NAFD forest disturbance analysis using a LTSS-VCT approach

Chengquan Huang

University of Maryland

The North American Forest Dynamics (NAFD) Project

~30 LTSS for Phase I (2005-2008), ~30 more for Phase II (2008-2011)

Goward, S.N., Masek, J.G., Cohen, W., Moisen, G., Collatz, G.J., Healey, S., Houghton, R., Huang, C., Kennedy, R., Law, B., Turner, D., Powell, S. & Wulder, M. (2008). Forest Disturbance and North American Carbon Flux. *EOS Transactions, American Geophysical Union*, *89*, 105-106.

Forest Change Analysis using LTSS – Overview

LTSS Production

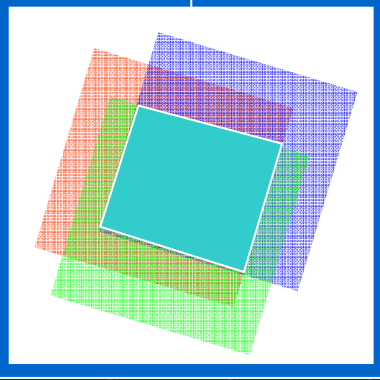
Select/ order images

- best quality
- leaf-on dates

LEDAPS ingestion and processing

- Orthorectification
- Calibration
- Atmospheric correction

Masking and clipping



Quality checking

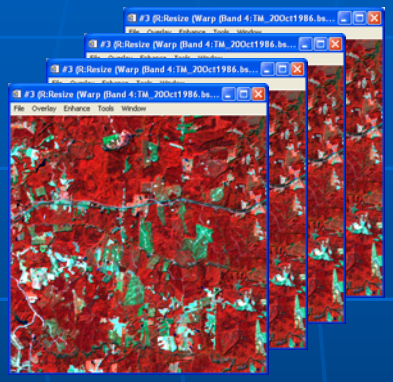
- Movie loops
- Spectral profiles

Change Analysis (VCT)

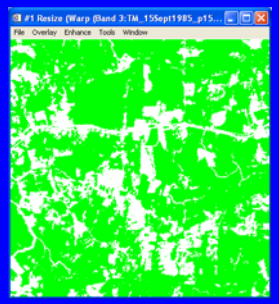
Huang, C., Goward, S.N., Masek, J.G., Gao, F., Vermote, E.F., Thomas, N., Schleeweis, K., Kennedy, R.E., Zhu, Z., Eidenshink, J.C. & Townshend, J.R.G. (in press). Development of Time Series Stacks of Landsat Images for Reconstructing Forest Disturbance History. *International Journal of Digital Earth*.

Vegetation Change Tracker (VCT)

