Grain production trends in Russia, Ukraine and Kazakhstan in the context of the global climate variability and change

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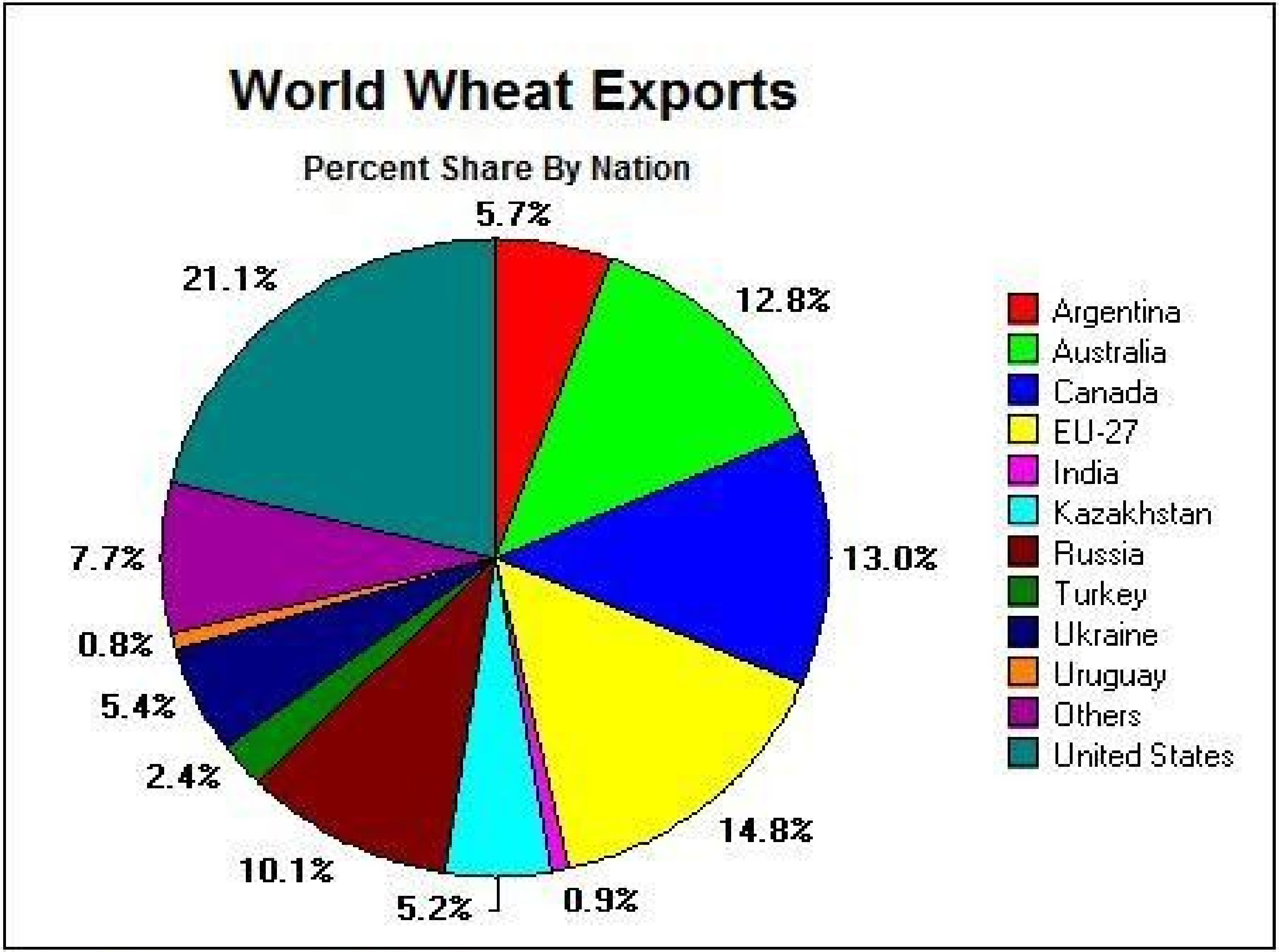
Recent trends, projections, and questions

- Despite the large reduction of arable areas grain exports by Russia-Ukraine-Kazakhstan (RUK) in 2006-11 averaged 41 million tons/year = ~ 14 % of the world total.
- By 2021 RUK are projected to provide 22% of the world's grain exports.
- Russia's wheat exports are projected to approach those of the US, and total wheat exports by RUK are expected to exceed those of the US by 87% (USDA 2013).

Arable area reduction after 1991

- The largest withdrawal of arable lands in recent history (Lioubimtseva and Henebry, 2012; Lioubimtseva et al., 2013)
- Between 1991 and 2001, 23 million hectares of arable lands has been removed from production, 90 % of which had been used for grain (FAO 2008).
- Inverse land-use trends have been observed in the past decade in Russia (cropland expansion, reclaim of previously abandoned lands).
- Most of the arable area reduction in the 1990s reflected withdrawal of marginal unproductive lands and only very significant increase of grain prices on the global market is likely to cause their return.

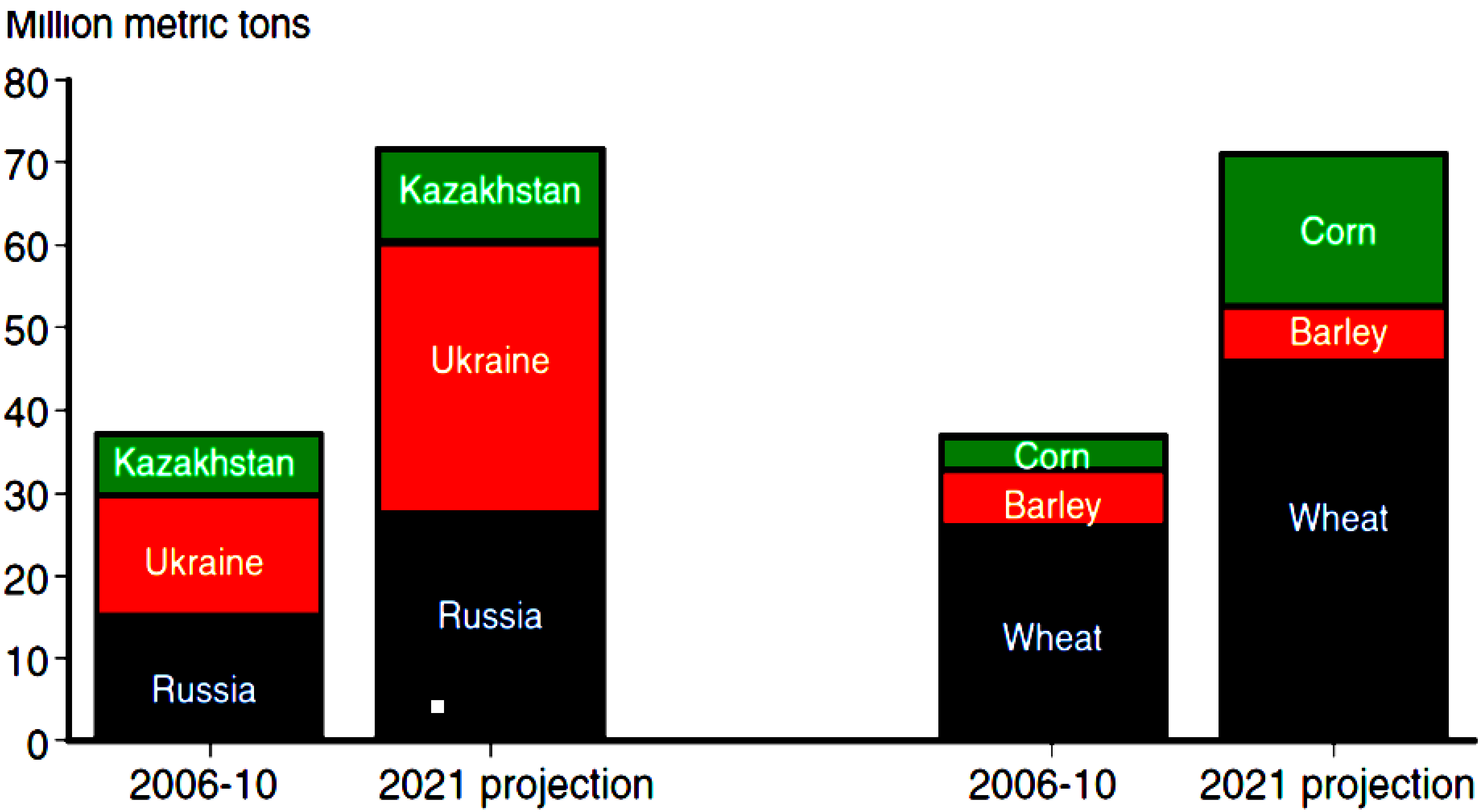


From USDA, 5-year average

Country	Grain production, million tons (cereals total)*						
	1992 1994	2004 2006	2012	projections for 2016-2017			
				OECD-FAO	IKAR	EBRD maximum potential scenario	USDA FAS**
Russia	**93**	**77**	**69**		**98**	**126**	**96**
Ukraine	**37**	**37**	**47**		**44**	**75**	**54**
Kazakhstan	**23**	**14**	**15**		**22**	**29**	**23**
All three	**152**	**128**	**131**	**159**	**164**	**230**	**173**

- Ada[ted from Lioubimtseva and Henebry 2012
- * *Estimated by the author based on the USDA FAS 2013 projections

Grain exports projections



Note: KRU region comprises Kazakhstan, Russia, and Ukraine. The bars for 2006-10 give average annual gross exports during the period.

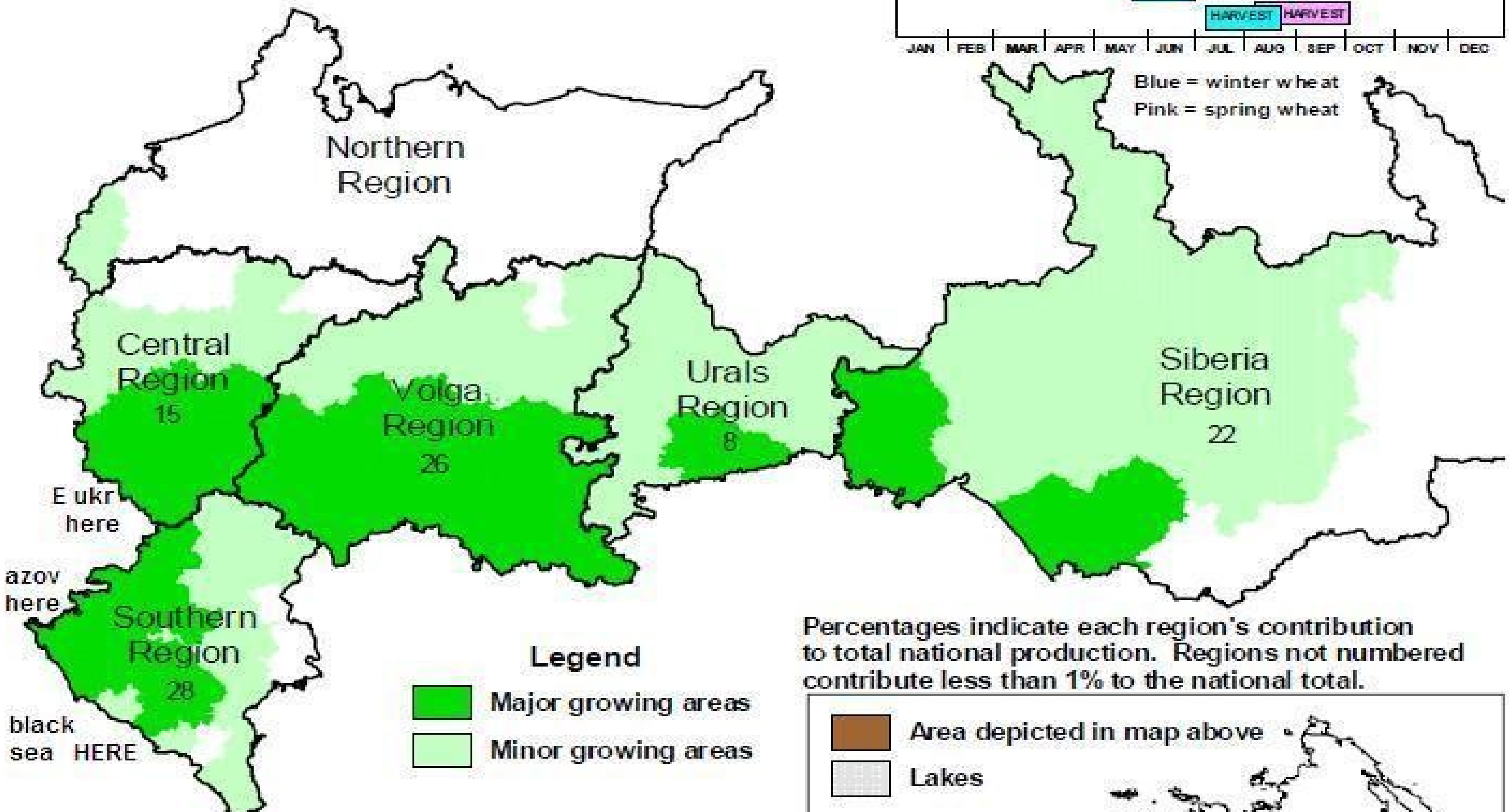
Source: U.S. Department of Agriculture, 2012.

What are the impacts of climate variability and change on the grain production trends?

Data and methods:

- Agricultural statistics;
- Meteorological data;
- Climate change scenarios (AOGCM and RCM), agro-ecological and bio-economic scenarios;
- Remote sensing data: NDVI trends retrieved from the NOAA Advanced Very High Resolution Radiometer (AVHRR) data from the Pathfinder Land (PAL) dataset and MODIS Terra NBAR for the period 2001-2010.
- Field observations.

