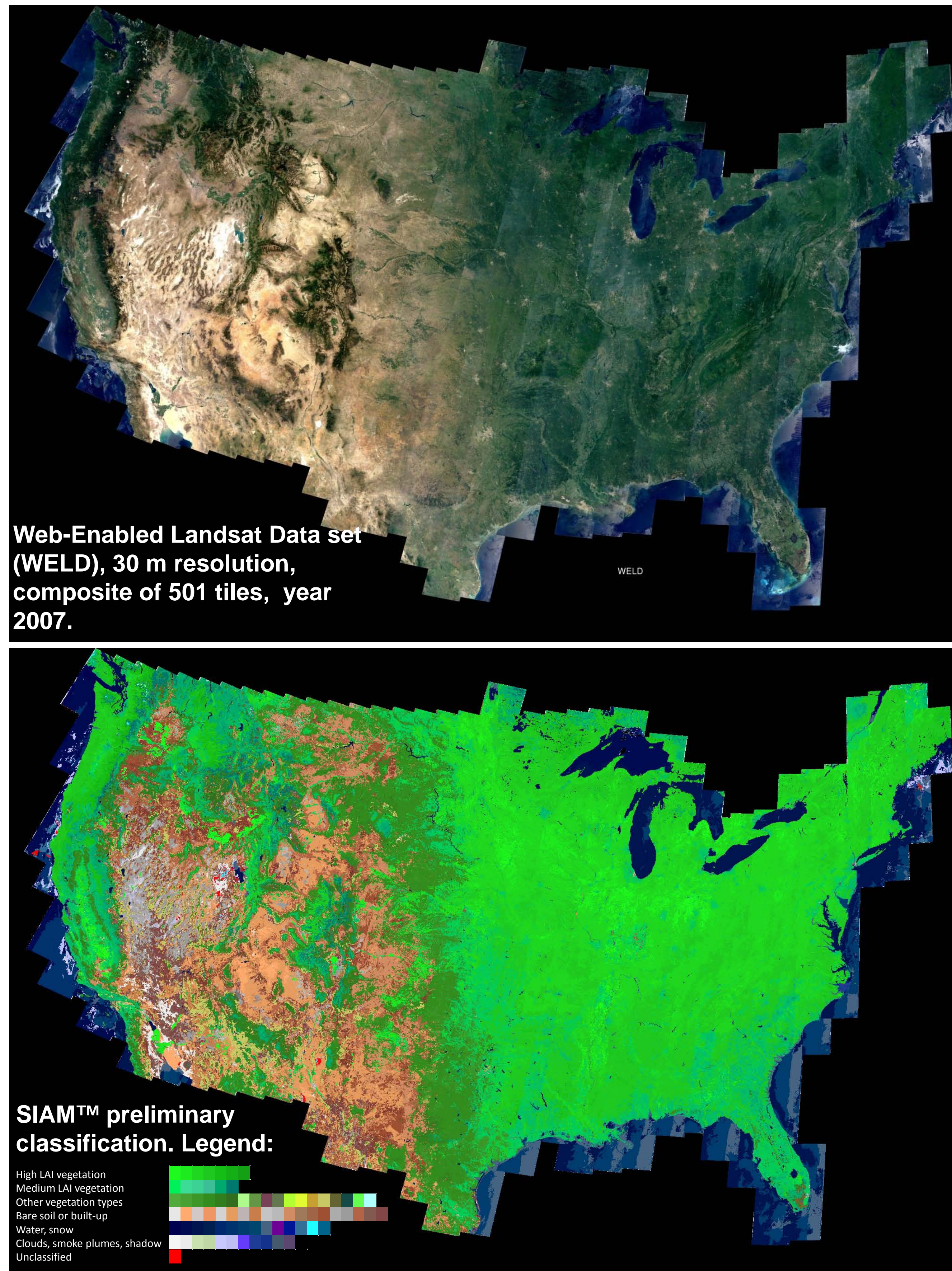# Satellite Image Automatic Mapper™ (SIAM™) - A first-stage preliminary classifier for automatic two-stage Land Cover classification and Change detection

