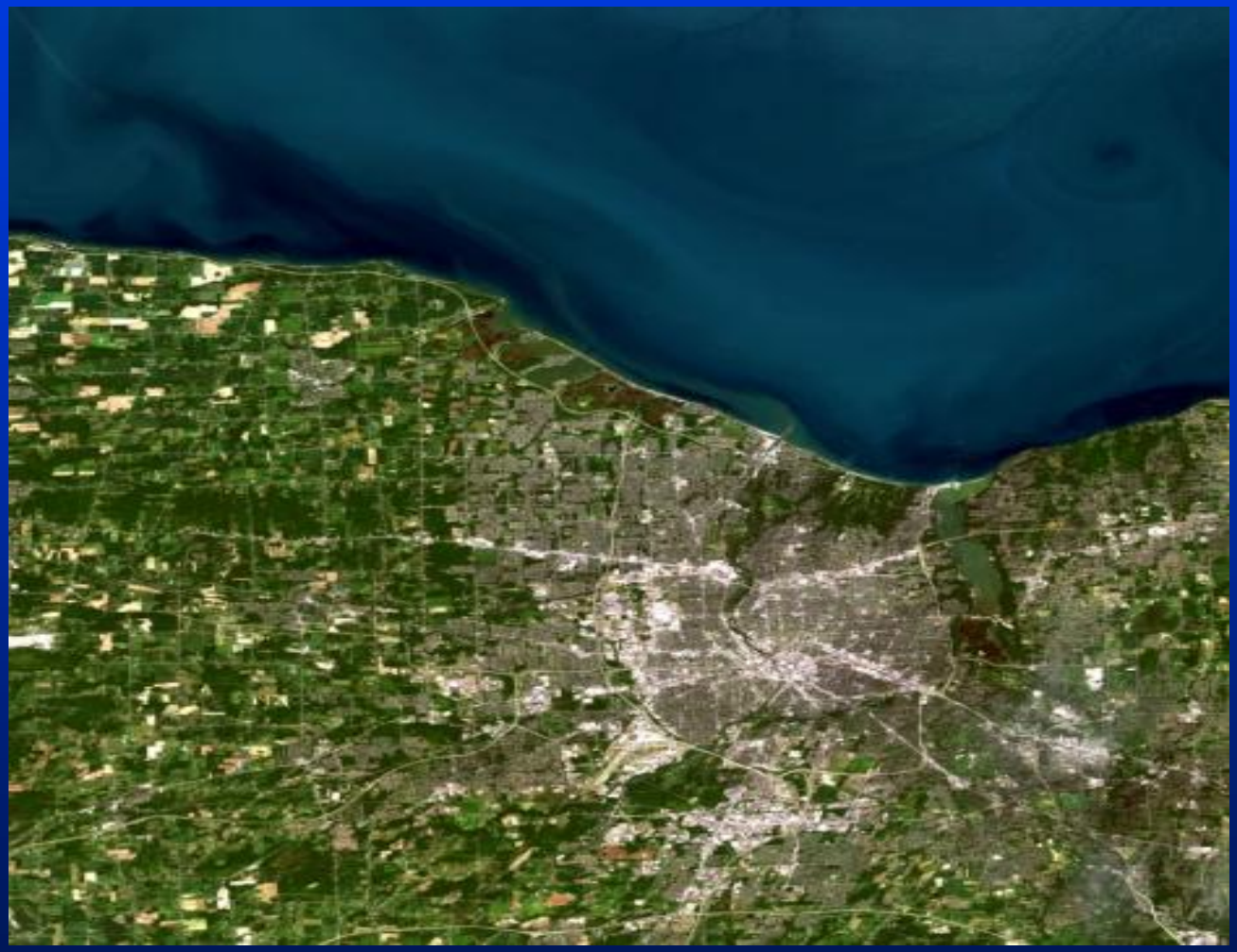
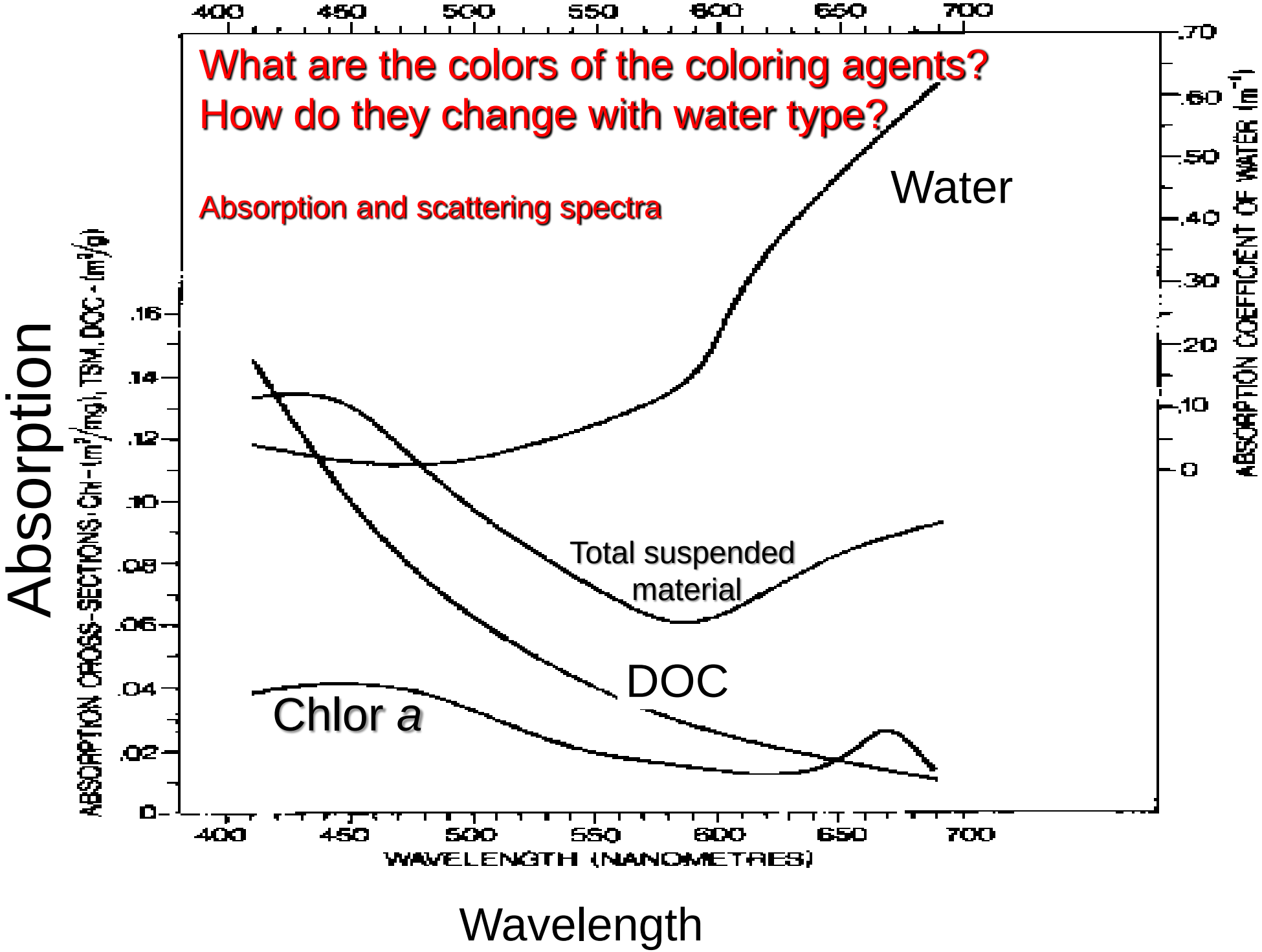
Landsat 8's potential for studying fresh and coastal waters

