Precipitation and temperature projections for the Indus River basin of Pakistan during 21st century using statistical downscaling

Session CL4.17
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The Indus River Basin: A Complex Climate Hotspot

Can relatively-low altitude stations explain orographic climate structure within the UIB? What observations tell us?

IRB and Study area

Study stations
K-Means Precipitation Clustering using Correlation

Clustering of HA stations around low-altitude stations

Basin-wide regionalization

HA-UIB regionalization

WS-DJFM)  MS-JAS)
Predictand-Predictor Modeling and Performance

- Time-series of selected regionally representative stations serve as Predictands
- GLM with gamma and Tweedie distributions used for precipitation regression models within a robust cross-validation framework by minimizing (maximizing) errors (MSESS) in 1000 random iterations.
- MLR for modeling Tmax and Tmin on seasonal scales.

- PC scores derived from S-mode PCA on selected dynamic and thermodynamic predictors of a reanalysis serve as Predictors

Precipitation Modeling performance

<table>
<thead>
<tr>
<th>Season Spatial Scale</th>
<th>No. of Regions</th>
<th>Avg. Val. MSESS (Range in %)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MS (UIB)</strong></td>
<td>5</td>
<td>32.73 (20.71 to 52.541)</td>
</tr>
<tr>
<td><strong>MS (LI)</strong></td>
<td>2</td>
<td>36.19 (32.06 to 40.32)</td>
</tr>
<tr>
<td><strong>PMS (UIB)</strong></td>
<td>4</td>
<td>43.90 (28.83 to 50.42)</td>
</tr>
<tr>
<td><strong>PMS (LI)</strong></td>
<td>2</td>
<td>38.88 (37.64 to 40.11)</td>
</tr>
<tr>
<td><strong>WS (UIB)</strong></td>
<td>3</td>
<td>34.69 (26.10 to 49.57)</td>
</tr>
<tr>
<td><strong>WS (LI)</strong></td>
<td>2</td>
<td>32.69 (28.75 to 36.63)</td>
</tr>
</tbody>
</table>
Anomalous MS Precipitation: Physical Mechanisms

Loading Pattern of $v_{a200}$

wind and $z_g$ at 200hPa

wind at 850hPa

a) 344 mm/m
b) 69 mm/m

a) 181 mm/m
Circulation-based Reference and Model Uncertainties and the GCM Selections

- We used precipitation governing circulations for computing reference uncertainty by comparing these with circulations of ERA5 and NCEP-NCAR-II.

- Loading patterns of circulations after performing S-Mode PCA are compared through Taylor diagrams for reference uncertainty.

- The reference uncertainty for MS ranges from 16% to 28% and for the WS it was 16 to 26% for the UIB.

- Similarly we compared circulations of CMIP5-GCMs to select models for simulations over the basin.

- CMCC-CMS perform best for MS and MPI-ESM-LR showed best correspondence during the WS.
Impact of Model Weights on Precipitation (MME) Signals

• We used weights of model to compute the MME signals.

• Better performing models (models with higher weights) further strengthen the change signals. MS changes were most prominent.

• The most wet part of the basin in observations along foothills of the southern Himalayans will remain stable to positive in all the seasons.
Conclusions

• Relatively low-altitudes stations can explain orography within the UIB
• Atmospheric circulations can resolve observed (fine-scale) patterns, explain governing mechanisms and help to select GCMs
• Precipitation during the WS (MS) increases but decreases during the PMS (over northwestern regions) and better performing models intensify these signals
• Spatial patterns suggest more northward penetrations of westerlies and MS regimes under RCP8.5 particularly over the central Karakoram
• Basin will warm, but increase in Tmin is more profound - a decrease in DTR. The WS (PMS) will warm significantly and follow EDW in UIB.
• A large portion of UIB will show MS cooling with less warming over the HA of the UIB.
• LI will exhibit more demand (rise in temp) in future for all seasons.
• A new dimension for future regional research