Black Soils Agroecological Monitoring for Russia Export Potential Development in Durum Wheat

Агроэкологический мониторинг чернозёмов для развития экспортного потенциала России по твёрдой пшенице

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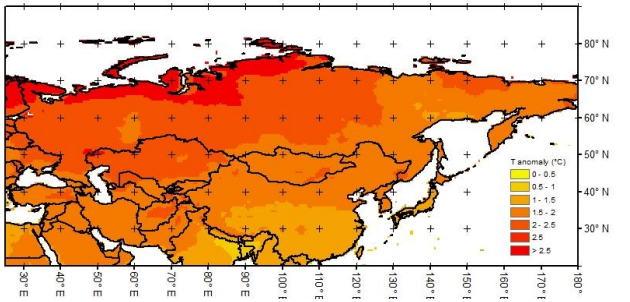
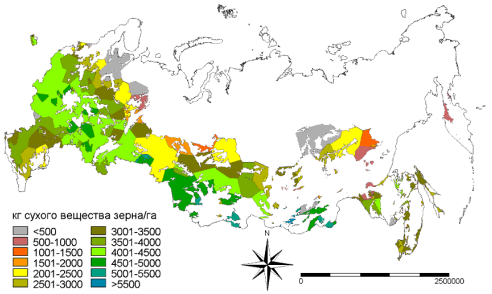
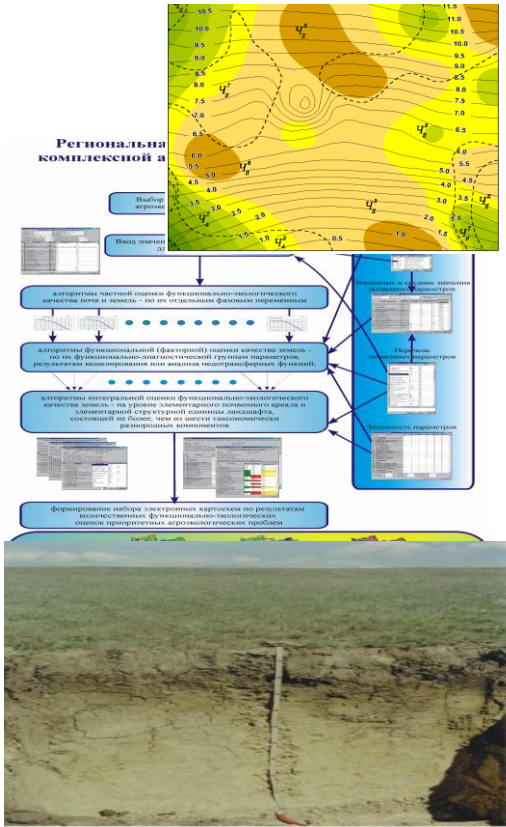
Why we need to do this especially in the Black Soil regions of Russia?



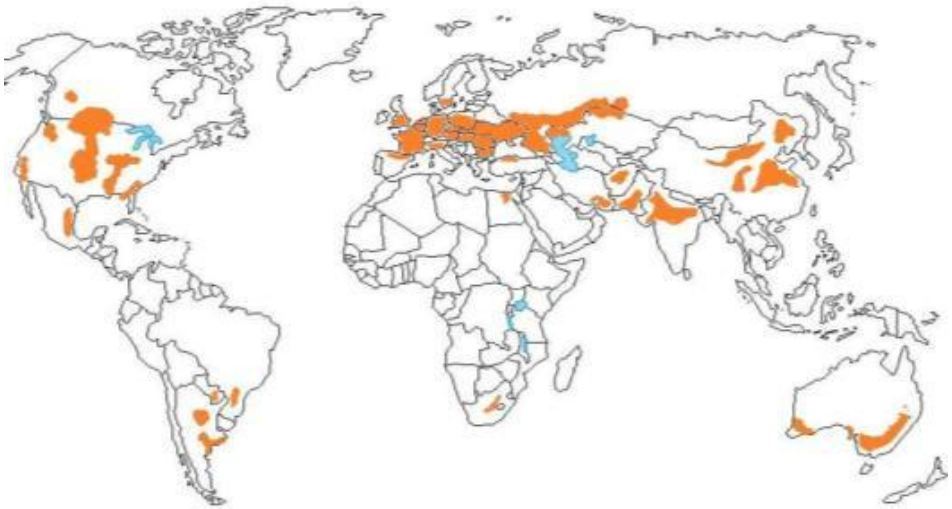




- While globally projected climate changes will result in most crop yields general decline, Russia benefits from warming due to an increasing of growing season and generally more mild climate conditions.
- Growing RF agricultural potential will be strengthened due to durum wheat production increasing in the Middle Volga and Southern Ural Regions with mostly favorable agroecological conditions.
- High spatial variability of land quality, intra- and inter-seasonal dynamics of soil moisture often create the serious agroecological problems.
- Especial attention by successful agricultural business to the best available technologies and crop yield prediction
- Growing demand in land agroecological quality evaluation due to sharply increased input risks value in case of intensive farming
- Current high variability of durum productivity levels: from 35 to 7-5 dt/ha within one region
- High within-field crop yield variability (40-75%) due to complicated soil cover patterns in frame of 50-200-ha fields
- Consequences of the aggregated soil degradation in frame of the universal land-use systems dominated in XX century

The geography and volume of soft wheat world production is much wider than durum one

soft wheat

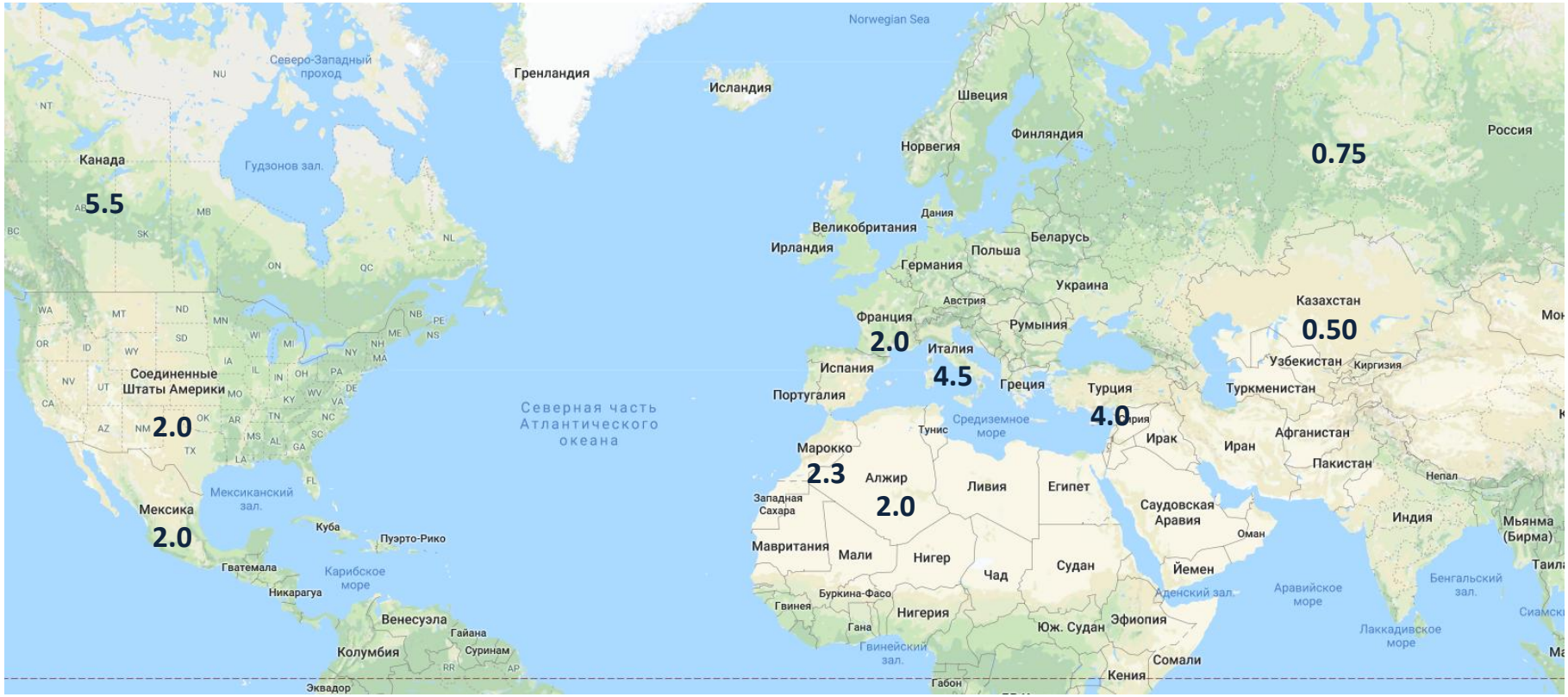


~ 95%

durum wheat

~ 5%

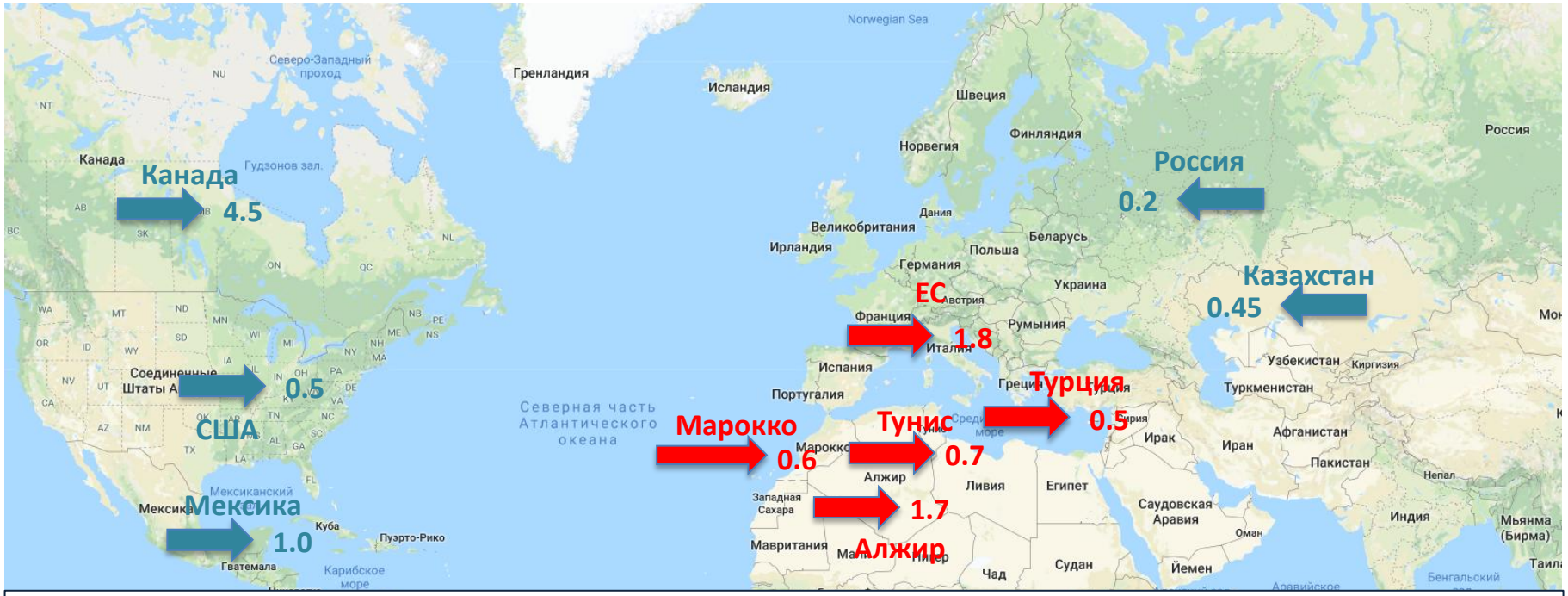
Main countries of the durum wheat production: Italy, France, Canada, USA, Mexico, Turkey, Morocco and Algeria, mln t



In comparison with soft wheat, Russia is not the world leader in durum wheat production, Russia's share in global durum wheat production is less than 2%.

Source: IGC, Grain Union of Kazakhstan

Main countries-exporters and importers of durum wheat



1) North American countries are the main exporters of durum wheat.
2) The countries of the Mediterranean basin are key importers.
3) Russia is not a key player in the global durum wheat trading market, being the No. 1 country in the export of soft wheat.
4) Kazakhstan exports almost the entire volume of durum wheat and is becoming one of the key players in the region.

