Priorities for Landsat MSS improvements

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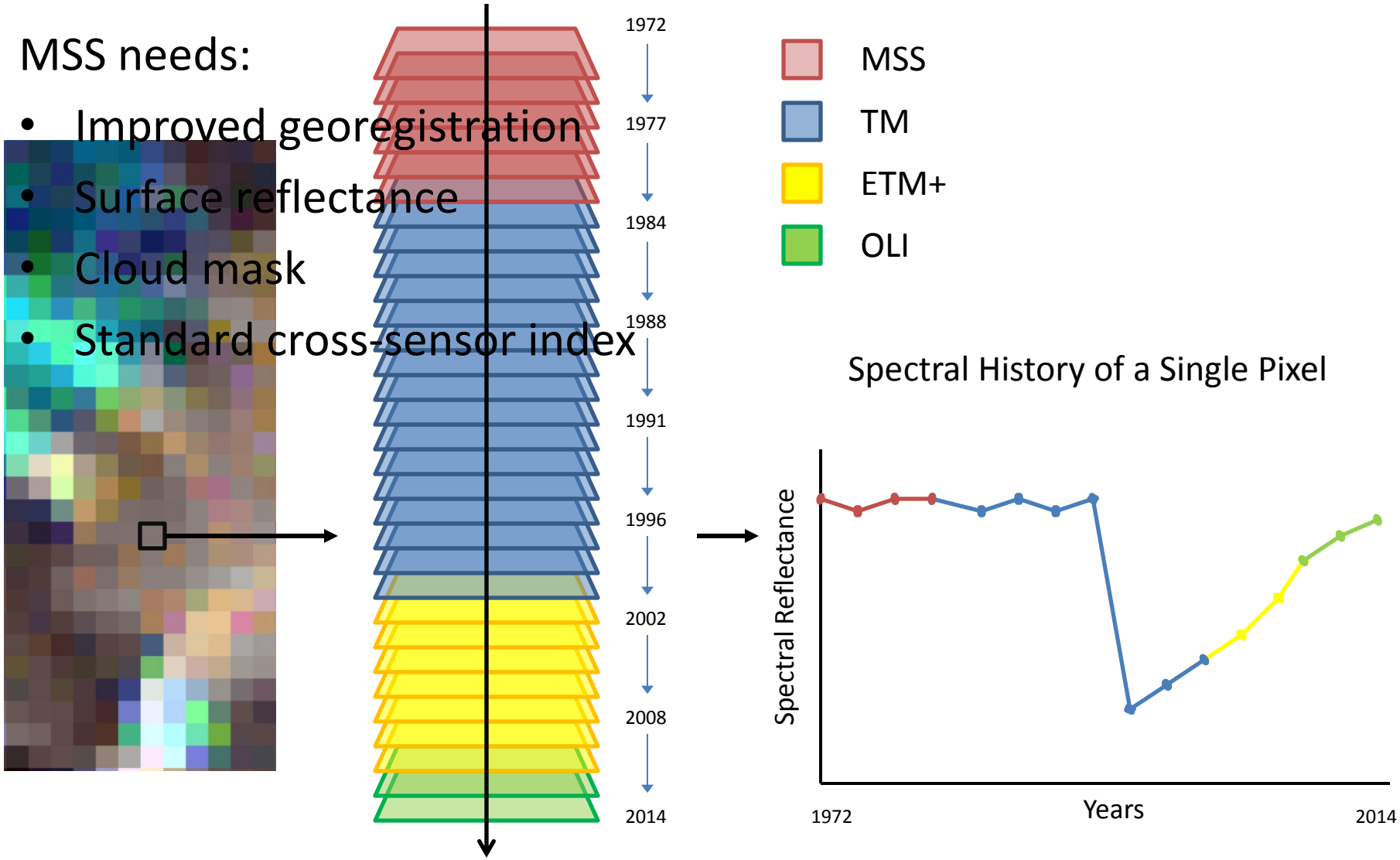
Agenda

- What: enhancing the MSS product
- Why: time is powerful
- How: (we do it)
- How: (it could be done better)
- Discussion

What: harmonious imagery across all sensors

MSS needs:

- Improved georegistration
- Surface reflectance
- Cloud mask
- Standard cross-sensor index



Spectral Comparison

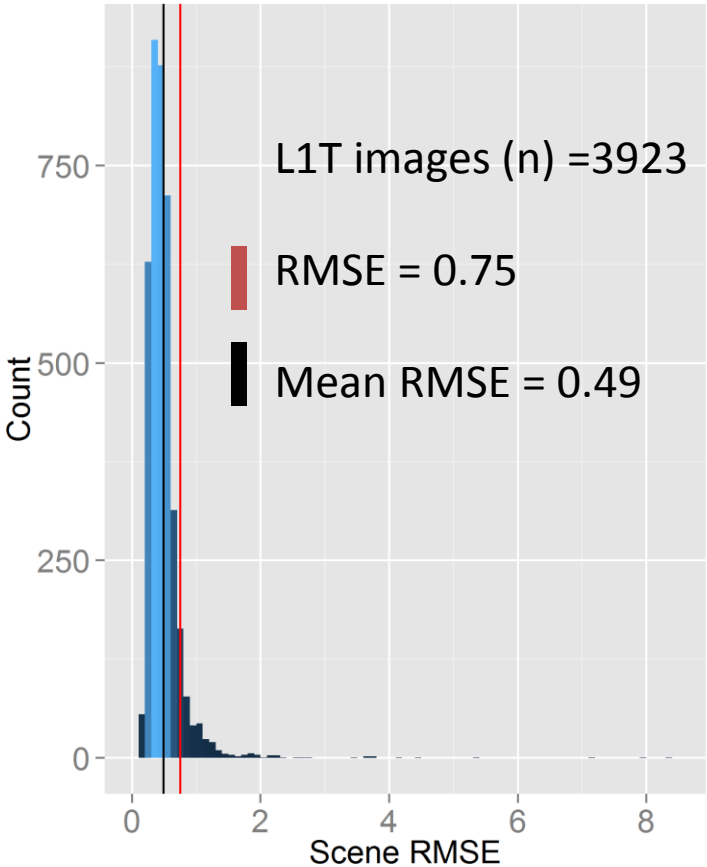
Attribute	MSS	TM	ETM+	OLI
Spectral (µm)				
Ultra-Blue	-	-	-	0.43 - 0.45
Blue	-	0.45-0.52	0.45-0.52	0.45 - 0.51
Green	0.50-0.60	0.52-0.60	0.52-0.60	0.53 - 0.59
Red	0.60-0.70	0.63-0.69	0.63-0.69	0.64 - 0.67
NIR	0.70-0.80	0.76-0.90	0.77-0.90	0.85 - 0.88
	0.80-1.10			
SWIR 1	-	1.55-1.75	1.55-1.75	1.57 - 1.65
Cirrus	-	-	-	1.36 - 1.38
SWIR 2	-	2.08-2.35	2.09-2.35	2.11 - 2.29
TIR	-	10.40-12.50	10.31-12.36	10.60-11.19
	-			11.50-12.51
Radiometric Resolution (bit)	6 (8)	8	8	12

Spatial Accuracy

Attribute	MSS	TM	ETM+	OLI
Spatial resolution (m)	~80 (60)	30	30	30

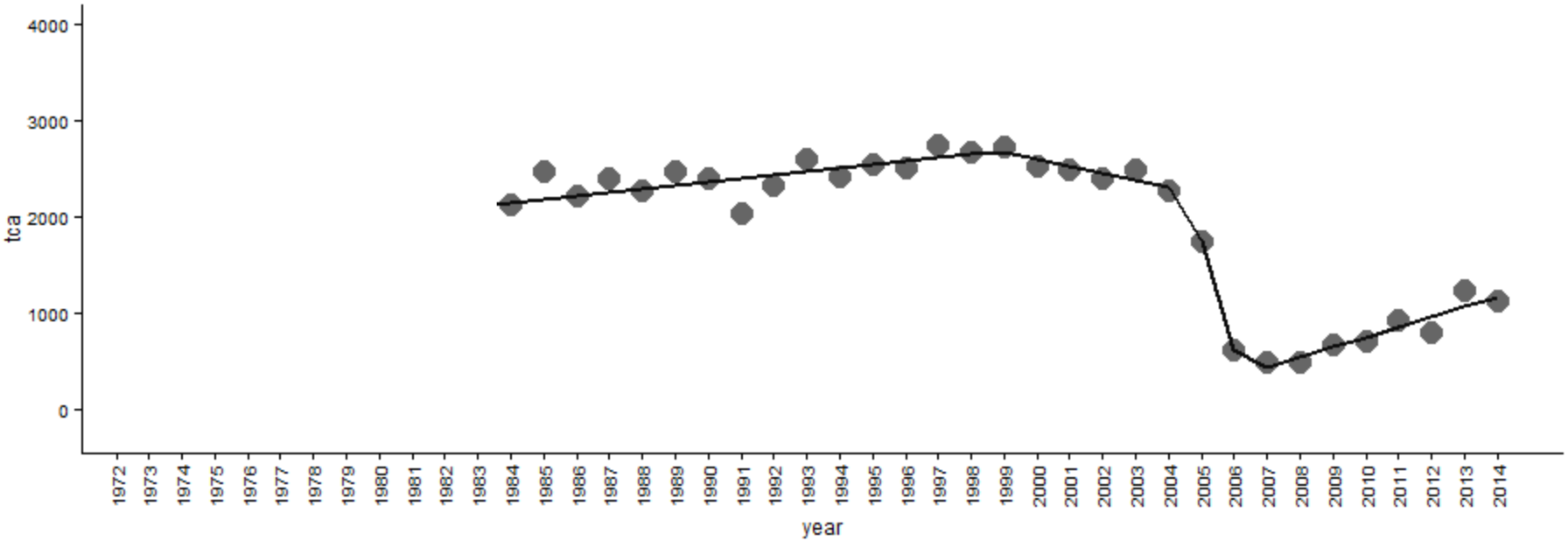
MSS Georegistration

- Terrain correction
  - Of 6965 MSS images from LCMS and Haiti, 56.3% were L1T
- Many L1Ts worth improving (Figure)



Why: time is powerful

- Increased observation
  - More durable temporal pattern identification
  - Better estimate of change rates
  - Better anomaly identification



Why: time is powerful

Historical disturbance pattern and monitoring

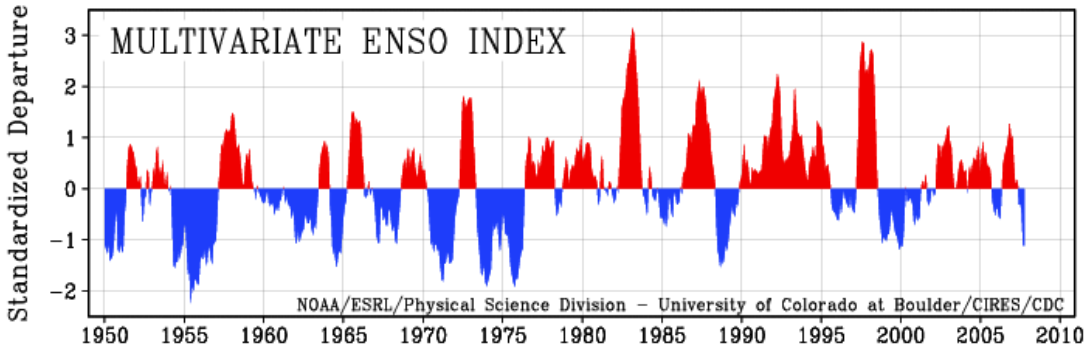
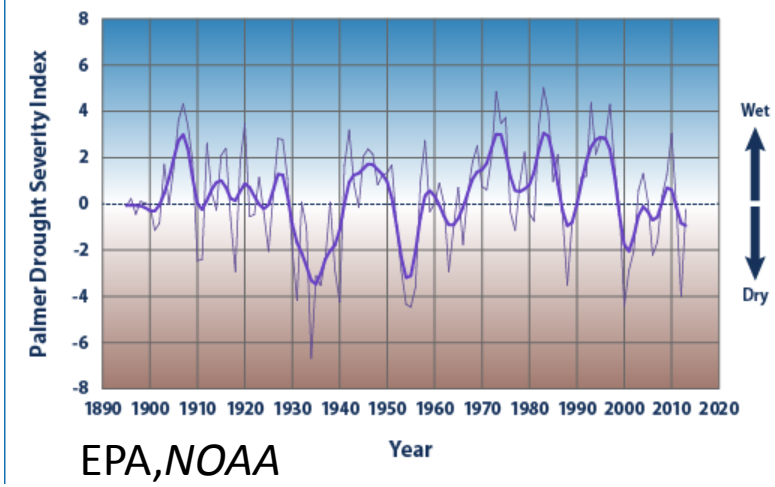
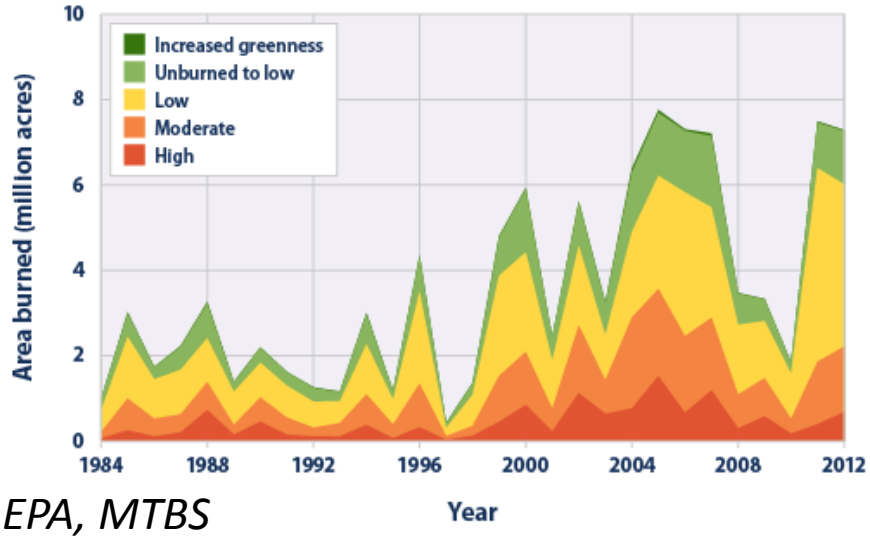


