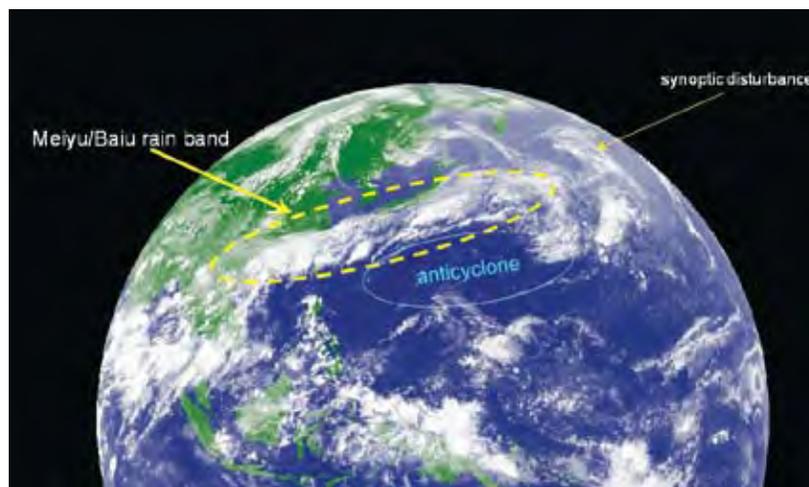


# Jet Stream Anchors Meiyu-Baiu Rainband



Satellite image of Meiyu-Baiu on June 12, 2008 (by Japan Meteorological Agency).

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The weather in June and early July is typically gloomy for residents in much of Japan and eastern China along, and south of the Yangtze River. Dark gray clouds hang in the sky, and the days are rainy and sticky. This weather is so distinct from the hot and sunny mid-summer that people call it “Meiyu” in China and “Baiu” in Japan, both words standing for “plum rains,” as plums ripen during this season. The Meiyu-Baiu brings much needed rain for the drier mid-summer; but the heavy rains can also cause flooding and landslides. It is not surprising, therefore, that the Meiyu-Baiu is viewed as an extremely important climate event in the highly

populated regions of East Asia, and that meteorologists have conducted and published extensive research on the topic, studying it mostly as a weather phenomenon. Yet, the mechanism that controls the formation—the location and timing—of the rainband has eluded us: why does the Meiyu-Baiu recur every year about the same time and the same place? Our recent research identified a key puzzle piece that sets the time and place of the rainband—the jet stream!

Satellite images during the Meiyu-Baiu season reveal the long cloudband stretching from the Yangtze River Valley in China to Japan and eastward over the North Pacific (satellite image). Embedded in the cloudband are mesoscale convective systems that produce heavy

rainfall as they move eastward. In contrast, south of the Meiyu-Baiu rainband are few clouds as the subtropical high hovers over this region.

What triggers the rainband and why does it occur as a long east-west band over the Yangtze River Basin and Japan? These questions have not been answered convincingly because complicated feedbacks exist between the rainband and the atmospheric circulation. In previous studies, the characteristics of the low-level circulation, such as low-pressure belt at the surface and strong moisture-laden southwest-erly winds, have been regarded as important in maintaining the rainband. The low-level circulation, however, is a result of heating from condensation in the rainband. This view, thus, leads to a chicken-and-egg problem, and no matter how much we examine those characteristics, we won't know what triggers the Meiyu-Baiu formation. Other studies have focused on the convective systems embedded in the elongated rain band: since convection produces heavy rain during the Meiyu-Baiu, releasing large amounts of latent heat into the at-





The close association between the Meiyu and winds is well known to those who dwell under the recurring rain band and whose livelihood depends on its behavior. The great poet Shi Su (1037–1101) of the Song Dynasty wrote, “As Meiyu ceases in July, southeast breezes bring home sails from far seas.” Chinese merchant ships sailed for the coasts of Southeast Asia and the Indian Ocean during the northeast monsoon, and rode home to Zhejiang Province on the southeasterly winds. Calligraphy by Guanglin Meng, member of the Shandong Calligraphy Society.

mosphere, convection has been regarded as the Meiyu-Baiu engine. Studying individual convective systems, though, does not reveal why central-eastern China and Japan are more prone to convection during June than other regions.

