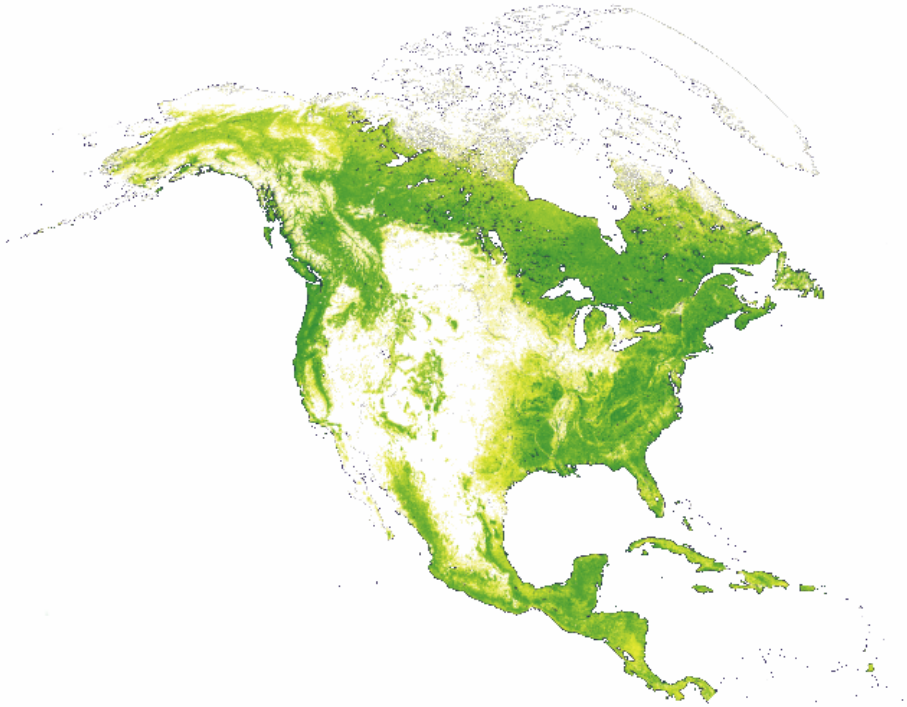
MODIS Vegetation Products



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MOD44C Composites

- 16-day global 250 m spatial resolution composites of MODIS visible, SWIR, NIR and thermal bands
  - For each 250 m pixel, the corresponding 500 m (visible/SWIR) or 1 km (TIR) observation for the same orbit is retained
- Extensive use of upstream QA to select suitable input data
- Optimized to retain the highest quality data available:
  - Eliminate cloudy and poor quality observations
  - Retain those observations which are nearest to nadir and have the maximum observation footprint relative to the geographic bounds of the output pixel
- Also perform water detection on each candidate pixel and retain daily results for further analysis
- Used to derive VCC and VCF products

