

In this section we will examine an ensemble of trajectories that looks at the sensitivity of those trajectories to the meteorological grid. Now, first the method of looking at trajectory sensitivity with respect to the grid, or how the data have been gridded, is a technique that's been around for quite some time. And we can do a simple manual version of this. Go ahead and open up the trajectory setup run menu, and go ahead and retrieve the previous mid boundary layer trajectory calculation. As you recall, that was named `traj_fwrd_control.txt` and if you don't have it either retrieve it from the files directory, or I will go over the entries in more detail shortly.

So the calculation starts on the 25th at 17 UTC from Dayton, Ohio, at 750 m, for 68 hours, using the North American Regional Reanalysis data. So let's go ahead and instead of computing one trajectory, let's compute three trajectories. And I'm going to copy and paste the Dayton location to the other two starting points. And then I'm going to select a location that is approximately 1 grid, 1 meteorological grid point, offset from the Dayton site. And let's just do this in the north-south direction for simplicity. We know that the reanalysis data are approximately 32 km resolution, so that would be about 0.3° in latitude, so if I add 0.3° to the location number one, that would be 40.2, and if I were to subtract 0.3° that'll be 39.6. So we now have the Dayton location in the center and a point slightly to the north, and a point slightly to the south. And then save, run model, and display.

And you can see in this very simple example that for most

of the trajectory duration the three trajectories stayed parallel to each other and that any gradients in the flow field, in terms of how that information was gridded in the meteorological data did not affect the calculation until the very end of the trajectory, where there was some departure. So the point here is that you would have a lot of confidence in one trajectory when you can see that at least for this first part of the path, when the two trajectories that are calculated at surrounding points, have a similar pathway. Now in HYSPLIT this particular computation can be automated. There's an option to compute trajectories about a three dimensional cube. So if the star represents my starting point that I'm interested in, I would compute automatically, trajectories using meteorological data offsets by one index in the north, south, east, west, as well as up-and-down directions, and this would give me a total of 27 starting locations.

This is actually set in one of the advanced menus, where the shift can be defined, and the default is one grid point in the X and Y direction and 1/100th of a Sigma unit in the vertical direction. If you recall the model domain in the vertical, the default is 25 km. So one hundredth, in other words, the 25 km represents one sigma unit. Therefore 1/100 of that 25 km is about 250 m. So we would be adjusting the vertical dimension of the starting locations by approximately 250 m.

So to do that calculation, go back to the set up run menu, let's go back to one starting location, actually let's just go back and retrieve the traj forward control file again, and

that will reset the starting locations back to Dayton, Ohio. Go ahead and save and now instead of trajectory run model, we'll do a special run, and we will do an ensemble. So this tab invokes an executable, a special trajectory executable that will automatically compute those 27 trajectories. And yes we want to do this, and this is a fairly quick calculation.

Let's go ahead and do a display, and as you can see now, unlike the sample calculation I showed you where we did one offset to the north and one offset to the south, these calculations all start at the same location. The only thing that is offset is the meteorological data that is used in the calculation. So for instance the one calculation that started with an offset one grid point to the north, means that it still starts from Dayton, but it uses that meteorological information from that grid point to north. So you can see in this example that as before the trajectories, as before in the simple case, all these 27 trajectories until the very end, until the last day, stayed together, so there is a high confidence level that the gridded meteorological data that you're using adequately represents the flow that actually is occurring in this domain, at least during this time period. The uncertainty increases at the latter part of the period.

A corollary to this calculation is that we can do the ensemble backwards. So go back to setup run and let's retrieve the mid boundary layer backward trajectory that we had done earlier, when we were looking at trajectory error. As you recall, it's labeled traj_back. OK, and in case again, if you don't have this, the calculation started

on the 28th at 13 UTC, and the starting location was 37.467 and 75.259 at 325.9 m above ground, and we are going backward, there's a negative number here, regardless of what the direction tab says, and let's go ahead and save, and let's run the trajectory special runs, ensemble, continue, and now display, and can see something very interesting, that in the backward calculation, the uncertainty is expressed almost immediately, and that all the trajectories are going in very different directions and very few of them actually make it back to the Dayton release location. And this goes along with the flow field that we looked at earlier, that the flow region in the Atlantic Ocean off the coast, eastern part of United States at this time period was not well-defined. The gradients were weak and the winds could've varied considerably from grid point to grid point, resulting in very different trajectories even with a slight change in the gridded data.

So this tool, of doing a trajectory ensemble, is really a quick way of determining whether, or determining qualitatively in a certain way, of much uncertainty there is in a single trajectory that you might want to represent something.

And that concludes the discussion of the meteorological grid ensemble.