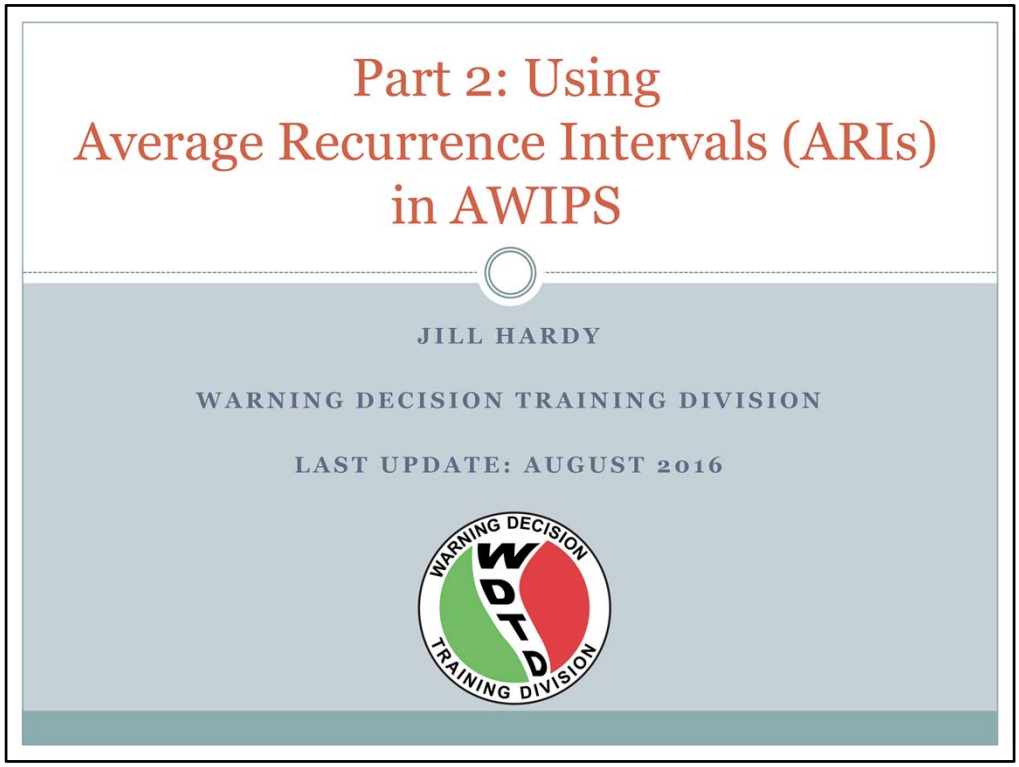
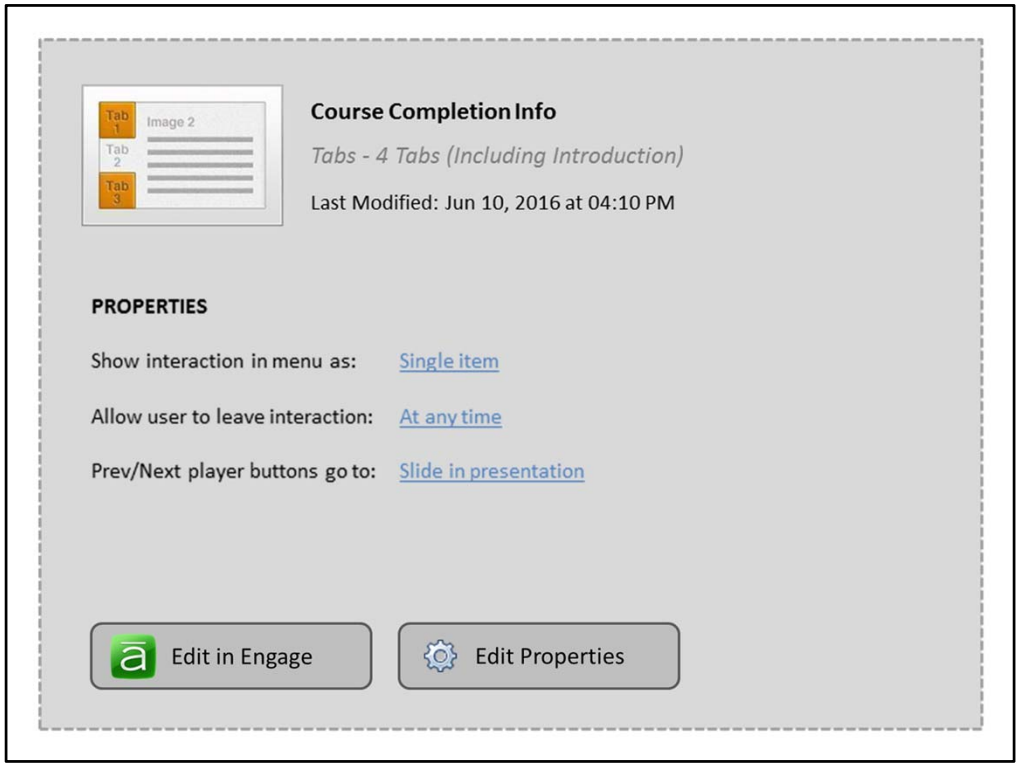


Hello. My name is Jill Hardy, and welcome to this second module about the NOAA Atlas 14 Average Recurrence Intervals (or ARIs) dataset. This is Part 2 of 2, and will focus on how to use ARI data in AWIPS, as well as some tips on how to effectively interpret ARI data for flash flood decision-making in FFMP.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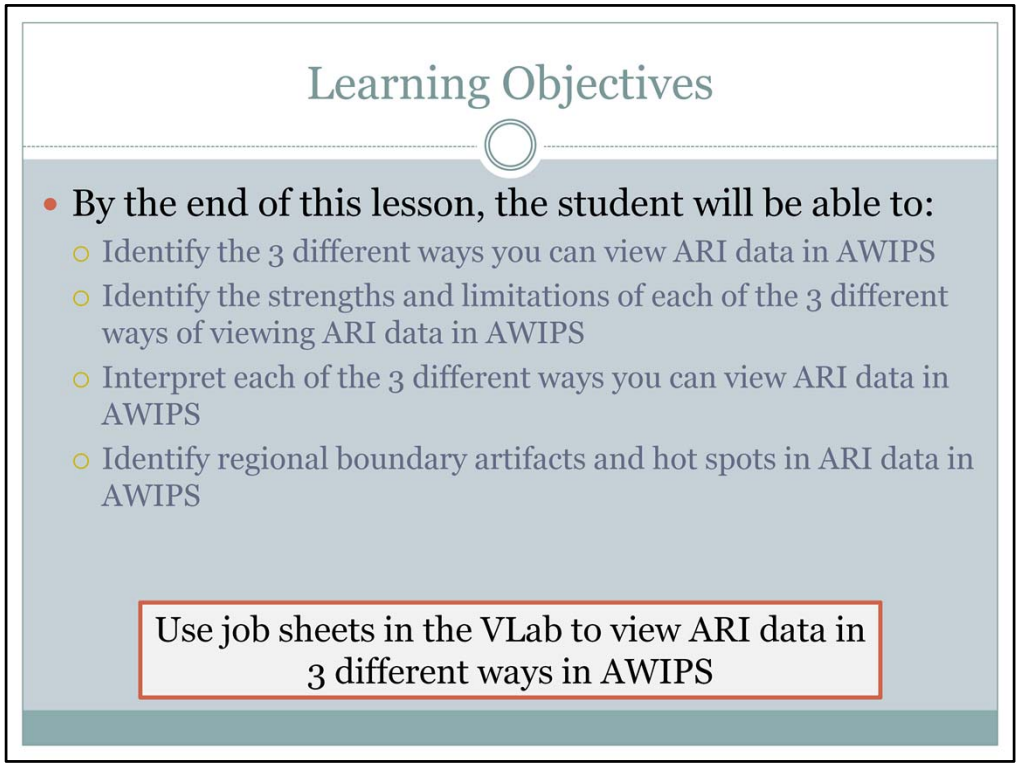
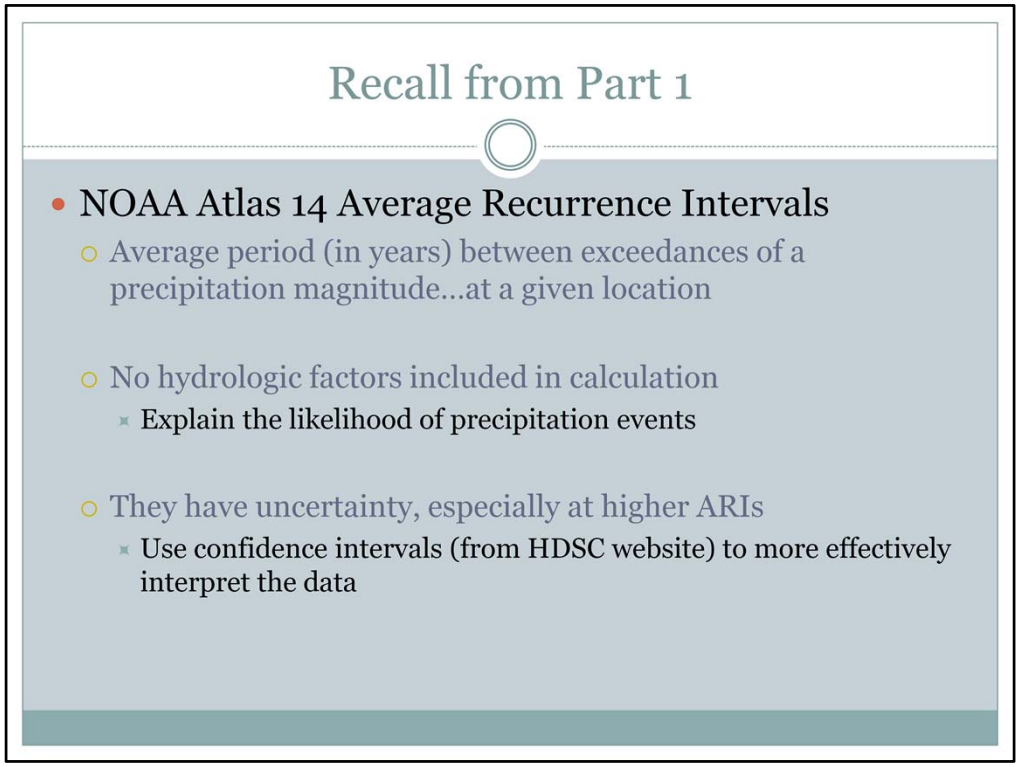


Here are the Learning Objectives for this lesson. The majority of this lesson will focus on introducing the three different ways you can view and interpret ARI data in AWIPS.

