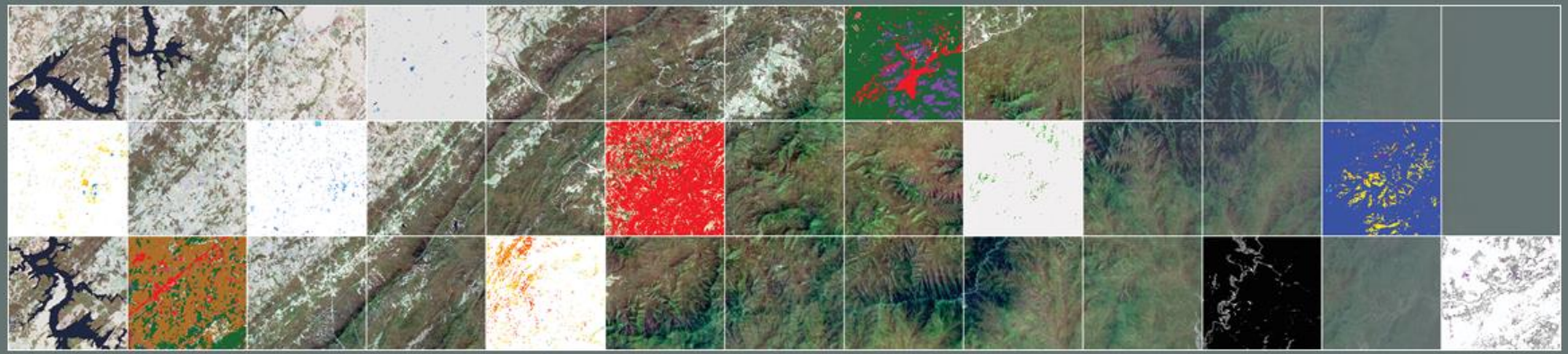
USGS
science for a changing world

Land Resources Mission Area
Earth Resources Observation and Science (EROS) Center

Introducing 10 New LCMAP Products



U.S. Department of the Interior
U.S. Geological Survey

Christopher P. Barber
ASRC Federal InuTeq, contractor to USGS/EROS
Nov 6, 2018

Introduction

- Land Change Monitoring, Assessment, and Projection
  - Inputs to Assessments & Projections

- Goal: Draw on current & historical Landsat observations
  - *All Available Observations*
  - Landsat ARD as inputs
  - Potential for inputs from other platforms (*e.g.* Sentinel)

- Time series modeling approach

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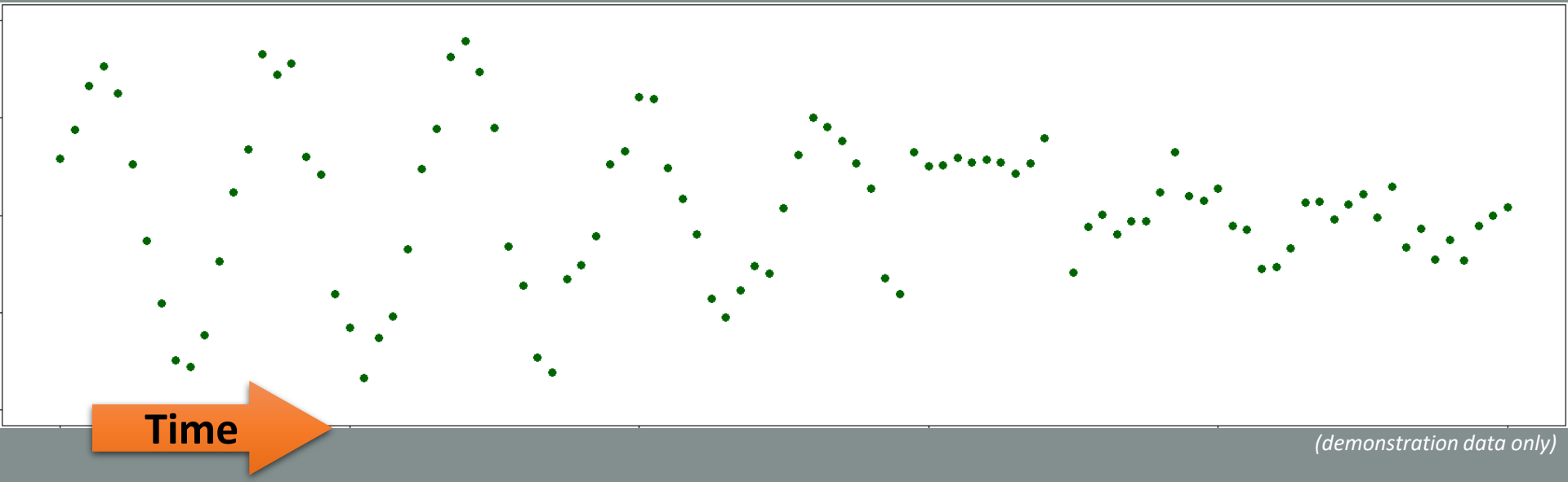
Time Series Modeling Approach

- **Continuous Change Detection & Classification (CCDC)**
  - *Zhu & Woodcock (2014)*
- **Fitting of harmonic models to Landsat surface reflectance**
- **Fitted models used to detect change and classify land cover**

Time Series Models

- Time series of Landsat surface reflectance



(demonstration data only)

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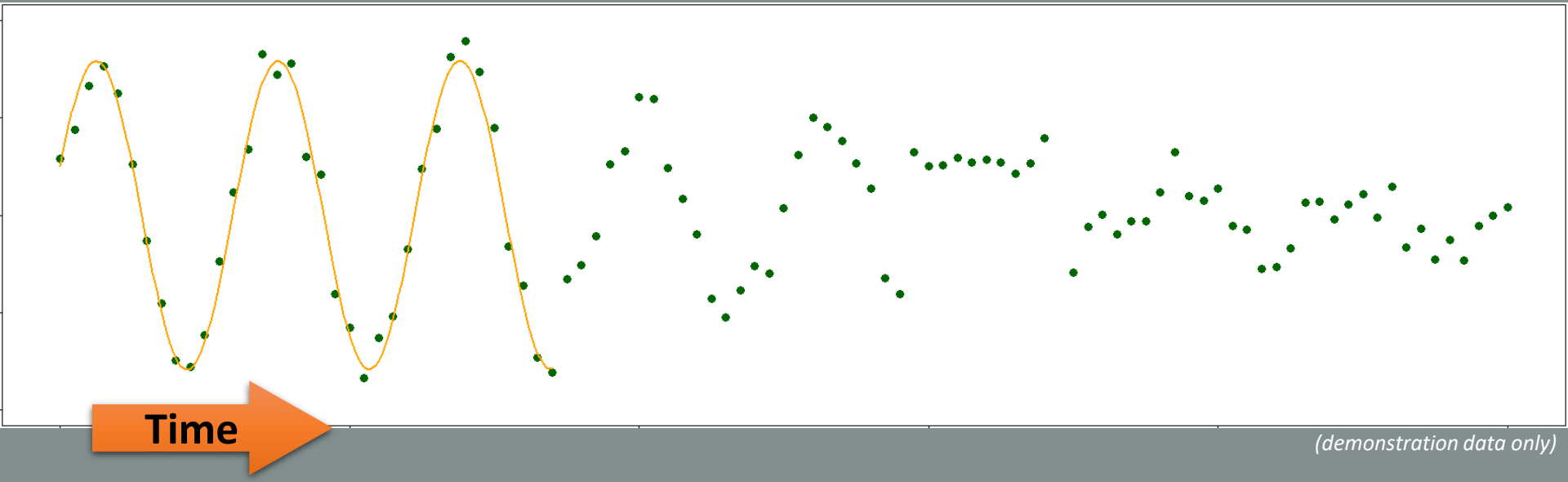
Time Series Models

- Fitted harmonic model



(demonstration data only)

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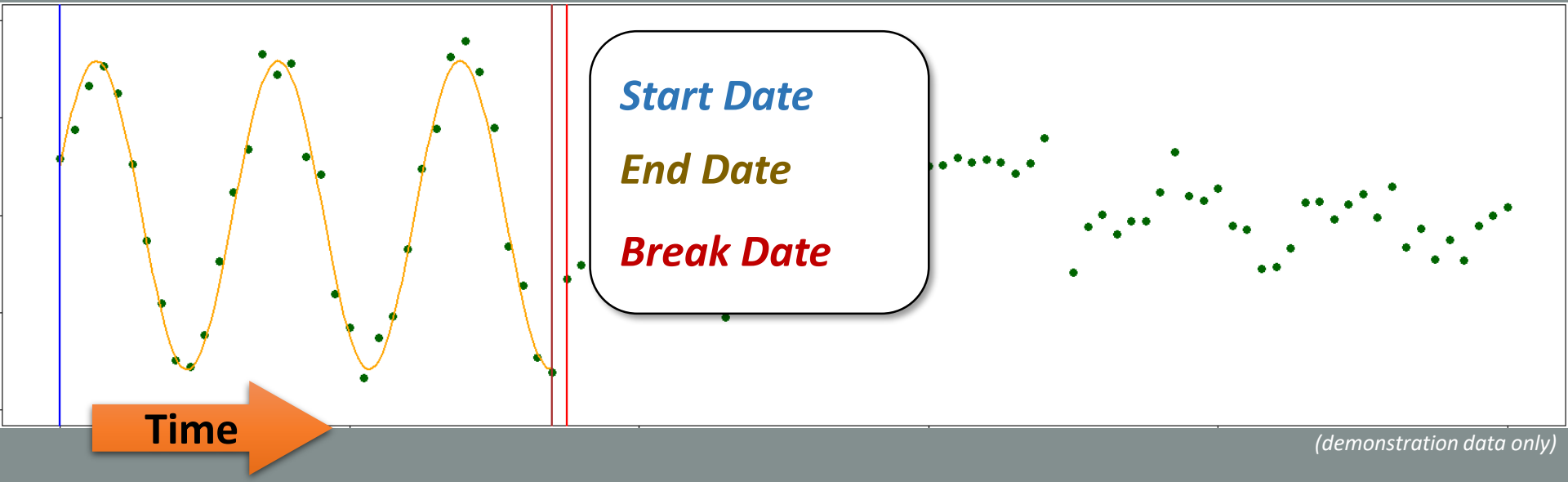
Time Series Models

- Model parameters/attributes define *segments*



(demonstration data only)

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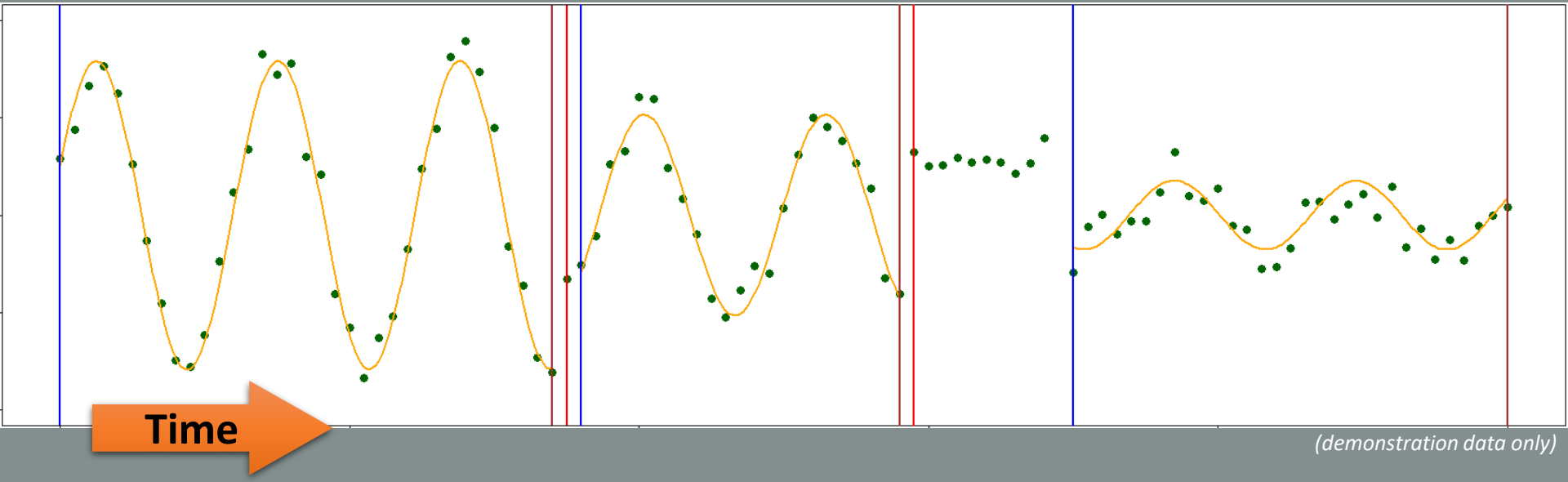
Time Series Models

- Sequence of successive segments (for each spectral band)



(demonstration data only)

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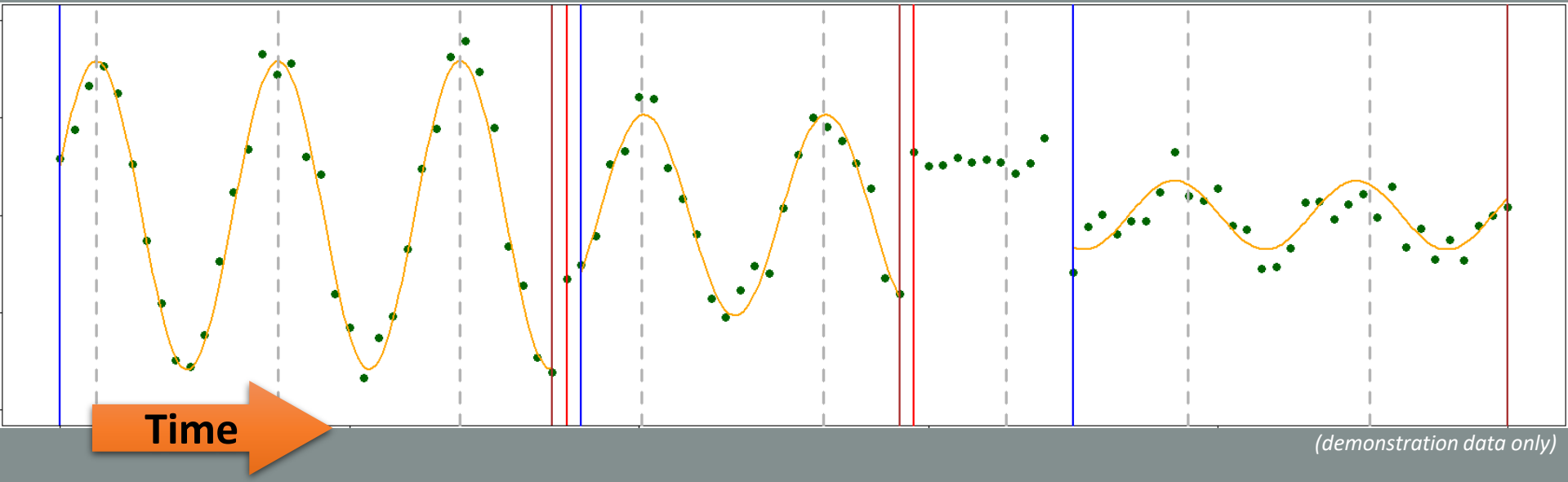
Time Series Models

