

Climatology based downscaling targeting at improved spatial resolution of COST-726 SOL-CMF's

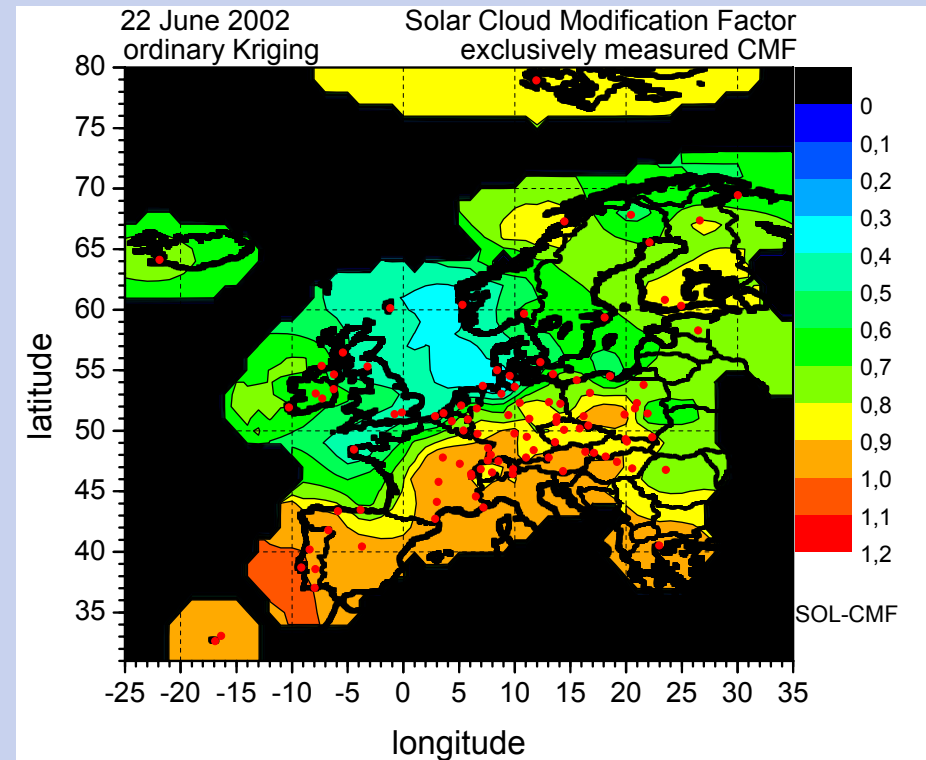
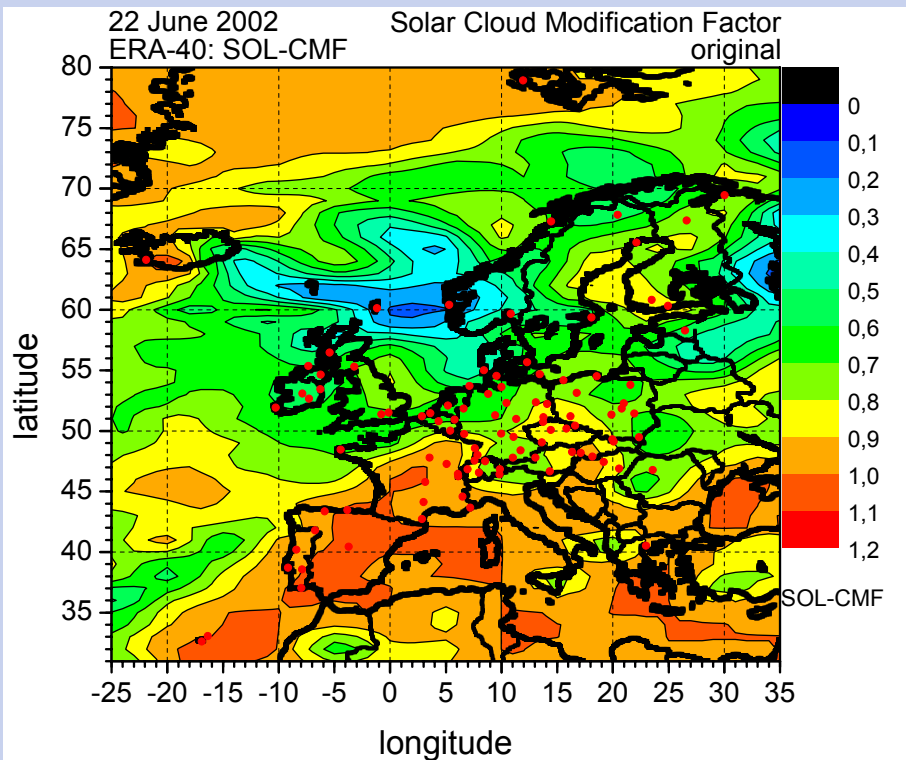
Henning Staiger, German Meteorological Service (DWD), emeritus

Outline:

- COST gridded SOL-CMF: distance measure in interpolation
- ESRA spatially high resolved 10-year monthly mean of irradiation
- Deviation factors for downscaling
- Spatial distribution of deviation factors
- Example of a downscaled map of monthly mean SOL-CMF

