

## CHANGES IN PARAMETERIZATIONS OF REGIONAL CLIMATE MODEL REGCM4.4.5: THE ROLE OF LAND COVER ON REGIONAL CLIMATE OVER MEDITERRANEAN

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### Abstract

*A parameter that affects significantly the local, regional and global climate system is land cover and the changes that may occur to it. During winter season, heavy precipitation assists vegetation growth of Mediterranean forests and woodlands, whereas during summer, absence of precipitation and severe heat waves result to arid and semiarid vegetation. For that reason, it was quite interesting to track the changes that may occur in the climate of the Mediterranean region due to land cover/land use changes on regional climate over the Mediterranean region. The main objective of the study is the assessment of the impacts of land cover/land use changes on regional climate over the Mediterranean region. The examined regional climate model used in the study is RegCM4.4.5. Its spatial resolution is 25x25km and different simulations were performed with changes in land cover/land use for the time period 1981-1990. The different simulated data were compared in order to examine the modifications that occur from land cover/land use changes in evapotranspiration and surface albedo to direct and diffuse radiation in the domain of study.*

**Keywords:** evapotranspiration, surface albedo, diffuse, direct, CORINE 2000.

### Περίληψη

*Μια παράμετρος που επηρεάζει σημαντικά το τοπικό, περιοχικό και παγκόσμιο κλίμα είναι η χρήση γης και οι αλλαγές που μπορεί να προκληθούν σε αυτή. Κατά τη διάρκεια του χειμώνα, οι έντονες βροχοπτώσεις βοηθούν την ανάπτυξη της βλάστησης στα Μεσογειακά δάση, ενώ κατά τη διάρκεια του καλοκαιριού, η απουσία των βροχοπτώσεων και τα έντονα κύματα καύσωνα έχουν σαν αποτέλεσμα ξηρή και ημίξηρη βλάστηση. Γι' αυτό το λόγο, ήταν ιδιαίτερα ενδιαφέρον να εντοπιστούν οι αλλαγές που μπορεί να προκύψουν στο μεσογειακό κλίμα λόγω αλλαγών στη χρήση γης. Κύριος στόχος της παρούσας εργασίας είναι η εκτίμηση των επιπτώσεων των αλλαγών στη χρήση γης στο τοπικό κλίμα της Μεσογείου. Το περιοχικό κλιματικό μοντέλο που χρησιμοποιείται στη συγκεκριμένη εργασία είναι το RegCM4.4.5. Η χωρική του ανάλυση είναι 25x25km. Για τους σκοπούς αυτής της εργασίας, έγιναν διαφορετικές προσομοιώσεις με αλλαγές στη χρήση γης για τη χρονική περίοδο 1981-1990. Τα διαφορετικά προσομοιωμένα δεδομένα συγκρίθηκαν για να εξεταστούν οι μεταβολές που προκύπτουν από τις αλλαγές στη χρήση γης στην εξατμισοδιαπνοή και στη λευκαύγεια από άμεση και διάχυτη ακτινοβολία στην περιοχή μελέτης.*

**Λέξεις κλειδιά:** εξατμισοδιαπνοή, λευκαύγεια, άμεση, διάχυτη, CORINE 2000.

## 1. Introduction

A parameter that has an important role in the local, regional and global climate system is land cover and the changes that may occur to it (Anav *et al.*, 2010). Land cover/Land use changes affect significantly the surface albedo, fluxes of radiation and momentum, heat, water vapor, carbon dioxide and other trace gases, aerosols and dust, and turbulence in the boundary layer (Halder *et al.*, 2015). When we refer to “land cover” we are referring to the physical and biological cover of land surface (water, vegetation, bare soil, artificial structures), whereas with the term “land use” we are also talking about the interaction of human activities (agriculture, forestry etc.) (Ellis, 2013).

