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Will Extremes Become the Norm under Future Climate Change?

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USAID FROM THE AMERICAN PEOPLE

- Climate change is an imminent threat to water and agriculture sectors worldwide
- In-depth assessments of local impacts are a must to guide adaptation strategies
- This is especially needed in the eastern Mediterranean basin (complex topography, water scarcity, poverty, increase in population, increase in temperature, decrease in precipitation)

http://www.worldatlas.com/

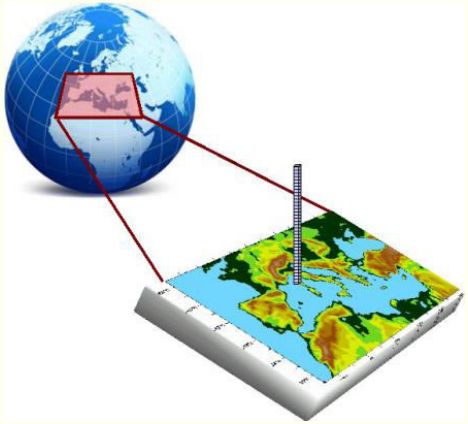
- Over complex topographic region, we expect an uneven distribution of extreme events (heat waves, droughts, flooding)
- Corresponding future climate cannot be evaluated by Global Climate Models (GCMs) only, due to their coarse resolution
- High resolution regional climate models (RCMs) are now used to dynamically downscale results from GCMs, to produce information at a local scale necessary to assess climate change impacts

Mahoney *et al.*, 2011

Objectives

1. Dynamically downscale global climate predictions over the eastern Mediterranean basin to a regional scale (focus: Lebanon) using the Weather Research and Forecasting (WRF) model forced by the High Resolution Atmospheric Model (HiRAM) for the past and the future

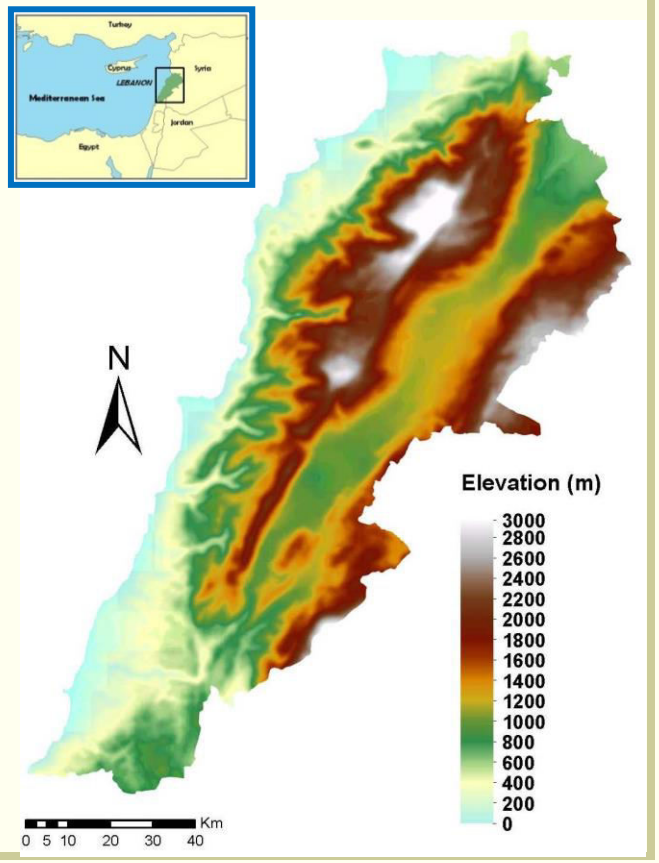
2. Use these simulations to evaluate the impact of climate change on temperature and precipitation extremes



