Diurnal cycle of tropical deep convection: a diagnostic study in ARPEGE

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Numerical Weather Prediction models or climate models are expected to predict (i) the right mean atmosphere state variables, e.g. temperature fields, (ii) the right mean fluxes, e.g. precipitation fields, and (iii) the right sensitivities and bifurcations, like the response of the atmosphere to a change in the gaseous composition or the right frequency of zonal versus blocking flows over the mid-latitudes. The first question addresses a 0 order problem, with respect to time derivatives: reducing variables biases. The second question addresses a 1st order problem: having the right tendencies for each individual physical process, in the mean time. The third question is the most difficult and is a 2nd order problem: having the right tendencies of the tendencies, i.e. the right bifurcations between meteorological attractors and feedbacks between atmospheric processes.

The way to deal with the first question is to compute biases, useful observations for that purpose are available on the Global Observing System. To deal with the second question, Single Column Modelling and comparisons versus Cloud Resolving Models may be done, and observations now become more offently available from Intensive Observation Periods. Tools to deal with the third question are emerging, and focus on sensitivity aspects and studies of non-stationnary states, like transition from stratocumulus to cumulus regimes, interactions between cyclogenesis and jets in the deepening process, or diurnal cycle.

The Figure compares predicted versus observed diurnal cycle of precipitation in the Tropics: observations[2] show that deep convection peaks in the morning over oceans, and in the evening over continents. The results from both a climate model[2] (University of Reading, Met-Office) and a Numerical Weather Prediction model (Meteo-France) present a quite similar behaviour, and show a large phase lead with respect to observations, on both oceans and continents. This indicates some major problems in individual parameterizations like clear sky turbulence, shallow convection, deep convection, and / or their feedbacks in a continuous transition process.

This kind of diagnostic is a powerful tool to improve our understanding of the atmospheric physics, at least in the tropics. Other related actions are in progress to deal with these 2nd order problems inside NWP and climate models, like the European Cloud Systems project, involving both sensitivity and deep convection diurnal cycle studies, in a SCM versus CRM validation approach.

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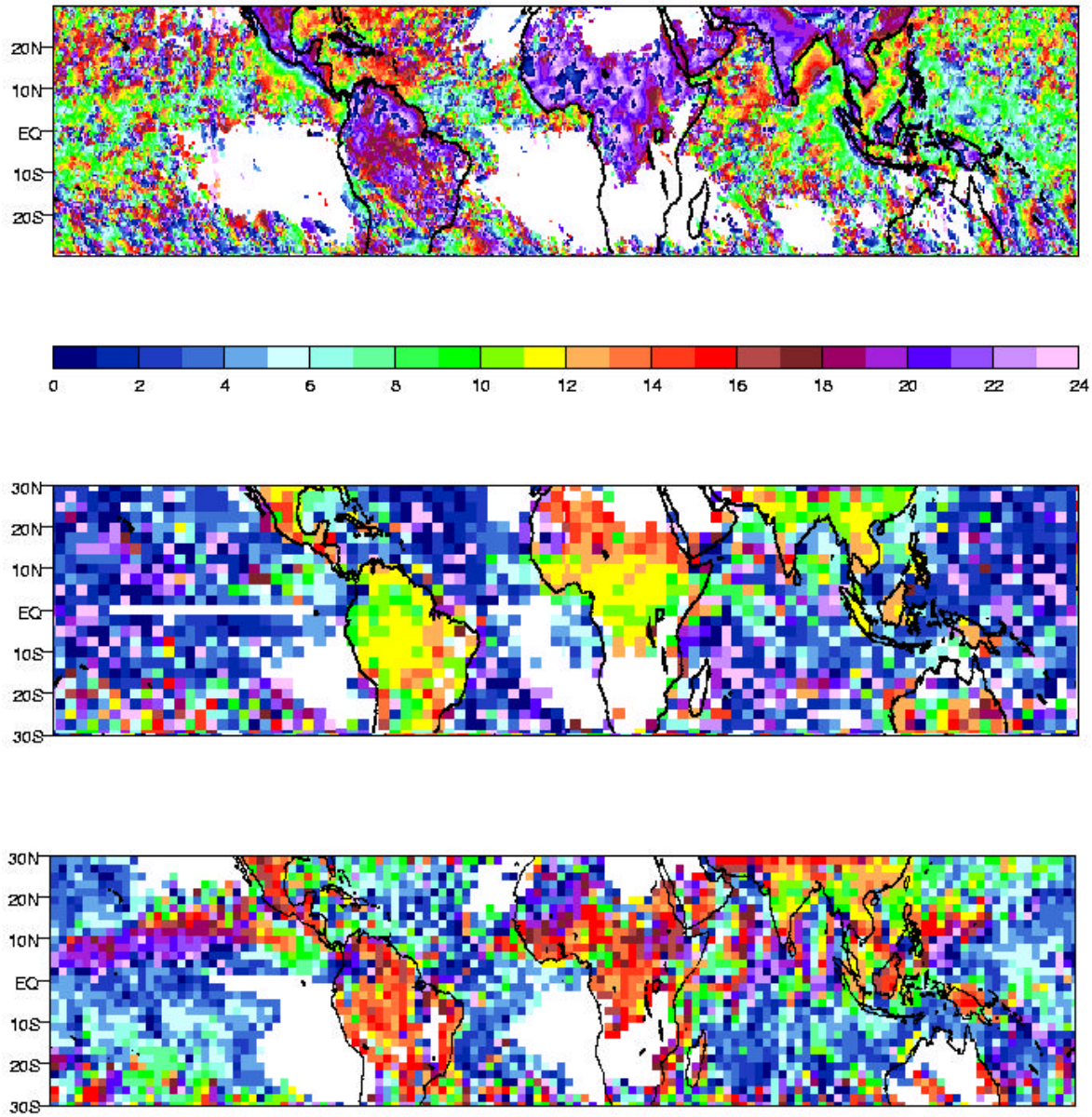
[2] With the courtesy of Prof. Julia Slingo, The University of Reading, UK



Mean phase of the diurnal harmonic of precipitation for JJA from (a) high resolution satellite window brightness temperatures, (b) the Unified Model (version HadAM3), and (c) the ARPEGE NWP Model. Local solar time of the maximum is given. (a) and (b) with the courtesy of Prof. Julia Slingo, The University of Reading, UK, from the article: Yang and Slingo 2001, Monthly Weather Review Vol. 129, No. 4, pp. 784-801.