Ukrainian agricultural dynamic as part of the European winter cropland expansion trend in the 21st century

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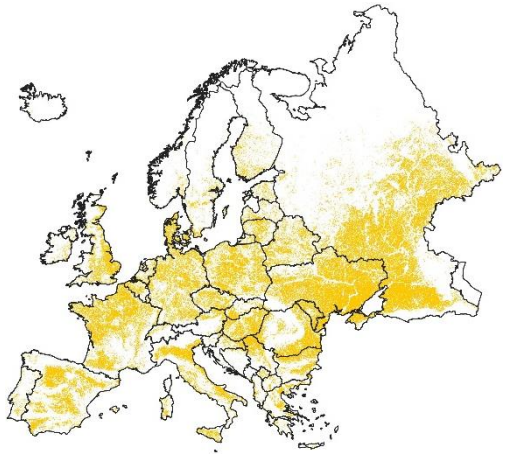
Climate Change and Winter Cropland

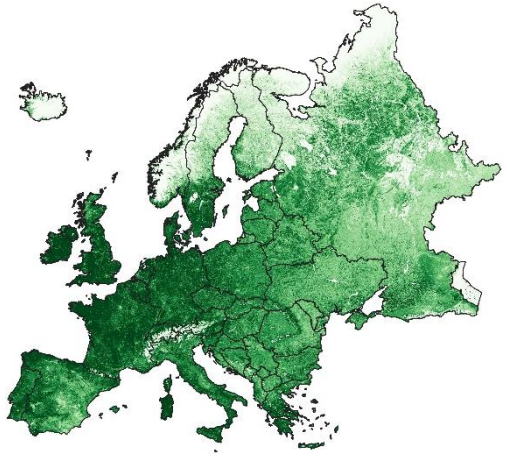
- Major winter crops like **Winter Wheat, Winter Barley and Winter Rapeseed** are essential commodities for the **Food Security** (FAO)
- The increase of the temperature of **1 to 2°C** due to global warming can result in a **4.7% reduction** in wheat production.
- New generations of crop growth models forecast a **15% drop** in cereals production until **2099** (Jägermeyr et al., 2021)
- It will lead to the large **redistribution** of the major crops **planting areas** locations (Jägermeyr et al., 2021)
- **Cropland Migrates** in Response to the Climate Change (Sloat et al., 2020)

Winter Cropland Mapping

Crop Mask (Potapov et al., 2022)



