

FRANCE

Ozone and UV radiation research in France is primarily managed by the CNRS – Institut National des Sciences de l'Univers (INSU) under a dedicated Programme National de Chimie de l'Atmosphère (PNCA), while the space component is managed by the Centre National d'Etudes Spatiales (CNES). Additional contributions are provided by the Institut Polaire (IFRTP), Météo-France, the Ministère of Environnement, the Ministère de la Recherche, the Institut National de Recherche Agronomique (INRA) and a number of Universities. Ozone research is also largely supported by the Direction Générale Recherche of the European Commission under the 5th Environmental Programme.

The research include the long term monitoring of the stratosphere and UV-B at a variety of ground-based stations and the study of ozone depletion mechanisms from space borne instruments, balloons and aircraft field campaigns, most of them in cooperation with other European and international institutes.

1. Ground-based Ozone and UVB Monitoring

France is running two primary stations of the international Network for Detection of Stratospheric Change (NDSC) at the Observatoire de Haute Provence (OHP) and the Antarctic station of Dumont d'Urville (DDU), a complementary site at Reunion Island in the Indian Ocean and a number of instruments at other international locations in cooperation with local institutes: Alomar in Norway and the SAOZ UV-Vis spectrometers network associated to NDSC at Scoresbysund (Greenland), Sodankyla (Finland), Salekhard and Zhigansk (Federation of Russia), Bauru (Brazil), Tarawa (Republic of Kiribati) and Kerguelen Island.

The list of instruments at OHP includes a series of lidar for stratospheric temperature, aerosol, wind and ozone, and tropospheric ozone and water vapour, a SAOZ UV-Vis spectrometer, a BrO UV spectrometer of IASB-BIRA in Belgium, an automated Dobson from NOAA, weekly ozonesondes and a spectral UV-B monitor at the nearby Alpine station of Briancon. Additional Dobson measurements are conducted at Bordeaux. The micro-wave CIO measurements at Plateau de Bure have been closed in 1999 after the reduction of activity of the station after an accident.

In Antarctica, the instruments run since 1988 are a PSC / aerosol lidar in cooperation with the Italian CNR, a SAOZ, a UV-B monitor and ozonesondes at Dumont d'Urville. The ozone lidar has been closed in 2001 but the measurements should resume in 2004. An additional SAOZ is in operation since 1995 at the sub-Antarctic Island of Kerguelen. The installation of a SAOZ and a microwave radiometer is anticipated at the inland French-Italian station of Concordia expected to run year round after February 2004.

At the tropical site of Reunion Island, the instruments permanently running are a temperature / aerosol lidar, a stratospheric and a tropospheric ozone lidars, a SAOZ and weekly ozone sondes. A high altitude station is under construction at Maïdo at 2500 m asl for hosting all previous instruments after 2003 together with a FTIR operated by the Belgium IASB-BIRA, as well as a microwave radiometer for ozone and water vapour.

France is also responsible for the temperature lidar measurements at the Norwegian-German lidar station of ALOMAR in Norway.

While part of the data (SAOZ ozone / NO₂ and ozonesondes) are made available in near real time to WMO and to the European data base at the Norwegian Institute for Air Research (NILU) for research programmes and satellite validation, all are made available to the international community after reprocessing through the NDSC archive center.

2. Satellites

Relevant to stratospheric ozone research, a variety of space activities have been carried out in France under the auspices of CNES:

- the scientific exploitation of the data of the Polar Ozone and Aerosol Monitoring (POAM) instruments of the Naval Research Laboratory in the United States placed on board the French CNES satellites (POAM II on SPOT III in 1994 and POAM III on SPOT IV in 1998), from which ozone destruction rates in the Arctic have been derived;
- a contribution to the exploitation of the measurements of the Japanese NASDA ILAS instrument flown on ADEOS in 1997;
- the starting analysis of the measurements of the SMR instrument (ozone, water vapour and ClO) on board the Swedish-Finnish-Canada-French ODIN satellite placed in orbit in 2001;
- the preparation of the data processing of the French proposed GOMOS instrument on board the ESA ENVISAT satellite in orbit since early March 2002, and more generally the contribution of a number of French scientists to the preparation of the two other stratospheric chemistry instruments MIPAS and SCIAMACHY; and,
- a strong involvement in the validation of the measurements of POAM, GOME-ERS-2, ILAS and ODIN from ground based and dedicated balloon flights measurements in the Arctic and at Mid-latitude.

