Meteorological Factors Affecting Intraseasonal Variability of Surface Ozone Concentrations in Santiago, Chile by Phase of the MJO

MIDN 1/C Sarah R. Pritchard
Advisor: Dr. Bradford Barrett

Introduction

• Santiago, Chile regularly has ozone (O_3) concentrations above 160 μgm^{-3} in the summer when temperatures and humidity are high and duration of insolation is greatest (Elshorbany et al. 2009, and Schmitz 2005)

•Concentration levels are determined by topographical features, such as elevation and proximity to mountains, in addition to pollution and meteorological factors, such as wind speed , humidity, precipitation, and temperature (Gramsch et al. 2006, Fig. 3)

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

• The MJO has been found to modulate rainfall and atmospheric circulation in Chile (Barrett et al. 2011).

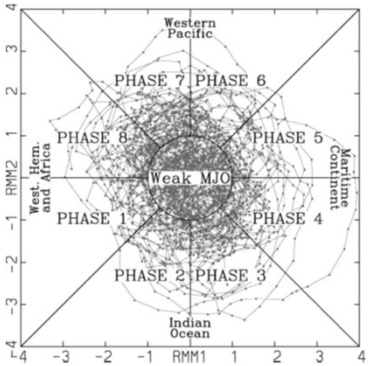

Figure 1: Phase space points for all available days in DJF season from 1974 to 2003. Eight defined regions of the phase space are labeled, as is the region considered to signify weak MJO activity.

Methods

•The MJO has been partitioned into 8 phases, however, its affect on surface ozone remains unknown (Wheeler and Hendon 2004; Fig. 1)

•To test the relationship between the MJO and ozone, we:

•Complied ozone data and atmospheric measurements for 9 stations around Santiago from SINCA (Sistema de Información Nacional de Calidad de Aire) for the summer months of October through February, 1988-2010.

•Analyzed daily 8-hour maxima of 3 stations (Fig. 2) for each MJO phase by time of day (Table 1)

•Examined wind speed, temperature, dew point, sea level pressure and ceiling height vs. MJO phase for various times of day.

Table 1: Frequency of MJO Phase from 1988 to 2010

MJO Phase	1	2	3	4	5	6	7	8	Neutral
Frequency (days)	290	321	375	337	355	336	334	316	1436
Percent of total	7.07	7.83	9.15	8.22	8.66	8.20	8.15	7.71	35.0

Purpose

• To analyze the variability of surface ozone concentrations in Santiago by phase of the leading mode of atmospheric intraseasonal variability, the Madden Julian Oscillation (MJO)

• To examine the relationship between temperature, wind and mixing, cloud fraction, and water vapor to surface ozone on the timescale of the MJO.

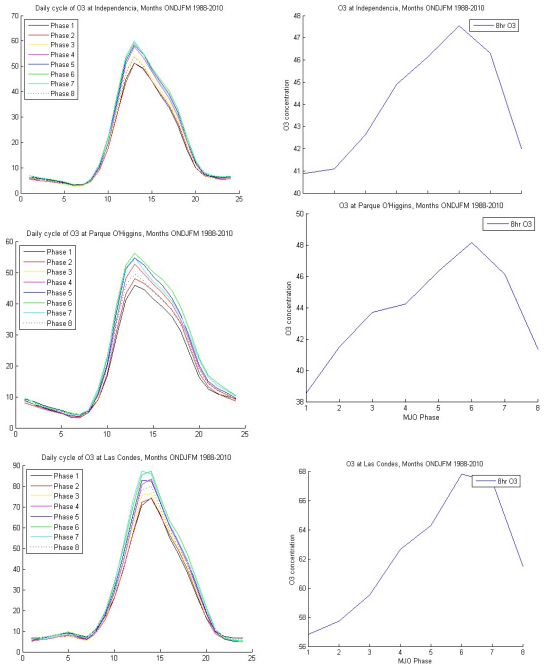

Figure 2: Ozone daily cycle and 8 hour maximum concentrations (in ppb) at 3 stations in Santiago by phase of the MJO. The maximum values occurred in Phase 6 while the minimum values occurred in Phase 1 at all three stations. The greatest concentrations were at Las Condes while the lowest readings were at Parque O'Higgins.

