Trajectories and streamlines

Much has been written about trajectories and streamlines in old meteorology texts. In particular, there are numerous equations for trajectories (such as in Holton), but they are of questionable practical use.

However, streamline analysis is very useful, especially in the tropics, and will be taught in synoptic meteorology.

It suffices to just define these concepts in this class.

A streamline represents the direction of flow at a fixed instant of time. A streamline is everywhere tangent to the velocity vectors. It is a "snapshot" of the velocity field at any instant.

A trajectory is a line representing the path followed by an air parcel over a finite period of time. Thus, a trajectory is a curve (along a path "s"), located in (x, y, z, t) space, that reveals the coordinates the parcel had (or will have) for every time "t."

The difference between a streamline and trajectory is important. Only for steady-state systems are they the same. As time passes for a changing and/or moving weather system, the streamlines must change, and parcels will not move parallel to the original (t=0) streamlines.

It is a complicated task to determine or deduce the trajectory of an air parcel, especially with observational data available only at 12-h intervals.

Horizontal trajectories are determined by integration of

$$\frac{Ds}{Dt} = \vec{V}(x, y, t)$$

This can be done using successive wind observations to solve $s(x, y, t)$. This is somewhat easily done in computer simulations, but using observations makes this tricky. Another difficulty is that actual motion is rarely horizontal, but subject to vertical velocities as well.

Hence, to solve for trajectories

$$\frac{Ds}{Dt} = \vec{V}(x, y, z, t)$$