Joint Virtual Workshop on “Connecting global to local hydrological modelling and forecasting: scientific advances and challenges”

Short-Range Streamflow Forecasting Using Multi-Models Over a Snow Dominated Basin In Turkey

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1- ABSTRACT

Transferring theory to short-term operational practice is challenging, especially for snowmelt runoff forecasting due to harsh topography and the complex response of basins. Many uncertainties arise from temporal and spatial variability of snow cover, forcings, modeling structure, and initial states. This study attempts to combine different techniques for reducing and estimating hydrological predictive uncertainty, such as the use of multi-prediction data (deterministic and probabilistic), multi models and error correction. A snow-dominated mountainous headwater basins in Turkey (upper Euphrates) is selected due to high runoff potential, extensive snow cover and the need for an operational forecast system. Probabilistic and deterministic numerical weather forecasts are obtained from Ensemble Prediction Systems (EPS, 9-day lead-time) and Weather Research and Forecast (WRF, 2-day lead-time). The basin is simulated using HBV and SRM conceptual hydrological models having different snowmelt routines. The first one produces snow cover extent by calculating snow water equivalent in the model itself. The latter directly takes satellite snow cover data as an input to the model. Snow depletion curves are acquired from MODIS cloud-filtered daily snow cover images. Both models are calibrated and validated for 2001-2008 and 2009-2014 periods, respectively, with acceptable Nash-Sutcliffe efficiency. The developed multi-model structure is evaluated under hindcasting experiment set-up for 2012-2015 period with various verification metrics (mean-CRPS, Brier Score). In the end, the pros and cons of using different forcings and multi-model structures are discussed in detail for exploiting uncertainty in the snowmelt processes.

2- STUDY AREA

Headwaters of the transboundary Euphrates River called Upper Euphrates (Karasu) Basin. Karasu Basin is in the mountainous eastern part of Turkey which is of great importance as it constitutes approximately 2/3 in volume of the total yearly runoff during spring and early summer months.

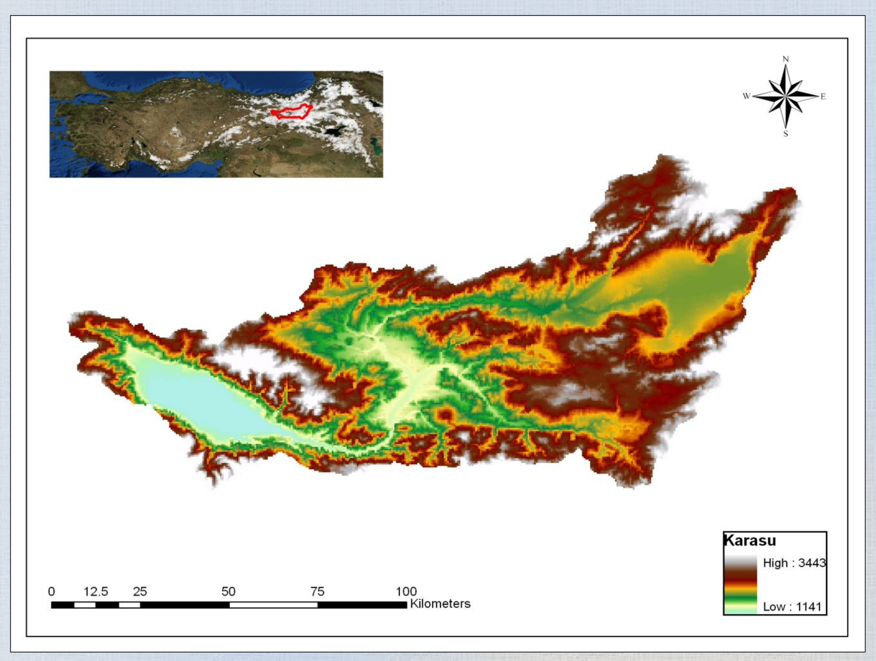

Figure 1. Study Area

SCAN ME

For details please visit EGU blog post entitled ‘’***Featured catchment: Water Towers of Mesopotamia: Snow feeding the cultural heritage***’’ by Uysal et al. (2020)

