SPECIAL PROJECT PROGRESS REPORT

Progress Reports should be 2 to 10 pages in length, depending on importance of the project. All the following mandatory information needs to be provided.

Reporting year	2017/2018……………………………………………….……
Project Title:	Coupling and feedbacks between soil moisture and two dominant monsoon systems for present and future climates……………………………………………….……
Computer Project Account:	spsemay……………………………………………….……
Principal Investigator(s):	Wilhelm May……………………………………….……
	……………………………………………………….……
Affiliation:	Centre for Environmental and Climate Research / Lund University……………………………………….……
Name of ECMWF scientist(s) collaborating to the project (if applicable)	……………………………………………………….…… ……………………………………………………….……
Start date of the project:	1.1.2017……………………………………………….……
Expected end date:	31.12.2019……………………………………………….……

Computer resources allocated/used for the current year and the previous one

(if applicable)

Please answer for all project resources

		Previous year		**Current year**	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	6,000,000	2,233,000	12,000,000	312,000
Data storage capacity	(Gbytes)	15,000	48	30,000	3,440

Summary of project objectives
(10 lines max)

The overall objective of the project is to investigate the role of soil moisture for the variability of two of the most dominant monsoon systems, i.e., the West African Monsoon and the Indian Summer Monsoon, for present-day and future climate conditions. In particular, the project will investigate the physical processes governing the coupling and feedbacks between soil moisture and the two monsoons and assess the contributions of the future changes in soil moisture to the overall future changes in the variability and the mean state of these monsoons in response to the projected increases in the anthropogenic climate forcing.

Summary of problems encountered (if any)
(20 lines max)

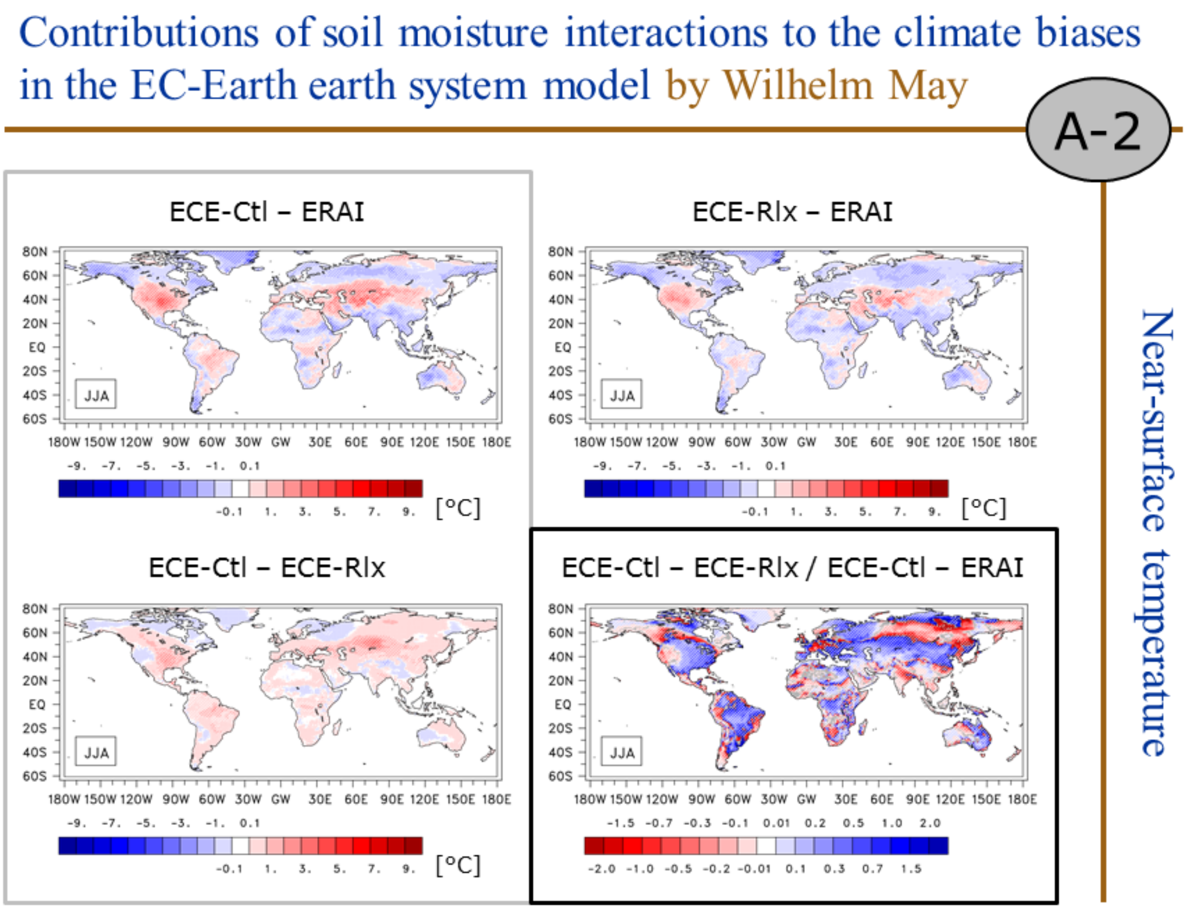
The release of the new version (v3.2) of the EC-Earth earth system model to be used for the CMIP6 experiments has been further delayed. Therefore, I have only performed a number of short test runs and several 10-year experiments with a preliminary model version instead of the long experiments that I had planned already for the last year.

