

Yield forecast for winter rapeseed, winter wheat and winter barley using radar satellite data

For a farm in Thuringia, we have developed a method for yield prediction that is based on our vegetation index ESVI (enhanced SAR Vegetation Index). To do this, we use data from the Sentinel-1 satellites from the Copernicus program of the European Space Agency (ESA).

The Sentinel-1 satellites send a microwave to the Earth's surface and measure the backscatter of the signal in two polarizations. The signal is suitable for estimating the fresh organic matter on agricultural land.

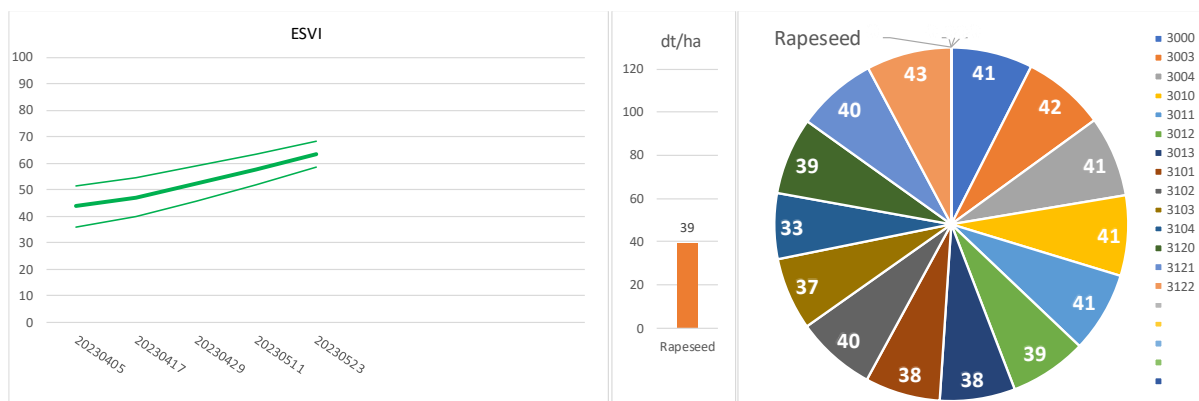
The main advantage of the method is that the signal is independent of cloud cover or daylight.

The measurements take place every 12 days in the same constellation. This means pixel for pixel (20x20m) always at the same angle and with the same amount of energy.

This means that changes in the measured value can be clearly assigned to the change in biomass development.

The farmer provided us with yield data from several plots for the years 2018 – 2022. Based on this data, we derived a yield forecast that delivered very good results, especially in the period from early to mid-May.

We had already reported on this in a previous article. In 2023, we used the existing formula to send the farmer a yield forecast every 12 days in the form of a dashboard.



On the left you can see the temporal development of biomass across all areas.

In the middle is the average expected yield value and on the right is the yield forecast for the individual areas.

In the current year 2023, the results were just as good as in previous years. The following table provides an overview of the deviation of the yield forecast from the actual measured yield for the years 2018 - 2023. A value of 96 indicates that the model underestimated the actually measured yield by 4%. Especially in the period from the beginning to mid-May, i.e. two months before the harvest, and in the case of grain two weeks before the last fertilization, the yield forecast is close to the actually measured yield. The results for the individual areas in 2023 can be found at the end of the document (Annex 1).

The results for previous years have already been published in the previous report.

2018	ha	20180407	20180419	20180501	20180513	20180525	20180606	20180618	20180630	20180712	20180724
Rapeseed	214	88	92	104	115	123	120	123	117	102	88
Wheat	220	93	113	113	112	116	117	117	118	113	89
Barley	167	99	117	108	107	111	129	129	117	106	92
2019	ha	20190402	20190414	20190426	20190508	20190520	20190601	20190613	20190625	20190707	20190719
Rapeseed	138	104	97	90	92	92	95	95	97	95	104
Wheat	241	110	104	112	117	122	114	109	107	111	98
Barley	177	72	75	82	89	88	82	85	86	93	89
2020	ha	20200408	20200420	20200502	20200514	20200526	20200607	20200619	20200701	20200713	20200725
Rapeseed	203	93	88	94	97	101	101	106	107	102	95
Wheat	207	90	93	94	94	100	103	108	109	109	89
Barley	116	95	95	94	95	99	103	105	105	103	89
2021	ha	20210403	20210415	20210427	20210509	20210521	20210602	20210614	20210626	20210708	20210720
Rapeseed	179	108	99	95	89	96	99	104	104	112	107
Wheat	234	87	92	94	98	88	75	73	76	94	109
Barley	201	91	97	102	98	87	74	75	93	114	119
2022	ha	20220410	20220422	20220504	20220516	20220528	20220609	20220621	20220703	20220715	20220727
Rapeseed	166	111	100	103	107	111	110	112	102	84	68
Wheat	161	98	113	113	112	107	104	103	97	86	61
Spelt	75	93	108	100	86	86	89	92	96	107	88
2023	ha	20230405	20230417	20230429	20230511	20230523	20230604	20230616	20230628	20230710	20230722
Rapeseed	218	101	93	95	98	100	106	112	114	104	106
Wheat	254	121	125	125	111	100	93	97	104	105	89
Barley	231	84	98	101	94	80	81	87	97	89	81

