Network for the Detection of Stratospheric Change

June 1992

Cover Photo: Lidar operating at Observatoire de Haute Provence (44 °N, 6 °E), NDSC Alpine Station. Courtesy of G. Mégie (Service d'Aeronomie, CNRS, France).

Summary

The Network for the Detection of Stratospheric Change (NDSC) is a set of high-quality, remote-sounding research stations for observing and understanding the physical and chemical state of the stratosphere. These stations, where ozone and key ozone-related parameters are measured, are complemented by both secondary stations and satellite measurements. Currently, over 65 scientists from 15 countries are involved with NDSC. The NDSC is a major component of the international upper atmosphere research effort and has been endorsed by national and international scientific agencies, including the International Ozone Commission, the United Nations Environment Programme (UNEP), and the World Meteorological Organization (WMO).

Scientific developments since the inception of the NDSC in 1986, in particular the growth of the ozone hole over Antarctica and evidence for world-wide ozone depletion, have all served to emphasize the importance of a high-quality, long-term monitoring network. Through the NDSC, a sound foundation has been laid for monitoring the state of the stratosphere at a time when significant changes due to human activities are becoming apparent. The NDSC complements other existing measurement efforts including the ground-based networks for monitoring ozone and long-lived gases such as chlorofluorocarbons and satellite measurement activities.

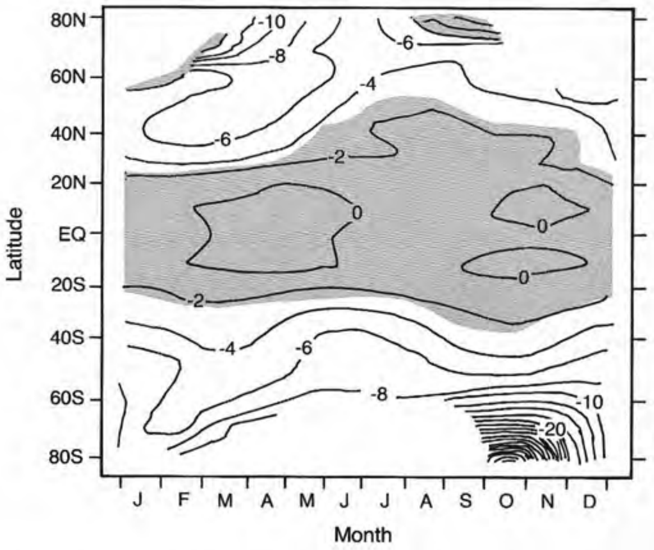
Following five years of planning, instrument design and implementation, the NDSC began network operations in January 1991. New scientific initiatives will add value to the data already being collected. This brochure summarizes the current status of the NDSC in order to introduce it to a wider audience.

Goals of the Network

- To make observations through which changes in the physical and chemical state of the stratosphere can be determined and understood. In particular, to make the earliest possible identification of changes in the ozone layer and to discern the cause of the changes.

- To provide an independent calibration of satellite sensors of the atmosphere.

- To obtain data that can be used to test and improve multidimensional stratospheric chemical and dynamical models, thereby enhancing confidence in the predictive and assessment capabilities of these models.

