Characterizing the impact of climate non-stationarity on Western U.S. drought

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CIRES

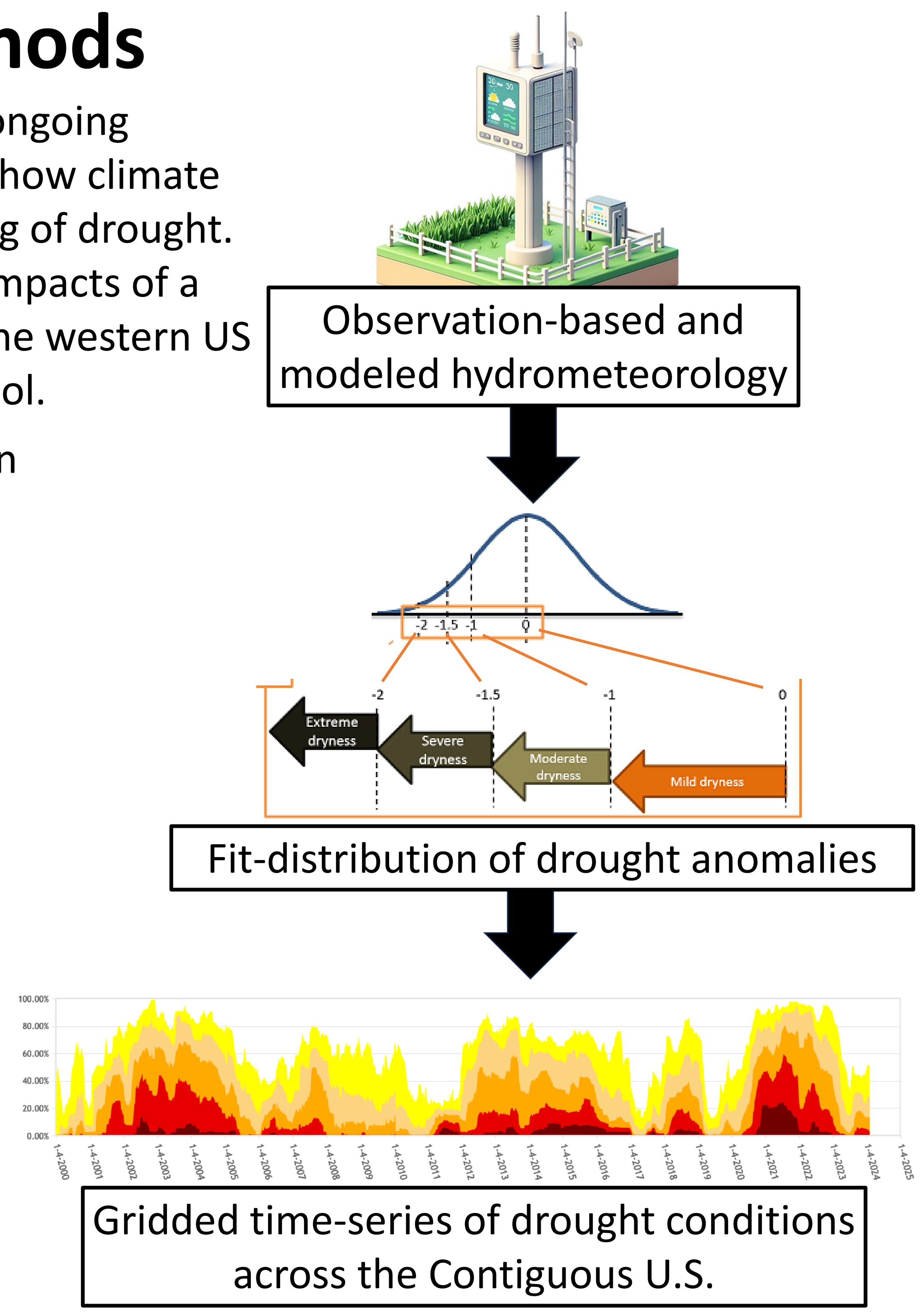
1. Introduction and methods

Here we describe the multiple phases of an ongoing project within CIRES and the WWA to assess how climate non-stationarity influences our understanding of drought. Through this work, we seek to evaluate the impacts of a rapidly changing climate on drought across the western US and communicate our findings with a web-tool.

