Comparison of the MM5 performance in ECMWF and NCEP driven simulations _ part B

Thus, MM5-ECMWF simulation was chosen to have the better potential for a good simulation of this event including synoptic environment, heavy precipitation and strong Bura processes.

Simulations were performed with different set of CPS and MPS parametrizations:

1. KF2-R1
2. KF2-R2
3. KF2-Sh
4. KF-R1
5. KF-R2
6. KF-Sh

These parametrizations were not chosen randomly. By courtesy of Daniele Mestrangelo (Univ. of Napoli), I have received the graph showing 60(!) simulations of the event testing the various combinations of CPS and MPS (Fig 1.). Domains in his simulations were of 67.5, 22.5 and 7.5km resolutions and verification was done on 7.5 km domain results.

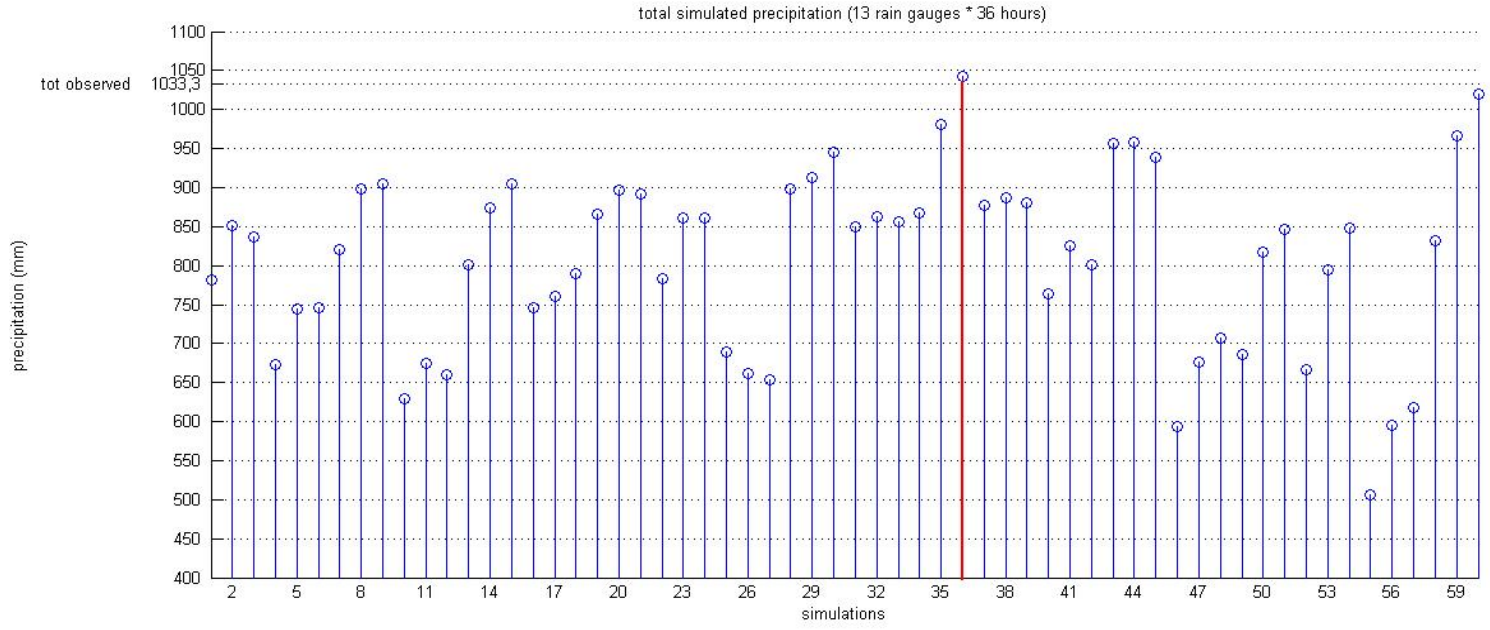


Fig.1. Total +36hr rainfall amounts in 60 simulations for all the 13 Salentine stations summed together (refer to part A) with various CPS and MPS parametrization used, from 12Nov12UTC-14Nov00UTC.

Total rainfall on the 13 Salentine locations together was 1033mm, as denoted on the graph. The apscise numbering denotes simulations and should be red like:

```
for CPS =[AK, Grell, KF-Gr, BM ]

   for ICUPA = [Simple Ice, Reisner I, Goddard, Reisner II, Shultz]

      for DOMAIN = [1, 2, 3]

      end
   end
end
```

They did not use KF2 CPS in their tests because they found it computationally unstable (with a lot of NaN values).

The parametriztions were the same for all 3 domains in one simulation, except for the KF, that used Grell parametrization in the highest resolution domain.

This graph is really interesting, and could be of help in evaluating your operational setup too. For example, it looks like Reisner2 had poor results on this case no matter what CPS is used. On the other hand Reisner1 and maybe even more Shultz have the best results averaged over the CPS and all 3 domains. However, this graph says nothing about the pressure patterns.

Also, KF CPS showed the best results over all the MPS and domains averaged. So, as UIB is operationally using KF2 and R2, I decided to the simulation series with the best of CPS with 2 best MPS (in Daniele's tests), as well as the KF2 and R2 options in the cocktail shaker – and it is the 6 simulations listed in the beginning.