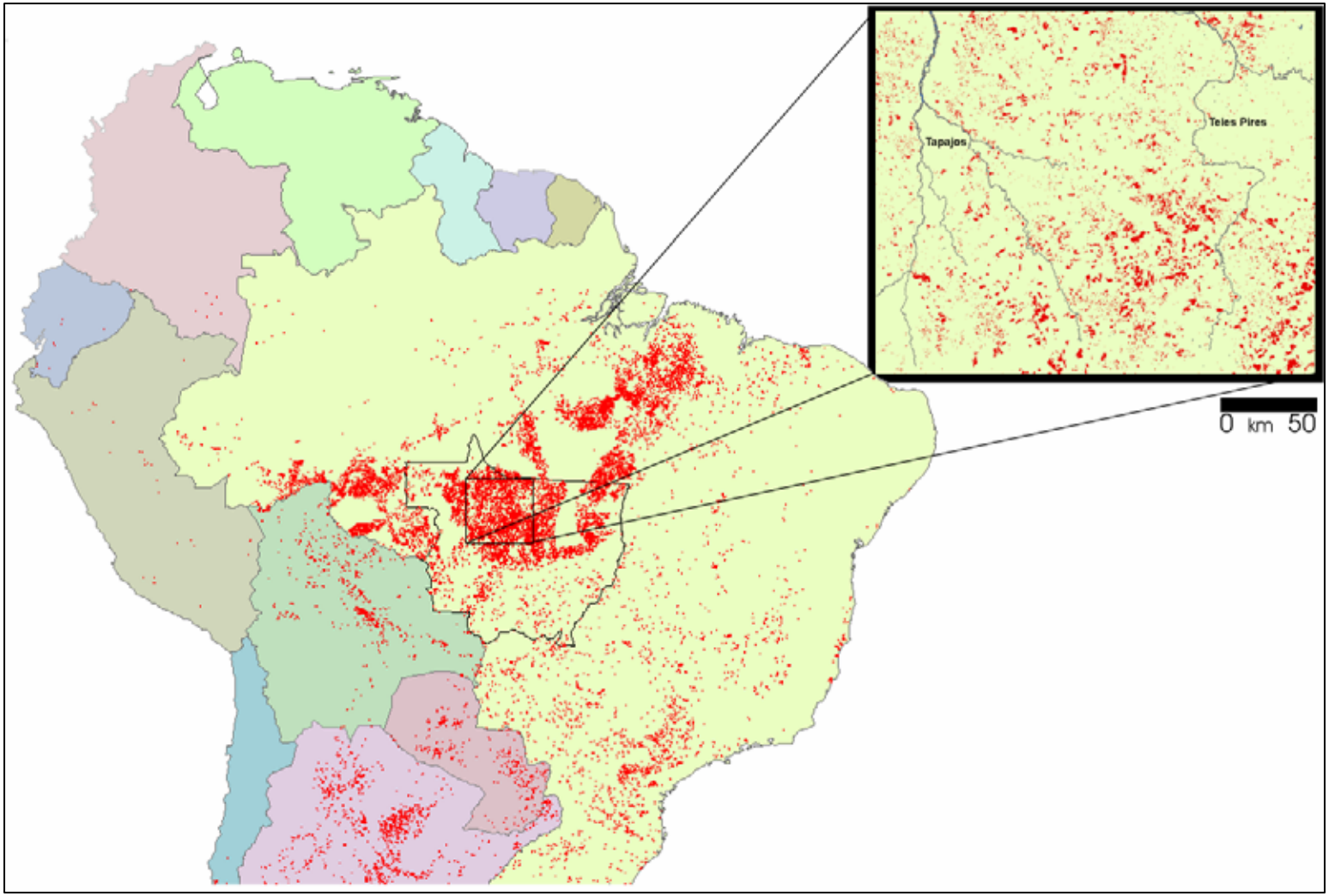
Vegetative Cover Conversion (VCC)

- Vegetative Cover Conversion product is a global alarm product for land cover change
    - The product is conservative to limit the errors of commission
    - Assumes that results will be used to drive further study
- Algorithm has evolved such that each type of change is identified by a separate algorithm
- Current change types that are detected
    - Deforestation
    - Change due to burning
    - Flooding

VCC-Deforestation Method

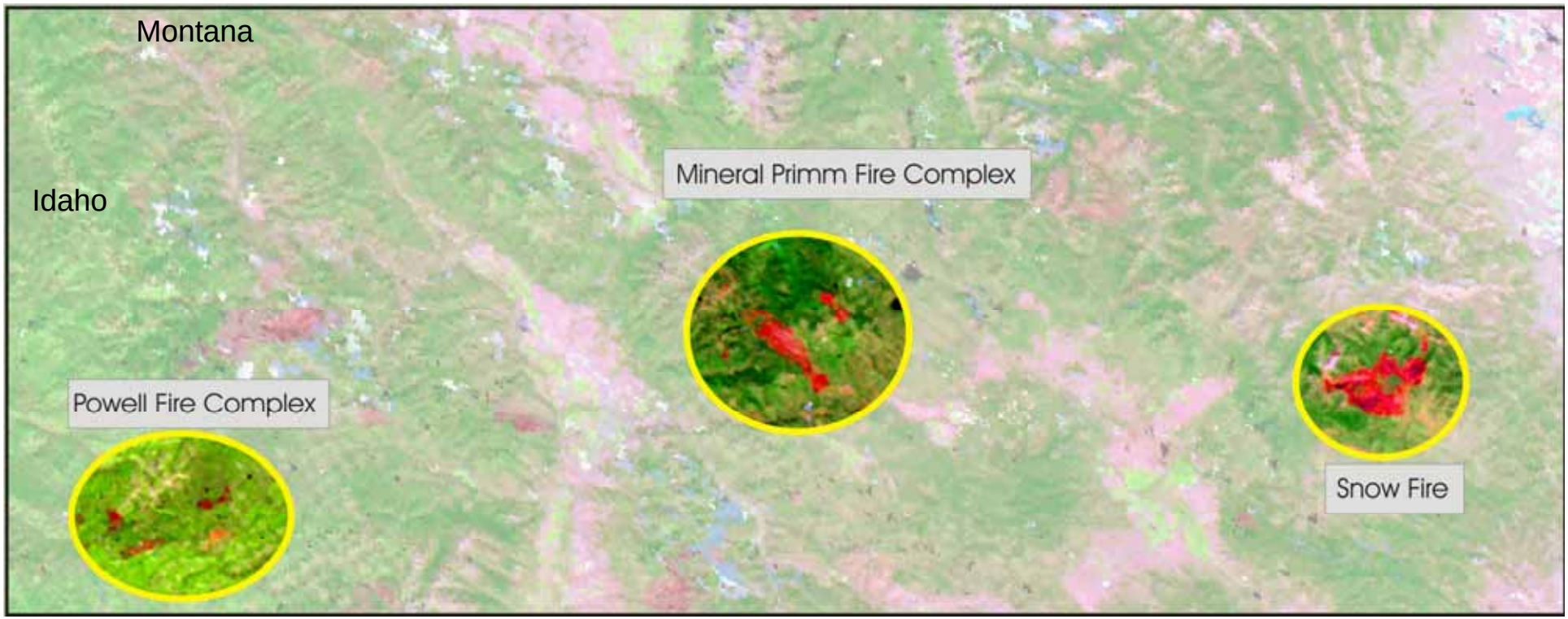
- VCC-Deforestation is generated using decision tree models to classify the input data
- Classes are derived by aggregating the percent tree cover from the MODIS Vegetation Continuous Fields product
- The classes are then compared to determine if the land cover has changed from one class to another
- Current process is run for the humid tropics (30° N to 30° S)
    - Uses data from 2001 and compares that to data from 2005 to yield a 4+ year change result
    - Improved data quality in collection 5 will allow use of 2000 data as baseline yielding a 5 year change result
- Change is determined to have occurred if an observation has moved from a forest class to a non-forest class

