Design-based validation of the MODIS Global Burned Area Product

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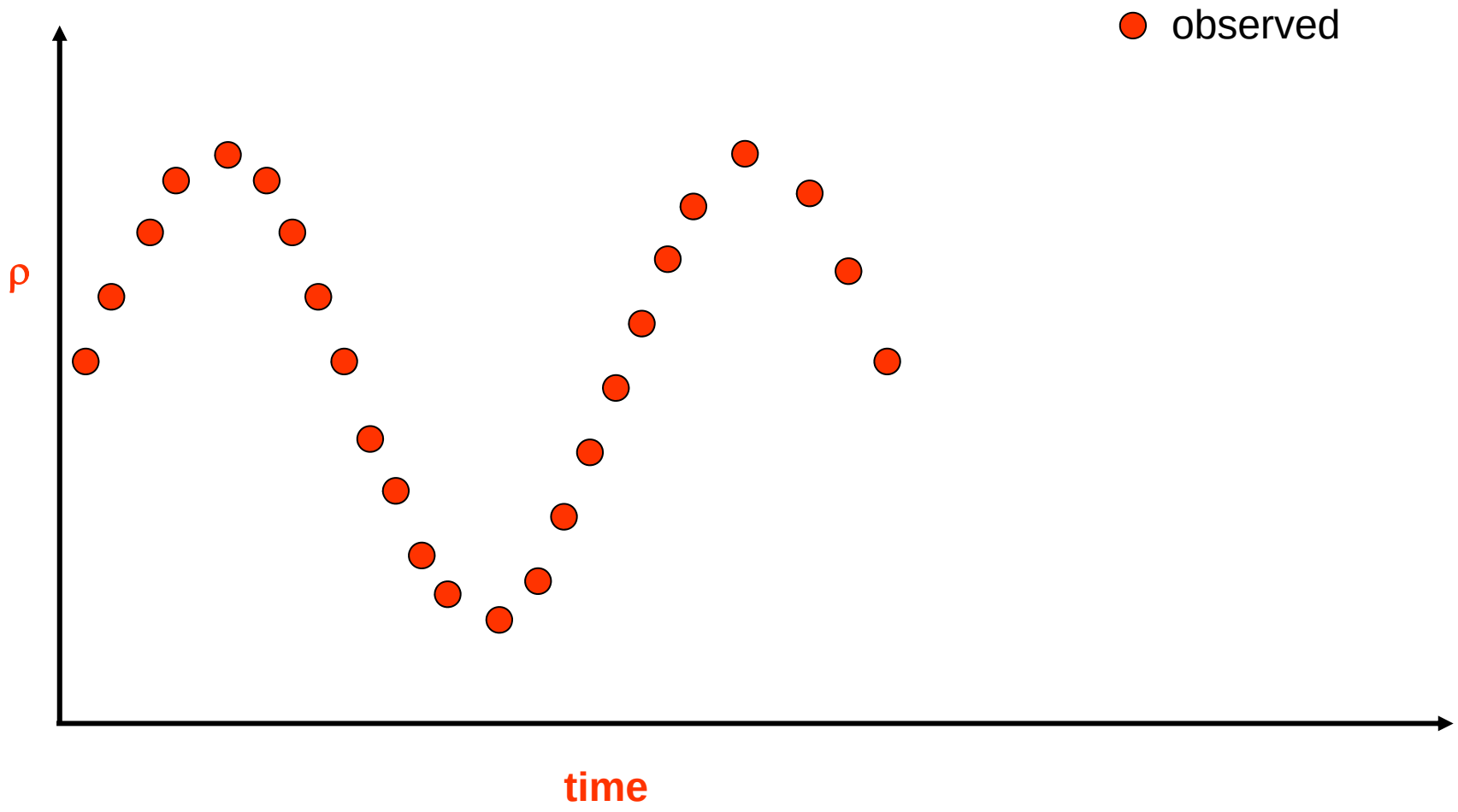
http://modis-fire.umd.edu/MCD45A1.asp

Recall – global burned area algorithm

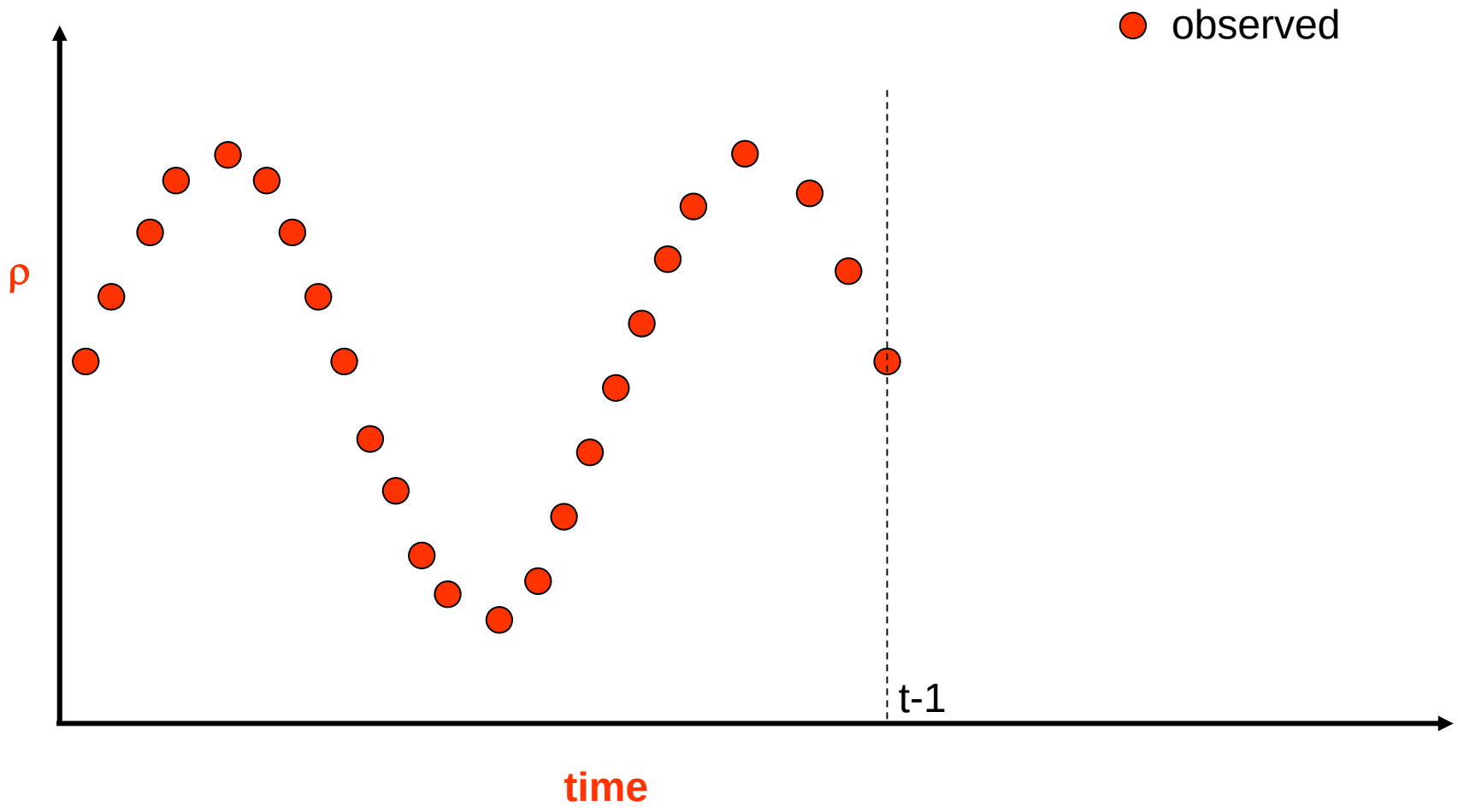
- *Rolling BRDF based expectation change detection*
- Semi-Physically based; less dependent upon imprecise but noise tolerant classification techniques; very few thresholds
- Automated, without training data or human intervention
- **Applied independently per pixel to daily gridded MODIS 500m land surface reflectance time series**

=> globally map 500m location and approximate day of burning

Conceptual Scheme (one pixel, time series)



Conceptual Scheme



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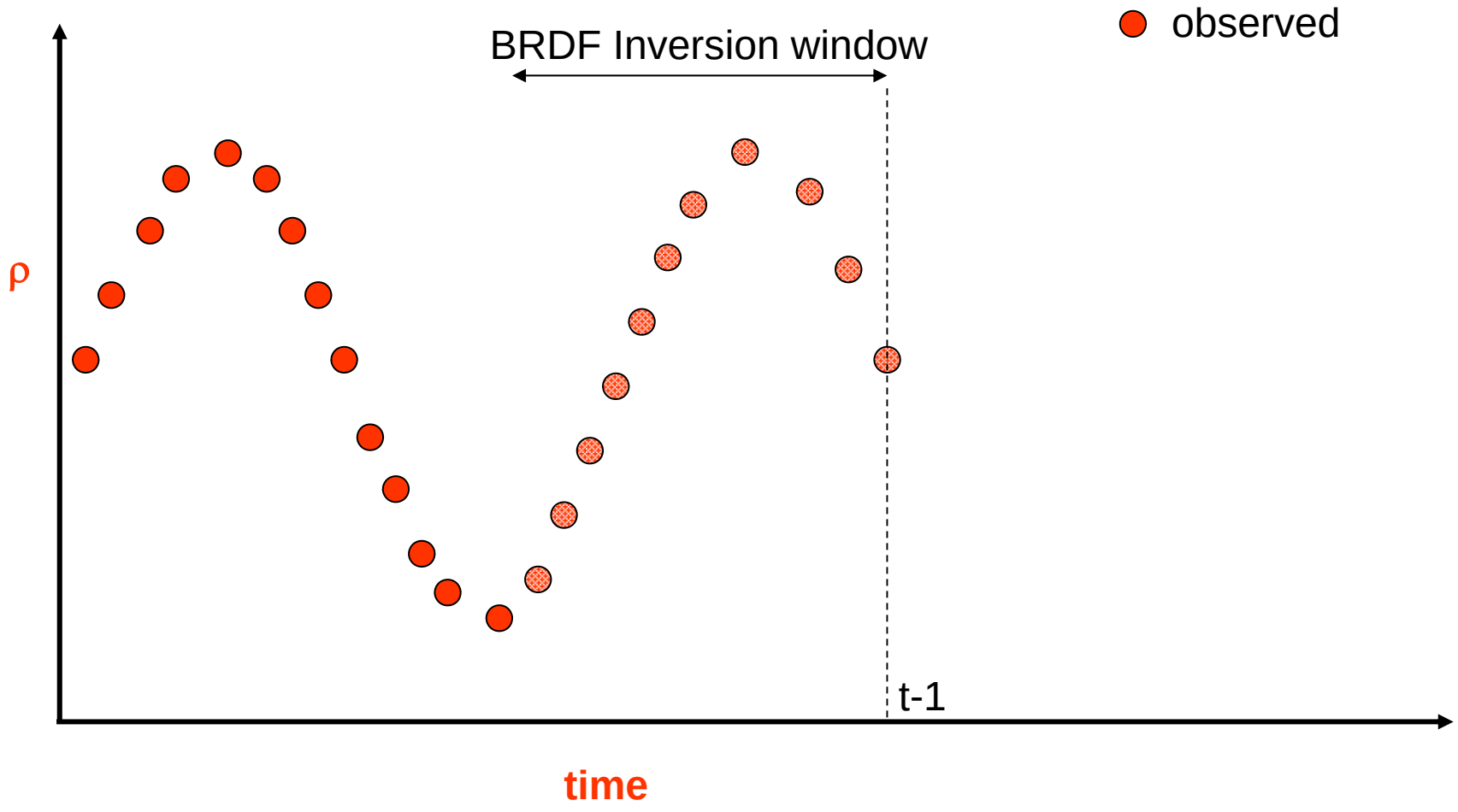

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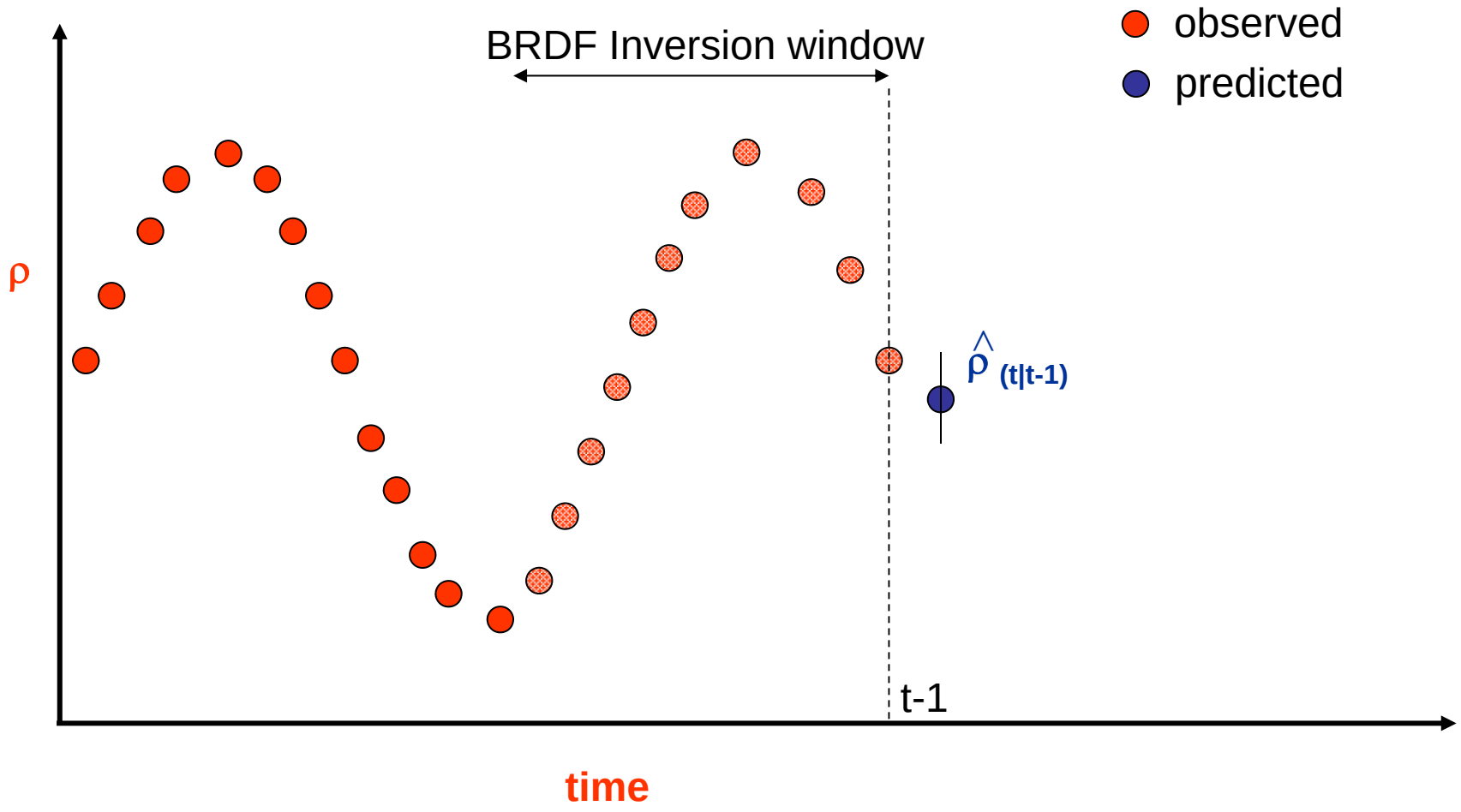

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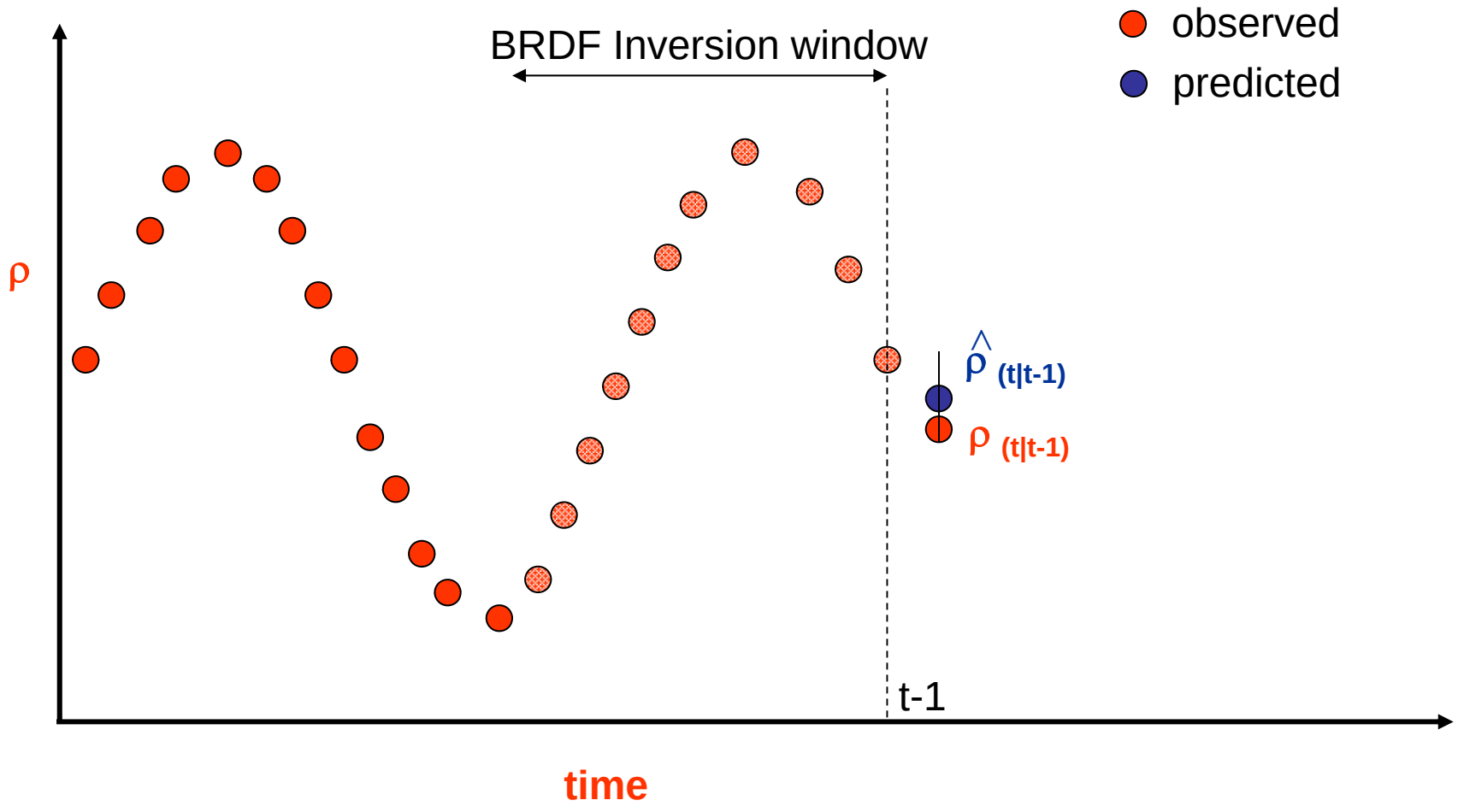
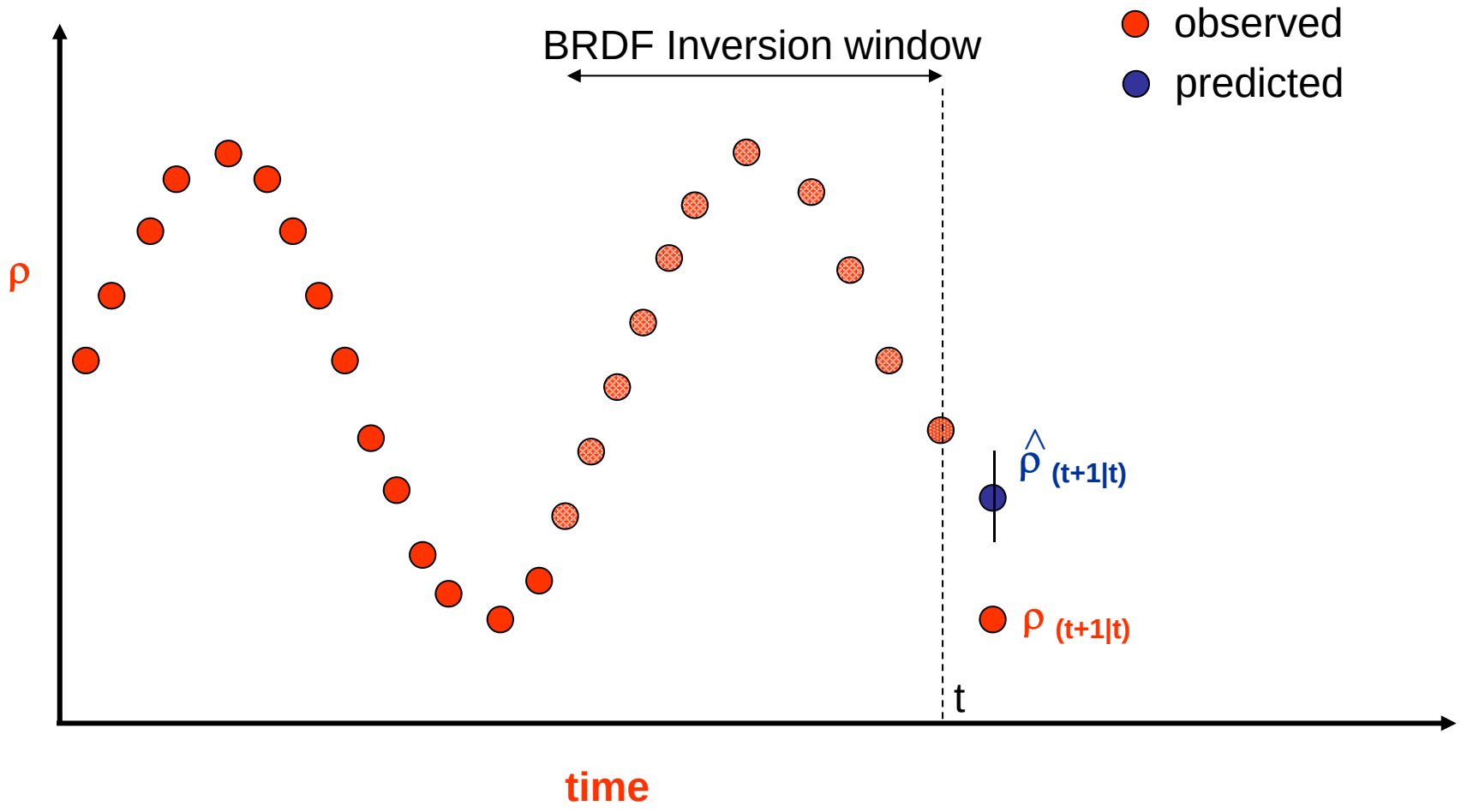
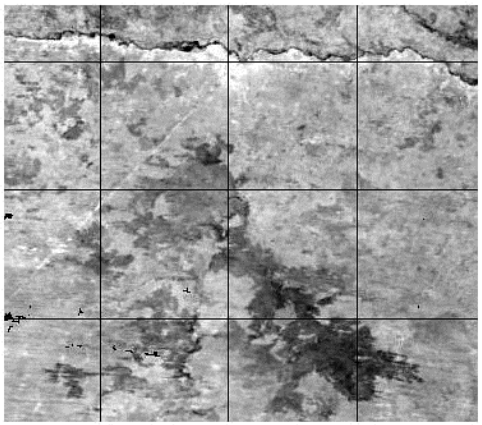