This part of study aimed at finding the best rainfall simulation at most. The methodology is the one applied in Daniele's diploma work – i.e. calculate total of the total rainfalls for 13 salentine stations and then for best of them look for the precip patterns to decide which one is really the best. (Of course, we should take a look at all 3 precip centres (see part A for their identification), but I had no detailed data for the other centres (no station lat-lon for Fucello data))

Fig. 2 shows 36 hour total MM5 simulated rainfalls for the 13 salentine stations summed together, for the parametrization combinations tested (data was red from the MMOUT file and bilinearly interpolated to the station location). The corresponding sum of the measured rainfall data from the 13 stations is 1033mm. In general, KF2 CPS seems to be better then KF, overall, and there were no problems with its potential computational instability. MM5-NCEP KF2-R2 simulation precipitation is added to the figure for convenience, although it was showed in part A that MM5-ECMWF simulation has better precipitation pattern then MM5-NCEP simulation (and that MM5-NCEP had significantly different synoptic environment). It is notable that even the best simulation underestimates that total Salentine precipitation (1033mm) for more then 20%. From the MPS used, best combination with KF2 had R1, then Sh and then R2. As these are all

better simulations then the ones that used KF CPS, these 3 simulations will be investigated in detail.

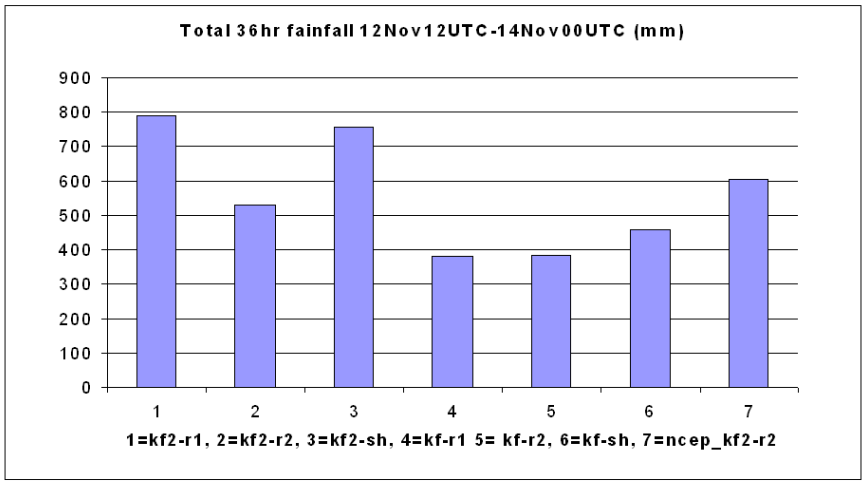


Fig. 2. 36-hour simulated total rainfalls for the 13 salentine stations summed together

Comparison of the simulations with KF2 CPS and R1,R2 or Sh MPS

1. SYNOPTIC ENVIRONMENT

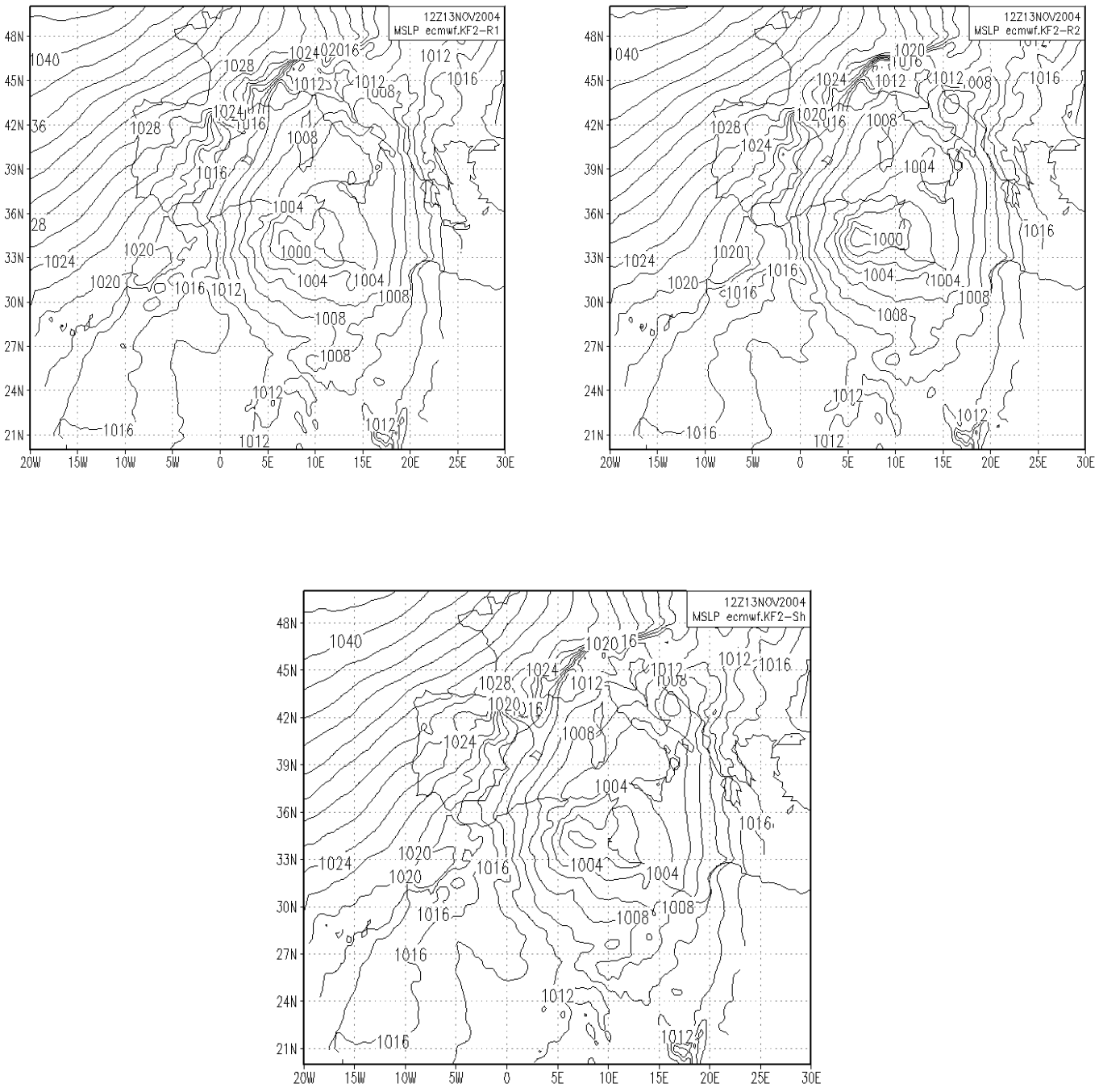


Fig 3. MSLP at 13 Nov 12 UTC for KF2-R1 (upper-left), KF2-R2 (upper-right), KF2-Sh (down). KF2-R2 is 2 hPa deeper then the KF2-R1 and KF2-Sh.

