

TABLA DE CONTENIDO

| | |
|---|----|
| 1.- Presentation and Background..... | 1 |
| 1.1.- Introduction | 1 |
| 1.2.- Goals | 4 |
| 1.2.1.- Main Goal..... | 4 |
| 1.2.2.- Secondary Goals..... | 5 |
| 1.3.- Concepts | 5 |
| 1.3.1.- Ozone | 5 |
| 1.3.2.- Aerosols..... | 5 |
| 1.3.3.- Optical Properties of aerosols | 7 |
| 2.- Data Base and Methods..... | 10 |
| 2.1.- Instruments and Data Base description | 10 |
| 2.1.1.- Instruments | 10 |
| 2.1.2.- Data Base | 11 |
| 2.1.2.1.- Equivalent Black Carbon | 12 |
| 2.1.2.2.- Angstrom exponent | 12 |
| 2.2.- Basic Statistics | 14 |
| 3.- Results | 15 |
| 3.1.- Variability Analysis | 15 |
| 3.1.1.- Ozone | 15 |
| 3.1.3.- Equivalent Black Carbon | 17 |
| 3.1.4.- Angstrom Exponents | 21 |
| 3.2.- Case Study..... | 24 |
| 4.- Conclusions | 30 |
| 5.- Bibliography..... | 32 |
| Appendix A - List of abbreviations | 37 |

ÍNDICE DE TABLAS

| | |
|--|---|
| Table 1. Parameters which are used to aerosol amount and type. | 8 |
|--|---|

ÍNDICE DE ILUSTRACIONES

| | |
|---|----|
| Figure 1. Location of Cerro Tololo (30°S, 70°W, 2200 m.a.s.l.). The map to the upper-left shows altitude contours in meters for the intervals: <0, 0–50, 50–200, 200–500, 500–2000, 2000–3500, 3500–5000 and above 5000 m. (Gallardo, Carrasco, & Olivares, 2000). Bottom shows a cross-section at 30°S, red circle represents Cerro Tololo site, bottom (right) axes shows horizontal distance from coastline (altitude) in kilometers (meters). | 2 |
| Figure 2. Monthly averages of ozone at Cero Tololo. The observation period is between April 1996 until April 1998. Error bars indicate one standard deviation of the mean. Figure from Gallardo, Carrasco, & Olivares (2000). | 3 |
| Figure 3. The upper panels show composite time series of ozone anomalies (solid curve) and water vapor pressure anomalies (dashed curve) for (a) W and (b) D cases relative to average values for the selected episode. The lower panels show the 12h-window running mean omega velocity (from NCEP/ NCAR reanalysis) composites for (c) W and (d) D cases at two different vertical levels over a grid point at 30°S and 70°W. Recall that negative values indicate upward motion. Dashed vertical lines indicate the initial increase in ozone. The solid curve represents 500-hPa, and the dashed curve represents 200-hPa. Figure from Rondanelli, Gallardo, & Garreaud (2002). | 4 |
| Figure 4. Scheme how to calculate absorption coefficient after introducing corrections in the attenuation coefficient obtained from Lambert-Beer Law (by Budi Satria, GAW Bukit Kototabang Station). | 8 |
| Figure 5. Scatter plot of AAE vs. organic fraction of submicron non-refractory aerosol mass, color coded by scattering Angstrom exponent. Results are from in situ measurements of aerosols by absorption photometer, nephelometer, and aerosol mass spectrometer on the C-130 mostly over Central Mexico during MILAGRO in March 2006 (Shinozuka Y. , Clarke, Howell, & al., 2008; DeCarlo, et al., 2008; Shinozuka Y. , et al., 2009). AAE and SAE are for total particles observed behind the aircraft inlet. (i.e., not submicron aerosol). Figure from Russel, et al. (2010). | 9 |
| Figure 6. Fixed panoramic picture of Cerro Tololo (by Nicolas Bukowiecki), dotted yellow circle represents Aerosol-ozone station. | 11 |
| Figure 7. Aerosol-ozone station at Cerro Tololo (by Nicolas Bukowiecki). | 11 |
| Figure 8. Hourly ozone distribution at TLL during 2013-2015. | 15 |
| Figure 9. Boxplot, diurnal cycle of hourly ozone concentrations [ppbv] at TLL during 2013-2015. Top and bottom of boxes mean percentile 25 and 75 (p25 & p75, respectively), red line in box represents median value for each hour, extreme of top and bottom dashed lines represent (2.5*p25 - 1.5*p75) and (2.5*p75 - 1.5*p25), and red marker are taken as outliers. | 16 |
| Figure 10. Daily ozone concentrations [ppbv] at TLL during 2013-2015. | 16 |
| Figure 11. Top: Time series of monthly ozone concentrations [ppbv] at TLL during 2013-2015. Red markers represent average for each month, top and bottom black bars are one standard deviation each. Bottom: amount of days in each month that are used to calculate monthly averages and standard deviations. | 17 |
| Figure 12. Boxplot, monthly cycle of daily ozone concentrations at TLL during 2013-2015. Top and bottom of boxes mean percentile 25 and 75 (p25 & p75, respectively), red line in box represents median value for each month, black markers mean average value of each month, | |

extreme of top and bottom dashed lines represent $(2.5 * p_{25} - 1.5 * p_{75})$ and $(2.5 * p_{75} - 1.5 * p_{25})$, and red marker are taken as outliers.17

