Final Report of project number 1676 entitled:
Effects of anthropic modification of Mediterranean landuse on the regional and global climate
by Matteo Zampieri, hosted by Laurent Z. Li at LMD-IPSL Paris

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Purpose of the visit

The study addressed the investigation of the effect of the vegetation and its variation in the Mediterranean region on the regional and global Climate. Previous studies show that changes of precipitation may have an important effect on the regional hydrological cycle and the surface vegetation cover in the Mediterranean basin. However, anthropic changes of the vegetation cover in Europe have not yet been taken into account in a climate model in order to investigate their effects on the regional and global climate.

Description of the work carried out during the visit

We implemented the recently-developed VEgetation Reconstruction by Diagnostic Equilibrium (VERDE, Zampieri and Lionello, 2007) into the global climate model LMDZ (Sadourny and Laval, 1984), with an enhancement of spatial resolution in the Mediterranean basin, and in a coupling mode to a slab representation of the Mediterranean Sea.

The reference paper of the VERDE model was completed during the visit and it is now going to be submitted to Global and Planetary Change.

The vegetation model was derived by the cluster analysis of the CRU 10' global 1961-1990 precipitation and mean temperature climatology (New et al, 2002) and the GLCC IGBP-type global 10' landuse fractional distribution from 1-km AVHRR data from April 1992-March 1993 (Loveland et al, 2000). The cluster analysis allows the association between climate and vegetation in regions with no human effect on vegetation. This is defined “potential natural vegetation”. This dataset is used for identifying the potential natural vegetation in regions where it has been replaced by crops.

The model derivation was repeated to be consistent with the vegetation model ORCHIDEE (Krinner et al., 2005) that is implemented in LMDZ, which is based on a different landuse classification with 13 functional types, that are: bare soil, tropical broadleaved evergreen and rain green trees, temperate needle-leaf evergreen and broadleaved evergreen/summer-green trees, boreal needle-leaf evergreen/summer-green and broadleaved summer-green trees, C3 and C4 grass, and C3 and C4 agriculture. The cluster analysis is performed on the observed distribution of these functional types at 5km resolution
(http://dods.ipsl.jussieu.fr/orchidee/SANORCHIDEE/IGCM/INIT/SRF/OL2/carteveg5km.nc).
An optimal vegetation reconstruction can be obtained by using the algorithm with 75 cluster and excluding cluster that are smaller that 20% the average cluster size.

A 10 year control simulation (CTR) is performed with LMDZ using the observed landuse. The models boundary condition is a climatological sea surface temperature (SST), thus there are no interannual fluctuation and the simulation length is enough to produce a stable climatology of the atmospheric fields. The climatology of monthly mean 2m temperature and monthly precipitation is used by VERDE to compute the corresponding potential natural vegetation. The new vegetation is substituted in LMDZ and another 10 year run is performed (1ITER). The procedure is iterated till potential natural vegetation and climate are in equilibrium, thus another 10 year simulation is performed (2ITER) and it is still running. Every LMDZ simulation takes 20 day, while VERDE runs in few seconds.