Conceptual Scheme



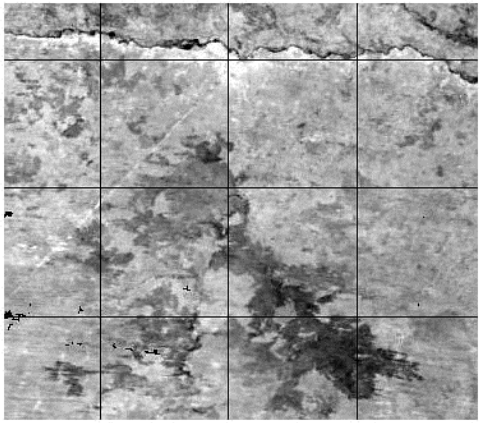
...looking at images:



BRDF predicted 1.24 micron reflectance (500m) day 275

Predicted Reflectance

...looking at images:



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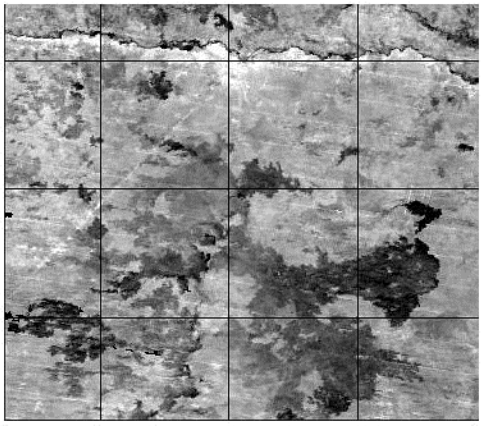
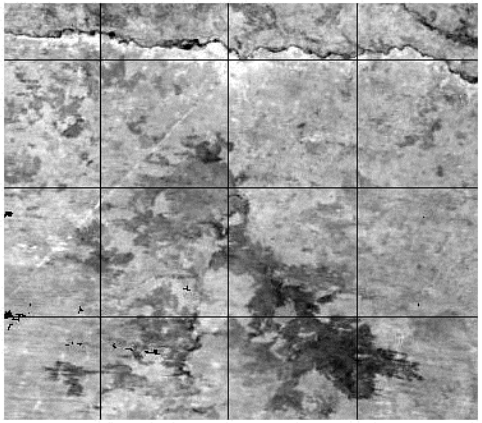
Predicted Reflectance



Observed 1.24 micron reflectance (500m) day 275

Observed Reflectance

...looking at images:



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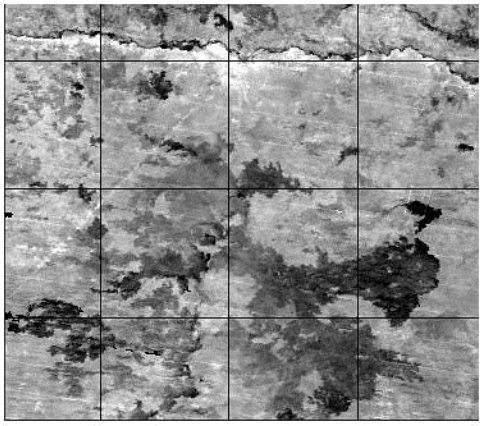

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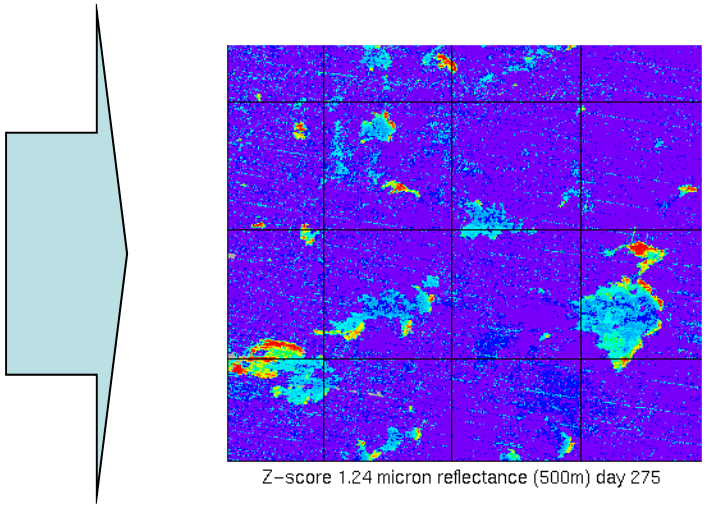

Z−score 1.24 micron reflectance (500m) day 275

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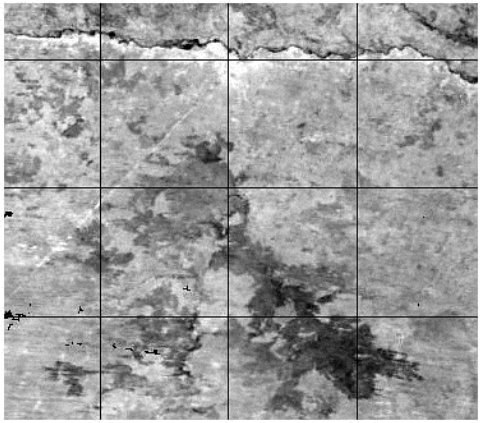

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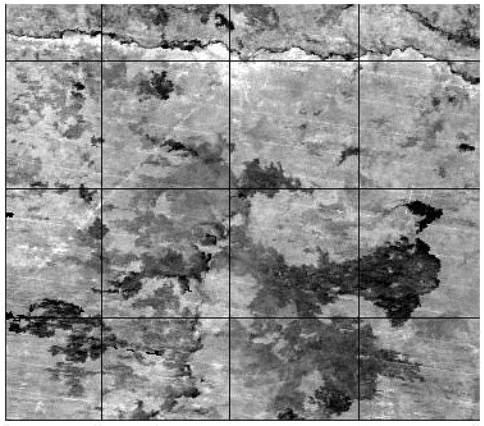

Observed 1.24 micron reflectance (500m) day 275

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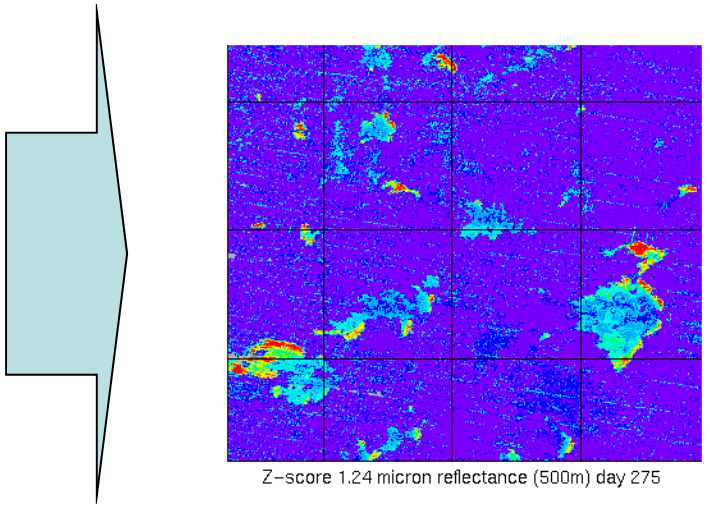
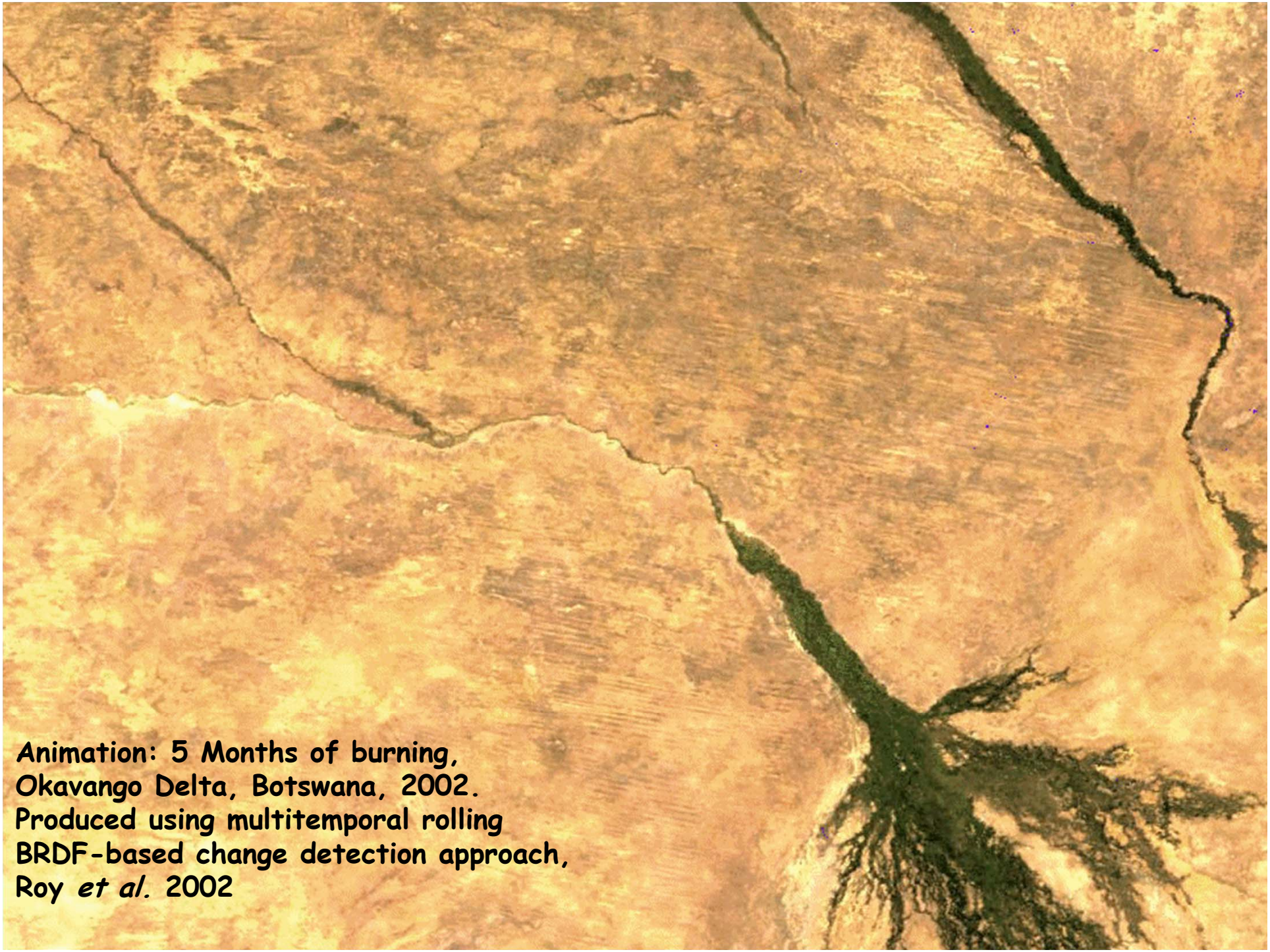


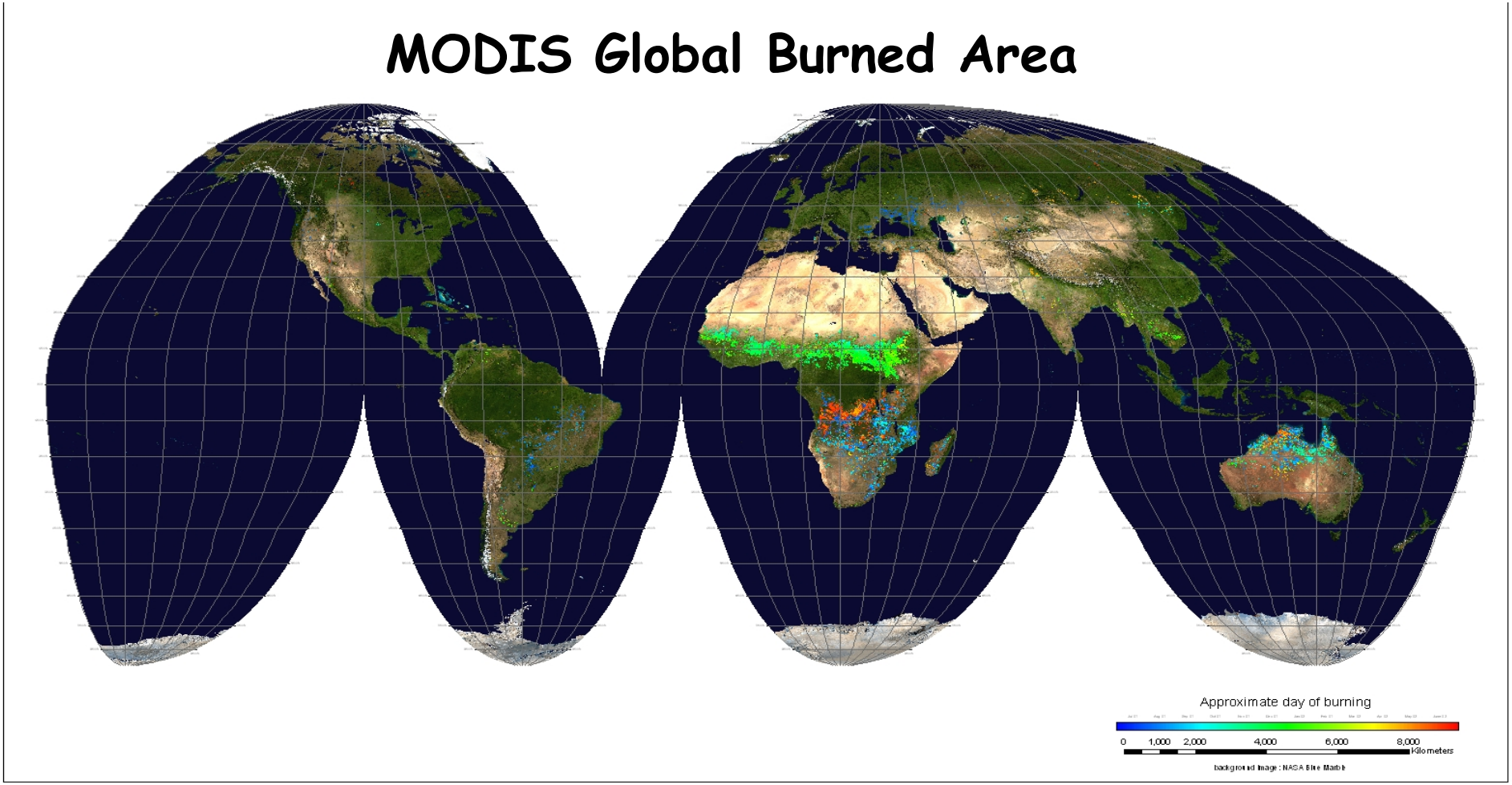
Z−score 1.24 micron reflectance (500m) day 275

probability of change:
Z-score = (predicted-observed)/error



Animation: 5 Months of burning,
Okavango Delta, Botswana, 2002.
Produced using multitemporal rolling
BRDF-based change detection approach,
Roy *et al.* 2002

MODIS Global Burned Area



- Algorithm run globally for first time in MODIS C5 - purposefully running to map burned areas conservatively
- Collection 5.1 currently being processed – will replace C5
- Product redesign and integration with active fires for C6
- **Validation: CEOS** Stage 2 for C5.1
- **Validation: CEOS** Stage 3 for C6

Components of the validation

The global burned area product provides information that is

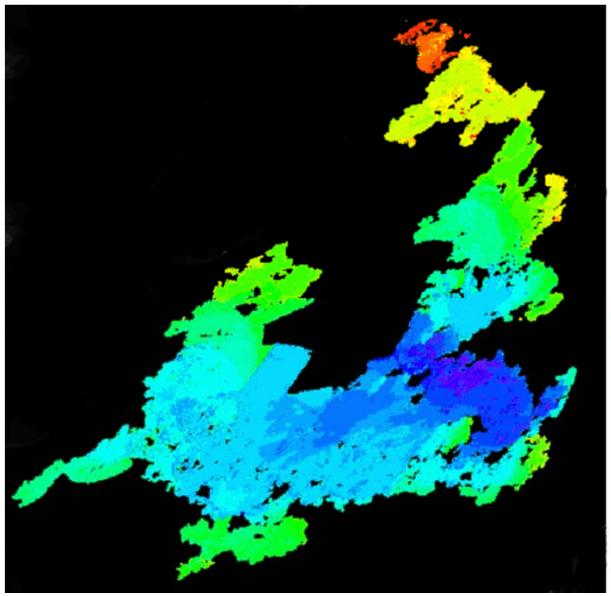
- temporal (day of detection)
- spatial (location and areal extent)

Two separate validation procedures

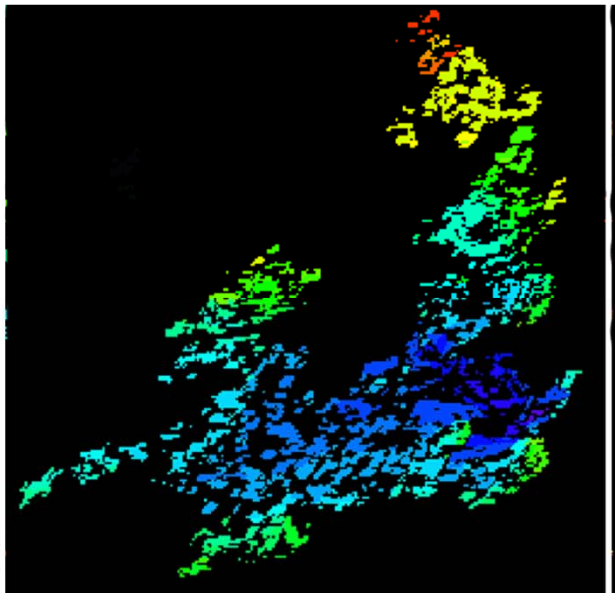
Validation of Burned Area Product

Temporal Reporting Accuracy

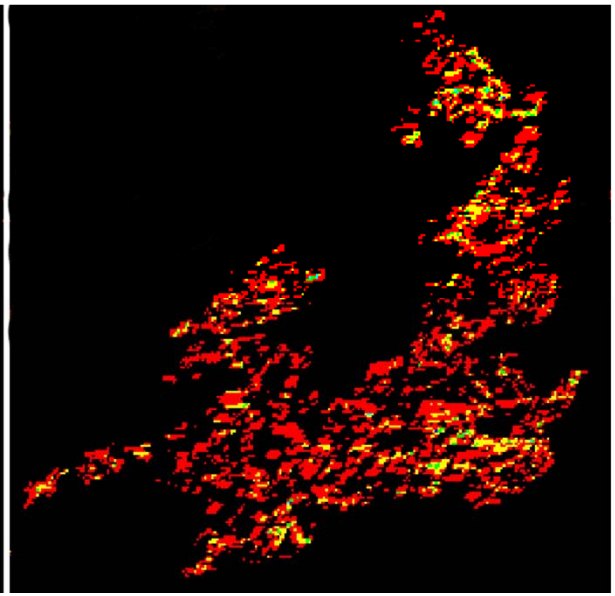
- To date we have concentrated on product spatial reporting accuracy
- The product also reports the ~day of detection
- The nominal uncertainty due to the daily rolling BRDF inversion window is 8 days
- Temporal product accuracy increasingly relevant to user community
  - near real time air quality
  - atm. transport models (weather on day of burn, plume injection height)
  - some regional assessment applications (nat. resource, disaster management)



Burned Area



Active Fire



Active Fire Detections

Red=1, Yellow= 2

- MODIS active fire product
  - validated to stage 3
  - very low commission error
  - date & time of active fire detection defined by orbit overpass

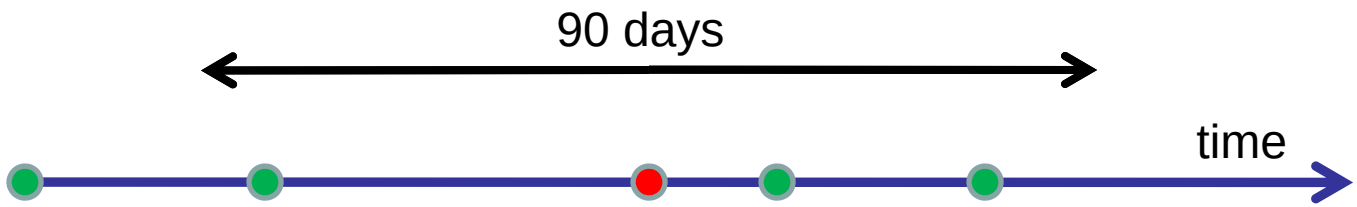
MODIS Burned Area Temporal Reporting Validation Approach

Comparison at all global locations where there is a burned area detection and an active fire detection

