

Peer Review File

Quantification of losses in agriculture production in eastern Ukraine due to the Russia-Ukraine war



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Web links to the author's journal account have been redacted from the decision letters as indicated to maintain confidentiality

7th Sep 23

Dear Professor Lin,

Your manuscript titled "Assessing Impacts of the Russia-Ukraine Conflict on Agricultural Production using Publicly Available Satellite Imagery" has now been seen by 3 reviewers, whose comments are appended below. In the light of their advice, we regret to inform you that we cannot publish your manuscript in Communications Earth & Environment.

Although the reviewers acknowledge the potential interest of the topic you address, all three reviewers feel that the current version of your manuscript lacks methodological clarity, accuracy, and validation assessment and ignores country-specific practices. Thus, we are unable to conclude that a revision is likely to result in a manuscript that offers a sufficiently novel and compelling advance over the body of related work in the literature for publication of this study in Communications Earth & Environment to be appropriate.

We are sorry that we cannot be more positive on this occasion and thank you for the opportunity to consider your work.

Best regards,

Martina Grecequet, PhD
Associate Editor,
Communications Earth & Environment
@CommsEarth

Reviewers' comments:

Reviewer #1 (Remarks to the Author):

This paper presents a very interesting topic about the Russian-Ukraine conflict on agricultural production using publicly available satellite images. The paper is well written with solid results, therefore I suggest it for publication after addressing the following issues.

1. The authors proposed a semi-supervised approach for crop type classification, which was built according to the spectral and phenology information. Although Fig. S3 presents the mean of NDVI of different crop types, it is better to also briefly discuss the uncertainties of these samples regarding their NDVI or spectral values.
2. It is better to show some illustrative cases about their different crop types with their validation samples, e.g., the spectral and phenology curve, the high-resolution images.
3. I suggest to put the uncertainty range of classified crop types, as well as the estimated loss, which is more reliable rather than determinative values.

Reviewer #2 (Remarks to the Author):

This manuscript reported the impacts of the ongoing conflict between Russia and Ukraine agriculture based on multiple remote sensing data sources. The topic is interesting, but I have concerns about the implemented methods and the accuracy assessments as below comments:

(1) The crop type map is fundamental in this research, but the accuracies reported in this manuscript were only based on limited samples acquired from four small areas, with cross-validation. It did not provide the crop type map's accuracy. I'd recommend estimating the accuracy and area adjustment for the maps with the "good practice".

(2) This manuscript adopted a simple NDVI threshold-based classification method to distinguish the planting conditions of crops, i.e., planted vs. non-planted. This may ignore the crop rotations, which also result in differences in NDVI. For example, "Ukrainian law requires agricultural enterprises to follow approved crop rotations in an effort to reduce the incidence of soil-borne fungal disease caused by too-frequent planting of sunflowers, a consistently and highly profitable crop". (ref: https://ipad.fas.usda.gov/cropexplorer/pecad_stories.aspx?regionid=umb&ftype=prodbriefs). What's more important is that this manuscript did not validate the assessment of classification between "planted" vs. "non-planted".

(3) This manuscript used Planet satellite data to verify the effectiveness of Sentinel-2 NDVI data, but the reason was not explained. As far as I understand, this analysis can indicate the observations from Sentinel-2 are similar to those from Planet, not relative to anything else like the loss assessment based on Sentinel-2 NDVI.

(4) Including NTL is a good idea, but the current analysis was superficial. Only one conclusion made is "This demonstrated the fact that croplands near severely war-impacted regions would have experienced higher production reductions.". This is not a finding.

Reviewer #3 (Remarks to the Author):

Lines 94 and 95 state "Our study makes the first attempt to provide a high-quality, spatially explicit evaluation of agricultural loss because of the Russia-Ukraine conflict."

This is not the first "attempt." A very large amount of research has been dedicated to the issue at hand. Several publications have been published in Nature, Science, Nature Food, Nature Sustainability, Nature Human Behavior, and importantly, in numerous Ukrainian outlets. Any paper on the topic needs to at least acknowledge this work.

Besides this serious flaw, the method of mapping agricultural loss by NDVI differencing is not novel and expected to generate imprecise results. Further, to make maps and then count pixels in maps as means to area estimation is not recommended by the remote sensing community. Instead, areas should be estimated in sampling-based approaches.

Response letter

Authors' general response:

Dear editors and reviewers,

We sincerely appreciate your precious time and constructive comments, which greatly help improve our manuscript. We have conscientiously addressed all raised concerns and made revisions focusing on three key perspectives. Firstly, we assessed the classification accuracy of the generated crop type map and adjusted the area estimates based on the "good practice" recommendations. Secondly, we conducted an in-depth evaluation of the NDVI threshold-based classification method and presented additional examples to substantiate its rationale. Thirdly, we delved into a more comprehensive analysis of how the conflict and other factors (such as climate and human activity) affect crop production in Ukraine using regression models. Please see our point-by-point responses to the three reviewers' specific comments below. All corresponding revisions are marked in tracked changes of the revised manuscript.

Best regards,

Prof. Chen Lin (On behalf of all authors)

Authors' responses to the reviewers' specific comments:

Reviewer #1 (Remarks to the Author):

This paper presents a very interesting topic about the Russian-Ukraine conflict on agricultural production using publicly available satellite images. The paper is well written with solid results, therefore I suggest it for publication after addressing the following issues.

> Thanks for your positive comments. Based on your constructive suggestions, we have carefully revised our manuscript to better present the methods and results. Please find our detailed responses to your comments below.

1. The authors proposed a semi-supervised approach for crop type classification, which was built according to the spectral and phenology information. Although Fig. S3 presents the mean of NDVI of different crop types, it is better to also briefly discuss the uncertainties of these samples regarding their NDVI or spectral values.

> Thank you for your suggestion. In Fig. R1, we have plotted the average monthly remote sensing signals of crop samples, including all Sentinel-2 and Sentinel-1 bands used in the study. For Sentinel-2 data, we utilized six original bands at 10-m spatial resolutions (Blue, Green, Red, NIR, SWIR1, SWIR2) and two additional indices calculated from the spectral bands ($NDVI = (NIR - Red) / (NIR + Red)$ and $NDYI = (Green - Blue) / (Green + Blue)$). For Sentinel-1 data, we considered VV and VH bands. As shown in Fig. R1, the time-series spectral and backscatter signals unveil the distinctive phenological characteristics of various crops, establishing the basis for our developed classification method. Wheat, typically sown in the preceding winter, exhibits its highest NDVI in spring, which precedes other crops. The Normalized Difference Yellow Index (NDYI) (Sulik and Long 2016) adeptly captures the increasing yellowness during flowering, proving valuable in detecting rapeseed and sunflower. Regarding SAR signals, the VH backscatter coefficient of sunflower and maize plants peaks in July, indicating the attainment of full ripeness.

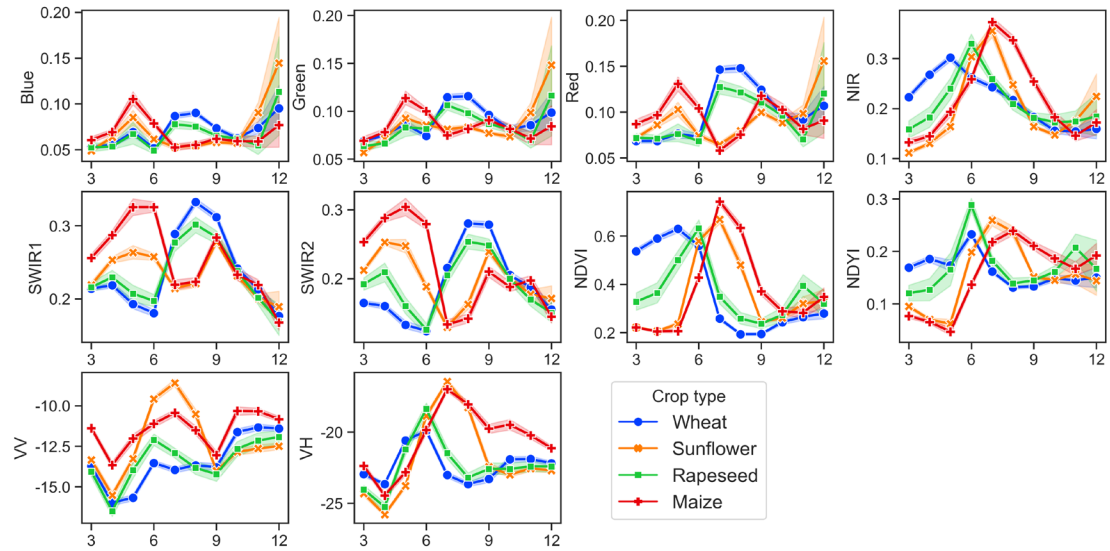


Fig. R1. Average monthly values of Sentinel-2 (Blue, Green, Red, NIR, SWIR1, SWIR2, NDVI, and NDYI) and Sentinel-1 (VV and VH) band signals of four major crop samples (wheat, maize, rapeseed, and sunflower). Each subgraph presents the time series signals of an individual band, with the x-axis representing different months from March 2020 to December 2020. Shadows denote the 95% confidence interval level of each metric.

