

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 synthetic IR imagery from the NSSL WRF-ARW with the NAM-Nest 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-Aligo 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.

8. A word about verifying synthetic imagery against GOES. As we just discussed, the areal extent of clouds will look more realistic in the NAM-Nest due to the microphysics package used. This does not necessarily mean the NAM-Nest outperformed the NSSL WRF-ARW. In other words don't use the pattern of areal extent of the cloud tops as the way to verify which model did better. Use the timing and location of the feature of interest, whether its convection or clouds or whatever. If you're using the IR imagery to forecast the possibility of clearing and subsequent destabilization, use the timing and location of the clouds to judge model performance.

9. This loop covers a nor'easter event on 7 March 2018. We're looking at 2 of the 3 GOES water vapor bands with GOES imagery on the top row and the corresponding bands of synthetic imagery from the NSSL WRF on the bottom row. When analyzing a cyclogenesis event, it's important to focus on the various components of cyclogenesis, for example the warm conveyor belt, dry slot or jet streaks that come in to intensify the system. One of the important aspects of this particular cyclone was the development of a TROWAL airstream which shows itself as a region of convection that develops east of New Jersey. This convection fills in between the warm conveyor belt offshore and the surface low along the coast. Once the convection fills in with its associated TROWAL airstream, this allows more unstable air from the warm sector to feed into the surface low, intensifying it and leading to more hazardous weather in general. This could have been analyzed with traditional model fields of RH, potential temperature and so forth but we can formulate our conceptual model in a more efficient way since we can conceptualize what is going on in GOES imagery based on our experience of satellite imagery interpretation and compare that with an integrated perspective of model output.

10. This is a short loop that spans between 07Z and 10Z and shows NSSL WRF synthetic imagery from the 3 GOES water vapor bands in addition to the IR band. We see a noticeable change occur in the cloud patterns between 08 and 09Z. This is the new model run, recall the NSSL WRF is displayed in AWIPS between 09Z of Day 1 to 12Z of Day 2. This is another reason it's important to understand which model you're looking at since there is variability in what forecast times are displayed.

11. In this example we have model output in the 2 panels on the left, with synthetic imagery from the NSSL WRF at 7.3 microns on top and on the bottom we have GFS 700-500 mb specific humidity. On the right 2 panels we have observed imagery, from GOES-16 7.3 microns on top and the advected layer precipitable water product in the 700 to 500 mb layer on the bottom. In this case, we're concerned about a mid-level dry intrusion that leads to steeper lapse rates and destabilization with daytime heating which is a concern for the convective weather forecast. The synthetic imagery at 7.3 microns depicts a region of warmer brightness temperatures that is associated with a mid-level dry slot as supported in the model specific humidity field in the 700-500 mb layer. The NSSL WRF has forecast convection in eastern Kansas by the end of the forecast loop in response to this mid-level dry slot. We can follow this feature in the GOES-16 and ALPW imagery, noting the timing and location of the dry slot. As the afternoon progresses we gain more confidence with the model solution as it continues to look similar to what is observed.

12. This is a short loop that spans between 09Z and 13Z over Arizona. In the upper left is the synthetic fog product from the NSSL WRF-ARW and the forecast is time matched to observed GOES-16 imagery. In the upper right is the GOES-16 fog product and the lower left is the GOES-16 Nighttime Microphysics product. In the lower right we have the ceiling and visibility plot.

Focus your attention on all 4 panels at this location.

The model forecasts low cloud or fog in this region as indicated by the positive brightness temperature difference values, which are blue in this color table. We can see that this region of low cloud or fog developed at roughly the same time that was forecast as we verify in the GOES fog product in the upper right and the GOES nighttime microphysics RGB in the lower left. Recall that the fog appears dull aqua to gray in the nighttime microphysics RGB. Note the rapid decrease at the site where visibility is observed and fog is confirmed.

Assess the model forecast via the synthetic imagery and if it appears close to observed GOES imagery timing and location, then this can give you increased confidence in the model forecast.

13. Synthetic IR imagery is a popular tool to help forecast lee wave or orographic cirrus clouds. These type of clouds develop along mountain ridges and are stationary therefore easy to spot in both synthetic and observed GOES imagery.

In this case, forecast synthetic IR imagery from the NSSL WRF-ARW is shown on the lower left and synthetic IR imagery from the NAM-Nest on the lower right. Since we span 09Z in the loop we change model run initialization times with the most recent 00z run in the later portion of the loop. Synthetic imagery can be compared with corresponding GOES-16 imagery to assess confidence in the model forecast. GOES-16 IR imagery is in the top left and GOES-16 nighttime microphysics RGB in the top right.

The NSSL WRF-ARW did a pretty good job of forecasting location and timing of lee wave clouds in Colorado and Wyoming. For the NAM-Nest, the update to the more recent 00Z run seemed to do a better job at catching on to the lee wave clouds in Colorado, but already had lee wave cloud development in Wyoming from the prior model run.

The green regions on the orographic cirrus during nighttime in the nighttime microphysics RGB is an indication of relatively small ice particles which are typical for these type of clouds.

We've presented just a few application examples of how to make use of synthetic imagery but there are many others.

14. 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 diagnosis 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 the 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