- Active Fire (Terra or Aqua)
- Burned area

MODIS Burned Area Temporal Reporting Validation Approach

Comparison at all global locations where there is a burned area detection and an active fire detection



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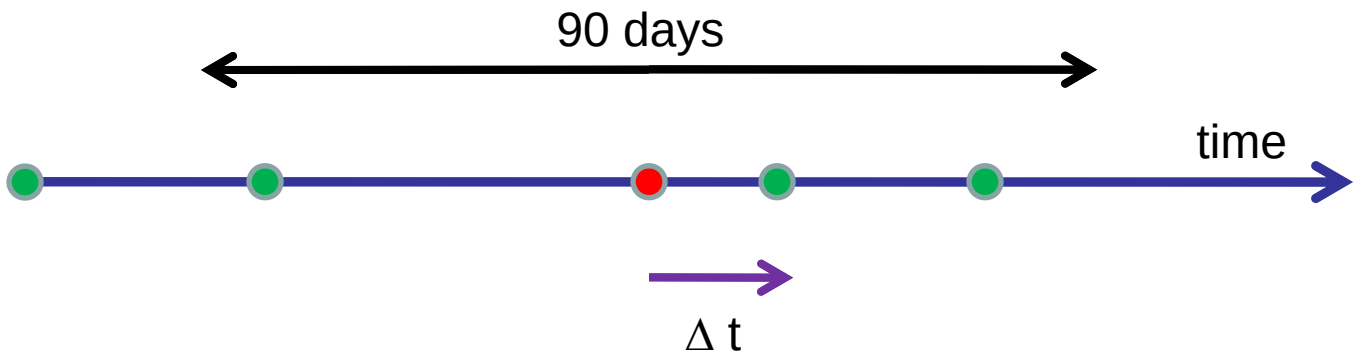
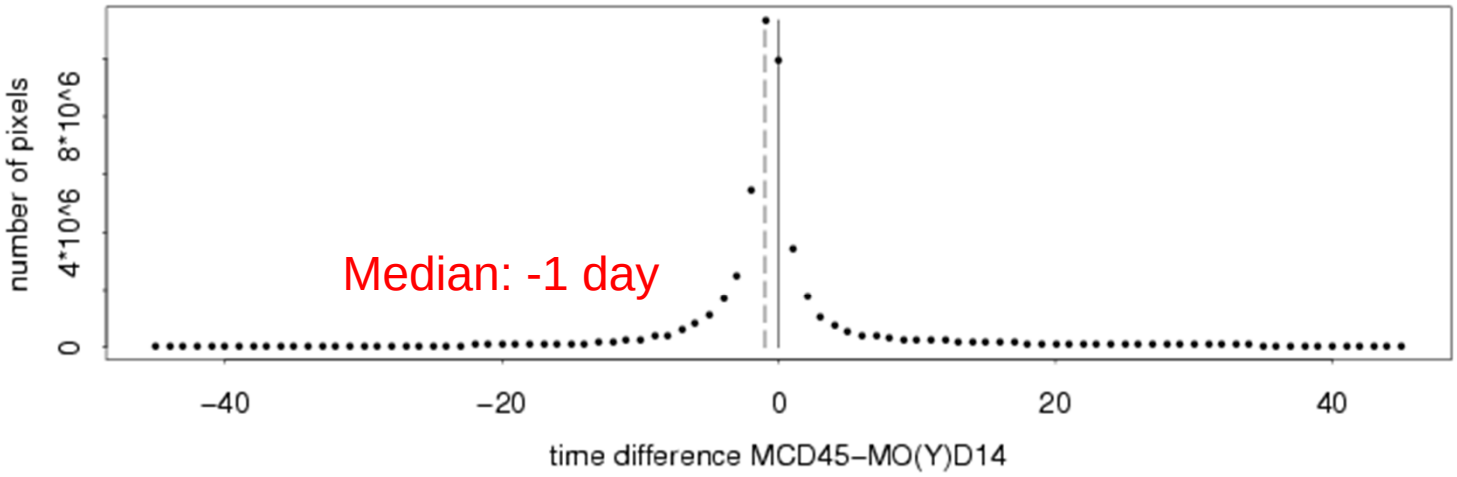
MODIS Burned Area Temporal Reporting Validation Approach

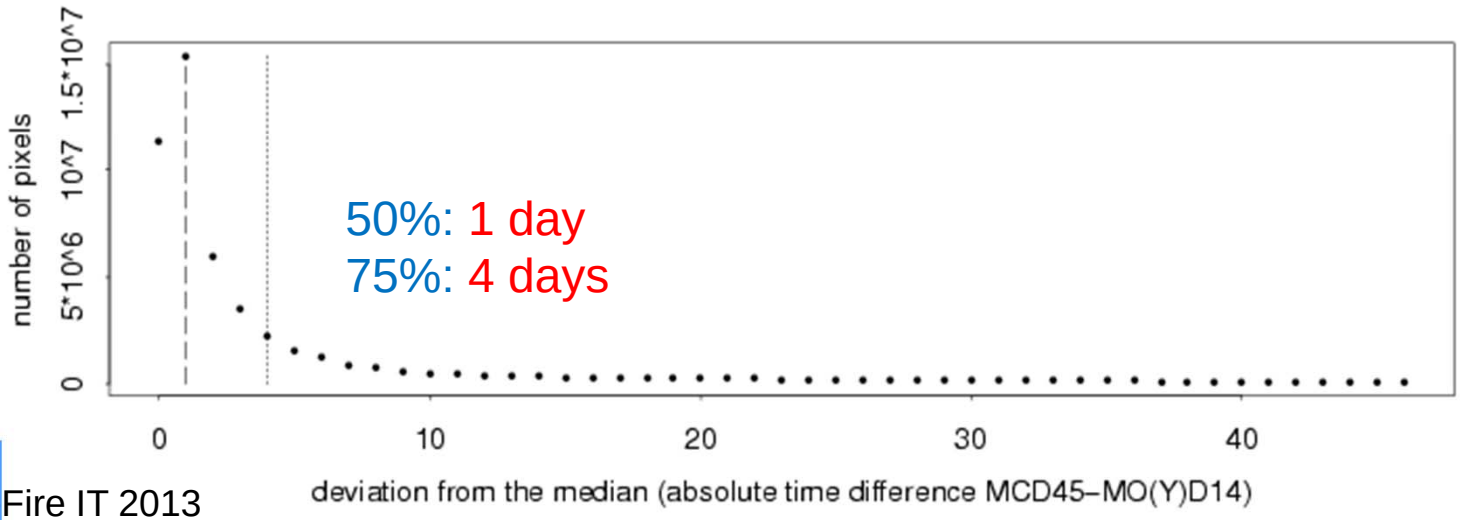
Comparison at all global locations where there is a burned area detection and an active fire detection



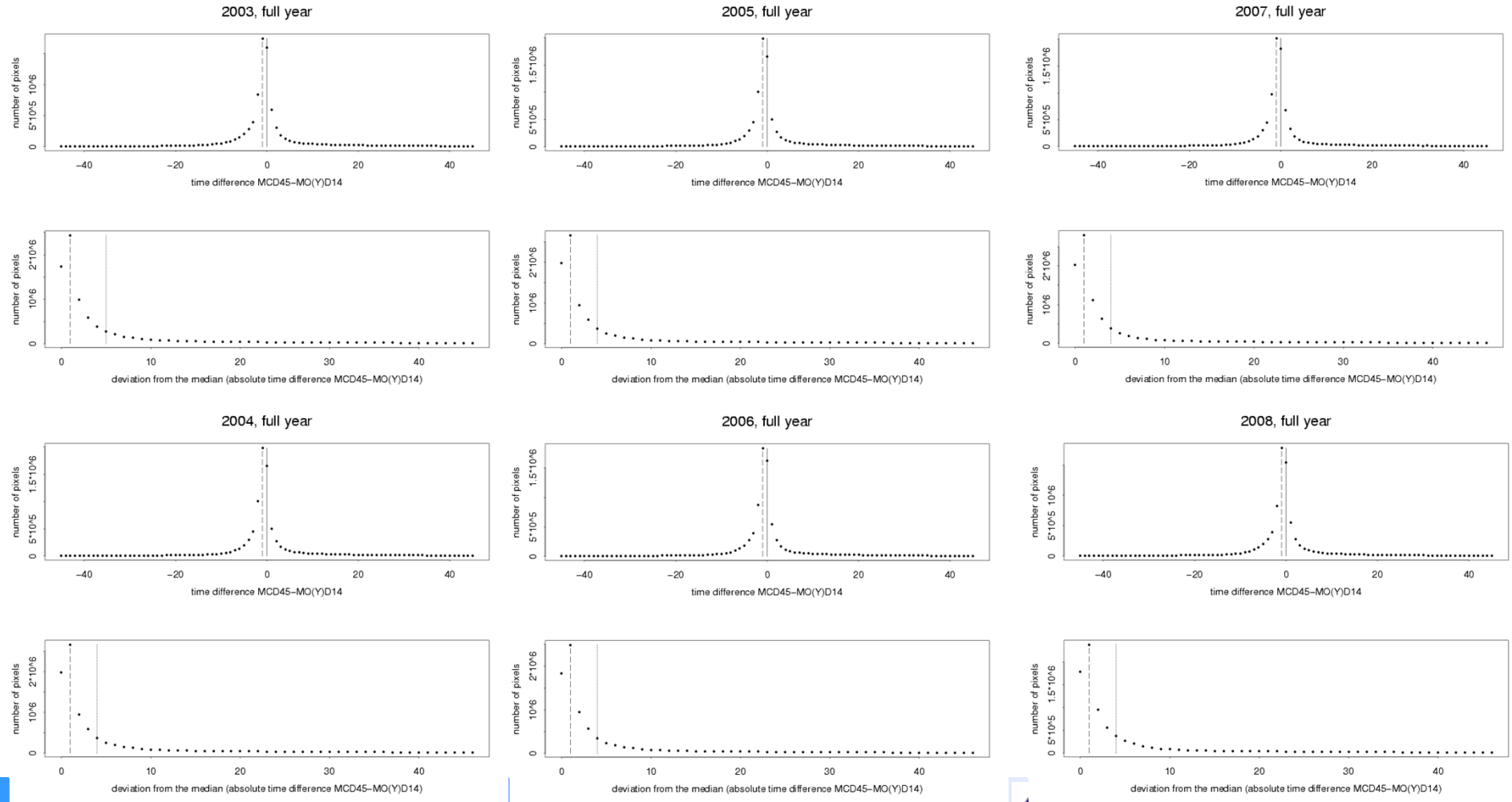
- Active Fire (Terra or Aqua)
- Burned area

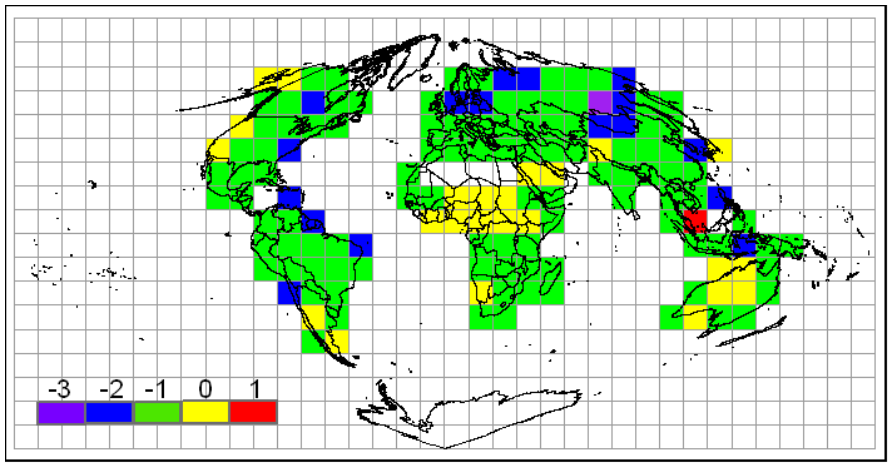
Time difference analysis global, 6 years



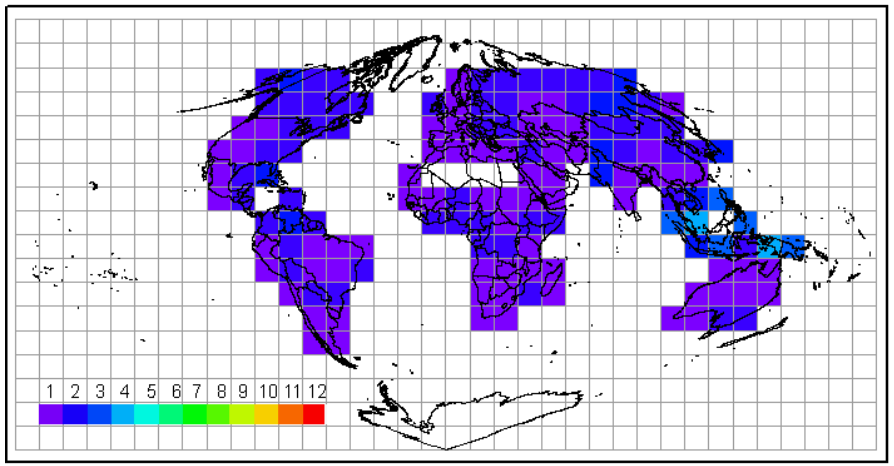


Consistent annual results

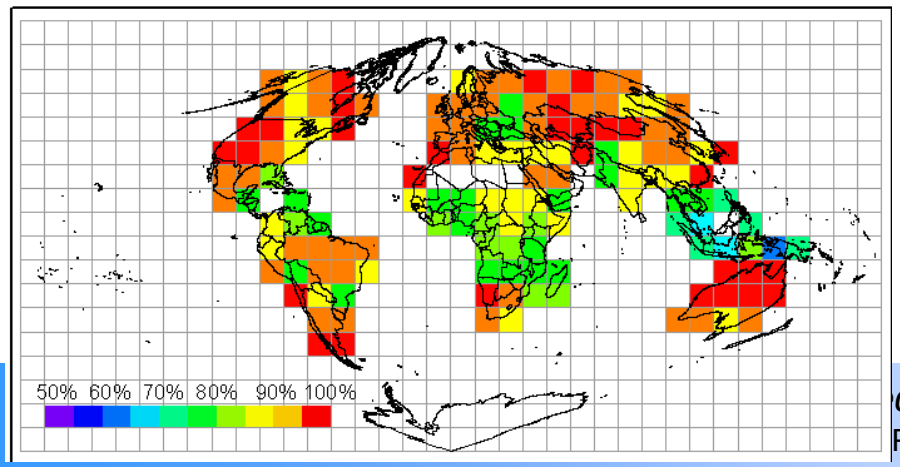




Median difference



50% of deviation from the median



% of pixels within the nominal 8 day uncertainty

d area validation
Roy, Stehman

Boschetti et al, 2010

Validation of spatial extent

- Based on CEOS Cal Val Protocol for the Production and standardization of validation reference data (community accepted standard).
- Sampling and Accuracy measures not included in the protocol yet (current research)
- Prototype of stage 3 validation for global burned area products

Burned Area Product Validation Protocol

- Compare MODIS burned area product with independent spatially explicit burned area data derived from multitemporal Landsat ETM+ data
- SAFNet field trip held to develop the mapping protocol and to discuss southern African fire information needs, Zimbabwe-Zambia, July 2000
- SAFNet members map the areas burned between 2+ Landsat acquisitions, augmented by limited fieldwork
- Consensus mapping protocol to ensure regionally consistent independent validation data
- protocol followed 2000-2002 at ~11 ETM+ scenes/year

Roy, D. et al. 2005, The Southern Africa Fire Network (SAFNet) regional burned area product validation protocol, *International Journal of Remote Sensing*, 26:4265-4292.

Reference dataset produced using pre-burn and post-burn data

Priorities:

1- ensure the accuracy of the reference data: local partners involved in the interpretation of the high resolution data

2- temporal consistency: map the changes between two acquisitions

3- spatial consistency: differentiate between unburned areas and areas that could not be interpreted due to data quality issues, or not visible because of clouds or shadows

Examples: Mapping the changes

Image 1: 10 Sept 2001

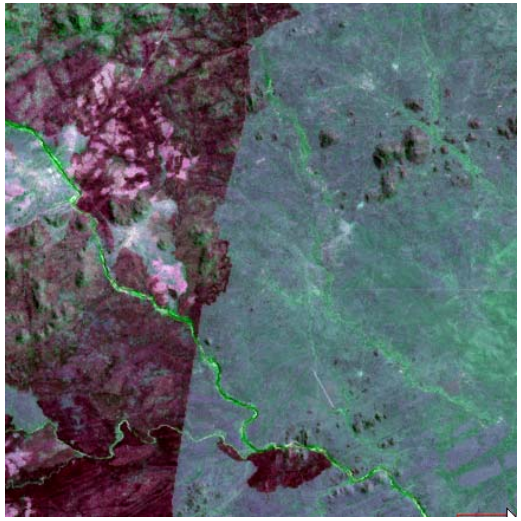
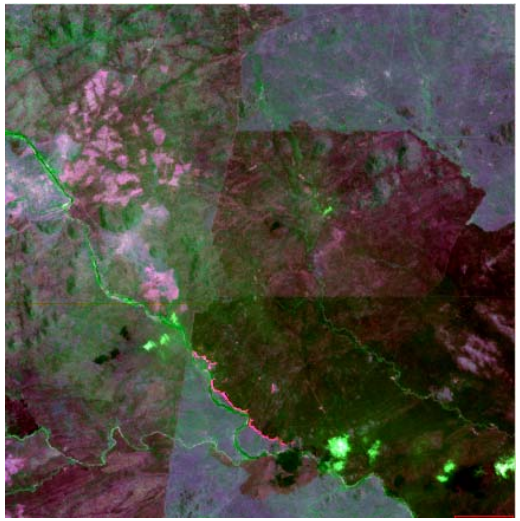


Image 2:12 Oct 2001



Interpretation

Examples: Mapping the changes

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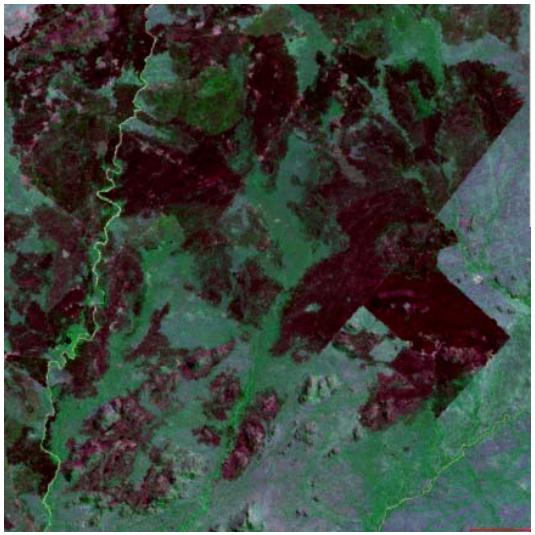

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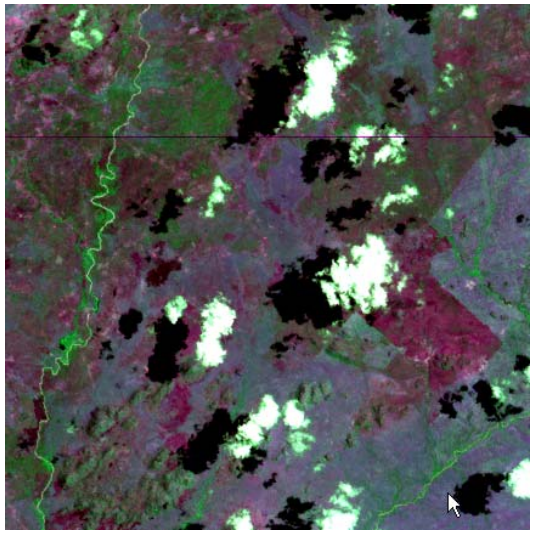


Interpretation

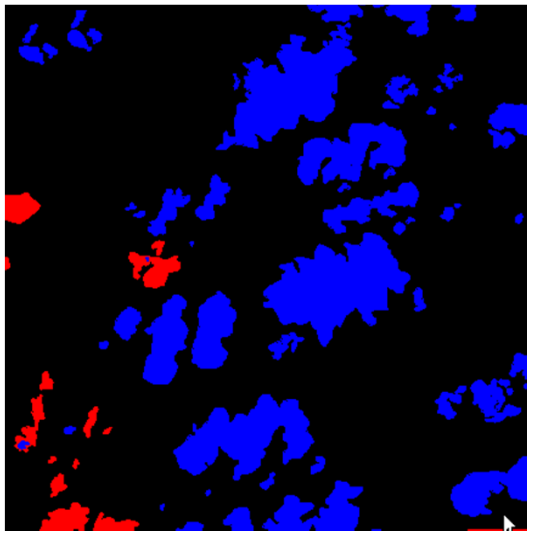


Image 1:

Landsat ETM+

Sept. 4th

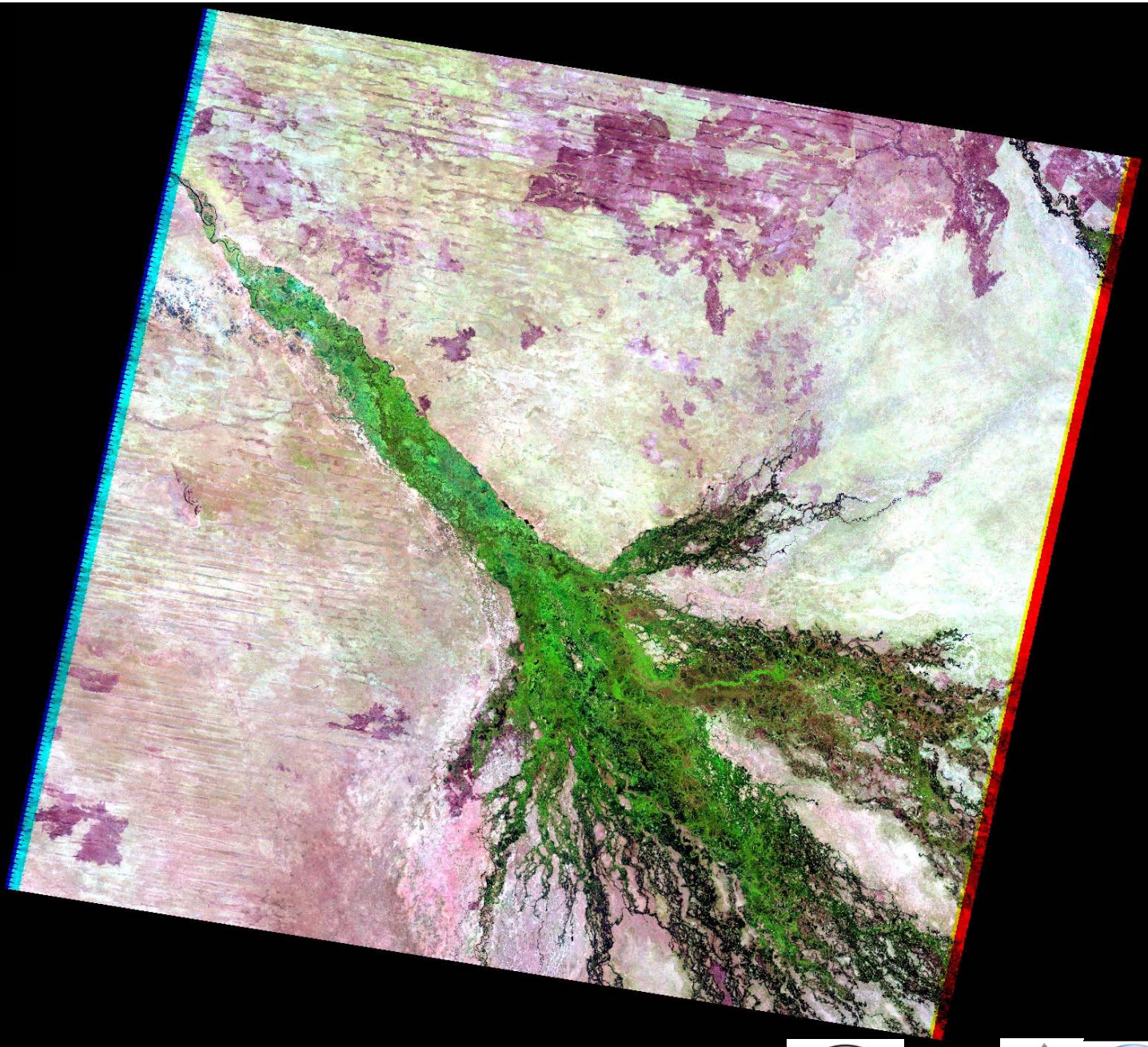
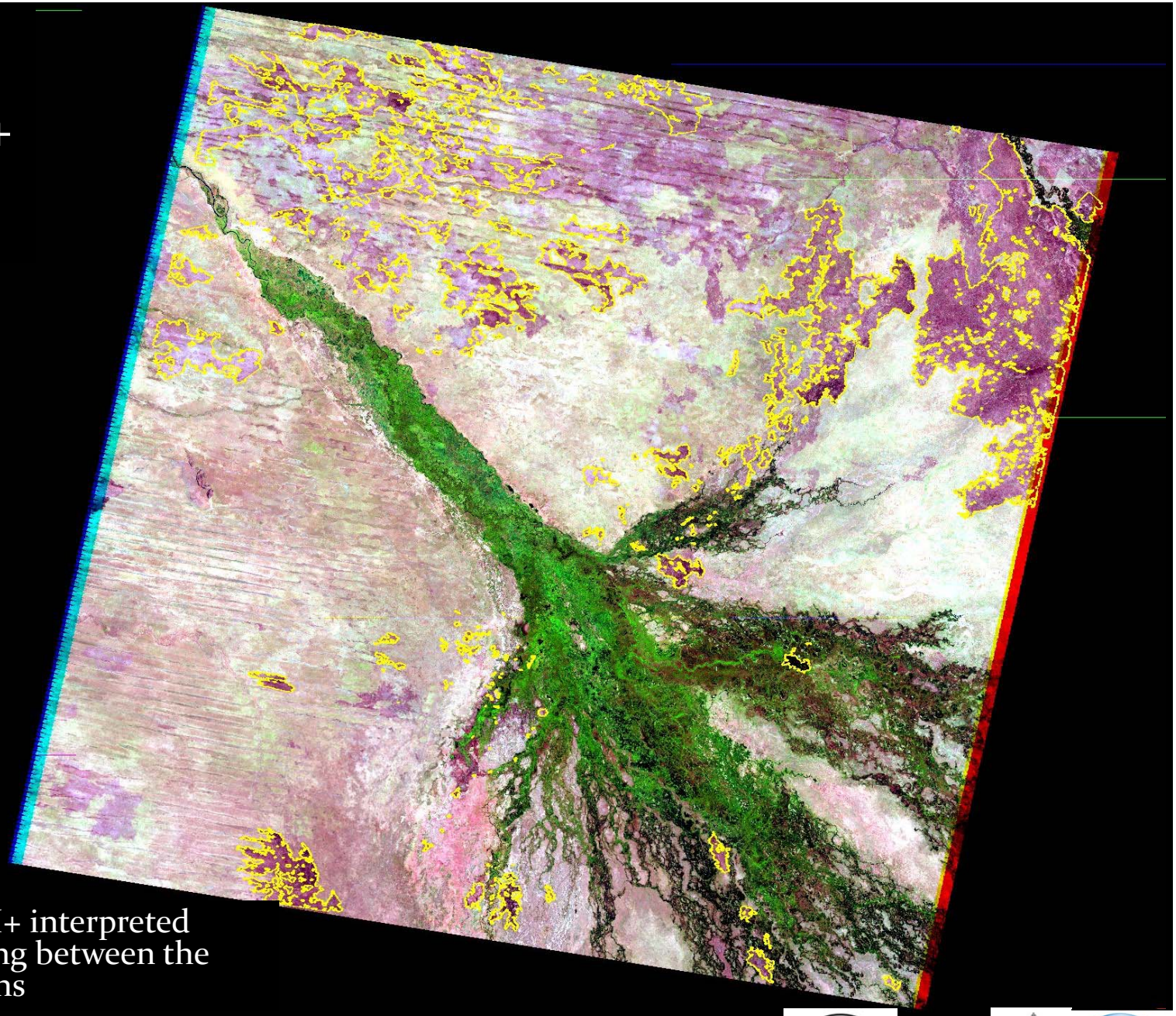


Image 2:

Landsat ETM+

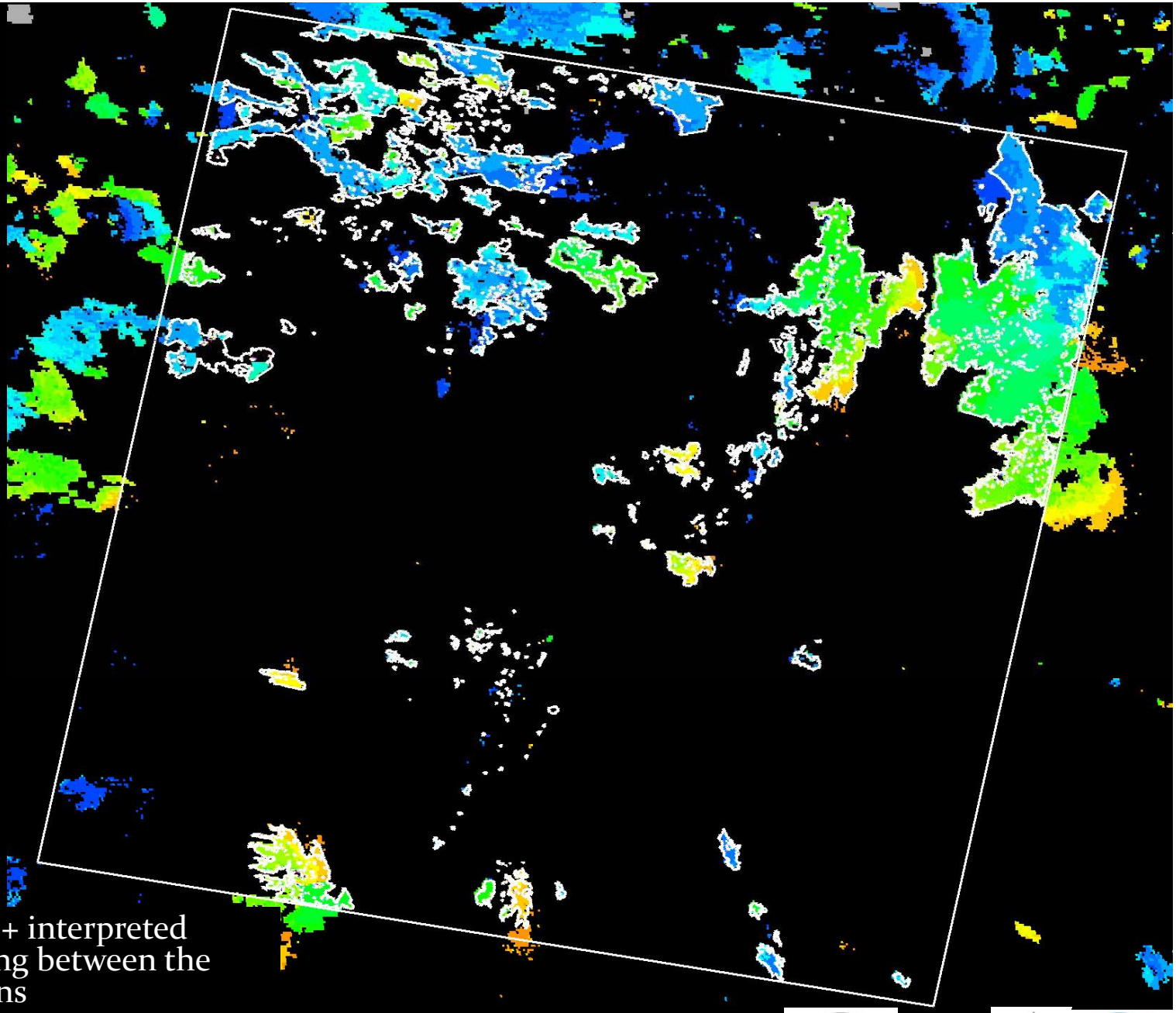
Oct 6th



Yellow vectors = ETM+ interpreted burned areas occurring between the two ETM+ acquisitions

MODIS 500m Burned Areas

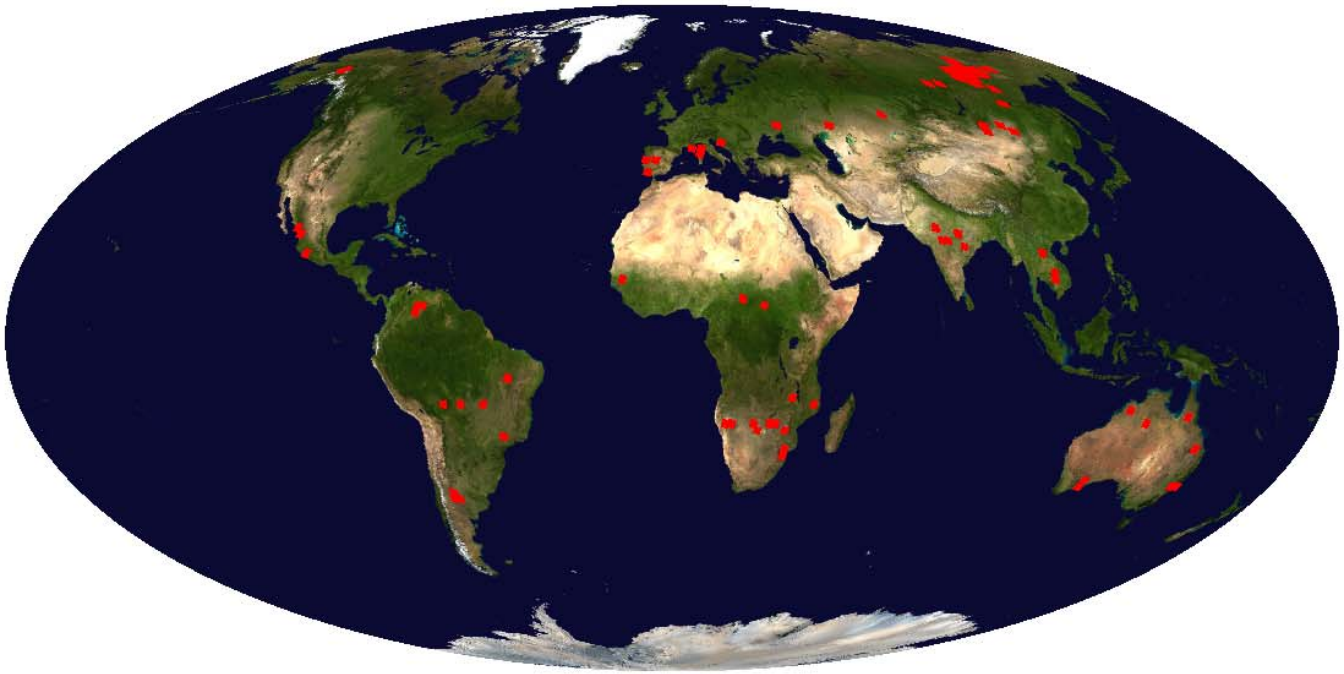
Sept. 4
to
Oct. 6

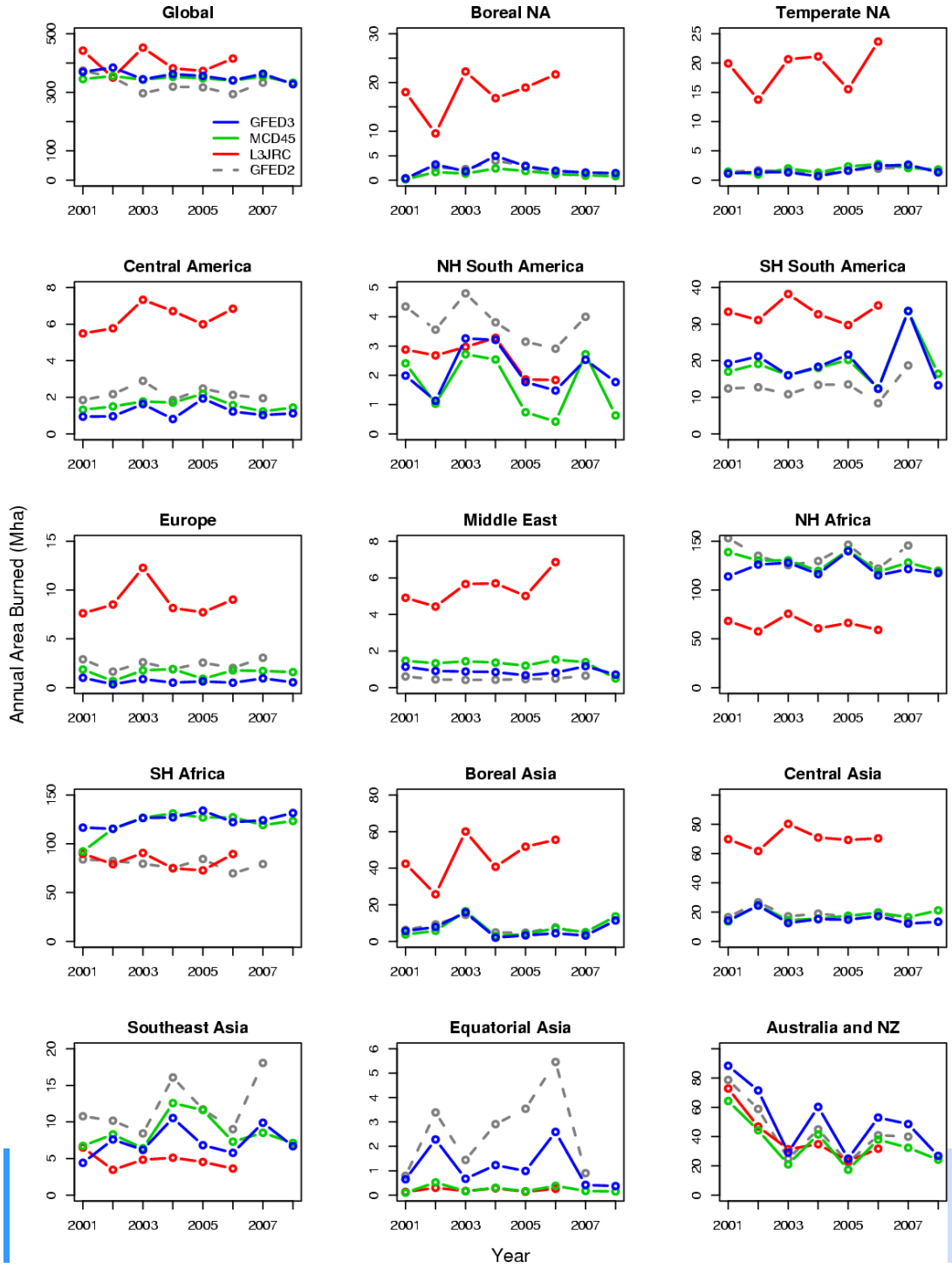


White vectors = ETM+ interpreted burned areas occurring between the two ETM+ acquisitions

The case for Stage 3 validation

- MODIS Stage 2 validation dataset. 100 Landsat image pairs



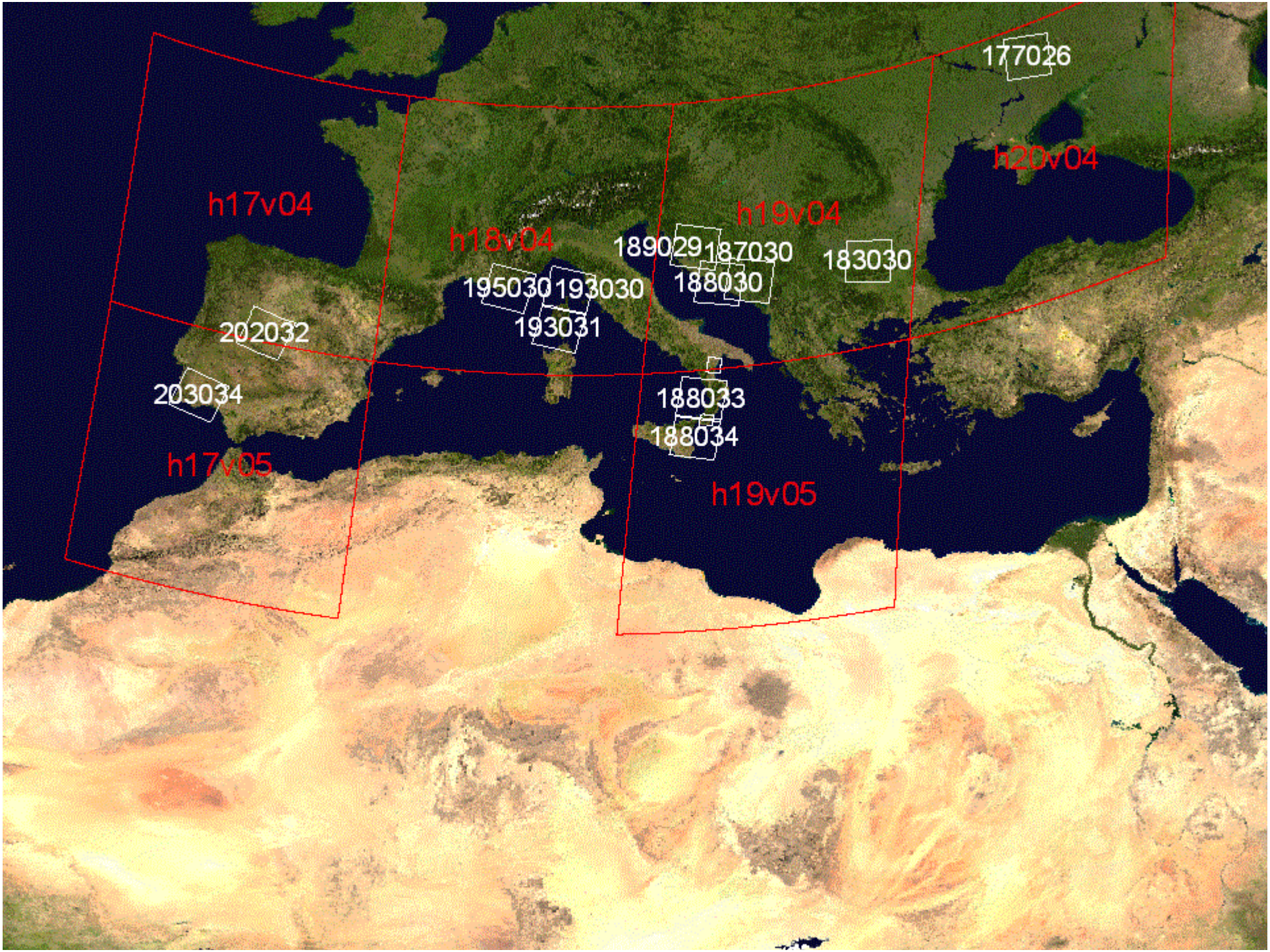


Product Intercomparison:

in the absence of validation it shows the differences and similarities between products, but it is insufficient to quantify the accuracy

Giglio et al., 2010


Nº 28
DICIEMBRE 2007
REVISTA DE TELEDETECCIÓN
ASOCIACION ESPAÑOLA DE TELEDETECCION
REVISTA DE LA ASOCIACIÓN ESPAÑOLA DE TELEDETECCIÓN
50km


