Towards the Application of Decadal Climate Predictions in Water Management

Erin Towler (NCAR)
D. PaiMazumder, J. Done, & D. Yates

2017 US CLIVAR Summit
PSMI Panel Breakout
Aug 9, 2017
Remote Webinar to Baltimore, MD
towler@ucar.edu
Goals:

1. Introduce our NSF-funded project on Understanding Decision-Climate Interactions on Decadal Scales (UDECIDE)

2. Present a framework towards the application of decadal climate predictions
UDECIDE aims to understand the role of decadal climate information for water management decisions.

What information is skillful on decadal scales?

Global Prediction
Regional Prediction
Impact Prediction

Decision Space
Decision Maker
Sector
Region

What information is needed on decadal scales?

20 interviews with water managers in Colorado to explore potential of decadal information
Interview results corroborate the three criteria needed for climate information to be used by decision makers identified by Cash et al. (2002):

*Saliency* - How relevant the information is to decision makers

*Credibility* - How authoritative, believable, and trustworthy the data and its source are considered to be by decision makers

*Legitimacy* - How “fair” an information producing process is and whether it considers appropriate values, concerns, and perspectives of different actors

(Andrews, Lazrus, Done, 2017 AMS)
Results also indicated two additional criteria: Compatibility and Contextual Acceptability.

*Compatibility* - How well the new data fits with existing processes, mathematical models, decision-making processes, and required activities

*Contextual Acceptability* - How well the new data fits with existing political, financial, and social forces

(Andrews, Lazrus, Done, 2017 AMS)
UDECIDE aims to understand the role of decadal climate information for water management decisions.

What information is skillful on decadal scales?

Given the skill, limitations and needs, how can we apply near-term climate data?

What information is needed on decadal scales?
We develop a three-step framework to explore how decadal temperature predictions could be applied by potential users. (Towler et al. 2017)

**Step 1. Evaluate Predictions**
- 1980-2010 Hindcasts*
  - ACC
  - MSSS

**Step 2. Manipulate Predictions**
- 2010 Hindcast*
  - Anomaly
  - Probabilistic

**Step 3. Translate Predictions**
- Case Study Watersheds
  - Climatology
  - Delta
  - Weighted resample
  - Hybrid

*(Credibility)
**Data:**
- NCAR CCSM4 *temperature* hindcasts
  - Initialized every year 1980-2010
  - Examine years 1-5
  - 10 ensembles

**Step 1. Evaluate Predictions**
- 1980-2010 Hindcasts
- ACC
- MSSS

**Step 2. Manipulate Predictions**

**Step 3. Translate Predictions**
- Hybrid Case Study Watersheds

Thirty 5-year time periods:
- Initialized
  - 1980
  - 1981
  - ...
  - 2010
- Years 1-5
  - 1981-1985
  - 1982-1986
  - ...
  - 2011-2015
Mean squared skill score (MSSS) is positive where hindcast is more skillful than climatology.

Colorado Watershed
(MSSS = -0.038

Ottawa Watershed
(MSSS = 0.25)
We develop a three-step framework to explore how decadal temperature predictions could be applied by potential users.

Step 1. Evaluate Predictions
- 1980-2010 Hindcasts
- ACC
- MSSS

Step 2. Manipulate Predictions
- 2010 Hindcast
- Anomaly
- Probabilistic

Step 3. Translate Predictions
- Case Study Watersheds
- Climatology
- Delta
- Weighted resample
- Hybrid

Compatibility

Like climate change projections
Like seasonal forecasts
Data:
- NCAR CCSM4 **temperature** hindcasts

**Step 1. Evaluate Predictions**
- 1980-2010 Hindcasts

**Step 2. Manipulate Predictions**
- Anomaly
- Probabilistic

**Step 3. Translate Predictions**
- Hybrid Case Study Watersheds

Examine 2011-2015 prediction period
Decadal temperature predictions can be presented like climate change projections (i.e., a delta)

Discrete temperature anomalies (deltas) for 2011-2015 (relative to 1981-2010) shows warming across the US.

