Med CORDEX
Coordinated Regional Climate Downscaling Experiment

IUSS
Scuola Universitaria Superiore Pavia

PhD SDC
SUSTAINABLE DEVELOPMENT
AND CLIMATE CHANGE

ENEA
Italian National Agency for New Technologies,
Energy and Sustainable Economic Development

Unravelling drivers of the future Mediterranean precipitation paradox during cyclones

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What we already know

- Cyclone contribution to the Mediterranean water cycle; *Flaounas, E. et al. (2015)*
- Extreme precipitation and strong winds -> socio-economic and environmental impacts; *Flaounas, E. et al. (2022)*

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- Increase of cyclone-related precipitation in the north-central Mediterranean but decrease in the southeast.
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Our framework:

- ➢ Investigating how changes in **moisture transport processes** impact cyclone-related precipitation
- ➢ Improving confidence in climate projections and attributing changes to climate change

Models and experiments

Climate Dynamics
https://doi.org/10.1007/s00382-023-07064-3

ORIGINAL ARTICLE

Dynamical downscaling of CMIP6 scenarios with ENEA-REG: an impact-oriented application for the Med-CORDEX region

Alessandro Anav[1,2] · Marta Antonelli[1] · Sandro Calmanti[1] · Adriana Carillo[1] · Franco Catalano[1,2] · Alessandro Dell'Aquila[1] · Roberto Iacono[1] · Salvatore Marullo[1] · Ernesto Napolitano[1] · Massimiliano Palma[1] · Giovanna Pisacane[1] · Gianmaria Sannino[1,2] · Maria Vittoria Struglia[1,2]

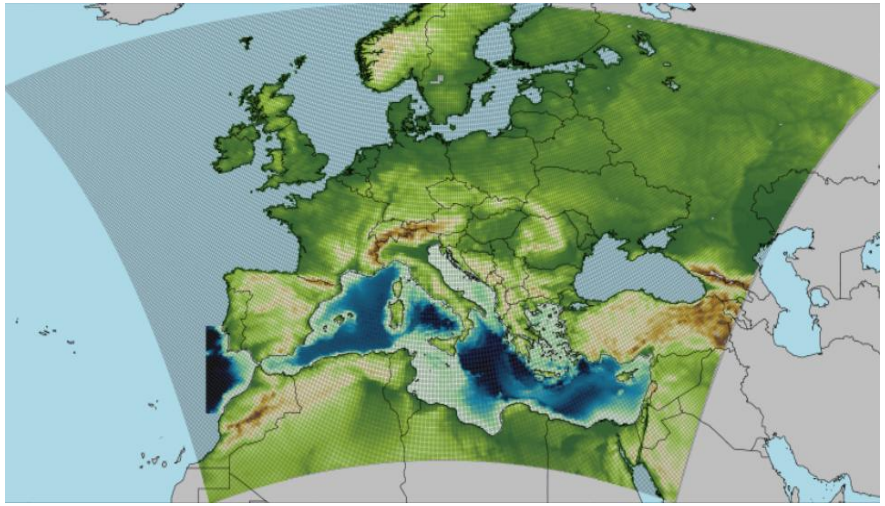
➔ Models:

A. ENEA-REG_v2 Regional Earth system model: Med-CORDEX domain, 12 km resolution;
dynamical downscaling of MPI-ESM1-2-HR
WRF 4.2.2 (atmosphere) + MITgcm (ocean) + HD (hydrology)

B. 6 CMIP6 ensemble (below 100 km resolution):
MPI-ESM1-2-HR, BCC-CSM2-MR, CMCC-ESM2, EC-EARTH3, MRI-ESM2-0, NorESM2-MM

➔ Experiments:

- **Historical**: 1982-2014
- **SSP 5-8.5**, **2-4.5**, **1-2.6**: 2015-2100



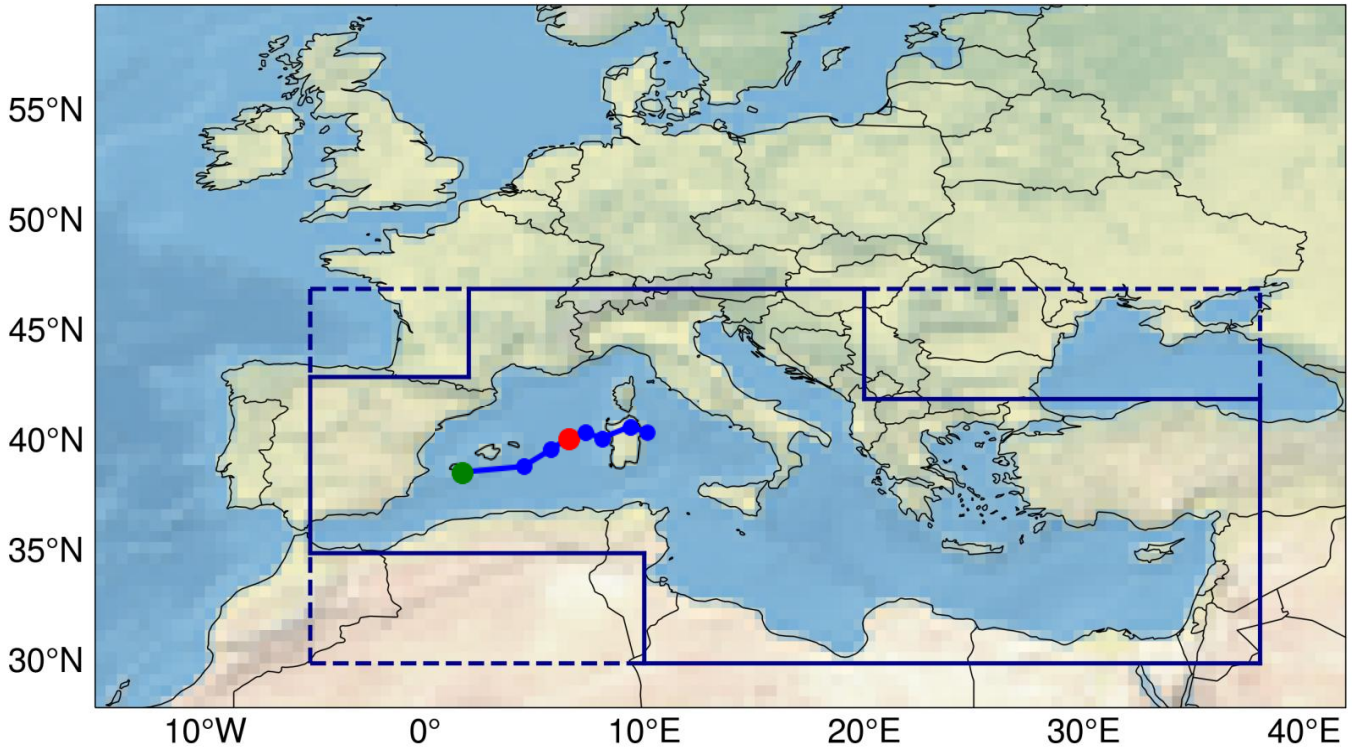
Methodology and analysis

- **Cylone tracking algorithm** based on Sea Level Pressure (**SLP**): "Cyclotrack", Flaounas et al. 2014

Intense Mediterranean cyclones:

- Intensity filter: **SLP < 1000 hPa**
- Mediterranean **area**

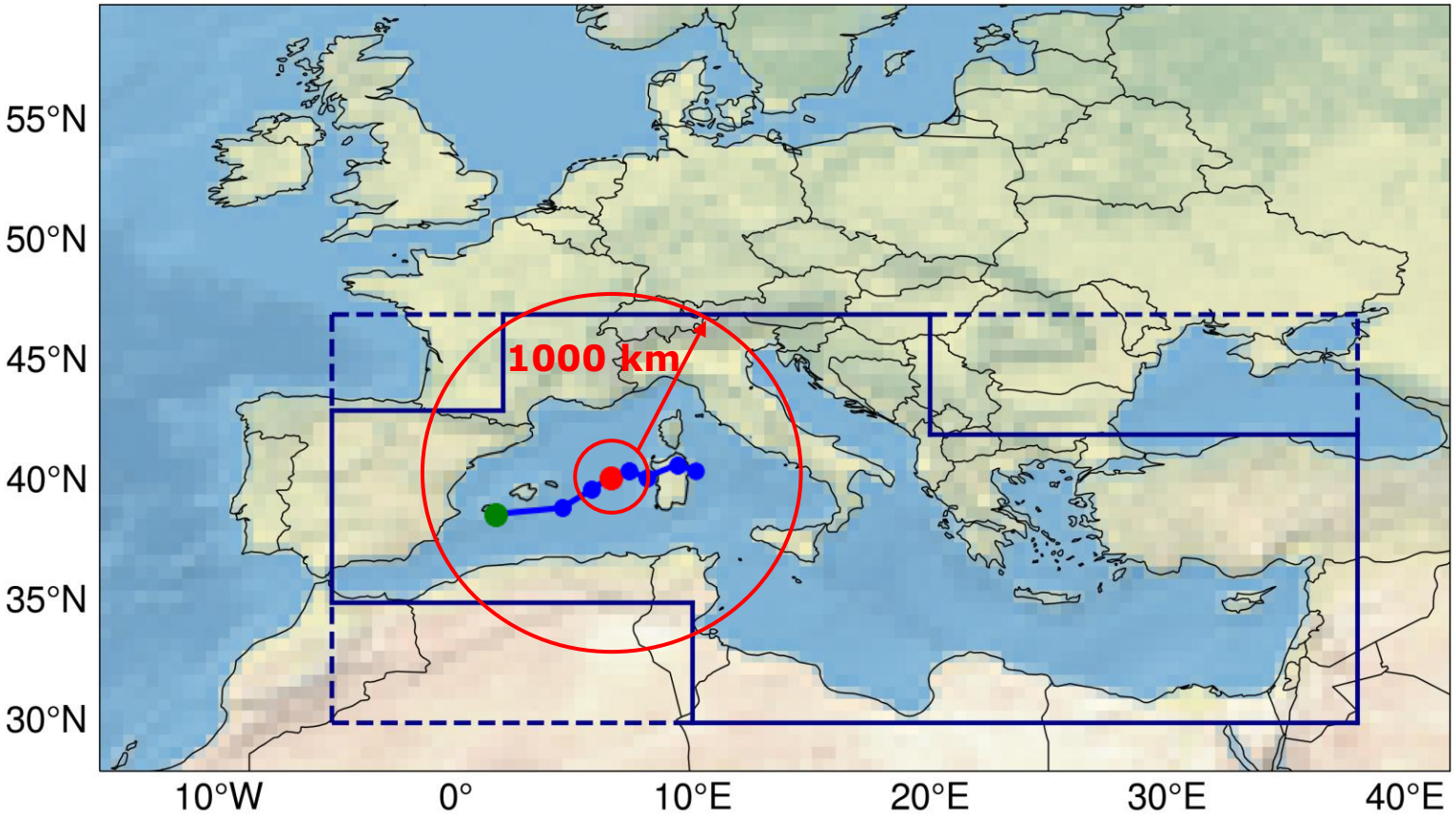
- Extended cold season (**ONDJFM**) analysis



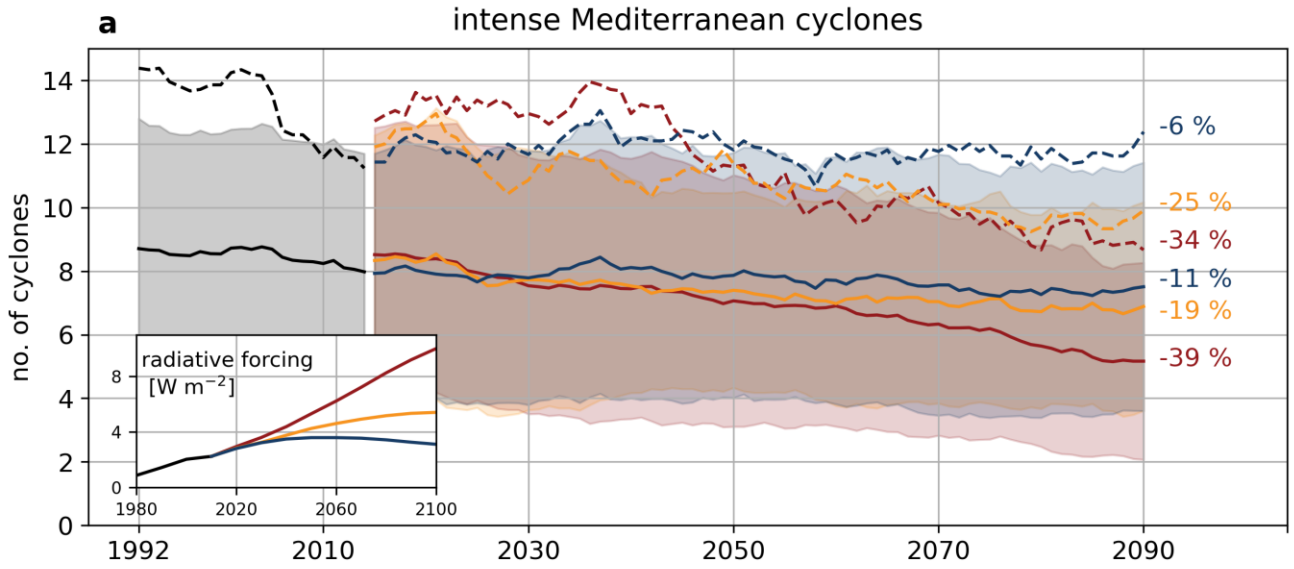
Methodology and analysis

- **Cyclone-related Precipitation**:

- during the **mature stage** of the **cyclone** (24 hr): from 12 hr before to 12 hr after the time of the minimum SLP
- Area: circular disk (radius of 1000km) around the SLP tracking points.



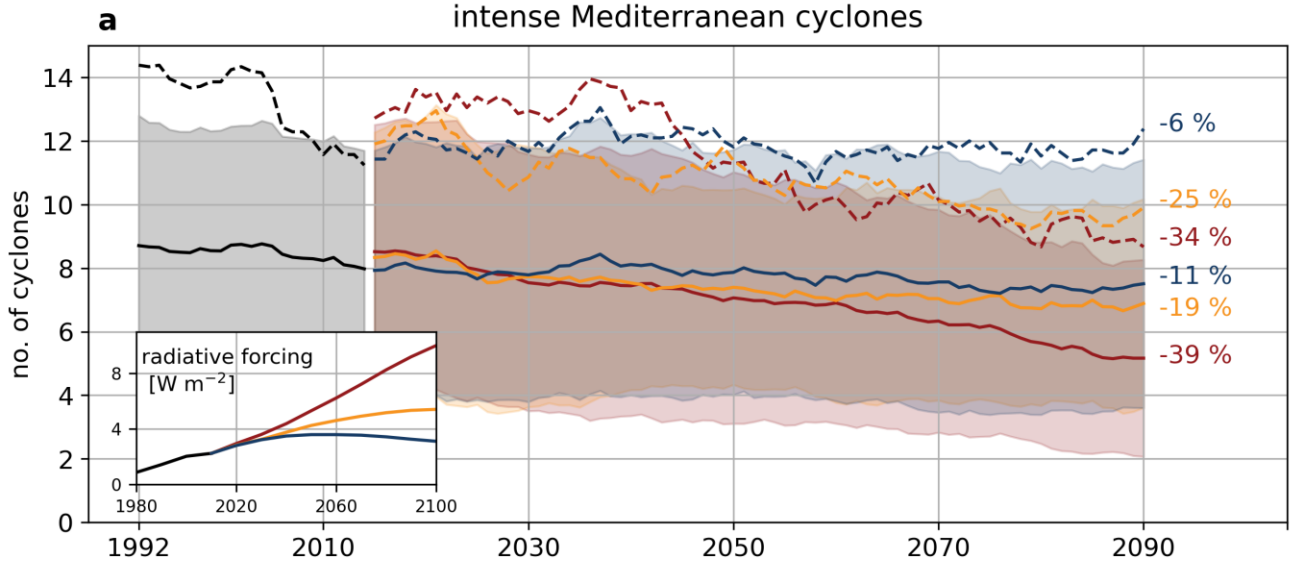
Future Mediterranean precipitation paradox