References:

Sulik, J.J., & Long, D.S. (2016). Spectral considerations for modeling yield of canola. *Remote Sensing of Environment*, 184, 161-174

Changes to the manuscript:

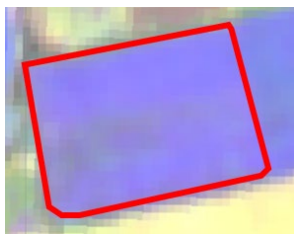
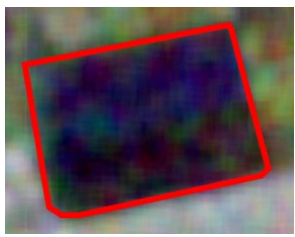
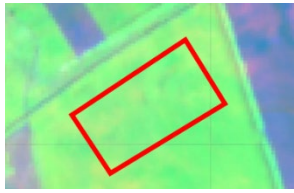
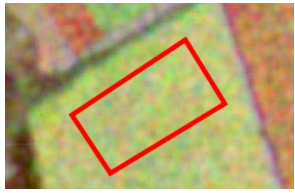
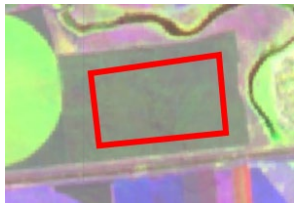
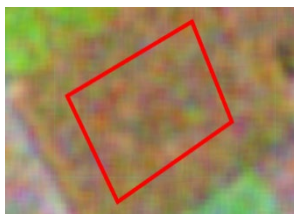
We replaced Fig. S3 with Fig. R1 in the supplementary materials.

2. It is better to show some illustrative cases about their different crop types with their validation samples, e.g., the spectral and phenology curve, the high-resolution images.

> Good point. We indeed consider a diverse range of spectral and phenological characteristics for different crops during sample collection, based on the collective information derived from time-series remote sensing signals, satellite images, and street view maps. To further illustrate this, we have presented four representative sample plots for wheat, sunflower, rapeseed, and maize in Table R1. In these cases, both the Sentinel-2 and Sentinel-1 images corresponded to monthly composition images, with mean band

values assigned in April, July, and October for the red, green, and blue channels, respectively. As previously highlighted, wheat achieves its highest NDVI value in spring (Fig. R1), resulting in a blue appearance in the NDVI composition image (Table R1). Additionally, the VV backscatter coefficient of sunflower crops peaks in July as they approach full ripeness (Fig. R1), imparting a green/yellow hue to the VV composition image (Table R1). Furthermore, street view images provide clear evidence of the yellowness of sunflower and rapeseed flowers during their growing seasons, a characteristic also captured in the high NDYI values in remote sensing images.

Table R1. Illustrative cases of four representative sample plots for wheat, sunflower, rapeseed, and maize. The Sentinel-2 NDVI and Sentinel-1 VV composition images showcase monthly compositions with mean band values in April, July, and October representing the red, green, and blue channels, respectively.

Crop type	Sentinel-2 NDVI composition image	Sentinel-1 VV composition image	Google Street View Maps
Wheat			
Sunflower			 (High NDYI in July)
Rapeseed			 (High NDYI in June)
Maize			

We provided additional explanations on crop sample collection in Methods and included Table R1 in the supplementary materials (corresponding to Table S6).

3. I suggest to put the uncertainty range of classified crop types, as well as the estimated loss, which is more reliable rather than determinative values.

> Revised. We expanded our crop sample set by collecting a total of one thousand validation points, with 200 samples allocated for each crop type, covering the entire country (Fig. R2). Using this supplementary dataset, we evaluated the uncertainty of the generated crop map and estimated sample-based area based on the "good practice" recommendation. Results revealed an overall accuracy of 87.60% for the classified crop map, with a Kappa coefficient of 0.85 (Table R2). In terms of sample-based area, maize accounted for the largest (105699.03 ± 4191.95), followed by wheat (99221.74 ± 4724.36), sunflower (72856.51 ± 4404.15), other crops (39124.33 ± 3373.56), and rapeseed (23766.36 ± 3291.37) (Table R3).

Furthermore, to validate the accuracy of the planting condition map, we manually collected additional five hundred samples categorized as "planted" and "not-planted" across the five eastern provinces (Fig. R3). The identification of planting condition samples primarily relied on the developed discriminant tool on GEE (Fig. S6), enabling us to compare multi-year Sentinel-2 satellite images and the associated NDVI time series changes. Fig. R4 and Fig. R5 showcase two examples of not-planted crop sample points for the year 2022 (Id=132 and Id=374, respectively), where NDVI experienced sharp reductions during the growing season in 2022. Based on these samples, we demonstrated that the overall accuracy of the planting condition map could reach as high as 89.60%, with a Kappa coefficient of 0.77 (Table R4).

In summary, these additional accuracy assessment results reaffirmed the precision and reliability of both our crop type map and planting condition map.

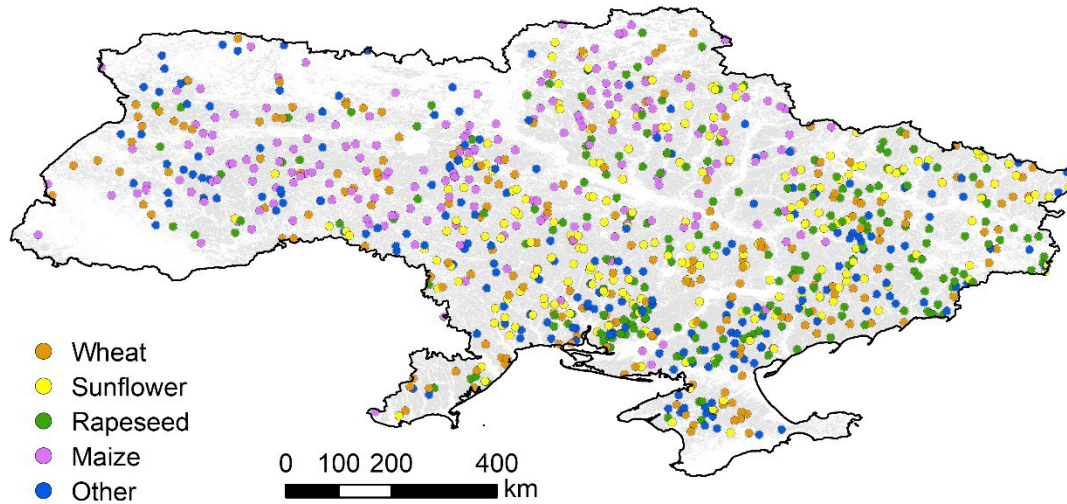


Fig. R2. Spatial distribution of crop type validation samples.

Table R2. Confusion matrix for the produced 10-m crop type map in Ukraine. Code from 01 to 05 represents wheat, sunflower, rapeseed, other, and maize, respectively. UA: user's accuracy. PA: producer's accuracy.

	01	02	03	04	05	Total	UA	PA
01	187	1	8	1	3	200	93.50%	83.48%
02	5	178	3	6	8	200	89.00%	88.12%
03	15	13	152	6	14	200	76.00%	90.48%
04	17	5	3	167	8	200	83.50%	92.27%
05	0	5	2	1	192	200	96.00%	85.33%
Total	224	202	168	181	225	1000		
Overall accuracy: 87.60%; Kappa coefficient: 0.85								

Table R3. Estimated map-based and sample-based areas of major crops in Ukraine.

Label	Crop type	Map-based area (km ²)	Sample-based area (km ²)
1	Wheat	94385.29	99221.74±4724.36
2	Sunflower	73149.20	72856.51±4404.15
3	Rapeseed	23154.35	23766.36±3291.37
4	Other	40759.89	39124.33±3373.56
5	Maize	100158.09	105699.03±4191.95

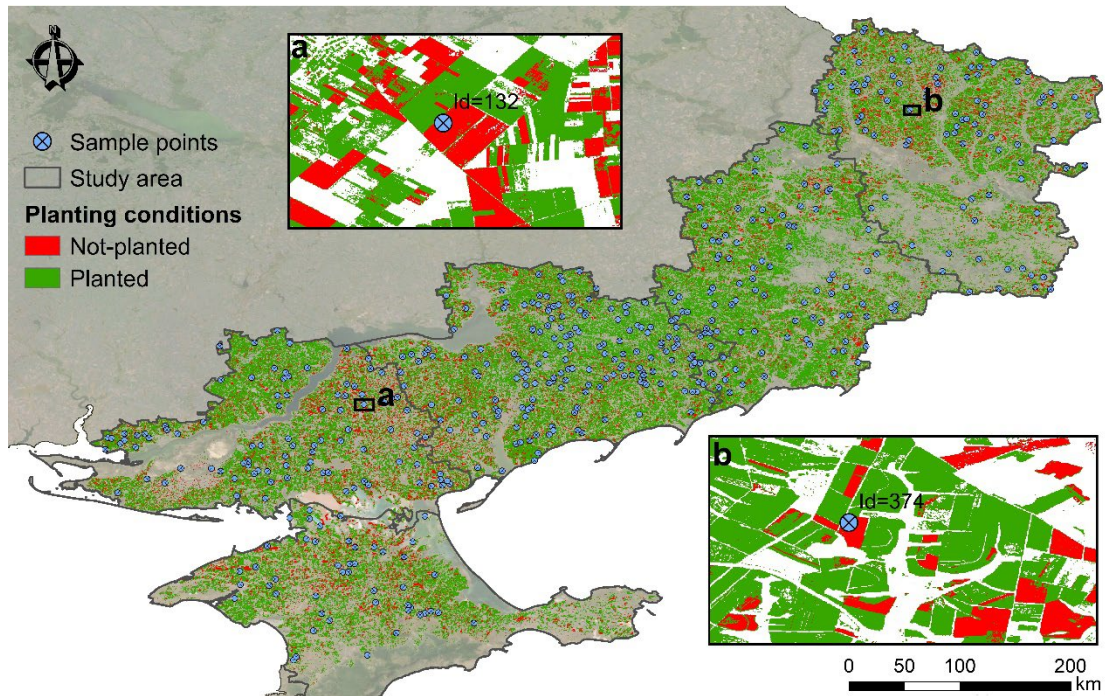


Fig. R3. Spatial distributions of planting condition samples in the five eastern provinces in Ukraine. The Sentinel-2 NDVI time series of the two non-planted sample points highlighted here (Id=132 and Id=374) are shown in Fig. R4 and Fig. R5, respectively.

