Automated Agricultural Field Extraction from Multi-temporal Web Enabled Landsat Data

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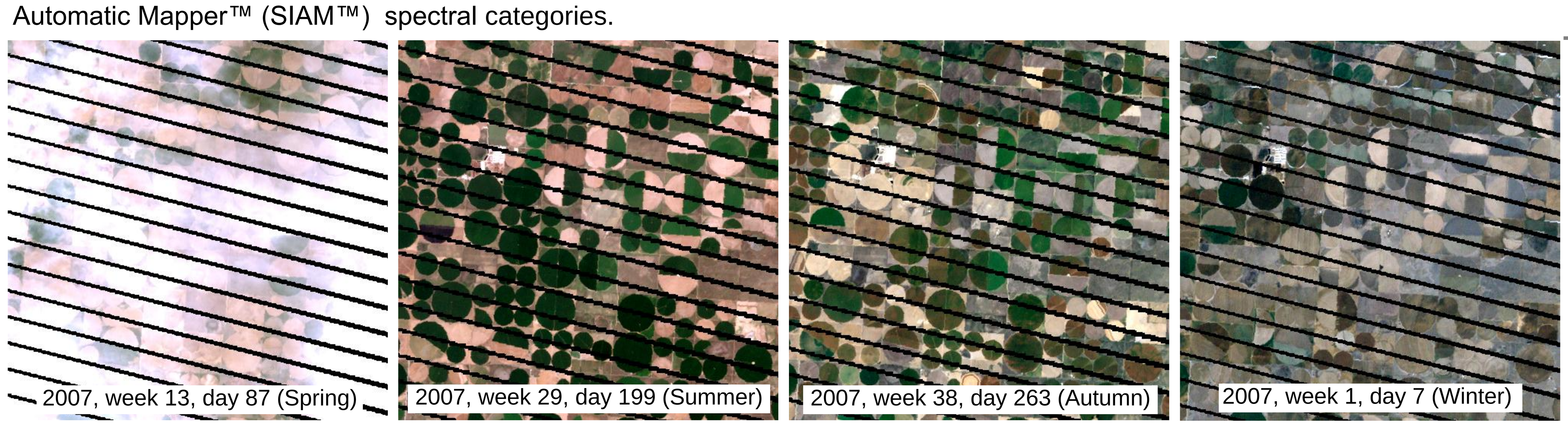
This poster presents preliminary research to develop and validate an automated computational methodology to extract agricultural field boundaries and derive field sizes from multi-annual weekly 30m Web Enabled Landsat Data (WELD) (http://weld.cr.usgs.gov) with the aim of applying the algorithm to conterminous United States WELD data on a decadal basis.

Commercial software can be used to extract fields from satellite data (see sister poster: White and Roy) but are inappropriate for large area application because they require considerable human interaction. A prototype automated agricultural field object extraction methodology has been developed using a Geographic Object Based Image Analysis (GEOBIA) approach applied to multi-temporal WELD data. Results shown are generated from 5 years (2006 to 2010) of weekly WELD data.

