Roughness length determination and tests

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Motivation: preparations for ALARO with SURFEX

With SURFEX we get, with respect to ISBA:

– **Different and more advanced databases of topographic and other surface data**;

– **Possibility to use new schemes.**

Validation in two ways:

– Experiments with ALARO-SURFEX while trying to eliminate databases influence;

– Enhancing the existing operational ALARO (using still ISBA) by moving at least partly to new databases.

Topographic characteristics - summary

Standard procedure combining the “PGD” file preparation and the e923 (923) configuration:

– **Orography and Land-Sea Mask**:

Calculated from GMTED2010, either with 30” or 7.5” resolution in PGD;

Orography is spectrally fitted (quadratic grid) in e923 (923).

– **Sub-grid orography characteristics needed in “Gravity wave drag” parameterizations family**

Variance, Anisotropy and Orientation:

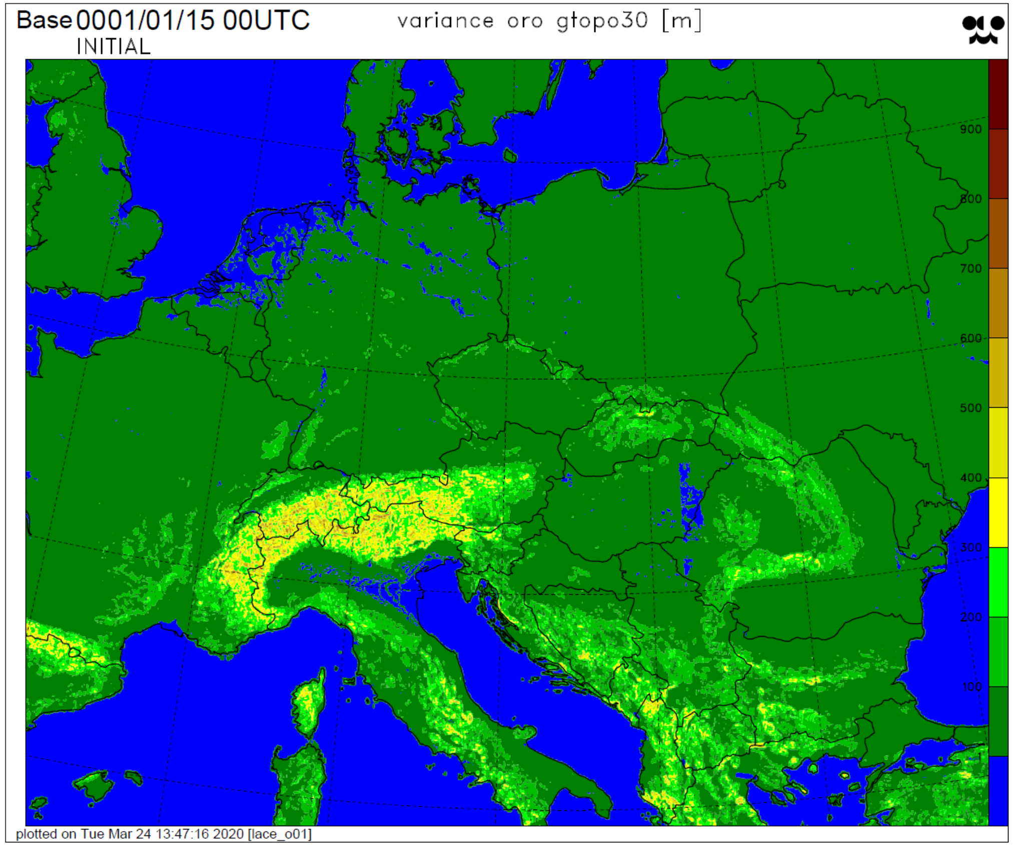
Calculated from the old GTOPO30 database in e923 (923).