ENEA-REG historical
CMIP6 historical
ENEA-REG SSP5-8.5
CMIP6 SSP5-8.5
ENEA-REG SSP2-4.5
CMIP6 SSP2-4.5
ENEA-REG SSP1-2.6
CMIP6 SSP1-2.6

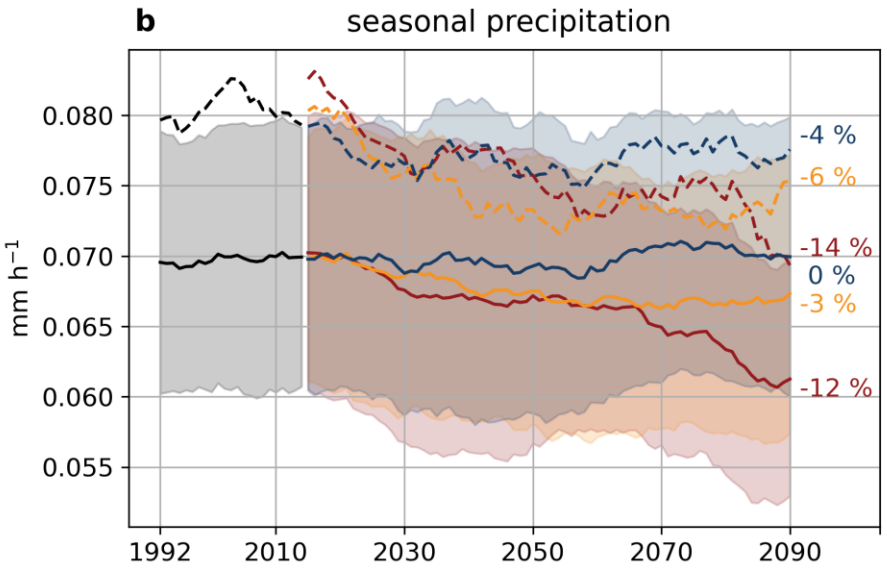
ONDJFM

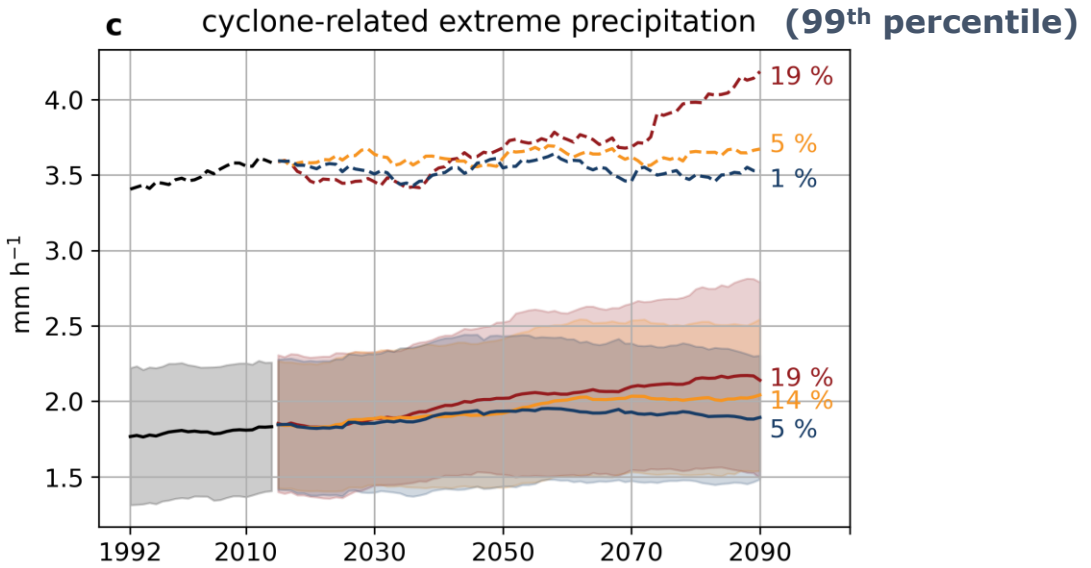
Future Mediterranean precipitation paradox



increased **aridity** + amplified **precipitation extremes**:

increase the **risk of inland flooding** from these storms, posing challenges for the **densely populated areas** of the Mediterranean basin





ENEA-REG historical
CMIP6 historical
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ENEA-REG SSP1-2.6
CMIP6 SSP1-2.6

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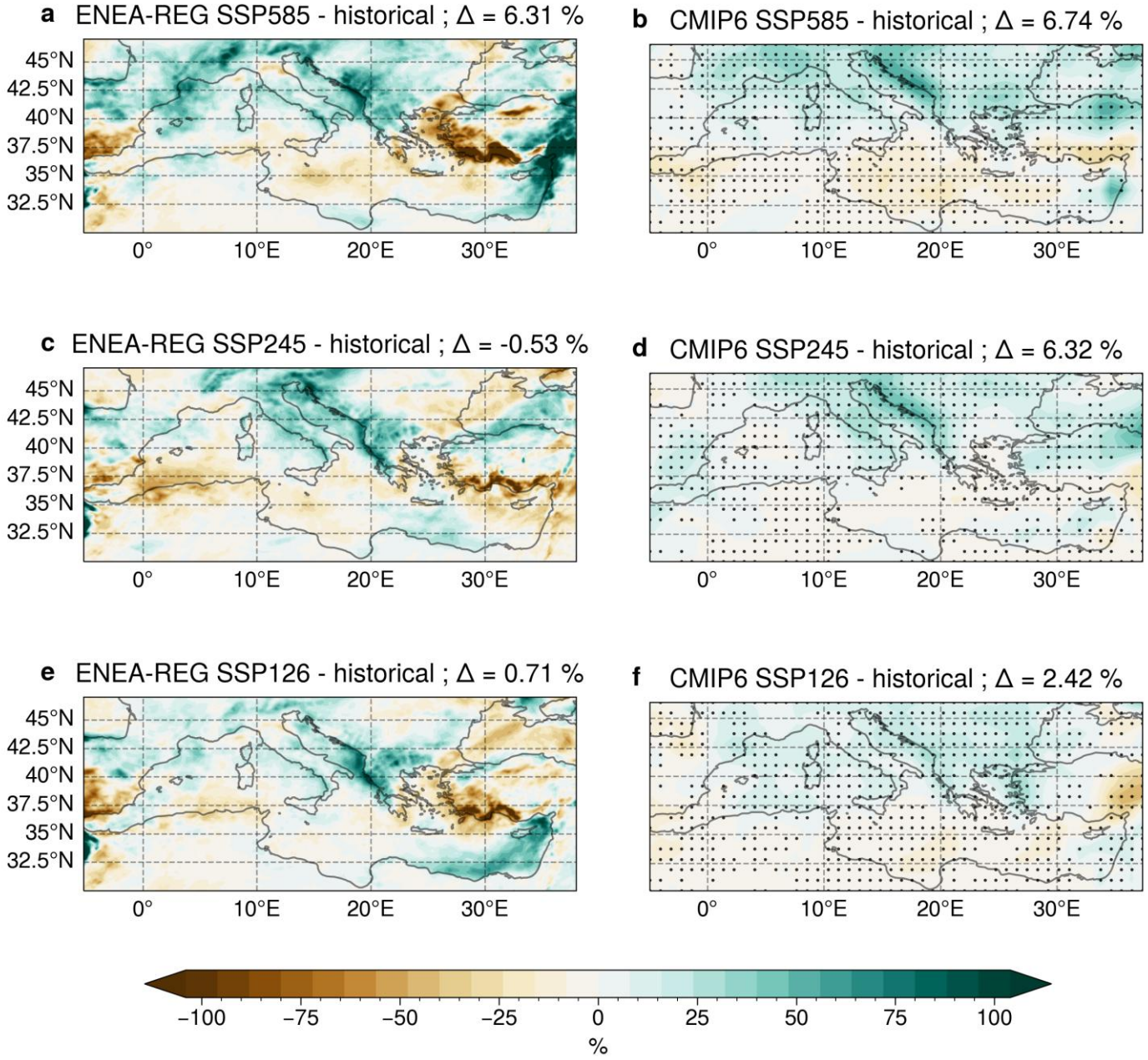
Regional pattern of projected changes in cyclone-related precipitation

