Repeat Frequency versus Clear View Coverage for a Landsat Observatory : An Empirical Assessment

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Landsat Science Team – LTAP Approach
U. Maryland and NASA/GSFC

LTAP Goal For Landsat 7

- "*Periodically refresh a global archive with substantially cloud-free, sunlit, land mass scenes*"

LTAP Goal For Landsat 8

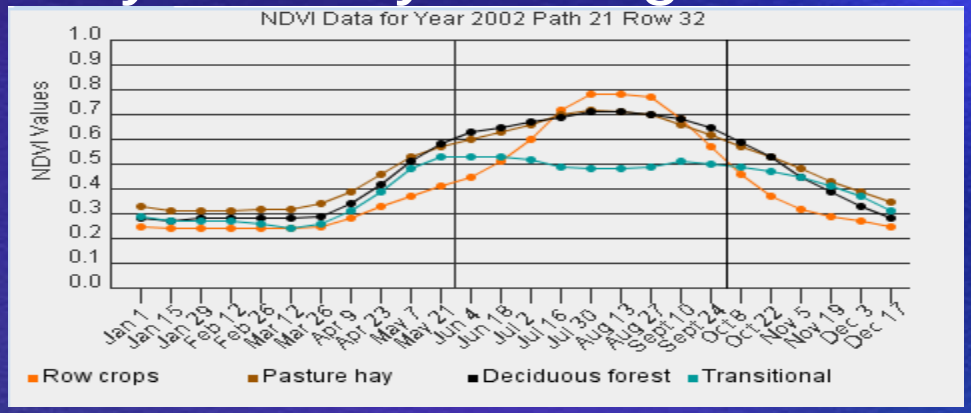
- "*Periodically refresh a global archive with substantially cloud-free, sunlit, land mass scenes*"
- No more and possibly less??

Science Goal for an Operational Land Observatory System (OLOS)

- Global Monitoring of Land Human/Environment Interactions (land cover/land use)
  - Food
  - Fiber (forests)
  - Fresh water supply
  - Habitation

Mission Requirements for OLOS

- Inter-annual dynamics assessment
  - Defined by within-year vegetation seasonality



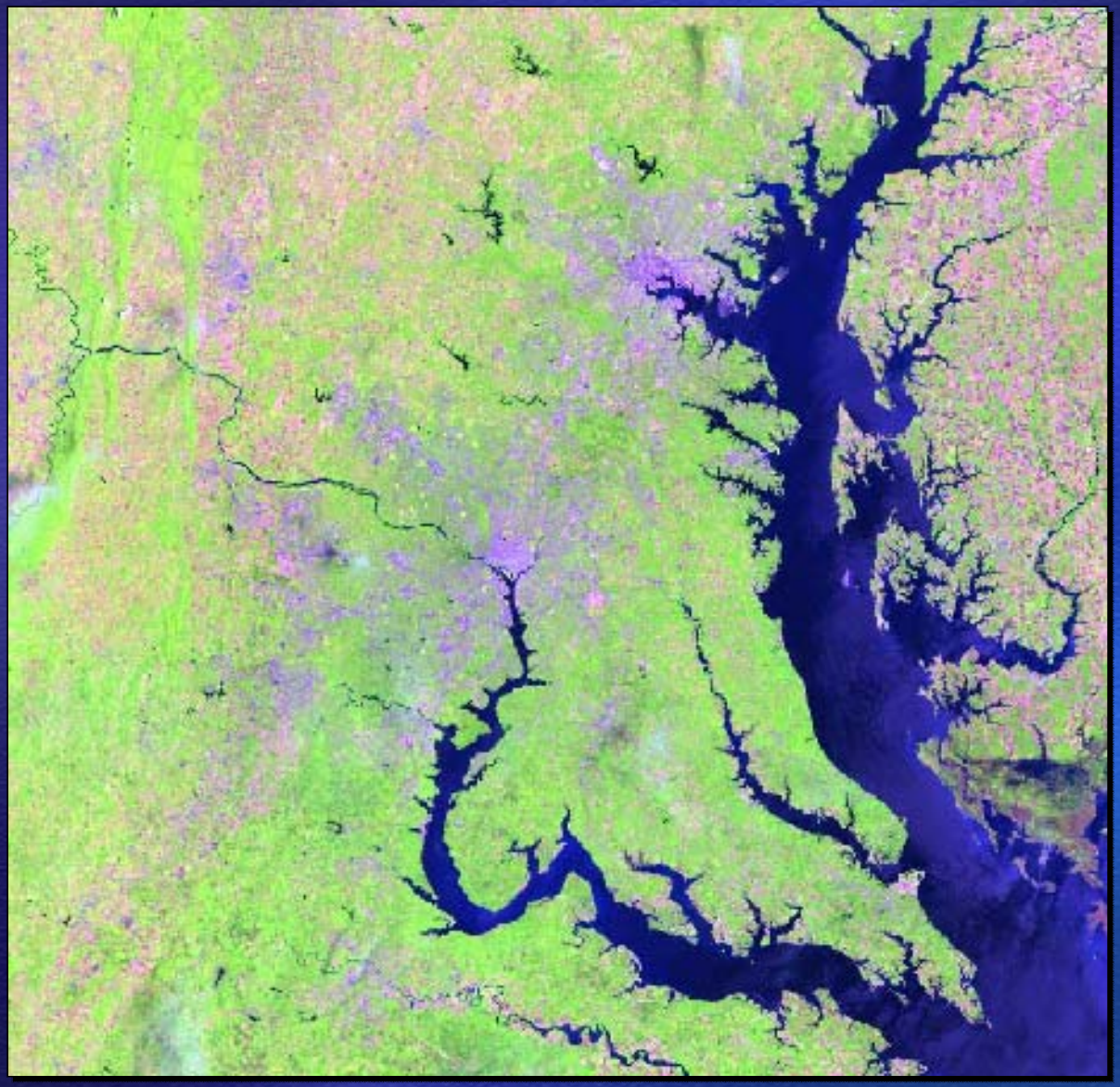
  - For best results requires weekly clear views

  - Cloud contamination a serious problem

MODIS TERRA Empirical Assessment

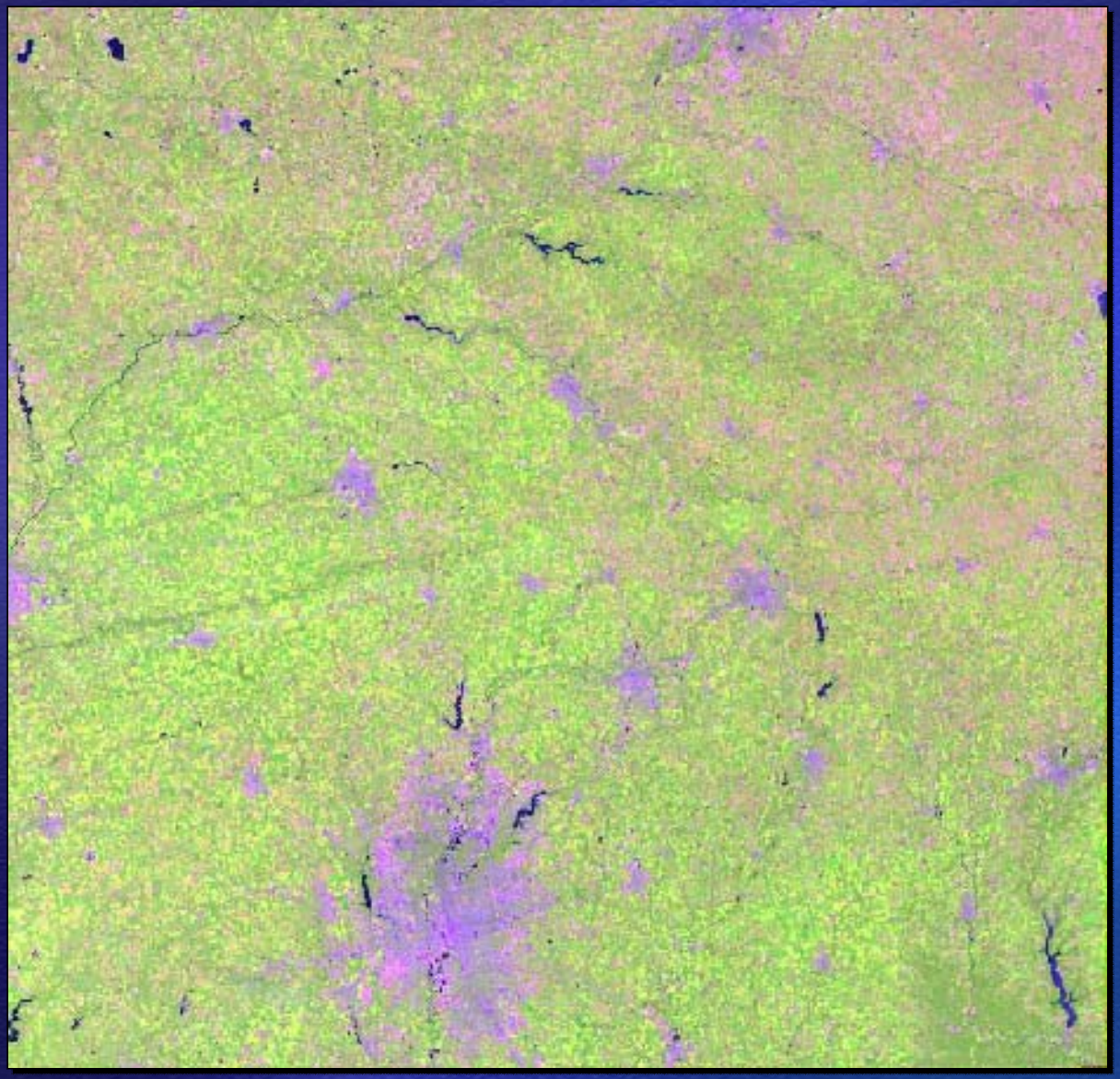
- Approach
  - 3 sites in eastern US evaluated
    - Maryland, Pennsylvania, Indiana
  - Daily MODIS surface reflectance images
    - 8 years (2001-08)
  - Visual analysis of Images for cloud cover
    - clear, mostly clear, mostly cloudy, cloudy
  - Compare 16, 8, 4, 2, 1 day repeat observations
    - Basic assumption is 180 Km swath