How are we classifying drought? Comparison of multiple common indices for drought including SPI, SPEI, and EDDI. These are compared with a vegetation based remotely sensed drought index and the USDM

How do we classify the sensitivity to non-stationarity? Using a block-bootstrap resampling of all possible 30-year reference periods, we can estimate the reference period dependence of the classification of any single drought event's severity.

What datasets are we using? ERA5-Land as the historical baseline for hydroclimate observations, gridded 10 km USDM, and MODIS derived NDVI to generate vegetation drought index



2. Phase I – Characterizing the landscape of drought indices

During the first phase of this project, **we leveraged WWA's connections with water managers, drought planners, scientific experts, and climate service providers** to gather perspectives, questions, and needs of stakeholders and partners.

		1,715 4.86% of total
1	Evaporative Demand Drought Index (EDDI) × Close Download	153
2	US Drought Monitor × Close Download	128
3	7-Day Precipitation Forecast × Close Download	114
4	30-day Precip as % Avg × Close Download	104
5	Water-Year Precip as % Avg × Note: This shows precipitation only since October 1, 2018	89
6	30-day Temp. Anomaly × Close Download	67
7	Standardized Precip Index (SPI) × Close Download	67
8	Upper Colorado Reservoirs × Close Download	64
9	Surface Soil Moisture Percentiles × Close Download	56
10	Soil Moisture Anomaly × Close Download	54

Most interacted with drought related content from the WWA Intermountain West Climate Dashboard analytics from June 2023 to December 2024

