The Australian Aerosol Ground Station Network: Status Report and Development of a Radiometric Calibration Facility.

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ABSTRACT:

As part of the global initiative to better characterize aerosol particles, in Australia CSIRO operates an Aerosol Ground Station Network (AGSNet) that is affiliated with NASA's Aerosol Robotic Network (AERONET). This paper describes the status of AGSNet including some recent results, and concludes with a discussion of the calibration facility under development at CSIRO laboratories in Canberra that forms part of AERONET's distributed calibration network.

Key words:

Australia, aerosol, biomass burning, dust, instrumentation, calibration.

REFERENCES AND WEB LINKS.

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[4] http://www.eoc.csiro.au/agsnet/tropas.htm
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1. Introduction.

The Aerosol Ground Station Network (AGSNet) operated by CSIRO has been affiliated with AERONET since the inception of AGSNet in 1998. The aim of the network is to characterize the optical properties of Australian continental aerosols, so that their radiative impact may be better understood and hence more accurately represented in climate models. In addition, better characterization is needed to improve the atmospheric correction of satellite images and hence improve the quantitative retrieval of surface information from satellite data. Mitchell and Forgan (2003)[1] described the instrumentation in AGSNet, established calibration protocols and documented the uncertainty in aerosol optical depths obtainable from sun photometry under Australian outback conditions.

AERONET is in the process of establishing a network of distributed calibration facilities, with part of the responsibility of instrument calibration delegated to regional laboratories. The calibration facility at the CSIRO Earth Observation Centre in Canberra will carry out calibration operations for the Australian region.

2. Aerosol sources.

The two primary non-urban aerosol sources on the Australian continent arise from biomass burning in the tropical north and wind blown dust in the central arid zone. Australia is a globally significant source of biomass burning emissions, with 38 Mha or 5% of the area of the continent burnt each year, mainly due to seasonal burning of savannah grasslands in the tropical north. Australia contributes about 10% of the annual global carbon emission from biomass burning (Graetz 2002)[2]. Optical properties of the smoke aerosol from this source are yet to be well determined, but radiative transfer studies indicate potentially large radiative effects and hence significant consequences for atmospheric dynamics (O'Brien and Mitchell 2003)[3].

Fire in the southern Eucalypt forests is less predictable but more devastating, as shown by the Canberra fires of January 18 2003 that resulted in the loss of 4 lives and 500 houses. A MODIS image of the smoke distribution from the fires is shown in Figure 1. As a result of fires such as this, fuel control measures have been adopted that involve more low level clearing burns through the year, with consequent expected increase in background aerosol levels over the forested parts of southern Australia.

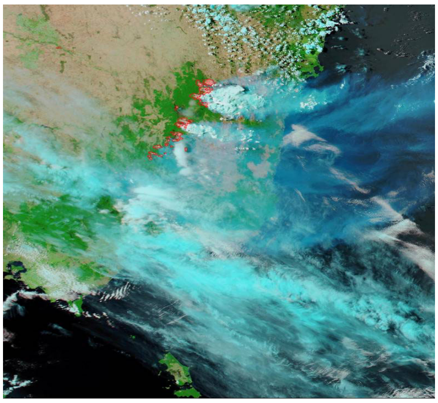

Figure 1. MODIS image from January 18 2003 shows the distribution of smoke from the bushfires in SE Australia.

Australia is subject to dust storms that have increased in frequency with the extended drought affecting much of the south east of the continent since 2002. These storms result in extensive loss of topsoil, in some cases depositing dust into the ocean leading to algal blooms due to iron enrichment, since Australian dusts are rich in hematite. Figure 2 shows the incursion of a large dust storm into Griffith, NSW, in November 2002.

Figure 2. A large dust storm approaching the town of Griffith, NSW, in November 2002

3. Aerosol Ground Stations.

The distribution of AGSNet sites is shown in Figure 3. The stations marked as green squares are currently active, while the stations shown as red squares are not presently operational. The station at Rottnest Island is operated independently. The three stations in the north target aerosol from biomass burning, while the Tinga Tingana station is located in the arid outback region and is ideally placed to sample wind blown dust aerosol. The station at Canberra was deployed just before the firestorm of January 2003. The data set acquired during this period is presently under analysis.

