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Generalized dynamics of monsoon and sea-land breeze circulations

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In the maritime continent the diurnal cycle is the most dominant component of wind (sea-land breeze) and rainfall, and other components such as the annual cycle (rainy season or monsoon, in particular in the southern-hemispheric part) appear as amplification of the diurnal cycle. The diurnal and annual cycles are both induced by the insolation varying astronomically with time (local time and season) and location (latitude and longitude). If the Earth's rotation is much slower (like Venus), these two periodicities are not clearly distinguished. If the Earth is an aqua planet without lands or a land planet without seas, only global modes between winter-summer hemispheres (like Martian atmosphere and Earth's middle atmosphere) or between day-night hemispheres (i.e., diurnal tide) are generated. Because of land-sea heat contrast, local modes around the coastlines are generated and are more dominant.

A quasi-two-dimensional (zonally uniform but permitted to move) linear convection equation on the equatorial beta-plane for a periodically-oscillating equatorially-anti-symmetric heating such as the case of a coastline along the equator (between the northern and southern hemispheres covered totally by land and sea, respectively) is analytically solved. For a periodicity shorter than the local Coriolis period (e.g., diurnal cycle near the equator) the solution becomes a sea-land breeze circulation (purely meridional in this case) consisting of a pair of internal (almost non-inertial) gravity waves, and the motion becomes non-hydrostatic and ageostrophic. For a periodicity longer than the earth's rotational period (e.g., annual cycle in the extratropics) the solution becomes a monsoon circulation consisting of mixed Rossby-gravity and Rossby waves with zero zonal wavenumber, and the motion is quasi-hydrostatic and quasi-geostrophic. In the latter vertical velocity is associated mainly with inertia-gravity waves, as so far shown by Kosaka and Matsuda (2005) for a steady heating.

In the Earth's history continent-ocean distribution is varied with 10^2 Myears, and glacier-interglacier oscillation is with 10^2 Kyears (due to variation of the Earth's rotation and revolution, known as Milankovic cycle). Variations of tropical rainfall and their effects on the global climate are discussed.

Keywords: monsoon, diurnal cycle, air-sea-land interaction, climate history, planetary rotation and revolution