Source: IGC, Grain Union of Kazakhstan

GOST (R 52554-2006) and the main global requirements of pasta manufacturers

Параметры	Классы зерна						Требования производителей пасты	
	1	2	3	4	5	б/к	Min	Max
Количество сырой клейковины, %	28	25	22	18	Не ограничено		26	-
Количество белка,% в с.в., не менее	13,5	12,5	11,5	10	Не ограничено		14-15	-
Количество зерна других видов,%, не более	**10**	**15**	**15**	**15**	**Не ограничено**		**-**	**3**
Число падения, сек., не менее	200	200	150	80	Не ограничено		Нет в спецификации	
Натура, г/л, не менее	770	745	745	710	Не ограничено		790	-
Стекловидность, %, не менее	75	70	60	Не ограничено			70	
Качество клейковины (индекс глютена)	**Не регулируется Российским законодательством**						**Зависит от методики**	
Индекс цвета "b" Минольта	**Не регулируется Российским законодательством**						**22**	**-**

1) **According to most parameters, the grain should correspond to class 1 and 2, but there is very little such quality grain in Russia.**
2) **The two most important parameters for the production of pasta: gluten Quality and color Index " b " (Minolta) - are not regulated by Russian legislation.**
3) **Most durum wheat producers in Russia are not familiar with these parameters, which negatively affects the interest in Russian durum wheat on the world market.**

Russia has great potential to increase domestic production of durum wheat, as well as its exports

What does exist for this

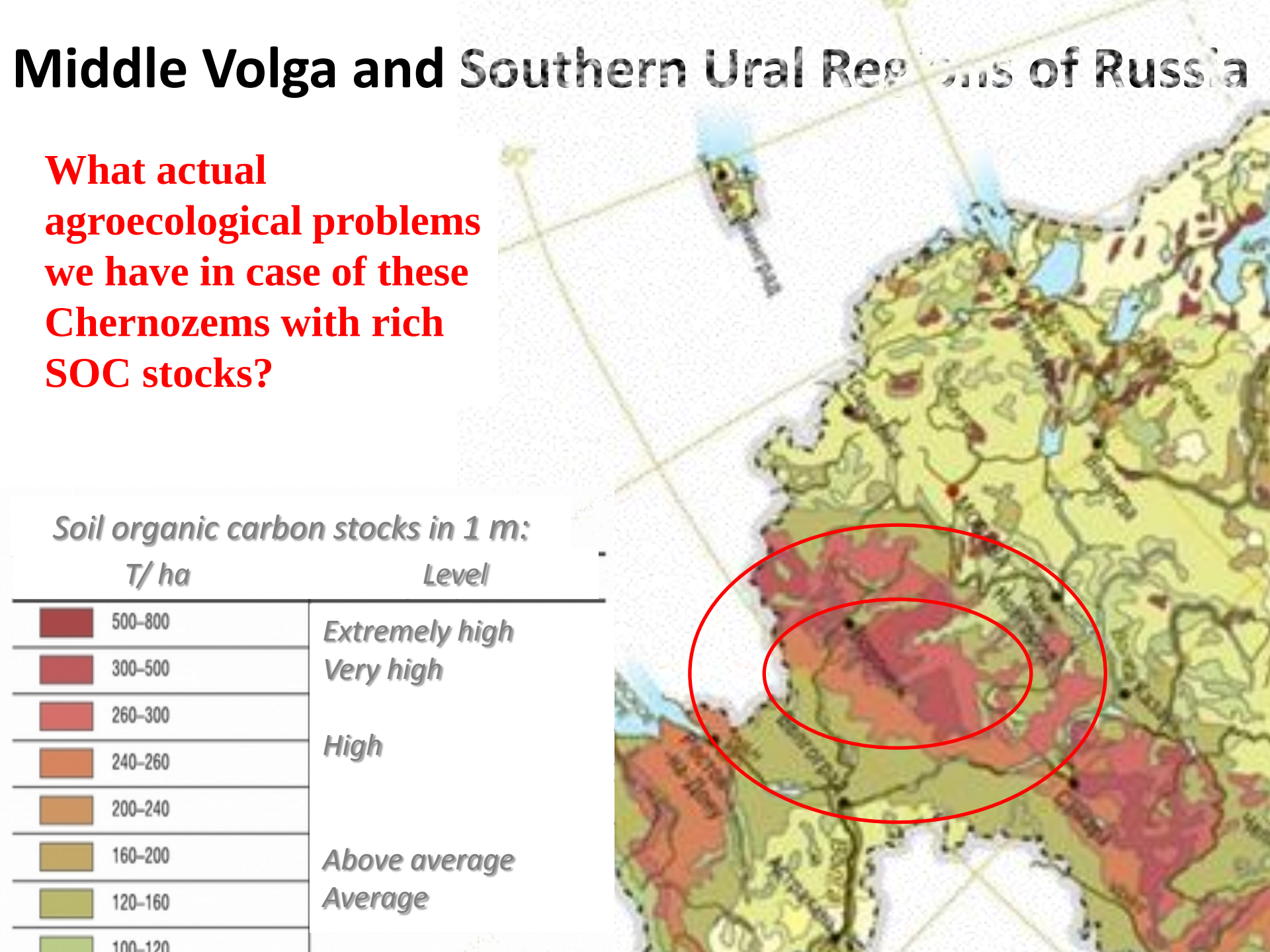
- Favorable climatic and soil conditions in various black soil regions of Russia
- The use of "Glyphosate" before harvesting is not as common as in North America
- Fusarium head blight and as a result the mycotoxin DON are not so common for durum wheat
- Short distance to the world's main import zones – the Mediterranean countries, in comparison with the countries of North America

What needs to change

- Developing the official statistics on durum wheat production by the RF Ministry of agriculture and Rosstat
- Selection of durum wheat varieties, targeted at improving the gluten quality and color index, as well as selection of durum wheat low-stem varieties resistant to lodging
- Simplification of the procedure for registration of durum wheat new varieties
- When registering a new variety of the durum wheat, take into account also its qualitative characteristics (gluten quality and color index)
- The inclusion in the RF standard of the durum wheat it’s parameters measured in the countries importing the durum wheat
- **Agroecological DSS development for durum producers support**

Middle Volga and Southern Ural Regions of Russia

What actual agroecological problems we have in case of these Chernozems with rich SOC stocks?



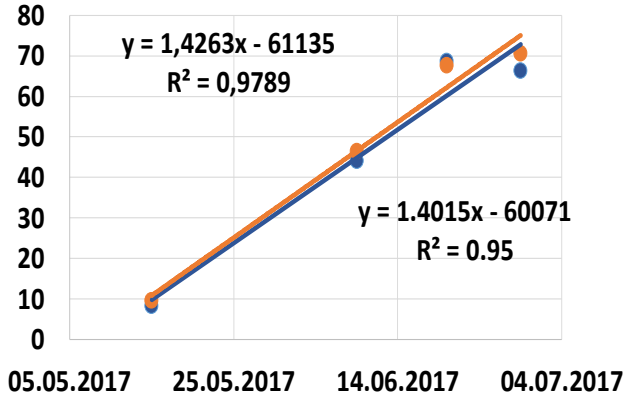
There are potential opportunities for durum wheat sustainable production here?
Yes, but… agroecological DSS would be very useful…

Objects and methods. We study dominated in these regions of Russia Black Soils' (Typical, Ordinary and Southern Chernozems) potential for durum wheat sustainable production in 2018 and 2019.

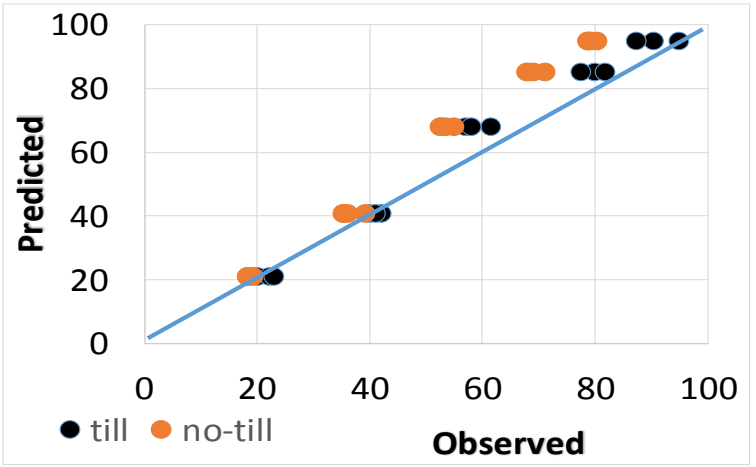
GIS-based land quality analysis combining with agroecological monitoring in the representative plots with different combinations of durum varieties, bioclimatic regions and farming practices were used for cloud-based DSS development.

The observed and predicted (by DSAAT) winter wheat growth rate and yield values in at the RSAU Field Experimental Station in 2017 (Pivchenko, Meshalkina, Vasenev, 2018)

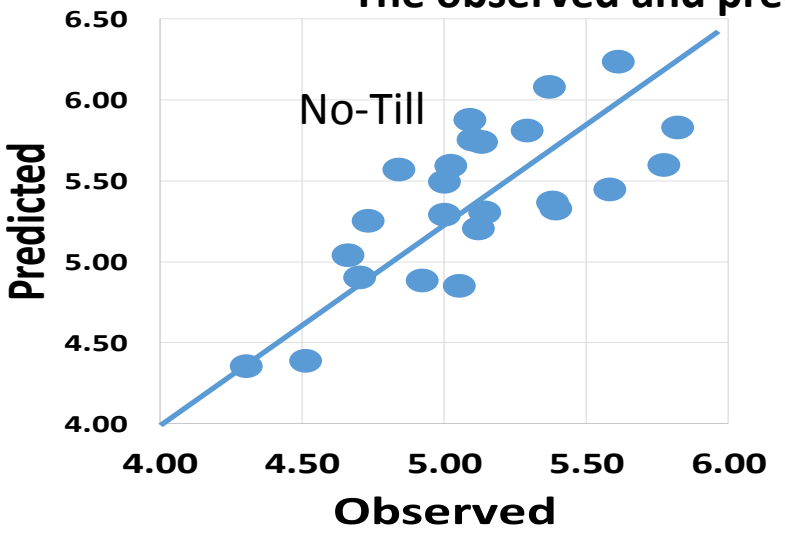
Model describing the growth of wheat plants from the beginning of intensive vegetation to flowering phase

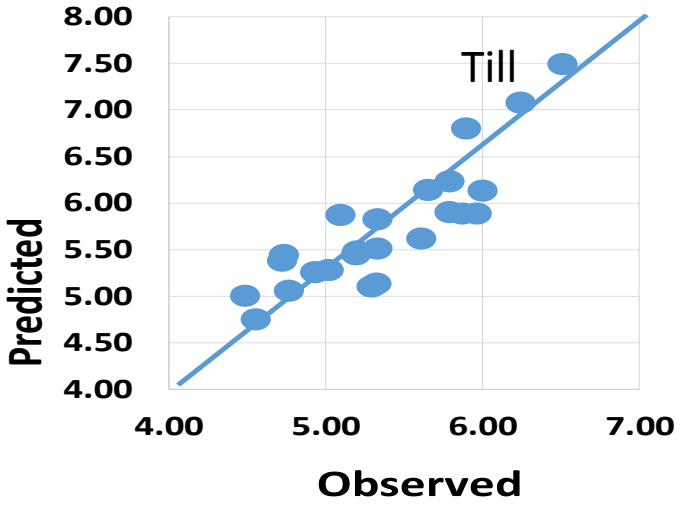


Observed and predicted values of plant growth by DSSAT (R^2=0.94) for different development phases



The observed and predicted yield values (t/ha)

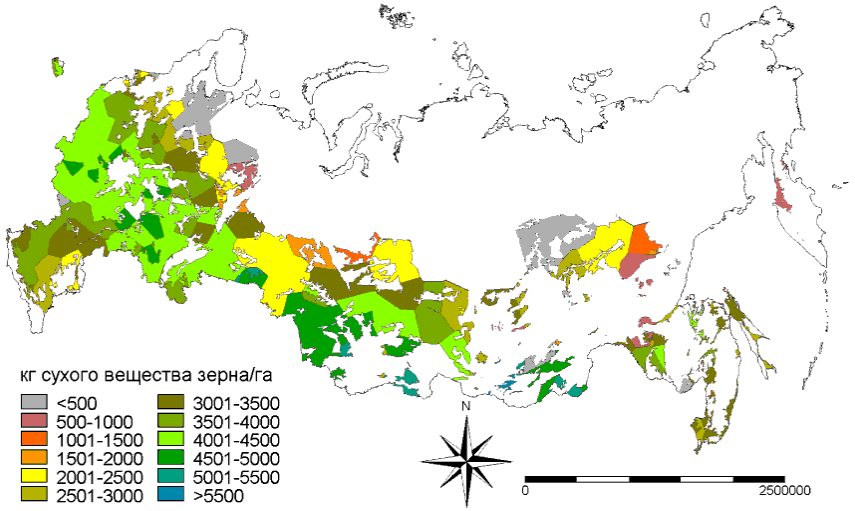




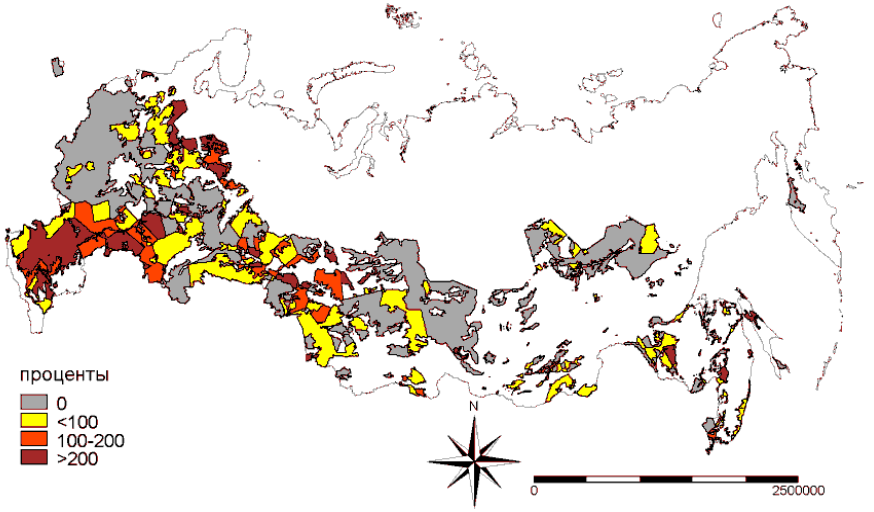
Agroecological modeling of wheat potential yield dynamics

(Savin e.a., 2016)

