Challenges in meteorology 3
EXTREME WEATHER AND IMPACT ON SOCIETY
Zagreb, 21-22 November 2013

Mediterranean climate in historical, RCP4.5 and RCP8.5 simulations using different PBL schemes in **RegCM4.3 model**

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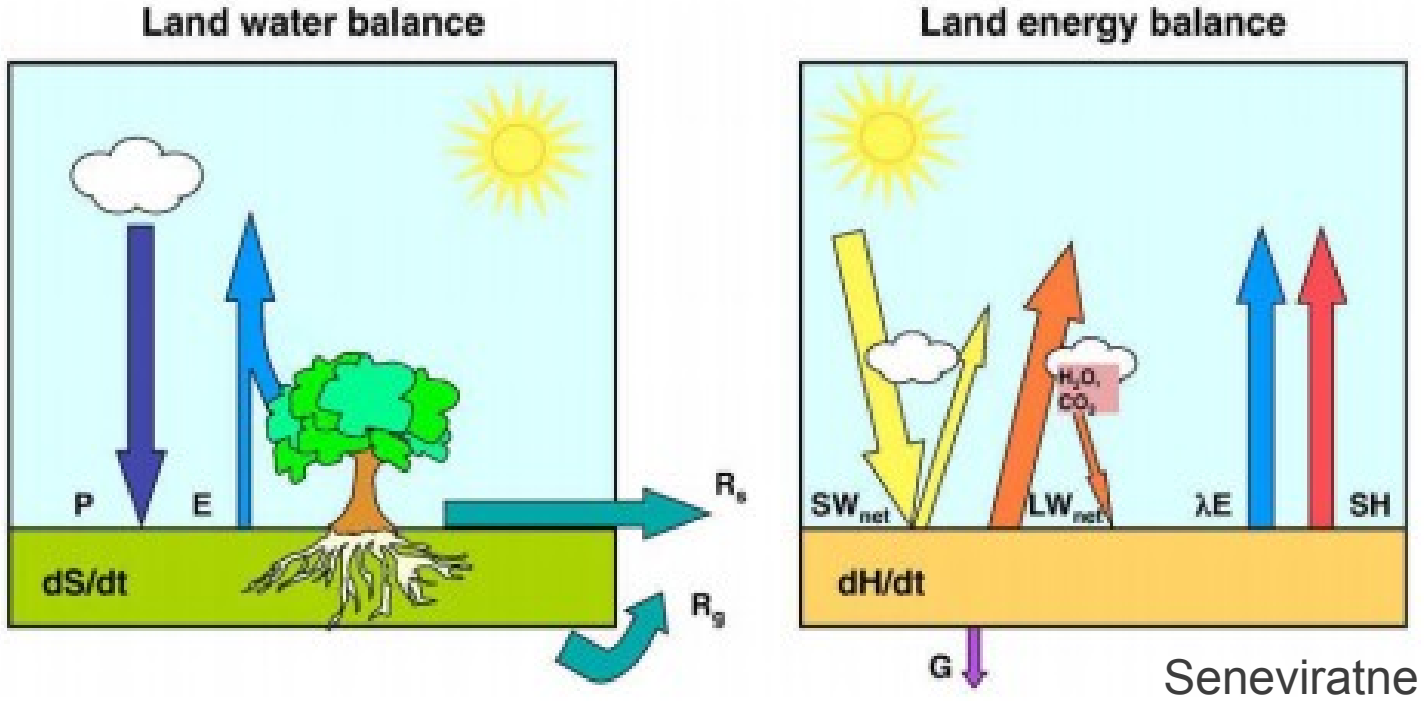
Experimental setup

The two planetary boundary layer (**PBL**) parameterisations are implemented in the regional climate model **RegCM4.3** (Giorgi et al. 2012):

1)diagnostic Holtslag scheme (Holtslag et al. 1990)
2)prognostic UW scheme (Grenier and Bretherton 2001).

In two sets of experimetns with different PBL schemes, the model at a 50-km horizontal resolution over the European and Mediterranean region was forced by:

1)HadGEM2-ES historical simulation from 1971 to November 2005
2)HadGEM2-ES RCP4.5 and RCP8.5 simulations from December 2005 to November 2099.



Seneviratne et al. (2010)

Representative Concentration Pathways (RCP)

