L-Università ta' Malta

The Abdus Salam International Centre for Theoretical Physics

Xjenza The Malta Council for Science & Technology

esplora

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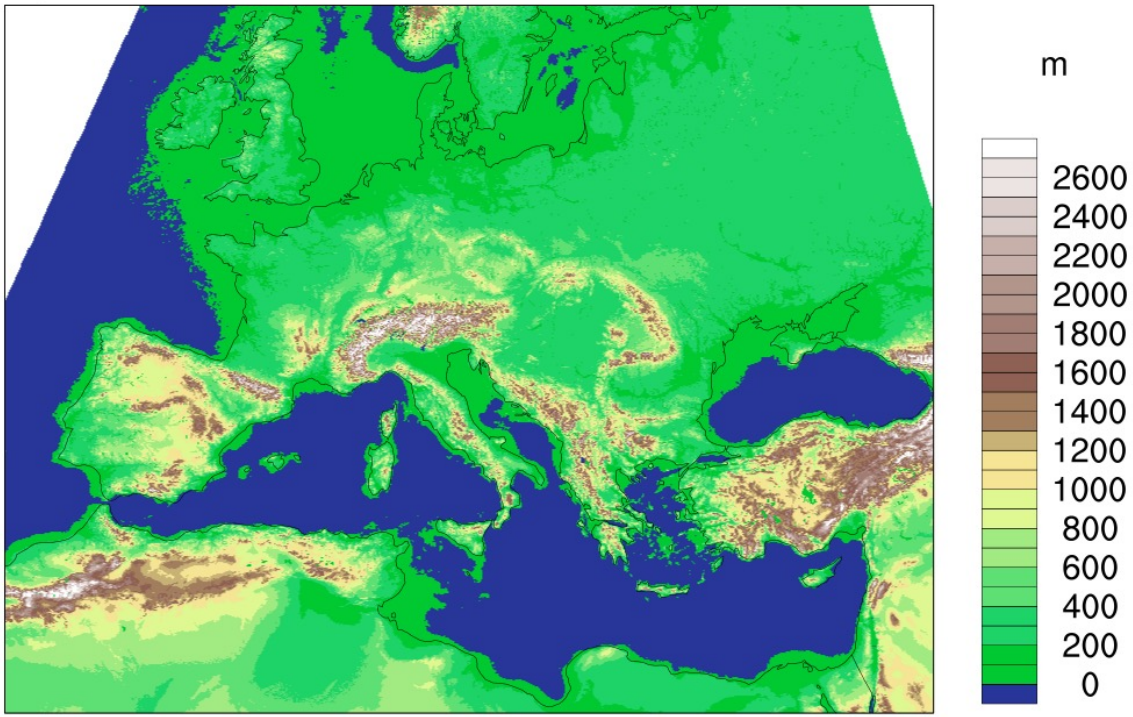
MARIE CURIE ACTIONS