<table>
<thead>
<tr>
<th>Anomaly (C)</th>
<th>Delta</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Colorado</td>
<td>0.9</td>
</tr>
<tr>
<td>Ottawa</td>
<td>0.2</td>
</tr>
</tbody>
</table>
Decadal temperature predictions can be presented like seasonal climate forecasts (i.e., probabilistic)

Probabilistic temperature predictions for 2011-2015 tilt towards “Above-normal” category

<table>
<thead>
<tr>
<th></th>
<th>Colorado</th>
<th>Ottawa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below-Normal</td>
<td>0</td>
<td>27</td>
</tr>
<tr>
<td>Probability (%)</td>
<td>27</td>
<td>30</td>
</tr>
<tr>
<td>Above-Normal</td>
<td>73</td>
<td>43</td>
</tr>
</tbody>
</table>
We develop a three-step framework to explore how decadal temperature predictions could be applied by potential users.

Step 1. Evaluate Predictions
- 1980-2010 Hindcasts*
- ACC
- MSSS

Step 2. Manipulate Predictions
- 2010 Hindcast*
  - Anomaly
  - Probabilistic

Step 3. Translate Predictions
- Case Study Watersheds
  - Climatology
  - Delta
  - Weighted resample
  - Hybrid

Compatibility & Salience
Step 1. Evaluate Predictions

Step 2. Manipulate Predictions
- 2010 Hindcast*
  - Anomaly
  - Probabilistic

Step 3. Translate Predictions
- Case Study Watersheds
  - Climatology
  - Delta
  - Weighted resample
  - Hybrid

Only look at Colorado watershed results...
Climatology is the observed average temperatures over the watershed from 1981-2010 (=30 years).
Step 2. Manipulate Predictions

Step 3. Translate Predictions

The **Delta** adds the average temperature **anomaly**

![Box plot showing annual average temperature (C) with a Delta of 0.9C added to climatology (1981-2010).]
The **Weighted Resample** resamples average temperatures over the watershed to reflect the **probabilistic hindcast**.

**Step 2. Manipulate Predictions**
- 2010 Hindcast*
- Anomaly
- Probabilistic

**Step 3. Translate Predictions**
- Case Study Watersheds
- Climatology
- Delta
- Weighted resample
- Hybrid

---

**Colorado**

<table>
<thead>
<tr>
<th>Probability (%)</th>
<th>Above-Normal</th>
<th>Normal</th>
<th>Below-Normal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probability (%)</td>
<td>73%</td>
<td>27%</td>
<td>0%</td>
</tr>
</tbody>
</table>
Step 2. Manipulate Predictions

2010 Hindcast*

Anomaly
Probabilistic

Step 3. Translate Predictions

Case Study Watersheds
Climatology
Delta
Weighted resample
Hybrid

The **Hybrid** re-centers the weighted resample over climatology, then adds the delta.

\[
\text{Hybrid} = (\text{Resamp}_{\text{Avg}} - \text{Clim}_{\text{Avg}}) + \text{Delta} (0.9C)
\]
Colorado Watershed

Annual Average Temperature (C)
Colorado Watershed: There is a distinct increase in average temperature from 1981-2010 to 2011-2015.
Colorado Watershed: Delta adds 0.9C to climatology & distribution shape stays the same.
Colorado Watershed: Weighted resample samples 0% from below-normal, 27% from normal, and 73% from above-normal climatology distribution; distribution shape changes.
Colorado Watershed: Hybrid re-centers weighted resample to climatological average, then adds the delta.
All three translation methods do better than climatology.

Average absolute % error (across selected quantiles) for 2011-2015 prediction

<table>
<thead>
<tr>
<th>Colorado</th>
<th>Avg Abs % Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clim</td>
<td>18%</td>
</tr>
<tr>
<td>Delta</td>
<td>4%</td>
</tr>
<tr>
<td>Weighted</td>
<td>5%</td>
</tr>
<tr>
<td>Hybrid</td>
<td>4%</td>
</tr>
</tbody>
</table>
Conclusions

- Decadal predictions are still experimental, but framework provides water managers with **systematic alternatives** to using climatology.
Conclusions

• Decadal predictions are still experimental, but these approaches give water managers **systematic alternatives** to using climatology.

• **Translations have pros/cons**
Conclusions

- Decadal predictions are still experimental, but these approaches give water managers **systematic alternatives** to using climatology.

- Translations have pros/cons & depend on user needs
  - Delta: Most straightforward
  - Weighted resample: Most conservative
  - Hybrid: Tailored for decadal predictions

- More simple vs. More complex
- Probabilistic vs. Discrete
Current Work:
Use hydrologic model to make predictions more relevant to water managers

WEAP Application (Hydrologic model)
Courtesy David Yates, NCAR
Thank you!
towler@ucar.edu