EUROPEAN SUMMER PRECIPITATIONS: SENSITIVITY TO SOIL MOISTURE INITIAL CONDITIONS

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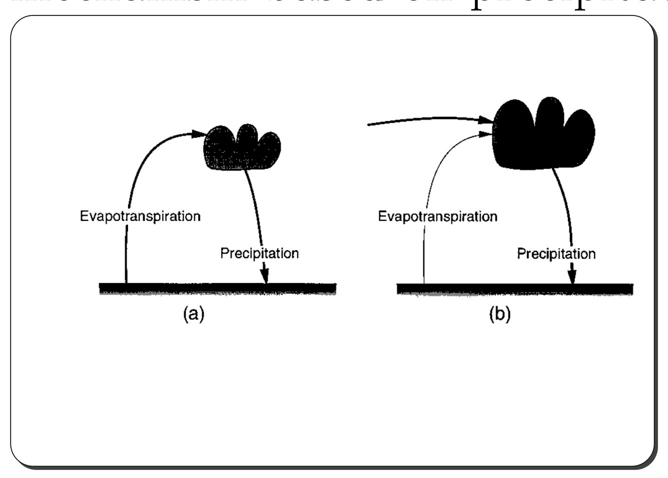
Introduction

Summertime European precipitation climate in a belt ≃1000 km wide between the wet Atlantic and the dry Mediterranean heavily depends upon the soil moisture content ([SLBH99]). In literature two kind of soil-precipitation feedback are proposed: a direct effect referred as *recycling* hypothesis and an indirect effect referred as *amplification* mechanism based on precipitation efficiency (see sketch below).



These remarks led to the conclusion that there's a positive feedback in soil-precipitation mechanism especially with summertime convective activity in absence of strong synoptic forcing (see [SLBH99]).

Nevertheless recently, [HBBS09] showed in numerical experiments over Alpine region how simulations, with explicit treatment of convection, are associated with predominantly negative feedback in soil-precipitation mechanism. Schematically explanation is: dry initial soil moisture ⇒ more vigorous thermals (due to stronger daytime heating) ⇒ more easily break through the stable air barrier ⇒ more deep convection activity.

Here presented are WRF simulations aimed at testing this negative feedback hypotesis.

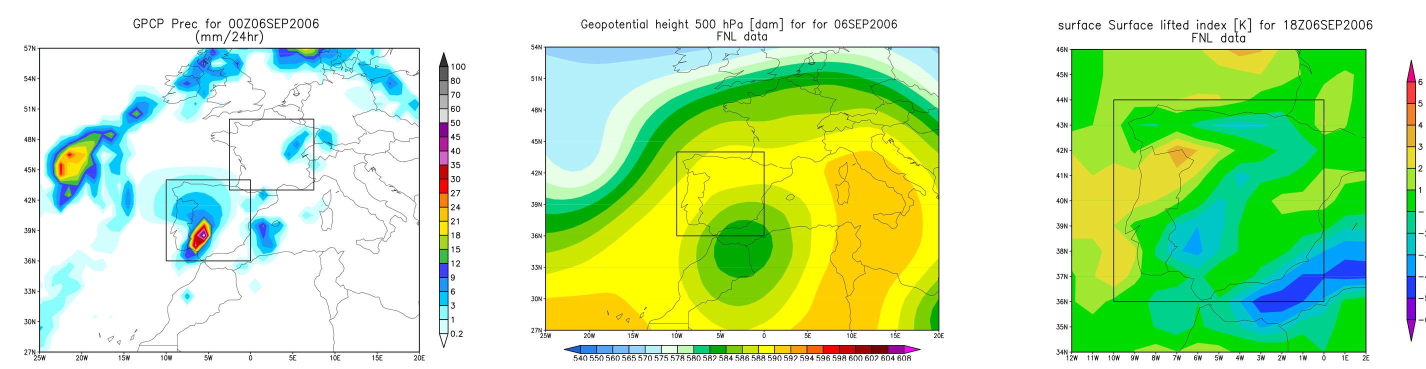
Data and methods

Starting from the 1st of June (for year in 2001,. . . ,2009) daily moisture budget for atmospheric column is computed (using 6-hour NCEP Final Analysis), aimed at selecting summer days with weak synoptic forcing. Atmospheric water budget follows:

$$\frac{1}{g}\int_{sfc}^{850\ hPa} \nabla\cdot\mathbf{u}(p)q(p)\,dp = P - E \qquad (1)$$

where g is gravity acceleration, p is pressure level, $\mathbf{u}$ is horizontal wind vector, q is specific humidity, P and E are precipitation and evaporation over the area of interest respectively. In this budget we neglect (as done in [SLBH99]) $\frac{\partial W}{\partial t}$, the change of total atmospherc water content. Water budget is averaged over Iberian peninsula defined in figures below.

Statistical properties of atmospheric moisture flux are computed in order to select period of weak convergence. Case study selected is 6 September 2006. It is characterized by weak atmospheric advection (i.e. left-hand side of equation (1) is ≃ 0) as confirmed by a surface low centered over Morocco and by some precipitation (GPCP data); atmosphere is very unstable as described by a wide upper-level-low (see geopotential height at 500 hPa) and by Lifted Index close to −4 (FNL analysis).

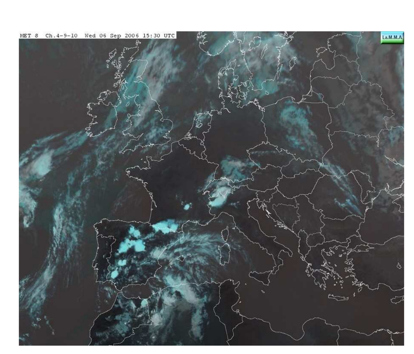


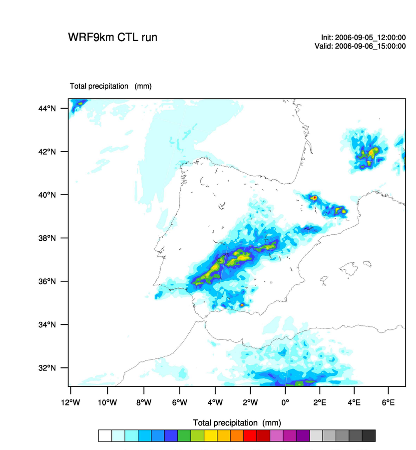
Three WRF experiments are conducted, all of which are driven by the same lateral boundary data. The first experiment is referred to 'CTL' and its soil moisture field is initialized at 00 UTC 5 September from FNL analysis for coarser grid, 12 UTC 5 September for intermediate grid and 00 UTC 6 September for finer grid. In the two sensitivity experiments adjustment of the initial soil moisture content in the 4 soil layers is performed. In experiment 'DRY' it is modified by multiplication with a uniform factor 0.5, and in experiment 'WET' by a factor 2 (same factors used in [SLBH99] for sensitivity studies). WRF-ARW model (release 3.0.1) is used for numerical experiments. All simulations run over three grids with resolution 27 km, 9 km, 3 km. Some numerical settings are showed in table below:

	Grid 27 km	**Grid 9 km**	**Grid 3 km**
time step	160	51	17
vertical levels	35		
microphysics option	WSM 3-class		WSM 5-class
land-surface option	unified Noah model		
boundary-layer option	YSU scheme		
cumulus option	Kain-Fritsch scheme		no cumulus

