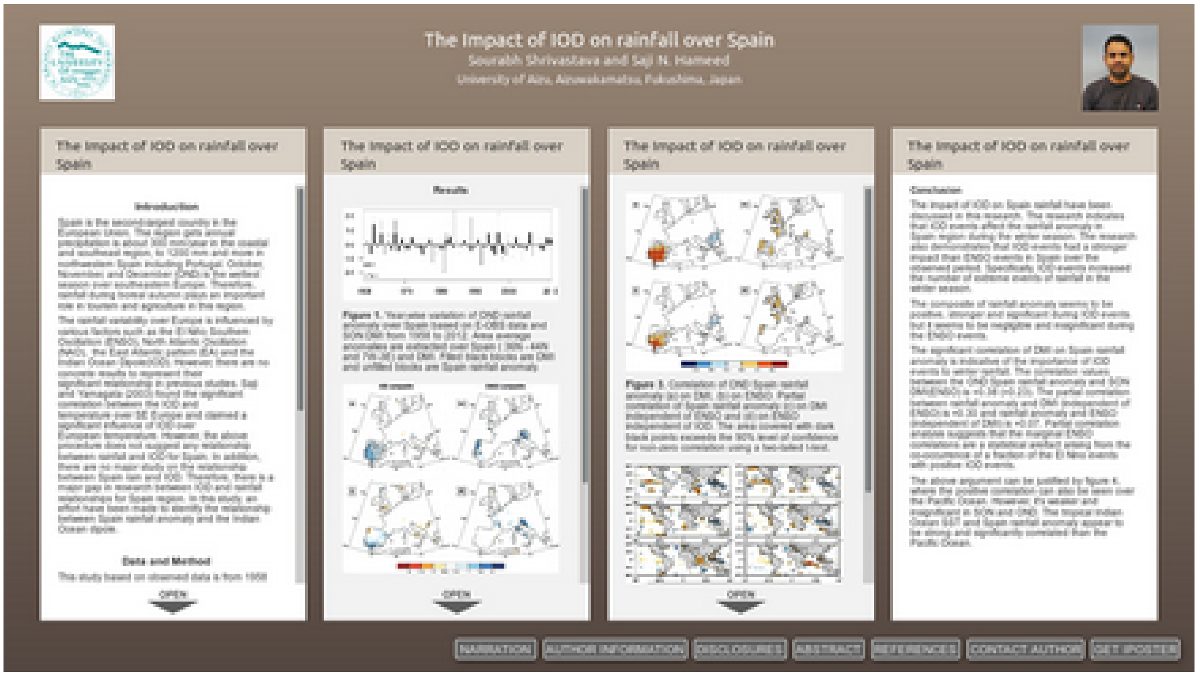
The Impact of IOD on rainfall over Spain



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PRESENTED AT:

JpGU - AGU Joint Meeting 2020
For a Borderless World of Geoscience
Japan Geoscience Union, American Geophysical Union

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Introduction

Spain is the second-largest country in the European Union. The region gets annual precipitation is about 300 mm/year in the coastal and southeast region, to 1200 mm and more in northwestern Spain including Portugal. October, November, and December (OND) is the wettest season over southeastern Europe. Therefore, rainfall during boreal autumn plays an important role in tourism and agriculture in this region.

The rainfall variability over Europe is influenced by various factors such as the El Niño Southern Oscillation (ENSO), North Atlantic Oscillation (NAO), the East Atlantic pattern (EA) and the Indian Ocean Dipole(IOD). However, there are no concrete results to represent their significant relationship in previous studies. Saji and Yamagata (2003) found the significant correlation between the IOD and temperature over SE Europe and claimed a significant influence of IOD over European temperature. However, the above procedure does not suggest any relationship between rainfall and IOD for Spain. In addition, there are no major study on the relationship between Spain rain and IOD. Therefore, there is a major gap in research between IOD and rainfall relationships for Spain region. In this study, an effort have been made to identify the relationship between Spain rainfall anomaly and the Indian Ocean dipole.

Data and Method

This study based on observed data is from 1958 to 2012. We choose the boreal autumn season (September–November as SON) because IOD and ENSO both are on the peak and have a significant influence on subtropical climate during this period. However, we also monitored the whole IOD cycle from JJA (June to August) to NDJ (November to January). The datasets used in this study are the European Daily High-Resolution Observational Gridded Dataset (E-OBS) 0.25x0.25 degree rainfall and The Japanese Meteorological Agency's Centennial Observation-Based Estimates of SSTs (COBE) - sea surface temperature with 1.0x1.0 degree spatial resolution.

Correlation and composite analysis as the basic analysis techniques are used in this study. The pre-processing technique of data has been adopted from Saji and Yamagata (2003). For each variable, monthly anomaly were found by subtracting the climatological seasonal cycle from the mean of each month. Linear trends and interdecadal anomalies longer than 7 years were also removed. JJA, JAS, ASO, SON, OND and NDJ are defined as a 3-month running mean for sst and OND for rain.