- Segments classified & annual products extracted at July 1



(demonstration data only)

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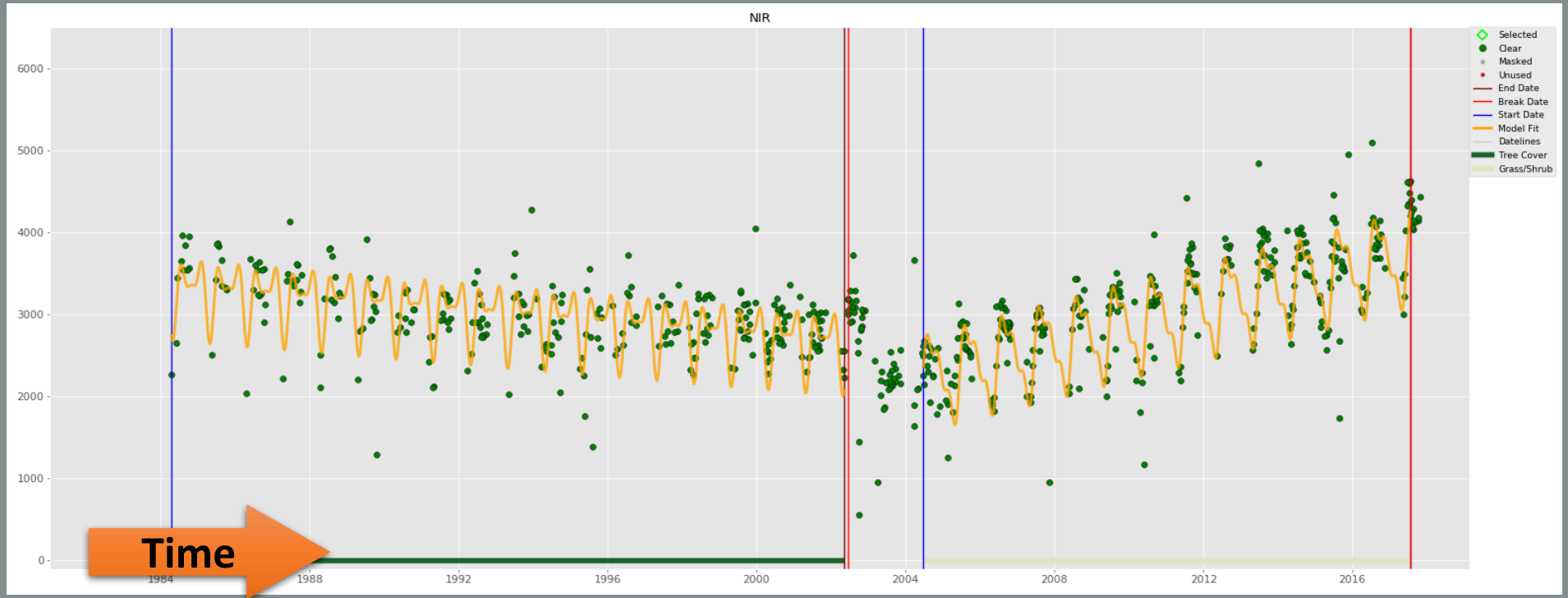
Time Series Models



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LCMAP Data Products

- Ten land change and land cover products
  - 5 products related directly to the time series models
  - 4 products resulting from classification of those models
  - 1 synthesis product
- All products produced on an annual basis beginning in 1985
- Goal: a product suite of maximum usefulness to largest proportion of the user community
  - Minimize user data preparation and/or pre-analysis manipulation

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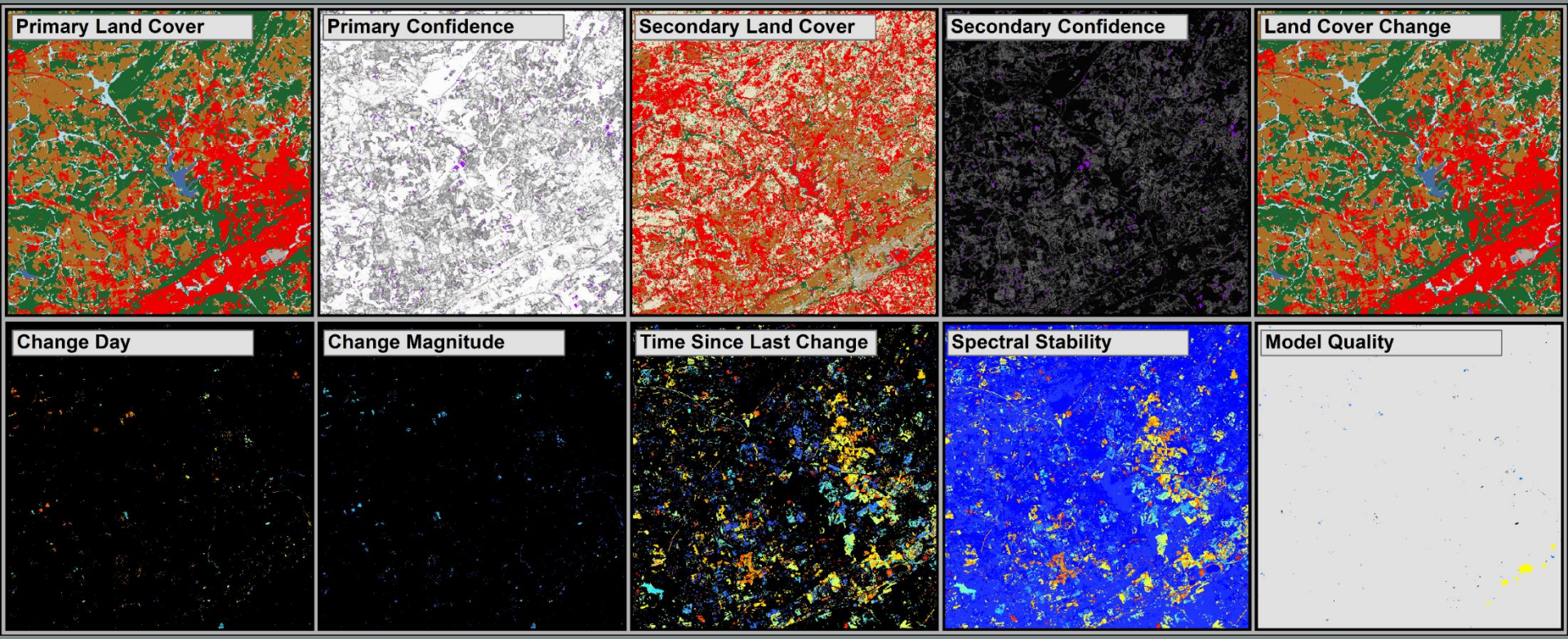
LCMAP Mapped Product Suite



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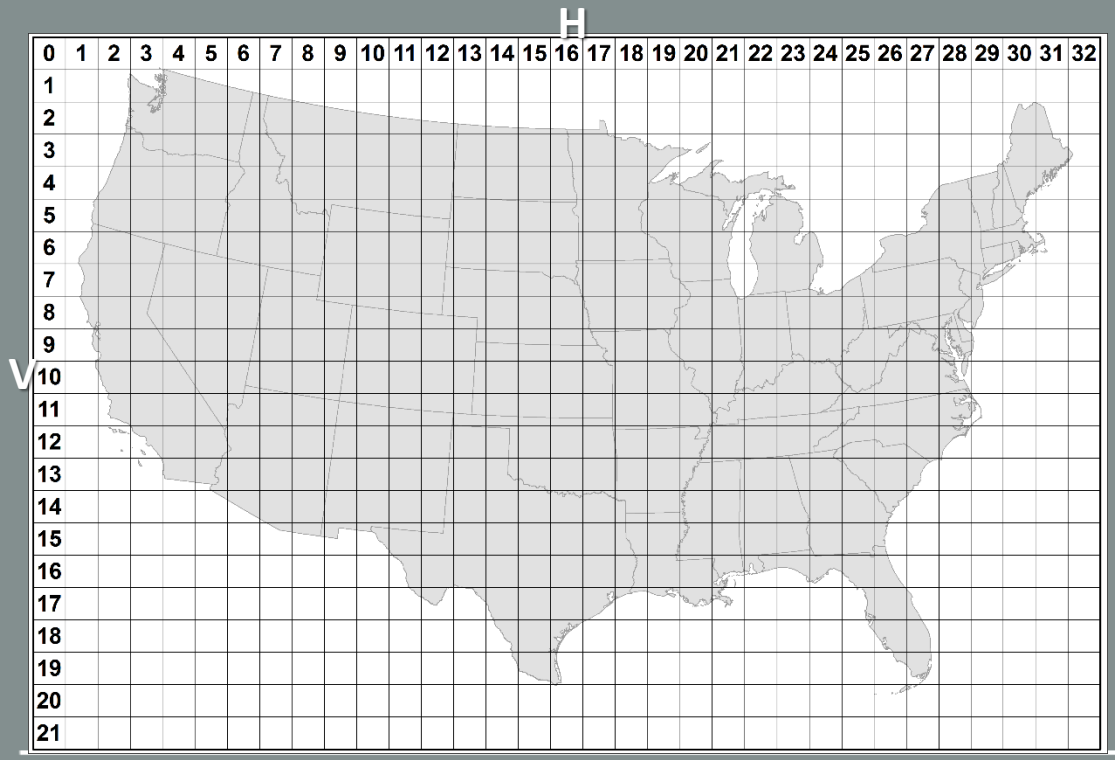
ARD Grid system



- Regular 150x150 km grid
- Referenced by “H”, “V” index system
- All LCMAP Products produced in same reference system

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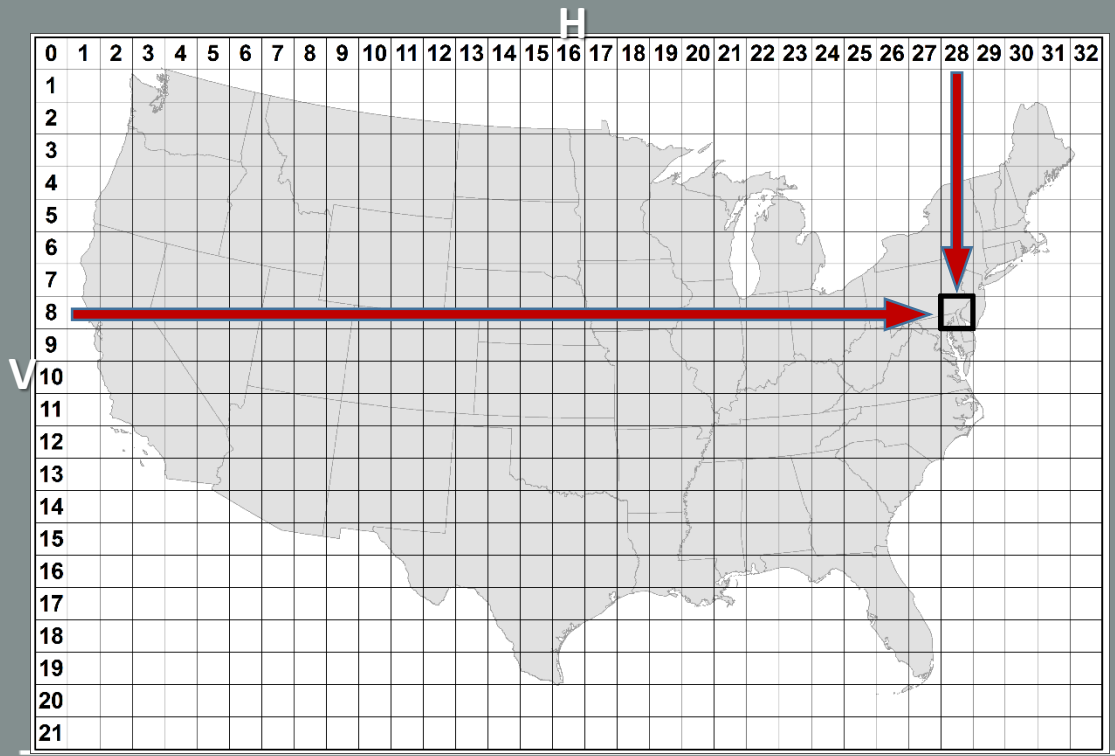
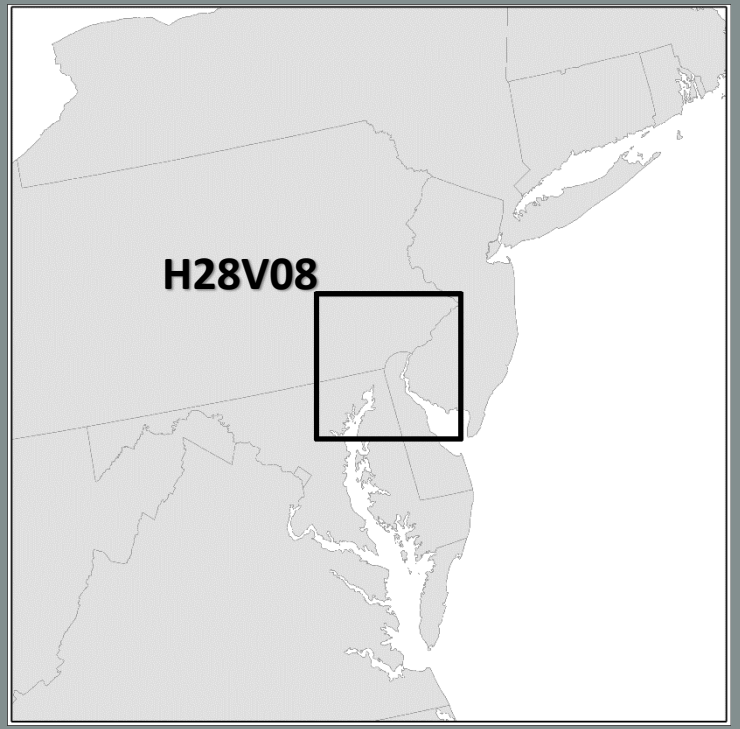
ARD Grid system