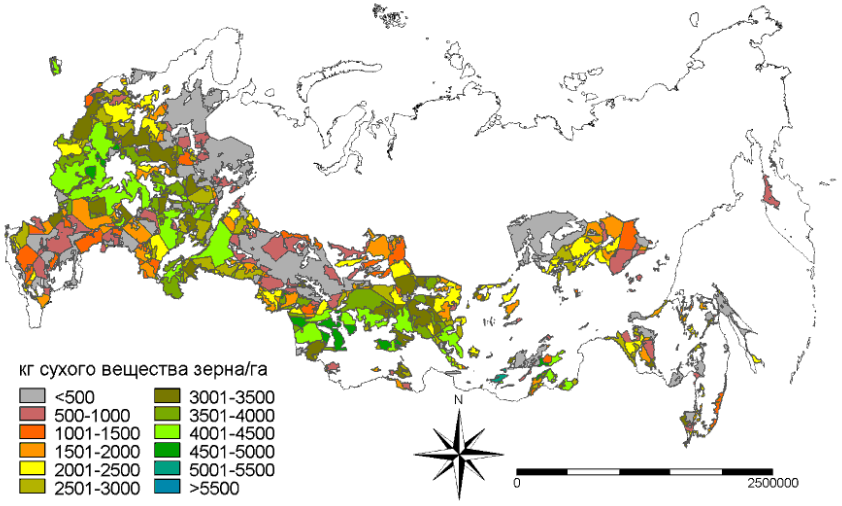
PAR and T limiting factors



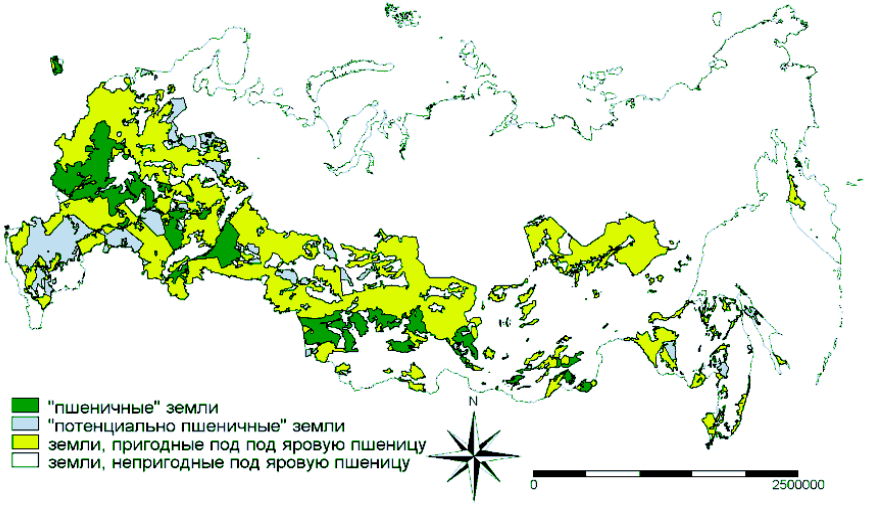
Negative effect of soil available water limiting factor



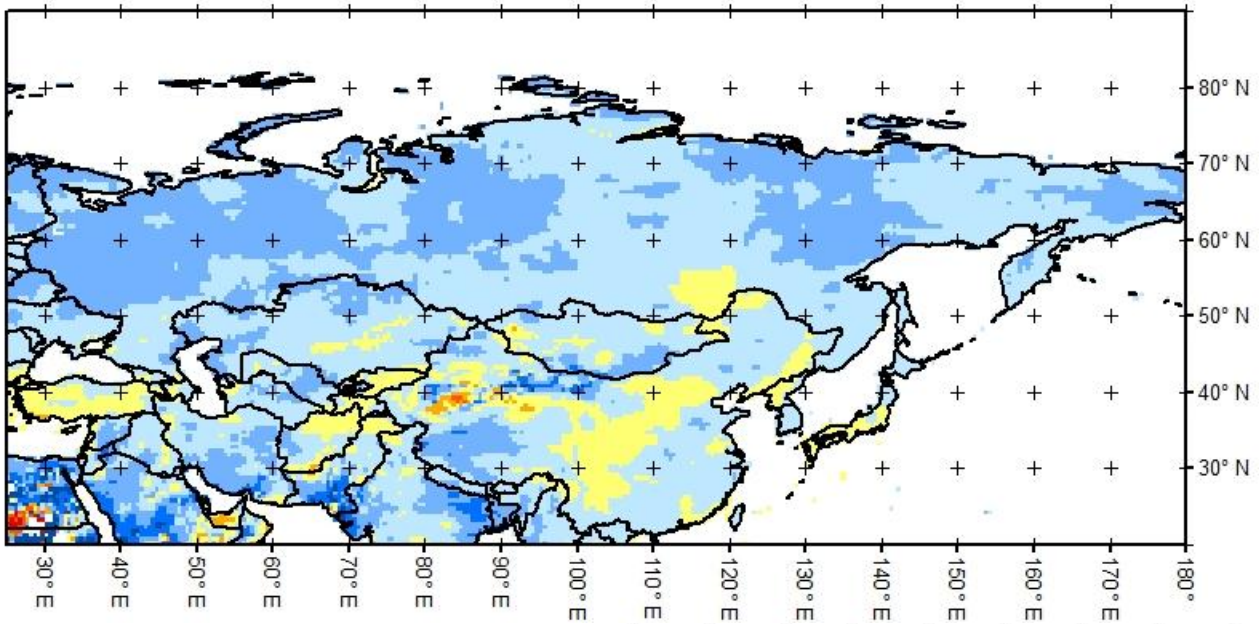
PAR and T and soil available water limiting factors

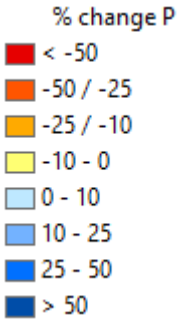


Land agroecological evaluation for spring wheat



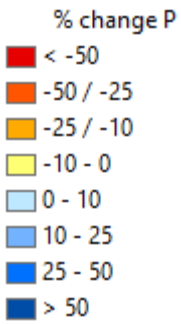
% change of Annual Precipitation Amount in the medium term 2006-2050 vs. 1961-2005

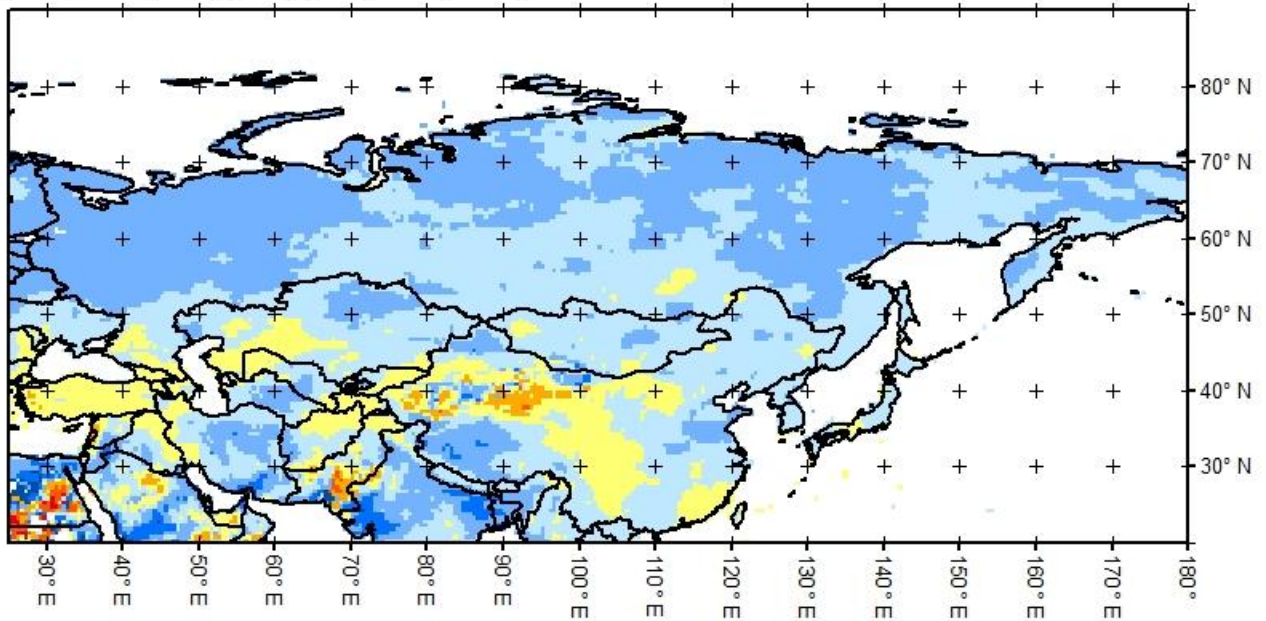




RCP 4.5

RCP 8.5





(CMCC and RTSAU – R. Valentini, I. Vasenev, 2015)

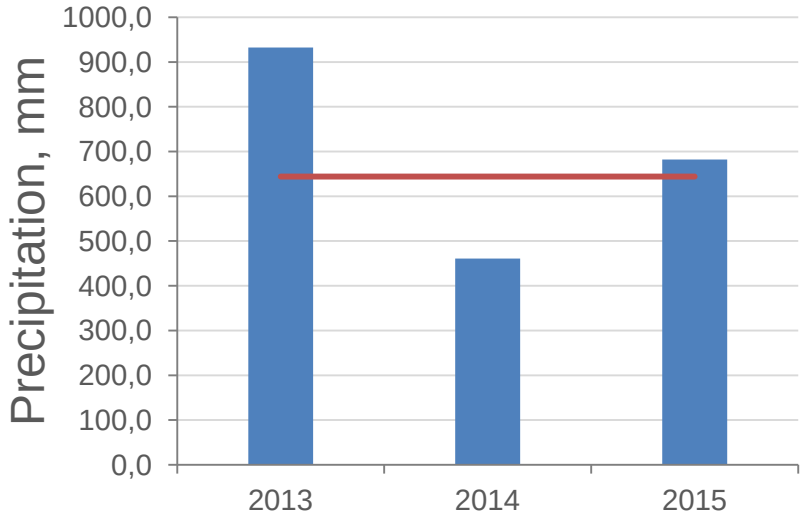
Crop potential yield calculation with 2-nd limiting factor (water supply)

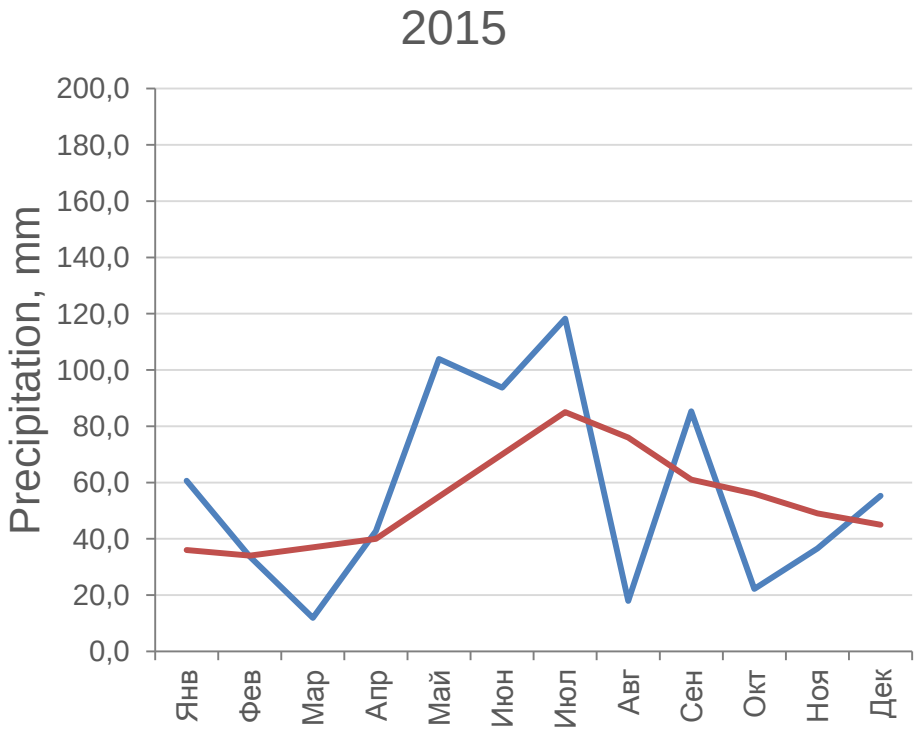
- $Y_{jw} = 10^5 * W_j / (K_j * L_j * (100 - \varepsilon_j))$,

where Kj is the water consumption coefficient, mm dt^{-1} ha^{-1} (bio-production).

