Variations in the Simulation of Climate Change Impact Indices due to Different Land Surface Schemes over the Mediterranean, Middle East and Northern Africa

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EEWRC

Introduction

Recent past:

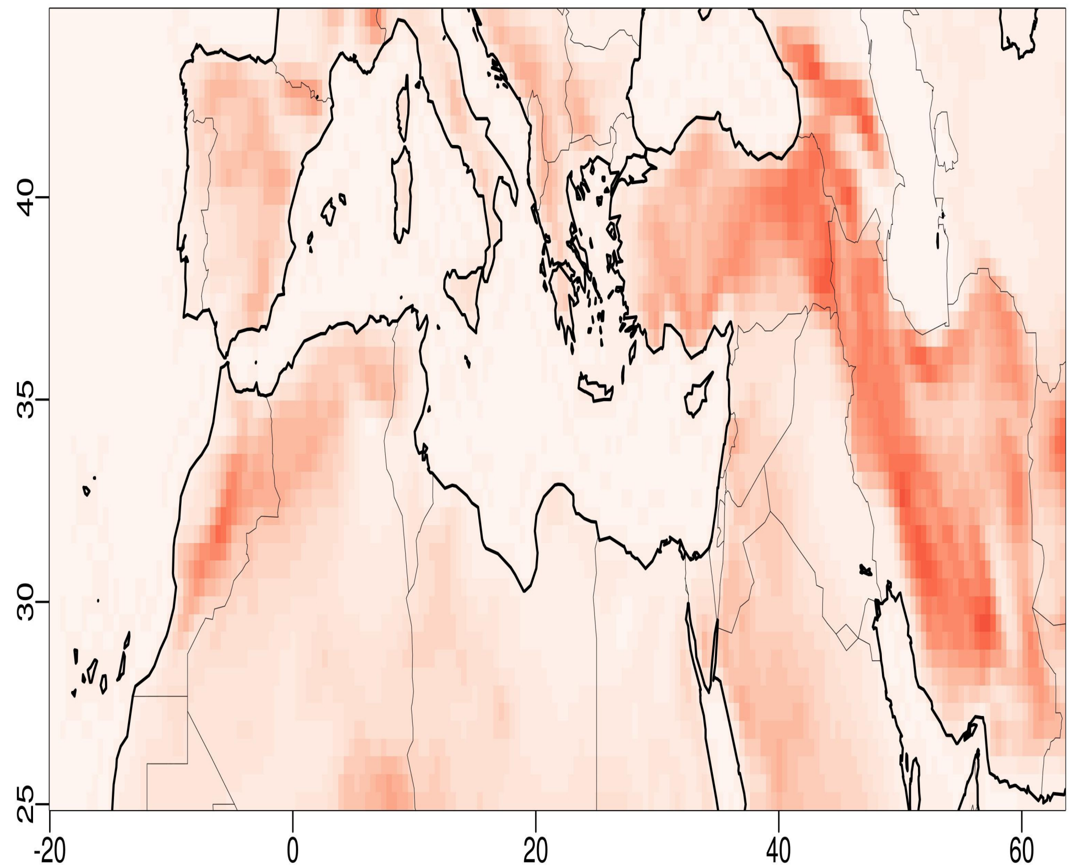
High temperatures & dryness

Future:

More extreme climatic conditions

Ecosystem & societal impacts

Mediterranean, Middle East and Northern Africa



Introduction

Regional Climate models (RCM) used for climate simulations (downscaling technique)

The output of the simulations are affected by different ***sources of uncertainty***

RCMs have uncertainties that are related to the representation of the ***dynamical & physical processes***

Land-Atmosphere interactions play an important role in climate through the *exchange of heat, moisture & radiation* between the ground and the air above it.
Land Surface Schemes (LSSs) are used to represent land surface processes in climate models

Introduction

Changes in prevailing climatic conditions simulated by RCMs

Consequences on society and natural ecosystems, projected and evaluated by impact assessments

Objective:
to explore the implied uncertainty of the variations of certain climate change impact related indices as it is induced by the modelled climate from different land surface schemes.