Maryland p15r33

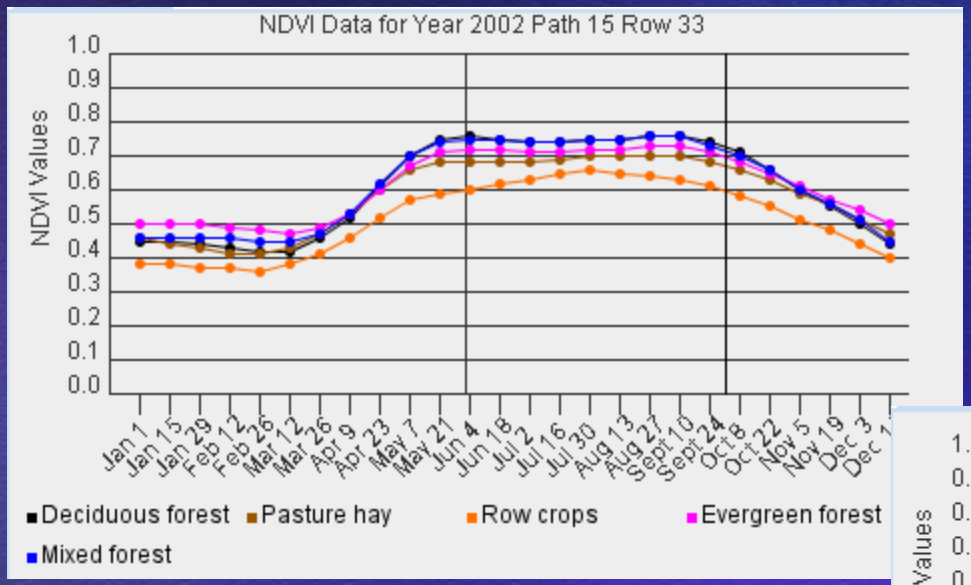


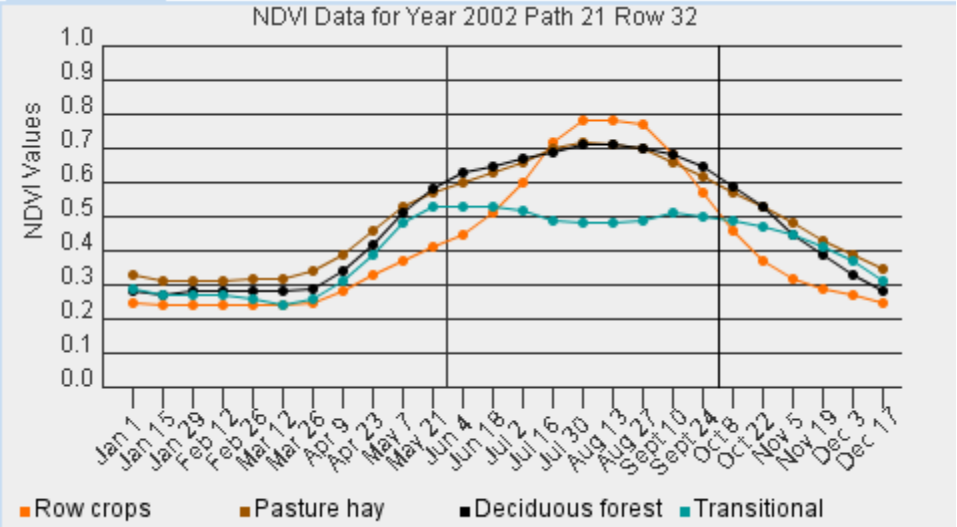
Pennsylvania p17r31

Indiana p21r32



MD


NDVI Data for Year 2002 Path 15 Row 33
NDVI Values
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Jan 1
Jan 15
Jan 29
Feb 12
Feb 26
Mar 12
Mar 26
Apr 9
Apr 23
May 7
May 21
Jun 4
Jun 18
Jul 2
Jul 16
Jul 30
Aug 13
Aug 27
Sept 10
Sept 24
Oct 8
Oct 22
Nov 5
Nov 19
Dec 3
Deciduous forest
Pasture hay
Row crops
Evergreen forest
Mixed forest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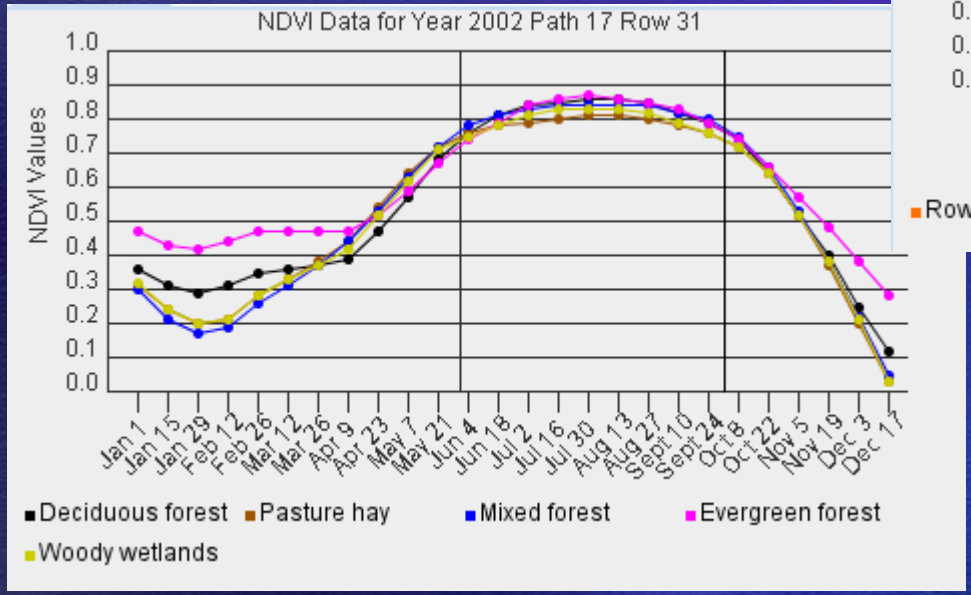
NDVI Values
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Jan 1
Jan 15
Jan 29
Feb 12
Feb 26
Mar 12
Mar 26
Apr 9
Apr 23
May 7
May 21
Jun 4
Jun 18
Jul 2
Jul 16
Jul 30
Aug 13
Aug 27
Sept 10
Sept 24
Oct 8
Oct 22
Nov 5
Nov 19
Dec 3
Row crops
Pasture hay
Deciduous forest
Transitional

PA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NDVI Values
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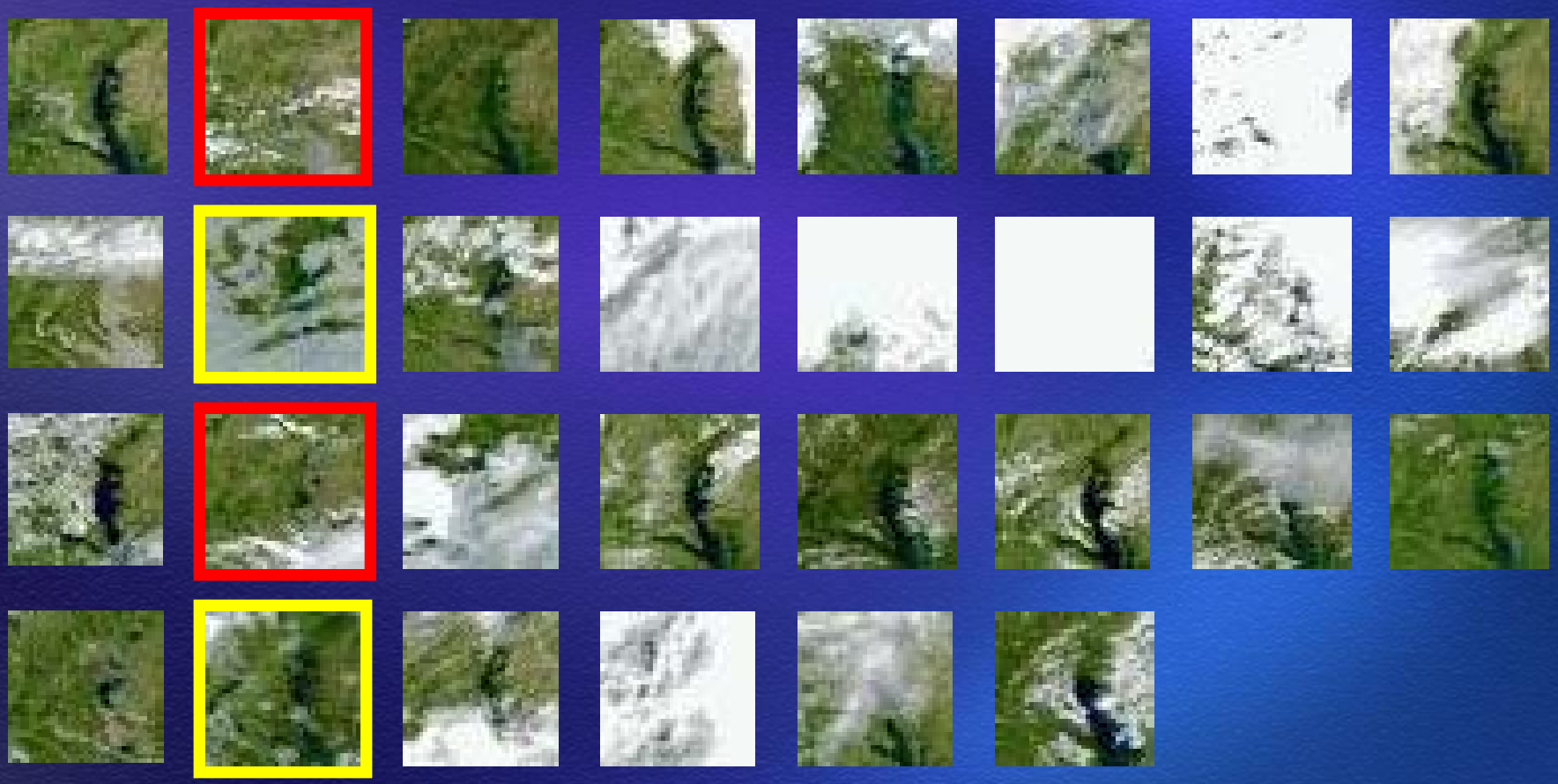
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Jan 1
Jan 15
Jan 29
Feb 12
Feb 26
Mar 12
Mar 26
Apr 9
Apr 23
May 7
May 21
Jun 4
Jun 18
Jul 2
Jul 16
Jul 30
Aug 13
Aug 27
Sept 10
Sept 24
Oct 8
Oct 22
Nov 5
Nov 19
Dec 3
Deciduous forest
Pasture hay
Mixed forest
Evergreen forest
Woody wetlands

