Cross validation and homogenisation of daily Solar Cloud Modification Factors (SOL− CMF)

- Clear-sky model
- Network requirements, data sources, spatial distribution
- Selection of appropriate Mediterranean sites and homogenisation
- Direct aerosol radiative effect in clear-sky SOL−CMF
- Cross-validation of daily SOL−CMF: flagging of possible outliers
- Site specific data products

Method in calculation of "measured" daily SOL– CMF

Definition:

$$SOL - CMF = \frac{I^{day}_{cloudy,measured}}{I^{day}_{clear-sky}}$$

Modelling daily clear-sky sums of global irradiation: $I^{day}_{clear-sky}$

- algorithm of the European Solar Radiation Atlas (ESRA) numeric representation, 1 min steps in integration (Scharmer and Greif, ed., 2000)
- Monthly means of Linke turbidity factor (Remund et al., 2003)
- factor to adjust for snow albedo. It is related to the albedo snow free surfaces set at 18 % (STARneuro, Schwander et al., 2001).

Network density and COST-726 objectives

COST objective: Resolve regional differences, deliver bias free results

Network requirements:

- dense, area-wide network
- sites representative for areas lacking in measurements (bias correction)

COST objective: UV climatology

Network requirements:

- long-term datasets

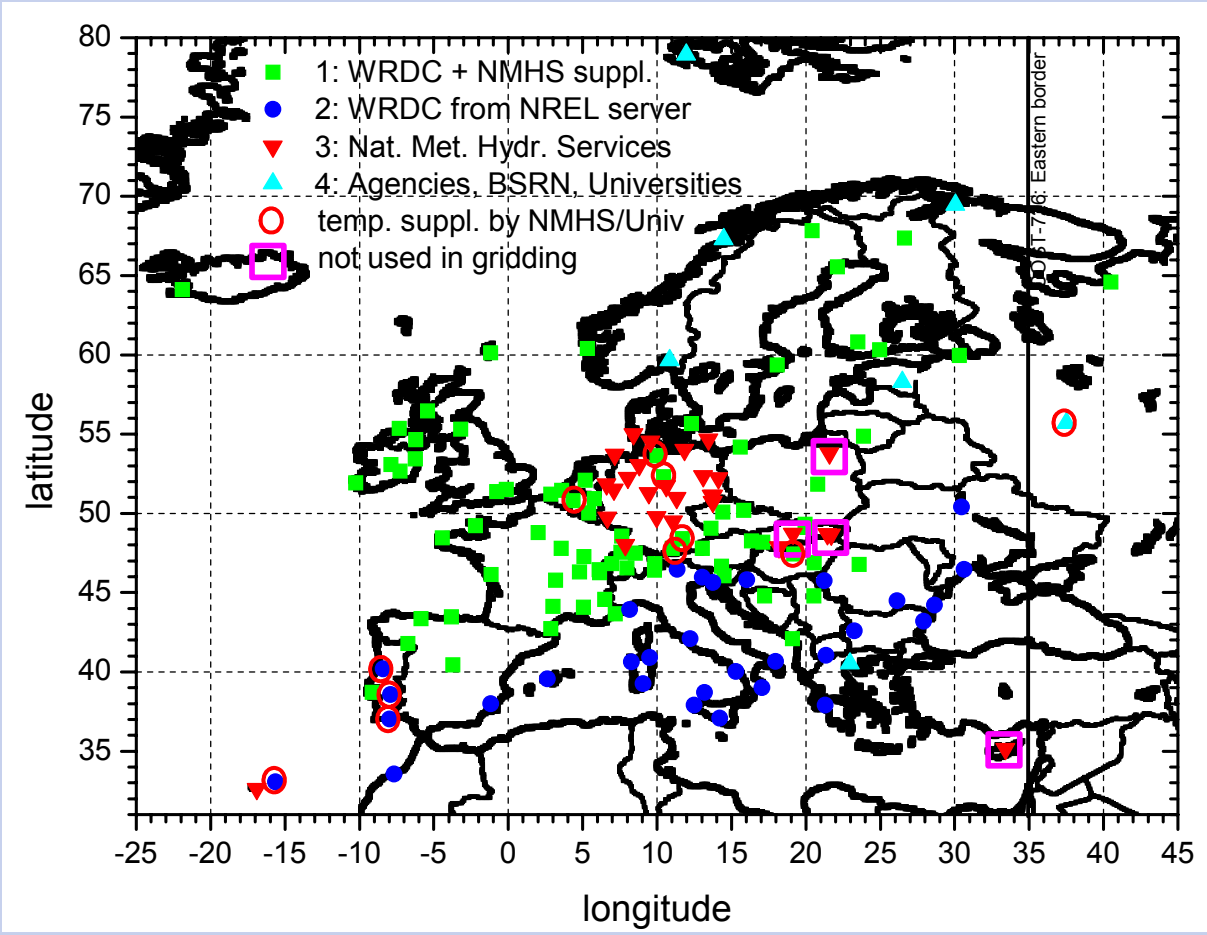
COST objective: UV trend analysis

Network requirements:

- high quality measurements

The different network requirements can be competing.

Data source, spatial distribution of (selected) sites



Data source

1	WRDC: best quality
2	WRDC / NREL: lower quality
3	NMHS: national quality controlled
4	Agencies, Universities

Detecting clear-sky days for a site and a year

Detecting a representative “measured” clear-sky day for a site and a year:

Assumption: highest SOL−CMFs will evolve from clear-sky conditions.

Detect 10 highest “measured” SOL−CMF constrained to

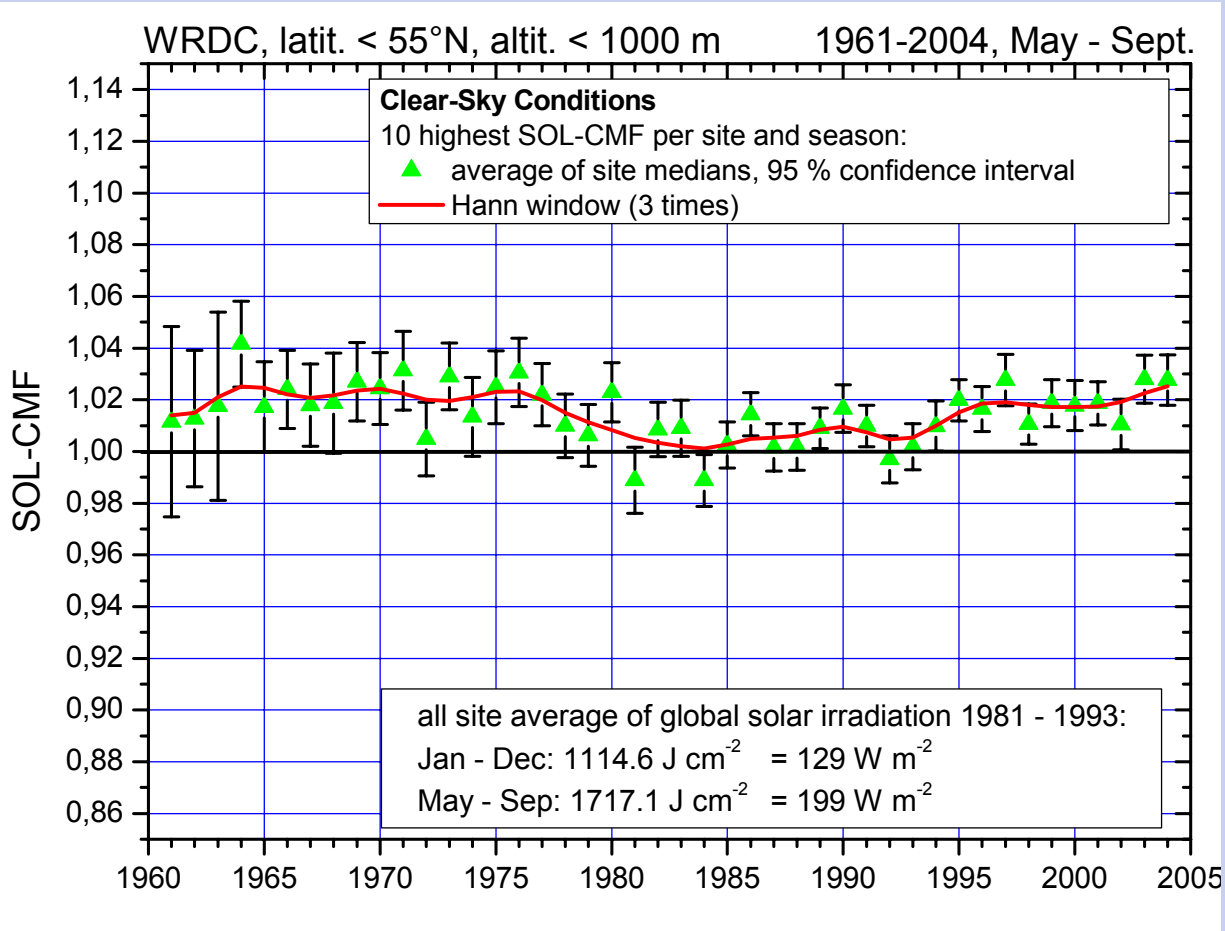
- May to September (low solar zenith angle at noon, high absolute values)
- sites with latitudes < 55°N, and altitudes < 1000 m (no snow)
- assess only values in the range 0.85 ≤ SOL−CMF ≤ 1.15

