



Extreme Precipitation in Southeast Alaska: Visualizing Climate Modeling with a Storymap (Part 1)



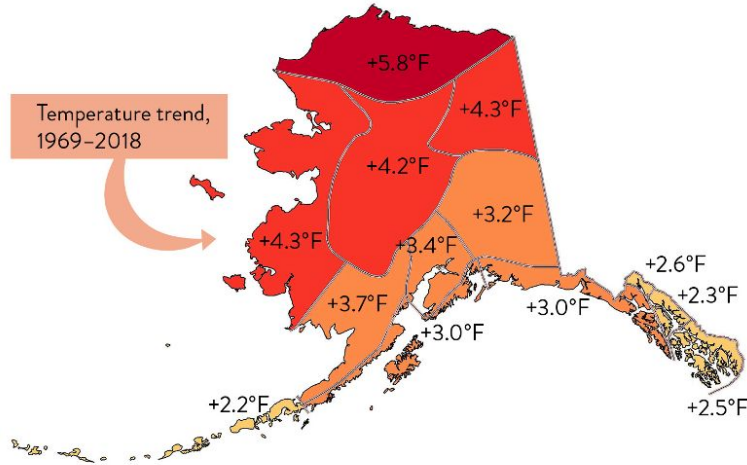
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February 27, 2024



Alaska trends are for warmer, wetter

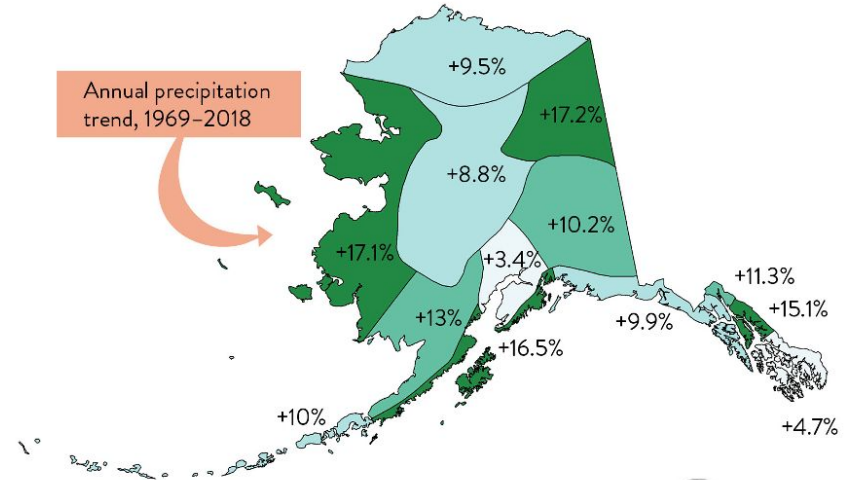
Warming across western and northern Alaska, 1969–2018



Credit: Rick Thoman, Alaska Center for Climate Assessment and Policy.
Data source: NOAA/NCEI



Alaska precipitation, 1969–2018



Credit: Rick Thoman, Alaska Center for Climate Assessment and Policy.
Data source: NOAA/NCEI



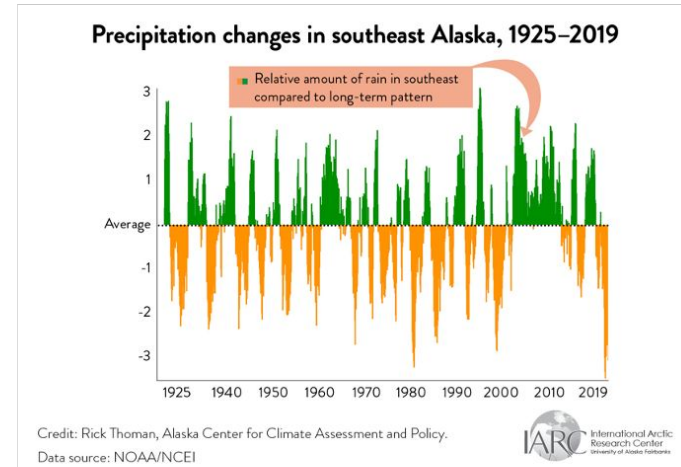
Thoman and Walsh 2019: "Alaska's Changing Environment"



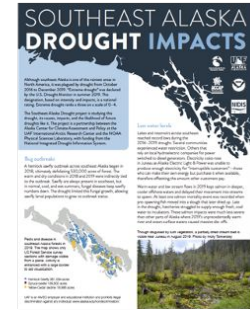
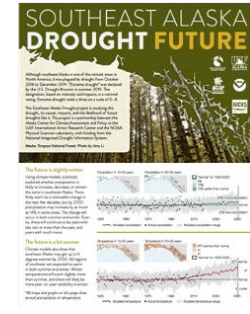
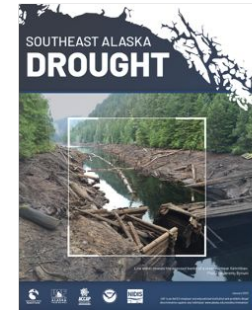
- Each one of the thirteen Alaska climate divisions shows a substantial trend toward warmer and wetter conditions.
- The rate of warming is much greater during the winter when compared to the summer season.

