Talking points for “Utilizing Synthetic Imagery from the NSSL 4-km WRF-ARW model in forecasting Low Clouds and Fog”.

1. This training session is part of a series that focuses on applications of synthetic imagery from the NSSL 4-km WRF-ARW model. In this training session we’ll consider applications of the synthetic fog product towards analyzing low clouds and fog. The primary motivation for looking at synthetic imagery is that you can see many processes in an integrated way compared with looking at numerous model fields and integrating them mentally.
2. Objectives. Regarding the reflected solar radiation being neglected, this is a limitation in that comparison between the synthetic fog product and the GOES fog product is only valid at night. However, there are other products to compare the synthetic imagery that we will discuss.
3. Synthetic imagery is model output that is displayed as though it is satellite imagery. Analyzing synthetic imagery has an advantage over model output fields (such as relative humidity) in that the feature of interest appears similar to the way it would appear in satellite imagery. There are multiple sources of synthetic imagery available on the web, for example the CRAS model at the university of Wisconsin has been available in AWIPS via the LDM for some time. The primary focus of this training session is synthetic imagery generated from the NSSL 4-km WRF-ARW model. The model is run once a day (at 0000 UTC), certain model fields are distributed to CIRA and CIMSS. These model fields are used as inputs into a model that generates the synthetic imagery. Gaseous absorption is calculated for cloud-free points, and Modified Diffraction Theory is used to obtain scattering and absorption by the cloud particles. The model outputs brightness temperatures for a number of satellite bands. For more information on the details of synthetic imagery generation, refer to the references on the student guide webpage.
4. Now we will discuss how the synthetic fog product is generated. It differs from the other synthetic bands since the 3.9 μm band is much more computationally expensive therefore an assumption must be made to make the imagery in a timely manner.
5. The color table used in this session will highlight the positive temperature difference in blue.
6. Hourly output is generated for the 9 to 36 hour forecast, valid 09Z of Day 1 to 12Z of Day 2. Once the new model run comes in, it writes over the 33 to 36 hour forecast valid between 09 and 12Z from the previous run. The bands are those that will appear on GOES-R since the project is based on demonstrating products that will be available on the GOES-R satellite, scheduled for launch around 2015. The bands are very close to those found on the current GOES satellites, so that the principles discussed in this training session readily apply to operational GOES satellites of the present.
7. Synthetic fog product for 27 January 2012. This is from the 0000 UTC 27 January model run. Easy to discriminate between high level clouds (black and dark grey) versus low clouds (light to dark blue). Remember that we cannot discriminate between low clouds and fog from this product alone, other datasets must be examined to address this. Note the regions that appear to be low cloud in the southwest US and Mexico that are there for the entire duration of the loop and do not move. This is a false cloud signature that is a consequence of surface emissivities at the two channels. The easiest way to spot the false signature is to look at the loop, and the areas that don’t move at all throughout the duration of the loop are likely false emissivity signatures. Also, these signatures tend to show up in the southwest US and Mexico. You may notice the odd streaks in the Pacific ocean off the west coast. This is due

to the way the data is processed in AWIPS, you will not see this in the product on the CIRA web-pages. This artifact in AWIPS leads to a +/- 0.5 °C uncertainty in the difference product, however by utilizing the advised color table, this artifact will not have a meaningful effect on the interpretation of the location of low clouds / fog. Across Louisiana, Mississippi and Arkansas we see the development of the low cloud signature during the nighttime hours, lets investigate this further by zooming into the region.

8. Synthetic fog product between 0900 – 1700 UTC 27 January 2012. In the eastern half of the scene, we see low clouds advecting towards the east / southeast. In the western half of the scene, we see the development of low clouds during the nighttime hours. These clouds appear to expand then dissipate more than advect, so we may suspect radiation fog development. We look at other datasets to confirm if this is radiation fog.
9. GOES heritage low-cloud / fog product over the same time period with observations overlaid. The METARs show a small temperature/dewpoint spread and light winds which would support radiation fog development. The fog product shows the development of low cloud regions in the same general area as the synthetic fog product and it appears to be a radiation fog rather than an advective fog, while the METARs provide confirmation of fog. Note that we see a transition from a positive temperature difference (blue) to a negative temperature difference (dark grey and black) as the sun is rising. This makes sense since we're introducing a solar reflected component which is detected in the 3.9 μm channel. This will not show up in the synthetic imagery because nighttime is assumed, therefore there is no solar reflected component. By the end of the loop we do see dissipation of the region of fog in Mississippi but it is complicated to some extent with the transition between a positive temperature difference and a negative temperature difference.
10. One way to get around this change in temperature difference between nighttime and daytime is to utilize the CIRA low cloud and fog product. This allows the user to observe low cloud or fog the same color, regardless of time of day. In this enhancement, low cloud or fog is light grey to white while high level clouds are color enhanced like the usual IR imagery.
11. Here is the GOES visible imagery starting from sunrise up to the end of the previous loop. The dissipation of the fog in Mississippi can readily be seen.
12. For our next example, we'll look at the synthetic fog product from November 30,2011. The area of interest is the central valley of California. Remember to neglect the false cloud signature that we see through portions of the southwest US into Mexico. Midway through the loop we spot low cloud or fog in the central valley of California that dissipates from north to south in time.
13. CIRA low cloud and fog product which shows the low cloud / fog signature over the central valley of California dissipating from north to south.
14. GOES visible imagery showing the low cloud / fog signature. The biggest question you may have is, why does the areal coverage of the low clouds / fog appear much larger than what was forecast in the synthetic imagery? This may be a result of inadequate vertical grid spacing in the model in a situation with a very shallow layer of fog. We've seen this trend in other cases as well.
15. Synthetic fog product between 0000 UTC and 1500 UTC 19 March 2012. Since the time spans across 0900 UTC, we introduce a new model run between 08 and 09 UTC so that the 0000-0800 UTC images are from the 0000 UTC 18 March model run, and from 0900 UTC on we are looking at the 0000 UTC 19 March model run. Up to 0800 UTC the trend appears to be the advection of low clouds from the Atlantic westward towards the coastline. With the

