Supplement

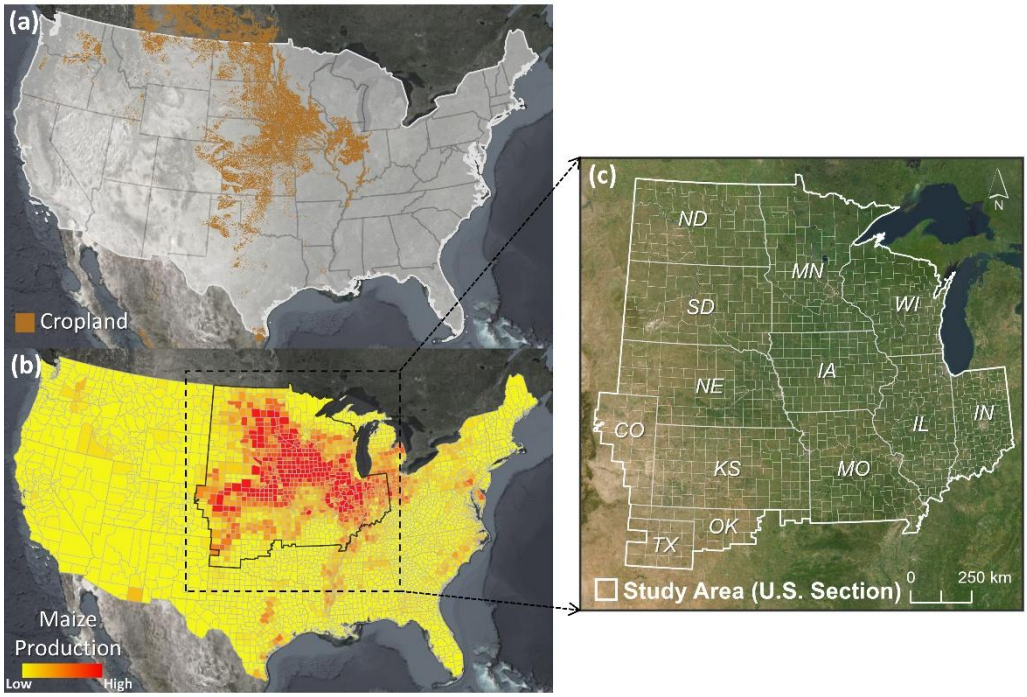

Fig.S1 Process of delineating the boundary of the U.S. Midwest Mollisol region. (a) Distribution of cropland within Mollisols, obtained by masking cropland from the ESA WorldCover 2020 dataset (Zanaga et al., 2021) with the Mollisol extent derived from the USDA soil database. (b) County-level maize production (corn for grain) in 2022, based on USDA/NASS statistics; the dashed rectangle indicates the region enlarged in panel (c). (c) Final county-based study area delineated by maximizing the inclusion of the spatially contiguous core of Mollisol cropland and high maize production while excluding isolated peripheral patches. The resulting study area comprises 943 counties across 13 states. State abbreviations: CO, Colorado; IA, Iowa; IL, Illinois; IN, Indiana; KS, Kansas; MN, Minnesota; MO, Missouri; ND, North Dakota; NE, Nebraska; OK, Oklahoma; SD, South Dakota; TX, Texas; and WI, Wisconsin.