MODIS NDVI

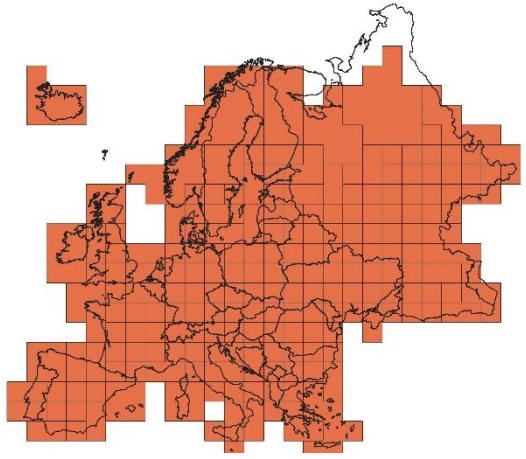


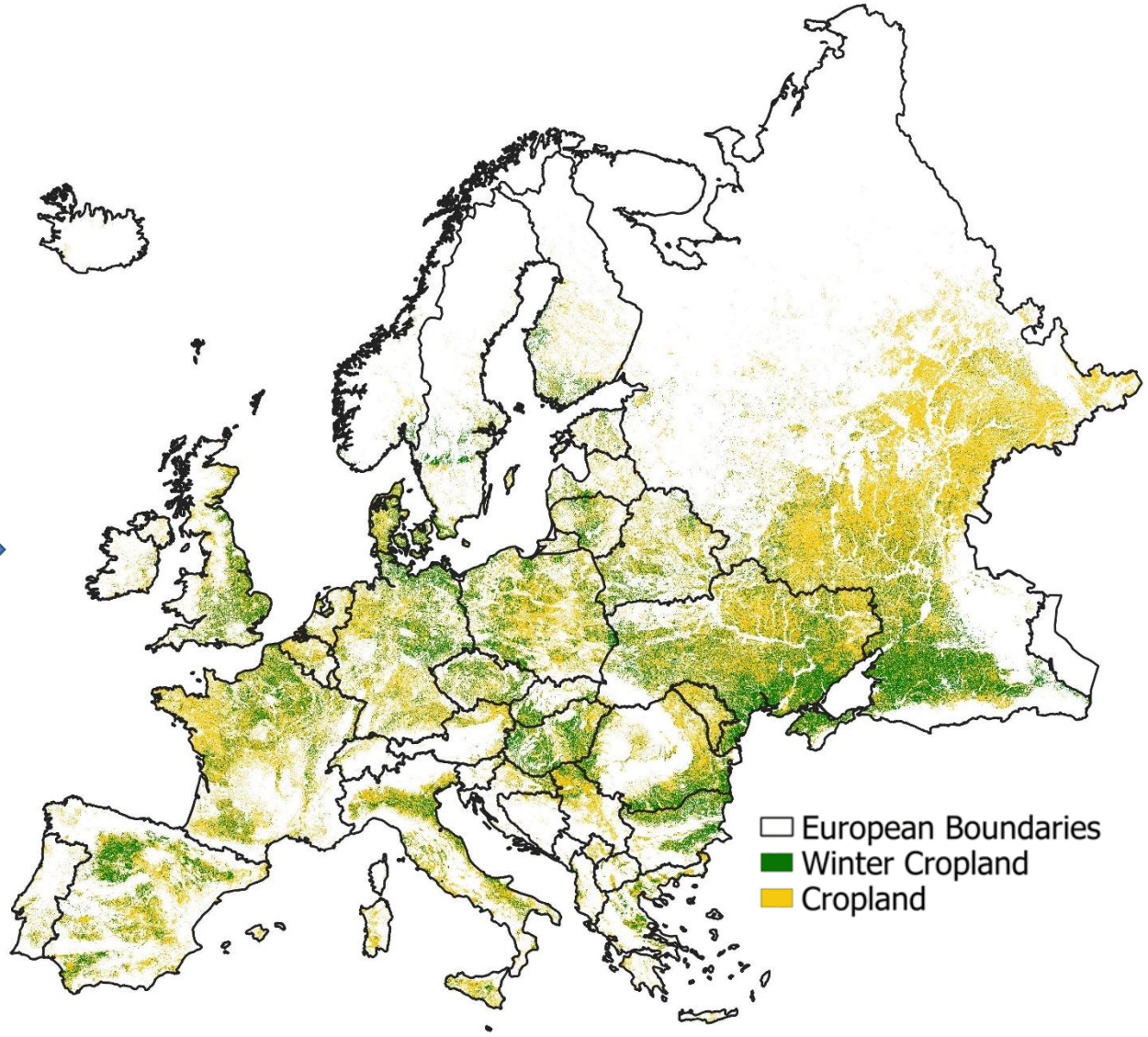
Mapping Model

Gaussian Mixture Model (Skakun et al., 2017

$$p(x) = \sum_{k \in K} \pi_k N(x|\mu_k, \sum_k)$$

200x200 km Grid





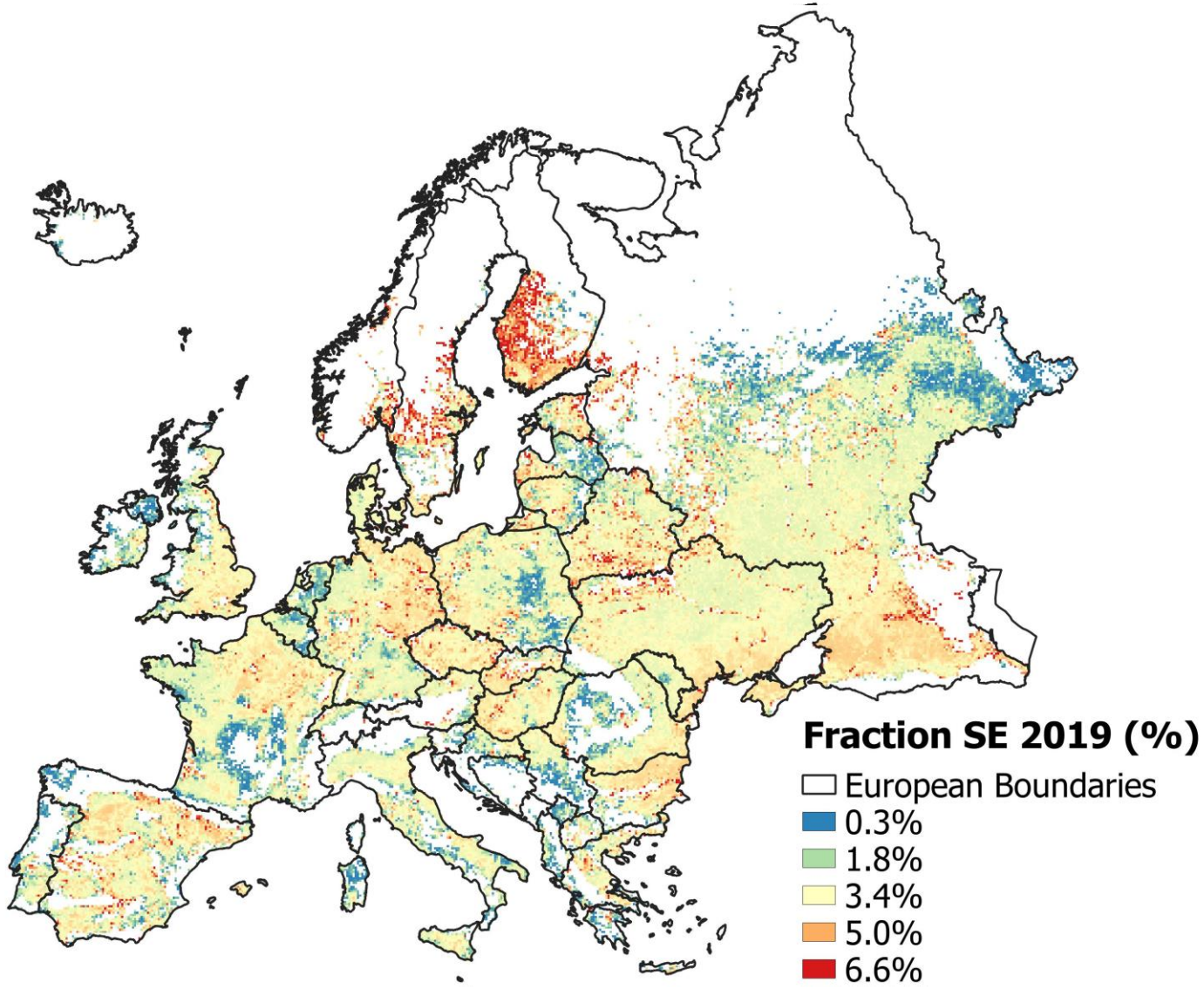
Winter Cropland Fraction Estimation

- Sample-based area and SE estimated on 1,400 points (Olofsson et al., 2014)
- Winter Cropland Fraction Estimation (Cochran et al., 1977)

