Equatorial coastlines controlling Earth's atmosphere

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Just half a century has passed since the theories of vertically evanescent tides (Kato, 1966) and equatorially ducting modes (Matsuno, 1966) as varieties of atmospheric gravity waves. Horizontal convections as superimpositions of upward/downward gravity waves are generated between dayside and nightside hemispheres and between land and sea surfaces by insolation with diurnal cycles. Importance of the latter category, so-called sea-land breeze circulation, has been emphasized by ground-based and space-borne observations over the equatorial troposphere. The cloud activity has diurnal and annual cycles dominantly on land, in contrast to intraseasonal and interannual variations mainly over oceans, and the tropical rainfall amount is expressed by functions of coastal distance and length (Ogino et al., 2016; Yamanaka, 2016). This explains the global cloud activity-rainfall maximum located over the Indonesian maritime continent (IMC) with the world’s longest coastlines.

The diurnal cycle is generated directly by land-sea temperature contrast along a coastline: solid land becomes hotter than liquid sea by solar heating through clear sky before noontime, and opposite contrast appears before the sunrise by evening rainfall-induced sprinkler-like land cooling in tropics (different from infrared cooling at clear night in extratropics). This is why the diurnal cycle is dominant in the rainy season, and also why the rainy season appears exactly in the summer-side hemisphere, because land heating in the clear morning and water-vapor transport by afternoon sea-wind are strongest in the season of maximum insolation. El Niño causes less rainfall, because lower sea surface temperature makes morning maritime convection weaker.

Those lower-atmospheric features are reflected in the middle- and upper atmospheric dynamics. As suggested so far (e.g., Ogino et al., 1995; Tsuda et al., 2000), the stratospheric gravity-wave activity takes maximum near the equator and in particular near IMC as does the convective activity. Here it is suggested from the latter that these activities are generated with diurnal cycles and horizontal scales of about 300 km along coastlines, which are fixed with the major islands and the whole IMC with zonal scales of 1,000 and 5,000 km, respectively. 14-year hourly 25 km-resolution cloud-top height data are analyzed to show spectral slopes of around -2 for frequency and -5/3 and -3 for higher and lower zonal wavenumbers (with a border of about 300 km in zonal wavelength), as have shown already for tropopausal gravity waves or quasi-two dimensional turbulence (e.g., Nastrom and Gage, 1985). A part of the insolation over equatorial lands sequentially with Earth’s rotation may contribute (through infrared absorption) to generation of migrating tides. All the features mentioned here appear on a land-sea coexistent planet like Earth, and differences in other planets are also discussed briefly.

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