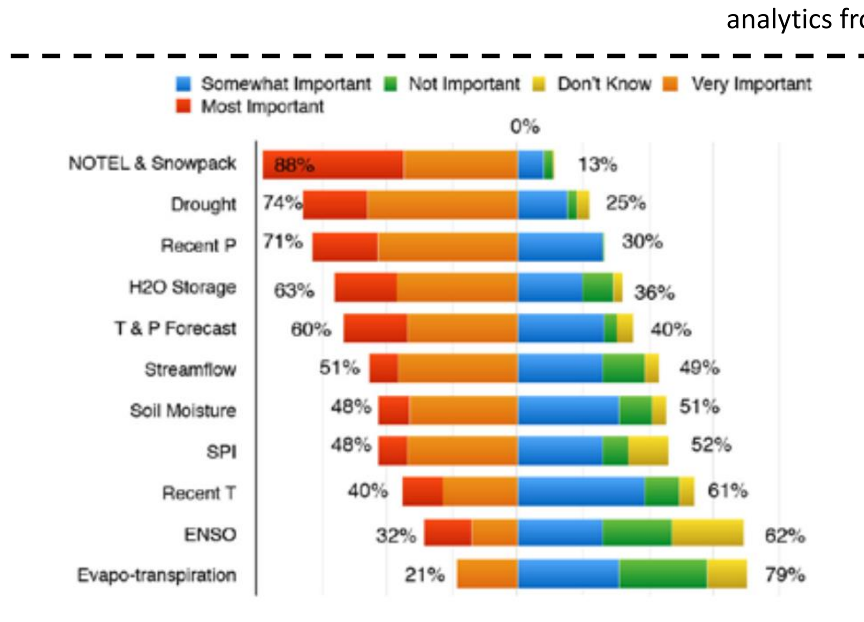


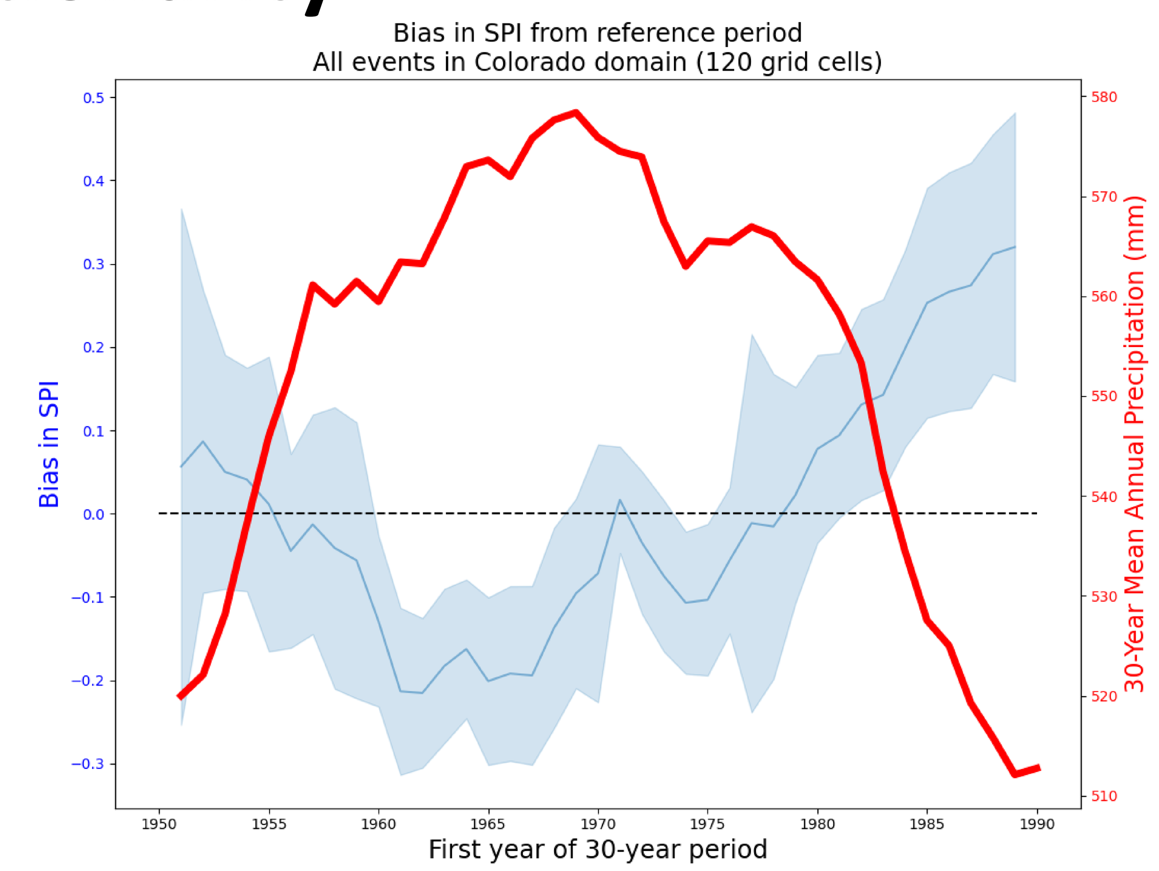
Figure 17 from McNie (2014) Evaluation of the NIDIS Upper Colorado River Basin Drought Early Warning System." . Value of product during 2nd quarter of water year, January – March.

We also leverage results from previous surveys conducted by experts in the WWA network to understand **how end users are using drought information and which indices are most commonly applied in planning applications**.

