# Assessment of the quality of variables provided in "climate" files produced in Meteo France

Martina Tudor & Stjepan Ivatek-Šahdan

These files are used when running interpolation from one grid to another. The fields are interpolated as differences from "climate". This is supposed to minimize the interpolation error. The 12 monthly files per domain can be produced (only) in Meteo France by running the so called configuration 923 since the procedure requires the input database available there. The files for LACE (the common LBC domain for LACE) domain and HR88 (8km resolution operational) domain were produced by Meteo France while the climate files for 2 and 4 km resolution domains were produced by mrpm610 and mrpm620 :)

There are some features in the fields of climate files that are unrealistic and rather different from nature. This report describes how these features are corrected (or could be improved) in the climate files used for operational forecast.

## Introduction

There are 2 domains currently in use for operational forecast, the 8 km resolution HR88 and 2 km resolution HR22. In order to explore the potential benefits of moving to higher resolution on larger HR88 domain, a new set of climate files in 4 km resolution has been created that covers the same area as HR88 (Figure 1).

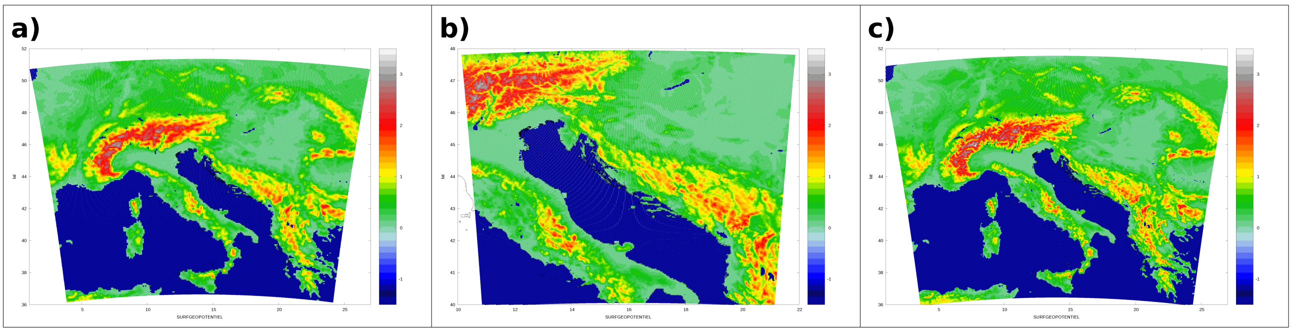


**Figure 1**. Domains covered and height of orography (multiplied by a function of the land sea mask, so that sea is dark blue) as represented by different domains HR88 (left) in 8 km resolution, HR22 (centre) in 2 km resolution and HR40 (right) in 4 km resolution.

There are extra land points along Adriatic coastline that yield some extra peninsulas along the Italian side and connect several large islands on the Croatian side to the mainland. These features are more obvious as one moves to higher resolution and produce difficulties when the data from the operational forecast is provided to oceanographers that run ocean and wave models coupled to these data.

Most of the climate variables have constant default values above the sea so correcting land points to the sea points can be done by replacing the values by the referent sea values. The exceptions are topography fields (orography, its standard deviation, anisotropy and main direction) that are left as they are, temperature fields that have to be interpolated from the sea points, percentage of land that has to be below 0.5 and upper air fields, such as aerosols and ozone that can be left as they are (see the chapter on peninsulas).

Fields describing surface roughness exhibit "chessboard" pattern over high mountains, especially Alps, that is worse in low resolution (8 and 4 km) than in the high resolution (2 km) files. This is corrected by applying smoothing on these fields (see the chapter on smoothing).

Several fields have identical values. Some fields are provided in low resolution, but with meaningful distribution over the domain. Other fields exhibit strange behaviour, possibly due to problems in interpolation. The summary is given in Table 1 that lists names of fields as provided in climate file, short description what the field represents, gives information if the field varies during the year (from one monthly file to the other), default value over the sea surface, range of the field (above land) for the HR88 domain and short note on the quality of the field and if any action has been performed in order to correct it.

**Table 1.** Fields in climate files and their properties.

| Variable name | Description | year | sea | Range | Quality and correction |
|---|---|---|---|---|---|
| SURFIND.TERREMER | Land/sea mask | no | 0 | 0 - 1 | Extra land points |
| SURFGEOPOTENTIEL | OUTPUT gp orography (*g) | no | - | -192- 29775 | ok |
| SURFET.GEOPOTENT | Std. dev. of orography (*g) | no | 0 | 0 - 9246 | ok |
| SURFVAR.GEOP.ANI | Anisotropy of topography | no | 1 | 0 - 1 | ok |
| SURFVAR.GEOP.DIR | Topography main direction | no | - | -1.71–1.71 | ok |
| SURFZ0.FOIS.G | Surface roughness (*g) | yes | 0.001 | 0.001-114.7 | 10*gz0therm, smooth |
| SURFZ0REL.FOIS.G | Roughness length (*g) | no | 0.001 | 0.001-113.8 | Chessboard, smooth |
| SURFGZ0.THERM | Heat roughness length (*g) | yes | 0.001 | 0.001-11.47 | Chessboard, smooth |
| SURFZ0VEG.FOIS.G | Vegetation roughness length | yes | 0 | 0-18.87 | Chessboard, smooth |
| SURFTEMPERATURE | Surface temperature (K) | yes | - | 259-305 | ok |
| PROFTEMPERATURE | Deep soil temperature | yes | - | 259-305 | Values as surftemp. |
| RELATEMPERATURE |  | Yes |  | 259-305 | Values as surftemp. |
| RELAPROP.RMAX.EA | Relax. deep soil wetness | yes | 1 | 0.14-1 | Could use improvement |
| SURFPROP.RMAX.EA | Clim. rel. surf soil wetn | Yes | 1 | 0.14-1 | values=relaprop.rmax.ea |
| PROFPROP.RMAX.EA | Clim. rel. deep soil wetn | Yes | 1 | 0.14-1 | values=relaprop.rmax.ea |
| SURFRESERV.NEIGE | Snow depth | yes |  | 0-71 | Could use improvement |
| SURFALBEDO | Albedo | yes | 0.07 | 0.07-0.35 |  |
| SURFEMISSIVITE | Emissivity | no | 0.96 | 0.96-0.975 | Could use improvement |
| SURFALBEDO.COMPL | Surf. albedo for non snow | no | 0.07 | 0.05-0.38 | vals = surfalbedo.solnu |
| SURFALBEDO.SOLNU | Surf. albedo for bare ground | no | 0.07 | 0.05-0.38 | vals = surfalbedo.compl |
| SURFALBEDO.VEG | Surf. albedo for vegetation | no | 0.05 | 0.05-0.2 | ok |
| SURFPROP.VEG.MAX | Maximum proportion of veg | no | 0 | 0-0.91 |  |
| SURFPROP.VEGETAT | percentage of vegetation | yes | 0 | 0-0.91 | Can > surfprop.veg.max |
| SURFPROP.URBANIS | Proportion of urbanisation | no | 0 (-) | 0-0.383 | ok |
| SURFPROP.TERRE | percentage of land | no | <0.5 | 0-1 | Correct for peninsulas |
| SURFPROP.ARGILE | Percentage of clay in soil | no | 3 | 3-58 | Low res, >0 over sea |
| SURFPROP.SABLE | Percentage of sand in soil | no | 6 | 6-92 | Low res, >0 over sea |
| SURFEPAIS.SOL | Soil depth | no | 8 | 0.7-8 | Larger than maximum |
| SURFEPAI.SOL.MAX | Maximum soil depth | no | 8 | 0.1-8 | Low resolution |
| SURFIND.VEG.DOMI | Index of vegetation | no | 1 | 1-4 |  |
| SURFRESI.STO.MIN | Stomatal minimum resistance | yes | 5000 | 40-200 |  |
| SURFIND.FOLIAIRE | Leaf area index | yes | 0 | 0.14-4 |  |
| SURFAEROS.SEA | Marine aerosols | yes | - | 0.001-0.01 | Low resolution |
| SURFAEROS.LAND | Continental aerosols | yes | - | 0.027-0.275 | Low resolution |
| SURFAEROS.SOOT | Carbon aerosols | yes | - | 0.002-0.045 | Low resolution |
| SURFAEROS.DESERT | Desert aerosols | yes | - | 0.002-0.18 | Low resolution |
| SURFA.OF.OZONE | First ozone profile (A) | yes | - | 0.054-0.072 | Low resolution |
| SURFB.OF.OZONE | Second ozone profile (B) | no | - | 3166 | Always = 3166.000000 |
| SURFC.OF.OZONE | Third ozone profile (C) | yes | - | 2.85-3.08 | Low resolution |
|  |  |  |  |  |  |

## Climate fields

### Terrain representation

Terrain height described as the surface geopotentiel (height of terrain multiplied by g=9.81). Mean orography is used, which means that the average terrain height is used for surface geopotentiel (as alternative to envelope orography that ads an envelope to this height so mountains appear to be higher). Other variables that describe the terrain in the climate files are fields of standard deviation of ororgraphy (multiplied by g=9.81), anisotropy and main direction of orography.

