A new centennial index to study the Western North Pacific Monsoon decadal variability

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1. Introduction

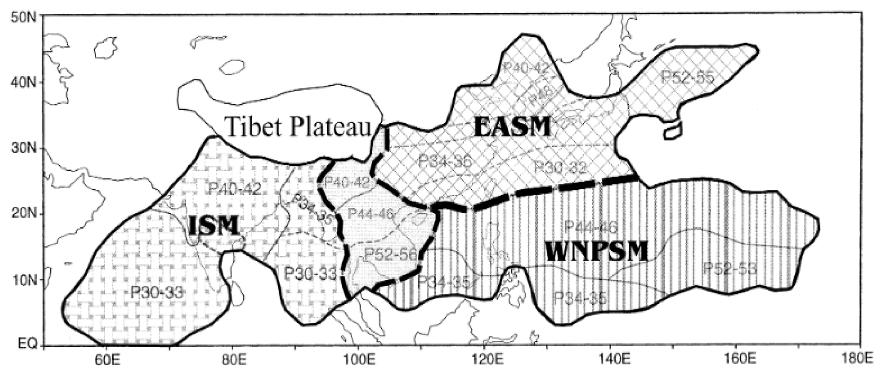


FIG 1: Division of Asian-Pacific monsoon. Taken from Wang and Linho (2002).

The Asian Monsoon region could be divided into three subregions: the Indian, the East Asian and the Western North Pacific. Both the Indian Summer Monsoon (ISM) and the East Asian Summer Monsoon (EASM) are continental while **the Western North Pacific Summer Monsoon** (WNPSM) is oceanic. Although the WNPSM has more profund impacts on the EASM and ENSO than the ISM, it has not been as studied as the latter, probably, because meteorological variables are required in open ocean to quantify the strength of the WNPSM.

The **Western North Pacific Monsoon Index** (WNPMI), the main index that has been used to characterize the WNPSM back to 1948, was defined as the difference of 850-hPa westerlies between two regions (D1 and D2 in Fig 2c) by Wang et al. (2001). Our goal has been **to extend** this index **as back in time as possible** by using **instrumental meteorological data** such as wind direction. Thus, it allows to study the **multidecadal variability** of the WNPSM.

2. Methodology

Our main source of wind data has been the International Comprehensive Ocean-Atmosphere Data Set (**ICOADS**) that contains marine surface data from logbooks of thousands of ships which have circumnavigated the globe since at least the 17th Century. Fortunately, both domains, D1 and D2, lie over some of the main historical ship routes sailing nearby Asia and, in consequence, there are a large number of available wind observations since early times. Therefore, we define the **Western North Pacific Directional Index** (WNPDI) using **solely wind direction** data as the sum of the persistence of the low-level westerly winds in D1 and easterly winds in D2.

$$WNPDI\,(monthly) = \left[\frac{number\ of\ westerly\ days\ (D1)}{days\ with\ observations} + \frac{number\ of\ easterly\ days\ (D2)}{days\ with\ observations}\right]\cdot 100$$

