

Table S1. Basic contextual information for the validation sites

Site	Latitude (°)	Longitude (°)	Mean annual air temperature (°C)	Mean annual incoming shortwave solar radiation (seasonal maximum and minimum range) (W m ⁻²)	Mean annual rainfall (mm)	Mean annual soil water content (seasonal maximum and minimum range) (%)	Mean annual cloud cover (%)	Soil type	Silt, clay and sand contents (%)	Crop rotations	Average length of fallow periods
BE-Lon	50.55	4.75	10.2	110.2 (22.8-267.9)	742.6	29.5 (13.4-40.3) (3-layer soil with depth of 25 cm)	63.2	Luvisol	78.1, 14.7, 7.2	4-year rotation: sugar beet-winter wheat-potato-winter wheat	60-90 days
FR-Lam	43.50	1.24	13.4	157.0 (43.8-283.4)	677.0	32.8 (11.1-51.1) (3-layer soil with depth of 30 cm)	55.1	Calcaric Fluvisol	31.8, 52.9, 15.3	2-year rotation: winter wheat-irrigated maize	90-180 days
FR-Aur	43.55	1.11	13.1	161.3 (40.3-280.6)	652.1	27.4 (13.0-39.1) (3-layer soil with depth of 30 cm)	55.1	Calcaric Cambisol	42.5, 39.4, 18.1	4-year rotation: winter wheat-rapeseed - barley-sunflower	60-120 days
FR-EM2	49.87	3.02	11.2	137.3 (24.1-269.5)	616.7	26.6 (18.6-33.3) (3-layer soil with depth of 75 cm)	60.0	Luvisol	74.4, 18.7, 6.9	6-year rotation: spring pea-rapeseed-winter wheat-spring barley-maize (or sugar beet)-winter wheat	60-90 days
DE-RuS	50.87	6.45	11.2	130.0 (25.0-276.8)	548.9	20.6 (8.2-36.7) (1-	60.1	Luvisol	32.0, 53.0, 15.0	5-year rotation:	60-120 days

						layer soil with depth of 5 cm)				sugar beet- winter wheat- winter barley- rapeseed- potatoes	
DE- Geb	51.1 0	10.91	9.2	126.0 (20.7- 275.3)	521.2	20.1 (8.4- 31.0) (3- layer soil with depth of 10 cm)	60.9	Chern ozem / Phaeo zem	32.0, 53.0, 15.0	8-year crop rotation: winter wheat- potatoes- rape- winter barley- sugar beet- peppermin t-durum- spring wheat	30-90 days
DE- Kli	50.8 9	13.52	8.1	130.6 (17.2- 290.2)	782.5	25.3 (8.7- 36.4) (1- layer soil with depth of 5 cm)	59.4	Camb isol	26.6, 46.9, 26.5	5-year crop rotation: rapeseed- winter wheat- forage maize- spring barley- winter barley- occasional catch crop	30-60 days
CZ- KrP	49.5 7	15.08	7.1	133.5 (26.4- 291.0)	620.0	17.4 (8.2- 24.2) (3- layer soil with depth of 20 cm)	57.7	Camb isol	44.0, 18.0, 38.0	winter wheat- spring barley- rapeseed- temporary leys	60-90 days
Ulu na in Upp sala	59.8 2	17.65	8.4	119.0 (6.1-290.2)	519.0	-	62.6	Eutric Camb isol	40.0, 42.0, 18.0	winter barley- spring wheat-	117 days (the year of 2019); 145 days

in Swe den											oats-rye	(the year of 2020)
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'-' means no data