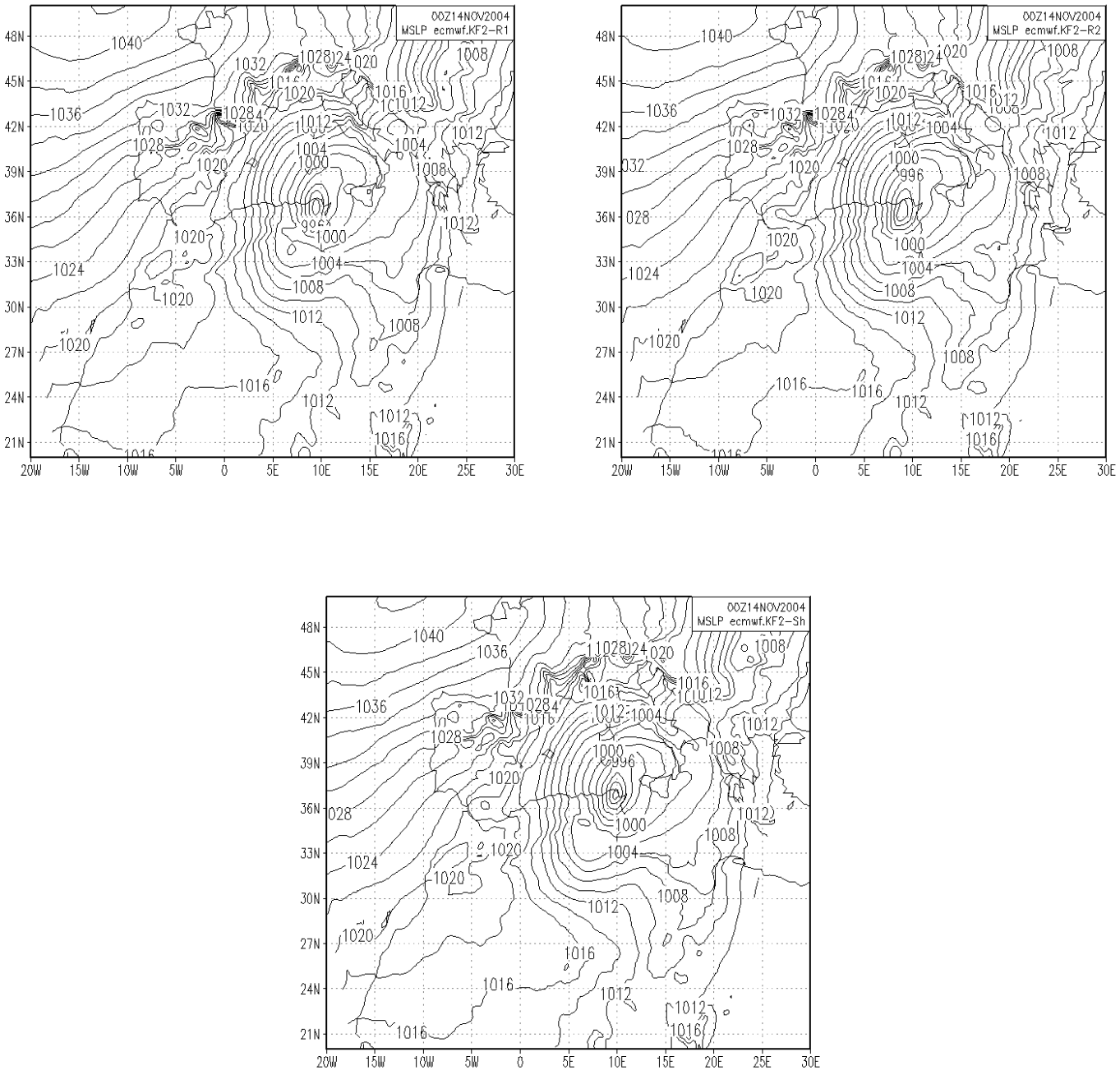


Fig 4. MSLP at 14 Nov 00 UTC for KF2-R1 (upper-left), KF2-R2 (upper-right), KF2-Sh (down). At this time KF2-Sh is 2 hPa deeper (990hPa) then the KF2-R1 and KF2-R2 (992hPa). The KF2-Sh MSLP value at the cyclone centre has a very good match with the BUFFR station 60715 (990.7hPa), while KF2-R1 and KF2-R2 correspond well to ECMWF analysis (992hPa) – refer to part_A. Error is greater in locations of the cyclone centres (compared to ECMWF analysis), then in MSLP values.