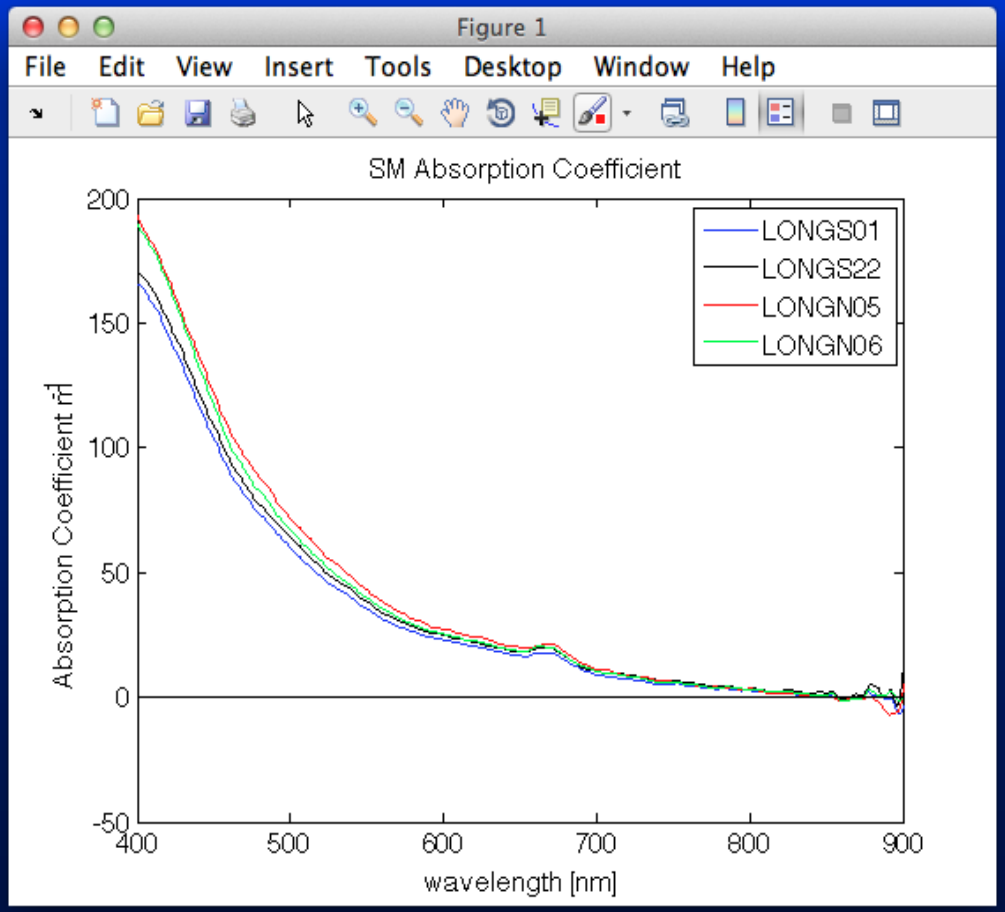


DIRS
Digital Imaging and Remote Sensing

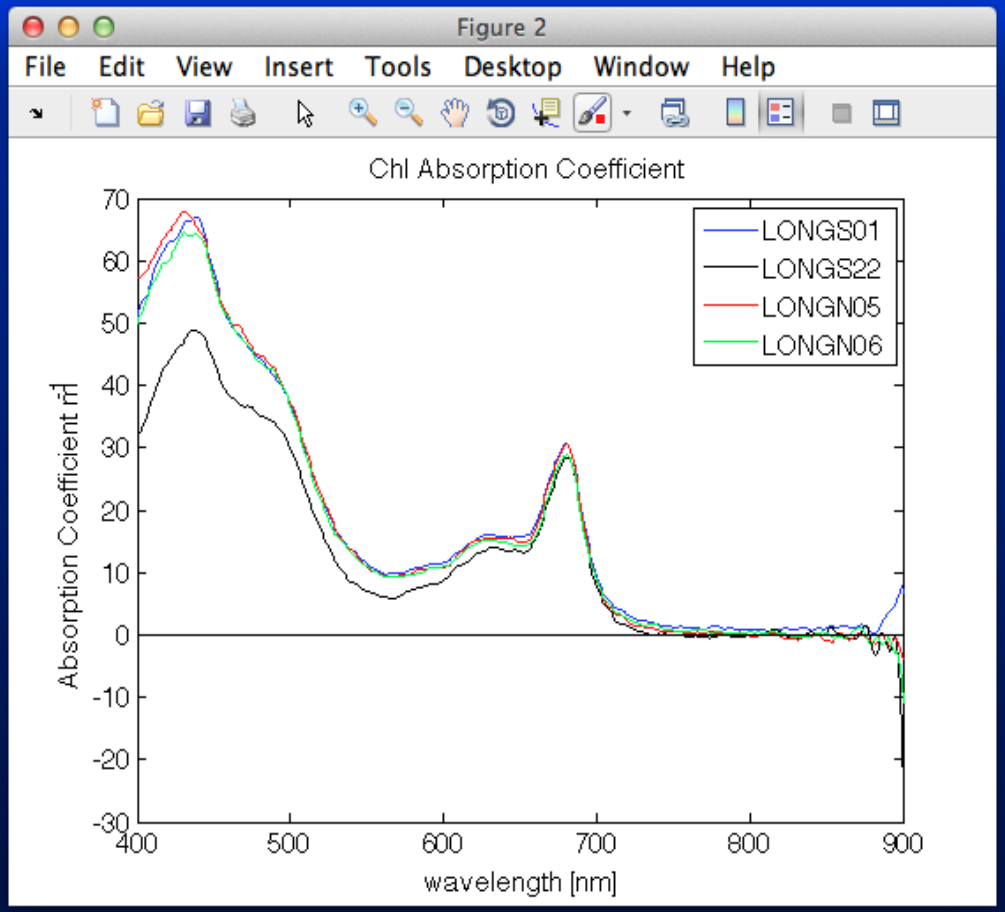
R·I·T


What are the colors of the coloring agents?
How do they change with water type?
Absorption and scattering spectra
Water
Total suspended material
DOC
Chlor *a*
Absorption
Wavelength
ABSORPTION CROSS-SECTIONS, Chl-(m²/mg), TSM, DOC-(m²/g)
ABSORPTION COEFFICIENT OF WATER (m⁻¹)
WAVELENGTH (NANOMETRES)
400
450
500
550
600
650
700
0
.02
.04
.06
.08
.10
.12
.14
.16
.10
.20
.30
.40
.50
.60
.70

Collection 6/22/2013
SM absorption coeff.



Collection 6/22/2013
Chl absorption coeff.