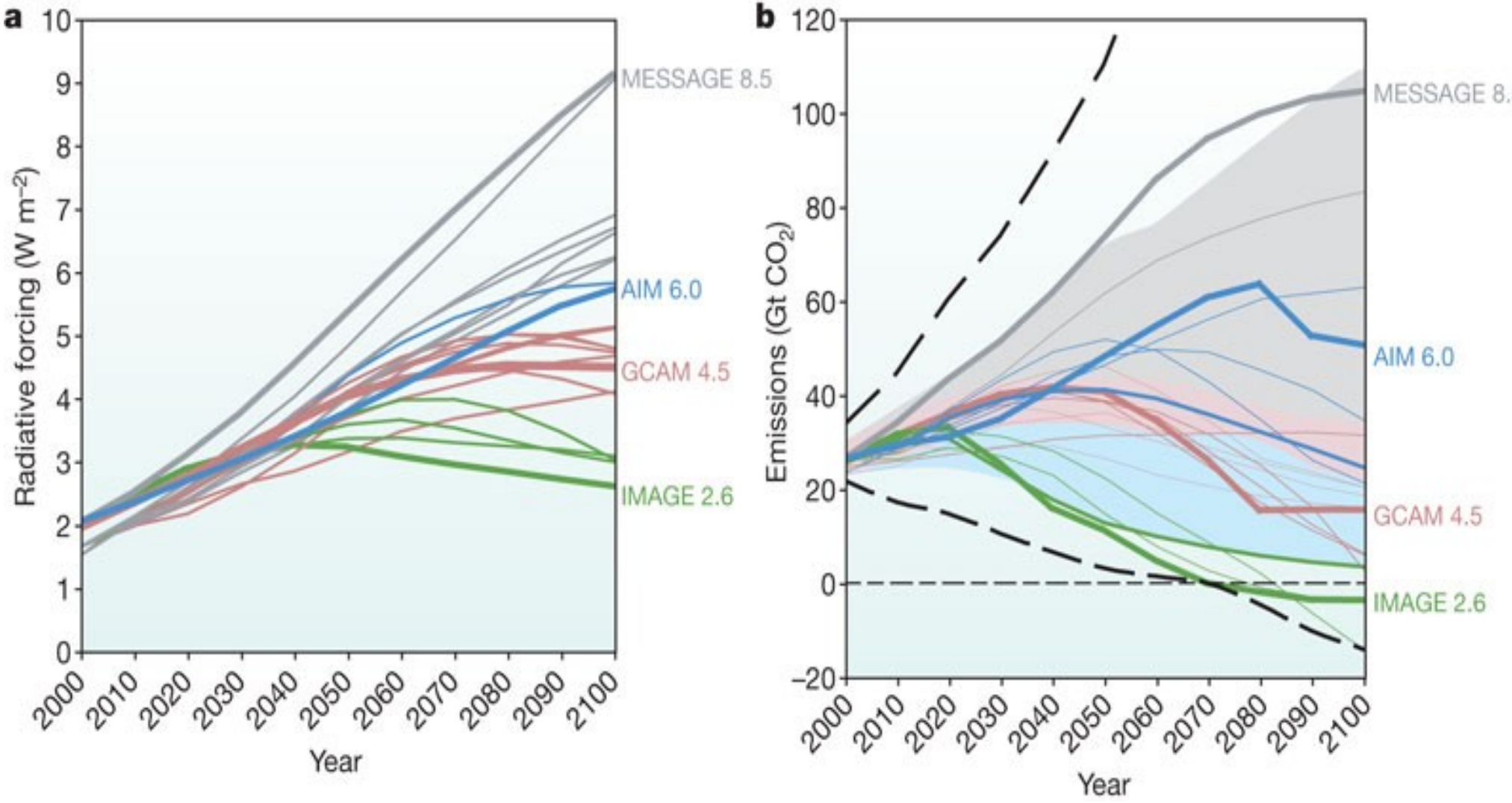


Fig. 5 from Moss et al. (2010) *Nature*

Planetary Boundary Layer (PBL) schemes in RegCM4 model

$$F_V\alpha = p^* \frac{\partial}{\partial z}\left[K\left(\frac{\partial \alpha}{\partial z} - \gamma\right)\right]$$

Holtslag i sur. (1990)

$$K_H = kz \cdot w_t \cdot \left(1 - \frac{z}{h}\right)^2$$

$$K_H = K_{H0} + (Ri_c - Ri)\, l_\infty^2 \sqrt{\left(\frac{\partial u}{\partial z}\right)^2 + \left(\frac{\partial v}{\partial z}\right)^2}$$

Troen i Mahrt (1986)

$$\gamma = C\frac{\overline{w'\theta'}_{SURF}}{w_t h}$$

Grenier i Bretherton (2001)

$$K_H = l \cdot \sqrt{2TKE} \cdot S_H$$

Blackadar (1962)

$$l_1 = \frac{\min(kz, 0.1\Delta z)}{1 + \min(kz, 0.1\Delta z)/\lambda}$$

$$l_2 = \min(kz, 0.1\Delta z)$$

Mellor i Yamada (1982)

Galperin i sur. (1988)

Nieuwstadt (1984)

$$l_1 = l_2 = \min\left(R_{STBL}\sqrt{\frac{TKE}{N^2}}, kz\right)$$

K_H: koeficijent turbulentne difuzivnosti topline
k: von Kármánova konstanta
w_t: turbulentna skala brzine
h: visina AGS-a
Ri: gradijentni Richardsonov broj

N: uzgonska frekvencija
l: turbulentna duljina miješanja
TKE: turbulentna kinetička energija
S_H: funkcija stabilnosti