Radiative Index of Dryness (RID)

Fuel Dryness Index (Fd)

Water-limited Yield (Yw)

Methodology

Data:

RCM: Weather Research Forecast (**WRF**) version 3.8.1
Boundary conditions: **ERA-Interim** reanalyses
Horizontal resolution: **50 km**
Time period: **December 2000 – November 2010**
Domain: **MENA-CORDEX** (Coordinated Regional Climate Downscaling Experiment)

Experiment No.	Land Surface Scheme	Number of soil layers
run1	Noah	4
run2	NoahMP (dynamic vegetation = OFF)	4
run3	NoahMP (dynamic vegetation = ON)	4
run4	CLM	10
run5	RUC	6
run6	RUC	9

Methodology

Impact Indices:

Radiative Index of Dryness (RID)

A non-dimensional measure of the long-term balance between rainfall and net radiation

$$RID = \frac{r_n}{\lambda H \times p}$$

r_n → net radiation
λH → latent heat flux
p → precipitation

Budyko et. al. 1974

Methodology

Impact Indices:

<u>Fuel Dryness Index (Fd)</u>

A simple way to calculate fuel moisture content and assess the fire risk in an area

$$Fd = 1 - \frac{LH}{r_n - G}$$

r_n → net radiation
LH → latent heat flux
G → ground heat flux

Snyder et. al. 2006

Methodology

Impact Indices:

<u>Water-limited yield (Yw)</u>

Agro-Ecological Zones (AEZ) methodology to assess the suitability of crops and to quantify expected production.

1. thermal suitability test: result to the suitable gird-boxes for cultivation of a certain crop

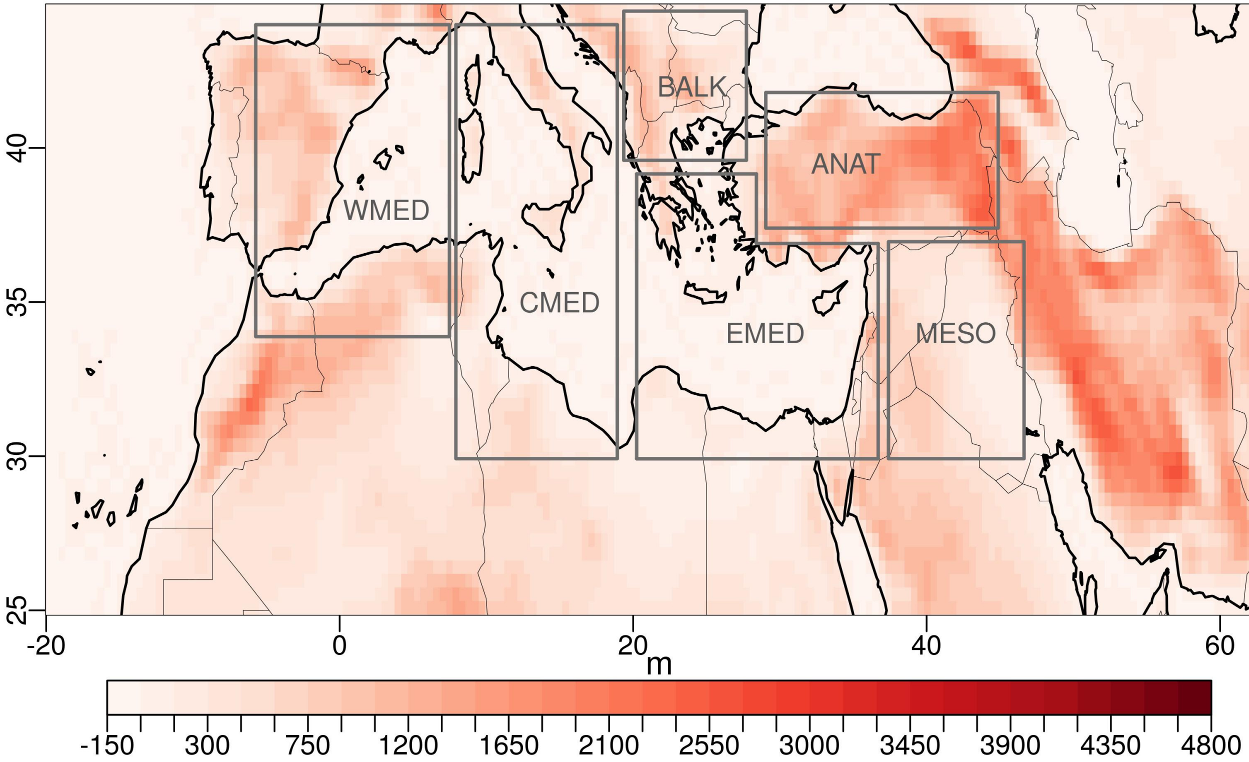
2. potential crop yields are calculated with regard to the prevailing temperature and radiation regimes