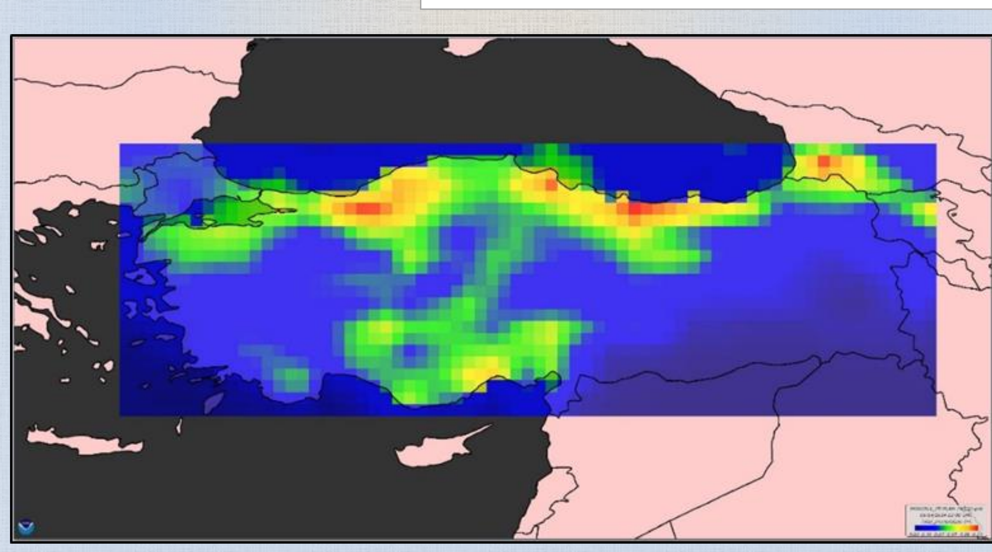

Figure 2. ECMWF Ensemble Prediction System (EPS) data over Turkey

$$CRPS_L = \frac{1}{n}\sum_{k=1}^{n}\left[\int_{-\inf}^{\inf}\left(F_t\left(y_{k,L}\right)-\Gamma\left(y_{k,L}\geq \hat{y}_k\right)\right)^2 dy\right] \quad (4)$$

where: $y_{k,L}$ represents the value of the forecast *k-L* with a lead time *L*, *k* is the indicator of the forecast, *n* is the number of ensembles, *F* is the cumulative distribution function, and *Γ* is a function which assumes probability 1 for values higher or equal to the observation and 0 otherwise.

The CRPS metric is equivalent to the mean absolute error when using deterministic forecasts. This metric is computed in this study using the Ensemble Verification System developed by NOAA (Brown et al., 2010).

3- HYDROLOGICAL MODELS

HBV

The HBV (Hydrologiska Byråns Vattenbalans) model can best be described as a semi-distributed conceptual model which uses daily precipitation and temperature besides monthly potential evaporation as input and also uses degree-day method for snowmelt to simulate the precipitation-runoff process. It was originally developed at the Swedish Meteorological and Hydrological Institute (SMHI) in the early 70´s to assist hydropower operations (Bergström and Forsman, 1973).

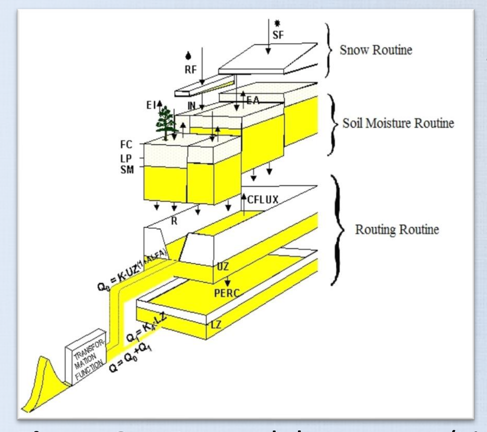

Figure 3. HBV model structure (Lindströmet al., 1997)

The model consists of subroutines for snow accumulation and melt, a soil moisture accounting procedure, routines for runoff generation and finally, a simple routing procedure (**Figure 3**). Discharge observations are used to calibrate, verify and correct the model before a runoff forecast. The main objective of calibration is to reduce the uncertainty associated with the model parameters.

SRM

The Snowmelt Runoff Model (SRM) (Martinec, 2008) is designed to simulate and forecast daily streamflow in mountain basins where snowmelt is a major runoff factor. It has recently been applied to evaluate the effect of a changing climate on seasonal snow cover and runoff. SRM was developed by Martinec (1975) for small European basins, with the progress of satellite remote sensing of snow cover, the model has been applied to larger basins.

