# Labeling a Land History:

## Continuity, Uncertainty, and Reliability in land cover and disturbance attribution

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*Also:*
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Rakesh Solankir

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Google Earth Engine

USGS
science for a changing world

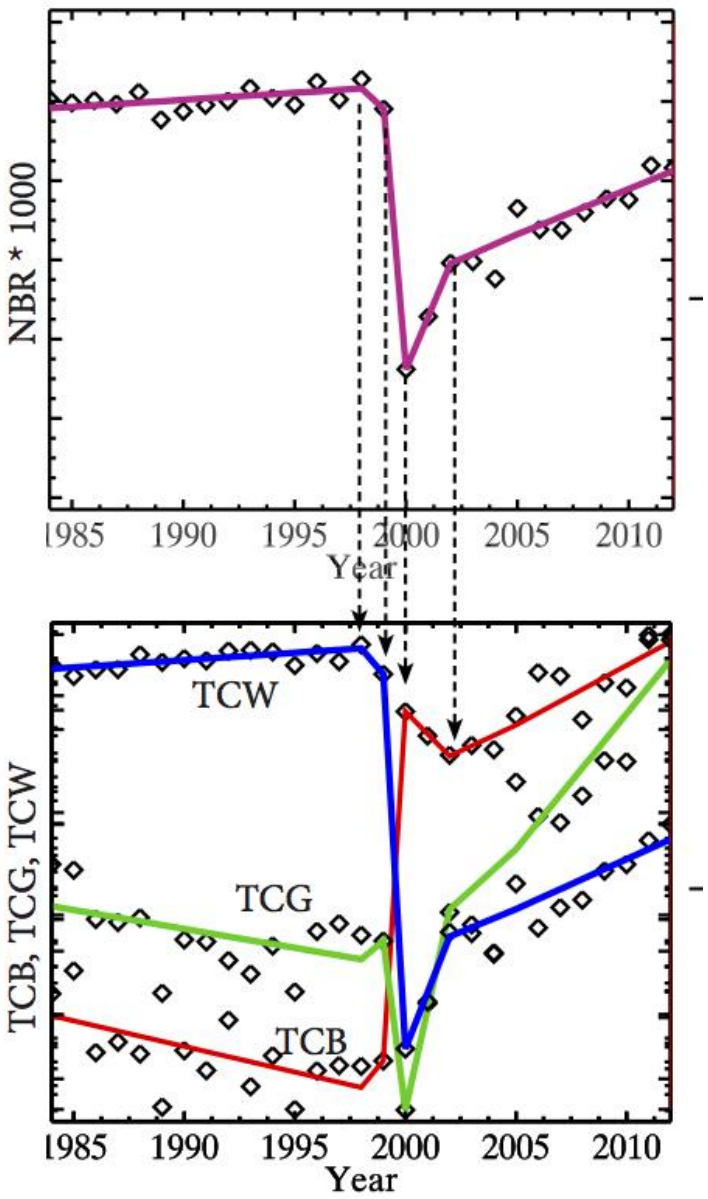
NASA

FOREST SERVICE
U S
DEPARTMENT OF AGRICULTURE

# What we do (briefly)

Segment a time series

Temporally stabilize indices



# LandTrendr Labeling

Joe Hughes (26: jhughes) | Sign Out

ndvi loaded.

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10: mr224_cal1

KML for Project #10

[045029] 34906
[045029] 42510
[045029] 55629
[045029] 64010
[045029] 64508 ✓
[045029] 67311
[045029] 73730
[045029] 76027
[045029] 78611
[045029] 80422
[045029] 86106
[045029] 86311
[045029] 96606

**Change Process**

Best Guess: Partial Harvest

Might be: Fire

Shape: Context: Trajectory:

phenology | cloud | misregistration | partial patch | snow | wrong year

Notes:

```
Partial harvest immediately
followed by fire.
```

**Before**

*Primary* — dominant

Land Use: Forest

Land Cover: Broadleaf

*Secondary*

Land Use:

Land Cover:

