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Numerical simulation of the Adriatic cyclone development

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This paper represents the first attempt to simulate the influence of the Dinaric Alps on the Adriatic cyclone using a high resolution hydrostatic model ALADIN. The reference experiment and two sensitivity studies are carried out to study the orography and diabatic effects on the cyclone development and maintenance. Verification confirms that the appearance of »twin cyclones« on either side of the Apennine peninsula is a realistic feature. The influence of Dinaric Alps is visible in a high-low couplet over the orography and strong winds behind the cyclone and along the coast. In the absence of the Dinaric Alps the cyclone is not bounded to this orography and the low pressure field quickly spreads over the entire Balkan peninsula and weakens. The absence of latent heat release leads to the weaker cyclonic circulation. An intercomparison of three experiments shows that the orographically induced pressure gradients, and not the pressure itself, are essential for the cyclone maintenance. These experiments have shown that the Adriatic cyclone is mainly induced by the Alpine orography whereas the Dinaric Alps through upstream blocking influence the subsynoptic processes over the Adriatic area.

Keywords: Numerical simulation, cyclone development, Adriatic cylone, influence of orography

1. Introduction

Numerous investigators have studied the development of cyclones in the lee of the Alps and the surrounding orography. In spite of the progress achieved, the details of the dynamic mechanisms and the role played by a number of physical factors are not yet fully understood (Egger, 1988). In the last decade following the Alpine Experiment (ALPEX) in 1982 the investigation of the orographic influence on cyclones has undergone a rapid development including both theoretical understanding and numerical modeling (Tibaldi et al., 1990). Numerical simulations based on the ALPEX data set (*e.g.* Dell'Osso, 1984; Zupanski and McGinley, 1989) have emphasized the importance of adiabatic and mechanical mechanisms relative to other physical processes. They have also stressed the critical importance of resolving and maintaining smaller-scale (Orlanski, 1975) triggering systems. It has been noted that further improvement in the realism of simulations of the Alpine cyclones should be possible by a straightforward increase in the resolution of models used (Mesinger et al., 1988), the failure of sophisticated global or limited-area models being likely due to the coarsness of their horizontal resolution (McGinley and Goerss, 1986).

Statistics of cyclones (Radinović, 1987; Alpert et al., 1990) over the Mediterranean indicate that the Genoa Bay is a place with the highest frequency of cyclone occurrence. Another maximum is located over the southern Adriatic, whereas cyclones appear less frequently in the northern Adriatic area. Although an early study by Van Bebber (1891) labeled the Adriatic Sea channel as a cyclonic path V^d, Adriatic cyclones have remained less known, and relatively rare subject in the studies of Alpine cyclogenesis, particularly in numerical studies. Local forecasters are familiar with a problem of early and reliable recognition of the northern Adriatic cyclogenesis, frequently followed by stormy weather along the eastern Adriatic coast. Intensity and movement of the Adriatic cyclones are related to severe bora behind the cyclones moving southeastward along the Adriatic Sea.

The location and intensity of Alpine cyclogenesis influence weather over the Adriatic region, specially the appearance of winter storms which place the Adriatic among more dangerous world seas. The difficulties of Adriatic cyclone investigation are partly due to the small spatial and temporal scales of this phenomenon. At the same time data scarcity makes any investigation difficult over the Adriatic. Therefore the observational studies of the Adriatic cyclone are quite rare. Jurčec et al. (1996) have employed an objective technique for scale separation and, in their case study, showed that the Adriatic cyclone was associated with an antisymetric dipolar structure in pressure and wind fields in the area of the Dinaric Alps.

Our purpose here is to investigate by numerical experimentation the role played by the Dinaric Alps and diabatic processes in the Adriatic cyclone development. This paper represents the first attempt to simulate the behaviour of the Adriatic cyclone with the high resolution mesoscale model ALADIN, evolving from the collaboration between Météo France and National Meteorological Services of several European countries. We intend to evaluate the capability of the model to resolve local features during the cyclone development, particularly to assess the influence of the Dinaric Alps and diabatic processes on the cyclone maintenance. In a case study selected for the present experiment we shall not concentrate on the cyclogenesis over the Adriatic. This problem requires larger domain than the one considered here as well as more detailed verification against the observational data. We are mainly interested in the factors which dictate the mesoscale structure of the Adriatic cyclone and its movement along the sea.

A central experiment and two sensitivity tests of a single case study are performed. Although a strict separation of orographic effects is impossible, it is certainly helpful to carry out a controlled experiment in which all conditions are identical except for the switch between orography and no-orography option. In his early pioneering experiment, Egger (1972) achieved successful idealized simulation of the Genoa Bay cyclogenesis and showed that no cyclogenesis occurs without mountains in the model. He also investigated the relative influence of other mountain ranges in the Mediterranean (*i.e.* Pyrenees and the Dinaric Alps) on the cyclone development. Running a model with and without orography, he reached a conclusion that »…taking into account of the Pyrenees and the Dalmatian mountains is not a necessary condition for the cyclogenesis but both mountain chains exert an influence on the development…«. In the following years many experimenters have aimed to simulate the effect of mountains by running parallel »no mountains« experiments, but contrary to Egger's study, most of these experiments completely canceled orography in the model. While the famous paper of Egger deals with the Genoa cyclone, recent work of Tafferner (1994) directs more attention to the specific topic of the Adriatic cyclone. Using an isentropic model with and without Alpine orography, his results reveal that the cyclone would not be generated without mountains. However, Tafferner did not consider the influence of the Dinaric orography on the cyclone development.

