Decadal Droughts and Consequent Climate Information Needs of Stakeholders in the Missouri River Basin

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- Importance of the Missouri River Basin
- Impacts of hydro-meteorological anomalies associated with the PDO and the tropical Atlantic SST gradient on water and crop yields
- Sectoral impacts of decadal droughts
- Decadal drought information needs of stakeholders
- Barriers to use of the information
- Summary

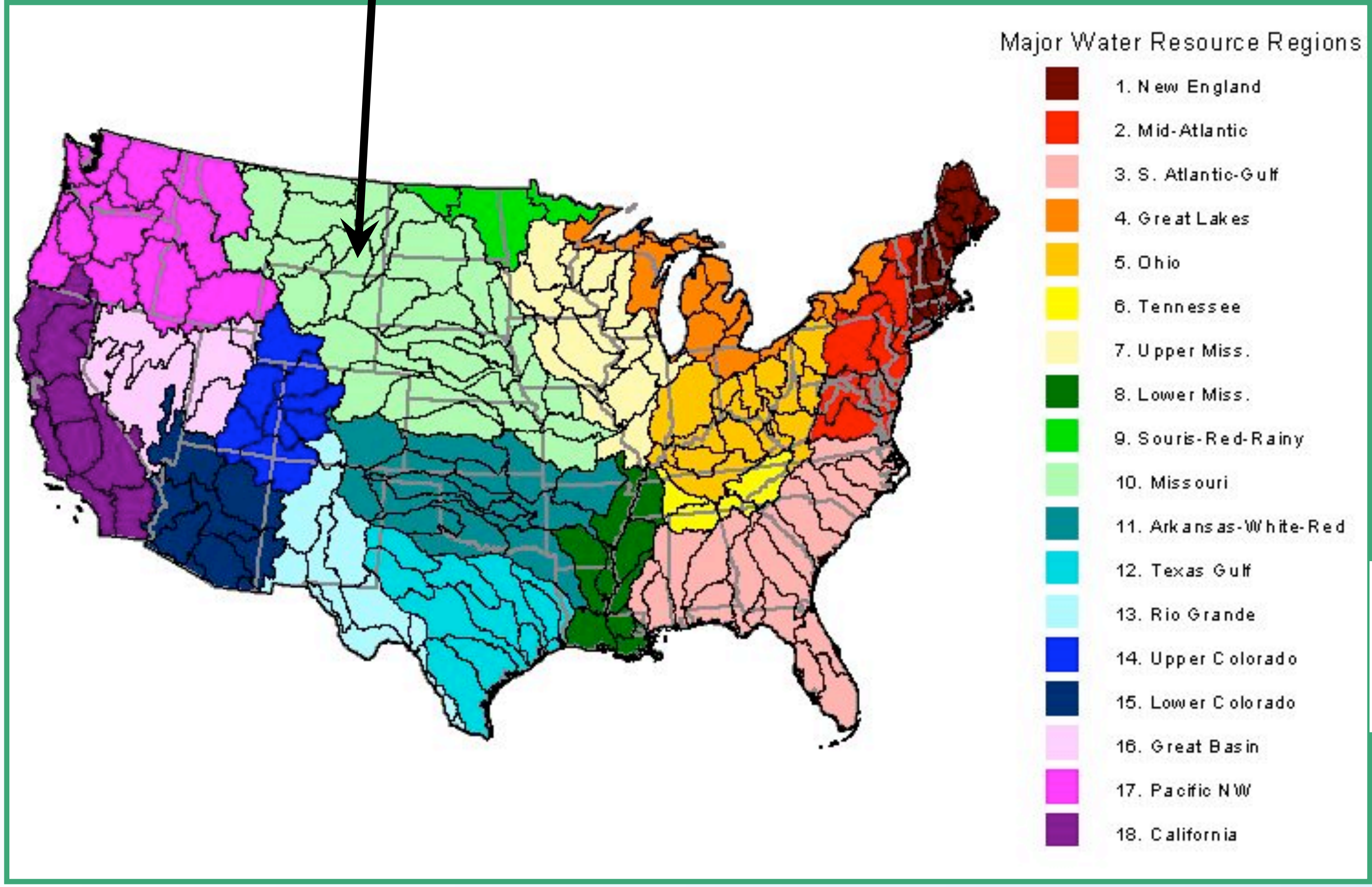
Importance of the Missouri River Basin

Missouri River Basin

Produces 46% of wheat, 22% of grain corn, 34% of cattle in the United States

Largest river basin in the US

Covers 500,000 sq. miles, 10 States, many Native American reservations, parts of Alberta and Saskatchewan

