Landsat Science Team Technical Meeting, Oct 27-29, 2009

Part I: Reference Based Approach for Temporal and Spatial Mosaics

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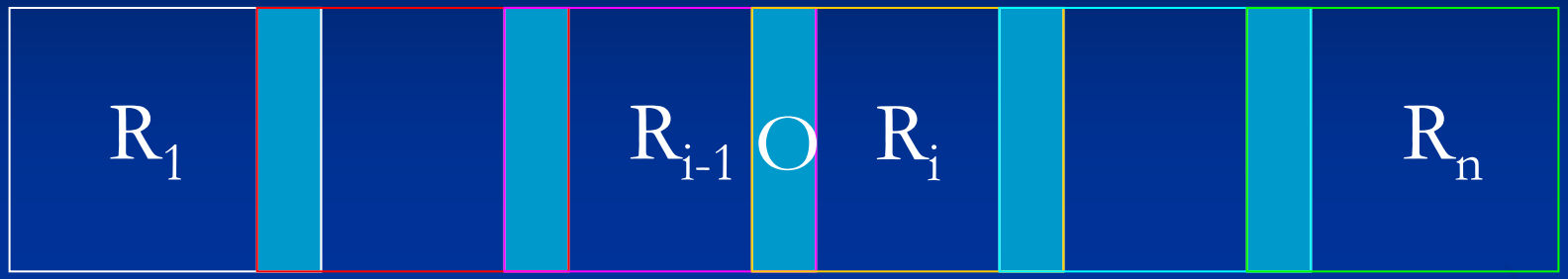
Traditional Approach



$$y_i = f_{i-1}(x_{i-1})$$

$x_{i-1} \in O$ and $x_{i-1} \in R_{i-1}$

$y_i \in O$ and $y_i \in R_i$

$O \subset R_i \bigcap R_{i-1}$

$$y_{i-1} = f_{i-1}(x_{i-1})$$

$x_{i-1} \in R_{i-1}$

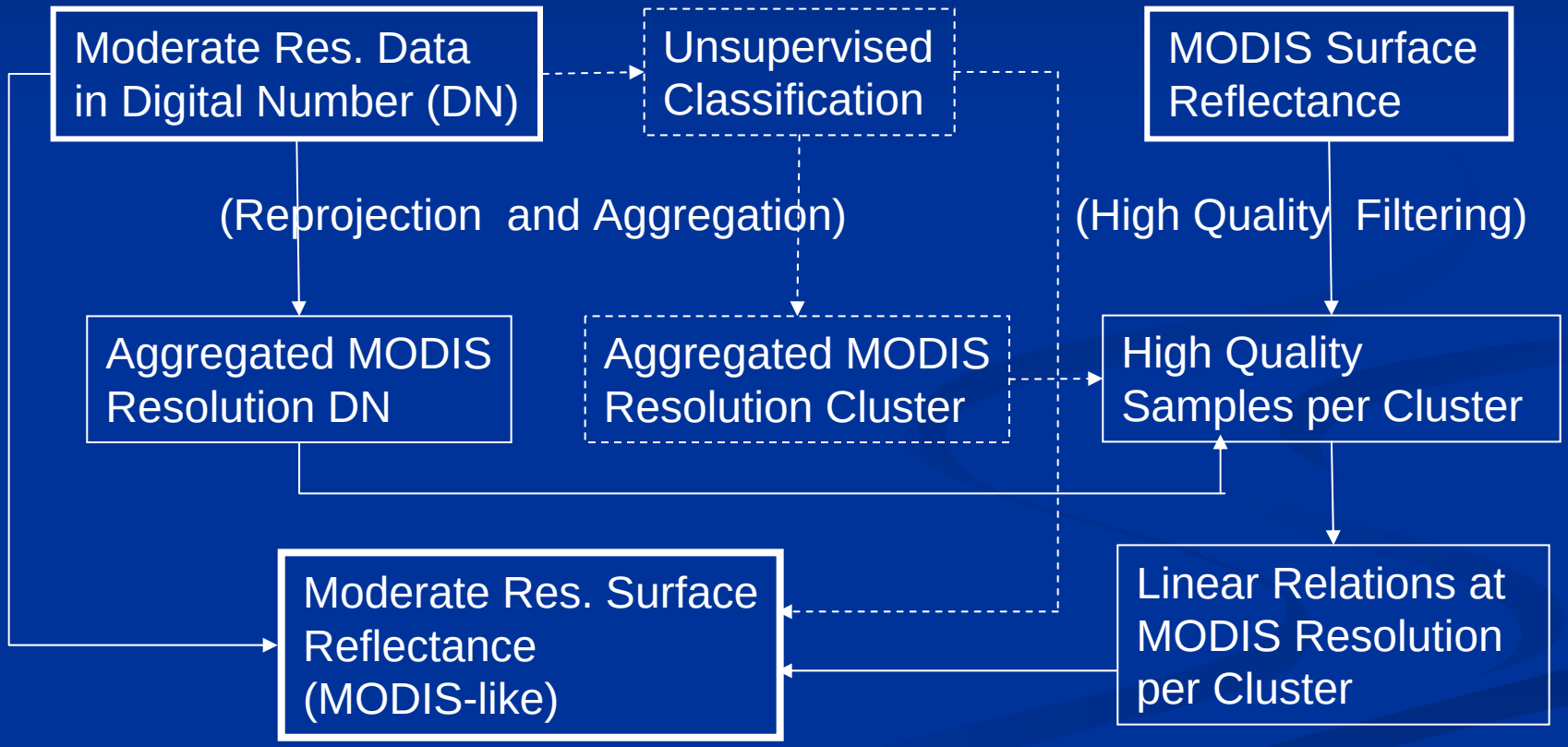
$$y_{i-2} = f_{i-2}(y_{i-1}) = f_{i-2}(f_{i-1}(x_{i-1}))$$

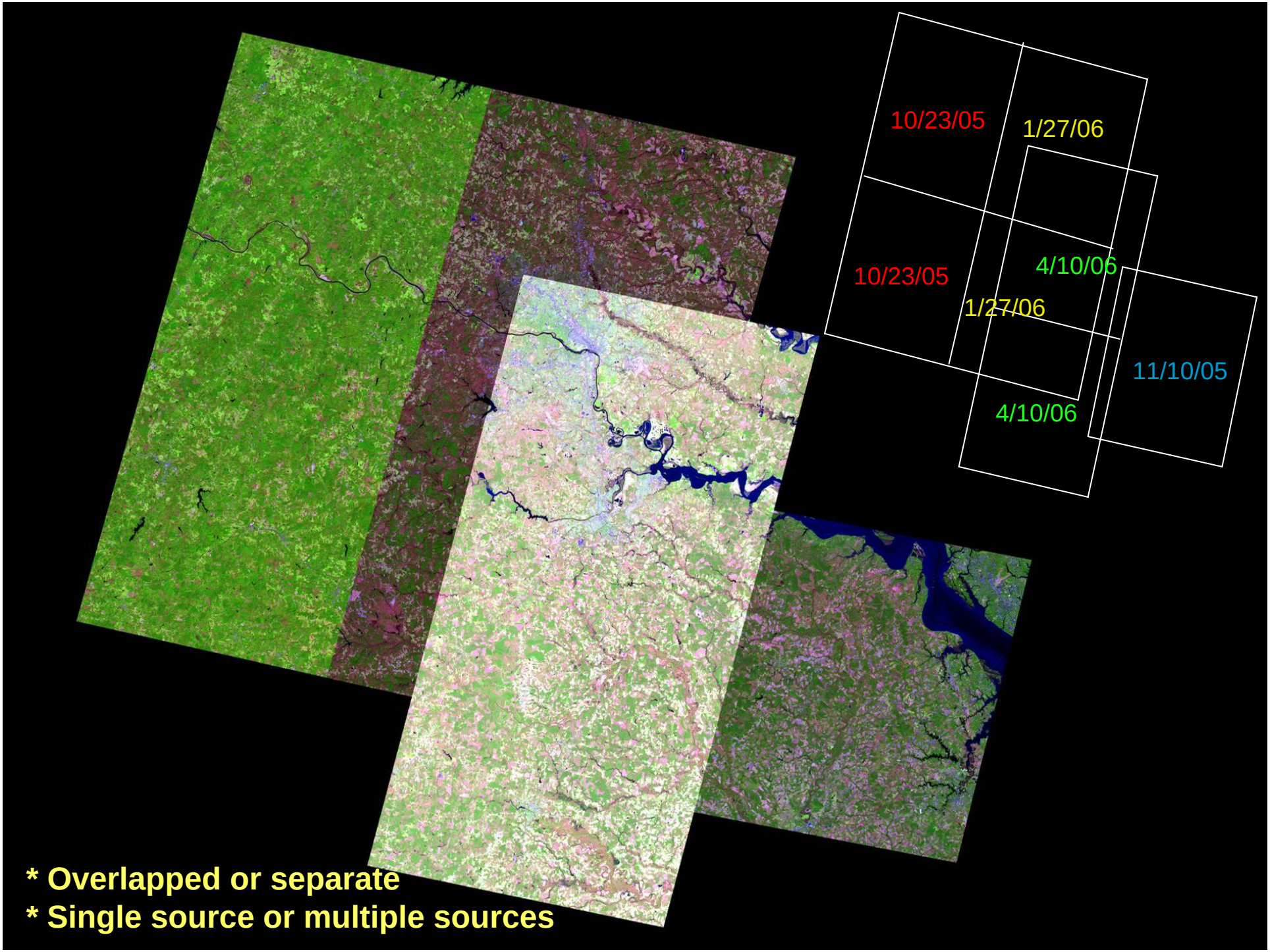
.....

