



07-20-2015



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Earth Observations for Informing Disaster Risk and Response to Drought, Wildfire, and Flooding in Mexico

Overview of Different Types of Droughts

May 9, 2023



Objective

By the end of this presentation, you will know how different types of droughts are identified.



Outline

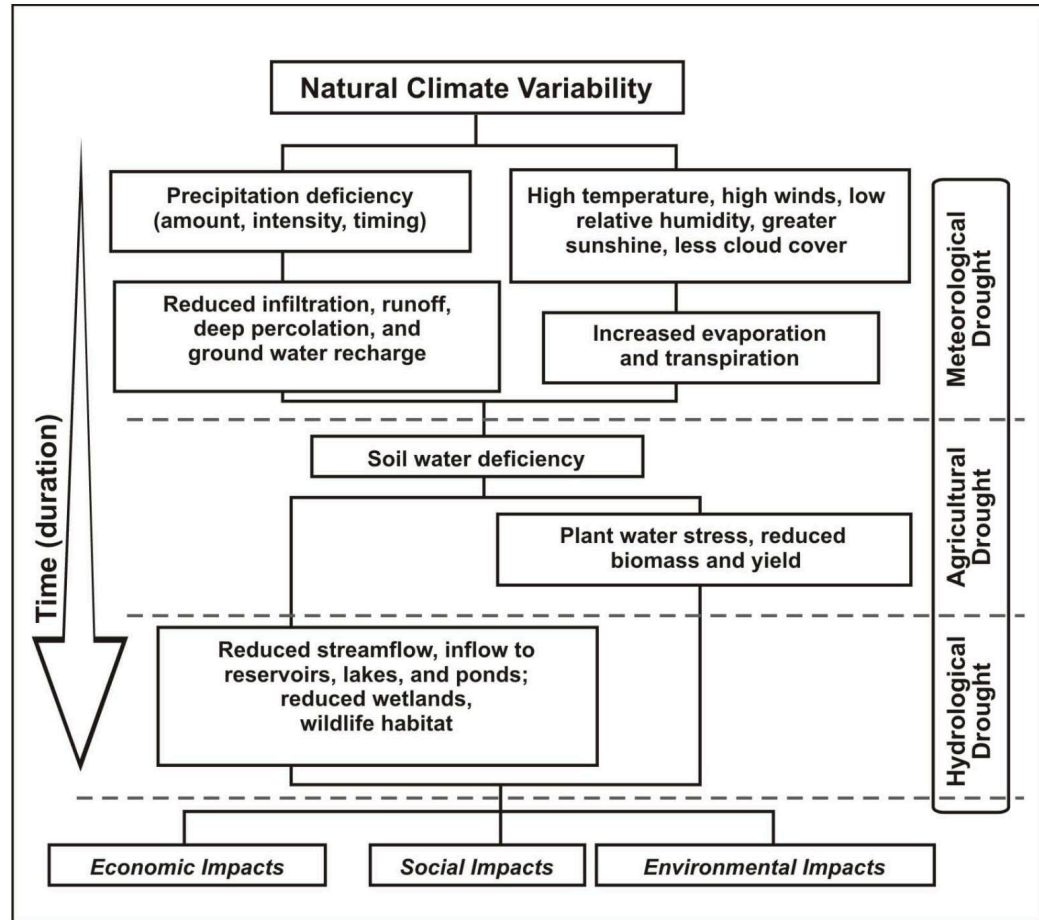
- Types of Droughts
- Drought Indices
- Demonstration: North American Drought Monitor



Types of Droughts

All droughts originate from “below normal” precipitation:

- Meteorological drought
- Agricultural drought
- Hydrological drought
- Ecological drought
- Socioeconomic drought



Sequence of drought occurrence and impacts for commonly accepted drought types. All droughts originate from a deficiency of precipitation or meteorological drought but other types of drought and impacts cascade from this deficiency. (Source: NDMC)

From: [National Drought Mitigation Center](https://www.nationaldroughtmitigationcenter.org/)



