FACRAF tuning for the 4.5 km resolution ALARO SHMÚ

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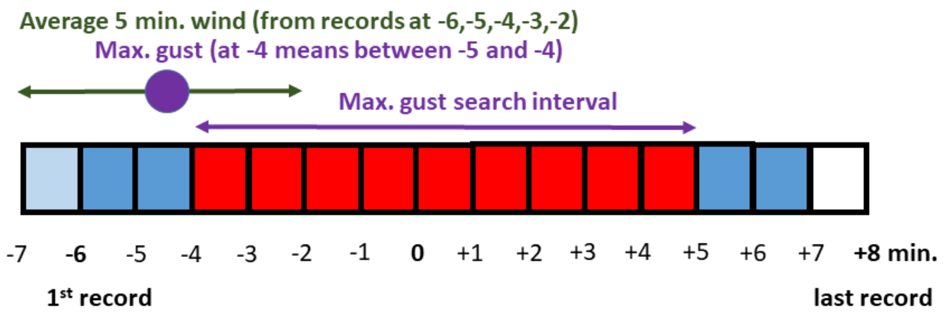
SHMÚ

Motivation/scheme

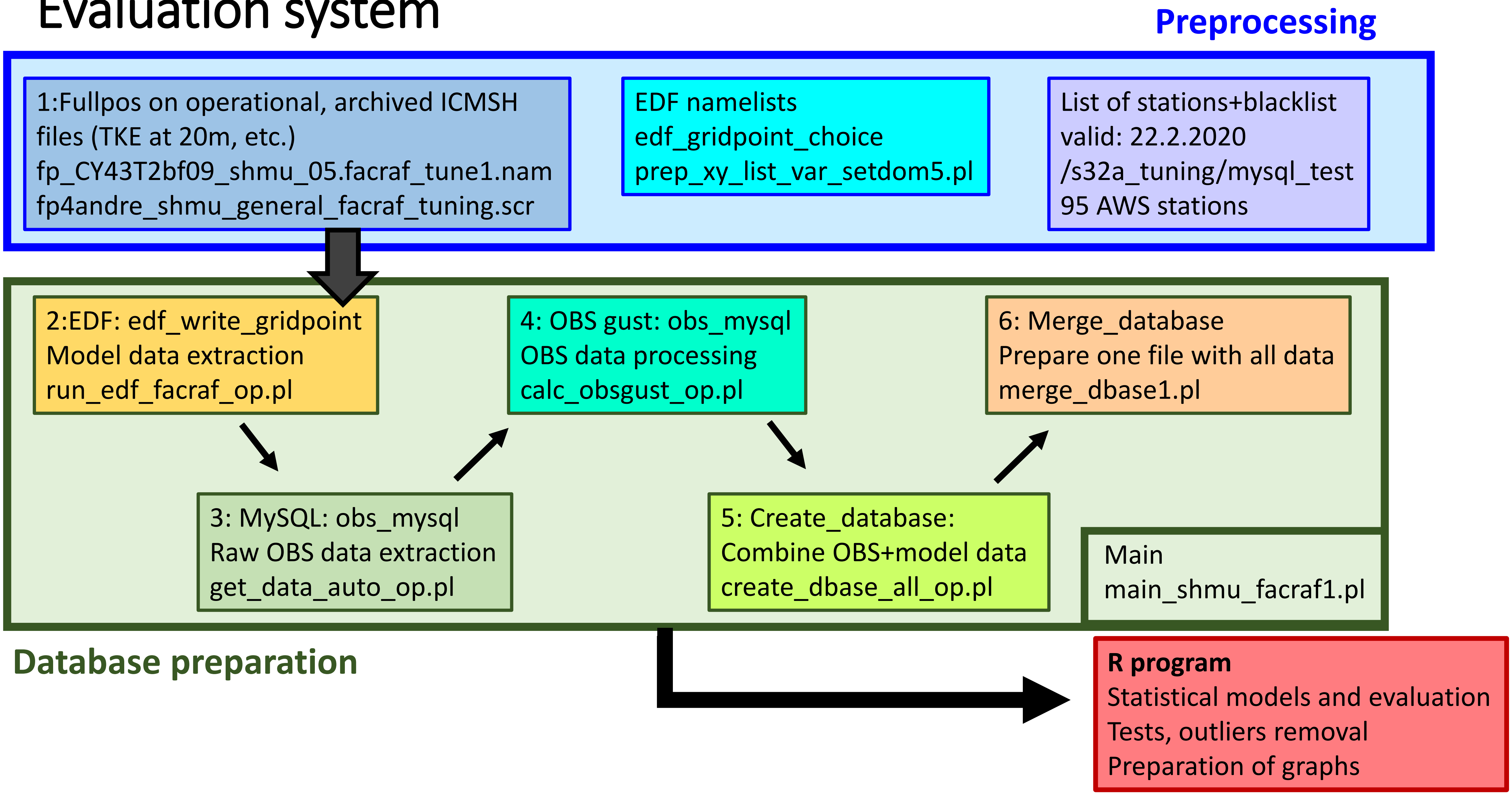
- TKE-based gusts (Seity et al. 2010): G=U+FACRAF*sqrt(TKE(20m))
- FACRAF is set to 3.5 in most parameterizations but this is dependent on the horizontal resolution of the model, because the amount of resolved TKE changes with the increase/decrease of the model scale
- FACRAF could be also wind-dependent as it was suggested by Schreur and Geertsma (2008)
- Current scheme based on dynamic velocity provides wind gusts, which are too strong in situations with convection (dimensions of FACRAF are principally different for the TKE-based scheme)

Method



- 7 (later 14) situations chosen with strong wind (from 2019-2021, I-XII months). Older AWS gusts (e.g. from 2017) not available in srv-mondo database yet.
- AWS wind and gust measurements were picked from the MySQL database (~95 stations) for each hour of the day. A 15 min. long period was examined and the strongest gusts was determined, as well as 5 min. average wind valid for this gust
- Quality control applied (e.g. on gust factor, gust excess, etc.)
- Model 10m wind, gust and 20m TKE were derived from postprocessed historical operational SHMÚ model files via EDF (+1 to +24h forecasts)
- Further filters were applied to avoid forecasts, which fail to reproduce wind and temperature OBS (expecting, model TKE could be close to OBS in such case)

