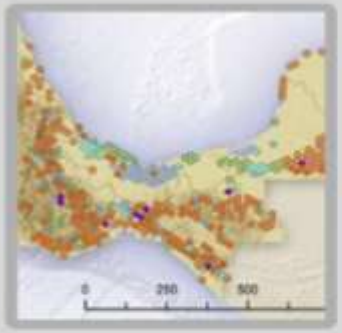
MAD-MEX: Landsat classification - Methodology







Dr. Steffen Gebhardt

MRV Satellite Monitoring System

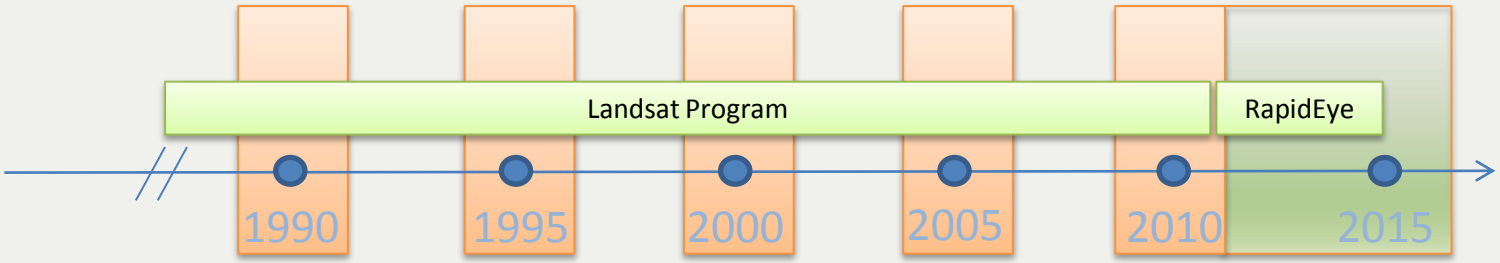
- MAD-MEX: “The Measuring, Reporting and Verification - Activity Data (MRV-AD) Monitoring System within the Mexican REDD+ program”

- Products at 1:100,000 and 1:20,000
    - Land Cover (LC)
    - Land Cover Change (LCC)
    - Forest / Non-Forest
    - Forest Change (FC)
    - Cover density

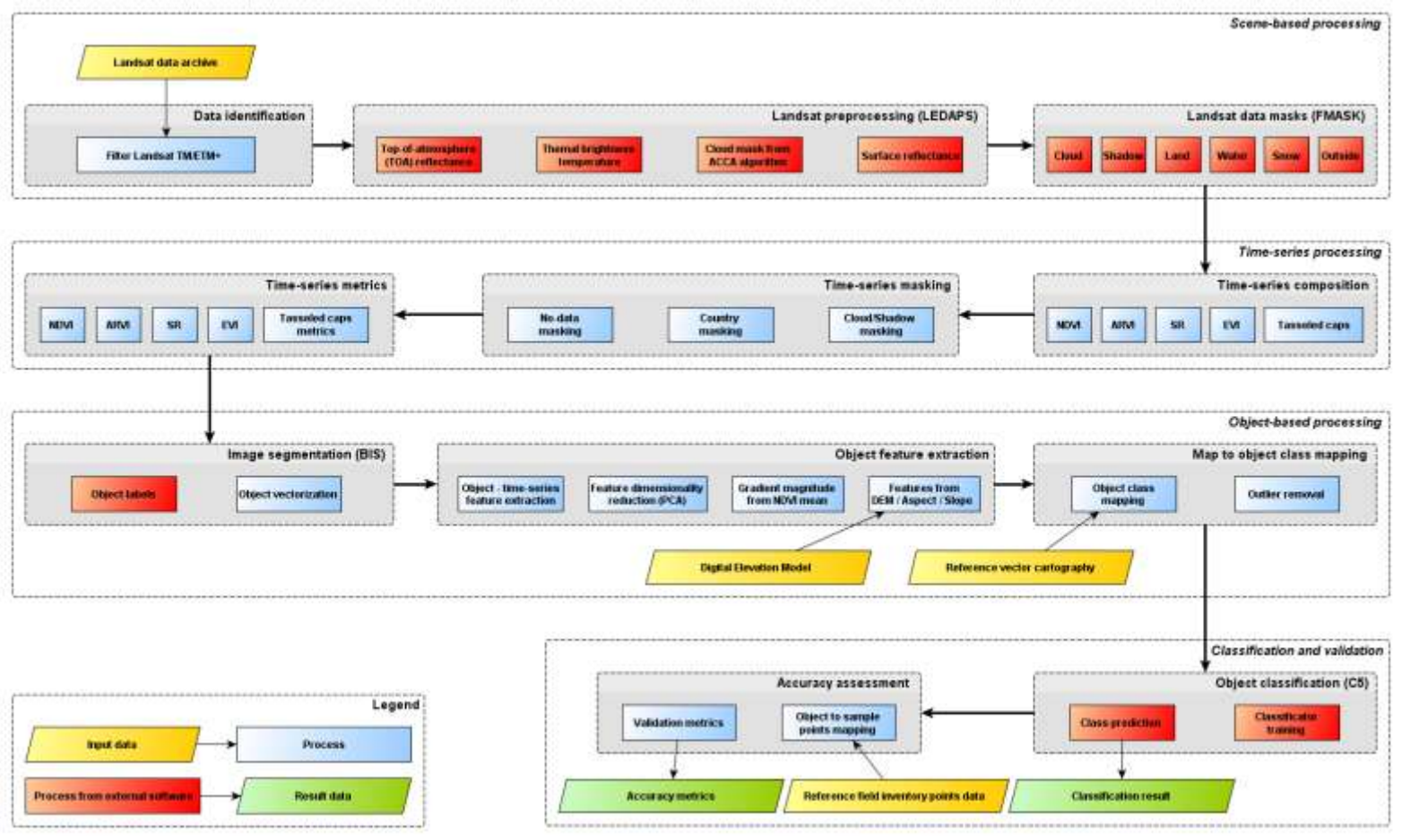
- Methods
    - Automated wall-to-wall baseline land cover mapping
    - “Map-to-Image” using (historical) land use cartography
    - Validation and calibration using field sampling data and imagery