$\lambda = 0.085\Delta z$
$R_{STBL} = 1.5$
C=8.5

RegCM4.2(ERA-Interim), 1989-1998, T2m errors

PBL: Holtslag

PBL: UW

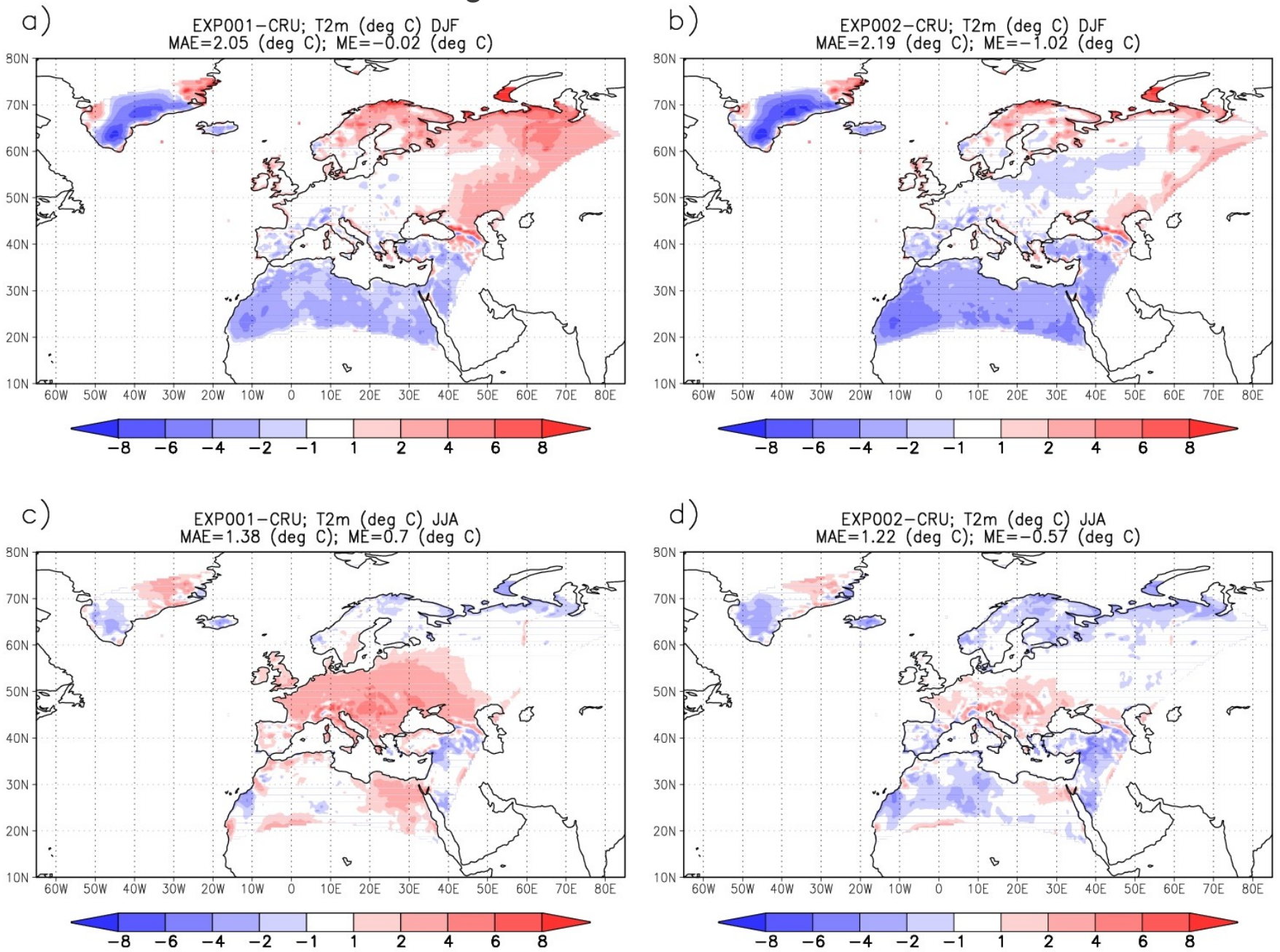


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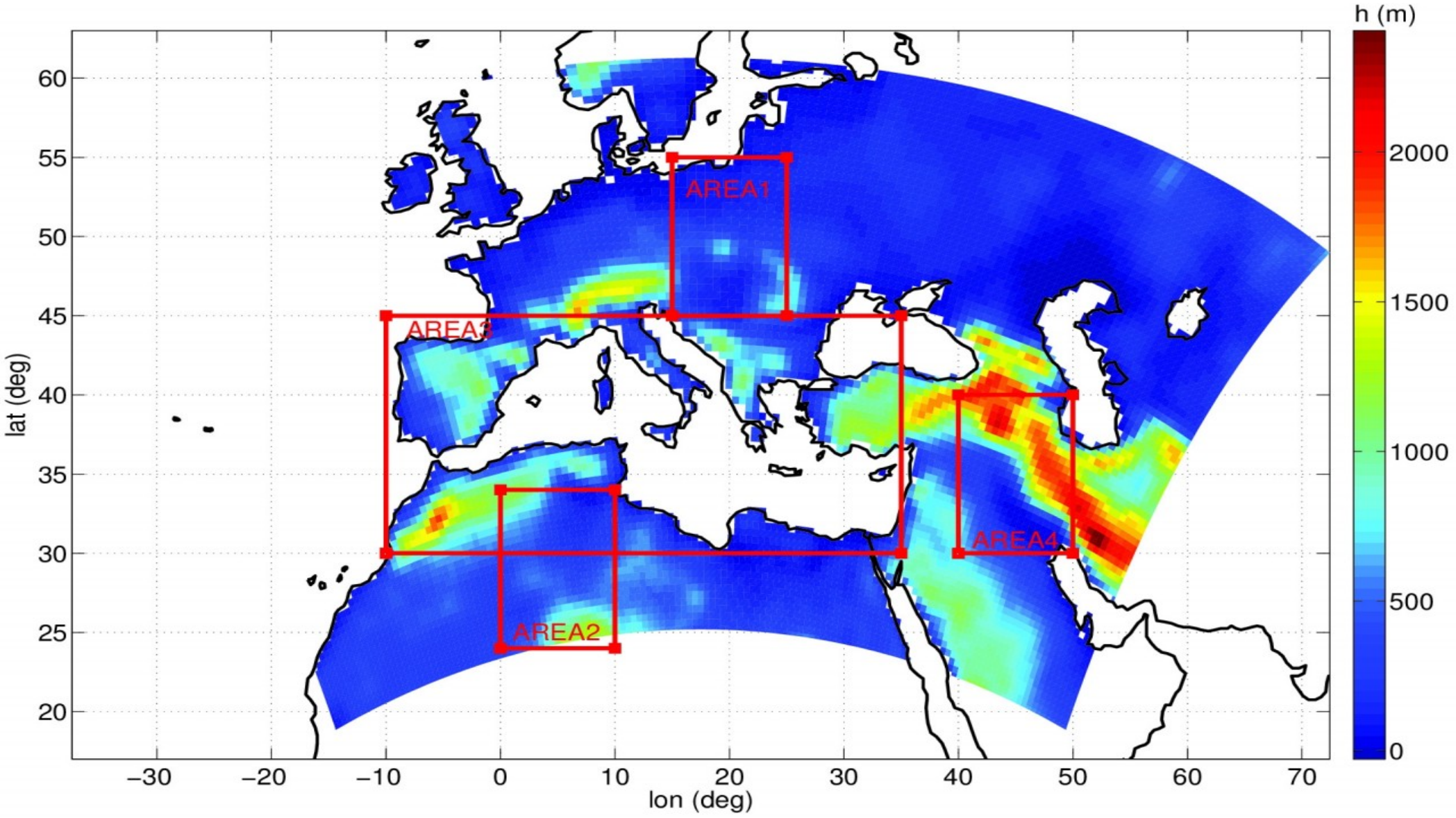
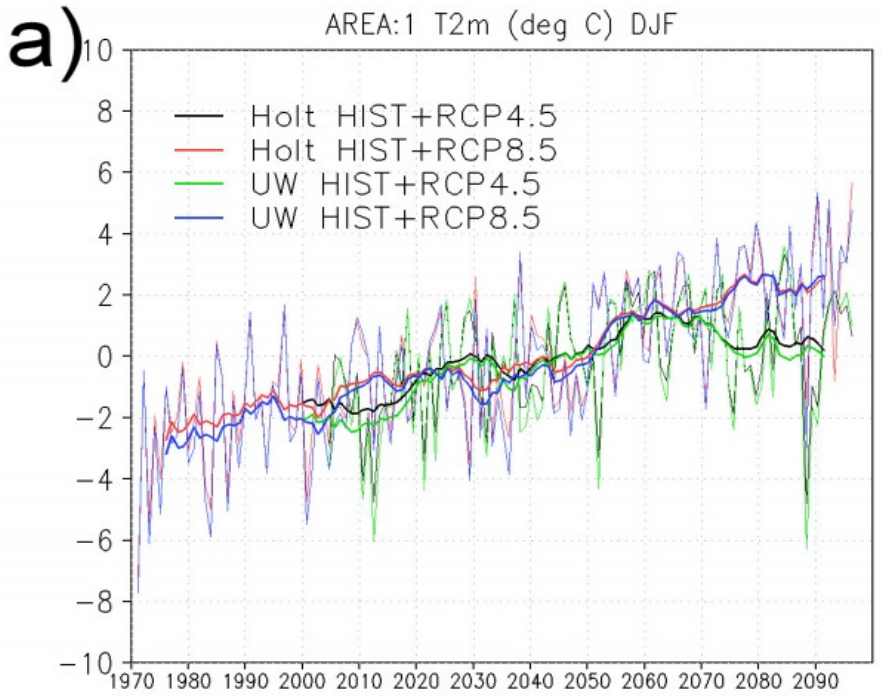
Fig. 2 from Güttler et al. (2013)