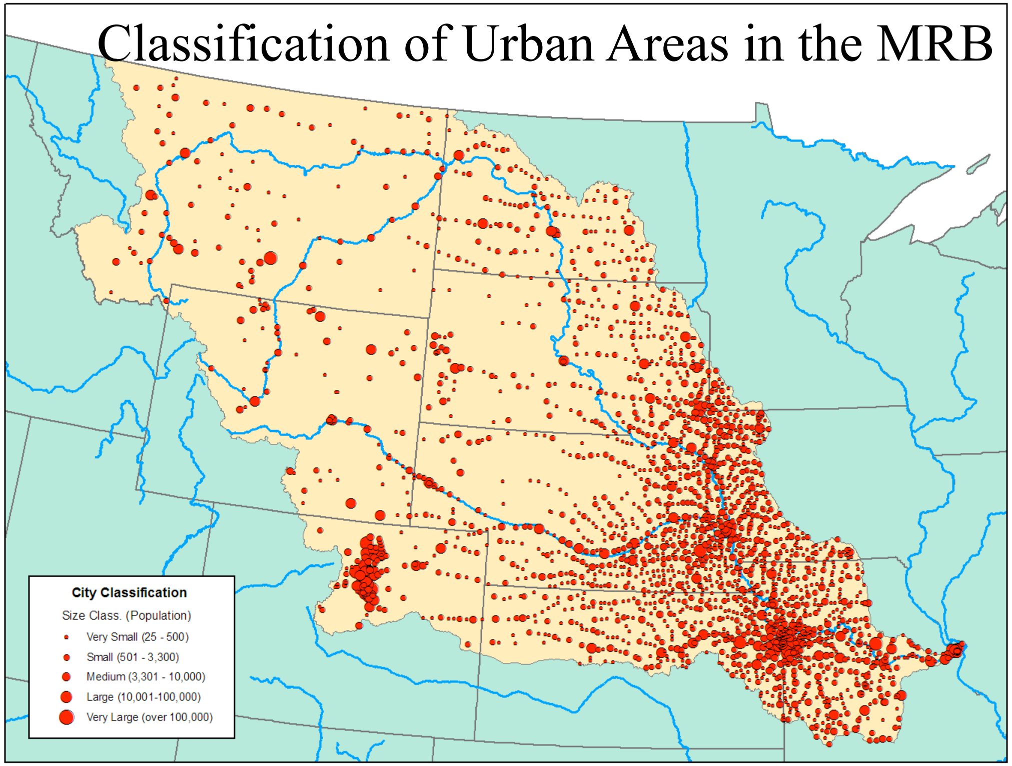


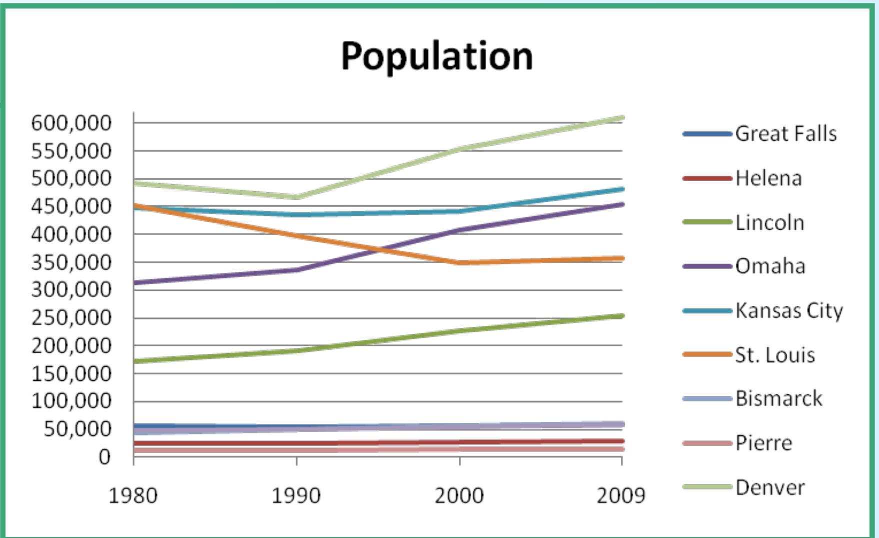
Value of crops and livestock over $100 billion in 2008