$$\frac{\sum_{h=1}^{H} A_{ww}\overline{y_h}}{\sum_{h=1}^{H} A_c\overline{x_h}}$$

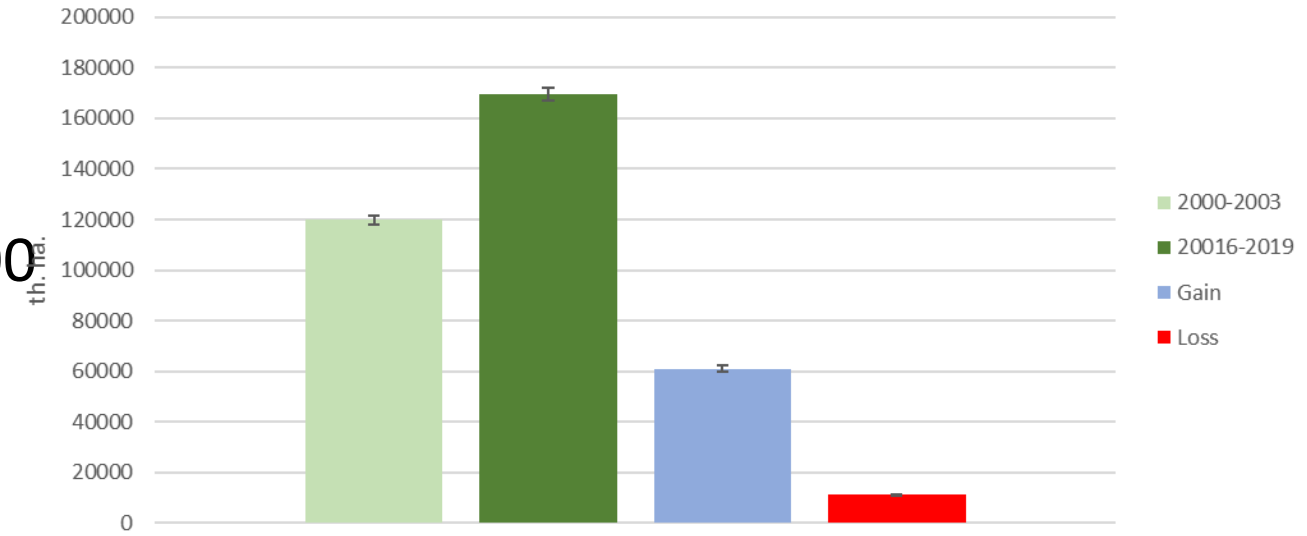
- Winter Cropland Fraction Standard Error Estimation

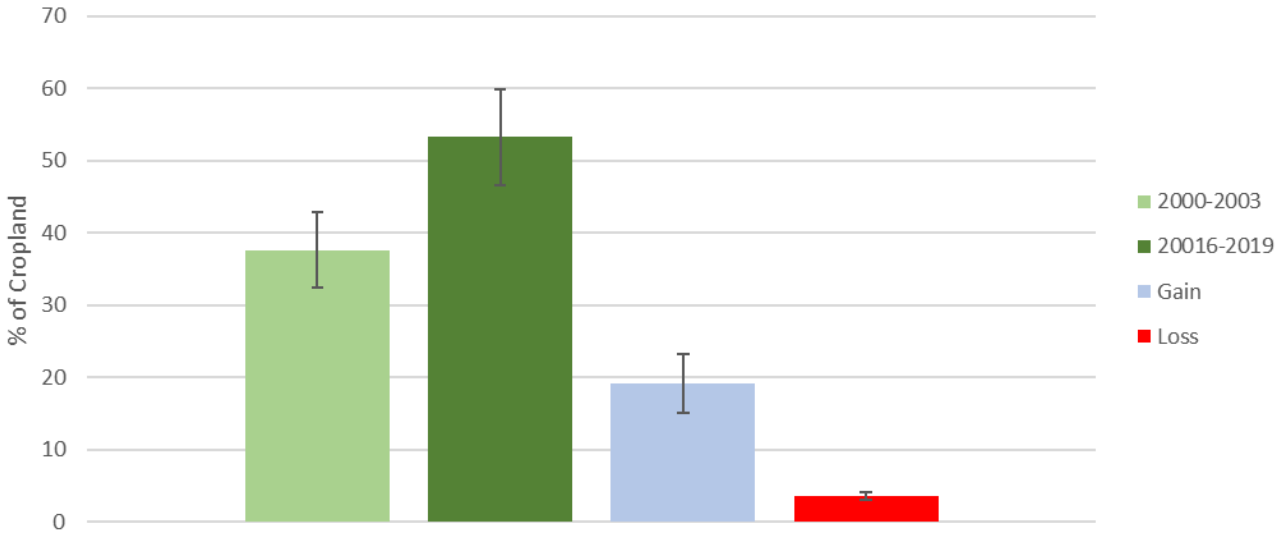
$$\sqrt{\frac{1}{\widehat{X^2}}\sum_{h=1}^{H} A_h^2\left(1-\frac{n_h}{N_h}\right)\left(s_{yh}^2+\hat{R}^2 s_{xh}^2-2\hat{R}s_{xyh}\right)}$$



Area Estimation

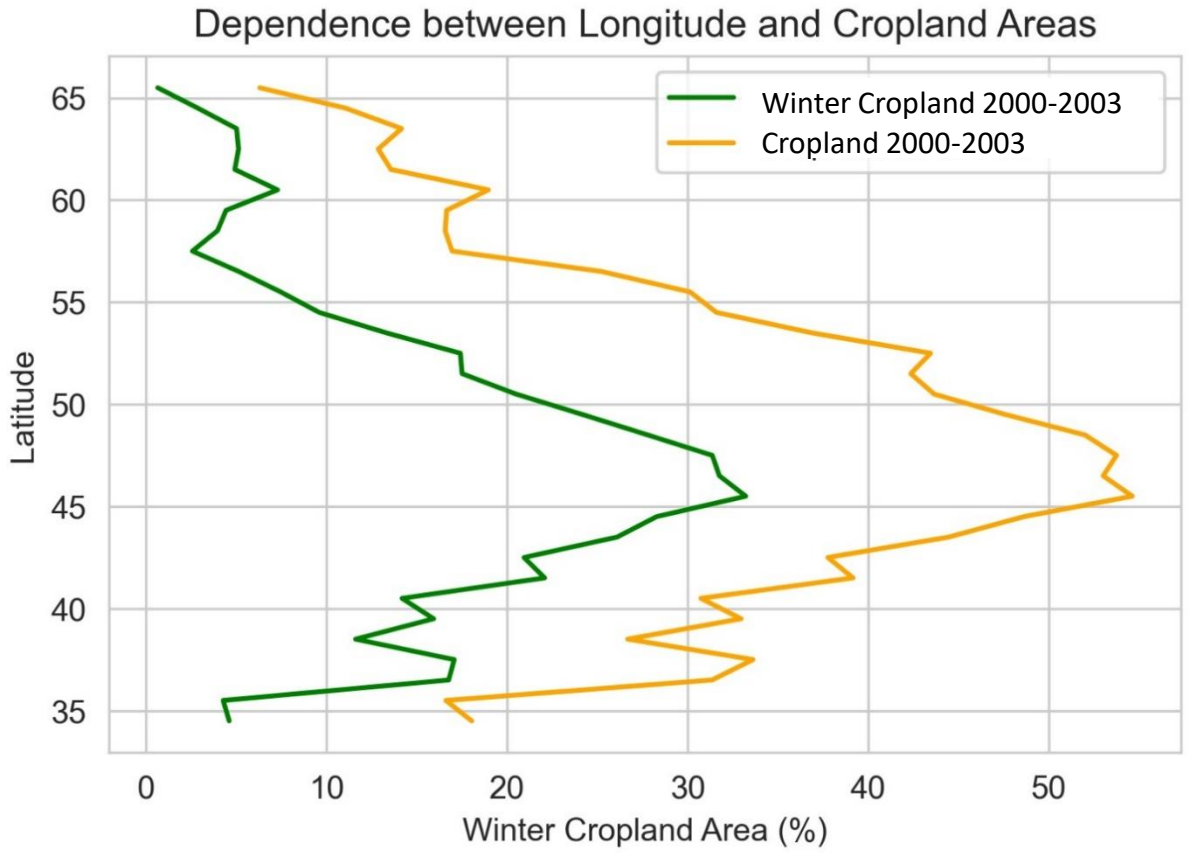
Winter cropland area increased for **49,763.6 ± 1,1343** th. ha (**~42%**) from 2000 to 2019.

