VERTICAL PROPERTIES OF CLOUDS AND AEROSOLS - MT. ARESKUTAN

Martin De'Ath

Mt. Areskutan was chosen as the base for the CAESAR 2014 campaign due to the mountain peak being in cloud-cover for a suitable length of time, as well as being centrally located with respect to the movement of different air masses.

INTRODUCTION

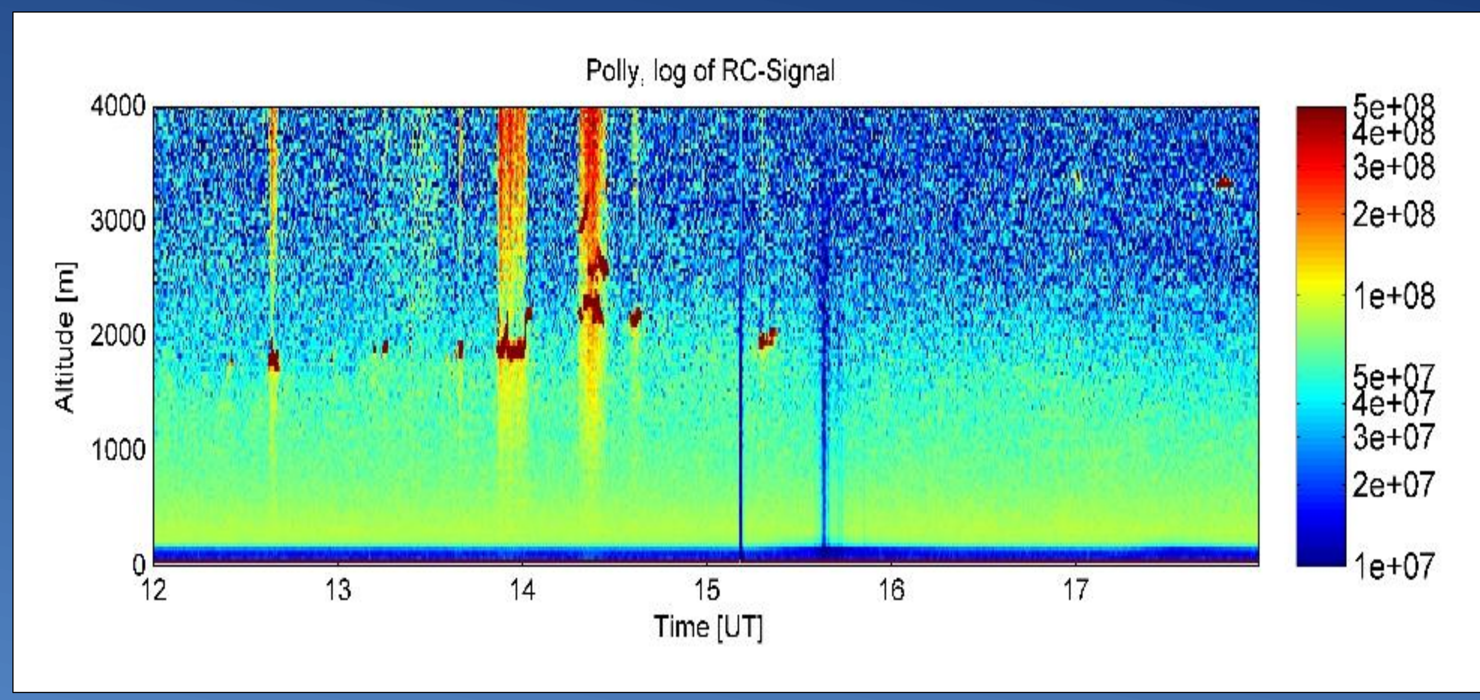
The CAESAR 2014 field campaign, carried out at Mt. Areskutan, Sweden, was an experiment aiming to address one of the most important environmental concerns of the present, climate change. It did this by observing aerosol and cloud properties in the region to attempt to determine the effects of these aerosols on cloud formation and lifetime. A large number of instruments were used, and the data of each must be analysed to get together a full picture of interaction in the Are region.

