Numerical experiments to study the possible meteorological changes induced by the presence of a lake.

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1. INTRODUCTION

The lake of Fucino was the largest reservoir of fresh water in the Abruzzo region until it was drained at the end of the last century (1873). The goal of this work is to study the possible local changes on both the climate and meteorological regime. A recent study by Schar et al.(1999), asses the sensitivity of the regional climate to the soil-moisture availability through a precipitation processes feedback; effects of the land-use on the weather were studied by Pielke and Dalu (1991) while effects on the climate were evaluated by Seath and Giorgi (1996). The effects of the lake on the local circulation (Avissar and Pan, 1999, Changnon et al.,1972) and on the regional climate (Bates et al., 1993, Scott and Huff, 1996, etc.) it is well known and this study is developed within the same framework. The MM5 is used to simulate few typical local meteorological situation with and without the lake.

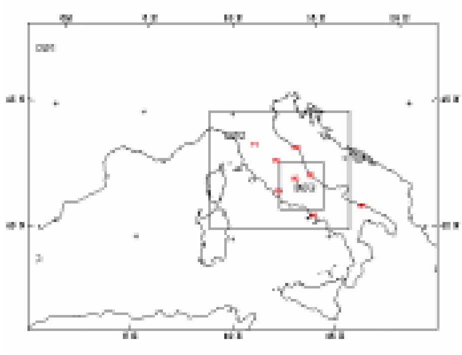

Figure 1: The Model Domains

2. MODEL CHARACTERISTICS

For this study the MM5 from NCAR/PSU (Dudhia, 1993 and Grell et al., 1994) is used, the model configuration is the one used operationally at PSTd'A/University of L'Aquila (Paolucci et al., 1999): 24 sigma levels not equally spaced; MRF (Troen and Mahrt, 1986) planetary boundary layer parameterization; Kain-Fritsch (Kain and Fritsch, 1993) cumulus convection parameterization associated to an explicit configuration of cloud water and rain. Three domains two way nested staring with a grid size of 27Km (Fig. 1), and ECMWF data analyses are used to initialize the model and the Boundary Conditions are upgraded every 6 hr.

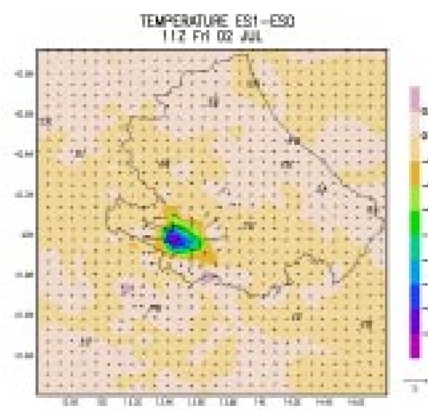

Figure 2: Differences of the temperature and wind fields at $\sigma = 1$ level

Several model simulation are performed to test the sensitivity to presence of the lake and to its surface temperature. A control simulation without the lake (ES0) is performed as reference. A simulation inserting the lake with the associated land-use characteristic (ES1) is performed to study the change on the local climate induced by the basin.

Several simulations to asses both the sensitivity to the lake surface temperature (LST) and to its diurnal variation are performed: ES1 setting $LST = 24^oC$; ES2 setting $LST = 15^oC$; ES3 setting $LST = 23^oC$ and finally ES4 setting the initial $LST = 15^oC$ and forcing it to vary by 1^oC during the day.

Furthermore a simulation adding the vegetation

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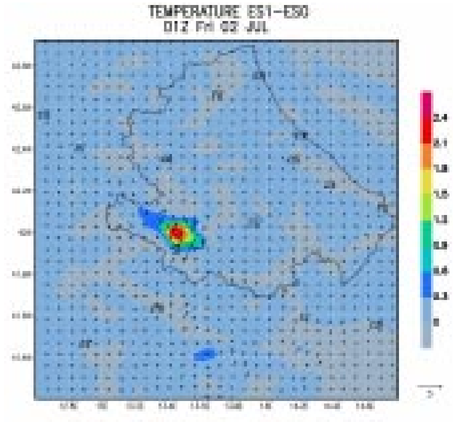

Figure 3: As Figure 2

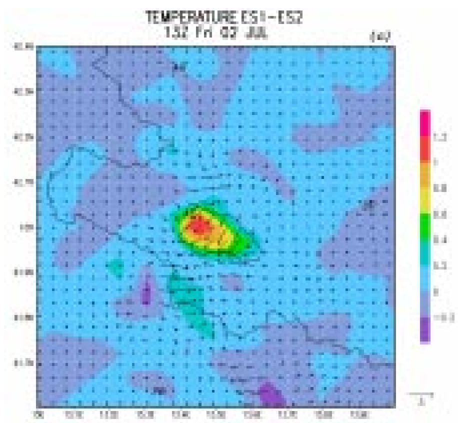

Figure 4: As figure 2 for ES1-ES2 case

around to lake (ES6), to roughly simulate a feedback processes produced by a possible increase in the precipitation occurrences with an associated vegetation, is performed.

