A proposed VHF radar experiment ~~to contribute~~ in relation to stratospheric pollution problems

Motivation

There is no need to stress here the importance of current stratospheric research motivated by possible man-made disturbances of the natural chemical equilibrium state of ozone in the stratosphere. The subject is discussed not only in the technical literature but in newspapers, magazines and television programs. This includes the effects of high flying aircraft, fluor carbon releases from aerosol cans and airconditioning units and more recently the effects of enhanced soil production of N_2O as a consequence of the use of artificial fertilizers.

A parameter of importance for the theoretical modeling of the dynamics and transport of all above mentioned contaminants is the effective Eddy diffusive coefficient at stratospheric heights or, more properly, the profile of Eddy diffusion coefficients as a function of altitude. Our ignorance with respect to this parameter is best illustrated by figure A.35 of the Nat. Academy of Sciences Report "Environmental Impact of Stratospheric Flight" which we have reproduced here. It can be clearly seen that the different models use profiles which differ in more than a order of magnitude!

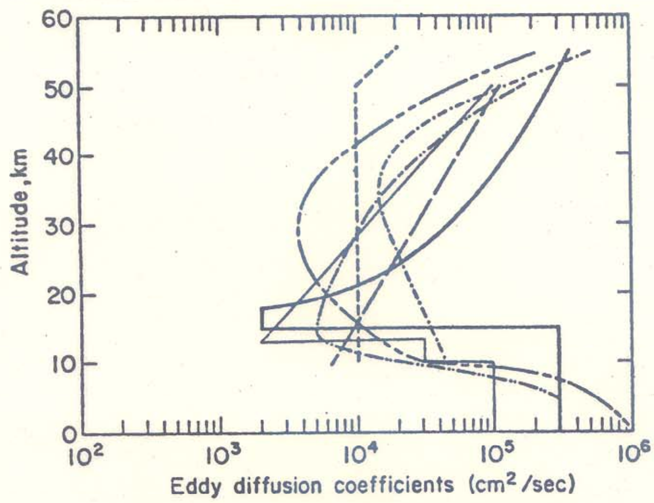

FIGURE A.35 Vertical profiles of eddy-diffusion coefficient as used in various one-dimensional models. ———, McElroy *et al.* (1974); ———, Hunten, (1974); – – –, Crutzen (1974); – • – • – • –, Whitten and Turco (1973); — • • — • •, Stewart (1973); — — —, Shimazaki and Ogawa (1974); – – – – – – –, Chang *et al.* (1974).

Recently N.W. Rosenberg and E.M. Dewan (1) have obtained an effective diffusion coefficient which agrees well with measured residence times of radioactive debris based on the hypothesis that CAT (Clear Air Turbulence) is the major source of transport. They assume a random distribution of a few layers of turbulence with about 100 meters of thickness and that vertical transport occurs only within this region. This work strongly motivates the statistical study of these layers, their thickness, probability of occurrence, tilt and horizontal extent, sweeping motion of the layers, their relationship to atmospheric gravity waves, latitudinal dependence etc.

Recently Woodman and Guillen (2) have shown the potential of powerful VHF radars in the detection of CAT to altitudes up to 35 kms. They reported measurements using the Jicamarca radar. Unfortunately the Jicamarca radar has, because of transmitter bandwidth limitation, a maximum resolution of 2.5 km, which is much higher than a desired 100-meter resolution, if the CAT layers are to be resolved.

The Max-Planck-Institute at Lindau on the other hand is constructing a 50-MHz radar with comparable power as the one used by Woodman and Guillen at Jicamarca, but with a maximum resolution of 100 meter. An antenna for this radar is being built in the Harz mountains, although it will have about 20 dB less gain than the Jicamarca antenna, it is expected the system should have sufficient sensitivity for the detection of turbulence to 20-25 km of altitude. The transmitter is built in movable containers and can be transported to other locations allowing the possibility to use the large antenna reflector at Arecibo and the large 50-MHz antenna at Jicamarca. (Another VHF radar is in operation at Sunset Valley, Boulder, Colorado (NOAA)).

The MPI radar will be capable then to monitor for extended periods of time the number, height and thickness of the turbulent layers as well as their time history at a given location and provide accurate statistical information for the derivation of average effective Eddy diffusion coefficients as a function of height and season using an approach similar to Rosenberg's and Dewan's. The operation of the radar with Arecibo and Jicamarca antennas will provide not only the additional sensitivity needed to higher altitudes but will allow to study any latitudinal effects as well as orographic influences caused by land masses and mountains. The improved angular resolution obtained with the larger antennas will reduce the antenna beam spectrum widening effect and interpret spectrum measurements as direct turbulence random velocity measurements.

Recommendations

- Include continuous high resolution power profile measurements as a high priority measuring program for the MPI VHF radar in the Harz.
- Perform similar measurements with the use of the Arecibo and Jicamarca antenna, the MPI VHF transmitter and the Sunset Valley (Boulder) VHF radar, including full spectrum measurements.
- Make necessary modifications to the Jicamarca transmitter to improve its frequency bandwidth and improve its altitude resolution.

R. Woodman
1 June 1976

(1) Rosenberg, N.W. and E.M. Dewan
"Stratospheric turbulence and vertical effective diffusion coefficients"
Third Conference on CIAP, February 1974, DOT-TSC-OST-74-15.

(2) Woodman, R.F. and A. Guillen
"Radar observations of winds and turbulence in the stratosphere and mesosphere"
Jour. Atm. Sci., Vol. 31, No. 2, 493-505, March 1974.

B

Recommended stratospheric and mesospheric VHF radar measurements

	Experiment	Motive
A	High resolution (100 meter) stratospheric and mesospheric power and spectral profiles.	Obtain quantitatively the role of CAT (strato-sphere) and mesospheric turbulence in vertical transport process.
B	Simultaneous partial reflection and VHF radar measurements.	Understand the mechanisms responsible for partial reflection and the role played in it by turbulence.
C	Simultaneous rocket electron density profiles, smoke trail and VHF radar measurements at mesospheric heights.	Relationship between wind shears, turbulence, electron density gradients and irregularities responsible of VHF backscatter echoes. Evaluate the effect of large short period oscillation in wind measurements performed by rockets.
D	Simultaneous rocket smoke trail (or other wind measurement techniques) and VHF radar measurements at stratospheric heights.	To supplement VHF CAT observations with rocket wind profiles and determine the potential of VHF radar to study winds and shears.

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