**After**

*Primary* — dominant

Land Use: Forest

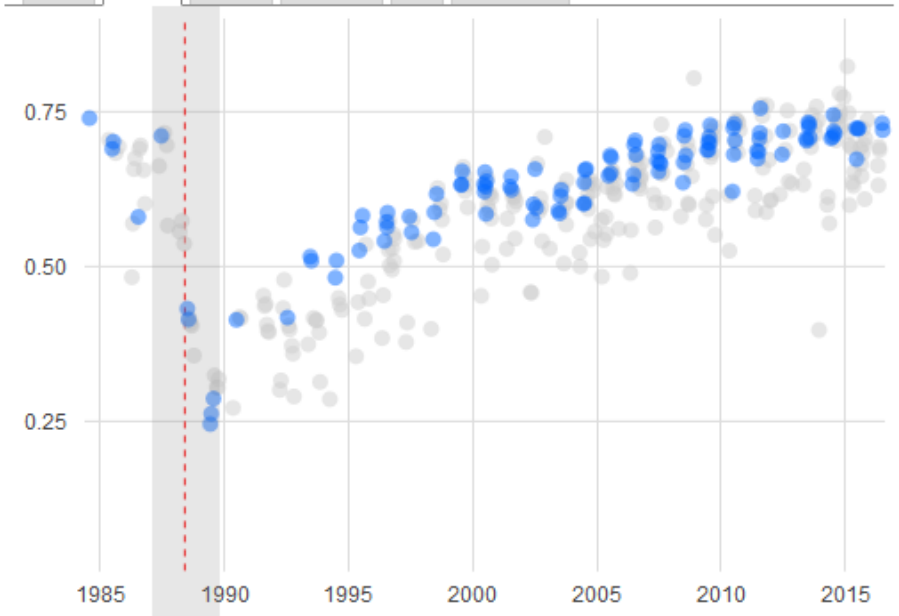
Land Cover: Barren

*Secondary*

Land Use: Natural non-forest veg

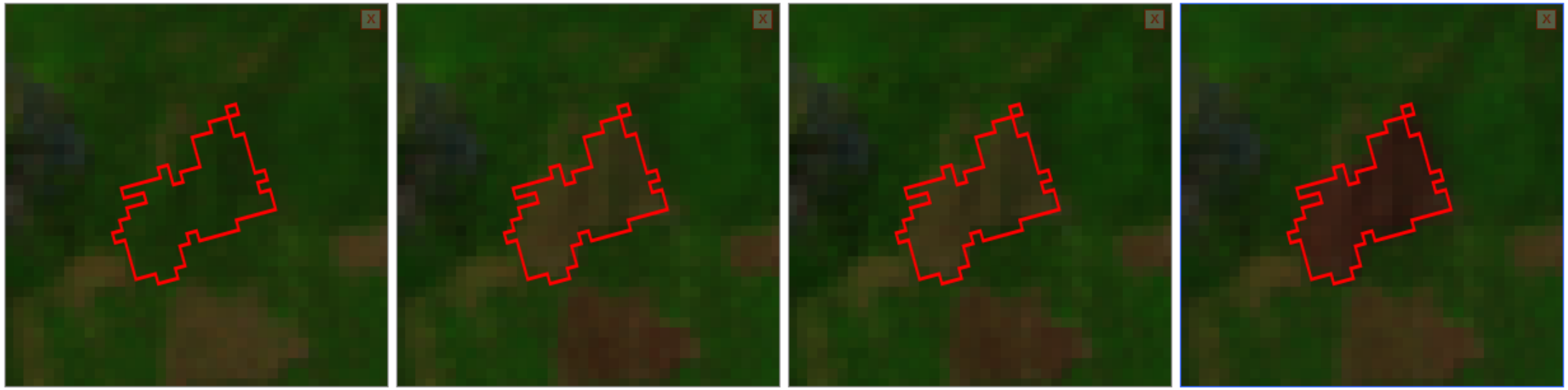
Land Cover: Shrubs

NBR | NDVI | NDMI | ANGLE | B5 | Wetness




Natural Look | Tassel Cap | Zoom: 8x

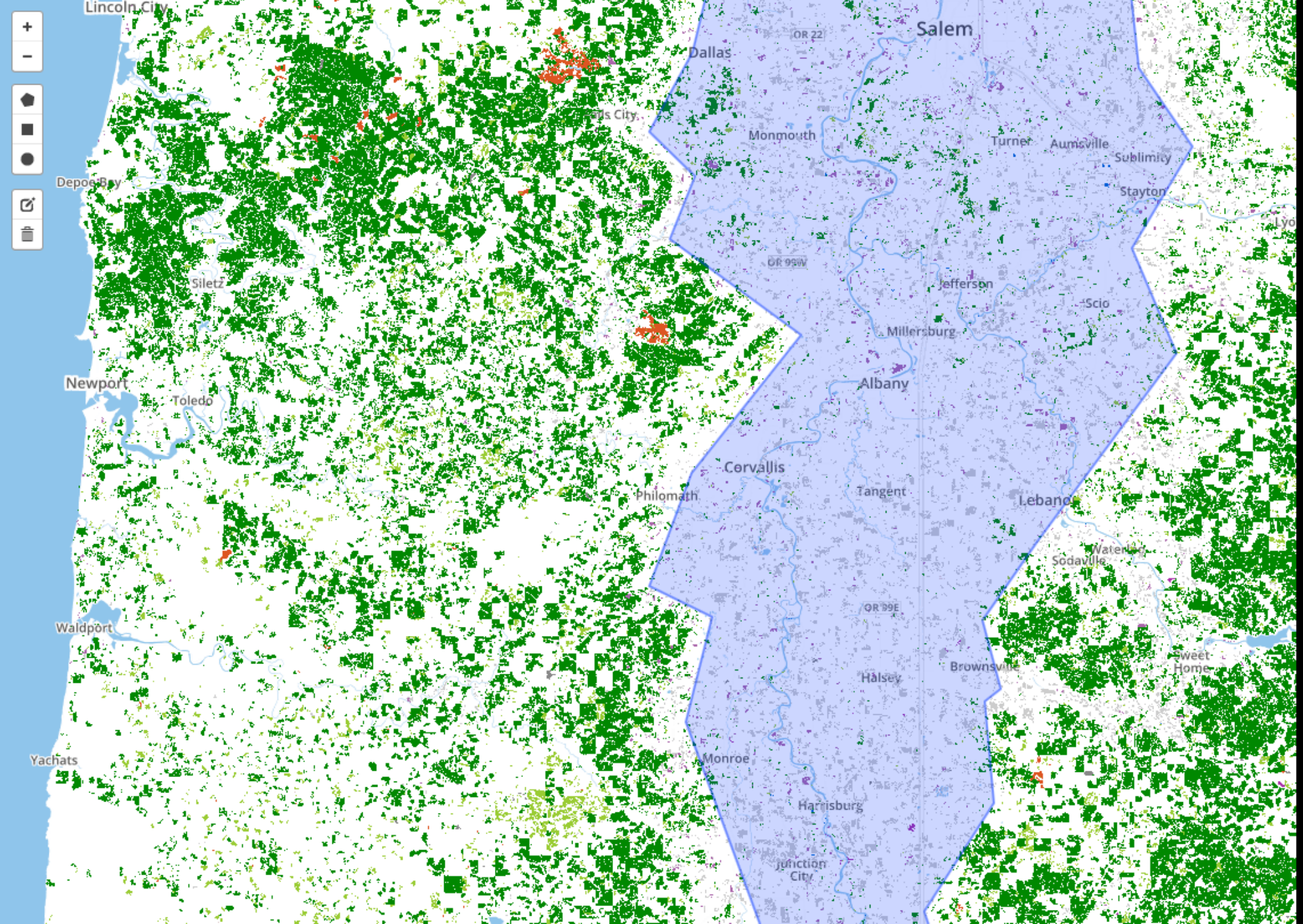
Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec



Fri Jun 19 1987 | Thu Jul 07 1988 | Sat Jul 23 1988 | Thu Jun 08 1989

# NLCD Remapping

Columbia River, East of Spokane WA




# Kennedy Lab Data Portal

☑ Show/Hide reference layer

**Layers:**

NWFP Disturbance (Expert)

[-] Hide Legend

- 0: Undisturbed
- 10: Unknown Agent
- 11: Other
- 20: Clearcut
- 21: Partial Harvest
- 22: Salvage
- 30: Development
- 31: Road
- 40: Fire
- 50: Insect/Disease
- 61: Water
- 62: Wind
- 70: Avalanche=> chute
- 71: Avalanche=> runout
- 72: Debris flow
- 73: Landslide
- 200: No Visible Change
- 201: False Change
- 254: ""
- 255: Undefined

Cursor: (44.8237, -122.6335) | Zoom: 10

## Request Selected Data

**Full Name:**

Joe Hughes

**Email Address:**

joe@science.org

# 1. Continuity

## extending long-term data series

Google Earth Engine

Search places and datasets...

Help | ramblingrek

**Scripts** | Docs

Filter scripts...

- **Private**
  - Basic LandTrendr - Demo +1
  - Basic LandTrendr - Demo +2
  - Basic LandTrendr - Demo-NV
  - Basic LandTrendr - with YOD and duration separate
  - Basic LandTrendr - with YOD and duration separate weir...
  - Basic LandTrendr dist and recovery - with YO...
  - Basic LandTrendr dist and recovery - with YOD and dura...
  - LT at GBILM
  - LT at GBILM (try magnitude)
  - LT with Ledaps - from yang
  - LT with growth
  - LTTesting
  - LTtest_round2
  - Simple Landsat Cloud Score
  - check lt B&B fire
  - lt at B&B

**Basic LandTrendr dist and recovery - with YOD and duration separate (copy)** | Get Link | Save | Run | Reset

Imports (1 entry)

var geometry1: GeometryCollection

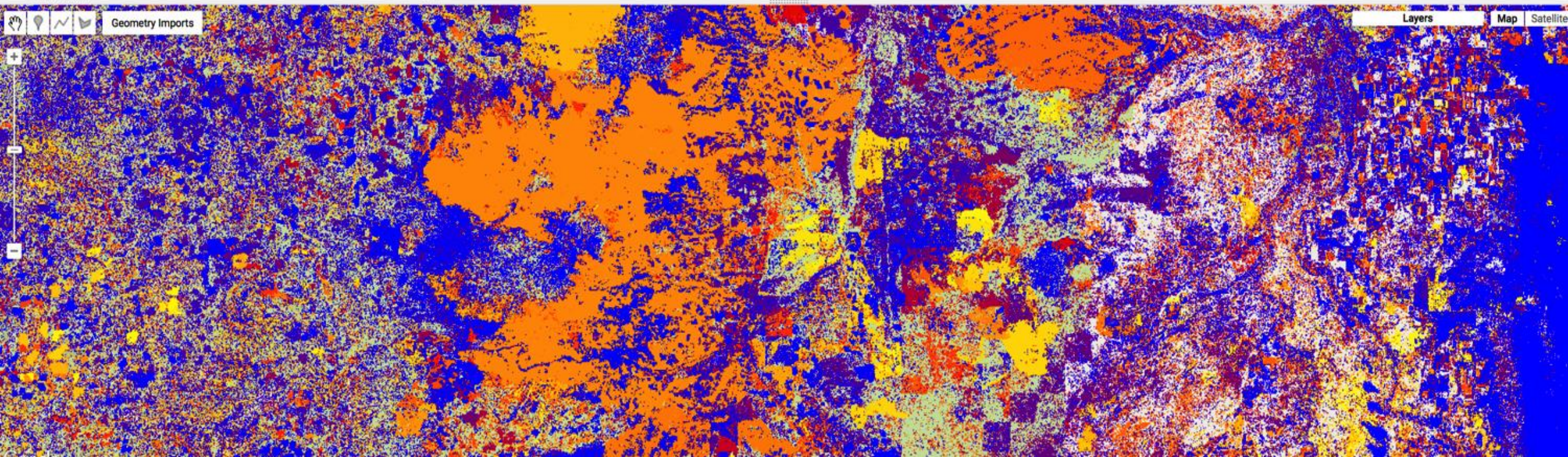
```
/* Basic LandTrendr - Demo

  Z. Yang

  This is a simple demo of Landtrend with basic post processing.

  Not full landtrendr post processing are in this script. For the purpose of what I need,
  I did not add the angle collapse in this version, which can be achieved in a similar way
  as the disturbance extraction.

  cloud score is not very effective for the image. In the temporal context it is ok for now.

*/

// A mapping from a standard name to the sensor-specific bands.
var LC8_BANDS = ['B2',   'B3',    'B4',  'B5',  'B6',    'B7',    'B10'];
var LE7_BANDS = ['B1',   'B2',    'B3',  'B4',  'B5',    'B7',    'B6_VCID_1'];
var LT5_BANDS = ['B1',   'B2',    'B3',  'B4',  'B5',    'B7',    'B6'];
var STD_NAMES = ['blue', 'green', 'red', 'nir', 'swir1', 'swir2', 'temp'];

// Compute a cloud score.  This expects the input image to have
// STD band names: ["red", "blue", etc], so it can work across sensors
```

