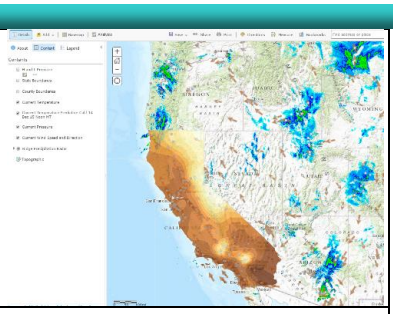
Analyzing Current Weather Data and Maps

Summary	Analyze weather data (temperature, pressure, wind speed, wind direction) in real time, symbolize and classify data, interpret patterns, and create interpolated surfaces. 
Disciplines	Geography, meteorology, climatology, GIS.
Level	University and upper secondary.
Time Required	20 questions. Two 60-minute class periods. Can be extended to 3 class periods.
Tools Used	ArcGIS Online from Esri. www.arcgis.com. Requires an organizational subscription. Requires broadband web connection.
Teaching Methods	Ideal: Each student runs the lesson on his or her own device (tablet or laptop). Alternative: Instructor runs lesson using 1 computer with projector, guiding students in engaged discussion.
Prerequisites	Some GIS background in analysis helpful. Some weather and climate knowledge helpful. Helpful introductory activity is to work through the lesson *How's the Weather* geoinquiry.
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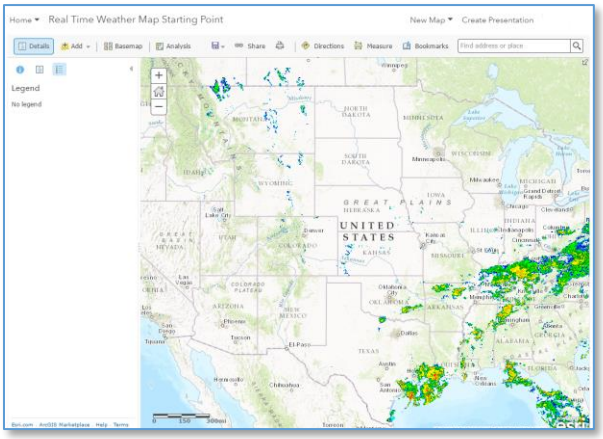
Open and Analyze Real-Time Weather Map

1. Open and save map. Access ArcGIS Online at www.arcgis.com and open the map: http://arcg.is/1qWu1D Its title is "Real Time Weather Map Starting Point." It will look similar to the map below:



Save this map in your own account's workspace. As you work through the steps below in this exercise, save your map after each step.

2. **Change Basemap and Note Effects of Local Terrain.** Your map contains the layers (1) state boundaries; (2) county boundaries; (3) Recent GOES weather satellite imagery; (4) current air temperature; (5) current pressure; (6) current wind speed and direction; (7) precipitation radar; (8) topographic basemap; and (9) other weather data, some of which is from a live weather feed from the National Oceanic and Atmospheric Administration (NOAA) through the Living Atlas of the World in ArcGIS Online.

Change the basemap to the other options such as the Light Gray Canvas so that you can more easily see the weather data. Change the basemap to imagery with labels, turn on current temperature, click on a few weather stations in the mountains versus the valleys, or coasts vs. interiors, and observe the differences and patterns. Why do these differences and patterns exist?

3. Consider Daily Effects. Use Bookmarks and make observations about current temperatures. What effect does the current time of day have on the temperatures, and why? Take note (conducting additional research if you need to) of the time of day that it is currently in other parts of the world.

4. Consider Seasonal Effects. Use Bookmarks and make observations on coastlines of continents versus their interiors. What effect do the time of year and the current season in the southern versus the northern hemisphere have on the temperatures, and why?

5. Examine Ocean Weather. Note the ocean buoy data that allows you to examine data in the oceans, near coasts. What patterns do you notice, and why do those patterns exist?

Change basemap back to topographic. Use Bookmarks and zoom back to Continental USA. Or, if teaching in an area outside the USA, use the procedures below for your own area of interest, noting that if few weather stations are mapped for any specific country, the interpolated surface below will be compromised in terms of predictability of resulting values.

