Report on "Adriatic Storm Cases"
RC LACE internal report

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November 2001

1. Introduction

Main idea of this work is to find causes of sometimes ALADIN overestimated cyclones on Adriatic Sea. Last summer there were several cases of a very strong cyclogenesis. Forecasted small-scale cyclones seemed unrealistic and too deep. First idea was about possible various cyclogenesis with different physical packages but preliminary studied a case from 20th July 2001 00UTC did not show much sensitivity either to the deep convection parameterisation settings or the evaporation/melting of falling resolved precipitation. Cutting the evaporation from sea surface which killed the development of the cyclone was only solution. My tasks were to examine whether the same behaviour exists also for other cases, to try to diagnose the mechanism of cyclogenesis, and, of course, to find a better way for getting the same results than cutting the evaporation. I solved some of these tasks, but did not succeed in last the most important one.

2. Cases

Except of mentioned case from 20th July 2001 00UTC run the same or similar situations with deep cyclones were also happened
at 17th and 18th June 2001,
and especially at 3rd, 4th and 5th September 2001.

Large scales features or what is happened on DWD analyses?

16-18 June 2001
At 16/06 00UTC cyclone (deeper than 1000hPa) exists on Great Britain, and frontal zone with small centre lies on western part of Alps, from Denmark on north to Spain on southwest. On Adriatic is weak anticyclone. At 06 UTC one cyclone appears on west Mediterranean Sea, and wave on front exists above Alps. At 12UTC the huge cyclone is on bigger part of Europe. Except of centres, which are northern of Alps, two centres (under 1010hPa) exist near Genoa bay, and also third small centre appears on middle Italy. Cold front is above east Alps. At 18UTC two centres inside 1010hPa exist on east (above east Hungary) and south of Alps (Genoa bay).
At 17/06 two centres are on south Scandinavia and one centre with his own frontal system exists on north Adriatic (between the river Po and Istria). At 12UTC two centres is still near Scandinavia, and one centre exists near Genoa bay. Cold front lies across north Adriatic, middle Italy and Sicily. At 18/06 06UTC cyclone's area is on east and southeast Europe. One centre is in west Russia and second (under 1010hPa) is on middle Adriatic. At 12UTC this centre is on the same place, and deeper one (under 1005hPa) exists in Bulgaria. Unfortunately, I don't have an analyses of upper-level atmosphere but some satellite images exist (see on /utemp/mma168/pictures/satellite/06*.jpg).

19-21 July 2001
At 19/07 00UTC similar situation is like at 16/06. Cyclone (smaller than 1000hPa) exists on east part of great Britain and Nordsea, frontal zone with wave lies from Denmark, across middle Europe and Alps to west Spain. One centre (under 1005hPa) exists above south Alps, northern of Genoa bay. On Adriatic is nongradient field, about 1007hPa. The similar situation is still at 06UTC and 12UTC. At 18UTC deep centre (under 1000hPa) exists in Genoa bay. Warm front is above north Italy and Alps, and cold front is above Corsica. MSL pressure on north Adriatic is under 1005hPa.
At 20/07 00UTC centre (under 1000hPa) is on northern part of Italy, but southern of river Po. This cyclone also exists on upper-level charts, on 850 and 700hPa. A huge valley is situated west from Alps through the whole atmosphere. Strong southwest flow exists above Adriatic and Croatia. MSL pressure on whole Adriatic is between 1000 and 1005hPa. At 06UTC deep centre (under 1000hPa) is on north Adriatic (between river Po and Istria). Cold front is near Croatian coast. At 12UTC cyclone's centre (under 1005hPa) is on east Austria and west Hungary and cold front is situated across east part of Croatia, Bosnia, and south Adriatic. Deep centre (under 1005hPa) appears on very small area on south Alps, northern of Genoa bay. At 18UTC "eastAustrian"'s centre (under 1005hPa) is moved on east Hungary and north Romania and centre on north Italy still exists but not so deep (under 1010hPa).
At 21/07 00UTC centre (under 1005hPa) exists in Romania. Possible existing centres on Adriatic and Italy are not signed. At 06UTC centre in Romania still exists but on smaller area. Small centre (between 1010 and 1015hPa) is on south Adriatic! Unfortunately again, I don't have upper-level analysis for 21/07. Satellite images exist.