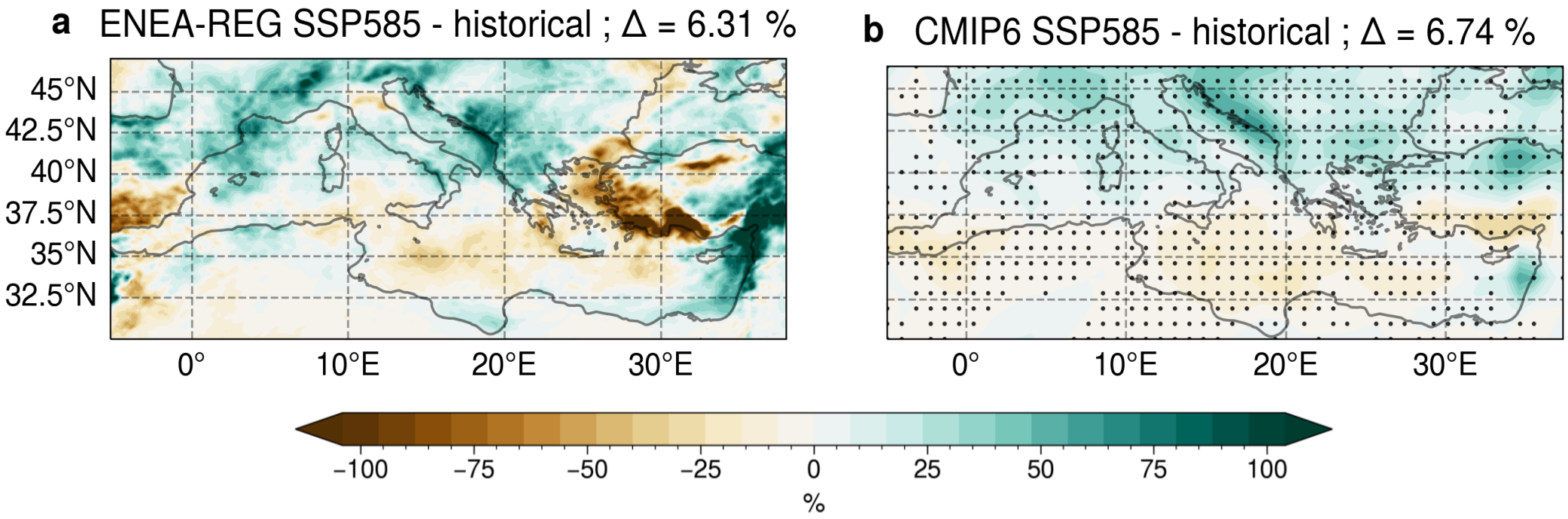


ONDJFM

Future – historical

(2071-2100) - (1985-2014)

cyclone-related precipitation changes under SSP 5-8.5



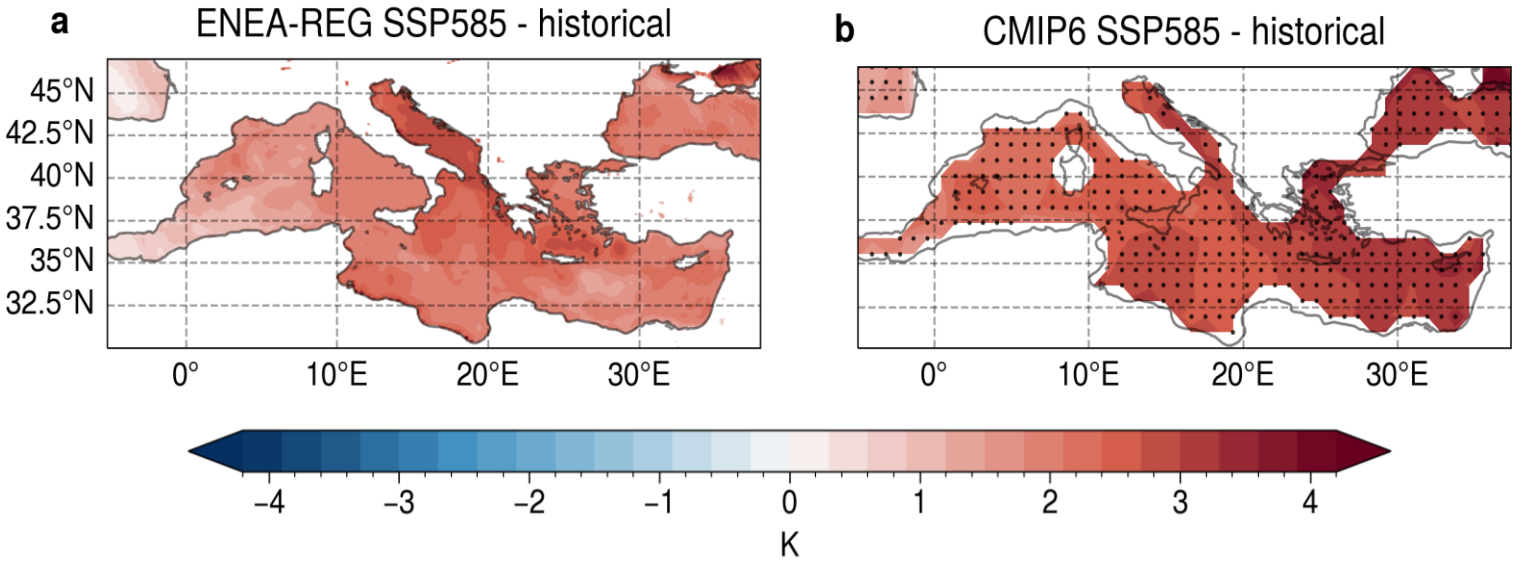
Interconnected dynamic and thermodynamic processes during Mediterranean cyclones.

