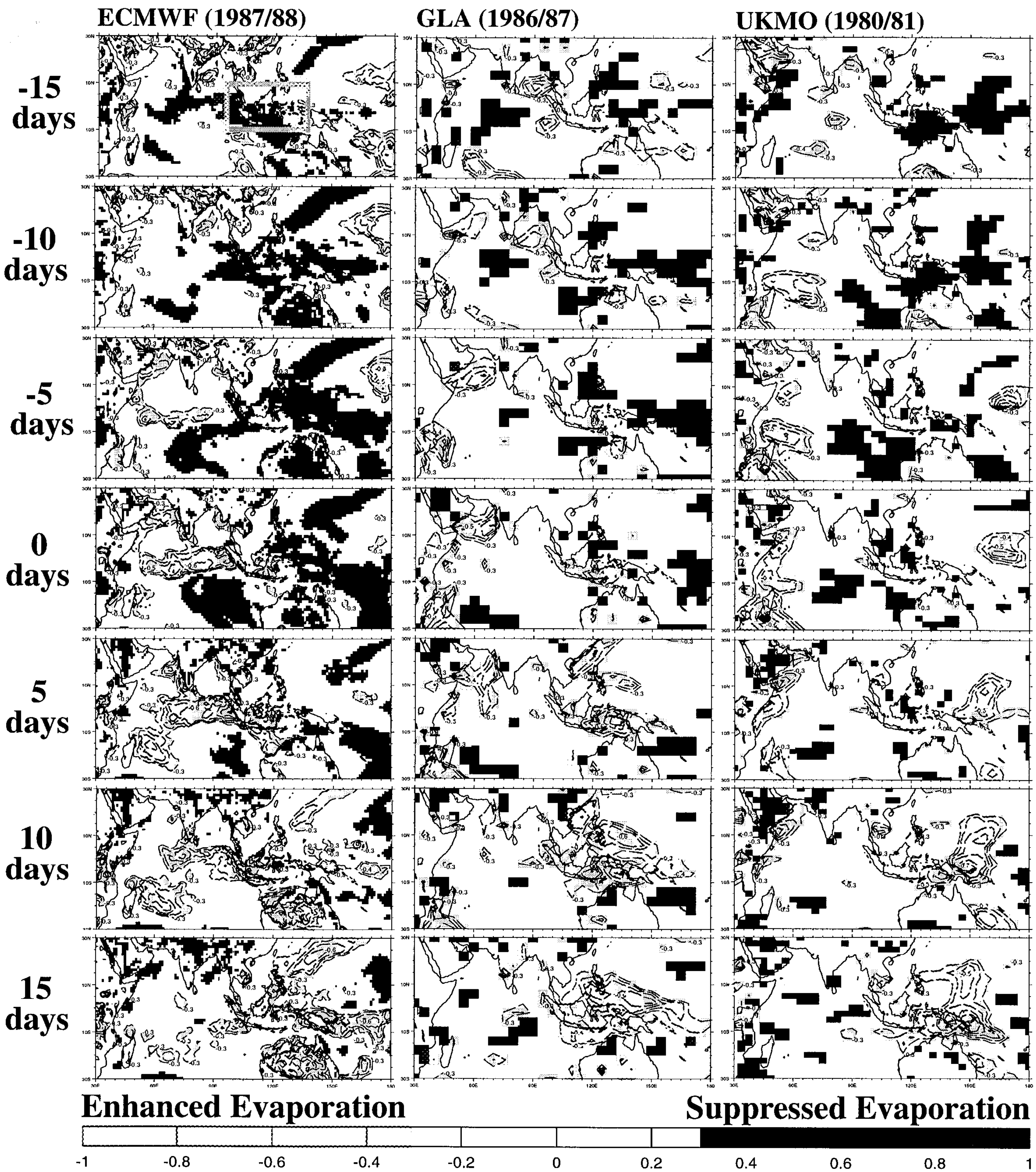

Fig.2 Correlations of the IO indexes with filtered latent heat flux from the ECMWF reanalysis (November 1987-May 1988), the GLA (November 1986-May 1987) and the UKMO (November 1980-May 1981) case study periods. Grey shading indicates enhanced latent heat flux (evaporation) with correlation coefficient contours plotted beginning at -0.3 at an increment of -0.1. The box in the upper left panel is the region from which the IO index was obtained.

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