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Lessons learnt from implementing a postprocessing suite for probabilistic seamless weather forecasts

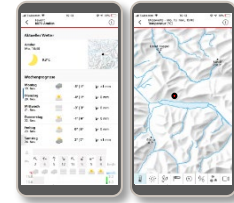
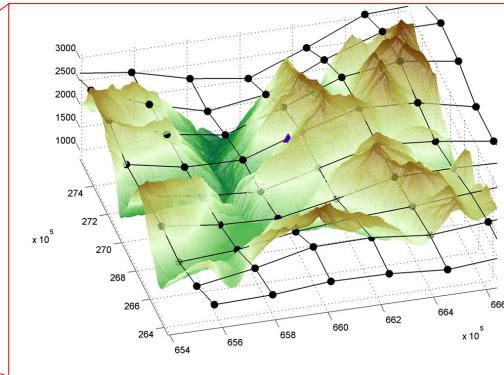
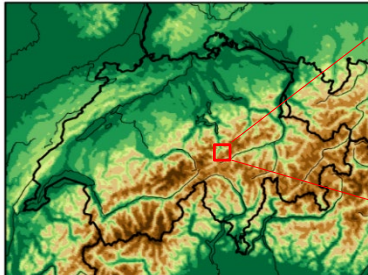
Christoph Spirig, Jonas Bhend, Stephan Hemri, Jan Rajczak, Daniele
Nerini, Lionel Moret, Mark A. Liniger

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The starting point

- increasing need of local forecast data
 - mobile app + www
 - internet of things (IoT)
- basis: NW predictions
 - regional model COSMO (2km + 1km ensembles)
 - ECMWF IFS-ENS



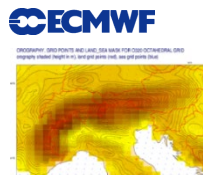
local forecasts on
MeteoSwiss
smartphone app



Postprocessing



ICON



Postprocessing



- Remove systematic biases
- Consider local conditions
- Calibrate uncertainty
- Combine and condensate different information sources



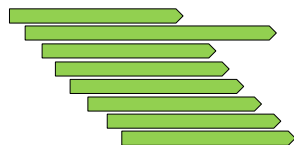
anywhere
probabilistic (calibrated)
seamless (consolidated)

?



Consolidated forecasts

- NWP models with different forecast ranges and update frequency



COSMO-1E, 33-45 hours (init. 00, 03, 06, 09, 12, 15, 18, 21)

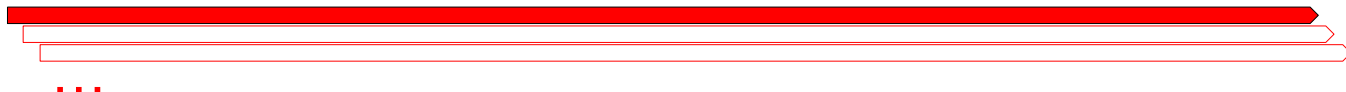


COSMO-2E, 5 days (init. 00, 06, 12, 18)



IFS-ENS (init. 00, 12)

postprocessed output: include latest available NWP, triggered by arrival of any new NWP run





Target parameters and method choices

Parameter	Currently implemented approach
temperature	ensemble model output statistics (gEMOS)
precipitation	gEMOS
cloud cover	gEMOS
wind	machine learning (DNN)



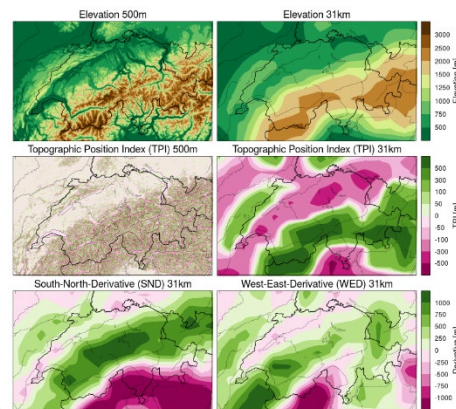
gEMOS – global ensemble model output statistics

