Nauru: Aerosol Optical Depth Properties and Trends

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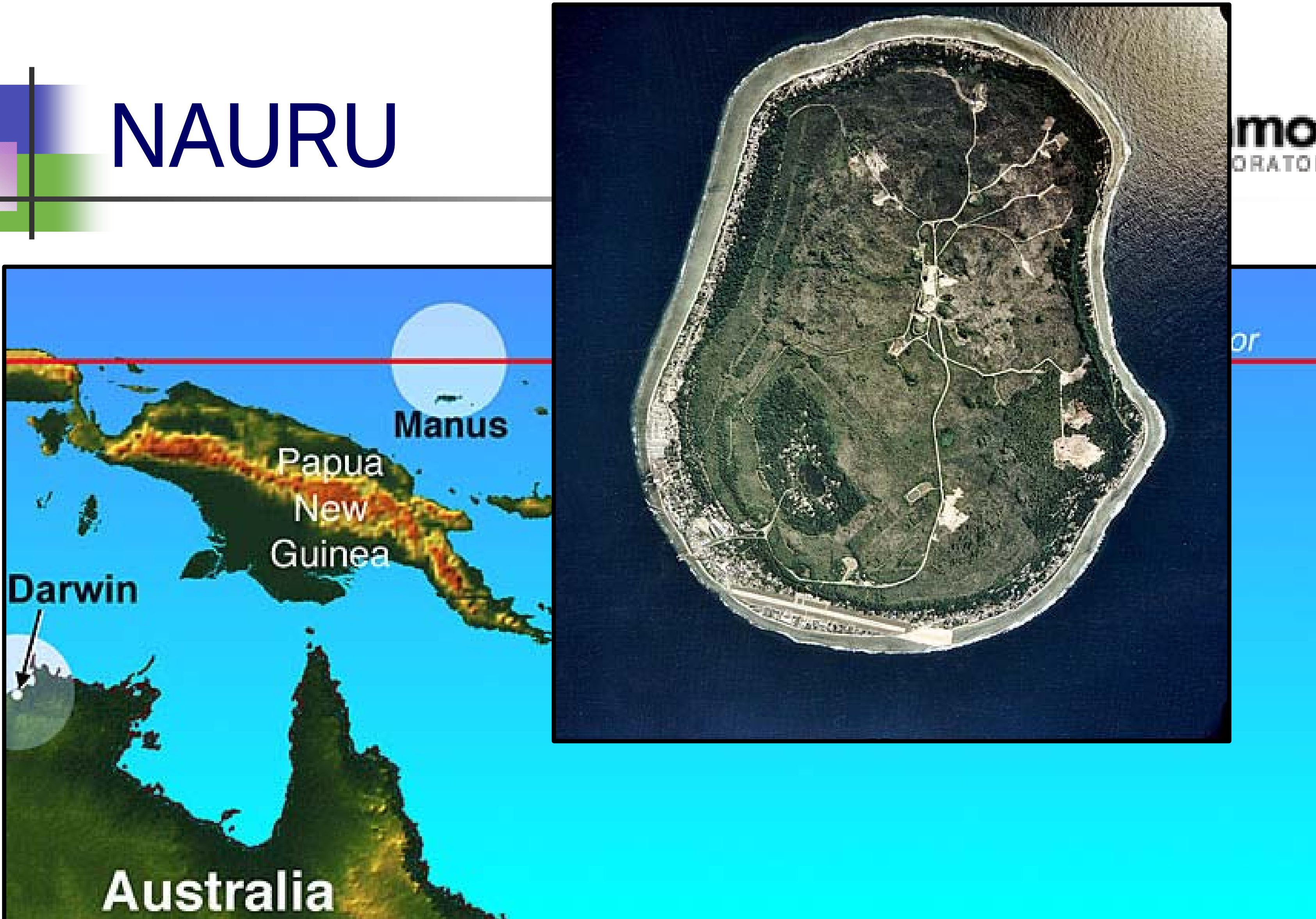
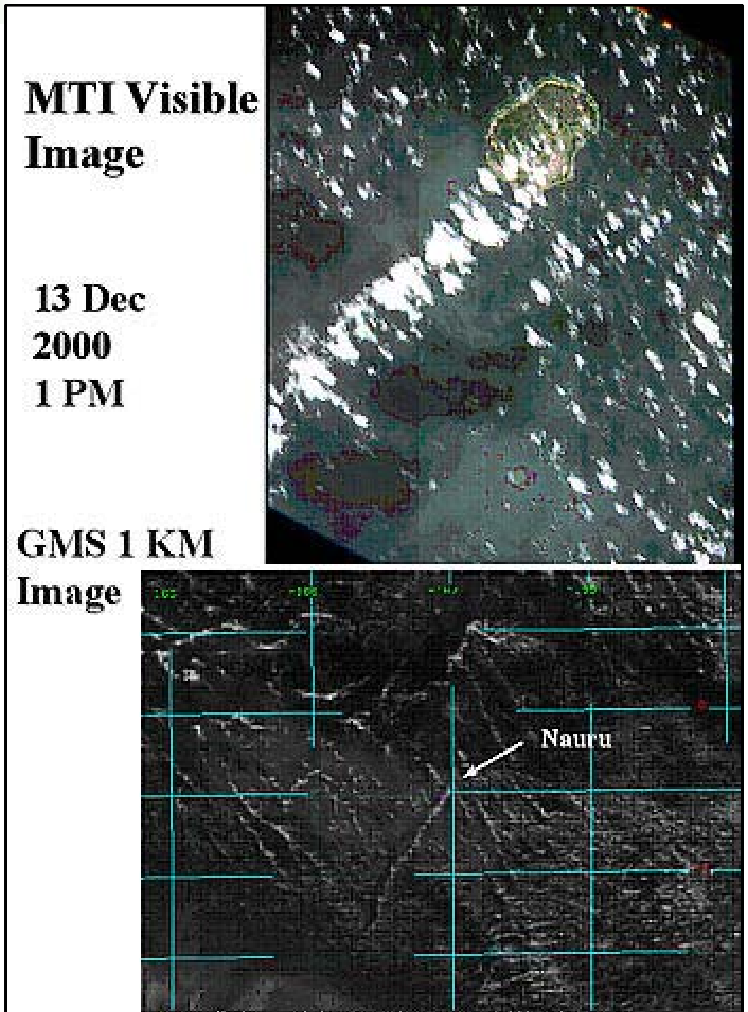
NAURU



