Abstract. Two configurations of RegCM3 regional climatemodel (RCM) have been used to downscale results of two atmosphere-ocean global climate model (AOGCM) simulations of the current (1961–1990) and future climates (2071–2100) over the eastern Mediterranean (EM) region. The RCM domain covering the EM region from northern Africa to central part of Asia Minor with grid spacing of 50 km was used. Three sets of RCM simulations were completed. Results of the RCM experiment support earlier projections of a temperature (annual precipitation) increase (decrease) to the end of 21st century over the EM. The roles of several major factors in controlling uncertainty of the climate change estimates are evaluated. The main uncertainty factors appear to be associated with possible inadequacies in RCM description of the EM-climate controlling developments over remotely located areas as well as those in the simulations of the global climate and its trends by the AOGCMs.

Akio Kitoh, Akiyo Yatagai and Pinhas Alpert First super-high-resolution model projection that the ancient “Fertile Crescent” will disappear in this century, Hydrological Research Letters 2, 1-4 DOI: 10.3178/HRL.2.1, 2008.

Abstract: The first full projections of rainfall and streamflow in the “Fertile Crescent” of Middle East are presented in this paper. Up until now, this has not been possible due to the lack of observed data and the lack of atmospheric models with sufficient resolution. An innovative super-high-resolution (20-km) global climate model is employed, which accurately reproduces the precipitation and the streamflow of the present-day Fertile Crescent. It is projected that, by the end of this century, the Fertile Crescent will lose its current shape and may disappear altogether. The annual discharge of the Euphrates River will decrease significantly (29-73%), as will the streamflow in the Jordan River. Thus countermeasures for water shortages will become much more difficult.

Abstract. Climate change trends over the southern east-Europe are evaluated according to results of a climate simulation experiment with the ICTP RegCM3 regional climate model driven from the lateral boundaries by results of ECHAM5/MPI-OM1 transient climate simulation from 1960 to 2060 (SRES A1B emission scenario after 2001). The trends projected include – precipitation: winter and spring – rise over the central east-Europe and drop over the eastern Mediterranean region, summer-autumn – drop over east-Europe and northern eastern-Mediterranean, rise over the Middle East (especially in autumn); 2-m air temperature: winter and spring – rise over the whole region with a maximum over its eastern and north-eastern (especially) and south-eastern parts, summer – rise with a maximum over the Middle East and minimum over north-eastern part, autumn – rise with maximum over the Caspian, Black Seas and northern areas of the European Territory of Russia.


Abstract Regional climate model (RCM) RegCM3 with 50 km horizontal resolution driven from the lateral boundaries by the data from NCEP/NCAR re-analysis is used in a series of ten climate downscaling experiments over the eastern Mediterranean (EM) region. Results of the experiments are characterized by seasonal precipitation patterns with notable offshore precipitation zones positioned 50 km westward of a less intense precipitation zone over the coastal area. Atmospheric processes determining the distribution of seasonal precipitation patterns in the EM are analyzed based on results of the RCM experiments performed. Level of success of the model representation of the actual precipitation over the ECM appears to be depending on that of precipitation balance over different parts of the domain. Excessive moisture convergence over a sub-area usually takes place at the expense of moisture divergence from neighboring areas. Synoptic mechanism causing formation of the precipitation zone in the offshore zone appears to be associated with the role of meridionally oriented atmospheric trough systems extending from Scandinavia or Siberia to the EM during the period with rainy events. In such situations, air flows with strong northern components lead to intense transport of cold air masses to the EM. Meeting of the cold air masses the warm and humid air over the sea surface in the offshore zone causes formation of persistent squall lines and heavy rains there. Such processes may continue quite long as long as the troughs are stationary.

