SAFARI 2000 C-130 Aerosol and Meteorological Data, Dry Season 2000

Summary:

The Met Office C-130 research aircraft was based at Windhoek, Namibia between September 5-16, 2000, where it conducted a series of 8 flights over Namibia as part of the SAFARI 2000 Dry Season Aircraft Campaign. Information reported for each flight include: the aircraft navigation data, basic meteorological measurements, ozone concentration, solar irradiance, several measures of aerosol physical and optical properties, and written flight summaries with maps. All data for a given flight are in one file (available in NetCDF and .csv formats) and all parameters have associated quality flags.

The outcome of the Met Office's C-130 flights include:

- In-situ measurements of the physical, chemical and optical properties of the aerosol. Size distributions to be measured using PCASP, FSSP and CVI instrumentation. Optical properties from PSAP and nephelometer data. The data set includes aerosol samples ranging from near source regions to aged plumes several hundreds of kilometres from source, some of which have been cloud processed.
- Data to investigate the direct radiative impact of aerosol over sea, land and low-level cloud. High-altitude radiation measurements taken from SAFIRE, ARIES, SWS and the broad-band radiometers will be used to infer the direct radiative impact of the aerosol. Low-level orbits and into- and down-sun runs will be used in an attempt to obtain radiative closure. Over land, the ground-based sun photometers may also prove useful for constraining the data.
- In-situ measurements of aerosol properties in conjunction with ground-based sites, in order to validate the ground-based retrievals of, for example, aerosol size distributions.
- In-situ measurements of aerosol properties in conjunction with TERRA overpasses, in order to validate the satellite-based retrievals of aerosol properties.
- In-situ measurements of stratus/stratocumulus cloud of Namibia/Angola in conjunction with TERRA overpasses, in order to validate satellite-based retrievals of cloud properties.

Publications describing these results and others are included in the reference section.

Background Information

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Project: SAFARI 2000

Data Set Title: SAFARI 2000 Atmospheric Data from the UK Met Office C-130 Aircraft

Site: Southern Africa

Data Set Citation:
Haywood, J. and S. Osborne. 2004. SAFARI 2000 C-130 Aerosol and Meteorological Data, Dry Season 2000. Data set. Available on-line [http://daac.ornl.gov] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A

Web Site: http://metresearch.net/africa/SAFARI2000.htm

Data File Information

C-130 Flight Summary Document

For each flight, a summary table is shown displaying start and end times of formal aircraft maneuvers. All times are in GMT (=UTC) in the format HHMMSS. Such maneuvers include straight and level runs (SLR) (e.g. R1, R2, R1.1, R1.2); profile ascents and descents (e.g. P1, P2, P1.1, P1.2); banked orbits (e.g. O1, O2); sawtooth profiles (e.g. S1.1, S1.2) which are normally consecutive shallow ascents and descents of fixed lower and upper altitudes. Profile rates are usually 500 feet/minute within the marine boundary layer (MBL) and lower free troposphere and 1000 feet/minute above that. Rates will normally be indicated in the comment column, however. Heights are displayed in feet above sea level or at flight levels (FL e.g. FL050 is 5000ft based on a standard atmosphere with a base pressure of 1013.2 mb). For the bottom few thousand feet above sea level the altitude will be taken from the radar altimeter. Headings are in degrees from magnetic north. Extra terminology in the comment column: IAS= indicated air speed (usually 180 knots but can vary); QNH= local measured pressure at sea level. AGL= above ground level; w0 = single scattering albedo of the aerosol (uncorrected).

C-130 Flight Map

Each C-130 file comes with a flight map in GIF format. This file shows the flight path of that mission on a lat-lon grid.

C-130 Data Files

The C-130 data (~ 65 parameters) are available from ORNL DAAC in NetCDF format data files and comma-delimited spreadsheet formatted files. For each C-130 flight, there is a flight summary report (PDF format) and a flight map (GIF format).

Quality Flags

Quality Flags are provided with every parameter, in the column after the data itself. A flag has a value between 0 and 3. Missing data is often listed as "0", with a Quality Flag of "3" (missing). The flags have the following meanings:

0 - Data is good
1 - Warning, data may be of reduced quality
2 - Error, data is present but is likely to be wrong
3 - Invalid, no valid data is present

Parameters

The following parameters are present in each data file. Each parameter column listed below is followed by a quality flag column (see above). The quality flag columns names are the parameter name with '_FLAG' appended to it, and the units are listed as 'qa' (except for TIME, which gets it's QA flag from the column SECS_FROM_MIDNIGHT_FLAG).