A. Baraldi, L. Boschetti , and C. O. Justice

Department of Geography, University of Maryland at College Park

email: andrea.baraldi@hermes.geog.umd.edu; luigi.boschetti@hermes.geog.umd.edu; justice@hermes.geog.umd.edu
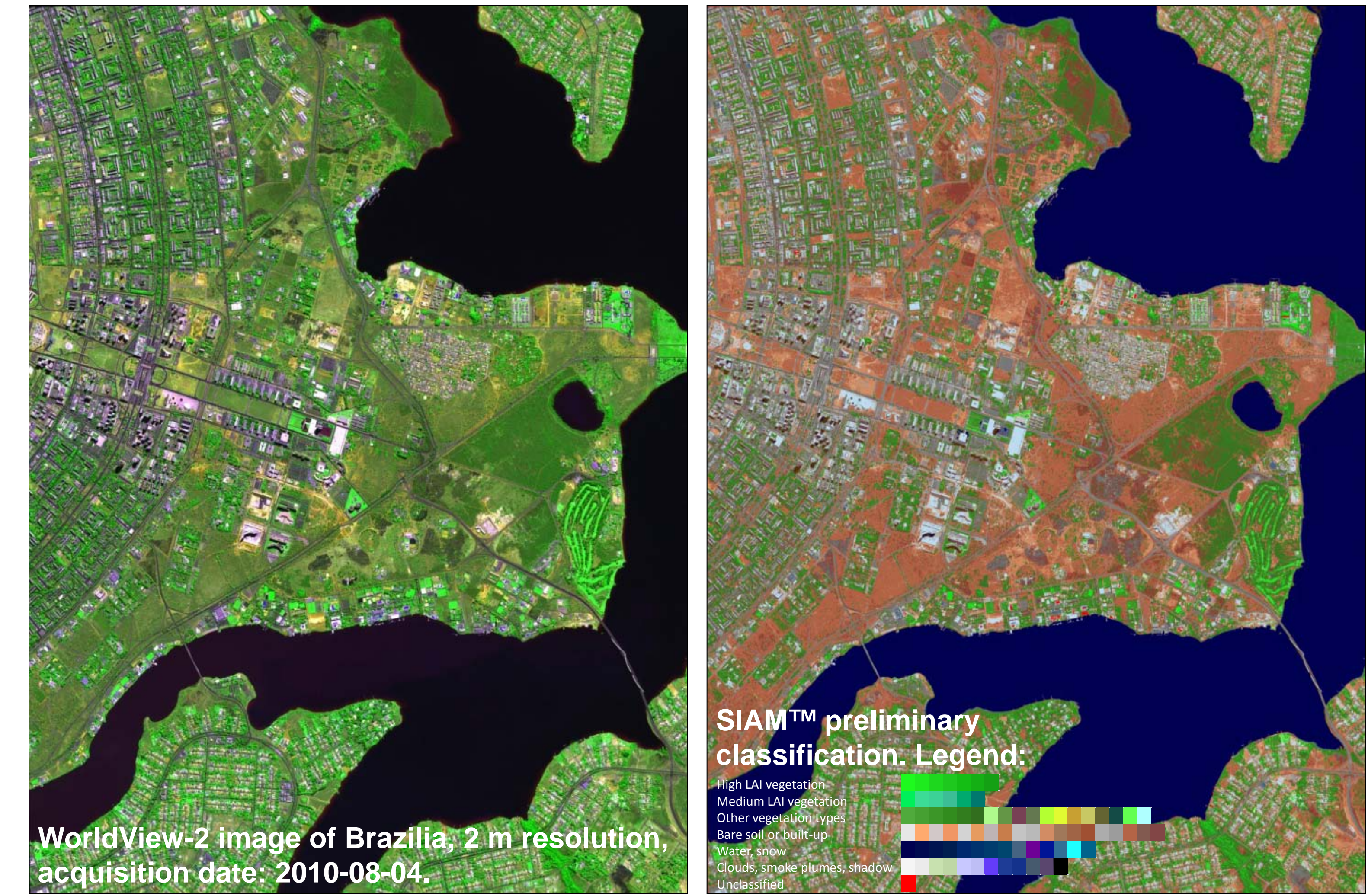
SIAM™ as a deductive physical model-based preliminary classifier

