

The Tropical Atmospheric Conveyor Belt: A Coupled Eulerian-Lagrangian Analysis of the Large-Scale Tropical Circulation

Dana Raiter, Eli Galanti and Yohai Kaspi
Weizmann Institute of Science

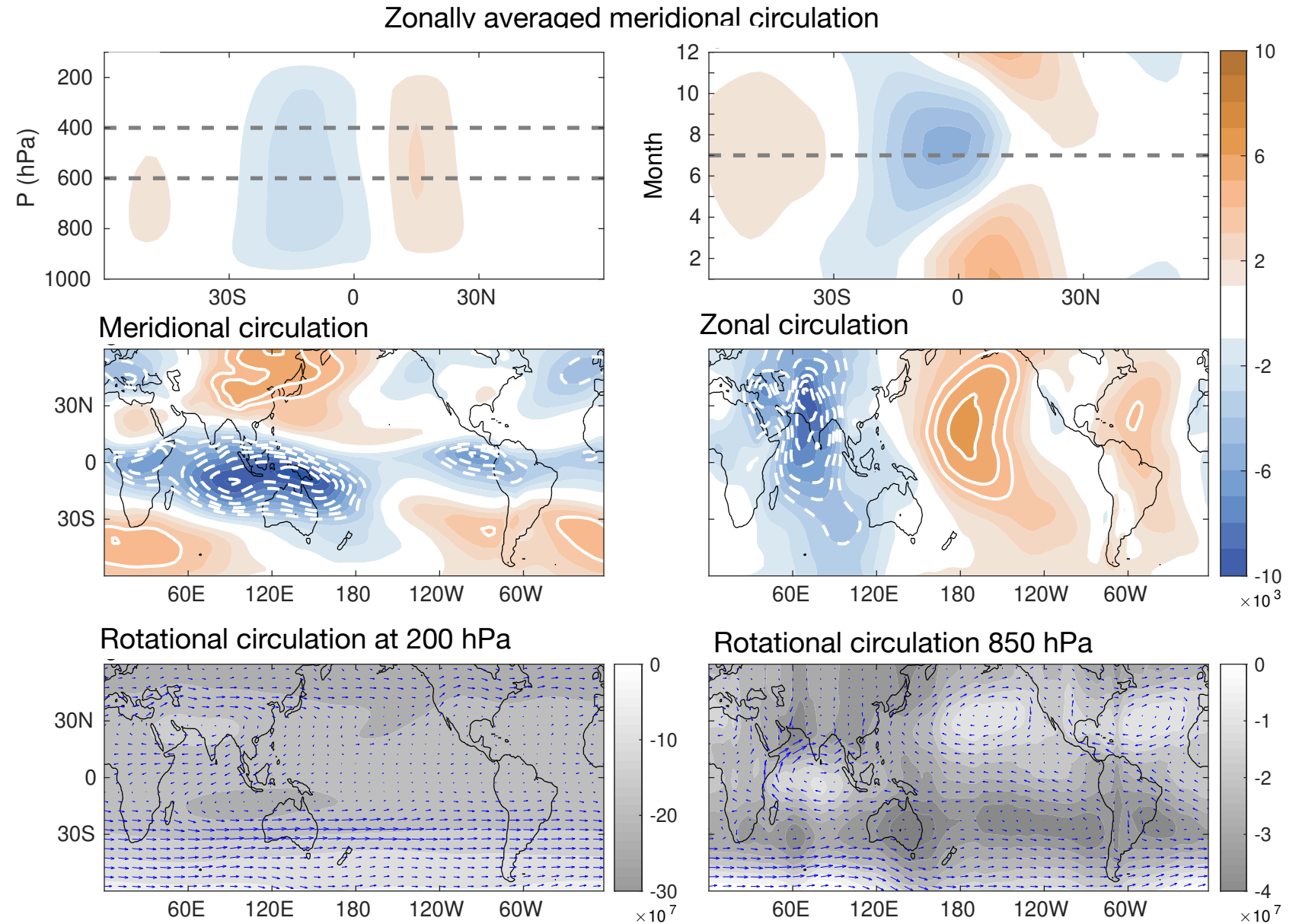
Raiter, D., Galanti, E. & Kaspi, Y. (2020). The tropical atmospheric conveyor belt: a coupled Eulerian-Lagrangian analysis of the large-scale tropical circulation. *Geophys. Res. Lett.* <https://doi.org/10.1029/2019GL086437>