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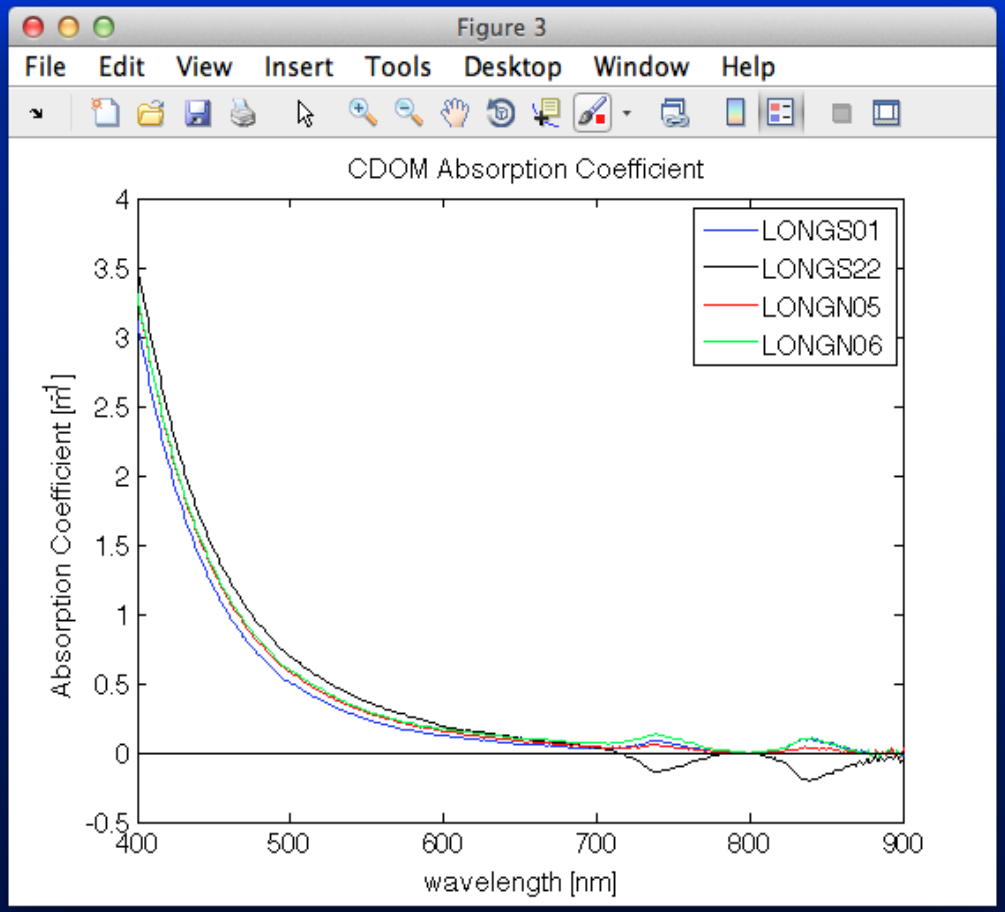
Collection 6/22/2013
CDOM absorption coeff.



