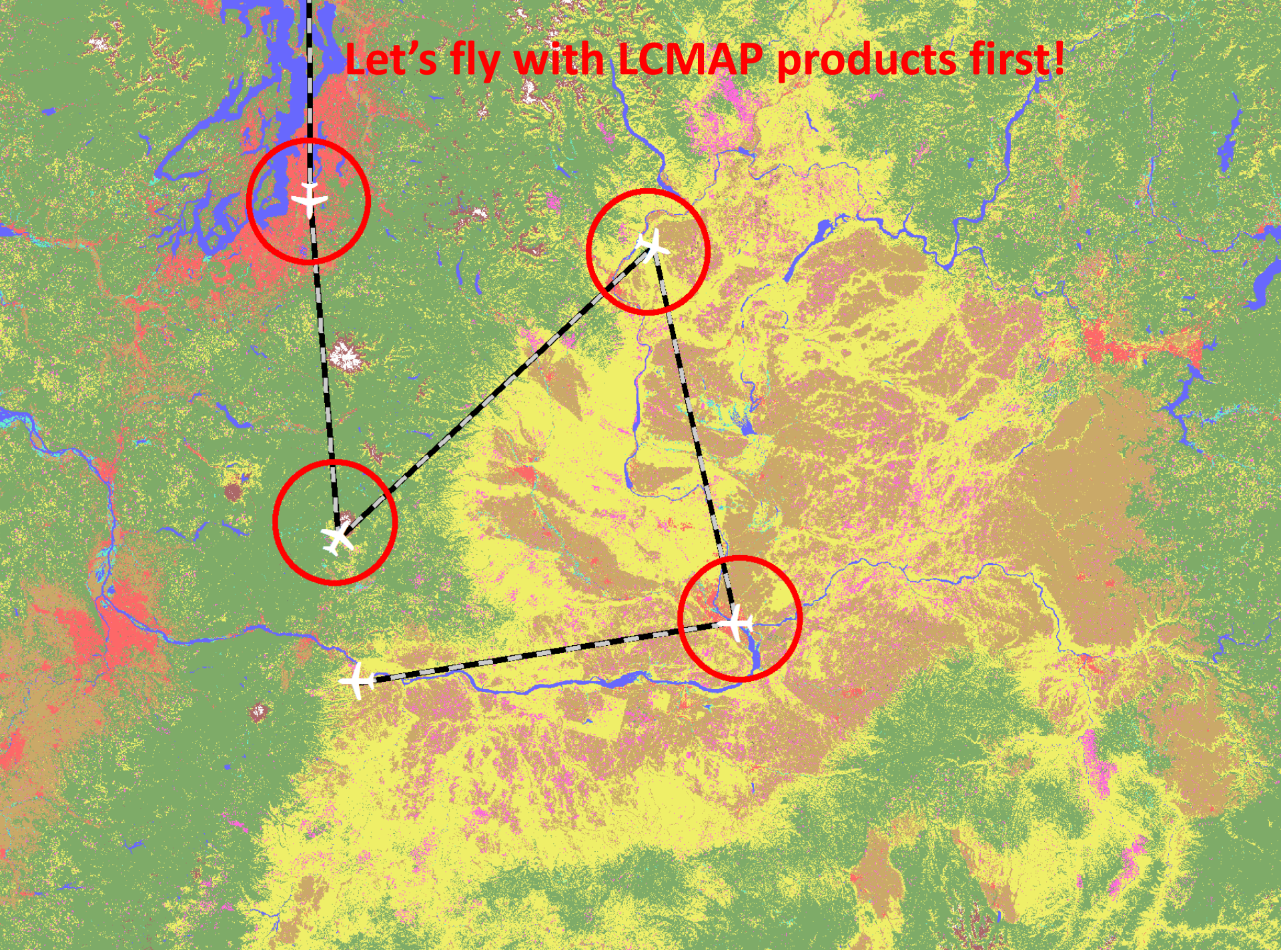
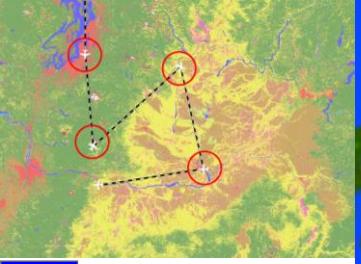
Progress of the LCMAP Initiative: From Algorithms to Products

Zhe Zhu and the LCMAP Team

Landsat Science Team Meeting, 07/28/2016, Brookings, SD


Let’s fly with LCMAP products first!



- Water
- Developed
- Disturbed
- Barren (naturally)
- Forest
- Grassland/Shrubland
- Agriculture
- Wetlands
- Perennial snow/ice

1985

Outline

- Goal
- Algorithm Development (LCMAP*-CCDC**)
- LCMAP “M” Products
- Conclusion

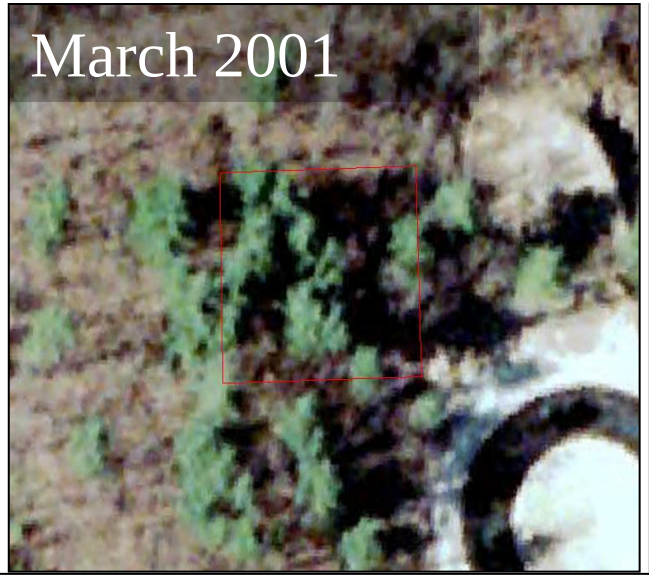
*Land Change Monitoring, Assessment, and Projection (LCMAP)

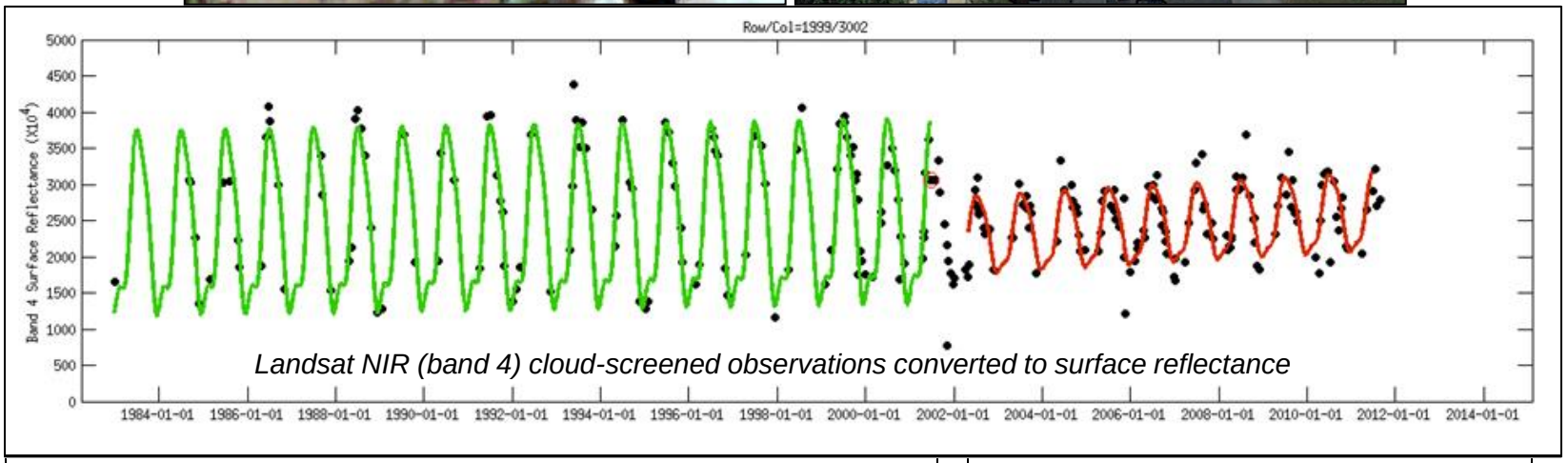
**Continuous Change Detection and Classification (CCDC)

Goal

- Provide 30-meter resolution maps of surface characteristics (i.e. cover, use, condition, and change) at any time between 1985 to 2015 for the entire United States.

