Intra-seasonal variability of surface ozone in Los Angeles and its relationship to the Madden Julian Oscillation

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INTRODUCTION

•Elevated surface ozone levels occur in the summer months in the city of Los Angeles, California when temperatures are highest and the air is driest (Lu et al. 1996).

•The chemical reaction formula for surface ozone production is:

0+02+m->03+m (m being some mass)

NO2+hv->NO+0 (hv being solar radiation)

03+NO->NO2+02

•The Madden-Julian Oscillation (MJO) is a global-scale circulation pattern that is the leading cause of atmospheric variability a 40-50 day window (Madden and Julian 1972).

•The MJO has been found to modulate temperature and wind in Los Angeles (Lorenz et al. 2006).

•However, the variability of surface ozone in Los Angeles on timescales of the MJO has not yet been explored.

PURPOSE

• To analyze the variability of surface ozone concentrations in Los Angeles by phase of the Madden Julian Oscillation (Madden and Julian 1972)

•To explain observed variability in surface ozone using relationships between phase of the MJO and surface temperature and low cloud cover

DATA

•Surface ozone measurements come from the Air Quality System (AQS), an EPA database.

•Five stations were examined in the Los Angeles area during summer months of June-September from 1980 until 2011 (Figure 1).

Figure 1: Ozone observing stations

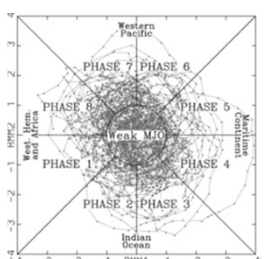

Figure 2: The Real-time Multivariate MJO phase space, defined by RMM1 and RMM2 (Wheeler and Hendon, 2004).

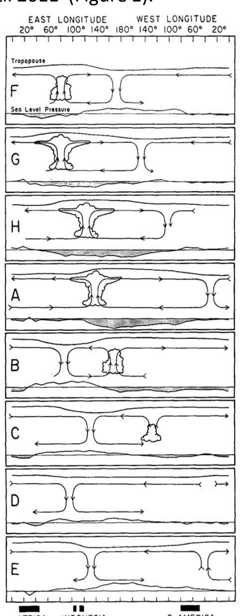

Figure 3: Longitudinal cloud patterns along the equator showing convection in the upper troposphere (Madden and Julian, 1972).

METHODS

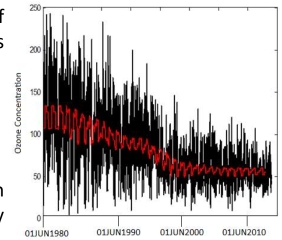

Figure 4: Station 70002 ozone values (ppb) black; 5-yr running mean (red)

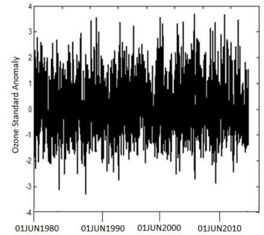

Figure 5: Station 70002 ozone standard anomalies after removing long-term trend.

Ozone Anomalies:

•Daily ozone anomalies for each station were calculated by subtracting the 5-year running average for each month from the daily ozone value (Figures 4 and 5).

•Daily ozone values were converted to standard anomalies by subtracting the 5-year running monthly average from the actual ozone value, and dividing the result by the 5-year running monthly standard deviation (Figure 5).

•Daily anomalies were binned by phase of the MJO defined according to the RMM Index.

Low cloud and temperature anomalies:

•Daily low cloud and temperature came from the National Centers for Environmental Prediction (NCEP) North American Regional Reanalysis (NARR), which assimilates hourly data from long periods of hydrometeorlogical variables at all levels of the atmosphere.

•Daily values of low cloud and temperature were taken at 2100 UTC from 1980 to 2011. Anomalies were calculated for each MJO phase.

•Mean anomalies were found by subtracting the mean for all phases from the mean value for that phase.

CONCLUSIONS

•Ozone varied by MJO phase, which also varies by month (Figure 6).