	PERCENT WHO USE
Snow Water Equivalent (SWE)	68%
Precipitation Percentiles, Ranks, Deciles, Departure from Norm	66%
U.S. Drought Monitor (USDM)	63%
Palmer Drought Severity Index (PDSI)	41%
Standardized Precipitation Index (SPI)	34%
Normalized Difference Vegetation Index (NDVI)	29%
Evaporative Drought Demand Index (EDDI)	27%
Surface Water Supply Index (SWSI)	25%
Standardized Precipitation Evapotranspiration Index (SPEI)	20%
Vegetation Drought Response Index (VegDRI)	20%

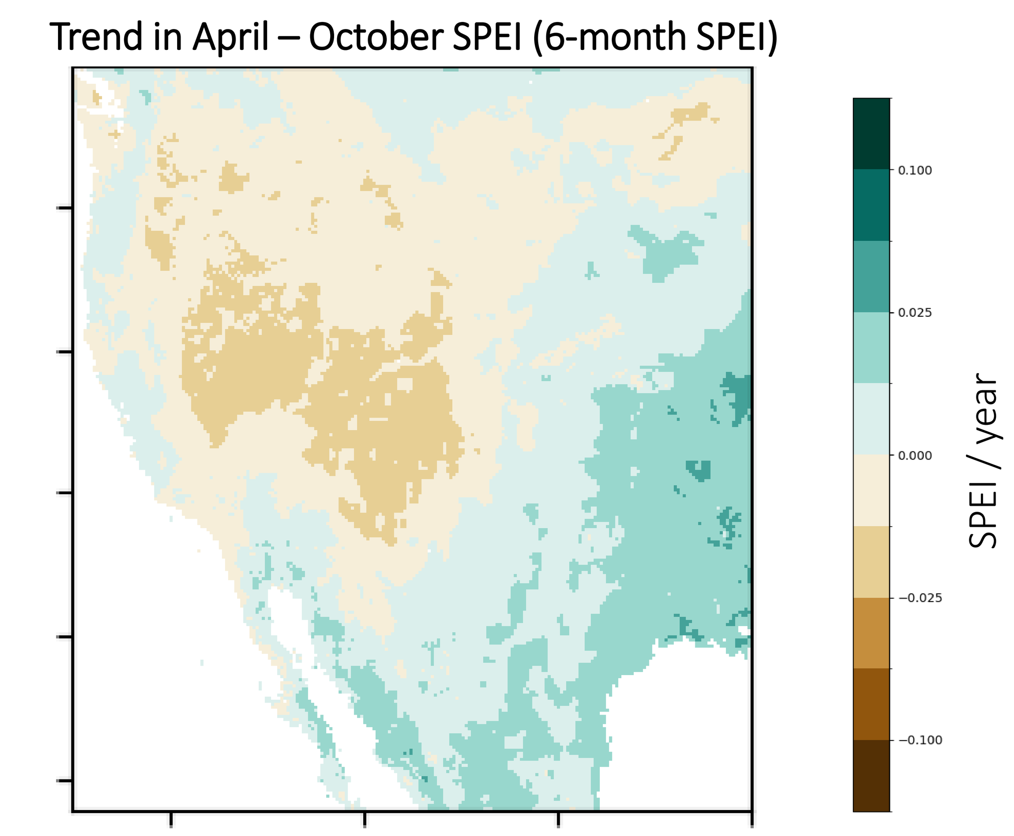
"Use of Drought Indicators and Indices by End Users in Nevada and Utah" (Haigh 2021)

