Proactive Drought and Extreme Event Preparedness: Seasonal Climate Forecasts offer Benefit for Decision Making in Water Management in Semi-arid Regions

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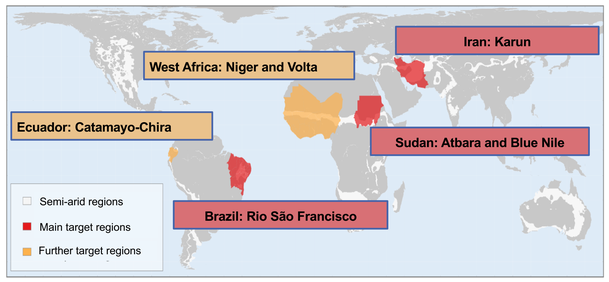
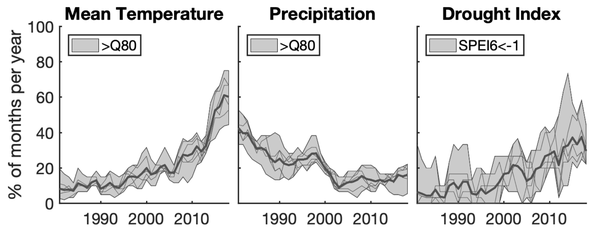
Semi-arid Regions - Mostly Affected by Droughts



Increasing relative frequency of hot extreme and drought months, decreasing frequency of wet extreme months



ERA5 % of months per year with $T > Q80$, $P > Q80$, $SPEI6 < -1$ for the Niger, Volta, São Francisco, Karun, Atbara and Blue Nile basins.

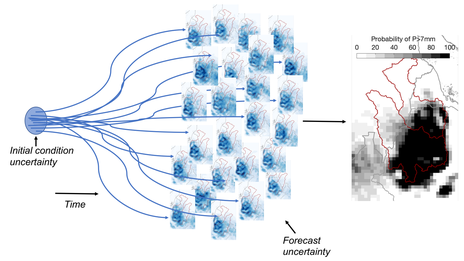
Proactive Drought and Extreme Events Preparedness by the Use of Seasonal Forecasts

Seasonal forecast system 5 (***SEAS5***) of the European Centre for Medium-Range Weather Forecasts **ECMWF**

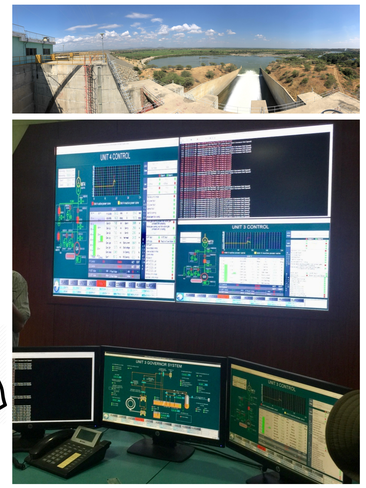
- (retrospective) forecasts up to 7 months in advance
- 25 ensemble members for analysis period of reforecasts (1981-2016)
- horizontal resolution: 35 km
- forecasts with 35 ensemble members available since 2017

With the use of drought indices and relative quantities (quantiles): no bias-correction necessary, i. e., usage of raw forecasts!

Seasonal-Forecast-based Action

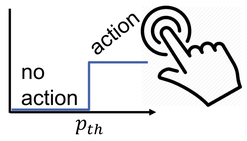


Water reservoir management



Action-derivation from probabilistic seasonal forecasts?

Probability Trigger needed (p_{th})



Action-Event Scenarios with Economic Costs and Losses

	No extreme **event** X_{crit} is not exceeded	Extreme **event** occurs X_{crit} is exceeded
Early action based on forecast p_{th} is exceeded	*False alarms (f)* Futile action Unnecessary costs for action (C)	*Hits (h)* Valuable action (Part of) losses avoided ($L_{event} - L$), costs for action (C)
No action p_{th} is not exceeded	*Correct rejects (r)* Valuable inaction No costs or losses (-)	*Misses (m)* Erroneous inaction No losses avoided (L_{event})

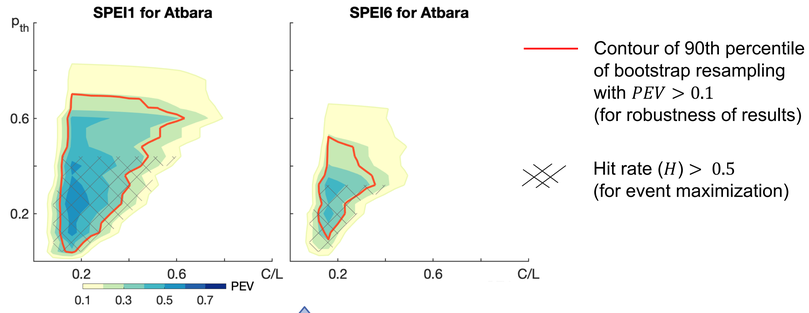
Potential economic value (PEV)

As a function of Hit (H) and False Alarm rate (F), the cost-loss ratio (C/L) and the climatological frequency of the event ($\bar{o}$) (Richardson 2000):

$$PEV\left(\frac{C}{L}, p_{th}\right) = \begin{cases} \dfrac{\frac{C}{L} - \bar{o} - \frac{C}{L}(1-\bar{o}) \cdot F(p_{th}) + \bar{o}\left(1 - \frac{C}{L}\right) \cdot H(p_{th})}{\frac{C}{L}(1-\bar{o})}, & \frac{C}{L} < \bar{o} \\ \dfrac{-\frac{C}{L}(1-\bar{o}) \cdot F(p_{th}) + \bar{o}\left(1 - \frac{C}{L}\right) \cdot H(p_{th})}{\bar{o}\left(1 - \frac{C}{L}\right)}, & \frac{C}{L} \geq \bar{o} \end{cases}$$

Economic Benefit of Seasonal Drought Forecasts – An Example for the Atbara Basin

Potential economic value of drought forecasts ($SPEI < -1$) as a function of the cost-loss ratio (C/L) and the probability threshold (p_{th}, trigger):



Choose most beneficial trigger (p_{th}) with maximum PEV for each C/L
- Possibility to consider robustness of results (red contour)
- Catch as many events as possible (cross-hatched area)

If no beneficial p_{th} can be found:
Use climatological approach:
Always act if $\frac{C}{L} < \bar{o}$, never act otherwise

Application to Water Reservoir Management at the Upper Atbara Dam

Costs and losses calculated for reservoir operations under drought conditions
- Without operation restrictions
- With operation restriction for sediment sluicing

for electrical energy production at the dam.
→ Different operation rules define different cost-loss situations

Possible avoidable losses and costs of proactive drought operations

No operation restrictions	Including sediment sluicing
10 Mio US $ a^{-1} vs. 6 Mio US $ a^{-1}	1 Mio US $ a^{-1} vs. 0.3 Mio US $ a^{-1}

Valuation approach as user- and application-oriented verification of seasonal forecasts

- Assistance of the user in the decision process by proposing beneficial probability thresholds for considered events and preventative action
- Even long forecast horizons (SPEI6) can provide economic benefit to a range of users
- Economic benefit of altered reservoir management can amount to several Mio US $

Contact
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