

V A R P A C K

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Part 7: Data assimilation, Variational computations

1. INTRODUCTION

The purpose of the work (10 May – 19 June 2004) has been to study the possibility of implementation of the CNRM/ GMAP/ 3DVAR/Aladin scheme for diagnostic and nowcasting purposes. Such a software (Varpack/Aladin) would have been an analogue of the CNRM/GMAP/Diagpack/Aladin, based on the CANARI OI scheme.

The work is based on the results, obtained in Auger (2004) , where the 3DVAR/Aladin scheme has been implemented for diagnostic studies. In that presentation the comparison between the Diagpack/Aladin CANARI OI scheme and the 3DVAR/Aladin scheme has been done by comparison of the meteorological fields (T, RH, wind on the last model levels). It has been shown that both schemes give similar results and that there is a possibility to improve the application of the 3DVar/Aladin as a diagnostic tool.

The aim of this work is to continue the comparison between Diagpack/Aladin and Varpack/Aladin by studying the distribution of some diagnostic parameters used for nowcasting purposes .The validation of the results , obtained here, has been done on the basis of comparison between the CAPE and MOCON parameters for two cases (2001100910-2001100915 and 2001081800-2001081815) with a run every hour over the ALADIN/FranX01 domain (304 x 300, mesh distance 9.5 km).

The report consists in five sections and 2 appendices :

Section I - Short description of Diagpack

Section II - Short description of Varpack

Section III - Case study 2001100910-2001100915

Section IV - Case study 2003081810-2001081815

Section V - Conclusions and plans for the future work

Appendix 1 - Case study 2001100910-2001100915.List of the figures. Fig.1 – Fig. 4

Appendix 2 - Case study 2001081810-2001081815.List of the figures. Fig.5 – Fig.12

2. Short description of Diagpack software and post-processing of the analysis data to derive CAPE and MOCON

2.1. Technical aspects

The scripts and namelists for performing Diagpack and fullpos are on

tora: ~mrpa657/script_2004/e701_hor

~mrpa657/script_2004/fp_cape_mocon_diag

The experiments with Diagpack have been done with
/u/marp/tampon/bin/ald/al25/al25t1_odb-op4main.01.L0209.x.exe

The post-processing (fullpos) of the meteorological fields has been done with the operational executable

/u/ch/mxpt/mxpt001/aladin/horaire/oper/exec/ALADIN_POS

2.2. Basics in application of Diagpack

With Diagpack / Aladin we have performed an operational hourly CANARI OI analysis of the geopotential, T, RH, T2, RH2 (temperature and relative humidity at the model levels and at 2m height) and V10 (wind at 10 m height) on the basis of:

- the post-processed by ee927 guess field started from an analysis at 06 UTC ;
- surface data, obtained from manual and automatic land and ship SYNOP stations.

When running the Diagpack/Aladin OI analysis, some constraints have been applied:

- in the analysis are utilized only stations below 1500 m height;
- the stations, for which the difference between the model orography and the altitude at the observation point is bigger than 800 m, are not assimilated.

The observation operators allow performing an analysis of geopotential, temperature and humidity at the model levels up to approx. 1500 m on the basis only on SYNOP observations, while T2, RH2, V10 analysis is done directly.

Those fields together with the diagnostic parameters CAPE and MOCON, derived after the post-processing (fullpos), are used afterwards for convection nowcasting purposes. In our study CAPE has been computed from mto standard 2m height out of fluxes (NFPCAPE = 4 in NAMFPC). MOCON is calculated as $\text{div}(q2 \times V10)$.

3. Short description of Varpack and post-processing of the analysis data

3.1. Technical aspects

The scripts and the namelists for performing Varpack and fullpos are on

toro: ~mrpa657/script_2004/file_date

Obs2Lamodb.ksh

AnalysAld_diag.ksh

~mrpa657/script_2004/namelist/lamflag_odb.nml

scr_3d_diag.nml

assim_diag.nml

~mrpa657/script_2004/fp_lam_var

fp_lam_var_3
fp_prepmocon
melange.ksh
fp_moconvar

3.2. Basic experiments with Varpack

Using SYNOP data , after screening , with 3DVar/Aladin scheme we have performed analysis of temperature, wind and specific humidity on the model levels on the base of the relevant observation operators. To study the possibility of using 3DVAR/Aladin as a diagnostic tool, 3 different kinds of experiments have been done:

3.2.1. bas3D experiment

In that experiment the basic 3DVar/Aladin scheme has been used , but the rate of the standard deviation reduction from the NMC co-variances on all model levels has been increased (REDNMC = 7 in NAMJG) to achieve better fit to the observations. For running that experiment the executable al26t1_odb-main.01.L0209.x.exe has been used.

3.2.2. mod3D experiment

In that experiment the 3DVar/Aladin scheme has been used but after some modifications. Keeping REDNMC = 7 for all model levels , at each step of the minimization the surface temperature TS has been artificially updated according to the temperature at the last model level (T41 at approx. 17 m) to enable more physical fit to the 2m temperature through the observation operator (Auger, 2004). For running that experiment the executable /cnrm2_mrpa/mrpa/mrpa645/alexec/ALADIN has been used

3.2.3. sod3D experiment

In that experiment the modifications of TS have been done as in mod3D, but the model error co-variances have been given bigger values in the PBL (planetary boundary layer) and keeping 1 on the upper levels (REDNMC = 7, 7, 5, 3, 1, ...1). For running that experiment the executable /u/gp/mrpa/mrpa645/pack/diag8/bin/ALADIN has been used.

3.3. Post-processing of the 3DVar/Aladin analysis data to derive CAPE and MOCON

The post-processing (fullpos) of the meteorological fields has been done with

- /u/dp/marp/marp001/tampon/bin/ald/al26/al26t1_main.01.L0209.x.exe for computing CAPE
- /u/gp/mrpa/mrpa645/pack/fullpos/bin/ALADIN for computing MOCON

In computation of CAPE, the experiments have been made with calculation from the last model level (script fp_lam_var with NFPCAPE = 1 in NAMFPC) and from mto standard height (2m) as recomputed values (script fp_lam_var_3 with NFPCAPE=3)

As far as in the 3DVar/Aladin analysis there are no 2m fields, some procedures have been applied before computation of MOCON :

- the script fp_prepmocon transforms the temperature, specific humidity and wind on the last model level to grid-point fields;

- by melange.ksh, those fields are written as CLS fields;
- by fp_moconvar, MOCON is computed as $\text{div}(q_{41}, V_{41})$ on the last model level

4. Case study 2001100910-2001100915

The results of the experiments with case 2001100910-2001100915 have been presented in Appendix 1, Fig.1 – Fig.4

As it could be seen from the radar images for the period from 10 to 20 UTC (Fig.1), there is an area with big echoes in the middle of the domain at midday and area with heavy rain in the evening. With Diagpack and Varpack (both bas3D and mod3d experiments) we have computed CAPE and MOCON for 2001100910-2001100915. MOCON values are multiplied by 10^{**6} . Only positive values of MOCON are drawn.

On Fig.2 the distribution of CAPE and MOCON as a result of Diagpack analysis is presented. It is seen that there is some coincidence between the areas with big values of CAPE and MOCON in the central part of the domain.

The comparison between the results , obtained by Diagpack and Varpack have been presented on Fig.3 (for CAPE) and Fig.4 (for MOCON). For Varpack CAPE is calculated from the last model level (NFPCAPE =1) .

It could be seen from Fig.3 that:

- for the all period the CAPE values above 1500 J/kg , calculated by Diagpack, are situated in an area along and over the Mediteranian sea and in the SW and east part of the domain;
- the high CAPE values, calculated by Varpack/bas3D experiment, are mainly over the mountaineous areas south-east of Massif Central ; the area along the sea side is less pronounced;
- the high CAPE values, calculated by Varpack/mod3D experiment, better coincide with the area of big signal in the radar pictures.

For that case we made an experiment with Diagpack, where the analysis was performed only for T2, RH2, V10 . CAPE was computed afterwards. It has turned out that there are no significant changes in the distribution of CAPE (figures are not presented) which means that only with SYNOP data the essential in computation of CAPE are the T2, RH2, V10 .

From Fig.4 is seen that :

- MOCON, computed from Varpack is smoother in comparison with that, computed from Diagpack;
- MOCON, calculated from Varpack/mod3D experiment corresponds to the area with high values of CAPE and to the radar echoes in the middle of the domain.

The differences between MOCON/Diagpack and MOCON/Varpack could be explained also with the fact that the latest parameter is calculated from humidity and wind on the last model level.

The conclusion that could be made from that case is that :

- MOCON fields, obtained by Diagpack and Varpack are similar , non-the-less those, obtained by Varpack are smoother;
- CAPE fields, obtained by Varpack (both bas3D and mod3D experiments) are different from CAPE, obtained by Diagpack;
- both for CAPE and MOCON , the Varpack/mod3D experiment gives results which correspond better to the radar pictures for the same time.

5. Case study 2003081810-2001081815

The results of the experiments with case 2001081810-2001081815 have been presented in Appendix 2, Fig.5 – Fig.12.

As it could be seen from the radar images for the period from 10 to 20 UTC (Fig.5), up to 14 UTC there are small spots with bigger radar echoes in the SE part of the domain. At 15, 16, 17 UTC there is an area with precipitations in the SW part along the coast. From 17 UTC there is a big area with significant radar echoes in the NW part of the region, oriented meridionally.

With Diagpack and Varpack (bas3D, mod3D and sod3D experiments) we have computed CAPE and MOCON for 2001081810-2001081815 (Fig.6 – Fig.10). For Varpack CAPE is calculated from the last model level (NFPCAPE =1) .

MOCON values are multiplied by 10^{*6} . As it has been mentioned above, for Varpack MOCON is computed from the wind and humidity on the last model.

On Fig.6 , left panel, the time evolution of CAPE, computed by Diagpack, is presented. It could be seen that there are:

- big CAPE values over the mountains;
- two almost persistent spots with big CAPE values (one in the upper central part of the domain and the second one in the lower central part along the coast);
- from 13 UTC there is an area with high values in SE, along the coast.

On Fig.6 , middle panel, the time evolution of CAPE, computed by Varpack/bas3D experiment is presented. It is seen that:

- the distribution of CAPE is smoother than the one , computed with Diagpack;
- there is an area of higher values in the middle of the upper part of the domain, existing on all the pictures and becoming an organized structure;
- there is no signal in the SE corner along the coast.

On Fig.6, rightmost panel, the time evolution of CAPE, computed by Varpack/mod3D experiment is presented. It is seen that the distribution of CAPE is similar to bas3D experiment with values, bigger than the bas3D ones. The meridionally oriented area with high values of CAPE is over the mountains and has no correspondence with the radar echo pictures.

On Fig.7 the time evolution of MOCON is presented (left panel – computed by Diagpack, middle panel – computed by Varpack/bas3D experiment and rightmost panel – computed by Varpack/mod3D experiment). It is seen that:

- the distribution of MOCON, computed by Varpack is smoother;
- the distribution of MOCON, computed by Varpack/bas3D is similar to the one, computed by Varpack/mod3D;
- there are areas of coincidence of the spots with big values of CAPE and MOCON, computed with Varpack.

Fig.8 is same as Fig.7, but only the higher values of MOCON ([1.2, 8]) are presented - that is done for better visualization of the areas with significant moisture convergence. The conclusions made from Fig.7 are valid for Fig.8 as well.

To estimate the impact of the vertical distribution of model error co-variances, a comparison has been made between CAPE and MOCON, obtained by Diagpack, Varpack/mod3D and Varpack/sod3D experiments.

As it could be seen from Fig.9 (left panel – CAPE, computed by Diagpack, middle panel – CAPE, computed by Varpack/mod3D, rightmost panel – CAPE, computed by Varpack/sod3D experiment) :

- the patterns, obtained by Varpack/mod3 and Varpack/sod3 experiments are similar, they both differ from CAPE, computed by Diagpack;
- the Varpack/sod3 experiment leads to slightly increase of CAPE values.

On Fig.10 the time evolution of MOCON, computed by Diagpack, Varpack/mod3D and Varpack/sod3d is presented. The conclusions, that could be made are:

- the distribution of MOCON, computed by Varpack, is smoother;
- there is a shift between the areas with big values of CAPE and those with big values of MOCON

Next step in studying a possible source of the difference between the distribution of CAPE, calculated by Diagpack and Varpack, is to compute it from 2m height for both packages. That has been done by post-processing the Varpack/mod3 and Varpack/sod3 analysis fields with NFPCAPE = 3. The results are presented on Fig.11.

It could be seen that:

- CAPE, obtained by Diagpack is quite different from CAPE, obtained by Varpack even when calculated from 2m fields;
- Varpack leads to increasing of the values of CAPE;
- CAPE field, obtained by Varpack, seems more relevant, since the spurious high values over mountains seem somehow smoothed.

The last experiment performed with Diagpack and Varpack was an attempt to evaluate the impact of the orography on the CAPE values. The simplest way of doing that was to eliminate the assumptions for stations altitude and model orography, mentioned in Section I. The results obtained are presented on Fig.12 (for Diagpack -on the left panel, for Diagpack with all stations in the middle

panel, for Varpack/sod3D experiment, computed from 2m height in the rightmost panel). It is seen that including all the stations in Diagpack leads to modification in the distribution of CAPE, but it is still too different from CAPE, computed by Varpack.

6. Conclusions and intents for the future work

The study presented in that report is a first attempt to compare some diagnostic parameters, derived by the well known Diagpack and the under-building Varpack.