Changes in **moisture transport processes** with climate change:

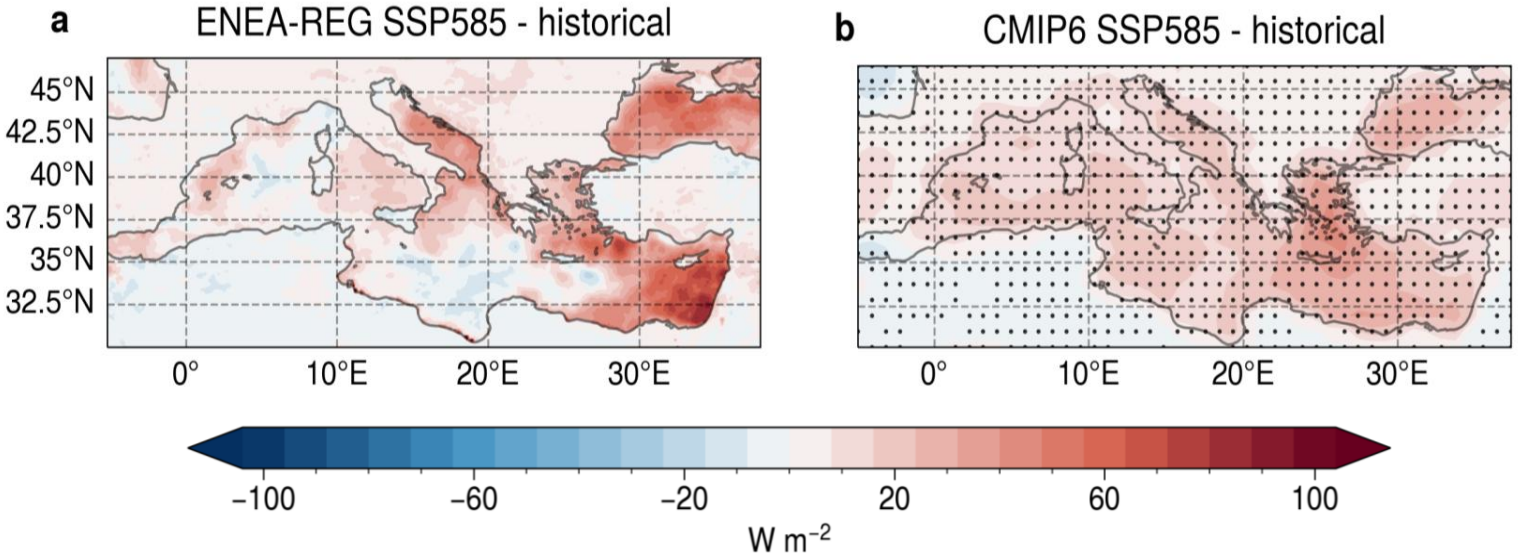
- **Evaporation** from the Sea (changes in temperature and surface winds)
- **Mid-level transport of specific humidity** (changes in cyclone-winds and atmospheric moisture)

Driving physical mechanisms: surface processes

SST



latent heat flux



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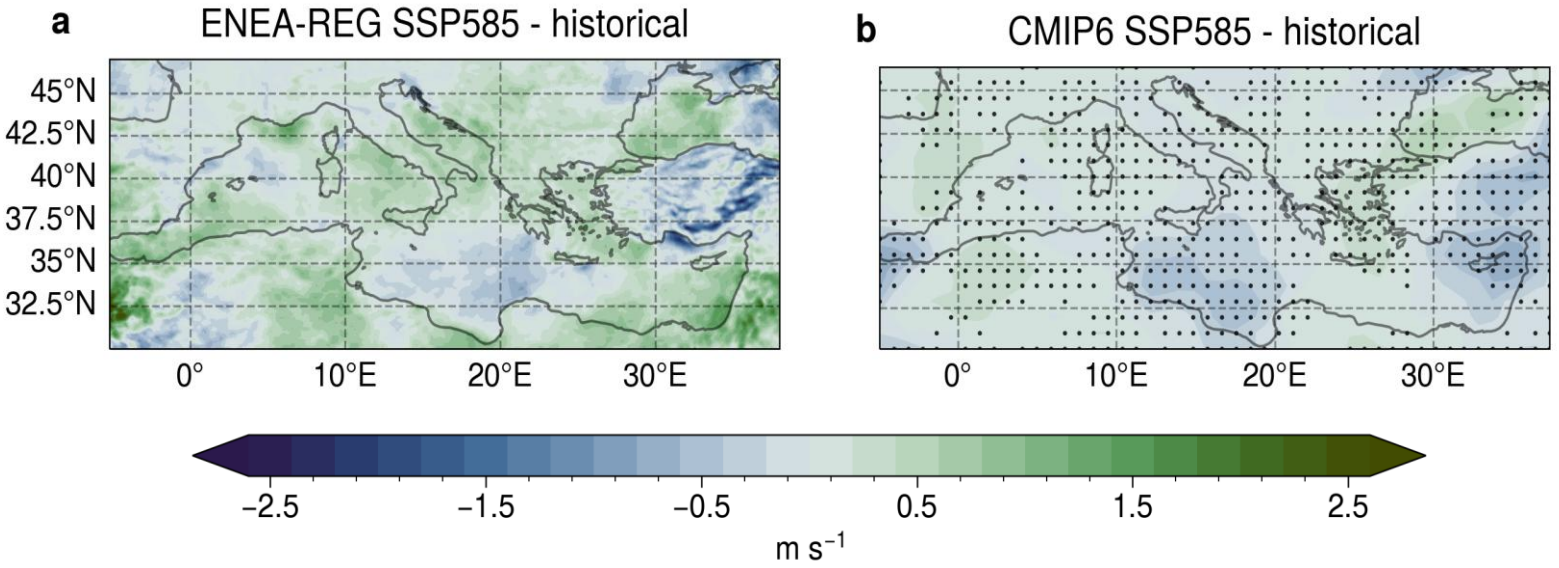
SSP585 – historical

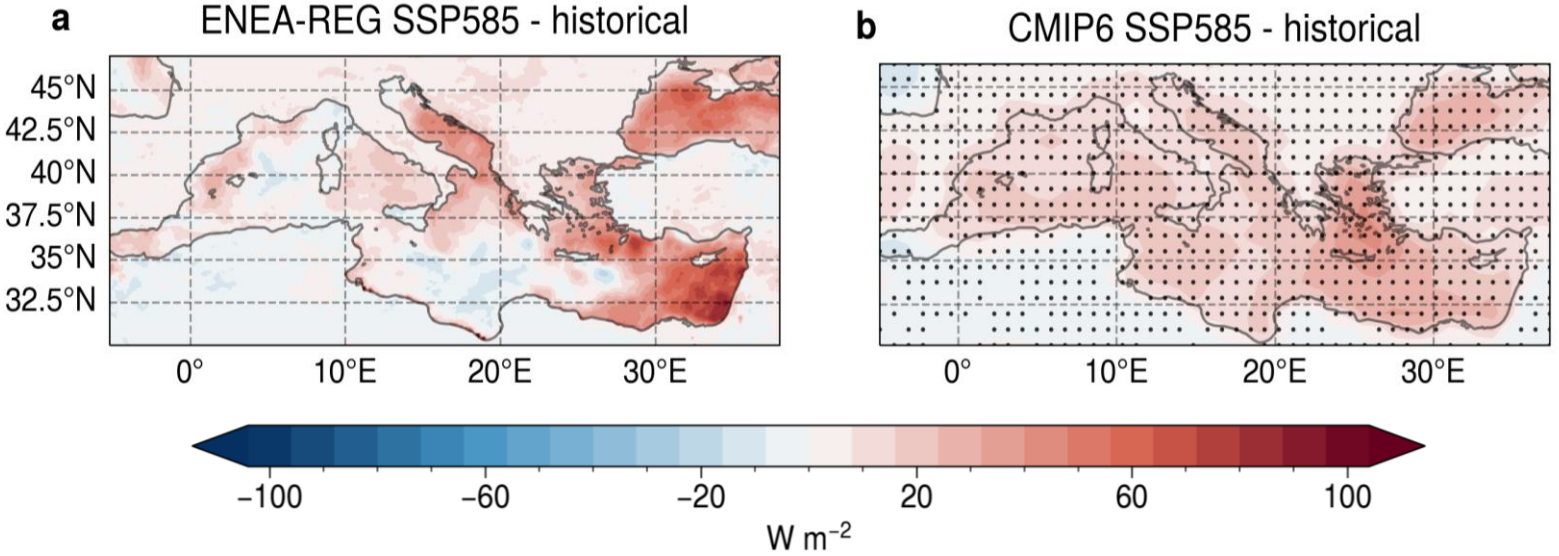
(2071-2100) - (1985-2014)