- extension of traditional (local) EMOS (Gneiting et al. 2005) by static predictor variables.
- choice of a target distribution (location and scale parameter) depending on parameter
 - (truncated) normal for temperature (cloud cover)
 - censored logistic for precipitation
- estimating location (loc) and scale (sca) parameter

$$\begin{aligned} \text{location} &= a + \underbrace{b_1x_1 + b_2x_2 + b_3x_3 + \dots}_{\text{dynamic NWP Predictors}} + \underbrace{b_4x_4 + b_5x_5 + \dots}_{\text{static predictor variables}} \\ \text{scale} &= c + d_1sd(x_1) + d_2x_5 + \dots \end{aligned}$$

predictors: $x_n, \dots$

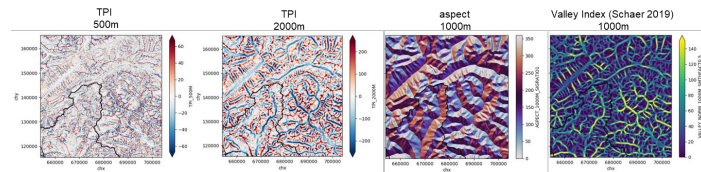
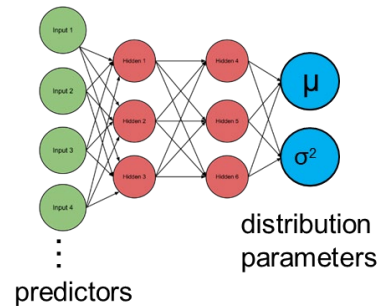
coefficients: $a, b_n, \dots, c, d_n, \dots$ $\text{optim} = \min(\text{CRPS})$





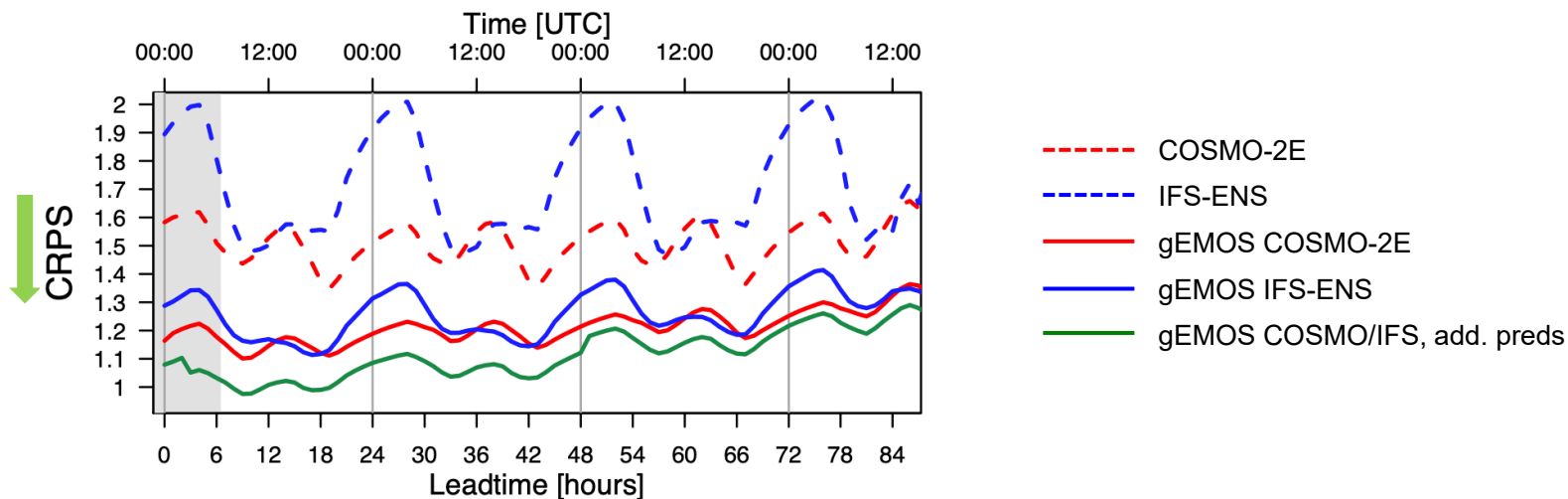
Wind postprocessing ('mlpp-wind')

- Neural Network: (wind speed, direction, gusts) regular **MLP** with distribution parameters as outputs.
- Inputs (predictors)
 - NWP predictions
 - topography (25m DEM) in form of various indices
 - ...
- Training
 - minimize CRPS vs observations
 - avoid overfitting (dropout ...)