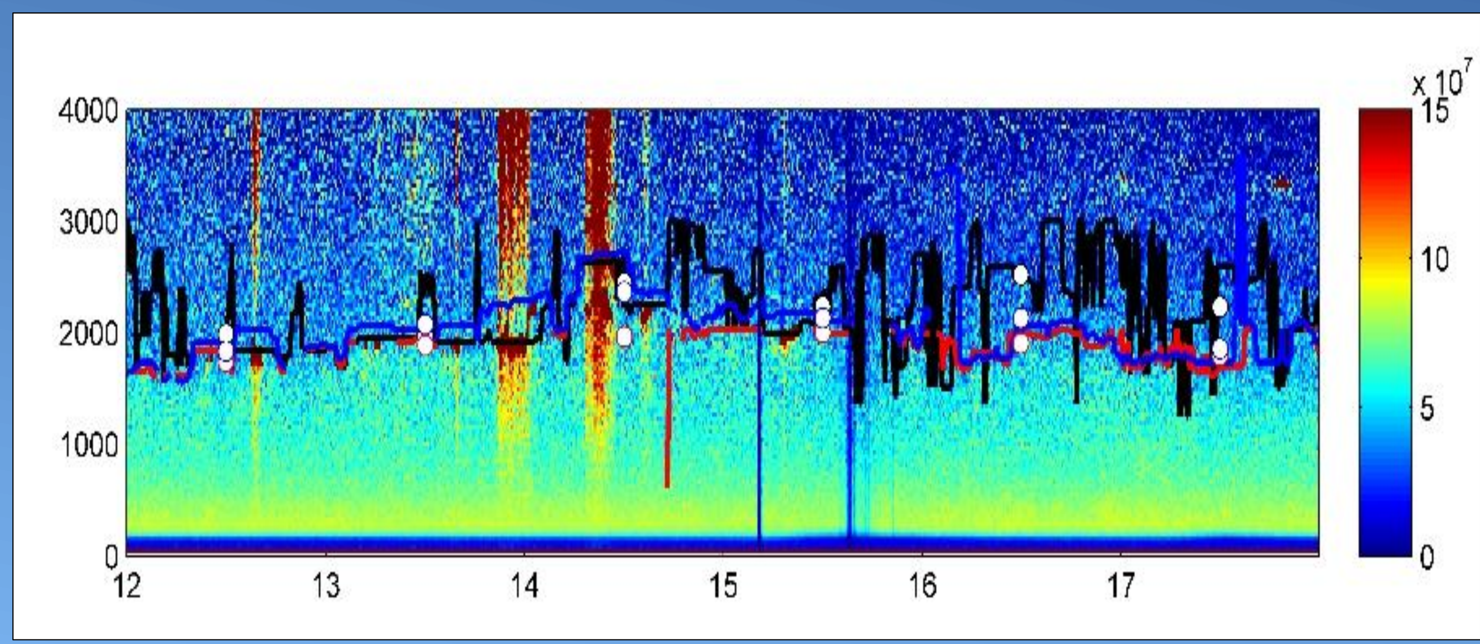
My goal for this project is to look at data from one of these instruments, the LIDAR (light-radar), and the images produced through manipulation of this data, to determine the answer to 2 primary questions:

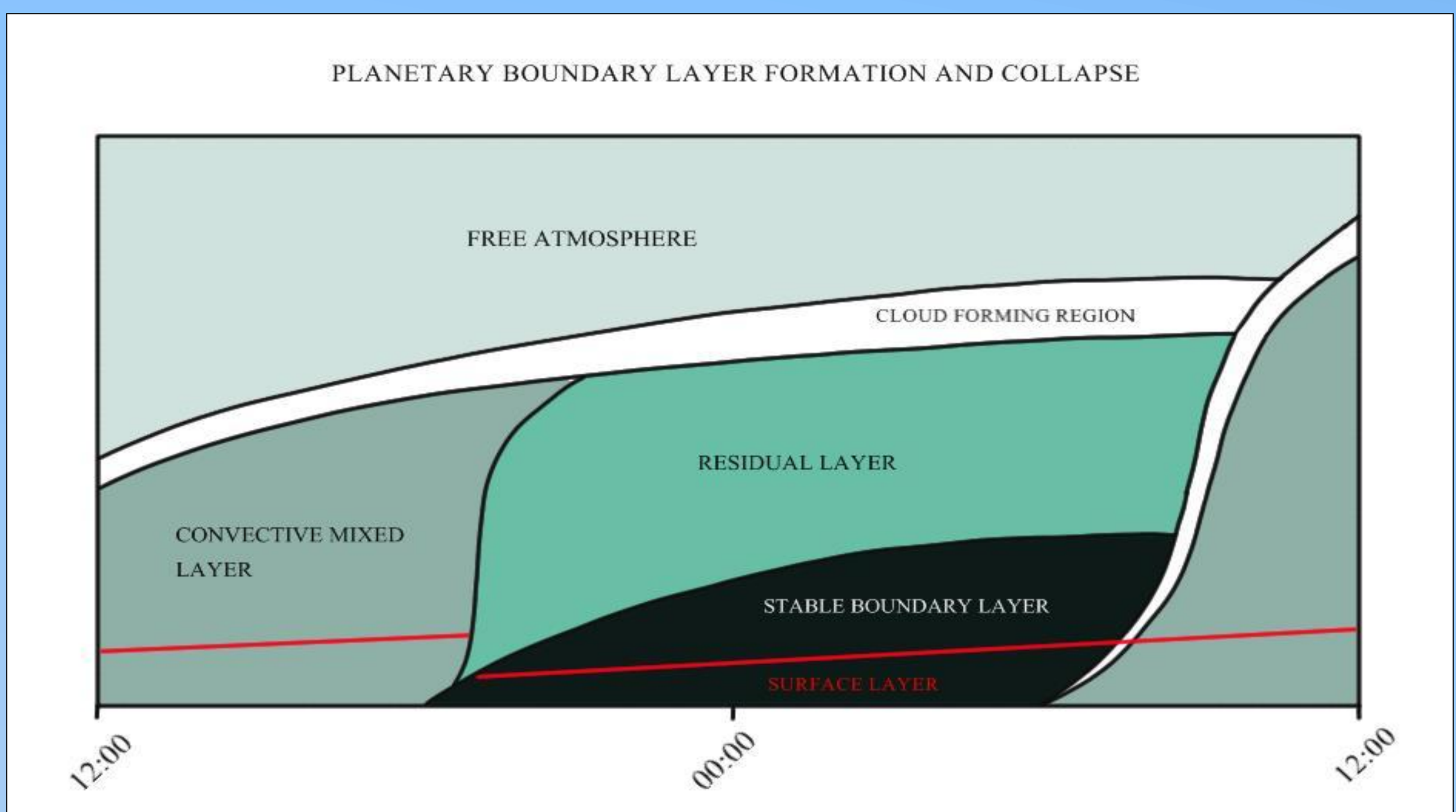
- **What is the height of the Planetary Boundary Layer (PBL)?**
- **At what height do clouds form in the region?**

WHY THESE QUESTIONS?

The PBL height is found since it can be used to determine the height to which local aerosols can be lifted. Cloud height is useful when looking into cloud properties, since researchers need to know where they are within the cloud so the correct methods of analysis for cloud interior or cloud base behaviour can be used.







THE PLANETARY BOUNDARY LAYER (PBL)

The PBL is considered to be the lowest part of the Earth's atmosphere, often defined as "the part of the troposphere that is directly influenced by the Earth's surface" (Stull, 1988). It ranges from a surface layer near the ground up to the base of the free atmosphere. The PBL is constantly changing however, rising and falling based on time of day and conditions in an area. In the hottest parts of the day, local aerosols are lifted via convection into higher regions. At night, during the coldest part of the day, the boundary layer collapses back down to a stable consistent layer closer to ground level.

