Montana Climate (past and future) trends and meteorological influences to drought

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Outline

1. Briefly talk about historical trends in temp and precip
2. Introduce the Montana Climate Assessment
3. Show future projections of temp and precip
4. Discuss connections between meteorological and hydrological drought
Montana Temperature Trends

Montana temperature has increased around 2°F from 1985-2015.
Precipitation has shown no statistically significant trend from 1985-2015.
Montana Climate Assessment

Climate

Agriculture
- Bruce Maxwell
  - MSU - LRES

Water Resources
- Wyatt Cross
  - MSU - Ecology

Forestry
- Ashley Ballentyne
  - UM - Forestry

Cathy Whitlock
Institute of Ecosystems
Timeline

- Listening Sessions
- Analysis
- Final Reports
- Present Results

Timeline:
- Jul. 2015
- Jul. 2016
- Jan. 2017
- Jul. 2017
Montana Climate Projections

20 different models make up the ensemble
  - This gives us a range of projections

Downscaled 4km resolution using statistical downscaling but aggregated to the Climate Division

Two RCP scenarios (4.5 and 8.5)

Comparison of mid- and end-of-century time periods
  - Historical (1971—2000)
  - Mid-century (2040—2069)
  - End-of-century (2070—2099)
Change Avg. Annual Temperature (°F)

Mid-Century RCP 8.5
Change in # of Days Above 90 °F

Mid-Century RCP 8.5
Change in Monthly Avg. Temp. (°F)

Mid-Century RCP 8.5
Change Avg. Annual Precipitation (%)

Mid-Century RCP 8.5
Change in # of Consecutive Dry Days

Mid-Century RCP 8.5
Change in Monthly Average Temps (°F)

Mid-Century RCP 8.5
How well (historically) does temperature and precipitation predict Montana streamflow?

Streamflow data:
- Continuous 60-year record (1950--2009)
- Currently active
- Watersheds < 50,000 sq. miles
- 29 USGS stream gages

Climate data:
- 4km PRISM precipitation
- 4km PRISM temperature
Streamflow vs. Martonne Index

Maximum Correlation

Histogram of R-squareds
Temperature has increased historically and is projected to increase by another 4-6 °F by mid-century. Precipitation has stayed about the same historically but is projected to increase by around 6-10 % by mid-century. Drought metrics (i.e. consecutive dry days) are not projected to change much but are highly uncertain. However, meteorological drivers only explain around ~60% of the variation in streamflow in Montana. Therefore, we need to be considering how to adapt our management of the other ~40%.
Montana Soil Moisture Monitoring

MT Mesonet Stations

A Blackfoot
B UPPER CLARK FORK
C Upper Missouri

- Active
- Funded
- Pending
- Proposed

Kevin Hyde
Mesonet Coordinator
Questions???

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Change in # of Freeze Free Days
Mid-Century RCP 8.5
Change in # of Days Above 1.0”

Mid-Century RCP 8.5
Streamflow vs. Temperature

Maximum Correlation

USGS Gage 06099500

R-squared = 0.39

Histogram of R-squareds
Streamflow vs. Precipitation

Maximum Correlation

Histogram of R-squareds
What about combining P and T?

Martonne Index (De Martonne, 1926):

\[ MI = \frac{P}{T + 10} \]
Streamflow vs. Martonne Index

Maximum Correlation

R-squared = 0.56

USGS Gage 06099500

Annual Runoff (mm/yr)

Annual Martonne Index (mm/°C)

Histogram of R-squareds
What’s left to explain Q?

\[ Q = P - ET - \Delta S \]

Evapotranspiration (ET)
- Irrigation
- Crop type
- Forest management
- Wildfire
- Beetle kill
- Vegetation adaptation
Broader perspectives on change...