Summary of results of the current year (from July of previous year to June of current year)

The code of the EC-Earth (v3.2) earth system model has been installed on cca, and I have implemented and tested a relaxation routine for the soil moisture content in the climate model. The relaxation routine is part of IFS, so that it can be used in all configurations of EC-Earth, i.e. the versions coupled to the NEMO ocean model and/or the LPJ-GUESS dynamical vegetation model. The relaxation routine is controlled by a namelist, allowing for no replacement or relaxation, for replacement, or relaxation with different relaxation times for individual surface layers.

I have, among others, performed several 10-year experiments (1991-2000) with the preliminary version of EC-Earth, a standard simulation ("ECE-Ctl") and a simulation ("ECE-Rlx"), where the soil moisture content was relaxed against the climatology from ERA-Interim/Land, which here was considered as the truth.

Based on these simulations, I have assessed the extent to which the soil moisture biases in EC-Earth contribute to climate biases in the earth system model. The figure below shows the results for the near-surface temperatures in boreal summer (June through August). Both simulations show characteristic temperature biases compared against ERA-Interim ("ERAI"), i.e. warm biases in North America and Central Asia but cold biases at high-northern latitudes. Overall, the magnitude of the temperature biases is reduced in ECE-Rlx as compared to ECE-Ctl, meaning that the soil moisture biases actually contribute to the temperature biases in EC-Earth (see the panel on the lower left). This can be seen in the panel on the lower right, which shows the ratio between the difference between the two simulations and the temperature bias of the standard simulations. Positive values (blue colours) indicate the areas, where the soil moisture biases contribute to the temperature biases, and negative values (red colours), where the soil moisture bias leads to reversed temperature biases.



List of publications/reports from the project with complete references

I presented a poster entitled "Contributions of soil moisture interactions to the climate biases in the EC-Earth earth system model" at the 8th GEWEX Open Science Conference 'Extremes and water on the edge' in Canmore, Canada (see below).

I also presented this work at the latest EC-Earth General Assembly in Reading, UK, as an oral presentation entitled "Controlling soil moisture in EC-Earth: First results from relaxation experiments".

Summary of plans for the continuation of the project

(10 lines max)

Once, EC-Earth (v3.2) will be released for CMIP6 (presumably during summer), I will be able to run the first long experiments with the earth system model. This will be both standard simulations but also simulations with a special version of the climate model, where the state of the land surface is replaced by or relaxed towards suitable external data, respectively. These experiments are contributions to LS3MIP, one of the model intercomparison projects within CMIP6.

Along with these experiments, I will further develop the relaxation routines to consider more variables describing the land surface, i.e. snow cover and soil temperatures.

Contributions of soil moisture interactions to the climate biases in the EC-Earth earth system model

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A Purpose of the study

In this study, the extent to which biases in the soil moisture content contribute to the biases in various aspects of climate in EC-Earth is assessed. For this, two simulations with the atmospheric version of EC-Earth have been performed. In one of the simulations, soil moisture is developing freely, while in the other soil moisture is relaxed towards the respective estimates from ERA-Interim/Land. Several aspects of climate (i.e. soil moisture, near-surface temperature and precipitation) obtained from these simulations are compared against observational estimates (i.e. ERA-Interim/Land, ERA-Interim, data from the Global Precipitation Climatology Centre). Furthermore, the two simulations are compared with each other. For each aspect of climate, the differences between these data sets yield a quantitative assessment of the contributions of the soil moisture interactions (i.e. in response to the modified 'realistic' soil moisture content) to the climate biases in EC-Earth.

B Data and methods

(1) Two AMIP-type simulations with a recent version (v3.2) of the EC-Earth earth system model (1) for 1990-2000 (first year not used): One with freely developing soil moisture ('ECE-Ctl') and one, where the soil moisture content is relaxed towards ERA-Interim/Land ('ERAI-L'; 2) ('ECE-Rlx').

(2) Soil moisture is relaxed towards ERAI-L for the three lower soil layers, while in the uppermost layer (0-7 cm) soil moisture is developing freely. The relaxation times vary by layer, i.e. 18 hrs for 7-28 cm, 12 hrs for 28-100 cm and 6 hrs for 100-255 cm.

(3) As observational data for 1991-2000 ERAI-L (soil moisture), ERA-Interim ('ERAI'; near-surface temperature) and data from the Global Precipitation Climatology Centre ('GPCC'; precipitation) are considered.

(4) Only long-term seasonal means for the boreal summer season, i.e. June, July and August, are presented.