$$y_1 = f_1(f_2(\ldots f_{n-1}(x_{n-1})))$$

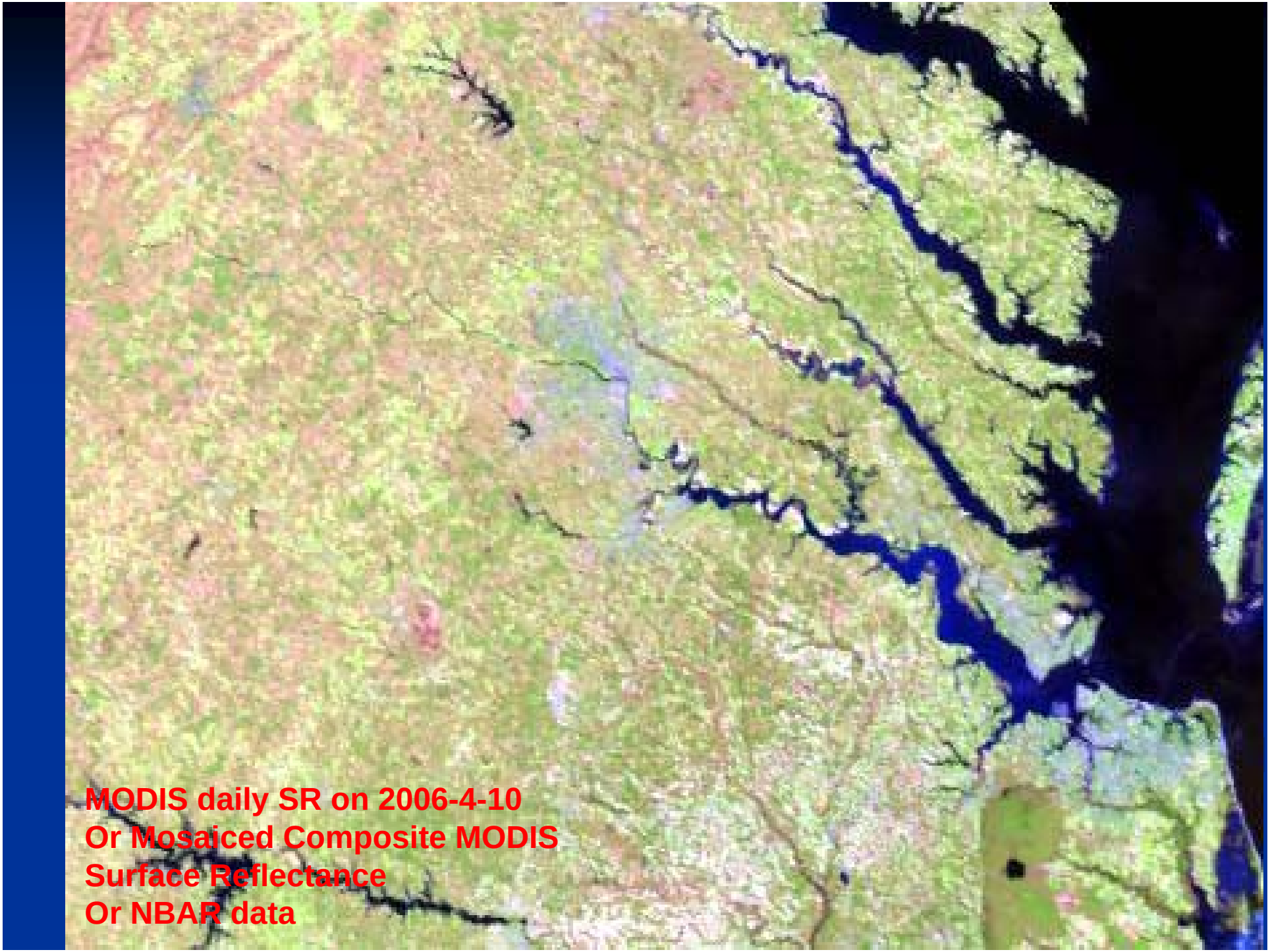
Function *f* can be linear or non-linear
(histogram match, regression tree, neural network)

