Developing Your Climate Data Story with The Northwest Climate Toolbox

(Handout 3)

About this Handout—This handout will help you develop your climate data story for the CIRC Spokane Community Adaptation Project (SCAP) by marrying your expertise and on-the-ground knowledge of the Spokane area with the Northwest Climate Toolbox and the data it provides. Consider this handout a reference that you can draw on as you work with the Toolbox.

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Climate Data Story—a narrative outlining the climate conditions your community faces.

About the Toolbox—The Northwest Climate Toolbox is a virtual toolbox of applications designed to help decision makers and resource managers respond to and prepare for climate impacts in the Pacific Northwest.

About CIRC—The Pacific Northwest Climate Impacts Research Consortium (CIRC) is a climate-science-to-action team funded by the National Oceanic and Atmospheric Administration's (NOAA) Regional Integrated Sciences and Assessments (RISA) program.

Resources:
- Northwest Climate Toolbox—climatetoolbox.org.
- CIRC website—pnwcirc.org.

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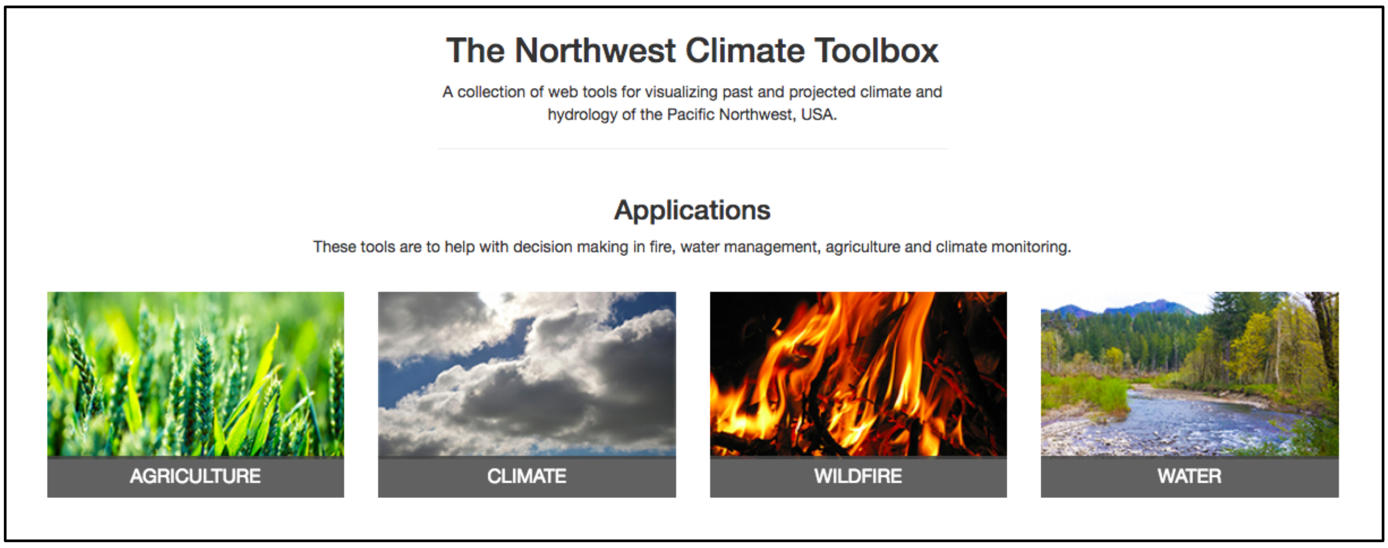
Navigating the Toolbox

Every tool in the Toolbox is a little different; however, there are common features and designs to keep in mind.

About the Tools

Tools in the Toolbox are organized according to four broad climate impact-related categories:

- ***Agriculture***—climatetoolbox.org/agriculture
- ***Climate***—climatetoolbox.org/climate
- ***Water***—climatetoolbox.org/water
- ***Wildfire***—climatetoolbox.org/wildfire



Common Navigation Features

Common navigation features are displayed as buttons found at the top right of a tool's page. These include:

- ***Documentation***—provides you with information on:
  - ***Source***—documentation concerning the tool's data sources.
  - ***Variables***—an explanation of the variables used.
  - ***Calculation***—an explanation of the calculations made by the tool.
  - ***Tool***—a rough description of the tool, its potential use, and its collaborators and funders.
- ***Example—***provides you with an example of how the tool could be used.
- ***Take a Tour***—guides you through a tool's functions and capabilities.
- ***Cite Tool***—describes Creative Commons licensing used and guidance on how to cite a figure developed using the tool.

Querying the Toolbox

Querying the Toolbox is a process of whittling and pruning. Start broad and then refine your climate-related question. Let the information from the Toolbox guide you to a more focused question.

1. Identify Your Climate Question

Frame your climate question by considering a climate condition or impact that currently affects your community or that you are concerned will affect your community in the future.

Tip:

- Climate impacts are effects on human communities and natural systems that result from changes in the climate. Climate impacts can result from human-caused climate change or from natural climate variability. Climate impacts covered by the Toolbox include drought, wildfire, and growing conditions.

2. Pick a Climate Category

Once you have a climate question in mind, choose a climate category that best fits your impact.

- ***Agriculture***—climatetoolbox.org/agriculture
- ***Climate***—climatetoolbox.org/climate
- ***Water***—climatetoolbox.org/water
- ***Wildfire***—climatetoolbox.org/wildfire

Tips:

- If you're interested in a broad climate impact, consider dividing your inquiry into pieces. For instance, climate impacts to human health can include poor air quality due to smoke (*Wildfire*) and impacts from rising temperatures, including heatstroke (*Climate*).
- Climate categories often share the same tools and variables.