Russia: Wheat



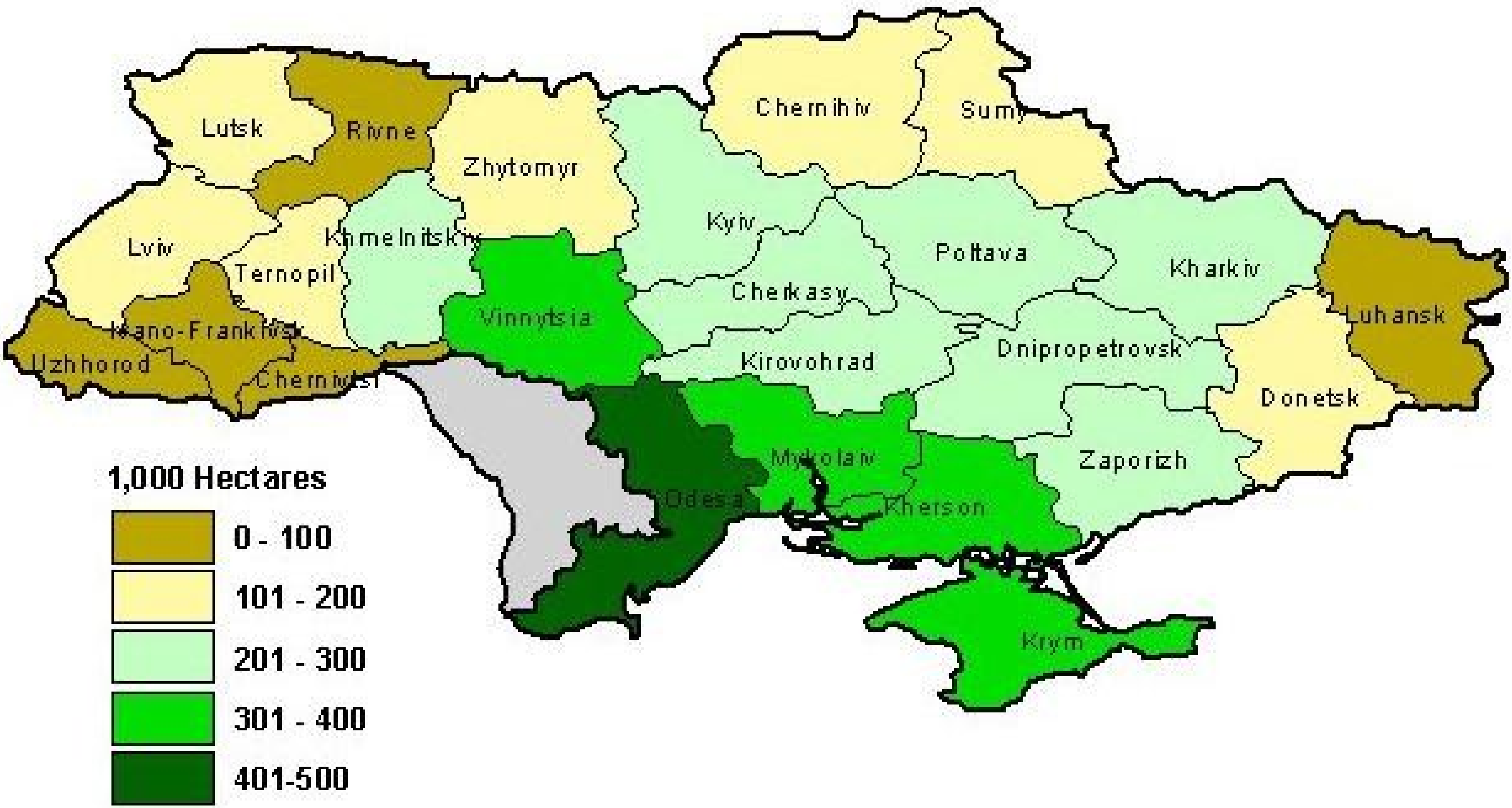
Percentages indicate each region's contribution to total national production. Regions not numbered contribute less than 1% to the national total.

- Major growing areas combined account for 75% of total national production
- Major and minor growing areas combined account for 99% of total national production
- Major and minor growing areas and country production percentages based upon averaged oblast-level data from 1996-2000.

Source: Sovecon Agrokhleb Bulletin Statistics and Forecasts February 18, 2003 Issue No.4 (41), 2002.

USDA JOINT AGRICULTURAL WEATHER FACILITY (JAWF)

Ukraine: Estimated Winter Wheat Area by Oblast



Production Estimates and Crop Assessment Division, FAS, USDA

Kazakstan
Wheat Regions
North Kaz
Kostanai
Akmola
Pavlodar
West Kaz
Aktubinsk
Karaganda
East Kaz
Atyr
Kzyl-Orda
Taras
Almaty
Mangystau
S Kaz
Major wheat region
Minor wheat region
Little or no wheat
USDA
Production Estimates and
Crop Assessment Division
Foreign Agricultural Service

The wheat belt of Russia, Ukraine and Kazakhstan

- After collapse of the USSR ~23 Mha of arable land idled in RUK
- Partial recovery of agricultural sector occurred over 2000s
- ~ 15% of the global wheat production in 2009-2012

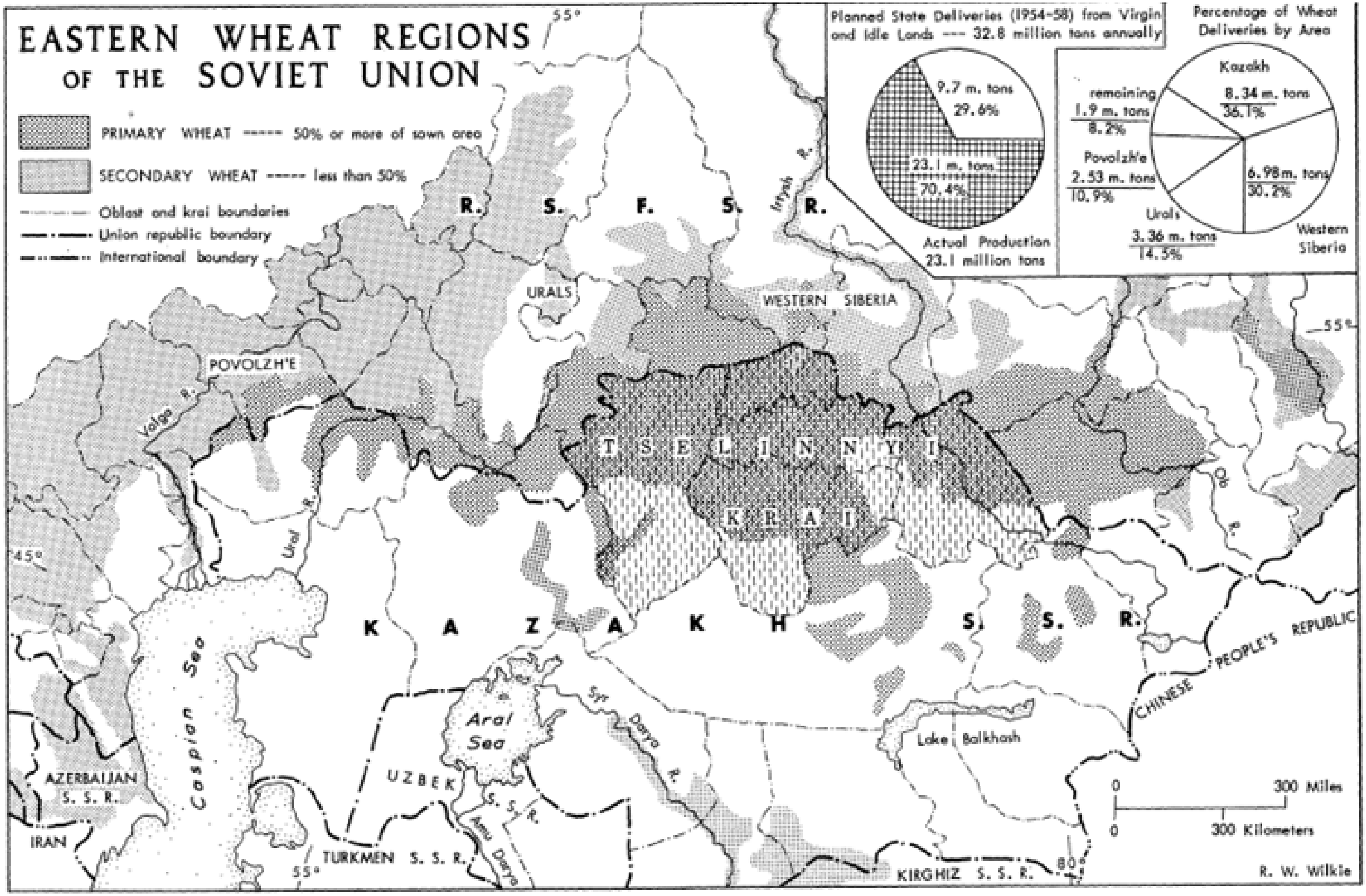
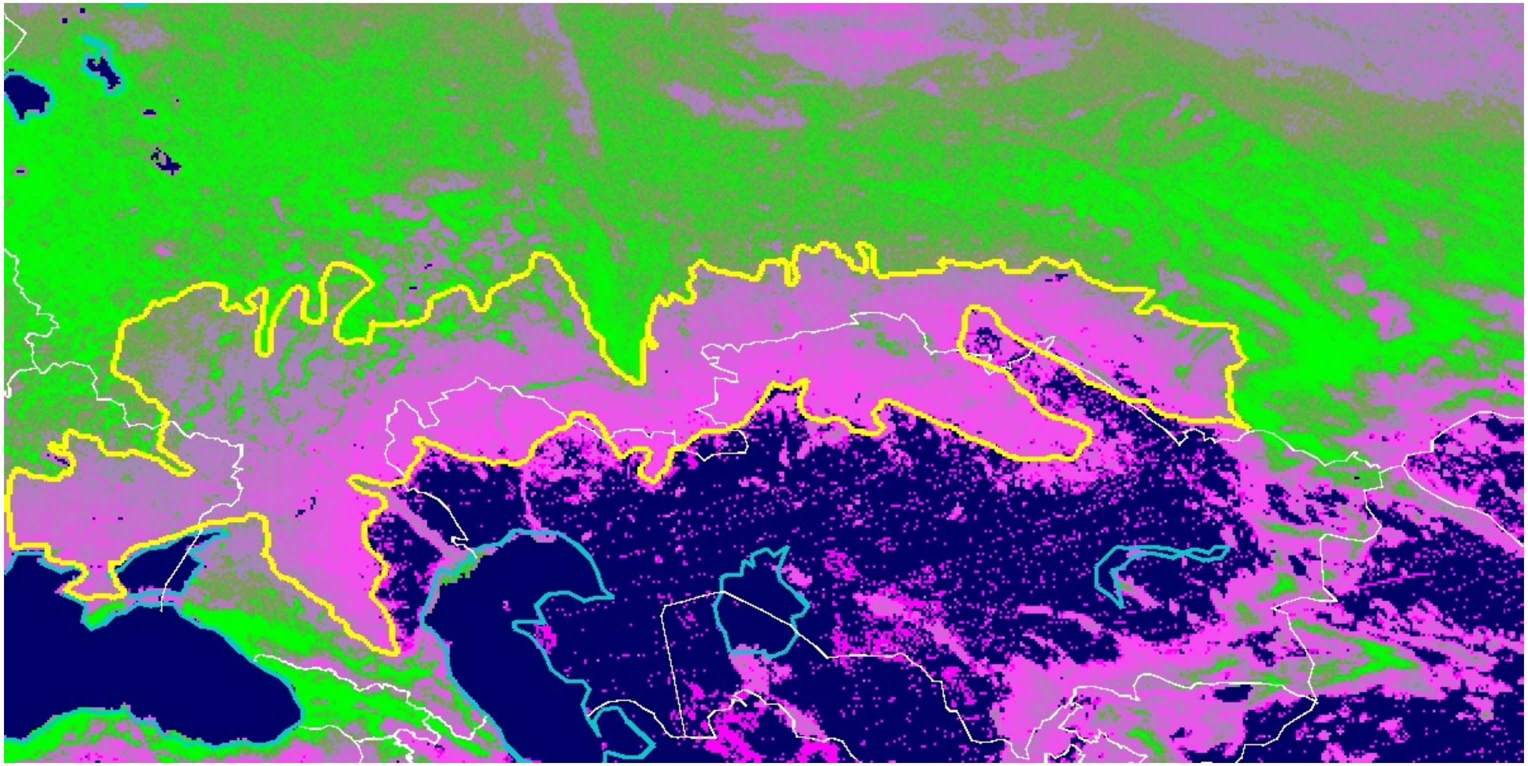


Fig. 1. (Sources: *Atlas Sel'skogo Khoziaistva SSSR* [Moscow, 1960], pp. 106–107, 116; *Narodnoe Khoziaistvo SSSR v 1959 Godu. Statisticheskii ezhegodnik* [Moscow, 1960], p. 373; *Pravda*, March 13, 1961.)

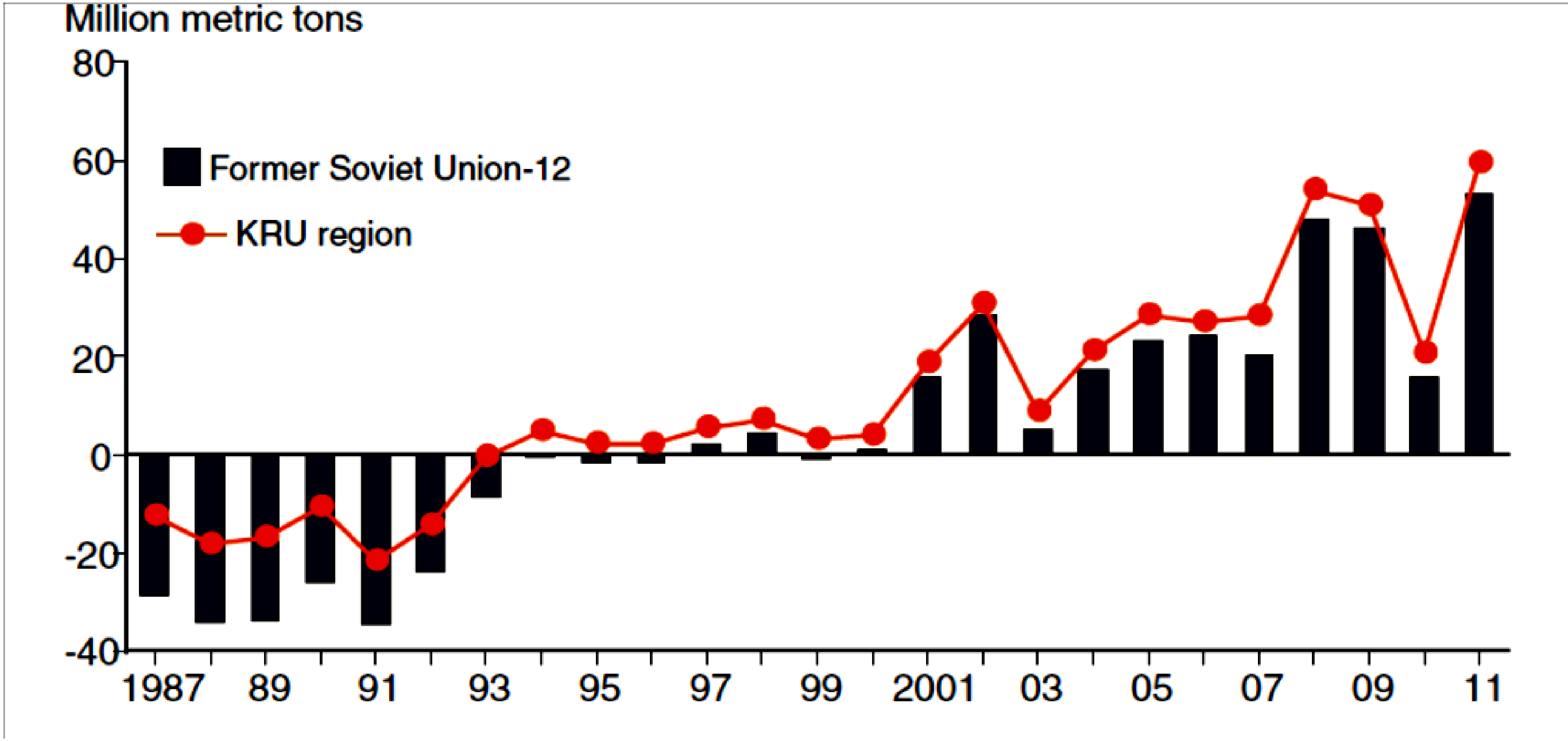
The RUK wheat belt PAL NDVI



The wheat belt of southern Ukraine, southern Russia, northern Kazakhstan)

