We are going to continue to examine the sensitivity of the air concentration to different parameters. Now we are going to look at the stability computation method. As you recall in the previous section, we found that the turbulence, that we used to describe the particle dispersion or the puff growth, was computed based on equations that were sensitive to the stability parameters u*, boundary layer depth, as well as a heat flux related stability parameter.

So the question is how are these computed and there are two approaches. In the first approach, if the meteorological model provides certain flux fields, that is the heat and the momentum flux, which is the amount of velocity that's being transported, the momentum of the velocity being transported to the surface, and a heat flux, then these quantities can be used to estimate the stability parameters through these equations and actually several more. A more detailed description is found in the Technical Memorandum that can be found in the documents directory. If no fluxes are provided by the meteorological model, we can estimate the normalized Monin-Obukhov length by computing a Bulk Richardson Number, which is just the ratio of the buoyancy over the wind shear. That is, the gradient in potential temperature over the gradient, vertical gradient in the wind velocity. So, this term gives us a ratio of the amount of, or the strength of the buoyancy, in terms of whether or not it enhances or suppresses the turbulence generated by the vertical wind shear. And there are then functional forms, and they differ depending upon the stability, that can be used to convert the Bulk Richardson Number to this normalized Monin-Obukhov length. And of course the other parameters such as u* can also be estimated once we have a stability parameter. Again I would direct you to the Technical Memorandum for more detail.

Now we do this computation using both approaches and examine the difference in the computation. So we will assume you're continuing on from the previous section, but let's start clean, and we're going to load the configuration that we had previously saved. So click on reset and then open up the set up run menu and retrieve the CONTROL file conc_case_control.txt, which we had saved originally after we did the case study optimization. Remember this uses the WRF data. In the advanced menu for the name list do the same thing, and retrieve conc_case_setup.txt and just to ensure that we're getting the right answer, run the model, and display.

Again if you were not continuing on from the previous section, some of these options may not be set. For instance, the map domain should be off centered a little bit, actually we don't need to bother with this. And we need to display the 1000 meter level and convert to pg, and set our own contour intervals of 50000, 20000, 10000, 5000, 2000, 1000, and finally 500. And the file for the measured data which was data_case.txt, in the tutorial directory, and display to 80%, and let's see what we get. Yes, and this is the result you had previously with a peak of 31,000 pico-grams per cubic meter, very close to the actual measured peak.

And if we go to the advanced configuration and look at menu number seven, the default approach that we just used is using the heat and momentum fluxes from the model, and it uses the Kanthar-Clayson by default, we didn't actually set this, but that we know it is the default.

So the next step is let's try the same calculation but instead of using the heat and momentum fluxes we will compute the stability from the wind and temperature profile using the Bulk Richardson Number. Save, save, and run model, and display.   And in this case we have, actually have, a quite dramatic difference, the plume has not mixed out as much in the along wind direction and the peak concentration is 22,000 rather than 31,000.   So this one was quite a dramatic difference and we know that, we used this temperature profile, because if we go to the MESSAGE file, we would see that the KBLS parameter is now set to 2 as is the PBL mixing scheme, or stability method I should say.

So now, in the last option, we can do one other thing. Look at the effect on stability.   So go back to menu seven. And normally the mixing profile varies with height in the boundary layer but let's instead use a constant value, replacing it by the average value for the entire PBL, that is below the mixed layer depth.   Now save and close these menus.   And what this means is back in the equation that we used to compute the, for instance the horizontal, the vertical diffusivity for heat, which is the surrogate for vertical mixing, you can see that it is sensitive to height.

So the further above ground, the larger the vertical eddys are that would redistribute the pollutant.   If we want the model to replicate an analytic solution, for instance the Gaussian solution for a source, then that analytic solution relies on the fact, or assumes that the vertical diffusivity is constant with height.   So to replicate those kinds of solutions you would make, you would set the flag to ensure that the diffusivity is constant with height. And the effect of that on the calculation, we can run the model again. Display, and you can see that the answer is almost the same, slightly different peak, but it's a very similar structure. It really had, in this case, had not much effect, and because of the way the PBL mixing is computed, it would have the greatest effect for shorter-range simulations, where we’re replacing a small vertical mixing coefficient, when the plume is near the ground with a much larger value, but for the longer-range simulations, it is less sensitive to that parameter

But the main point of the discussion on sensitivity here is that there are two approaches to computing stability; the gradient method and the fluxes from a model, the meteorological model.   And what I would like to point out is that these two approaches are not identical, so that the stability approach, the Richardson Number approach, uses the, for lack of a better word, the instantaneous values of wind and temperature that are output from the meteorological model to compute the stability at that particular time step.   Whereas the flux output from a meteorological model, the momentum flux, the friction velocity that this output rather than u*, it depends, or the sensible heat flux, these fluxes are very, in very many models, output as averages, time averages. So if the model is outputting every three hours or six hours, those values may well be six-hour averages or three-hour averages. So it's not really a one-to-one comparison and between the profile approach and the flux approach. And the flux approach is preferable, but it's preferable if the averages, the averaging period is much smaller. So there is no one answer here, but you need to understand the model sensitivity to these parameters, the dispersion model sensitivity. But in most situations it is going to be outside of the scope of the kind of control you have over the simulation. But it is something that goes into producing a dispersion ensemble when we try to determine what possible range of solutions might apply for a particular simulation.

And that concludes the stability method discussion.