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Results

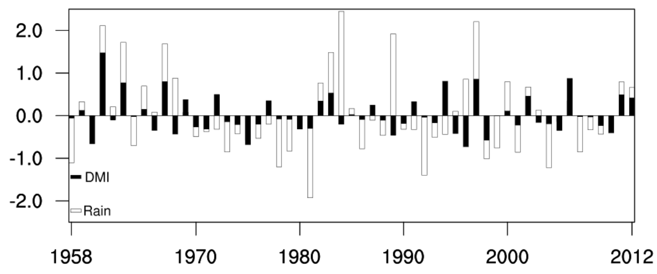

Figure 1. Year-wise variation of OND rainfall anomaly over Spain based on E-OBS data and SON DMI from 1958 to 2012. Area average anomalies are extracted over Spain (36N - 44N and 7W-3E) and DMI. Filled black blocks are DMI and unfilled blocks are Spain rainfall anomaly.

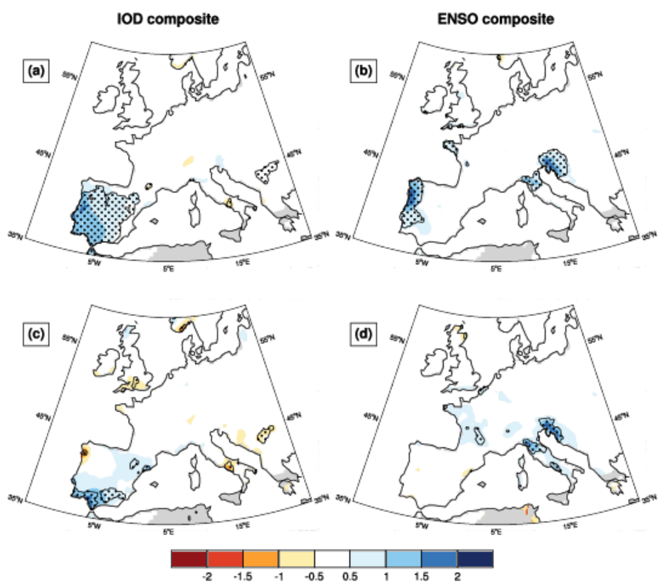

Figure 2. Composite of European rainfall anomaly during OND (a) 20 IOD events, (b) 21 ENSO events, (c) 11 ENSO-independent IOD events and (d) 12 IOD-independent ENSO events. A positive value shows increasing rainfall anomaly and negative value shows decreasing rainfall anomaly. The statistical significance of the analysed anomalies were estimated by the two-tailed t-test. Anomalies of rainfall exceeding 90% significance are indicated by dark black points.

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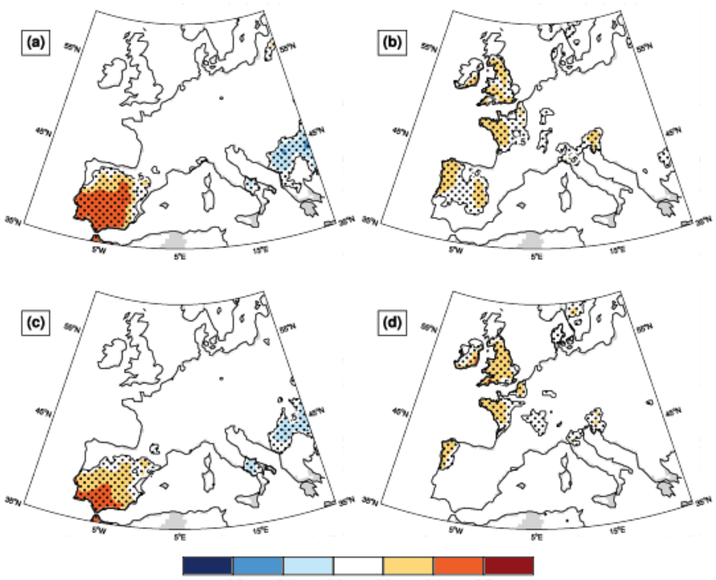

Figure 3. Correlation of OND Spain rainfall anomaly (a) on DMI, (b) on ENSO. Partial correlation of Spain rainfall anomaly (c) on DMI independent of ENSO and (d) on ENSO independent of IOD. The area covered with dark black points exceeds the 90% level of confidence for non-zero correlation using a two-tailed t-test.