First 'Extreme Drought' of record occurred in 2019 across Southeast Alaska

- The 2016-19 drought was the most severe of record (see time series of the Standardized Precipitation Index to the right).
- The drought had severe impacts, including:
 - Municipal water restrictions
 - Reduced electricity from hydropower
 - Increased wildfire in Tongass NF (2018)
- Regional climate modeling indicates an increased risk of spring/summer drought from warming temperatures, but little change to precipitation during these seasons.



Thoman and Walsh 2019: "Alaska's Changing Environment"



Followed by unprecedented rainfall amounts

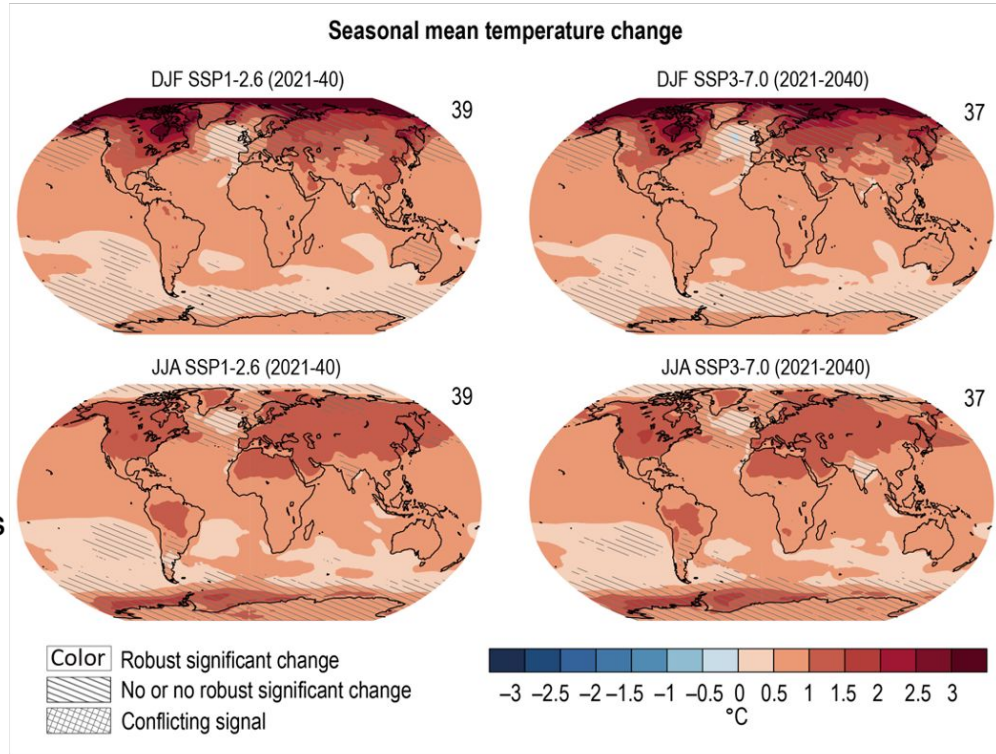


- Daily precipitation records were set across Southeast Alaska in December 2020.
- Haines, Alaska received 6.62" on 12/2 and 14.93" from 12/1-12/7, causing landslides.
- Rainfall from an atmospheric river (AR).

Source: Haines, Alaska (US Coast Guard)

Continued warming is 'baked in' to the climate system

- Global temperatures in the near term will continue to warm due to greenhouse gases that have already been emitted into the atmosphere. This is due to their residence time.
- The near-term projected warming varies little between climate scenarios (i.e., SSPs), with the greatest warming in the Arctic in the winter and northern land areas in the summer.



