We will now continue the discussion on deposition by looking at the dry deposition for particles. The only difference between the deposition, the dry deposition of particles versus that of gases, is that we add a deposition, or a what we call a settling velocity to the particle deposition. So the dry deposition flux at the surface, when the particle or a gas is in the surface layer, stays the same, that equation stays the same, where we multiply the deposition velocity times the concentration. However for a particle, we additionally add a velocity, what we are calling a settling velocity to the particles motion throughout the atmosphere, not just in the surface layer. So that particles will slowly settle toward the ground. And this particle settling velocity, calculated for a spherical particle, is related to the particle diameter, the gravitational acceleration, the particle density, the air density, and the viscosity of the atmosphere.

To do the calculation, let's go back to the menu, if you're continuing on from before, I think probably as a prophylactic to prevent unknown errors, let's do a reset, and then we will load the previously saved CONTROL and name list files, which were called deposit_control and deposit_setup. To configure the simulation, let's open the main menu bar for concentration setup, and this basic configuration already includes the deposition layer, so we're ready to go. But now we need to define the dry deposition for a particle. To make the calculation similar to the gaseous calculation, we will force a dry deposition velocity of 1 cm/s. Now this is still a gas, so we should define it as a particle. So if I click on particle, it populates this with nonzero values, but I don't want it to calculate the gravitational settling using these numbers, but what I want to do is override that. So if the deposition velocity is defined in the second line for dry deposition, it will override these values, and use this number, of 1 cm/s. Therefore it doesn't really matter what these numbers are, as long as they are nonzero. This essentially defines a particle and this particle will gravitationally settle with a velocity of 1 cm/s, as well as it will deposit to the surface, in the surface layer, when it reaches the surface layer, at a rate of also 1 cm/s. And that's all that's required to do particle dry deposition.

You may now run the model. Let's go ahead and do the display. We do need a both levels, we need the multiplier for picograms, and we should look at the total deposition sum, and I will skip right to the end, and you can see the deposition pattern, but I'm more interested in the concentration pattern. And at the last time period the peak concentration is now 4500 picograms per cubic meter. This is actually much higher than the dry deposition, gaseous dry deposition, which the peak was 3000, and the reason for this is the gravitational settling. If we were to look at the message file, I can do that, and scroll to the end here, you can see that instead of, what I think 130000, 130 kg, that we had in the gaseous run, we've removed even more mass, we only have 95 kg left. So there was actually more removal going on, but in the lowest four layers, we have 18, 19, or 20% of the mass is now in the lowest four layers, instead of the 10% that we had for the gaseous deposition. So the reason is that in the gaseous case, material was being removed in the lowest layers, so the concentrations and the mass went down in these layers, but as mass is being removed, less mass was available to deposit, so we actually had more mass aloft, for the same removal rate, 1 cm/s.   But the difference in the particle calculation is that particles were gravitationally settling from the upper layers into the lower deposition layers, resulting in higher concentration, higher air concentrations, and correspondingly more mass removal.   Note that we still have 20,000 particles and about hundred kilograms or 100,000 g of mass, so each particle contains approximately 5 grams of mass.

I'm sorry, yes, right, we've reduced mass.   Next there's another approach for doing particle deposition, but before, before we move on, let's just save the, let’s rename those output files by going to the working directory, and let's rename the MESSAGE file so we have it for future use, so the MESSAGE, let's say particle, and also the graphic, we'll call it plot particle. So there is a second approach to doing particle dry deposition, if you go to the name list and you open menu number 10, for conversion modules, there is an option here where I we can deposit the particles rather than reducing the mass of each particle.   What this means is that when we did the original calculation, we had 10 g per particle, that is we released 20,000 particles and we had 200,000 g of tracer distributed over those 20,000 particles.   Now by doing this other approach, what we do is compute a probability of whether or not a particle will deposit, and that probability is related to the time factor, the removal, the dry deposition removal time constant and the time step. So if the computer generated number is less than this value we will deposit the particle, that is, it will remove it from the calculation.   So one of the advantages of this approach is that as more material gets deposited, the model certainly runs faster, because it is tracking fewer particles, but the downside of this approach is that the calculations may get noisy in the more distant domains because the spatial density of the particles is not sufficient to give us a smooth pattern.

So to do this calculation, save after we made that change, and we run model again.   And let's do the display and let's proactively rename the output here to plot_prob and execute.   And let's go to the end, so the last concentration time period also shows a comparable peak concentration 4600 pg.   If I were to look at the MESSAGE file, scroll down to the end here, you'll see that we still have about 95, 96 kg of mass left at the end, but now instead of 20000 particles, we have only 10000 particles, which means that, let's say rounding off here, a hundred thousand grams, 10000 particles, that's 10 g per particle, which is the same value that we released.   So that the mass on the particles does not change.   Whereas, in the other approach, the mass on the particles was reduced, we had, you know 100000 grams, but only over 20,000 particles, which meant we had half the mass on each particle in that approach.   But we still maintain the particle density, if you will, in terms of the calculation.

You can look at the peak concentrations for each of the time periods here and you can see the particle calculation, the dry deposition particle calculation, gives us comparable results to the probability approach.   And both, of course, show somewhat higher concentrations here compared with the gaseous at the end. And of course all of them are lower than the base case with no deposition.

So normally when running HYSPLIT we just use the particle approach where we are depleting mass on the particle rather than deleting particles because of the issue with insufficient particle density at the longer downwind distances.

And this concludes our destruction of dry deposition of particles.