Revisiting a Mei-Yu Front Associated with Heavy Rainfall over Taiwan during 6–7 June 2003

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Abstract

During 6–7 June 2003, a Mei-Yu jet/front system over Southern China is characterized by appreciable horizontal temperature contrast below the 850 hPa level (>8 K), where the cold, dry, postfrontal northeasterlies converge with the warm, moist southwesterly flow, and above the 400–hPa level (>18 K) associated with an upper-level front. The frontal baroclinic zone tilts northward with a slope of ~1/100. During the passage of a midlatitude trough, the upper-level jet/front system advances southeastward. The thermally direct circulation across the subsynoptic low-level jet (SLLJ)/Mei-Yu front system, coupled with dynamic forcing aloft on the equatorial side of the entrance region of a subsynoptic upper-level jet (SULJ), provides a favorable environment for the development of a frontal cyclone over Southern China. A southwesterly marine boundary layer jet (MBLJ) develops between the deepening Mei-Yu frontal cyclone and the West Pacific Subtropical High (WPSH). The MBLJ transports moisture from the northern South China Sea (NSCS) to Southern China. All three jets (SULJ, SLLJ, and MBLJ) interact together during the deepening of the Mei-Yu frontal cyclone with positive feedback effects of latent heat release. **On 7 June 2003, as the Mei-Yu front arrives near the Taiwan area, the warm, moist, and unstable air associated with the MBLJ decelerates as it approaches the Central Mountain Range (CMR). The warm, moist, and unstable air is orographically lifted by the CMR and enhances the vertical motion already present with the frontal zone. A region of widespread heavy rainfall develops, with a maximum of more than 350 mm/day, over a region extending from the southwestern coast of Taiwan to the windward slopes of the CMR.**

This Mei-Yu frontal system possesses the following characteristics:

(1) a large thermal contrast, greater than 8 K, below the 850 hPa level, between the postfrontal cold northeasterlies and the prefrontal warm, moist southwesterly monsoon flow;
(2) a pronounced axis of frontogenetical forcing along the frontal boundary in the low levels;
(3) warm air advection in the prefrontal atmosphere;
(4) northward tilt of the baroclinic zone with a slope about 1/100;
(5) large temperature gradients associated with the upper-level frontal zone with an SULJ greater than 40 m s^{-1};
(6) a thermally direct circulation driven by a moist baroclinic process;
(7) descending motion associated with the thermally direct circulation in the upper troposphere, which transports the high-PV stratospheric air downward with tropopause folding.