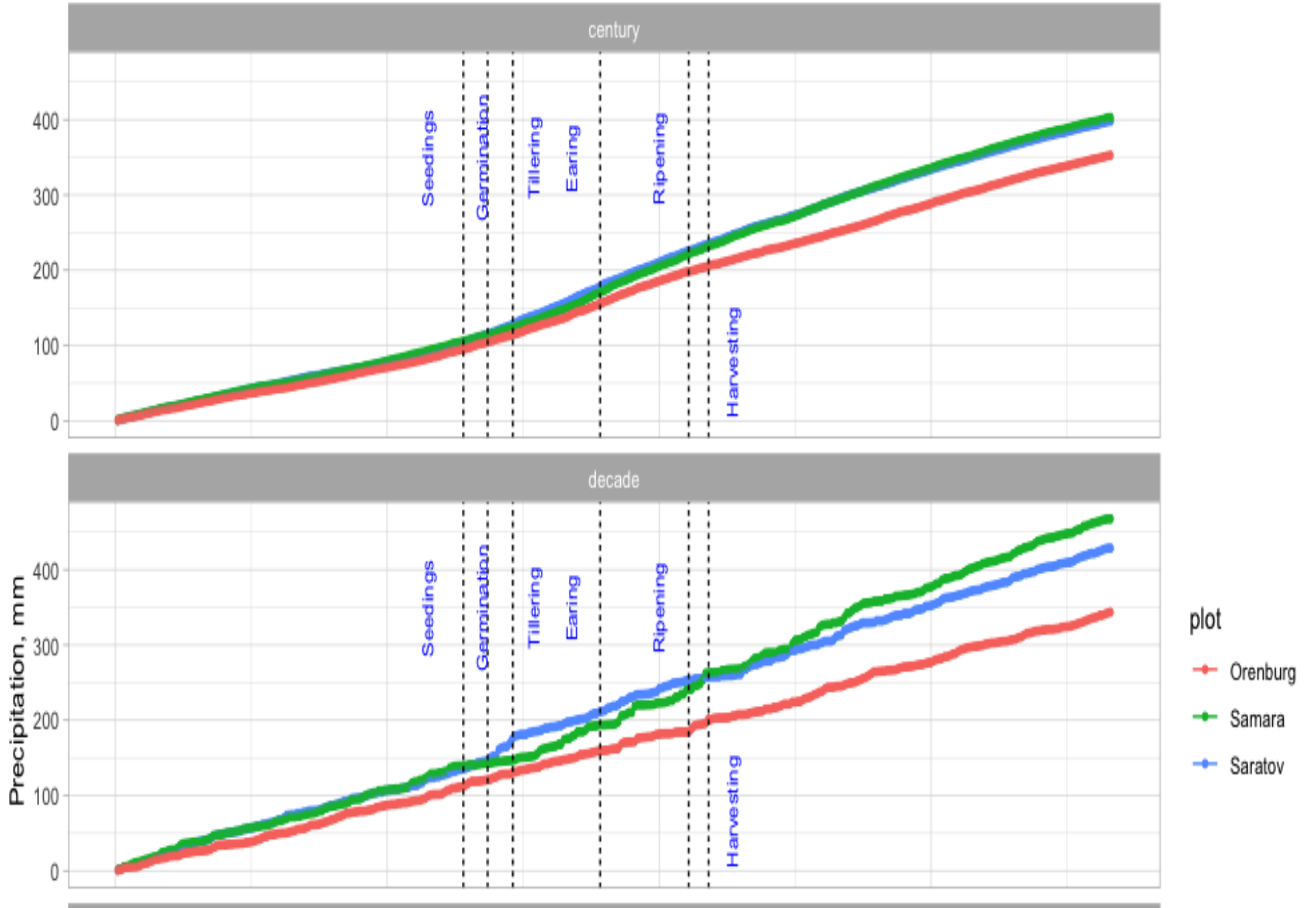
- The calculations use the adapted to the region conditions pedotransfer functions of productive moisture seasonal dynamics - depending on the seasonal distribution of precipitation, evaporation and traditional balance.

The average annual precipitation is 644.0 mm

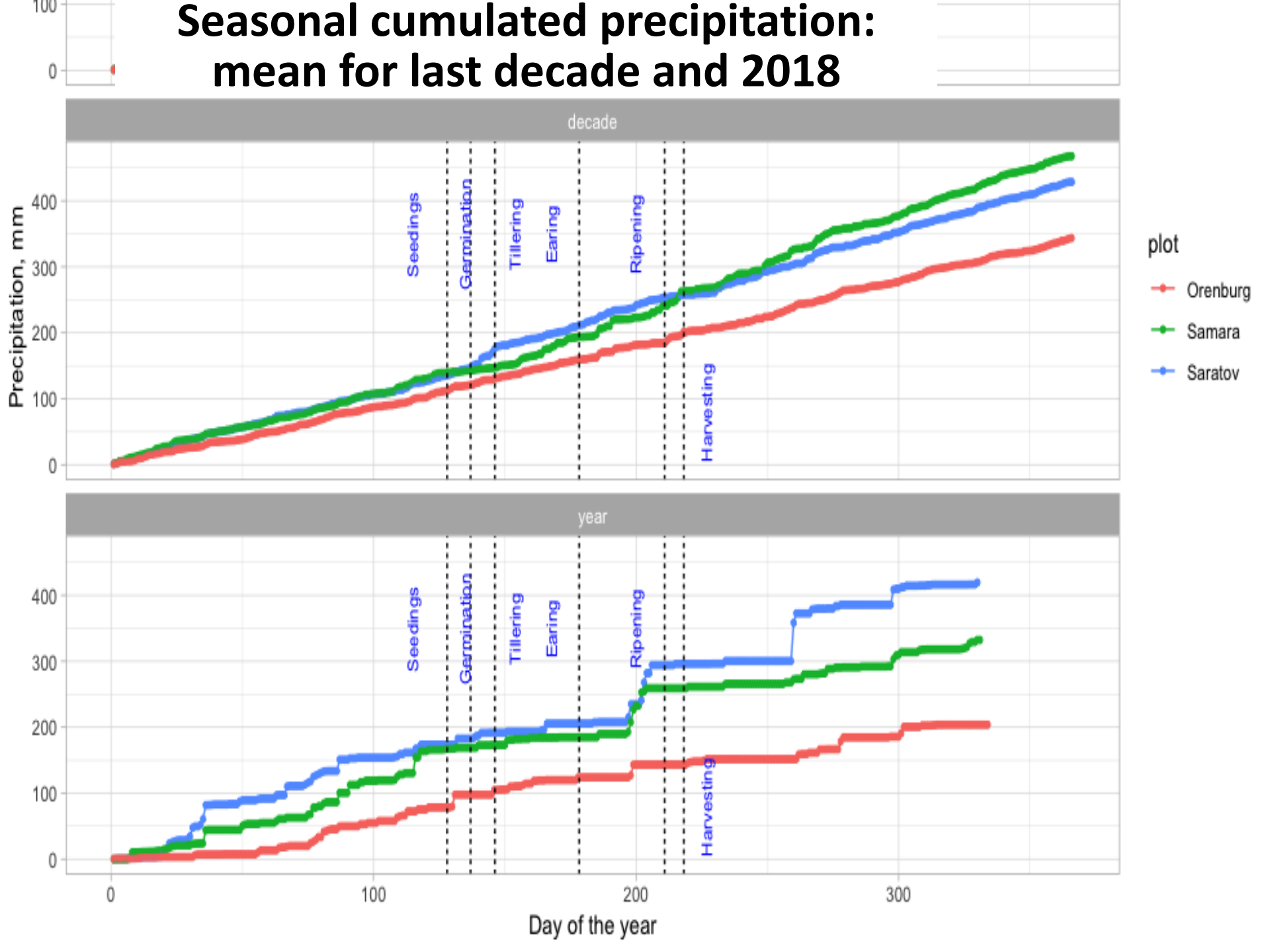




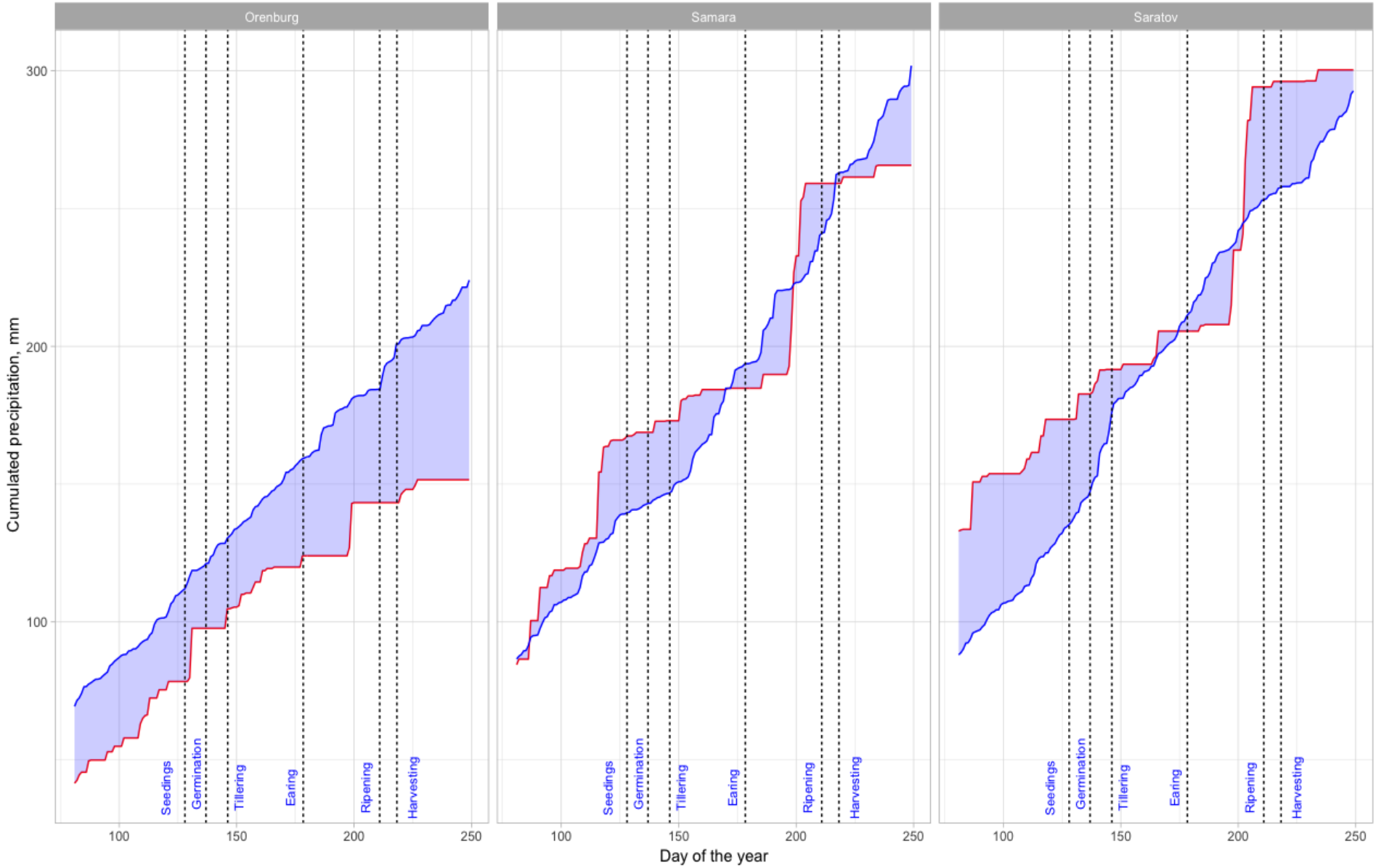
Mean seasonal cumulated precipitation: century → decade



Seasonal cumulated precipitation: mean for last decade and 2018

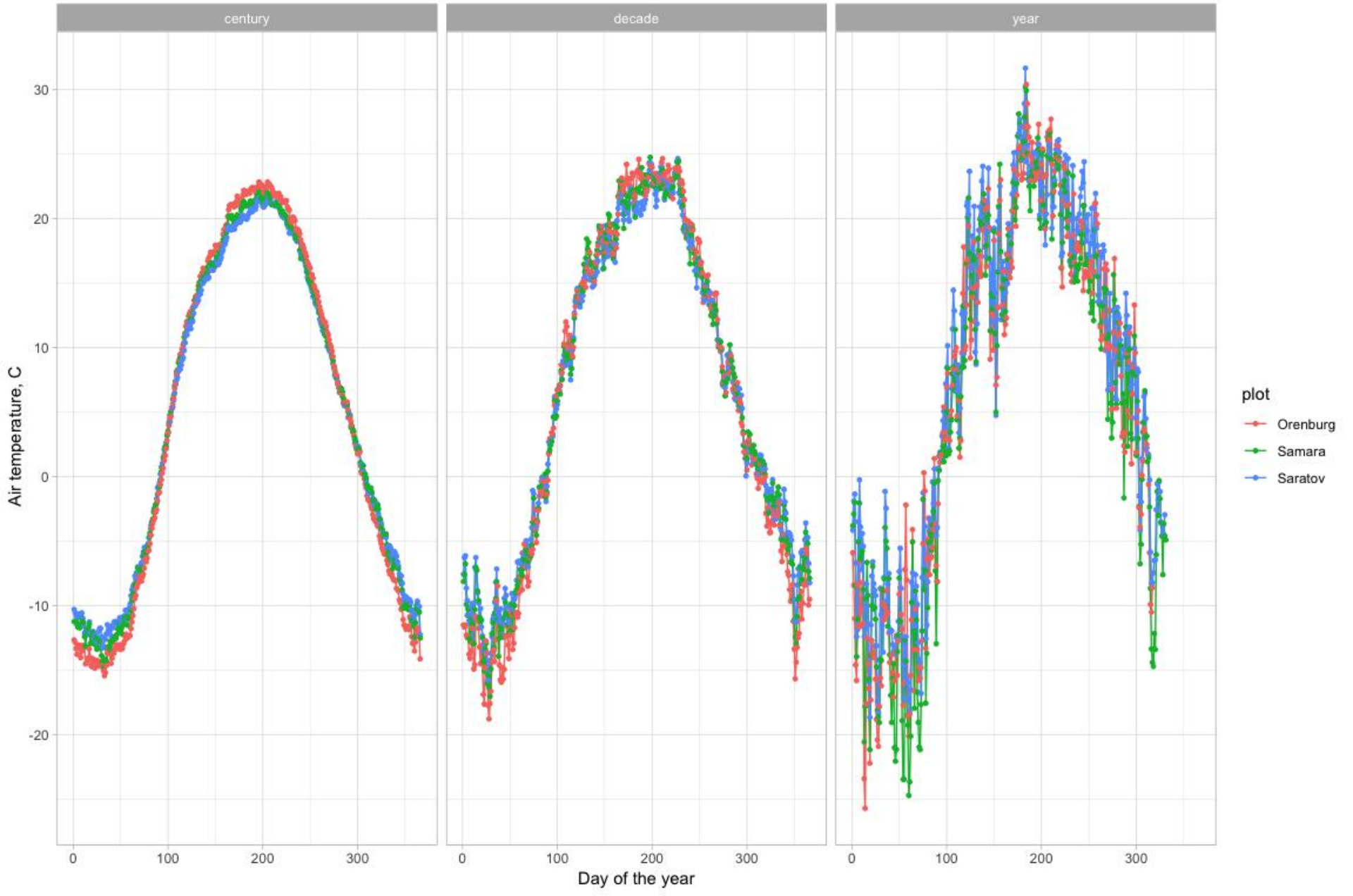


Seasonal cumulated precipitation 2018 vs decade average: Southern Ural and Volga regions