WHY NAURU?

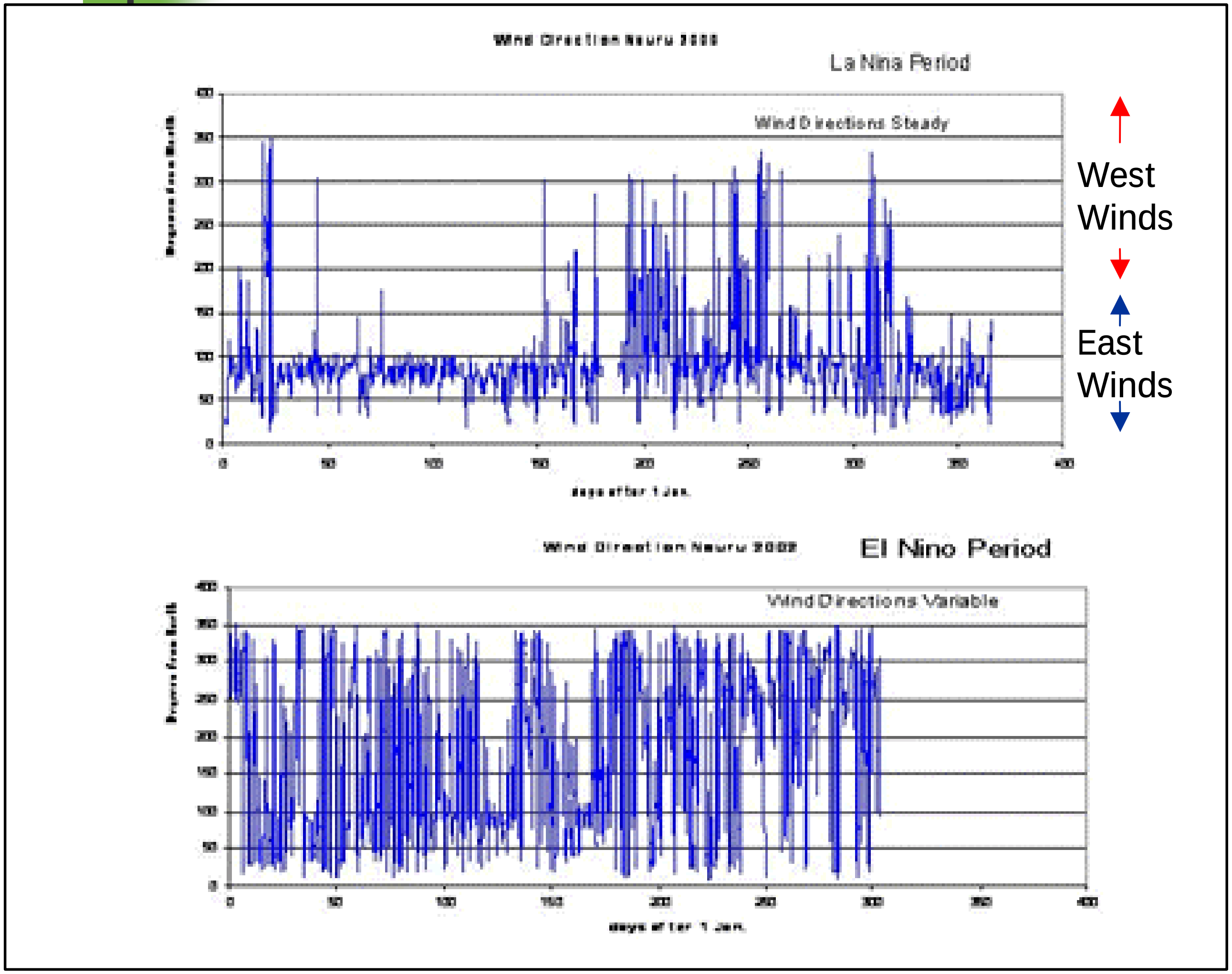
- influences interannual variability observed in the global climate system.
- consistently has the warmest sea surface temperatures on the planet, and is referred to as the Pacific "warm pool."
- supplies heat and moisture to the atmosphere, resulting in the formation of deep convective cloud systems and produce high-altitude cirrus clouds.

Nauru ARM Site



- cloud systems regulate the amount of solar energy reaching the earth’s surface and the amount of the earth's heat energy escaping into space
- better understanding of the interaction between clouds and the exchange of energy will improve the general circulation models used for climate research.