177026
h20v04
h17v04
h19v04
h18v04
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195030
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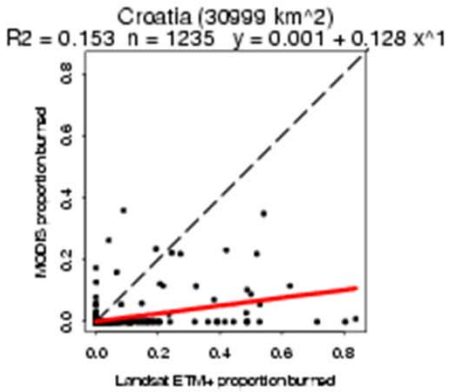
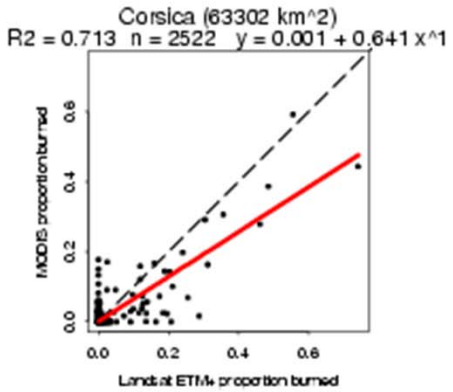
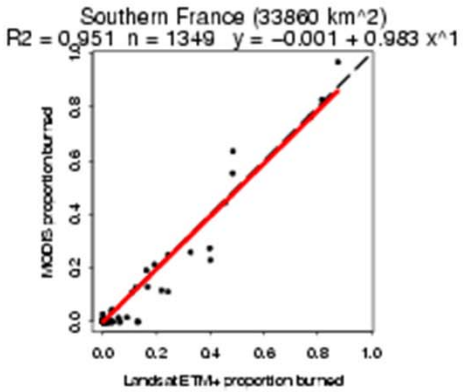
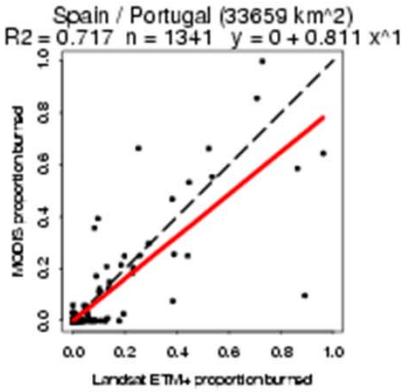
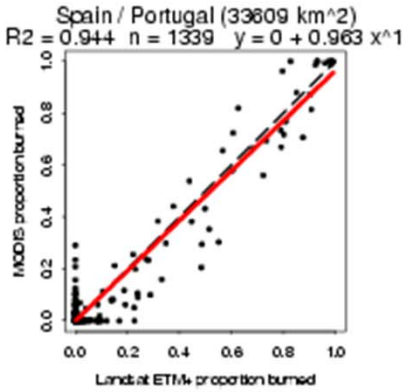
h17v05
h19v05

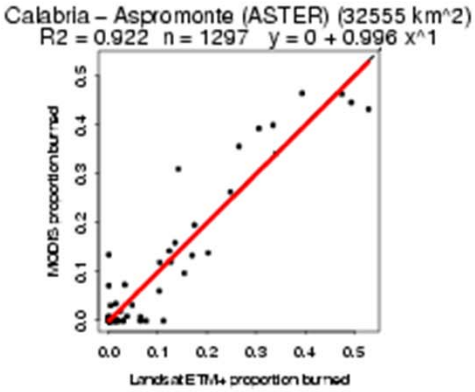


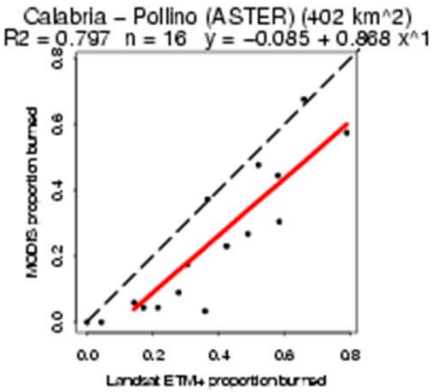






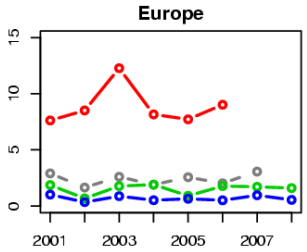






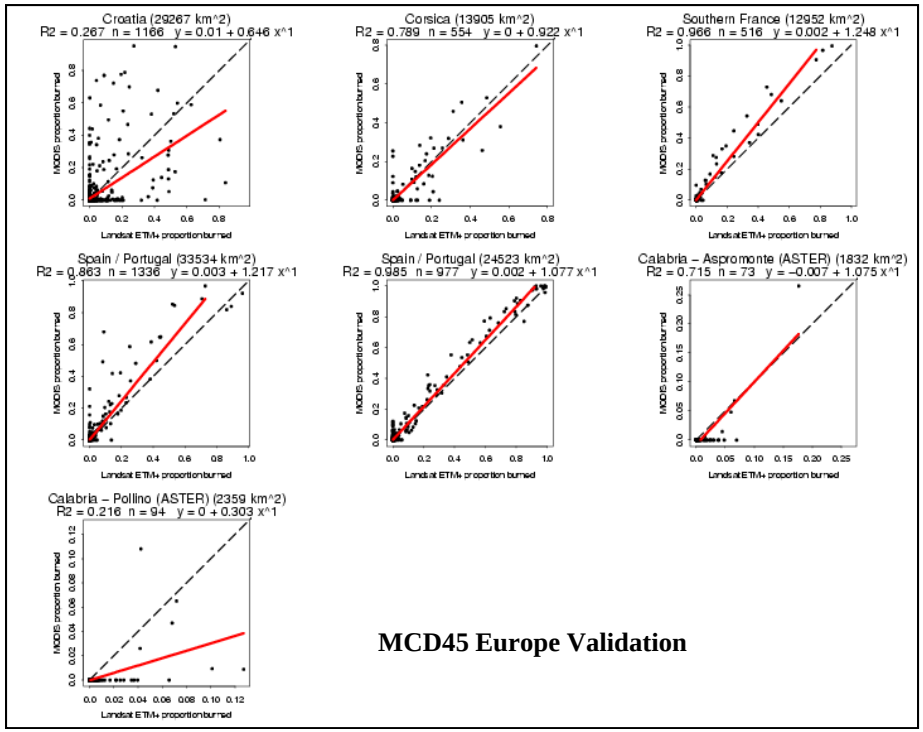
2003 VALIDATION: L3JRC
REGRESSION OVER 5KM X 5KM CELLS

- L3JRC performs very well on MODIS Europe validation dataset.
- Intercomparison: Giglio et al 2010, shows that L3JRC detects more than MCD45, GFED 2 and GFED 3 in Europe



- **Is the Stage 2 dataset enough to conclude that L3JRC has the right estimate?**

- MCD45 also performs well on Stage 2 dataset!



MCD45 Europe Validation

- Stage 3 needed to characterize fully the variability! (sampling in space and time)

Designing a Stage 3 validation dataset

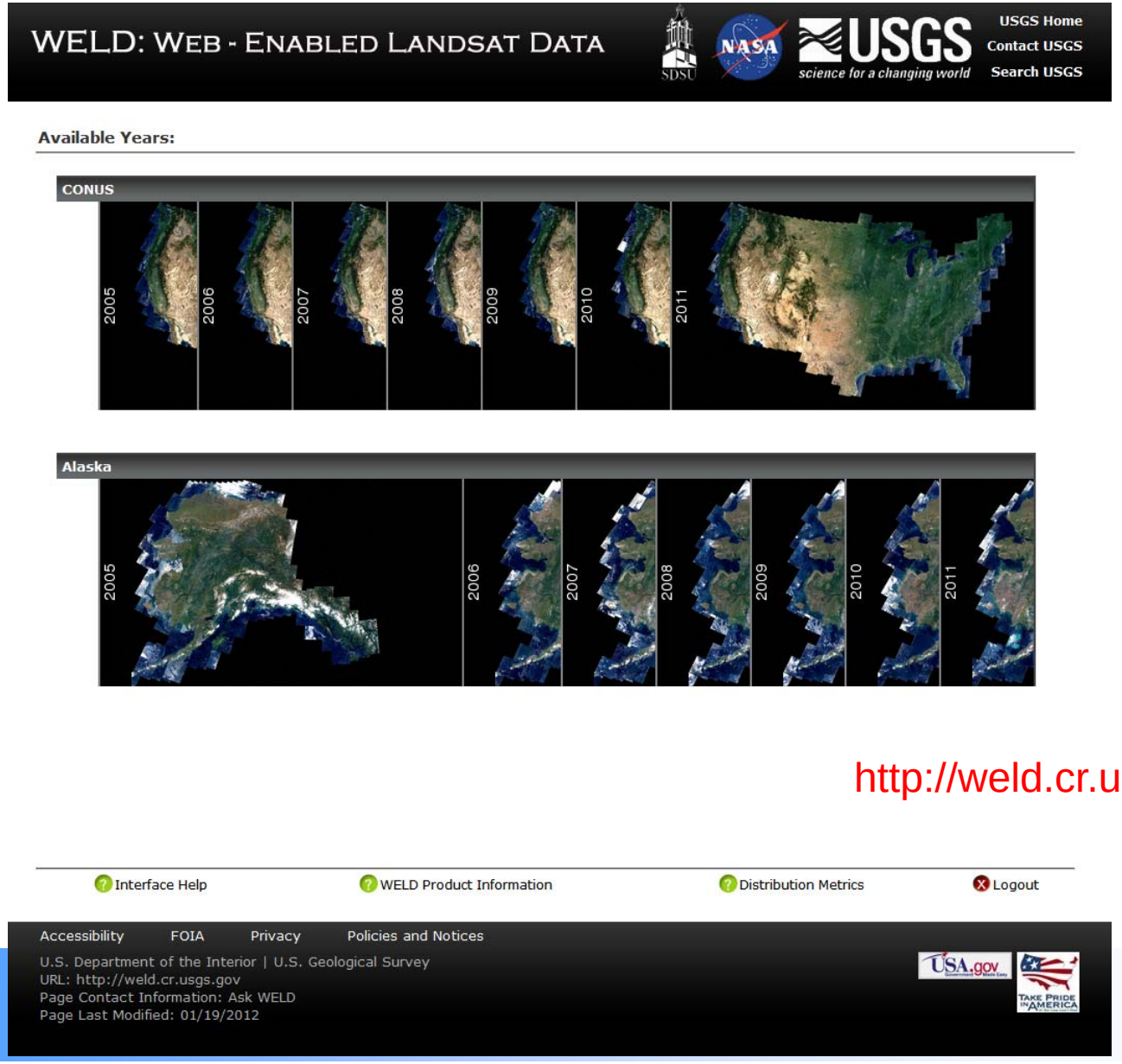
Characteristics of the Stage 3 sampling

- Stratified random sampling
- Total population of the dataset: all the Landsat pairs which respect the CEOS protocol requirements
  - Cloud free
  - Within a set time period (~2 months)
- Stratification
  - In space: sub-continental regions
  - In time: fire seasonality based on MODIS active fire detections
- Number of samples guided by the results of stage 2 validation on C5.1

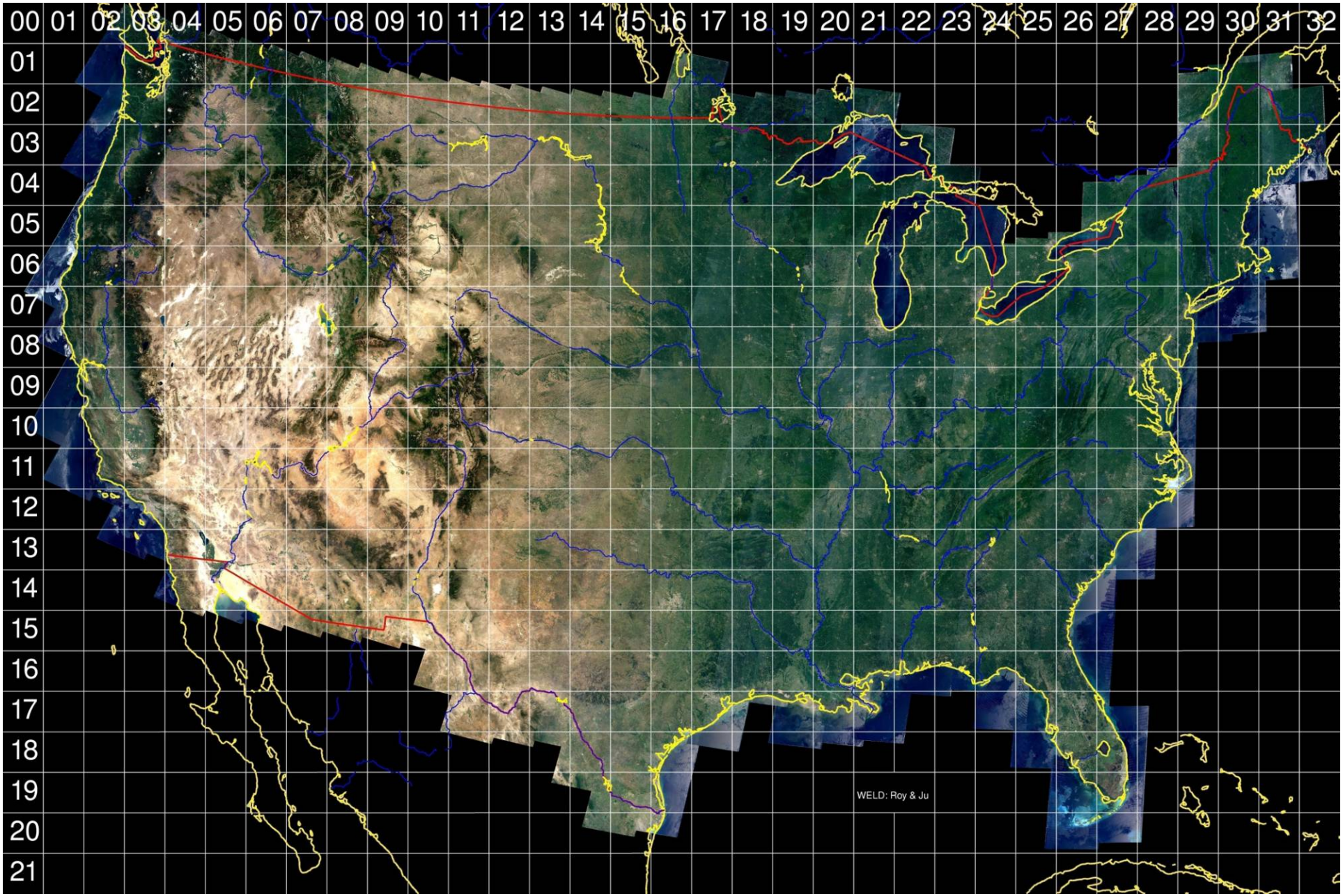
MODIS-Landsat data fusion for high spatial resolution multi-annual wall to wall burned area mapping of the conterminous United States

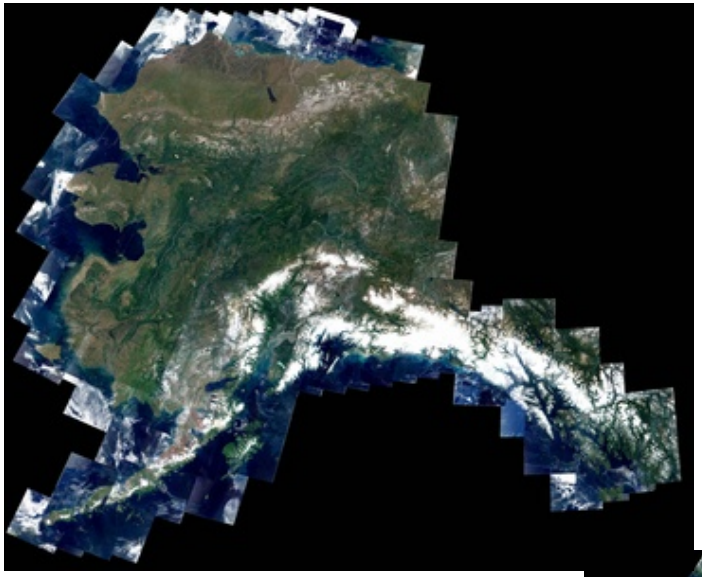
Prototype developed under NASA funding
February 2011 – January 2014

7+ Years of Landsat ETM+ WELD products



WELD Tile Map (CONUS has 501 5000x5000 30m pixel tiles in Albers)



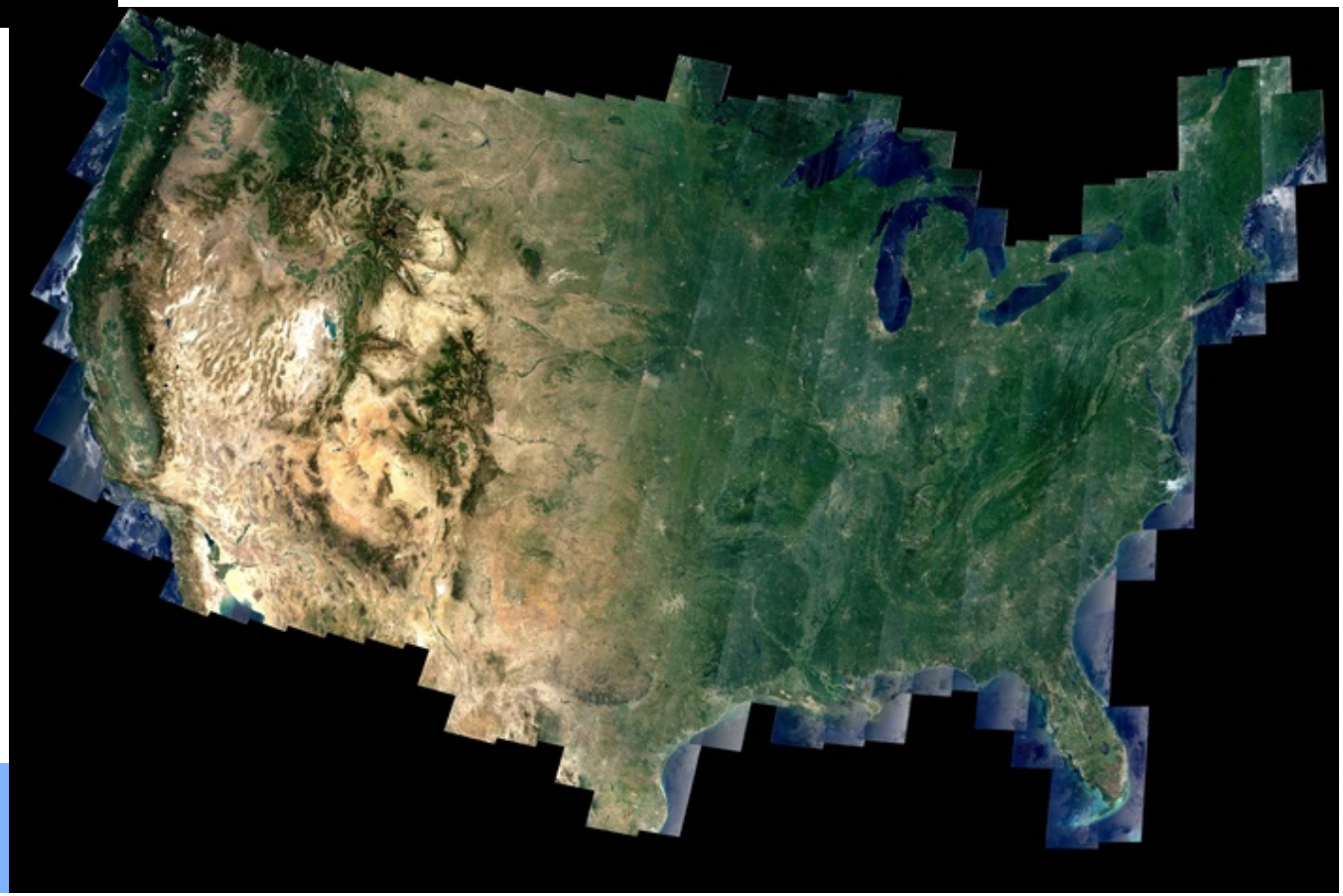


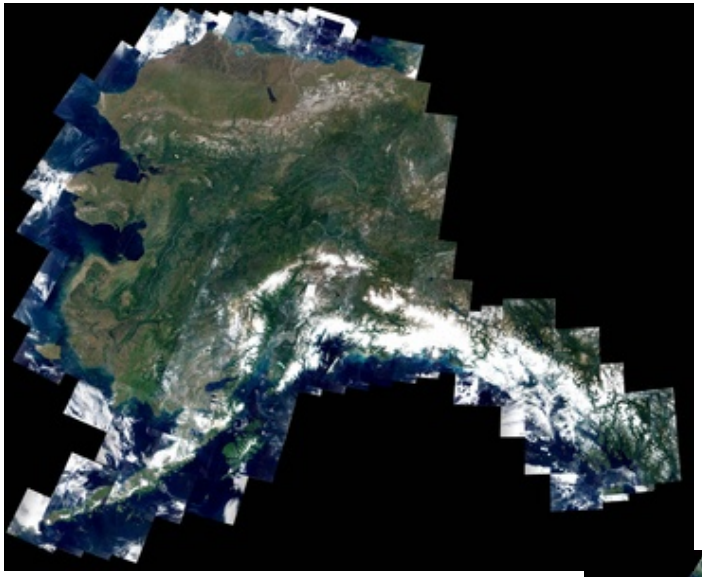
Annual

(December 2009 – November 2008)