new model run, we see extensive low cloud development from eastern North Carolina northward to Pennsylvania.

16. We'll analyze the GOES heritage low-cloud / fog product only during the nighttime hours and end the loop before sunrise. Although the coverage of low cloud is less than the model forecast, we can see localized areas of low cloud development between eastern North Carolina and Pennsylvania as the model indicated. Overlay the METARs to identify what areas have fog. The predominant areas are around coastal NC, the shoreline of Maryland, and just north of Chesapeake Bay from Maryland into southeast PA.
17. In the GOES IR imagery, it is more difficult to identify the regions of low-level cloud that we just identified in the GOES fog product. Perhaps the best use here is to identify some areas where higher level clouds are advecting over areas where low-level clouds exist.
18. The CIRA low cloud product along with the METARs as an overlay highlight localized areas of low cloud / fog (in lighter shades of gray or white in this enhancement), outside of areas where higher level clouds are moving by. For example, the eastern coast of NC, southeast coast of Virginia, the coast of Maryland, and the northern Chesapeake Bay region around Baltimore into southeast PA. Near the end of the loop, you can see some areas where the low cloud / fog is dissipating.
19. Here is the CIMSS GOES-R fog / low stratus product. This is an analysis product that shows the probability of IFR conditions expressed as a percent. Ideally, the synthetic imagery would be used to see where fog may occur, and this product would show if the forecast is verifying. It does have an advantage over the CIRA low cloud / fog and GOES heritage fog product, for example, in that it is a fused product that makes use of satellite imagery as well as very short term NWP output so that it can discriminate between fog and low-cloud, and multi-layered cloud decks are not an issue. In our example, we can see maximum values around the Chesapeake Bay peaking around 10:15 UTC and decreasing significantly by 14:15 UTC. This is quite similar to what was forecast by the model, shown in the synthetic imagery.
20. The synthetic imagery can be very useful on days that you are expecting convection, and one of the forecast questions is how much insolation will take place for sufficient instability to develop. In the synthetic IR imagery we see low clouds forecast during the morning hours over portions of the Plains from Texas to Nebraska. These clouds are forecast to dissipate over a large portion of the region, with the exception of further north in eastern Nebraska and parts of Kansas. Convection is forecast to develop along a boundary that becomes apparent by 2200 UTC.
21. Synthetic fog product for the same period of time. The thing to note is how much easier it is to identify the low level clouds of interest. The low clouds are easier to identify, and discriminate from the higher level clouds and also the ground. The color table helps identify the low-level cloud as it stands out being colored blue. The only disadvantage to mention, is that we do have regions of false cloud signature in far west Texas and New Mexico that is a consequence of emissivities of the 2 channels as discussed earlier.
22. Comparison between synthetic fog product and GOES visible imagery at 1400 UTC. Fade between the images to identify regions where the model was doing well versus areas where it did not do so well.
23. Here is the GOES IR imagery to see what took place. Most of the low cloud dissipation that took place over Texas, Oklahoma and Kansas was well forecast, allowing sufficient insolation to take place in the warm sector ahead of the dryline where convection developed late in the day. Note the region of clouds in southeast Nebraska where they appear to be

breaking up to some extent by afternoon to allow for some insolation to occur. We see convection develop in southeast Nebraska by the end of the day.

24. The GOES visible imagery during the same time period offers the best resolution data possible which is important for regions like southeast Nebraska. In the IR imagery it appeared to have some clear breaks within a field of low-level clouds by late afternoon. The visible imagery, with its higher resolution, shows considerably more clearing than looking at the IR imagery alone. Keep in mind, that this resolution effect may show up in the synthetic imagery as well. The synthetic imagery is at 4 km resolution so that a field of partly cloudy skies may be smoothed out at 4km resolution and appear to be greater cloud coverage than reality.
25. Conclusions (1)
26. Conclusions (2) – refer to VISIT web-pages for more information on the GOES-R fog / low stratus (FLS) product.
27. Where to view the synthetic imagery. Using an appropriate color table is very important for this product due to the cutoff point for the positive difference. We recommend the color table shown in this training which you can download at this ftp site. See the SIMFOG enhancement in the color table file.
28. Contact information.