DIRS Digital Imaging and Remote Sensing

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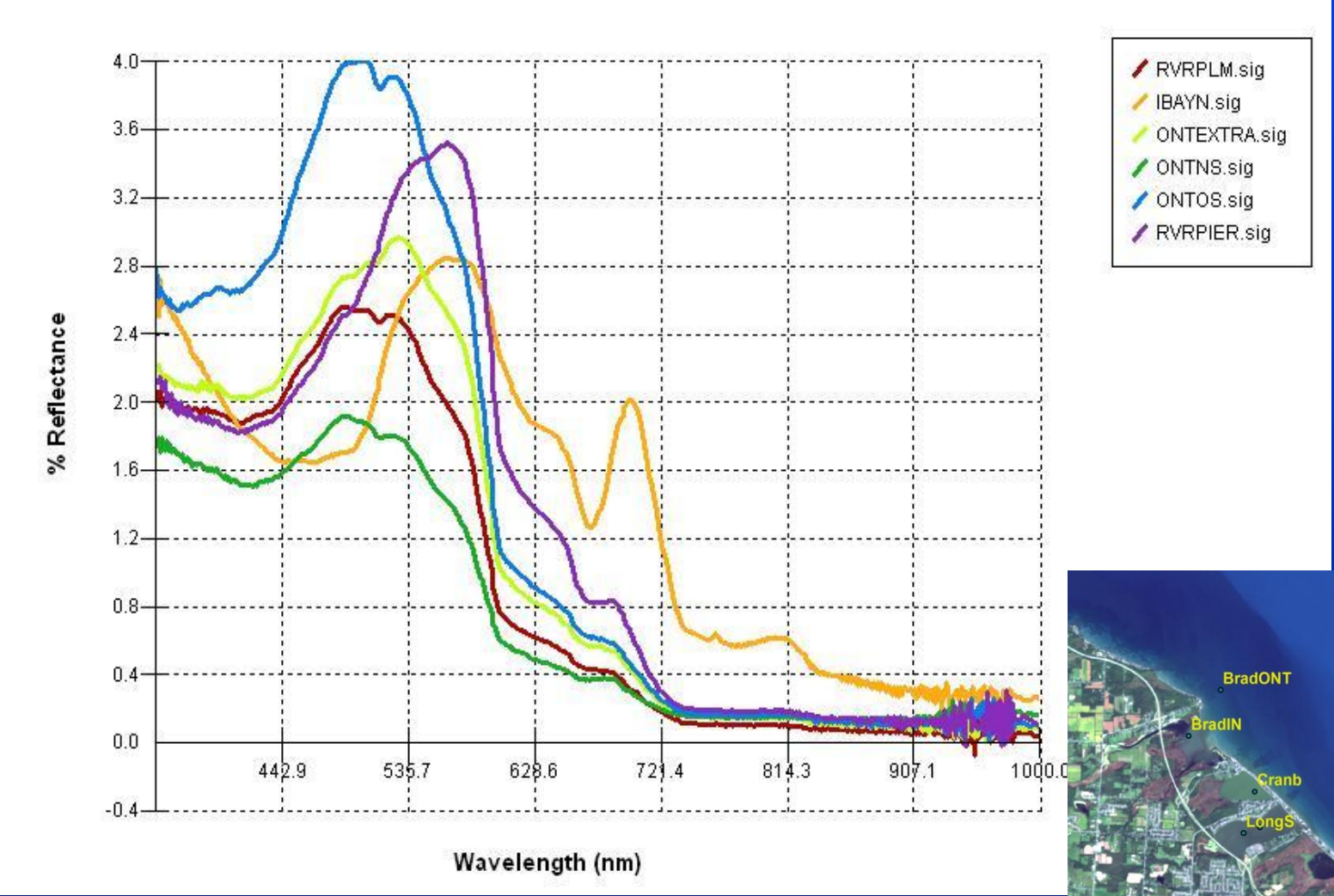
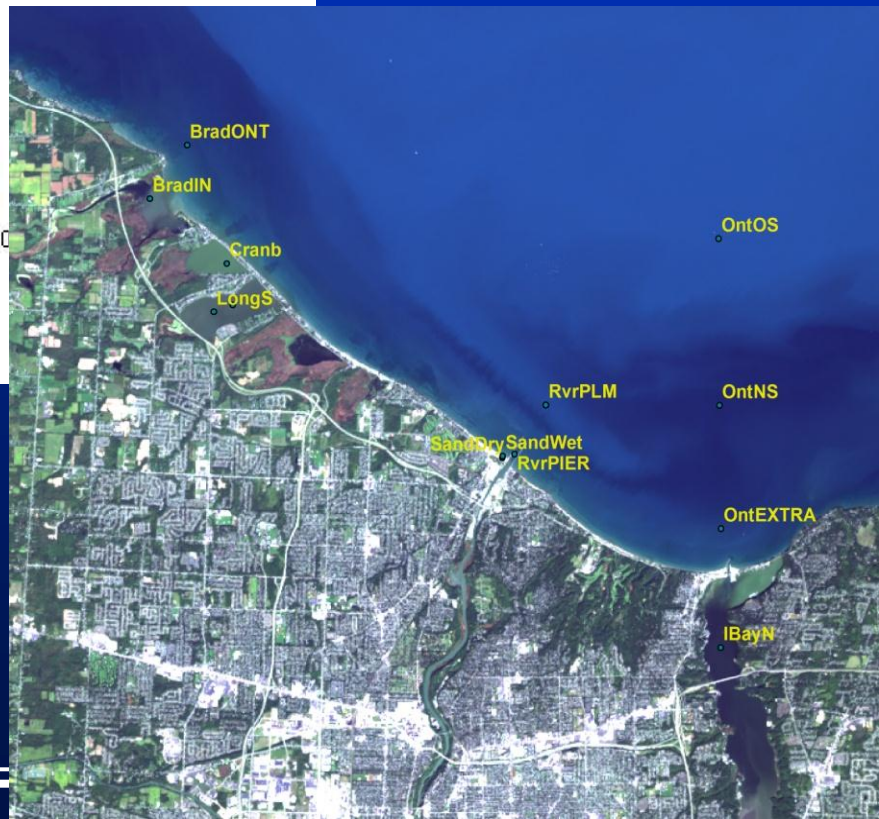
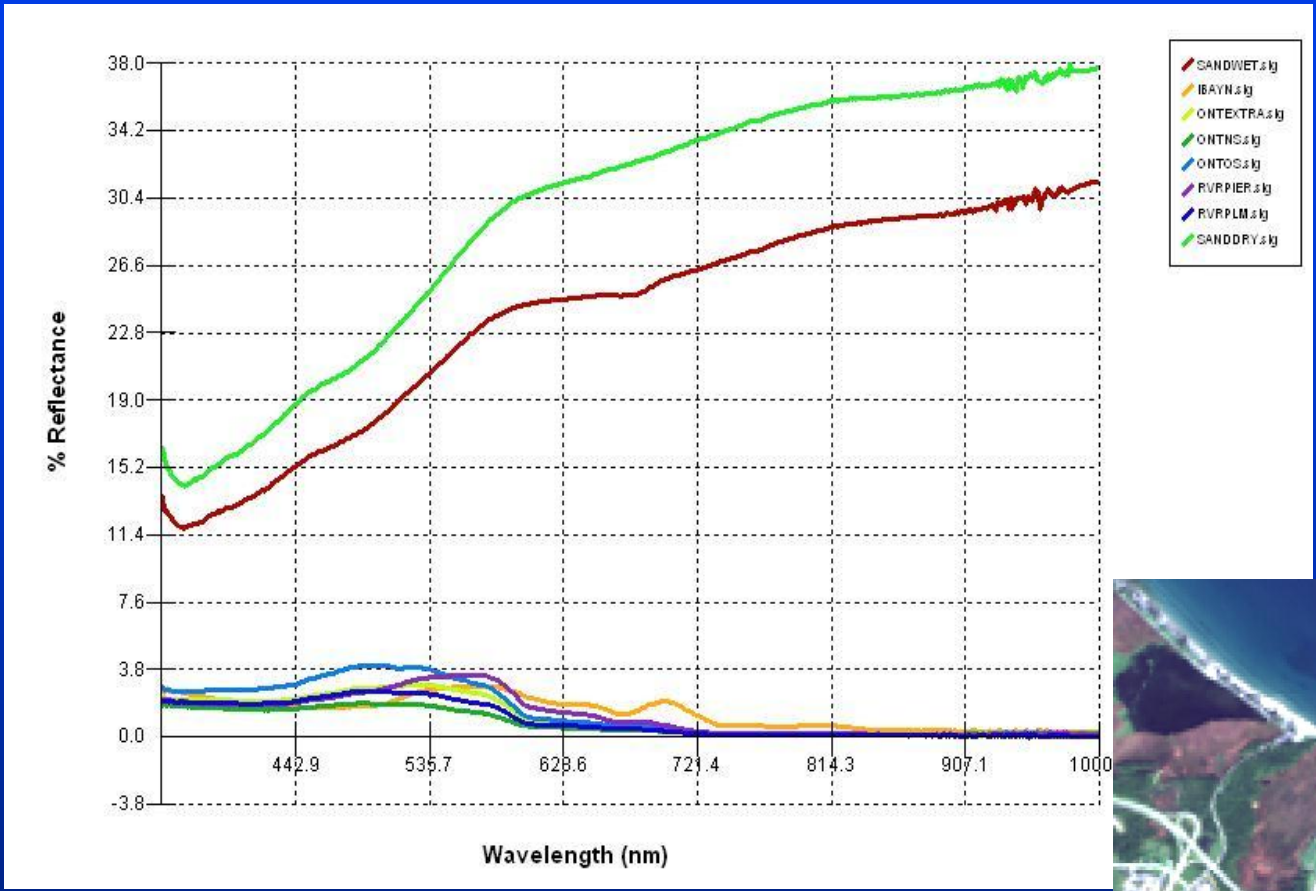
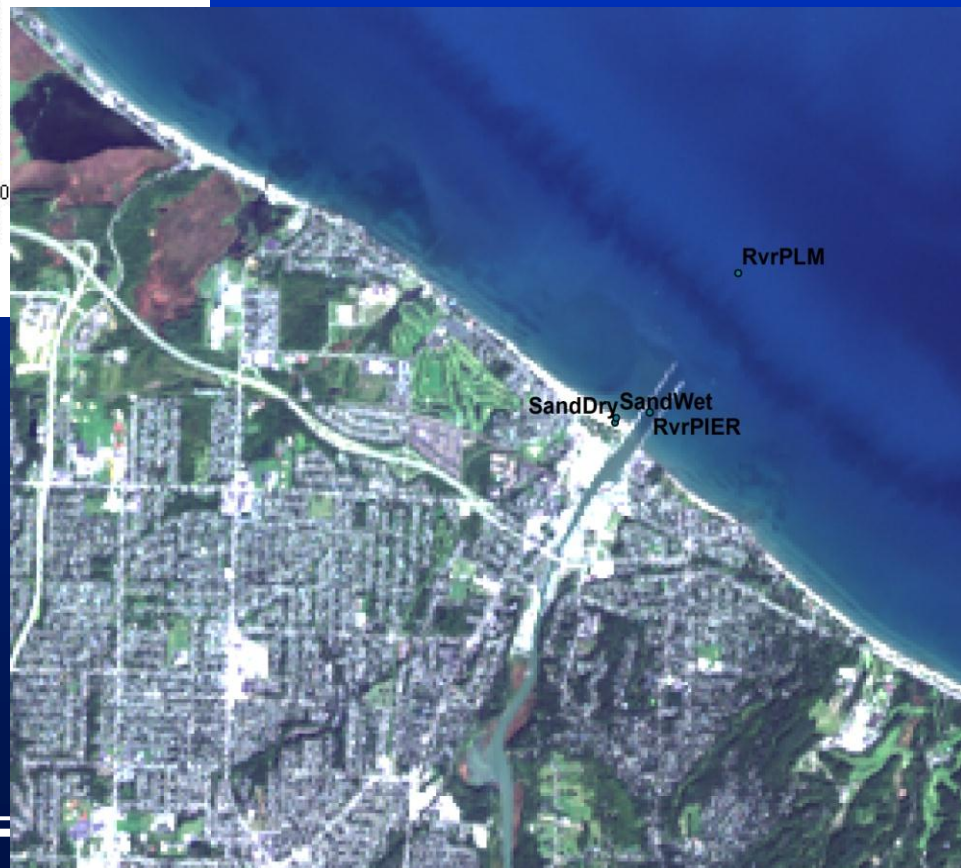
Water Spectra taken with SVC HR1024i Sept 19, 2013