Description of the main results obtained

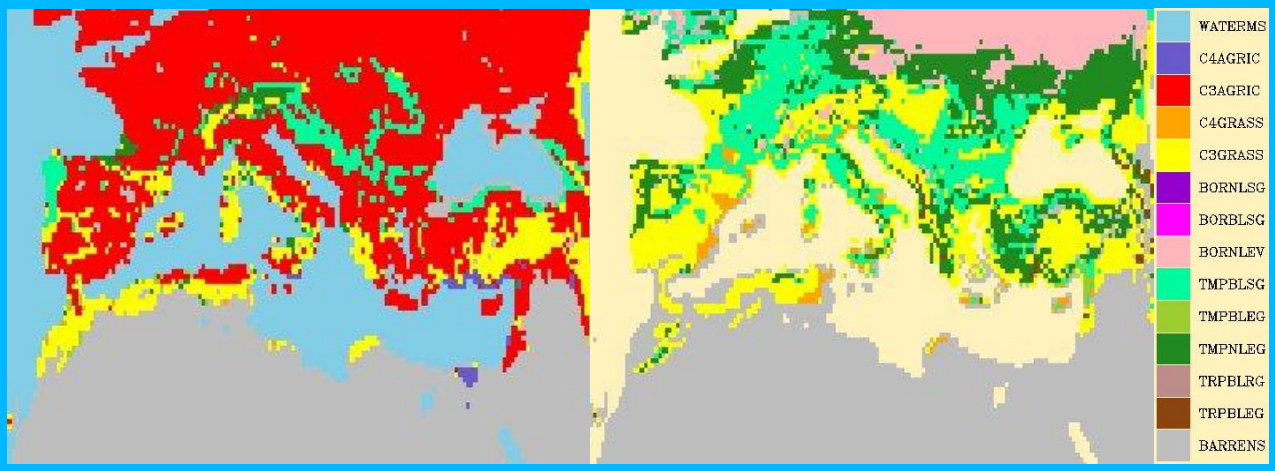

Figure 1: observed dominant vegetation type (left) – dominant vegetation type computed by VERDE after CTR simulation. See text for explanations.

Figure 1 shows the observed vegetation that is used by LMDZ for the CTR simulation and the natural vegetation that is computed by VERDE from the climate produced by the CTR simulation. In the observation most of Europe landuse is characterized by agriculture. VERDE produces mainly grass in the Mediterranean area and temperate forest in Central Europe and the Balkans. Boreal forest is produced in North-eastern Europe.

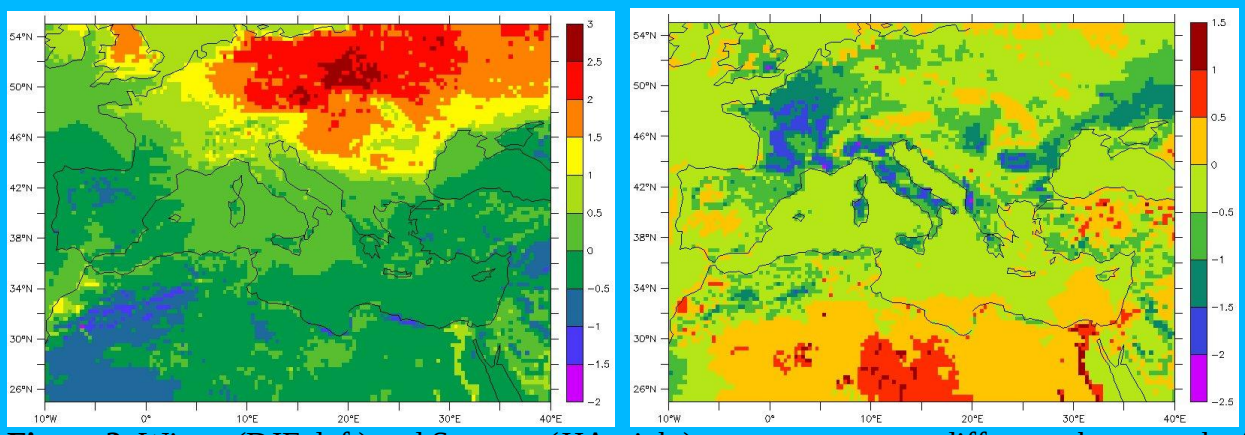

Figure 2: Winter (DJF, left) and Summer (JJA, right) mean temperature difference between the first iteration (1ITER) and the CTR simulation.

Figure 2 shows the temperature difference after the first iteration (i.e. LMDZ simulation with the vegetation showed in the right panel of Figure 1) and the CTR simulation. In winter the main difference is a positive anomaly in Central-Eastern Europe, while in summer a negative anomaly is located over France and Italy. In general, spontaneous vegetation produces milder climate in Europe.