To better analyze the model response the previous experiments are performed for a case with weak forcing. The initial condition for ES0 - ES6 are all the same starting at 1200UTC July 1 and ending at 1200UTC July 3, 1999.

Finally two more experiments, with a strong forcing (July 23, 1999) producing precipitation in the area nearby the lake, are performed: a control run without the lake (EP0) and another with the lake (EP3) using $LST = 20^oC$. Both simulations starting at 1200 UTC on 23 July 1999 and ending 48 hr later.

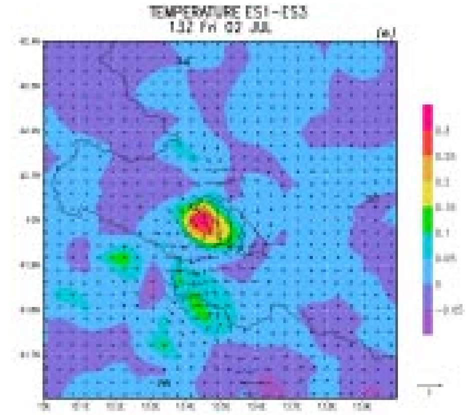

Figure 5: As figure 2 for ES1-ES3 case

Name Run	Vegetation	Lake	LST
ES0	NO	NO	NO
ES1	NO	YES	24^oC
ES2	NO	YES	15^oC
ES3	NO	YES	23^oC
ES4	NO	YES	15^oC
ES6	YES	YES	NO
EP0	NO	NO	NO
EP3	NO	YES	20^oC

3. METEOROLOGICAL SITUATION

A case of high and low pressure system during the winter and the summer season are analyzed: on July 1, 1999 a typical anticyclonic circulation characterized the mediterranean area associated with a weak southeastward wind, no precipitation was detected at that time; on July 23, 1999 a cyclonic circulation entered the mediterranean area developing in a cyclogenesis over the south Tyrrenian sea. Strong easterly wind advecting warm and humid air toward the eastern italian coast produced heavy precipitation.

4. SENSITIVITY TESTS

4a. Sensitivity to lake surface temperature

The great thermal inertia of the water usually acts to reduce the diurnal and increase the nocturnal temperature, over and around the lake.
In addition, evaporation from the lake is a large source for atmospheric moisture. These effects are well reproduced by the model where the surface temperature differences for ES1-ES0 are reported (Fig. 2). These feature enhances during the night (Fig 3).

A strong sensitivity to the different initial LST is found: using ES1 as reference, response to the LST variation is inferred by analyzing the ES1-ES2 and ES1-ES3. The results show (Fig. 4 and 5) an increase in the breeze regime strength proportional to the LST differences. The same structure is found for the night with

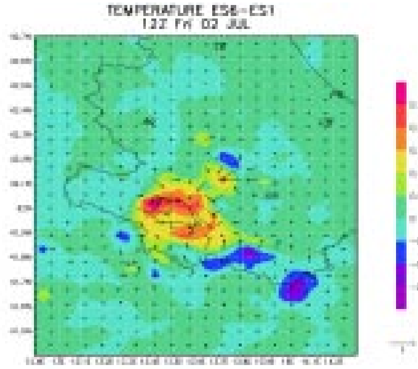

Figure 6: As figure 2 for ES6-ES1 case

an even stronger breeze regime (not shown). The simulation performed forcing the LST to have a diurnal variation does not produce large differences with respect to the control run (ES4-ES2); the differences in the temperature are of order of $1/10^oC$. The effect of small temperature variations during the day time is probably more evident on the long term. Therefore this last experiment allow to keep LST constant during the next experiments.

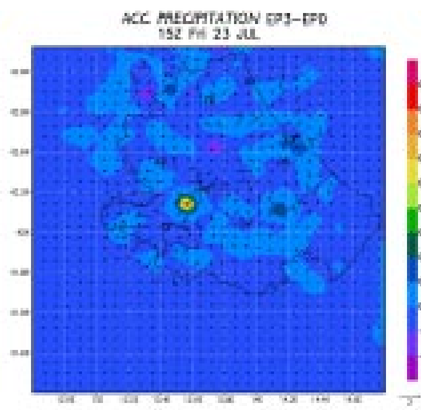

Figure 7: Differences of 2hr Accumulate Precipitation (cm) and wind (m/s) fields for $\sigma = 12$ level

4b. Feedback on the vegetation

The last experiment is performed to study feedback processes by the vegetation that was surrounding the lake. The increase in the surface covered vegetation would produce a temperature increase in the area around the lake (Avissar and Pan, 2000); the model correctly reproduces this effect, as shown in Fig. 6 which refer to the ES6-ES1 case.

