



Comparison of Three Interpolation Schemes for Six Parameters

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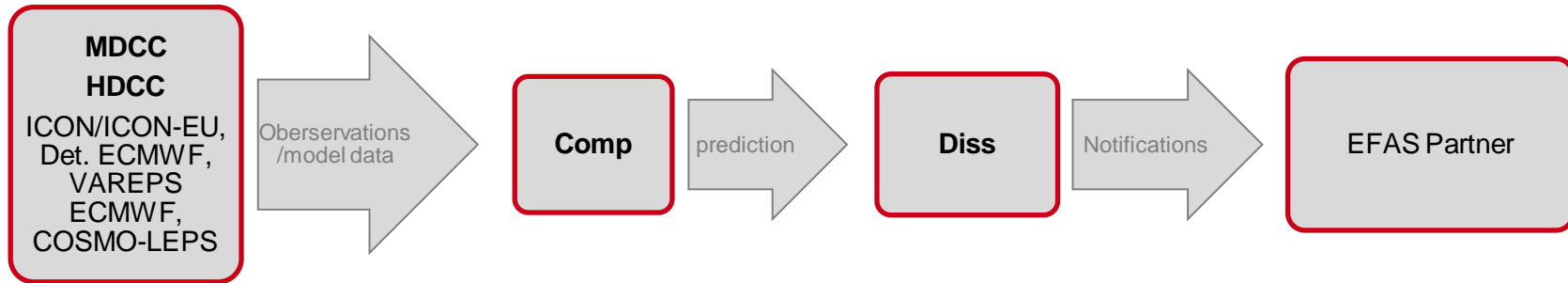
Comparison of three Interpolation Schemes

- 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

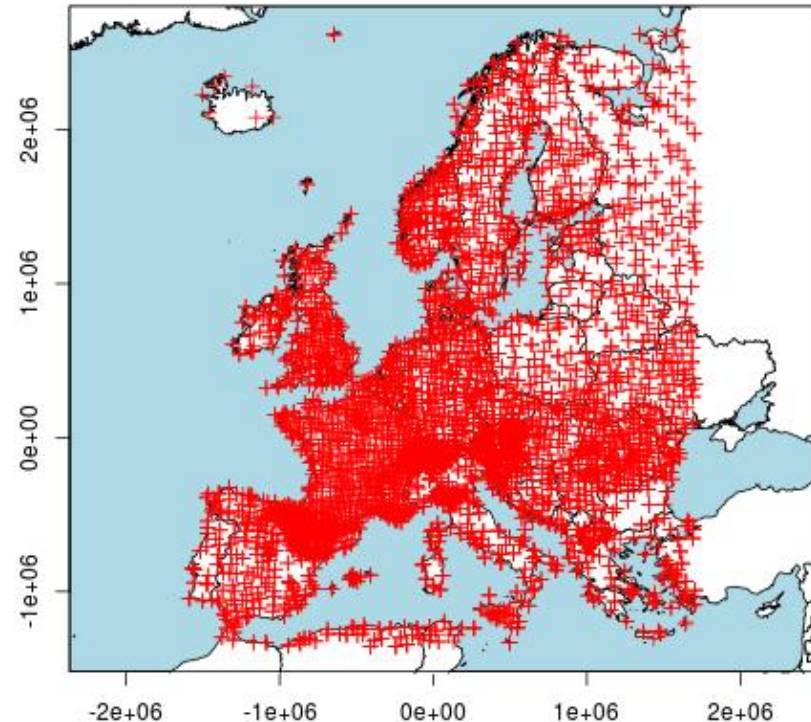
- first operational European system for monitoring and forecasting floods across Europe
- flood early warning information up to 10 days in advance
- hydrological model: LISFLOOD
- collection of daily and sub-daily station observations

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 ($\sim 1/d^2$) 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
 - **Mean Error** (ME)
 - **Mean Absolute Error** (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/m ²]	22	17	15	2152	2284	2153