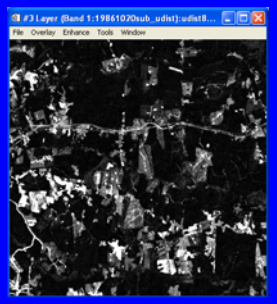
Landsat time series stacks



Individual image analysis



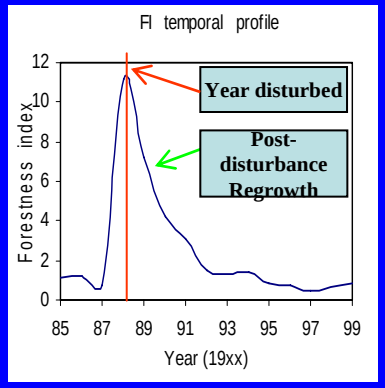
Confident forest



Forest index

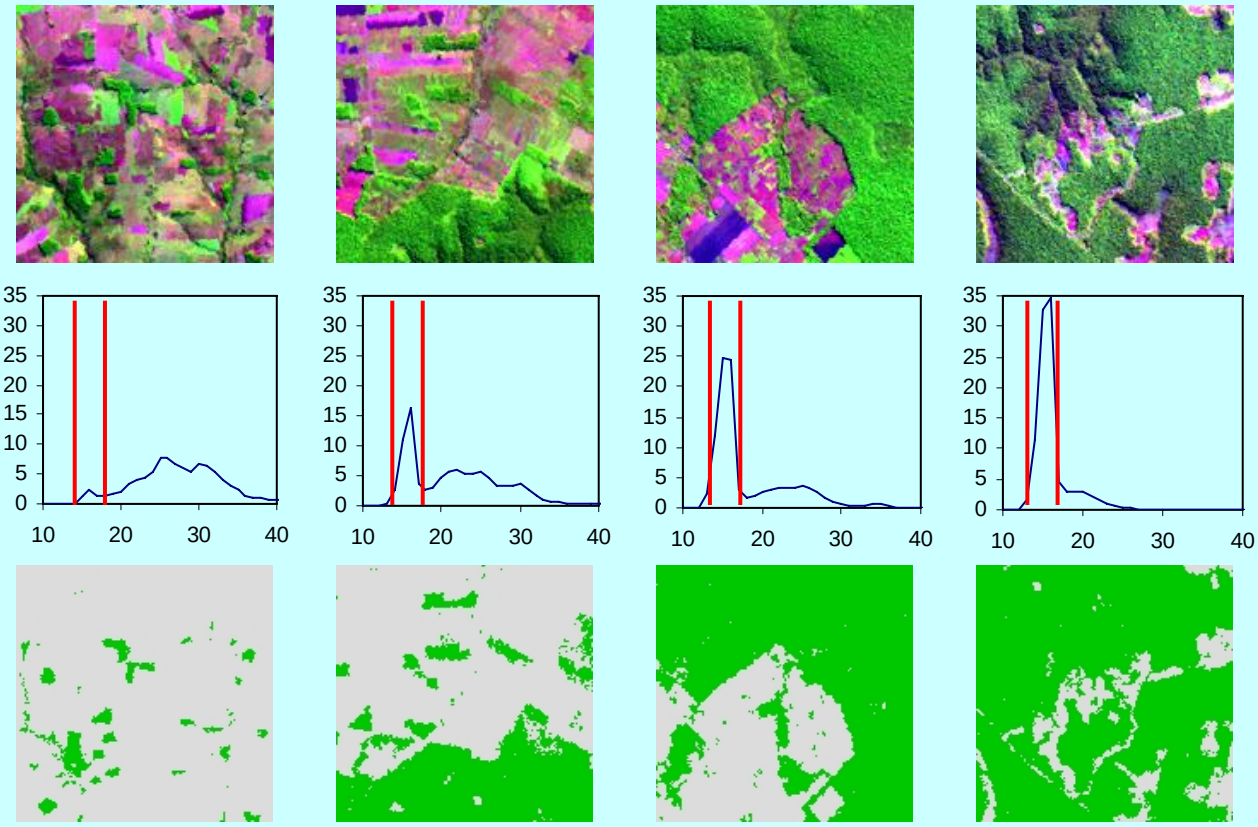
Time series analysis

Forest index time series



disturbance map

Individual Image Analysis – Forest Sample Delineation



(a) 5% forest (b) 30% forest (c) 60% forest (d) 80% forest

Automatic delineation of forest pixels reported in:

Huang, C., Song, K., Kim, S., Townshend, J., Davis, P., Masek, J. & Goward, S.N. (2008). Use of a Dark Object Concept and Support Vector Machines to Automate Forest Cover Change Analysis. *Remote Sensing of Environment*, 112, 970-985.