With this method, additional data such as weather or soil data is deliberately avoided because these data usually have a different temporal and spatial resolution.

It is impossible to know whether the amount of precipitation at the nearest weather station is actually representative for the observed plots.

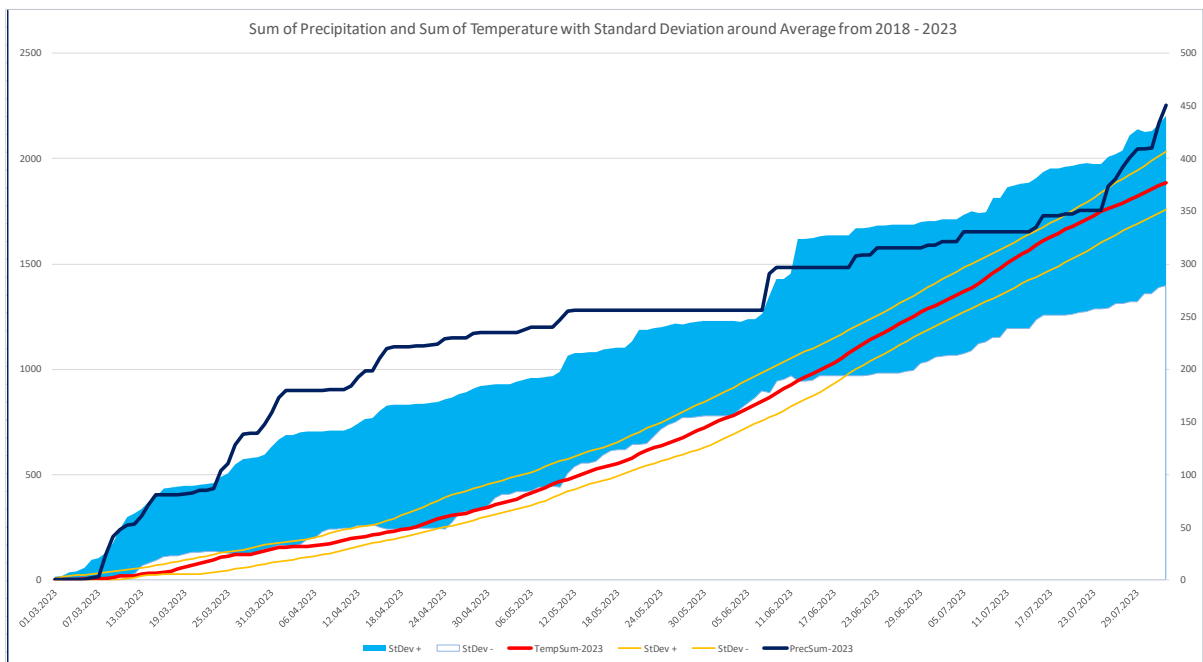
Temperature data may need to be adjusted based on altitude. Soil maps can lose their informative value due to structural changes such as road construction or drainage.

We believe that the real growth conditions are reflected in the pixel values of the biomass index and we measure with the sensor every 12 days using the same methodology.

An examination of the weather data from the nearest weather station, which is approx. 15 km away from the farm, shows no clear trend over the 6 years of the study. (see Annex 2-7)

The following graphic shows an analysis of the weather data for 2023 compared to the years 2018 - 2023. The mean value was calculated for both the temperature sum and the precipitation sum over a period of 6 years. In addition, the simple standard deviation was calculated, which represents the confidence interval in the graphic. The blue line shows the precipitation total for 2023 and the blue area shows the corresponding confidence interval, which is derived from the data from 2018 - 2023.