MRV Baseline

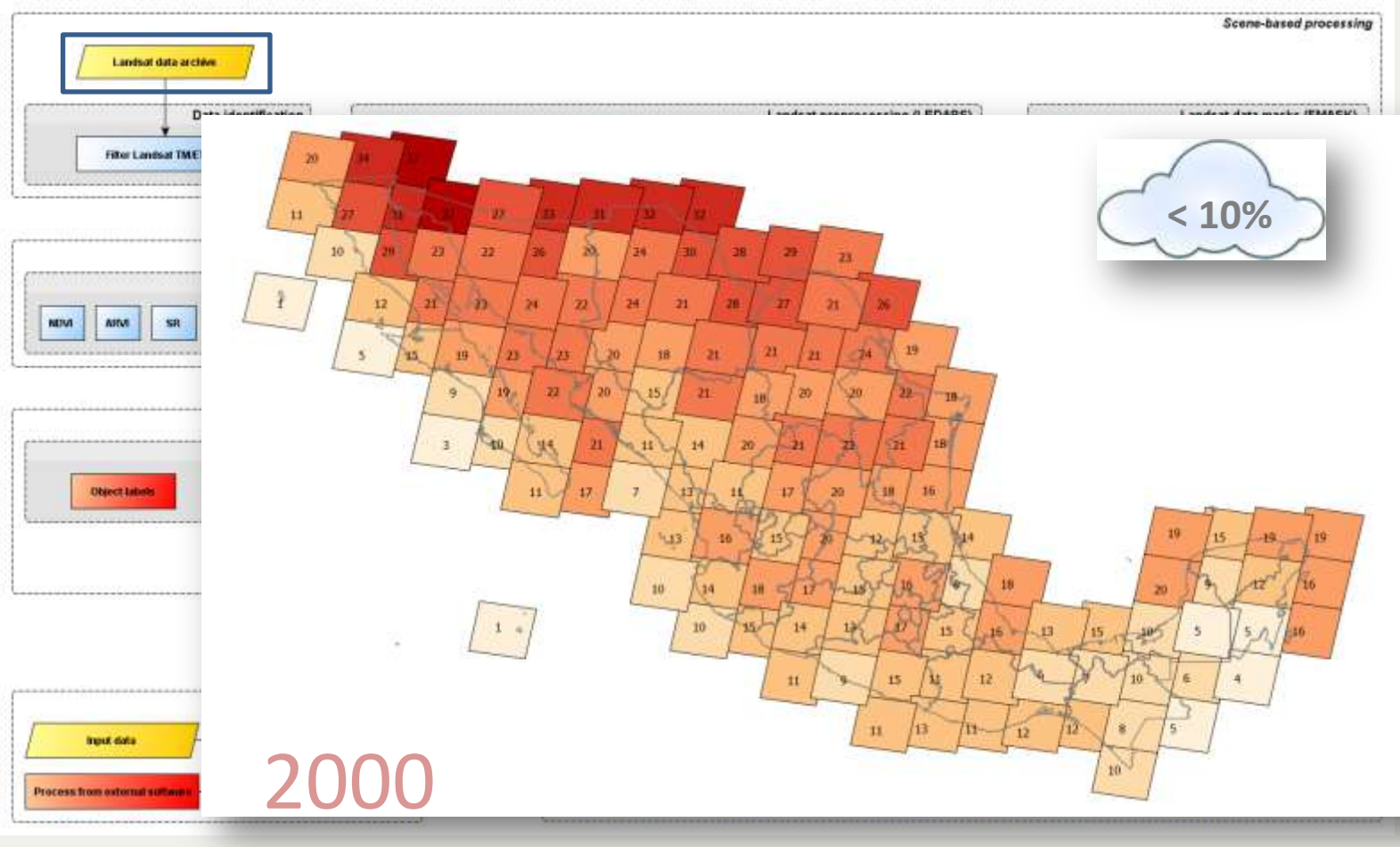
- Historical baseline utilizing the Landsat archive
  - 40 years data archive freely available since 2008
  - Multi-temporal coverage per year
- Todays and future monitoring based on RapidEye
  - High spatial resolution
  - Pre-processed data of high accuracy in geo-location
  - Constellation of satellites, continuity, likelihood of multi-temporal coverage



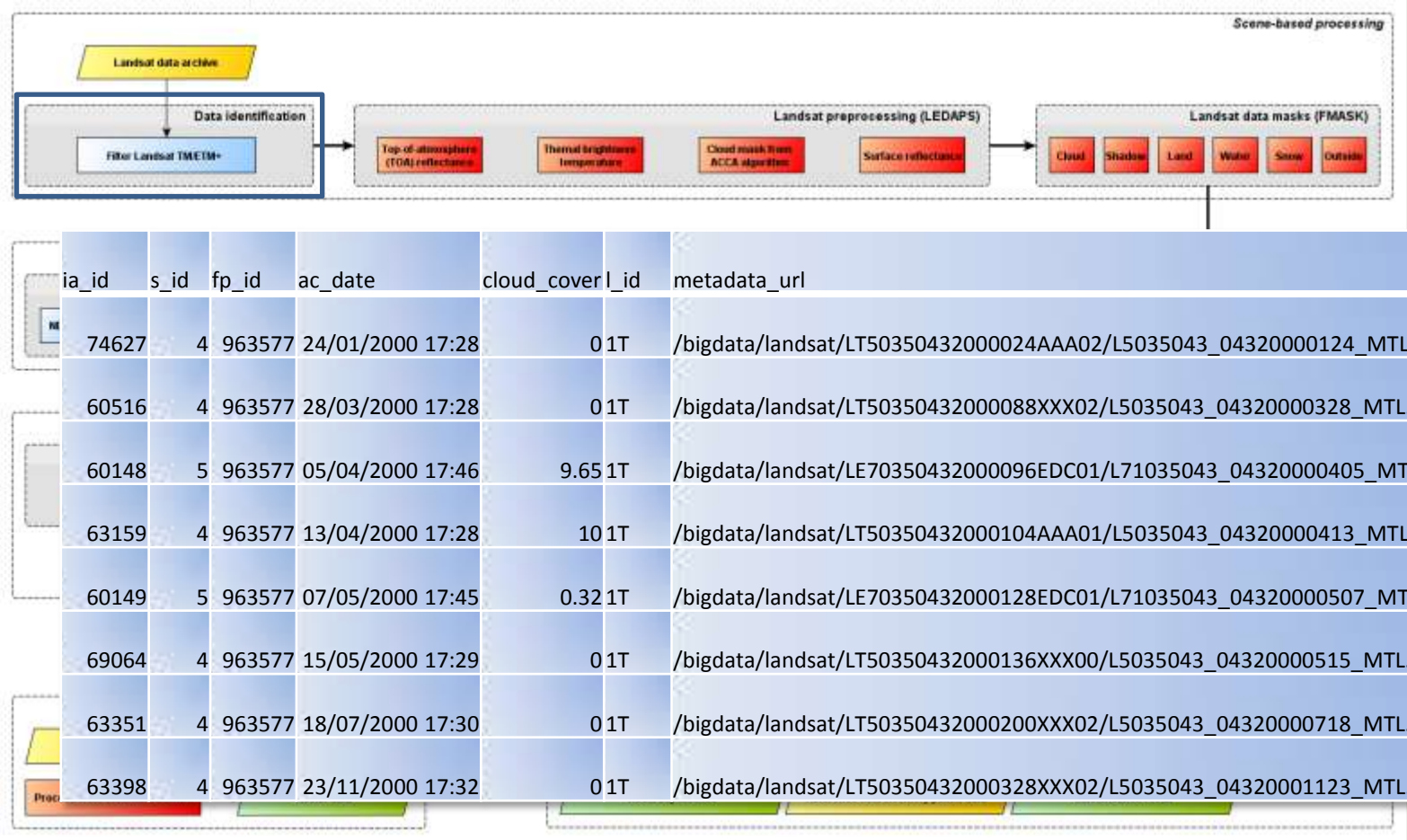
MAD-MEX Landsat processing



MAD-MEX Landsat processing



MAD-MEX Landsat processing



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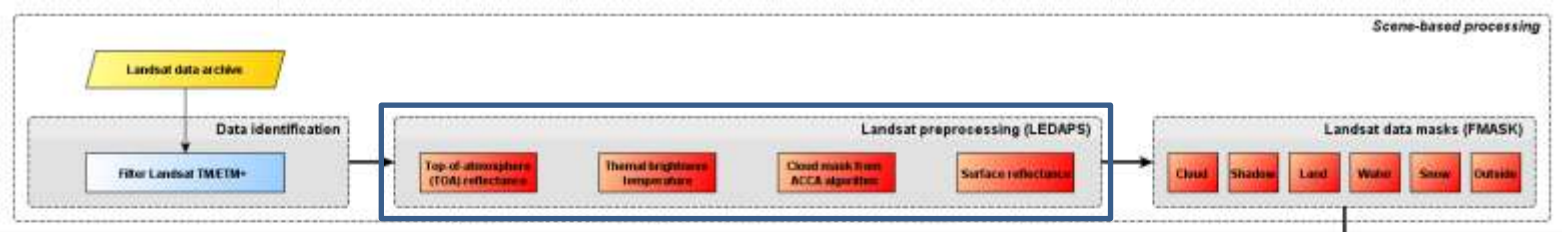
MAD-MEX Landsat processing

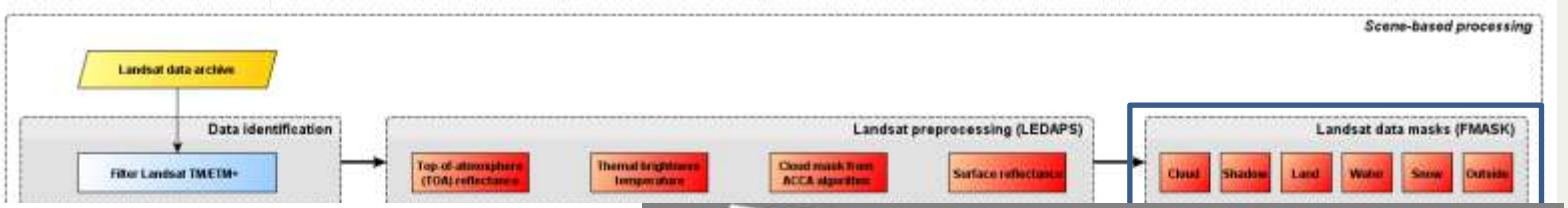


LEDAPS Landsat Calibration, Reflectance, Atmospheric Correction Preprocessing Code. Model Product. Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A., 2012.