Terrain height is not zero or constant above the sea. Surface geopotentiel also has spectral representation used for the spectral space computations in the model dynamics. This is why surface geopotentiel varies around zero above the sea. The field is shown in Figure 2.

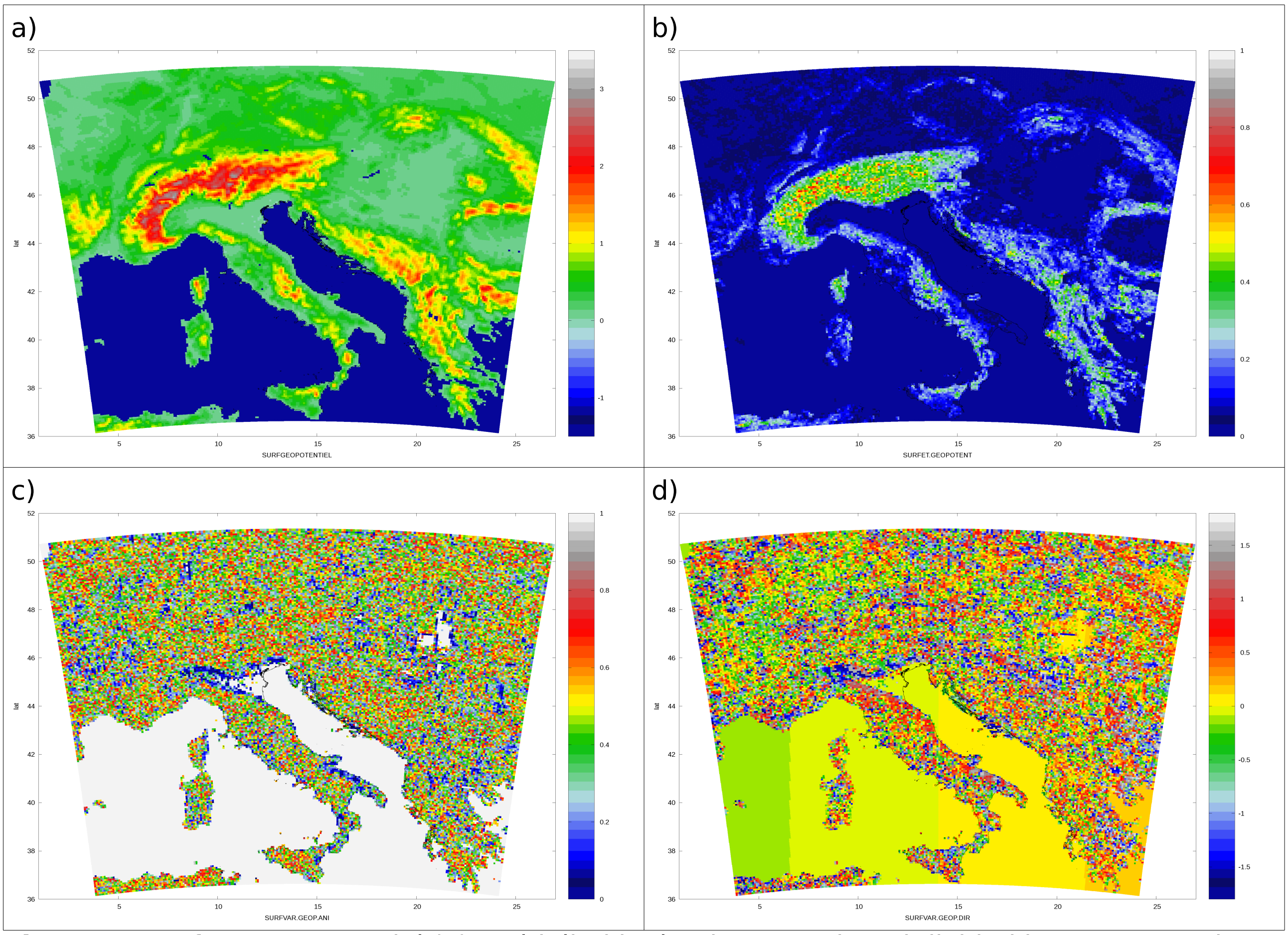


**Figure 2.** Surface geopotentiel (a) multiplied by land sea mask and divided by g=9.81 and 1000 to represent terrain height in km, standard deviation of orography (b) divided by g=9.81 and 1000, anisotropy of topography (c) and mean angle of topography (d) that varies from -pi/2 to pi/2 for the HR88 domain in 8 km resolution.

Standard deviation of orography (Figure 2b) has default value zero over the sea, while anisotropy is 1 (Figure 2c). Mean angle shows curvature of the earth over flat terrain, especially the sea surface (Figure 2d).
There are two peninsulas along Italian coast of Adriatic that do not exist in nature. The figures above are from the 8 km resolution climate files. The removal of extra peninsulas from the climate files will be described later in the text. Also, there are fields describing surface roughness that will be described later since these fields required corrections.

## Aerosols

There are four fields describing monthly climatologies of aerosol, for marine (Figure 3c), continental (Figure 3b), carbon (Figure 3d) and desert (Figure 3a) aerosols. All these aerosols are represented in rather low resolution. The fields have reasonable distribution and vary significantly during the year. We could test alternatives, using monthly averages derived from the satellite measurements, such as from MODIS data and other sources of aerosol measurements.

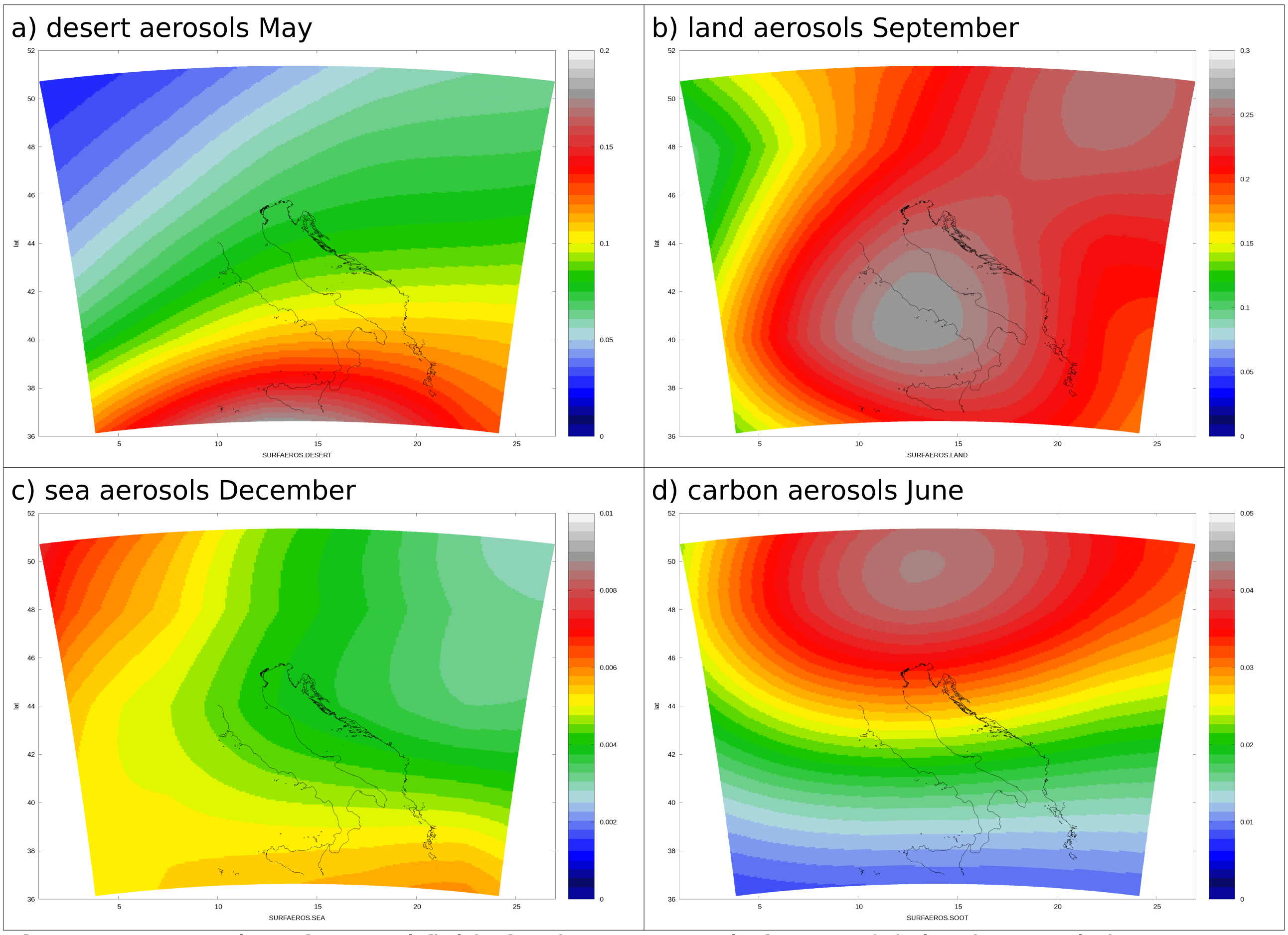


**Figure 3.** Examples of aerosol fields for desert aerosols for May (a), land aerosols in September (b), sea aerosols in December (c) and carbon aerosols in June (d) for the HR88 domain in 8 km resolution.