The year 2023 was characterized by a wet spring from the end of March to mid-May. end of July there was renewed rainfall, which led to delays in the harvest of winter rapeseed and winter wheat. In contrast, the total temperature remained within the normal range.



As the next steps, we are planning test runs on additional farms and additional crops.

In Argentina we have already achieved similarly good results with the crops of wheat, corn, soy and sunflower.

<https://cropix.ch/wp-content/uploads/Yield-prediction-based-on-ESVI-in-Argentina.pdf>

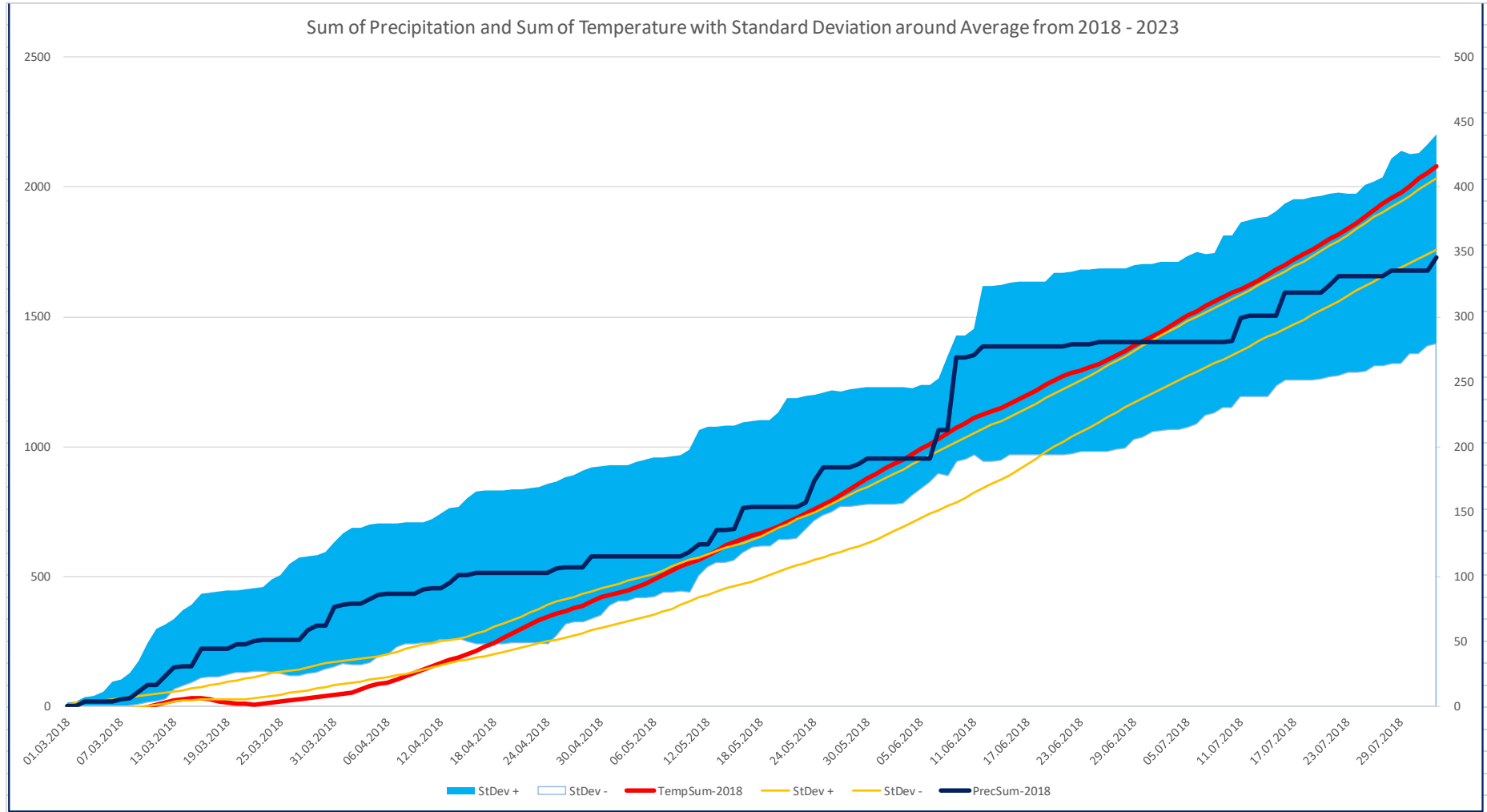
Annex 1 : Result of the individual areas for the crops winter rapeseed, winter wheat and winter barley in 2023. The average values can be found in the upper data series. The results for the individual areas for the years 2018 – 2022 can be found here:

<https://cropix.ch/wp-content/uploads/Yield-prediction-for-field-crops-based-on-ESVI.pdf>

Plot ID	Yield/ha	ha	Yield	20230405	20230417	20230429	20230511	20230523	20230604	20230616	20230628	20230710	20230722
Rapeseed	39	218	9214	101	93	95	98	100	106	112	114	104	106
3000	44	84,2	3690	100	90	91	93	94	99	104	107	96	88
3003	45	4,0	180	90	82	83	88	92	96	101	103	96	104
3004	43	12,6	537	102	92	93	95	95	100	105	109	102	103
3010	42	29,1	1210	98	90	92	95	98	104	110	113	100	91
3011	41	2,0	82	110	100	105	103	99	98	99	101	97	107
3012	39	19,4	747	106	97	98	100	101	107	115	119	107	104
3013	37	15,8	588	105	97	98	100	102	110	119	125	113	107
3101	39	3,8	147	112	101	99	99	98	103	106	106	97	106
3102	44	7,8	344	101	93	94	94	91	95	99	101	95	105
3103	32	15,9	509	93	90	97	107	114	126	135	139	125	123
3104	26	7,8	537	84	88	101	115	128	146	158	162	150	161
3120	43	8,0	340	92	84	85	88	92	98	104	107	96	95
3121	38	5,2	195	116	105	109	110	108	112	116	117	105	109
3122	40	2,7	107	100	91	94	102	108	112	116	117	103	103
Wheat	77	254	19534	121	125	125	111	100	93	97	104	105	89
6	82	21,8	1796	117	122	121	105	90	83	88	97	99	81
12	83	17,6	1467	114	120	117	102	92	87	92	98	97	77
14	74	17,7	1317	130	129	125	110	104	100	106	113	113	93
15	73	22,1	1619	142	146	140	122	111	103	107	118	121	98
1000	76	17,7	1343	119	124	124	110	97	90	96	108	114	98
1008	72	24,9	1802	131	135	134	118	108	100	104	108	108	91
1011	80	28,9	2313	116	119	119	107	100	94	100	106	109	100
1013	85	27,3	2307	95	100	107	100	94	84	86	90	93	86
2010	71	23,2	1655	121	130	134	123	114	107	113	118	115	91
3100	73	37,5	2751	132	139	140	120	105	91	93	102	100	83
3105	79	14,8	1162	118	120	117	103	94	87	89	93	94	82
Barley	80	231	18644	84	98	101	94	80	81	87	97	89	81
1003	89	4,2	376	81	92	92	87	78	86	94	105	97	89
1006	72	7,4	535	98	115	116	107	92	98	113	131	116	96
1007	90	3,8	342	95	107	102	91	77	88	97	108	99	88
1018	77	4,9	376	104	115	110	99	83	91	100	114	107	94
5200	93	52,6	4869	85	94	90	81	68	76	87	100	90	81
5202	107	7,1	760	56	68	70	64	51	49	55	72	67	61
5204	91	15,1	1372	69	81	84	79	66	70	83	100	89	78
5205	71	4,9	349	100	117	119	109	92	94	98	105	102	99
5400	75	13,3	994	72	87	101	100	87	87	90	91	82	75
8028	75	19,9	1487	88	104	115	115	99	85	82	92	94	97
8030	68	29,5	2005	90	109	119	113	93	89	82	79	67	62
8031	77	61,9	4794	76	93	103	98	80	76	76	81	73	69
8032	56	6,8	383	88	107	120	116	100	89	83	85	73	65