Continuous Change Detection and Classification Algorithm





Mixed Forest

Low Density Residential

Continuous Change Detection and Classification Algorithm

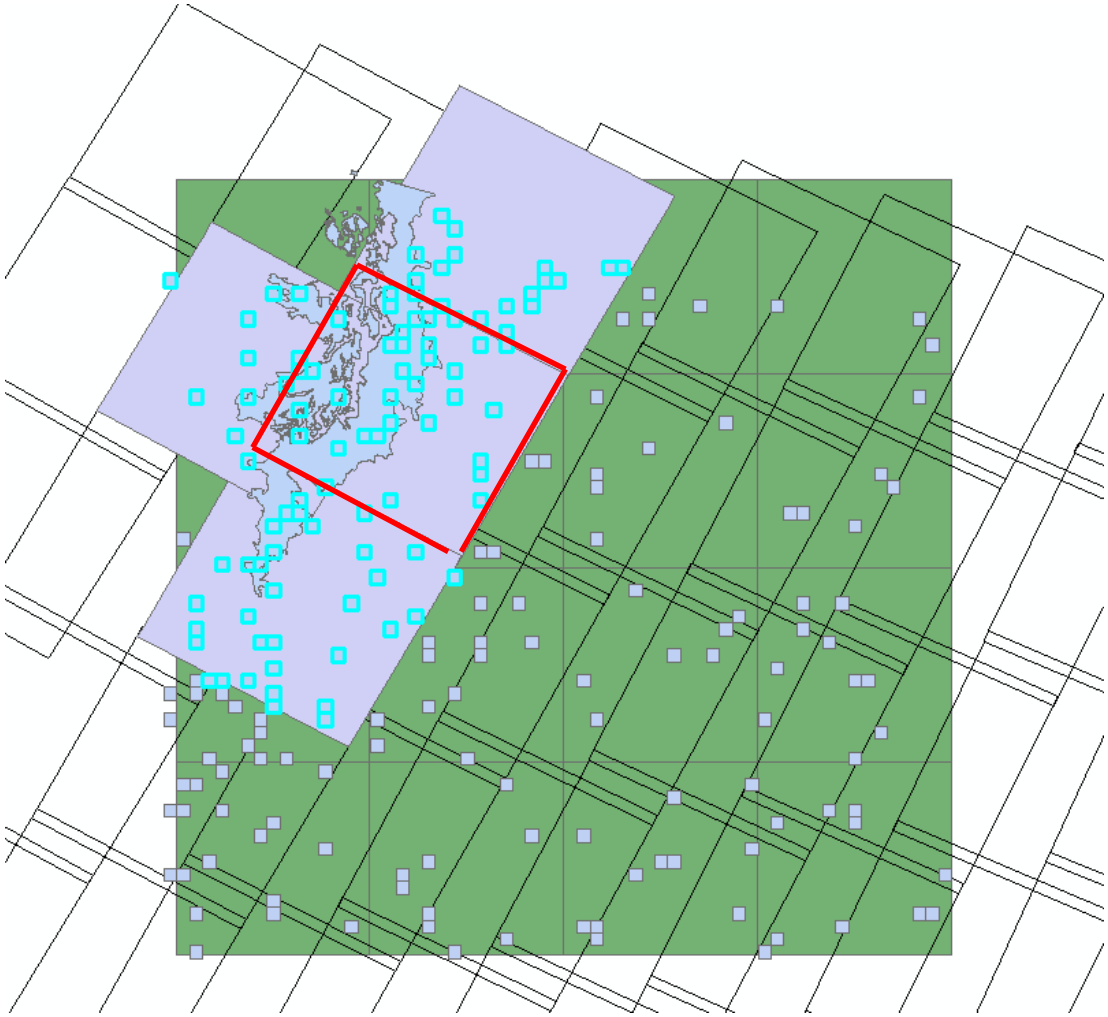
Progress of the CCDC algorithm

- Zhe Zhu, Curtis E. Woodcock, Pontus Olofsson. 2012. Continuous monitoring of **forest disturbance** using all available Landsat imagery. *Remote Sensing of Environment*, 122: 75-91
  - CCDC version 1.0
- Zhu, Z. and C.E. Woodcock. 2014. **Continuous change detection and classification** of land cover using all available Landsat data. *Remote Sensing of Environment*, 144: 152–171
  - CCDC version 7.3
- Zhu, Z., Woodcock, C.E., Holden, C. and Yang, Z., 2015. **Generating synthetic Landsat images** based on all available Landsat data: Predicting Landsat surface reflectance at any given time. *Remote Sensing of Environment*, *162*: 67-83
  - CCDC version 11.4
- Zhu, Z., et al., In Preparation**. Large area annual land cover** maps derived from analysis ready Landsat time series data
  - CCDC version 12.31; LCMAP-CCDC

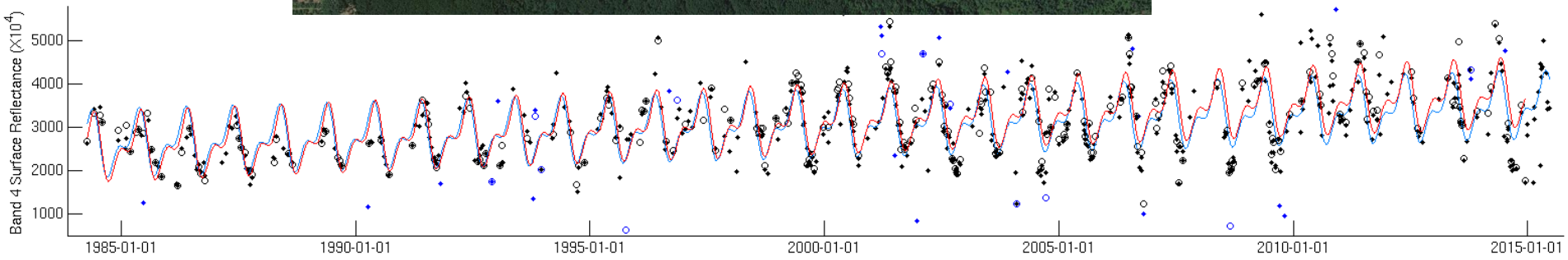
The “missing puzzle pieces” between CCDC and LCMAP