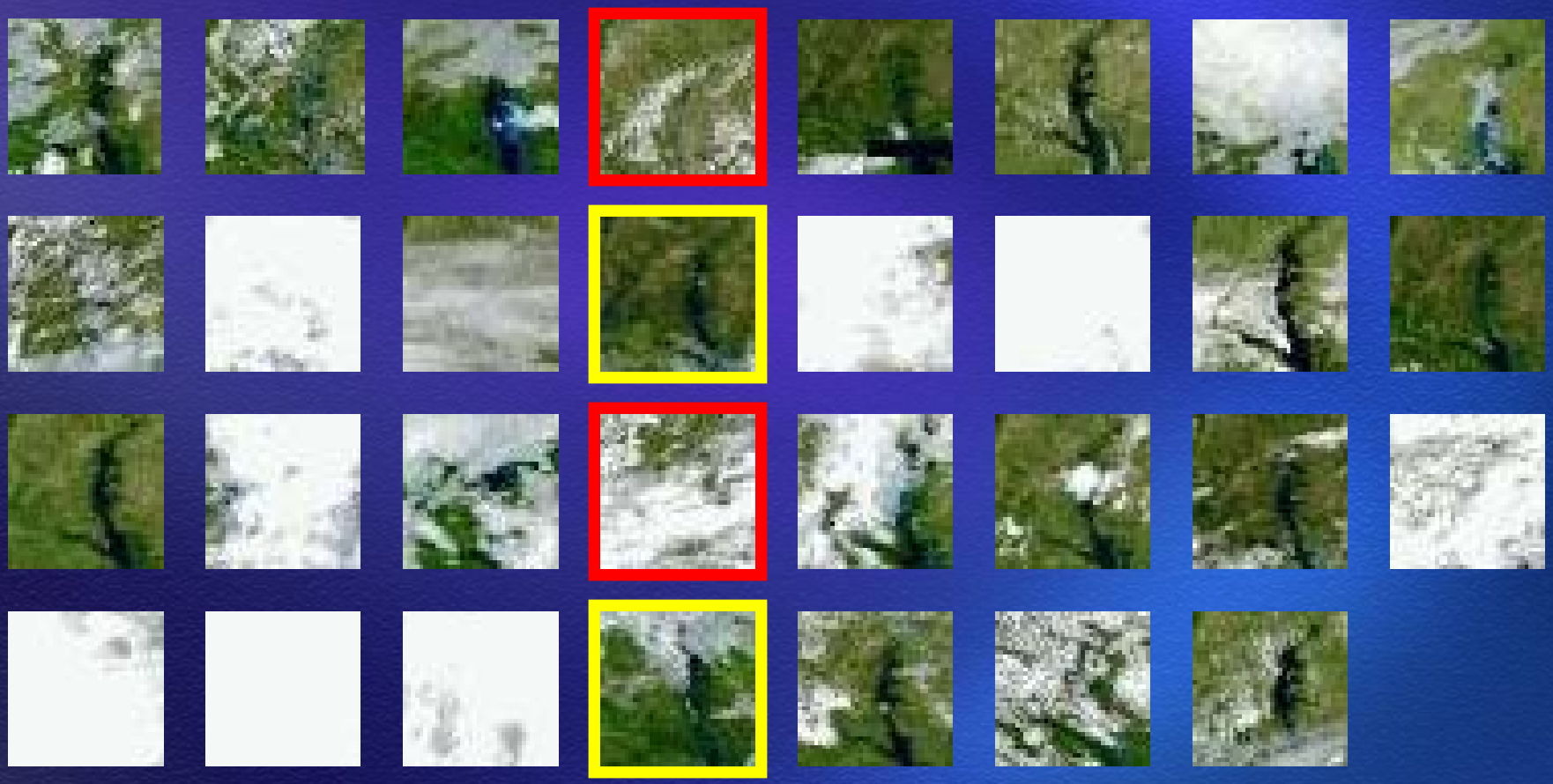
IN

MD p15r33 June 2002

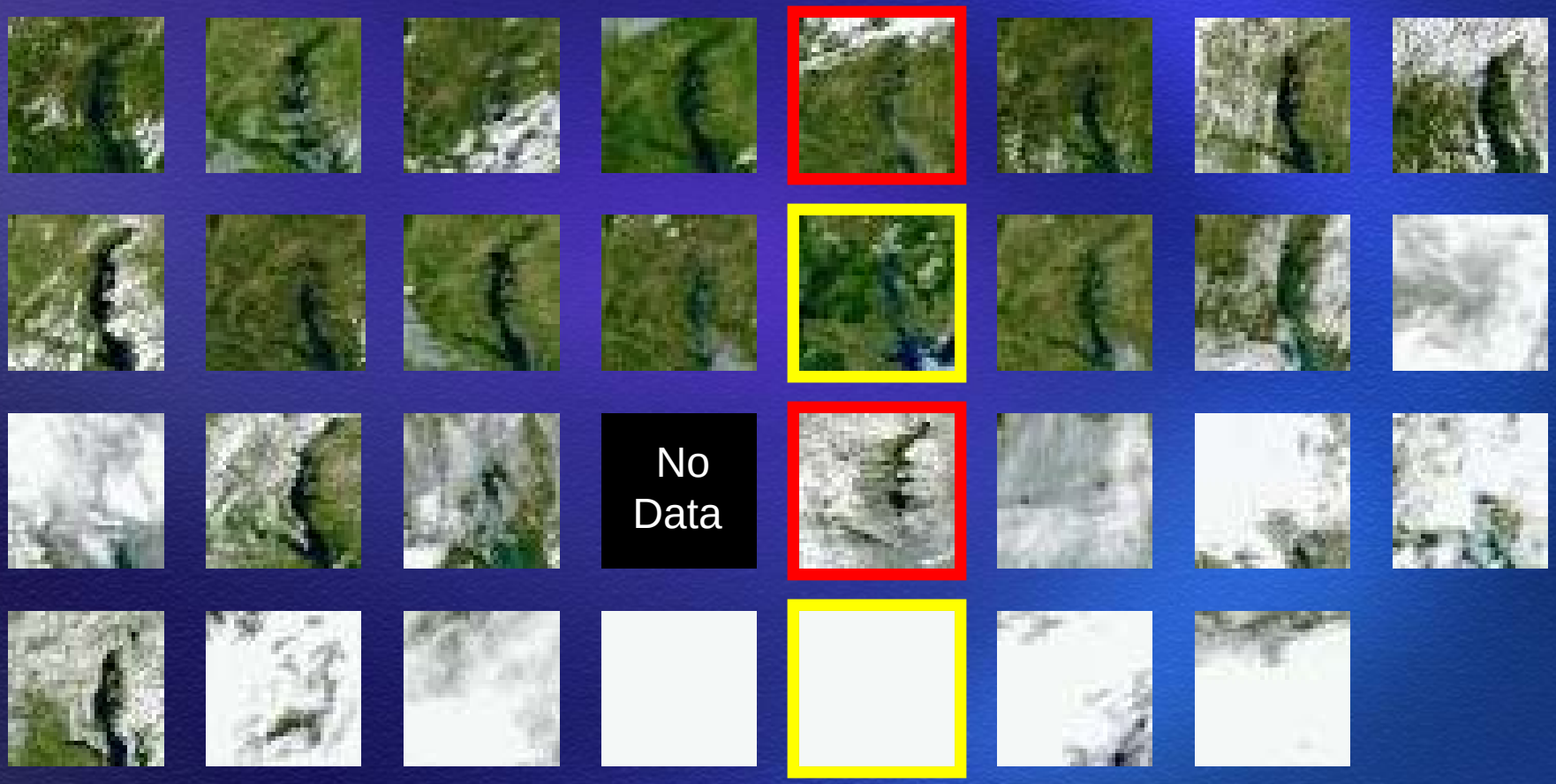


Note: Images outlined correspond to Landsat 5 and 7 observation dates

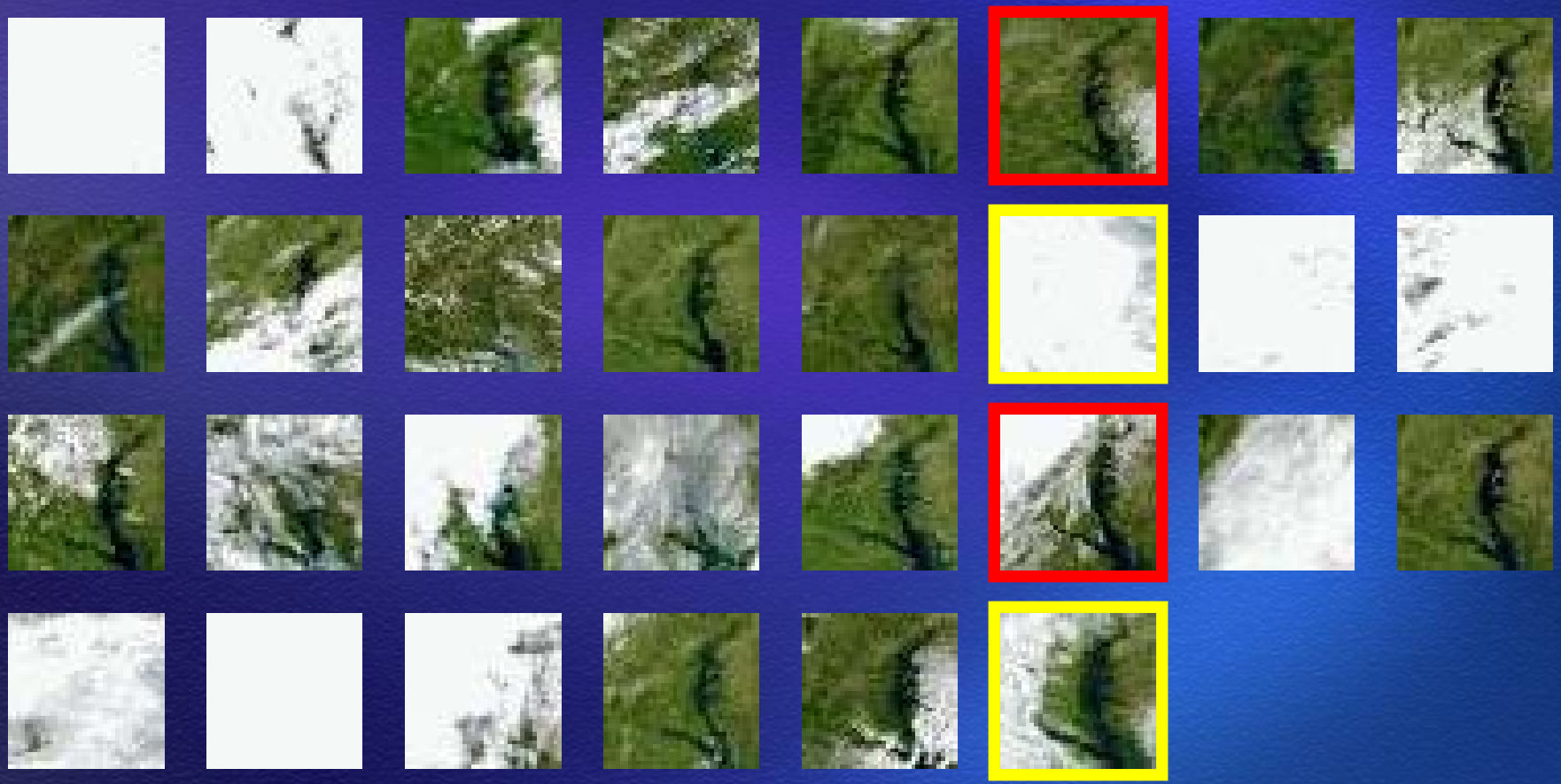
MD p15r33 July 2002



MD p15r33 August 2002



MD p15r33 September 2002



Analysis Method

- Visual assessment of cloud cover
- Each image assigned a rank of 1-4 based on the apparent cloud cover present in an individual scene
  - Examples