The main conclusions, that could be done on the basis of both case studies are:

- MOCON fields, derived from Varpack, are very similar to those, derived from Varpack, but smoother. That could be explained partly by the fact, that the 3DVAR analysis is smoother, and partly because the computation of MOCON by Varpack is done from the last model level, but not from CLS;
- CAPE fields, derived from Diagpack and Varpack are quite different. For the first case (cas2001100910-2001100915) Varpack might give better diagnostic although CAPE seems to be too strong on the SE of Massif Central. Perhaps for that case it would be interesting to see the NFPCAPE=3 diagnostics.
- From the second case (cas2001081810-2001081815) it is seen that NFPCAPE = 3 diagnostic is more relevant :
 - Varpack and Diagpack are closer:
 - some CAPE maxima have the same localization,
 - but there are still differences over the mountaineous areas..

The further evaluation of CAPE and MOCON, derived from Diagpack and Varpack analysis requires :

- intensive study of more synoptic situations of different types and comparison with the relevant radar images;
- to study and put more attention on the comparison between the Diagpack and Varpack humidity analysis;
- to study CIN, derived from Diagpack and Varpack and to see how CIN could prevent the occurrence of convection in areas with high values of CAPE;
- to study the possibility of using new observations in Diagpack and Varpack analysis

7. Acknowledgements

The authors are mostly grateful to F. Taillefer and F. Bouyssel for their help in performing the experiments and in the discussion of the obtained results.

8. References

Auger L. (2004) - Analyse diagnostique de type variationnel (Diagnostic analysis with variational method). Internal Workshop (07.05.2004), MeteoFrance, Toulouse, France

9. Appendix 1

9.1. Case study 2001100910 - 2001100915

9.1.1. List of the figures

Fig.1 Radar images for 20011009, 10 to 20 UTC

Fig.2 Distribution of CAPE and MOCON , obtained by Diagpack for 20011009 , 10 to 15 UTC.

MOCON values are multiplied by 10^{**6}

Fig.3 Comparison between the distribution of CAPE, obtained by Diagpack (`_diag_cape`), Varpack/bas3D experiment (`_bas3D_cape`) and Varpack/mod3D experiment (`_mod3d_cape`) for 20011009, 10 to 15 UTC.

CAPE, obtained by Varpack is computed from the last model level (NFPCAPE=1)

Fig.4 Comparison between the distribution of MOCON, obtained by Diagpack (`_diag_mocon`), Varpack/bas3D experiment (`_bas3D_mocon`) and Varpack/mod3D experiment (`_mod3D_mocon`) for 20011009, 10 to 15 UTC.

MOCON, obtained by Varpack is computed from the humidity and wind on the last model level. MOCON values are multiplied by 10^{**6}

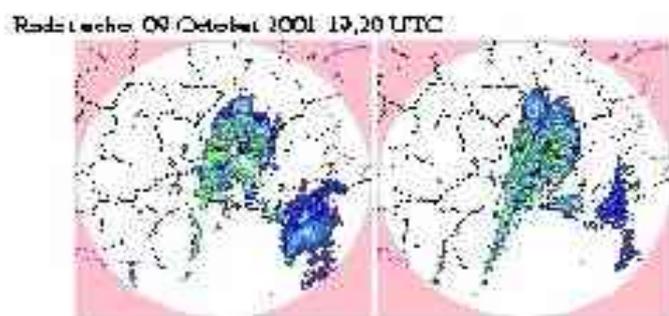
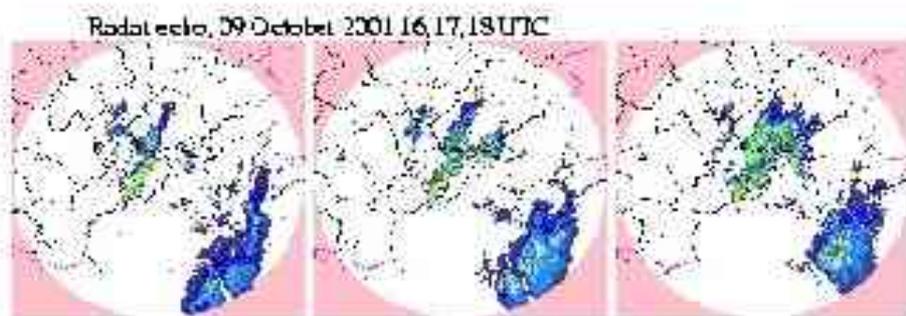
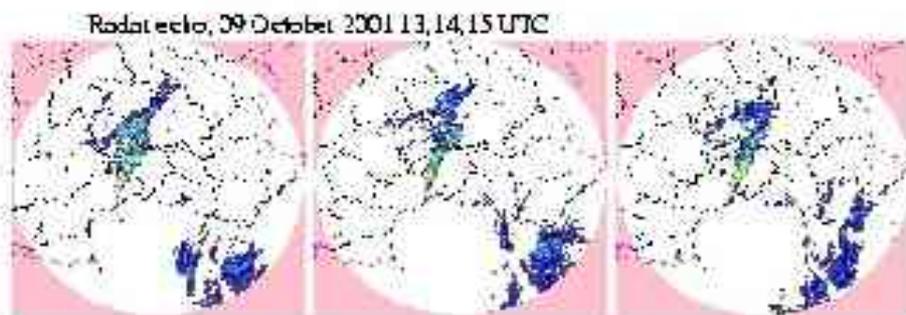
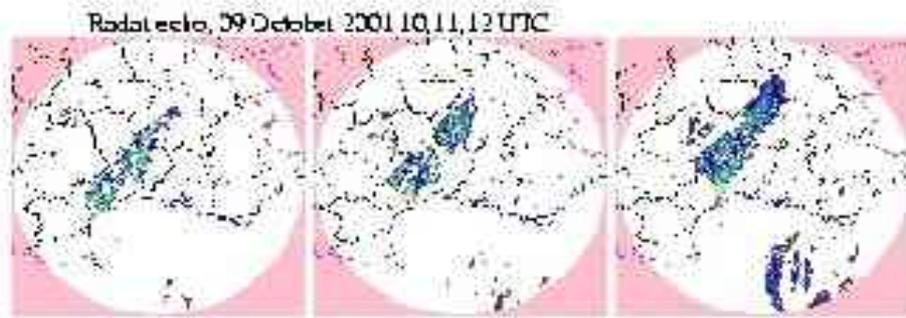


Fig 1

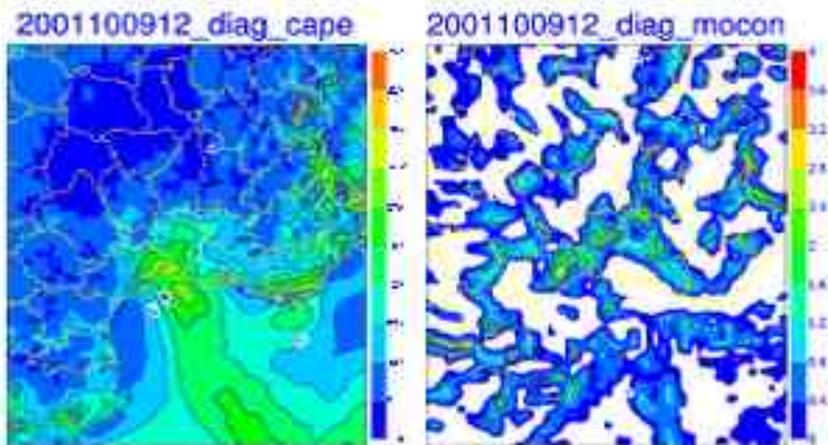
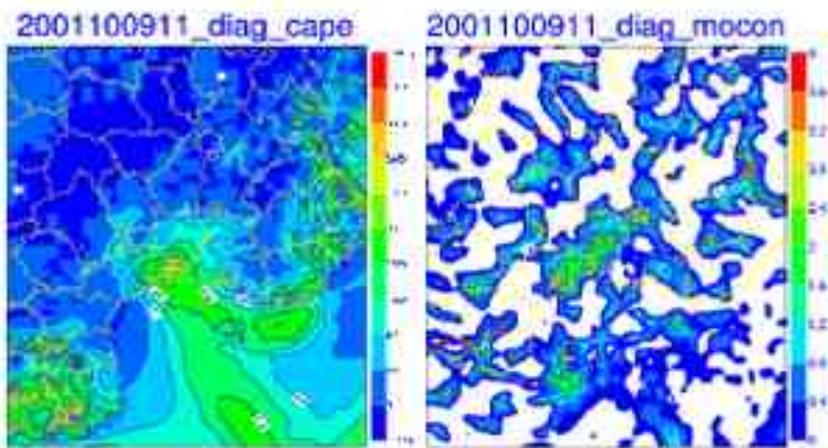
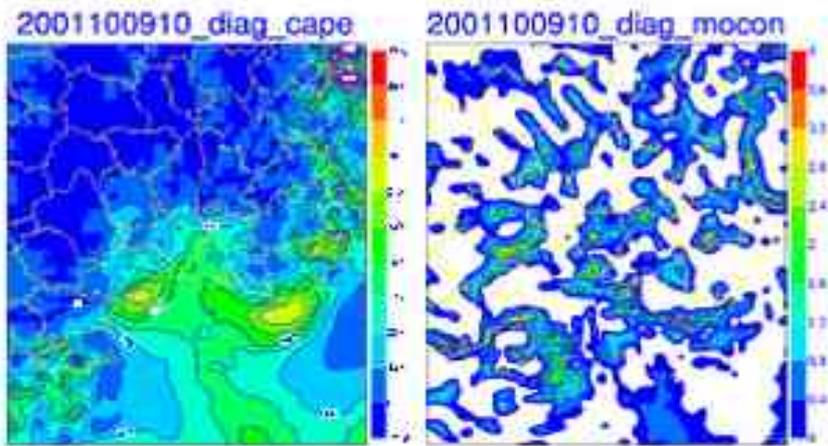


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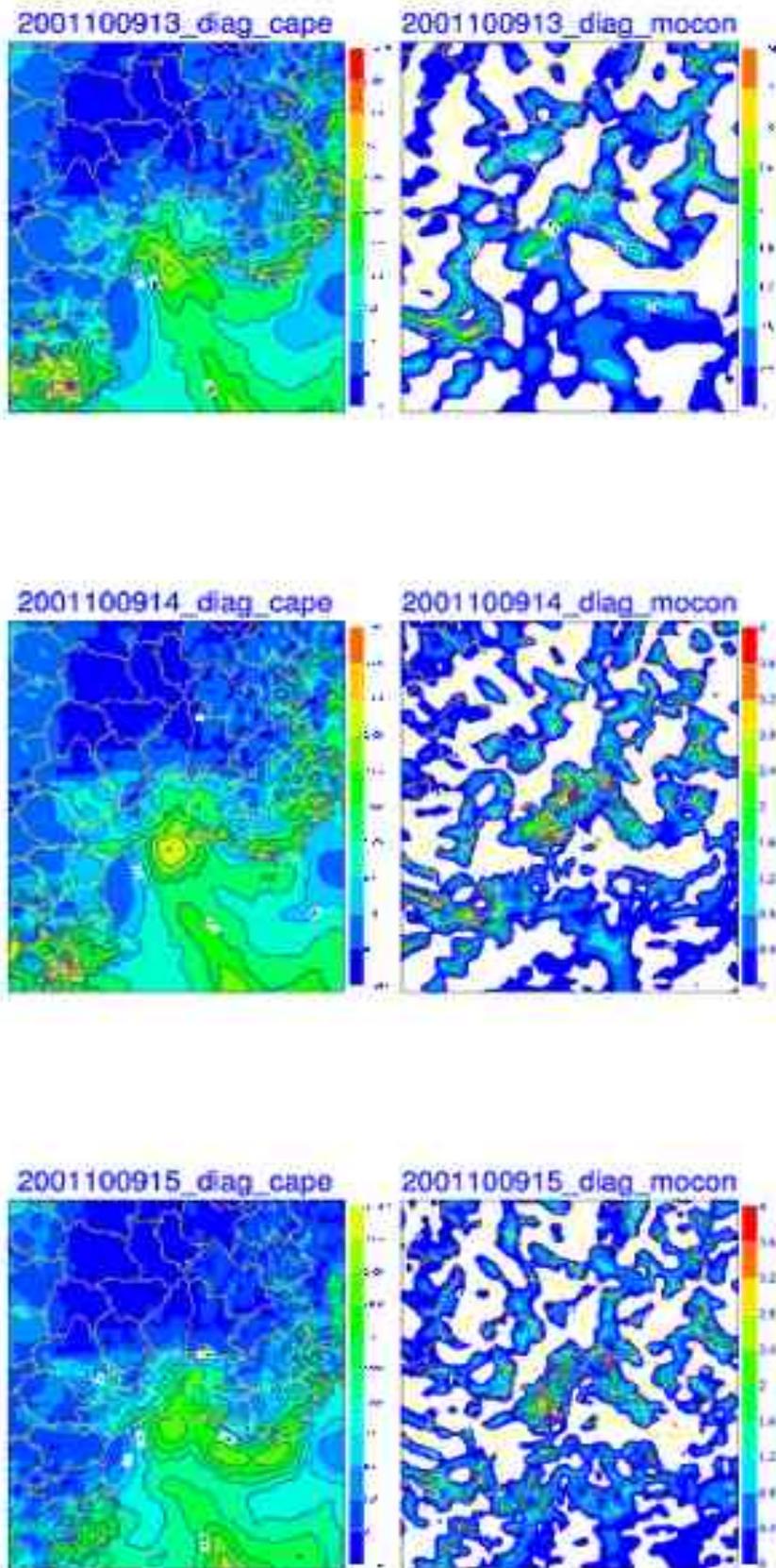