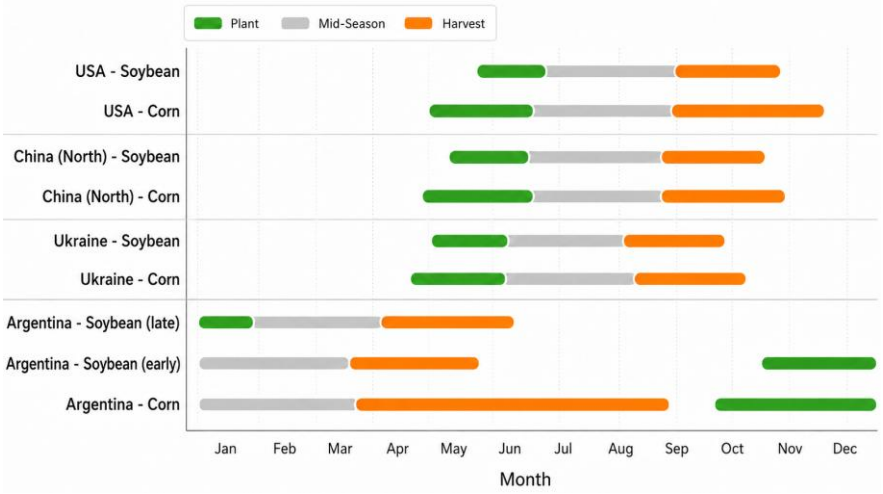

Fig.S2 Crop calendar of dominated crops across the study area.

855

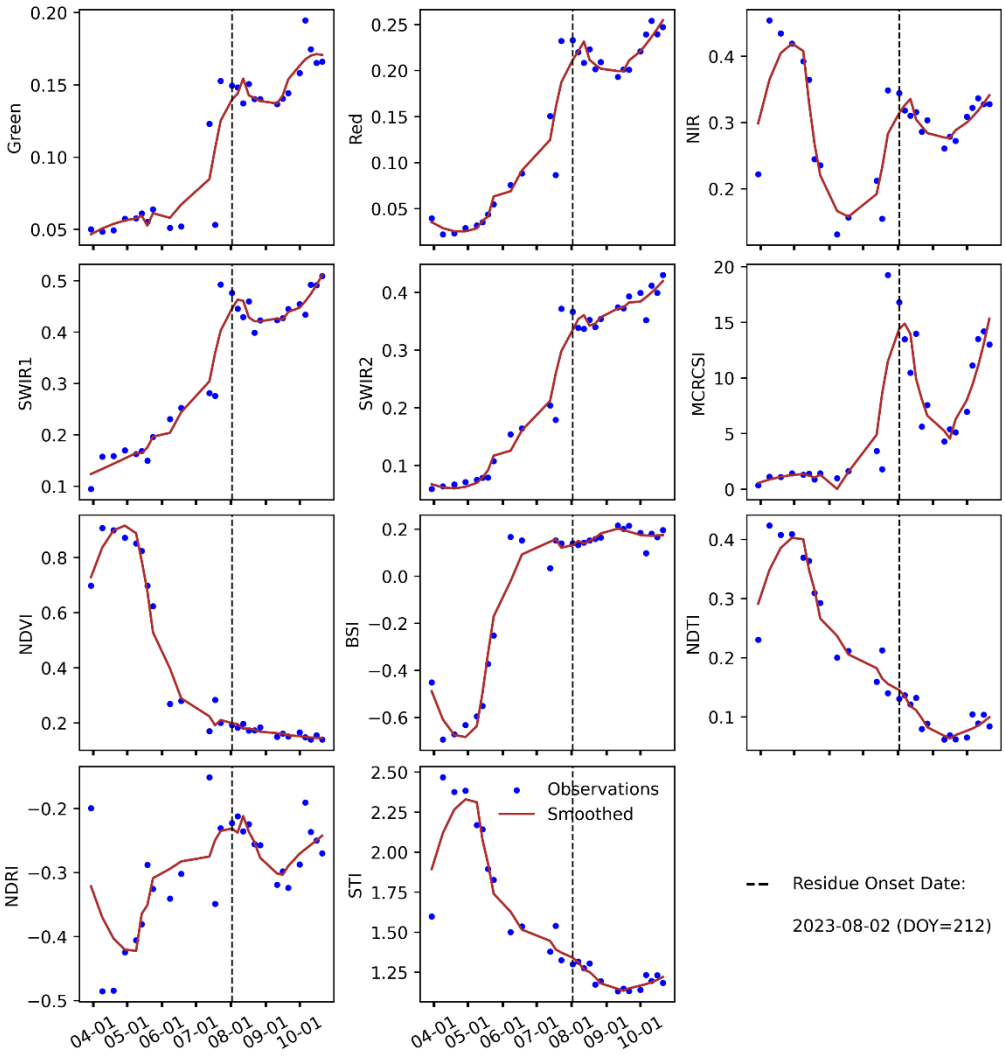

Fig.S3 Sentinel-2 time series of residue during the 2024 non-growing season in Argentine Pampas

