

The CARIBIC Database: A Comprehensive Collection of Aircraft-based Measurements of Atmospheric Trace Constituents Recommended for Chemical Tracer Model Evaluation and Comparison

A contribution to subproject GLOREAM

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Summary

GLOREAM (*GLO*bal and *RE*gional Atmospheric *MO*delling) is devoted to the development of numerical models for the investigation of processes and phenomena which determine the chemical composition of the troposphere over Europe and on a global scale. Indispensable in the context of this development is the validation of such models, a process which requires extensive use of observations.

CARIBIC (*C*ivil Aircraft for *RE*gular *I*nvestigation of the atmosphere *B*ased on an *I*nstrument *C*ontainer) is an scientific project with the aim to collect such observational data of the chemical composition of the air on long distance flight tracks all around the earth. The novel idea is to take advantage of passenger aircraft.

A package of automated instruments which is installed in an one ton capacity aircraft freight container positioned in the forward cargo bay of a Boeing 767 ER can register a vast amount of atmospheric data during regular long-distance flights. The air inlet system which is mounted on the fuselage directly below the container comprises both an aerosol inlet, a separate inlet for trace gas sampling, and an air exhaust. The current instrument package consists of a fast-response chemiluminescence sensor as well as a conventional uv absorption detector for O₃, a gas chromatograph for CO, three condensation nuclei counters for particles larger than 5, 12, and 18 nm respectively, and a 12 canister large capacity whole air sampler for laboratory tracegas analysis such as hydrocarbons, halocarbons, CO₂, CO, CH₄, SF₆ and N₂O, and isotopic composition of CO.

CERA2 (*C*limate and *E*nvironmental data *R*etrieval and *A*rchive system) is a database model that has been designed by PIK, DKRZ, and AWI with the aim to enable interchange of metadata information on geo-referenced data. It is implemented at various sites and provides permanent storage of data and metadata. Due to its semantic interface a comfortable retrieval capability of data and their associated metadata exists. The CERA database model matches the requirements for geographically distributed data storage to adapt the FGDC metadata standard in the current version of CERA2.

The analysed data records of the species mentioned above together with the relevant meteorological parameters are stored for 40 flights of the years 1997 through 2001 within this framework. Access to the database will be made available to the scientific community and is recommended for atmospheric chemistry model evaluation and comparison.

The structure of the CARIBIC-CERA2 database and representative results are subject of this presentation.

Introduction

According to the project definition of **GLOREAM** (*GLO*bal and *RE*gional Atmospheric *Modelling*) the EUROTRAC atmospheric chemistry/transport modelling efforts aim at the investigation of the processes and phenomena which determine the chemical composition of the troposphere over Europe and on a global scale including photo-oxidant formation, acidification and aerosols.

The correct behaviour of such models has to be evaluated. There is a great deal of uncertainty inherent in the complex 3-dimensional chemistry transport models, even being continuously developed, improved, and refined to better simulate the essential features of atmospheric chemistry. Difficulties range from incomplete reaction schemes through inappropriate parameterisations in basic aspects like advection and diffusion.

Measurements remain vital for validation. Of central importance for model improvement and development is thus their evaluation and validation making extensive use of observations. The collection of air samples and their laboratory analysis, make it possible to achieve very precise measurements for a host of trace gases. Up to date, however such data were only available for ground based stations, where local pollution is a problem and the data are often not representative for large parts of the atmosphere.

Scientific topics of CARIBIC

Main scientific research topics of CARIBIC are the investigation of physical and chemical links between upper troposphere and lowermost stratosphere, the quantification of the frequency, intensity, and influence of vertical transport (in particular convection processes) reaching into the upper troposphere, and the accumulation of a comprehensive data set of trace gas variations.

