Orthogonal matrix transformed density mapping of vegetation features

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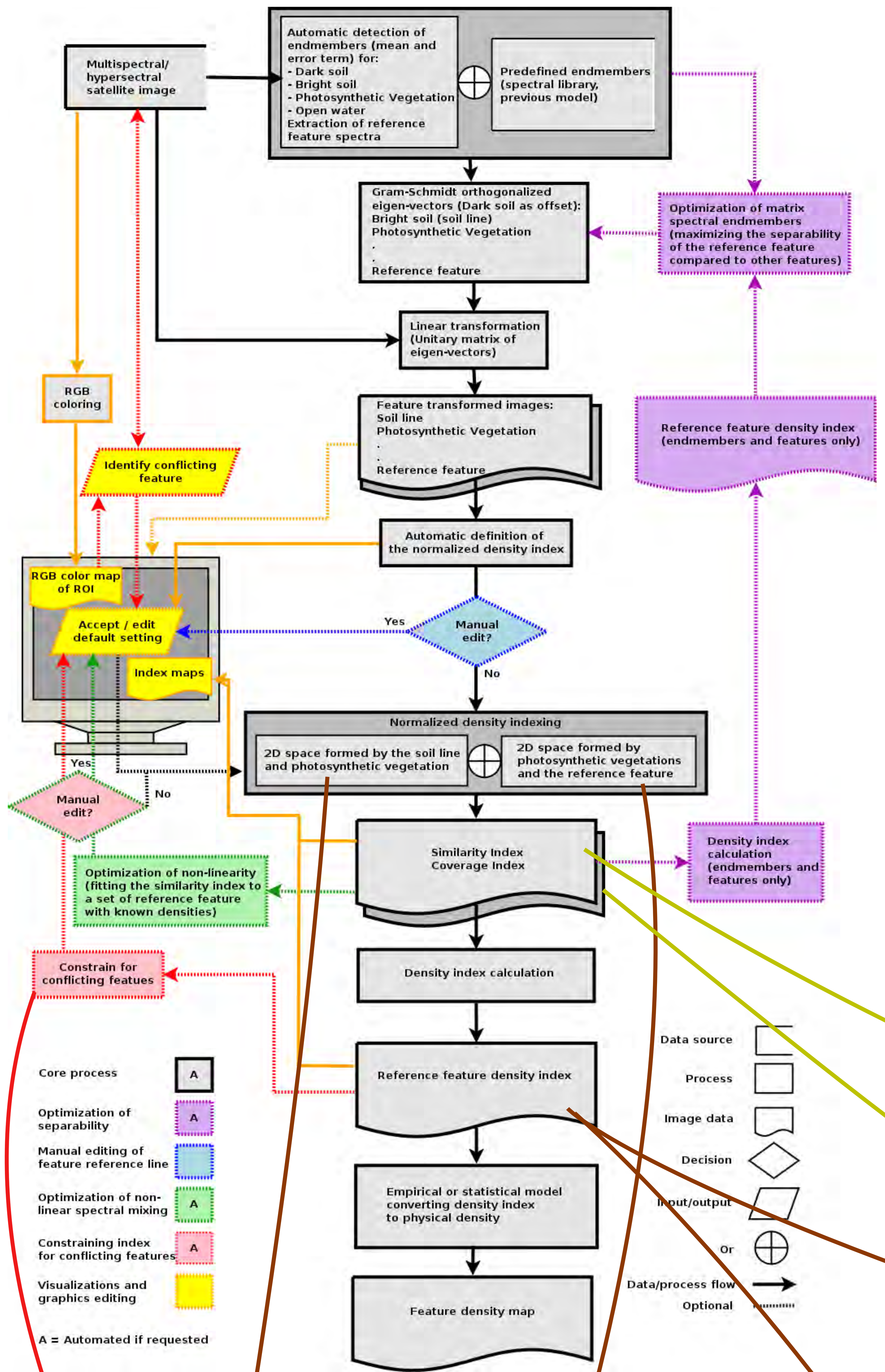
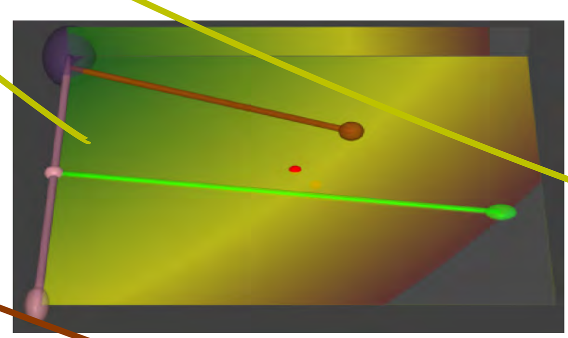
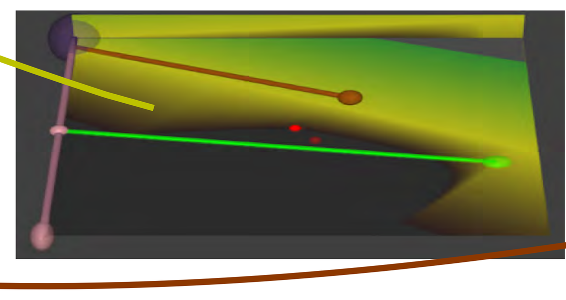