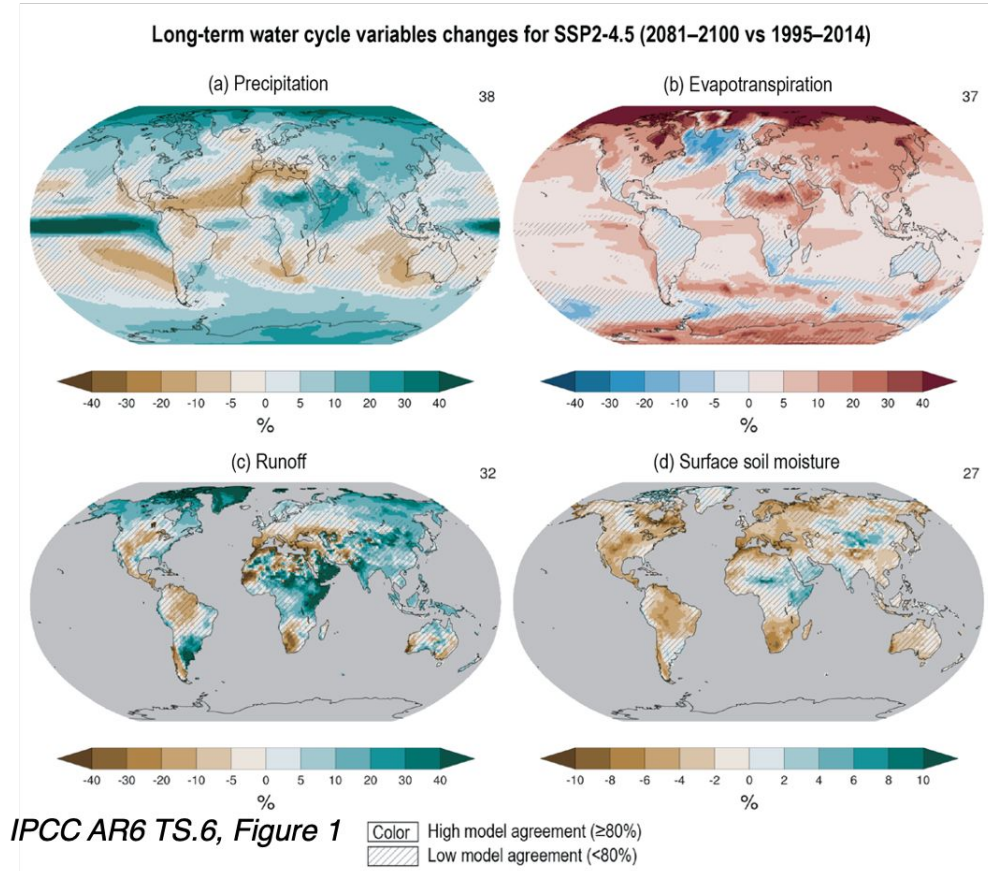
IPCC AR6 WG1, Figure 4.12

Changes are relative to 1995-2014

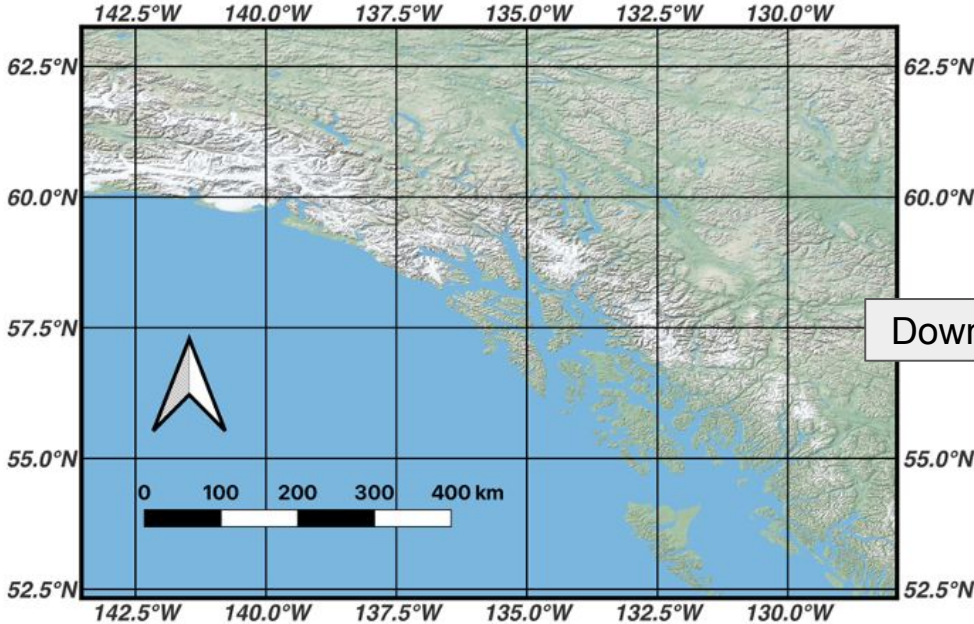


Long-term precipitation projections in Alaska show agreement

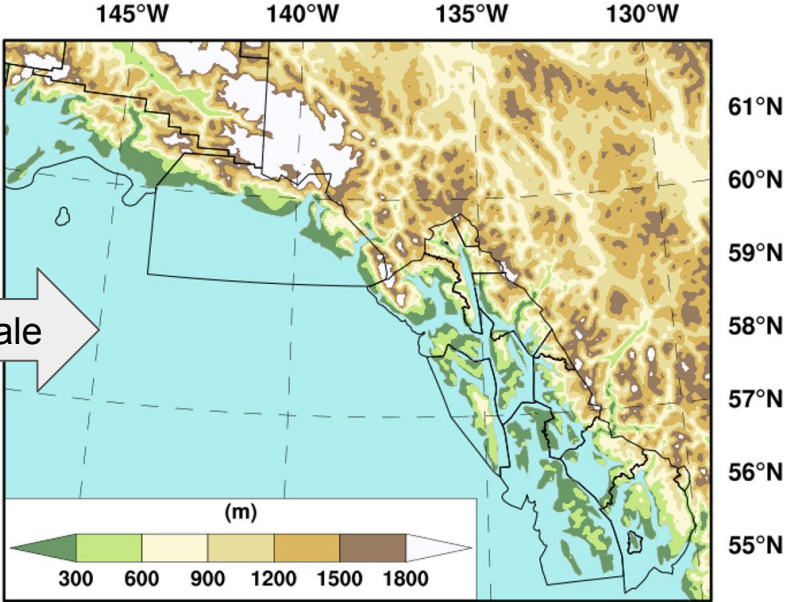
- All of Alaska is projected to have greater precipitation, greater evapotranspiration, more runoff, and decreased surface soil moisture
- However, uncertainty among the models tends to increase in southern portions of southeast Alaska
