Assessing hydrological regime sensitivity to climate change in a convective rainfall environment: a case study of medium-sized eastern Mediterranean catchments

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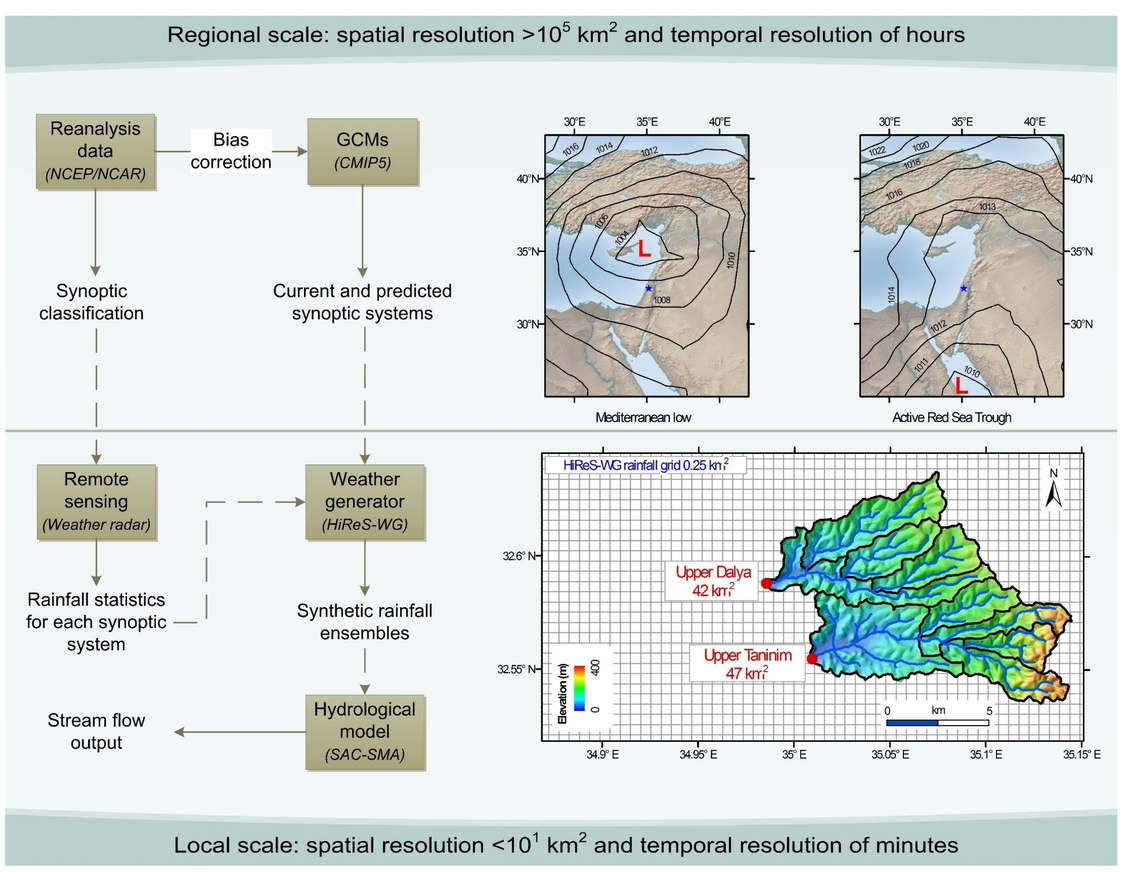
Summary

A modeling framework is formulated and applied to assess the sensitivity of the hydrological regime of two catchments in a convective rainfall environment with respect to projected climate change. The framework was applied to a case study in two medium-sized Mediterranean catchments in Israel, affected by convective rainfall, by combining the HiReS-WG rainfall generator and the SAC-SMA hydrological model. The projected climate change impact on the hydrological regime was examined for the RCP4.5 and RCP8.5 emission scenarios, comparing the beginning of the 21st century and the mid-21st-century periods from three GCMs available from CMIP5.

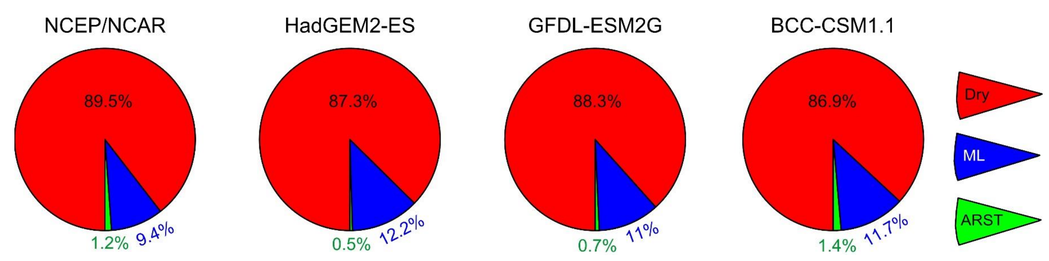


Conceptual framework

(1) a synoptic classification is performed to determine the regional synoptic system prevalent during rainfall events; (2) a record of remotely sensed rainfall estimate is used to derive the relevant rainfall spatiotemporal statistics; (3) the HiReS-WG is used to generate rainfall realizations that represents the historical climate; (4) the GCM synoptic variables are bias adjusted and projected changes in the occurrence frequency of future synoptic systems are then estimated; (5) the HiReS-WG is used to generate an ensemble of projected rainfall scenarios; and (6) the synthetic rainfall ensembles are used as input to the SCA-SMA hydrologic model.