Parameter	Description
TIME	The time of the observation, in hhmmss GMT. This column was created by the SAFARI staff from SECS_FROM_MIDNIGHT using the following formula: trunc(SECS/3600)*10000+trunc(mod(SECS,3600)/60)*100+ mod(SECS,60).
SECS_FROM_MIDNIGHT	Number of seconds from midnight, GMT.
TRUE_AIR_SPEED	True airspeed of the aircraft, in meters/sec.
DEICED_TRUE_TEMP	True air temperature after de-icing, in degrees K.

DEW_POINT	Dew point temperature, in degrees K.
INS_ROLL	Aircraft reference datum from inertial navigation system, +ve roll is right wing down, in degrees.
INS_PITCH	Aircraft reference datum from inertial navigation system, +ve pitch is nose pointing upwards, in degrees.
CNC_CONCENTRATION	Cloud condensation nuclei concentration in particles per cm^3. Counts all aerosol particles down to a nominal 3 nanometres in diameter.
TOTAL_WATER_CONTENT	Lyman-alpha radiation absorption hygrometer, 64 Hz possible, in gm/kg.
OZONE_MIXING_RATIO	Volume mixing ratio, in ppbv.
RADAR_HEIGHT	Aircraft altitude, effective to about 1500 meters, in meters.
STATIC_PRESSURE	Ambient barometric pressure, in mb.
PRESSURE_HEIGHT	Altitude of the aircraft based on air pressure, in meters.
GPS_LATITUDE	GPS-based latitude of the aircraft, in degrees.
GPS_LONGITUDE	GPS-based longitude of the aircraft, in degrees.
GPS_ALTITUDE	GPS-based altitude of the aircraft, in meters.
SOLAR_AZIMUTH	Solar azimuth angle, in degrees.
SOLAR_ZENITH_ANGLE	Solar zenith angle, in degrees.
PSAP_LIN_ABS_COEFF	Radiance Research Inc. particle soot absorption photometer linear absorption coefficient, units are per meter. 30 second averaging period; so data should be corrected for this time 'delay'. Not to be trusted in ascents or descents due to the pressure change which affects flow rate. Note: the absorption coefficient needs correcting for over-reading as per Bond, et al., 1999 Aerosol Sci. Technol., 30, 582-600.
PSAP_LOG_ABS_COEFF	As above but logarithmic.
CORR_SURFACE_TEMP	Surface temperature from a Heimann thermal infrared radiometer. Measures upwelling brightness temperature over the spectral range 8-14 µm. For accurate values the aircraft should be at an altitude of no more than a few hundred feet. This parameter has not been corrected for the affect of ozone, but this is small for runs at ~100ft.
NORTHWARD_WIND_COMPT	Northward component of the wind velocity, in meters/sec.
EASTWARD_WIND_COMPT	Eastward component of the wind velocity, in meters/sec.
VERTICAL_WIND_COMPT	Vertical component of the wind velocity, in meters/sec.
CORR_SURFACE_TEMP	Corrected surface temperature, in degrees K.
CORRECTED_NORTH_VEL	Corrected northward aircraft velocity component, in meters/sec.
CORRECTED_EAST_VEL	Corrected eastward aircraft velocity component, in meters/sec.
NEPH_PRESSURE	TSI 3-wavelength integrating nephelometer (model 3563); barometric pressure inside the unit, in mb.
NEPH_TEMPERATURE	Air temperature of the sample, in degrees K.
NEPH_BLUE_SP	Scattering coefficient for total (7-170 degree) captured

