# Companion Documentation for the South African Weather Bureau JRA & JRB Aircraft Dry Season 2000 Intensive Campaign during SAFARI 2000

## Data Sets:

## SAFARI 2000 JRA Aerocommander Trace Gas, Aerosol and CCN Data, Dry Season 2000

## SAFARI 2000 JRB Aerocommander Trace Gas and Aerosol Data, Dry Season 2000

### Abstract


During the dry-season 2000 intensive campaign of SAFARI-2000 in August and September 2000, data were collected from a pair of South African Weather Bureau aircraft (JRA and JRB) during a total of 57 flights. Flights were conducted throughout the eastern half of southern Africa, and were designed to characterize aerosols and trace gases in the boundary layer. In particular, sources of pollutants were identified, and the effect of meteorological conditions and transport of aerosol particles and trace gases was investigated. Both aircraft flew out of Pietersburg (South Africa) for the duration of the campaign, although the operation was temporarily relocated to Kasane (Botswana), Lusaka (Zambia) and Vilancolus (Mozambique).


The JRA Aerocommander in Pietersburg, South Africa

The aircraft were equipped with a similar suite of instruments that measured state parameters, aerosol concentrations and size distributions, cloud droplet spectra and trace gases. In addition to optical probes and trace gas analyzers, a cloud condensation nucleus (CCN) counter was mounted on board JRA, and CCN activity spectra were measured on a variety of different air mass types (biomass burning, industrial, maritime). An airborne streaker sampler was used to collect aerosol samples. Twenty-four flights were conducted with the CCN counter aboard. From 11 September onwards, the US Forestry Service used JRA for measurements associated with fires; a total of 16 flights were conducted, ending on 24 September.

In addition to measuring aerosol and trace gas properties, JRB conducted flights between the surface and 28,000 ft asl to validate carbon monoxide concentrations detected by MOPITT. Air samples were collected at regular intervals by the NOAA investigators. Volatile organic compound (VOC) canisters were used to collect VOCs present over various land surface types.

The data described here include all data collected on the aircrafts' Data Acquisition System. This is **Version 3 (October 2002)** of the data as described on the Aerocommanders Data Page of SAFARI 2000 [ http://metsys.weathersa.co.za/safari2000/index.html ]. Data collected using other systems can be obtained from the responsible Investigators directly. Their contact information is included below or available on the Aerocommanders Data Page of SAFARI 2000.

## Background Information

**Investigators:**
Stuart J. Piketh (stuart@crg.bpb.wits.ac.za)
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**Project:** SAFARI 2000

**Data Set Title:** SAFARI 2000 JRA AEROCOMMANDER TRACE GAS, AEROSOL AND CCN DATA, DRY SEASON 2000

**Site:** Southern Africa

- Westernmost Longitude: 15.88378
- Easternmost Longitude: 36.91508

- Northernmost Latitude: -15.3247
- Southernmost Latitude: -28.7782

**Data Set Title:** SAFARI 2000 JRB AEROCOMMANDER TRACE GAS AND AEROSOL DATA, DRY SEASON 2000

**Cite this data set as follows:**

Piketh, S. J., T. Elias, and D. C. Stein. 2004. SAFARI 2000 JRB Aerocommander Trace Gas and Aerosol Data, Dry Season 2000. Data set. Available on-line [http://www.daac.ornl.gov] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, USA.

**Site:** Southern Africa

- Westernmost Longitude: 22.15599
- Easternmost Longitude: 33.16346
- Northernmost Latitude: -17.8293
- Southernmost Latitude: -30.1916

## Data File Information

The data files contain trace gas and aerosol property measurements collected from the the JRA and JRB aircraft. The files are organized and named by aircraft, date, and daily flight number. For example, data file b20000815_1.dat contains data collected on the first flight of the JRB aircraft on August 15, 2000. The data are stored as ASCII files in comma-separated-value format.

**The reported values are ten second averages.** All parameters were originally recorded on the aircraft Data Acquisition System with a temporal resolution of 1 Hz (i.e., Data acquisition mode -> 0 = 1Hz ). No measures of uncertainty are provided (e.g., standard deviation). The average speed of the aircraft during data collection was 100 m $s^{-1}$. Data have been processed and corrected.

The data described here include all data collected on the aircraft Data Acquisition System. Data collected using other systems can be obtained from the responsible Investigators directly. For example, trace gas data collected on JRB using University of Maryland (UMD) instrumentation should been obtained from Bruce Dodderidge directly (bruce@metosrv2.umd.edu).

## Data file column headings, units, missing value codes, and variable descriptions.

| VARIABLE | UNITS | MISSING DATA | LONGNAME |
|---|---|---|---|
| DATE | UTC | -999 | Study date (dd-mm-yyyy) |
| TIME | UTC | -999 | Study time (hh:mm:ss) |
| mode | none | -999 | Data acquisition mode -> 0 = 1Hz and 1 => 10Hz |
| GLAT | deg_east | -999 | GPS latitude (decimal degrees) |
| GLON | deg_west | -999 | GPS longitude (decimal degrees) |
| GDATE | UTC | -999 | GPS date (ddmmyy) |
| GTIME | UTC | -999 | GPS time (hhmmss) |
| GSPD | m/s | -999 | GPS ground speed |
| GHEAD | deg | -999 | GPS heading |
| GSTAT | none | -999 | GPS status |
| ATBR | degC | -999 | Ambient Temperature |
| RHUM | % | -999 | Vaisala humidity |
| PSBC | hPa | -999 | Corrected Static Pressure |
| TAS | m/s | -999 | Derived True Air Speed |
| ATBF | degC | -999 | Ambient Temperature |
| TAS1 | m/s | -999 | Derived True Air Speed |
| GALT | m | -999 | NACA Pressure Altitude |
| ALTF | feet | -999 | NACA Pressure Altitude |
| THETA | K | -999 | Potential Temperature |
| THETAE | K | -999 | Equivalent Potential Temperature |
| THETAV | K | -999 | Virtual Potential Temperature |
| SPHUM | g/kg | -999 | Specific Humidity |
| MR | g/cm^3 | -999 | Mixing Ratio |
| RHO | g/cm^3) | -999 | Absolute humidity (Vapour Density) |
| TDEW | degC | -999 | Dewpoint Temperature |
| TVIR | K | -999 | Virtual Temperature |

| | | | |
|---|---|---|---|
| PRNG_LWO | none | -999 | PCASP-100X range |
| DBARP_LWO | uM | -999 | PCAS-100 mean particle diameter |
| DISPP_LWO | none | -999 | PCAS-100 dispersion (sigma/dbarx) |
| CONCP_LWO | #/cm^3 | -999 | PCAS-100 total concentration |
| CPCAS_LWO_(1-15) | #/cm^3/uM_ival | -999 | PCAS-100 corrected concentration |
| FRNG_LWI | none | -999 | FSSP-100 range |
| CONCF_LWI | #/cm^3 | -999 | FSSP-100 total concentration |
| DBARF_LWI | uM | -999 | FSSP-100 mean particle diameter |
| DISPF_LWI | none | -999 | FSSP-100 dispersion (sigma/dbarx) |
| LWCF_LWI | g/cm^3 | -999 | FSSP-100 Liquid Water Content |
| CFSSP_LWI_(1-15) | #/cm^3/uM_ival | -999 | FSSP-100 corrected concentration |
| SO2 | PPB | -999 | S02 Concentration |
| O3 | PPB | -999 | O3 |
| CO | PPB | -999 | CO_signal |
| NO | PPB | -999 | NO_signal |
| SO2C | PPB | -999 | SO2 Concentration transformed to 1 atmosphere at 25 Deg C |
| O3C | PPB | -999 | O3 Concentration transformed to 1 atmosphere at 25 Deg C |
| COC | PPB | -999 | CO Concentration transformed to 1 atmosphere at 25 Deg C |
| NOC | PPB | -999 | NO Concentration transformed to 1 atmosphere at 25 Deg C |

The variable **'CPCAS_LWO'** has 15 particle concentration values corresponding to a size bin. This PCASP instrument operated in only one range.