Representative measured clear-sky SOL−CMF:

median of the highest values.

- constraints: at least 4 SOL−CMF > 0.85, and max. 9 SOL−CMF > 1.15.
- violated constraints: flag all daily values of the site and the year.

Clear-sky aerosol direct effect in solar global irradiation



WRDC best quality

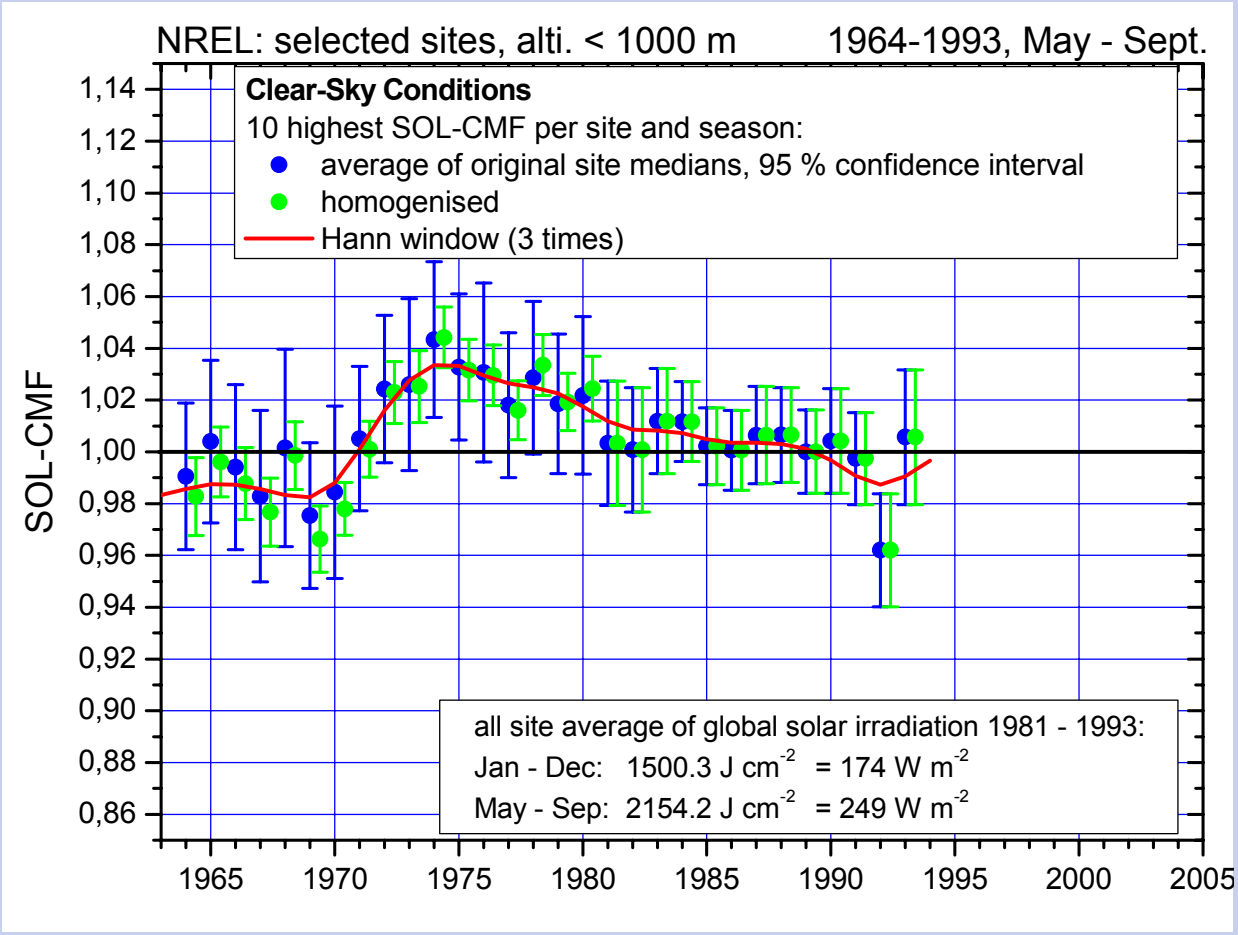
1981 – 1993 overall average of “measured” clear-sky SOL−CMF :