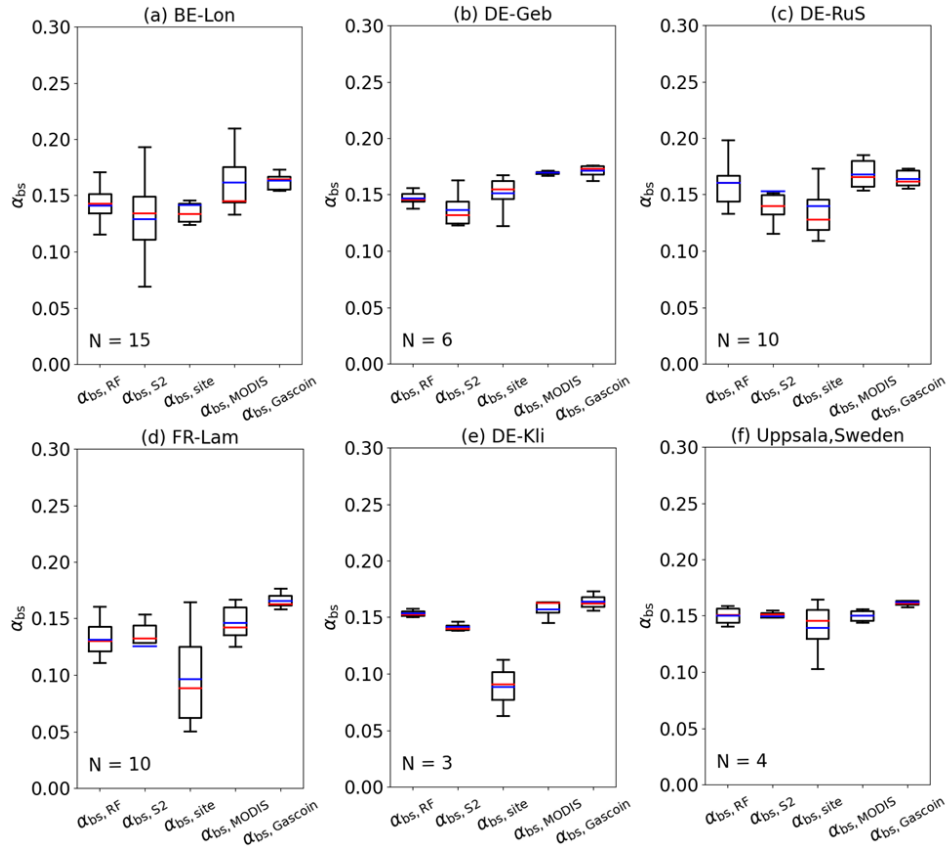


Figure 5 The boxplots of $\alpha_{bs, RF}$, $\alpha_{bs, MODIS}$, $\alpha_{bs, Gascoin}$, $\alpha_{bs, S2}$ and $\alpha_{bs, site}$ at six cropland sites during the same bare soil periods from 2018 to 2020. The values of $\alpha_{bs, RF}$ are the bare soil albedo derived from the spatiotemporal random forest models. The values of $\alpha_{bs, S2}$ are extracted from the Sentinel-2 surface albedo products, while the values $\alpha_{bs, site}$ are computed by site eddy covariance measurements (see Table 3). The values of $\alpha_{bs, MODIS}$ are extracted from 500m daily MODIS surface albedo product (MCD43A3). $\alpha_{bs, Gascoin}$ are computed by the exponential function of SM using the 1 km GSSM SM product (see Table 3). The red and blue lines in each figure represent the median and mean values, respectively.

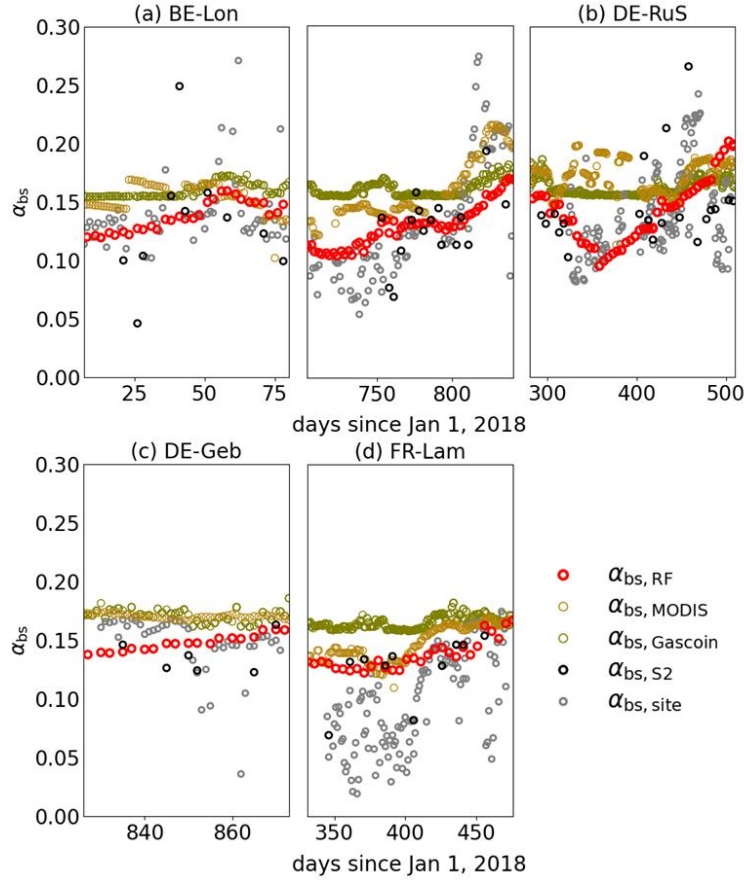


Figure 6 Values of $\alpha_{bs, RF}$, $\alpha_{bs, MODIS}$, $\alpha_{bs, Gascoin}$ at four sites during the same bare soil periods from 2018 to 2020, compared with $\alpha_{bs, S2}$ and $\alpha_{bs, site}$ (see Table 3). Values of $\alpha_{bs, RF}$ are the bare soil albedo derived from the spatiotemporal random forest models (red hollow dots). Values of $\alpha_{bs, S2}$ are extracted from the Sentinel-2 surface albedo products (black hollow dots), while $\alpha_{bs, site}$ values are computed by site radiation measurements (gray hollow dots). The values of $\alpha_{bs, MODIS}$ are extracted from 500 m daily MODIS surface albedo product (MCD43A3) (yellow hollow dots). The values of $\alpha_{bs, Gascoin}$ are computed by the function of soil moisture (SM) using the 1 km GSSM SM product (brown hollow dots). ‘Period X’ in each plot indicates the bare soil period identified by daily or weekly site photos. Plot in-between (a) and (b) belongs to BE-Lon site but in Period 2.