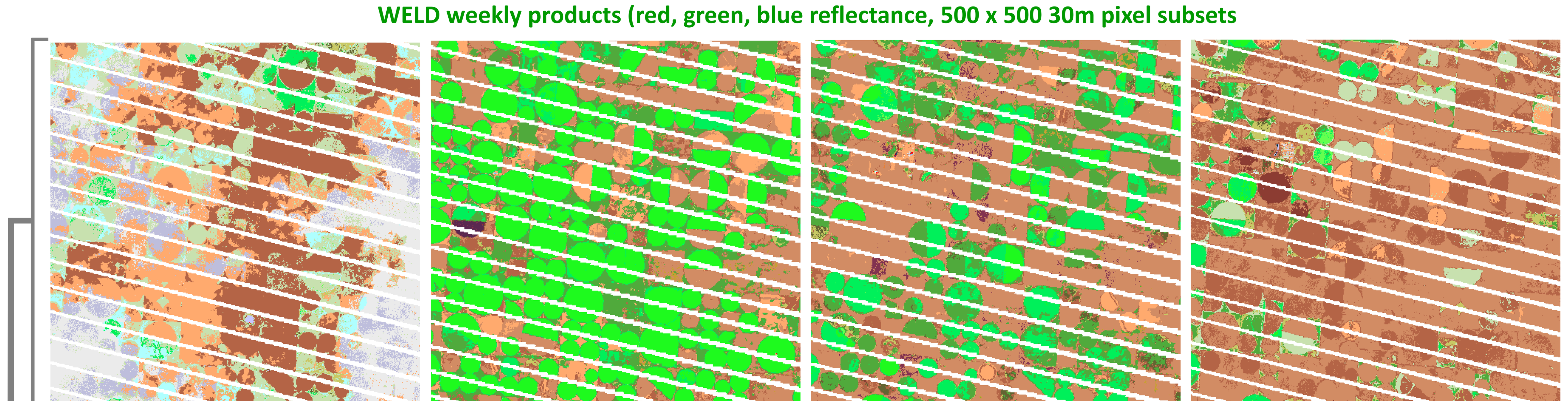
Future research, including the integration of geometric and texture properties to improve the robustness, accuracy and computational efficiency of the prototype methodology, is being developed, prior to continental scale application. Results are being validated by comparison with high spatial resolution images obtained from the National Geospatial-Intelligence Agency (NGA) Commercial Archive (http://cad4nasa.gsfc.nasa.gov/) and will be used to inform the algorithm development and to characterize the field object extraction performance.

1. SIAM multi-temporal spectral category classification

WELD weekly 30m products (reflectance and brightness temperature) for 5 years are classified automatically into 95 Satellite Image Automatic Mapper™ (SIAM™) spectral categories.



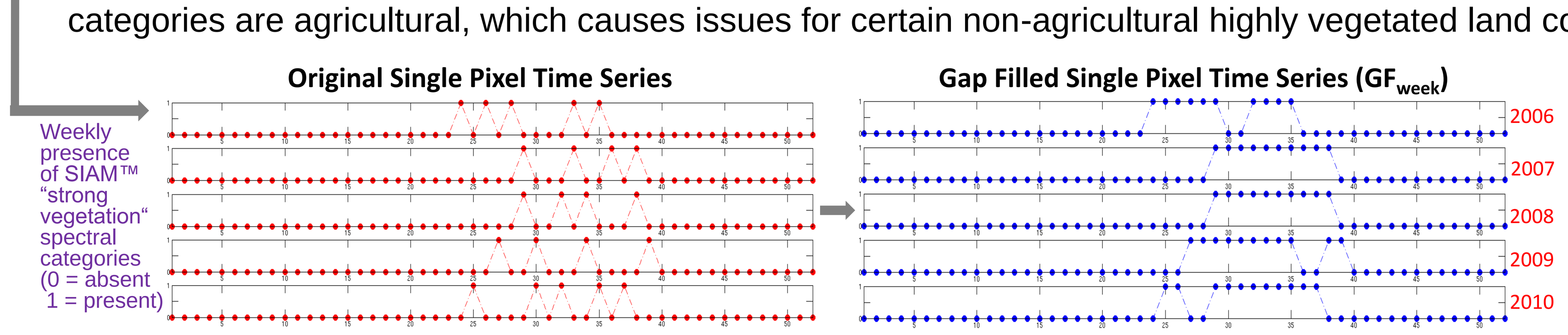
WELD weekly products (red, green, blue reflectance, 500 x 500 30m pixel subsets)