Additionally, we have provided job sheets in the VLab that walk you through how to view ARI data using each of these methods, for when you are ready to do it at your AWIPS workstation. We will talk more about this VLab page later.

When you have finished reading, please move onto the next slide.

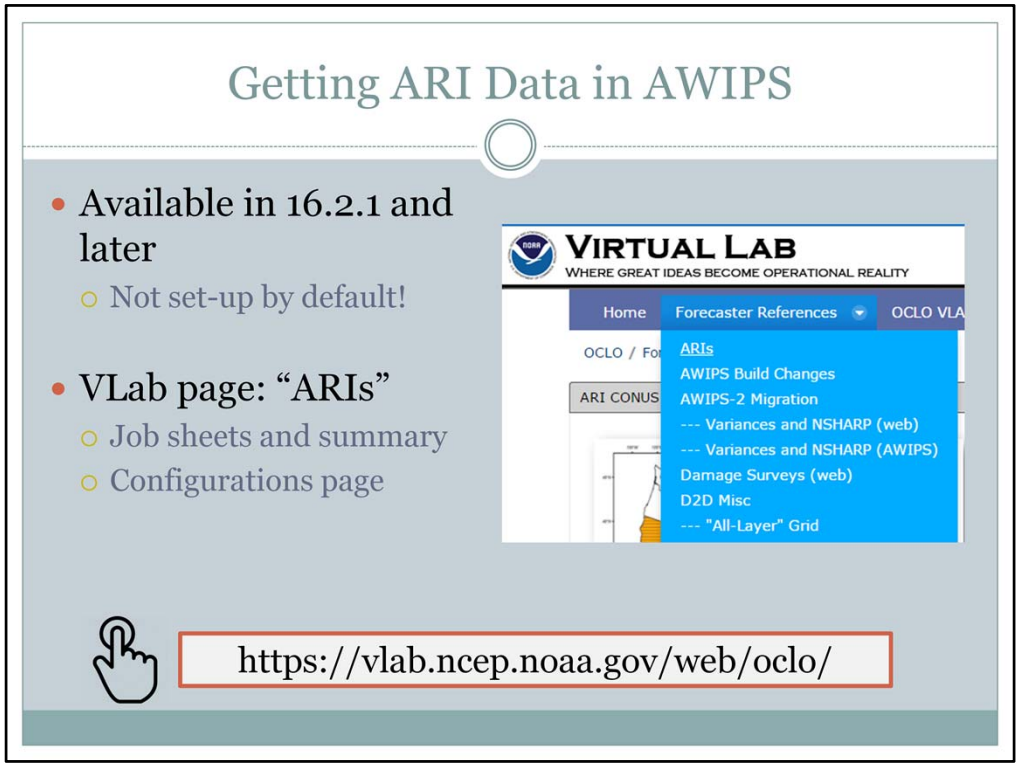


As a brief reminder from Part 1, the NOAA Atlas 14 Average Recurrence Intervals are the *average* period (in years) between exceedances of a precipitation magnitude, at a given location.

The ARIs do not include any hydrologic factors in its calculation, they simply explain the likelihood of *precipitation* events.

And recall that these estimates have uncertainty, especially at higher ARIs. So remember to use the confidence interval information (available from the Hydrometeorological Design Studies Center website) to more effectively interpret the ARI data.

Okay, let's jump into using this dataset in AWIPS!



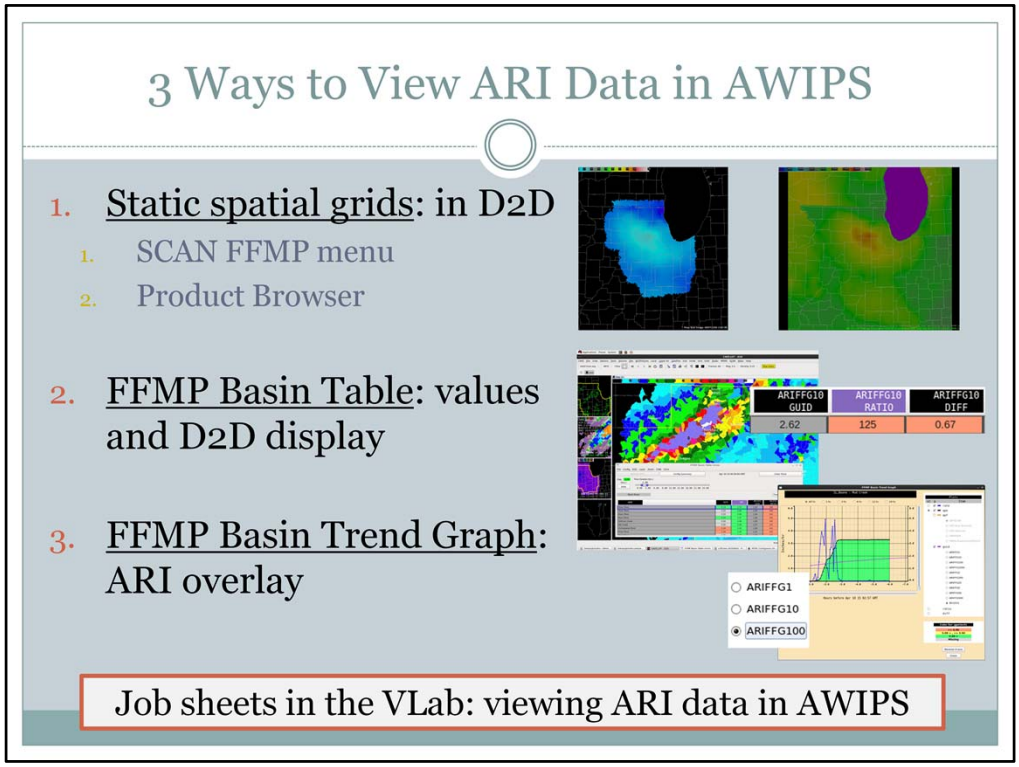
Alright, first thing's first….getting ARI data at your AWIPS workstation.

As of 16.2.1, ARI data is available in AWIPS. However, it is not set-up by default. Your AWIPS Focal Point needs to follow supplemental instructions provided with the build install.

As mentioned on the Objectives slide, we have created a quick reference page on the VLab, simply called "ARIs". This page has job sheets and an ARI summary for forecasters, as well as a Configurations subpage for AWIPS Focal Points which will help with the set-up.

The URL provided below will take you to the OCLO homepage seen here, with no log-in necessary. From the homepage, hover over "Forecaster References" in the upper left and click "ARIs" to access the main page.

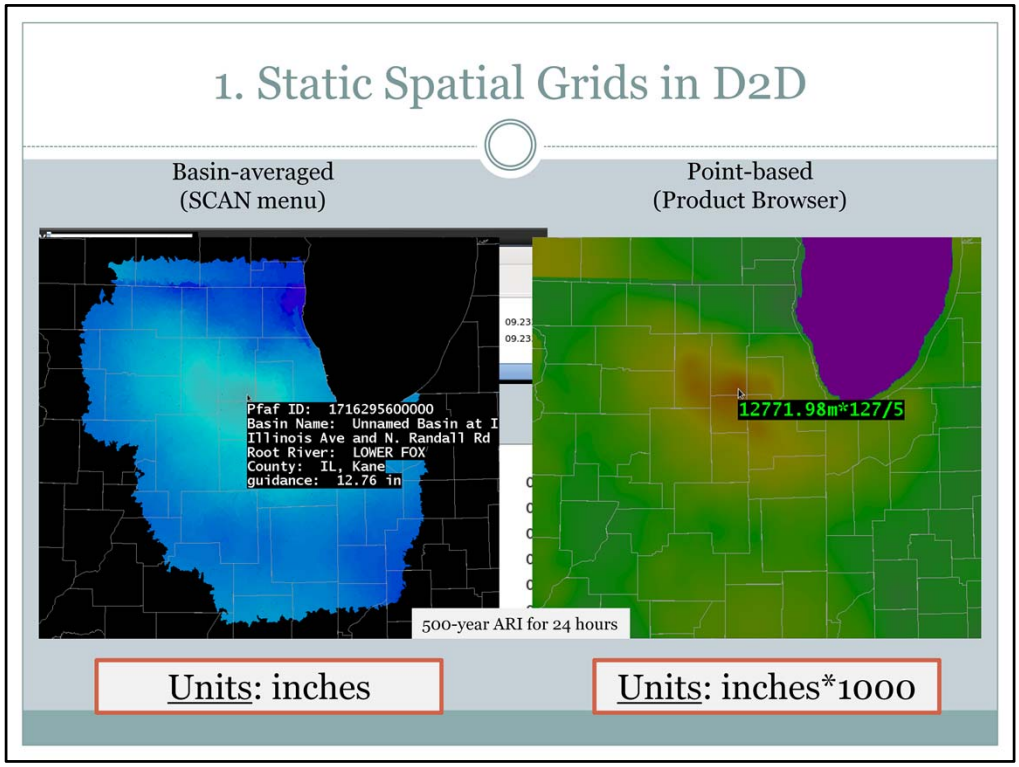
This link is also provided under Resources in the upper right corner of this lesson.