3. Pick a Tool by Considering Time and Space

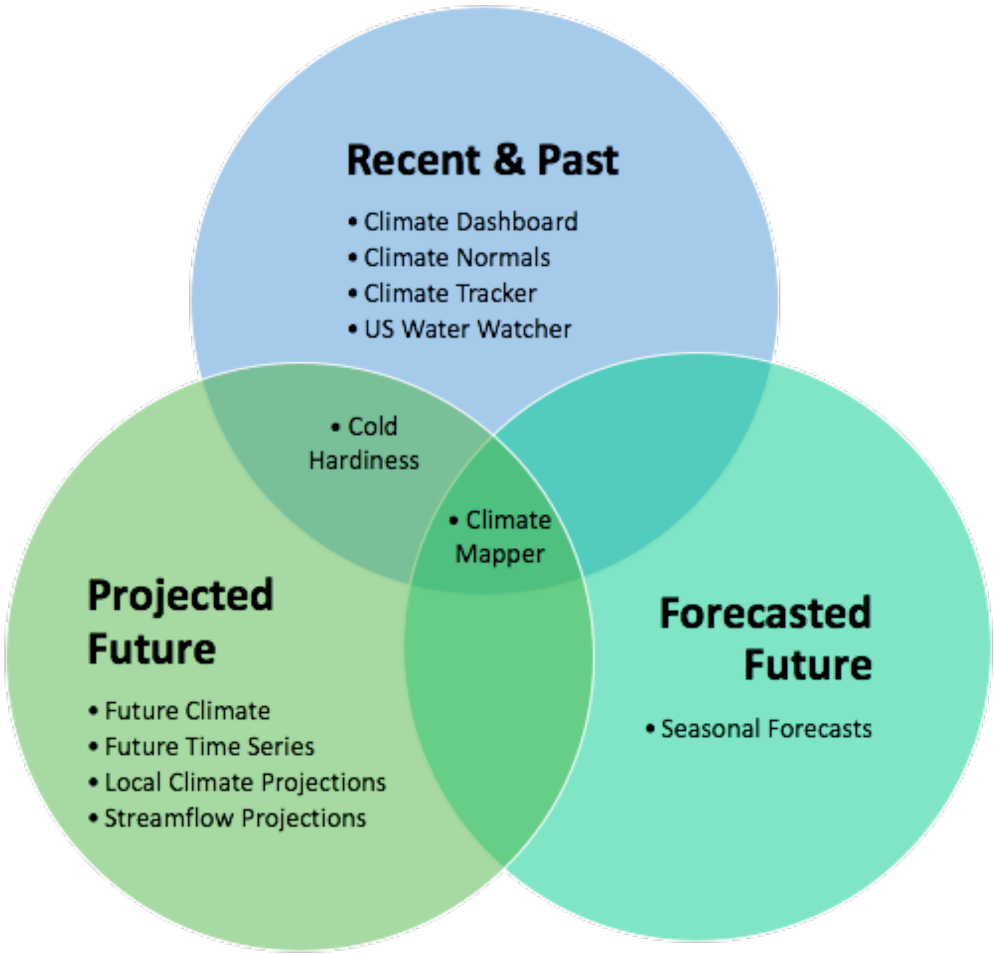
Now it's time to pick a tool. Consider the timeframe and location/geographic area you are interested in by asking yourself two questions:

- Am I interested in past, present, or projected future conditions?
- Do I need a tool that includes a mapping feature so I can consider a large geographic area or will a specific location work?

A. Consider Time When Picking a Tool

The Toolbox uses three basic categories to represent time:

- ***Recent & Past Conditions***—examines current climate conditions and how they stack up to conditions experienced in recent decades.
- ***Forecasted Future Conditions***—provides short-term (on the order of months) climate and weather forecasts.
- ***Projected Future Conditions***—provides long-term (on the order of decades) climate projections.



Tools Sorted by Time

Note: Projected Future Scenarios and Representative Concentration Pathways

Representative Concentration Pathways (RCPs) are used as proxies for the warming associated with CO_2 and other greenhouse gasses. RCPs are the standard used to represent future emissions of greenhouse gases, also called *emission scenarios.*

While a broad range of scenarios exist, the Toolbox uses just two RCPs:

Higher Emissions Scenario (RCP 8.5)—considers the current trajectory of increased greenhouse gas emissions and population growth through the end of the century with nominal policies to reduce emissions. This "business as usual scenario" assumes warming will continue at its current high rate.

Lower Emissions Scenario (RCP 4.5)—considers a curtailment in greenhouse gas emissions through greenhouse gas mitigation efforts. Assumes warming will continue but will slow from its current rate.

Projected Future Scenarios employing RCP projections can be viewed for the early (2010–2039), middle (2040–2069), and late decades (2070–2099) of this century.

B. Consider Location/Geographic Area When Picking a Tool
Considered spatially, Toolbox tools have two main designs:

- **Mapping Tools**—tools that display climate data on maps of the United States.
- **Dashboard Tools (*Set Location*)**—tools that create graphs and other visualizations for specific locations using climate data.

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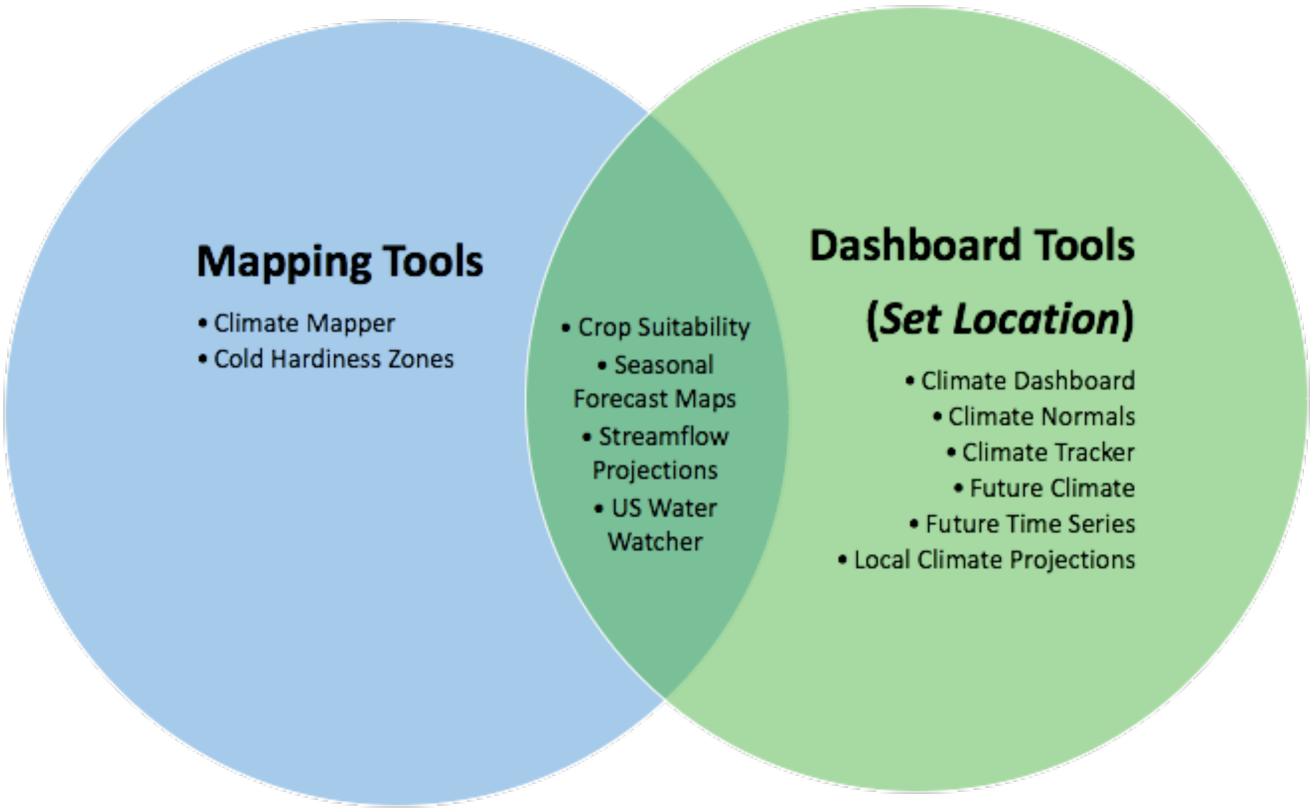