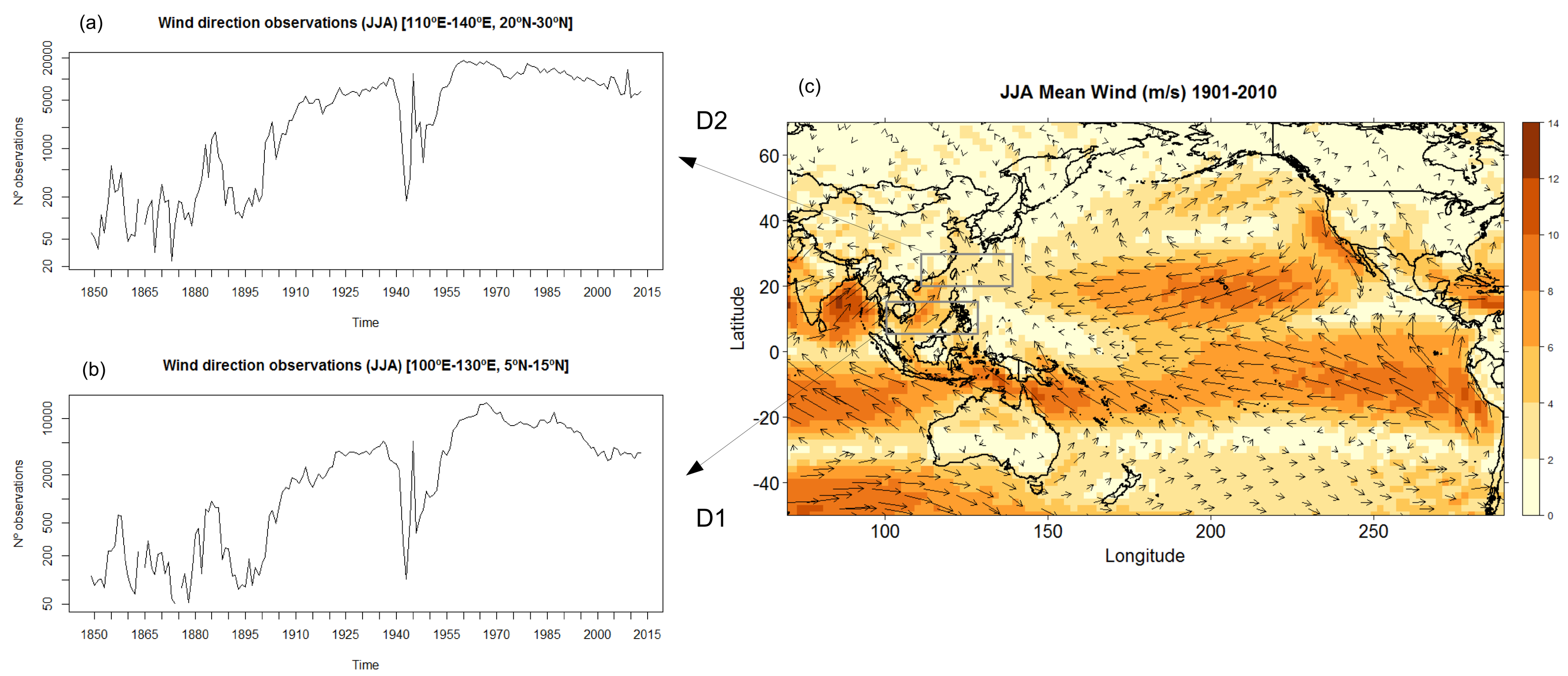


FIG 2: Time series of the number of observations inside the regions D2 (a) and D1 (b). Mean low-level wind in summer (JJA) during the 1901-2010 period.

Our WNPDI shows a high correlation (r = +0.87, p < 0.01) with the previous WNPMI in summer for the concurrent 1948-2009 period.

3. Results

(a) The Index

Our index could be computed in a more or less continuous way since the 1880's thus providing the longest record of the WNPSM variability up to date. The **extreme monsoons** (points in Figure 3), strong and weak, are determined by the WNPMDI's 90th and 10th percentiles, respectively, for the 1901-2010 period. These events have been considered to study the impact of strong monsoons on both atmospheric and oceanic variables (Figure 4). The composites strong-minus-weak monsoon highlight the anomalies associated with strong monsoons due to, in general, they tend to have opposite polarities in relation to the weak monsoons.