The Dinaric Alps is a mountain chain extending northwest-southeast along the eastern Adriatic coast with the width varying from 50 to 200 km on the northern and southern Adriatic coast, respectively. The height of mountain peaks of the Dinaric Alps along the northern Adriatic coast vary around 1500 m, with maxima up to 1900 m. The average temperature difference between the Adriatic Sea surface and the neighboring orography reaches up to 15 °C. We aim to investigate the role of this orography by considering the difference between Dinaric Alps/no Dinaric Alps experiments. The main difference between our approach and those previously mentioned is that the current simulations are carried out with a mesoscale model containing full physics. We expect that the step from 350 and 50 km horizontal grid sizes (used by Egger and Tafferner, respectively) down to 10 km used here will enable us to get an insight into the mesoscale processes over the Adriatic region. The previous studies could not have provided answers to the questions addressed here due to their coarse resolution and absence of moist thermodynamics.

Many studies of Alpine lee cyclogenesis (*e.g.* Dell'Osso and Radinović, 1984) have revealed that in the first stage of development there is no significant difference between results of models with full and dry physics. The majority of Adriatic cyclones do not show significant surface pressure change in their centre during the movement along the Adriatic. This would suggest that the orographic influence in such a small area is of the greatest importance for the cyclone development which is too rapid to allow latent heat release to contribute significantly to the cyclone intensification. To verify this hypothesis we run the model without moist processes.

The Adriatic cyclone case of 27–28 March 1995 is presented in Section 2. Some numerical and modeling aspects are provided in Section 3. In Section 4 the results of simulation are described and compared with observations. Main results are summarized in Section 5.

2. Surface and upper air observations of the Adriatic cyclone

A cold air outbreak over the Alps on 27–28 March 1995 was one of the strongest storms in the coastal region of Croatia. Strong winds were associated with cyclogenetic processes over the northern Adriatic and the cyclone moving fast along the Adriatic Sea on March 28. The event was accompanied by intense rain and snow, even on the outer islands along the Dalmatian coast. The maximum measured bora gusts exceeded 45 m/s, damaging electrical power system in the coastal part of Croatia. Frontal passage over any particular location was followed by a pressure rise and strong temperature fall.

The synoptic situation one day before our initial field (*i.e.* on 26 March 1995) was characterized by a broad low pressure area in the northern Europe with a center of 995 hPa over the North Sea, an anticyclone of 1030 hPa west of the Great Britain and France, and the front already reaching the Alps and the Pannonian Plain. Due to a strong westerly flow the frontal system did not move to the south within the next 24 hours, and a part of this front remained over the Dinaric Alps. On March 27 a low of 975 hPa in the northern Europe was deepening fast but the upper level charts did not show a pronounced trough in the lee of the Alps. However the temperature field on 500 hPa indicated a relatively weak thermal trough in the direction of the western Mediterranean. Both geopotential and thermal troughs deepened in the next 24 hours and continued to move toward the Alps, and the lee cyclone developed in the north Adriatic (Fig. 1). Apparently such a fast development in the northern Europe did not allow a strong low level blocking upstream of the Alps, which usually leads to the cyclogenesis in the Genoa Bay.

Another feature which we believe is contributing to the maintenance and intensification of the Adriatic cyclone is the front over the Dinaric Alps and the cold air outbreak behind it. Such a situation is also a consequence of a fast development in northern Europe and its frontal system extending to the new cyclone generated in the north Adriatic Sea.

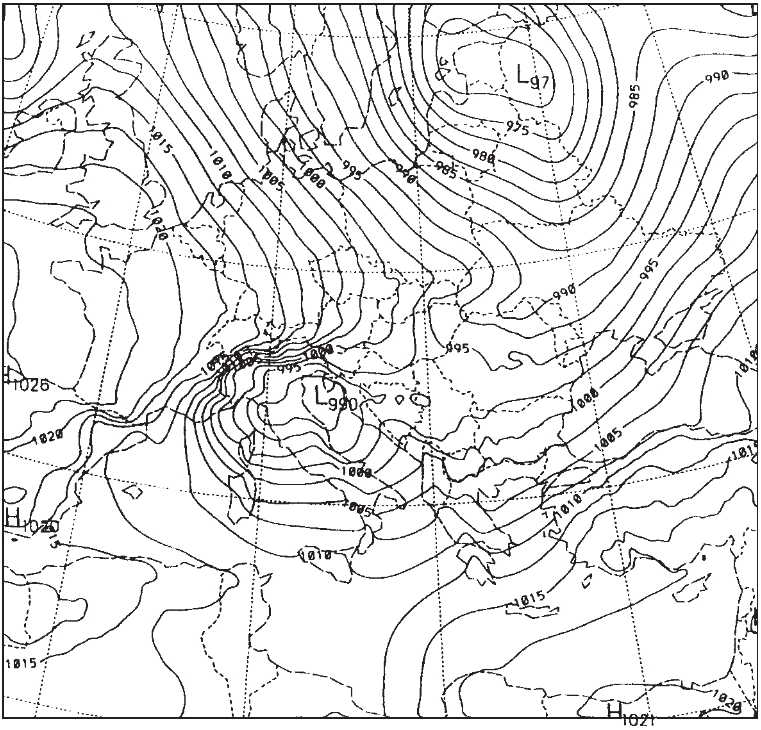


Figure 1. Objective analysis of mean sea level pressure over Europe on 28 March 1995, 00 UTC. Increment 2.5 hPa. Continental and political borders are overlayed

