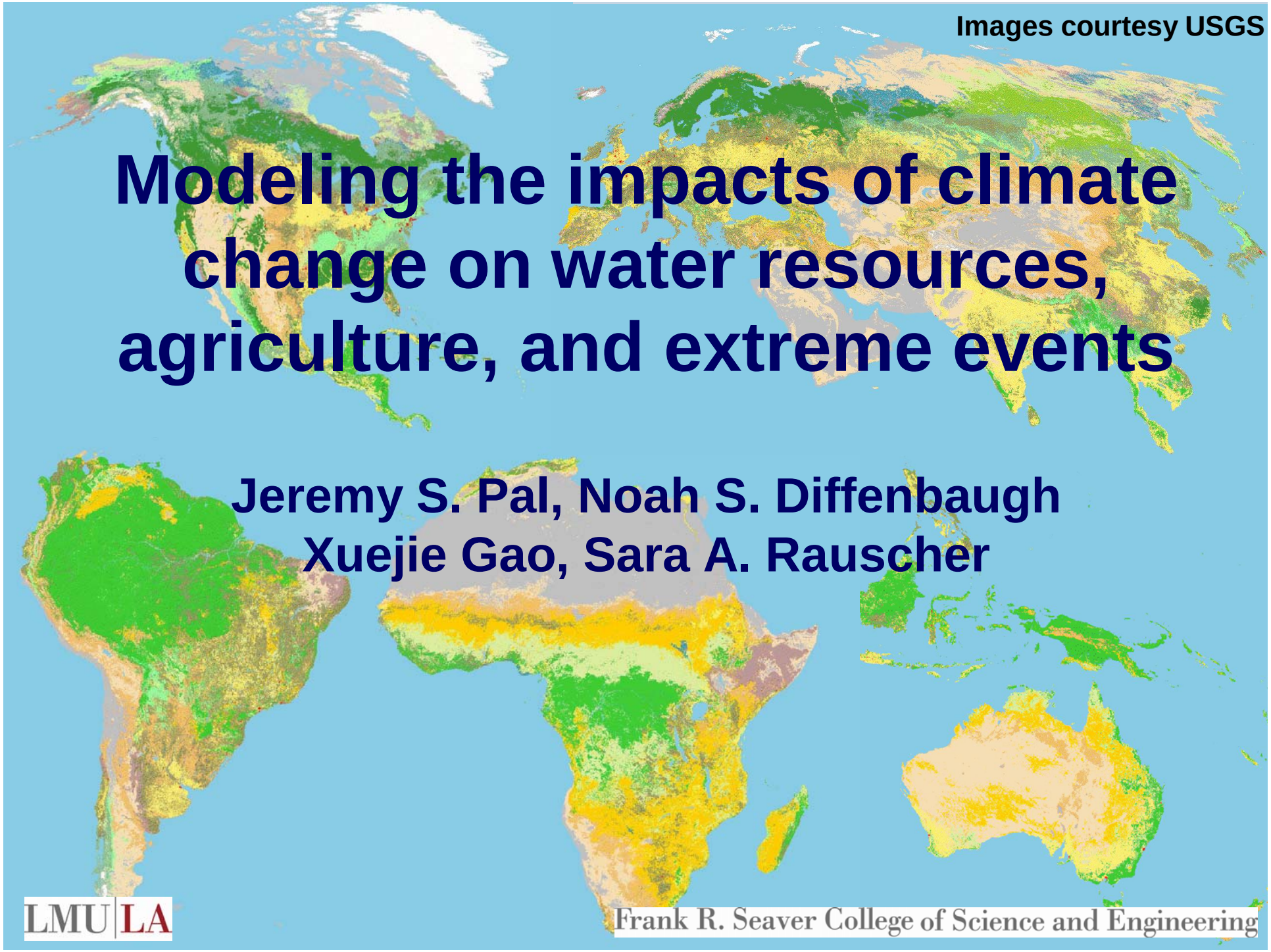


Images courtesy USGS

Modeling the impacts of climate change on water resources, agriculture, and extreme events

Jeremy S. Pal, Noah S. Diffenbaugh
Xuejie Gao, Sara A. Rauscher

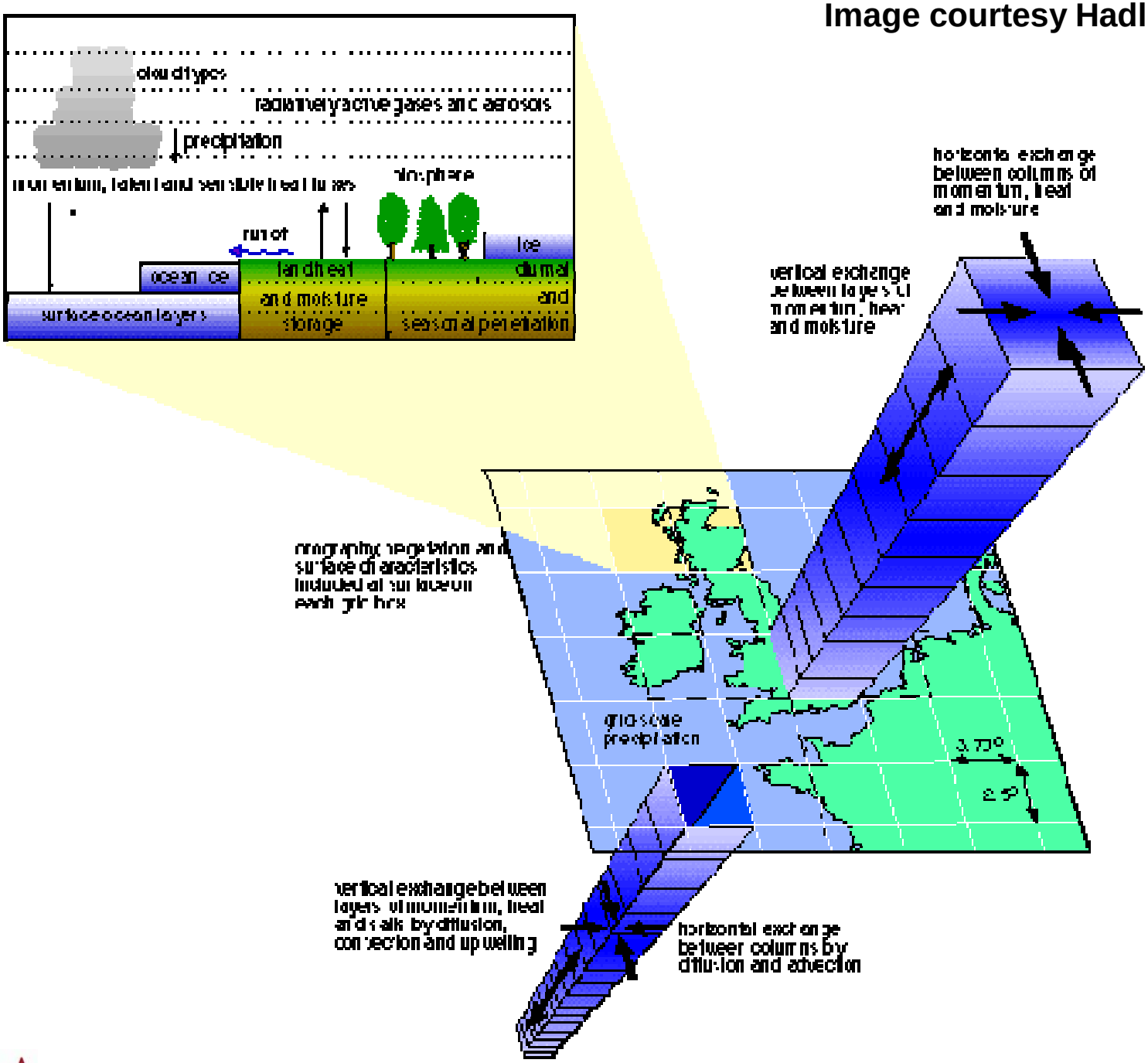
LMU|LA
Frank R. Seaver College of Science and Engineering

Outline

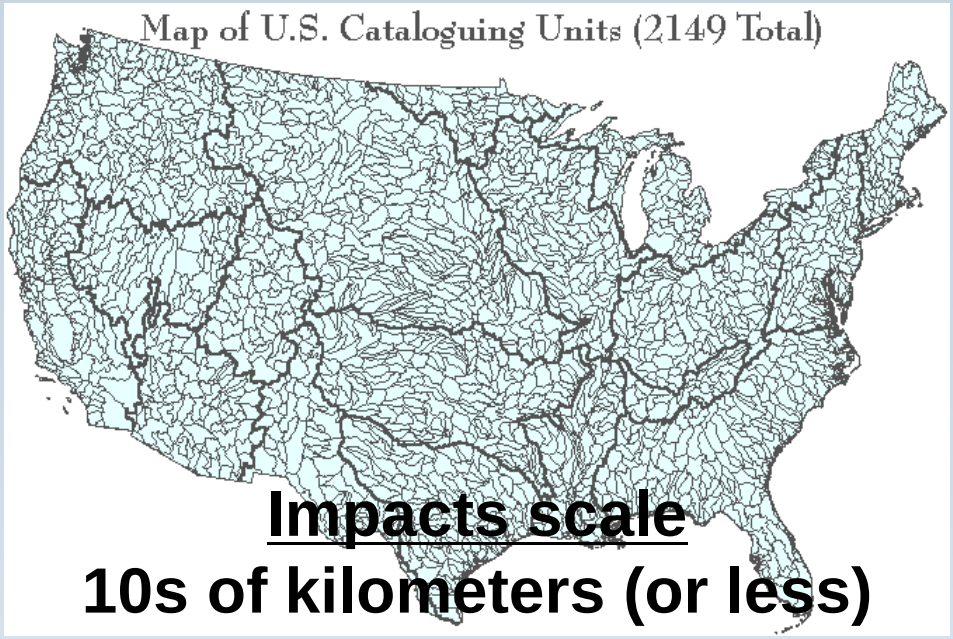
- **Part I: Regional Climate Modeling**
- **Part II: Impacts**

Part I:
Regional Climate Modeling

Image courtesy Hadley Centre

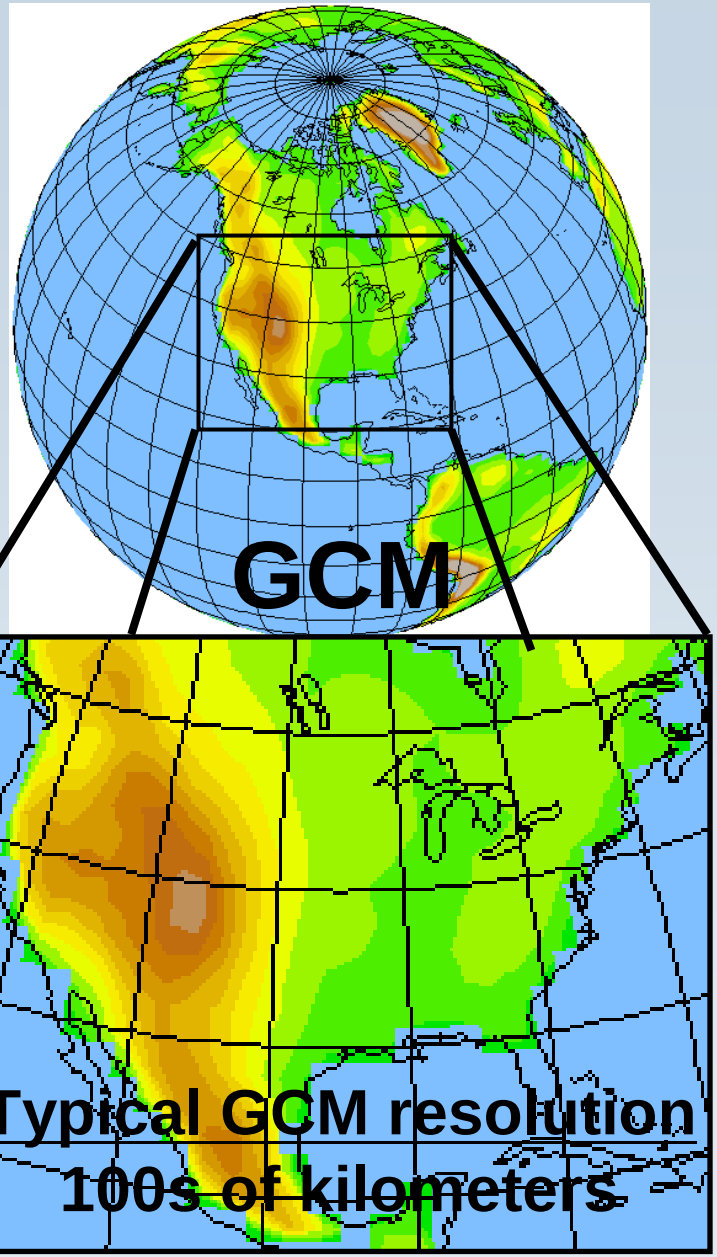


Bridging the Scaling Gap



Impacts scale
10s of kilometers (or less)