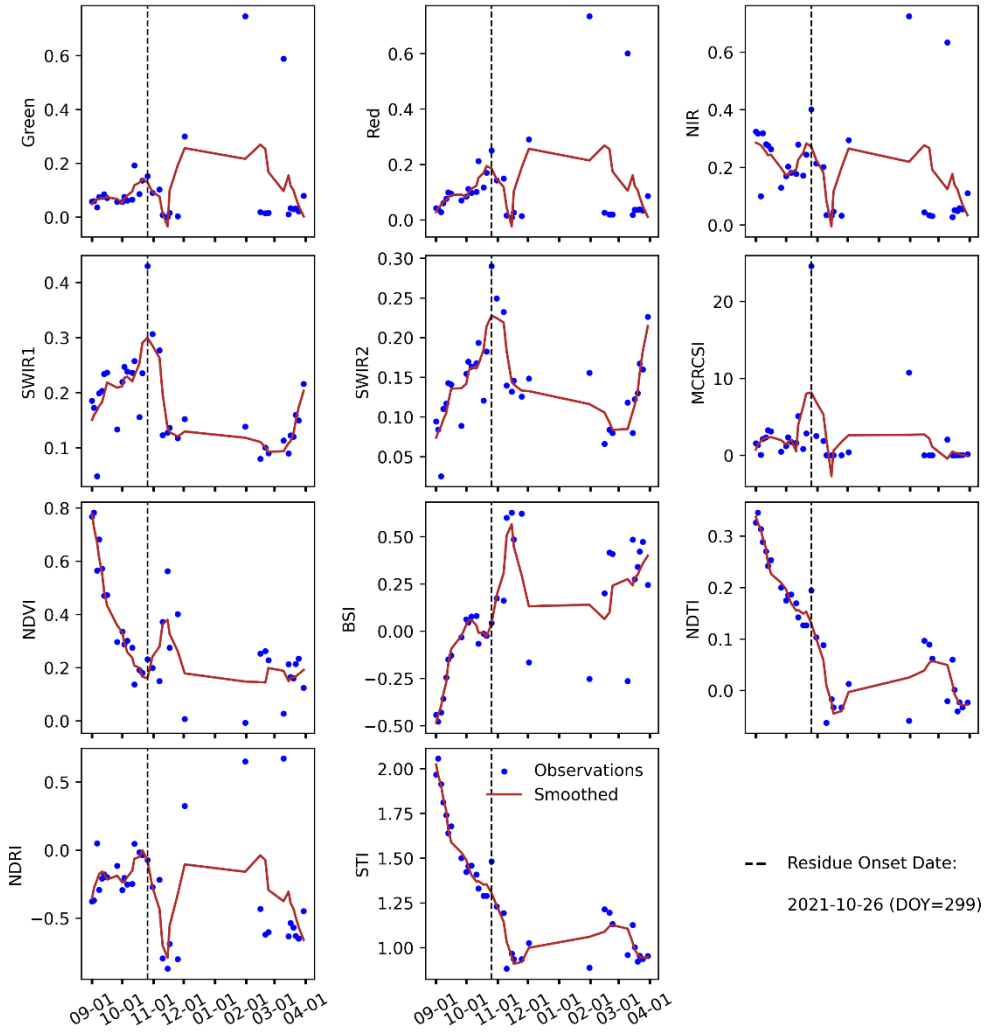

Fig.S4 Sentinel-2 time series of residue during the 2024 non-growing season in Ukraine