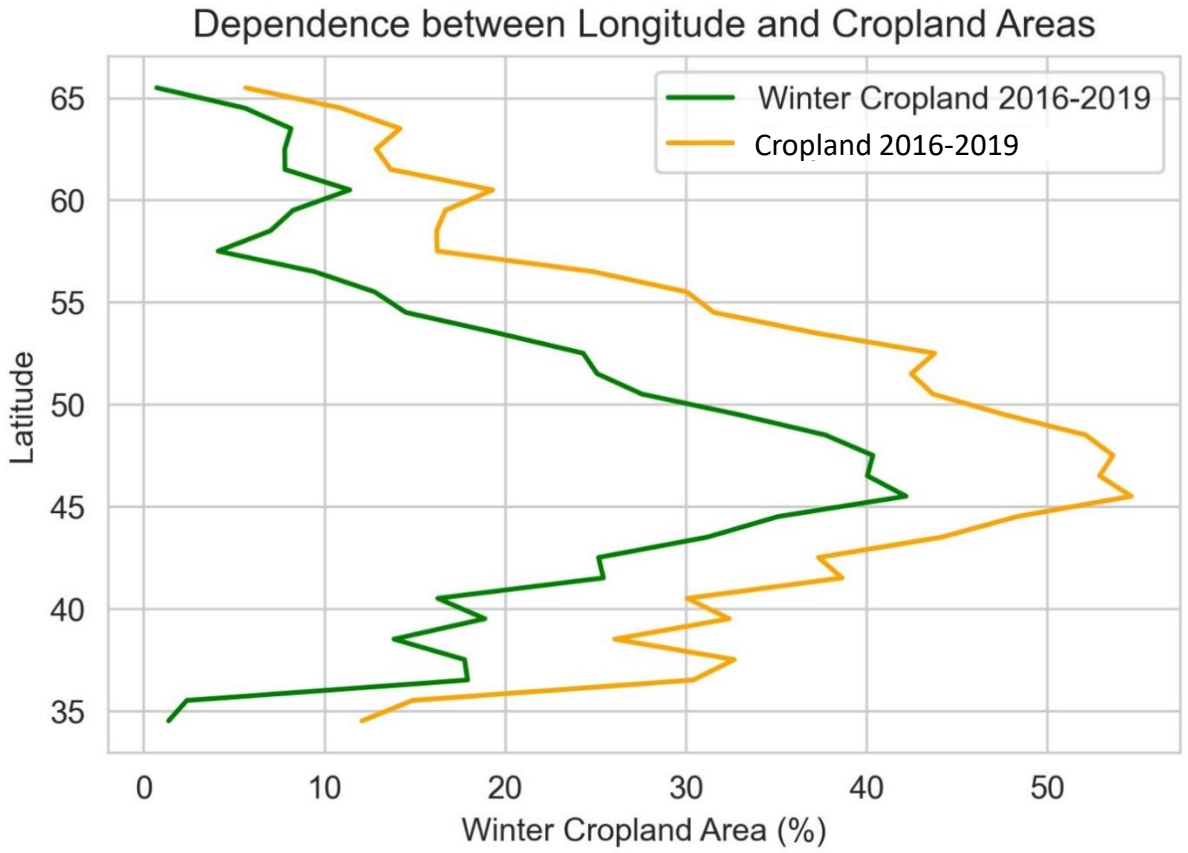




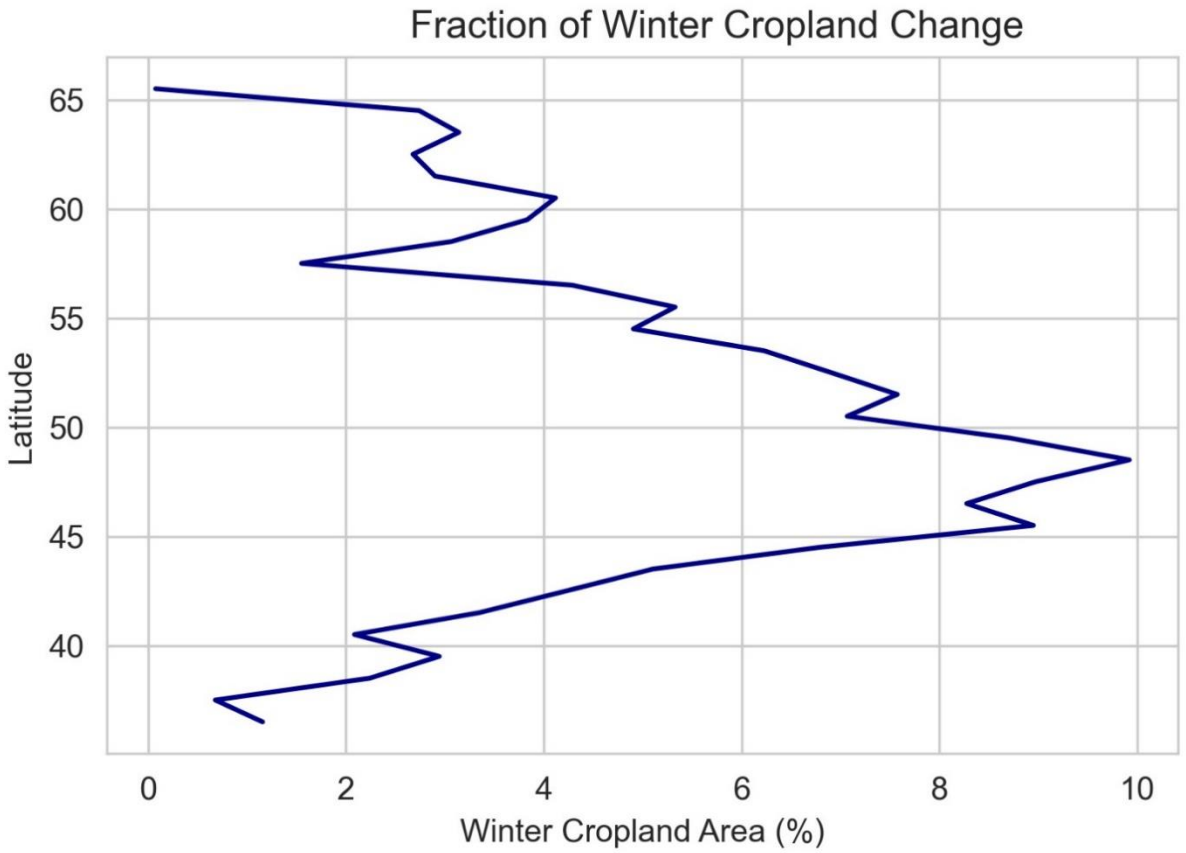
Fraction of winter cropland over total cropland increased for **15 ± 4.1%** from 2000 to 2019