04-06 September 2001
On 04/09 12UTC the main cyclone (under 1000hPa) is on south Scandinavia. Frontal zone, with wave on Alps, lies across Poland, Austria, southwest France and northwest Spain. Second centre (under 1010hPa) exists on south Alps. During afternoon this centre becomes deeper (under 1005hPa at 18UTC) and moves to Genoa bay.
At 05/09 00 UTC MSL centre (under 1005hPa) is situated on larger area on north Italy. Cold front of cyclone on Scandinavia is on Hungary, warm front of "Italian"'s cyclone is above north Adriatic, Slovenia and west Croatia, and cold front is above middle Italy. Deep trough (valley) exists on analytic charts of upper-level atmosphere from Scandinavia till Alps and north Italy, where cyclone on 700hPa also exists. Strong southwest flow exists above Adriatic and Croatia. At 06 UTC on MSLP analysis cyclone is on middle Adriatic. Centre is deeper than before (under 1000hPa) and is situated on small area. It seems like one cyclone which moves toward Adriatic where becomes deeper, but small scale features gives another story, well known from many articles (about two centres and one of them, on Adriatic, becomes dominant). At 12UTC deep centre (under 1000hPa) is situated on larger area than before and is moved on middle-south Adriatic. Small centre (between 1005 i 1010hPa) appears on "popular" place, on south Alps, little northern of Genoa bay. At 18UTC main centre (under 1000hPa) is above Romania, and it is interesting that DWD analysis also "see" small cyclones in Genoa bay and north Italy.

3. Cycora testing

First of my tasks is to check an idea about possible various cyclogenesis with different physical packages. So, I used 4 morgane scripts on the same lancelot output. The cyclones are presented for all the tested physical packages we have recently in ALADIN: pre cycora, cycora, cycora-bis and even cycora-ter. Some of differences between these cycoras, which are important in my case, are in deep convection parameterisation setting and in evaporation/melting of falling resolved precipitation. They are (I found explanations in program code):
LSRCON=key to subtract large-scale precipitation from moisture convergence before passing it to deep convection (feeding convection scheme). If .true. than the convective scheme will use in input humidity and heat fluxes coming from vertical diffusion but also those from stratiform precipitation.
GCOMOD=exponent used in modulation of moisture convergence and cape consumption (deep convection).
REFLKUO=reference length for KUO-closure in deep convection.
GCCSV=vertical stability criteria choice.
LCVDD=key for downdraft computation.
EVAP=parameter for the evaporation of precipitation (instead of that in namelist was mentioned
LCVEVAP=key for convective evaporation.
FONT=parameter for the melting of precipitation.

I found that values in namelists for different cycoras were like follows:

variable\for	pre-cycora	cycora	cycora-bis	cycora-ter
LSRCON	.false.	.true.	.true.	.true.
GCOMOD	1.	0.	0.	1.
REFLUKOU	-	-	-	10000.
GCCSV	-	-	1.	0.
LCVDD	.false.	.true.	.true.	.true.
(LCV)EVAP	.true.	.false.	.false.	.false.
FONT	-	-	-	-

"-" means that variable not exist

After adaptation and preparing scripts for lancelot and morgane, first what I done was controlling my results (MSLP fields) for 20/21 July cyclona with those, which made before in Toulouse. For easier following and understanding in pictures pre-cycora is signed by c1, cycora by c2, cycora-bis by c3 and cycora-ter is sign by c4.

Conclusions are:
a/pre-cycoras are equal;
b/ cycoras are equal, too;
c/cycora-bises have a few differences, for example, in shape of isolines on north Adriatic and Slovenia, but the depth and position of Adriatic cyclone is equal;
d/cycora-ters have more differences, but the main shapes of fields are equal. For example, for +24h forecast, of 00UTC run, Toulouse's centre of cyclone has 994hPa, and mine 996hPa. For +36h, 997hPa and 1000hPa, respectively.