Abstract. The integration of climate change projections into hydrological and other response models used for water resource planning and management is challenging given the varying spatial resolutions of the different models. In general, climate models are generated at spatial ranges of hundreds of kilometers, while hydrological models are generally watershed specific and based on input at the station or local level. This paper focuses on techniques applied to downscale large-scale climate model simulations to the spatial scale required by local response models (hydrological, agricultural, soil). Specifically, results were extracted from a regional climate model (RegCM) simulation focused on the Middle East, which was downscaled to a scale appropriate for input into a local watershed model [the Hydrological Model for Karst Environment (HYMKE)] calibrated for the upper Jordan River catchment. With this application, the authors evaluated the effect of future climate change on the amount and form of precipitation (rain or snow) and its effect on streamflow in the Jordan River and its tributaries—the major water resources in the region. They found that the expected changes in the form of precipitation are nearly insignificant in terms of changing the timing of streamflow. Additionally, the results suggest a future increase in evaporation and decrease in average annual rainfall, supporting expected changes based on global models in this region.


The projection of robust regional climate changes over the next 50 years presents a considerable challenge for the current generation of climate models. Water cycle changes are particularly difficult to model in this area because major uncertainties exist in the representation of processes such as large-scale and convective rainfall and their feedback with surface conditions. We present climate model projections and uncertainties in water availability indicators (precipitation, run-off and drought index) for the 1961–1990 and 2021–2050 periods. Ensembles from two global climate models (GCMs) and one regional climate model (RCM) are used to examine different elements of uncertainty. Although all three ensembles capture the general distribution of observed annual precipitation across the Middle East, the RCM is consistently wetter than observations, especially over the mountainous areas. All future projections show decreasing precipitation (ensemble median between −5 and −25%) in coastal Turkey and parts of Lebanon, Syria and Israel and consistent run-off and drought index changes. The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4) GCM ensemble exhibits drying across the north of the region, whereas the Met Office Hadley Centre work Quantifying Uncertainties in Model Projections—Atmospheric (QUMP-A) GCM and RCM ensembles show slight drying in the north and significant wetting in the south. RCM projections also show greater sensitivity (both wetter and drier) and a wider uncertainty range than QUMP-A. The nature of these uncertainties suggests that both large-scale circulation patterns, which influence region-wide
drying/wetting patterns, and regional-scale processes, which affect localized water availability, are important sources of uncertainty in these projections. To reduce large uncertainties in water availability projections, it is suggested that efforts would be well placed to focus on the understanding and modelling of both large-scale processes and their teleconnections with Middle East climate and localized processes involved in orographic precipitation.


Abstract A double-resolution regional experiment on hydrodynamic simulation of climate over the eastern Mediterranean (EM) region was performed using an International Center for Theoretical Physics, Trieste RegCM3 model. The RegCM3 was driven from the lateral boundaries by the data from the ECHAM5/MPI-OM global climate simulation performed at the MPI-M, Hamburg and based on the A1B IPCC scenario of greenhouse gases emission. Two simulation runs for the time period 1960-2060, employing spatial resolutions of 50 km/14 L and 25 km/18 L, are realized. Time variations of the differences in the space distributions of simulated climate parameters are analyzed to evaluate the role of smaller scale effects. Both least-square linear and non-linear trends of several characteristics of the EM climate are evaluated in the study. One of the key findings with regard to linear trends is a notable and statistically significant precipitation drop over the near coastal EM zone during December-February and September-November. Statistically significant positive air temperature trends are projected over the entire EM region during the four seasons. Also projected are increases in air temperature extremes and the relative contribution of convective processes in the Southern Mediterranean coastal zone (ECM) region. A notable sensitivity of projected larger-scale climate change signals to smaller-scale effects is also demonstrated.