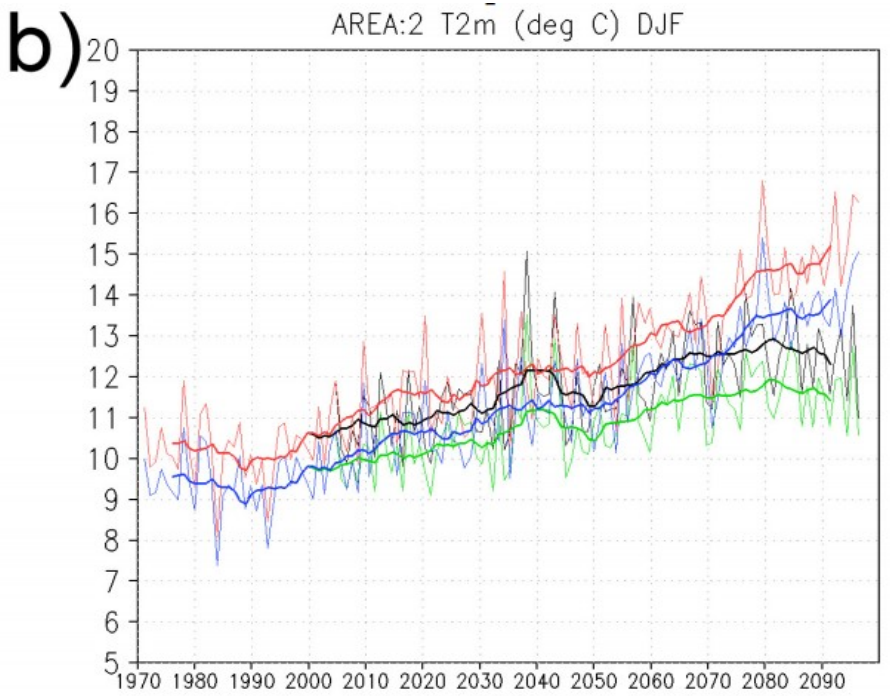
Domain, topography and selected areas

RegCM4.3(HadGEM2-ES), 1971-2099



RegCM4.3(HadGEM2-ES), 1971-2099, T2m





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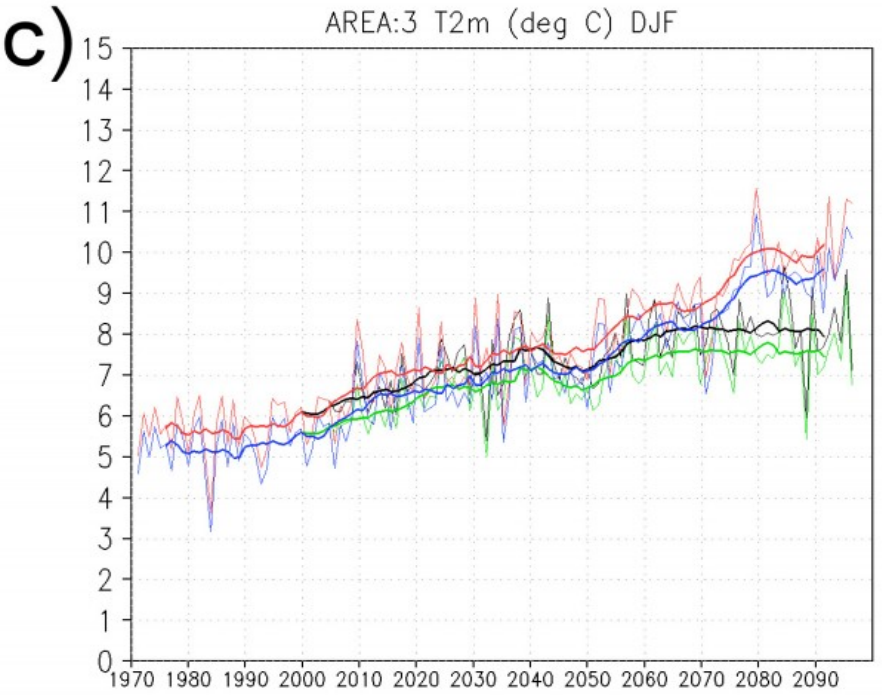

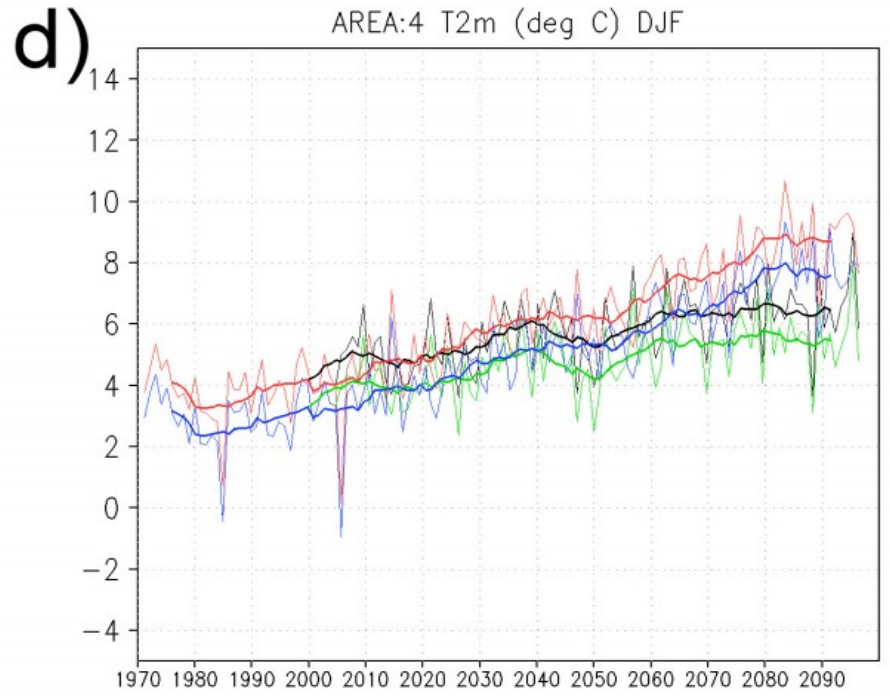

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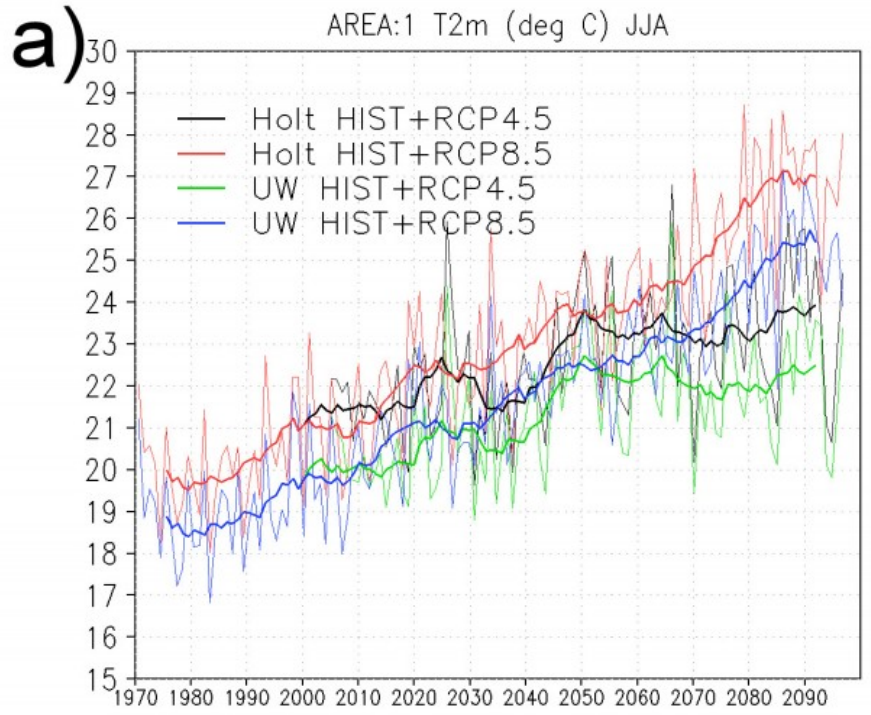
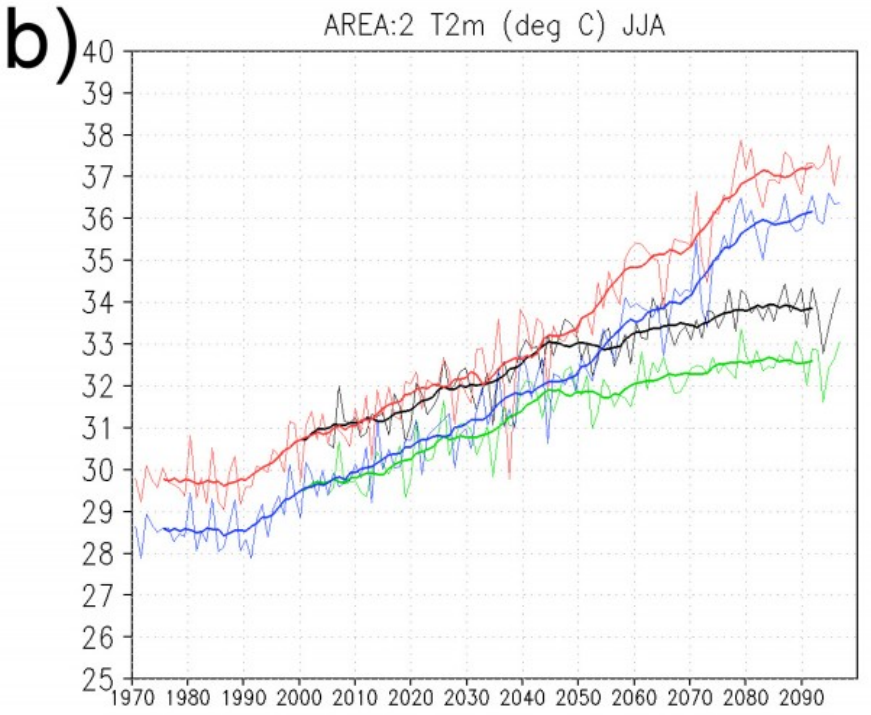
RegCM4.3(HadGEM2-ES), 1971-2099, T2m