1.004 ± 0.042

Conclusion:

- close to clear-sky modelling applying the 1983- 95 related Linke turbidity climatology.
- clear-sky direct aero-sol effect detectable.

Selection of appropriate Mediterranean sites



NREL (lower quality):

Selection of sites:

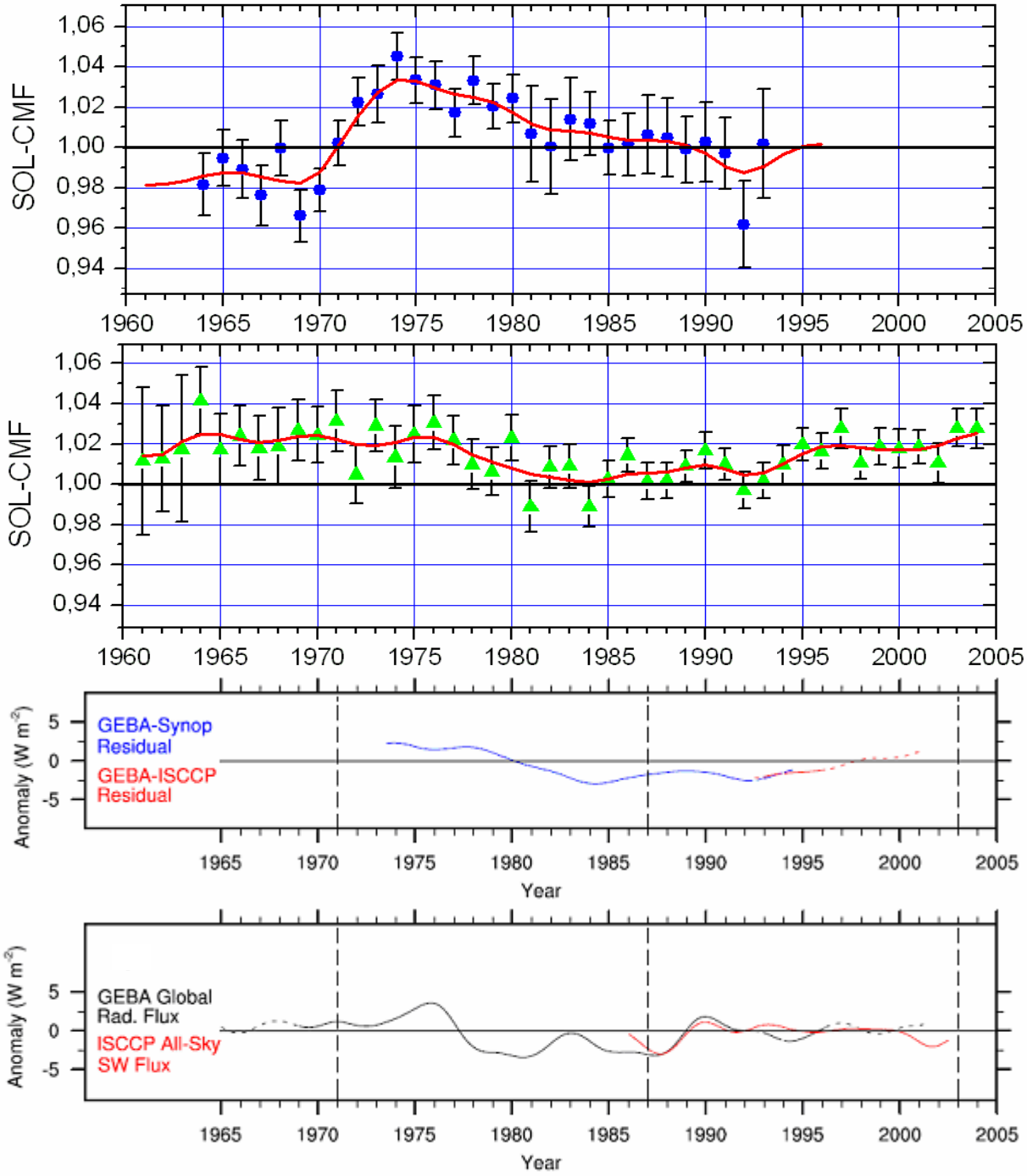
- 1981-93: ≥ 5 years of measurements
- 0.94< SOL−CMF <1.06
  std. deviation < 0.06
- 20 years with data