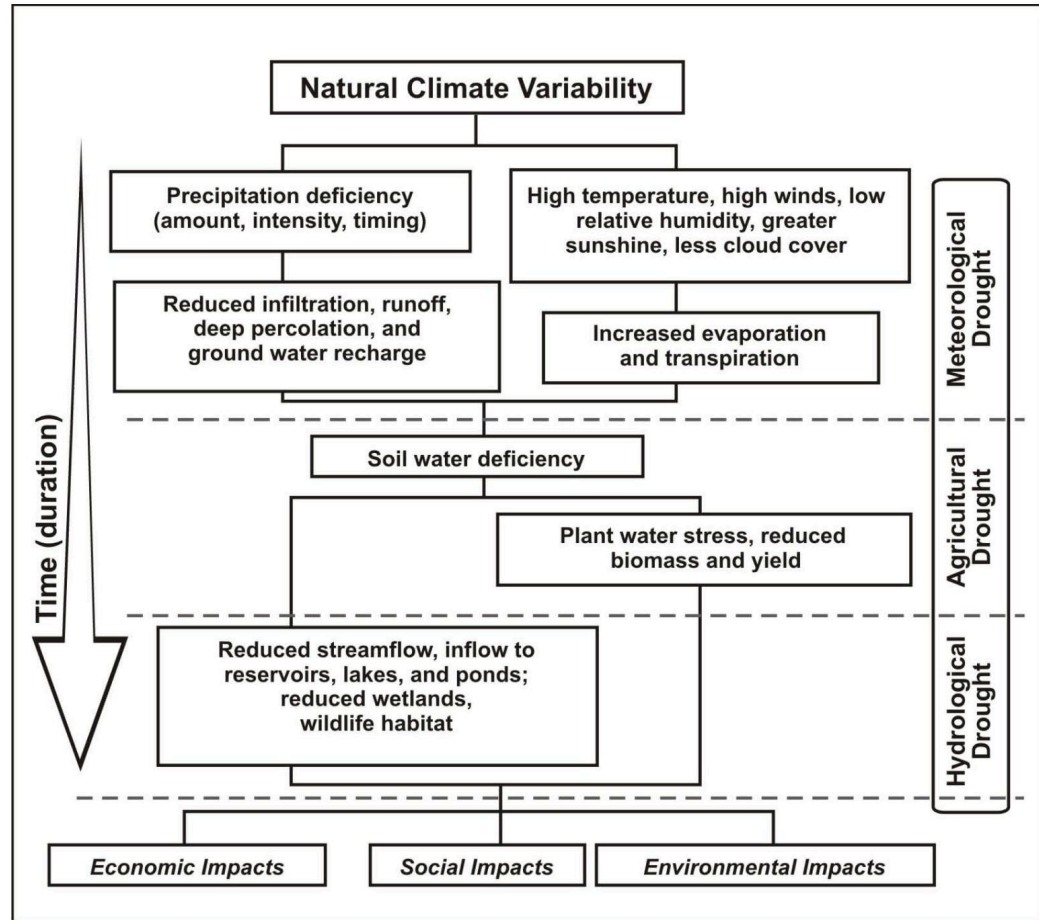
Types of Droughts

Meteorological Drought

- Related to degree of dryness compared to 'normal' precipitation
- Region-specific and high spatial variability

Agricultural Drought

- Related to various conditions related to precipitation shortage, evapotranspiration, soil water deficiency, reduced biomass