Fig 2 part 2/2

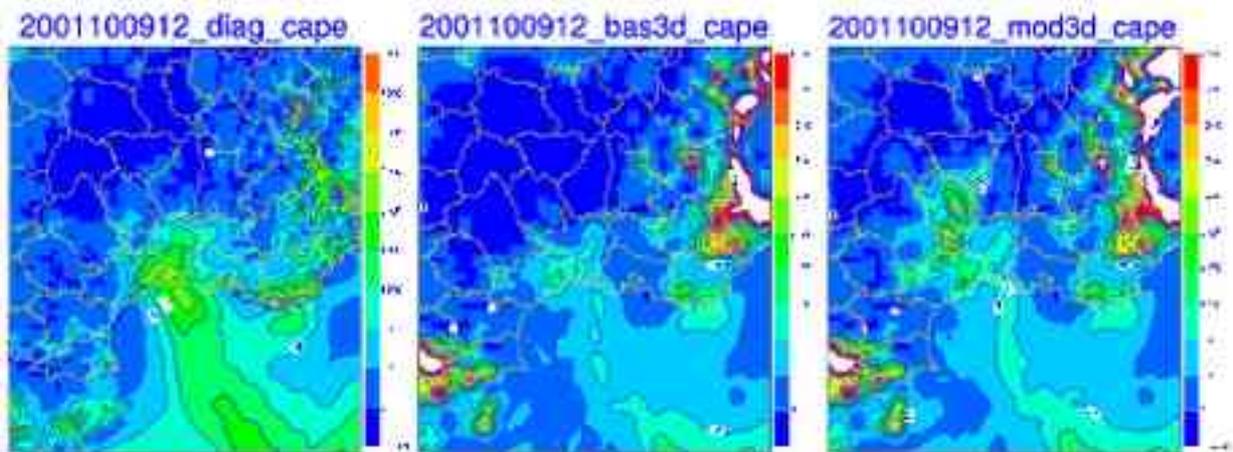
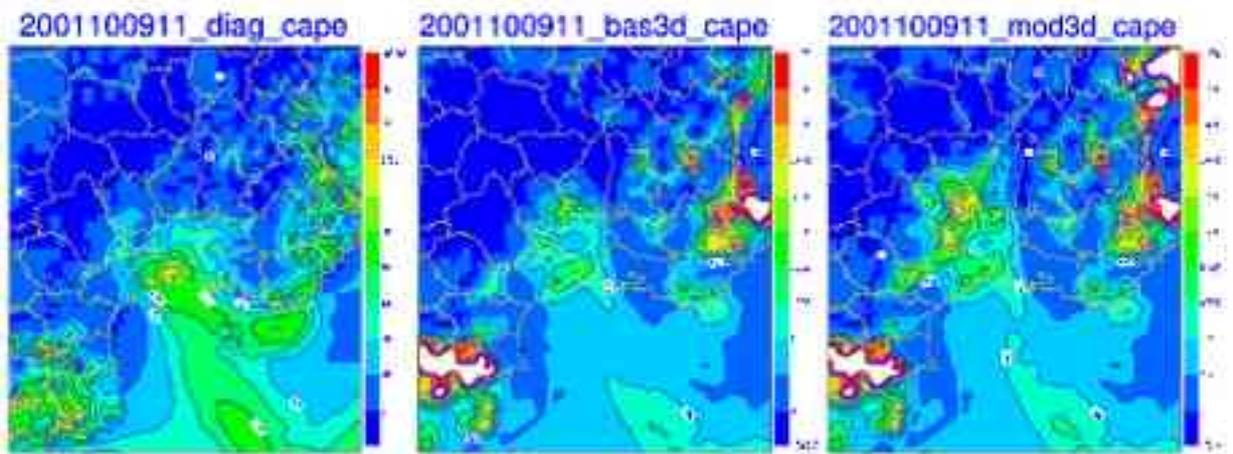
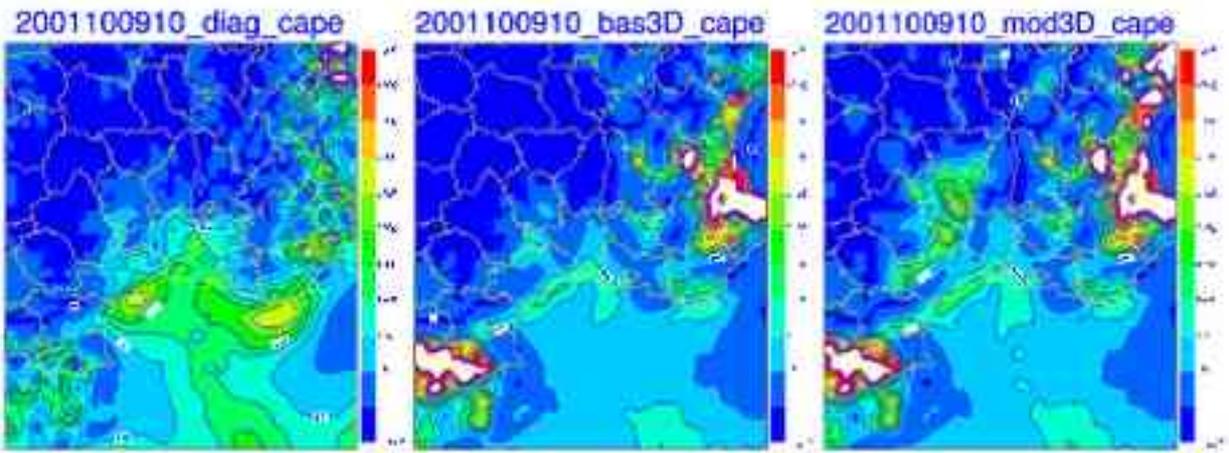


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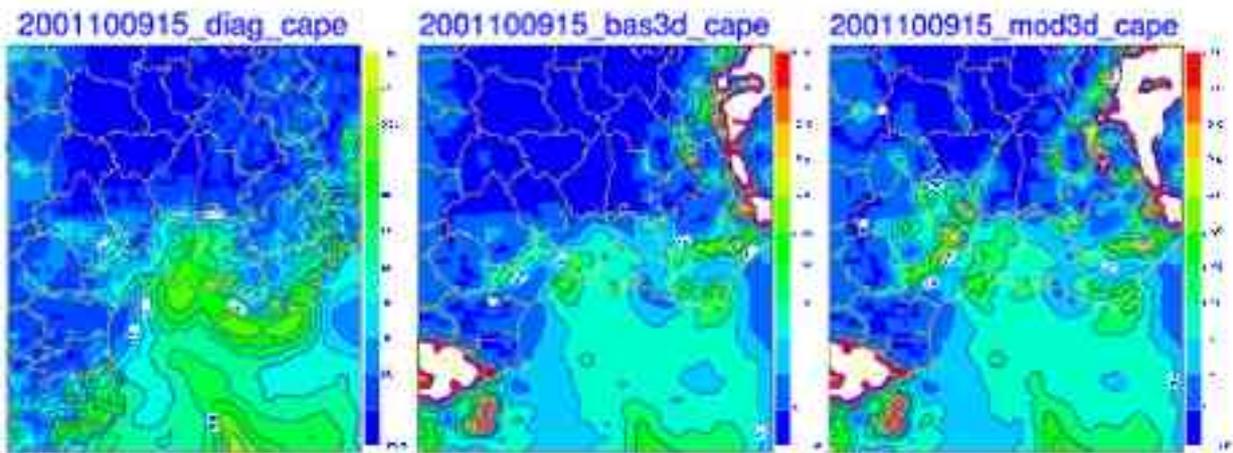
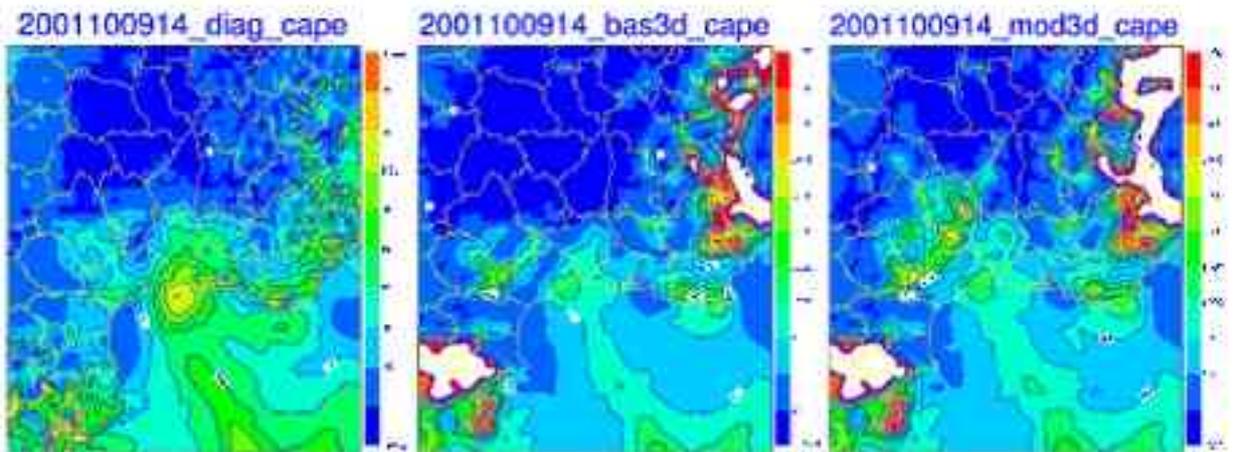
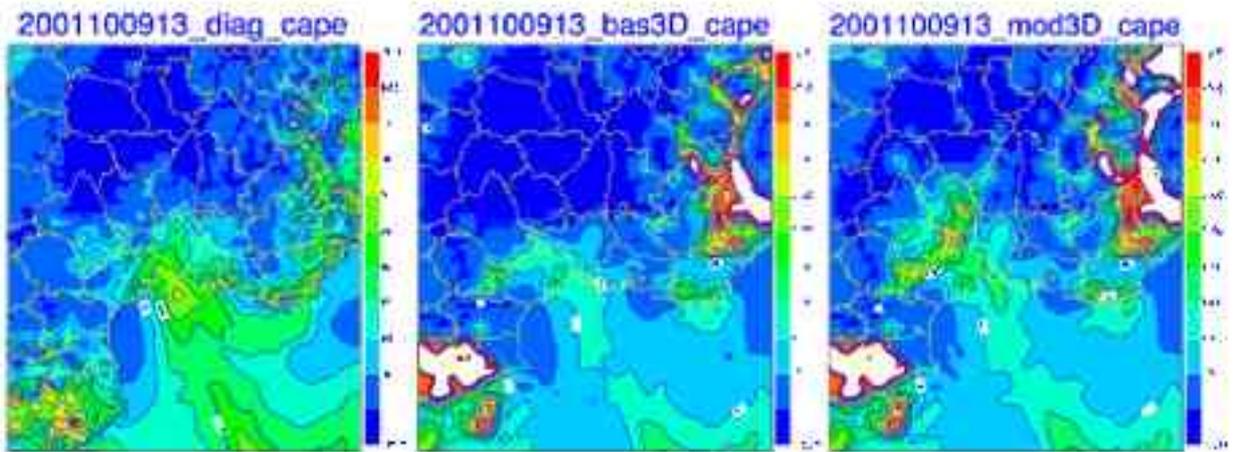


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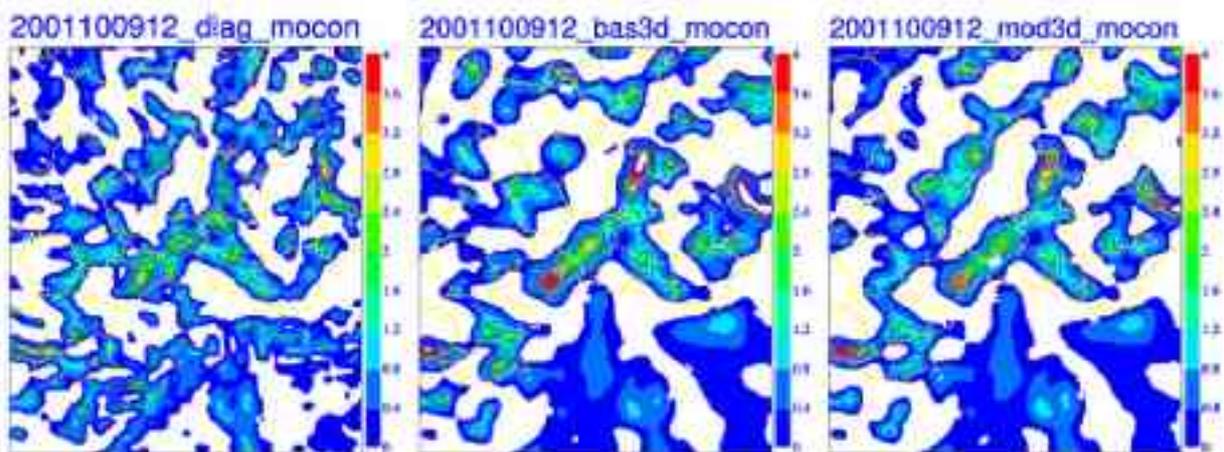
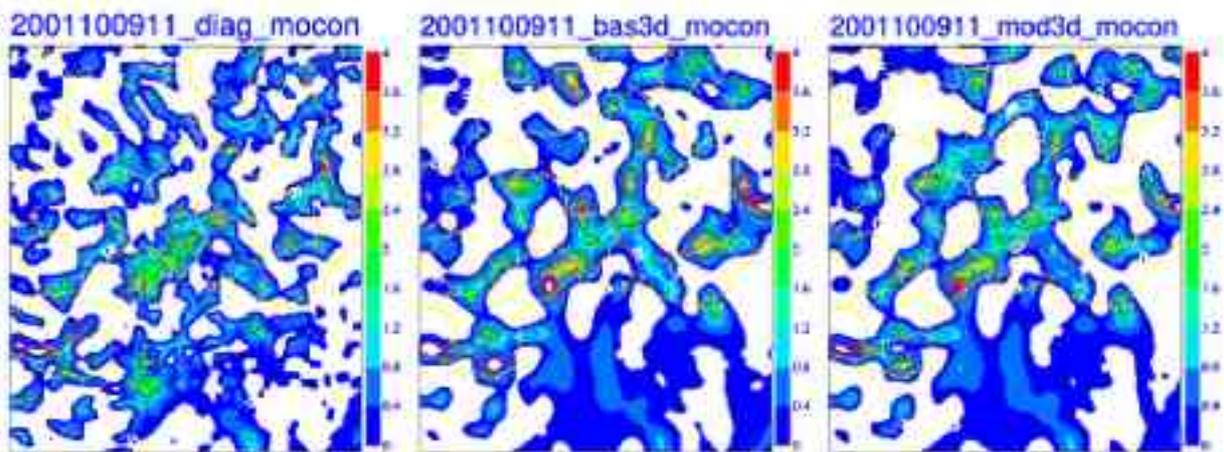
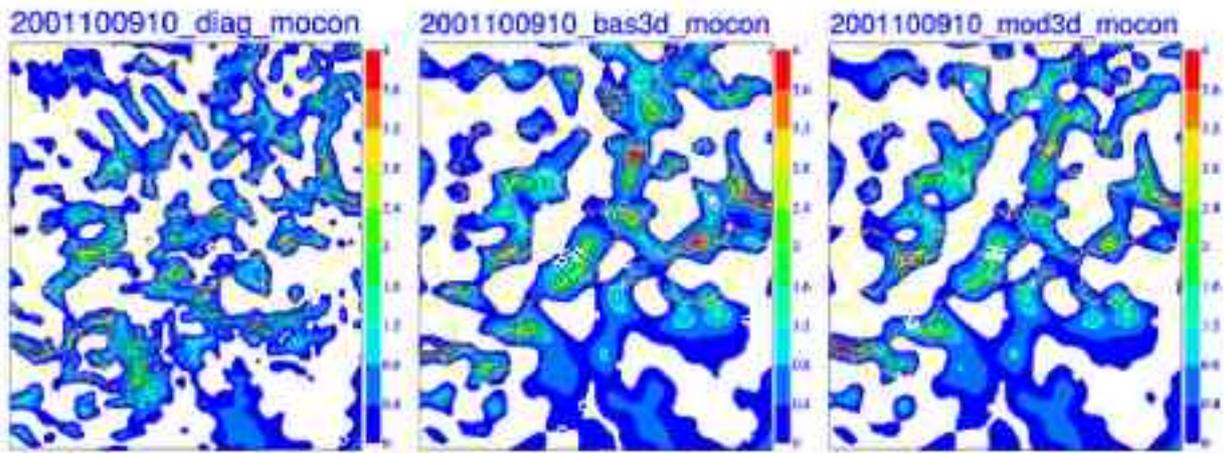