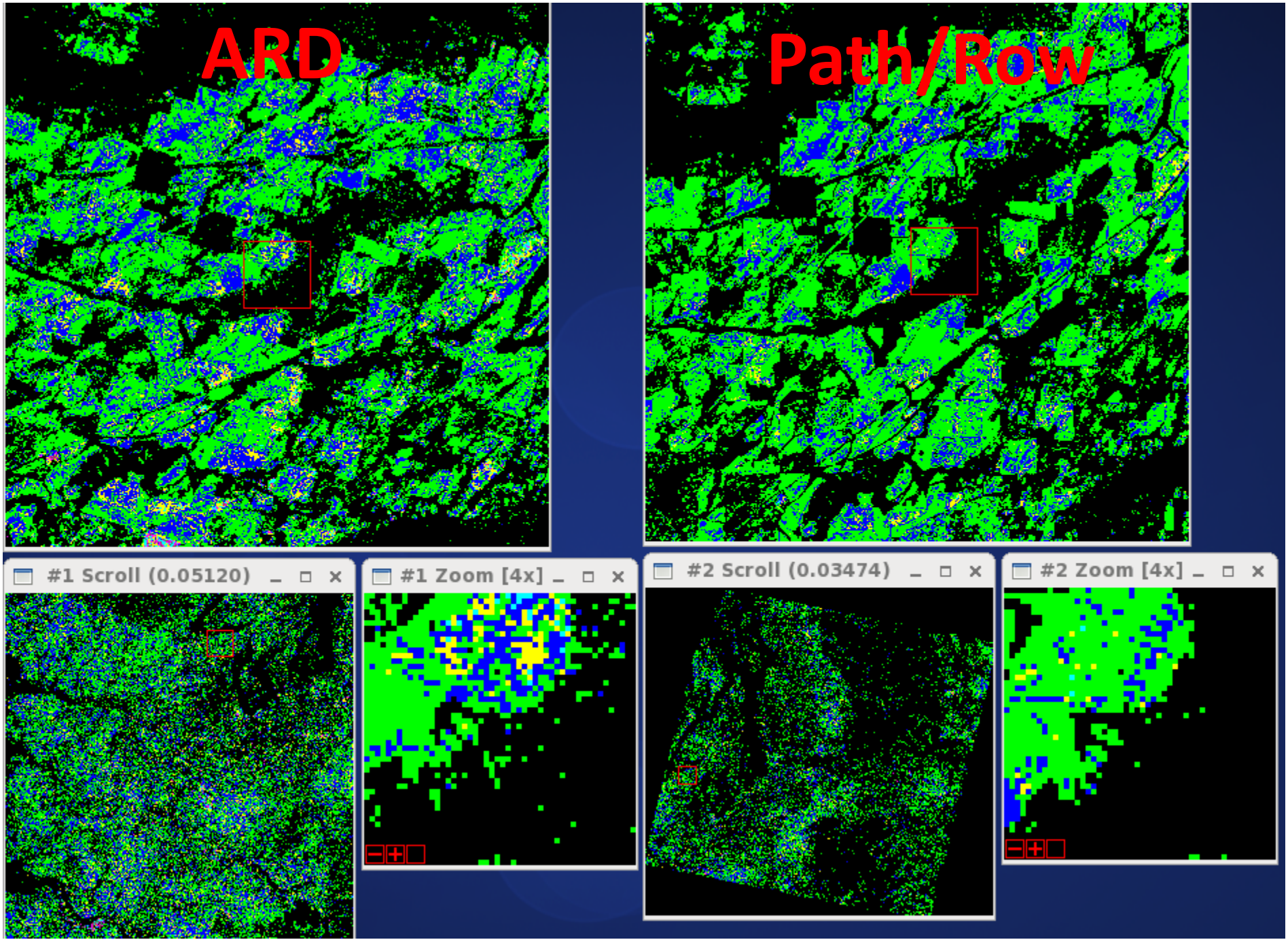
- **Change**
  - How to use Analysis Ready Data (ARD) for more frequent clear observations?
- **Condition**
  - How to generate vegetation condition maps for places that have undergone change?
- **Cover and use**
  - How to better use training and ancillary data for land cover classification?
  - How to classify large area seamlessly and continuously?
  - How to handle cover at different forest succession stages?

Change: How to use Analysis Ready Data (ARD) for more frequent good observations?



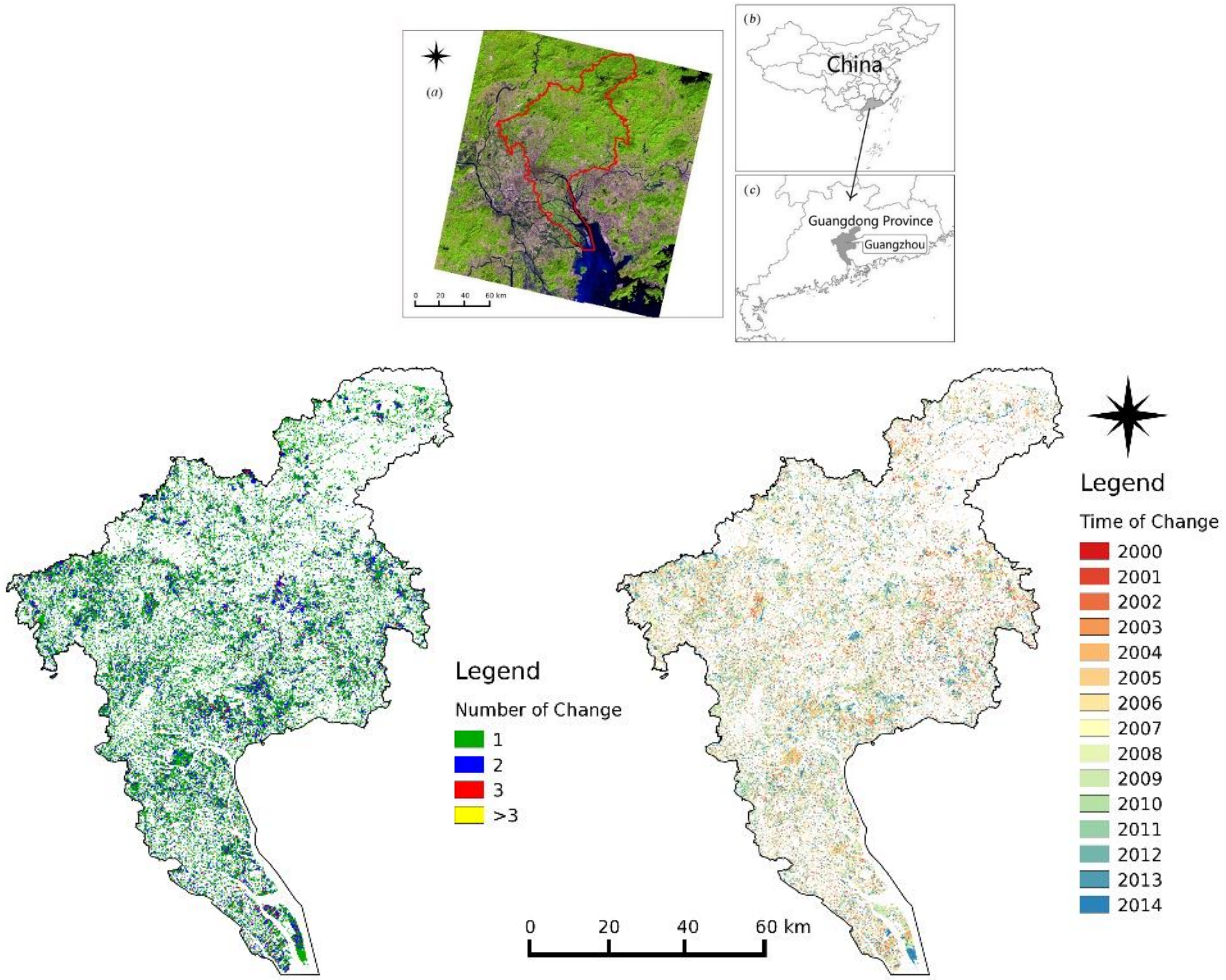
Change: How to use Analysis Ready Data (ARD) for more frequent good observations?