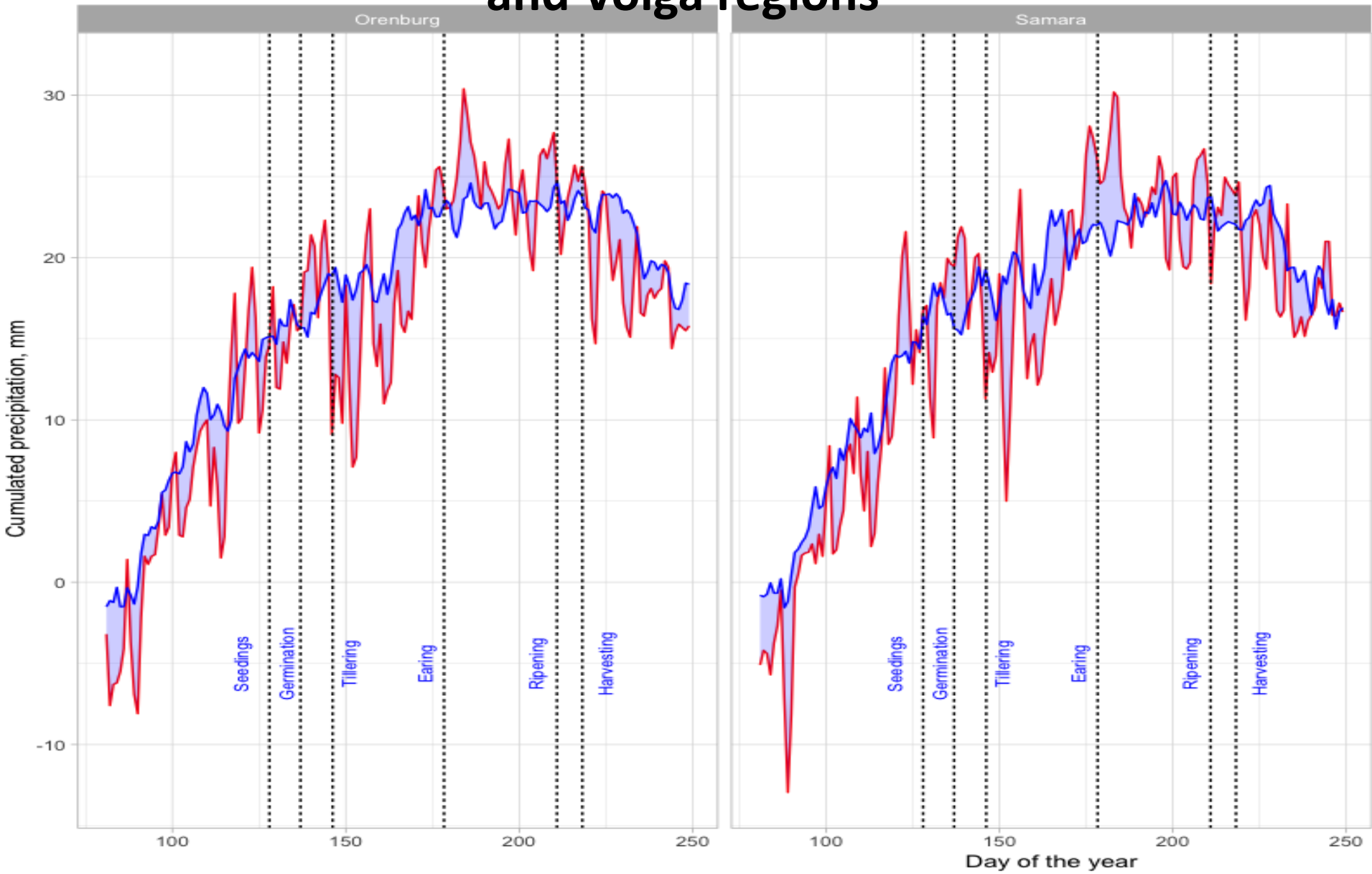


Red line – 2018, Blue line – decade average

Mean seasonal dynamics of air temperature: century → decade → 2018

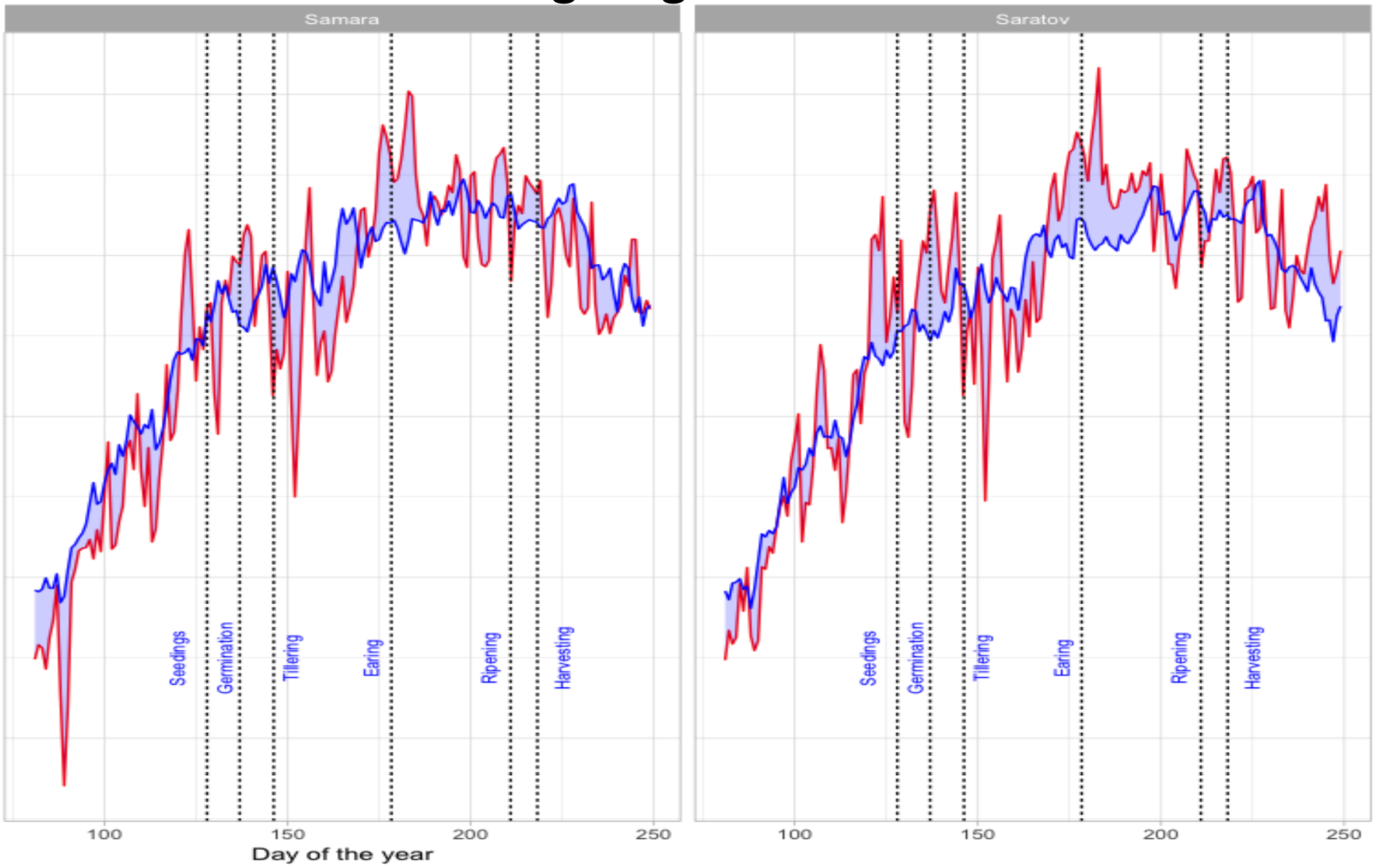


Daily precipitation 2018 vs decade average : Southern Ural and Volga regions



Red line – 2018, Blue line – decade average

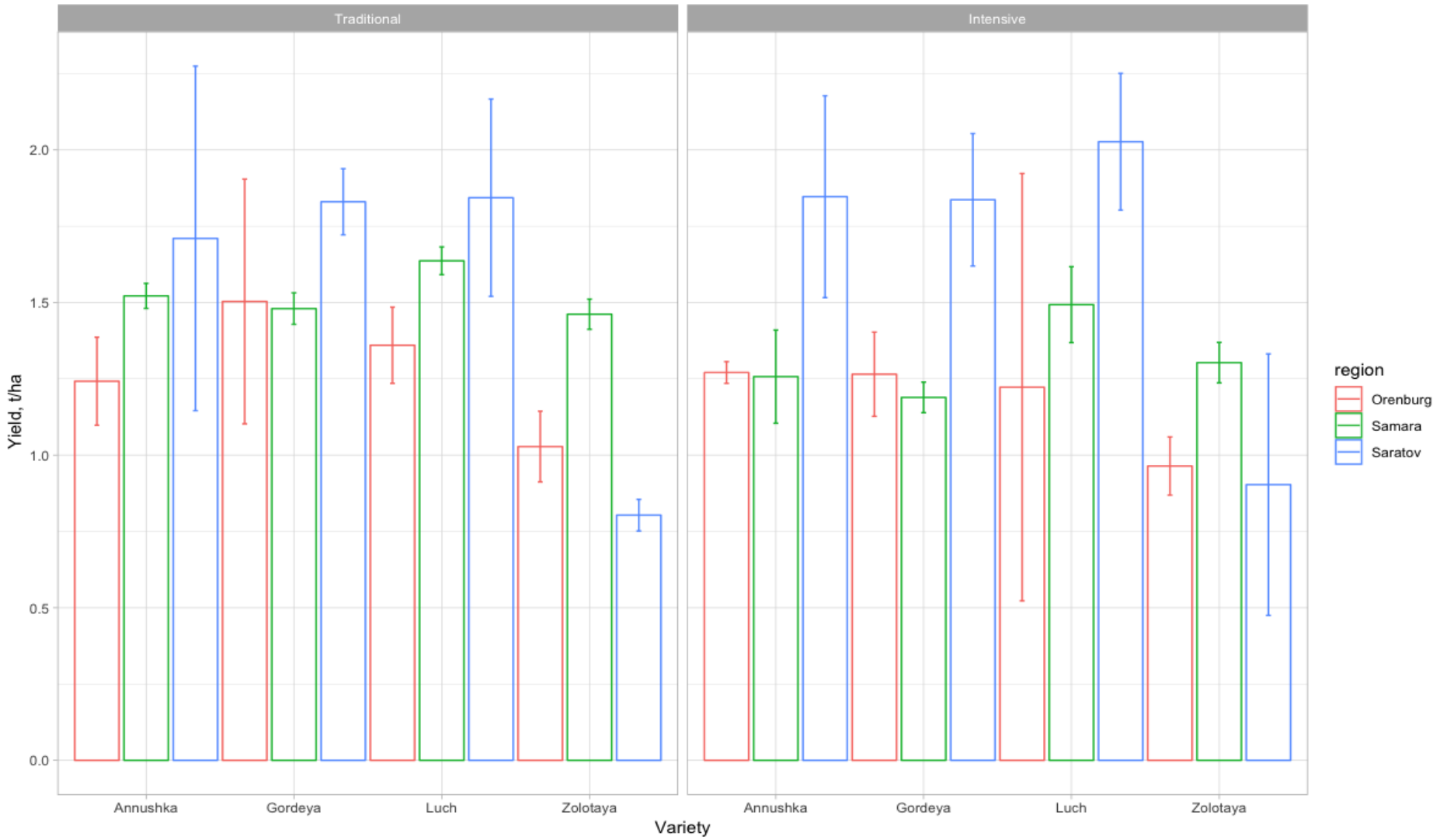
Daily precipitation 2018 vs decade average : 2 Volga regions



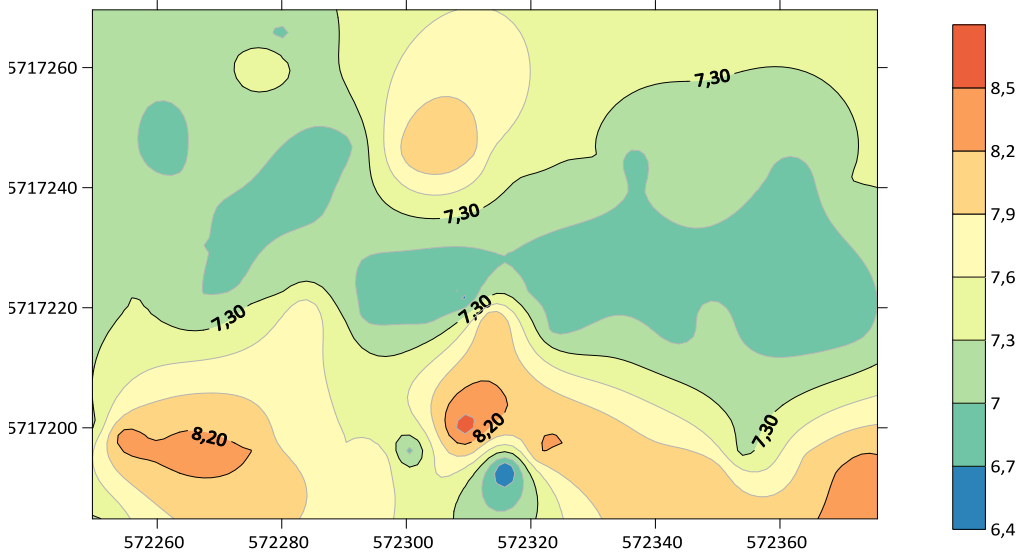
Red line – 2018, Blue line – decade average

Comparative analysis of the four investigated durum wheat varieties quantity and quality in Saratov, Samara and Orenburg regions shows principal regularities of their spatial distribution in conditions of very dry summer.