Figure 1. Average Drought Conditions in the Contiguous 48 States, 1895–2013

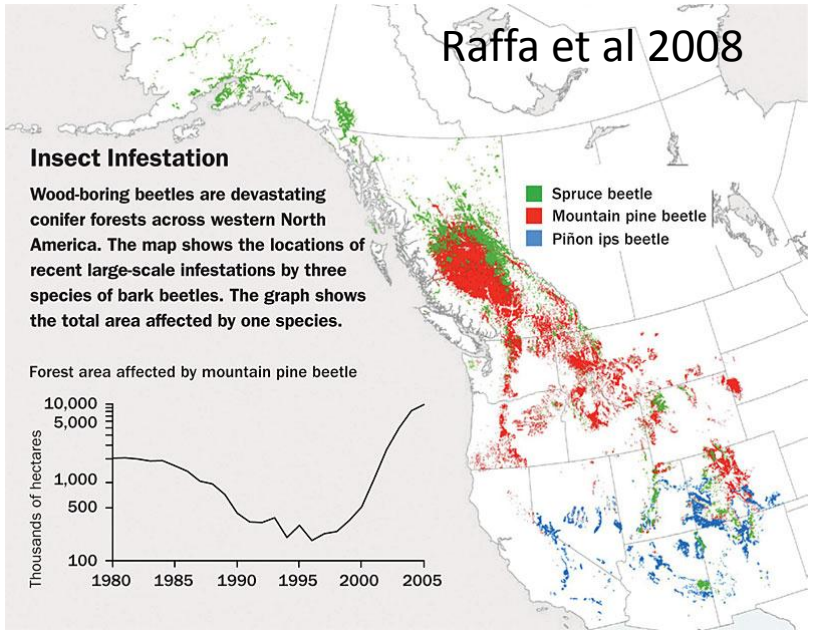


EPA,*NOAA*

Figure 3. Damage Caused by Wildfires in the United States, 1984–2012



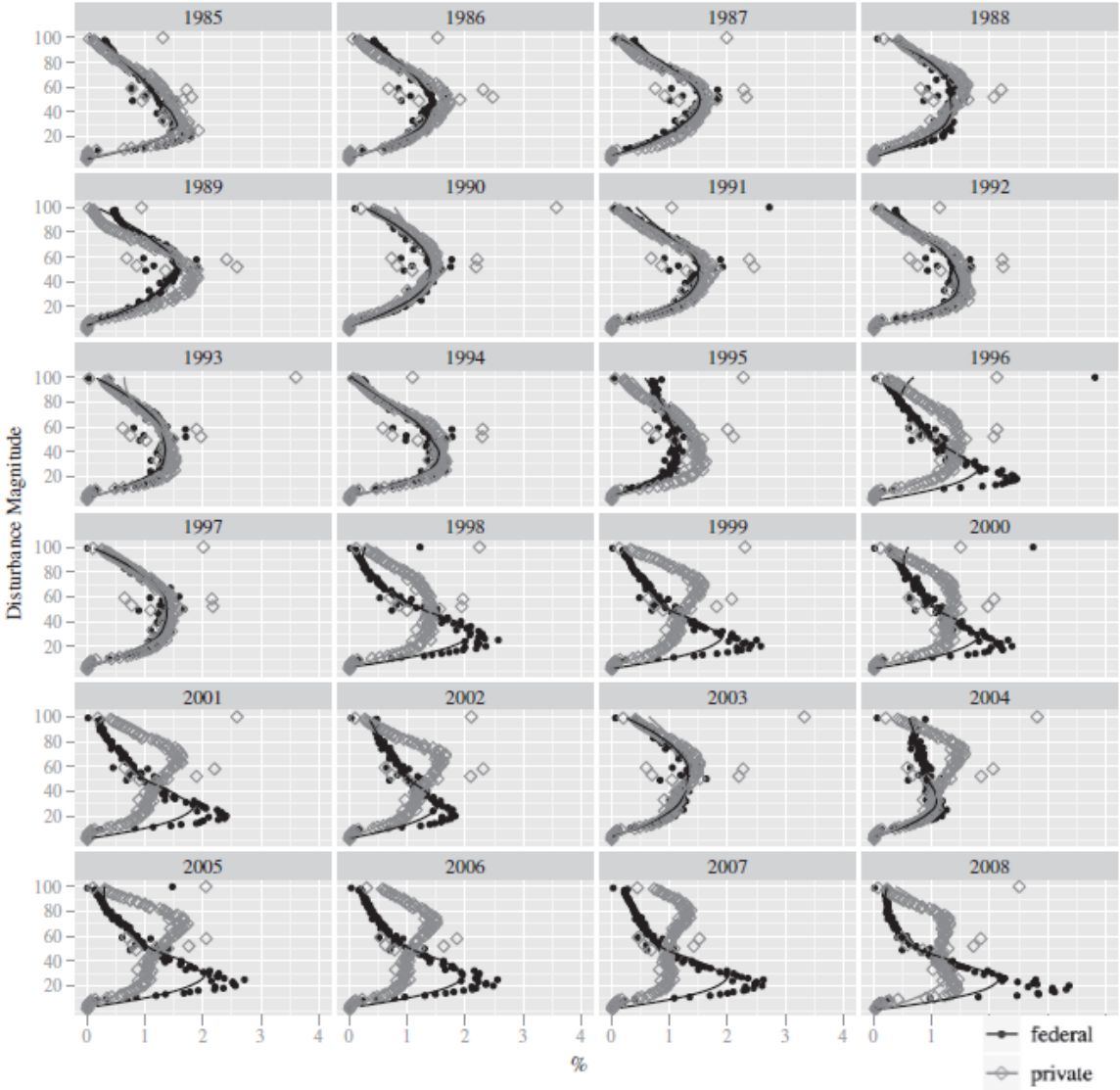
EPA, MTBS



Why: time is powerful

Before/after effect of policy change.

1970's environmental movement.

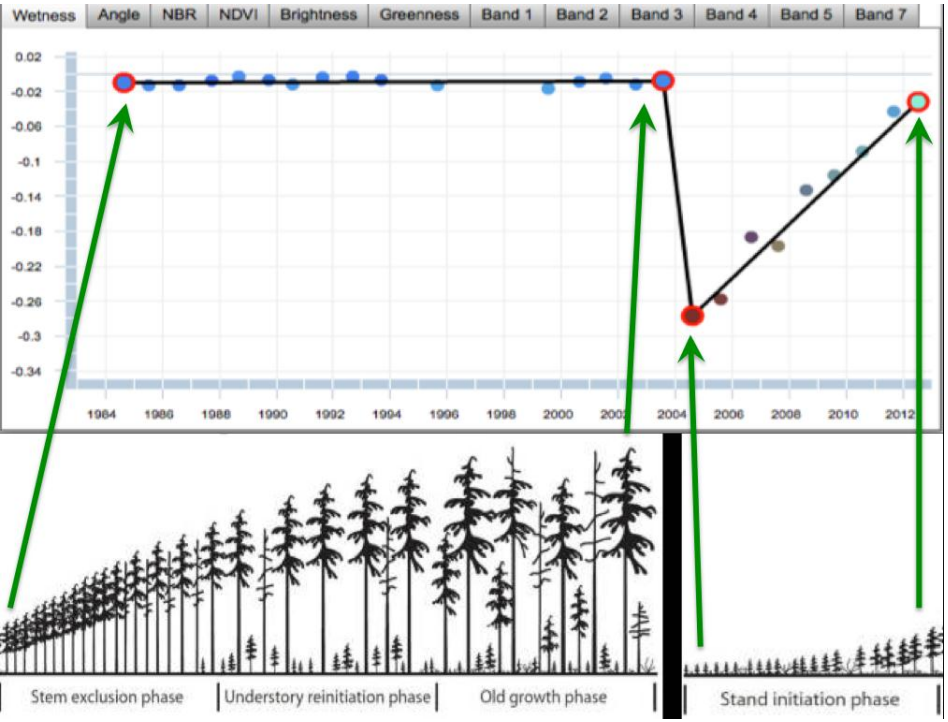


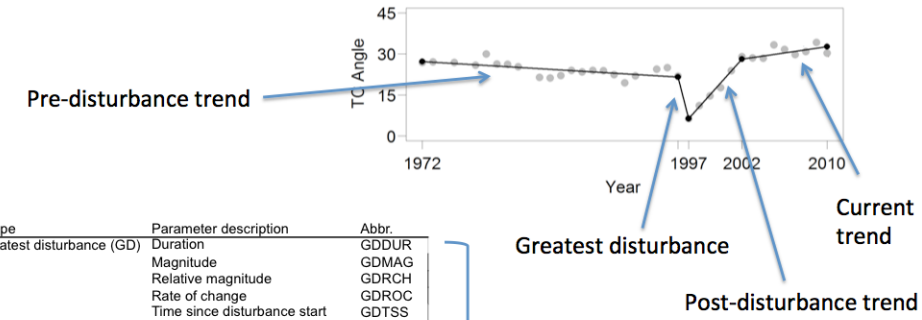
Kennedy et al 2012

Why: time is powerful

-Practical rationale: overcome the problem of reflectance saturation in dynamic vegetative cover.

-Knowing the history of a pixel can enhance prediction of current condition





Scope	Parameter description	Abbr.
Greatest disturbance (GD)	Duration	GDDUR
	Magnitude	GDMAG
	Relative magnitude	GDRCH
	Rate of change	GDROC
	Time since disturbance start	GDTSS
	Time since disturbance end	GDTSE
Pre-disturbance (BD)	Spectral value	BDVAL
	Magnitude	BDMAG
	Duration	BDDUR
	Rate of change	BDROC
Post-disturbance (AD)	Spectral value	ADVAL
	Magnitude	ADMAG
	Duration	ADDUR
	Rate of change	ADROC
	Spectral value after 5 years	ADVA5
	5-year magnitude	ADMG5
	Overall recovery	ADREC
	Overall recovery after 5 years	ADRE5
Last monotonic trend (LM)	Duration	LMDUR
	Magnitude	LMMAG
	Rate of change	LMROC
Current condition (CC)	Spectral value	CCVAL
Current trend (CT)	Rate of change	CTROC

- Vertex values
- Segment
  - ✓ Magnitudes
  - ✓ Durations
  - ✓ Rates
- Disturbance agent (not shown)

Using Landsat-derived disturbance history (1972–2010) to predict current forest structure

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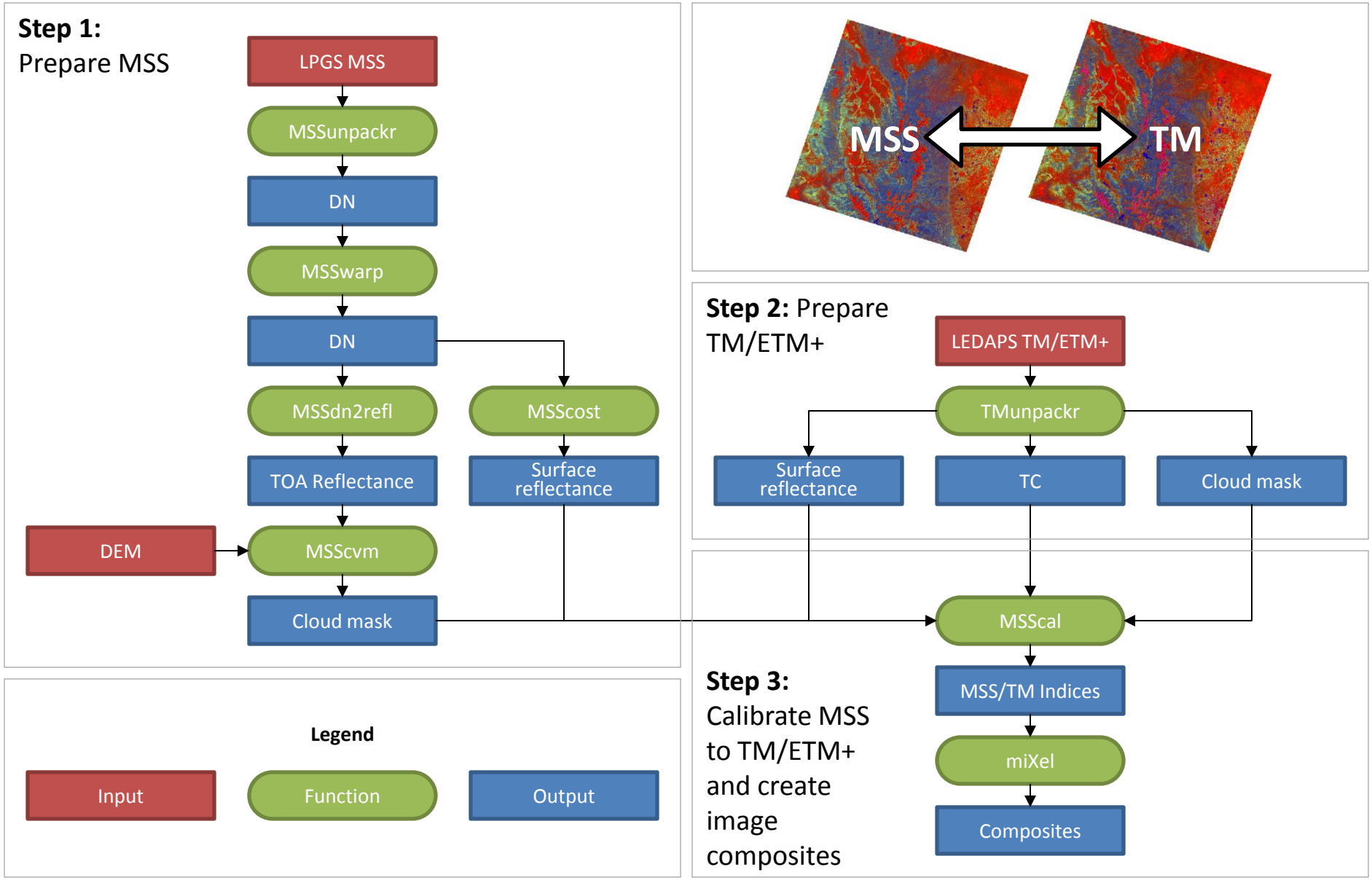
How: (we do it)