3. Numerical model

The model used for numerical simulations is the ARPEGE/ALADIN (Aire Limitée Adaptation Dinamique Développement InterNational), designed to be a limited area version of the global forecast model ARPEGE (Action de Recherche Petite Echelle Grande Echelle). The project initiated by Météo-France in 1990 currently joins together 13 National Meteorological Services. Meteorological and Hydrological Service of Croatia has joined the ALADIN project in 1995. Since July 1996 the model is running operationally twice a day for 48 hours centred over the central European region.

Initial and boundary conditions are obtained by interpolation from the analyses and forecasts of the global spectral model ARPEGE to the integration domain of ALADIN. The ratio between the global and the limited area model over the European region varies between 1 and 3. Digital filter initialization procedure (Lynch and Huang, 1992) is applied to the initial fields after interpolation. The ALADIN model (Bubnova et al., 1995), being a part of the ARPEGE/IFS (Integrated Forecasting System) system (Courtier at al., 1991) keeps the same vertical discretization, grid point dynamics and physics. The main difference is the use of bi-Fourier series instead of spherical harmonics. Following approach of Machenhauer and Haugen (1987) Fourier series are limited by an elliptic truncation to ensure an isotropic resolution. The model integration domain consists of the inner integration zone, outer extension zone (in order to make fields biperiodic) and intermediate coupling zone where the large scale fields are merged with the ALADIN fields following the Davies (1976) relaxation technique. A hybrid η coordinate (Simmons and Burridge, 1981) is used for vertical discretization. Prognostic equations are solved for the wind components, temperature, specific humidity and surface pressure. The time-step algorithm (Radnoti, 1995) utilizes a three time level semi-Lagrangian scheme with a semi-implicit correction for fast gravity waves. Physical parametrizations are the same for ARPEGE and ALADIN. A vertical diffusion parametrization follows Louis et al. (1982), extended by Geleyn (1987) to incorporate shallow convection at the top of the atmospheric boundary layer. Simplified Kessler-type scheme is employed for the large scale precipitation, deep convection is parametrized according to Bougeault (1985), the radiation processes according to Geleyn and Hollingsworth (1979) and Ritter and Geleyn (1992). These schemes take into account stratiform and convective cloudiness. Vertical moisture and heat transport in the soil are parametrized in two layers.

The hydrostatic version of the model has been applied to the flow past the Pyrenees (von der Emde and Bougeault, 1997) and the idealized simulations of frontal waves (Horanyi and Joly, 1996). The nonhydrostatic version of the model has also been developed (Bubnova et al., 1995).

For this experiment, the operational, full physics version of the model was used without any change except in the integration domain and in the horizontal resolution. The domain of integration covers most of the central Europe, Adriatic Sea and the Apennine peninsula (Fig. 2). Horizontal grid contains 109×117 points, with the grid size of 10.6 km, and 24 vertical levels. The model takes initial and lateral boundary conditions from the operational ARPEGE results by interpolation with the 6 hours frequency of coupling.

4. Results

4.1. Reference experiment

This simulation starts at 00 UTC 27 March 1995, about 24 hours before the cyclogenesis took place following a strong cold front propagating fast over the Alps. The intensity of the process is illustrated with a pressure drop of about 20 hPa in the 18 hour interval preceding cyclogenesis. (Fig. 3). At 21 UTC a low pressure of 990 hPa in the northern Adriatic is present (Fig. 4a), while along the eastern Adriatic coast strong SE jugo wind is blowing. In the

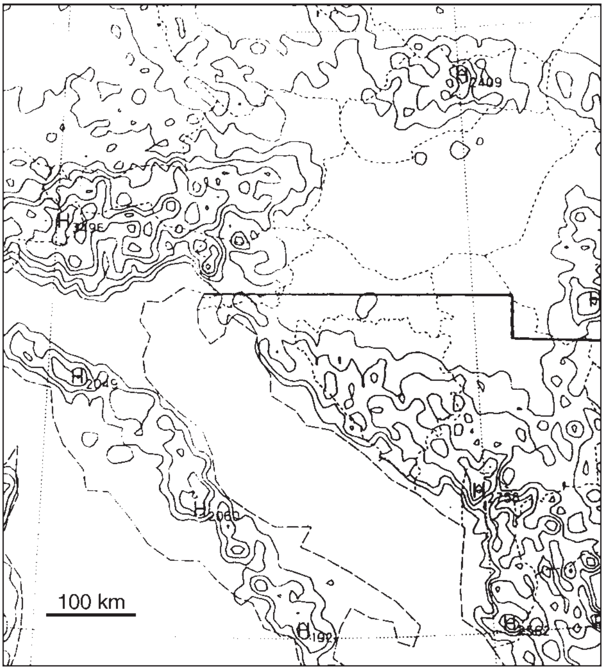


Figure 2. Location of the integration domain with the fine mesh orography. Contour interval is 500 m. The sea level (0 m) contour is not plotted. The area where the mountains are removed out in the no Dinaric Alps experiment is indicated by thick line.