Once your AWIPS is set-up to ingest ARI data, there are 3 different ways to view the data.

First, you can load static spatial products in D2D. This is done via the SCAN FFMP menu or the Product Browser. The second way is using the FFMP Basin Table to view numerical values, as well as an FFMP-based D2D display. And finally, the FFMP Basin Trend Graph can be used to quickly view multiple ARIs for different QPE durations.

In the next slides, we will review these three display methods, but for step-by-step instructions on loading, we have created job sheets in the VLab. See the previous slide, or the Resources tab for the URL.

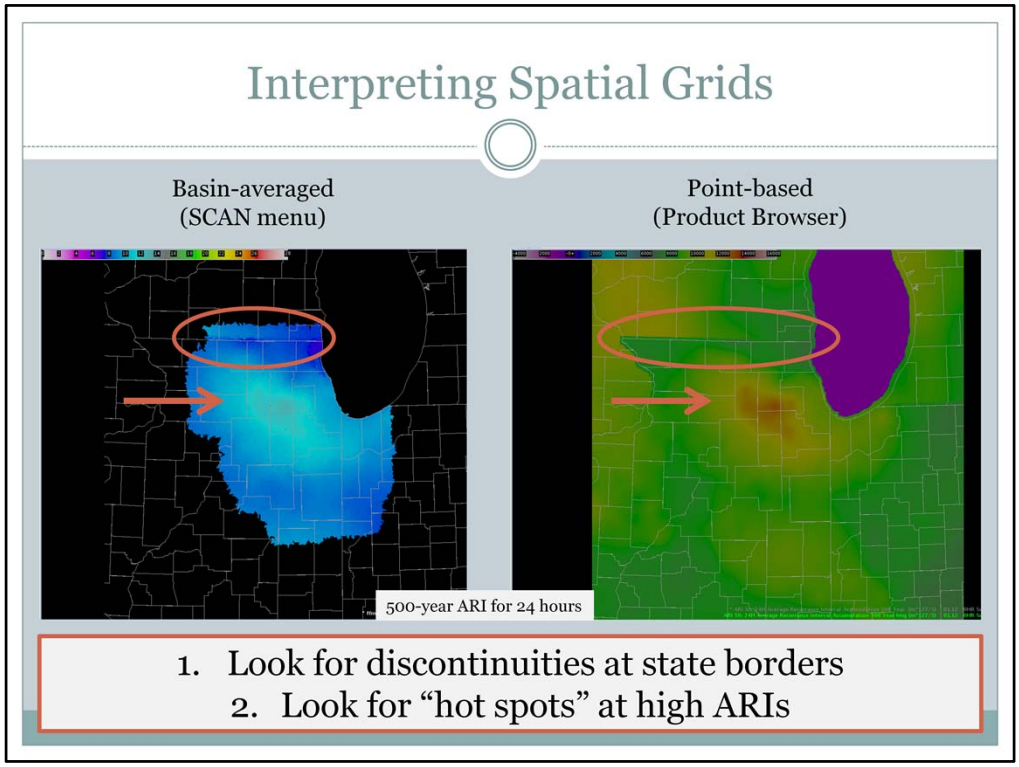


Let's start by looking at the static spatial grids in D2D. The basin-averaged ARI grids are available from the SCAN FFMP menu and Guidance submenu. Here, you will see the list of all available ARIs, ranging from 1 to 1000 years. Each of these options then has a submenu of all of the available durations, from 30 minutes up to 24 hours. Here is an image of a 500-year ARI for the 24 hour duration.

The raw point-based ARIs are available through CAVE's Product Browser. Under the Product Browser's Grid and ARI drop-downs, you will find all the point-based ARI grids. Keep in mind it will start as a contour product, so you will have to "Load as Image" to get this final image, which is the same 500-year ARI for a 24 hour duration.

Note how the clipping is different for each. The SCAN image on the left is clipped to the FFMP domain. While the Product Browser image on the right has a much larger domain which is particularly helpful in identifying important regional and local ARI variations.

Also, if we sample each of these images, look at the units: For the basin-averaged grids, the units are inches. However, for the point-based grids, the units are inches*1000, with some really weird labels. To interpret this grid, simply divide by 1000 to get a value of around 12.77 inches. And because of the basin-averaging on the left, you may see slightly different values between these grids, as shown here.

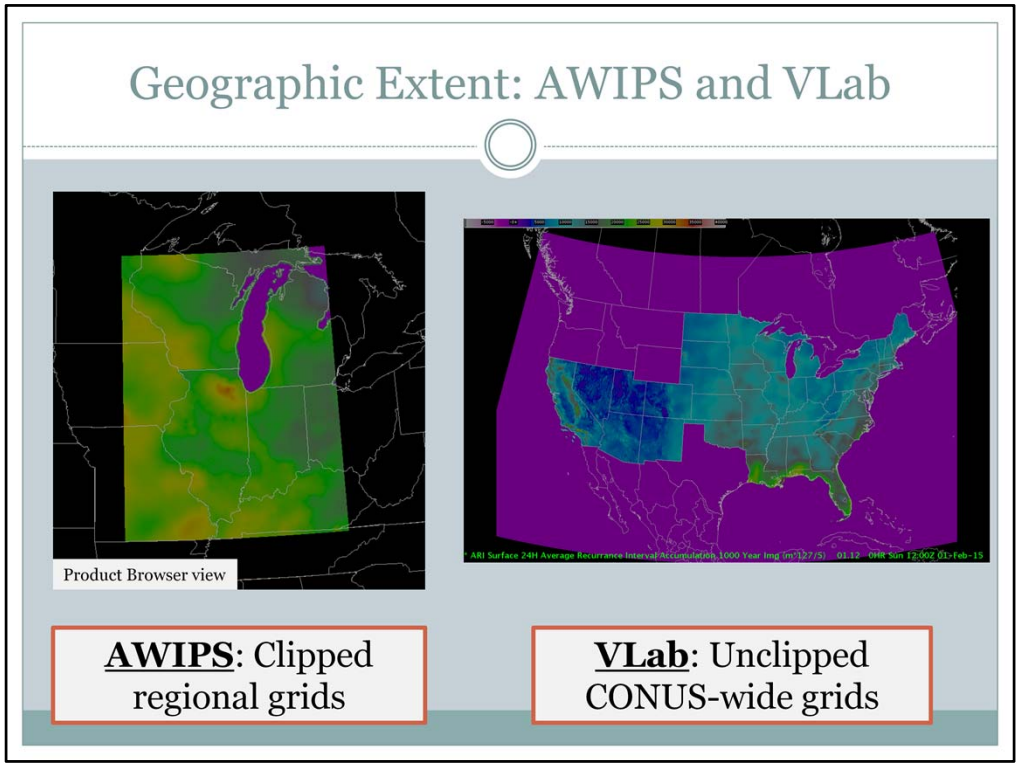


One of the first things you should do before trying to use ARIs in FFMP is to familiarize yourself with any significant spatial features in the static ARI data. This is best done with the Product Browser grids, though you may also use the SCAN menu grids.

First, look for discontinuities at state borders along regional boundaries in the NOAA Atlas 14 data that were covered in Part 1 of the training. Values may change abruptly at these boundaries due to different calculation techniques. In this example, we see this happen along the Illinois-Wisconsin border.

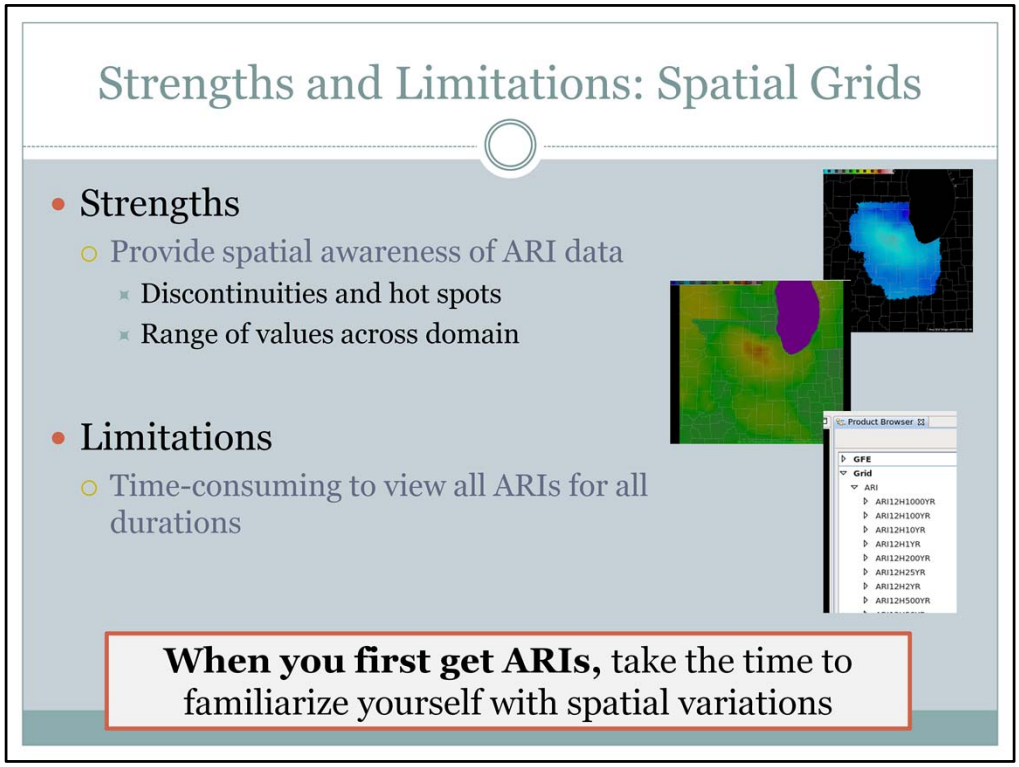
Second, look for noticeable "hot spots" at higher recurrence intervals. This example shows a 500-year ARI. And it is easy to see the "hot spot" in north-central Illinois on both images. These hot spots arise from limited observational data and should be evaluated carefully to assess if the hot spots are too high or the surrounding areas are too low.