3. water-limited yield are derived using the potential yields and a water-stress limiting factor

Crop: ***Durum wheat***
(Triticum tirgidum)
Growing cycle: ***180 days***
1st November - 30th April

Constantinidou et. al. 2016

Results



Sub-domains:

Western Mediterranean

Central Mediterranean

Eastern Mediterranean

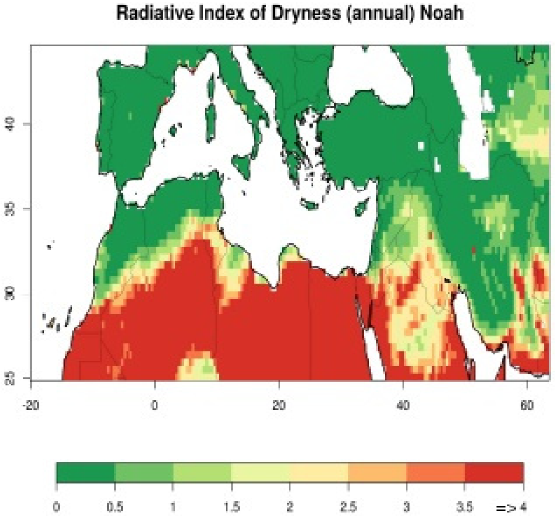
Balkans

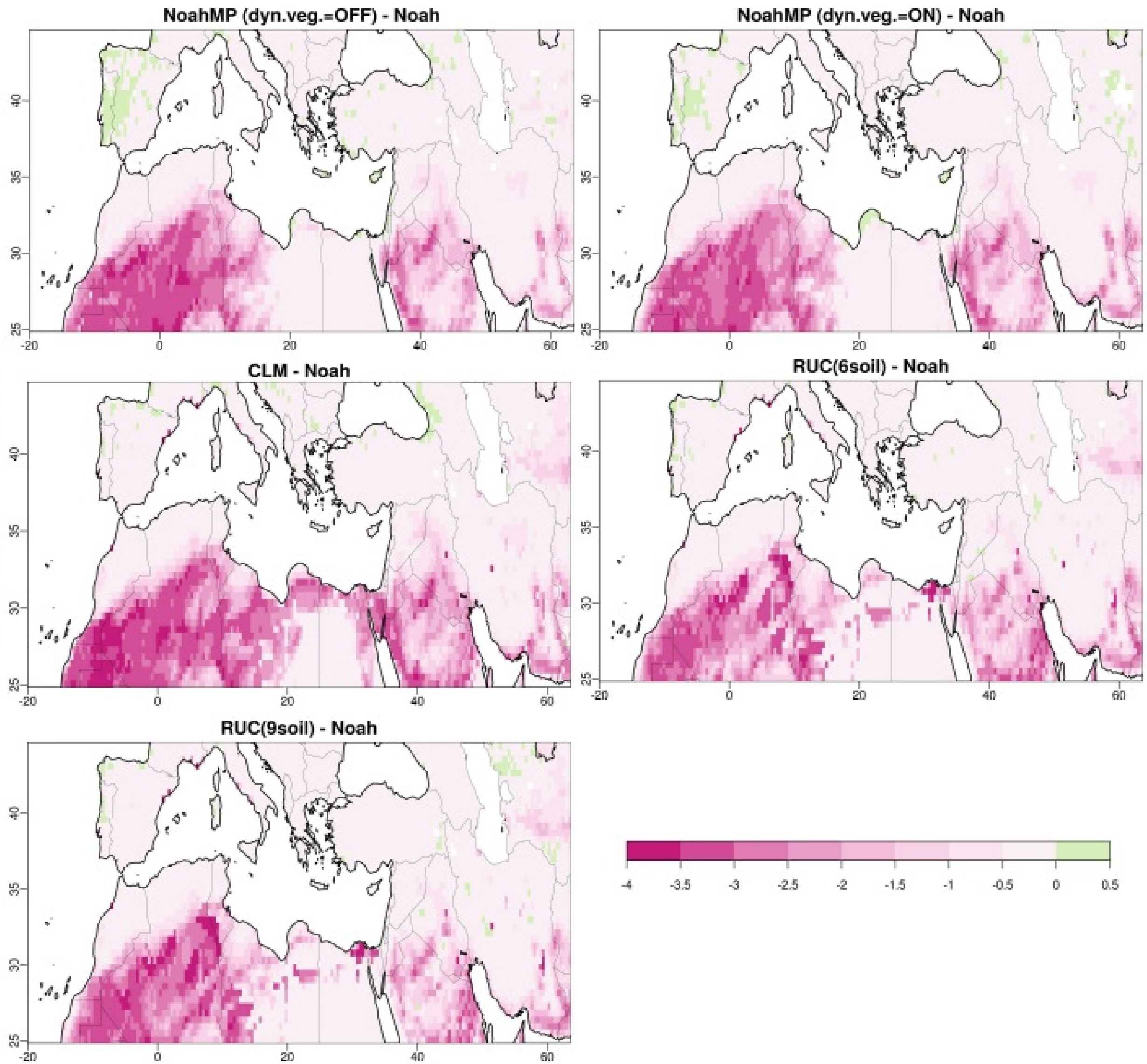
Anatolia

Mesopotamia

For each of the sub-domain and for every index