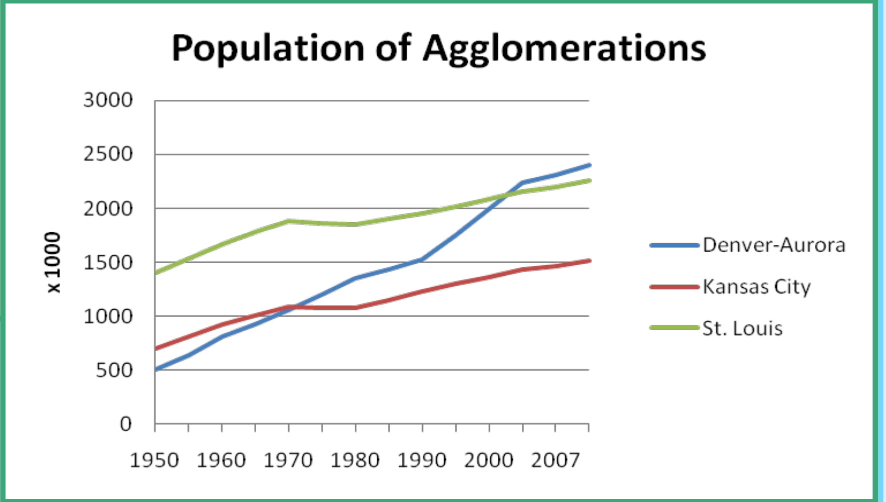
117 million acres cropland, only12 million acres irrigated

Dependence on the Missouri River for drinking water, irrigation and industrial needs, hydro-electricity, recreation, navigation, and fish and wildlife habitat