The bottom line is you must take these features into account while calibrating rainfall ARIs with flash flooding in your area.



When using the ARI dataset in AWIPS, grids have been clipped to your region, as shown on the left. But in the VLab, we have provided unclipped CONUS-wide images for all ARI intervals and durations.

These CONUS images can be a useful first look into the data for the whole CONUS, and you can check them out right now. But the best way to become familiar with the spatial variations in your CWA is to use the regional grids in AWIPS.

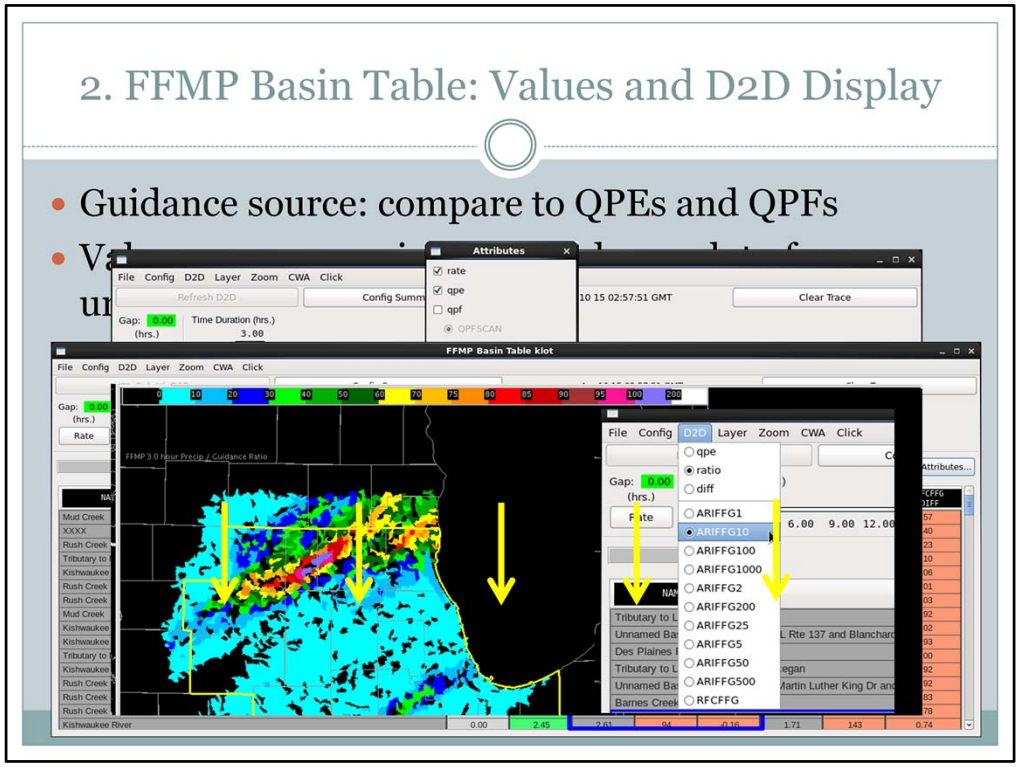


There are strengths and limitations for each of the three viewing methods.

The strength of the spatial grids is simple…they provide spatial awareness. They allow you to visualize potential discontinuities and hot spots, as well as get a feel for what the range of values are across your domain.

However, the main limitation is that it is quite time-consuming to view **all** ARIs for all durations this way. In fact, there are 70 possible combinations to consider!

So the very first time you get ARIs ingested at your workstation, take the time to go through these static grids and familiarize yourself with the spatial variations in the products.



Okay, so now let's talk about Option #2 which is using the FFMP Basin Table to look at numerical values, and a D2D display.

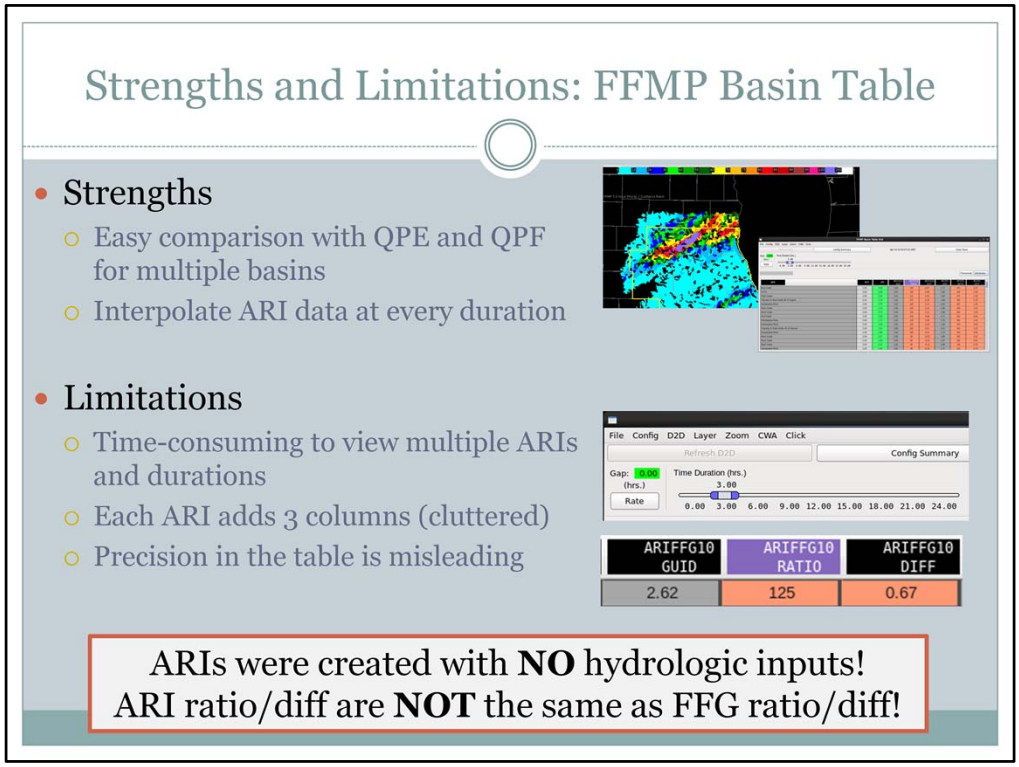
ARIs are given in FFMP as a Guidance source, similar to Flash Flood Guidance. So they have a lot of the same functionality as FFG, including being primarily used for comparison with QPEs or QPFs to assess the severity of a precipitation event.

ARI display in the FFMP Basin Table is managed through the "Attributes" button on the right-hand side. Here is where you can choose a desired recurrence interval. Let's just pick the 10-year interval. For each ARI you choose, three new columns will be added to your table: the basin-averaged ARIs, Ratio and Diff. As with FFG, the Ratio and Diff columns are calculated against QPE.

So in this image, for the first basin, Mud Creek, 3.29 inches of rain has fallen in the last 3 hours, and the RFC FFG is 1.72 inches. So we should already be concerned about flash flooding in this basin. But we can look at the ARI data loaded onto the table to get a better idea of how common this rainfall is for this area. The 10-year ARI for this basin is 2.62 inches. When comparing this value to QPE, QPE has exceeded the 10-year basin-averaged ARI by 0.67 inches, with a basin-averaged ratio of 125%. If you believe the QPE, the ARI information would add to our confidence that this is a fairly uncommon rainfall (less than 10% annual chance). And with time, you might have a better idea how this magnitude rainfall affects the flash flood potential in your area. However, BE CAREFUL interpreting these values as precisely as they are given. We showed in Part 1 that there is a lot

uncertainty with these estimates that isn't being shown in this table.