Abstract: For the estimation of future climate conditions in the Jordan River region, the National Center for Atmospheric Research–Penn State University meteorology model in the versions 3.5 and 3.7 driven with boundary data from the Max-Planck-Institute for Meteorology and Hadley Centre global circulation models and the Special Report on Emission Scenarios A1B emission scenario has been used. The spatial resolution of the nested dynamic downscaling approach was 18.6 km, and the transient runs were performed for the period 1960–2099. The investigated statistics include mean precipitation, frequency and intensity of wet days and strong precipitation events, as well as mean temperature and heat wave duration index. The results show that the models satisfactorily reproduce the mean temperature and precipitation patterns. The comparison
with the observational reference for the period 1961–1990 reveals a bias in the annual mean precipitation ranging from −20% to +17%, with an ensemble mean of −3%. The models show limitations in reproducing the precipitation seasonality. All models underestimate the wet day frequency and show differences in the strong precipitation events. The simulations of the future climate signal indicate an ensemble mean increase of the annual mean temperature of approximately 2.1 K in the period 2031–2060 and 3.7 K for the period 2070–2099 related to the 1961–1991 mean. In the same periods, the annual mean precipitation is simulated to decrease by approximately −11.5% and −20%, respectively, which means a reduction of expected water availability in the Jordan River region. All models show an increase of the heat wave duration index. A significant elevation dependence is present in the simulated future climate signal on both temperature and precipitation. The simulations show an increased coefficient of variation in annual precipitation, indicating that larger interannual precipitation variability can be expected in the future. Significant reduction of expected water availability in the Jordan River region Significant elevation signal present in the simulated future climate Increased coefficient of variation in simulated future annual precipitation

Shohami, David; Dayan, Uri; Morin, Efrat Warming and drying of the eastern Mediterranean: Additional evidence from trend analysis Journal of Geophysical Research. Atmospheres, 116(22) DOI: 10.1029/2011JD016004, 2011

Abstract: Trends in atmospheric variables over EM indicate warmer and drier conditions Significant warming was found in surface station summer temperature data Precipitation trends are negative but insignificant due to high natural variance The climate of the eastern Mediterranean (EM), at the transition zone between the Mediterranean climate and the semi-arid/arid climate, has been studied for a 39-year period to determine whether climate changes have taken place. A thorough trend analysis using the nonparametric Mann-Kendall test with Sen's slope estimator has been applied to ground station measurements, atmospheric reanalysis data, synoptic classification data and global data sets for the years 1964-2003. In addition, changes in atmospheric regional patterns between the first and last twenty years were determined by visual comparisons of their composite mean. The main findings of the analysis are: 1) changes of atmospheric conditions during summer and the transitional seasons (mainly autumn) support a warmer climate over the EM and this change is already statistically evident in surface temperatures having exhibited positive trends of 0.21°C/decade; 2) changes of atmospheric conditions during winter and the transitional seasons support drier conditions due to reduction in cyclogenesis and specific humidity over the EM, but this change is not yet statistically evident in surface station rain data, presumably because of the high natural precipitation variance masking such a change. The overall conclusion of this study is that the EM region is under climate change leading to warmer and drier conditions.
Abstract: Identifying and quantifying future climate effects on water resources has major economic and societal implications, rendering such studies extremely important for water planners. Here we integrate output from one high resolution global (Japan Meteorological Agency) and three regional (ECHAM-RegCM, Hadley-MM5, ECHAM-MM5) climate models into three hydrological tools (1. annual incoming water volumes; 2. evaporation from the lake; and 3. lake salinity) to provide first approximations of climate change impacts on water quantity and quality in Lake Kinneret (also known as Sea of Galilee), the major freshwater resource in Israel. Meteorological data extracted from the climate models were used as input data into the models. Results were calculated for the historical 1979–2009 and the future 2015–2060 periods. The modeled historical period was verified against observed data, first by each model alone, and then by the combined model structure. Predicted results varied between the climate models. The ECHAM-RegCM predicted decreased precipitation in an average rate of 7 mm year\(^{-1}\) (0.8% annually) while the trends of precipitation predicted by the other models were less obvious. According to the combination of ECHAM-RegCM, ECHAM-MM5 and Hadley-MM5 with the lake evaporation model, the evaporation will increase by 0.2–0.6 Mm\(^3\) (0.10–0.25%) annually while according to the JMA no trend was found. The lake salinity is mostly impacted by changes in inflows and therefore only the ECHAM-RegCM predicted significant increase of salinity (from 280 ppm Cl today to 450 ppm Cl in 2060), while the trends of salinity according to other models were mild.