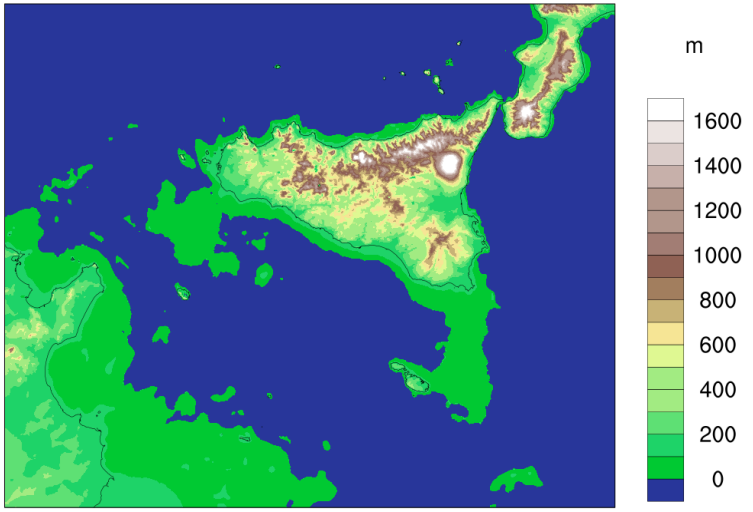
Paleoclimate experiments using RegCM5

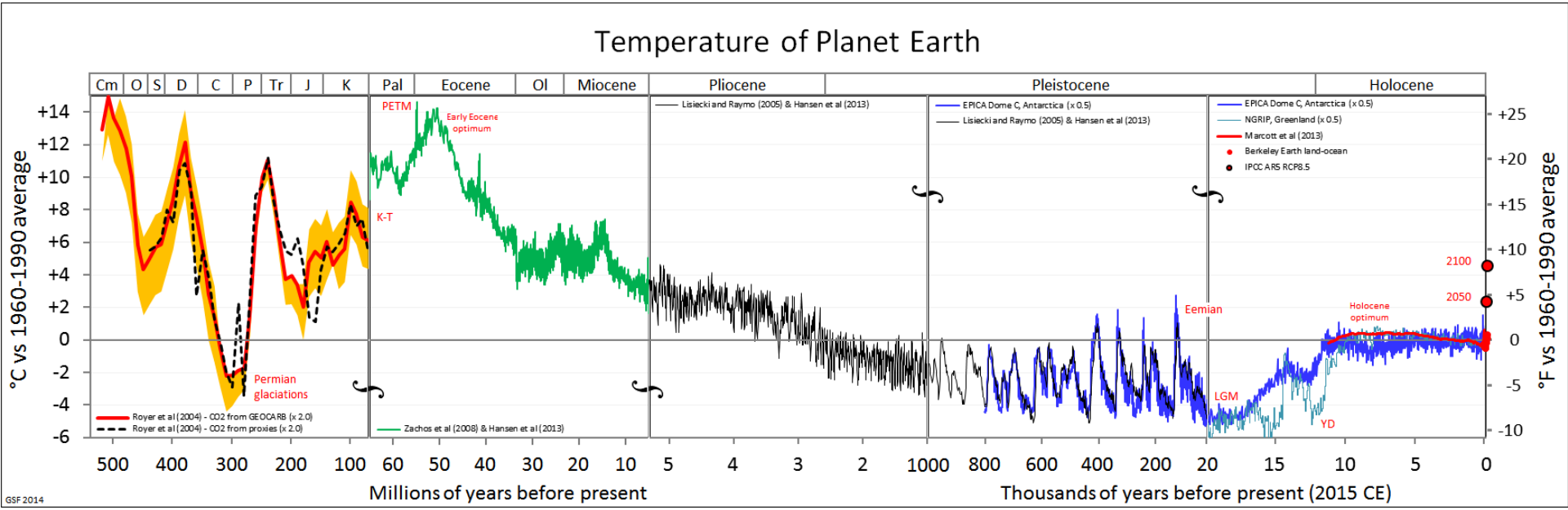
James Ciarlo`



Why?

Topography with sea level @-130m
[~21ka, Last Glacial Maximum]





Regional Paleoclimate Modelling

- Global input data
- Orbital parameters
- Gas concentrations
- Elevation
  - *Sea level change, glacial mass*
  - *…plate tectonics*
  - *(volcanic formation, erosion and deposition, major earthquakes??)*
- Vegetation and Land-use

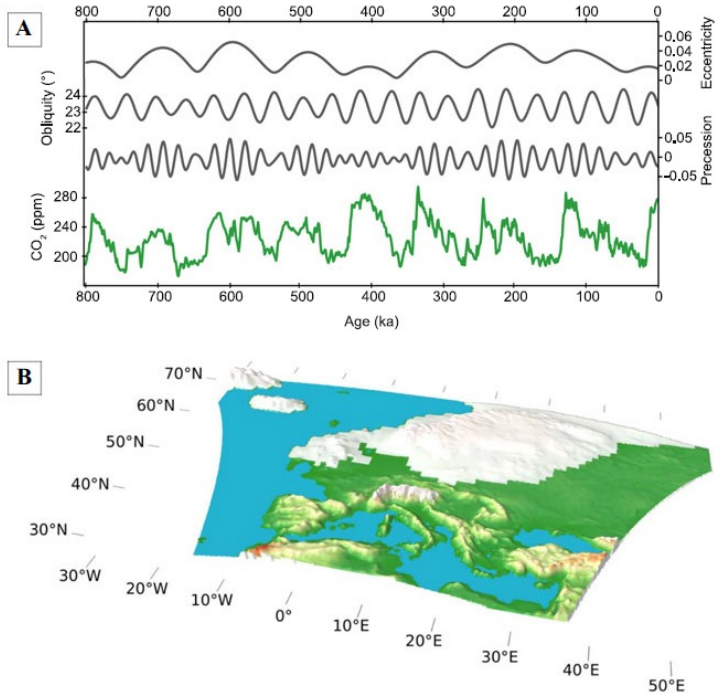


Figure 4. (A) Orbital parameters over the past 800 ky and atmospheric concentration of CO_2 from Antarctic ice cores (adapted from IPCC 2013, fig. 5.3).[1] (B) RCM domain adapted to LGM surface boundary conditions (land-sea-mask and ice-sheets based on PMIP3 21Ka experimental design).[72]

