WATER AUTHORITY

SWIM and Horizon 2020 Support Mechanism

Working for a Sustainable Mediterranean, Caring for our Future

Regional on-site training and study tour on “Drought Risk Management Mainstreaming” (REG-7 and ST-6)

Presented by:

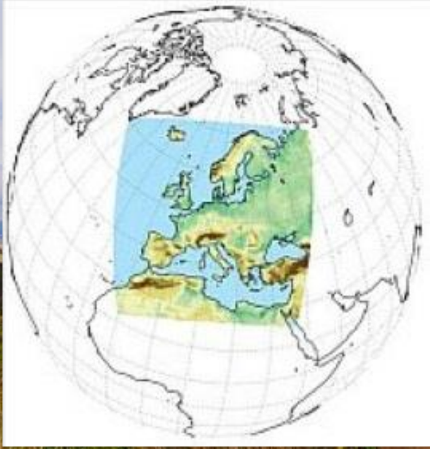
Dr. Amir Givati, Israeli Hydrological Service – Water Authority

24-27 September 2018, Murcia, Spain

This Project is funded by the European Union

WATER AUTHORITY

Operational early warning system for drought based on seasonal hydro-meteorological modeling in Israel



Background

- Israel climate conditions, as other countries in the southern part of the Mediterranean, is dominated by semi-arid to arid conditions. The precipitation regime is characterize by high annual and inter-annual variability.

- Water demand in the cpuntry is increasing and its higher then the natural sources can supply.

- Therefor the Israeli water sector is using an integrated water resources management methodology. The water supply to all sectors is based on various sources:
  - Natural water sources (Aquifers, surface water), mostly for agriculture, industry
  - Treated vast water (agriculture)
  - Sea water (Mediterranean) Desalinated water (Drinking water, municipals)

LDK
CONSULTANTS

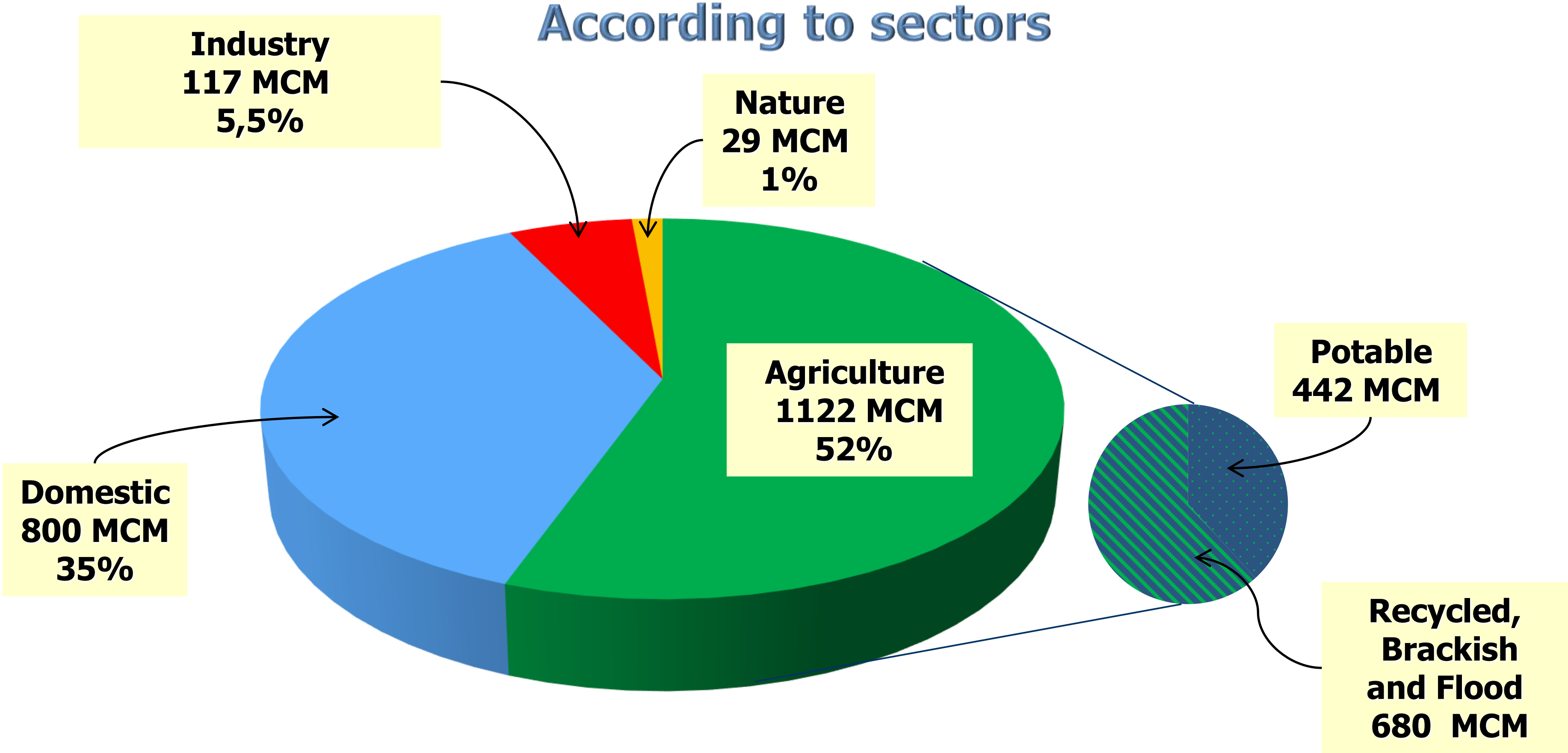
WATER RESOURCES ← → WATER DEMAND

- Average total natural enrichment – 1.3 billion m^3/annum
- Water demand – more than 2.2 billion m^3/annum
- Forecast for potable water demand:

2020 ~ 1.7 billion m^3/annum
2030 ~ 1.95 billion m^3/annum
2040 ~ 2.2 billion m^3/annum
2050 ~ 2.45 billion m^3/annum

Water Consumption in Israel

According to sectors



Total: 2200 MCM

Supply to PA – 61 MCM (West Bank) + 5 MCM (Gaza Strip)
Supply to Kingdom of Jordan – 54 MCM

Water demand
RESTRAINT

Water supply
INCREASE

- Governance & Regulation
- Integrated Water Resources Management
- Reuse of treated effluents
- Brackish water for agriculture and industry
- Seawater and brackish water desalination
- Development of the national and regional infrastructure

Background

- The Israeli Water Authority is allocating every year the water amount to all sectors from the different sources.
  Information regarding the currant and expected hydrological situation in the coming months is extremely important for decision making.

- The Israeli Hydrological Service (a unit in the Water Authority) is monitoring and analyzing the hydrological information (underground, springs, streamflow reservoirs and lakes) and operate tools in order to simulate the future water amounts in respect to climate projections.

Methodology

1. Using an ensemble of global seasonal climate models (precipitation, temperature): NMME (7 north American climate models), ECMWF, Meteo-France, UKMet, CMCC.

2. Extracting the global models data for a chosen domain (selected country/region)

3. Calculate precipitation anomalies: The model forecasts vs. it climatology

4. Statistical downscaling from the global models to reginal scale using local observations

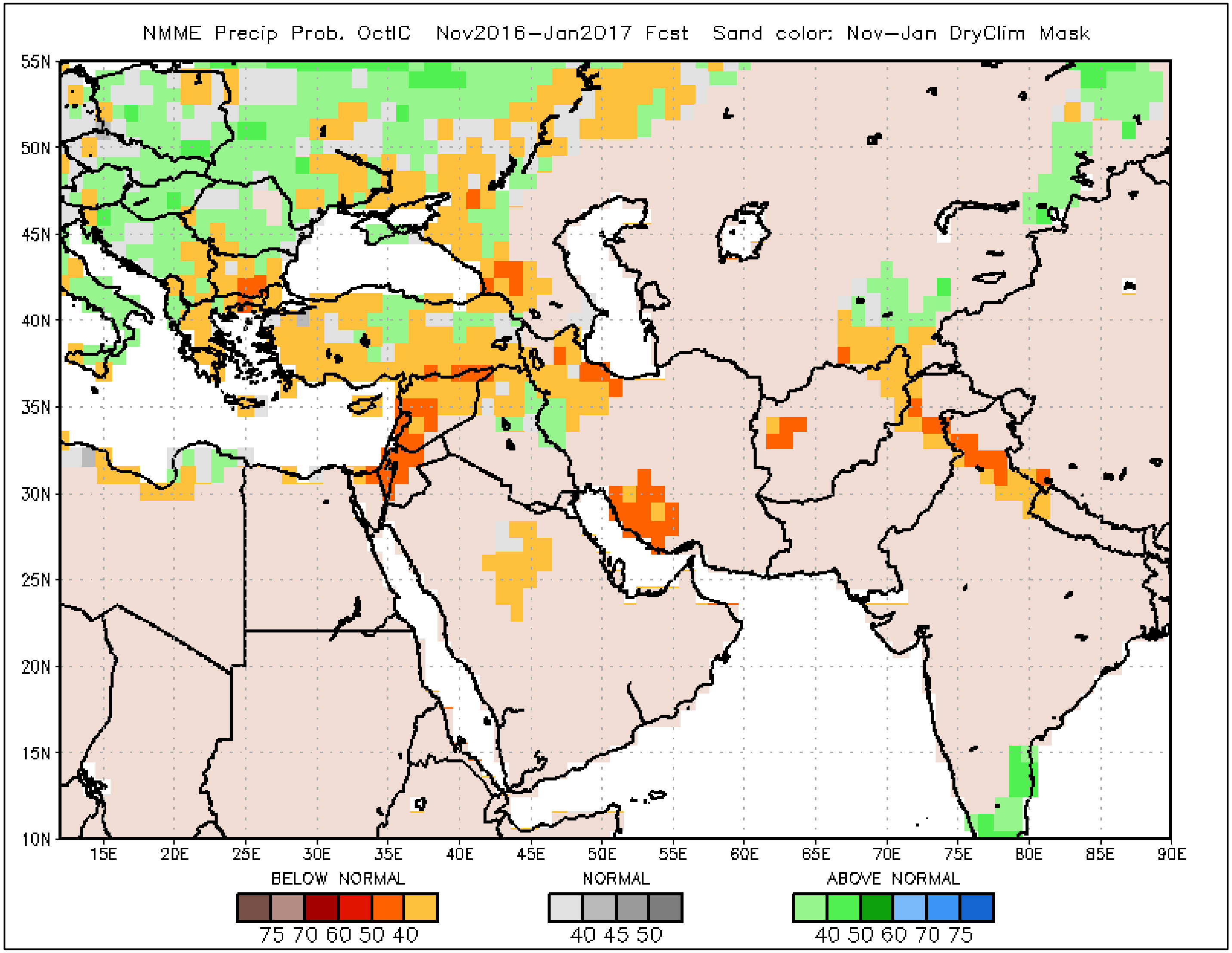
5. Translating climate data into water:
   Running Hydrological model (calibration period, validation, warmup and forecast mode) based on observation and the forecast from the climate models.

