A New Surface-Water Index of Permanence in the Upper Missouri River Basin, 1989-2021

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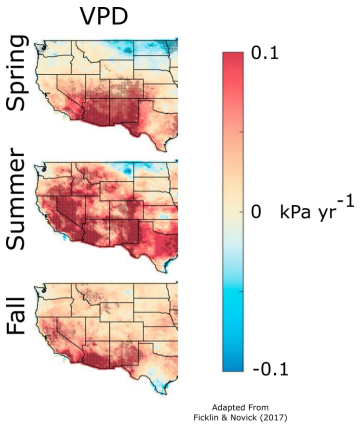
Atmospheric Effects on Terrestrial Systems

Vapor Pressure Deficit (VPD)

- thirst of the atmosphere
- increasing across the west
- exception in Northern Great Plains

Changes in Saturation Vapor Pressure

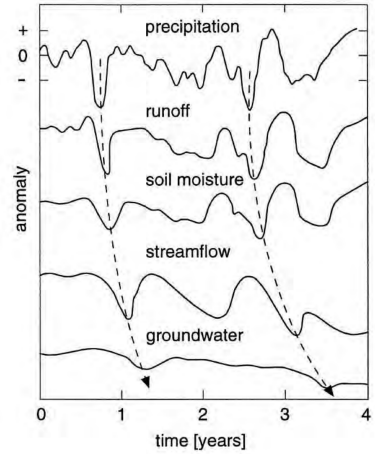
- associated with changes in temps
- warmer air holds more water



Atmospheric Effects on Terrestrial Systems

Drought Characteristics

- propagation
- lag
- attenuation

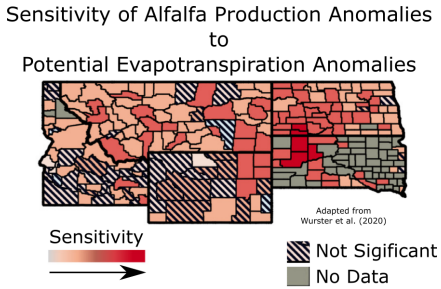


VanLoon (2013)

Atmospheric-Terrestrial Impacts

Alfalfa Production Anomalies

- terrestrial impacts vary spatially
- impacts propagate through other systems, space, and time



Expand upon limited **terrestrial drought metrics**

Task at Hand

Surface-water permanence - surface-water bodies that persist on the landscape over a given water-year.

- streams
- wetlands

Develop **standardized indices** that describe **anomalies** in surface-water permanence.

- abnormal active-channel length (km)
- abnormal inundated surface-water area (km^2)

Surface-Water Index of Permanence

Objective

Index for any geographic shape

- Upper Missouri River basin
- HUC digits 4-12 (basin to sub-watershed)

Assumptions

- end of water-year is the minimum extent

logo by
Lindsey Thurman, SWIPe Team

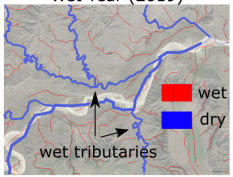
Inputs - Streams

PROSPERum (Sando et al., 2018)
PRObability of **S**treamflow **PER**manence for the **U**pper **M**issouri

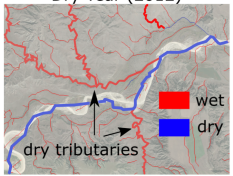
Random Forest Model

- physio/meteorologic variables
- areal photography
- expert field observations

Wet Year (2019)



Dry Year (2012)



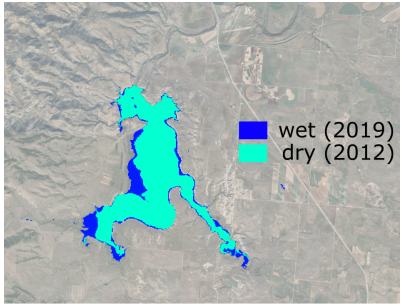
Wurster (WSDHC2024)
Data: Sando et al. (2018)

Inputs - Wetlands

DSWE (Jones, 2019)
Dynamic Surface-Water Extent

Linear Spectral Mixture Model

- Landsat 5-8
- passive reflectance classes-
  - vegetation
  - soil/rocks
  - water



Wurster (WSDHC2024)
Data: Jones (2019)

Trends

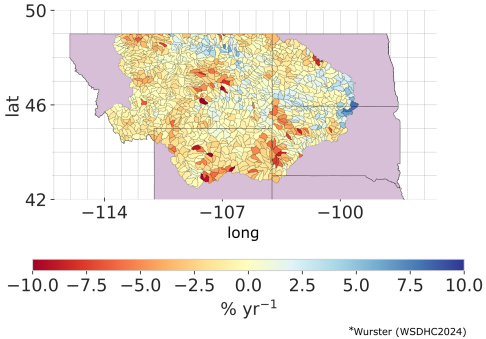
Anomalies relative to

- space
- time

Tabulate **totals**

- wetland area
- stream length
- 1989-2021

Detrend timeseries

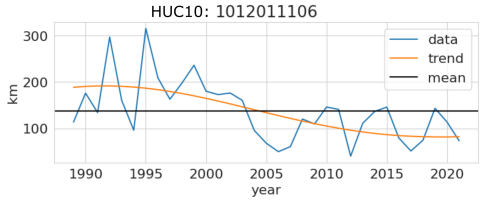


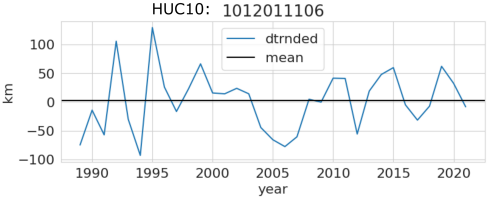
*Wurster (WSDHC2024)