Individual Image Analysis

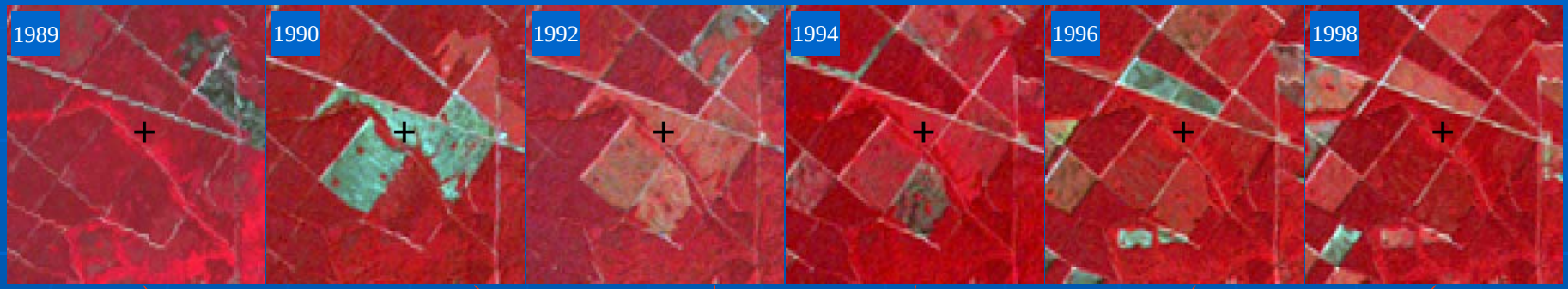
$\bar{b}_i$ SD_i →

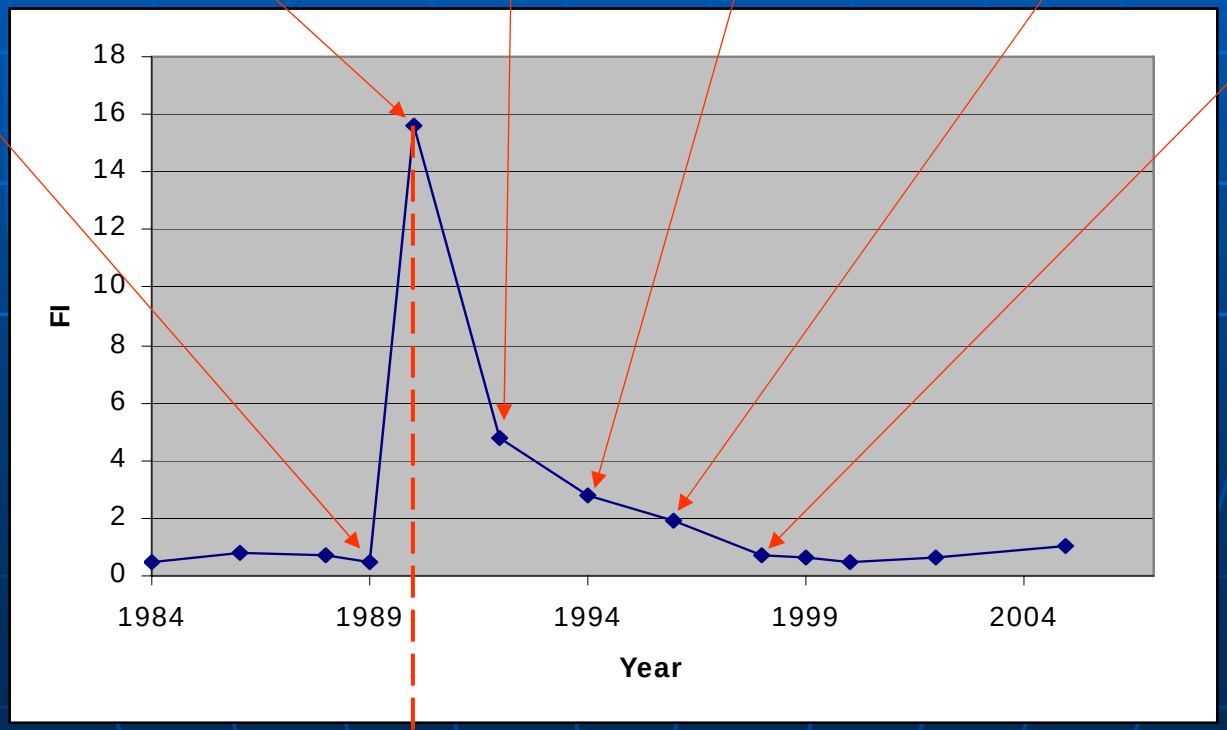
$$FZ_{pi} = \frac{b_{pi} - \bar{b}_i}{SD_i}$$

$$FI_p = \sqrt{\frac{1}{NB}\sum_{i=1}^{NB}\left(FZ_{pi}\right)^2}$$

The closer to 0 a pixel's *FI* value, the more likely that pixel being a forest pixel. The higher the value, the more likely a nonforest pixel.