**Lower and upper particle site limits (micrometers) for 'CPCAS_LWO' size bins.**

| Size Bin | Lower Limit (um) | Upper Limit (um) |
|---|---|---|
| 1 | 0.10 | 0.12 |
| 2 | 0.12 | 0.14 |
| 3 | 0.14 | 0.17 |
| 4 | 0.17 | 0.20 |
| 5 | 0.20 | 0.25 |
| 6 | 0.25 | 0.30 |

| | | |
|---|---|---|
| 7 | 0.30 | 0.40 |
| 8 | 0.40 | 0.50 |
| 9 | 0.50 | 0.70 |
| 10 | 0.70 | 0.90 |
| 11 | 0.90 | 1.20 |
| 12 | 1.20 | 1.50 |
| 13 | 1.50 | 2.00 |
| 14 | 2.00 | 2.50 |
| 15 | 2.50 | 3.00 |

The variable **'CFSSP_LWI'** has 15 values corresponding to a size bin.
The different instrument operating range values of **'FRNG_LWI'** will determine the bin size limits.

**Lower and upper particle site limits (micrometers) for 'CFSSP_LWI' size bins for instrument operating ranges.**

| | Range 0 | | Range 1 | | Range 2 | | Range 3 | |
|---|---|---|---|---|---|---|---|---|
| Size Bin | Lower Limit (um) | Upper Limit (um) | Lower Limit (um) | Upper Limit (um) | Lower Limit (um) | Upper Limit (um) | Lower Limit (um) | Upper Limit (um) |
| 1 | 2.00 | 5.00 | 2.00 | 4.00 | 1.00 | 2.00 | 0.50 | 1.00 |
| 2 | 5.00 | 8.00 | 4.00 | 6.00 | 2.00 | 3.00 | 1.00 | 1.50 |
| 3 | 8.00 | 11.00 | 6.00 | 8.00 | 3.00 | 4.00 | 1.50 | 2.00 |
| 4 | 11.00 | 14.00 | 8.00 | 10.00 | 4.00 | 5.00 | 2.00 | 2.50 |
| 5 | 14.00 | 17.00 | 10.00 | 12.00 | 5.00 | 6.00 | 2.50 | 3.00 |
| 6 | 17.00 | 20.00 | 12.00 | 14.00 | 6.00 | 7.00 | 3.00 | 3.50 |
| 7 | 20.00 | 23.00 | 14.00 | 16.00 | 7.00 | 8.00 | 3.50 | 4.00 |
| 8 | 23.00 | 26.00 | 16.00 | 18.00 | 8.00 | 9.00 | 4.00 | 4.50 |
| 9 | 26.00 | 29.00 | 18.00 | 20.00 | 9.00 | 10.00 | 4.50 | 5.00 |
| 10 | 29.00 | 32.00 | 20.00 | 22.00 | 10.00 | 11.00 | 5.00 | 5.50 |
| 11 | 32.00 | 35.00 | 22.00 | 24.00 | 11.00 | 12.00 | 5.50 | 6.00 |
| 12 | 35.00 | 38.00 | 24.00 | 26.00 | 12.00 | 13.00 | 6.00 | 6.50 |
| 13 | 38.00 | 41.00 | 26.00 | 28.00 | 13.00 | 14.00 | 6.50 | 7.00 |
| 14 | 41.00 | 44.00 | 28.00 | 30.00 | 14.00 | 15.00 | 7.00 | 7.50 |
| 15 | 44.00 | 47.00 | 30.00 | 32.00 | 15.00 | 16.00 | 7.50 | 8.00 |

## Example Data Records

**Example data file (b20000815_1.dat).**

DATE,TIME,mode,GLAT,GLON,GDATE,GTIME,GSPD,GHEAD,GSTAT,ATBR,RHUM, PSBC,TAS,ATBF,TAS1,GALT,ALTF,THETA,THETAE,THETAV,SPHUM,MR,RHO, TDEW,TVIR,PRNG_LWO,DBARP_LWO,DISPP_LWO,CONCP_LWO,CPCAS_LWO_1, CPCAS_LWO_2,CPCAS_LWO_3,CPCAS_LWO_4,CPCAS_LWO_5,CPCAS_LWO_6, CPCAS_LWO_7,CPCAS_LWO_8,CPCAS_LWO_9,CPCAS_LWO_10,CPCAS_LWO_11, CPCAS_LWO_12,CPCAS_LWO_13,CPCAS_LWO_14,CPCAS_LWO_15,FRNG_LWI, CONCF_LWI,DBARF_LWI,DISPF_LWI,LWCF_LWI,CFSSP_LWI_1,CFSSP_LWI_2, CFSSP_LWI_3,CFSSP_LWI_4,CFSSP_LWI_5,CFSSP_LWI_6,CFSSP_LWI_7, CFSSP_LWI_8,CFSSP_LWI_9,CFSSP_LWI_10,CFSSP_LWI_11,CFSSP_LWI_12, CFSSP_LWI_13,CFSSP_LWI_14,CFSSP_LWI_15,SO2,O3,CO,NO,SO2C,O3C, COC,NOC

15-08-2000,07:28:11,0,-23.861,29.457,150800,72811,0.000,318.000,1,20.593,36.373, 902.227,7.113,20.525,7.112,968.188,3176.469,302.514,0.018,303.629,0.006,0.006, 6.504,5.227,294.836,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000, 0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,1.000,0.000,0.000,0.000, 0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000, 0.000,0.000,0.000,13.916,2.227,321.602,2.267,14.993,2.399,346.484,2.443

15-08-2000,07:28:21,0,-23.861,29.457,150800,72821,0.000,318.000,1,20.621,36.536, 902.386,6.807,20.432,6.804,966.738,3171.712,302.528,0.018,303.650,0.006,0.006, 6.544,5.315,294.871,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000, 0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,1.000,0.000,0.000,0.000, 0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000, 0.000,0.000,0.000,13.718,2.237,325.837,2.296,14.780,2.410,351.074,2.474

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## Aerocommander Instrumentation

**Instruments mounted on board JRA**

| Parameter | Instrument | Manufacturer | Supplier | Investigator |
|---|---|---|---|---|
| State parameters | | | SAWB/METSYS | Roelof Burger |
| Accumulation mode aerosols | PCASP-100x | PMS | NCAR | Roelof Bruintjes |

| | | | | |
|---|---|---|---|---|
| Condensation nuclei | CNC - model 3760/3762 | TSI | NCAR | Roelof Bruintjes |
| Cloud condensation nuclei | CCN counter-100A | University of Wyoming | NCAR | Roelof Bruintjes |
| Cloud droplets | SPP-100 | PMS | NCAR | Roelof Bruintjes |
| Cloud droplets | FSSP-100 | PMS | SAWB/METSYS | Roelof Burger |
| Cloud droplets | 2DC | PMS | SAWB/METSYS | Roelof Burger |
| Precipitation particles | 2DP | PMS | SAWB/METSYS | Roelof Burger |
| Ozone | $O_3$ analyser-49C | TEI | Wits | Stuart Piketh |
| Carbon monoxide | CO analyser-48S | TEI | Wits | Stuart Piketh |
| Sulphur dioxide | $SO_2$ analyser-43C | TEKO | Wits/DEAT | Stuart Piketh |
| Aerosol samples | ABS-1 | Wits/Max Planck | Wits | Stuart Piketh |
| Scattering | Nephelometer | | ESKOM TSI | Neil Snow |