Methodology: Model verfications

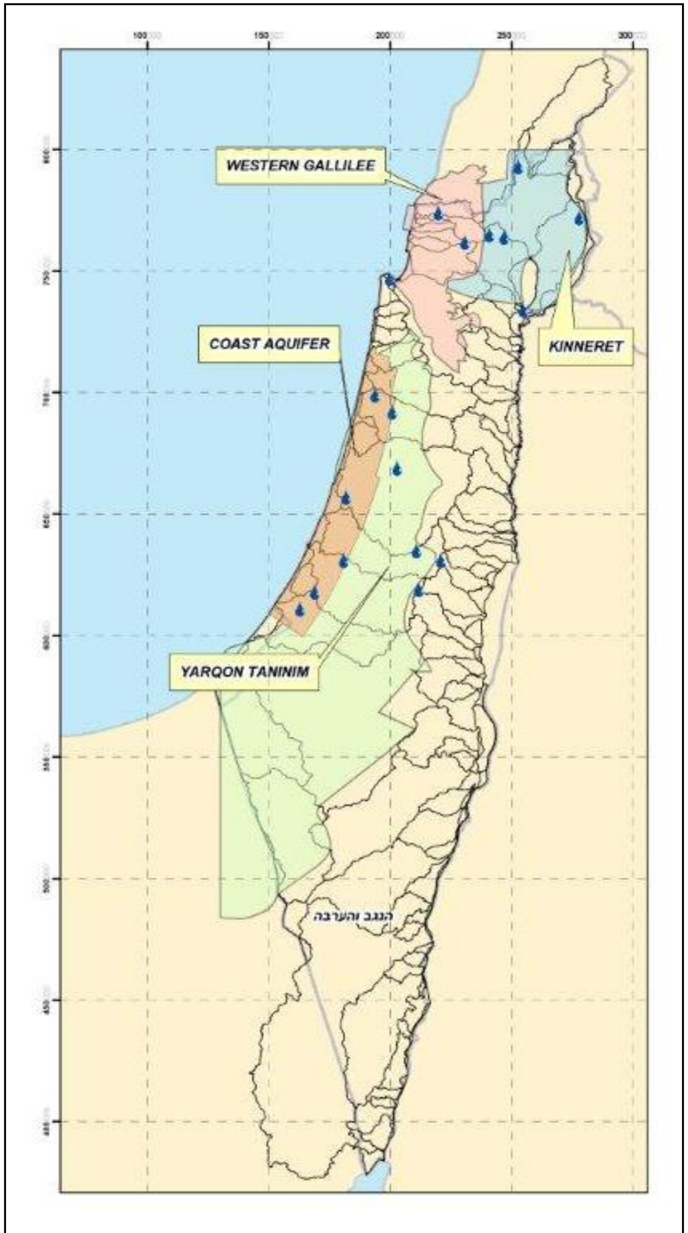
- The models performance were validated using Person Correlation (R), Root of Mean Square error (RMSE) the Nash-Sutcliffe Efficiency (NSE) and KGE.

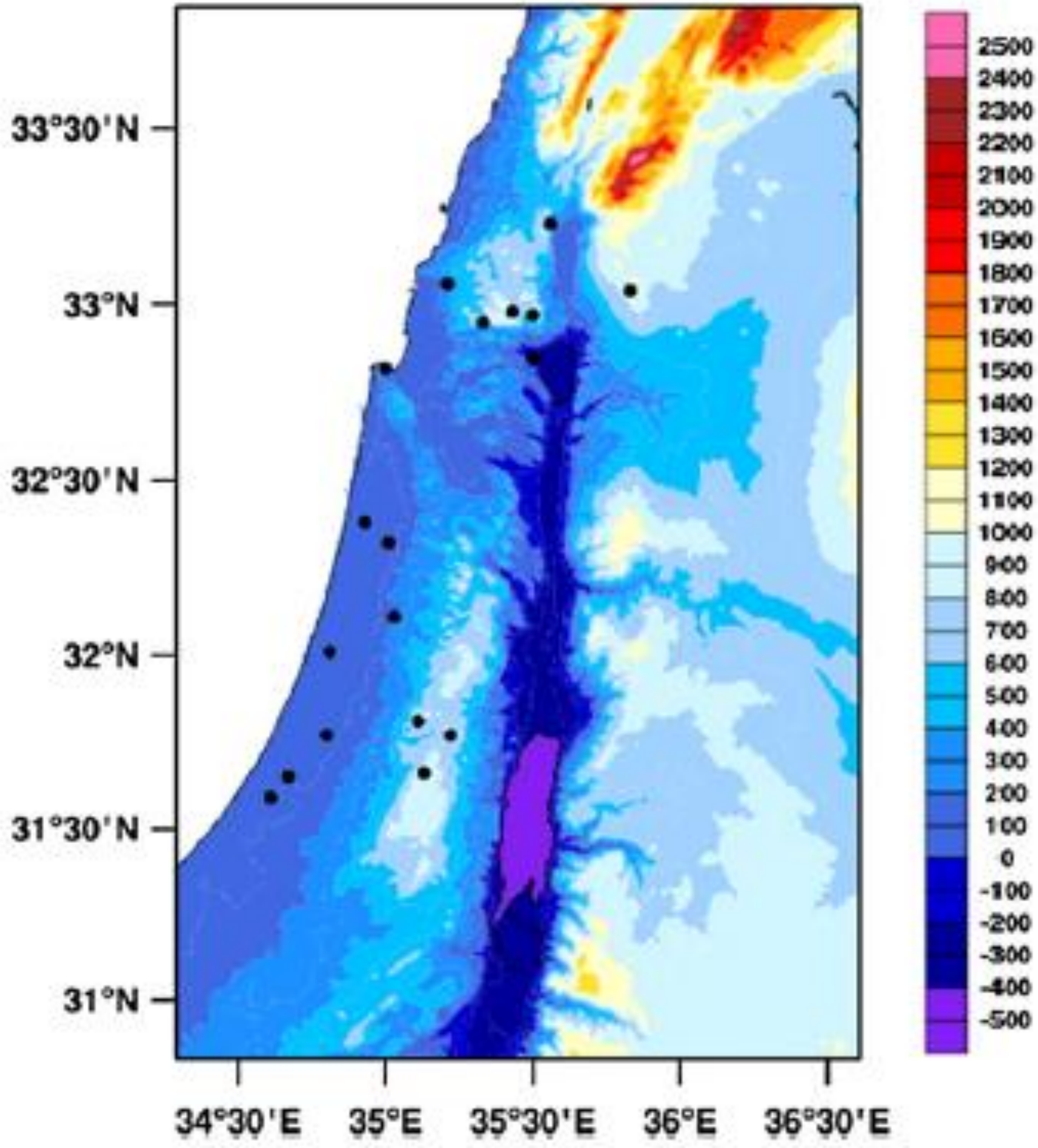
- Additionally, we tested each model and the multi IMME model scores against the climatology in order to quantify their added value over the naïve climatology prediction.

Moving from global to regional scale

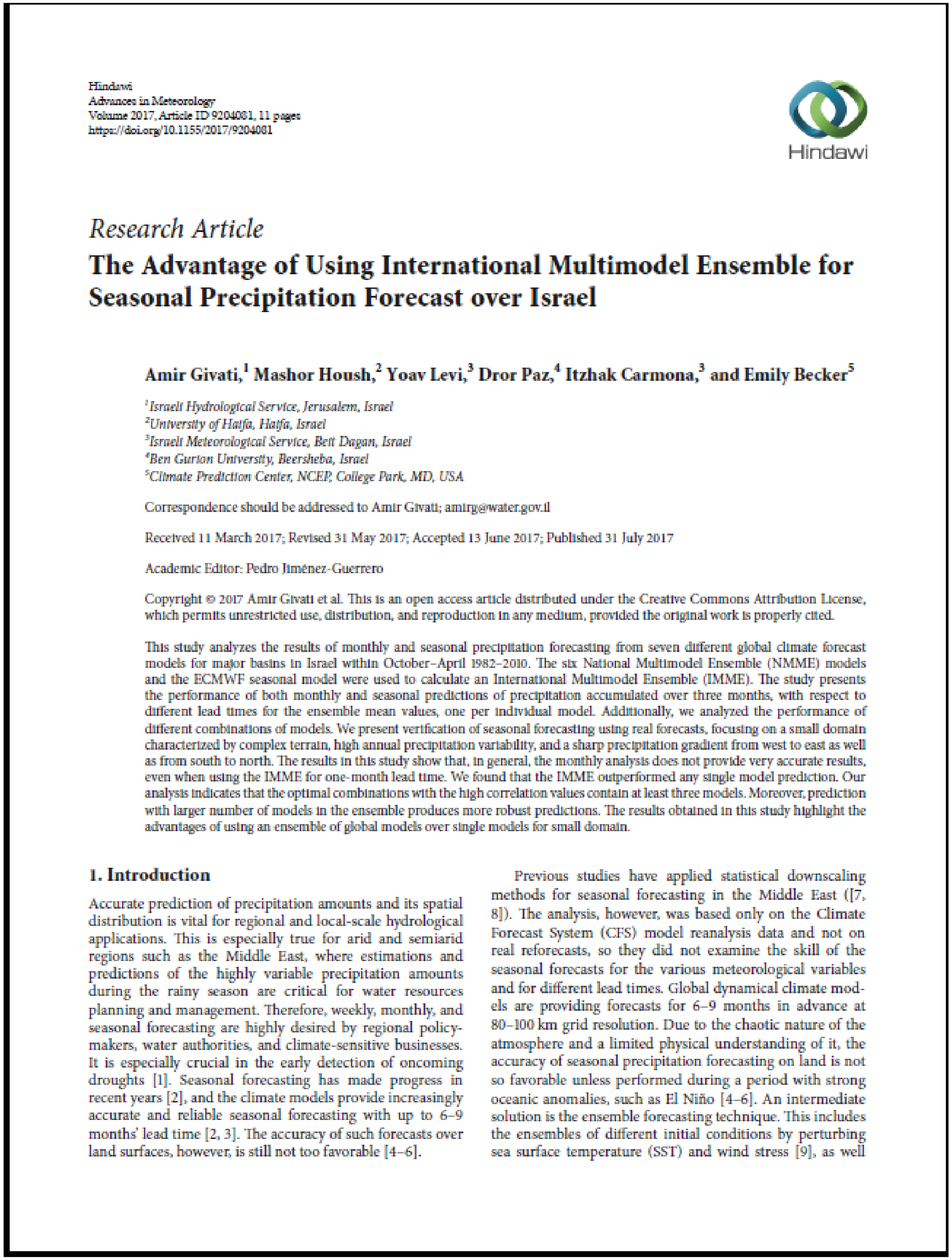


Statistical downscaling :
Selecting rain gauges at the major Aquifers in Israel for statistical downscaling:





All the details regarding the climate models scores can be view in Givati et . al 2017



Hindawi
Advances in Meteorology
Volume 2017, Article ID 9204081, 11 pages
https://doi.org/10.1155/2017/9204081

Research Article

The Advantage of Using International Multimodel Ensemble for Seasonal Precipitation Forecast over Israel

Amir Givati,[1] Mashor Housh,[2] Yoav Levi,[3] Dror Paz,[4] Itzhak Carmona,[3] and Emily Becker[5]

[1] *Israeli Hydrological Service, Jerusalem, Israel*
[2] *University of Haifa, Haifa, Israel*
[3] *Israeli Meteorological Service, Beit Dagan, Israel*
[4] *Ben Gurion University, Beersheba, Israel*
[5] *Climate Prediction Center, NCEP, College Park, MD, USA*