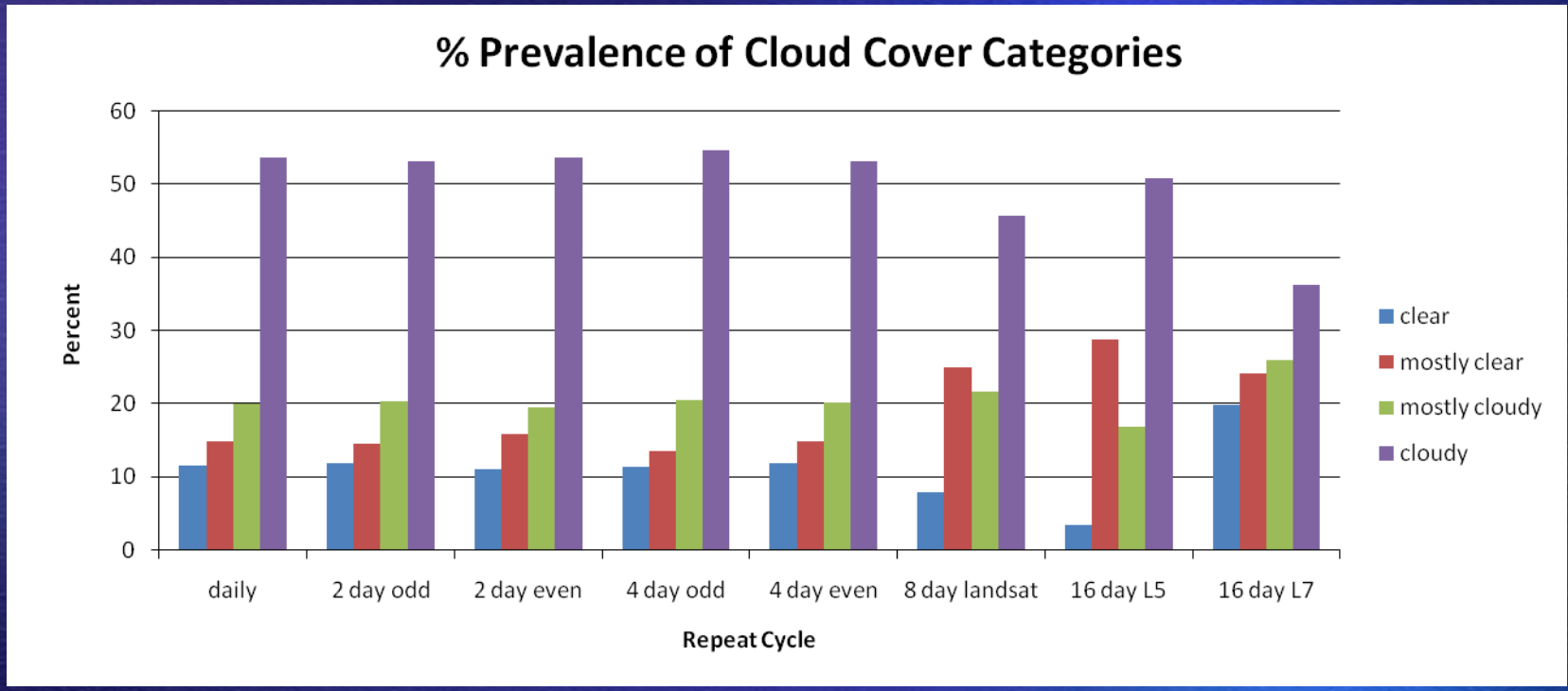
Clear
rank = 1

Mostly Clear
rank = 2

Mostly Cloudy
rank = 3

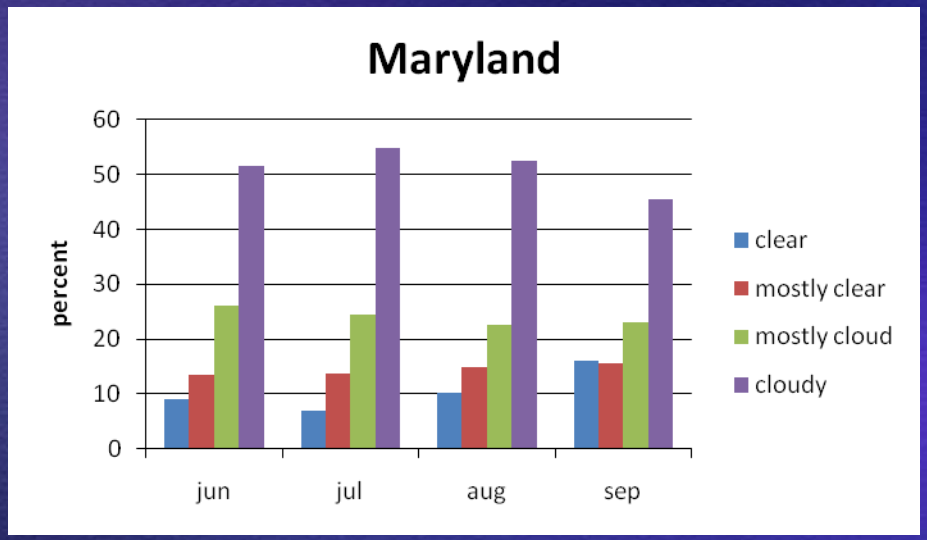
Cloudy
rank = 4

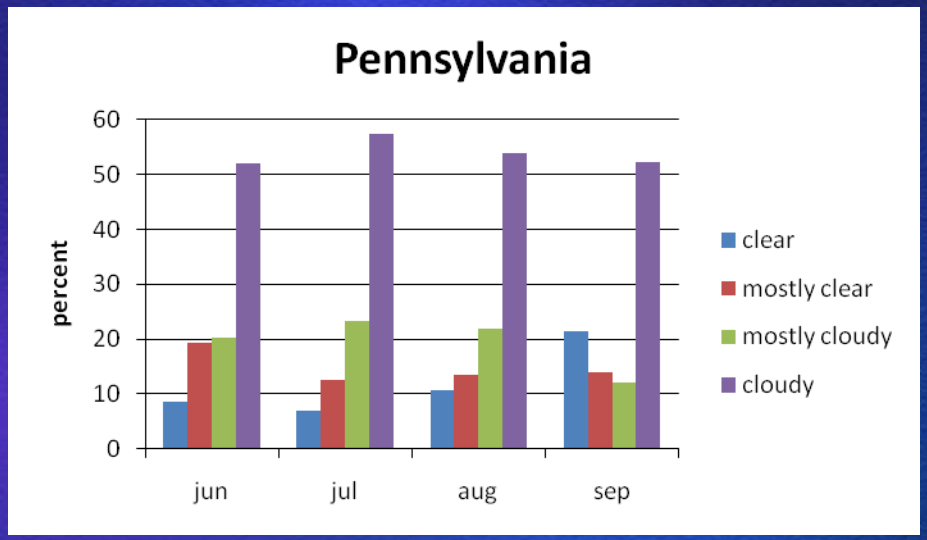
Pennsylvania

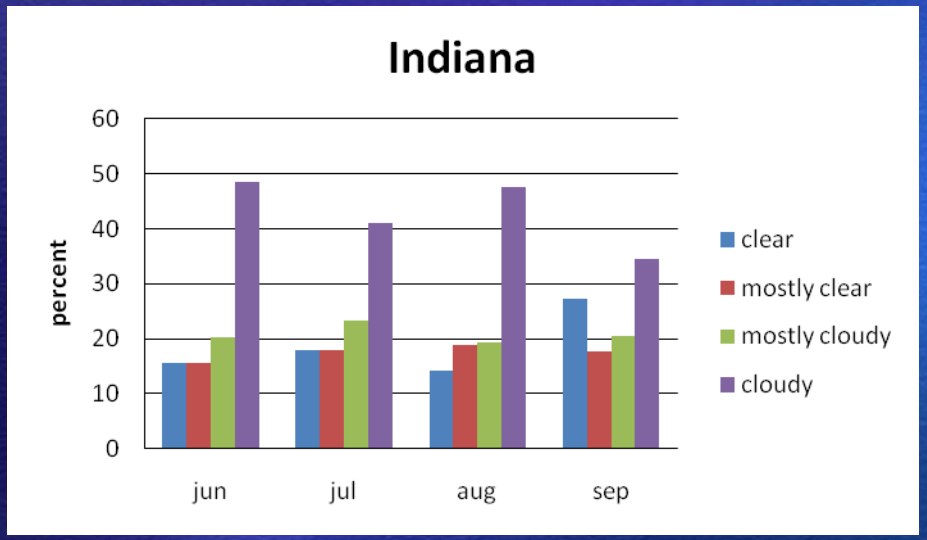


	Daily	2 day odd	2 day even	4 day odd	4 day even	8 day Landsat	16 day L5	16 day L7
Clear	11.9	11.8	11.1	11.4	11.9	7.8	3.4	19.8
Mostly Clear	14.7	14.3	15.8	13.5	14.8	25	28.8	24.1
Mostly Cloudy	19.5	20.4	19.5	20.4	20.2	21.6	16.9	25.9
Cloudy	53.9	53.5	53.6	54.7	53.1	45.7	50.8	36.2

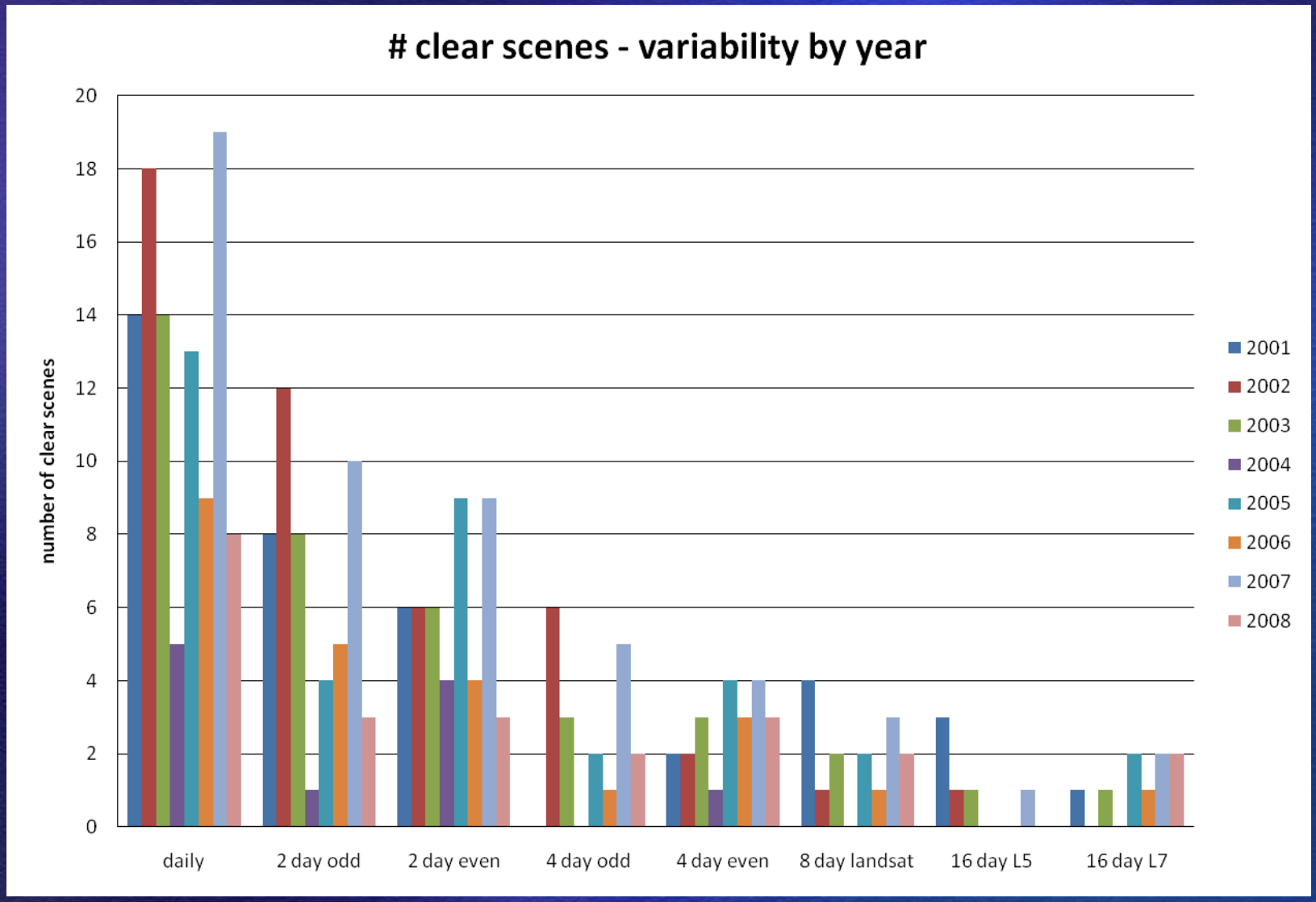
Monthly Breakdown of Cloud Cover Categories







Maryland


clear scenes - variability by year