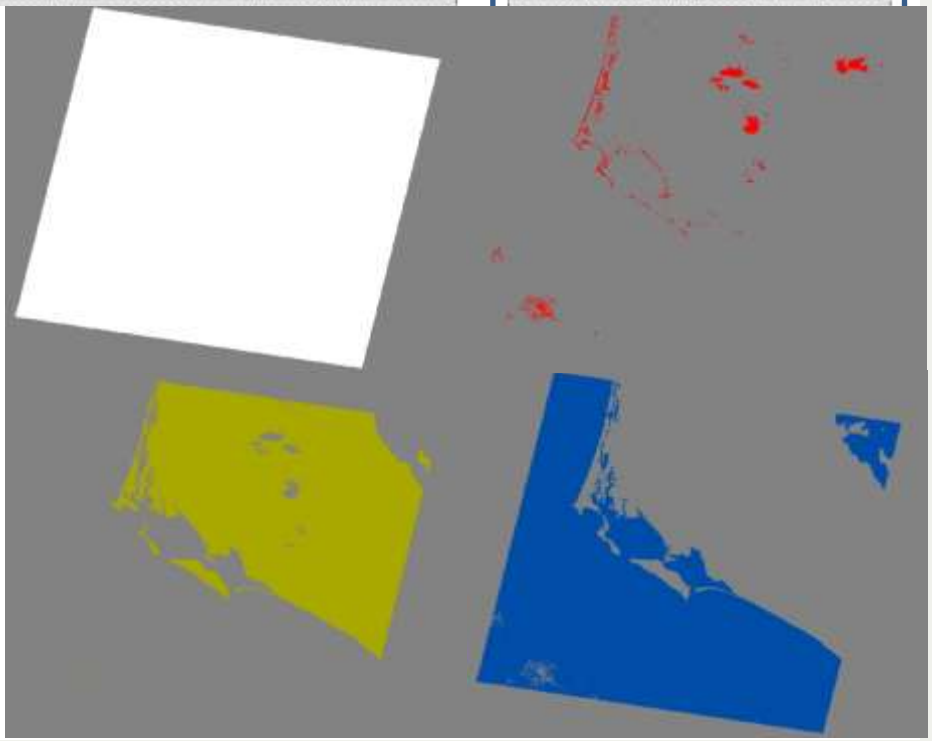
Feng, Min, Chengquan Huang, Saurabh Channan, Eric F. Vermote, Jeffrey G. Masek, and John R. Townshend. "Quality Assessment of Landsat Surface Reflectance Products Using MODIS Data." *Computers & Geosciences* 38, no. 1 (January 2012): 9–22.
Masek, J.G., Vermote, E.F., Saleous, N., Wolfe, R., Hall, F.G., Huemmrich, F., Gao, F., Kutler, J., and Lim, T.K. "A Landsat Surface Reflectance Dataset for North America, 1990–2000." *IEEE Geoscience and Remote Sensing Letters* 3, no. 1 (2006): 68–72.

Landsat 1T calibration, TOA reflectance, cloud masking, and atmospheric correction; LEDAPS Preprocessing software

MAD-MEX Landsat processing

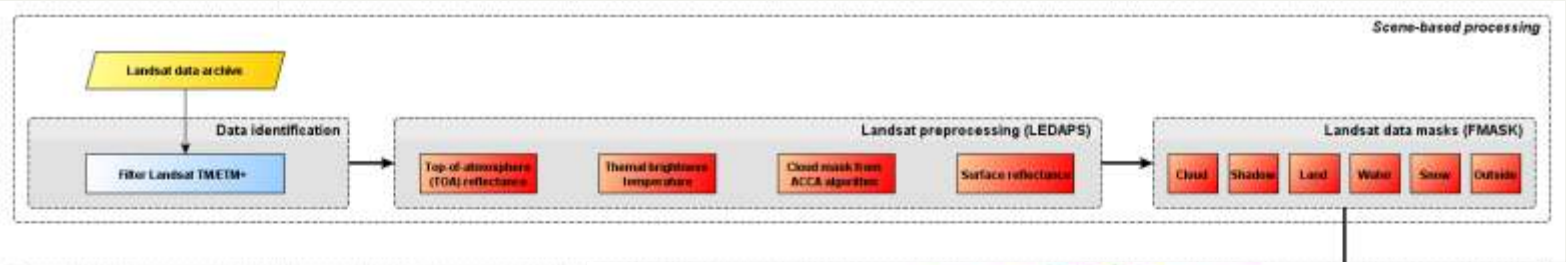


Fmask: Automated clouds, cloud shadows, land, water, nodata and snow masking for Landsat TM/ETM+ image



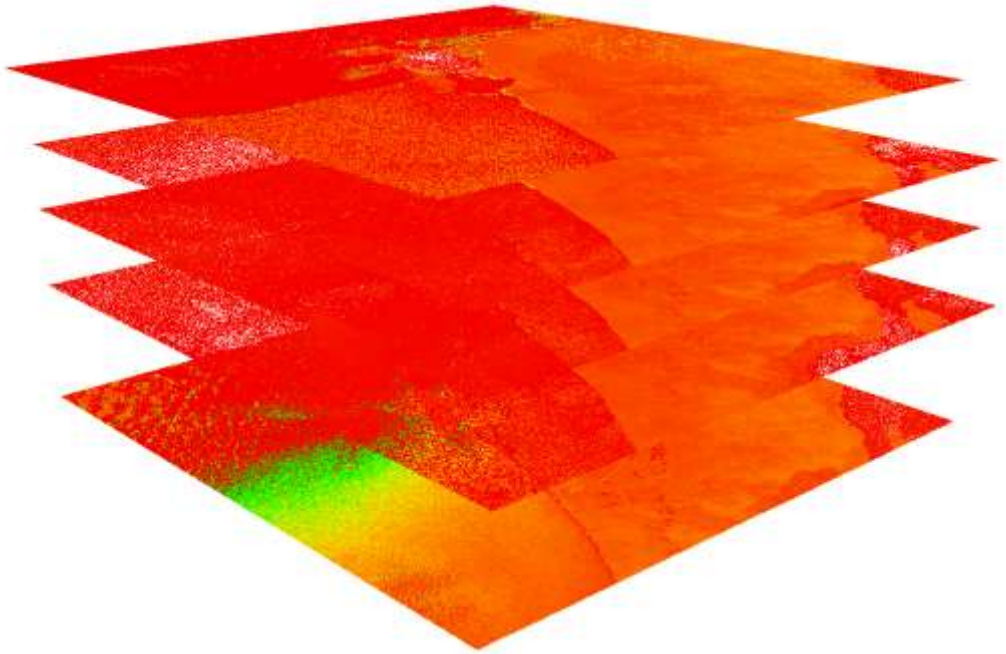
Zhu, Zhe, and Curtis E. Woodcock. "Object-based Cloud and Cloud Shadow Detection in Landsat Imagery." Remote Sensing of Environment 118 (March 15, 2012): 83–94.
Zhu, Zhe, Curtis E. Woodcock, and Pontus Olofsson. "Continuous Monitoring of Forest Disturbance Using All Available Landsat Imagery." Remote Sensing of Environment (n.d.).
http://www.sciencedirect.com/science/article/pii/S0034425712000387.