Motivation

The Hadley circulation (HC) is traditionally defined as the zonally averaged meridional circulation in the tropics, therefore treated as a zonally symmetric phenomenon. However, differences in temperature between land and sea cause zonal asymmetries on Earth, dramatically affecting the circulation. The longitudinal dependence of the HC evokes questions about where and when the actual large scale tropical circulation occurs. **In this study, we look into the connection between the longitudinally dependent HC and the actual large scale movement of air in the tropics using a coupled Eulerian and Lagrangian approach.**

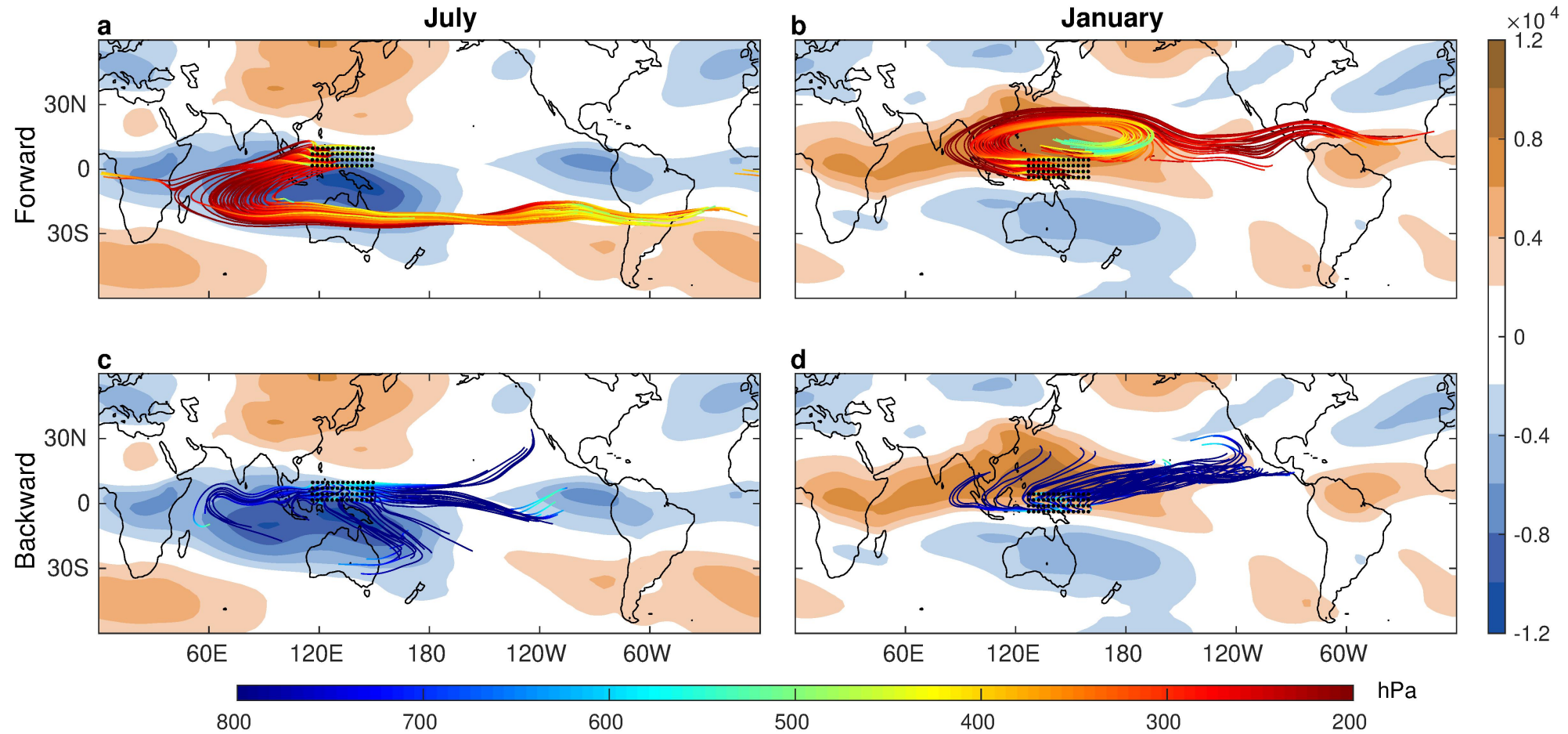
Eulerian Approach

We use the **Helmholtz decomposition** to decompose the velocity field into rotational and divergent components, and calculate the zonal, meridional and rotational circulation as function of longitude and latitude.