Problem	Solution
-Radiometric calibration	USGS LPGS processing, (Chander et al. 2009, Helder et al. 2012)
-Geolocation	USGS LPGS L1T processing, LandsatLinkr::MSSwarp (Kennedy & Cohen 2003)
-Atmospheric correction/ Surface reflectance	LandsatLinkr::MSScost (Chavez, 1996)
-Cloud masking	LandsatLinkr::MSScvm (Braaten, et al. in review)
-Spectral integration	LandsatLinkr::MSScal

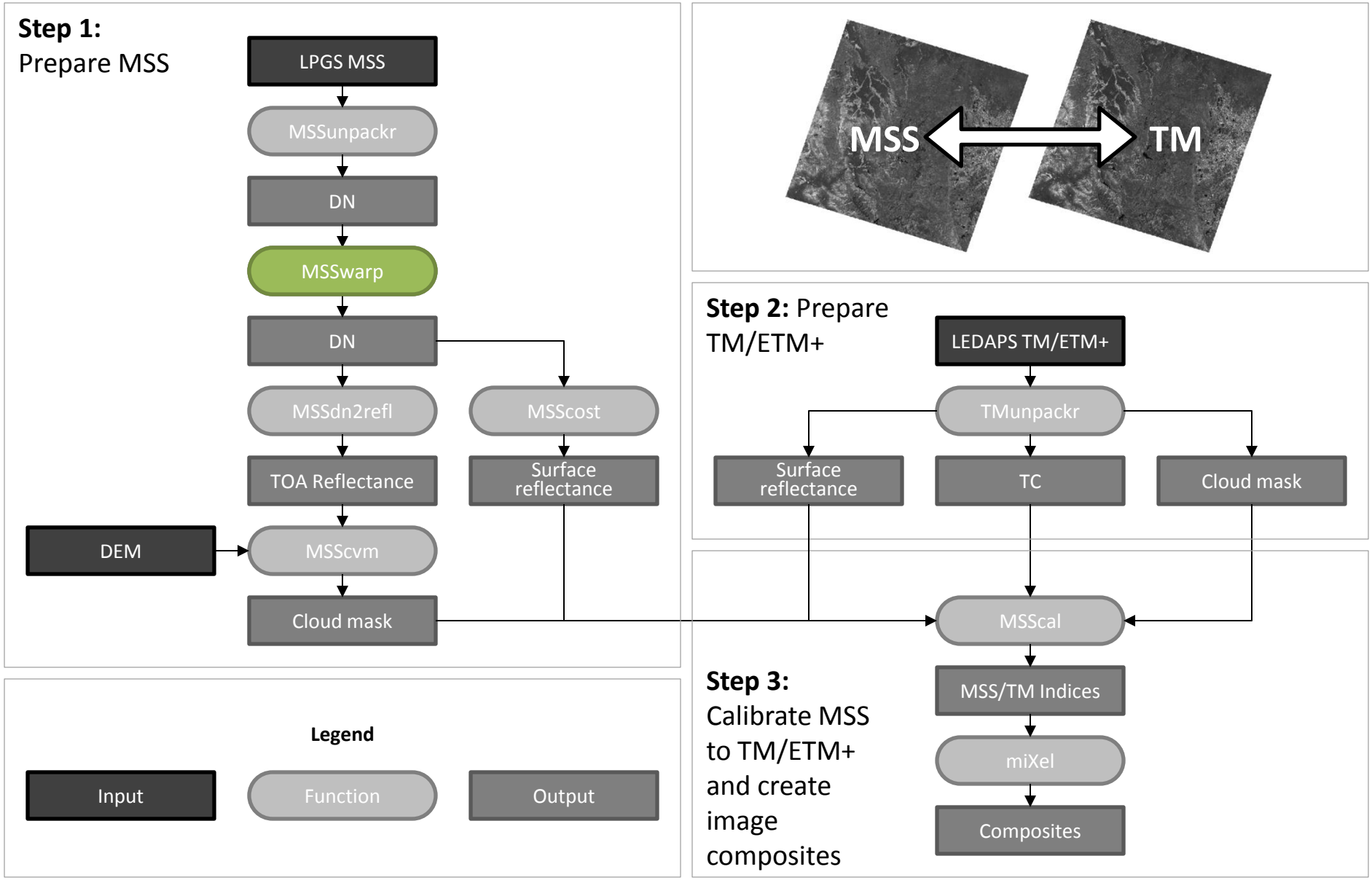
Radiometric Calibration

- LPGS uses cross-calibration gains, biases, and time-dependent variables to map MSS data to TOA radiance using the Normalized Radiance method
  - Radiance values are scaled to a 0-255 range with 0 reserved for fill, 1 (QCalMin) for low saturation value (LMin), and 255 (QCalMax) for high saturation value (LMax)
  - LMin, Lmax, QCalMin, and QCalMax reported as image metadata for conversion to top-of-atmosphere (TOA) radiance
- All MSS sensors are cross-calibrated to Landsat 5 MSS, so TOA reflectance calculations possible, but need to use Landsat 5 MSS parameters for ESUN
- Thank you Helder (et al. 2012, Chander et al. 2009, EROS LPGS!)

