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# Ground-Based Optical Remote Sensing Activity in Atmospheric Science

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The atmosphere has undergone considerable change due to human influences over the last 30 years. Perhaps the most spectacular is the formation of the Antarctic ozone hole. Ozone depletion in the stratosphere, with harmful consequences for life, alerted the world community to the fragility of the atmospheric environment. Evidence of ongoing atmospheric change has led to important questions for policymakers and the world community. How will stratospheric ozone respond as the abundance of ozone-destroying chemicals decreases? How will atmospheric composition respond to and influence climate? In this regard, comprehensive yet focused atmospheric research has never been more vital. The international Network for the Detection of Stratospheric Change (NDSC) was formed to provide a consistent, standardized set of long-term measurements of atmospheric trace gases, particles, and physical parameters via a suite of globally distributed sites. Such measurements constitute the scientific bedrock upon which sound policy decisions are based. Since its creation 10 years ago, the NDSC has contributed to the understanding of stratospheric ozone depletion at the poles and midlatitudes, and documented the increase and leveling-off of ozone-depleting chemicals in the atmosphere and the continued growth of greenhouse gases. The NDSC is supported by national and international agencies.

The objectives of the NDSC require high-precision, state-of the-art measurements of not just ozone but also of a broad range of chemical species and long-lived tracers that influence ozone and climate. Such measurements are needed to determine whether stratospheric changes are due to chemistry or to atmospheric transport and dynamics. Remote-sensing instruments were selected for their capability for continuous, long-term field operation, potentially in isolated locations. The aim is to equip the primary NDSC stations with a full set of instruments, subject to specific site characteristics such as geography and meteorology, in order to make the most complete and internally consistent set of measurements. The current measurement capabilities at NDSC sites and stations are listed on the NDSC Web site (www.ndsc.ws).

The principal goals of the Network have been expanded to address the broader scope of atmospheric change and related concerns. The current objectives of the NDSC are:

- to study the temporal and spatial variability of atmospheric composition and structure in order to provide early detection and subsequent long-term monitoring of changes in the physical and chemical state of the stratosphere and upper troposphere; in particular, to provide the means to discern and understand the causes of such changes;
- to establish the links between changes in stratospheric ozone, UV radiation at the ground, tropospheric chemistry, and climate;
- to provide independent calibrations and validations of space-based sensors of the atmosphere and to make complementary measurements;

- to support field campaigns focusing on specific processes occurring at various latitudes and seasons; and
- to produce verified data sets for testing and improving multidimensional chemistry and transport models of both the stratosphere and troposphere.

The table below lists the optical instruments deployed at NDSC stations.

| ***Measurement*** | ***Range*** | ***Instrument*** |
|---|---|---|
| O3 total column | | Dobson; Brewer; other UV/Visible spectrometers |
| O3 profile | 018 km1560 km1265 km | DIAL ($\lambda$<300 nm) DIAL ($\lambda$>300 nm)wave radiometers |
| Temperature | 1535 km3095 km | Raman lidars Rayleigh lidars |
| ClO profile | 2545 km | wave radiometers |
| H2O profile | 015 km4080 km | Raman lidarswave radiometers |
| Aerosol distribution | 030 km | Backscatter lidarsBackscatter sondes |
| NO2 | Stratospheric column | UV/Visible and FTIR |
| HCl and ClONO2 | Columns | FTIR spectrometers |
| N2O, CH4, and CFCs | ColumnsStratospheric profiles | FTIR spectrometerswave radiometers |
| HNO3 and NO | Columns | FTIR spectrometers |
| HF and COF2 | Columns | FTIR spectrometers |
| Other species (OH, HO2, OCS, ...) | | UV fluorescence lidars, FTIR spectrometers, wave radiometers |

This lecture will present brief details of the optical instruments and measurements being made within the framework of the NDSC. Emphasis will be given to lidar instruments since the JPL Atmospheric Lidar Group currently operates three ground-based differential absorption lidar (DIAL) systems, and also has two new lidar systems under development. The current systems provide high-resolution vertical profiles of tropospheric and stratospheric ozone and aerosols, and stratospheric and mesospheric temperature. The original system located at the JPL-Table Mountain Facility, California (TMF, 34.4N, 117.7W) has been measuring nighttime ozone number density from ~18-50 km and temperature from ~30-75 km, since 1988. An improved system was installed at the Mauna Loa Observatory, (MLO, 19.5N, 155.6W), Hawaii, in 1993, allowing ozone, aerosol, and temperature measurements between 15-90 km. A new tropospheric system has been recently developed at TMF, operating routinely since late 1999, and providing high-resolution ozone profiles between 5-20 km. Each of these lidars makes observations2 to 3 nights a week, on average, and a very large database of ozone profiles has been obtained since 1998 allowing climatologies to be developed and a wide range of temporal variability to be investigated. Results from these lidars have also been used for validation of numerous satellite instruments including, for example, those onboard the Upper Atmosphere Research Satellite (UARS), and ENVISAT. They will provide the basis for validation of a number of upcoming satellite missions, such as AURA and CALIPSO.

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