•Phases with higher ozone concentration may have higher concentration in June and July but lower in August and September, indicating seasonality.

•Phases 4 and 5 had the most amount of low cloud cover correlating to the lowest amount of ozone, whereas Phases 2, 3 and 6 had less low cloud cover and more ozone.

•Cooler than normal temperatures were found in Phases 4, 5 and 8, when lower ozone was present, and warmer temperatures were found in Phases 2 and 6.

ADDITIONAL RESEARCH

•Study the effect on ozone of humidity and precipitation

•Examine the effect that surface wind direction has on ozone concentration at each of the 5 different stations

RESULTS: OZONE

•Surface ozone was found to vary by MJO phase at all observing stations. High ozone occurred in Phases 3 and 6 and low in Phases 4 and 5 (Figure 6)

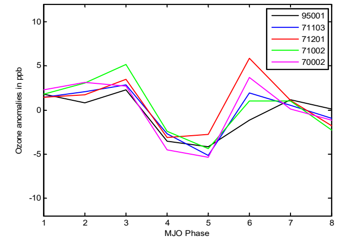

Figure 6: Mean ozone anomalies by MJO phase

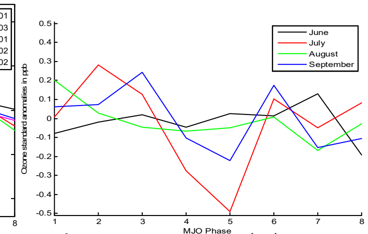

Figure 7: Mean ozone standard anomalies by phase for all of the stations combined

RESULTS: LOW CLOUD AND TEMPERATURE

•High ozone phases (phase 3 and 6) had less lower cloud cover (red), while low ozone phases (phases 4 and 5) had more low cloud cover (blue) (Figure 8).

•Higher temperatures produce higher ozone therefore phases with higher ozone are due to higher temperatures in certain phases (Figure 9).

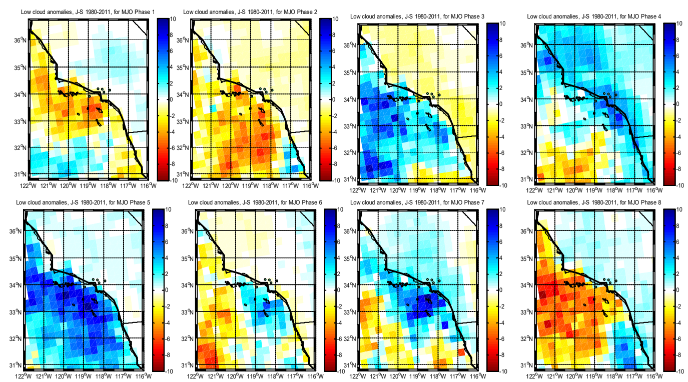

Figure 8: Low cloud anomalies by phase of the MJO. Blue represents cloudier skies than normal and red represents sunnier skies than normal for each phase.

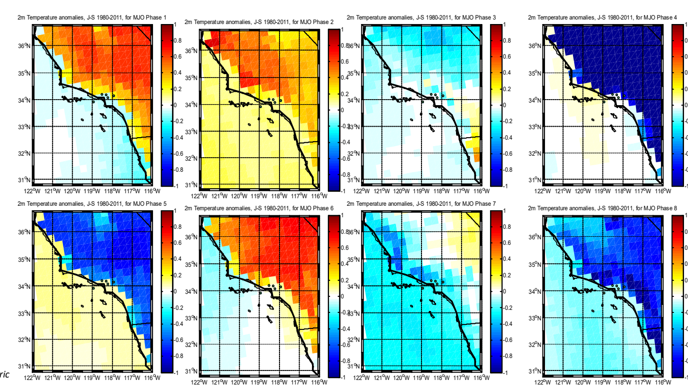

Figure 9: Temperature anomalies measured at 2m above the surface by phase of the MJO. Red represents warmer temperatures than normal and blue represents cooler temperatures than normal for each phase.

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