IMPROVING THE REPRESENTATION OF OROGRAPHY IN ARPEGE / ALADIN

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CONTENTS

1. Introduction

The purpose of the present work is to compare the results obtained from two cost functions, with two different datasets, and to improve the spectral fit of the orography for Aladin/Romania.

Configuration e923 is a procedure which interpolates climatic and topographic information from global fields into a chosen limited domain. This configuration has 6 steps. Every step defines different fields. There are six routines for each step:

- EINCLI1 defines orography;
- EINCLI2 defines constant fields for surface, soil, and vegetation;
- EINCLI3 defines monthly climatic fields;
- EINCLI4 defines fields describing vegetation for the ISBA surface scheme;
- EINCLI5 introduces more accurate data for Europe;
- EINCLI6 improves some of the monthly climatic fields.

We were especially using the first step of configuration.

In section 2, we describe some details about running this configuration. In section 3, the two datasets are compared. In section 4, the various options of parameters from the cost function are analysed.

2. Running configuration e923 on Fujitsu VPP5000 and on workstation (Sun)

For running configuration e923 step 1 on VPP, we chose the domain Aladin/Romania, with the coordinates

ELAT1=41.91284257
ELAT2=49.80342137
ELON1=20.68979003
ELON2=32.12558703

and resolution of 10 km.

The namelist parameters are:

```
&NAMCLA
        LNORO=F               - no new orography is to be read at the end
        LKEYF=F               - no spectral fit
        LNEWORO
        LNEWORO2              - choice of spectral fit
        FENVN=1,              - amplitude of the envelope orography
        FACZO=0.53            -scaling factor for the orographic part of roughness length
&NAMCT0
        NCONF=923,
        LELAM=T,
        LRPLANE=T,
        NFFTCR=1,
        LMLTSK=F,
        LECMWF=F,
        CNMEXP='ROUM'
&NAMMCC                       - choice of step
        LN923=T,
        N923=1                - or 2,3,4,5,6
&NAMDIM, NEMGEO               - geometry of domain Aladin
```

For running this configuration, global data are necessary. Datasets are prepared from GLOB95 data in resolution 2'30''. For first step, we need the following input files:

Water_Percentage	- land/sea mask (% of water)
Oro_Mean	- mean orography (mean of H)
Sigma	- sub-grid standard deviation of Hmean
Nb_Peaks	- number of sub-grid peaks
Urbanisation	- fraction of urbanization (% of city)
Dh_over_Dx_Dh_over_Dy	- mean of dHmean/dx*dHmean/dy
Dh_over_Dx_square	- mean of (dHmean/dx)**2
Dh_over_Dy_square	- mean of (dHmean/dy)**2
Hmax-HxH-Hmin_ov4	- mean of (Hmax-Hmean)(Hmean-Hmin)/4

The output fields are:

SURFIND.TERREMER	- land(1)/sea(0) mask
SURFGEOPOTENTIEL	- surface geopotential (grid point)
SPECSURFGEOPOTEN	- surface geopotential (spectral)
SURFET.GEOPOTENT	- G x the standard deviation of the orography
SURFVAR.GEOP.ANI	- the anisotropy coefficient
SURFVAR.GEOP.DIR	- the direction of principal axis of topography (in radian)
SURFZ0REL.FOIS.G	- G x the roughness length of bare surface
SURFPROP.URBANIS	- the fraction of urbanization
SURFPROP.TERRE	- the fraction of land
SURFZ0.FOIS.G	- at this step, same as SURFZ0REL.FOIS.G

Files with global data are huge. For running step 1 of configuration e923 on workstation, we must extract a subdomain from global datasets (a little bigger than Aladin/Romania). The script for extraction subdomain needs the namelist:

```
&NAMORO
        FILE_IN='$1'
        FILE_OUT='$2'      - name of the input and output files
        NDATX=8640         - x-size of the dataset (longitude)
        NDATY=4320         - y-size of the dataset (latitude)
        ELATSW=40
        ELONSW=19          - coordinates of subdomain
        ELATNE=51
        ELONNE=34
&END
```

Script can be found on Kami: /u/gp/mrpm/mrpm611/extract/

With those new data files, we can run step 1 of configuration e923, on workstation. The namelist is the same as for VPP , apart from the specification of the new dataset (location, size) in NAMCLI:

```
&NAMCLI
        LGLOBE=F
        ELATSW=40
        ELONSW=19
        ELATNE=51
        ELONNE=34
        NDATX=360
        NDATY=264
&END
```