**Inspector** | **Console** | Tasks

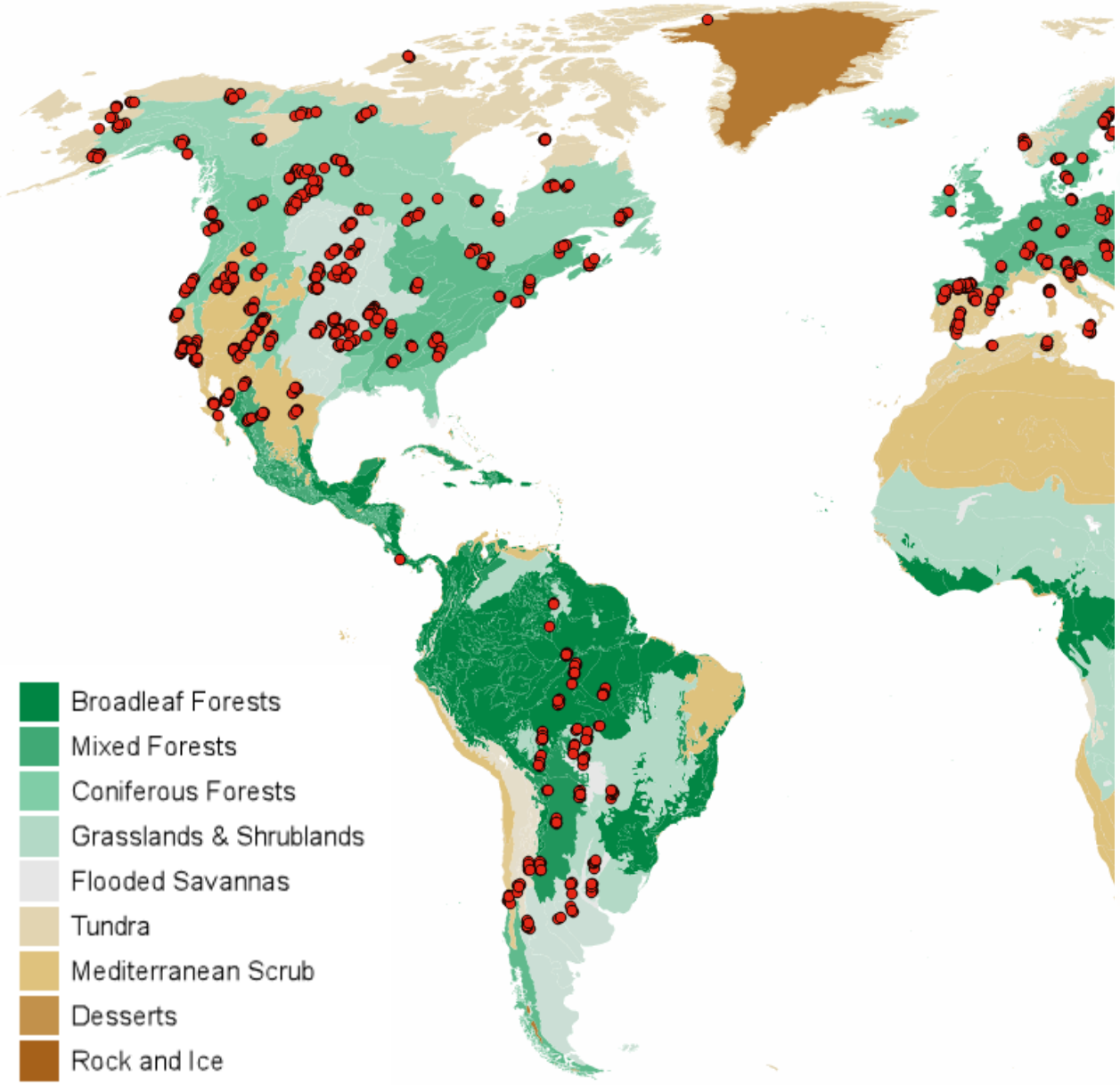
Use print(...) to write to this console.

-122.93221 44.99801

-122.81891 45.02877



# ETM+ / OLI Spectral Harmonization




Terrestrial

L7 – L8 sidelap

+/- [illegible]

SR [illegible]

Obstruction [illegible] (FMask)

