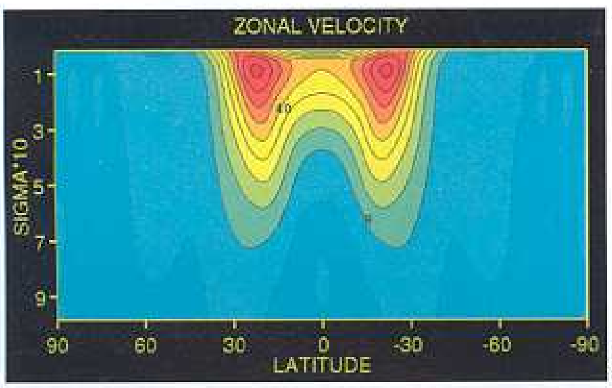
Super Circulations

In global circulation models, baroclinically unstable zones in midlatitudes normally produce medium-scale planetary waves that propagate toward the Tropics, where they generate easterlies while transferring westerly momentum poleward to maintain the jet. When the baroclinically unstable zone is moved into low latitudes, however, the equatorward side of the jet can also produce a barotropic instability whose large-scale eddies lead to a strong superrotating westerly current at the equator. A stable superrotating regime exists when the baroclinicity center lies equatorward of 20° and implies that an alternative terrestrial climate could occur.

Westerly winds are rarely observed at the equator in the troposphere. But they occasionally arise in models that are subject to an additional low-wavenumber forcing in the Tropics. The main problem in understanding the superrotating regime involves finding wave sources, such as the barotropic instability, that can produce a strong permanent equatorial westerly under simple conditions.

In new calculations with a simplified global, multilevel, spectral, primitive equation model, the low-latitude jets are developed for a wide range of rotation rates. The model omits moisture, topography, and interhemispheric asymmetries. Using such a model helps isolate the cause of the superrotation found earlier at high and low rotation rates for a more comprehensive, moist circulation model.



The meridional structure of the mean tropical jets and the equatorial superrotation as defined by a contour interval of 8 m s^{-1}, a maximum of 75 m s^{-1}, and dotted lines for the zero values. The vertical sigma coordinate involves the pressure normalized by its surface values.

As well as providing a measure of the stability and variability of Earth's climate, the existence of a stable superrotating regime at all rotation rates implies that other planets could also have such a state. Observations show that equatorial westerlies do indeed dominate the atmospheric motions of Jupiter, Saturn, and Venus. But whether or not a stable superrotation can exist in more complete terrestrial models with a strong seasonal variation has yet to be resolved.—G.P. Williams (NOAA/GFDL). *"Barotropic Instability and Equatorial Superrotation," in the 1 September* Journal of the Atmospheric Sciences.

Such a climate requires high temperature gradients in low latitudes and low temperature gradients in high latitudes, a state that would most likely occur under glacial conditions. The regime can exist for all rotation rates that allow baroclinic and barotropic instabilities.