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LCMAP Data Product

- A “land cover science” product description
- A “time series modeling” product description
- More details
- Example

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Synthetic Landsat Imagery

- CCDC fits predictive models to observations of surface reflectance in the Landsat wavelengths
- Modeled/predicted reflectance compared against observed to assess probability of “change”
- Modeled reflectance can be used to create cloud-free *synthetic* Landsat imagery for any given day
- Not a standard LCMAP Product

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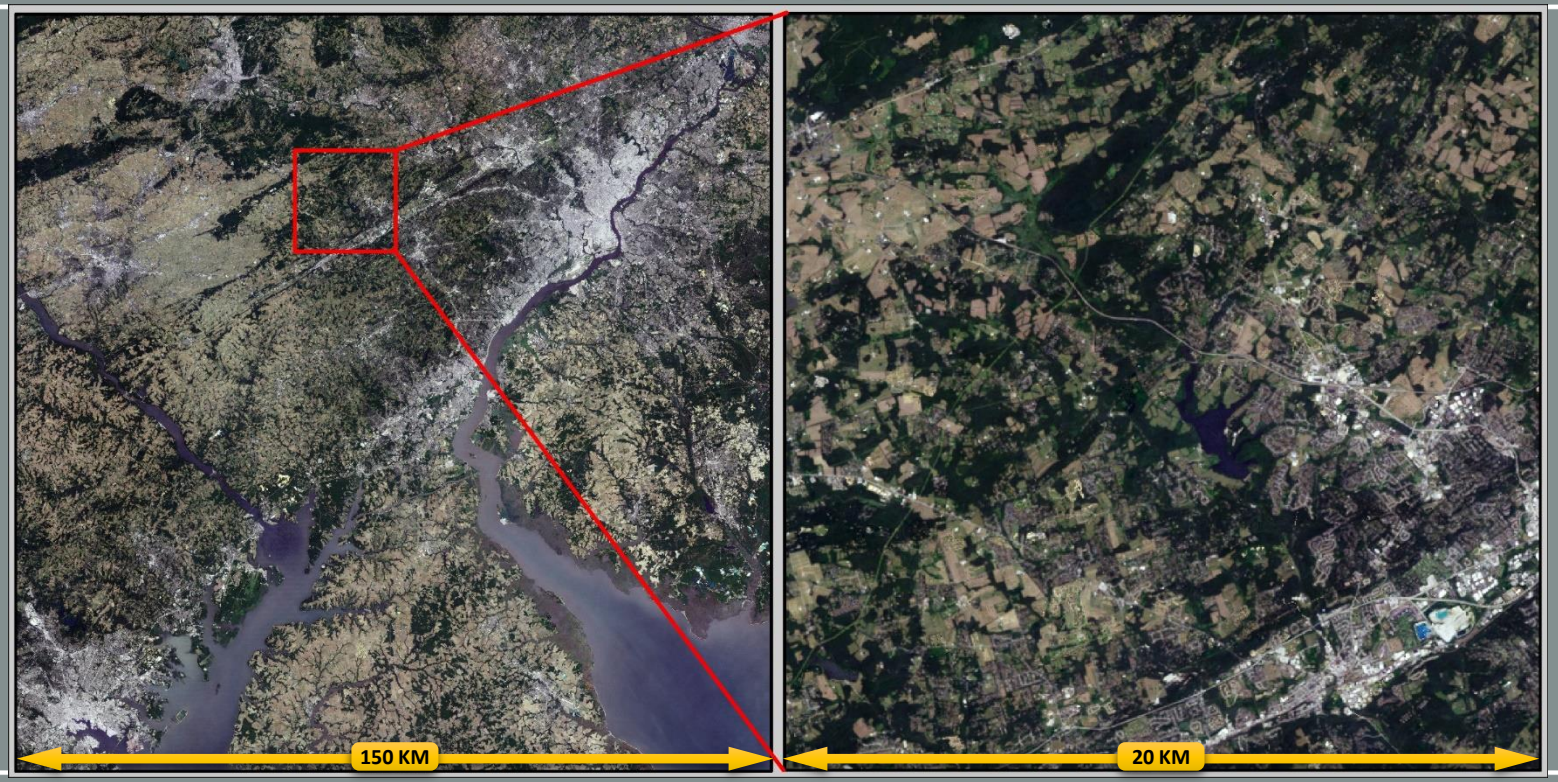
Synthetic Landsat Imagery: 2015



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Change Day

- **Timing of Change. The day-of-year (DOY) of detected spectral change in a given year.**

- **The DOY of the 1st observation which initiated a “break” in the time series model. (*Break Date*)**

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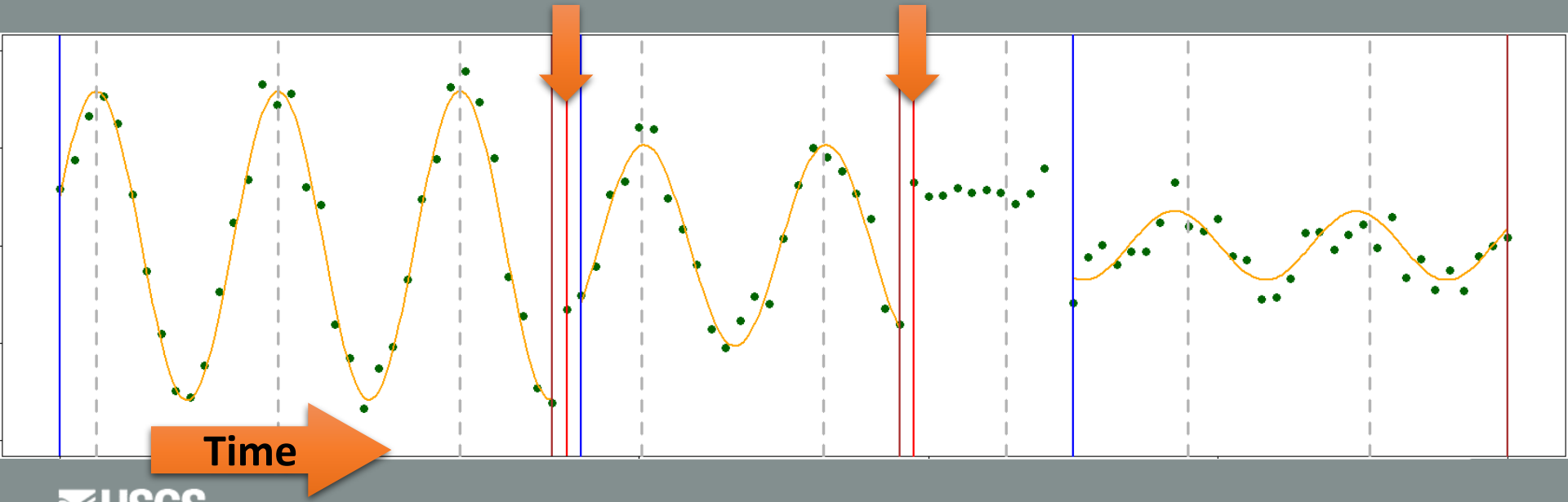
Change Day

- Timing of Change. The day-of-year (DOY) of detected spectral change in a given year. (model *Break Date*)



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Change Day: 2015

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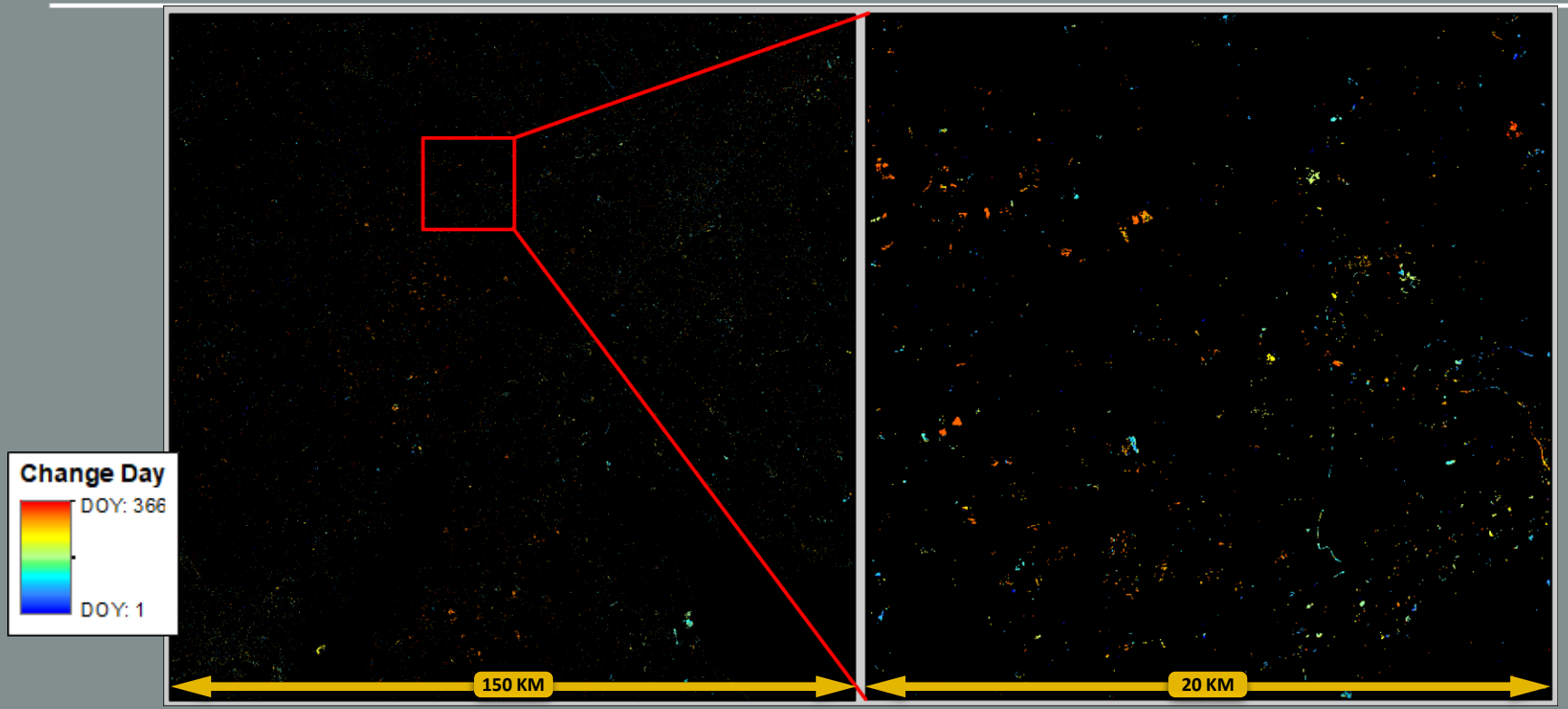
Change Day: 2015



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Change Magnitude

- Relative size of the spectral change associated with a spectral change detection (Change Day). Unitless.

- Euclidean norm of the median spectral residuals across spectral bands (blue & thermal excluded). Unitless.

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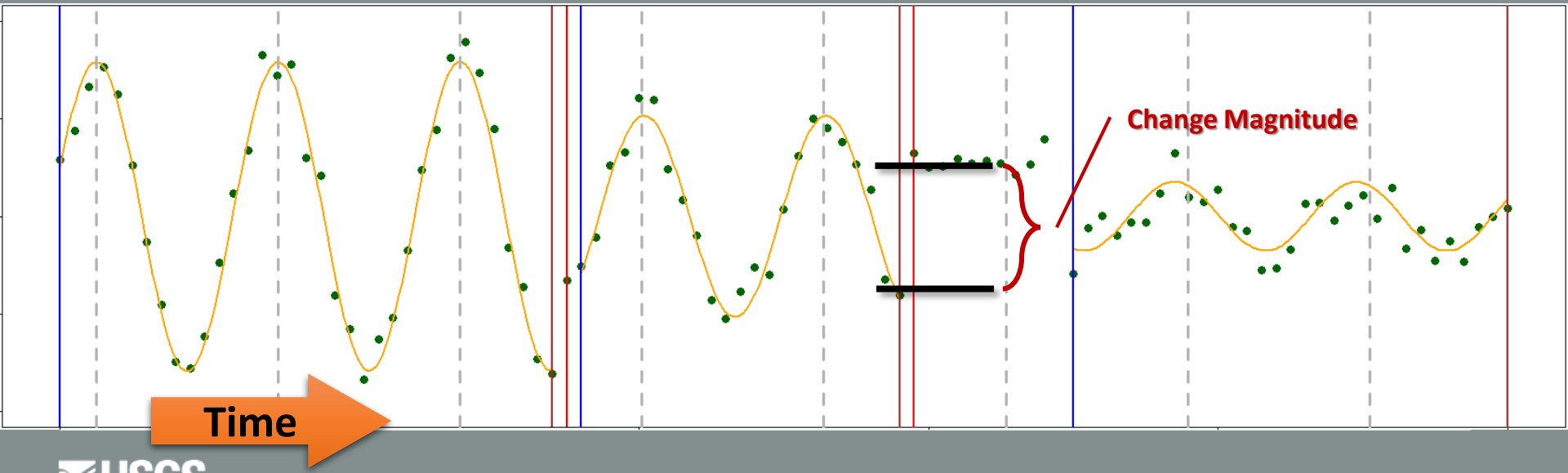
Change Magnitude

- Relative size of the spectral change associated with a spectral change detection. Unitless.