(PAL NDVI imagery for 1982-99 with binary threshold filter selecting pixels with NDVI> 0.5) (Lioubimtseva and Henebry 2009)

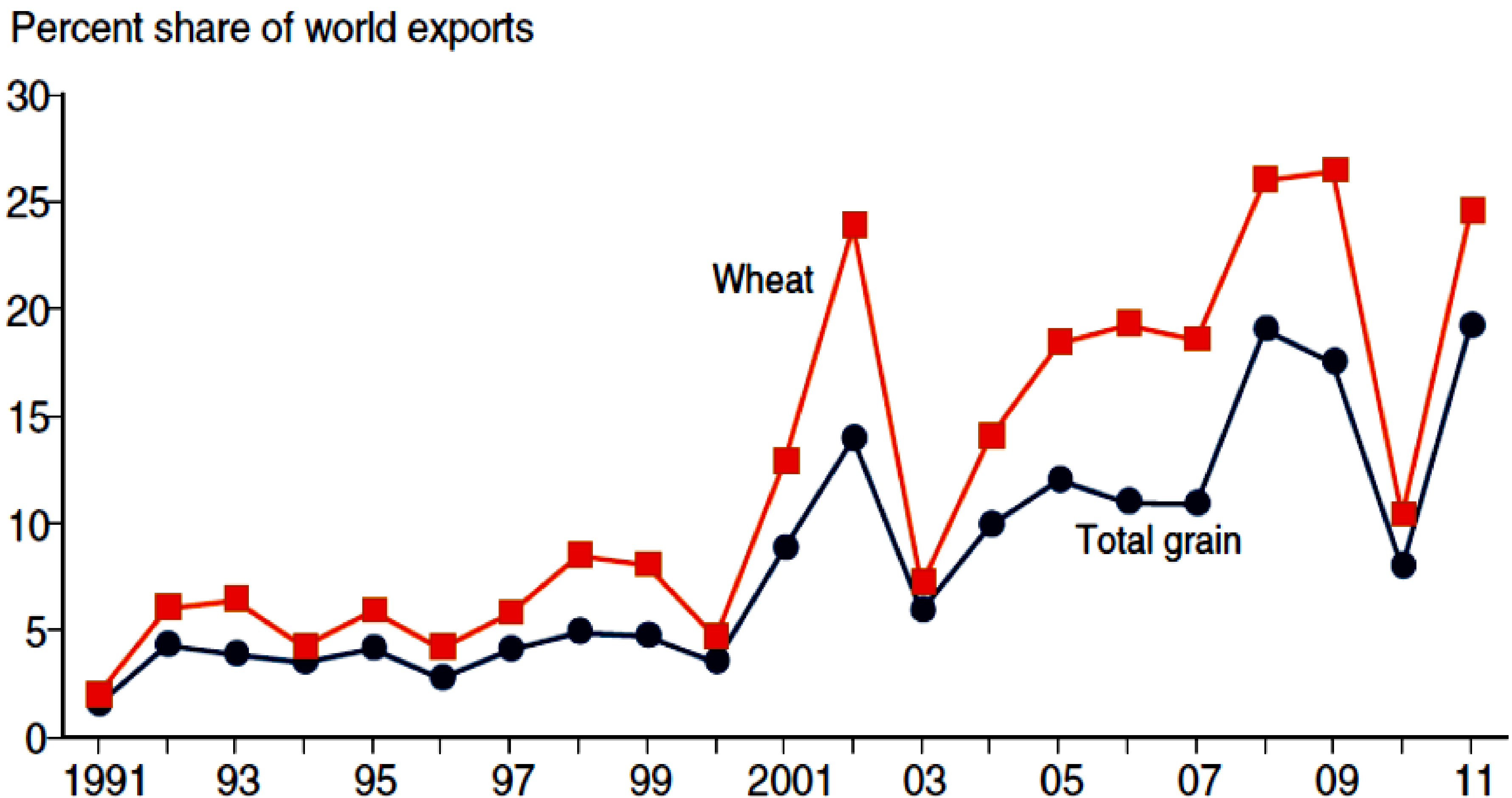
Change from a major importer to exporter of grain



Imports and exports are net of trade among the KRU countries, and net vis-à-vis the rest of the world. The FSU-12 are the republics of the former Soviet Union minus Lithuania, Latvia, and Estonia.

Source: FAS Production, Supply and Distribution Online (USDA PS&D), http://www.fas.usda.gov/psdonline/.

Share of world exports of wheat and total grain by Russia, Ukraine and Kazakhstan



Source: FAS Production, Supply and Distribution Online (USDA PS&D), http://www.fas.usda.gov/psdonline/.

Key reasons for the grain export growth

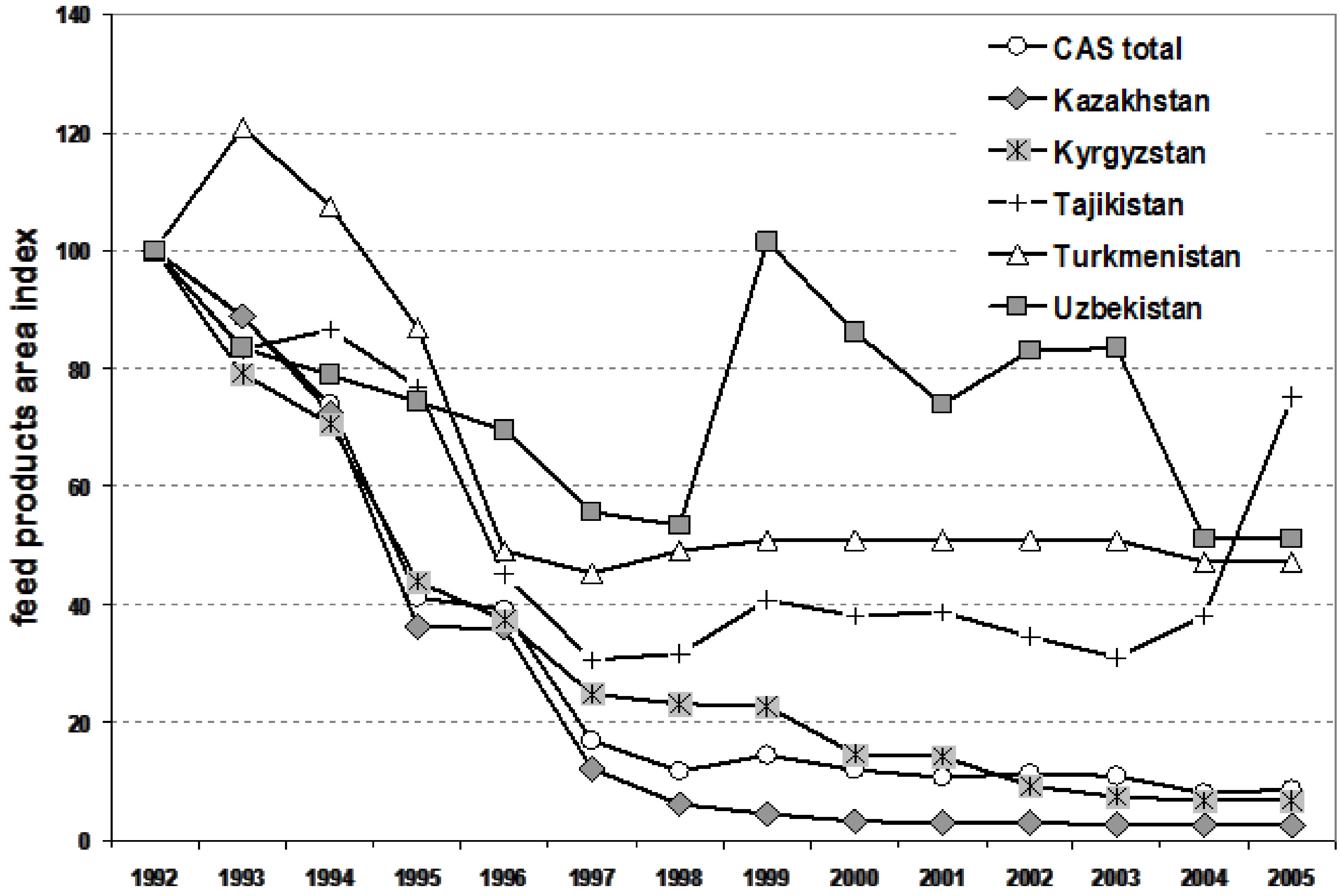
- Downsizing of the livestock sector that reduced domestic demand for feed grain.
- Improvement in farm-level management and technology that increased productivity.
- Favorable weather conditions during most of the past decade (except 2010 and 2012-2013)

Livestock decline between 1992 and 2006:

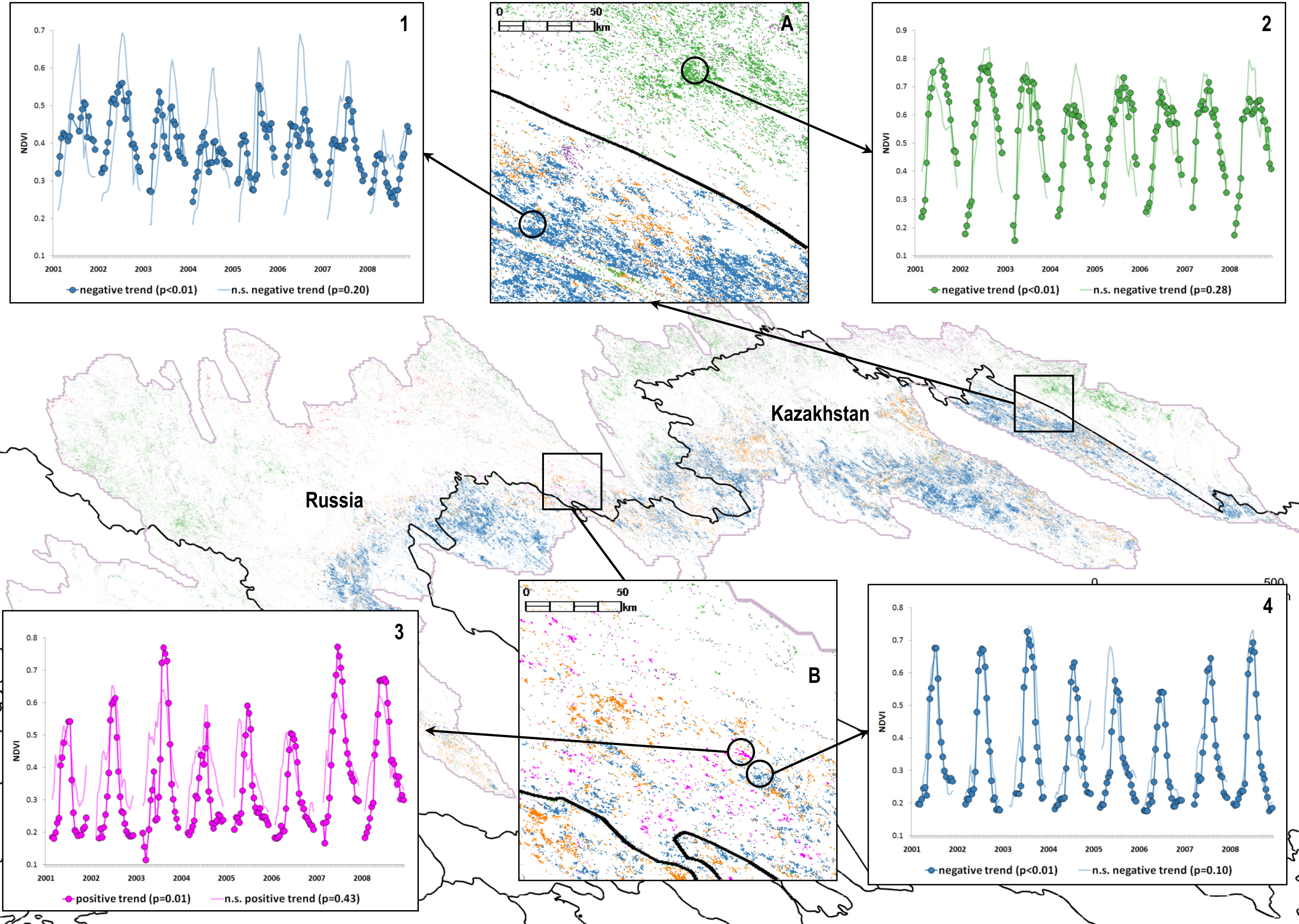
- In Russia the number of cattle dropped from ~ 20 million to 10.3 million heads, the number of pigs fell from more than 36.3 million to 18.7 million, and the number of sheep dropped from 20 million to 7 million (FAOSTAT).

- In Kazakhstan, two-thirds of the sheep population of the country was lost between 1995 and 1999 (Lioubimtseva and Henebry 2009).
- Similar trend in Central Asia and all other FSU countries (Prischepov et al 2012, Lioubimtseva et al 2012).