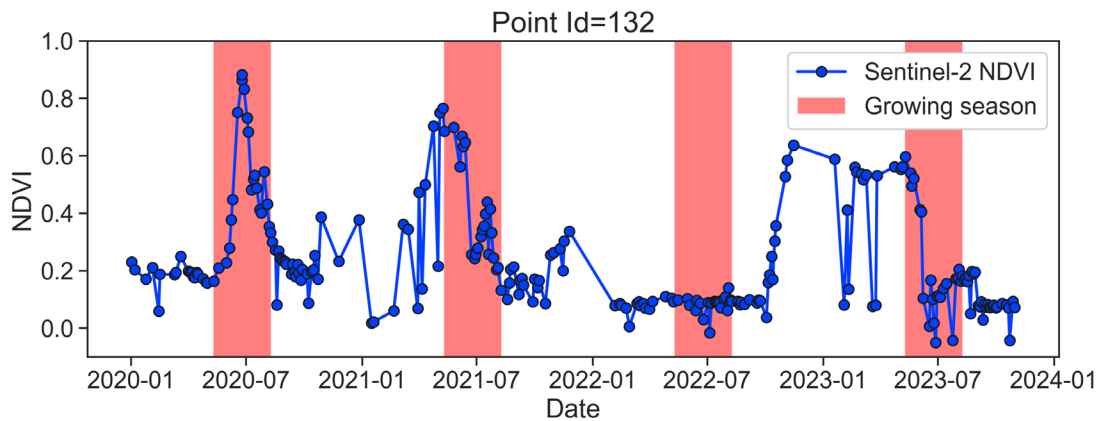


Fig. R4. Sentinel-2 NDVI time series for the rapeseed sample point (Id=132).

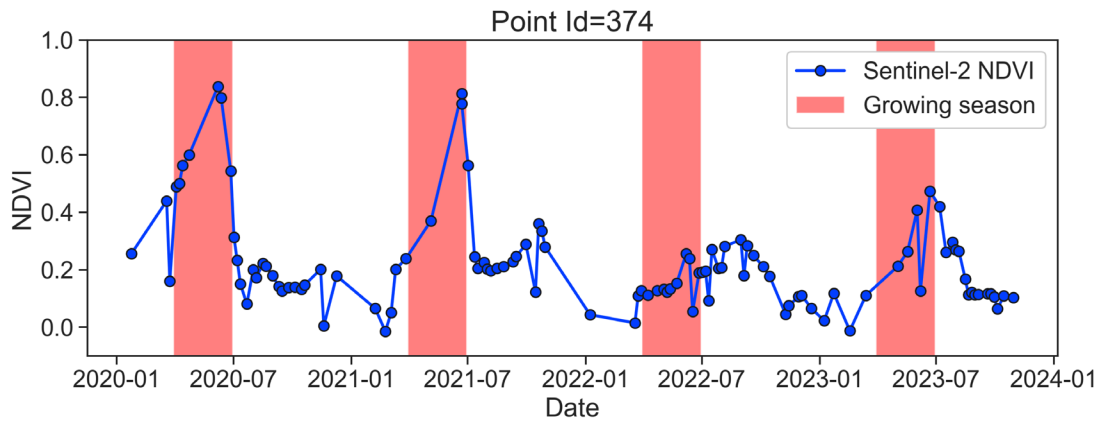


Fig. R5. Sentinel-2 NDVI time series for the wheat sample point (Id=374).

Table R4. Confusion matrix for the generated planting condition map for the five eastern provinces in Ukraine. UA: user's accuracy. PA: producer's accuracy.

	Not-planted	Planted	Total	UA	PA
Not-planted	150	37	187	80.21%	90.91%
Planted	15	298	313	95.21%	88.96%
Total	165	335	500		
Overall accuracy: 89.60%; Kappa coefficient: 0.77					

Reviewer #2 (Remarks to the Author):

This manuscript reported the impacts of the ongoing conflict between Russia and Ukraine agriculture based on multiple remote sensing data sources. The topic is interesting, but I have concerns about the implemented methods and the accuracy assessments as below comments:

> Thank you for your detailed review. Based on your insightful suggestions, we have carefully revised our manuscript refining the methods and results. Please find our point-by-point responses to your comments below.

4. The crop type map is fundamental in this research, but the accuracies reported in this manuscript were only based on limited samples acquired from four small areas, with cross-validation. It did not provide the crop type map's accuracy. I'd recommend estimating the accuracy and area adjustment for the maps with the "good practice".

> Same response to Comment 3. We have provided additional accuracy assessment and area estimation to the produced crop type map. The results indicated an overall accuracy of 87.60% and a Kappa coefficient of 0.85 (Table R2). Wheat and maize achieved relatively higher user's accuracies (UAs) while rapeseed and other crops demonstrated higher producer's accuracies (PAs). Following the "good practice" recommendation, we observed that maize had the largest mapped area, followed by wheat, sunflower, other crops, and rapeseed (Table R3). We believe that these analyses contribute valuable insights into the uncertainty of the crop type map.

5. This manuscript adopted a simple NDVI threshold-based classification method to distinguish the planting conditions of crops, i.e., planted vs. non-planted. This may ignore the crop rotations, which also result in differences in NDVI. For example, "Ukrainian law requires agricultural enterprises to follow approved crop rotations in an effort to reduce the incidence of soil-borne fungal disease caused by too-frequent planting of sunflowers, a consistently and highly profitable crop". (ref: https://ipad.fas.usda.gov/cropexplorer/pecad_stories.aspx?regionid=umb&ftype=prodbriefs). What's more important is that this manuscript did not validate the

assessment of classification between “planted” vs. “non-planted”.

> Thank you for raising this concern. As addressed in our response to Comment 3, we conducted an additional accuracy assessment of the planting condition map, manually interpreting a total of five hundred samples across the five eastern provinces in Ukraine (Fig. R3). Our estimation suggested that the overall accuracy of the planting condition map could reach as high as 89.60%, with a Kappa coefficient of 0.77 (Table R4). Besides, we re-examined the number of crop planting and harvesting cycles within a full year in Ukraine using the global cropping intensity (GCI) dataset (Zhang et al., 2021). As depicted in Fig. R6, 80% of croplands in Ukraine exhibited a GCI value of 1 (i.e., single cultivated), with the remaining 20% having double planting. This indicates that the cropping intensity in Ukraine is relatively simple, supporting the rationale of our classification approach. In conclusion, despite its simplicity, the NDVI threshold-based classification method offers a fast and reliable approach for discerning the planting condition of crops during wartime.

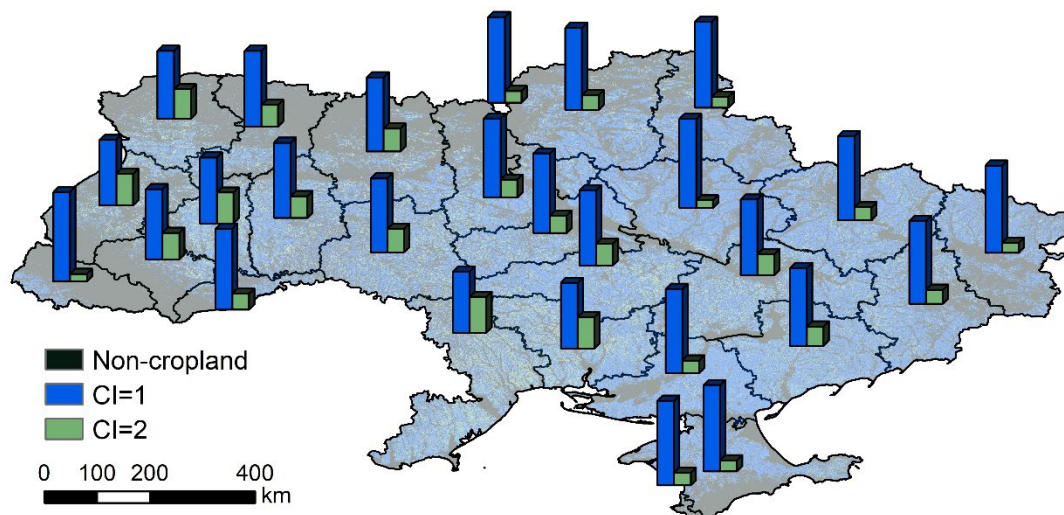


Fig. R6. Distribution and composition of cropping intensity (CI) in Ukraine.

References:

Zhang, M., Wu, B., Zeng, H., He, G., Liu, C., Tao, S., Zhang, Q., Nabil, M., Tian, F., Bofana, J., Beyene, A.N., Elnashar, A., Yan, N., Wang, Z., & Liu, Y. (2021). GCI30: a global dataset of 30-m cropping intensity using multisource remote sensing imagery. *Earth System Science Data*, 13, 4799-4817

6. This manuscript used Planet satellite data to verify the effectiveness of Sentinel-2 NDVI data, but the reason was not explained. As far as I understand, this analysis can indicate the observations from Sentinel-2 are similar to those from Planet, not relative to anything else like the loss assessment based on Sentinel-2 NDVI.

> Thanks for your good question. Yes, NDVI (Normalized Difference Vegetation Index) is the proxy we used for loss assessment. Therefore, the 10-meter resolution Sentinel-2 proxies, which may consist of some mixed pixels, require specific verification. Given the relatively high spatial resolution of Planet data at 3 meters, we believe it provides a more detailed and convincing data source for cross-checking the effectiveness of Sentinel-2 NDVI in our analysis.