Tools Sorted By Mapping and Dashboard (*Set Location*) Functions

Tip:

- When framing your climate question for your location/geographic area, ask yourself whether your climate question includes just the Spokane region or whether a larger region should be considered.
    - **Mapping Tools**—useful when considering region-wide impacts that also create local impacts, such as impacts to the regional watershed from changes in mountain snowpack or impacts to the regional airshed due to smoke from fires, which may or may not burn locally.
    - **Dashboard Tools**—are useful when considering narrower local climate impacts and concerns, such as average maximum temperature and average minimum temperature.
- **Setting Your Location**
    - **Mapping Tools**—allows you to set specific geographic locations by
        - Clicking on a map
        - Typing in a location
        - Typing in a coordinate using degrees of longitude and latitude
    - **Dashboard Tools**—allow you to set specific geographic locations by using a *Set Location* function to view specific data for that location.

4. Pick a Variable in Your Chosen Tool

Variables differ from tool to tool, ranging from simple metrics to more complex ones. Variables can be viewed in their simple, raw form or expressed as percentiles or anomalies. Choose from the list of variables most relevant to your climate condition or impact question.

5. Calendar Time Periods—Considering Time Again

Climate conditions and impacts can differ significantly during different times of the year. Along with allowing you to examine variables across past, present, and projected future climate conditions, the Toolbox also allows you to examine variables across specific *Calendar Time Periods*, including:

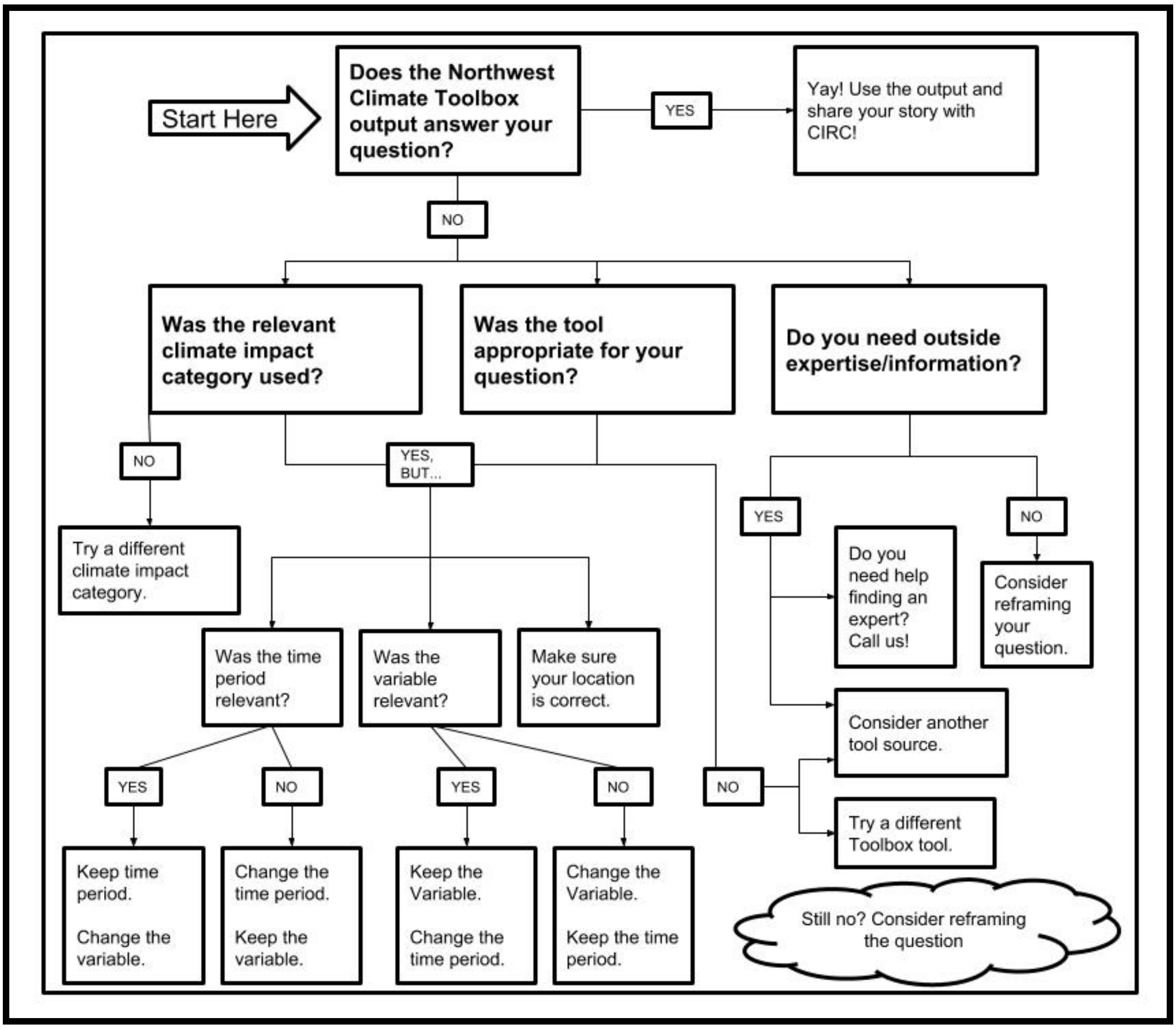
- *Yesterday* (literally yesterday)
- *Last 7 Days*
- *Last 15 Days*
- *Last 60 Days*
- *Last 90 Days*
- *Since the 1st* of each calendar month (*Since Oct. 1st*, *Since Jan. 1st*, etc.)
- *Winter (Dec/Jan/Feb)*
- *Spring (Mar/Apr/May)*
- *Summer (June/July/August)*
- *Fall (Sept/Oct/Nov)*
- *Annual* (conditions across all months of the year)

Tip:
- Compare multiple time periods when asking your climate question. For example, it might have rained more than normal over the past 7 days, but less than normal over the past 90 days.

Assessing Toolbox Outputs

The following section will help you assess whether the Toolbox has answered your climate question or if you need to take additional steps to get your answer.

Northwest Climate Toolbox Climate Data Story Flowchart



Tip:

- Querying the Toolbox takes practice. Keep playing with it and be patient. If you continue to struggle, give CIRC a call and we will help.

Downloading and Citing Your Results

To tell your Climate Data Story, there is a short list of to-dos you should perform to download and cite your work.

Downloading Data

Some Toolbox tools allow you to download the data used in your visualizations. This varies from tool to tool.