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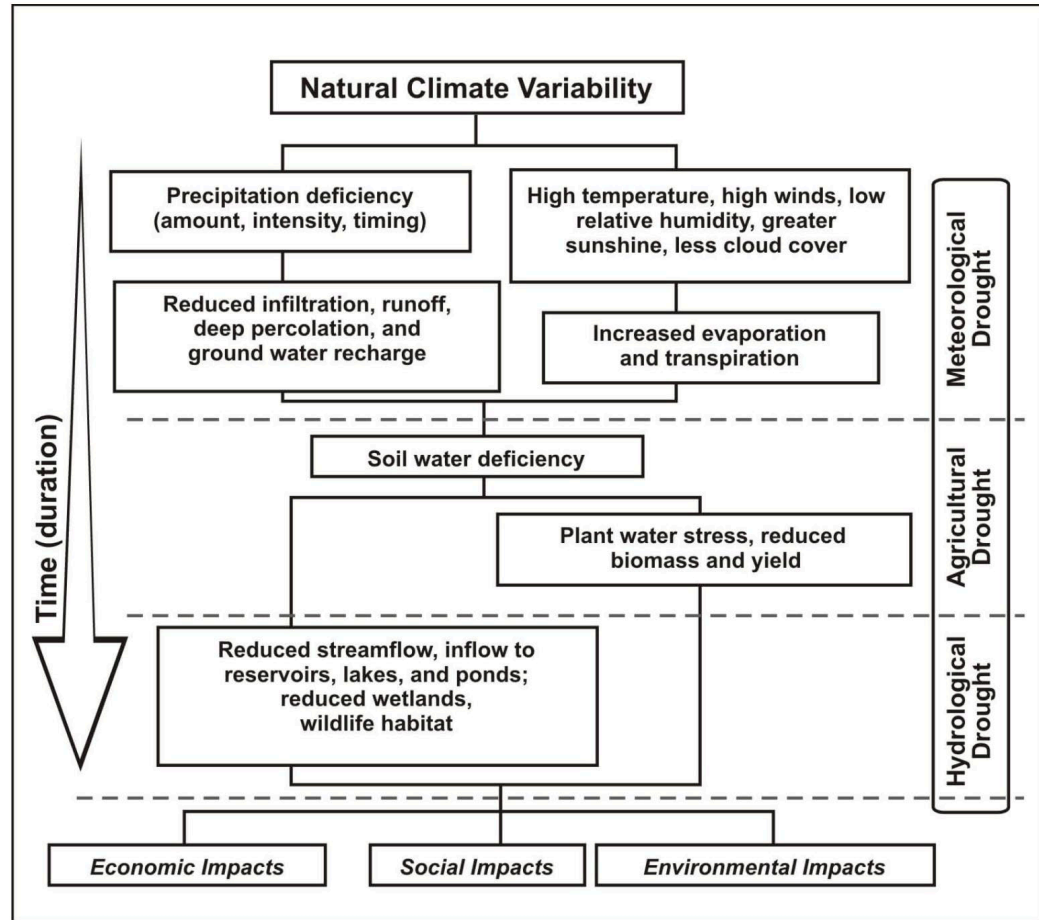
Types of Droughts

Hydrological Drought

- Related to rain and snow shortfall
- Impact surface and subsurface water supply
- Affects agricultural drought

Ecological Drought

- Prolonged and widespread deficit in naturally available water supplies that create multiple stresses across ecosystems



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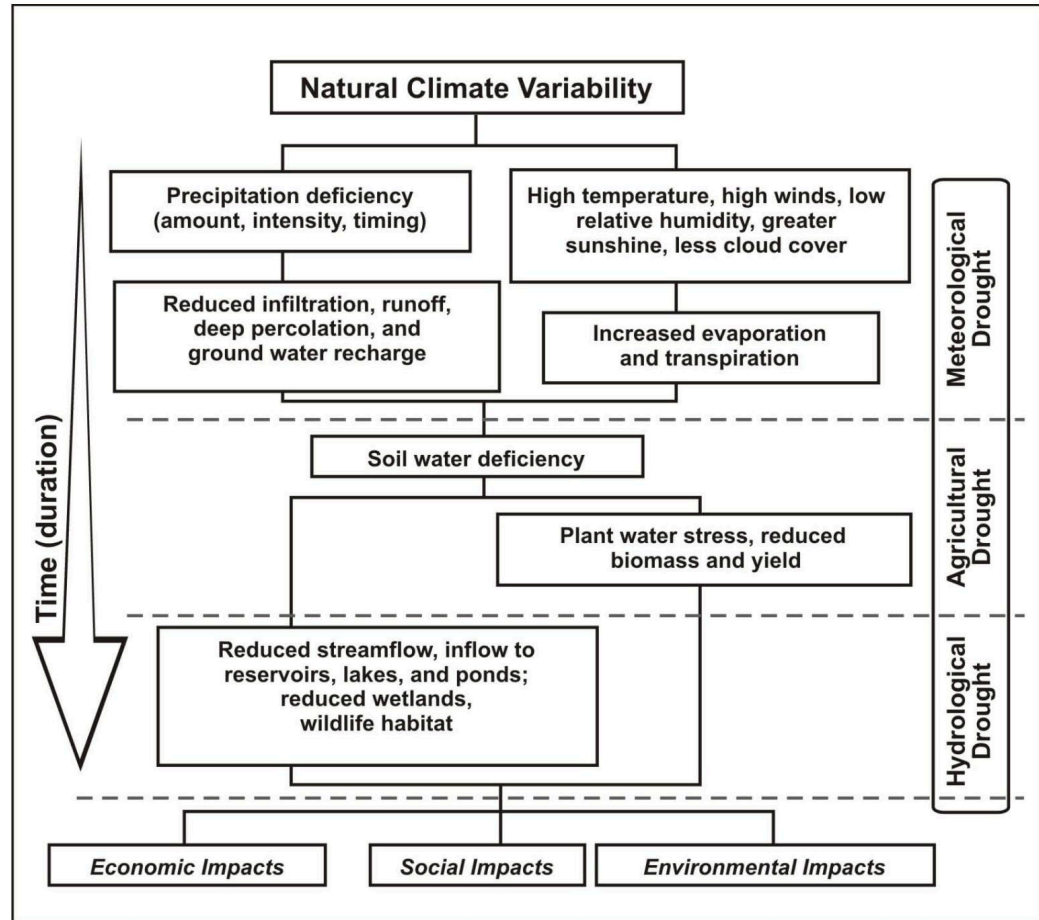
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Types of Droughts