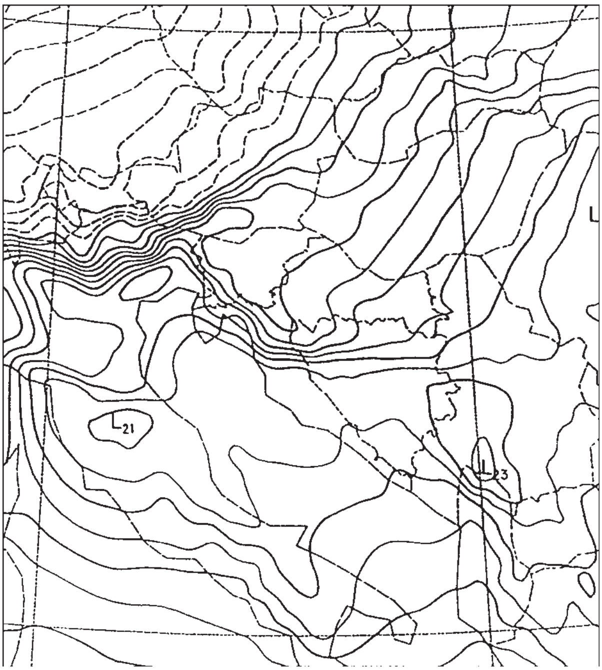


Figure 3. Mean sea level pressure difference forecast between 6 and 24 UTC on 27 March 1995. Contour inteerval is 2 hPa, with negative contours dashed and positive contours solid.

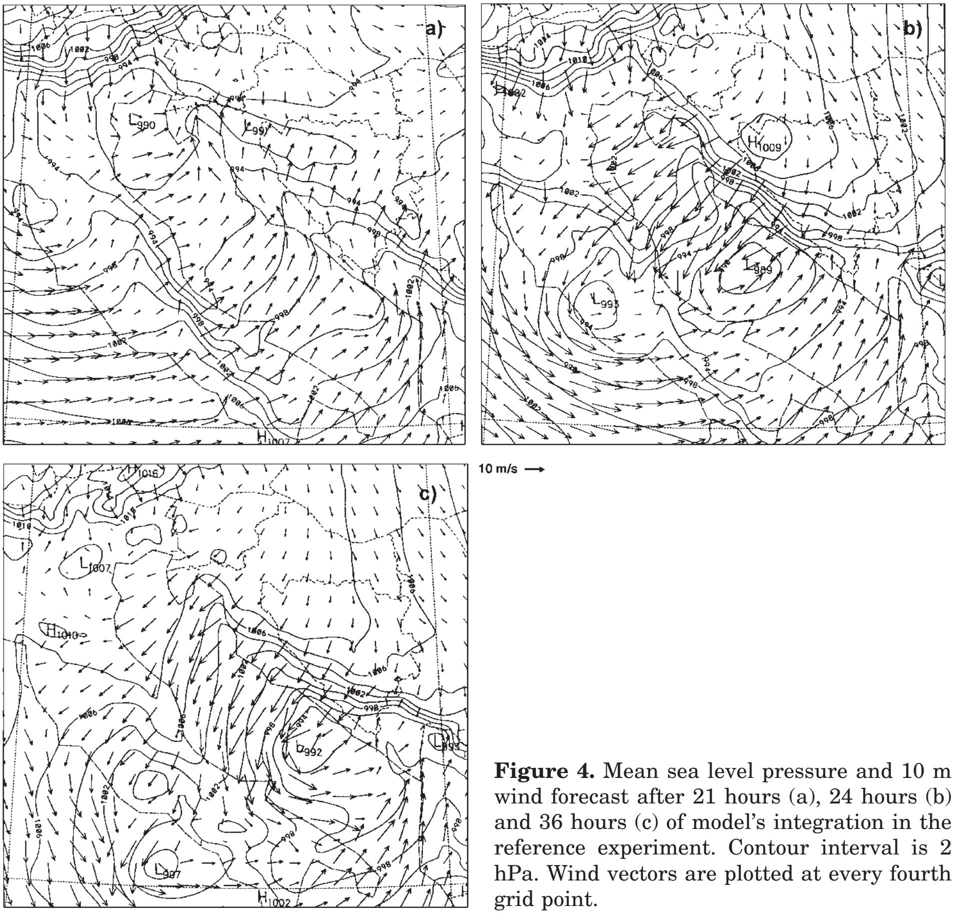


Figure 4. Mean sea level pressure and 10 m wind forecast after 21 hours (a), 24 hours (b) and 36 hours (c) of model's integration in the reference experiment. Contour interval is 2 hPa. Wind vectors are plotted at every fourth grid point.

continental part of Croatia there is a strong wind shear along the stretched front. Behind the front a N flow is propagating toward the Dinaric Alps. Figs. 4a, b, c, show the mean sea level pressure and 10 m wind forecasts after 21, 30 and 36 hours. The mesoscale pressure field after 24 hours of integration (not shown) reveals two lows, the stronger one over the northern Adriatic, and the other one over the Ligurian sea. The latter low was indicated on synoptic charts and objective analyses only as an extended surface trough. It is weaker in both pressure and wind fields in comparison with the Adriatic cyclone, but nevertheless the mesoscale wind fields confirm the existence of both vortices at sea level. During the next 12 hours of integration (Figs. 4b, c) we can follow their movement to the southern Adriatic and the Tyrrhenian Sea. Cyclonic circulation is strengthening, developing in both vortices, but it is significantly stronger in the Adriatic cyclone. Upper level charts (not presented) show a deep cyclone centred over the mid Adriatic at 12 UTC on 28 March. On its rear side there is a NE flow over the Dinaric Alps, the Adriatic Sea and the Apennines.