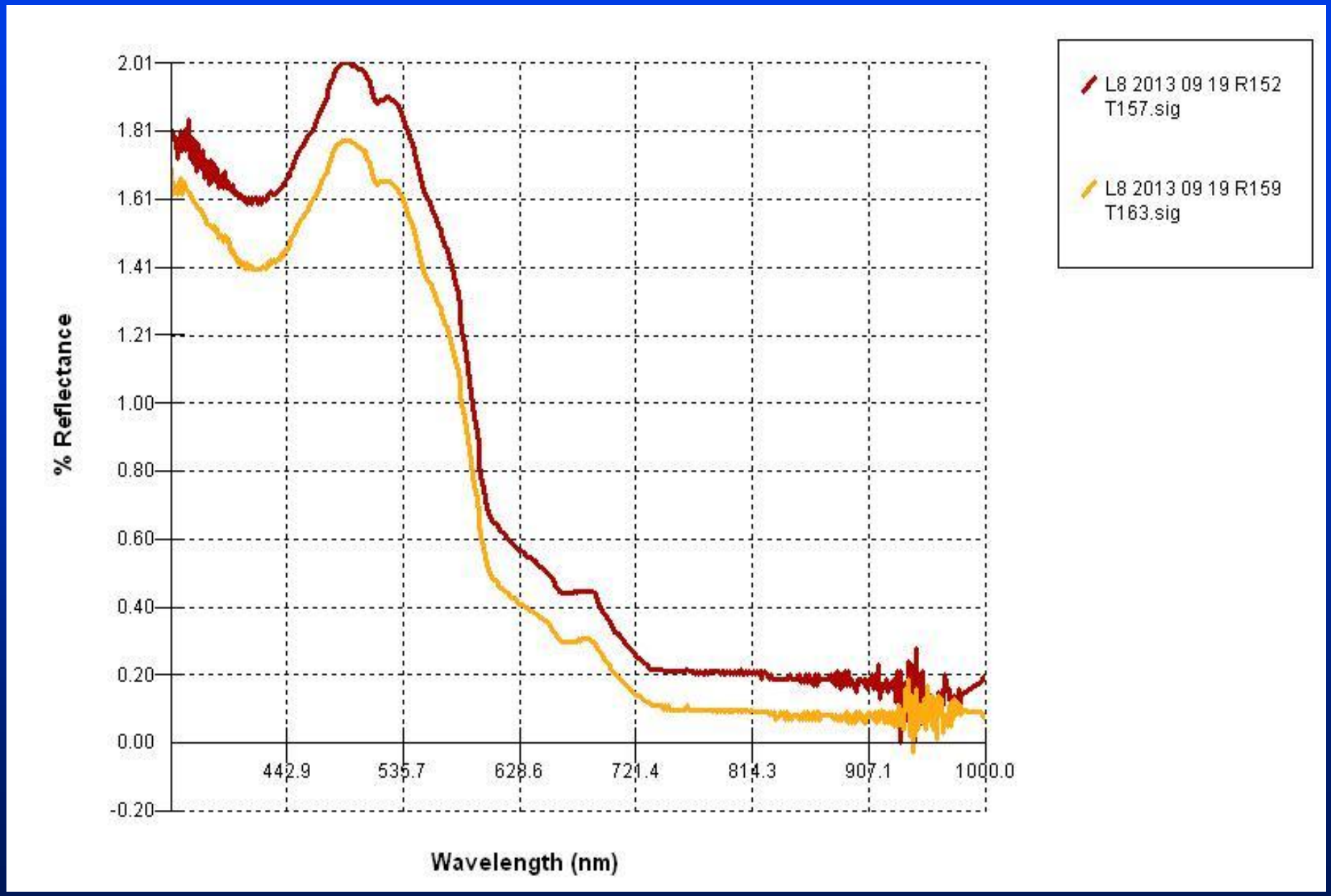


Water Spectra taken with SVC HR1024i, Sept 19, 2013





Imagine what a red boat could do!!!!



Water spectra (red) and same water with black tarp over boat (yello

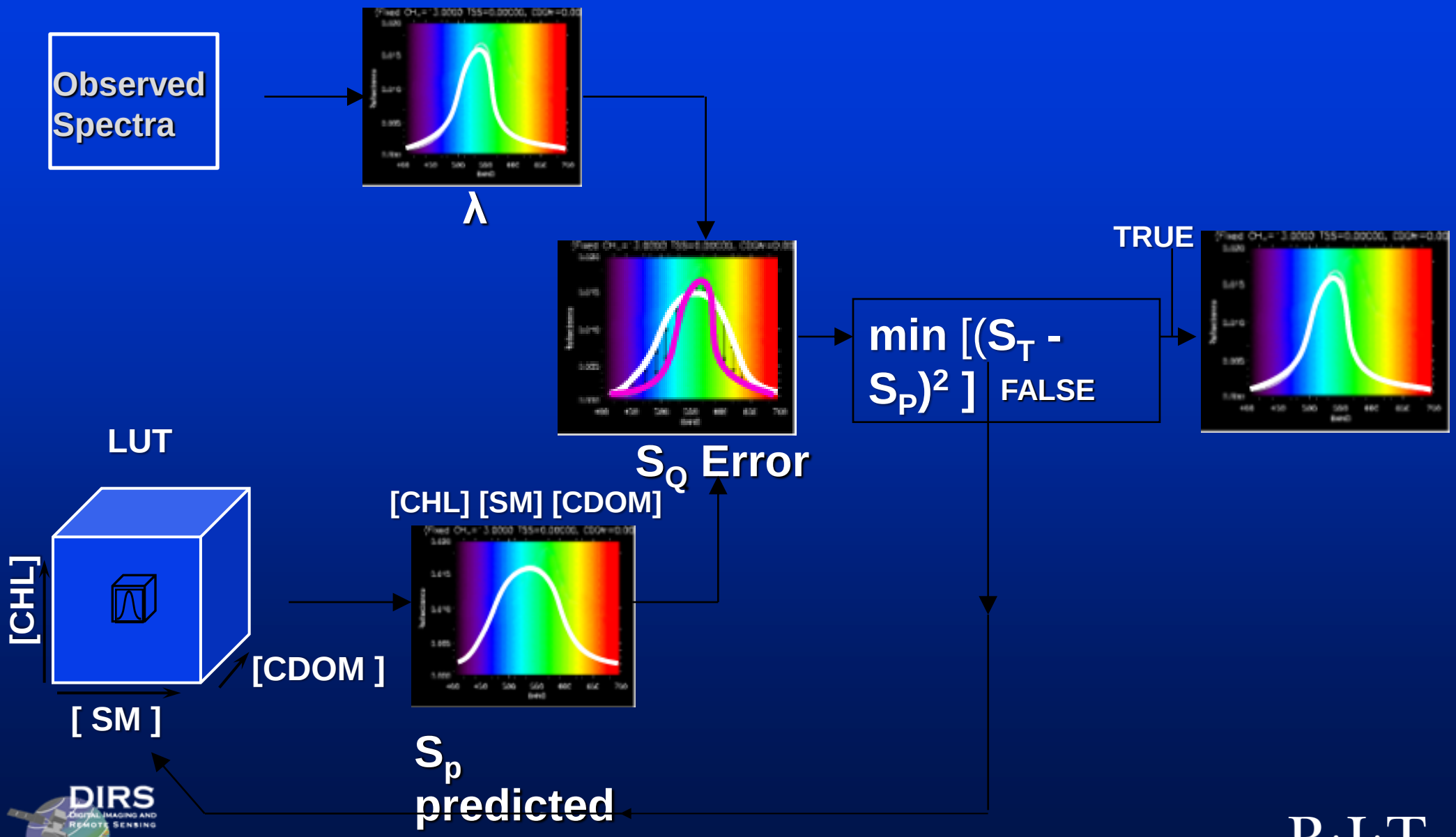
Collection 6/22/2013
Chl concentration

Water Column Chlorophyll *a* Calculations
samples collected:
samples analyzed:
Note: Chl *a* concentration in [mg/m^3] or [ug/L]