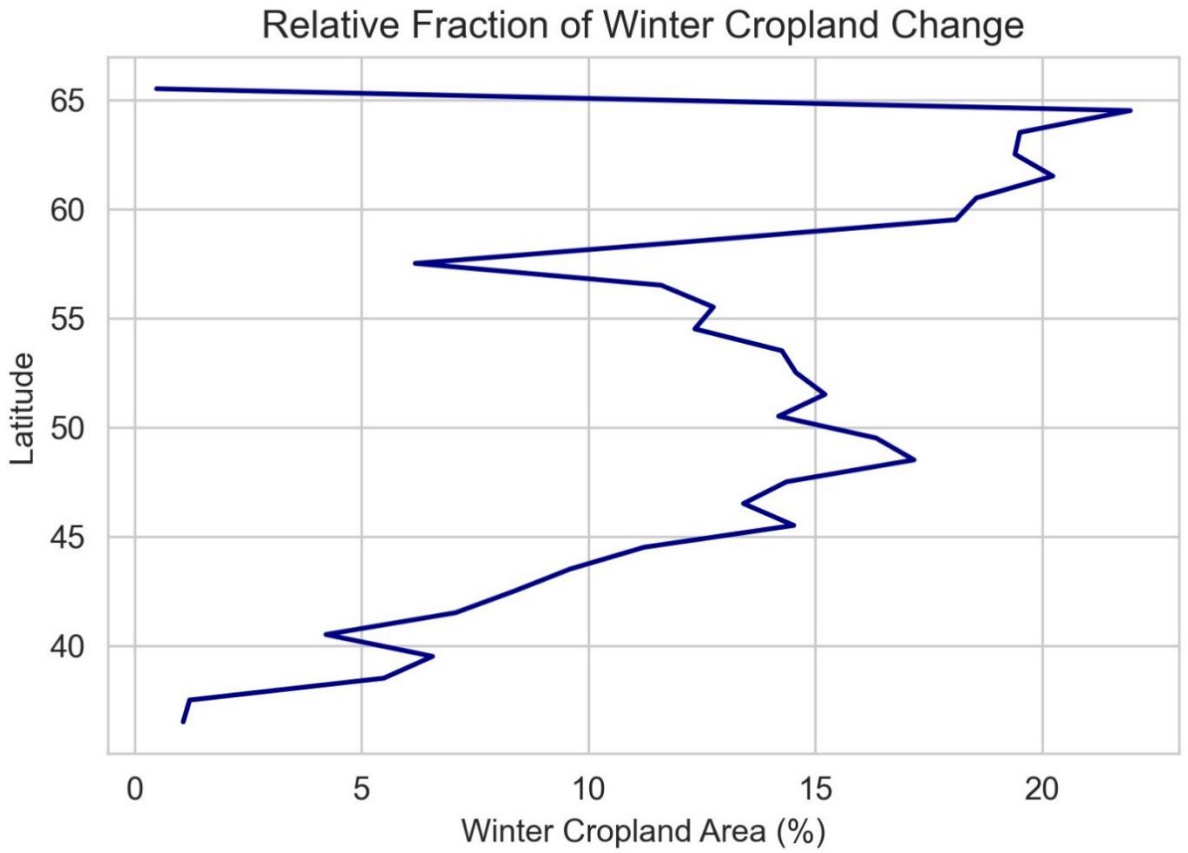
Winter Cropland Area Change



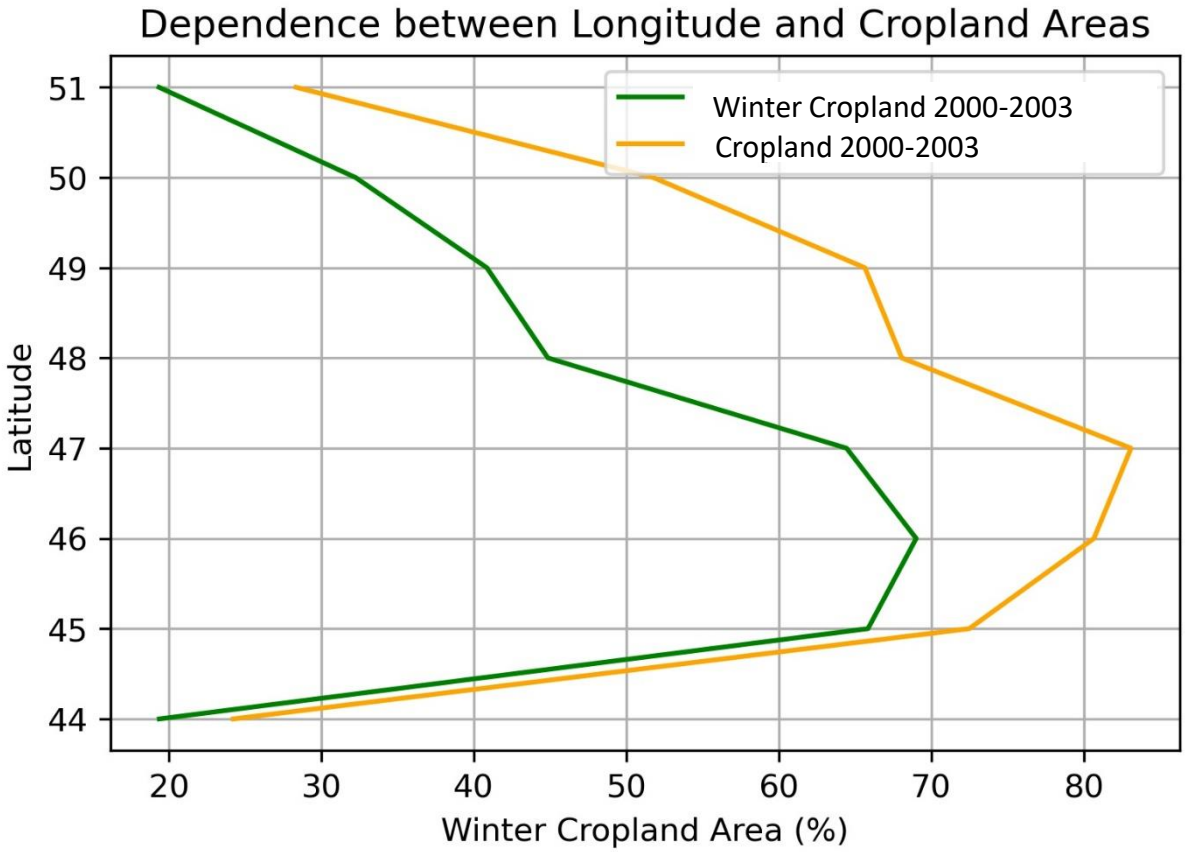