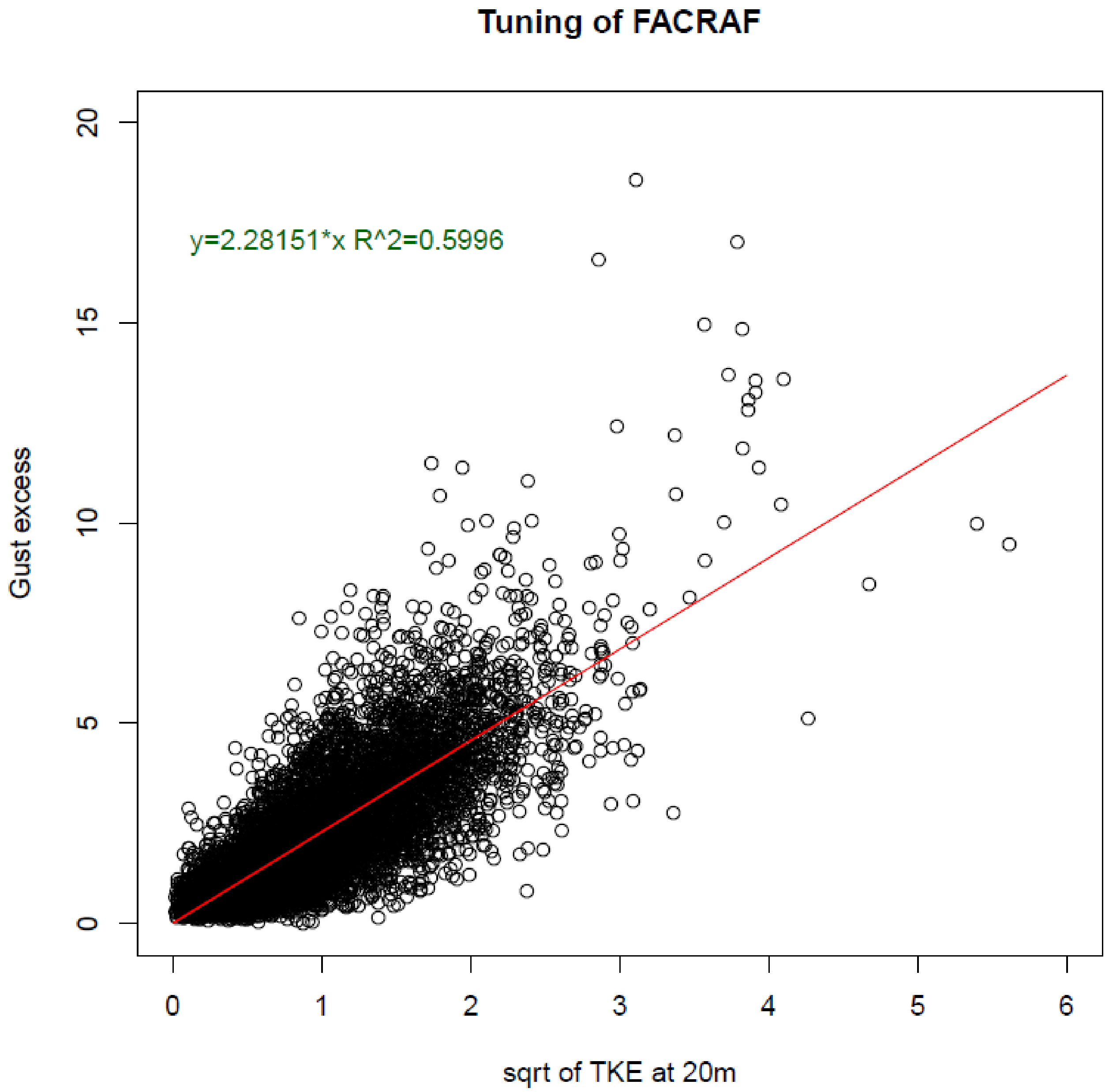
Evaluation system



Evaluation in R

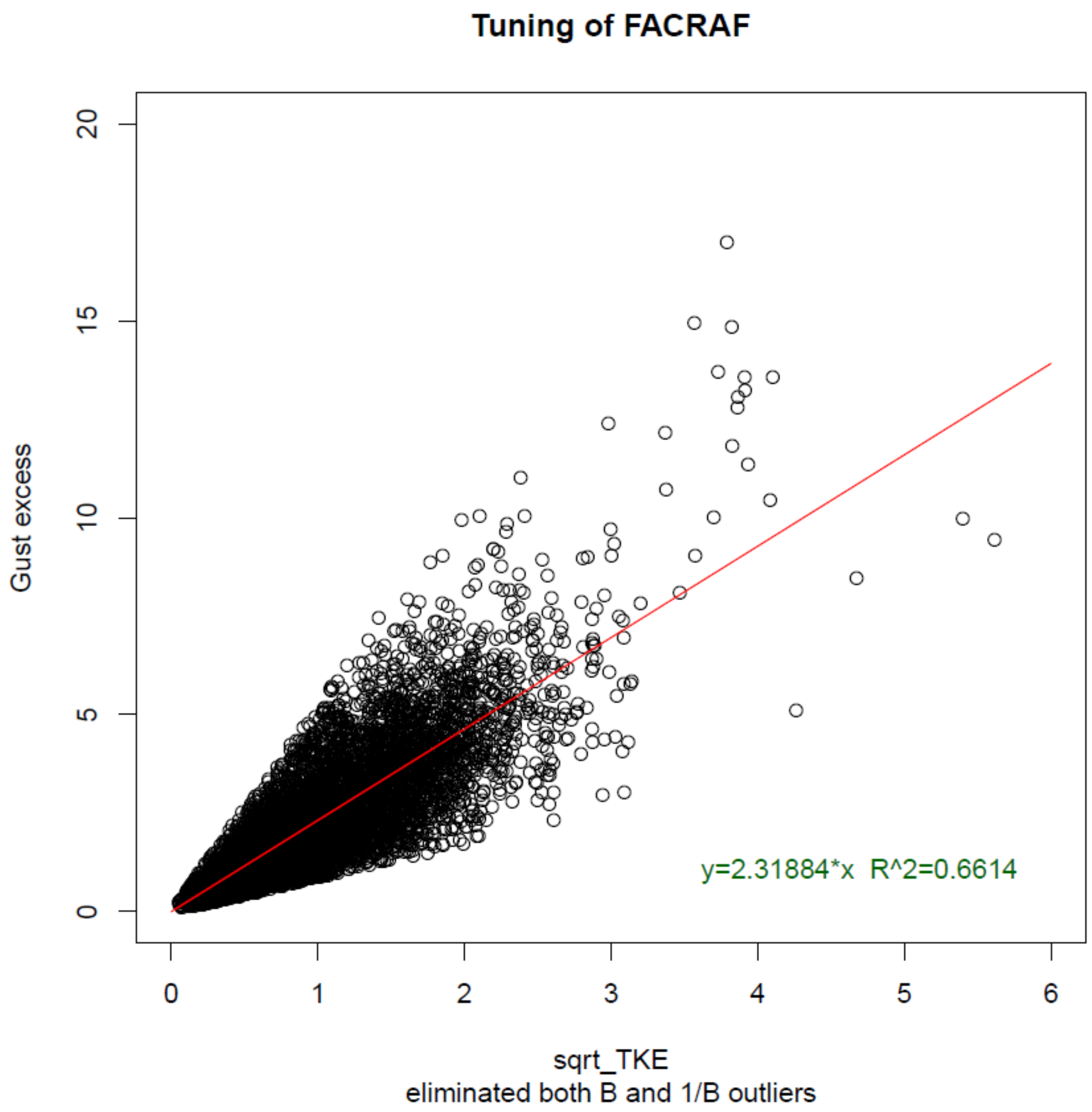
- Expect $(G\text{-}U)_{OBS} \sim (TKE)_{model}$
- Simple linear model (lm)
- $|U_{model} - U_{OBS}| < 1.5$ m/s
- $|T_{model} - T_{OBS}| < 2°C$
- 6446 data of 15806 (40.8%) meets these criterions+OBS quality control