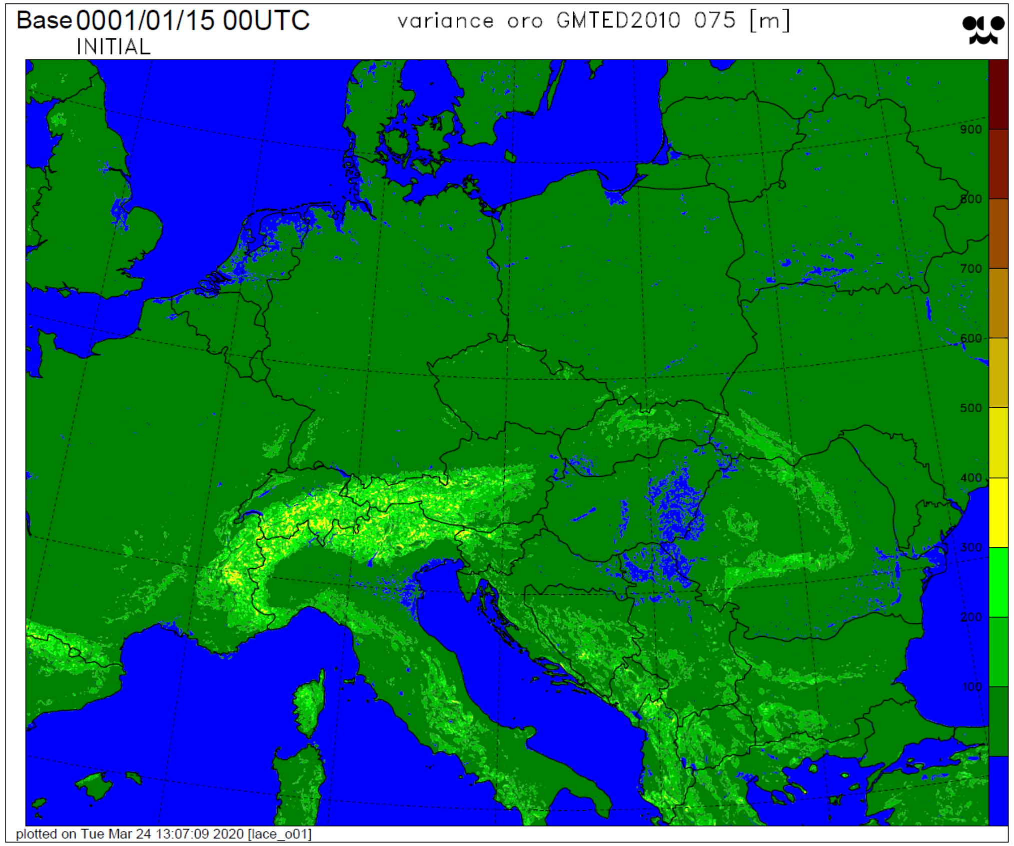
– **Sub-grid orography characteristics needed in turbulence:**

Orographic roughness

Calculated from the old GTOPO30 database in e923 (923), if not SURFEX.

Orographic variance fields - example





Left: orographic variance calculated from the old database GTOPO30. Right: orographic variance calculated from GMTED2010 with 7.5” resolution. Model grid: 2 325 m.

Clearly, new database yields less variance.

First comparisons of fields and model response

The logical goal is to use the GMTED2010 database also for sub-grid scale topographic features.

– Comparing sub-grid scale orographic variance (previous slide):

  There is less variance compared to the old GTOPO30 database;

  By consequence, the parameterizations of sub-grid-scale orographic effects on the flow are less active;

– Comparing orographic roughness (more on the slides to come):

  It is higher compared to the old GTOPO30 database;

Combining the two effects, at least regarding the impact close to the surface, we can aim at removing the “GWD” parameterizations at resolutions higher than say 3 km, as expected.

