

Talking points for low-level jet features

1. Title
2. Our learning objective is to introduce GOES-R capabilities for identification of various types of low-level jets, we'll spend most of this session discussing the sting jet. Recall the sting jet develops during frontal occlusion phase as the bent back warm front begins to encircle the surface low. The region labeled as SJ is the sting jet and is important since very strong winds would be associated with this feature. Note the sting jet does not last long as the cold conveyor belt catches up with the sting jet, strong winds may still occur but the highest wind speeds associated with the sting jet are over.
3. We will setup the case study of interest with a large scale depiction of the cyclone. We utilize imagery from the Himawari satellite as a proxy for GOES-R. This is the 7.0 micron mid level water vapor channel or Band 9. This loop covers the period leading up to the development of a sting jet associated with an intense cyclone in the northwest Pacific in December 2015.
4. Now we zoom in to the region of interest which is the center of the cyclone where we can view the evolution of the sting jet. This is the 6.2 micron upper level water vapor channel, we can easily see the warm conveyor belt, the cold conveyor belt and to a lesser extent the sting jet. Remember the weighting function for this channel is the highest in altitude of the 3 water vapor channels so we expect a more clear depiction of the sting jet as we get lower in altitude with the other 2 water vapor bands.
5. This is the 7.0 micron mid level water vapor channel, somewhat close to what you're accustomed to viewing with current GOES, except this is at 2 km spatial resolution rather than 4 km which provides more details in the imagery. In this loop we can follow the evolution of the sting jet, with the later portion of the loop showing it wrap up into the circulation. A sting jet refers to the fast moving descending air from the tip of the cloud head into the dry slot ahead of it. It usually doesn't last for more than a few hours.
6. This is the 7.3 micron low level water vapor channel, since the weighting function peaks lower than the other 2 water vapor bands, this band will be quite useful in analyzing the sting jet. Note how much more detail we can see in the evolution of the sting jet. Early in the loop, we see multiple cloud bands evolve into the cloud head associated with the sting jet.
7. Let's look at the early stages of sting jet development more closely from a 3-dimensional perspective. Analyzing the 3 water vapor images at the same time early in the evolution shows multiple cloud bands in the location where the sting jet develops. Browning referred to these as the banded cloud head, compare the conceptual diagram with the 3 water vapor bands. The conceptual diagram labels 3 banded cloud heads in a case over the UK which I highlight in a blue box, while our example just happens to also depict 3 banded cloud heads – see the yellow arrows over the lower and mid water vapor images. The band that shows this feature the most clearly is the 7.3 micron band, which makes sense since the weighting function is the lowest in altitude of the 3, providing more details where these clouds exist.

8. In this loop of the 7.3 micron lower level water vapor imagery. Note the early development of clouds where the sting jet initiates. The clouds we observe in the imagery develop just below the sting jet in a way depicted in this conceptual diagram from Clark and others. Note that the strongest winds are ahead of the banded cloud head, within the sting jet which descends from mid-levels.
9. Here is IR perspective of what we've been discussing as shown in the 10.4 micron loop. The banded clouds head is produced by slantwise motions and consists of alternating ascending/descending branches. Evaporative cooling from precipitation enhanced descent.
10. Browning and Field proposed that each banded cloud head produced a separate sting jet pulse. Clouds form along the convergence line at the leading edge of the sting jet pulse and are indicated by the arrows in the 7.3 and 10.4 micron imagery. The strongest wind gusts exist just behind the convergence line where enhanced evaporative cooling associated with precipitation in the banded cloud head. More than one may exist but in this case we see just one. One thing to keep in mind is that with an intense cyclone such as this, there will be strong winds over a broad region. The sting jet is a signature that indicates particularly strong and likely damaging winds. In this case, wind gusts at the nearest observing station at Adak Island were in the 70 to 80 knot range with higher gusts after this time, however the sting jet passed west of this station so we don't have an observation of the highest wind gust within the sting jet.
11. Now we'll look at a few other low level jet features with a focus on higher temporal resolution imagery that will be available with GOES-R, in particular 1-minute imagery. In this 1-minute visible loop of a developing cyclone off the east coast, note all the details we can see. Of note is the intense low-level jet on the northwest flank of the circulation. The 1-minute imagery allows you to see fast moving clouds more readily than route scan modes currently available with GOES. This is particularly helpful for brief looks over multi-layered cloud decks, for example this region north of the warm front.
12. This is another example of 1-minute imagery, in this case 7 February 2016. The 1-minute imagery makes it very easy to identify where the low-level jets are around this intense extra-tropical cyclone. Early in the loop, north of the circulation center we see very fast moving low-level cloud elements in northeast flow. Due south of the circulation center we see strong northerly flow in the low-level cloud field. Further southeast of that in the warm sector we see the warm advection region of the low-level jet. Finally, later in the loop we can see the low-level wind direction change as reflected in the low-level clouds as the circulation wraps up. The 1-minute imagery adds value in being able to track low-level clouds and assessing their motion relative to other clouds in the vicinity.
13. This is a single image from the previous loop to illustrate the position of the very strong low-level winds relative to the bent back front. The developing bent back front is depicted in the yellow dashed lines, and the low-level cumulus and stratocumulus is within the orange oval. These clouds were moving very fast as we observed in the 1-minute imagery on the previous slide.
14. In summary, GOES-R capabilities will improve low-level jet identification with respect to new bands, in particular the 3 water vapor channels used in tandem to provide a 3-dimensional

perspective. Also, the greater spatial and temporal resolution will aid in identification of low-level jets.