Increasing Urbanization in the Missouri River Basin

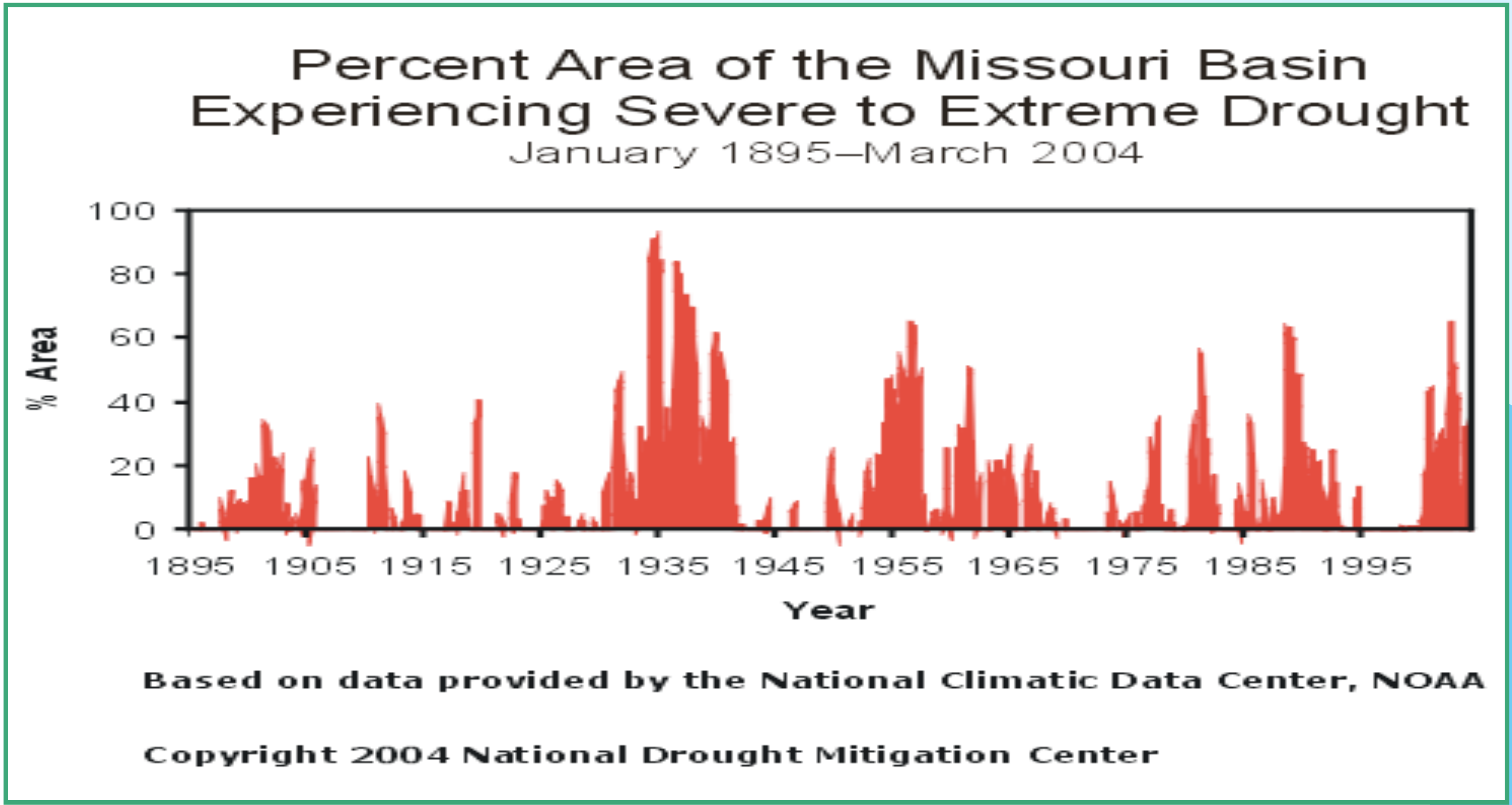






Over 1000 urban areas in the Basin;
Population increase in most urban areas.

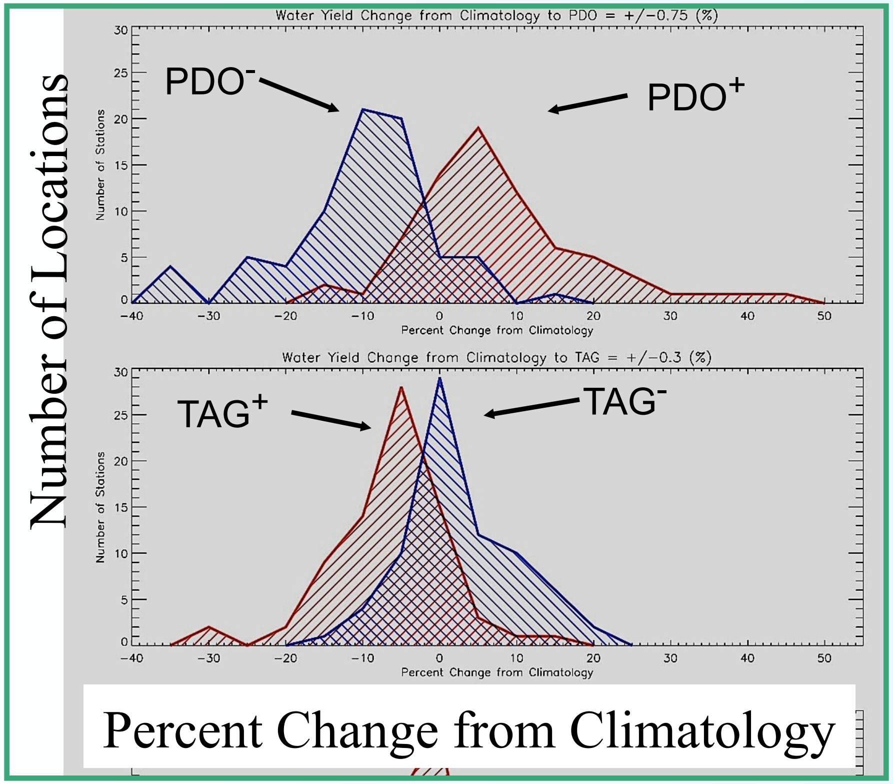
Droughts in the Missouri River Basin



The MRB experiences severe to extreme decadal droughts.