The orographic influence on the separation of centres on the Adriatic and the Tyrrhenian areas is apparent at the levels bellow 700 hPa. The occurrence of two centres offshore on either side of the Apennine peninsula appears to be a realistic feature. Fig. 5 shows an objective surface pressure analysis on the operational model grid. It reveales even stronger pressure gradients over the Dinaric Alps whereas gradients over Apennines are overestimated by the model. Similar case of cyclogenesis was simulated by Mesinger and Strickler (1982) who called it an »eyeglasses cyclogenesis« referring to the locally used expression in Italy »ciclogenesi ad occhiali«. We chose a name »twin cyclones«, because of the close connection in both origin and development of these vortices.

The Adriatic twin cyclone is the deepest after 30 hours (Fig. 4b) when the pressure gradient across the Dinaric Alps reaches its largest value of 20 hPa. The essential feature on this chart is the high pressure center upstream of the Dinaric Alps. This map reveals a characteristic »dipole structure« (Speranza et al., 1985) of the mountain induced surface pressure perturbation, well known from many numerical simulations. At the same time there is no such high-low couplet over the Apennines. However, 6 hours later, at 12 UTC (Fig. 4c), the flow over the Alps towards the Po valley has lost its intensity and the pressure gradients over the Italian peninsula have strengthened.

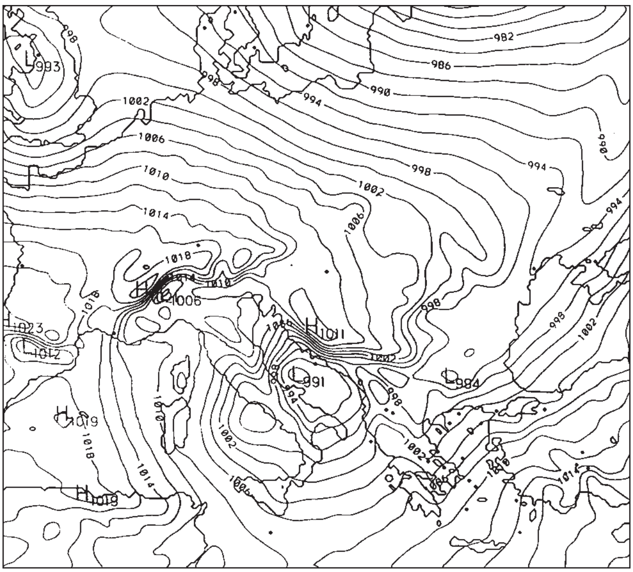


Figure 5. Objective analysis of mean sea level pressure over Europe on 28 March 1995, 12 UTC. Increment 2 hPa. Land-sea mask is overlayed.

Steinacker (1981) provided a time history of the cold front deformation by the Alps and the surrounding orography. The front is shown to slow down over the Dinaric Alps in association with the cold outbreak behind it. At 850 hPa a front appears as an area of pronounced gradients in a temperature field over the Dinaric Alps. Fig. 6 demonstrates the position of the frontal zone in the 30 hour forecast chart of the equipotential temperature field. Strong temperature gradient exists to the north of the southern Adriatic coast from 24 to 36 hours, clearly indicating the orographic influence on the development of the Adriatic cyclone. Such a subsynoptic scale feature was not shown in the earlier, lower resolution experiments by other authors.

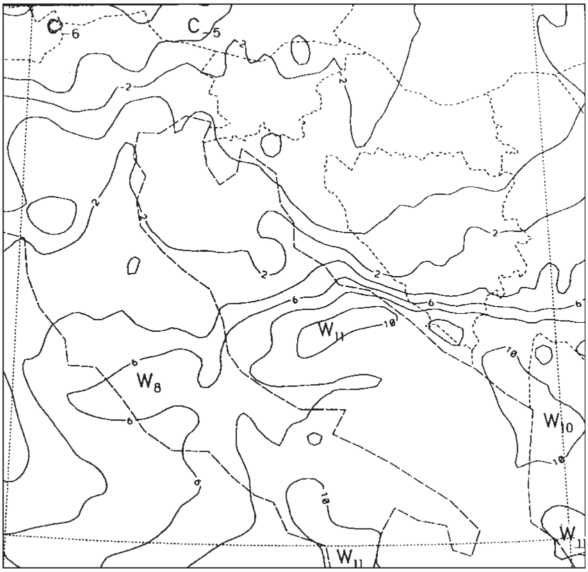
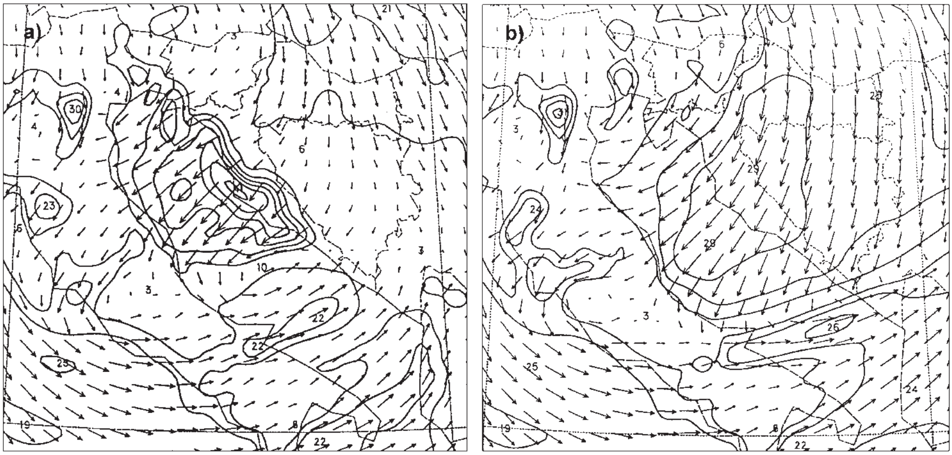