Correspondence should be addressed to Amir Givati; amirg@water.gov.il

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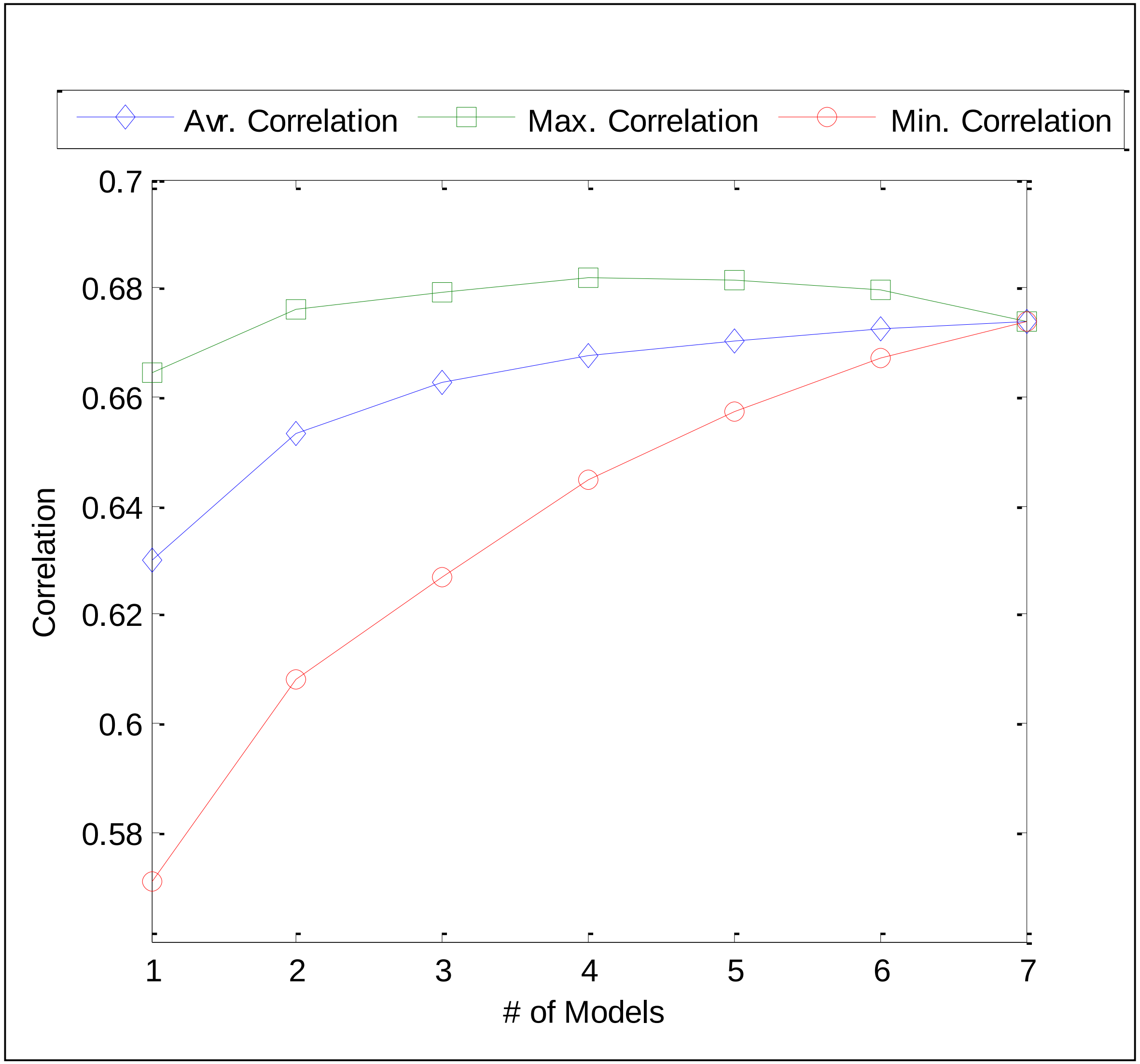
This study analyzes the results of monthly and seasonal precipitation forecasting from seven different global climate forecast models for major basins in Israel within October–April 1982–2010. The six National Multimodel Ensemble (NMME) models and the ECMWF seasonal model were used to calculate an International Multimodel Ensemble (IMME). The study presents the performance of both monthly and seasonal predictions of precipitation accumulated over three months, with respect to different lead times for the ensemble mean values, one per individual model. Additionally, we analyzed the performance of different combinations of models. We present verification of seasonal forecasting using real forecasts, focusing on a small domain characterized by complex terrain, high annual precipitation variability, and a sharp precipitation gradient from west to east as well as from south to north. The results in this study show that, in general, the monthly analysis does not provide very accurate results, even when using the IMME for one-month lead time. We found that the IMME outperformed any single model prediction. Our analysis indicates that the optimal combinations with the high correlation values contain at least three models. Moreover, prediction with larger number of models in the ensemble produces more robust predictions. The results obtained in this study highlight the advantages of using an ensemble of global models over single models for small domain.

1. Introduction

Accurate prediction of precipitation amounts and its spatial distribution is vital for regional and local-scale hydrological applications. This is especially true for arid and semiarid regions such as the Middle East, where estimations and predictions of the highly variable precipitation amounts during the rainy season are critical for water resources planning and management. Therefore, weekly, monthly, and seasonal forecasting are highly desired by regional policy-makers, water authorities, and climate-sensitive businesses. It is especially crucial in the early detection of oncoming droughts [1]. Seasonal forecasting has made progress in recent years [2], and the climate models provide increasingly accurate and reliable seasonal forecasting with up to 6–9 months' lead time [2, 3]. The accuracy of such forecasts over land surfaces, however, is still not too favorable [4–6].

Previous studies have applied statistical downscaling methods for seasonal forecasting in the Middle East ([7, 8]). The analysis, however, was based only on the Climate Forecast System (CFS) model reanalysis data and not on real reforecasts, so they did not examine the skill of the seasonal forecasts for the various meteorological variables and for different lead times. Global dynamical climate models are providing forecasts for 6–9 months in advance at 80–100 km grid resolution. Due to the chaotic nature of the atmosphere and a limited physical understanding of it, the accuracy of seasonal precipitation forecasting on land is not so favorable unless performed during a period with strong oceanic anomalies, such as El Niño [4–6]. An intermediate solution is the ensemble forecasting technique. This includes the ensembles of different initial conditions by perturbing sea surface temperature (SST) and wind stress [9], as well

Combination analysis for average, maximum and minimum correlation for 1 month lead time precipitation between the models and the reforecast, as a function of the number of models in the ensemble in the northern part of the domain

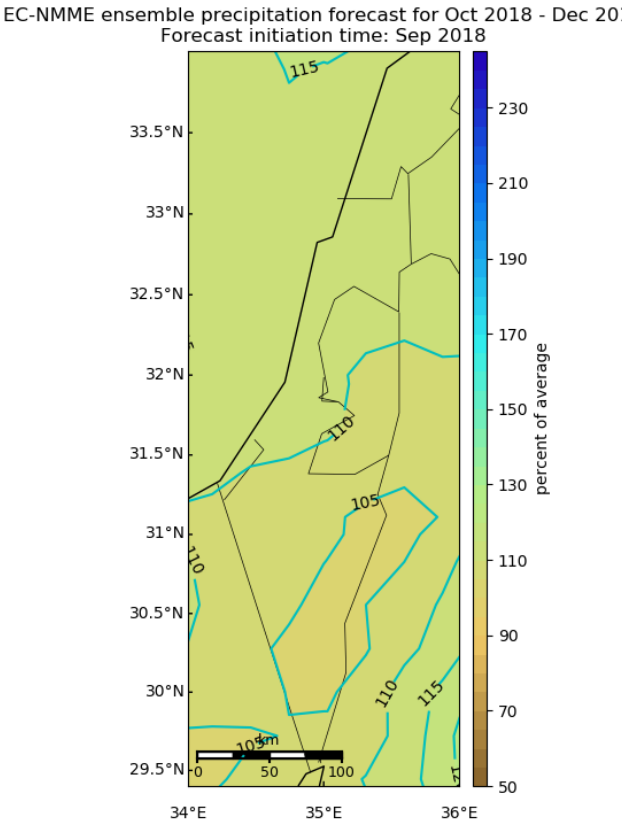


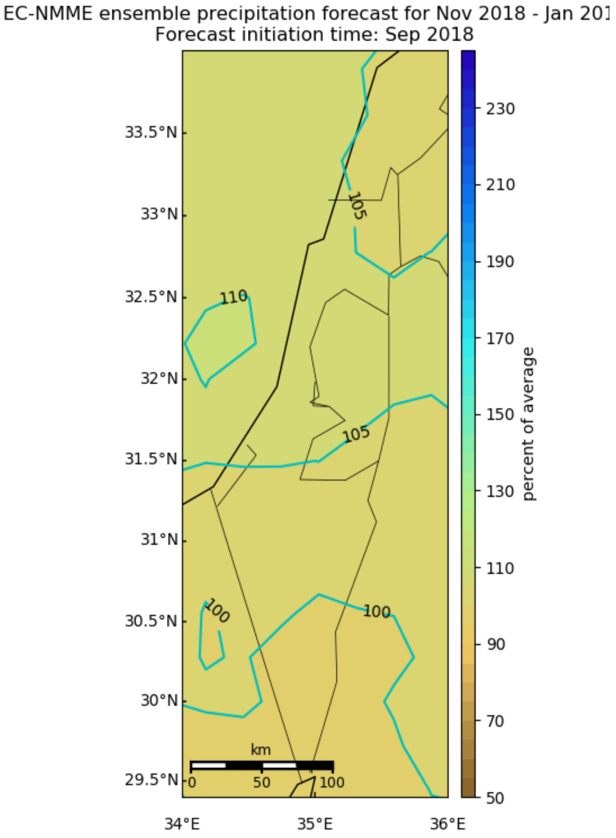
Precipitation forecast for the rainy season 2018/19: Ins. Conditions: Sep. 2018

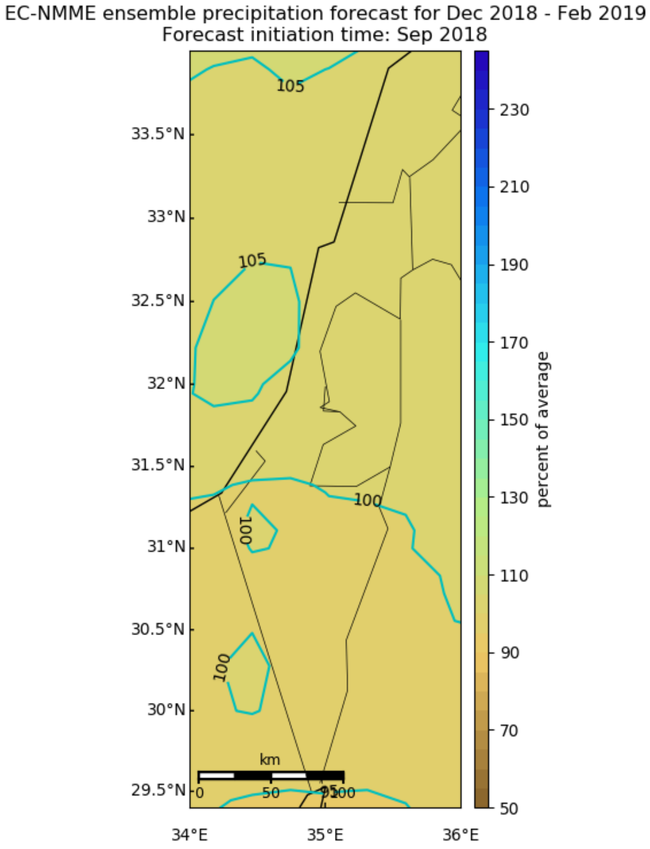
Accumulate perception: OND

Accumulate perception: NDJ

Accumulate perception: DJF

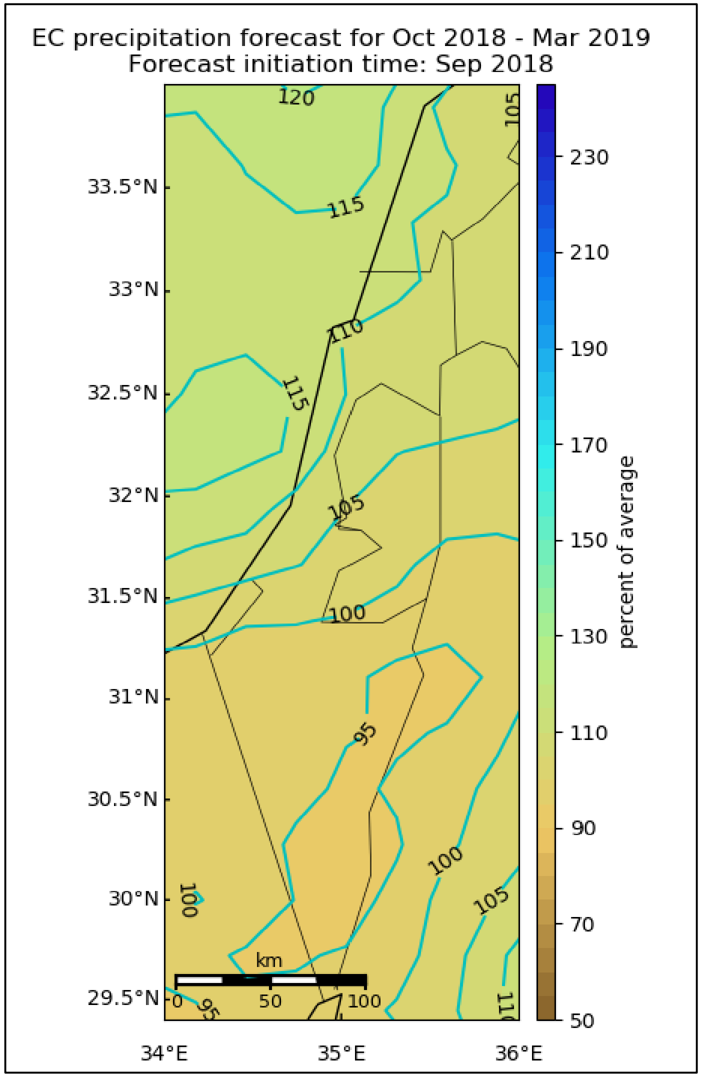

EC-NMME ensemble precipitation forecast for Oct 2018 - Dec 20
Forecast initiation time: Sep 2018