**Instruments mounted on board JRB**

| Parameter | Instrument | Manufacturer | Supplier | Investigator |
|---|---|---|---|---|
| State parameters | | | SAWB/METSYS | Roelof Burger |
| Aerosols | PCASP-100x | PMS | Wits | Stuart Piketh |
| Condensation nuclei | CN counter -- model 3010 | TSI | Wits | Stuart Piketh |
| Cloud droplets | FSSP-100 | PMS | SAWB/METSYS | Roelof Burger |
| Cloud droplets | 2DC | PMS | SAWB/METSYS | Roelof Burger |
| Precipitation particles | 2DP | PMS | SAWB/METSYS | Roelof Burger |
| Ozone | $O_3$ analyser-49C | TEI | UMD | Deborah Stein |
| Nitrogen oxides | NOx analyser-42C | TEI | UMD | Deborah Stein |
| Carbon monoxide | CO analyser-48S | TEI | UVA | Deborah Stein |

| | | | | |
|---|---|---|---|---|
| Sulphur dioxide | $SO_2$ analyser | TEI | ESKOM TSI | Neil Snow |
| Scattering | Nephelometer-3563 | TSI | CGE | Thierry Elias |
| Carbon monoxide | Trace canisters | | NOAA | Paul Novelli |
| Volatile organic canisters | VOC canisters | | UVA/Wits | Stuart Piketh |

**Aerocommander Instrumentation Table Acronyms:**

| Acronym | Definition |
|---|---|
| CGE | Centro de Geofísica de Évora (Geophysics Centre of Évora) [ http://www.cge.uevora.pt ] University of Évora, Portugal [ http://www.uevora.pt ] |
| DEAT | South African Department of Environmental Affairs and Tourism |
| ESKOM | Eskom Group [ http://www.mbendi.com/eskomenterprises/about/eskom.htm ] |
| METSYS | SAWS Meteorological Systems and Technology |
| NCAR | National Center for Atmospheric Research |
| NOAA | National Oceanic and Atmospheric Administration |
| SAWB | South African Weather Bureau |
| SAWS | South African Weather Service |
| UMD | University of Maryland |
| UVA | University of Virginia |
| WITS | University of the Witwatersrand |

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## Aircraft Operations

The two aircraft were operated for the most part in a coordinated fashion. The aim of coordinated flights was to sample air at different positions within the same atmospheric transport mechanism. The basis for positioning the airborne resources within the region was made by subdividing the atmospheric circulation into six sectors, centered around the micrometeorological flux tower in Maun, Botswana (19.93° S, 23.59° E) (**Figure 1**). The research aircraft deployment plan was to take multiple observations in each of the sectors for different circulation patterns. The aim of measuring aerosol and trace gas characteristics simultaneously at different locations was to create a regional model of the evolution, maturation and decay of the southern African atmospheric circulation system. Missions were designed according to synoptic meteorology (Poolman, 2004), atmospheric haze conditions, satellite overpasses, and ground based validation targets. Some flights were designed to provide the maximum synchronous under flight time with the ER-2 remote sensing aircraft and the Terra satellite. The aircraft flights were also coordinated with the remote sensing platforms. After under flying Terra, research aircraft would move on to other targets of interest (Swap et al., 2002).

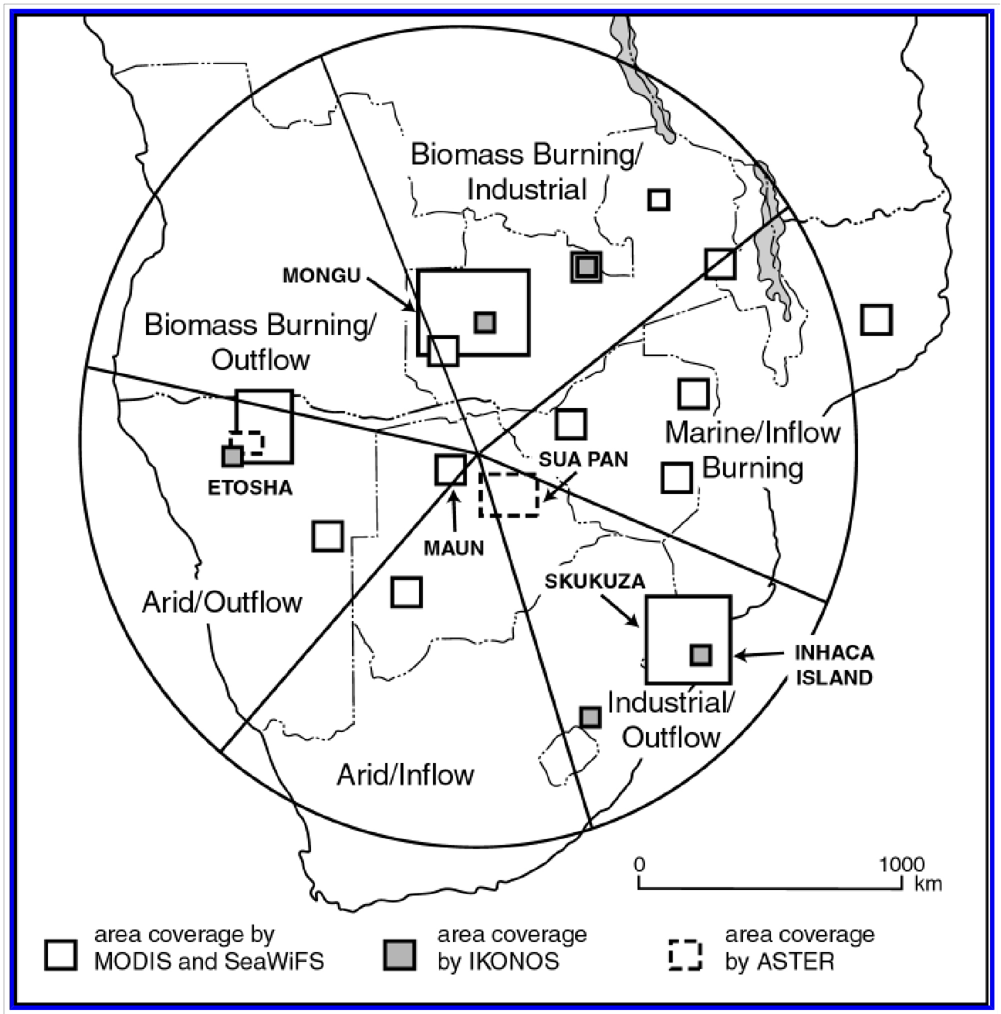


**Figure 1.** The sectors used to position the aircraft contained a least one ground-based instrument, which part of each flight overlapped.

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## JRA and JRB Flight Tracks

The flight tracks for JRA for the Dry Season 2000 SAFARI 2000 campaign for both JRA and JRB are given in **Figures 2 and 3**. The spatial coverage over the subcontinent obtained by JRA was better than JRB. Flights were conducted using JRA for an additional two weeks after 14 September 2000.