These fields should represent long term climatological averages for the given month, so smooth fields with low spatial variability are probably the best option to use.

## Ozone ABC profile fields

The fields that describe spatial variability of ABC ozone profiles are represented in rather low resolution. They have considerable variability during the year (as expected), except for B that has a constant value in time and space. It would be interesting to examine if the ozone profile fields could benefit from climatology derived from more recent satellite measurements. These fields are used as background when the fields from the coupling files (and resolution and grid) are interpolated to the operational forecast grid so that the difference from climatology is interpolated, not the values themselves. As for aerosols, smooth low resolution fields are probably most reasonable representation (figure 4).

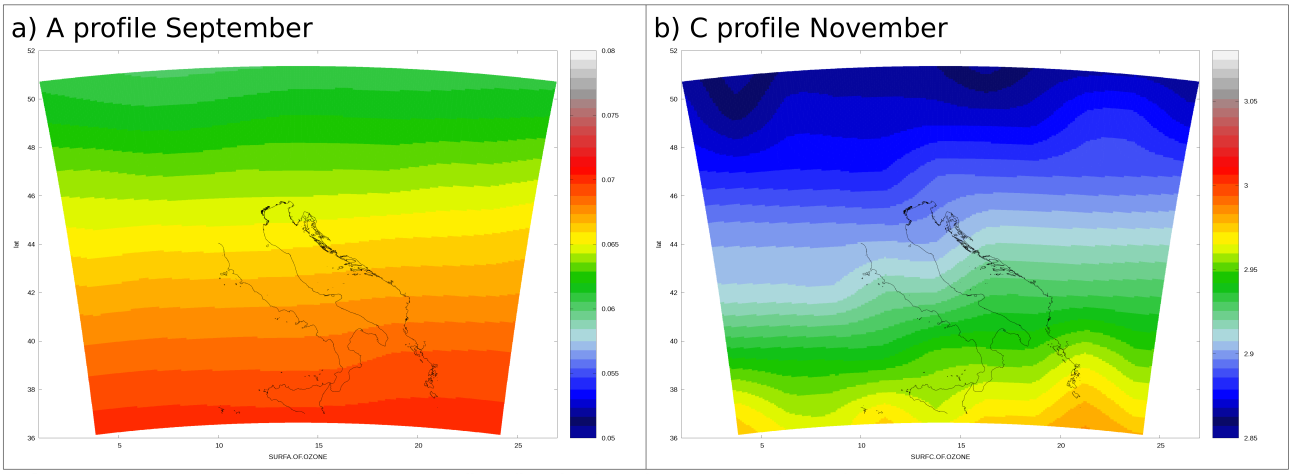


**Figure 4.** Examples of ozone profile fields for the HR88 domain in 8 km resolution.

## Albedo and surface emissivity

Surface albedo and emissivity determine heat balance of the soil surface with respect to the budget of short wave and long wave radiation at surface. Fortunately, the fields from the climate files are used only as background. Several fields have rather questionable features as a consequence of poor resolution and probably inadequate interpolation. Fields of albedo of bare ground and not snow covered surfaces have identical values (Figure 5c). Surface emissivity (Figure 5b) and albedo of bare ground show features difficult to explain by any physical reasoning. Only surface albedo (Figure 5a) varies during the year, while albedo of bare ground and vegetation (Figure 5d) do not change.

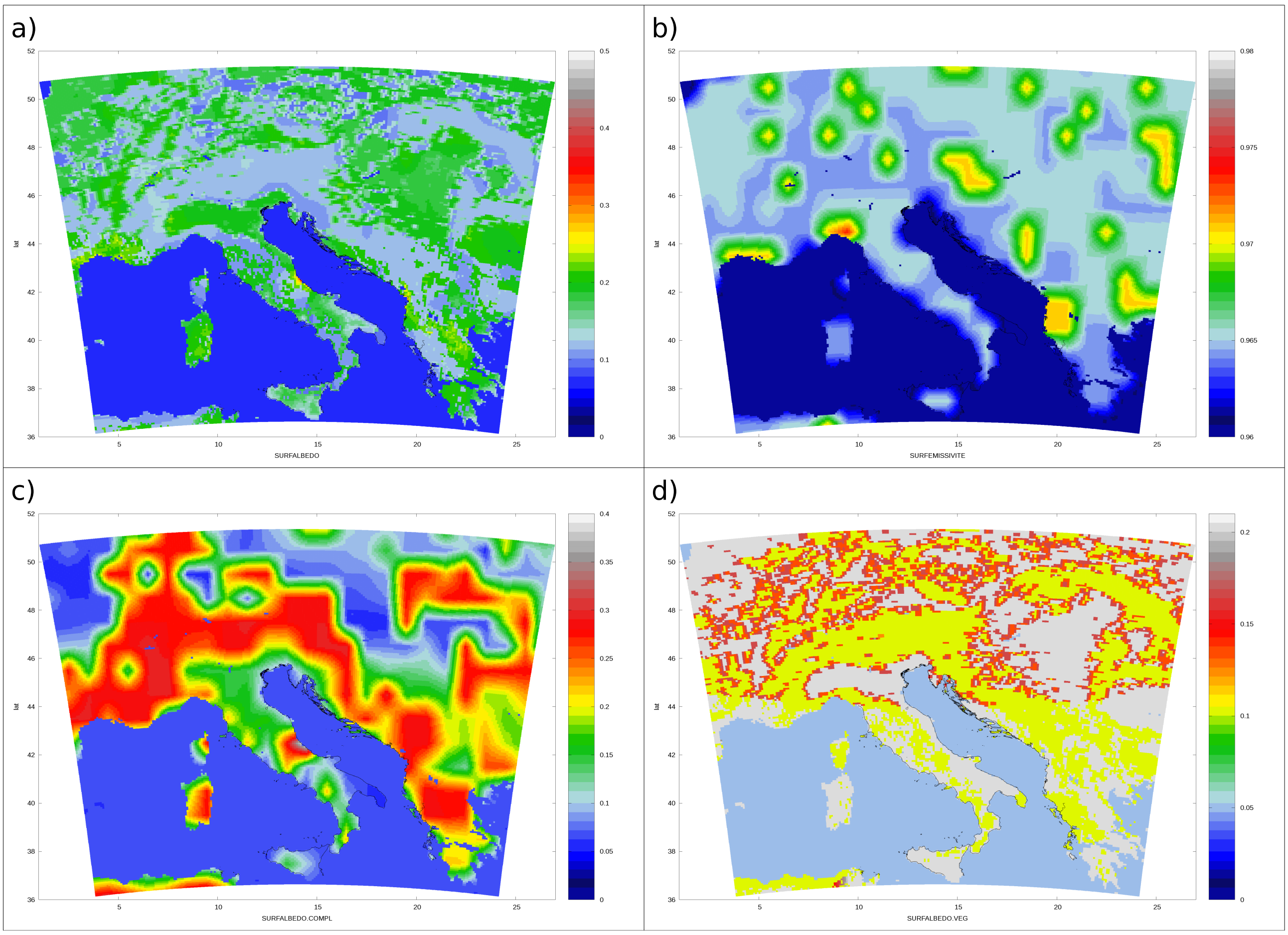


**Figure 5.** Examples of surface albedo (a), emissivity (b), albedo for non snow (c) and vegetation albedo (d) for the HR88 domain in 8 km resolution.