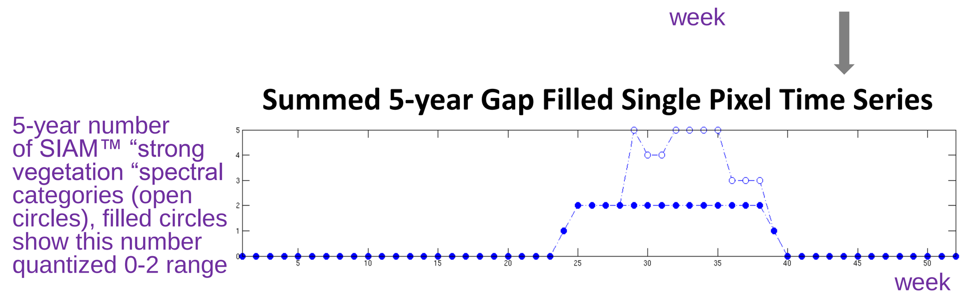


Corresponding SIAM™ spectral categories (primarily cloud, soil, and vegetation categories)

3. Agriculture probability map generation

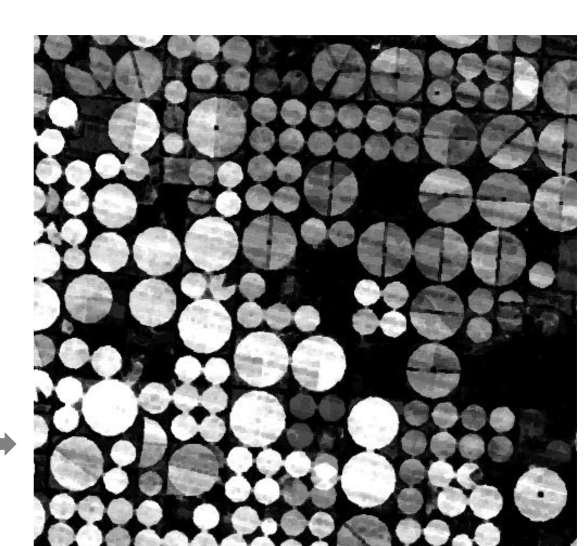
For each pixel the weekly SIAM™ spectral categories are filtered to consider only "strong vegetation" categories. To accommodate gaps in the SIAM™ time series (due to clouds, no Landsat acquisition, and Landsat SLC-off stripes), those weeks not labeled as a "strong vegetation" category are filled as this category if they are temporally adjacent to a week labeled as this category and occur within a period of less than 6 weeks between weeks labeled as "strong vegetation". The sum of the gap-filled 5-year weekly time series is computed and the probability of agriculture at the pixel is defined as a normalized sum of these values. This assumes that the "strong vegetation" categories are agricultural, which causes issues for certain non-agricultural highly vegetated land cover types such as forest.