- Forecast is rather successful by low U (G-U), whereas we are rather interested in high G-U
- FACRAF ~ 2.3 for average situations



Outlier removal

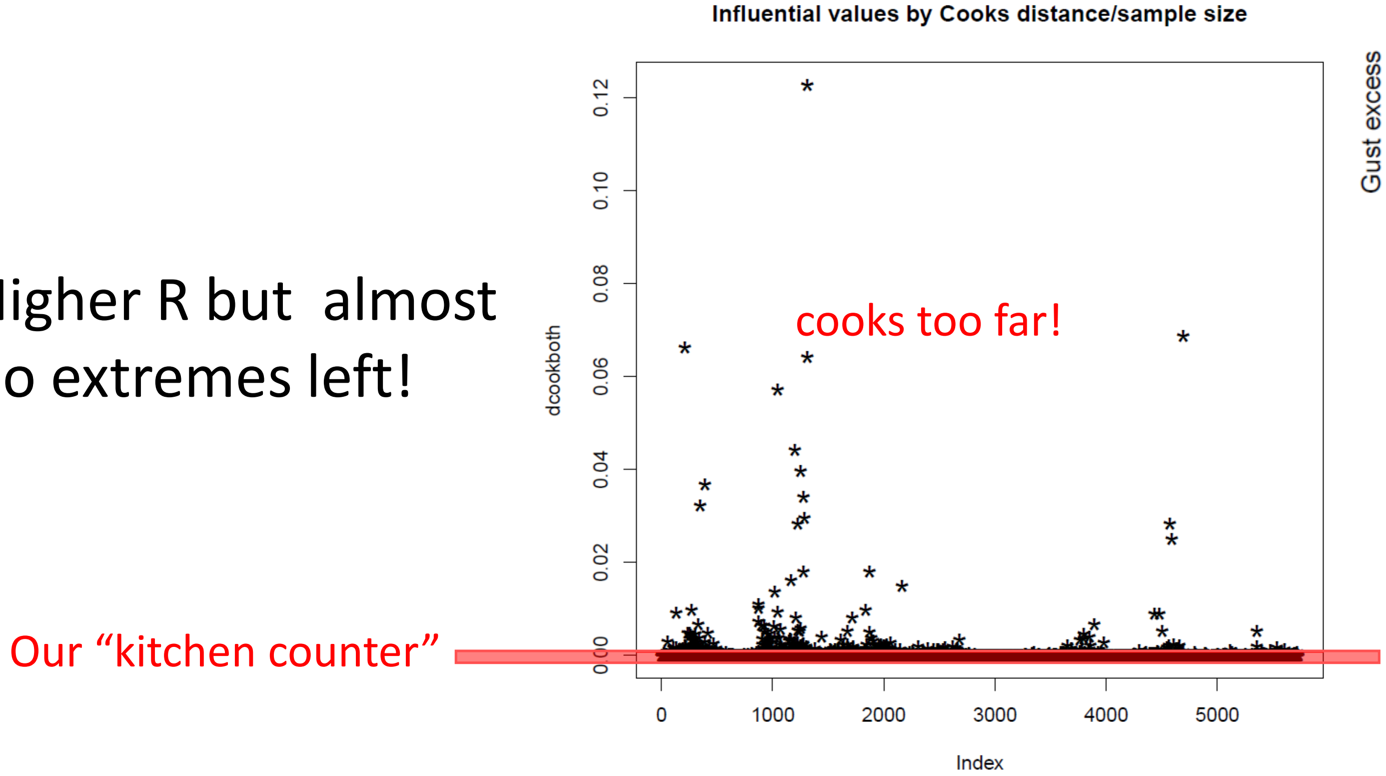
- IQR method : IQR is the 75% and 25% Quantile difference
- Applied on both bratio=(G-U)/sqrt(TKE) and obratio=sqrt(TKE)/(G-U)
- bratio ∈ ($Q_{25\%}$-1.5iqr,$Q_{75\%}$+1.5iqr)
- obratio ∈ ($Q_{25\%}$-1.5iqr,$Q_{75\%}$+1.5iqr)
- 5724 data (36.2%) remain
- Improved correlation, little FACRAF change
- But, alas, we've lost some extremes!

