

기후 분과 [P-157]

Compound Heatwaves and Heavy Frontal Precipitation Intensified by the Northward Migration of the East Asian Summer Front

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East Asian summer front (EASF) is a critical weather system that contributes to more than 40% of summer precipitation, and its intensification is amplified under the global warming. While the climate impacts of EASF are well recognized, its long-term evolution remain less understood. Using the ERA5 reanalysis dataset for 1979-2024, this study identifies a significant northward migration of the EASF of up to 1.26°N in the latter 20 years compared to the first 20 years. The northward shift is particularly pronounced in July (+0.64°N), August (+1.38°N), and September (+0.62°N). This migration is closely associated with the strengthened and expanded western North Pacific subtropical high (WNPSH). The WNPSH enhances warm and moist air transport into East Asia (EA) and intensifies frontal precipitation, especially over the northern EA such as central Korea and the Shandong Peninsula. In addition to precipitation impacts, the northward migration of the EASF also contributes to warmer conditions across much of EA, raising concerns about greater exposure to summer heatwaves. Our findings highlight that the northward migration of EASF has recently intensified both heatwaves and heavy frontal precipitation, often leading to compound extremes across EA. Understanding the mechanisms of front migration under the global warming condition is therefore essential for reducing societal risks and supporting climate adaptation strategies.

Keywords: East Asian summer front, compound extremes, heavy frontal precipitation, heatwaves, front migration