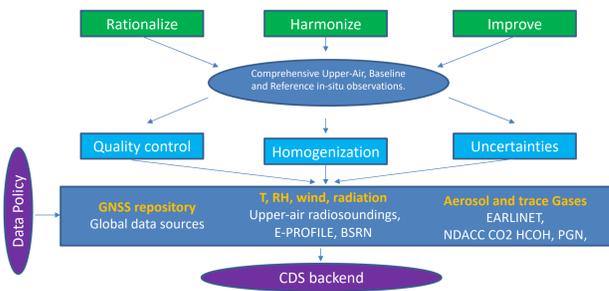


# C3S2 311 Lot2 - Comprehensive Upper-Air, Baseline and Reference in situ observations

## The concept and main objectives

Copernicus is the Earth observation component of the European Union's space programme. The European Centre for Medium-Range Weather Forecasts (ECMWF) has been appointed by the European Commission with funding from the EU to operate the Copernicus Atmosphere Monitoring Service and the Copernicus Climate Change Service on its behalf. Institute of Methodologies for Environmental Analysis (IMAA) of the National Research Council (CNR) has been contracted by ECMWF to implement the C3S2 311 Lot2 "Comprehensive Upper-Air, Baseline and Reference in situ observations", which valorises the effort spent in Cop1 within the C3S 311a Lot3 ("Access to observations from baseline and reference networks") and C3S 311c Lot2 ("Historic In Situ Upper Air Database") contracts.



The contract started on 1<sup>st</sup> September 2021 and has a duration on 48 months.

**Lead Contractor:** Institute of Methodologies for Environmental Analysis, National Research Council



- Update and extend the access to Reference and Baseline in situ datasets offered in Cop1 (GRUAN, IGRA, NDACC, TCCON, SHADOZ, WOUDC, USCRN, IGS, Eubrewnet) for several ECVs
- Expand the number of ECVs and in situ datasets in the CDS
- Harmonize the upper-air temperature, humidity, wind and ozone datasets provided in Cop1 from multiple sources and generate new added value datasets also in support of the future ERA6 reanalysis
- Establish a repository for GNSS-Precipitable Water observations
- Extend the governance structure and operating rules defined in Cop1 to the new datasets proposed to the CDS and adopt a unified data license for the GNSS data
- Improve the current database structure for CDS in situ datasets and implement the CDS back-end for new datasets
- Promote the adoption of the Copernicus license for the in situ datasets and actively contribute to the C3S outreach activities.

## Datasets provided in COP1 to the CDS (updating on August, 2023)

<https://cds-test.climate.copernicus.eu/#!/home>

- Datasets published**
- GRUAN** → **Global Climate Observing System (GCOS) Reference Upper-Air Network**  
In situ temperature, relative humidity and wind profiles (since 2006, 17 stations)  
CDS page: <https://cds.climate.copernicus.eu/cdsapp#/dataset/insitu-observations-gruan-reference-network>
  - IGRA & RHARM** → **Integrated Global Radiosounding Archive (IGRA) and the Radiosounding Harmonization (RHARM)**  
Vertical profiles of temperature, relative humidity and wind (since 1978, 700 stations)  
CDS page: <https://cds.climate.copernicus.eu/cdsapp#/dataset/insitu-observations-igra-baseline-network>
  - WOUDC** → **World Ozone and UV radiation Data Center (WOUDC)**  
Total column ozone (TCO) and ozone profiles (since 1924, 233 stations for TCO and 150 stations from ozonesonde instrument)  
CDS page: <https://cds.climate.copernicus.eu/cdsapp#/dataset/insitu-observations-woudc-ozone-total-column-and-profiles>
  - GNSS-IGS** → **Global Navigation Satellite System (GNSS) - International GNSS Service (IGS)**  
Zenith Tropospheric Delay (ZTD) and Integrated Precipitable Water (IPW) from IGS network and the EPN-REPRO2 datasets (since 2000, 681 stations)  
CDS page: <https://cds.climate.copernicus.eu/cdsapp#/dataset/insitu-observations-gnss?tab=overview>

