Feasibility of using Sentinel-1 radar data for crop classification

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Introduction

Over the past decade, remote sensing techniques have evolved to play an important role in today's agricultural practice. Concerns over food security and production efficiency have contributed to the need for accurate, extensive and readily available information on crop characteristics and land cover. Space-borne platforms can help to fulfil these demands, and a common practice is to use optical satellite imagery for agricultural applications. However, one of the main concerns with optical data is the impact cloud and weather conditions have on an image's quality. In many cases, a satellite (such as Landsat-8) can return weeks of unusable imagery (due to high levels of cloud cover). Due to this reason, the use of radar imagery is an inviting prospect, thanks to its ability to penetrate cloud cover and remove the influence of weather conditions. For areas like the UK, radar data can provide an important substitute to optical data.

Aim

- To determine whether the addition of Sentinel-1 radar data improves an optical-based crop classification

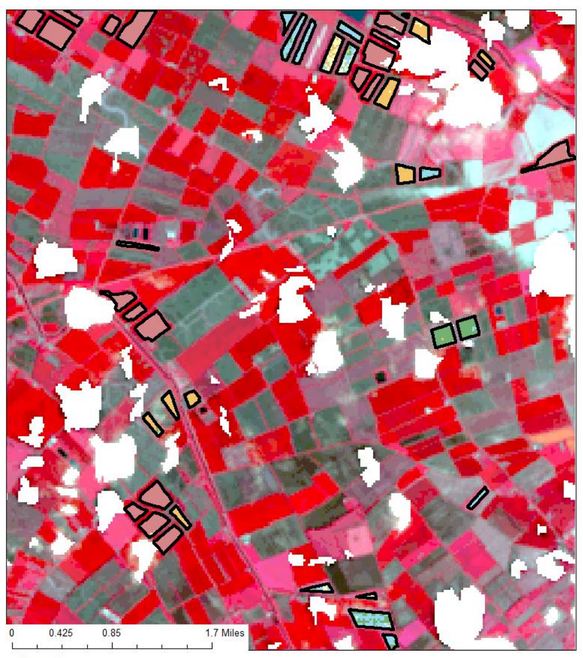
Objectives

- Conduct a supervised crop classification for a Landsat-8 image, investigating five crop types: celery, gem lettuce, iceberg lettuce, maize, and wheat
- Conduct supervised classifications for 3 Sentinel-1 dates, and determine the influence of polarisation on radar crop classification
- Investigate methods of data fusion in order to determine whether the addition of radar data improves the accuracy of an optical-based crop classification

Methodology

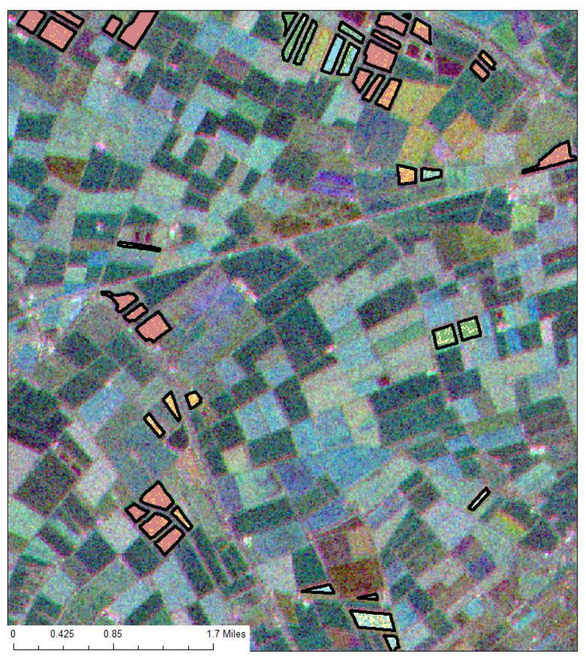
- Optical imagery (from 27th May 2015) was obtained from the USGS and image pre-processing techniques were used (such as rescaling, layer stacking, and cloud masking)
- Radar imagery (for 27th May, 16th June, 2nd July 2015) were obtained from the Sentinel-1 Data Hub and data processing techniques were employed (including rescaling, terrain correction, and data separation and fusion)
- A number of data fusion techniques were tested: including RGB to IHS to RGB, and resolution merge (PCA)
- Training and validation data were created from the G's field database provided by G's Fresh. The total number of fields for each crop were: Celery = 11, Gem = 10, Iceberg = 19, Maize = 12, Wheat = 25. The fields for each crop were separated into training and validation data at a ratio of 70:30. In addition, a field visit was undertaken in order to cross validate the field information