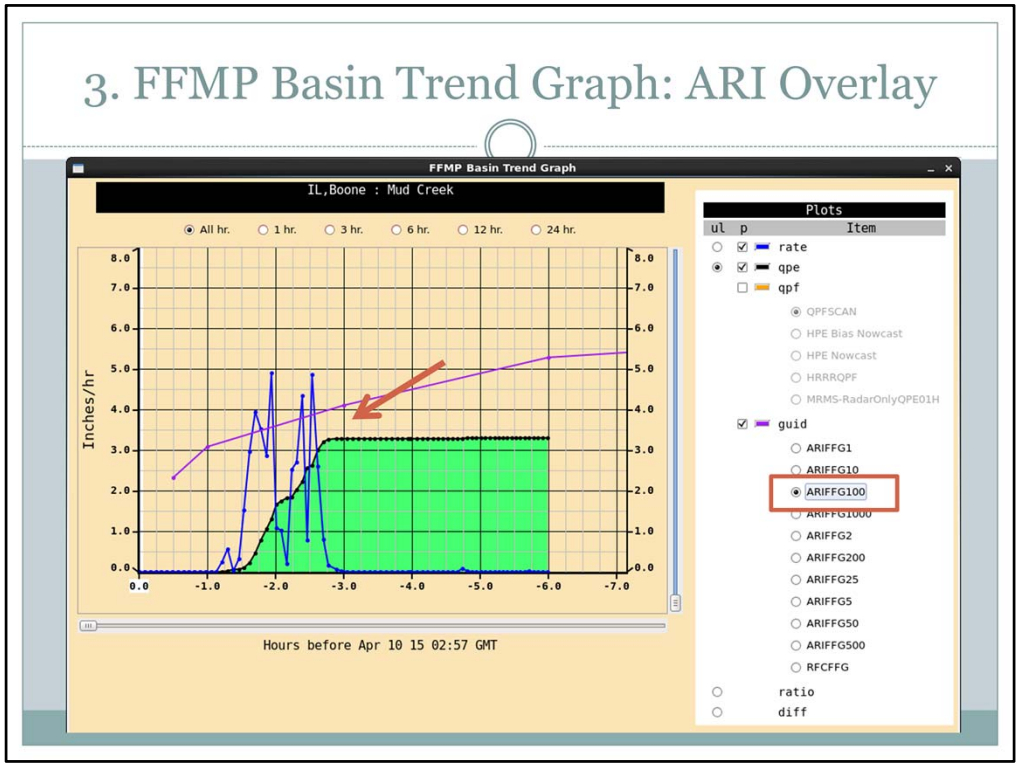
And lastly with this method, you can change the FFMP D2D display to show any ARI ratio or difference. For example, the default D2D display is the RFC FFG, and we're looking at Ratio. Looks like we're exceeding FFG in a pretty big swath across the northern border of the CWA. Now, let's change the display to show the 10-year ARI Ratio. Now we see that there a few basins where the 3-hour QPE is close to, or already, exceeds the 10-year ARIs. And again, over time with experience, you will begin to find out what this means for your local flash flood potential.



For this method, the biggest strength is that you can easily compare single ARIs with QPE and QPF for multiple basins, using both the FFMP table and D2D display. And ARI data can be interpolated at every duration because of FFMP's on-the-fly calculations.

The biggest limitation of this method is that it is time consuming to step through multiple durations for different ARIs. Another downside is that for each ARI you add to the table, you get 3 new columns. This can clutter the table pretty quickly if you don't remove anything. Finally, the precision in the table can be misleading since there is a lot of uncertainty and overlap in the ARI data.

When using ARIs in FFMP, I can't stress this enough: While they are a useful guidance source, remember that they were created solely based on rainfall information, with no hydrologic inputs! So be careful when interpreting ARI ratios and differences because they do NOT mean the same thing as FFG ratios and differences. But with time, you may become better calibrated to how ARIs *can* be used for flash flood prediction in your area, as long as you remember they are inherently different than FFG.



So the third, and final, way to view ARI data is with the FFMP Basin Trend Graph which can be launched by right-clicking on the basin name.

Let's pick Mud Creek again. Now, once we make sure the guidance box is checked, we can quickly and easily step (in order) between all of the available ARI's, starting with 1-year. For each recurrence interval on the right, the purple line will show the values for EVERY duration, up to 24 hours. And when the black QPE line is higher than the purple guidance line, QPE will have exceeded the ARI for that duration. So in this example, we start with the one-year ARI toggled on. Up until almost the 2-hour duration, QPE is below the 1-year ARI threshold. However, for the 2- to 6-hour durations, we have exceeded a 1-year rainfall.

Let's toggle on the 2-year ARI. Notice how the purple ARI line has shifted up, denoting that you need more rainfall to exceed a higher ARI. Here, the two-hour duration is again the point where QPE switches from not exceeding to exceeding.

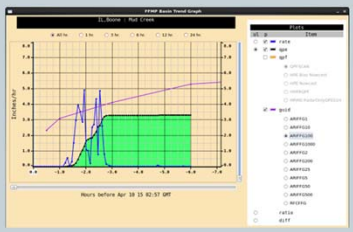
Now let's look at the 5-….10-….and 25-year ARI. We see that only a small portion of durations, around 3 hours, exceeds a 25-year rainfall. And moving up to 50-year, that *no* durations exceed a 50-year rainfall. So we can say that the QPE for this basin suggests a 25-year rainfall recurrence, or rather, has a 4% chance of occurring in any given year.

When you believe your QPEs, and the rainfall recurrence is more rare, then you can have a little more confidence when considering issuing a Flash Flood Warning or Urban and Small Stream Advisory.

At this point, if there were additional storms approaching the area, and you were concerned about an even bigger event, take a look at some of the higher intervals, like 100-year and up. This will help you to see roughly how much *more* rainfall you would need to reach those truly historic levels. Looking at the 100-year ARI, for a three-hour duration, we're less than an inch away from exceeding. That's not much.

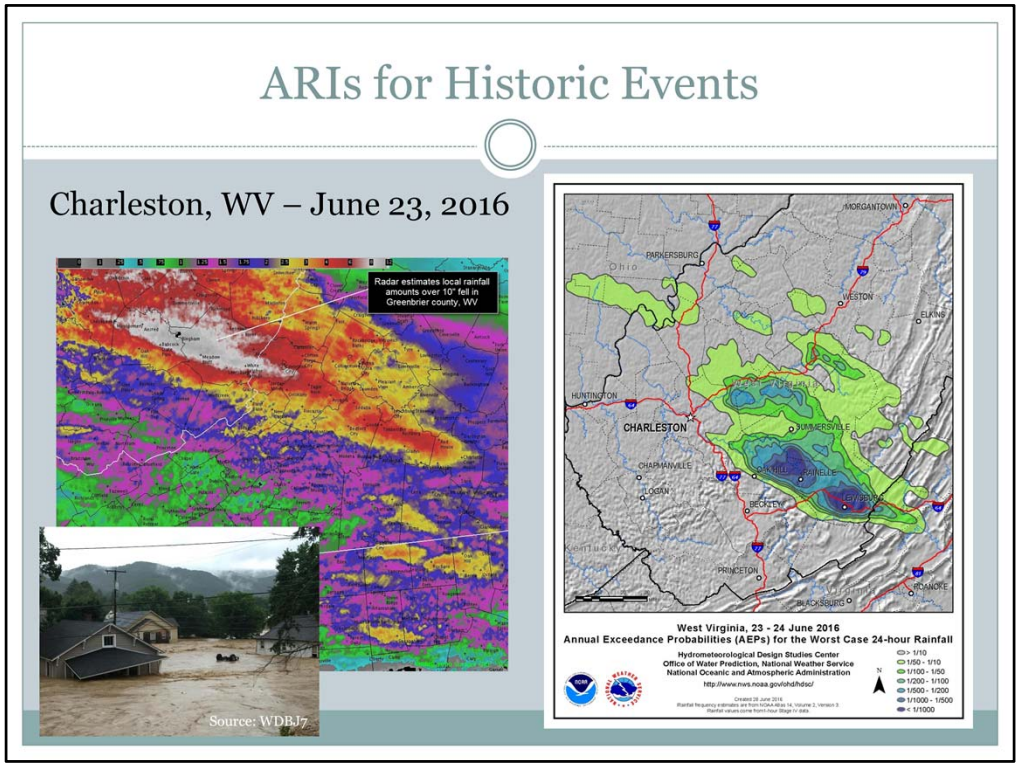
Strengths and Limitations: Basin Trend Graph

- Strengths
  - Fastest, easiest manipulation between ARIs
  - Can see all durations in one graph
  - Easy comparison with QPE and QPF
- Limitations
  - Can only look at one basin at a time



This method is the fastest, easiest way to jump between different ARIs. Additionally, you can see all the durations in one graph, which saves even more time. Finally, this method provides an easy way to compare the ARIs with QPE or QPF, just like the table. And arguably, the graph helps you get a better “big picture” view, without focusing too much on the precise values.

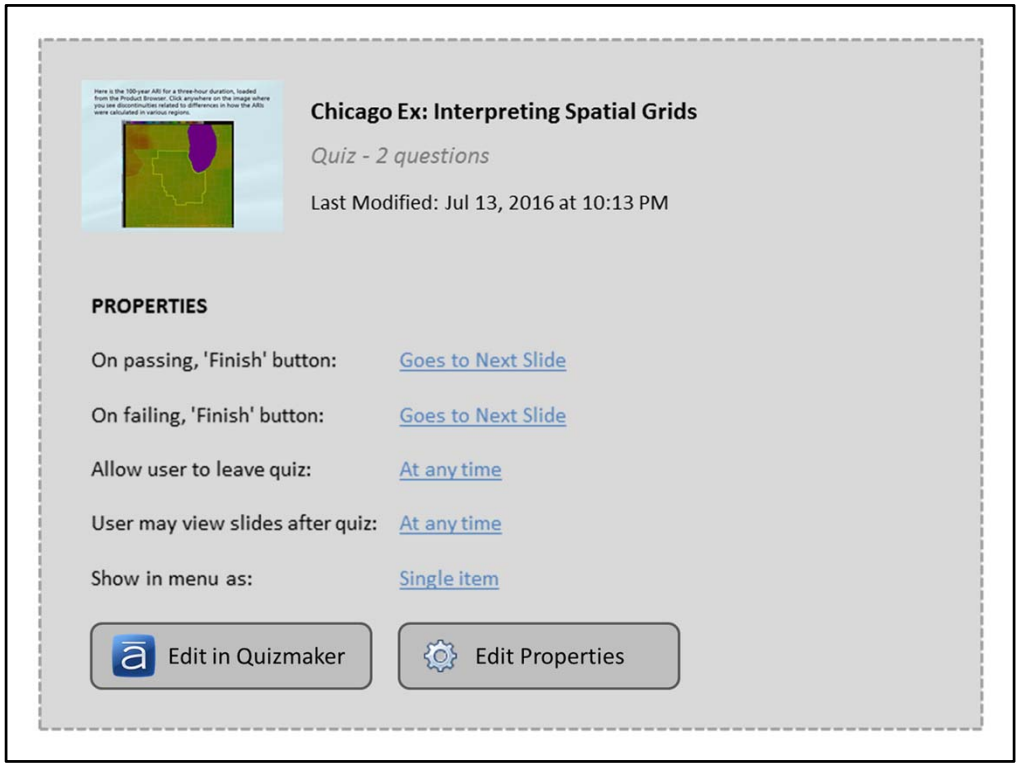
However, the biggest limitation of the graph is that you can only look at one basin at a time.