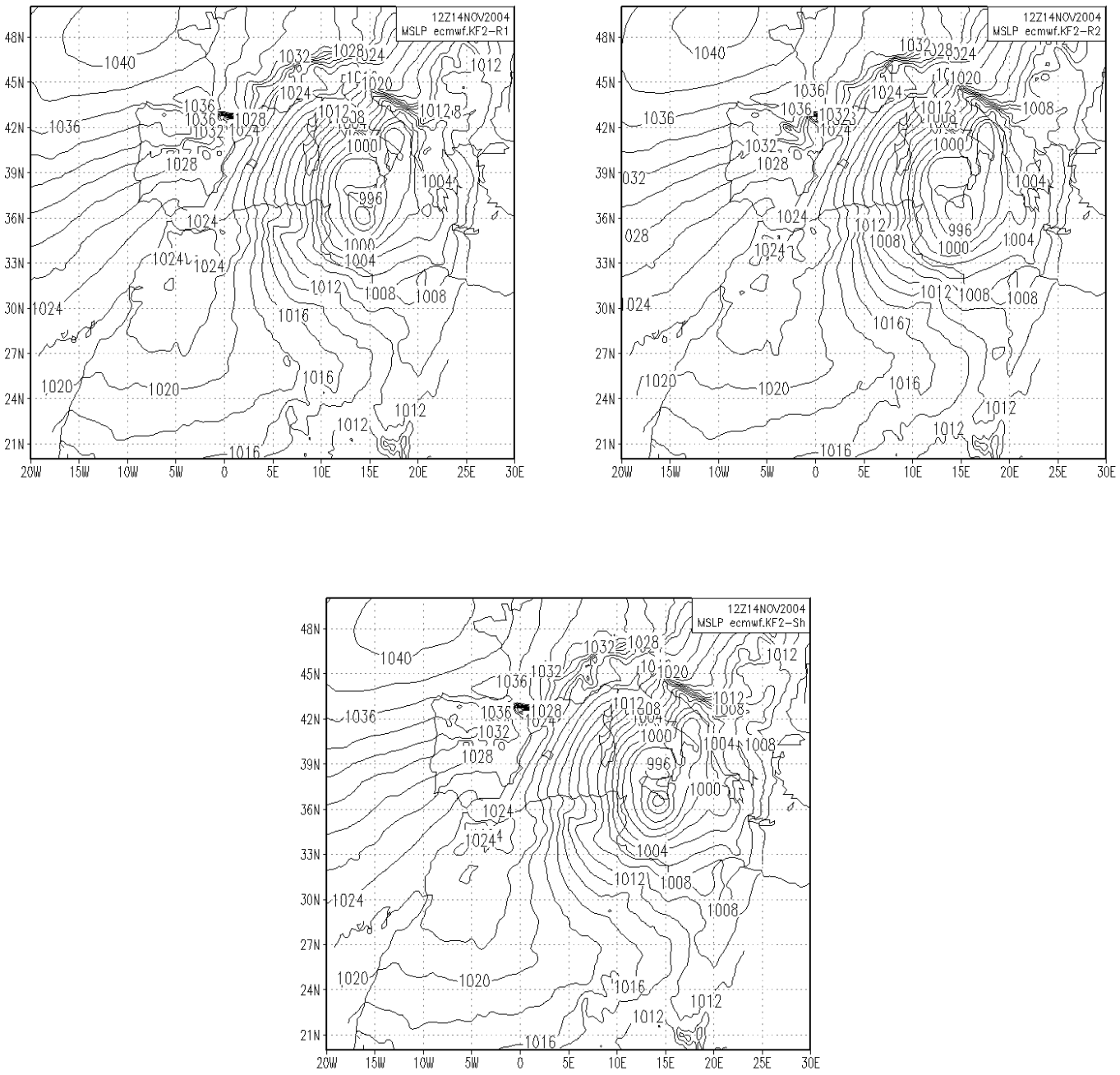
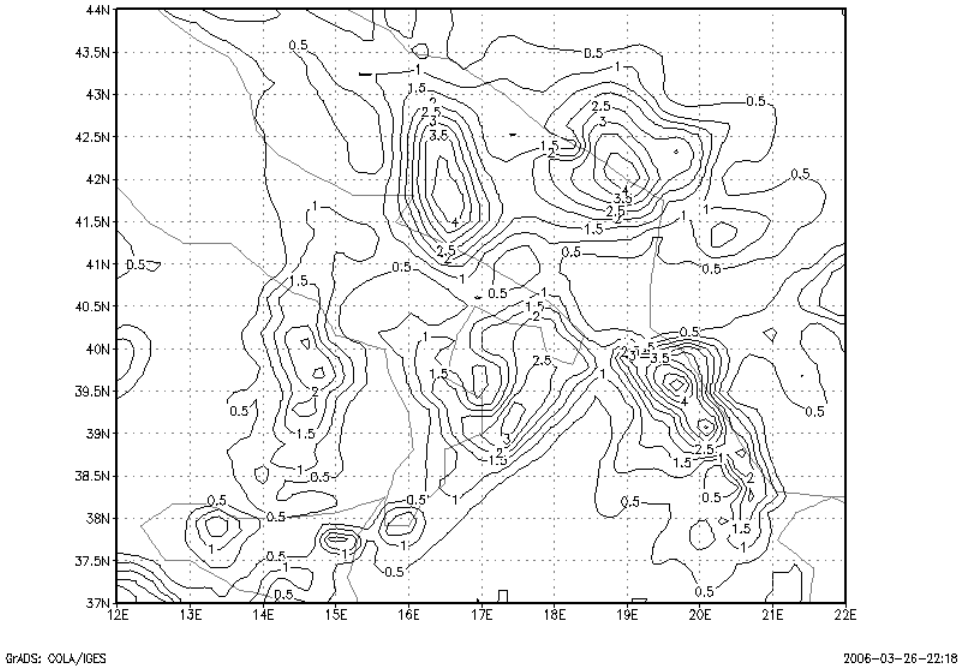


Fig 5. MSLP at 14 Nov 12 UTC for KF2-R1 (upper-left), KF2-R2 (upper-right), KF2-Sh (down). At this time KF2-Sh is shows 992hPa, KF2-R1 994hPa and KF2-R2 996hPa. The KF2-Sh MSLP value at the cyclone centre has a very good match with the ECMWF analysis (990.7hPa) – refer to part_A. However, location of cyclone centre is for all 3 simulations equally displaced compared to ECMWF analysis that has centre to the NE of Sicily.