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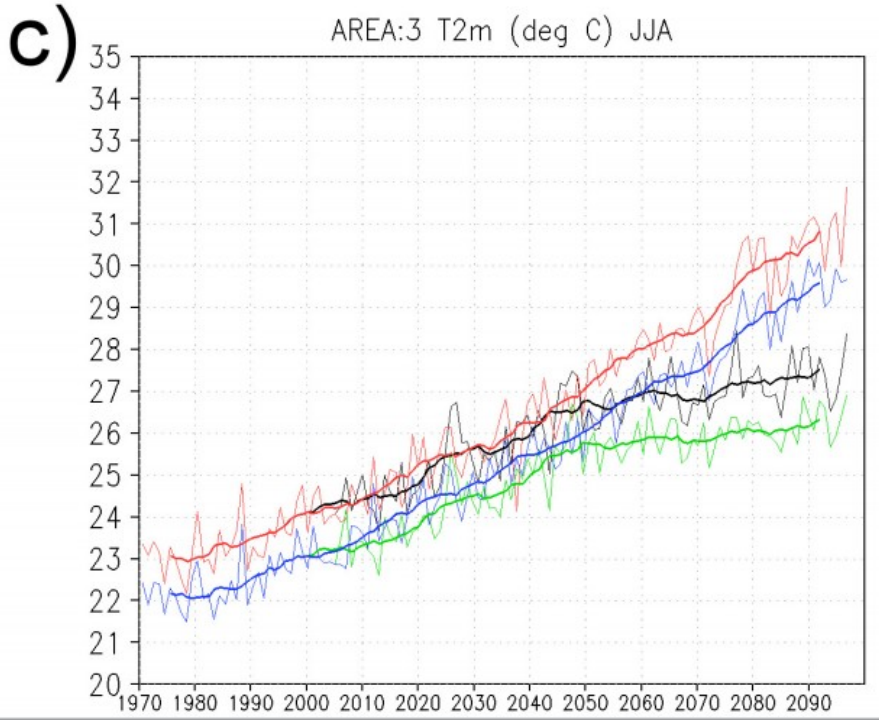