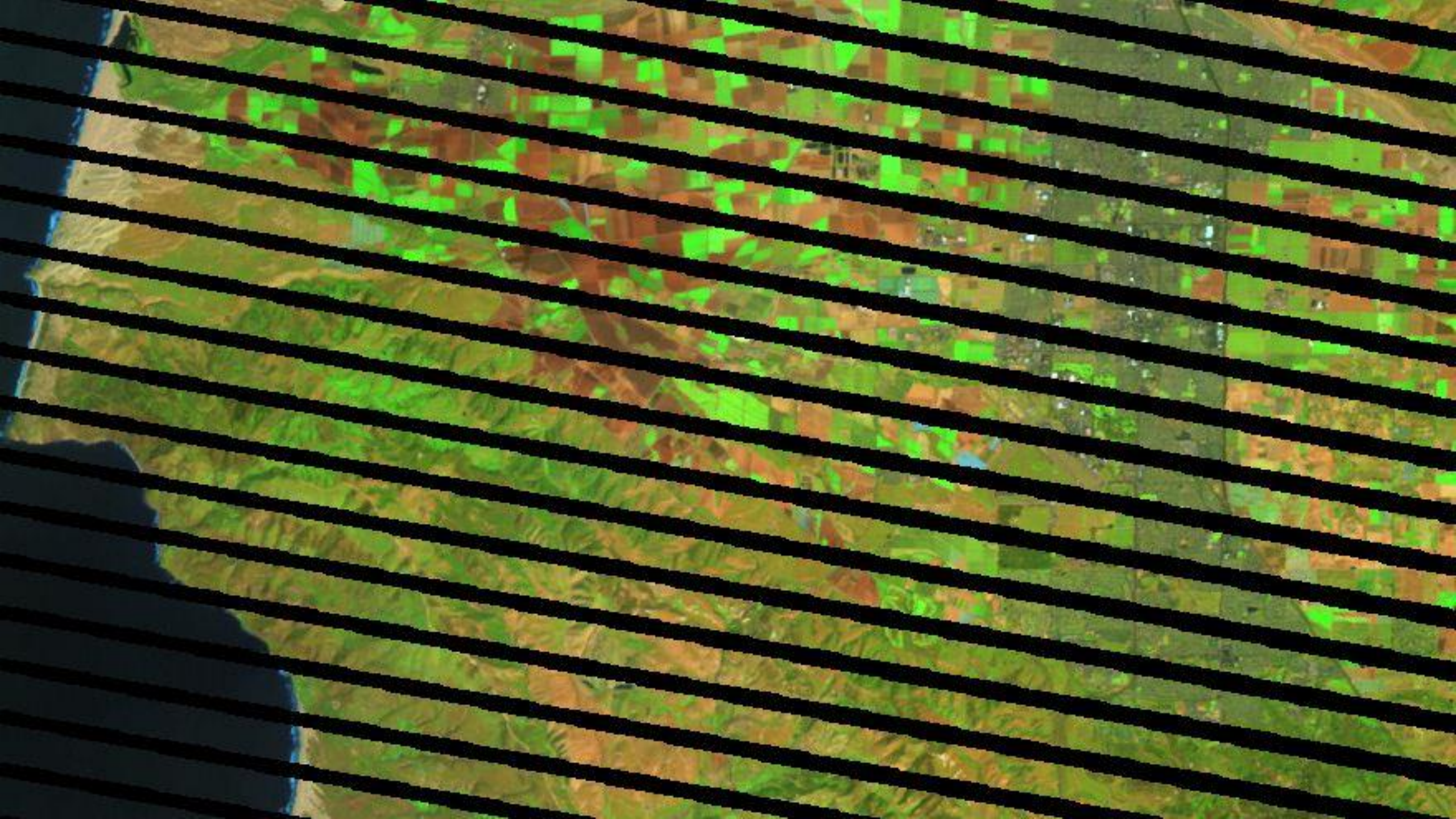
NDVI +/- 0.1

1 sq km chips

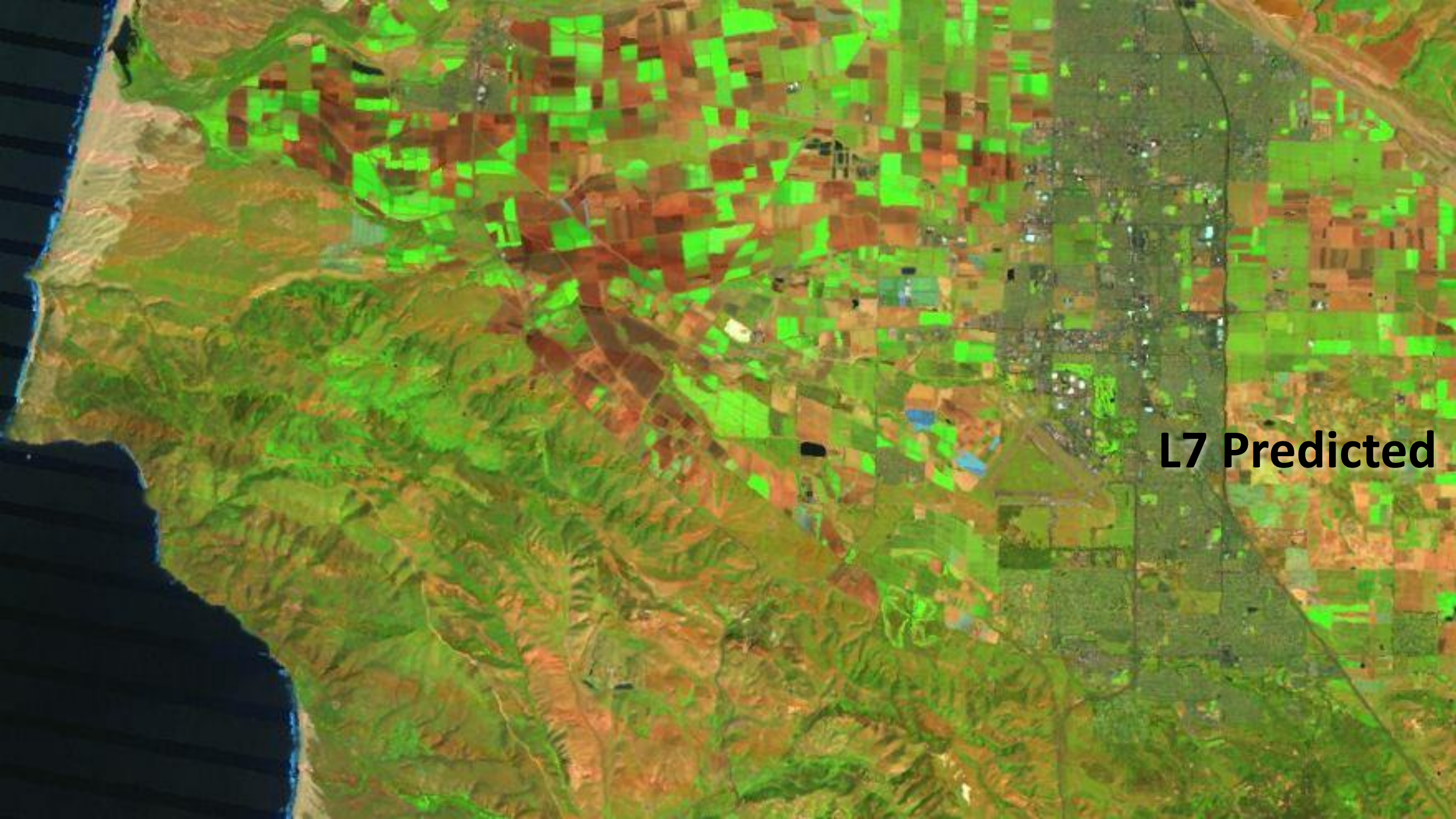
~ 35 million pixels

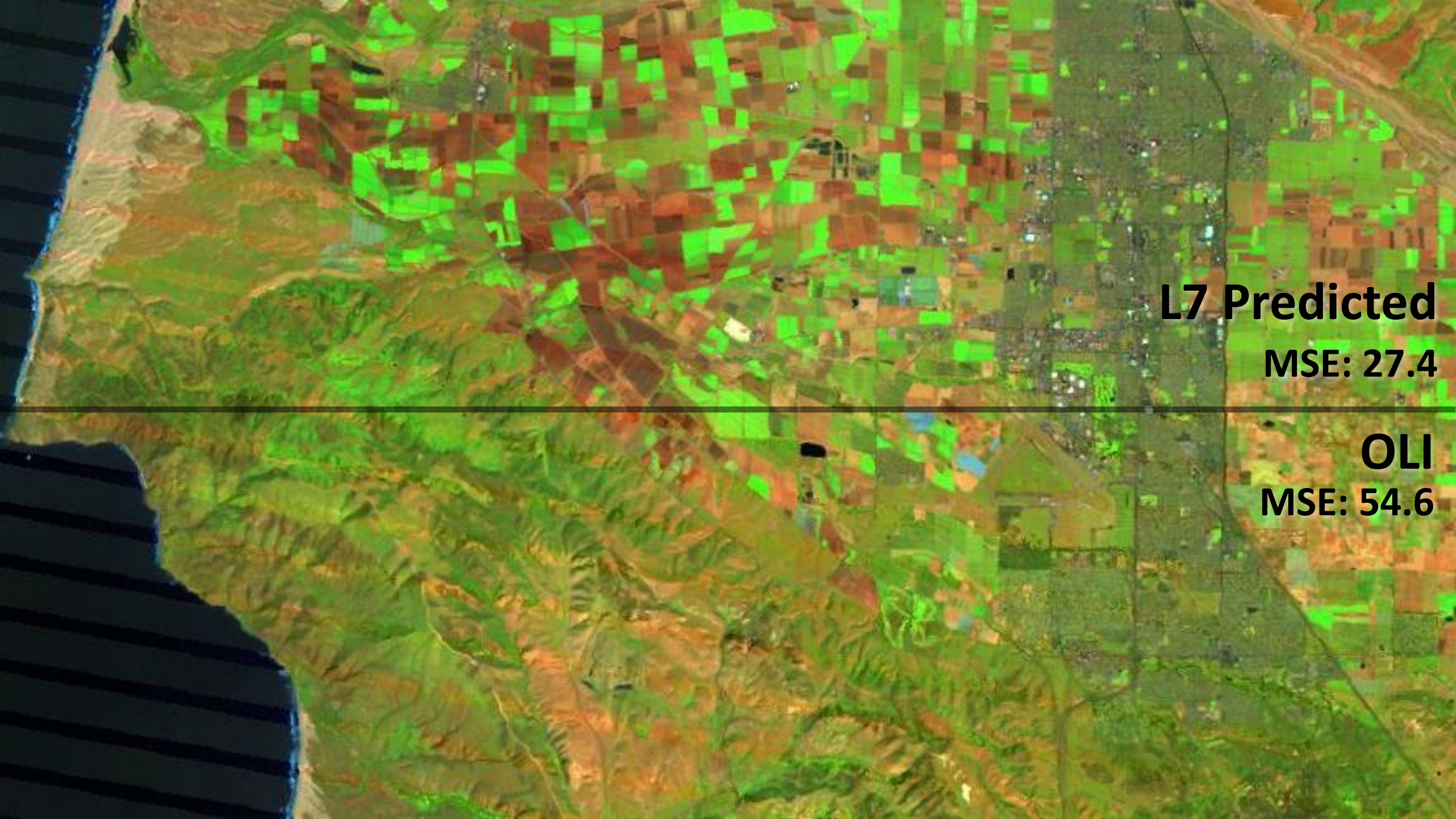
**Multivariate, Linear Regression for each Ecoregion**

dozens of worse-performing methods not discussed



OLI


L7 Predicted


L7 Predicted
MSE: 27.4
OLI
MSE: 54.6

# 2. Uncertainty

**knowing where we don’t know**

# Last Year: Promising Too Many Classes

Insufficient Information + Over-Ambitious Researcher / Desire To Help Everyone = A Map that Lies to Users

**Solutions:**

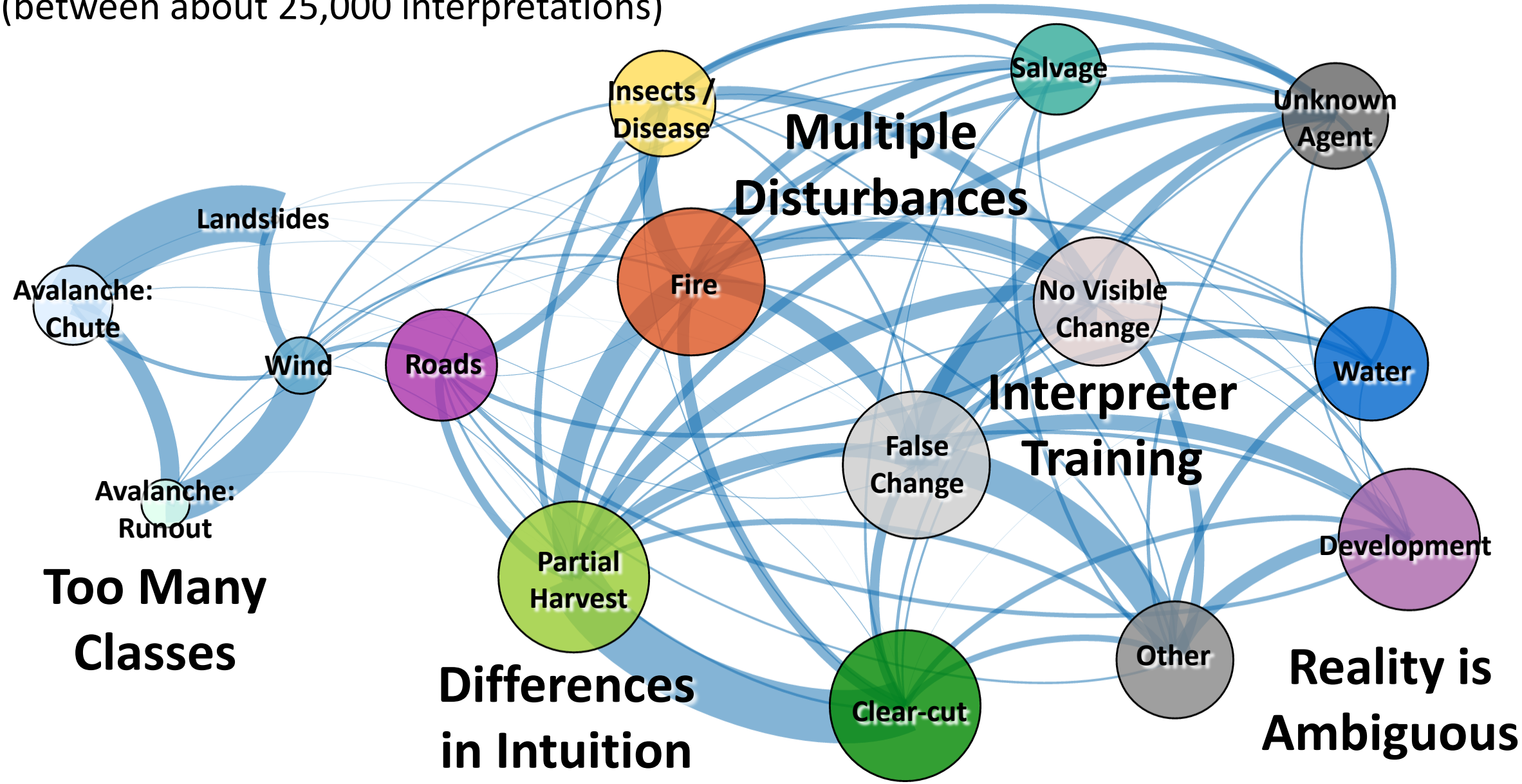
1. Do Better
2. Provide Spatially-Explicit Uncertainty
3. Optimize Classes to Fit the Data (Last Year's Topic)

# Uncertainty Part 2:
# Interpreter Disagreement

## (our truth isn’t true)

# Disagreement between Interpreters

(between about 25,000 interpretations)