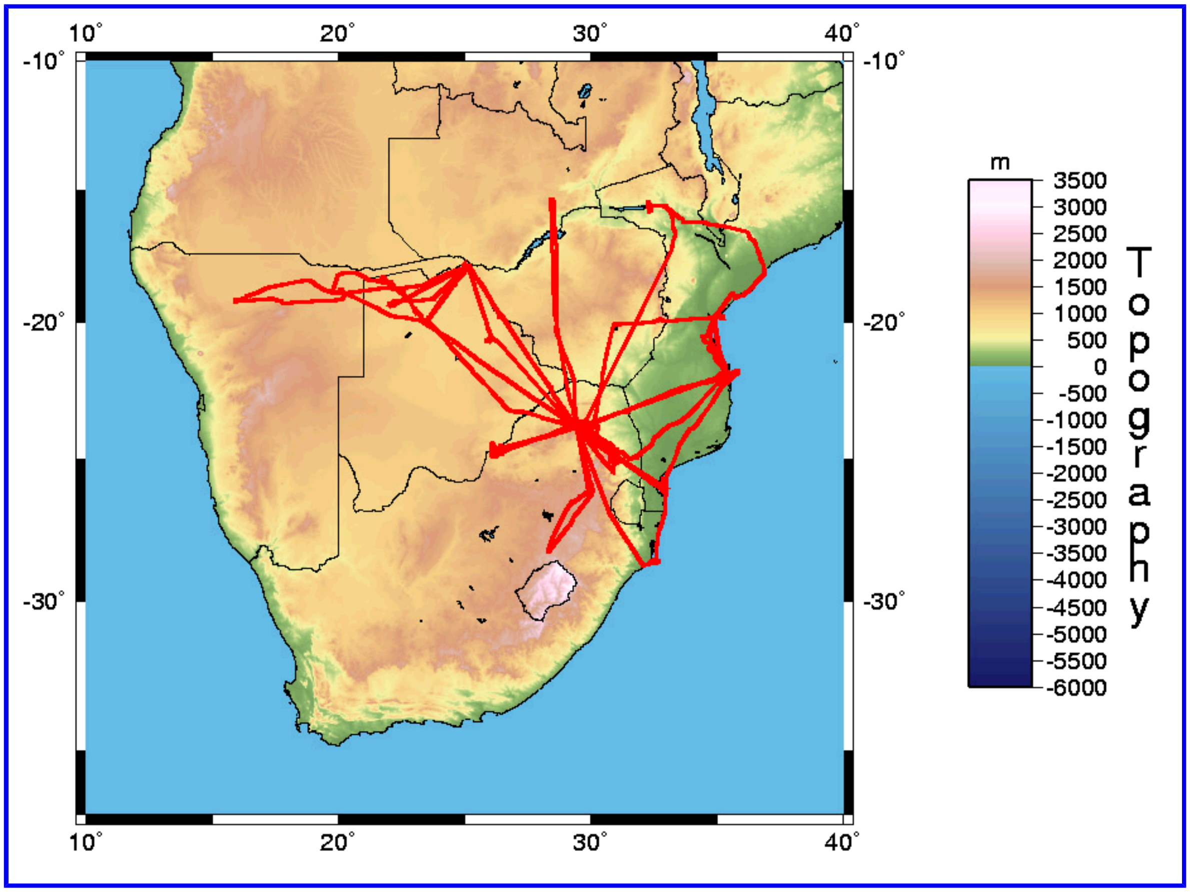


**Figure 2.** Flight tracks during SAFARI 2000 for the Aerocommander JRA. Data were collected in at least five of the six sectors (see Fig. 1).

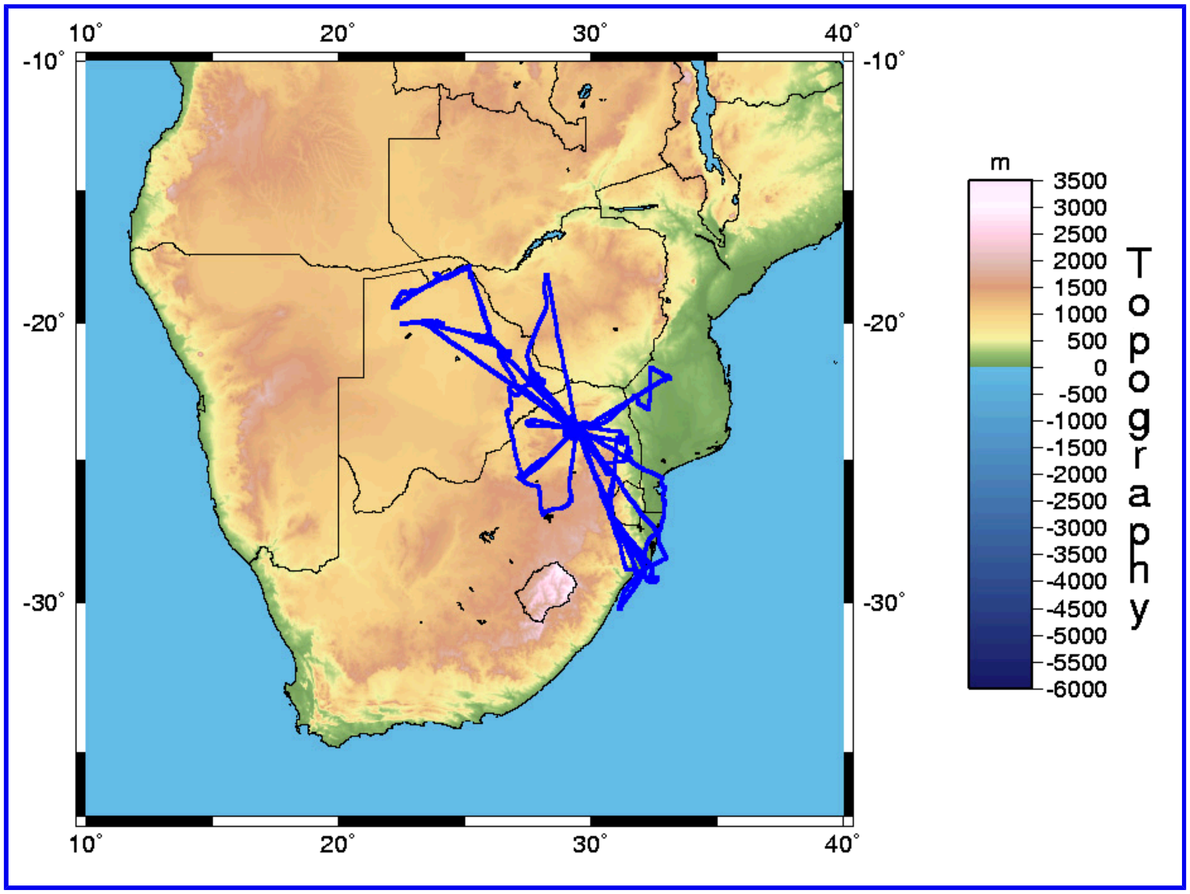


**Figure 3.** Flight tracks during SAFARI 2000 for the Aerocommander JRB. Data were collected in at least three of the six sectors (see Fig. 1).

