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Spatially consistent postprocessing of probabilistic cloud cover forecasts

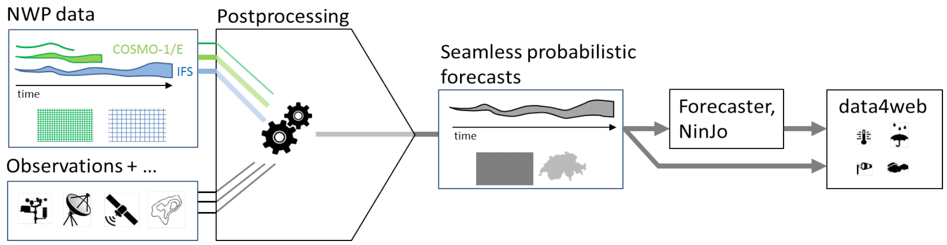
Zurich R-User Meetup: Spatial Data Analysis

Joint work with C. Spirig, J. Bhend, Y. Dai, L. Moret and other members of the postprocessing team at Meteoswiss

Outlook

- Introduction to statistical postprocessing
- Univariate postprocessing of cloud cover
- About R (and Python)
- Reintroducing spatial cloud cover structure

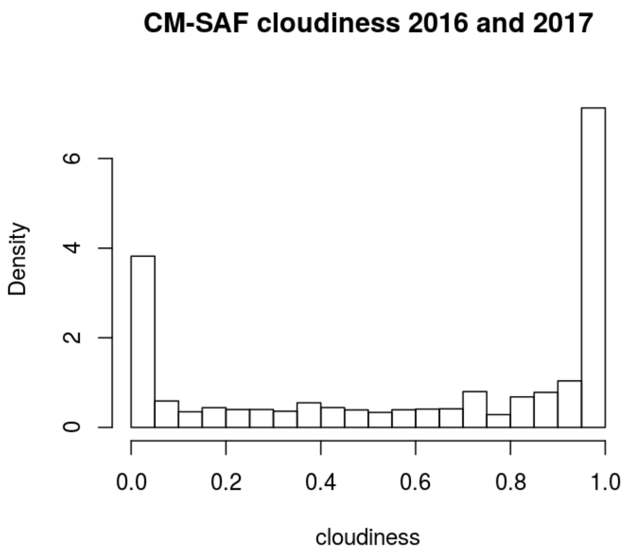
Postprocessing project at MeteoSwiss



- Numerical weather prediction ensemble forecasts tend to be biased and underdispersed
- Statistical postprocessing (PP) removes systematic biases and dispersion errors
- PP project at MeteoSwiss: generation of spatial, probabilistic, seamless postprocessed probabilistic forecasts for surface temperature, precipitation, wind, and cloud cover
- This talk: focus on spatially consistent PP of cloud cover (CC)

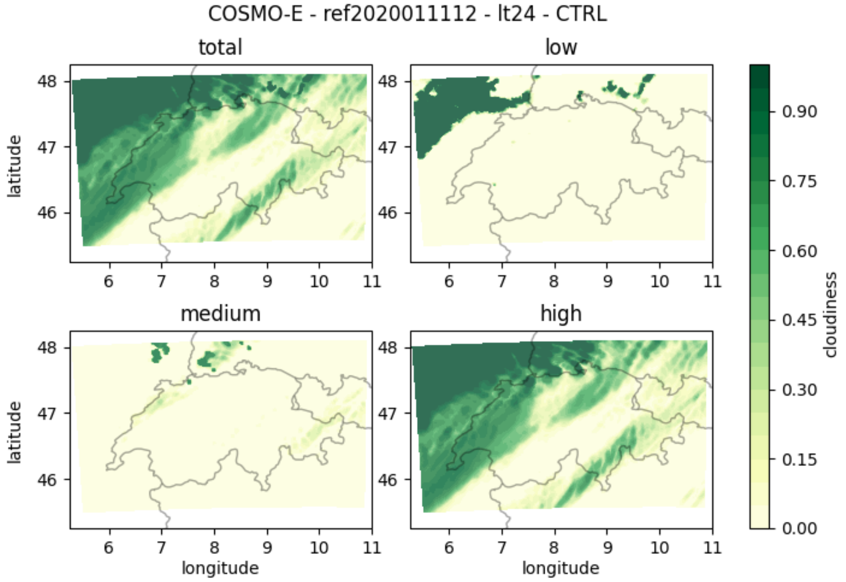
Cloud cover basics

Climatology



Considerable point masses at 0 and 1

Example forecast



Dataset

- Predictors
  - Numerical forecasts (COSMO-E and IFS [+12h])
    - Training set: 05.2016 - 04.2018
    - Validation set: 05.2018 - 04.2019
    - Test set: 05.2019 - 04.2020
- Observations
  - EUMETSAT CM-SAF satellite data, 2 × 2 km resolution