## Soil depth and type

Field that describes soil depth varies from 0.7 to 3.5 over land, while the value for sea is set to 8. This field is limited by another field – the maximum soil depth, that varies from 0.1 to 3.5 over land and is set to 8 over water. Maximum soil depth suffers from poor horizontal resolution and inadequate interpolation. Consequently, it has lower values than the soil depth field on many locations (Figure 6).

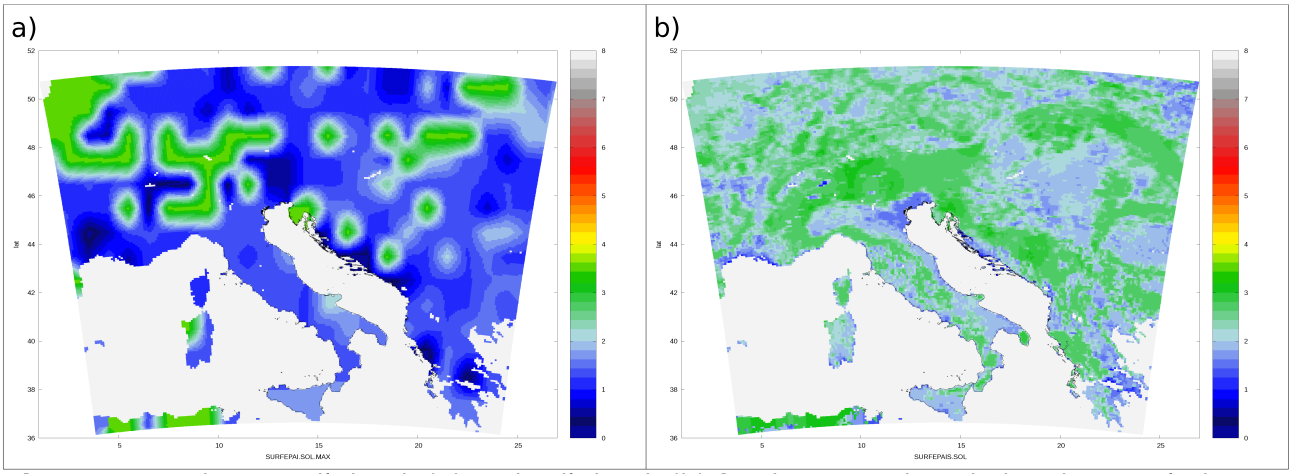


**Figure 6.** Maximum soil depth (a) and soil depth (b) for the HR88 domain in 8 km resolution.

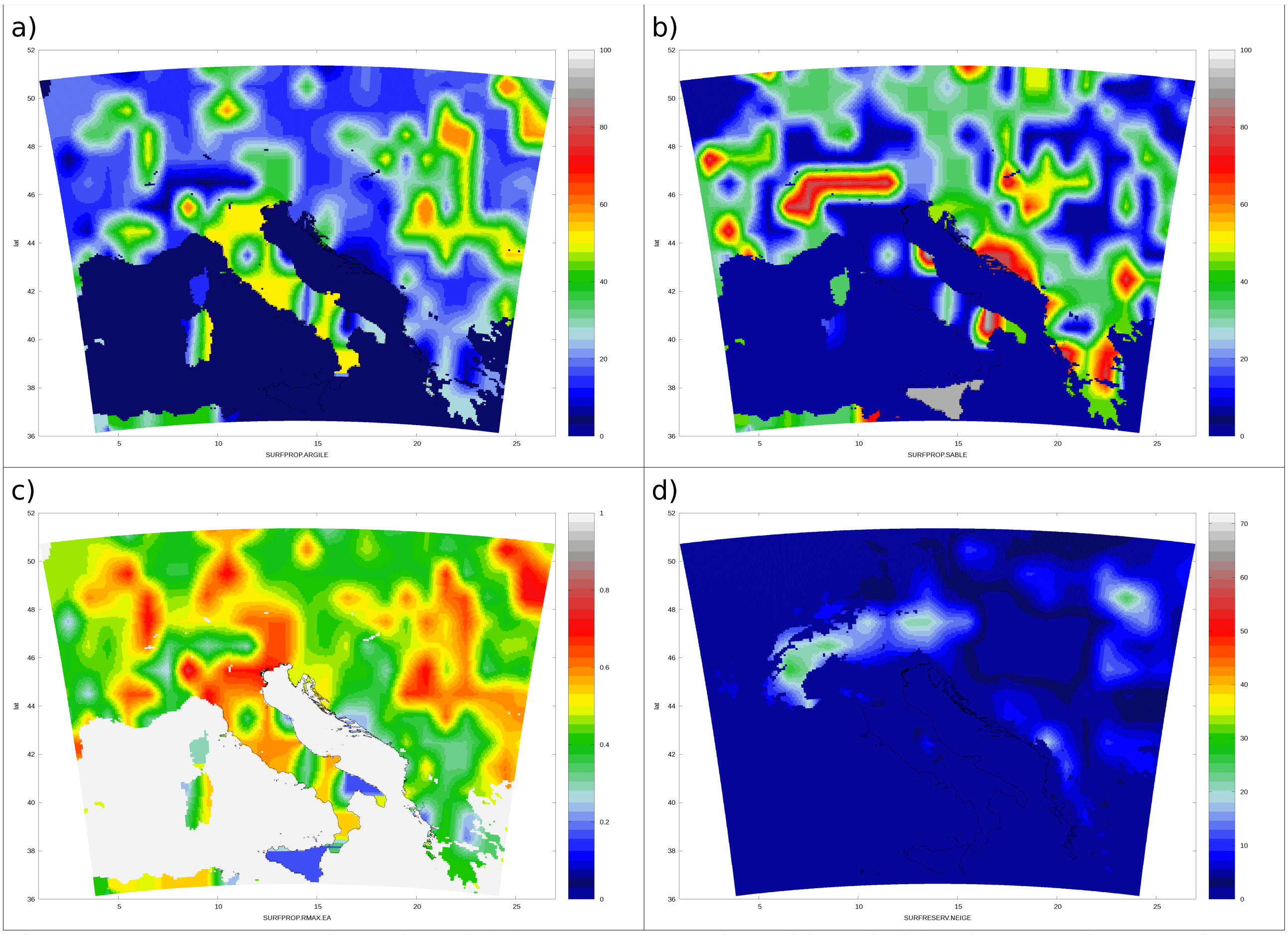


**Figure 7.** Percentage of clay in soil (a), percentage of sand in soil (b), climatological relative surface soil wetness (c) and snow depth (d) for the HR88 domain in 8 km resolution.

Unfortunately, other fields describing the soil, such as percentages of clay (Figure 7a) and sand (Figure 7b) in the soil also exhibit unrealistic features. Sicily is a special case since apparently there is no data in the database that describe the soil there, so the values are features of the interpolation procedure, not the real data. Such features encourage investigation of alternative sources for these data.