7. Including NTL is a good idea, but the current analysis was superficial. Only one conclusion made is “This demonstrated the fact that croplands near severely war-impacted regions would have experienced higher production reductions.”. This is not a finding.

> Thank you for your insightful suggestion. In the revised manuscript, we have integrated in-depth regression analyses to evaluate the impact of the conflict and other factors on crop production. Previous studies have demonstrated that both natural factors (such as precipitation and the number of growing degree days (GDDs)) and non-natural factors (such as labor displacement, changes in agricultural infrastructure, alterations in agriculture markets, or regime policies during conflicts) can influence cropland productivity (Deininger et al. 2023; Eklund et al. 2017; Li et al. 2022). Building on this foundation, our research attributed changes in crop production (i.e., NDVI) primarily to the natural impacts of precipitation and GDDs, and the non-natural impacts of conflict and human activity, denoted as not-planted area and NTL, respectively (Table R5). Given the varied spatial resolution of these datasets, we established thousands of $0.1^{\circ} \times 0.1^{\circ}$ grids covering the five eastern provinces of Ukraine (Fig. R7) and calculated mean NDVI, precipitation, GDD, and NTL for each grid in each year from 2019 to

2022. Noted that we only considered grids with a total cropland area greater than 10 km² for regression analysis. All the datasets used in this analysis can be freely accessed through the GEE platform. Below we summarized key methods and findings of the regression analyses.

Table R5. Summary of variables used in the regression analysis.

Category	Variable	Description	Data source	Spatial resolution	Year coverage
Crop production	<i>NDVI</i>	Mean NDVI	Sentinel-2	10 m	2019-2022
Climate	<i>Precp</i>	Accumulated precipitation	ERA5	0.01°	2019-2022
Climate	<i>GDD</i>	Number of growing degree days	ERA5	0.01°	2019-2022
Human activity	<i>NTL</i>	Mean nighttime light intensity	VIIRS	500 m	2019-2022

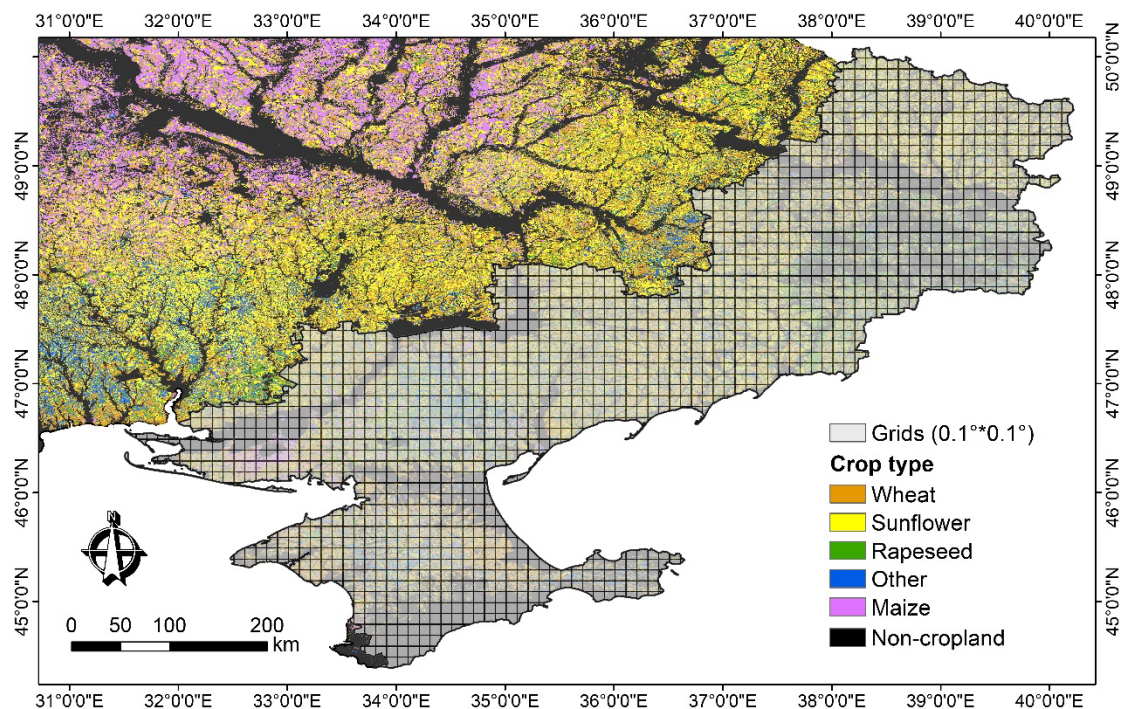


Fig. R7. Spatial distribution of 0.1°*0.1° grids for the five eastern provinces in Ukraine, which are used as the basic unit for quantitatively assessing the impact of conflict and other factors on crop production.

Methods

We developed two regression models to assess the factors influencing crop production. The first model is a fixed-effects model (Model I), which depicts the relationship between crop production and various natural and non-natural factors:

$$NDVI_{i,t} = \beta_1 Pre_{i,t} + \beta_2 GDD_{i,t} + \beta_3 NTL_{i,t} + \mu_i + \delta_t + \varepsilon_{i,t} \quad (R1)$$

where the response variable $NDVI_{i,t}$ represents the mean NDVI of crops for the i -th grid in year t , whereas the independent variables $Pre_{i,t}$, $GDD_{i,t}$, and $NTL_{i,t}$ are the mean precipitation, GDD, and NTL values for the i -th grid in t year. μ_i are grid fixed effects that control for time invariant factors across regions, δ_t are time fixed effects, and $\varepsilon_{i,t}$ is random error term.

Two specific sets of coefficients in Eq. (R1) are of particular interest: a vector of estimated coefficients β measures the impact of climatic variables and human activities on crop production, while δ_{2022} captures the deviation of year 2022 from the common mean. To the extent that time invariant variables such as agronomic suitability, access to infrastructure and economic opportunities, and local leadership quality are controlled for, this can provide an upper-bound estimate of conflict effects.

Moreover, we explored the attribution of changes in crop production by constructing a multi-linear regression model (Model II) correlating the difference in NDVI with changes in impacting factors:

$$dNDVI_i = \beta_1 dPre_i + \beta_2 dGDD_i + \beta_3 dNTL_i + \beta_4 NPA_i + \varepsilon \quad (R2)$$

where $dNDVI_i$, $dPre_i$, $dGDD_i$, $dNTL_i$ denote the mean difference of crop NDVI, precipitation, GDD, and NTL between 2019-2021 and 2022 for the i -th $0.1^\circ \times 0.1^\circ$ grid. NPA is the area of not-planted cropland in 2022 compared to the previous three years, which was computed based on the prior planting condition classification results.

Results

Results showed that crop production was significantly affected by climatic variables, with larger precipitation ($\beta_2=0.154, p<0.01$) and GDD ($\beta_3=0.002, p<0.1$) corresponding to higher NDVI values (Table R6). In contrast, human activity (represented by *NTL*) had a limited impact on crop production ($\beta_1=0.001$). Moreover, the negative and highly significant time fixed effects variable δ_{2022} indicated a noteworthy agricultural production reduction during the Russia-Ukrainian conflict. The mean NDVI of crops in 2022 was 11.5% lower than the average level, which may reflect conflict-induced manpower shortages, challenges in accessing purchased inputs—especially fuel—or an anticipation of lacking market demand when the crops are harvested.

Table R6. Regression results for the fixed-effects model (Model I).

Variable	Coefficient	Estimated effect
<i>NTL</i>	β_1	0.001 (0.002)
<i>Precp</i>	β_2	0.154*** (0.014)
<i>GDD</i>	β_3	0.002* (0.001)
Time effects	δ_{2019}	0.049*** (0.023)
	δ_{2020}	0.025*** (0.023)
	δ_{2021}	0.041*** (0.023)
	δ_{2022}	-0.115*** (0.023)
Intercept	-0.225 (0.244)	
R^2	0.132	
Observations	1148	

Standard errors are shown in parentheses. * $p<0.1$; ** $p<0.05$; *** $p<0.01$.

By further contrasting the changes in NDVI and changes in other influencing factors, we found a positive relationship between the difference in NDVI ($dNDVI$) and the difference in NTL ($dNTL$), indicating that larger reductions in NTL were associated with greater NDVI losses (Fig. R8). However, there was no significant relationship between $dNDVI$ and $dPrecp$ or $dGDD$, implying that climate change had little impacts on crop production change (Fig. R8). According to the results of the multi-linear regression model, a one unit reduction in NTL accounted for 1.4% NDVI loss of crops

(Table R7, $\beta_4=0.014$, $p<0.1$). Notably, the regression results indicated that $dNDVI$ was predominantly influenced by NPA (Table R7, $\beta_4=0.002$, $p<0.01$), highlighting that conflict-related agricultural activities (such as cropland abandonment or destruction) were the major causes of crop production loss in 2022. Taken together, these analyses underscore the extensive impacts of conflict on crop production in Ukraine.

