

October 2001 Progress Report:

Aircraft Radiation and Aerosol Measurements Near Hawaii: Satellite Validation At the Moby Buoy and the HOTS Site.

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INTRODUCTION

Aircraft measurements are being carried out over the MOBY (Marine Optical Buoy) and the HOT (Hawaii Ocean Time-Series) sites near Hawaii to test/validate EOS-AM1 satellite algorithms. The aircraft measurements include:

AIRCRAFT RADIATION MEASUREMENTS (John Porter)

- AEROSOL OPTICAL DEPTH (MICROTOPS 5 μ) (all flights)
- SKY RADIANCE (from 350-1100 nm) (on selected flights)
- UPWELLING RADIANCE (from 350-1100 nm) (on all future flights)
- DOWNWELLING IRRADIANCE (BROADBAND AND SPECTRAL) (on Seneca flights)
- UPWELLING IRRADIANCE (BROADBAND AND SPECTRAL) (on Seneca flights)

AIRCRAFT IN-SITU AEROSOL MEASUREMENTS (Antony Clarke)

- AEROSOL SCATTERING COEFFICIENT (b_{sp} at 530nm) (on selected Seneca flights)
- AEROSOL SIZE DISTRIBUTION (on selected Seneca flights)
 - (Custom MET1-H OPC, 0.1-0.6 μ m) (on selected Seneca flights)
 - (External FSSP, 0.5-20 μ m) (on selected Seneca flights)
- CONDENSATION NUCLEI CONCENTRATION ($D_p > 0.01 \mu$ m) (on selected Seneca flights)

ADDITIONAL MEASUREMENTS

- GPS (AIRCRAFT POSITION) (on Seneca flights)
- AMBIENT RELATIVE HUMIDITY (on all flights)
- AMBIENT TEMPERATURE (on all flights)
- PRESSURE (on all flights)
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The instruments are mounted on dedicated aircraft doors and are installed on the light aircraft prior to flight. Removing the original aircraft door and replacing them with our instrumented doors takes approximately 2 hours. This approach requires little modification to the plane. We use a Piper Seneca or a Chieftan aircraft, to climb above the trade wind inversion (~2.1 km) over Hawaii. Aircraft flights are designed to fly over the ship or buoy at altitude for 20 minutes, then descend at the time of the satellite overpass and make additional low-level measurements for 20 more minutes. The high and low level flight tracks are flown along the satellite azimuth-viewing angle (and at 180 degrees to it) in order to have the same viewing angle as the satellite for our scanning radiometer. The data sets collected are placed on our web sites where anyone can download them (<http://www.soest.hawaii.edu/porter> or <http://pali.soest.hawaii.edu>). Aircraft measurements were made on Dec. 1, Dec. 7, Dec 8, 2000 and October 19, 2002. A planned flight for October 28, 2001 had to be canceled due to dangerous high winds. We are currently planning our last set of flights during Dec 2001 through January time period.

OAHU DECEMBER 8, 2000 FLIGHT

On January 26, 2000 a flight was carried out on the west side of Oahu in coordination with a Dennis Clark cruise. The aircraft position and height are shown in Figure 1 and 2. The area was cloud free throughout the flight time period. A fire smoke plume was evident from Oahu but was not seen over the aircraft decent area. The atmosphere was very clean with low aerosol optical depths (Figure 3).

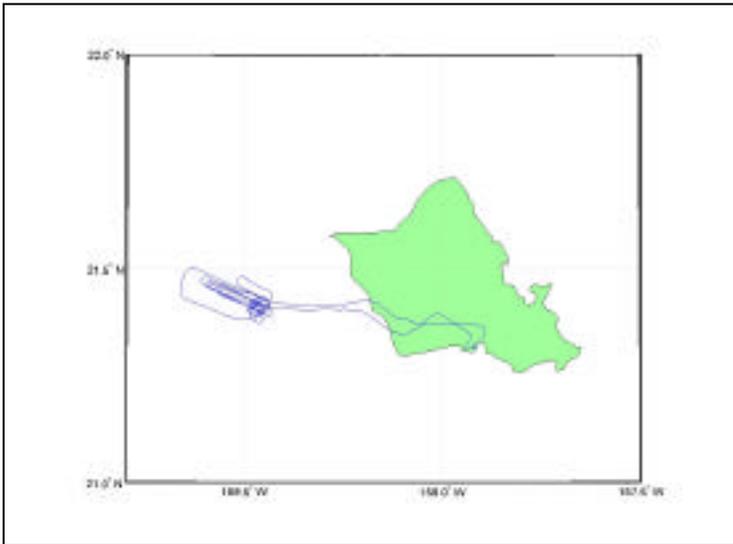


Figure 1 Aircraft flight track .

