**NASA DEVELOP National Program**



Langley Research Center

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CALIPSO: Global Health & Air Quality

Creating a Tool with the ability to Classify Aerosols within CALIPSO Data to Help Improve Future Research and Decision Making

 **Technical Report** 

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# I. Abstract

[Placeholder - do not put anything here until the final draft submission. The abstract in the project summary is where the working draft of the abstract should “live”]

**Keywords**

CALIPSO, CALIOP, Remote Sensing, Lidar, Atmospheric Composition, Atmospheric Aerosols, Smoke, Clouds, Dust, Air Quality, Python

# II. Introduction

**Background Information**

Current Study

The Cloud-Aerosol Lidar Infrared Pathfinder Satellite Observation (CALIPSO) was among the first satellite-based lidar systems in orbit. Its purpose is to observe clouds and aerosols in the atmosphere, allowing researchers to track and understand their effects. Due to the relatively new quality of lidar data, formatting data and accessibility can be enhanced in many ways (Winker et al., 2013). To increase ease of access in one respect, the DEVELOP team’s objective is to improve upon a pre-existing IDL tool. The current tool allows a user to upload an HDF file containing L1 and L2 data products from CALIPSO, and visualize these objects as images on a grid with axes of time and altitude. The user can then select cloud and aerosol objects of interests by freehand in order to classify the data. However, the IDL platform is not ideal for distribution and adaptation, due to its proprietary nature. Moreover, it remains difficult to access various items that have been previously selected and labeled by users.

Previous Studies

In the recent years, there has been a number of algorithms developed to automatically discern cloud and aerosol layers. For example, the selective, iterated boundary location (SIBYL) algorithm scans the backscatter signals through multiple iterations and averages the signal depending on the background noise (Vaughan et al, 2009). Then, additional algorithms such as the Scene Classification Algorithm (SCA) attempt to identify what type of aerosol or cloud the SIBYL detected. The Hybrid Extinction Retrieval Algorithm (HERA) uses known lidar ratios and scattering ratios to further create backscatter profiles for clouds and aerosols (Winker et al, 2006).

A previous team of researchers at the University of Colorado at Boulder built a tool for analyzing spectrometer imaging by combining high spectral resolution and spatial data presentation. The Spectral Image Processing System (SIPS) was an integrated system and user interface developed in IDL that allowed analysis, utilities for formatting, and visualizing data sets from AVIRIS, GERIS, and Eos HIRIS (Kruse et. al., 1993). The user interface of this tool had the ability to zoom and edit the image created based off the images in addition to saving the image in a BSQ format (Kruse et. al., 1993). In addition to the built in User Interface, SIPS could export any data to a GIS software in order to allow the user to perform further analysis (Kruse et. al., 1993).

**Objective**

The goal of this project is to update this IDL tool in the open source Python programming environment, which will give it much wider distribution base. Once it is translated over to Python, the tool can be updated to allow for selected objects to be exported into a web-based database, allowing for greater ease of access for many users. Additionally this will allow for a consolidation of all prerequisite code and tools, which proved challenging to collect and run due to its disparate nature. An additional goal of this project is to assist those scientists interested in cataloguing smoke plumes, which have significant impact on the air quality on a region. Smoke is difficult to track over time because of its various possible compositions and visual similarity to clouds. With an organized, accessible database, researchers will be able to better recognize the impact of smoke as it travels further from source fires.

**Area of Study**

This project has a global area of study, as the tool can be used with any CALIPSO data.

**Period of Study**

2006 - Present

**National Application Addressed**

This project addresses the health and air quality application area. It will allow researchers to better document the lifecycles and effects of various atmospheric aerosols throughout the globe. One aerosol that requires such attention is smoke. Because of its various compositions and change in structure over time, it is difficult to track smoke plumes as they move through the environment from source fires. Generally, smoke particles begin as chains of nanometer sized particles. However, “with aging these chains tend to collapse into irregular aggregates of small particles,” (Sun et al, 2013). These chains are more difficult to detect with the algorithms listed above. Our proposed tool will help researchers document smoke plume objects with a human eye and track them as they move across the environment.

**Project Partners**

Our partners include the NASA CALIPSO science team, with the point of contacts Dr. Charles Trepte and Dr. Amber Soja. Both are hoping for a centralized location for organized CALIOP data objects.