Five Year Vegetative Cover Conversion Showing Tropical Deforestation



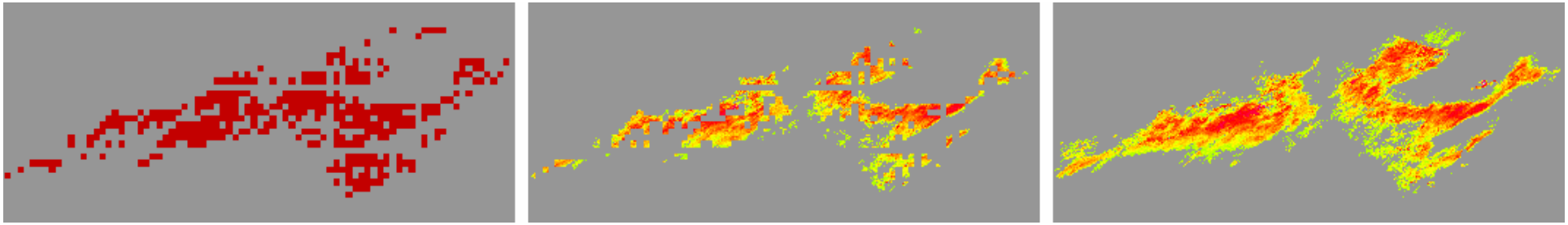
MODIS VCC showing deforestation for South America from 2001 to 2005. The outline box in the large image shows the location of the full resolution data in the upper image from Mato Grosso, Brazil. Change is shown in red.

Vegetative Cover Conversion – Change Due to Burning (VCC-CDB)



VCC-Change Due to Burning (VCC-CDB) is generated at 250m resolution using data from the MODIS instrument using Normalized Burn Ratio (NBR) calculated (NIR – SWIR/NIR +SWIR) from 16-day composite.

Methods for Change Due to Burning



1a 1b 1c

The images above show the progression of the VCC-CDB algorithm for the Grand Prix and Old fires in Southern California in October/November 2003.

- 1a shows the MODIS active fire location points converted to 1km observations and projected onto a 250m grid to match the input data
- 1b shows the dNBR (difference of Normalized Burn Ratio) calculated underneath of the mask created by the fire location points for two composites a year apart
- 1c shows the final product after the fire has been “grown” using the dNBR threshold of 0.2

This process is repeated for every fire that is determined to be in a wooded area.

Vegetative Cover Conversion – Change Due to Burning (VCC-CDB) Validation

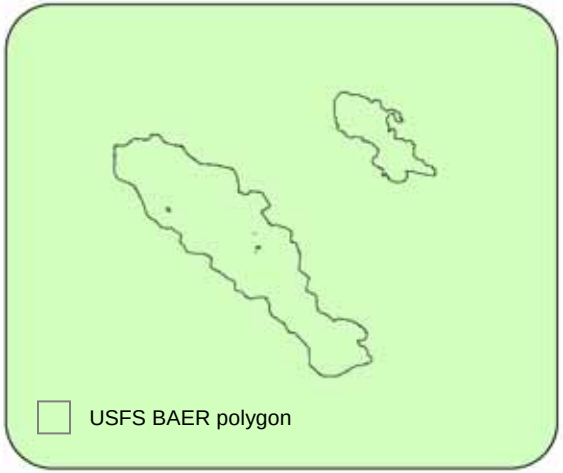


Figure 1 - USFS BAER polygons showing 23,830 acres burned.