In general, it seems that KF2-Sh shows the greatest accuracy in MSLP value at cyclone centre. All 3 simulations have a rather displaced cyclone location (compared to the ECMWF analysis) at 14 Nov 12 UTC. However, as mentioned in part_A, at there was already no significant rainfall in South Italy at that time.

2. RAINFALL



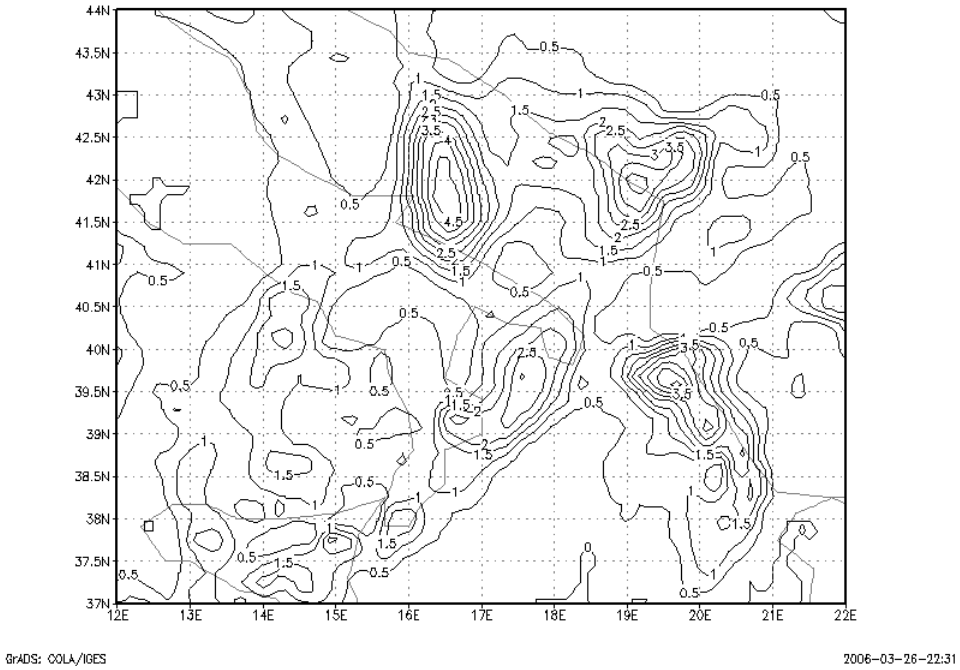


Fig. 6.a-b: 24hr model simulated total precipitation in cm (12 Nov 00 UTC – 13 Nov 00 UTC) for MM5-ECMWF KF2-R1 and KF2-R2 simulations. These figures should be compared to Fuccello data on 12 Nov (attached).

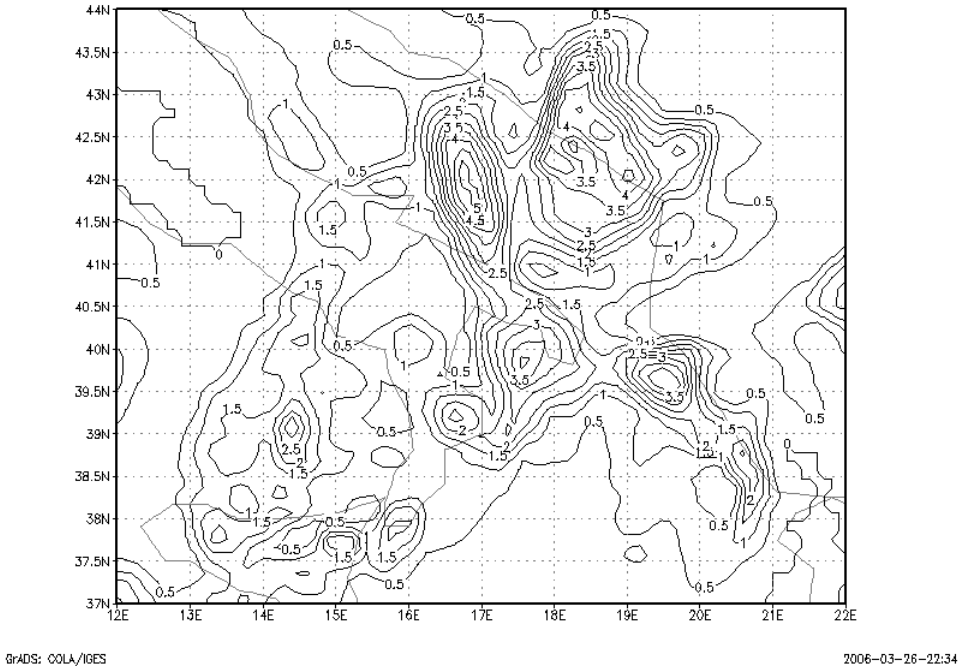


Fig. 6.c: 24hr model simulated total precipitation in cm (12 Nov 00 UTC – 13 Nov 00 UTC) for MM5-ECMWF KF2-Sh simulation. This figure should be compared to Fuccello data on 12 Nov (attached).

When looking at South Italy, KF2-Sh and KF2-R2 have produced better Calabrian maximum (Fig 6), although it is highly underestimated (25mm compared to 100mm in Fuccello data). KF-R1 does not seem to have so much detail in precipitation pattern, and did not produce this maximum at all.

Second maximum that was present in Fuccello data on 12 Nov (~250mm/24hours) near the northern edge of Taranto bay was NOT reproduced by either of the simulations AT ALL.