3. Phase II – Exploring the sensitivity of drought indices to non-stationarity

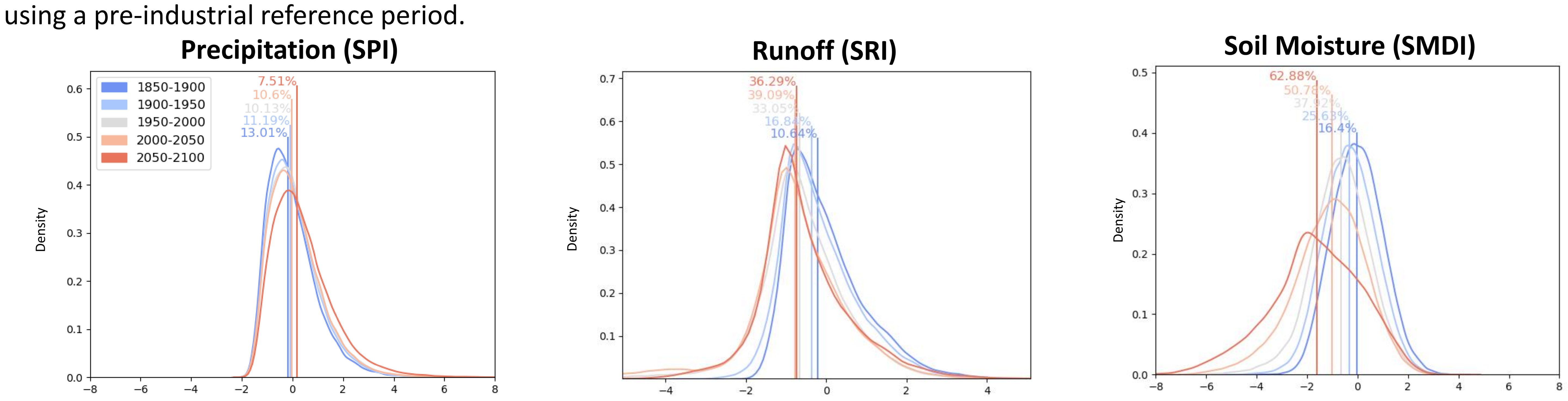


Decadal non-stationarity of the climate can lead to variability in the classification of drought events. For example, classification of any single precipitation drought event (SPI) (left) can vary from **-0.3 to +0.5** standard deviations **dependent on the reference period.**

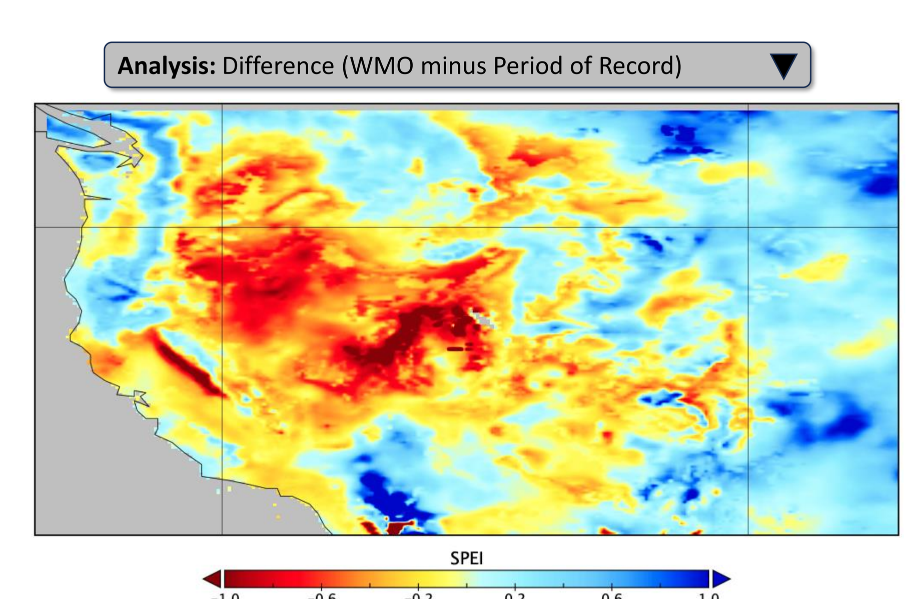
Non-stationarity in the form of **long-term climate trends** in temperature (and evaporative demand shown right through Western U.S. SPEI trends) also introduce uncertainty into the classification of drought events. The question arises: **are recent droughts more anomalous/severe or is this the new normal?**