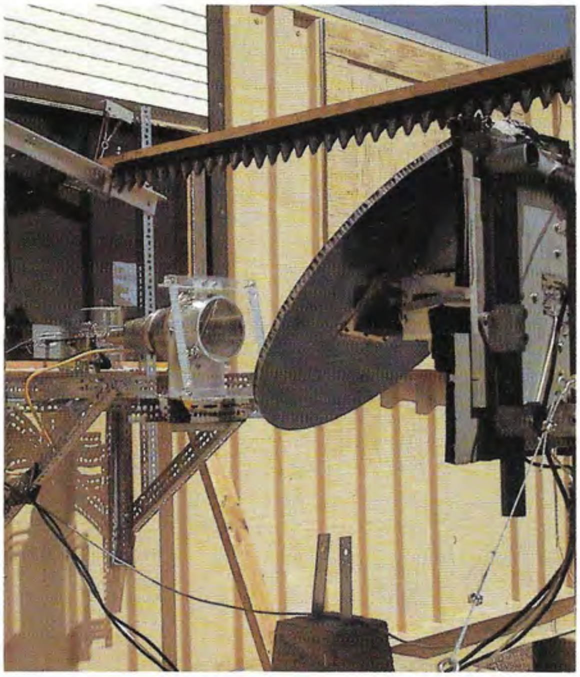


Trend in percent per decade obtained from TOMS total ozone data as a function of latitude and season. Data extend from November 1978 through March 1991. Unshaded area indicates where trends are statistically significant at the 2-sigma level. Adapted from R. Stolarski et al., Science, vol. 256, p. 342, April 1992.

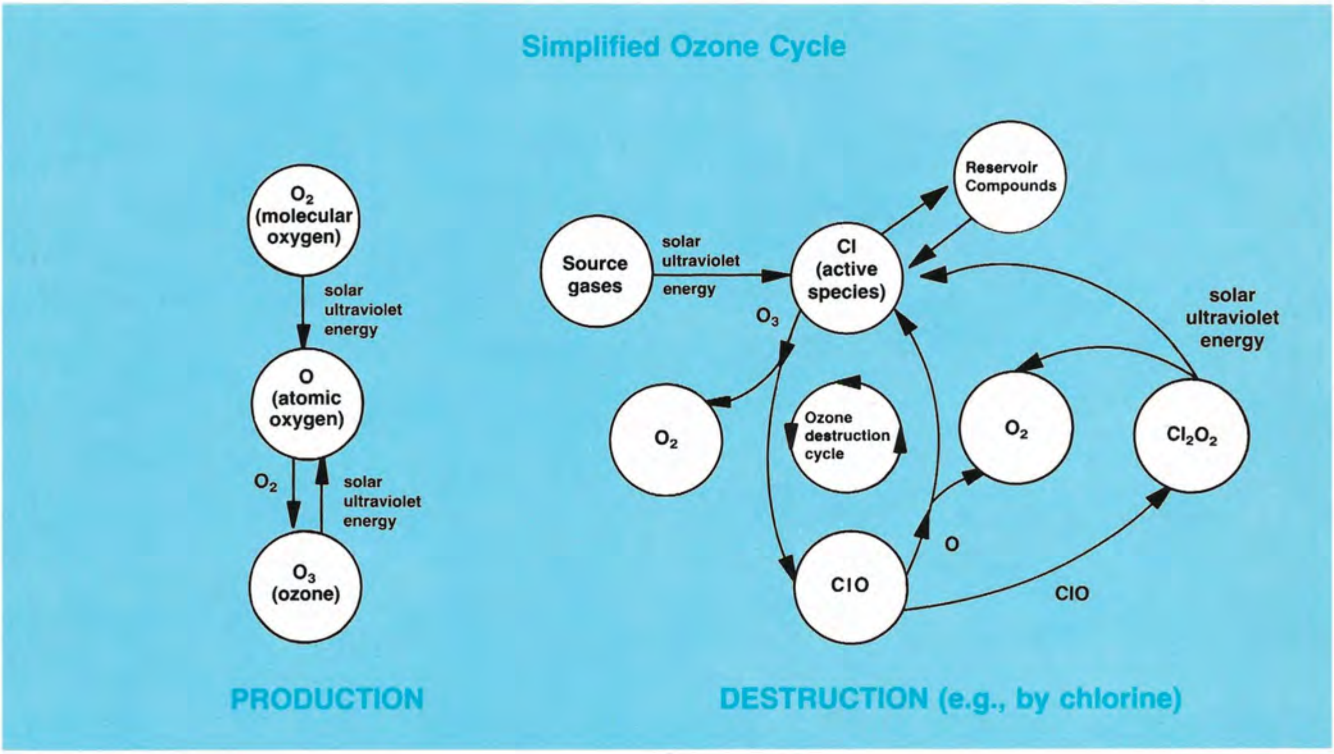
The main focus is to make global measurements in the altitude region from the tropopause to about 50 km. The following measurements have been identified as being of the highest priority to the NDSC:

- Column ozone
- Vertical profile of ozone (0-70 km)
- Temperature (0-70 km)
- Vertical profile of ClO
- Vertical profile of H_2O
- Vertical distribution of aerosols
- Vertical profile or column of NO_2
- Stratospheric column of HCl
- Vertical profiles of long-lived tracers: CH_4 and N_2O
- Other species (HNO_3, $ClONO_2$, and OH)

These priorities are based on the assumption that existing and planned satellite measurement activities will continue, as will the ground-level monitoring of ozone and long-lived gases by existing networks.



Stratospheric water vapor microwave radiometer at Table Mountain Observatory (34 °N, 118 °W). Photo courtesy of I.S. McDermid (JPL, USA).



Instruments

Instruments were selected on the basis of being remote sensors, capable of continuous, long-term field operation, potentially in remote locations. Depending on specific site characteristics such as geography, meteorology, and complementary existing programs, each of the primary NDSC stations will be equipped with most or all of the set of instruments listed below, in order to make the following measurements:

Species	Altitude Range	Instrument
O_3 column	total column	Dobson, Brewer, UV/visible spectrometers
O_3 profile	0-20 km 15-45 km 25-75 km	YAG lidar excimer lidar microwave
Temperature	0-45 km	lidar
ClO	25-45 km	microwave
H_2O	0-30 km > 20 km	balloon hygrometer microwave
aerosols	0-30 km	lidar
NO_2	stratospheric column	UV/visible spectrometer
HCl	stratospheric column	Fourier transform infrared spectrometer (FTIR)
CH_4	stratospheric column	FTIR
N_2O	20-50 km	microwave, FTIR
HNO_3	stratospheric column	FTIR
$ClONO_2$	stratospheric column	FTIR
OH	40-60 km	UV fluorescence excimer lidar
HO_2	30-60 km	microwave

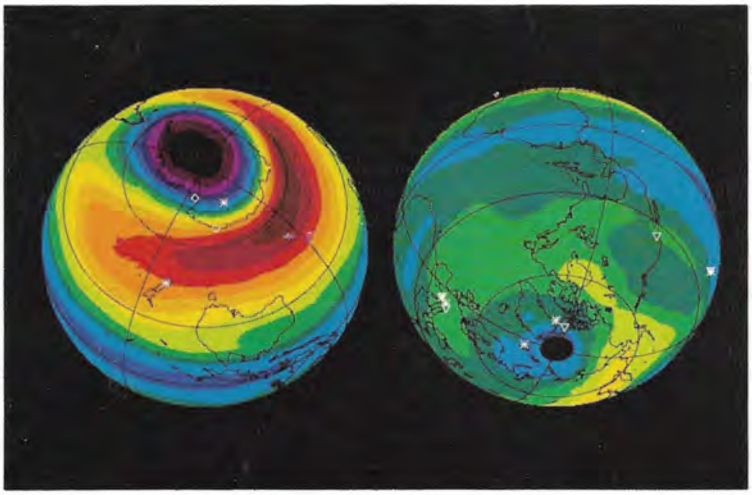
Since the beginning of the planning for NDSC in 1986, technical advances have been made in instrument development. Most of the instruments listed above are currently being used in routine observing mode or have at least been used in a research mode for the particular species, but need more work in order to become network operational.

Station Considerations

For nearly all of the instruments, it is desirable to locate the monitoring station at high elevation (> 2000 meters) in order to minimize the tropospheric water and aerosol columns. The goal of understanding the cause of changes, rather than merely detecting them, requires that the instruments be co-located to an extent consistent with the temporal and spatial requirements of the measurements and the realities of site availability. Where it is not feasible to co-locate all the instruments on the same site, a composite station may be formed with individual instruments or groups of instruments at different sites.