- Notably, these are annual mean changes, meaning that seasonal variations are possible inside these projected changes



Climate model data are often too coarse

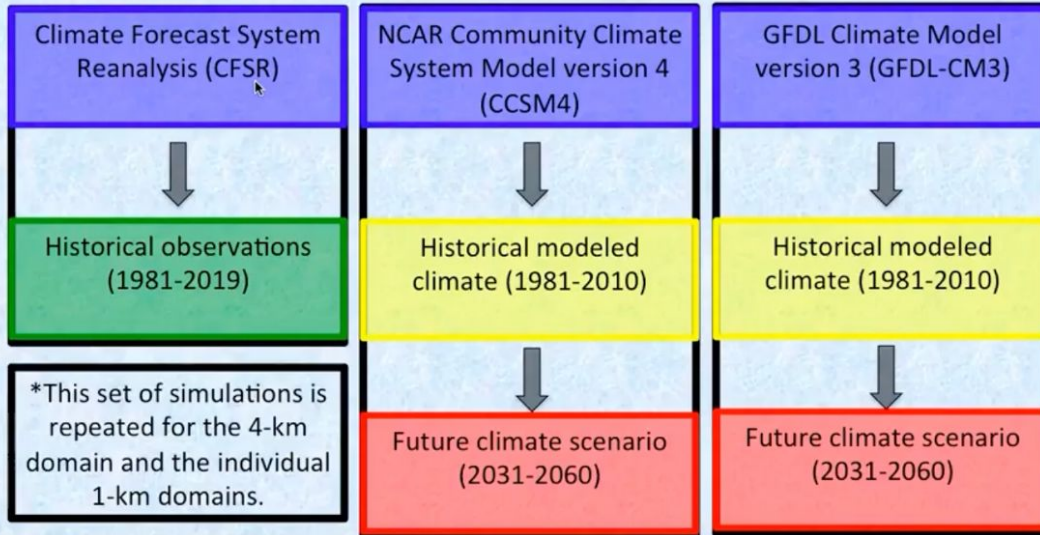


Downscale



Downscaled dataset for Southeast Alaska

Simulations



Available surface variables

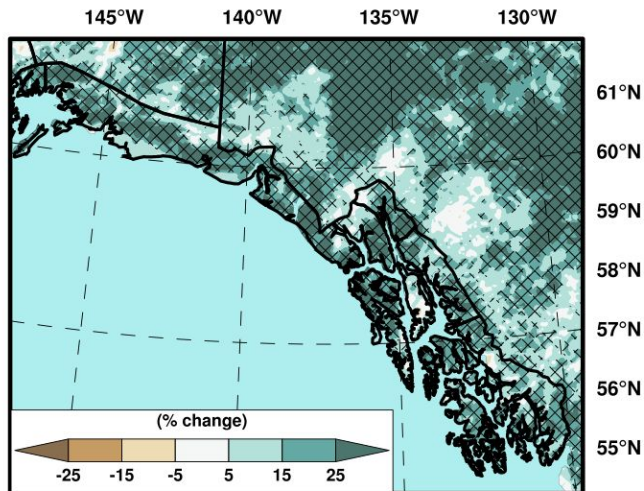
- Temperature (max/min/avg)
- Precipitation
- Snowfall
- Snow cover
- Winds
- Specific humidity
- Sea level pressure
- Surface pressure
- Precipitable water
- Albedo
- Radiation fluxes