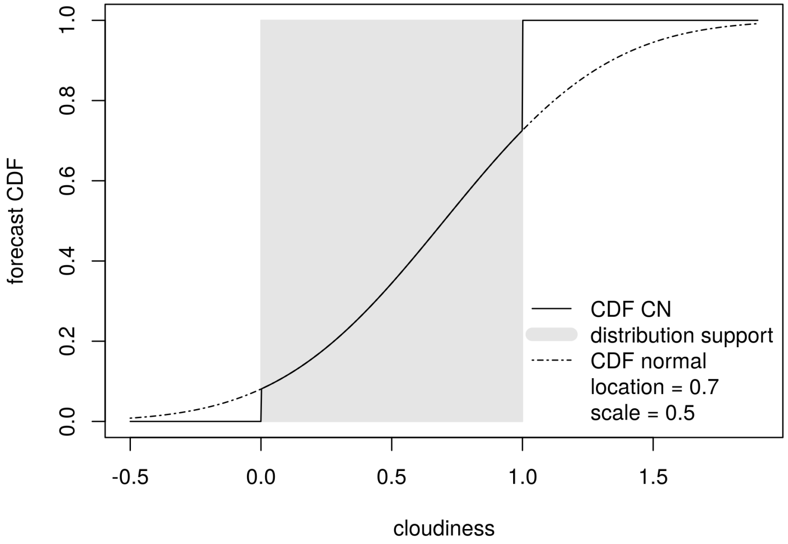
gEMOS as univariate postprocessing approach

- Postprocess hourly COSMO-E and ECMWF-IFS cloud cover ensemble forecasts
- Use an ensemble model output statistics approach (EMOS, Gneiting et al. 2005)
- global EMOS (gEMOS) models fitted seasonally (same season other years) for each lead time separately
- Estimation of coefficients by minimization of the continuous ranked probabilitiy score (CRPS)

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.

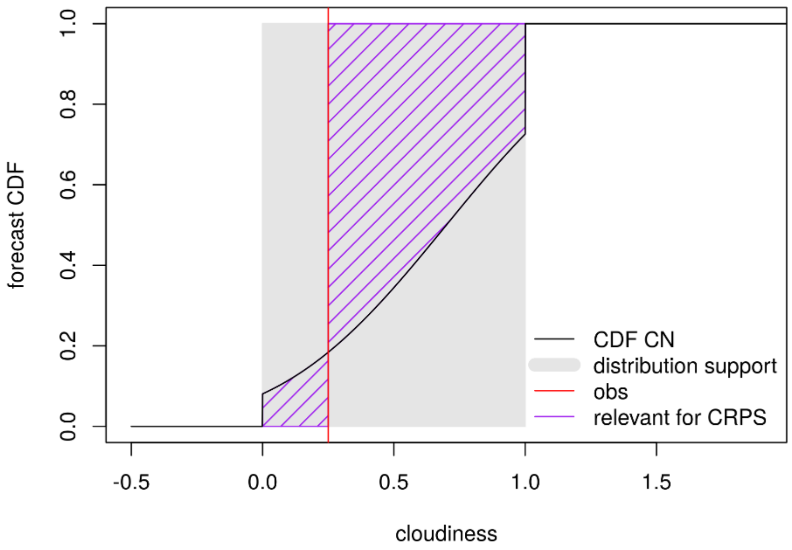
Doubly-censored normal ensemble model output statistic



Location predictors $f_{j,i}$:
- COSMO-E cloud cover mean
- ECMWF-IFS cloud cover mean
- COSMO-E 2meter temperature mean

Scale predictors $s_{k,i}^2$:
- COSMO-E cloud cover variance
- ECMWF-IFS cloud cover variance

Continuous ranked probability score (CRPS)



Used for model estimation and verification

Implementation in R (and Python)

Original approach:

- Data handling in Python
- Model estimation, prediction, and verification in R
- Use scoringRules R package for CRPS of doubly censored normal distribution
- Use rpy2 Python library as Python interface to R

Towards operational use:

- Two languages approach too tedious
- Python easier to fit into anticipated operational framework
- Decided to migrate the complete code to Python

Implementation in R (and Python)

Original approach:

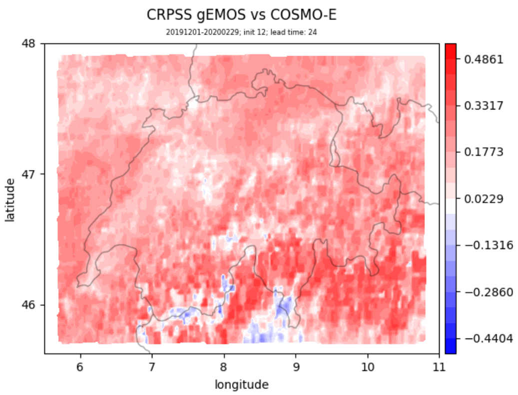
- Data handling in Python
- Model estimation, prediction, and verification in R
- Use scoringRules R package for CRPS of doubly censored normal distribution
- Use rpy2 Python library as Python interface to R
- Advantage: R packages allow for faster - and less error-prone;) - development of statistical methods

Towards operational use:

- Two languages approach too tedious
- Python easier to fit into anticipated operational framework
- Decided to migrate the complete code to Python
- Advantage: Cleaner code and easier to maintain

Univariate verification: test set

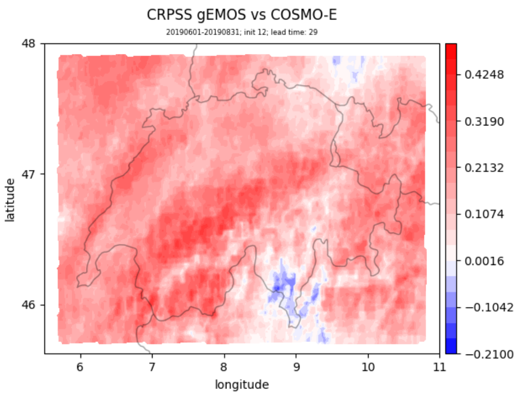
Winter



gEMOS better

COSMO-E better

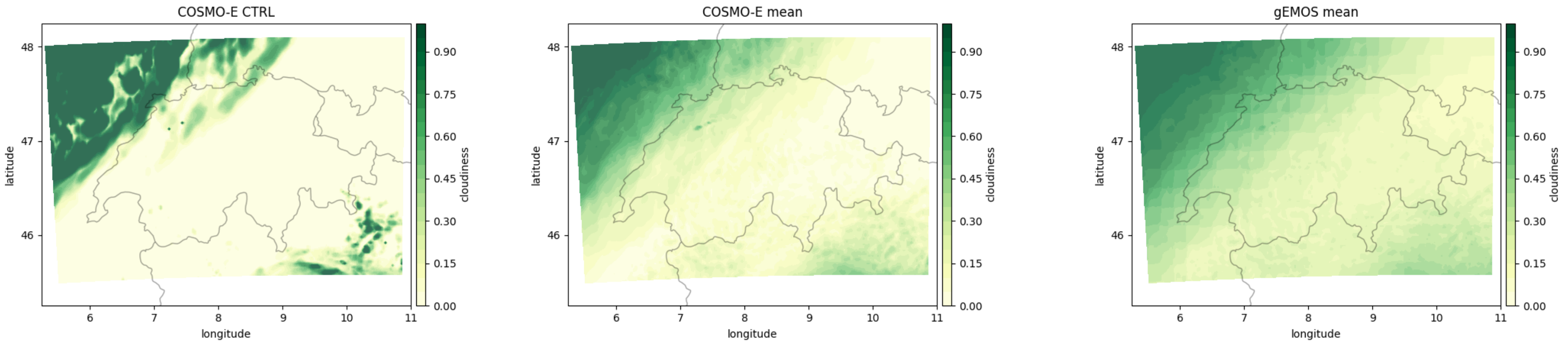
Summer



gEMOS better

COSMO-E better

What does gEMOS do in practice?



