Supporting Information for "The two diurnal modes of tropical upward motion"

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Introduction

A sensitivity simulation is conducted to quantify the direct influence of ice–shortwave absorption on the diurnal variations of vertical motion ω, which is identical to the primary simulation described in the study (CTLSIM) except with cloud ice hydrometeors set to be transparent to both longwave and shortwave radiative fluxes (RADICEOFF). The transparency is implemented for both the longwave and shortwave fluxes because their respective heating tendencies often cancel to a large degree; thus, if clouds are only made transparent to shortwave fluxes, spurious responses in circulation and convection would likely develop near the tops of anvils where longwave cooling is strong. The simulation is initiated from the state of CTLSIM at day 10, and integrated for 5 days. A composite is then generated by averaging the simulation as a function of local time (L).

The simulations CTLSIM and RADICEOFF are compared in Fig. S1, which shows time-mean profiles of ω for all regions and time-height series of ω for EPAC and IO. The CTLSIM composite is from 10–14 d (inclusive), which corresponds to the 5-d integration period of RADICEOFF. (Note that this period is distinct from the composite period used in the paper.) The mean profiles of RADICEOFF exhibit differences from CTLSIM due to the transparency of high clouds. This comparison requires caution, as the idealization causes these simulations to drift toward slightly distinct climates. Yet the influence of ice cloud–shortwave absorption on the diurnal variation of ω is evident from the comparison of the time–height series. In EPAC, both simulations exhibit a pronounced increase in upward motion in the morning in the lower troposphere (diurnal range of $\sim$2 hPa h^{-1} around 3 km) in response to nocturnally enhanced deep convection and latent heating. The phase-shifted variation of upward motion in the upper troposphere, however, is reduced by a substantial measure in RADICEOFF: the diurnal range is 1.7 hPa h^{-1} at 10 km in CTLSIM, and 1.1 hPa h^{-1} in RADICEOFF (a 35% reduction). This effect is accentuated in the more top-heavy IO region (which implies much more prevalent cloud ice; see Fig. 3 of paper), with a 43% reduction of diurnal range in RADICEOFF (the effect of making ice clouds transparent also generally disrupts the diurnal cycle in IO). That the diurnal variation of ω at upper levels is weakened yet remains in RADICEOFF attests to the likely additional role of water vapor and liquid clouds in absorbing diurnal shortwave flux in the deep convection zones.

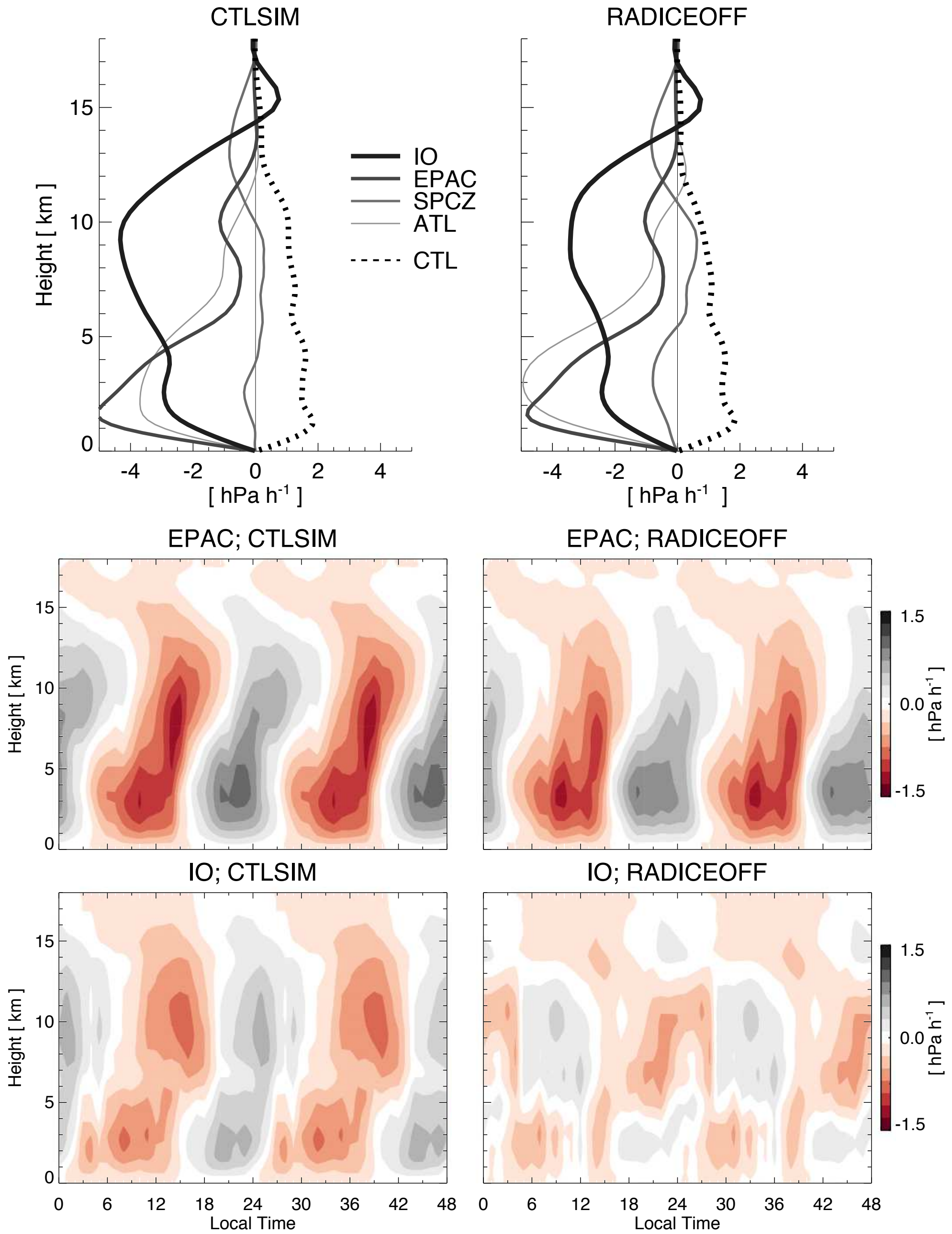

Figure S1. (upper) Profiles of mean vertical pressure velocity ω in simulations (left) CTLSIM and (right) RADICEOFF for each composite region (see Fig. 1 of paper). Time–height series of ω with the mean subtracted for (middle) EPAC and (lower) IO.