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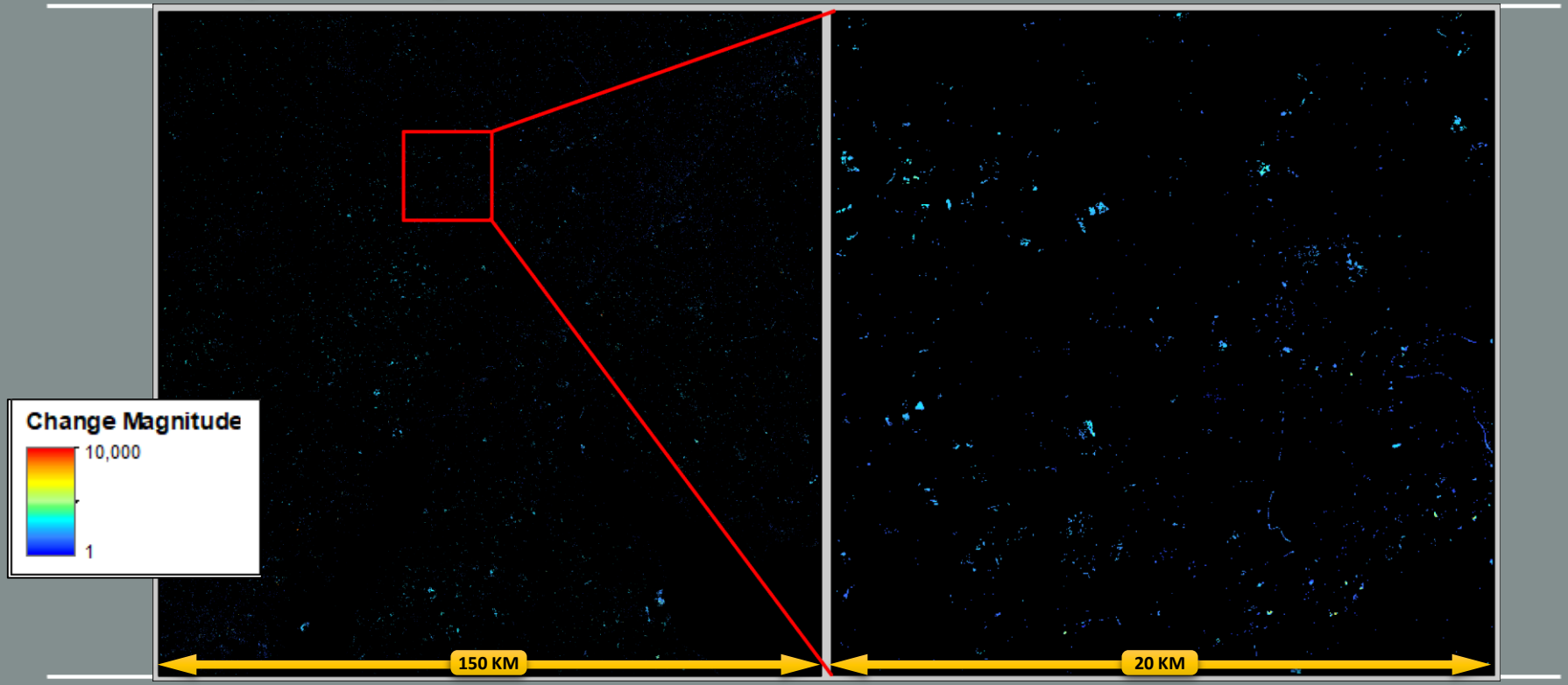
Change Magnitude: 2015



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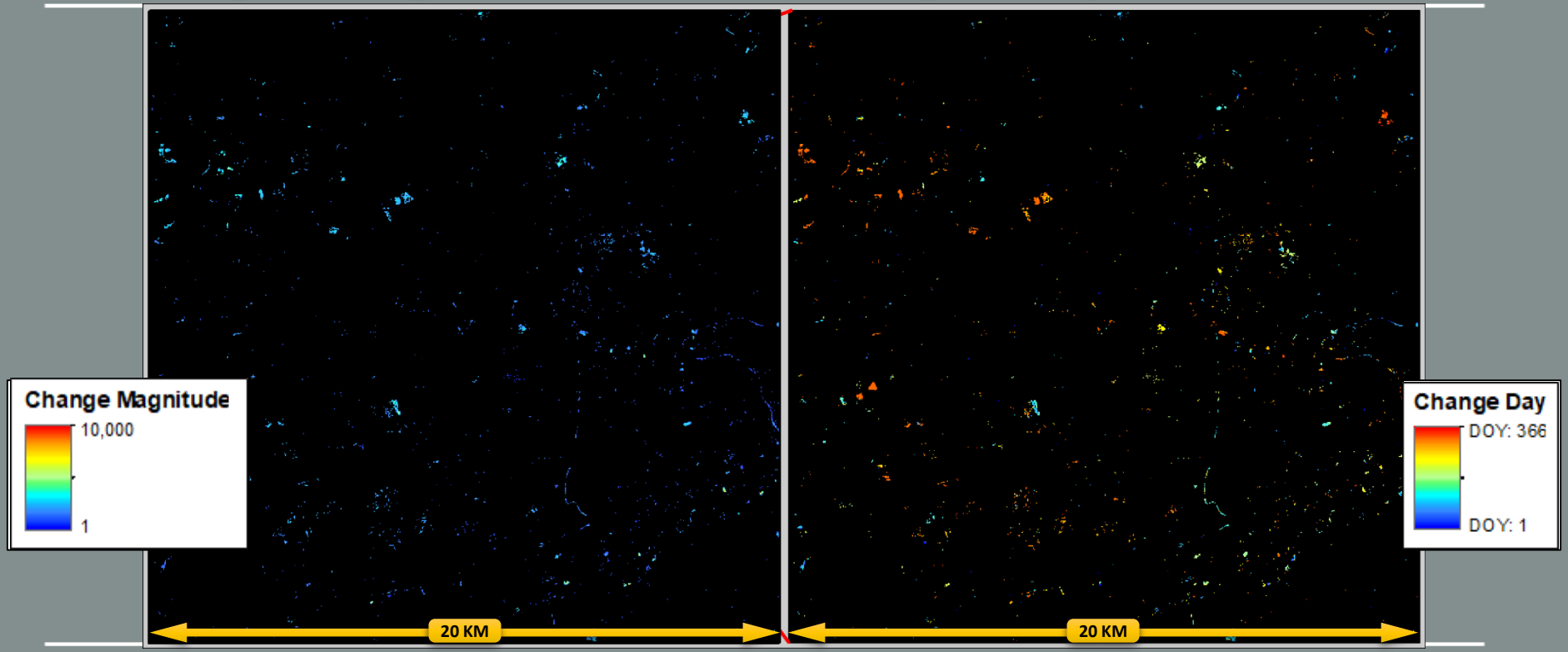
Change Magnitude vs. Change Day



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Time Since Last Change

- Amount of time since a pixel underwent a spectral change.

- The number of days from July 1st of the current year to the *Break Date* of the previous segment.

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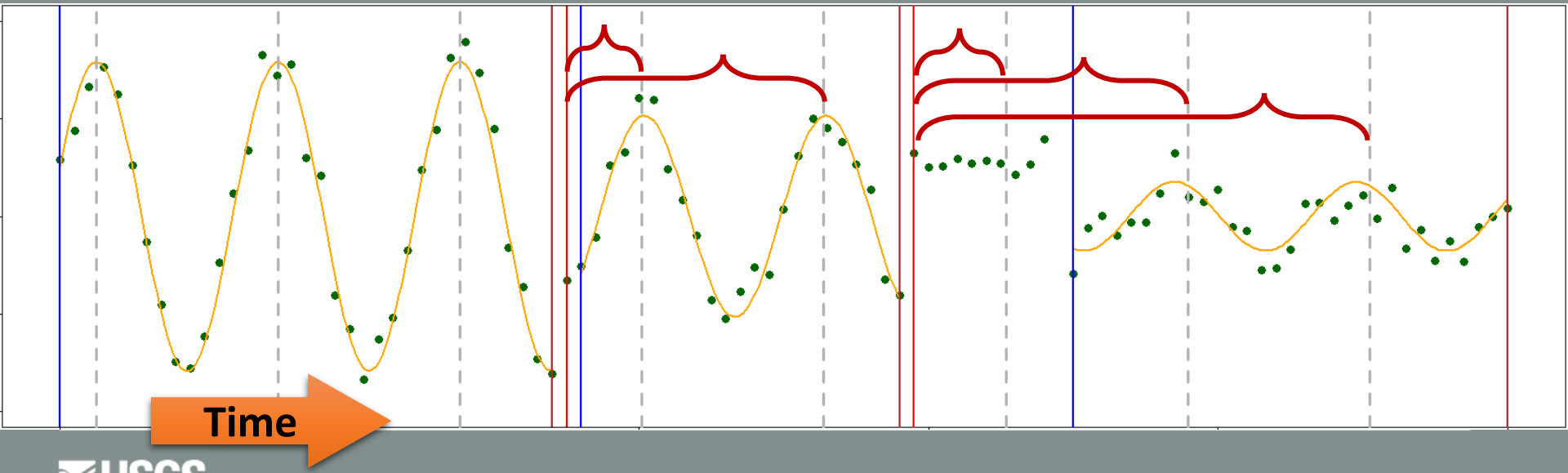
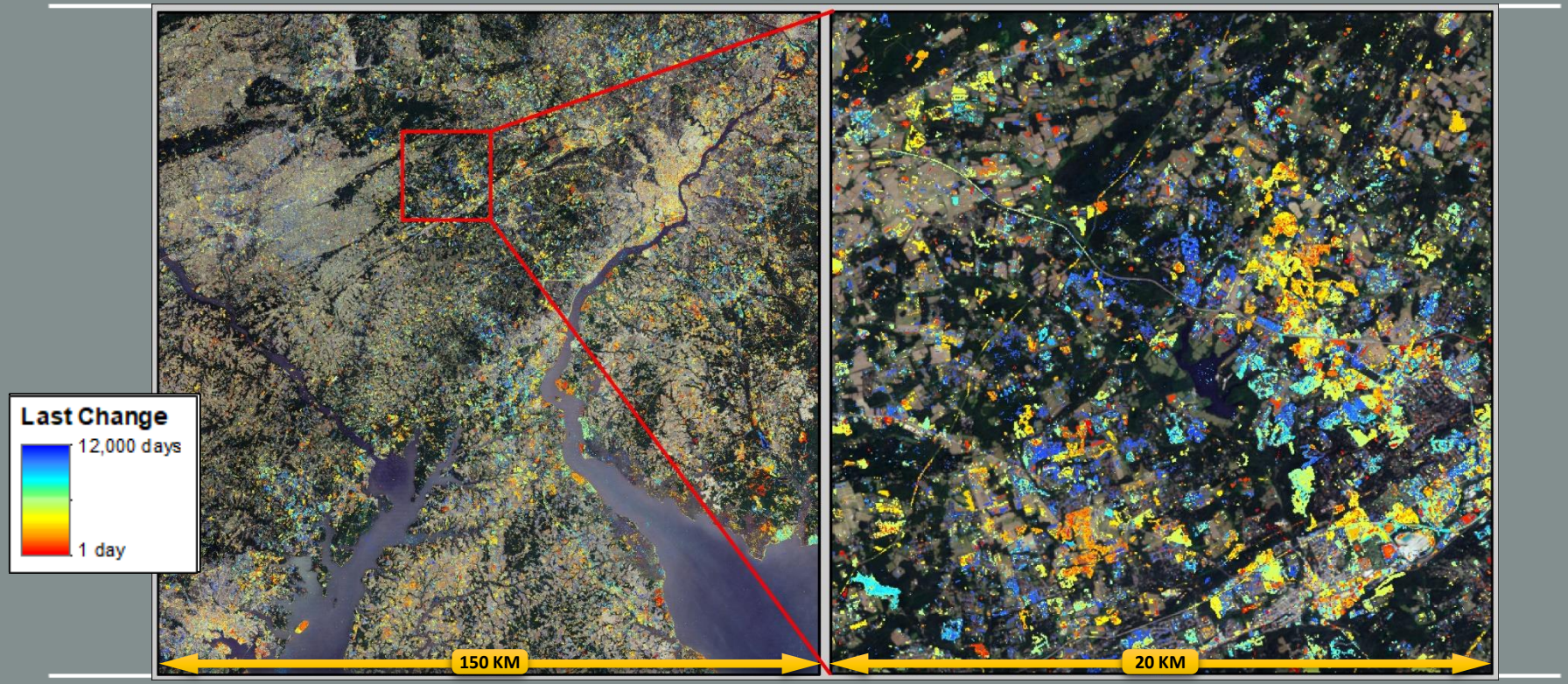
Time Since Last Change

- Amount of time since a pixel underwent a spectral change. (time since last *Break Date*)



