Maximizing The Value Of The Landsat Archive For Forest Disturbance Monitoring

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Monitoring Forest Disturbance

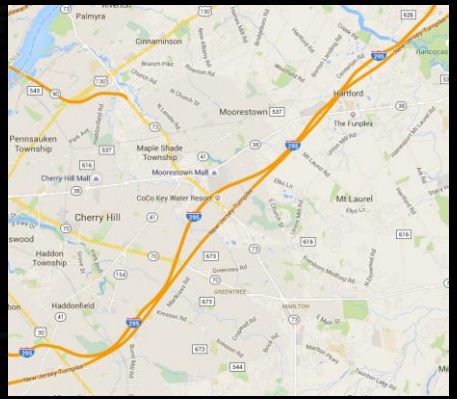
1. Landscape Change Monitoring System (LCMS)
   - *Focusing the new Landsat revolution*
2. Incorporating MSS data in time series analyses
   - *Bringing up the rear*

Part 1. Landscape Change Monitoring System

- LCMS: USFS program for Landsat-based forest monitoring
  - Outgrowth of MTBS (Monitoring Trends in Burn Severity)
  - Initial vision: All disturbances, all cover types, all land, all the time
  - Current reality: All forest all ownerships (globally), all the time
  - Ongoing science support for production
    - Healey & Cohen science leads
    - Remote Sensing Applications Center (Megown) product distribution & user support
  - Approach: Ensemble integration of disturbance maps
    - Strength in numbers – so many algorithms (and maps), why use just one?
  - Collaborations with host of “algorithm developers” – World class folks!

Landscape Change Monitoring System

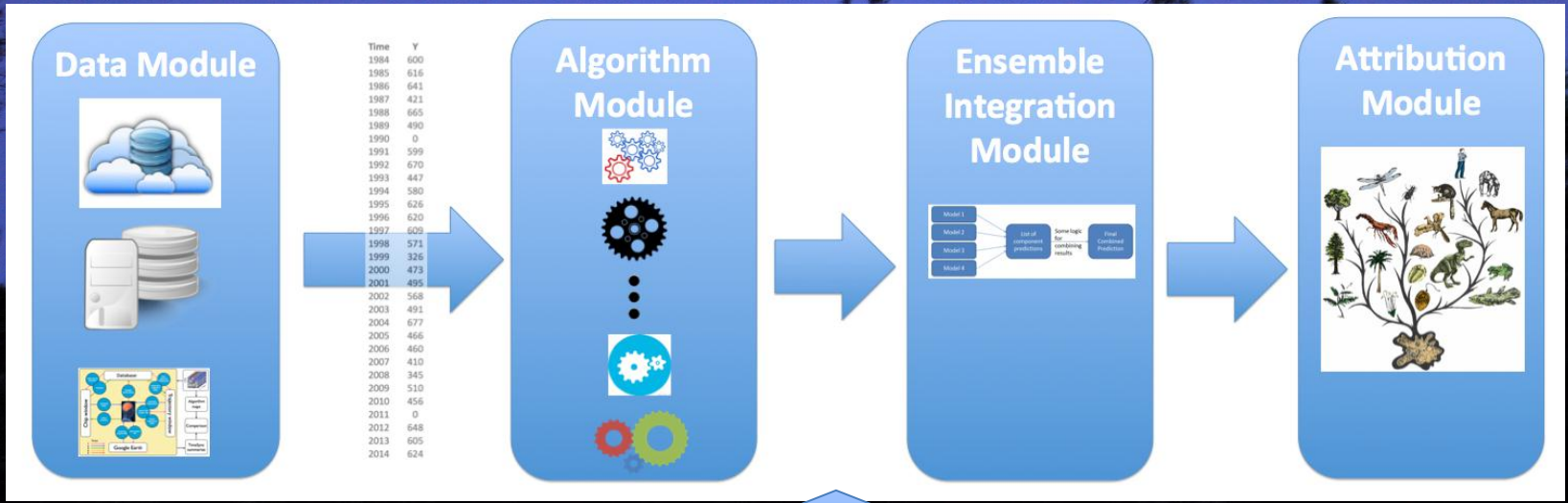
- Partnerships with USGS
  - Heritage: MTBS a huge success story for fire monitoring
    - Eidenshink (GS), Brewer & Schwind (FS)
  - Present: LCMS (Healey/Cohen/Yang et al., forest) + LCMAP (Loveland et al., all cover/use types)
    - Parallel tracks with regular communication
      - Progress: recent nuts & bolts session
        - » Common reference data sampling design
        - » Common legend
      - T. Schroeder could be the ideal liason



Landscape Change Monitoring System

- Ensemble implementation
  - "Bring the algorithms to the data" *à la P. Hostert*
  - Any cloud'll do! if the data are spinning
    - Currently using Google Earth Engine, but recognize there may be other options down the road (Amazon, MicroSoft, EROS?)

LCMS Implementation Strategy

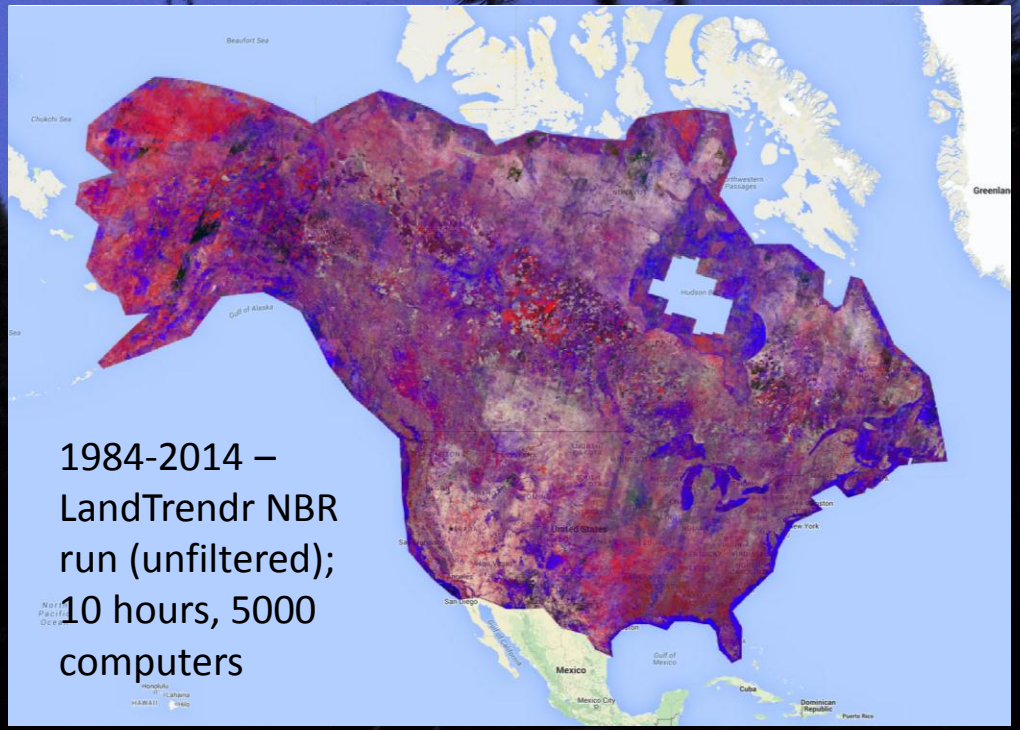


Web Application (RSAC)

