Talking points for Pre-convective environment

1. Title
2. Learning objectives
3. One of the critical tasks of satellite imagery during the pre-convective environment is to monitor for approaching shortwaves or jet streaks for potentially leading to convective initiation. Unlike pre-GOES-R imagery with only 1 water vapor band, the GOES-R series has 3 water vapor bands which can help identify shortwaves. In this example, we analyze the 3 water vapor bands along with the air mass RGB to monitor a shortwave moving southeastward from South Dakota into Iowa. The shortwave is characterized by a region of warmer brightness temperatures in the 3 water vapor bands. Once the shortwave becomes juxtaposed with a low-level convergence boundary in central Iowa, which appears in the Air Mass RGB, convective initiation occurs.
4. This is a loop of GOES-16 IR imagery at 10.3 microns using 4 different color tables. Thunderstorms developed across west Texas and moved eastward, where they can be seen moving through the Dallas area. As the ground warms up due to daytime heating, we observe streaks of cooler brightness temperatures.   The streaks correspond to relatively moist soil due to the thunderstorms. These features are particularly noticeable when the soil moisture before the event is relatively dry, so that the contrast between dry and moist soil is maximized. The streaks appear during the daytime hours since the dry soil heats up much faster than the wet soil, making for a contrast in brightness temperatures. Being aware of regions of higher soil moisture can be important not only for potential differential heating boundaries where afternoon convection can develop, but also temperature forecasts. Although the default color table in the upper left shows the feature of interest, a steep linear type of color table, such as Rainbow_11_bit may be better suited for identifying ground features.
5. Remember it's important to monitor these soil moisture boundaries for potential later convective initiation along these differential heating boundaries. A study from Taylor et al. 2011 found that under light synoptic conditions an ascent region is generated where the shallow, strong current opposes the mean wind. Convective initiation tends to occur on the downwind edge of the dry patch due to the heating gradient. An additional area of convergence is found on the upwind edge of the dry patch.
6. Under clear sky conditions, along a low-level convergence boundary the split window difference product, that is the 10.3 minus 12.3 micron bands, may be useful to identify convective initiation before cumulus clouds develop. In the absence of clouds, larger positive split window difference values may correspond to deepening low-level moisture. We tend to see this where moisture is relatively shallow, not in regions of deep low-level moisture. In this example, an MCS outflow boundary oriented east-west is moving southward in the Texas panhandle. The visible imagery in the upper-right indicates clear skies along this MCS outflow boundary. The other 3 panels are the split window difference product with color tables indicated. Note that the MCS outflow boundary appears in this product since larger positive values indicate localized moisture deepening prior to the development of convective clouds. Experience has shown that the linear color with a narrower range of values across the scene to be quite useful since split window difference values vary with diurnal heating across the entire scene.

7. The GOES-R ABI band at 7.3 microns can be used to track the elevated mixed layer, or EML, an important ingredient for severe thunderstorms. Before we begin looking at imagery, let's understand why the 7.3 micron band is useful for detection of the EML. On the bottom right we see a sounding that is characterized by an elevated mixed layer. The low-level moist air mass exists under a capping inversion, with a relatively dry air mass above the inversion. Within the dry air mass at mid-levels, the lapse rates are typically very steep, which is one of the favorable factors for the EML in a severe thunderstorm environment. On the lower left we see the weighting function profile for the 3 water vapor bands on the GOES-R series along with the old GOES imager water vapor band valid for clear sky conditions. The peak of the weighting function values at 7.3 microns exist within the EML which means this band can be used to track it. The 6.2 and 6.9 micron bands peak at a higher altitude, typically too high to detect the EML. Later on, we'll also use the 7.3 micron band to identify cold fronts aloft for the same reasoning as identifying the EML.

