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Towards operational postprocessing of cloud cover at MeteoSwiss

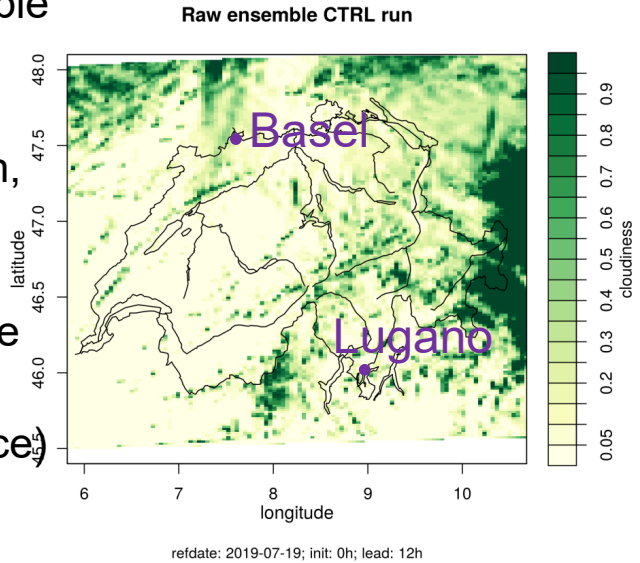
Stephan Hemri, Christoph Spirig, Jonas Bhend, Lionel Moret, and Mark Liniger

Key points

- Goals
  - Implementation of a statistical post-processing (PP) suite for cloud cover
  - Needs to work in a seamless manner in an operational setting:
    - Handle input/predictors from different numerical weather prediction (NWP) models
  - Focus on correction of winter low stratus / fog cases
- Results
  - Grid-point wise ensemble model output statistics (EMOS) improves skill considerably
  - Additional gain in skill by combining COSMO-E with ECMWF-IFS
  - Adding other NWP variables as EMOS predictors improves skill for winter low stratus / fog

Local EMOS as univariate PP method

- Hourly COSMO-E total cloud cover (TCC) ensemble forecasts are univariately postprocessed using EMOS (Gneiting et al. 2005)
- EMOS models are fitted seasonally (same season, other years) for each lead time separately; EUMETSAT CM-SAF satellite data as reference
- CRPS minimization; used scoringRules R package implementation of the CRPS
- Predictors: Ensemble statistics (mean and variance) of TCC and various auxiliary predictors like e.g. pressure gradient Basel - Lugano

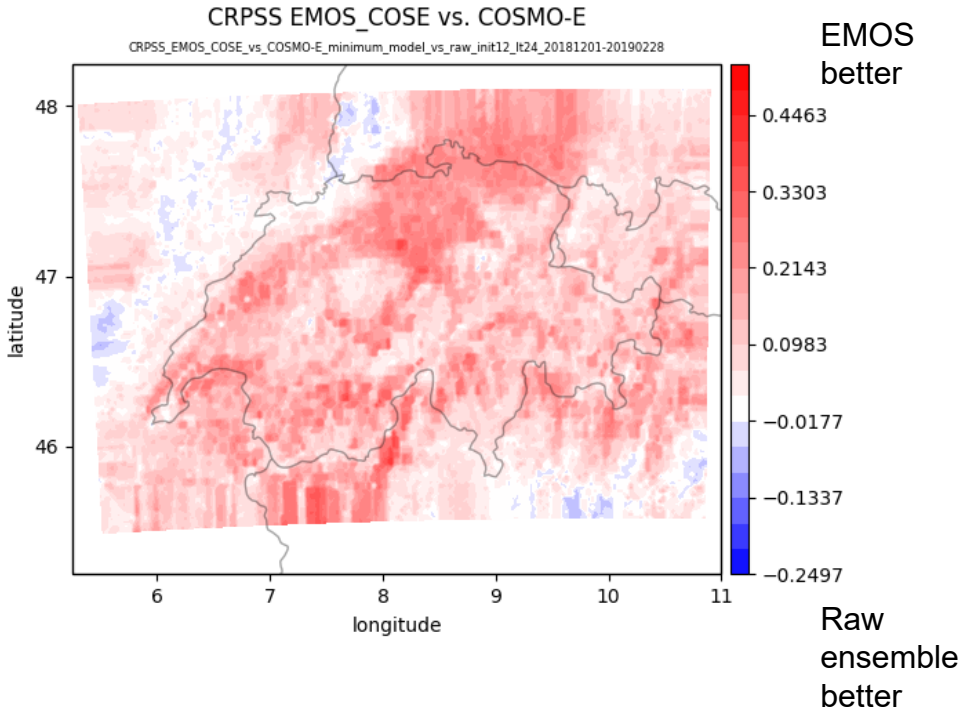


Reference:

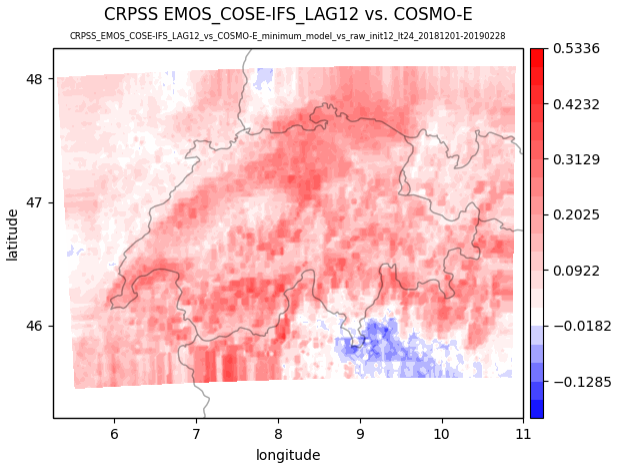
- Gneiting, Tilmann, et al. "Calibrated probabilistic forecasting using ensemble model output statistics and minimum CRPS estimation." *Monthly Weather Review* 133.5 (2005): 1098-1118.

DJF skill of EMOS relative to COSMO-E

- CRPSS of seasonal fitted EMOS vs. COSMO-E over DJF 18/19
- Forecasts initialized at 12 UTC
- Lead time 24h, i.e. 12 UTC
- Some dependence of forecast skill on topography
- Considerable improvement in skill over the Swiss plateau, which is affected by fog and low stratus

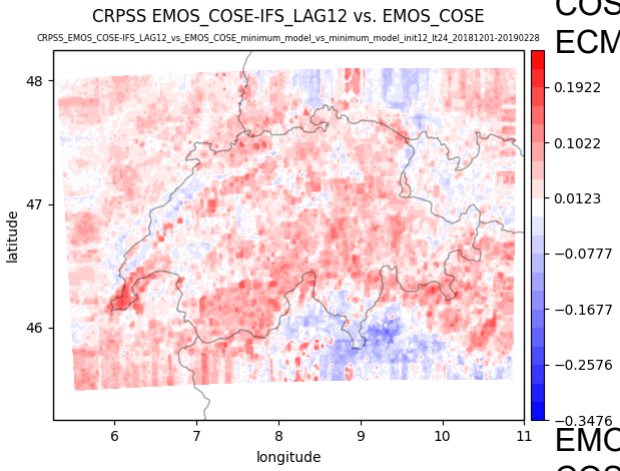


Skill of multi-model EMOS



EMOS based on COSMO-E and ECMWF-IFS better

Raw COSMO-E ensemble better



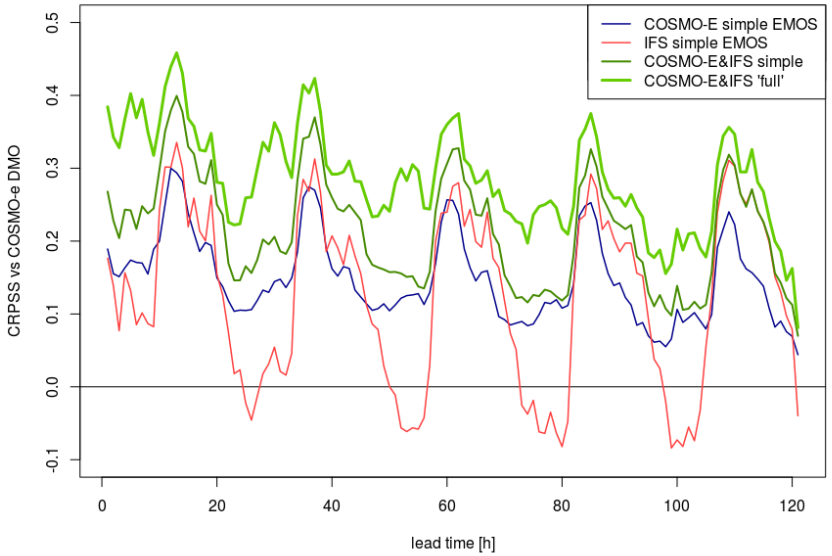
EMOS based on COSMO-E and ECMWF-IFS better

EMOS based on COSMO-E only better

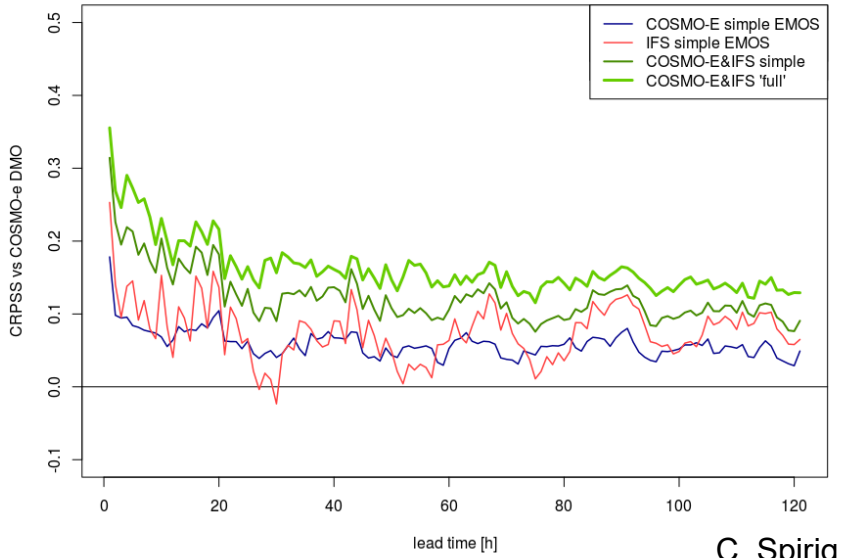
Same setting as on previous slide, but EMOS based on COSMO-E and ECMWF-IFS. Note that ECMWF-IFS runs are 12h ‘older’ than COSMO-E runs in order to mimic operational data availability.