***mean values** derived from the 6 experiments,*
*the **difference (Δ) of each run from the overall mean value**,*
two times the standard deviation
*and **“relative dispersion”** (2σ/mean(r1:r6)) are calculated.*

Results


Radiative Index of Dryness (annual) Noah
40
35
30
25
-20
0
20
40
60
0
0.5
1
1.5
2
2.5
3
3.5
=> 4

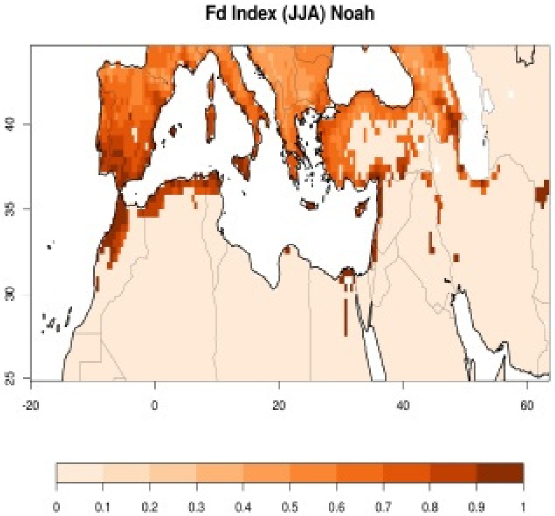

NoahMP (dyn.veg.=OFF) - Noah
NoahMP (dyn.veg.=ON) - Noah
CLM - Noah
RUC(6soil) - Noah
RUC(9soil) - Noah
40
35
30
25
-20
0
20
40
60
-4
-3.5
-3
-2.5
-2
-1.5
-1
-0.5
0
0.5