Wind Directions: La Niña and El Niño



Winds blowing almost exclusively from east during La Niña period

Winds coming from both east and west for El Niño period

From East there are no continents where aerosols can originate, so overall the air is clean

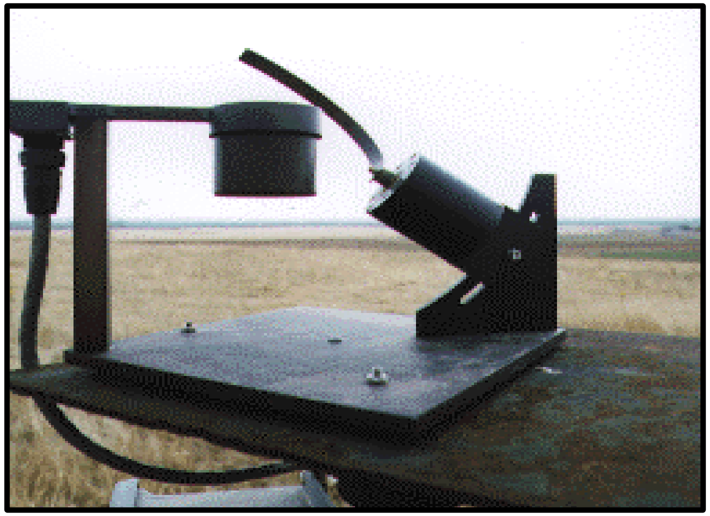
From the West there is a greater chance for aerosols from nearby land masses

GENERAL OBJECTIVE

Determine if there is a relationship between wind directions (La Niña and El Niño) and aerosol amount and light scattering characteristics

INSTRUMENTS

Cimel Sunphotometer (CSPOT)



Multi-Filter Rotating Shadowband Radiometer (MFRSR)

Multi-Filter Rotating Shadowband Radiometer (MFRSR)

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Measures:

- the direct normal solar spectral irradiance
- The total horizontal solar spectral irradiance
- The diffuse horizontal solar spectral irradiance
  - At wavelengths of 415, 500, 615, 673, 870, and 940 nm
- Measurements at each wavelength are by single filtered detector with a nominal 10nm FWHM (Full Width at Half Maximum) bandwidth:

~415 aerosol	~500 aerosol, ozone
~615 aerosol, ozone	~673 aerosol, ozone
~ 870 aerosol	~940 water vapor

- Rayleigh scattering most strongly affects the shorter wavelength channels

Cimel Sunphotometer (CSPOT)

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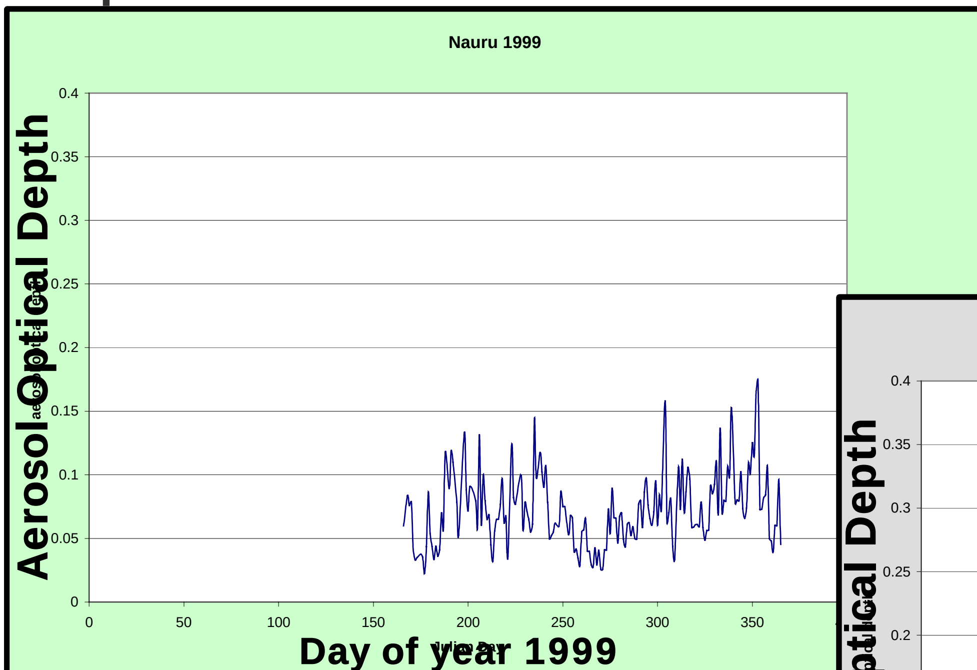
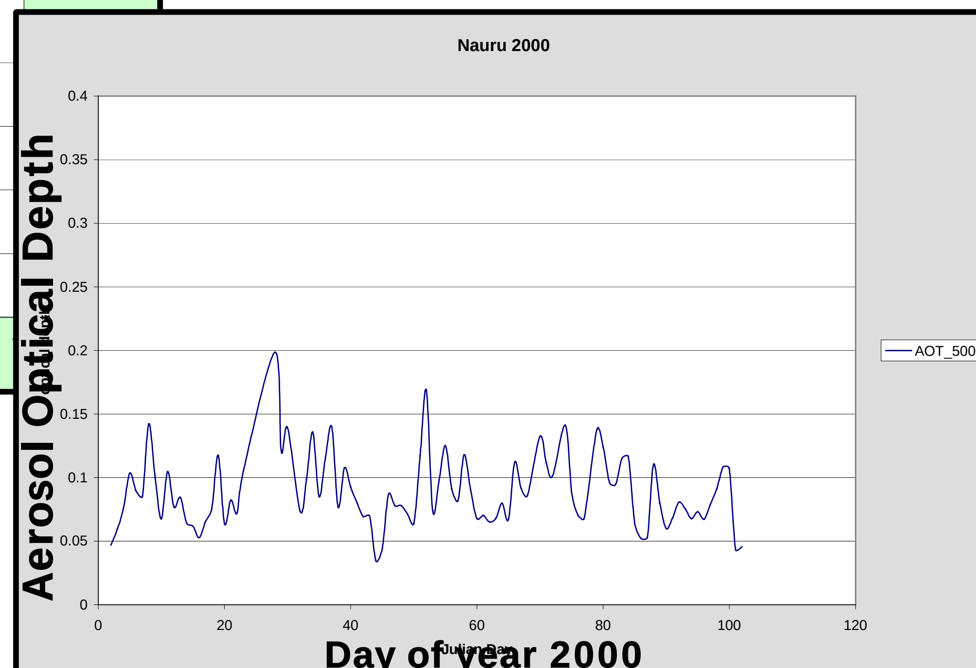
Measures:

- vertical aerosol optical thickness derived to an accuracy of +/- 0.02-0.04 at these wavelengths (339, 380, 440, 449, 670, 870, 940, and 1019 nm)
- aerosol distribution 0.1-3 micron size range derived from the sky radiance measurements using radiative transfer algorithms

CIMEL data:

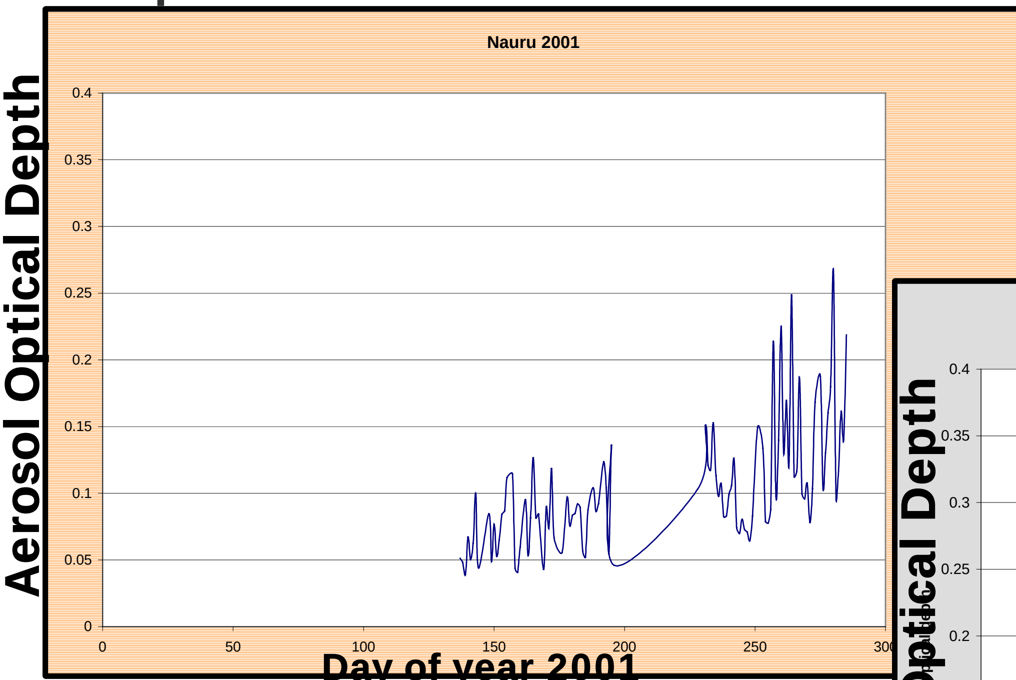
1999 and 2000 La Niña

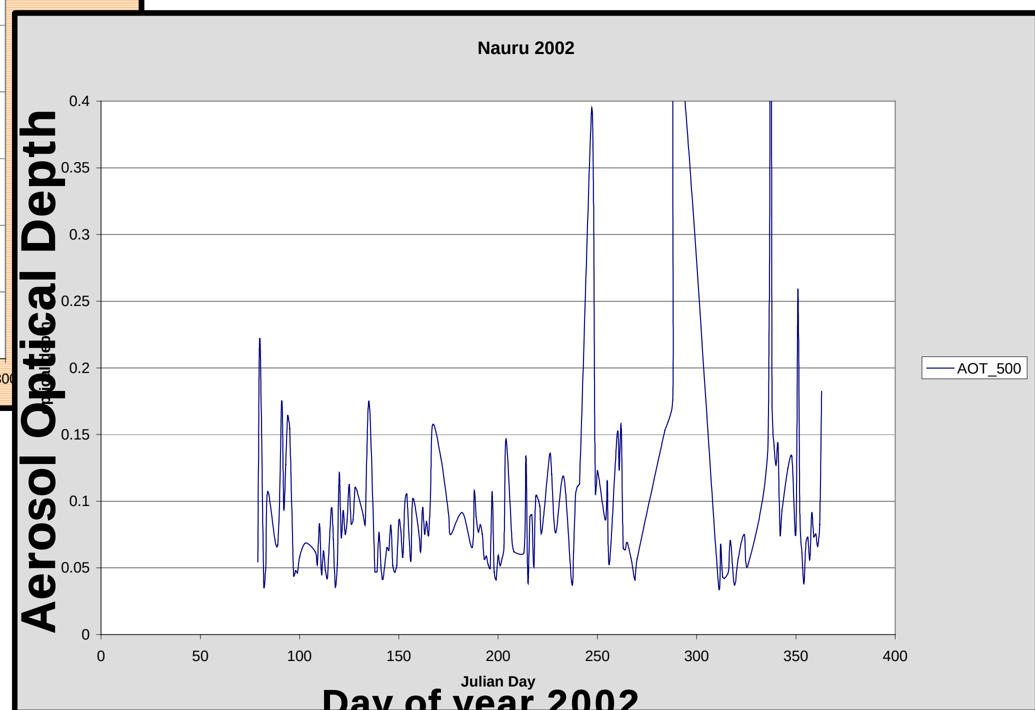




CIMEL data:

2001 and 2002 El Niño



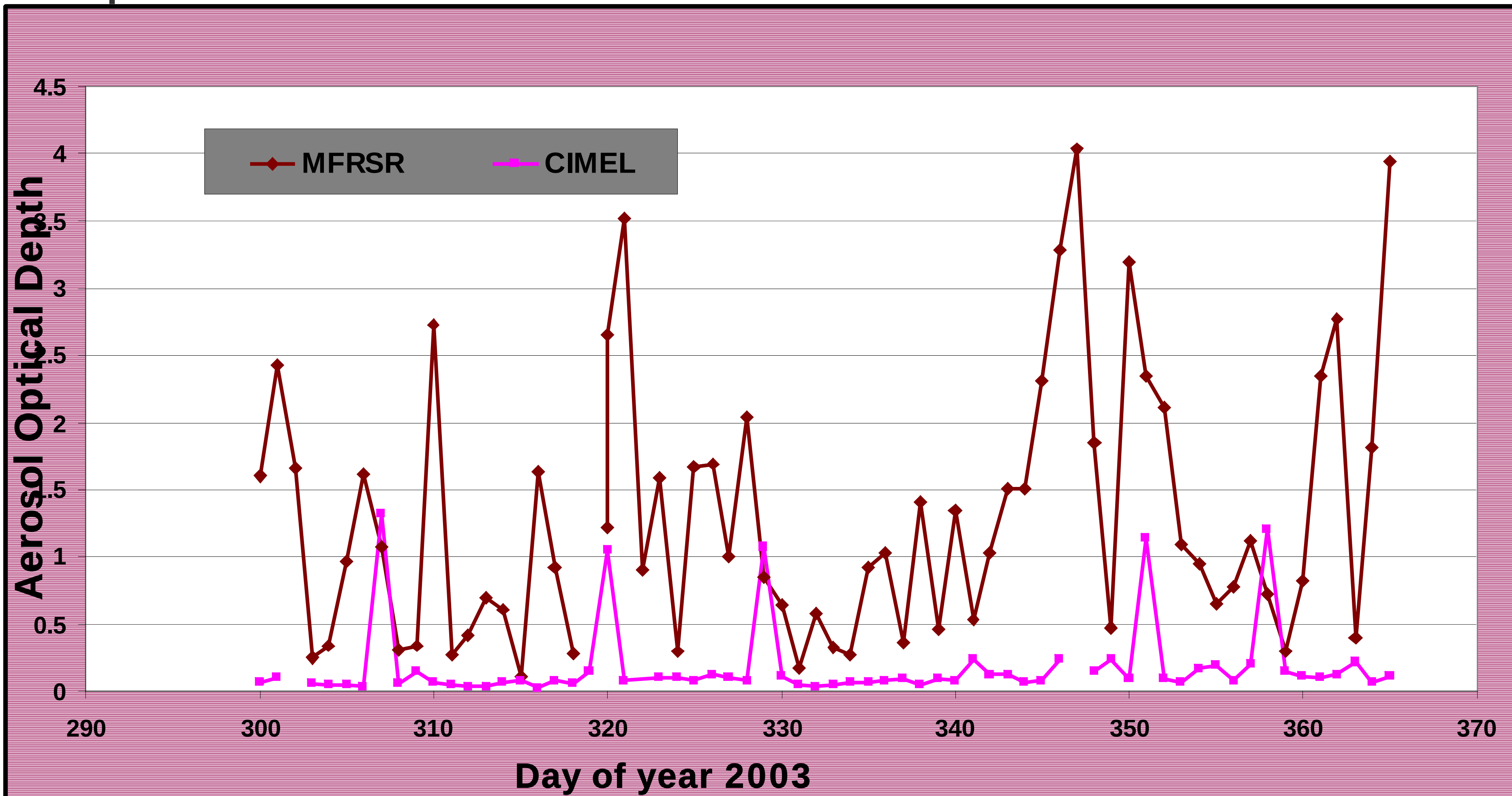


SPECIFIC OBJECTIVES

- Preliminary investigation of CIMEL data seemed to show periodic aerosol increases during last El Niño. We needed to compare MFRSR to CIMEL data during this period to convince ourselves that this was a real effect and not a problem with cloud removal or other artifact.