Good
Neutral
Bad

Site	Date Extraction	Cuvette	Volume Filtered [L]	Extract Volume [ml]	665o	750o	665a	750a	Chl [mg/m^3] or [ug/L]
R-01	6/28/13		0.130	9	0.044	0.006	0.033	0.008	24.03
R-01	6/28/13		0.130	9	0.042	0.005	0.031	0.007	24.03
R-22	6/28/13		0.130	9	0.047	0.006	0.035	0.008	25.88
R-22	6/28/13		0.130	9	0.047	0.007	0.037	0.009	22.18
R-22	6/28/13		0.130	9	0.042	0.002	0.029	0.003	25.88
R-22	6/28/13		0.130	9	0.046	0.006	0.033	0.006	24.03
R-22	6/28/13		0.130	9	0.044	0.004	0.031	0.004	24.03
R-05	6/28/13		0.130	9	0.044	0.006	0.034	0.009	24.03
R-05	6/28/13		0.130	12	0.035	0.004	0.027	0.006	24.65
R-06	6/28/13		0.130	9	0.045	0.006	0.034	0.007	22.18
R-06	6/28/13		0.130	9	0.043	0.004	0.032	0.006	24.03

Interpolation Process

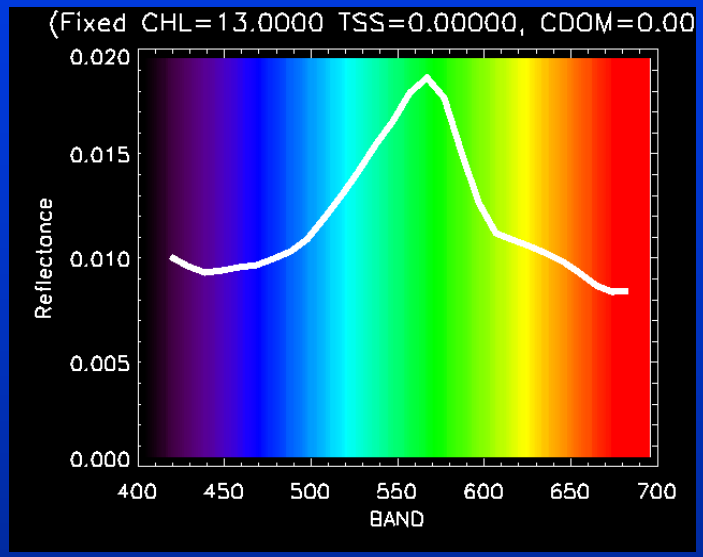


The Inversion process: Built a new LUT using HydroLight, an in water radiation transport model

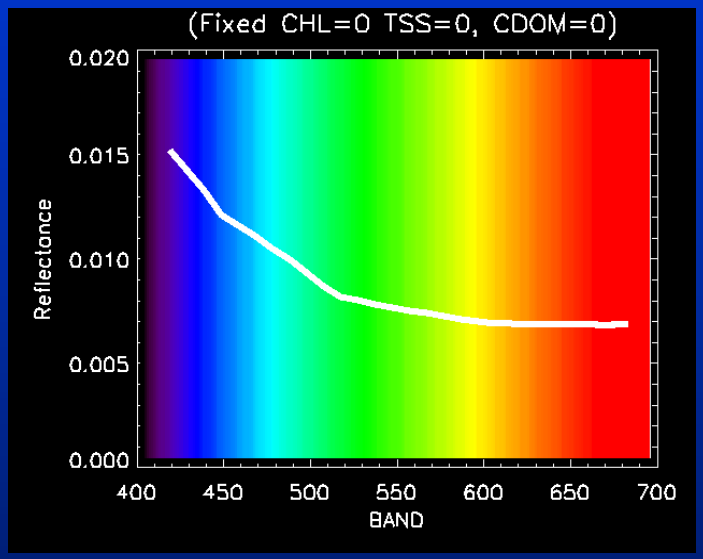
- Case 2 waters: 4-component IOP model
  1. Pure Water
  2. Chlorophyll-bearing particles
  3. CDOM
  4. SM-Mineral Particles