Period 12Nov12UTC-14Nov00UTC(Fig. 7) is to compared with Salentine data presented in part_A. Salentine maximum was in terms of location and precipitation amout rather well forecasted, primarily by KF2-R1 and KF2_Sh and then by KF2-R2.

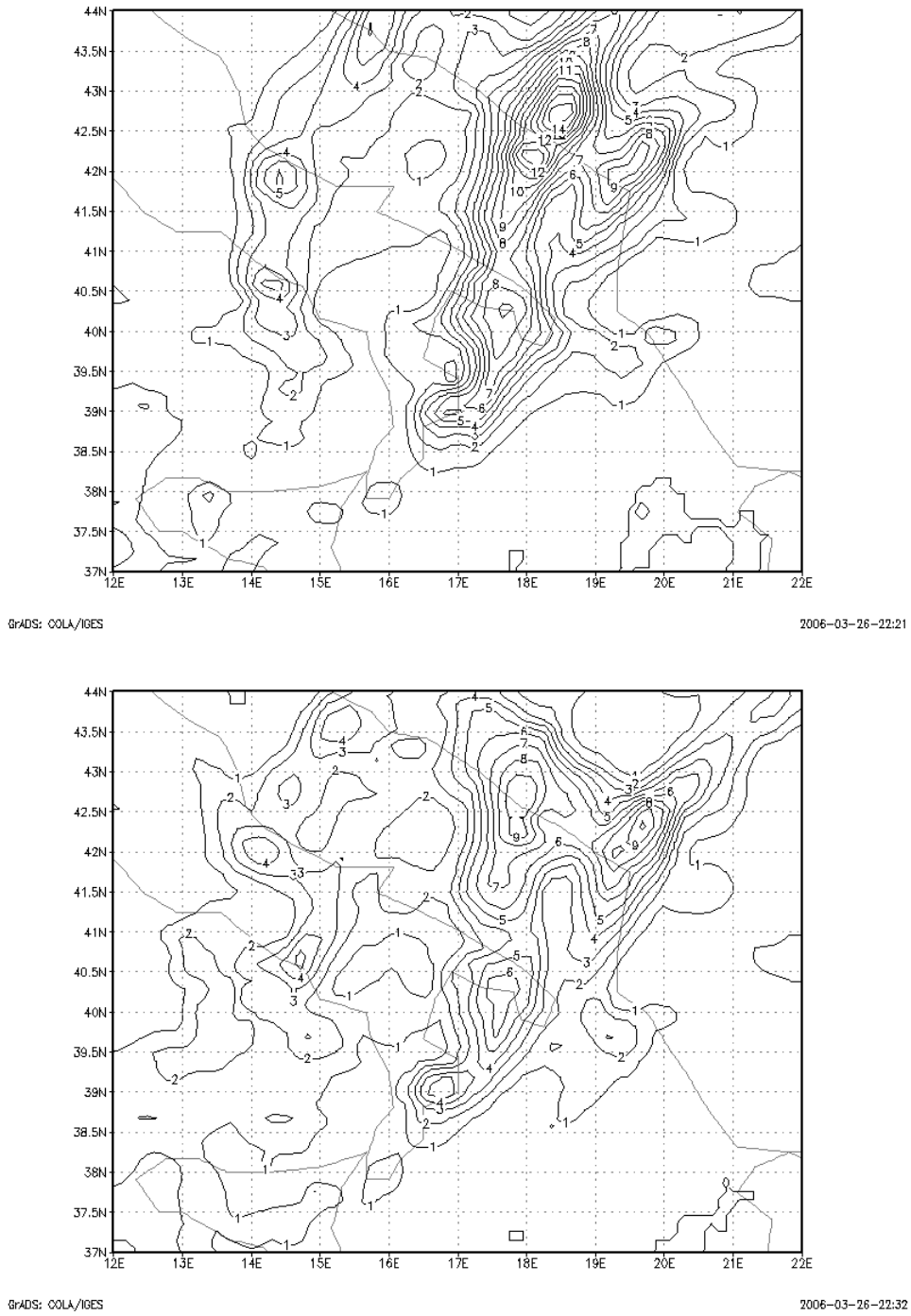


Fig. 7.a-b: 36hr model simulated total precipitation in cm (12 Nov 12 UTC – 14 Nov 00 UTC) for MM5-ECMWF KF2-R1 and KF2-R2 simulations. These figures should be compared to Salentine data (see part_A).

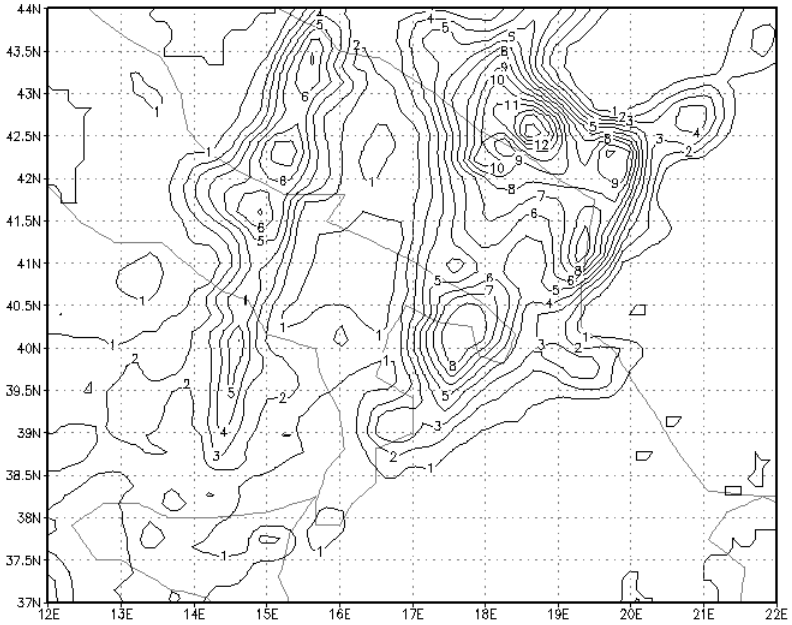


Fig. 7c: 36hr model simulated total precipitation in cm (12 Nov 12 UTC – 14 Nov 00 UTC) for MM5-ECMWF KF2-Sh simulation. This figure should be compared to Salentine data (see part_A).