USGS

Time Since Last Change: 2015



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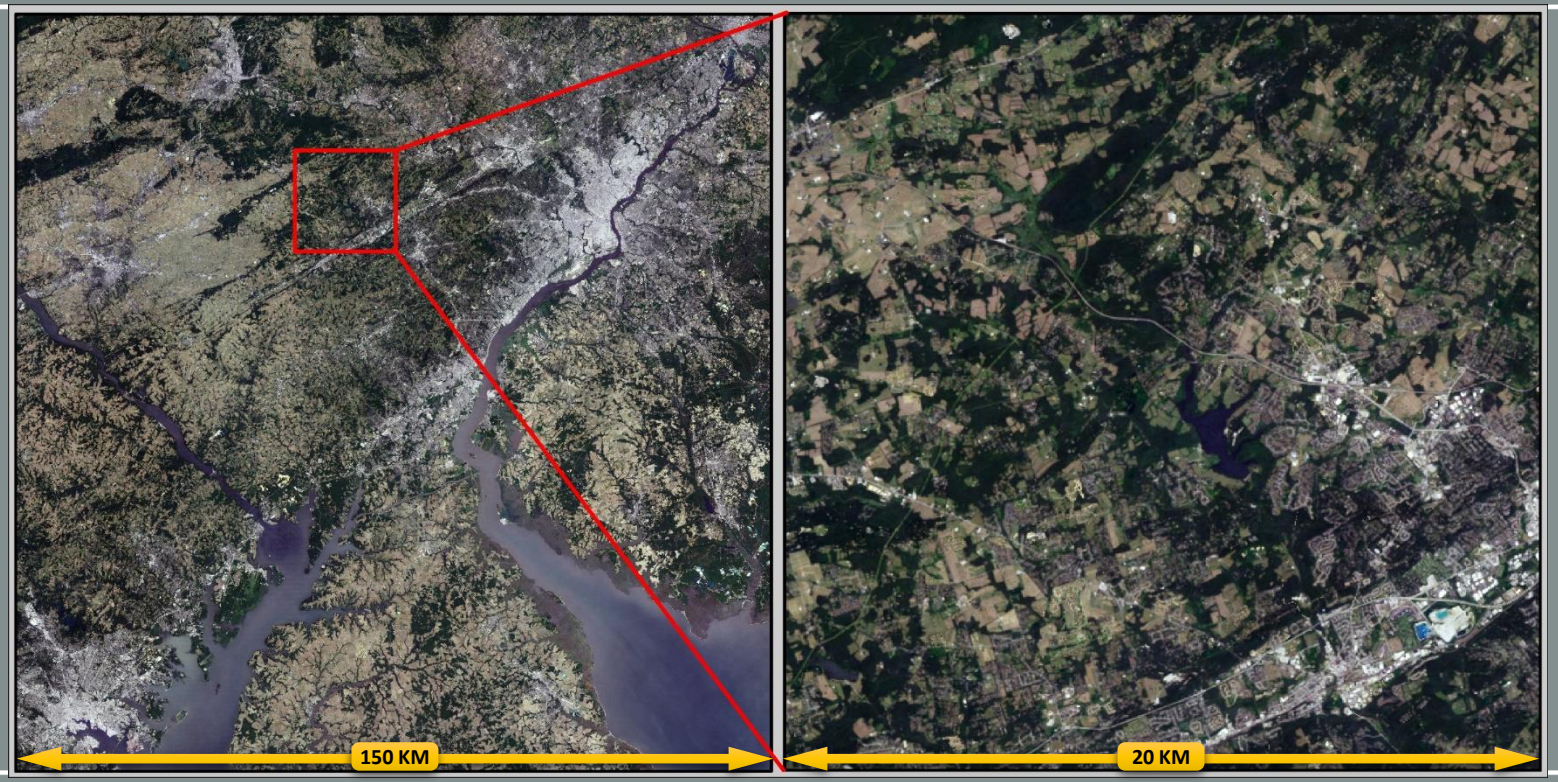
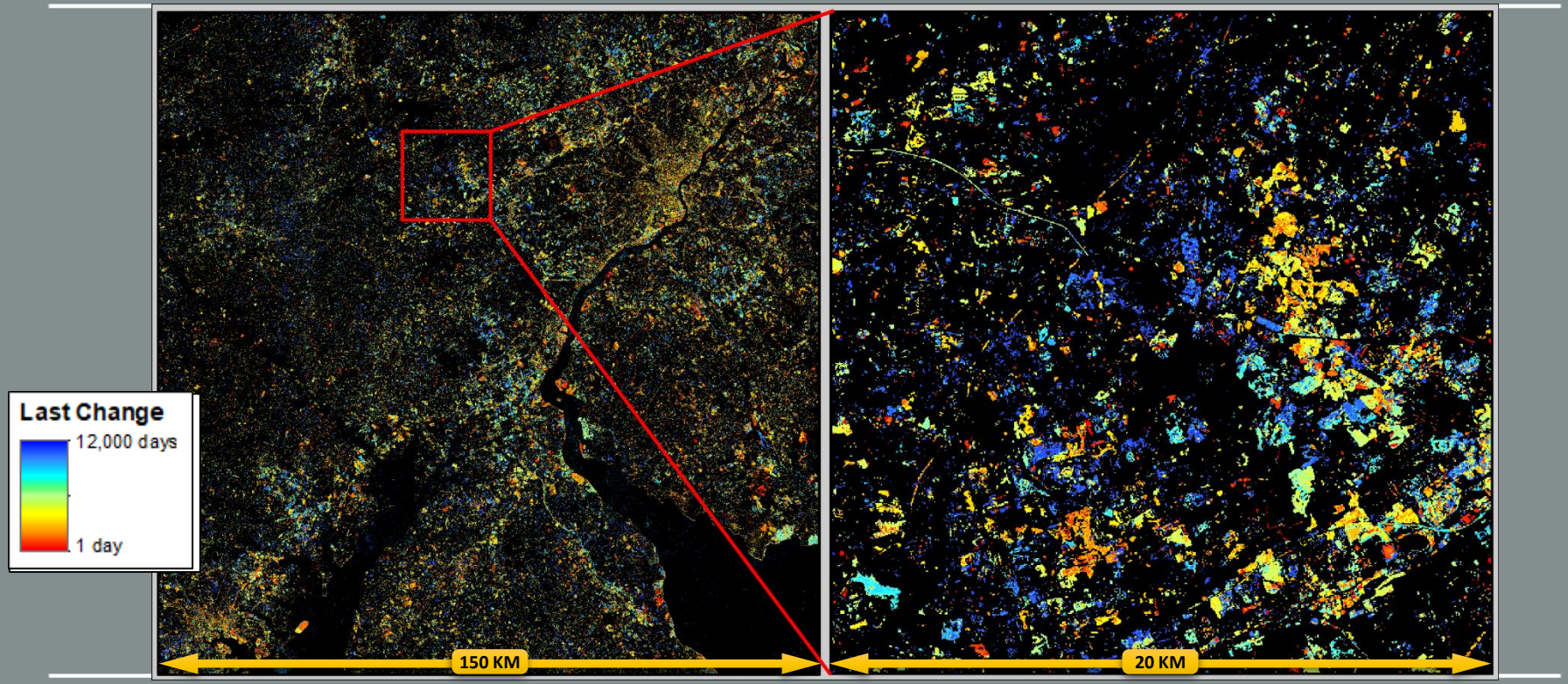
Synthetic Landsat Imagery: 2015



USGS

Time Since Last Change: 2015



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Spectral Stability

- Amount of time that a pixel has been represented by the current time series segment.

- Number of days from July 1st of the current year to the *Start Date* of the current segment.

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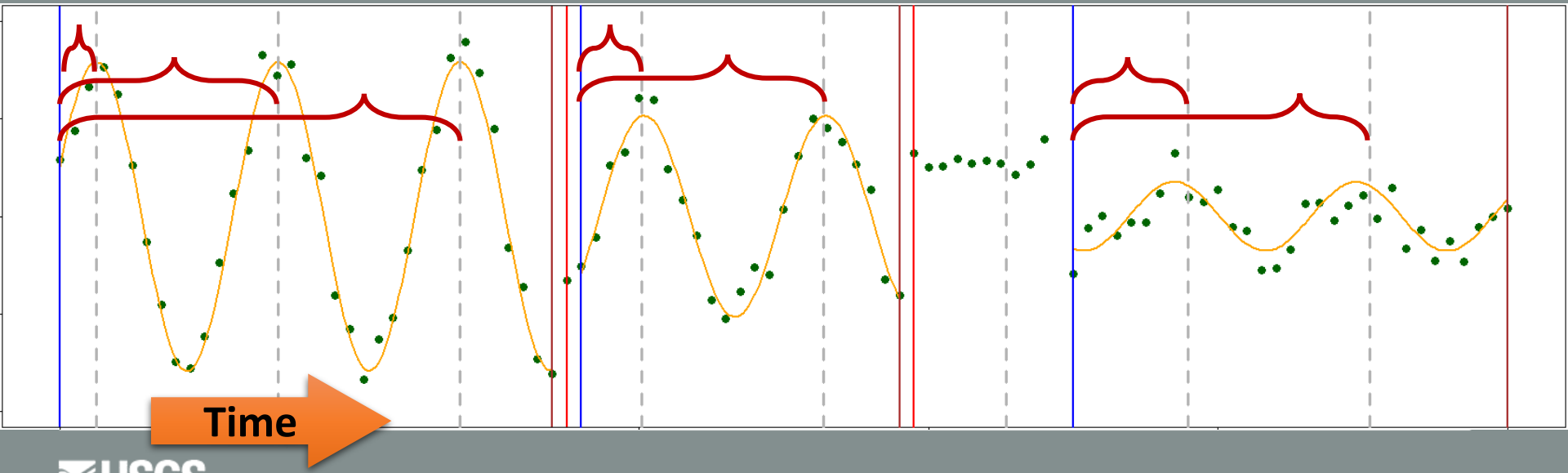
Spectral Stability

- Amount of time that a pixel has been represented by the current time series segment. (days since current *Start Date*)



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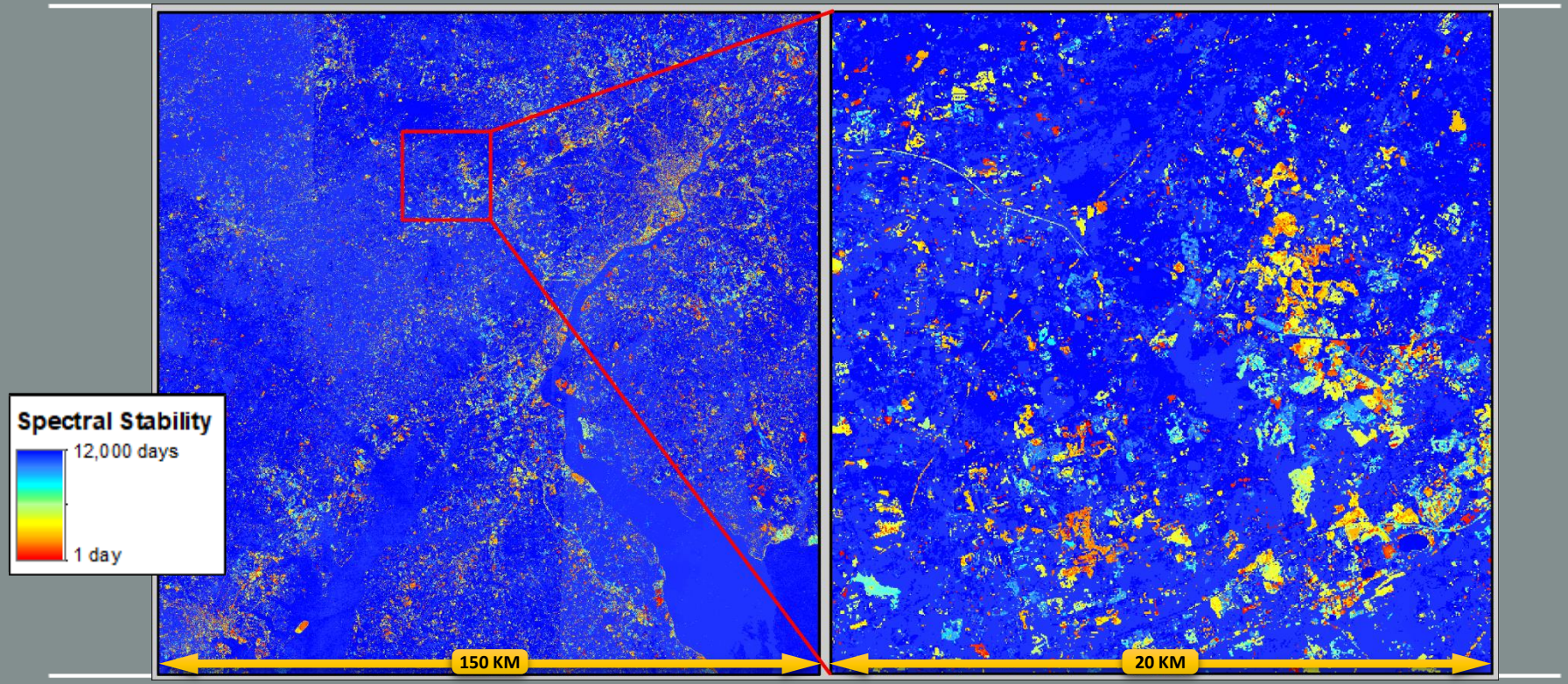
Spectral Stability: 2015



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Model Quality

- Categorical indication of quality in the current result.

- Indication of the type of model and/or procedure in use on July 1st of a given year.