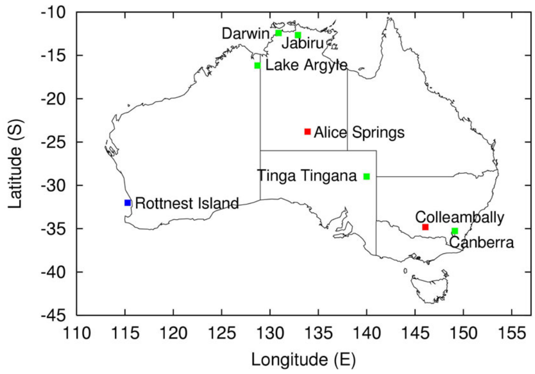

Figure 3. The location of AGSNet ground stations.

The AGSNet instrument complement includes a Cimel sun photometer, a Radiance Research integrating nephelometer, and environmental sensors (wind speed and direction, temperature, and pressure). Data are relayed via a commercial satellite phone, allowing for the greater data volumes from the expanded instrument complement over the standard AERONET setup, and permitting instrument control via two-way communications. The instrument configuration is shown in Figure 4.

Figure 4. The AGSNet installation at Tinga Tingana.

4. Sample Results.

An important initial goal of AGSNet is the assembly of a climatology of biomass burning aerosol in the Australian tropics for the validation of aerosol modules in global climate models. Figure 5 shows monthly mean aerosol over two tropical stations at Lake Argyle and Jabiru plotted against each other for the months April to December. This period excludes the monsoon season when little data are available. The data fall into two groups, the early dry (April to July) showing little correlation between stations, and the burning season of August to December, covering the peak of the burning season in September – October. Even though the stations are separated by 800 km, the two sites are clearly correlated in the burning season. Hence the monthly mean aerosol loading from biomass burning can be understood as a regional phenomenon, simplifying the task of representing it in climate models. Further information on the characteristics of Australian tropical aerosol is given in Mitchell (2002)[4].

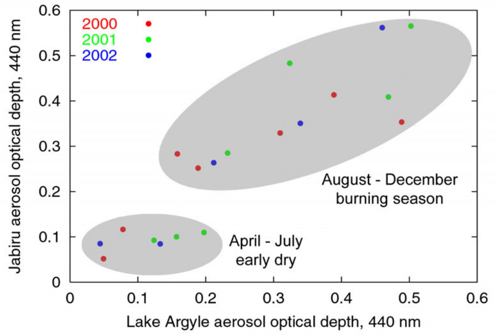

Figure 5. The annual cycle of monthly mean aerosol over two tropical stations, Lake Argyle and Jabiru.

Extended areal coverage for both smoke and dust aerosol has been achieved using TOMS data. In the case of wind blown dust, the TOMS Aerosol Index (AI) was correlated with aerosol optical depth measured at Tinga Tingana. This correlation was then applied to the TOMS data to map aerosol optical depth spatially. An example of this is shown in Figure 6. The maximum to the west of Tinga Tingana corresponds to fine sediments lofted from the dry bed of Lake Eyre by the prevailing south westerly winds.

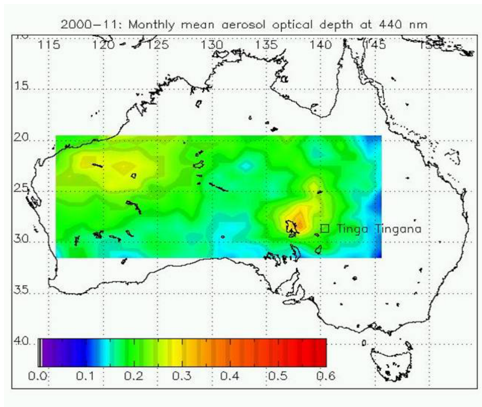

Figure 6. A map of monthly mean aerosol optical depth for November 2000, created using the correlation between TOMS AI and aerosol optical depth at Tinga Tingana.

Correlations between TOMS AI and AERONET aerosol optical depth obtained for other desert regions of the world (Hsu et al 1999)[5] were tested but found to overestimate the aerosol optical depths measured at Tinga Tingana, suggesting that Australian arid zone dust has distinctive optical properties.