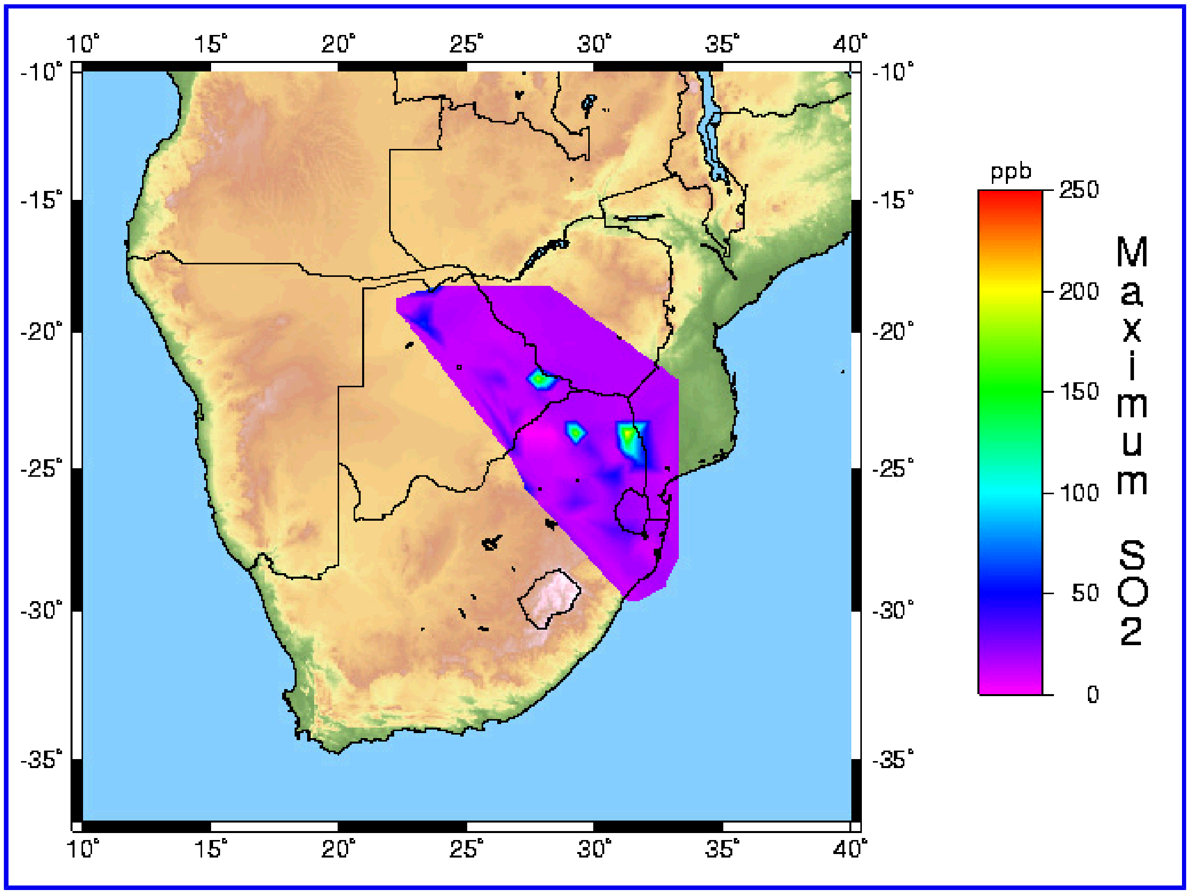


**Figure 4.** Average boundary layer concentrations of sulfur dioxide over southern Africa during SAFARI 2000.

The data sets have been divided into 2.5x2.5 degree grids over the southern African region. Average values have been calculated between the surface and 3000 m above seal level (asl). This gives a first good estimate of the spatial distribution of the constituent being considered as well as the magnitude of the average concentrations within the boundary layer. An example of this is given for sulfur dioxide concentrations over southern Africa. The concentrations are recorded in the major industrial source regions (**Figure 4**).

## The dates when the JRA and JRB were flying, and the number of flights each day.

**JRA Flights**

| Date | # of Flights |
|---|---|
| 2000-08-15 | 2 |
| 2000-08-16 | 2 |
| 2000-08-18 | 1 |
| 2000-08-20 | 1 |

**JRA Flights** (cont.)

| Date | # of Flights |
|---|---|
| 2000-09-13 | 2 |
| 2000-09-14 | 2 |
| 2000-09-17 | 2 |
| 2000-09-18 | 2 |

**JRB Flights**

| Date | # of Flights |
|---|---|
| 2000-08-15 | 2 |
| 2000-08-16 | 2 |
| 2000-08-20 | 2 |
| 2000-08-22 | 2 |

| | |
|---|---|
| 2000-08-23 | 1 |
| 2000-08-24 | 2 |
| 2000-08-26 | 1 |
| 2000-08-27 | 1 |
| 2000-08-29 | 2 |
| 2000-09-01 | 3 |
| 2000-09-02 | 2 |
| 2000-09-05 | 1 |
| 2000-09-06 | 1 |
| 2000-09-07 | 2 |
| 2000-09-11 | 1 |
| 2000-09-12 | 1 |

| | |
|---|---|
| 2000-09-22 | 2 |
| 2000-09-23 | 2 |
| 2000-09-24 | 2 |

| | |
|---|---|
| 2000-08-23 | 1 |
| 2000-08-24 | 3 |
| 2000-08-25 | 2 |
| 2000-08-26 | 2 |
| 2000-08-27 | 2 |
| 2000-08-29 | 3 |
| 2000-08-31 | 1 |
| 2000-09-02 | 2 |
| 2000-09-03 | 2 |
| 2000-09-05 | 2 |
| 2000-09-06 | 1 |
| 2000-09-07 | 2 |

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## JRA/JRB Intercomparison

On 23 August 2000, an intercomparison was conducted between the measurements collected from JRA and JRB. The aircraft flew alongside each other for about 1 hour. Results of the intercomparison are shown below. In all cases, the measured parameters compare favorably.