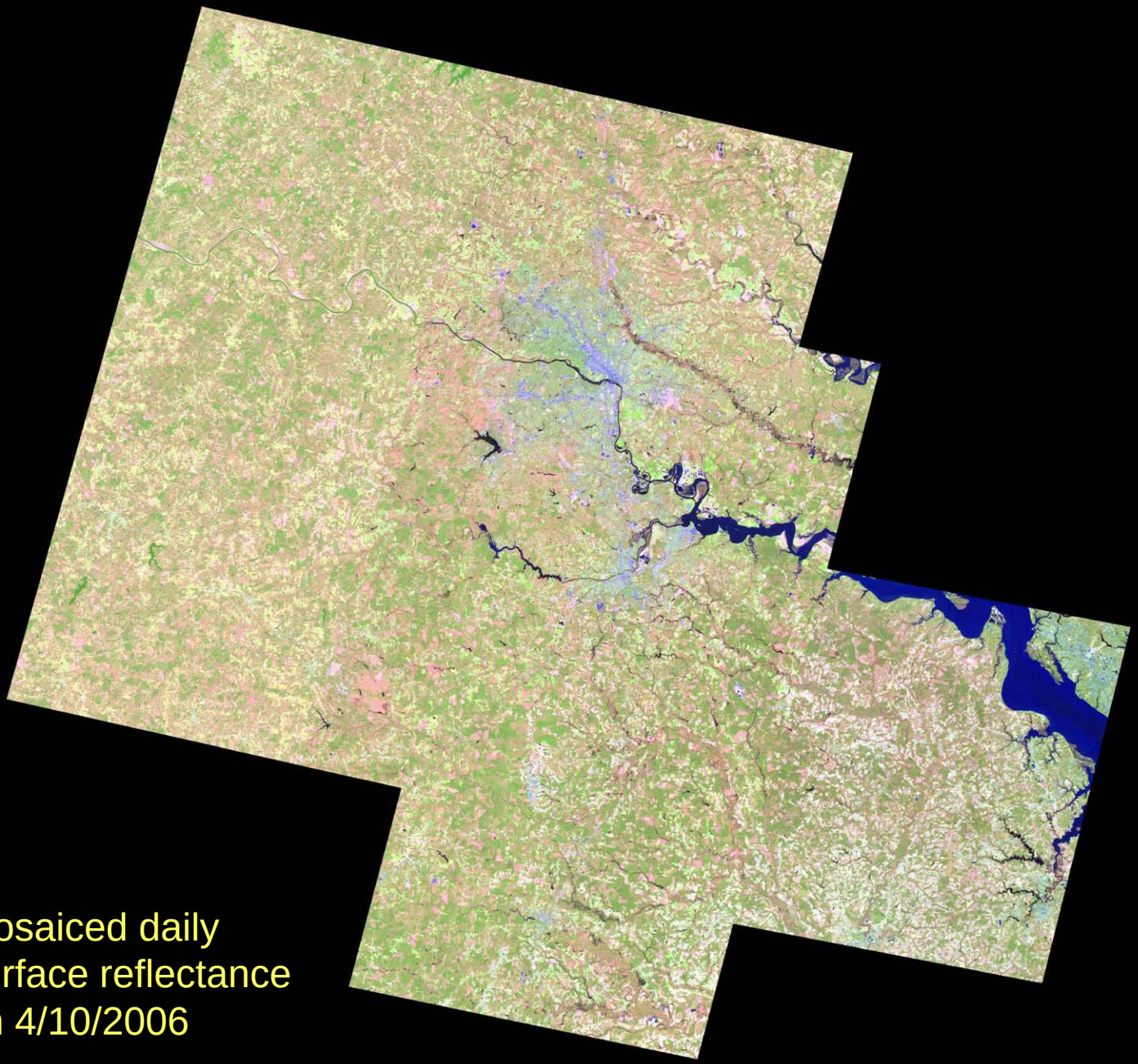
Reference Based Approach



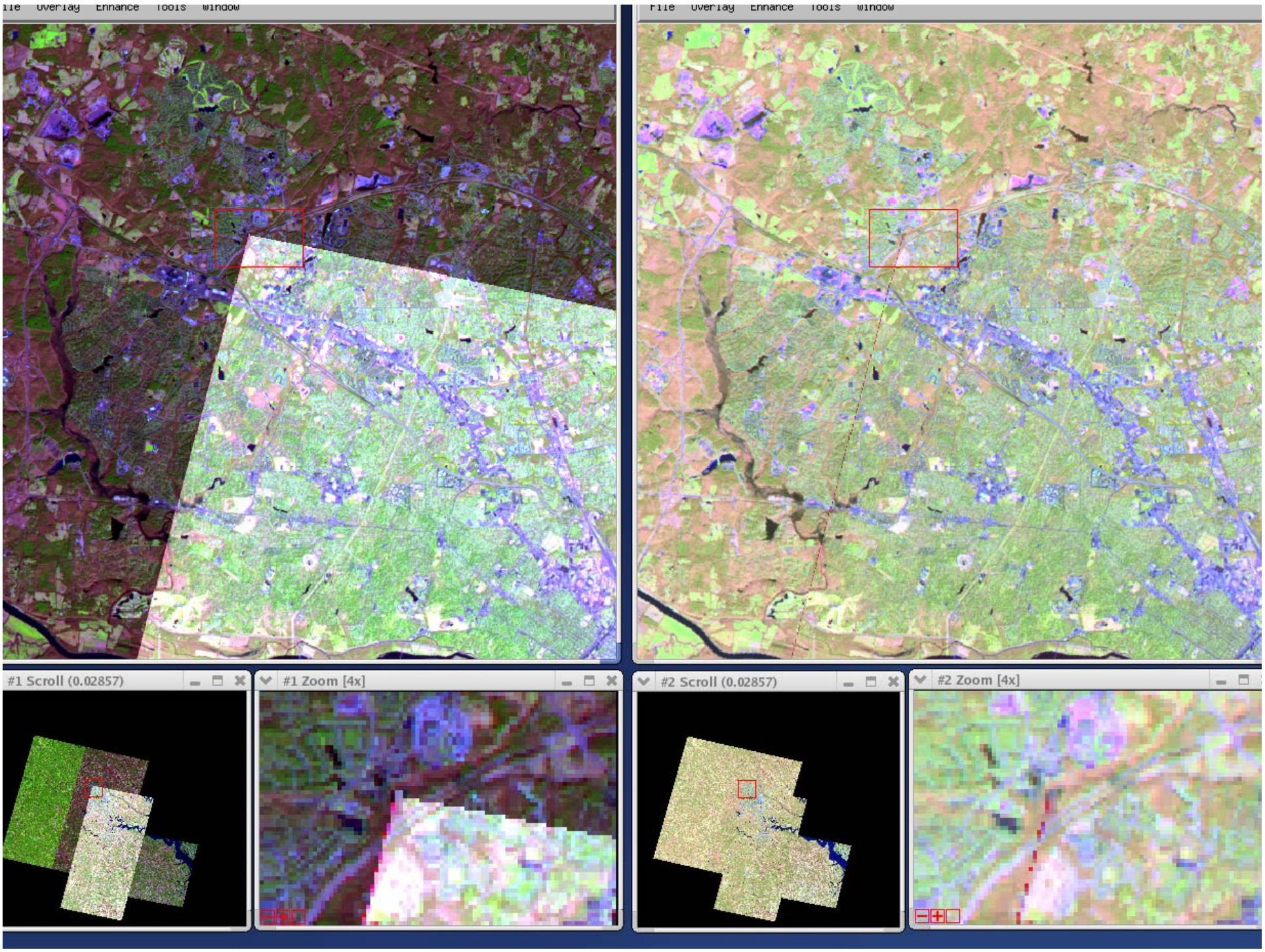


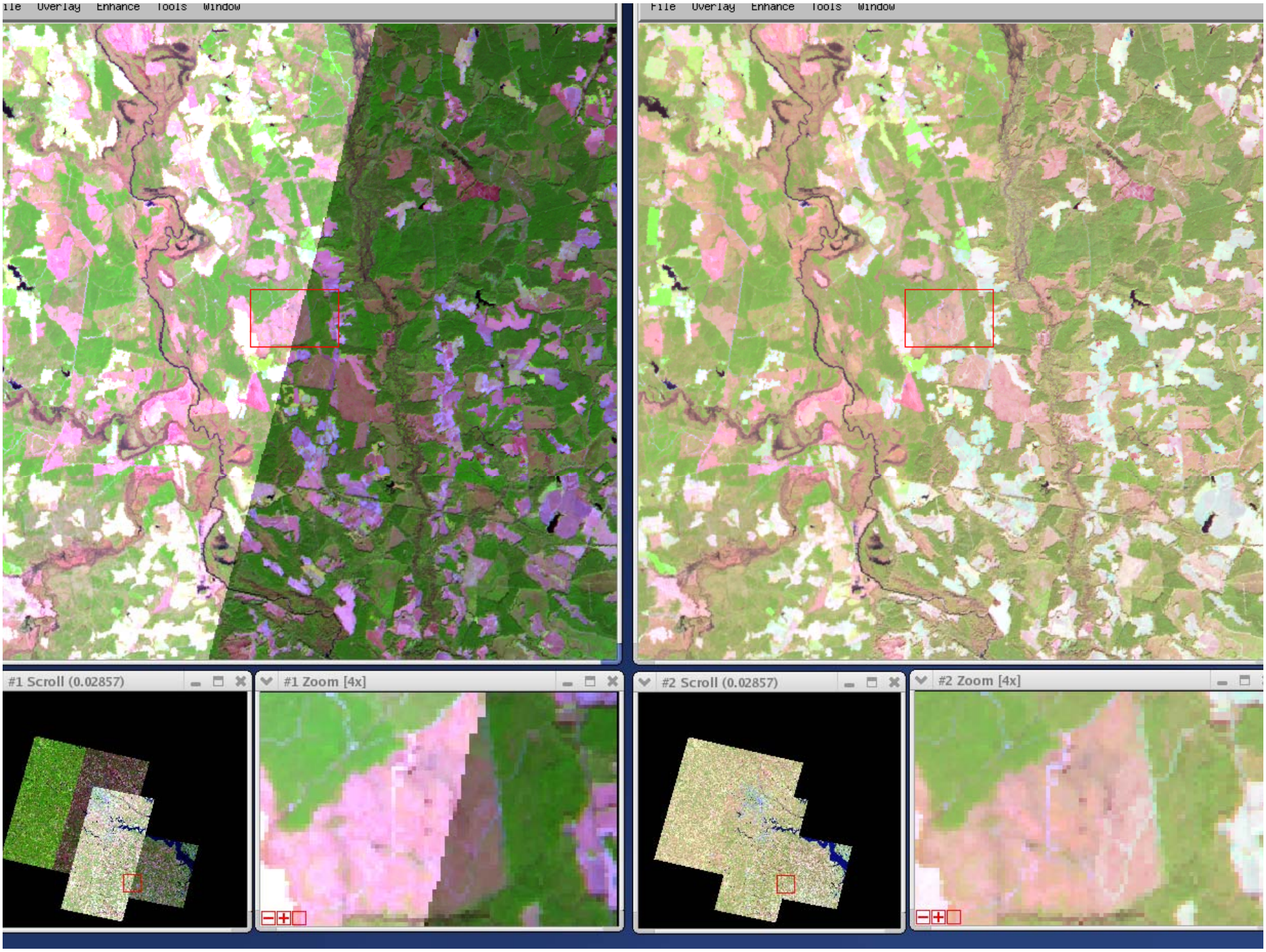
*** Overlapped or separate**
*** Single source or multiple sources**