Orographic roughness

Questions:

– **What about the roughness reduction factor:**

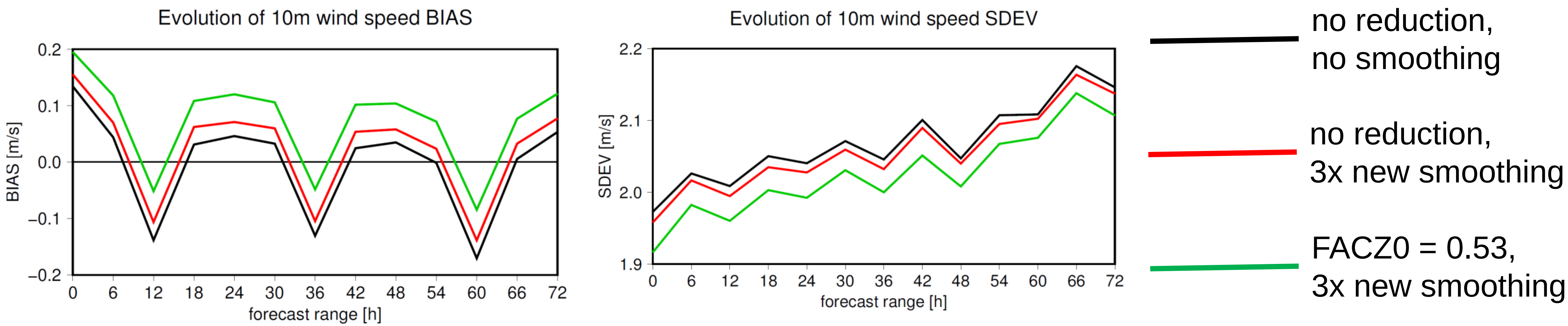
FACZ0 = 0.53 has been used since years while with SURFEX it is set to FACZ0=1.; i.e. there is no reduction;

– **What about smoothing the roughness:**

In e923 a smoothing has been applied 3 times (NLISSZ=3).

However the e923 smoothing operator gets problems for high resolution target grids => we propose to use a standard Laplace-type smoothing operator instead.