User Requests, Product Delivery

LCMS Algorithm Implementation Status

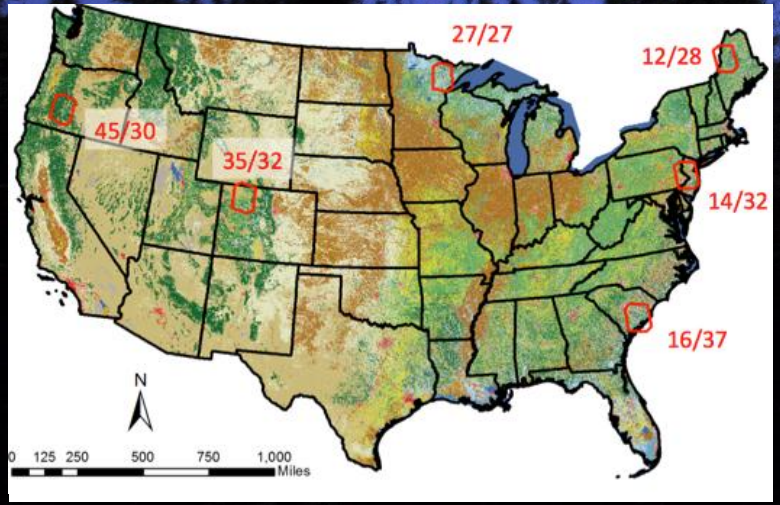
- 9 change mapping algorithms
  - Developers part of the team
- Convert from source code
  - Various stages of readiness
  - Close collaboration with Noel G.
- Algorithms can be run over any geographic extent
- Ensembles require training data, TimeSync LTS visualization tool
- Forest focus, but not limited to forest applications



1984-2014 – LandTrendr NBR run (unfiltered); 10 hours, 5000 computers

First Steps: LCMS Pilot

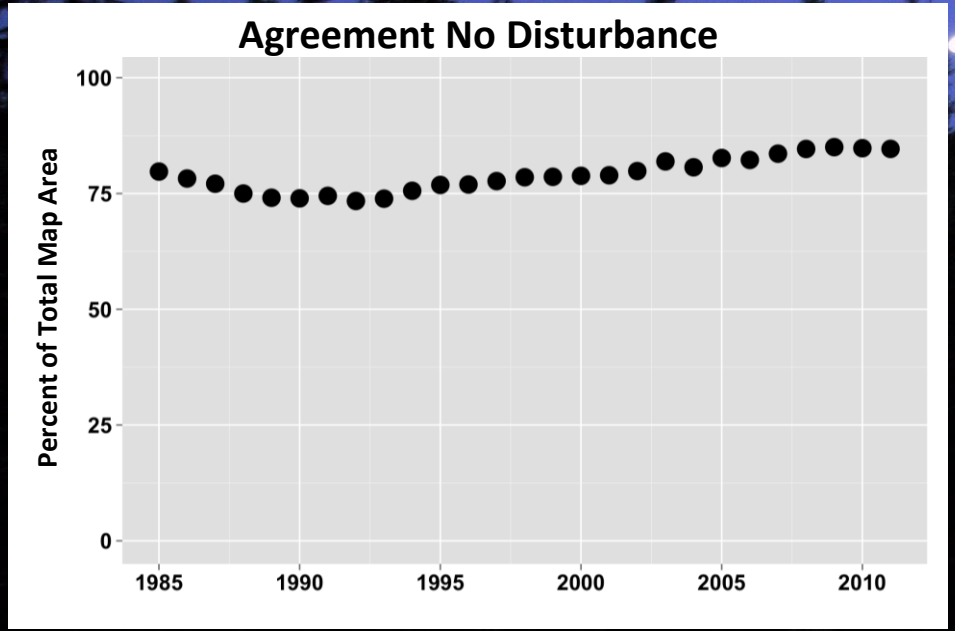
- Question 1: Do the different algorithms produce similar maps?

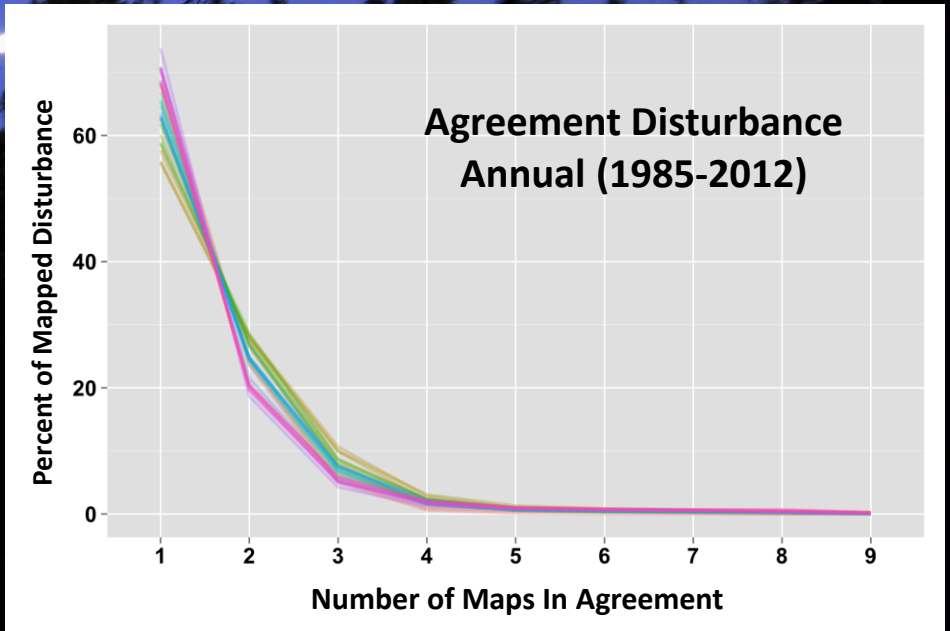


- 6 scenes
- Common forest mask
- 7 algorithms +2 runs for 2
  - 9 maps/scene

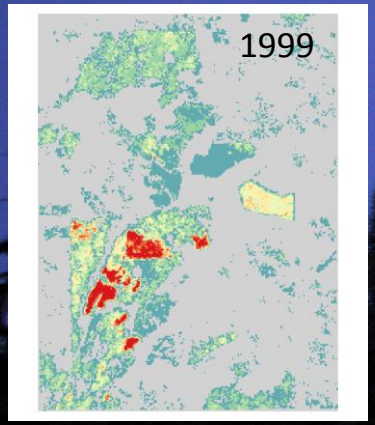
Map Agreement

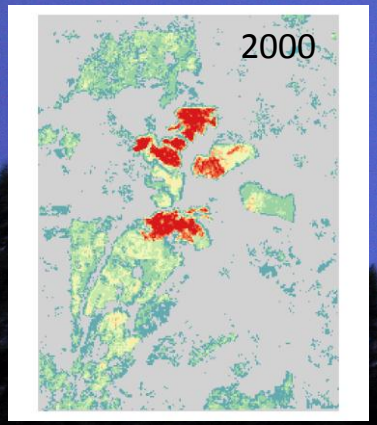
- Aggregate pixel-level agreement (all maps, all scenes)
  - High agreement no disturbance
  - Low agreement disturbance (timing, magnitude factors)