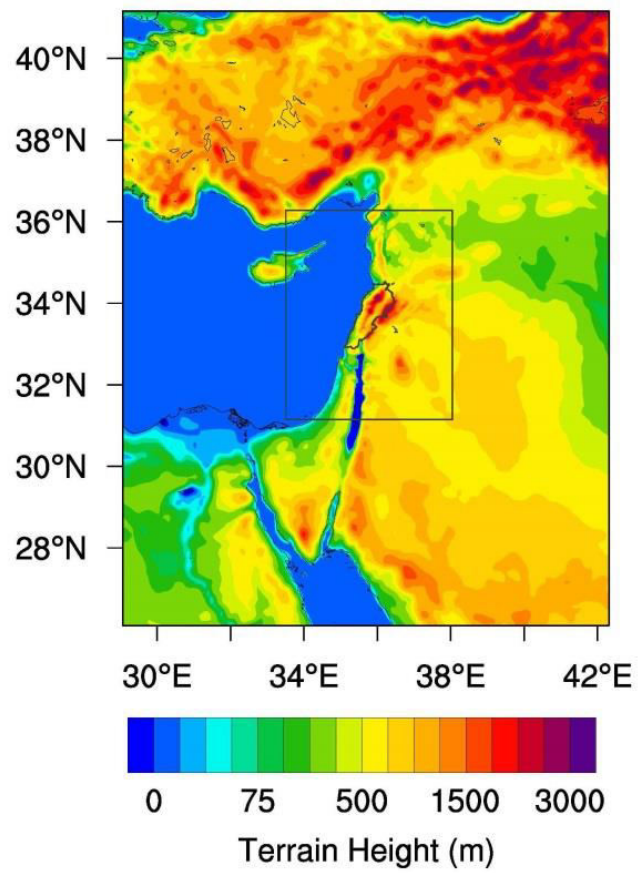
Lebaupin Brossier *et al.*, 2009

Study Area: Lebanon

- Eastern Mediterranean basin
- Area = 10,452 km^2
- High complex topography
  (results applicable in similar locations)
- High climate variability:
  - Subtropical coast
  - Mediterranean at low altitudes
  - Cold weather at high altitudes (snow)
  - Semi-desert inland plain



- GCM: HiRAM (resolution 25km)
- RCM: WRF, 2 domains (9:3km)
- One-way nesting (no nudging)
- MODIS (2001) land use data
- Dynamics and physics:
  - Dudhia SW radiation
  - RRTM LW radiation
  - Eta PBL scheme
  - Noah LSM
  - WSM 6-class microphysics scheme
- Vertical levels: 28
- HiRAM IC/BC/SST every 6hrs



- Select the two extreme years for the past (a mild/wet year, and a hot/dry year) and eight years in the future (one hot/dry year per RCP per decade) based on the following anomaly score:

$$Anomaly\ Score = \frac{1}{2}\left(\frac{P_i - \langle P_i \rangle}{max(P_i - \langle P_i \rangle)} + \frac{-(T_i - \langle T_i \rangle)}{\max(T_i - \langle T_i \rangle)}\right)$$

