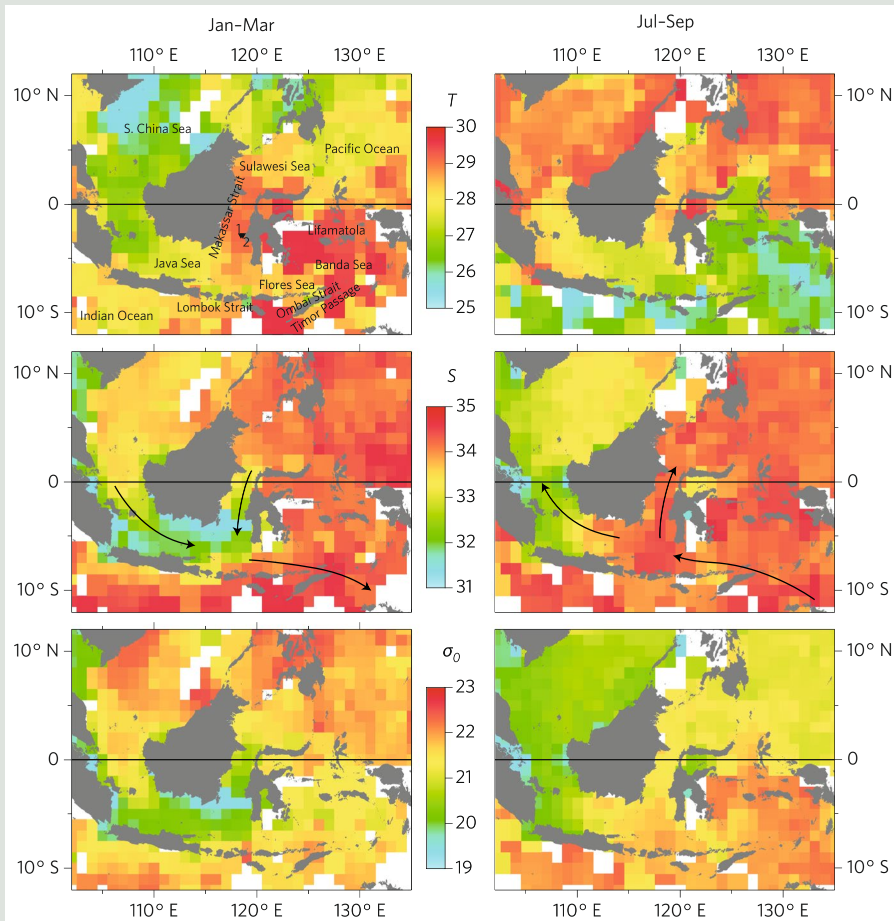
ANNIVERSARY RETROSPECTIVE

Tropical interchange

In Earth's past, the tropical seas encircled the globe. Today, the only tropical ocean exchange occurs in Indonesia. Here, water from the Pacific meanders through the Sunda Islands before entering the Indian Ocean. The bulk of the Indonesian throughflow passes through a single strait, nestled between Borneo and Sulawesi islands. Even though the Makassar Strait sits at the heart of the Indo–Pacific warm pool, and the water entering it has previously traversed the tropical Pacific, the mean transport of the Indonesian throughflow is fairly cool, well under 20 °C. In 2003, Arnold Gordon and colleagues unravelled the mystery of this relatively cold transport, and inspired part of my own PhD project.

Gordon and colleagues showed that the key to this cool flow lies in the surface salinity of the Makassar Strait (*Nature* **425**, 824–828; 2003), specifically, in seasonal salinity variations in the southern end of the strait. Water in this region is fairly low in salinity to start with, at least by ocean standards. Gordon et al. showed that from January to March, winds blowing to the northwest push low-salinity surface water from the Java Sea into the southern end of the Makassar Strait. This freshwater plug blocks the surface flow — sometimes even resulting in northward flow in the upper 50 metres. With surface flow limited for some months of the year, the greatest transport of Indonesian throughflow occurs at about 200-m water depth, where water is much cooler.

For me, the most exiting finding was that the salinity difference between the northern and southern end of the Makassar Strait can be used as a rough measure of whether warm surface water is transported in the Indonesian throughflow. Quite conveniently, a suite of marine sediment cores was collected from this region in 1998, including two long, high-resolution cores at the northern and southern end of the Makassar Strait that were to form the basis of my PhD work. I was inspired to use a fairly new combination of geochemical measurements on surface-dwelling foraminifera to try to track this salinity difference over the past 2,000 years. Together with my supervisor Robert Thunell, I was able to document centennial-scale variations in surface transport through the Makassar Strait that broadly co-varied with changes in the El Niño–Southern Oscillation.



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After I moved to *Nature Geoscience*, I soon realized I was not the only one inspired by this work; the resulting efforts spanned a range of timescales. A look at recent years identified further links between heat transport by the Indonesian throughflow and the El Niño–Southern Oscillation and the Indian Ocean Dipole (*Nat. Geosci.* **7**, 487–492; 2014). A Holocene-long reconstruction suggested that the infamous freshwater plug may only have appeared following the submergence of the Sunda shelf at the start of the Holocene (*Nat. Geosci.* **3**, 578–583; 2010). And related work by Gordon and colleagues formed a key basis of an article that showed that the restriction of the Indonesian gateway to its present configuration about three million years ago caused the thermocline in the tropical Indian Ocean to shoal (*Nat Geosci.* **2**, 434–438; 2009).

The importance of the Indonesian throughflow was certainly appreciated well before 2003. But Gordon and colleagues were able to explain why it was relatively cool, and hint at the relationship between the Indonesian throughflow and regional wind patterns. This became a cornerstone of efforts to explore the oceanographic impacts of this current and how it interacts with Pacific climate. ❐

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