

also have somatostatin^{19,20}, γ -aminobutyric acid²¹ and catecholamine-containing neurites²². It is probable that cholinergic deafferentation of the cortex (including the hippocampus) is an important contributor to the cognitive impairments of Alzheimer's disease. However, the hypothesis that subcortical cholinergic neurones, by virtue of their particular metabolism or other molecular specialization, are the primary focus of Alzheimer's pathology seems no longer tenable. If cholinergic subcortical degeneration is not the primary focus, it may reflect a disease process acting concurrently on diverse independent structures, or it may be the result of abnormalities of the target cortical regions. The latter possibility is compatible with observations that the neuronal loss in different parts of the cholinergic basal forebrain system in Alzheimer's disease is proportional to the extent of neuritic plaque formation in their respective cortical targets²³, and with the observation of degenerative changes in cholinergic neurones of the basal forebrain following

cortical lesions in rats^{24,25}, monkeys and humans²⁶. □

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Atmospheric chemistry

Reservoir species discovered in the stratosphere

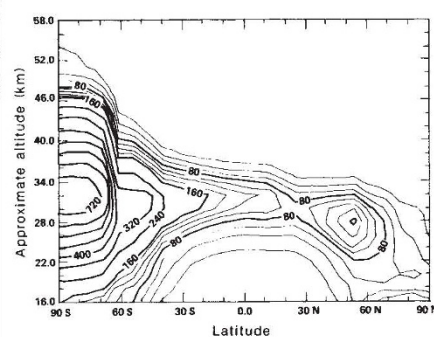
from Donald J. Wuebbles

It is now recognized from theoretical models that several trace constituents of the stratosphere affect the distribution of ozone. But because of difficulties in achieving enough sensitivity, the stratospheric concentrations of many of these species, particularly those termed 'reservoir' species, have remained unobserved. Now, Toon *et al.*, on page 570 of this issue¹, report the first conclusive measurement of the reservoir species N_2O_5 .

Reservoir species are those trace constituents, such as HNO_3 , HCl , N_2O_5 and $ClONO_2$, that are produced from the more reactive ozone-destroying species, but are longer-lived and less reactive. In a sense, these gases act as temporary reservoirs or holding tanks for the more reactive ozone-destroying forms of nitrogen-, chlorine- and hydrogen-containing species in the stratosphere. Of these reservoir species, only HNO_3 and HCl have been measured extensively. The concentration distribution observed by Toon *et al.* applies only to a particular latitude and longitude on a single day, but nonetheless represents an important step towards the validation of key aspects in the theory of ozone-controlling mechanisms.

Many recent studies have concerned the possibility that increasing concentrations of trace-gas emissions caused by human use, such as methane, nitrous oxide (N_2O) and chlorocarbons (particularly $CFCl_3$,

and CF_2Cl_2) affect the distribution of stratospheric ozone. These trace gases, although emitted at the Earth's surface, are sufficiently long-lived to be transported to the upper atmosphere, where they dissociate into by-products that can



Two-dimensional model simulation of the latitudinal variation in N_2O_5 concentrations determined for May at local noon. By definition, the mixing ratio is the concentration divided by the air density. From the model of S. Solomon and R. Garcia.

react with ozone catalytically. The rate of conversion of the reactive species to the less-reactive, reservoir species largely determine the ultimate effect of these trace gases on stratospheric ozone. It has been noted that model-derived concentrations of the reservoir species are particularly

sensitive to remaining uncertainties in atmospheric chemical reaction rates. For all these reasons, it was essential to measure the concentrations of reservoir species in the stratosphere.

N_2O_5 has long been thought to be important in the diurnal variation of NO_2 , which reacts with ozone. The slow photolysis of N_2O_5 should produce NO_2 slowly during the day, while production of N_2O_5 should reduce NO_2 concentrations slowly in the night-time stratosphere. Observations of the sunrise-sunset differences in the NO_2 profile^{2,3} and a recent analysis⁴ of satellite-observed NO_2 at varying zenith angles have tended to verify the importance of this process. The observations by Toon *et al.*¹ are in general agreement with the expected diurnal behaviour of N_2O_5 .

Model calculations suggest that N_2O_5 concentrations are particularly large in the high-latitude winter (especially in the Arctic) and that N_2O_5 is the major portion of total reactive nitrogen in the high-latitude stratosphere (see figure). Trajectory analyses⁵ suggest that the conversion of NO_2 to N_2O_5 in the winter polar night explains the so-called Noxon cliff, in which sharp gradients in the total vertical column content of NO_2 are observed at high latitudes. Measurements of N_2O_5 concentrations in the polar winter stratosphere in tandem with further observations of NO_2 concentrations are needed to test this suggestion. In addition, heterogeneous mechanisms⁶ have been proposed for the conversion of N_2O_5 to HNO_3 in the arctic winter. This could also be tested by observations of N_2O_5 .

The observed profile of N_2O_5 in Toon *et al.*'s study is in general agreement with the expected theoretical distributions determined with models such as the Lawrence Livermore National Laboratory one-dimensional model, but a direct comparison depends on knowing the NO_2 and O_3 concentrations at the same location. As the measurements of Toon *et al.* depend on assumed profile shape, the next step is to reduce this dependence. Clearly, based on the expected diurnal behaviour and from results (see figure) that show the strong winter high-latitude gradients, observations of N_2O_5 are needed at a wide range of seasons and locations, as well as at various times throughout the day, to validate the theory. □

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