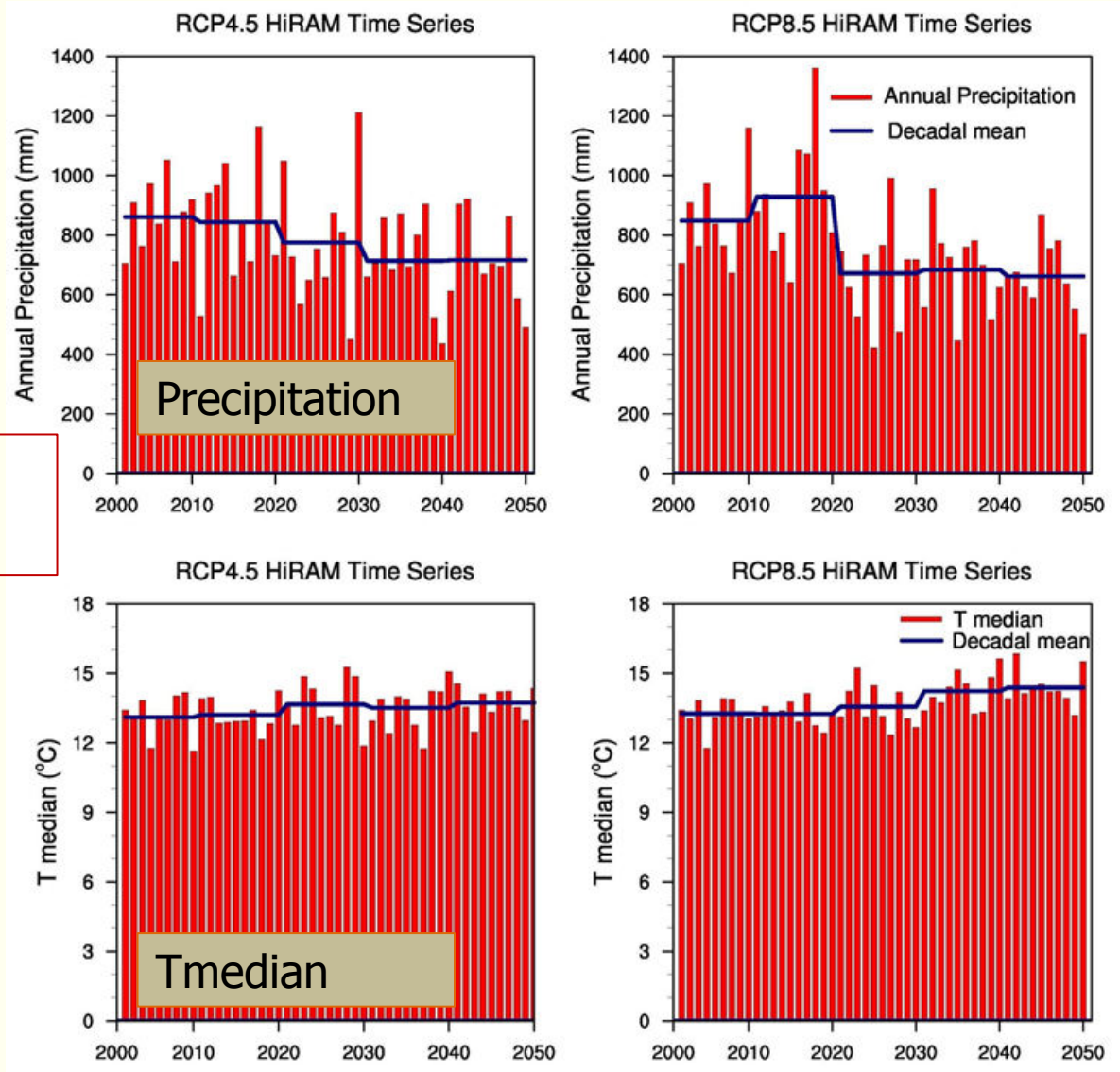
  - P_i is the cumulative precipitation for year *i*
  - $\langle P_i \rangle$ is the decadal-average of yearly precipitation P_i
  - T_i is the yearly median temperature for year *i*
  - $\langle T_i \rangle$ the decadal-average of median temperatures T_i

- The resulting minimum negative score will correspond to the critical/worst year of the decade **from a water resources perspective**

2003 (mild/wet)

2008 (hot/dry)