Network Deployment

Since the purpose of this network is to provide early identification of stratospheric change, it is prudent to locate the stations with as much latitude coverage as possible, given the obvious constraints of funds and resources. Therefore a representative network would consist of at least five stations: mid-latitude and polar in both hemispheres, as well as a tropical station. Further value is obtained when the stations are actually a composite of sites within a given latitudinal zone.



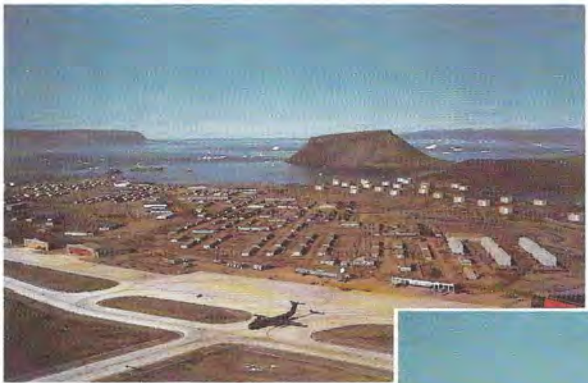
Global maps showing primary and secondary stations. Figure provided by P. Newman (NASA, USA).

Primary Stations

Five primary stations have been selected, some of which are composite sites:

1. Arctic station: Eureka (80 °N, 86 °W), Thule (76 °N, 69 °W), Ny Ålesund (78.5 °N, 12 °E).
2. Alpine station: Observatoire de Haute Provence (44 °N, 6 °E), Jungfraujoch (46 °N, 7 °E), Plateau de Bure (44 °N, 6 °E).
3. Mauna Loa and Mauna Kea (20 °N, 155 °W)
4. Lauder, New Zealand (45 °S, 170 °E)
5. Antarctic station: Dome C (74.5 °S, 124 °E), beginning in 1995. Interim sites at McMurdo (77.8 °S, 166 °E) and Dumont D'Urville (67 °S, 140 °E).

In addition, Table Mountain Observatory (34 °N, 118 °W) acts as an intercomparison and test research site for many of the primary instruments, and French agencies have started to fund activities at the Ile de la Réunion (23 °S). Sites for the tropical station are still under evaluation.



Thule Site (76 °N, 69 °W), courtesy of T. Jorgenson (Danish Meteorological Institute).

Jungfraujoch Site (46 °N, 7 °E), courtesy of R.A. Cox (NERC, UK).

McMurdo Site (77.8 °S, 166 °E), courtesy of S. Solomon (NOAA, USA).

Operations

Lidar operating at McMurdo (77.8 °S, 166 °E). Photo courtesy of S. Solomon (NOAA, USA).

Full implementation of the NDSC requires international collaboration both scientifically and managerially, with numerous national co-sponsors, complemented by WMO and UNEP monitoring activities. Each of the primary stations will be equipped with most of the primary instruments listed previously. In addition, other measurements, designated secondary, may be made at these primary stations using ancillary measurement capabilities. Important scientific information may also be collected at other (secondary) stations with partial instrument complements. In this way, new scientific initiatives can be incorporated, adding value to the data already being collected.

It is essential that the design phase for the network involves experimentalists, theorists, data analysts, and statisticians to address issues of measurement frequency, accuracy, and precision. Quality control must be achieved through rigorous calibration procedures and intercomparisons. This is a difficult undertaking, especially where multiple sites are involved. However, the success of the Global Atmospheric Gases Experiment network in monitoring long-lived gases demonstrates that this can be achieved. A firm commitment to data quality will be essential to achieving the goals of the network. Furthermore, the funding organizations and agencies must recognize that the project requires long-term investment.

Scientists using the high resolution FTIR instrument at the Lauder station (45 °S, 170 °E). Photo courtesy of A. Matthews (DSIR, NZ).