Socioeconomic Drought

- Related to supply and demand rates of goods and economy
- Affected by agricultural, ecological, and hydrological aspects
- Social and economic changes



Sequence of drought occurrence and impacts for commonly accepted drought types. All droughts originate from a deficiency of precipitation or meteorological drought but other types of drought and impacts cascade from this deficiency. (Source: NDMC)

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NASA Remote Sensing Data Available for Drought Monitoring

Type of Drought	Parameters	Satellites
Meteorological Drought	Precipitation	GPM constellation (IMERG)
Agricultural Drought	Normalized Difference Vegetation Index (NDVI), Evapotranspiration	Landsat, Aqua & Terra MODIS
Hydrological Drought	Soil Moisture, Ground Water	SMAP, GRACE

Using GEE:

- We will analyze precipitation and NDVI data for drought monitoring using GEE.
- We will learn to visualize soil moisture and evapotranspiration anomalies for drought monitoring.





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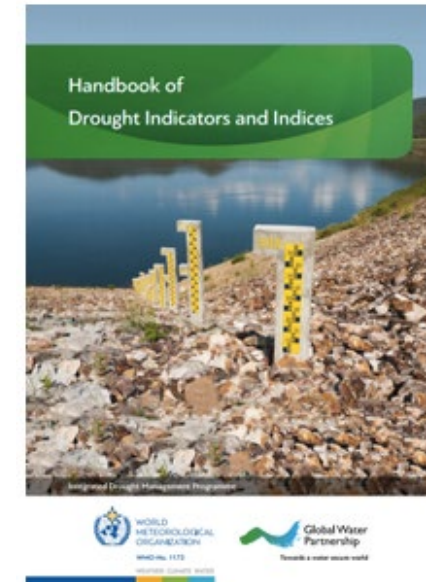
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Drought Indices

Precipitation-Based Drought Indices

- Drought indices are mathematical representation of water deficit (and excess) compared to historical data.
- Help decide when to start implementing water conservation or drought response measures.
- Can be used to analyze drought frequency, severity, and duration for a given location and period.
- Source: [National Drought Mitigation Center; Handbook of Drought Indicators & Indices](#)
- Commonly used operational drought indices are:
 - Standardized Precipitation Index (SPI)
 - Palmer Drought Severity Index (PDSI)



Standardized Precipitation Index (SPI)

<http://www.cpc.ncep.noaa.gov/products/Drought/Monitoring/spi.shtml>

- Primarily defined to characterize meteorological drought
- Mathematically, historical rainfall data at any location fitted with gamma distribution represent cumulative probability function.
- If a rainfall event is a low probability on the cumulative probability function, it is indicative of a drought event.
- The SPI values can be interpreted as the number of standard deviations by which the observed rainfall anomaly deviates from the long-term mean.

Reference: Guttman, N. B., 1999: Accepting the Standardized Precipitation Index: A calculation algorithm. J. Amer. Water Resour. Assoc., 35(2), 311-322.