When we set out on our Meiyu-Baiu study, we wanted to know what drives and steers the climatological rainband. We needed to take a new path. After months of trial and error, we noticed something special about the circulation at the

mid-tropospheric level, at an altitude of about 5.5 km (18,000 ft). An experiment with a linear model showed us that deep-heating by convection and rainfall in the rainband generates a strong response in the upper and lower troposphere, but only a weak wind response in the mid-troposphere. Thus, we realized that by examining what happens in the mid-troposphere, we can skip the chicken-and-egg problem between convection and low-level flow.

Our analysis of the mid-tropospheric circulation revealed that the location of the rainband corresponds closely to the region in which the jet stream advects warm air (Figure 1). In early June, as the Tibetan Plateau warms up, active monsoon convection takes place north of the Bay of Bengal, giving rise to a mid-tropospheric temperature maximum over the southern flank of the Tibetan Plateau. The westerly jet stream at the mid-troposphere advects this warm air eastward and northeastward to central-eastern China, Japan, and the North Pacific around 35°N (Figure 2). This horizontal advection forces air upward (Figure 1). The induced updraft in the mid-troposphere pumps the low-level warm moist air upward, triggering convection and precipitation. Once convection kicks in, it releases large amounts of latent heat that greatly amplifies the upward motions. Eventually the updraft

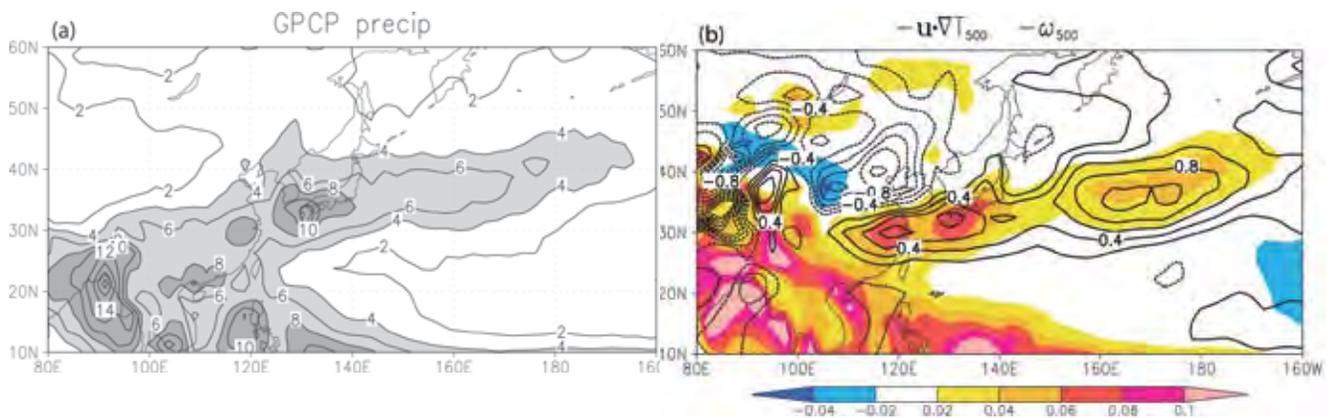


Figure 1. (a) Map of rainfall (mm/day) during 6/16–7/15, averaged from 1979 to 2004. (b) Map of horizontal advection of temperature (contour, K/day) and upward velocity of air (color, Pa/s) at 500 hPa.