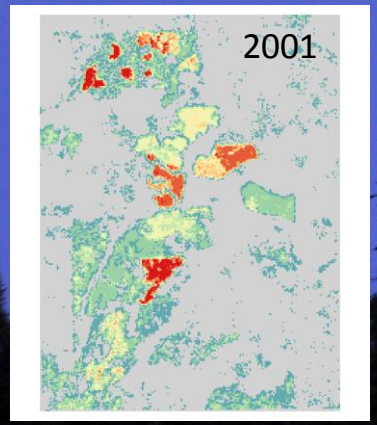


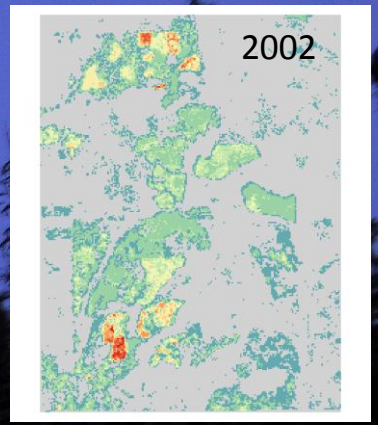


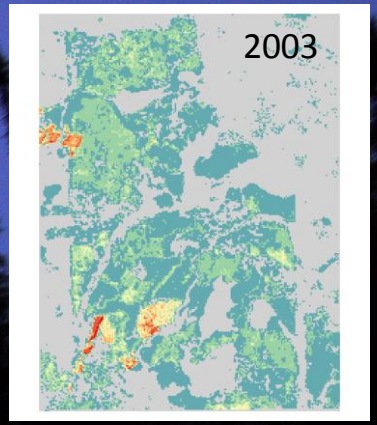
Map Agreement (Example Section)

