Ocean Depth Affects Local Climate

It is well known that topography of the land surface affects weather and climate. For example, the Pacific Coast of South America is desert, while Amazonia on the other side of the Andes is rich in rainfall and hosts the largest rain forest of the world. On the global scale, the Tibetan Plateau is a controlling element in Northern Hemisphere climate. Even the tall mountains of the tiny Hawaiian Islands have been shown to exert far-reaching effects on the Pacific Ocean and atmosphere.

The influence of the shape of the ocean bottom on climate, however, has been studied less widely. To many, it may even sound absurd that submerged bottom topography can change winds and clouds. A team of scientists at the IPRC (**S.-P. Xie, J. Hafner,** and **H. Xu**), the Jet Propulsion Laboratory (**W.T. Liu**), and Hokkaido University (**Y. Tanimoto** and **H. Tokinaga**) has detected such an improbable bathymetric effect on the winter climate of the Yellow and East China Seas.

These seas, located between China, Korea and Japan, together form one of the largest shelf seas of the world. They are shallow, ranging in depth from a few meters to not much more than 100 m; but their bottom topography is uneven with deeper and shallower tongue-like regions. The team has discovered that during winter the sea surface over the deep channels is warmer than over the shallow parts (Figure 3a). They propose the following mechanism to account for this relationship. The northerly monsoon winds carry the frigid and dry continental air over the seas, cooling their surface. Heat is transferred from the ocean bottom upward through convection. The deeper the area, the more heat it contains, and the slower the surface cools so that the cooling rate of the water column is determined by its thickness. In other words, shallow regions cool much faster than the deep channels. This mechanism may combine with the advection of warm Kuroshio water (see p. 3) by shelf currents. A quantitative assessment of how much the warm Kuroshio water contributes to the warm SST tongues during winter in the Yellow and East China Seas must await further observations in this, as yet, little charted region.

The bathymetric effect of the seas does not stop with causing variations in the sea surface temperature (SST). New measurements with the QuikSCAT and TRMM satellites reveal remarkable spatial co-variations in wind speed and SST. High winds and increased cloudiness are found over the bathymetric-induced warm tongues. One such band of ocean-atmosphere co-variation meanders through the Yellow Sea between China and Korea, following a deep channel for 1000 km (Figure 3b). The mechanism for this ocean effect on the winds is thought to be the convectively induced vertical mixing in the atmosphere over the warm tongue, similar to that over the Kuroshio (see p. 3).

The Kuroshio is steered northeastward along the shelf break, where there is another bathymetric effect (Figure 3a). A sharp SST front forms in winter between the warm Kuroshio and the cold shelf water. Examining ship logs of the past 30 years, the team found that the static instability of the atmosphere near the surface—measured by the difference between air and sea surface temperatures—peaks at the Kuroshio (Figure 3c). This instability causes strong vertical mixing that brings down swift winds from aloft to the surface, producing a local maximum in surface wind speed on the warmer flank of the Kuroshio front, as observed by the QuikSCAT satellite (Figure 3b). The strong atmospheric convection further manifests itself as a band of precipitating clouds that is fueled by the moisture supply from converging surface winds (Figure 3d). The wind convergence appears to result from both the hydrostatic pressure and the convectively induced accelerations of cross-frontal flow at the surface. Satellite images capture both this cloud band and the wind convergence.

Suggested Further Readings:

Ichikawa, H. and R.C. Beardsley, 2002: The current system in the Yellow and East China Seas. J. Oceanogr., 58, 77-92.

Xie, S.-P., J. Hafner, Y. Tanimoto, W.T. Liu, H. Tokinaga and H. Xu, 2002: Bathymetric effect on the winter sea surface temperature and climate of the Yellow and East China Seas. *Geophys. Res. Lett.*, DOI 10.1029/2002GL015884R, in press.

