Comparison of Three Interpolation Schemes for Six Parameters

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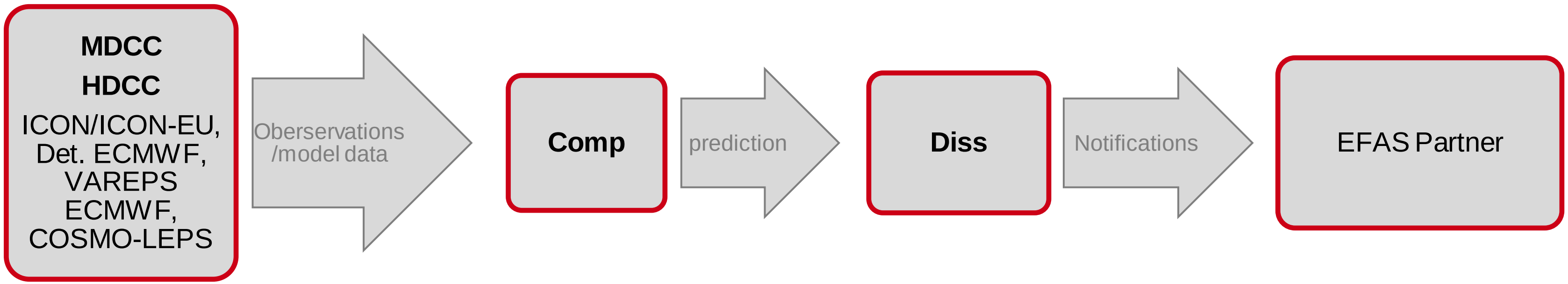
Comparison of three Interpolation Schemes

- European Flood Awareness System –

  The EFAS Meteorological Data Collection Center
- Data basis
- Methods
- Results
- Summary

The operational EFAS
(https://www.efas.eu/about-efas.html).

European Flood Awareness System - EFAS



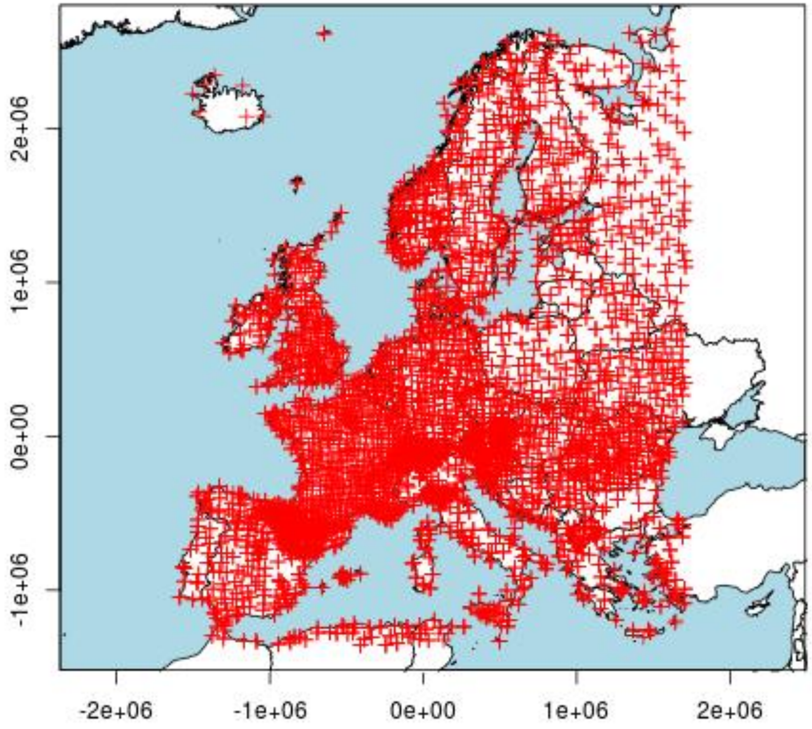
- **EFAS Meteorological data collection Centre**: KISTERS AG and Deutscher Wetterdienst
- **EFAS Hydrological data collection Centre**: REDIAM (ES) and ELIMCO (ES)
- **EFAS Computational Centre**: European Centre for Medium-Range Weather Forecasts (UK)
- **EFAS Dissemination Centre**: Swedish Meteorological and Hydrological Institute, Rijkswaterstaat (NL) and Slovak Hydro-Meteorological Institute