Alaska ~ 1,700 L1T acquisitions / year

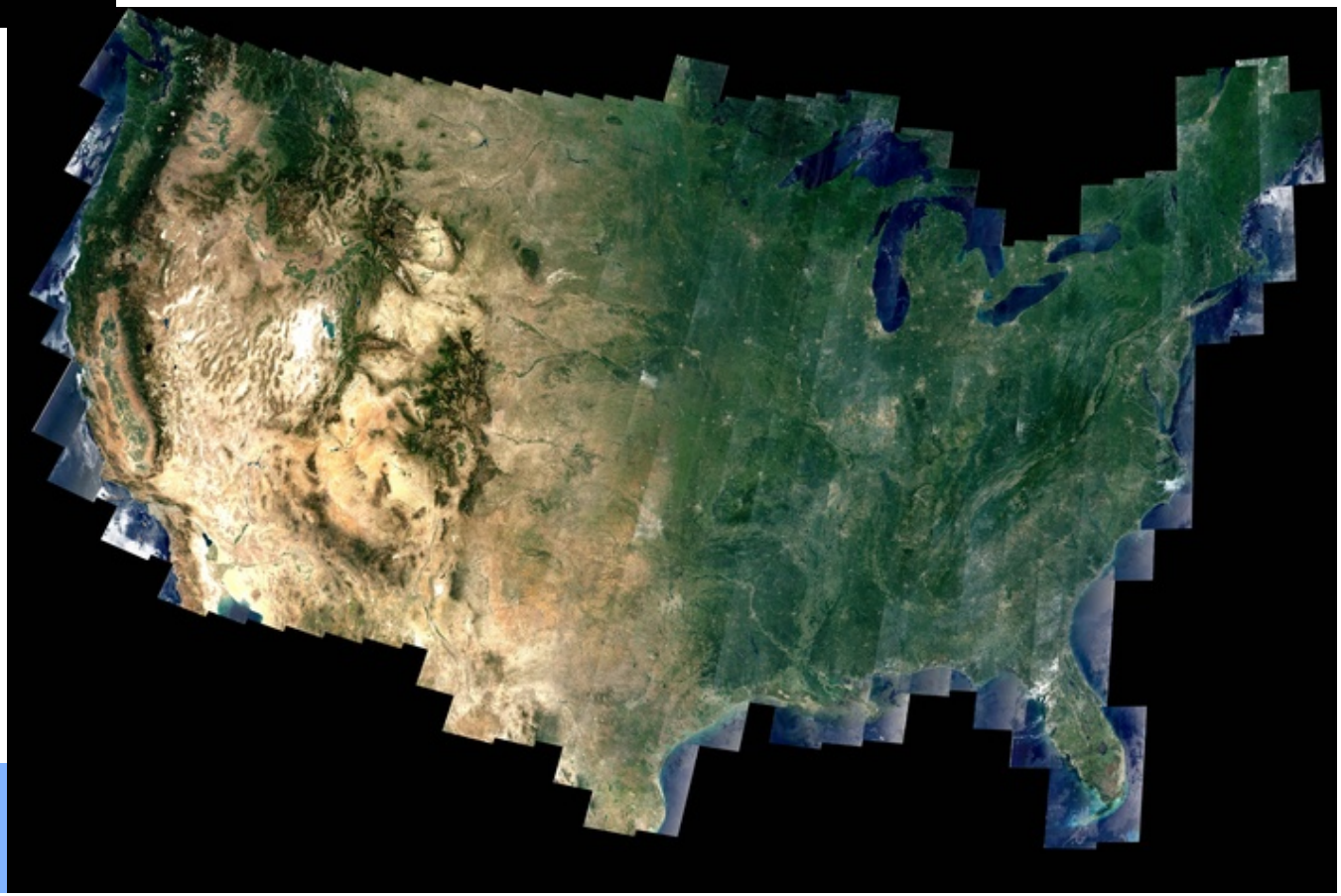
CONUS ~ 8,000 L1T acquisitions / year

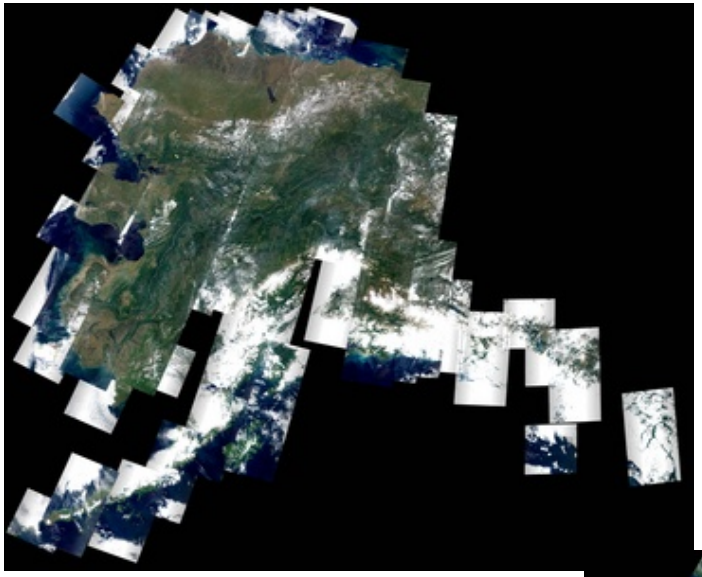




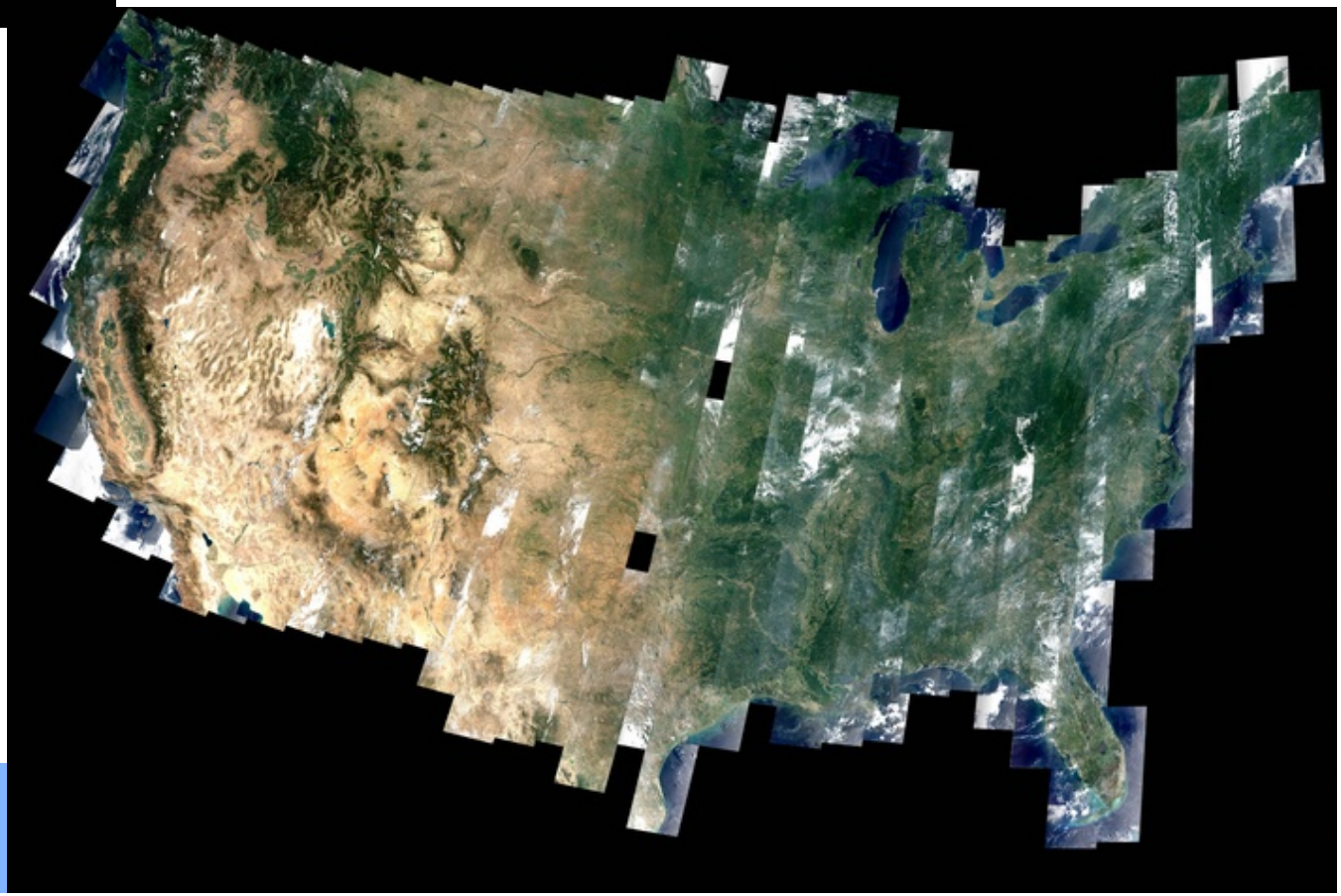
Summer

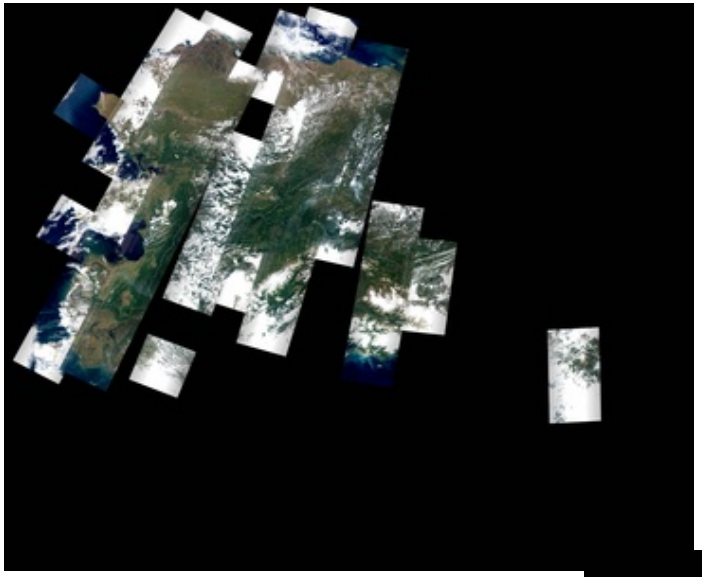
(June, July, August) 2008



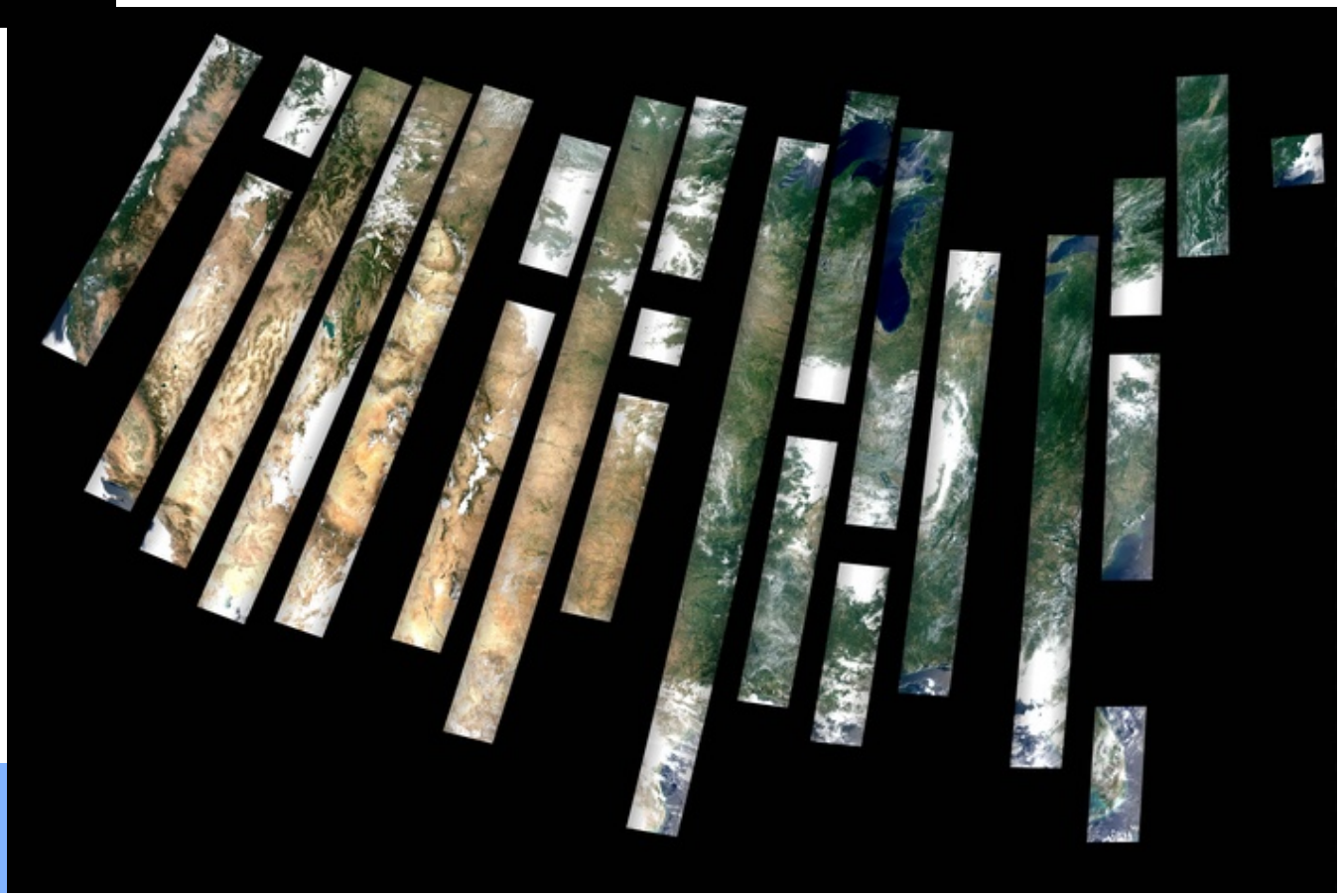


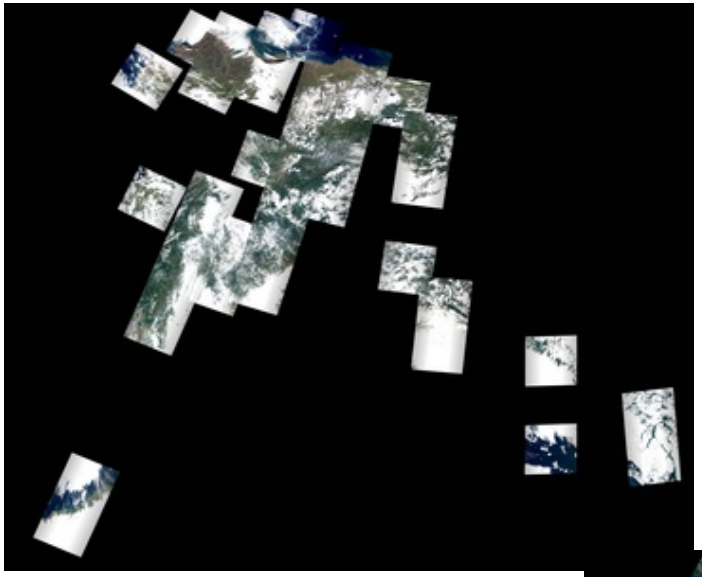
July 2008



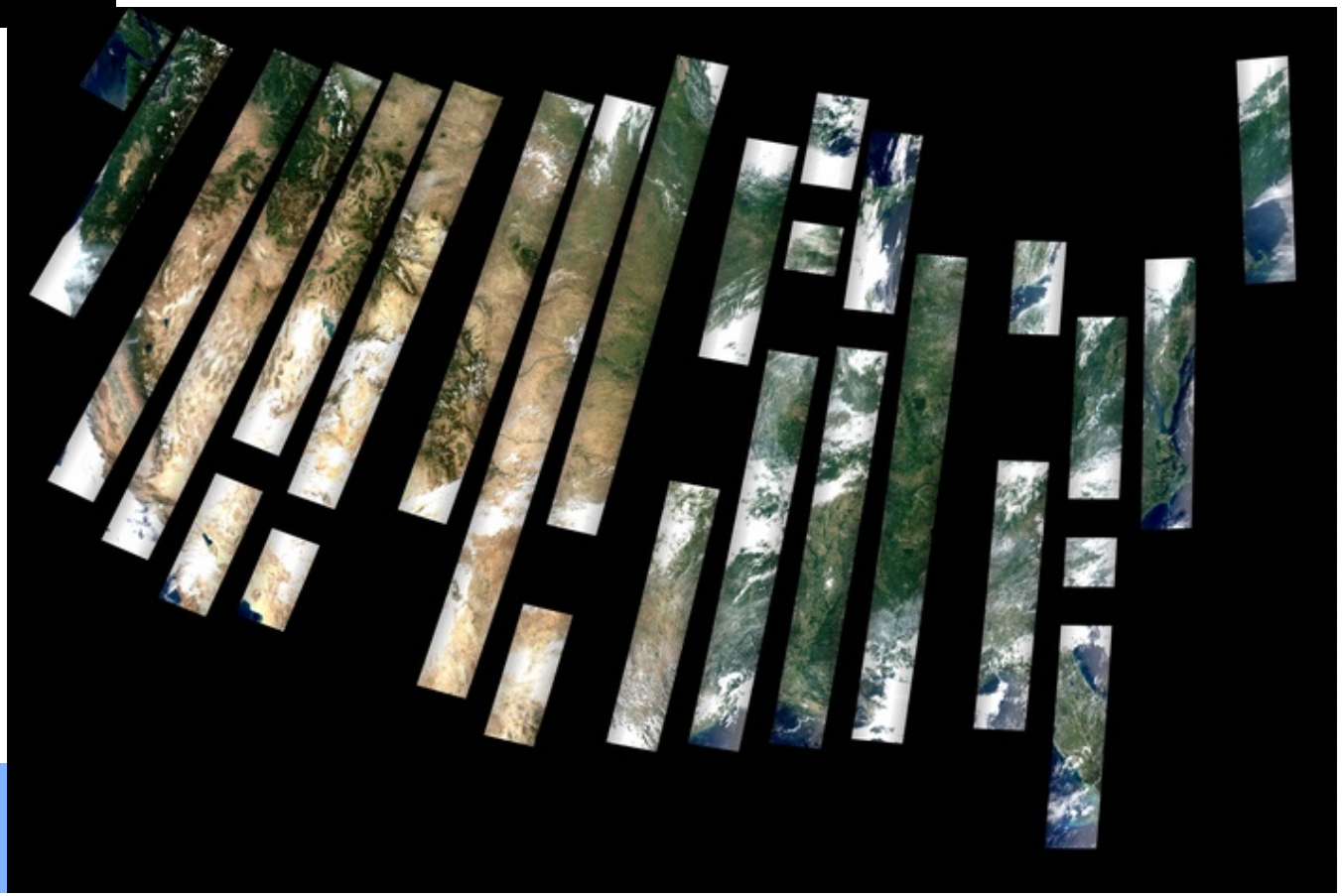


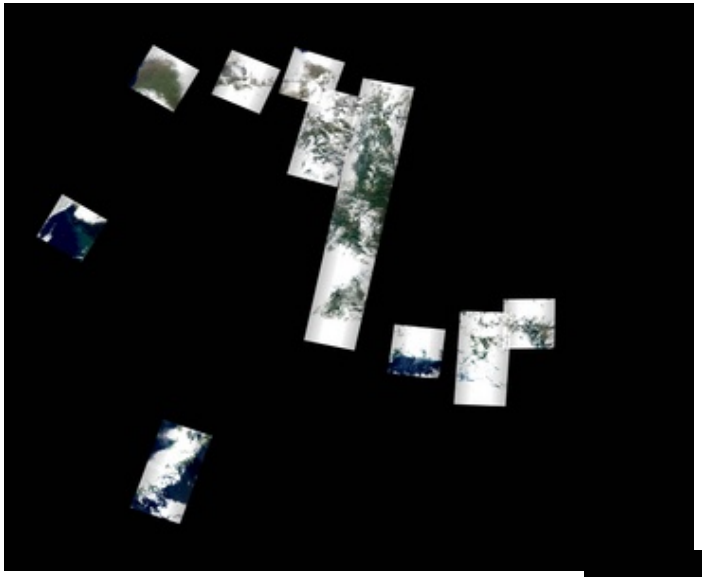
Week 27: July 8 - 14 2008



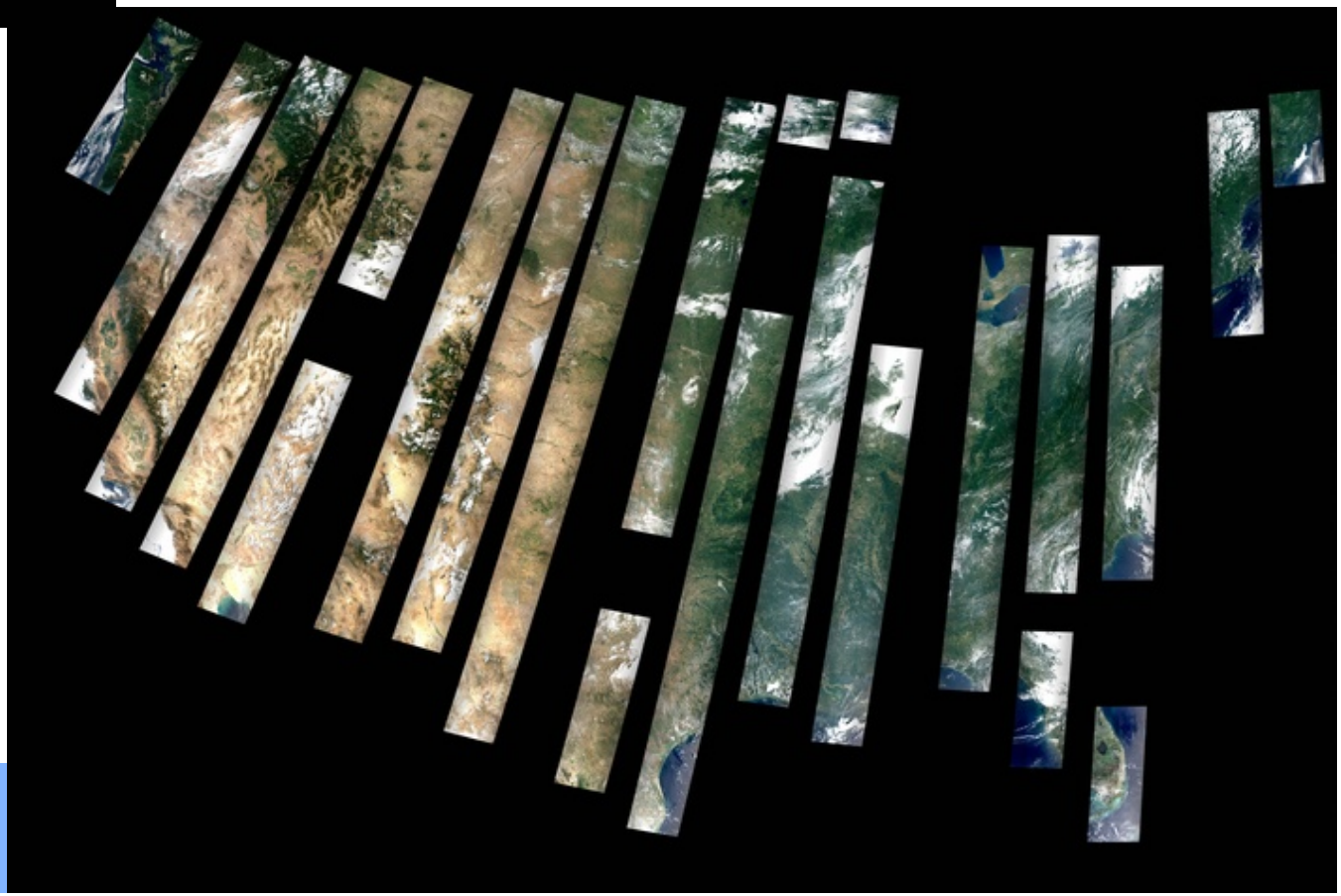