8. Now let's look at a case from October 2017 from the GOES-16 7.3 micron band. We overlay GFS 750 mb temperatures to assist with interpretation. The elevated mixed layer will show up as a region of warmer brightness temperatures. Keep in mind there are many reasons why you may observe warmer brightness temperatures in this channel, synoptic scale subsidence will commonly show up as warmer brightness temperatures so we need to confirm the region of warmer brightness temperatures are indeed associated with the elevated mixed layer. A loop of the 7.3 micron imagery will generally show where the region of warmer brightness temperatures originated from, the EML will commonly develop over the higher elevations of western North America and track eastward. We can follow the origins of the region of warmer brightness temperatures in this animation back to Arizona, New Mexico and northern Mexico. Note that the plume of warmer brightness temperatures corresponds well with GFS 750 mb temperatures, we chose this level based on soundings which we will analyze next from Norman, OK and Topeka, KS.

9. The most important confirmation for the presence of an EML is the sounding. The soundings on the left are before the region of warmer brightness temperatures advect over the sounding sites while the soundings on the right are the corresponding sites after the region of warmer brightness temperatures have arrived. The soundings at 1200 UTC shows a characteristic EML with a low-level moist airmass capped by a relatively strong inversion and dry air above the inversion at mid-levels. The warm and dry mid-level air mass is what is being primarily observed by this band. Note how much the mid-level lapse rate has steepened by 1200 UTC. Now that you've confirmed the location of the elevated mixed layer, animated imagery can be used to track it. Keep in mind that convection will tend to at least locally weaken the EML due to diabatic heating aloft.

10. Summary of EML tracking. One of the questions you may be wondering about is why not use just model analyses to track the EML? While model output typically informs you that the EML may be a factor, the details of how the EML is evolving can only be verified with observational data. Model output may be incorrect in the forecast of convection, which has a large influence on the EML due to its contribution of diabatic heating at mid-levels. It's better to look at observational data, in this case a blend of the GOES 7.3 μm band and soundings, to track details

of the EML and see where convection may weaken the EML. This technique of verifying the models with observational data can increase situational awareness of the potential role of an EML on a given day.

11. Next we'll identify elevated cold fronts with the GOES 7.3 micron band, again for the same reason we use this band to identify the EML, it's also where elevated cold fronts usually exist, the other water vapor bands are typically too high in altitude. In this static image, we'll start by indicating the elevated cold front within this yellow oval on the 7.3 micron band. Compare this with the surface analysis in the lower right, which shows the surface cold front west of the elevated cold front at this time. The elevated cold front will show up in the GOES 7.3 micron band as a leading edge of a line of warmer brightness temperatures. These can be important to track as they provide ascent for thunderstorm development. Now that you know where to focus your attention, we'll look at the animation.

12. In the animation, we observe a relatively subtle line of warmer brightness temperatures ahead of the surface cold front. The elevated cold front stays out ahead of the surface cold front and acts to focus thunderstorm initiation along a narrow segment I'll highlight in the next slide.

13. Here is the elevated cold front denoted by the yellow oval with severe storms that initiated along it. This was well out ahead of the surface cold front with no discernable signal in the METARs.

14. You may gain confidence in an elevated cold front by analyzing model cross sections. It is identified as the leading edge of cold advection at mid-levels, coincident with the region where the weighting function peaks for the GOES 7.3 micron band. Once the location of the elevated cold front is confirmed, it can be tracked with the GOES 7.3 micron imagery. Thunderstorms developed along this elevated cold front since it can be an area of ascent ahead of the surface cold front as can be seen from this figure from Parker 1999. As we discussed with tracking the EML, this technique of verifying the models with observational data can increase situational awareness of the potential role of an elevated cold front on a given day.

15. Interactive exercise

16. The answer is true, the 3.9 micron channel may also be used to detect soil moisture gradients. Here are the streaks of moist soil from the case we looked at earlier for 3.9 micron channel from GOES-16 using different color tables. Remember during the daytime, there is a solar reflected component in this band so that diurnal trends will appear readily.

17. In summary, GOES-R will bring new capabilities to monitor the pre-storm environment. This includes a new channel at 7.3 microns which can identify the elevated mixed layer and elevated cold front as well as 12.3 microns for convective initiation under certain conditions. The improved spatial and temporal resolution improves not only these new techniques but also familiar ones like using IR imagery to identify differential heating boundaries and the 3 water vapor bands to identify shortwaves and jet streaks.