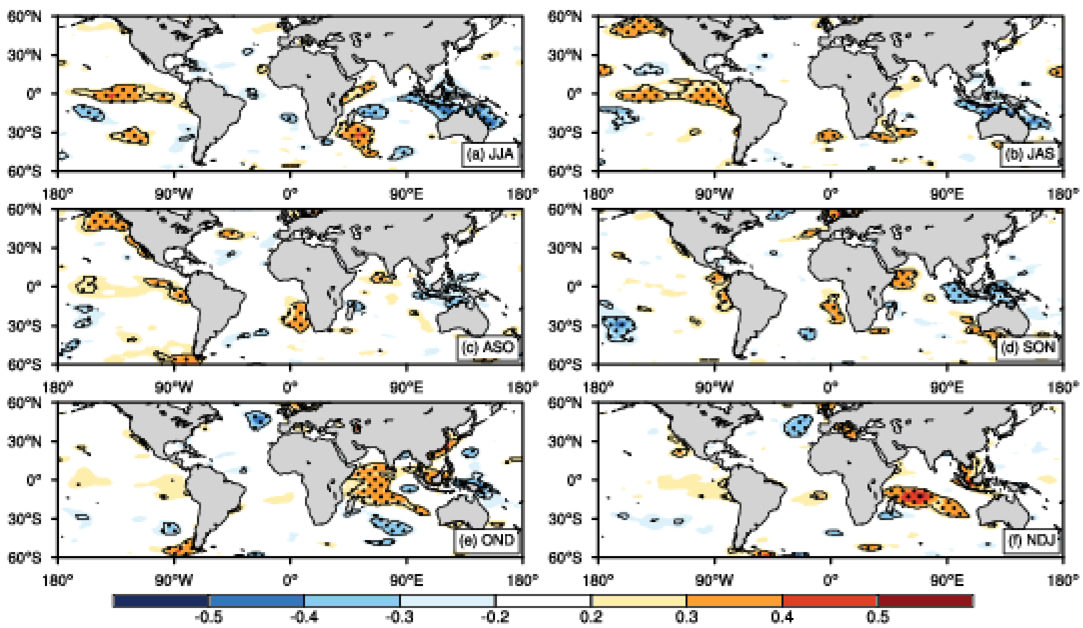

Figure 4. Correlation of OND Spain rainfall anomaly and (a) JJA, (b) JAS, (c) ASO, (d) SON, (e) OND, (f) NDJ global SST anomaly. Whole IOD cycle studied for the OND Spain rainfall anomaly and global SST anomaly correlation. The area covered with dark black points exceeds the 90% level of confidence for non-zero correlation using a two-tailed t-test.

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Conclusion

The impact of IOD on Spain rainfall have been discussed in this research. The research indicates that IOD events affect the rainfall anomaly in Spain region during the winter season. The research also demonstrates that IOD events had a stronger impact than ENSO events in Spain over the observed period. Specifically, IOD events increased the number of extreme events of rainfall in the winter season.

The composite of rainfall anomaly seems to be positive, stronger and significant during IOD events but it seems to be negligible and insignificant during the ENSO events.

The significant correlation of DMI on Spain rainfall anomaly is indicative of the importance of IOD events to winter rainfall. The correlation values between the OND Spain rainfall anomaly and SON DMI(ENSO) is +0.38 (+0.23). The partial correlation between rainfall anomaly and DMI (independent of ENSO) is +0.30 and rainfall anomaly and ENSO (independent of DMI) is +0.07. Partial correlation analysis suggests that the marginal ENSO correlations are a statistical areifact arising from the co-occurrence of a fraction of the El Nino events with positive IOD events.

The above argument can be justified by figure 4, where the positive correlation can also be seen over the Pacific Ocean. However, it's weaker and insignificant in SON and OND. The tropical Indian Ocean SST and Spain rainfall anomaly appear to be strong and significantly correlated than the Pacific Ocean.

Sorry for the inconvenience!

AUTHOR INFORMATION

I, my self Dr Sourabh Shrivastava. Currently, I am working as a Visiting Researcher at the University of Aizu. My areas of study are climate variability and machine learning.

ABSTRACT

Previous studies have shown that the Indian Ocean Dipole (IOD) has a significant impact on land temperatures over southern Europe. However, whether IOD influences rainfall over this region and how this impact compares to that of El Nino Southern Oscillation (ENSO) have not been established. Here using the E-OBS gridded rainfall datasets for the period 1958 to 2012, we have analyzed the influence of IOD and ENSO on European rainfall. We find that IOD impacts are predominantly felt over southwestern Europe in a region covering Spain and Portugal during the peak phase of the event. Correlations exceeding 0.4 are observed over the central regions of Spain. We find that ENSO impacts on European rainfall are substantially weaker compared to that of IOD, but occur with a pattern similar to the latter. Partial correlation analysis suggests that the marginal ENSO correlations are a statistical areifact arising from the co-occurrence of a fraction of the El Nino events with positive IOD events. Possible dynamical mechanisms by which IOD impacts rainfall over southwestern Europe will be discussed.

REFERENCES

Saji, N. H., and Yamagata, T. (2003). Possible impacts of Indian Ocean dipole events on global climate. Clim. Res., 25, 151–169.

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