A Decade of Wheat Mapping for Lebanon

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Motivation

Food Security

Wheat provides nearly 20% of global calories, crucial for nutrition

Accurate Mapping

Precise field mapping supports better crop monitoring and policy

Focus on Lebanon

Assessing wheat dynamics over ten years informs local agriculture

Problem Statement

Segmentation Challenges

Remote sensing often leads to poor field delineation and merged boundaries

Prediction Noise

Models struggle with noisy outputs causing unreliable field maps

Traditional Model Limits

Under- and over-segmentation reduce accuracy in wheat mapping

Our Contribution

Accurate Parcel-Level Wheat Mapping

Use precise field delineation to improve wheat mapping results

Refined Post-Processing

A set of post-processing steps to improve field delineation results

A Decade Long Analysis of Wheat Mapping in Lebanon

A comprehensive case study evaluating wheat field trends over a ten-year period, with actionable statistics for policy makers and stakeholders to act on

Previous Work

Crop Segmentation

- 3D U-Net, ConvLSTM, and temporal attention CNNs used with Sentinel-1/2 and Planet imagery
- Temporal-Spatial Transformers outperform prior models on datasets like PASTIS
- Standard methods use ~70 images/year → high memory usage
- Others achieved strong results with only 12 images/year using an efficient pipeline

Field Delineation

- Early work used UNet with Sentinel-2 as a baseline for field delineation
- Models performed well in France but struggled in India due to smaller field sizes
- Recent studies show weakly supervised learning improves delineation, especially with limited data

We build on these foundations using TSViT trained on PASTIS, fine-tuned with PEFT for wheat segmentation using time-series Sentinel-2 data and incorporated ftw-basline model for field delineation

Proposed Methodology

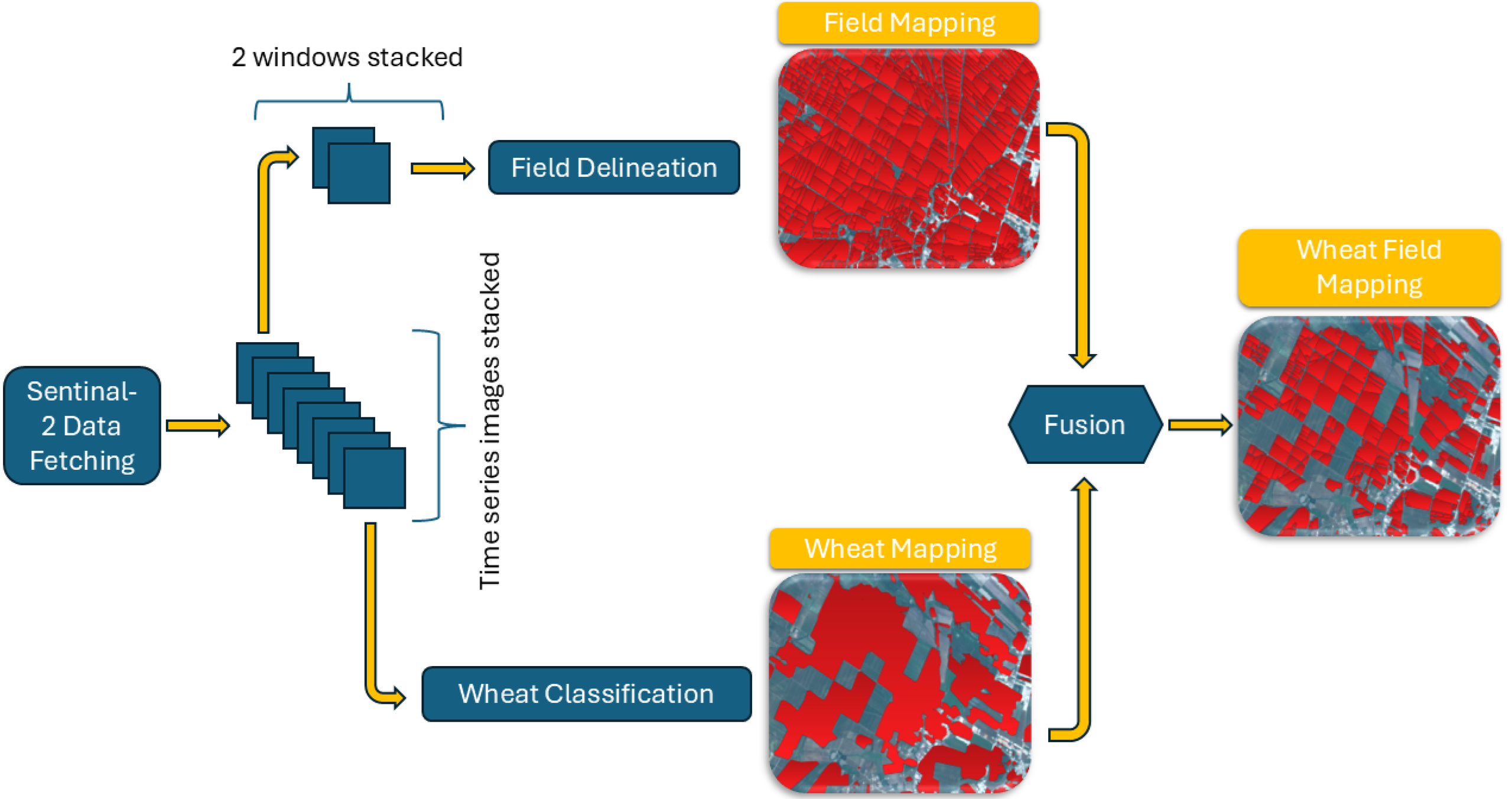
Sentinel-2 Data Fetcher: Automatically retrieves and preprocesses multi-temporal Sentinel-2 imagery to prepare input for both segmentation models