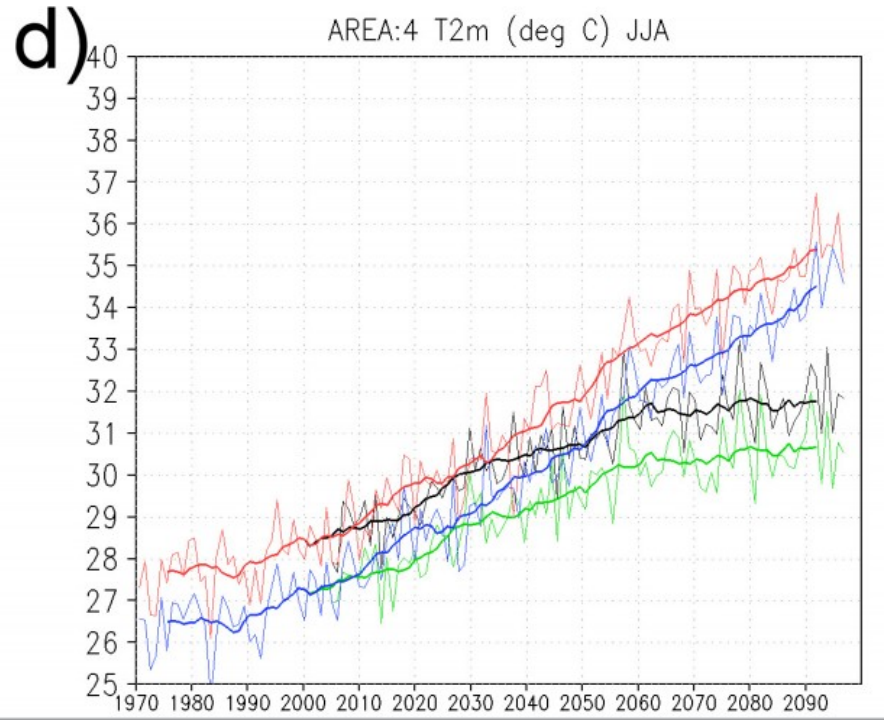

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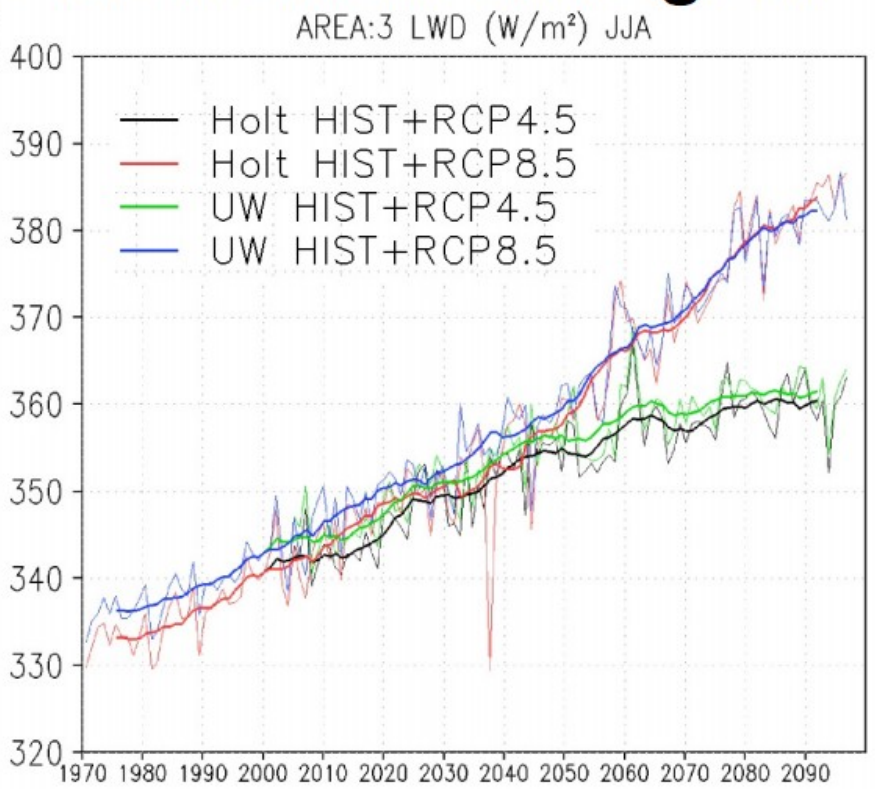
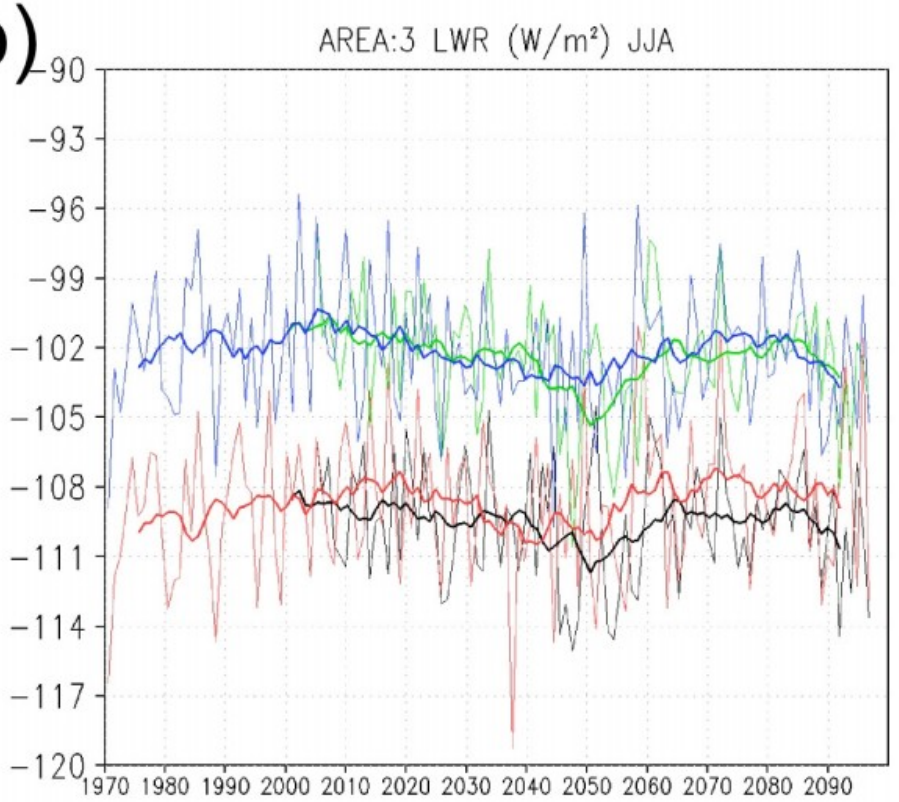
3. Time series of the mean summer surface variables over the Mediterranean region

a)



b)



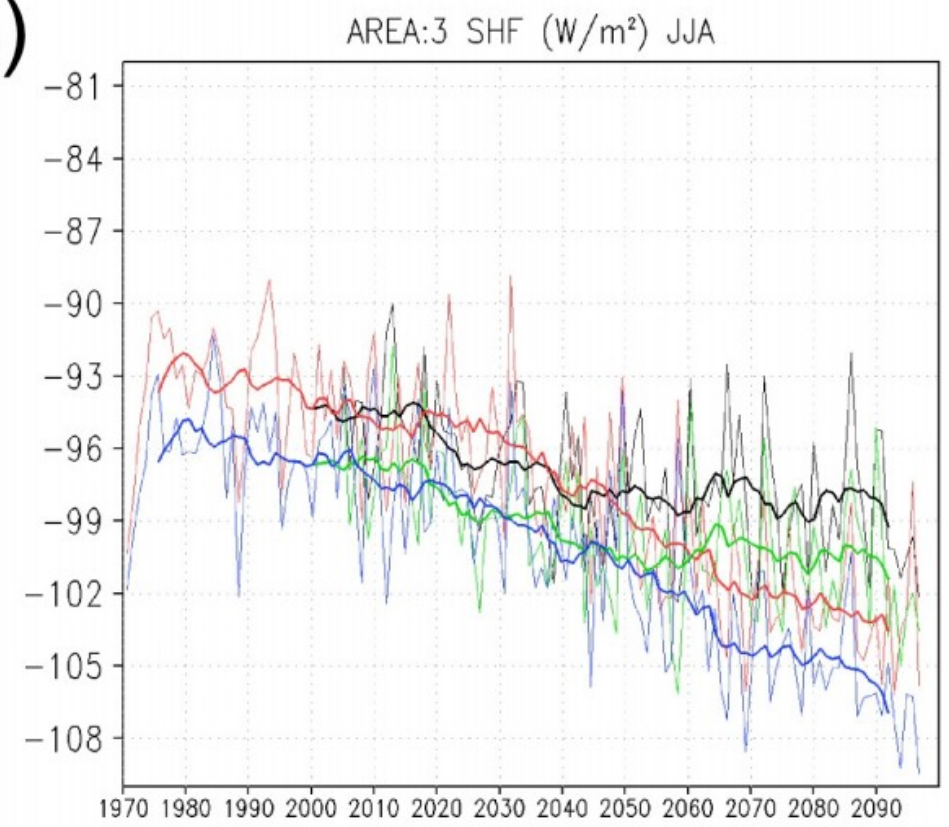
$$SWR = SWR_{SFC}\downarrow - SWR_{SFC}\uparrow = (1-ALB)\,(1-CLD)\,SWR_{TOA}\downarrow$$

$$LWR \equiv LWR_{SFC}\downarrow - LWR_{SFC}\uparrow = \sigma TS^4\left(0.165CLD^2 - 0.25\right)$$