Testing with 4 cycora for the same case gives a few differences between them. For example, at 20/21 July cyclone, each cycora gives a cyclone on approximately the same position, but with different depth. It is obviously that pre-cycora is the most mild in majority of cases, but not every time (picture pic0904_36.ps), which means that it gives not too deep cyclone. Differences between other cycoras are about 1 to 4 hPa.
I also noticed some differences during testing and checking results of dynamical adaptation cycora-bis which I done and corresponding from operational model (with blending).
For example, it is obviously on pictures from 17th June, 00UTC run, after +36h, especially for +42h.
pictures: operational model pic0617_42_c3archiv_voo.ps,
mine cycora-bis pic0617_42_c3.ps
Depth of Adriatic cyclone on operational model is 999.1hPa and mine is 1004.5hPa. Of course, wind speed in cyclones also has a small variability, and centres of cyclone are not at the same place.
After suggestion of Mrs. Siroka I retrieved ICMSHALADINIT from archive, and rerun morgane with cycora-bis...
pictures: pic0617_42_c3a.ps (NSTDFI=7, TAUS=10800)
pic0617_42_c3ab.ps (NSTDFI=4, TAUS=5400)
The results are different again. More similar, almost the same like operational, are results on picture pic0617_42_c3ab.ps (the last isobar is 1000hPa. On pic0617_42_c3a.ps depth of cyclone is even deeper than on operational (997.9hPa).
So, it is important to notice different results for the same forecast range, but with little different initial condition ICHSHALADINIT (the old story, now I got some kind of a little ensemble prediction system).
On picture from 20th July, 00UTC run, for +24h, differences also exist, but not so many. Centre of cyclone is shifted a little, and there are small differences in wind speed.
It can be concluded that my testing with different cycoras did not give a spectacular various results. Preliminary results from Toulouse about 20th July are confirmed in other two cases. Deep cyclones occurred in all physical packages and differences in MSLP and wind on 10m are small. There are also exist differences in other parameters, for example accumulated precipitation, but, as is visible on pictures, can not be concluded that any cycora always gives the most or the least amount.

4. Mechanism of cyclogenesis

I already explain what is really happened on large scale according to DWD analysis in part 2, but ALADIN forecast is the most important here. So, I will try to describe why so strong cyclogenesis are forecasted, especially at case from the beginning of September. A lot of forecasted fields and vertical profiles are made for understanding mechanisms of cyclogenesis. There are: geopotential and temperature on 300, 500, 700, 850hPa, MSLP, wind on 10m and 850hPa, potential vorticity on 9767, 2812 and 1604m, relative humidity on 2812m, equiv.-potential temperature on 20m and accumulated precipitation. I done also some vertical space cross-sections (from point 48.006N 8.985E to 40.097N 18.904E) (6 variables in two namelists because more than 3 variables in one script always stopped procedures). All pictures are situated on /utemp/mma168/pictures.
First sign of "strange case" of the Adriatic storm was forecast from 03/09 for 4th Sep (pictures 0903c4_gt_300-850.ps and 0903_MSLPw.ps). Deep cyclone appeared on south part of Alps and on north Adriatic Sea. It is, probably, well known and in literature described cyclogenesis on the lee of Alps (Ivancan-Picek, 1998), when cold air which passes (maybe better words are "goes around") on east part of Alps, comes on warm sea surface and causes or accelerates frontogenetic and cyclogenetic processes. This processes are also helped by upper-level potential vorticity stream which came from NW Europe to the Alps (pictures 0903c4_pv_10km.ps shows potential vorticity (PV) development on 10th level=9767m~10km). First wave of PV came at 4th in the morning, and second, stronger, in the evening, toward the end of simulation. Forecast from 04/09 00UTC confirmed the former one. PV maximum came almost in the same time. Upper-level charts gave a strong cold air penetration on middle and south-east Europe. Cyclone on 500 hPa also appeared. On MSLP fields (0904c4_pv10MSLPw.ps shows combination of potential vorticity on 10km, MSLP and 10m wind) it is looked like follows.
Till +9h cyclone is on the lee of Alps, near Genoa bay and north Italy, and then small cyclone begins near Croatian and Hungarian border.
>From +9 to +18h both cyclone are became deeper, especially one on Italy.
At +21h centre on land (Croatia/Hungary) is disappeared, but new one appears on north Adriatic (according with theory, and real data, which give NE wind on north part of Istria).
At +24h cyclone on north Adriatic becomes deeper, and NE wind is on north part of Istria.
To +30h cyclone on north Adriatic exists, and 3 new centres appear in Dalmatia, central part of Italy and NW part of Bosnia.
At +33h two centres exist on Adriatic, but northern is much deeper, and one in Bosnia.
At +36h "northern" Adriatic centre comes down on south (cycora-ter gives that it disappears and main centre is on Bosnia!).
At +39 the main shape of field pressure is the same on all cycoras, but exist differences in positions and depths of centres.
At +42h and further cyclone is on SE Europe...
So, initiation of the cyclone was indicated as a deviation in the geopotential field and subsequent development is associated with the deepening of the upper-level trough, especially after 00UTC at 5th Sep. To illustrate the simulated synoptic-scale development, except PV in upper-level atmosphere, PV low-lever field also cans helps. Picture 0903c4_pv_3km.ps shows potential vorticity on 20th model level (2812 m~3km), and picture 0904c4par_850gwPV.ps (only left side) shows the geopotential height and wind fields on 850hPa level in combination with potential vorticity on 23rd model level=1604m. Appearance maximum low-lever PV is obviously in the similar time and place with cyclone. Diabatic effects are also shown on picture 0904c4_3kmRHet.ps (left side). Big differences are visible in the field of equipotential temperature because of coming humid and cold air, first above Croatian land and after 6UTC (+30h) above Adriatic, especially. Warm Adriatic, which is additional source of humidity, also can help in forming stronger cyclogenesis in such cases.
00UTC model run of 5th Sep does not give such deep cyclone on north Adriatic like before run. Upper-level situation (geopotential and temperature) is a little milder than before, without cyclone on 500hPa. 10km PV maximum at 00UTC is moved easterly so deeper cyclone exists near Genoa bay and Italy than on Adriatic. After 6UTC deeper cyclone appears on middle and south Adriatic where is 10km PV maximum bigger than run from 4th Sep. At 9UTC real fields of MSLP and 10m wind is somewhere between these forecasts, maybe little closer to 5th Sep run, according to Croatian data, but at 12UTC this run gives deeper centre's minimum on middle Adriatic than 4th Sep run and measurements. At 15UTC forecasts give different depths of cyclones on various places but real measured data are not sufficient for checking (some stations have break between 14 and 19UTC).

