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A survey of proximal methods for monitoring leaf phenology in temperate deciduous forests

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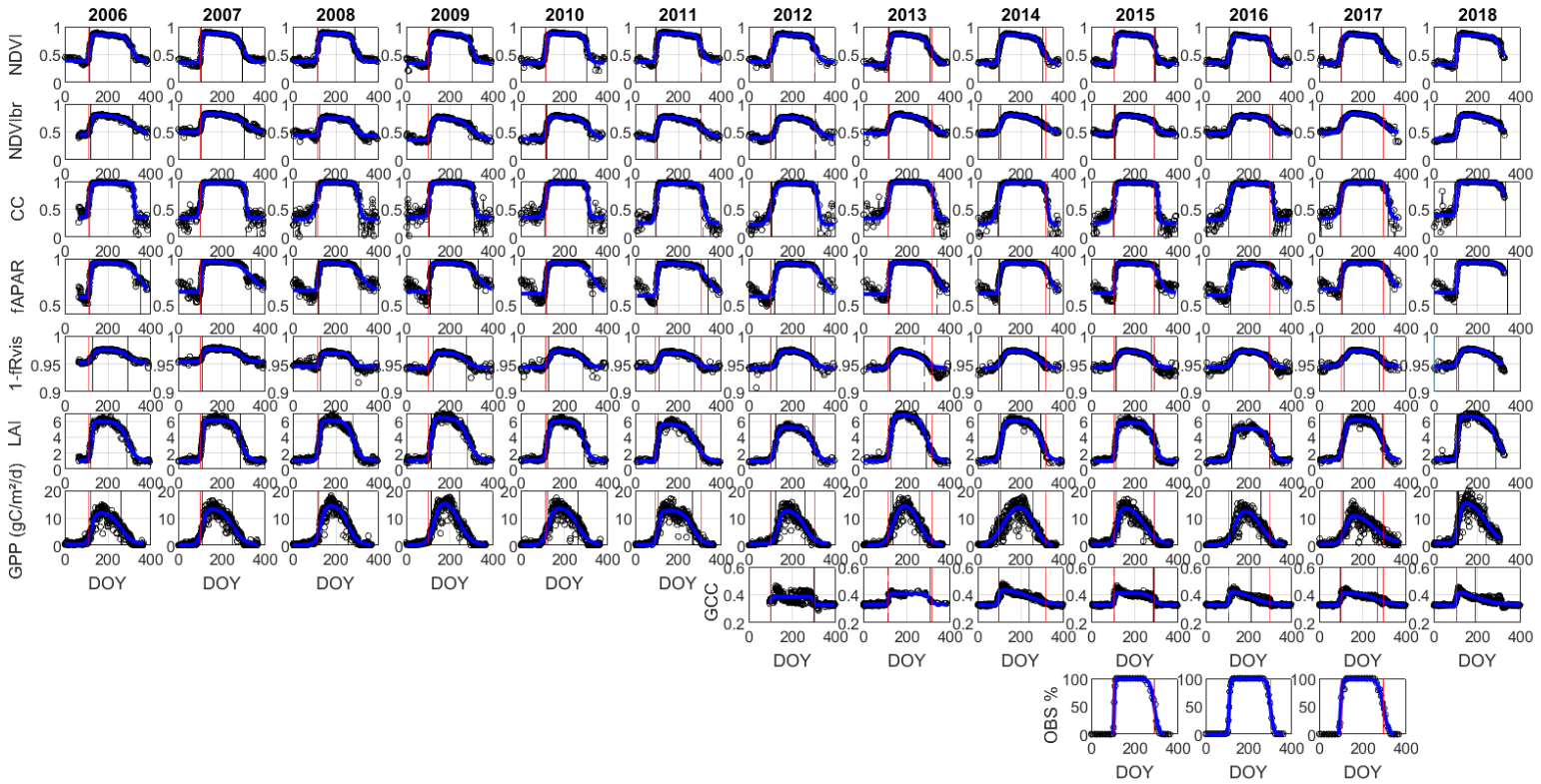
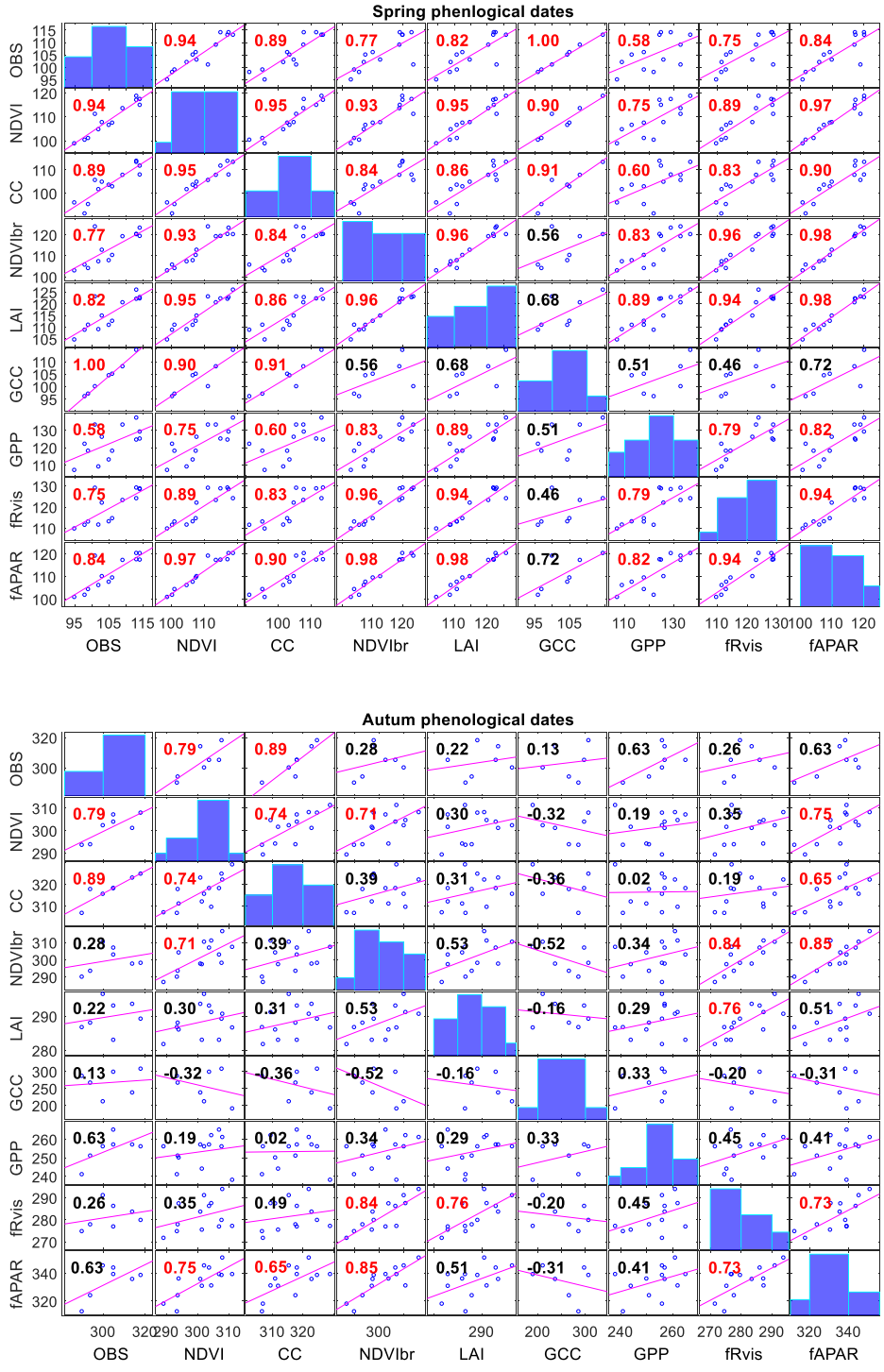