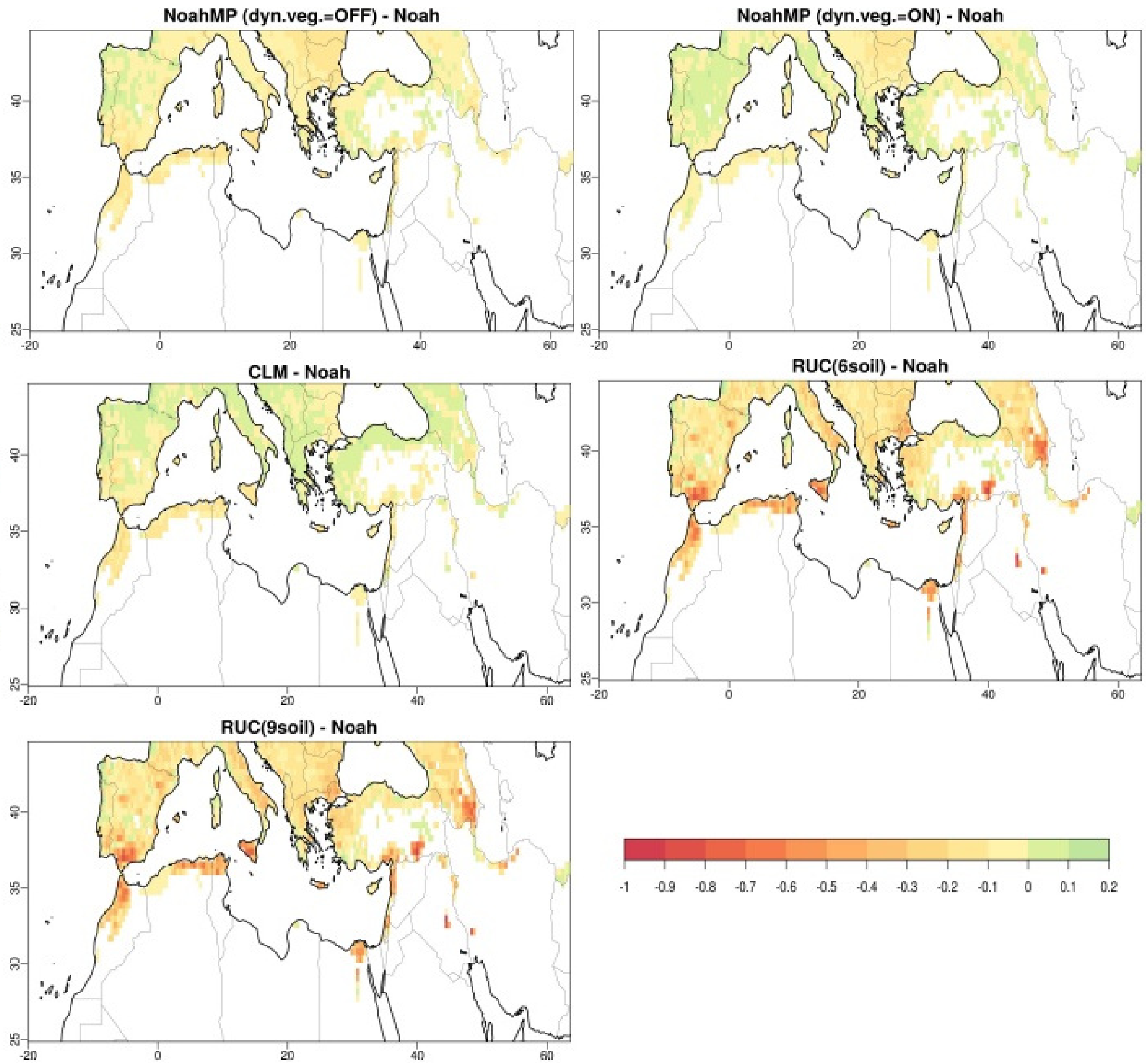
Results

RID	anat	balk	wmed	cmed	emed	meso	Whole Domain
Mean (r1:r6)	0.301	0.176	5.846	11.473	27.379	8.212	3.511
ΔNoah	0.110	0.064	−3.618	7.594	34.397	6.660	7.038
ΔNoahMP (dyn.veg. = off)	0.001	0.008	9.114	4.097	0.670	−0.149	−1.464
ΔNoahMP (dyn.veg. = on)	−0.023	−0.012	9.595	4.608	0.028	−0.071	−1.450
ΔCLM	−0.052	0.004	−5.120	−6.715	−19.813	−4.905	−2.529
ΔRUC (6soil)	−0.015	−0.031	−4.945	−4.626	−7.700	−1.216	−0.978
ΔRUC (9soil)	−0.022	−0.034	−5.027	−4.959	−7.581	−0.318	−0.616
2*σ	0.114	0.072	14.536	12.224	36.801	7.484	3.507
Rel. Disp.	0.379	0.409	2.487	1.065	1.344	0.911	$\boxed{0.999}$

2*σ – 2 * standard deviation
Rel. Disp. - "Relative dispersion"