SIAM™ is an automatic, multi-sensor, multi-resolution, near real-time, non-adaptive (deductive, physical model-based) decision-tree classifier based on prior spectral knowledge of surface types observed from space. Its prior spectral knowledge base comprises a reference dictionary of spectral signatures in top-of-atmosphere reflectance or surface reflectance, acquired from off-line data observations and/or existing literature. Since its knowledge base is available before looking at the specific image to be classified, SIAM™ belongs to the family of physical models, also called deductive inference systems. Employed as a preliminary classification first stage of a two-stage remote sensing image understanding system, SIAM™ enforces a shift in learning paradigm from traditional first-stage inductive Machine-Learning-from-data (e.g., image segmentation) to deductive Machine-Teaching-by-rules.

Web-Enabled Landsat Data set (WELD), 30 m resolution, composite of 501 tiles, year 2007.

SIAM™ preliminary classification. Legend:
High LAI vegetation
Medium LAI vegetation
Other vegetation types
Bare soil or built-up
Water, snow
Clouds, smoke plumes, shadow
Unclassified

First-stage SIAM™ preliminary classification onto a discrete and finite set of spectral categories

The first-stage SIAM™ preliminary classifier requires as input multi-spectral images radiometrically calibrated into top-of-atmosphere or surface reflectance, and brightness temperature. SIAM™ is pixel-based (non-contextual), i.e., it is based on spectral properties exclusively. It maps each pixel onto a discrete and finite set of spectral categories (spectral-based semi-concepts, land cover class sets) belonging to a set of six spectral super-categories (spectral end members): (I) clouds, (II) snow or ice, (III) water or shadow, (IV) vegetation, (V) bare soil or built-up and (VI) outliers.

WorldView-2 image of Brazilia, 2 m resolution, acquisition date: 2010-08-04.

SIAM™ preliminary classification. Legend:
High LAI vegetation
Medium LAI vegetation
Other vegetation types
Bare soil or built-up
Water, snow
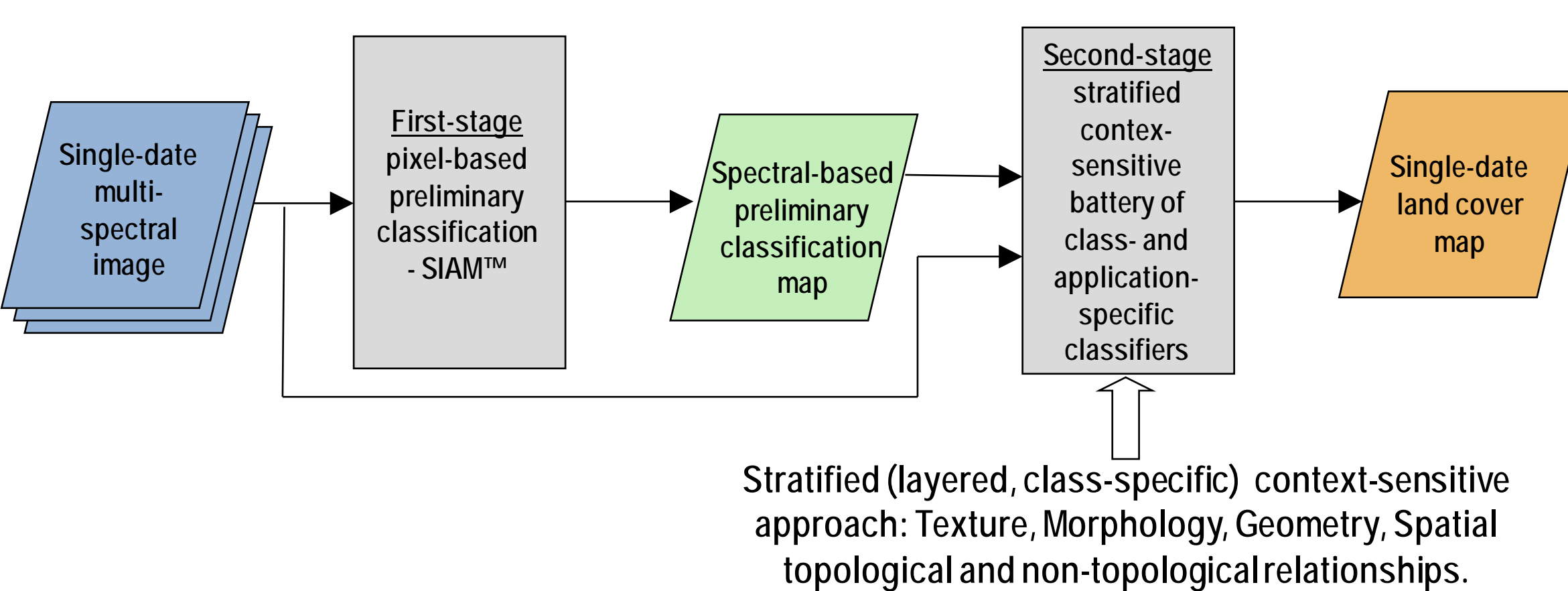Clouds, smoke plumes, shadow
Unclassified