Driving physical mechanisms: surface processes

10 m wind speed



latent heat flux



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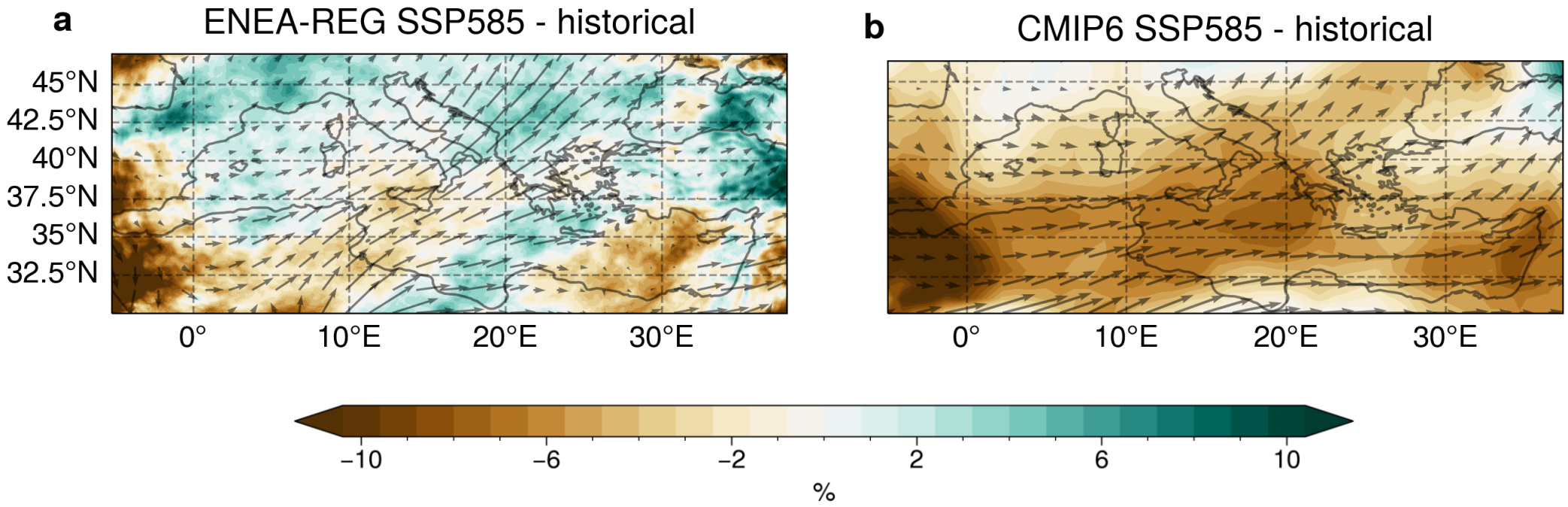
Mid-level (500 hPa) moisture transport and relative humidity



ONDJFM ; SSP 5-8.5 (2071-2100) – historical (1985-2014)

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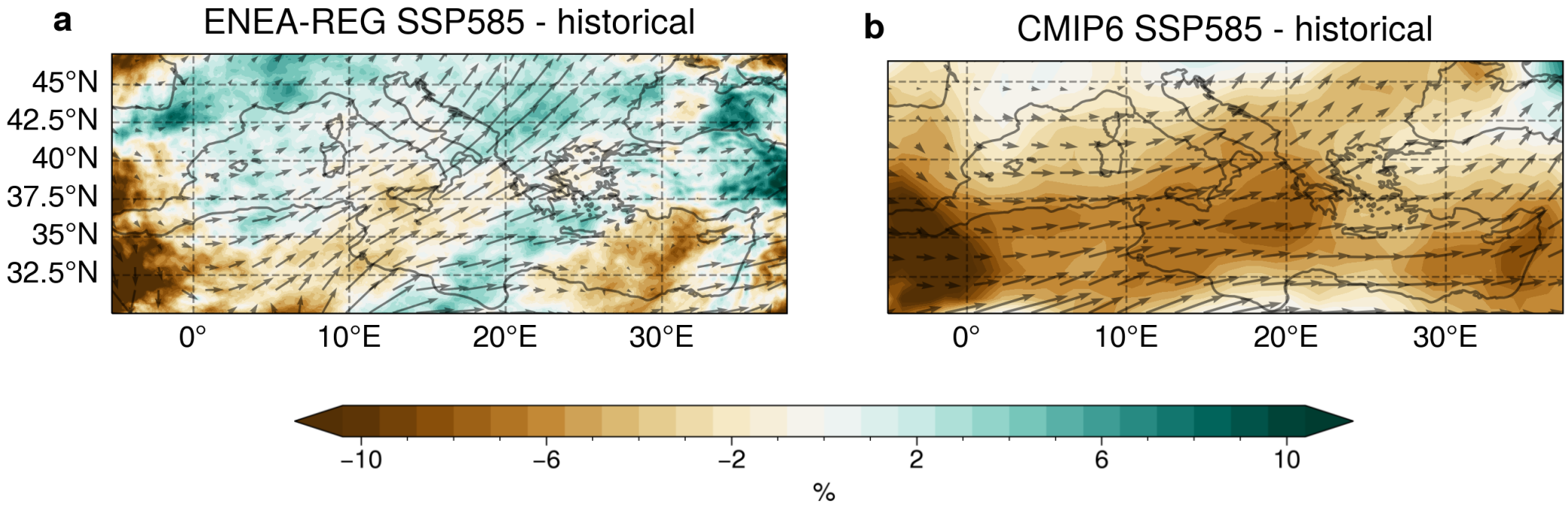

- The **high-resolution coupled model** helps to unravel the physical mechanisms driving changes in precipitation during intense storms in the Mediterranean.
- Combining different **models** are essential to improve confidence in climate projections.
- **Future step**: include more regional models from new phase of Med-CORDEX simulation.
- **Future step**: apply **storyline approach** (Zappa 2017) to improve confidence in regional climate projections.