## Datasets submitted and under implementation

- SHADOZ** → **Southern Hemisphere Additional Ozonesondes (SHADOZ)**  
Ozone in situ observations (since 1988, 15 stations)
- USCRN** → **NOAA's U.S. Climate Reference Network (USCRN)**  
Near-Surface Temperature (NST) (139 stations since 2006)
- NDACC** → **Network for the Detection of Atmospheric Composition Change (NDACC)**  
O<sub>3</sub>, CH<sub>4</sub>, CO vertical profiles and column content (since 1963, 54 stations)
- ICOS** → **Integrated Carbon Observation System (ICOS)**  
CO, CO<sub>2</sub> and CH<sub>4</sub> (>140 stations since 2015)
- CUON** → **Comprehensive Upper-air Observation Networks (CUON)**  
Digitized in-situ upper-air weather observations (prior to 1979, and homogenized datasets after 1979)
- TCCON** → **Total Carbon Column Observing Network (TCCON)**  
Total column concentrations of CO<sub>2</sub> and CH<sub>4</sub> (since 2007, 4 stations)
- EuBrewNet** → **European Brewer Network (Eubrewnet)**  
O<sub>3</sub> column content (since 1998, 44 stations)
- EARLINET** → **European Aerosol Research lidar network (EARLINET)**  
Aerosol optical properties along with estimation of uncertainties at Level 3 (31 stations)

## Recent addition to the CDS in situ catalogue

- BSRN** (Baseline Surface Radiation Network) for surface radiation budget.

BSRN was established in 1992 by the World Climate Research Programme (WCRP), under the auspices of the World Meteorological Organization (WMO). BSRN is a project of the Data and Analysis Panel from the Global Energy and Water Exchange (GEWEX). It aims at detecting important changes in the Earth's radiation field at the Earth's surface which may be related to climate changes. As on June 2023, BSRN has in total 76 stations (out of which, 51 are active, 9 are declared as inactive and 16 are closed) in varied climatic zones, across seven continents as well as island-based stations in the Pacific, Atlantic, Indian and Arctic Oceans, between 80°N to 90°S (Fig.1).



Fig. 1 Locations of BSRN stations across the globe

These stations measure solar and atmospheric radiation at a higher temporal resolution (1 to 3 minutes) using state-of-art instruments. BSRN data are quality checked and additionally verified by C3S to minimize the impact of residual outliers as well as to select only 100% complete time series for the aggregation at hourly, daily and monthly time scales.

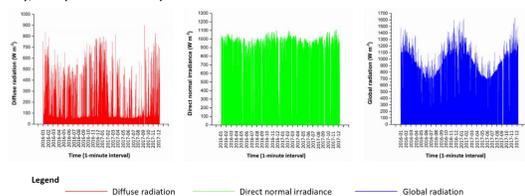


Fig. 2 Time-series of BSRN (1-minute interval) measurement of diffuse radiation, direct normal irradiance and global radiation at Alice Springs (ASP) station, Northern Territory, Australia (-23.7980, 133.8880)

- PGN** (Pandonia Global Network) for NO<sub>2</sub>, O<sub>3</sub>, SO<sub>2</sub> and HCHO

The PGN provides real-time, standardized, calibrated and verified air quality data and associated uncertainty values measured world-wide at 137 stations (Figure 3). PGN also seeks to coordinate and implement network standards regarding common algorithms and data processing, instrument operating routines, quality control, real-time data processing and data archiving.



Fig.3 Global distribution of the PGN stations

The PGN dataset offered to the CDS includes time series of ozone (O<sub>3</sub>), nitrogen dioxide (NO<sub>2</sub>), sulfate dioxide (SO<sub>2</sub>), and formaldehyde (HCHO).

