**NASA DEVELOP National Program**



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LaRC CALIPSO Cross-Cutting III

Interacting with CALIPSO Data through a

Graphical User Interface

 **Technical Report**

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# I. Abstract

**Keywords**

Atmospheric Aerosols, CALIPSO, CALIOP, LiDAR, Python

# II. Introduction

The Earth’s atmosphere is a complex and dynamic system, with many factors contributing to, and interacting with, different ecological systems and processes.. Some of the major factors in this system are clouds and aerosols, which consist of various particulates that permeate the layers of the atmosphere. Understanding how clouds and aerosols form, travel, and extinguish in the atmosphere helps us to understand the composition of the atmosphere with much greater clarity (Omar et al. 2009). Aerosols are created by a variety of sources—both anthropogenic and natural—and, as they are located in the atmosphere, can travel across large geographic areas. As a result, understanding their life cycle is important to understanding how various environmental entities interact. There are many ground and air-based means of studying aerosols but these lack the range and the longevity to properly study the effects of aerosols on the environment. With these limitations, a space-based means of studying aerosols was approached to alleviate both of these issues (Winker et al, 2009).

On April 20, 2006, the Cloud-Aerosol LiDAR Infrared Pathfinder Satellite Observation (CALIPSO) was launched as a follow-up to the shuttle based LiDAR In-Space Technology Experiment (LiTE) to serve as a more long-term platform for continuing this study, and is still collecting data. Its purpose is to provide measurements of clouds, aerosols, and their interactions and roles in the climate system (Winker et al, 2010). CALIPSO carries three instruments as its payload. The primary active sensor instrument is the Cloud-Aerosol LiDAR with Orthogonal Polarization (CALIOP), a, new, nadir-viewing, two-wavelength, polarization-sensitive LiDAR sensor (Winker et al, 2009). The remaining two are passive sensors: a wide field camera and an infrared imaging radiometer (Winker et al, 2009). CALIPSO can determine an aerosol’s type by measuring backscatter and volume depolarization ratio measurements (Omar et al. 2009). The algorithm takes altitude, integrated attenuated backscatter, location, surface type, and volume depolarization ratio as parameters (Omar et al, 2009). With the advent of CALIPSO output, researchers have access to more aerosol data and can better track aerosols through the atmosphere as well as determine crucial information about where aerosols travel.

The CALIPSO mission is pertinent across a wide variety of the NASA Applied Sciences National Applications Areas, most specifically, Health & Air Quality, Climate, Weather, and Disasters. Because of this multidisciplinary focus, it is considered a “Cross-Cutting” mission. A major challenge researcher’s face when working with CALIPSO data is the data presentation style, which is different from many other commonly used datasets. CALIPSO collects vertical profile data of the atmosphere, rather than wide-swath data, which means that many common tools for visualization have difficulties displaying CALIPSO data. To overcome this obstacle, a proprietary visualization tool was developed specifically to view and manipulate CALIPSO data. However, this tool was written in IDL, an uncommon proprietary language, which makes it difficult for new developers to update and maintain. In the spring of 2015, a DEVELOP group created an updated visualization tool in Python to alleviate this difficulty. They integrated a Python-based tool known as the CALIPSO and CloudSat Plotter (CCplot) that takes CALIPSO data as an input and outputs two-dimensional plots. However, this tool had no user interface and had limited ability to manipulate the data once plotted. In two terms of DEVELOP, this tool has been updated to reflect the needs of researchers, becoming the Visualization of CALIPSO (VOCAL) tool. Continuing to update this tool to better fit the needs of the researchers, we have enabled the tool to be easily installed in Apple’s Mac OS X and we have integrated web-based data acquisition in a client-server relationship. This will allow researchers greater flexibility when working with the tool as well as alleviate the need to download and store the large datasets.