During winter season, heavy precipitation assists vegetation growth of Mediterranean forests and woodlands, whereas during summer, absence of precipitation and severe heat waves result to arid and semiarid vegetation (Velikou *et al.*, 2014). For that reason, it was quite interesting to track the changes that may occur in the climate of the Mediterranean due to land cover/land use changes on regional climate over the Mediterranean region.

## 2. Data and Methodology

### 2.1. Data

The examined regional model is RegCM4.4.5, which is a hydrostatic, compressible, sigma-p vertical coordinate model (Giorgi *et al.*, 1993a, b; Elguindi *et al.*, 2014). Its dynamical core is similar to that of the hydrostatic version of Mesoscale Model version 5 (MM5) (Grell *et al.*, 1994). Its spatial resolution is 25x25km. In this study we used data for evapotranspiration, surface albedo to direct shortwave radiation and surface albedo to diffuse shortwave radiation. These parameters are generally connected to land cover/land use. Evapotranspiration is the sum of evaporation from the Earth’s land and ocean surface to the atmosphere and plant transpiration, whereas surface albedo is the fraction of the incident sunlight that the surface reflects (Coakley, 2003).

### 2.2. Methodology

Different simulations were performed with changes in land cover/land use for the time period 1981-1990 (Figure 1). More specifically, we used the model’s default land cover/land use types and CORINE 2000 land cover data. In these simulations ERA-INTERIM data were utilized for sea surface temperature (SST) and initial and boundary conditions (ICBC) in order to “run” the latest version of the regional climate model (RegCM4.4.5.1).

The different simulated data were processed on a seasonal basis and the differences between the CORINE 2000 land cover/land use and the model’s default land cover/land use were calculated, mapped and compared. In order to find the statistical significance of these differences the Student’s t-test was performed (Wilks, 2006).

#### 2.2.1. Model’s Default Land Cover/Land Use (BATS)

Biosphere-Atmosphere Transfer Scheme (BATS) is a surface package which describes the role of vegetation and interactive soil moisture in modifying the surface-atmosphere exchanges of momentum, energy and water vapour (Dickinson *et al.*, 1993; Elguindi *et al.*, 2014). It divides land cover in 20 vegetation types according to soil texture and soil colour.

#### 2.2.2. CORINE Land Cover Project

The main objective of the CORINE (Coordination of information on the environment) program of the European Commission is to gather, coordinate and ensure the consistency of information on the state of the environment and natural resources. The land cover project (CLC) is part of the CORINE program and is intended to provide consistent localized geographical information on the land cover. It is produced by the European Environmental Agency (EEA) and its member countries and is based

on the results of IMAGE2000, a satellite imaging program undertaken jointly by the Joint Research Centre of the European Commission and the EEA (<http://www.eea.europa.eu/>).