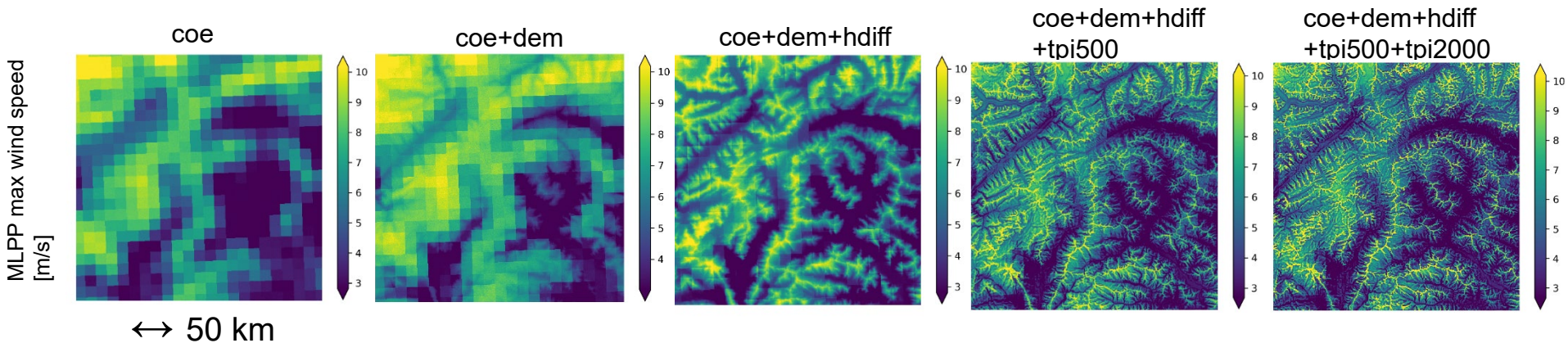


Skill improvements: Multimodel postprocessing



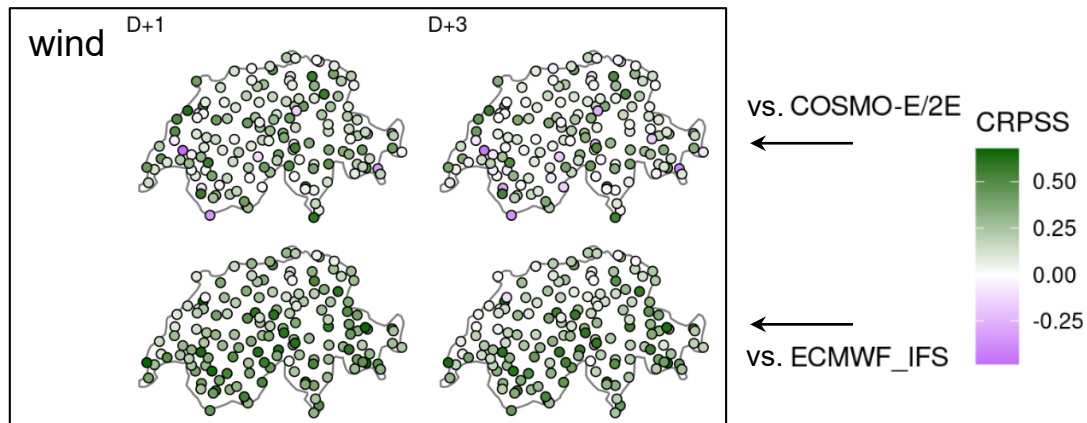
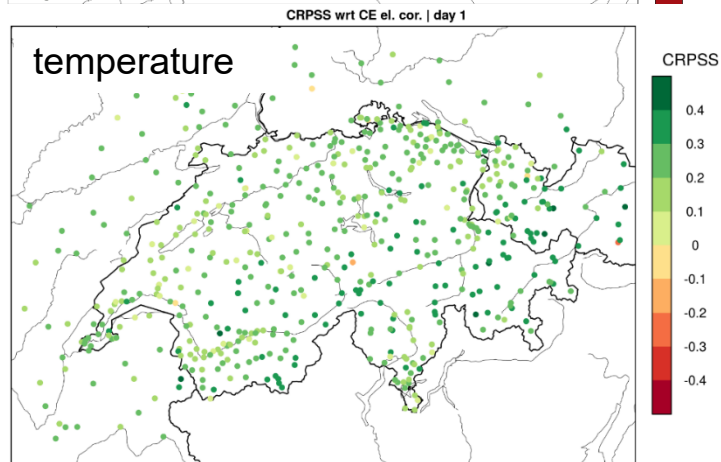
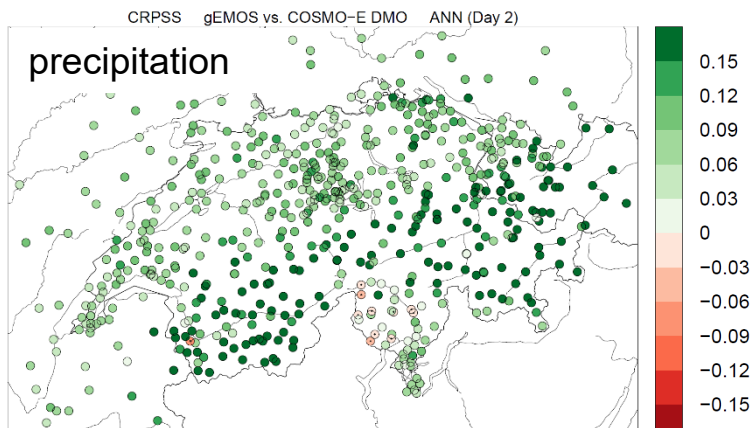