Detect forest disturbance using FI





Year of disturbance

Year of Disturbance Map

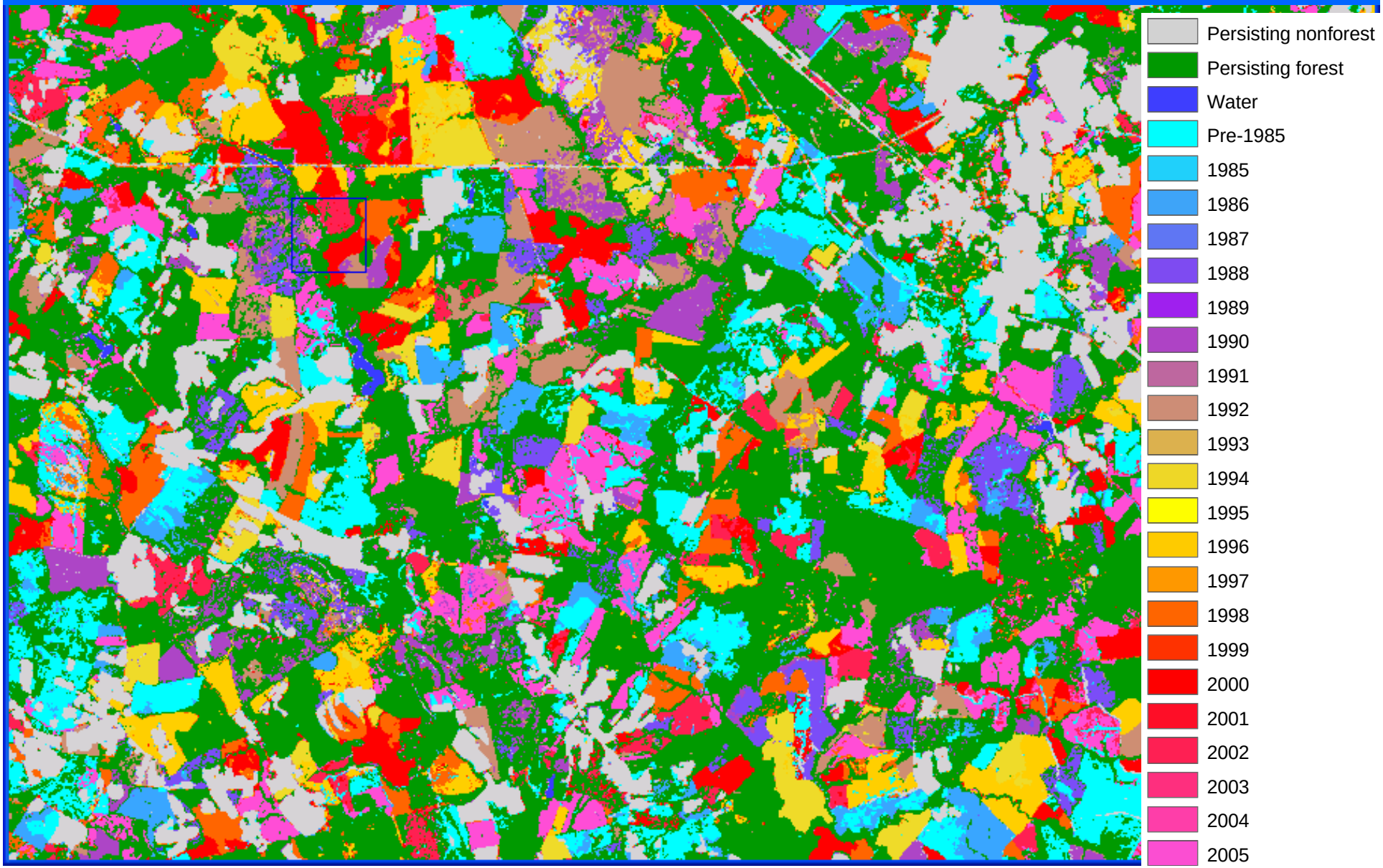


Table 3
Confusion matrix for the VCT derived disturbance year map for WRS path 21/row 37.