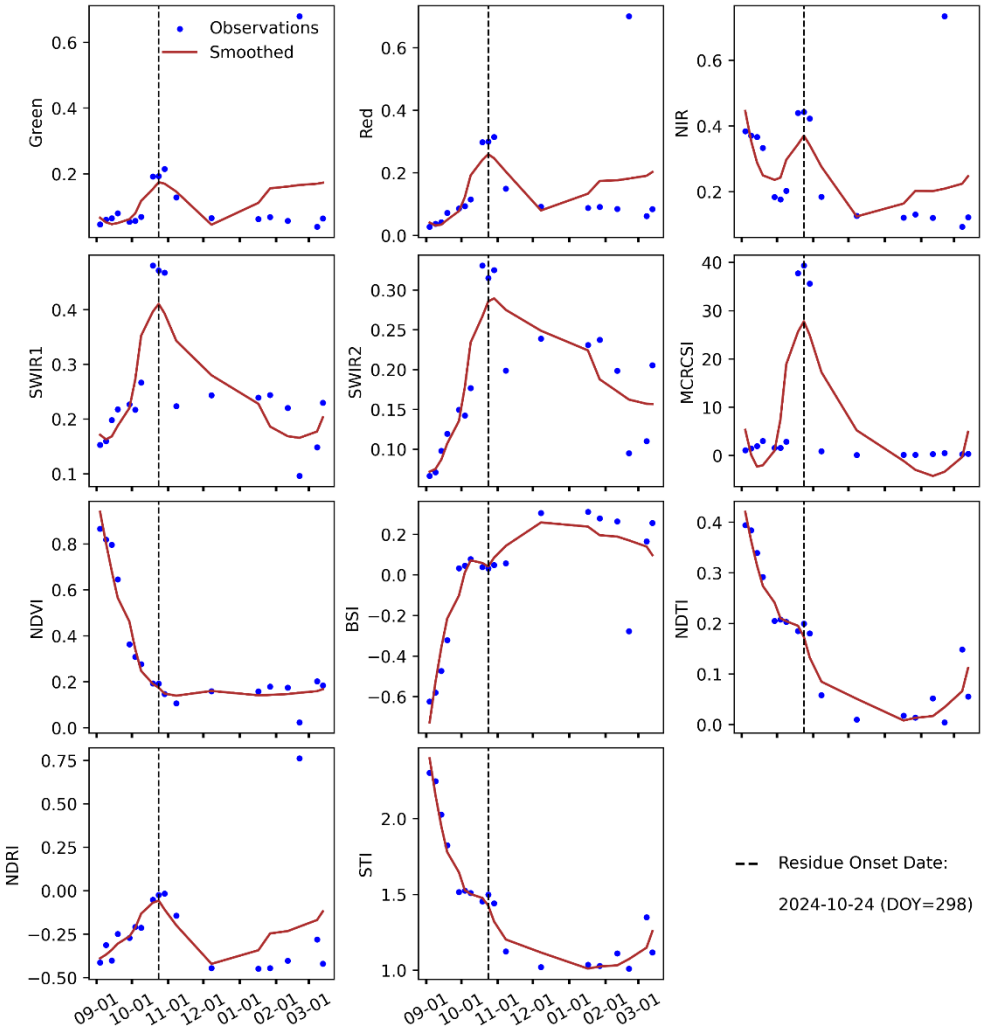

Fig.S5 Sentinel-2 time series of residue during the 2024 non-growing season in U.S. Midwest