In this project use is made of passenger aircraft for making frequent atmospheric chemistry measurements mainly in the tropopause region. Up to now relatively few measurements were available for this important region. Three major topics which are of special interest for model development are addressed:

1. The cross-tropopause transport mechanisms: Data are going to be collected in order allow reliable estimates of how much ozone is imported from the stratosphere.
2. The chemistry in the tropopause region: A better understanding of the complex transport/chemistry system in this region is required to explain the impact of pollutants uplifted from the boundary layer, or injected in situ by the growing fleet of aircraft.
3. The atmospheric aerosol: Detailed knowledge about its abundance, size distribution, and chemical composition is required, because the atmospheric aerosol presently deserves increasing attention with respect to radiative forcing, and its role in cloud formation.

The following trace constituents are measured along different long distant flight tracks and stored in the CARIBIC database:

- In situ: O₃, CO, H₂O, CO₂^{*}, NO/NO_y^{*}, Aerosol particle concentration
- Laboratory: Aerosol soot analysis and particle chemical composition
- Laboratory analysis of 12 (30^{*}) whole air samples: CO₂, CH₄, N₂O, SF₆, COS, ~ 20 non-methane hydrocarbons (NMHC), ~ 20 halogenated components

^{*} from 2002 on

- Meteorological data along the flight tracks provided by KNMI based on ECMWF analyses.

The CARIBIC-CERA Database

The CARIBIC-CERA Database: The database at M&D (Modelle & Daten) is open for the scientific community and can be accessed through the CERA WWW-Gateway (<http://mad.dkrz.de/java/CeraStart.html>). The interface is implemented as a Java applet and allows direct interaction with the database. It includes search by key words (eg. "CARIBIC" - cf Fig. 1a - , "ozone", "aerosol", etc) as well as by experiment names. In the near future the interface will permit searches by physical quantities, time and location. The primary criterion of order is the "experiment name" which corresponds to an individual flight. The associated metadata gives information on flight track, general information including contact persons, short description and further flight specifics. Connected to an experiment are the "datasets" which represent the individual database entries. They provide information about the measuring instrument, the resolution, the quality, the person and institution in responsibility etc. Based on the metadata description of a dataset it is possible to directly download the affiliated physical data. The format is the NASA standard format for data exchange. As a first step, the original readings, as they are retrieved from the measurements, were stored within CARIBIC-CERA. These data can therefore be used as reference data later on. Next steps in relation to CERA will be the storage of processed data, eg. timeseries of single variables in combination with refined metadata.

Due to the use of CERA a secure and highly flexible mechanism of data storage and retrieval has been made possible for data within the CARIBIC project.