SIAM™ multi-sensor multi-resolution capabilities

SIAM™ is a multi-sensor multi-resolution classification system of systems eligible for use with all existing spaceborne optical sensors whose: (a) spectral resolution overlaps with, but is inferior to, Landsat's and (b) spatial resolution ranges from 0.5 m (pan-sharpened WV-2) to 3 km (Meteosat SEVIRI). SIAM™ consists of six sub-systems.

- 7-band Landsat TM-like (L-SIAM, 95/ 47/ 18 spectral categories)
- 4-band SPOT HRVIR-like (S-SIAM, 68/ 40/ 15 spectral categories)
- 4-band AVHRR-like (AV-SIAM, 82/ 42/ 16 spectral categories)
- 5-band AATSR-like (AA-SIAM, 82/ 42/ 16 spectral categories)
- 4-band IKONOS-like (I-SIAM, 52/ 28/ 12 spectral categories)
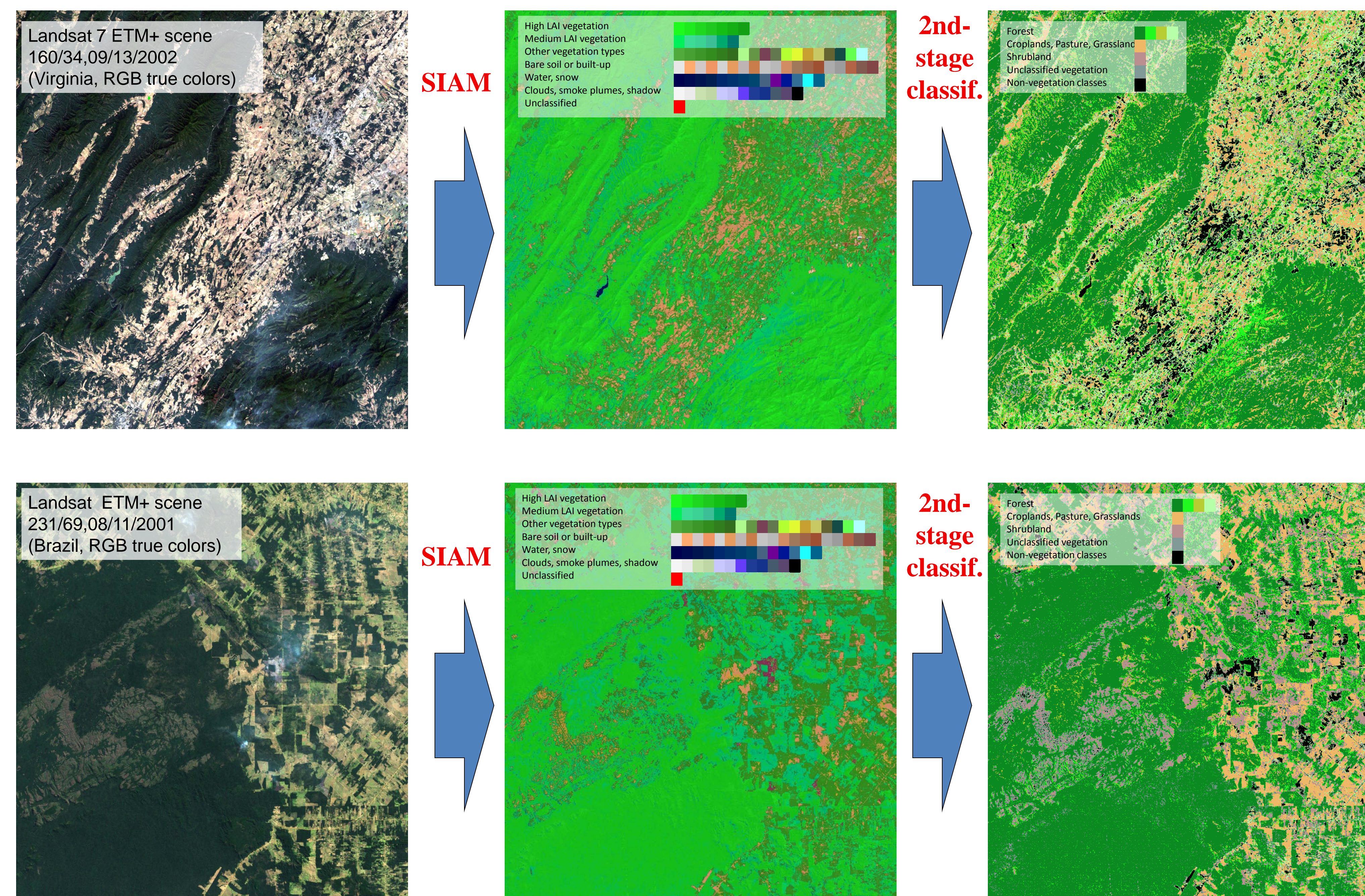- 3-band DMC-like (D-SIAM, 52/ 28/ 12 spectral categories)