- During periods when CIMEL and MFRSR aerosol optical depths compared well we then compared aerosol light scattering with wavelength to see if we could separate local and large-scale effects

Initial Comparison



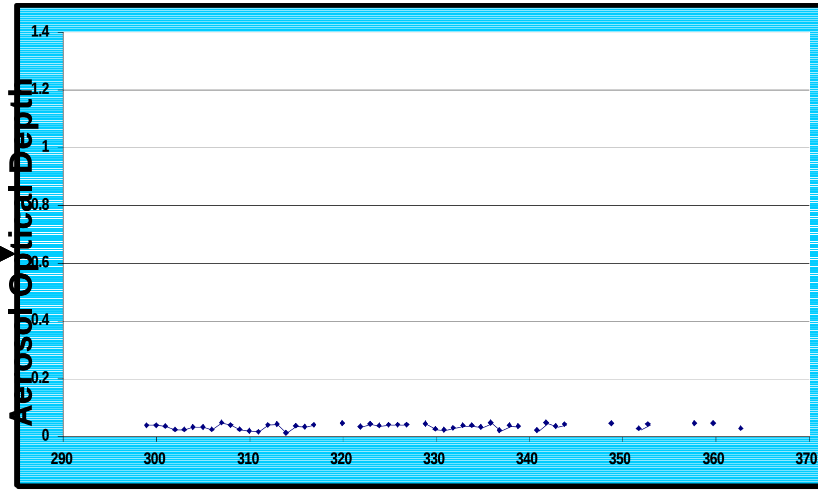
PROBLEMS

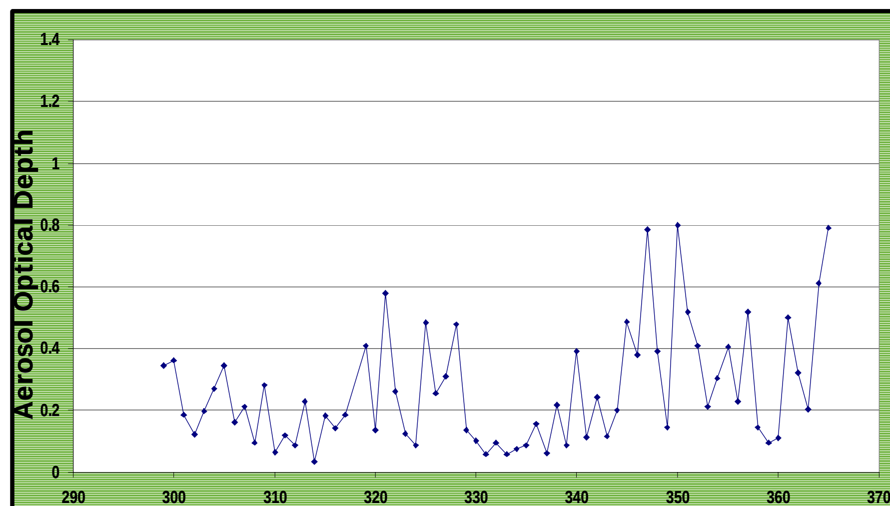
- Clouds affect aerosol optical depth measurements
- Quality of MFRSR data is questionable because clouds are not filtered out
- CIMEL uses a cloud filtering algorithm, which helps to eliminate affected data
- At the moment there is no cloud screening done for the MFRSR aerosol optical depth retrievals
- MFRSR data points don't match up very well with CIMEL data points

MFRSR: various attempts to remove clouds

Data points not included:

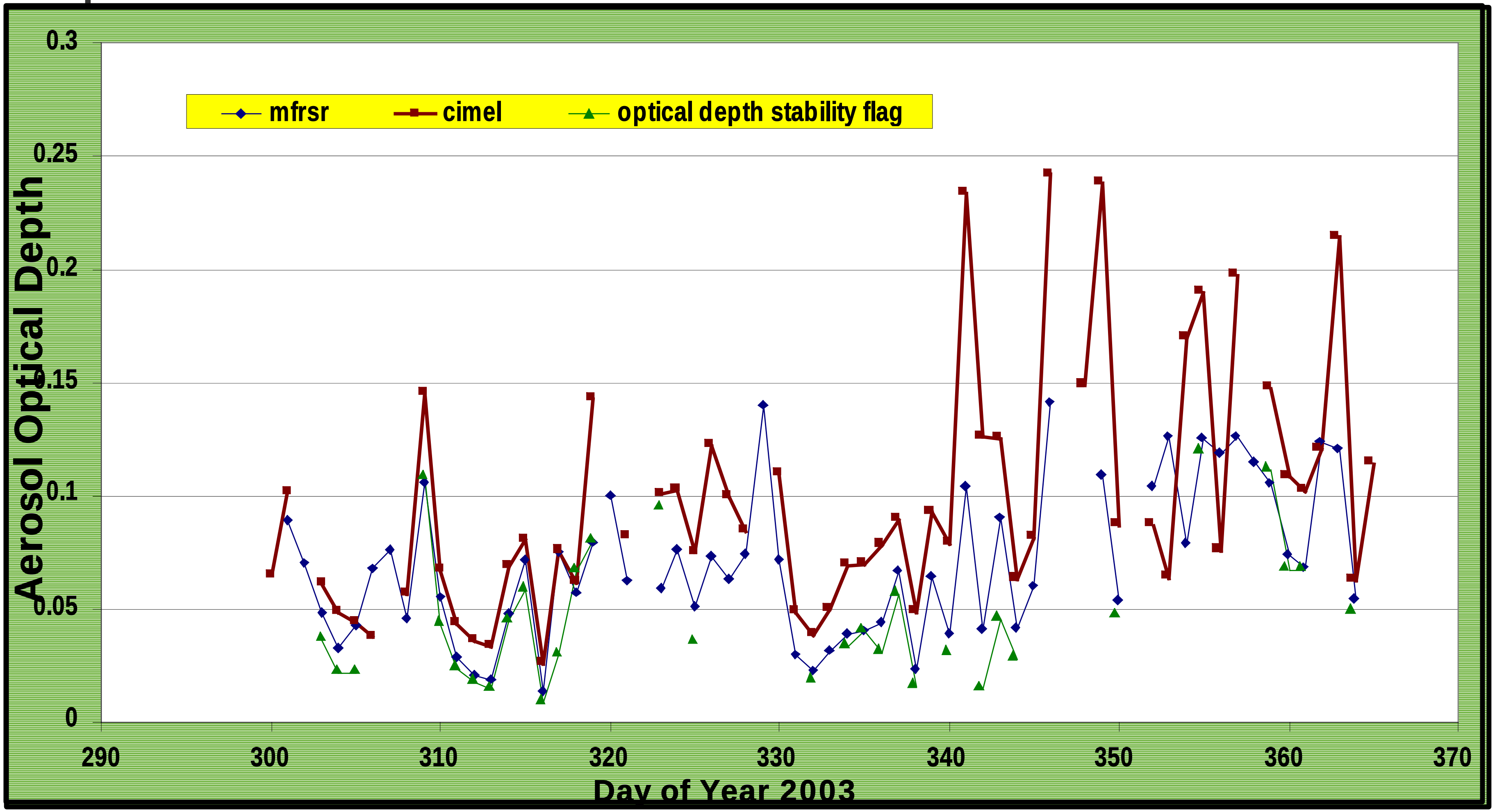
- Total optical depth < 0.2
- Total optical depth < 1