# Disagreement is Information

1 Humans are uncertain at class-boundaries → Disagreement Highlights **Class Boundaries**

2 Labels / Names segment continuous reality + Label definitions are arbitrary → Disagreement Highlights **USERS' Intuitions** about the Map

## Don’t:

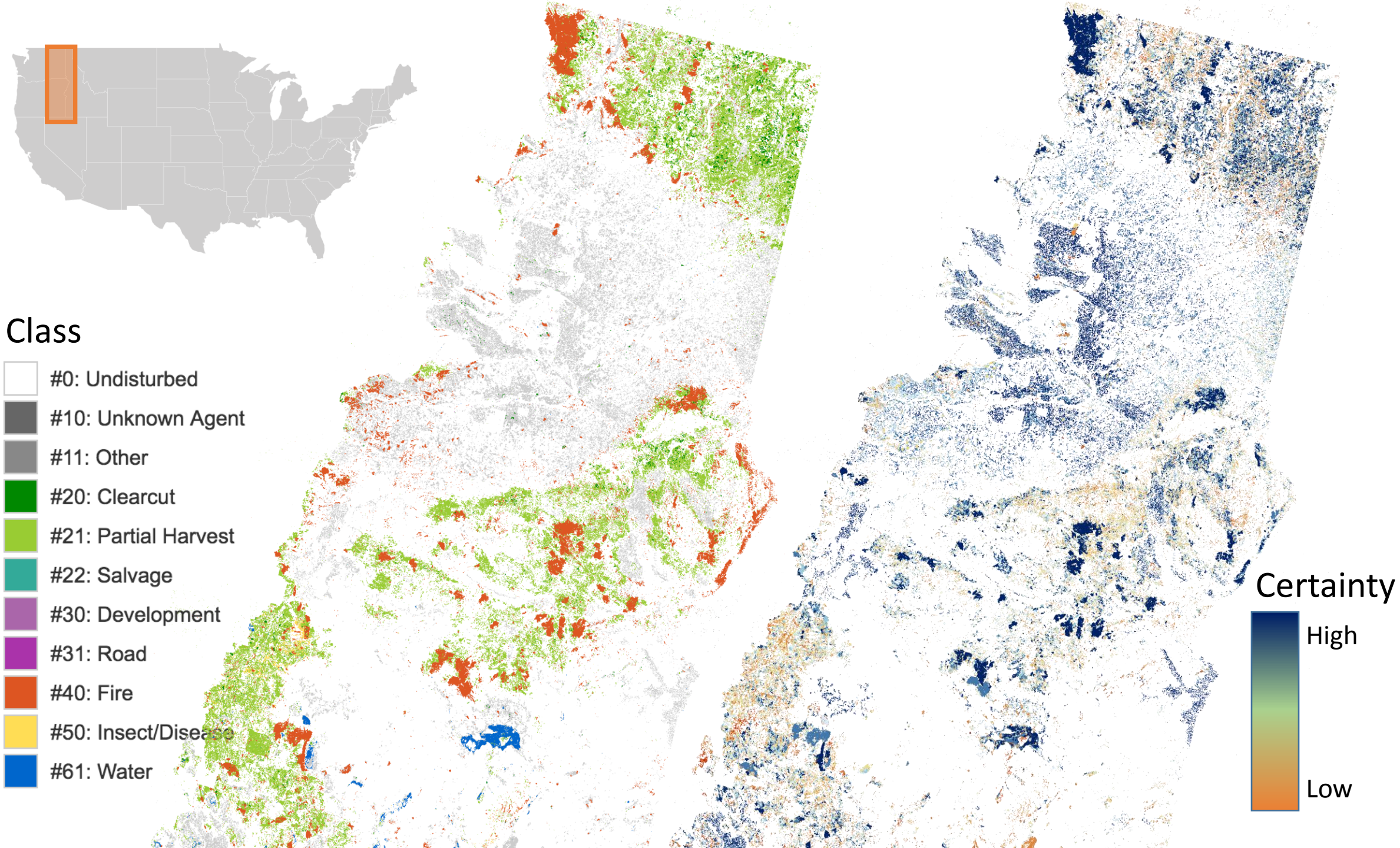
1. **Determine a ‘correct’ classification**

   This discards information.

2. **Update definitions for edge cases.**

   Obscures variance in human intuition

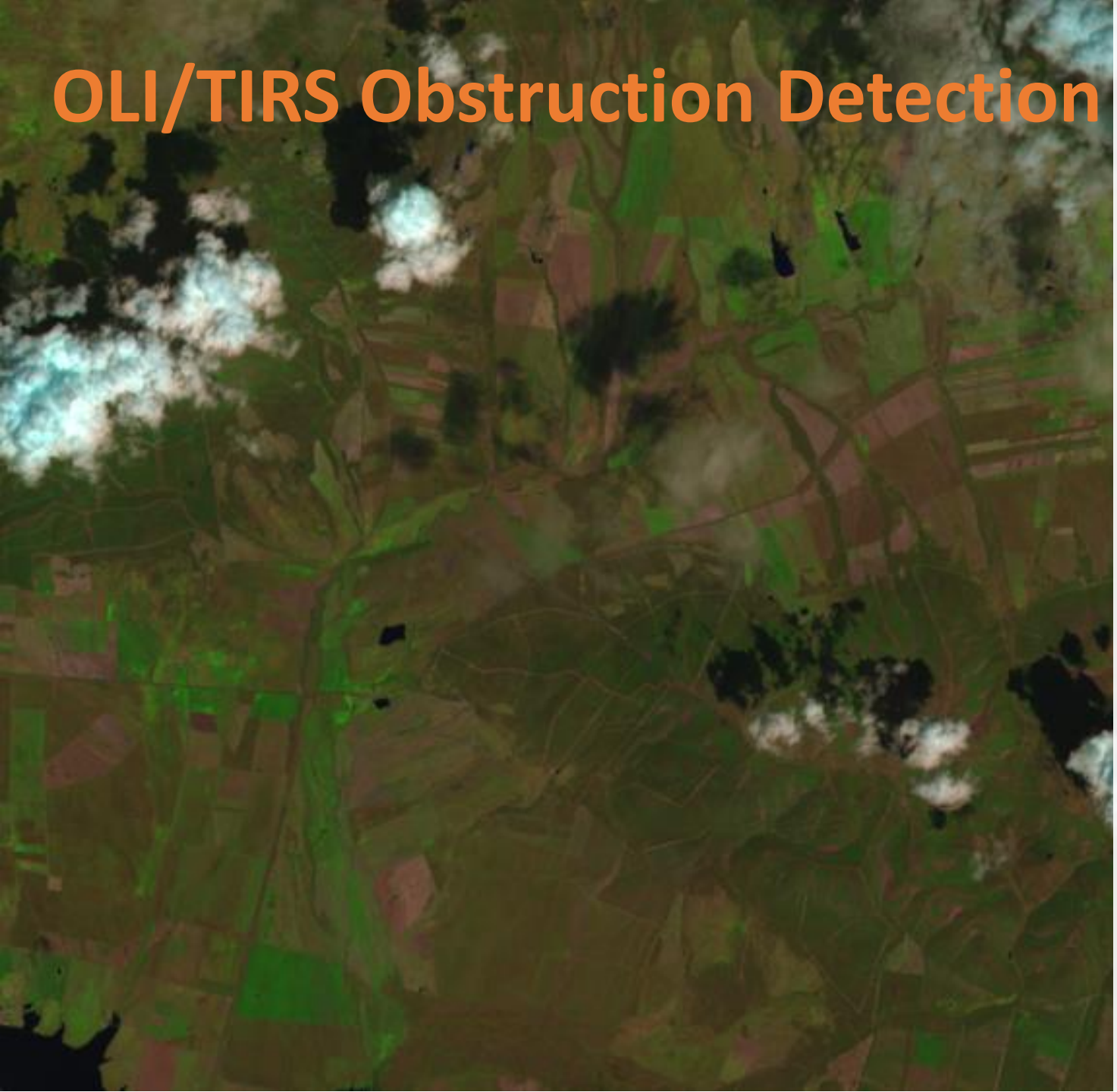
   (no one will read the 50+ page document)


Class
#0: Undisturbed
#10: Unknown Agent
#11: Other
#20: Clearcut
#21: Partial Harvest
#22: Salvage
#30: Development
#31: Road
#40: Fire
#50: Insect/Disease
#61: Water
Certainty
High
Low