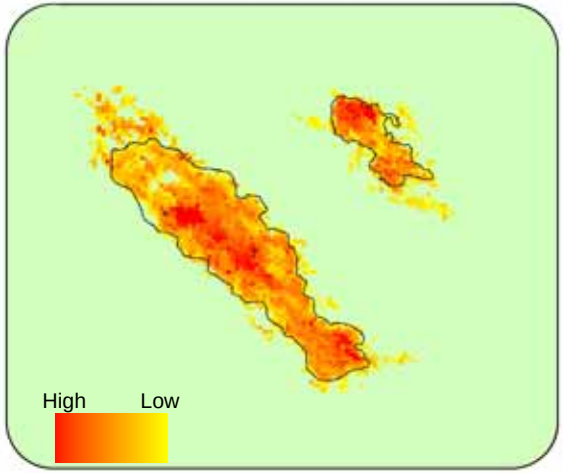


Figure 2 - MODIS VCC-CDB fire intensity (yellow = low while red = high).

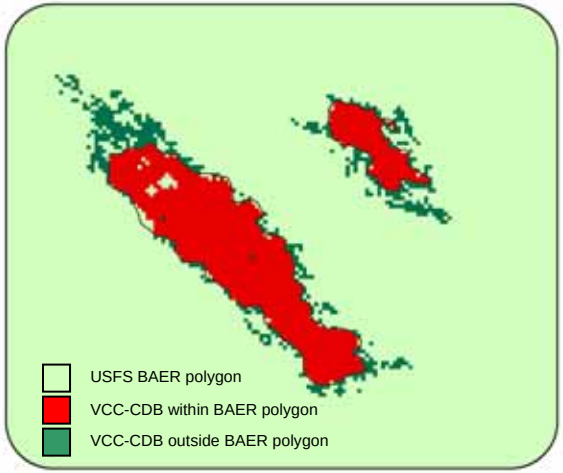


Figure 3 - Area in red represents VCC-CDB within the BAER polygon; dark green shows VCC-CDB outside the BAER polygon.

The figures above are from the Mineral Primm fire complex in Montana, USA, in the summer of 2003. Figure 3 shows that VCC-CDB identified :

- 22,753 of 23,830 acres inside the burn perimeter
- Less than 5% of total area omitted inside the burn perimeter
- 11,271 acres were identified by VCC-CDB outside of the USFS BAER polygons
    - Over 60% of these came from observations that were adjacent to the burn perimeter polygon
    - Likely caused by the coarser resolution of MODIS (250m) compared to Landsat data (30m) that was used to derive the BAER data.

Vegetative Cover Conversion – Change Due to Burning (VCC-CDB) Validation

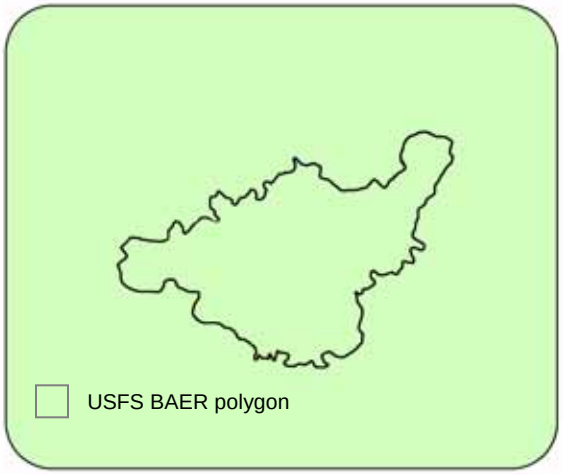


Figure 1 - USFS BAER polygon showing 38,069 acres burned.

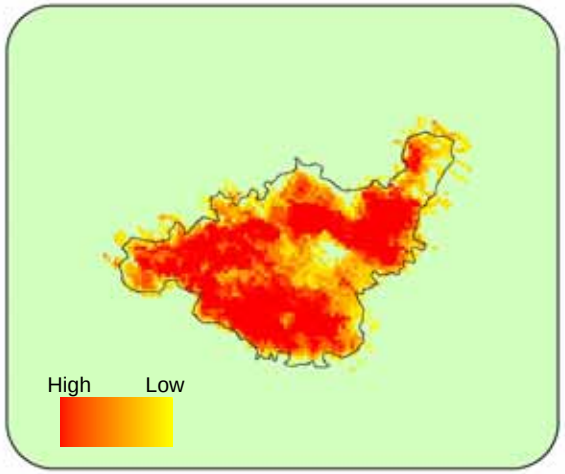


Figure 2 - MODIS VCC-CDB fire intensity (yellow = low while red = high).