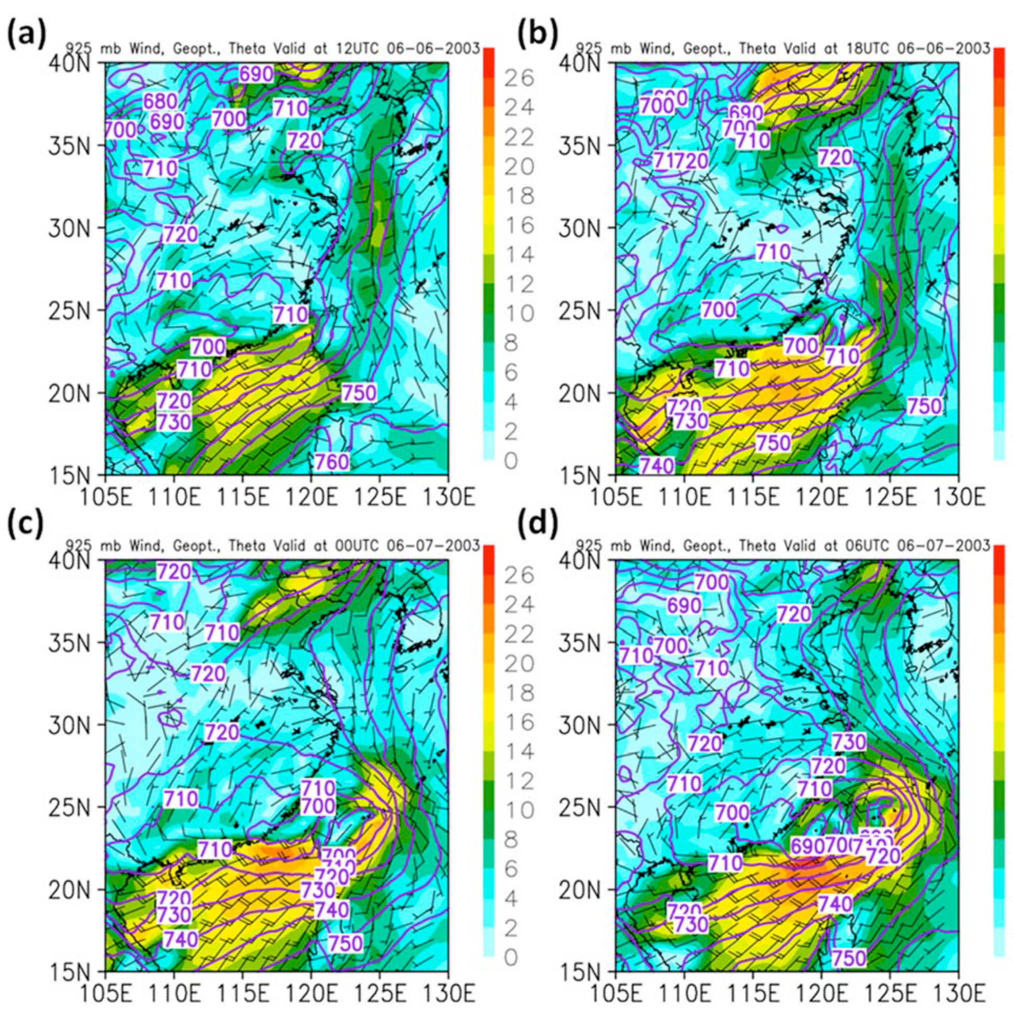

Figure 1. The CFSR geopotential height (gpm, contoured), wind speed (V; m s^{-1}, shaded), and winds (m s^{-1}) (full barb and half barb represent 10 and 5 m s^{-1}, respectively) at 925 hPa at (**a**) 1200 UTC (2000 LT) 6 June; (**b**) 1800 UTC 6 June (0200 LT 7 June); (**c**) 0000 UTC (0800 LT) 7 June; and (**d**) 0600 UTC (1400 LT) 7 June 2003.