MODIS daily SR on 2006-4-10
Or Mosaiced Composite MODIS
Surface Reflectance
Or NBAR data



Mosaiced daily surface reflectance on 4/10/2006


File Overlay Enhance Tools Window
File Overlay Enhance Tools Window
#1 Scroll (0.02857)
#1 Zoom [4x]
#2 Scroll (0.02857)
#2 Zoom [4x]


File Overlay Enhance Tools Window
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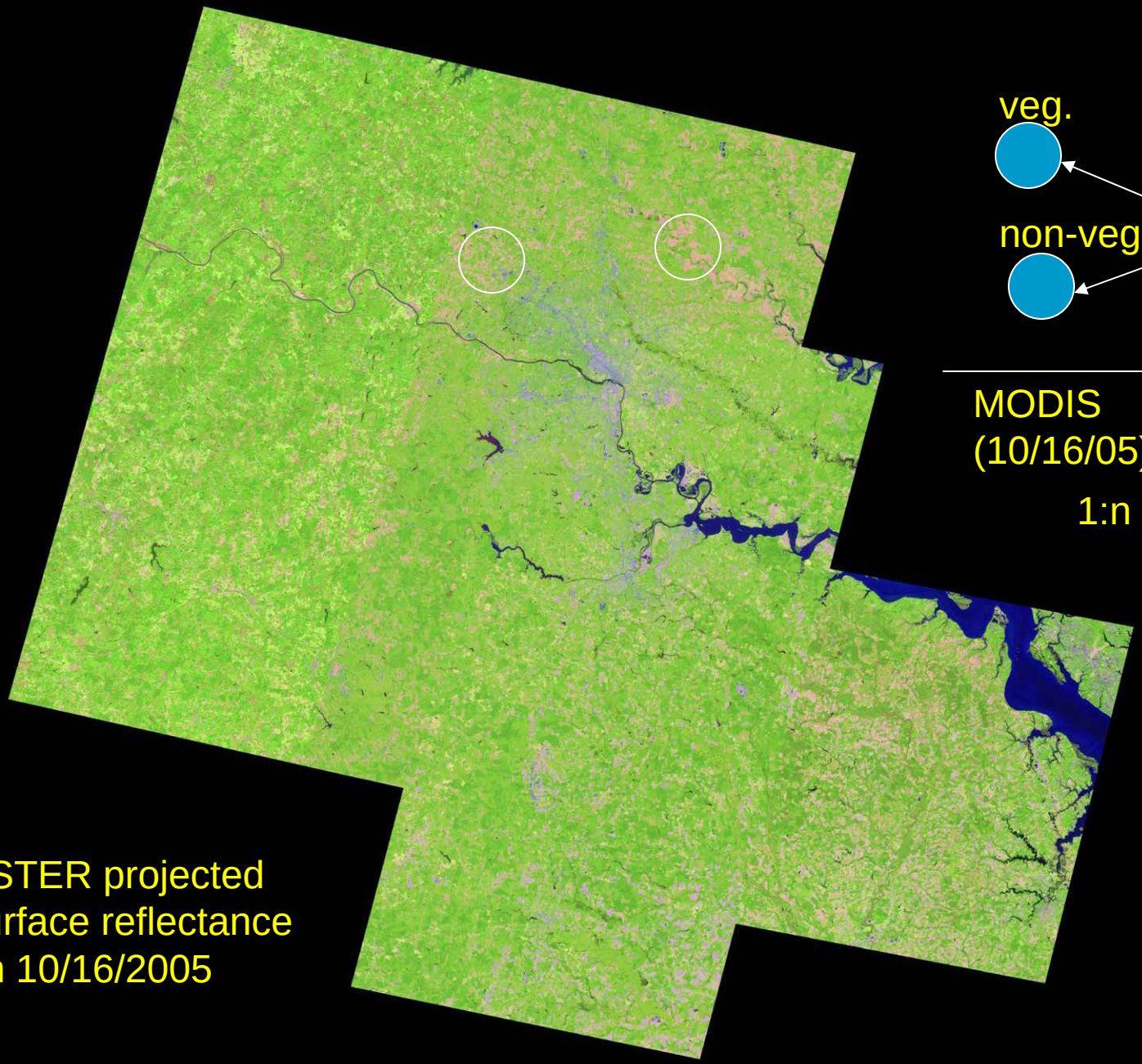
#1 Scroll (0.02857)
#1 Zoom [4x]
#2 Scroll (0.02857)
#2 Zoom [4x]

MODIS SR on 2005-10-16



veg.

non-veg.

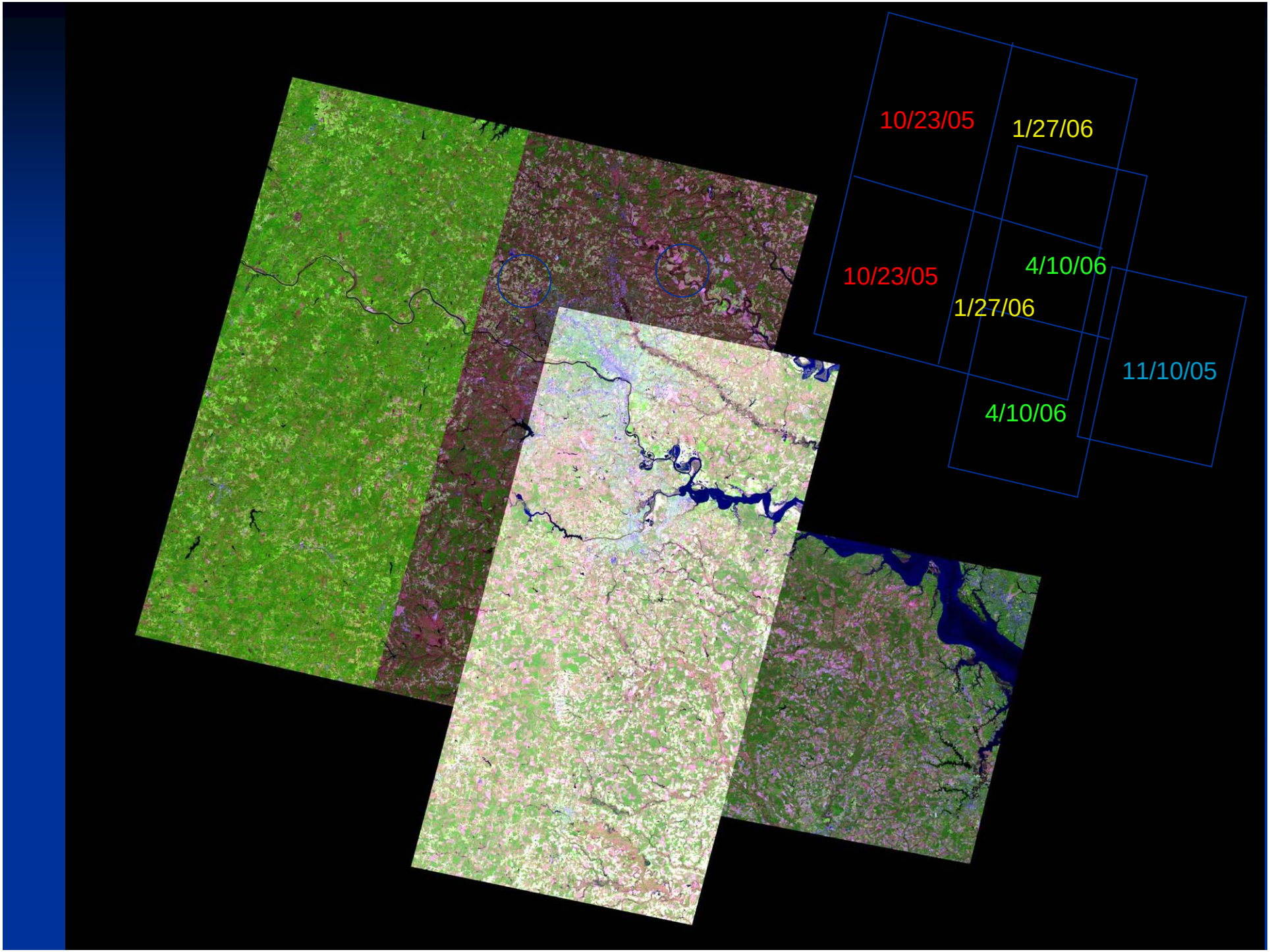
non-veg.