Skill improvements: Topographical predictors

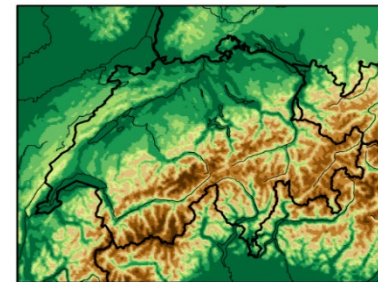




Skill improvements: Spatial picture



- largest in areas of complex topography
- seasonal differences
- differences in rel. improvements





Skill improvements vs regional DMO

Parameter	Currently impl. Approach	Improvement vs COSMO-2E (CRPS)
temperature	gEMOS	20 - 35% (vs el.-corrected COSMO-E)
precipitation	gEMOS	5 – 10 %, exc. for summer (0%)
cloud cover	gEMOS	10 – 20 %
wind	ML	20 – 25 %



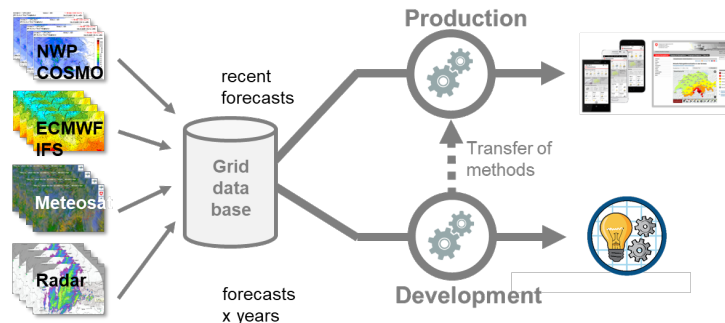
Lessons learnt I:

- Both gEMOS and ML allow postprocessed forecasts even at sites without observations
- Combined postprocessing of COSMO and ECMWF allows seamless forecasts and improves skill
- More predictors (topographical, dynamic) = more skill
- Inclusion of regional area models with higher resolution are beneficial
- ML approaches tend to outperform classical methods



... II: Implementation aspects

- postprocessing: training & prediction
 - efficient data access is key
 - cloud-ready
- availability of training records
 - coping with NWP model changes
 - simpler approaches requiring fewer training data vs. best skill
- agile development
 - start with MVPs
 - aim for flexible (modular) tools and extensibility





...III: Insights from pre-operational test phase



Overall skill improvement

- postprocessing optimizes bulk of forecasts
- general purpose postprocessing
-> calibration



Forecast quality as experienced by users

- focus on special weather situations
- inflated spread



Routes for improvements

- training of postprocessing models with scores giving more weight to tails
 - switch between general and warning-relevant PP regime?
➡ Talk by S. Allen, OSA 1.5, Wednesday 12:45, HS 5-6
- increasing sharpness
 - potential of ML approaches, e.g. Y. Dai and S. Hemri, 2021
 - exploit with appropriate framework
➡ Talks by S. Hemri and D. Nerini, OSA 1.9
- improving precipitation PP
➡ Talk by J. Bhend, OSA 1.4, Friday 9:45, HS 7





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