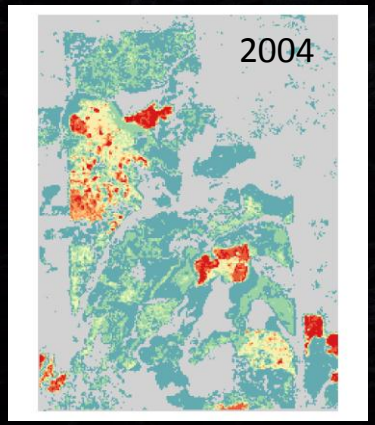


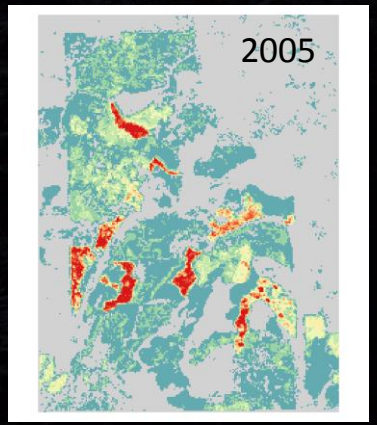


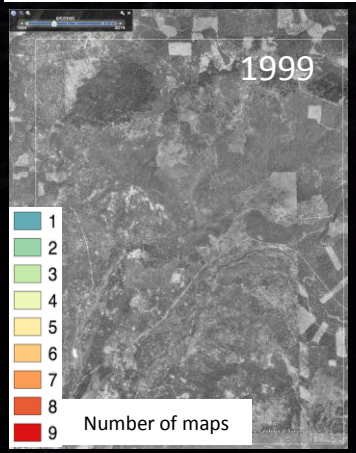












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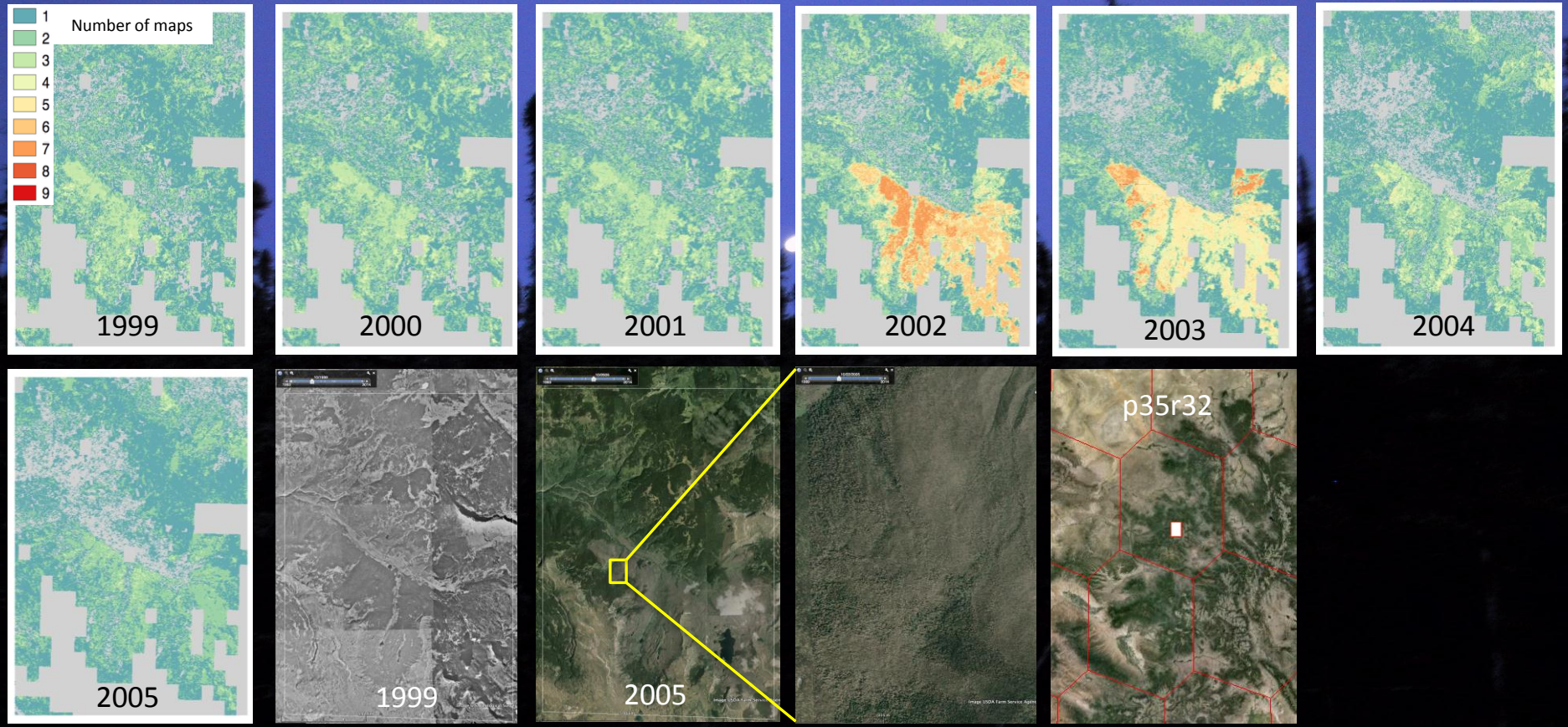
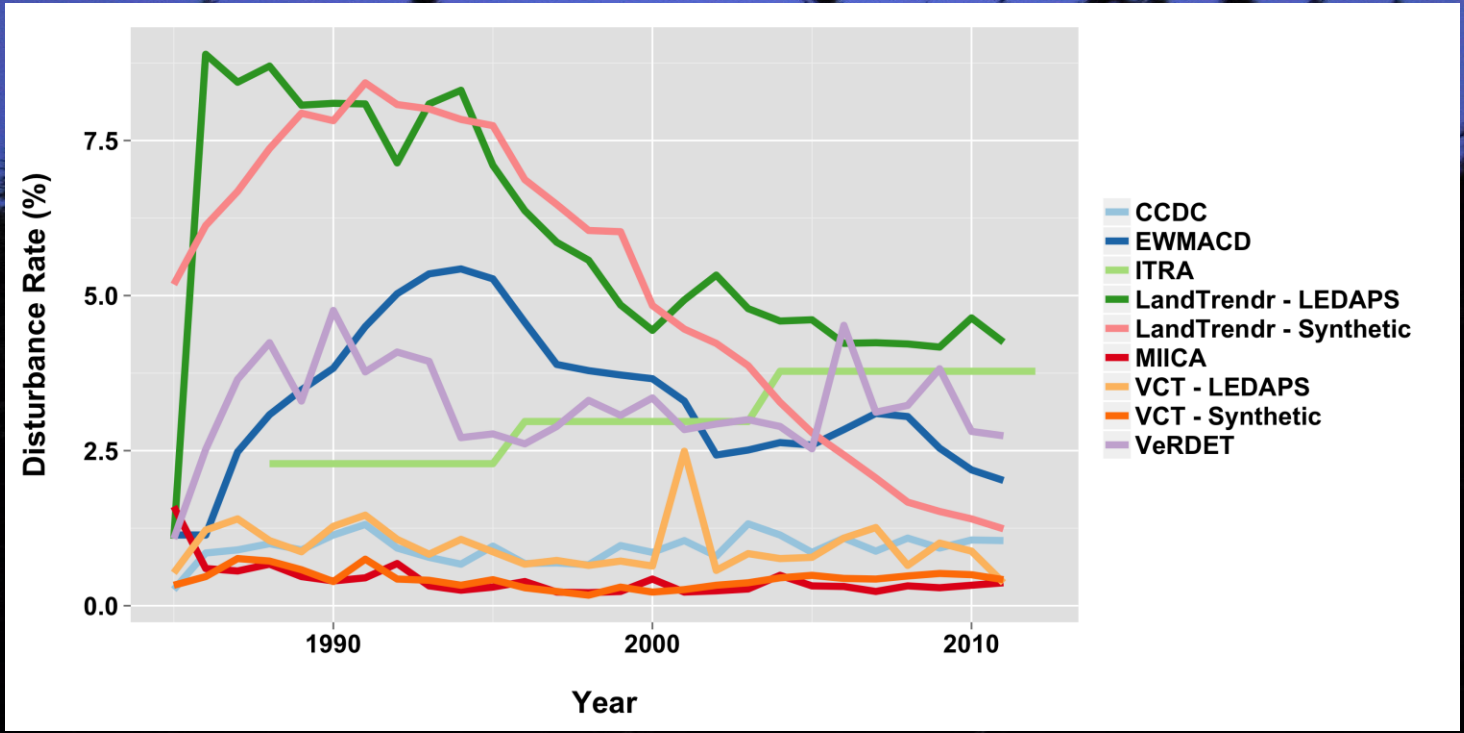