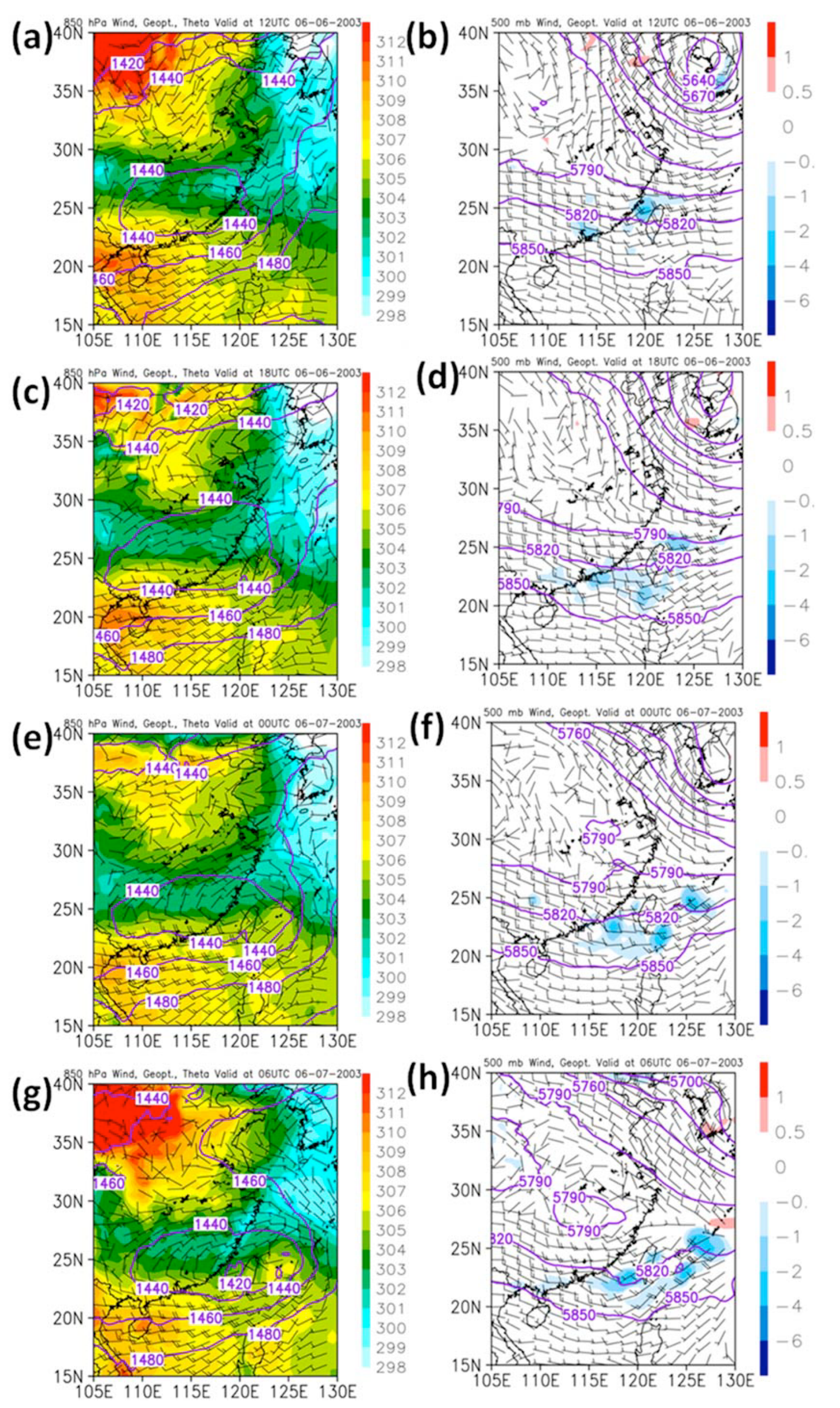

Figure 2. The CFSR geopotential height (gpm, contoured), potential temperature (K, shaded), and winds (V; m s^{-1}) (full barb and half barb represent 10 and 5 m s^{-1}, respectively) at 850 hPa at (**a**) 1200 UTC (2000 LT) 6 June; (**c**) 1800 UTC 6 June (0200 LT 7 June); (**e**) 0000 UTC (0800 LT) 7 June; and (**g**) 0600 UTC (1400 LT) 7 June 2003. (**b**,**d**,**f**,**h**) are at the same time as (**a**,**c**,**e**,**g**), respectively, but for vertical motion (Pa s^{-1}, shaded), geopotential height (gpm, contoured), and wind (V; m s^{-1}) at 500 hPa.