MODIS (10/16/05)

ASTER (1/27/06)

1:n relations

ASTER projected surface reflectance on 10/16/2005


10/23/05
1/27/06
10/23/05
4/10/06
1/27/06
11/10/05
4/10/06

Discussion

	Traditional	Reference-based
Overlapped Area	Required	Not required
Ancillary Data	Not required	MODIS/VIIRS
Registration	High requirement	Medium (coarse)
Cloud (in overlap area)	Significant effect	Only cloudy area
Cloud (in non-overlap)	Only cloudy area	Only cloudy area
Land Cover Change	Significant effect	Only changed types
Seasonal Change	Handles well	Handles well
Error Transmission	Pass across scenes	Only within scene
Handle Multiple Mod. Res. Data Sources	Depends on the size of the overlapped area	Yes, may solve 1:n problem

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Part II: Retrieval Landsat Albedo from Landsat Surface Reflectance and MODIS BRDF

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Theoretical Basis

$$R_\lambda(\theta_v,\theta_s,\phi) = f_{iso,\lambda} + f_{vol,\lambda}K_{vol}(\theta_v,\theta_s,\phi) + f_{geo,\lambda}K_{geo}(\theta_v,\theta_s,\phi)$$

$$\overline{R}_\lambda(\theta_s) = \frac{1}{\pi}\int_0^{2\pi} d\phi \int_0^1 R_\lambda(\theta_v,\theta_s,\phi)\mu_v d\mu_v$$

$$\overline{\overline{R}}_\lambda = \frac{1}{\pi}\int_0^{2\pi} d\phi \int_0^1 \overline{R}_\lambda(\theta_s)\mu_s d\mu_s$$

← MODIS BRDF/Albedo

$$R_{\lambda,nadir}(\theta_s) = R_\lambda(0,\theta_s,\phi)$$

$$\overline{a}_\lambda(\theta_s) = \overline{R}_\lambda(\theta_s) / R_{\lambda,nadir}(\theta_s)$$

$$\overline{\overline{a}}_\lambda(\theta_s) = \overline{\overline{R}}_\lambda / R_{\lambda,nadir}(\theta_s)$$

← A/N Ratio

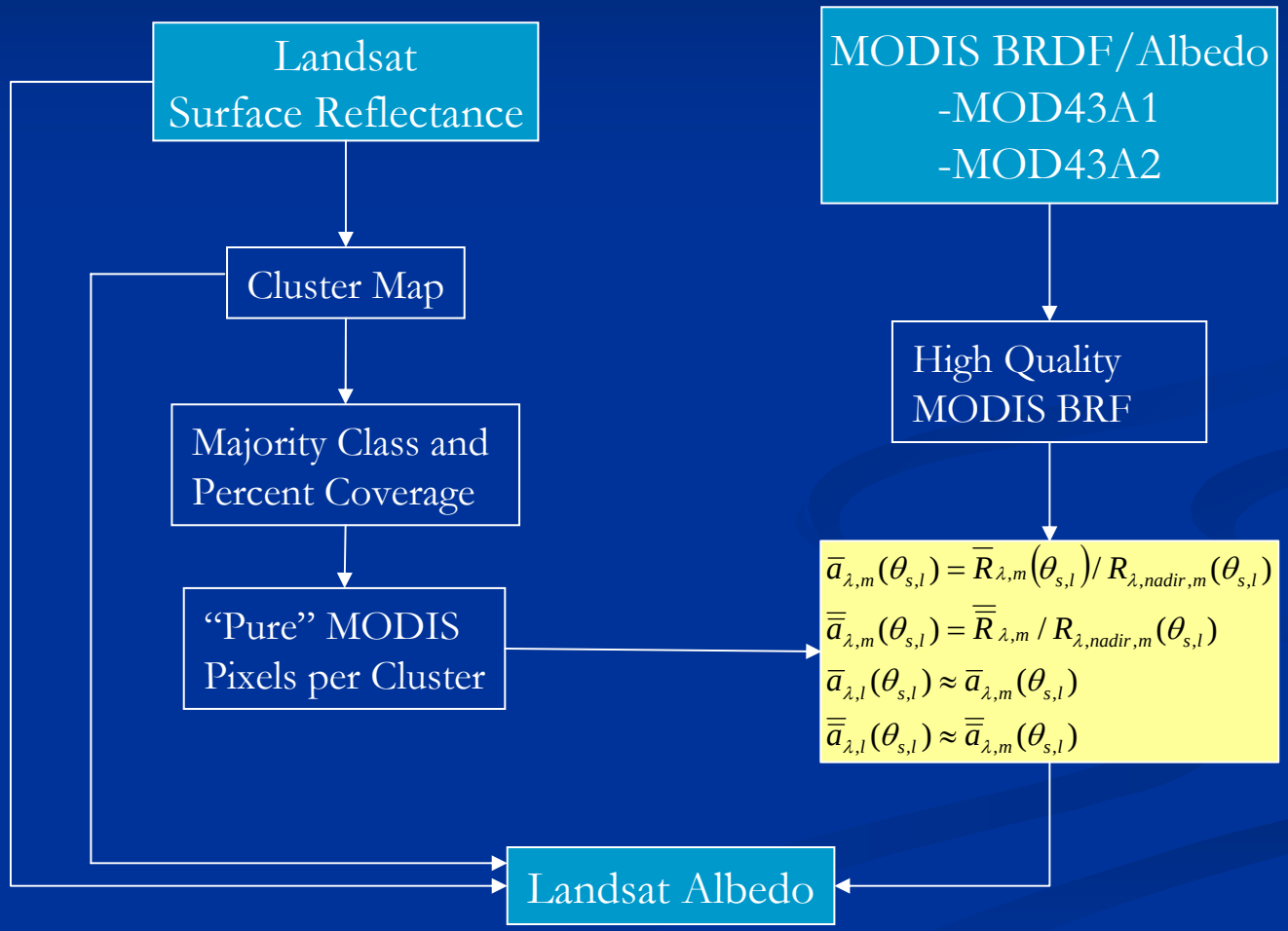
$$\overline{a}_{\lambda,l}(\theta_{s,l}) \approx \overline{a}_{\lambda,m}(\theta_{s,l}); \qquad \overline{\overline{a}}_{\lambda,l}(\theta_{s,l}) \approx \overline{\overline{a}}_{\lambda,m}(\theta_{s,l})$$

$$\overline{R}_{\lambda,l}(\theta_{s,l}) = \overline{a}_{\lambda,l}(\theta_{s,l}) \bullet R_{\lambda,l}(\theta_{s,l})$$

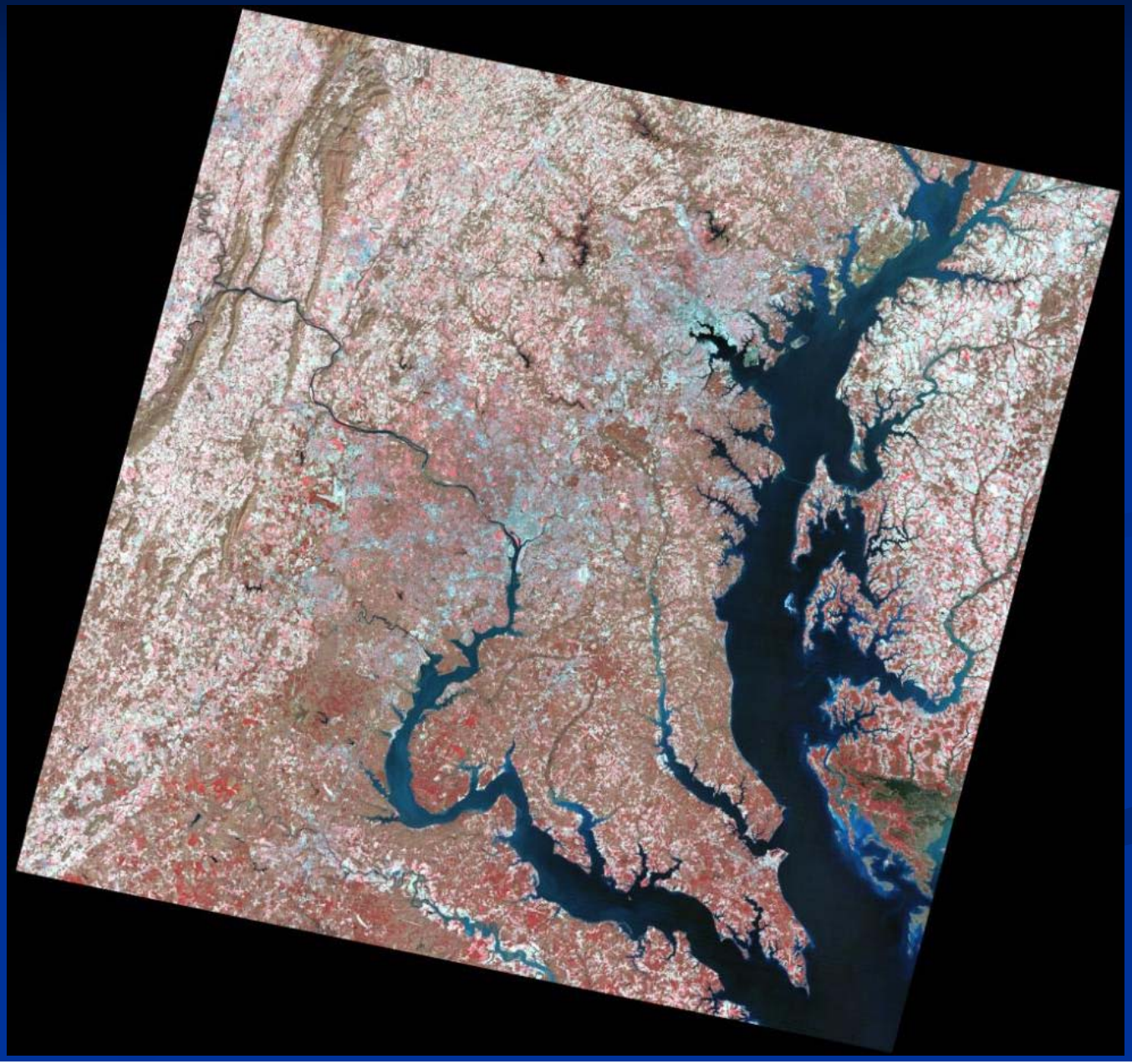
$$\overline{\overline{R}}_{\lambda,l} = \overline{\overline{a}}_{\lambda,l}(\theta_{s,l}) \bullet R_{\lambda,l}(\theta_{s,l})$$