Average yield per variety per plot

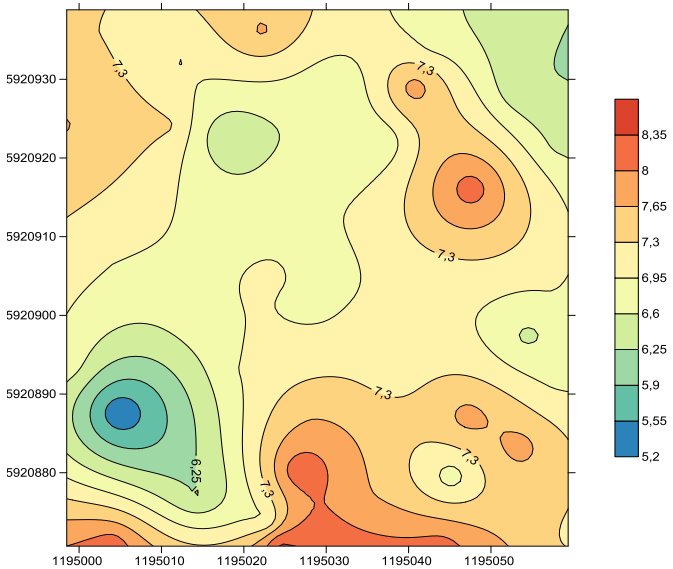


Whiskers show 95% confidence interval

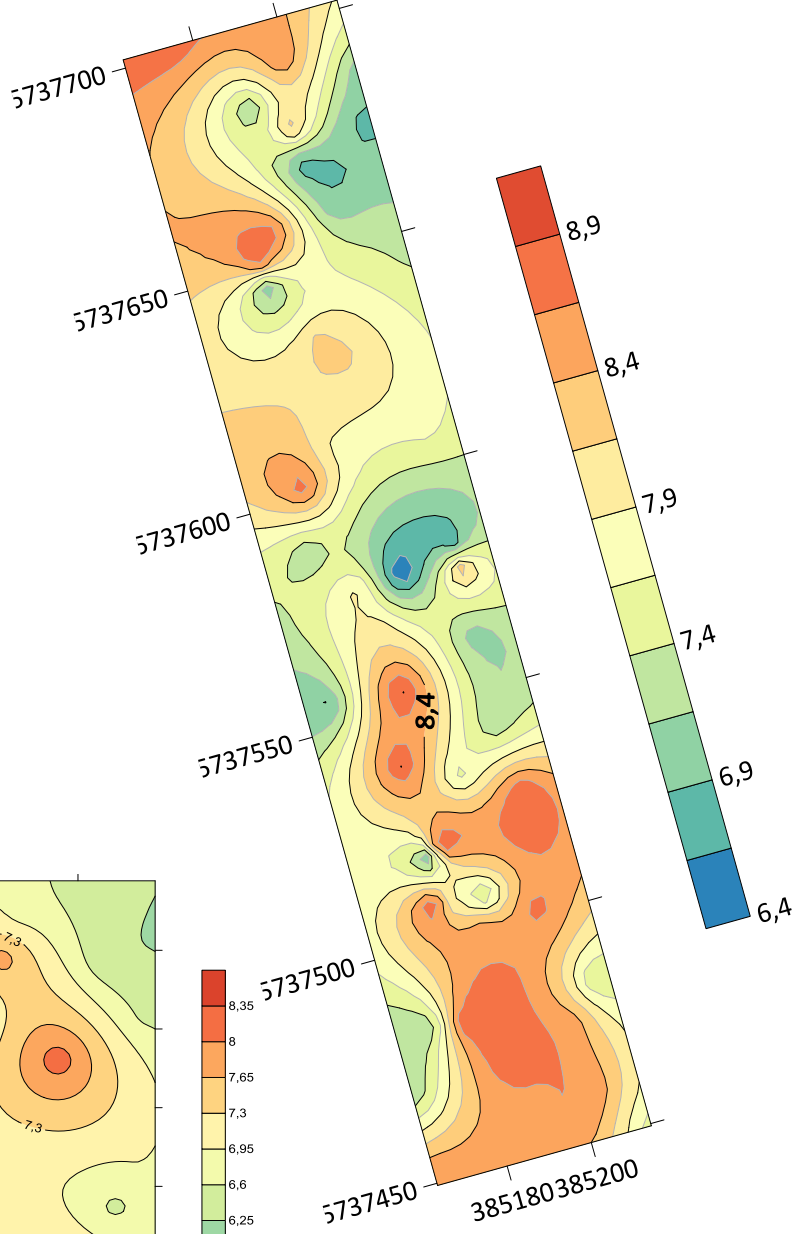


Plot in Saratov region

Maps of pH (H_2O) as limiting factors for 3 1-ha field plots in the representative sites with Haplic Chernozems in Saratov, Samara and Orenburg regions (April, 2018)

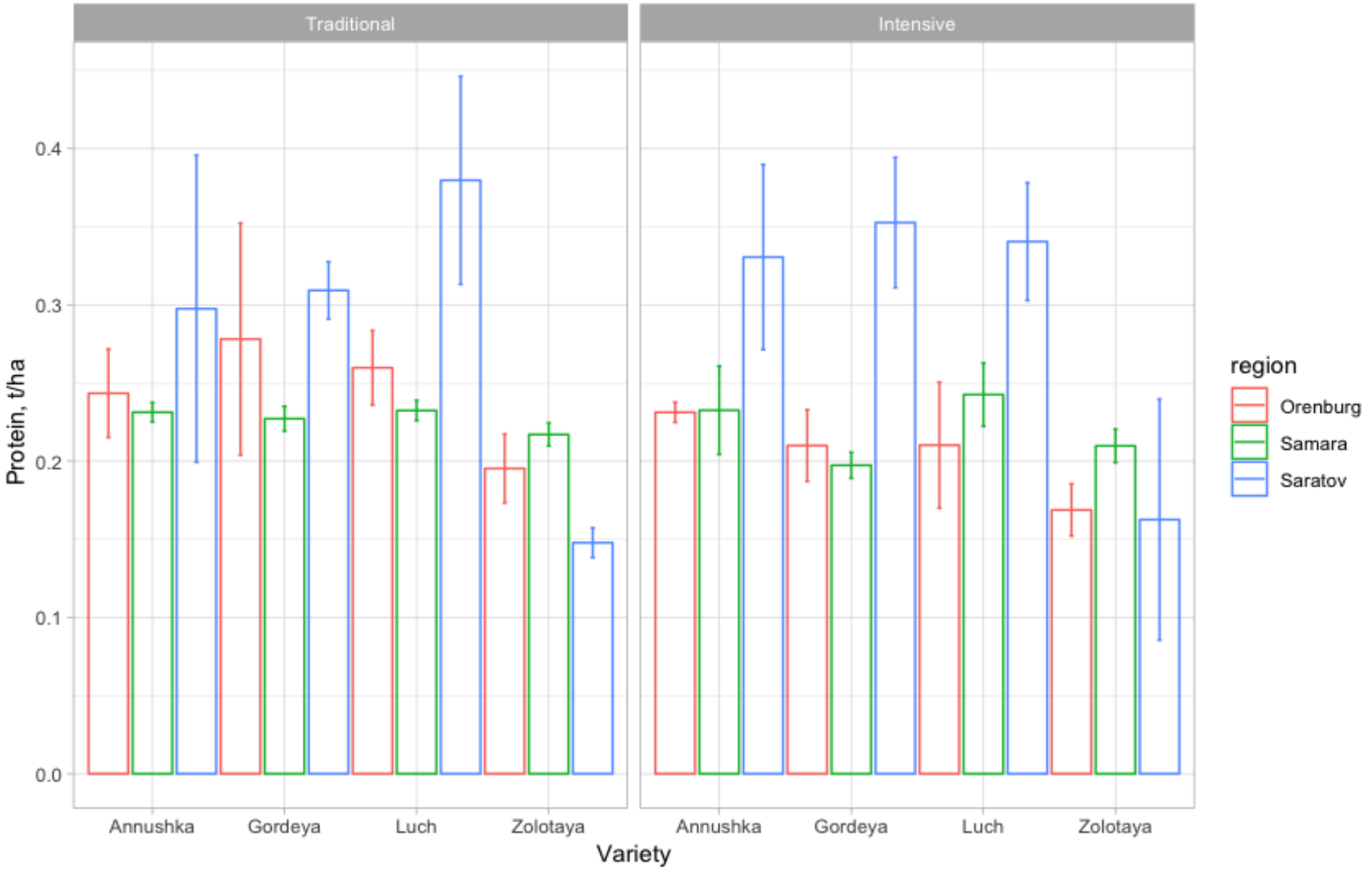


Plot in Samara region



Plot in Orenburg region

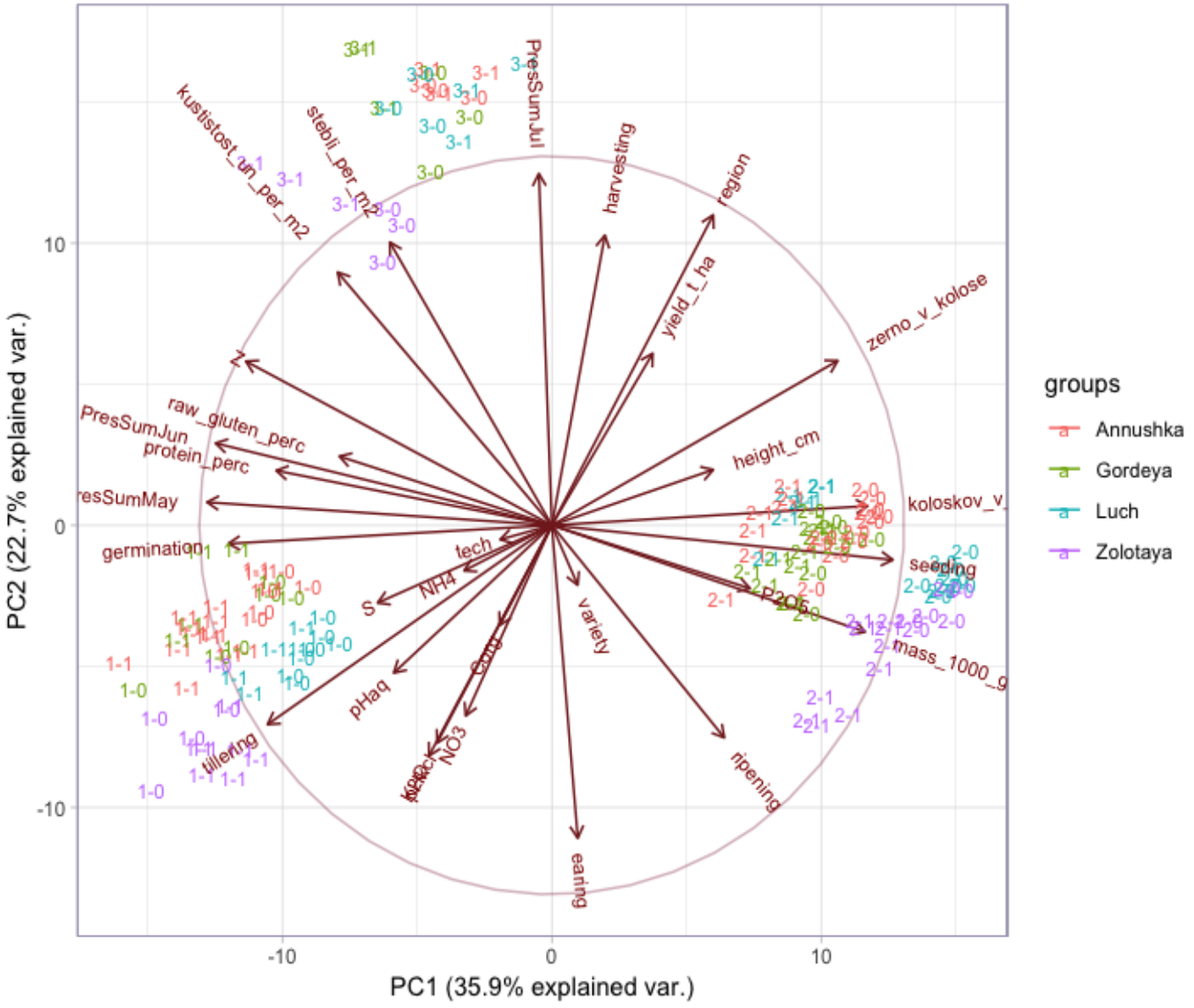
Average protein yield per variery per plot