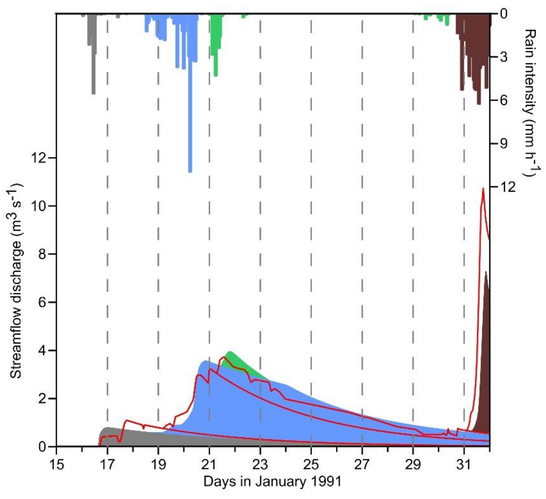
Climate change projection using CMIP5 models

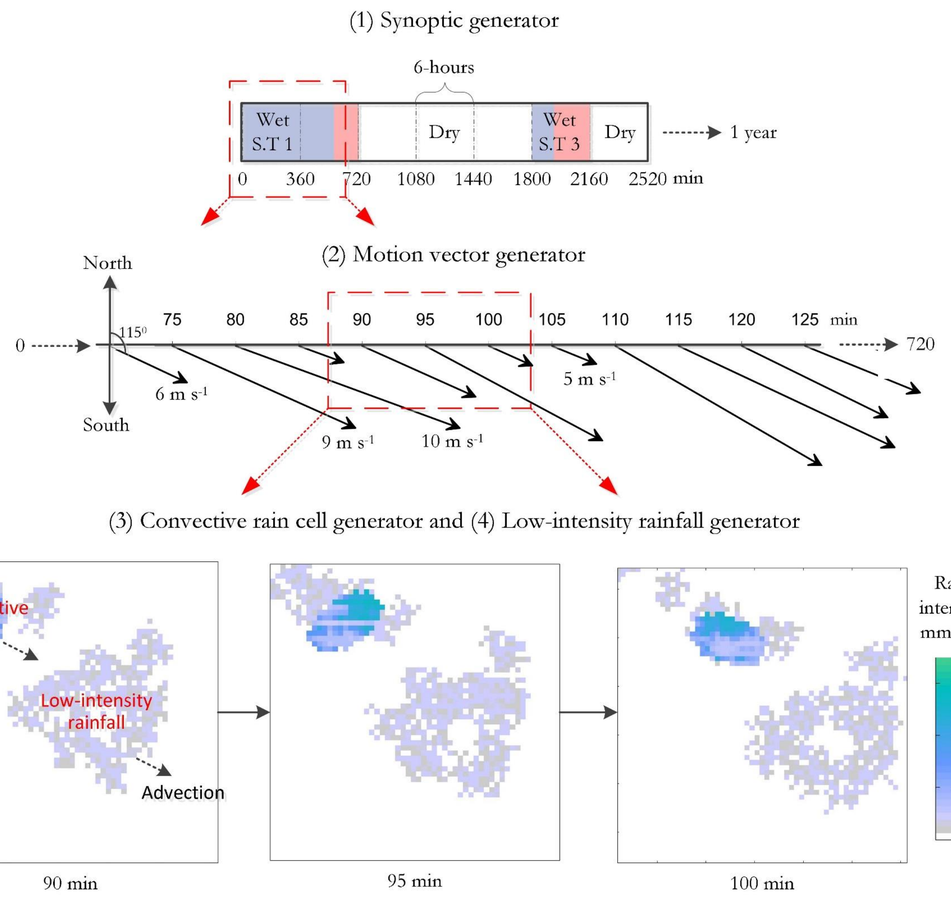
The CMIP5 simulations were used to compare the wet synoptic systems' occurrence between the beginning of the 21st century and the mid-21st-century periods for the RCP8.5 and RCP4.5 emission scenarios. It was found that: rain in the region will become less frequent because of a reduction in the occurrence frequency of wet synoptic systems, the wet season period will be shortened mainly from the ending of the wet season and the occurrence frequency of ARST will increase at the expense of the ML.