- **Download Data**—To download data in the Climate Mapper, click on the *Download Data* button on the left.
- **Save Dashboard**—Dashboard tools like the Climate Projection Dashboard and Real-Time Climate Dashboard have *Save Dashboard* buttons that allow you to save their dashboards as simple image files.
- **"Hamburger" (Three Stacked Lines)**—Other apps use an icon made of three stacked lines—sometimes called a "hamburger"—that functions as a download button. Click the icon to see your download options.

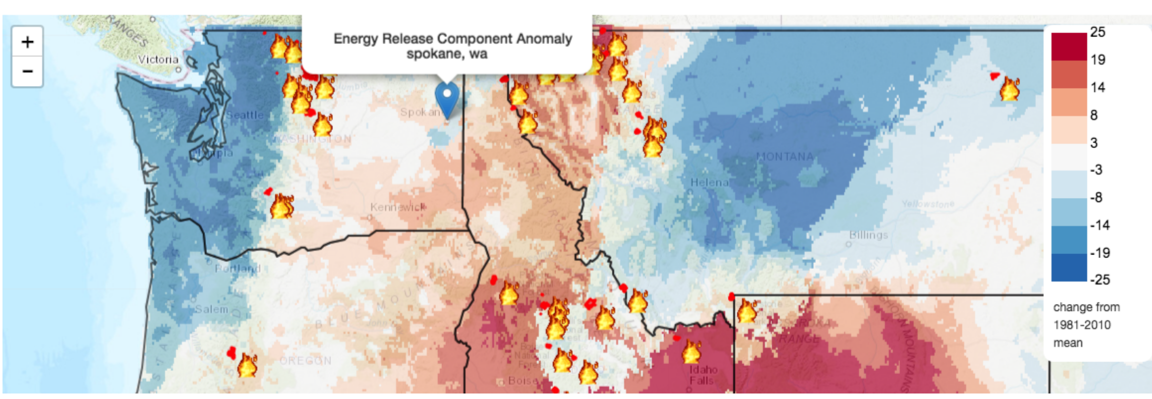
Screenshots

Perhaps the easiest way to save your work is by taking a screenshot. Instructions on how to take a screenshot using different operating systems can be found alongside many of the Toolbox's mapping tools.

- **Mac**—Press Shift-Command-4. Pointer changes to a crosshair. Move the crosshair to where you want to start the screenshot. Click and hold your mouse/trackpad. Drag crosshair, creating a rectangle that encompasses desired area. Release mouse or trackpad when ready. Image file will download to your computer.
- **Windows**—Microsoft includes a built-in utility for Windows called the *Snipping Tool*. In the Snipping Tool, click the *New* button. This freezes the screen and lets you frame your screenshot by clicking the mouse on the screen and dragging it to form a rectangle view of the screen. Once the screenshot is taken, the image is automatically pasted into a new *Paint* window. It is also copied to the clipboard, so you can paste it into another program.

Citing Figures and Data

Click on the *Cite Tool* button to cite a figure. A suggested citation will populate at the bottom of the window. If you want to cite the data a figure uses, click *Documentation* then *Source* to find a suggested citation for the data used in your visualization. Below is an example map pulled from the Climate Mapper tool listing a citation.



Caption: Energy release component anomalies and active fire parameters displayed for September 15, 2018.
Citation: Hegewisch, Katherine C., John T. Abatzoglou, Bart Nijssen, Liz Clark, Hordur Bragi, Oriana Chedwiggen, Nathan Gilles, and Holly Hartmann. "Climate Mapper web tool, The Northwest Climate Toolbox." *The Pacific Northwest Climate Impacts Research Consortium, a NOAA RISA Team*. Accessed on Sept 17, 2018. https://climatetoolbox.org/tool/Climate-Mapper.

Using Your Results to Tell Your Climate Data Story

Once you've concluded that the data you have informs your question (see *Assessing Toolbox Outputs*) it is time to use your expertise and knowledge to craft a locally relevant climate data story.

Make Your Story About Local Issues

- **Apply Local Knowledge and Expertise**—The most essential piece to telling your climate data story is you, your local knowledge and expertise, and how your knowledge integrates with the impersonal data provided by the Toolbox. Add your knowledge to make your story locally relevant.
- **Add Your Sense of Place**—Be sure to make the local landscape a key feature of your climate story. This will help contextualize your climate data for your community.
- **Know Your Audience**—Tailor your communication to your audience. Different audiences come with different concerns and different levels of knowledge about climate science. Ask yourself, who will be using your information and what decisions they might make based on your climate data story.

Tip:

- Be transparent. Whenever possible cite data sources and note your assumptions and how comparisons have been made.

Make Meaningful Comparisons

- **Historical Baselines**—The Toolbox uses several different databases that cover different historical periods. These periods form the different historical baselines used by the Toolbox. Historical baselines tend to be different based on the variable of interest. Be sure to describe what historical baseline you used when telling your climate story.
- **Calendar Time Comparisons**—When considering a variable displayed as a unit of *Calendar Time—Last 90 days*, *Winter (Dec/Jan/Feb),* etc.—be sure to describe both the unit of Calendar Time and the historical baseline.
    - For instance, when describing the variable *Maximum Temperature Percentile* for the calendar period *Last 90 Days*, you are comparing your last 90 calendar days to the same 90-day calendar period for each year from 1979 to 2015 (1979–2015 is the historical baseline used for this variable).
- **Use Both Percentiles and Anomalies**—Because they tell slightly different stories, it's helpful to use both percentiles and anomalies when examining a variable. Percentiles help you gauge how current conditions compare to past conditions. Anomalies help you determine how far outside of "normal" (historical mean) current conditions are. Using them together tells a rich climate story that appeals to a wider audience.

Percentiles—The Toolbox calculates percentiles as follows: ● record lowest ● bottom decile (bottom 10%) ● bottom tercile (bottom 33%) ● middle tercile (middle 33%) ● top tercile (top 33%) ● top decile (top 10%) ● record highest Historical baselines are used to rank current or future conditions against past ones. Baselines can differ from variable to variable.	***Anomalies***—The Toolbox expresses anomalies as the difference from a climatological average expressed over a 30-year base-period—for instance, 1981–2010 or 1971–2000. Conditions above the historical mean are displayed in positive numbers while conditions below the historical mean are displayed as negative numbers.

Describe Terms, Calculations, and Tricky Concepts

- **Variables**—The Toolbox uses multiple variables to help you tell your climate story. When you present your story to a broader audience, be sure to explain what the variables are and note your data sources.
- **Projections, Not Predictions**—The future climate projections, or *future scenarios*, the Toolbox uses present probable future effects of climate change. These projections are based on the best available science, but they are not predictions depicting a set-in-stone future. It's key when talking about future climate projections that you use the word *projection*.

Learning to Think Inside the Toolbox

Learning to work inside the Toolbox can be complicated and even frustrating at the beginning. Keep with it! As you have questions, please reach out to the CIRC team.