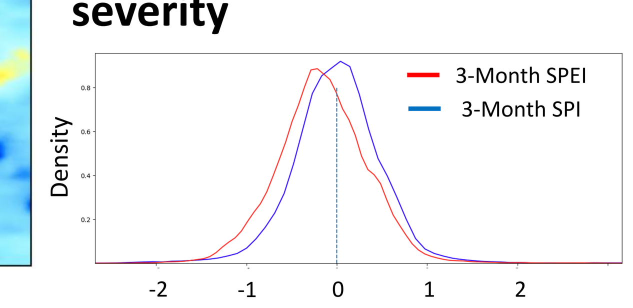
We use the **CESM-2 Large Ensemble** (50 simulations) of climate projections to further investigate **how climate non-stationarity changes perspectives on drought**. Percentages below indicate what percentage or warm seasons (JJA) experience moderate or worse drought using a pre-industrial reference period.

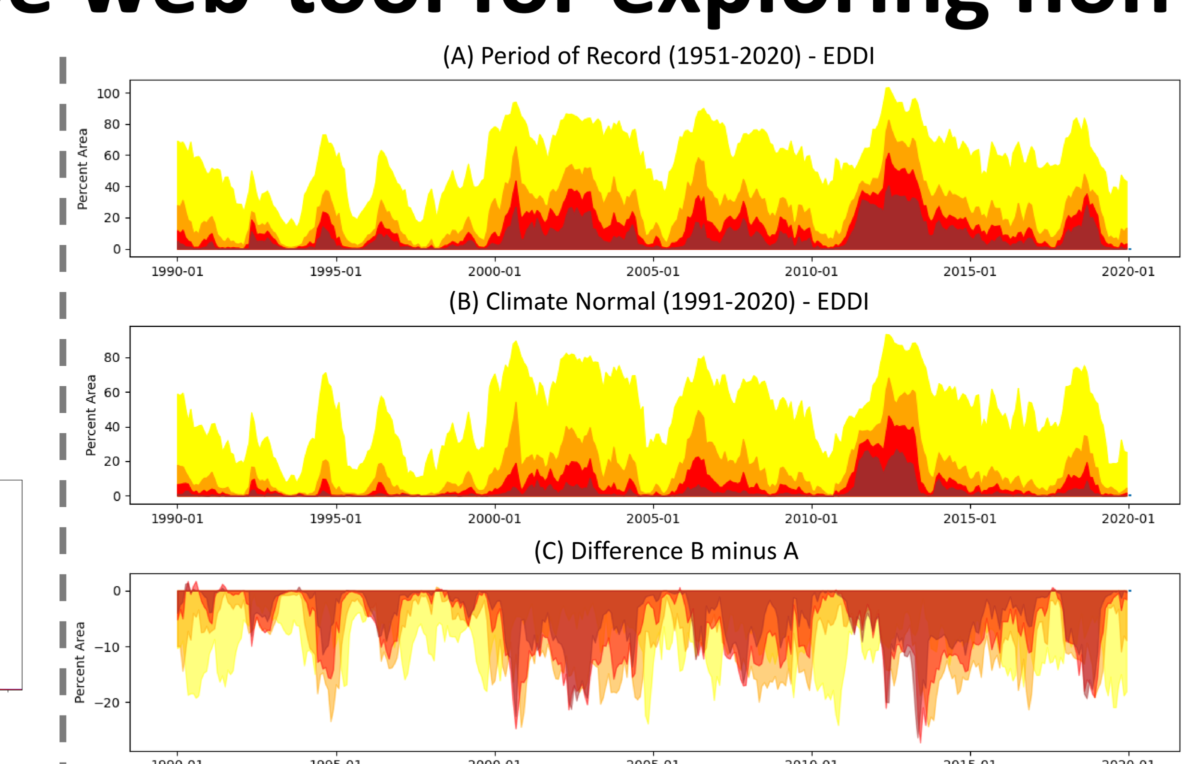


4. Phase III – Developing a prototype web-tool for exploring non-stationarity and drought



Users can use the tool to evaluate **how reference period alters the perspective of drought severity**





Users can use the tool to evaluate **how drought extent varies dependent on reference period**

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