	radiation in sensing volume at 0.45 µm (bandwidth of 0.05 µm, similar for the other wavelengths), in meters-1. Note all scattering coefficients require correcting for 'missing' radiation and STP as per Anderson and Ogren (1998) Aerosol Sci. Technol., 29, 57-69.
NEPH_GREEN_SP	As above but at 0.55 µm.
NEPH_RED_SP	As above but at 0.70 µm.
NEPH_BLUE_BSP	Back-scattered (90-170 degree) component at 0.45 µm, in meters-1.
NEPH_GREEN_BSP	Back-scattered component at 0.55 µm, in meters-1.
NEPH_RED_BSP	Back-scattered component at 0.70 µm, in meters-1.
NEPH_HUMIDITY	Relative humidity measured within the sample, in percent.
NEPH_STATUS	Describes the nephelometer set-up; this will not be a problem during standard runs and profiles. So you can ignore this parameter.
CORR_UPPER_CLR_FLUX	Corrected upper clear flux (irradiance). Broad band radiometer mounted on top of the aircraft, so measures downwelling solar fluxes over the wavelength range 0.3-3.0 µm, in Watts/meter^2.
CORR_UPPER_RED_FLUX	As above but for the range 0.7-3 µm, in Watts/meter^2.
CORR_UPPER_I/R_FLUX	Broadband infrared irradiance over the range 4-50 µm, in Watts/meter^2.
CORR_LOWER_CLR_FLUX	As above for upper radiometer but mounted on bottom of aircraft, so measures upwelling irradiances. Similar for red and I/R, in Watts/meter^2.
FSSP_CONCENTRATION	Particle Measuring System (PMS) Forward Scattering Spectrometer Probe (FSSP). With advanced electronics with zero dead-time that allows all droplets to be detected. Measures water droplets in the size range 1-23 µm radius, in number of droplets per cm^3. This parameter indicates total concentration across all 15 size channels covering the stated size range.
FSSP_LIQUID_WATER_CO	Total liquid water content derived from the FSSP number versus droplet radius size distribution, in grams/cm^3. This method is generally regarded as less robust than the other LWC instruments, mainly because of the errors involved in 'cubing' the sizes.
FSSP_VOLUME_RADIUS	Mean volume radius derived from the FSSP size distribution i.e. that equivalent radius that gives the same water volume as the whole distribution, in microns.
FSSP_EFFECTIVE_RADIUS	Ratio of the third to the second moment of the FSSP size distribution, in microns.
FSSP_SPEC_BINCONC_0 to FSSP_SPEC_BINCONC_14	There are 15 columns here (labeled 0 to 14), which are the concentration of particles within bin 1 to 15, in number of particles per cm^3. The mid-bin radii of the FSSP are: 1.75, 3.25, 4.75, 6.25, 7.75, 9.25, 10.75, 12.25, 13.75, 15.25,

	16.75, 18.25, 19.75, 21.25, 22.75 µm.
PCASP_CONCENTRATION	PMS Passive Cavity Aerosol Spectrometer Probe. Measures aerosol particles in the size range 0.05-1.5 µm radius over 15 size channels, in number of particles per cm^3. This parameter is the total concentration over all size channels.
PCASP_VOLUME_RADIUS	Equivalent mean volume radius derived from the PCASP size distribution, in microns.
PCASP_EFFECTIVE_RADIUS	Ratio of the third to the second moment of the PCASP size distribution, in microns.
PCASP_SPEC_BINCONC_0 to PCASP_SPEC_BINCONC_14	There are 15 columns here (labeled 0 to 14), which are the concentration of particles within bin 1 to 15, in number of particles per cm^3. The mid-bin radii of the PCASP are: 0.055, 0.065, 0.077, 0.092, 0.112, 0.137, 0.173, 0.2235, 0.296, 0.397, 0.52, 0.67, 0.865, 1.12, 1.37 µm.
AUTOCORRECT_NEV_LWC	Nevzerov liquid water content, in grams/cm^3.
AUTOCORRECT_NEV_TWC	Nevzerov total (liquid plus ice) water content, in grams/cm^3.
AUTOCORRECT_JW_LWC	Johnson-Williams hot wire probe liquid water content, in grams/kg. Efficiency falls off for larger drizzle drops ~ 50 µm.

Sample Data Records

These are sample records, without the top two lines in each data file -- column names and units.