Abstract. Understanding and predicting changing trends and frequency of extreme rainfall and temperature events are extremely important for optimal planning in many sectors including agriculture, water resource management, health and even economics. For people living in the Jordan River region of the Middle East such changes can have immediate devastating impacts as water resources are already scarce and over-exploited and summer temperatures in the desert regions can reach 45 degrees or higher. Understanding and forecasting shifts in frequency and intensity of extreme events can provide crucial information for planning and adaptation. In this paper we present results from regional climate model simulations with RegCM3 and MM5 centered on the Eastern Mediterranean region. Our analysis focuses on changes in extreme temperature and rainfall events. We show that maximum daily summer temperature is expected to increase by between 2.5-3\(\cdot\)16 \(^{\circ}\)C with an increase in warm spell length. Precipitation extremes are expected to increase with longer dry spells, shorter wet spells and increases in heavy rainfall. Model agreement for the control period 1961-1990 is higher in the southern region than in the north, perhaps due to the complex topography suggesting that
even small differences in spatial scale play an important role. In addition, we notice that the chosen global model plays an important role in determining future temperature trends while the choice of regional climate model is critical for understanding how precipitation is expected to evolve.

Wanli Wu, Yubao Liu, Ming Ge, Dorita Rostkier-Edelstein, Gael Descombes, Pavel Kunin, Thomas Warner, Scott Swerdlin, Amir Givati, Thomas Hopson, David Yates


Abstract Most of the annual rainfall in the Southeastern Mediterranean falls in the wet season from November to March. It is associated with Mediterranean cyclones, and is sensitive to climate variability. Predicting the wet season precipitation with a few months advance is highly valuable for water resource planning and climate-associated risk management in this semi-arid region. The regional water resource managements and climate-sensitive economic activities have relied on seasonal forecasts from global climate prediction centers. However due to their coarse resolutions, global seasonal forecasts lack regional and local scale information required by regional and local water resource managements. In this study, an analog statistical-downscaling algorithm, k-nearest neighbors (KNN), was introduced to bridge the gap between the coarse forecasts from global models and the needed fine-scale information for the Southeastern Mediterranean. The algorithm, driven by the NCEP Climate Forecast System (CFS) operational forecast and the NCEP/DOE reanalysis, provides monthly precipitations at 2–4 months of lead-time at 18 stations within the major regional hydrological basins. Large-scale predictors for KNN were objectively determined by the correlations between the station historic daily precipitation and variables in reanalysis and CFS reforecast. Besides a single deterministic forecast, this study constructed sixty ensemble members for probabilistic estimates. The KNN algorithm demonstrated its robustness when validated with NCEP/DOE reanalysis from 1981 to 2009 as hindcasts before applied to downscale CFS forecasts. The downscaled predictions show fine-scale information, such as station-to-station variability. The verification against observations shows improved skills of this downscaling utility relative to the CFS model. The KNN-based downscaling system has been in operation for the Israel Water Authority predicting precipitation and driving hydrologic models estimating river flow and aquifer charge for water supply.


Winter and summer Mediterranean precipitation climatology and trends since 1950 as simulated by the newest generation of global climate models, the Coupled Model Intercomparison Project phase 5 (CMIP5), are evaluated with respect to observations and the previous generation of models (CMIP3) used in the Intergovernmental Panel on Climate Change Fourth Assessment Report. Observed precipitation in the Mediterranean region is defined by wet winters and drier summers, and is characterized by substantial
spatial and temporal variability. The observed drying trend since 1950 was predominantly due to winter drying, with very little contribution from the summer. However, in the CMIP5 multimodel mean, the precipitation trend since 1950 is evenly divided throughout the seasonal cycle. This may indicate that in observation, multidecadal internal variability, particularly that associated with the North Atlantic Oscillation (NAO), dominates the wintertime trend. An estimate of the observed externally forced trend shows that winter drying dominates in observations but the spatial patterns are grossly similar to the multimodel mean trend. The similarity is particularly robust in the eastern Mediterranean region, indicating a radiatively forced component being stronger there. Results of this study also reveal modest improvement for the CMIP5 multi-model ensemble in representation of the observed six month winter and summer climatology. The results of this study are important for assessment of model predictions of hydroclimate change in the Mediterranean region, often referred to as a “hotspot” of future subtropical drying.