number of clear scenes
0
2
4
6
8
10
12
14
16
18
20
daily
2 day odd
2 day even
4 day odd
4 day even
8 day landsat
16 day L5
16 day L7
2001
2002
2003
2004
2005
2006
2007
2008

Pennsylvania
Probability of Acquiring Weekly Clear Views

Daily Repeat	4	3	2	1
June	25%	37.5%	62.5%	100%
July	0%	12.5%	37.5%	87.5%
August	0%	25%	100%	100%
September	50%	75%	87.5%	100%

2 Day Odd	4	3	2	1
June	0%	0%	37.5%	100%
July	0%	12.5%	12.5%	75%
August	0%	12.5%	37.5%	87.5%
September	12.5%	62.5%	87.5%	100%

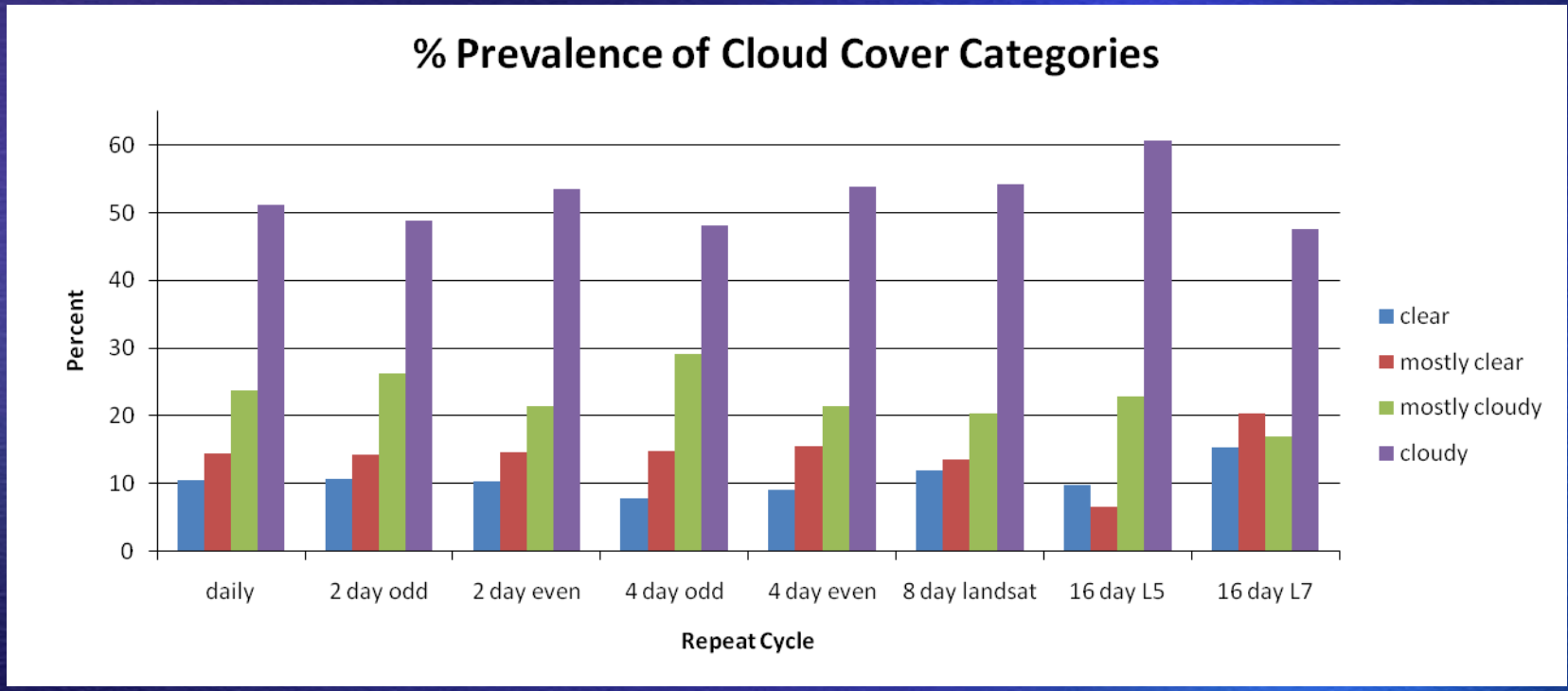
2 Day Even	4	3	2	1
June	12.5%	25%	37.5%	75%
July	0%	0%	12.5%	62.5%
August	0%	0%	62.5%	100%
September	12.5%	62.5%	75%	75%