Orographic roughness tuning

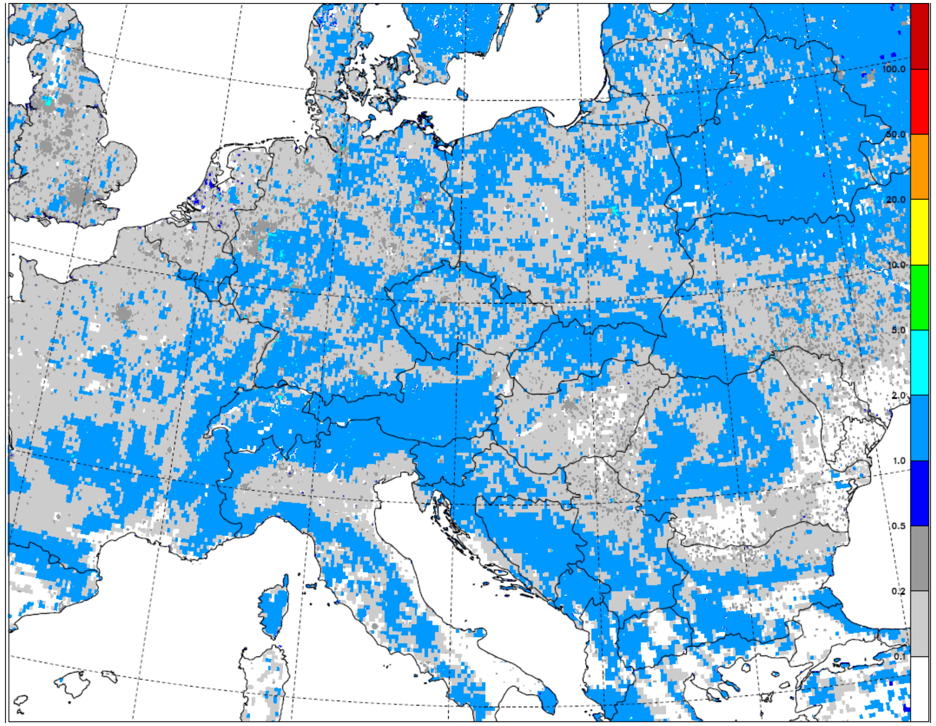


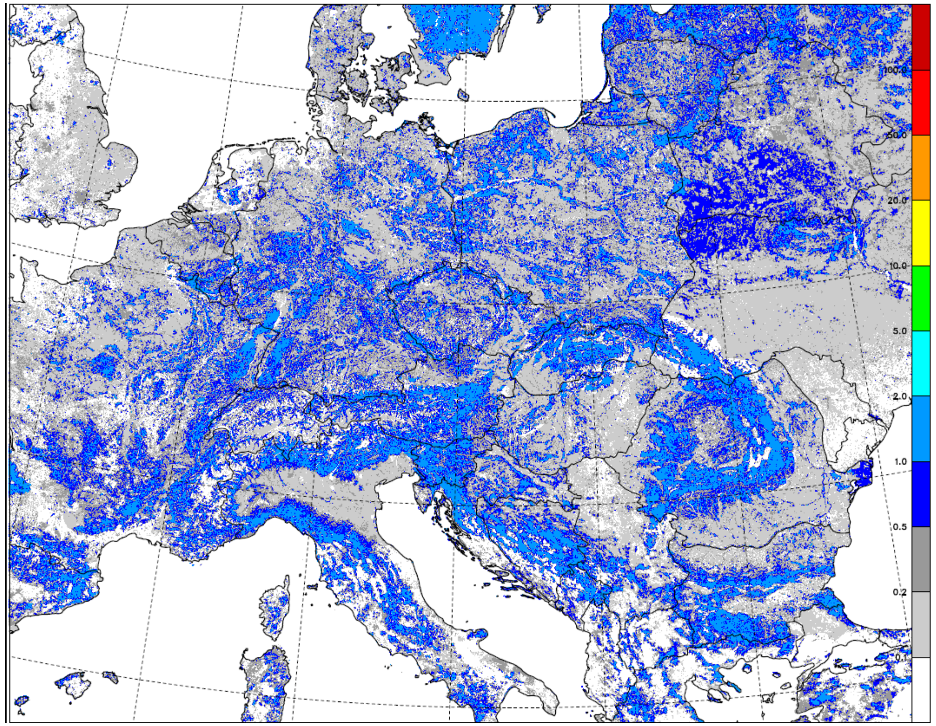
Wind speed at 10 m: bias (left) and standard deviation (right) for three experiments with different choice of the orographic roughness, see the legend. Verification domain: Central Europe, period November 2019.

Smoothing and reduction of orographic roughness increases naturally the wind speed a bit, at the same time it reduces the random error.

The old choice of FACZ0 = 0.53 seems somehow unbeatable.