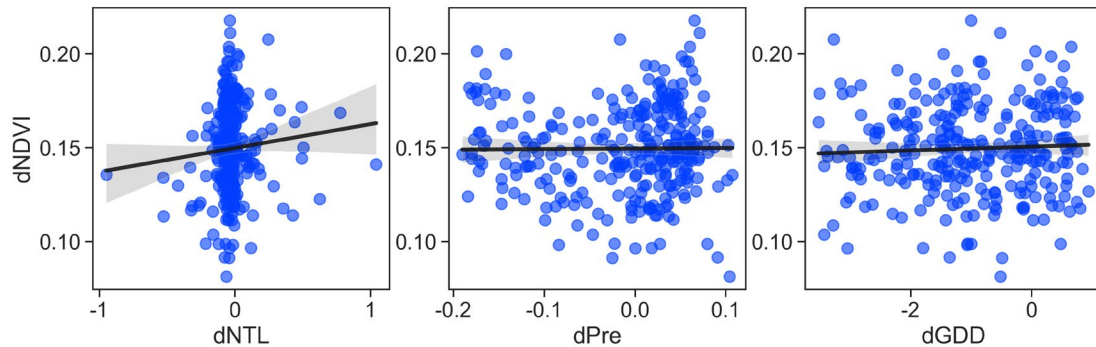


Fig. R8. Scatter plot results between the difference in NDVI ($dNDVI$) and the difference in other factors ($dNTL$, $dPre$, $dGDD$) at the $0.1^\circ \times 0.1^\circ$ grid scale. Noted that all the difference values referred to the change between wartime observations in 2022 and the average value of the pre-war period (that is, 2019-2021), which were calculated by subtracting the annual observations in 2022 from the pre-war average.

Table R7. Regression results for the multi-linear regression model (Model II).

Variable	Coefficient	Estimated effect
$dNTL$	β_1	0.014* (0.009)
$dPrecp$	β_2	-0.004 (0.018)
$dGDD$	β_3	0.001 (0.001)
NPA	β_4	0.002*** (0.000)
Intercept	0.140*** (0.003)	
R^2	0.107	
Observations	286	

Standard errors are shown in parentheses. * $p<0.1$; ** $p<0.05$; *** $p<0.01$.

References:

- Deining, K., Ali, D.A., Kussul, N., Shelestov, A., Lemoine, G., & Yailimova, H. (2023). Quantifying war-induced crop losses in Ukraine in near real time to strengthen local and global food security. *Food Policy*, 115, 102418
- Eklund, L., Degerald, M., Brandt, M., Prishchepov, A.V., & Pilesjö, P. (2017). How

conflict affects land use: agricultural activity in areas seized by the Islamic State.

Environmental Research Letters, 12, 054004

Li, X.-Y., Li, X., Fan, Z., Mi, L., Kandakji, T., Song, Z., Li, D., & Song, X.-P. (2022).

Civil war hinders crop production and threatens food security in Syria. *Nature*

Food, 3, 38-46

Reviewer #3 (Remarks to the Author):

8. Lines 94 and 95 state "Our study makes the first attempt to provide a high-quality, spatially explicit evaluation of agricultural loss because of the Russia-Ukraine conflict." This is not the first "attempt." A very large amount of research has been dedicated to the issue at hand. Several publications have been published in Nature, Science, Nature Food, Nature Sustainability, Nature Human Behavior, and importantly, in numerous Ukrainian outlets. Any paper on the topic needs to at least acknowledge this work.

> We sincere apologies for any oversight with our "first attempt" claim. While there exists notable research in renowned journals, in-depth spatial-temporal evaluations detailing the agricultural repercussions of the Russia-Ukraine Conflict are sparse. In the revised manuscript, we have duly recognized and referenced prior work on this subject.

9. Besides this serious flaw, the method of mapping agricultural loss by NDVI differencing is not novel and expected to generate imprecise results. Further, to make maps and then count pixels in maps as means to area estimation is not recommended by the remote sensing community. Instead, areas should be estimated in sampling-based approaches.

> Thank you for your feedback. We have addressed uncertainties in the generated crop type map and the associated sample-based area. We have also evaluated the precision of the NDVI threshold-based classification method and the resulting planting condition map. Results revealed an overall accuracy of 87.60% for the classified crop map (Table R2) and 89.60% for the planting condition map (Table R3). For more details, please refer to our response to Comment 3, which is duplicated below.

We expanded our crop sample set by collecting a total of one thousand validation points, with 200 samples allocated for each crop type, covering the entire country (Fig. R2). Using this supplementary dataset, we evaluated the uncertainty of the generated crop map and estimated sample-based area based on the "good practice" recommendation. Results revealed an overall accuracy of 87.60% for the classified crop map, with a Kappa coefficient of 0.85 (Table R2). In terms of sample-based area, maize accounted

for the largest (105699.03 ± 4191.95), followed by wheat (99221.74 ± 4724.36), sunflower (72856.51 ± 4404.15), other crops (39124.33 ± 3373.56), and rapeseed (23766.36 ± 3291.37) (Table R3).

Furthermore, to validate the accuracy of the planting condition map, we manually collected additional five hundred samples categorized as "planted" and "not-planted" across the five eastern provinces (Fig. R3). The identification of planting condition samples primarily relied on the developed discriminant tool on GEE (Fig. S6), enabling us to compare multi-year Sentinel-2 satellite images and the associated NDVI time series changes. Fig. R4 and Fig. R5 showcase two examples of not-planted crop sample points for the year 2022 (Id=132 and Id=374, respectively), where NDVI experienced sharp reductions during the growing season in 2022. Based on these samples, we demonstrated that the overall accuracy of the planting condition map could reach as high as 89.60%, with a Kappa coefficient of 0.77 (Table R4).

In summary, these additional accuracy assessment results reaffirmed the precision and reliability of both our crop type map and planting condition map.

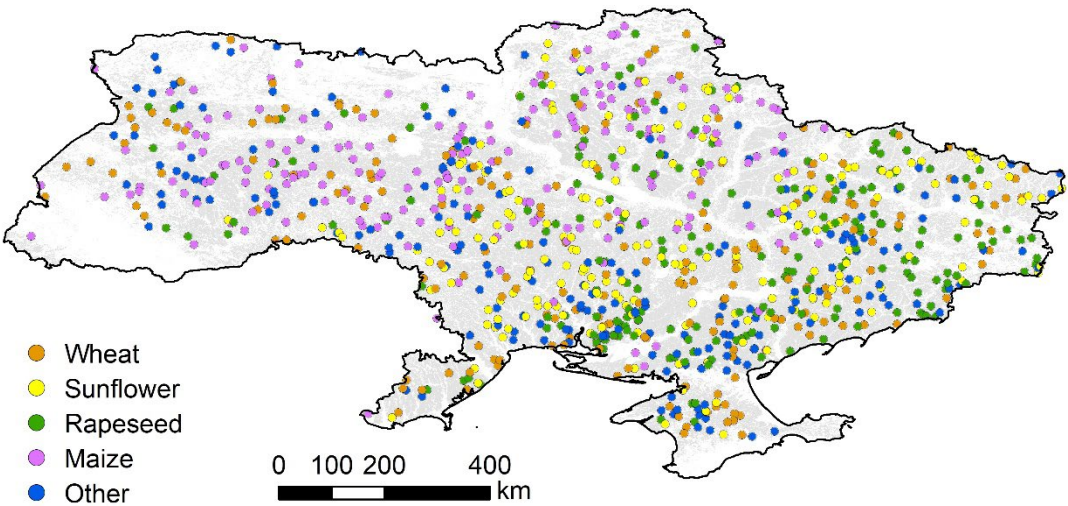


Fig. R2. Spatial distribution of crop type validation samples.

Table R2. Confusion matrix for the produced 10-m crop type map in Ukraine. Code from 01 to 05 represents wheat, sunflower, rapeseed, other, and maize, respectively. UA: user’s accuracy. PA: producer’s accuracy.

	01	02	03	04	05	Total	UA	PA
01	187	1	8	1	3	200	93.50%	83.48%
02	5	178	3	6	8	200	89.00%	88.12%
03	15	13	152	6	14	200	76.00%	90.48%
04	17	5	3	167	8	200	83.50%	92.27%
05	0	5	2	1	192	200	96.00%	85.33%
Total	224	202	168	181	225	1000		
Overall accuracy: 87.60%; Kappa coefficient: 0.85								

Table R3. Estimated map-based and sample-based areas of major crops in Ukraine.

Label	Crop type	Map-based area (km ²)	Sample-based area (km ²)
1	Wheat	94385.29	99221.74±4724.36
2	Sunflower	73149.20	72856.51±4404.15
3	Rapeseed	23154.35	23766.36±3291.37
4	Other	40759.89	39124.33±3373.56
5	Maize	100158.09	105699.03±4191.95

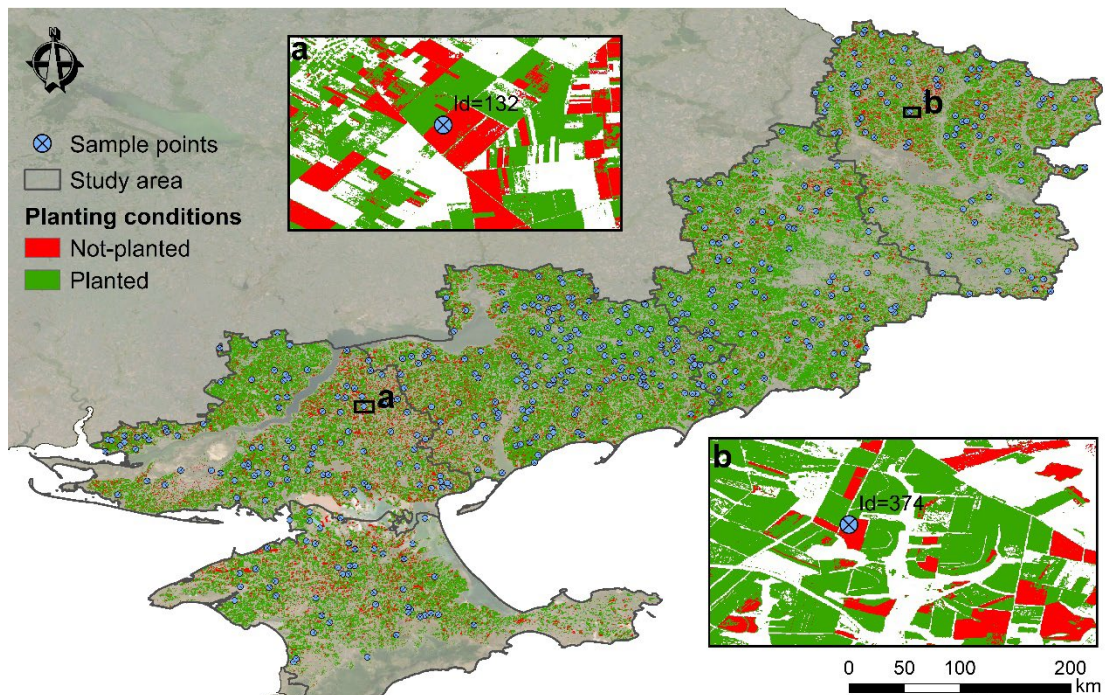


Fig. R3. Spatial distributions of planting condition samples in the five eastern provinces

in Ukraine. The Sentinel-2 NDVI time series of the two non-planted sample points highlighted here (Id=132 and Id=374) are shown in Fig. R4 and Fig. R5, respectively.

