In the previous section, we showed how following just a few puffs, representing the growth of the particle distribution with time, gave comparable results to following the individual particles as they dispersed with turbulence. However, one limitation of the puff approach, is that the meteorological conditions, used for the transport and dispersion, are valid only at the puff center position. As the puff expands beyond a few meteorological grid points, one data point can no longer be used to represent the conditions of the puff. HYSPLIT, in this situation, will split a single puff into multiple puffs, each with a proportional fraction of the original mass, and we call this puff splitting.

To show how this works, go back to the graphical user interface, and if you're proceeding from the previous section, you should just be able to continue. However if not retrieve the Gaussian CONTROL file and set up file, into the menu.

So open, set up run, and just to be sure I'm going to do the retrieve, and also in the advanced menu, retrieve. Now let's make sure that it's configured for the way we want, for menu number 4 we are releasing just one puff for the emission cycle, and the constant, oh, and we should also check make sure that it's Gaussian, that will be menu three, and indeed that's what it should be set for.

Now we are already know what the 12 hour simulation looks like. So were going to run this a little longer, out to 48 hours, so that we can see the effects of puff splitting. Now just go ahead and run model with setup, and now

display.

Now this takes a bit longer, because there are more frames to plot. First of all, you can see that the map domain is much larger, because the map is automatically scaled to the largest domain, or the largest coverage required in this series of frames. So this starts out after six hours, or three hours I should say, again with this simple single Gaussian puff, composed of one puff. And we will continue on at three, and now between these two times, we have a circular single puff, and now we become more structured, so you can see that splitting is going on. And as we continue on in time, at the end of the 48 hours, it's quite a complicated structure.

If you were to open up the MESSAGE file, you can see the calculation starts out with one puff, and then at 13 hours, after 12 hours simulation time, we now have five puffs, because at that point the radius of the puff exceeded two meteorological grid cells, and we know that a grid cell is 32 km. And a Gaussian puff will split into five parts whereas a top hat puff, will only split into four puffs. The difference is that in the Gaussian, the fifth puff goes over the center position, to represent the larger mass toward the middle, or the central region. And again after an additional six hours, these puffs split again, and so now instead of five puffs, each of those split into five as well, and so now we have 25. But notice the total mass is still one. Also the coverage in the vertical is much more complex. It is covering four different levels compared to when we only had one puff. Obviously it could only be at

one level, because these are particles in the vertical, these have no vertical distribution. The vertical distribution in the concentration output is determined by the distribution of the individual puffs at the different levels; because each one of the puffs had no vertical dimension. And again another split occurs after 25 hours, 125 puffs, and again at 31 hours, and will continue on.

At the end of the simulation, it appears to stabilize at around 4300, but this stabilization, if you will, is an artifact of the setting of the maximum number of puffs. So if you go in the advanced menu, we have 10,000 as the maximum number of particles or puffs that are permitted in the simulation. And because of puff splitting, the model will never let the number of puffs exceed half the maximum, thereby leaving room in the array for additional emissions, additional puffs to be emitted. So that is one of the uses of the maximum parameter, and also clearly, this puff growth cannot continue unabated, it would quickly dominate the computational resources. Because the puffs increase at the rate of five to the power of the number of splits that occur. So there are subroutines within HYSPLIT that will merge puffs together. We will not be discussing this in any of the tutorial sections, but you can read about these routines in the help files, and the parameters that can be set to control the merging of puffs. But there is an error introduced, in a sense, when puffs are merged together, because the mass at two different positions will then be represented by a mass at only one position, even though the radius of the puff will be increased to compensate for that or other factors that go

into the merging process. In general puffs need to be within a certain distance of each other, and is of comparable size, and at a comparable level in the vertical, and also of a comparable age, to be to be qualified to be merged.

This this concludes our discussion of puffs.