In this section we will examine the difference between a forward dispersion calculation and a backward dispersion calculation. Previously, in the trajectory sections, we have done trajectory calculations from a source going downwind and also we have done the backward trajectory calculation, where the source would be the downwind location, and the trajectory shows the path, the upwind path, that would've been taken to get to that source location. We can do the same calculation with the dispersion model and the particle trajectories that make up the dispersion pattern can also be reversed. The practical application of this calculation would be an extension of what we have done in the previous section, where we had a known source location and we tried to determine what the emission rate was based on the dilution pattern to several downwind measurement sites, by dividing the unit source calculated values, the dilution factors, into the measurements, we obtained an estimate of the source. If the source location is unknown.

Another approach would be to do a backward dispersion calculation from the receptor location or the measurement location, and assume that the dilution factors from the receptor to the potential source regions would be the same if the calculation were to have been done from the source to that receptor. And that information could then be used to determine the source term required to obtain that measurement, or potentially when there are many measurements available, the location of the source could also, possibly be determined. To test the basic underlying calculation, we're going to compare, a forward,

the dilution factors from a forward calculation, and compare them with the dilution factors from the backward calculation. To do this we want to limit the calculation a little bit more in its scope.

So let's start by doing a reset, and loading the previously saved CONTROL and name list files. So I'm opening up the menu for the name list file and you will retrieve the unit source calculation that we had saved: the SRCFWRD and you should do the same for the CONTROL file.

And now we're going to make some changes to this calculation. This unit calculation started at 15, which was the starting time of the meteorological data. We will start again at 17, when the actual emissions started. And we're going to set the emission rate to a unit emission for one hour, we'll keep it short and keep it simple. And the only other thing we need to do is change the output intervals. So we will output every hour, the concentration field, and we will start at the time of the release. We're not at this point trying to match this calculation up with any real measurement data. We just want to compare the forward and the backward calculation. You may save and at this point you can run the model.

Let's briefly take a look at the results. You don’t need to change anything and what we want to do is select a location along the centerline of the plume that will see the material coming and going. So we can clearly identify the peak. And probably something along this time period. This will be the end, so we want to be, perhaps

somewhere around in Ohio, where we can see it coming and going, and perhaps we know the station. So let's select that location and take a look in more detail to what the concentrations are.

To do that we will go to the utilities, Convert to Station, and the Central Ohio location was 316, station three sixteen, at 41.3, you can check the CAPTEX report, and 82.22 W. Let's give the output a unique name and I believe that, oh and one last thing, let's go to integer units, since we only released one unit here, a pico-gram conversion is not sufficient, we should do a femto-gram conversion, which would be 10^{15}.

And now we should be able to extract data and you can see here that at hour 6 we've achieved the peak concentration or the peak dilution factor.

So from this location we should do a backward calculation, starting with a one hour release at 7 Z. So to configure that, let's quit and set up run and we will start on the 26th at 07 from this Oberlin, Ohio, location, which was 41.3, 82.22, and we don't need to run the full 21 hours, 14 should be sufficient to take us back to the forward calculation release start time. And one last correction is required in the grids menu, we need to start the sampling on the 26th at 07 and we will terminate the sampling, because we are going backwards in time, on the 25th at 17. And now we should run the model.

And in theory the dispersion factor we get in this backward

calculation from Oberlin, Ohio, to Dayton should be very close to the dilution factor we would get from forward calculation from Dayton to Oberlin, Ohio. And then with that information you could estimate the source. Let's take a look at the display very quickly. And we start here and in Ohio and we go backwards in time, taking us to somewhat close to the Dayton, Ohio, release point. So computationally what that would mean is this dilution factor, say from this, the red square here, should be very similar to the dilution factor to the other here going down wind to the receptor location. And if that's the case, if you have a measurement here, and you divide by the dilution factor, that would tell you how much source, would have to have been released from this location to give you the measurement here, at the Oberlin, Ohio, location.

Of course we don't know exactly where the source could be, right. If you're trying to do a source location you would be more information to triangulate the source position. But clearly as you go off the axis, here, the dilution factors are greater by four orders of magnitude out here, which means that if the source were out in this location in the cyan contour region, then you would need to release four times as much material to achieve the measured value at that downwind receptor location.

Okay, let's go back and take a look at exactly what those numbers are at the source location and we go to the utility menu, Convert to Station, and this will now be a backward calculation, and we're actually going to want to know what the value is at the Dayton, Ohio, release point. So that

was 39.9 and 84.22 and the multiplier should be E+15. And that should be it, extract data.

And you can see here for the hour of the release 17 to 18, the dispersion for the concentration prediction is 213 versus the 259 we have gotten in the forward calculation. So there is about a 20% difference between the forward and backward dilution factors. And this is not entirely surprising, because we know already from the forward and backward calculations of the trajectories, just simple trajectories without dispersion, that when a trajectory intersects the ground, it loses some of its reversibility, so there is an additional uncertainty added to the calculation. But in addition when we compute particle dispersion, remember that the turbulent velocity, that's applied to the particle motion each time step, depends upon the turbulent velocity the previous time step times an autocorrelation. So what that means is that there is memory associated with the turbulence, so that the amount of turbulence that is applied to the calculation this time, is partly dependent upon what it was the previous time. So practically speaking, if you were doing a calculation, let's say that's going from a high turbulence regime to a low turbulence regime, say from daytime to nighttime, some of that history of the larger turbulence will be carried over into the low turbulence calculation. But when the dispersion calculation is reversed and we go from a low turbulence regime to a high turbulence regime, we are carrying forward some of the low turbulence, backwards if you will in time, into the high turbulence region. So that the forward and backward mixing is not the

same because they have a different time history.

Because this equation cannot be reversed, we don't know what the turbulence should be before we get to the location. We don’t know that in the back calculation, so we have to use the history, the up in time history, going backward in time, so it it's not the same and it can never be the same. Practically speaking the approach, the approach where you assume that the backward dispersion calculation is similar, gives you the same answer as the forward, practically speaking, the results are close enough that it can be used for many problems and give very satisfactory answers. However, there is more uncertainty in the backward approach.

And this concludes the discussion of the difference between a forward and backward dispersion calculation.