# 3. Reliability

**trustworthy inputs for automation**

# OLI/TIRS Obstruction Detection



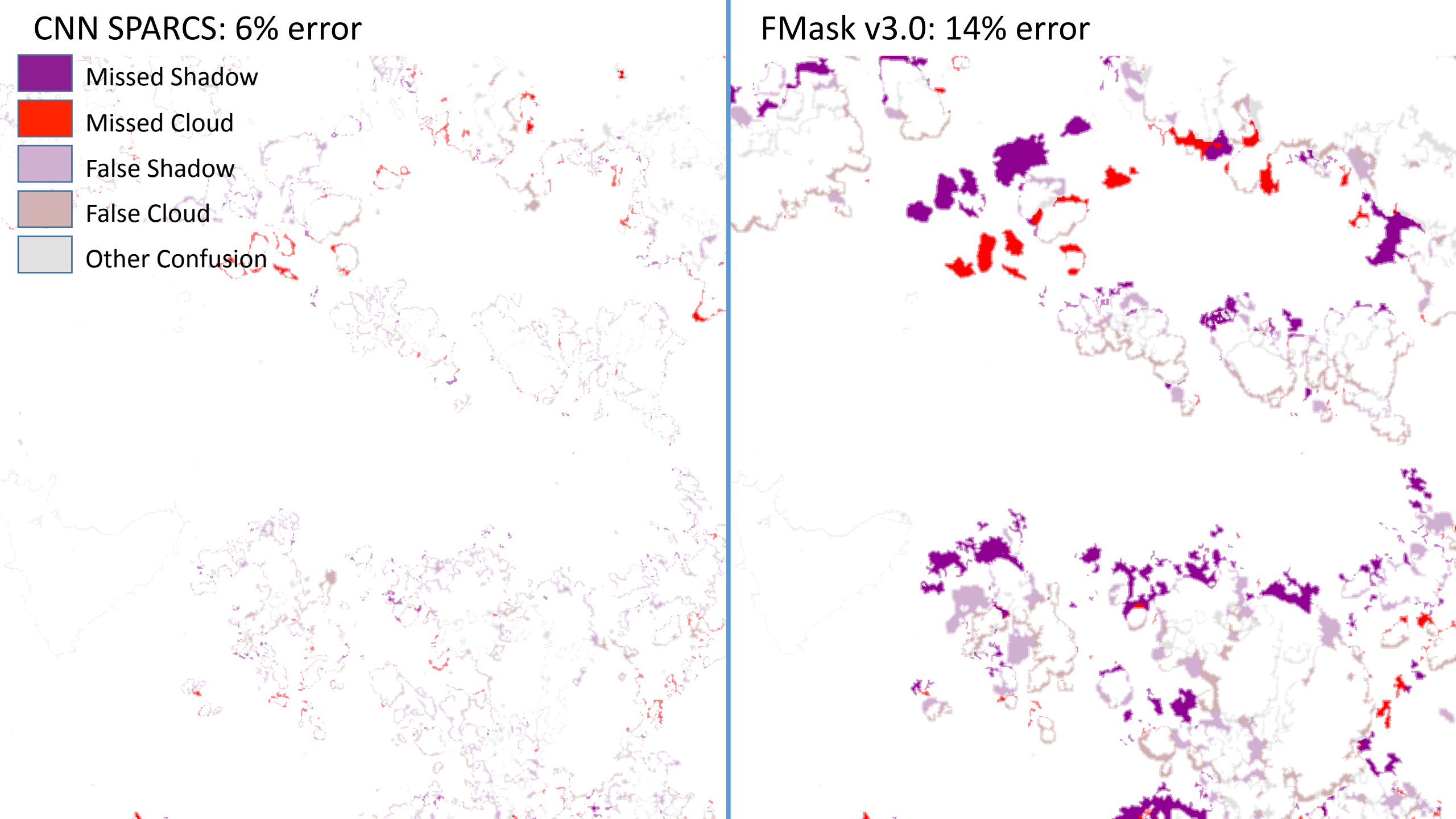
**Humans** can see clouds & shadow in **single-date** imagery **without** knowing cloud **temperature**, **sun angle**, **elevation** ...

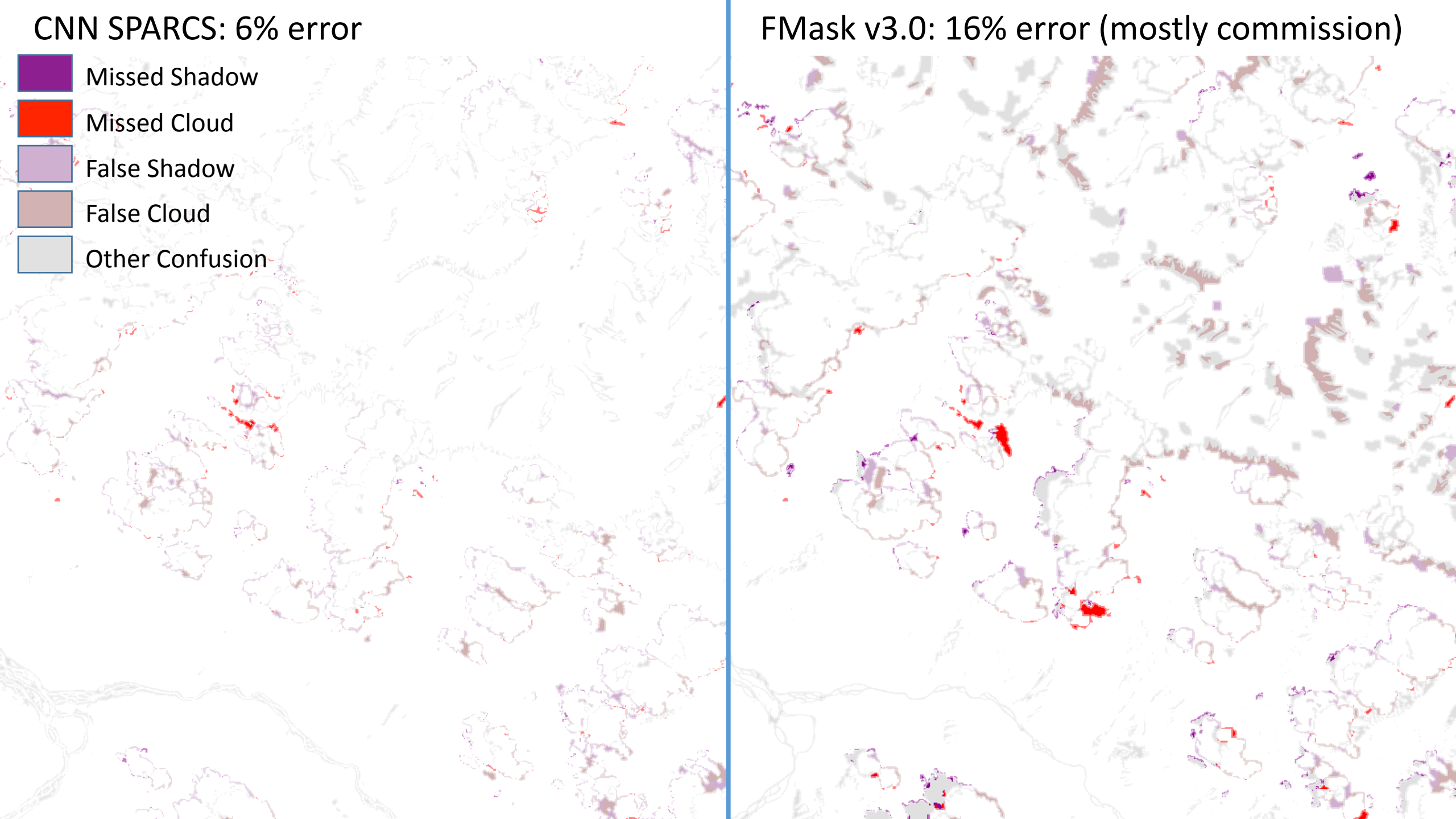
The **information** is there.

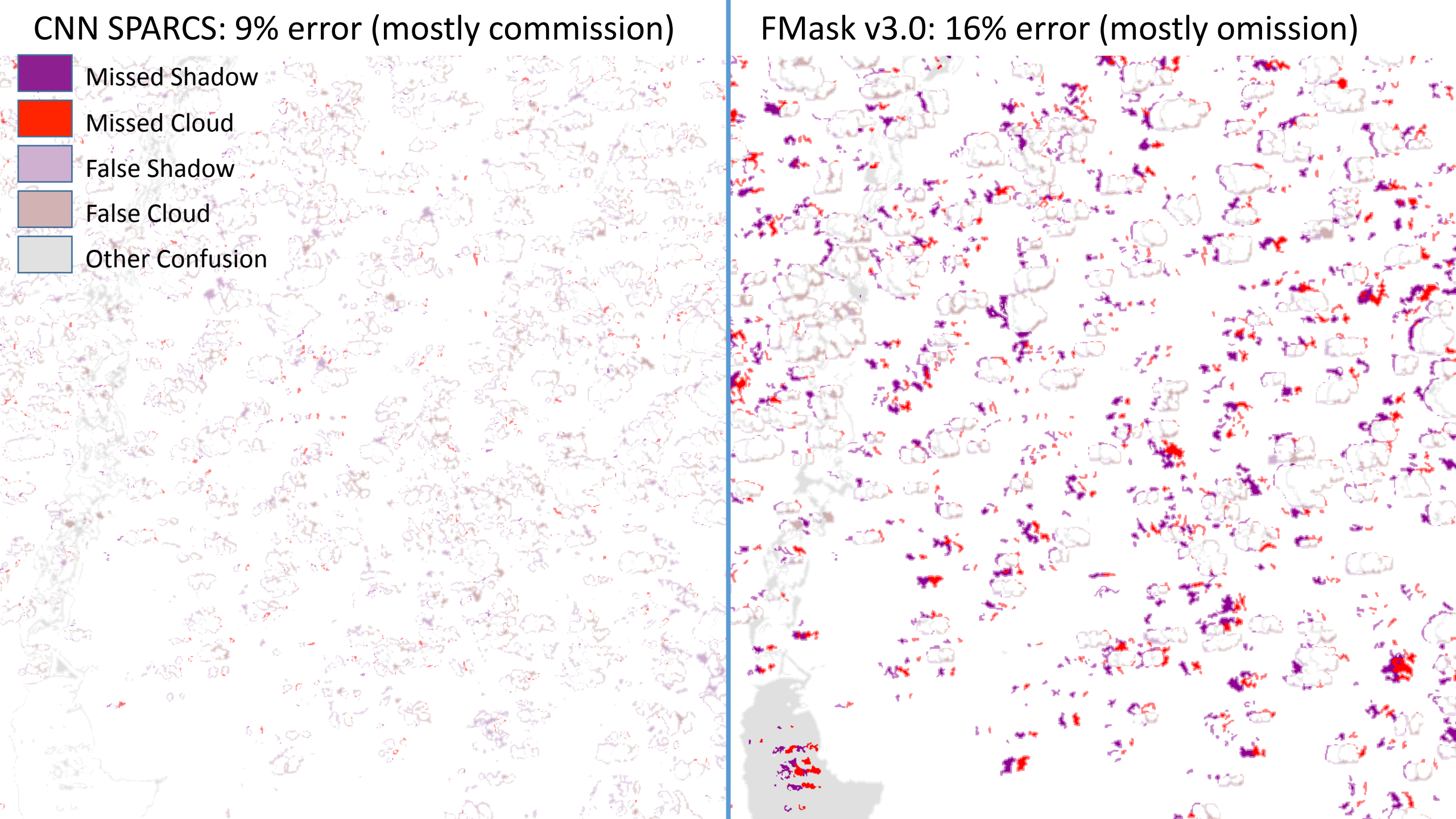
# Deep Learning with Convolutional Neural Networks