Thoughts

- Cloud cover dominates acquisition success
- Some hints of cloud periodicity (GCT)
- For mid-latitude eastern North America daily needed for near-weekly coverage
- Partly cloudy image merging may help
- The LTAP Cloud avoidance approach needs to evaluated versus MODIS-observed conditions

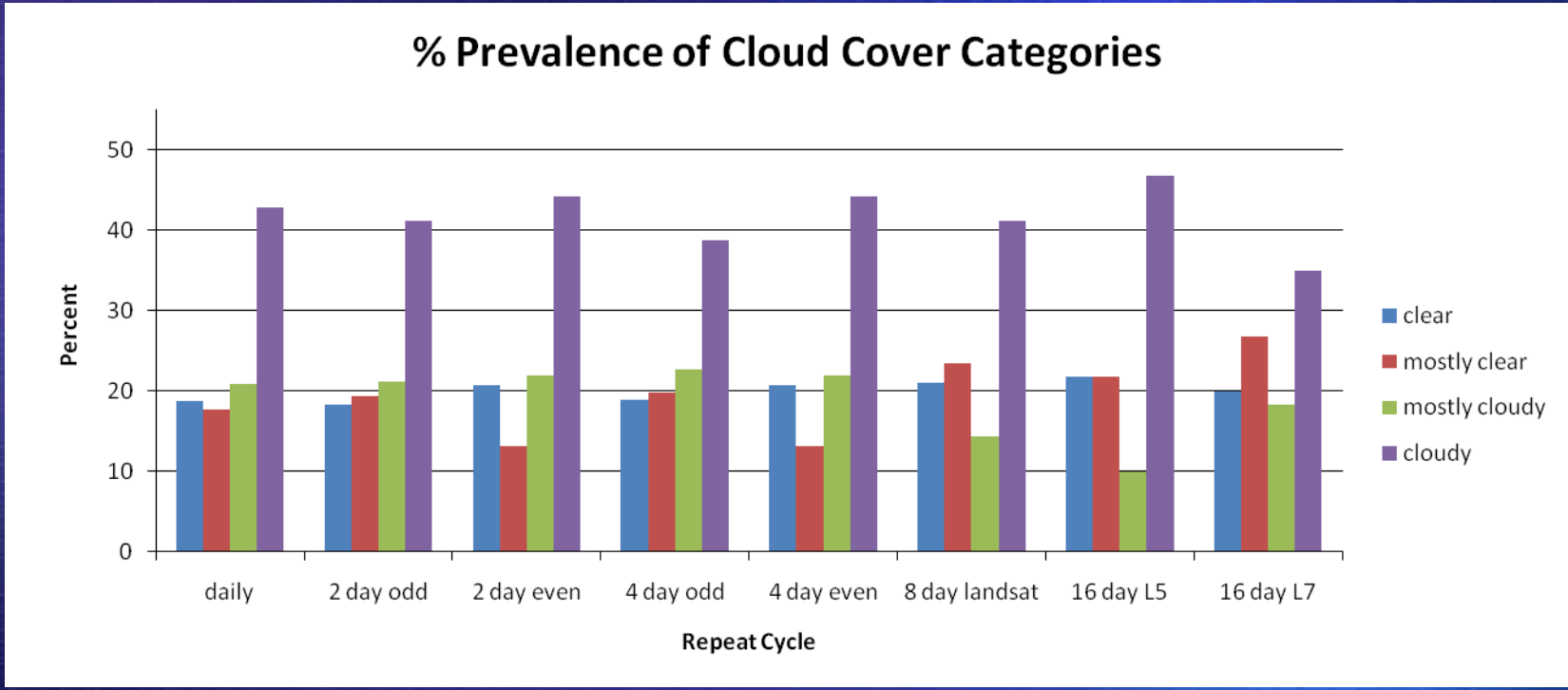
BACKUP SLIDES

Maryland



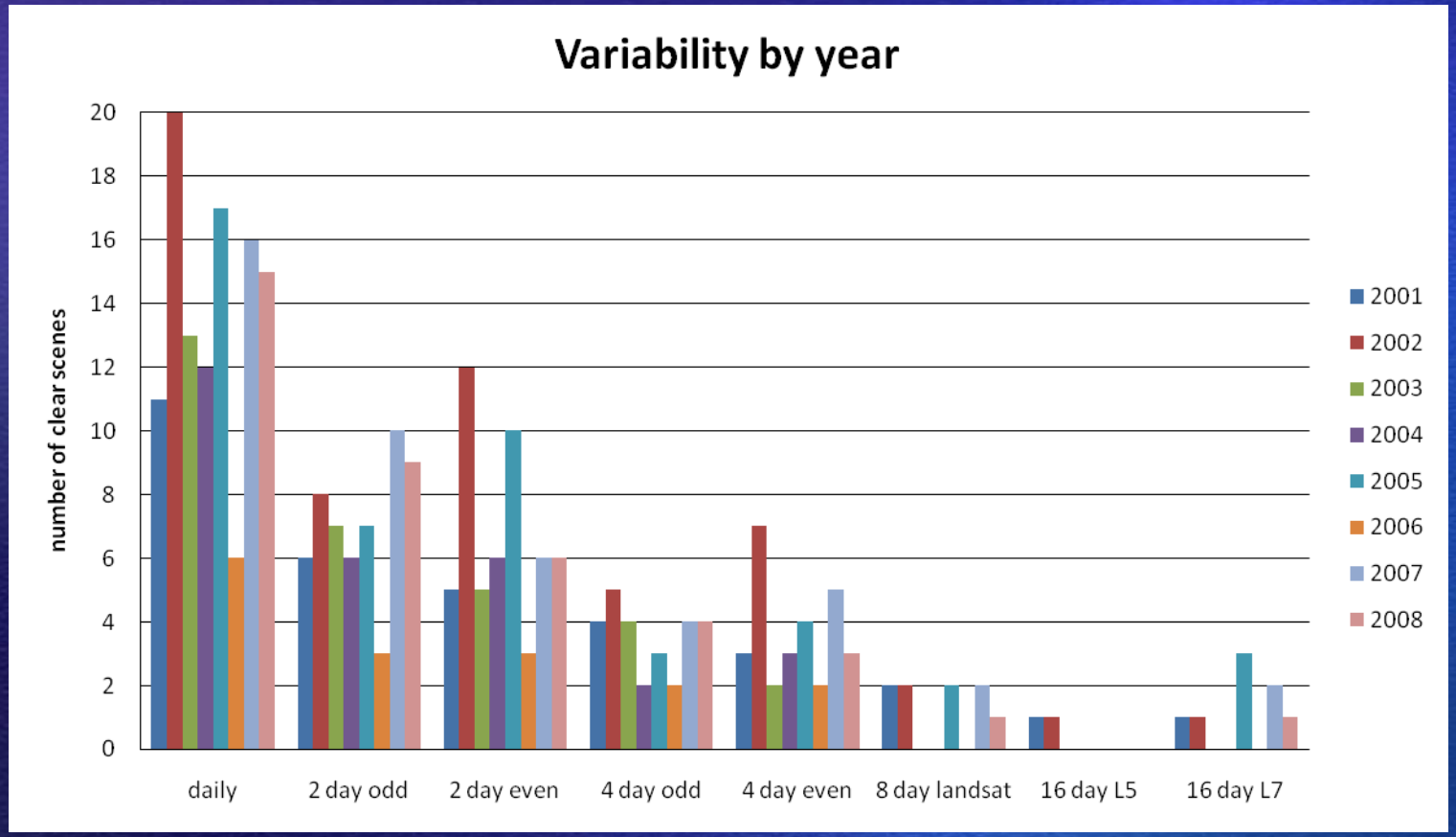
	Daily	2 day odd	2 day even	4 day odd	4 day even	8 day Landsat	16 day L5	16 day L7
Clear	10.5	10.3	10.3	7.8	9.1	11.9	9.8	15.3
Mostly Clear	14.3	14.7	14.7	14.8	15.6	13.6	6.6	20.3
Mostly Cloudy	26.2	21.5	21.5	29.2	21.4	20.3	22.9	16.9
Cloudy	48.8	53.5	53.3	48.1	53.9	54.2	60.7	47.5