Figure 13. Hourly distribution of eBC concentrations at Cerro Tololo during 2013-2015.18

Figure 14. Daily series of eBC at TLL during 2013-2015.19

Figure 15. Boxplot, diurnal cycle of hourly eBC concentrations at TLL during 2013-2015. Top and bottom of boxes mean percentile 25 and 75 (p_{25} & p_{75} , respectively), red line in box represents median value for each hour, extreme of top and bottom dashed lines represent $(2.5 * p_{25} - 1.5 * p_{75})$ and $(2.5 * p_{75} - 1.5 * p_{25})$, and red marker are taken as outliers.19

Figure 16. Top: monthly series of eBC concentrations at TLL during 2013-2015. Red markers represent average for each month, top and bottom black bars are one standard deviation each. Bottom: amount of daily averages in each month that are used to calculate monthly standard deviations and averages.20

Figure 17. Boxplot, monthly cycle of daily eBC concentrations at TLL during 2013-2015. Top and bottom of boxes mean percentile 25 and 75 (p_{25} & p_{75} , respectively), red line in box represents median value of each month, black markers mean average value of each month, extreme of top and bottom dashed lines represent $(2.5 * p_{25} - 1.5 * p_{75})$ and $(2.5 * p_{75} - 1.5 * p_{25})$, and red marker are taken as outliers.20

Figure 18. Hourly distribution at Cerro Tololo during 2013-2015. Top for AAE, middle SAE and bottom SSAAE.21

Figure 19. Boxplot, diurnal cycle of hourly Angstrom exponents at TLL during 2013-2015. Left for AAE, middle SAE and right SSAAE. Top and bottom of boxes mean percentile 25 and 75(p_{25} & p_{75} , respectively), red line in box represents median value for each hour, extreme of top and bottom dashed lines represent $(2.5 * p_{25} - 1.5 * p_{75})$ and $(2.5 * p_{75} - 1.5 * p_{25})$, and red marker are taken as outliers.22

Figure 20. Time series of daily Angstrom Exponents at Cerro Tololo during 2013-2015. Top for AAE, middle SAE and bottom SSAAE. Black (yellow, B and C) zones represent BC (dust, A and D) episodes.23

Figure 21. Monthly series of Angstrom Exponents at Cerro Tololo during 2013-2015. Top for AAE, middle SAE and bottom SSAAE. Black (yellow, C) zones represent BC (dust, D) episodes.23

Figure 22. Monthly cycle at TLL for Dust Events: left represents boxplot of daily concentrations of ozone, middle boxplot of daily concentrations of eBC, and right monthly values of scattering coefficients.....24

Figure 23. Monthly cycle at TLL for NO Dust Events: left represents boxplot of daily concentrations of ozone, middle boxplot of daily concentrations of eBC, and right monthly values of scattering coefficients.....25

Figure 24. Dust case, 07/Mar/2014. Aerosol optical properties: top AAE, middle SAE, and bottom SSAAE. Yellow zone represents DU event.26

Figure 25. Dust case, 07/Mar/2014. Top ozone, bottom eBC, and bottom scattering coefficient. Yellow zone represents DU event.26

Figure 26. Dust case, 04/Nov/2014. Aerosol optical properties: top AAE, middle SAE, and bottom SSAAE. Yellow zone represents DU event.27

Figure 27. Dust case, 04/Nov/2014. Top ozone, bottom eBC, and bottom scattering coefficient. Yellow zone represents DU event.27

Figure 28. NO dust case, 24/Dec/2013. Aerosol optical properties: top AAE, middle SAE, and bottom SSAAE. Yellow zone represents ND event.28

Figure 29. NO dust case, 24/Dec/2013. Top ozone, bottom eBC, and bottom scattering coefficient. Yellow zone represents ND event.28

Figure 30. NO dust case, 05/May/2015. Aerosol optical properties: top AAE, middle SAE, and bottom SSAAE. Yellow zone represents ND event.29

Figure 31. NO dust case, 05/May/2015. Top ozone, bottom eBC, and bottom scattering coefficient. Yellow zone represents ND event.29