ARD
Path/Row
#1 Scroll (0.05120)
#1 Zoom [4x]
#2 Scroll (0.03474)
#2 Zoom [4x]

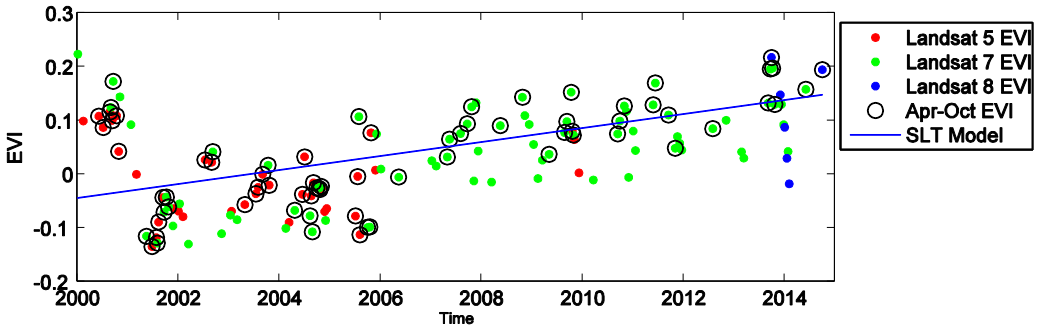
Condition: How to generate vegetation condition maps for places that have undergone change?

The Earth surface is change!

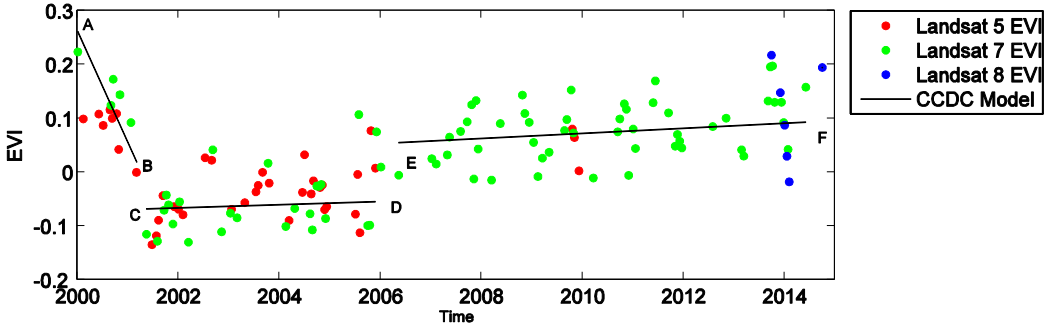


Condition: How to generate vegetation condition maps for places that have undergone change?

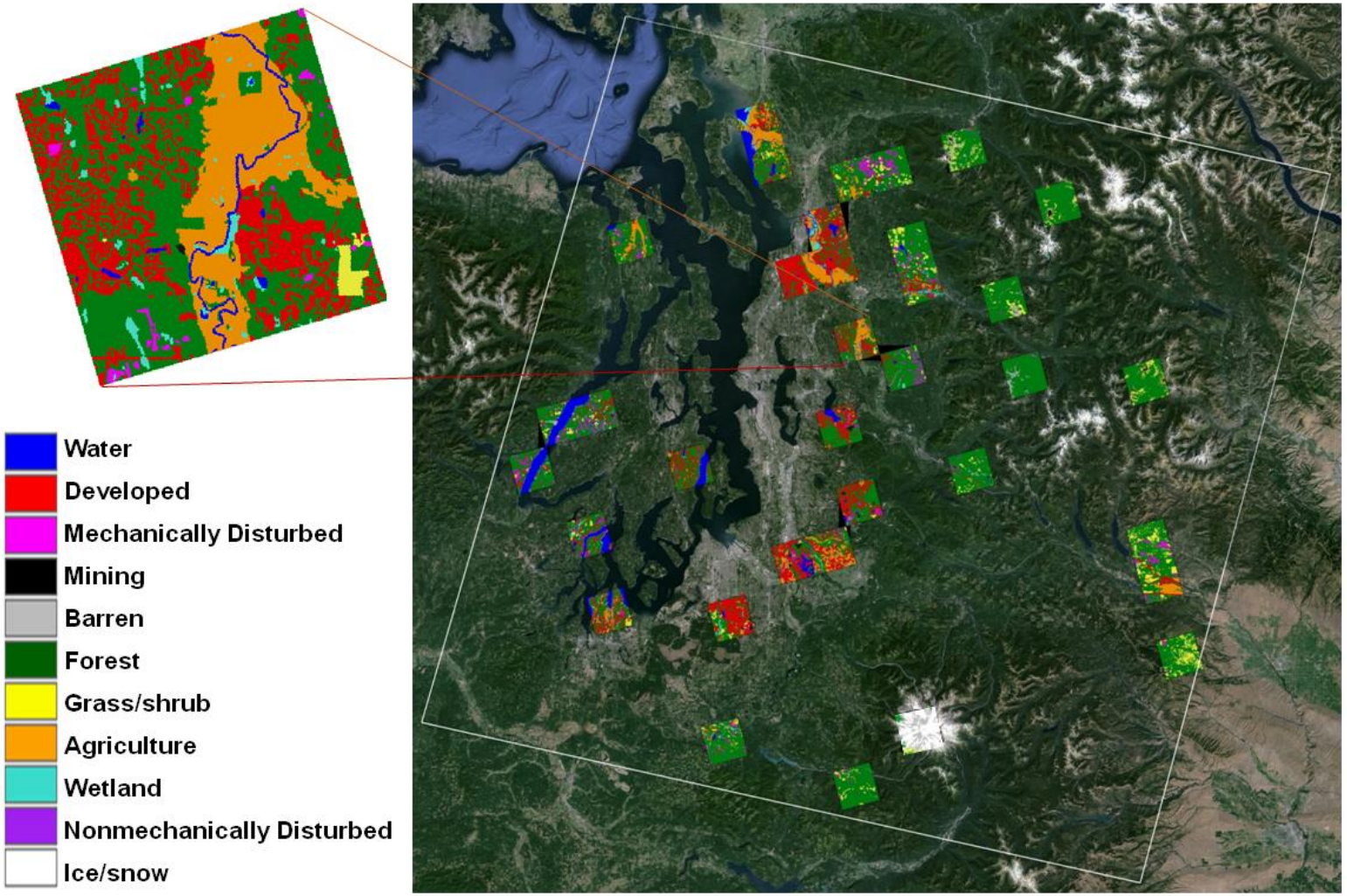
Land surface change can easily break the assumption for trend analysis



Solution: Find breaks before trend analysis



Cover and use: How to better use training data for land cover classification?



Cover and use: How to better use ancillary data for land cover classification?