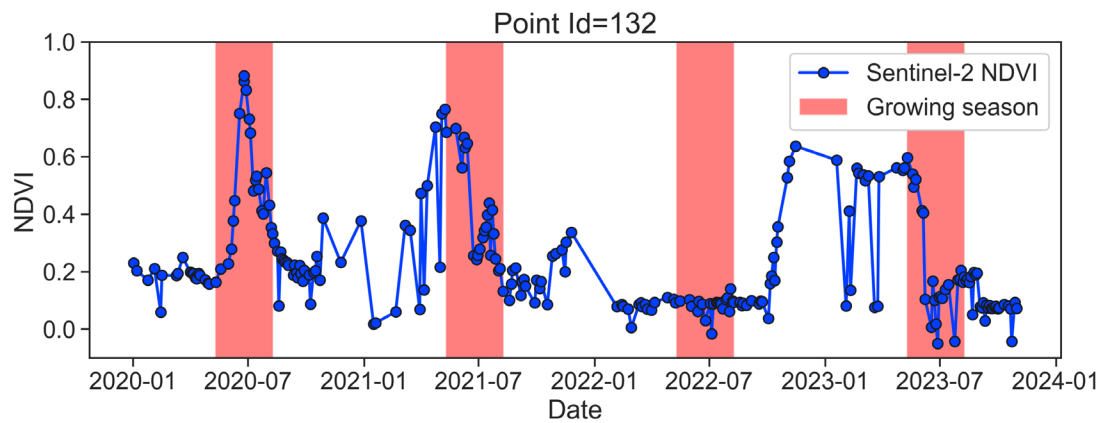


Fig. R4. Sentinel-2 NDVI time series for the rapeseed sample point (Id=132).

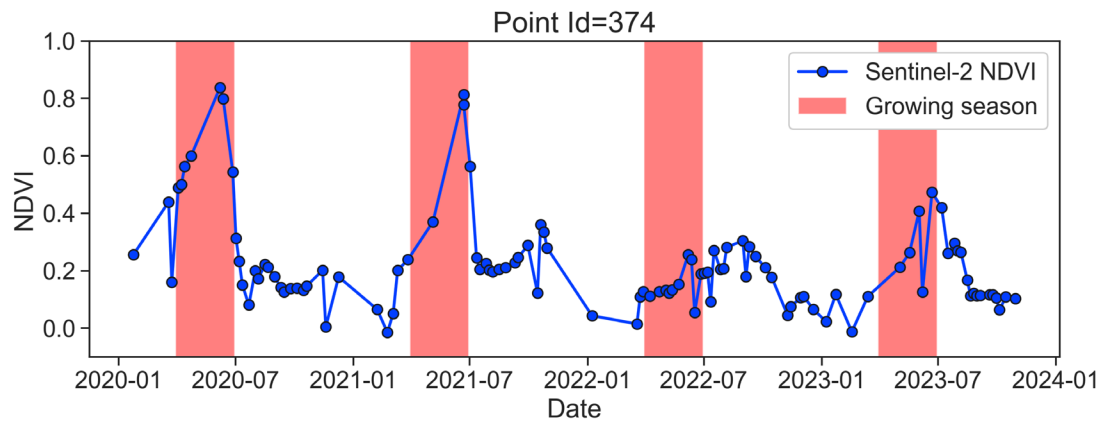


Fig. R5. Sentinel-2 NDVI time series for the wheat sample point (Id=374).

Table R4. Confusion matrix for the generated planting condition map for the five eastern provinces in Ukraine. UA: user's accuracy. PA: producer's accuracy.

	Not-planted	Planted	Total	UA	PA
Not-planted	150	37	187	80.21%	90.91%
Planted	15	298	313	95.21%	88.96%
Total	165	335	500		
Overall accuracy: 89.60%; Kappa coefficient: 0.77					

29th Jan 24

Dear Professor Lin,

Your manuscript titled "Assessing Impacts of the Russia-Ukraine Conflict on Agricultural Production using Publicly Available Satellite Imagery" has now been seen by 3 reviewers, and we include their comments at the end of this message. They have raised quite substantial concerns that must be addressed. Given that several issues were of concern before but were not addressed in the revision, we are unsure whether you are willing and able to resolve the remaining criticisms conclusively. However, if you are, we would be happy to consider a further revised manuscript before we make a final decision on publication.

We therefore invite you to revise and resubmit your manuscript, along with a point-by-point response that takes into account the points raised. Please highlight all changes in the manuscript text file. In particular, for publication in Communications Earth & Environment we request that you:

***Provide novel and well supported insight into agricultural and economic losses in high-risk, eastern Ukrainian provinces affected by Russia - Ukraine war.

***Provide a detailed and robust outline of methodology and uncertainty analysis, taking into account reviewer 1's queries regarding map-based versus sample-based results, and compelling ground-truthing for the Sentinel-2 NDVI data. "

Please note that we also ask that you reword the term "conflict" to "war." Please also avoid using the terms - dispute and/or operation.

We are committed to providing a fair and constructive peer-review process. Please don't hesitate to contact us if you wish to discuss the revision in more detail.

Please use the following link to submit your revised manuscript, point-by-point response to the referees' comments (which should be in a separate document to any cover letter), a tracked-changes version of the manuscript (as a PDF file) and the completed checklist:

[link redacted]

** This url links to your confidential home page and associated information about manuscripts you may have submitted or be reviewing for us. If you wish to forward this email to co-authors, please delete the link to your homepage first **

We hope to receive your revised paper within six weeks; please let us know if you aren't able to submit it within this time so that we can discuss how best to proceed. If we don't hear from you, and the revision process takes significantly longer, we may close your file. In this event, we will still be happy to reconsider your paper at a later date, as long as nothing similar has been accepted for publication at Communications Earth & Environment or published elsewhere in the meantime.

Please do not hesitate to contact us if you have any questions or would like to discuss these revisions further. We look forward to seeing the revised manuscript and thank you for the opportunity to

review your work.

Best regards,

Martina Grecequet, PhD
Associate Editor,
Communications Earth & Environment
@CommsEarth

EDITORIAL POLICIES AND FORMATTING

We ask that you ensure your manuscript complies with our editorial policies. Please ensure that the following formatting requirements are met, and any checklist relevant to your research is completed and uploaded as a Related Manuscript file type with the revised article.

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Furthermore, please align your manuscript with our format requirements, which are summarized on the following checklist:

[Communications Earth & Environment formatting checklist](#)

and also in our style and formatting guide [Communications Earth & Environment formatting guide](#).

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In particular, the Data availability statement should include:

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- Accession codes where appropriate
- If applicable, a statement regarding data available with restrictions
- If a dataset has a Digital Object Identifier (DOI) as its unique identifier, we strongly encourage including this in the Reference list and citing the dataset in the Data Availability Statement.

DATA SOURCES: All new data associated with the paper should be placed in a persistent repository where they can be freely and enduringly accessed. We recommend submitting the data to discipline-specific, community-recognized repositories, where possible and a list of recommended repositories is provided at <http://www.nature.com/sdata/policies/repositories>.

If a community resource is unavailable, data can be submitted to generalist repositories such as [figshare](#) or [Dryad Digital Repository](#). Please provide a unique identifier for the data (for example a

DOI or a permanent URL) in the data availability statement, if possible. If the repository does not provide identifiers, we encourage authors to supply the search terms that will return the data. For data that have been obtained from publically available sources, please provide a URL and the specific data product name in the data availability statement. Data with a DOI should be further cited in the methods reference section.

Please refer to our data policies at <http://www.nature.com/authors/policies/availability.html>.

REVIEWER COMMENTS:

Reviewer #1 (Remarks to the Author):

I appreciate authors' efforts in addressing my concerns. They did an extensive analyses and now the presented results are clear and easy to understand.

One comment for the uncertainty part is the difference between map-based and sample-based results. In my opinion, they should be the same, because the uncertainty was estimated from the confusion matrixes using these samples. The paper below can be used for reference.

Olofsson, P., Foody, G.M., Herold, M., Stehman, S.V., Woodcock, C.E., & Wulder, M.A.(2014). Good practices for estimating area and assessing accuracy of land change.Remote Sensing of Environment, 148, 42–57.

Thank you again for your efforts in improving this manuscript.

Reviewer #2 (Remarks to the Author):

I am generally satisfied with the revised version, but I still do not understand why PlanetScope data were used to validate Sentinel-2 NDVI. Can the PlanetScope data be considered "ground truth"? The spatial resolution of PanetScope is higher than that of Sentinel-2, but PanetScope often remains uncertain in reference and geo-location (Houborg and Matthew, 2018, RSE). I'd like to pass this question to the authors and the editor to decide on how to move forward.

Reviewer #3 (Remarks to the Author):

The authors state in the rebuttal that "In the revised manuscript, we have duly recognized and referenced prior work on this subject."