MAD-MEX Landsat processing

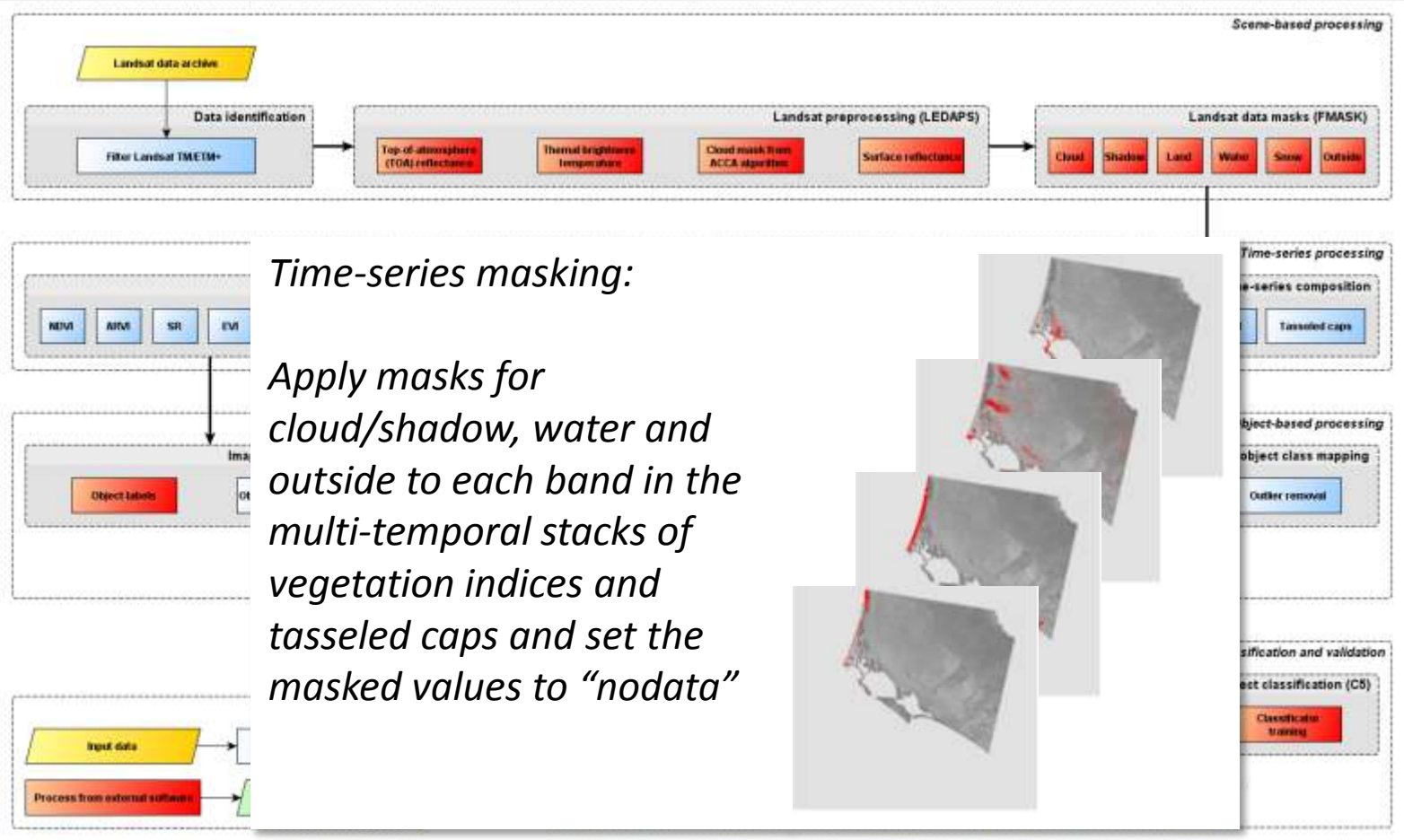


Time-series generation:

Creation of multi-temporal image stacks over vegetation indices, tasseled caps and masks



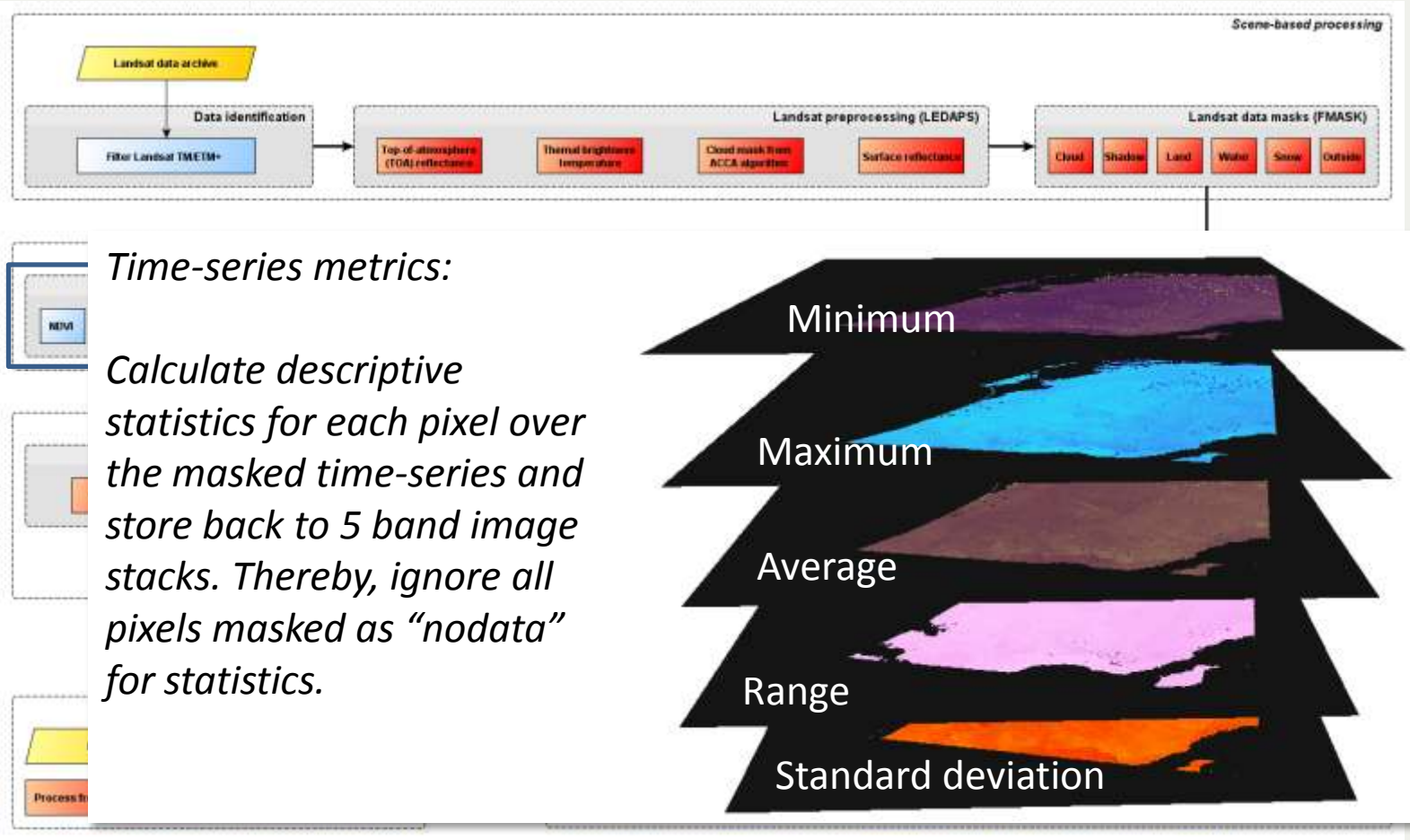
MAD-MEX Landsat processing



Time-series masking:

Apply masks for cloud/shadow, water and outside to each band in the multi-temporal stacks of vegetation indices and tasseled caps and set the masked values to "nodata"

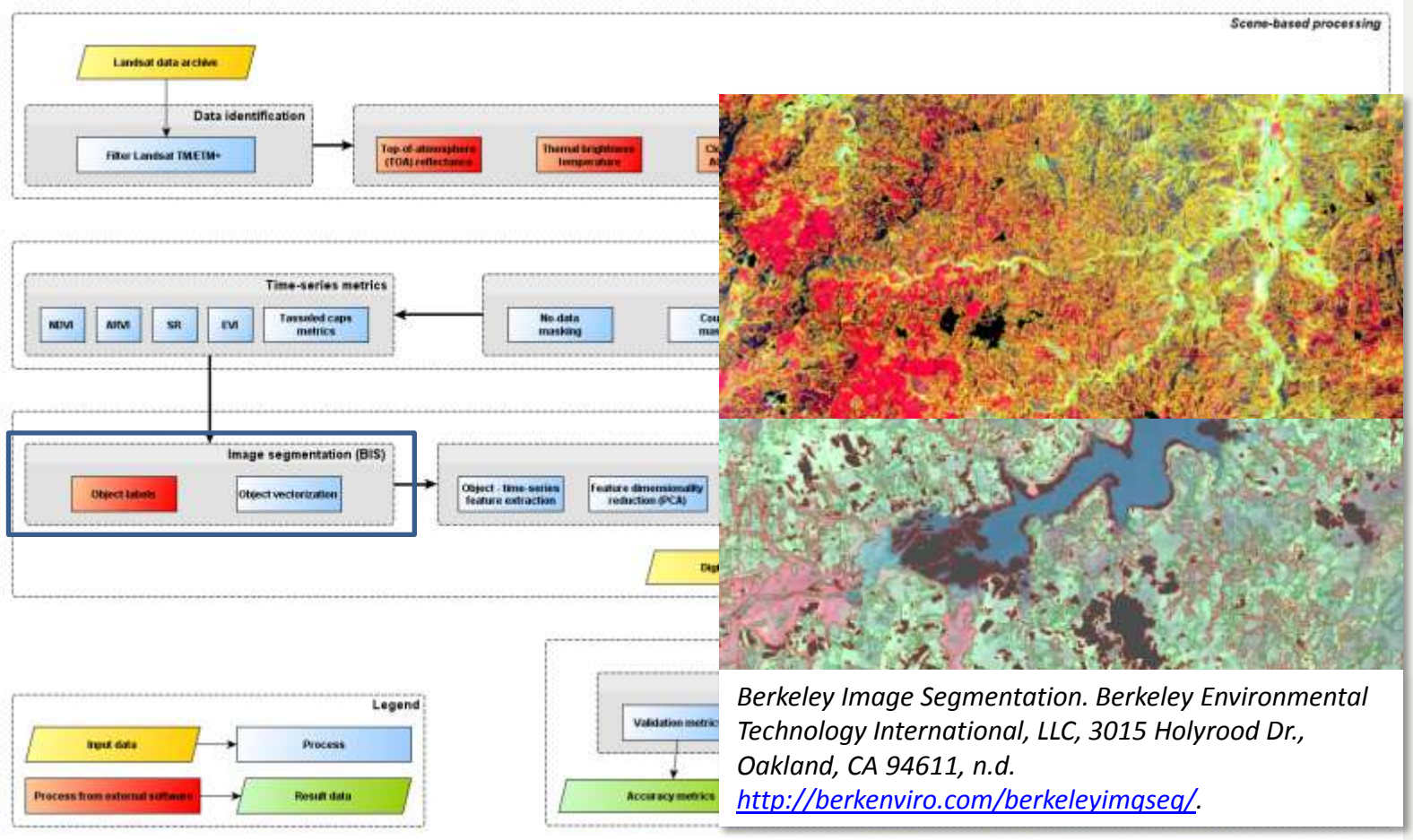
MAD-MEX Landsat processing



Time-series metrics:

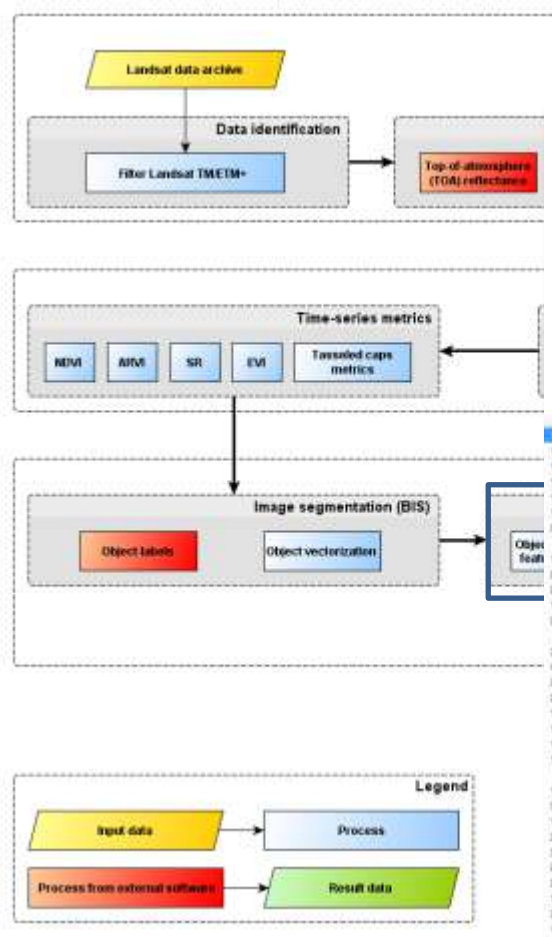
Calculate descriptive statistics for each pixel over the masked time-series and store back to 5 band image stacks. Thereby, ignore all pixels masked as "nodata" for statistics.

MAD-MEX Landsat processing



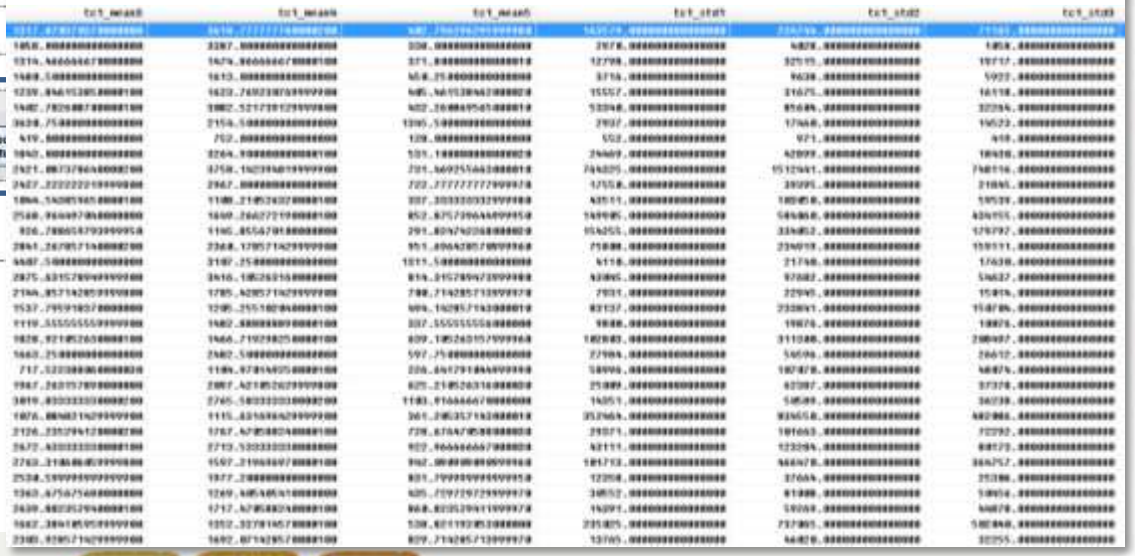
Berkeley Image Segmentation. Berkeley Environmental Technology International, LLC, 3015 Holyrood Dr., Oakland, CA 94611, n.d. http://berkenviro.com/berkeleyimgseg/.