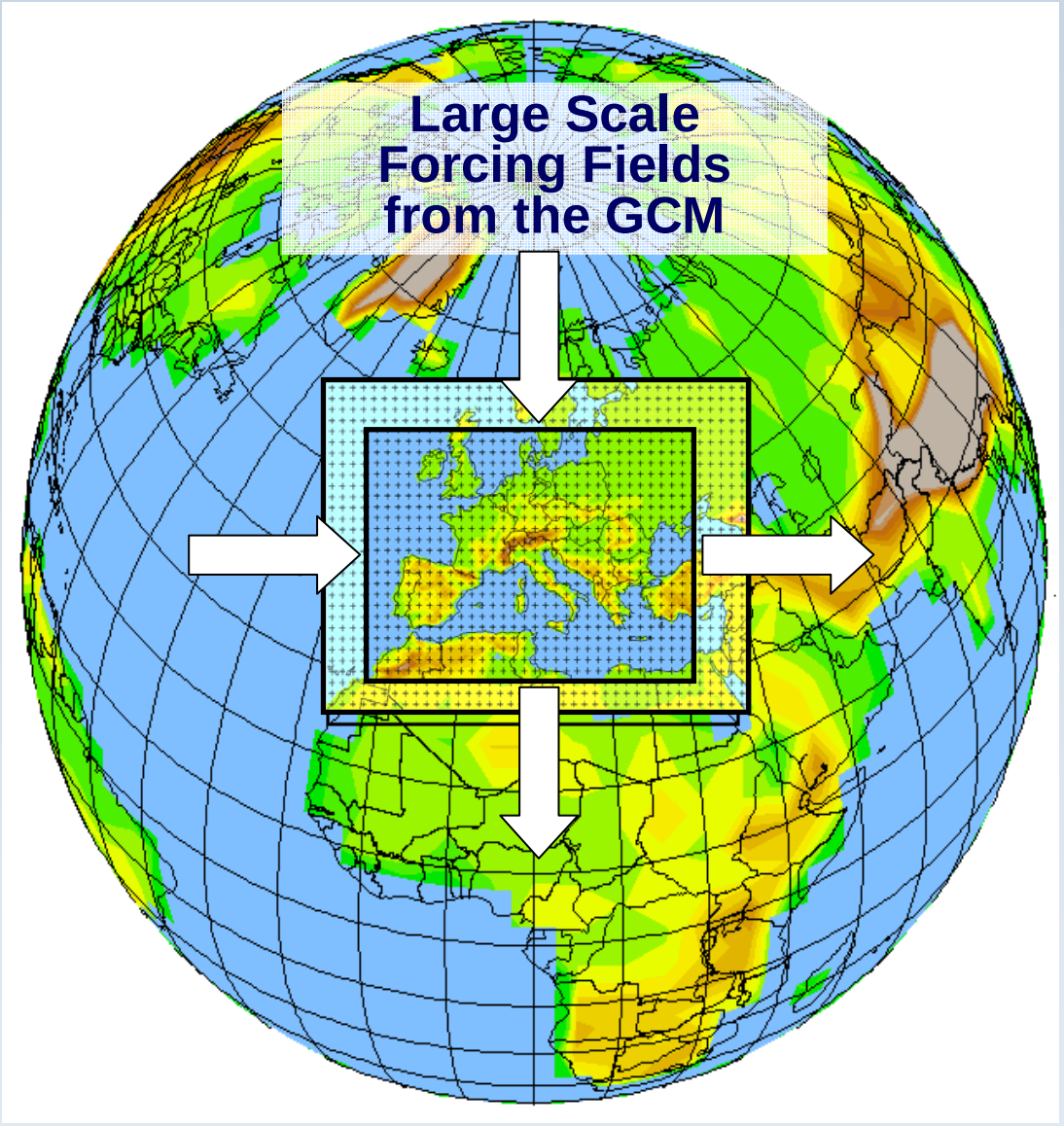
How do we go from the GCM scale to the impacts scale?



Typical GCM resolution
100s of kilometers

Regional Climate Modeling

- Regional Climate Models (RCMs) can be “nested” within a GCM
  - Increase resolution to 10s km.
- Lateral boundary conditions are obtained from the GCM.
  - “Relaxed” in via the buffer zone.
- Intended to enhance the GCM simulation.
  - Garbage in, garbage out.