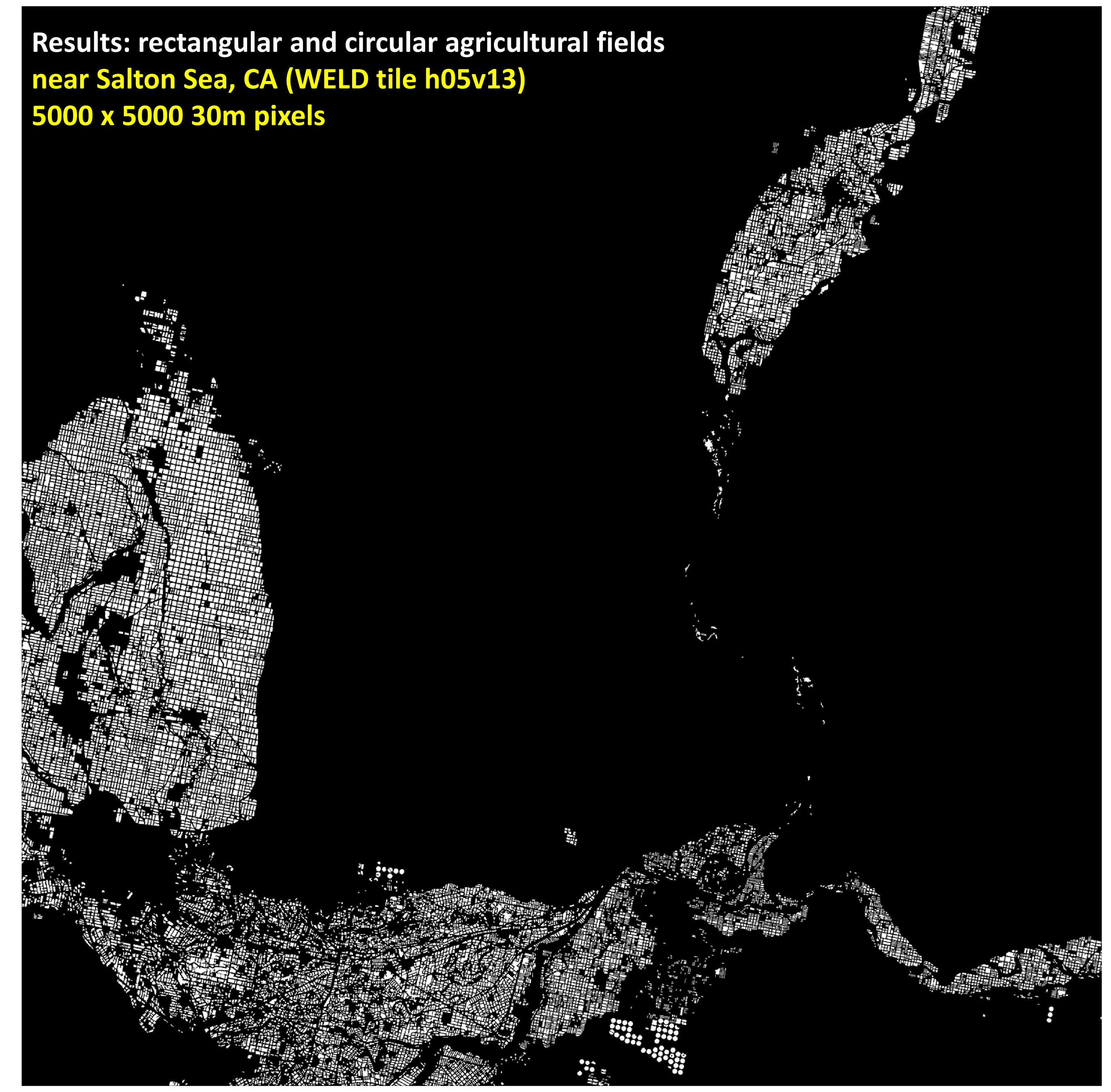


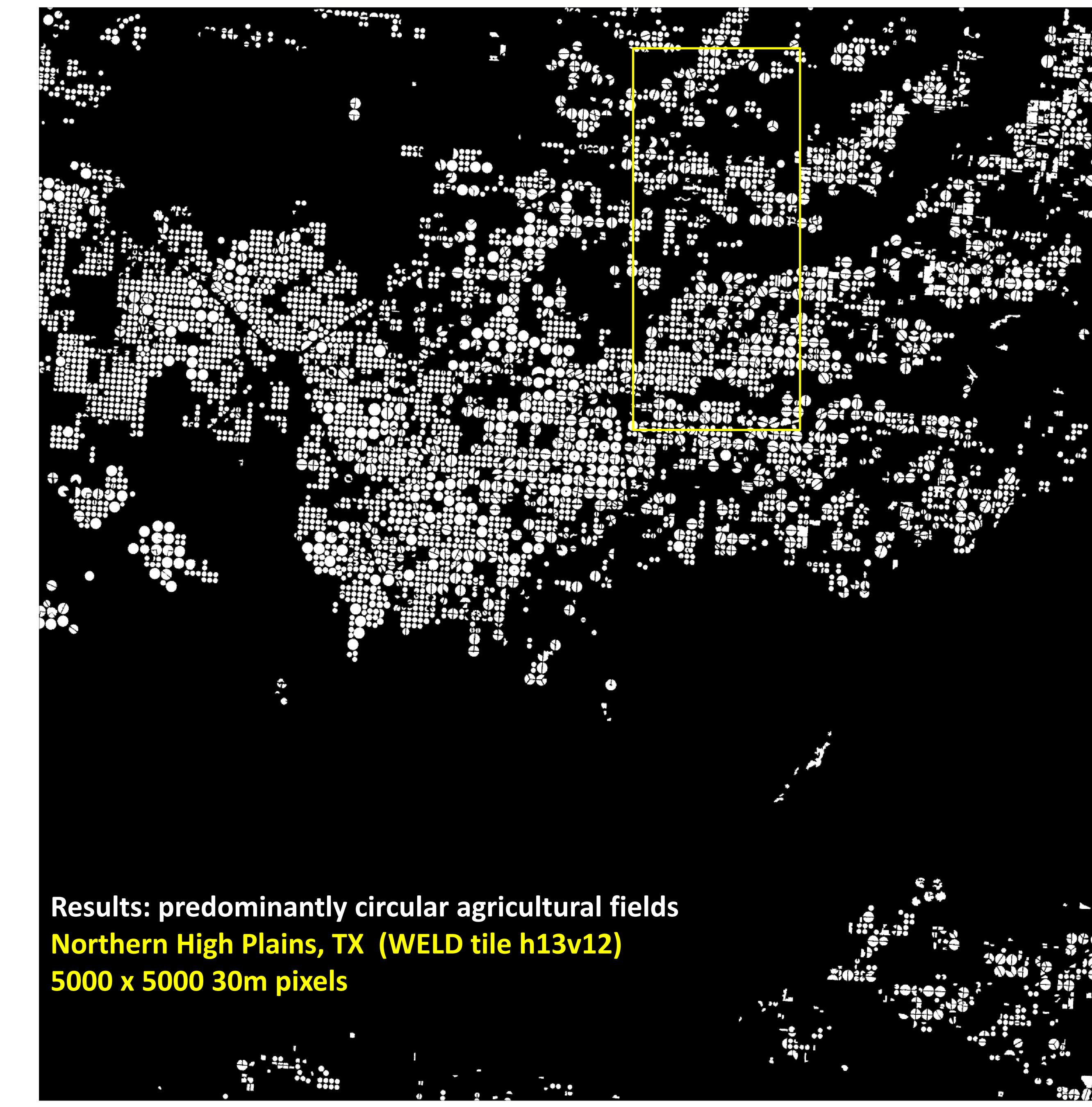
$$probability = \frac{\sum_{week=1}^{52} Q\left(\sum_{year=1}^{5} GF_{week}\right)}{52 \times 2}$$