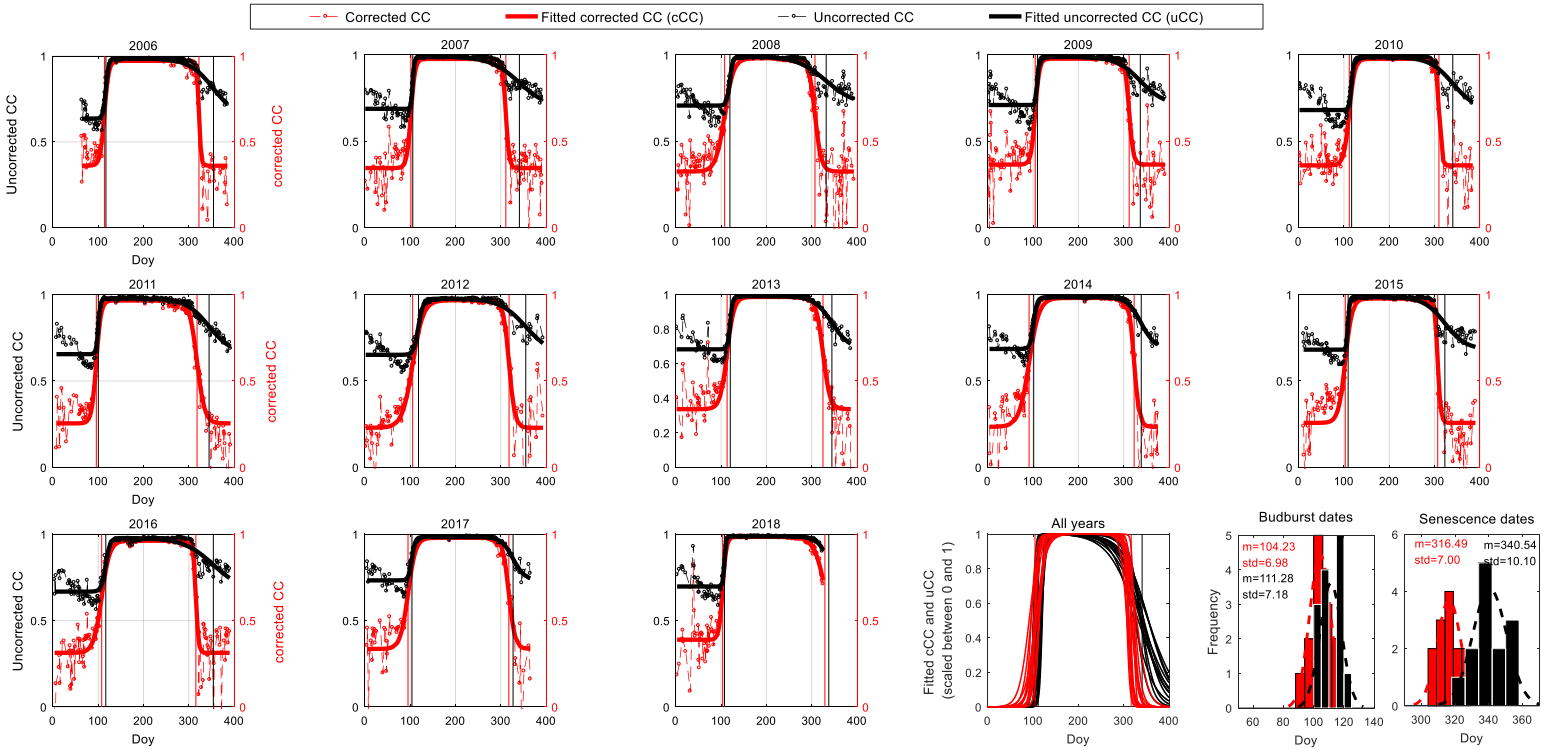
S1: Time-series of NDVI (Normalized Difference Vegetation Index), broad-band NDVI (NDVI*br*), 1-fR_{vis} (1-fraction of reflected radiation), *f*APAR (fraction of absorbed PAR), LAI (Leaf Area Index), CC (Canopy Closure) and GPP (Gross Primary Production) over the period 2006-2018, GCC (Greenness Chromatic Coordinate) over the period 2012-2018 and human-eye observations OBS based on an intensive sampling over 2015-2017. Circle: data; continuous curve (blue): fitted ADS function. Vertical lines: observed phenological dates (red) and predicted dates (black) in spring (BB-OBS over 200-2018) and autumn (LS-OBS 2011-2017).