Going further – vegetation roughness

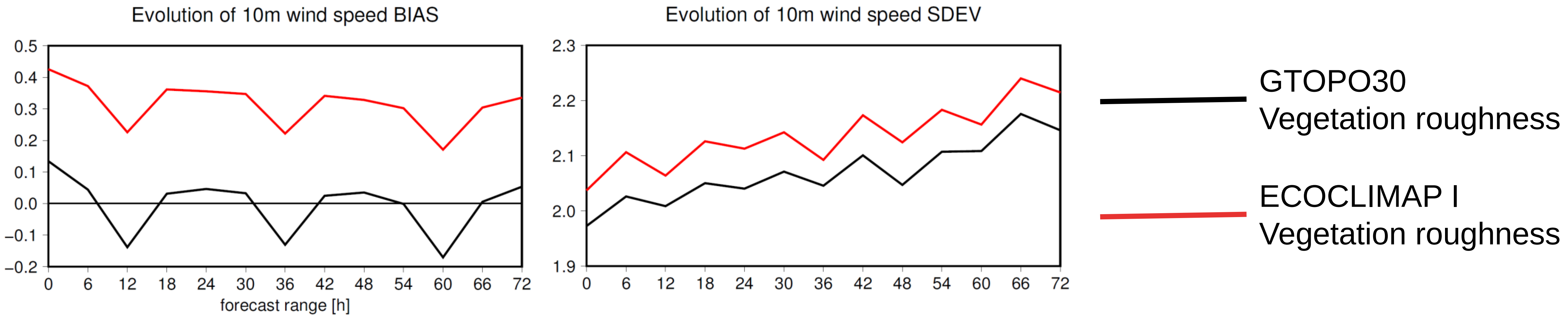




Left: vegetation roughness calculated from the old e923 database; Right: idem from ECOCLIMAP I; July maps.

The ECOCLIMAP I database gives more detailed field but quite lower roughness in general.