EC-NMME ensemble precipitation forecast for Nov 2018 - Jan 201
Forecast initiation time: Sep 2018

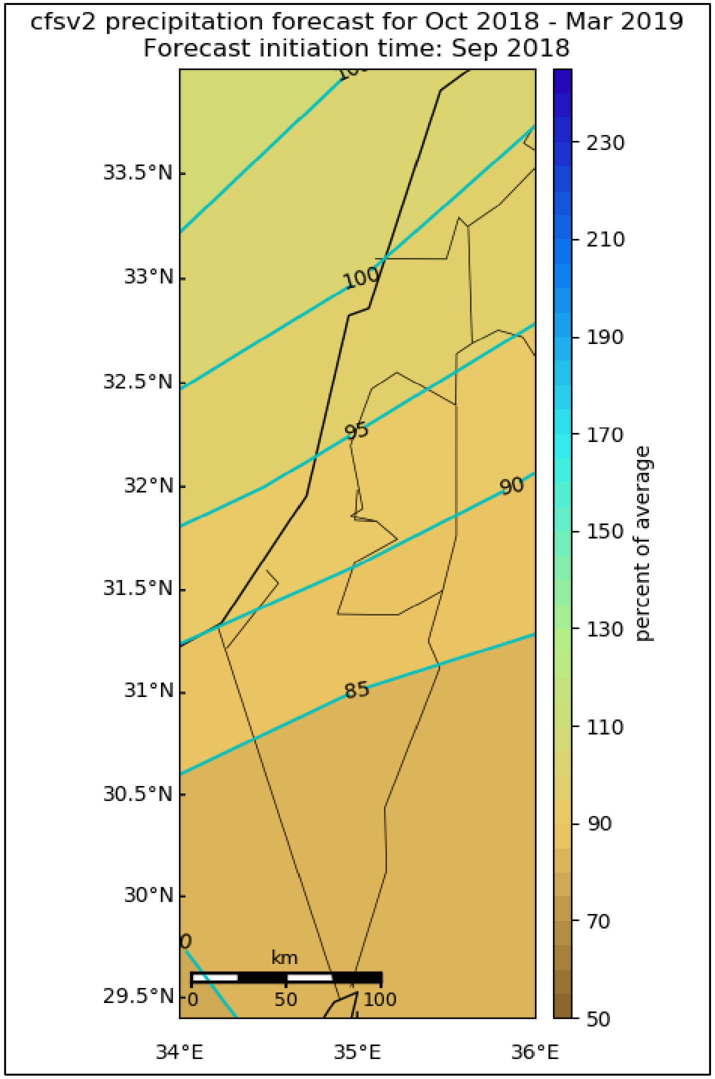

EC-NMME ensemble precipitation forecast for Dec 2018 - Feb 2019
Forecast initiation time: Sep 2018

Precipitation forecast for the rainy season 2018/19:
Oct-Mars
Ins. Conditions: Sep. 2018

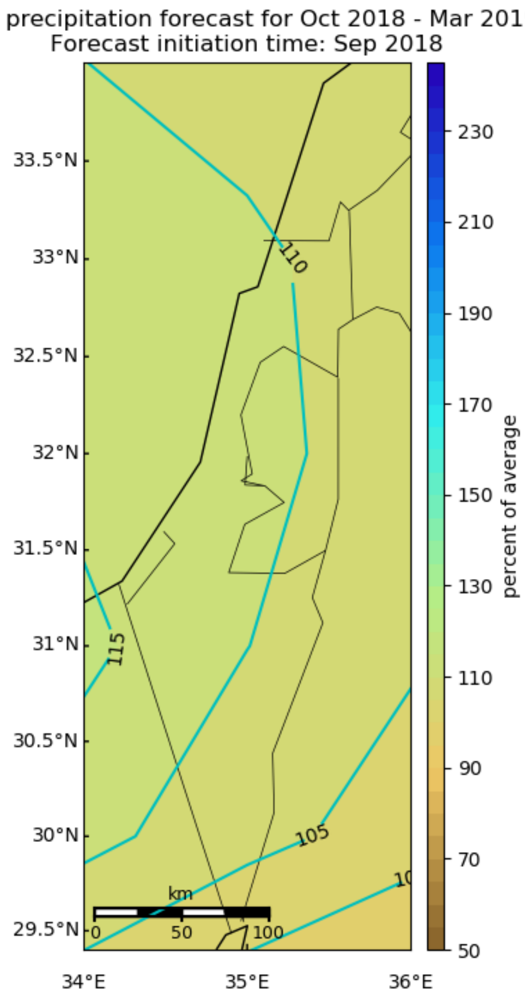
(European center) ECMWF



(U.S) CFS

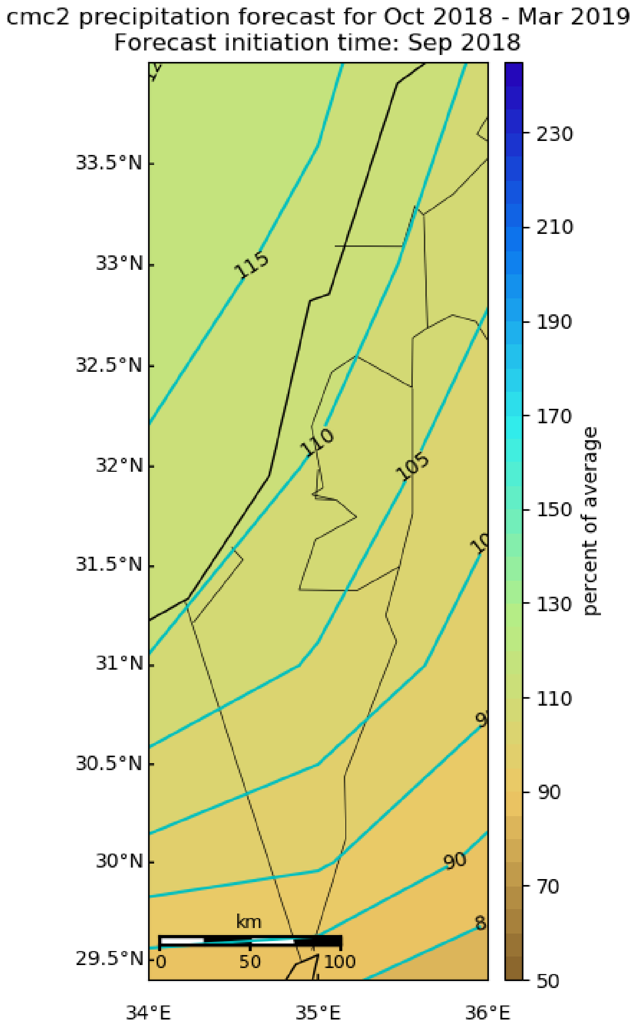


GFDL



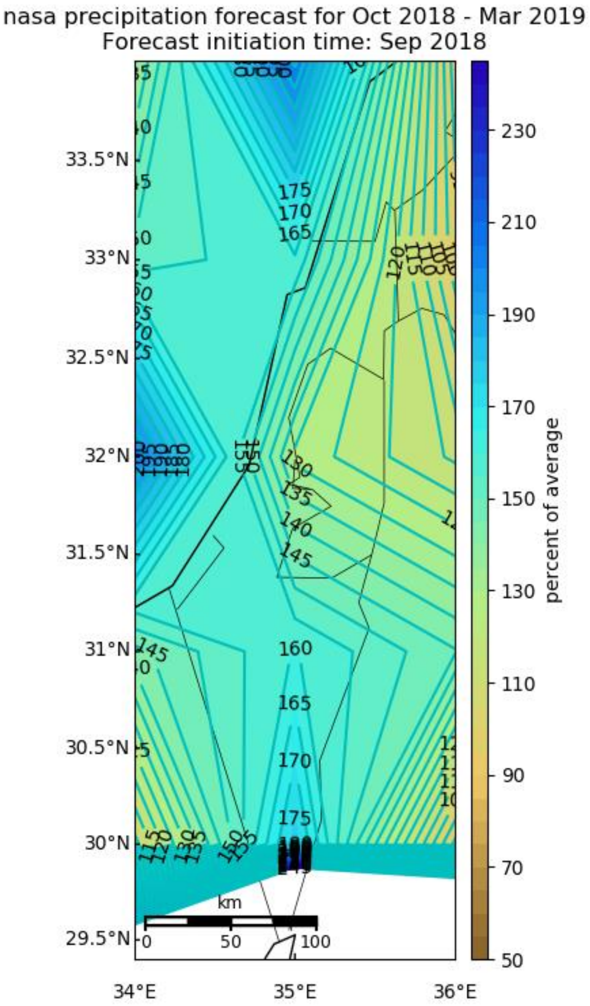
precipitation forecast for Oct 2018 - Mar 2019
Forecast initiation time: Sep 2018