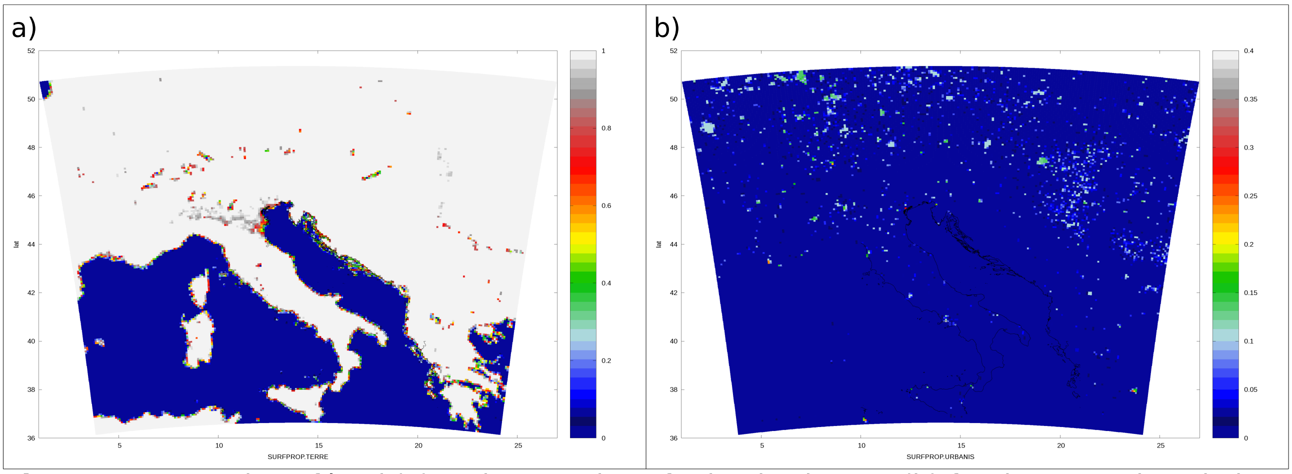


**Figure 8.** Proportion of land (a) and proportion of urbanised areas (b) for the HR88 domain in 8 km resolution.

## Vegetation

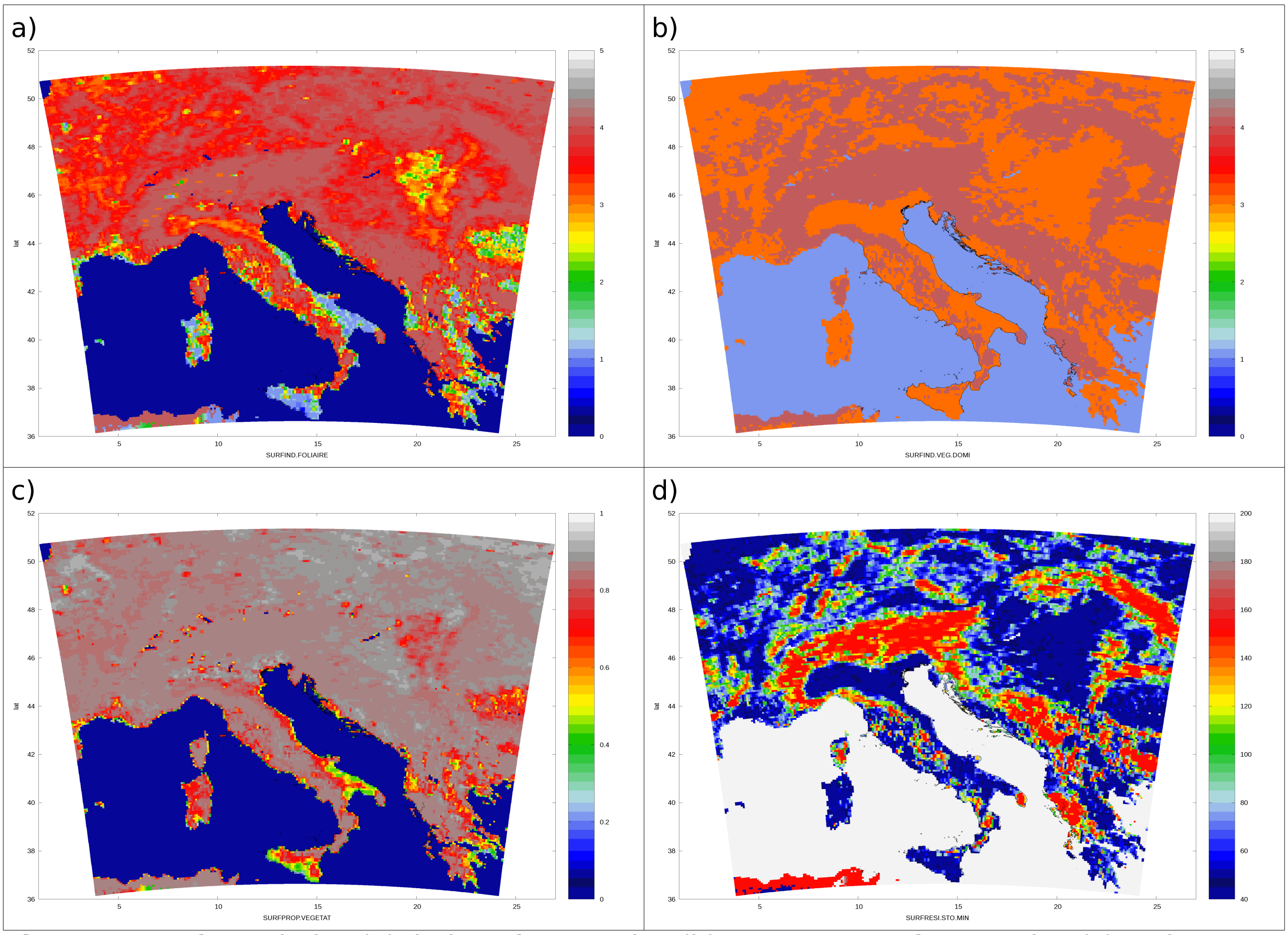


**Figure 9.** Leaf area index (a), index of vegetation (b), percentage of vegetation (c) and stomatal minimum resistance (d) for the HR88 domain in 8 km resolution.

Vegetation index (Figure 9b) is constant during the year, while leaf area index (Figure 9a) and percentage of vegetation (Figure 9c) vary. Stomatal minimum resistance field (Figure 9d) changes from one month to the other but only for a small patch of land in the north of Tunisia.

## Correcting surface roughness

Surface roughness fields exhibit a chess board pattern above high mountains. The figures of the fields were plotted by plotting a small square on the latitude – longitude position of the grid-point in the colour determined by the value of the surface roughness. This way any interpolation imposed by the graphics package was avoided.