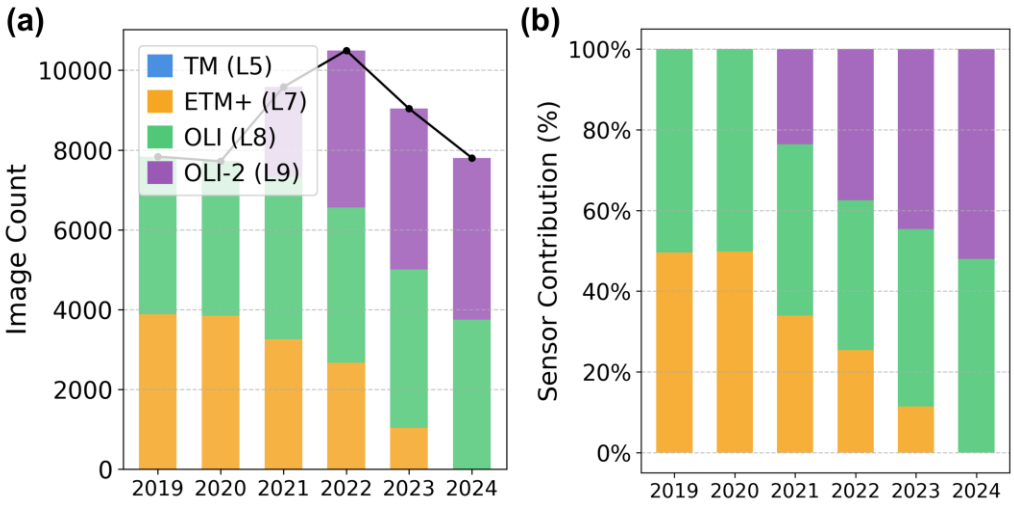

Fig.S6 Available images from Landsat-series from 2019 to 2024

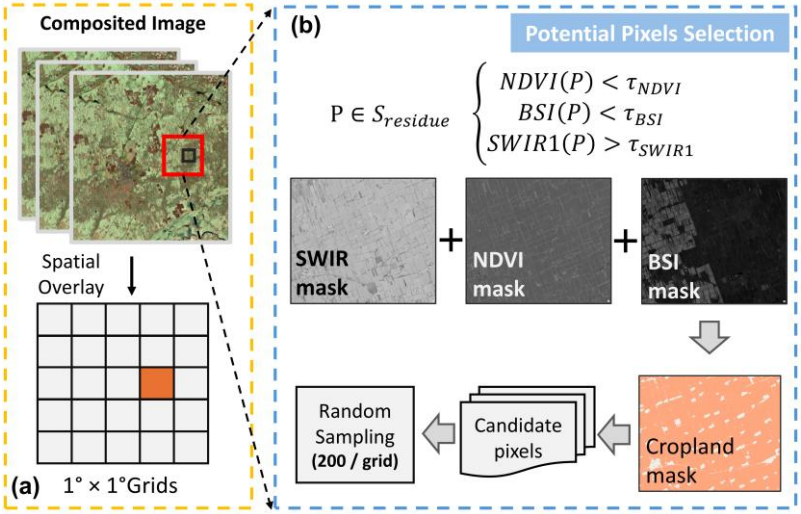

Fig.S7 Processing of potential residue pixels selection.