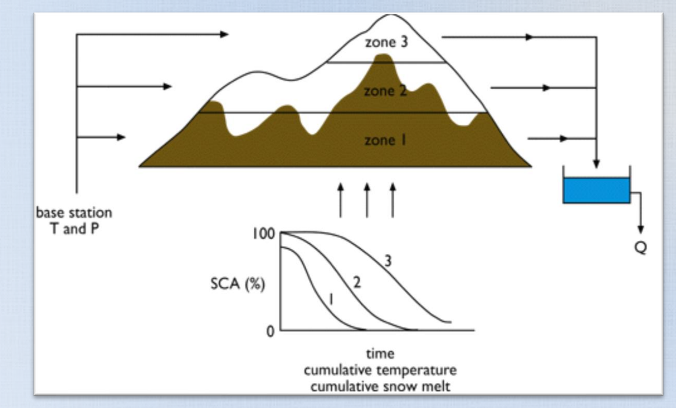

Figure 4. SRM model structure (Martinec, 2008)

Each day, the water produced from snowmelt and rainfall is computed (**Figure 4**), superimposed on the calculated recession flow and transformed into daily discharge from the basin according to the equation below.

$$Q_{n+1} = [c_{Sn} \cdot a_n (T_n + \Delta T_n) S_n + c_{Rn} P_n] \cdot (A \cdot 10000 / 86400) \cdot (1-k_{n+1}) + Q_n k_{n+1}$$