(a) five variables used by the National Land Cover Database,
(b) three variables from the cloud screening “Function of mask” (Fmask) statistics
(c) two variables from the change detection results of CCDC

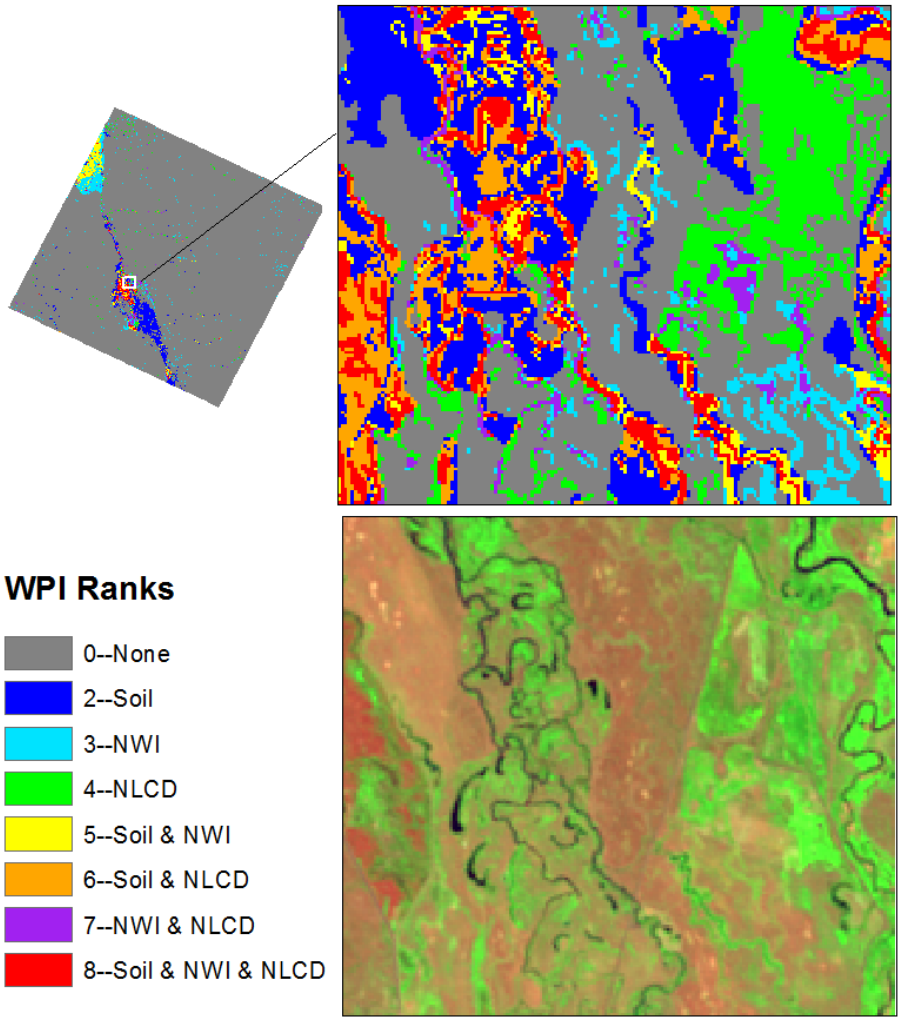
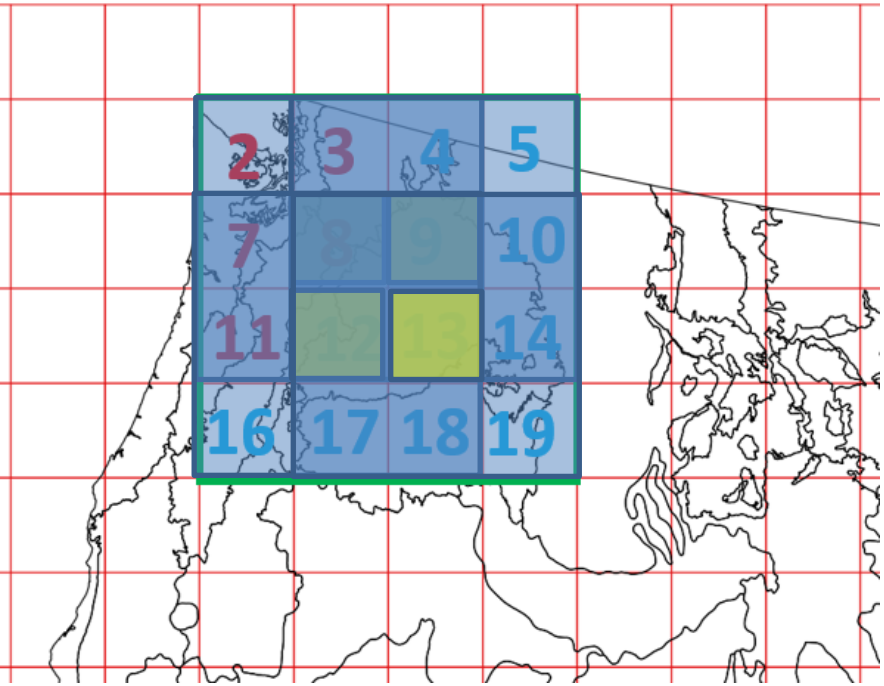
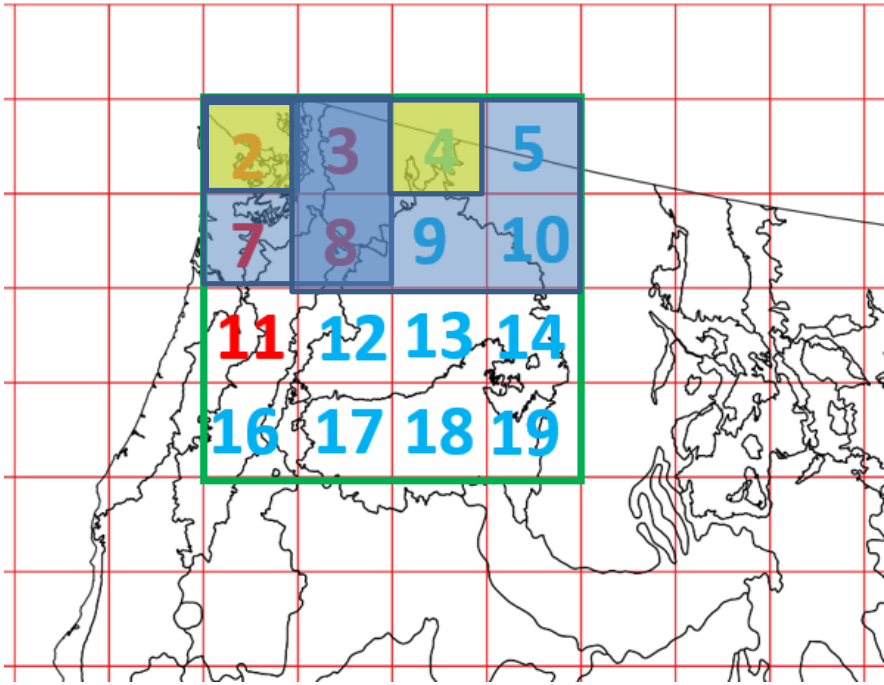