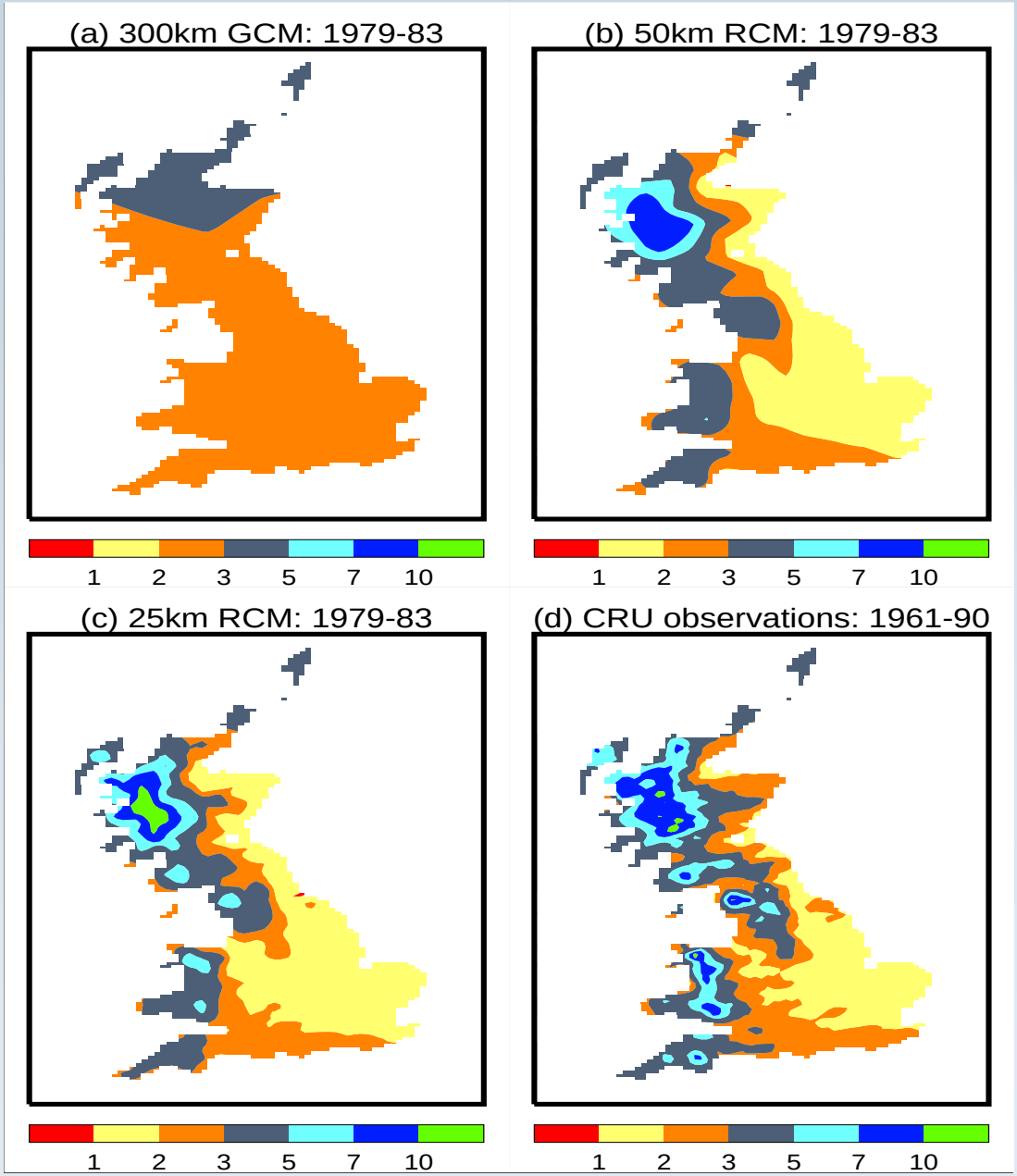
Winter Precipitation over Britain

300km GCM

50km RCM

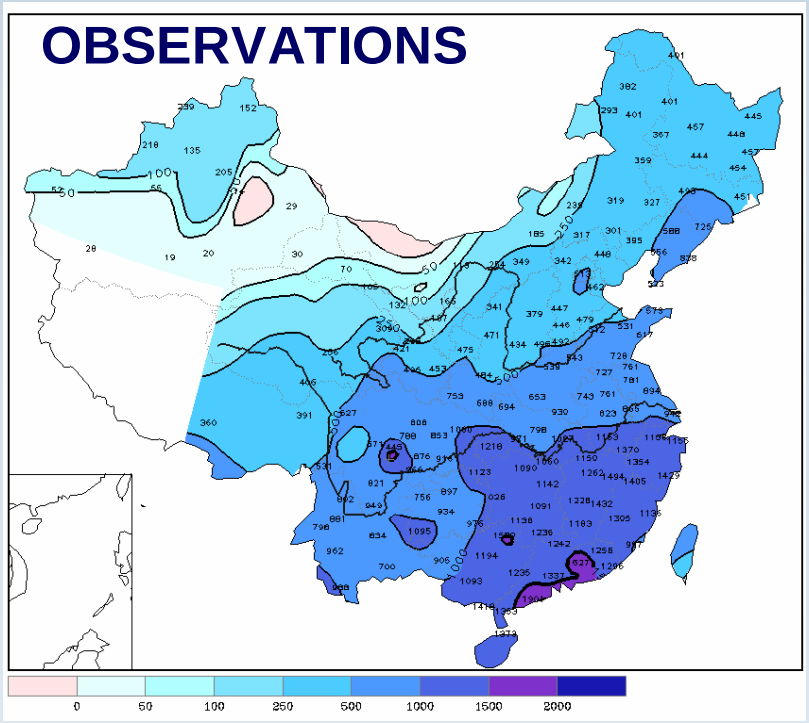
25km RCM

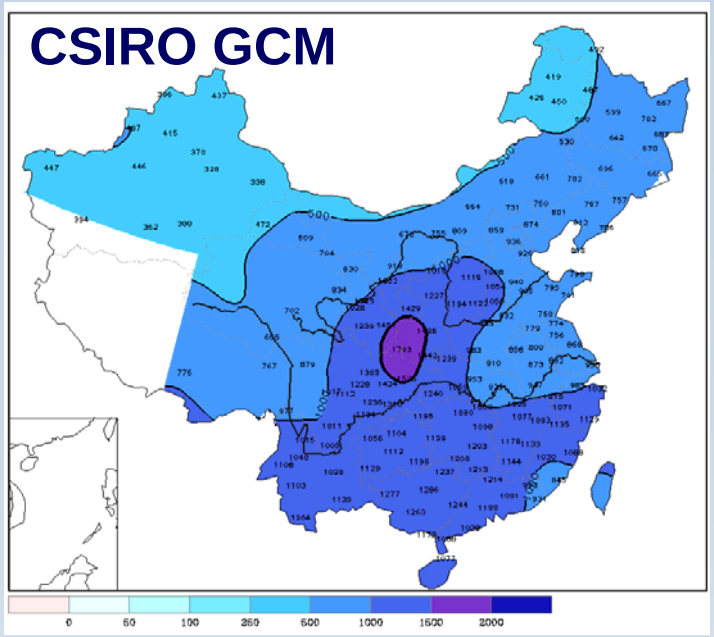
Observed

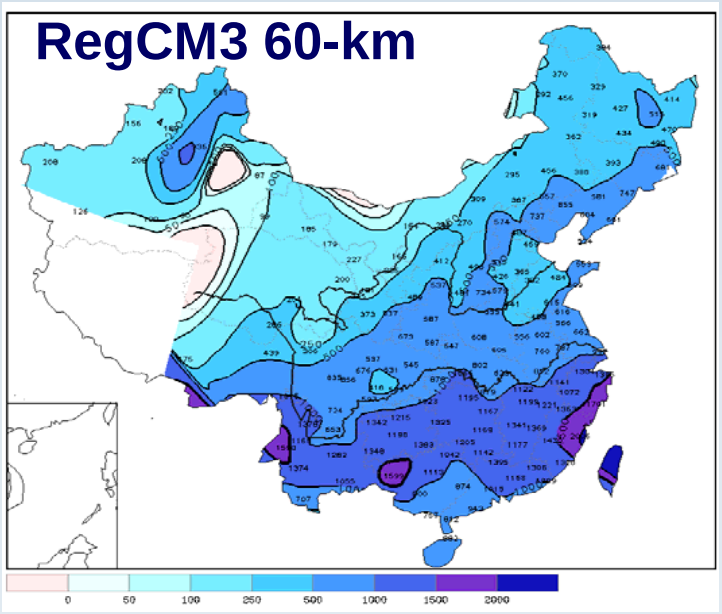


Courtesy: R. Jones
Hadley Centre

East Asian Monsoon Precipitation

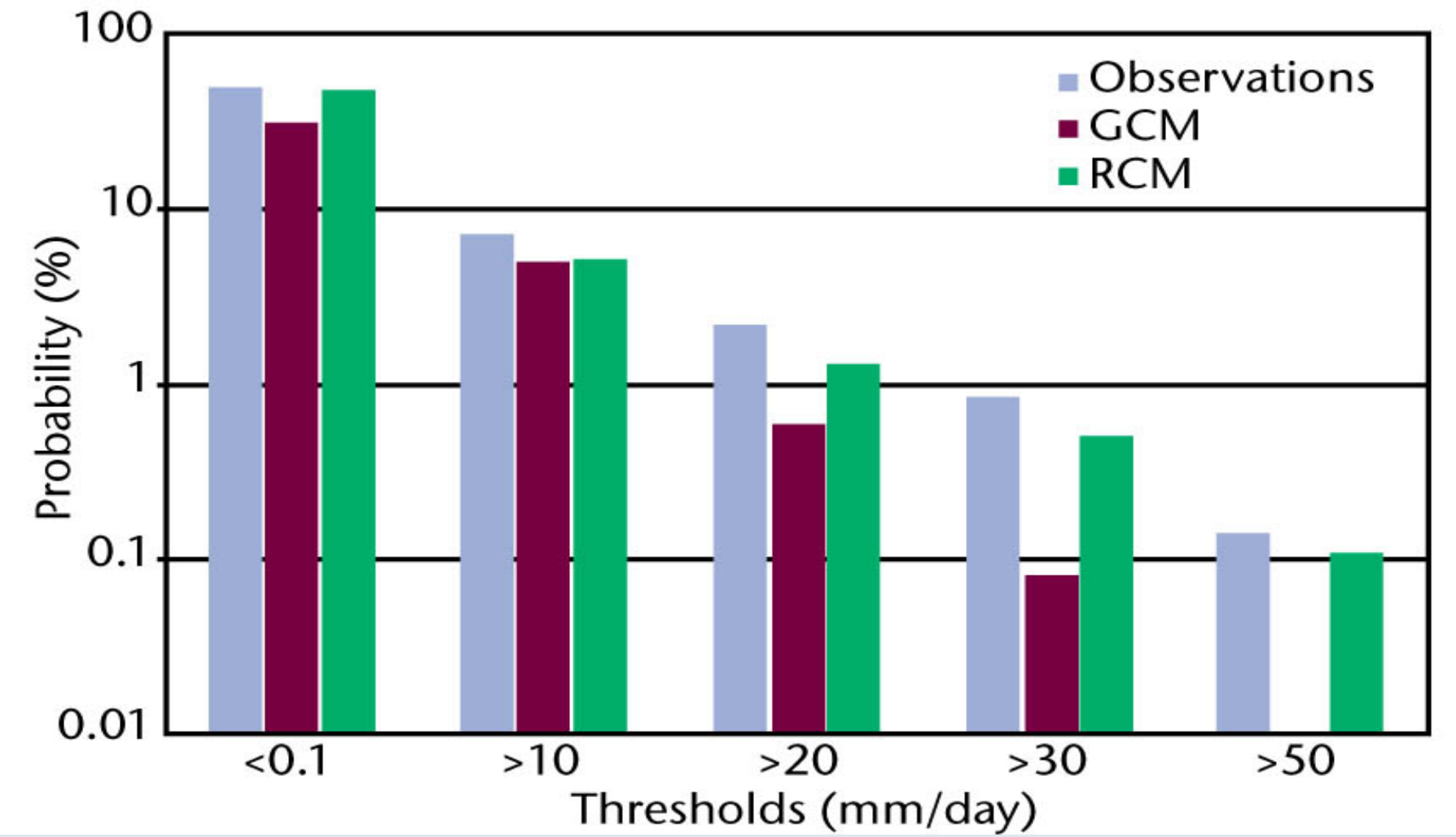






Gao et al 2006

Winter Daily Precipitation over the Alps

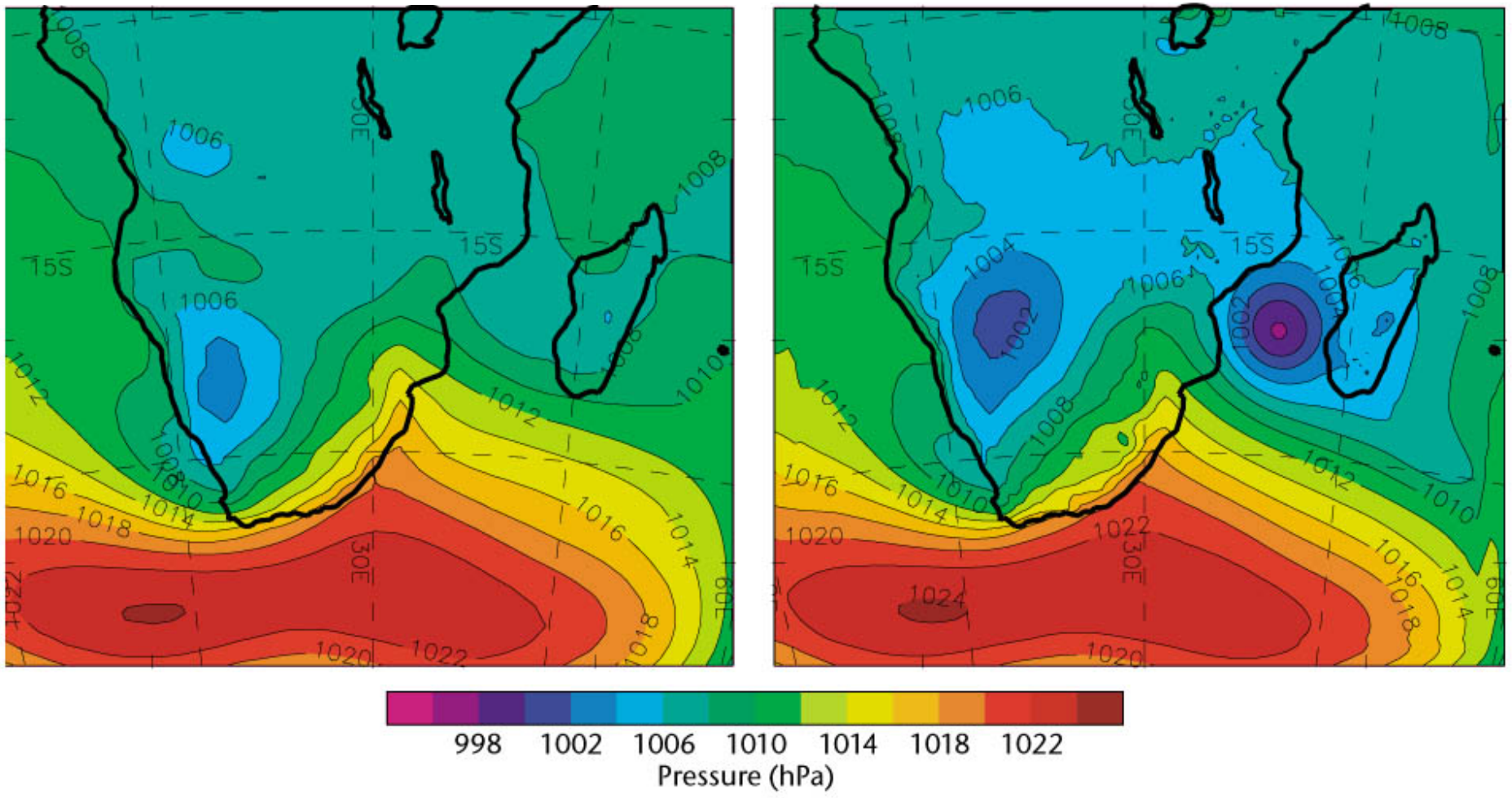


RCMs typically simulate extreme precipitation better than GCMs. They also tend to better simulate interseasonal variability.

Simulation of a Tropical Cyclone

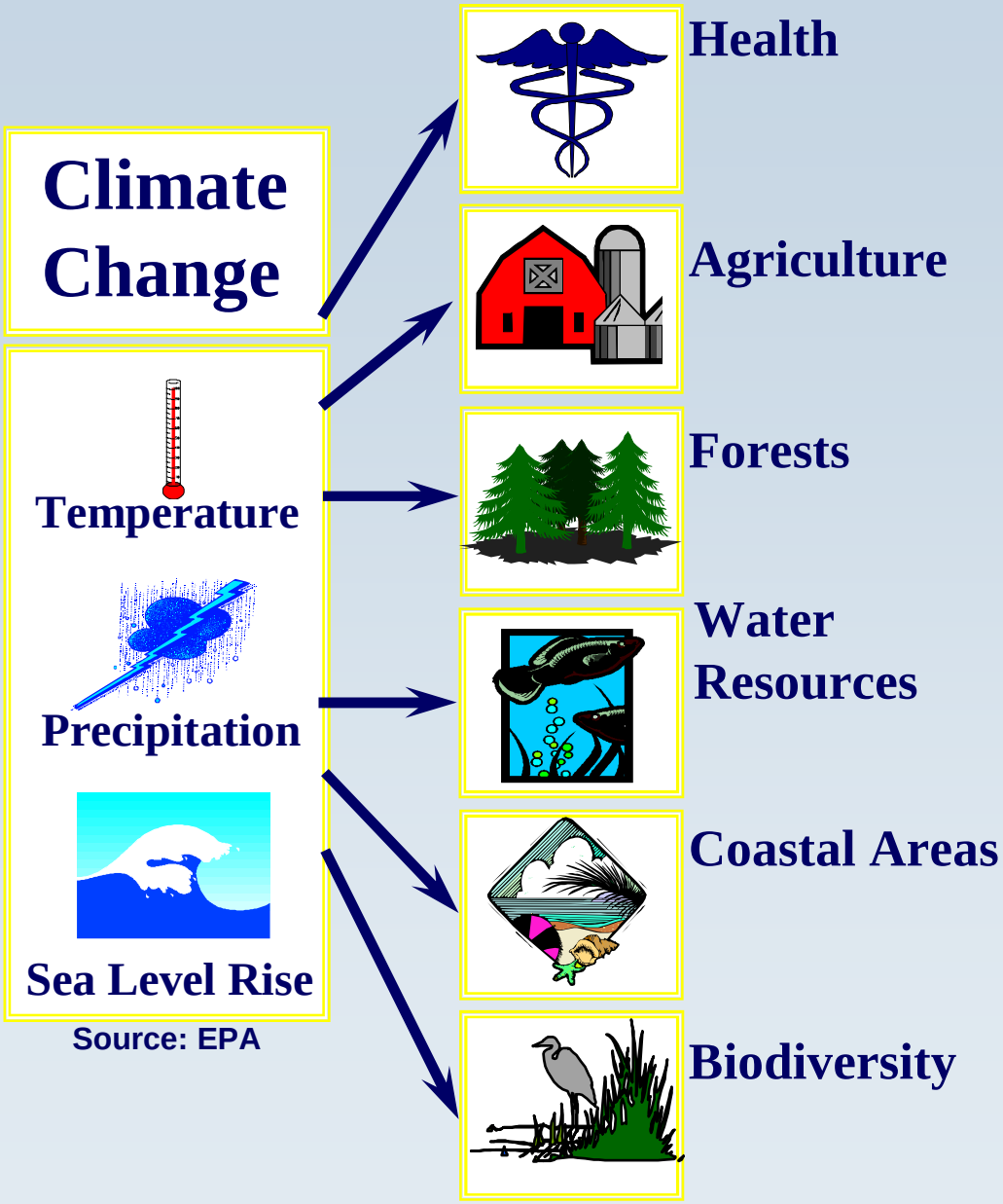
Global Climate Model

Regional Climate Model



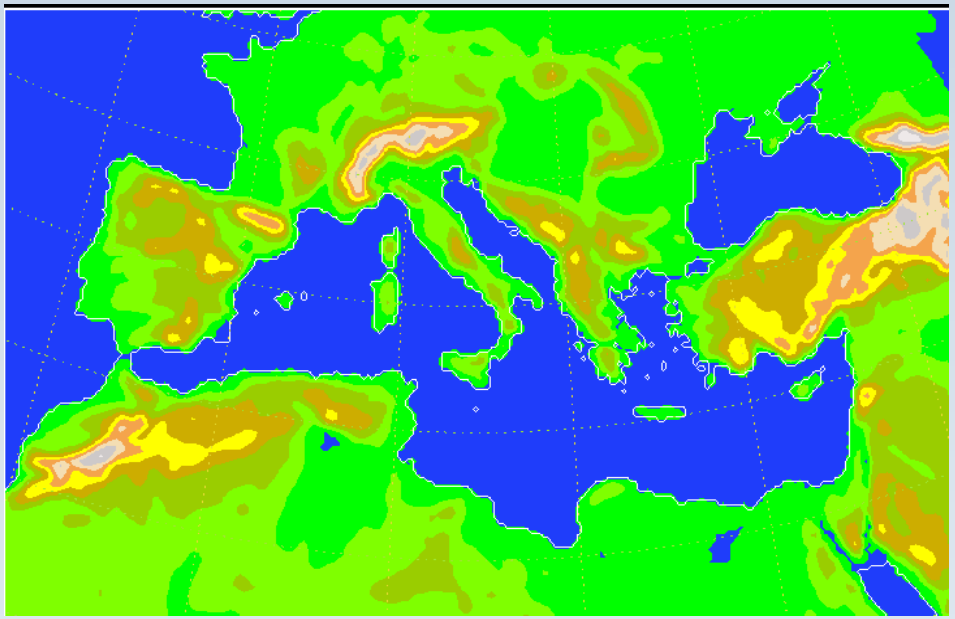
RCMs can simulate circulation features not resolved by GCMs

Part II: Impacts



High resolution double-nested simulations

- **Model configuration**
  - **20-km grid point spacing**
  - **Full Mediterranean domain**
- **Experiment design**
  - **Forcing fields from PRUDENCE RegCM simulations**
  - **Reference simulation (1961-1990)**
  - **A2, B2 scenarios (2071-2100)**