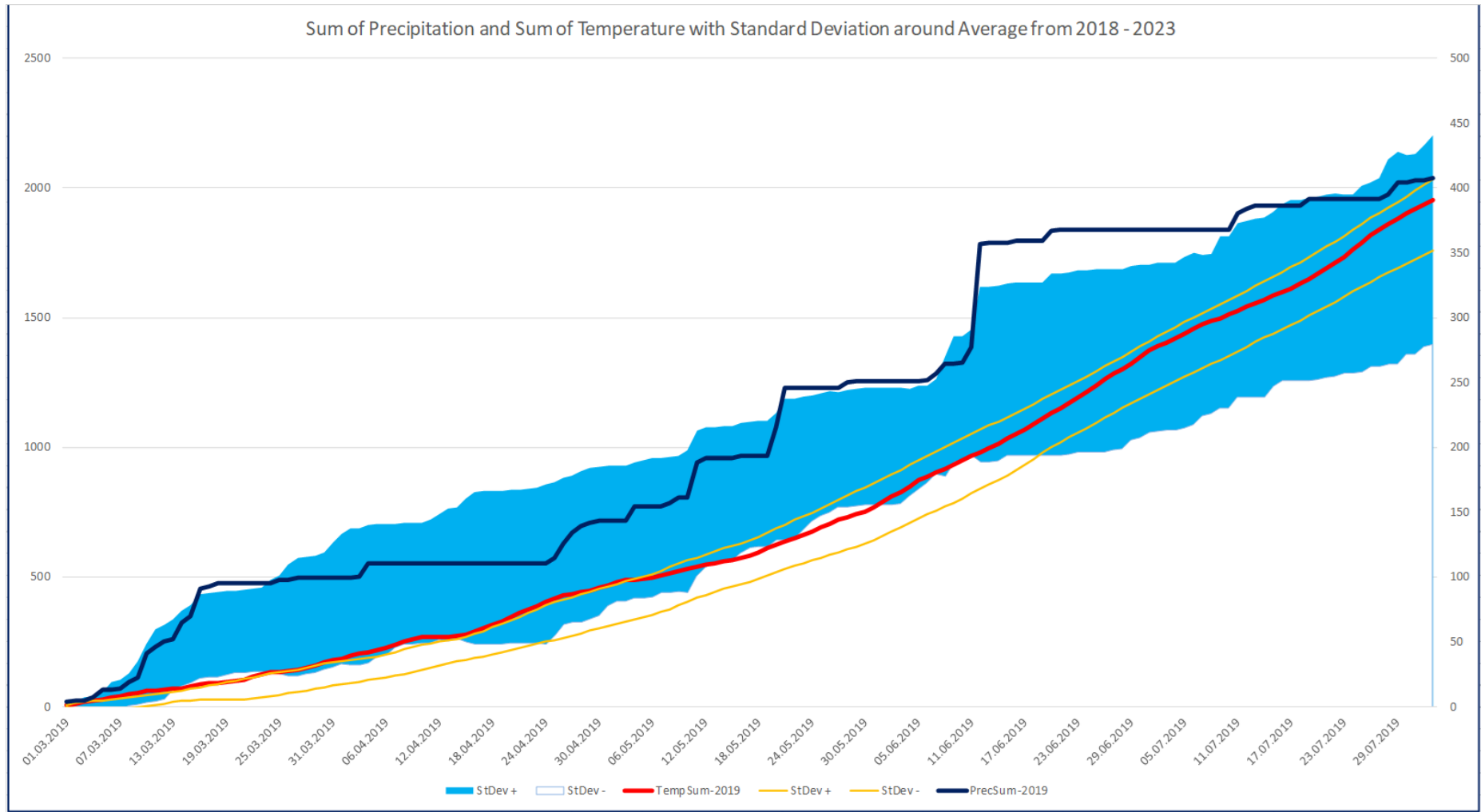
Annex 2:

2018	ha	20180407	20180419	20180501	20180513	20180525	20180606	20180618	20180630	20180712	20180724
Rapeseed	214	88	92	104	115	123	120	123	117	102	88
Wheat	220	93	113	113	112	116	117	117	118	113	89
Barley	167	99	117	108	107	111	129	129	117	106	92