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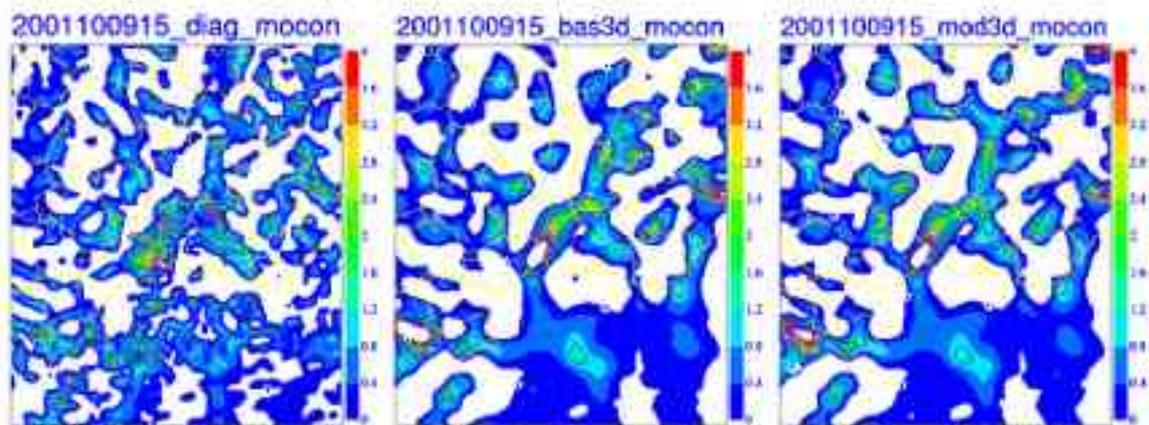
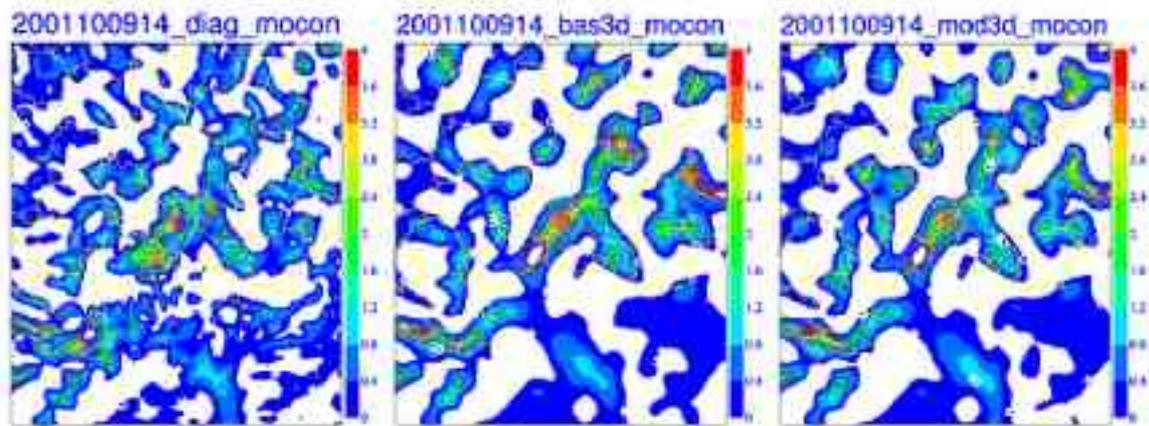
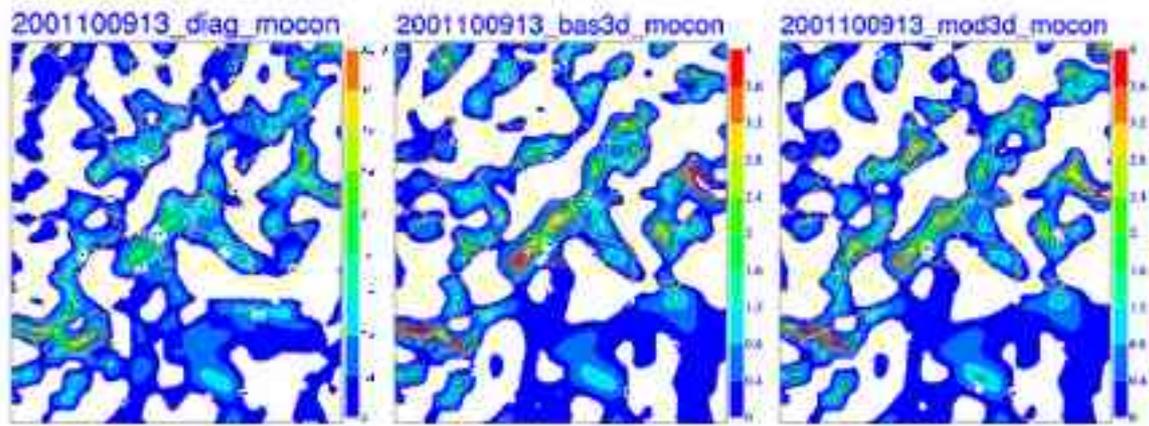


Fig 4 part 2/2

10. Appendix 2

10.1. Case study 2001081810 - 2001081815

10.1.1. List of the figures

Fig.5 Radar images for 20010818, 10 to 20 UTC

Fig.6 Comparison between the distribution of CAPE, obtained by Diagpack (`_diag_cape`), Varpack/bas3D experiment (`_bas3D_cape`) and Varpack/mod3D experiment (`_mod3d_cape`) for 20010818, 10 to 15 UTC.

CAPE, obtained by Varpack is computed from the last model level (NFPCAPE=1)

Fig.7 Comparison between the distribution of MOCON, obtained by Diagpack (`_diag_mocon`), Varpack/bas3D experiment (`_bas3D_mocon`) and Varpack/mod3D experiment (`_mod3D_mocon`) for 20010818, 10 to 15 UTC.

MOCON, obtained by Varpack is computed from the humidity and wind on the last model level. MOCON values are multiplied by 10^{**6}

Fig.8 Same as Fig.7, but the higher values of MOCON ([1.2,8]) are presented (`_diag_mocon_nw`, `_bas3D_mocon_nw`, `_mod3D_mocon_nw`)

Fig.9 Comparison between the distribution of CAPE, obtained by Diagpack (`_diag_cape`), Varpack/mod3D experiment (`_mod3D_cape`) and Varpack/sod3D experiment (`_sod3d_cape`) for 20010818, 10 to 15 UTC.

CAPE, obtained by Varpack is computed from the last model level (NFPCAPE=1)

Fig.10 Comparison between the distribution of MOCON, obtained by Diagpack (`_diag_mocon_nw`), Varpack/mod3D experiment (`_bas3D_mocon_nw`) and Varpack/sod3D experiment (`_sod3D_mocon`) for 20010818, 10 to 15 UTC.

MOCON, obtained by Varpack is computed from the humidity and wind on the last model level. MOCON values are multiplied by 10^{**6}

Fig.11 Same as Fig.9 , but CAPE, obtained by Varpack is computed from 2M height as recomputed values (NFPCAPE=3)

Fig.12 Comparison between CAPE, obtained by Diagpack (`_diag_cape`), Diagpack without any limits to the observations altitude (OROLIM and ORODIF excluded) (`_diag_oro_cape`) and Varpack/sod3d experiment with NFPCAPE=3 (`_3sod3D_cape`)

Radar echo, 8 August 2001 10,11,12 UTC



Radar echo, 8 August 2001 13,14,15 UTC



Radar echo, 8 August 2001 16,17,18 UTC



Radar echo, 18 August 2001 19,20 UTC

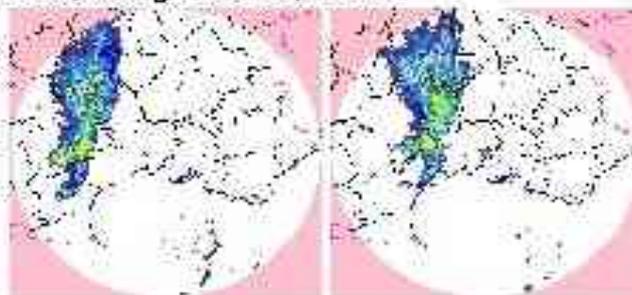


Fig 5

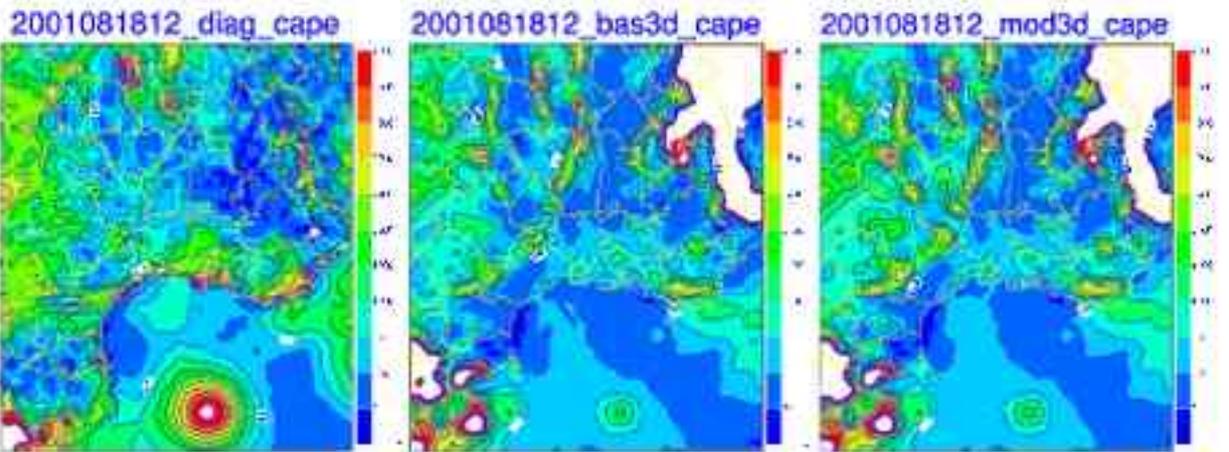
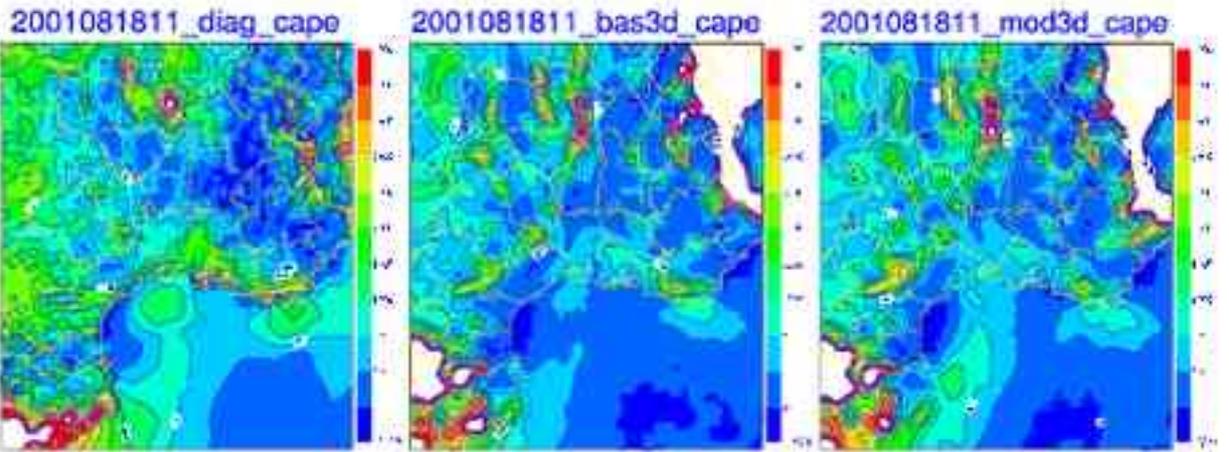
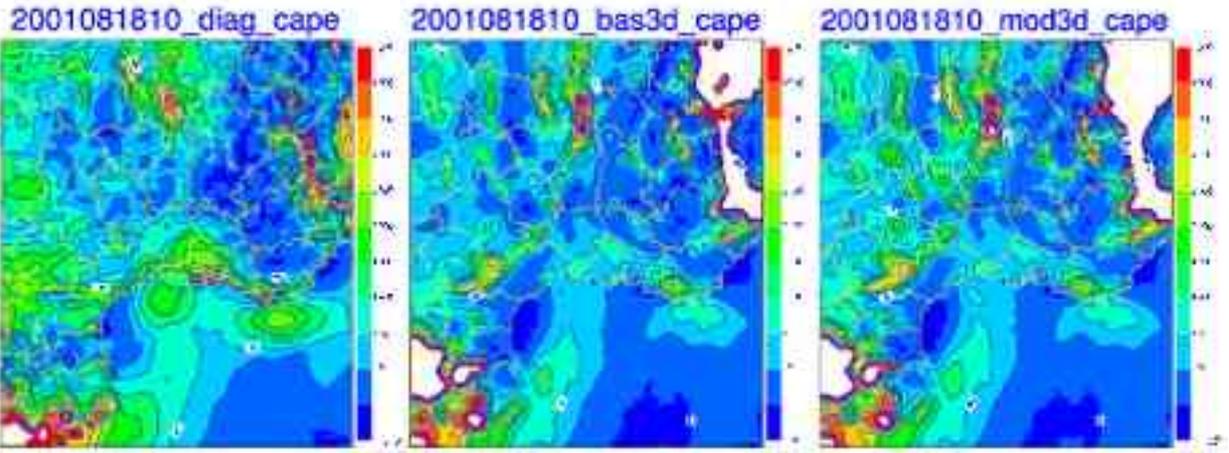