4- METHODOLOGY & RESULTS

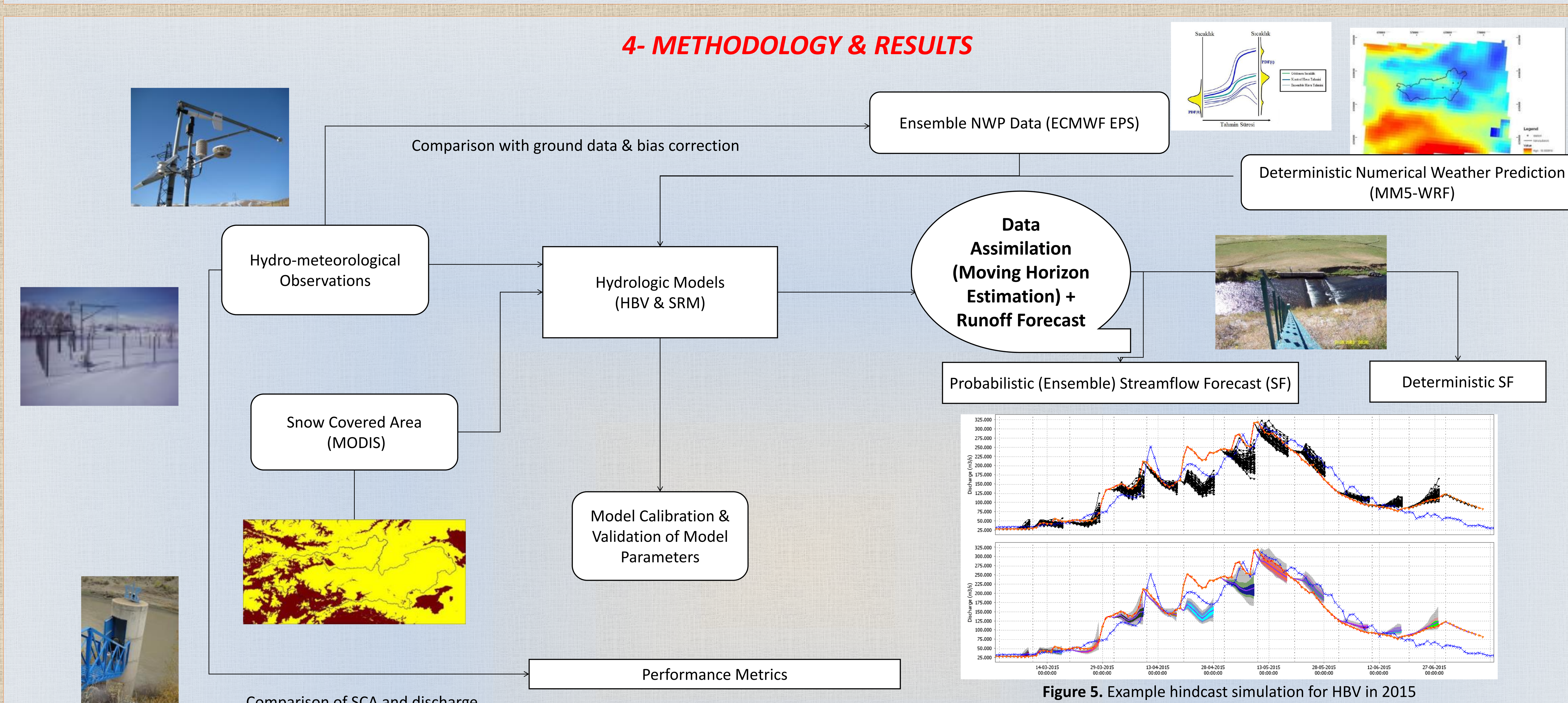

Figure 5. Example hindcast simulation for HBV in 2015 (red line and blue line indicates ensemble average and observed runoff)

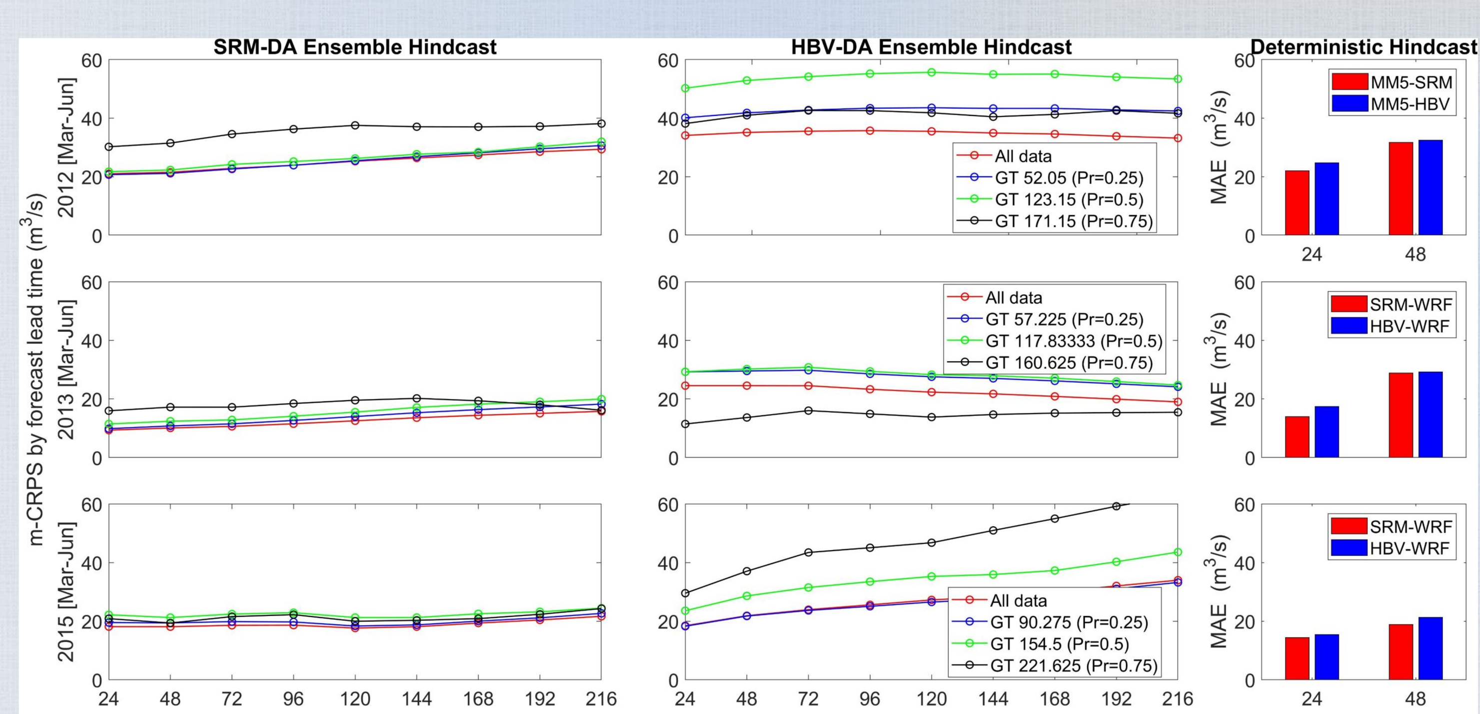

Figure 6. Mean Continuous Ranked Probability (CRPS) and Mean Absolute Error (MAE) by forecast lead time