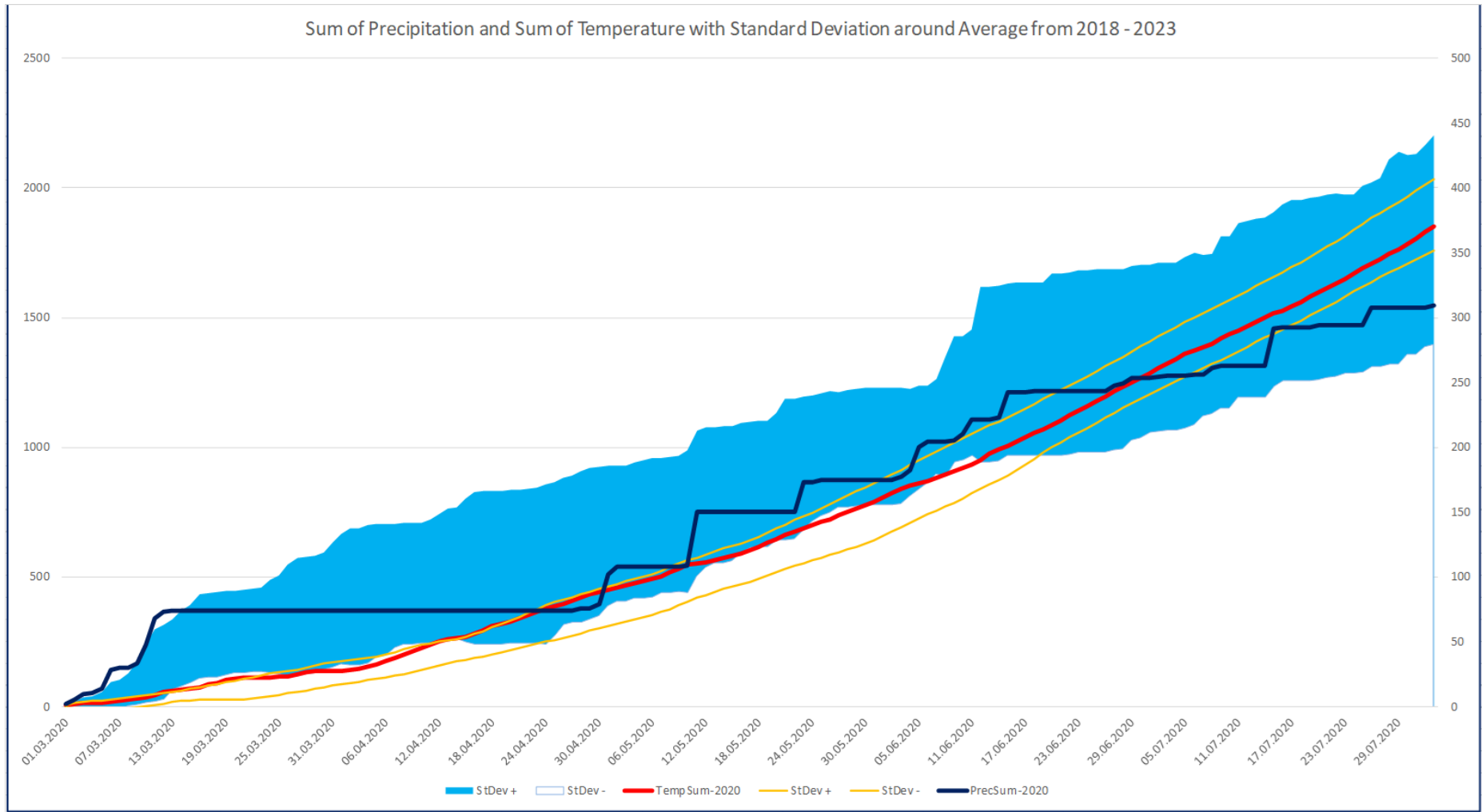
Annex 3

2019	ha	20190402	20190414	20190426	20190508	20190520	20190601	20190613	20190625	20190707	20190719
Rapeseed	138	104	97	90	92	92	95	95	97	95	104
Wheat	241	110	104	112	117	122	114	109	107	111	98
Barley	177	72	75	82	89	88	82	85	86	93	89