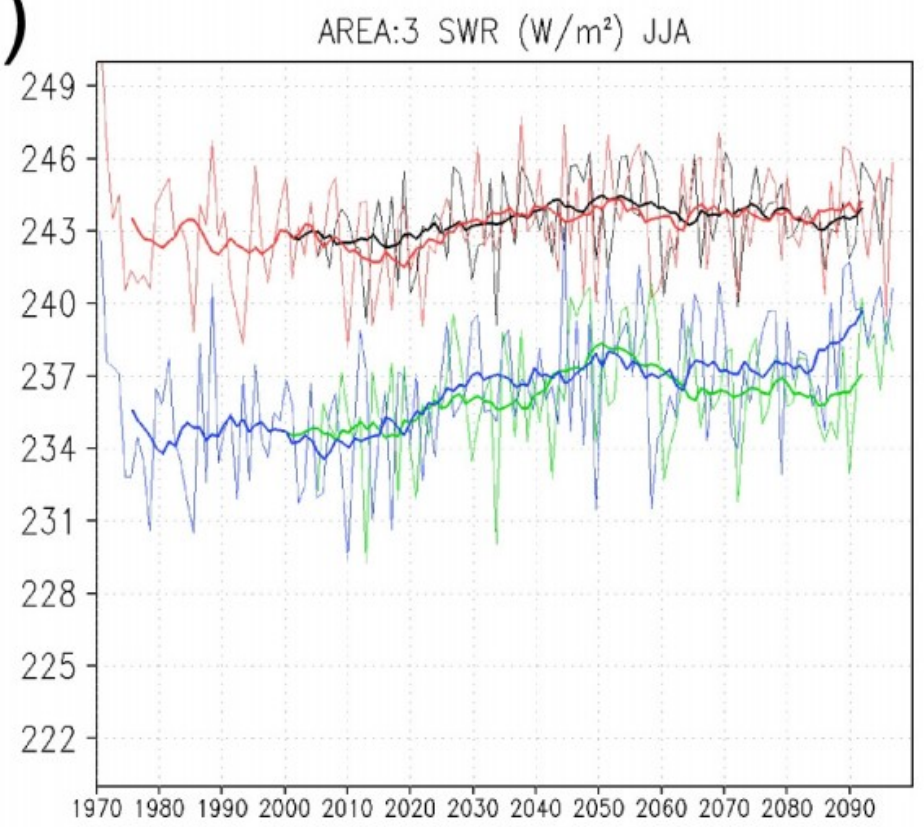
Kothe et al. (2010)

RegCM4.3(HadGEM2-ES), 1971-2099
Sensible heat flux (**SHF**) and surface net SW radiation (**SWR**)

c)



d)



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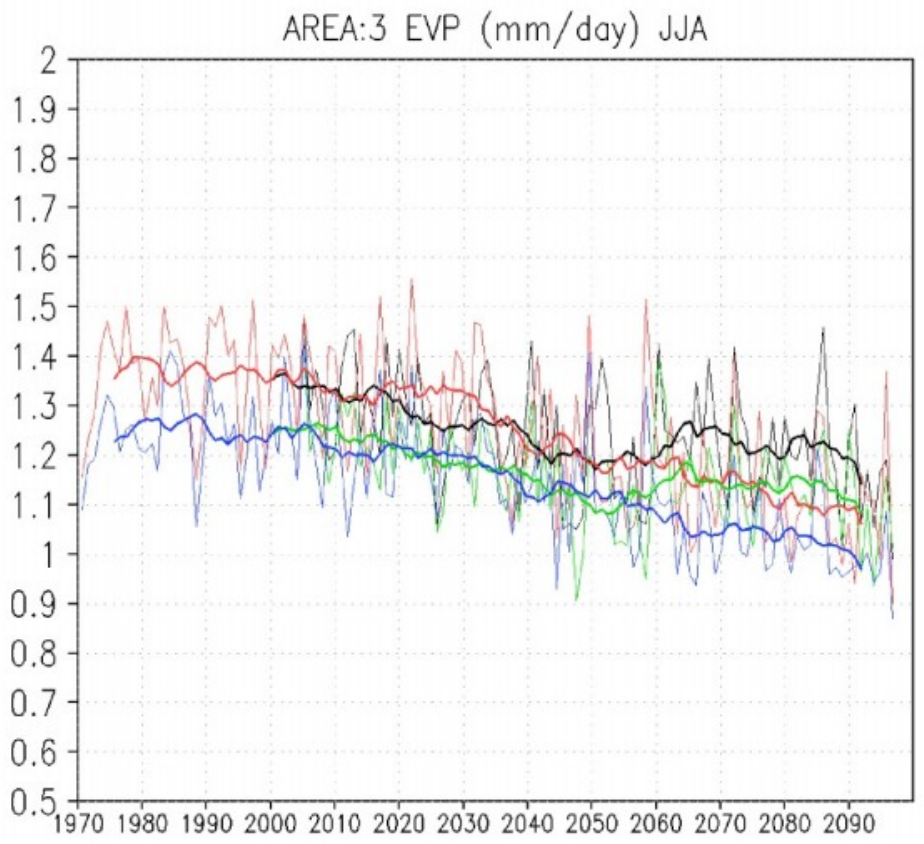
$$SHF = \rho_{AIR} C_D V_{AIR}\,(T_{AIR} - TS)\,c_p$$

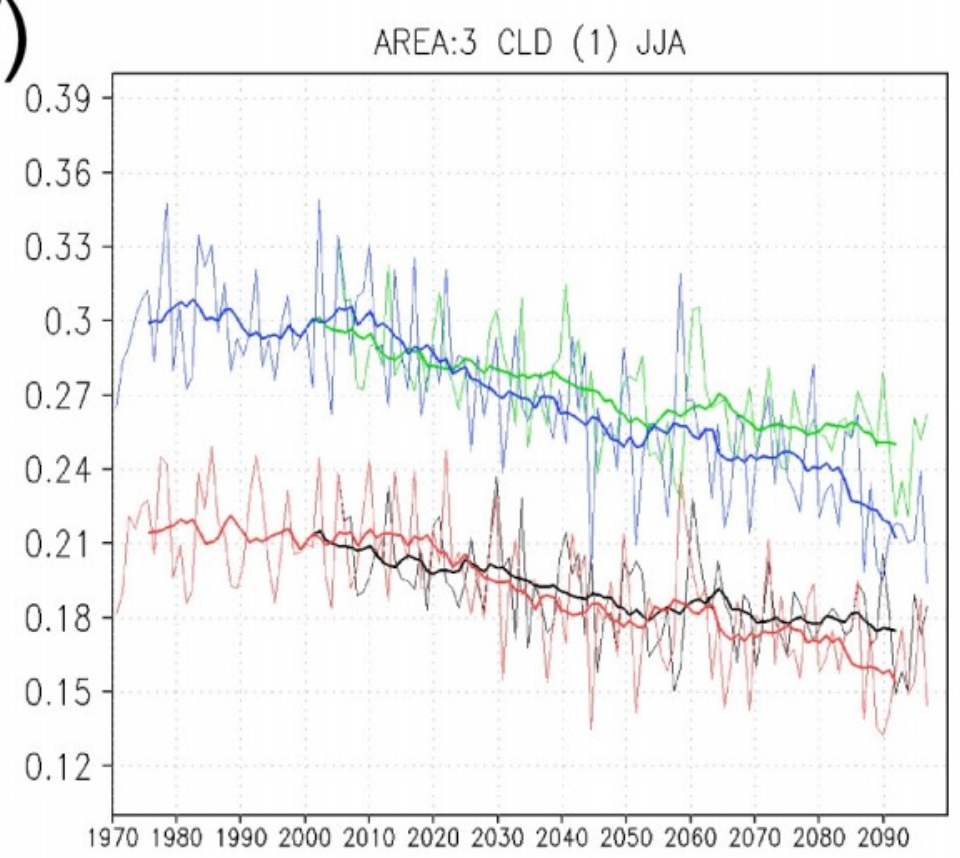
$$LHF = \rho_{AIR} C_D V_{AIR}\,(q_{AIR} - q_{SAT})\,L_v f_g$$