CMC



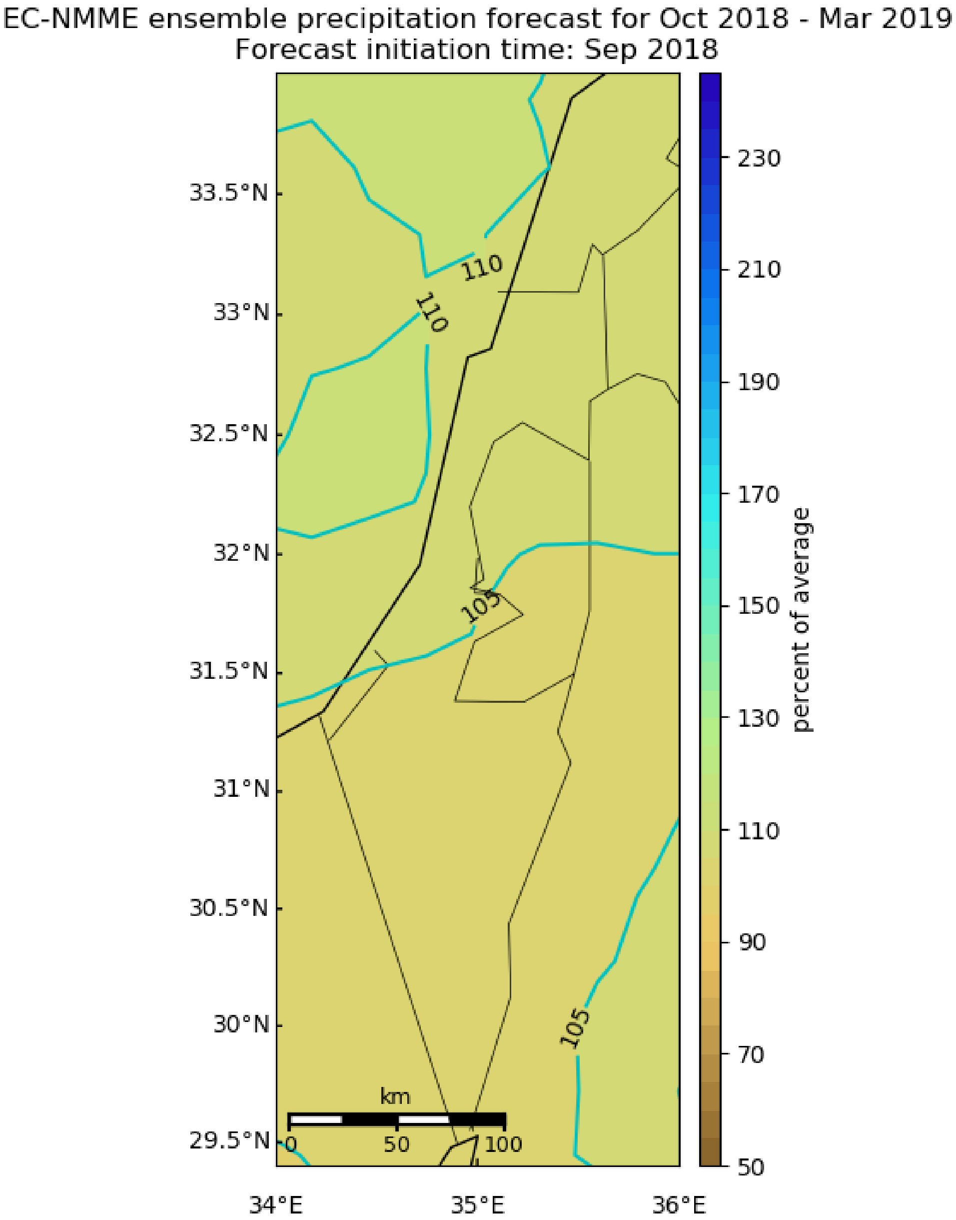
cmc2 precipitation forecast for Oct 2018 - Mar 2019
Forecast initiation time: Sep 2018

NASA



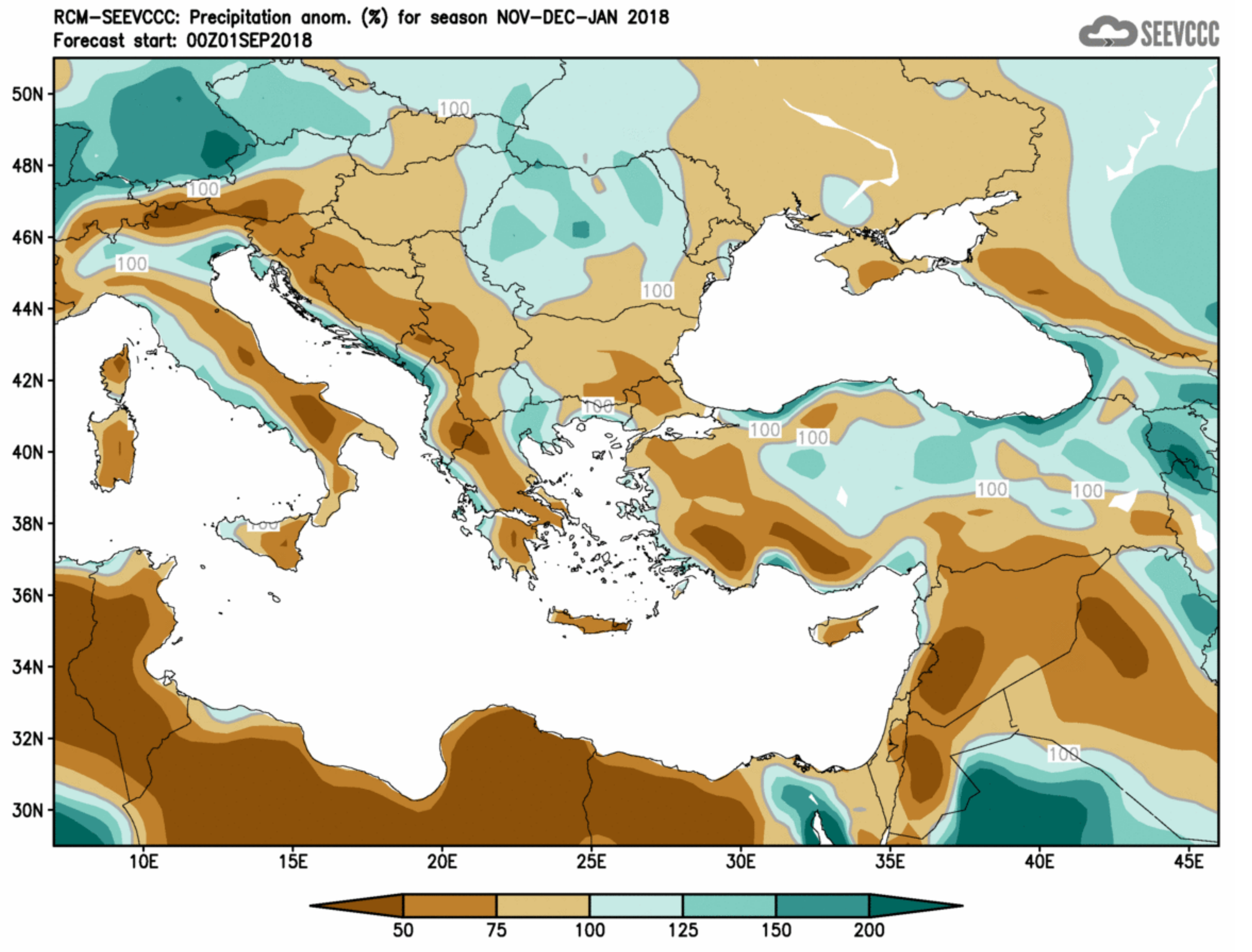
nasa precipitation forecast for Oct 2018 - Mar 2019
Forecast initiation time: Sep 2018

Ensemble of precipitation forecast for the rainy season 2018/19: Oct-Mars
Ins. Conditions: Sep. 2018

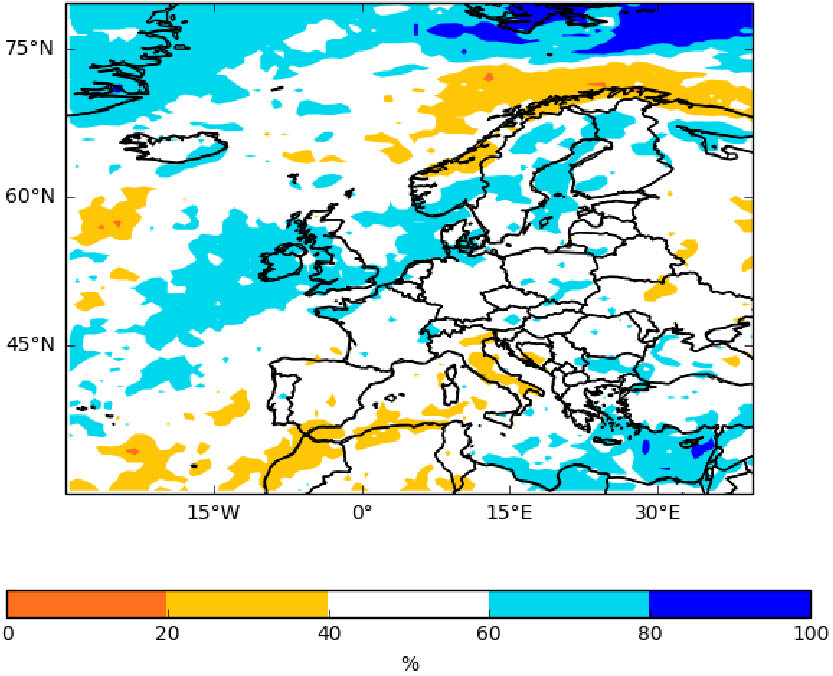


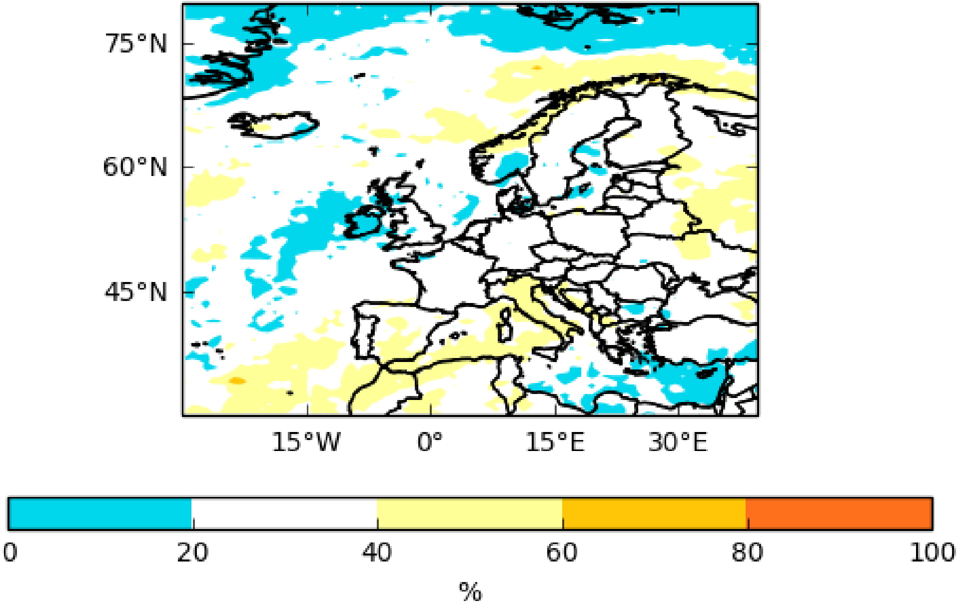
Precipitation forecast for the rainy season 2018/19:
Nov-Jan
Ins. Conditions: Sep. 2018

South East European Climate Change Center : The highest resolution seasonal forecast available



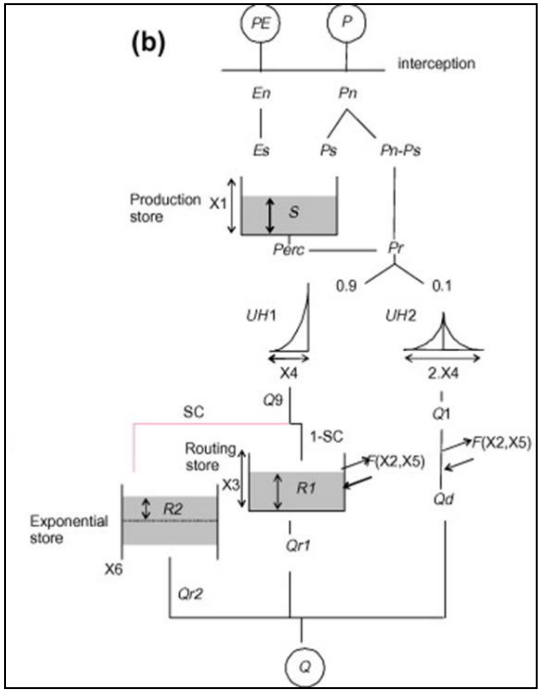
UKMet：
Probability for above/below normal precipitation