Example LUT Entries

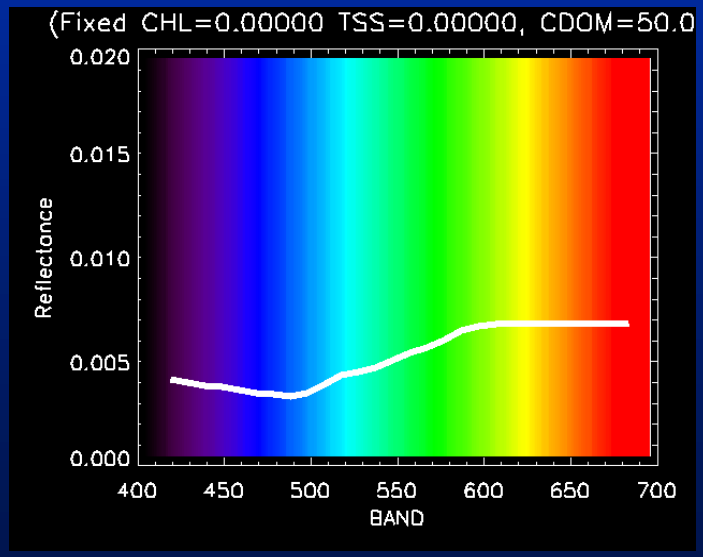
[C]=13
[SM]=0
[CDOM]=0



[C]=0
[SM]=0
[CDOM]=0

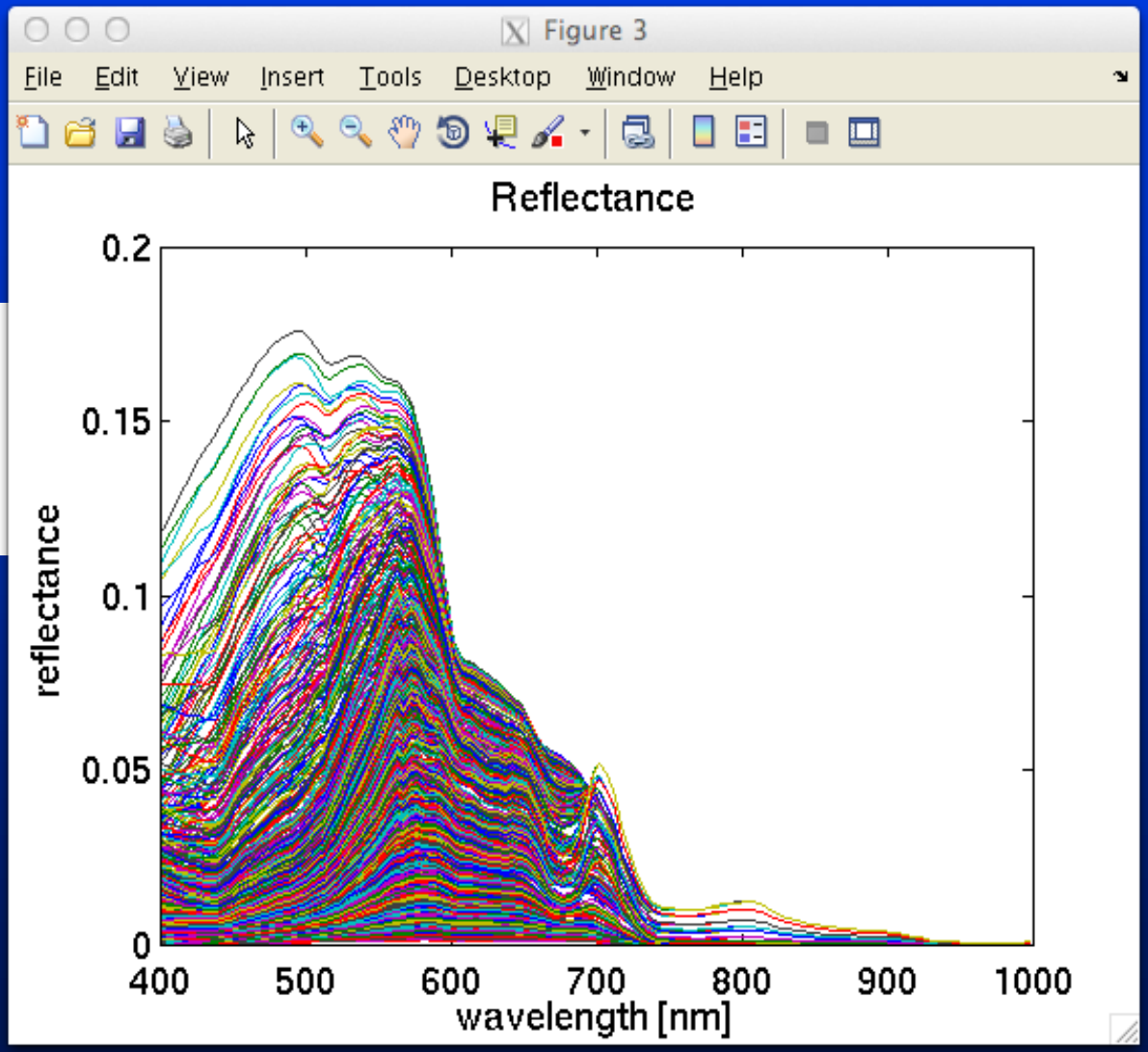


[C]=0
[SM]=0
[CDOM]=50

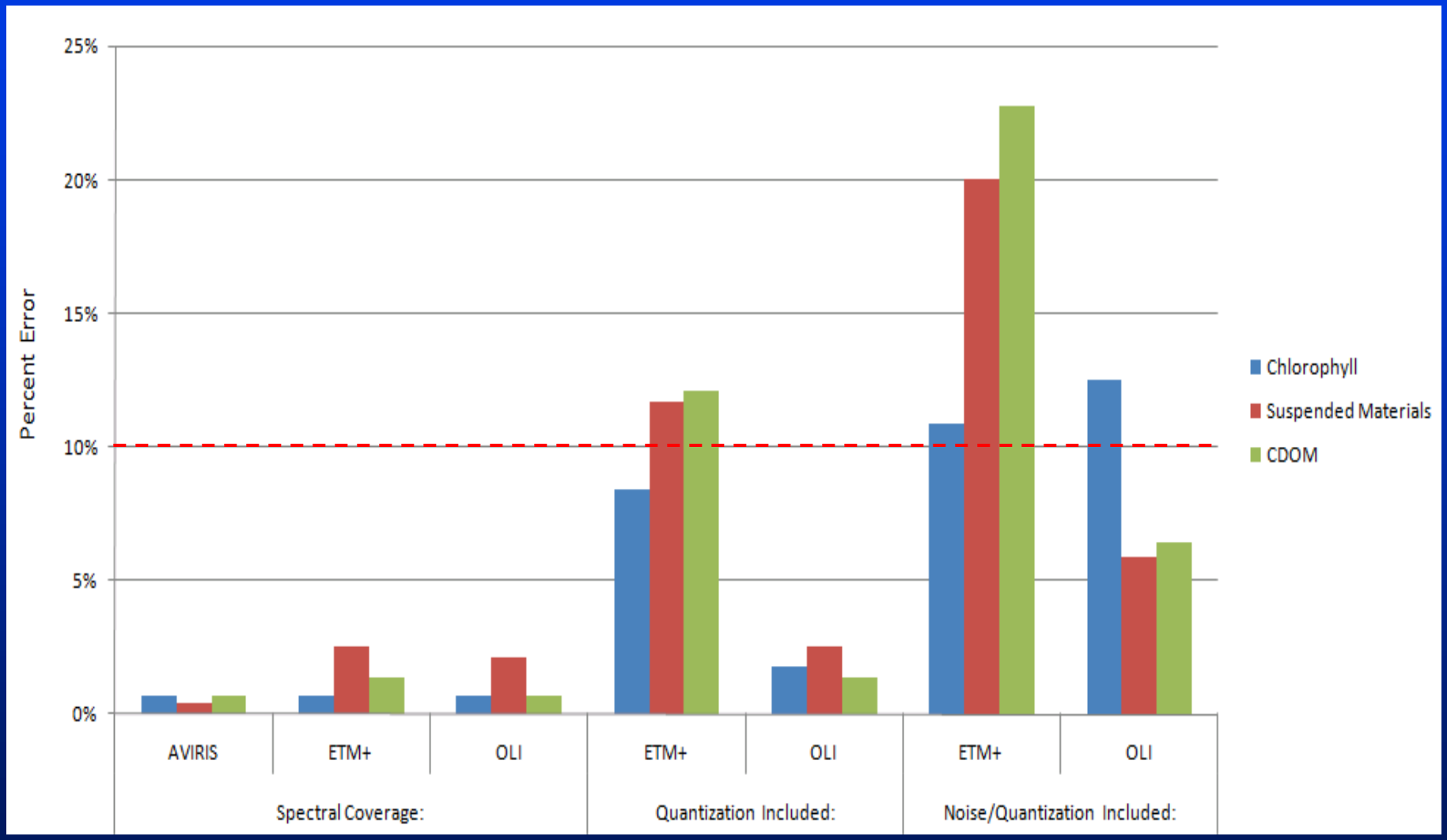