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10843,0,0,3,0,3,291.9823,0,0,3,0,3,0,3,0,3,53.63083,0,0,3,1006.502,0,56.32101,0,0,3,
0,3,0,3,0,3,0,3,1.395941e-08,1,1.008881e-
07,1,0,3,0,3,0,3,298.455,0,0,3,0,3,2.398673,0,0.6004496,0,0,3,0,3,0,3,0,3,0,3,0,3,
1.665313,0,0,0,0,3,0,3,435.1964,1,-1.612915,1,-
2.557099,1,426.1109,1,0,3,0,3,0,3,0,3,0,3,0,3,0,3,0,3,0,3,0,3,0,3,0,3,0,3,0,3,0,3,0,
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10844,0,0,3,0,3,291.9823,0,0,3,0,3,0,3,0,3,107.5087,0,0,3,1006.527,0,56.1169,0,0,3,0,3,0,
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0.6982045, 0,0,3,0,3,0,3,0,3,0,3,0,3,1.738629,0,0,0,0,3,0,3,435.9155,0,-2.016144,0,
-2.429245,0,426.6348, 0,0,3,0,3,0,3,0,3,0,3,0,3,0,3,0,3,0,3,0,3,0,3,0,3,0,3,0,3,0,3,0,3,
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10845,0,0,3,0,3,292.0065,0,0,3,0,3,0,3,0,3,161.7553,0,0,3,1006.535,0,56.04886,0,0,3,0,3,
0, 3,0,3,0,3,1.395941e-08,1,1.003219e-07,1,0,3,0,3,0,3,298.4916,0,0,3,0,3,2.104911,0,
0.6004496, 0,0,3,0,3,0,3,0,3,0,3,0,3,1.494242,0,0,0,0,3,0,3,435.2924,0,-1.612915,0,
-2.72757,0,426.0239, 0,0,3,0,3,0,3,0,3,0,3,0,3,0,3,0,3,0,3,0,3,0,3,0,3,0,3,0,3,0,3,0,
3,0,3,0,3,0,3,0,3,0,3, 0,3,0,3,0,3,0,3,0,3,0,3,0,3,0,3,0,3,0,3,0,3,0,3,0,3,0,3,0,0,0,0,0,0
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C-130 Flight Summary

The UK Met Office C-130 was based in Windhoek, Namibia between September 5-16, 2000. The flights performed included flights off the coast of Namibia, over over the Etosha pan surface CIMELS site, and in a fresh biomass plume near Otavi. Data collected included standard meteorological variables such as temperature, dew point, wind-speed and direction etc. Specialist aerosol, cloud, chemistry and radiation equipment was also carried enabling characterisation of the physical and optical properties of aerosol and radiative closure studies.

UK Met Office C-130

1. **Competing direct/indirect effects. Flight a787.** Investigations of the direct/indirect effect of tropospheric biomass aerosols off the coast of Namibia. This is a particularly interesting case as first impressions indicate that the aerosol did not interact with the 1000ft thick Sc off the coast of Namibia. However, the high reflectivity is likely to mean that there is a strong positive direct radiative forcing.
2. **Radiative Closure Tests over ocean. Flights a785, a787, a788, a789, a791, a792.** These flights all included in-situ sampling, SLRs above the aerosol layer, and into-and down- sun runs below the aerosol layers. Many of them contain orbits at low altitudes and two of them contain orbits at high altitude. These flights are probably the best flights to examine the data from the SWS and ARIES.
3. **Comparison of the aerosol optical depth/size distribution with those from CIMELS sites. Flights a786, a790.** These two flights may prove useful in comparisons with the size distribution derived by CIMELS. The optical depths may be more difficult to compare when derived from into- and down- sun runs owing to some of the aerosol existing below the lowest operating level of the aircraft. Orbits were also performed.
4. **Evolution of the aerosol size distribution/ chemistry and radiative properties. Flights a790, a791, and others.** Although no specific Lagrangian experiment was performed the evolution of the aerosol size distribution and chemistry may be traced. Of particular interest will be the flights a790 (flying through smoke plume), a791 (aerosol appeared to have been cloud processed), and the bulk of the other flights where background aerosol was sampled. This will be of particular interest to the modelers, and the filters, mass spectrometer and ORAC will prove very useful.
5. **Comparison of the aerosol/cloud microphysical properties and chemistry with those from MODIS/MOPPIT/MISR. Flights a786, a790 (cloud-free over land), a789, a791, a792 (cloud-free over sea) and a787, a789, a791 (cloudy-skies over sea).** A primary objective of MODIS is to be able to retrieve aerosol optical depths/optical properties over land. Additionally MOPPIT will be attempting to derive atmospheric chemistry profiles such as CO. The correlation between CO and the aerosol number concentration could therefore also be assessed. This might tie in best with 3.