Figure. Wetland Potential Index (WPI) map

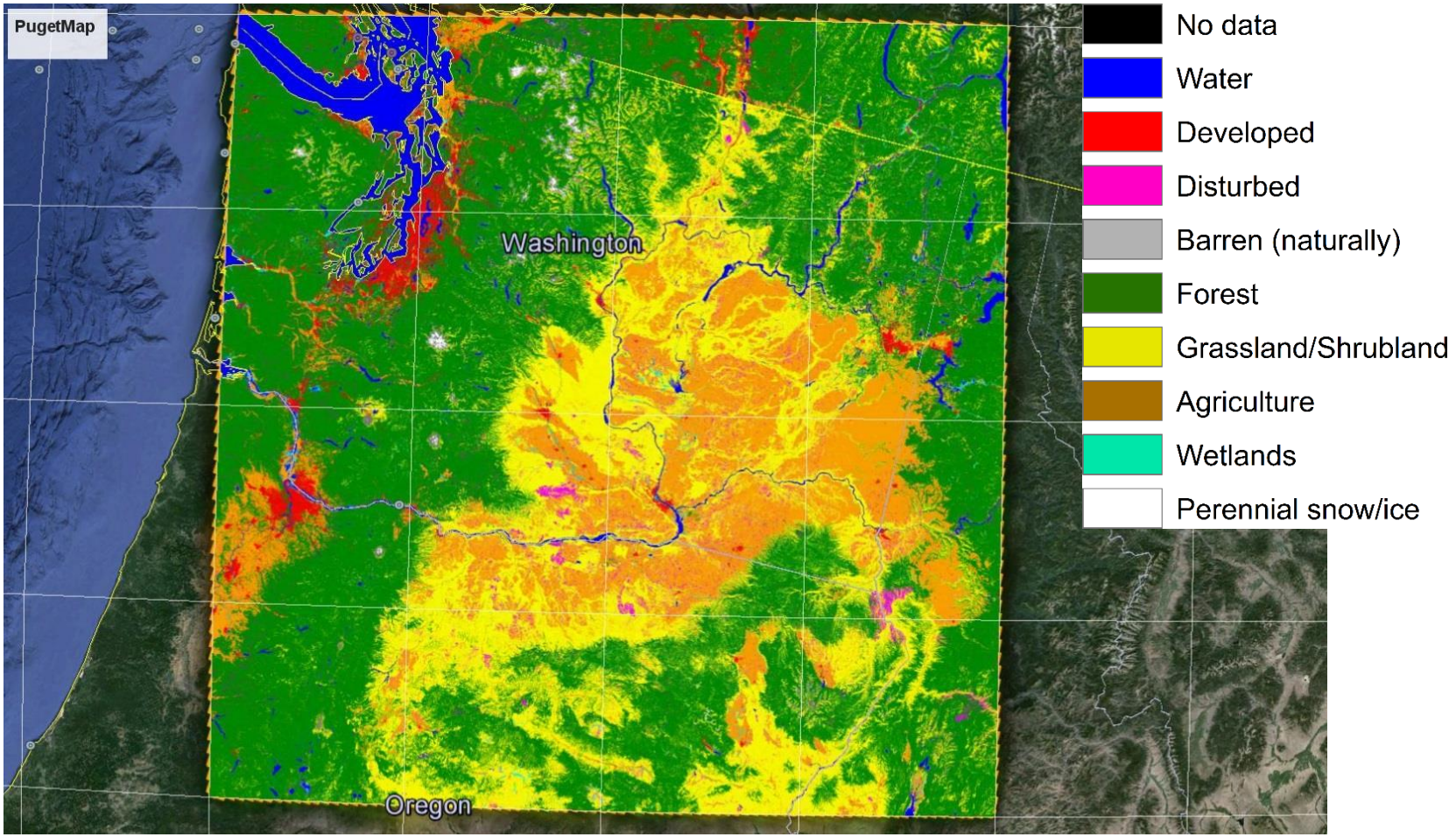
Cover and use: How to classify large area seamlessly and continuously?

"Moving Window" for local and seamless training

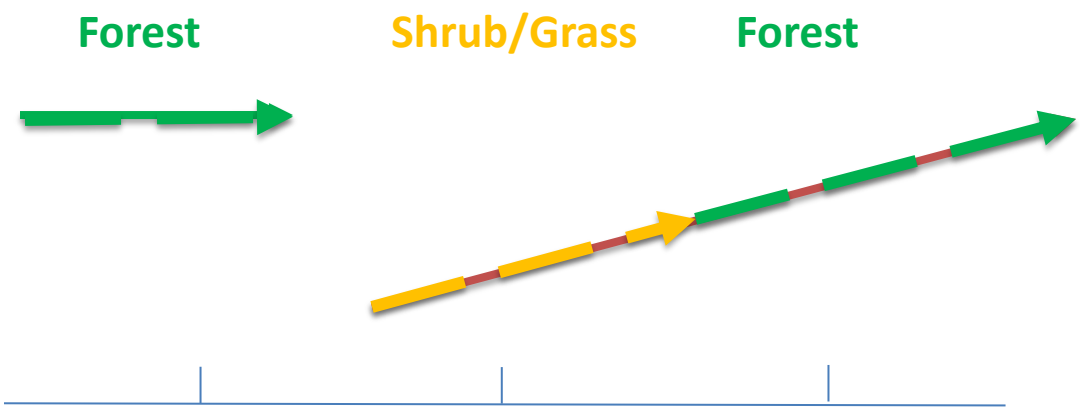




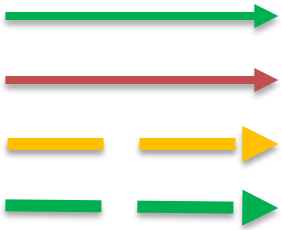
Cover and use: How to classify large area seamlessly and continuously?



Cover and use: How to handle cover at different forest succession stages?



Forest
Regenerating Forest
Shrub/Grass
Forest

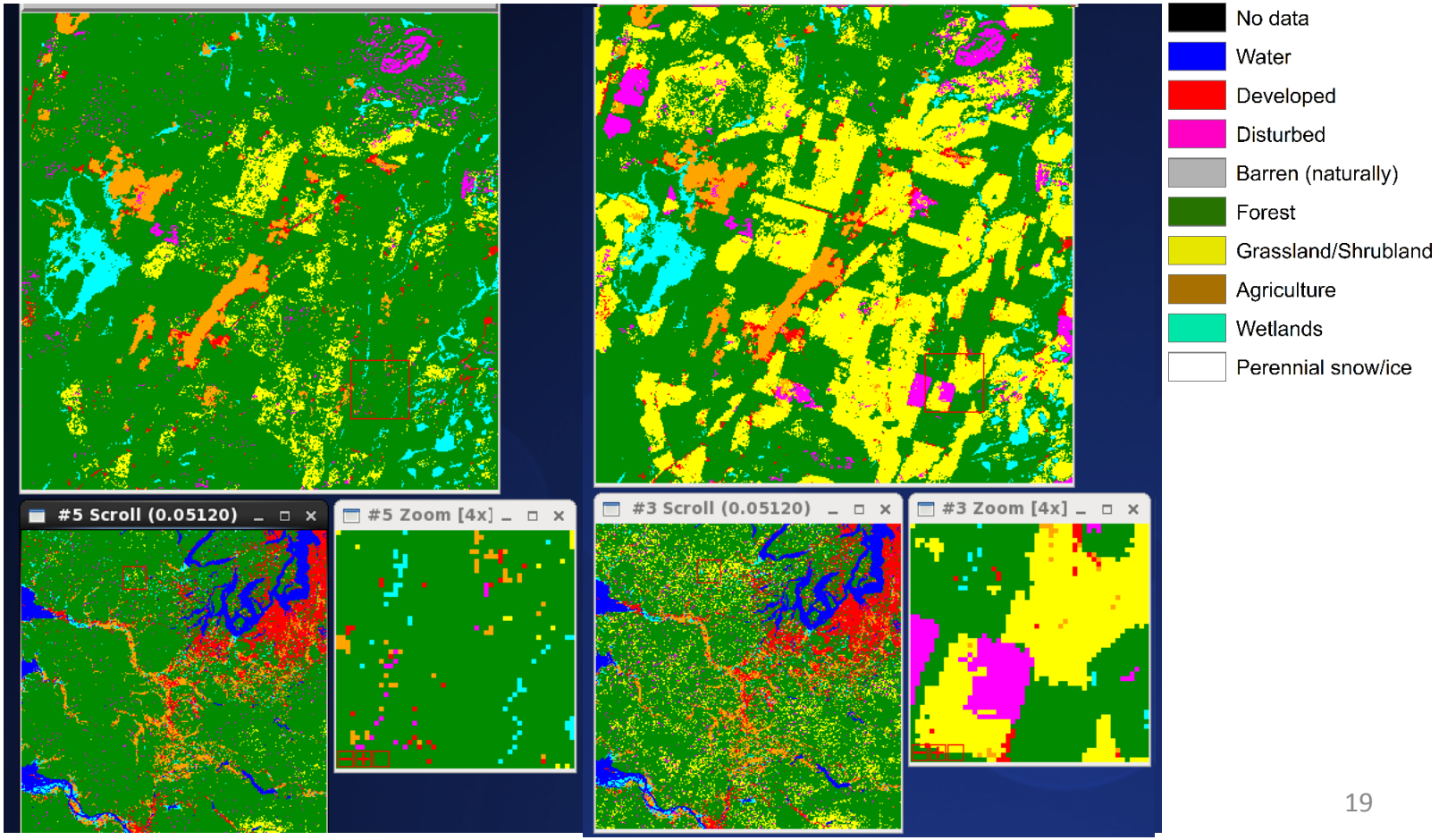


Only apply this algorithm to segments with significant (<0.05) NBR slope

Cover and use: How to handle cover at different forest succession stages?