Where? The Main Text section in the revised version is more or less identical to that of the original submission. On line 91, the authors still claim that this is the "first attempt" to map agricultural loss following the Russian invasion of Ukraine. As clearly described, communicated, and emphasized in the original review, there's a multitude of literature and sources tracking the impact of the invasion on agriculture -- all *still* unacknowledged by the manuscript in question. No edits have been made to address this issue. Please don't state you "have conscientiously addressed all raised concerns and made revisions" when you haven't.

Another issue of the submission is the use of pixel-counting as means to area estimation. This issue was noted by other reviewers as well. The revised version presents estimates with uncertainty that (I assume) were estimated from the sample data. However, it appears that only the area of standing crop types at one a single point in time were estimated, whereas the results of the paper pertain to change in area. Why estimate the areas of standing standing crops if the conclusion of the paper is based on areas of change estimated by counting pixels in maps?

Further, how were areas estimated? How was the sample data collected? The following line in the rebuttal, "expanded our crop sample set by collecting a total of one thousand validation points, with 200 samples [sic] allocated for each crop type," suggests stratified sampling. If so, the strata weights need to be accounted for in the estimators. It is unclear which estimators that were used.

Response letter to reviewers

Reviewer #1 (Remarks to the Author):

I appreciate authors' efforts in addressing my concerns. They did an extensive analyses and now the presented results are clear and easy to understand.

> Thank you for your positive feedback and acknowledgment of our efforts.

One comment for the uncertainty part is the difference between map-based and sample-based results. In my opinion, they should be the same, because the uncertainty was estimated from the confusion matrixs using these samples. The paper below can be used for reference. Olofsson, P., Foody, G.M., Herold, M., Stehman, S.V., Woodcock, C.E., & Wulder, M.A.(2014). Good practices for estimating area and assessing accuracy of land change. *Remote Sensing of Environment*, 148, 42–57.

> We sincerely appreciate your insight into the difference between map-based and sample-based results. We agree with you that the mapping uncertainty is estimated based on the confusion matrix, a cross-tabulation of the class labels allocated by the classification map against the reference samples. In the Methods section of the revised manuscript, we have outlined the methodologies employed for map accuracy assessment following the “good practice” recommendations. To enhance the clarity and coherence of our manuscript, we have now incorporated the results from sample-based area estimation as the primary support for all analyses presented in the main text. For more details on these issues, please refer to our specific responses to Reviewer #3's second and third comments.

Thank you again for your efforts in improving this manuscript.

> Many thanks. We are grateful for your constructive engagement in the review process.

Reviewer #2 (Remarks to the Author):

I am generally satisfied with the revised version, but I still do not understand why PlanetScope data were used to validate Sentinel-2 NDVI. Can the PlanetScope data be considered "ground truth"? The spatial resolution of PlanetScope is higher than that of Sentinel-2, but PlanetScope often remains uncertain in reference and geo-location (Houborg and Matthew, 2018, RSE). I'd like to pass this question to the authors and the editor to decide on how to move forward.

> Thank you for acknowledging our revisions and for pointing out the NDVI data validation issue. In the revised manuscript, we have removed all analyses involving the use of PlanetScope NDVI to validate Sentinel-2 NDVI. Additionally, we acknowledge that despite the widespread usage of NDVI, there may be some uncertainties when using it for production estimation. We have highlighted this limitation in the Discussion section, which is duplicated as follows.

“While this research offers valuable insights, we acknowledge certain uncertainties remain. First, although we generate the 10-m spatial resolution map of major crops that make up about 90% of Ukraine’s commodity production in Ukraine, details about other cropland types are not included because of the limited availability of high-quality samples and associated collection difficulties. In addition, our use of the pre-war average (2019-2021) as the normal baseline may introduce potential biases, given the existence of interannual crop conversions. Second, the socioeconomic impact of agricultural production losses involves a cascading process. However, our loss estimate is based solely on a summary of unplanted croplands and reduced productions in planted croplands without modeling downstream effects on food production, supply-chain disruption, and health threats. Moreover, we employed NDVI data extracted from Sentinel-2 imagery as a measure of crop production. Despite its widespread usage, recent studies have shown its limited capacity in yield estimation compared to other vegetation indices⁴¹ or land-based measurements³¹, thereby potentially introducing additional uncertainties. Third, our analysis and associated results in this study represent the first year-round assessment of the conflict impacts on agricultural

production; however, since the military conflict continues, the cumulative effects from physical disruptions on agricultural production may be exacerbated, which requires time-series tracking and evaluation. Despite these inherent uncertainties, our approach enables a complete, in-depth, and precise evaluation of the damage to agriculture caused by the conflict and provides spatially explicit information on changes in agricultural production, which can be applied in various scenarios beyond the Russia-Ukraine conflict.”

Reviewer #3 (Remarks to the Author):

The authors state in the rebuttal that "In the revised manuscript, we have duly recognized and referenced prior work on this subject." Where? The Main Text section in the revised version is more or less identical to that of the original submission. On line 91, the authors still claim that this is the "first attempt" to map agricultural loss following the Russian invasion of Ukraine. As clearly described, communicated, and emphasized in the original review, there's a multitude of literature and sources tracking the impact of the invasion on agriculture -- all *still* unacknowledged by the manuscript in question. No edits have been made to address this issue. Please don't state you "have conscientiously addressed all raised concerns and made revisions" when you haven't.

> Thank you for taking the time to review our manuscript. We understand the significance of wording accurately and incorporating relevant sources, and we sincerely apologize for any oversight in this matter.

In the revised manuscript, we have thoroughly revised throughout the entire manuscript, removing imprecise statements such as the use of "first attempt". Additionally, in the Introduction section, we have incorporated previous studies that assess the agricultural impacts of the Russian-Ukraine conflict. These additions highlight the limitations present in the existing literature, and the duplicated text is as follows.

"Since its outbreak, several studies have endeavoured to assess the grain loss during the Russia-Ukraine war. Their estimates, albeit insightful, are limited to some extent given the following considerations. On the one hand, existing analyses of war-induced agricultural losses often hinge on descriptive approaches^{4, 21, 22} or hypothetical scenarios that make strong assumptions about the war's progression^{18, 19}. Carriquiry, Dumortier¹⁹, for example, projected an increased price of up to 4.6% and 7.2% for maize and wheat, respectively, assuming a 50% reduction in grain exports from Russia and no Ukrainian exports. Yet these assessments tend to be static and cannot capture the heterogeneities across space and time. On the other hand, earth observation

satellites have emerged as one of the most reliable and effective tools for delineating cropland distributions and monitoring agricultural activities during and after wartime^{24, 25}, and they have been recently utilized to quantify agricultural impacts of the Russia-Ukraine conflict^{23, 26, 27, 28, 29}. However, current research often focuses on a single crop, such as wheat^{23, 26}, or lacks a clear distinction between specific crop species^{27, 28, 29}. Furthermore, although previous research has demonstrated a significant decrease in Ukraine's crop production in 2022 compared to pre-war periods^{23, 27}, it remains unclear how much of the reduction is associated with conflict-related impact intensity.”

Another issue of the submission is the use of pixel-counting as means to area estimation. This issue was noted by other reviewers as well. The revised version presents estimates with uncertainty that (I assume) were estimated from the sample data. However, it appears that only the area of standing crop types at one a single point in time were estimated, whereas the results of the paper pertain to change in area. Why estimate the areas of standing standing crops if the conclusion of the paper is based on areas of change estimated by counting pixels in maps?

> Thank you so much for pointing out this issue. To enhance the clarity and coherence of our manuscript, we have now used sample-based estimation for all analyses presented in the Main text. As shown in Table R1, the total area of unplanted crops derived from samples ($16,956 \pm 2308 \text{ km}^2$, $18.11 \pm 2.47\%$) exceeded that of map-based estimation ($13,902 \text{ km}^2$, 14.85%), with variations observed across different crops and provinces. Building upon these findings, we proceeded to calculate the direct and indirect economic losses for the five eastern provinces in 2022 (Fig. R1 and Table R2). Consistent with our earlier observations from map area counting, the sample-based estimation indicated that indirect impacts surpassed direct impacts for all three crops. Specifically, indirect economic losses were $\$520.31 \pm 22.51$, $\$427.56 \pm 24.61$, and $\$206.72 \pm 11.63$ million, while direct economic losses were $\$395.85 \pm 60.55$, $\$202.31 \pm 67.11$, and $\$94.7 \pm 31.7$ million for wheat, sunflower, and rapeseed crops, respectively.

The manuscript has been revised to focus on the sample-based area estimation results, including planting change areas and the associated economic losses. In the Methods section, we outlined the methodologies employed for sample-based area estimation and economic loss calculation. We also replaced Table 1 with Table R1 and Fig. 2 with Fig. R1 in the Main text. Additionally, within the supplementary materials, Table S5 has been substituted with Table R2.

Table R1. Map-based and sample-based estimation of non-plating areas for wheat, sunflower, and rapeseed crops in the five eastern provinces of Ukraine in 2022.