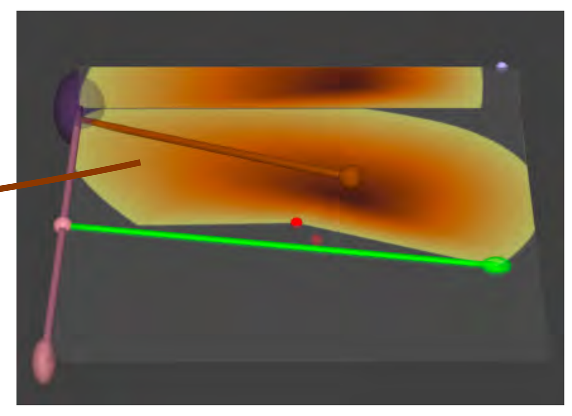
Detection and density mapping of vegetation features in remotely sensed imagery is complex, and largely reserved image classification experts. This study presents the preliminary results of a biophysically oriented, and user easy system for detecting and mapping the density of vegetation features. At its core the system uses an orthogonal matrix transformation of spectral end-members, and presents results as a density map of the vegetation feature given by the user. The system automatically detect the spectral end-members for 1) water, 2) dark soil, 3) light soil and 4) photosynthetic vegetation (PV). These end-members can be detected either from reflectance corrected data, or from uncorrected digital numbers (DN). The method for detecting end-members from DN is simpler, but produces less accurate results. Using the end-members the first vector of the orthogonal matrix is defined using either water or dark soil as an offset, and aligns to light soil. The second transformation vector is orthogonal to the first, and aligns towards PV, the third vector aligns to the vegetation feature defined by the user. The density function for the mapped feature can either be extracted directly from the third (feature) vector, or using a perpendicular or modified normalized difference (ND) approach. The normalized density index (NDI) approach differs compared to traditional ND by using a trigonometric, scale preserving, rotation, and the density estimation considers both the feature similarity and the feature coverage. Further, any other (conflicting) feature entered by the user can be used for adjusting the NDI and restricting the classification space. The system also has an optimization routine, that can adjust the spectral end-members (not the feature) within a pre-defined statistical space to allow better separability between either different features, or between a feature and the spectral end-members. If several features are classified the third orthogonal vector is re-oriented to reflect each separate feature, and each feature is classified using a different classification space. Apart from the reduced input needs, the biophysical orientation of the classification system allows a graphical presentation relating the feature to the end-members (and conflicting features), easy to interpret for thematic experts in vegetation (rather than image processing experts). The graphical presentation is in 3D and also depicts the density space of the mapped features. By default the classified map is presented in the same color scheme as the graphical 3D presentation, facilitating the calibration and interpretation of the results. The system is a combination of spectral unmixing and image classification, but by restricting the system to only use three spectral end-members for the orthogonal rotation (using dark soil or water as offset). the system can unmix data from any optical sensor with four bands or more. Features other than soil, PV and the mapped feature are then placed in the space of these three end-members.