Organization

The organization of the NDSC consists of a Steering Committee and a Science Team. The Science Team consists of all the Principal Investigators (PIs) associated with each of the instrument types at each primary NDSC site. The Steering Committee consists of a chair and vice-chair (Dr. M. Kurylo, NASA, USA, and Dr. R. A. Cox, NERC, UK, respectively), a representative sub-group of the PIs, independent scientists who act as peer reviewers, and ex-officio members from the NDSC funding agencies.

As the primary managerial body for the NDSC, the Steering Committee has responsibility for activities such as internal operational oversight, scientific oversight, and recommending implementation and funding actions.

Lauder Site (45 °S, 170 °E), courtesy of A. Matthews (DSIR, NZ).

Mauna Loa Site (20 °N, 155 °W), courtesy of G. Mount (NOAA, USA).

Data Archiving and Data Protocol

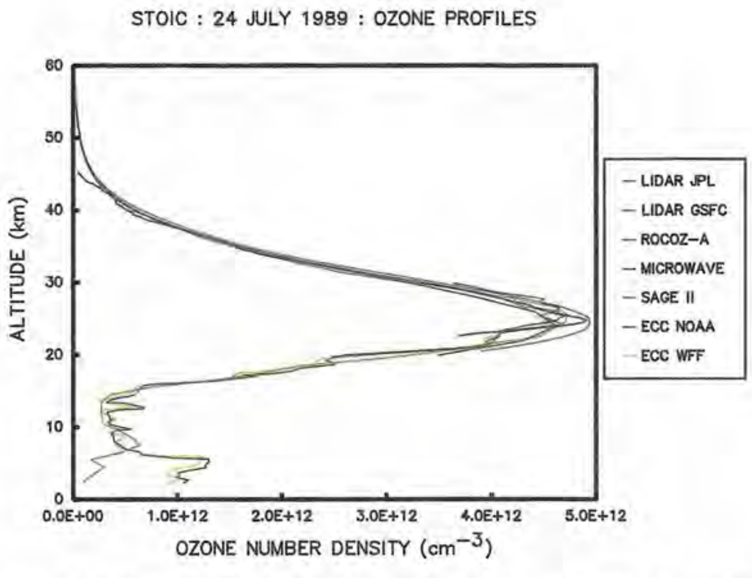
The network's data lie at the heart of its contribution to understanding stratospheric change. The nature of long-term trends measurement requires these data to be fully verified before they can be used for comparison with models or to deduce trends. It is the spirit and purpose of the NDSC to foster the broadest possible collaboration among all interested scientists as quickly as possible. However, as with any good research, the PIs bear the ultimate responsibility for data quality. In order to achieve a verifiable data set, sufficient time is needed to collect, reduce, test, analyze, and intercompare the anticipated streams of continuous preliminary data from each of as many as five sites. The NDSC data protocol is aimed at achieving the dual goals of excellent data quality and ready data access. The main features are:

- Any NDSC PI may establish the scientific collaborations necessary for the optimum testing and verification of their own measurements.
- All PIs shall place their preliminary analyses of measurements in the NDSC archive as rapidly as possible and no later than one year after measurement.
- Given the nature of small trends detection, it is recognized that multiple seasonal analyses may be required. It is expected that such a procedure will yield the verifiable product referred to as "NDSC data" within a two-year period after acquisition.
- After the above verification, NDSC data will be available to anyone through a centralized scientific archiving and distribution facility and will be accessible by electronic transfer.

Results

Complementary interfaces with other measurement programs are being developed. One of the foremost of these will be with the Upper Atmosphere Research Satellite which was launched in September 1991. In the future, it will be possible to compare global data plots derived from satellite-borne instruments to the local measurements from the NDSC.

A closely coupled effort in theory, modeling, and statistical analysis is necessary for interpreting the measurements. This is facilitated by having theorists associated with experimentalists for each of the instrument types and/or sites. Participation of the international science community in the NDSC through complementary measurements, theory, modeling, and data analysis is invited via international and national funding agencies.



Plot of representative results from STOIC. Courtesy of I.S. McDermid (JPL, USA).

NDSC Steering Committee

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R. A. Cox, Vice Chair	Natural Environment Research Council, UK

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NDSC

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