ECOCLIMAP I vegetation roughness results

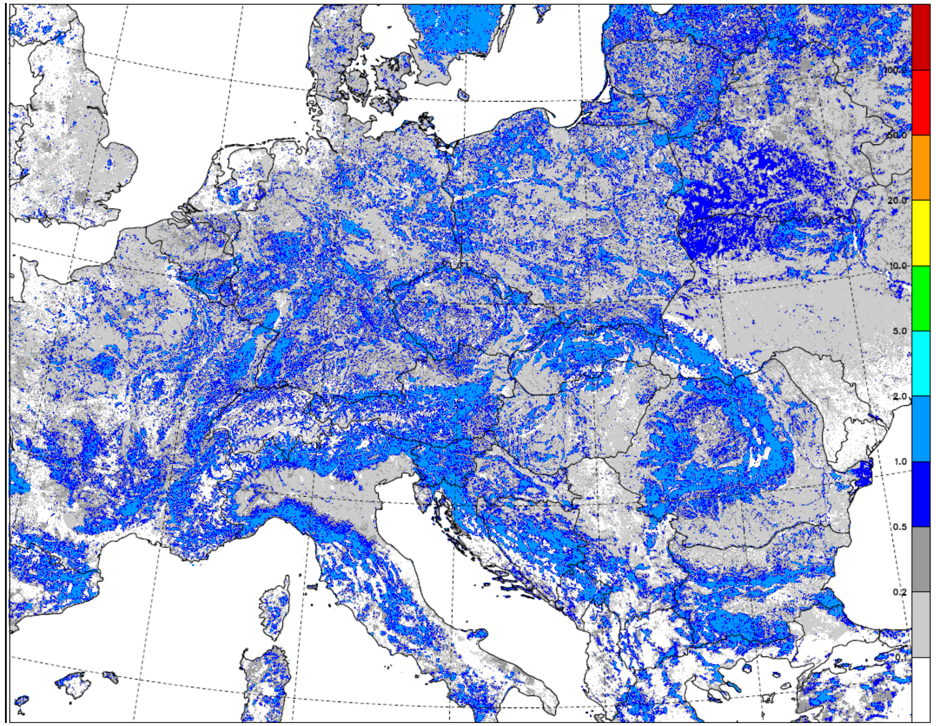


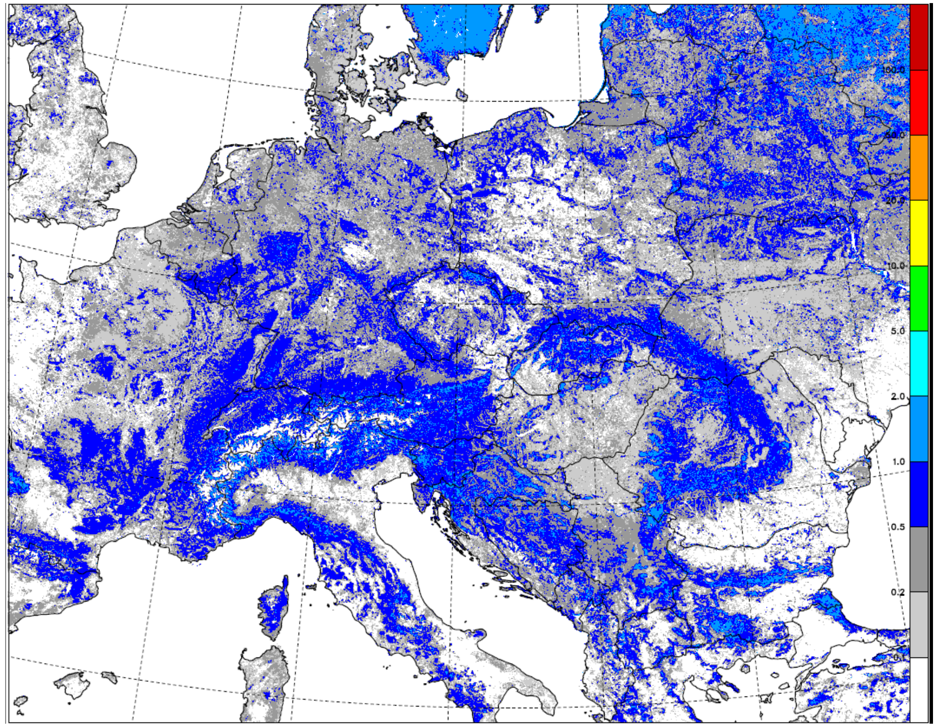
Wind speed at 10 m scores over Central Europe, period in November 2019.

Increased Bias shows insufficient roughness, the wind speed is stronger.

Random error is also bigger.

Vegetation roughness – ECOCLIMAP II





Left: vegetation roughness calculated from ECOCLIMAP I; Right: idem from ECOCLIMAP II; July maps. Clearly, there are quite some differences in structures.