Fig 6 part 1/2

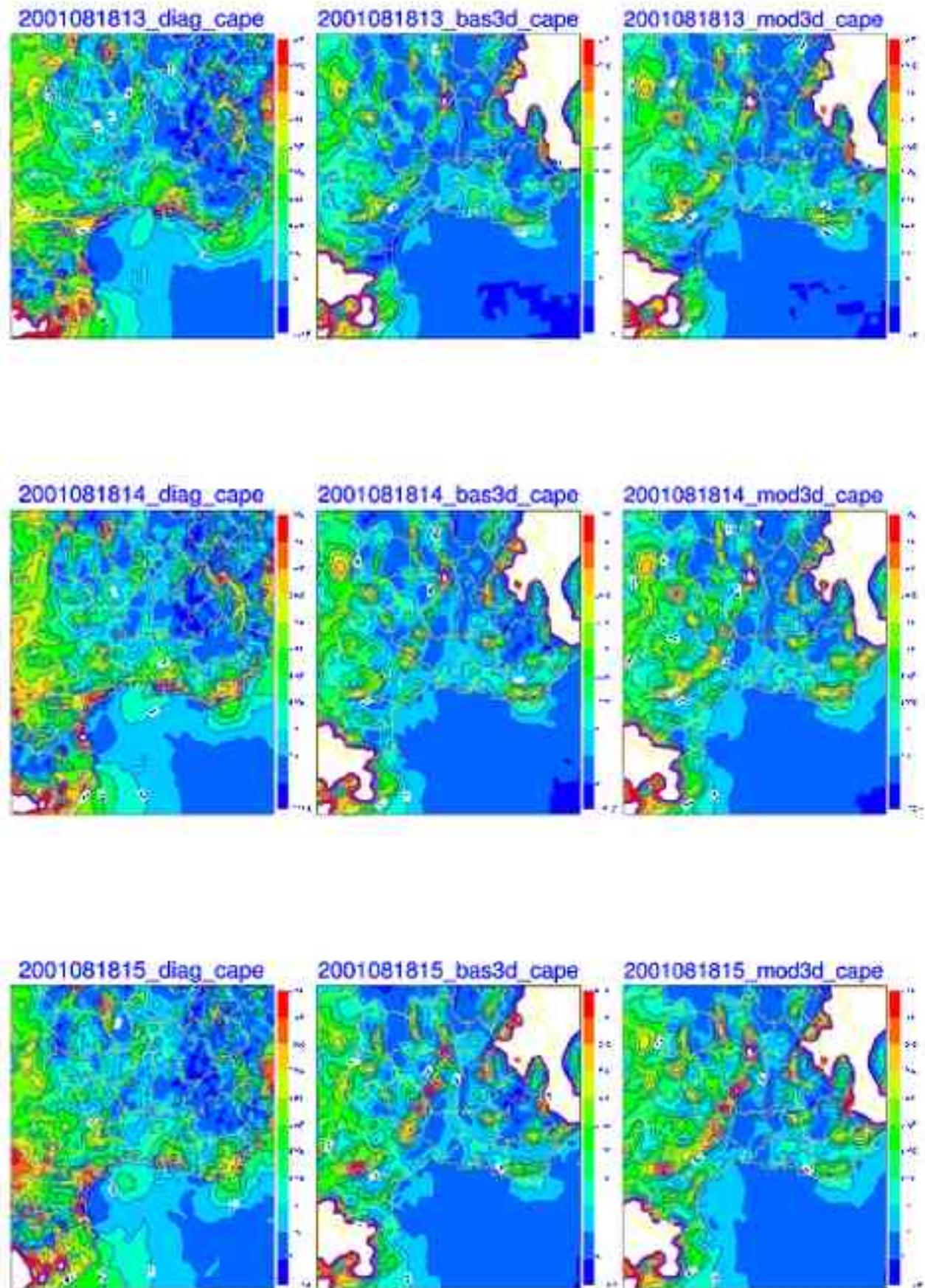


Fig 6 part 2/2

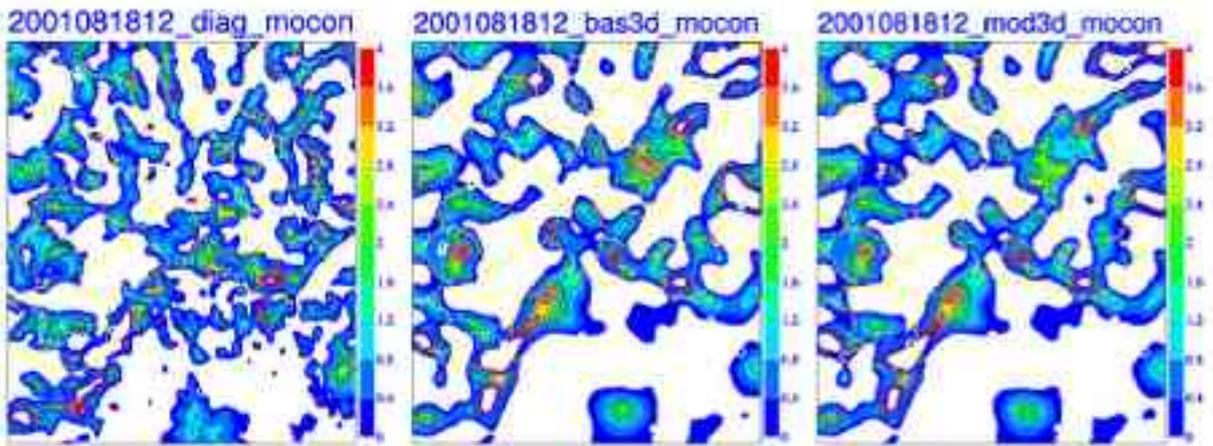
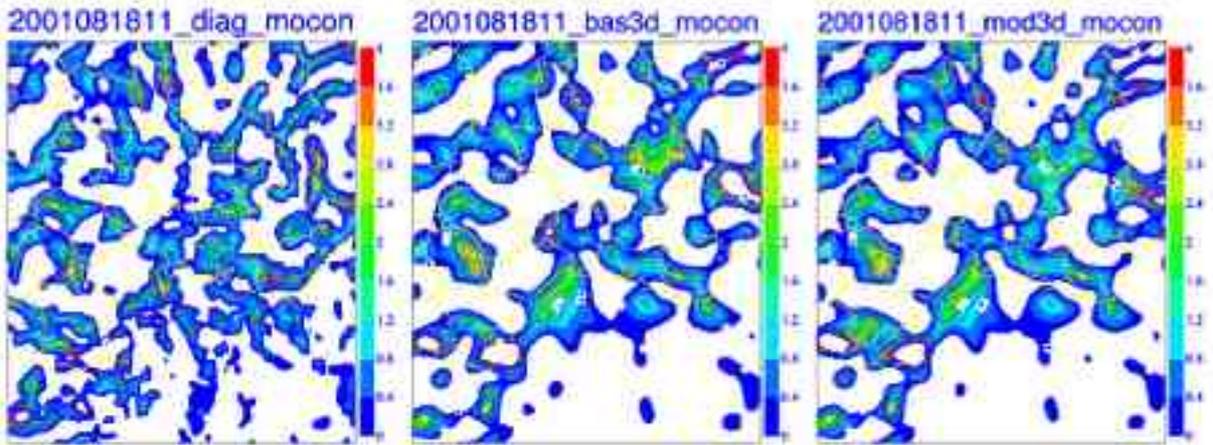
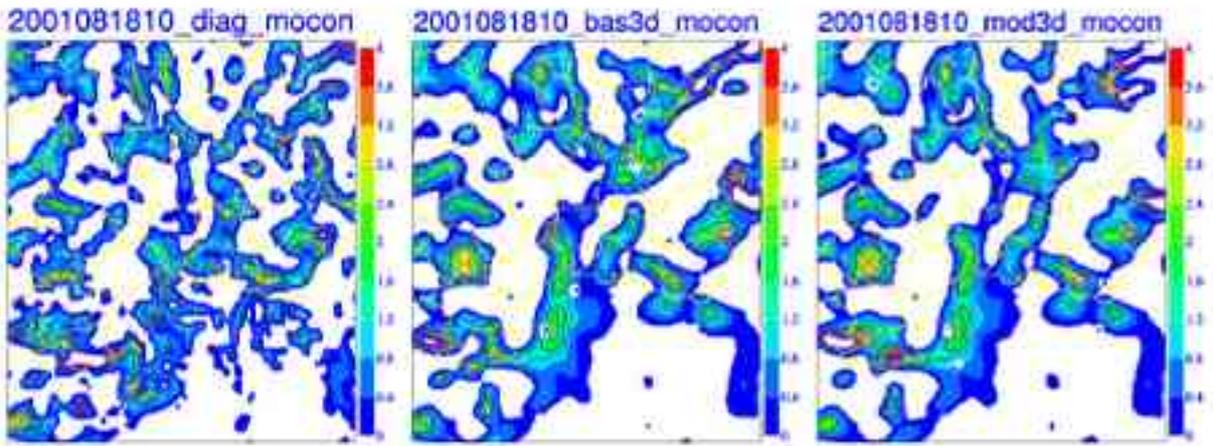