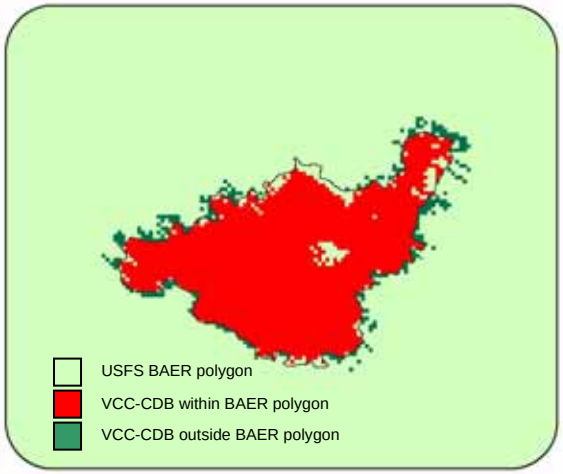


Figure 3 - Area in red represents VCC-CDB within the BAER polygon; dark green shows VCC-CDB outside the BAER polygon.

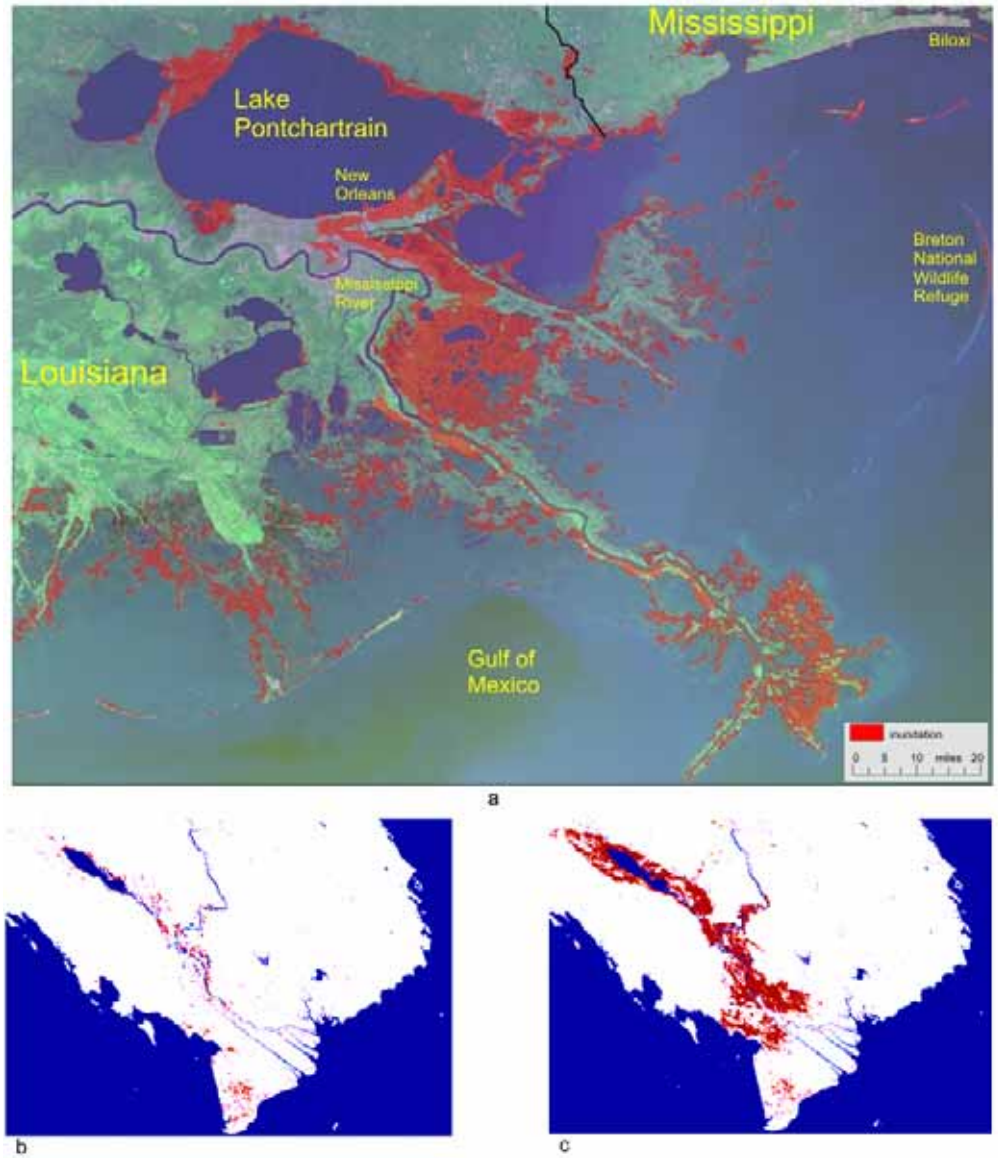
The figures above are from the Snow fire in Montana, USA in the summer of 2003.
Figure 3 shows that VCC-CDB identified:

- 35,161 of 38,069 acres inside the burn perimeter
    - Less than 8% of total area omitted
- 6,198 acres outside of the USFS BAER polygons
    - Over 70% of these came from observations that are adjacent to the burn perimeter
        - Likely caused by the coarser resolution of MODIS (250m) compared to Landsat data (30m) that was used to derive the BAER data.

VCC-Flooding Method

- Decision tree classification performed on daily data to determine presence of water
- Presence of water accumulated during the compositing process from daily data to 16-day composites in MOD44C
- Resulting “hits” of water are accumulated over the study period and compared against a static water mask
- Areas with water “hits” that deviate from the static water mask are identified as potentially inundated
- This product represents areas that remain inundated at least until the next instrument overpass
- Sample products have been generated for Hurricane Katrina and flooding in Cambodia/Vietnam
- Complete product will result from MODIS Collection 5 retrospective processing currently underway

Vegetative Cover Conversion – Inundation: Daily Detection is Critical



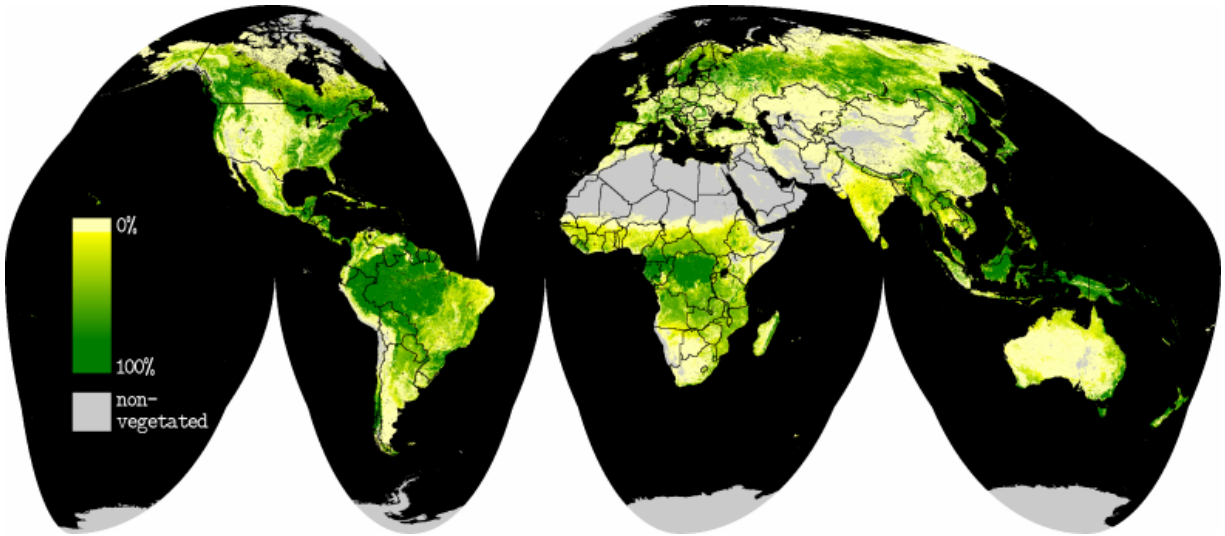
a) MODIS detected persistent inundation from Hurricane Katrina in Louisiana, September 2005. The background image is a mosaic of Landsat scenes, inundated areas are shown in red. Images in b) and c) are from Southeast Asia in September, 2002. b) shows the result when a 16-day composite image is used as the input to the water detection algorithm. c) shows the result when water detection is performed on a daily basis. Only by using daily data can one capture the nature and extent of the inundation in the area. The images are approximately 800 km in width.