	Reference															
VCT	1	2	14	17	18	20	21	23	25	27	29	31	33	35	Row Total	*User's acc.*
1	**0.2637**		0.0094	0.0052		0.0005									0.2789	0.946
2		**0.1970**	0.0086	0.0084	0.0134	0.0144	0.0043	0.0211	0.0153	0.0043	0.0061	0.0091	0.0086	0.0021	0.3126	0.630
14		0.0014	**0.0725**	0.0033											0.0772	0.940
17			0.0041	**0.0465**	0.0036										0.0541	0.858
18	0.0026			0.0015	**0.0215**										0.0256	0.839
20				0.0014		**0.0254**									0.0267	0.949
21				0.0030			**0.0170**								0.0200	0.849
23			0.0019		0.0009		0.0009	**0.0258**							0.0296	0.872
25					0.0014		0.0007		**0.0234**						0.0255	0.917
27	0.0017				0.0006	0.0011	0.0017		0.0007	**0.0246**					0.0303	0.810
29			0.0009		0.0017	0.0026	0.0009	0.0009	0.0009		**0.0239**				0.0316	0.757
31			0.0009			0.0009	0.0018	0.0018		0.0009		**0.0180**		0.0009	0.0251	0.714
33				0.0014	0.0017	0.0013	0.0011	0.0006	0.0006				**0.0158**	0.0010	0.0234	0.677
35		0.0019	0.0017	0.0010	0.0019	0.0019		0.0029	0.0010	0.0019	0.0010	0.0010		**0.0181**	0.0340	0.532
Column Total	0.2679	0.2003	0.1000	0.0715	0.0467	0.0481	0.0284	0.0530	0.0418	0.0316	0.0309	0.0280	0.0244	0.0221	0.9947	
Producer's acc.	0.984	0.984	0.726	0.649	0.460	0.527	0.599	0.487	0.560	0.776	0.773	0.641	0.649	0.819	Overall	**0.797**