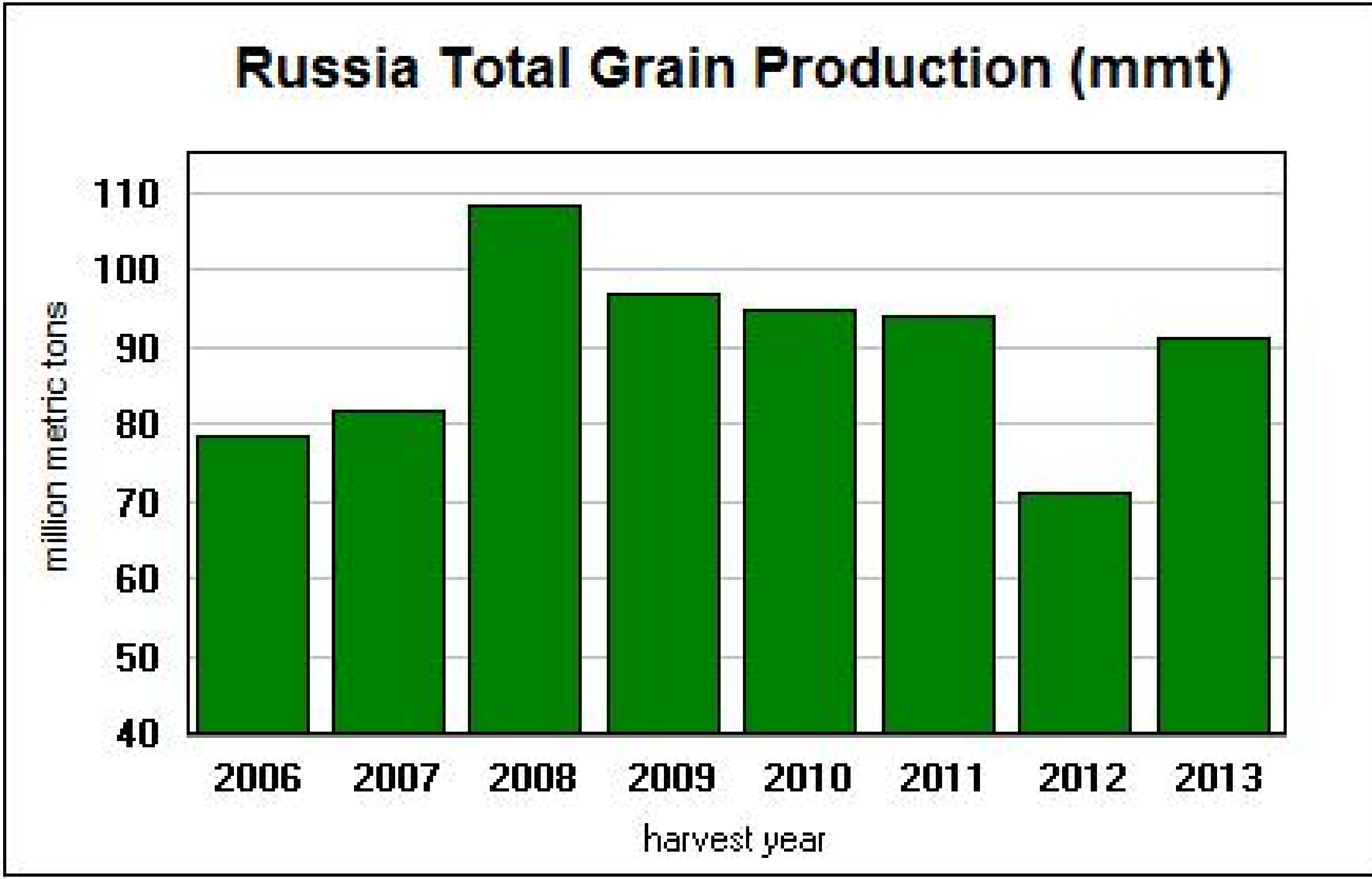
- The drop in livestock inventories led in turn to a drop in demand for feed grain and pastures across the region.



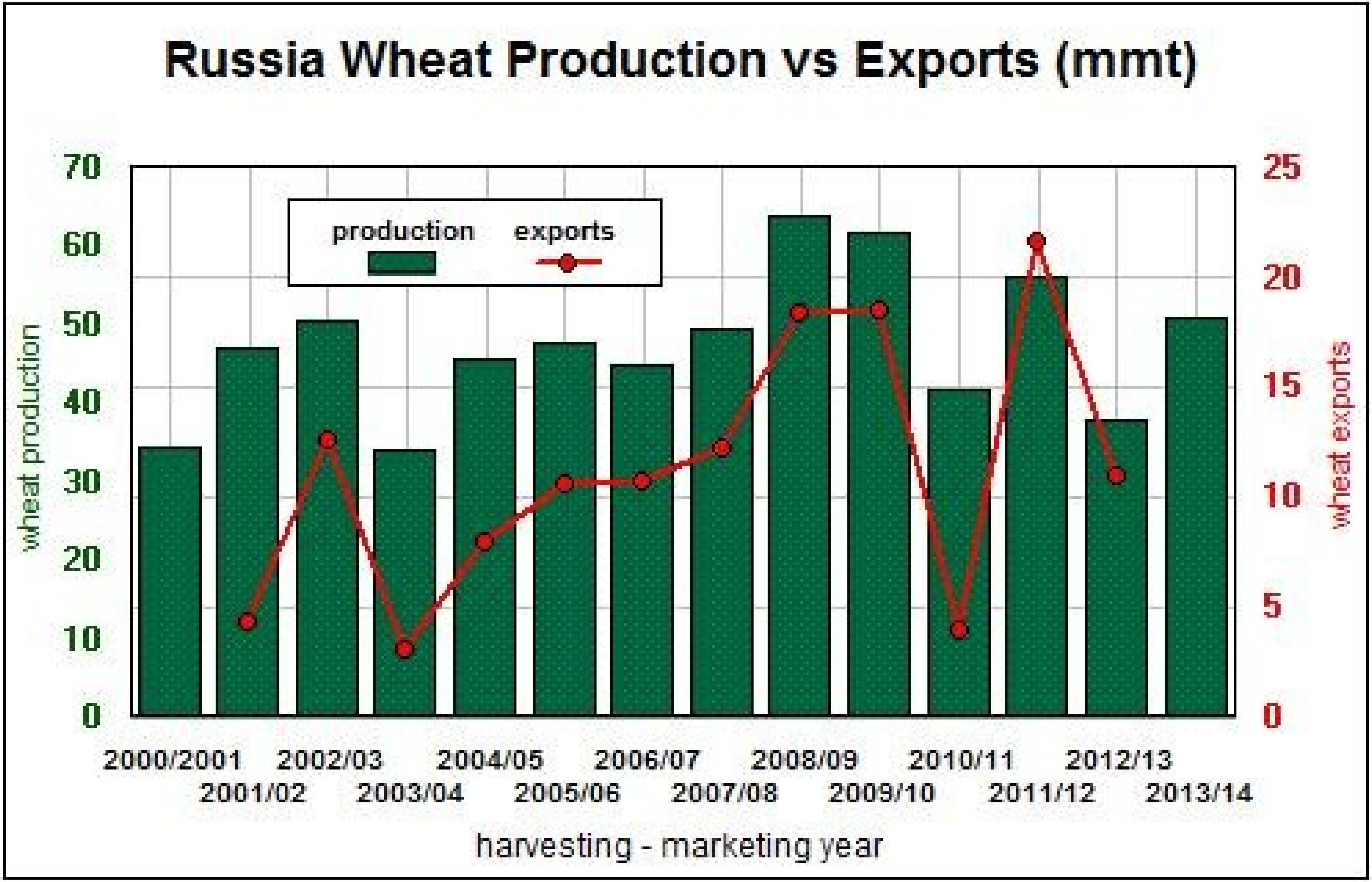
Source: Lioubimtseva and Henebry 2009



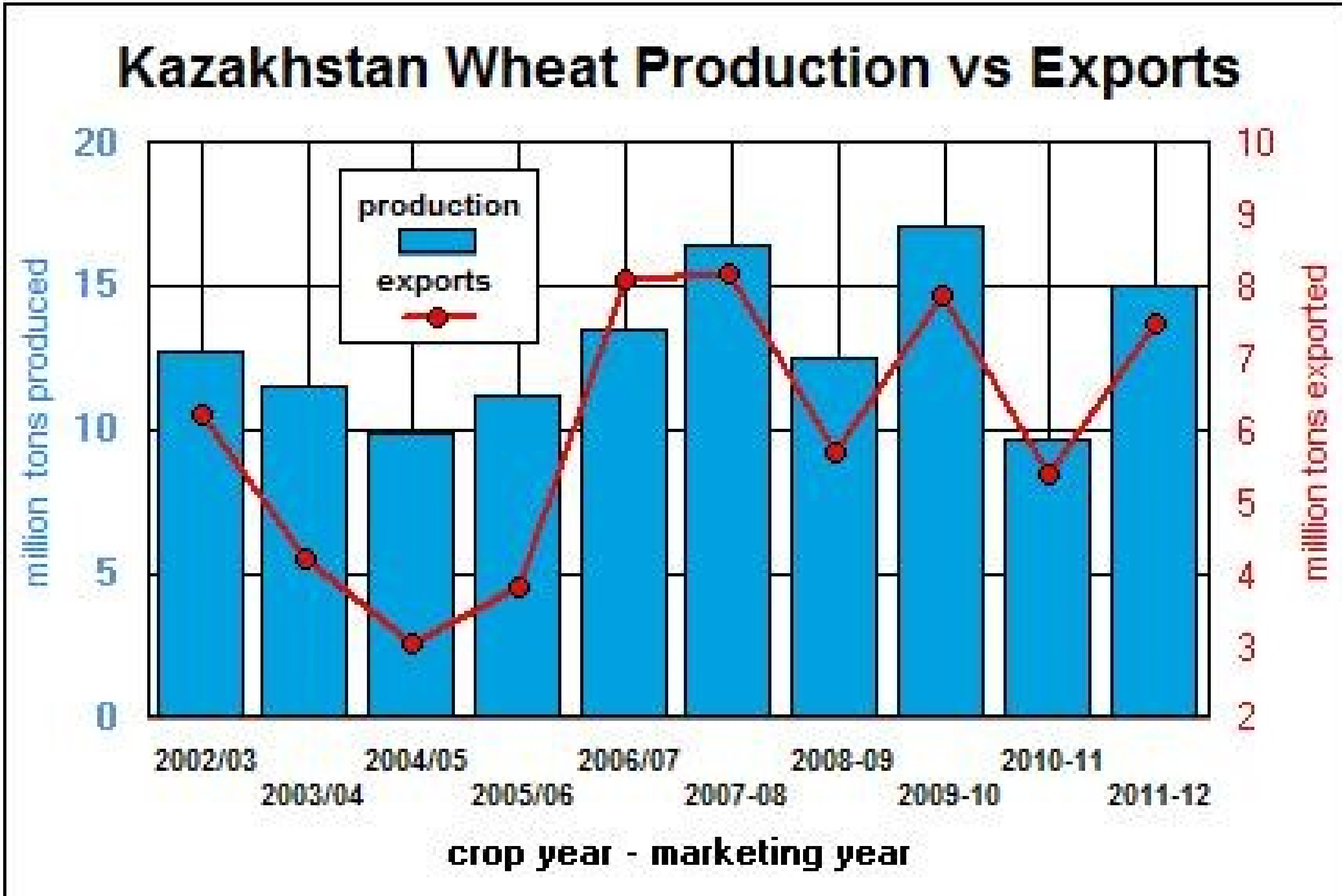
Source: Wright , deBeurs, Henebry 2012



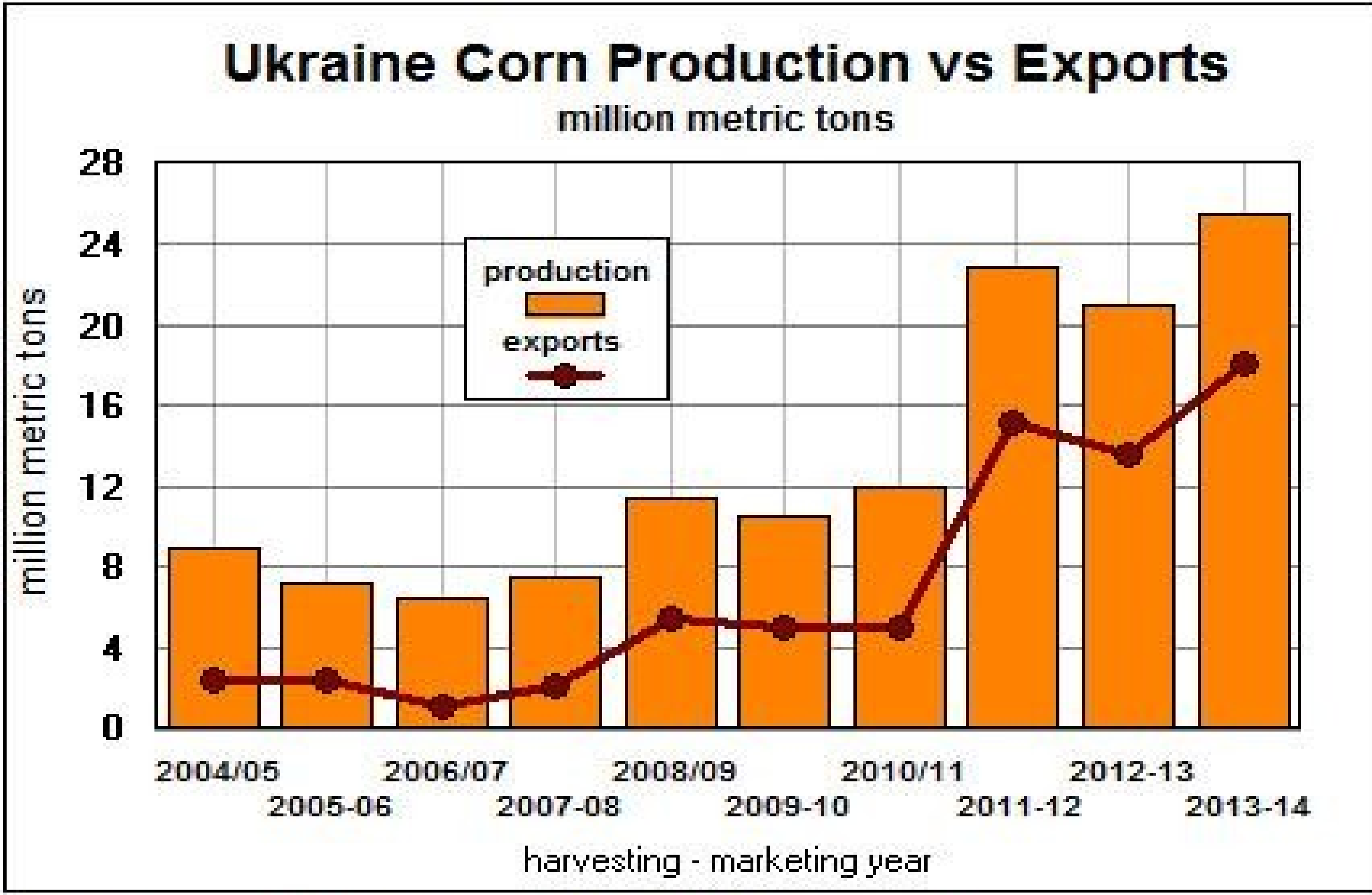
Data source USDA; 2013 mid-point estimate from Agriculture Ministry