European Flood Awareness System - EFAS

- first operational European system for monitoring and forecasting floods across Europe
- flood early warning information up to 10 days in advance
- hydrological model: LISFLOOD
- collection of daily and sub-daily station observations

Data basis

- May 2014
- Parameters:
  - precipitation totals [mm/day]
  - minimum temperature [°C]
  - maximum temperature [°C]
  - mean vapour pressure [hPa]
  - mean wind speed [m/s]
  - radiation totals [J/m²]



Station locations for precipitation measurements in May 2014 (EFAS domain).

Methods

- **Inverse Distance Weighting (IDW)**
  (Ntegeka et al., 2013)
  - geometric scheme
  - used as reference to assess the tested schemes
  - weight depends on distance (~ $1/d^2$) and number of available stations
  - simple, robust scheme
  - low computational cost

- **Modified SHPEREMAP (SP)**
  (Shepard, 1968;
  Willmott et al., 1985)
  - geometric scheme with distance and angular weighting
  - weight depends on distance, distribution and number of available stations

- **Ordinary Kriging (OK)**
  (Krige, 1966)
  - spatial correlations between observations
  - weights calculated by means of variograms

Results - Overview

- cross-validation (leave-one-out approach)
- different error metrics
  - **M**ean **E**rror (ME)
  - **M**ean **A**bsolute **E**rror (MAE)
- Yamamoto

Results - Different measures of errors

Table 1: Summary of error measures ME and MAE for three interpolations schemes.

Parameter	ME			MAE		
	IDW	SP	OK	IDW	SP	OK
Precipitation totals [mm/day]	0.89	**-0.02**	-0.02	2.32	**1.36**	1.40
Minimum temperature [°C]	0.06	**0.04**	0.06	**1.60**	1.62	1.62
Maximum temperature [°C]	0.04	0.05	**0.00**	**1.76**	1.78	1.79
Wind speed [m/s]	0.03	**0.01**	0.03	**0.96**	1.02	0.97
Vapor pressure [hPa]	0.01	**0.00**	0.02	0.85	**0.84**	0.85
Radiation totals [J/m²]	22	17	**15**	**2152**	2284	2153

➔ computing times for EFAS domain (1‘500‘000 grid points, including ocean areas)

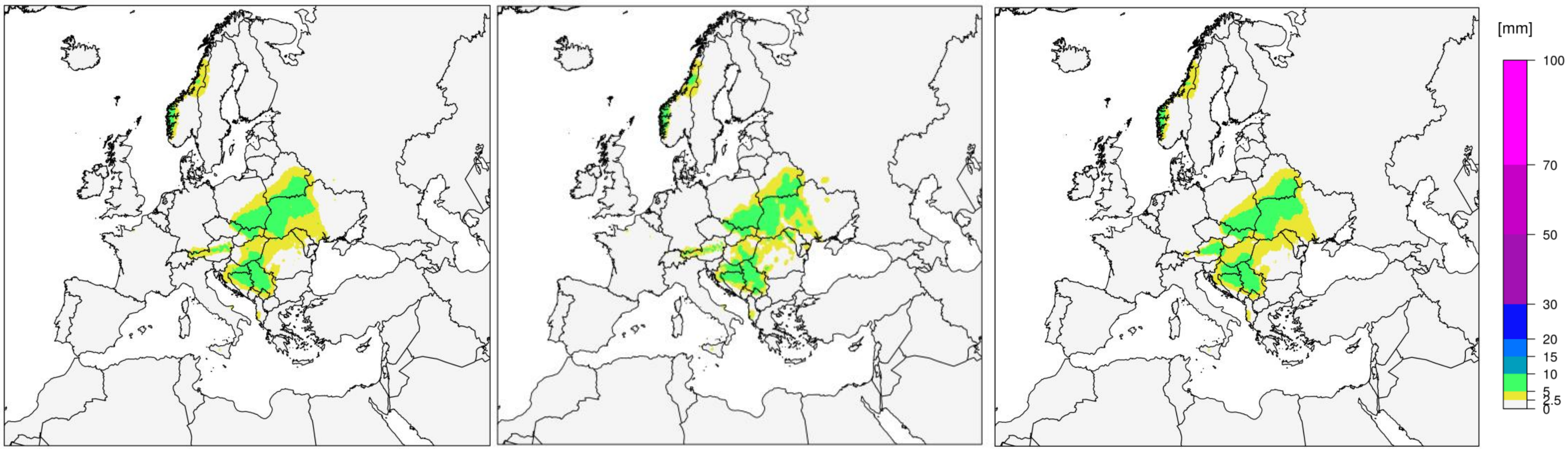
IDW	modified SP	OK
470 sec	550 sec	700 sec