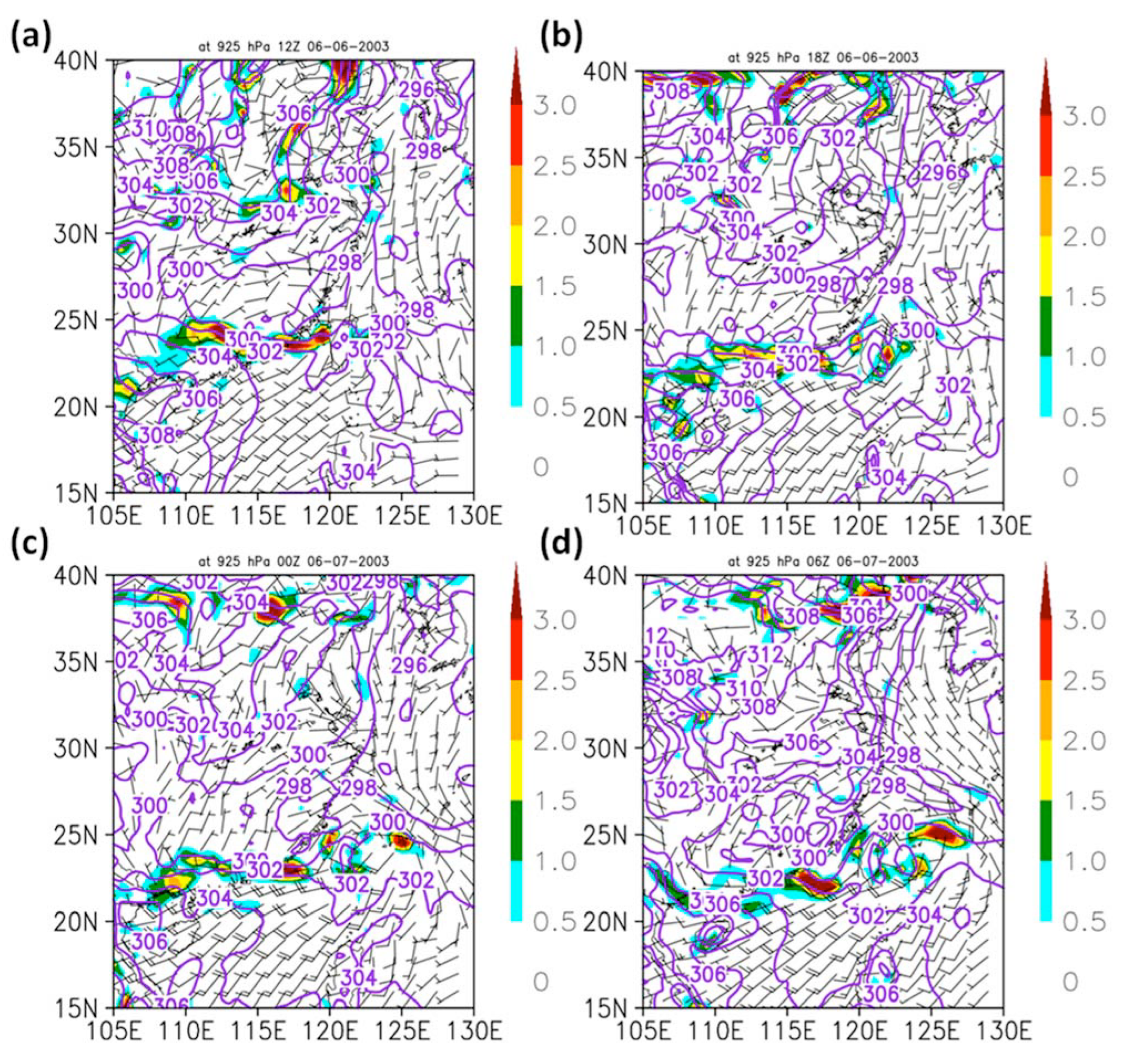

Figure 3. The CFSR frontogenesis at 925 hPa (10^{-9} K m^{-1} s^{-1}), winds (V; m s^{-1}, full barb and half barb represent 10 and 5 m s^{-1}, respectively), and potential temperature (K, purple lines every 2 K) at (**a**) 1200 UTC (2000 LT) 6 June; (**b**) 1800 UTC 6 June (0200 LT 7 June); (**c**) 0000 UTC (0800 LT) 7 June; and (**d**) 0600 UTC (1400 LT) 7 June 2003.