Available upper-air variables

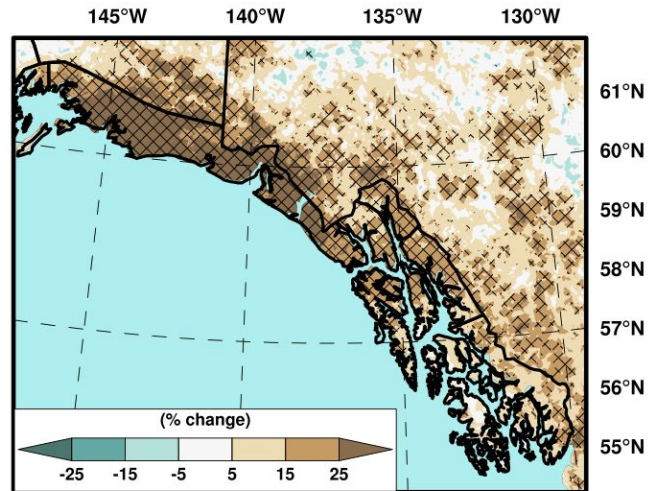
- Temperature
- Winds
- Cloud fraction
- Water vapor mixing ratio
- Geopotential height

Variability of certain precipitation extremes increases

Maximum 1-day precipitation
(Projected % change)



Maximum consecutive dry days
(Projected % change)



Results show projected percent change (2031–60 relative to 1981-2010) from the dynamically downscaled (4 km) GFDL-CM3 RCP8.5.

Results from Lader et al. (2022) in Earth Interactions, “Projections of Hydroclimatic Extremes in Southeast Alaska under the RCP8.5 Scenario”.



Projected percent change in heavy precipitation increases more at shorter time intervals



Percent precipitation change (2031-2060; RCP8.5) relative to historical (1981-2010)

<i>Model</i>	<i>Annual</i>	<i>RX5</i>	<i>RX1</i>
CCSM	+6.2	+7.4	+12.6
GFDL	+3.3	+16.0	+19.8

- **Bold** indicates a statistically significant change at the 95% confidence level
- Each of the 4 southeast Alaska climate divisions projected increased amounts for all 3 measures, with most being significant



Temperatures warm but precipitation change depends on season

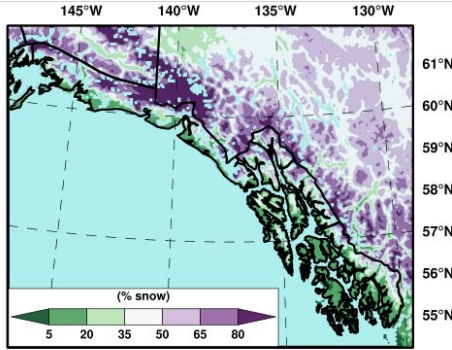
Mean change among land grid cells in Southeast Alaska
(2031-2060 relative to 1981-2010)

Temperature $\pm^{\circ}\text{C}$	CCSM (RCP8.5)	GFDL (RCP8.5)	Precipitation $\pm\%$	CCSM (RCP8.5)	GFDL (RCP8.5)
Winter (DJF)	+2.0	+2.1	Winter (DJF)	+6.7	+11.5
Spring (MAM)	+1.1	+2.0	Spring (MAM)	+2.5	-4.7
Summer (JJA)	+2.1	+3.3	Summer (JJA)	-0.7	-0.6
Fall (SON)	+2.1	+1.9	Fall (SON)	+12.3	+3.8



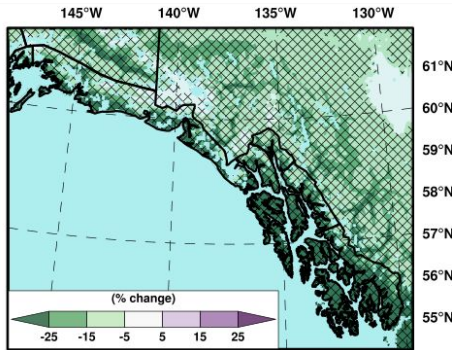
Results from Lader et al. (2020) in *Journal of Meteorology and Climatology*, “Dynamical Downscaling for Southeast Alaska: Historical Climate and Future Projections”.