31 appropriate sites :

1981–93: **1.002 ± 0.045**

Homogenisation 1964-80

factor yearly site clear-sky SOL-CMF to spatial mean applied to all days



NREL-WRDC selected Mediterranean sites: Median of 10 highest clear-sky SOL-CMF per year and site: Average of 31 sites.

WRDC original via A. Lindfors: Median of 10 highest clear-sky SOL-CMF per year and site: Average of sites (latit. ≤ 55°N, altit. < 1000 m)

Fig. 3b: residual anomalies after removing synoptic-estimated SW CCRE from GEBA (blue) and ISCCP (red). GEBA global radiation flux (black), ISCCP all-sky downward SW flux

Norris JR, Wild M, J. Geophys. Res. 112, D08214, 2007.

Cross-validation of daily SOL− CMFs

Objective:

- identify extreme SOL- CMFs compared to a neighbourhood reference,
- and thus, to avoid isolated singularities in the mapping process.

SOL−CMF can be regarded to be

- high-pass filtered global irradiation (removed seasonal course), and thus
- akin to “anomalies” related to long-term monthly means and frequently applied in quality control and homogenisation instead of absolute values.

Two step procedure in calculating a reference based on neighbouring sites:

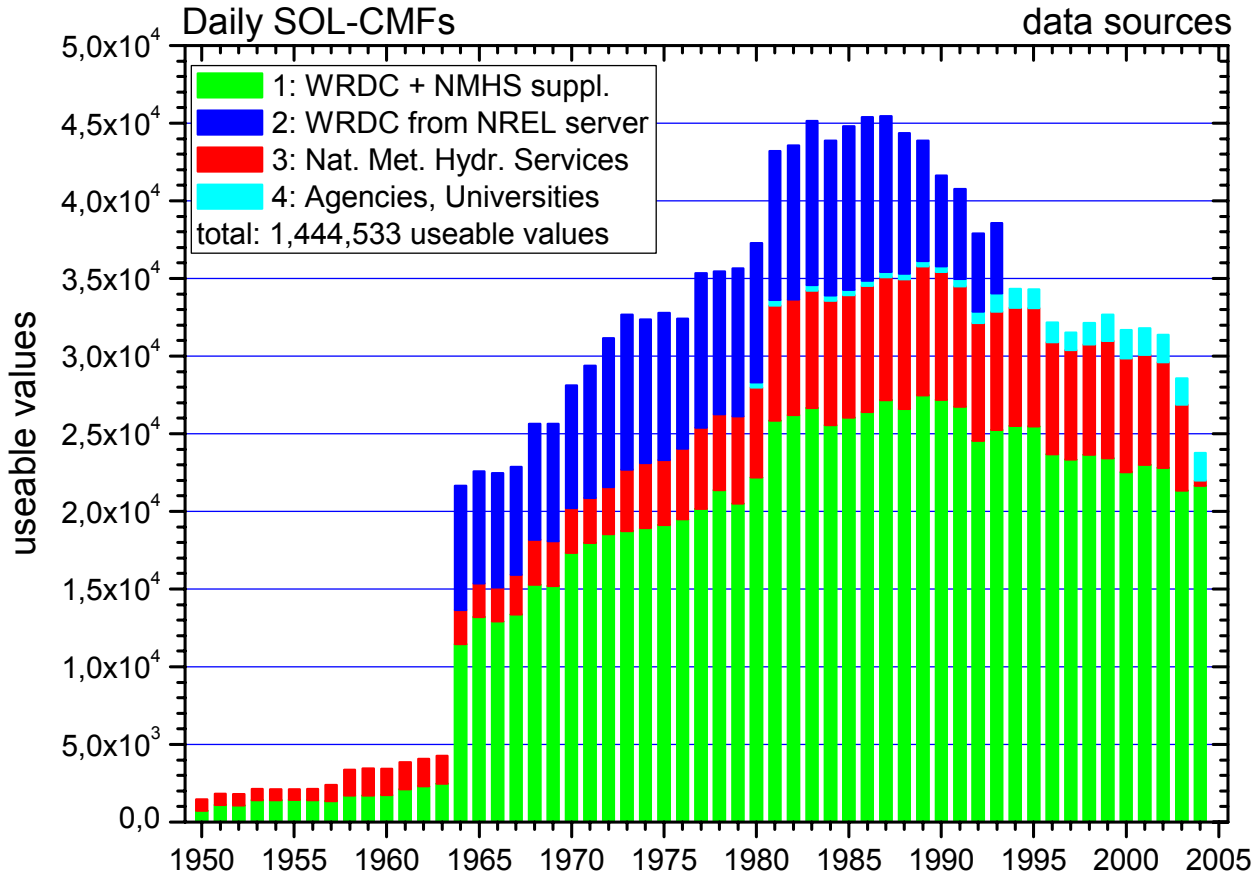
1. Reference applying Shepards gravity method. Median absolute deviation in outlier detection (less influence of extremes in small samples).
2. Ordinary Kriging, excluding values flagged by step one.