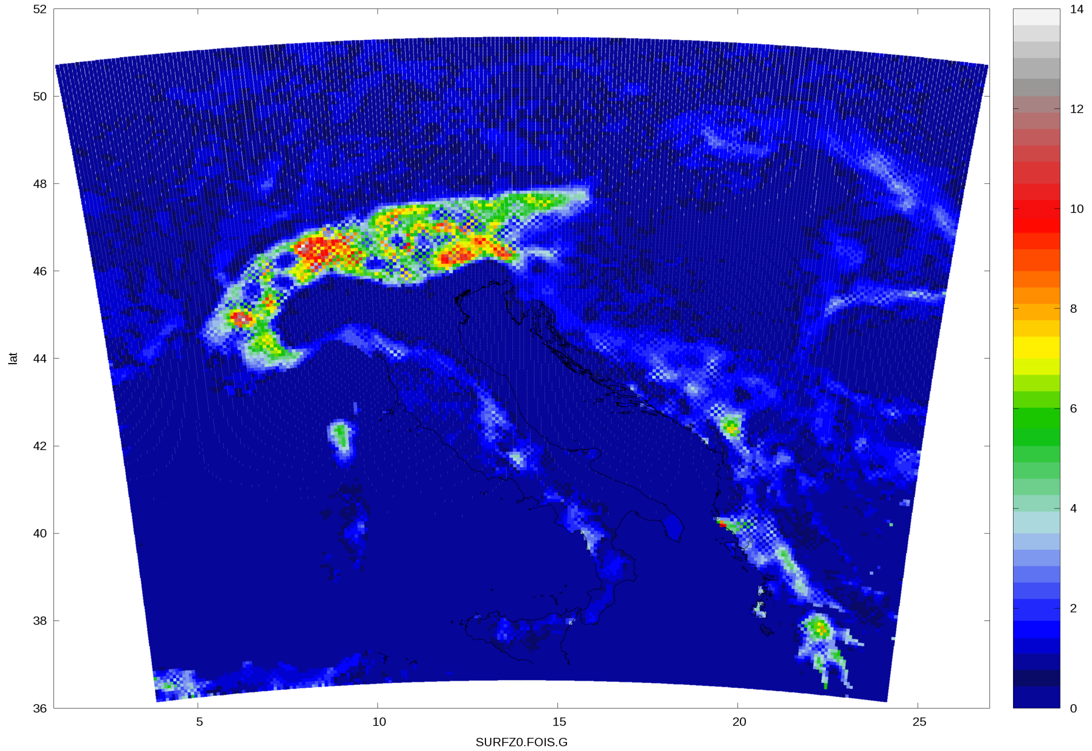


**Figure 10**. Surface roughness from the HR88 domain climate files as provided by Meteo France.

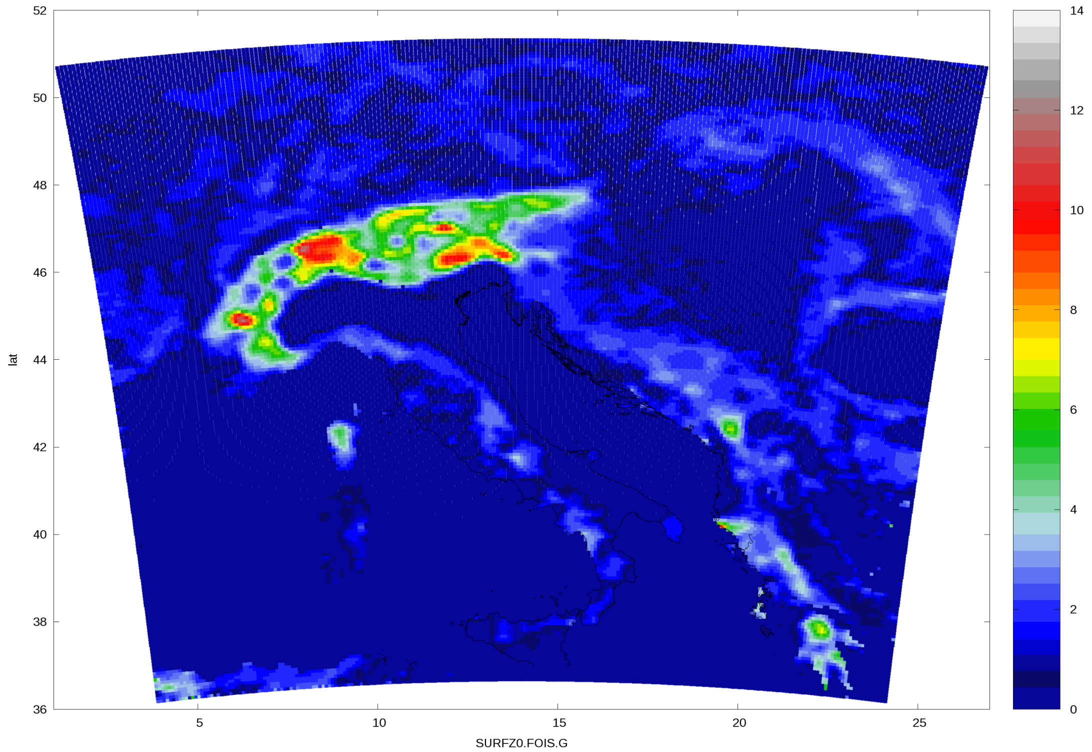


**Figure 11**. As Figure 2, after smoothing is applied.

Figure 10 shows surface roughness field SURFZ0.FOIS.G as provided in the climate file that exhibits an unnatural chessboard pattern over high mountains. Similar pattern is obvious in other surface roughness fields, such as for temperature, relaxation and less pronounced in the roughness for vegetation. All these fields have been smoothed using the same parameters and the same function. The resulting field for surface roughness in 8 km resolution is shown in Figure 11.