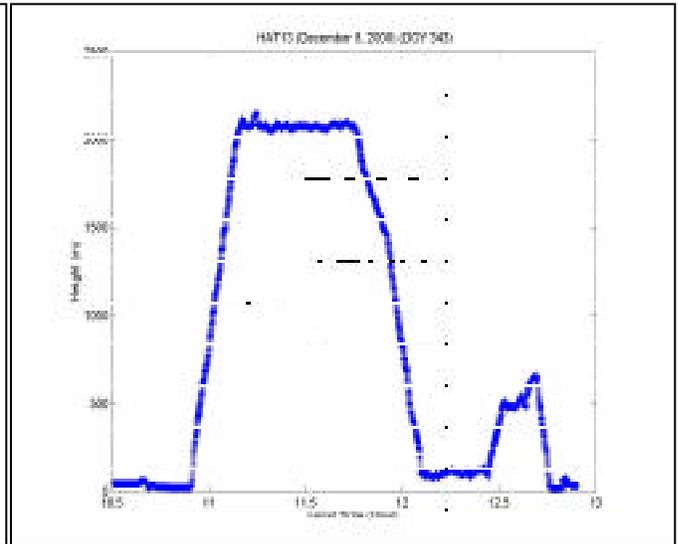


Figure 2 the aircraft altitude.

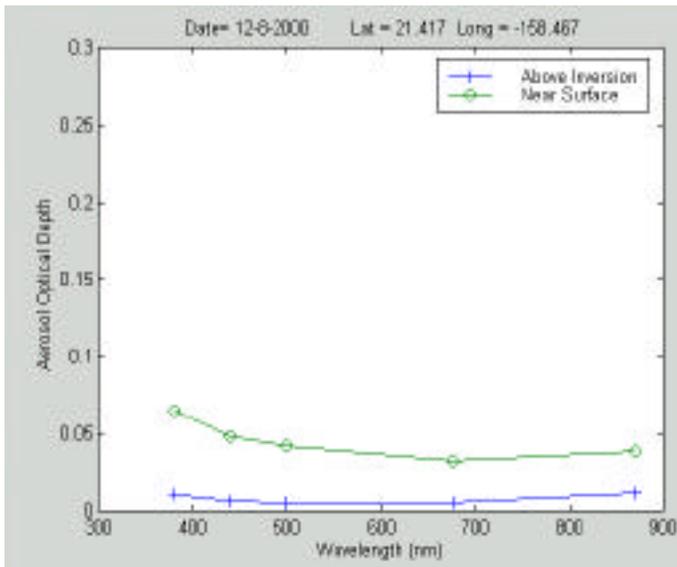


Figure 3. Average aerosol optical depth near surface above the trade wind inversion.



Figure 4. Aerosol size distributions obtained by the FSSP.

The aerosol size distribution was typical of clean marine conditions with background amounts of accumulation mode aerosol with larger amounts of sea salt (Figure 4). The aerosol optical depth (at 500 nm calculated from the size distribution was 0.042 in good agreement sun photometer measurements.

BIG ISLAND AND MOBY BUOY FLIGHT (OCTOBER 19, 2001)

During October 2001 the NASA AVIRIS sensor was in Hawaii collecting images of various land and ocean features. On October 19, 2001 we carried out the flight shown in Figure 5 with vertical profiles off SW Hawaii and over the MOBY buoy (South of Molokai). On this day, the AVIRIS (on the ER2 aircraft) collected images at ~9:30, our aircraft did vertical profiles over SW Hawaii at 10:30, and the MODIS image was collected at ~11:15. The winds on the lee of Hawaii (south Kona) were very light with glassy seas so it likely that the aerosol concentration and type did not change much during this time