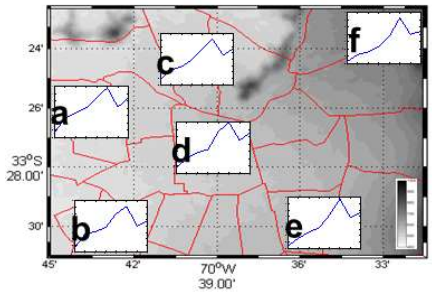

Figure 3: Ozone concentration anomalies (in ppb) across the 8 active phases of the MJO for the six individual air quality monitoring stations sampled in this study. The stations are (a) Pudahuel (b) Cerrillos (c) Independencia (d) Parque O'Higgins (e) La Florida, and (f) Las Condes. The consistent signal throughout each station represents an increase in general concentration anomaly, peaking in Phase 6.

Meterological Factors

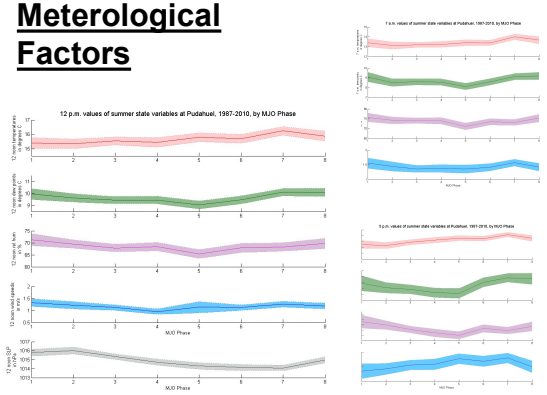

Figure 4: Temperature, dew point, relative humidity, wind speed and sea level pressure in Pudahuel at 0700, 1200 and 1700. Peak ozone concentrations are observed in Phase 6 and minimums in Phase 1.

Analysis

•Ozone was most abundant at 1400 LT (Fig. 2). This corresponded to the hour of maximum insolation.

•Stations with higher elevations had higher surface ozone concentrations (Gramsch et al, 2006).

•Warmest (coldest) temperatures generally occurred on days with highest (lowest) ozone concentrations (Fig. 4).

•Sea level pressure (and anomalies) create a sine wave through the phases.

Conclusions

- A relationship exists between MJO phase and surface ozone concentrations. Ozone is most abundant in Phase 6 and least abundant in Phase 1 throughout the basin.
- More research is needed to determine if the slight increase in ozone at 0500 in Las Condes is significant.
- More data, gathered over a longer period of time, would be useful in analyzing meteorological factors and drawing conclusions about the variables.
- Satellite readings would be a helpful addition to the process of data gathering. However, problems may be encountered when taking measurements on overcast days.

References

Barrett, B.S., et al., 2011, Madden-Julian Oscillation (MJO) modulation of atmospheric circulation and Chilean winter precipitation. Journal of Climate, submitted.

Elshorbany, Y.F. et al., 2009, Summertime photochemical ozone formation in Santiago, Chile: Atmospheric Environment, vol. 43, no. 40, p.6398-6407.

Gramsch E., Cereceda-Balic F., Oyola, P., von Baer D., 2006, Examination of pollution trends in Santiago de Chile with cluster analysis of PM10 and Ozone data: Atmospheric Environment, vol 40, no. 28, p. 5464-5475

Madden, Roland A., and Paul R. Julian. 1972, Description of Global-Scale Circulation Cells in the Tropics with a 40-50 Day Period: Journal of the Atmospheric Sciences, vol 29 , p.1109-123.

Schmitz, R., 2005, Modelling of air pollution dispersion in Santiago de Chile: Atmospheric Environment, vol. 39, no. 11, p.2035-2047.

Wheeler, M.C. and Hendon, H.H., 2004, An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction: Monthly Weather Review, vol. 132, no. 8, p. 1917-1932.