Data source USDA except 2013-14 SovEcon



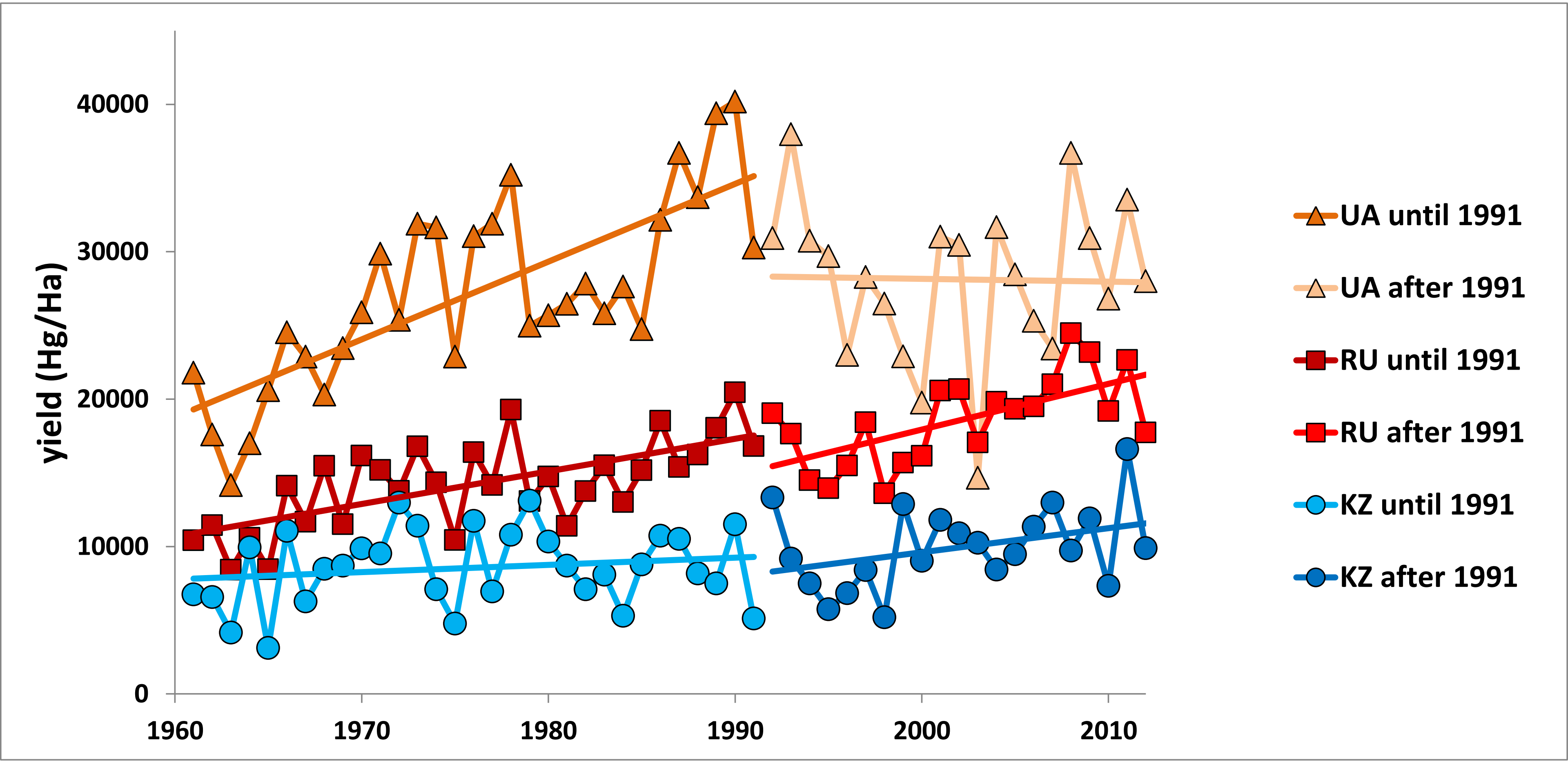
Data source USDA. New crop estimates 2011-12 issued in July



Data source USDA except 2013-14 UkAgroConsult

Corn production nearly doubled from 2008 to 2011, from 11.5 million metric tons to 22.8 MMT in 3 years. The 2013 has harvest established another record with 25.5 million metric tons, according to UkrAgroConsult (2013).

Wheat Yields in Ukraine, Russian Federation, and Kazakhstan from 1960-2012



Data from FAOSTAT 2013

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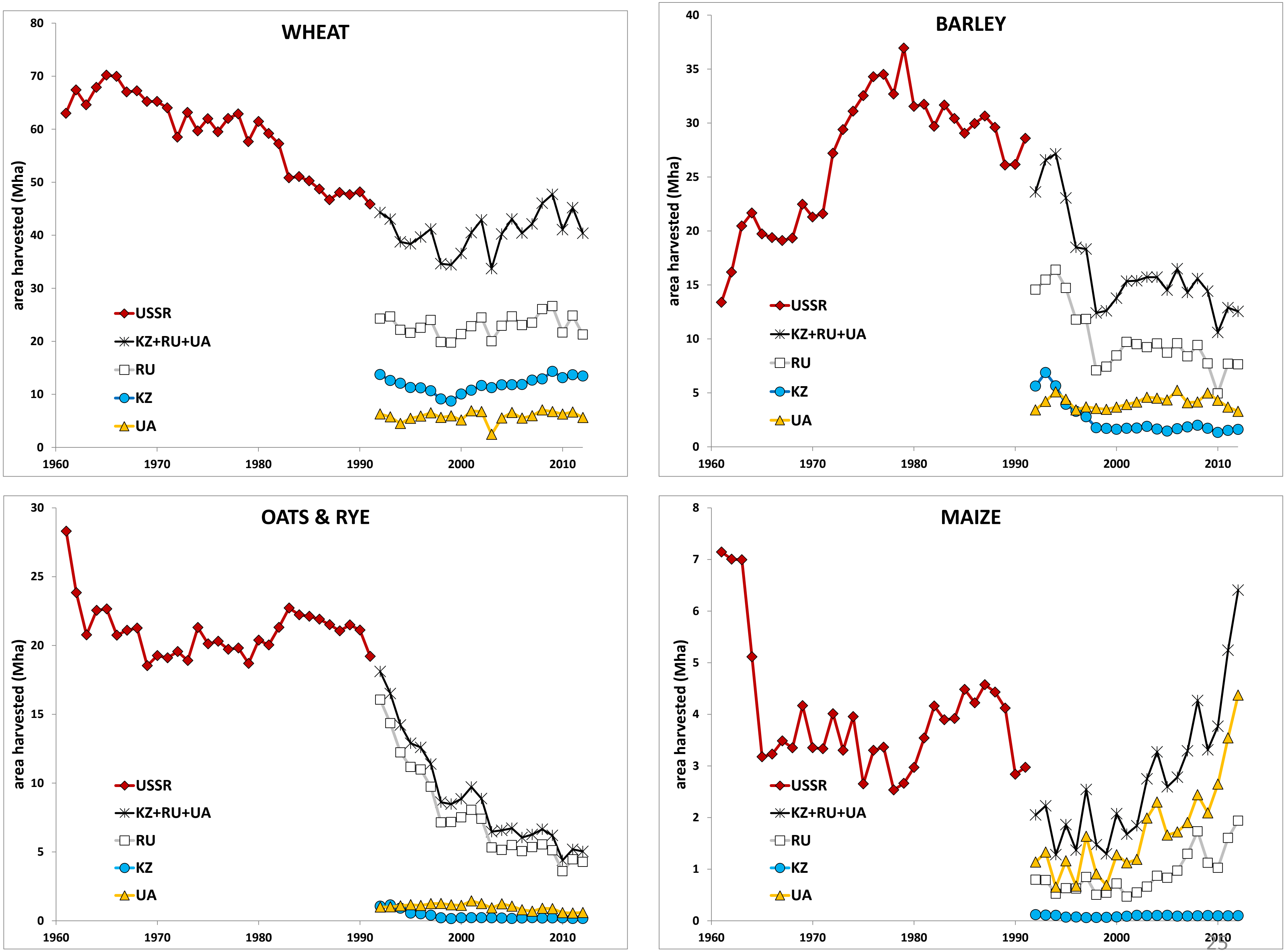

Data from FAOSTAT 2013

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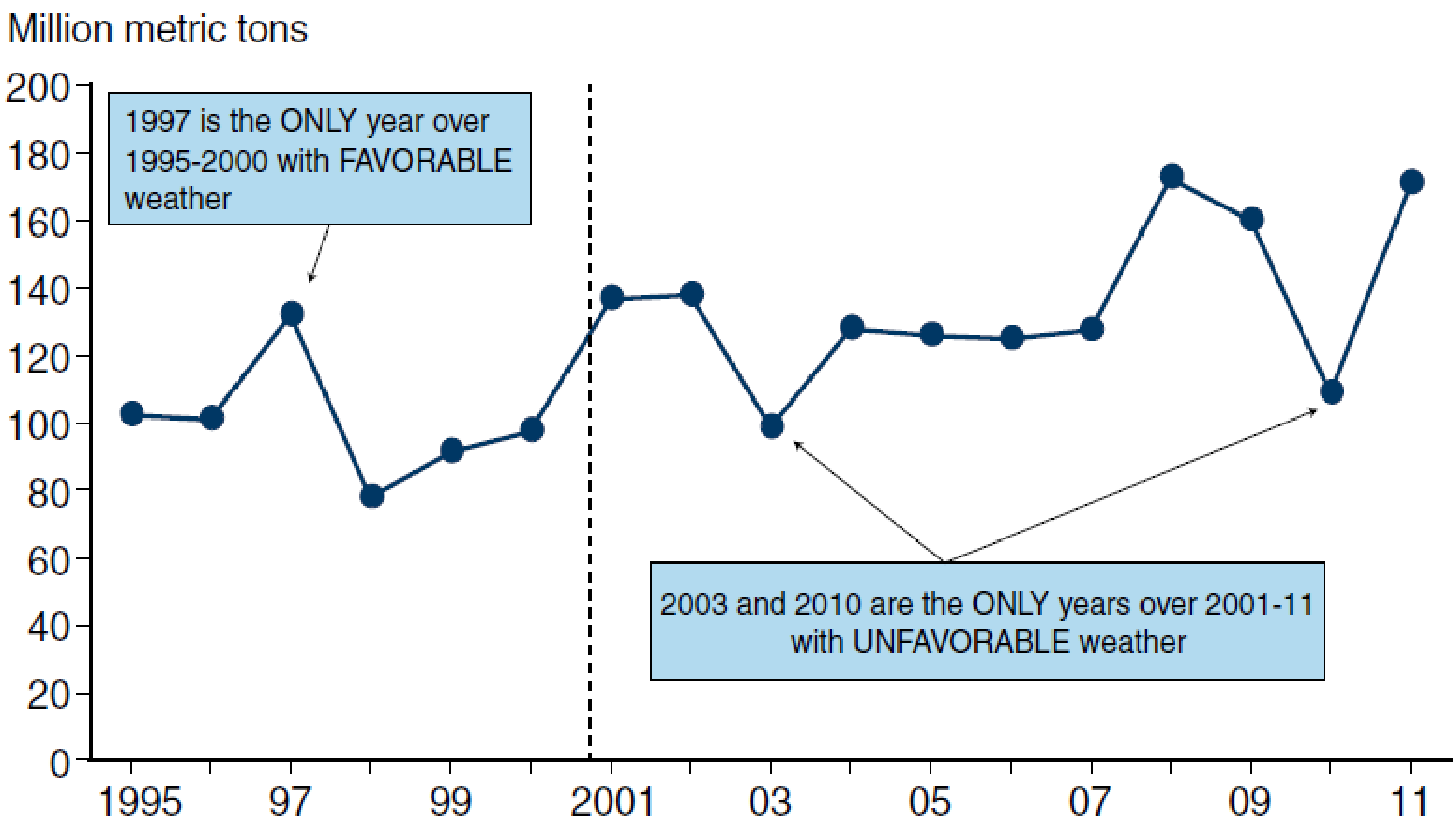
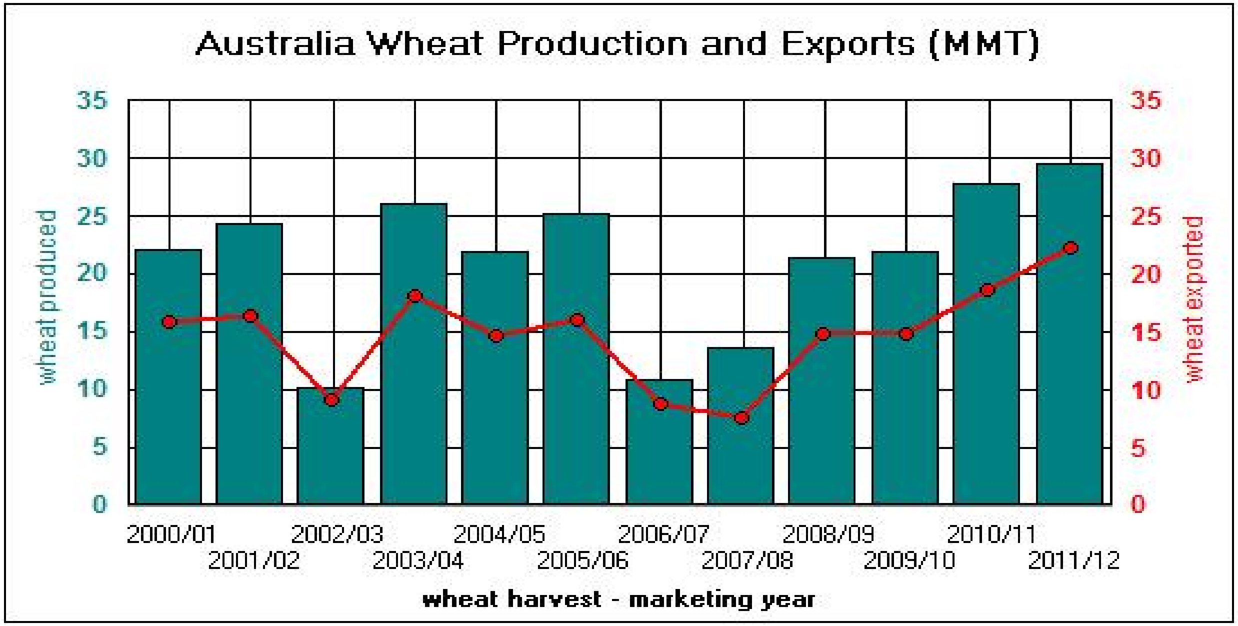
Grain production and weather