Ludwig P, Gómez-Navarro JJ, *et al.* (2019). Perspectives of regional paleoclimate modeling. Ann. N.Y. Acad. Sci., 1436: 54-69. https://doi.org/10.1111/nyas.13865

Paleoclimate in RegCM

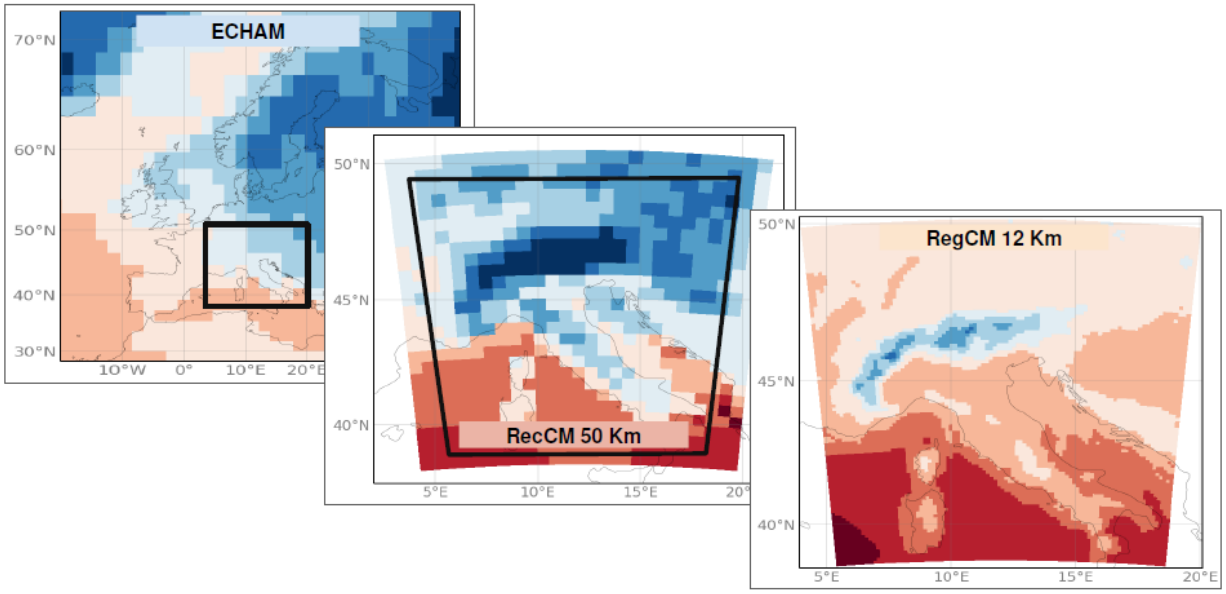


FIGURE 3.5: The applied nesting chain. The models are represented from the low-resolution MPI-ESM-P to the high-resolution RCM RegCM4.7. The black boxes indicate the domain of the higher-resolution simulations.

Del Gobbo C (2021). Use of the Regional Climate Model RegCM4 to assess circulation, precipitation and temperature patterns sustaining the Tagliamento glacier (southeastern Alps) at 21 ka (**Doctoral thesis**). Università degli Studi di Trieste, Trieste, Italy. Available from https://arts.units.it/handle/11368/2988360

- Control simulation
  - *compared to observation/ reference data*
  - *(various evaluation metrics)*