Method	Spring budburst			Autumn leaf senescence and leaf fall		
	SOS	**MOS**	**EOS**	**SOF**	**MOF**	**EOF**
OBS: ***2006-2018***	-	106	-	-	-	-
2012-2018 (spring) and 2012-2017 (autumn)	-	104	-	-	303	-
2015-2017	97	104	111	272	295	317
NDVI	100	109	117	269	301	332
	98	108	118	268	300	332
	98	107	115	269	296	323
NDVI*br*	100	114	126	243	302	360
	97	113	127	244	299	353
	96	111	125	254	298	341
GCC	-	-	-	-	-	-
	96	104	110	209	267	321
	98	103	108	199	254	323
***f*R$_{vis}$**	101	119	137	237	281	324
	97	118	139	238	282	325
	94	116	139	241	281	320
*f*APAR	103	111	119	280	334	375
	102	111	120	284	332	367
	101	110	119	278	327	354
CC	87	104	120	303	316	329
	83	103	122	304	318	330
	82	102	121	302	313	323
LAI	101	116	129	246	288	330
	100	116	130	251	291	330
	98	115	131	254	290	327
GPP	95	123	152	203	253	317
	96	125	158	204	251	321
	94	123	152	202	249	326

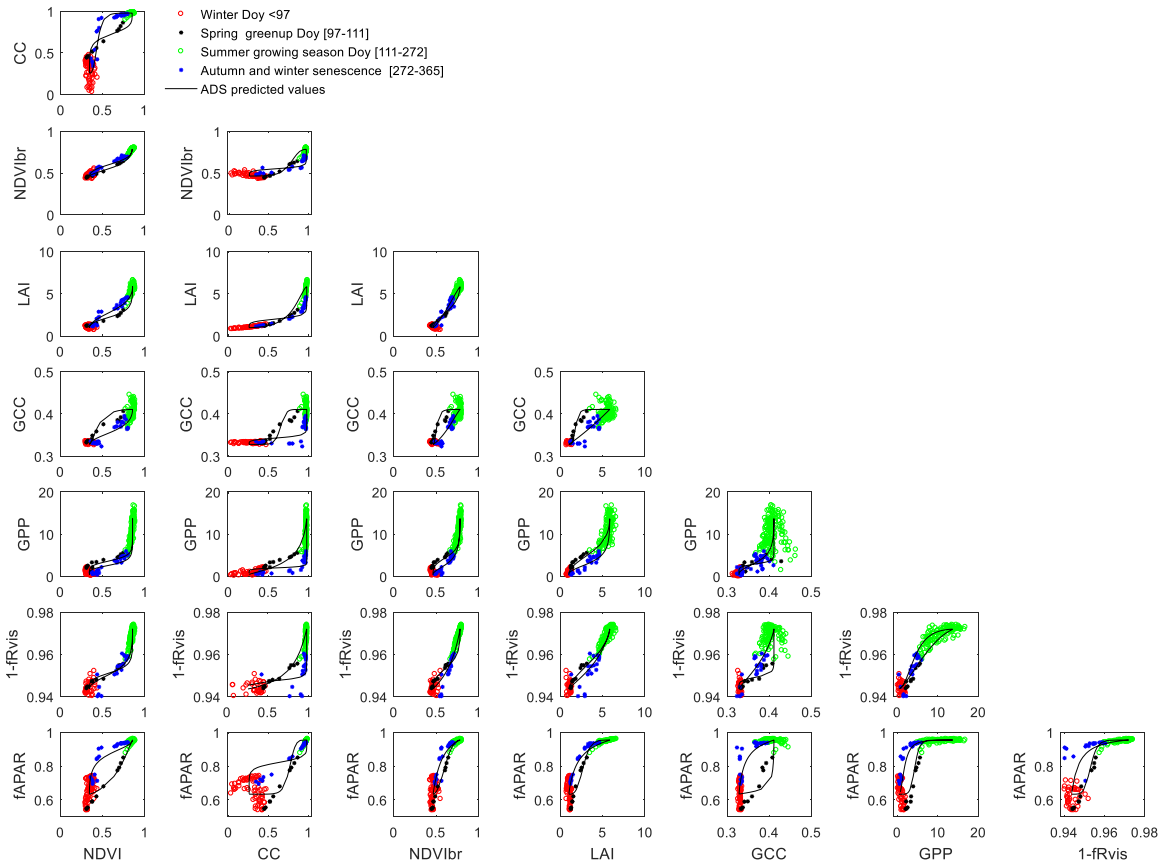
S2: Average phenological dates observed and estimated from the different methods and using the six phenological markers (SOS, MOS, EOS, SOF, MOF, EOF). In each cell, the first line corresponds to average dates calculated over the whole period 2006-2018. The second line corresponds to average dates calculated over 2012-2018 in the spring and over 2012-2017 in the autumn (the two periods that are common to all methods in spring and in autumn, respectively). The third line corresponds to average dates calculated over 2015-2017 for which the six phenological metrics are determined from the intensive sampling protocol.



S3 : Correlation matrix of MOS and MOF between the different methods : Human-eye observations (BB-OBS and LS-OBS), NDVI (Normalized Difference Vegetation Index), GCC (Greenness Chromatic Coordinate), broad-band NDVI (NDVI*br*), *f*R$_{vis}$ (fraction of reflected radiation), *f*APAR (fraction of absorbed PAR), LAI (Leaf Area Index), CC (Canopy Closure) and GPP (Gross Primary Production). Pearson's coefficient of correlation: significant at 5% in red, not significant in black.



S4: Time-series of cosine corrected (red) and uncorrected canopy closure (black) over 2006-2018. Circle: data; continuous curves : fitted time-series using ADS function. Vertical lines: predicted phenological dates from corrected (red) and uncorrected CC (black) in spring and autumn. Penultimate and last subplots are fitted time-series for all years scaled between 0 and 1 and histograms of predicted phenological dates in spring and autumn from cosine corrected (red) and uncorrected CC (black). Mean (m) and standard deviation (std) are superimposed on the histograms.



S5: Relationships between the different variables during 2015. Four phenological phases are distinguished: the winter phase (red, DoY 1-97), the budburst and leaf expansion phase in spring (black, DoY 97-111), the summer growing season (green, DoY 111-272) and the autumn and winter senescence phase (DoY 272-365). The date ranges are determined by considering the average observed phenological dates during the period 2015-2017 (the *suppl. Table S2*).