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

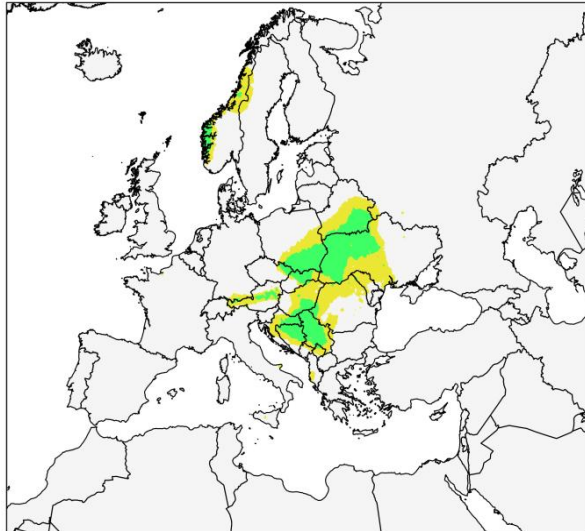
IDW	modified SP	OK
470 sec	550 sec	700 sec

Results – Yamamoto's approach

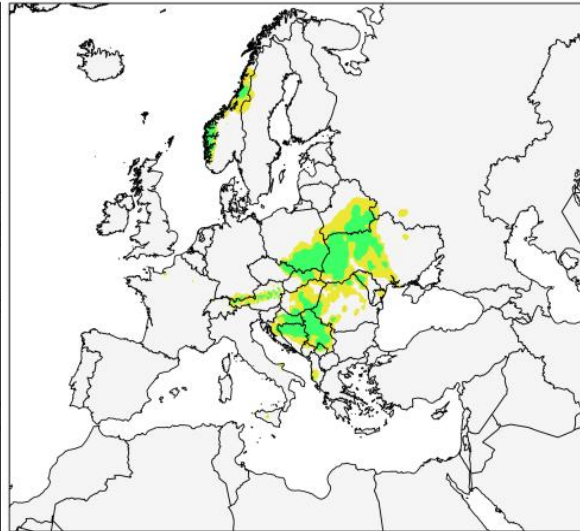
- interpolation standard deviation (Yamamoto, 2000)
- at each grid point as the weighted average of the squared differences between observations and interpolated values
 - reasonable computational effort
 - correlated with CV-error
 - underestimates CV-error
- provides reliable uncertainty estimates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

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

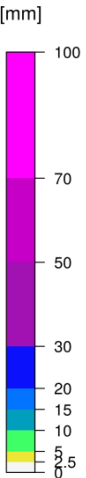
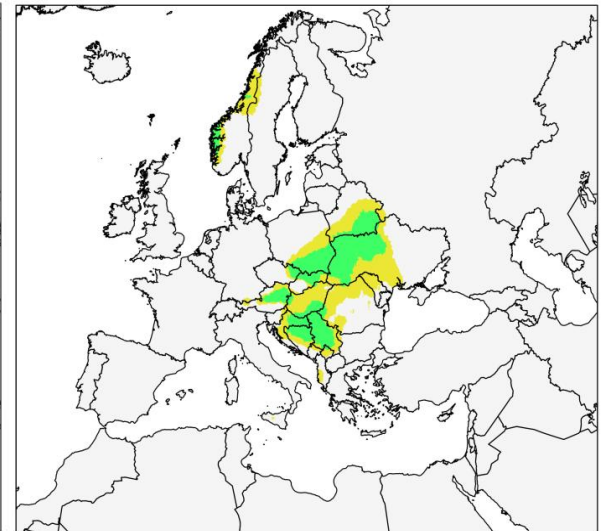
IDW



SP (modified)