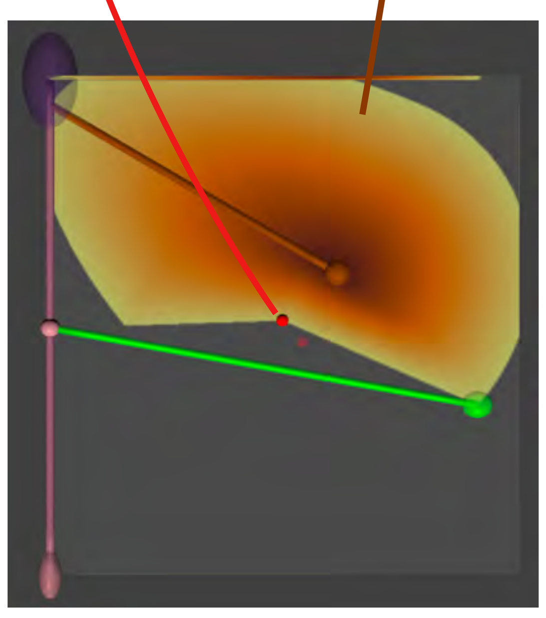
Coverage index in 3D visualization. The coverage index is non-linearly rescaled to force a zero value of photosynthic vegetation in the density index

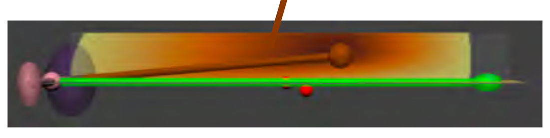


Similarity index in 3D visualization. The similarity index is non-linearly rescaled to force a zero value of the conflicting featue in the density index

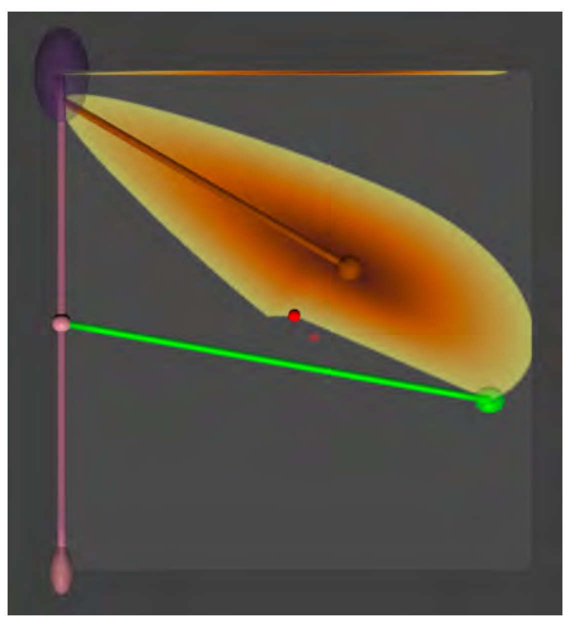


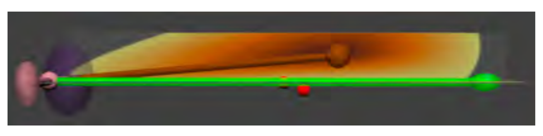
Density index in 3D visualization, calculated as the distance from the reference feature in the space formed by the coverage and similarity indexes





Intermediate scaling of similarity index, default setting if only one reference feature given. Parameter settings as illustrated in 3D illustrations to the right,





Constrained scaling of similarity index, set to reflect the difference in similarity between the reference feature and photosynthetic vegetation. Results in a more restricted feature density map (to the right)