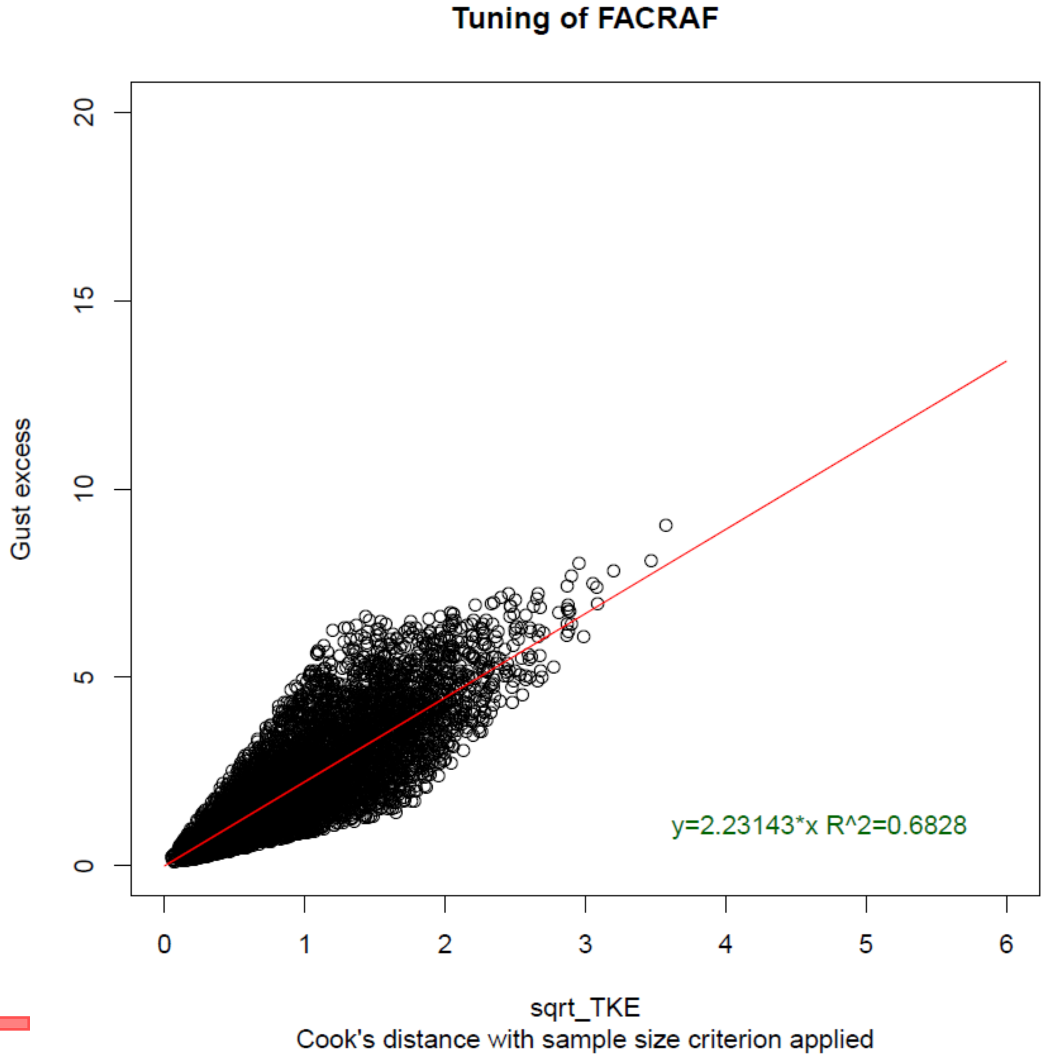


Cooks'distance

- Too big distance – not a good meal!
- Based on cross-validations, more objective
- Dcook>4/N , N = sample size
- 5408 data (34.2%)

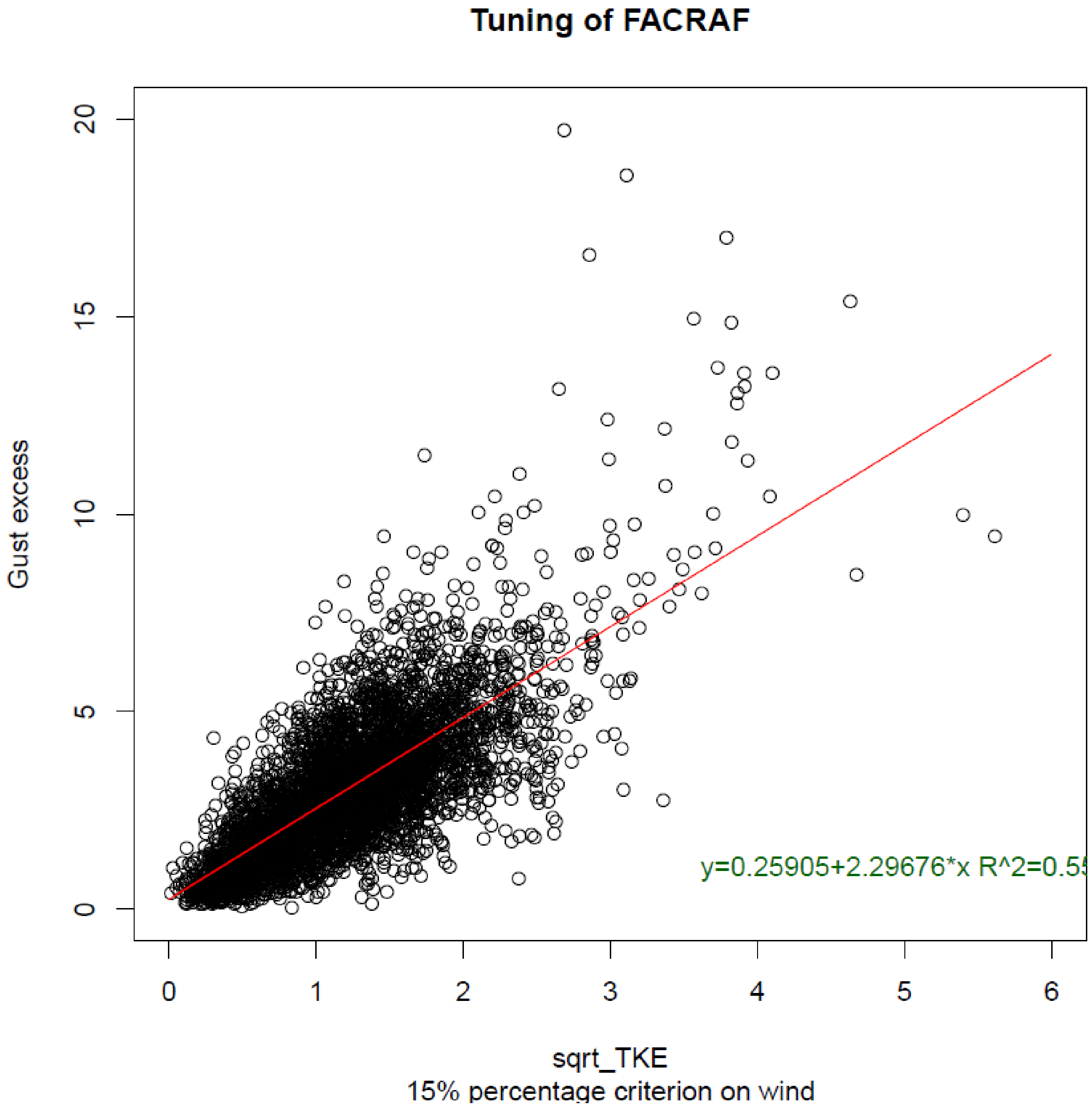
Higher R but almost no extremes left!