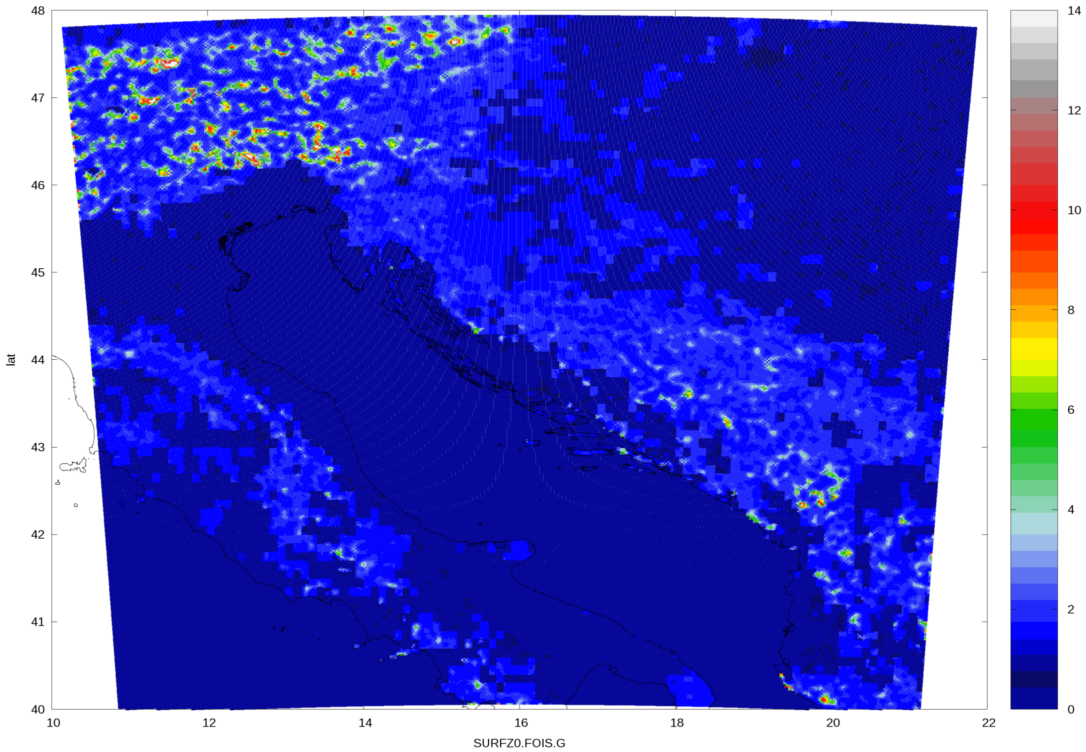


**Figure 12**. Surface roughness from the HR22 domain climate files in 2 km resolution.

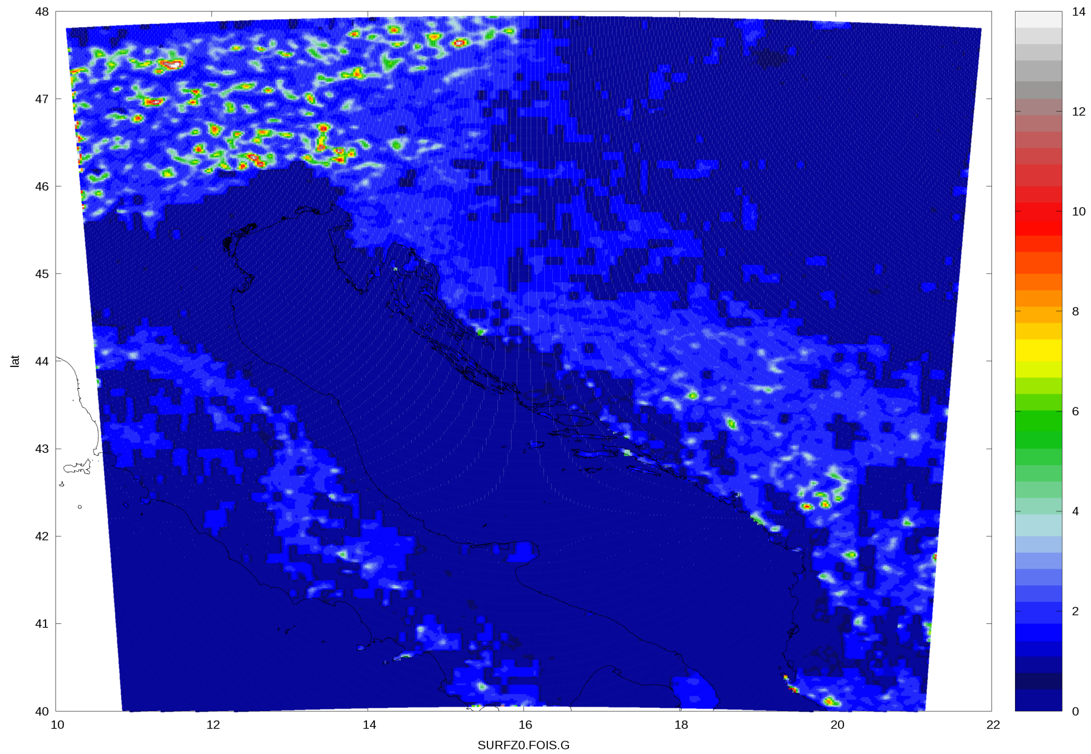


**Figure 13**. Surface roughness from the HR22 domain climate files in 2 km resolution after smoothing.

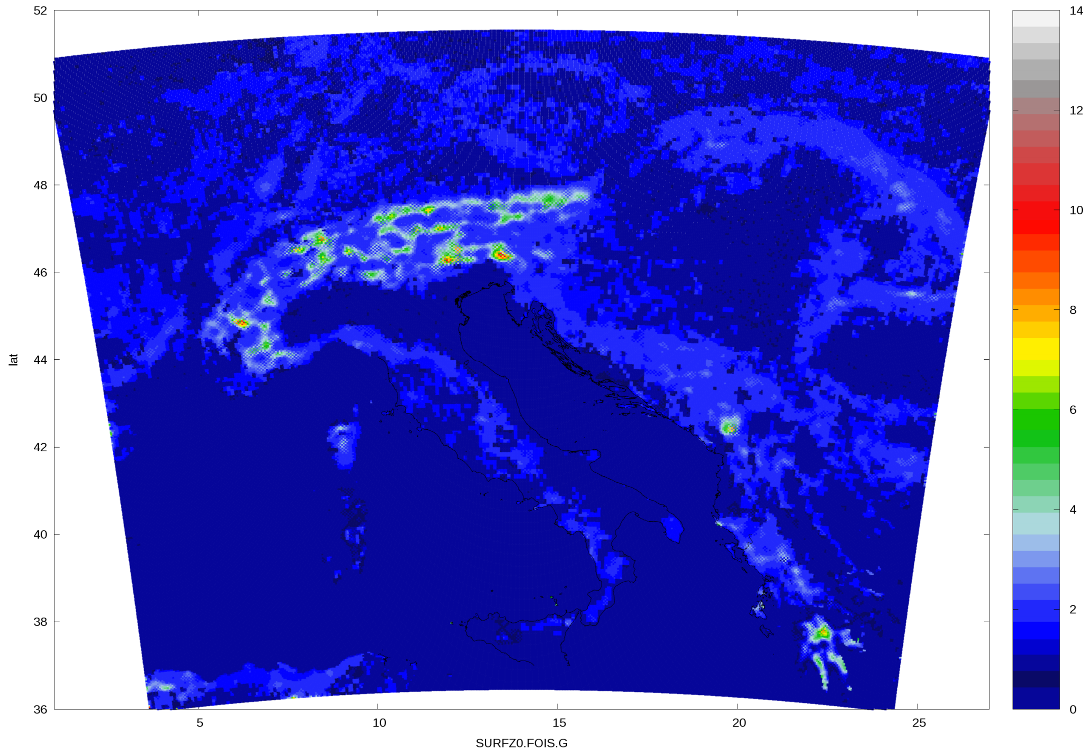

**Figure 14.** Surface roughness from HR40 domain climate files in 4 km resolution.

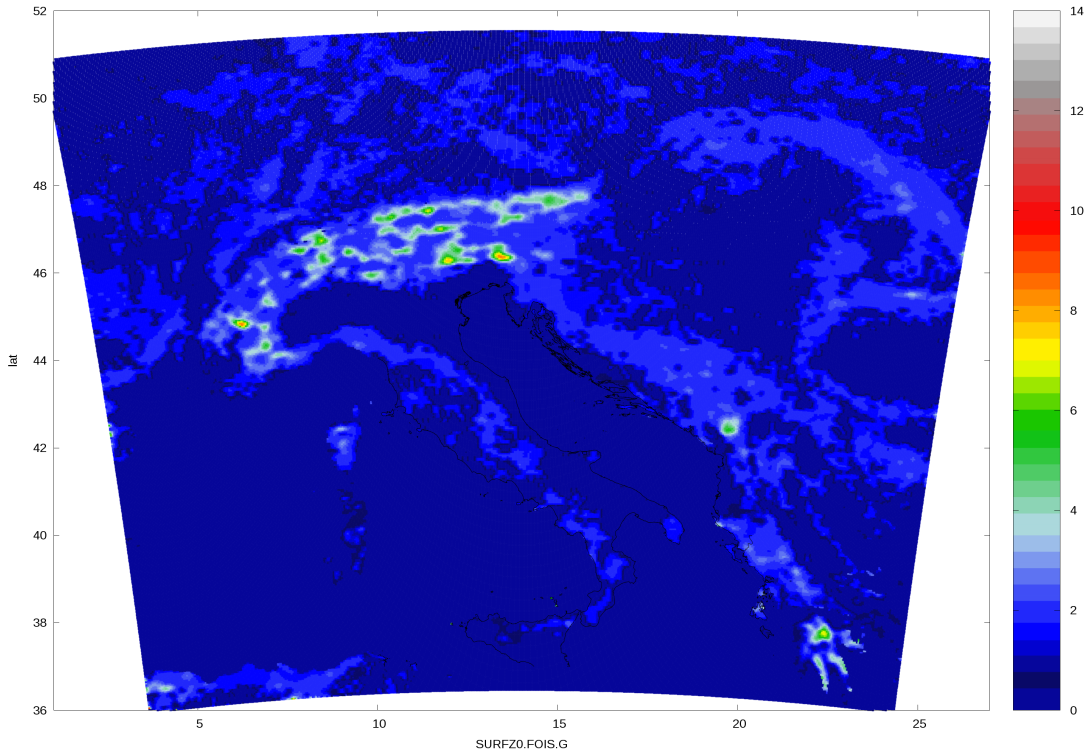

**Figure 15.** Surface roughness from HR40 domain climate files in 4 km resolution after smoothing.

The problem of the chessboard pattern above mountains is far less pronounced in high resolution climate files created for HR22 domain in 2 km resolution (Figure 12) but rather intensive in 4 km resolution (Figure 14). Similar smoothing, but using different parameters has been applied to the 2 km fields (Figure 13) and the 4 km resolution fields (Figure 15). Smoothing is applied to all the roughness fields: total surface roughness for momentum, thermal surface roughness, relaxation and vegetation surface roughness. The vegetation surface roughness is responsible for the square patches that can be seen in valleys due to large differences if the land is covered by grass or trees (Figure 16).

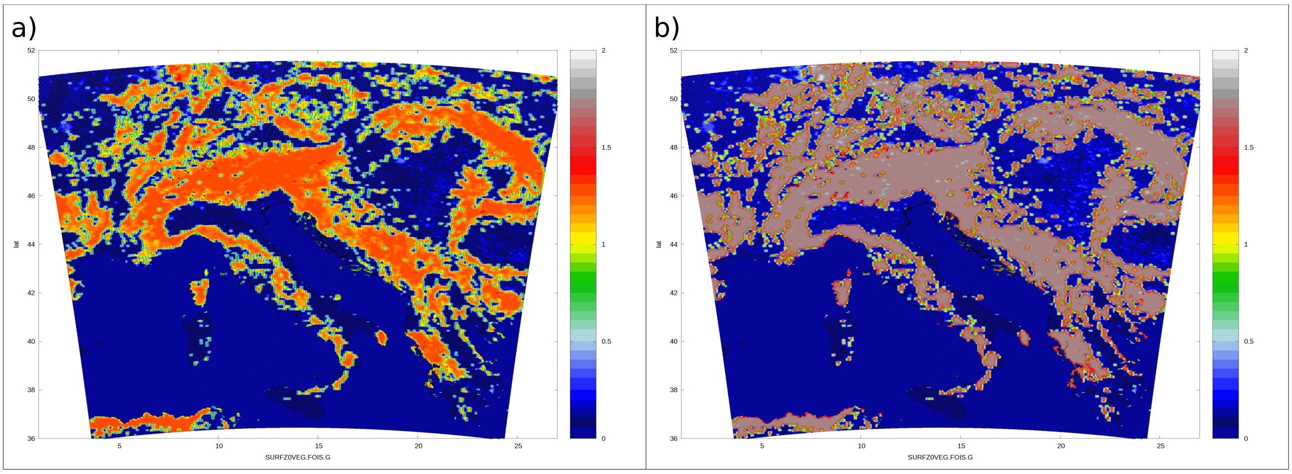


**Figure 16.** Surface roughness due to vegetation for January (a) and July (b), 4 km resolution.

Surface roughness has a significant impact to the forecast of 10 m wind. It could be further improved at certain locations. For example surface roughness could be estimated from the wind measurements for a certain location in order to improve 10 m wind forecast (or forecast for some other height above ground). Also, if the gustiness varies depending on the wind direction, this could help determine more realistic surface roughness for few grid-points upstream, at least in high resolution. As a result, forecast wind speed should improve when compared to the measurements, especially in high resolution and in dynamical adaptation mode.

## Removal of false peninsulas

In the climate fields, there are two extra peninsulas on the Italian side of the Adriatic coast that do not exist in nature (Figure 17a). Also, several large islands are connected to the mainland on the Croatian side of the Adriatic coast. These false land points are turned into the sea points. The features are more pronounced in higher resolution. It is expected that these features have an impact on the local forecast of surface parameters as well as on the forecast of the 2m and 10m parameters measured on the stations nearby.