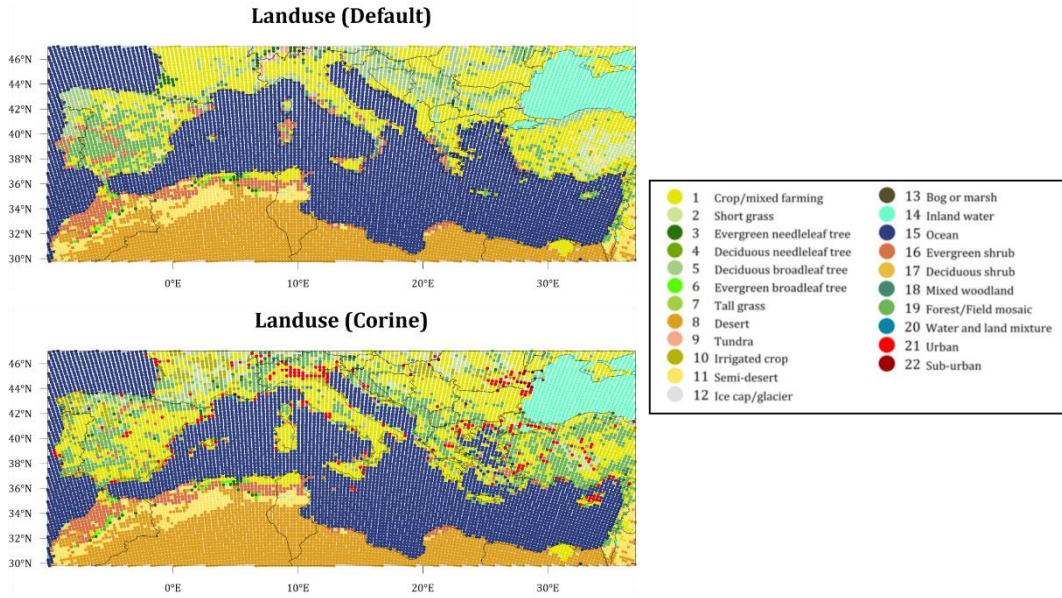


Figure 1 - Simulation domain and land cover types from the different simulations.