MAD-MEX Landsat processing



Object feature extraction

Descriptive statistics (min,max,mean,std,var) over the object pixels from the metrics of vegetation indices and tasseled caps (= 250 features)



MAD-MEX Landsat processing

Object feature reduction

Dimensionality reduction based on principal component analysis by keeping those transformed components explaining 95% of total variance

tc1_min1	tc2_min1	tc4_min1	tc3_min1	tc5_min1	tc6_min1	ndvi_min1
tc1_min2	tc2_min2	tc4_min2	tc3_min2	tc5_min2	tc6_min2	ndvi_min2
tc1_min3	tc2_min3	tc4_min3	tc3_min3	tc5_min3	tc6_min3	ndvi_min3
tc1_min4	tc2_min4	tc4_min4	tc3_min4	tc5_min4	tc6_min4	ndvi_min4
tc1_min5	tc2_min5	tc4_min5	tc3_min5	tc5_min5	tc6_min5	ndvi_min5
tc1_max1	tc2_max1	tc4_max1	tc3_max1	tc5_max1	tc6_max1	ndvi_max1
tc1_max2	tc2_max2	tc4_max2	tc3_max2	tc5_max2	tc6_max2	ndvi_max2
tc1_max3	tc2_max3	tc4_max3	tc3_max3	tc5_max3	tc6_max3	ndvi_max3
tc1_max4	tc2_max4	tc4_max4	tc3_max4	tc5_max4	tc6_max4	ndvi_max4
tc1_max5	tc2_max5	tc4_max5	tc3_max5	tc5_max5	tc6_max5	ndvi_max5
tc1_mean1	tc2_mean1	tc4_mean1	tc3_mean1	tc5_mean1	tc6_mean1	ndvi_mean1
tc1_mean2	tc2_mean2	tc4_mean2	tc3_mean2	tc5_mean2	tc6_mean2	ndvi_mean2
tc1_mean3	tc2_mean3	tc4_mean3	tc3_mean3	tc5_mean3	tc6_mean3	ndvi_mean3
tc1_mean4	tc2_mean4	tc4_mean4	tc3_mean4	tc5_mean4	tc6_mean4	ndvi_mean4
tc1_mean5	tc2_mean5	tc4_mean5	tc3_mean5	tc5_mean5	tc6_mean5	ndvi_mean5
tc1_std1	tc2_std1	tc4_std1	tc3_std1	tc5_std1	tc6_std1	ndvi_std1
tc1_std2	tc2_std2	tc4_std2	tc3_std2	tc5_std2	tc6_std2	ndvi_std2
tc1_std3	tc2_std3	tc4_std3	tc3_std3	tc5_std3	tc6_std3	ndvi_std3
tc1_std4	tc2_std4	tc4_std4	tc3_std4	tc5_std4	tc6_std4	ndvi_std4
tc1_std5	tc2_std5	tc4_std5	tc3_std5	tc5_std5	tc6_std5	ndvi_std5
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feat_1
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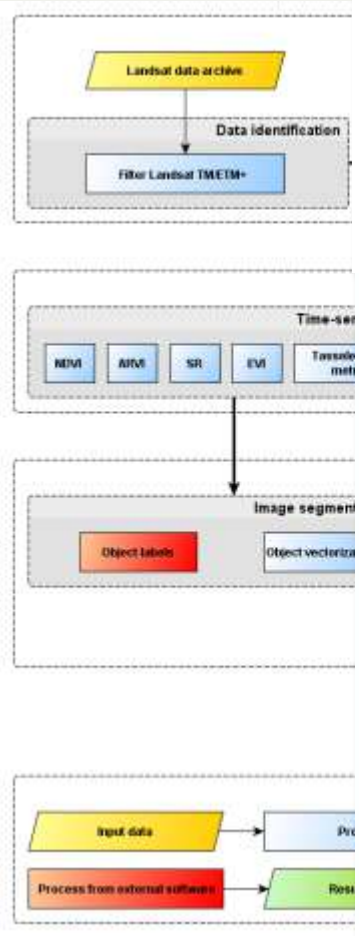
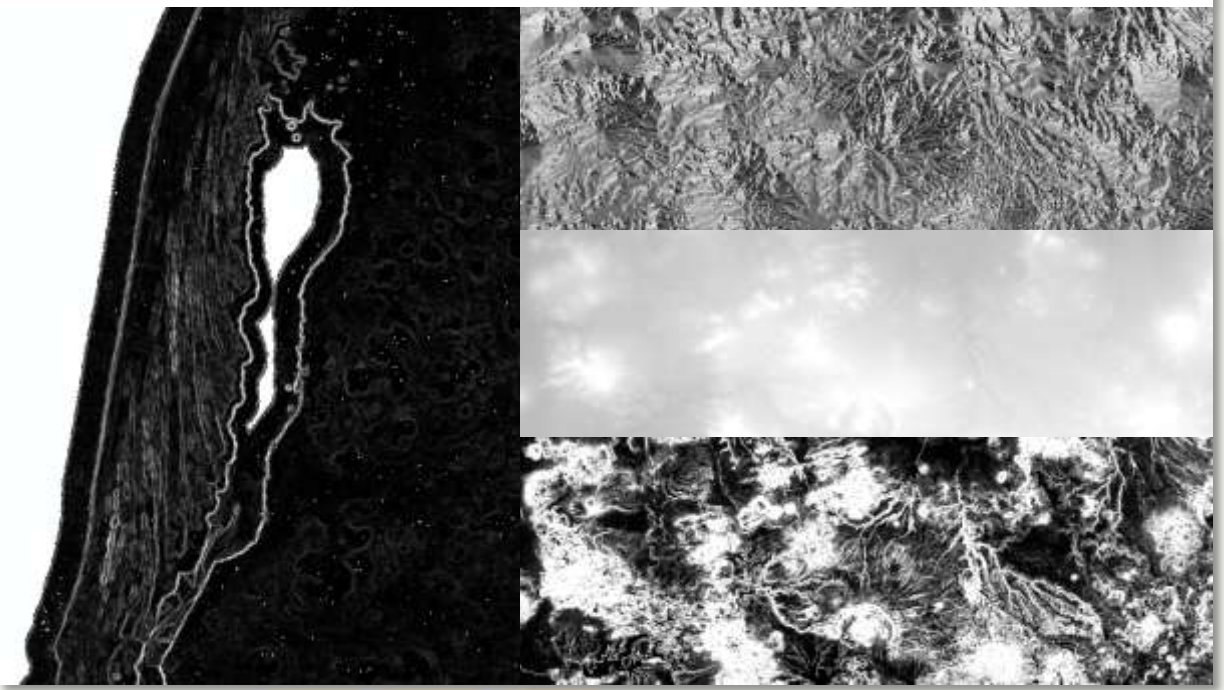
MAD-MEX Landsat processing



Object texture and elevation feature extraction

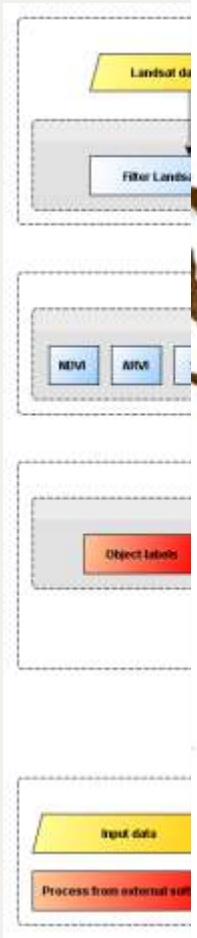
Descriptive statistics (min,max,mean,std,var) over the object pixels from the DEM, Aspect and Slope as also from the magnitude of the sobel gradient over NDVI mean image