Percentage-based quality criterion

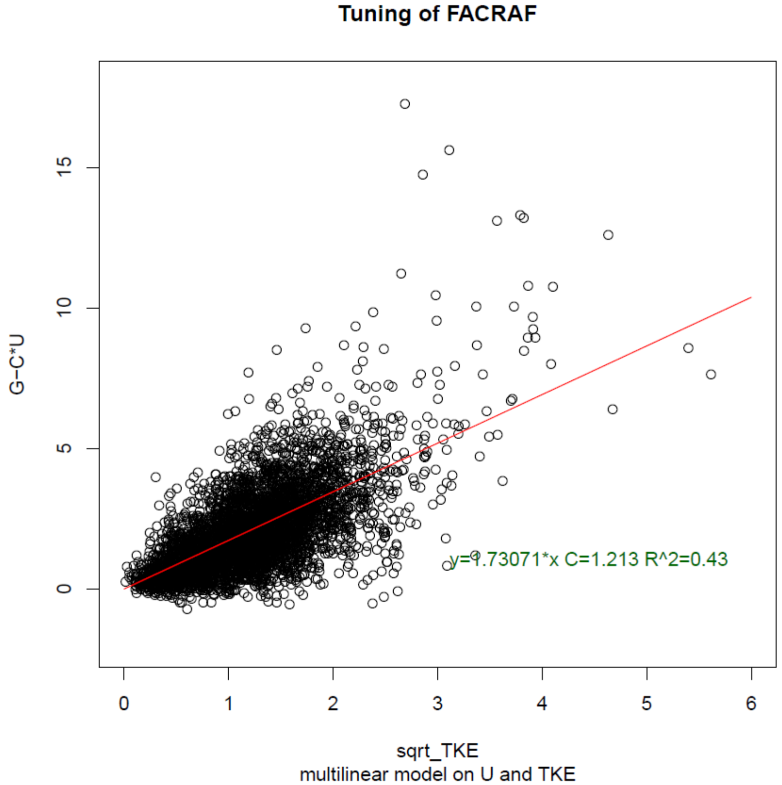
- Bigger tolerance for high, less for small U
- $0.85U_{OBS} <= U_{model} <= 1.15U_{OBS}$
- More OBS (14 situations)
- Only 4363 samples left of 31483 OBS (13.9%)
- However, results did not become better! Even we have a non-negligible intercept, R^2 is worse
- FACRAF still around 2.3



Why multilinear model does not help us?

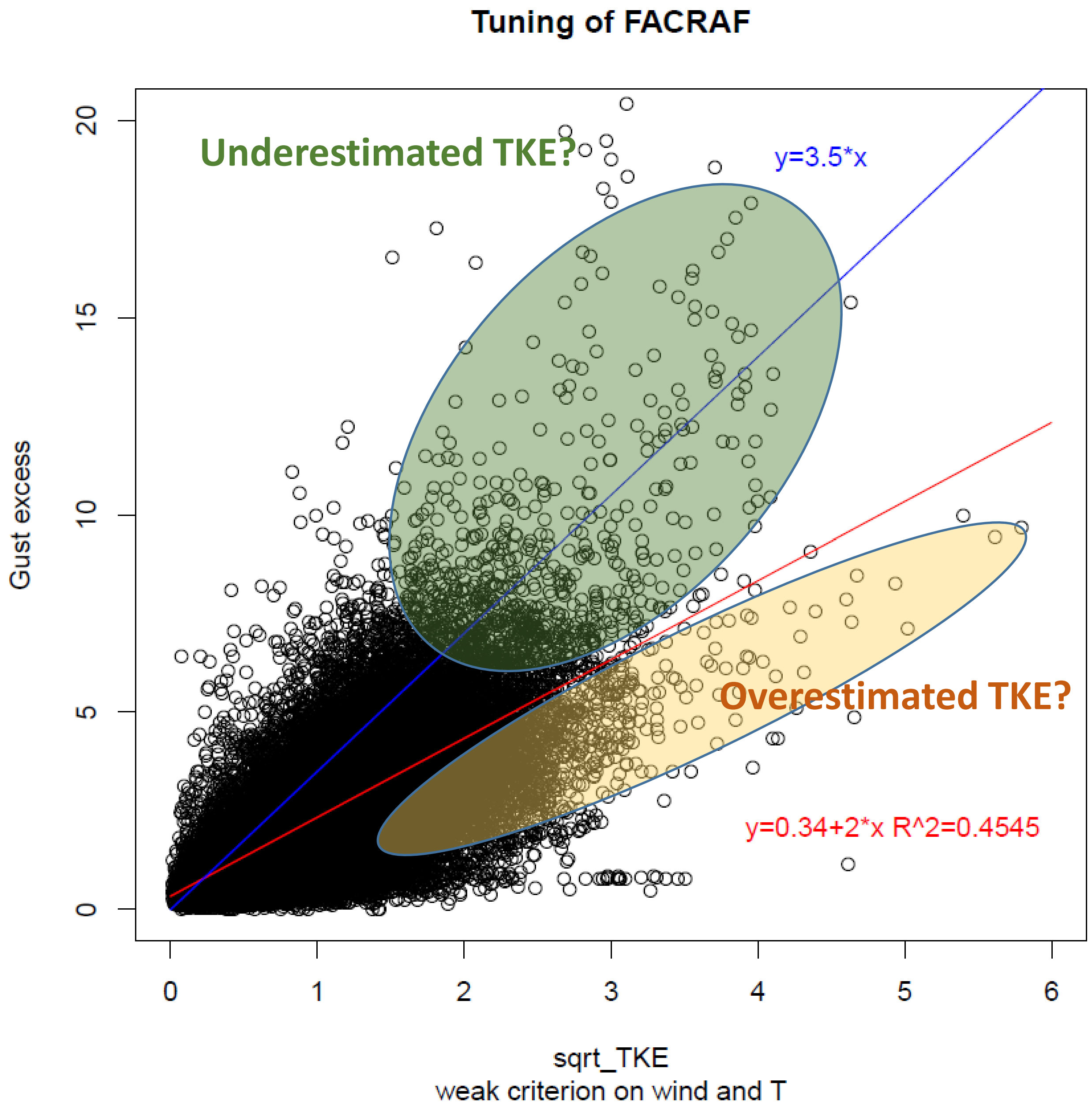
- Let expect $(G)_{OBS} \sim (U)_{OBS} + (TKE)_{model}$
- We obtain: G=1.213U+1.73(sqrt(TKE))
- This model has **R^2 = 90.8% !**