LandsatLinkr

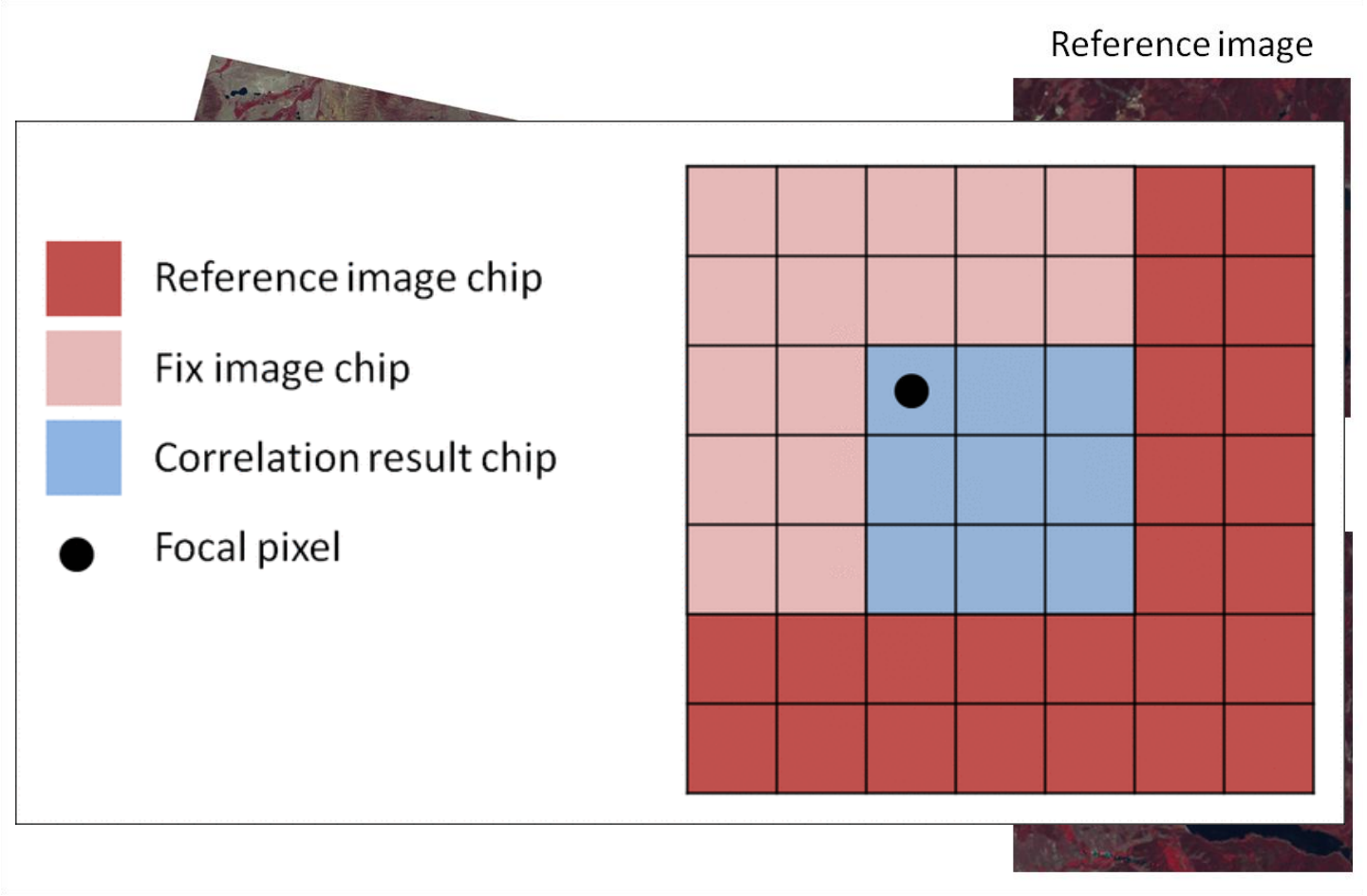


Geolocation

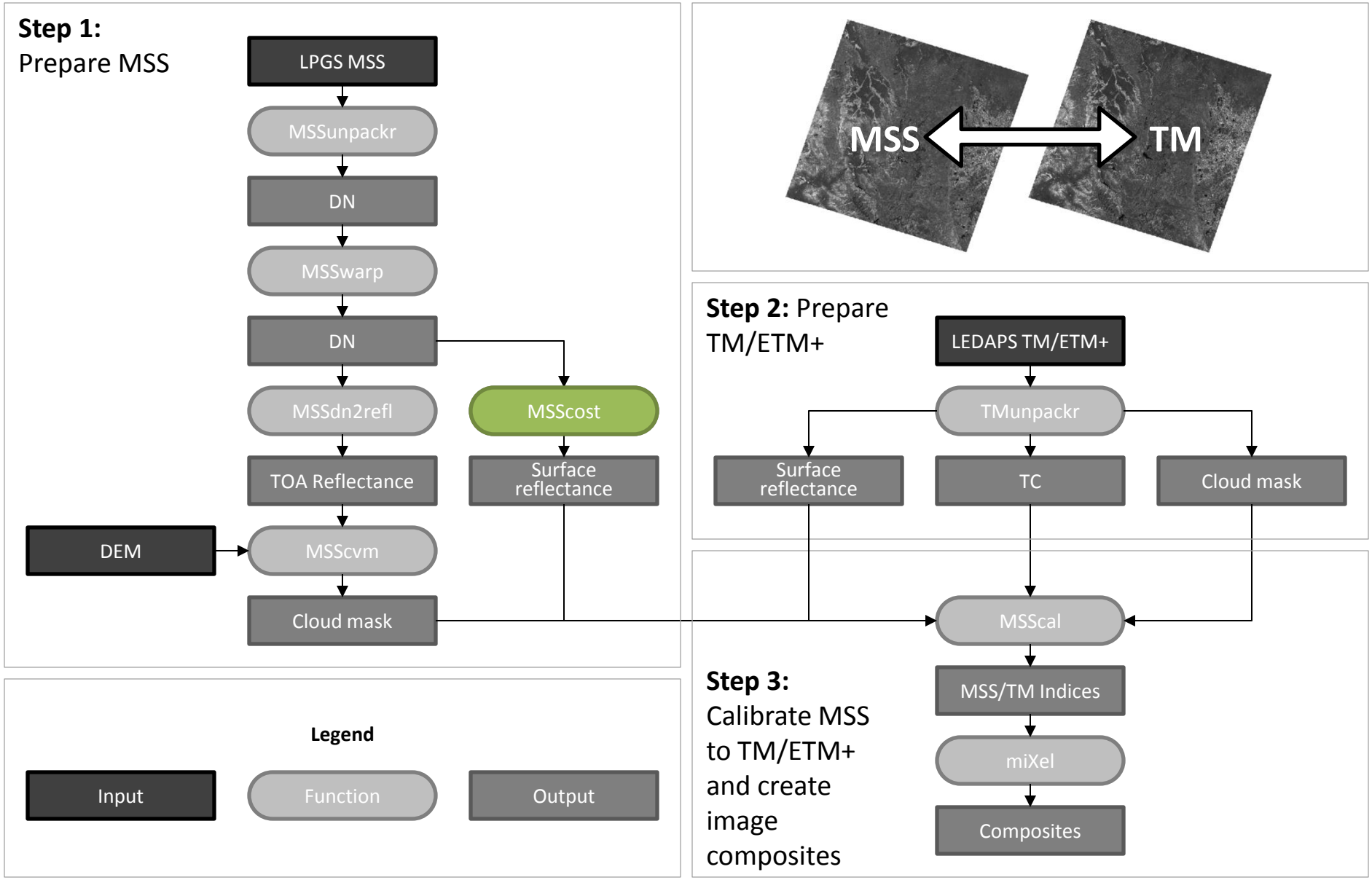


Geolocation

- Automated image-to-image tie-point search and warp

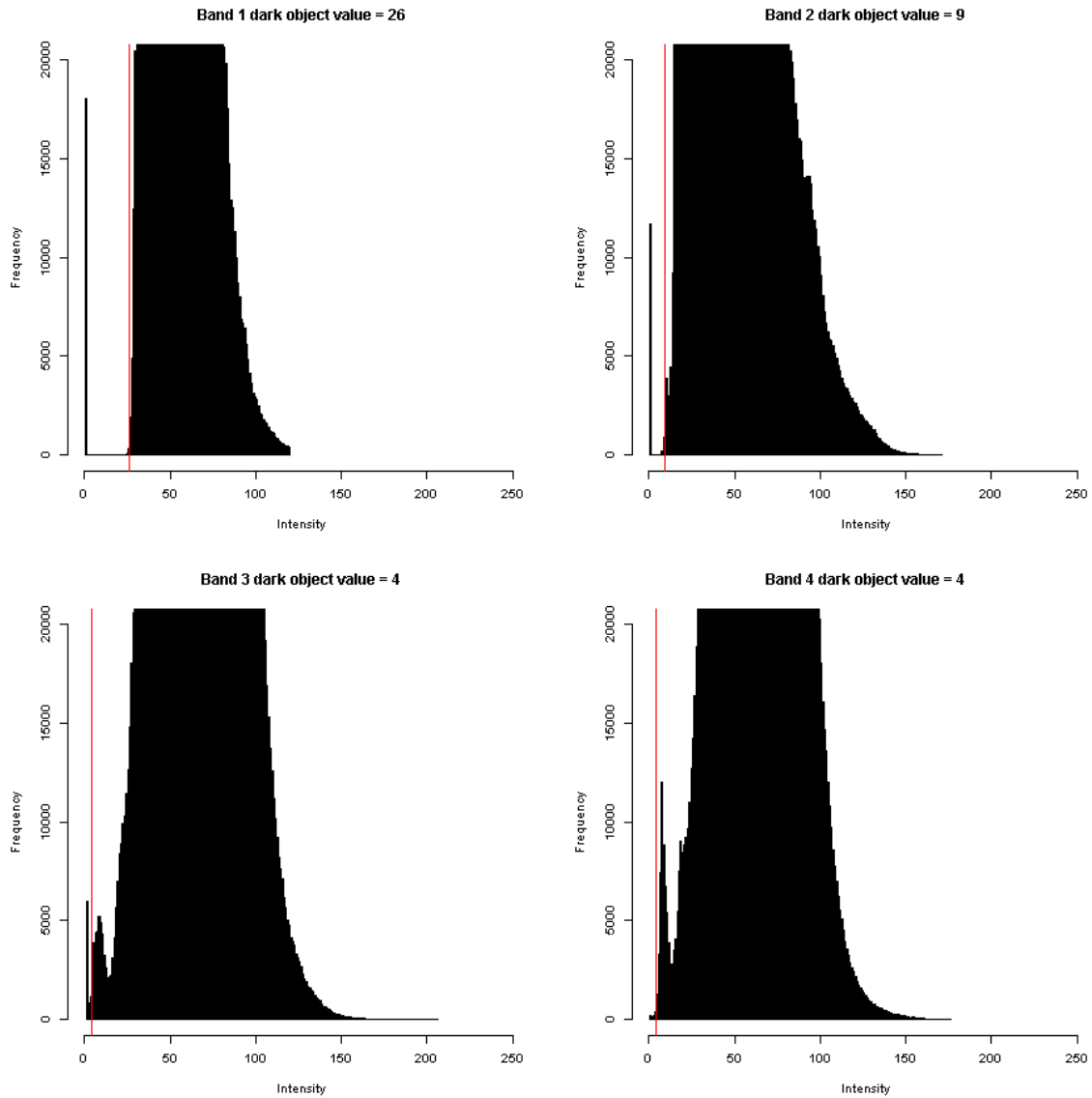


Atmospheric Correction/Surface Reflectance

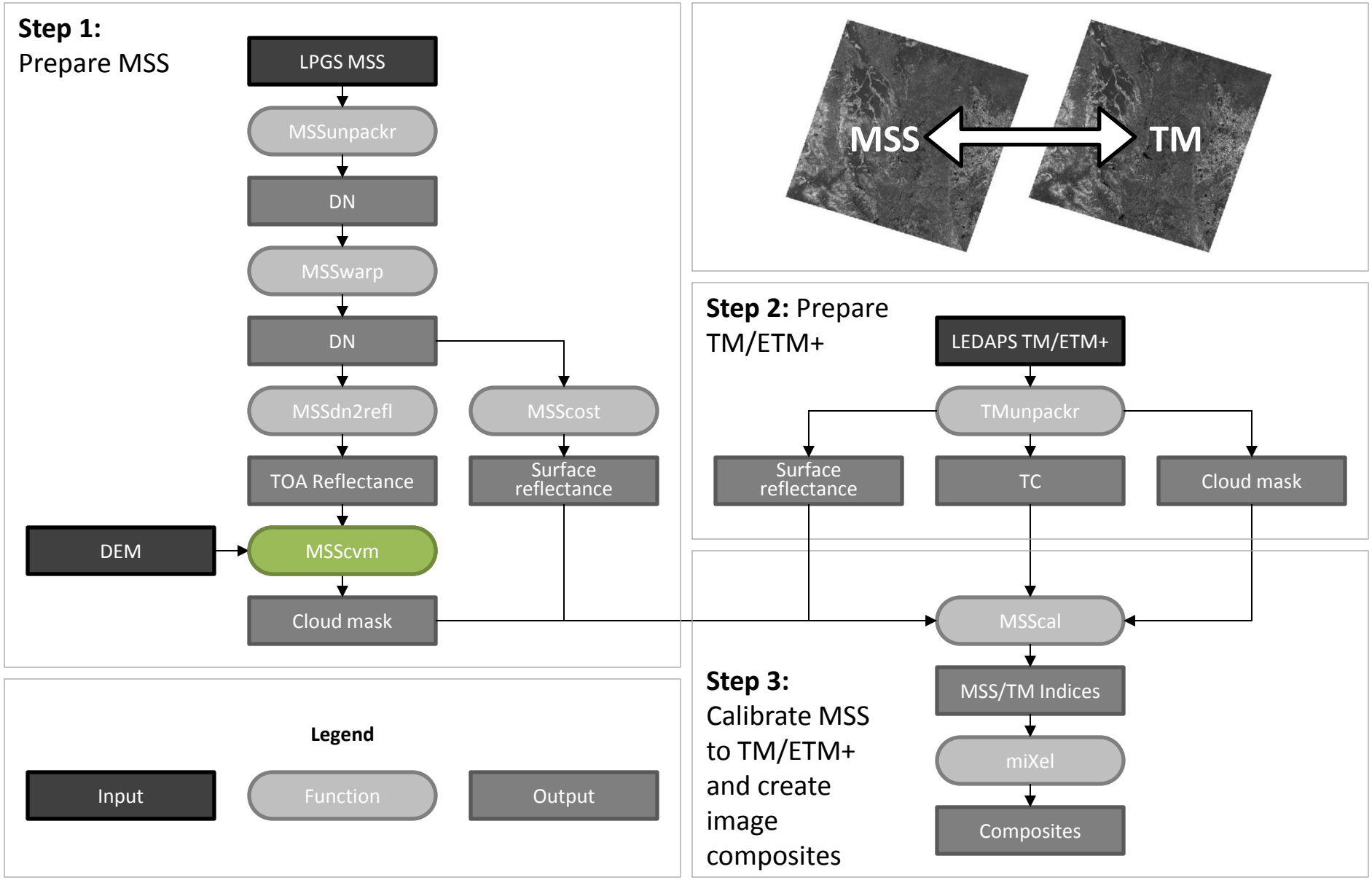


Atmospheric Correction/Surface Reflectance

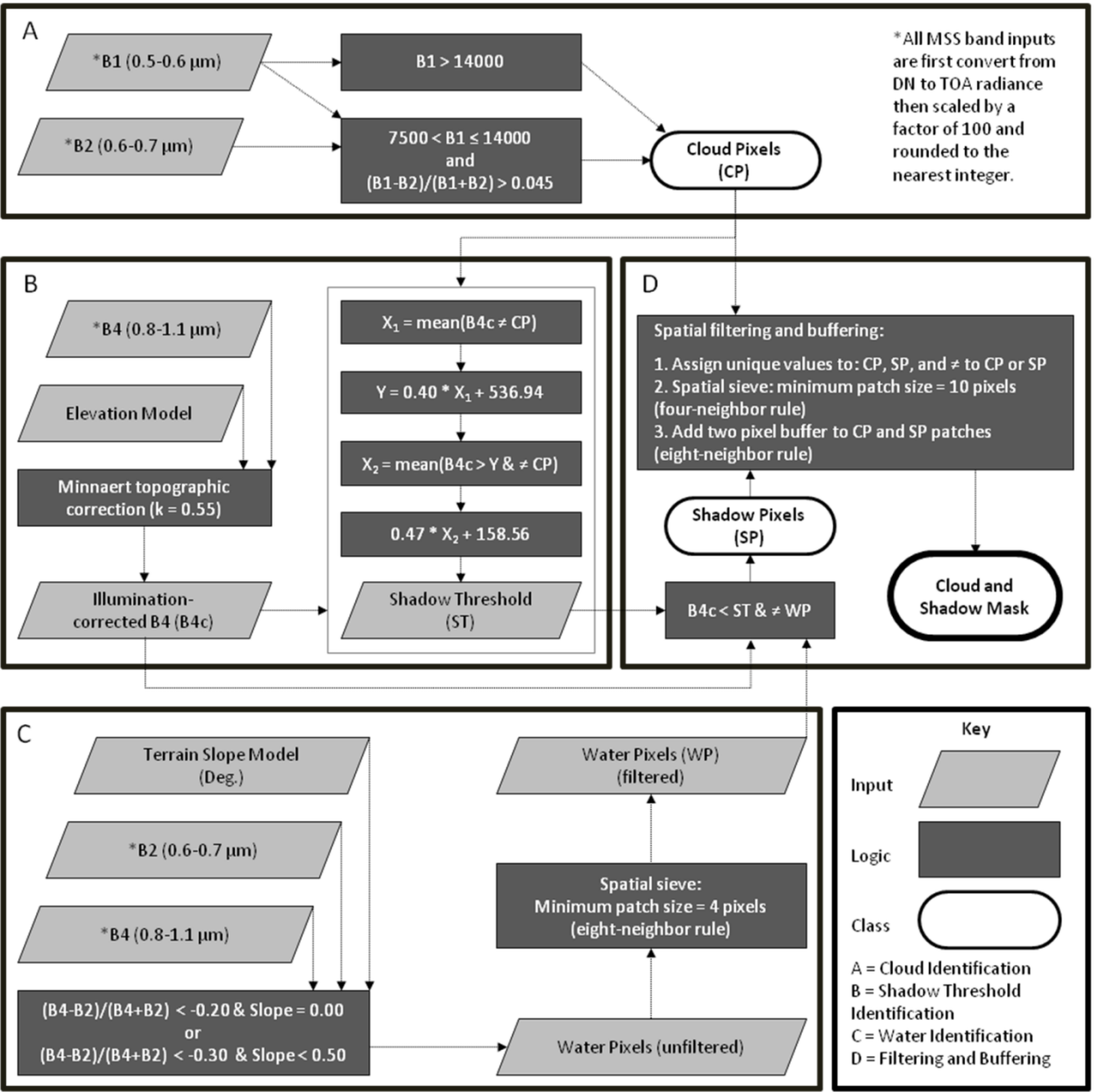
- Dark object subtraction with automated dark object value identifier based on band-specific brightness histogram
- Calculate surface reflectance:



Cloud and Shadow Masking



Cloud and Shadow Masking



-Clouds and shadows obscure land cover, contaminating change detection analyses – need to mask them out

