**Syllabus Formation: PHY478**

## Project Outline

This project is divided into two parts and involves the analysis of ozone measurements taken by ACE-MESTRO (Atmospheric Chemistry Experiment - Measurement of Aerosol Extinction in the Stratosphere and Troposphere Retrieved by Occultation) over the past 17 years.

1. Intercomparison of simultaneous UV & VIS measurements from MAESTRO (measurements taken from different spectral regions).
2. Examine trends in ozone variation as seen by ACE-MAESTRO.

## Objectives & Methodology

The first objective is to understand where there are differences between the measurements taken in the UV and VIS regions. This will be done by first performing an <u>intercomparison of simultaneous UV and VIS measurements of ozone from ACE-MAESTRO.</u> This will be done by comparing simultaneous measurements of the measured quantity (ozone volume mixing ratio) using the reduced major axis method (and/or ordinary least squares method). This will be done for the complete dataset but may also be done year-by-year to investigate yearly patterns. Metrics for validation will be the mean relative/absolute differences, root mean square deviation, and standard deviation.

Following this, the second objective is to <u>determine the drift in ozone seen by ACE-MAESTRO over the past 17 years.</u> This will be done by estimating linear drift for the satellite - ground station differences (ie, MAESTRO over Eureka). One could estimate drift using only data over Eureka or can include comparisons over other stations with ground-based instruments and determine the ground-network averages. Then the Iterative Tukey-bisquare reweighted least-squares procedure will be used to fit the daily averaged relative difference time series to a linear regression model. There will be a cross-check regression analysis with a bootstrapping regression analysis with a smaller coincidence interval to check the calculation of both the weighted mean and its uncertainty.

<u>The final objective is to examine trends in ozone variation as seen by ACE-MAESTRO</u>. A multilinear parametric trend, including a linear term and several harmonics, can be used. One can first approximate the temporal development of an atmospheric state variable as a straight line, and then introduce sinusoidal terms to the model with varying periods (24 and 12 months, and possibly others). Use of the full covariance matrix when minimizing the cost function accounts for any bias. The final trend is found by subtracting the drift calculated by the instrument from the multilinear parametric trend model.

## Description of Student Participation

The student will begin the project by completing the assigned readings and creating an annotated bibliography. Following this, she will develop python code to open and read ACE-MAESTRO data and create a program to perform the comparison analysis for the first objective. After completing this, she will develop code for the second objective of determining the drift of the instrument measurements, and finally, the program for the third objective. Before moving onto the next objective, she will produce results and analyze/document them. As she develops her programs, she will produce a report outline which will contain the framework of the final resulting report. As the semester finishes, she will deliver a presentation of her results and write a final report summarizing her work over the term.

## Grading Scheme

| Item | Description | Weight | Date |
|---|---|---|---|
| Annotated Bibliography | Document summarizing readings (related to project, important to the final report). | 10 % | Before drop date, before reading week. February 11. |
| Report Outline | Outline of final report. | 15 % | 1 month before oral exam.<br>March 11. |
| Oral Examination | Required final presentation (15-20 min) describing my work. | 40 % | End of term (before written report)<br>March 17. |
| Written Report | Required summary report of my work over the term. | 35 % | End of term (1-2 weeks after oral exam).<br>March 25. |

## Readings


1. Eckert, Ellen, von Clarmann, T., Kiefer, M.: Drift-corrected trends and periodic variations in MIPAS IMK/IAA ozone measurements, *Atmos. Chem. Phys., 14, 2571–2589, 2014 www.atmos-chem-phys.net/14/2571/2014/ doi:10.5194/acp-14-2571-2014, 2014.*
2. von Clarmann, T., Trend estimation from irregularly sampled, correlated data, Atmos. Chem. Phys., 10, 6737–6747, 2010 www.atmos-chem-phys.net/10/6737/2010/ doi:10.5194/acp-10-6737-2010, *2010.*
3. *Hubert, Daan, Lamber,* J. C. , Verhoelst, Tijl.: *Ground-based assessment of the bias and long-term stability of fourteen limb and occultation ozone profile data records Atmos. Meas. Tech., 9, 2497–2534, doi:10.5194/amt-9-2497-2016, 2016.*
4. *Street, J. O., Carroll, R. J., and Ruppert, D.: A Note on Computing Robust Regression Estimates Via Iteratively Reweighted Least Squares, The American Statistician, 42, 152–154, doi:10.1080/00031305.1988.10475548, 1988.*
5. *Efron, B. and Tibshirani, R.: Bootstrap Methods for Standard Errors, Confidence Intervals, and Other Measures of Statistical Accuracy, Statist. Sci., 1, 54–75, doi:10.1214/ss/1177013815, 1986.*
6. *Dufour (2005), Intercomparison of Simultaneously Obtained Infrared (4.8 μm) and Visible (515-715 nm) Ozone Spectra Using ACE-FTS and MAESTRO*