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- https://climatecirculatororg.wordpress.com

Twitter:

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Facebook:

- @PNWclimate

Developing Your Climate Data Story with The Northwest Climate Toolbox

(Worksheet 1)

About this Worksheet

This worksheet will help you apply the knowledge you've learned from *Handout 3—Developing Your Climate Data Story with The Northwest Climate Toolbox*.

Using the framework from the handout, you will go through the following exercises:

- Example—We will work through the process together.
- Exercise A—Groups work through two provided questions using the Toolbox.
- Exercise B—Groups develop and answer two questions using the Toolbox.

Come back together to share in the group

Example Question:	
1. Identify Your Climate Question:	4. Pick a Variable in Your Chosen Tool:
2. Pick a Climate Impact Category:	5. Consider Location/Geographic Area:
3. Pick a Tool:	6. Time Periods:
What outputs did the Toolbox provide?	Can you use the outputs from the Toolbox to answer your question?
What are your next steps?	

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Group Exercise A Question 1: Was summer weather in 2018 unusual?	
1. Identify Your Climate Question:	4. Pick a Variable in Your Chosen Tool:
2. Pick a Climate Impact Category:	5. Consider Location/Geographic Area:
3. Pick a Tool:	6. Time Periods:
What outputs did the Toolbox provide?	Can you use the outputs from the Toolbox to answer your question?
What are your next steps?	

Group Exercise A Question 2: Can I grow Gala apples in Spokane in 50 years?	
1. Identify Your Climate Question:	4. Pick a Variable in Your Chosen Tool:
2. Pick a Climate Impact Category:	5. Consider Location/Geographic Area:
3. Pick a Tool:	6. Time Periods:
What outputs did the Toolbox provide?	Can you use the outputs from the Toolbox to answer your question?

What are your next steps?

Group Exercise B Question 1:	
1. Identify Your Climate Question:	4. Pick a Variable in Your Chosen Tool:
2. Pick a Climate Impact Category:	5. Consider Location/Geographic Area:
3. Pick a Tool:	6. Time Periods:
What outputs did the Toolbox provide?	Can you use the outputs from the Toolbox to answer your question?
What are your next steps?	

Group Exercise B Question 2:	
1. Identify Your Climate Question:	4. Pick a Variable in Your Chosen Tool:
2. Pick a Climate Impact Category:	5. Consider Location/Geographic Area:
3. Pick a Tool:	6. Time Periods:
What outputs did the Toolbox provide?	Can you use the outputs from the Toolbox to answer your question?

What are your next steps?	

Scratch

Climate Impacts of Highest Importance to the Spokane Community

About this Handout—The table on page 2 and 3 of this handout lists the climate variables identified as of highest importance for the Spokane region during the May 25th, 2018 meeting of the Spokane Community Adaptation Project (SCAP). This information from this handout will be used by SCAP participants to focus on which Climate Data Story themes to work on first.

About the Table—The table connects the Spokane community-identified variables (*SCAP Variables*) to variables used by the Northwest Toolbox (*Toolbox Variables*).

The CIRC team sorted the SCAP Variables into impact categories and provided a general definition for each variable. Note: Some variable definitions will require SCAP participants to add local context (e.g. local timing).

Direct and Derivable Variables—The CIRC team identified two types of SCAP Variables: SCAP Variables that can be directly translated into Toolbox variable outputs (*Direct*) and SCAP Variables that can be derived using Toolbox variable outputs combined with further analyses and information found outside of the Toolbox (*Derivable*).

- ***Direct***—A SCAP Variable that translates directly into a Toolbox Variable output.
- ***Derivable***—A SCAP Variable that can be derived from a Toolbox Variable output and will require additional information.

Instructions—

1. Refresh your memory of the SCAP Variables.
2. Use the *Vote* column to indicate the 5 SCAP Variables that are most important to you.
3. We will vote on which SCAP Variables we will work on.
4. The chosen SCAP Variables will become your Climate Data Story topics and how you will sort into your Climate Data Story teams—see *Climate Data Story Team Assignment (Worksheet 2)*.

Impact	Vote	SCAP Variable	Definition	Toolbox Variable(s)
Agriculture		*Chilling Hours*	A unit of chill accumulation defined as the number of hours between 32°Fahrenheit and 45°F accumulated between October 1st and April 30th.	—Direct— *Chill Hours*
		Growing Degree Days	Accumulated growing degree days is a proxy for the heat accumulation needed to assess the thermal suitability of various crops in order to achieve maturity. Four growing degree thresholds are used to span the requirements for a variety of crops: 32°F, 37.4°F, 41°F, and 50°F.	—Direct— *Growing Degree Days*
		Length of Growing Season	Number of days between the last spring freeze and the first fall freeze.	—Direct— *Growing Season Length*
		Mean Evapotranspiration	Mean evapotranspiration during specified months.	—Direct— *Potential Evapotranspiration*
		Summer Soil Moisture	Mean soil moisture during the months of June, July, and August.	—Direct— *Soil Moisture*
Drought & Flooding		*Precipitation Timing*	Length of rain-free days. The duration and magnitude of drought.	—Derivable—
		River Flow Rate	Mean/min/max streamflow during the months of ___ to ___.	—Derivable—
		Storm Frequency/Severity	Rare storm defined as a 1 in ___ year precipitation event or precipitation amount exceeding ____ inches.	—Derivable—
Fish & Wildlife		*River Flow Rate*	Mean/min/max streamflow during the months of ___ to ___.	—Derivable—
		Water Temperature (Streams/Lakes)	Mean stream temperature during the months of ___ to ___.	—Derivable—
Impact	**Vote**	**SCAP Variable**	**Definition**	**Toolbox Variable(s)**

Human & Animal Health		*Heat Extremes/Waves*	Max daily temperature over a specified time period.	—Derivable—
		Summer Temperature	Average daily temperature during the months of June, July, and August.	—Direct— *Mean Temperature*
		Cool Season Temperature	Average daily temperature during the months of October to March.	—Direct— *Mean Temperature*
Water		*Summer Precipitation*	The amount of precipitation received over the months of June, July, and August.	—Direct— *Precipitation*
		Winter Precipitation	Mean precipitation during the months of December, January, and February.	—Direct— *Precipitation*
		Snowpack	The amount snowpack defined by *snow water equivalent*—the water contained in the snowpack.	—Direct— *Snow Water Equivalent*
Wildfire		*Fire Frequency*	The number of fires in a fire season.	—Derivable—
		Fire Intensity	The number of days each year in which the 100-hour fuel moisture is less than the __th percentile. *100-hour fuel moisture*—the amount of moisture in dead vegetation which is 1-3 inch in diameter and is available to burn in a fire.	—Direct— *100 Hour Fuel Moisture*
		Fire Season Length	The number of consecutive days where Energy Release Component is greater than ___. *Energy Release Component*—A calculation how hot a fire could burn (the energy release part) given recent climate and weather conditions specifically the moisture content of the various fuels (vegetation) present, both live and dead.	—Derivable—

Writing a Climate Data Story
(Handout 5)

Climate Data Story—a narrative outlining climate conditions specific to your community.