Flight No. & Date	Region	Objective	Comments (aircraft scientist's name in brackets)
A785 5 Sept. 2000	Off coast of Namibia	Investigation of direct radiative effect of biomass burning aerosols.	The main interest in this flight is from the in-situ properties of the aerosol. Down- and into sun legs were performed in clear skies together with a co-located SLR run above the aerosol layer at high altitude. No orbits were performed. (Haywood)
A786 6 Sept. 2000	Over land near Etosha surface site	Investigation of the radiative properties of aerosols in conjunction with CIMELS surface site.	The main interest from this flight is in the extensive measurements of the size distributions which may be used to help verify the CIMELS derived size distributions. Orbits were also performed together with a series of SLRs at different altitudes. Possible validation data for MODIS and MOPITT in cloud-free skies over land. (Haywood)
A787 7 Sept. 2000	Off coast of Namibia/ Angola	Investigation of the microphysical and radiative properties of Sc.	The main interest in this flight was that there was in the very thick (1000ft), relatively homogeneous Sc cloud with a 'clean layer' of 5000 ft above it followed by the aerosol layer. Could prove a very interesting in terms of direct vs. indirect effect competition. Possible validation data for MODIS in cloudy skies over sea. (Osborne)
A788 10 Sept. 2000	Off coast of Namibia	Investigation of in-situ properties of biomass aerosols and direct effect.	Very good set of in-situ observations in biomass aerosol. Additional low-level and high level orbits were performed. Down- and into- sun runs in almost clear sky conditions were performed together with high level runs (box-pattern) above the aerosol layer. (Francis)
A789 11 Sept. 2000	Off coast of Namibia/ Angola	Investigation of microphysical properties of clouds/direct radiative effect of aerosols. In conjunction with ER-2, and TERRA overpass.	The beginning of the flight concentrated on measuring the microphysical properties of Sc clouds. As these broke up during the flight, the second half of the experiment concentrated on measuring the direct effect with orbits at low and high levels, and into- and down-sun runs. Possible validation data for MODIS, MOPITT and MISR in cloudy and cloud-free skies over sea. (Francis)

A790 13 Sept. 2000	Over land near Etosha surface site	Investigation of the radiative properties of aerosols in conjunction with CIMELS surface site and TERRA overpass. Flights through smoke plumes at source.	The first part of the flight concentrated on determining the aerosol size distributions and optical depth near the CIMELS site in Etosha. The second part of the flight was through a large biomass plume. This will prove particularly interesting in terms of determining the chemical composition and size distributions of the biomass aerosols at source. Additionally the aging process from the source may be studied. Possible validation data for MODIS, MOPITT and MISR in cloud-free skies over land. (Haywood)
A791 14 Sept. 2000	Off coast of Namibia/ Angola	Investigation of the microphysical properties of aerosol.	At first site the aerosol appeared to have been cloud processed in some of the operating region. This may be of particular interest to the modelers. A radiative closure experiment was performed including low-level orbits and down- and into-sun runs in clear skies. Possible validation data for MODIS in cloudy and cloud-free air over sea. (Haywood)
A792 16 Sept. 2000	Off coast of Namibia/ Angola	Investigation of the direct radiative effect of biomass/dust aerosols.	Good set of in-situ observations in biomass aerosol just off Angolan coast, contrasting with almost total wash-out of aerosol further south off Namibian coast after passage of cold front. Low-level orbits and down- and into- sun runs in almost clear sky conditions were performed together with a high-level run above the aerosol layer. Possible validation data for MODIS, MOPITT and MISR in generally cloud-free air over sea. (Francis)

Note: Click on links above to view or download a detailed flight summary of that flight (in PDF format).

Additional C-130 data collected during the flights in and out of the African continent (i.e., flights A784 and A793 from and to Ascension Island, respectively) are available from the UK Met Office at [http://metresearch.net/africa/SAFARI2000.htm]. Both of these flights were investigations of cloud fraction/cloud microphysics associated with stratocumulus. The microphysical properties of the cloud were determined by performing runs above and below the cloud with profiles in-between.