-Developed automated cloud and shadow identification system (MSScvm)

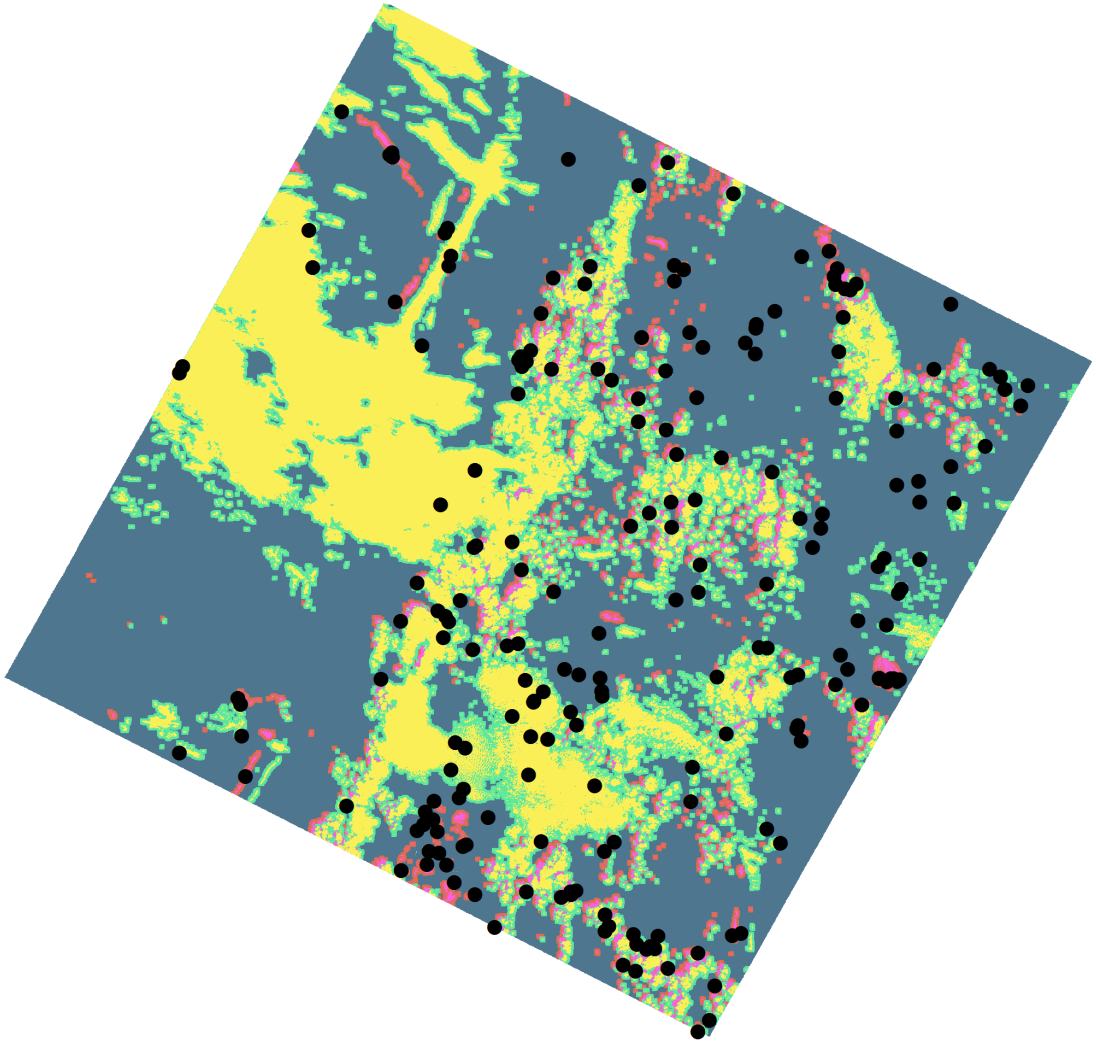
-With no thermal band, identification is based on reflectance brightness thresholding, differential brightness between bands, and topography

Accuracy Assessment

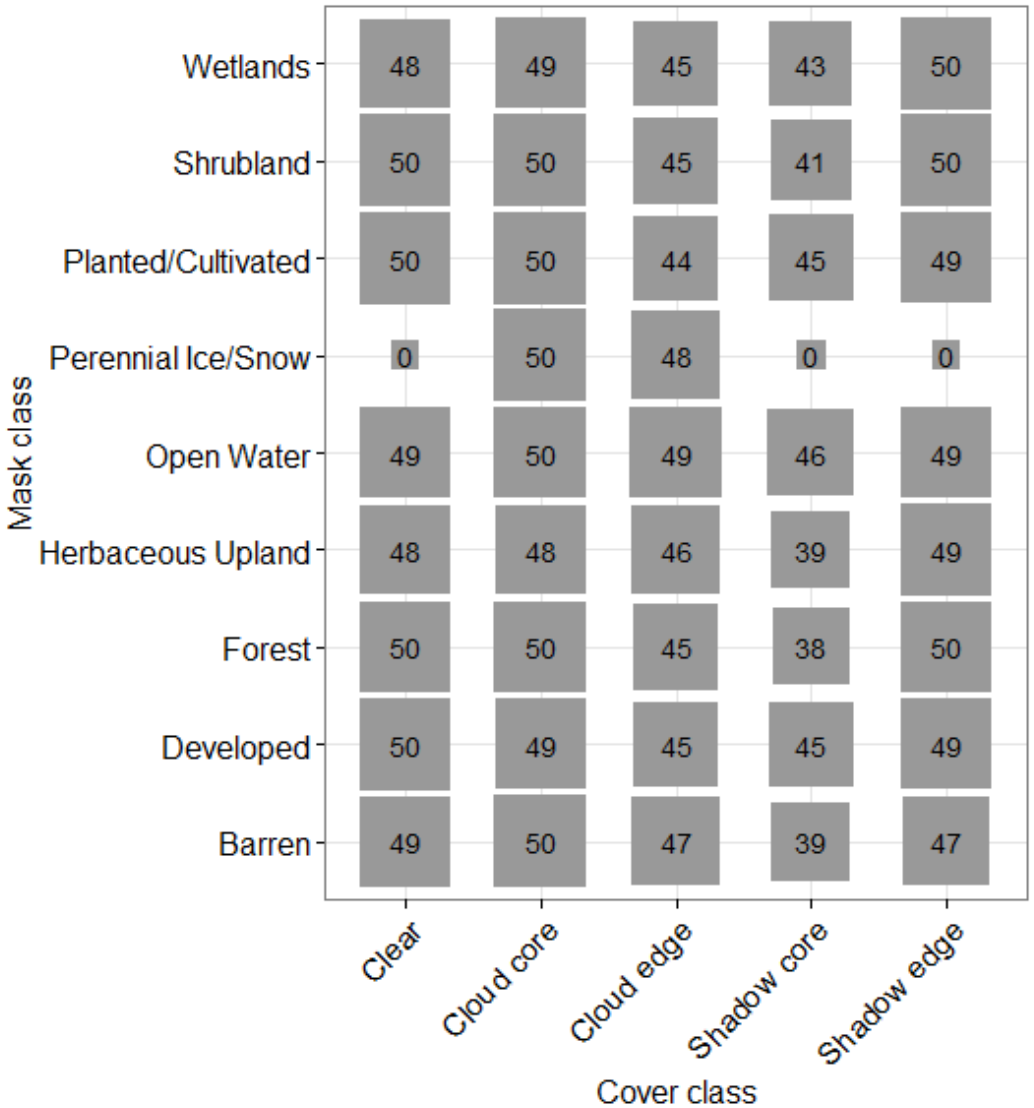
-Clear
-Core cloud
-Cloud edge
-Shadow core
-Shadow edge

X

NLCD land cover classes



Accuracy Assessment

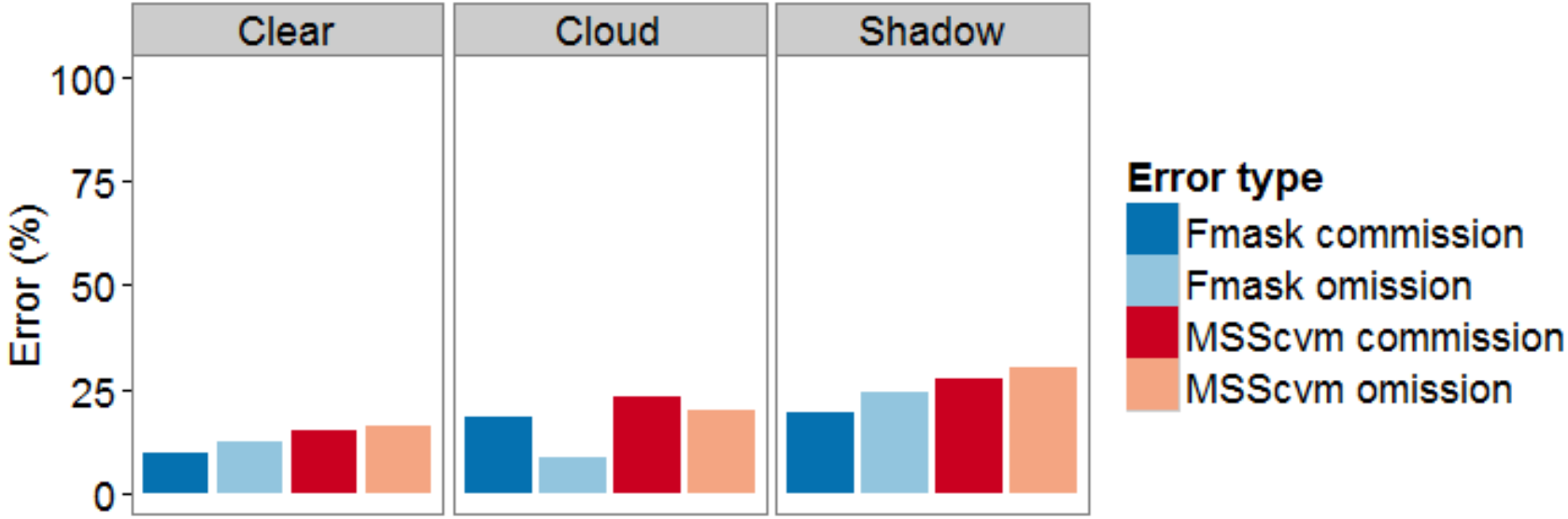


Accuracy Assessment

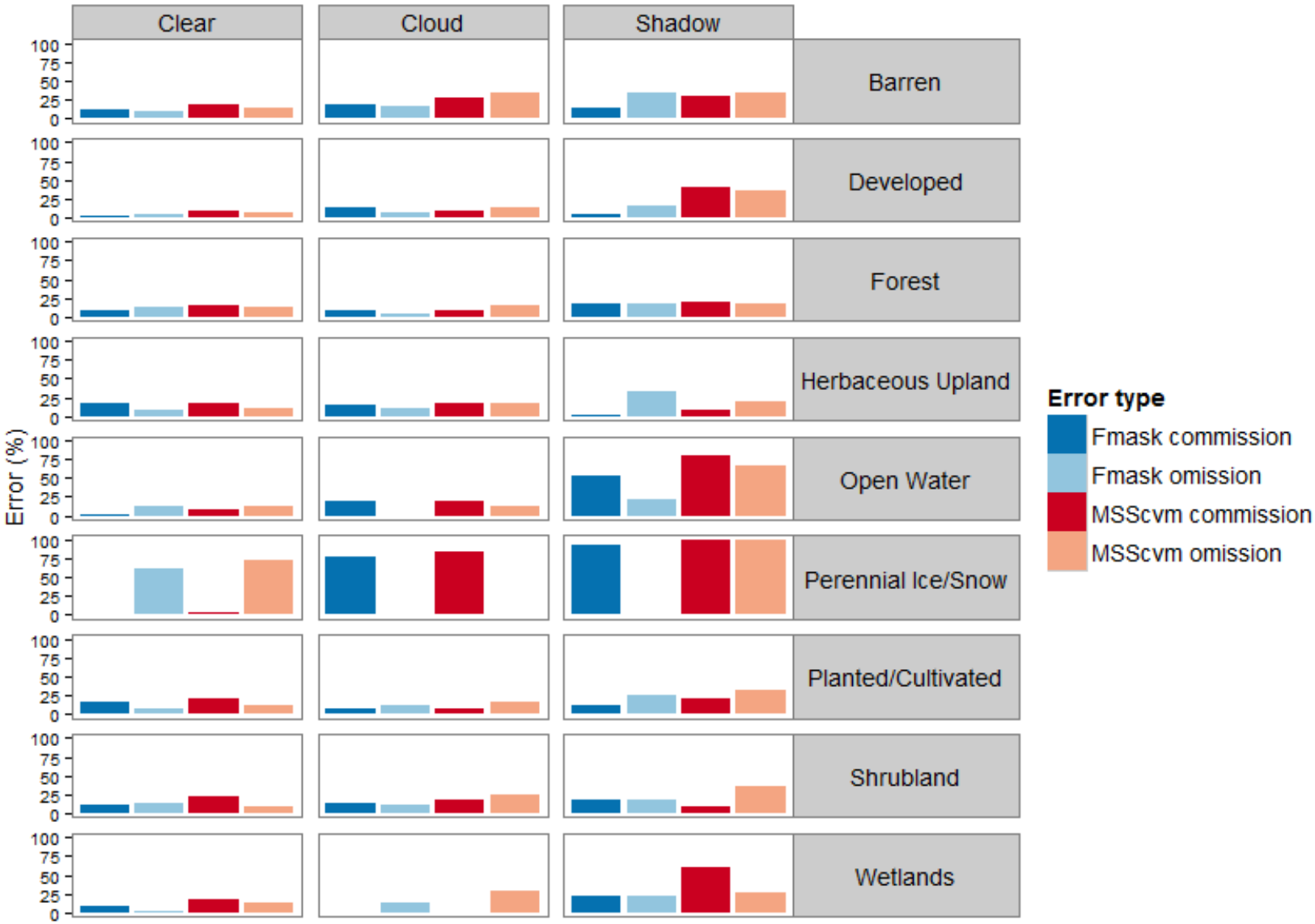
Overall accuracy (%)

