Factsheet No 1

Climate Change in the Mediterranean: Observed trends and future projections

Water Availability and Security in Southern EuRope and the Mediterranean
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Climate change research in WASSERMed

In brief:

- *Climate change impact analysis in WASSERMed was based on a synthesis of existing Regional Climate Model simulations*
- *Regional Climate Models are very good at compensating for the bias of Global Climate Models for temperature, but are less successful for precipitation*
- *Results from Regional Climate Models for the A1B emission scenario indicate that in the mid 21st century the Mediterranean region will be warmer and drier than today*
- *An intercomparison of observational data and trends with EOBs and the CRU datasets shows qualitative agreement; it also indicates that existing public archives are inadequate in representing precipitation over Northern Africa and the Middle East because of data scarcity and limited representation of regional variability*

The research objectives of WASSERMed included a **synthesis of existing Regional Climate Model (RCMs) simulations** to provide the basis for analysing climate change impacts for the Mediterranean Basin and for selected areas. This involved the extension of existing syntheses, which are mostly based on Global Climate Models (GCMs) and the identification of the most suitable dataset for the specific Case Study (CS) areas. In addition, and as resolution is considered a main issue in the Mediterranean region, it was important to assess the uncertainty of RCM results and the improvement compared to GCMs.

Furthermore, an analysis was carried out on **observed precipitation trends,** focusing on Northern Africa and the Middle East. This is considered particularly important, due to the increased water demand in these areas and the expectation of the onset of progressively drier climate conditions during the 21st century.

During the second half of the 20th century, the observed precipitation trend is negative over several areas, including the Balkan and Italian peninsulas, the southern Anatolian coast, and part of northwest Africa in winter. However, precipitation trends are not assessed with sufficient robustness over important parts of Northern Africa and Middle East, due to the limited records of long, reliable time series. As a result, and although there are gridded datasets that cover the entire Mediterranean region, their accuracy over the specific areas is not clear; this is due to the statistical methods used to compensate for the variable density of meteorological stations and for periods with no data in single time series.

Methods and tools

Observed precipitation trends

For the purpose of deriving current trends, datasets were first analysed in terms of quality, and time series with more than 25% missing values were removed. Three homogeneity tests were applied to test the presence of break points: (a) the Standard Normal Homogeneity test for a single break, (b) the Buishand range test, and (c) the Petit test.

For time series that passed all tests, monthly precipitation totals were computed. Trends were evaluated using the Sen's Estimate and statistical significance was assessed through the Mann-Kendall test. Additionally, the Spearman ranks correlation between precipitation data and the north hemisphere teleconnection patterns (NAO, Scandinavian pattern, Eastern-Atlantic-Western Russia, etc.) were computed.

Regional Climate Projections

Five models, whose domains include the entire Mediterranean region at high spatial resolution (25 km) were extracted from the set produced in the ENSEMBLES project. All simulations covered the period 1951-2050 and concerned the A1B emission scenario. This RCM dataset would allow to analyse trends and regime shifts at high resolution. The reliability of simulations was assessed by comparing the monthly precipitation and temperature climatology produced by the RCMs with the gridded observational CRU dataset of the East Anglia University.

The five simulations were used for producing a multi-model ensemble, currently considered the most robust and reliable climate projection for all variables and statistics. Climate change was assessed by comparing the seasonal values of temperature and precipitation for the 2021-2050 and 1961-1990 periods. The annual cycles of the same variables were computed for the same periods and for 1971-2100.

For each CS area a validation was performed to select the model that would most accurately reproduce local precipitation by comparing model results with "in-situ" data. The selected RCM was then used to produce continuous time series of climate variables, which were further analysed to assess potential trends.

Further Information
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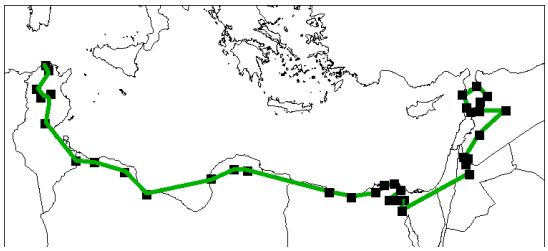
Main results

