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Portfolio

Compressible Thermal Starting Plume

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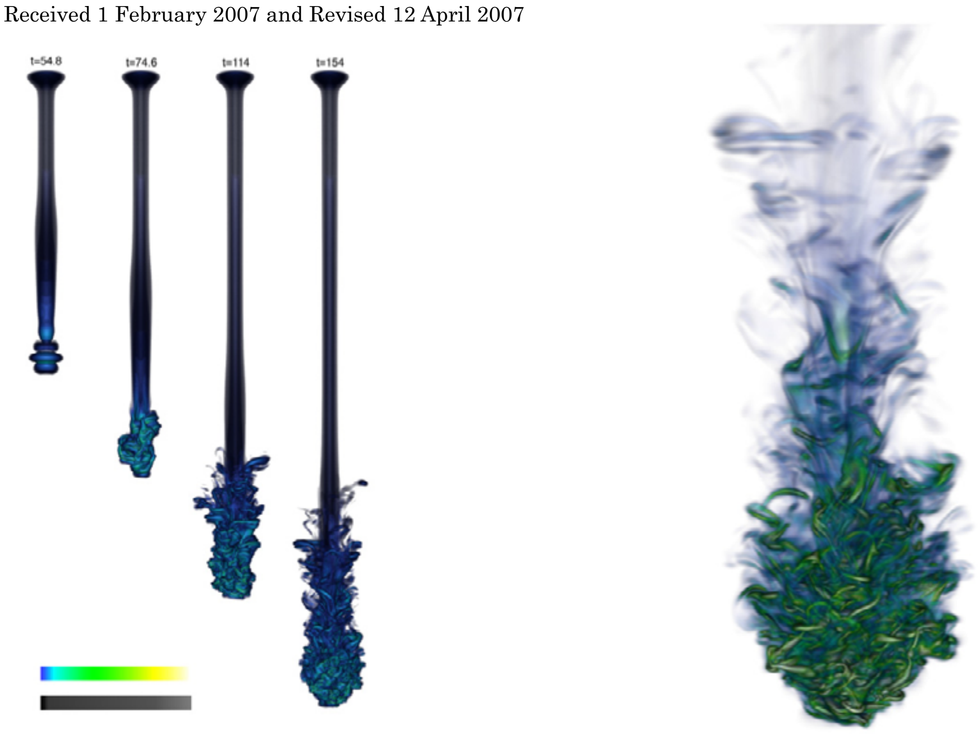

Fig. 1. Numerical simulation of a fully–compressible three–dimensional thermal starting plume descending through an adiabatically stratified domain. Temporal evolution, with time indicated in units of the isothermal sound travel time across the plume diameter at the domain top, on left. On right, a close up of plume head at late time. Images are volume renderings of the flow enstrophy. The color and opacity transfer functions are scaled between zero and the maximum value in the domain at each time step. Opacity bar shows full transparency as black.

The outer one third of the Sun is convectively unstable, driven by heat production in the interior and radiative loss from the photosphere. Surface cooling is non-uniform leading to vigorous new downflow plume formation. These plumes play a crucial role in the dynamics of the flow, interacting to form larger convective scales, and possibly also descend through the entire highly stratified convective layer to play a key role in the transport of heat, momentum, and magnetic field into the overshoot region below. The images above illustrate the enstrophy of a single compressible downflow plume, initiated and maintained by a fixed temperature perturbation imposed on the upper boundary (three – dimensional version of Case E in Rast, M.P., 1998, JFM, 369, 125). The plume is subject to vigorous secondary instability with the successive penetration and disruption of the leading vortex torus by the stem flow from behind. This generates the tangled mass of vortex filaments at the plume head. The computational grid employed was horizontally periodic and highly non – uniform. Only the central one third of the domain is shown after uniform resampling. The images were produced using an open source analysis/visualization package developed at NCAR named VAPoR (www.vapor.ucar.edu).