For the comparison with our results, Fig. 8 shows the mm5 KF(67.5,22.5)-Grell(7.5) total rainfall in the 36 hour period 12Nov 12UTC-14Nov00UTC. The Salentine maxmimum was forecasted much better, specially taking into account not only the “Salentine” data, but also “Fuccello” data showing ~200mm/24hr on 13Nov(00-00UTC).

Also, the high-resolution setup managed to produce the other 2 maximas, at least to a certain degree of reality (if compared to Fucello data, don’t forget the model simulation showes a 36hr period rainfall starting 12Nov12UTC).

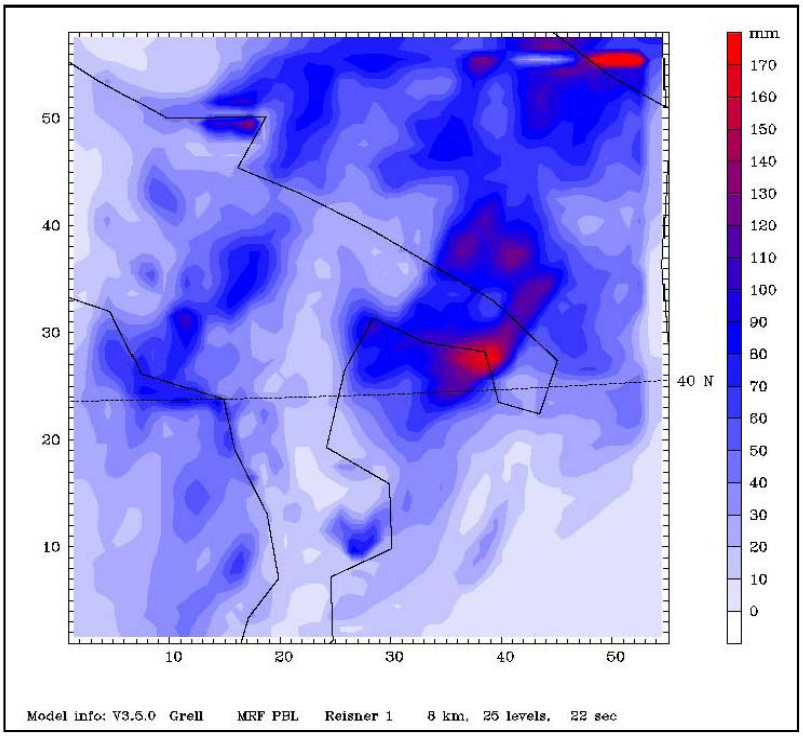


Figura 3.20: precipitazioni simulate per il periodo di 36 ore dalle 1200 UTC del 12 novembre alle 0000 UTC del 14 novembre.

Fig. 8: 36hr model simulated total precipitation in mm (12 Nov 12 UTC – 14 Nov 00 UTC) for “the best” simulation of Daniele Mastrangelo’s tests (verifying only the Salentine maximum though!). Salentine maximum is well reproduced, and there are indications of other two maximas present in Fuccello data from 12Nov00UTC-13Nov00UTC, despite the start of rainfall accumulation period for this figure started at 12Nov12UTC (in other words MM5 probably did even better). DM’s simulation was initiated at 11Nov00UTC (courtesy of Daniele) for 72 hours with ECMWF IC and LBC.

3. Bura

Bura on the northern Adriatic did not show much sensitivity to indirect influence of different tested model parametrizations. As going to the south, bura is usually more sensitive to presence of a cyclone in Mediterranean, but even more to induced pressure pattern in Adriatic (recall my Plinius presentation). Result for middle-Adriatic station Split (Fig. 8) show that KF2-R2 had the best performance for bura in middle Adriatic (and probably south Adriatic too), with the start of Bura especially well reproduced. However, all 3 simulations did not reproduce particularly well Bura maximum intensity and timing in the analysed period.