SCA-SMA hydrological model

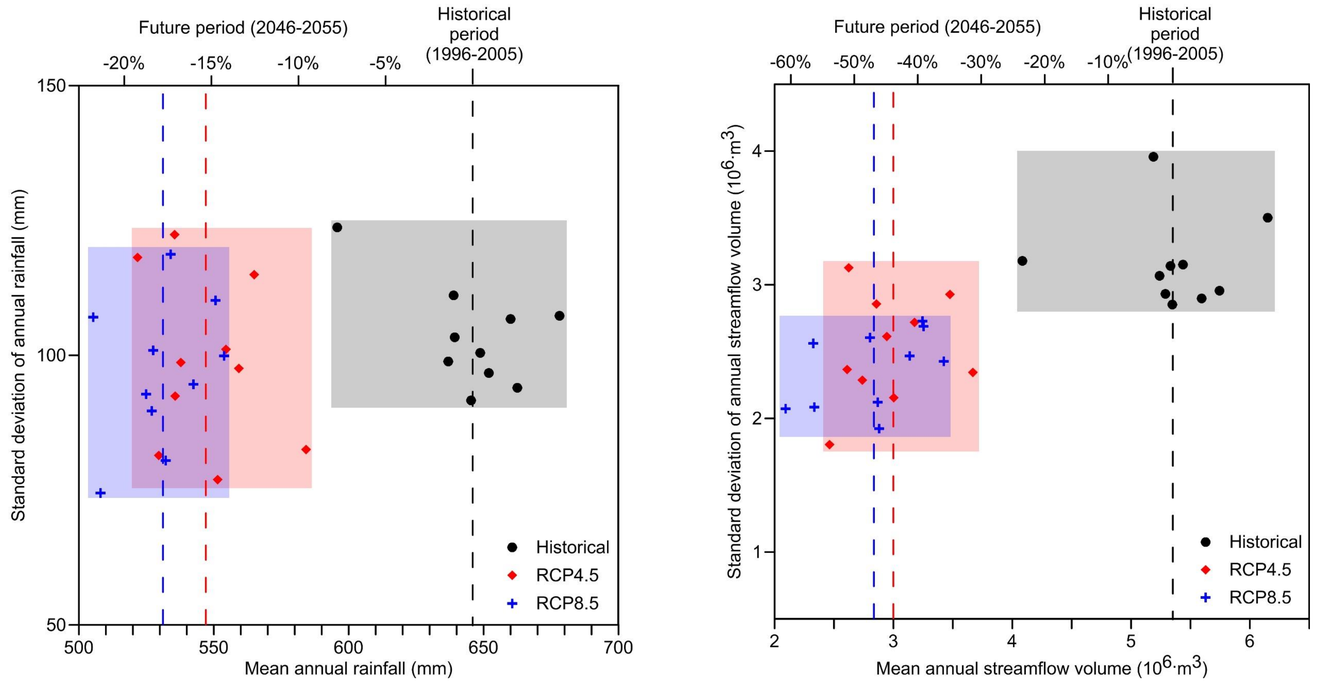
The Sacramento Soil Moisture Accounting Model (SAC-SMA) is a conceptual, continuous, and aerial-lumped model that describes the wetting and drying processes in the soil. An example of rainfall and streamflow discharge from the upper Dalya catchment separated into different events of rainfall and streamflow is given in the right figure. Red line represents the observed hydrograph and filled areas represent the simulated hydrograph.





HiReS-WG precipitation generator

The high resolution synoptically conditioned weather generator (HiReS-WG) is a stochastic model that generates rain fields with a substantial proportion of convective features. The rain fields were generated for the catchments in a spatial resolution of 0.25 km^2 and a temporal resolution of 5 min. Two ensembles of 300 years of likely rainfall realizations that represent the historical and projected periods were generated.



Changes in rainfall amounts and streamflow volumes

Three ensembles (the beginning of the 21st century, RCP4.5 and RCP8.5) each with 10 realizations of 30 years of rainfall were generated. The mean annual rainfall is projected to decrease from 646 to 547 mm (15% reduction) and 531 mm (18%) for the RCP4.5 and RCP8.5 emission scenarios, respectively. The projected range of the mean annual rainfall reduction over the catchments is 2–23% (RCP4.5) and 7–25% (RCP8.5). The mean annual streamflow volume calculated from the ensembles is projected to decrease from 5.34x10^6 m^3 to 2.96x10^6 m^3 (45%) for the RCP4.5 scenario and to 2.84x106 m^3 (47%) for the RCP8.5 scenario. The projected reduction range of the mean annual streamflow volume is 10–60% (RCP4.5) and 16–66% (RCP8.5). The amplification in reduction of streamflow volumes relative to rainfall amounts is related to the projected reduction in soil moisture, as a result of fewer rainfall events and longer dry spells between rainfall events during the wet season.

Reference

Peleg, N., Shamir, E., Georgakakos, K. P., and Morin, E.: A framework for assessing hydrological regime sensitivity to climate change in a convective rainfall environment: a case study of two medium-sized eastern Mediterranean catchments, Israel, *Hydrol. Earth Syst. Sci.*, 19, 567-581, 2015.

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