Crop	Province	Map-based estimation		Sample-based estimation	
		Area (km ²)	Proportion (%)	Area (km ²)	Proportion (%)
Wheat	Crimea	1181	13.71	1350±740	15.67±8.59
	Donets'k	1448	16.32	2067±839	23.29±9.45
	Kherson	1812	20.52	2198±777	24.89±8.8
	Luhans'k	1626	25.95	1690±381	26.98±6.08
	Zaporizhzhya	2053	18.09	2415±680	21.28±5.99
	Total	8120	18.48	9688±1482	22.05±3.37
Sunflower	Crimea	635	20.13	1106±1251	35.07±39.66
	Donets'k	370	5.28	247±242	3.52±3.45
	Kherson	698	14.54	1382±1340	28.78±27.92
	Luhans'k	1032	12.63	1220±904	14.93±11.06
	Zaporizhzhya	672	8.23	1198±730	14.66±8.94
	Total	3407	10.88	4630±1536	14.79±4.91
Rapeseed	Crimea	504	20.17	504±0	20.17±0.0
	Donets'k	250	4.87	657±798	12.79±15.54
	Kherson	929	21.97	1123±380	26.56±9.0
	Luhans'k	247	8.34	185±121	6.25±4.08
	Zaporizhzhya	447	12.61	268±215	7.57±6.06
	Total	2375	12.93	2644±885	14.39±4.82
Total		13902	14.85	16956±2308	18.11±2.47

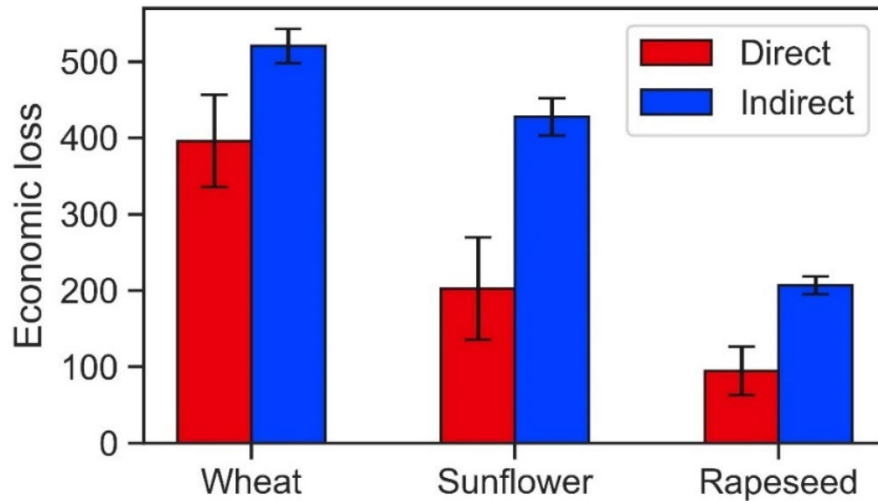


Fig. R1. Direct and indirect economic loss due to production change for wheat, sunflower, and rapeseed crops in the five eastern provinces of Ukraine in 2022. The direct impact signifies the economic loss caused by the inability to plant crops during the conflict, while the indirect impact refers to the economic loss of planted crops caused by reduced production. The areas of affected crops are calculated based on sample estimation, with error bars indicating the 95% confidence interval values. Unit: million USD.

Table R2. Direct and indirect economic loss due to production change for wheat, sunflower, and rapeseed crops in the five eastern provinces of Ukraine in 2022. Unit: million USD.

Province	Map-based estimation					
	Direct loss			Indirect loss		
	Wheat	Sunflower	Rapeseed	Wheat	Sunflower	Rapeseed
Crimea	48.26	27.75	18.05	101.93	32.34	20.46
Donets'k	59.17	16.17	8.96	135.50	103.42	68.83
Kherson	74.04	30.50	33.28	113.50	70.67	37.78
Luhans'k	66.44	45.09	8.85	68.13	122.18	40.56
Zaporizhzhya	83.89	29.36	16.01	125.24	117.68	40.55
Total	331.79	148.86	85.15	544.29	446.29	208.19
Province	Sample-based estimation					
	Direct loss			Indirect loss		
	Wheat	Sunflower	Rapeseed	Wheat	Sunflower	Rapeseed
Crimea	55.17±30.25	48.32±54.66	18.05±0.00	99.61±10.15	26.29±16.06	20.46±0.00
Donets'k	84.45±34.27	10.78±10.56	23.54±28.59	124.21±15.31	105.34±3.76	63.10±11.24
Kherson	89.82±31.74	60.37±58.55	40.23±13.63	107.26±12.56	58.89±23.09	35.56±4.36
Luhans'k	69.06±15.57	53.32±39.48	6.64±4.34	67.19±5.59	118.96±15.46	41.48±1.81
Zaporizhzhya	98.68±27.77	52.34±31.91	9.61±7.69	120.36±9.16	109.43±11.46	42.89±2.81
Total	395.85±60.55	202.31±67.11	94.7±31.7	520.31±22.51	427.56±24.61	206.72±11.63

Further, how were areas estimated? How was the sample data collected? The following line in the rebuttal, "expanded our crop sample set by collecting a total of one thousand validation points, with 200 samples [sic] allocated for each crop type," suggests stratified sampling. If so, the strata weights need to be accounted for in the estimators. It is unclear which estimators that were used.

> Thank you for your comment. We appreciate the opportunity to clarify our approach for estimating area with samples. Let n_{ij} represents the sample count at cell (i, j) in the confusion matrix ($q \times q$). The stratified estimator of the area for class k is calculated as:

$$\hat{A}_k = A \times \sum_{i=1}^q W_i \frac{n_{i,k}}{N_i}$$

where A is the total map area, W_i is the proportion of area mapped as class i , and N_i is the summation for the i -th row in the confusion matrix (i.e., the number of samples mapped as class i , $N_i = \sum_{j=1}^q n_{i,j}$).

The standard error of the estimated area is given by:

$$S(\hat{A}_k) = A \times \sqrt{\sum_{i=1}^q W_i^2 \left[\frac{n_{i,k}}{N_i} \left(1 - \frac{n_{i,k}}{N_i} \right) \right] / (N_i - 1)}$$

An approximate 95% confidence interval (CI) of the sample-based area is obtained as $\hat{A}_k \pm 1.96 \times S(\hat{A}_k)$.

Indeed, we used stratified sampling into our estimator, guided by the “good practice” recommendations (Olofsson et al. 2014) that “Stratified random sampling is a practical design that satisfies the basic accuracy assessment objectives and most of the desirable design criteria. Stratified random sampling affords the option to increase the sample size in classes that occupy a small proportion of area to reduce the standard errors of the class-specific accuracy estimates for these rare classes” (Section 2.2).

To ensure the reliability of our results, in this round, we conducted a thorough review of all the validation samples for both the crop map and the planting condition map. Samples with relatively low confidence, such as disagreement between researchers and cloud obscuration, were discarded. In the end, we retained 954 and 472 validation

samples for the crop map and the planting condition map, respectively. The associated confusion matrices can be found in Tables R3-4.

In the Methods section of the revised manuscript, we have incorporated the above specifics on map accuracy assessment and sample-based area estimation. In the supplementary materials, we replaced Table S1 with Table R3 and Table S3 with Table R4.

Table R3. Confusion matrix for the produced 10-m crop type map in Ukraine. Labels from 01 to 05 represent wheat, sunflower, rapeseed, other, and maize, respectively. UA: user’s accuracy. PA: producer’s accuracy.

	Reference							UA	PA
Map		01	02	03	04	05	Total		
	01	187	5	7	9	0	208	89.90%	93.50%
	02	1	170	10	5	4	190	89.47%	89.01%
	03	8	3	152	3	1	167	91.02%	82.16%
	04	1	5	6	161	1	174	92.53%	87.03%
	05	3	8	10	7	187	215	86.98%	96.89%
	Total	200	191	185	185	193	954		
	Overall accuracy: 89.83%; Kappa coefficient: 0.87								

Table R4. Confusion matrix for the generated planting condition map for the five eastern provinces in Ukraine. UA: user’s accuracy. PA: producer’s accuracy.

	Reference				UA	PA
Map		Unplanted	Planted	Total		
	Unplanted	137	24	161	85.09%	87.26%
	Planted	20	291	311	93.57%	92.38%
	Total	157	315	472		
	Overall accuracy: 90.68%; Kappa coefficient: 0.79					

4th Apr 24

Dear Professor Lin,

Your manuscript titled "Assessing Impacts of the Russia-Ukraine Conflict on Agricultural Production using Publicly Available Satellite Imagery" has now been seen by our reviewers, whose comments appear below. In light of their advice we are delighted to say that we are happy, in principle, to publish a suitably revised version in Communications Earth & Environment under the open access CC BY license (Creative Commons Attribution v4.0 International License).

We therefore invite you to comply with our format requirements and to maximise the accessibility and therefore the impact of your work.

EDITORIAL REQUESTS:

Please review our specific editorial comments and requests regarding your manuscript in the attached "Editorial Requests Table".

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Best regards,

Martina Grecequet, PhD
Associate Editor,
Communications Earth & Environment

REVIEWERS' COMMENTS:

Reviewer #1 (Remarks to the Author):

The authors have now addressed my concerns and I appreciate their efforts in improving this manuscript. As such, I recommend it for publication in Communication Earth & Environment.

Reviewer #2 (Remarks to the Author):

This revision is good to me.

Response letter

Your manuscript titled "Assessing Impacts of the Russia-Ukraine Conflict on Agricultural Production using Publicly Available Satellite Imagery" has now been seen by our reviewers, whose comments appear below. In light of their advice we are delighted to say that we are happy, in principle, to publish a suitably revised version in Communications Earth & Environment under the open access CC BY license (Creative Commons Attribution v4.0 International License).

- Thank you very much for you and the reviewers' constructive comments and suggestions over the past two rounds, which are very helpful to enhance this study.

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- We have carefully checked the editorial requests table and made revisions accordingly. The term issues regarding Russia-Ukraine war have been double checked throughout the entire manuscript.

Reviewer #1 (Remarks to the Author):

The authors have now addressed my concerns and I appreciate their efforts in improving this manuscript. As such, I recommend it for publication in Communication Earth & Environment.

- Thank you very much for your constructive comments and suggestions on this work.

Reviewer #2 (Remarks to the Author):

This revision is good to me.

- Thank you.