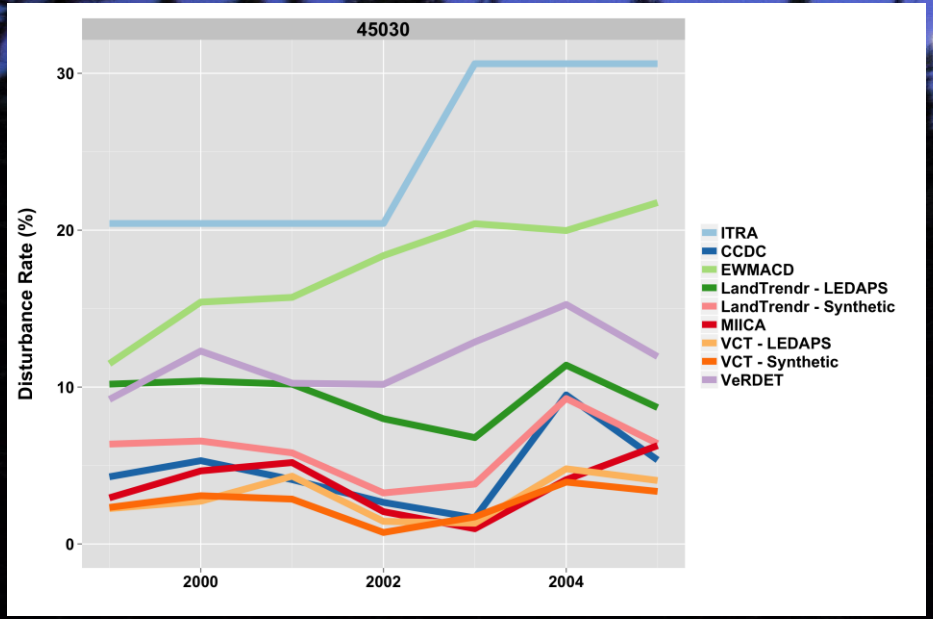
Summary Map Disturbance Rates

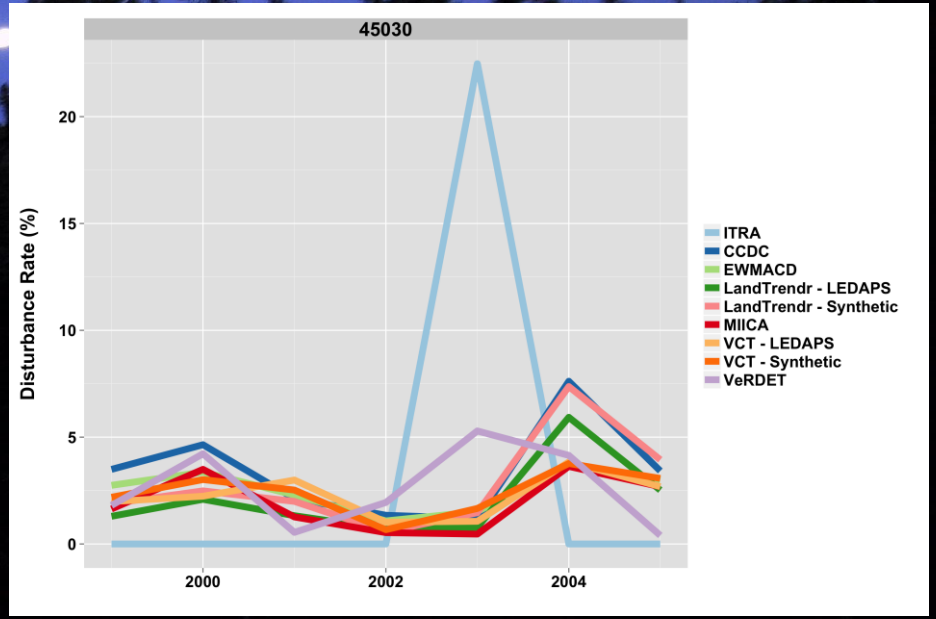
- Aggregate disturbance rates: 9 maps across 6 scenes



Map Agreement Revisited

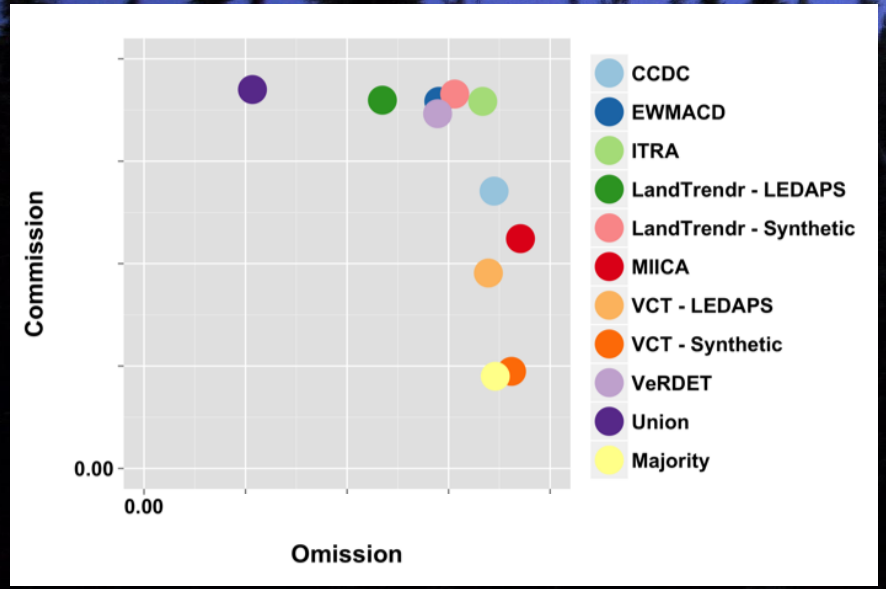
- Aggregate disturbance rates: p45r30 map section
- Extensification only

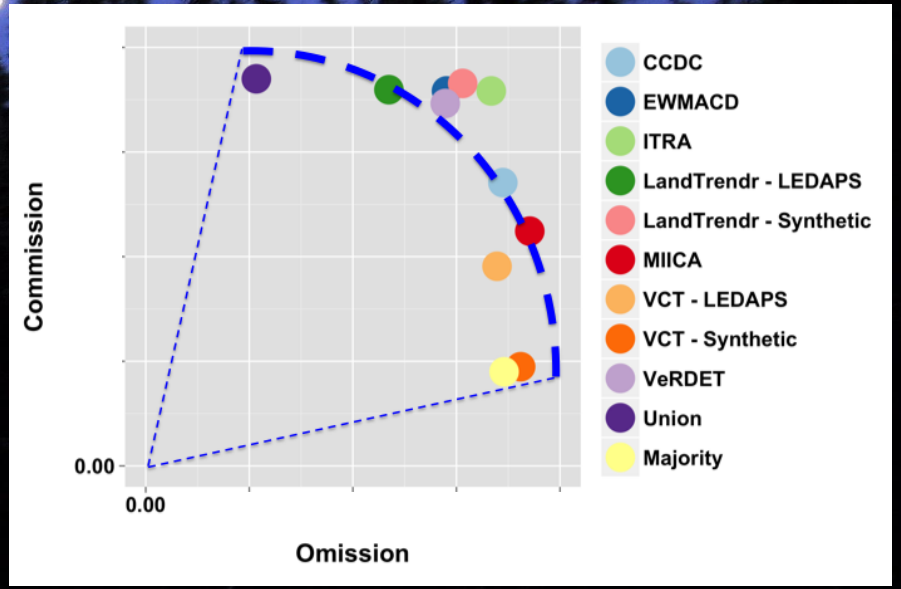




Maps v. Reference Data

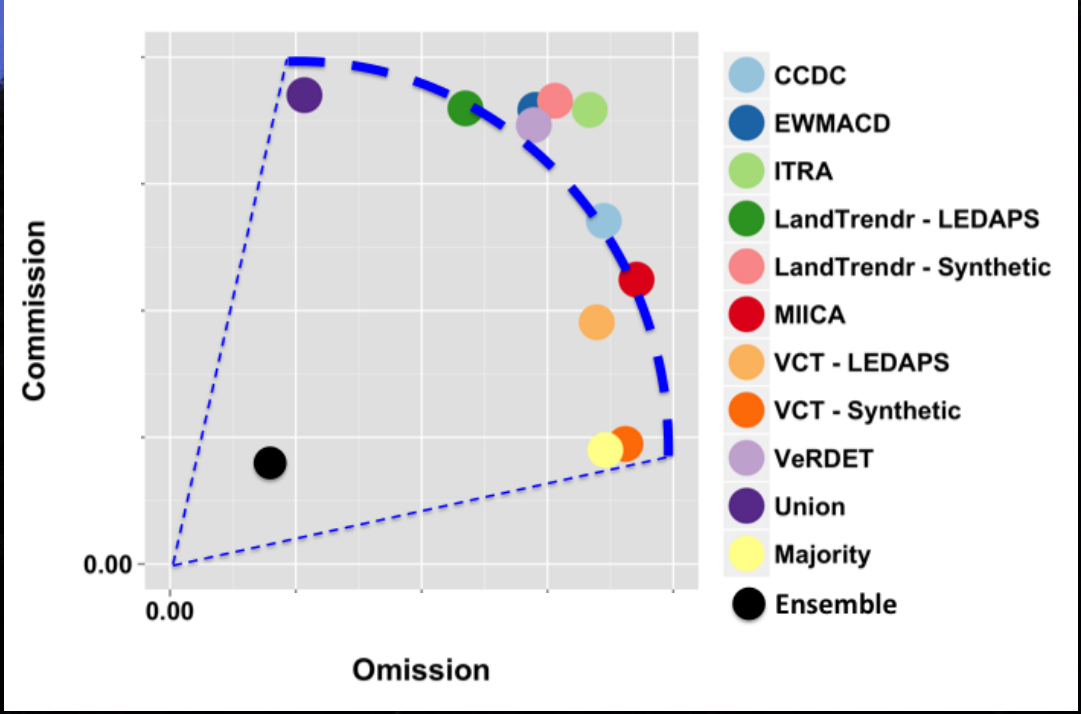
- Omission vs. Commission – cost of sensitivity
- Arc of error