Vegetation Continuous Fields

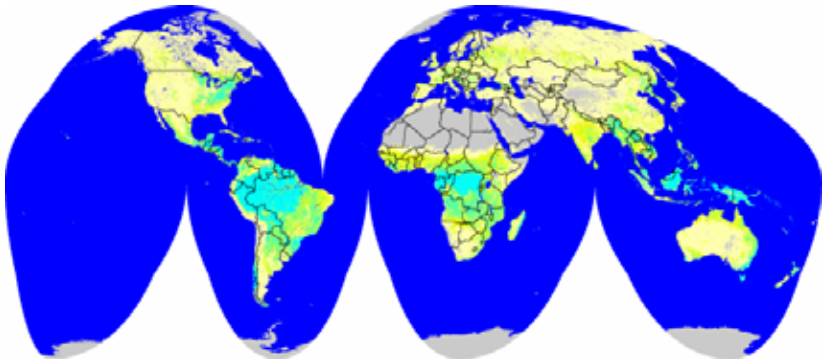
- Sub-pixel estimate of percent cover
  - Woody, herbaceous and bare
  - Leaf type, leaf longevity, crop cover and water cover
- Employs annual metrics based on reflectance and temperature variations
- Regression tree provides cover estimate in 1% step
- 500m spatial resolution, 250m in Collection 5
- Updated annually
- Can be used to derive changes in forest cover

Continuous fields

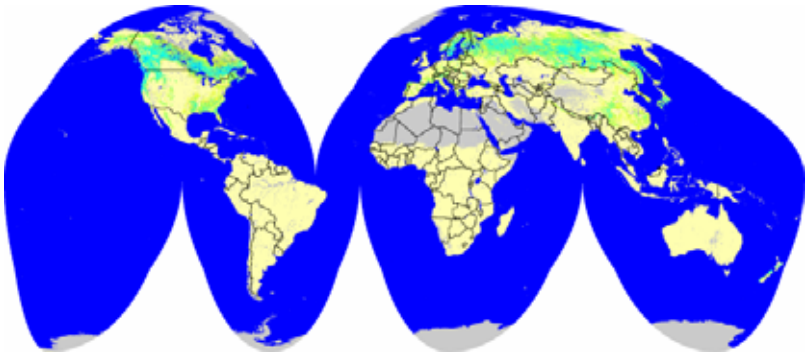
- Overcome artificial boundaries inherent in classification approaches
- Independent of strict class type definitions
- Possible to apply temporally to identify changes in % cover
- Derived from coarse resolution remote sensing imagery with calibration and validation from high resolution data



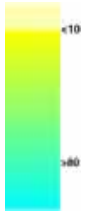
Leaf type



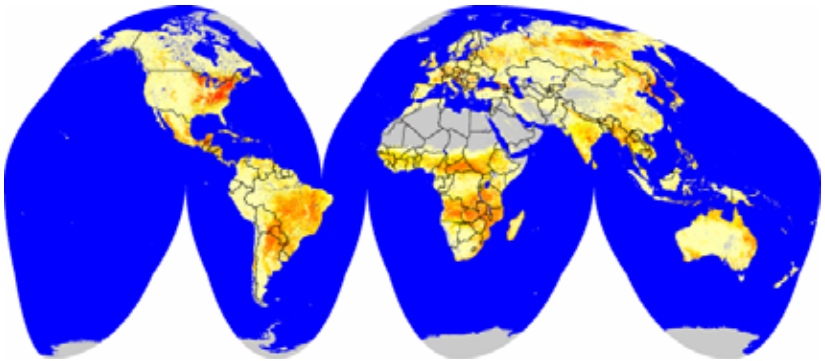
% broadleaf



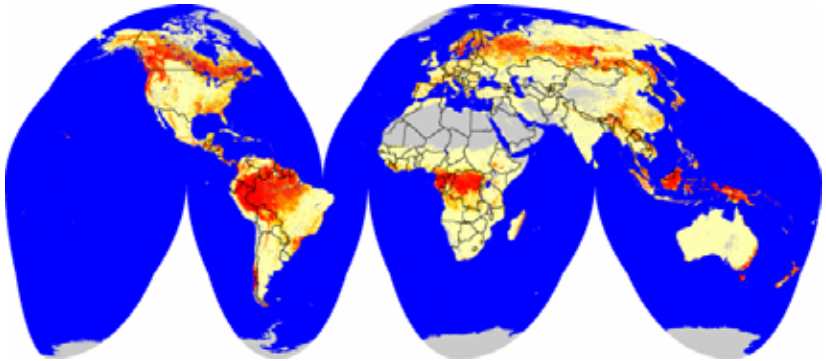
% needleleaf



Leaf longevity



% deciduous



% evergreen

Algorithm for automatic generation of global tree cover estimates

- Regression tree
  - For a given node *i*, all *j* cases of *y* and the mean value of those cases, *u*

$$D_i = \sum_{cases(j)} (y_j - u_{[j]})^2$$

- Solution of best split
  - Where *s* is parent node, *t* is left split, u is right split