Measurements are flagged, if outside the 4-fold std.- deviation of reference.

Results of cross-validation

Flag	Meaning	Frequency, %
0	High quality value (or quality analyses was not made)	91.50
1	National Meteorological Service (NMHS): Questionable value	0.26
2	WRDC+NMHS+COST-726: Missing value	5.13
3	NMHS: Calculated or interpolated value	0.00
4	WRDC+NMHS+COST-726: Polar night	0.74
5	WRDC: Questionable value (too high value)	0.01
6	WRDC: Possible outlier	0.00
7	WRDC: Questionable value (too low value)	0.00
8	COST-726: Questionable clear sky calibration	1.42
9	COST-726: Outlier compared to bias corr. ERA-40 SOL−CMF	0.13
10	COST-726 (intermediate: reference step 1):	n / a
11	COST-726: Outlier compared to reference (step 2)	0.81

Useable daily SOL– CMFs



Data source

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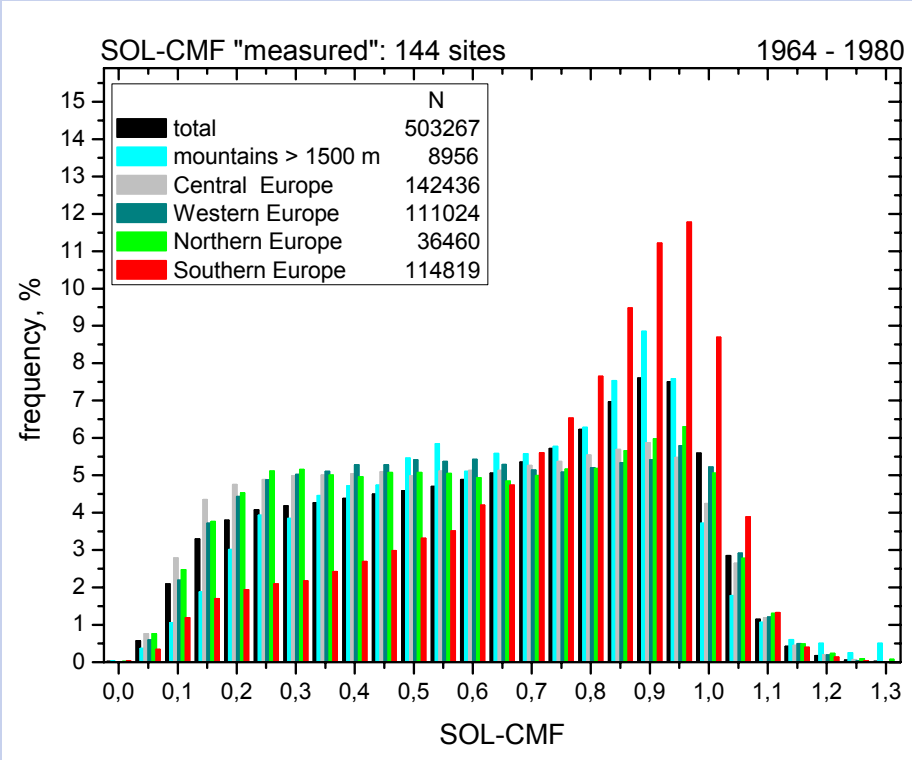
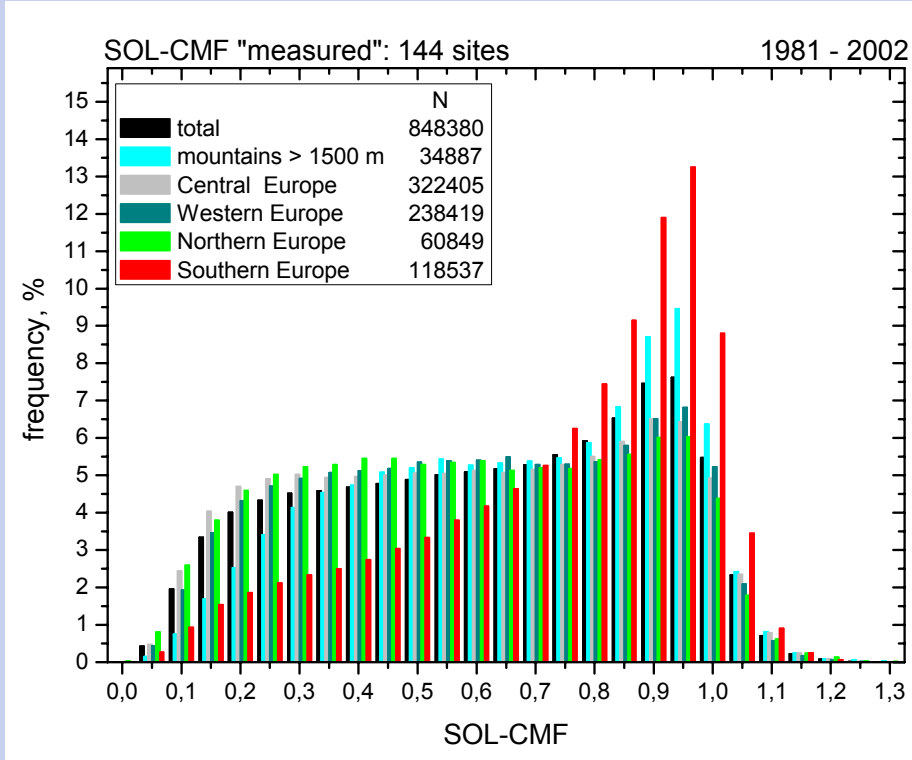
3	NMHS: national quality control
1	WRDC: best quality

SOL−CMF frequency distribution for European regions





1964 - 1980 no significant differences 1981 - 2002

Site specific data: cmf_3_wrdc_nmhs_etal.zip + cmf_3_nrel.zip

Date	year (including century), month, day