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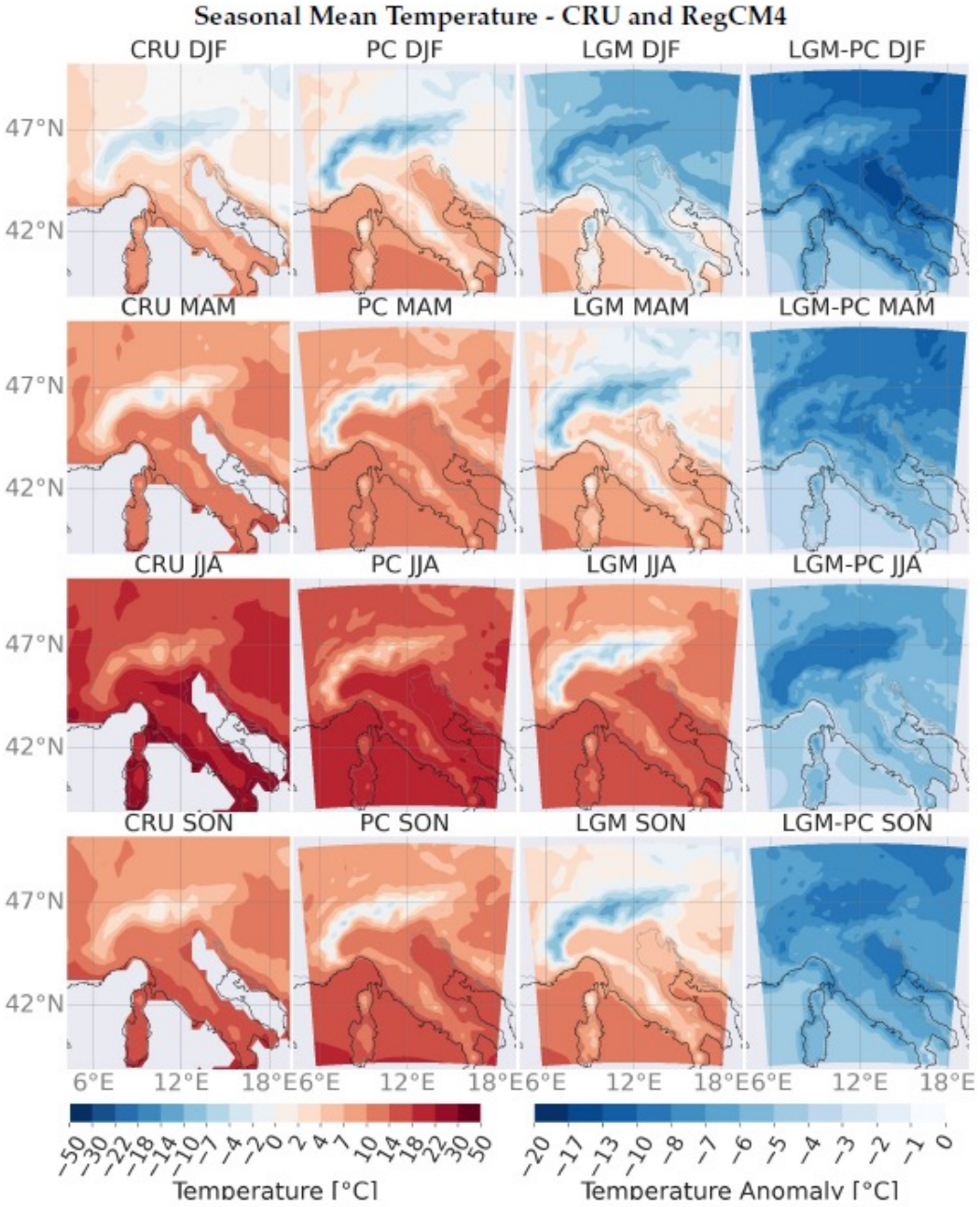


FIGURE 4.7: CRU (left) and RegCM4 seasonal mean temperature in °C for PC (center-left), LGM (center-right), and anomaly (right).

- Paleo-simulation
  - *compared to proxy data*
  - PAGES Dataset
    - (Past Global Changes)
    - https://pastglobalchanges.org/

