Talking points for Pre-convective environment

1. Title
2. Learning objectives
3. This is a loop of GOES-15 IR imagery at 10.7 microns. Focus your attention on west Texas where evening thunderstorms develop at the start of the loop and move northeastward. The thunderstorms dissipate by the early morning hours. During the following day, after sunrise as the ground warms up we observe streaks of cooler brightness temperatures in the region of interest.   The streaks correspond to relatively moist soil due to thunderstorms from the previous day. Notice that the streaks line up with the thunderstorm tracks from the start of the loop. 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.
4. As a proxy for GOES-R ABI imagery, we'll consider the MODIS 11.0 micron band which is at 1 km spatial resolution. This is slightly better resolution than GOES-R, but the key to note here is the improved resolution over current GOES-15 10.7 micron band. Color coordinated arrows point to the same streaks that correspond to cooler brightness temperatures and thus relatively moist soil left from convection the previous day. 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. The greater spatial resolution of GOES-R will allow you to fine tune where these soil moisture gradients exist and monitor them for potential convective initiation.
5. This is an example using data from the Himawari satellite as a proxy for GOES-R. We are looking in northwest China at convection in the 10.4 micron imagery with the rainbow-11 bit color curve to help enhance the ground temperature since it's of interest here. A region of convection develops, as indicated by the development of the blue and purple colder cloud tops and left behind in the wake of the convection are streaks of cooler brightness temperatures which show up yellow in this color table. These streaks of cooler brightness temperatures correspond to moist soil left by the convection. This region is semi-arid so that the contrast between moist and dry soil is sufficient to show up in the satellite imagery.
6. This is the same loop we just looked at, except with a different color table. This color table was designed for fire detection with the 3.9 micron band, which means the curve was designed to look at ground temperatures. The cooler ground left by convection shows up as shades of black in this color table, making them appear more clearly due to sufficient contrast.   The lesson here is to be adaptable to using different color tables since some color tables may show the same feature with less ambiguity.
7. Here is a still image at the same time of the 10.4 micron imagery with the only difference being the color table. I highlighted in red ovals the streaks of cooler brightness temperature so you can compare how the same feature appears between different color tables.
8. In our example, the streaks of cooler brightness temperatures were quite obvious, however some cases are more subtle and you may need to look back in time to compare if streaks of

cooler brightness temperature are indeed associated with convection. In this case, we can immediately tell the streaks were not present the day before, providing further confirmation that the streaks were caused by convection. Remember it's important to monitor these soil moisture boundaries for potential later convective initiation along these differential heating boundaries.

9. 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.
10. 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 GOES sounder 7.4 micron band, note that the peak of the weighting function values exist within the EML which means this band can be used to track it. The GOES-R ABI band is at 7.3 microns, very close to the GOES sounder 7.4 micron band shown here and in the case study we will be looking at. Recall in the training modules on water vapor imagery that the weighting function profile for the other 2 water vapor bands at 7.0 and 6.2 microns peak at higher altitudes than 7.3 microns, usually above the level where the EML exists, this is why we choose the 7.3 micron band for EML identification.
11. Now let's look at a case from April 2015 from the GOES sounder 7.4 micron band. The elevated mixed layer will show up as a region of warmer brightness. 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 7.4 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 and New Mexico.
12. The most important confirmation for the presence of an EML is the sounding. Now we take a closer look at the sounding from Springfield, Missouri (which is located in the southwest portion of the state) before and after the passage of a region of warmer brightness temperatures with origins over the elevated terrain New Mexico and Arizona. On the 1200 UTC 7.4 micron sounder image, note the yellow dashed line in eastern Kansas, this is the eastern edge of the region of warmer brightness temperatures, hypothesized to be the eastern edge of the EML. The sounding from Springfield at 1200 UTC is below the satellite image which is clearly not associated with an elevated mixed layer since its east of the eastern edge of the EML. There is a

lack of dry air aloft and its associated steep mid-level lapse rates. In fact the 700-500 mb lapse rate is -6.6 °C / km. However, by 1800 UTC, the region of warmer brightness temperatures is now over Springfield, with the eastern edge of it denoted in the dashed Yellow line in eastern Missouri. The sounding at 1800 UTC shows a characteristic EML with a low-level moist airmass capped by a relatively strong inversion and dry air at above the inversion at mid-levels. The dry mid-level air mass is what is being primarily observed by this channel. The lapse rate has steepened to -7.6 °C / km by this time. 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.

13. As proxy data for the GOES-R ABI, we make use of the 7.3 micron band from the AHI instrument on the Himawari satellite. This is an example of an elevated mixed layer that develops over northern India and advects eastward towards Bangladesh. An intense isolated thunderstorm develops along a dryline associated with this EML. We do have some contribution from ground temperatures warming up during the day since the weighting function profile is low enough in altitude to pick up this as well. The main idea with this loop is notice how much more clear this imagery is compared to the GOES sounder. Remember the GOES sounder is at 10 km spatial and hourly temporal resolution. This loop is at 2 km spatial resolution, the same as GOES-R, and also the temporal resolution is 10 minutes, GOES-R will be routinely available at 5 minutes over CONUS and even 1-minute when you are in a mesoscale sector during flex scanning mode. The improved spatial and temporal resolution of GOES-R will make it much easier to monitor the elevated mixed layer with the 7.3 micron band.
14. 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.
15. Chris Gitro from the Pleasant Hill, MO WFO has looked into using the GOES Sounder 7.4 micron band to identify elevated cold fronts. These can be important to track as they provide ascent for thunderstorm development. In this case from June 2011, an elevated cold front could be tracked in the GOES sounder 7.4 micron band as the leading edge of a line of warmer brightness temperatures. We see the eastward progression of the elevated cold front labeled on the images at the bottom.
16. In this case from November 2015, a cold front aloft is identified in the model cross section as the leading edge of cold advection at mid-levels, coincident with the region where the weighting function peaks for the GOES sounder 7.4 micron band. Once the location of the elevated cold front is confirmed, it can be tracked with the GOES sounder 7.4 micron imagery. Thunderstorms developed along this elevated cold front since it can be an area of ascent ahead of the surface cold front. 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.   Again, the enhanced spatial and temporal resolution of GOES-R will make this technique that much easier to apply routinely.

17. Interactive exercise
18. 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 in the 3.9 micron channel from GOES-15 and 3.8 microns from MODIS. Remember during the daytime, there is a solar reflected component in this band so that diurnal trends will appear readily.
19. 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. 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.