- General Computer Vision
- Learn Multi-Spectral Image Filters
- Computationally expensive to train – previously unfeasible.
- Efficient prediction on modern hardware (GPUs)
- Python library: Theano

| | | | | | |
|---|---|---|---|---|---|
| | Cloud | | Water | | Snow/ice |
| | Shadow | | Flood | | Clear Land |

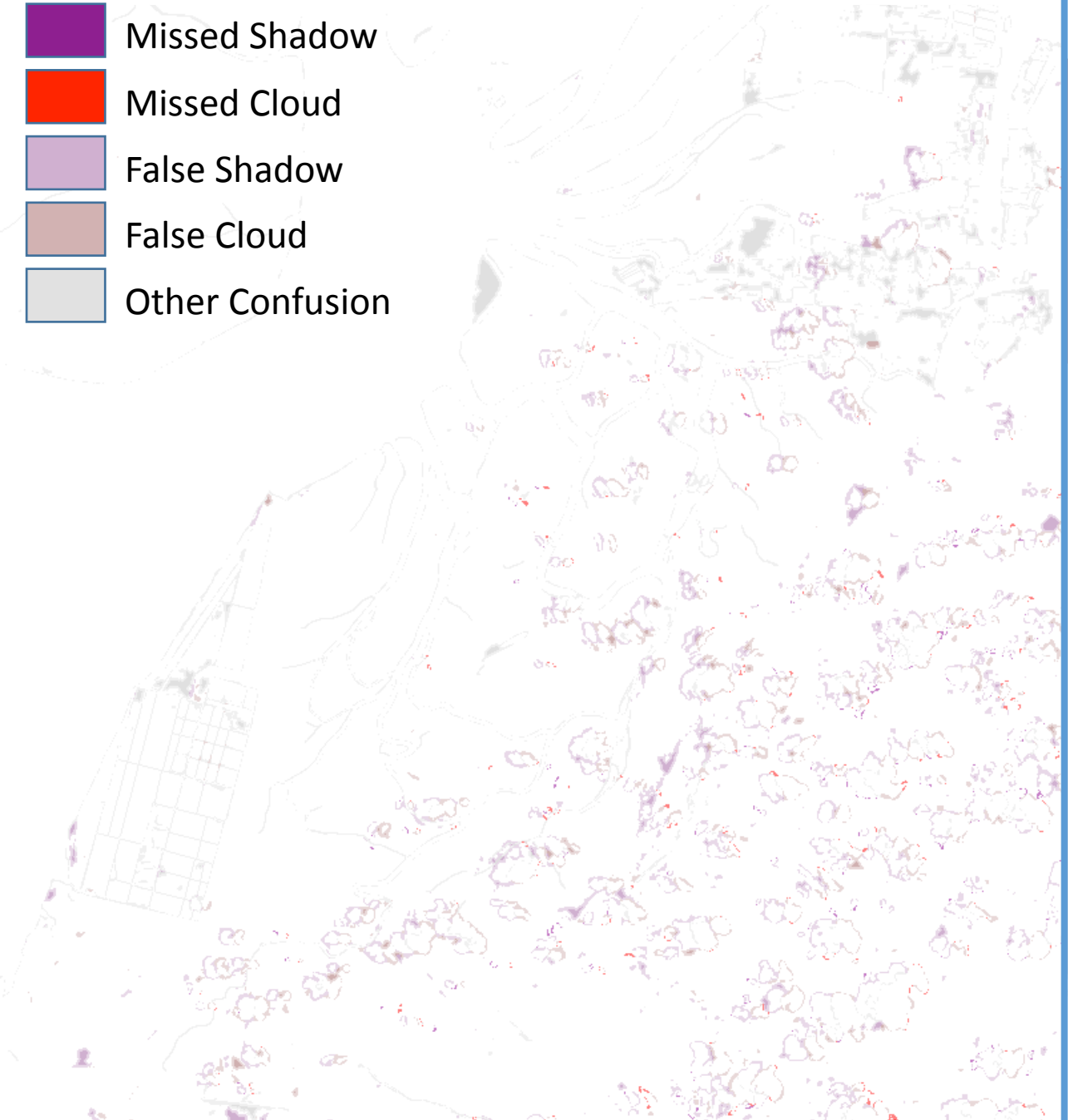

CNN SPARCS: 6% error
Missed Shadow
Missed Cloud
False Shadow
False Cloud
Other Confusion
FMask v3.0: 14% error


CNN SPARCS: 6% error
Missed Shadow
Missed Cloud
False Shadow
False Cloud
Other Confusion
FMask v3.0: 16% error (mostly commission)


CNN SPARCS: 9% error (mostly commission)
Missed Shadow
Missed Cloud
False Shadow
False Cloud
Other Confusion
FMask v3.0: 16% error (mostly omission)

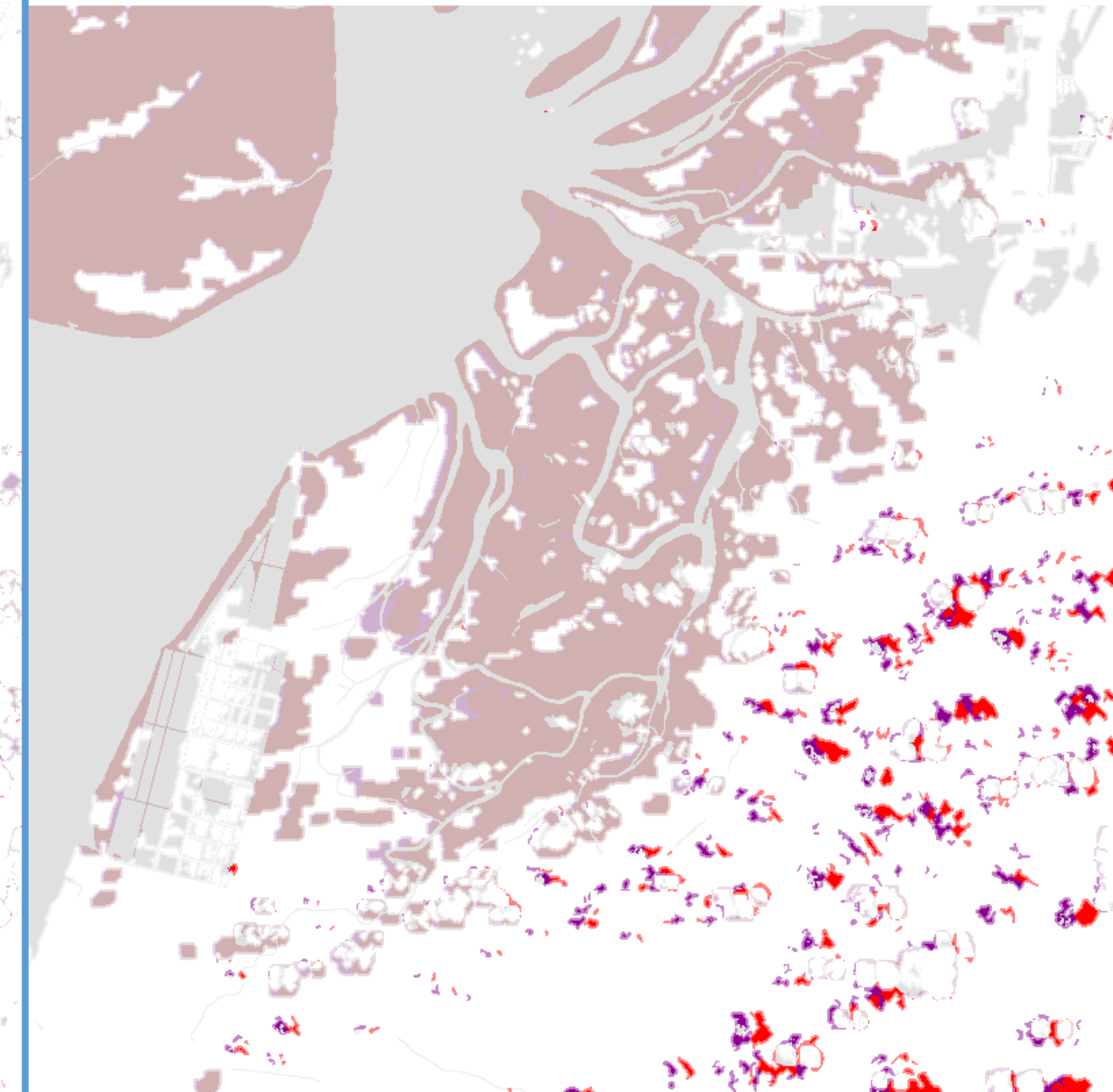
## CNN SPARCS: 5% error (mostly commission)

