SEASONAL VARIABILITY OF WIND-WIND CLIMATE IN NORTH INDIAN OCEAN AND THEIR CORRELATION WITH VARIOUS CLIMATE INDICES

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Abstract: The present study deals with seasonal variability of the wind-wave climate system for the North Indian Ocean covering the two distinct marginal seas, the Arabian Sea (AS) and Bay of Bengal (BoB). A comprehensive investigation explores on the seasonal variability of maximum significant wave height (SWH) and maximum wind speed (MWS) for these water bodies. The data framework in current study uses the past 21 years of satellite altimeter data (1992-2012) from eight satellite missions. The seasonal nomenclature covers the four austral seasons viz; December-February (DJF); March-May (MAM); June-August (JJA); and September-November (SON) months. The study performs Empirical Orthogonal Function (EOF) technique on these seasonal datasets to understand the dominant modes of variability in SWH and MWS. The Principal Components (PCs) of respective EOF modes are correlated to establish its relationship with various climate indices. In this context, correlation analysis was performed with well known climate indices such as SOI (Southern Oscillation Index), NINO3 (El Nino Southern Ocean Index), QBO (Quasi Biennial Oscillation), Indian Ocean Subtropical Dipole (IOSD), Dipole Mode Index (DMI) and Southern Annual Mode Index (SAMI). The analysis signifies the first three EOF modes exhibit a reasonable good correlation with the above mentioned indices for wind-waves.

Introduction

The chapter on 'Changes in Climate Extremes and their Impacts on the Natural Physical Environment' in the IPCC Report (Seneviratne et al., 2012) highlights on the importance of wind-waves in modeling the climate system. The report mentions on the importance and need to connect ocean wave climate to various climate indices is an emerging field necessary to understand the climate in a better perspective. It is necessary to understand wind-wave climate variability in regional seas to provide solutions for authorities dealing with coastal zone management projects, coastal engineering, maritime officials etc. Past studies on wind-wave climate variability covered the Atlantic and Pacific Ocean basin, with limited work performed for the Indian Ocean (Bhaskaran et al., 2014). Therefore, the objective in this study is to understand the seasonal variability of wind-wave climate in the regional basins such as Bay of Bengal and Arabian Sea, and establish a correlation connecting this variability with well-known climate indices. A brief description if the various climatic indices used for the present study is given here, whereas for a detailed description reads can refer to the references provided.

The Dipole Mode index

Data and Methodology

The current study used quality checked altimeter data (Queffeulou, 2013) for a period of 21 years (1992-2012) from eight satellite missions viz; ERS-1/2, TOPEX/Poseidon, GFO, JASON-1/2, ENVISAT, and CRYOSAT. The analysis region is bounded by geographic coordinates 5° N - 25° N; 50° E - 75° E for the Arabian Sea, and 5° N - 25° N; 78° E - 103° E

for the Bay of Bengal. The binary data from these eight satellites were processed using the BRAT (Basic Radar Altimeter Toolbox, Rosmorduc et al., 2012) with uniform grid spacing of 1° × 1°. The final post-processed data from BRAT was smoothed using 5 × 5 cell digital filter Gaussian smoothing algorithm with a radius (standard deviation) of 2.8° (Woolf et al., 2002). The EOF analysis used the final smoothed data corresponding to four austral seasons DJF, MAM, JJA, and SON months to understand the dominant modes of variability. The principal components corresponding to the three EOF modes were correlated with well established climate indices to understand their inter-dependency.

Results and Discussion

The analysis of wind variability for the AS exhibited a strong correlation with IOSD for all the austral seasons. In addition, the correlation also show dependency with other climate signals such as SAMI during DJF; NINO3, DMI, and SOI during MAM, NINO3 and SOI for SON months. The frequency cycle exhibited an interesting trend such as 2-3 years cycle connecting the indices NINO3, DMI, and QBO during DJF; IOSD and QBO during MAM; DMI during JJA, whereas SON showed no such cycle. The study also revealed another cycle that has a periodicity of 8 to 11 years and exhibits a good correlation with SAMI during DJF; DMI and IOSD during JJA; DMI, QBO and NINO3 during SON, with no correlation for MAM months. The study signifies that the correlation of climate indices between wind and waves were different for the regional basins. The dominant modes of variability for waves show a 2-3 year cycle that correlates well with IOSD, QBO and SAMI during DJF; DMI, QBO and NINO3 show a good correlation during JJA; NINO3 and SOI correlated during MAM, whereas SON showed no correlation with any climate index. The cycle corresponding to 3-7 years had a good correlation with SOI, QBO and NINO3 during DJF; IOSD and QBO during MAM; IOSD and QBO during SON, whereas JJA had a cycle of 10.6 years correlated with IOSD.

Analysis for winds in the BoB showed a good correlation with NINO3, SOI, DMI, and IOSD during MAM and SON months. Cycle with a periodicity of 2-4 years correlated well with SOI and QBO during DJF. The NINO3, DMI, SOI, and QBO relates well during JJA; and IOSD during SON, whereas MAM showed no correlation with any climate index. The variability in waves had a cycle of 2-4 years that correlated well with QBO during JJF; NINO3 during JJA; NINO3, DMI and SOI during SON months. Unlike the AS, a cycle of 6-11 years is evident in BoB that correlates with NINO3 and SOI during DJF; NINO3, DMI and SOI during MAM; IOSD, SAMI and QBO during JJA, with no significant correlation during SON months.

Conclusion

The present study highlights the importance of wind-wave climate, its variability and dependency with various well established climate indices for AS and BoB basins. This study is based on the analysis from measured satellite altimeter data for a period of 21 years. The presence of IOSD is clear for AS during all seasons, whereas BoB exhibited a good correlation with NINO3 and SOI during all seasons except JJA months. The dependency of climate signals on the variability of waves showed a mixed response.

References

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