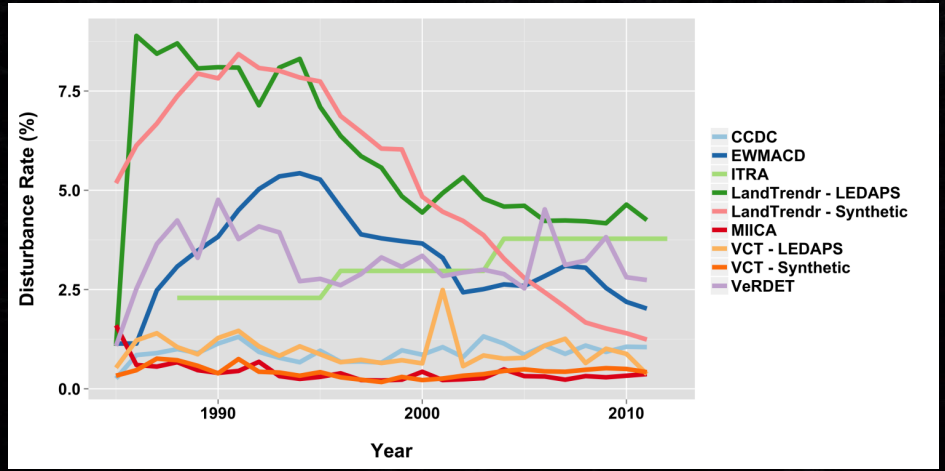
Strength in Numbers

- Question 2: Does ensemble integration work?
  - All map output
  - Topography & forest type



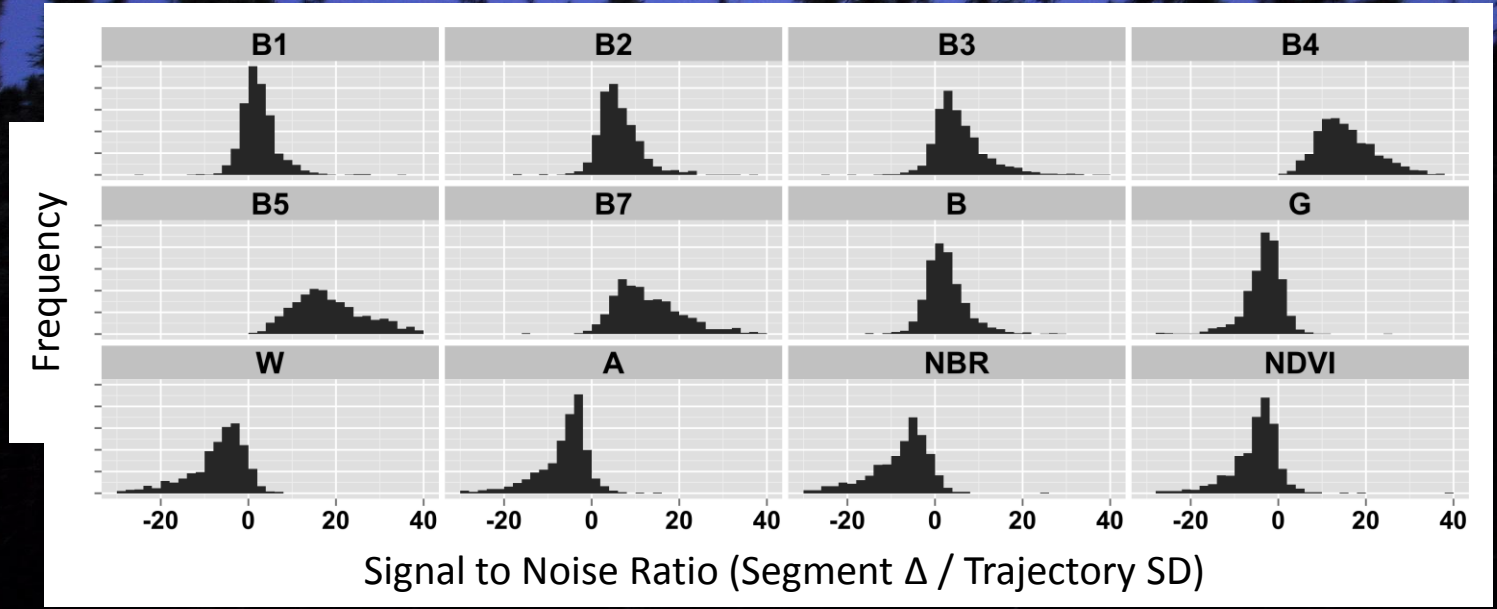
Summary Map Disturbance Rates

- Ensemble yields much improved aggregate annual rates
  - Individual maps
  - Ensemble map vs. reference data estimate (with 95% CI)



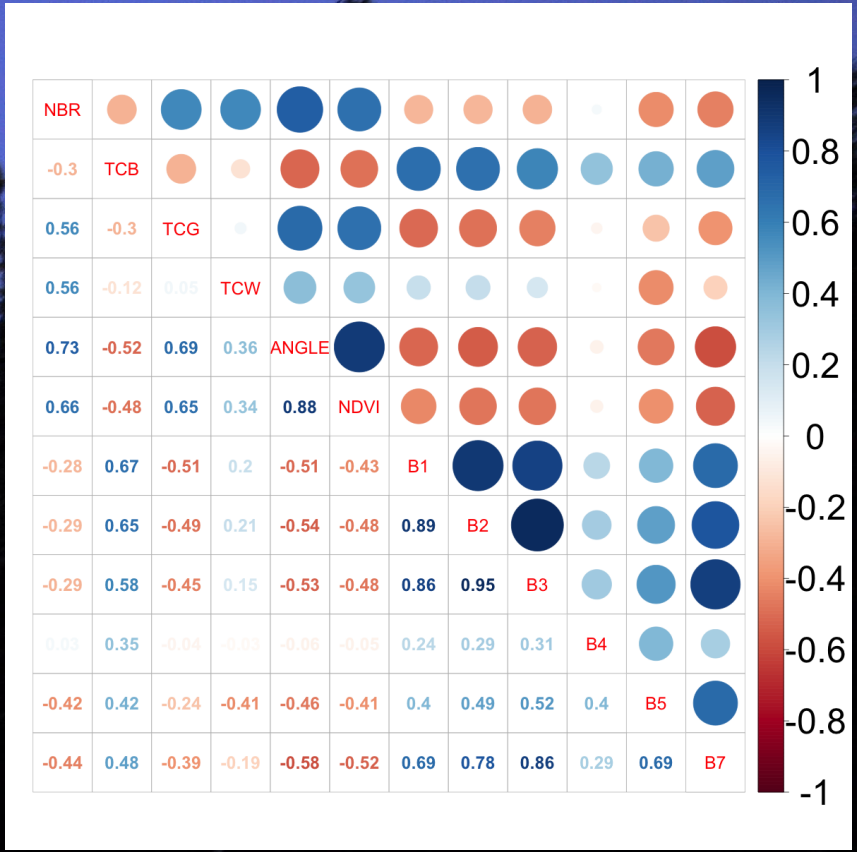
Lessons Learned: (1) Band/Index SNRs

- Each algorithm uses different spectral slice(s) – does that matter?
- Band 5,4,7 highest median SNRs – 4,5 all non-0, positive
- Several indices, with NBR and Wetness slightly best, Brightness worst