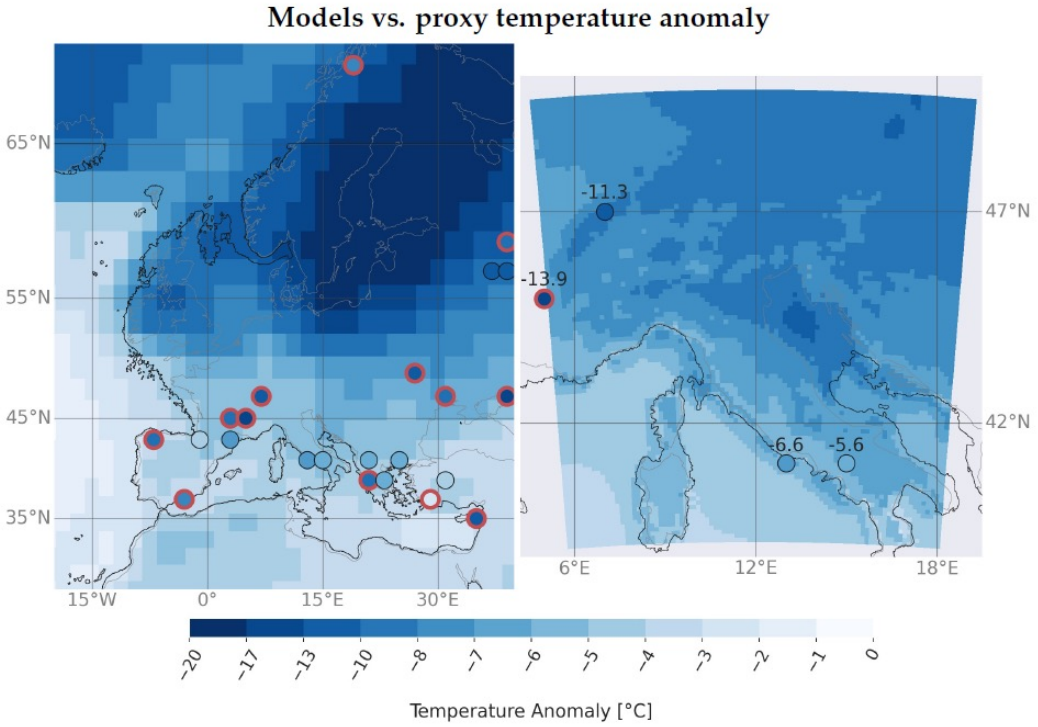


FIGURE 4.23: MPI-ESM-P (left) and RegCM4 (right)temperature anomaly (LGM-PC) compared with proxy reconstruction from Bartlein et al. (2010). The red circles indicate model LGM-PC anomaly falls out of the error range for the proxies.

Del Gobbo C (2021). Use of the Regional Climate Model RegCM4 to assess circulation, precipitation and temperature patterns sustaining the Tagliamento glacier (southeastern Alps) at 21 ka (**Doctoral thesis**). Università degli Studi di Trieste, Trieste, Italy. Available from https://arts.units.it/handle/11368/2988360

Ongoing research with RegCM

- US Geological Survey
  - 100 year Western US @50km
    - Paleoclimate and 2xCO2 experiments
  - 50 year Western US coast nested @10km

- University of Malta & ICTP
  - 20 year paleoclimate runs
    - 50km Extra-European
    - 12km Europe
    - 3km West/Central Mediterranean

Input Data

- Required input parameters (icbc code preparations)
  - **orog** (fx), **tos** (day/mon), **ps** (6hr),
  - **hus/ta/ua/va** (6hrLev/Pt – with "reasonable" number of **levels**)
    - formula paremeters in ncdump: **p = ap + b*ps**

- PaleoGCM communities
- Paleoclimate Modelling Intercomparison Project
  - CMIP5 – PMIP3
  - CMIP6 – PMIP4
  - Existing experiments (**some** on ESGF)
    - historical (modern-times)
    - PiControl (1850)
    - past2k/past1000 (recent millenia)
    - midHolocene (~6ka)
    - lgm - Last Glacial Maximum (~21ka)
    - lig127k - Last Inter-glacial (~127ka)
    - midPliocene (~3Ma)
    - *new experiments in development…*