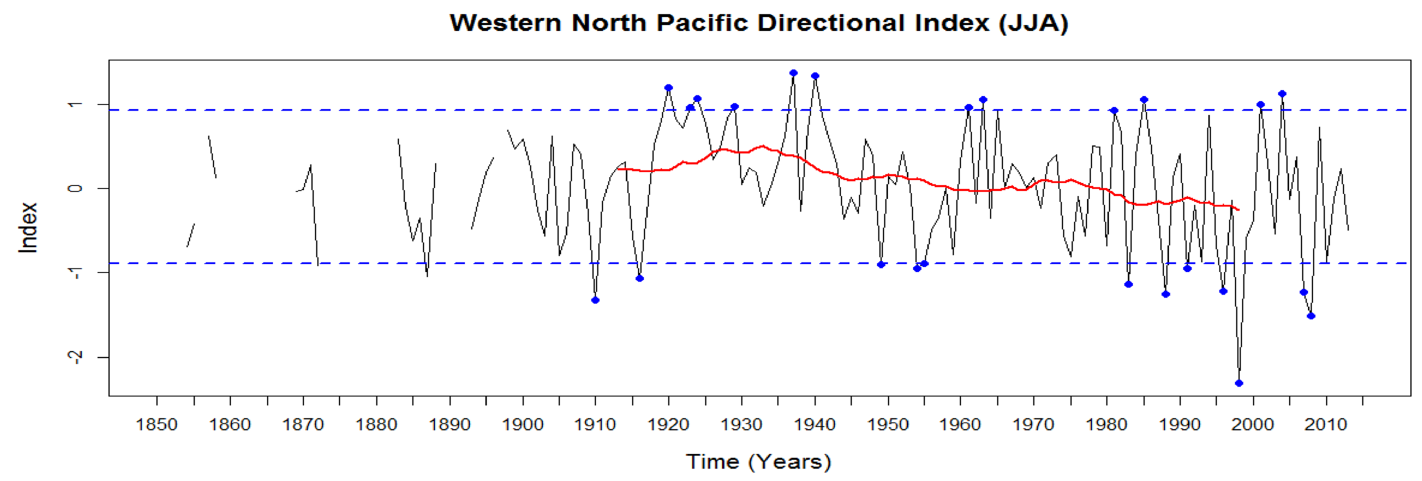
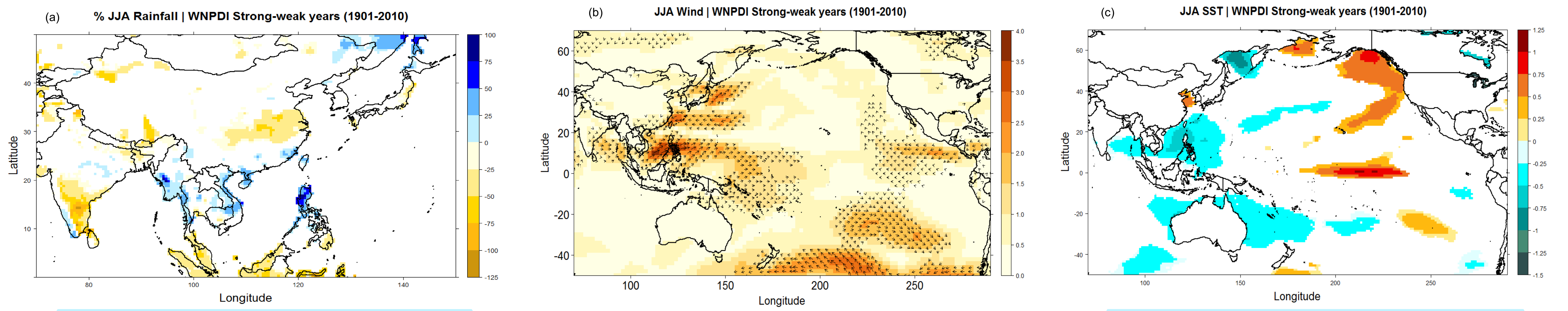


FIG 3: Time series (black line), running mean 31-yr (red line), 10th and 90th percentiles (dashed blue lines) of the Western North Pacific Directional Index and extreme events (blue points).

(b) Anomalies of precipitation, wind and SST associated with strong monsoons

FIG 4: Difference of summer composites of: (a) precipitation -GPCC data set-, (b) low-level winds -20CR- and (c) SST -KOBE- in strong and weak monsoon years through the 1901-2010 period. In colour what is significant at 95% level.