← Landsat Albedo

Relating MODIS BRDF to Landsat



Example



Data Sources

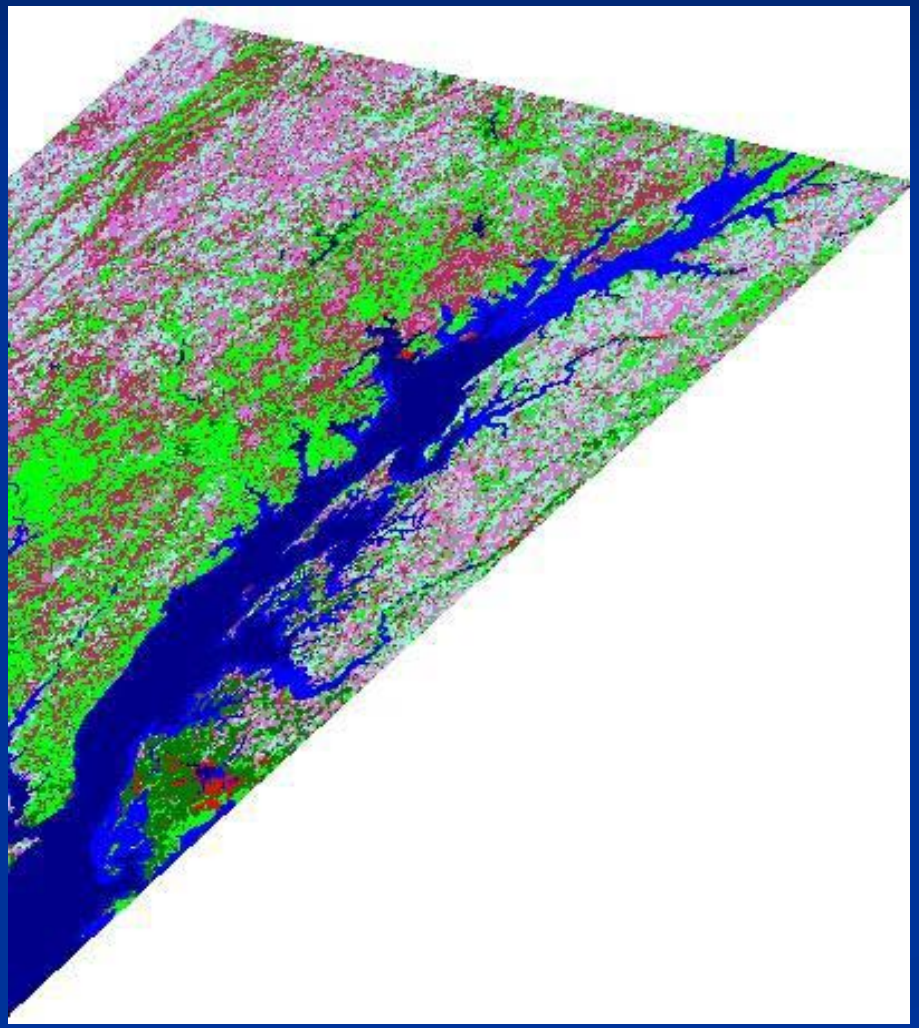
Landsat5 TM
Surface Reflectance
Path 15 Row 33
March 19, 2001

MODIS BRDF
MOD43A1
MOD43A2
2001-073

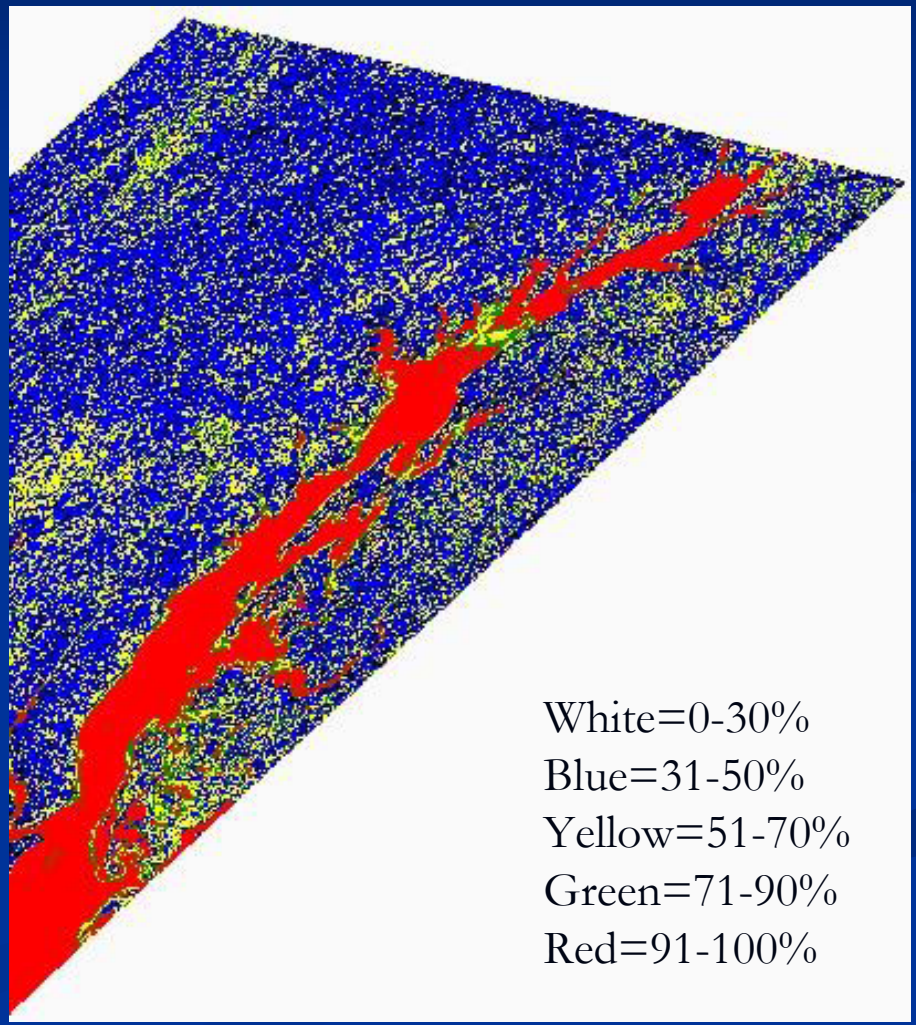
Cluster Map (K-mean)

Cls	Color	%
0	White	42.63
1	Dark Blue	5.55
2	Light Blue	3.55
3	Red	0.74
4	Dark green	4.20
5	Light green	11.56
6	Maroon	12.43
7	Orchid	9.04
8	Aquamarine	6.43
9	Thistle	3.33
10	Orchid	0.53

