PREDICTING AIR QUALITY THROUGH THE PHASING OF THE MADDEN-JULIAN OSCILLATION IN SANTIAGO, CHILE

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Abstract

The Madden-Julian Oscillation (MJO) is the leading mode of intraseasonal variability in the tropics. This modulation is a slow moving eastward propagation that affects both precipitation and atmospheric circulation on a 30-60 day cycle. The MJO can be broken up into eight phases, and each phase is associated with unique precipitation and atmospheric circulation characteristics. Phases 8, 1 and 2 are associated with positive precipitation anomalies in central and south-central Chile (30–45°S), and negative precipitation anomalies are associated with Phases 3-7. Precipitation events have been found to clean the atmosphere of pollution particles such as PM_{10}, thus contributing to improved air quality. The objective of this study was to test whether the MJO, which modulates winter seasonal precipitation events, would also modulate surface PM_{10} concentrations. The positive (negative) precipitation anomalies during wet (dry) MJO phases should cause lower (higher) concentrations of PM_{10}. The MJO can then be used to predict air quality in central Chile, and those predictions can then be used to reduce concentrations of PM_{10}, which is critical for improving human respiratory health in the metropolitan area.

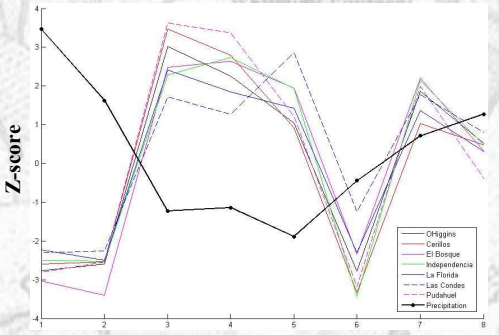
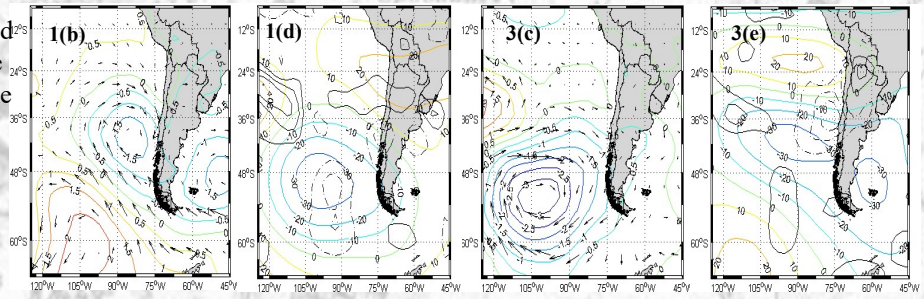


Fig. 1: a) PM_{10} concentration from Parque O'Higgins in Santiago, Chile.b) and c) represent reanalysis-based sea level pressure (contours in m, every 0.5 mb) and surface wind anomalies for Phases 1 and 3 respectively.d) and e) represent reanalysis-based200-hPa geopotential height and 700-hPa omega (pressure-coordinate vertical velocity, in mb hr^{-1}) anomalies.



Results/Conclusions

The PM_{10} pattern fit this precipitation pattern, besides the Phase 6 PM_{10} surface concentrations. The high (low) values of surface PM_{10} generally coincide with the low (high) anomalous precipitation. The precipitation during the austral winter in Santiago is forced by the Madden-Julian Oscillation. This oscillation creates specific days of anomalously high precipitation. During these days of anomalous rain there is a cleansing affect on the atmosphere. As the rain falls, the rain droplets gradually absorb the PM_{10} and remove them from the atmosphere above Chile. In order to further explain how the PM10 in Phase 6 does not match the pattern of the other 7 Phases; we looked at the wind patterns on the mesoscale and synoptic scale. The large scale circulations in Phases 3 and 4 (Fig. 7) support the original hypothesis that the most PM_{10} throughout Santiago occurred during Phases 3 and 4. The cyclonic flow off the cost forces the PM10 from the industrious eastern portion of Santiago to western Santiago, where the PM_{10} cannot flow over the mountain.

Relevance

Because PM_{10} has such a large impact on the health of the young and elder in all over the world, it has become a heavily studied pollutant in the scientific community. However, few studies have connected the intraseasonal variability or connection the Phase of MJO. The results in this study confirmed that for the Santiago metropolitan region, both maximum daily PM_{10} concentrations and precipitation varied by Phase of the MJO, with lowest PM_{10} occurring on days with the MJO Index in Phases 8, 1 and 2 and highest PM_{10} occurring on days with the MJO Index in Phases 3,4,5 and 7. This research