Projection of Snow droughts under climate change scenarios in the Urmia Lake basin

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Introduction & Motivation

Urmia Lake (Figure 1), a globally significant saline lake, has encountered severe droughts and reduced water levels. The region's climate and hydrology are heavily influenced by mountain processes. Climate change affects snow properties, vital for water resources. This study explores the climate-snow link and identifies future snow changes for improved lake management strategies.

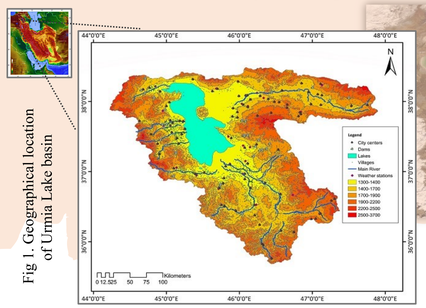

Fig 1. Geographical location of Urmia Lake basin

Study area:
The Urmia catchment :
- ✓ 51,676 km² in the north-west of Iran
- ✓ 65% mountain areas
- ✓ 25% foothills and plains
- ✓ 10% lake area
- ✓ The mean lake elevation : ~1270 (MSL)

Aims: understand the potential impacts of climate change on snow droughts in the Urmia Lake Basin by:
- ✓ evaluating CMIP6 climate simulations for drought-relevant variables,
- ✓ projecting future drought characteristics across three emission scenarios

Data & Method

- ❖ ERA5-Land : As a suitable proxy for bias correction, given its similarity to the observational data. (*Habibi et al.* 2021).

For the input data through an in-depth analysis using Taylor diagrams (Figure 2), and other statistical calculations, various bias correction methods were applied to different CMIP6 models:
- ✓ precipitation in the TaiESM1 model corrected by PTF
- ✓ snow depth in the CMCC-CESM model corrected by DIST
- ✓ Tmax in the NorESM2-MM model and Tmin in MRI-ESM2-0 model adjusted by QM

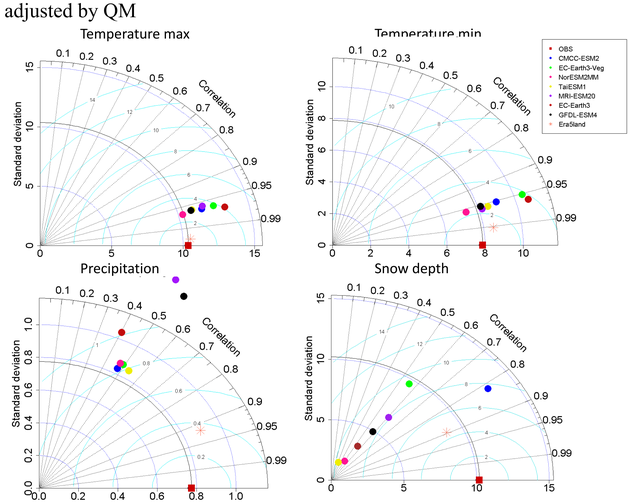

Fig 2. Taylor diagram the climate variables

- ❖ SMRI: Standardized Snowmelt and Rain Index (Staudinger *et al.* 2014).

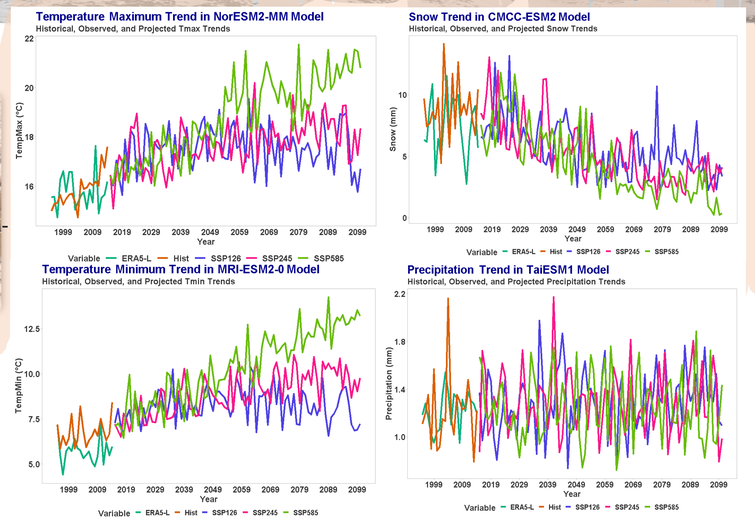

Fig. 3: Fluctuations in the climate variables under SSPs vs. baseline.

•Figure 3 Key findings:
- Projected precipitation patterns align with base period observations
  - ✓ Suggests continuation of historical trends
- Decrease in snow depth trends from 10mm to nearly 0mm by 2100s.
  - ✓ Indicates potential shifts in snowfall patterns and accumulation
- Upward trend in min and max temperature projections Influenced by respective SSPs
  - ✓ Could significantly impact snow, leading to faster melting, and decreased snow cover.

Result & Discussion

Temporal Evaluation

- Figure 4 key findings:
  - ✓ Distinct implications for future drought conditions:
- SSP2-4.5 & SSP5-8.5:
  - ➢ Similar trends
  - ➢ Severe droughts predicted between 2060-2100
- SSP1-2.6:
  - ➢ Oscillatory pattern
  - ✓ Basin consistently experiences sever snow drought conditions under SSP5-8.5 starting 2060s
  - ✓ Highlights potential consequences of high-emission pathways on water availability.