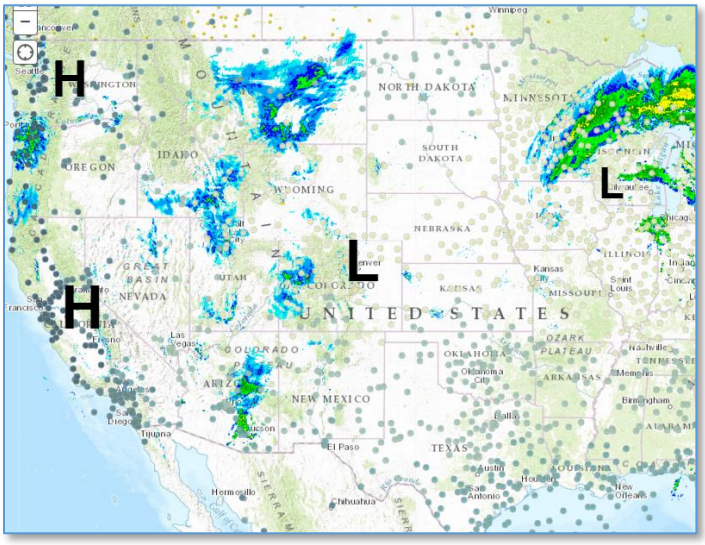
6. Observe Precipitation Patterns. Change it back to topographic when you done experimenting so that you can consider the effect of elevation and landforms on the observed weather. Turn on the layer "Ridge Precipitation Radar." Make 2 observations about the pattern of current precipitation and clouds. If time permits, search for a traffic or other webcam located in the areas experiencing storms. Does the weather as shown in the webcams match your prediction for the ground conditions there? Turn on the GOES satellite imagery and compare the precipitation to the cloud cover in the imagery.

7. Predict the Weather! Based on the Ridge precipitation layer, and knowing that the prevailing winds across the continental United States typically move from west to east, what do you predict the precipitation map will look like in 12 hours? In 24 hours? Name 2 cities that are dry now but could expect precipitation by this same time tomorrow.

8. Predict Pressure. Based on your knowledge of the relationship between precipitation and pressure, and based on your observations of the Ridge Precipitation layer, where do you predict the current pressure to be lowest and highest? Why?

9. Examine Pressure. Turn on the Current Pressure layer. Feel free to change the number of classes in or colors for your data under Change Style > Choose Attribute to show "Altimeter Pressure (Millibars)" > Counts and Amounts (Color) > OPTIONS > Classify Data > Currently, the data is classified as Quantile with 5 classes. Change classification method, number of classes, or colors if you wish > OK > Done. Was your hypothesis about where pressure is lowest and highest confirmed? Describe the pattern of current pressure across the 48 contiguous United States and its relationship to current precipitation and storms.

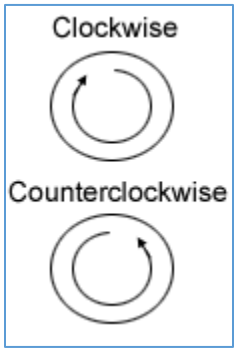
10. Create Pressure Map. Add Map Notes and name your map notes layer "H and L Pressure." Select the text symbol and add 2 locations labeled L where you believe a low-pressure system is currently centered, and 2 locations where you think a high-pressure system is centered, based on your observations of the pressure layer. After editing, click off of the H and L symbols, grab the edges, and make the text larger, such as shown below:



11. Analyze Current Temperature. Based on the current time of day and time of year, what do you predict the pattern of lowest and highest temperatures to show? Turn on Current Temperature. Show Legend. What do you observe about the current pattern of temperatures? Was your hypothesis about the pattern of temperatures confirmed? How does your own city's temperature (or one nearby) compare to those in your surrounding region?

12. Analyze Wind Speed and Direction. Turn on the Current Wind Speed and Direction layer. What do you observe about the current wind speed and direction? Does wind speed have any relationship to current precipitation and storms? If so, what is it? Remember that air in the Northern Hemisphere moves counterclockwise around a Low Pressure system and clockwise around a High Pressure System. In

the Southern Hemisphere, air moves counterclockwise around a High-Pressure System and clockwise around a Low-Pressure System.