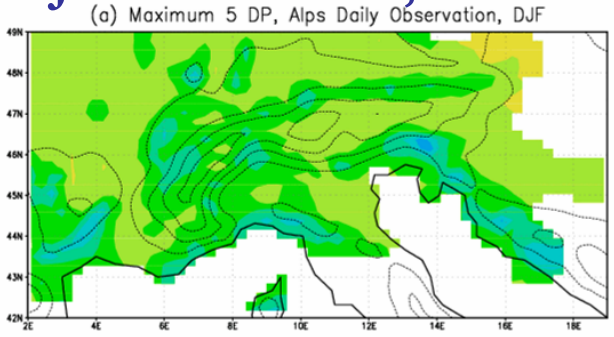
ICTP Regional Climate Model, RegCM3

- **Dynamics:**
  MM5 Hydrostatic (Grell et al 1994)
- **Radiation:**
  CCM3 (Kiehl 1996)
- **Large-Scale Clouds & Precipitaion:**
  SUBEX (Pal et al 2000)
- **Cumulus convection:**
  Grell (1993)
  MIT (Emanuel 1991)
- **Boundary Layer:**
  Holtslag (1990)
- **Tracers/Aerosols:**
  Solmon et al 2005
  Zakey et al 2006
- **Land Surface:**
  BATS (Dickinson et al 1993)
  SUB-BATS (Giorgi et al 2003)
  CLM3 (Bonan; In progress)
- **Ocean Fluxes**
  Zeng et al (1998)

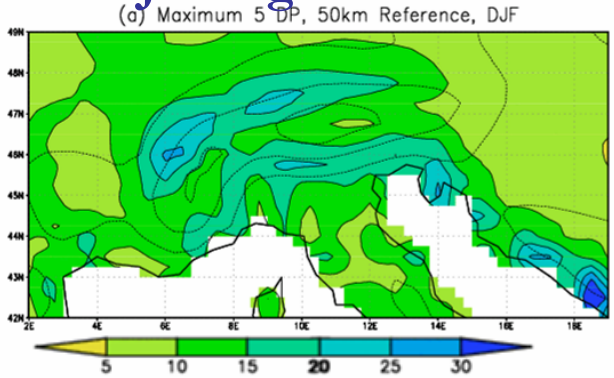
Pal et al 2007, BAMS

Maximum 5 Day Precipitation (1961-1990)