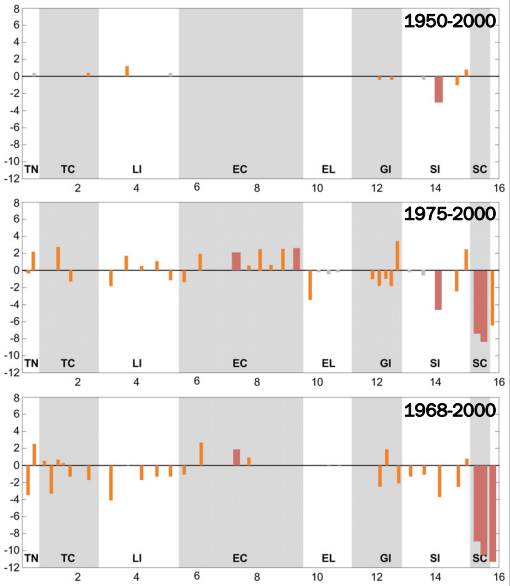
Observed precipitation trends

For precipitation, large coherent negative trends based on observed values concern only Syria. However, the large majority of trends in the latest period are negative (though mostly they are not statistically significant), suggesting the onset of progressively drier conditions in the last decades of the 20th century. The lack of data prevents the assessment of trends over long time periods, with few exceptions, which show very small trends at multi-decadal scale.



Location of meteorological stations used for the assessment of observed precipitation trends in Northern Africa and the Middle East

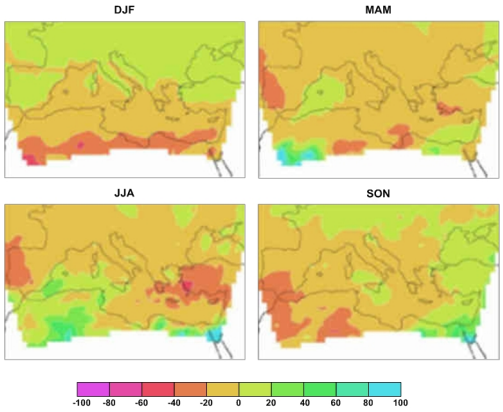
The NAO (North Atlantic Oscillation) is the teleconnection pattern that exerts the largest influence on precipitation and is positively correlated with precipitation patterns in the winter months from Libya to Jordan.



Precipitation trends for different periods; data are ordered from east to west along the green line in the map [TN: Tunisia North; TC: Tunisia Centre; LI: Libya; EC: Egypt Coast; EL: Egypt Interior; GI: Jordan; SI: Syria Interior; SC: Syria Coast]. Thick red bars represent statistically significant values at the 95% confidence level

Regional Climate Projections

The monthly precipitation and temperature climatology produced by RCMs for the Mediterranean region show that RCMs are very good at compensating the GCM bias for temperature, but less successful for precipitation. In fact, RCMs outperform GCMs quite convincingly in summer months for both variables, but not for winter precipitation. However, RCMs are very effective at reducing systematic GCM errors in coastal areas and over complicated orography. The results of RCMs using the A1B SRES show that in the mid 21st century the Mediterranean region will be warmer and drier than now. The most important feature is the contrasting precipitation change during the October-March period between the northern areas (that become marginally wetter than now) and the southern ones (that become drier than now). Temperature projections for the CS areas confirm for all a substantial increase in temperature in the range of 1.5 to 2.5°C and a wet season precipitation decrease by about 10-30% in the mid of the 21st century. Precipitation in the Jordan River Basin and in the Egypt hinterland shows a possible transition to a different (wetter) regime after the mid of the 21st century.



Spatial distribution of the variation of total seasonal precipitation between the 2021-2050 and the 1961-1990 periods (DJF: winter, MAM: spring, JJA: summer, SON: autumn)

Key findings and considerations

- RCM simulations have some advantages over GCMs for regional and sub-regional applications. The most reliable RCM (i.e. the one that can better reproduce present climate) depends on the specific area. The ensemble mean does not necessarily produce more accurate climatology than the individual members of the ensemble.
- Existing public archives are not adequate for representing precipitation over Northern Africa and the Middle East because of data scarcity and misrepresentation of regional variability. Data from the WASSERMed Case Studies show that trends that are not spatially homogeneous and depend on the area considered. However, the bulk of data suggest the onset of dry conditions in the last two decades of the 20th century.

Further reading

- L.Congedi, P.Lionello, 2011 Assessing improvement of RCM with respect to GCM climate simulations over the Mediterranean region: mean monthly fields. Geophysical Research Abstracts Vol. 13, EGU2011-8766.
- C. Pizzigalli ,L. Congedi, P. Lionello, A. H. Fahmi, M. Shatanawi, Z. L. Chabaane, 2011, Climate data analysis in the WASSERMed project, Geophysical Research Abstracts , Vol. 13, EGU2011-8920-1.