The paradox of water cycle extremes in the Mediterranean

Philippe Drobinski
Institut Pierre Simon Laplace – Laboratoire de Météorologie Dynamique
philippe.drobinski@lmd.polytechnique.fr
Two reasons to investigate the Mediterranean water cycle ...

Critical water resources and droughts

- Index of exploitation of water resources in 2000

- Demand multiplied by 2 since 1950
- 60 million inhabitants lacking water
- 20 million inhabitants without access to drinkable water

Heavy precipitation and floods

- Between 1990 and 2006
  - more than 175 flood events
  - more than 29 140 M€ damages and 4 500 deaths

- Gard, Sept. 2002: ~700 l/m²
  20 deaths; 1 200 M€ damages

- Alger, nov. 2001: ~260 l/m²
  886 deaths; 4 000 M€ damages

More details in flash talk by P. Quintana Segui

More details in flash talks by S. Khodayar and H. Roux
… in a global climate change context

- Strong regional response to climate change
- Projections: significant warming (between +1.4°C and +5.8°C in 2100), decrease of the mean annual rainfall and increase of rainfall variability

Giorgi (2006)
Precipitation extremes

An already measurable change

Vautard et al. (2014)

4% / decade

Probability 3x larger in 2014 than in 1950 (factor 1.3 à 12)
Precipitation extremes

Météo-France weather stations

Drobinski et al. (2016)

Clausius-Clapeyron

Fall Mediterranean HPE

Spring convection

Winter frontal precipitation

Arid summer, lower precipitation efficiency

Temperature break

Southern France

Precipitation extreme (mm h⁻¹)

Temperature (°C)
Precipitation extremes

Drobinski et al. (2018)
Precipitation extremes

RCP8.5 Mean change in 20-year extreme precipitation

Tramblay and Somot (2018)
Precipitation and droughts

RCP8.5 Mean change in 20-year extreme precipitation

Tramblay and Somot (2018)

Drobinski et al. (2020.)

Humidity change relative to Clausius–Clapeyron law
Precipitation and droughts

Hoerling et al. (2012) Decrease of precipitation in the Mediterranean region

Sheffield and Wood (2011) Decrease of soil humidity in the Mediterranean

Impact of the summer 2003 heat wave and drought on agriculture and forestry in 5 selected countries

Impact on production 2003/2002

Financial impact

- Poultry
- Potatoes
- Maize
- Wheat
- Fodder

Austria 107 Mio €
Spain 615 Mio €
Italy 4-5,000 Mio €
Germany 1,000 Mio €
France 4,000 Mio €

(1 Mio € is only for the beef sector)

Data source: COPA-COGECA 2009
Precipitation and droughts

Raymond et al. (2018)
Conclusion and sad perspectives...

- In a warming climate, **precipitation extreme** should **increase in the North** and **decrease in the South** of the Mediterranean.

- In the Mediterranean, projections of humidity support this trend unevenly:
  - In Europe mainland, increased precipitation extremes projected with **land acting as a humidity source for the atmosphere** which partly damps the temperature induced drying effect.
  - In arid regions, besides **the sea is the only source of moisture so drying is due to enhanced warming over land only** and may not be enough to compensate the land aridification leading to less intense precipitation extremes.

- Climate change is already occurring and measurable with **consistent trend between simulations and observations**.

- Climate change is occurring but its magnitude is far from its projected value in the second half of the 21st century (especially in the Mediterranean) → rapid amplification of such trends (precipitation extremes, droughts) should be foreseen and anticipated.