Merging ERA-40 and observed SOL-CMF's

22 June 2002

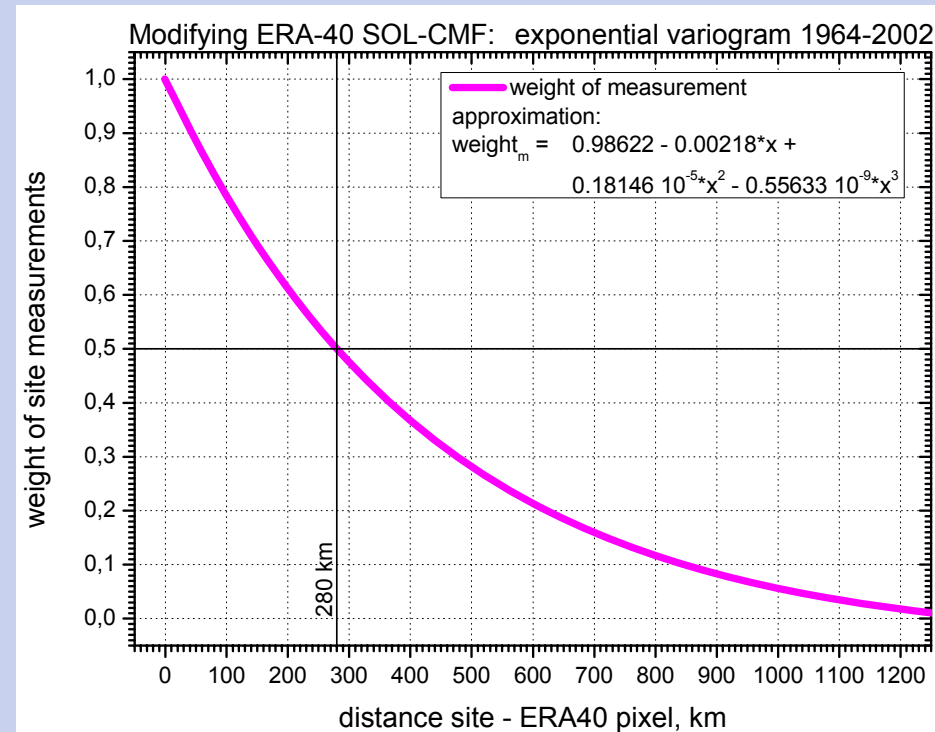
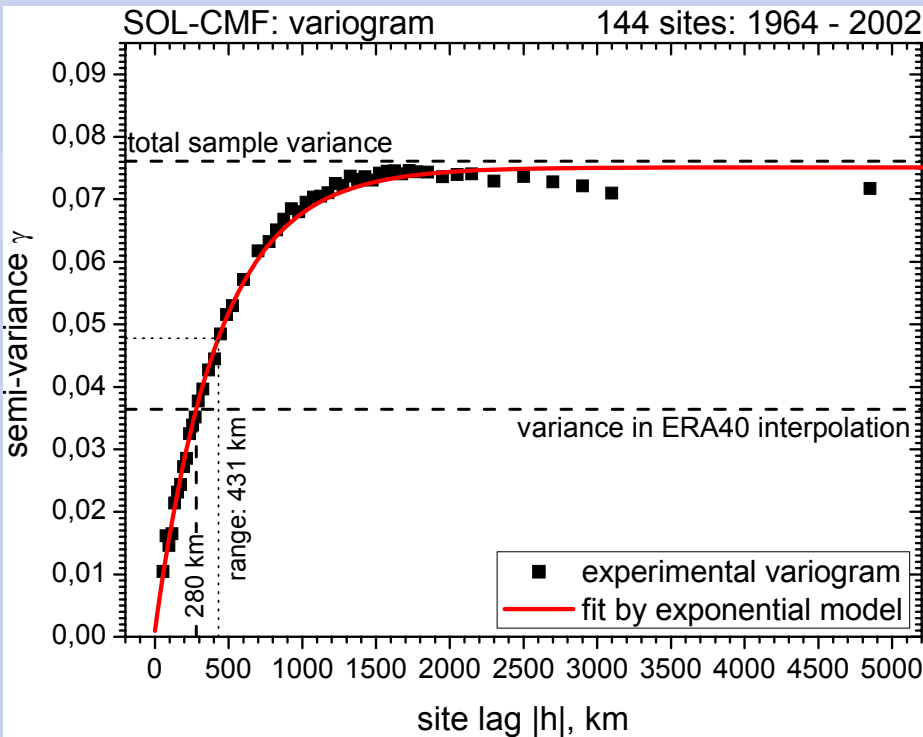


ERA-40 original

gridded observations

Merging ERA-40 and observed SOL-CMF's

1964 - 2002



semi-variance in ordinary Kriging

weight of observations in merging

Interpolation: Distance measure

$$\text{value} = \frac{\sum (w_i \cdot \text{value}_i)}{\sum w_i}$$

$$w_i = \left[\frac{r_{\text{search}}}{d_i} - 1 \right]^2$$

$$d_i = \sqrt{d_{\text{hor},i}^2 + (\Delta z_i \cdot f)^2}$$

Interpolation:

w_i = weight of location with index “i” in interpolation

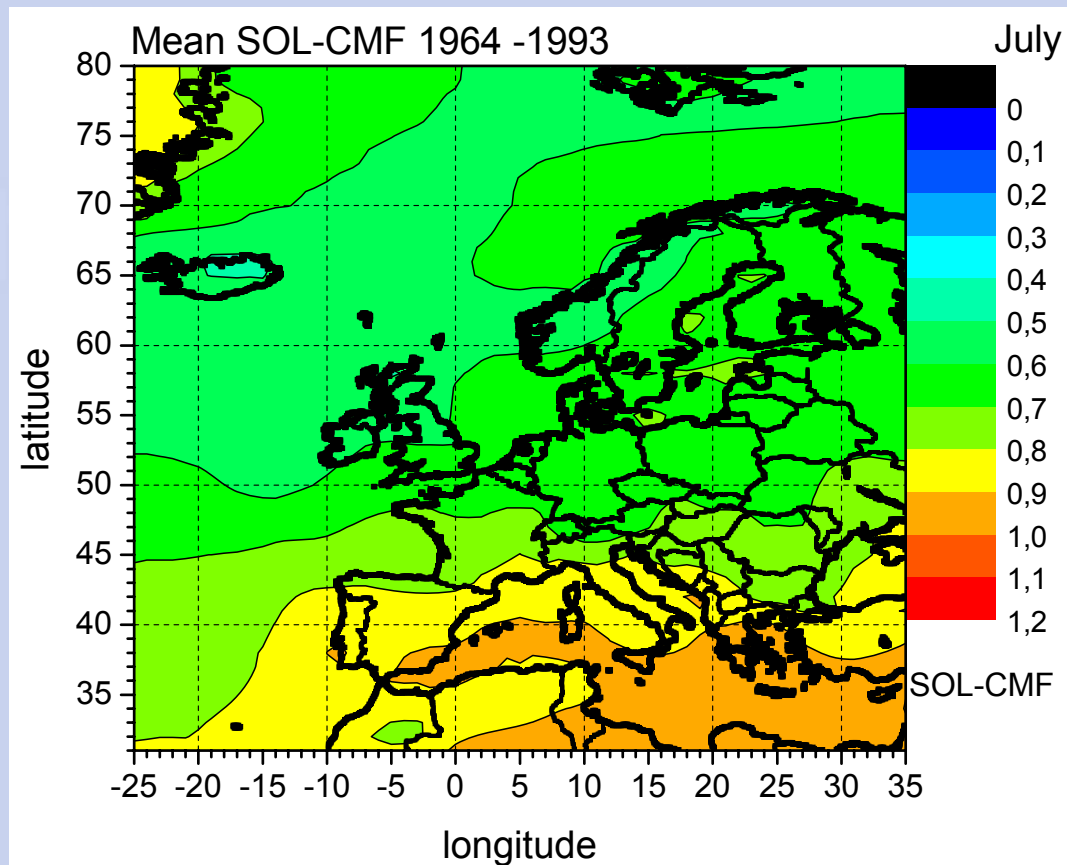
Shephard’s gravity interpolation:

- constraint: $0 < d_i < r_{\text{search}}$

Distance measure (Zelenka & Lasic):

- $d_{\text{hor},i}$ = horizontal great circle distance, km
- $f = 0.1$ [km/m]: equivalence horizontal and vertical distance

COST-726 daily solar cloud modification factors (SOL-CMF)



COST-726 database

1958 – 2004 daily SOL-CMF

Geographical coverage:

- 25°W to 35°E
- 30°N to 80°N

Spatial resolution/topography:

- 1°×1° ≈ 112 km × 112 km
- ERA-40

SOL-CMF representative for pixel area

Shortcoming in COST SOL-CMF's

Limited spatial resolution of $1^\circ \times 1^\circ$ due to

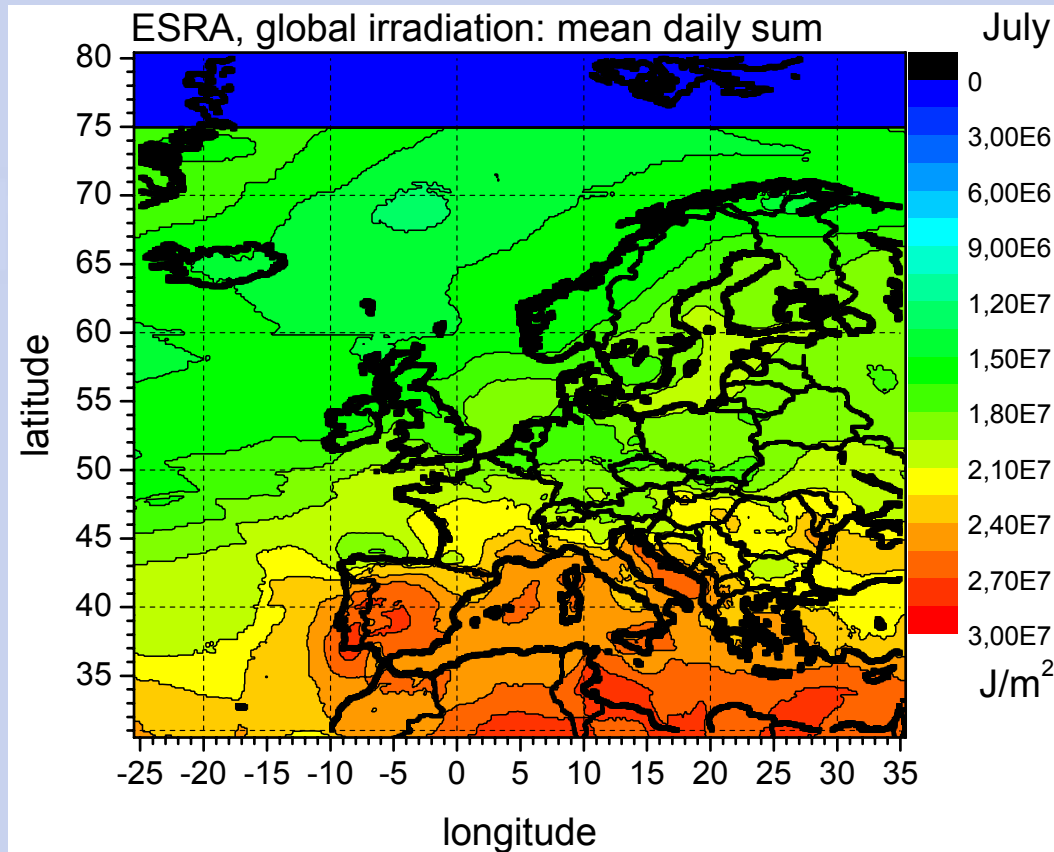
- merging with ERA-40;
- threshold of achievable spatial resolution in ordinary Kriging of observed SOL-CMF's dependent on minimum site distance (48.3 km) used in structural analysis.