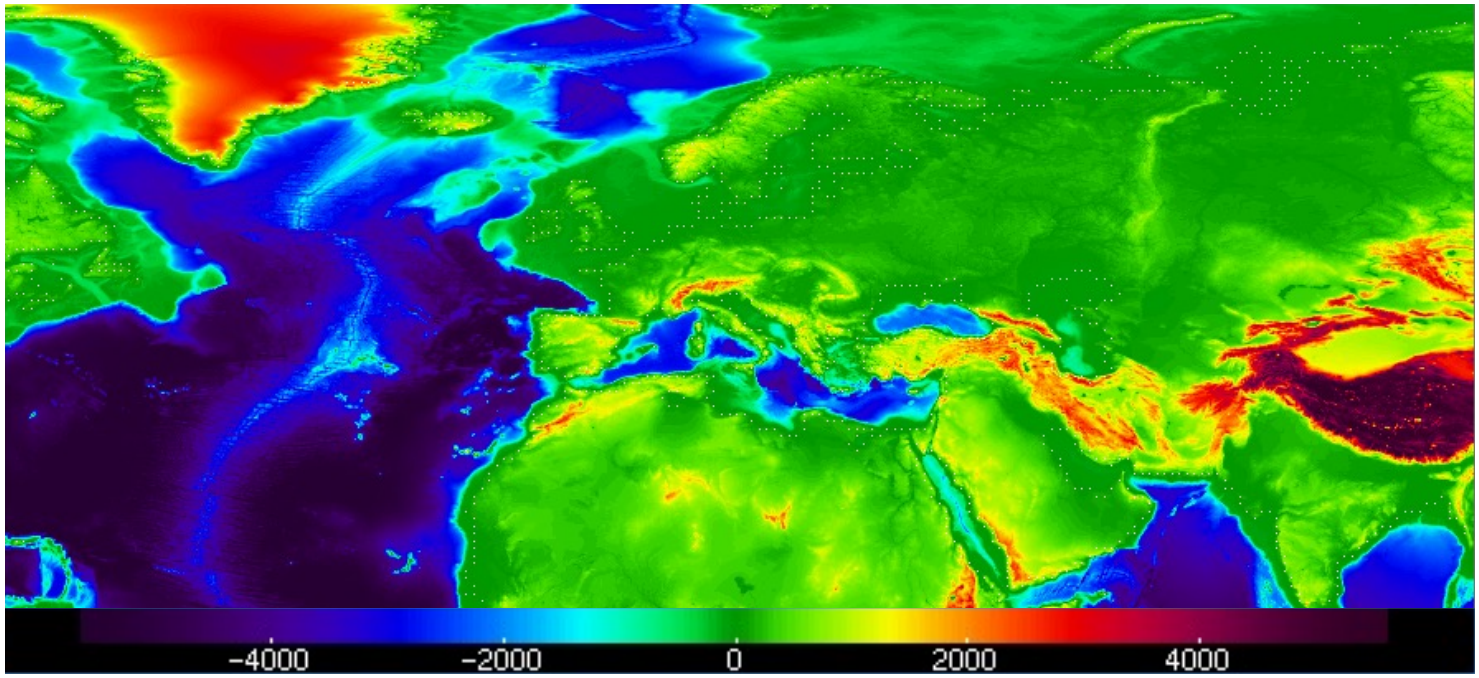
Namelist

```
&physicsparam
     scenario =    'CONST', ! IPCC Scenario to use in A1B,A2,B1,B2
     ghg_year_const = 1950, ! values coded in Main/mpplib/mod_ipcc_scenario.F90
        ! year, CO2 (ppm), CH4 (ppb), N2O (ppb), CFC11 (ppt), CFC12 (ppt)
        ! 1950, 310.70,    1147.50,   290.00,    0.00,        0.00
        ! modification factors in tweakparam with iteak = 1
      year_offset =  -21000, ! corrects astronomical parameters
                             ! eccentricity, obliquity, perihelion
        ! The algorithm is valid only to 1,000,000 years past or hence
      itweak =            1,

 &tweakparam
      itweak_sst = 0,              ! Enable adding sst_tweak to input TS
      itweak_temperature = 0,      ! Enable adding temperature_tweak to input T
      itweak_solar_irradiance = 0, ! Add solar_tweak to solar constant
      itweak_greenhouse_gases = 1, ! Multiply gas_tweak_factors to GG concentrations
      sst_tweak = 0.0,             ! In K
      temperature_tweak = 0.0,     ! In K
      solar_tweak = 0.0,           ! In W m-2 (1367.0 is default solar)
      gas_tweak_factors = 0.611522, 0.326797, 0.689322, 0.0, 0.0,
        !                   CO2  CH4   N2O   CFC11 CFC12
```

Paleotopography

- Start by merging topography and bathymetry
  - http://clima-dods.ictp.it/Data/RegCM_Data/SURFACE/