Abstract. The Standardized Precipitation–Evaporation Index (SPEI) was applied in order to address the drought conditions under current and future climates in the Jordan River region located in the southeastern Mediterranean area. In the first step, the SPEI was derived from spatially interpolated monthly precipitation and temperature data at multiple timescales: accumulated precipitation and monthly mean temperature were considered over a number of timescales – for example 1, 3, and 6 months. To investigate the performance of the drought index, correlation analyses were conducted with simulated soil moisture and the Normalized Difference Vegetation Index (NDVI) obtained from remote sensing. A comparison with the Standardized Precipitation Index (SPI), i.e., a drought index that does not incorporate temperature, was also conducted. The results show that the 6-month SPEI has the highest correlation with simulated soil moisture and best explains the interannual variation of the monthly NDVI. Hence, a timescale of 6 months is the most appropriate when addressing vegetation growth in the semiarid region. In the second step, the 6-month SPEI was derived from three climate projections based on the Intergovernmental Panel on Climate Change emission scenario A1B. When comparing the period 2031–2060 with 1961–1990, it is shown that the percentage of time with moderate, severe and extreme drought conditions is projected to increase strongly. To address the impact of drought on the agricultural sector, the irrigation water demand during certain drought years was thereafter simulated with a hydrological model on a spatial resolution of 1 km. A large increase in the demand for irrigation water was simulated, showing that the agricultural sector is expected to become even more vulnerable to drought in the future.

ABSTRACT: A divergence metric was used to combine 4 high-resolution climate models to generate more reliable simulations of future rainfall. The approach is based on the assumption that the use of multiple models (an ensemble) is superior to the use of a single model, even if one of the models is shown to better capture past trends. Such an approach is especially useful in areas with steep climatic gradients, where large-scale climate models are not effective in capturing orographic and local effects. We applied the methodology to the Middle East, and specifically to Israel, where climate shifts from arid to humid temperate occur over a distance of around 400 km. Model weights were determined by calculating the similarity between the probability distributions of the models and those of the historical data using the Jenson-Shannon divergence metric. These weights were then applied to future model projections. Annual amounts of rainfall, numbers of wet days and numbers of 3 d wet spells were analyzed. Compared with observed data, the weighted ensemble outperformed the equal weights ensemble, which outperformed the best model. For the northern and central stations, average annual amounts of rainfall decreased in both near- and far-future periods, with most of the change occurring at the peak and in the left-hand tail and less change in the right-hand tail of the probability distribution. This, combined with the change in the right-hand tail of the distribution in numbers of wet spells in the near future, suggests that the decline in overall rainfall will be higher than the corresponding decline in extreme events; or in other words even though there will be less rainfall, the extreme events will remain, and even possibly increase. In the south, a mixed trend of slightly increasing median amounts of rainfall and slightly decreasing extreme events is projected.


ABSTRACT: This study demonstrates the capability of the Weather Research and Forecasting (WRF) model with four dimensional data assimilation (WRF-FDDA) to produce a high-resolution climatography of seasonal precipitation over Israel and the surrounding areas. The system was used to dynamically downscale global Climate Forecast System (CFS) reanalysis with continuous assimilation of conventional and unconventional observations. Precipitation seasons (December-January-February) in 7 years, including two extreme dry and wet seasons observed in the past decades, were generated at 2-km spatial resolution. Verification against rain-gauge observations shows that the WRF-FDDA system effectively reproduces the spatial and inter-annual variability, as well as the timing, intensity, and length of wet and dry spells. The best agreement between model and observations was obtained at areas dominated by complex terrain, illustrating the benefit of the high-resolution lower boundary forcing in the dynamical downscaling process. In contrast, some biases were observed over coastal-flat terrain. The model was able to reproduce some of the extreme events, but exhibited limitations in the case of rare events. This specific discrepancy between the model and observations suggests that further fine tuning and different model configurations may be needed to correctly simulate extreme events. The use of an objective weather regimes verification procedure reveals the skill of the climatography for different types of extratropical cyclones: while biases are larger at coastal-flat areas under shallow-cyclonic
conditions, deep-cyclonic conditions lead to more significant biases in complex terrain regions. The weather-regimes dependent information may be used for further calibration of the downscaled precipitation.