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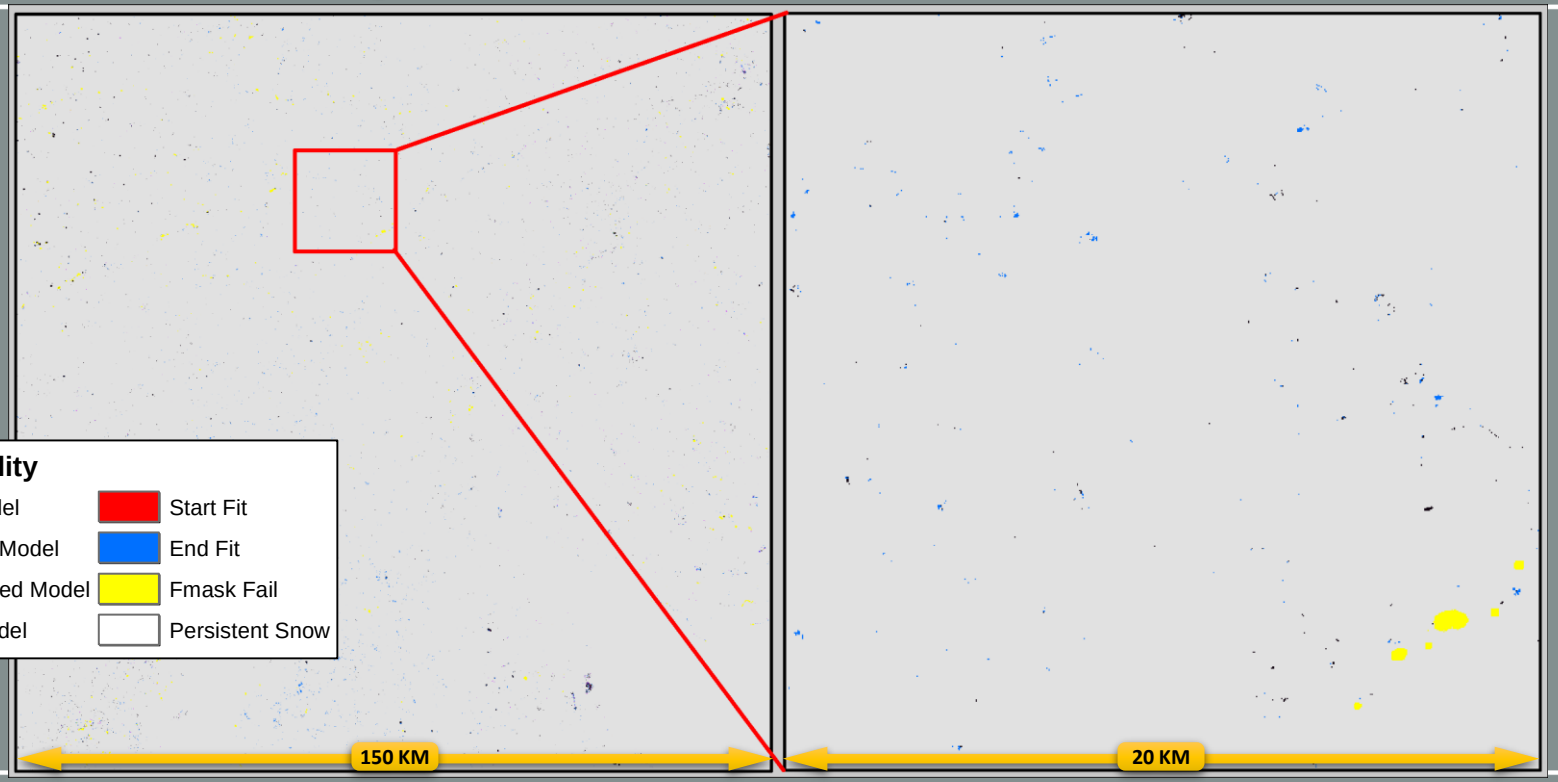
Model Quality: 2015



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Primary Land Cover

- The most likely land cover class.
- Anderson Level-1 classes most relevant to broad scale land cover change science.
- Determined as the LC class with the highest likelihood by decision tree classification of model parameters and ancillary data.

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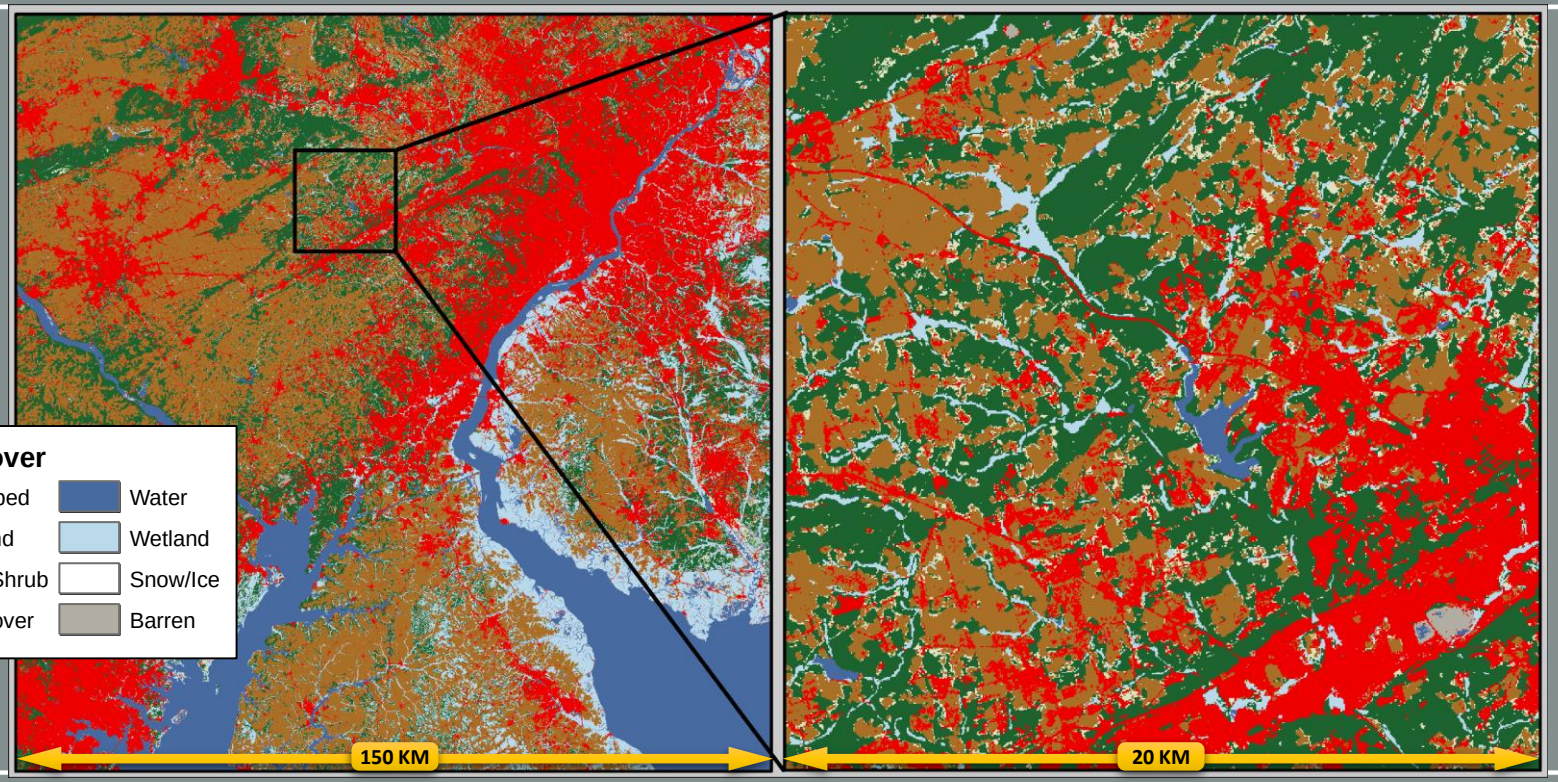
Primary Land Cover: 2015



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Primary LC Confidence

- Represents the likelihood of the Primary Land Cover class reported by classification.
- Likelihood scaled 1-100.
- Additional values >100 for pixels modified by post-classification procedures and/or unclassified pixels.
- All post-classification modification labeled as such.

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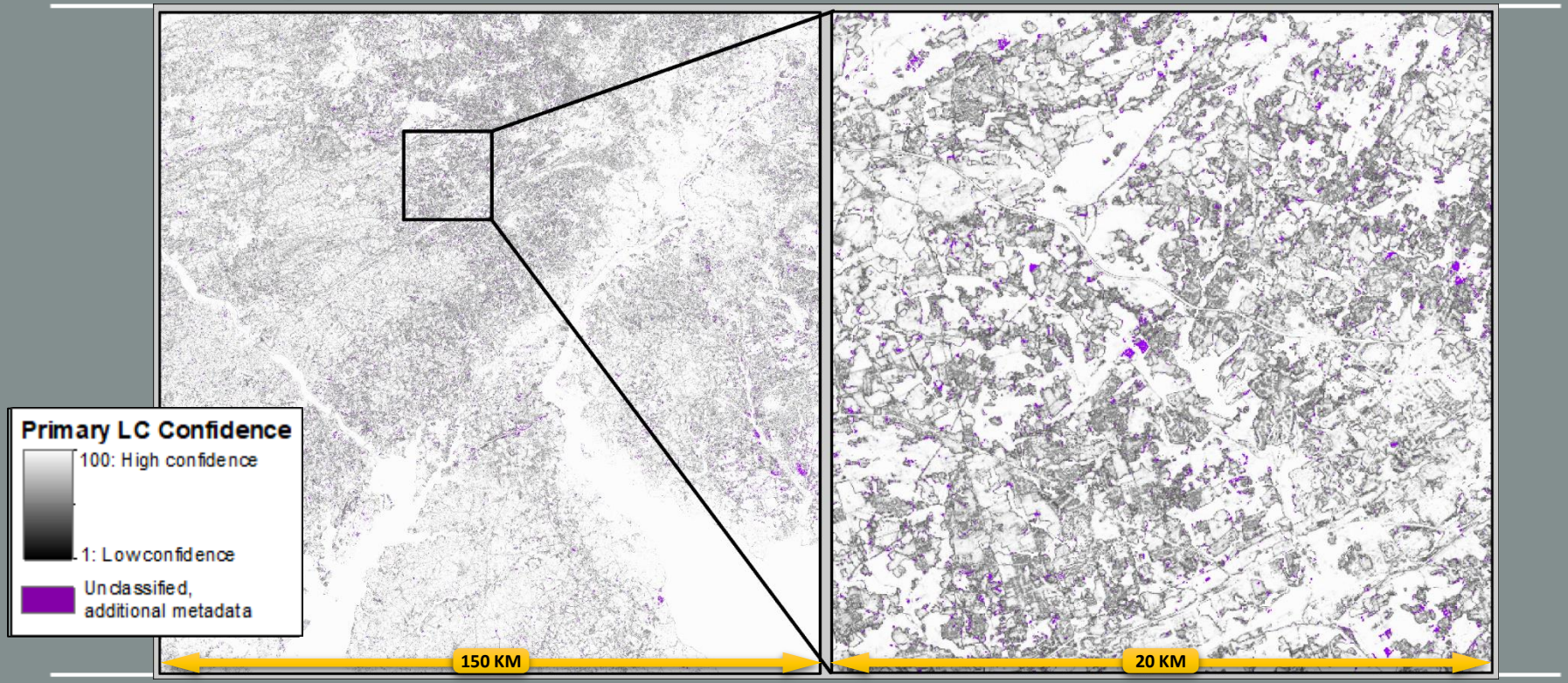
Primary LC Confidence: 2015



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Primary LC Confidence: Additional metadata

Value	Name	Description/Action
1-100	Classified	Pixel was classified, no change.
151/152	Forest transition segments	Pixel was classified & identified as Grass/Shrub ⇔ Tree Cover transition, further analysis modified Primary LC.
201	No Data	No models for entire time series, filled with NLCD-2001.
202	No End Data	Insufficient input data to extend time series model to July 1st of last year (or earlier), filled with last known LC.
211/212	Gap-fill between same/different LC class	Gap between established models spans July 1st. Filled with adjacent known LC class.
213	No Start Model	No model initialized by July 1st of first year (or later), LC backfilled from first known LC type.
214	Late Break	Model break near end of time series, insufficient data to establish new model. Filled with last known LC.

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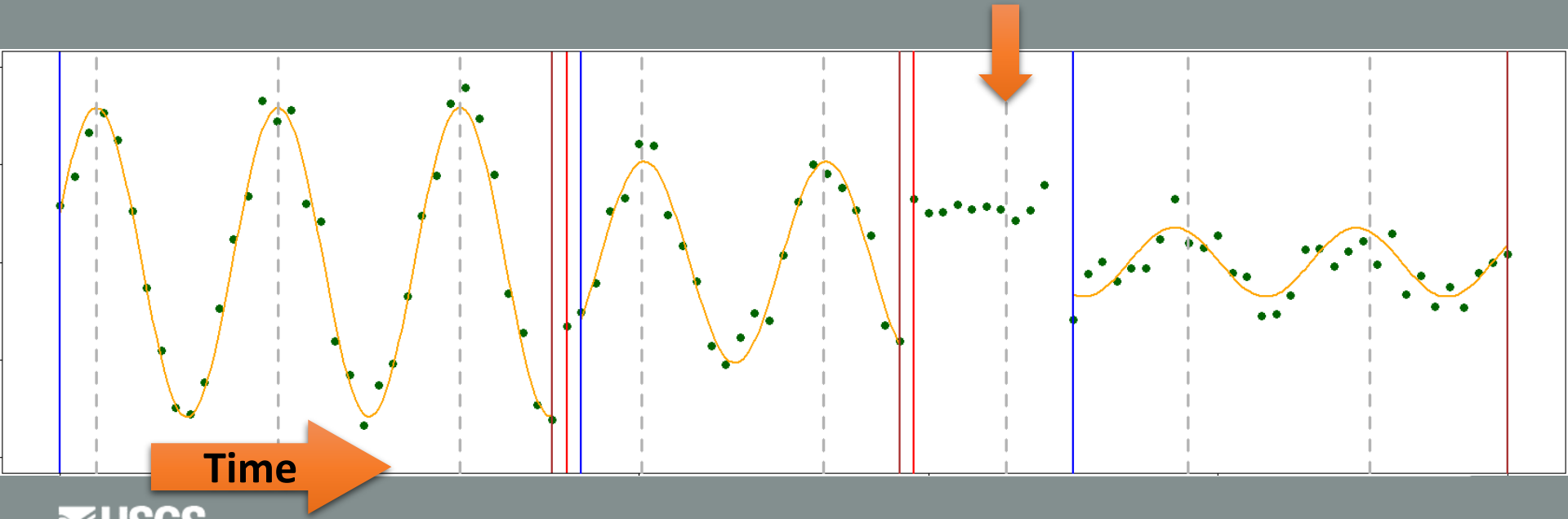
Primary LC Confidence: Additional metadata

- Example: no existing model on July 1st requires post-classification rule-based procedure to avoid data gaps.