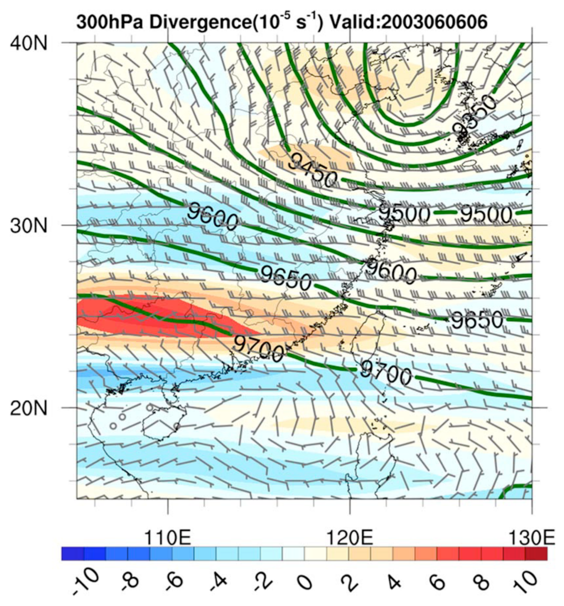

Figure 4. The CFSR divergence at 300 hPa (10^{-5} s^{-1}), winds (V; m s^{-1}, full barb and half barb represent 10 and 5 m s^{-1}, respectively), and geopotential height (gpm, dark green lines) at 0600 UTC (1400 LT) 6 June 2003.

For this case, a pronounced frontal cyclone develops within the Mei-Yu trough north of the Southern China coast. The frontal cyclone at 925 hPa first appears in the leeside of the Yun-Gui Plateau during 0600–1200 UTC 6 June beneath 500 hPa westerlies over the plateau. The development of the frontal cyclone occurs when an upper-level jet/front system advances southward during the passage of a mid-latitude trough.
The rising motion associated with the Mei-Yu jet/front system is coupled with upper-level divergence on the equatorial side of the SULJ entrance region, which provides the dynamic forcing aloft for the release of potential instability and the subsequent deepening of the frontal cyclone.