Wheat Classification: Uses a full-season time-series stack to generate a mask highlighting regions classified as winter wheat

Field Delineation : Applies a model to paired image windows to detect individual field boundaries, enhanced through post-processing

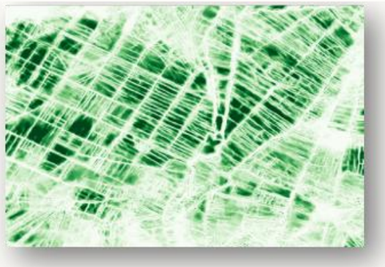
Fusion Module: Aligns wheat classification results with delineated fields, labeling a field as wheat if over 50% of its area is covered by wheat pixels

Noise Filtering and Regularization: Removes small fields and smooths geometries using the Ramer-Douglas-Peucker algorithm to produce a clean, field-accurate wheat map

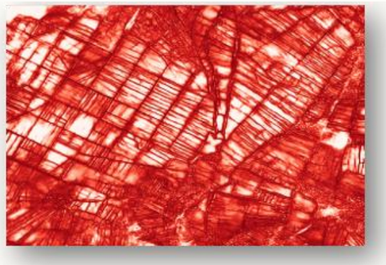


https://geogroup.ai/publication/2025earthsense_wheatdecade/figure1decadewheat

Fields Mask

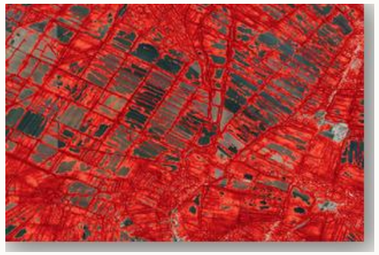


Boundaries Mask



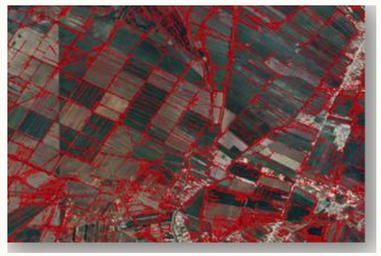
Threshold at 0.5

Threshold at 0.5

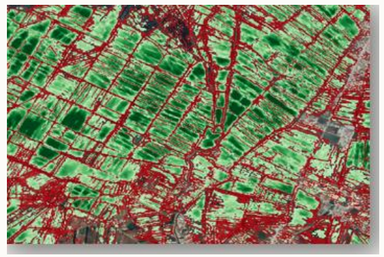


Threshold at 0.2

Threshold at 0.8



Gradual Thresholding



Watershed

Enhanced Post-Processing

Gradual Thresholding

Soft classification thresholds replace hard argmax decisions

Watershed Segmentation

Separates adjacent fields into distinct instances effectively

Improved Boundary Accuracy

Reduces field merging and enhances delineation precision

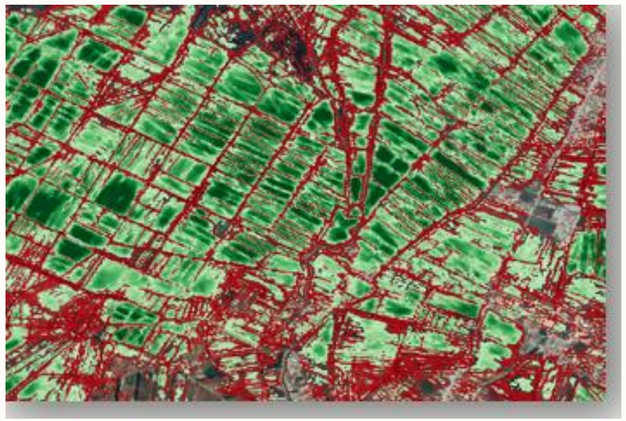
ArgMax vs. Gradual Thresholding

ArgMax Approach

- Assigns each pixel to the most confident class.
- Tends to under segment fields—merging distinct areas.