My work in identifying the PBL height throughout the campaign is important for the following reasons:

- **The height of the PBL indicates the height to which aerosols can be lifted. If this height surpasses that of the mountain station then aerosol properties measured at the peak will relate to locally sourced aerosols.**
- **The top of the PBL often indicates the start of cloud formation. Cloud base height can be found, enabling researchers to identify where they are situated in the cloud and what information they are gathering.**

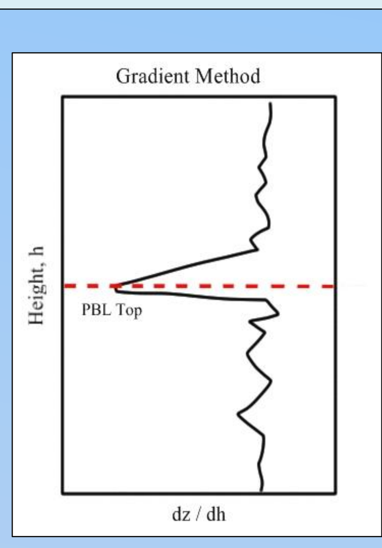
METHODS USED – LIDAR ANALYSIS

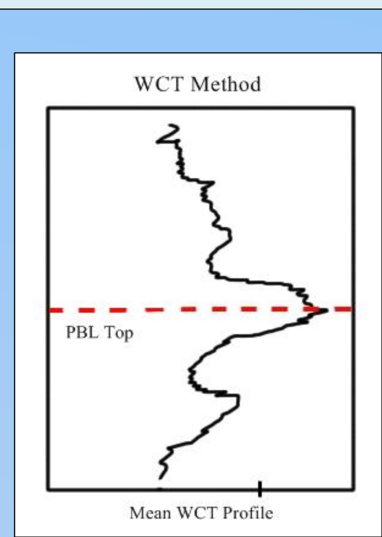
A LIDAR, or "light radar", device measures the backscatter of light off of particles in the atmosphere, using a setup as shown. These backscatter signals can be used to produce vertical profiles of atmosphere backscatter, such as those shown in the log plots above. These profiles allow the variability in PBL height and cloud cover to be visually represented.

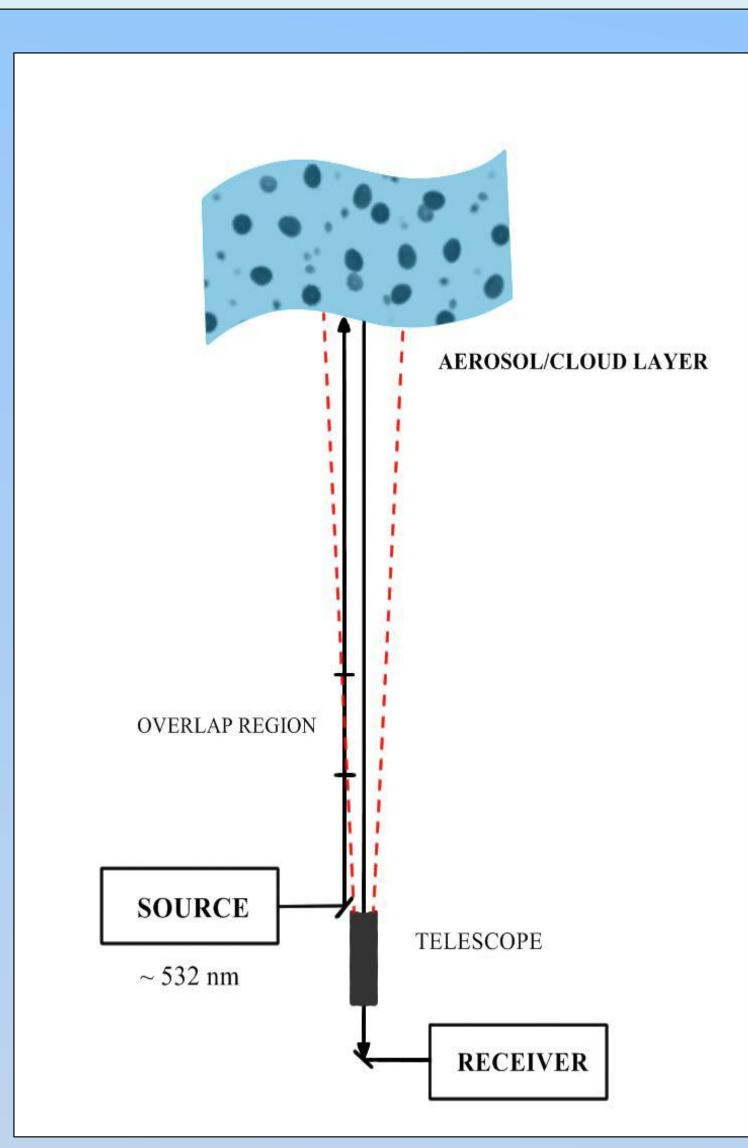
When it comes to numerically determining the PBL height however, looking by eye is not very effective. To gain a truer representation, the following 2 methods have been used, with their respective results plotted on the second vertical profile image.