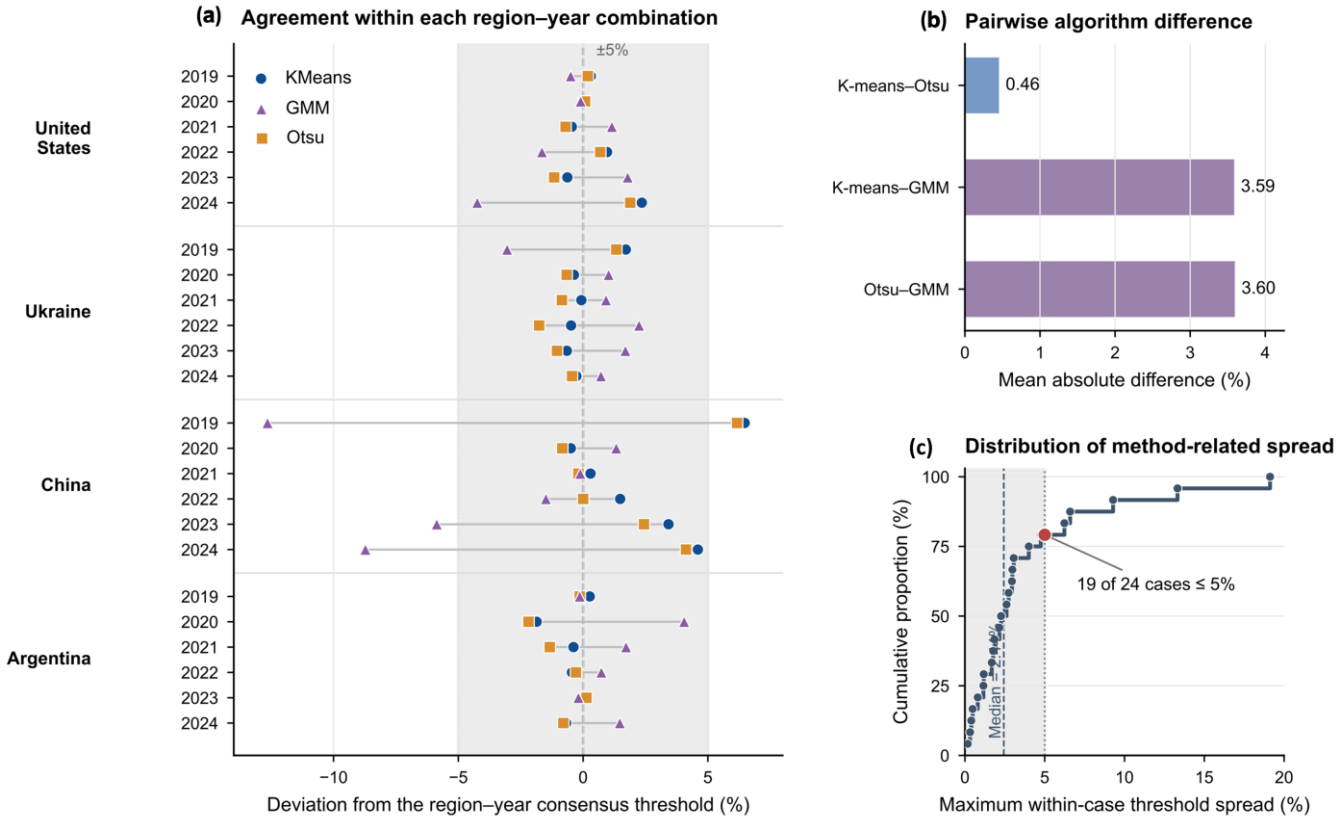

Fig.S8 Sensitivity of thresholds to algorithm choice. a, Method-specific thresholds are expressed as percentage deviations from the arithmetic mean of the K-means, Otsu, and GMM thresholds for each region–year combination. Horizontal lines connect the minimum and maximum deviations, while the shaded region denotes a descriptive ±5% interval rather than a confidence interval. b, Mean absolute pairwise threshold differences across the 24 region–year combinations. c, Empirical cumulative distribution of the maximum relative threshold spread within each combination. The median maximum spread was 2.44%, and 19 of 24 combinations exhibited a spread of no more than 5%, indicating that threshold estimation was generally insensitive to algorithm choice.