Gradual Thresholding

- Applies confidence-based thresholds progressively.
- Preserves field diversity and boundaries more effectively.



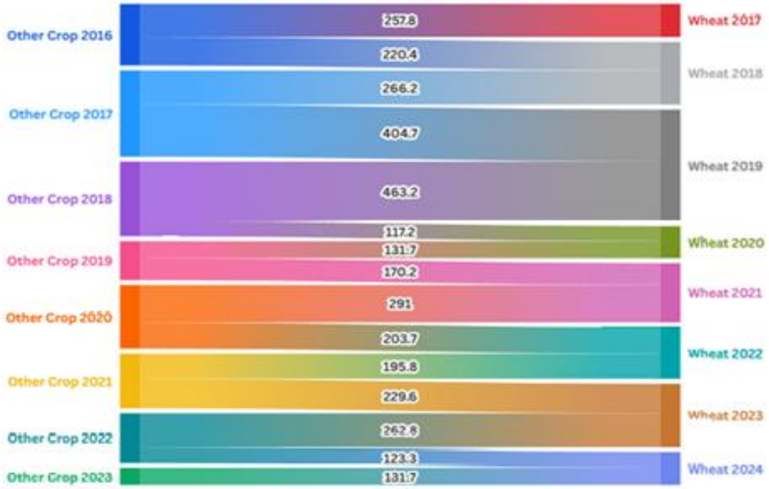
Conclusion: Gradual thresholding offers superior delineation by handling uncertainty more flexibly than ArgMax

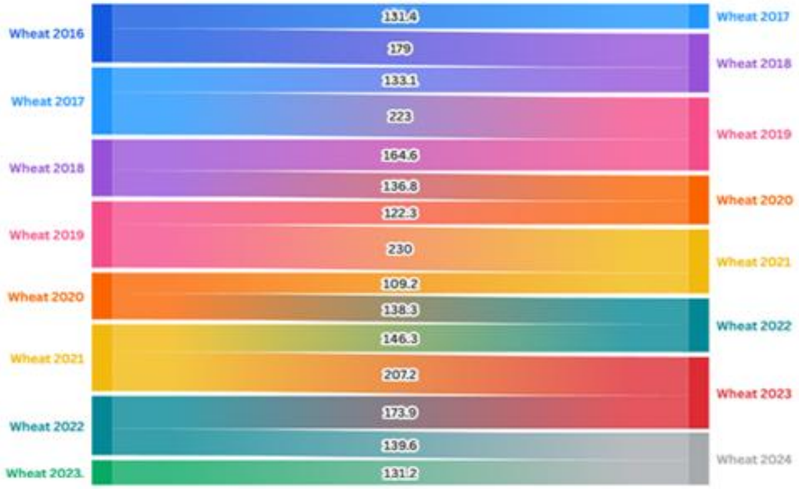
Performance Metrics

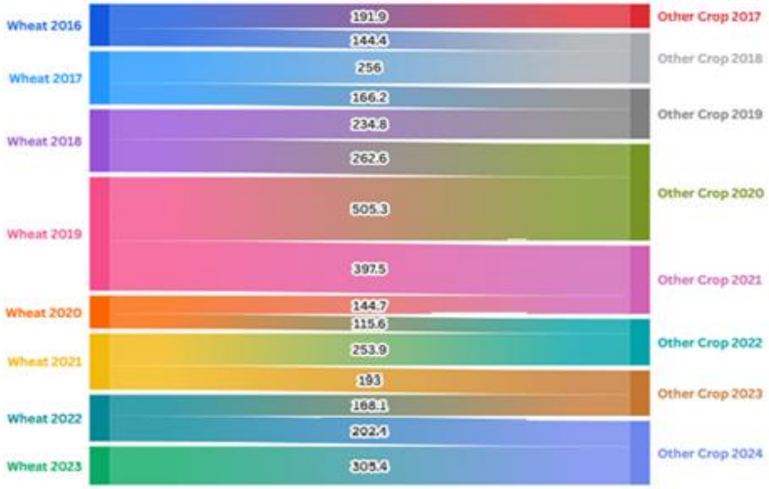
Metric	Argmax	Gradual Thresholding
F1-score	0.78	0.85
IoU	0.70	0.80
Precision	0.75	0.83
Recall	0.81	0.87