- However, we did a test with simple linear model:
- $(G\text{-}1.213U)_{OBS} \sim (TKE)_{model}$
- We get $(G\text{-}1.213U)_{OBS}$=1.73(sqrt(TKE)), which is O.K. but **R^2 = 43.6% only!!!**
- This indicates that higher R^2 for multilinear models is even more misleading as usually expected



Tuning of FACRAF for all cases

- Similarly, polynomial model approaches or exclusion of low (G<7 m/s or G<15m/s) gusts fail. At high gusts or high G-U the models show little correlation
- FACRAF of 2.3 or similar, which would be ideal for most of the cases, clearly does not predict extremes. In forecasting of severe weather, usually some territorial extremes are considered.
- To tune the gust parameterization with respect to such extremes we need so many data as possible, even if the model forecasts of U/TKE were not realistic
- We omitted most of the restrictions (used **30422 OBS**) and selected several models



Evaluated models (predicted G~f(U, sqrt TKE)$_{model}$ vs G_{OBS})

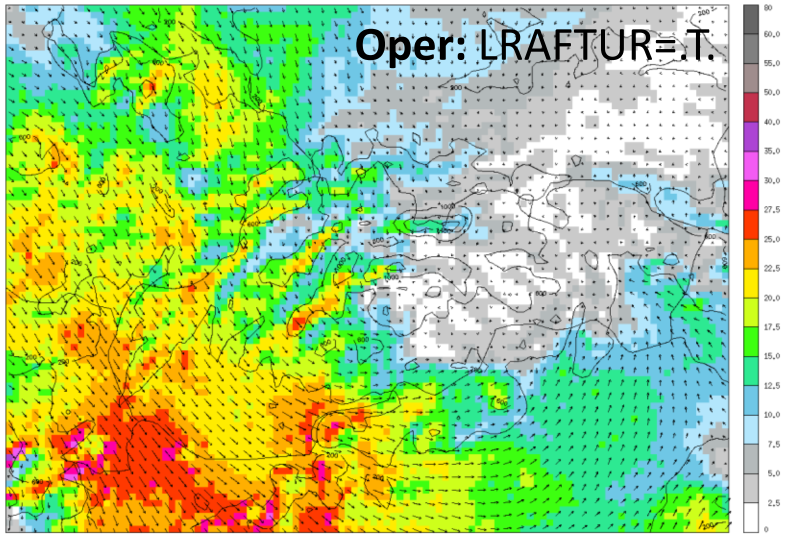
model	formula	explanation
1	U+3,5*sqrt(tke)	default model TKE scheme in cy43 by FACRAF=3,5
2	0,33861+Uala+1,99912*sqrt(TKE)	from R: (G-U) on sqrt(TKE) on all records
3	0,150462+1,229604*Uala+1,419745*sqrt(TKE)	from R: multilinear G on U and sqrt(TKE) on all records
4	0,2758+Uala+1,66985*sqrt(TKE)	from R: (G-ff_ALA) on sqrt(TKE) on all records
5	0,49366+0,75302*Uala+2,37441*sqrt(TKE)	from R: multilinear G on ff_ALA and sqrt(TKE) on all records
6	Uala+2,8*sqrt(TKE)	model TKE scheme with FACRAF=2,8
7	1,212942*Uala+1,730708*sqrt(TKE)	from R: multilinear G on U and sqrt(TKE) on perc records
8	Uala+4,5*sqrt(TKE)	model TKE scheme with FACRAF=4,5
9	Uala+5,5*sqrt(TKE)	model TKE scheme with FACRAF=5,5
10	Uala+5,0*sqrt(TKE)	model TKE scheme with FACRAF=5,0
11	Uala+4,75*sqrt(TKE)	model TKE scheme with FACRAF=4,75
12	Uala+5,25*sqrt(TKE)	model TKE scheme with FACRAF=5,25
13	Uala+5,13*sqrt(TKE)	model TKE scheme with FACRAF=5,13
14	Uala+4,87*sqrt(TKE)	model TKE scheme with FACRAF=4,87

Results for gusts > 15 m/s (1258 records)

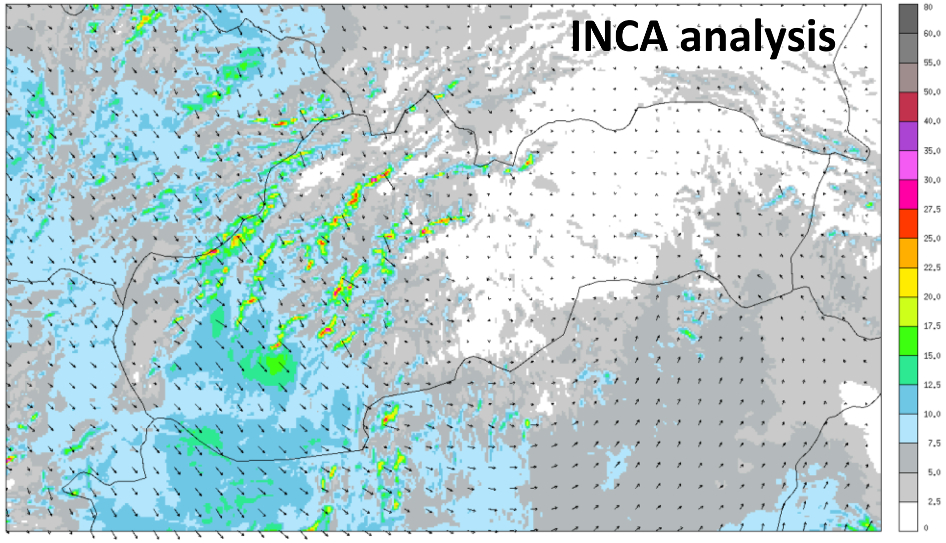
Rather small differences in “scores” between FACRAF=4.5 and 5.5