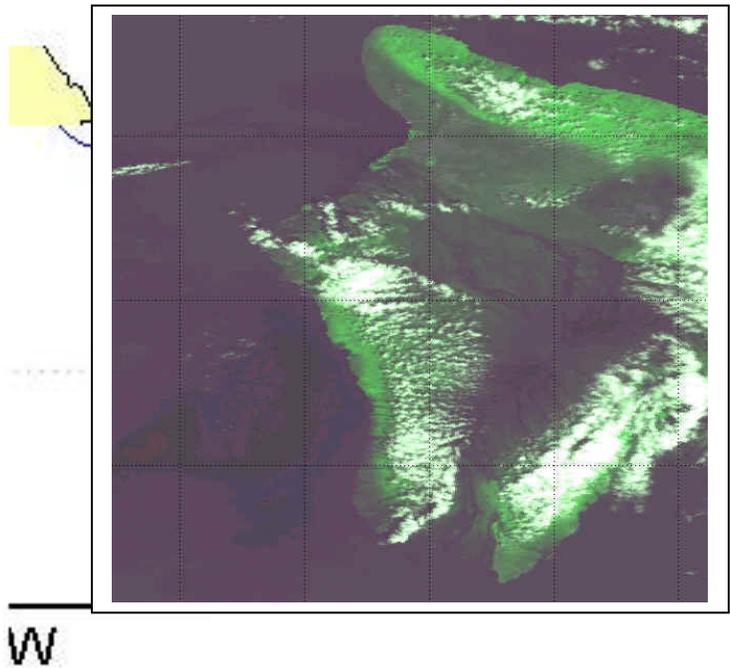
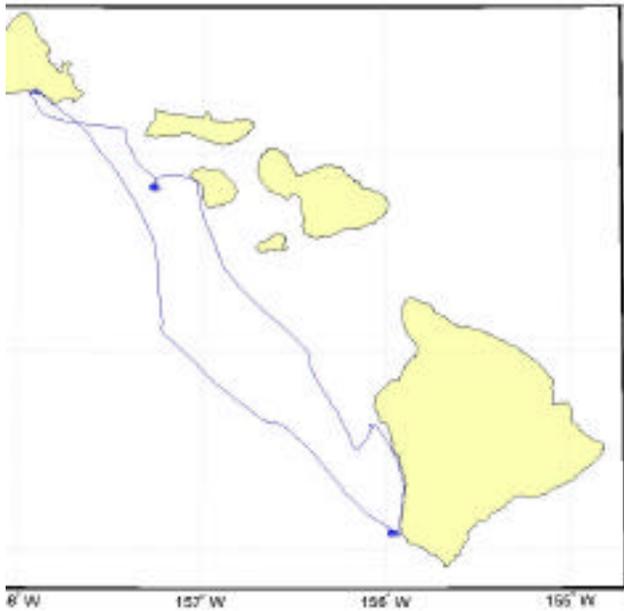


Figure 5. The aircraft track. Vertical profiles were carried out off SW Hawaii and at the MOBY buoy.

Figure 6. MODIS images collected October 19, 2001 by the direct broadcast facility in Hawaii. (Image provided courtesy of Torben Nielsen)

period. On the same flight vertical measurements were also carried out over the MOBY buoy on the flight back. It can be seen from the MODIS image (Figure 6) that the region off SW Hawaii was very clear as we also observed from the aircraft. The AVIRIS images for this flight (see ftp://popo.jpl.nasa.gov/pub/01qlook/f011019t01p03_r04.q1.jpg) also had cloud free conditions over the water. The presence of the Hawaii volcano plume was clearly visible from the aircraft off the Hawaii leeward side. The sun photometer measurements collected below and above the volcano plume are shown in Figure 7. It can be seen that above the trade wind inversion the aerosol optical depths were low but that larger optical depths were occurring at 870 nm. Although the sky was observed to be very clear

(no visible cirrus), cirrus was occurring to the west of Hawaii and it is possible that some sub-visual cirrus was being carried over our site as well. As aerosol size distribution measurements were not possible on this flight we have carried out an inversion on the sun photometer data (Lienert et al., 2001). Although the bimodal inversions for the free troposphere were not well constrained, they generally show an accumulation mode near $0.1 \mu\text{m}$ diameter and a coarse mode above $5 \mu\text{m}$ diameter which suggest some amount of sub-visual cirrus may have indeed have been present. We are currently working to process the sky radiance measurements, which can better constrain the inversion of the free troposphere size distribution. Figure 8 shows the aerosol size distribution inverted from the differential optical depth due to the volcano plume (surface optical depths minus above inversion optical depths). As shown, for a uni-modal size distribution the inversion is well constrained. In addition the composition of the volcano plume is also well known.