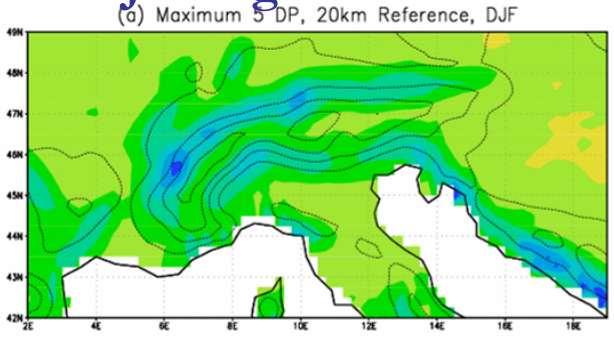
DJF Frei & Schär, 1998 Obs

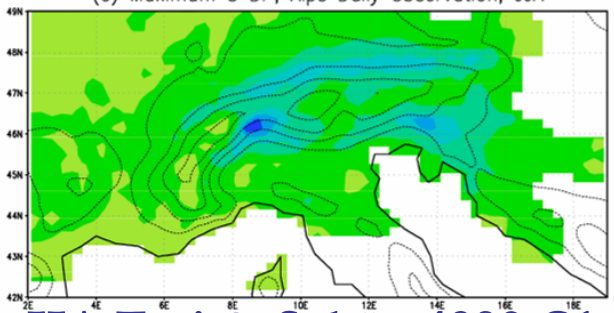


DJF RegCM3 50-km

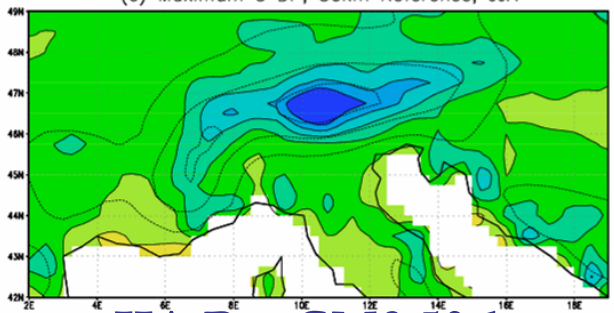


DJF RegCM3 20-km

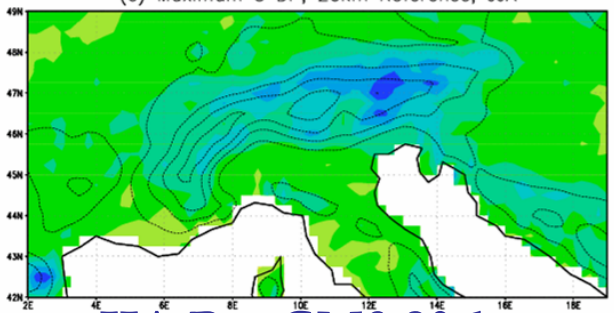




JJA Frei & Schär, 1998 Obs

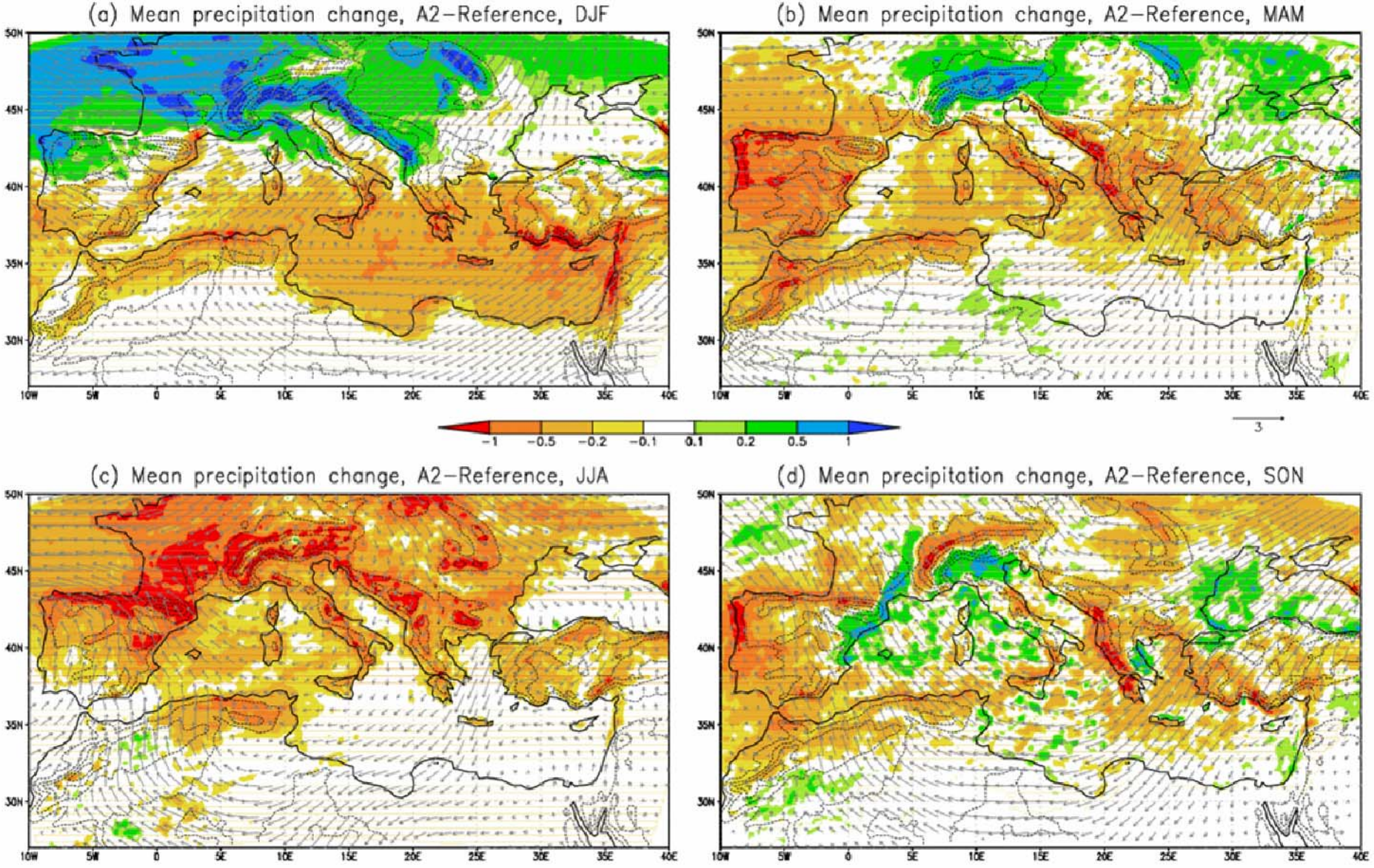


JJA RegCM3 50-km

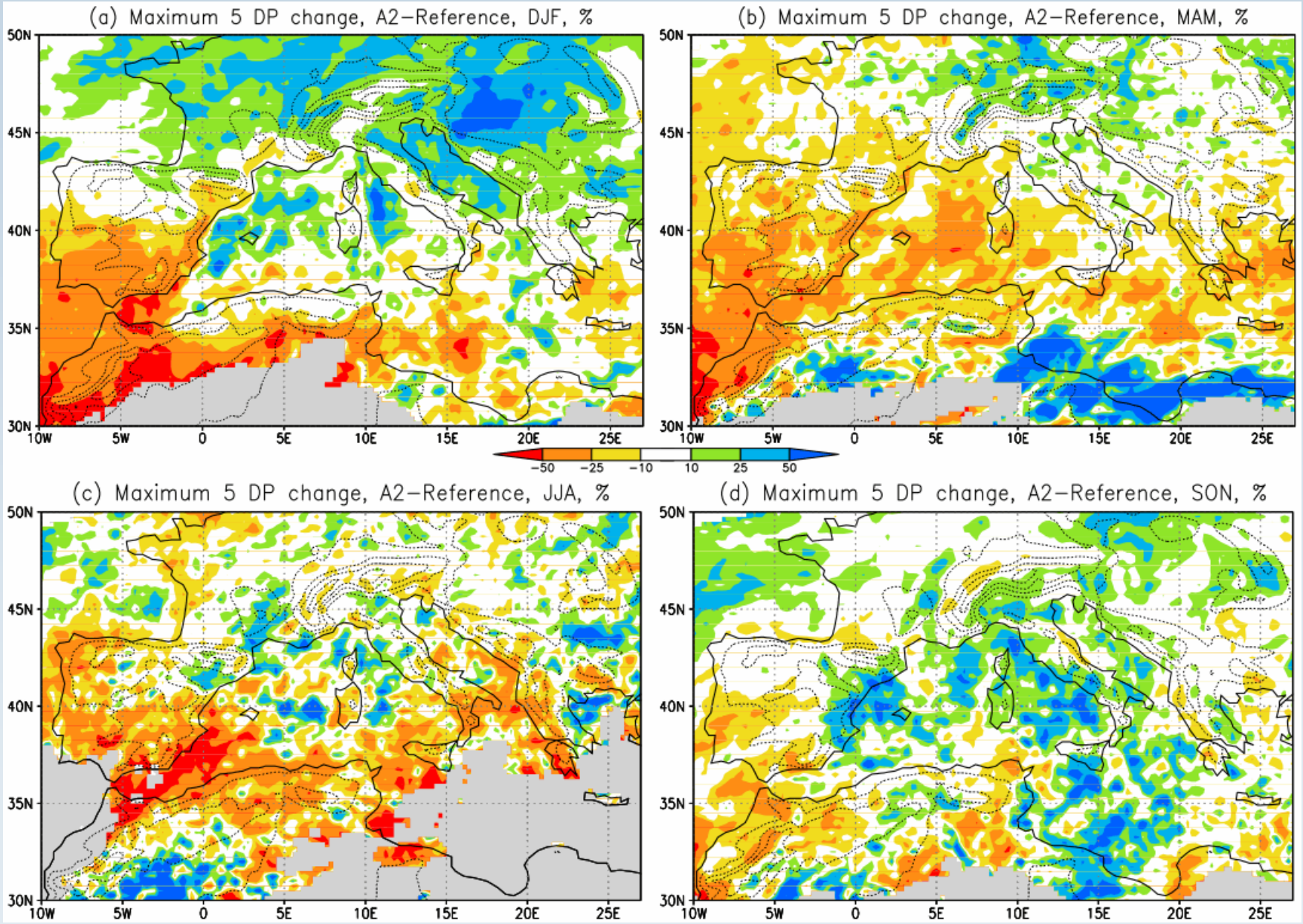


JJA RegCM3 20-km

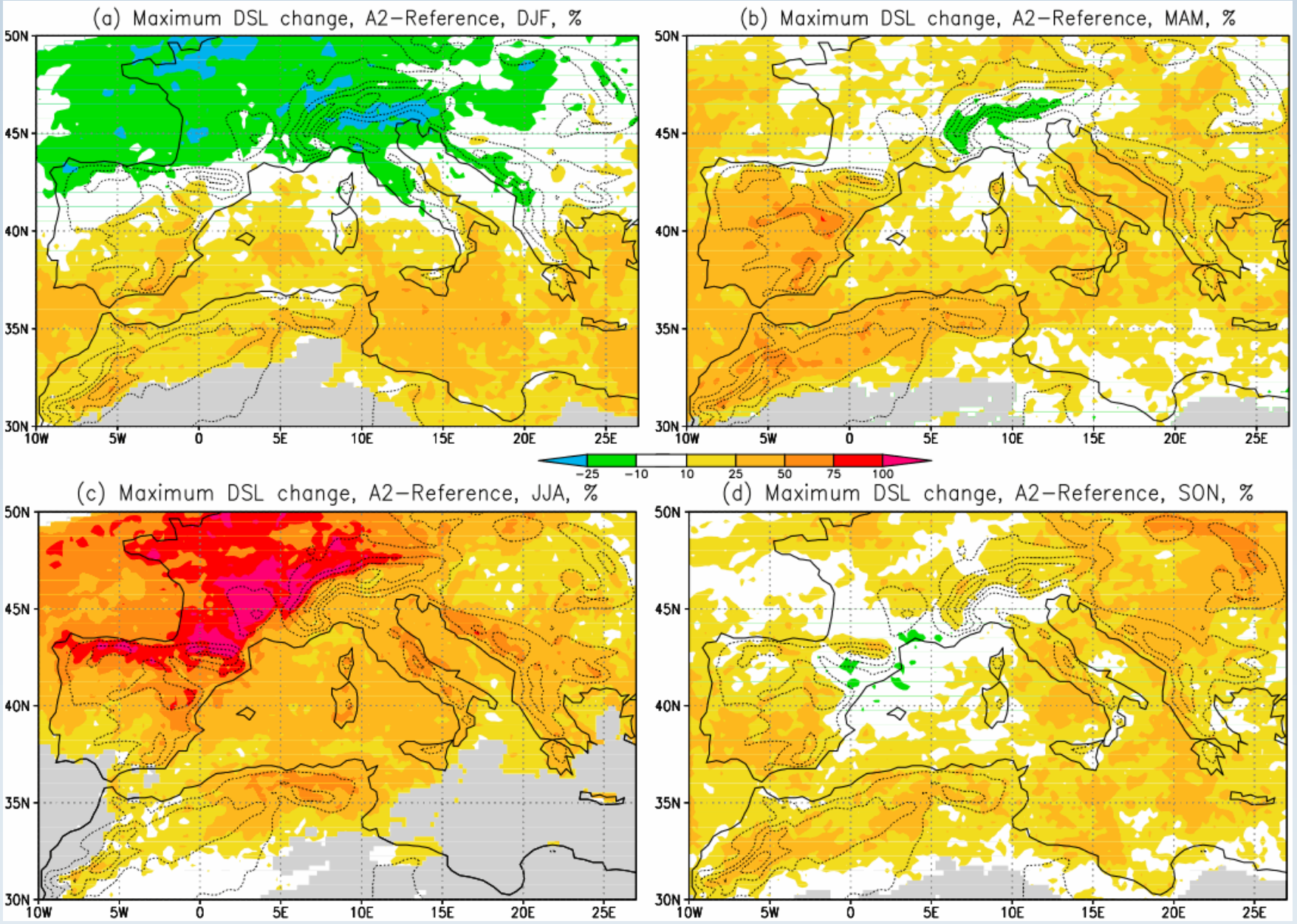
Precipitation Change: A2-REF



Max 5 Day Precipitation Change: A2-REF



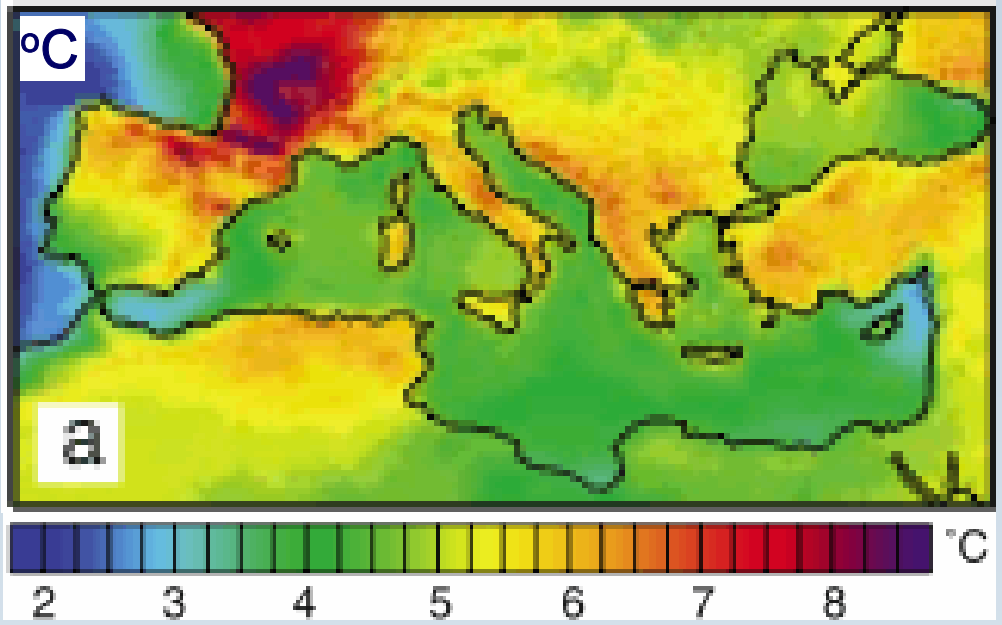
Max Dry Spell Length Change: A2-REF



Maximum Heat Stress

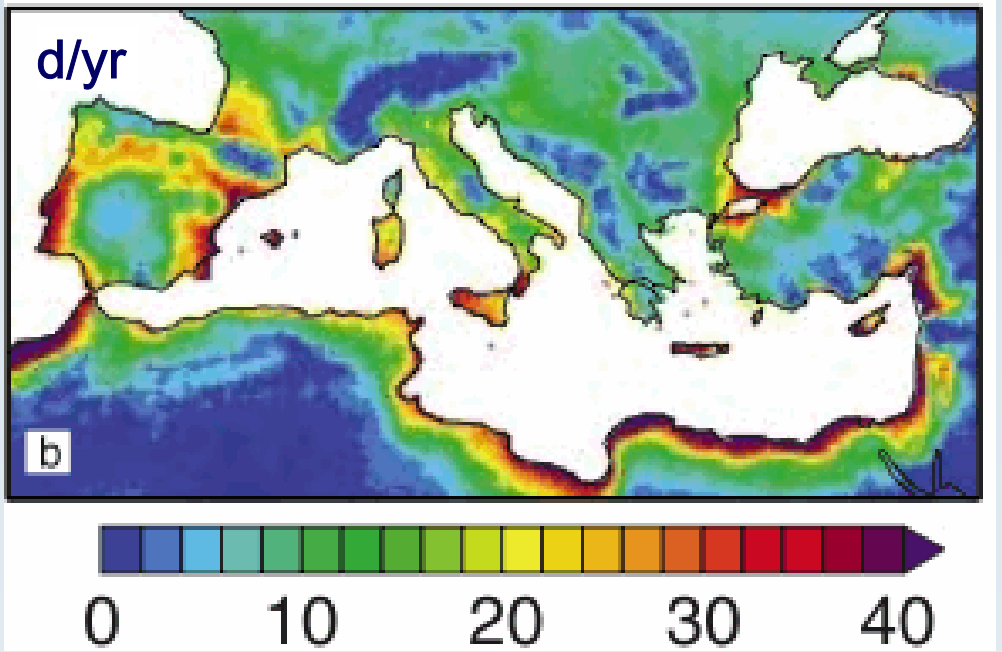
Tmax 95

(A2 – REF)



Heat Index > Danger,
Extreme Danger

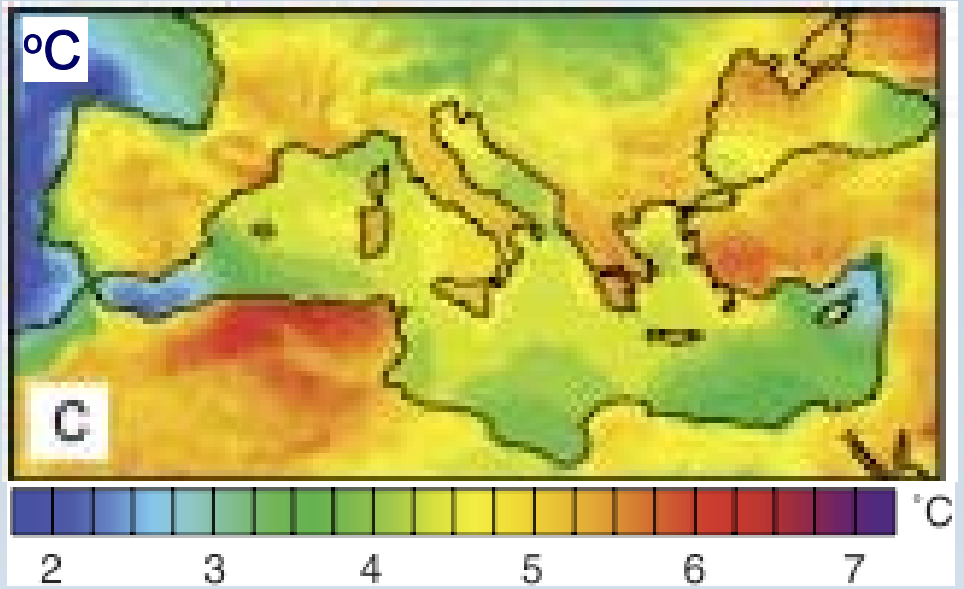
(A2 – REF)



Nighttime Heat Stress

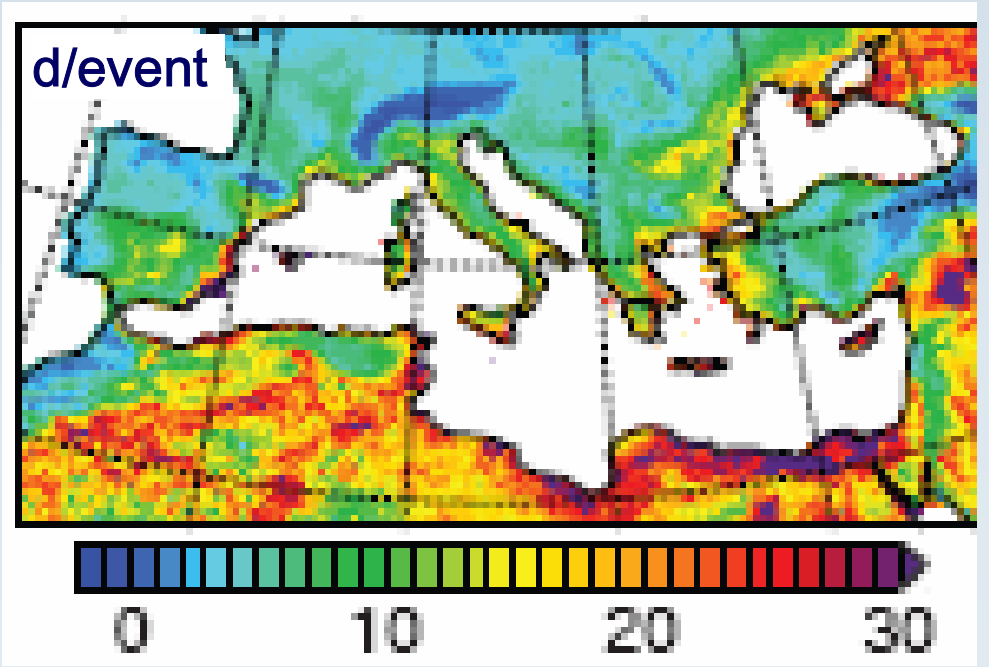
Tmin 95

(A2 – REF)

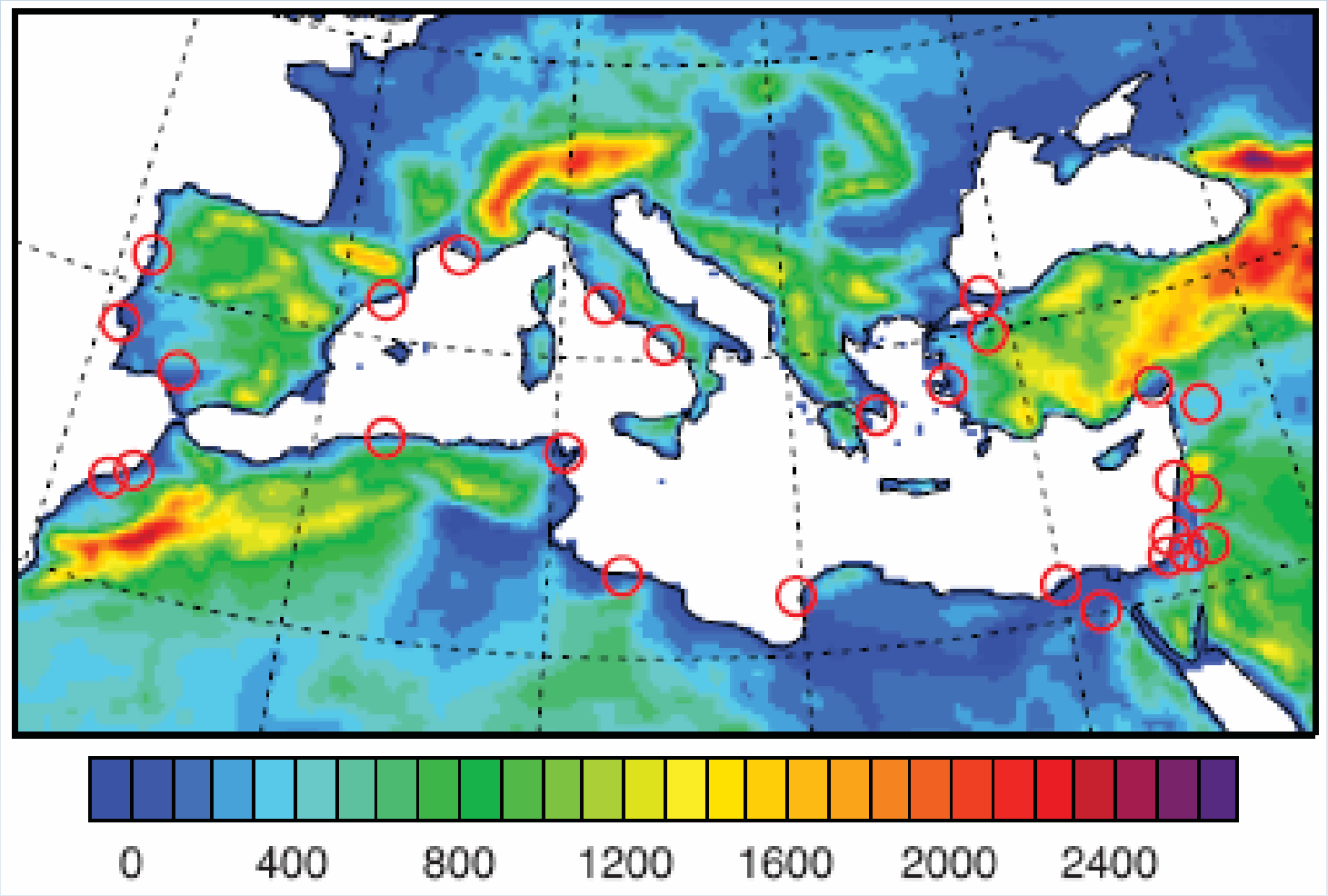


Nighttime heat-wave length

(A2 – REF)