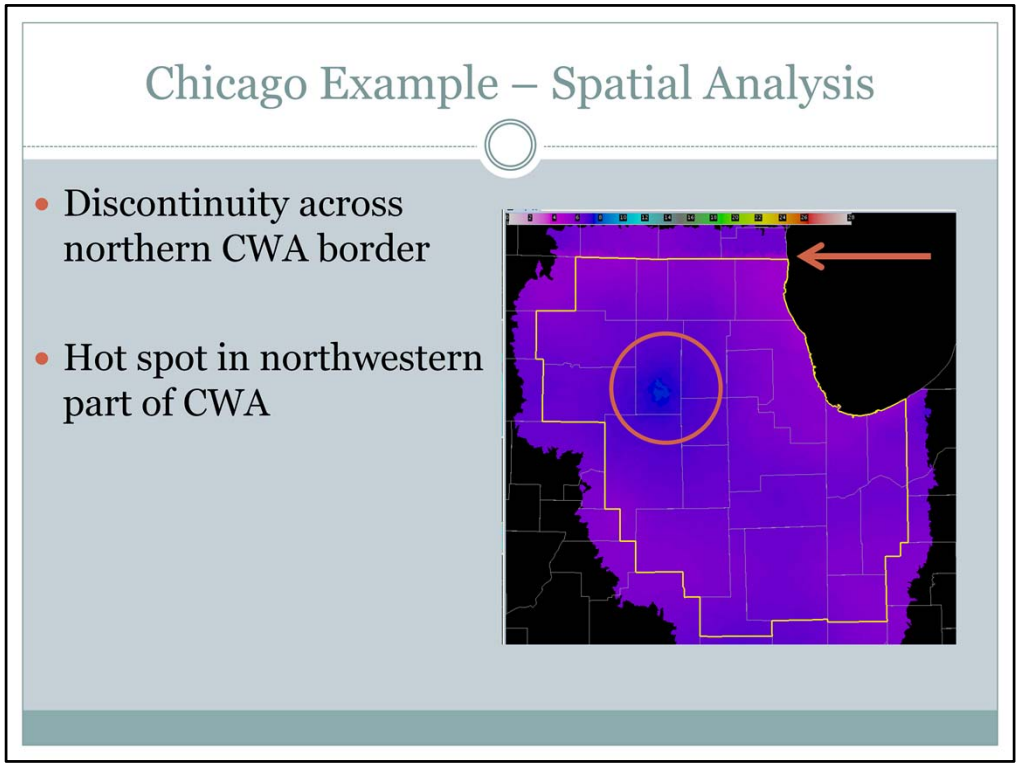
In general, forecasters and the public are probably most familiar with ARIs being used in the context of extreme flash flood events. Take for instance the historic event near Charleston, WV on June 23rd, 2016. Where, over a 24 hour period, MRMS estimated at least 8-10 inches of rainfall. After the event, the Hydrometeorological Design Studies Center made this map of annual exceedance probabilities, which shows areas that received 24-hour rainfall amounts that correspond to a 0.1% annual chance, or 1000-year rainfall.

In these truly historic events, it is likely that very high ARIs are going to correspond well with extreme flash flooding.

But what is going to be more challenging for forecasters is calibrating ARIs to the more day-to-day rainfall, where flash flooding isn't always a guarantee. The rest of this lesson will focus on a case such as this.



Here is an example from the Chicago CWA in April 2015. So the first step is to familiarize yourself with the ARI spatial grids. Don’t worry, these questions aren’t graded.



Okay, so we saw there was a discontinuity across the northern border of your CWA. Additionally, there was a hot spot in the northwest part of your CWA.

Both of these features may affect your interpretation of higher ARIs, where values could vary as much as a couple inches over a short distance. So keep this in mind when looking at higher ARIs for this example.

Chicago Example – Precip Source Analysis

- Two-hour duration event
- First decision point: 01Z at Rockford, IL
  - KRFD @ 2354Z and 0056Z
- MRMS out-performed Legacy and Dual-Pol

Alright, so the next step is to evaluate ARIs and QPE for a given precip source. This event occurred mainly over a two-hour duration, with two different Flash Flood Warning decision points. The first is at 01Z, in the urban area of Rockford, IL. Here, we had METAR data to compare to radar estimates over the previous two hours. For the sake of time, we already looked at all the sources, compared to observations, and found that MRMS performed the best during this event.

But for the ARI analysis, it's important to let you compare the Rockford METAR and MRMS data, in order to get a feel for precip amounts during this period. The next slide will step you through analyzing the data over the two-hour period ending at 01Z.

Comparing MRMS with METARs

Quiz - 4 questions

Last Modified: Aug 02, 2016 at 03:47 PM

PROPERTIES

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On failing, 'Finish' button:	Goes to Next Slide
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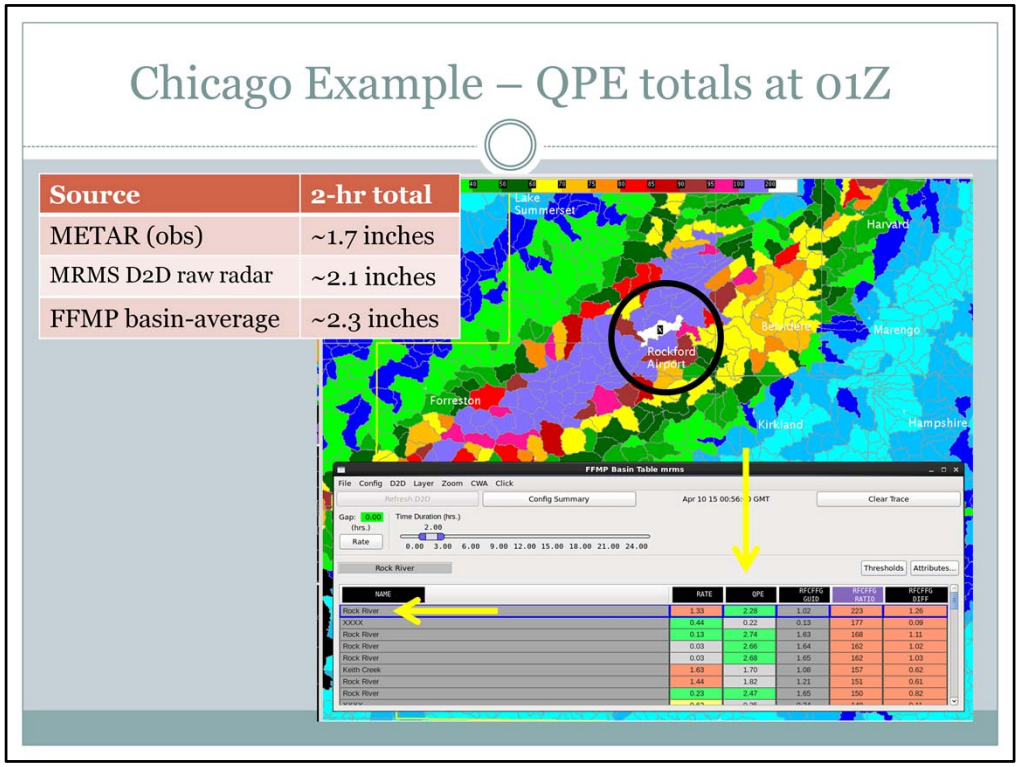
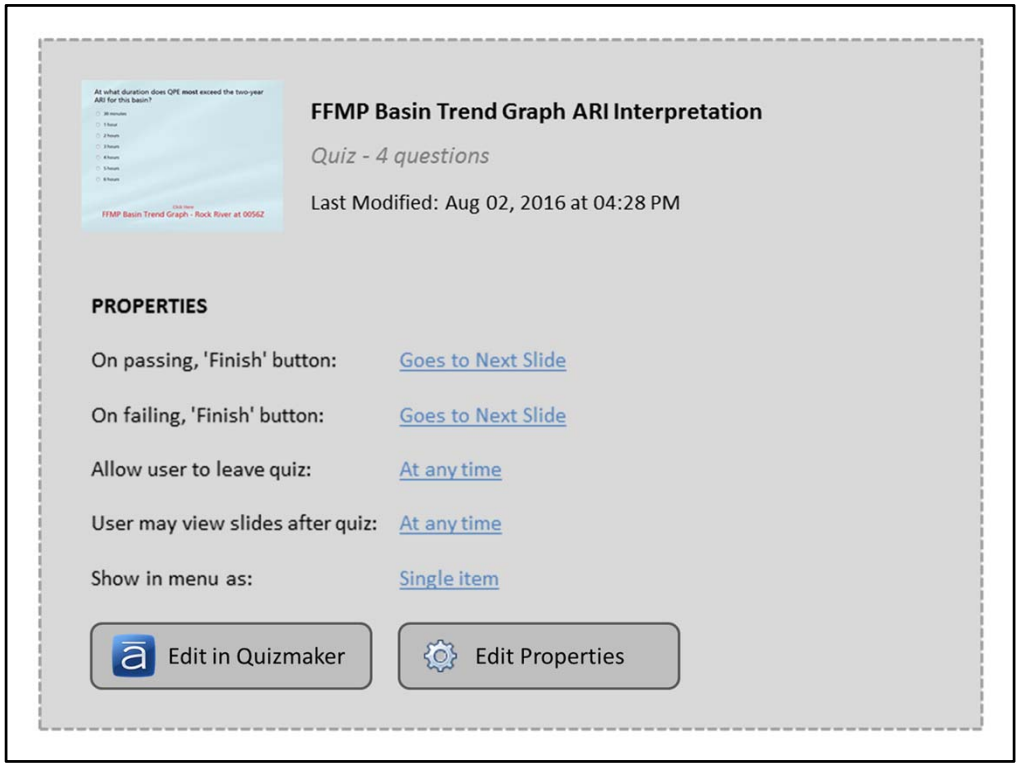