Using various filters on different parameters, hopefully the MFRSR plots will resemble the CIMEL plots.

Optical Depth Stability Flag and TOD <0.3



Wavelength Dependence

The aerosol optical depth is related to the amount of aerosol above the island

The wavelength dependence of the aerosol optical depth is related to the size distribution of these aerosols

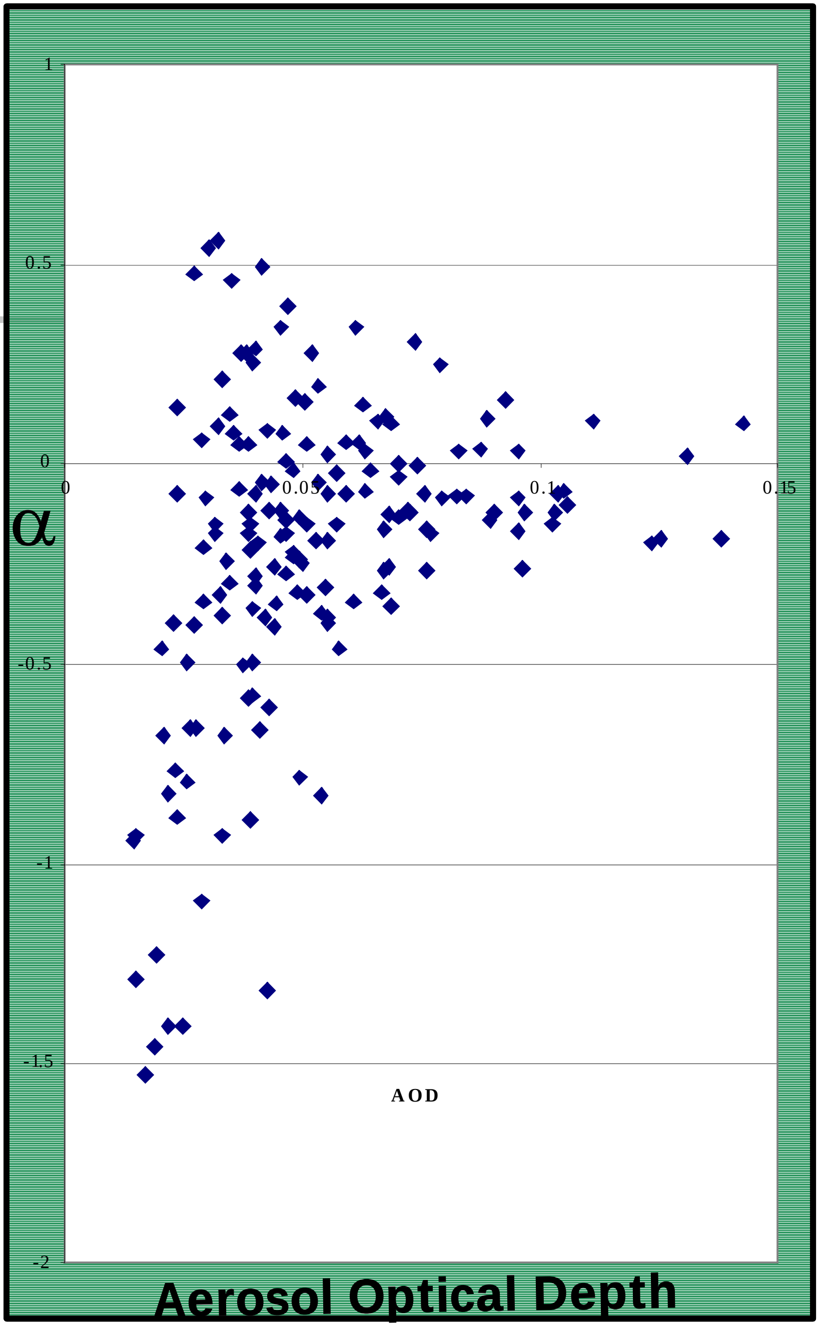
The Angström exponent α :

$$\text{Extinction}(\lambda) = S \cdot \lambda^{-\alpha}$$

- α small means large particles
- α large means small particles

Background aerosol likely to be large

MFRSR: Å Exponent (α) vs AOD for 2003



•Smaller particles means more positive angstrom exponents

•While larger particles correspond to more negative angstrom exponents

Why -α Interesting?