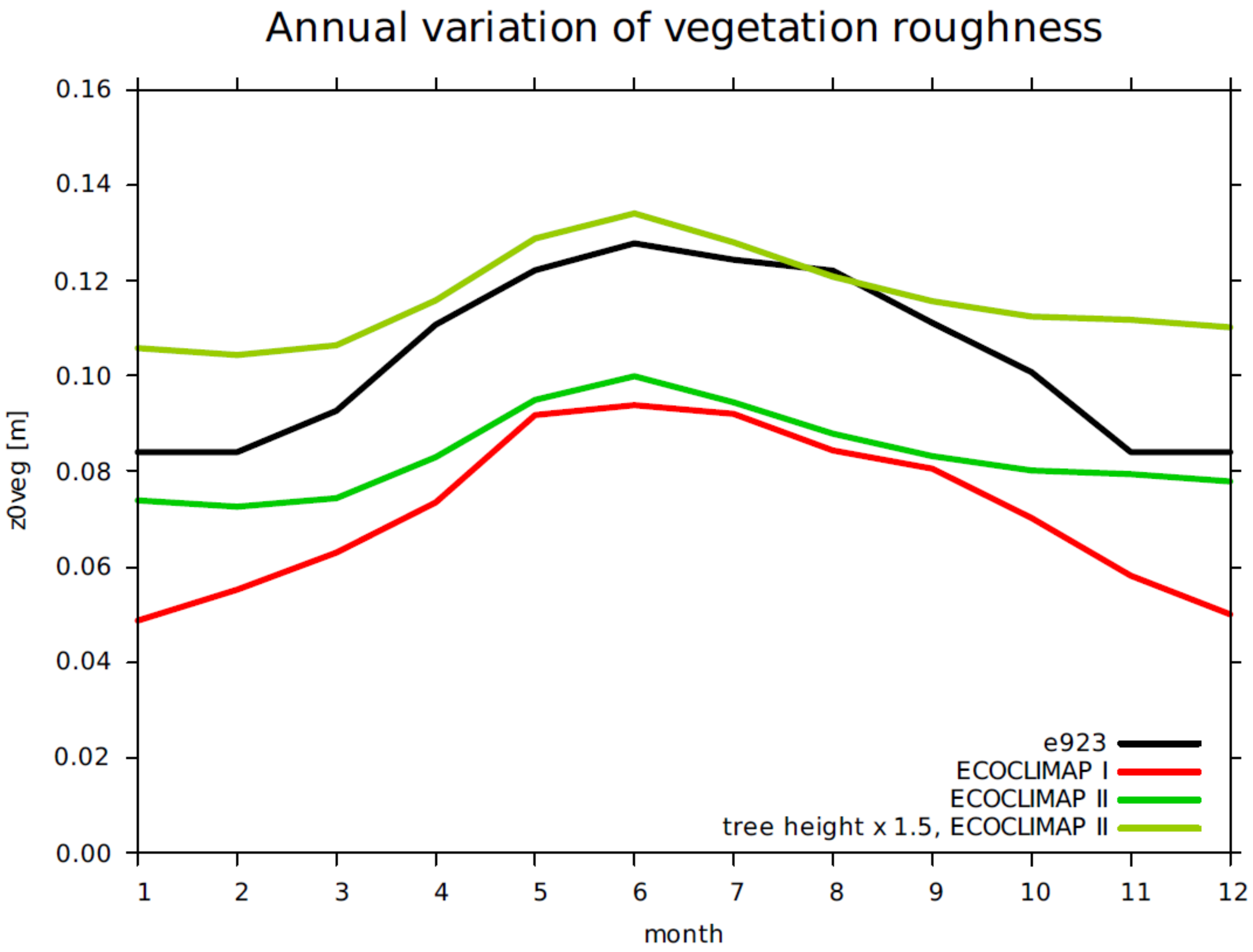
Vegetation roughness – annual magnitude

Vegetation roughness comparison over Central Europe from different databases, annual overview.

ECOCLIMAP I: it copies the e923 solution but is systematically lower.

ECOCLIMAP II: it has a different annual shape – in cold season we get more roughness, while in summer it is comparable to ECOCLIMAP I.

Multiplying the tree height by 1.5 gives us a plausible solution for getting a right model response.



Proposal for the next e-suite

– Use the orographic roughness calculated from the GMTED2010 database with the tuning:

FACZ0 = 0.53;

Laplace-type smoothing operator applied 3 times.