About this Handout—This handout is a set of recommendations to consider as you develop and draft your Climate Data Story. Think of this handout as a guide.

The considerations outlined below are intended to aid you, not restrict you. Likewise, the Northwest Climate Toolbox as well as the sources listed on the accompanying handout "Data Sets, Subject Matter Experts, and Studies (Handout 6)" are intended to extend your effort, not limit it.

Your organizations and those of your SCAP colleagues are also great resources!

The following steps and questions were introduced during the last public meeting of the Spokane Community Adaptation Project and can be found in the handout "Developing your Climate Data Story with the Northwest Climate Toolbox (Handout 3)."

Querying the Toolbox

1. Identify your Climate Question
2. Pick a Climate Category
3. Pick a Tool by Considering Time and Space
4. Pick a Variable in Your Chosen Tool
5. Calendar Time Periods—Considering Time Again

Assessing Toolbox Outputs

1. What outputs did the Toolbox provide?
2. Can you use the outputs from the Toolbox to answer your question?
3. What are your next steps?

Using Your Results to Tell Your Climate Data Story

1. Make Your Story About Local Issues
2. Make Meaningful Comparisons
3. Describe Terms, Calculations,

Composing Your Climate Data Story

Using the information you have gathered begin to compose your climate data story. Use the definitions and guidelines found below as a companion tool to the document "Writing a Climate Data Story (Worksheet 3)."

***Topic*—**Introduce a clear topic at the start of your Climate Data Story.
Start general. Then go into the specifics.
Think of your topic as composed of two broad themes:

1. ***facts***—all the scientific data and information you have gathered.
2. ***impacts***—what the information you have gathered means for your community.

***Definitions*—**Climate science and social science use many specialized, or jargon, terms. Remember to define these terms for your audience. This should include defining the variables related to the information you are presenting. In the Toolbox, you can find definitions of variables in the *Variables* tab found under the *Documentation* tab. You can also find definitions in the previous meeting document "Climate Variables of Highest Importance to the Spokane Community (Handout 4)."

Calculations and tools—Describe which tools you used to develop your Climate Data Story and how you queried the Toolbox (how you considered time, space, and what variables you used, etc.). If it was necessary to derive, or calculate, information, include that information as well as a short description of that process. Be transparent about your methods and assumptions and share what you do and do not know.

***Data*—**Cite and describe where your data came from. When possible describe the assumptions and limitations of the data sets you used. See "Downloading and Citing Your Results" in "Developing your Climate Data Story with the Northwest Climate Toolbox (Handout 3)."

***Results*—**Describe your results simply and succinctly.

***Analysis*—**Start your narrative. What story does your data tell? Use your local expertise to provide a context for the data you're presenting. Again consider your two themes.

1. ***facts***—Ask yourself,
   a. What are the assumptions inherent in your data sets?
   b. Are there limitations to my information that restrict how I can extrapolate impacts?
2. ***impacts***—Ask yourself,
   a. What key systems and stakeholders are affected and how?
   b. What actions can be taken?

***Summary*—**What is your take-away message? In 1-2 sentences, remind readers why your topic is important and describe what they can do with the information you present.
Include:

- Decisions that can be informed by your Climate Data Story
- Further study and analysis that might be needed

Charts and figures—Remember to provide captions for all figures and tables. See "Developing your Climate Data Story with the Northwest Climate Toolbox (Handout 3)." You can use any style depending on your institution's standards. Just be sure to provide enough information for others to replicate your work and conclusions.

***References*—**List sources you used to form your conclusions. You'll need to include enough information so that other people can refer back. At CIRC, we use the Chicago Manual of Style for our references.

***Example*[1]—**Excerpt from the "Boise Climate Adaptation Assessment Report"

Metric III: Irrigation demand

Defined: Evapotranspiration is the water lost through evaporation and transpiration from vegetation. To keep both crops and urban landscapes "well watered" during periods where precipitation does not meet the water demands of vegetation, additional water is required through irrigation.

How it is calculated: Reference evapotranspiration (ETo) is the potential amount of water used by a reference grass surface for given ambient meteorological conditions. ETo is calculated using the Penman-Monteith equation, which is the standard for estimating crop water use in Idaho when meteorological observations are complete (Allen et al., 1998). Actual evapotranspiration can differ from ETo as a function of both vegetation type and if vegetation undergoes water stress. For the purposes of this exercise, ETo will be used as it approximates the amount of water a reference grass surface will use when it is well watered. The total ETo from April through October is used to approximate the irrigation demand. Although precipitation does occur during this time period, it is typically insufficient to meet ETo demands.

Data: Monthly temperature, wind speed, solar radiation and humidity data were obtained from 20 downscaled

[1] Remember, this example was prepared by a professional climate scientist consulting for the City of Boise. Your climate data story may have a different audience, friends, family, etc.

climate models (Table 3.1) for a ~2.5 mile by 2.5 mile grid point centered over Boise, Idaho (43.61°N, 116.2°W). These data were downscaled using the Multivariate Adaptive Constructed Analogs (MACA, Abatzoglou and Brown, 2012) statistical downscaling method that applies observational relationships between fine-scale and coarse resolution meteorology to the coarse resolution output of global climate models. The gridded observational dataset of Abatzoglou (2013) from 1979-2016 was used as the training data. These data are not intended to provide fine-scale information on climate at the scales of individual buildings, parks, or neighborhoods -- all of which have their own microclimate, but rather a broader scale representation of climate experienced throughout the Boise metropolitan area. An additional factor is further included to account for the fact that under elevated carbon dioxide concentrations, crops before more water efficient by closing their stomata and limiting transpiration rates. There are numerous ways to approximate this effect, and science is still evolving on precisely how climate change and additional carbon dioxide will alter water use by crops. For the purposes of this analysis, an empirical transformation of Kruijt et al. (2008) is applied for a grass surface that effectively reduces ETo with rising levels of carbon dioxide. A scalar factor is applied to each year by considering the projected changes in atmospheric carbon dioxide levels under low and high emission scenarios from a reference 1980 baseline. This has the effect of approximately reducing the calculated ETo for low and high emissions scenarios by 1.5% and 1.8%, respectively, for the early 21st century (2020-2049), and 2.25% and 3.65% for the mid 21st century (2050-2079).

Analysis: The total ETo during irrigation season (April-October) was calculated for the historical modeled data (1950-2005) and future climate scenarios for the early (2020-2049) and mid-21st century (2050-2079).

Results: The annual April-October ETo over the contemporary climate was 41.4 inches, which is comparable (about 3% higher) with that of the Boise AgriMet station. Despite the enhanced water use efficiency of crops with enhanced carbon dioxide concentrations, estimated ETo is projected to increase by approximately 2 inches (5%) by the early-21st century, and an average of 2.6 inches (+6.4%) and 4 inches (+9.7%) by the mid-21st century. These increases are based on substantial warming of summer temperatures, increased vapor pressure deficit (difference between atmospheric moisture and potential water holding capacity of the air), and slight increases in solar radiation (a function of more clear days). For the mid-21st century under high-emissions, a couple models project increase in ETo of 6 or more inches (14.5%), whereas a couple project more subtle increases of around 2 inches.