Locations become increasingly rain dominant

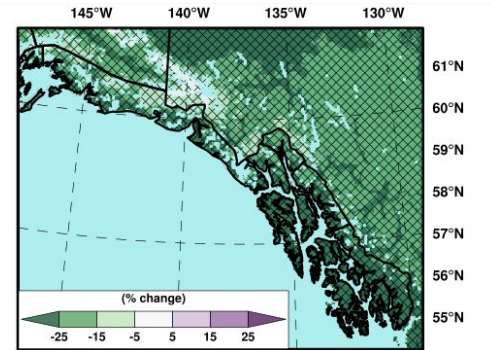


CFSR SNF climatology
1981-2010

- The downscaled climate models agree on direction, magnitude and location of change
- Largest changes are in the south and in coastal areas

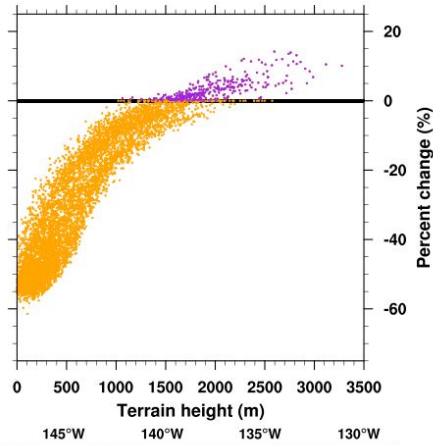


Projected % change
CCSM 2031-2060

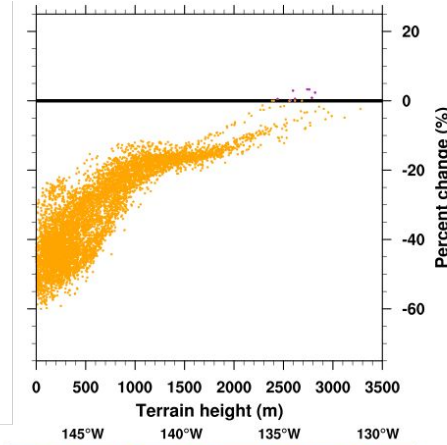


Projected % change
GFDL 2031-2060

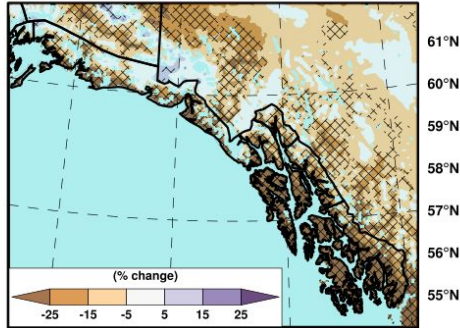
Snowfall decreases at all but highest locations



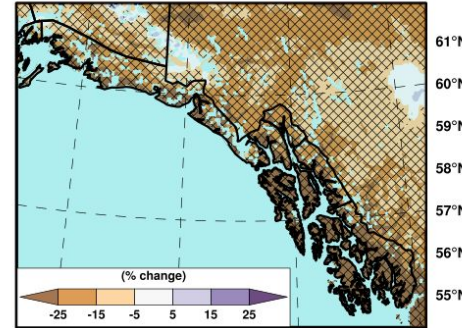
Projected % change by elevation
CCSM 2031-2060



Projected % change by elevation
GFDL 2031-2060



Projected % change
CCSM 2031-2060

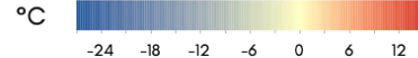
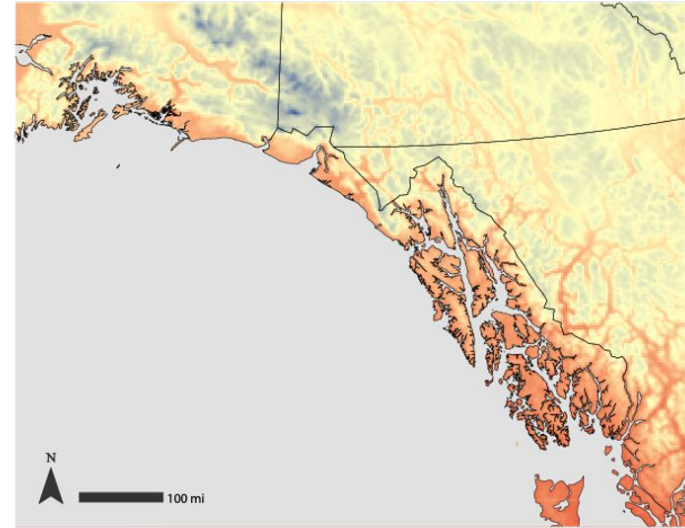


Projected % change
GFDL 2031-2060

Customized downscaled drought metrics for Southeast Alaska

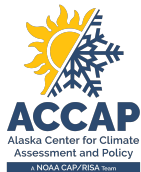
- The 4 km downscaled climate/reanalysis dataset for Southeast Alaska is being used to calculate historical and bias-corrected projections of:
 - Standardized Precipitation Index (SPI)
 - Standardized Evapotranspiration Index (SPEI)
 - Seasonal temperature and precipitation climatologies/trends
- The products were produced in multiple formats (netCDF, TIFF, PDF) for easy accessibility and broad usage.