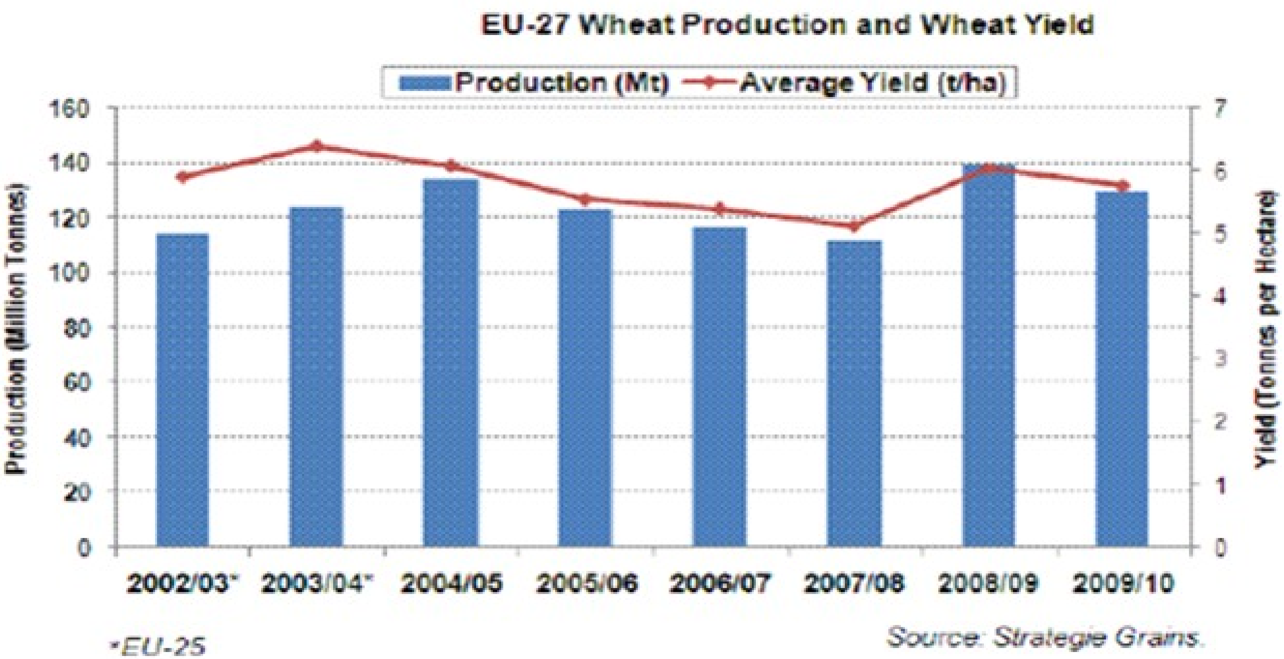
Note: KRU countries combined (Kazakhstan, Russia, Ukraine).

Source: FAS Production, Supply and Distribution Online (USDA PS&D), http://www.fas.usda.gov/psdonline/.



Data source USDA, except 2011-12 Australia Bureau of Agricultural Resource and Economics

Comparative advantage on the market in 2003-2009, due to unfavorable weather in Europe and Australia



Scenarios for Russia and RUK from climate, agro-ecological and bio-economic modeling experiments

Study	Experiment	Scenario summary
Mendelsohn et al. 2000	Global Impact Ricardian Model -combined **AOGCM scenarios**, economic data, and climate-response functions by market sector	a 2°C temperature increase can bring agricultural benefits of US$124-351 billion, due to a combination of increased winter temperatures, extension of the growing season, and CO2 fertilization
Pegov et al. 2000	FAO **agro-ecological zoning (AEZ)** combined with the IIASA **Basic Link Combination (BSL)** economic models	Significant increase of grain production due to a northward shift of agro-ecological zones

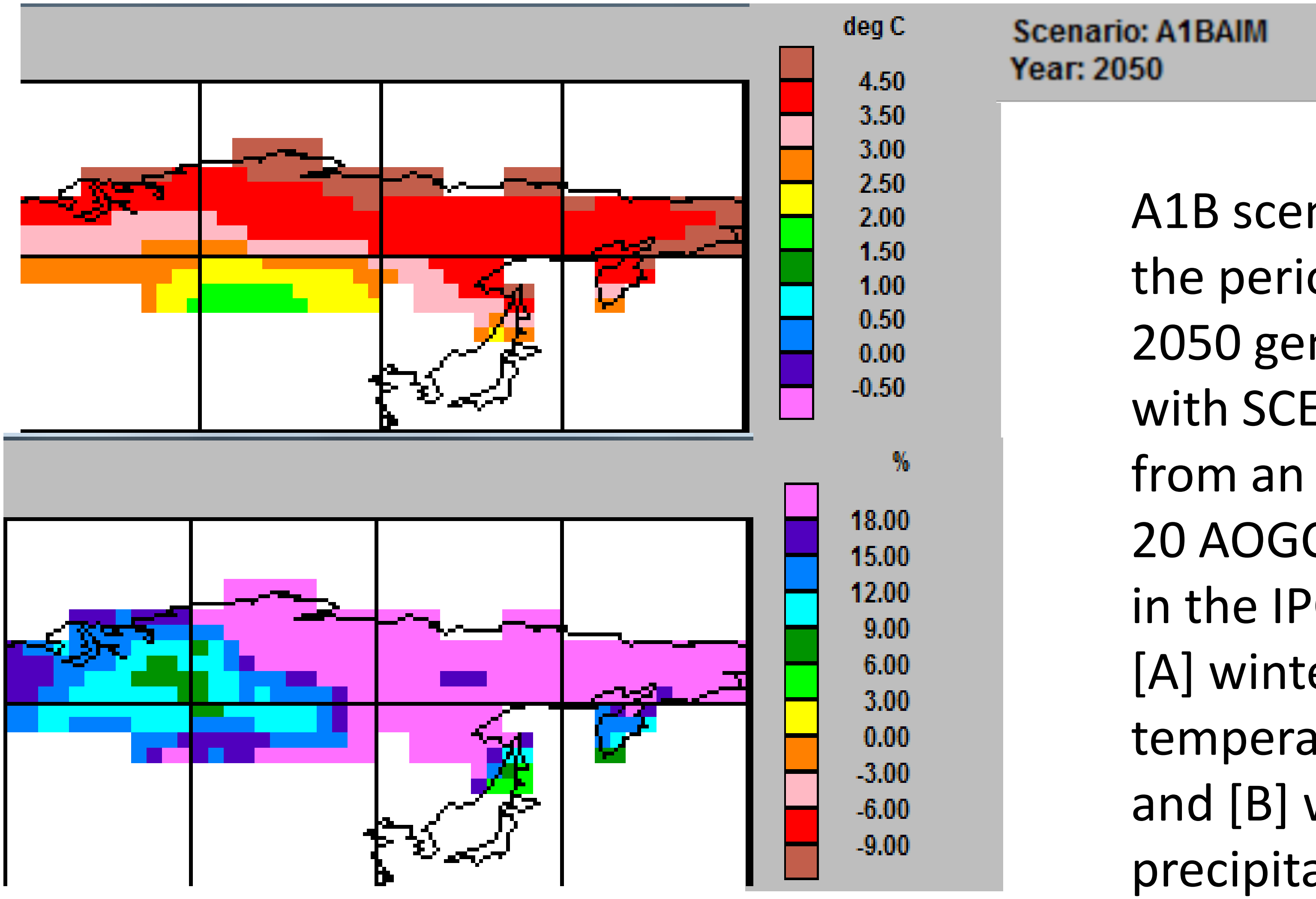
For a detailed discussion, see Lioubimtseva, Henebry, DeBeurs 2013

Study	Experiment	Scenario summary
Golubev and Dronin, 2004	**GLASS model** examining changes in agricultural production and water supply in as a result of global climate change	Production increase in the more humid central and northern regions. The net average yield in Russia will decrease considerably due to a severe increase in droughts in the most productive regions.
Fischer et al. 2005, Fischer, 2007	FAO **agro-ecological zoning (AEZ)** combined with the IIASA **Basic Link Combination (BSL)** economic models	Total area with agro-ecological constraints will decrease, the potential for rain-fed cultivation of major food crops will increase due to due to temperature increase and the CO_2 fertilization effect

Study	Experiment	Scenario summary
Alcamo et al. 2007	the Global Assessment of Security (GLASS) model (containing the **Global Agro-Ecological Zones (GAEZ)** crop production model and the **Water-Global Assessment and Prognosis (WaterGAP 2)** water resources model).	increase in average water availability in Russia, but also a significantly increased frequency of high runoff events in much of central Russia, and more frequent low runoff events in the already dry crop growing regions in the South. The increasing frequency of extreme climate events will pose an increasing threat to the security food system and water resources.
Dronin and Kirilenko 2008	Adapted the **GAEZ** and **WaterGap2** model	Temperature and precipitation increase throughout Russia, precipitation decline and increase of drought frequency in the key grain-producing regions, net decline of grain production.

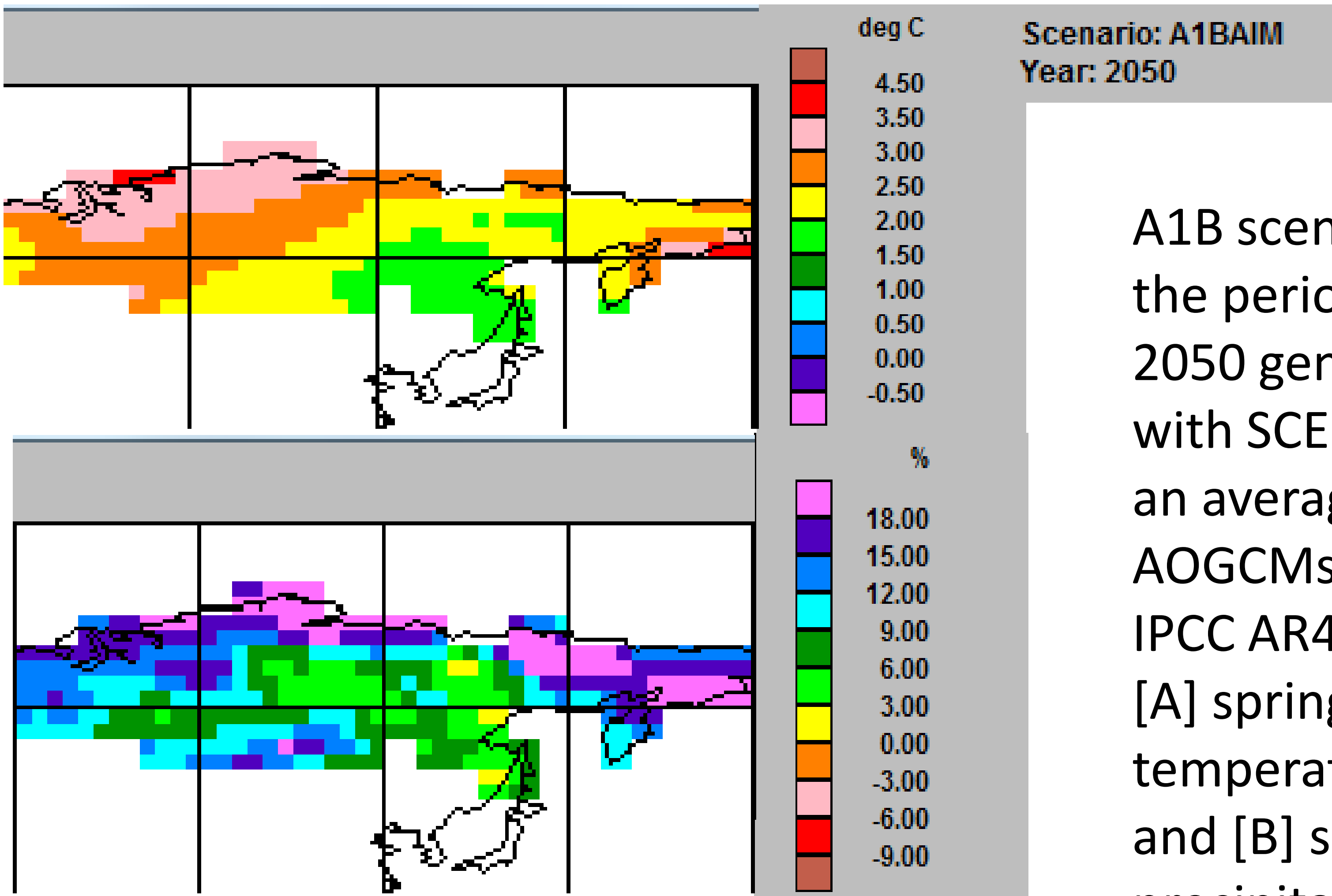
	Winter wheat	Spring wheat
Seasons	Planting: September-October Heading: May-June Harvest: July-August	Planting: May-June Heading: July Harvest: August-October
Geographic regions	Southern part of European Russia (Black Sea region), North Caucasus, Volga Valley, Siberia, most of Ukraine, southern and eastern Kazakhstan (<10%),	Northern Kazakhstan, Northern Ukraine, Southern Siberia
Key variables	Fall, winter, spring, summer temperature, fall, spring, summer precipitation. Needs exposure of the seedlings to temperatures in the 3 degrees to 8 degrees C range.	Spring, summer, fall temperature and precipitation. Does not require exposure to cold temperature, can be planted in spring.