Abstract Variations and trends in the rain regime of Israel are analyzed for 1975–2010, when persistent global warming has been observed. Negative trend is observed over the majority of Israel, statistically significant only in the super-arid region. The decrease is significant over the majority of Israel only in the spring, reflecting a shortening of the rainy season, [3 days/decade. The dry spells are becoming longer, significantly in most of the stations. The factors affecting these variations, synoptic systems, largescale oscillations and global temperature, were studied for extended period, 1953–2010. A simple multiple stepwise regression model applied for the inter-annual rainfall variations indicates that the occurrence of Cyprus lows is the dominant factor and the Mediterranean oscillation index, MOI2, is also a significant factor. In order to reduce the inter-annual noise and reveal inter-decadal variations, the time-series of the rainfall and its potential predictors were smoothed by 11-year window, showing an increase toward the 1990s, followed by a decrease, at a higher rate, onward. Correspondingly, the aridity lines propagated southward till the mid-1990s and then withdrew back, at a larger rate. The large-scale oscillations and the global temperature explain 83 % of the variance on the interdecadal time-scale, half of it explained by the global temperature alone. The findings of this study support the expected poleward expansion of the Hadley cell due to global warming.


Abstract In this study, human-induced climate change over the Eastern Mediterranean–Black Sea region has been analyzed for the twenty-first century by performing regional climate model simulations forced with large-scale fields from three different global circulation models (GCMs). Climate projections have been produced with Special Report on Emissions Scenarios A2, A1FI and B1 scenarios, which provide greater diversity in climate information for future period. The gradual increases for temperature are widely apparent during the twenty-first century for each scenario simulation, but ECHAM5-driven simulation generally has a weaker signal for all seasons compared to CCSM3 simulations except for the Fertile Crescent. The contrast in future temperature change between the winter and summer seasons is very strong for CCSM3-A2-driven and HadCM3-A2-driven simulations over Carpathians and Balkans, 4–5 _C. In addition, winter runoff over mountainous region of Turkey, which feeds many river systems
including the Euphrates and Tigris, increases in second half of the century since the snowmelt process accelerates where the elevation is higher than 1,500 m. Moreover, analysis of daily temperature outputs reveals that the gradual decrease in daily minimum temperature variability for January during the twenty-first century is apparent over Carpathians and Balkans. Analysis of daily precipitation extremes shows that positive trend is clear during the last two decades of the twenty-first century over Carpathians for both CCSM3-driven and ECHAM5-driven simulations. Multiple-GCM driven regional climate simulations contribute to the quantification of the range of climate change over a region by performing detailed comparisons between the simulations.