where $Q(x) = \begin{cases} x, & x = 0,1 \\ 2, & x \geq 2 \end{cases}$



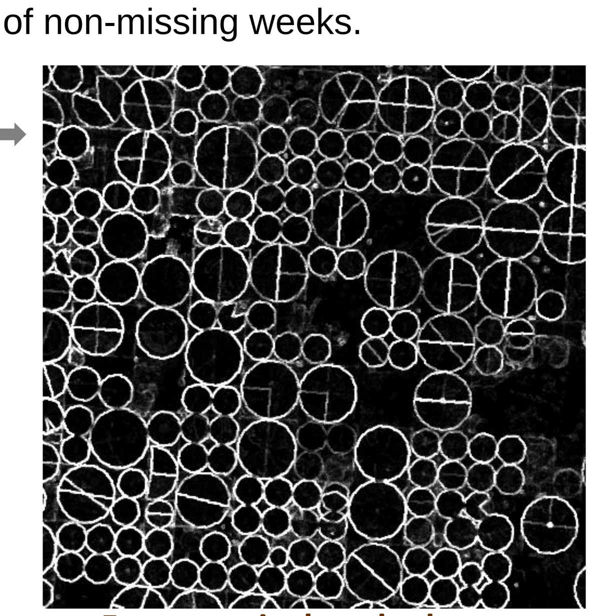
5-year agricultural probability map





2. Agricultural pixel edge map extraction

For each pixel in each weekly WELD product defined as, or adjacent to, a SIAM™ "strong vegetation" category, the spectral distance (over the WELD reflective bands) with its neighboring pixels is computed. The edge strength is then defined as the sum of these values over the 5 years divided by the number of non-missing weeks.



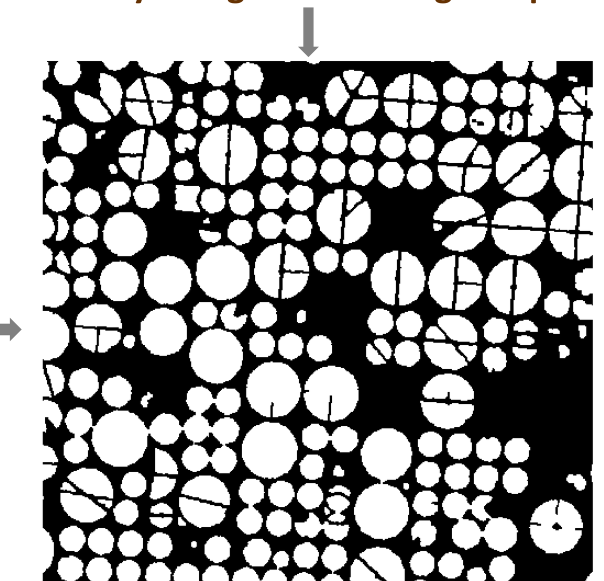
5-year agricultural edge map

4. Candidate agricultural field extraction by region-based geometric active contour (RGAC)

The agricultural edge map and agricultural probability map are fused to generate a candidate agricultural field map. This is done using a refined RGAC iterative model as:

$$\frac{\partial \phi}{\partial t} = \delta_{\varepsilon}(\phi)(I_{prob.} + \lambda \cdot I_{edge} + \mu \cdot \kappa)$$

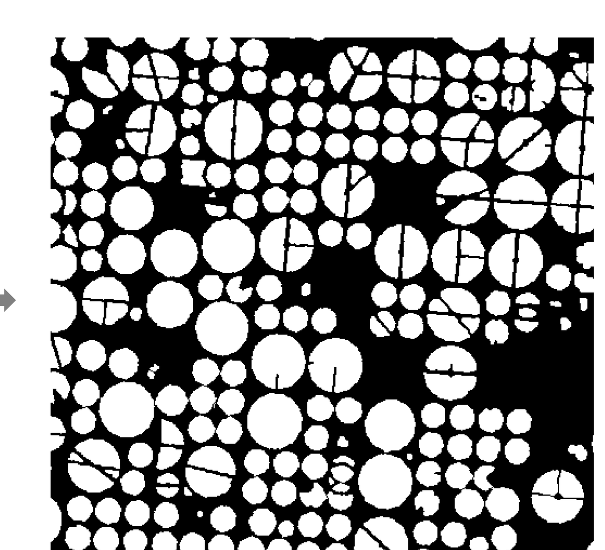
I_{prob} : probability map
I_{edge} : edge map
ϕ: signed distance function defined with respect to candidate agricultural field boundaries
κ: curvature map, $\kappa = \frac{\phi_x^2 \phi_{yy} - 2\phi_x \phi_y \phi_{xy} + \phi_y^2 \phi_{xx}}{|\nabla \phi|^3}$