Summary: Human-caused climate change will increase evaporative demand and hence irrigation demand during the warm season across Boise. An increase of approximately 2 inches of irrigation is projected by the early 21st century and up to 4 inches of irrigation by the mid-21st century under high emissions scenario.

Figure 3.1: Modeled average reference evapotranspiration (ETo) from April-October under historical (left), early 21st century (middle) and mid-21st century (right) from 20 downscaled climate models for low

emissions (RCP 4.5) and high emissions (RCP 8.5) scenarios. The black box shows the average of the 20 models.

Table 3.1: Average reference evapotranspiration (inches) from April-October for different models (rows) and time period/scenarios (columns).

	1950-2005	2020-2049 RCP45	2020-2049 RCP85	2050-2079 RCP45	2050-2079 RCP45
inmcm4	41.6	42.7	43.0	43.1	44.8
CSIRO-Mk3-6-0	41.6	44.0	43.9	44.7	46.3
CanESM2	41.5	43.6	43.8	44.3	45.0
CNRM-CM5	41.5	42.8	43.6	44.0	45.2
MIROC5	41.5	44.0	43.6	44.2	43.7
GFDL-ESM2M	41.5	42.2	44.2	43.7	45.3
GFDL-ESM2G	41.6	42.9	42.7	43.3	44.9
MRI-CGCM3	41.5	42.2	42.3	42.3	43.0
HadGEM2-ES365	41.5	44.9	44.8	45.3	48.1
HadGEM2-CC365	41.6	44.0	44.4	44.7	47.2
bcc-csm1-1	41.5	44.3	44.8	44.6	46.4
MIROC-ESM	41.5	43.9	44.3	45.2	46.2
MIROC-ESM-CHEM	41.5	44.0	43.9	45.2	46.5

BNU-ESM	41.5	43.0	42.9	43.9	45.0
bcc-csm1-1-m	41.5	43.0	43.0	44.1	45.6
CCSM4	41.5	43.2	43.4	43.5	44.8
IPSL-CM5A-LR	41.5	43.5	44.3	44.5	46.2
IPSL-CM5A-MR	41.5	43.5	44.1	44.3	46.4
IPSL-CM5B-LR	41.6	43.3	42.9	43.6	44.4
NorESM1-M	41.5	44.2	44.5	44.8	46.0
MEAN	**41.5**	**43.5**	**43.7**	**44.2**	**45.6**

References:

- Abatzoglou, John T., and Timothy J. Brown. "A comparison of statistical downscaling methods suited for wildfire applications." *International Journal of Climatology* 32, no. 5 (2012): 772-780. https://doi.org/10.1002/joc.2312.
- Abatzoglou, John T. "Development of gridded surface meteorological data for ecological applications and modelling." *International Journal of Climatology* 33, no. 1 (2013): 121-131. https://doi.org/10.1002/joc.3413.
- Allen, Richard G., Luis S. Pereira, Dirk Raes, and Martin Smith. "Crop evapotranspiration-Guidelines for computing crop water requirements-FAO Irrigation and drainage paper 56." Fao, Rome 300, no. 9 (1998): D05109.
- Kruijt, Bart, Jan-Philip M. Witte, Cor MJ Jacobs, and Timo Kroon. "Effects of rising atmospheric CO2 on evapotranspiration and soil moisture: A practical approach for the Netherlands." Journal of Hydrology 349, no. 3-4 (2008): 257-267.https://doi.org/10.1016/j.jhydrol.2007.10.052.

Data, Subject Matter Experts, and Studies (Handout 6—work in progress….)

About this handout—This handout provides you with resources outside of the Northwest Climate Toolbox that you can use to help you formulate your climate data story.

Resources are organized by the Climate Data Story Themes and have been broken into three categories:

1. ***Data and Resources***—other tools and data sets.
2. ***Subject Matter Experts***—regional experts in your chosen topic.
3. ***Studies***—peer-reviewed literature providing a broader context for local climate impacts.

Precipitation
Suggested Data and Resources: Multivariable Adaptive Constructed Analogs (MACA) https://climate.northwestknowledge.net/MACA/
Subject Matter Experts: David Rupp, Oregon State University Nick Bond, Washington State Climatologist
Sample Studies: Klos, P. Zion, Timothy E. Link, and John T. Abatzoglou. "Extent of the rain□snow transition zone in the western US under historic and projected climate." *Geophysical Research Letters* 41, no. 13 (2014): 4560-4568. https://doi.org/10.1002/2014GL060500. Rupp, David E., John T. Abatzoglou, and Philip W. Mote. "Projections of 21st century climate of the Columbia River Basin." *Climate Dynamics* 49, no. 5-6 (2017): 1783-1799. https://doi.org/10.1002/jgrd.50843. • **Publications on Precipitation Extremes**

Parker, Lauren E., and John T. Abatzoglou.
"Spatial coherence of extreme precipitation events in the Northwestern United States."
International Journal of Climatology 36, no. 6 (2016): 2451-2460.
https://rmets.onlinelibrary.wiley.com/doi/abs/10.1002/joc.4504.

River Flow and Temperature
Suggested Data and Resources: Climate Toolbox https://climatetoolbox.org/tool/streamflow-projections Hydrologic Response of the Columbia River Basin to Climate Change http://www.hydro.washington.edu/CRCC/ NorWest stream temperature tool https://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.html
Subject Matter Experts: Bart Nijssen, University of Washington Daniel Isaak, US Forest Service
Sample Studies: Vano, Julie A., Bart Nijssen, and Dennis P. Lettenmaier. "Seasonal hydrologic responses to climate change in the Pacific Northwest." *Water Resources Research* 51, no. 4 (2015): 1959-1976. https://doi.org/10.1002/2014WR015909. Li, Dongyue, Melissa L. Wrzesien, Michael Durand, Jennifer Adam, and Dennis P. Lettenmaier. "How Much Runoff Originates as Snow in the Western United States, and How Will That Change in the Future?." *Geophysical Research Letters* (2017). https://doi.org/10.1002/2017GL073551. Isaak, Daniel J., Michael K. Young, David E. Nagel, Dona L. Horan, and Matthew C. Groce. "The cold□water climate shield: delineating refugia for preserving salmonid fishes through the 21st century." *Global Change Biology* 21, no. 7 (2015): 2540-2553.https://www.fs.fed.us/rm/pubs_journals/2015/rmrs_2015_isaak_d001.pdf.