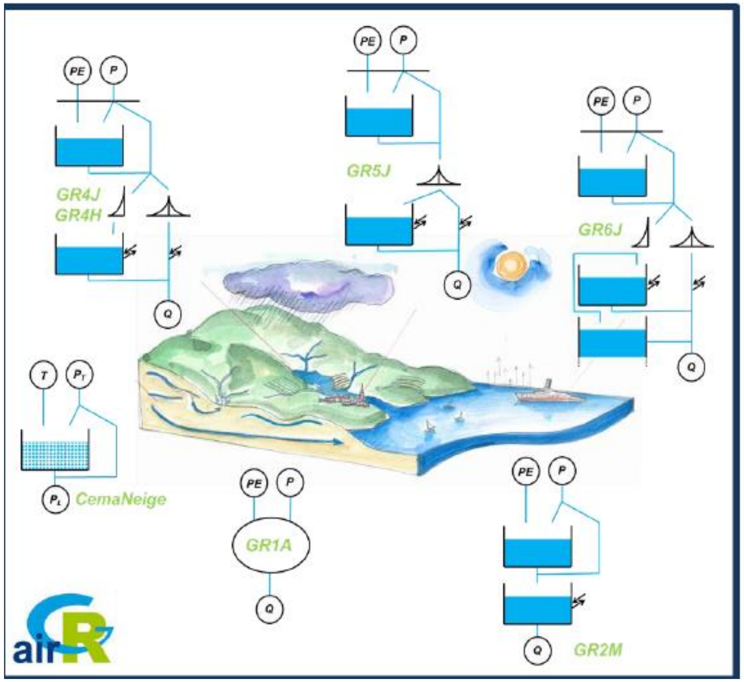

Probability of above median precipitation Nov/Dec/Jan
Issued September 2018


below normal precipitation

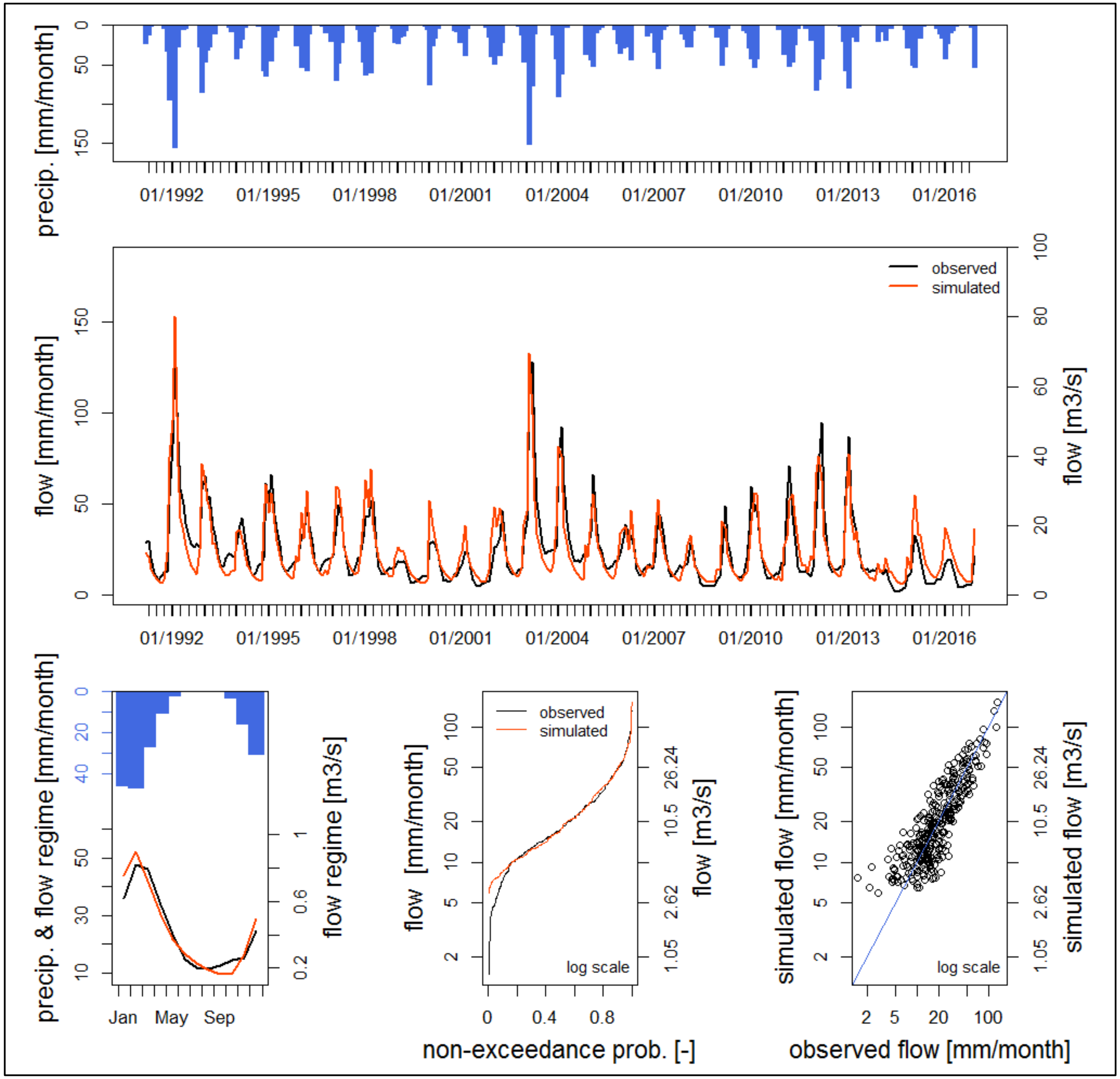
Moving from climate to Hydrological seasonal forecasting using the AirGR models

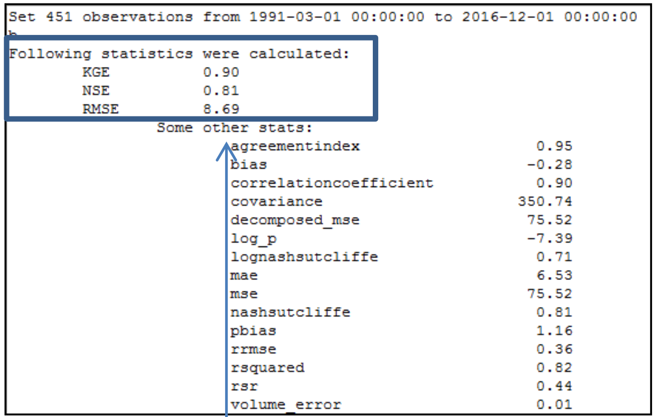
The GR (GR4,5,6J) is daily/monthly/annual hydrological models developed at "Irstea'-France. The model is a conceptual representations of the rainfall-runoff relationship at the basin scale. The model is basically made of two major components:





Calibration the Hydrological model with observed meteorological data





```
Set 451 observations from 1991-03-01 00:00:00 to 2016-12-01 00:00:00
h
Following statistics were calculated:
        KGE             0.90
        NSE             0.81
        RMSE            8.69
                Some other stats:
                        agreementindex                    0.95
                        bias                             -0.28
                        correlationcoefficient            0.90
                        covariance                      350.74
                        decomposed_mse                   75.52
                        log_p                            -7.39
                        lognashsutcliffe                  0.71
                        mae                               6.53
                        mse                              75.52
                        nashsutcliffe                     0.81
                        pbias                             1.16
                        rrmse                             0.36
                        rsquared                          0.82
                        rsr                               0.44
                        volume_error                      0.01
```

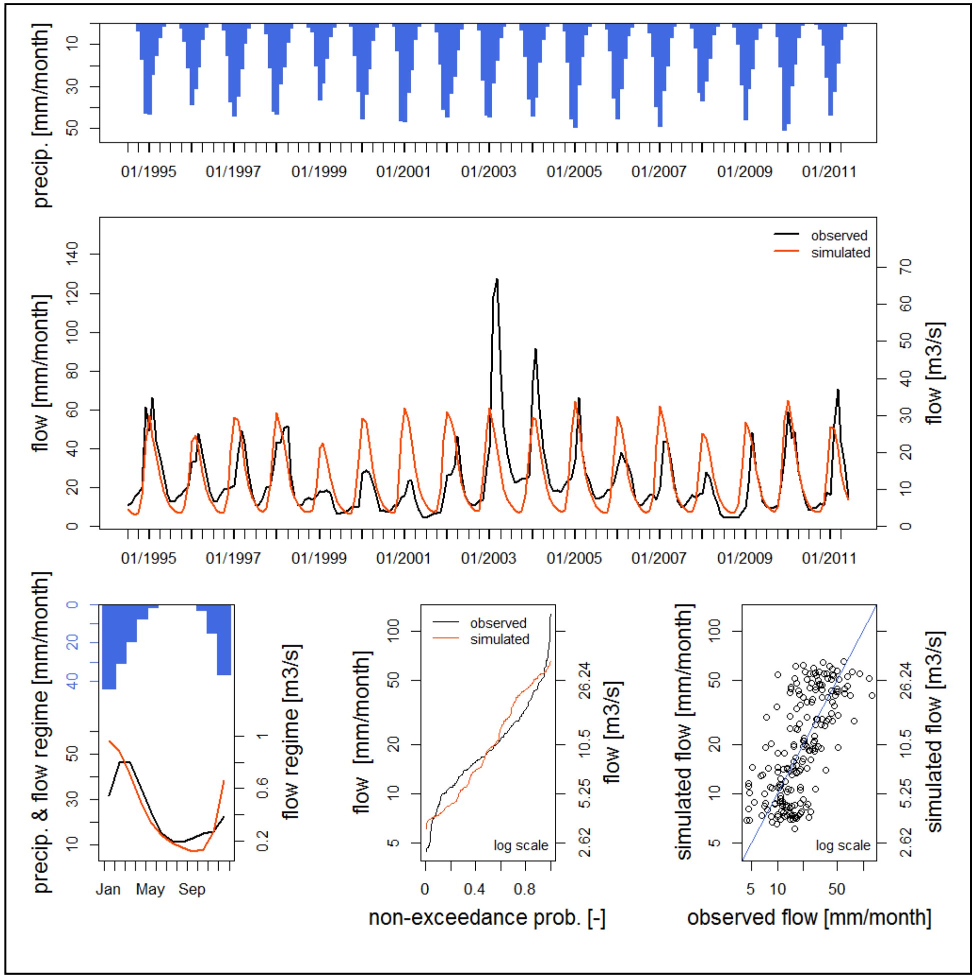
A very good agreement between the observed and the simulated flow

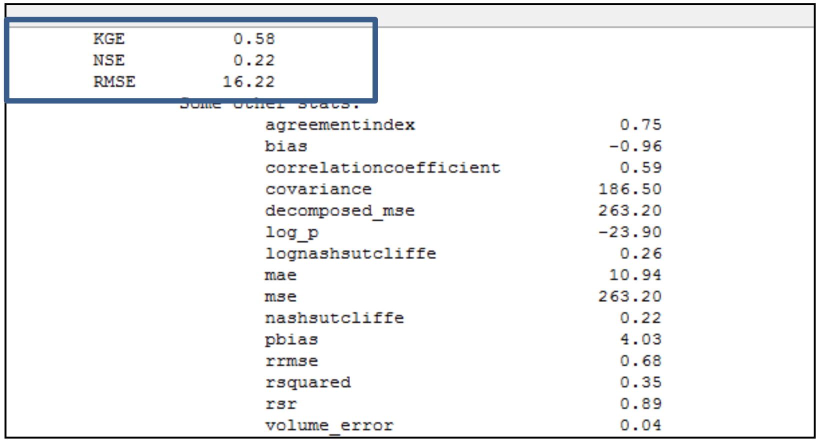
$$KGE' = 1 - \sqrt{(r-1)^2 + (\beta-1)^2 + (\gamma-1)^2}$$

