

Tropical coastal dehydrator: A new view in global atmospheric water circulation

*Shin-Ya Ogino¹, Manabu D. Yamanaka¹, Shuichi Mori¹, Jun Matsumoto^{1,2}

1. Department of Coupled Ocean-Atmosphere-Land Processes Research, Japan Agency for Marine-Earth Science and Technology, 2. Department of Geography, Tokyo Metropolitan University

1. Introduction

Water plays an essential role in global climatological energy budget through the transport and release of latent heat, and through radiative processes. Clarifying the water circulation is necessary for understanding the Earth's climate. Previous studies estimated the global water budget between the ocean and the land by separating Earth into two regions (ocean and land), and provided a basic view: Evaporation is greater than precipitation over the ocean, and vice versa over the land, and the consequent imbalance is compensated for by the landward water vapor transport and by river discharge to the ocean (Fig. 1 (a)).

A remarkable amount of precipitation occurs over the coastal region in tropics associated with the land-sea breeze especially over the Indonesian maritime continent (e.g., Mori et al., 2004). We recently quantified the annual precipitation in the tropics as a function of distance from the coastline, and showed that the tropical precipitation over the coastal region occupies the one third of the total precipitation over the whole tropics (Ogino et al., 2016).

Here we re-examine the ocean-land water circulation taking into account tropical coastal precipitation.

2. Data and method

We estimated the landward water vapor transport from the column water vapor flux of thirty-year JRA-55 data from 1981 to 2010.

3. Results

The landward water vapor transport peaks at about 150 km offshore, and rapidly decreases over the coastal region stretching a few hundred km inland from the peak (Fig. 1 (c)). About half of the water vapor transported inland from the oceans precipitates out along a coastal region, and the rest can reach inland. We can recognize that coastal precipitation plays the role of a dehydrator along the ocean-land water vapor transport route. Based on this fact, we propose an updated view that separates the globe into three regions: open ocean, coastal region, and inland, which represents the actual ocean-land water circulation (Fig. 1 (b)).

4. Discussions

The global water circulation affects the maintenance of the Earth's climate through the energy and radiation budget. Especially, Yamanaka (2016) suggested a possibility that the maritime continent with the world's longest coastlines may produce the largest precipitation on Earth. We showed that latent heating due to tropical coastal precipitation occupies about 20% of global total (Yamanaka et al., 2017).

The coastline distribution may interact with the interannual change of climate: Climate change may cause the sea level change, which result in the changes in length, shape, and distribution of coastlines. The continental aggregation and dispersal on a geological time scale may also change the coastlines. Those coastline changes cause climate changes through the distribution and intensity changes in the coastal precipitation.

5. Summary

We proposed a new concept on global ocean-land water circulation, three-region model that consist of open ocean, coastal region, and inland, taking into account the coastal precipitation. About a half of the water vapor is consumed as coastal precipitation, and the rest of the water vapor reaches the inland (Ogino et al., 2017).

The next step in our research is to clarify the mechanism that drives the tropical coastal dehydrator and its role in the atmospheric general circulation. Our approach to describe the physical quantities as a function of distance from the coastline can be applied to various purposes to investigate the ocean-land interaction, which will deepen our understanding on the Earth's climate. Our approach to describe the physical quantities as a function of distance from the coastline can be applied to various purposes to investigate the ocean-land interaction, which will deepen our understanding on the Earth's climate.

References

- Mori, S., et al., 2004, Mon. Wea. Rev., 132, 2021-2039.
Ogino, S.-Y., et al., 2016, J. Clim., 29, 1231-1236.
Ogino, S.-Y., et al., 2017, Geophys. Res. Lett., 44, 11,636-11,643.
Trenberth, K. E., et al., 2009, Bull. Amer. Meteor. Soc., 90, 311-323.
Yamanaka, M. D., 2016, Atmospheric Research, 178-179, 231-259.
Yamanaka, M. D., et al., Prog. Earth Planet. Sci., accepted.

Keywords: Ocean-land water circulation, Coastal precipitation

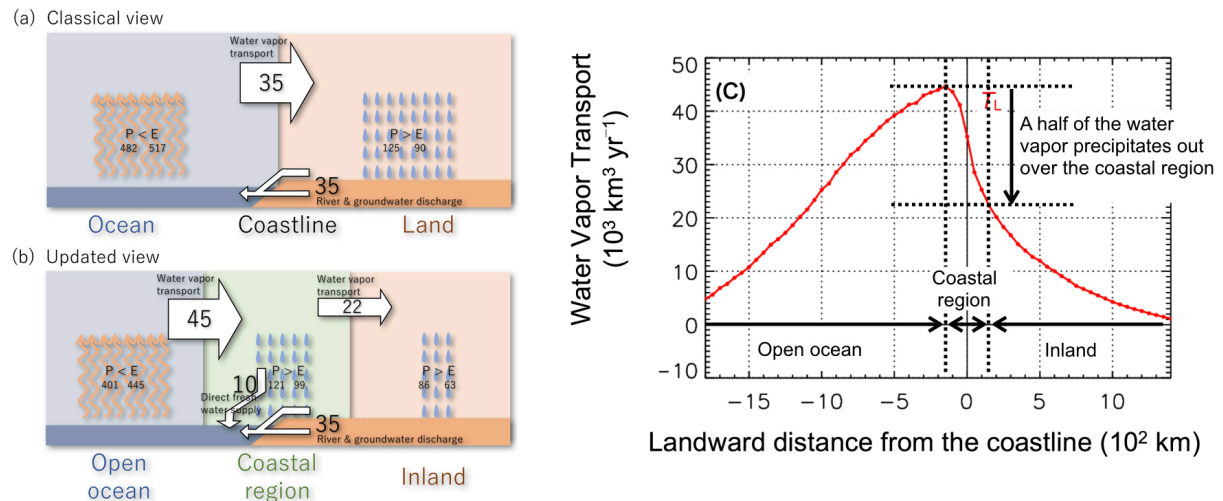


Figure 1: Schematic figures of global ocean-land water circulation: (a) A classical two region view and (b) an updated three-region view. (c) Landward water vapor transport estimated from the JRA-55 column water vapor flux data.