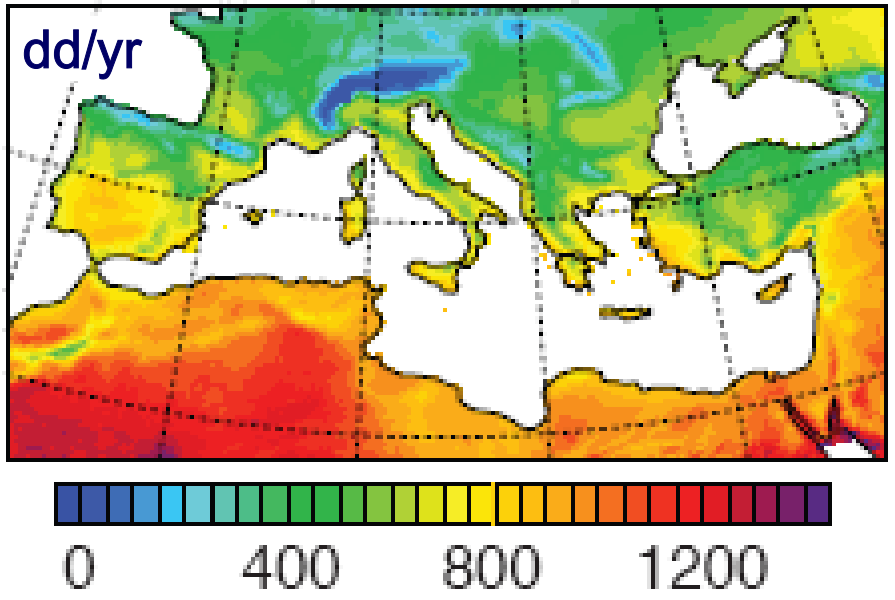
Locations of coastal population centers with greater than 1 million inhabitants.



Cooling Demand

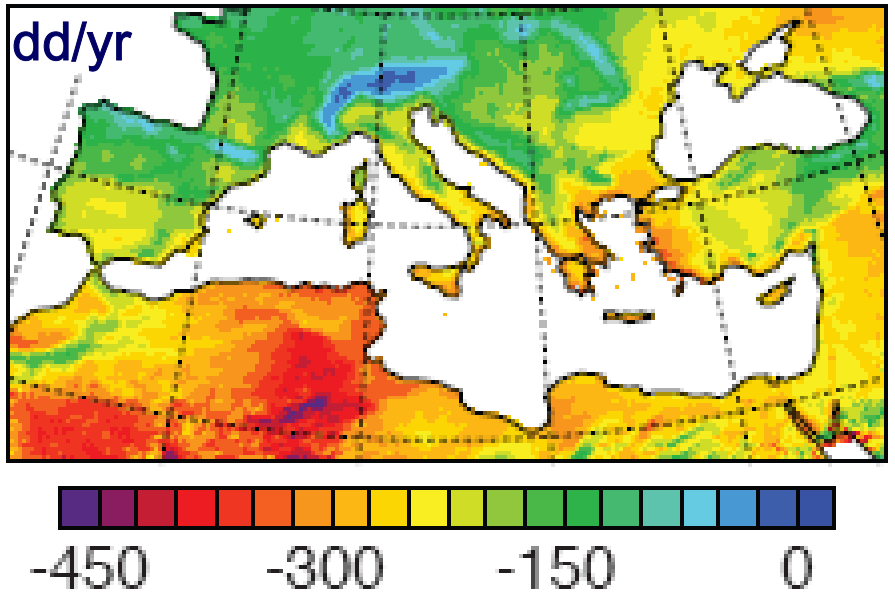
Total Cooling Demand

(A2 – REF)



Deceleration Effect

(A2 – B2)



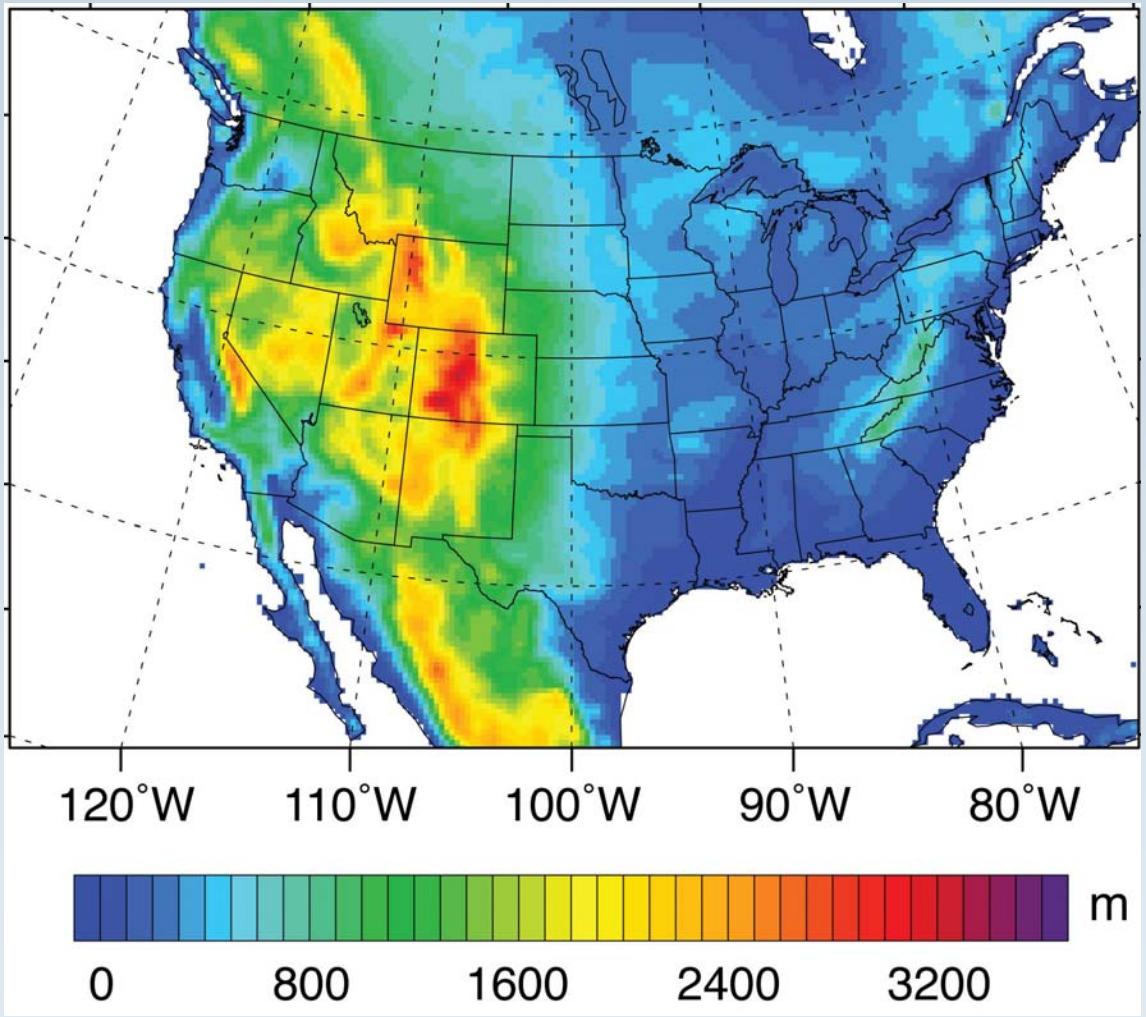
High resolution Nested simulations

Model configuration

- 25-km grid point spacing
- Modern satellite-derived land cover

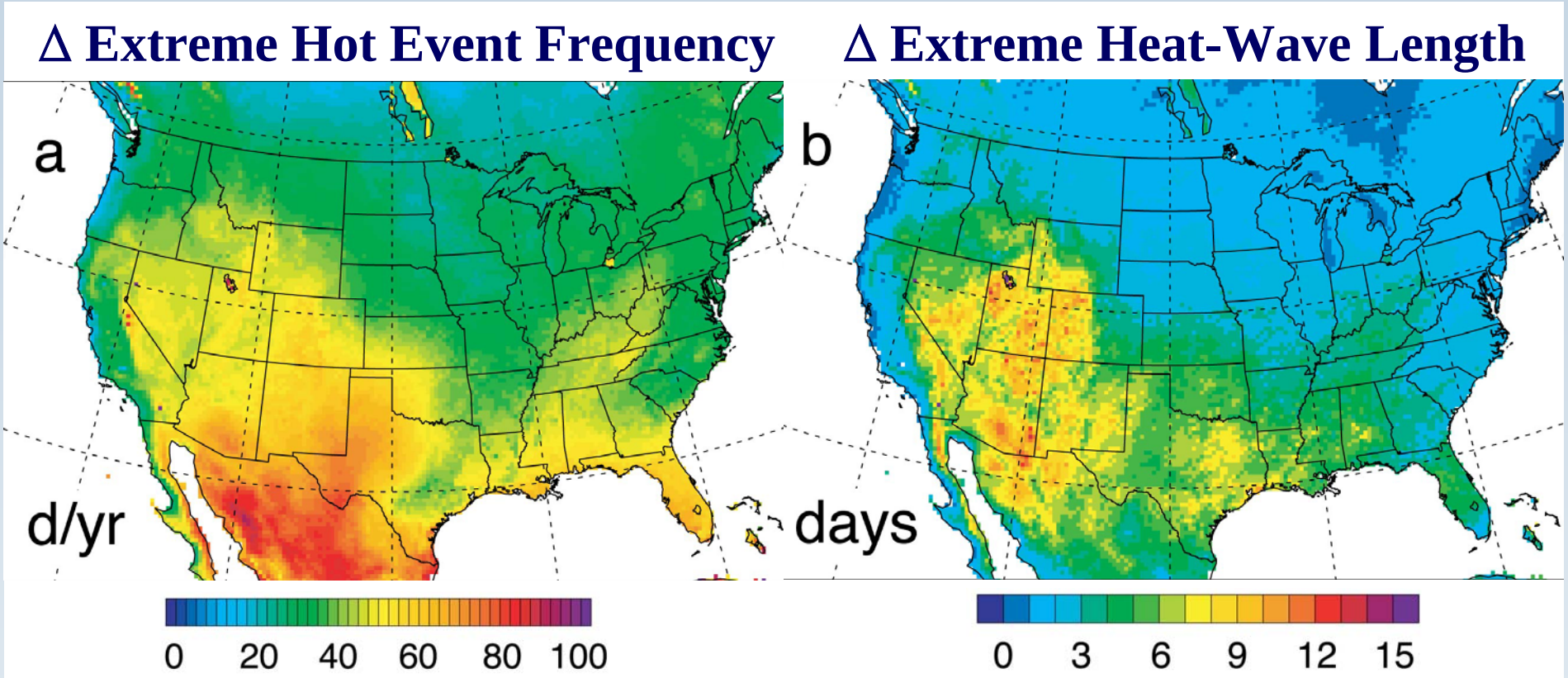
Experiment design

- NASA finite volume GCM provides large-scale conditions
- Reference simulation (1961-1985)
- A2 scenario (2071-2095)