possible realizations



2011

RCP4.5:
2020,
2029,
2040,
2050

2015

RCP8.5:
2017,
2023,
2035,
2050

- Rainfall

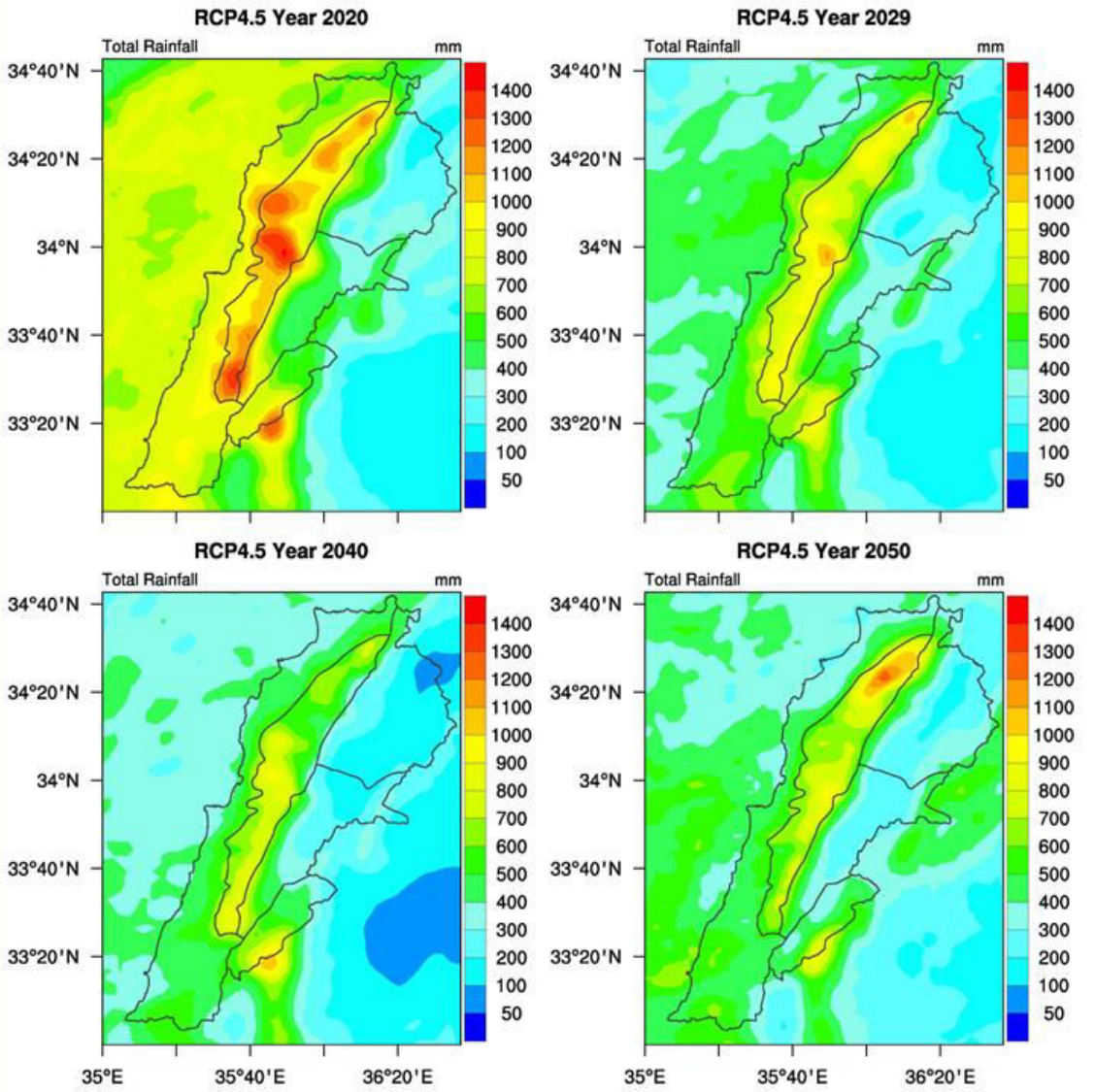
RCP4.5

+3%

-20%

-35%

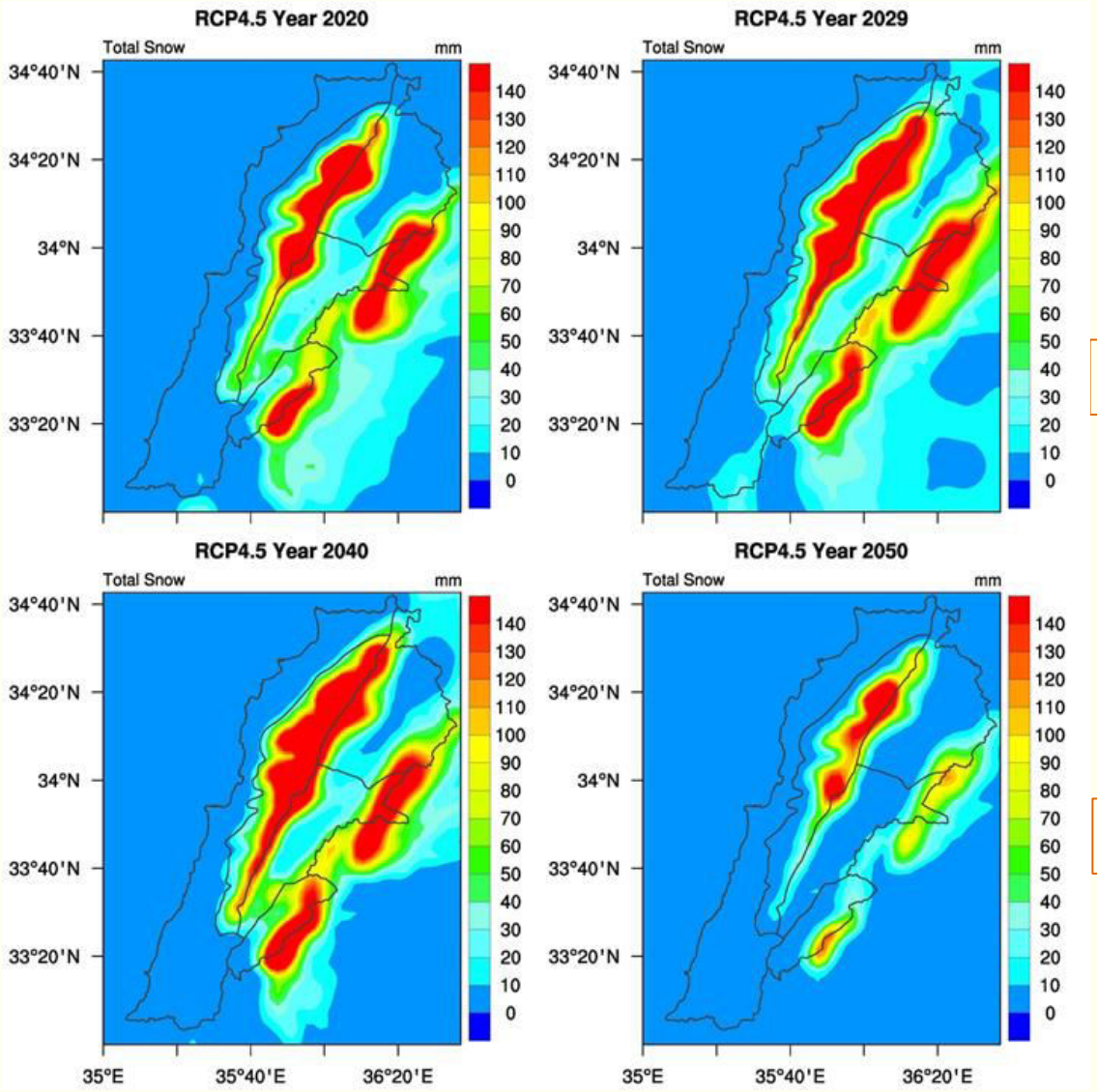
-29%



- Snowfall
  RCP4.5

+18%