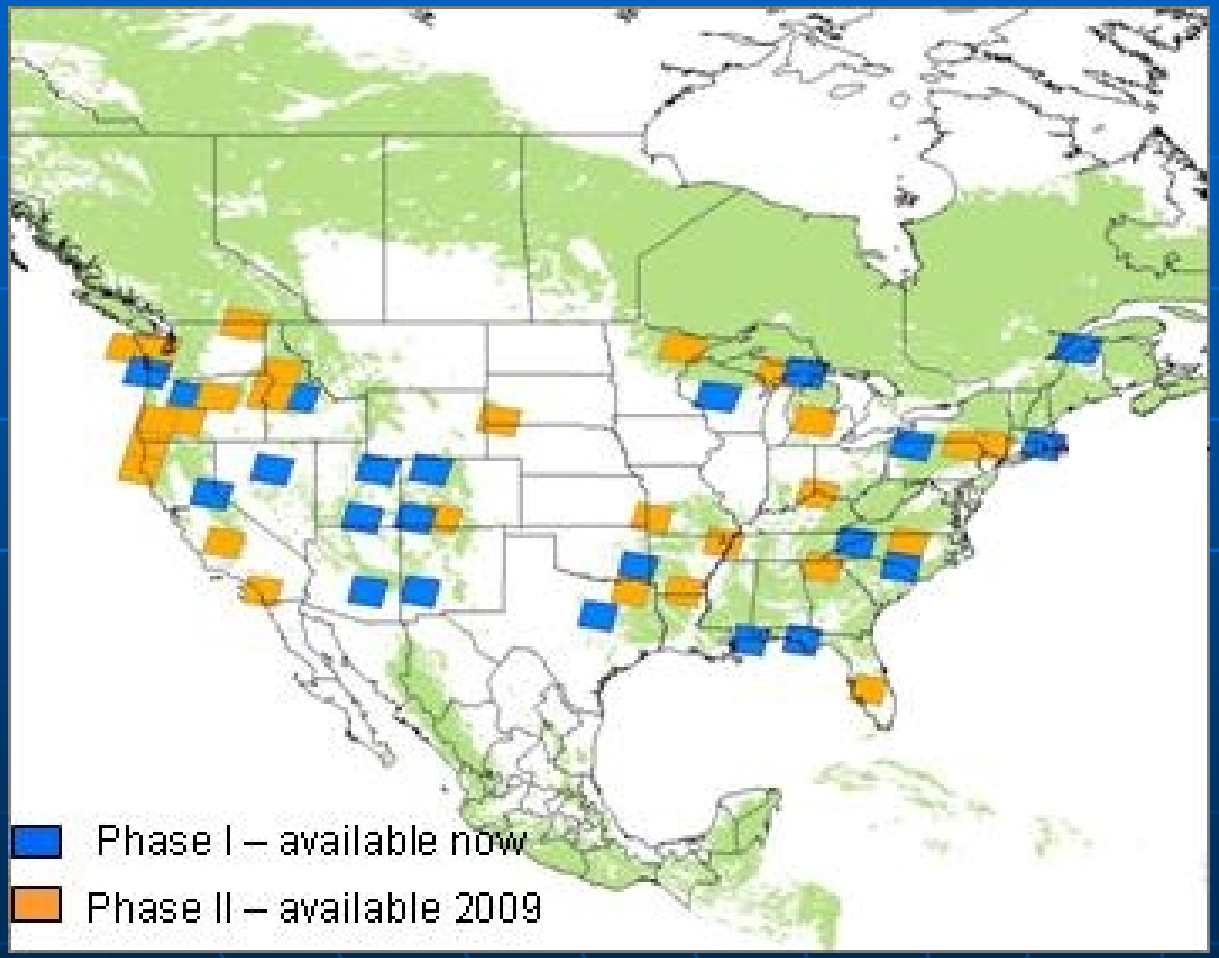
The overall accuracy is 79.7%. Per class agreements are in bold face. Class code is defined as follows: 1 — persisting non-forest, 2 — persisting forest, 14 — pre-observation disturbance, 15–36 — disturbance year by adding 1970 to the code (e.g. 17 indicates a 1987 disturbance).

Table 2. Overall accuracy and and average producer's and user's accuracy values of the VCT disturbance year products assessed for all land cover and disturbance year classes of those products

WRS2 Path/row	*Location*	Overall accuracy	Average producer's accuracy	Average user's accuracy
12/31	Massachusetts	0.87	0.60	0.62
15/34	Virginia	0.84	0.67	0.78
21/37	Mississippi/Alabama	0.84	0.64	0.79
27/27	Minnesota	0.82	0.64	0.80
37/34	Utah	0.86	0.31	0.50
45/29	Oregon	0.86	0.57	0.72

Huang, C., Goward, S.N., Masek, J.G., Thomas, N., Zhu, Z. & Vogelmann, J.E. (in press). An Automated Approach for Reconstructing Recent Forest Disturbance History Using Dense Landsat Time Series Stacks. *Remote Sensing of Environment*, *doi:10.1016/j.rse.2009.08.017*.

Available LTSS-VCT Products (current and near future)



NAFD Phase I & II Sample

5 samples in Canada

5 samples in Mexico

State level:

Utah, Mississippi, Alabama, Maryland, North Carolina

LTSS-VCT Summary

- Highly automated creation of Landsat time series stacks
- Efficient algorithm to identify stable forest pixels throughout the stack
- Calculation of a “forestness index” describing deviation from the population of pixels
- Robust detection of forest disturbance in a range of forest types