Using Era-Interim reanalysis data for July from 1979-2018

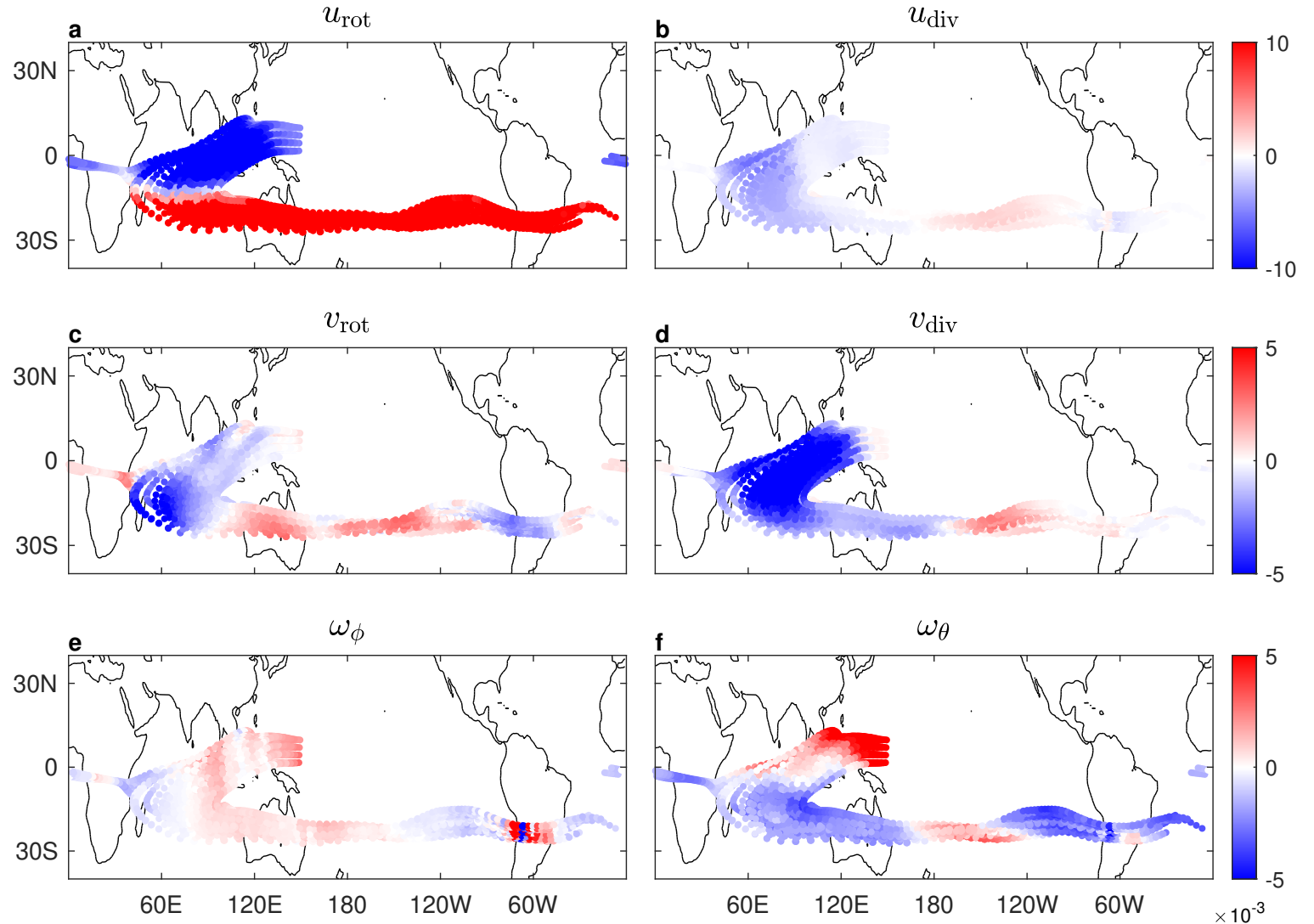
Lagrangian Approach



- We calculated the mean flow trajectories.
- Starting positions are marked in black dots.
- Color indicates height.