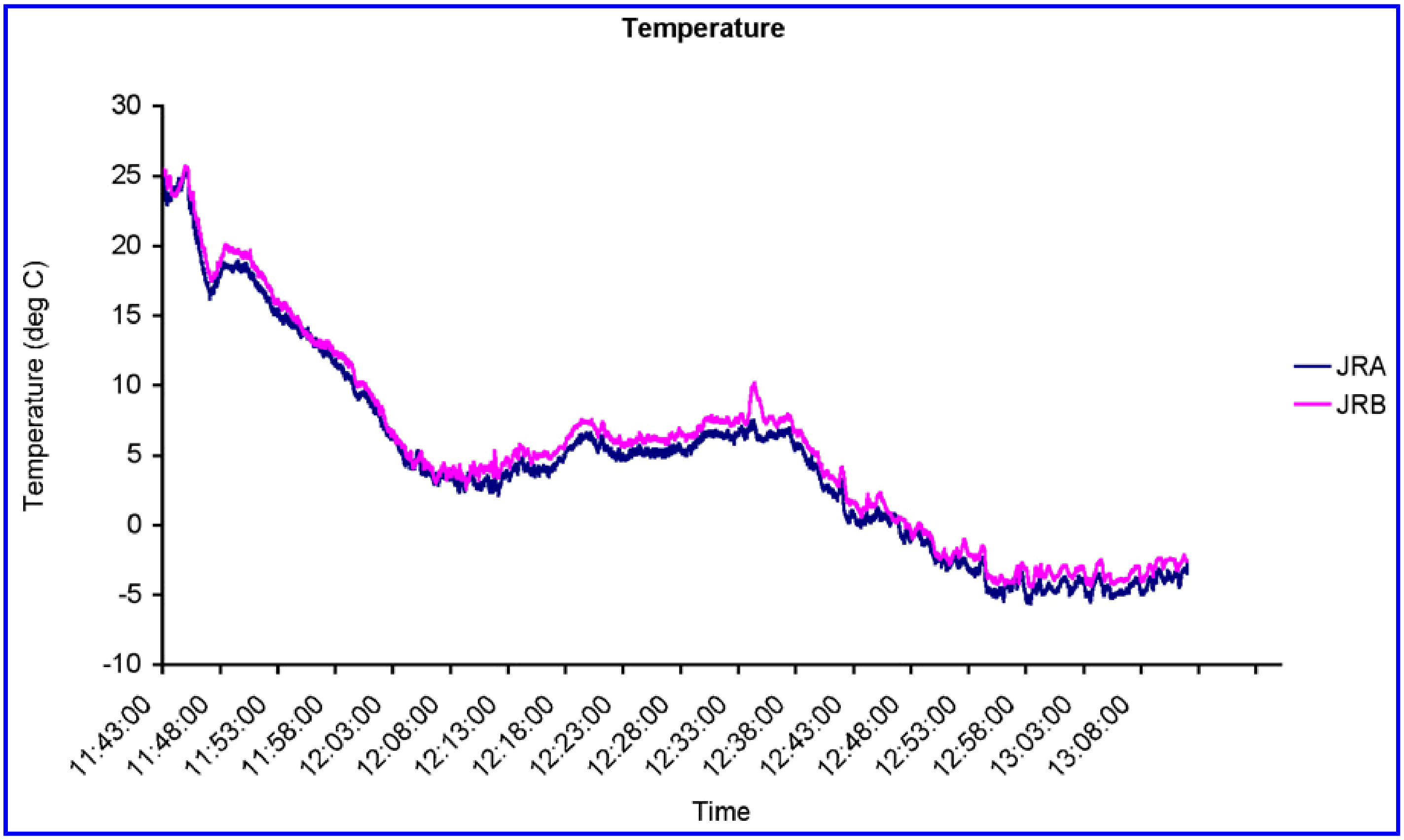
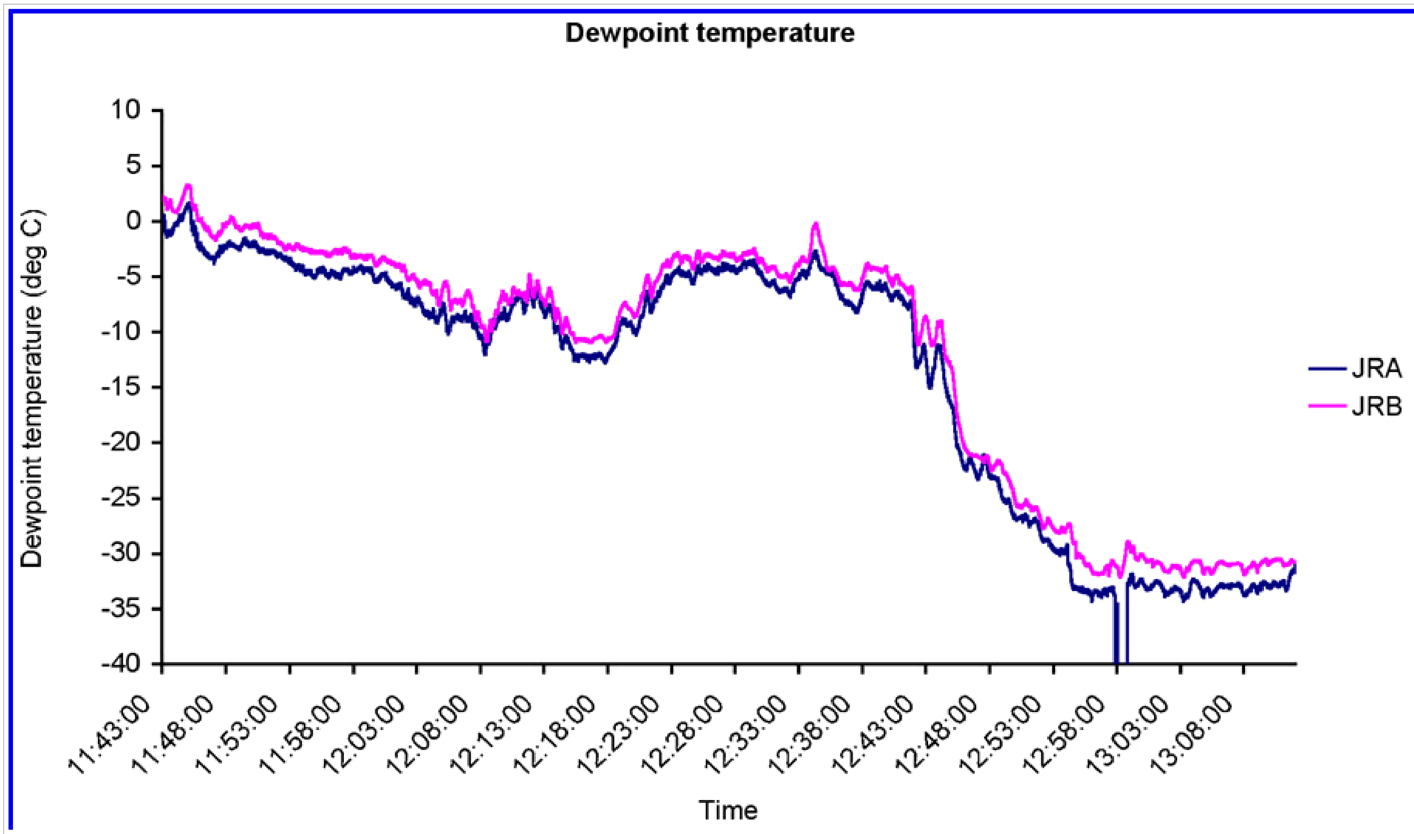