Nephelometer data plays an important role, particularly during dust storms when the sun photometer data is often unavailable due to cloud contamination or if the dust storm occurs after sunset. Figure 7 shows the time series of scattering coefficient at 530 nm at Tinga Tingana during the spring and summer of 2002/2003. Typical dust storms (scattering coefficient over 100 Mm^{-1}) occur at a rate of approximately two per week, and several major storms with scattering coefficient over 1000 Mm^{-1} are evident. One such event took place on the night of 22 October 2002, leading to a dust crescent extending approximately 2000 km and clearly visible on the MODIS image shown in Figure 8.

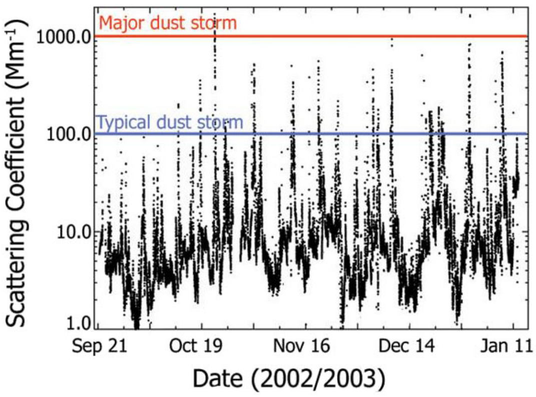

Figure 7. Plot of nephelometer data collected at Tinga Tingana during the spring and summer of 2002/2003.

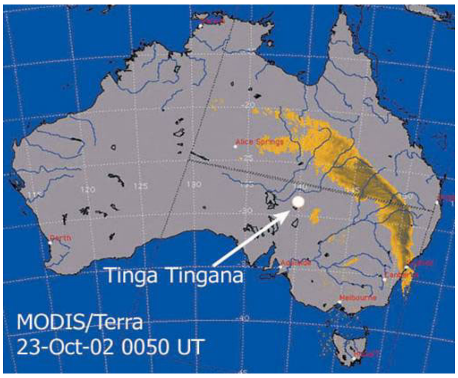

Figure 8. A major dust storm captured by MODIS (Terra) on 23 October 2002.

5. Calibration Facility

The Calibration Facility at CSIRO Earth Observation Centre was established in response to AERONET's distributed calibration concept, whereby a significant part of AERONET's calibration activities are managed by regional laboratories. The facility is based on a Labsphere URS-600 Uniform Radiance Source that features calibration certification traceable to the US National Institute of Standards and Technology (NIST). The URS-600 is shown in Figure 9.

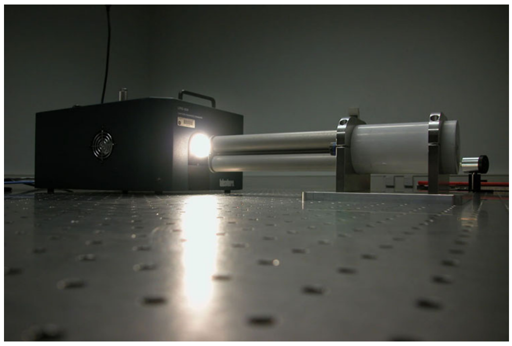

Figure 9. Calibrating the Cimel sky radiance channels against the URS-600.

Initial performance of the facility is being assessed by comparing Cimel instruments recently calibrated on the 30-inch sphere at NASA/GSFC with results obtained using the URS-600 at CSIRO. Table 1 shows differences in gains between the two systems for the high gain sky channels of three Cimel instruments. Differences are generally smaller than 2% except at 870 nm where differences of 4 – 6% were found. Although still within the combined standard uncertainty of 6 – 10% given that each system is traceable to NIST with 3 – 5% uncertainty, understanding and eliminating the systematic difference at 870 nm is required to bring all channels within the nominated target of 3%. This will be addressed in part through the circulation of travelling standard Cimel instruments between calibration facilities. In addition, a Quantum Efficient Detector (QED) is being developed at the CSIRO facility to enable the output of the uniform radiance source to be monitored, and to improve calibration linkage with other laboratories.

TABLE I

Percentage differences in gains between the NASA/GSFC and CSIRO calibration systems for the high gain sky channels of three Cimel instruments.

Wavelength (nm)	Cimel #121 20031020	Cimel #33 20031024	Cimel #67 20040213
440	-0.4	+0.07	-1.5
670	-2.3	-1.3	-0.3
870	+4.9	+4.5	+6.3
1020	-0.3	-1.8	+0.6

Acknowledgments.

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