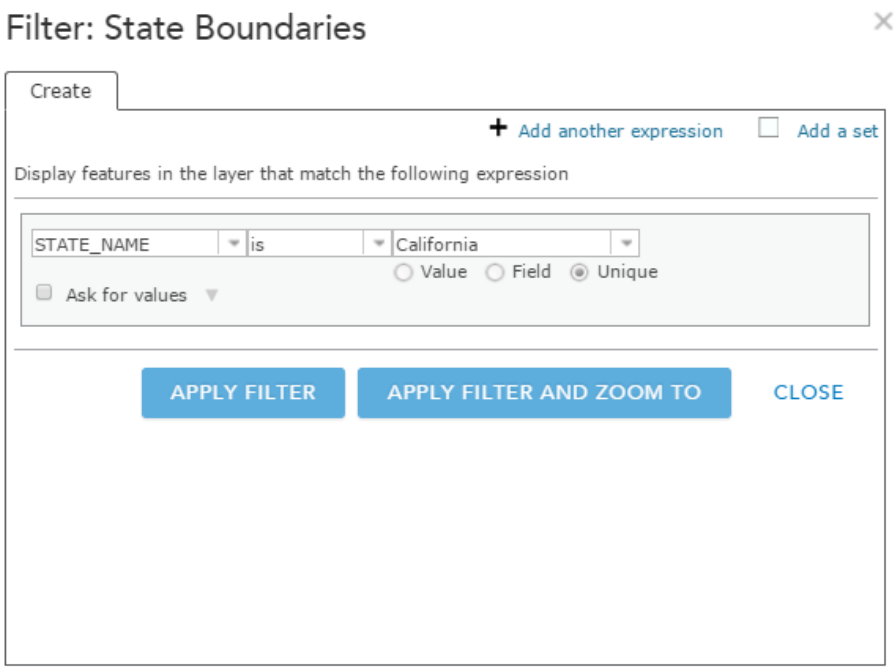


Based on this information, the Ridge Precipitation radar layer, and the current pressure, are your map notes indicating L and H (low and high pressure systems) confirmed by the wind direction arrows?

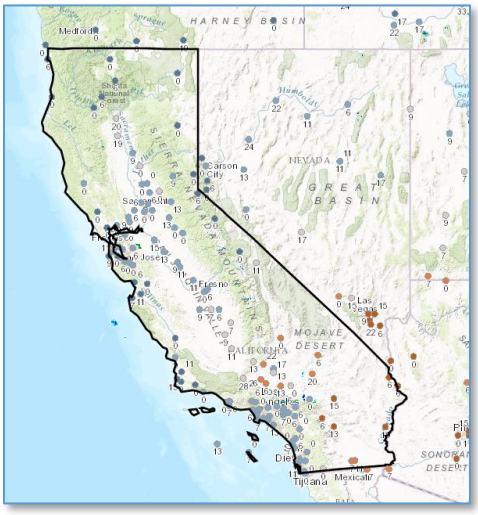
13. Predict the weather in 2 Locations. Use the "Find Address or Place" search box in the upper right and find "Des Moines, Iowa." Based on the Ridge Precipitation Radar, pressure, wind direction, and temperatures upwind from Des Moines, predict what the weather will be like in Des Moines in 12 to 24 hours. Select a different place, such as your own city or a place you are interested in, and predict the next day's weather there. How does your hypothesis compare to the predicted weather from www.weather.com or another source?

14. Interpolate a Temperature Surface. The temperature, pressure, and wind speed data that you have been analyzing are displayed as points on the map. The data points only exist for weather stations. GIS analysts often want to predict a value in other locations. To do that, they interpolate a surface. Let's say that you want to interpolate a surface from your weather points, so that you could predict the value of temperature, pressure, and wind speed at other locations, in a specific state. To do that, first turn on the State Boundaries and Temperature layers. Next, you will need to select a state. Let's start with California. Turn on the state boundaries layer. This is your "cookie cutter" that you will use as the bounding box for your interpolated surface.