+49%

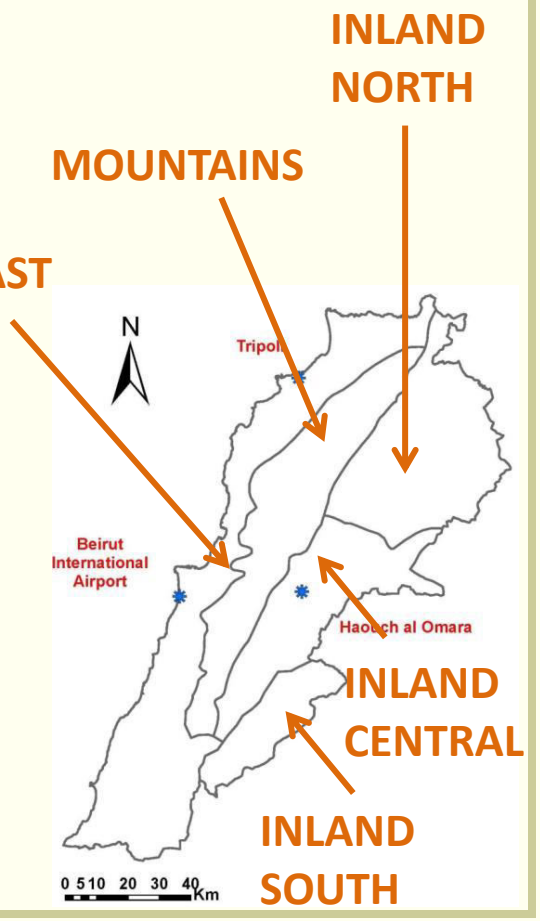


+42%

-52%

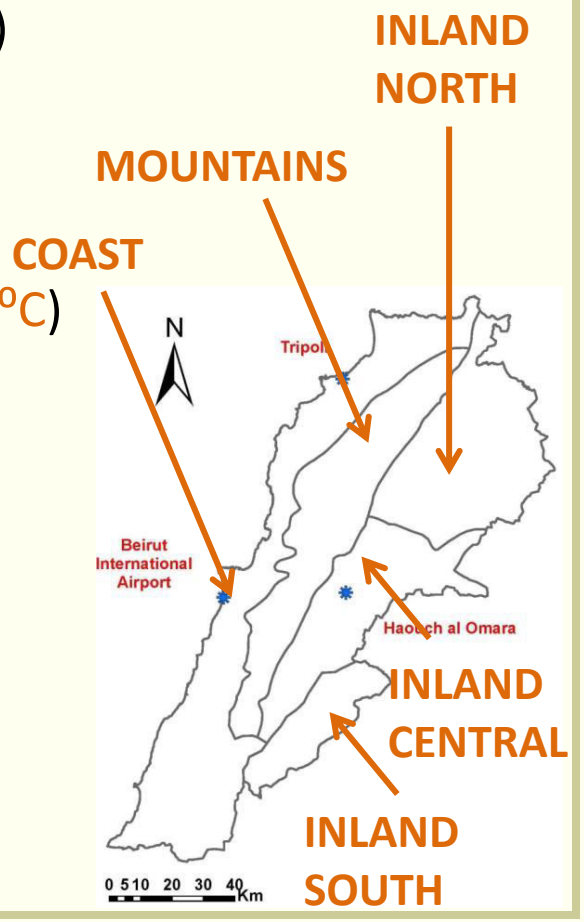
Hydrological Impacts

- **Increase** in consecutive dry days (CDD) (up to 75% in mountains)
- **Decrease** in consecutive wet days (CWD) (> 50% in inland regions)
- **Decrease** in days of heavy rainfall (R10MM) and very heavy rainfall (R20MM) (up to 50% in inland zones)
- **Decrease** in maximum one day precipitation (all regions except on the mountains, where WRF projected **a slight increase)**