Pure MODIS Pixels Selection



Majority Class

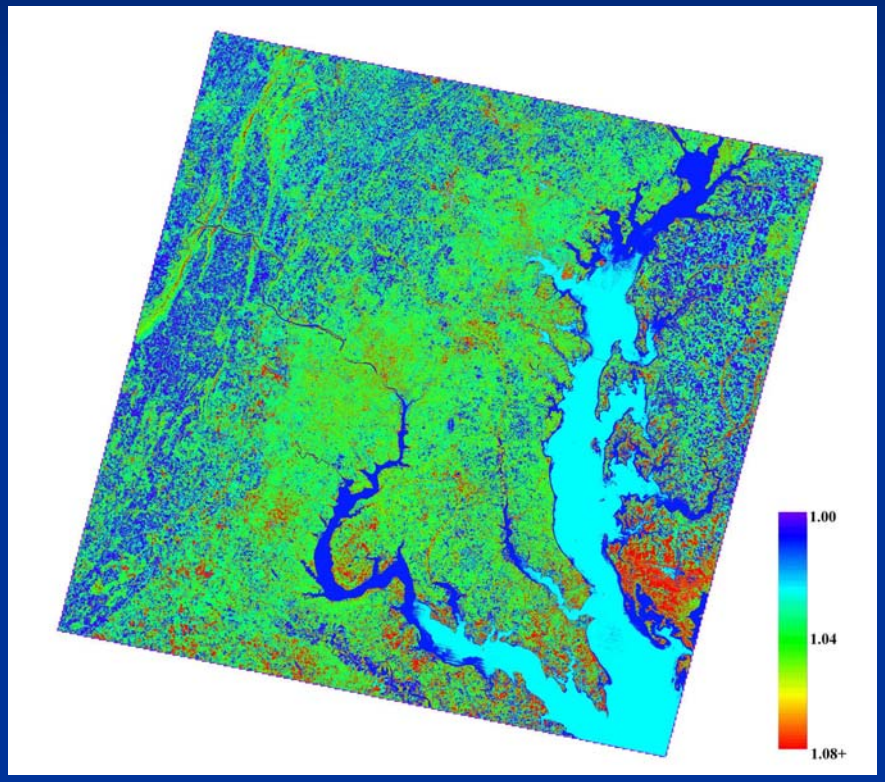


Percentage of Majority Class

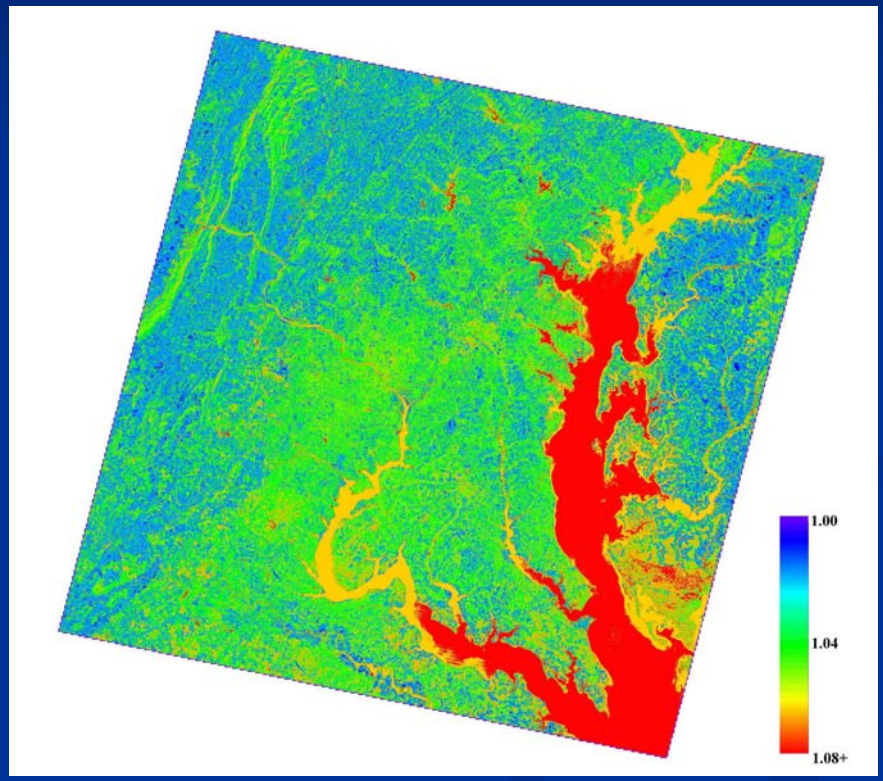
Mean A/N Ratios

CLS #	B1	B2	B3	B4	B5	B6	B7	#Pure Pixels	Thres-hold
1	1.026	1.071	1.021	1.020	1.071	1.048	1.048	732	=100%
2	1.014	1.074	1.022	1.015	1.093	1.090	1.088	1355	=100%
3	1.073	1.080	1.068	1.078	1.079	1.087	1.088	83	>60%
4	1.085	1.058	1.079	1.085	1.056	1.071	1.081	221	>90%
5	1.051	1.046	1.047	1.063	1.034	1.036	1.038	135	>81%
6	1.037	1.040	1.035	1.052	1.026	1.026	1.024	139	>71%
7	1.031	1.021	1.025	1.028	1.028	1.040	1.041	170	>80%
8	1.009	1.025	1.007	1.012	1.021	1.017	1.014	292	>60%
9	1.003	1.021	1.001	1.005	1.017	1.008	1.005	221	>60%
10	1.005	1.014	1.003	1.006	1.010	1.009	1.005	43	>40%