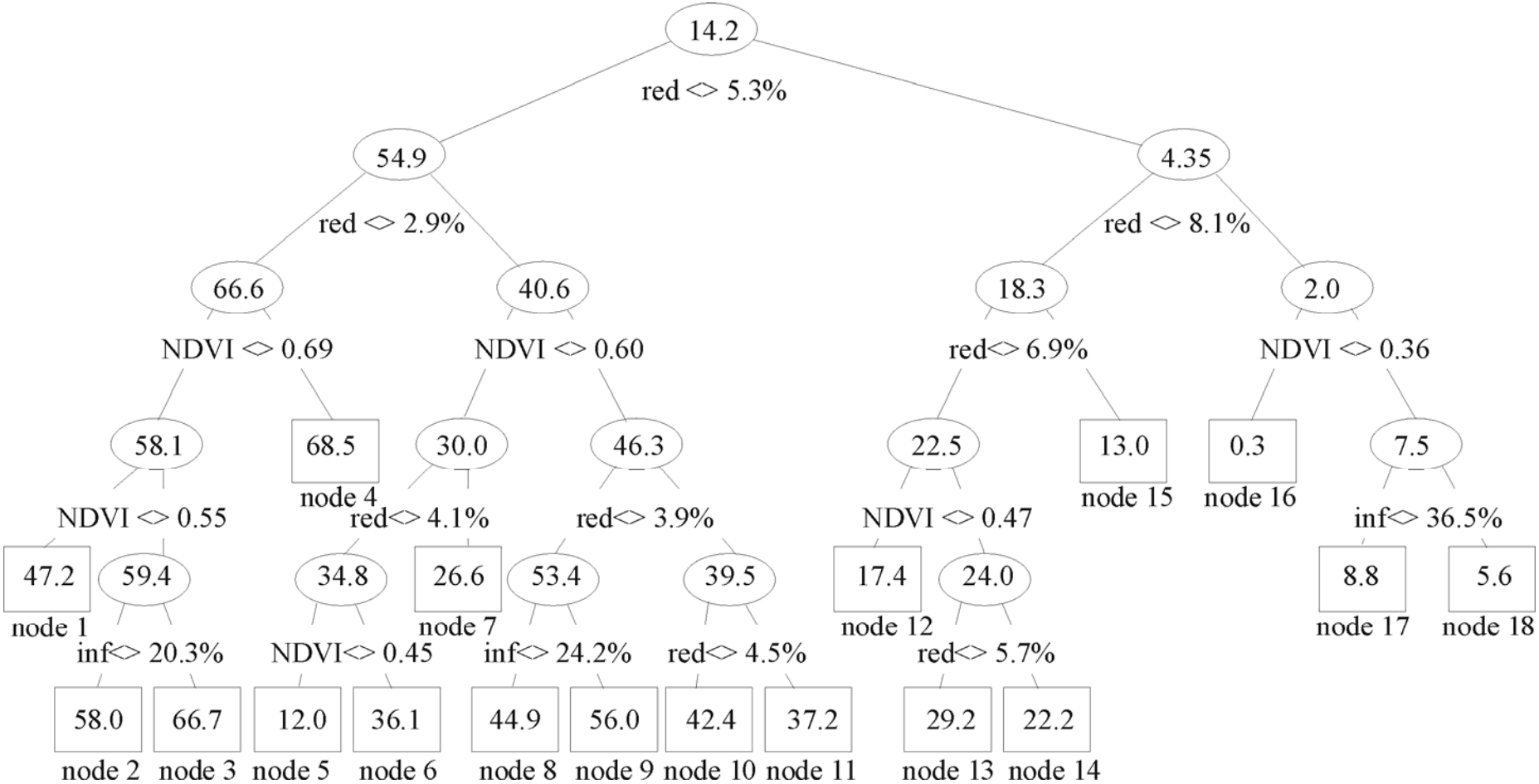
$$D = D_s - D_t - D_u$$

- Stepwise regression applied to each node

- Bias adjustment for skewed distributions

Example of Tree Object

(before stepwise regression)



Status

- VCC
  - Global CDB available annually from 2002-2004
  - Deforestation Humid Tropics available showing 2001-2005 change
- VCF
  - Collection 3 product available globally for 2001
  - Collection 4 annual provisional version available for tree cover for 2000 - 2005

For data http://landcover.org

Summary of C4 to C5 changes

- VCC
  - Addition of inundation identification
  - Expanded record for the change due to burning
  - Deforestation results for temperate and boreal zones
- VCF
  - Change in resolution from 500m to 250m
  - Addition of the following layers
    - Leaf type
    - Leaf longevity
    - Crops
    - Water
  - Regional tuning of percent tree, herbaceous and bare

For data http://landcover.org