3. Testing new input data (GTOPO30 vs GLOB95)

GLOB95 is the first global dataset at 2'30'' resolution, produced in 1996, combining the US-NAVY 10' dataset, the NOAA 5' TerrainBase and the NOAA 30'' (but with partial coverage of the Earth). All files contain 8640x4320 values. These data files can be found on Kami: /u/gp/mrpe/mrpe603/923/RELIEF_G/GLOB95/

The GTOPO30 dataset, produced in 1998, uses a real global 30'' mean altitude description, plus some informations on the oceans. The resolution is the same as in GLOB95. These files are on delage: /cnrm2_a/mrpe/mrpe603/RELIEF_G/edc.

To describe fraction of urbanization, we used the UrbaMixte file, combining data from US-NAVY (at 10' resolution) and from the University of Maryland (at 1 km resolution).

The results of tests for GLOB and GTOPO data, are presented further.

To see the differences between some fields, for these two datasets, we started from Aladin file. For SURFIND.TERREMER field, the results are identical for the both cases (Fig. 1 a).

Also comparing the SURFPROP.TERRE field for the two datasets, no difference was found, on the domain Aladin/Romania (Fig. 1 b).

There is a better representation of fraction of urbanization for the GTOPO data, as seen, in Fig. 1d.

For SURFET.GEOPOTENT field, we can see that in the case of representation for GTOPO data, there is higher values on the intracarpathian side (west and north part) of the Carpathians and in the south of the Danube, the Tatry Mountains (zone 1). For GLOB data, the field has some higher values on the extracarpathian side (the south and east part) and in the Apuseni Mountains, the Balkans (the zones 4, 11). (Fig. 2 a, 2 b)

For the SURFZ0.FOIS.G field, we can see that for GTOPO data, there are higher values in the Fagaras Mountains, the Rodna Mountains (the zones 7, 3), in the south of the Danube, and for GLOB data, a little higher on the Apuseni Mountains (zone 4). (Fig. 2 c, 2 d)

Also comparing the SURFVAR.GEOP.ANI field, for the two datasets, a small difference was found (just in some points of the domain). The same behaviour we observed for SURFVAR.GEOP.DIR field . There are small differences. (Fig. 3)

To compare the orography obtained for the two datasets, we chose 4 cases. They are:

1) LKEYF=F		(fit1)
2) KLEYF=T, LNEWORO=F, LNEWORO2=F		(fit2)
3) LKEYF=T, LNEWORO=T, LNEWORO2=F	(first cost function)	(fit3)
4) LKEYF=T, LNEWORO=F, LNEWORO2=T	(the second cost function)	(fit4)

After the comparison of all these cases, we can conclude that: GLOB data show an increase of values in the south-west part of the domain, in the Tatry Mountains (zone 1), on the extracarpathian side of the Carpathian, and GTOPO data show an increase in the north part, on the intracarpathian side and in the Fagaras Mountains (the zone 7), and a decrease in the west part and in the Danube Plain (the zone 9).

The comparison between the orography (without spectral fit, LKEYF=F) and the spectrally fitted orography in the case of the first cost function (LNEWORO=T), show a decrease of values in the Danube Plain, the Balkans, the Tatry Mountains, the Caliman Mountains, the Apuseni Mountains (zones 9, 11, 1, 12 4), and an increase in the Fagaras Mountains (the zone 7).

Also comparing the orography (without spectral fit, LKEYF=F) with the spectrally fitted orography, but in the case of the second cost function (LNEWORO2=T), it was observed that there is a decrease in the Tatry Mountains, the Balkans Mountains and the Danube Plain (the zones 1, 11, 9), and an increase of values in the Tisa Plain - west part of domain (the zone 5), in the Carpathian Mountains. (Fig. 4, 5, 6, 8)

The comparison between the two spectrally fitted orography show that the first (obtained using LNEWORO=T), present higher values in the Balkans, the Retezat and the Fagaras Mountains (the zones 11, 6, 7), while the second one (LNEWORO2=T), has smaller values in the Danube Plain (the zone 9), a better representation of the Carpathian, and in the Tisa Plain (the zone 5). (Fig. 7)

As a result of comparison between the real orography and the spectrally fitted orography, for the two datasets, it seems that, using the second cost function (LNEWORO2=T), the orography is better represented on the domain of Aladin/Romania.