ABSTRACT The impact of climate change on the future water availability of the upper Jordan River (UJR) and its tributaries Dan, Snir, and Hermon located in the eastern Mediterranean is evaluated by a highly resolved distributed approach with the fifth-generation Pennsylvania State University–NCAR Mesoscale Model (MM5) run at 18.6- and 6.2-km resolution offline coupled with the Water Flow and Balance Simulation Model (WaSiM). The MM5 was driven with NCEP reanalysis for 1971–2000 and with Hadley Centre Coupled Model, version 3 (HadCM3), GCM forcings for 1971–2099. Because only one regional–global climate model combination was applied, the results may not give the full range of possible future projections. To describe the Dan spring behavior, the hydrological model was extended by a bypass approach to allow the fast discharge components of the Snir to enter the Dan catchment. Simulation results for the period 1976–2000 reveal that the coupled system was able to reproduce the observed discharge rates in the partially karstic complex terrain to a reasonable extent with the high-resolution 6.2-km meteorological input only. The performed future climate simulations show steadily rising temperatures with 2.2K above the 1976–2000 mean for the period 2031–60 and 3.5K for the period 2070–99. Precipitation trends are insignificant until the middle of the century, although a decrease of approximately 12% is simulated. For the end of the century, a reduction in rainfall ranging between 10% and 35% can be expected. Discharge in the UJR is simulated to decrease by 12% until 2060 and by 26% until 2099, both related to the 1976–2000 mean. The discharge decrease is associated with a lower number of high river flow years.

Giuseppe Zappa Matthew K. Hawcroft Len Shaffrey Emily Black · David J. Brayshaw Extratropical cyclones and the projected decline of winter Mediterranean precipitation in the CMIP5 models, Clim Dyn DOI 10.1007/s00382-014-2426-8, 2014

Abstract The Mediterranean region has been identified as a climate change “hot-spot” due to a projected reduction in precipitation and fresh water availability which has potentially large socio-economic impacts. To increase confidence in these projections, it is important to physically understand how this precipitation reduction occurs. This study
quantifies the impact on winter Mediterranean precipitation due to changes in extratropical cyclones in 17 CMIP5 climate models. In each model, the extratropical cyclones are objectively tracked and a simple approach is applied to identify the precipitation associated to each cyclone. This allows us to decompose the Mediterranean precipitation reduction into a contribution due to changes in the number of cyclones and a contribution due to changes in the amount of precipitation generated by each cyclone. The results show that the projected Mediterranean precipitation reduction in winter is strongly related to a decrease in the number of Mediterranean cyclones. However, the contribution from changes in the amount of precipitation generated by each cyclone are also locally important: in the East Mediterranean they amplify the precipitation trend due to the reduction in the number of cyclones, while in the North Mediterranean they compensate for it. Some of the processes that determine the opposing cyclone precipitation intensity responses in the North and East Mediterranean regions are investigated by exploring the CMIP5 intermodel spread.

Simon O. Krichak & Joseph Barkan & Joseph S. Breitgand & Silvio Gualdi & Steven B. Feldstein

The role of the export of tropical moisture into midlatitudes for extreme precipitation events in the Mediterranean region


Abstract

The aims of the study are twofold: firstly, to investigate the role of the export of humid tropical air in the formation of cool season heavy precipitating events (HPEs) in the Mediterranean region (MR); and secondly, to examine the possible linkage between the export of humid tropical air and the multiyear trend in extreme precipitation in the region. For this purpose, we analyze the spatial distributions of a number of key atmospheric variables with a reanalysis data for more than 50 intense HPEs for the MR. The results of this evaluation for both individual and composite events suggest that the HPEs are associated with atmospheric rivers (ARs). The MR HPEs are being characterized by the poleward export of humid air of tropical origin into the midlatitude MR from the Atlantic Ocean and Arabian Sea. These export events appear to be associated with the effects of hurricanes or intense cyclones in the North Atlantic. It was also found that the linear trend (for 1979–2013) of the frequency of humid days (days with precipitable water greater than 20 kg m⁻²) is consistent with recent changes in the character of precipitation over the MR and southern Europe.