RegCM4.3(HadGEM2-ES), 1971-2099
evapotranspiration (**EVP**) and total cloud cover (**CLD**)

e)



f)



$$SWR = SWR_{SFC}\downarrow - SWR_{SFC}\uparrow = (1-ALB)\,(1-CLD)\,SWR_{TOA}\downarrow$$

$$LWR = LWR_{SFC}\downarrow - LWR_{SFC}\uparrow = \sigma TS^4\left(0.165CLD^2 - 0.25\right)$$

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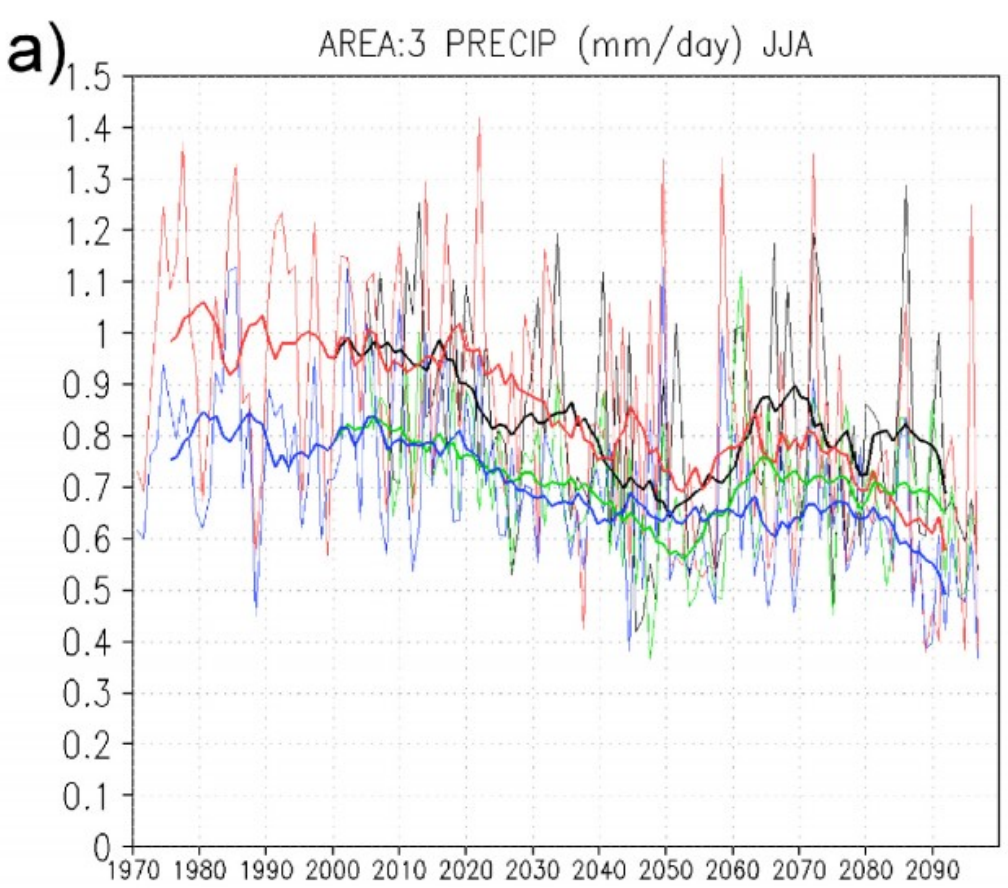
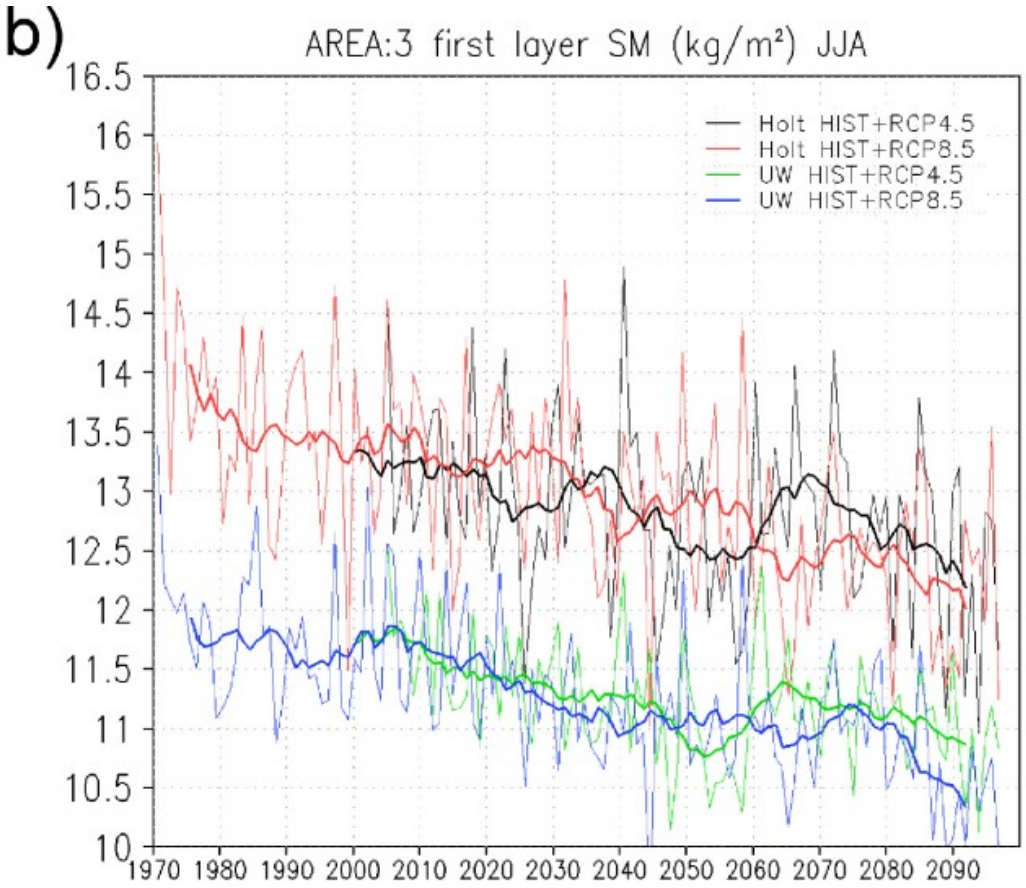
RegCM4.3(HadGEM2-ES), 1971-2099
total precipitation (**PRECIP**) and soil moisture in 1st layer (**SM**)





Summer drying over Mediterranean region projected in many independent studies (e.g. IPCC 2007, 2013)

Summary & Conclusions

[1] Model development and validation is a continuous process.

[2] The implementation of the new PBL scheme improves some aspects of the RegCM model.

[3] Our analysis indicates trend are (sometimes) not sensitive to different model physics. This needs further investigation.

[4] Mediterranean region is under high risk of major changes in the climate system under strong greenhouse gas concentration increase.

Thank you for your attention!

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