Candidate agricultural fields

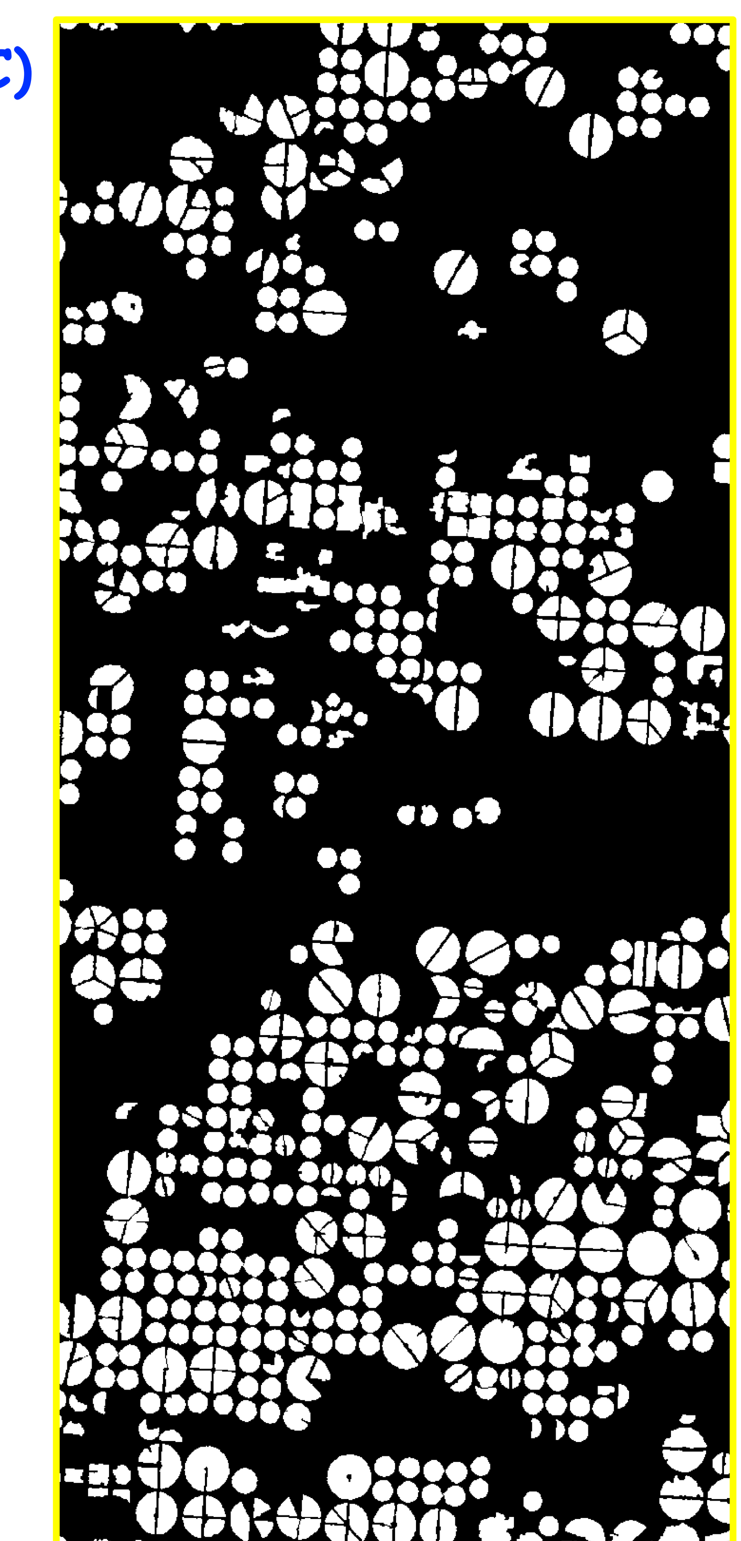
5. Agricultural field object isolation

A geometry-based algorithm is used to isolate any connected segments belonging to multiple fields into coherent isolated field objects.