Annarita Mariotti · Yutong Pan · Ning Zeng · Andrea Alessandri


Abstract

Long-term climate change and decadal variability in the Mediterranean region during 1860–2100 are investigated based on observational data and the newly available Coupled Model Intercomparison Project—Phase 5 (CMIP5) experiments. Observational records show that decadal variability and a general tendency for annual-mean conditions to be warmer and drier have characterized the Mediterranean during 1860–2005. Consistency with CMIP5 model simulations including greenhouse gases (GHG), as well
as anthropogenic aerosols and natural forcings, suggest that forced changes have characterized aspects of Mediterranean climate during this period. Future GHG-forced change will take place in the midst of decadal variability, both internal and forced, as it has occurred in the past. However, future rates of forced warming and drying over the Mediterranean are projected to be higher than in the past century. The degree to which forced change and internal variability will matter depends on the climatic quantity being considered. For surface air temperature and Mediterranean Sea annual-mean evaporation and surface freshwater fluxes, variability and forced change have become comparable and the forced signal has already emerged from internal variability. For quantities with large internal variability and relatively small forced signal such as precipitation, forced change will emerge later on in the twenty-first century over selected regions and seasons. Regardless, the probability distribution of future precipitation anomalies is progressively shifting towards drier conditions. Overall, results highlight that both mean projected forced change and the variability that will accompany forced mean change should be considered in the development of future climate outlooks.


A new method for identifying high impact large-scale wind and precipitation events in the extended Mediterranean region is outlined and applied to the European Centre for Medium-range Weather Forecasts (ECMWF) reanalysis dataset ERA-Interim for the years 1979–2012. The method highlights large-scale 10m gust and precipitation events that classify as extreme if integrated over a spatial scale of 1000 km and a temporal scale of 3 days. The method detects successfully high impact events, and reveals clear seasonal differences among the subregions of the Mediterranean. Western Mediterranean precipitation extremes are more intense, and occur mainly in autumn, while eastern Mediterranean events occur in winter. Composite dynamical analyses of large-scale wind and precipitation extremes, and a combination of them, highlight coherent dynamical flow structures associated with the extremes in the different subregions of the Mediterranean. Precipitation events are preceded by an upper-level trough and strong jet on its western flank, followed by cyclogenesis (mainly in the western Mediterranean), and/or merging of the polar with the subtropical jet over northeastern Africa (in the eastern Mediterranean). Strong surface wind extremes develop around cyclones that intensify south of a deep parent cyclone near the exit of a strong anticyclonically curved jet, propagate eastwards and create a cold and dry northerly wind anomaly at the surface. Furthermore, combined large-scale wind and precipitation extremes often occur simultaneously near cyclones, either North Atlantic cyclones, which project the wind and precipitation into the western Mediterranean, or Mediterranean cyclones. The latter produce wind extremes over a localized area, which often overlaps entirely with the region that receives extreme

Michiel Baatsen · Reindert J. Haarsma · Aarnout J. Van Delden · Hylke de Vries Severe Autumn storms in future Western Europe with a warmer Atlantic Ocean Clim Dyn 45:949–964 DOI 10.1007/s00382-014-2329-8 2015
Abstract Simulations with a very high resolution (~25 km) global climate model indicate that more severe Autumn storms will impact Europe in a warmer future climate. The observed increase is mainly attributed to storms with a tropical origin, especially in the later part of the twenty first century. As their genesis region expands, tropical cyclones become more intense and their chances of reaching Europe increase. This paper investigates the properties and evolution of such storms and clarifies the future changes. The studied tropical cyclones feature a typical evolution of tropical development, extratropical transition and a re-intensification. A reduction of the transit area between regions of tropical and extratropical cyclogenesis increases the probability of reintensification. Many of the modelled storms exhibit hybrid properties in a considerable part of their life cycle during which they exhibit the hazards of both tropical and extratropical systems. In addition to tropical cyclones, other systems such as cold core extratropical storms mainly originating over the Gulf Stream region also increasingly impact Western Europe. Despite their different history, all of the studied storms have one striking similarity: they form a warm seclusion. The structure, intensity and frequency of storms in the present climate are compared to observations using the MERRA and IBTrACS datasets. Damaging winds associated with the occurrence of a sting jet are observed in a large fraction of the cyclones during their final stage. Baroclinic instability is of great importance for the (re-)intensification of the storms. Furthermore, so-called atmospheric rivers providing tropical air prove to be vital for the intensification through diabatic heating and will increase considerably in strength in the future, as will the associated flooding risks.