Downscaling

Downscaling to improved spatial resolution requires additional information; possibilities:

- Dynamic interrelationships → nesting in ERA-40 (not available).
- climatological / statistical relations in improved spatial resolution → e.g., European Solar Radiation Atlas (ESRA).

European Solar Radiation Atlas (ESRA) Ten year monthly means of daily global radiation



ESRA database

1981 – 1990 monthly means of daily global irradiation.

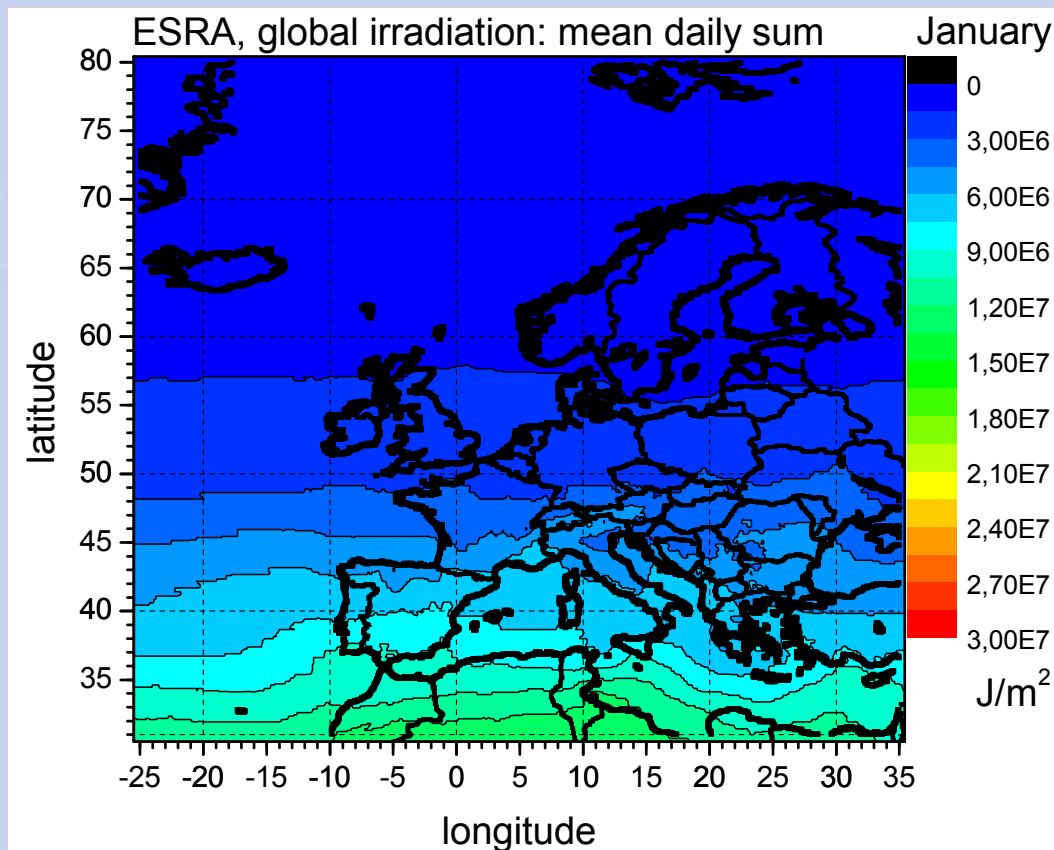
Geographical coverage:

- 30°W to 70°E
- 29°N to 75°N

Spatial resolution:

- 5 min×5 min ≈ 10 km×10km
- topography: ETOPO5

European Solar Radiation Atlas (ESRA) Ten year monthly means of daily global radiation



Data sources for ESRA maps of global irradiation

Ground based daily sums:

- WRDC 314 sites 1981-90

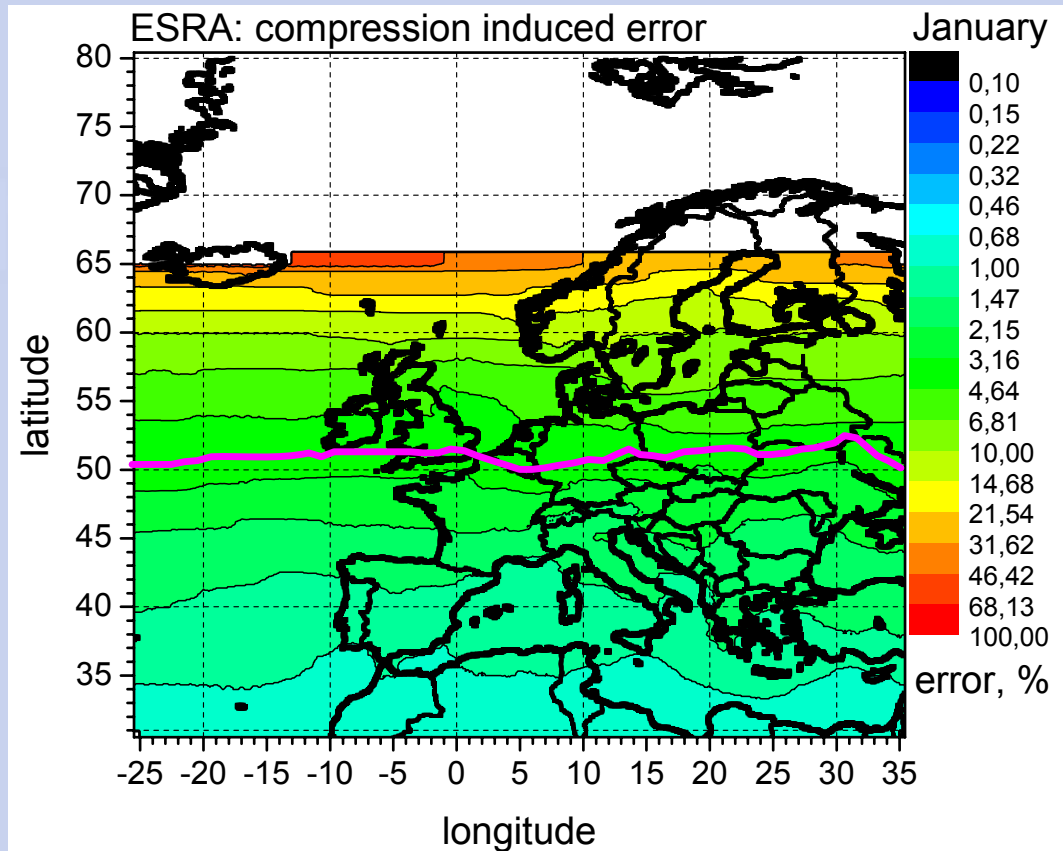
Ground based monthly means:

- NMS 558 sites 1981-90

Satellites:

- SRB 180 km 1985-88
- METEOSAT 10 km 1983-85 (Western + Central Europe)

European Solar Radiation Atlas (ESRA) Ten year monthly means: Compression induced error



Compression of 10-year monthly mean into 1 byte:

- division by $0.18 \times 10^6 \text{ J m}^{-2}$;
- truncation to integer

Truncation induced absolute error $\pm 0.09 \times 10^6 \text{ J m}^{-2}$

Accepted monthly means:

Truncation error relative to monthly mean $< 3.75 \%$.

Downscaling by climatological deviation factors

- Generate monthly mean SOL-CMF per high resolving pixel (hi):

$$\overline{\text{SOL} - \text{CMF}}_{\text{mon,hi}} = \overline{G_{\text{all-sky}}}_{\text{mon,hi}} / \overline{G_{\text{clear-sky}}}_{\text{mon,hi}}$$

- Calculate area mean SOL-CMF per coarse COST pixel (cj) from assigned hi-pixel:

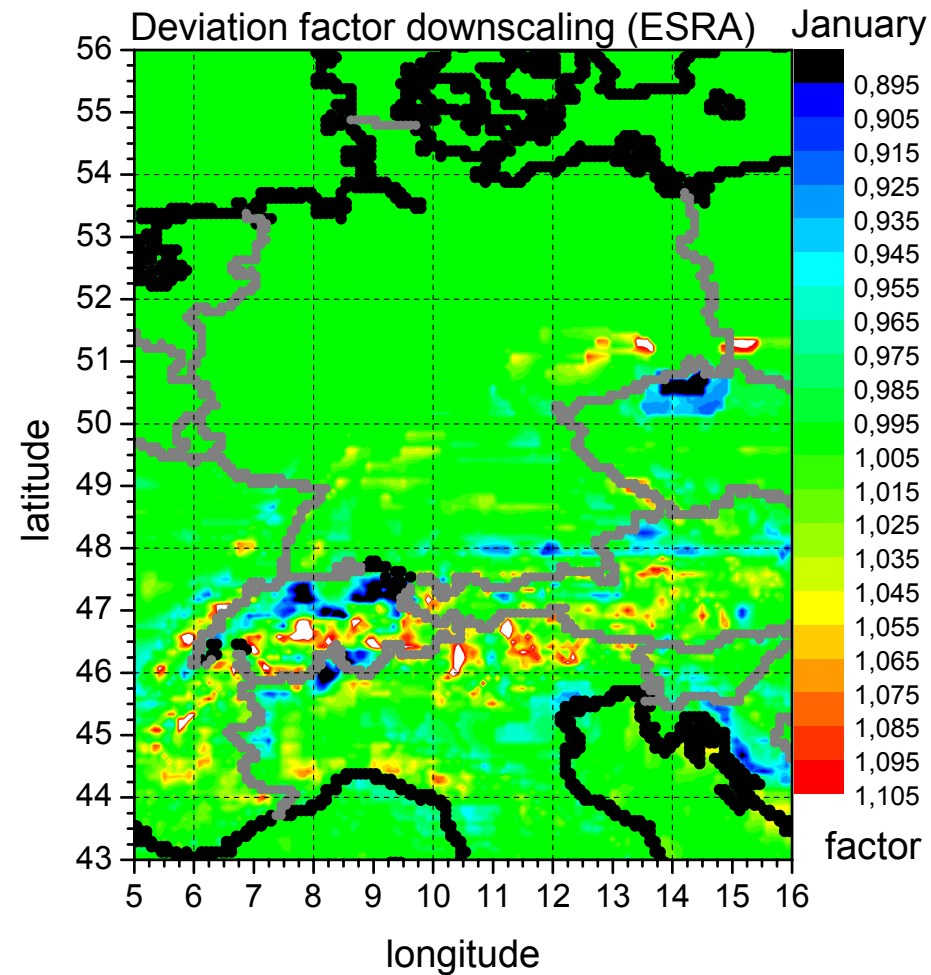
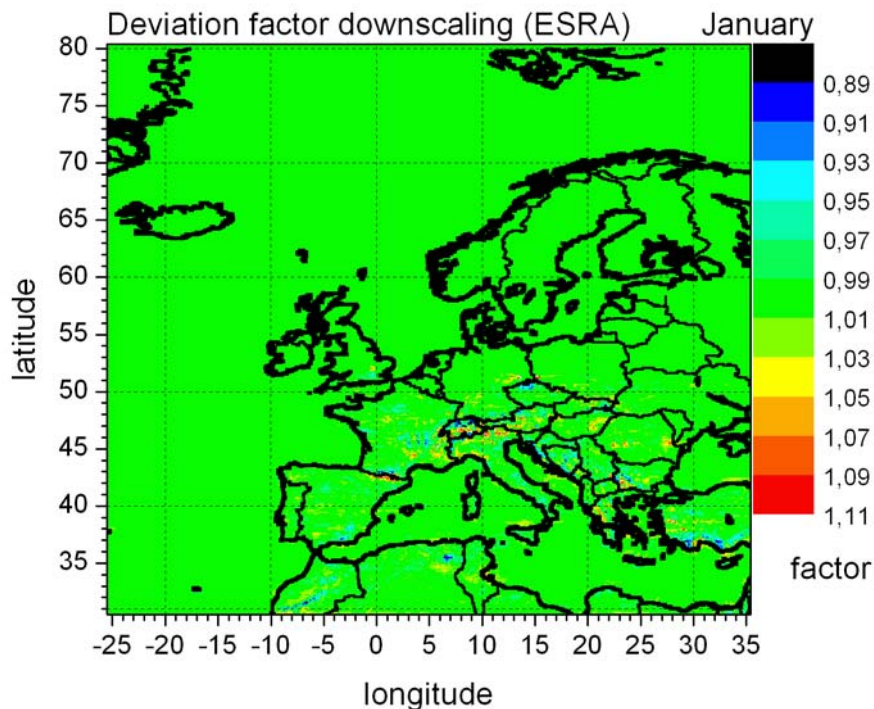
$$\overline{\text{SOL} - \text{CMF}}_{\text{mon,cj}} = \frac{1}{144} \cdot \left(\sum_{\text{lon}=\text{hi}(\text{cj})-6}^{\text{hi}(\text{cj})+5} \cdot \sum_{\text{lat}=\text{hi}(\text{cj})-6}^{\text{hi}(\text{cj})+5} \overline{\text{SOL} - \text{CMF}}_{\text{mon,hi}(\text{cj})}(\text{lon}, \text{lat}) \right)$$