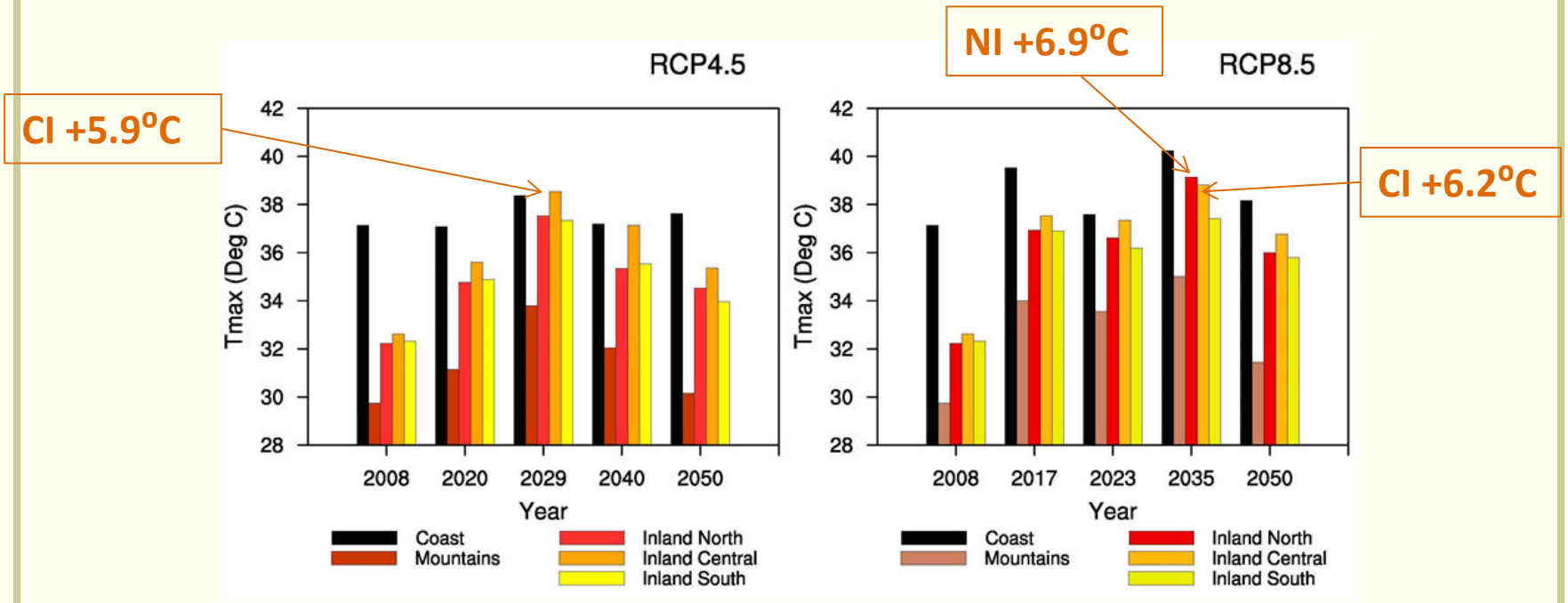
Impacts on Average Temperature

- Tavg during RCP4.5:
  - **Decreases** in the winter (1.3°C) & spring (1.4°C)
  - **Increases** in summer (1.5°C) & autumn (2.5°C)
- Tavg during RCP8.5:
  - **Decreases** in the winter (0.63°C) & spring (0.94°C)
  - **Increases** in summer (1.2°C) & autumn (2.2°C)
- Most affected regions are the **mountains** and **inland** regions (increase in summer **~ 3°C** & autumn **~ 3.9°C**)



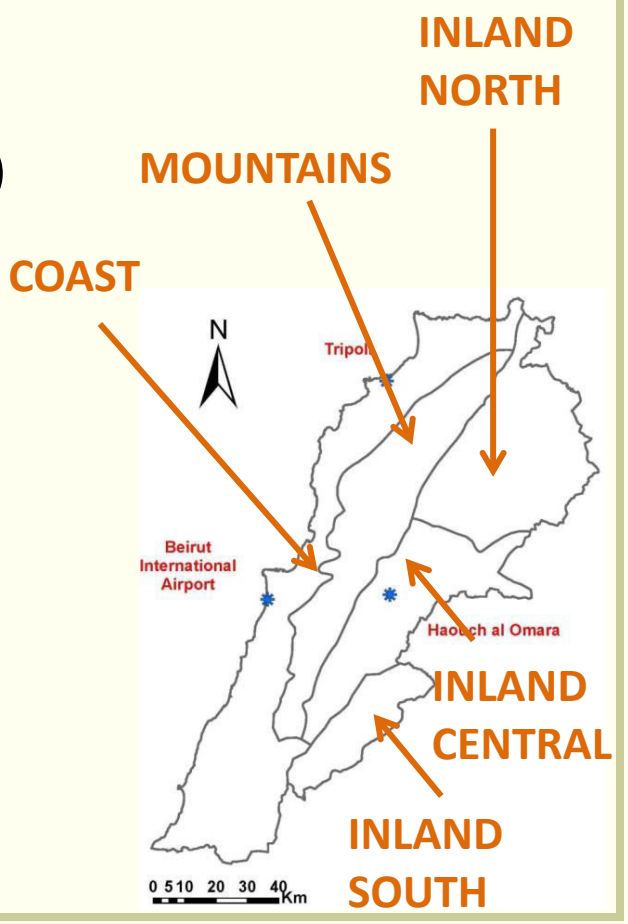
Extreme Heat Impacts

- Tmax are expected to increase on average from 1% (coast) to 15% (inland)
- Inland region experiencing the worst warming on average