Climate change scenarios



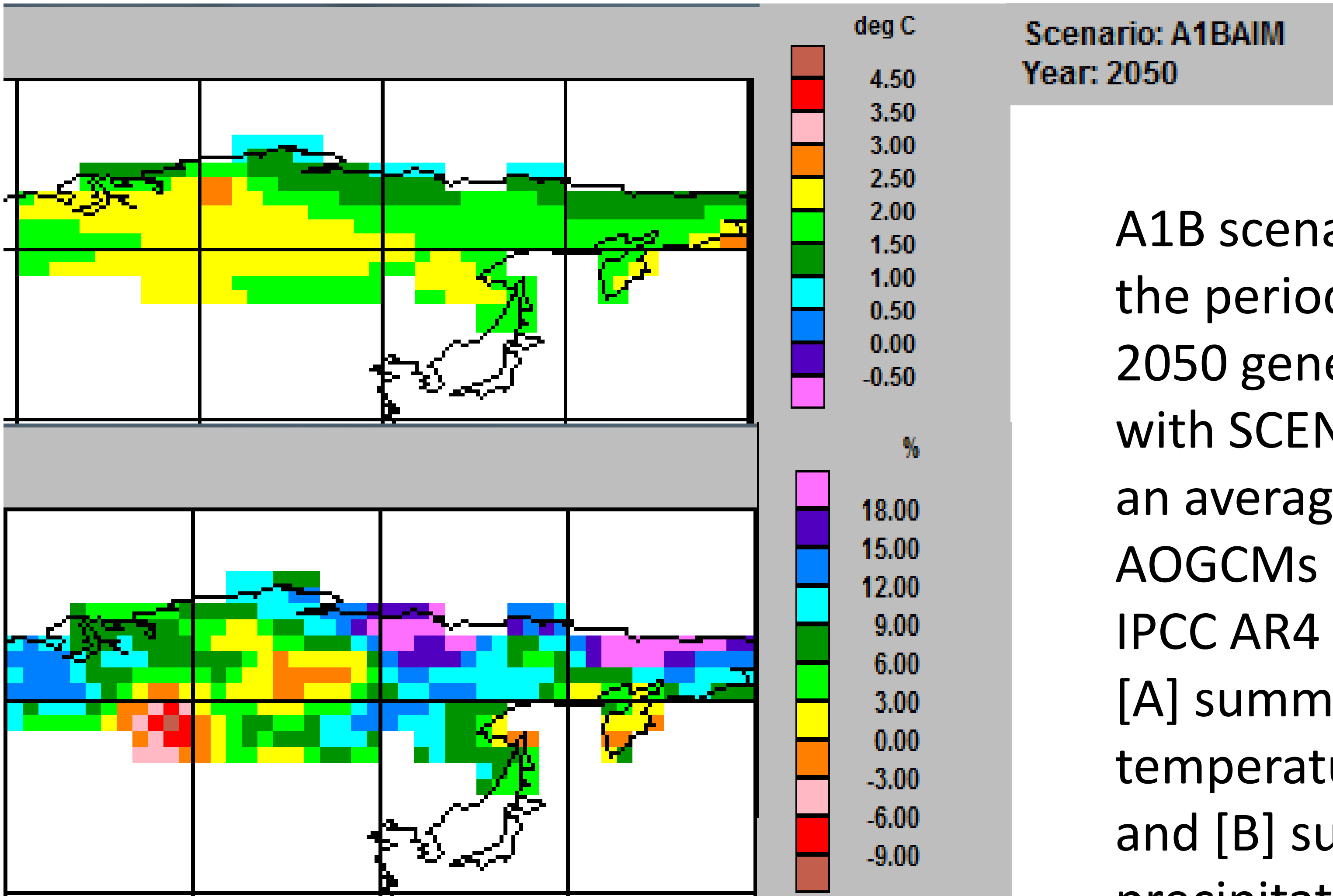
A1B scenarios for the period around 2050 generated with SCENGEN from an average of 20 AOGCMs used in the IPCC AR4 [A] winter (DJF) temperature (°C) and [B] winter precipitation (%).

Climate change scenarios



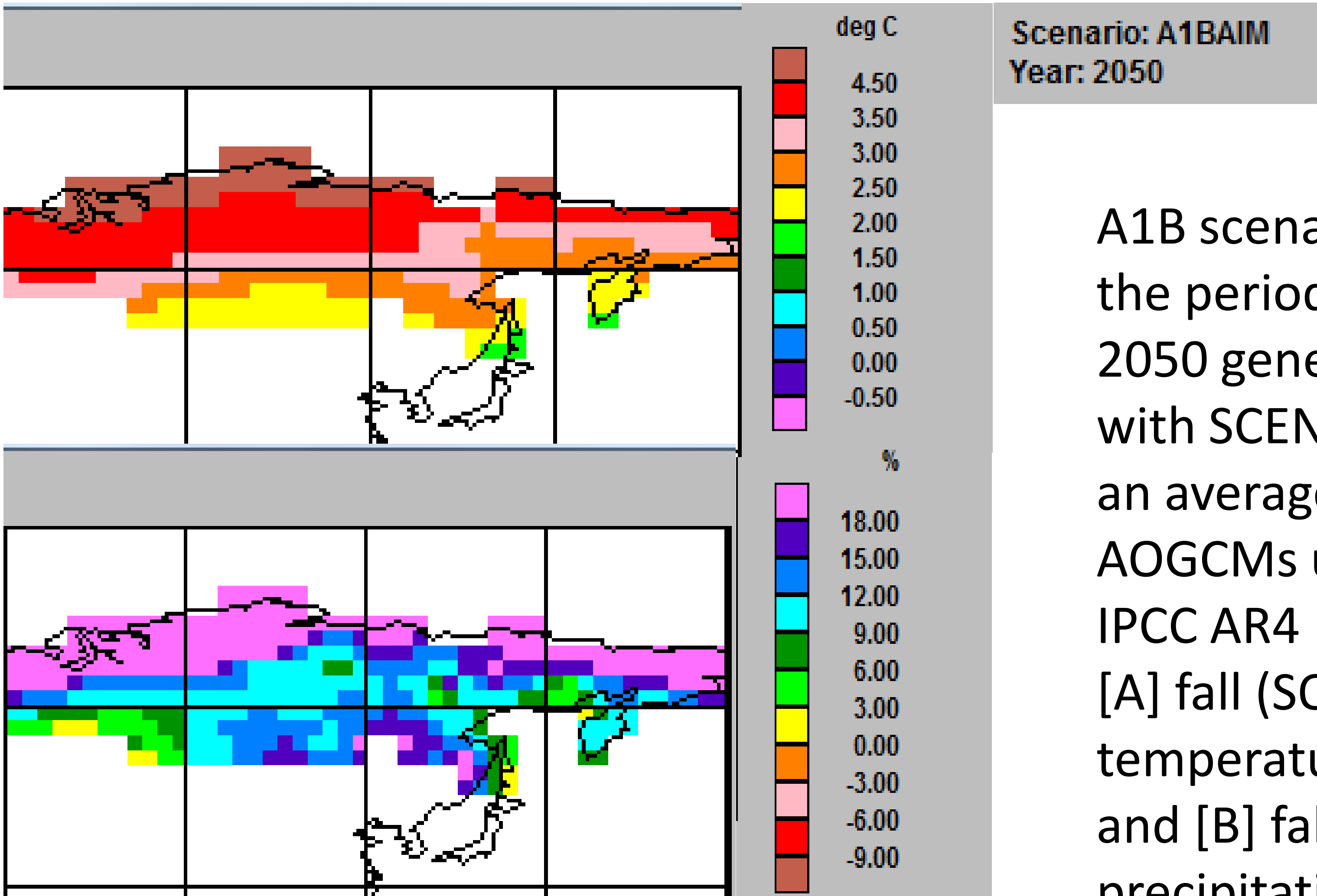
A1B scenarios for the period around 2050 generated with SCENGEN from an average of 20 AOGCMs used in the IPCC AR4
[A] spring (MAM) temperature (°C) and [B] spring precipitation (%).

Climate change scenarios



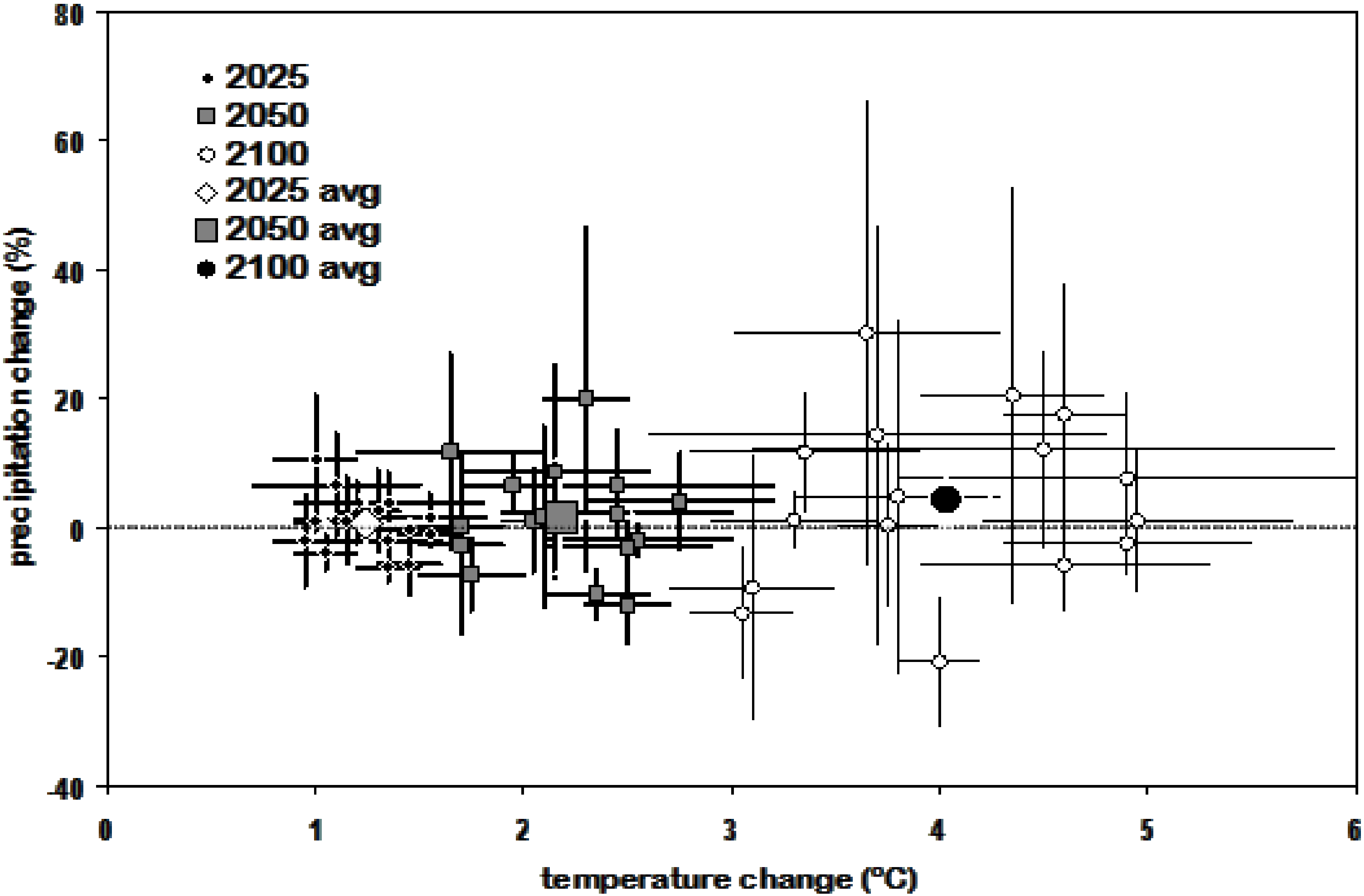
A1B scenarios for the period around 2050 generated with SCENGEN from an average of 20 AOGCMs used in the IPCC AR4
[A] summer (JJA) temperature (°C) and [B] summer precipitation (%).

Climate change scenarios



A1B scenarios for the period around 2050 generated with SCENGEN from an average of 20 AOGCMs used in the IPCC AR4

[A] fall (SON) temperature (°C) and [B] fall precipitation (%).



Lioubimtseva and Henebry 2009

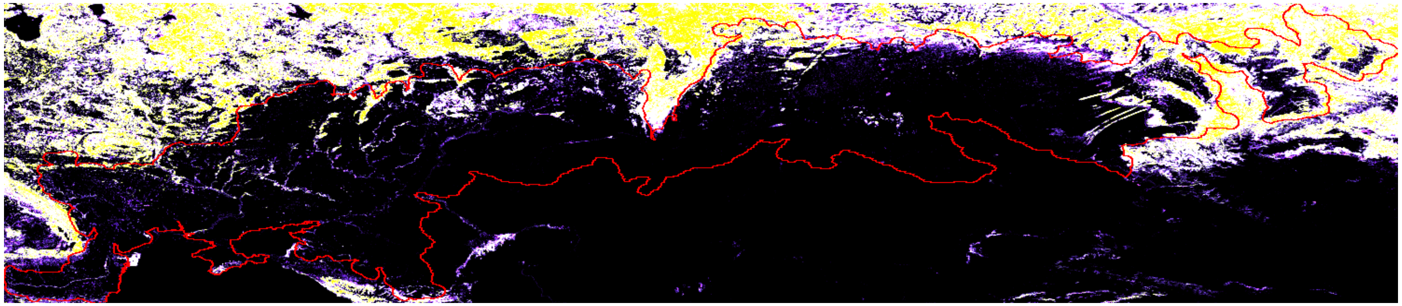
Grain productivity is likely to benefit from

- warmer winters,
- longer growing season,
- less frosts and possibly
- Possibly CO_2 fertilization and water-use efficiency increase caused by CO_2.

Grain productivity is threatened by

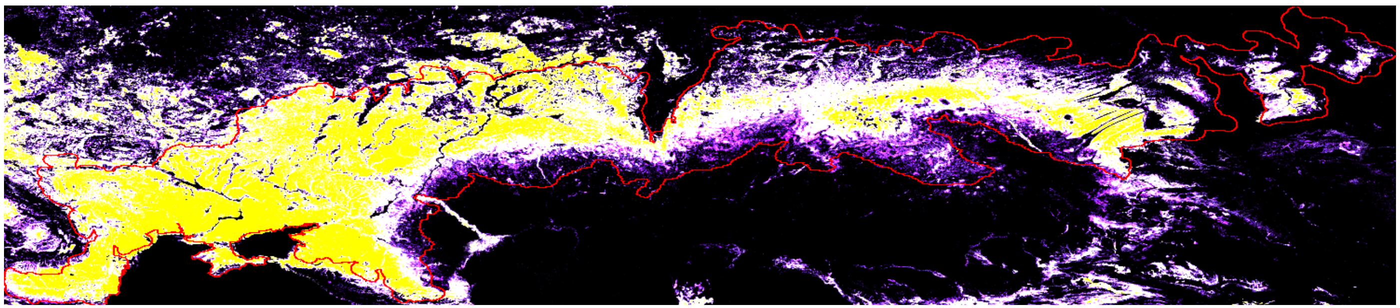
- increase in summer temperatures and PET,
- decrease in summer precipitation and soil moisture
- possibly increase in fall precipitation.
- more frequent and longer droughts,
- possibly more crops diseases and pest infestations.

