Talking points for "Utilizing Synthetic Imagery from the NSSL 4-km WRF-ARW model in analyzing Cyclogenesis".

1. Title slide
2. It's recommended that you take the VISIT training session "Cyclogenesis: Analysis Utilizing Geostationary Satellite Imagery" before taking this course as it stresses satellite identification of various air-streams important for cyclogenesis and different types of cyclogenesis.
3. Objectives. The objectives will be very similar to the previous cyclogenesis session identified in the prerequisites. The difference here being that we're applying these principles to the synthetic imagery rather than the GOES imagery.
4. Background information on the synthetic imagery we will be discussing.
5. 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 imagery is available to view between 10 and 14 UTC depending on the band. Keep in mind, if you look at this in the morning time frame, you will be looking much further into the future compared to looking at this in the evening. Some of the cases we look at in this training start at 12Z, these cases took place before we changed the first image to display to 09Z. 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.
6. Comparison between NSSL WRF-ARW water vapor synthetic imagery (at 6.95 μm) and GOES water vapor imagery (at 6.5 μm). Recall that the model is run once a day at 0000 UTC. At the time, the new model run started at 12Z rather than what is done currently which is 09Z. The early synthetic images between 0500-1100 UTC 1 February 2011 come from the 0000 UTC 31 January model run, while those from 1200 UTC forward are from the 0000 UTC 1 February model run. This explains the discontinuity between the 1100 and 1200 UTC 1 February synthetic images. One of the main differences between the synthetic and GOES imagery is that brightness temperatures are warmer in the WRF-ARW. This is a known bias that is primarily due to the wavelength being at 6.95 μm versus 6.5 μm, which would look lower down into the atmosphere (thus, warmer). Be sure to focus on features rather than getting caught up in brightness temperature differences. Another bias is the areal coverage of the colder cloud tops are typically underdone in the synthetic imagery. Given these biases, we can begin to look at important signatures related to cyclogenesis. Early in the loop we see a baroclinic leaf in the Kansas, Missouri, Oklahoma, Arkansas region. A dry slot over Texas is observed moving northeast and in time develops the familiar comma shape to the cyclone. The eastern portion of the comma shape corresponds to a warm conveyor belt that extends from the Gulf of Mexico northward to the Ohio Valley (between 1500-0300 UTC). One of the common forecast questions associated with cyclogenesis is: what regions will be affected by the dry slot and when? We can pose the question in this comparison loop, how well did the model depict the dry slot (keeping in mind the bias of warmer brightness temperatures in the synthetic imagery)? Another question would be, how well did the model handle the deformation zone on the northwest flank of the cyclone? From our earlier cyclogenesis training session, we would refer to this as a basic type of cyclogenesis, which seems to be depicted pretty well by the synthetic imagery.

7. Comparison of synthetic (left) and GOES (right) water vapor imagery for the 13-15 March 2011 case. Compare the timing of the initial convective development from Kansas into Missouri early in the loop, and this appears to be when the system begins to really "wrap up". After this initial development stage, we see convection in Arkansas and Missouri. The next important stage is TROWAL development across Missouri (by 1800 UTC 14 March). This is followed by another round of convection, which may be related to TROWAL development across western Kentucky and southern Illinois by 0500 UTC 15 March. In this example, we see a couple of different times where TROWAL development took place, and the model appeared to do well with the location and timing.
8. Comparison of synthetic (left) and GOES (right) water vapor imagery for the 25-27 December 2010 case. The initial convective development off the coast can be seen being caught up to in the new model run between 11 and 12 UTC December 26. We can identify the development of a cusp between Georgia and North Carolina in the 04-12 UTC December 26 time period. Soon thereafter, we see a dry slot just east/northeast of the cusp. The dry slot moves northward along the coast, with the western edge of it being the boundary between the precip in the deformation zone on the northwest flank of the cyclone and the dry air within the dry slot. The dry slot moves north/northeast and eventually goes away as the cyclone becomes wrapped up. Recall from the cyclogenesis VISIT training session that the cusp can provide information on the position of the surface low, this comparison can provide more or less confidence in the surface low position, as well as the dry slot for cyclogenesis events where terrain does not play an important role, such as this coastal cyclogenesis setup.
9. Synthetic water vapor imagery (at 6.95 μm) from the NSSL WRF-ARW between 13-15 April, 2011 (note that this spans multiple model runs). The early portion of the loop shows a shortwave moving eastward from Nevada towards Colorado. Considerable convection occurs in response to this approaching shortwave over Kansas and Nebraska on the 14^{th}. Soon after the convection, we see a large increase in the vorticity associated with the shortwave over western Kansas. The colder brightness temperature associated with the initial convection wrap entirely around the low, giving indications that the system is becoming cutoff. What is the relationship between the edge of the dry region (edge of warmer brightness temperatures) and where we see convection develop in KS/OK on the afternoon of the 14^{th} and then later in northeast Texas? (this corresponds to the dryline)
10. GOES water vapor imagery (at 6.5 μm) between 13-15 April 2011. South of the shortwave previously discussed note the region of warmer brightness temperatures which expands in areal coverage (located over northeast New Mexico by 1200 UTC 14 April). This feature is present in the synthetic imagery, but is much more subtle due to the bias in warmer brightness temperatures so the contrast does not make it stand out as readily. Once we see this region of warmer brightness temperatures wrap cyclonically back towards the northwest, we observe cusp development from southwest Kansas towards the northern Texas panhandle. The timing of this is around 17:00 UTC 14 April, very close to the timing that was forecast by the WRF-ARW. The initial convection around the Kansas / Nebraska border develops soon after this takes place. Later in the afternoon, more robust convection develops along the edge of the region of warmer brightness temperatures, which corresponds to the dryline.
11. February 2-3, 2012 Synthetic Water vapor imagery: Large cutoff low in the west. The sub-tropical jet is situated southeast of this trough. In the 1900-2100 UTC 2 Feb. time range, convection develops from southeast Colorado towards northwest Oklahoma. This likely indicates the development of a warm conveyor belt (WCB). This WCB becomes better