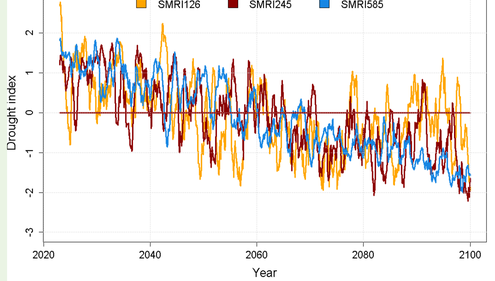

Fig 4. Future snow drought under SSP1-2.6, SSP2-4.5 and SSP5-8.5.

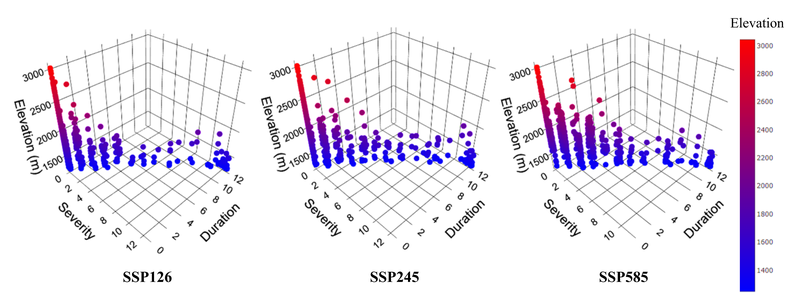

Fig. 5. Linear regression of elevation vs. drought severity/duration

•Figure 5 key findings:
- ✓ Elevation dependency observed in drought characteristics
- ✓ Correlation reveals: Drought severity and duration generally decrease with increasing elevation

SNOW DROUGHT

Spatial Evaluation

- Figure 6: Frequency of drought events
  - ✓ Central and northeast parts of the basin expected to experience several years of extreme drought events from 2071-2100
- Figure 7: Severity of drought events
  - ✓ Highlights significant drought hotspots
  - ✓ Spatial distribution of moderate and severe/extreme drought conditions in the 2100s.
  - ✓ Most extensive range of drought severity covers nearly entire catchment
  - ✓ Extreme drought anticipated under all three scenarios, except in small section of higher-altitude areas

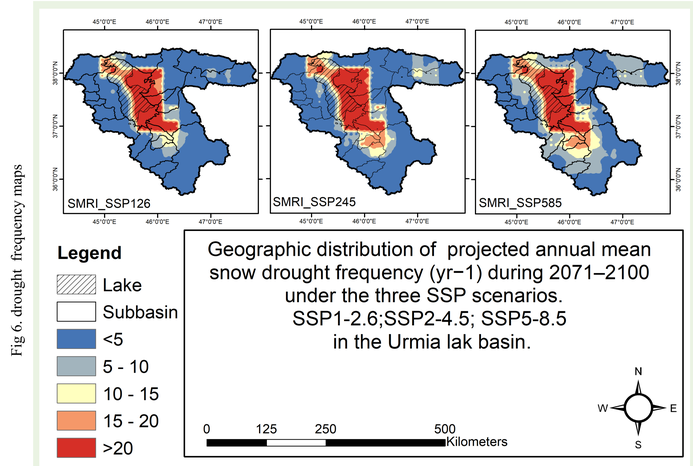

Fig 6. drought frequency maps

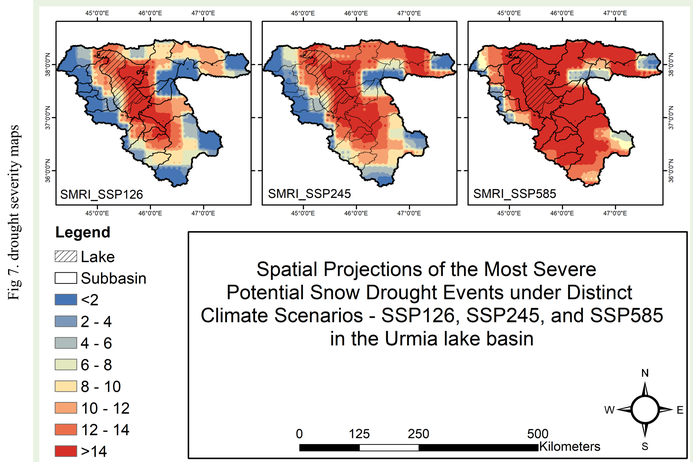

Fig 7. drought severity maps

Conclusion & Future work

•Investigation findings:
- Snow drought events expected to expand across entire basin starting 2060s
- Melting process likely to cause more extreme events: Increased runoff at end of winter and beginning of spring
- Snow cover restricted to higher elevated areas

•Recommendations for future research:
- Comprehensive study of elements influencing future snow changes.

References
Staudinger, M.; Stahl, K.; Seibert, J. A drought index accounting for snow. Water Resour. Res. 2014, 50, 7861–7872.
Habibi, M.; Babaeian, I.; Schöner, W. Changing Causes of Drought in Lake Urmia Basin—Increasing Influence of Evaporation and Disappearing Snow Cover. Water 2021, 13, 3273.

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Download the abstract and poster:

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