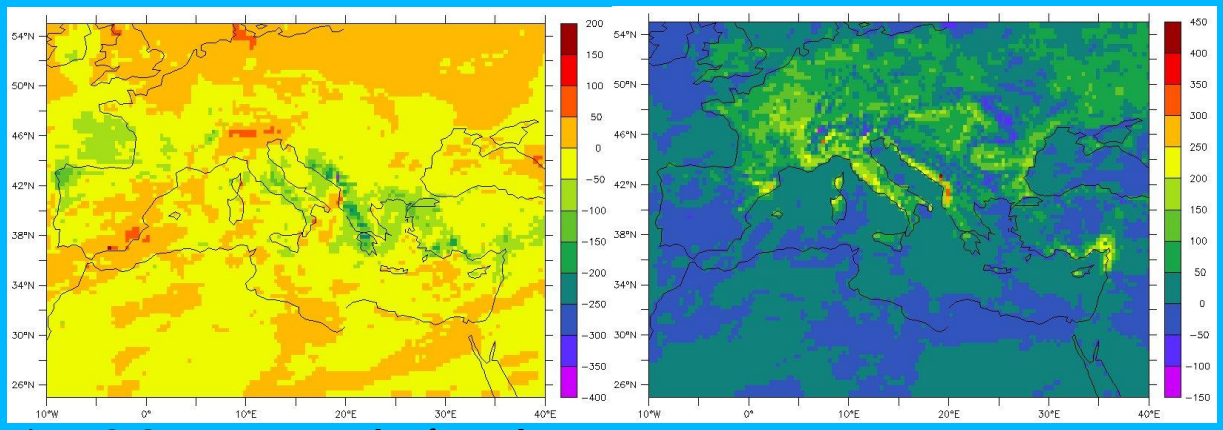

Figure 3: Same as Figure 2, but for total precipitation, in mm.

Figure 3 shows the precipitation anomaly after 1ITER simulation respect to CTR. The most important signal is found in summer, where a positive anomaly is found over all the domain except region where almost no precipitation is found in summer.

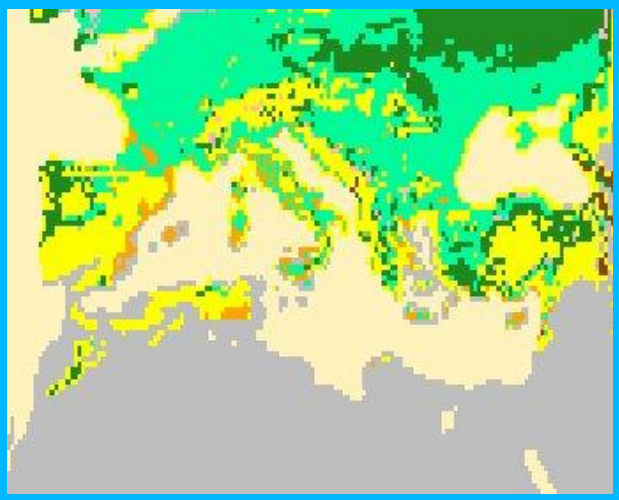

Figure 4: Same as right panel of Figure 1, but for the vegetation computed by VERDE after 1ITER simulation.

Figure 4 shows the resulting vegetation after the 1ITER simulation. The vegetation is similar to the result of the CTR simulation (right panel of Figure 1) is most regions, meaning that the iteration are going to converge toward the climate/vegetation equilibrium. However, in North-Eastern Europe temperate neddle trees take place of boreal needle trees. This is consistent with the milder climate that is produced in the 1ITER simulation respect to CTR.

Future collaboration with host institution

Iteration of LMDZ and VERDE model has to be repeated till vegetation and climate are in equilibrium. Previous test with the regional climate model RegCM (Zampieri and Lionello, 2008) showed that 2 iteration are sufficient for the convergence. With LMDZ more iteration could be necessary because it takes into account also global feedbacks. At the end a deeper analysis of the results will be performed to produce a scientific paper. Preliminary results will be presented in the context of a seminar at the LMD at the Ecole Polytechnique.

Projected publications/articles resulting or to result from your grant

A article on the obtained results about regional and global climate sensitivity to European anthropic landuse modifications will be prepared after the simulations are completed.

References

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Sadourny, R., and K. Laval, 1984: January and July performance of the LMD general circulation model. In *New Perspectives in Climate Modeling*, A.L. Berger and C. Nicolis (eds.), Elsevier Press, Amsterdam, 173-197

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