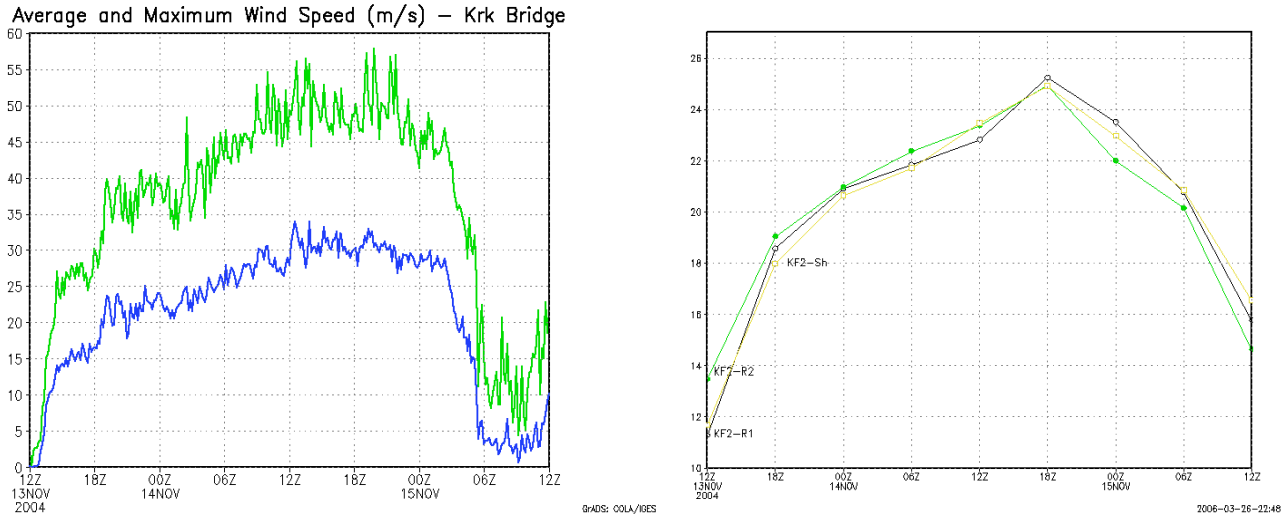


Fig 7. Measured wind speed and wind gusts (left) and simulated MM5-ECMWF bura wind speed on location of the bridge Krk (North Adriatic)

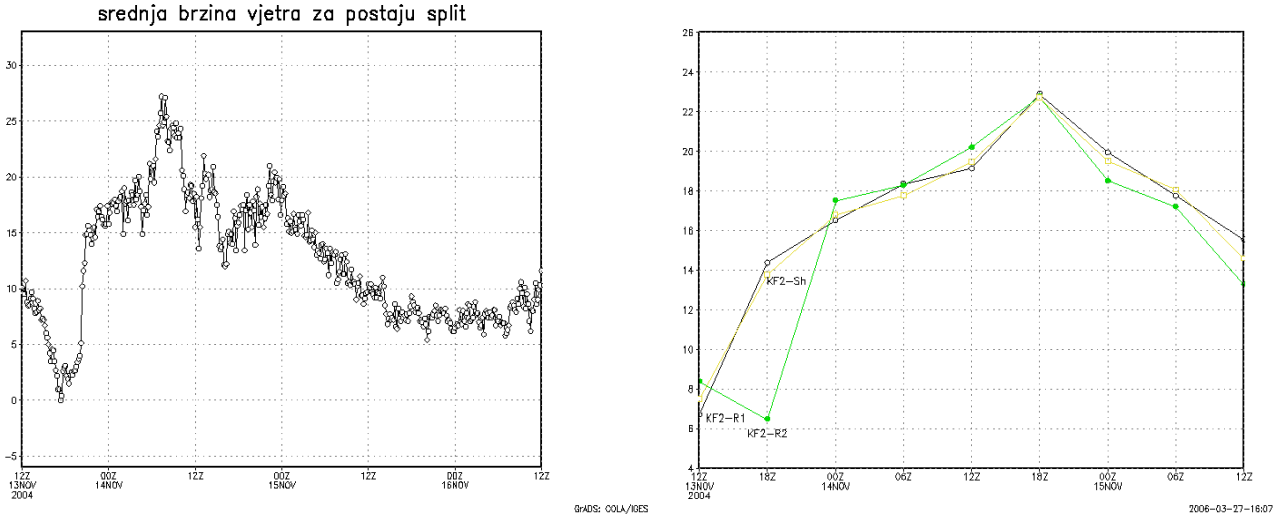


Fig 8. Measured Simulated MM5-ECMWF bura wind speed on location of the bridge Krk (compare with data in part_A). Sorry for the different x-axis domain.

FINAL CONCLUSIONS

Differences between three tested simulations including KF2 CPS and R1, R2 and Sh MPS are not big, however, they do exist. Regarding the synoptic environment, KF2-Sh simulations showed the best results, mainly in MSLP centre forecast, as all three simulations equally misplaced the cyclone centre.
Simulations showed that even more intensive heavy rain was present in Montenegro (parts of Albania, Croatia of Greece too) then in Southern Italy. However, the data used for verification was the South Italian data from two sources ("Fuccello" and "Salento"). Results indicate ~250mm/24 rain (Fuccello:12Nov00UTC-13Nov00UTC) maximum near the northest point of Taranto bay was not simulated at all by any of the simulations analysed, not even poorly, what seems to be a big model failure. The Calabria maximum (100mm/24hr, from 12Nov00UTC-13Nov00UTC) was present in all 3 simulations, but precipitation amounts were reaching 20-30mm/24hr at the same period.
The best simulated precipitation maximum was the Salentine one, where simulated precipitation maximum reached almost 100 mm/36hr (12Nov12UTC-14Nov00UTC), quite comparable with "Salento" data showing station maximum of ~135mm/36hr in the same period. On the other hand the other source of data, "Fuccello", shows station in the region having a ~200mm/24hr in period from 13Nov00UTC-14Nov00UTC. This data implies that precipitation maximum was rather underestimated in case of this precipitation maxima as well.
Another picture of the simulated Salento precipitation is viewed through the total precipitation sum of all the station data. In this case, the best 22.5km simulation KF2-R1 showed ~20% underestimation, with KF2-Sh simulation closely behind. However, precipitation pattern of KF2-R1 sometimes might look too smooth (like in Figure 6).
For the Bura flow, differences are not big, but it seems that KF2-R2 simulation managed to reproduce the event with the greatest accuracy, although timing and intensity of the Bura maximums in the episode were not reproduced especially well in Southern Adriatic (in Northern Adiratic Bura is in general not so much sensitive on the cyclone presence anyway).

As a *summary of summaries*, I am of impression that KF2-Sh simulation was the best one, keeping in mind that it had forecasted synoptic environment the best, and that it's rainfall amount prediction is comparable with KF2-R1 simulation (with others being worse), with possibly the best precipitation pattern in south Italy.

In the end, it should be mentioned that the high resolution (6.5km) simulation results presented here showed a potential to predict the rainfall amounts and precipitation patterns much better.