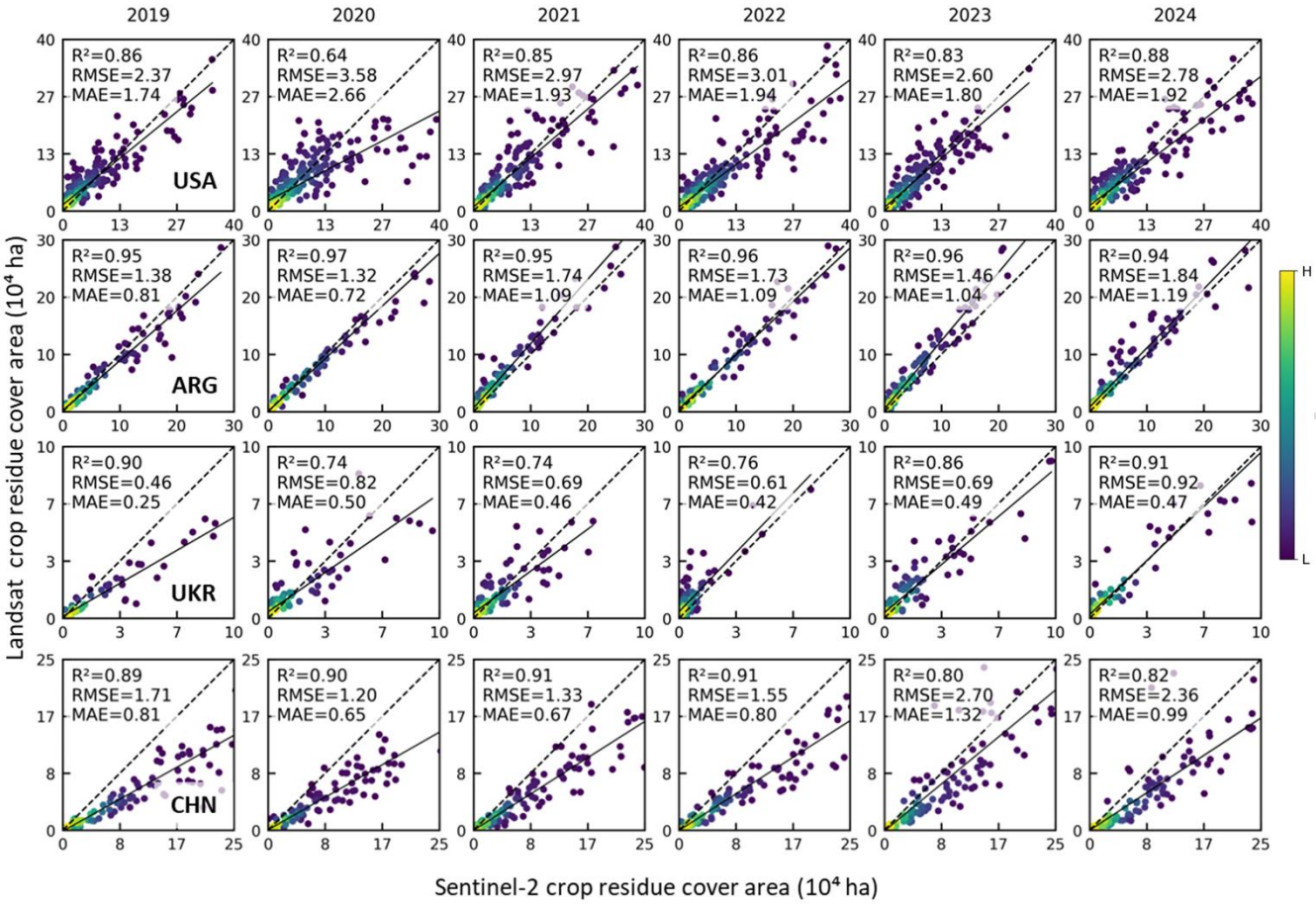

Fig.S9 Comparison of Sentinel-2 and Landsat derived datasets for the same years (2019-2024)