Precipitation: ▼100% in southeast India; ▲ 75-100% in the north of Philippines and in the west of Myanmar

Wind: ▲4m/s in the South China Sea; Convergence winds in the central Pacific

SST: ▼ in west Pacific; ▲ in northeast and central Pacific. These anomalies remind the PDO and El Niño Modoki patterns

(c) Relationship between the WNPDI and PDO/EMI/EN3/DMI

Index/Lag	-2 (DEF)	-1 (MAM)	0 (JJA)	1 (SON)	2 (DEF +1yr)
PDO 1900-2013	0.18	0.06	0.02	0.13	0.28
EMI 1898-2013	0.05	0.15	0.38	0.46	0.42
EN3 1898-2013	-0.10	-0.04	0.16	0.30	0.38
DMI 1898-2007	-0.13	0.08	0.19	0.34	-0.16

Table 1: Lag correlation (seasonal) between WNPDI (JJA) and climatic patterns (the PDO, El Niño Modoki, El Niño and the IOD) indices. Significant correlations (p<0.05) are shown in red.

Lag correlations between the WNPDI and the climatic patterns indices are weak over the entire period available and they are only significant for summer or the following autumn/winter to the summer monsoon. However, computing the 31-yr window running correlation higher values of correlation (up to 0.7) are obtained. The periods and lags of significant values of correlation differ for each index.