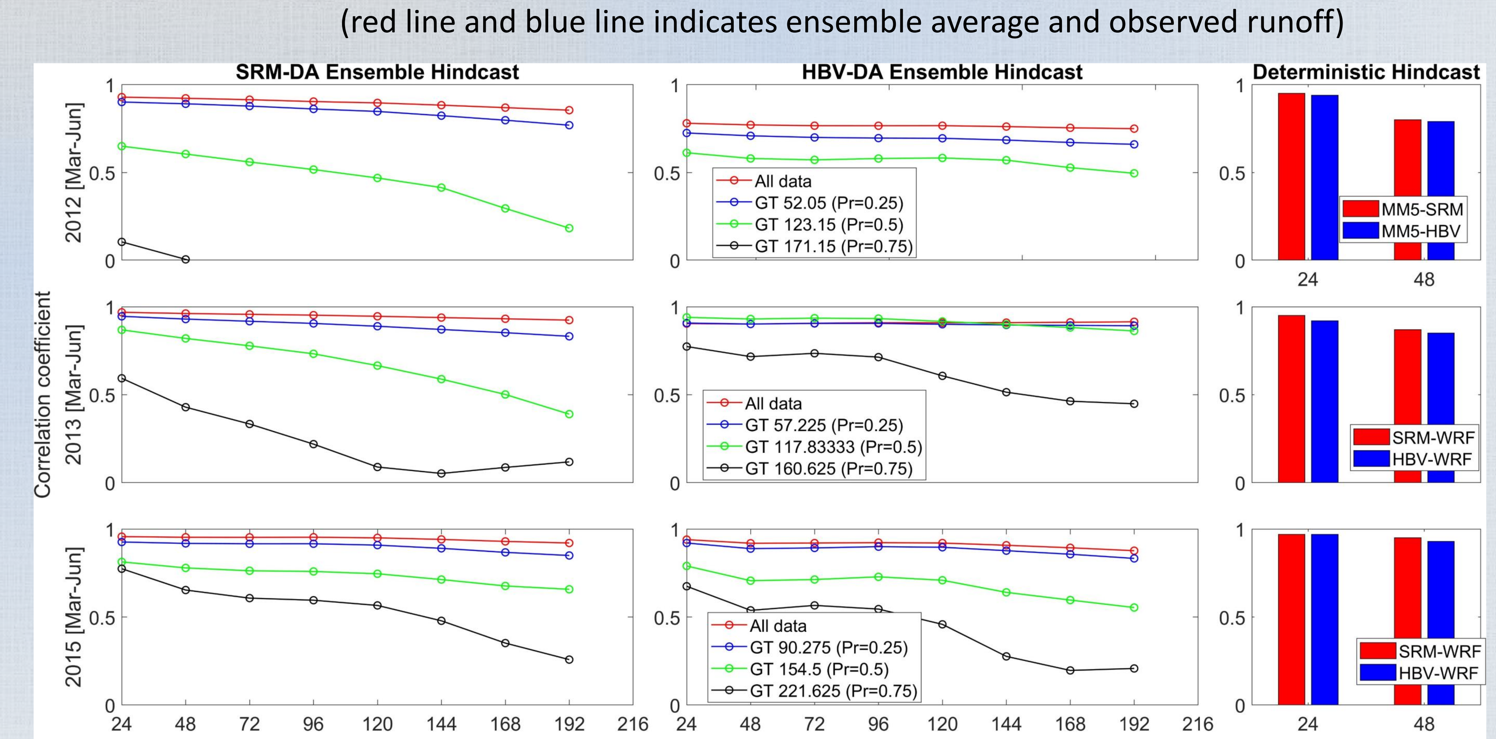

Figure 7. Correlation coefficients of the observations and ensemble average by forecast lead time

5- CONCLUSION

- ❑ Having a high snow potential especially on the eastern part, streamflow forecasting is a an important topic in Turkey for the operation of downstream reservoirs.
- ❑ Ensemble streamflow forecasts provide longer leadtime, and using multi-model with data assimilation techniques reduces uncertainty.
- ❑ Potential future use as operational platform (suitable to transfer knowhow to governmental agencies),
- ❑ Uysal et al. (**in preperation**) ‘’Comparison of Ensemble Forecast Skill for HBV and SRM Models over Snow Dominated Basins in Turkey’’.

References

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