Results


Fd Index (JJA) Noah
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1

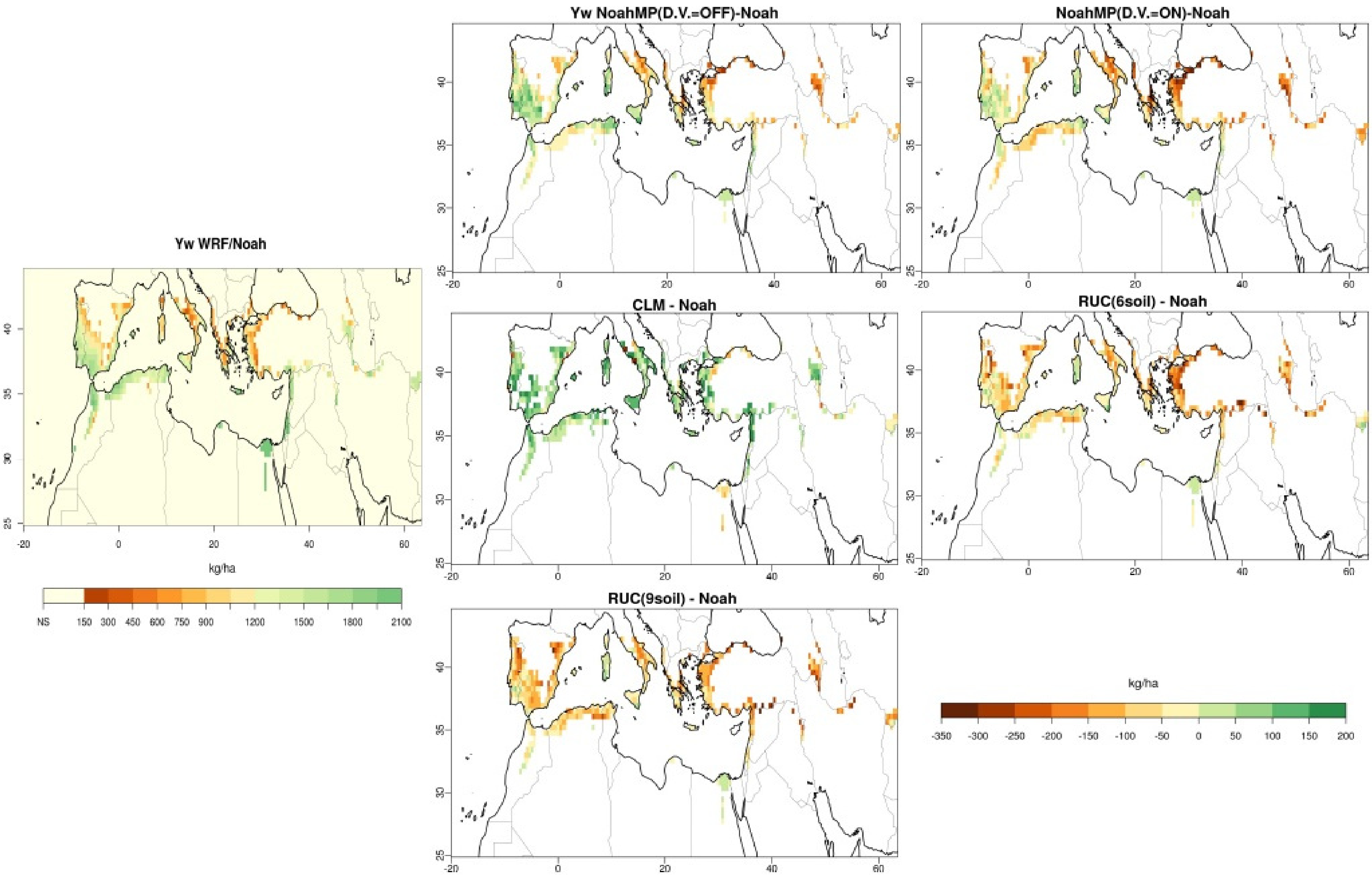

NoahMP (dyn.veg.=OFF) - Noah
NoahMP (dyn.veg.=ON) - Noah
CLM - Noah
RUC(6soil) - Noah
RUC(9soil) - Noah
-1 -0.9 -0.8 -0.7 -0.6 -0.5 -0.4 -0.3 -0.2 -0.1 0 0.1 0.2