Then, we tried to see the differences between fields, for the two datasets, but starting from Arpege files. Using PSHA program, with the following options in namelist:

```
&NAMPSHA
        CGCONF='XYZI'
        CLCHA(1)='SURFGEOPOTENTIEL'       - name of the field
        CLNFE(1)='R199_R_1'               - name of the Arpege file
        LGCOORD=F
        LGDEBU=F
        LGRGRI=F
        LGSURF=F
        LRENS=T
        N1SURN=0
&END
&NAMZOOM
        LLZOOM                            - choice of zoom for an horizontal
                                          domain
        ZLA1=40
        ZLA2=51                           - coordinates of window
        ZLO1=19                           (for the domain Aladin/Romania)
        ZLO2=34
&END
```

we can obtain a representation of the field on a window of Aladin/Romania domain or of the whole globe.

Further, we compare the fields for the two datasets on the whole globe.

We can say that for SURFIND.TERREMER field, there is a difference for the two datasets. It seems that, GLOB data has 82 values considered land, while GTOPO data treated those like a sea points, but only for 4 points, the opposite is true. (Fig. 9)

Comparing the orography, we can see that GLOB data have higher values over Alaska, the north of Canada, Greenland, the South America, the west part of Africa, Antarctica, and for GTOPO data , in Africa, Australia, the west of the United States of America, Arabic Peninsula, the North Pole. (Fig. 9)

For the SURFPROP.URBANIS field, we observed that in the central Europe, Japan, GLOB has a better representation of fraction of urbanization, and GTOPO in the United States of America, eastern Europe and Russia. (Fig. 10)

For the SURFVAR.GEOP.ANI field, in the representation for the two datasets, there are higher values in Alaska, Canada, the North Pole, Greenland, South America, in the central and west part of Africa, the north of Europe, for GLOB data, and in the north of Africa, the south and central part of South America, the Arabia Peninsula, for GTOPO data. (Fig.10)

Also comparing the SURFET.GEOPOTENT field, for the two datasets, we can say, that there are higher values on the North and South Pole, the east and west part of Africa, and a little in the Himalayas and in South America, for GLOB data. For GTOPO, we observed high values in Alaska, Antarctica, the New Guinea, Borneo, the north and west part of the South America, in the west and south of Greenland. (Fig. 11)

For the SURFZ0.FOIS.G field, we can see that there are higher values for GTOPO data on the Himalayas, the Andes, Rocky Mountains, Alaska, the North and South Pole, New Guinea, Iran, the north of Canada, the east of Africa and the east of Greenland. (Fig. 11).

These are the conclusions drawn from observing Arpege files.

4. Improving the spectral fit of the orography

The calling tree is:

INCLI0 -> EINCLI1 (if LELAM=T)
-> ERELSPE
-> INIPZ (calculates the weights of the grid points)
-> SIMREL (calculates the function and its gradient)

The two cost functions, from Arpege model, are proposed one by Bouteloup (LNEWORO=T) and another by Jerczynski (LNEWORO2=T).

The first cost function is:

$$F = \sum_i \omega(i) \left[\frac{|R(i) - Rs(i)|}{HDIM} \right]^{W(i)}$$

$$W(i) = QMIN + (QMAX - QMIN) \cdot \exp\left(\frac{-R}{HMIN}\right)$$

where R is the grid-point orography, Rs the spectrally fitted grid-point orography to obtain, ω the field of Gaussian weights, HDIM a dimensioning factor, W a field of weights allowing a geographical modulation of the cost function, QMAX, QMIN maximum, minimum of the field of weights, HMIN land/sea height factor.

The second cost function (for the case LELAM=T) is:

$$F = \sum_i \omega(i) \cdot \left[W(i) \cdot (Rs - R)^2 + (QCONST \cdot |Rs - R|)^{QPOWER} \right]$$

$$W(i) = \left[1 + (XINCOC - 1) \cdot \exp\left| \frac{-R}{HMIN} \right| \right]$$

where XINCOC weight multiplicator over the ocean in the orography optimization, QCONST constant used in the minimization function, QPOWER exponent used in the minimization function.

The parameters HDIM, QMAX, QMIN, HMIN, XINCOC, QCONST, QPOWER are set by namelist NAMCLA.

In section 3, we show that the spectrally fitted orography in the case of the second cost function (LNEWORO2=T), represents better the orography on the domain Aladin/Romania.