**Figure 5.** JRA/JRB intercomparison of temperature measurements.



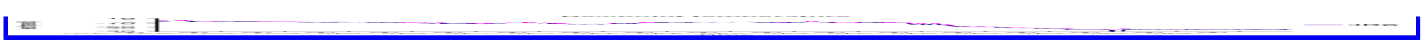


**Figure 6.** JRA/JRB intercomparison of dewpoint temperature measurements.

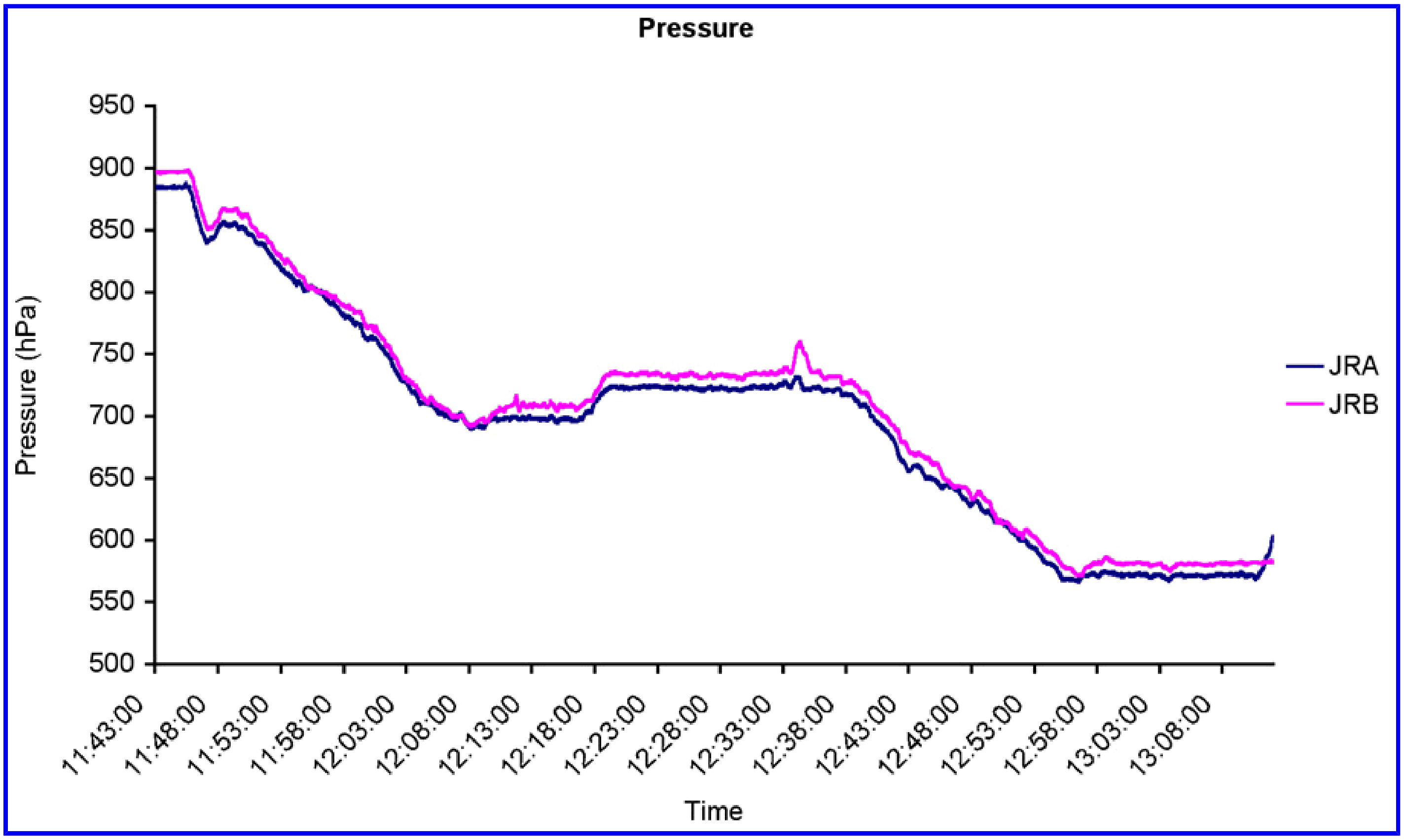
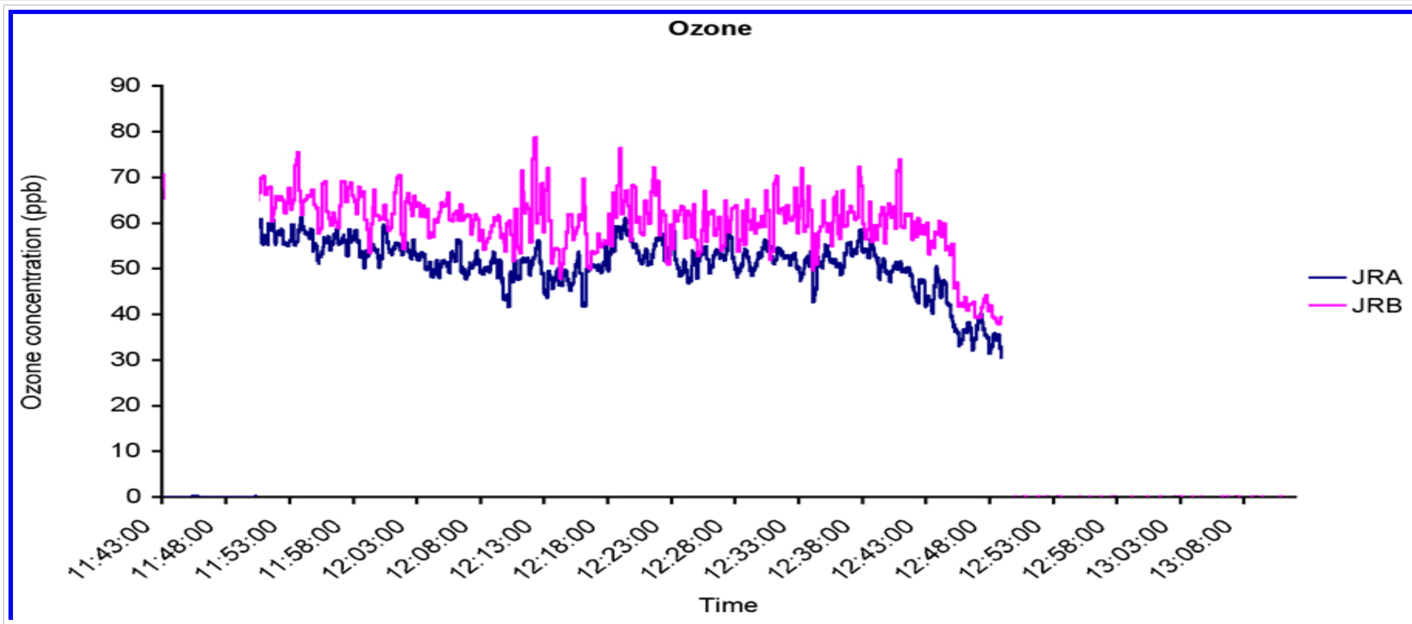