MAD-MEX Landsat processing

Object class mapping

Utilizing persistent polygons from INEGI USV series mapped to classification scheme

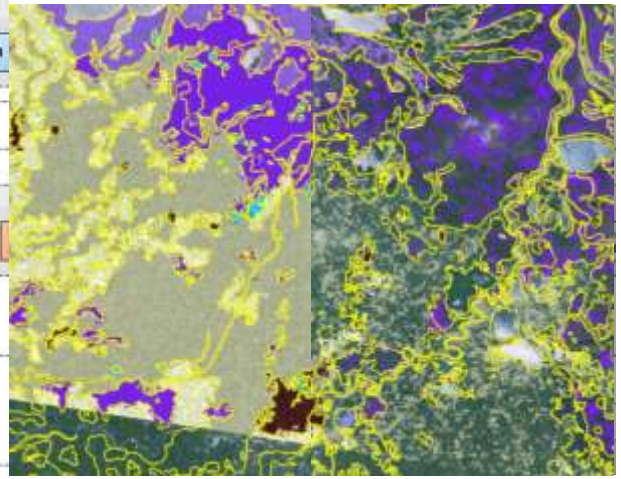


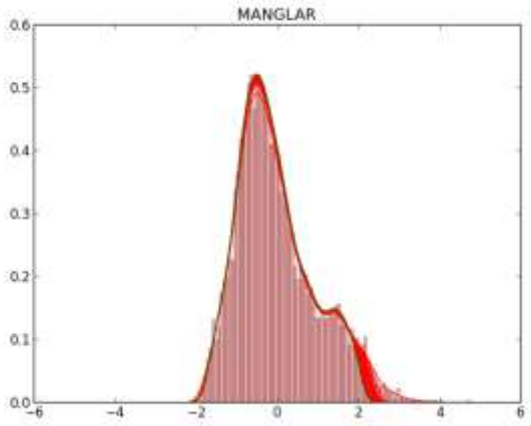
- AGRICULTURA
- BOSQUE DE CONIFERAS
- BOSQUE DE CONIFERAS ARBOREA
- BOSQUE DE CONIFERAS ARBUSTIVA
- BOSQUE DE CONIFERAS HERBACEA
- BOSQUE DE ENCINO
- BOSQUE DE ENCINO ARBOREA
- BOSQUE DE ENCINO ARBUSTIVA
- BOSQUE DE ENCINO HERBACEA
- BOSQUE DE ENCINO-PINO Y PINO-ENCINO
- BOSQUE DE ENCINO-PINO Y PINO-ENCINO ARBOREA
- BOSQUE DE ENCINO-PINO Y PINO-ENCINO ARBUSTIVA
- BOSQUE DE ENCINO-PINO Y PINO-ENCINO HERBACEA
- CUERPO DE AGUA
- MATORRAL XEROFILO
- MATORRAL XEROFILO ARBOREA
- MATORRAL XEROFILO ARBUSTIVA
- MATORRAL XEROFILO HERBACEA
- PASTIZALES
- PASTIZALES ARBUSTIVA
- SELVAS HUMEDAS Y SUBHUMEDAS Y BOSQUE MESOFILO
- SELVAS HUMEDAS Y SUBHUMEDAS Y BOSQUE MESOFILO ARBOREA
- SELVAS HUMEDAS Y SUBHUMEDAS Y BOSQUE MESOFILO ARBUSTIVA
- SELVAS HUMEDAS Y SUBHUMEDAS Y BOSQUE MESOFILO HERBACEA
- SELVAS SECAS
- SELVAS SECAS ARBOREA
- SELVAS SECAS ARBUSTIVA
- SELVAS SECAS HERBACEA
- SUELO DESNUDO
- URBANO Y CONSTRUIDO
- VEGETACION HIDROFILA
- VEGETACION HIDROFILA ARBUSTIVA

MAD-MEX Landsat processing

Outlier removal

To account for discrepancies between reference map and image objects – to create "clean" training dataset
Outlier removal utilizing classwise iterative histogram trimming on the first 3 principal component features





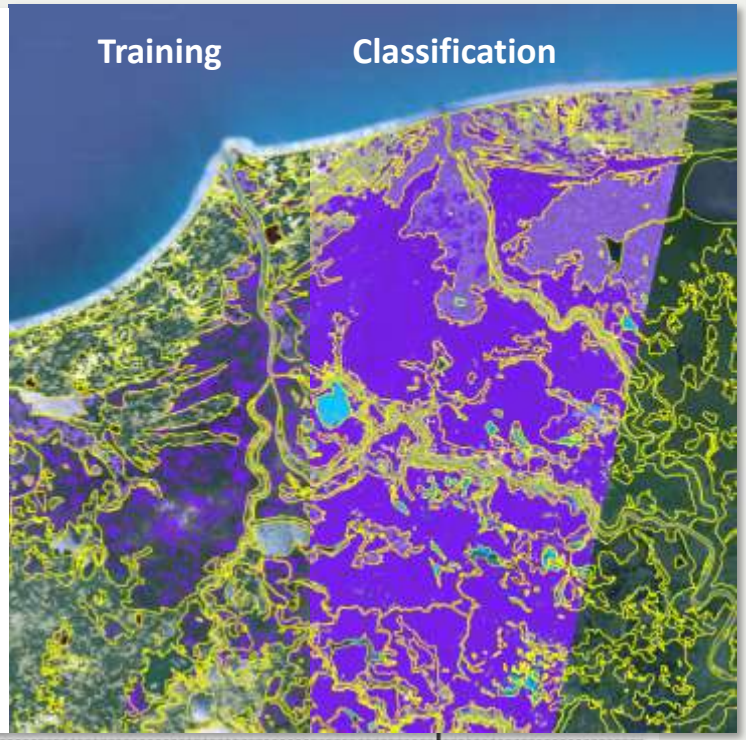
Radoux, Julien, and Pierre Defourny. "Automated Image-to-Map Discrepancy Detection Using Iterative Trimming." Photogrammetric Engineering & Remote Sensing 76, no. 2 (2010): 173–181.

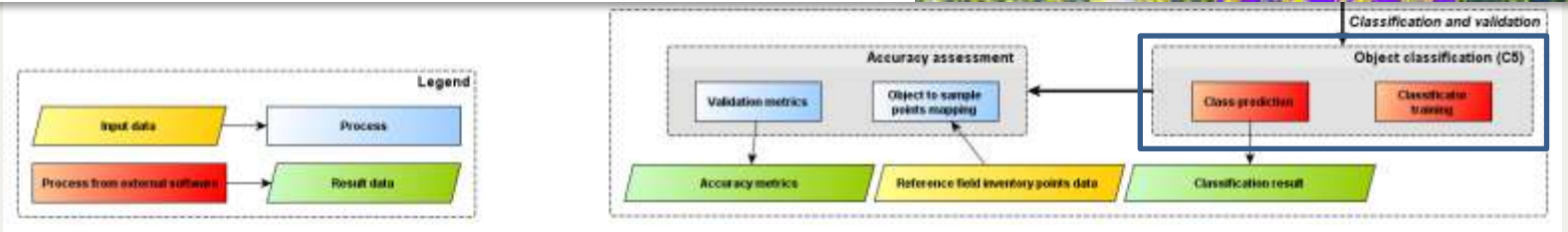
MAD-MEX Landsat processing

Object classification based on C5 decision tree

Training of the classifier based on the outlier cleaned training data.
Training of 10-folded boosted decision tree.
Classification of all objects and export to Shapefile.