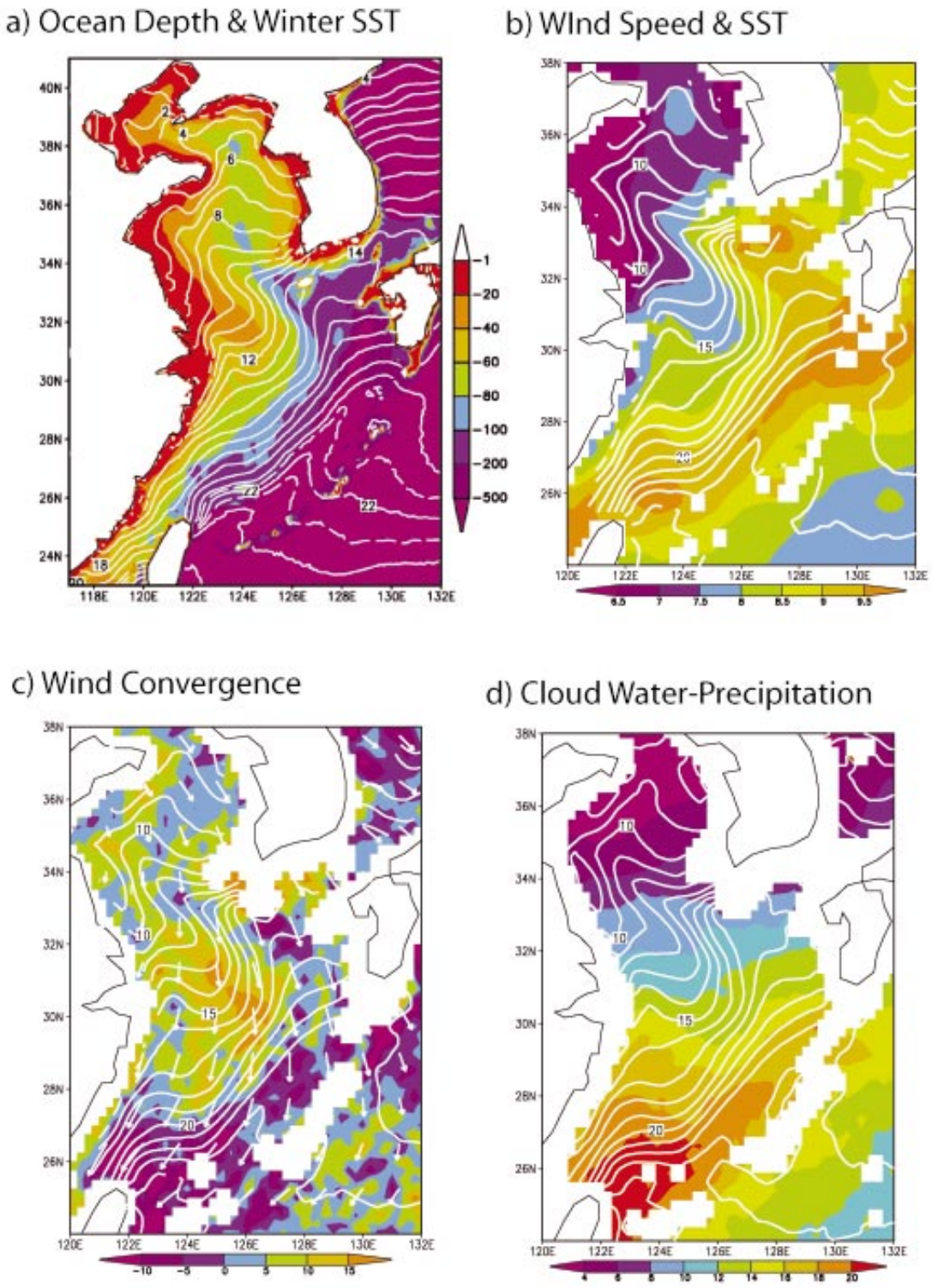

Figure 3: *Winter climate in the Yellow and East China Seas and the adjacent Kuroshio region. White contours represent sea surface temperatures (in °C): (a) Bottom depth (color: in m); (b) speed (color: in m/s); (c) convergence of surface wind (color: in $10^{-6}s^{-1}$); and (d) cloud liquid water (color: in 10^{-2}mm).*