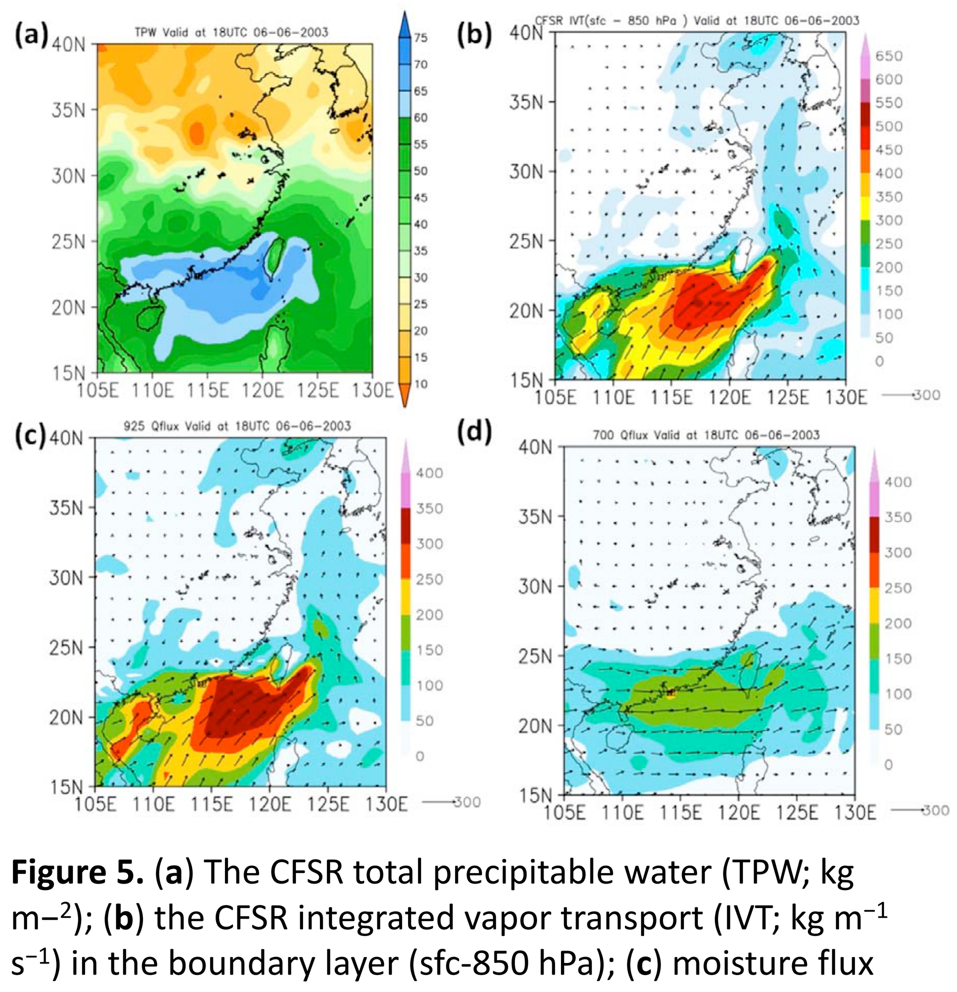

Figure 5. (**a**) The CFSR total precipitable water (TPW; kg m^{-2}); (**b**) the CFSR integrated vapor transport (IVT; kg m^{-1} s^{-1}) in the boundary layer (sfc-850 hPa); (**c**) moisture flux (g kg^{-1} m s^{-1}) at 925 hPa; and (**d**) same as (**c**) but for 700 hPa at 1800 UTC 6 June (0200 LT 7 June) 2003.

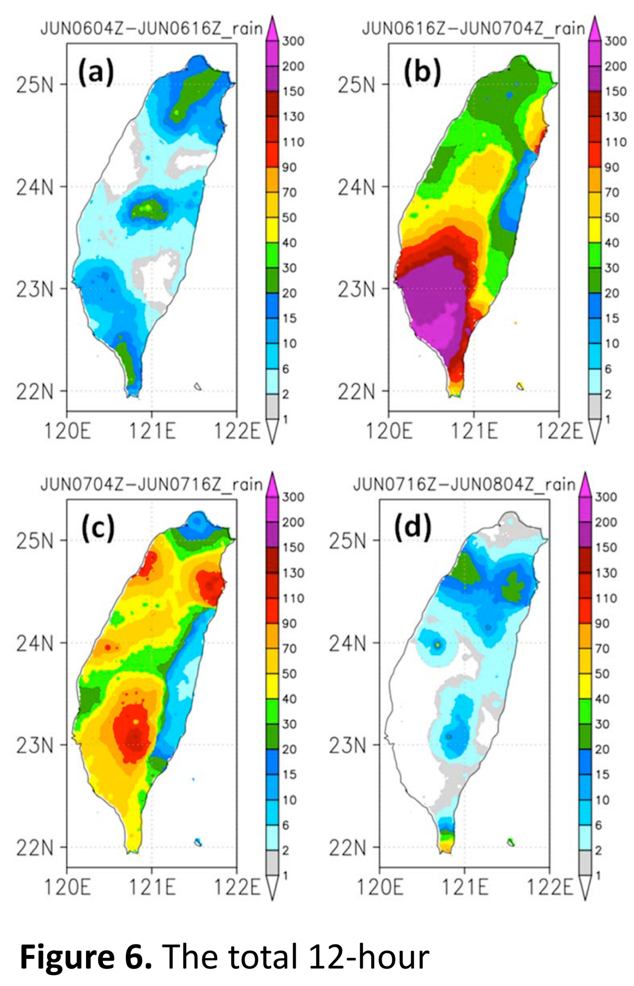

Figure 6. The total 12-hour accumulated rainfall (mm) during (**a**) 12–24 LT 6 June; (**b**) 0–12 LT 7 June; (**c**) 12–24 LT 7 June; and (**d**) 0–12 LT 8 June 2003.