Nevertheless, it can be said that real data from Adriatic coast and islands are almost in a harmony with forecast. Thunderstorms were, and rain also. During 4th Sep afternoon, till 18UTC, on station Pula (14 309) on Istria 15mm of rain and showers was measured and thunderstorms was noticed. Forecast from

3rd Sep gave a maximum a little eastern of Pula, so it is very good. During night 18UTC 4th till 6UTC 5th Sep in Rijeka (14216) was 104 mm of rain, in Zadar (14428) 98 mm, and near Rijeka 136 mm was measured also. There are only the biggest amounts, but many places had 25 to 80 mm of rain. Maximum forecasted amounts were about 150mm (all cycoras)! During 5th Sep, from 06 till 18 UTC, rain was almost in Dalmatia. The most measured value on synoptic stations was in Split (14445) 58 mm which was underestimated in forecast (maybe local influence). Pictures with forecasted accumulated precipitation also exist (for example 0904_rain42.ps). Forecast of rain on Adriatic did not been overestimated! There is overestimated centre in Slovenia and Gorski kotar (hilly part of Croatia), according to data, which I had. Most of wind data are also very similar with forecast. It can be compared for example on picture maxwind0904.ps and 0904c4_MSLPw.ps (only left side). On picture maxwind0940.ps Umag is station on west coast of Istria, and other stations have numbers: Senj=14323, Rab=14321, Mali Losinj=14314, Pag is NW of Zadar=14428, Hvar=14447, Komiza=14441 and Dubrovnik=14472.
It is hard to confirm that depths of cyclones are unrealistic because of lack of data above the sea. It is true, according to data I had, that some forecasted cyclones seem deeper than in nature. But, for example, for station Pula airport (14 307), for 5th Sep in the morning gives a MSLP about 1001hPa what is almost equal with forecasts (pic0904_30.ps, pic0905_06.ps. Nevertheless what all stations on coast and on near islands give MSLP above 1000hPa, it can not be forgotten that centre of cyclone is on the sea, not near the coast. Station Palagruza (14 443), for example, on the open sea, and stations Komiza (14 441) and Lastovo (14 452), are little closer to coast than Palagruza, give MSLP about 999.5hPa during 9 to 12 UTC.
Generally speaking, without more data for this situation, it can be said that the pressure drop in the centre of the cyclone is somewhat overestimated, but the simulated synoptic-scale developments are fairly consistent with observation.