### 3. Results

#### 3.1. Evapotranspiration

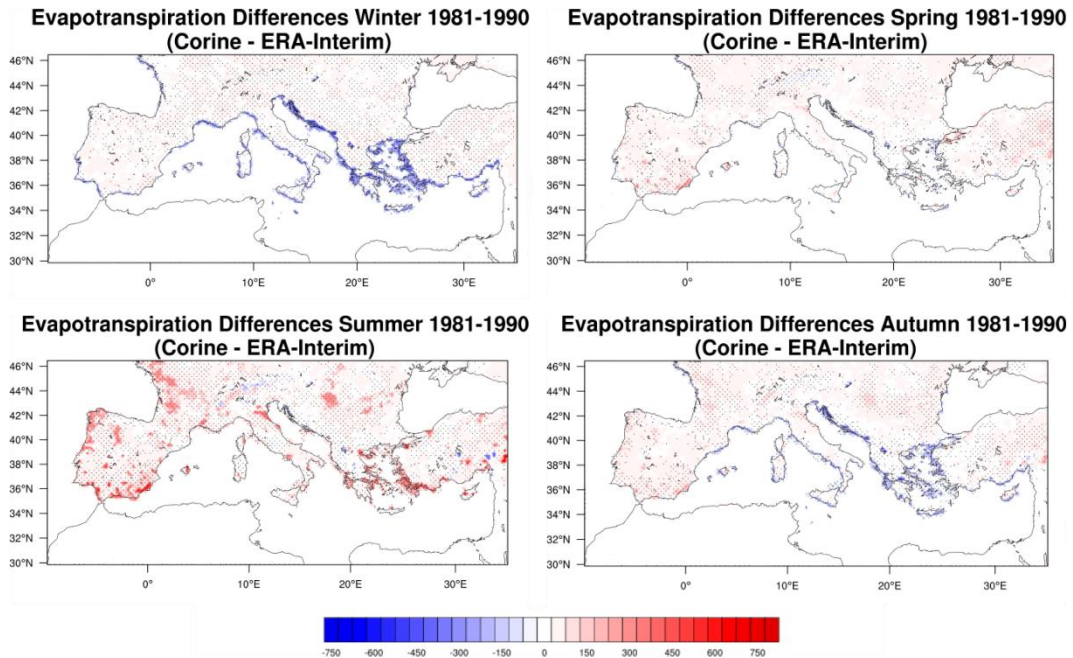


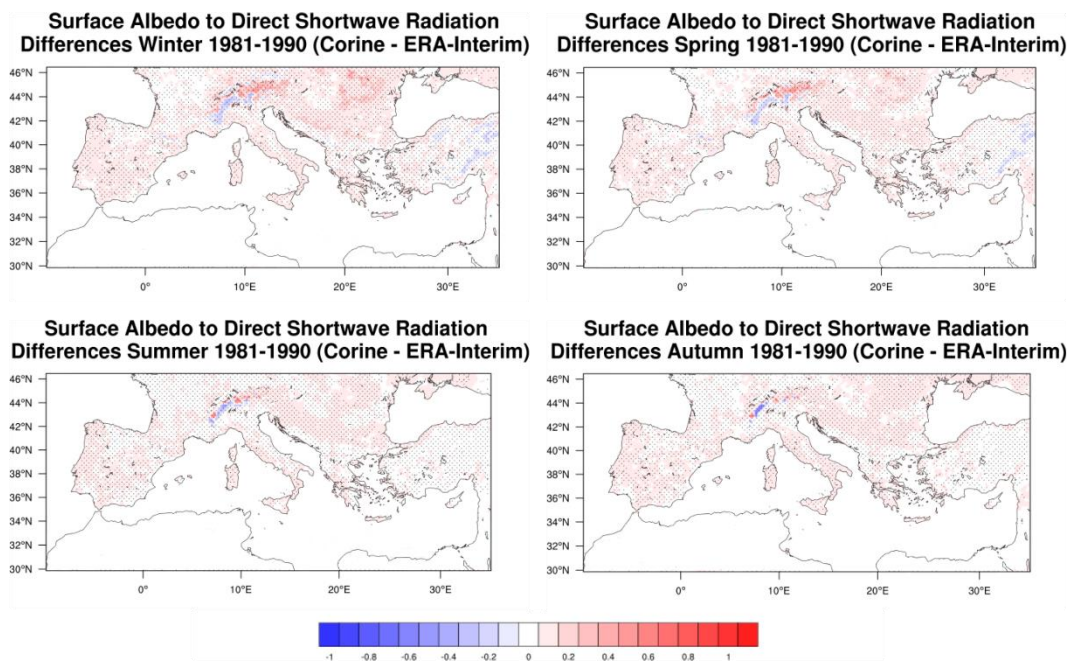
Figure 2 - Seasonal differences in evapotranspiration between the simulation with CORINE 2000 land cover and the simulation with the model's default land cover for the time period 1981-1990. The statistical significance is shown with dots.

Regarding the changes in evapotranspiration due to changes in the model's default land cover/land use, the most significant decrease is observed during winter and autumn mainly in the coastal areas, whereas an intense increase of this parameter is observed during summer in coastal areas and the mainland of the Iberian Peninsula and central Europe (Figure 2).

This may be due to the fact that CORINE 2000 has more information about land cover/land use in the coastal areas and island regions compared with the model's default land cover/land use. Furthermore, the differences in the vegetation types and the occurrence of urban and sub-urban activity between the CORINE 2000 and the model's default land cover/land use, resulting to changes in the rate of transpiration and evaporation, can explain the significant increase and decrease of evapotranspiration in inland, coastal areas and island regions. In the mainland, throughout the year, a small but significant increase of the parameter is observed.

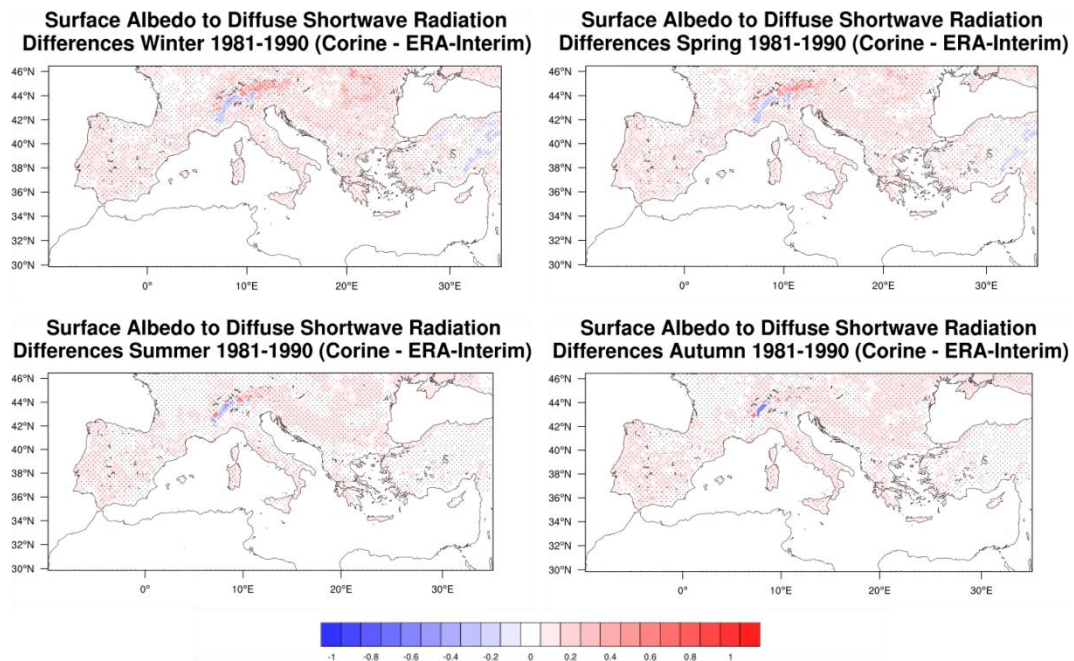
### 3.2. Surface Albedo to Direct and Diffuse Shortwave Radiation