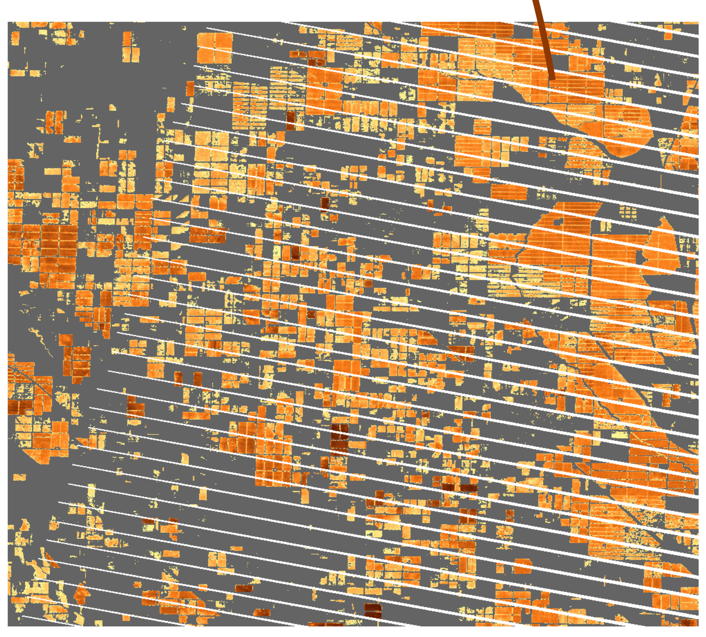
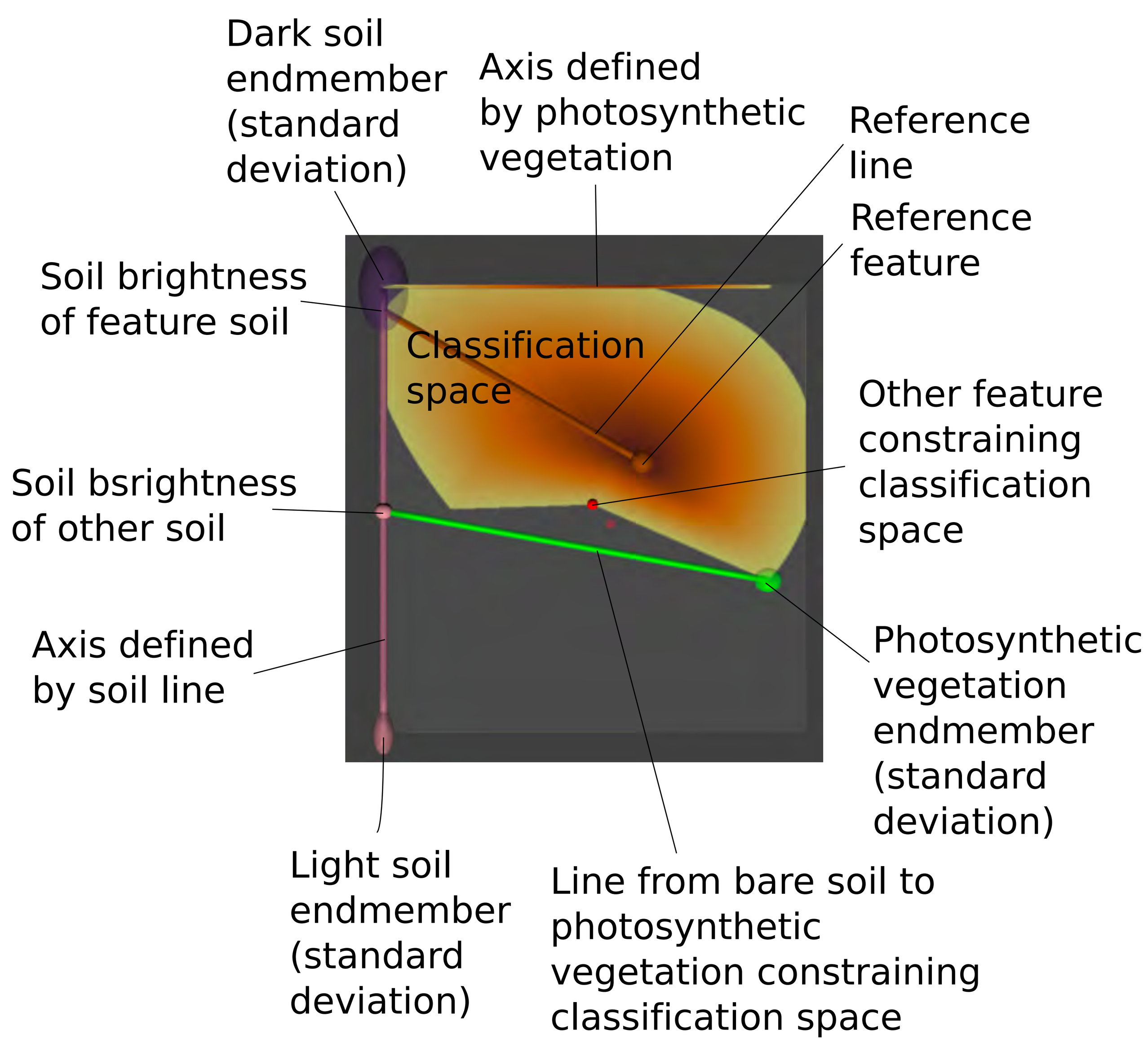
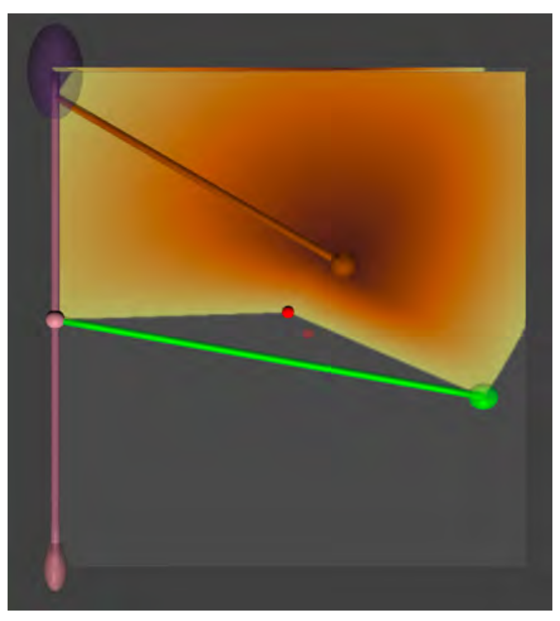
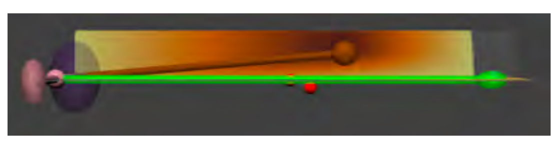