Results – Yamamoto‘s approach

- interpolation standard deviation (Yamamoto, 2000)
- at each grid point as the weighted average of the squared differences between observations and interpolated values
  - reasonable computational effort
  - correlated with CV-error
  - underestimates CV-error
- provides reliable uncertainty estimates for operational applications

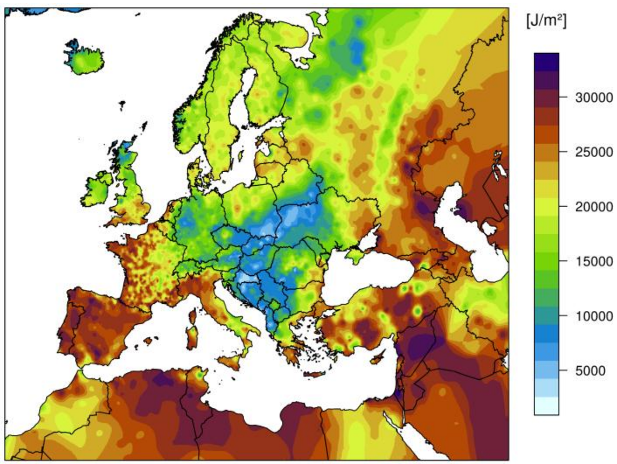
Results (15.05.2014) – Precipitation totals [mm/day]

IDW | **SP** (modified) | **OK**

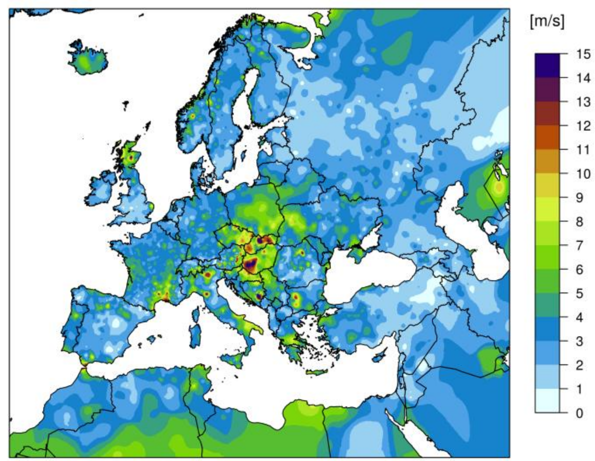


Results (15.05.2014) – SPHEREMAP (modified)