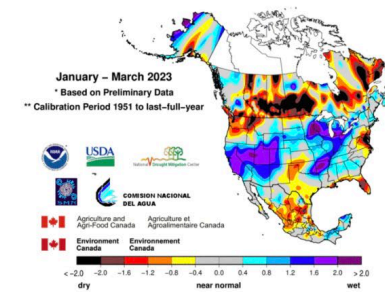
Standardized Precipitation Index (SPI)

<https://www.ncei.noaa.gov/access/monitoring/nadm/indices/spi/div>

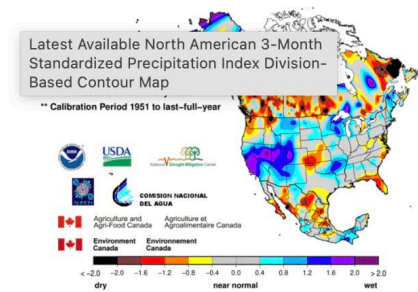
SPI averaged over different time periods indicate severity and duration of drought.

- 3-month SPI: reflects short- to medium-term moisture conditions
- 6-month SPI: reflects medium-term precipitation conditions, including seasonal precipitation patterns
- 9-month SPI: reflects medium-term drought that potentially affects agriculture
- 12-month and longer SPI: represents drought that potentially affects streamflow, reservoir levels

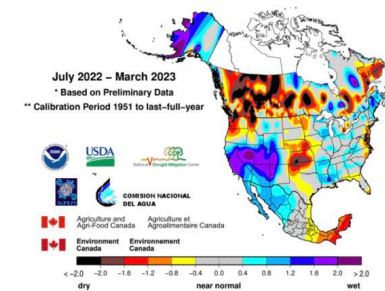
3-Month Standardized Precipitation Index



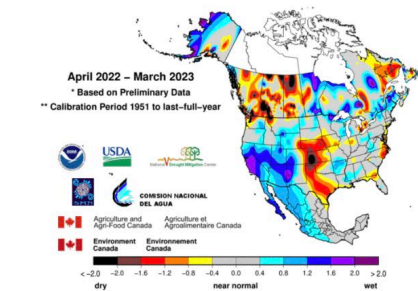
6-Month Standardized Precipitation Index



9-Month Standardized Precipitation Index



12-Month Standardized Precipitation Index



SPI: Strengths and Limitations

<http://climatedataguide.ucar.edu/climate-data/standardized-precipitation-index spi>

Strengths

- Easy to calculate based on precipitation
- Different time scales indicate duration of drought and impacts on hydrology and agricultural.

Limitations

- Based on precipitation (water supply) alone and does not take into account temperature or evapotranspiration (water depletion)
- Values depends on the climatological precipitation used.
- Does not consider precipitation intensity of rain or how it affects runoff, streamflow, and water availability for a given region



Palmer Drought Severity Index (PDSI)

<http://climatedataguide.ucar.edu/climate-data/palmer-drought-severity-index-pdsi>

- An index for evaluating the severity and frequency of prolonged periods of abnormally dry or wet conditions
- Uses **temperature** and **precipitation** data and a physical water balance model to estimate relative dryness
- A standardized index that goes from -10 (dry) to +10 (wet)

$$PDSI(m) = PDSI\{m-1 + [Z(m)/3 - 0.103 PDSI(m-1)]\}$$

- m = month index
- Z(m) = moisture anomaly index (based on a water balance model)

References:

Palmer, W. C., 1965: Meteorological drought. Research Paper 45, U.S. Dept. of Commerce, 58 pp.

Dai, A., K. E. Trenberth, and T. Qian, 2004: A global data set of Palmer Drought Severity Index for 1870-2002: Relationship with soil moisture and effects of surface warming. *J. Hydrometeorology*, 5, 1117-1130.



PDSI: Strengths and Limitations

<http://climatedataguide.ucar.edu/climate-data/palmer-drought-severity-index-pdsi>

Strengths

- More effective for long-term drought
- Takes account of surface air temperature and potential evapotranspiration, not just precipitation
- Takes prior month's condition into account

Limitations

- Lacks multi-time scale features
- Not comparable across regions, but self-calibrating PDSI can alleviate this issue
- Assumes that precipitation is immediately available (delayed runoff due to snow or ice not considered)





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Demonstration: North American Drought Monitor



Thank You!

