Trace Gas Transport in the Troposphere and the Interpretation of In Situ Concentration Measurements

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Final Report

Summary of science results

The research conducted comprised two sub-projects: 1) definition of the major transport pathways in the troposphere with focus on low-level transport in baroclinic systems, and (2) investigation, and assessment of the usefulness of, tracer-tracer correlations in the troposphere.

1) Low-level diabatic transport in baroclinic waves

We have run simulations of the dynamics of, and tracer transport in, baroclinic waves in a global, pseudospectral, dynamical model. Quasi-isentropic mixing in the free troposphere has previously been investigated by others. We have focused on the low-level diabatic transport associated with equatorward "cold air outbreaks": this component of the transport takes place within isentropic surfaces that intersect the ground and is associated with the equatorward return flow in the midlatitude tropospheric mass circulation. Our simulations show tracers injected into the high latitude boundary layer being trapped within the boundary layer at first as they are transported equatorward by this process: results show this transport can be accurately thought of as simple advection by this branch of the mass circulation. Subsequently, the air is lofted and transported poleward isentropically by large scale mixing processes. Simultaneously,

tracers in the free troposphere are entrained into the boundary layer.

The amount of diabatic tracer transport associated with these low-level processes is comparable with that estimated to be typical of large-scale diabatic transport in the atmosphere. Thus this process is probably at least competitive with convection, and may be the dominant mechanism for diabatic transport in the extratropical troposphere.

2) Tracer-tracer correlations in the troposphere

Numerical model results suggest that, remote from sources, long-lived tracers should exhibit correlations in the troposphere just as they do in the stratosphere. We have analyzed ground-based data from the AGAGE network. These data exhibit day-to-day fluctuations in association with the passage of synoptic systems and, in some places and for some species, these fluctuations are highly correlated. Long-lived tracers whose sources are dominated by emissions in northern middle and high latitudes (*e.g.*, CFCs, SF_6) show very tight and linear relationships in the tropics and southern hemisphere. More surprisingly, species with more extensive sources (such as CH_4 and N_2O) show similar behavior. Theoretical arguments suggest a relationship between the slopes of these relationships and the lifetimes and growth rates of these species: this prediction is borne out by the observed correlation slopes.

Publications

A paper presenting results from subproject (2) is in an advanced state of preparation, and will be submitted to *Geophys. Res. Lett.* by the end of June 2000. Two papers on subproject (1) are currently being written, and will be submitted for publication before the end of the year. Each of these papers, once submitted, will be available on **http://eaps.mit.edu/~rap/preprints.html**.

Personnel

Two graduate research assistants have been supported in part by this project, and have conducted their research under the PI's supervision.. Mr Tieh Yong Koh has been responsible for the day-to-day aspects of subproject (1), and this research will form part of his Ph D thesis, to be defended sometime in 2001. Ms Nikki Privé, a first-year graduate student, has conducted the analysis of subproject (2), but it is not expected that her Ph D research will develop from this work.