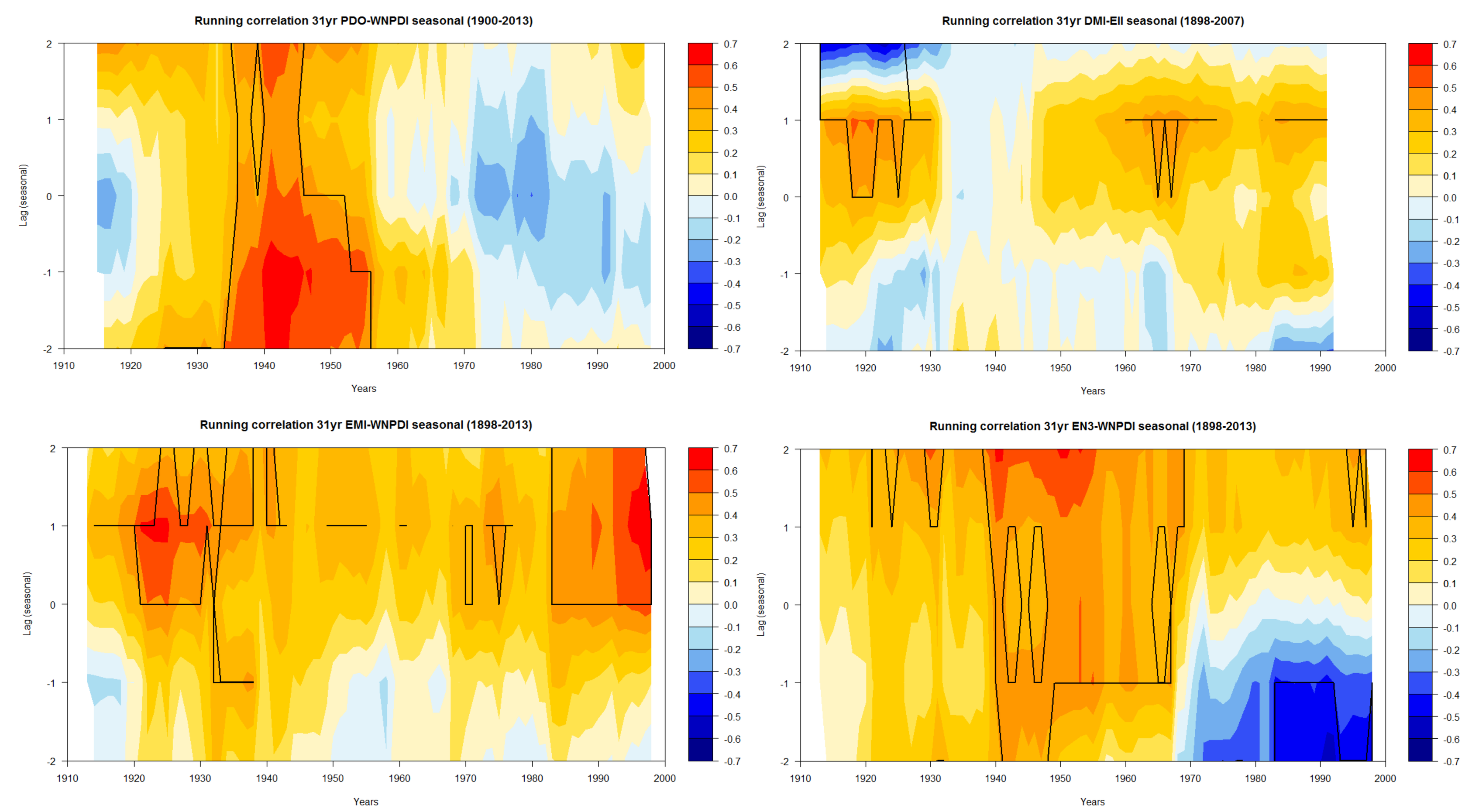


FIG 5: Running correlation (31yr-window) between the JJA WNPDI and climatic pattern indices [(a) PDO, (b) El Niño Modoki, (c) El Niño3 and (d) IOD] for different seasonal lags: -2 to 2 (DEF to DEF +1yr, respectively).

Conclusions

- It is possible to compute a quantitative **index** of the **WNPSM strength without** the use of the **wind speed**, a value usually rather uncertain for historical wind measurements.
- **The WNPDI** goes back to the **middle of the 19th Century** and is 100 years longer than any previous index characterising the WNPSM*, which allows to study the decadal variability of the WNPSM.
- The WNPDI has a strong **impact** on the precipitation in densely populated areas in South-East Asia, such as the Philippines or the west coast of Myanmar where the **changes in precipitation between** well developed and weak monsoons can exceed **75% or -100%** (related to the summer mean precipitation) in southeast India. When the WNPSM is strong, the **wind** in the South China Sea **increase up to 4m/s** and the anomalies of **SST** in the Pacific Ocean remind the **PDO and El Niño Modoki patterns**.
- The **relationships** between the **WNPDI** and global climatic patterns such as the **PDO**, the **ENSO** or **El Niño Modoki** are extremely complicated and our results suggest that the influence of these patterns is **highly non stationary**. We are currently working on this complex relations.

*It would be possible to extend the WNPDI further back in time as soon as more observations in logbooks, preserved in historical archives, are digitized.

References

- Barriopedro, D. et al. (2014): Witnessing North Atlantic westerlies variability from ship's logbooks (1685-2008). *Climate Dyn.* 43 : 939 – 955.
- Gallego, D. et al. (2015): An instrumental index of the West African Monsoon back to the nineteenth century. *Q.J.R. Meteorol. Soc.*, 141: 3166–3176.
- Wang, B. and LinHo (2002): Rainy season of the Asian-Pacific summer monsoon. *J. Climate*, 15, 386–398.
- Wang, B. et al. (2001): Interannual Variability of the Asian Summer Monsoon: Contrasts between the Indian and the Western North Pacific–East Asian Monsoons. *Journal of Climate*, vol 14, 4073-4090.
- Wheeler, D. & R. Garcia-Herrera (2008): Ship's logbooks in climatological research: reflections and prospects. *Ann NY Acad Sci.* 1146:1-15.
- Worley, S.J.et al. (2005): ICOADS Release2.1 data and products. *Int. J Climatol*, 25, 823-842.

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