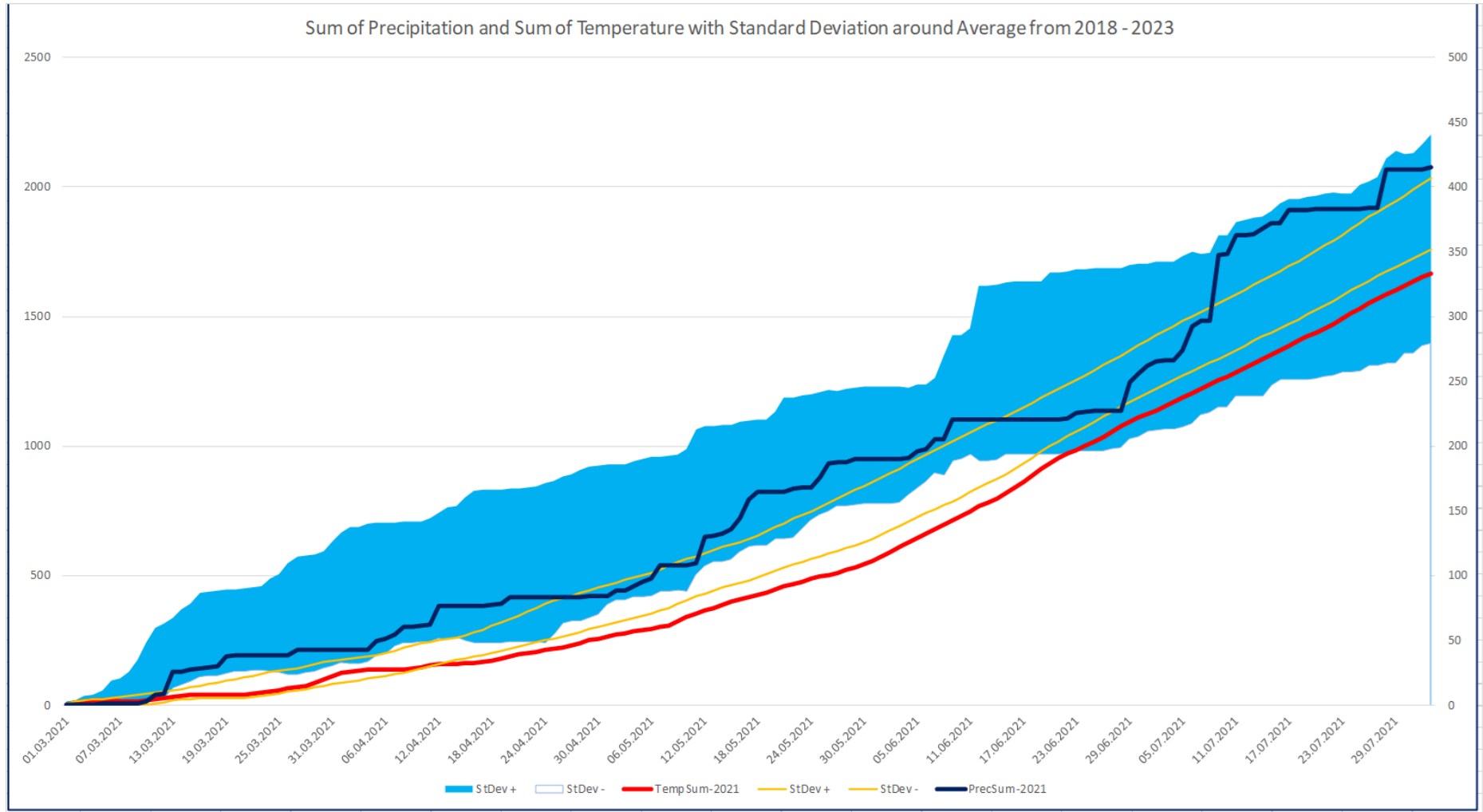
Annex 4

2020	ha	20200408	20200420	20200502	20200514	20200526	20200607	20200619	20200701	20200713	20200725
Rapeseed	203	93	88	94	97	101	101	106	107	102	95
Wheat	207	90	93	94	94	100	103	108	109	109	89
Barley	116	95	95	94	95	99	103	105	105	103	89