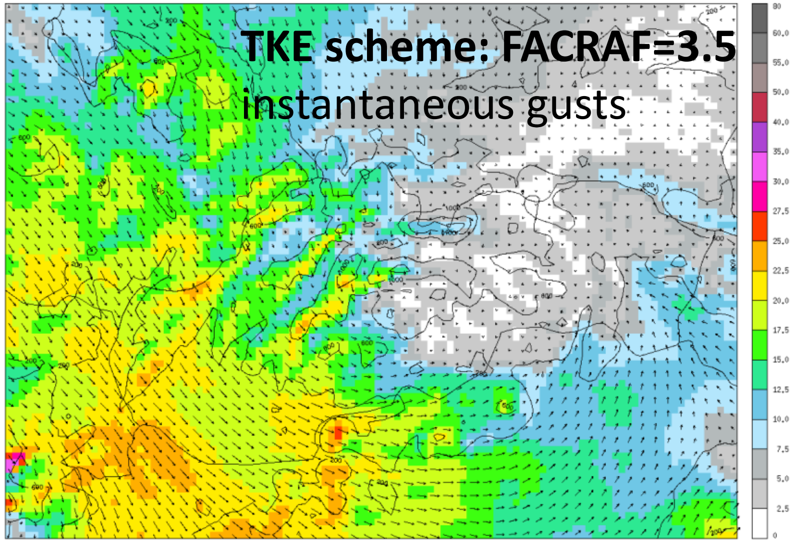
model	formula	MAE	RMSE
10	Uala+5,0*sqrt(TKE)	4,138054	5,449748
13	Uala+5,13*sqrt(TKE)	4,141095	5,454947
14	Uala+4,87*sqrt(TKE)	4,146051	5,459053
12	Uala+5,25*sqrt(TKE)	4,157427	5,475992
11	Uala+4,75*sqrt(TKE)	4,163809	5,509326
8	Uala+4,5*sqrt(TKE)	4,235278	5,521512
9	Uala+5,5*sqrt(TKE)	4,239543	5,620492
1	U+3,5*sqrt(tke)	5,010346	6,296091
6	Uala+2,8*sqrt(TKE)	5,954934	7,221562
7	1,212942*Uala+1,730708*sqrt(TKE)	6,461632	7,78901
3	0,150462+1,229604*Uala+1,419745*sqrt(TKE)	6,767218	8,083477
2	0,33861+Uala+1,99912*sqrt(TKE)	7,045254	8,236261
4	0,2758+Uala+1,66985*sqrt(TKE)	7,744506	8,868346
5	0,49366+0,75302*Uala+2,37441*sqrt(TKE)	7,956239	8,949604

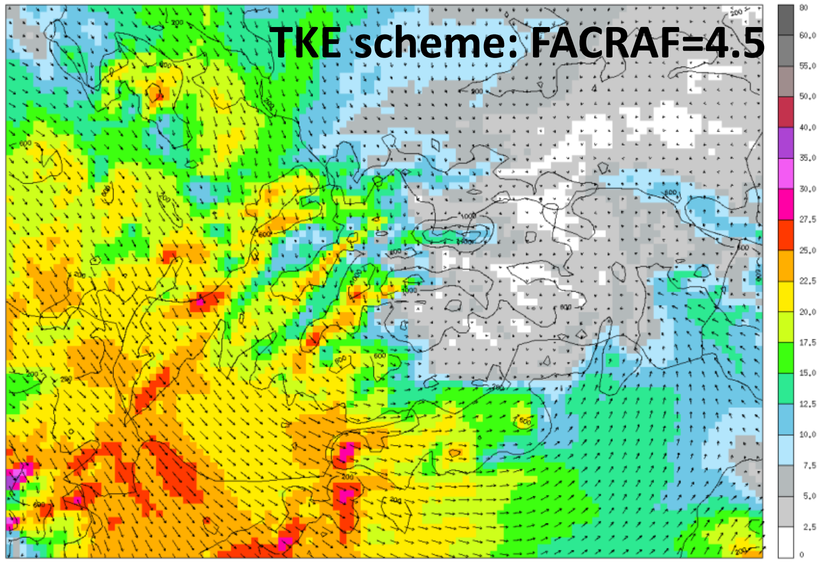
04 February 2020 windstorm: 12 UTC (instantaneous gusts)



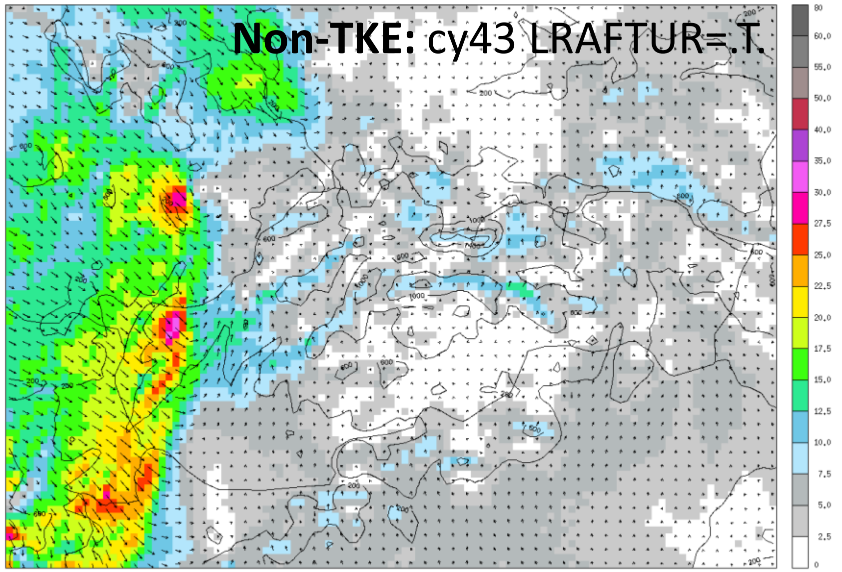
11812:25.1 m/s
11855:24.4 m/s
11916:32.7 m/s



