A summary of Australian research activities relevant to the ozone layer.

In Australia atmospheric research programs relevant to studies on the ozone layer are, by in large, carried out by the CSIRO Division of Atmospheric Research and by the Bureau of Meteorology. These organisations jointly operate the Baseline Air Pollution Monitoring Station at Cape Grim, Tasmania, at which several of the following research programs are based.

CSIRO has conducted research on stratospheric ozone in the Southern Hemisphere since the late 1950's. Over a twenty year record variability on several time scales has been identified, the most important are being annual cycles (winter maximum, summer minimum), biennial cycles and a decreasing trend (approximately 4% over 20 years), the latter being barely statistically significant and possibly due to long term changes in the strength of stratospheric circulation. The Bureau of Meteorology now operates the five Dobson ozone stations, between 27°S and 54°S, at Brisbane, Perth, Melbourne, Hobart and Macquarie Island. All stations make daily total ozone measurements and weekly Umkehr observations. The Melbourne program is augmented by fortnightly Mast-Brewer ozone sonde measurements at nearby Laverton. The instrument used at Perth is fully automated and operated in conjunction with LIDAR measurements on stratospheric aerosols, the latter through the Western Australian Institute of Technology. Future stations are planned for Darwin (12°S) and Alice Springs (23°S) using automated instrumentation. The Hobart station may be closed down, due to its proximity to Melbourne. The ozone data collected at these stations are periodically logged with the World Ozone Data Center. The Bureau of Meteorology have recently appointed a scientist who will supervise the ozone/radiation program and do data analysis and interpretation.

CSIRO has been researching tropospheric ozone since the 1960's. Surface ozone measurements have been made at Cape Grim since 1976 in a program designed to detect long term changes in ozone concentrations in the lower atmosphere. An ozone annual cycle at Cape Grim has been identified, again with a winter maximum and a summer minimum, caused by seasonal variations in the transport of ozone rich stratospheric air into the troposphere at mid-latitudes of the southern hemisphere, and by summertime photochemical destruction in this clean southern hemispheric air. Analysis is under way to determine the meteorological influences on ozone levels at Cape Grim. Long term trends in ozone concentration at Cape Grim have not been detected, in agreement with results from other Baseline Stations (Samoa, South Pole). Tropospheric ozone removal processes have also been studied and the loss of ozone from the atmosphere over a variety of natural surfaces has been investigated and ozone destruction rates deduced.

Halocarbons (CCl_3F, CCl_2F_2, CH_3CCl_3, CCl_4) and nitrous oxide (N_2O) observational programs have also been conducted at Cape Grim since 1976. Long term trends have been detected and modelled using global release data to deduce the atmospheric lifetimes of these chemicals, which are precursors of catalysts capable of ozone destruction. Halocarbon growth rates at Cape Grim have been used to calibrate the transport component of a 2-dimensional tracer transport model or, conversely, given the known transport fields and atmospheric residence times, to deduce global releases. Since 1978 this program has formed an integral part of the Atmospheric Lifetime Experiment (ALE), involving scientists from CSIRO, the USA (Oregon Graduate Center, the Massachusetts and Georgia Institutes of Technology) and from the UK (University of Bristol). Since early 1985 this program has been expanded to include methane and CCl_2FCFCl_2, and renamed GAGE (Global Atmospheric Gases Experiment).

A number of other atmospheric chemical constituents are significant in ozone chemistry. Methane, carbon dioxide and nitrous oxide are important 'greenhouse' gases which help determine average stratospheric temperatures and thus ozone levels. Methane also reduces chlorine catalysed ozone destruction by partial removal of stratospheric chlorine, some of which originates from the above anthropogenically released organochlorine compounds. Carbon monoxide levels control the abundance of hydroxyl (OH) radicals, which in turn regulate the fluxes of certain trace gases from the troposphere to the stratosphere.

Methane (CH_4) and carbon monoxide (CO) have been studied at Cape Grim and over SE Australia since 1978. A long term trend has been measured for CH_4 (ca. 1% per year) and significant seasonal cycles in CH_4 and CO quantified. Modelling experiments suggest that the trend in CH_4 is due to expanding anthropogenic industrial and agricultural activities, and the seasonal cycles appear to be responding to calculated seasonal changes in OH radical levels.

Carbon dioxide (CO_2) observations commenced at Cape Grim in 1976 and complement a CSIRO program of CO_2 measurement over SE Australia that commenced in 1972. Trends, seasonal cycles and vertical gradients have been measured. The data have been used in conjunction with global data from the Scripps Institute of Oceanography and the National Oceanographic and Atmospheric Administration (USA), in a 2-dimensional model, to refine the magnitudes of the known sources and sinks of CO_2, especially the biosphere, that are part of the global carbon cycle.

Oxides of nitrogen are important precursors in tropospheric ozone chemistry, as are non-methane hydrocarbons. A sensitive chemiluminescent nitrogen oxides (NO, NO_2) detector has been operating at Cape Grim intermittently since 1978, to study the reactive gas chemistry of the background maritime airmass. Studies are also underway at CSIRO to determine the influence of biological sources of oxides of nitrogen (denitrification and nitrification) on the NO/NO_2 budget of the remote continental atmosphere. To this end measurements of NO/NO_2 fluxes have been made over various fertilized and unfertilized agricultural areas. A research program has just commenced at Cape Grim investigating the level of and temporal variations in non-methane hydrocarbons (largely ethane) in background maritime air.

CSIRO have also been involved in the measurement of stratospheric constituents over Australia. NO, NO_2, HNO_3, O_2, N_2O, CCl_3F, H_2O, CH_4 and aerosols have been analysed at 23°S and 34°S during the Austral autumn and spring, corresponding with the times of O_3 minimum and maximum in the stratosphere. Such measurements provide important tests of the chemical and dynamical theories of the stratosphere.

In conjunction with US scientists (Temple University), erythermally effective ultraviolet radiation (UV-B) has been measured at Aspendale and Brisbane since 1975. To date the data show no significant change in UV-B, the radiation responsible for skin damage, consistent with the observation that very little change has occurred in total ozone.

CSIRO is conducting research into atmospheric dynamics relevant to stratospheric ozone. In conjunction with Monash University the climatology of the southerm hemisphere stratosphere is being established, and the dynamics of wintertime stratospheric warmings and meriodial circulations are being studied. CSIRO is also researching the theory of 2-dimensional transport parameterizations and, in conjunction with Geophysical Fluid Dynamics Laboratory (NOAA) and Goddard Space Center (NASA), is deriving 2-dimensional transport coefficients from the output of general circulation models of the atmosphere as well as from direct observations.

Adelaide University is conducting research into the study of mesospheric winds, planetary waves, and gravity waves, and with CSIRO, large scale atmospheric transport in the mesosphere.

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Recent Research results and planned and ongoing activities

Relevant to the World Plan of Action on the Ozone Layer

Submitted by Italy