Whiskers show 95% confidence interval

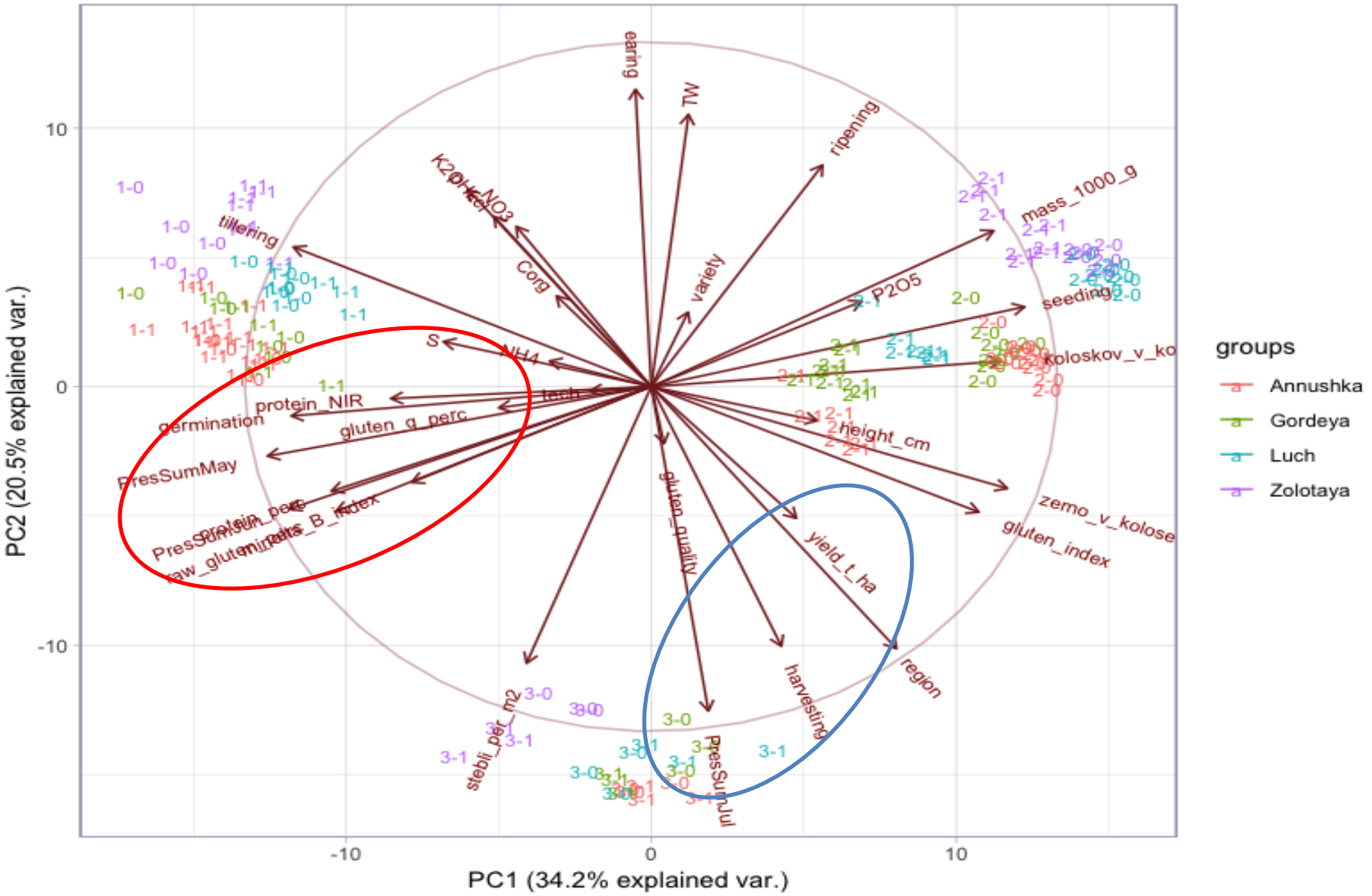
PCA for all measured variables

Principal component analysis shows clear agroecological differentiation of 3 regional groups of samples with almost independent segmentation of durum yield and gluten quality factors (the most stable in Orenburg).



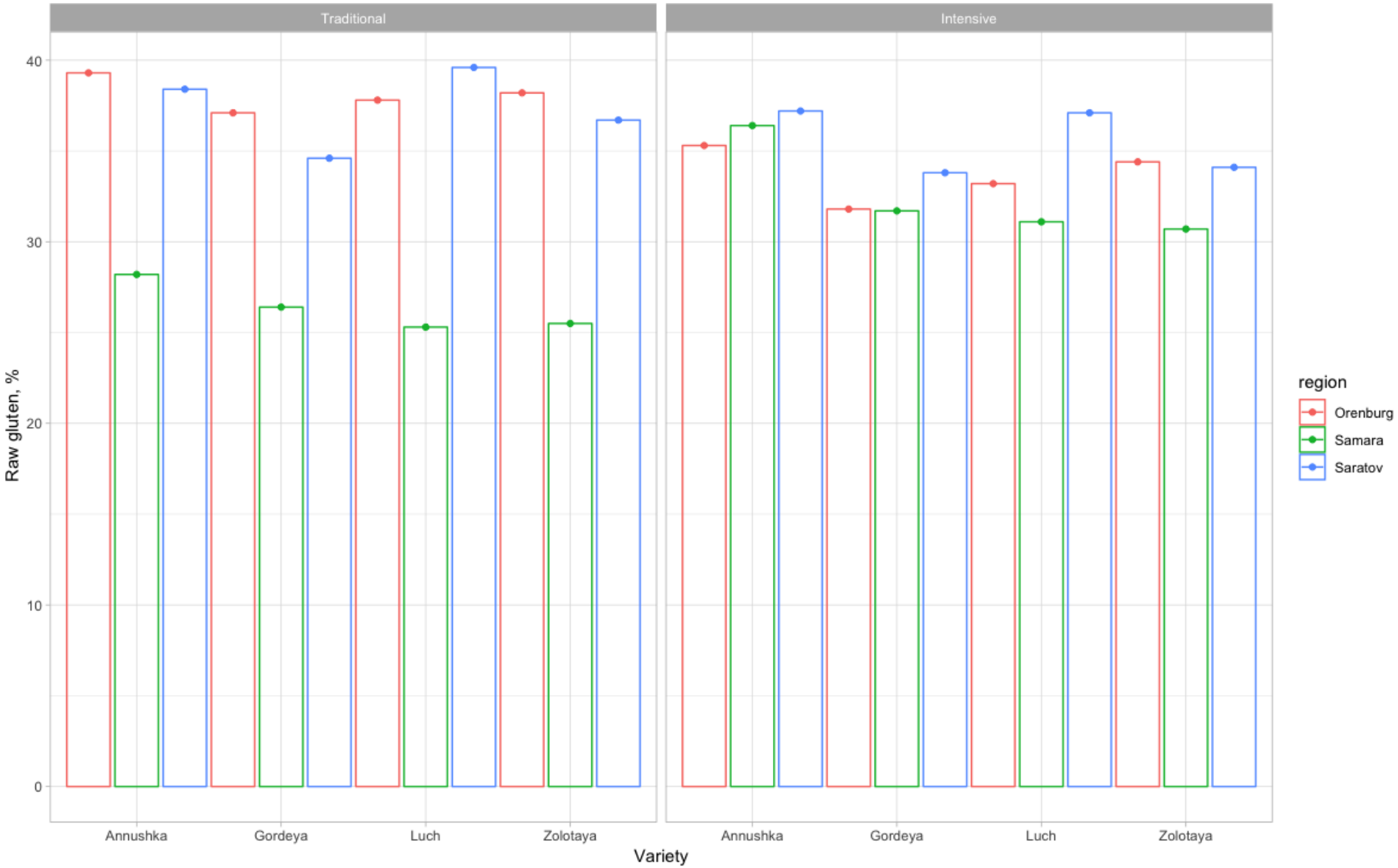
1 - Orenburg 2 - Samara 3 - Saratov (first number); 0 - Traditional technology, 1 - Intensive technology (second number)

PCA for filtered variables



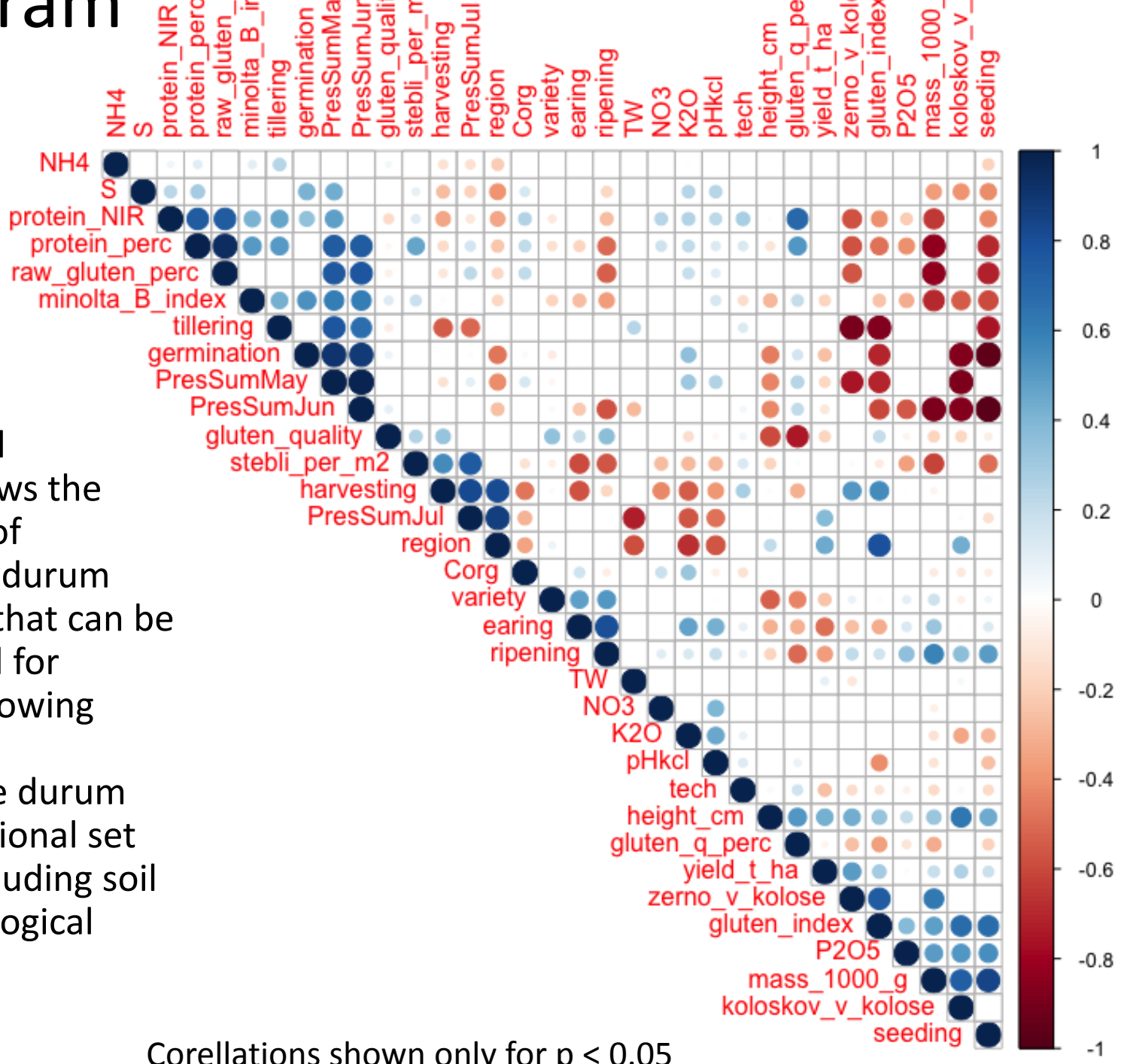
Crop varieties and applied technology have been separated only at the subgroup level. More intensive techno-logy allows decrease the level of regional and varietal differentiation

Average raw gluten content per variery per plot



Whiskers show 95% confidence interval

Corellogram

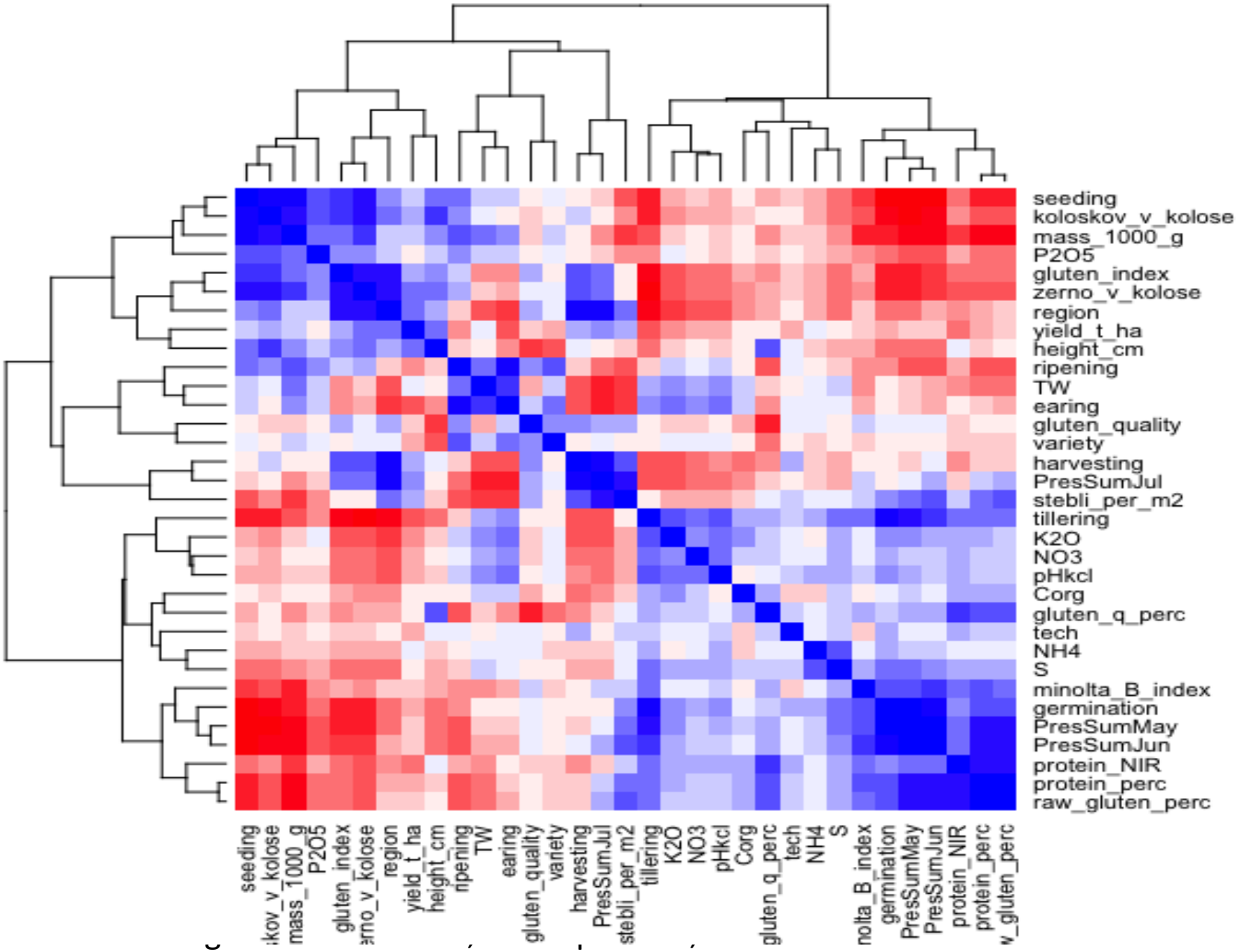


Significance level correlogram shows the dominated role of precipitation for durum yield prediction that can be especially typical for extremely dry growing season.