- Deviation factor for each hi-pixel relating its monthly mean SOL-CMF to a value interpolated from the coarse grid applying Zelenka & Lasic's distance measure and Shephard's interpolation:

$$f_{\text{dev}}_{\text{mon,hi}} = \frac{\overline{\text{SOL} - \text{CMF}}_{\text{mon,hi}}}{\text{interpolated}(\overline{\text{SOL} - \text{CMF}}_{\text{mon,cj}(\text{hi})})}$$

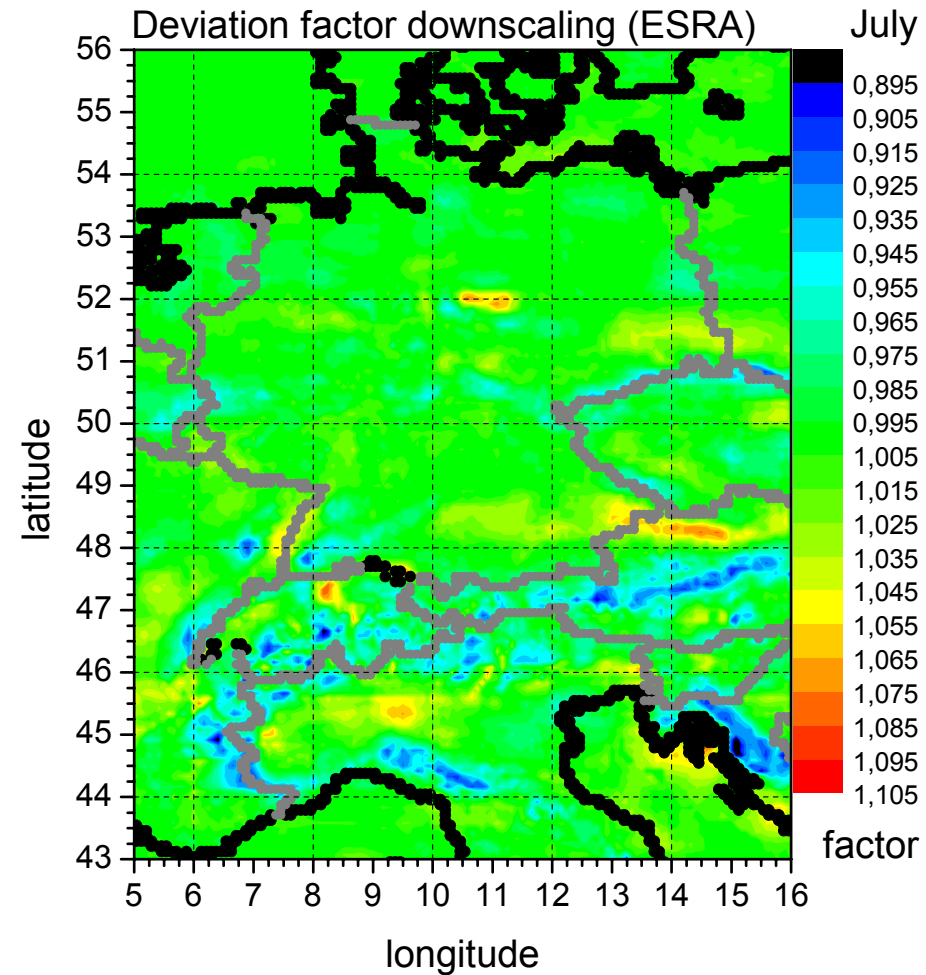
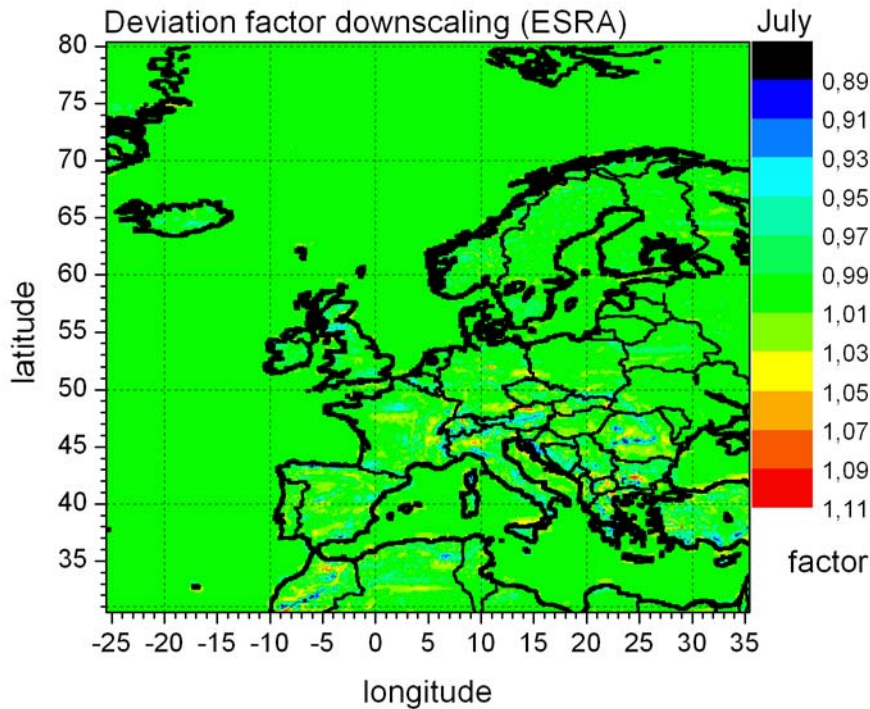
Deviation factors for spatially high resolving maps