Fig 7 part 1/2

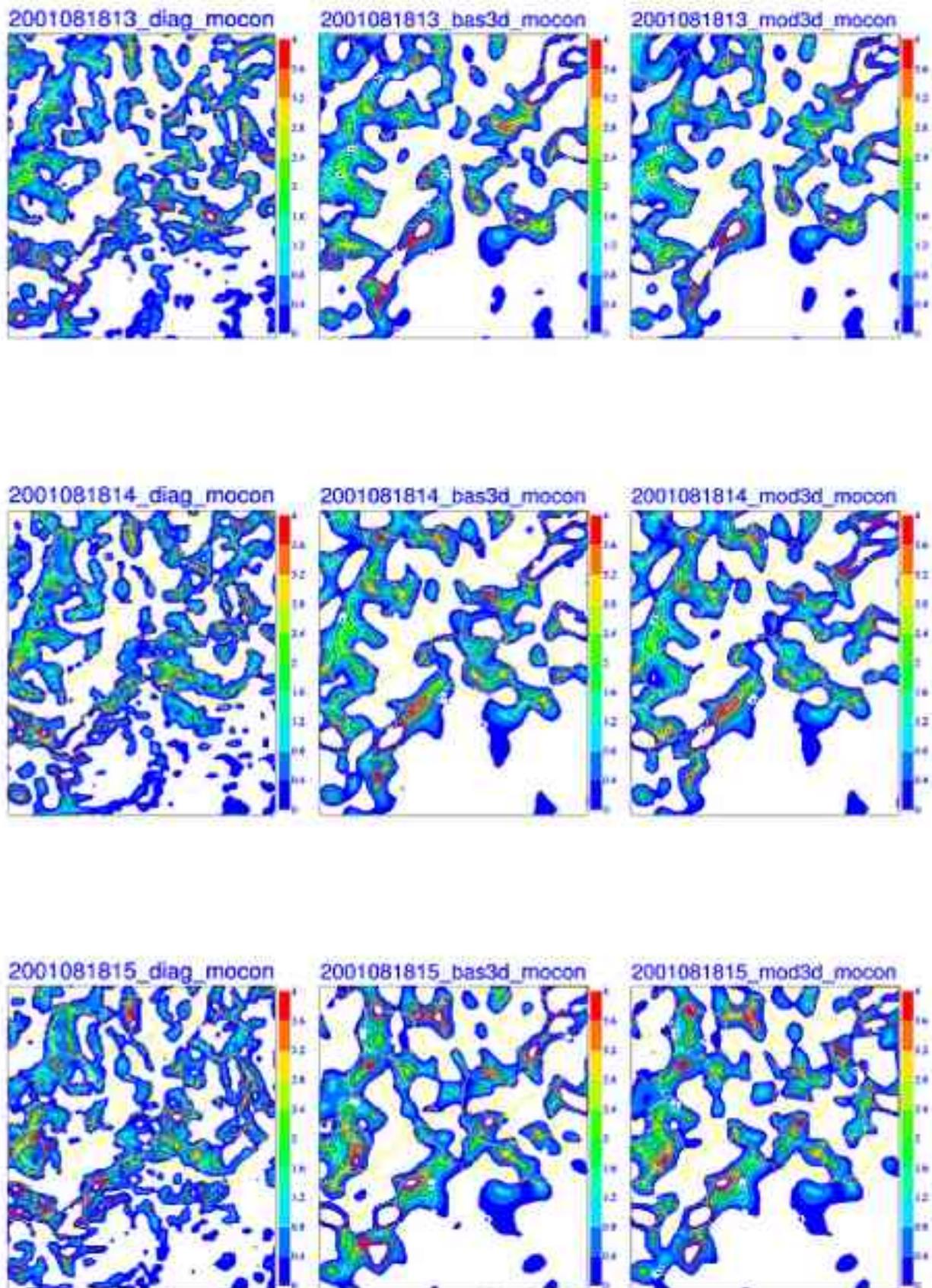


Fig 7 part 2/2

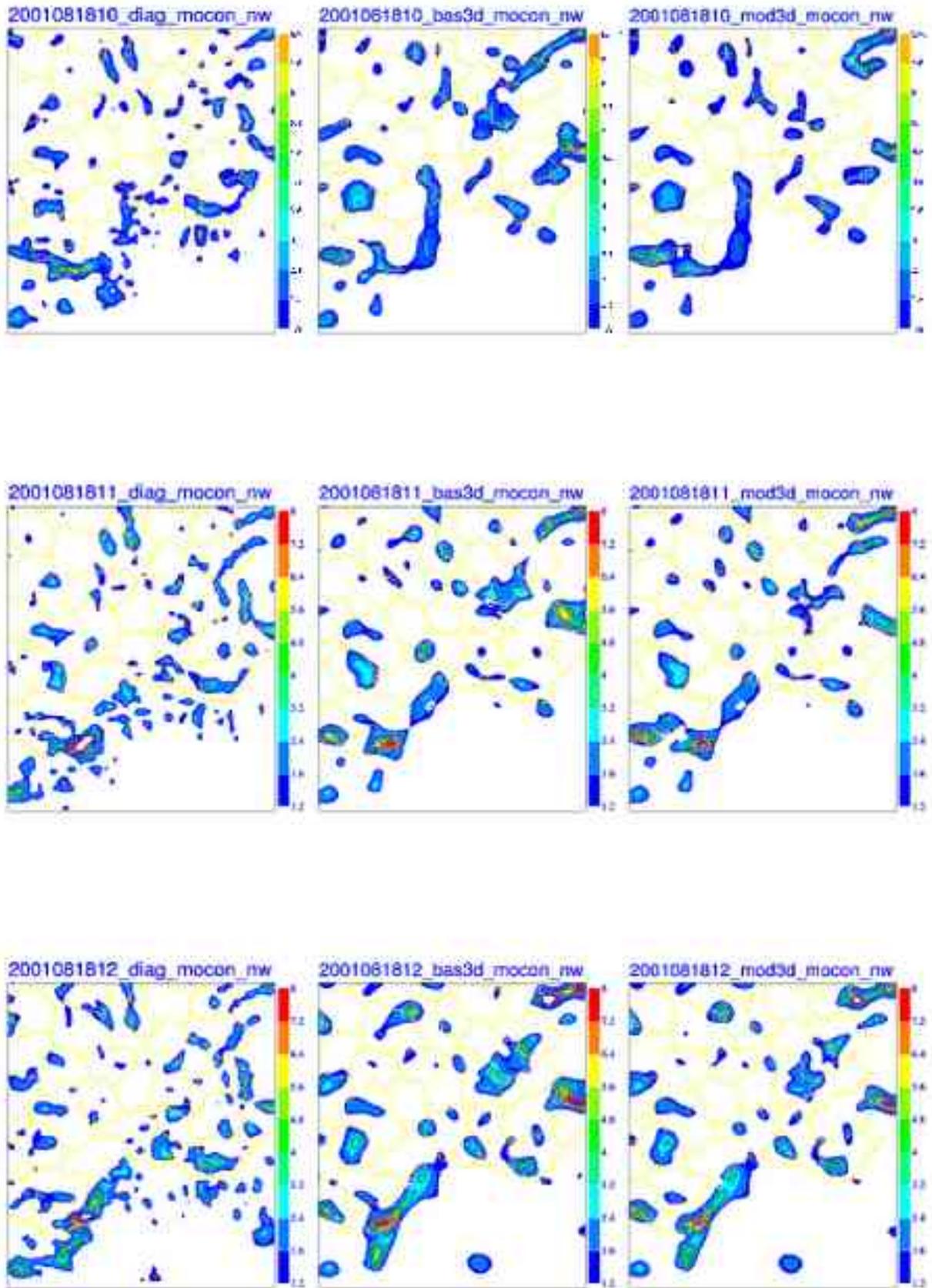


Fig 8 part 1/2

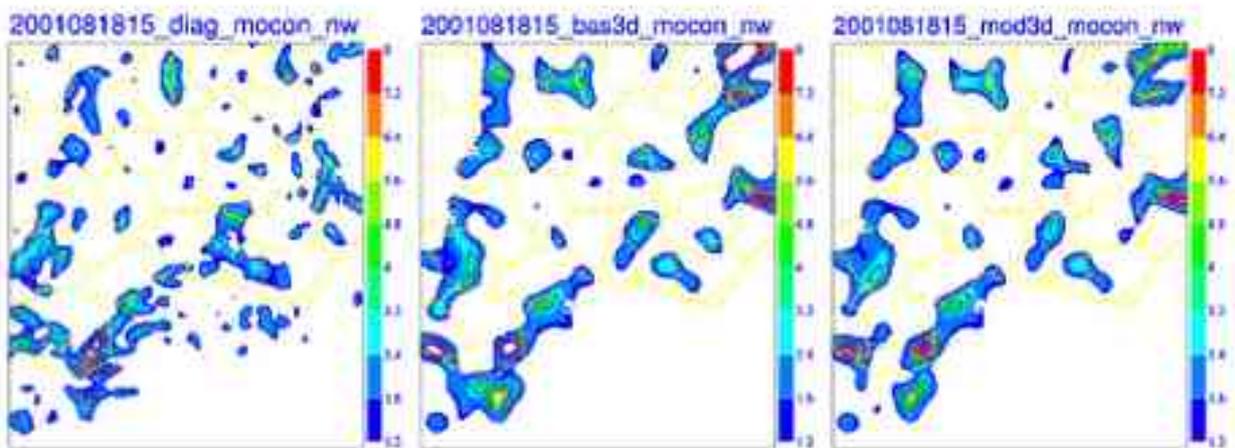
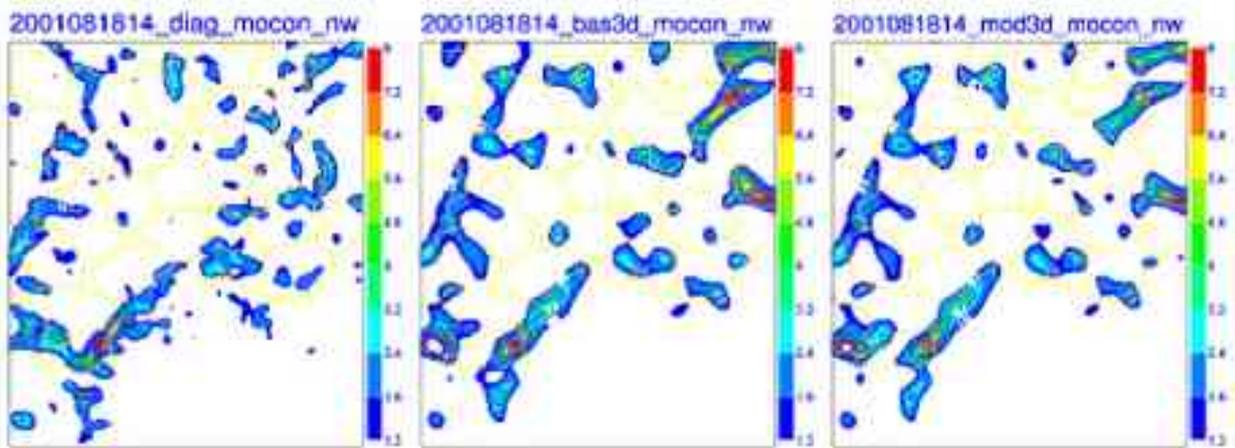
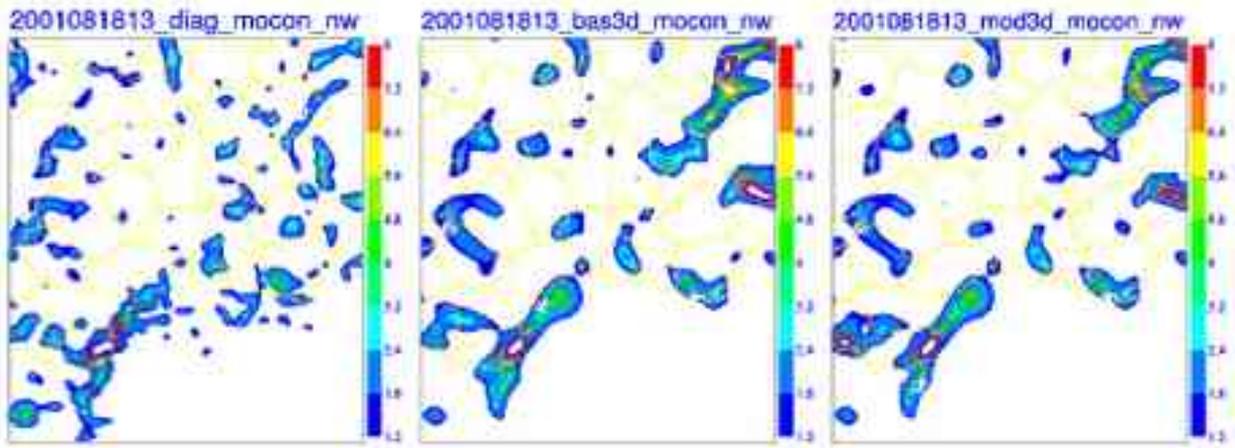