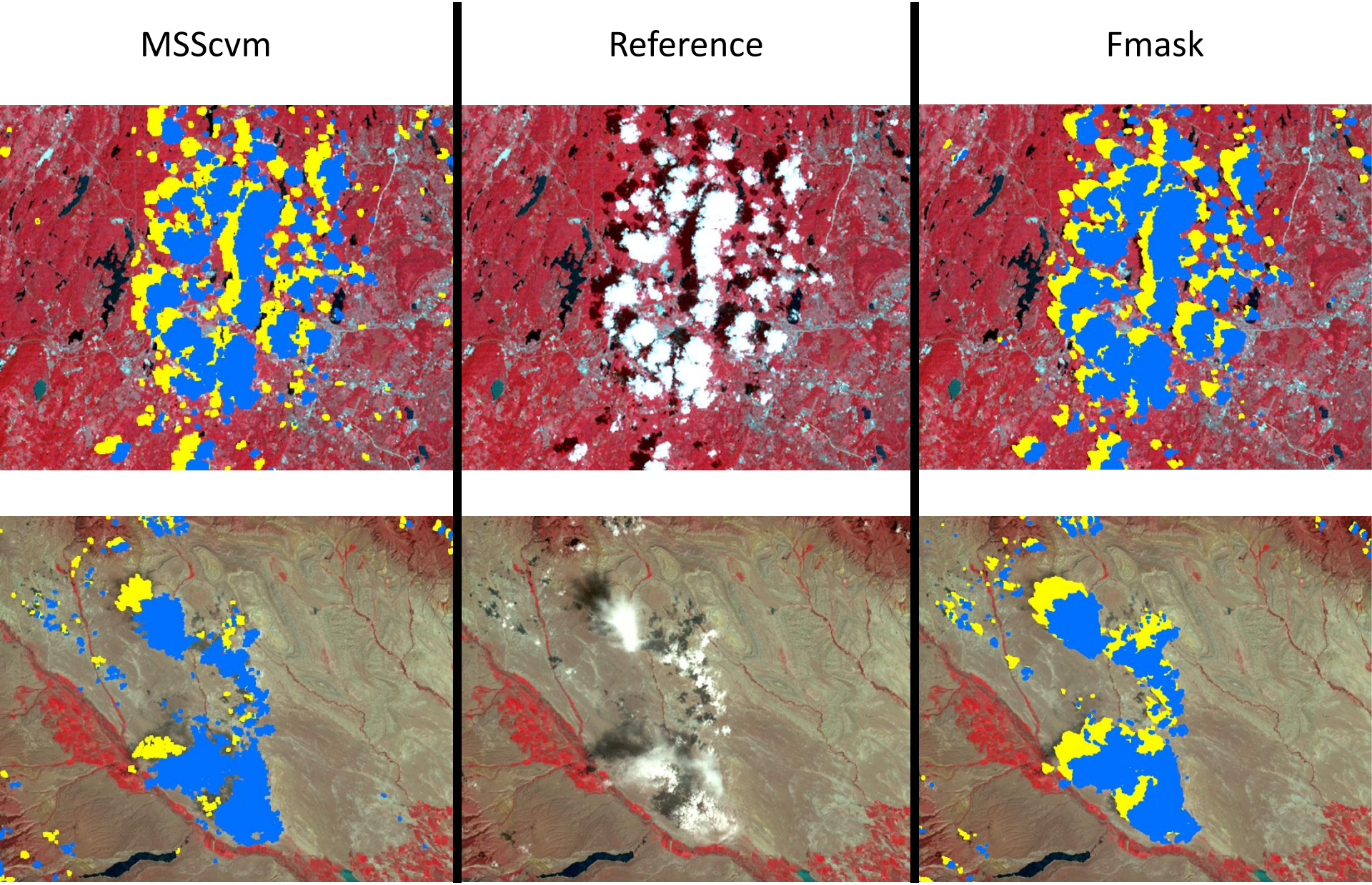
-MSScvm = 81.0

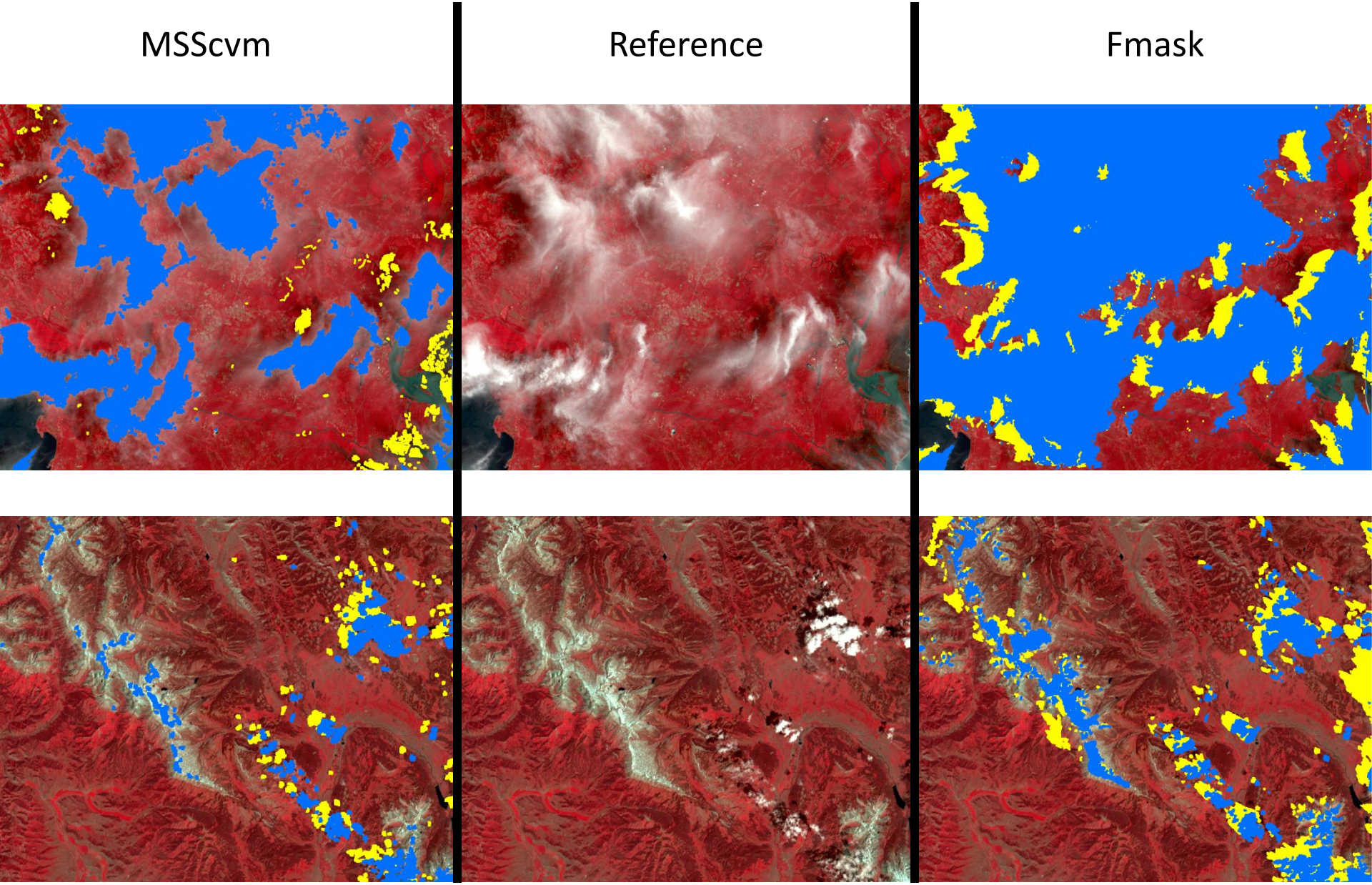
-Fmask = 86.7



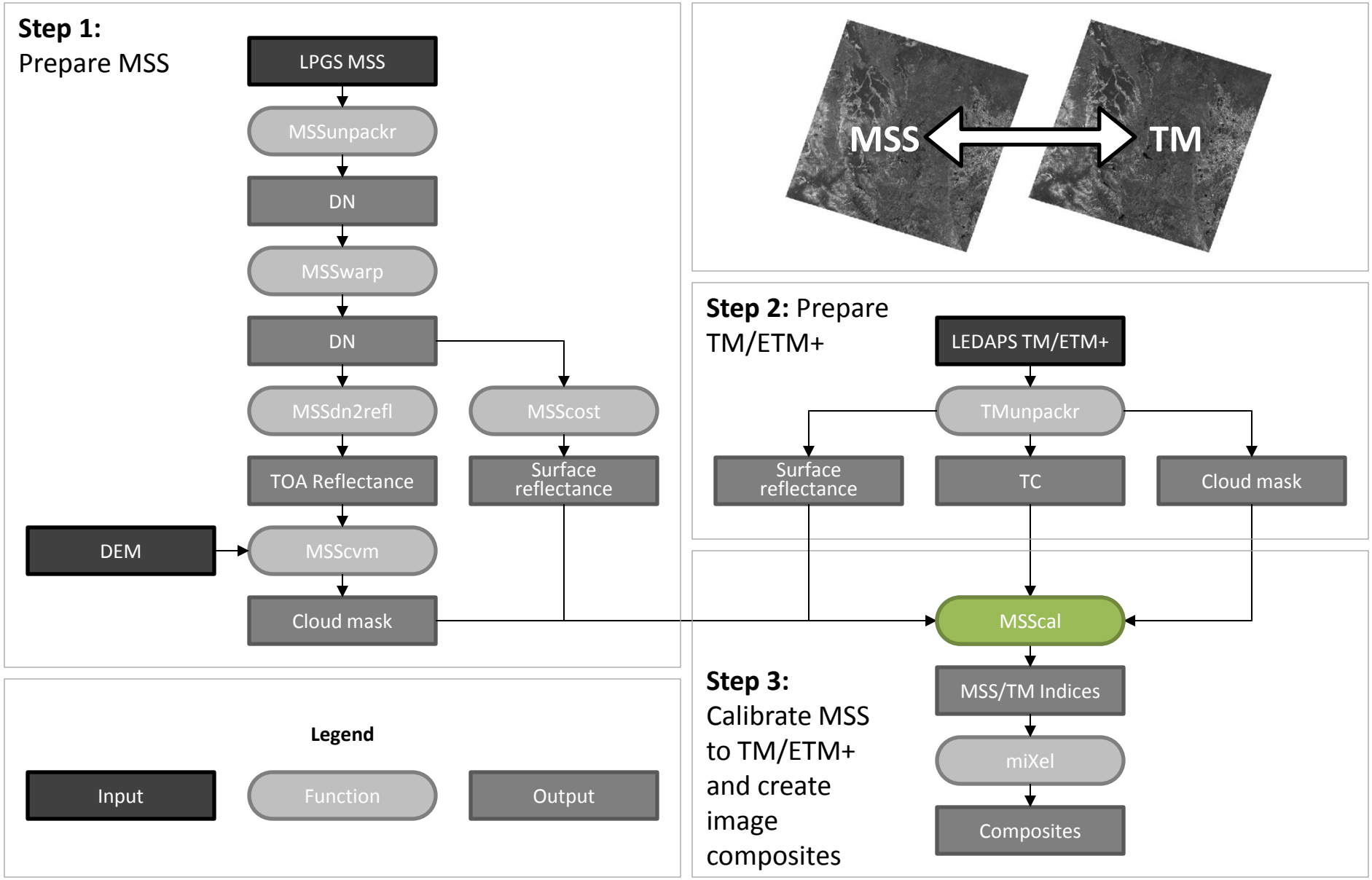
Accuracy Assessment




MSScvm
Reference
Fmask


MSScvm
Reference
Fmask

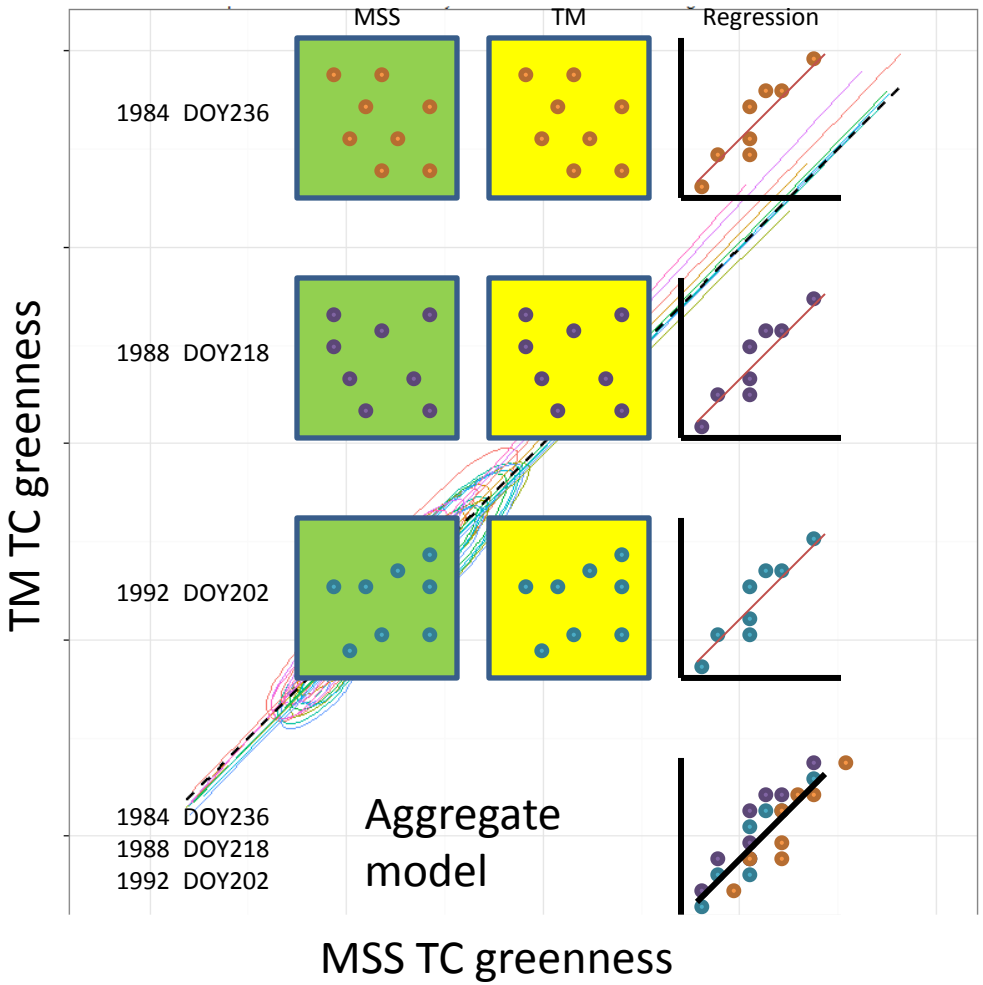
Spectral Integration



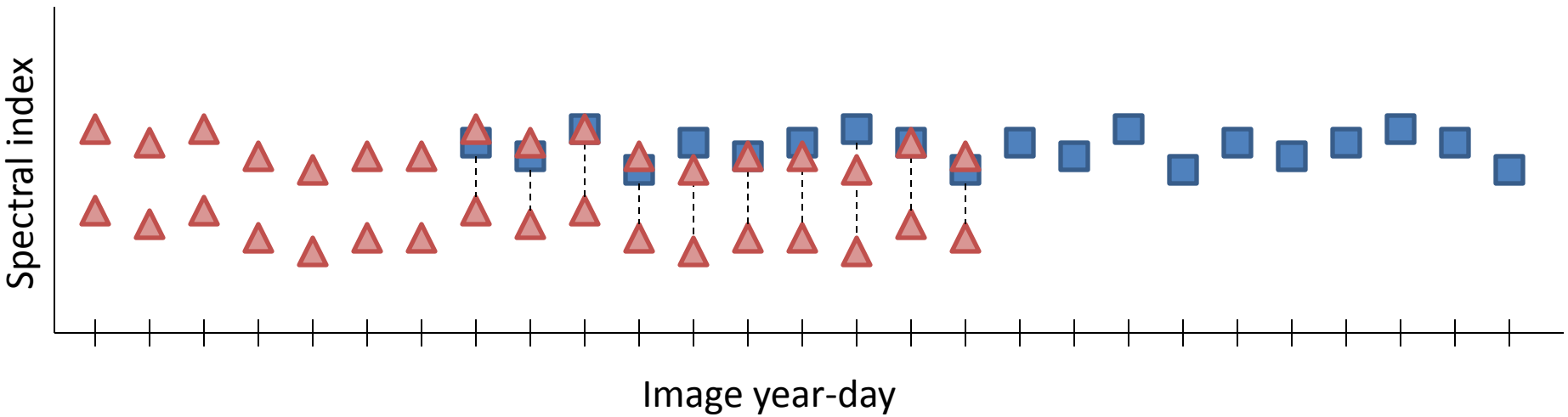
Spectral Integration

- Corresponding indices:
  - Tasseled Cap brightness
  - Tasseled Cap greenness
  - Tasseled Cap Angle
  - Tasseled Cap Distance
  - NDVI
- Modeled indices:
  - Tasseled Cap brightness (r = 92%)
  - Tasseled Cap greenness (r = 92%)
  - Tasseled Cap wetness (r = 85%)
  - Tasseled Cap Angle (r=92%)
  - Tasseled Cap Distance
  - NDVI
  - NBR
  - EVI
  - NDWI

Spectral Index Modeling



MSS Pixel-level Spectral Index Adjustment



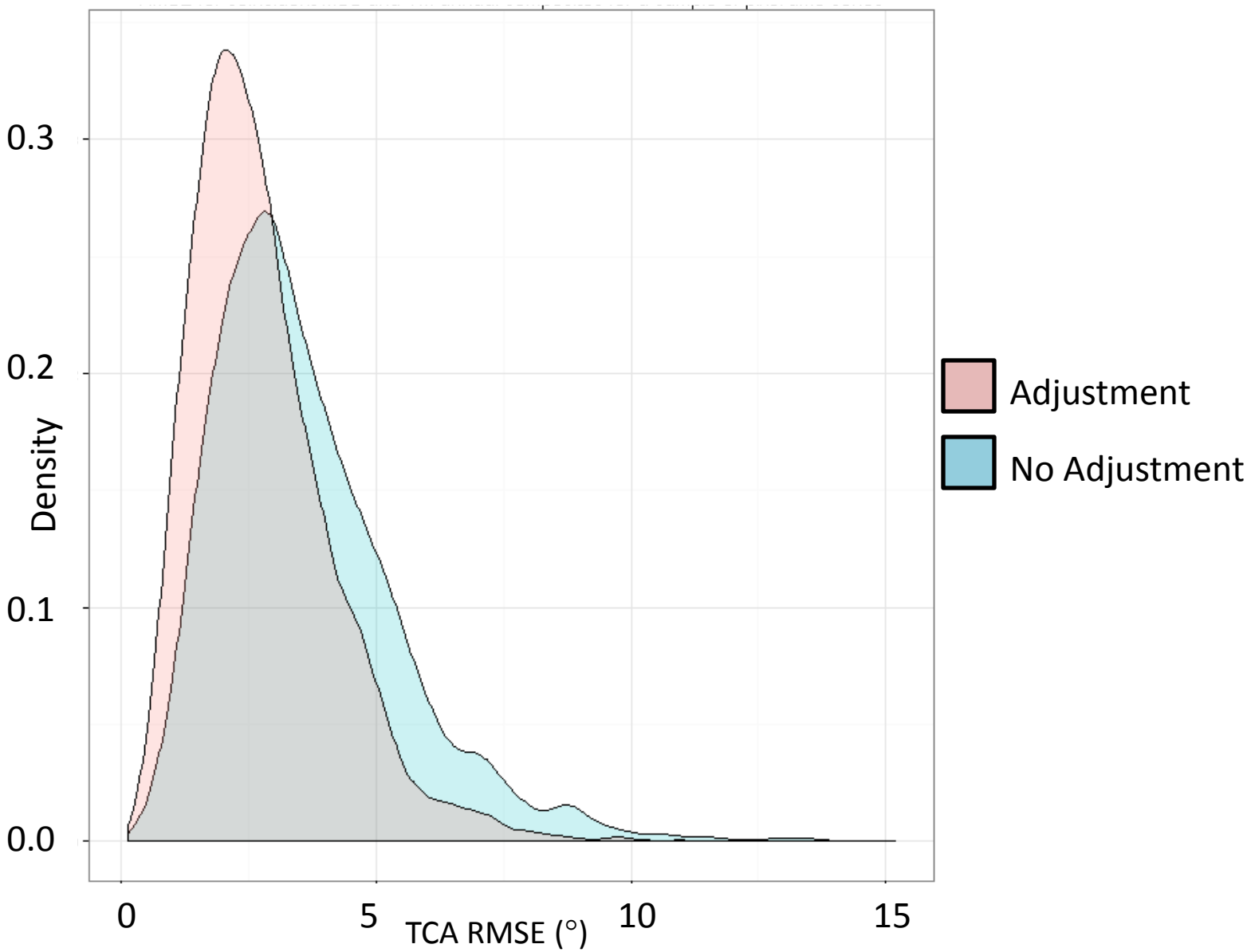
TM

MSS

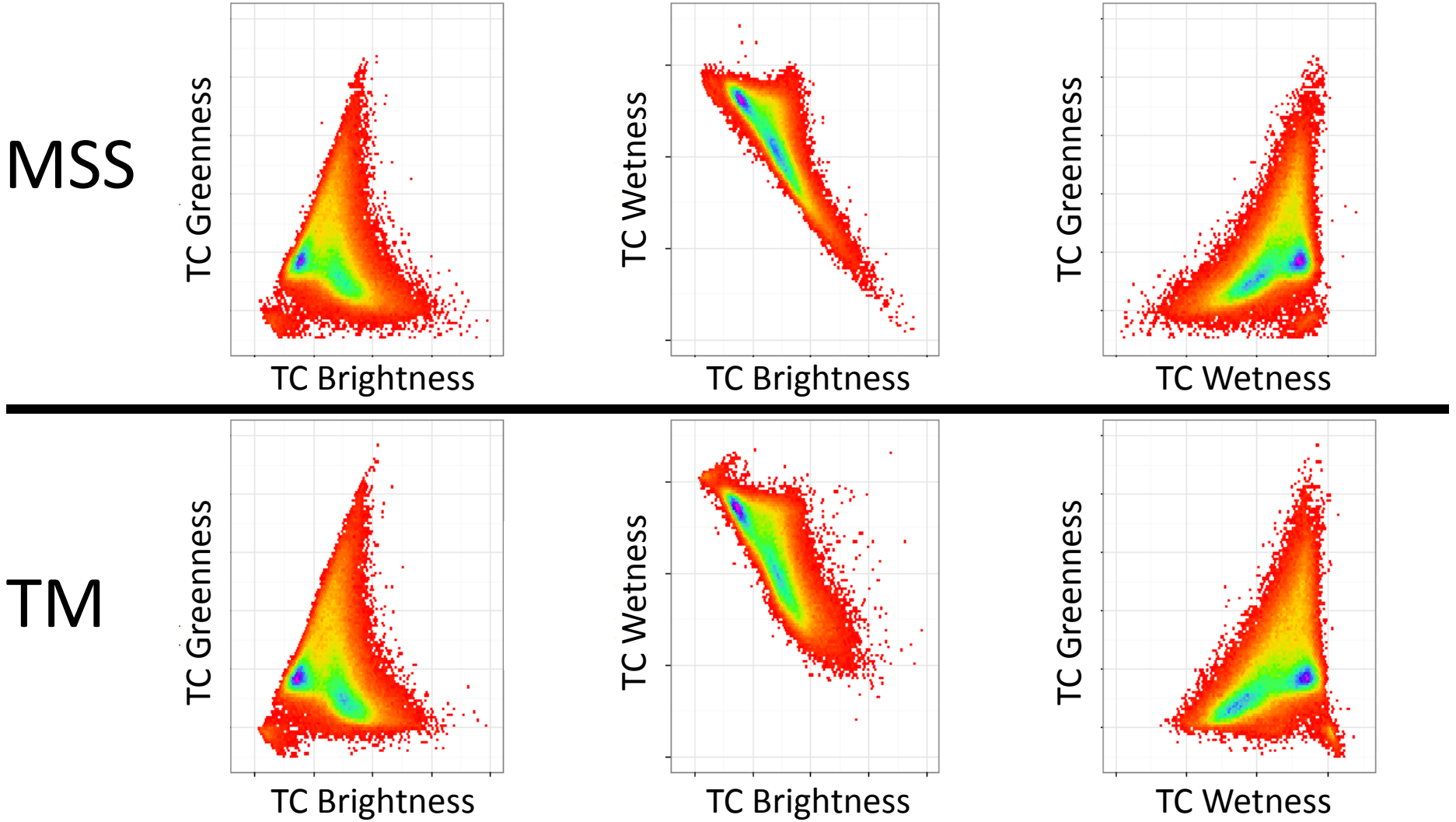
Pair-wise difference

Correct for pixel-level offset by taking the mean of all pair-wise offsets and adjusting all MSS values according to the result.