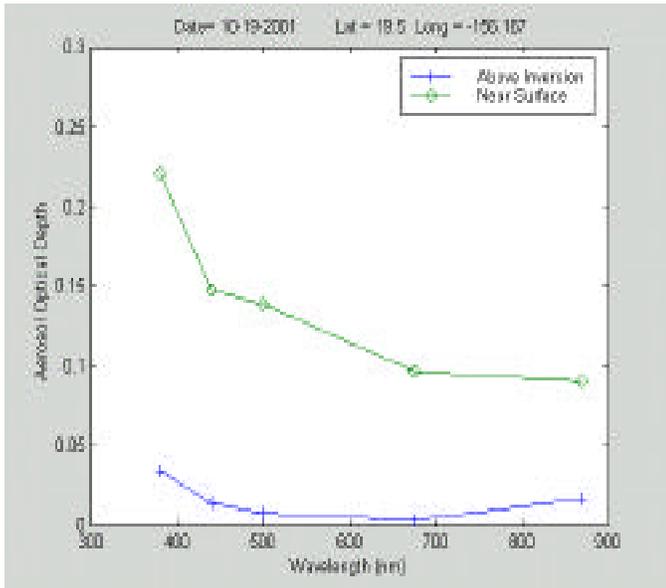


Figure 7. Aerosol optical depths measured above and below the Hawaii volcano plume.

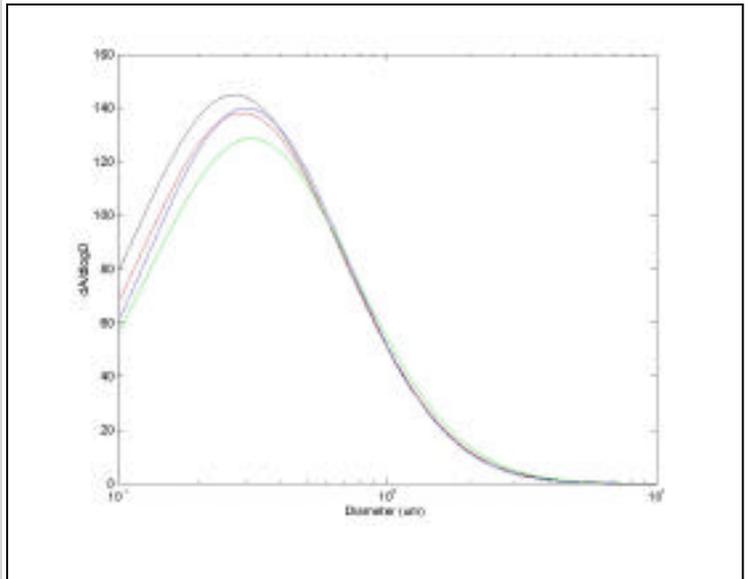


Figure 8. Aerosol size distribution inverted from the volcano plume optical depths.

LIDAR AND POLAR NEPHELOMETER MEASUREMENTS

Through NASA funding we have built two polar nephelometers (mentioned in earlier reports), as well as a mini dual wavelength lidar system. Figure 9 shows some recent measurements we have collected with the lidar system while driving around the SE side of Oahu on a day with strong trade wind conditions (15-30 mph). It can be seen that the sea salt is mixed up to heights of ~ 500 m with average aerosol scattering coeff. values of 10^{-4} m^{-1} with some higher scattering values near Makapuu where we drove close to breaking waves. The aerosol optical depths collected on the same day are shown in Figure 10, which shows the typical flat spectral dependence for sea salt. We are currently working on an algorithm to derive aerosol size information from multi-wavelength lidar data. We plan to carry out combined lidar and polar nephelometer measurements in winter 2001-2002 period as part of this satellite validation effort.