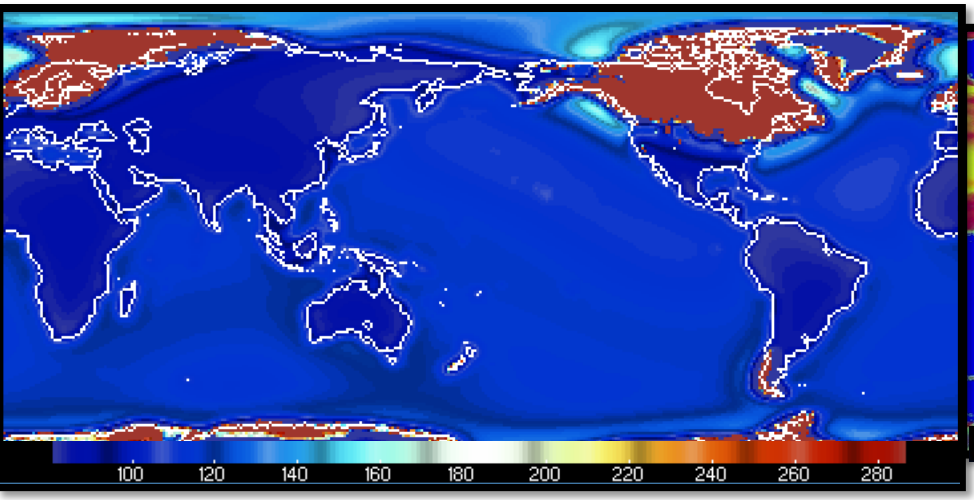


Paleotopography

- Modify RegCM elevation input
  - change sea level (constant global)
  - OR apply change field

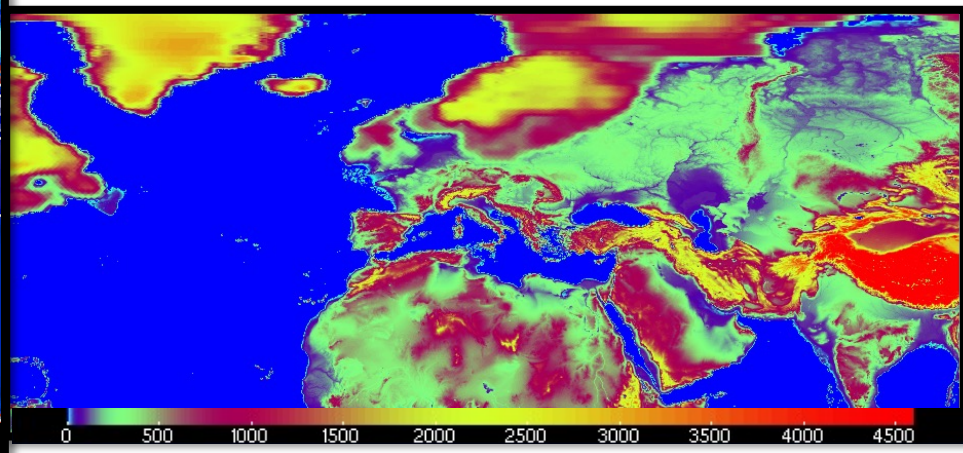
ICE7G change in elevation (m)

- Sea level difference
- Glaciers / Post-glacial rebound



Modified elevation (m) input

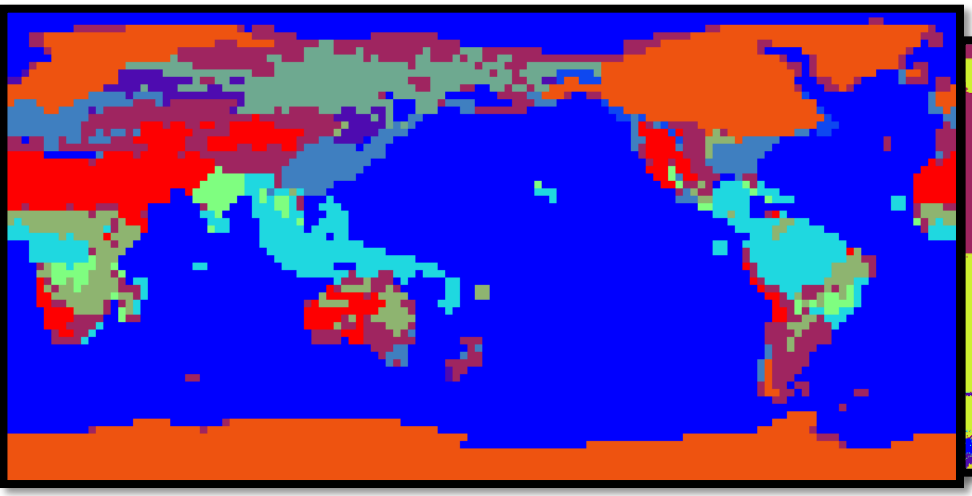
- Including change
- Smoothing over glacier area



Paleogeography (land-use)

- Land-use
  - Use PMIP Land-categories
  - Derive Land-categories from Köppen-Geiger classification
  - Keep basic land-categories
    - fill “new land” with nearest-neighbour (*“brute force”*)

PMIP4 MIROC land-use (LGM)