Additional predictors

CRPSS averaged over 4 stations in the Swiss Plateau; cases, for which low clouds are expected



CRPSS averaged over 4 stations in the Swiss Plateau; cases, for which low clouds are NOT expected

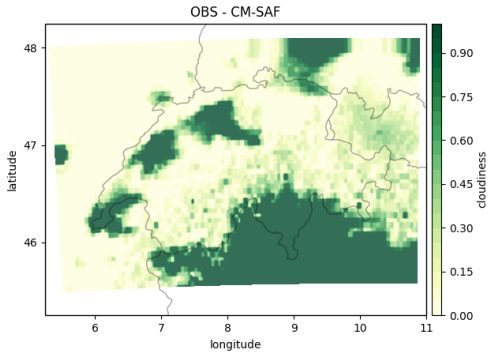


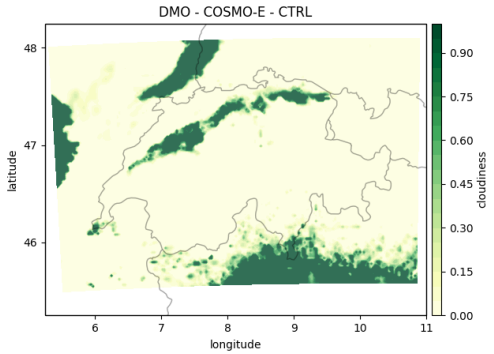
C. Spirig

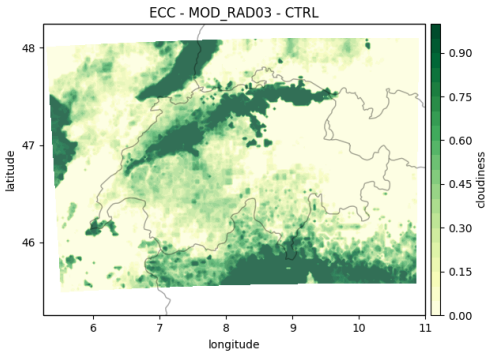
Predictors from NWP:

- Simple: total cloud cover (TCC)
- Full: TCC, interaction between mean/high level clouds and TCC, surface pressure difference orthogonal and parallel to the Alps, height of boundary layer, regional temperature lapse rates, surface downwelling longwave flux in air

Example forecast: Ref. 2016-12-03 12h, 24h lead







CM-SAF:
- satellite data
- 5km resolution
- nearest neighbour interpolation to COSMO-E grid

COSMO-E:
- 21 member regional NWP model
- covers Alpine region
- 2.2 km horizontal resolution / 60 vertical layers
- 2 runs per day

EMOS-ECC:
- EMOS
- Ensemble copula coupling following Scheuerer and Hamill (2018) with modifications for cloud cover

MeteoSwiss

Reference:
- Scheuerer, Michael, and Thomas M. Hamill. "Generating calibrated ensembles of physically realistic, high-resolution precipitation forecast fields based on GEFS model output." *Journal of Hydrometeorology* 19.10 (2018): 1651-1670.

Technical details: doubly-censored normal EMOS for cloud cover

- Normal distribution censored at 0 and 1
- Location parameter *m* at location *i*, time indices omitted:

$$m_i = a_{0,i} + \sum_{j=1}^{J} \sum_{k=1}^{K_j} a_{i,j,k} \bar{f}_{i,j,k}$$

- Scale parameter σ at location *i*, time indices omitted:

$$\sigma_i{}^2 = b_{0,i} + \sum_{j=1}^{J} b_{i,j} s_{i,j}^2$$

- $\bar{f}_{i,j,k}$: Predictor for location parameter. The index *j* denotes the NWP model (here COSMO-E or ECMWF-IFS). The index $k = 1, \ldots, K_j$ denotes the set of predictors chosen from model *j*. The bar indicates that only ensemble means are considered.
- $s_{i,j}^2$: Predictor for scale parameter, i.e. ensemble variance of model *j*.

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MeteoSwiss
Operation Center 1
CH-8058 Zurich-Airport
T +41 58 460 91 11
www.meteoswiss.ch

MeteoSvizzera
Via ai Monti 146
CH-6605 Locarno-Monti
T +41 58 460 92 22
www.meteosvizzera.ch

MétéoSuisse
7bis, av. de la Paix
CH-1211 Genève 2
T +41 58 460 98 88
www.meteosuisse.ch

MétéoSuisse
Chemin de l'Aérologie
CH-1530 Payerne
T +41 58 460 94 44
www.meteosuisse.ch