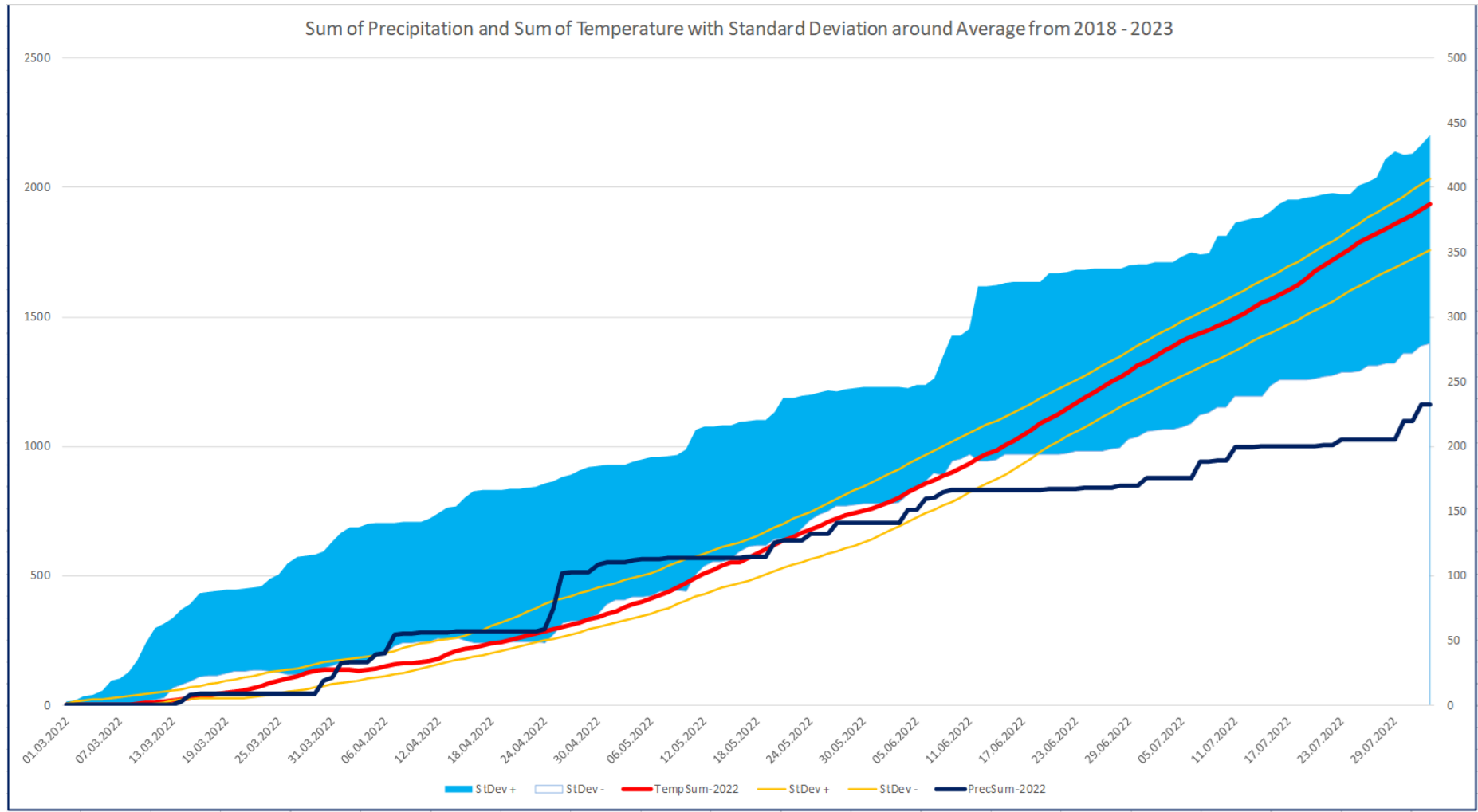
Annex 5

2021	ha	20210403	20210415	20210427	20210509	20210521	20210602	20210614	20210626	20210708	20210720
Rapeseed	179	108	99	95	89	96	99	104	104	112	107
Wheat	234	87	92	94	98	88	75	73	76	94	109
Barley	201	91	97	102	98	87	74	75	93	114	119



Annex 6

2022	ha	20220410	20220422	20220504	20220516	20220528	20220609	20220621	20220703	20220715	20220727
Rapeseed	166	111	100	103	107	111	110	112	102	84	68
Wheat	161	98	113	113	112	107	104	103	97	86	61
Spelt	75	93	108	100	86	86	89	92	96	107	88



Annex 7

2023	ha	20230405	20230417	20230429	20230511	20230523	20230604	20230616	20230628	20230710	20230722
Rapeseed	218	101	93	95	98	100	106	112	114	104	106
Wheat	254	121	125	125	111	100	93	97	104	105	89
Barley	231	84	98	101	94	80	81	87	97	89	81