Average Annual Temperature Southeast Alaska, 2031-2060



Data source: NOAA GFDL CM3

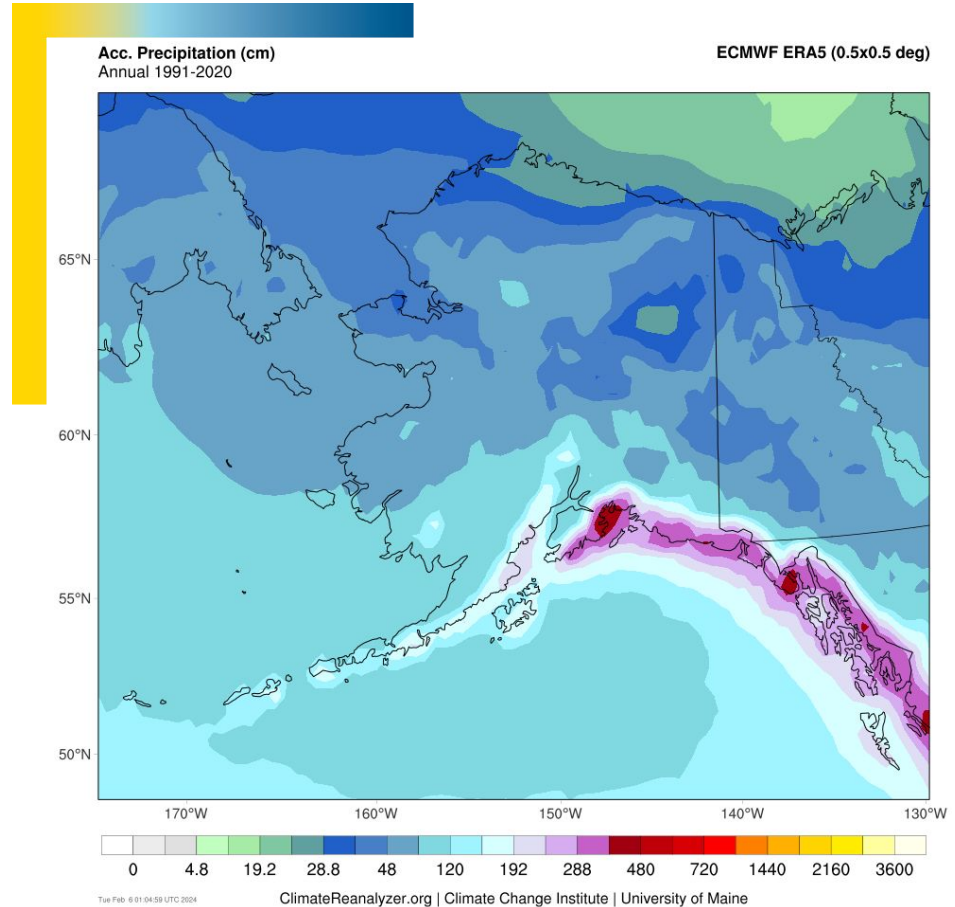
AK CASC
Alaska Climate Adaptation Science Center



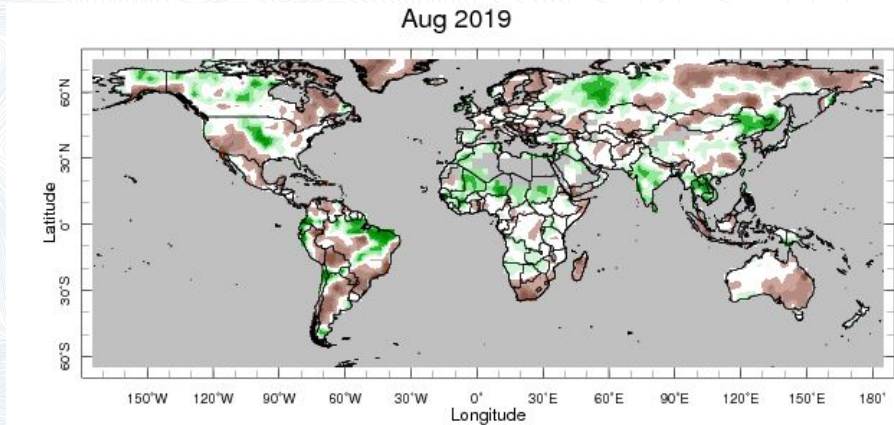
<https://akcasc.org/about-us/climate-projections-for-southeast-alaska/>

Precipitation amounts vary greatly by location in Alaska

Consideration of drought requires *standardization* of data to compare across regions



Standardized Precipitation Index (SPI)



