Comment on "Tropical Cyclone–Upper-Atmospheric Interaction as Inferred from Satellite Total Ozone Observations"

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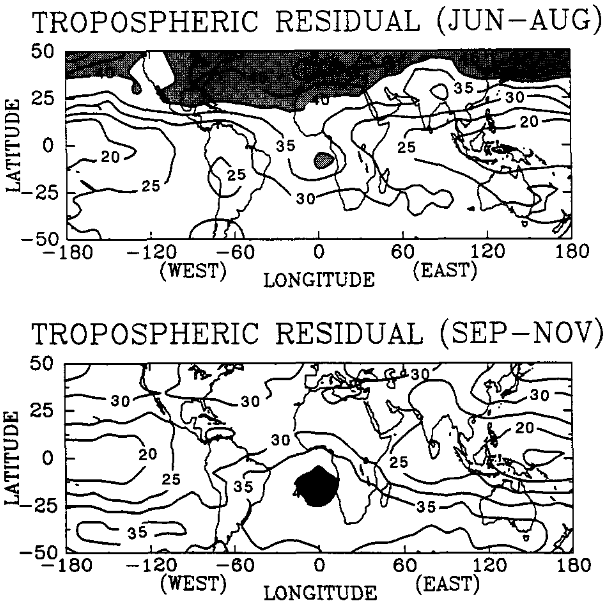
The interaction between circulation flow fields around tropical cyclones and the distribution of total ozone determined from the Nimbus-7 Total Ozone Mapping Spectrometer (TOMS) is discussed in a recent paper by Rodgers et al. (1990). In that study, it was found that the TOMS-observed total ozone distribution within the subtropics during the tropical cyclone season correlated well with the tropopause topography, similar to earlier midlatitudinal observations.

The use of satellite ozone data to deduce circulation patterns in otherwise data-sparse areas is an important scientific advance for which the study is to be commended. In addition to the points brought forth in the Rodgers et al. study, however, I describe another consideration that may account for some of the total ozone features that they identified.

For the past several years, a considerable effort has gone forth to discern a tropospheric ozone signal using satellite datasets. The result from this research has been the successful development of the global distribution of tropospheric ozone, using the total ozone information from TOMS concurrently with stratospheric ozone measurements from the Stratospheric Aerosol and Gas Experiments (SAGE I and SAGE II). By subtracting the integrated amount of ozone in the stratosphere obtained from the ozone profiles measured by SAGE from the amount of TOMS total ozone at the same location, Fishman et al. (1990) have shown that the resultant "tropospheric residual" produces a tropospheric ozone climatology that is accurate to better than 15% when compared with in situ measurements. The resultant distributions for Northern Hemisphere summer (June–August) and autumn (September–November), the same period as the tropical cyclone season, are shown in Fig. 1.

Of particular interest is the existence of a pronounced latitudinal gradient in the northern tropics and subtropics. For the climatologies depicted in this figure, the gradient is more pronounced in the summer than in the autumn. Along the 60°W meridian in the summer, tropospheric ozone amounts are less than 30 Dobson units (DU, where 1 DU = 2.69×10^{16} mol O_3 cm^{-2}) at low latitudes (near 10°N), whereas values of nearly 45 DU are found at 35°N. An even stronger latitudinal gradient in the northern tropics and subtropics is found over the Pacific Ocean at this time of the year.

Fishman et al. (1990) hypothesize that the primary reason for the high amounts of tropospheric ozone found at northern midlatitudes is that much of the Northern Hemisphere is polluted by industrialized anthropogenic activity. As a result, hemispheric-scale photochemical smog is present, and this vast smog episode is most pronounced during the summer. The gradient in the northern subtropics is less pronounced in the autumn because of less photochemistry (less sunlight) taking place at northern midlatitudes and



TROPOSPHERIC RESIDUAL (JUN–AUG)

TROPOSPHERIC RESIDUAL (SEP–NOV)

FIG. 1. The climatological distribution of the integrated tropospheric residual amounts for two seasons is depicted. Tropospheric residuals >40 DU have been shaded (from Fishman et al. 1990).

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because of the large amount of ozone pollution formed from tropical biomass burning in Africa and South America, which is generally most intense in September and October.

If a strong cyclonic flow were embedded in this gradient between 10° and 30°N, ozone-poor air could be advected from the tropics and wrap itself around the circulation center. The resultant total ozone distribution in the vicinity of the tropical cyclone could be quite similar to what was observed for the case study (Hurricane Irene) described in detail in Rodgers et al. (1990).

Verification of the aforementioned scenario would be extremely difficult using the tropospheric residual method described in Fishman et al. (1990), since the spatial and temporal resolution of the SAGE datasets do not allow for a meaningful case study analysis. It is also quite likely that the deformation around the subtropical upper-tropospheric jet does result in some of the features seen in the TOMS data. On the other hand, the use of TOMS data to study jet-stream features at midlatitudes is successful primarily because of the large differences in the height of the tropopause on either side of the jet stream (Shapiro et al. 1982). For example, Fishman et al. (1987) show an increase of total ozone of more than 40 DU between two stations separated by ~600 km, due to a tropopause height difference of 4.2 km. Being a tropical warm-core low, rather than an extratropical cold-core low, the hurricane's interaction with upper-tropospheric dynamics is considerably different. Therefore, the extreme gradient of the tropopause height found at midlatitudes is not likely to be present in conjunction with the formation of tropical cyclones.

The work of Rodgers et al. (1990) correctly acknowledges the finding in Fishman et al. (1987) that man-made pollution episodes over tropical and subtropical land regions may enhance tropospheric ozone and cause errors in estimating tropopause topography from TOMS-measured total ozone. Subsequent research efforts leading to the analysis described in Fishman et al. (1990) show that ozone pollution can be identified on a hemispheric spatial scale using satellite measurements. Because of this, even analyses in remote regions of the world must take into account the distribution of ozone pollution when using total ozone information to infer characteristics of atmospheric dynamics.

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