o3_DU	ozone, DU, interpolated from NIWA/COST-726 database
CMF_ERA	original ERA-40 SOL−CMF
ALB%	UV surface albedo at 360 nm, %
fac_alb	factor snow/ice albedo impact on clear-sky SOL−CMF
CMFmeas	"measured" SOL−CMF
Q1	quality control flag set at WRDC+NMHS
H	flag on data homogenisation: 0= no, 1= yes
Q2	flag of intermediate step in quality control
Q3	flag of intermediate step in quality control
CMF_ref	reference SOL−CMF from max. 9 nearest neighbours
STD_ref	accuracy (standard deviation) of reference SOL−CMF
TN	base of generating reference SOL−CMF
Q4	final flag of quality control (should be used)
CMFcost	SOL−CMF interpolated based on the COST-726 grid

Site specific climatology: sites_clim.zip

DOY	day of the year
alb_%	FMI MTW surface albedo at 360 nm (Tanskanen 2004)
Linke	Linke turbidity factor (Remund et al. 2003)
AOD308	aerosol optical depth at 308 nm (N. Chubarova)
AOD550	aerosol optical depth at 550 nm (N. Chubarova)
ssaGADS	Single scattering albedo at 300 nm (Koepke et al. 1997)
SZA_noon_degree	solar zenith angle at local noon, degree
Gclear-sky_J/m2	daily sum of clear-sky solar global irradiation, J m^{-2} (constant surface albedo).

Thank you for your attention