ONDJFM ; SSP 5-8.5 (2071-2100) – historical (1985-2014)

Thank you for your time and interest ☺

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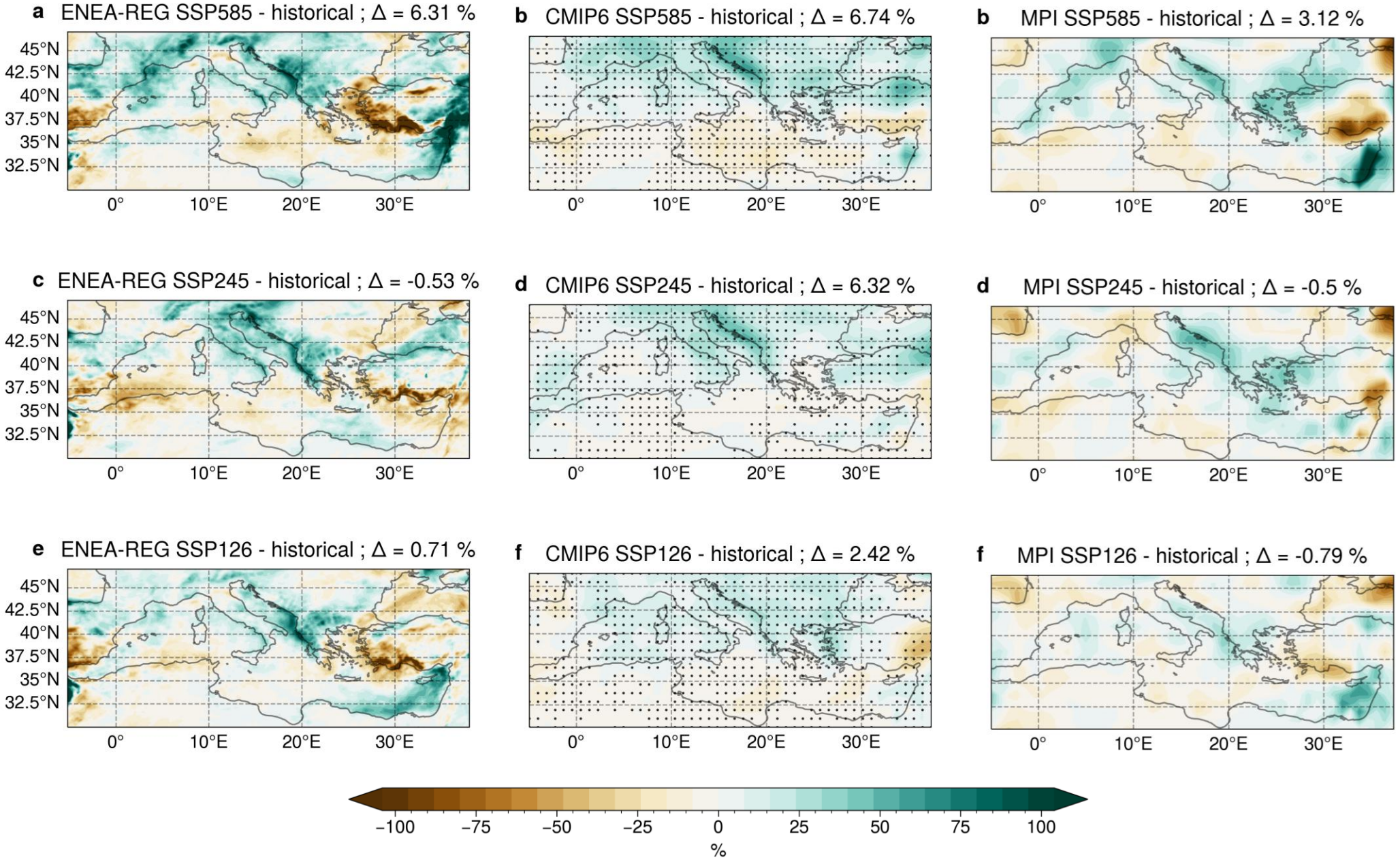
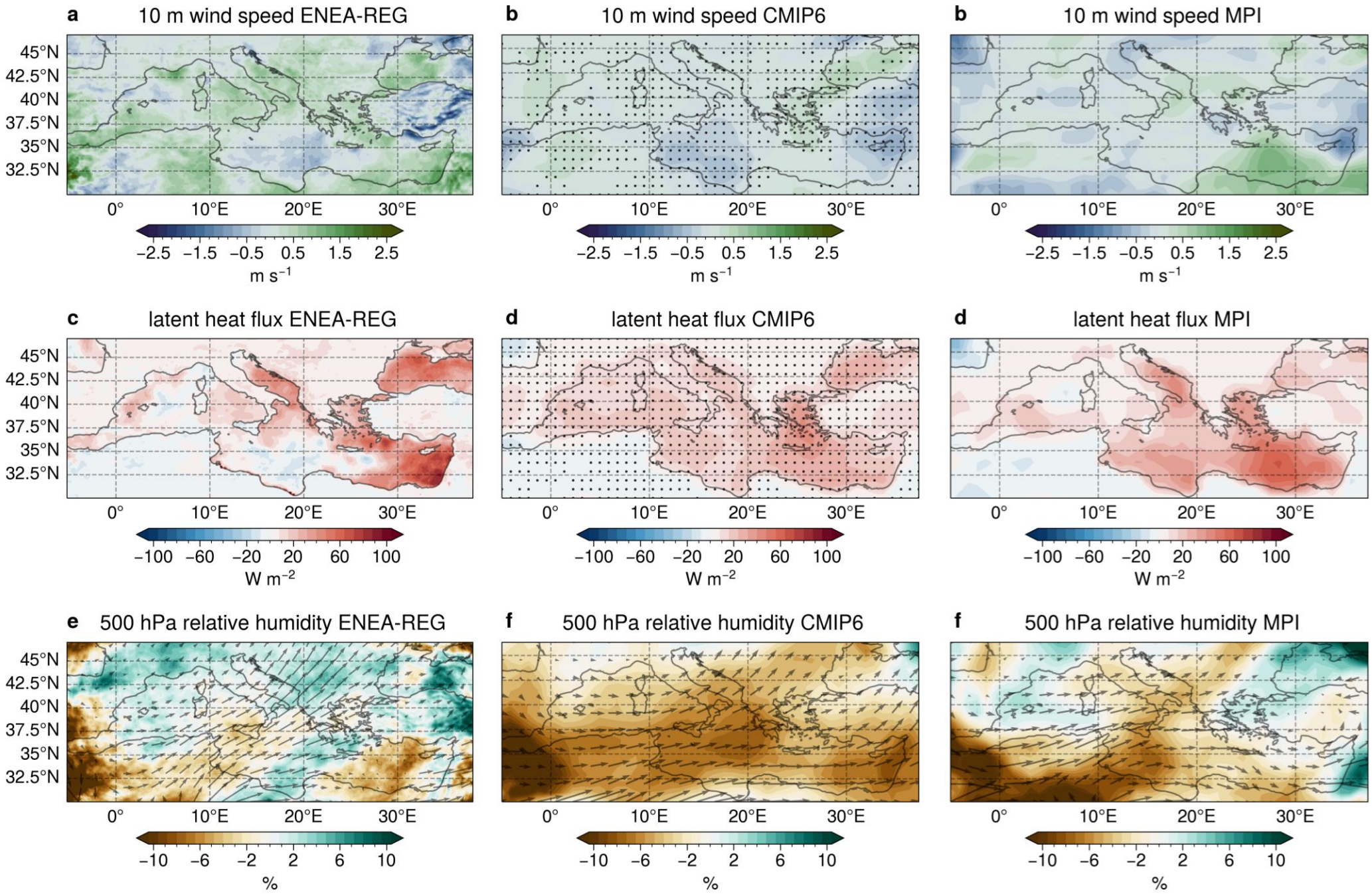
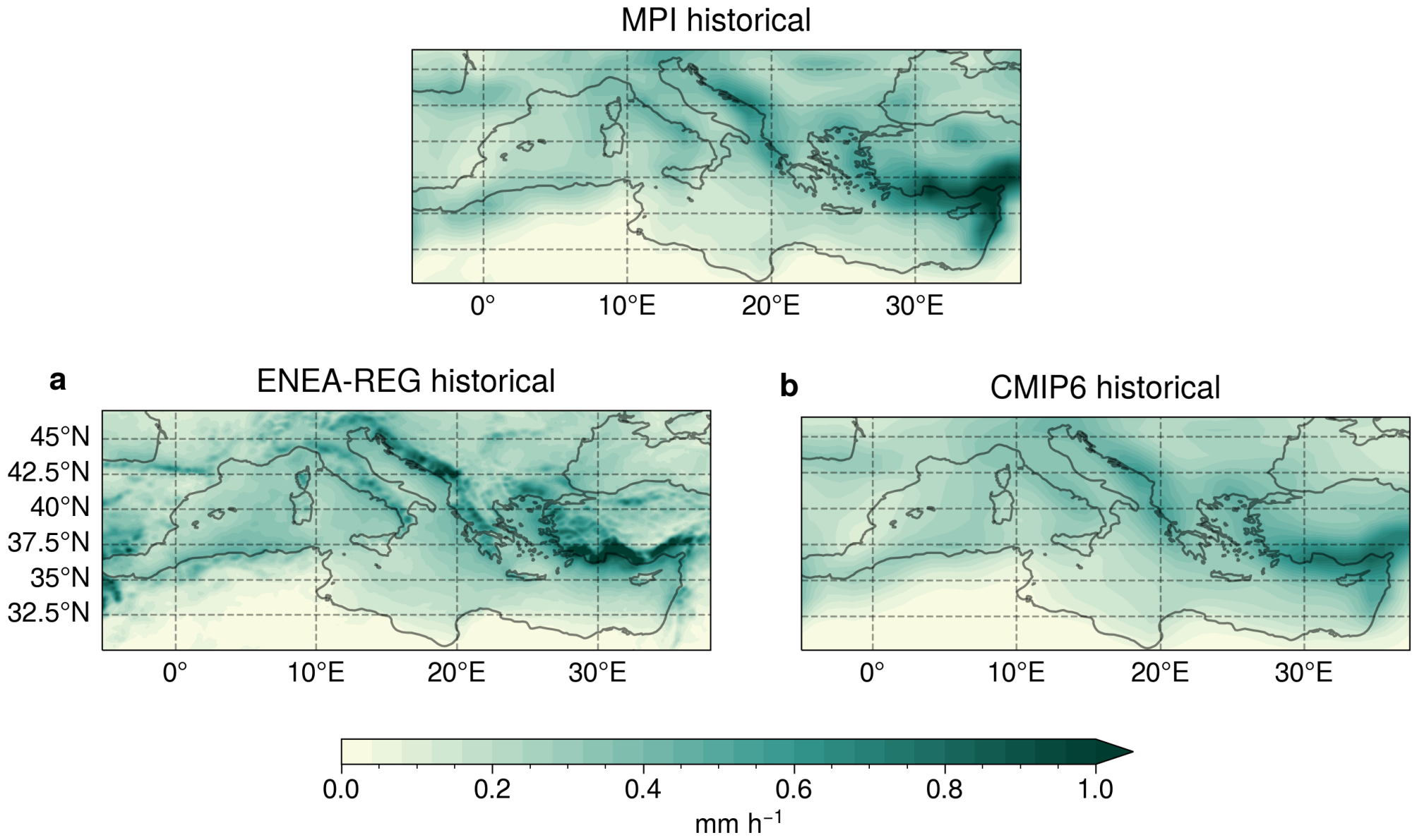