Regarding surface albedo to direct shortwave radiation, the main modification due to land cover/land use changes occur mainly in the Alps. This is observed in all examined seasons. More specifically, a decrease of the surface albedo is observed in the side of the French Alps, whereas in the central eastern part an increase of the parameter is observed (Figure 3). For the rest of Europe, a small increase of surface albedo is evident, whereas in the eastern part of Turkey a small decrease of the parameter is observed, mainly in winter and spring. This is a result of the different reflectivity and absorption efficiency of radiation from the vegetation that is provided by CORINE 2000 compared to the model's default vegetation. Analogous were the results in the case of surface albedo to diffuse shortwave radiation (Figure 4).



**Figure 3 - Seasonal differences in surface albedo to direct shortwave radiation between the simulation with CORINE 2000 land cover and the simulation with the model's default land cover for the time period 1981-1990. The statistical significance is shown with dots.**





**Figure 4 - Seasonal differences in surface albedo to diffuse shortwave radiation between the simulation with CORINE 2000 land cover and the simulation with the model's default land cover for the time period 1981-1990. The statistical significance is shown with dots.**

#### 4. Conclusions

In this study we applied the latest version of a regional climate model (RegCM4.4.5) in order to simulate the changes and the variability in evapotranspiration and surface albedo to direct and diffuse shortwave radiation under two different land cover/land use parameterizations. The selected domain of interest is the Mediterranean region and the simulations covered the time period 1981-1990. The first simulation used the model's default land cover/land use and the second used land cover/land use data taken from the CORINE Land Cover European Union Programme (<http://www.eea.europa.eu/>) (Figure 1). The results from the simulation with the CORINE 2000 land cover/land use were compared with the corresponding results from the simulation with the model's default land cover/land use in the area of study.

According to the analysis of the results, the most significant changes in evapotranspiration are observed during winter and autumn in the coastal areas of the Mediterranean region, where evapotranspiration presents a decrease. Additionally, significant increase of the same parameter is observed during summer not only in the coastal areas but also in the mainland of the Iberian Peninsula and central Europe.

In the case of surface albedo to direct and diffuse shortwave radiation, the results are quite similar in both cases. More specifically, the most significant changes are observed in the Alps, where throughout the year surface albedo shows a decrease in the French Alps. Conversely, in central eastern Alps surface albedo seems to increase. These changes are more evident during winter and spring.

Changes in land cover/land use lead to different vegetation types and as a result this differences affects evaporation and transpiration rates as well as the reflectivity and absorption efficiency of the different surfaces. The hydrology, the agriculture, the forests of a region can be influenced not only

by climate parameters but also by changes in land cover/land use, which may occur from natural reasons or from human interactions (e.g. land use or water management).

As future work, more parameters should be studied and also a comparison with real data should be performed in order to be able to conclude about the most appropriate land cover/land use scheme that should be used with regional climate model RegCM.

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