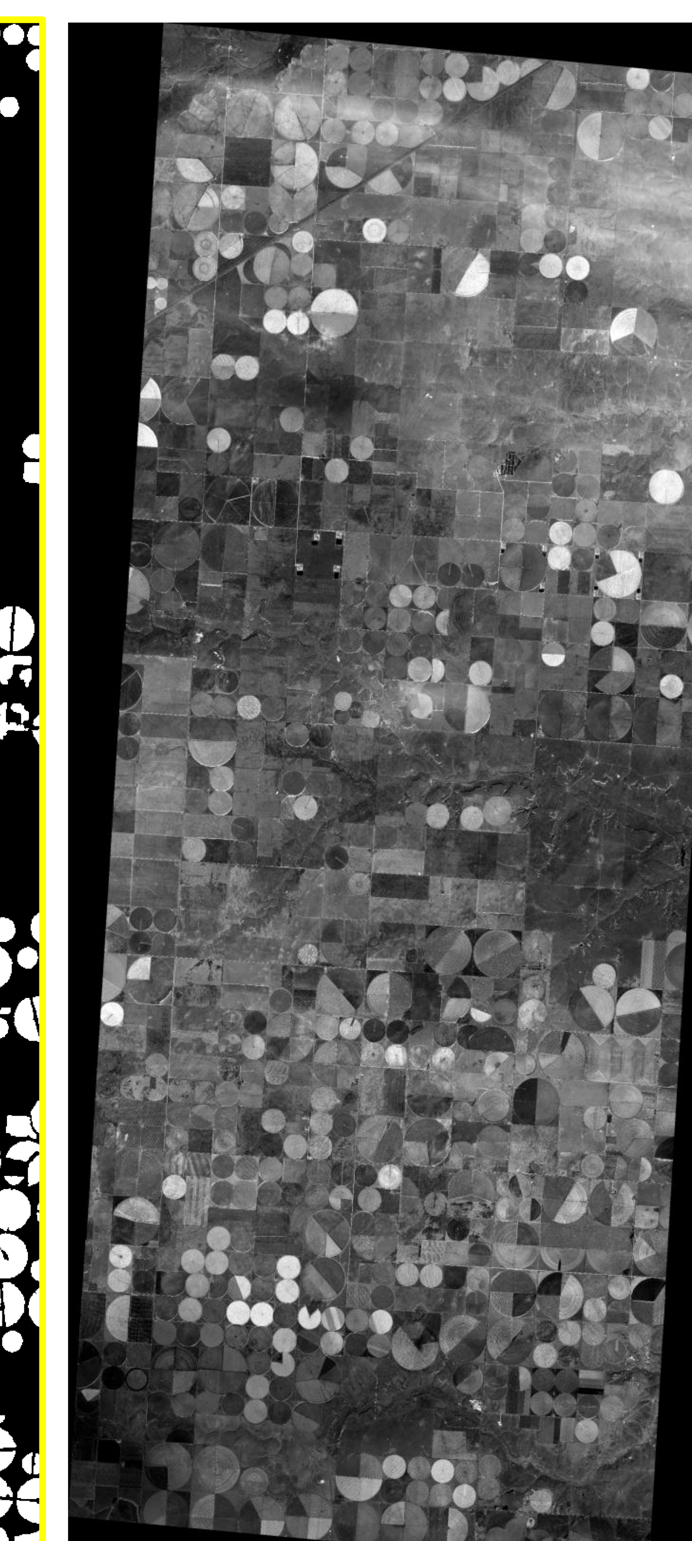


Isolated agricultural fields

6. Qualitative Validation



750 x 1733 30m pixel subset of above Northern High Plains result (located near Amarillo, TX)



Three 0.5m panchromatic World View-1 images acquired December 17th 2007 (courtesy of NASA GSFC, NGA Commercial Archive Data)