



## The evolution of the Western North Pacific Summer Monsoon during the 20th Century

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The Western North Pacific Summer Monsoon (WNPSM) is an oceanic monsoon driven essentially by the meridional gradient of sea surface temperature, unlike the Indian and East Asian summer monsoons. Its circulation is characterized by low-level southwesterlies and upper-tropospheric easterlies in the region [100°-130° E, 5°-15°N], which modulates the precipitation of densely populated areas such as the Philippines.

First recognised as an independent monsoon in 1987, the variability of the WNPSM commenced to be studied in the 2000s, possibly due to the lack of observations over open ocean. To date, the WNPSM has been quantified by the so-called Western North Pacific Monsoon Index (WNPMI), an index based on zonal wind speed anomalies over large domains of the Western North Pacific. The WNPMI is computed by using reanalysis data and, consequently, its length is limited to 1948-2014. In this work we have extended the index back to 1898 by using historical wind direction observations taken aboard ships. Our Western North Pacific Directional Index (WNPDI), is defined as the sum of the persistence of the sea surface westerly winds in [5°-15°N, 100°-130°E] and easterly winds in [20°-30°N, 110°-140°E]. The correlation between the WNPDI and the WNPMI reaches +0.87 ( $p < 0.01$ ) for the concurrent period (1948-2014), indicating that the new approach based on wind direction alone (a variable that can be considered instrumental even before the 20th Century) captures a large part of the variance associated with the monsoon.

Previous studies found two basic characteristics of the WNPSM during the second part of the 20th Century: a large interannual variability and a significant relation between the WNPSM and the El Niño/Southern Oscillation (ENSO), meaning that a strong (weak) WNPSM tends to occur during El Niño (La Niña) developing year or/and La Niña (El Niño) decaying year. Nevertheless, the analysis of our extended series suggests a more complex scheme. We have found evidences of a persistently strong WNPSM during 1918-1948, when the WNPSM was considerably less variable than today and a change in the ENSO-WNPSM relationship during the first half of the 20th Century, with a reversal in the sign of the WNPSM-ENSO correlation for ENSO decaying years.

Research funded by the Spanish Ministerio de Economía, Industria y Competitividad through the project INCITE (CGL2013-44530-P, BES-2014-069733).