Vertical space cross sections also help in understanding. There are made with "aui" software. On picture vscs_0904rh.ps, for example, is very well visible how moist air goes and propagates on Adriatic Sea, especially on south Adriatic (right side of picture). Minimum humidity (less then 40%) disappears after +24 in upper level, and second minimum or less humid air (about 50%) exists till +30h near sea surface.
Vertical structure of equipotential temperature is presented on picture vscs_0904et12-24.ps. It is obviously how cold and humid air descending on warm sea, especially after +24h.
I am not satisfied with visualisation of vorticity (I expected values about - and + 10e-8 till 10e-3, but on cross section is drawn only 0-isolines. I try with +/- 10e+5 but results were the same.) Only 10e-5 isolines are appeared in a few situations. Well, positions of 0-isolines are mainly adequate and expected, but I don't know why more different isolines are not exist (maybe is a problem with too small units or my bad knowledge).

Situation from June (pictures which names started by 0617* and 0618*) is similar in many points with described one, but generally is milder, especially on Adriatic. A few cyclones exist on initial MSLP fields from 17th June. One of them (under 1007.5hPa) is on north Adriatic and north Italia. Maximum value of potential vorticity on 10km is above Alps and second maximum is near Great Britain. The large termobaric valley exists on west Europe in whole atmosphere. Strong southwest flow is above Adriatic and Croatia. During day and especially evening cold air comes on east. One part of cold air goes around Alps early in the morning. Cyclone on north Adriatic becomes deeper, but +24h forecast has a lot a differences between initial fields from 18th June 00UTC run. So, bigger differences in day-to-day run exists here than in case from September. Cyclone activities are overestimated in forecast from 17th June, first on north Adriatic then on south. Forecast from 18th June is closer to reality, does not give a strong cyclone on south Adriatic like forecast from 5th Sep, but is still overestimated.

Situation from July (pictures which names started by 0720*) is also similar with case from September, even stronger and more overestimated in some parameters. Large termobaric valley exists on initial fields and 10 km PV maximum is bigger then in September. Low lever PV can not be neglected. Story about cyclogenesis is repeated. Amount of precipitation forecast is smaller then in September but relative errors are much bigger. Minimum MSL pressure in centre is a bigger for 2 or 3 hPa. Vertical space cross section of relative humidity is impressive like in 4th Sep.

5. Tests without the latent heat flux at the surface

In order to better understanding what mechanism in the model causes the exaggerated deepening of the Adriatic cyclone; the following test is tried. Latent heat flux at the surface was disabled and the atmosphere was let to re-arrange the moisture. This test has been stopped fictitious development from July's situation last summer. So, Mrs. Siroka prepared a programme from SX4 ~mma109/cycora_ter/acdifus_noslhf, which is the modified source of acdifus.F90. I run all cases but only with cycora-ter. All pictures from this test have in name "noslhf" (no surface latent heat flux). What is happened maybe is the best to see on vertical cross section first, for example on pictures vscs_0904c4rh.ps and vscs_0904c4rh_noslhf.ps. Of course, the initial situations are the same, but differences appear already after +6h. Relative humidity is less then 40% on the right side of picture without surface flux, near sea surface, while is about 50% on the same place of picture with flux. It becomes more obviously on next forecasted periods. For example at +24, relative humidity is under 40% near sea surface on mainly part of Adriatic, on south even under 30%, and on north part (on picture it means right side, after hill) between 50 and 70%. At the same time relative humidity is a bigger than 60%, even bigger than 90% on northern Adriatic part on picture with flux. The similar situations, maybe sometimes more obviously, are happened also in cases from June and July.
Differences in other parameters are visible in pictures with parallel fields, which have "par" in the name. It is important to notice that a main shape of fields did not change, but cyclogenesis without surface flux is not so strong like with flux. Centres of cyclones became higher. It is not true for a first few hours, where cyclone is in Genoa bay or north Italy. In those cases sometimes happens that centre without flux is little deeper (maybe 1 hPa). Centres on Adriatic are higher. For example, differences of MSLP depth in hPa for some forecast (fcst) time are:

0720par_MSLPw.ps			0904par_MSLPw.ps			0905par_MSLPw.ps		
fcst time	with	without flux	fcst time	with	without flux	fcst time	with	without flux
at +21h	997.0	1003.6	+27h	998.2	1001.4	+15h	995.6	1000.3
at +24h	996.0	1005.4	+30h	993.2	1001.1	+18h	995.1	1000.1
at +33h	998.4	1007.5	+33h	<995	~1005	+24h	995.5	1000.7

Different situation occurs only on 17th June, where depths of cyclone on Adriatic are not deeper with flux, but only for the first 27 hours.