Results : Lebanon Wheat Map

Year	Wheat Fields (km^2)	Number of Fields	Vast Wheat Areas (km ^2)
2016	247.6	15,691	75.6
2017	252.4	12,327	136.8
2018	241.9	15,635	157.4
2019	365.6	20,914	262.1
2020	203.0	12,113	50.9
2021	283.8	16,805	116.4
2022	263.1	15,049	78.9
2023	315.2	17,867	121.5
2024	199.1	11,638	63.7







Sankey Diagrams

Crop Transition

Flows from other crops to wheat show conversion trends

Persistence

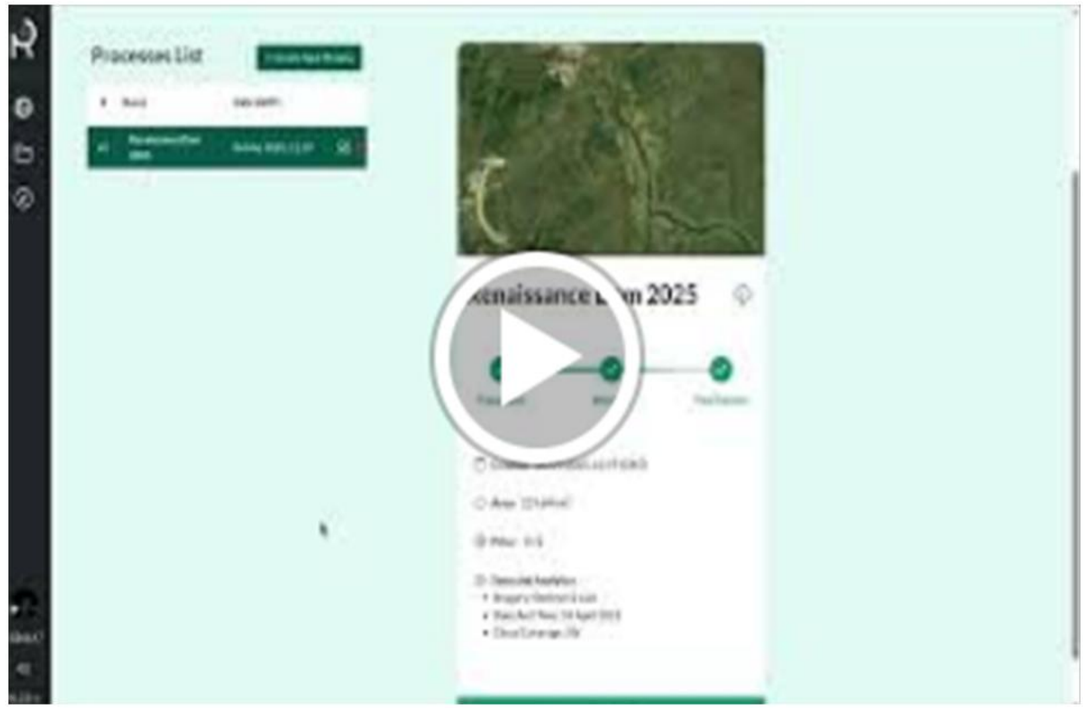
Wheat fields’ persistence over years signifies stable cultivation

Abandonment

Wheat to other crops reflects regional land use changes

RASID SaaS

- Link: https://app.rasid.ai/ (Claim your 10 euros credits now!)
  - Intuitive interface for geospatial experts to effortlessly access automated AI-powered services.
  - Single-click AI analysis without coding.
  - Higher added value at a competitive cost.



- Field Delineation Demo Video (1:08min): [YouTube]
- Sentinel-1 SAR Fetcher Demo Video (1:13 min): [YouTube]
- Buildings' Detection Demo Video (1:12 min): [YouTube]

- Sentinel-2 Spectral Analytics Demo Video (1:40 min): [YouTube]
- Scene Parsing Teaser Video (1:25 min): [YouTube]

Future Work and Discussion

Breed Classification

Develop methods to distinguish between durum and soft wheat parcels to reflect yield variations by wheat type.

Irrigation Detection

Incorporate classification of rainfed vs irrigated fields using satellite and ancillary data for improved productivity estimates.

Yield Estimation Accuracy

Integrate crop type and irrigation labels into the pipeline to enhance the precision of national wheat yield assessments.

THANK YOU

Q & A