With r *the correlation coefficient*, $\beta = \frac{\mu_{sim}}{\mu_{obs}}$

and $\gamma = \frac{CV_{sim}}{CV_{obs}} = \frac{\sigma_{sim}/\mu_{sim}}{\sigma_{obs}/\mu_{obs}}$

Running the Hydrological model with re-forecast meteorological data



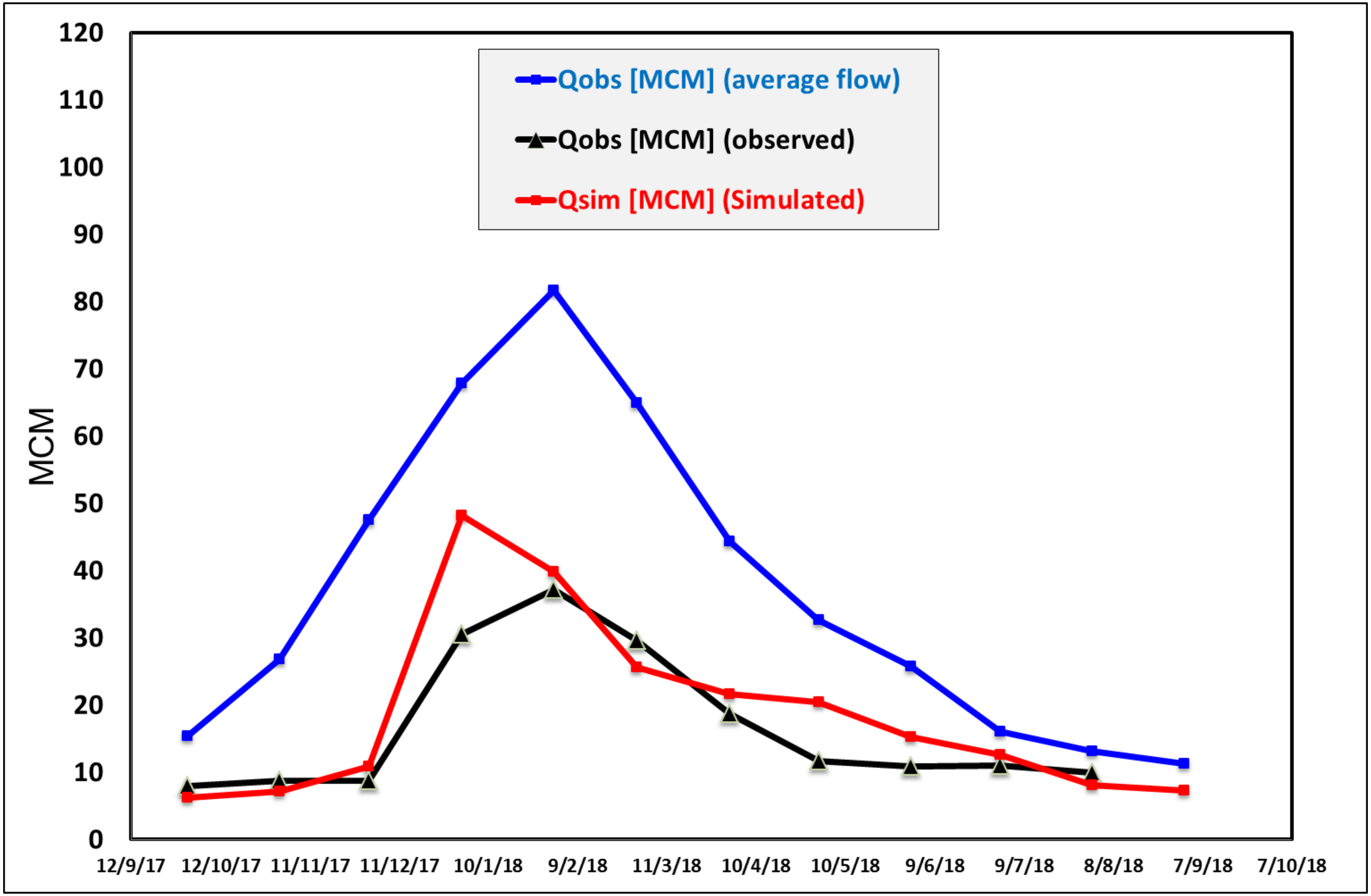


```
        KGE             0.58
        NSE             0.22
        RMSE           16.22
                Some other stats:
                        agreementindex                   0.75
                        bias                            -0.96
                        correlationcoefficient           0.59
                        covariance                     186.50
                        decomposed_mse                 263.20
                        log_p                          -23.90
                        lognashsutcliffe                 0.26
                        mae                             10.94
                        mse                            263.20
                        nashsutcliffe                    0.22
                        pbias                            4.03
                        rrmse                            0.68
                        rsquared                         0.35
                        rsr                              0.89
                        volume_error                     0.04
```

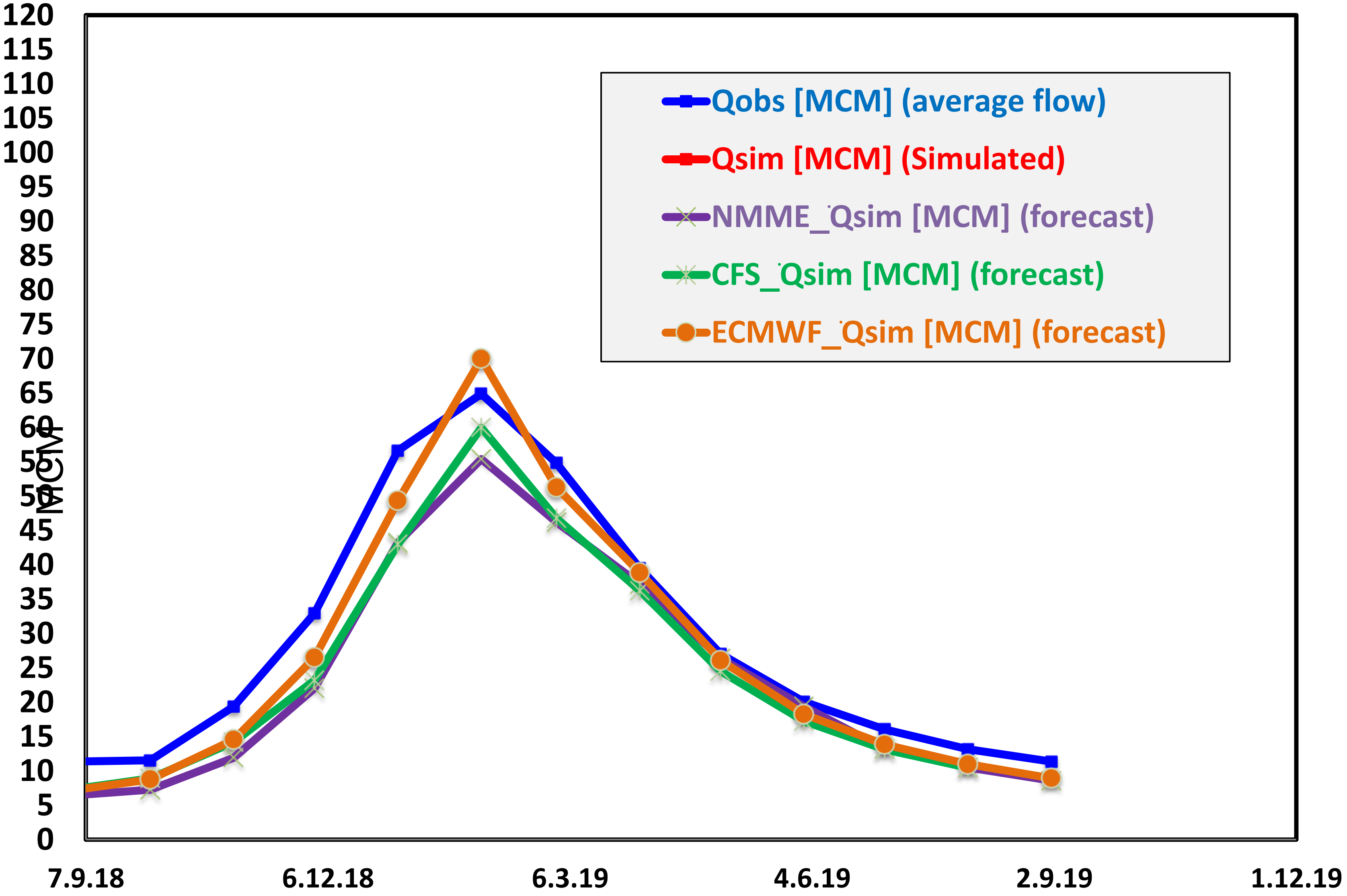
It can be seen that the hydrological forecast having added value. The KGE test for the observed and the simulated flow is 0.58.

Validation for the hydrological year 2017/18:
Feeding the Hydrological model with ensemble of seasonal climate models

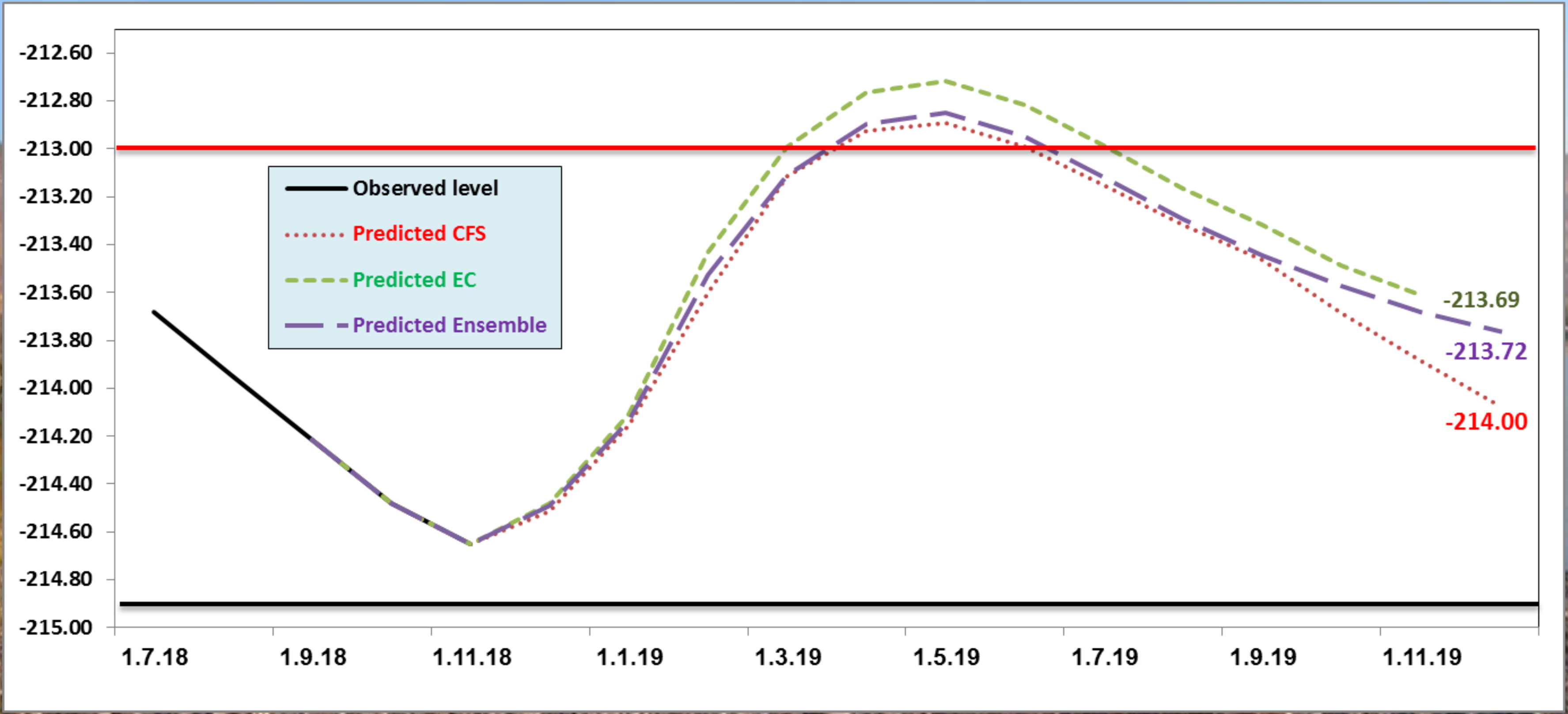
Observed vs. simulated monthly flow volumes at the Jordan River in respect to average flow