- Missed Shadow
- Missed Cloud
- False Shadow
- False Cloud
- Other Confusion



## FMask v3.0: 68% error

(Flood labeled Water or Clear-Land counted as correct)

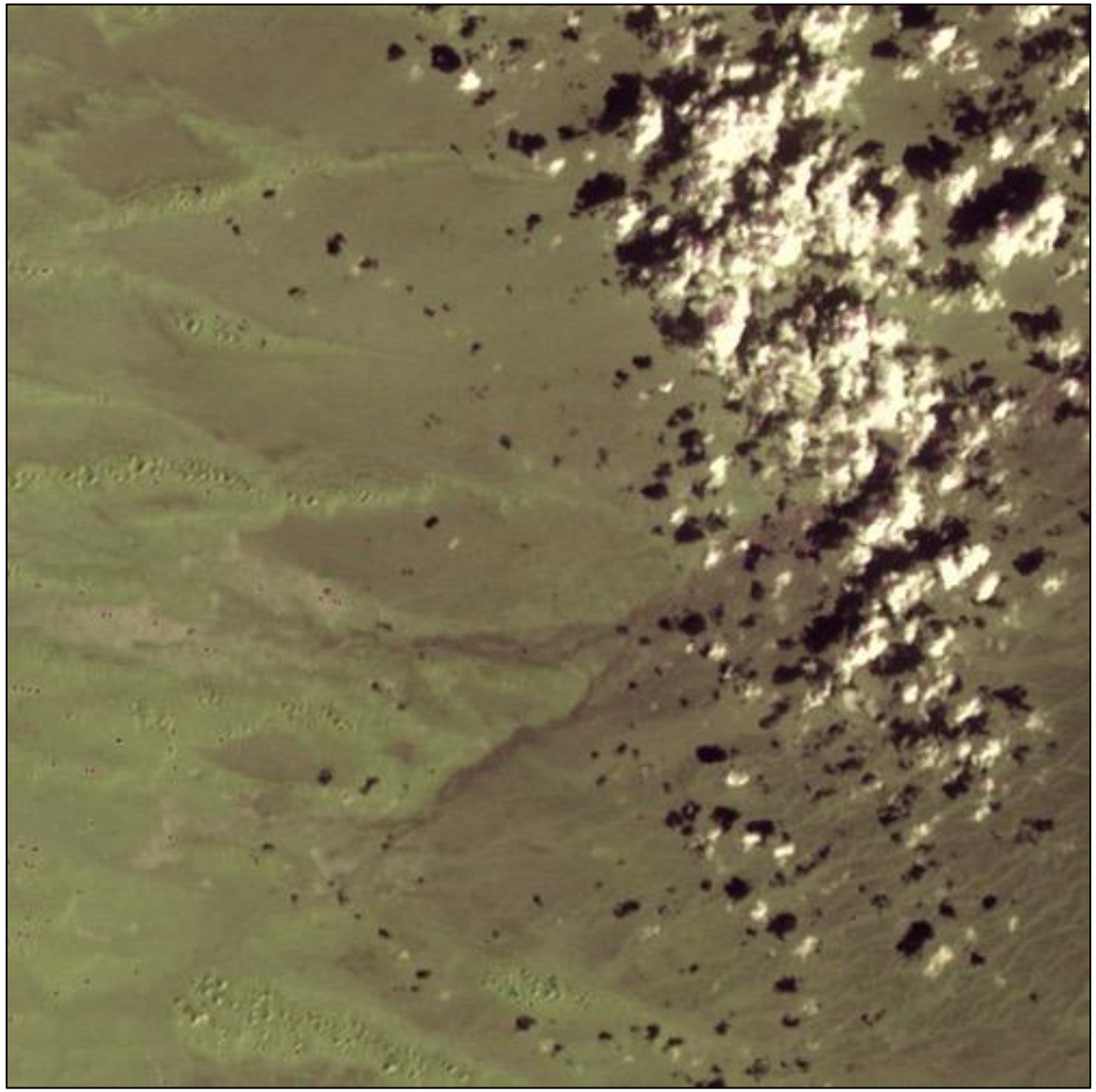


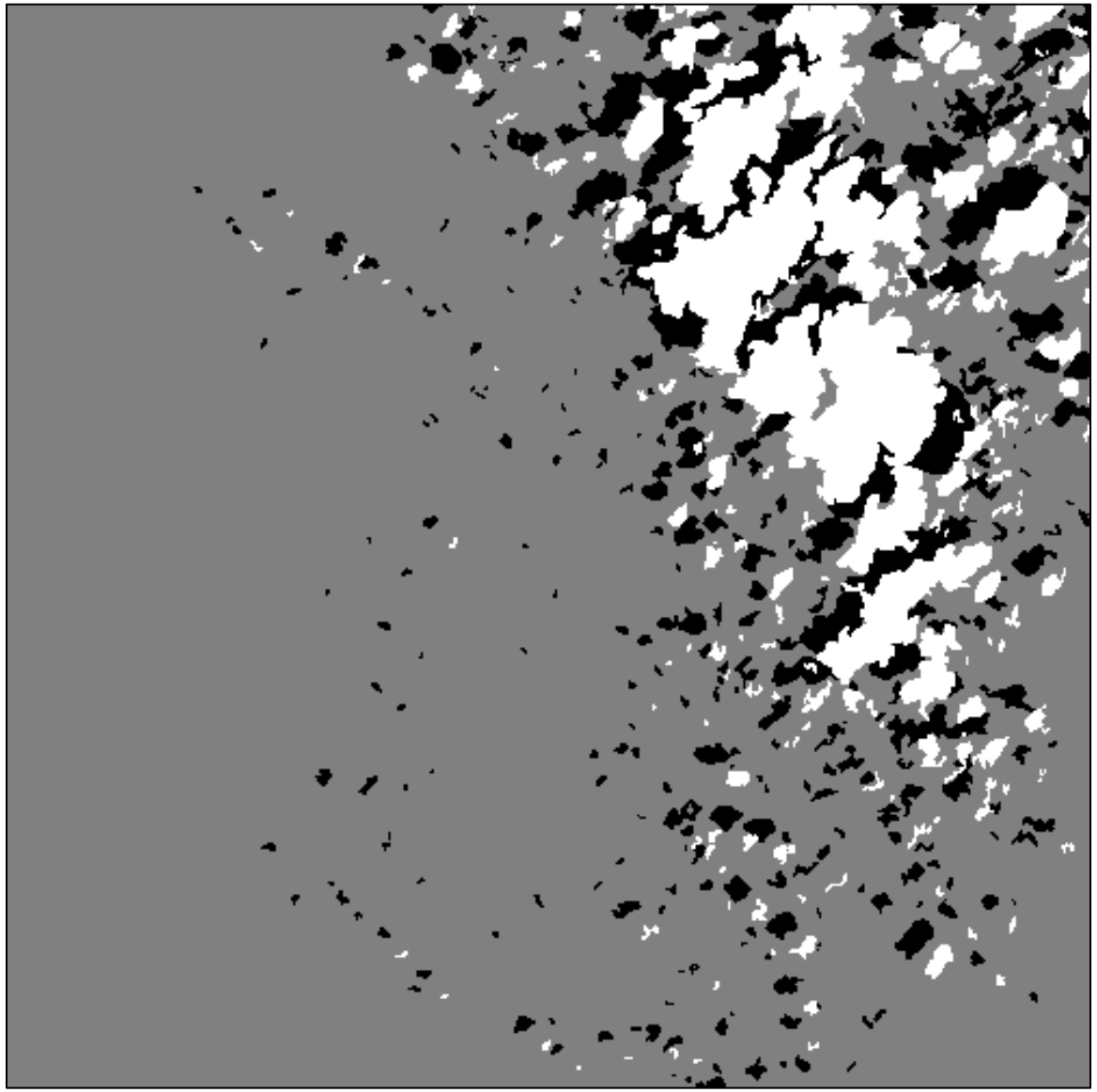
# CNN SPARCS

| | | |
|---|---|---|
| Cloud | Water | Snow/ice |
| Shadow | Flood | Clear Land |

- 7% total error on 10 test scenes
  - FMask at 13%
- Most error at object edges
  - clouds and shadows are fuzzy
- Approaching human ability.
  - interpreter has 5% disagreement when reclassifying same scene

# Advance Look: MSS Clouds





# IMPROVEMENTS:

Sources of Data

Data Access

Processing Power

**Improved Ability to Describe State and Change**

# NEEDS:

Appreciation for Uncertainty

Consistent Automation

Reliable Data (Free of Lies)