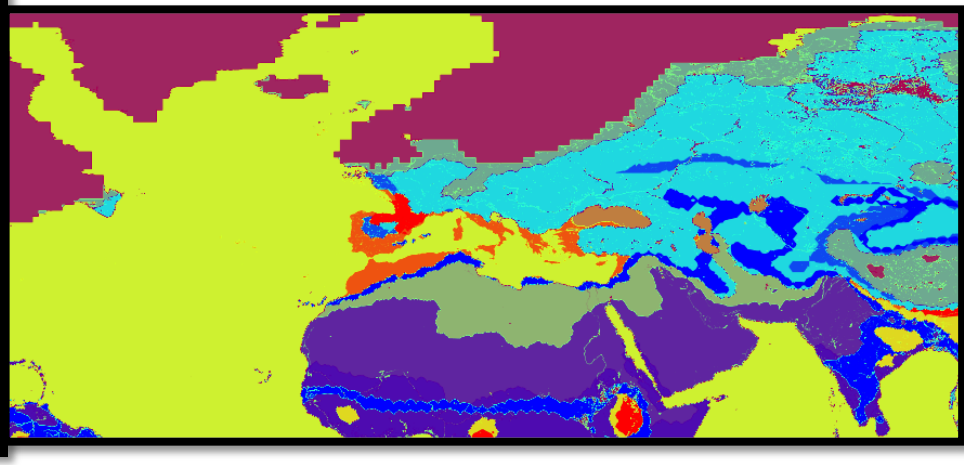


BATS (partially-modified) land-use

Grey – glaciers applied

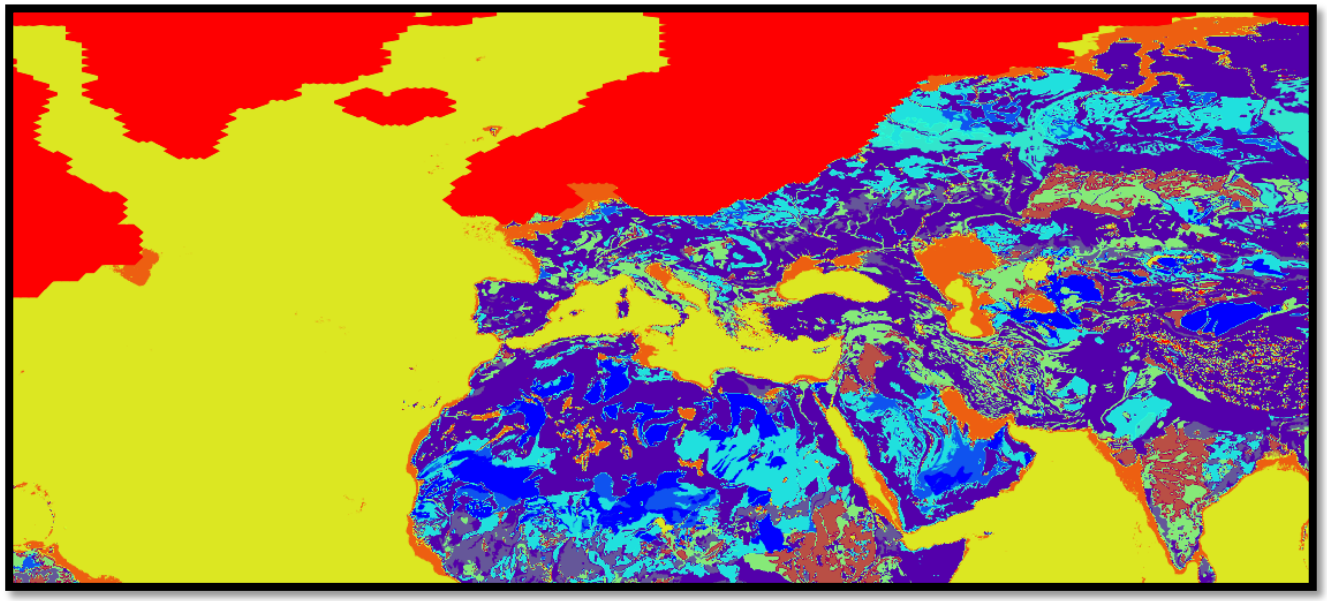
Red – unspecified land-categories

(due to lowering of sea-levels, and human-related-categories)



Paleogeography (soils)

- when using BATS
  - nearest-neighbour (*"brute force"*)
  - bedrock
  - existing? datasets



Run the model…

Thank you

- Email: james.ciarlo@um.edu.mt
- https://www.um.edu.mt/projects/paleosim/