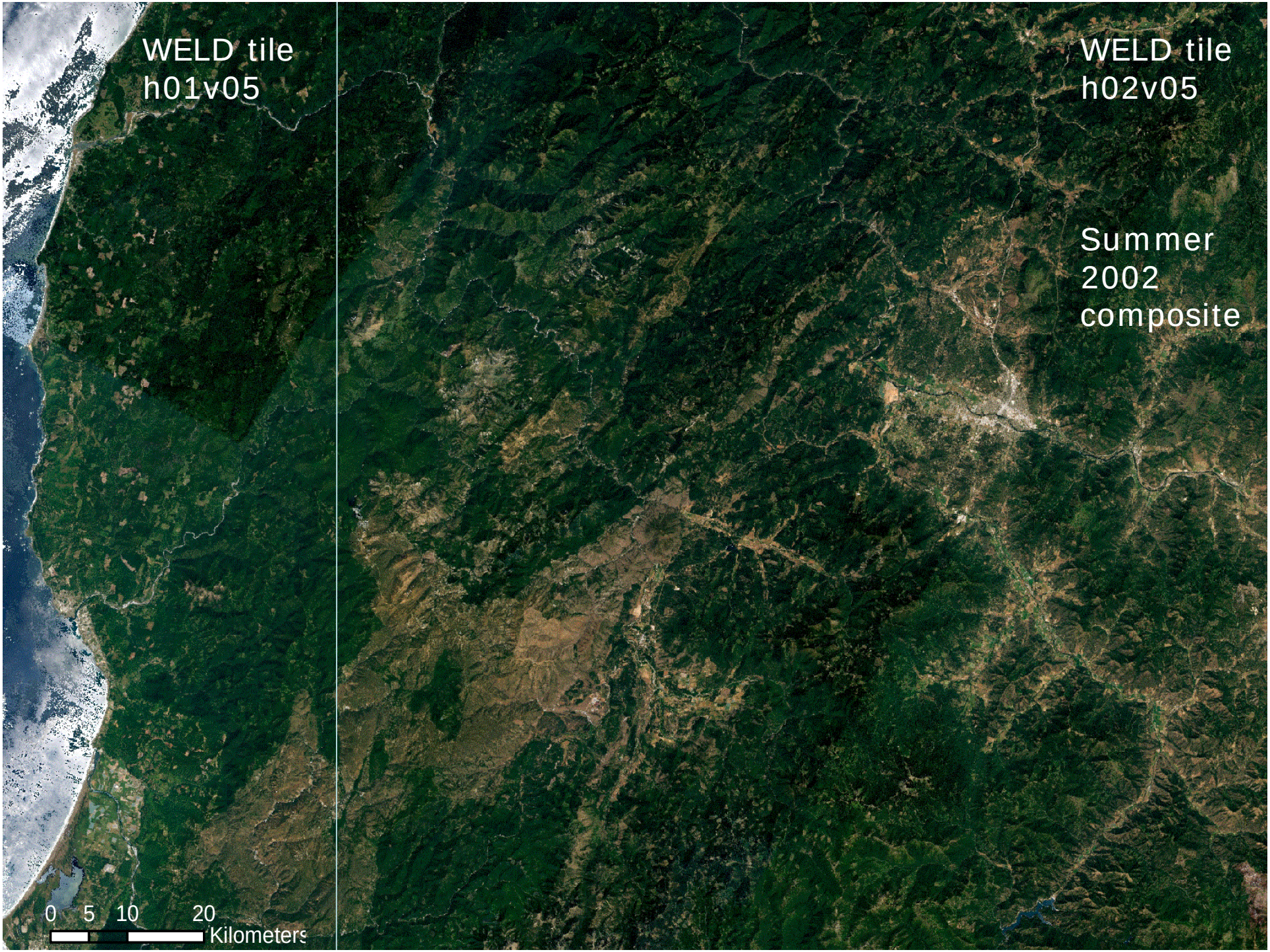
Week 28: July 8 - 14 2008

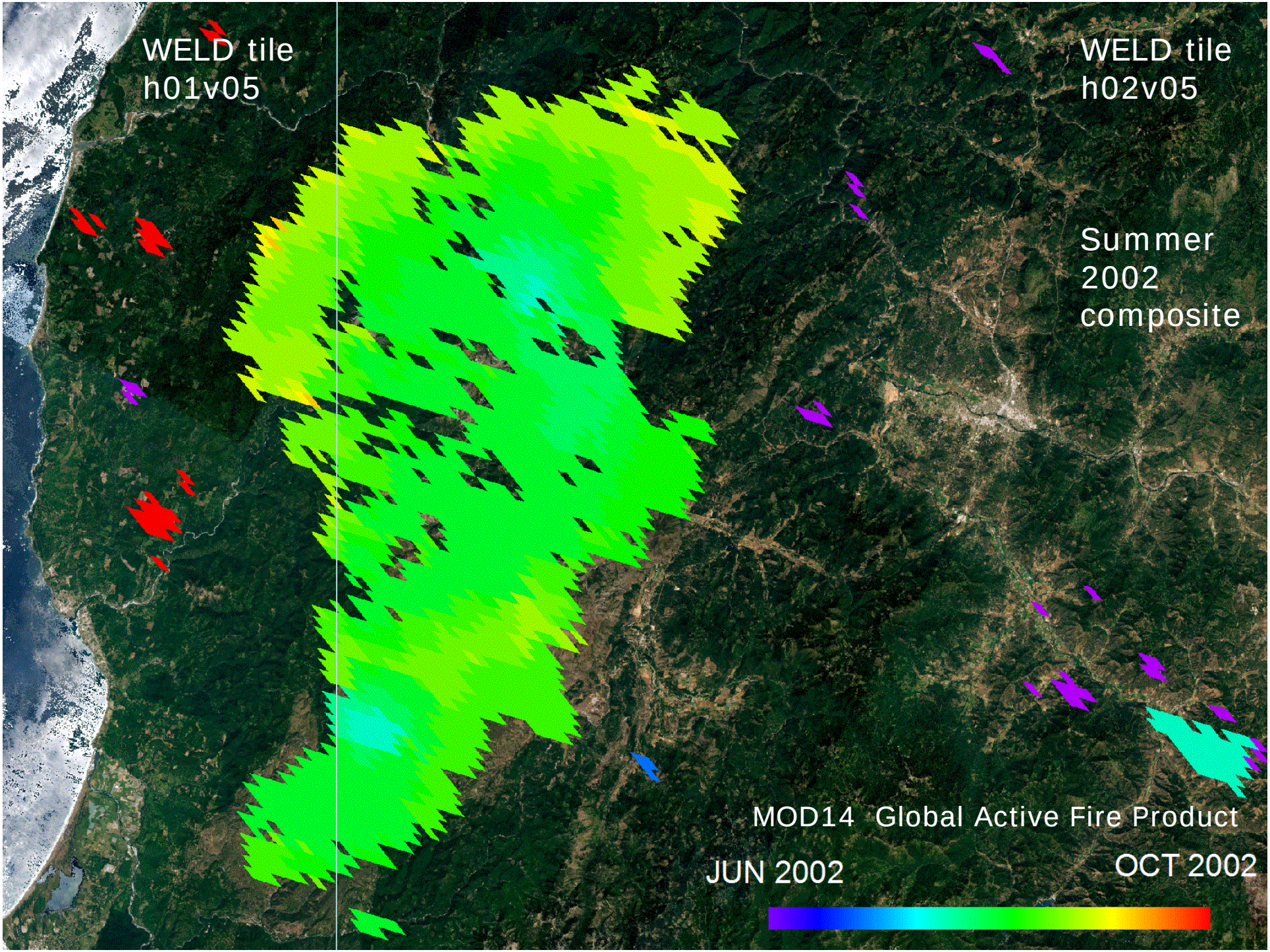


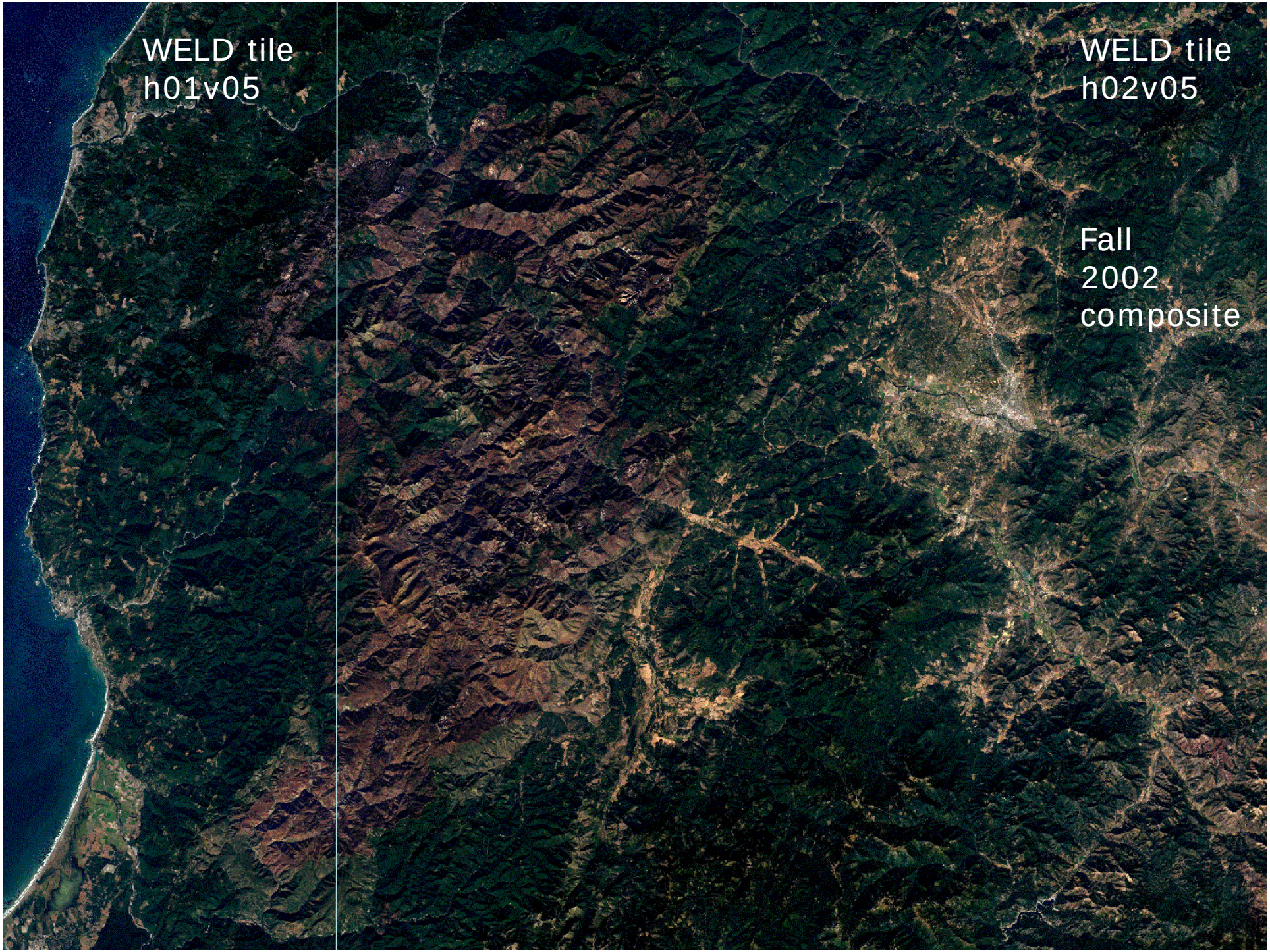


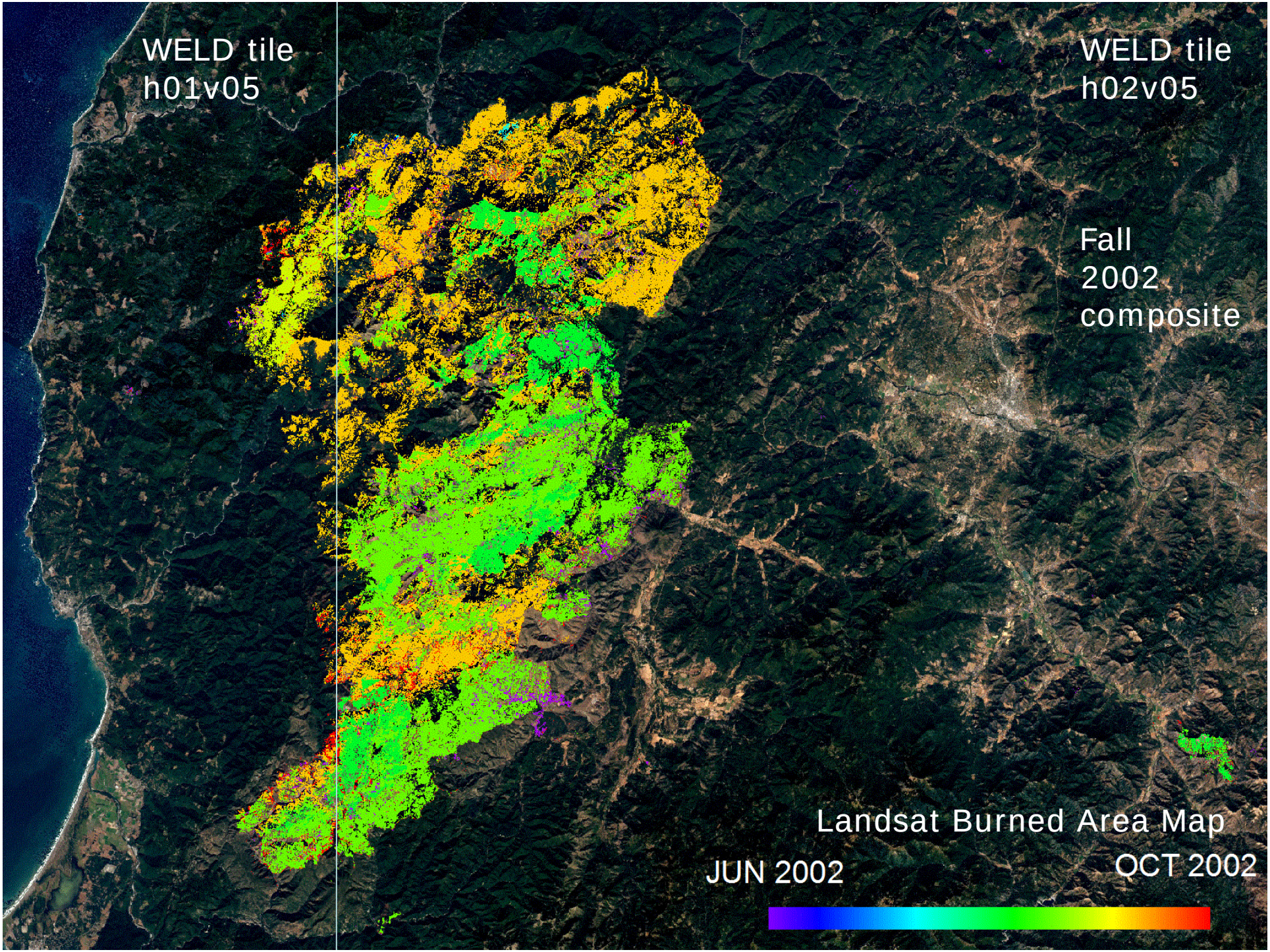
Week 29: July 15 - 21 2008

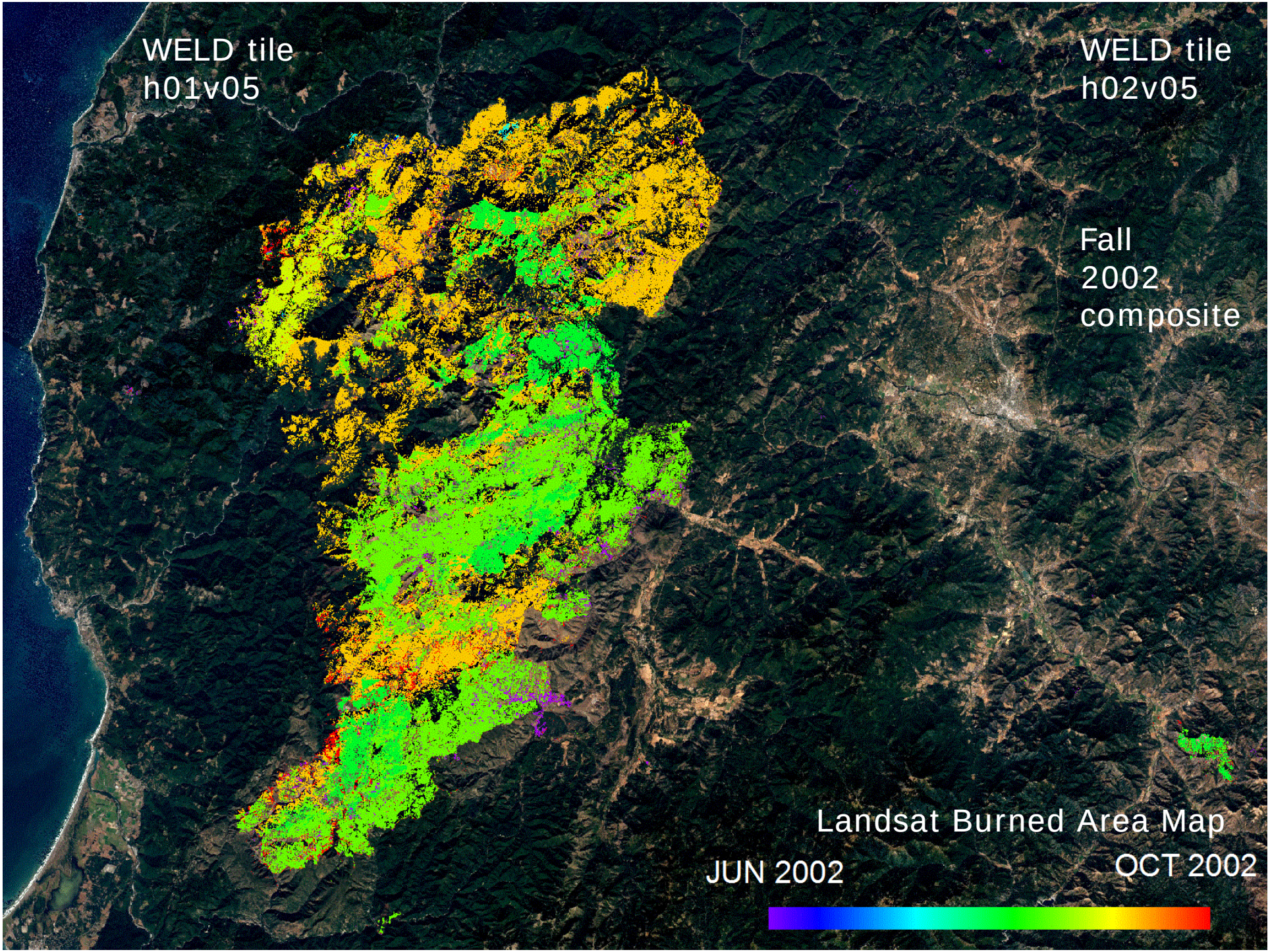


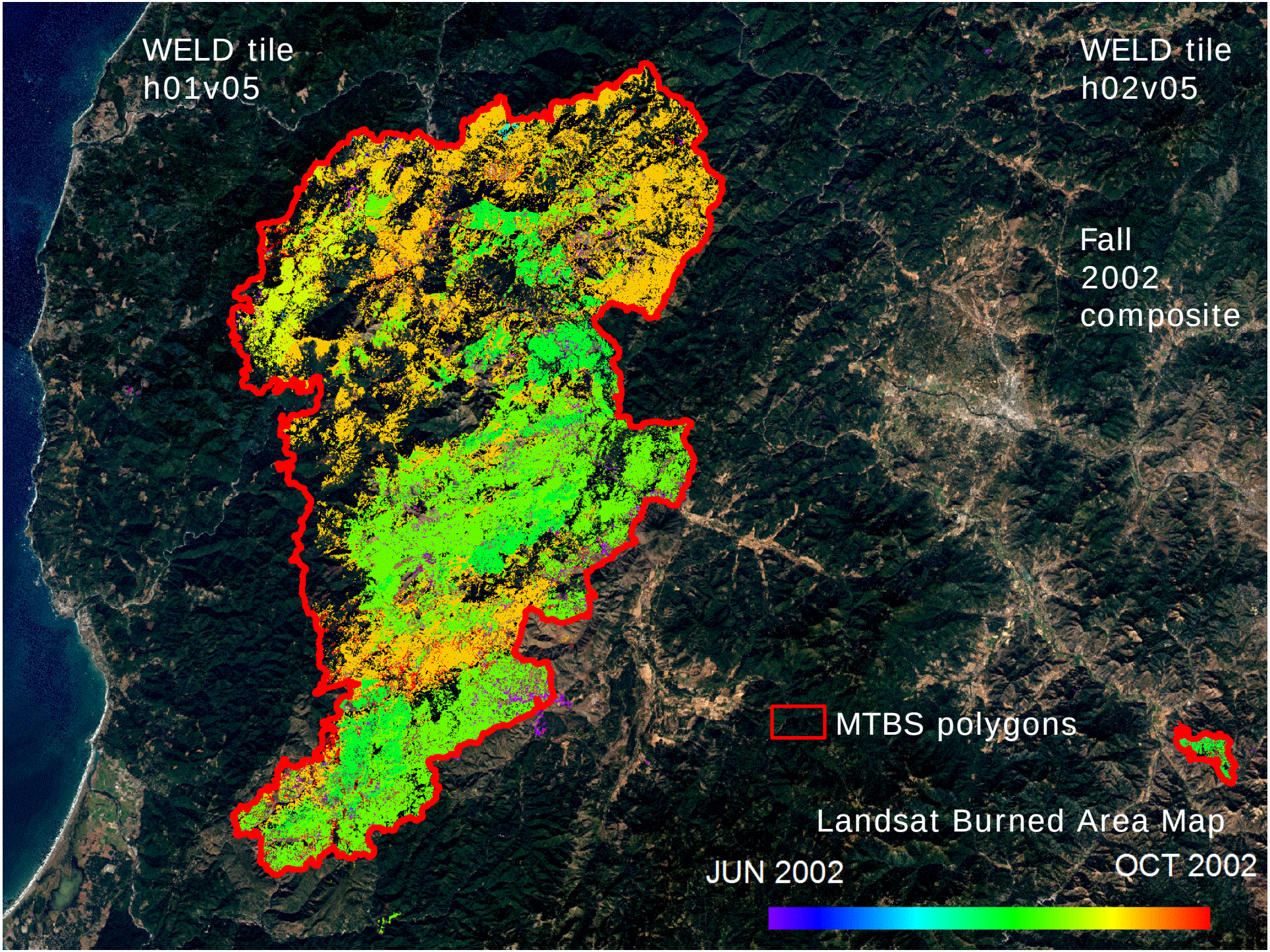

WELD tile
h01v05
WELD tile
h02v05
Summer
2002
composite
0 5 10 20
Kilometers


WELD tile
h01v05
WELD tile
h02v05
Summer
2002
composite
MOD14 Global Active Fire Product
JUN 2002
OCT 2002

