To complete section 9 on air concentration parameter sensitivity, we will take a closer look at the turbulent kinetic energy. The turbulent kinetic energy is defined as the sum of the turbulent components, the turbulent velocities squared in each of the three component directions. Some meteorological models predict this field and it is preferable from the standpoint of a dispersion computation to use this field directly rather than trying to estimate the turbulence from the vertical gradients of temperature and wind or from the flux fields, momentum or heat fluxes, by using various parameterization equations.

So, therefore, when HYSPLIT recognizes that a meteorological model output file has the TKE field, it will use that rather than the other default method to compute the turbulence, which was the Kanthar-Clayson equations. However, there was one complication. Normally the models, the meteorological models, will only predict the total turbulent kinetic energy, not the individual components. Therefore we still have to make an assumption. And in the case of HYSPLIT, we assume and an anisotropy factor, that is a fixed ratio between the vertical and the horizontal turbulent components. The default ratio that we use is .18, that is 18% of the total turbulence is defined in the vertical component. There are options to change this. We will review that in this section.

Now the previous calculations that were done used the WRF data. The particular version of WRF, the configuration of WRF, that you used to generate these fields for CAPTEX, did not have the turbulent kinetic energy as an output option. However the field is available in the North American Regional Reanalysis. So the first step is to redo the calculation using the NARR data. Now if you have been continuing on from the previous section, we have been making a lot of changes to the name list file and other files, or other graphical user interface parameters. So therefore, before we get started, it's best to RESET and then load the previously saved configuration that we had generated earlier in section 9 regarding the base case optimization. So go to set up and retrieve the file conc_case_control.txt file and do the same thing for the name list file.

Now to change the calculation to use NARR, you should all already know what to do, and that is just open up the menu, clear the meteorology field, and add the NARR field. And that is all the change that's required, and then run. Now we open display and because we did a reset, we need to relabel, define the 1000 meter layer where the aircraft was, the multiplier for picograms, we are going to have user set contours, and we will select the measured data for the case that we're looking at here, and zoomed 80%. And the result is something similar to what we have before, except for three things, two things. One the concentration, the peak concentration is much higher. Recall that it was 31,000 before when using the WRF data, but now it's 53,000. Also the tracer plume is running a little slower, it is not as advanced downwind as in the previous calculation. If you don't remember that you could just look here, where we show you a saved version. Remember the 31,000. So it's close but not quite the same, which is not unexpected.

Now how do we know what happened. If you go to the MESSAGE file for this simulation you will see right in the beginning, well I didn't have to do this, that because the NARR data does not have valid fluxes, the model will use the wind and temperature profiles, but because it also has TKE and the turbulence method was undefined, that is KBLT was initially set to zero, the model will select the TKE for doing the turbulence calculations, the particle mixing calculations. In fact it really doesn’t care about the wind and temperature profiles. It is really one advantage of having the turbulent kinetic energy field available, in that it does simplify the dispersion calculation and in a sense it makes it much more accurate because the TKE field coming from the meteorological model is much more consistent with the data fields, the wind and temperature structure and gradients in those fields of the meteorological model than if we try to estimate that after-the-fact using other equations that may not be the same equations that were used in that meteorological model.

So let's compare, as a next step, just out of interest, what would we have gotten, if we can compare the NARR simulation directly with the WRF simulations, can we make everything the same, except the meteorological data fields. And to do that we need to go back to the menu seven on the name list, and in this case the vertical turbulence method is undefined, right, that was the default, so we will force it to use Kanthar-Clayson even though we have TKE available.   So we are forcing it to use this which will be then the same as the WRF calculation, which also uses the Kanthar-Clayson approach.   And even though this here is defined as a default, it doesn't really matter it's going to use the temperature profile because the fluxes are not available in this field.   So it doesn't really matter which one of these you check, but this is actually what we will be doing, and as I mentioned if we were using TKE, this is where that field would be set, the anisotropy ratio, but now we're not using it.

So save and then go ahead and run the model.   And now show the result, and it's quite dramatically different.   The peak concentration is much lower, 14000, and also more compressed, but interestingly it is faster than the previous calculation with the TKE mixing.   So probably the result of slightly different mixing puts some of the material in faster winds.   So can we compare this with the WRF calculation that was done several sections ago. I believe we might have that saved, here, that was the right one, that was not the right one, we need to go back to this menu, yes.   So this was a calculation that we have done in that section, when we're looking at different stability schemes, and we used the temperature profile and the Kanthar-Clayson approach but this time with the WRF data and you can see it has a similar structure to what we had calculated with the NARR data. The concentrations are also lower, 22,000 not quite as low as 14,000 but it also had this smaller, not as elongated plume. So really the only difference between these calculations, they used the same stability method, temperature profile, and the same approach to computing the turbulence, the Kanthar-Clayson equations. The only difference between these two is that one uses NARR for winds and the other uses WRF data for the winds. The mixing selections can be quite important.

And lastly let's take a look at the sensitivity to the TKE. Now the first calculation we did with the TKE gave us that the peak of 53000, 54,000 if you recall.   So let's go ahead and this time let the model compute the ratio, the anisotropic ratio for the TKE.   So let's back to menu seven and we will explicitly tell it to use the TKE field, but what we're going to do is we're going to define, here in the anisotropy factors, we're going to select, set this to none, and make these value zero.   And when that factor is set to zero, the model will compute the anisotropy factor and it will use the, probably no surprise here, the Kanthar-Clayson equations to compute the ratio between the W prime, and U prime, and V prime.

So save, save, and let's display the results.   Now you can see the plume is more elongated as it was before and the peak is down to 37,000 rather than 54,000.   Recall the original calculation, not that original calculation, that original calculation, they look very similar except perhaps the new one is a little faster but certainly the peaks are lower.

And lastly let's do one more thing let's, just as a last example, let's force the ratio, and we're going to give it a value, a rather dramatically lower value like 5%, 0.05, so we're going to have much less turbulence in the vertical that will constrain the mixing and do a save. Now the reason you may want to do this is that you may know something about the meteorological situation or the local area that the model is being applied to and perhaps there is a local stability, maybe it's in a valley, that has more stable conditions and you want to restrict the vertical mixing, a little bit more. You can do that by essentially partitioning the turbulence in one direction or another. So now what we get, of course, is a much higher concentration, a more circular pattern.

This is similar to the other option that's available in this menu, where I mentioned, you can also force urban here, which essentially puts more turbulence in the vertical component at night. For instance, studies have found that the enhanced roughness in an urban area that is added by the buildings and other structures would cause more vertical mixing than in the surrounding suburban and rural areas. And if the meteorological model output does not really reflect the effects of the urban area, because maybe the grid cell resolution is too course or it's just not defined in that model as a land-use change, then you can adjust the mixing because of what you know in terms of local conditions being different than the conditions for which the meteorological model was run to generate those fields. So in those situations you may want to force the partition of the turbulence.

And that concludes the discussion of the turbulent kinetic energy.