Negative angstrom exponents were not expected because Sun photometers only work during the daylight :

1. Gas-to-particle conversion enhanced by solar energy (short λ's/high energy) makes very small particles
2. Relative humidity makes large wet particles, but relative humidity usually less during the day

Caveats

Evaluations of aerosol properties from light scattering characteristics are difficult because:

1. Many aerosols are not spherical
2. Some aerosols absorb light as well as scatter light
3. We are not sure we have removed all cloud effects (especially cirrus)

CONCLUSIONS

Nauru during the 2003 El Nino experienced episodes of relatively high amounts of aerosols (compared to La Nina periods 1999 and 2000).

When the aerosol concentrations were low (background aerosols) the aerosols were large in size (negative or small α).

Periods of higher concentrations of aerosols could be caused by the winds coming from the west (direct long range continental transport or ocean fertilization and biogenic aerosol formation).

These aerosols tended to be smaller in size (positive α)

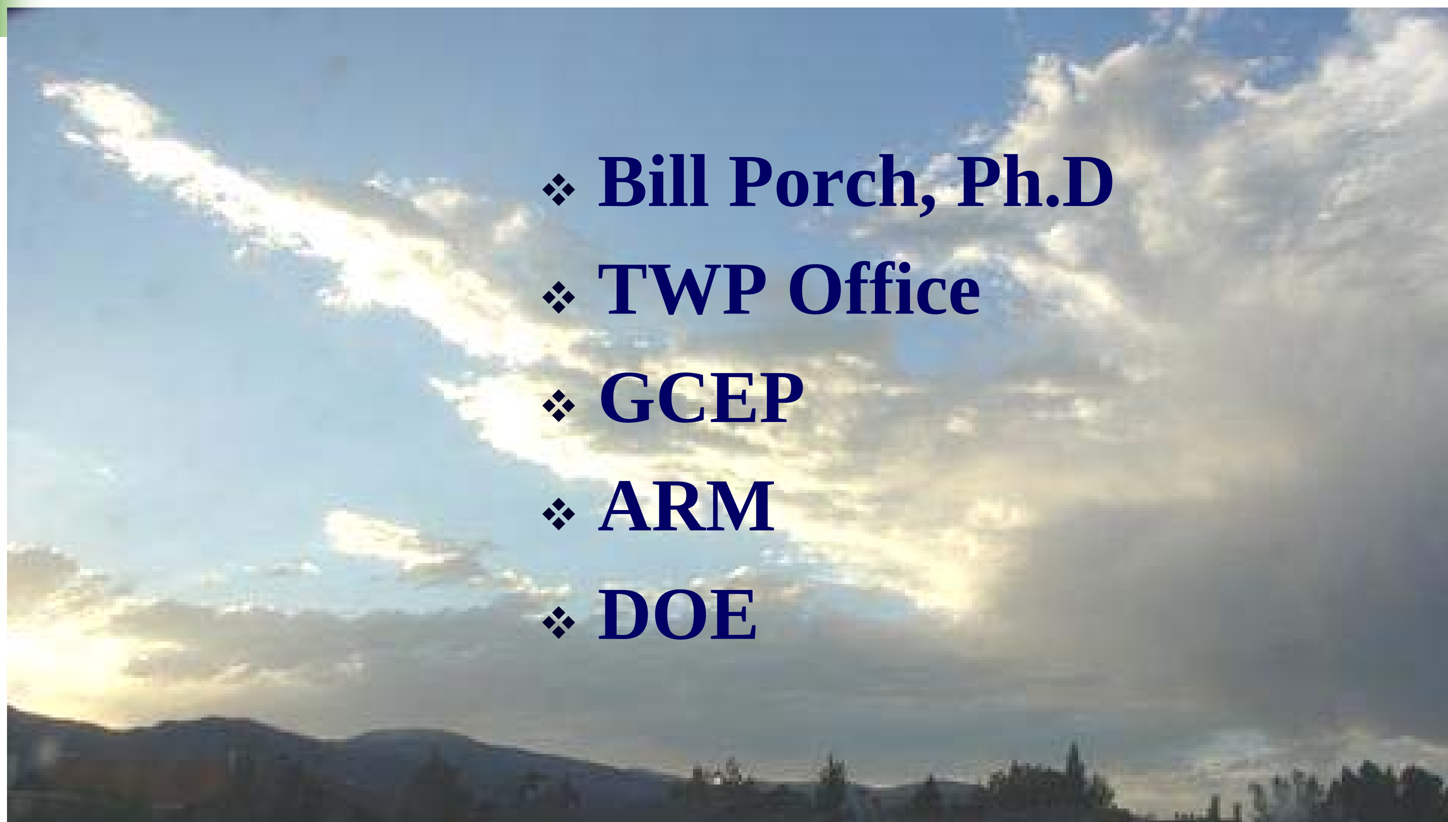
Future Work

Further work can be done to validate these findings and describe the characteristics of the aerosols that were present during this period.

We hope to find out through future work whether the aerosols were generated locally or are the result of long range transport.

This will involve the coordination of satellite data and case by case analysis of ARM data at higher temporal resolution (local characteristics)

Acknowledgements



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