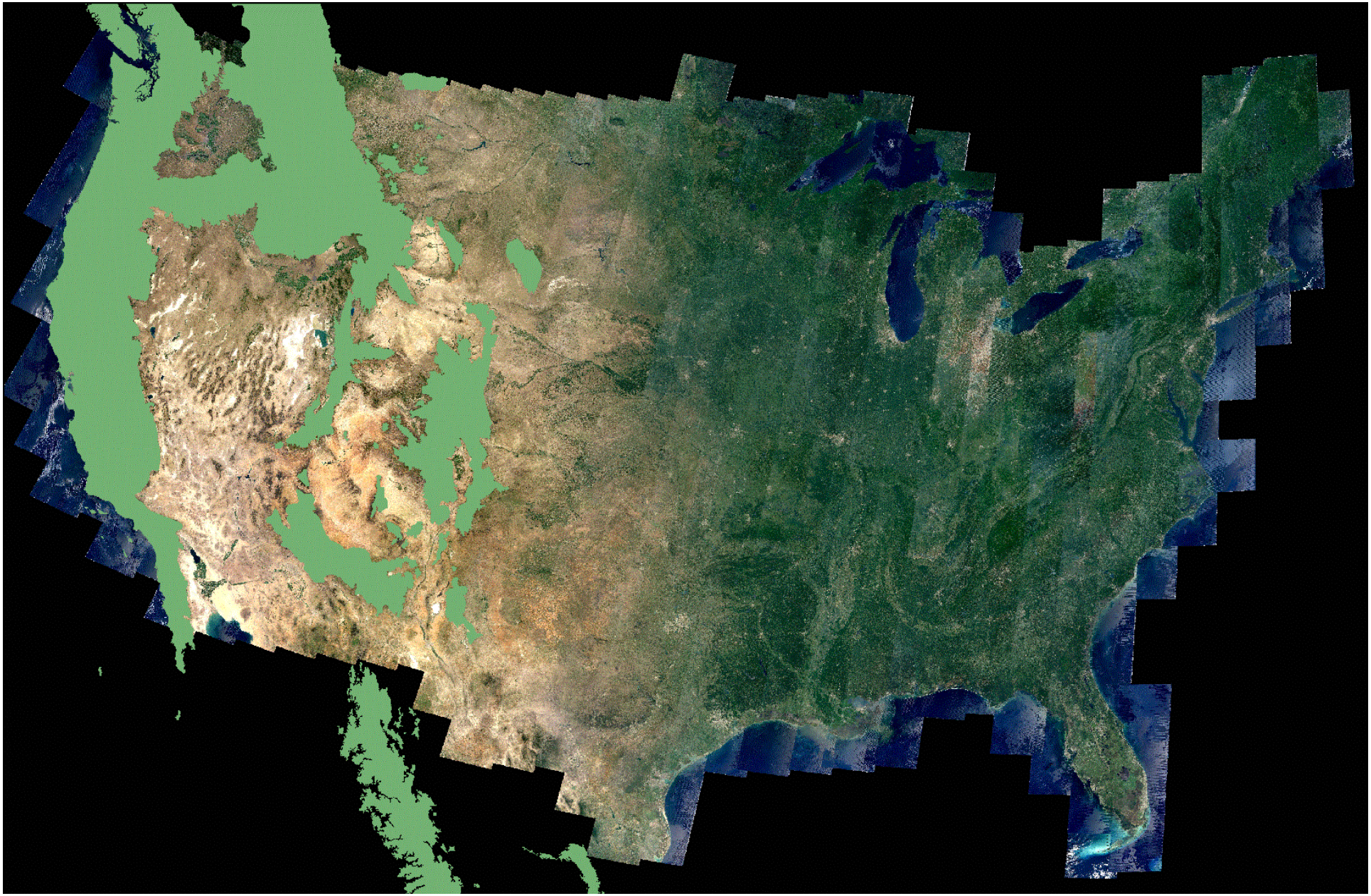

WELD tile
h01v05
WELD tile
h02v05
Fall
2002
composite


WELD tile
h01v05
WELD tile
h02v05
Fall
2002
composite
Landsat Burned Area Map
JUN 2002
OCT 2002

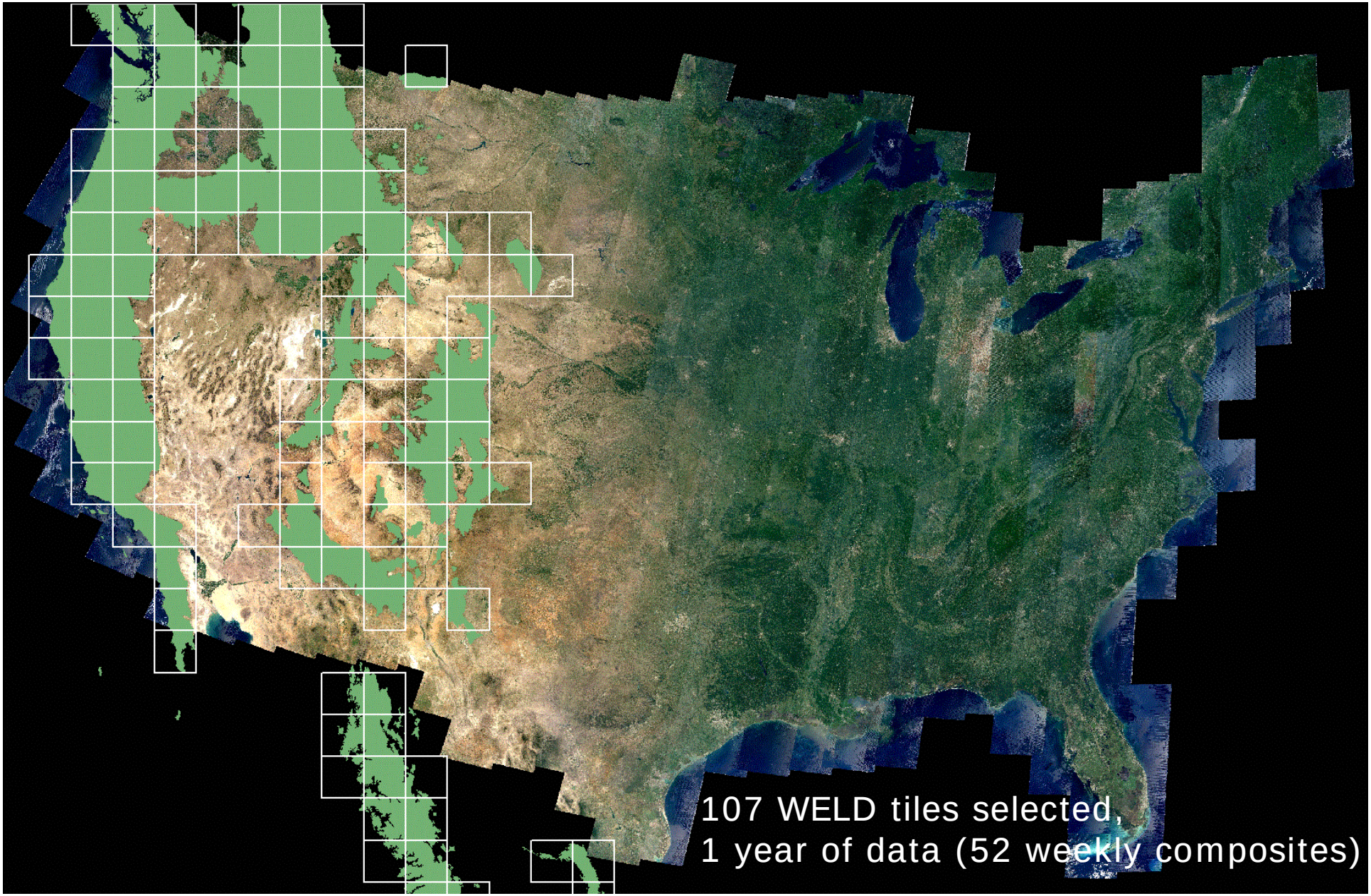

WELD tile
h01v05
WELD tile
h02v05
Fall
2002
composite
Landsat Burned Area Map
JUN 2002
OCT 2002

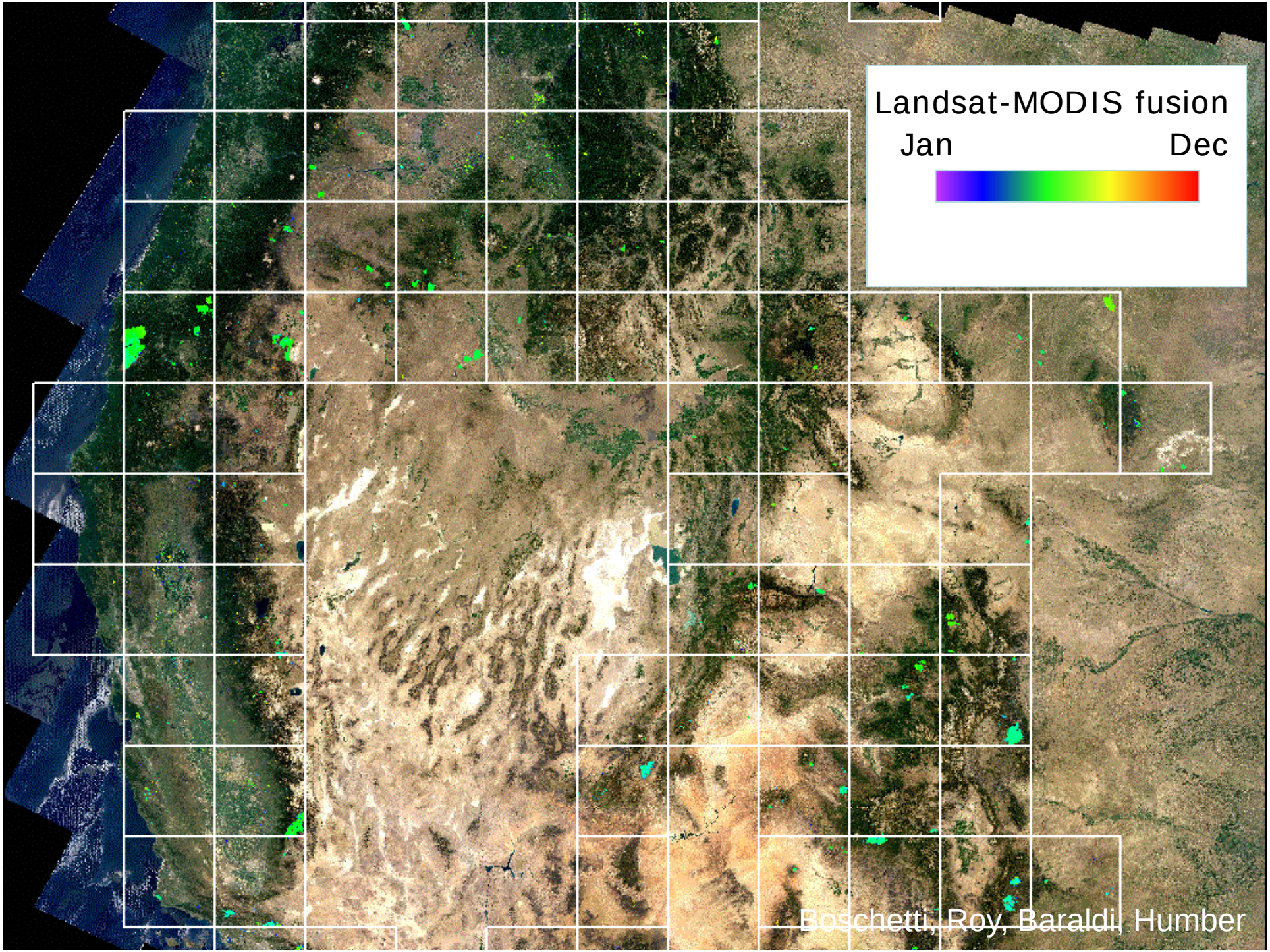

WELD tile
h01v05
WELD tile
h02v05
Fall
2002
composite
MTBS polygons
Landsat Burned Area Map
JUN 2002
OCT 2002

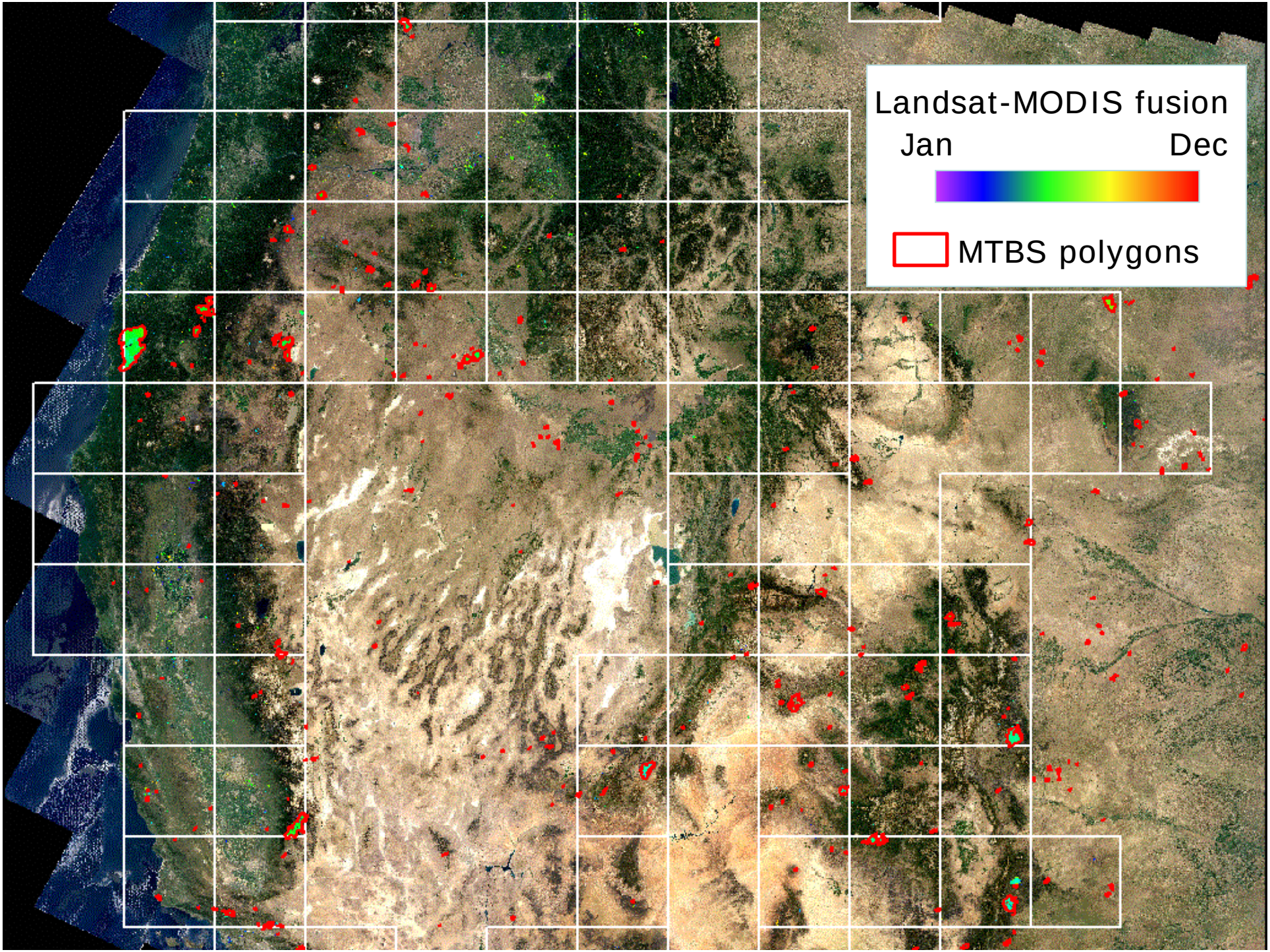
Western US Forests

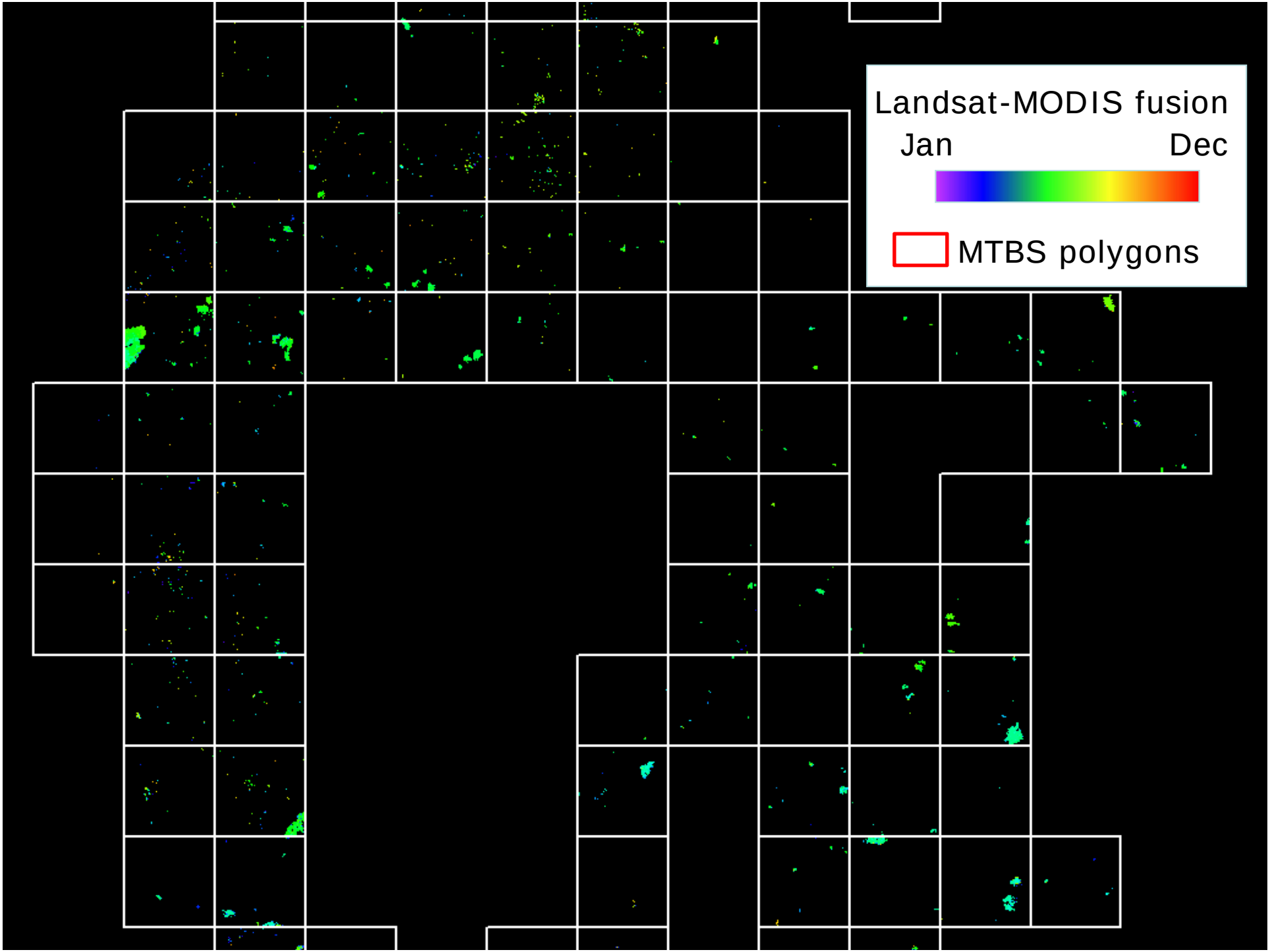


Western US Forests




Landsat-MODIS fusion
Jan
Dec
Boschetti, Roy, Baraldi, Humber


Landsat-MODIS fusion
Jan
Dec
MTBS polygons


Landsat-MODIS fusion
Jan
Dec
MTBS polygons

Conclusions

- Statistically robust sampling is essential for proper characterization of presence/absence of fire, the current validation datasets are biased and are not suitable to detect false positives
- Need to validate separately temporal and spatial aspect
- The method for validation through the interpretation of image pairs has been widely tested and published in peer reviewed literature
- Data availability is the main limiting factor, currently the sampling is prototyped using 2002 SLC-on Landsat 7
- Pathfinding operational validation for future production of ECVs (systematic coverage with LCDM/Sentinel 2)

Thanks