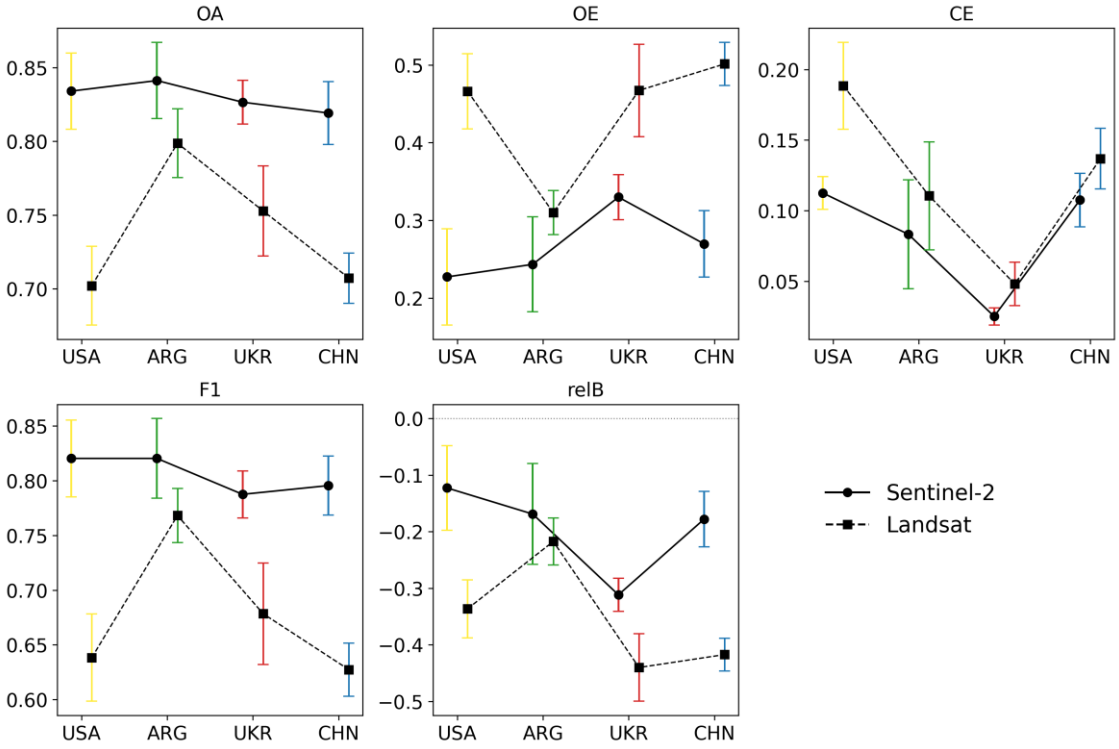

Fig.S10 Accuracy assessment comparison of Sentinel-2 and Landsat derived datasets

Table S1 Spectral information of Landsat series and Sentinel-2 satellite used in the study

Satellite sensor	Band #	Central wavelength(nm)	Wavelength Range (nm)
Landsat 5/7/8/9	B3-Red	660	630 – 690
	B4-NIR	830	760 – 900
	B5-SWIR1	1650	1550 – 1750
	B7-SWIR1	2155	2080 – 2350
	B3-Red	660	630 – 690
	B4-NIR	835	770 – 900
	B5-SWIR1	1650	1550 – 1750
	B7-SWIR1	2155	2080 – 2350
Sentinel-2	B4-Red	655	640 – 670
	B5-NIR	865	850 – 880
	B6-SWIR1	1610	1570 – 1650
	B7-SWIR2	2200	2110 – 2290
	B4-Red	665	649 – 680
	B8A-Narrow NIR	865	854 – 875
	B11-SWIR1	1610	1568 – 1659
	B12-SWIR2	2190	– 2289

885

Table S2 Available Sentinel-2 MSI images (cloud probability threshold = 0.9)

Region	Year	Period	Image Count
Northeast China	2019	09-10 to 02-25 (Next year)	14194
	2020		13898
	2021		13971
	2022		14216
	2023		14116
	2024		14287
U.S. Midwest	2019	09-10 to 02-28 (Next year)	18513
	2020		18608
	2021		18641
	2022		18634
	2023		18623
	2024		18513
Ukraine	2019	09-10 to 02-25 (Next year)	7770
	2020		7839
	2021		7682
	2022		7770
	2023		7829
	2024		7990
Argentine Pampas	2019	03-30 to 10-30	11302
	2020		11131
	2021		11430
	2022		11224
	2023		11260
	2024		11206

890 **Table S3** Cross-sensor surface reflectance (SR) transformations based on Ordinary Least Squares (OLS) regression

Band#	TM/ETM+ to OLI	OLI to MSI
Red	OLI = 0.0061+0.9047×ETM+	MSI = 1.0058×OLI+0.0001
NIR	OLI = 0.0412+0.8462×ETM+	MSI = 0.9796×OLI+0.0069
SWIR1	OLI = 0.0254+0.8937×ETM+	MSI = 1.0136×OLI+0.0073
SWIR2	OLI = 0.0172+0.9071×ETM+	MSI = 1.0044×OLI+0.0051

Table S4 Crop maps used in this study

Crop type maps	Period	Spatial Resolution(m）	Reference
Northeast China Crop Maps	2019-2023, yearly	10	You et al. (2021)
USDA-NASS Crop Data Layer	2019-2024, yearly	30	Boryan et al. (2011)
Ukraine Crop Maps	2020	10	Chen et al. (2024)
Argentina Map of National Crops	2018-2024, yearly	30	De Abelleyra et al. (2024)

Table S5 Accuracy assessment comparison of Sentinel-2 and Landsat derived maps

Product	OA	F1	OE	CE	relB
Sentinel-2-based maps	0.83	0.806	0.268	0.082	-0.195
Landsat-based maps	0.74	0.678	0.436	0.121	-0.353
Difference, S2 - LS	0.09	0.128	-0.168	-0.039	0.158