Stratospheric Plume Dispersion: Measurements from STS and Titan Solid Rocket Motor Exhaust

Abstract:

Plume expansion was measure from nine Space Shuttle and Titan IV vehicles at altitudes of 18, 24, and 30 km in the stratosphere. The plume diameters were inferred from electronic images of polarized, near-infrared solar radiation scattered from the exhaust particles, and these diameters were found to increase linearly with time. The expansion rate was measured for as long as 50 min after the vehicle reached altitude. Measurements made simultaneously at multiple altitudes showed that the expansion rate increased with increasing altitude for six measurements made at Cape Canaveral but decreased between 24 and 30 km for the one measurement made at Vandenberg AFB. The average expansion rates for all measurements are 4.3 ± 1.0 m/s at 18 km, 6.8 ± 1.9 m/s at 24 km, and 8.7 ± 2.5 m/s at 30 km. Expansion rates varied from launch to launch by as much as a factor of 1.6 at 18 km, 2.2 at 24 km, and 2,7 at 30 km. No correlation between the expansion rate and wind speed or shear was evident. These data are compared to several models for diffusivity and are used to update a comprehensive particle model of solid rocket motor exhaust in the stratosphere. The expansion rates are required by models to calculate the spatial extent and temporal persistence of the local stratospheric ozone depletion cause by solid rocket exhaust.