Some sensitivity tests have been done in order to study the impact of a variation of the parameters involved in the cost function formulation. These are: XINCOC, HMIN, QCONST and QPOWER. We increased and decreased every one of these, and compared the results. The standard values for these parameters are:

QPOWER=3.5
QCONST=0.4
XINCOC=2500
HMIN=150

When XINCOC<2500, we observed an increase in the Tatry Mountains, the Apuseni Mountains, the Mountains in the south part of the Danube (the zones 1, 4, 10), and a smoothing of the values in Fagaras Mountains, the Rodna Mountains, the Tisa Plain, the plain nearest of the Tatry Mountains (the zones 7, 3, 5, 2). (Fig.12 a)

In the case XINCOC>2500, there is a smoothing in the Retezat Mountains, the Mountains in the south part of the Danube (the zone 6, 10) and an increase in the Fagaras Mountains (the zone 7), and just a little on the Balkans (zone 11). (Fig. 12 b)

For the case HMIN<150, we can observe a smoothing of the values in the Balkans (the zone 11), and an increase in the north-west part of the domain (zone 1), in the Apuseni Mountains, the Caliman Mountains (the zone 4, 12) and just a little in the Danube Plain, the Mountains in the south part of the Danube (the zones 9, 10). (Fig. 12 c)

When HMIN>150, there is an increase, in the Fagaras Mountains, the Balkans (the zones 7, 11), and a smoothing in the plain nearest of the Tatry Mountains, the Mountains in the south part of the Danube, the Tisa Plain, the Tatry Mountains (the zones 2, 10, 5, 1). (Fig. 12 d)

For the case QCONST<0.4, we observed an increase, just a little in the plain nearest of the Tatry Mountains, the Fagaras Mountains, the Balkans, the Danube Plain (the zones 2, 7, 11, 9) and a smoothing in the Tatry Mountains, the Rodna Mountains, the Apuseni Mountains, the Retezat Mountains (zones 1, 3, 4, 6). (Fig. 13 a)

When we increase QCONST>0.4, we can see an increase in the Tatry Mountains (the zone 1), with a smoothing on the plains from the zones 2, 5. In the same time, there is an increase in the Apuseni Mountains (the zone 4). (Fig. 13 b)

And when QPOWER<3.5, there is an increase in the Retezat Mountains, the Fagaras Mountains, the Balkans, the plain nearest of the Tatry Mountains, the Danube Plain (the zones 6, 7, 11, 2, 9). (Fig. 13 c)

In the case QPOWER>3.5, we can see an increase in the Tatry Mountains, the Retezat Mountains, the Balkans, the Caliman Mountains (the zones 1, 6, 11, 12), and a decrease in the Fagaras Mountains (the zone 7). When QPOWER=7.0 there is a discordant decrease (with negative values on the plain) in the plain nearest of the Tatry Mountains, the Tisa Plain, the Danube Plain (the zones 2, 5, 9), very much noise and a significant increase of the Gibbs waves on the sea (until 80 meters). (Fig. 13 d)

We tried to see the representation of orography, at the variation of XINCOC, HMIN and QCONST, QPOWER. In this way, we chose six cases:

a) XINCOC, HMIN increase, and QCONST, QPOWER constants: there is an increase in the Fagaras Mountains, the Balkans, the Danube Plain, the Retezat Mountains (the zones 7, 11, 9, 6), and a smoothing in the Tatry Mountains (the zone 1) and just a little in the plain nearest of the Tatry Mountains, the Rodna Mountains, the Tisa Plain (the zones 2, 3, 5) (Fig. 14 a , XINCOC=4000, HMIN=250, QCONST=0.4, QPOWER=3.5)

b) XINCOC, HMIN constants, and QCONST, QPOWER increase: there is a smoothing in the plain nearest of the Tatry Mountains, the Tisa Plain, the Fagaras Mountains, the Danube Plain (the zones 2, 5, 7, 9), and an increase in the Tatry Mountains, the Apuseni Mountains, the Retezat Mountains, the Mountains in the south part of the Danube (zones 1, 4, 6, 10) and just a little in the Balkans (zone 11) (Fig. 14 b, XINCOC=2500, HMIN=150, QCONST=0.5, QPOWER=3.6).

c) XINCOC, HMIN decrease, and QCONST, QPOWER constants: there is an increase in the Tatry Mountains, the Apuseni Mountains, the Retezat Mountains (1, 4, 6), and a smoothing in the plain nearest of the Tatry Mountains, the Fagaras Mountains, the Tisa Plain, the Balkans, (the zones 2, 7, 5, 11). (Fig. 14 c, XINCOC=1500, HMIN=75, QCONST=0.4, QPOWER=3.5)

d) XINCOC, HMIN constants, and QCONST, QPOWER decrease: there is an increase in the plain nearest of the Tatry Mountains, the Fagaras Mountains, the Retezat Mountains, the Danube