Figure 6. Equipotential temperature field forecast at 850 hPa level for 30 hours of model's integration in the reference experiment. Contour interval is 2 °C.

Finally, figures show that the model captured well the onset and strengthening of severe NE bora wind behind the Adriatic cyclone. The bora intensification is related to the cold air supply from the NW around the eastern Alps which turns to the Adriatic Sea across Slovenia and northwestern Croatia. After 30 hours the strongest bora behind the cyclone reached up to 25 m/s at the surface, with isotachs stretching along the coast and around the rear side of the cyclone. At this time the wind strength is strongly increasing with height, and at 925 hPa level (Fig. 7a) maximal speeds along the northern Adriatic coast reach 40 m/s. Unfortunately, in the situation with no upper air observations over the Adriatic the vertical structure of severe bora obtained from the model can not be verified.



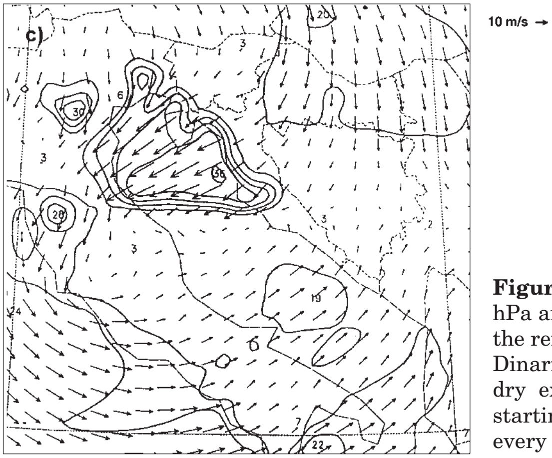
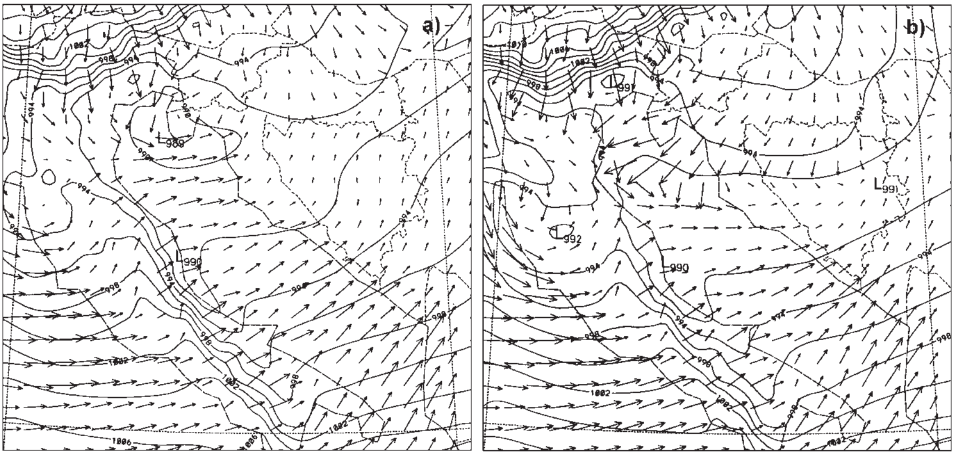


Figure 7. (a) Isotachs and wind vector at 925 hPa after 30 hours of of model's integration in the reference experiment; (b) As (a), but for no Dinaric Alps experiment; (c) As (a), but for the dry experiment. Contour interval is 5 m/s, starting at 15 m/s. Wind vectors are plotted at every fourth grid point.

4.2. No Dinaric Alps experiment

In this section we discuss the results of simulation without the Dinaric Alps. In comparison with previous similar experiments our has higher resolution ensuring more detailed orography modeling. Thick line in Fig. 2 indicates the area where orography is set to 1 m height. Smoothing is applied to several points around the cut line to avoid sharp gradients. Objective analyses are used for both initial and boundary conditions to provide proper boundary forcing. Boundary fields are interpolated to the new orographic conditions. The integration starts at the same time as the reference simulation and lasts 36 hours, until 12 UTC, 28 March 1995.