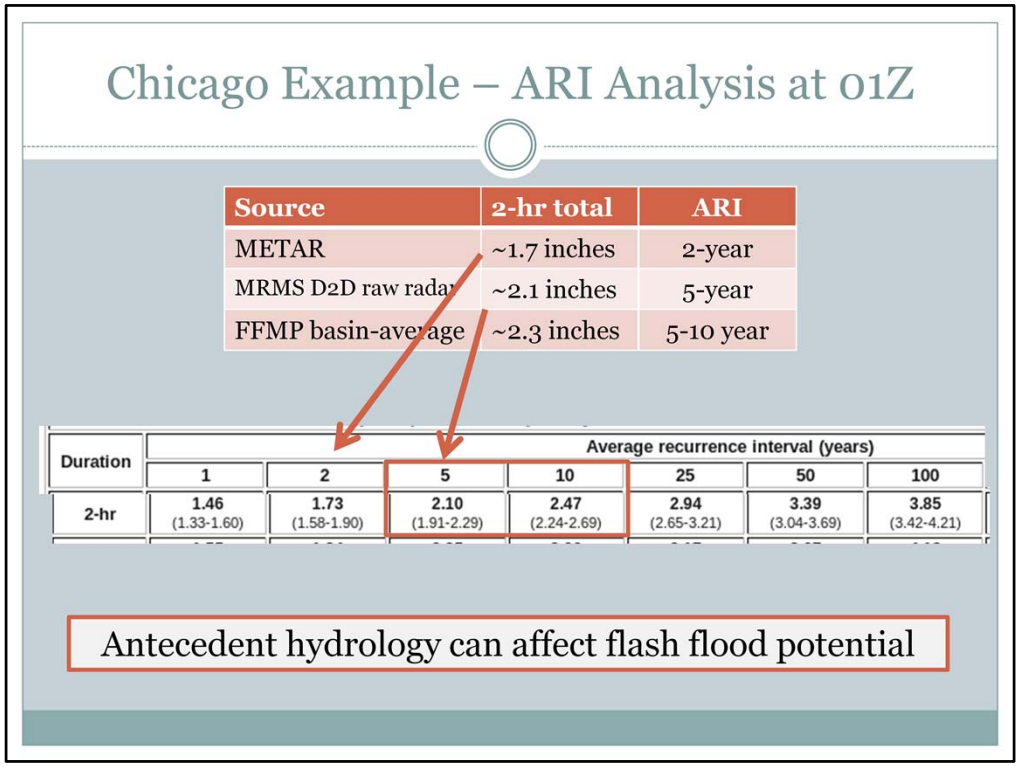
So now that you've looked at the data, let's start organizing some of this information into a table. Based on the questions you just answered, the two-hour total for the Rockford METAR was about 1.7 inches, and MRMS was about 2.1 inches at that location.

Now let's take a look at what FFMP is showing. Here is the Basin Table for the same two-hour duration. At this time, the basin near Rockford is actually showing the highest flash flood threat, based on ratio. Its two-hour QPE was about 2.3 inches. So let's add this to the table.

Since we noted earlier that the FFMP Basin Trend Graph was the easiest way to interpret ARI data quickly, on the next slide, we are going to use this method to interpret ARI information for the Rock River basin near the town of Rockford.



To get the FFMP Basin Trend Graph for Rock River, either click the red text on the screen, or go to the Resources tab in the upper-right.



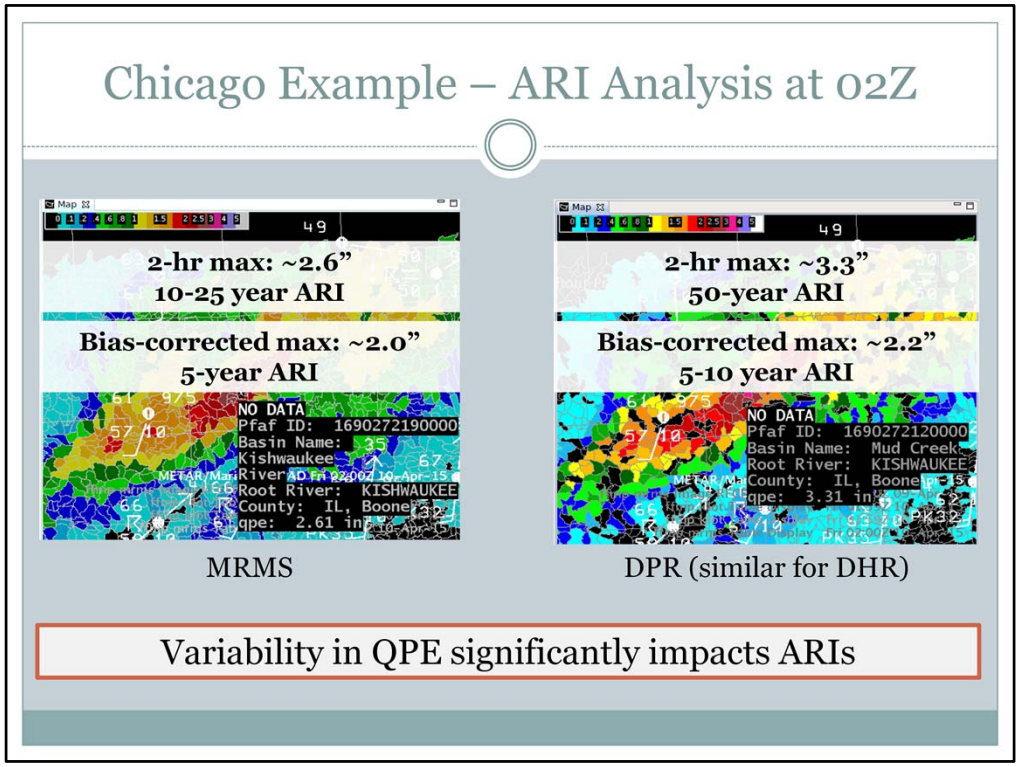
Okay, so let's look again at our two-hour totals. And let's add an ARI column so we can start comparing the values. Remember, ARIs have uncertainty associated with them, so let's also make sure to have the online ARI table up, so we have can look at the confidence intervals.

First, using the Trend Graph, you just calculated the ARI for the FFMP basin-average. This came out to be around a 5-10 year rainfall, and we can confirm this using the table below to see that 2.28 inches falls between the two ARIs. Next, our initial estimate of 2.1 inches sits comfortably within the bounds of a 5-year rainfall.

But the kicker here is that the ground observation of 1.7 inches corresponds to just a 2-year rainfall. Meaning, a 50% chance of occurring in any given year. This event shows how a 0.6 inch QPE overestimate on a 1.7 inch 2-hour accumulation can be the difference between a 2-year common ARI and a 5-10 year less common ARI. In this event, the Chicago office issued an Urban and Small Stream Advisory and did not receive any flooding reports.

But keep in mind….For your area, a 2-year rainfall could be associated with flash flooding, if the antecedent hydrologic conditions are right.

Now let's look at our second decision point, an hour later at 02Z.

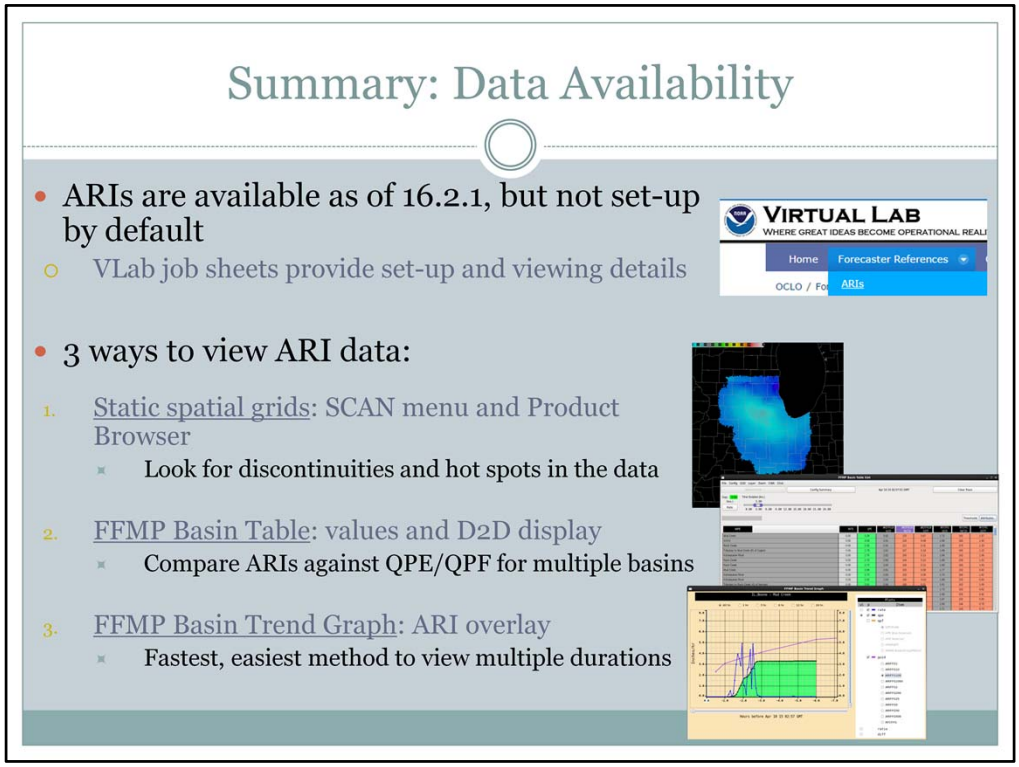


For this event, the max two-hour QPEs occurred an hour later, at 02Z. Here is the FFMP basin-averaged two-hour QPE from MRMS, which corresponded to a 10-25 year ARI. And to show how ARI can vary with precip source selection, here is the DPR max QPE for the same period, corresponding to a 50-year rainfall.