organized and would result in considerable precipitation in Colorado and Kansas, as well as surface low deepening as air from the warm sector advects towards the low, providing more baroclinic energy. This WCB persists across Colorado and southeast Wyoming for an extended period of time until it finally appears cutoff by 1000 UTC 3 Feb. Nighttime convection develops in Kansas, Oklahoma, and Texas in the 0300 to 0600 UTC 3 Feb. time range, and it appears to correspond well with the upper jet moving from New Mexico towards Oklahoma.

12. February 2-3, 2012 GOES water vapor imagery. There is good agreement between what we saw in the synthetic imagery and the GOES imagery. The key to remember is our objective is a comparison of various airstreams related to cyclogenesis between the synthetic imagery and the GOES imagery so that confidence in what happens next can be assessed.
13. January 25-26, 2011 synthetic water vapor imagery. Initially, appears to be a cold air cyclogenesis example (note the switch to the new model run at 1200 UTC 25 Jan.). Between 2000-0200 UTC 26 Jan. the WCB becomes better organized across Alabama, northward into Tennessee and Kentucky. We don't see a clearly defined cyclonic branch that wraps back around the surface low with this, so it doesn't appear to be a secondary WCB. However, at this time the comma head / deformation zone appears better developed on the west and northwest flank of the cyclone. The dry slot is forecast to move towards the Mid-Atlantic region by 1300 UTC 26 Jan. Note the new model run by 1200 UTC 26 Jan. The biggest difference between the model runs appears to be the area of colder cloud tops across eastern Kentucky and West Virginia. Southern New England is brushed by the cold cloud tops within the WCB, but then replaced by cold cloud tops in the deformation zone on the northwest flank of the cyclone by 0400 UTC and this persists through the last image (0800 UTC). Another key question while viewing the entire loop is phasing with the shortwave moving southeastward out of Canada and over the Great Lakes.
14. January 25-26, 2011 GOES water vapor imagery. The overall picture is similar to that depicted in the synthetic imagery. Next, we will compare various times to look more closely for differences.
15. 1200 UTC 26 January comparison between synthetic and GOES water vapor imagery. The position of the upper low, WCB and approaching shortwave (over Wisconsin) seem to agree quite well. There is a discrepancy over the dry slot from Virginia Pennsylvania, but this may be attributed to the warm bias in the synthetic imagery. Overlays are for comparison with RUC 00 hour tropopause pressure (yellow) and 300-500 mb layer relative humidity (cyan). These fields may also be used to outline the position of the upper low, shortwave over Wisconsin, dry slot and warm conveyor belt off the east coast.
16. 1800 UTC 26 January comparison between synthetic and GOES water vapor imagery. Assess where there are differences. RUC RUC 00 hour tropopause pressure (yellow) and 300-500 mb layer relative humidity (cyan) can be overlaid to assist in the comparison
17. 0000 UTC 27 January comparison between synthetic and GOES water vapor imagery. Overall, there is good agreement between the model forecast and the GOES imagery. As before, RUC 00 hour tropopause pressure (yellow) and 300-500 mb layer relative humidity (cyan) can be overlaid to assist in the comparison.
18. Conclusions.
19. Where to view synthetic imagery
20. Contact information.