Fig 8 part 2/2

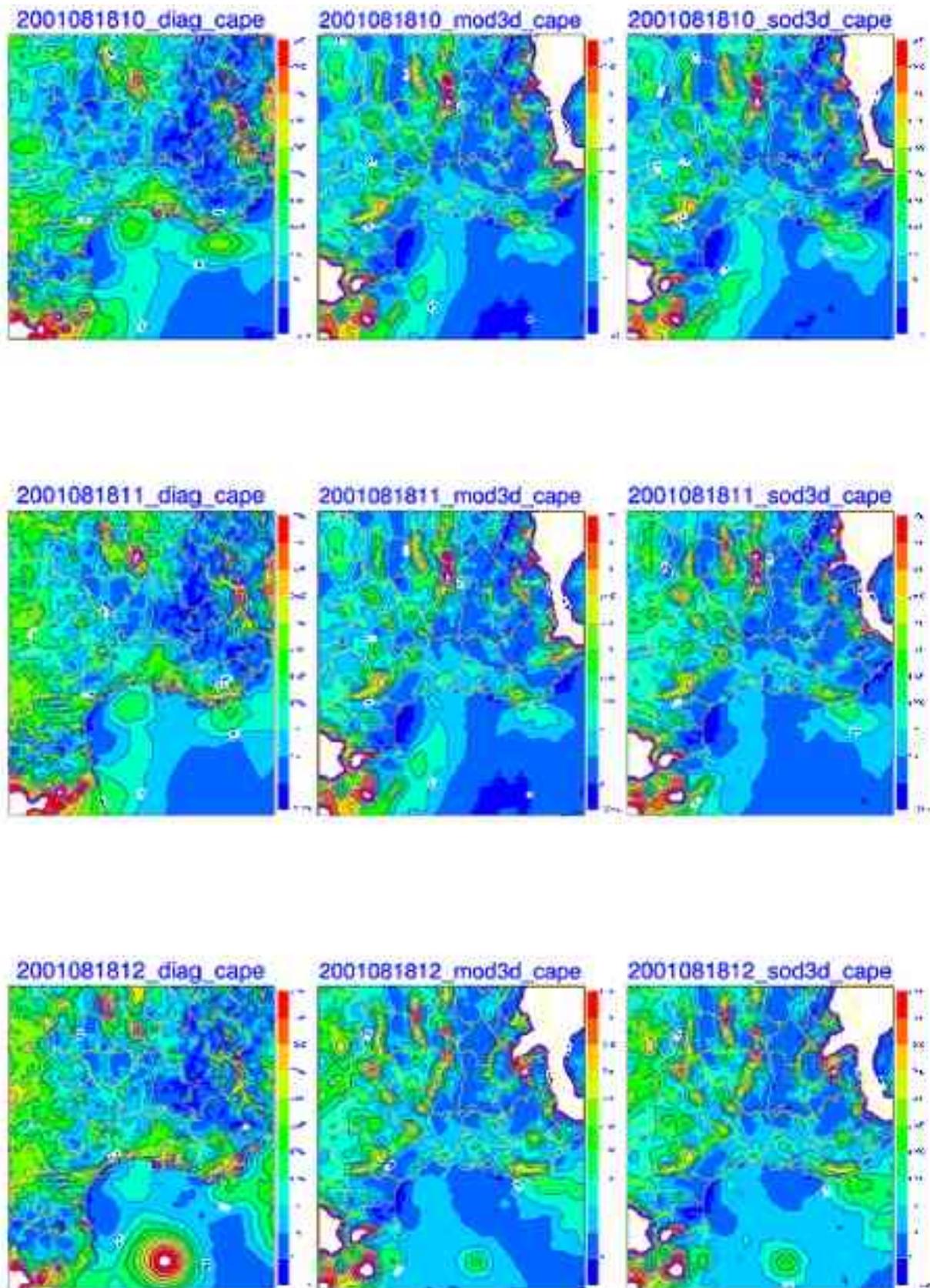


Fig 9 part 1/2

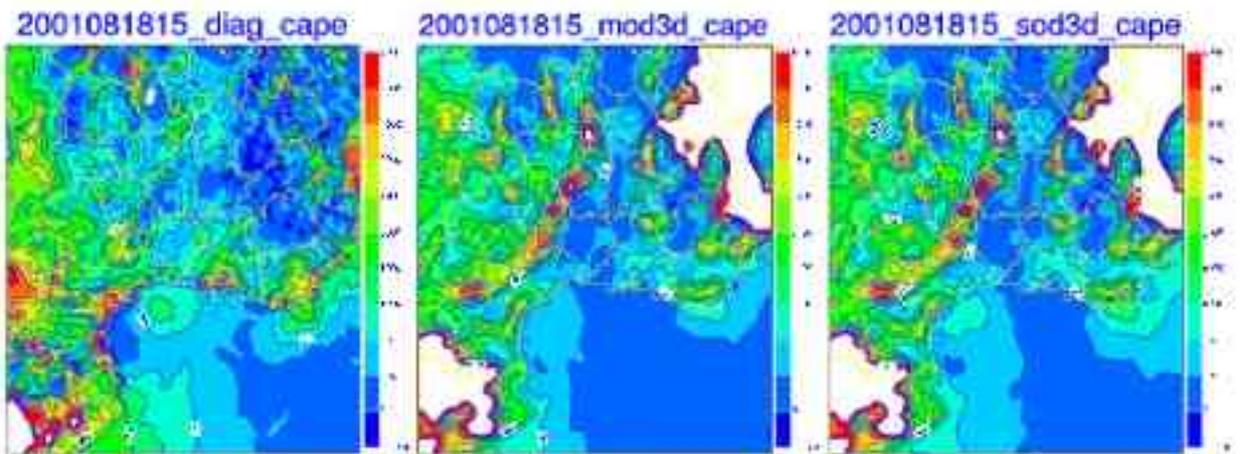
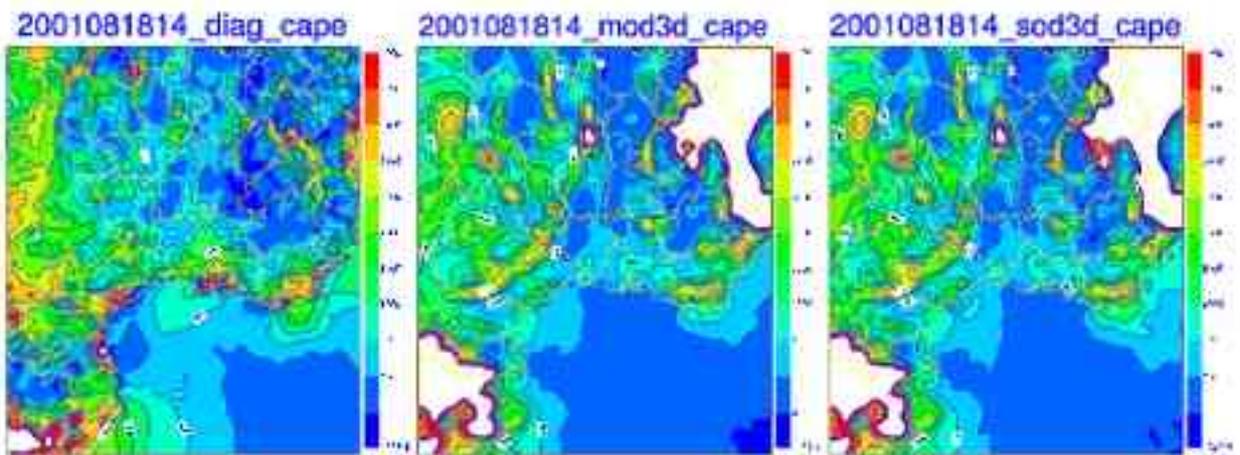
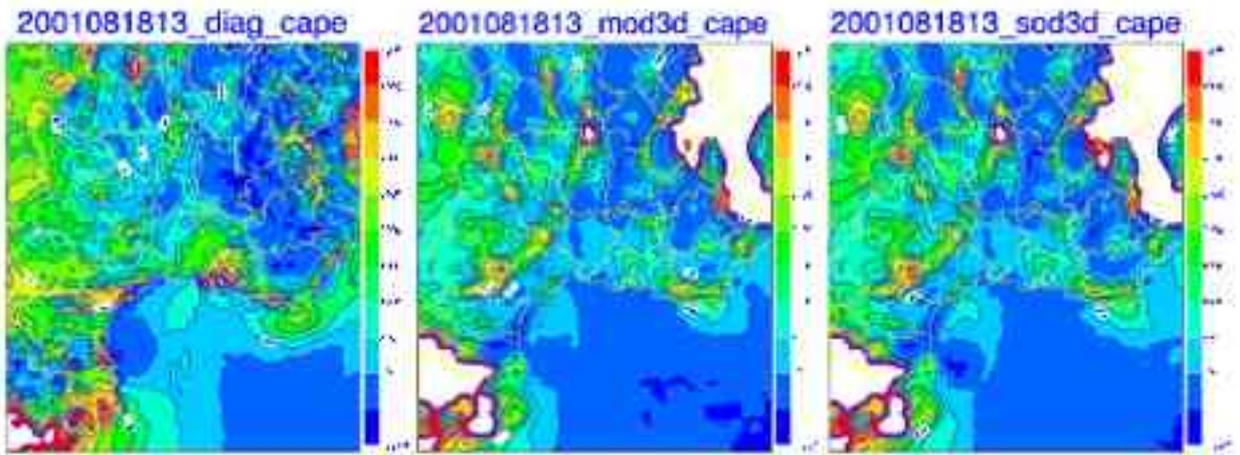


Fig 9 part 2/2

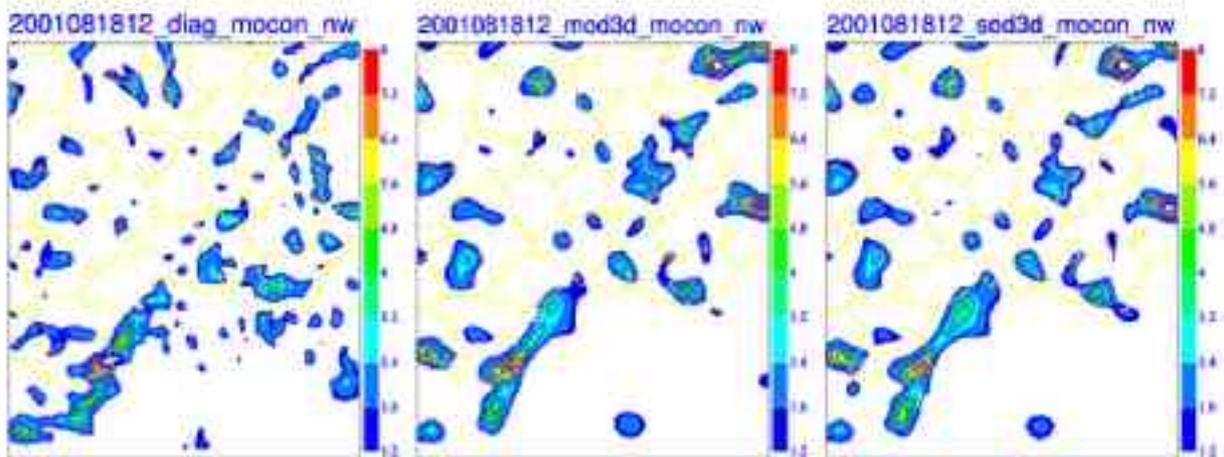
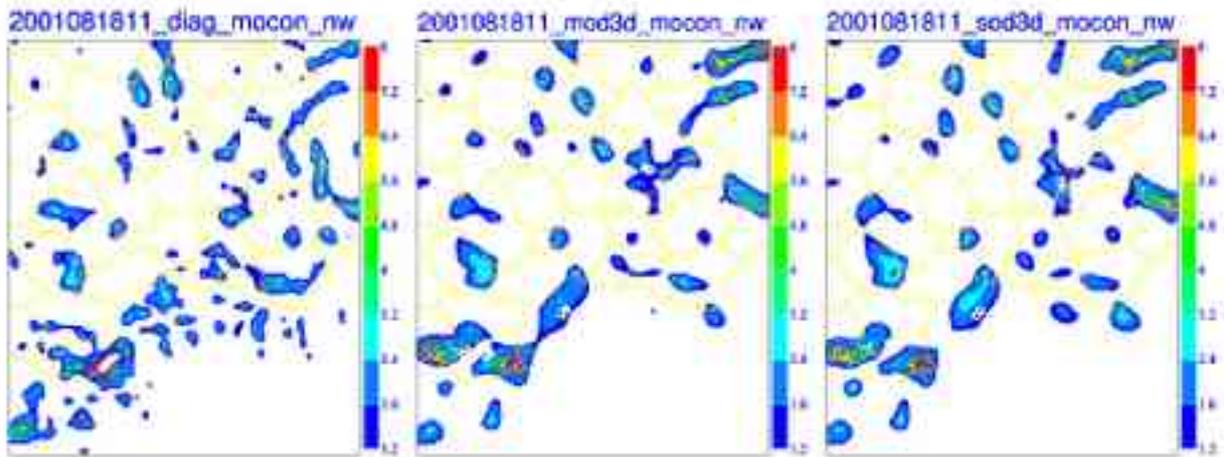
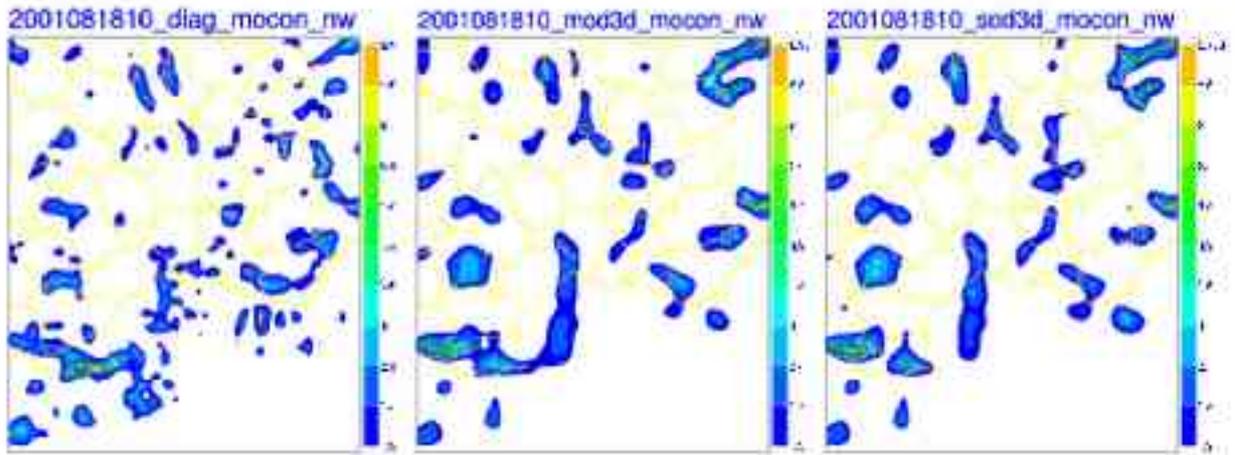