Near the location of the maximum, there was a COOP observation that we used to compare to radar estimates. And we found that the radar over-estimated by 25-50% (depending on the source). If we manually bias-correct the MRMS value, the new max corresponds to a little more than a 5-year rainfall. This is still a bit higher than the 2-year Rockford observation, and no flooding was reported. Let’s also manually bias-correct the DPR value, and we get a max that is more like a 5-10-year rainfall. The DHR Legacy precip source ended up being about the same as DPR in this event.

So all three sources over-estimated this rainfall event as compared to observations, yielding ARIs between 10-50 years. If we correct for the radar biases using nearby surface observations we see the actual ARIs in the peak rainfall areas were a little over 5 years, and there was still no flooding reported. So, the bottom line is that routine differences between radar rainfall estimates and surface precip estimates can yield significantly different ARIs and that ARIs of a little over 5 years are not necessarily associated with flash flooding.

So when you want to use ARIs for more day-to-day rainfall events, the value of ARI data is not as clear as in the historic cases. In all situations it is essential to choose your QPE carefully, and compare to surface observations and reports. This will help you more effectively calibrate ARIs to flooding, so that you can eventually use ARIs to build confidence during flash flood warning decision-making.



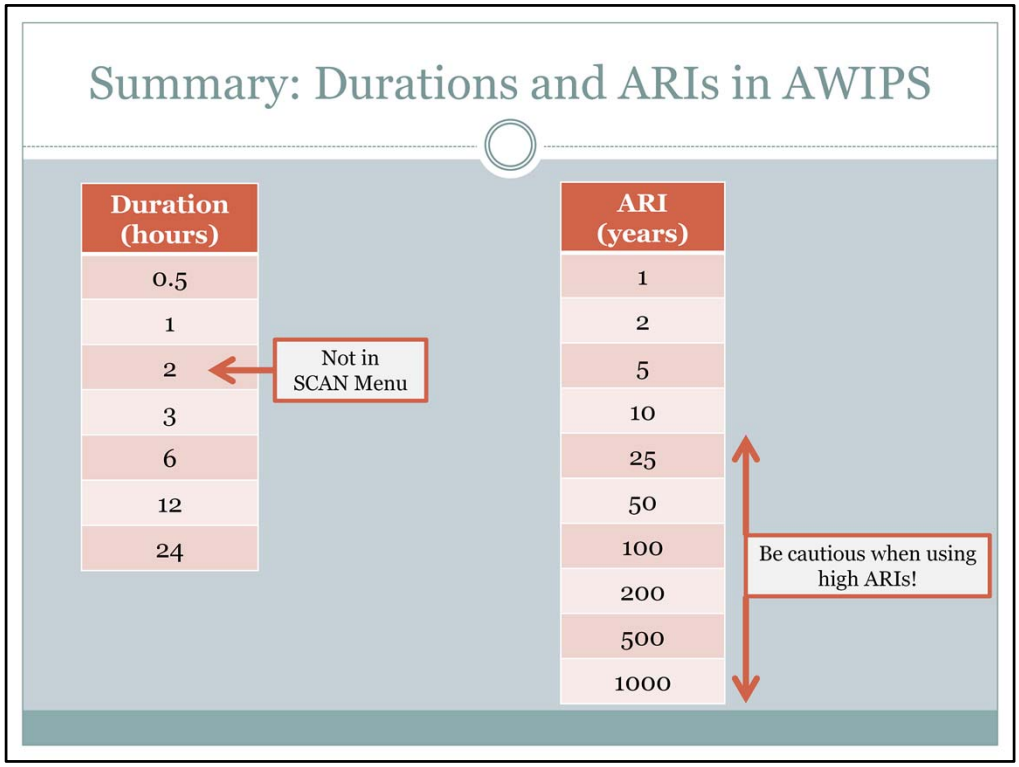
So let's summarize…

ARIs are available as of 16.2.1, however are not set-up by default. We have provided job sheets on the VLab with details for ingesting the dataset, as well as how to view the data in different ways.

And there are three different ways you can view the ARI data. First is the static spatial grids that are accessed either via the SCAN FFMP menu, or using the Product Browser. These should be your first stop when you first get the dataset, in order to familiarize yourself with potential discontinuities and hot spots across your domain.

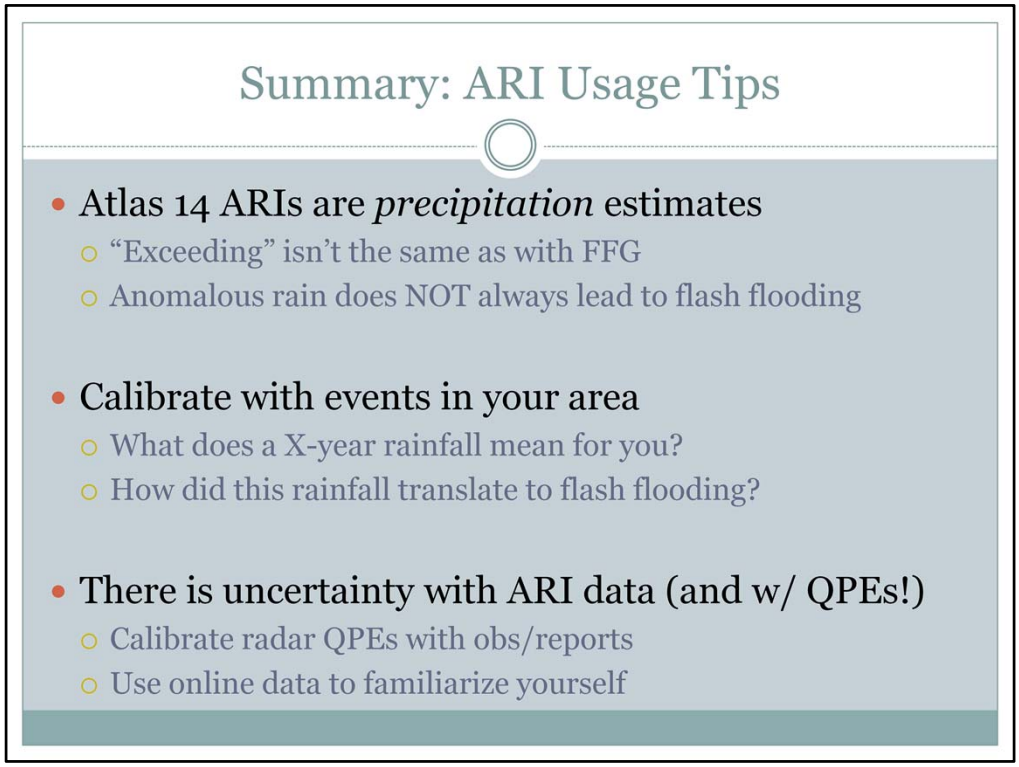
Next, there is the FFMP Basin Table, where you can add ARI columns to the table, and display in D2D. This is an easy way to compare against QPE or QPF, and see multiple basins' information.

Finally, the FFMP Basin Trend Graph provides the fastest and easiest way to manipulate the ARI data, and you can see multiple durations in one graph.



Recall from Part 1 that only a subset of the online data has been put onto AWIPS, for both duration and ARIs. For duration, the only nuance is that the SCAN, basin-averaged grids do not use the 2-hour data.

As for the recurrence intervals, the 10 options are the same for all viewing methods. But remember, be cautious when using the 25-year ARI or above, since these values were estimated with limited observational data and have a lot of uncertainty.



And while you are using ARIs in operations, there are some things to keep in mind…

For one, never forget that Atlas 14 ARIs are JUST *precipitation* frequency estimates…They were not calculated using hydrologic inputs, unlike FFG. While ARIs are treated like a Guidance source in FFMP, to "exceed" an ARI threshold does not give you the same information as exceeding FFG. And remember, anomalous rainfall does NOT always lead to flash flooding. It's also the hydrologic information that helps determine this threat.

Therefore, you will get the most use out of ARIs if you become better calibrated to how ARIs *can* be used for flash flood prediction in your area. What does a 5-year, 10-year, 100-year rainfall mean for your CWA? Did it cause significant flash flooding, or minor nuisance flooding? For a given ARI, how do impacts change with duration? Does a 30-min rate-driven event have higher impacts than 3-hour training storms?

And finally, remember there is uncertainty with ARIs and with QPEs that can be significant. Routinely calibrate your radar QPEs with observations and reports, and use the online data described in Part 1 alongside AWIPS to become more familiar with ARI uncertainties and their relationship to heavy precip events.

This concludes Part 2: Using ARIs in AWIPS. When you are ready, please go onto the next slide to complete the quiz and receive credit on the LMS.

Lesson 2: Using ARIs in AWIPS

Quiz - 14 questions

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