Extras

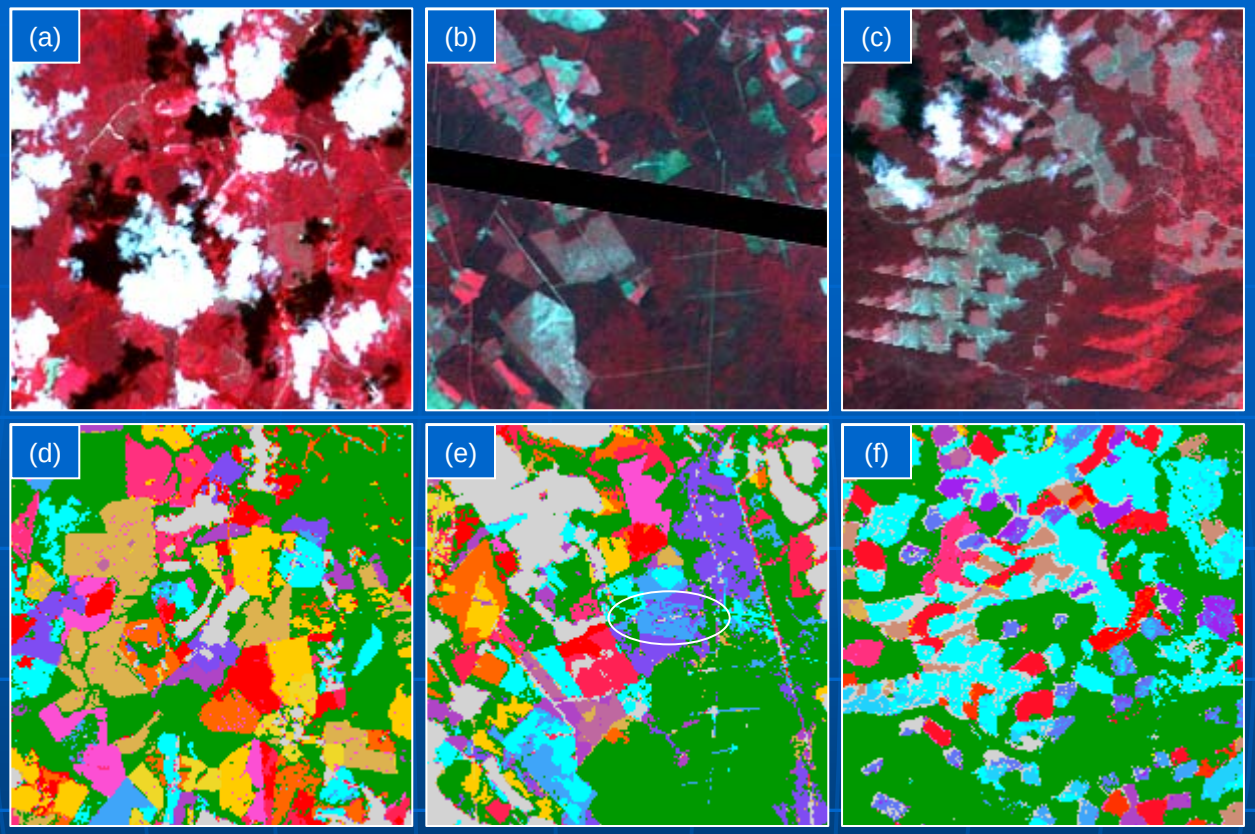


Fig. 10. Bad observations such as cloud/shadow contamination (a, WRS path 16/row 36, acquired on August 14, 2000), missing scan lines (b, WRS path 16/row 36, acquired on September 25, 1986), or duplicate scan lines (c, WRS path 45/row 29, acquired on August 13, 1984) in individual images leave little or no signs in the disturbance maps produced by the VCT (d, e, and f, produced with a, b, and c, respectively, as part of the inputs). When preceding a 1988 disturbance, however, the missing scan line in (b) caused the 1988 disturbance to be mapped as a 1986 disturbance (circled in (e)). The images in (a-c) are shown with bands 4, 3, and 2 in red, green and blue. See Fig. 7 for the legend for the disturbance maps.

Funding agencies

- NASA
- USGS EROS