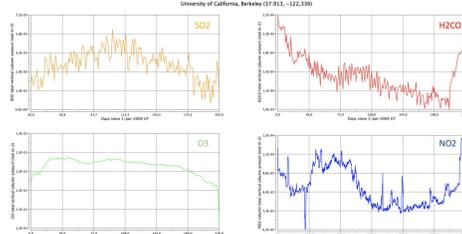


Fig.4 Example of time series of sulfur dioxide, formaldehyde, ozone, and nitrogen dioxide retrieved from the measurements collected at the University of California, Berkeley

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Website: <https://climate.copernicus.eu/access-observations-baseline-and-reference-networks>

**Acknowledgment**  
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- Two Unified ozone datasets for ozone ozonesounding and total column ozone.**

The "Unified ozone datasets" have been created through the harmonization of quality-controlled ozone partial pressure profiles from SHADOZ (The Southern Hemisphere Additional Ozonesondes), NDACC (Network for the Detection of Atmospheric Composition Change) and WOUDC (World Ozone and Ultraviolet Radiation Data Center) datasets, and of total column ozone data from EUBREWNET (European Brewer Network), NDACC and WOUDC.

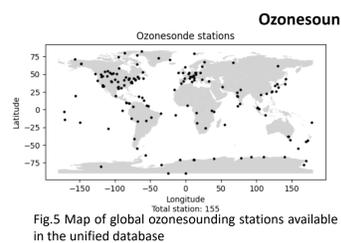
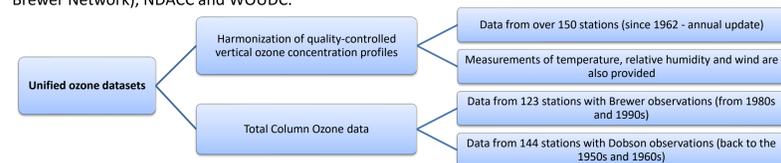


Fig.5 Map of global ozonesounding stations available in the unified database

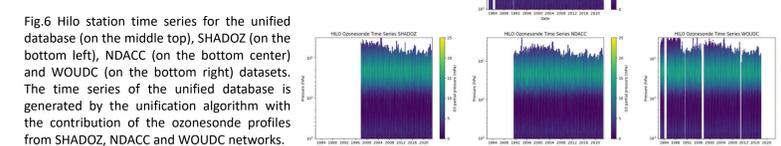


Fig.6 Hilo station time series for the unified database (on the middle top), SHADOZ (on the bottom left), NDACC (on the bottom center) and WOUDC (on the bottom right) datasets. The time series of the unified database is generated by the unification algorithm with the contribution of the ozonesonde profiles from SHADOZ, NDACC and WOUDC networks.

**Total Column Ozone**  
The total column ozone (TCO) unified datasets is the result of the harmonization of Brewer and Dobson data available from the NDACC, WOUDC and EUBREWNET databases.

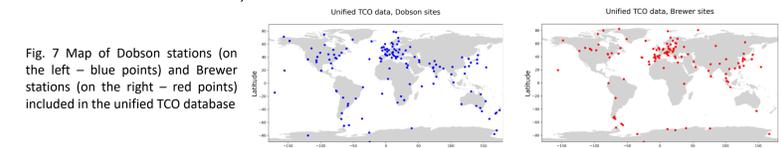


Fig. 7 Map of Dobson stations (on the left - blue points) and Brewer stations (on the right - red points) included in the unified TCO database

## Upcoming CDS in situ datasets

- GNSS** (Global Navigation Satellite System) for the repository of Precipitable Water products, starting from what is already available in the CDS
- NDACC** (Network for the Detection of Atmospheric Composition Change) for formaldehyde (HCHO) and NO<sub>2</sub> along with estimation of uncertainties.
- E-PROFILE**, the EUMETNET network of wind radar, providing continuous wind profile observations.