<https://iridl.ldeo.columbia.edu/>

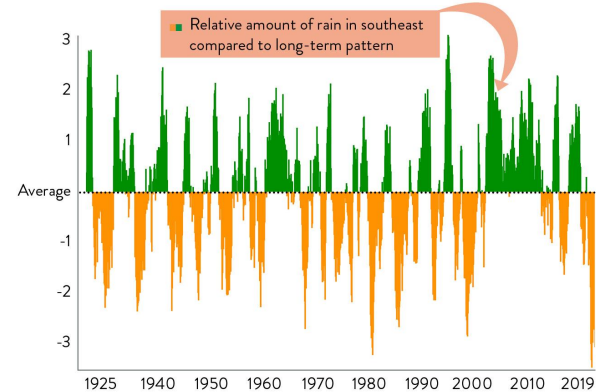
1-month SPI

Data are transformed to a standard normal distribution based on mean & standard deviation

Calculated using monthly data for 1-month to multi-years, relative to defined reference period

SPI does not include evapotranspiration, but SPEI does (e.g., P-PET)

Precipitation changes in southeast Alaska, 1925–2019



Credit: Rick Thoman, Alaska Center for Climate Assessment and Policy.

Data source: NOAA/NCEI



Characterizing drought and precipitation extremes

What do these values mean?

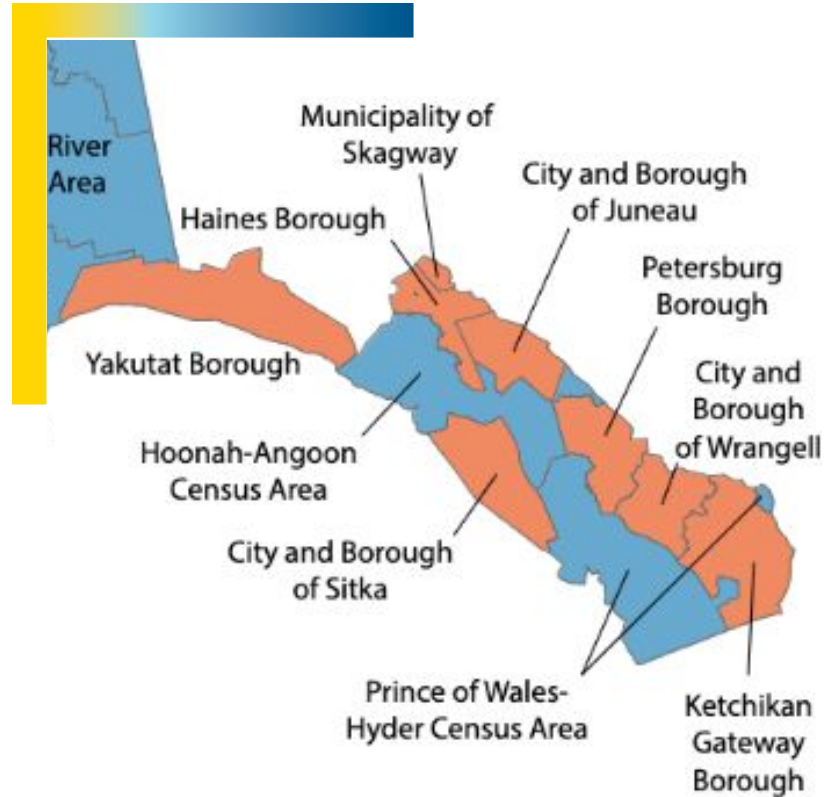
SPI classifications offer a systematic way to interpret precipitation levels in a region, determining whether conditions are exceptionally, extremely, severely, moderately, or abnormally wet or dry, compared to a near-normal classification.

Common qualitative thresholds

- +/- 2.00+: Exceptionally [wet, dry]
- +/- 1.60 to 1.99: Extremely [wet, dry]
- +/- 1.30 to 1.59: Severely [wet, dry]
- +/- 0.80 to 1.29: Moderately [wet, dry]
- +/- 0.51 to 0.79: Abnormally [wet, dry]
- +/- 0.50: Near normal

A step forward would be to relate these thresholds to specific events and impacts

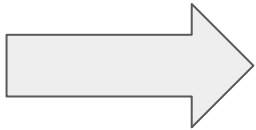
Data analysis conducted for 10 Alaska Borough & Census Areas in Southeast Alaska



Adapted from source: Alaska Department of Labor and Workforce Development, Research and Analysis Section

Methods

- Standardized Precipitation Index (SPI) and Standardized Precipitation Evapotranspiration Index (SPEI) calculated for 3-, 6-, 12-, and 24-month periods using historical (1981-2010) and projected (2031-2060) downscaled climate data from two models (NCAR CCSM4 and GFDL-CM3)
- Model data were calibrated to an observation-based reanalysis (CFSR) to produce bias-corrected projections
- Analysis was conducted for the 10 Borough and Census Areas of Southeast Alaska



Zav will present on some of the results in the Storymap next



Additional info

Possible Next steps

Inclusion of snow into analysis (e.g., snow drought)

Relating impacts to index thresholds

Downscaling of CMIP6 underway at IARC

Send me an email

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