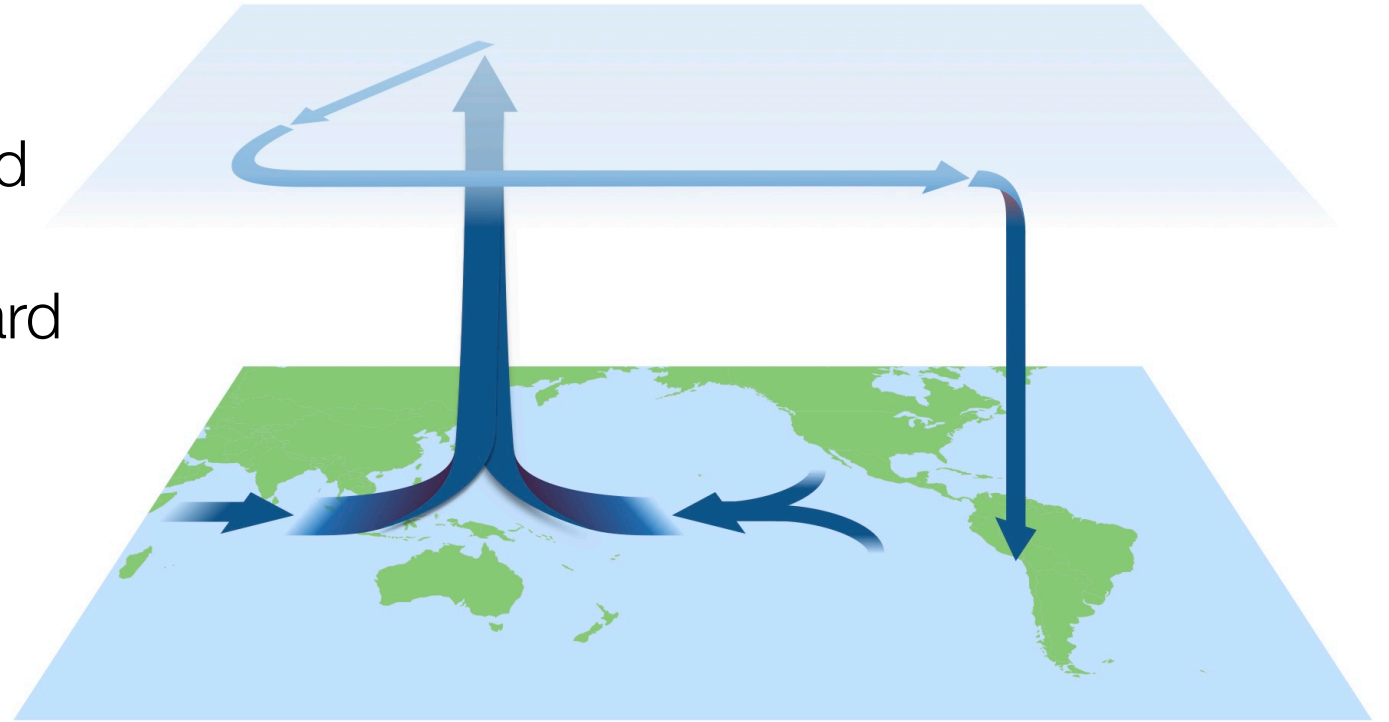
Combined Eulerian-Lagrangian Approach

We present the contribution from the different velocity components at the locations of the air parcels in the mean flow trajectories.



The Tropical Atmospheric Conveyor Belt

- Air converges into the Indo-Pacific Warm Pool, which acts as the engine of the circulation.
- This air ascends, moves westward in the upper levels with the rotational winds, and then poleward with the meridional circulation.
- It reaches approximately 25°S (or 25°N in the opposite season) merges into the jet stream and moves rapidly to the east.
- Finally, it descends near the Americas.



Summary

- **Eulerian approach:**
 - The meridional circulation has strong longitudinal dependence.
 - Strongest values of the Longitudinally dependent meridional circulation are measured in the Indo-Pacific region.
- **Lagrangian approach:**
 - Mean flow trajectories show dominating movement of air parcels participating in the circulation.
 - The motion of these air parcels is influenced from all components of the velocity field (e.g., meridional circulation, trade winds, jet stream).
- Combining the Eulerian and Lagrangian approaches, we are able to analyze the circulation in the tropics considering all aspects of the circulation, without any presumptions.
- The tropical conveyor belt, accurately represents the circulation in the tropics and shows the regionality and three-dimensionality of the circulation as manifested in the Eulerian and Lagrangian analyses.