C-130 Measurements and Instruments

The instruments onboard the C-130 were designed and operated by several different international organisations, including the Met Office (UK), Max Planck Institute (Germany), University of Leeds (UK), Centre for Ecology and Hydrology (UK), University of Stockholm (Sweden), and KFA (Germany). The measurements can be split up into four categories:

1. Standard Parameters

a. temperature
b. pressure
c. dew point
d. wind speed and direction
e. vertical wind
f. liquid water content
g. total water content
h. position and attitude of aircraft
i. forward- and downward-facing video
j. radiometric surface temperature

2. Cloud Physics and Aerosol Measurements

a. Particle Measuring Systems (PMS) passive cavity aerosol spectrometer probe (PCASP), used to measure aerosol particles in the size range 0.1 - 3.0 µm
b. fast forward scattering spectrometer probe (FFSSP), used to measure aerosol particles and cloud droplets in the size range 1.0 - 45 µm
c. PMS 2D-C cloud probe, used to measure cloud and precipitation droplets in the size range 25 - 800 µm
d. PMS 2D-P precipitation probe, used to measure cloud and precipitation drops in the size range 200 - 6400 µm
e. Cloud-scope (J. Hallett, DRI), used to provide a visual indication of the phase of a particle for sizes greater than 10 µm by using a video camera that views a 0.2 mm 2 window perpendicular to the direction of travel
f. Small ice detector (SID), used to count, size and shape particles down to 1 µm by the use of laser light scattering (Hirst et al., 2000)
g. Cloud condensation nuclei (CCN) activation spectra based on a thermal gradient diffusion chamber device, usually set-up for supersaturations between 0.1-1.1 % with respect to water
h. TSI model 3025 condensation nuclei counter (CNC), used to measure the total aerosol count down to a nominal 3 nm in size
i. Counter-flow virtual impactor (CVI) used to measure the size and chemistry of the residual aerosol particles from cloud droplets; can also be operated out of cloud to sample dehydrated aerosol; incorporates a TSI 3010 CNC (sizes down to a nominal 10 nm) and a PCASP (0.1-10 µm)
j. Filter samples, where two isokinetic sampling lines can be operated simultaneously to collect particles onto (i) quartz filter packs (for black and organic carbon analysis) and (ii) Nuclepore and Teflon filter packs (for major cation and anion chromatography)

3. Chemistry Measurements

a. TECO 49 ozone using a UV photometric method (0-1000 ppb, sensitivity 2 ppb)
b. Carbon monoxide using a resonance fluorescence method for continuous fast response
c. TECO 42C NO-NO_2-NOx analyser
d. Mass spectrometer based on atmospheric pressure chemical ionisation; tuned to detect acetone, acetonitrile and methanol, and SO_2
e. Gas chromatograph for in-flight analysis of non-methane hydrocarbons
f. Bottle samples for analysis of CO and N_2O
g. Bag samples for analysis of non-methane hydrocarbons

4. Radiation Measurements

a. Broad-band irradiances for total solar (0.3 - 3.0 µm), near-infrared (0.7 - 3.0 µm) and thermal infrared (4 - 50 µm), upwelling and downwelling
b. Scattering coefficient at 450 nm, 550 nm and 700 nm with TSI 3563 nephelometer
c. Absorption coefficient at 565 nm with Radiance Research particle soot absorption photometer (PSAP)
d. Nadir or zenith radiances in the 0.55 - 2.0 µm wavelength range with scanning airborne filter radiometer (SAFIRE)
e. Nadir radiances in the 0.4 - 1.7 µm wavelength range with short-wave spectrometer (SWS)
f. Nadir or zenith radiances in the 3.3 - 16 µm wavelength range with ARIES interferometer
g. Microwave airborne radiometer scanning system (MARSS) at frequencies of 89, 157 and 183 GHz over 9 upward and 9 downwind views

Additional Sources of Information

References

Crutzen, P. J. and M. O. Andreae. 1990. Biomass burning in the tropics: Impact on atmospheric chemistry and biogeochemical cycles. Science, 250:1669-1678.

Garstang, M., et al. 1998. The contribution of aerosol and water-borne nutrients to the functioning of the Okavango Delta ecosystem. South African Journal of Science, 94:203-208.

Harris, G. W. et al. 1996. Airborne observations of strong biogenic NOx emissions from the Namibian Savanna at the end of the dry season. J. Geophys. Res., 101, 23,707-23,711.

Haywood, J. M., P. N. Francis, M. D. Glew, and J. P. Taylor. 2001. Optical properties and direct radiative effect of Saharan dust: A case study of two Saharan dust outbreaks using aircraft data. Journal of Geophysical Research, 106 (D16):18417-18430, AUG 27, 2001.

Haywood, J. M., V. Ramaswamy, and B. J. Soden. 1999. Tropospheric aerosol climate forcing in clear-sky satellite observations over the oceans. Science, 283:1299-1303.