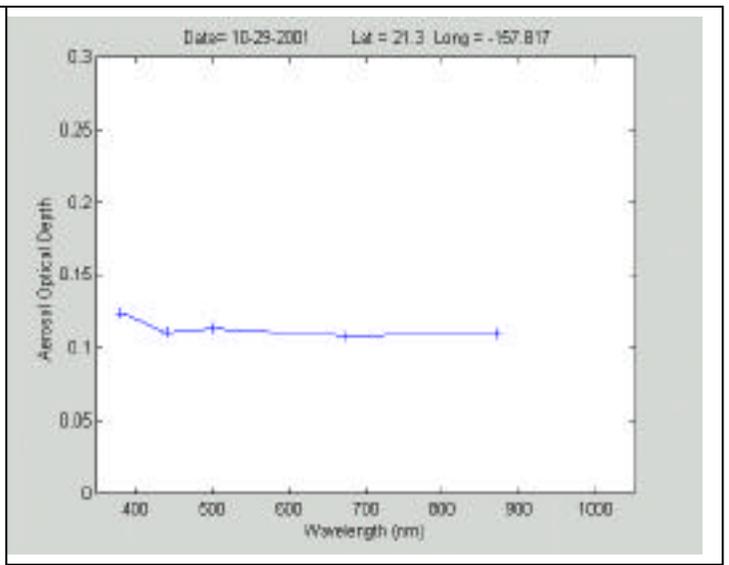
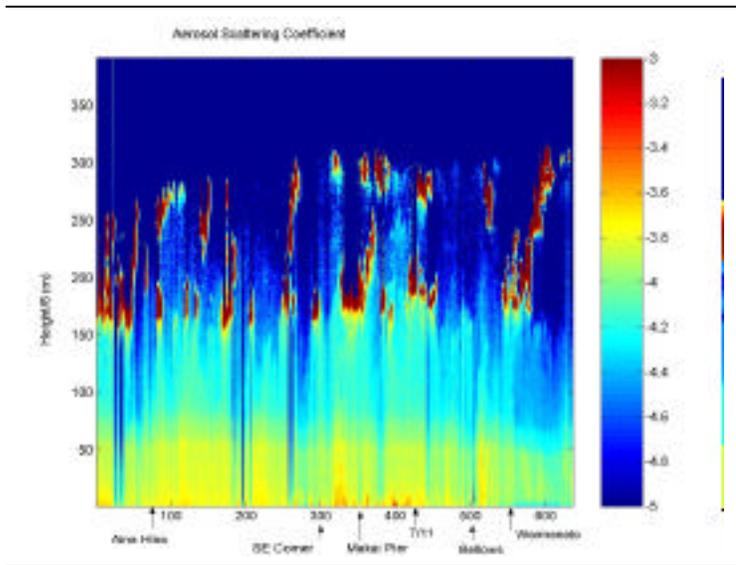


Figure 9. Aerosol scattering coefficient derived from lidar measurements around SE Oahu. Clouds are shown in dark values.

Figure 10. Aerosol optical depths measured on the same day showing flat spectral dependence.

FURTHER STUDIES

During Dec 2001 through February 2002 we will carry out 2 carefully planned measurement efforts following discussions with Howard Gordon. Our current plans are to collect sun photometer, lidar and aerosol phase function measurements at Makapuu Point (SE Oahu) in coordination with aircraft flights (to collect aerosol size distributions, and other measurements). This experiment will characterize the sea salt conditions which will be compared with those derived from satellite. Our second experiment will be based off SW Hawaii with a similar set of measurements to characterize the volcano plume aerosols. During these experiments we will try to coordinate with Dennis Clark and his ship measurements but this may be difficult because they are currently planning only day cruises out of Oahu.

PUBLICATIONS (published, submitted and in preparation)

Porter, J. N., A.D. Clarke, and B. R. Lienert, Aircraft/Surface Derived Aerosol Optical Properties Near Hawaii For Satellite Validation, Proceedings of the SPIE Remote Sensing of the Atmosphere, Environment and Space, Sendai, Japan, ISBN 0-7803-6362-0, 167-174, 2001.

Lienert, B.R., J.N. Porter, and S.K. Sharma, Repetitive Genetic Inversion of Optical Extinction Data, Applied Optics, vol. 40, No. 21, 3476-3482, 2001.

Lienert, B, J.N. Porter, N. Ahlquist, D. Harris, S.Sharma, A 50 MHz Logarithmic Amplifier for use in Lidar Measurements (submitted to J. of Atmospheric and Oceanic Technology), 2001.

Porter, J.N., B. R. Lienert, S.K. Sharma, Using Realistic Models To Limit the Range of Aerosol Possibilities In Deriving Aerosol Properties from Multi-Wavelength Lidar, (to be submitted to Journal of Atmospheric and Oceanic Technology).

Porter, J.N., Ocean Color Atmospheric Correction Under the Hawaii Volcano Plume: Using Different Aerosol Size Distribution and Epsilon Wavelength Dependences (to be submitted to Applied Optics).