Simulation of DCV Impacts on Water Yields with the Hydrologic Unit Model of the U.S.-Soil and Water Analysis Tool (HUMUS-SWAT)

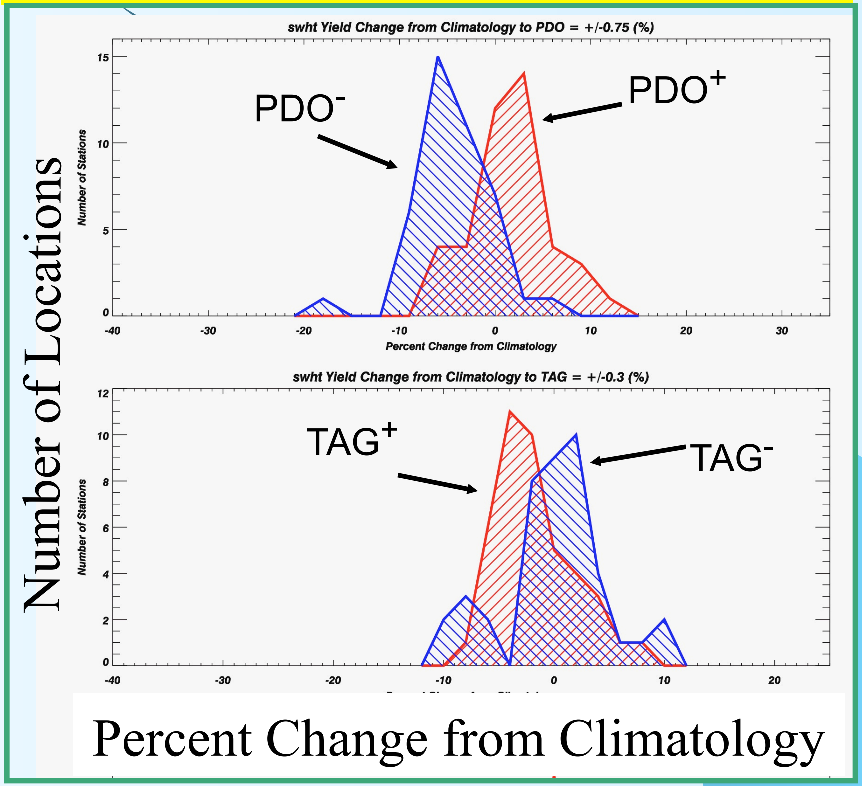
Basin-aggregated Water Yield Changes



Simulation of DCV Impacts on Crop Yields with the Environmental Policy Integrated Climate (EPIC) model

(Spring and winter wheat, corn, soybeans)

Basin-aggregated Spring Wheat Yield Changes



- Potentially dramatic impacts of the DCV phenomena on water, wheat, and corn yields.
- May be possible to forecast some multiyear to decadal measure of water and crop yields with some skill if decadal climate evolution can be forecast.

Assessment of decadal drought information needs of stakeholders for decision support

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- (1) Workshops and individual meetings with stakeholders;
  (2) Development of retrospective, decadal dry and wet period scenarios; and
  (3) Development of sectoral impact evaluations through use of the HUMUS and EPIC models driven by the retrospective scenarios
- Individual discussions with approximately 30 stakeholders and policymakers in Nebraska; December 2006
- Three Workshops involving approximately 80 participants representing agriculture, water and electric power utilities, academics, NWS climate and river forecast services, Native American tribes, fish & wildlife service, transportation, local-state-federal government, urban water systems, others
- Kansas City, Missouri; April 27-28, 2009
- Helena, Montana; June 24-25, 2009
- Lincoln, Nebraska; November 16-17, 2010
- Further interactions via e-mail, newsletter *Missouri Basin Climateer*

The PIs explaining purpose of meeting to the Nebraska City group 9 Dec. 2006

Larry Murphy, Corps of Engineers, describing impacts of droughts in the MRB Kansas City, 27 Apr. 2009

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Interactions with Stakeholders

Purposes of the Workshops

1. To show that climatic events on the decadal scale have major effects, including major droughts and wet periods;

2. To gather information about the effects of droughts in the 1980s and from 2001 to 2007; as well as the prolonged wet period of the 1990s;

3. To explore the potential for developing future decadal climate outlooks and potential management options that would be useful in preparing for and coping with decadal droughts and wet periods.