At the same time durum quality has additional set of predictors including soil limiting agroecological factors.

Corellations shown only for $p < 0.05$

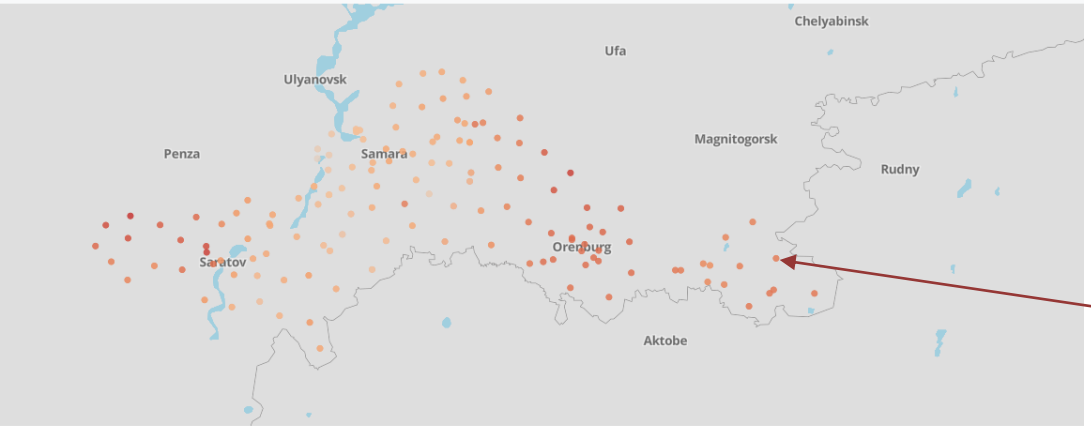
Clustering corellated variables



euclide distance in cluster analysis

DSS for Durum Project

Description Contacts



In the interactive map you can choose the closest meteorological station to your fields, which represented by color dots.

Choose meteorological station closest to your field

Climatic condition | Field features | Resulting yield

This is climatic conditions in your area according to closest weather station, if you are shure that you have more precise data, fill free to enter it

Precipitation sum per month, mm

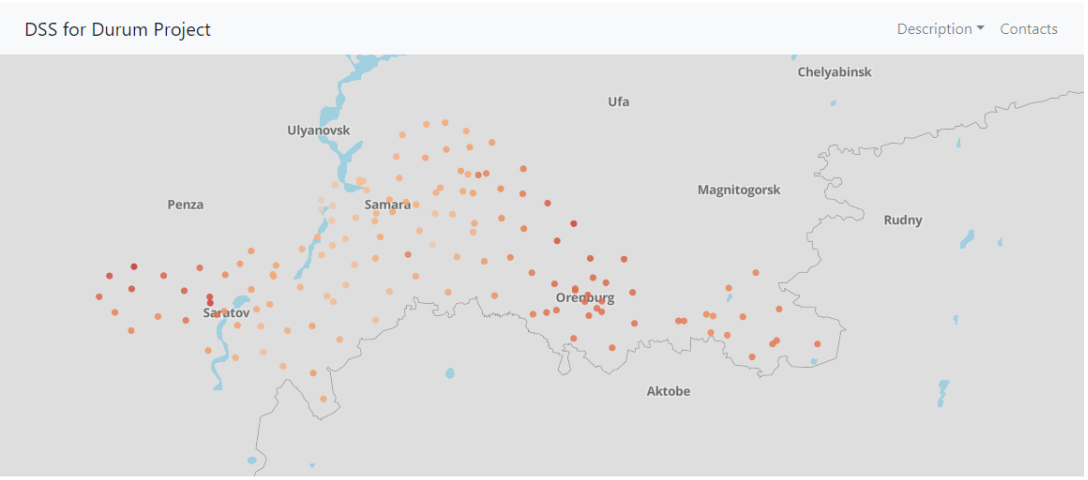
January	February	March	April	May	June	July	August	September	October	November	December
16.8	18.6	53.9	18.6	16.2	25.8	9.2	61.4	13.4	26.5	18	16.4

Sum of active temperatures(above 5 C), C

January	February	March	April	May	June	July	August	September	October	November	December
0	0	7.7	191.8	504.1	606.4	678.1	652	404.8	138.4	16.1	0

Sum of active temperatures(above 10 C), C

January	February	March	April	May	June	July	August	September	October	November	December
0	0	2	136.5	480	601.8	678.1	651	366	67.3	0	0



Choose meteorological station closest to your field

Climatic condition | Field features | Resulting yield

This is climatic conditions in your area according to closest weather station, if you are shure that you have more precise data, fill free to enter it

Precipitation sum per month, mm

January	February	March	April	May	June	July	August	September	October	November	December
21	19.9	28.4	24.5	28.5	29	34.1	31.8	19	28.9	22.6	28.7

Sum of active temperatures(above 5 C), C

January	February	March	April	May	June	July	August	September	October	November	December
0	0	10.3	212.5	467.7	618	693.8	644.1	396.1	148	11.5	0

Sum of active temperatures(above 10 C), C

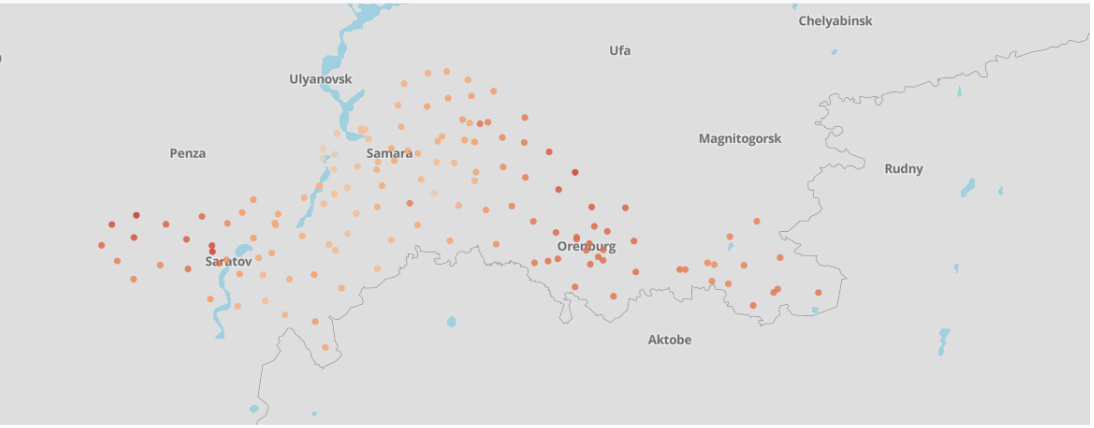
January	February	March	April	May	June	July	August	September	October	November	December
0	0	2.8	149.9	437	614.7	693.8	641.8	349.5	68.7	0	0

In the interactive map you can choose the closest meteorological station to your fields, which represented by color dots.

In the tab “Climatic condition”, after clicking on any meteorological station all fields will be **updated** according to data from this station (averaged for last decade).

DSS for Durum Project

Description Contacts



Choose meteorological station closest to your field

Climatic condition | Field features | Resulting yield

This is climatic conditions in your area according to closest weather station, if you are shure that you have more precise data, fill free to enter it

Precipitation sum per month, mm

January	February	March	April	May	June	July	August	September	October	November	December
21	19.9	28.4	24.5	28.5	29	34.1	31.8	45	28.9	22.6	28.7

Sum of active temperatures(above 5 C), C

January	February	March	April	May	June	July	August	September	October	November	December
0	0	10.3	212.5	467.7	618	693.8	644.1	396.1	148	11.5	0

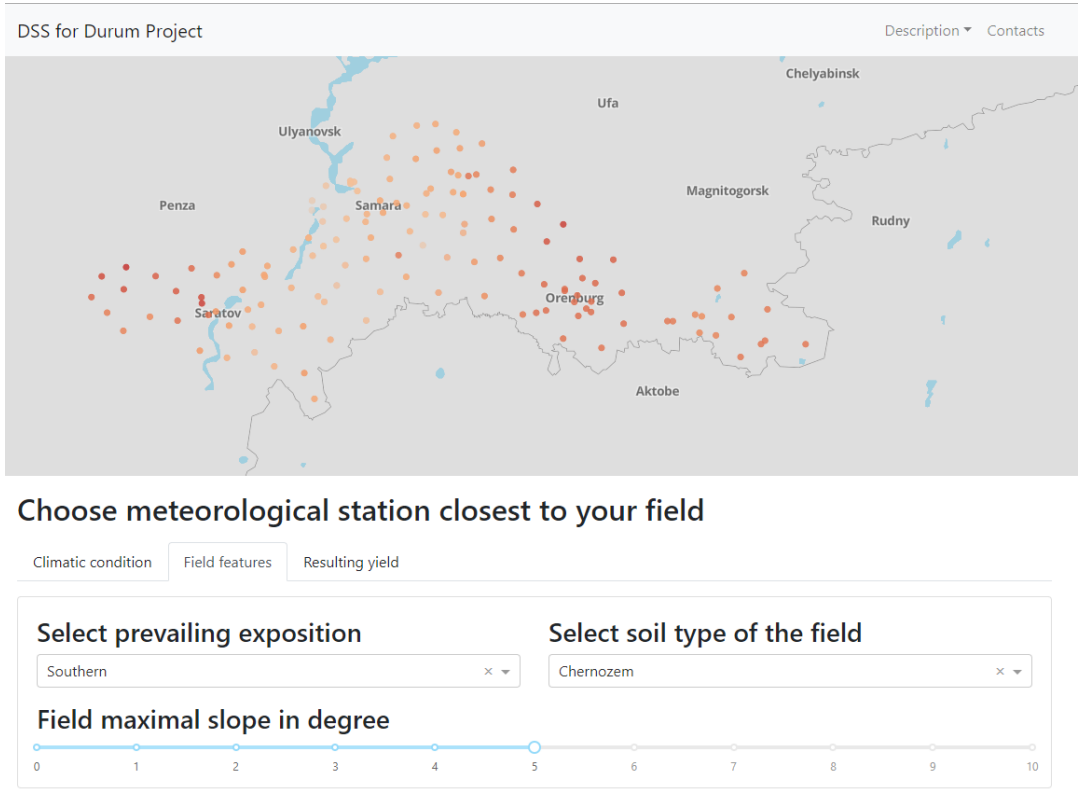
Sum of active temperatures(above 10 C), C

January	February	March	April	May	June	July	August	September	October	November	December
0	0	2.8	149.9	437	614.7	693.8	641.8	349.5	68.7	0	0

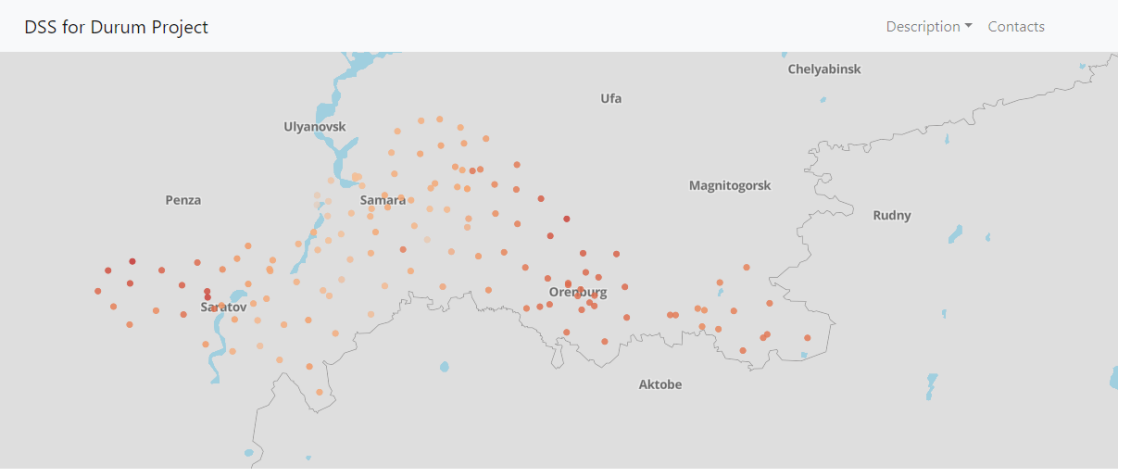
In the interactive map you can choose the closest meteorological station to your fields, which represented by color dots.

In the tab “Climatic condition”, after clicking on any meteorological station all fields will be updating according to data from this station (averaged for last decade).

If you have more precise data for your site feel free to enter it in **any** field



In the tab “Field features”, you should enter prevailing exposition, maximal slope and soil type specific for your field



Choose meteorological station closest to your field

Climatic condition | Field features | Resulting yield

Yield assessment

Yield according to obtained PAR:

2.08 t/ha

Yield according to precipitation limitations:

0.76 t/ha

Yield according o precipitation and soil type limitations:

0.61 t/ha

In the tab “Resulting yield”, you can different predicted yields:

Yield according to obtained PAR – yield prediction taking into account only PAR calculated from active temperatures, with assumption that precipitation and field features was ideal

Yield according to precipitation limitations – yield prediction taking into account PAR and precipitation, with assumption that field features was ideal

Yield according to precipitation and soil limitations – yield prediction taking into account PAR, precipitation and field features

Conclusions.

Developed basic element of the DSS for agro-ecologically based choice of best available land, durum wheat variety and agro-technology version, regional agro-climate GIS allows to calculate the durum wheat yield taking into account the principal land characteristics and one from three versions of the DSS algorithms:
Yield according to local PAR,
Yield according to precipitation limitations,
Yield according to precipitation and soil type limitations,
that becomes more and more interesting for innovative land-users in the steppe zone at the European territory of Russia.