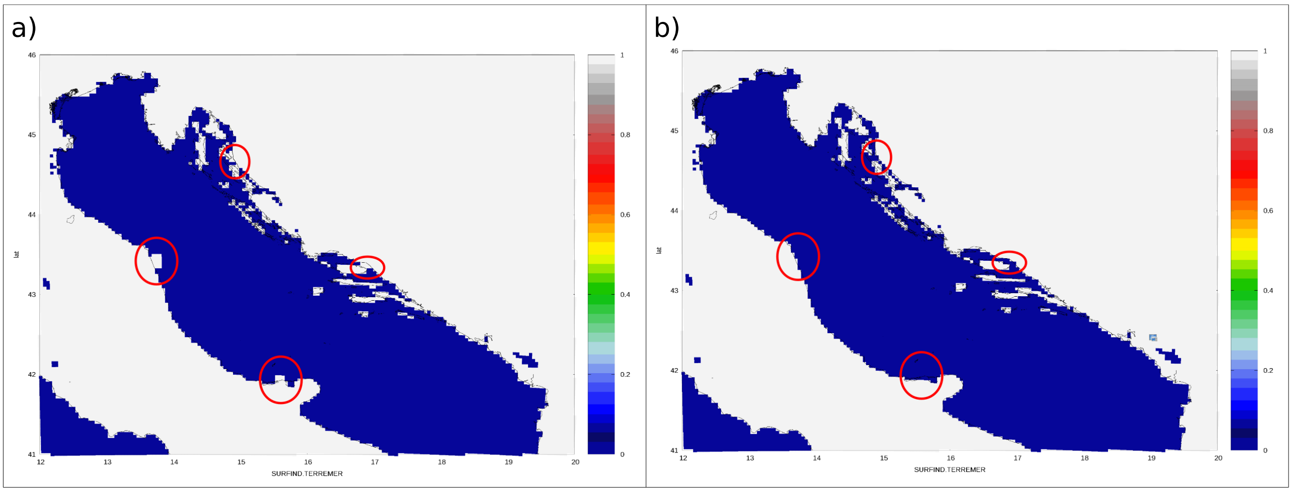


**Figure 17.** Land-sea mask from the climate files before the correction (a) and after the correction (b) for domain HR40 in 4 km resolution.

Land sea mask values are set to 0 in those grid-points (Figure 17b). Other climate fields are set to the default sea values, with the exception of geopotentiel, ozone and aerosol fields that remained the same. The land proportion field was set to values below 0.5 (Figure 18). The temperature fields are taken from the sea points nearby.

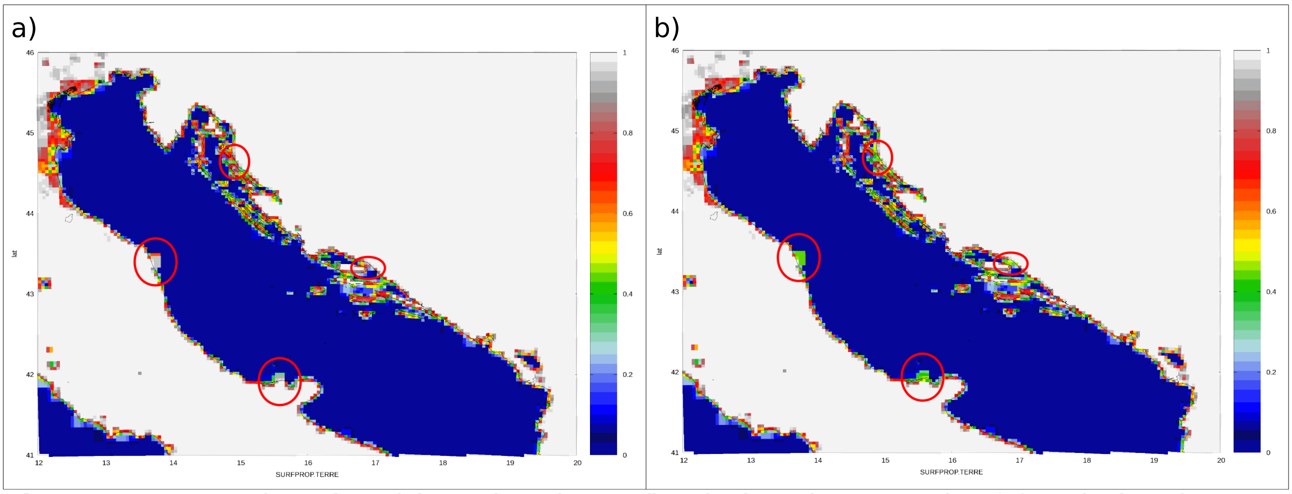


**Figure 18.** Proportion of land from the climate files before the correction (a) and after the correction (b) for domain HR40 in 4 km resolution.

The impact of the proposed corrections on the model forecast remains to be tested. Script that would set the values of climate fields to default sea values for the given list of points is under development. This should semi-automate the procedure since it has to be done for 30 fields in 12 monthly files.

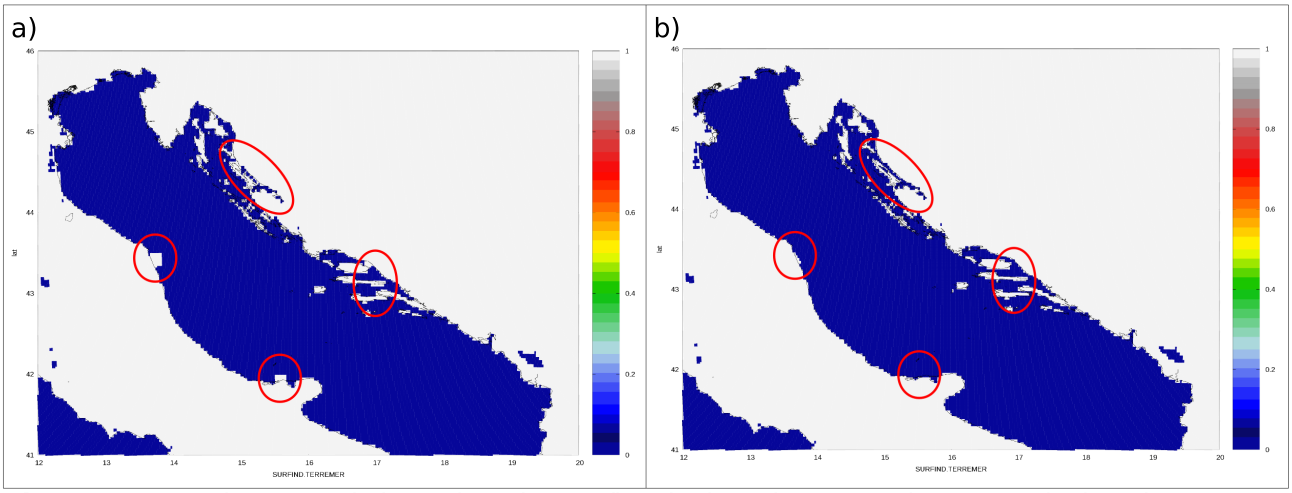


**Figure 19.** Land-sea mask from the climate files before the correction (a) and after the correction (b) for domain HR22 in 2 km resolution.

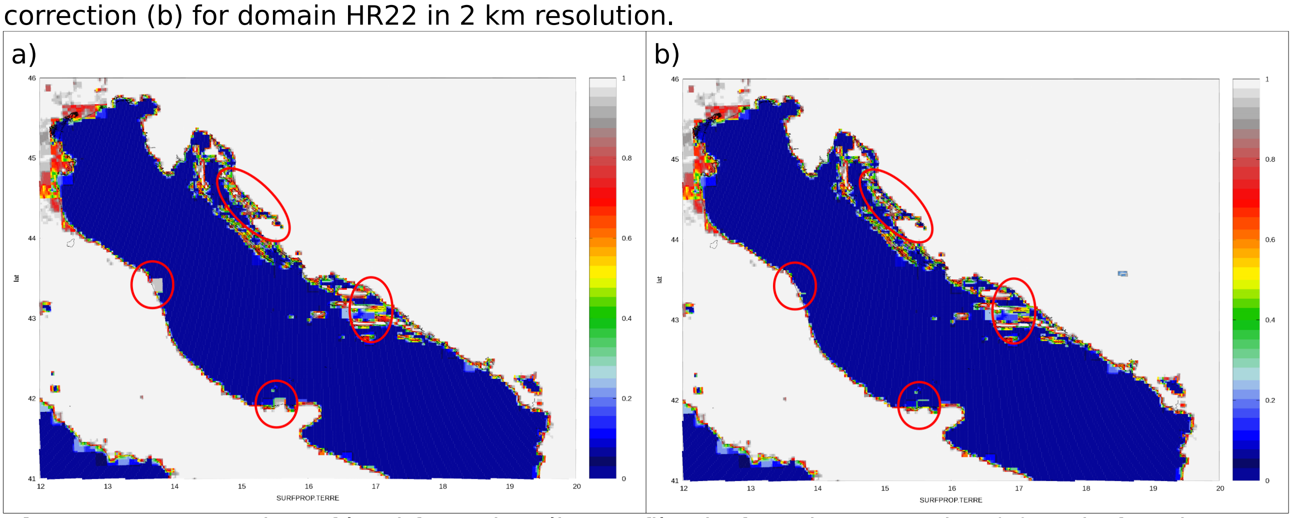


**Figure 20.** Proportion of land from the climate files before the correction (a) and after the correction (b) for domain HR22 in 2 km resolution.