Fig.10 part 1/2

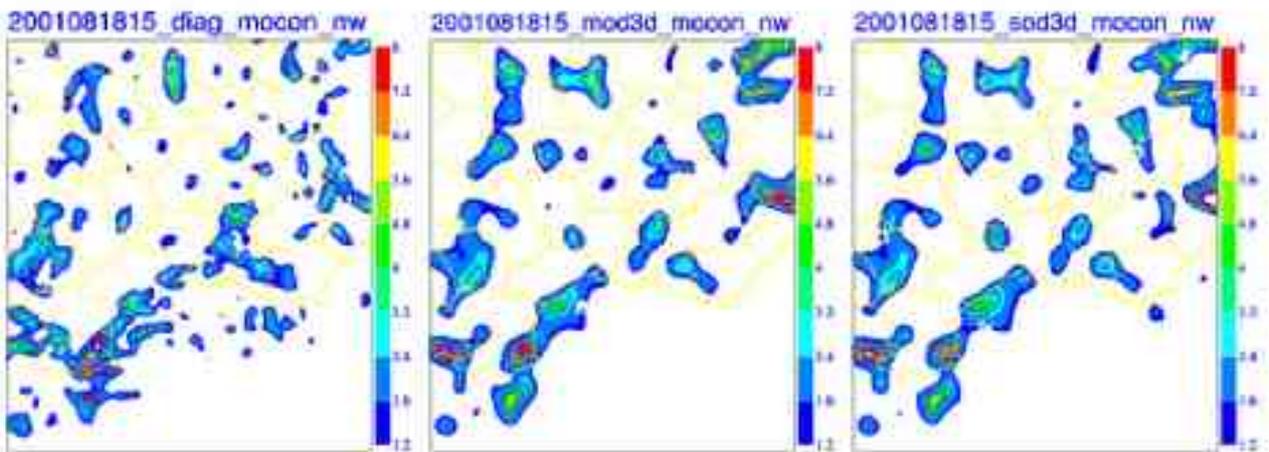
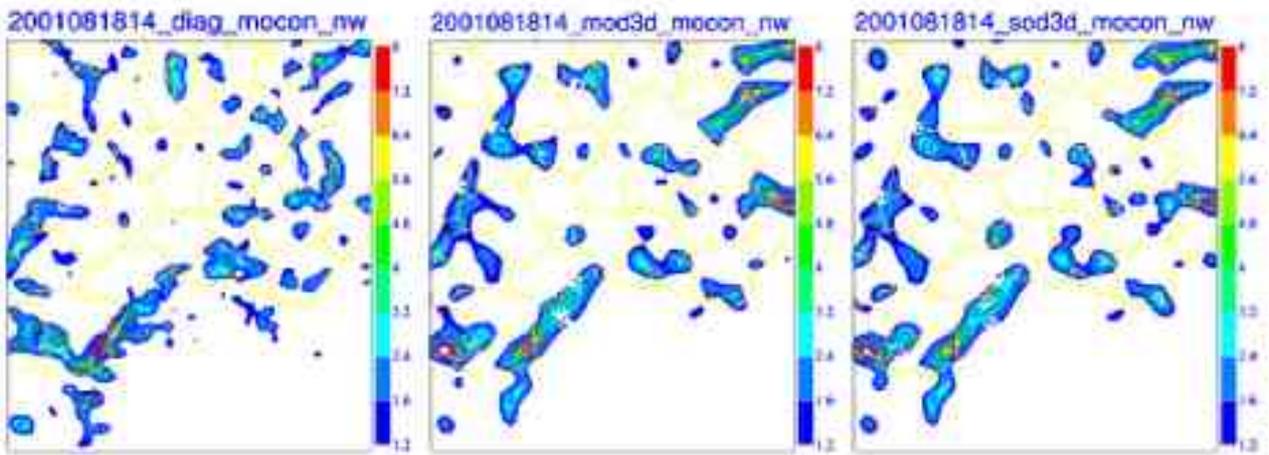
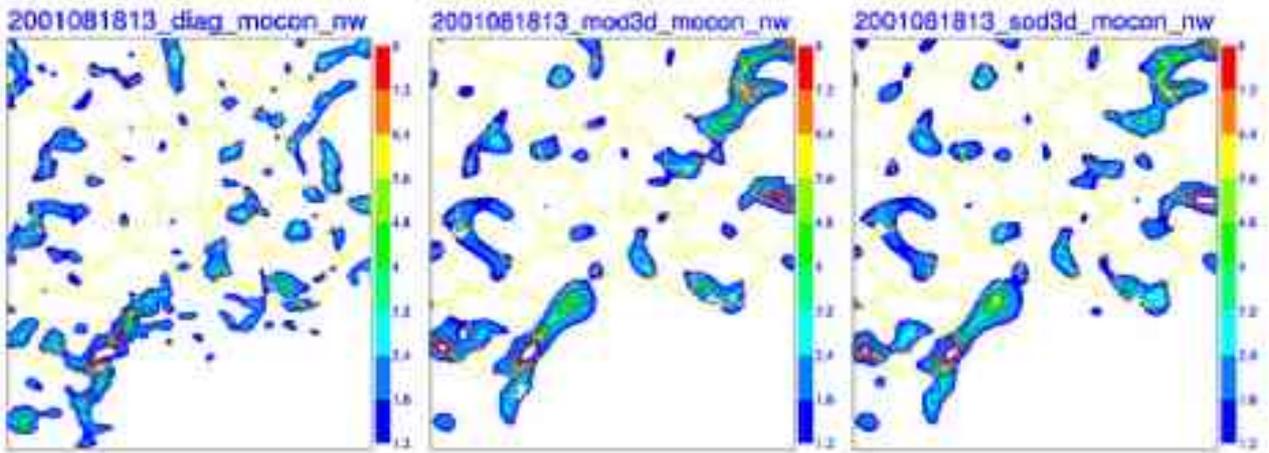


Fig 10 part 2/2

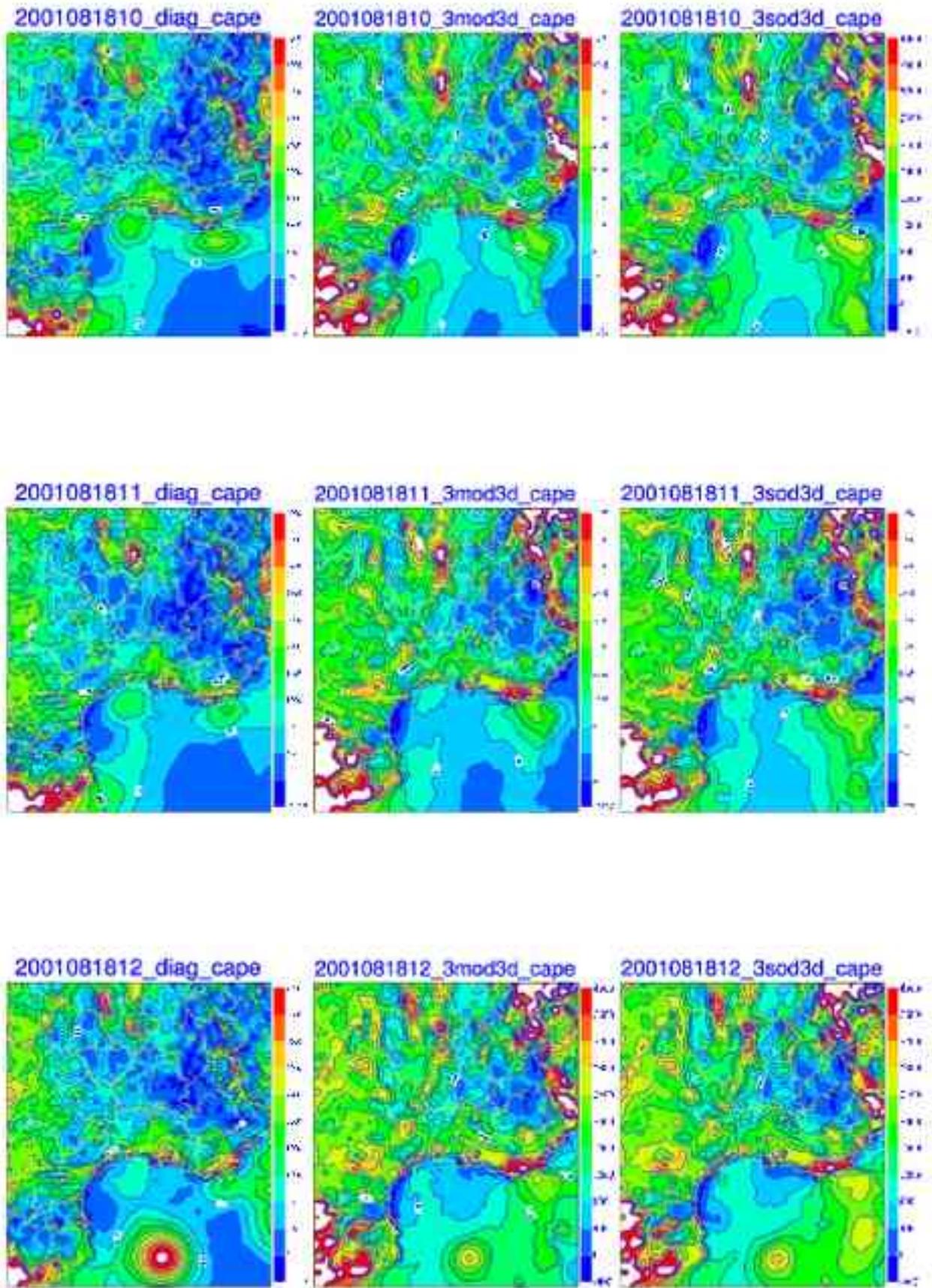


Fig 11 part 1/2

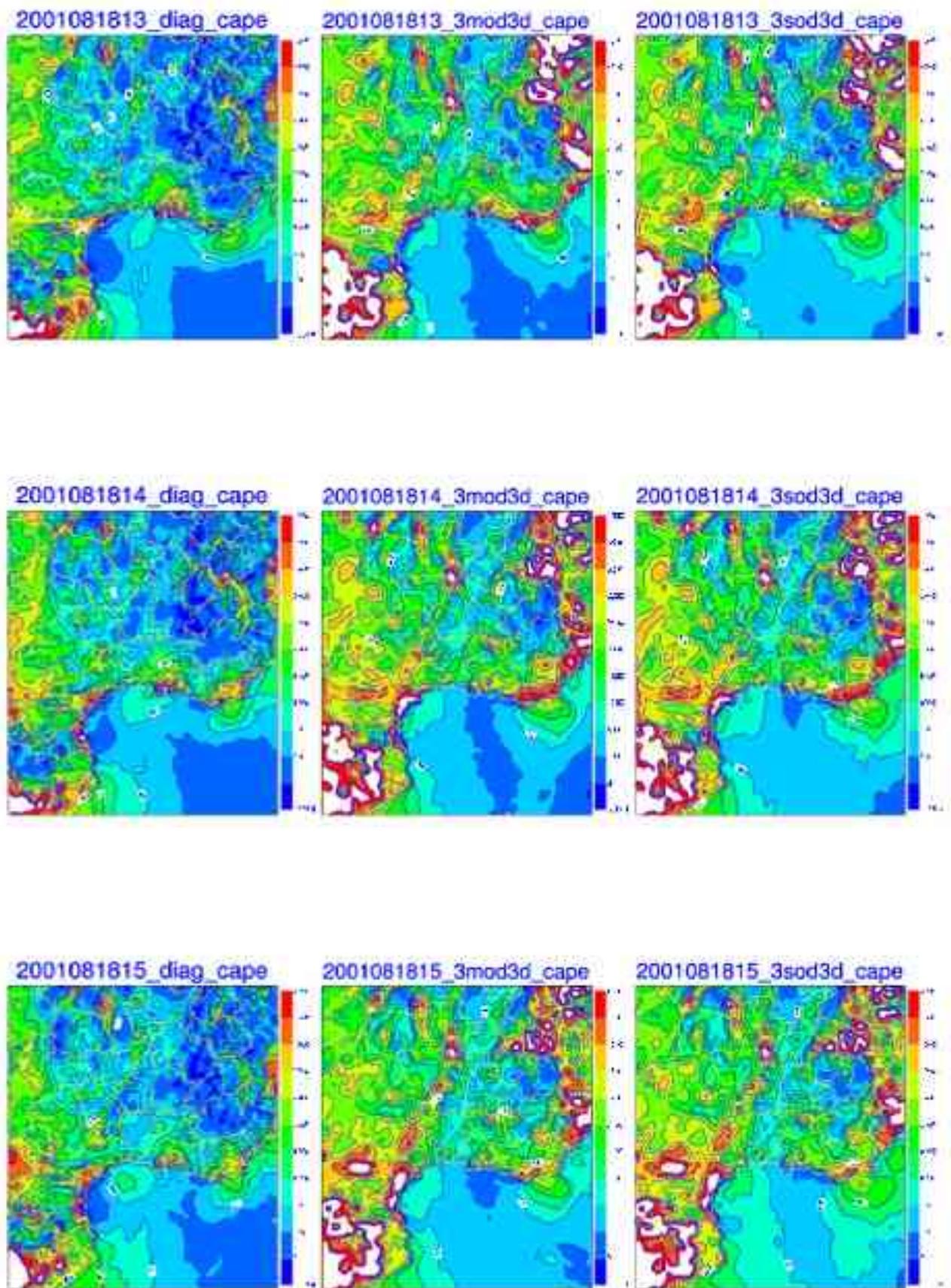


Fig 11 part 2/2

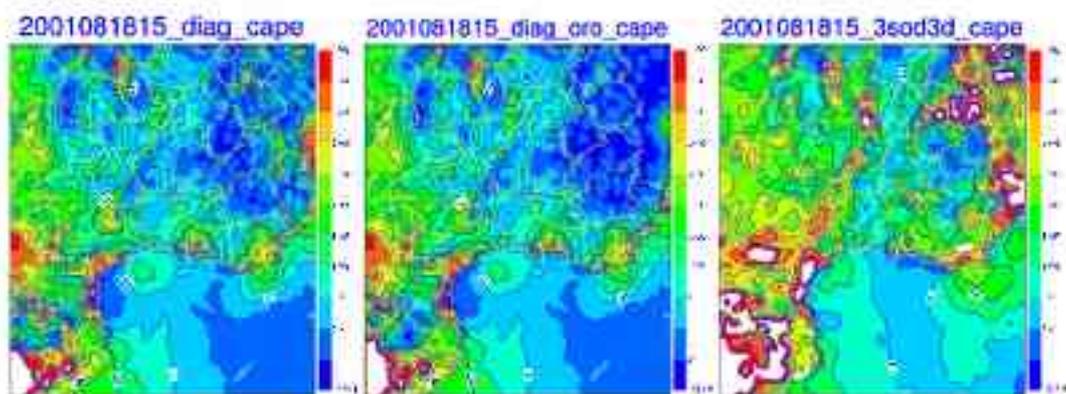


Fig 12

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