Temporal stability of major land cover types in the black earth (chernozem) region 2003-2010 as seen by NASA's MODIS sensors (false color composite)

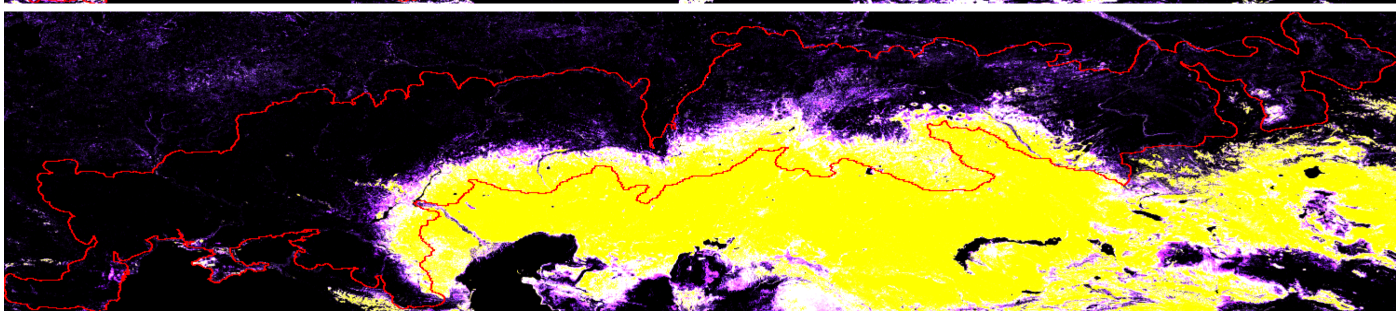


← Mixed Forest

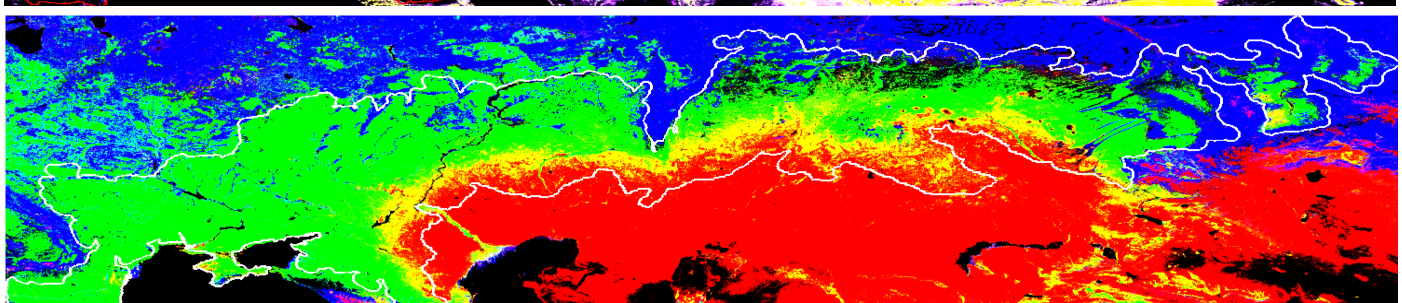
Yellow is stable core
White is unstable core
Magenta is unstable periphery
Black is absence of class



← Cropland



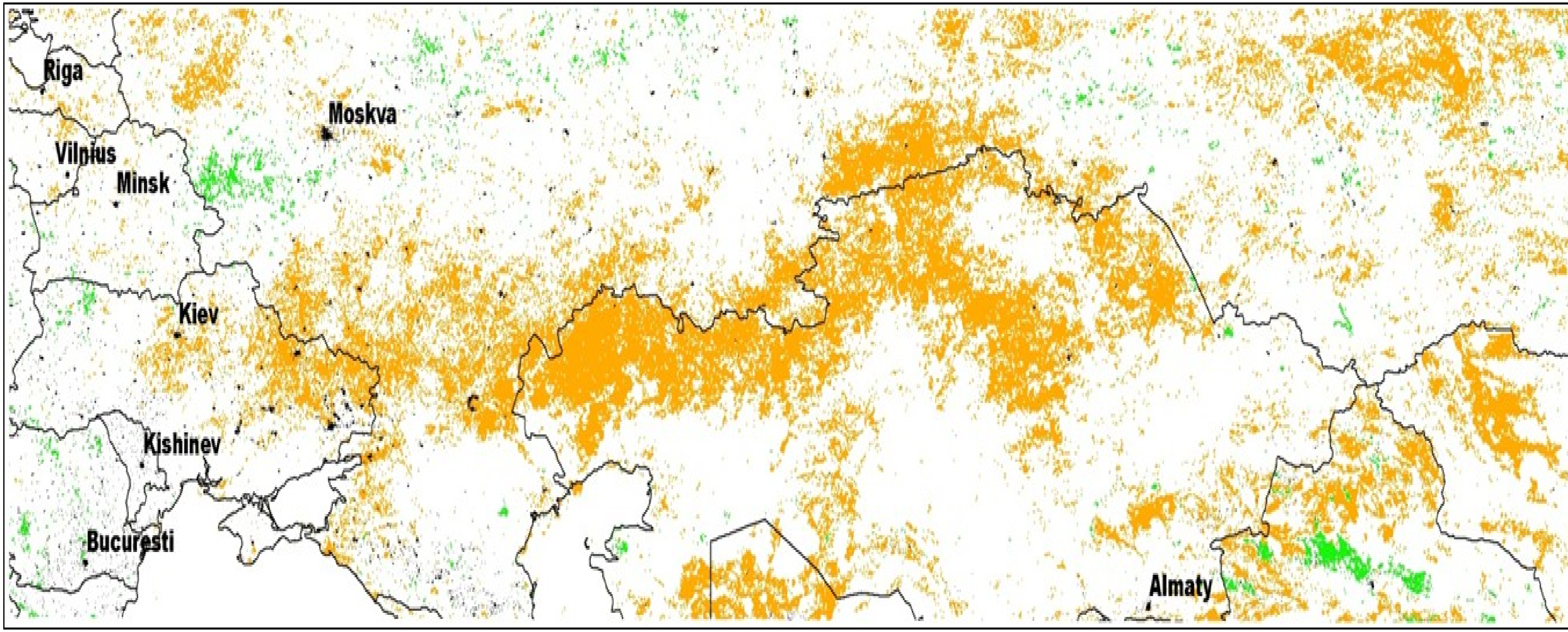
← Grassland



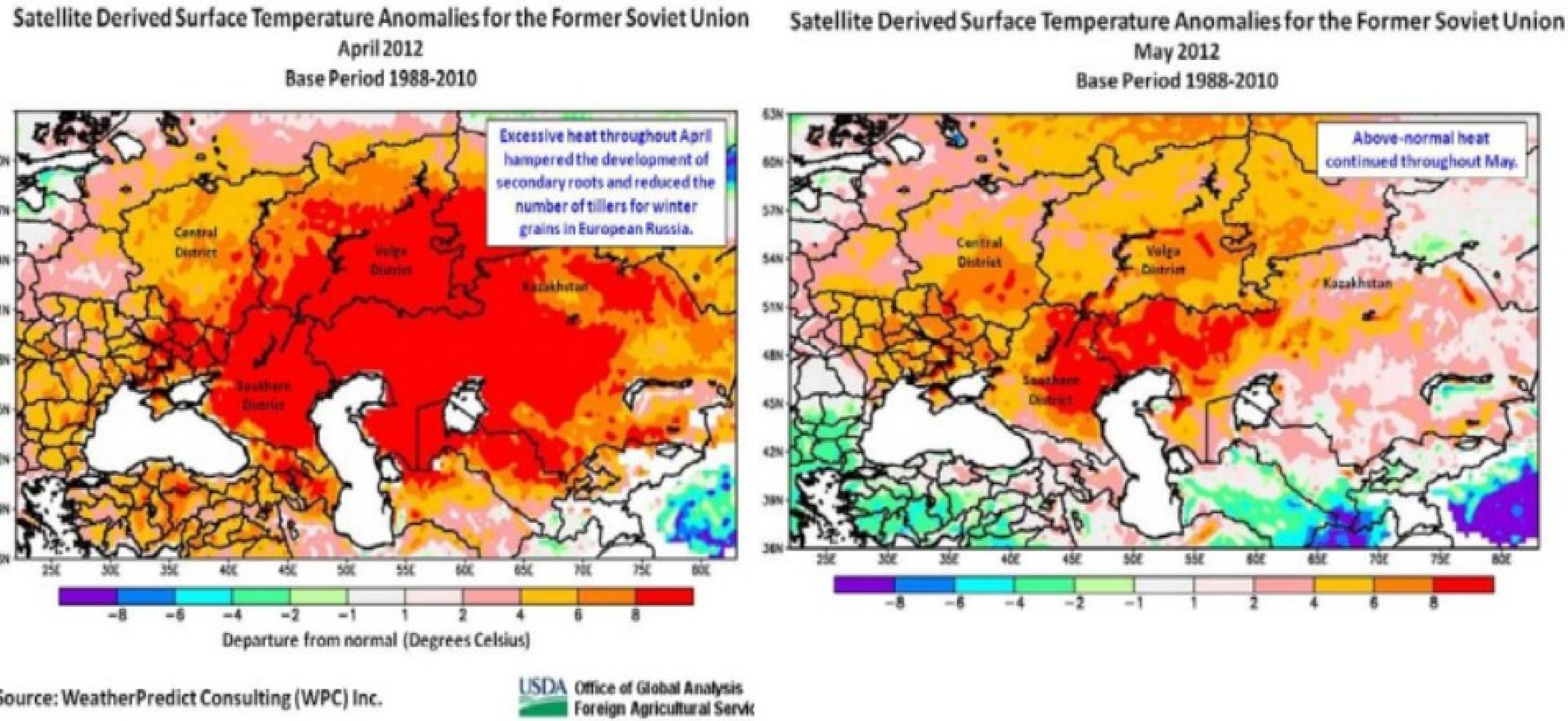
← Max percentages
red = Grassland
green = Cropland
blue = Mixed Forest

G. Henebry, SDSU

Significant changes ($p<0.01$) in the vegetated land surface over the 2001-2010 growing seasons as revealed by the nonparametric Seasonal Kendall test. Orange indicates a significant negative change, while green indicates a significant positive change. Data are from MODIS NBAR 16-day composites at 0.05 degree resolution.

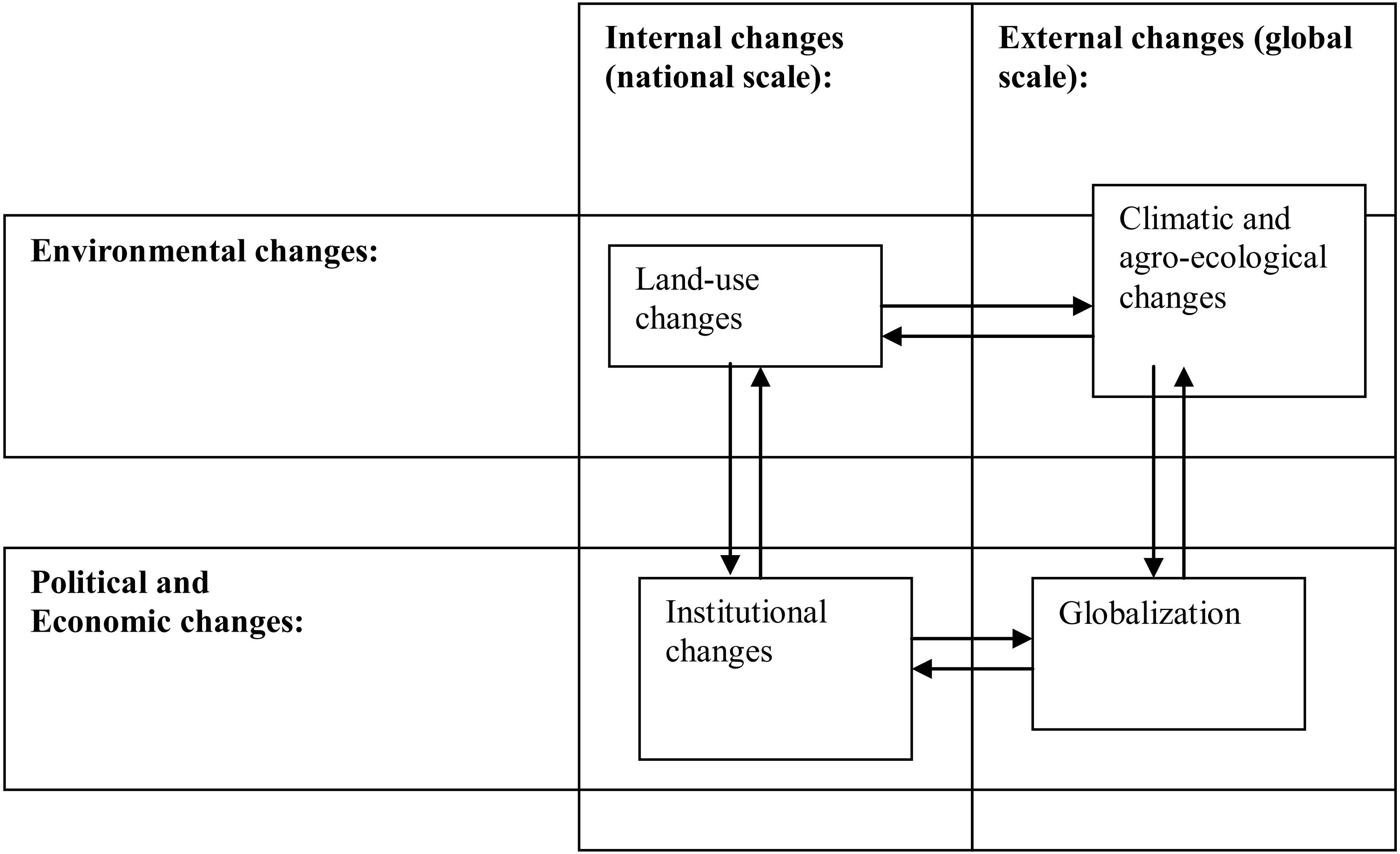


Modified from Wright CK, KM de Beurs, GM Henebry 2012



Dry and hot conditions had negative impact on winter wheat in Southern district of Russia that account for about 50% of all Russia’s winter wheat output

Groups of factors affecting grain production



Adapted from Lioubimtseva and Henebry, 2012

Key uncertainties about the impacts of climate change on the RUK's grain production

Climatic and agro-ecological:

- Precipitation patterns and variability (both spatial and temporal)
- Temperature patterns
- CO_2-fertilization and WUE efficiency increase, no FACE experiments i9n the region

LULCC:

- Cropland vs. pasture vs. grassland conversion trends (climate or market driven)
- NDVI sensitivity to drought signal vs. LC conversion.

Global markets:

Comparative (dis)advantages vs. other grain-producing regions, e.g. EU, China, US, Australia, Argentina, etc.

Policies:

Climate change adaptation policies in agriculture

Agricultural policies (regulations, subsidies, trade regulations, interregional exchange)

Land policies (land market, land code, land tenure and real estate)

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- Christopher K. Wright - Geographic Information Science Center of Excellence, South Dakota State University, Brookings, SD 57007, USA
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Thank you!
Questions?
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