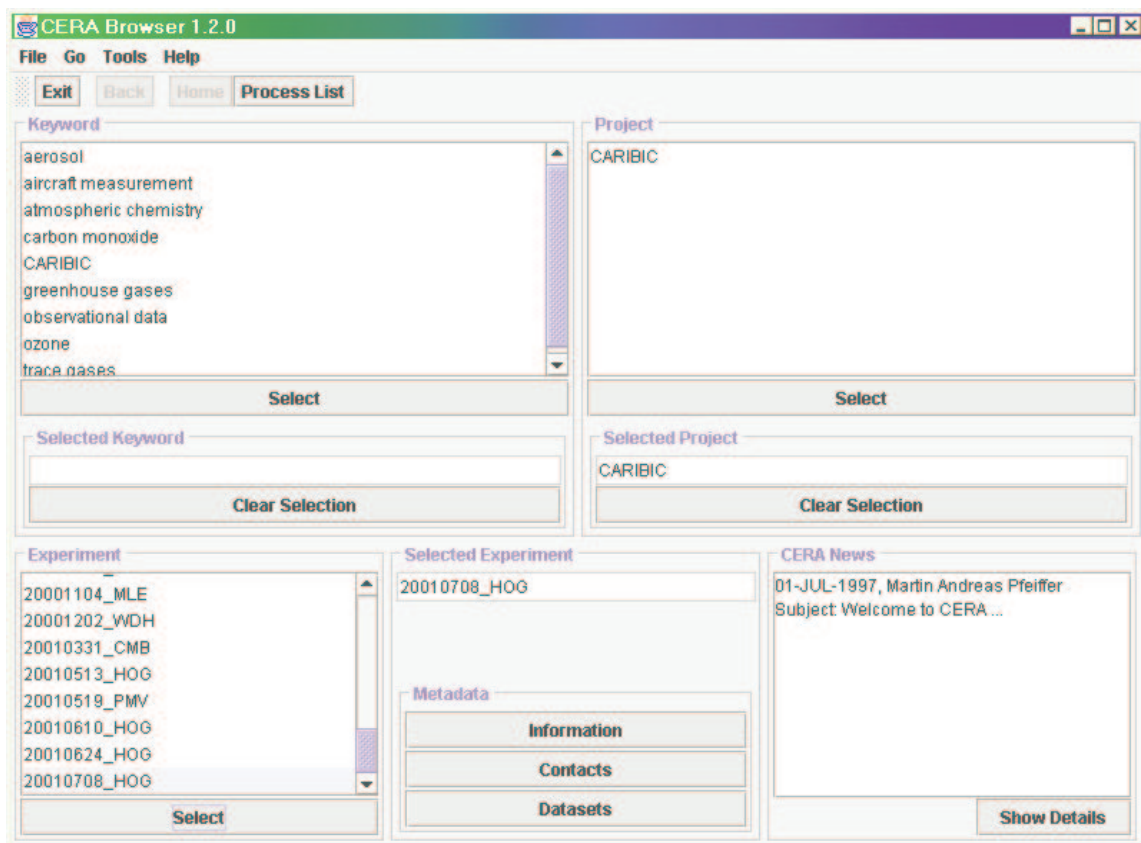


Figure 1a. The CERA gateway: Project CARIBIC, downmost flight selected.

Acronyms:

ECMWF: European Centre for Medium-Range Weather Forecasts, Reading, UK
KNMI: Het Koninklijk Nederlands Meteorologisch Instituut, The Netherlands
DKRZ: Deutsches Klimarechenzentrum, Hamburg, Germany
AWI: Das Alfred-Wegener-Institut, Bremerhaven, Germany
PIK: Das Potsdam-Institut für Klimafolgenforschung, Germany
FGDC: Federal Geographic Data Committee, Reston, VA USA

Information for Experiment 20010708_HOG

File Go Tools Help

Exit Back Home Process List

General Project Quality

Experiment Name
20010708_HOG

Description
FLIGHT_DUS_HOG_20010708

Creation Date
26-NOV-2001

Review Date
26-NOV-2001

Future Review Date
26-NOV-2011

Purpose
Not yet specified in CERA2

Summary

CARIBIC stands for Civil Aircraft for Regular Investigation of the Atmosphere Based on an Instrumentation Container. In CARIBIC, an automated air chemistry measurement container (2.4m x 1.6m x 1.5m, gross weight ~1100kg) is deployed in the forward cargo bay of a Boeing 767-ER of LTU International Airways (Duesseldorf, Germany). Long-distance measurement flights are made from Germany to the Indian Ocean, southern Africa, and the Carribean. The inlet system is mounted directly underneath the container, ~10m from the bow of the aircraft. The instrumentation (~800kg) comprises two O3 monitors (a fast 10Hz chemiluminescence sensor calibrated against a conventional u.v. absorption monitor), a gas chromatograph for CO, three condensation particle counters (CPC), a 14 sample aerosol impactor for elemental/chemical analysis, and a 12 canister air sampler for laboratory analysis of CO2, CH4, CO, N2O, SF6, ~40 halocarbons, ~15 hydrocarbons and the isotope composition (13C/12C, 14C/12C, and 18O/16O of CO and CO2).

Figure 1b. Information frame on Flight Düsseldorf – Honguin (Cuba).

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