Temperature
Suggested Data and Resources: Multivariable Adaptive Constructed Analogs (MACA) https://climate.northwestknowledge.net/MACA/
Subject Matter Experts: Nick Bond, Washington State Climatologist David Rupp, Oregon State University
Sample Studies: Abatzoglou, John T., David E. Rupp, and Philip W. Mote. "Seasonal Climate Variability and Change in the Pacific Northwest of the United States." *Journal of Climate* 27, no. 5 (2014): 2125-2142. https://doi.org/10.1175/ JCLI-D-13-00218.1. Rupp, David E., John T. Abatzoglou, and Philip W. Mote. "Projections of 21st century climate of the Columbia River Basin." *Climate Dynamics* 49, no. 5-6 (2017): 1783-1799. https://doi.org/10.1002/jgrd.50843. Rupp, David E., Sihan Li, Philip W. Mote, Karen M. Shell, Neil Massey, Sarah N. Sparrow, David CH Wallom, and Myles R. Allen. "Seasonal spatial patterns of projected anthropogenic warming in complex terrain: a modeling study of the western US." Climate dynamics 48, no. 7-8 (2017): 2191-2213. https://doi.org/10.1007/s00382-016-3200-x. Rupp, David E., John T. Abatzoglou, Katherine C. Hegewisch, and Philip W. Mote. "Evaluation of CMIP5 20th Century Climate Simulations for the Pacific Northwest USA." *Journal of Geophysical Research: Atmospheres* 118, no. 19 (2013). https://doi.org/10.1002/jgrd.50843. Littell, J. S., M. McGuire Elsner, L. C. Whitely Binder, and A. K. Snover. "The Washington Climate Change Impacts Assessment: Evaluating Washington's Future in a Changing Climate-Executive Summary." (2009). http://www.cses.washington.edu/db/pdf/wacciaexecsummary638.pdf.

Snowpack
Suggested Data and Resources: Historical— Snow Telemetry Network (SNOTEL) https://www.wcc.nrcs.usda.gov/gis/snow.html Snow Drought Page https://www.drought.gov/drought/data-maps-tools/snow-drought Projections— Northwest Climate Toolbox Integrated Scenarios
Subject Matter Experts: Philip Mote, Oregon State University Anne Nolin, Oregon State University
Sample Studies: Gergel, Diana R., Bart Nijssen, John T. Abatzoglou, Dennis P. Lettenmaier, and Matt R. Stumbaugh. “Effects of Climate Change on Snowpack and Fire Potential in the Western USA.” *Climatic Change* 141, no. 2 (2017): 287-299. https://doi.org/10.1007/s10584-017- 1899-y. Mote, Philip W., Sihan Li, Dennis P. Lettenmaier, Mu Xiao, and Ruth Engel. “Dramatic declines in snowpack in the western US.” *Nature Partner Journals: Climate and Atmospheric Science* volume 1, 2. (2018). https://doi.org/10.1038/s41612-018-0012-1. Mote, Philip W., David E. Rupp, Sihan Li, Darrin J. Sharp, Friederike Otto, Peter F. Uhe, Mu Xiao, Dennis P. Lettenmaier, Heidi Cullen, and Myles R. Allen. “Perspectives on the Causes of Exceptionally Low 2015 Snowpack in the Western United States.” *Geophysical Research Letters* 43, no. 20 (2016). https://doi.org/10.1002/2016GL069965.

Fire
Suggested Data and Resources: National Interagency Fire Center https://www.nifc.gov/ Northwest Climate Toolbox
Subject Matter Experts: John T. Abatzoglou, University of Idaho Ed Delgado, Bureau of Land Management
Sample Studies: Abatzoglou, John T., and A. Park Williams. "Impact of Anthropogenic Climate Change on Wildfire across Western US Forests." *Proceedings of the National Academy of Sciences* 113, no. 42 (2016): 11770-11775. https://doi.org/10.1073/pnas.1607171113. Barbero, Renaud, John T. Abatzoglou, Narasimhan Larkin, Crystal A. Kolden, and B. J. Stocks. "Climate Change Presents Increased Potential for Very Large Fires in the Contiguous United States." *International Journal of Wildland Fire* 24, no. 7 (2015): 892-899. https://doi.org/10.1071/WF15083. Littell, Jeremy S., Donald McKenzie, Ho Yi Wan, and Samuel A. Cushman. "Climate Change and Future Wildfire in the Western United States: An Ecological Approach to Nonstationarity." *Earth's Future* 6, no. 8 (2018): 1097-1111.https://doi.org/10.1029/2018EF000878. Gergel, Diana R., Bart Nijssen, John T. Abatzoglou, Dennis P. Lettenmaier, and Matt R. Stumbaugh. "Effects of Climate Change on Snowpack and Fire Potential in the Western USA." *Climatic Change* 141, no. 2 (2017): 287- 299. https://doi.org/10.1007/s10584-017-1899-y. Sheehan, Timothy J., Dominique Bachelet, and Ken Ferschweiler. "Projected Major Fire and Vegetation Changes in the Pacific Northwest of the Conterminous United States under Selected CMIP5 Climate Futures." *Ecological Modeling* 317 (2015): 16-29. https://doi.org/10.1016/j.ecolmodel.2015.08.023.

Northwest-wide Climate Assessments
Dalton, Meghan M., Philip W. Mote, Amy K. Snover, eds. *Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities.* Washington, DC: Island Press, 2013. Print ISBN: 9781610914284. E-Book ISBN: 9781610915120. https://pnwcirc.org/sites/pnwcirc.org/files/climatechangeinthenorthwest.pdf. Mote, Philip W., Amy K. Snover, Susan Capalbo, Sanford D. Eigenbrode, Patty Glick, Jeremy Littell, Richard Raymondi, and Spencer Reeder. "Chapter 21: Northwest." In Climate Change Impacts in the United States: The Third National Climate Assessment, edited by Jerry M. Melillo, Terese (TC) Richmond, and Gary W. Yohe, 487-513. Washington, D.C.: US Global Change Research Program, 2014. https://pnwcirc.org/sites/pnwcirc.org/files/nca3_full_report_21_northwest_highres.pdf.

Writing a Climate Data Story
(Worksheet 3)

About this worksheet—This worksheet provides a structure you can use to organize the recommended components of your Climate Data Story.

Step 1. Query the Toolbox

Question:	
1. Identify Your Climate Question:	**4. Pick a Variable in Your Chosen Tool:**
2. Pick a Climate Impact Category:	**5. Consider Location/Geographic Area:**
3. Pick a Tool:	**6. Time Periods:**
What outputs did the Toolbox provide?	**Can you use the outputs from the Toolbox to answer your question?**
What are your next steps?	

CIRC Climate Impacts Research Consortium A NOAA RISA TEAM

RISA Regional Integrated Sciences and Assessments

Step 2. Construct your narrative using the following structure as a guide

Topic (facts and impacts):	**Definitions:**
Calculations and Tools:	**Charts and figures:**
Data:	
Results:	
Analysis (facts and impacts):	
Summary:	
References:	

Climate Impacts Research Consortium
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RISA Regional Integrated Sciences and Assessments