Fig. 8 presents results of integration after 21, 24 and 36 hours. During the first 18 hours of integration there is no significant difference between the reference and no Dinaric Alps experiment, except that fields are smoothed over the removed orography. At 21 UTC, 27 March there is 990 hPa low in the northern Adriatic (Fig. 8a). It occupies a larger area than its reference counterpart, extending to the northern Adriatic coast. Within the next 3 hours a drastic change occurs (Fig. 8b). Low pressure field spreads over the Adriatic and the Balkan peninsula with a centre moving to the east and weakening. After 36 hours (Fig. 8c) no cyclone is present to the east of Italy. The northerly winds cover the entire middle and southern Adriatic instead of S and SE flow as predicted in the run with the Dinaric Alps. Winds at the surface and throughout the lower troposphere are generally weaker than in



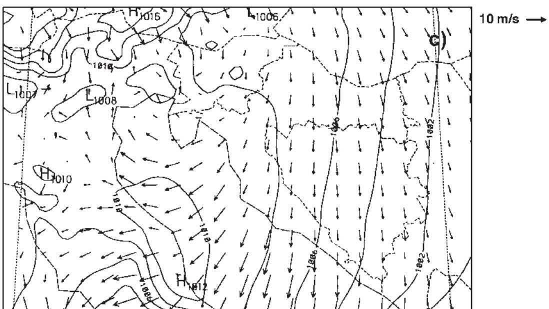


Figure 8. Mean sea level pressure and 10 m wind forecast for 21 hours (a), 24 hours (b) and 36 hours (c) of model's integration in the no Dinaric Alps experiment.Contour interval is 2 hPa. Wind vectors are plotted at every fourth grid point.

the reference experiment (Fig. 7b), with no bora maximum along the coast. Development without the blocking upstream of the Dinaric Alps influences also a »twin cyclone« over the Tyrrhenian sea. Northerly winds accelerating over the Adriatic cause stronger blocking effect and a »dipole structure« across the Apennines: the Tyrrhenian low has the same depth as in the reference experiment, but the pressure gradients are stronger and the anticyclonic centre is shifted southeastward. (It can be noted in Fig. 9, in comparison with Figs. 4 and 8, that the depth of cyclone over the Tyrrhenian Sea is not influenced by the orography of the Dinaric Alps).

After 12 hours the development in the no Dinaric Alps experiment is very fast. The lowest pressure appears earlier, as seen locally in Split (Fig. 10). The difference between the sea level pressure in the reference and no Dinaric Alps experiment after 36 hours is shown in Fig. 9a. There is a significant dif-

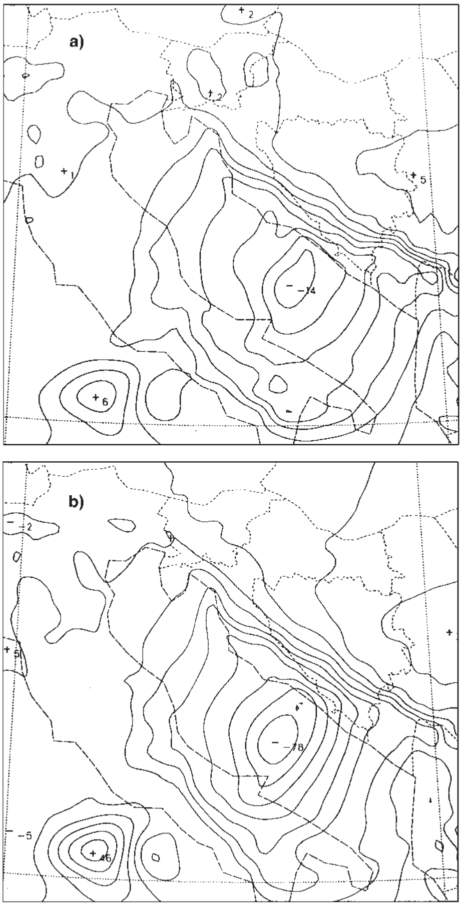


Figure 9. (a) Mean sea level pressure difference (hPa) between the reference and no Dinaric Alps experiment for the 36 hour forecast. (b) Geopotential height difference (gpm) between the reference and no Dinaric Alps experiment at 850 hPa level 36 hours forecast. Contour intervals are 2 hPa and 10

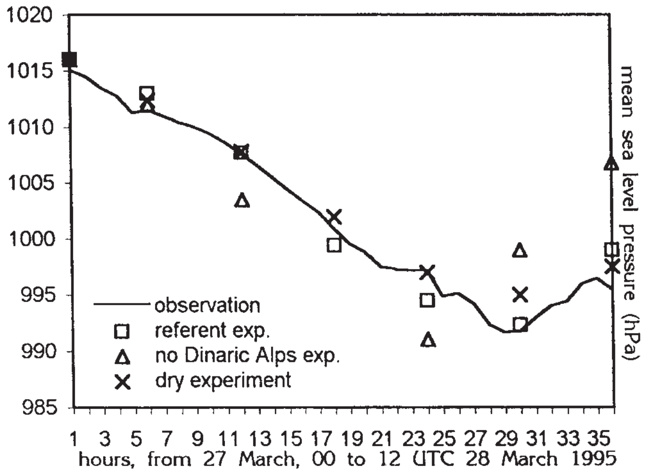


Figure 10. Hourly values of mean sea level pressure at Split-Marjan station, compared to the model outputs each 6 hours in the reference, »no Dinaric Alps« and »dry« experiment, during the period 27 March, 00 UTC, to 28 March 1995, 12 UTC.

ference of 14 hPa in the center of the cyclone. At the same location the difference in geopotential heights at 850 hPa is 78 gpm (Fig. 9b) and 47 gpm at 700 hPa (not shown). These results confirm that significant perturbations are induced by the mountains, as seen in many other numerical experiments. They also emphasise the importance of high resolution model in resolving spatial variability of wind and pressure fields at low levels.