*Data are provisional and subject to revision until they have been thoroughly reviewed and received final approval.

Trends

Retain **variability** while removing **irreversible** change.





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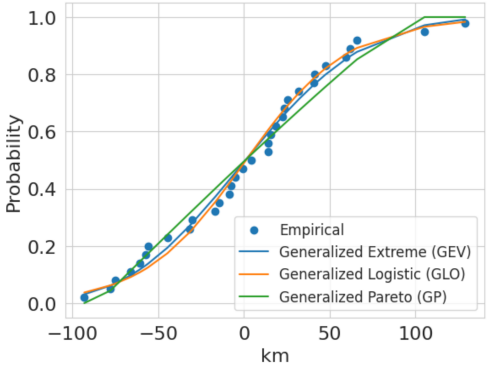
Standardization

Methodology followed Vicente-Serrano et al. (2010)
SPEI

Standardized Precipitation-Evapotranspiration Index

and Hobbins et al. (2017)
EDDI

Evaporative Demand Drought Index



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Theoretical and empirical cumulative distribution functions

Standardization

Standardized Values

- mean around zero
- standard deviation around 1

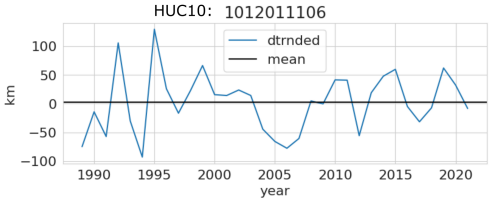
Interpretation (McKee 1993)

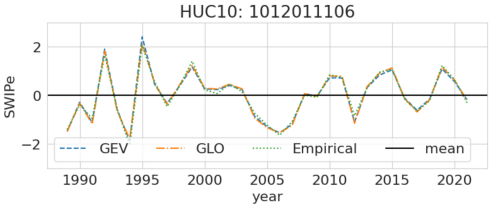
$<$ 0 to -0.99: **mild** dry

-1 to -1.49: **moderate** dry

-1.5 to -1.99: **severe** dry

$<$ -2: **extreme** dry





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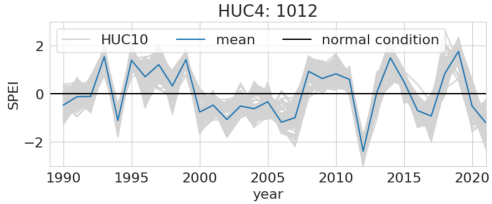
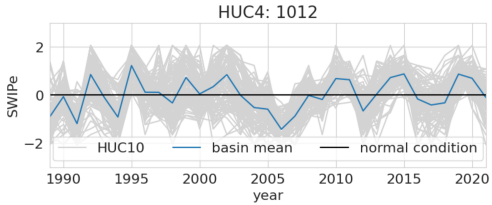
Atmosphere and Streamflow Permanence

SPEI less spatially variable

- **propagation**
- **lag**
- **attenuation**





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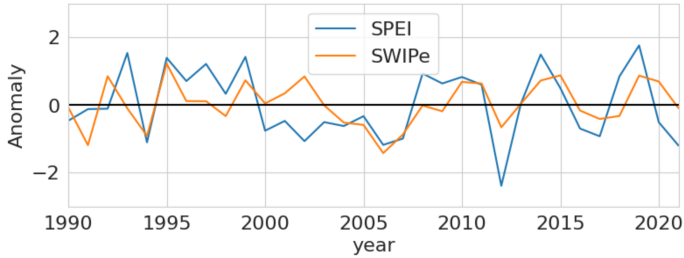
Quantify Earth's capacity as a **low pass filter**

Atmosphere and Streamflow Permanence

- **propagation**
- **lag**
- **attenuation**



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Quantify Earth's capacity as a **low pass filter**

Key Points

1. **SWIPe** provides a **terrestrial** metric of drought.
2. **Normalized** with respect to **time**.
3. Help explain **propagation**, **lag**, and **attenuation**.

Interested in working with **Grad Students** - Low Hanging Fruit!

Upcoming

1. Data release end of 2024
2. https://webapps.usgs.gov/prosperum/

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NORTHWEST
Climate Adaptation
Science Center

NORTH CENTRAL
Climate Adaptation
Science Center

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Questions

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