# III. Methodology

VOCAL is a graphical user interface (GUI) that enables a user to load a Hierarchical Data Format (HDF) file, which is the output of the CALIPSO satellite. The user can then visualize the data and interact with it by tagging target regions in the image in a “lasso”-style. Because the previous DEVELOP teams emphasized the object-oriented, organized, and expandable nature of the code, much of the infrastructure and functionality of the current VOCAL version have been rolled into the current term. Upon this code base, our team has improved the system in two major spaces: cross-platform functionality and efficiency. Here, we give a brief overview of how VOCAL works, followed by our specific additions to the project and their importance to the study of Earth observations as a whole.

**A. System Overview**

At the core of the VOCAL system is the interaction between three general components: shapes (and their manager), the database (and its manager), and the GUI. A user that wants to view CALIPSO data launches the VOCAL GUI and either loads in an HDF file or previously-created shapes from a JavaScript Object Notation (JSON) file. These shapes are each associated with a particular HDF file so that shapes cannot become “orphaned.”

Whether or not the user loads previous shapes, the user can draw on the image, creating a polygon. On completion of the drawing, VOCAL associates attributes with the shape, including the polygon’s coordinates and an assigned color for identification purposes. The user can draw an unlimited number of shapes but if these crowd the image space, the user can hide selected shapes from view while continuing to work in the same view. However, because VOCAL also accommodates zooming in/out and panning, the user has multiple options for focusing on a desired region of the image. Lastly, shapes can be moved and erased. They are purely a means for denoting regions of interest on the image and enabling this data to persist after the current VOCAL session.

To this end, VOCAL has an integrated database for storing and loading shapes. Utilizing the SQLAlchemy database manager, VOCAL saves previous shapes, each in a JSON file, and this file is also associated with the HDF file from which it was originally taken. Because attributes such as the local image coordinates are saved, the user can immediately return to work on this particular shape or share it with another user of VOCAL. Herein lies one of the best features of VOCAL: the facilitation of collaboration.

The current features of VOCAL are in place largely to serve the purpose of unambiguous discussion of atmospheric aerosol data. Earth observations, such as those produced by the CALIPSO satellite, are pinned down in location on a global scale but this vantage potentially loses accuracy as well as intuitiveness when one starts to work on a subset of a cross-section of the atmosphere. Now, multiple scientists can be remotely located but certain that they are discussing the same region, stored on the same file. Our task, then, became a matter of how to increase the collaborative capabilities of the software and its data.

**B. Cross-platform Compatibility**

Before the current term, we had an involved, multi-step process for installing VOCAL on its primary operating system, Windows 7. Limited by the compatibility of the CCPlot library, the installation on Windows is 32-bit. To increase the ease of installation and use of the software, we created a VOCAL installation executable (EXE) file that would streamline the installation process.

The primary users of the VOCAL system are expected to be the CALIPSO science team, many of whom work on Apple computers running Mac OS X, so, we worked to integrate Mac functionality into the VOCAL installation. Similarly to the Windows installation, the major obstacle was CCPlot and its associated dependencies. As the methods and means of installation on a Mac differ from those on a Windows system, the process had to be fine-tuned and tested for operability. [Also, may have to talk about converting to 64-bit code here.]

**C. OPeNDAP Integration**

One of the bottlenecks in using VOCAL is the need for locally-stored HDF files, which can oftentimes become very large, very quickly. This both hinders storage capacity by taking up a large amount of memory as well as creates lengthy download speeds for gathering data. Collaboration with the Atmospheric Science Data Center (ASDC), the organization responsible for collecting and storing CALIPSO data, has led to the utilization of the Open-source Project for a Network Data Access Protocol (OPeNDAP). OPeNDAP is a protocol for accessing scientific data over the Internet. OPeNDAP integration allows researchers using VOCAL to select only the portion of the dataset in which they are interested directly from the VOCAL interface, rather than having to download the data ahead of time and then load it into the program. This reduces the storage and download requirements on the researcher's part, as well as facilitates easier sharing of findings and data between researchers.

# IV. Results & Discussion

This is currently the third generation of this project. Since the first term, the CALIPSO Cross-Cutting teams have built and continued to add functionality to the visualizer. It continues to become an increasingly useful program through which scientists can interact with image data.

# V. Conclusions

# VI. Acknowledgments

Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Aeronautics and Space Administration.

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# VIII. Content Innovation

# IV. Appendices