- Smoothing (corrects for DMO being ‘too’ certain)
- Destroy the physics

Ensemble copula coupling

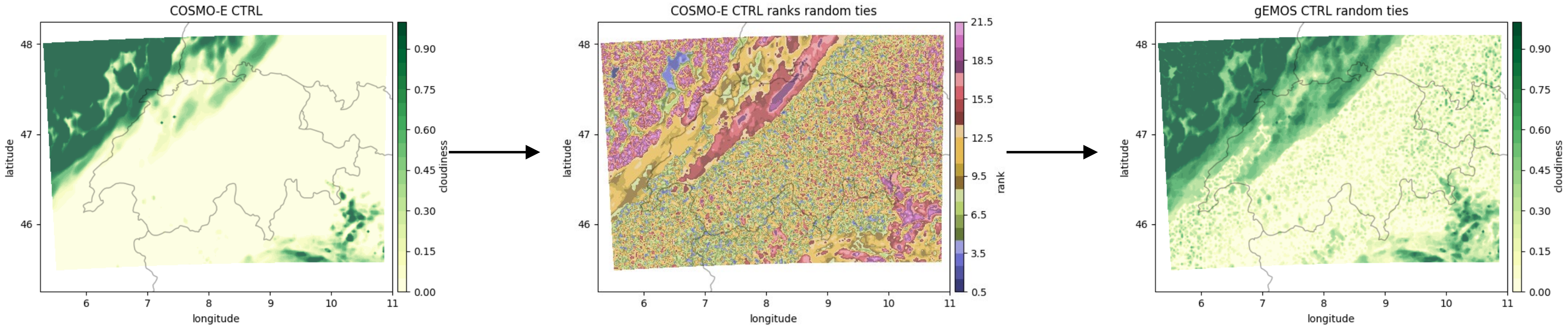
- Ensemble copula coupling (ECC; Schefzik et al. 2013) reintroduces spatio-temporal dependence structure
- Reordering of gEMOS forecast quantiles
- For cloud cover a modified ECC variant (Scheuerer et al., 2018) originally developed for precipitation seems appropriate

References:

- Schefzik, Roman, Thordis L. Thorarinsdottir, and Tilmann Gneiting. "Uncertainty quantification in complex simulation models using ensemble copula coupling." *Statistical science* 28.4 (2013): 616-640.
- 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.

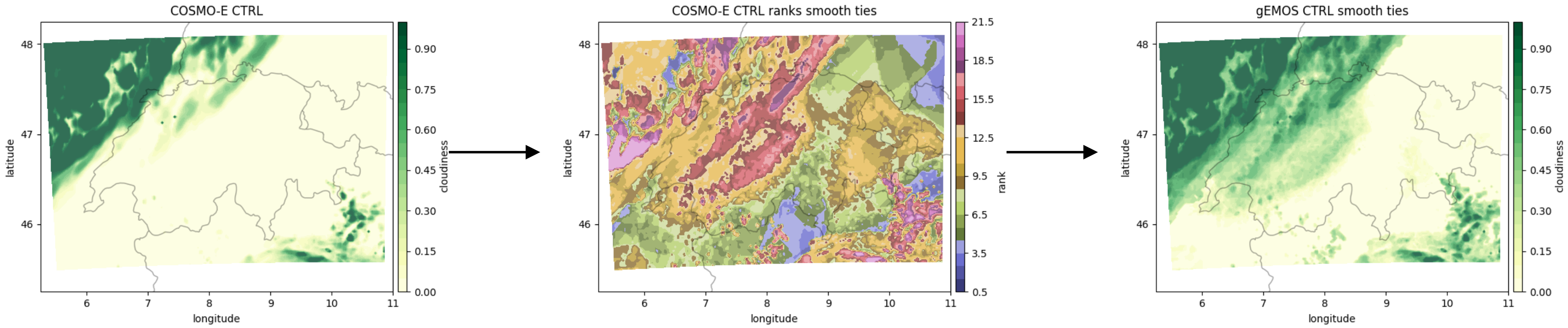
ECC in practice: standard approach

ties resolved at random



ECC in practice: modified approach

ties resolved using artificial cloudiness below 0 and above 1 and tricubic kernel smoothing



 Stephan Hemri

Conclusions

- gEMOS improves forecast skill
  - improvement may partly be explained by the “regression to the mean” tendency of gEMOS for CC
- Modified ECC as proposed by Scheuerer and Hamill (2018) leads to quite realistic spatial forecast scenarios
- R more appropriate for development of gEMOS methods than Python
- Python easier to fit into anticipated operational framework

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