A review of climate change projections over the Mediterranean region

Filippo Giorgi
Abdus Salam ICTP, Trieste
IPCC : Global temperature change projections for the 21st century

CMIP3, AR4 (2007)

CMIP5, AR5 (2013)
The climate of the Mediterranean

Hot - Dry

Marked spatial variability

Temperate-Wet

Marked seasonality
Cold wet winters
Warm dry summers

Atlantic storms

Topography

Local cyclogenesis

Land-Atmosphere Interactions

Coastlines

Ocean heat source

Atmospheric aerosols and desert dust
Regional distribution of projected temperature and precipitation change (A1B scenario, 2090-2100)

Temperature change DJF

Temperature change JJA

Precipitation change DJF

Precipitation change JJA
Mediterranean climate change projections from Global Climate Model (GCM) ensembles (CMIP3, CMIP5)
Temperature change, CMIP3
A1B Scenario, 20 AOGCMs

Winter

Spring

Summer

Fall

2081-2100 minus 1961-1980
Temperature variability change, CMIP3 A1B Scenario, 20 AOGCMs

Winter

Sprig

Summer

Fall

2081-2100 minus 1961-1980
Precipitation change, CMIP3 A1B Scenario, 20 AOGCMs

Winter
Spring
Summer
Fall

2081-2100 minus 1961-1980
Observed change in annual precipitation over land

1901–2010

1951–2010

(mm yr$^{-1}$ per decade)
Precipitation variability change, CMIP3 A1B Scenario, 20 AOGCMs

2081-2100 minus 1961-1980
The European Climate Change Oscillation (ECO)
CMIP3 ensemble average change as a function of emission scenario


**Precipitation change**

- **Temperature change**
Precipitation change (2071-2100), CMIP5 RCP8.5 Scenario, 21 AOGCMs

Winter

Spring

Summer

Fall
Projections of temperature and precipitation change over the Mediterranean in 32 CMIP5 AOGCMs
Scenario RCP8.5, 2071-2100

Winter

Summer
Change in seasonal precipitation distribution
CMIP3 Ensemble (%: 2071-2100 minus 1961-1990),
Trends in hydroclimatic indices (2006-2100) 
RCP8.5, 9 CMIP5 AOGCMs (Giorgi et al, 2014)

- **Mean Prec. Int.**
- **R95Tot**
- **Dry Spell Length**
- **Wet Spell Length**
Hydroclimatic response to global warming emerging from the analysis of multiple interconnected indices (Giorgi et al. 2011, 2014)

Global warming should lead to more intense and extreme, more concentrated and less frequent precipitation events
Projections from Regional Climate Model (RCM) ensembles (ENSEMBLES, EURO-CORDEX, MED-CORDEX)
Simulation of summer precipitation patterns by the EURO/MED CORDEX RCMs
Simulation of daily precipitation intensity PDFs by GCMs and RCMs

RCMs are always closer to OBS (also when upscaled)
Change in mean annual precipitation (left column) and temperature (right column) in different RCM ensembles

2071-2100 minus 1971-2000

Jacob et al. 2014
Change in heavy precipitation (95%) in the EURO-CORDEX ensemble (RCP8.5, 2071-2100 minus 1971-2000)
Change in mean annual “long” dry spell (95%) in different RCM ensembles (2071-2100 minus 1971-2000)
Change in warm season heat waves in different RCM ensembles

2021-2050 minus 1971-2000

3cd > 99%

2071-2100 minus 1971-2000

3cd > 99%

2071-2100 minus 1971-2000

5cd > 5C
High resolution can lead to some surprises: Summer precipitation change over the Alps. (Giorgi et al. 2015)

GCMs

RCMs

0.11°

Anomaly

Observed summer precipitation change (1975-2004)
Summary of current projections

Model projections indicate some robust signals over the Mediterranean region

– Maximum warming and drying in the warm season for mid to long range time horizons throughout the Mediterranean basin. Wetting over the Alps in winter.

– Increase of interannual variability of temperature and precipitation in the warm season

– Increase in heat waves, temperature extremes and dry spells

– Change of the hydrologic regime to less frequent but more intense, extreme and concentrated events.

– Fine scale modulation of changes by topography and coastlines

– **Overall much drier and warmer conditions, decreasing in severity for lower global warming conditions.**
Future challenges in Mediterranean climate change projections

- Larger GCM and RCM ensembles of projections
  - Better characterization of uncertainty
  - CMIP6 (IPCC AR6), COPERNICUS, CORDEX

- Higher model resolutions
  - Down to 1-3-km scale with convection permitting RCMs
  - EUCP, CORDEX FPS

- Development of coupled models for the Mediterranean
  - Air-sea interactions, aerosols

- Inclusion of the human component
  - Land-use change, urbanization
THANK YOU
Projections of temperature and precipitation change over the Mediterranean in 9 CMIP5 AOGCMs
Scenario RCP2.6, 2071-2100

Winter

Summer
Causes of concern?

- Water availability and water management to become a much bigger issue
- Large effects on agriculture
- Increased aridity and risk of desertification, especially in the southern Mediterranean
- Increased risk of fire
- Health issues related to coping with summer heat
- Increased pollution related to higher temperatures and reduced precipitation
- Large decrease of glaciers and snow
- Problems with the tourism industry
- Problems with coastal areas (heat, sea level rise)
- Adaptation of ecosystems (land and marine)
Projections of temperature and precipitation change over the Mediterranean in 21 CMIP3 AOGCMs

Scenario A1B, 2090-2100

S Europe, N Africa, DJF, SRESA1B vs 20C3M

Winter

S Europe, N Africa, JJA, SRESA1B vs 20C3M

Summer
Temperature change (2071-2100), CMIP5 RCP8.5 Scenario, 21 AOGCMs

Winter

Spring

Summer

Fall
Temperature change (2071-2100), CMIP5 RCP2.6 Scenario, 9 AOGCMs
Precipitation change (2071-2100), CMIP5 RCP2.6 Scenario, 9 AOGCMs