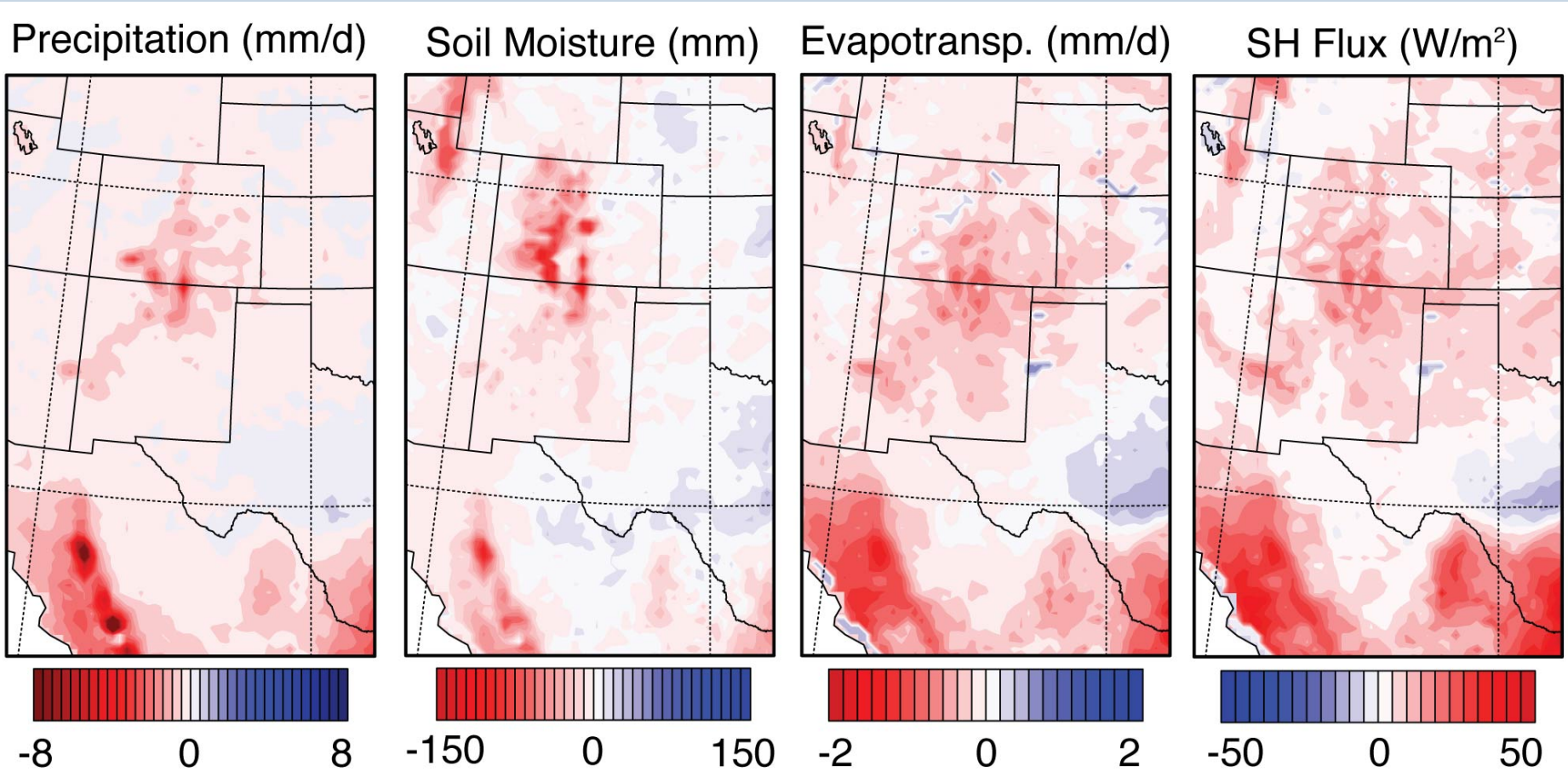
Diffenbaugh et al. 2005, PNAS

Change in Extreme Hot Events



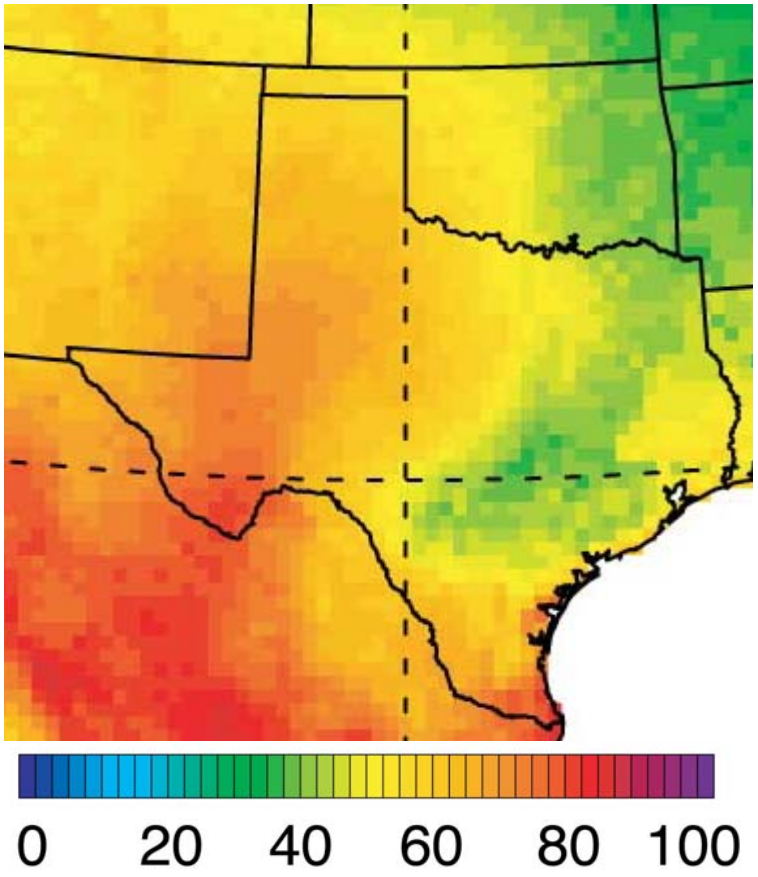
- **Increases of 100 to 560 % in frequency and 50 to 550 % in duration**

Δ Jun-Jul-Aug Moisture Balance

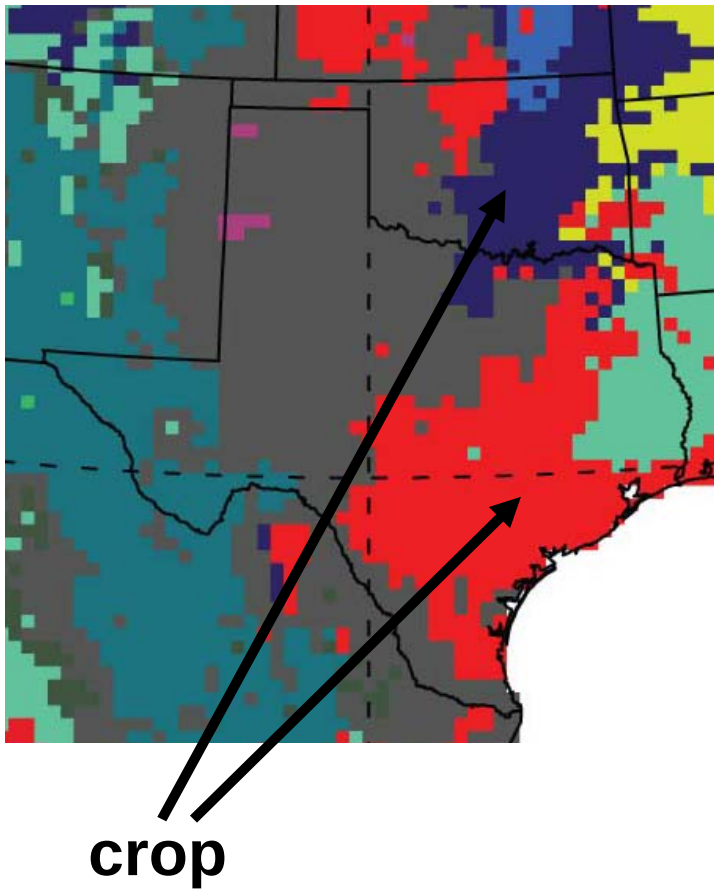


- **Change in surface moisture balance enhances warming**

Δ Extreme Hot Frequency



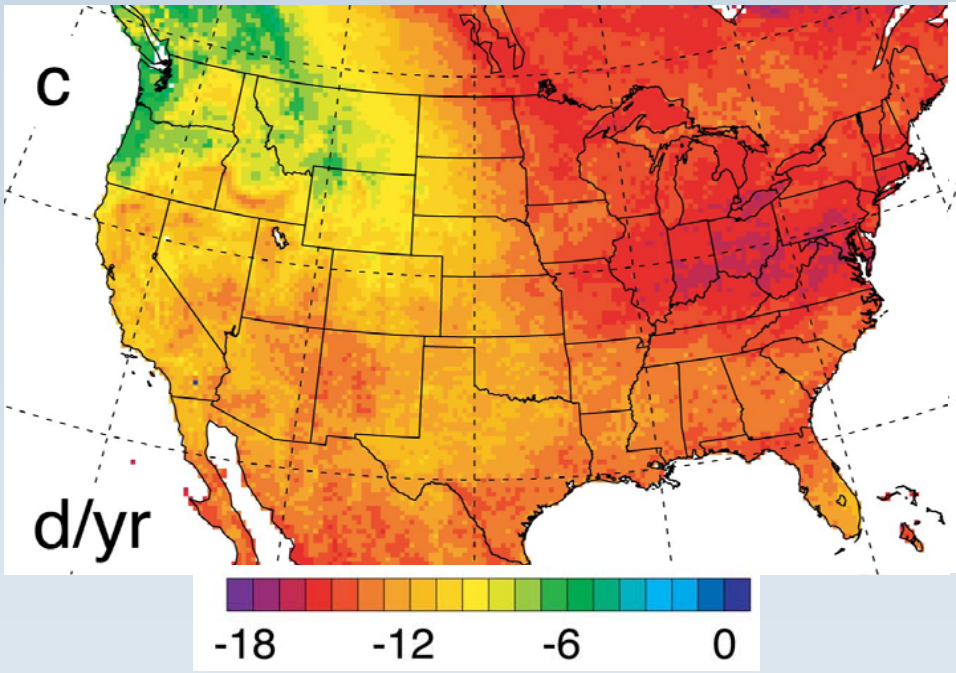
Land Cover



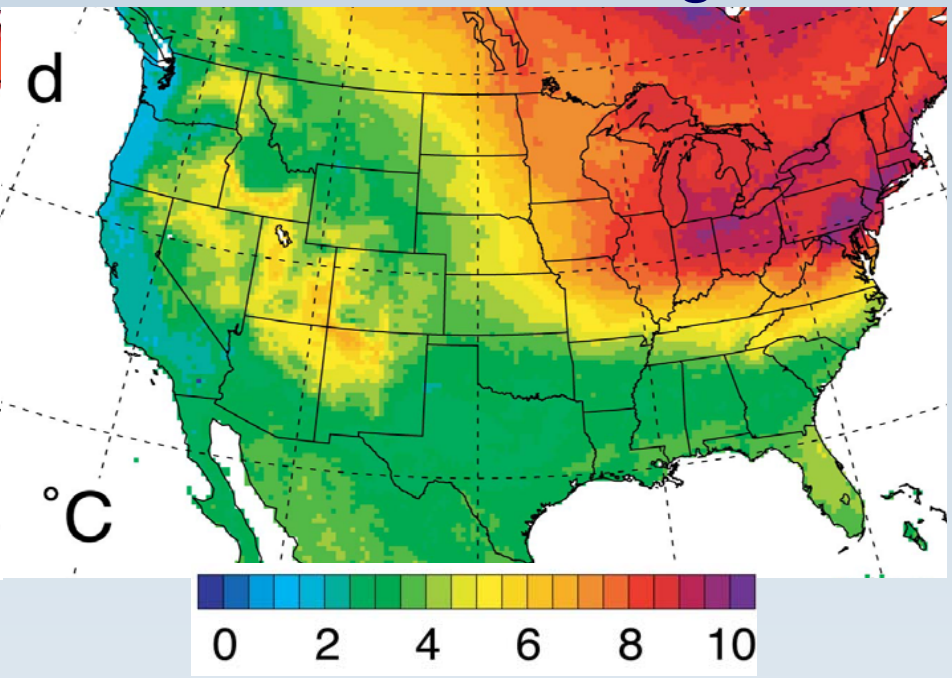
- **Response of extreme hot events muted in crop areas**