Held, G., et al. 1996. Air pollution and its impact on the South African Highveld. Environmental Scientific Association, Cleveland, S.A. and the National Association for Clean Air, 35-46.

Higurashi, A. and T. Nakajima. 1999. Development of a two-channel aerosol retrieval algorithm on a global scale using NOAA AVHRR, J. Atmos. Sci., 56:924-941.

Hirst, E., P. H. Kaye, R. S. Greenaway, P. R. Field, and D. W. Johnson. 2000. Discrimination of micrometre-sized ice and super-cooled droplets in mixed-phase cloud. Atmos. Environ., 35:33-47.

Ramaswamy, V., O. Boucher, J. Haigh, D. Hauglustaine, J. M. Haywood, G. Myhre, T. Nakajima, G. Y. Shi, and S. Solomon. Radiative Forcing of Climate Change. Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change [Houghton, J.T., Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell, and C.A. Johnson (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 349-416, 881pp.

Related Publications

Abel, S., J. M. Haywood, E. J. Highwood, J. Li, and P. R. Buseck. 2003. Evolution of biomass burning aerosol properties from an agricultural fire in southern Africa, Geophysical Research Letters, 30, 15, 1783, doi:10.1029/2003GL017342.

Formenti, P., W. Elbert, W. Maenhaut, J. M. Haywood, S. R. Osborne, and M. O. Andreae. 2003. Inorganic and carbonaceous aerosols during the Southern African Regional Science Initiative (SAFARI 2000) experiment: Chemical characteristics, physical properties, and emission data for smoke from African biomass burning, 2003. Journal of Geophysical Research, 108(D13), 8488, doi:10.1029/2002JD002408.

Haywood, J. M., P. N. Francis, O. Dubovik, M. D. Glew, and B. N. Holben. 2003b. Comparison of aerosol size distributions, radiative properties, and optical depths determined by aircraft observations and Sun photometers during SAFARI-2000. Journal of Geophysical Research, 108(D13), 8471, doi:10.1029/2002JD002250.

Haywood, J. M., S. R. Osborne, P. N. Francis, A. Keil, P. Formenti, M. O. Andreae, and P. H. Kaye. 2003. The mean physical and optical properties of regional haze dominated by biomass burning aerosol measured from the C-130 aircraft during SAFARI 2000, Journal of Geophysical Research, 108(D13), 8473, doi:10.1029/2002JD002226.

Haywood, J. M., S. R. Osborne, and S. Abel. 2004. The effect of overlying absorbing aerosol layers on remote sensing retrievals of cloud effective radius and cloud optical depth. Quarterly Journal of the Royal Meteorological Society, 130(598): 779-800 Part A, Apr 2004.

Jost, C., D. Sprung, M. O. Andreae, and K. Dewey. 2003. Deposition of acetonitrile to the Atlantic Ocean off Namibia and Angola and its implications for the atmospheric budget of acetonitrile, Geophysical Research Letters, 16, 1837, doi:10.1029/2003GL017347.

Kaufman, Y., J. M. Haywood, P. V. Hobbs, W. Hart, R. Kleidman, and B. Schmid. 2003. Remote sensing of vertical distribution of smoke aerosol off the coast of Africa, Geophysical Research Letters, 30, 16, 1831, doi:10.1029/2003GL017068.

Keil, A. and J. M. Haywood. 2003. Solar radiative forcing by biomass aerosol particles over marine clouds during SAFARI 2000: A case study based on measured aerosol and cloud properties. Journal of Geophysical Research, 108(D13), 8467, doi:10.1029/2002JD002315.

Myhre, G., T. K. Berntsen, J. M. Haywood, J. K. Sundet, B. N. Holben, M. Johnsrud, and F. Stordal. 2003. Modeling the radiative impact of aerosols from biomass burning during the Southern African Regional Science Initiative (SAFARI-2000) experiment, Journal of Geophysical Research, Vol. 108 (D13), 8501, doi 10.1029/2002JD002313.

Osborne, S. R., P. N. Francis, J. M. Haywood, and O. Dubovik. 2003. Short-wave radiative effects of biomass burning aerosol during SAFARI2000, Quarterly Journal of the Royal Meteorological Society, submitted.

Swap, R. J., et al. 2002. The Southern African Regional Science Initiative (SAFARI 2000): Overview of the dry season field campaign, South African Journal of Science, 98:125-130.

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