4.3. Dry simulation

A dry forecast experiment, without condensation and convection, is designed to show the effects of the latent heat release on the evolution of the Adriatic cyclone.

During the first part of the model integration there is no significant difference between the reference and dry simulations. The cyclone formed in the absence of moist processes. The differences in the wind field, which is here weaker than in the reference experiment after 24 hours appear on the front side of the Adriatic cyclone. The wind field at 925 hPa in Fig. 7c can be compared to the same result from the reference and no Dinaric Alps experiments (Figs. 7a and 7b). It can be noted that the wind strength over the northern Adriatic is about 10% weaker but the difference is much larger near the centre of the cyclonic circulation. During the later stage of development the Adriatic cyclone is moving faster from the southern Adriatic to the Aegean sea and the Balkan peninsula. We speculate that the Adriatic cyclone owes its persistence over the southern Adriatic also to the Mediterranean circulation, not only to the cold air supply over the Dinaric Alps. A flow in the upstream region of the Dinaric Alps and the Apennines remains the same as in the moist case.

4.4. Verification of the local pressure forecast in Split

The lack of surface observations over the Adriatic is a serious problem when trying to verify pressure in the centre of the cyclone. Therefore we use mean sea level pressure measured at the coastal station Split and compare its hourly values to the model output every 6 hours (Fig. 10). Values and changes of pressure are well simulated in the reference experiment. In the dry simulation pressure forecast fits very well the observation except for the pressure minimum. This indicates that the moist processes are an essential factor during the most intense phase of the lee cyclone development, as suggested by Buzzi and Tibaldi (1978). The development in the experiment without coastal orography is faster and the minimum is lower than observed, but also occurs earlier. This means that orographic blocking slows down the development and prevents such a fast deepening of the cyclone. The pressure changes are generally stronger, particularly for the last 12 hours.

The detailed verification of the Adriatic cyclone simulation is difficult in situation with no upper air measurements on the Croatian side of the Adriatic. Further numerical simulations will require surface and upper level observations which will hopefully become possible after establishment of the sounding in Split planned for the near future.

5. Conclusions

Although most of the operational models have predicted an occurrence of the Alpine lee cyclogenesis by the end of March 1995, the results presented here reveal that the ALADIN model with the resolution ~10 km is capable of giving a detailed description of the Adriatic cyclone evolution. It offers a possibility for investigating the effects of local orographic features on the cyclone development. The results of simulations presented here led to recognition of the decisive role played by the Dinaric Alps on the Adriatic cyclone maintenance. A frontal deformation helps the intensification of the Adriatic cyclone producing a characteristic »dipole structure« across the Dinaric Alps.

The effects of the Dinaric Alps on the development and maintenance of the Adriatic cyclone were revealed by the comparison of the reference and no Dinaric Alps experiments. These experiments have supported the conclusion by Tafferner (1994) on the importance of orography on the cyclone formation. Moreover it is shown here that including the Dinaric Alps in this case study is not a necessary condition for cyclogenesis in the northern Adriatic, but is very important for the later cyclone development. Removing those leads to the faster development and stronger pressure changes. The effects of the Dinaric Alps on the Adriatic cyclone development can be seen both in pressure and temperature fields indicating strong gradients across the orographic barrier.

A comparison between moist and dry forecasts leads to a conclusion that ommision of the latent heat release is a much less important factor for the cyclone development than the orographic influence. However without moist processes cyclone centre is shallower, winds weaker and the cyclone moves faster over the southern Adriatic.

More case studies have to be done before the results obtained in this study can be generalized.

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SAŽETAK

Numerička simulacija razvoja Jadranske ciklone

Nedjeljka Brzović i Vesna Jurčec

U radu su prikazani prvi rezultati simulacije utjecaja Dinarida na Jadransku ciklonu pomoću hidrostatičkog modela visoke rezolucije ALADIN. Izvedeni su referentni eksperiment i dva dodatna eksperimenta za ispitivanje utjecaja orografije i vlage na razvoj i održanje ciklone. Verifikacija potvrđuje da je pojava »ciklona blizanki« na obje strane Apeninskog poluotoka realistična osobina. Utjecaj Dinarida se očituje u paru visokog i niskog tlaka preko orografije i jakim vjetrovima iza ciklone i uzduž obale. U odsutnosti Dinarida ciklona nije više vezana uz tu orografiju već se polje niskog tlaka brzo proširuje preko cijelog Balkanskog poluotoka slabeći. Odsustvo vlažnih procesa uzrokuje slabiju ciklonalnu cirkulaciju. Usporedba tri eksperimenta pokazuje da su orografski uzrokovani gradijenti tlaka, a ne tlak sam, bitni za održanje ciklone. Ovi eksperimenti pokazali su da je Jadranska ciklona prvenstveno uvjetovana Alpskom orografijom dok Dinaridi, blokiranjem zraka u navjetrini, utječu na podsinoptičke procese na području Jadrana.

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