- **The "Gradient" method:**
  Uses gradients in vertical backscatter signals to identify where different layers exist. Constraints can be put onto results to omit gradients found at the base of the detection range.

- **The "Wavelet covariance transform" (WCT) method:**
  Analyzes aerosol signatures and similarities between the range-corrected signal profiles (Baars et al., 2008) to produce layer estimates that are less affected by signal noise than the gradients measured above. Threshold values can be implemented to determine which layer is accepted as the PBL.







RESULTS SO FAR AND UPCOMING GOALS

By utilizing the above methods, simple case studies can be represented for different observation times. In the table below, the numerical values for the PBL and cloud height ranges can be observed for the case study related to the plots above. The cloud heights presented can be identified within the produced plots. The PBL heights through both methods are fairly consistent and indicate that measurements made at the mountain peak during this time relate to locally sourced aerosols. Having obtained data from a number of simple case studies, my next aim is to work on more elaborate cases, including some of the following:

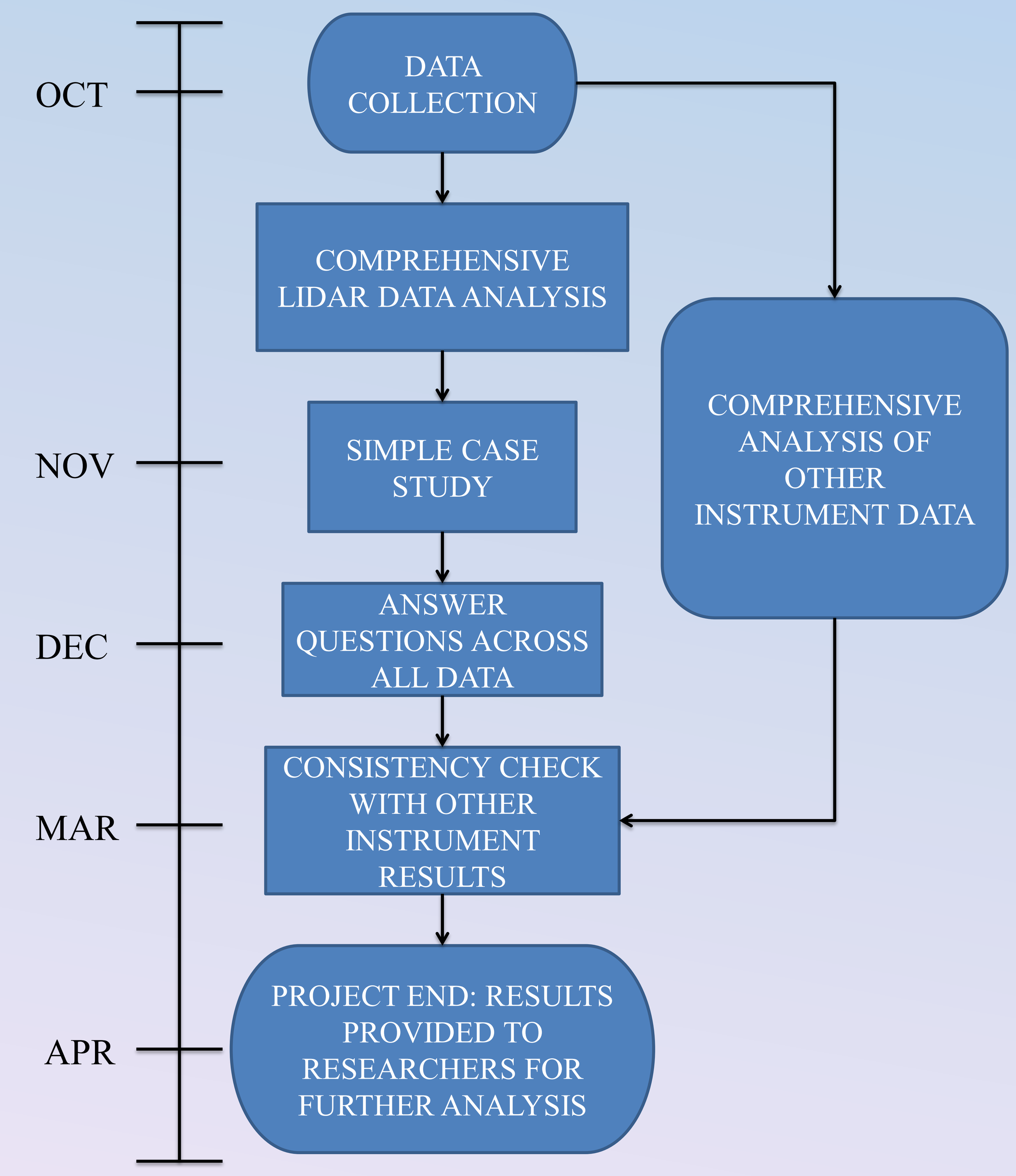
- **Working with combined data sets to produce daily PBL fluctuation charts**
- **Identify periods of time where aerosols are not locally sourced (low PBL)**