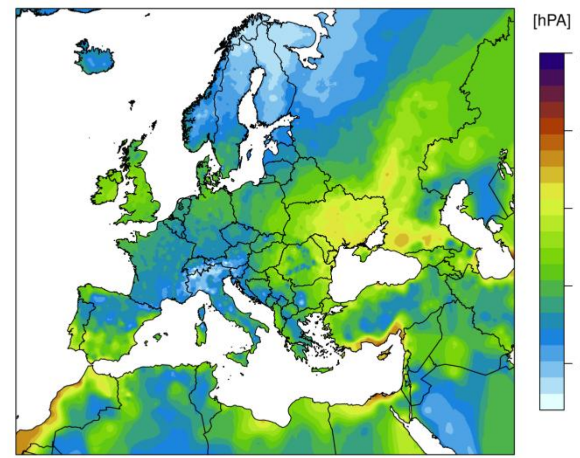
Radiation totals [W/m²]



Wind speed [m/s]



Vapour pressure [hPa]



Summary

- Inverse Distance Weighting (IDW) performs best regarding **M**ean **A**bsolute **E**rror (MAE) and computational time, modified SPHEREMAP regarding **M**ean **E**rror (ME)
- Ordinary Kriging (OK) yields highest error values
- **modified SPHEREMAP is recommended as interpolation method, because…**
  - reliable grids
  - low bias
  - robust against variable station density

Questions / Comments?

Literature review

V. Ntegeka, P. Salamon, G. Gomes, H. Sint, V. Lorini, M. Zambrano-Bigiarini, J. Thielen; 2013; EFAS-Meteo: A European daily high-resolution gridded meteorological data set for 1990 – 2011; DOI: 10.2788/51262.

C.J. Willmott, C.M. Rowe, W.D. Philpot; 1985; Small-scale climate maps: A sensitivity analysis of some common assumptions associated with grid-point interpolation and contouring; The American Carthographer; Vol. 12; pp. 5-16.

D.G. Krige; 1966; Two-dimensional weighted moving average trend surfaces for ore valuation; Proceedings of the Symposium on Mathematical Statistics and Computer Applications in Ore Valuation; pp. 13-38.

C. J. Willmott, K. Matsuura; 2006; On the use of dimensioned measures of error to evaluate the performance of spatial interpolators; International Journal of Geographical Information Science; DOI: 10.1080/13658810500286976.

J. K. Yamamoto; 2000; An Alternative Measure of the Reliability of Ordinary Kriging Estimates; Mathematical Geology; DOI: 10.1023/A:1007577916868.

D. Shepard; 1968; A two-dimensional interpolation function for irregularly spaced data; Proc. 23rd ACM Nat. Conf.; Brandon/Systems Press; Princeton; NJ; pp. 517-524.

Important equations

Inverse Distance Weigthing

$$z^*(x_0) = \frac{\sum_{i=1}^{n} \frac{z(x_i)}{d^x(x_0,x_i)}}{\sum_{i=1}^{n} \frac{1}{d^x(x_0,x_i)}}$$

Ordinary Kriging

$$z^*(\boldsymbol{u}) = \sum_{\alpha=1}^{n(\boldsymbol{u})} \lambda_\alpha(\boldsymbol{u}) z(\boldsymbol{u}_\alpha) + \left[1 - \sum_{\alpha=1}^{n(\boldsymbol{u})} \lambda_\alpha(\boldsymbol{u})\right] m(\boldsymbol{u})$$

YAMAMOTO

$$s_0 = \sqrt{\sum_{i-1}^{n} \lambda_i [z(x_i) - z * (x_0)]^2}$$

Modified SPHEREMAP

$$\Delta z_k = \left\{ \left[\frac{\partial(\Delta z)}{\partial \lambda}\right]_k d^s_\lambda(j,k) + \left[\frac{\partial(\Delta z)}{\partial \phi}\right]_k d^s_\phi(j,k) \right\} \times \{v/(v + d^s_{j,k})\},$$

$$\hat{z}_j = \begin{cases} \sum_{k=1}^{n_j} W_k(z_k + \Delta z_k) / \sum_{k=1}^{n_j} W_k, & d_{j,1} > \epsilon \\ m^{-1} \sum_{k=1}^{m} z_k, & d_{j,1} \leqslant \epsilon, \end{cases}$$