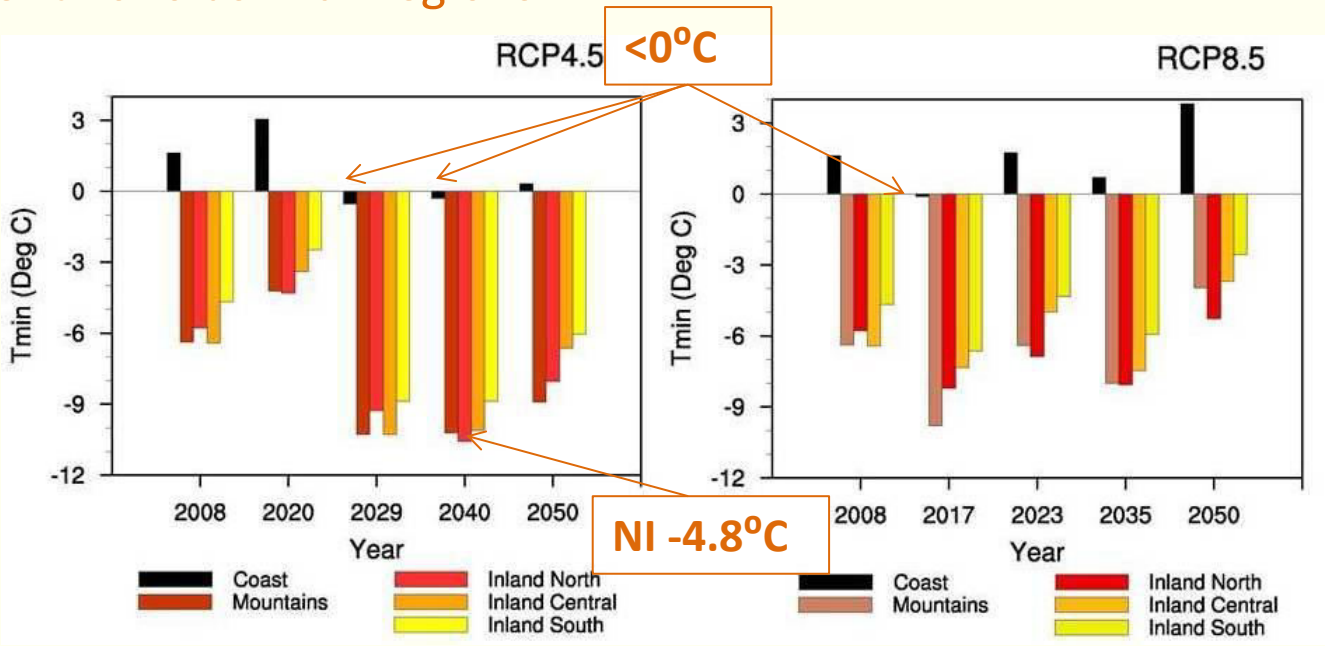
Extreme Heat Impacts

- Summer days (Tmax>25°C): increase 98% in RCP4.5 & 82% in RCP8.5 over the mountains
- Consecutive summer days (CSU) (Tmax>25°C) could double in the inland region, & triple for the mountainous region in both RCPs
- Percent of very warm days : increases up to 25% (RCP4.5) and up to 21% (RCP8.5) in inland zones



Impacts on Cold Spells

- Tmin are projected to decrease across all regions and more pronounced in RCP4.5 (1.7°C) than RCP8.5 (0.3°C)
- Number of consecutive frost days (CFD) in RCP4.5 would increase by over two folds in all regions



- This research focused on extreme future weather over the complex region of the Eastern Mediterranean: **we found that these extremes will be significantly exacerbated by climate change**.

- All WRF future simulations projected a warming over the study region with different intensities depending on the year and/or RCP under consideration, with the worst case scenario occurring in the inland and the mountainous regions

- A significantly drier climate over nearly the entire study area is predicted by the middle of this century, with reduction in annual precipitation of about 30%

- Precipitation (and snowmelt) in mountains feeds the most productive agricultural regions and these changes could undermine future production due to future water shortage

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Thank you

Questions?