Indiana

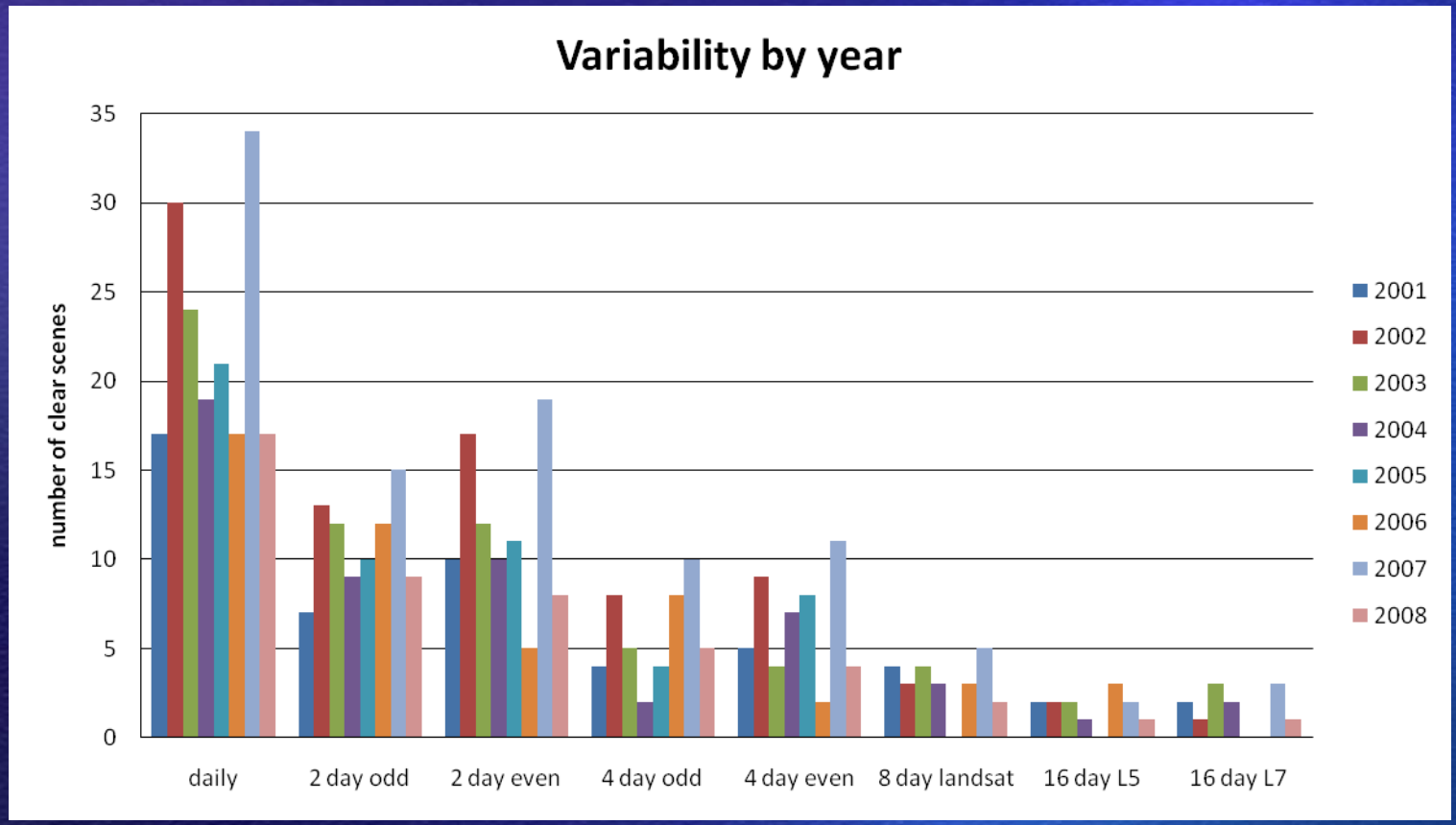


	Daily	2 day odd	2 day even	4 day odd	4 day even	8 day Landsat	16 day L5	16 day L7
Clear	18.8	18.7	20.7	18.9	20.7	21	21.7	20
Mostly Clear	17.6	19.2	13.2	19.8	13.2	23.5	21.7	26.7
Mostly Cloudy	20.8	21.5	21.9	22.6	21.9	14.3	10	18.3
Cloudy	42.8	40.6	44.2	38.7	44.2	41.2	46.7	35

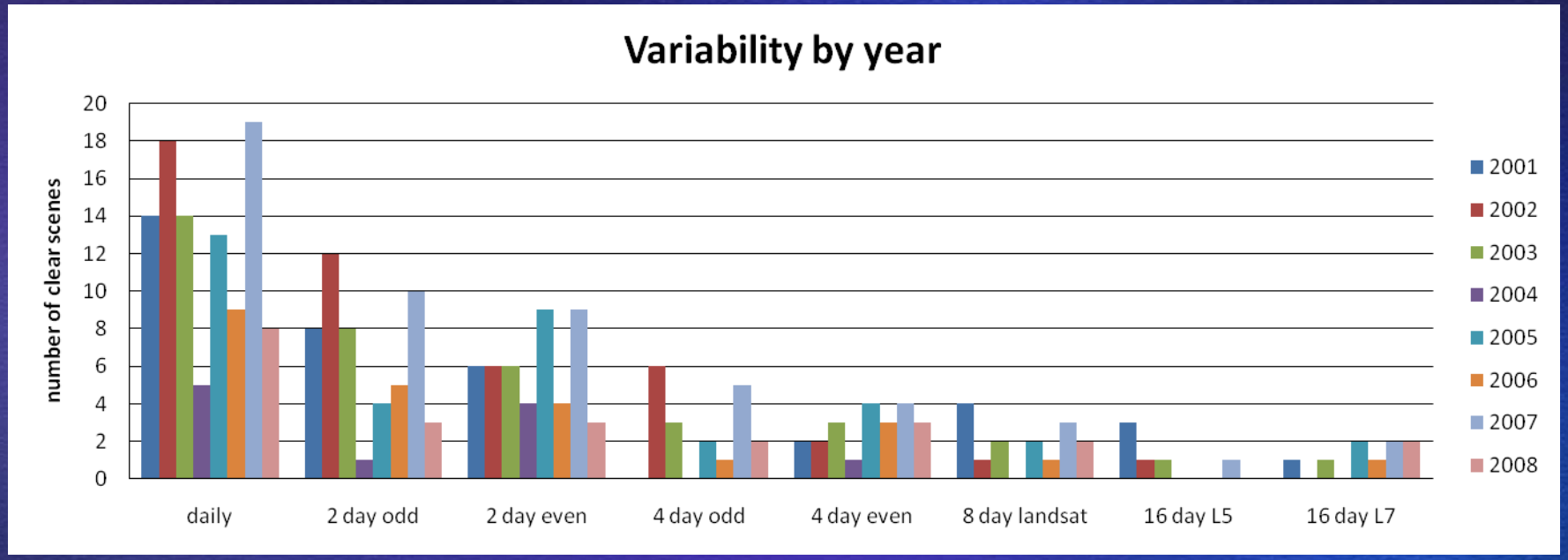
Pennsylvania

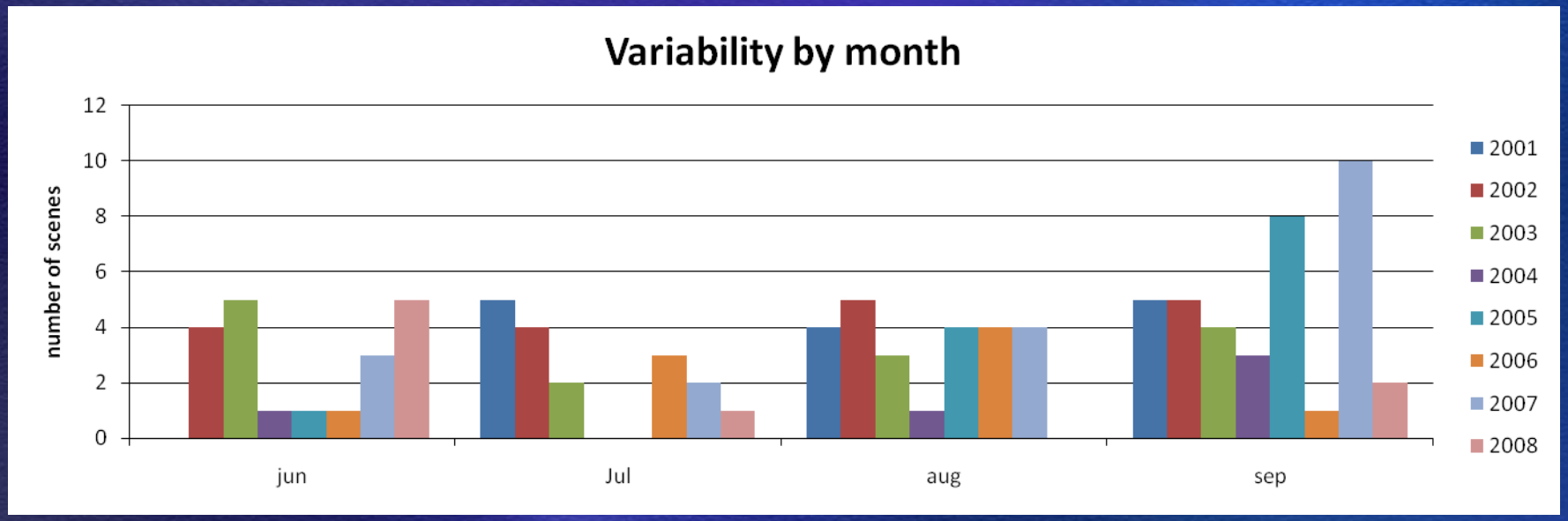


Indiana

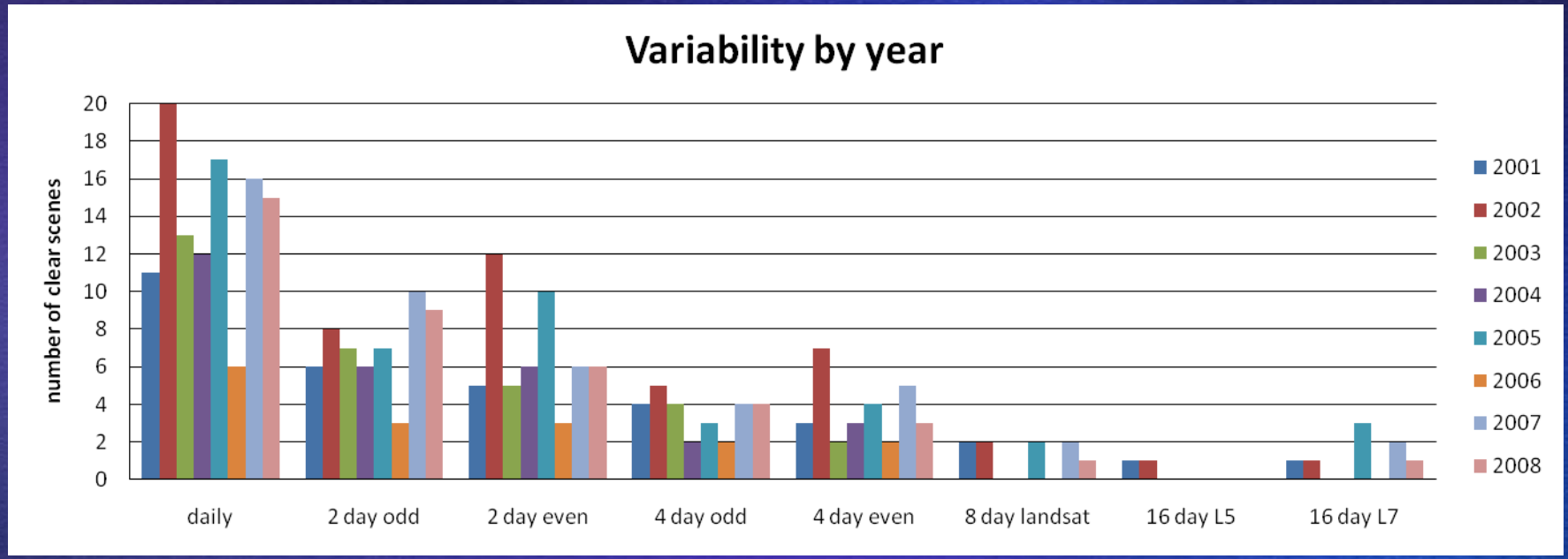

Variability by year
number of clear scenes
35
30
25
20
15
10
5
0
daily
2 day odd
2 day even
4 day odd
4 day even
8 day landsat
16 day L5
16 day L7
2001
2002
2003
2004
2005
2006
2007
2008