Original CCDC

LCMAP-CCDC



LCMAP “M” Products

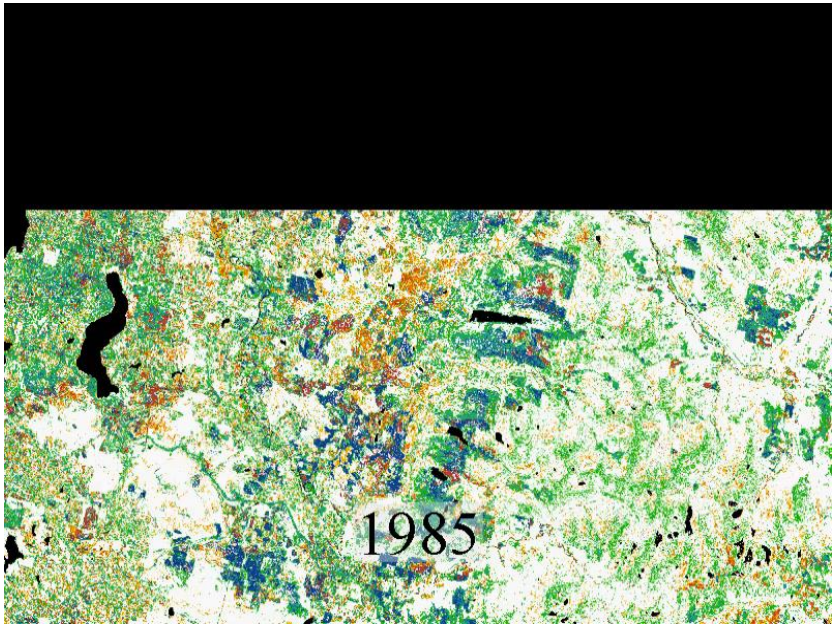
- Land Cover Land Use
  - land cover land use map
  - land cover land use confidence map (QA)
- Condition
  - Vegetation index slope maps
  - Vegetation index slope significance map (QA)
- Change
  - Change time map
  - Change magnitude map
  - Change agent map
  - Change procedure map (QA)
- Hybrid
  - Land cover land use and change map

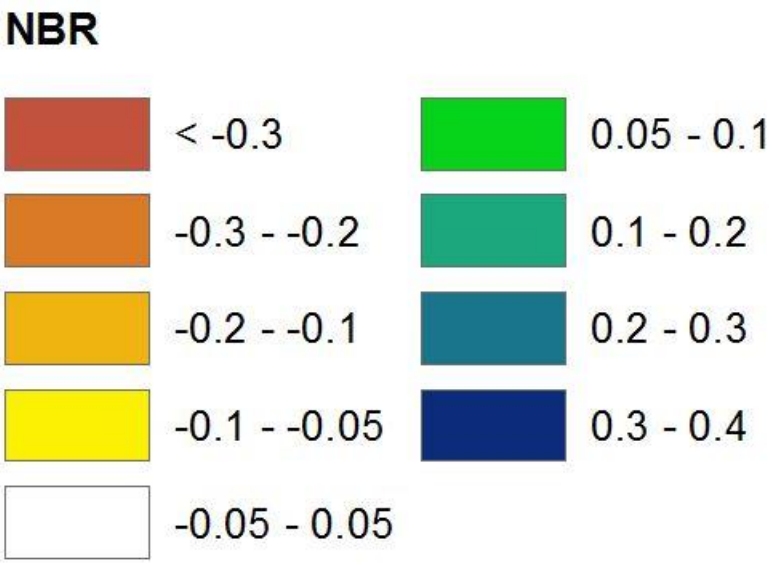
Land Cover Land Use

- Land cover land use map: Annual thematic maps representing thematic cover as of July 1st (mid-summer anniversary date we selected for this assessment) using the classification scheme of the USGS Land Cover Trends project. Cell values are 8-bit integers corresponding with the following 11 classes:
  - *water*
  - *developed (includes mining)*
  - *barren (naturally)*
  - *forest*
  - *grassland/shrubland (includes pasture)*
  - *agriculture*
  - *wetlands*
  - *perennial snow/ice*
  - *mechanical disturbed*
  - *non-mechanical disturbed*
  - *Fire*
- Land cover land use confidence map (QA): Represents a measure of how frequently the "winning" class for a pixel was chosen among the decision trees for a given year. The confidence metric used is the unsupervised ensemble margin and is calculated by number of votes for the most-voted class minus number of votes for the 2nd most-voted class divided by the total number of votes

Condition

- Slope map: annual maps of vegetation condition, where condition is represented as the regression slope of all available summer (June, July, and August) NDVI, EVI, and NBR observations for time intervals between periods of abrupt changes.
- Slope significance map (QA) provides the significance of the NDVI, EVI, and NBR slopes.





Change

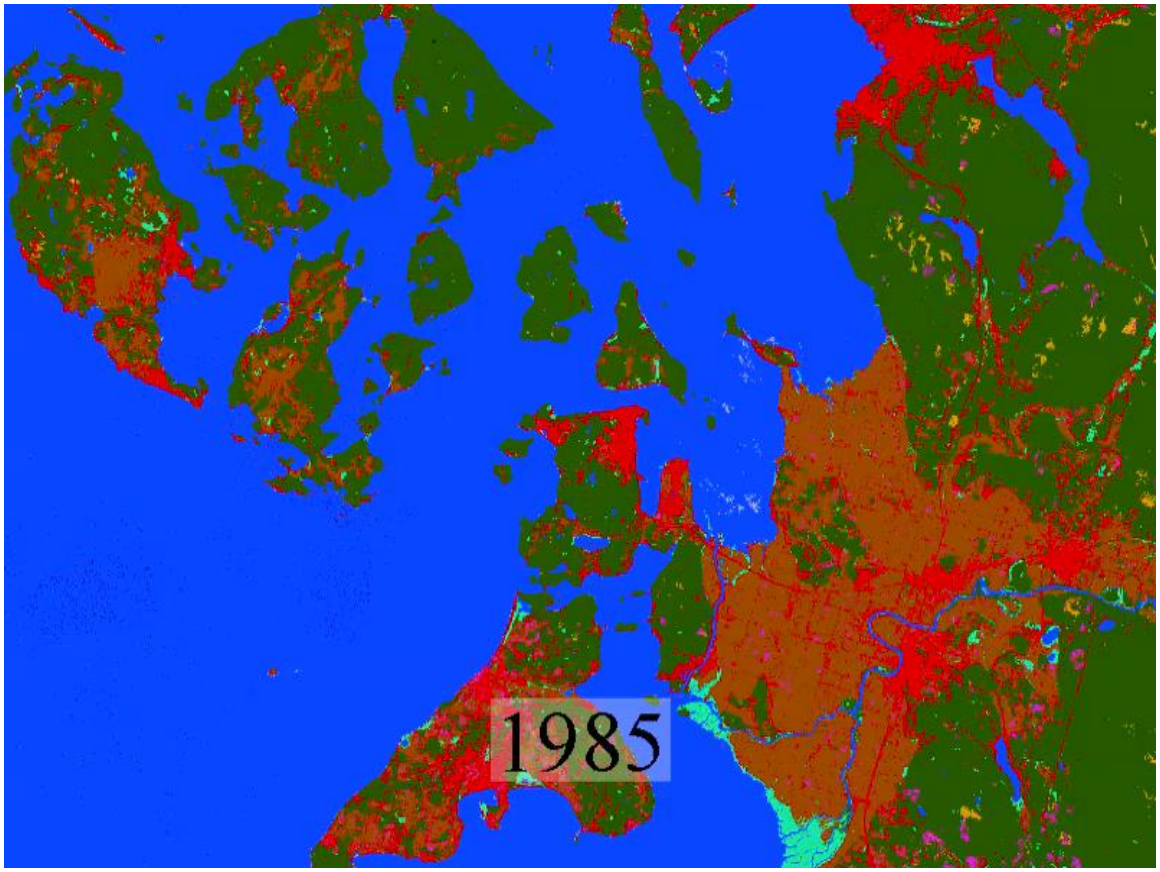
- Change time map: Annual maps showing the day-of-year (DOY) when change was first detected. DOY values are 16-bit integers ranging from 1 to 365 (366 in leap years).
- Change magnitude map: Annual maps from 1985–2014 showing the change vector magnitude across all bands.