Change in Extreme Cold Events

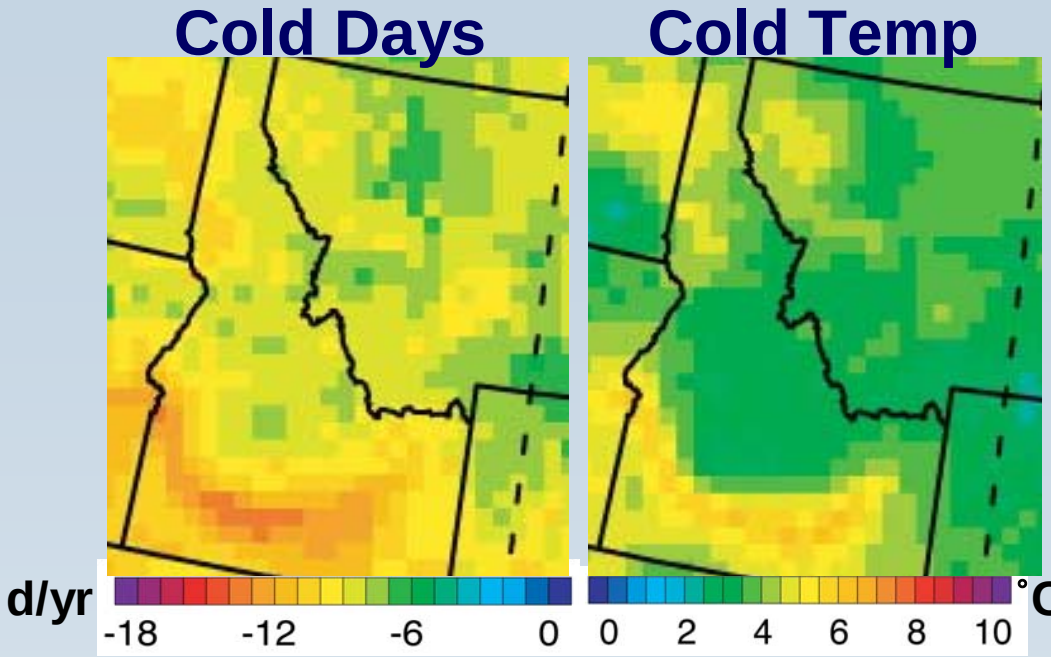
Δ Extreme Cold Frequency



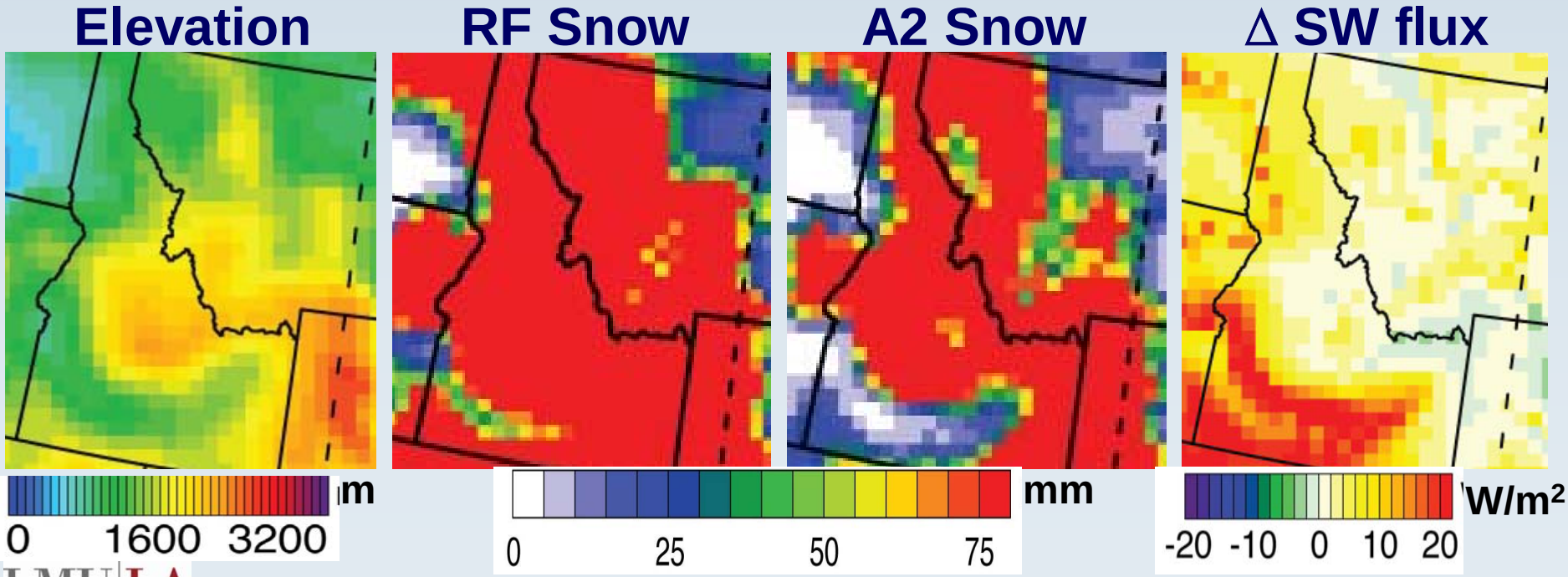
Δ Extreme Cold Magnitude



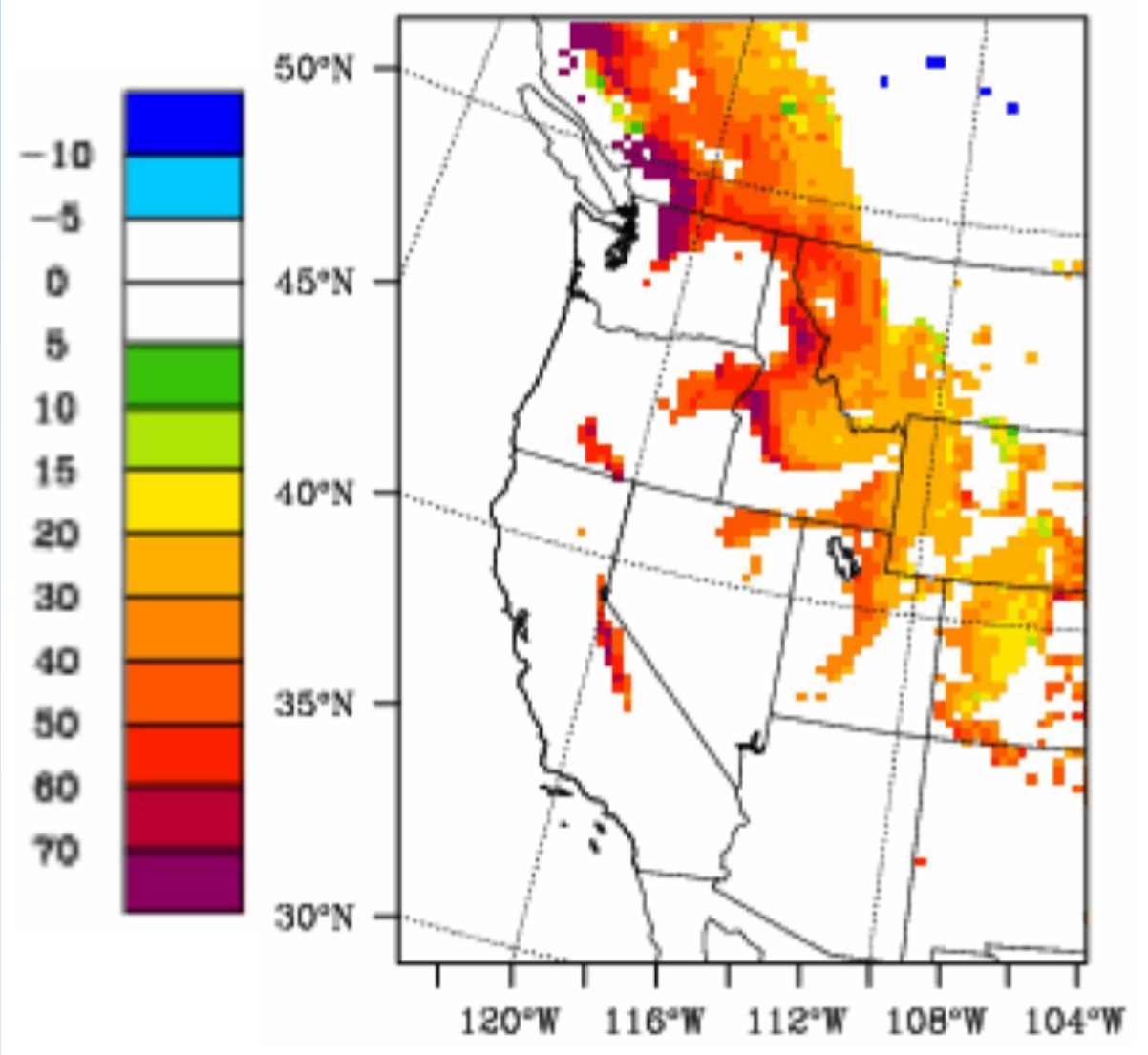
- **Decreases of 25 to 90 % in frequency**



Snow-albedo feedbacks enhance warming at lower elevations



Shift to Earlier Runoff

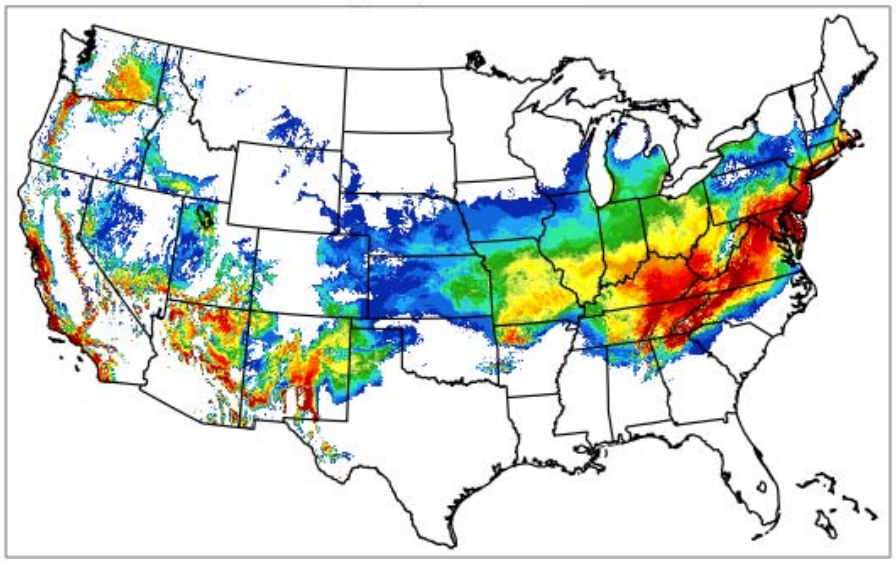


Rauscher et al 2008, GRL, Submitted

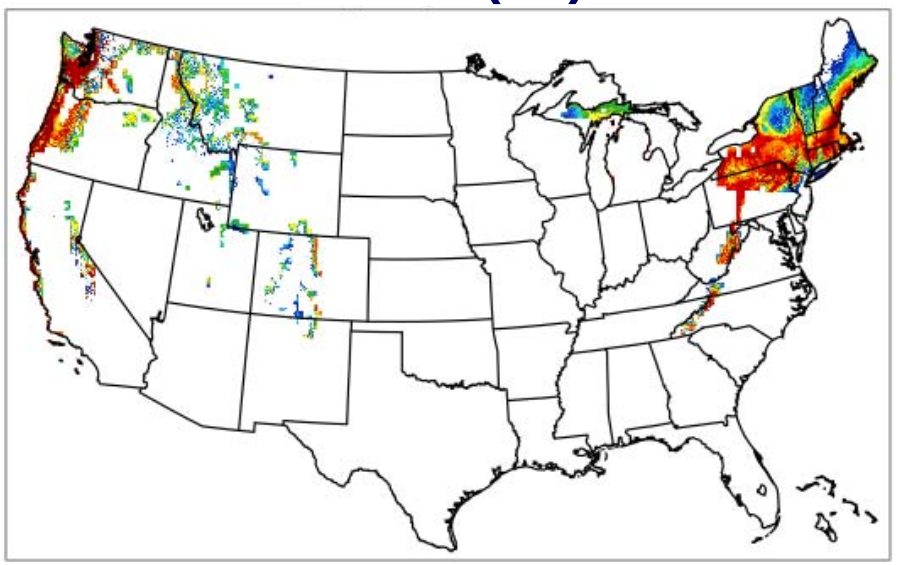
Premium Grape Production:
Suitable Years (out of 24)

Heat Tolerant & Cold Tolerant Grapes

Reference



Future (A2)

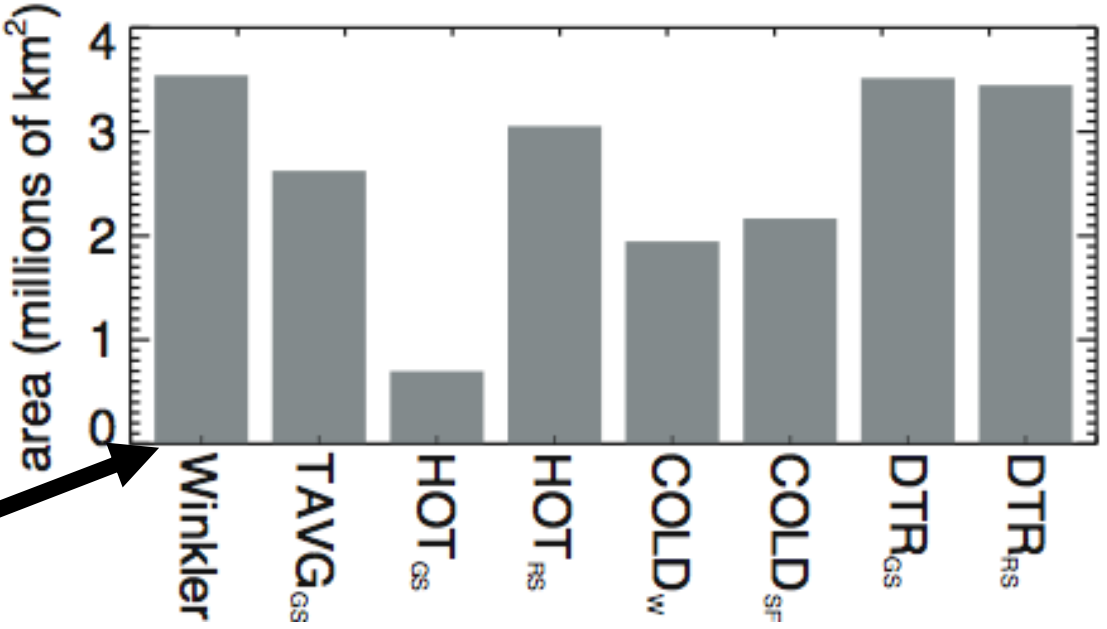


White et al 2006, PNAS

Premium Wine Production:
Single Factor Reductions

Heat Tolerant
Cold Tolerant

Winkler Based on Growing Degree Days (i.e., mean climate only)



	Heat tolerant cold tolerant
GS growing degree days	1111-2499
GS average temperature	13-20°C
GS & RS hot days (> 35C)	14
W & S/F cold days (<-12C & <-7C)	14
GS & RS diurnal temperature range	20°C

Summary

- Regional Climate models are powerful tools that can be used to investigate the regional impacts of climate change.
- Fine-scale processes regulate the response of extreme events.
- RegCM3 is being effectively used by scientists from around the world for a variety of relevant climate related studies.
  - Available at: http://users.ictp.it/RegCNET/model.html
- The RegCNET aims to build and empower a community of scientists from economically developing nations to perform high level regional climate research.
  - Available at: http://users.ictp.it/RegCNET
  - To join RegCNET email forum, go to http://users.ictp.it/RegCNET/list.html