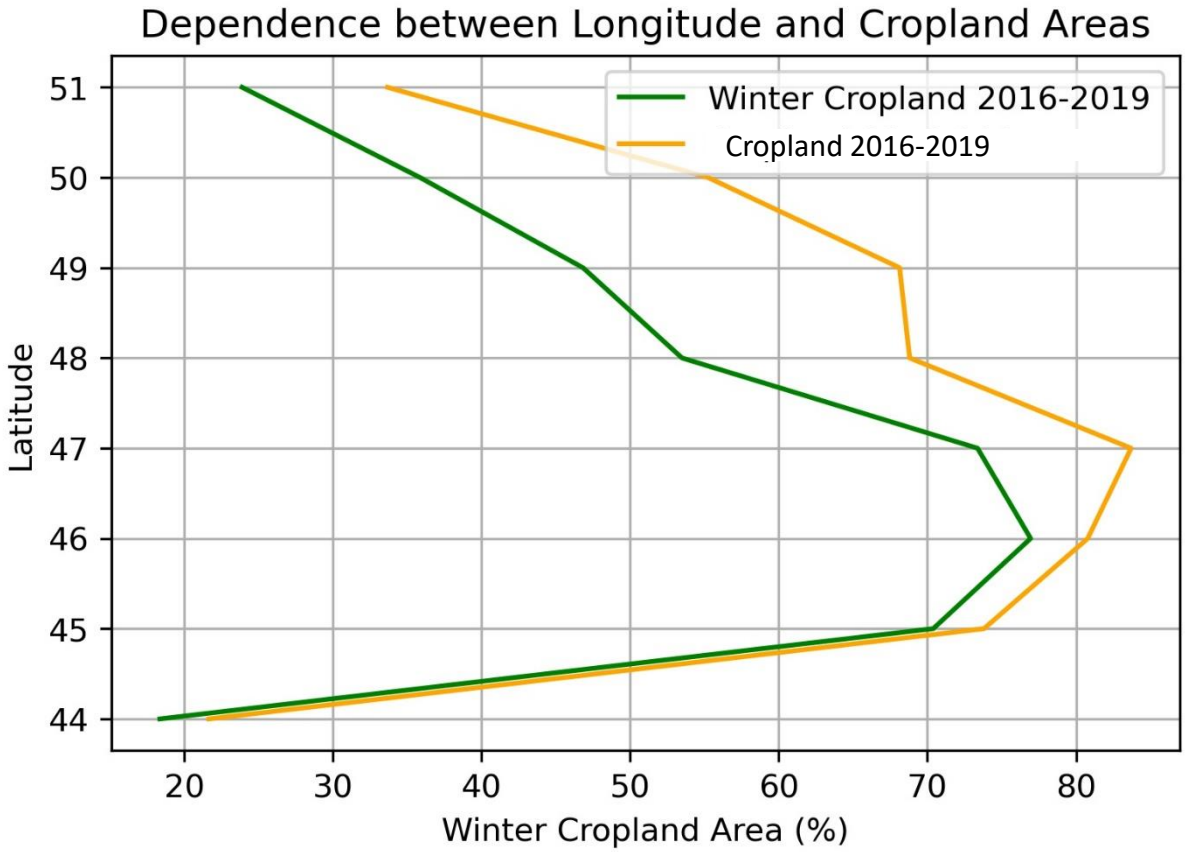
Absolute vs Relative Change of Winter Cropland Area