Stakeholder interaction techniques

- Newsletter
- Workshops

Write-up about Workshop's purposes and questionnaire
Presentations by project team members and others
Discussions during and between presentations
Thematic discussions among small groups of participants
Final questionnaire at the end of Workshop
Workshop report

Project team members conducting presentations and discussions

Kansas City, 27 Apr. 2009

Sectoral Impacts of Decadal Droughts Based on Stakeholder Recollections

The 1980s Drought

- Run-off into MR reservoirs reduced as much as 50%
- Impacted municipal and power plant water supplies
- Water use restrictions in major cities
- "Dirty Thirties"-like dust storms
- Shortened navigation season on the MR
- First major stress on the MR reservoir system, competition and lobbying among MRB states for stored water
- Decreased crop yields (e.g. corn yield decreased by 30%)
- Financial crisis for farms; consolidation
- Increased investments in center-pivot irrigation systems
- Increased livestock sell-off
- Increased use of ground and surface water for irrigation
- Increased wild fires, including in Yellowstone Nat. Park
- Increased water pollution, requiring new water treatment plants
- Increase in temporary wells for water supply in many urban areas; water systems in small urban areas unable to operate due to low reservoir/river levels
- National legislation for water efficiency requirements for appliances

Fort Peck Reservoir on the Missouri River in Montana During the 1980s drought;

Dam length 6 kms., height 90 m

A center-pivot irrigation system near Lincoln, Nebraska

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Sectoral Impacts of Decadal Droughts Based on Stakeholder Recollections

The 2000s Drought

- Wide-spread water shortages; curtailment of irrigation rights in favor of senior right-holders
- Installation of additional pumps for municipal and power plant water supplies
- Water use restrictions in urban areas
- Significant crop losses over wide areas
- Financial crisis for farms; consolidation
- Increased investments in center-pivot irrigation systems
- Increased livestock sell-off
- Increased use of ground and surface water for irrigation
- Increased wild fires, including in Yellowstone Nat. Park
- Increased water pollution, requiring new water treatment plants
- Increase in temporary wells for water supply in many urban areas; water systems in small urban areas unable to operate due to low reservoir/river levels (e.g. Lake Oahe)
- Increased substance abuse and family discord
- Adverse impacts on fish and wildlife
- Denver Water System lost $50 million per year in revenue
- $500 million per year impacts in Missouri (state)
- New water and drought management legislations and increased participation in multi-state water management activities

Usefulness of Decadal Climate Outlooks to Stakeholders

Benefit in planning in all sectors, even from some reliable information about the current state of each DCV phenomenon relevant to the MRB

Some information about decadal weather statistics necessary

Agriculture: Guidance about crops and varieties to plant, correct mixture of crops to plant, irrigation planning, and fertilizer application

Transportation systems: Decisions about crops transportation to market by truck, train, or barge

Reservoir operations: Planning of water level, and water release times and amounts in spring

Honorable John Bohlinger, Lt. Governor of Montana, explaining the importance of this project in the Helena, MT Workshop

Fire-fighting: Purchase of equipment for fighting wildfires, required number of fire-fighters, and timing of controlled burns

Municipal water supply and drainage systems: Decision-making about sources, prices, water use restrictions

Fisheries and wildlife hatcheries: Management decisions

If decadal climate outlook indicates dry/wet epoch longer than a decade, then…

Agriculture: Irrigation systems planning, crop and seed types; planting acreage; insurance coverage; timing of fertilizer, herbicide and pesticide application; and disease control

Groundwater: Quality and protection, more accurate surface water outlooks

Land management: Controlled burns and timing of environmental habitat restorations

Ecosystem management, fisheries and wildlife management

Livestock production: Decision-making about holding or selling livestock, range or lot feeding, purchasing water to maintain cattle on range or in lots, environmental stress, and estimate feed-to-production ratios

Public water supply: Construction of new wells or reservoirs, establishing new pipelines

River navigation and commodity transportation planning and implementation: Investment decisions of rail and barge companies

Electricity-generation industry:
Construction of new plants, number of water intakes, wholesale purchase of fuel, and wholesale marketing of electricity

Thermal power plants:
Very stringent regulations about temperature of cooling water released into the environment;
planning operations of such plants and in legalities of effluent water temperature management

Nuclear power plants: Even more stringent water temperature regulations than coal- or oil-fired power plants

River- and reservoir-based recreation industry:
Improved marina planning and dredging, and decisions about ramp construction and public access at existing marinas

If decadal climate outlook indicates dry/wet epochs longer than a decade, then…

Likelihood of floods/wet epochs: Guidance for protective measures for critical infrastructure in flood plains, i.e. whether or not to build new levees, encourage flood zone buyouts, install internal drainage infrastructure in flood zones, provide flood insurance, manage spring runoff, and incorporate estimates of possible damage in budgets.