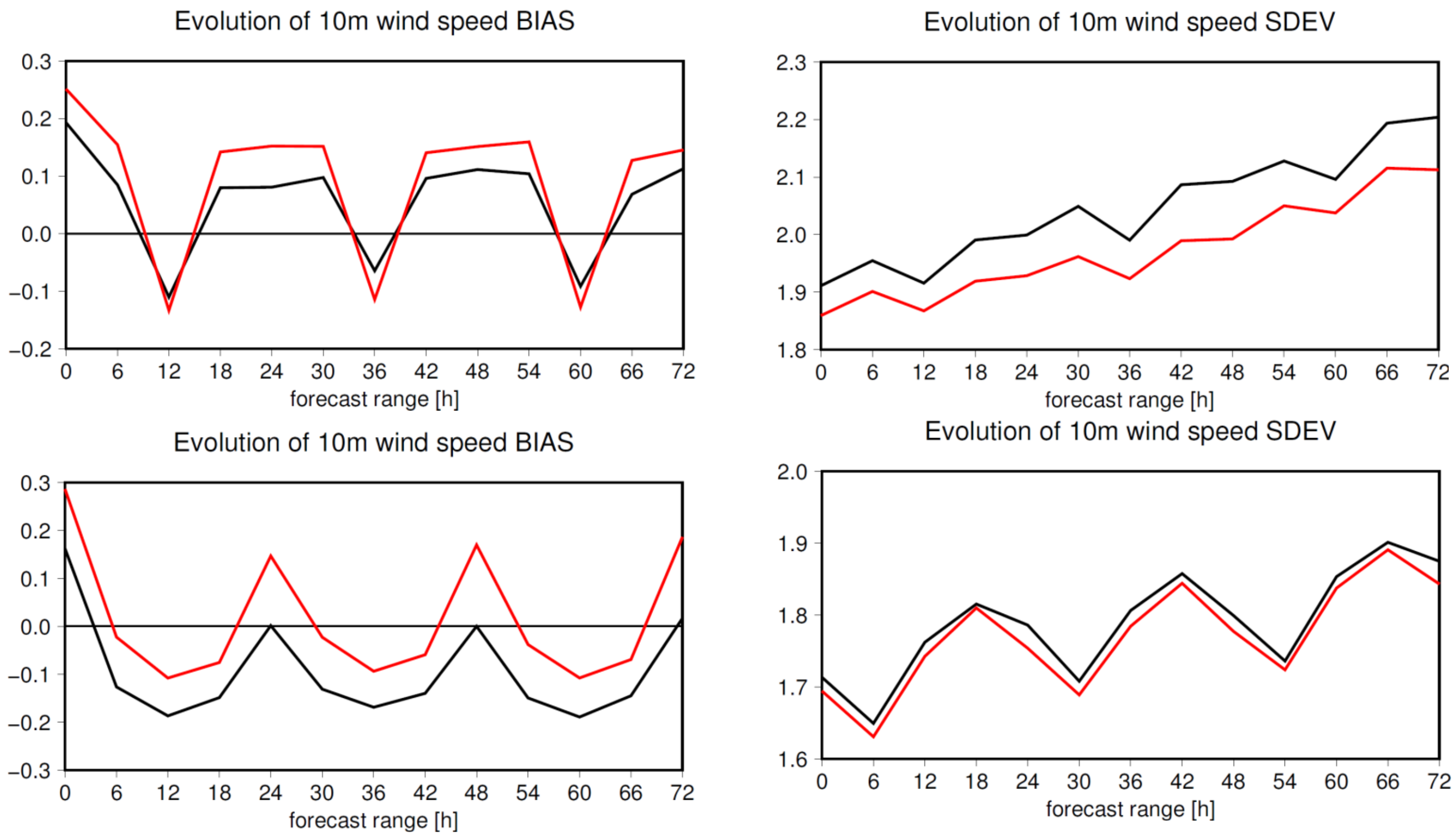
– Switch off the parameterizations of the “gravity wave drag” family at the model resolution of 2.3 km (otherwise the needed fields can be calculated from GMTED2010 as well);

– Use the vegetation roughness calculated from the ECOCLIMAP II database with the tuning:

Multiply tree height by the factor of 1.5

Laplace-type smoothing operator applied 3 times.

New proposal: results



Operational reference

New proposal

Wind speed at 10 m scores over Central Europe.

Upper row: winter period (21 Nov – 10 Dec 2019);

Lower row: summer period (14 May – 31 May 2019).

Night increase of wind speed is namely due to GWD removal.

Improved random error is namely due to the new orographic + vegetation roughness.

Conclusions

- **Even when still using ISBA, it is beneficial to move to better databases where feasible;**

- **Provided we calculate sub-grid-scale orographic fields from GMTED2010, the “gravity wave drag” parameterization family can be switched off at resolutions higher than app 3 km;**

- **When GWD needed at coarser resolutions, GMTED2010 database can and should be used for variance, anisotropy and orientation of orography. Beware of a likely retuning in such a case;**

- **Using orographic roughness from GMTED2010 and vegetation roughness from ECOCLIMAP II, we improve especially screen level wind forecast. To retain:**

  the effect of roughness is local and domain dependent, targeted tuning is necessary;

- **In case of interest, we can provide the assistance to get more advanced climate files, based on the Climake procedure.**

Special thanks to

- **François Bouyssel for many useful advices, namely on the tree height hint;**

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Thank you for your attention

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