- **Investigate the effect of cloud cover regions at various altitudes on data results**

Over the course of the project, a general picture of the interaction between clouds and aerosols will be built up, allowing comparisons to be made with the results from other cloud-aerosol experiments.

Year	Month	Day	Hour	PBLheight (Gradient)	PBLheight (WCTmax)	PBLheight (WCTopt)	Cloud occurance	Cloud Top (Range)
			(h)	(m) *Black*	(m) *Red*	(m) *Blue*	(h)	(m)
2014	7	21	12:30	1990	1745	1839	12:36, 13:18	1847.87 - 2295.85
2014	7	21	13:30	1970	1888	2076	13:38, 13:51, 14:17	1959.87 - 3154.48
2014	7	21	14:30	2442	1966	2367	14:35, 15:16	2034.53 - 2333.18
2014	7	21	15:30	2235	2002	2134	-	-
2014	7	21	16:30	2522	1908	2134	16:59	3453.13 - 3602.45
2014	7	21	17:30	2233	1798	1861	17:45	3341.13 - 3453.13

Once all results have been gathered, I aim to check for consistency with results from other instrument analysis if available.

Any valuable findings shall be passed on to researchers related to the CAESAR 2014 campaign for use in further analysis, resulting in useful information for climate change modellers to utilize.



References: **1.** Stull, R. (1988). *An introduction to boundary layer meteorology.* Dordrecht: Kluwer Academic Publishers **2.** Baars, H., Ansmann, A., Engelmann, R. and Althausen, D. (2008). Continuous monitoring of the boundary-layer top with lidar. *Atmos. Chem. Phys. Discuss.*, 8(3), pp.10749-10790