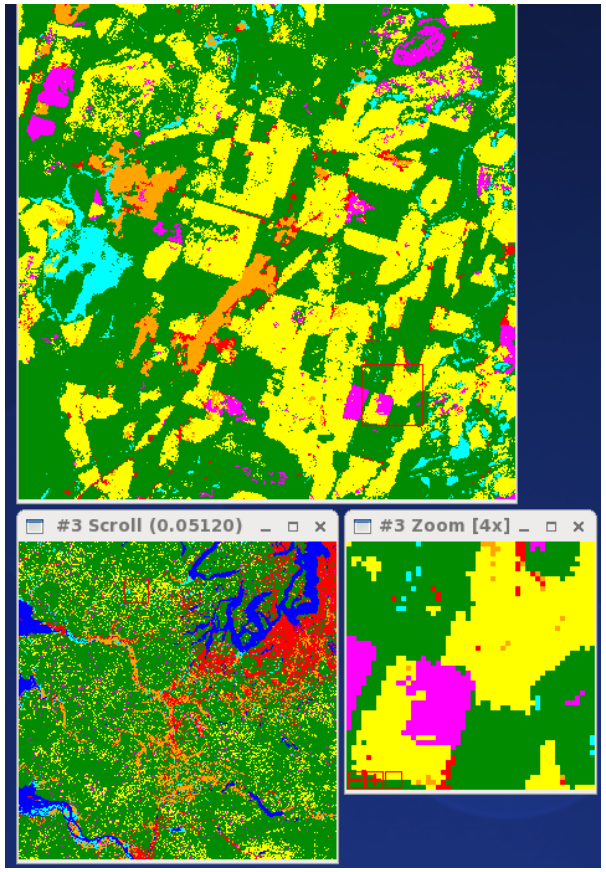
$$\sqrt{\sum_{i=1}^{n} (predicted - Observed)^2}$$

- Change agent map: Three classes will be identified: *mechanical, non-mechanical, and fire.* The algorithm for separating the three change agents is still in development. Training data from Land Cover Trends, LANDFIRE, and TimeSync collected points are being tested as possible sources.
- Change procedure map (QA): Annual maps with two-digit categorical code (8-bit integer data) relating to how the time-series model was estimated. The first bit refers to what procedure was used for the model and the second bit indicates how many coefficients were used.

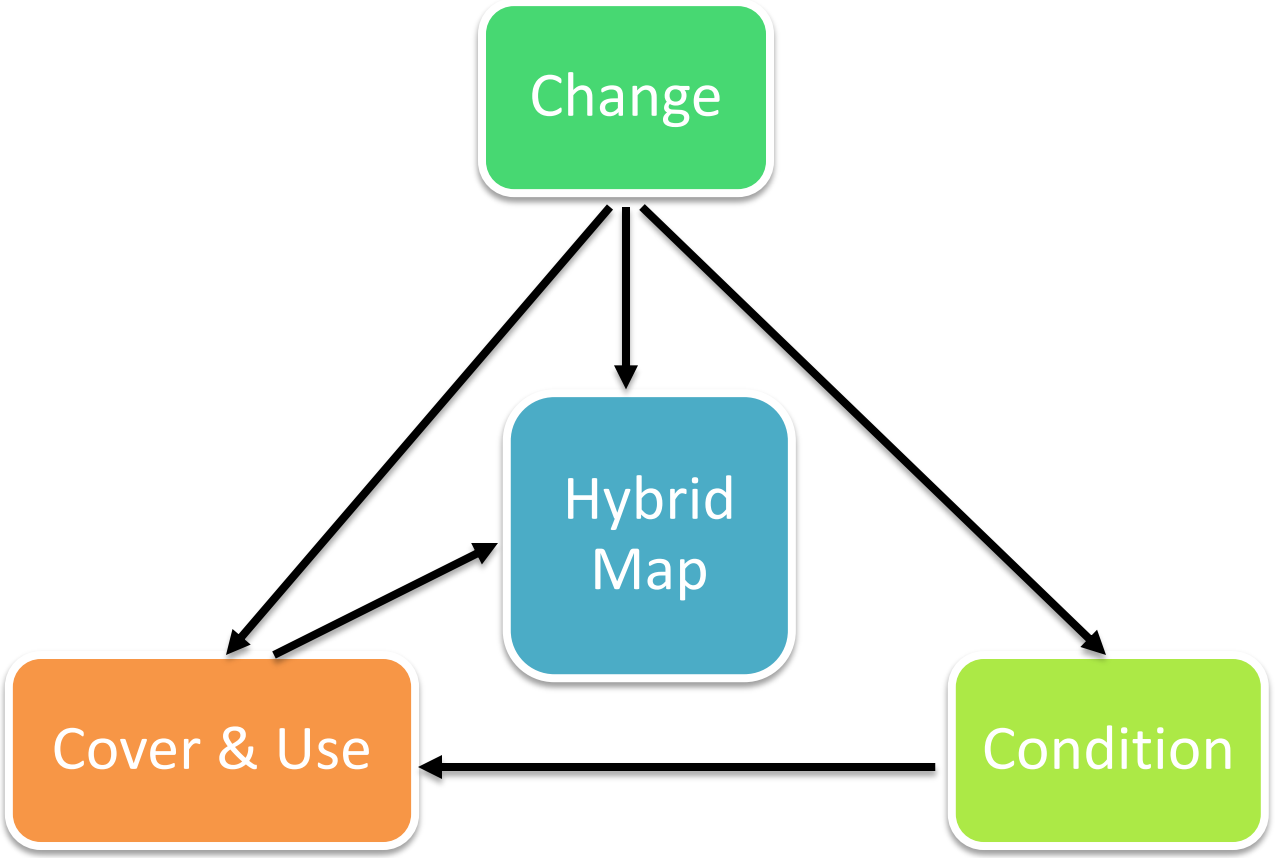
Hybrid

A combination of land cover, use ,and change maps





Relationship among “M” products



Conclusions

- Change detection is the basis for better characterizing cover, use, and condition.
- The CCDC algorithm specifically designed for LCMAP (LCMAP-CCDC) is capable of providing all the “M” related products.
- With all the missing puzzle pieces found, LCMAP is almost ready to go operational!