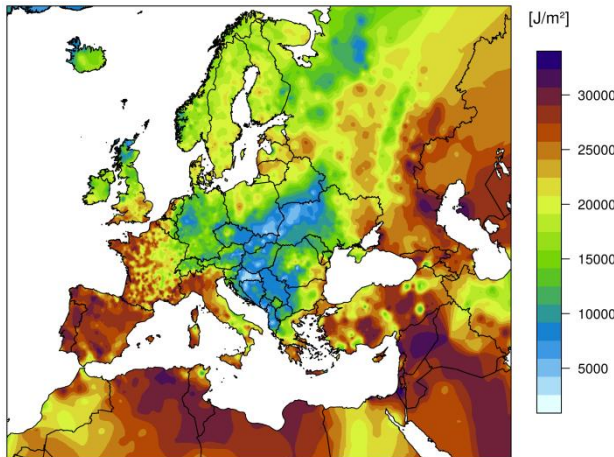


OK

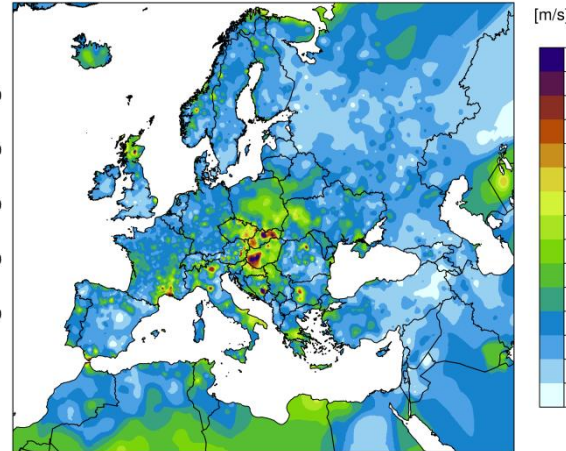


Results (15.05.2014) – SPHEREMAP (modified)

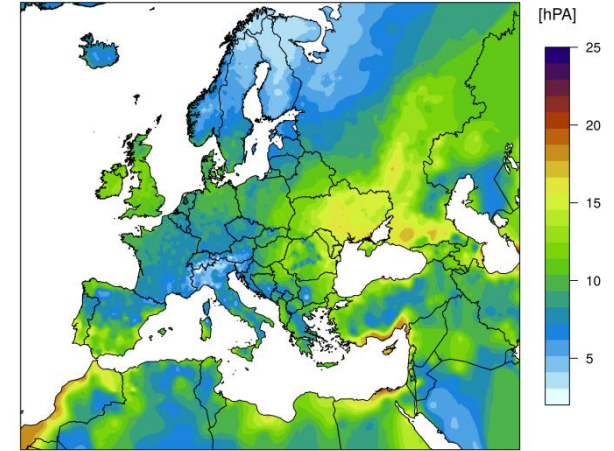
Radiation totals [W/m²]



Wind speed [m/s]



Vapour pressure [hPa]



Summary

- ➔ Inverse Distance Weighting (IDW) performs best regarding **Mean Absolute Error (MAE)** and computational time, modified SPHEREMAP regarding **Mean Error (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



Thank you!

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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 Cartographer; 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

$$z^*(\mathbf{x}_0) = \frac{\sum_{i=1}^n \frac{z(x_i)}{d^x(\mathbf{x}_0, x_i)}}{\sum_{i=1}^n \frac{1}{d^x(\mathbf{x}_0, x_i)}}$$

Ordinary Kriging

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

YAMAMOTO

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

Modified SPHEREMAP

$$\Delta \mathbf{z}_k = \left\{ \frac{\partial(\Delta \mathbf{z})}{\partial \lambda} \right\}_k \mathbf{d}_{\lambda}^s(j, k) + \left\{ \frac{\partial(\Delta \mathbf{z})}{\partial \phi} \right\}_k \mathbf{d}_{\phi}^s(j, k) \right\} \times \left\{ \mathbf{v} / (\mathbf{v} + \mathbf{d}_{j, k}^s) \right\},$$

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