Automatic two-stage land cover classification

Stratified (layered, class-specific) context-sensitive approach: Texture, Morphology, Geometry, Spatial topological and non-topological relationships.

A novel automatic two-stage land cover classification system is proposed. It employs: (i) SIAM™ as its preliminary classification first stage and (ii) a second-stage battery of stratified context-sensitive class- and application-specific rule-based classifiers. Possible input features to the second stage are listed below.

- Spectral categories generated by the first-stage SIAM™ preliminary classifier.
- (Achromatic) brightness.
- Multi-scale texture features.
- Multi-scale morphological features.
- Segment-based geometric attributes.
- Inter-segment spatial relationships:
  - Topological (e.g., adjacency, inclusion).
  - Non-topological (e.g., distance, angle).

For example, a two-stage forest/non-forest classification of 30 m resolution 7-band Landsat TM and ETM+ images is shown on the right. In series with SIAM™ the novel two-stage classifier employs brightness and multi-scale texture as inputs to the context-sensitive second stage.

Landsat 7 ETM+ scene 160/34,09/13/2002 (Virginia, RGB true colors)

SIAM

2nd-stage classif.

Landsat ETM+ scene 231/69,08/11/2001 (Brazil, RGB true colors)

SIAM

2nd-stage classif.

Satellite multi-spectral image

First-stage preliminary classification in spectral categories – SIAM™

Second-stage land cover classification

Operational quality indicators of SIAM™

- Degree of automation. Fully automatic (no user-defined parameter, no training samples).
- Efficiency. Near real-time (less than 5 min to classify a Landsat scene with a laptop computer).
- Accuracy. > 90% (evaluated globally up to Stage 2, i.e., across a range of representative conditions and a variety of spaceborne sensors.
- Robustness to changes in the input data set acquired across time, space, and sensors. Very high, refer to literature.
- Maintainability, scalability, reusability. Eligible for use with all spaceborne multispectral optical sensors.
- Timeliness. Real time processing with no user supervision.
- Economy. Maximized (no manpower, low computing power).

Essential references

- SIAM™ is a registered trademark of Andrea Baraldi and University of Maryland
- A. Baraldi, V. Puzzolo, et al., "Automatic spectral rule-based preliminary mapping of calibrated Landsat TM and ETM+ images," IEEE TGRS, vol. 44, no. 9, pp. 2563-2586, 2006.
- A. Baraldi, L. Durieux, et al., "Automatic spectral rule-based preliminary classification of radiometrically calibrated SPOT-4/-5/IRS, AVHRR/MSG, AATSR, IKONOS / QuickBird / OrbView / GeoEye and DMC/SPOT-1/-2 imagery," IEEE TGRS, vol. 48, no. 3, pp. 1299 - 1325, 2010.