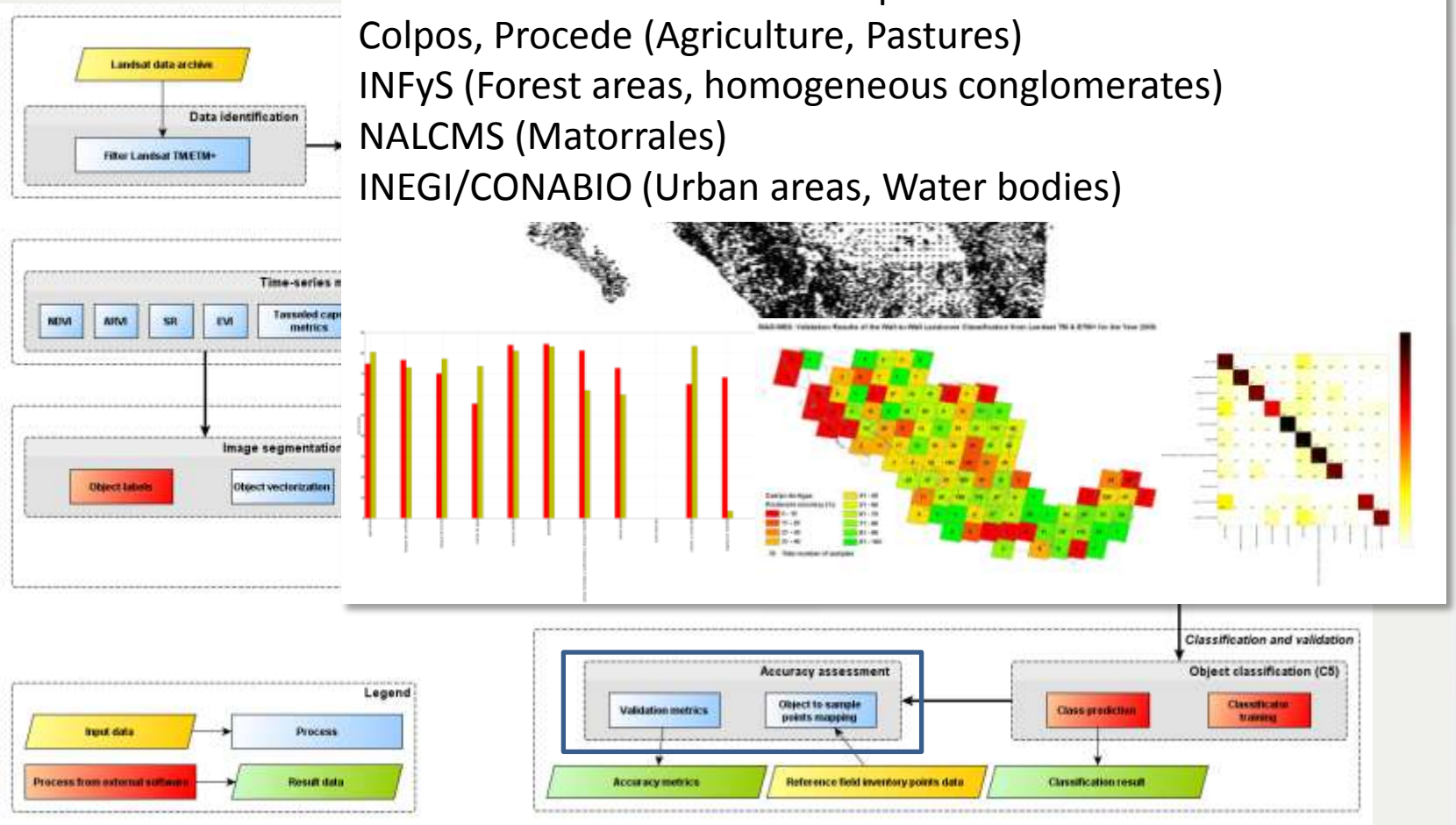
Hodge, Victoria, and Jim Austin. "A Survey of Outlier Detection Methodologies." Artificial Intelligence Review 22, no. 2 (2004): 85–126.
Quinlan, J. Ross. C4.5: Programs for Machine Learning (Morgan Kaufmann Series in Machine Learning). 1st ed. Morgan Kaufmann, 1992.



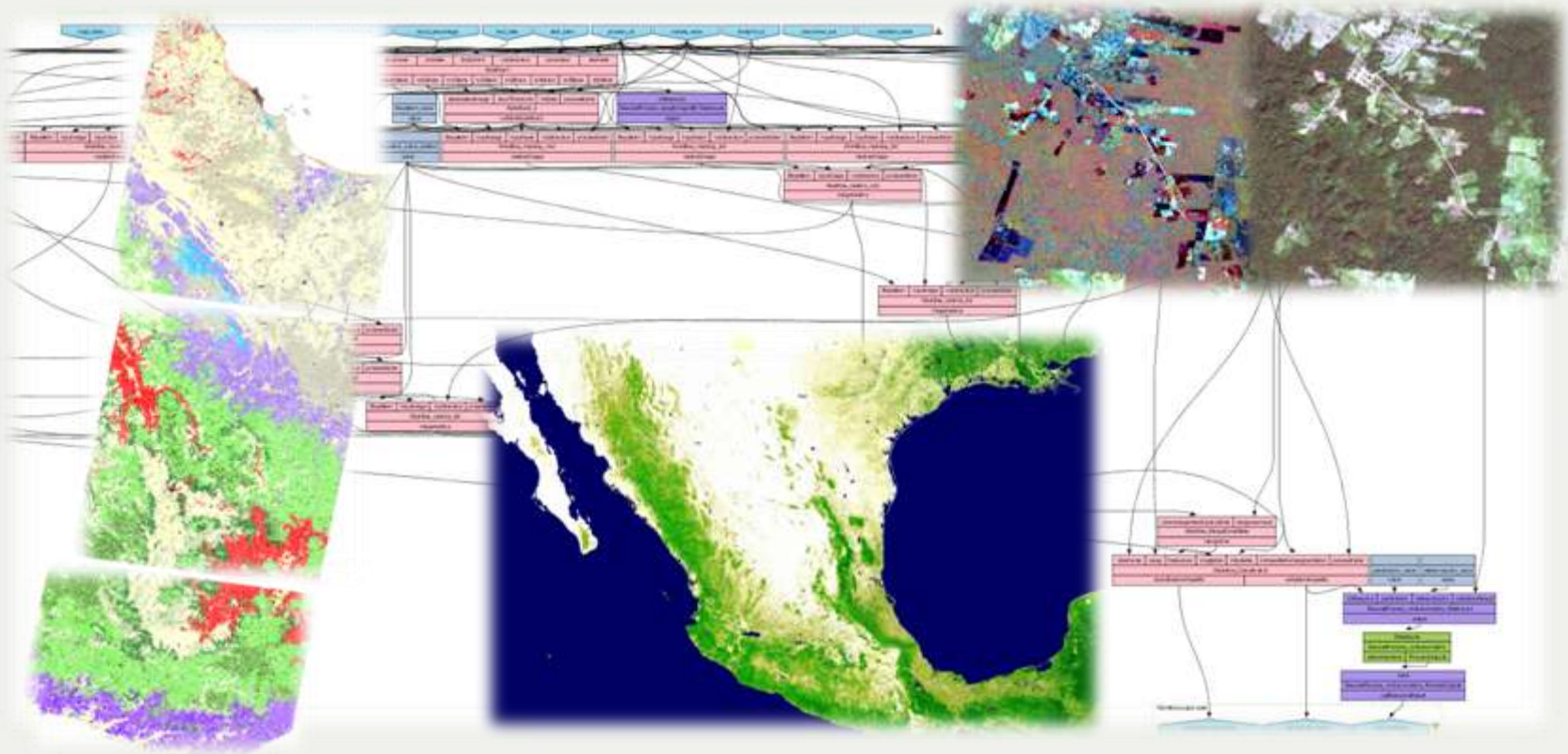


MAD-MEX Landsat processing

Validation based on reference points available from:
Colpos, Procede (Agriculture, Pastures)
INFyS (Forest areas, homogeneous conglomerates)
NALCMS (Matorrales)
INEGI/CONABIO (Urban areas, Water bodies)



Thank you



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