Plain, the Balkans (2, 7, 6, 9, 11), and a decrease in the Tatry Mountains, the Tisa Plain, the Mountains in the south part of the Danube (the zones 1, 5, 10). (Fig. 15 a, XINCOC=2500, HMIN=150, QCONST=0.2, QPOWER=2.0)

e) XINCOC, HMIN, QCONST, QPOWER increase: there is a smoothing in the plain nearest of the Tatry Mountains, the Tisa Plain, the Danube Plain, somewhat less Gibbs waves (the zones 2, 5, 9, 12), and an increase in the Tatry Mountains, the Apuseni Mountains, the Balkans, the Mountains in the south part of the Danube (1, 4, 11, 10). (Fig. 15 b, XINCOC=4000, HMIN=250, QCONST=0.5, QPOWER=3.7)

f) XINCOC, HMIN, QCONST, QPOWER decrease: there is an increase in the Retezat Mountains, the Fagaras Mountains, the Balkans, the Caliman Mountains (6, 7, 11, 13) and a smoothing in the Tatry Mountains, more Gibbs waves on the Black Sea, the Mountains in the south part of the Danube (the zones 1, 10). (Fig. 15 c, XINCOC=1500, HMIN=75, QCONST=0.2, QPOWER=2.0)

Testing all these parameters, we saw that in the case of HMIN=250, XINCOC=4000, QCONST=0.5, QPOWER=3.6, the orography from Romania is better represented. Comparing with the grid-point orography, we can say that we improve it in the Fagaras Mountains, the Retezat Mountains, the Apuseni Mountains, the Tisa Plain, the Danube Plain, the Balkans, the plain nearest of the Tatry Mountains (the zones 7, 6, 4, 5, 9, 11, 2) just over land. With same tuning we can avoid too much Gibbs waves. (Fig. 16)

5. Conclusions

1. In the case of comparison between the two global datasets, the general conclusion is that: GLOB data show a systematic increase in the south-west part of the domain, on the Tatry Mountains, on the extracarpathian side of the Carpathians, in the Apuseni and Retezat Mountains (the zones 5, 1, from 3 to 8, 4, 6), and GTOPO data show an increase in the north part, on the intracarpathian side and on the Fagaras Mountains (the zone 7) , and a decrease in the west part and on the Danube Plain (zone 9).
2. After the study of all these variations of the parameters from the second cost function we can conclude that: the increase of the weight W(i) determines increase of the values in the zones the Fagaras Mountains, the Danube Plain, the Balkans (the zones 7, 9, 11), and smoothing in the Tatry, the Apuseni and the Rodna Mountains (the zones 1, 4, 3) ; and the increase of the constant and exponent from minimization function causes increase in Tatry, the Apuseni Mountains, in the south of the Danube (zones 1, 4, 10) and decrease on the plain nearest of Tatry Mountains, the Fagaras Mountains, the Tisa Plain and the Danube Plain (zones 2, 7, 5, 9).
3. Comparing the following fields SURFGEOPOTENTIEL, SURFET.GEOPOTENT, SURFVAR.GEOP.ANI, SURFVAR.GEOP.DIR from Arpege files we can say that for GLOB data, there is an increase in Greenland, Alaska, the north of Canada, South America, Africa, the north and south Pole, and for GTOPO data in Australia, Arabia Peninsula, South America, Africa, the north and south Pole, Greenland, Alaska, the north of Canada, Malaysia .
4. For the domain Aladin/Romania, modifying the values of HMIN, XINCOC, QCONST, QPOWER, we can obtained an improvement of the orography.

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7. References

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8. Appendix

To be easier to see the results on the maps, I make the following notations:

zone 1 - the Tatry Mountains
zone 2 - the plain nearest of the Tatry Mountains
zone 3 - the Rodna Mountains
zone 4 - the Apuseni Mountains
zone 5 - the Tisa Plain
zone 6 - the Retezat Mountains
zone 7 - the Fagaras Mountains
zone 8 - the Bucegi Mountains
zone 9 - the Danube Plain
zone 10 - the Mountains in the south part of the Danube
zone 11 - the Balkans
zone 12 - the Caliman Mountains.