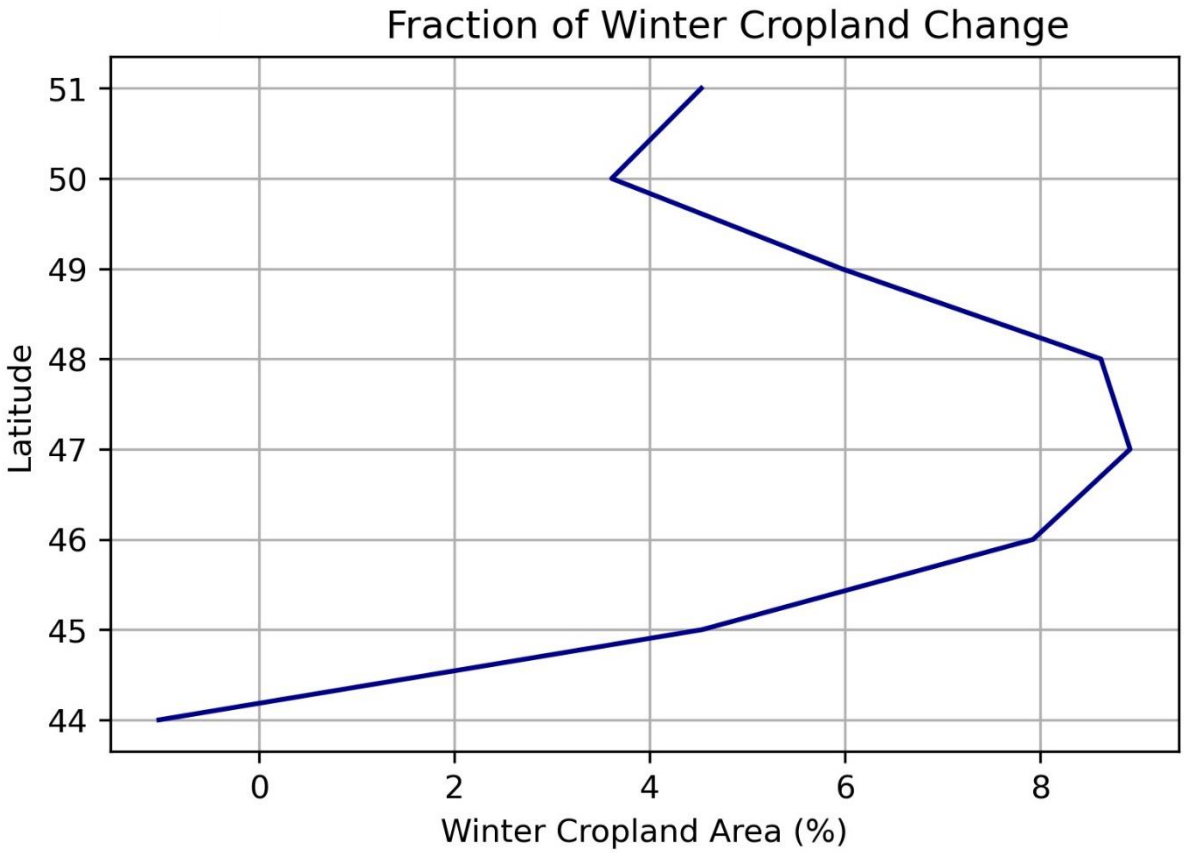


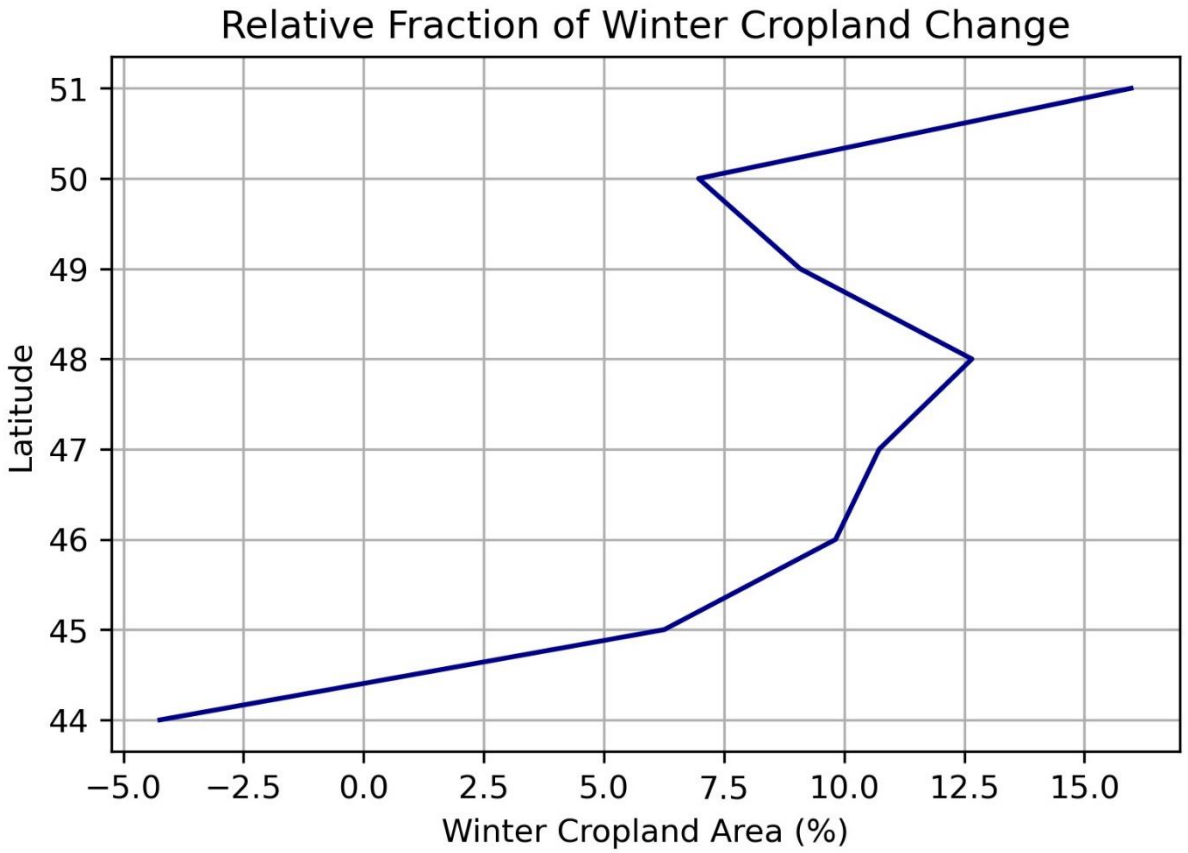
Trend of Changes in Ukraine



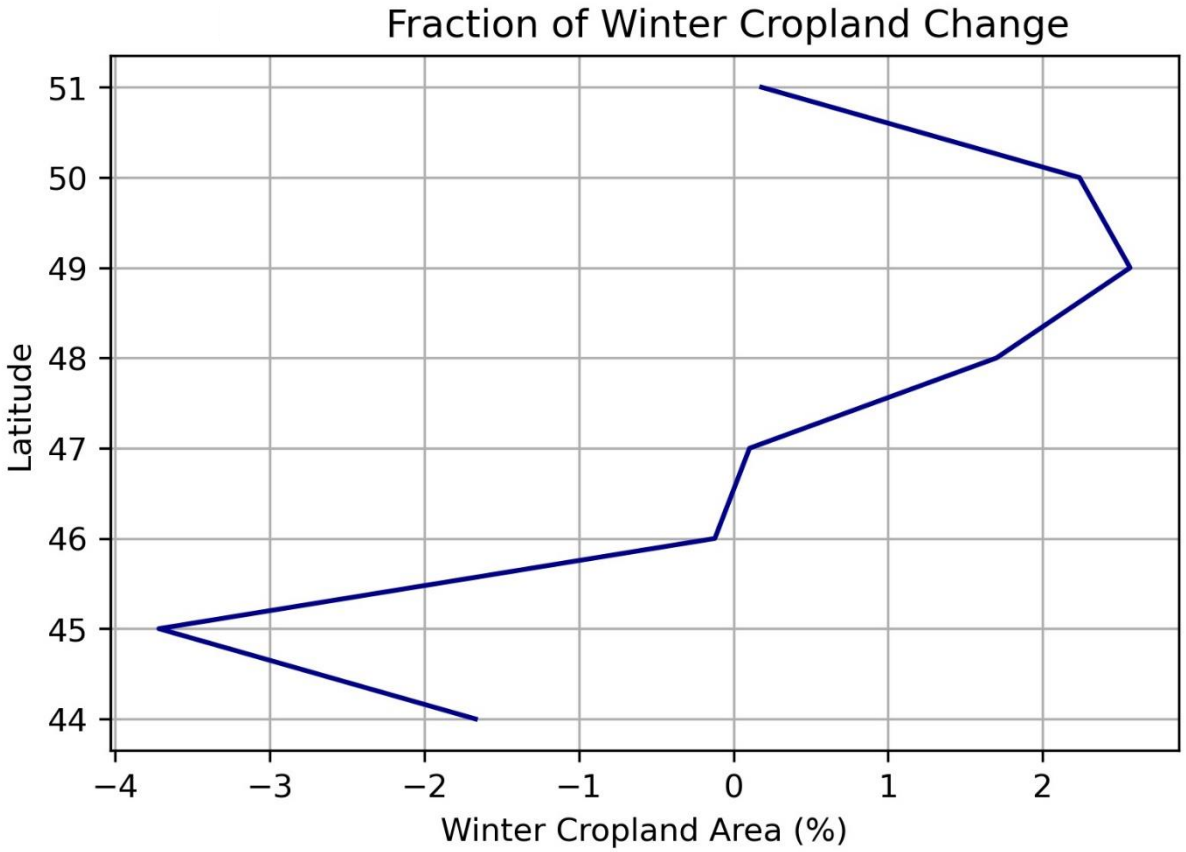


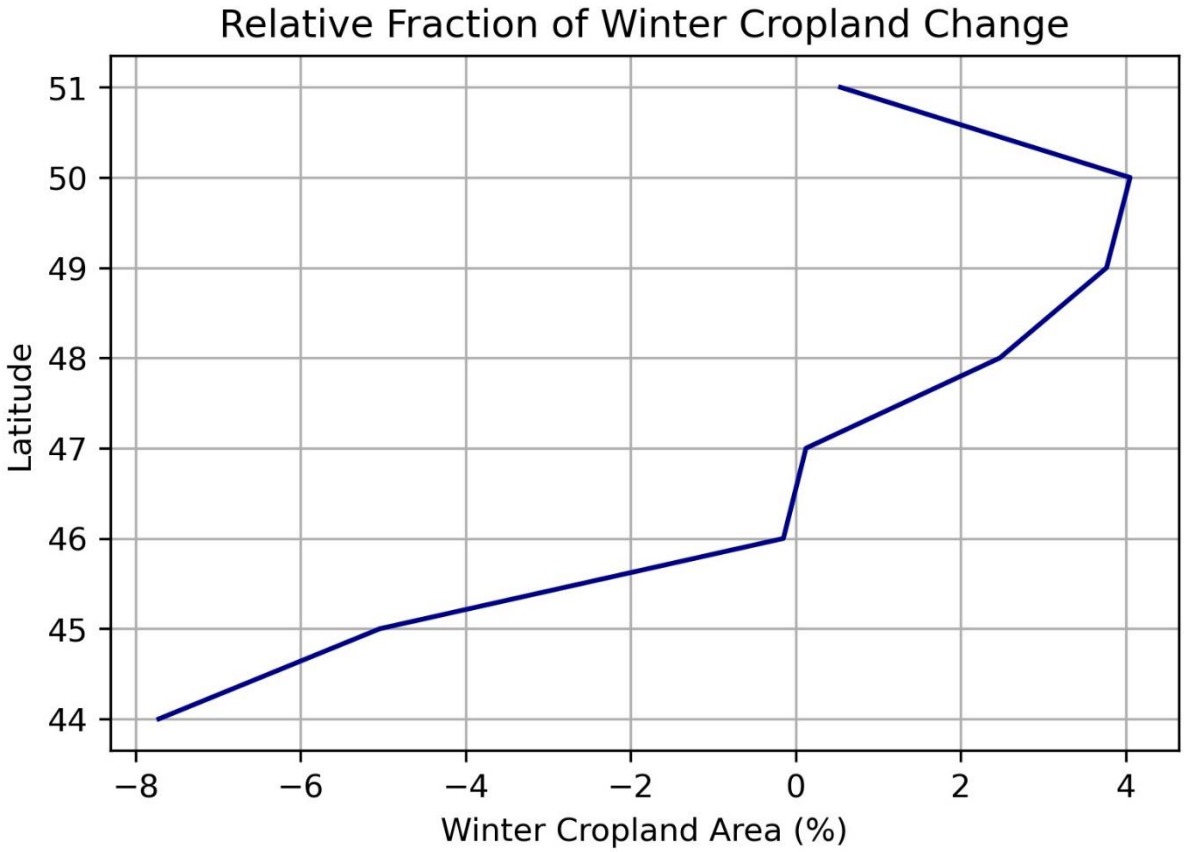
Absolute vs Relative Change in Ukraine





War Impact (2021-2024 vs 2016-2019)





Conclusion

- We observe **significant increase** of the Winter Cropland **Area and Fraction** in the Europe
- Area Increase has patterns of the **expansion** to the north
- Fraction of the winter cropland over total cropland areas shows that **northern latitudes** have much **higher rates** of the winter cropland expansion then southern
- Expansion trends of winter cropland in **Ukraine** are **consistent** with the **European continental observations**
- **Russian Aggression in Ukraine** caused significant **reduction** of winter cropland on the **South** and **boosted** expansion to the **North**