Now planned in 2002-2003 for the validation of ENVISAT, the US SAGE III-METEOR and the Japanese ILAS-ADEOS II, are several balloon campaigns in France, Sweden and Brazil.

Finally, Météo-France is contributing to the preparation of EUMETSAT's Ozone Monitoring Satellite Application Facilities hosted by the Finnish Meteorological Institute. This facility will deliver ozone and minor constituents products derived from the GOME-2 and HIRS instruments on board METOP, the European meteorological polar platform to be launched in 2005. The derivation of ozone columns in the lower stratosphere from METEOSAT Second Generation and for METOP/HIRS is the specific contribution of Météo-France.

3. Aircraft

Two research aircraft operated by INSU have been used for stratospheric investigations: the ARAT Fokker aircraft carrying the LEANDRE lidar for studying Polar Stratospheric Clouds in the Arctic and a Mystère 20 equipped with the ALTO ozone lidar for studying horizontal transport across the vortex edge as well as the sub-tropical barrier. Both aircraft are to be replaced in 2003 by an ATR 42 and a newer Mystere 20 respectively.

France is also running since 1994 and in cooperation with other European institutes, the MOZAIC programme of in situ ozone, water vapour and NO_y (in 2002) measurements on in-service commercial aircraft, from which tropospheric ozone climatology are derived at a number of airport worldwide. <http://www.aero.obs-mip.fr/mosaic/access.html>

4. Balloons

The French contribution to balloon activities is twofold: CNES balloon manufacturing and operations in France, Sweden and Brazil for a number of European and international scientists, and development of scientific instruments designed for ozone related research at French laboratories.

The balloons used during the past several years include large open stratospheric balloons carrying heavy (500-600 kg) payloads for few hours (20 flights/year), small flexible and cheaper balloons which could be flown more frequently particularly in the Arctic in the winter for studying fast chemical changes (20 flights/year) and long duration balloons of two types: Infra-Red Montgolfier carrying 60 kg at 25 km flown for few weeks in the Arctic or in the tropics, and constant level super-pressure balloons carrying 20 kg at 19 km for few weeks.

Stratospheric chemistry instruments developed in France include:

- a large FTIR (LPMA) for measuring profiles of long lived, reservoir and radical species;
- a tuneable diode laser system (SPIRALE) for the in-situ measurement of NO_x and NO_y species;
- a star occultation UV-Visible spectrometer (AMON) for the night-time measurement of O₃, NO₂, NO₃ and OCIO; and several light weight instruments flown more frequently on small balloons together with other European instruments at a variety of sites:
- the SAOZ UV-visible spectrometer for O₃, NO₂, BrO and OCIO by solar occultation;
- its SALOMON moon occultation version;
- the SDLA diode laser for in-situ CH₄, CO₂ and water vapour; and,
- the Rumba meteorological payload for long duration balloons.

5. Scientific programmes

Asides from the NDSC long-term involvement, most of activities are carried out under cooperative programmes supported by the European Commission in conjunction with ESA and European national agencies:

- the THESEO European Ozone Arctic campaigns in 1998 and 1999 and the follow-up Europeo-American THESEO-SOLVE during the winter of 2000 during which all above aircraft and balloon experiments have been flown several times for studying NO_x, chlorine and bromine chemistry, polar stratospheric clouds and denitrification of the vortex, meteorology and finally ozone loss, and,
- balloon flights for the validation of ILAS in 1997, POAM in 1999 and 2000, and ODIN in 2001.

Planned in the near future are:

- a European VINTERSOL campaign in the Arctic during the winter of 2002/2003 for the validation of ENVISAT, SAGE III and ILAS II as well as ozone depletion scientific objectives;
- short and long duration circumnavigation balloon flights at the tropics within a new HIBISCUS European project for investigating the impact of deep convection on the stratosphere in 2002 and 2004;
- a VORCORE long duration constant level balloon project for studying the dynamics of Antarctic vortex in 2003.

6. Data interpretation, exchange and archival

Though the data are analysed through many cross-exchanges with international scientists and particularly Europeans within cooperative projects, France institutes have developed a full set of models ranging from Lagrangian, 3-D chemical transport (CTM), contour advection, meso-scale and assimilation models. While the experimental data as well the results of modelling relevant to European projects are archived into the NILU data base available through an appropriate protocol, all French space and field data relevant to the stratosphere are archived into a newly built national data base ETHER.