Results

Fd	anat	balk	wmed	cmed	emed	meso	Whole Domain
Mean (r1:r6)	0.332	0.417	0.453	0.107	0.120	0.039	0.154
ΔNoah	0.023	0.101	0.053	0.023	0.017	0.006	0.018
ΔNoahMP (dyn.veg. = off)	0.015	−0.028	0.015	0.004	0.011	0.004	0.005
ΔNoahMP (dyn.veg. = on)	0.019	0.006	0.048	0.015	0.015	0.007	0.014
ΔCLM	0.030	0.087	0.030	0.011	0.011	0.004	0.014
ΔRUC (6soil)	−0.040	−0.079	−0.071	−0.026	−0.027	−0.011	−0.025
ΔRUC (9soil)	−0.046	−0.086	−0.076	−0.027	−0.026	−0.010	−0.026
2*σ	0.068	0.160	0.117	0.043	0.042	0.016	0.041
Rel. Disp.	0.205	0.384	0.258	0.402	0.350	0.406	0.265

2*σ – 2 * standard deviation
Rel. Disp. - “Relative dispersion”

Results



Yw WRF/Noah
kg/ha
NS 150 300 450 600 750 900 1200 1500 1800 2100
Yw NoahMP(D.V.=OFF)-Noah
NoahMP(D.V.=ON)-Noah
CLM - Noah
RUC(6soil) - Noah
RUC(9soil) - Noah
kg/ha
-350 -300 -250 -200 -150 -100 -50 0 50 100 150 200

Results

Yw	anat	balk	wmed	cmed	emed	meso	Whole Domain
Mean (r1:r6)	701.225	737.064	803.143	354.810	487.295	60.329	241.175
ΔNoah	0.314	26.180	25.759	12.039	2.900	−2.519	2.287
ΔNoahMP (dyn.veg. = off)	100.220	22.357	3.994	−5.814	14.032	9.782	3.942
ΔNoahMP (dyn.veg. = on)	17.929	−35.816	6.455	−11.823	0.770	5.657	−21.633
ΔCLM	33.076	88.141	91.379	36.844	17.946	5.119	26.918
ΔRUC (6soil)	−171.354	−127.924	−72.245	−8.818	−23.278	1.734	−4.329
ΔRUC (9soil)	19.814	27.062	−55.341	−22.429	−12.370	−19.773	−7.186
2*σ	181.581	147.875	117.824	42.491	31.277	21.056	22.056
Rel. unc.	0.259	0.201	0.147	0.120	0.064	0.349	0.091

2*σ – 2 * standard deviation
Rel. Disp. - “Relative dispersion”

Summary & Conclusions

Aim: to investigate the variations in the estimation of three climate change-related indices from RCM output due to different LSS.

The indices are: Radiative Index of Dryness (RID), the Fuel Dryness Index (Fd) & Water-limited Yield (Yw) of durum wheat.

6 performed simulations using the *WRF RCM* over the *MENA-CORDEX* domain driven by *ERA-Interim* reanalysis data for the period of *2000–2010* using *4 different LSSs* (Noah, NoahMP, CLM and RUC).

The indices directly related to certain impact sectors are found to be sensitive to the choice of LSSs employed.

Summary & Conclusions

RID:

CLM simulations deviate the most from Noah (reference) and gives less dry simulated conditions (Δ CLM)

MENA's relative dispersion = 1 (0 < RID < 4)

Fd (JJA):

Most vulnerable areas: western Mediterranean and Balkans

Fire potential: CLM and both options of NoahMP - high

RUC → reduced

Fd (JJA) ==> Noah: highest & RUC: lowest

"Relative dispersion": sub-domains = 0.2 - 0.4, MENA region ~ 25%

Yw (Durum wheat):

Southern & most of the northern parts of MENA: not suitable

All LSSs (except CLM): lower values compared to Noah

Yw ==> Mesopotamia:lowest & western Mediterranean highest

"Relative dispersion": MENA ~ 10%, sub-regions up to 40%

A certain degree of uncertainty in these indices should be expected because of the land surface treatment.

atmosphere

Article

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Thank you !!!

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