Landsat A/N Ratio Map



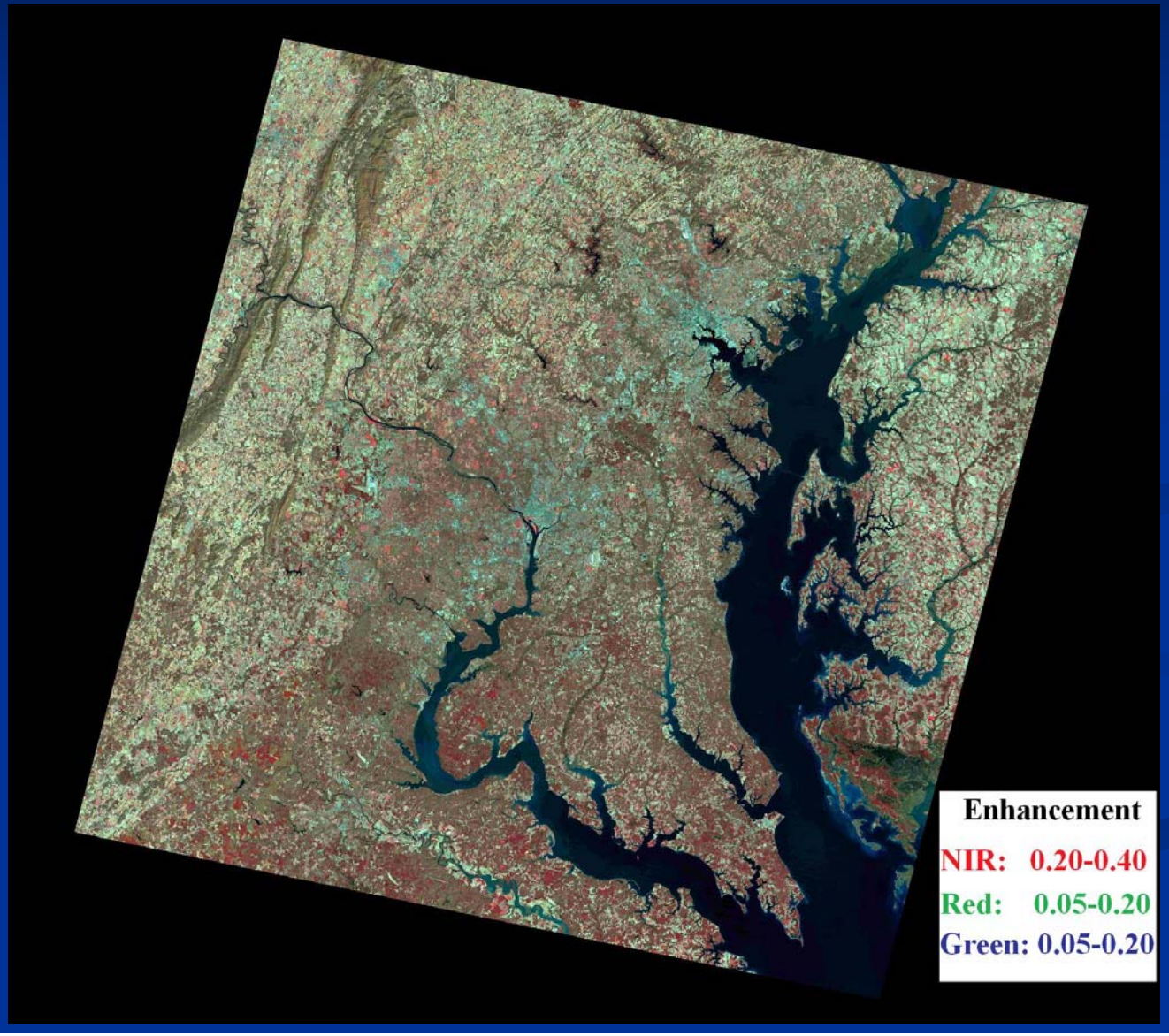
red



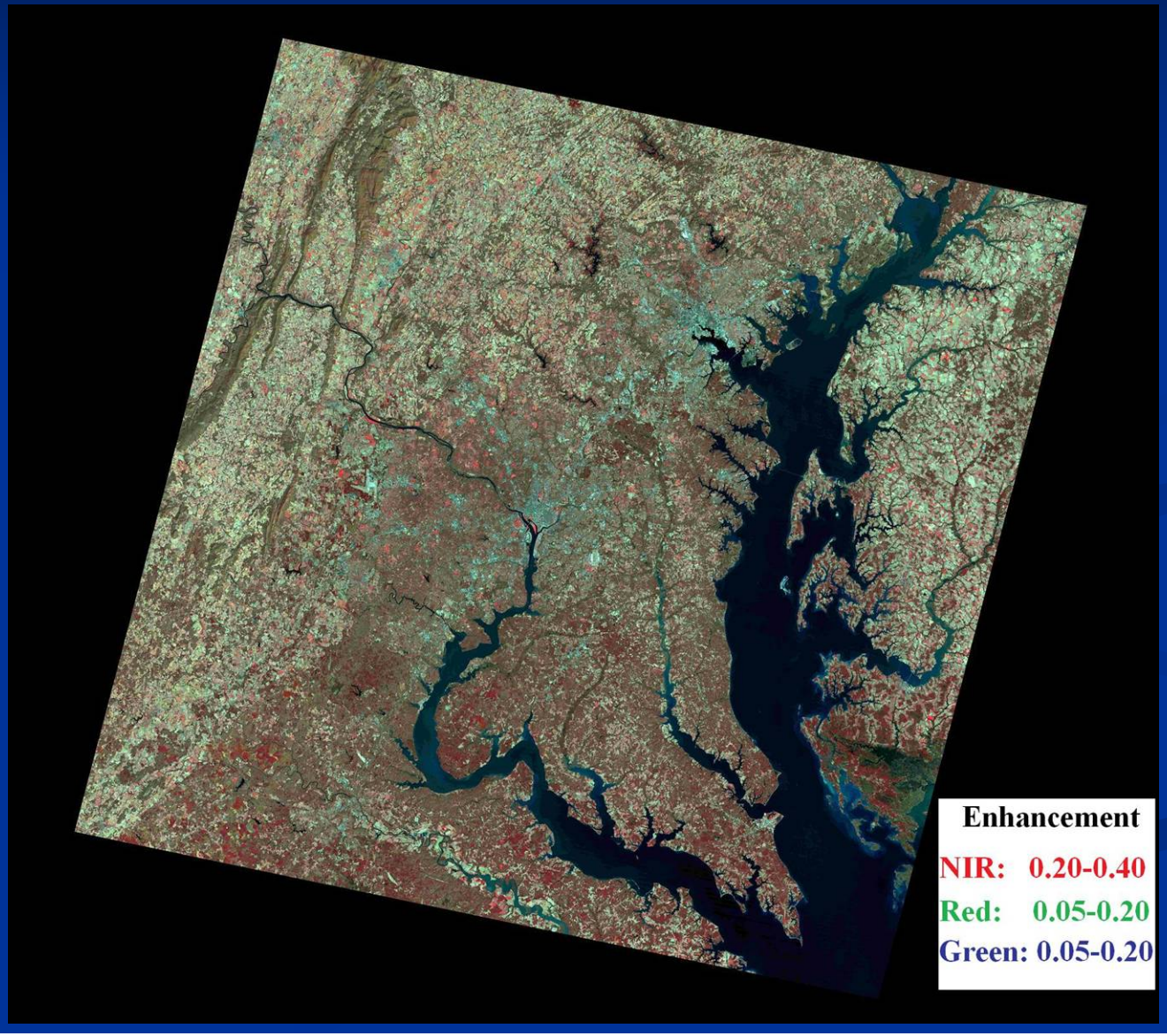
NIR

1.0 1.02 1.04 1.06 1.08

Landsat Albedo



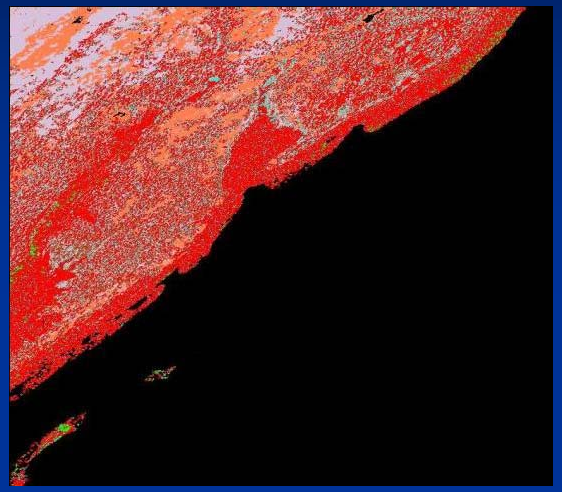
Landsat Surface Reflectance



MODIS Seasonal A/N Ratios

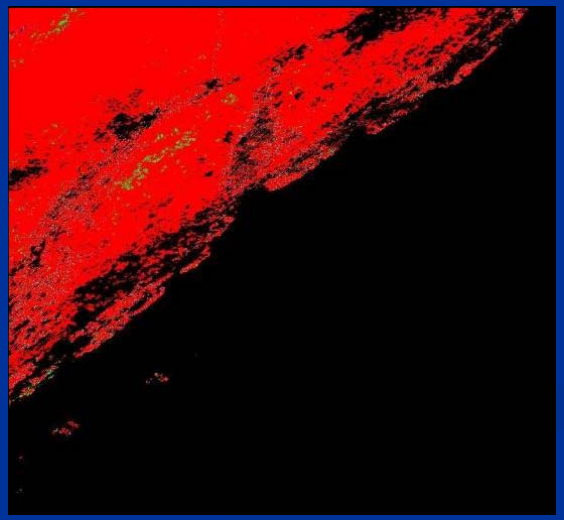
Color Scheme

0.0-0.5 = Yellow
0.6-0.8 = Green
0.8-1.0 = Red
1.0-1.05 = Cyan
1.05-1.10 = Coral
1.1-1.2 = Thistle
1.2-2.0 = Sienna

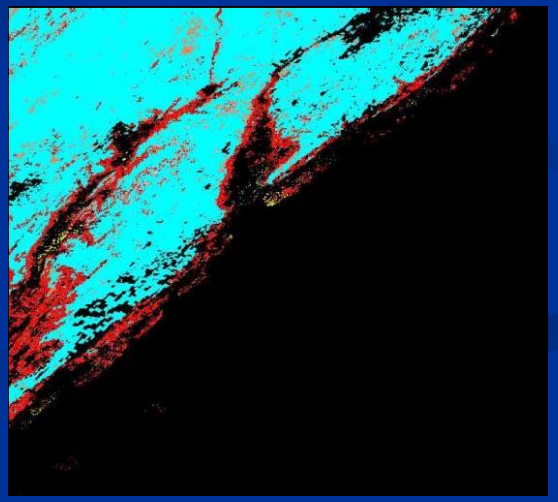


Red, 2001-073

NIR, 2001-073



Red, 2001-177



NIR, 2001-177

Discussion

- 5-10% (conservative estimation) variation of A/N ratio does matter for albedo estimation
- Needs ancillary BRDF support for Landsat albedo
- "Pure" MODIS pixels detection
  - Pure pixel thresholds vary for different cluster
  - Limit small/trivial clusters
- A/N ratio variation within clusters