January



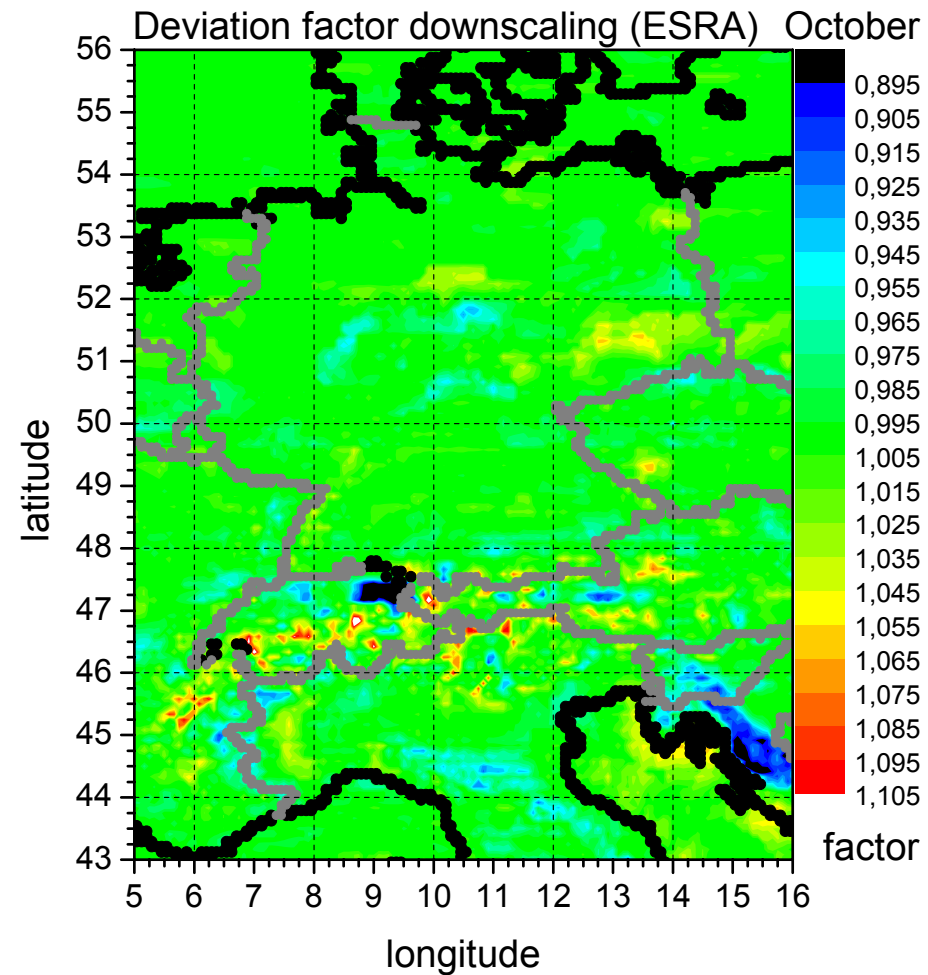
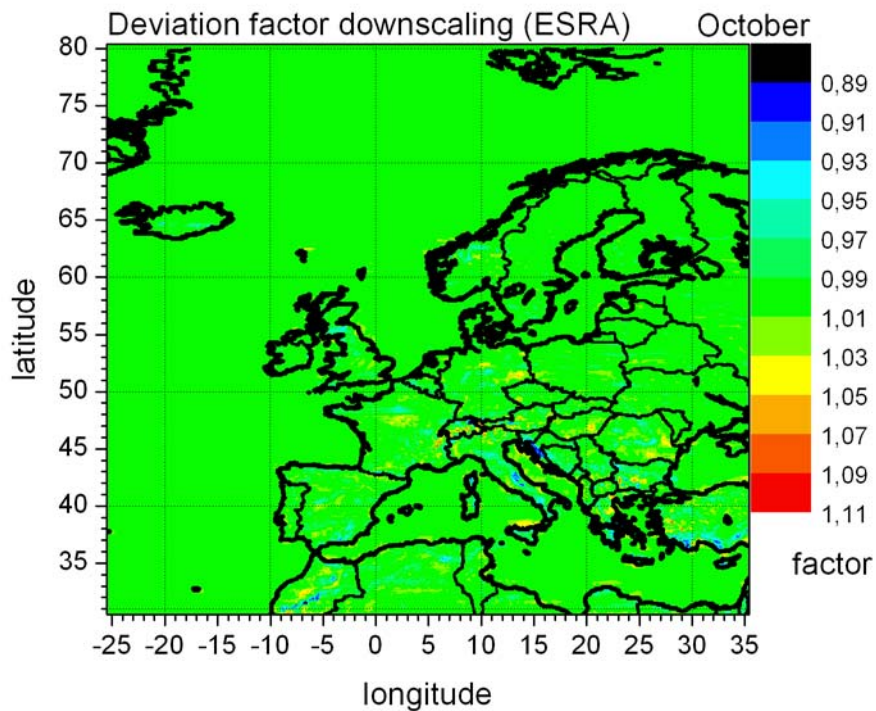
Deviation factors for spatially high resolving maps