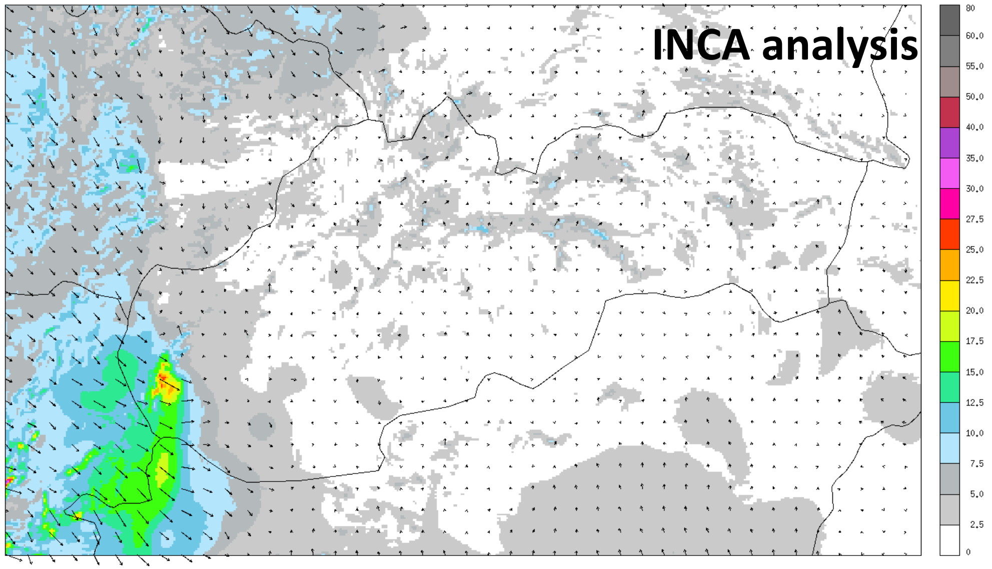


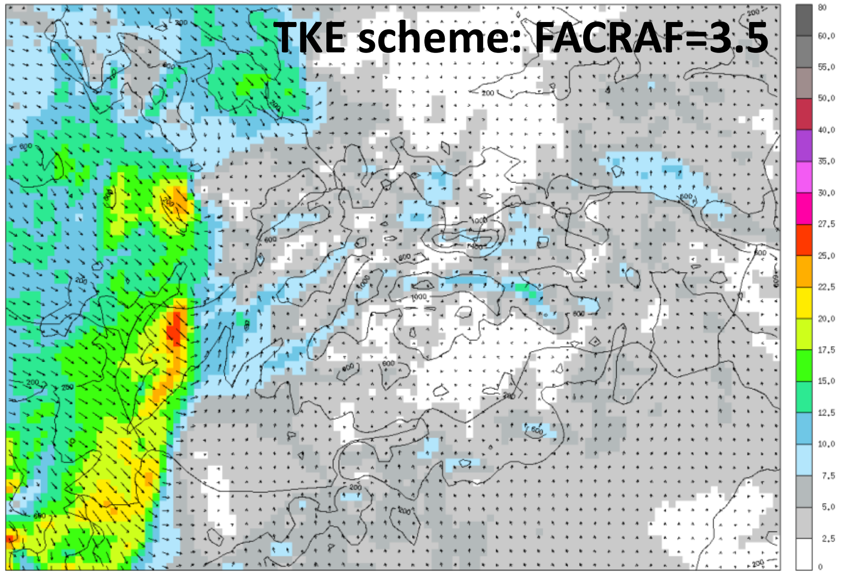


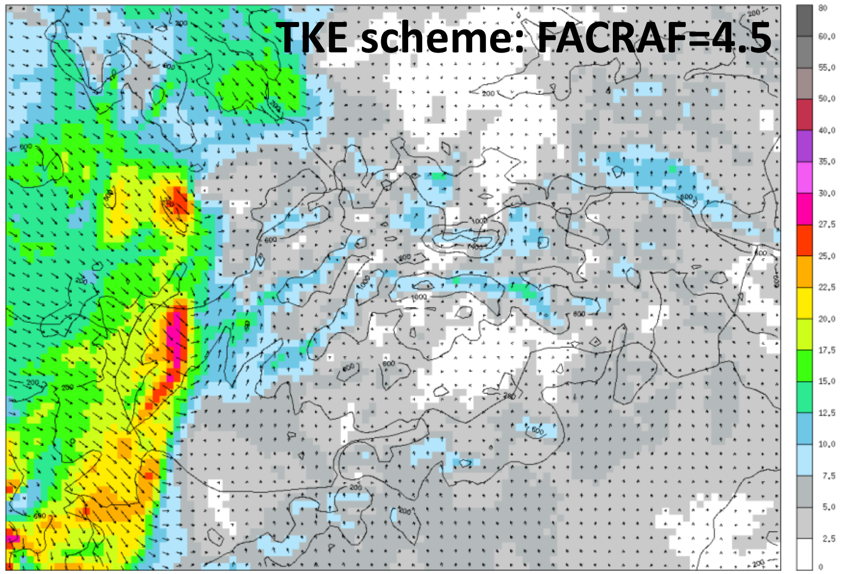
23 May 2020: 21 UTC (false windstorm prediction, overestimated gusts)



11812:25.8 m/s
11815:16.5 m/s
11816:16.3 m/s







Conclusion

- The relationship between near-surface TKE and gust is nearly linear only for low-moderate TKE and G-U. In extreme situation it is probable that other factors (e.g. upper-air-momentum) play also an important role. Now we supply them with high FACRAF.
- FACRAF is currently overestimated, statistics indicates that even lower than theoretical (~3) value would be optimal for the entire spectrum, which can be due to problems (overestimation) of TKE or underestimation of U in stable cases
- In case of high gusts the situation changes and the "optimal" FACRAF seems to be around 5 (4.5 would be sufficient), which is comparable with the present dynamic velocity scheme (LRAFTUR=.T.)
- The model has a poor performance in case of high average wind and stability in mountains, e.g. no forecast met the criterions for observations at Chopok (11916)
- The advantage of TKE gust scheme is in more proper forecasting of high gusts in relatively stable and strong wind conditions (e.g. thunderstorm outflows). This is relevant for NH models with explicit convection. The study above was also primarily oriented on non-convective winds.
- Further improvement would require different coding of the TKE scheme, e.g. making FACRAF dependent on other parameters (wind, stability, etc.)