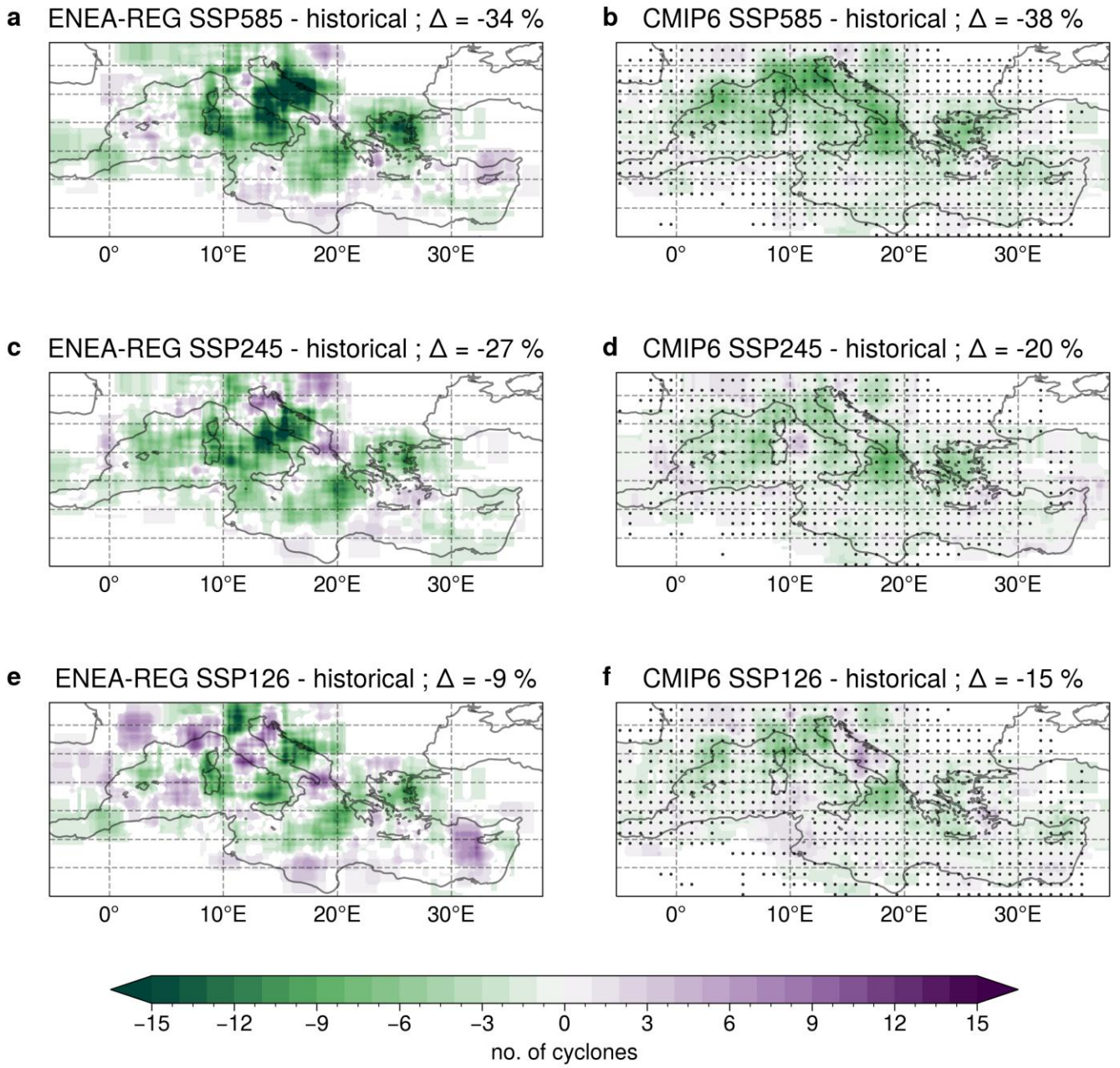
SSP585 - historical



Spatial distribution of cyclone-related precipitation



Changes in spatial distribution of intense Mediterranean cyclones



ONDJFM season

Future – historical

(2071-2100) - (1985-2014)