Results



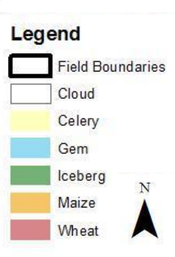
Landsat multispectral image & supervised classification (subset of study AOI)

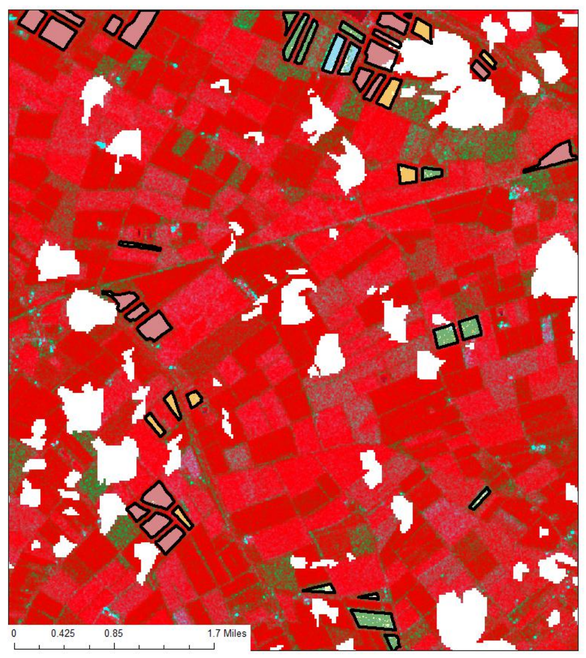
Crop	Producer Accuracy	User Accuracy
Celery	18.18%	26.09%
Gem	13.21%	13.21%
Iceberg	35.53%	38.57%
Maize	60.00%	45.00%
Wheat	94.06%	98.86%
Overall Accuracy: 52.94%		



Radar (VV) multi-temporal image & supervised classification (subset of study AOI)

Crop	Producer Accuracy	User Accuracy
Celery	33.33%	11.96%
Gem	18.87%	31.25%
Iceberg	34.21%	66.67%
Maize	45.76%	48.21%
Wheat	88.24%	86.54%
Overall Accuracy: 50.77%		





Landsat & Radar (VV) combined image & supervised classification (subset of study AOI)

Crop	Producer Accuracy	User Accuracy
Celery	12.12%	20.00%
Gem	5.66%	42.86%
Iceberg	92.11%	52.63%
Maize	53.33%	48.48%
Wheat	95.05%	98.87%
Overall Accuracy: 63.47%		

Discussion

The supervised crop classification of the single Landsat 8 optical image provided a poor overall accuracy of 52.94%. However, both the user and producer accuracy for wheat were 98.86% and 94.06% respectively. It is hypothesised that this high percentage is due to the continuous nature of wheat fields (compared to vegetable fields), alongside the 30m resolution of Landsat-8. Furthermore, during the projects time span, only a single date (27th May) had below 20% cloud coverage. With an additional date or two, allowing for a multi-temporal optical classification, the overall accuracy and individual crop accuracies would likely be improved.

From the 3 multi-temporal radar images classified, VV was found to have the best overall accuracy of 50.77%; with VH at 34.06% and VHVV at 45.20%. A possible influence on the VV images higher accuracy levels is the NW path taken by Sentinel-1. From the fields with a known row direction, a total of 42% are planted in a NW direction.

Amongst the image fusion methods tested, the RGB-IHS-RGB process (using the VV radar image alongside the Landsat-8 image) found an overall accuracy of 63.47%. Notable increases in accuracy were found for iceberg and gem lettuce. The addition of the radar's polarisation with the optical image bands aided this increase.

Conclusion

- The addition of Sentinel-1 radar data improves the overall accuracy of an optical-based classification by 10%
- A single optical image classification possesses a high accuracy level for wheat, but poor levels for the 4 other crops investigated
- VV polarisation has the highest overall classification accuracy of the three polarisations tested (VV, VH, and VHVV)
- However, a limitation of these findings is the small field sample size used. Increasing the sample size of the fields would improve the integrity of the findings
- Nevertheless, it is feasible to use Sentinel-1 for crop classifications, especially as a substitute for when a multi-temporal optical image is unattainable

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