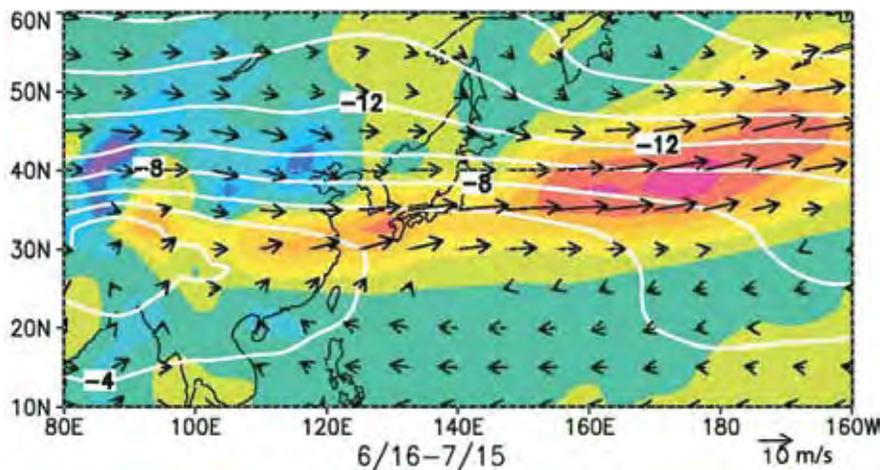


Figure 2. 500-hPa temperature (white line), wind vector, and temperature advection (color). Warm advection forms downstream of the temperature maximum over the continent, along the southern flank of the jet stream.

becomes much stronger than that first induced by the mid-tropospheric warm advection. Weather disturbances in midlatitudes guided by the jet stream into the Meiyu-Baiu region further increase atmospheric instability and the strong updraft, fueling convection along the jet stream. The cyclonic vortex from the eastern slope of the Ti-

betan Plateau may also foster storms in the upper reaches of the Yangtze River Valley.

The pattern of mid-tropospheric warm advection by the jet stream also explains the season of the rainband. In May, when the temperature maximum is over northern Indochina, the warm advection by the jet stream oc-

curs downstream over southern China, Taiwan and Okinawa, consistent with a peak of precipitation observed there. In June, when the jet stream has migrated to 30°N-35°N, the Meiyu-Baiu rain band forms over central-eastern China and Japan. The end of the rainy season there is then marked by the further northward migration of the jet stream to around 45°N in mid-July. At this position, the jet stream, flowing far north of the temperature maximum anchored over southern Tibet around 30°N, no longer advects much warm air.

As a first step toward developing climate dynamics of the Meiyu-Baiu formation, our research will help to understand and make better predictions of early summer climate in East Asia.

This story is based on

Sampe, T. and S.-P. Xie, 2009: Large-scale dynamics of the Meiyu-Baiu rain band: Environmental forcing by the westerly jet. *J. Climate*, DOI: 10.1175/2009JCLI3128.1, in press.



Two ladies cross Benkei Bridge in Tokyo in 1932. They wear ashida or tekageta, high sandals worn in the rain.

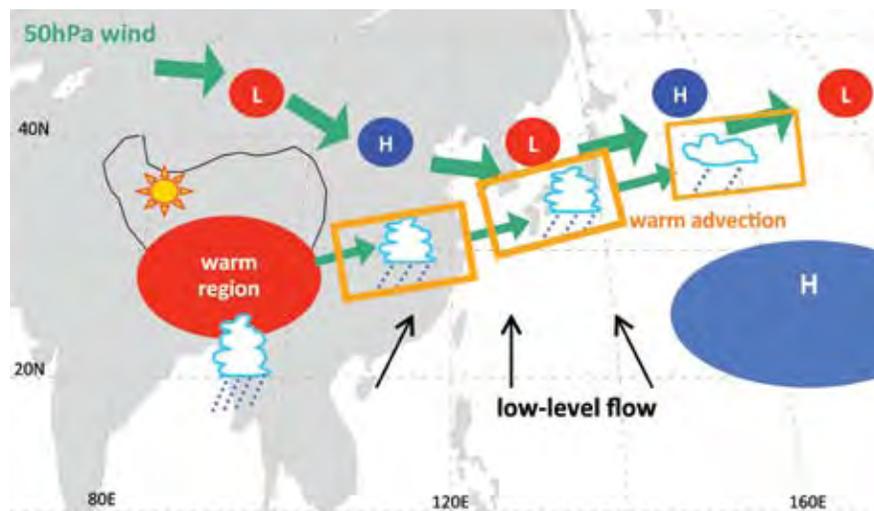


Figure 3. Schematic showing important factors in the formation of the Meiyu-Baiu rainband. Mid-tropospheric winds (green arrows) advect warm air south of the Tibetan Plateau to central China and Japan (orange), which induces updraft and triggers convection in the presence of low-level warm moist air from the south. An upstream branch of the jet stream steers weather disturbances (small circles with "H" and "L") from midlatitudes into the Meiyu-Baiu region to help trigger convection.