5. EFFECTS ON THE LOCAL METEOROLOGICAL REGIME

The increase of the soil-moisture availability produces

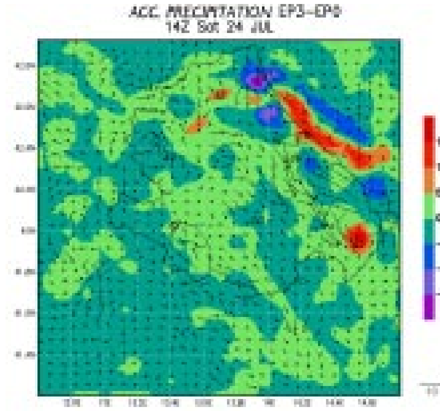

Figure 8: As figure 7 but after 26 hr

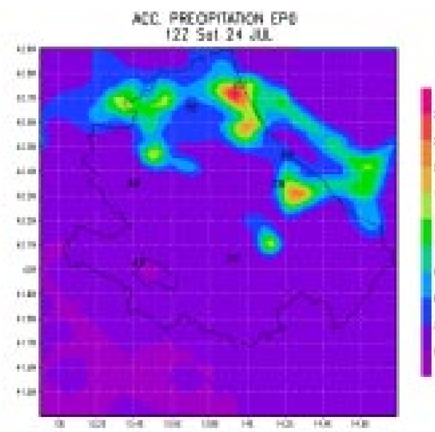

Figure 9: 24 hr Accumulated precipitation for EP0 case

both an increase in the precipitation locally and on a larger area (Schar et al., 1999) generating the so called soil-precipitation feedback. Similarly the presence of the lake may induce an increase in occurrence of the precipitation in the area surrounding the lake, but also an increase of the water wapor content that may be advected away from the lake itself. The lake-precipitation feedback is shown by EP3-EP0. There is a first stage of enhancement of the orographic precipitation close to the lake (Fig. 7), whereas in the following hours the northeastward advection of moisture produces an increase of the precipitation over the sea side (Fig. 8).

The 24 hr accumulated precipitation for EP0 (Fig. 9) and EP3 (Fig. 10) clearly show the strong effects produced by the lake on both areal extent and the amount of the precipitation.

Finally the cross-section of the EP3-EP0 along the precipitation pattern shows the advection of the water vapor. At the initial stage the EP3-EP0 shows an increase of the water vapor content only on the lake area (Fig. 11), forced to move upward by the mountain and moving toward the sea (Fig. 12).

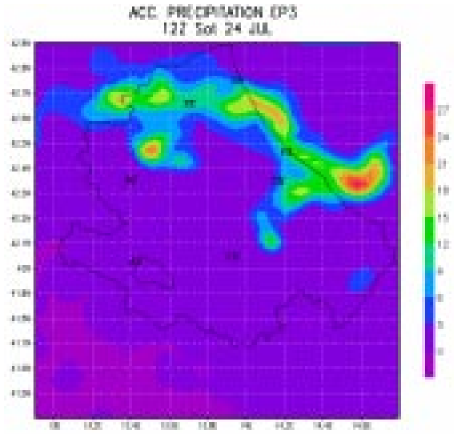

Figure 10: As figure 9 but for EP3 case

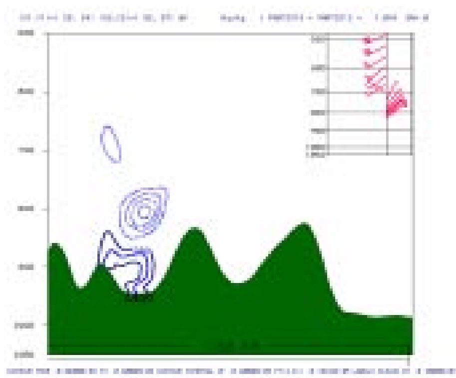

Figure 11: Differences of the QV field along the cross-section

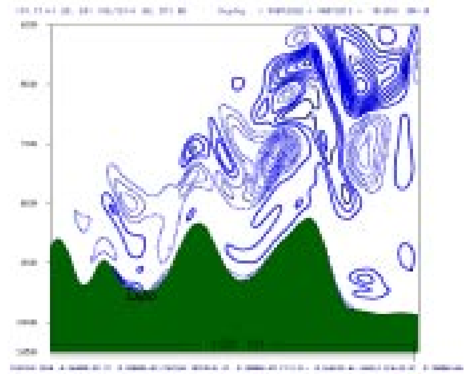

Figure 12: As figure 11

6. CONCLUSIONS

A set of sensitivity test are carried out using the MM5. The results show a strong response of the model to the presence of the lake as it was expected. Furthermore the initial LST seems to be important to correctly reproduce the lake breeze regime, whereas the diurnal variation of the LST does not influence the local circulation. The feedback vegetation produced by the presence of vegetation has been also verified.
An experiment is has performed to evaluate the impact of the lake on the meteorological regime. The results confirm the role of the soil-precipitation feedback mechanism. Indeed the effect involve not only the area close to the lake, but the whole region around the lake.

6. REFERENCES

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