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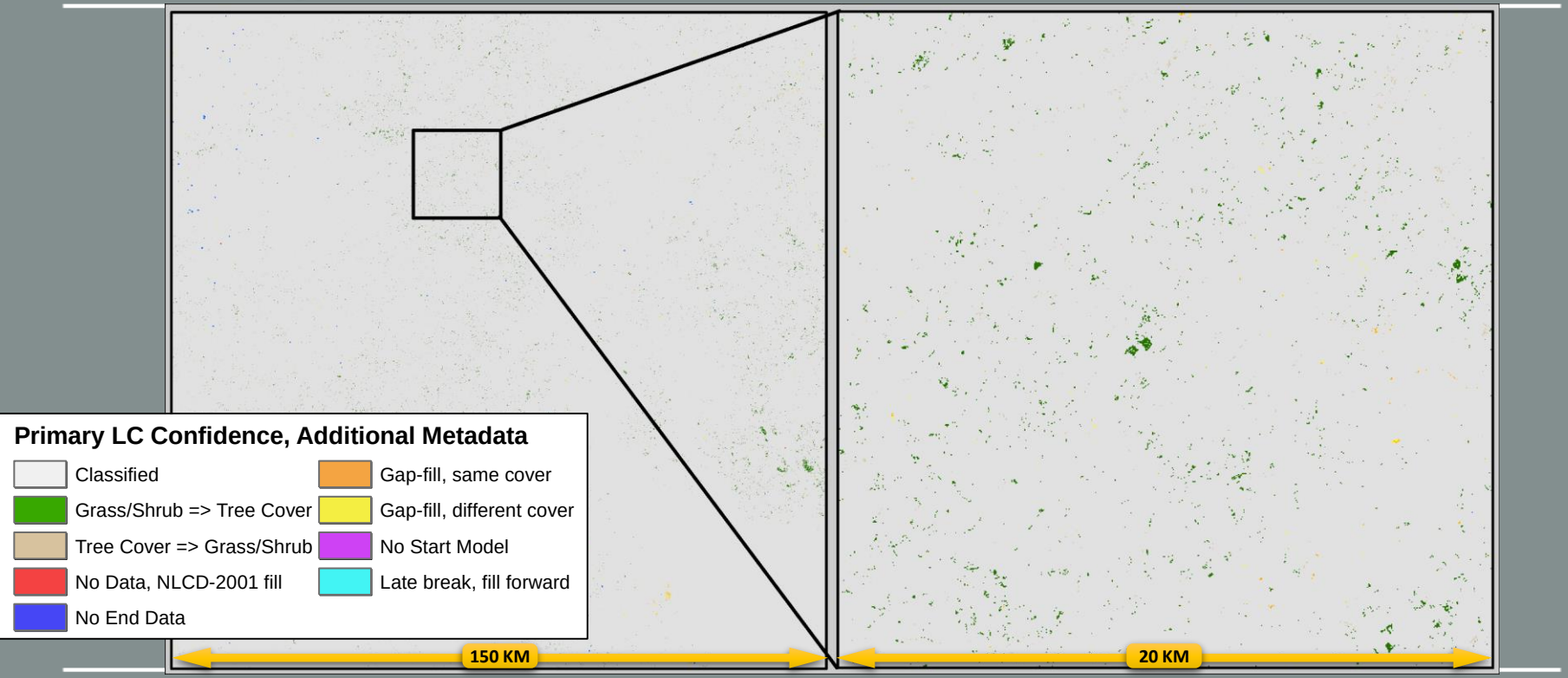
Primary LC Confidence: Additional metadata



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Secondary Land Cover

- The 2nd most likely land cover class reported by the classifier.
- Identical LC schema to Primary LC.
- Most useful when Primary LC Confidence is relatively low.
- Paired with Secondary LC Confidence product.

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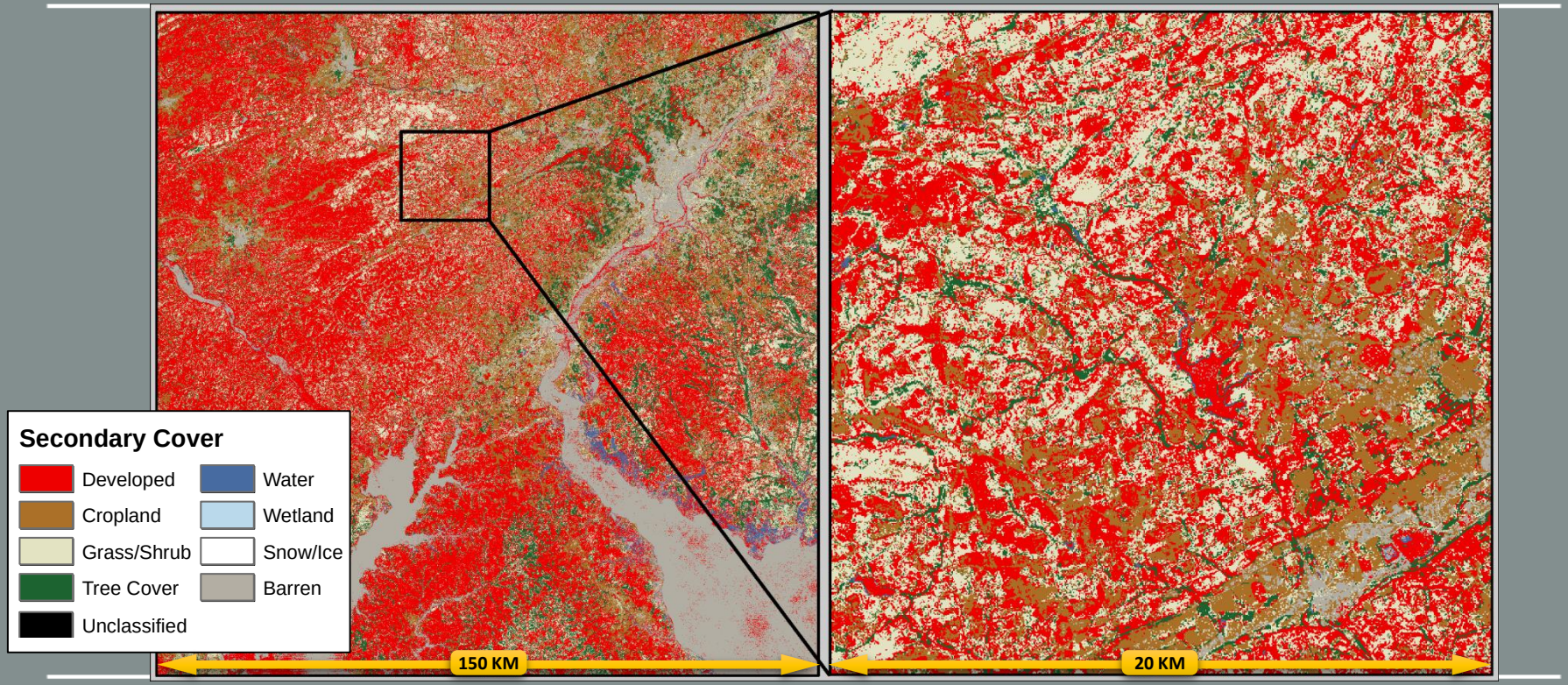
Secondary Land Cover: 2015



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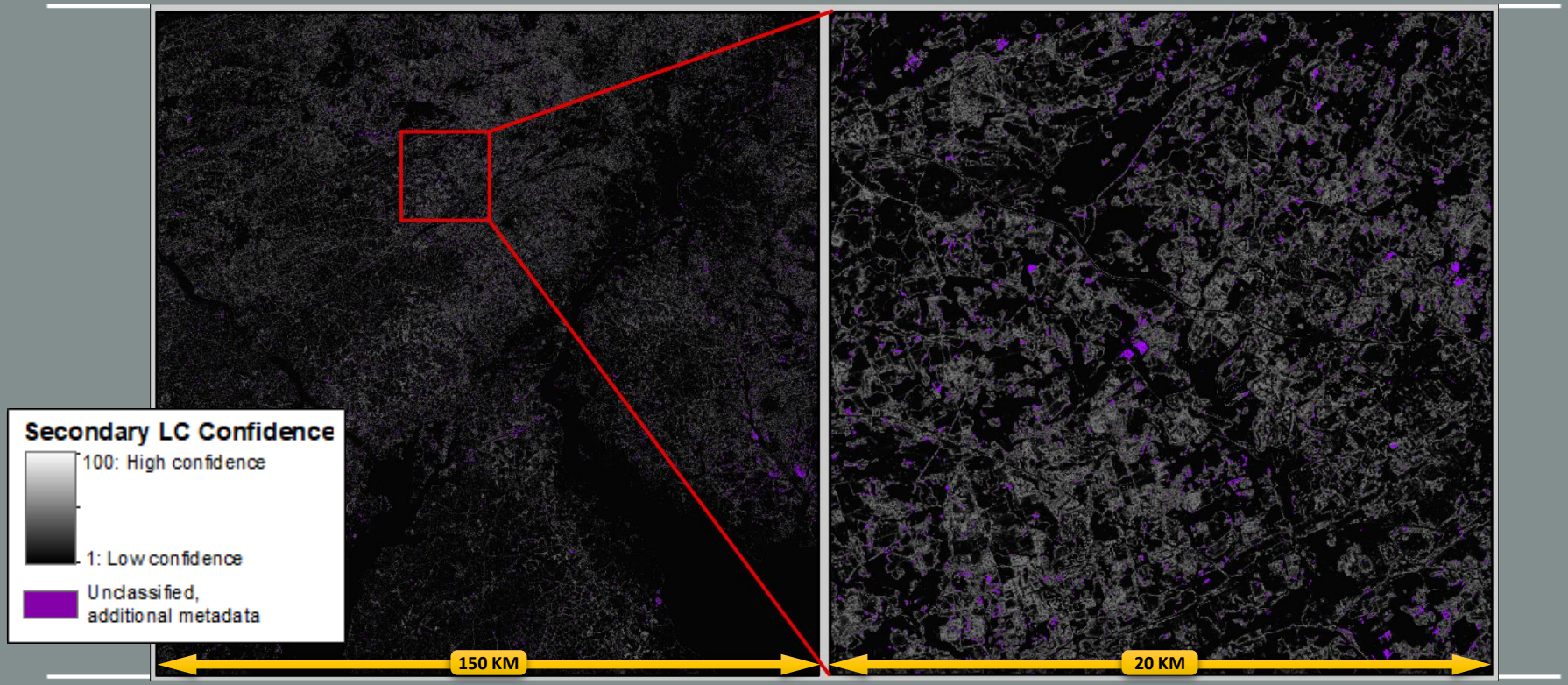
Secondary LC Confidence: 2015



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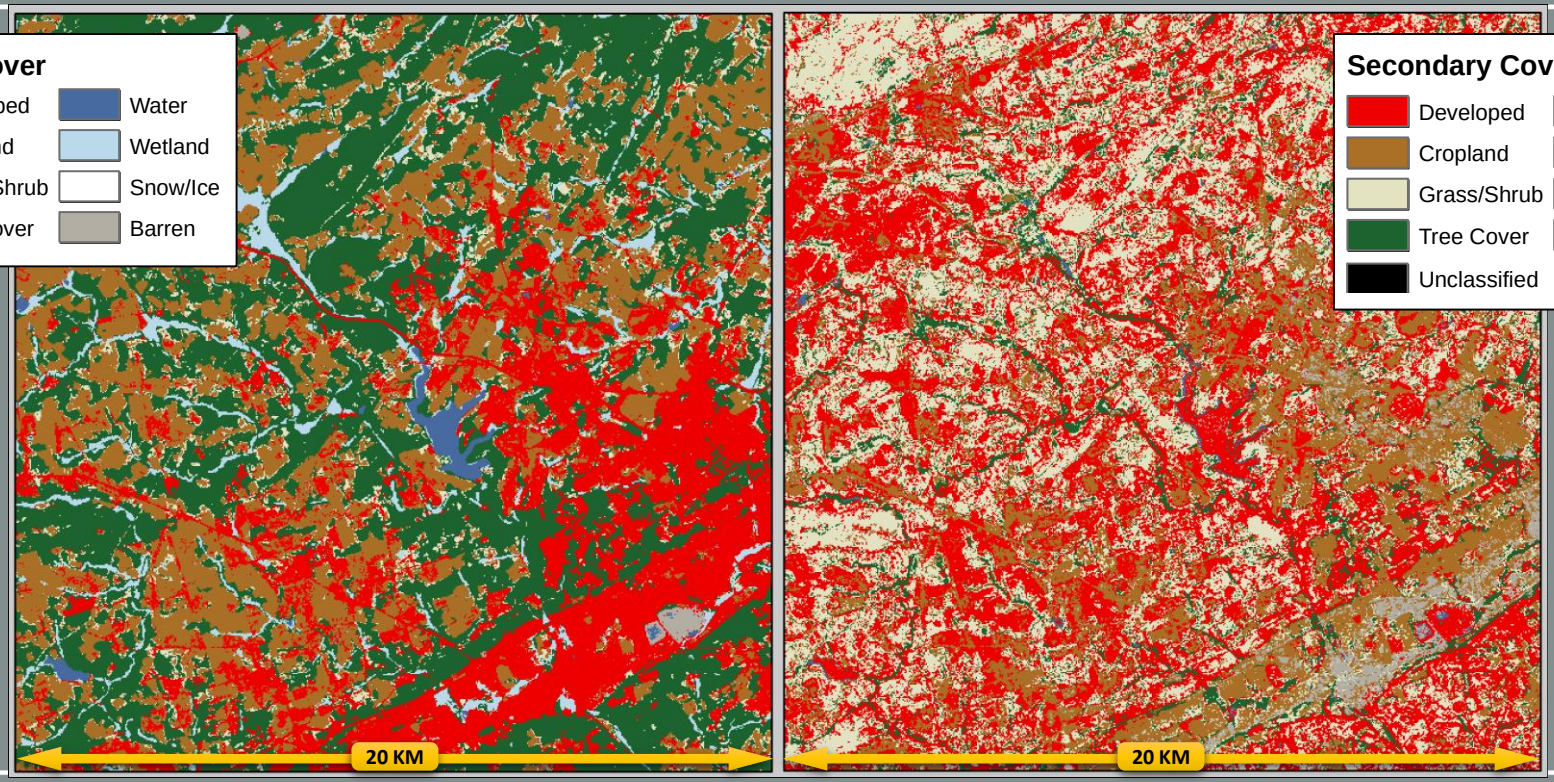
Primary vs. Secondary LC