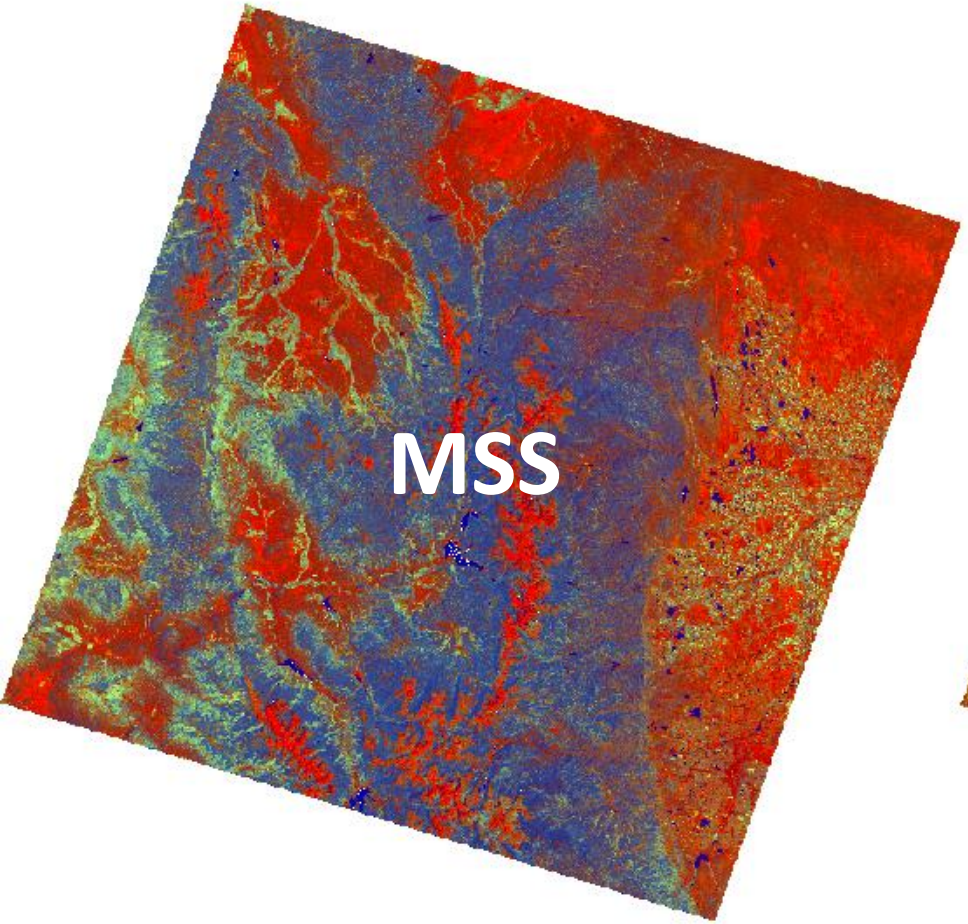
Offset RMSE

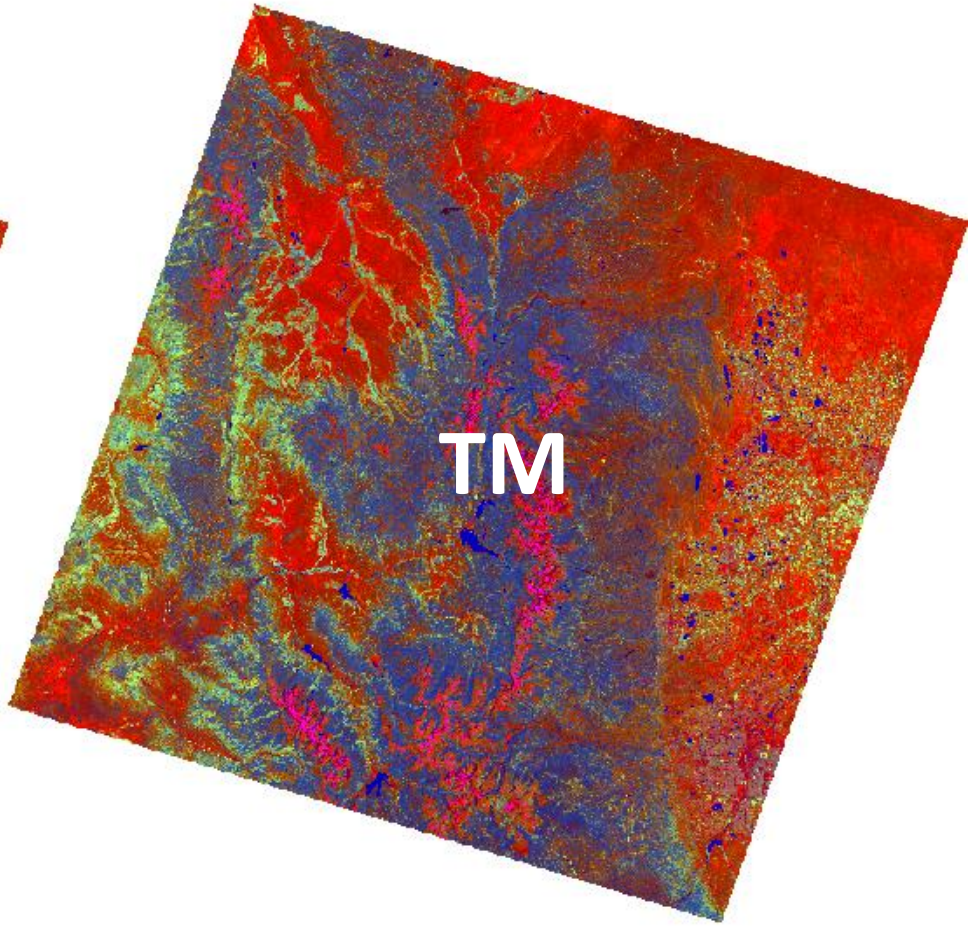

0.3
0.2
0.1
0.0
Density
0
5
10
15
TCA RMSE (°)
Adjustment
No Adjustment

Standard Tasseled Cap Planes - MSS to TM comparison

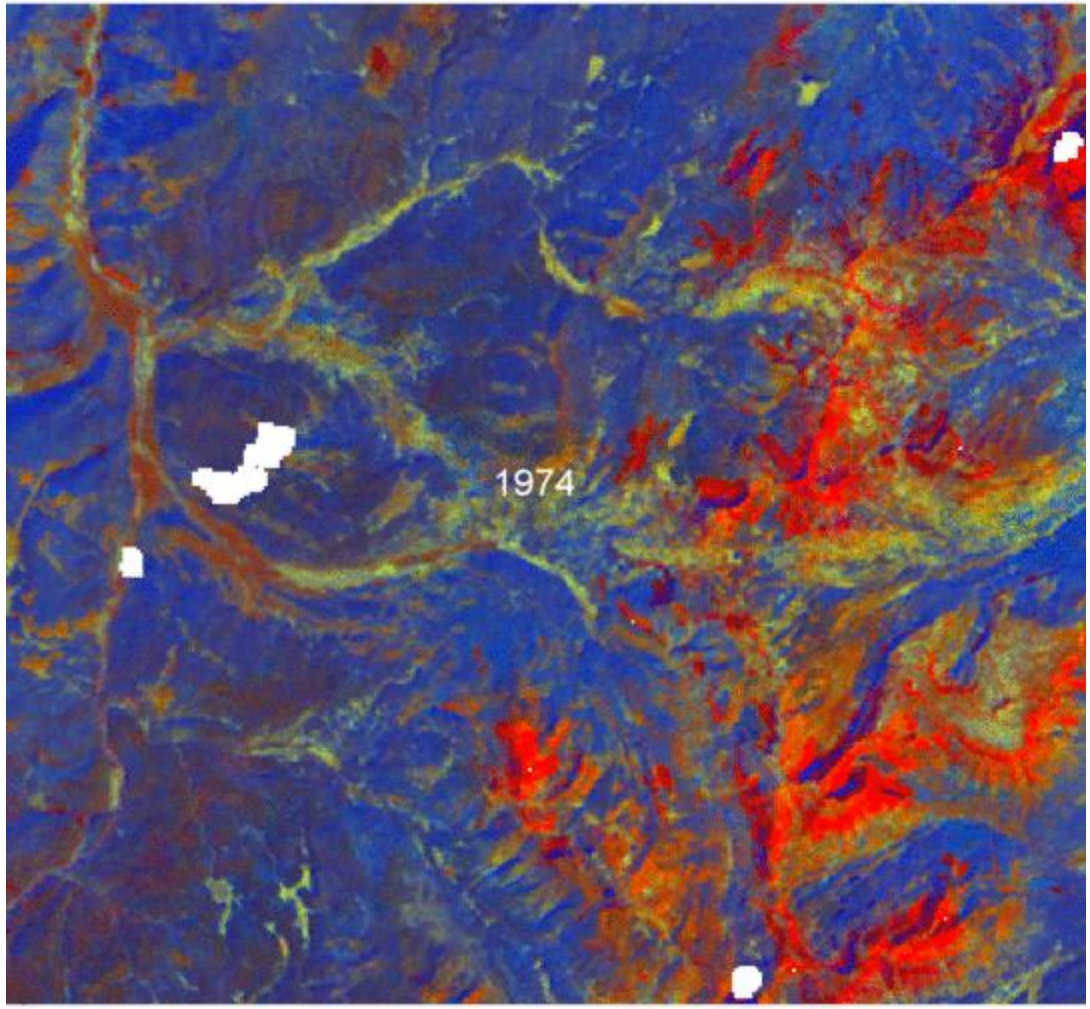


TC BGW/RGB display – MSS to TM comparison with standardized stretch

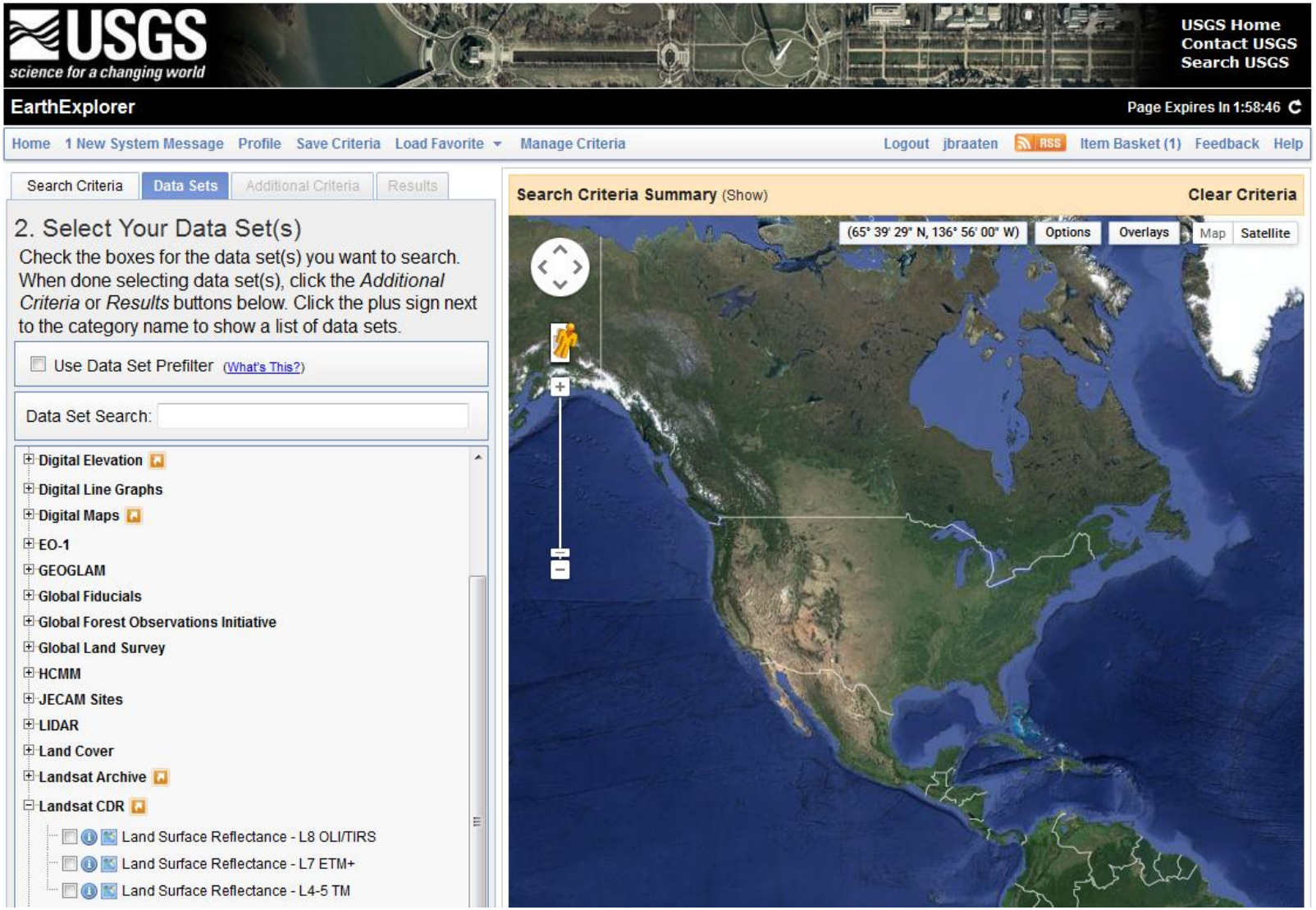




Seamless annual TC time series



How: (it could be done better)



How: (it could be done better)

- Standard surface reflectance algorithm
- Standard cloud mask algorithm
- Standard cross-sensor spectral index
- Processed by USGS
- Easy access

Discussion

- Is there general interest in making MSS a more usable product?
  - How would you want to use it?
- Is it feasible?
  - Algorithm development
  - USGS-processed and distributed
- Next steps