Talking points:

1. Title

2. For our Learning Objectives we’ll look to understand the generation, display and limitations of the synthetic / simulated imagery. We’ll also introduce how the use of synthetic / simulated satellite imagery from NWP can aid in the forecast process of cloud cover, low cloud / fog, convection, as well as extra-tropical cyclogenesis. Finally, we’ll look at how to verify synthetic / simulated satellite imagery with GOES-R imagery.

3. Throughout this module we’ll be looking at the synthetic imagery from two different models, the NSSL WRF-ARW model and the NAM-Nest, both at 4 km horizontal resolution with output from the 0000 UTC run. Certain model output fields, including cloud water, cloud ice, temperature, water vapor and so forth as used as inputs to a model that generates the synthetic imagery. The radiative transfer model uses inputs from those model fields and outputs brightness temperatures at a number of spectral bands. For more detailed information, refer to this article.

4. Synthetic / simulated satellite imagery is becoming more popular; we expect this to eventually become a standard model output field much the way simulated radar reflectivity has become. For that reason, be aware of which model you are analyzing.

5. The forecast output availability will vary by model, for example, from the NSSL WRF it’s available hourly for the 9 to 36 hour forecast valid 09Z of Day 1 to 12Z of Day 2. For the NAM Nest it’s hourly for the 00 to 36 hour forecast valid 00Z of Day 1 to 12Z of Day 2 but then 3 hourly after that for the 39 to 60 hour forecast, it does go out further in time.

6. Another reason you want to be aware of which model you’re looking at is that the microphysics package has a large influence on the appearance of simulated clouds. For more details about this refer to the article, in the next slide we’ll be looking at an example.

7. Lets compare the IR imagery from the NSSL WRF-ARW with the NAM-Nest, both at 4 km spatial resolution with the same color table. The bands are slightly different but for all practical purposes are the same for this comparison. What is different between these is the microphysics package, the NSSL WRF uses WSM6, while the NAM-Nest uses Ferrier microphysics. The WSM6 microphysics package has a known bias to underestimate areal extent of convective clouds. That’s with respect to GOES or the NAM-Nest synthetic imagery. Keep in mind, just because the NSSL WRF is underestimating areal extent of convective clouds, it doesn’t necessarily make it a worse or better forecast than the NAM-Nest.

8. This is the synthetic 10.35 micron band from the NSSL WRF-ARW model. This spans from the morning hours to the afternoon hours. It shows an area of stratus across much of the central and southern plains during the morning hours, forecast to dissipate by the afternoon and with that we see some afternoon convection develop in this region.
9. Here’s the GOES 10.7 micron imagery and you can see an agreement with the model output. Much of the stratus that we saw across the plains has dissipated by mid-day allowing for sufficient insolation and destabilization to take place for thunderstorm development from Nebraska down into Oklahoma.

10. This is the synthetic low cloud / fog product from the NSSL WRF-ARW model. This imagery is produced by subtracting the simulated brightness temperatures at 3.9 microns from those at 10.35 microns. This appears similar to the GOES low cloud / fog product you may be used to analyzing, however there are a couple key differences. First, due to computational limitations nighttime is assumed constant in the calculation of the 3.9 micron imagery therefore the brightness temperature difference remains positive even during the daytime since there’s no reflected solar radiation. Second, there’s a false cloud signature in the southwest at certain times due to surface emissivity at these wavelengths, we can see a few of these in New Mexico, Arizona and also out in this region as well. You can identify these positive brightness temperature regions that are stationary for long periods and appear in generally in the same places in the southwest US. Keep in mind that the simulated imagery does not discriminate between low clouds and fog, the GOES-R Fog / low stratus is recommended to make that discrimination at analysis time. Note how easy it is to discriminate between forecast high and low clouds in this product. High clouds are these black / gray clouds while low clouds are various shades of blue like we see over the plains with increasing confidence of low clouds in the darker shades of blue as we see in this color table. This color table choice is important for this product, therefore we advise this color table for analysis.

11. This is the synthetic water vapor imagery at 6.95 microns from the NSSL WRF-ARW on the left, and corresponding GOES 6.5 micron on the right using identical color tables. This slight difference in wavelengths accounts for why brightness temperatures generally appear warmer with the synthetic imagery on the left. When analyzing extra-tropical cyclones, focus on cyclogenesis components such as the conveyor belts, jet streaks and shortwaves that may contribute to intensification and so forth. In this particular example we will pretend that we are focusing on the Boston CWA and we’re concerned with the dry slot moving in.

Model confidence can be assessed using the synthetic imagery.

12. For this case, we will be analyzing the synthetic 10.35 micron imagery from the NSSL WRF-ARW. Let’s pretend that we’re forecasting for the region I highlight. You will be assessing the clearing trends for potential thunderstorm development during the afternoon hours across the region of interest. This process entails identifying where morning clouds may exist and if/when they’re forecast to dissipate so that insolation may contribute to destabilization. I’ll let you analyze this loop for a moment before moving on to the morning GOES imagery to assess your confidence in this forecast.

13. Here is the verifying GOES visible imagery through 19Z. For the region of interest, assess your confidence in the model forecast. You may go back and forth between this slide and the previous if you need more time looking at the simulated IR imagery.
14. Here is the verifying GOES visible imagery during the late afternoon and evening hours. Hopefully you caught on to the trend that low clouds were persisting in northeast Colorado and western Nebraska much longer than forecast by the WRF. The low clouds prevented destabilization and therefore thunderstorm development across that region where thunderstorms had been forecast. The model seemed to do a better job in central / southeast Wyoming where clearing and destabilization took place. The storm in southeast Wyoming was severe for a period of time before eventually moving into the region of low clouds causing it to weaken. This example illustrates how to compare the simulated imagery with the observed imagery throughout the day so that you may assess confidence in the model output in an efficient way.

15. In conclusion the synthetic / simulated imagery allows one to see many processes in an integrated way compared to looking at numerous model fields and integrating them mentally. We looked at a number of applications including cloud cover, low cloud / fog, remember from the forecast perspective you can utilize the synthetic / simulated imagery and for a diagnose use the GOES-R fog / low stratus product. For convection, with the IR imagery, look for clearing trends for destabilization, with the water vapor band look for jet streaks, shortwaves, you can also analyze elevated mixed layer, elevated cold fronts and so forth. For extra-tropical cyclogenesis, remember to focus on cyclogenesis components such as conveyor belts, jet streaks / shortwaves that contribute to intensification