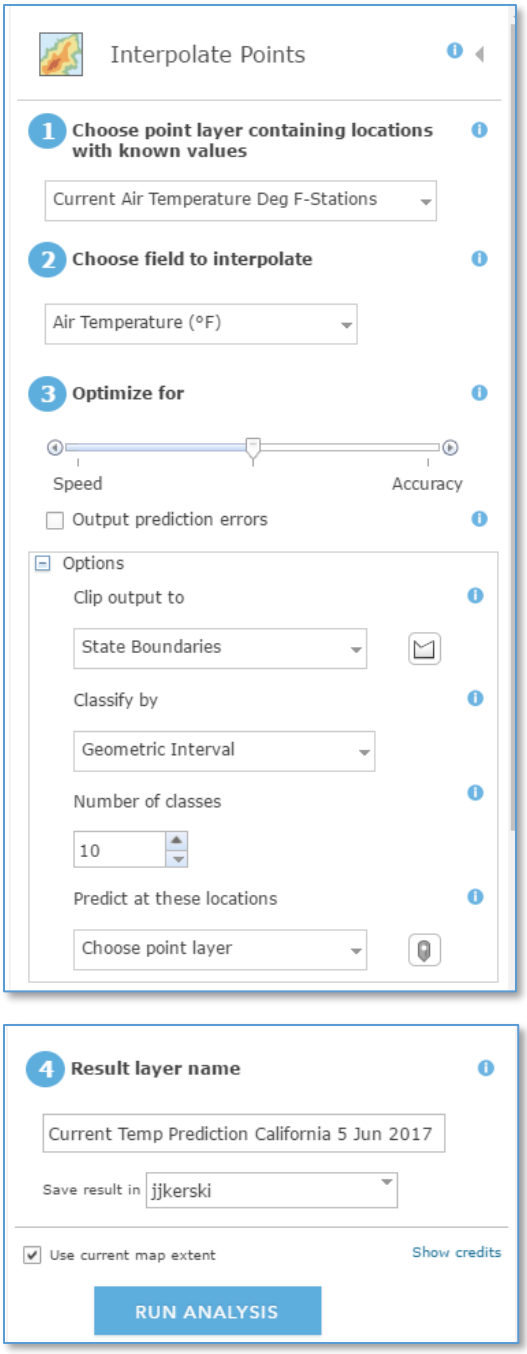
Under the state boundaries layer, use Filter > to select only the state of California, choosing "unique", as shown below:



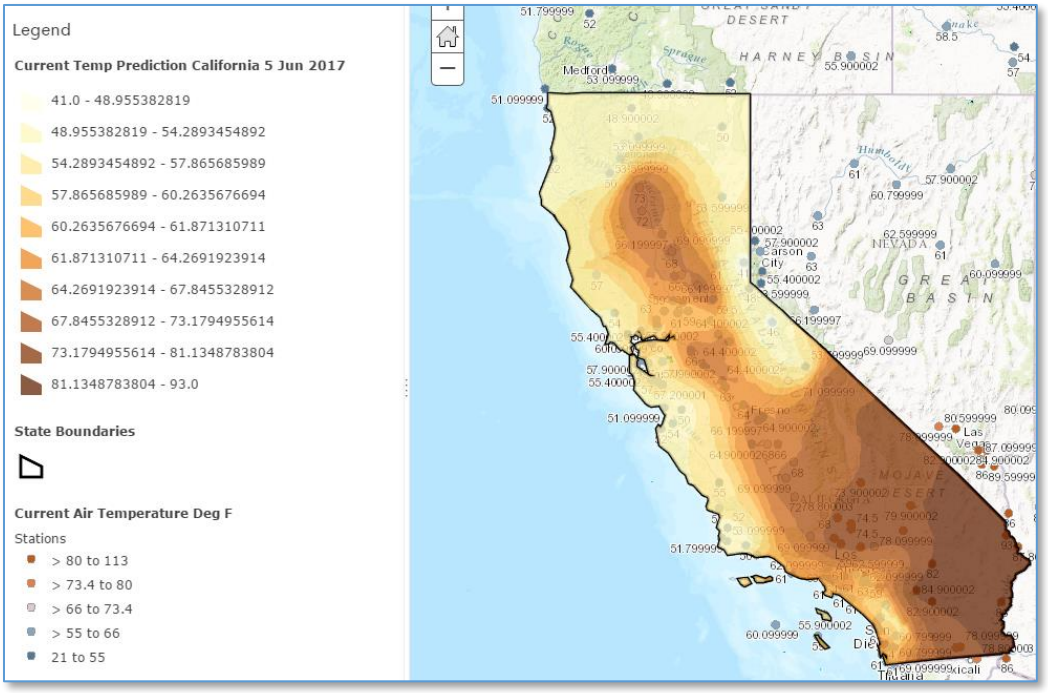
After selecting "Apply Filter and Zoom To" – you should see only the state of California's outline on your map, as shown below:



Next, select Analysis > Analyze Patterns > Interpolate Points > 1. Choose point layer containing locations with known values: Current Temperature > 2. Choose Field to interpolate: Air Temperature Degrees F > 3. Under Optimize for – Options – Clip output to **State Boundaries.** 4. Result layer name: Current Temperature Prediction California <Today's Date and Time> (as shown below) > Run Analysis. Be patient while the analysis completes.



15. **Observe the spatial pattern of temperature, proximity to ocean, and elevation.** Observe your new interpolated surface layer. It should look similar to that below, except yours will display a different pattern based on the temperatures current as of the time you perform the analysis.



What is the relationship of temperature to proximity to the Pacific Ocean? Why does this pattern exist? California contains some of the highest and lowest elevations in the United States, from sea level at the coasts to the low elevations in the Sacramento and San Joaquin Valleys and areas below sea level in Death Valley, all the way to the high elevations in the Sierra Nevada Mountains. What is the relationship of temperature to elevation? Why does this relationship exist?

Note that there is another difference between your point data and your surface data. Your real-time weather points are updated every 15 minutes, but your interpolated surfaces show a "snapshot in time" and are only current when you create them. Also note that the satellite GOES imagery is not real time but "recent" – composites for the last 3 hours.

16. Compare your predicted surface to existing point data. Compare a few observed temperature points to the predicted zone or area that those points fall into. How well did your predicted surface match the existing points? Interpolate points tool uses the *empirical Bayesian kriging* to perform the operation. Read about this technique here: http://desktop.arcgis.com/en/desktop/latest/guide-books/extensions/geostatistical-analyst/what-is-empirical-bayesian-kriging-.htm. How confident are you in the accuracy of your interpolated surface?

17. Consider the number of data points used in the interpolated surface. Zoom to the northeastern corner of California and note the location of the weather station at Alturas:

Alturas has no other weather stations nearby. Click in the polygon indicating the predicted temperature range in the region in which Alturas falls. Does the temperature in Alturas fall within this range? How confident are you in the predicted temperature surface here versus in the San Francisco Bay region, where numerous weather stations exist? Why?

Next, comment about your confidence in the accuracy of the surface in the middle of California versus along the border of California with Oregon, Nevada, and Arizona. Do you think your interpolated surface would be different if you were considering the weather stations on the other side of the border? If time permits, re-interpolate the temperature layer after filtering California and adding Nevada to your filter, saving as a new layer and comparing it to your California temperature layer.

In a similar way, pan the map to Sudan. How many weather stations are shown on the map in Sudan? If you made a predicted surface of temperature, pressure, or wind speed, how confident can you be in the results?

18. Create a pressure and wind speed predicted surface. Observe the pattern of atmospheric pressure in California. Make a prediction about the pattern from an interpolated surface of atmospheric pressure. Create an atmospheric pressure interpolated surface for California in a similar way in which you created a temperature interpolated surface above. Make 2 observations about your results. How well do your results compare to your prediction? Next, make an interpolated surface using wind speed or wind direction and make 2 observations about your results.

Additional Explorations

19a. Create interpolated surfaces for a different state or country. Create a temperature, pressure, and wind speed interpolated surface for the state in which you live or another state or country of interest.

For country, you will need to add a layer containing country boundaries. Compare these surfaces to that of California.

19b. Examine additional weather data. The real-time weather layers you have been examining contain additional attributes. Open the table to determine which attributes exist; these include elevation, humidity, dew point, visibility, wind gusts, and other information. Choose 1 or more of these additional attributes, map, and analyze it using any of the tools in this exercise (filter, classify and symbolize data, interpolate surface).

20. Write your own question! You have explored a few aspects of real time weather from a spatial perspective, but much more could be done. Write your own question about real time weather, investigate it, and answer it!

A sample "Real Time Weather Map Ending Point" map is shared here for you to examine, based on the above steps:

http://arcg.is/1D4fif

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