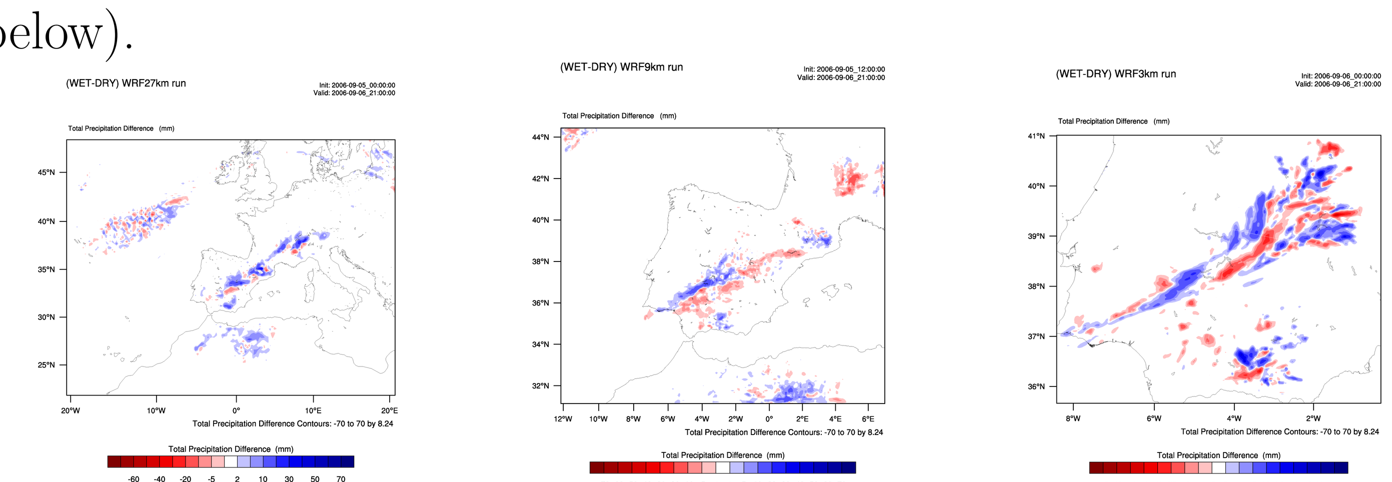
Results and discussion

All model's runs show good agreement between observed and simulated precipitation. See for example comparison between strong convective activity detected by infrared satellite for 15.30 UTC 6 September 2006 and accumulated precipitation on the previous hour forecastd by control run (intermediate grid).

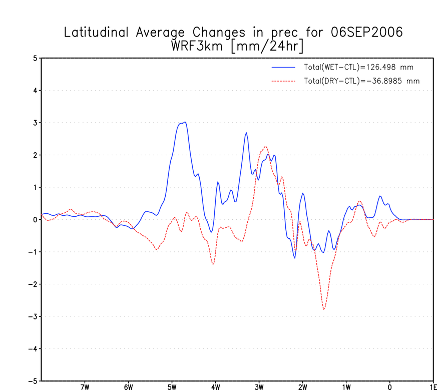




Nevertheless we found a positive feedback mechanism between soil moisture and atmospheric processes as shown in the comparison of the three grids, with (WET-CTL) precipitation differences decreasing, but generally positive, from the coarser grid to the finer (see figures below).



Moreover even in the cloud resolving grid, longitudinal cross section of precipitation for (WET-CTL) and (DRY-CTL) differences show positive feedback mechanism:



[HBBS09] addressed the predominant negative feedback in soil-precipitation mechanism by means of these considerations: drier soil yield smaller latent heat fluxes, larger sensible heat fluxes, and thus higher Bowen ratios and deeper PBLs. Although the level of free convection (LFC) is higher over dry soils, the more rapidly growing PBL can overcompensate this difference, while, in the wet soil case, the PBL remains too shallow. In few words, convection is triggered in dry conditions by bringing the PBL top up to the LFC through thermals. In our case, parametrized and explict simulations showed how the positive feedback mechanism proposed in [SLBH99] rules. The guess is that, even in the DRY case, diurnal heating is not strong enough to break the barrier of stable air. Moreover [HBBS09] tested their hypothesis on the Alpine region where orographic forcing enhances thermal induced convection, while our target area is mainly flat.

References

[HBBS09] C. Hohenegger, P. Brockhaus, C.S. Bretherton, and C. Schär. The soil moisture-precipitation feedback in simulations with explicit and parameterized convection. *J. Climate*, 22(19):5003–5020, 2009.

[SLBH99] C. Schär, D. Lüthi, U. Beyerle, and E. Heise. The soil-precipitation feedback: A process study with a regional climate model. *J. Climate*, 12:722–741, 1999.