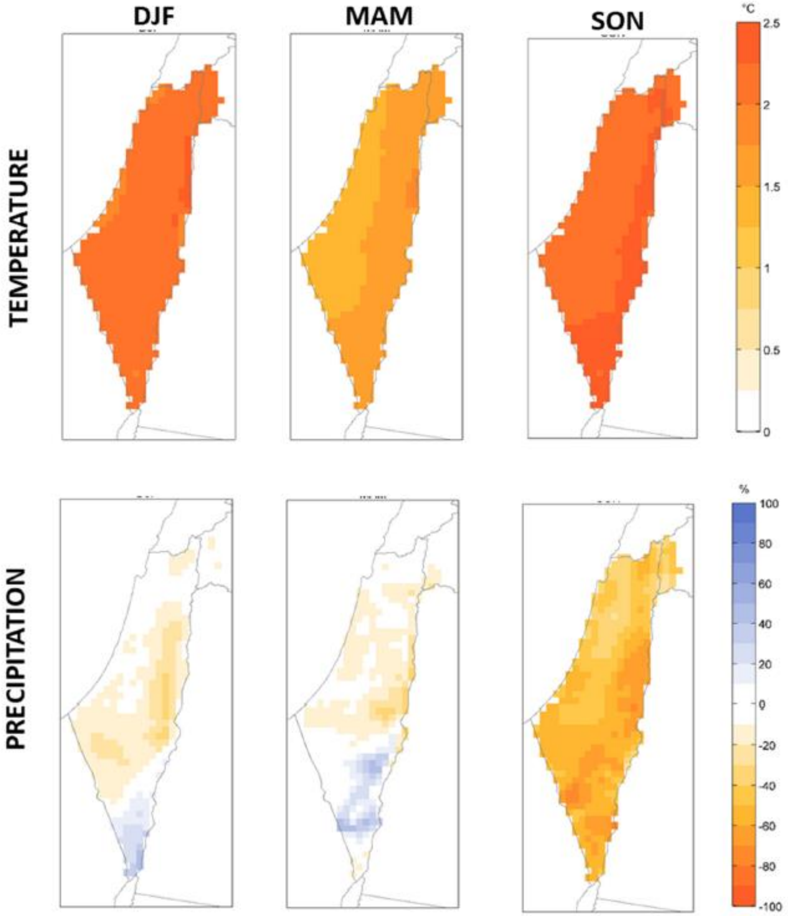
Forecast for 2018/19 hydrological year using ensemble of seasonal climate models

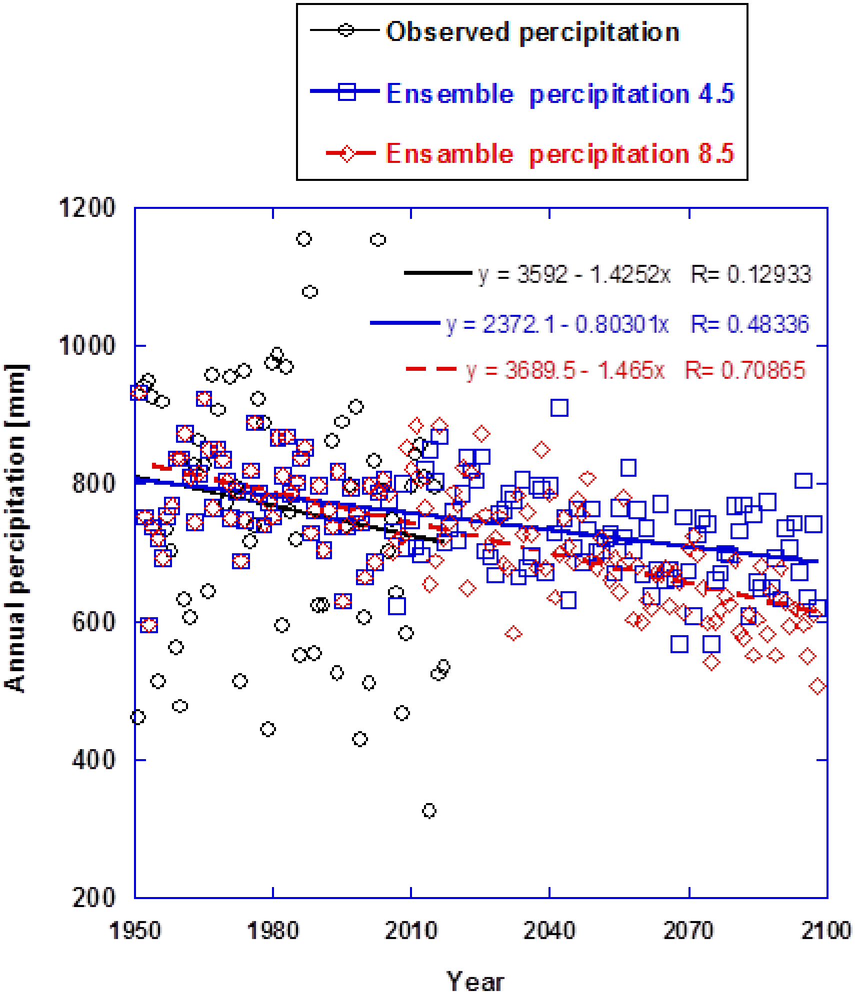


Lake of Galilee level: Forecast for 2018/19 hydrological year using the different seasonal climate models



The methodology of using ensemble of climate models for hydrological prediction was applied by the Israeli Hydrological Service also for long term simulations

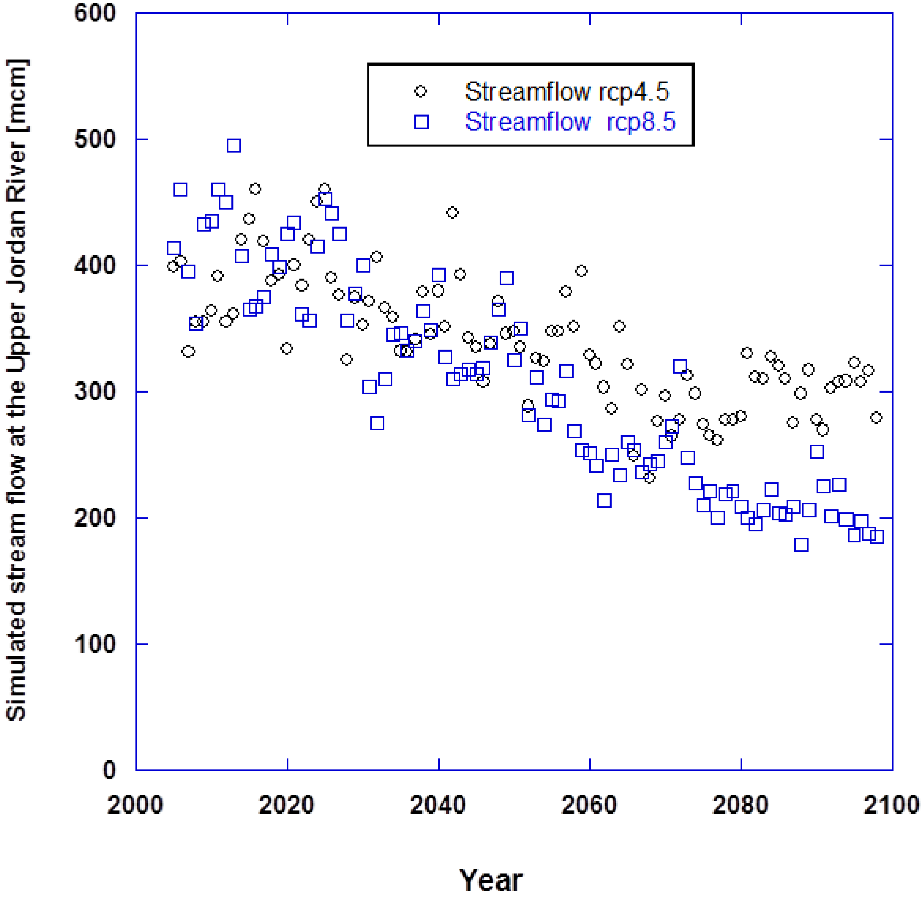




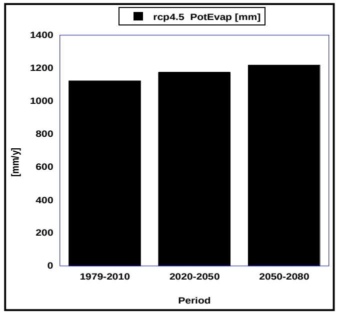
Hochman et al , 2018

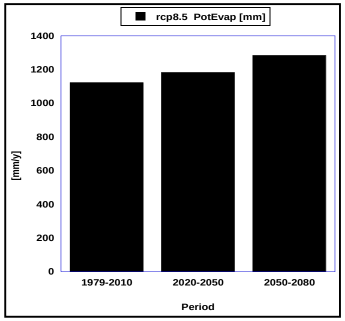
Givati et al. 2018

Effects of climate change on the Hydrological cycle at the upper Jordan River basin using different climate scenarios

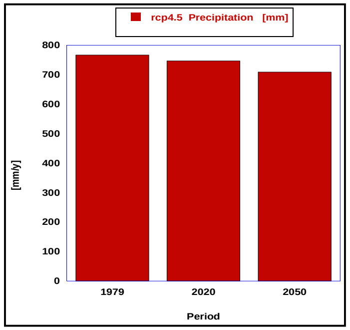


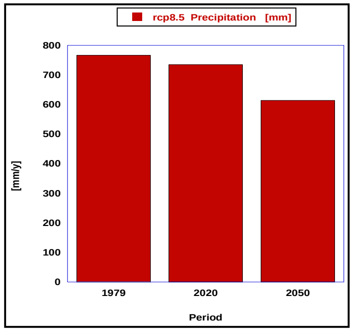
Precipitation



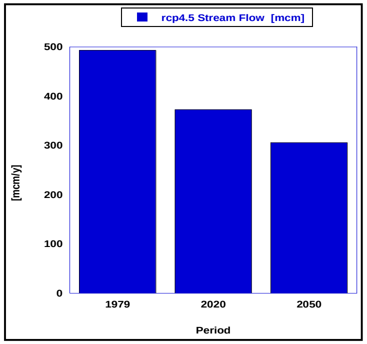


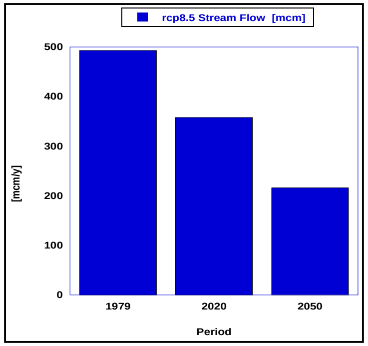
Evaporation





Annual streamflow





Conclusions

The Israeli Hydrological Service runs monthly, seasonal and long term hydrological forecasting. The operational runs show the advantage of using an ensemble of global models. Water related decision makers, such as the Israeli Water Authority (IWA), are able to decide whether to take action or not, knowing the forecast skill for the different lead times.

Such methodologies can fit for other countries that use an integrated water resources management approach, which requires Hydro-climate forecasting to derive the optimal management policy.

SWIM-H2020 SM

For further information

Website

www.water.gov.il

E: amirg@water.gov.il