Lessons Learned: (2) SNR Correlations

- Band 4 has lowest correlations in general, and pairs best with high-performance indices…
  - Especially Wetness and NBR (& Angle, NDVI)
  - Greenness too, but low SNRs
- Band 7 pairs best with Wetness and Band 4 for a best, generally useful three-dimensional forest disturbance mapping set



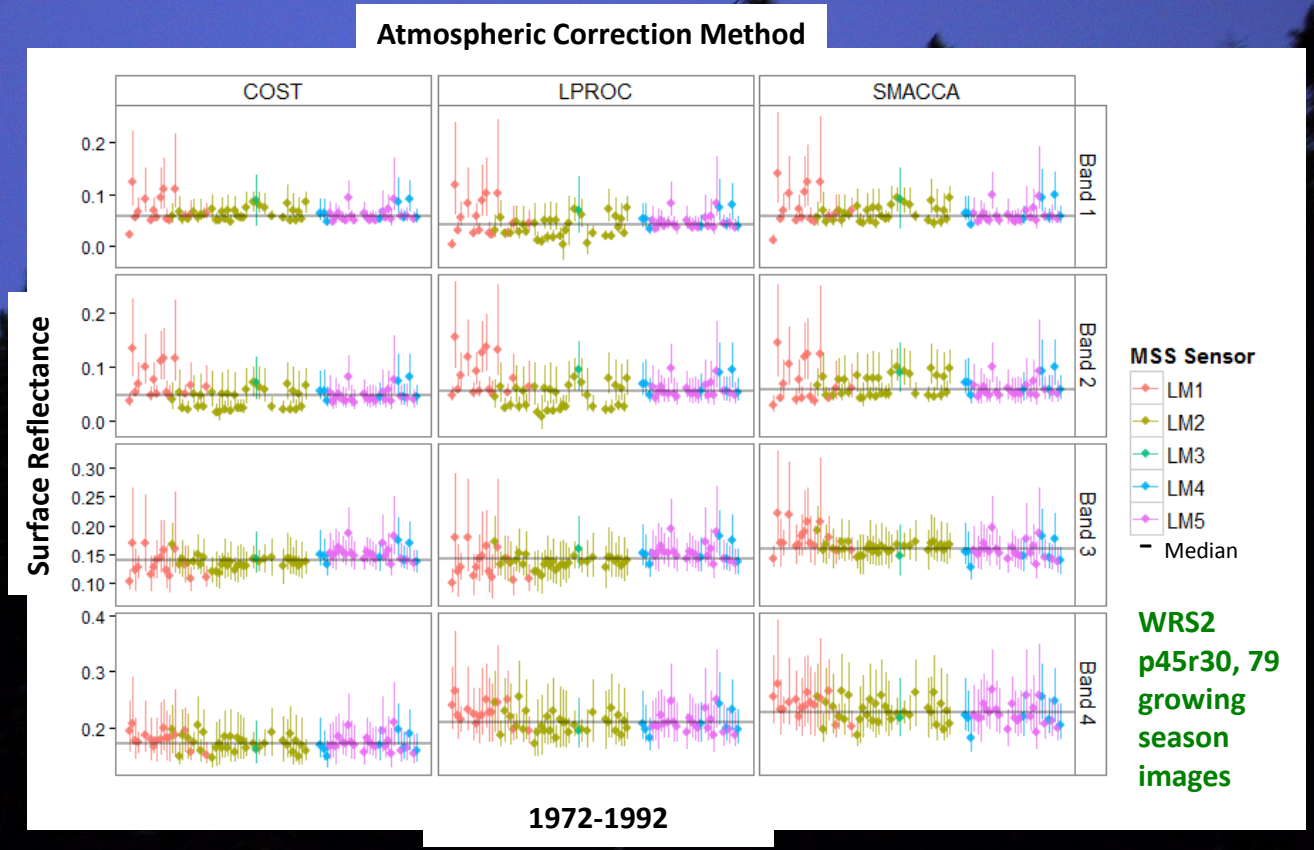
Part 2. Incorporating MSS

- Goals
  - Develop an approach for near-seamless incorporation of MSS into time series analyses
  - Implement solution across the archive

Problem	Status	Solution
Radiometric Calibration	✓	USGS LPGS L1T
Geolocation Accuracy	✓	USGS LPGS L1T + ITPFind (Kennedy & Cohen, 2003)
Cloud Masking	✓	Braaten et al., RSE (revision submitted)

MSS Surface Reflectance – Example

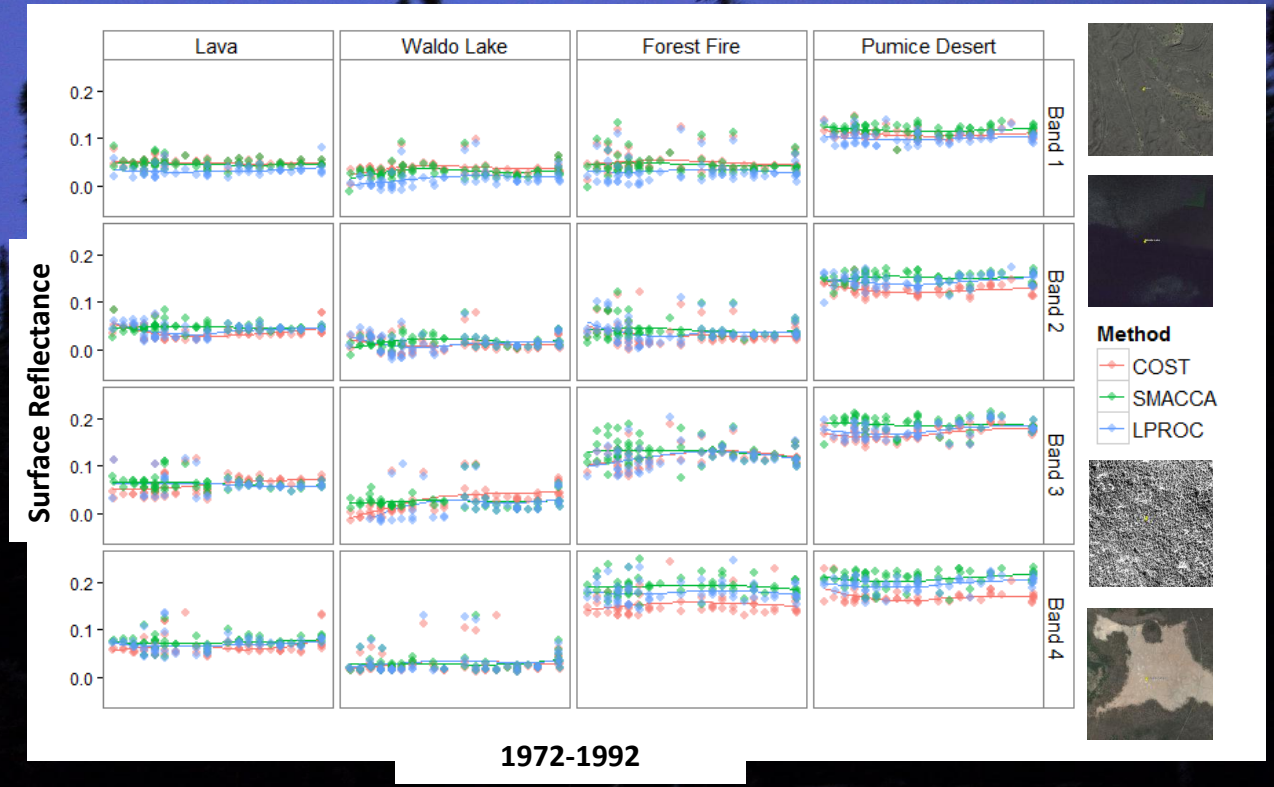
- All similar results
- Landsat 1 noisy
- LPROC lower than SMACAA all bands
- COST lower than LPROC, except B1
- SMACAA hugs median line better than LPROC (B1-B3)
- Practicalities:
  - COST
  - LPROC
  - SMACCA