July

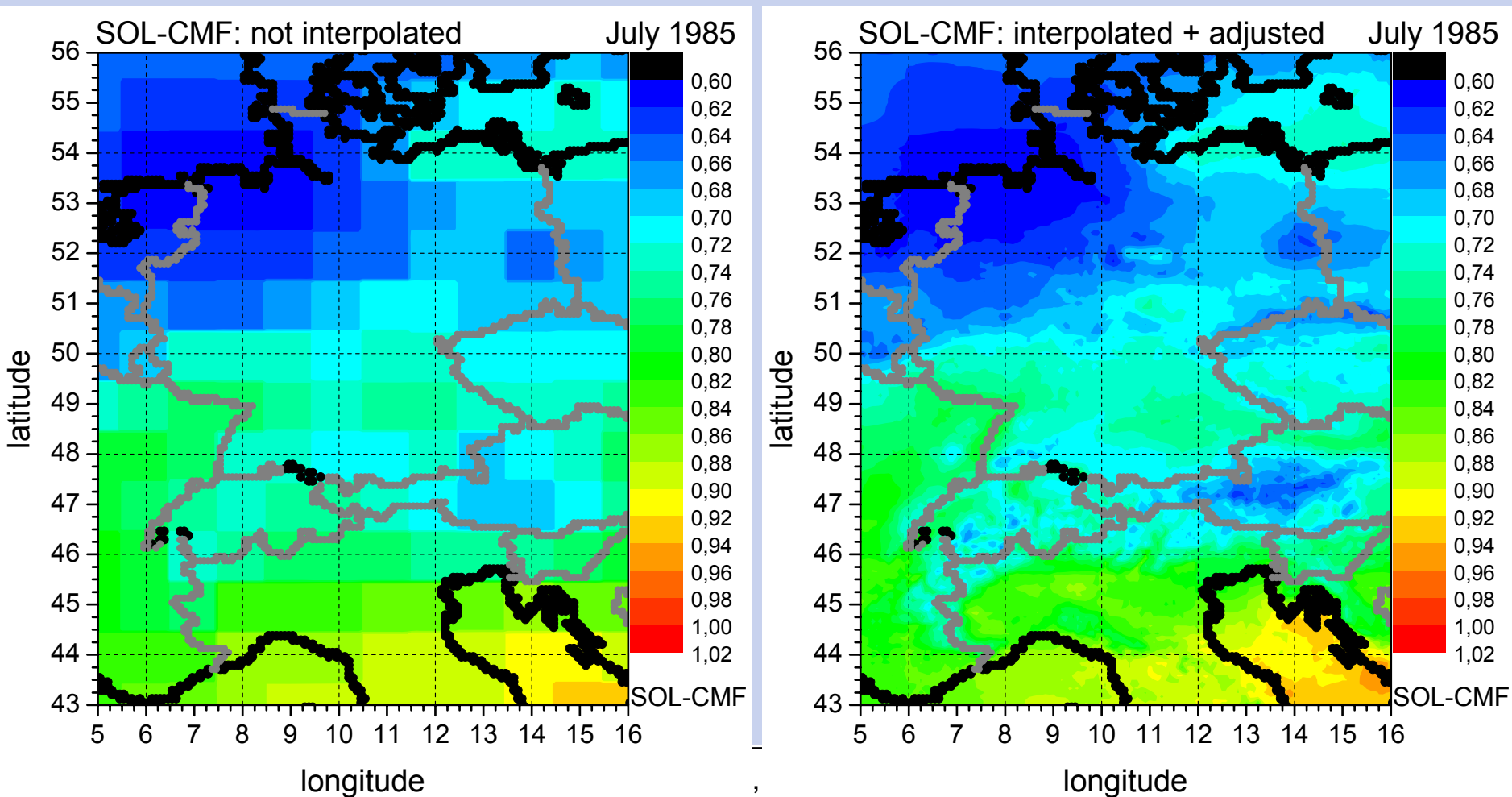


Deviation factors for spatially high resolving maps

October



Mean SOL-CMF July 1985 : Impact of interpolation and adjustment



Conclusions:

- In principal, the procedure is suited for downscaling of SOL-CMF:
 - from a climatological point of view the results are reliable;
 - applied on a daily basis, the climatology may bias extremes, however, improved results can be expected for a temporal resolution of one month.
- The procedure does not depend on ESRA as database.
- Preferable would be:
 - a temporally improved climatology;
 - a climatological basis with improved accuracy (not compressed).



Thank you for your attention