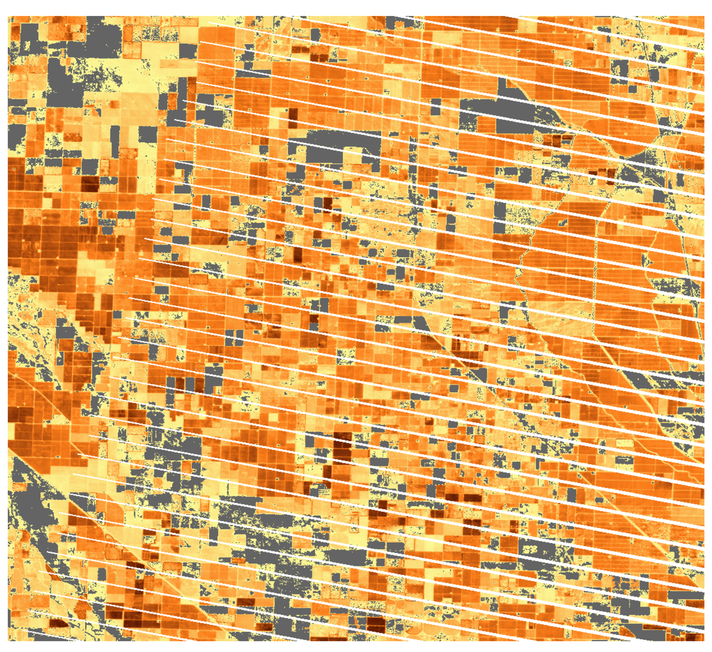
Diagram components

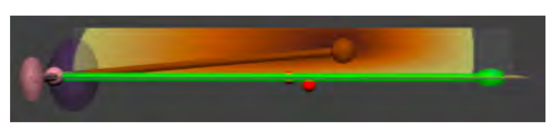






Maximized scaling of similarity index. Results in a wider feature density map (to the right)





Z-axis defined by the feature itself