WRS2 p45r30, 79 growing season images

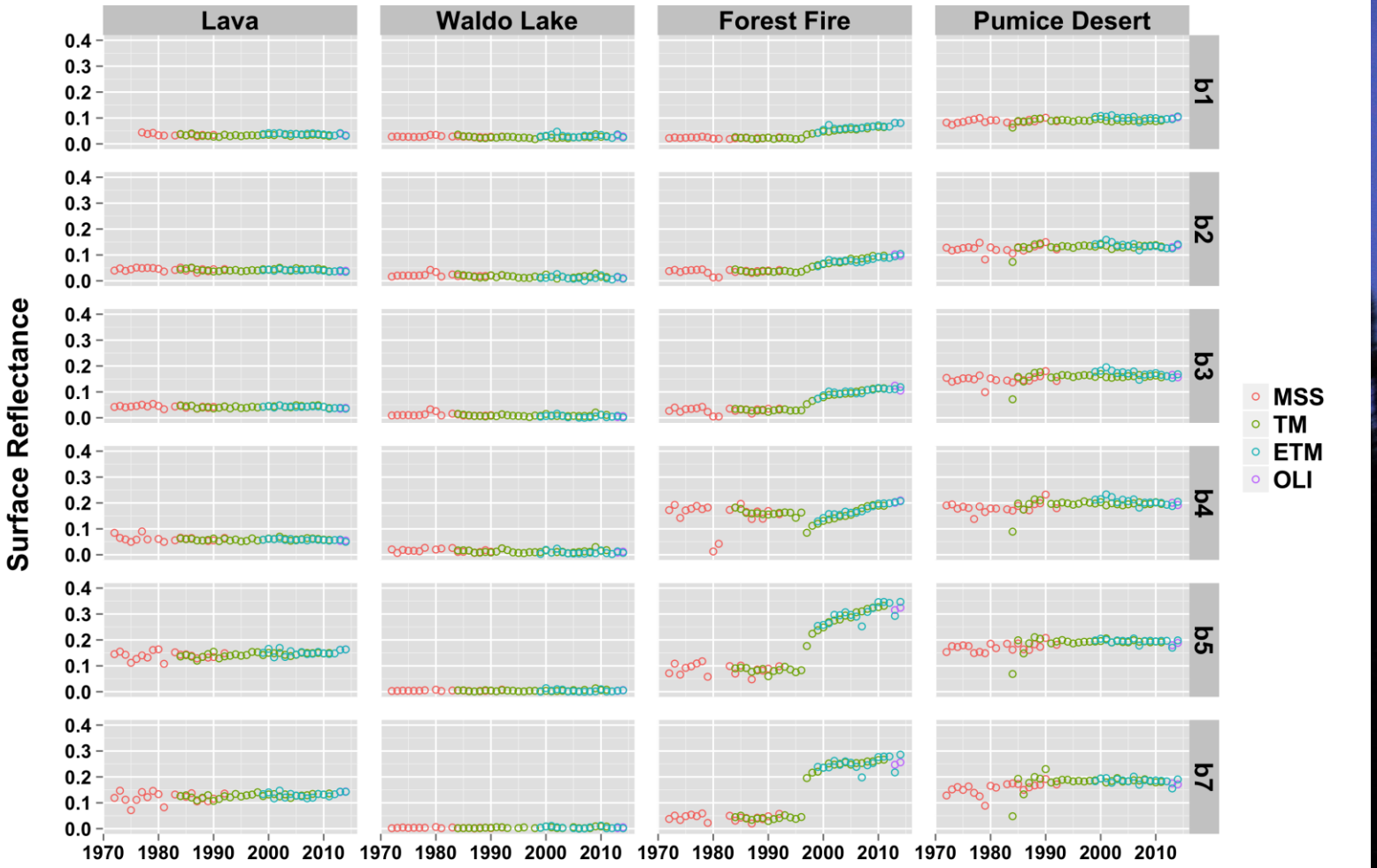
MSS Surface Reflectance - Pixels

- 4 targets stable in this period
- Little difference for dark targets
  - Some residual outliers, cause not investigated
- COST lower for bright targets, in B4



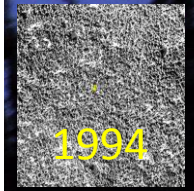
Spectral Harmonization – Examples

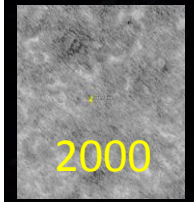
- Goals
  - Predict TM LEDAPS SR bands 1-5,7 (and indices) from MSS SR (Step 1)
    - Aggregate scene-level, band-specific statistical models
      - Example: 9 coincident L5 MSS-TM acquisitions (p45r30)
      - Common set of 10,000+ sample point
  - Remove residual pixel-level bias (Step 2)
    - Mostly associated with bright and dark targets not adequately harmonized



Lava

Waldo Lake





Forest Fire

Pumice Desert

Archive Implementation

- Grant (to OSU, RE Kennedy) from Google for Compute Engine hours & related – Yang & Noel
- Implementation once fully tested (months)
- Then what?
  - Availability in GEE highly likely
  - EROS ???
  - Use in LCMS for ensemble modeling (MSS-OLI)
    - 6 scenes for LCMS/CMS project
    - Run results nationally with NAFD reference data
    - Build global reference database, run globally
    - Include causal attribution