OBSERVATIONS TO EXAMINE TRANSPORT CHARACTERISTICS IN THE LOWER STRATOSPHERE

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Abstract

Observations of methane (CH4) and ozone (O3) from both the Halogen Occultation Experiment (HALOE) and the ER-2 aircraft have been used to examine transport characteristics in the lower stratosphere. A modified Lagrangian-mean (NMLM) analysis of the HALOE CH4 data provided a unique method for identifying so-called transport barriers (i.e., regions where quasi-horizontal transport is inhibited). The NMLM technique can be used with any long-lived tracer provided adequate spatial coverage can be achieved over a reasonably short period. We show how the NMLM technique can be implemented with HALOE occultation data. The HALOE data set is unique in providing an extended record (8 years) of long-lived tracer data. Because the solar occultation sampling pattern of HALOE requires approximately one month to achieve near-hemispheric coverage, synoptic hemispheric distributions of CH4 are reconstructed through correlations with the United Kingdom Meteorological Office (UKMO) potential vorticity (PV) distributions for 7-day periods which are then analyzed for the presence of transport barriers. The NMLM technique was used to construct area equivalent latitude versus potential temperature cross sections of CH4 mixing ratio and "equivalent lengths" for these periods. Regions of minimum equivalent length are identified as barrier regions where meridional transport is restricted. Application of this technique to solar occultation data was validated, and it is concluded that the NMLM formalism can be applied to occultation data provided a suitable synoptic distribution of PV can be obtained for the desired period.

Unlike the satellite data, the localized in situ data obtained by instruments aboard aircraft can not be used in the NMLM technique. Instead, correlations between the mixing ratios of various tracer constituents have been used extensively to provide insight into the relative roles of chemistry and transport in the lower stratosphere. However, tracer correlations include the effects of both chemistry and transport and are spatially restricted. Separating the effects of chemistry and transport and accurately interpreting tracer correlations is often difficult. We show that associating an aircraft tracer correlation with a coincident HALOE NMLM analysis provides for a less ambiguous evaluation of the correlations and a more comprehensive approach in studying transport in the lower stratosphere. However, if only one analysis is employed to deduce information about transport, the NMLM technique is preferred to tracer correlations. This analysis not only captures the tracer distribution but also identifies the location, shape and strength of transport barriers and mixing regions. A disadvantage of the method is that it is implemented using global satellite data of lower resolution than the aircraft data. Fortunately, the very good agreement achieved between the aircraft and HALOE CH4 and O3 correlations in the lower stratosphere demonstrate that the satellite data can be used confidently in global analyses.