0617par_MSLPw.ps

fcst time	with	without flux
at +15h	1005.6	1003.9
at +24h	1005.3	1004.3
at +27h	1006.0	1004.2
but		
at +45h	1004.0	1007.0

Differences are small, but exist.

Parallel looking other fields, geopotential height, temperature or potential vorticity, gives the similar conclusions. Cyclogenesis are weaker when surface heat latent flux is not used!
It is also visible on pictures with forecasted precipitation (for example 0904_rain42h) where cycora-ter fields of precipitation with and without flux can be compared. In many cases forecasted amounts of precipitation are similar like observed, but differences are occurred for 4th Sep on a big part of Croatian coast.
The similar sensitivity experiments with other models were already done and described in a few articles (Dell'Osso and Radinovic, 1984, Kuo et al, 1995, Aebischer, 1996).
Generally conclusion is the same like here: dry simulation shows that developing cyclone is substantially weaker than in moist experiments. Moist processes play an important role, although it is not the primary mechanism since the cyclone forms also exist in the dry experiments. The moist dynamics has a big importance for alpine lee cyclogenesis.

6. Conclusion

Many of conclusions are already mention above. So, I will notice only a few.
Tests with different cycoras shown that all four cycoras have a similar behaviour.
An idea of overestimated cyclogenesis is proved.
Diagnose the mechanism of cyclogenesis is the same like well known from literature. Two cyclones appear on the lee of Alps-one in Genoa bay and north Italy and another on north Adriatic. Sometimes

these cyclones are connected in one, which goes across south Adriatic. Many articles exist about lee cyclogenesis; Adriatic storm is something like that. All of the wide palette of conceptual models can explain some of observed characteristics but none can completely describe the complicate responsible mechanisms.
Tests with cutting surface latent heat flux gave a more realistic cyclogenesis, but in these cases sometimes can be occurred problem with underestimated precipitation.
Better way for getting the same results than cutting the evaporation did not find!

7. Maybe interesting

- chagal's pictures on voodoo and on sx4 have differences in number of plotting dots.
pictures: pic0617_42_c3archiv_voo.ps
pic0617_42_c3archiv_sx4.ps
On sx4 some information with small areas with strong wind can be lost.

- when picture of 10m wind is made, it is very important what is put first in chagal namelist.
pictures: pic0720_24_c3zm.ps
pic0720_24_c3mz.ps (bad!)
If CVARFA(0)='VENT.MERIDIEN' and CVARFA(1)='VENT.ZONAL' wind will be drawn BAD!
For correct wind direction have to be CVARFA(0)='VENT.ZONAL' and
'CVARFA(1)='VENT.MERIDIEN'.

-news in chagal (still not exist on web manual)
NLBCOL=1 for black numbers when field is coloured....

- during work one idea is occurred but not tested. Maybe key of solving this problem lies in sea temperature, which was in June between 19 and 23 Celsius degree, in July 23 till 26, and in September between 20 and 25. More overestimated cases were in July and September.

- question what is born during work: is it better that I have overestimated cyclone or underestimated one? Of course, overestimated! Why? With overestimated cyclone I will not be surprised by bad weather conditions and I can prepared myself. I suppose, of course, that money what I can invest in protection from bad weather is smaller than I can spend without protection...

- I noticed lack of real data. Maybe, one of possible way for solving this problem is "waiting a cyclone", like tornadoes are waited in USA. When forecasts give such kind of "unrealistic" cyclone, team of experts can make measurements... or something similar.

8. Acknowledgements

The four weeks I spent at CHMI was an interesting, enjoyable, but intensive time in which I was accompanied by the friendship and support of many friends. I would like to express my especially gratitude to
Marija Siroka, for patience, learning and introducing in work,
Martina Tudor and Stjepan Ivatek-Sahdan, for every day support and help of any kind,
Dijana Klaric, for preparing me for work,
Branka Ivancan-Picek, her dissertation helped me so much in understanding cyclogenesis on Adriatic,

9. Sources for namelist, scripts and results

~mma168
voodoo: /scripts
        /scripts/presjeci
        /scripts/namelist

sx4: /namelist
     /tmp

/utemp/users/mma168/pictures/satellite -images: infra-red (ir), 10.3-11.3μm and 11.5-12.5 μm
visible (vi), 0.725-1.10μm)

results:
mma168@voodoo:/utemp/users/mma168/pictures -all result

10. References

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