# III. Methodology

**Satellites and Sensors**

 On April 20, 2006 CALIPSO, was launched from Vandenberg Air Force base in California (Winker et al, 2007). Since then, CALIPSO has monitored changes and continuations in the Earth’s atmosphere. CALIPSO’s instrument package is comprised principally of the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP), along with a Wide Field Camera (WFC) and an Imaging Infrared Radiometer (IIR). CALIOP sends pulses of 532nm and 1064nm into the atmosphere. By utilizing two receiver channels for the 532 nm wavelength and a total attenuated backscatter at the 1064 nm wavelength CALIPSO has the ability to identify several different types of aerosol, both anthropogenic (biomass burning and urban pollution) and biogenic ( desert dust, natural, sea salt, and volcanic) (Omar et al, 2009). With the data taken from the measurements, scientists are able to further chemically classify the aerosols (black carbon, organic carbons, sulfates, etc.) (Omar et al, 2009). CALIPSO determines the type based on an algorithm consisting of both backscatter measurements and volume depolarization ratio measurements (Omar et al, 2009). The algorithm uses at least five input parameters to make this determination: altitude, integrated attenuated backscatter measurements, location, surface type, and volume depolarization ratio (Omar et al, 2009). Although this algorithm does generate the aerosol subtype, it cannot discriminate between the sources of the aerosol (Omar et al, 2009).

**Data Used**

CALIPSO provides 6 L1 and 10 L2 data products. Before the DEVELOP spring 2015 term, the CALIPSO science team viewed this data using an IDL program that was developed in early 2007 for the team. Although this program has undergone updates and improvements over the years, due to the proprietary nature of IDL it has remained somewhat inaccessible to researchers. A program, the CloudSat and CALIPSO plotting tool (ccplot) was built to remedy this issue in a more accessible language that would allow researchers to view CALIPSO data. This tool was developed in order to allow for an easy to acquire and simple to use method of visualizing CloudSat and CALIPSO data. To this end it was written in Python, which is a free to use language, in contrast to proprietary languages such as IDL and MatLab which have been used to build previous tools. It was released under a two part BSD license, meaning it may be used and integrated into other products, so long as the original license is retained (Kuma, 2010). Over the five years, Python has been used more frequently in the atmospheric science due to the added features of array handling and other data structures (Lin, 2012). Python also has a clear and natural syntax that is easy to read by resembling pseudo-code. Finally since Python is an open-source language, the users have to ability to use or create their own customized packages (Lin, 2012). Since Python can utilize several different packages with a single interpreted environment, the code is more concise and flexible (Lin, 2012).

**Project Process**

The DEVELOP Team has endeavored to expand the ease of use and functionality of ccplot. In its native form, ccplot requires the acquisition and installation of numerous disparate python libraries, since it was optimized for use in a UNIX (meaning linux or MACos) environment. However, most users are coming from a Windows user system. By consolidating ccplot with each of the required libraries included, users will be able to simply download and install ccplot, rather than acquiring each library separately. Acquiring a library separately can cause issues with versioning and incorrect library usage, leading ccplot to fail. In addition, the team has developed a graphical user interface (GUI) to make ccplot more usable. Natively, ccplot uses a command line interface, which requires an understanding of command line usage as well as directory navigation. A GUI both gives access to a much wider user base and speeds up the process of inputting data and outputting results. Eventually the DEVELOP team would like to introduce tools that will allow researchers to manipulate the output images, allowing them to select aerosol elements of interest for further consideration. Once an element is selected, it can be flagged, categorized, and exported into a MySQL database so other scientists can view various objects organized by similar characteristics.

# IV. Results & Discussion

Insert images, graphs, maps, charts, etc. here. Choose the most important results to highlight here. Things to discuss:

* Analysis of Results: What can you tell from your graphs, images, etc? What does this mean for your project?
* Errors & Uncertainty: What factors could you not account for, what things didn’t work out like you expected they would, etc
* Future Work: If this project was to be selected for another term, what would be the focus? What other areas would be of interest?

# V. Conclusions

Final conclusions. Word count: 200-600.

# VI. Acknowledgments

Insert here. Keep to a concise paragraph or bullets of names. End with the following sentence.

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# VIII. Appendices

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