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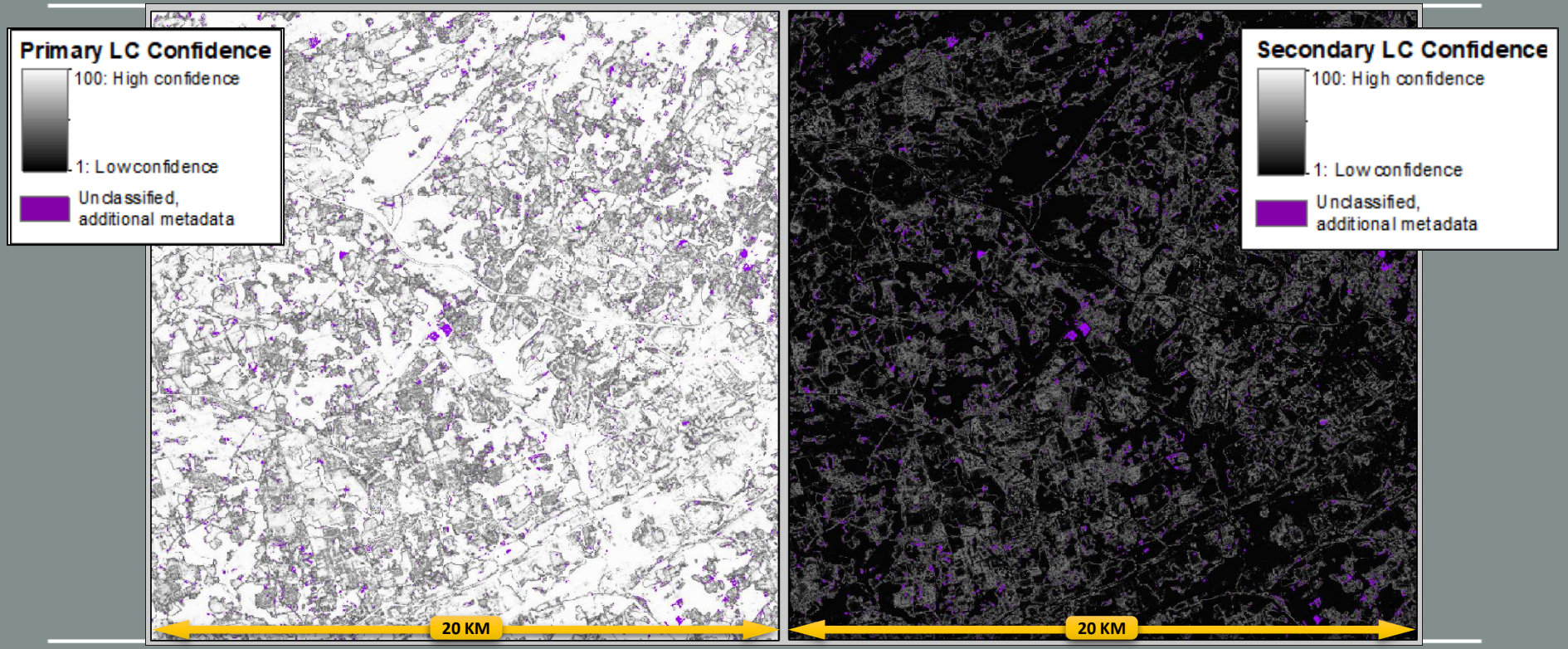
Primary vs. Secondary LC Confidence



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Land Cover Change

- Synthesis product generated from Primary LC products
- Identifies thematic LC change in current year from previous
- Unchanged pixels labeled as unchanged LC class
- Change pixels labeled with concatenation indicating change
  - “32” indicates LC-3 (Grass/Shrub) => LC-2 (Cropland)
  - “41” indicates LC-4 (Tree Cover) => LC-1 (Developed)

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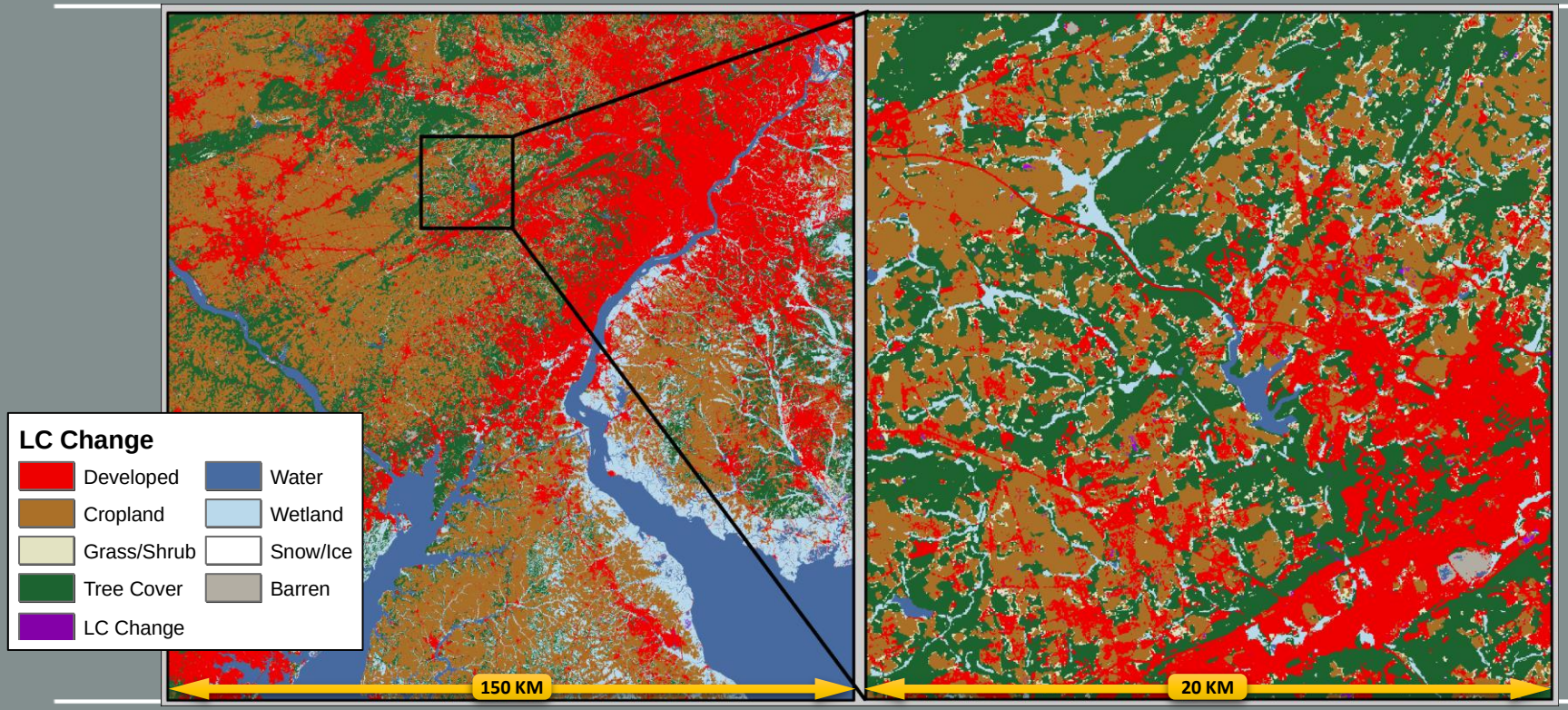
Land Cover Change: 2015



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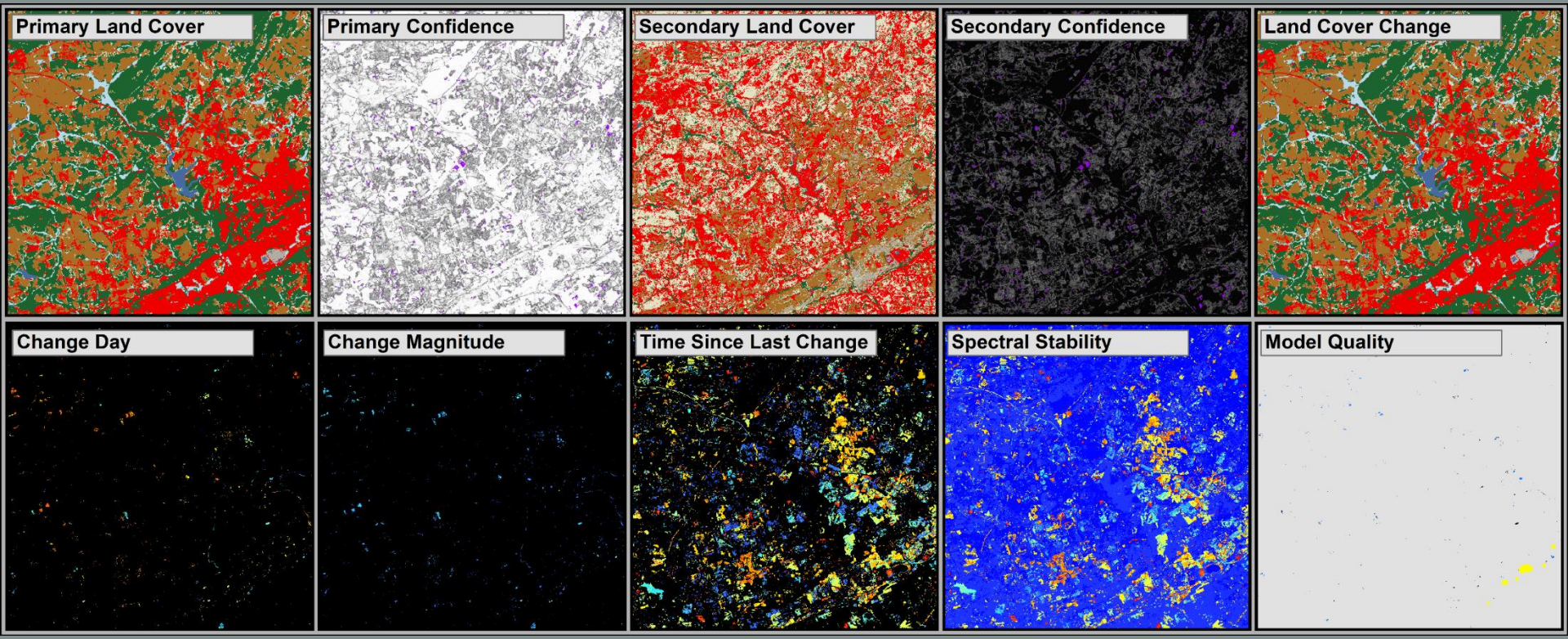
LCMAP Mapped Product Suite



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Introducing 10 New LCMAP Products

- Coming soon …
- Function as an integrated set – products inform each other.
- Quality & Confidence layers have proven invaluable.
- R&D on time series updates, product improvement, and potentially new products ongoing …
- Sample dataset (H03V10, northern California) available soon.

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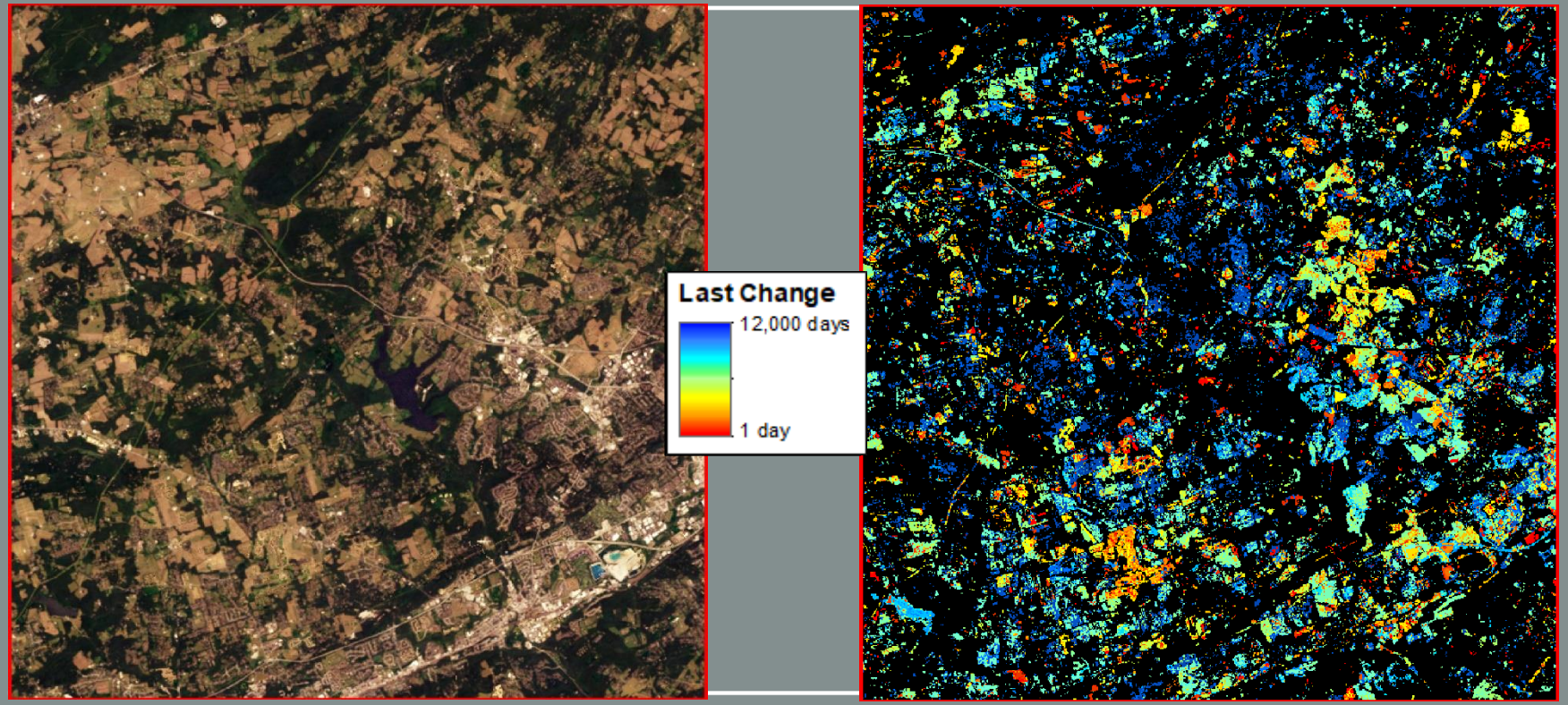
One last example…



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For more ARD & LCMAP information…

- Landsat Analysis Ready Data (ARD)
  - https://landsat.usgs.gov/ard/
- LCMAP
  - https://eros.usgs.gov/science/land-change-monitoring-assessment-and-projection-lcmap
- EROS Customer Services
  - custserv@usgs.gov

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