**Figure 7.** JRA/JRB intercomparison of pressure measurements.



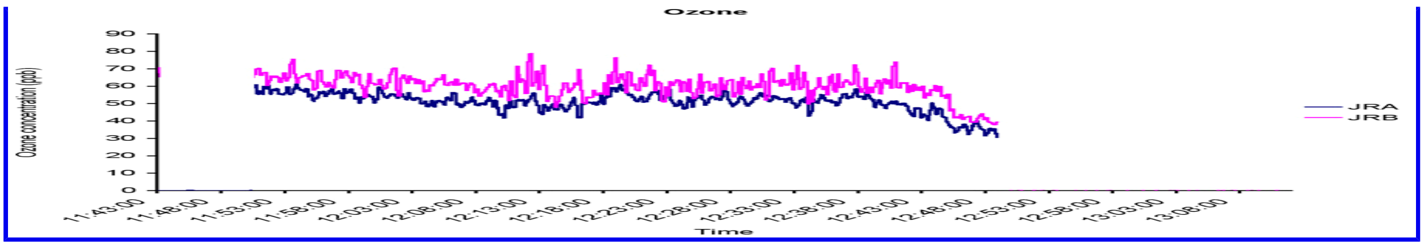



**Figure 8.** JRA/JRB intercomparison of ozone measurements.

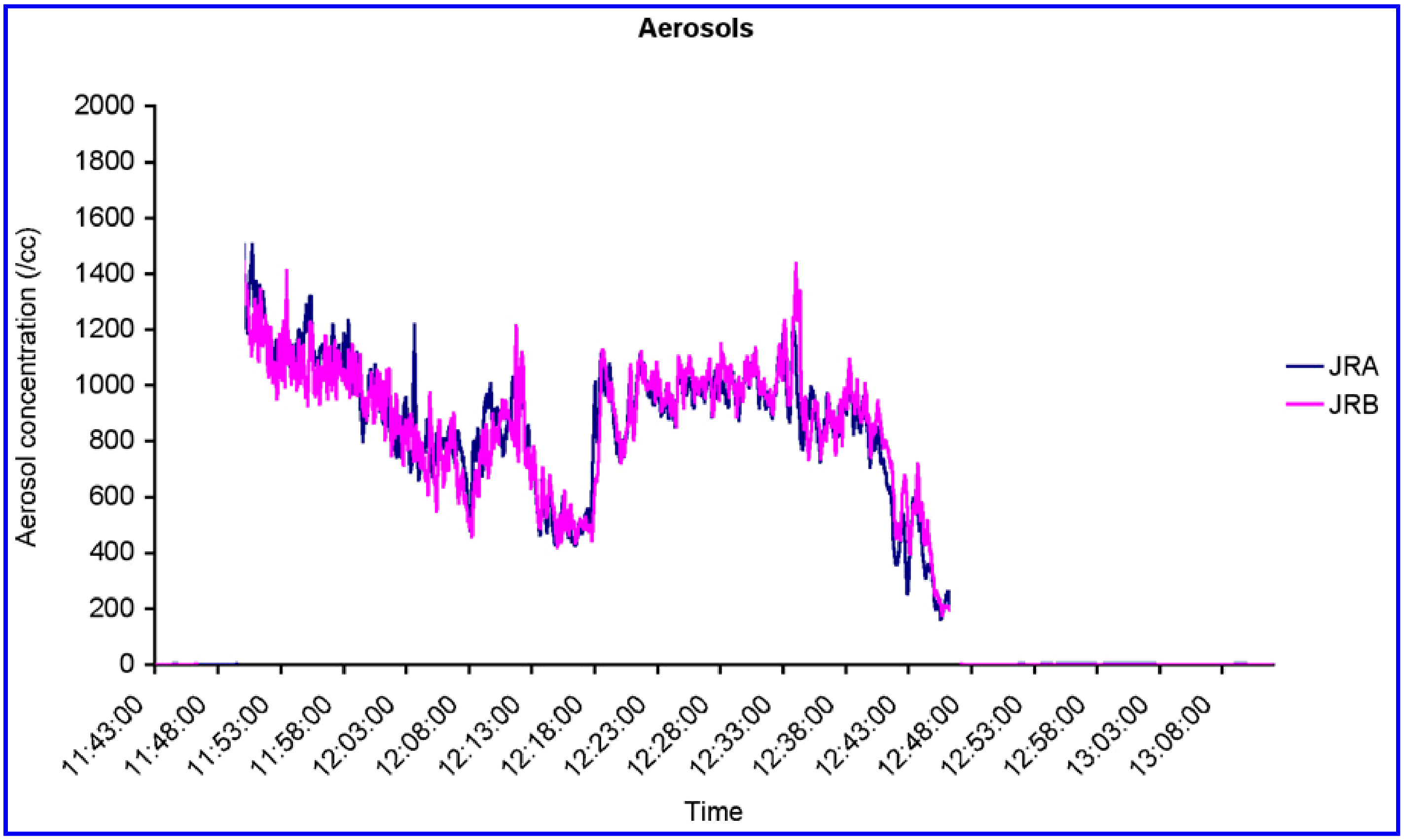
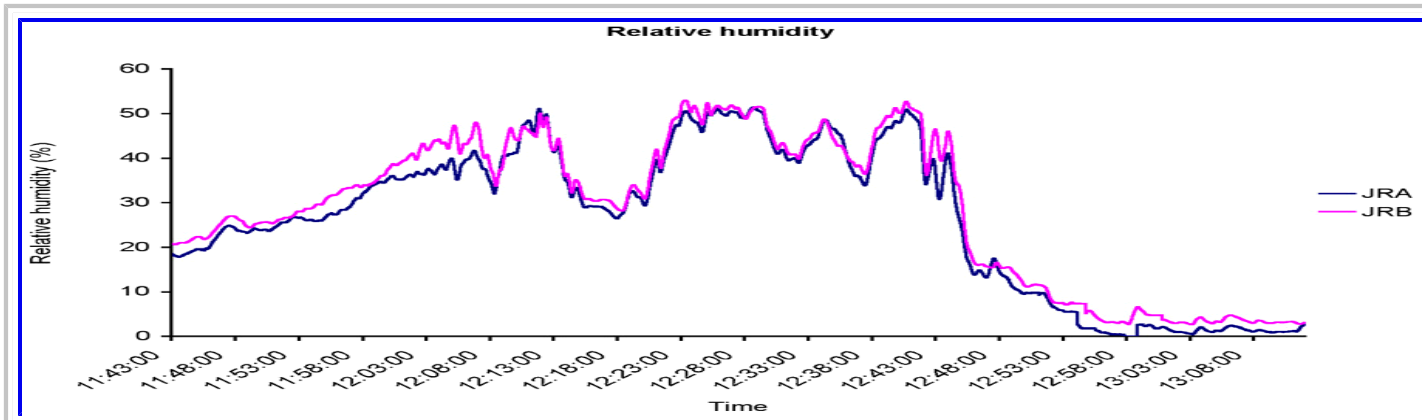



**Figure 9.** JRA/JRB intercomparison of aerosols measurements.



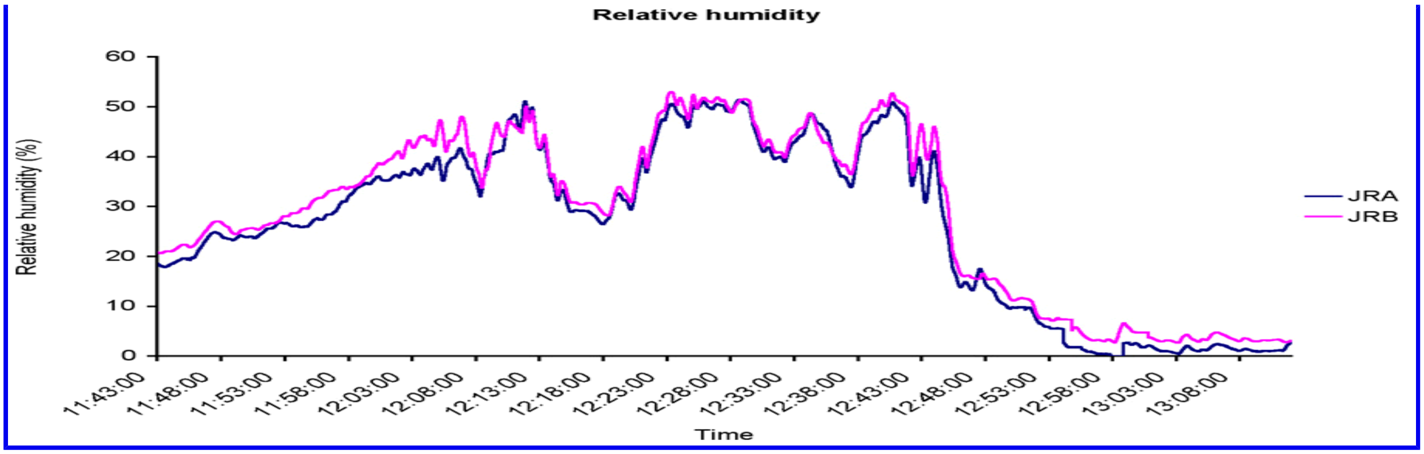



**Figure 10.** JRA/JRB intercomparison of relative humidity measurements.

## Additional Sources of Information

### References

Terblanche, D.E., M.P. Mittermaier, S.J. Piketh, R.T. Bruintjes and R.P Burger, The Aerosol Recirculation and Rainfall Experiment - ARREX: An initial study on aerosol-cloud interactions over South Africa, South African Journal of Science, 96, 15-21, 2000.

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