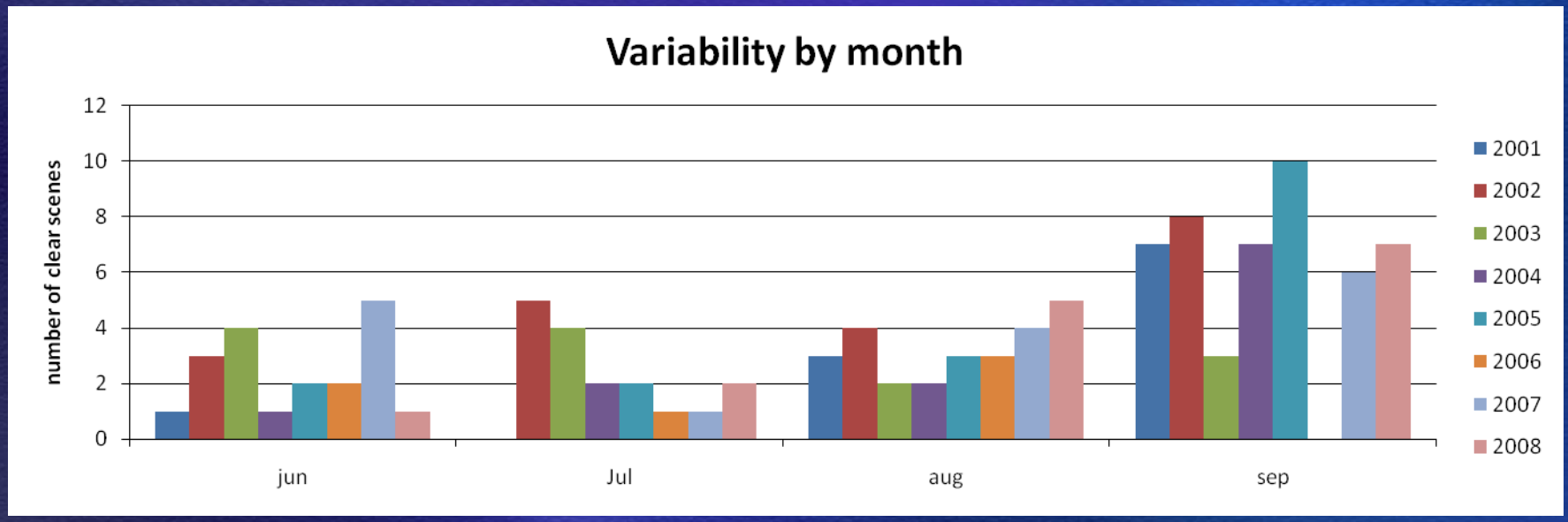
Maryland


Variability by year
number of clear scenes
20
18
16
14
12
10
8
6
4
2
0
daily
2 day odd
2 day even
4 day odd
4 day even
8 day landsat
16 day L5
16 day L7
2001
2002
2003
2004
2005
2006
2007
2008

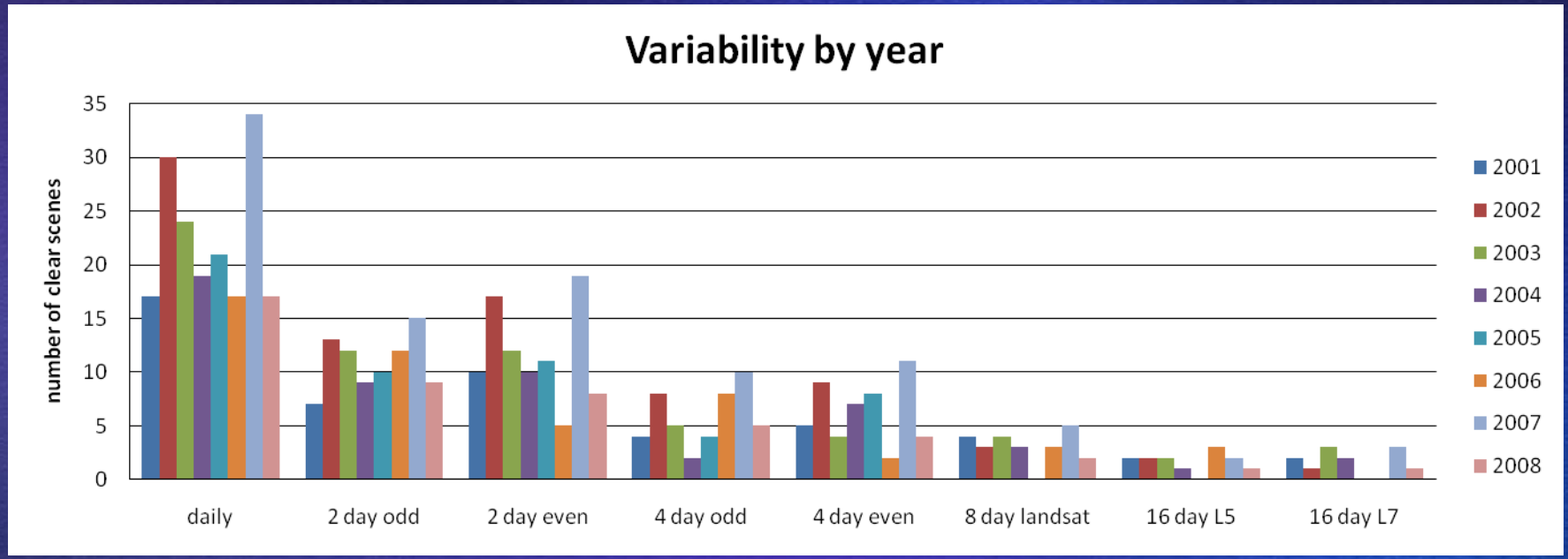

Variability by month
number of scenes
12
10
8
6
4
2
0
jun
Jul
aug
sep
2001
2002
2003
2004
2005
2006
2007
2008

Pennsylvania





Indiana


Variability by year
number of clear scenes
35
30
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0
daily
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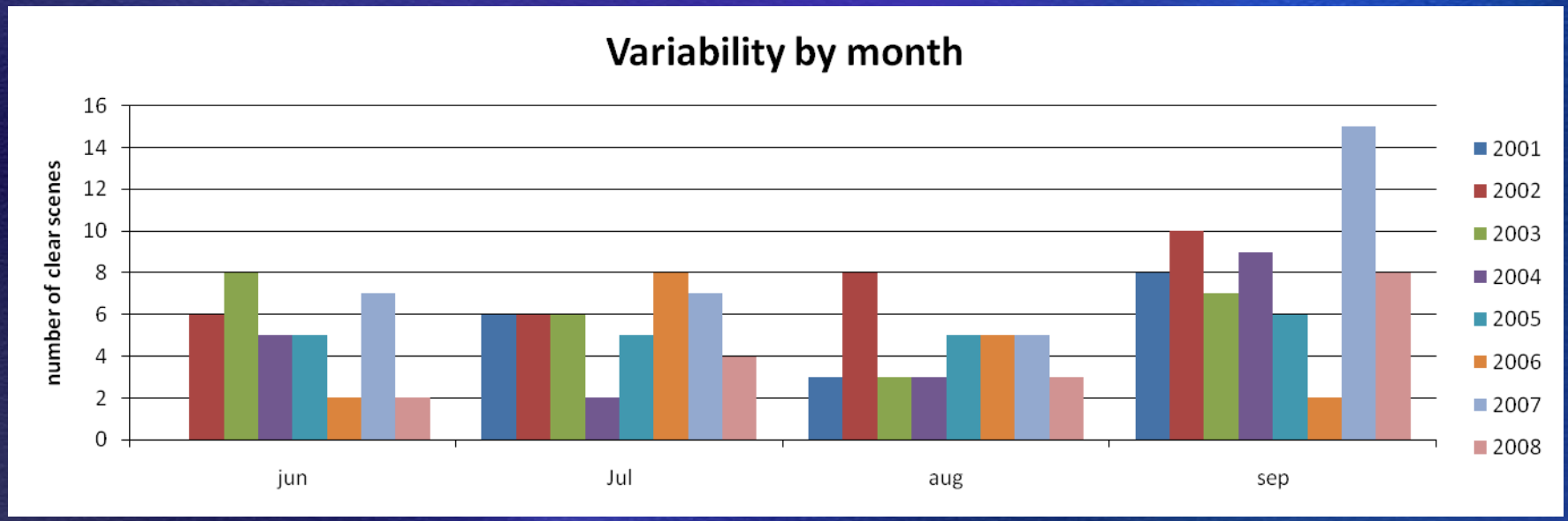
Variability by month
number of clear scenes
16
14
12
10
8
6
4
2
0
jun
Jul
aug
sep
2001
2002
2003
2004
2005
2006
2007
2008