State government planning and preparation: Droughts/wet periods, improved planning of emergency response strategies.

Federal government: Decisions regarding erosion control, international trade regulations, and biofuels production in affected states.

Personal and business decisions

Barriers to Using Decadal Climate Outlooks (DCOs)

Reliability: The most important potential barrier; build the information users' confidence in the DCV science and DCOs by demonstrating understanding and prediction skill about past DCV phenomena.

Importance of accuracy: Specify probability limits; overall decision-making process in many sectors complex and sensitive to risk perception, and a subjective/objective hedging involved; climate just one of the variables; can be a bigger part of the decision-making process as forecast accuracy improves.

Involvement of users: Try to bridge the gap between stakeholders' and lay people's experiences and observations and climate scientists; acute need for mutual education.

Consequences of a wrong forecast: Consider importance in decision-making process, including the possibility of litigation brought on by wrong decisions.

Institutional barriers: Under the National Environmental Policy Act (NEPA) of 1970, detailed statements assessing environmental impact of and alternatives to major federal actions required. Under NEPA, water release decisions by USACE based on actual water in storage and past history of weather and climate variability; **weather/climate forecasts not currently used in decision-making.** A clear demonstration of climate forecast accuracy and reliability might overcome these institutional barriers by changes to NEPA and the Corps' operating rules.

Barriers to Using Decadal Climate Outlooks (DCOs)

Limited flexibility in changing the amount of reservoir storage space allocated for flood storage due to legislative authority. Some changes in a reservoir's authorized uses may require action by the U.S. Congress. Also, decision-making processes driven by events, seasons, and availability of funds, so these processes would have to be changed before DCOs can become useful.

Clarity in information-delivery very important, including explanations of sources of potential predictability, and limits of predictions.

Scenario-planning exercises lacking among user communities, and climate scientists should become involved in designing and conducting such exercises.

General consensus: DCOs would be useful, even if of limited accuracy, if they are clearly defined within levels of uncertainty and provide the kind of information needed by stakeholders.

Specific Recommendations for Providing Decadal Climate Outlooks

1. Climate scientists and climate information should be readily accessible to stakeholders at the right time for decision-making. Communications between climate scientists and stakeholders need to be improved, including a clear explanation of differences between scenarios/projections and predictions.

2. Existing user networks should be engaged to channel climate information, and there should be more coverage of climate-related matters on TV and other regional/local news media.

3. Social impacts of DCV should be considered a part of the totality of DCV impacts and social scientists should be engaged in assessment and prediction of DCV impacts.

4. Climate scientists should select a few promising sectors and work with stakeholders in those sectors to convey the usefulness of DCV information to their general user communities.

5. Stakeholders should be involved in assessing the usefulness of experimental DCOs.

Summary

- Substantial associations between hydro-meteorological anomalies in the MRB; and PDO and TAG DCV patterns.
- USGS stream flow variability in the MRB shows association with DCV phenomena.
- Hydro-meteorological anomalies associated with realistic values of the PDO and TAG indices applied to HUMUS-SWAT led to substantial impacts on water yields (the model variable closest to stream flow).
- USDA-NASS crop yields in the MRB show association with DCV phenomena.
- Hydro-meteorological anomalies associated with realistic values of the PDO and TAG indices applied to EPIC led to substantial impacts on yields of spring and winter wheat, corn, and soybeans.
- Combined and cumulative positive/negative impacts of various DCV phenomena can be dramatic and potentially devastating.

Summary

- Growing awareness among MRB stakeholders (e.g., farmers, water managers, cattle producers, transportation managers) and policymakers at the local, state, and federal level about natural DCV and its distinctness from global warming.
- Existing need for climate and societal impacts information about decadal dry and wet periods.
- Users beginning to think how they would use decadal climate and impacts information, even the current phases of major DCV phenomena.
- Many potential barriers to producing and using decadal climate outlooks, but users eager to work with climate scientists.
- MRB a very important and ‘fertile’ region to sow seeds of climate services, but sustained efforts required to build credibility of climate science and scientists.

Thank you!!