C Conclusions

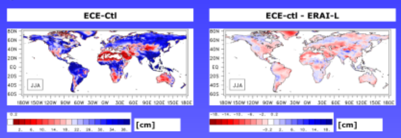
(1) EC-Earth has a general tendency to underestimate soil moisture ('sm'), particularly in the central tropics, the Northern Hemisphere subtropics and parts of the Northern Hemisphere mid-latitudes. EC-Earth overestimates sm in the northern part of the tropics, the western part of North America and Southern Africa.

(2) The sm bias gives a major contribution to a corresponding soil moisture bias in the uppermost layer (0-7 cm), except for Northern and Southern Africa as well as the subtropical part of South America.

(3) EC-Earth has a warm temperature bias in the central tropics and in the Northern Hemisphere mid-latitudes and a cold bias in the northern part of the tropics and at high northern latitudes. The sm bias gives a major contribution to the warm bias in the central tropics and in the Northern Hemisphere mid-latitudes, except for the western part of North America.

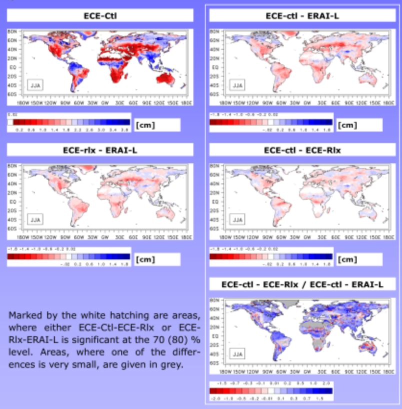
(4) EC-Earth has a general tendency to underestimate precipitation in the central tropics, the Northern Hemisphere subtropics and parts of the Northern Hemisphere mid-latitudes (here, mainly linked to the sm bias). EC-Earth overestimates precipitation in the northern part of the tropics and at high northern latitudes.

1 Soil moisture (0-100 cm)



Seasonal mean soil moisture (0-100 cm) for ECE-Ctl and the difference between ECE-Ctl and ERAI-L. Units are cm, the contour interval is 2 cm. Marked by the white hatching is the significance of the differences at the 97.5 % level.

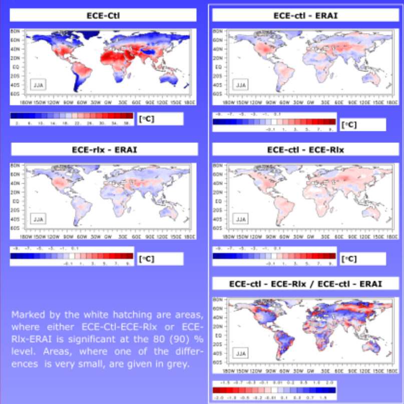
2 Soil moisture (0-7 cm)



Marked by the white hatching are areas, where either ECE-Ctl-ECE-Rlx or ECE-Rlx-ERAI-L is significant at the 70 (80) % level. Areas, where one of the differences is very small, are given in grey.

Seasonal mean soil moisture (0-7 cm) for ECE-Ctl as well as the differences between ECE-Ctl and ERAI-L, between ECE-Rlx and ERAI-L and between ECE-Ctl and ECE-Rlx. Units are cm, the contour interval is .2 cm. Marked by the white hatching is the significance of the differences at the 97.5 % level. Furthermore, the ratio between ECE-Ctl-ECE-Rlx and ECE-Rlx-ERAI-L. Units are standard unit, the contour interval is variable.

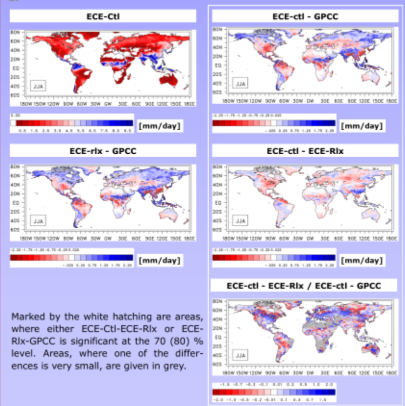
3 Near-surface temperature



Marked by the white hatching are areas, where either ECE-Ctl-ECE-Rlx or ECE-Rlx-ERAI is significant at the 80 (90) % level. Areas, where one of the differences is very small, are given in grey.

As for (2), but for the near-surface temperature, with observations from ERAI. Units are °C, the contour interval is 1 °C. Note the reversed colour scale in the four upper panels!

4 Precipitation



Marked by the white hatching are areas, where either ECE-Ctl-ECE-Rlx or ECE-Rlx-GPCC is significant at the 70 (80) % level. Areas, where one of the differences is very small, are given in grey.

As for (2), but for precipitation, with observations from GPCC. Units are mm/day, the contour interval is .5 mm/day.

D References

(1) Hazeleger W, et al. (2012) EC-Earth V2.2: description and validation of a new seamless earth system prediction model. Clim Dyn 39: 2611-2629

(2) Balsamo G, et al. (2015) ERA-Interim/Land: a global land surface reanalysis data set. Hydrol Earth Syst Sci 19: 389-407

E Acknowledgement

MERGE

The research presented here is a contribution to the Swedish strategic research area 'Modelling the Regional and Global Earth System (MERGE)'.

8TH GEWEX OPEN SCIENCE CONFERENCE 'Extremes and water on the edge' in Canmore, Canada