Water Leaving Reflectance

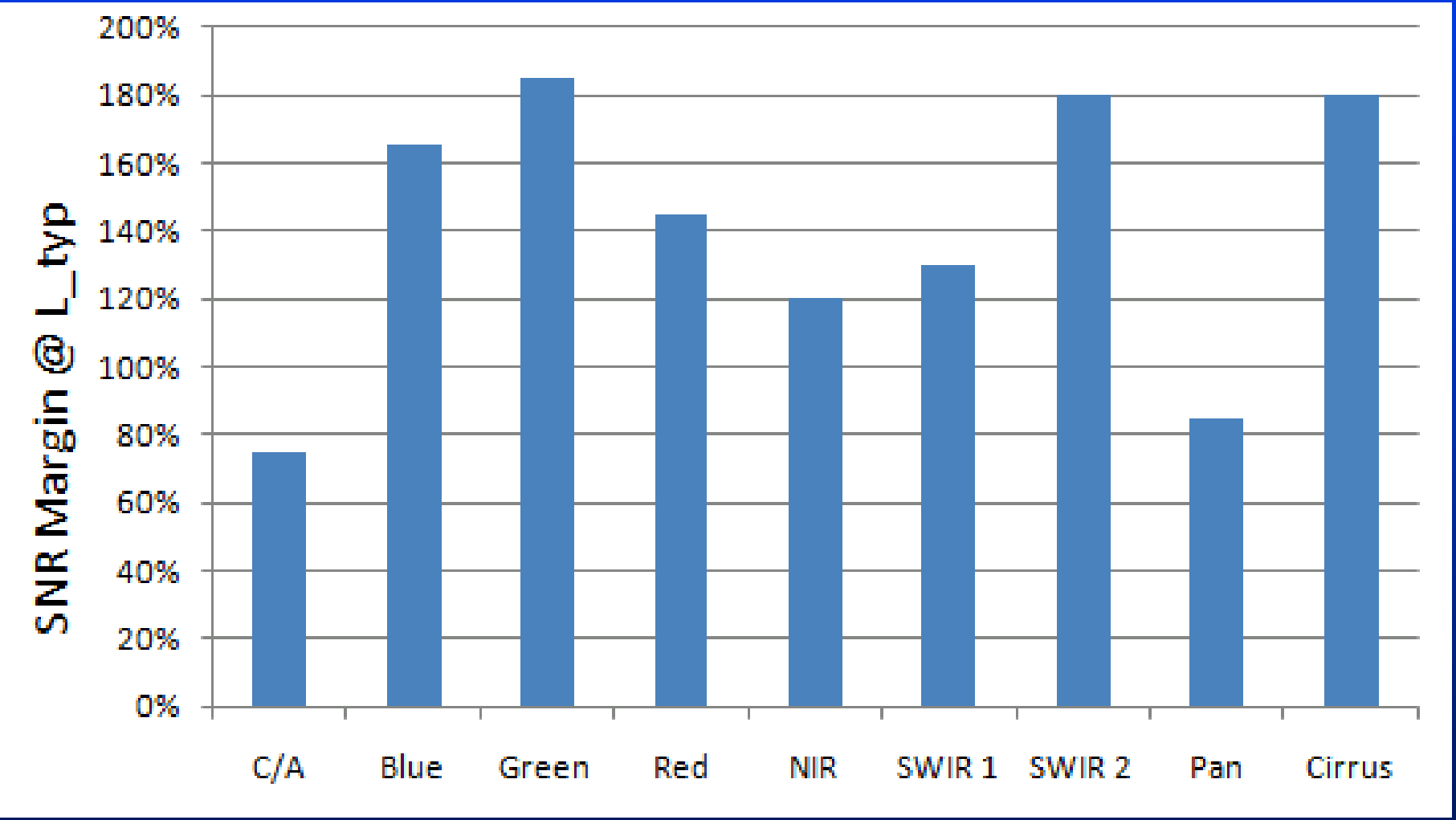
$$\rho = \frac{L_w * \pi}{E_d}$$



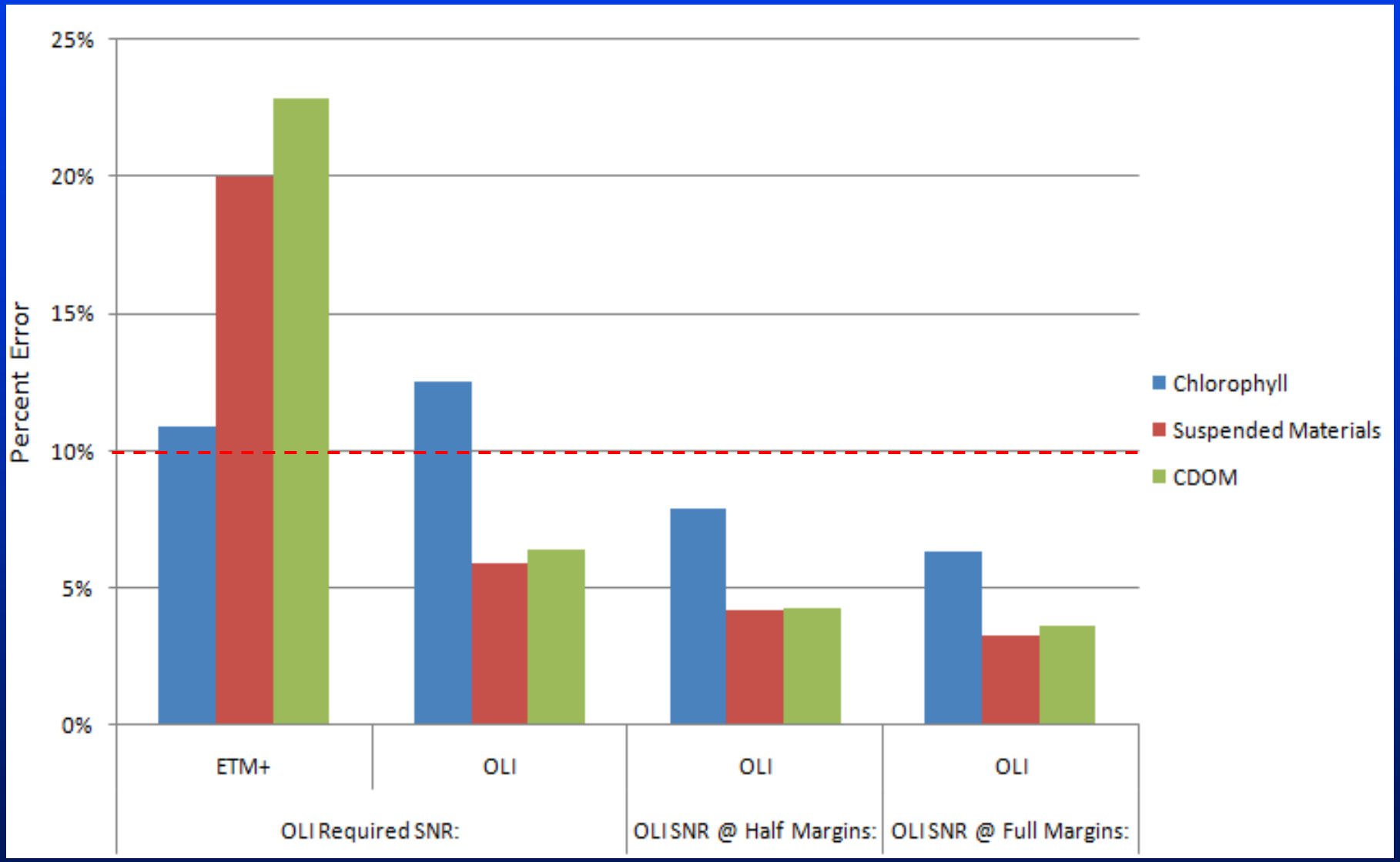
Previous Results: Perfect atmospheric compensation



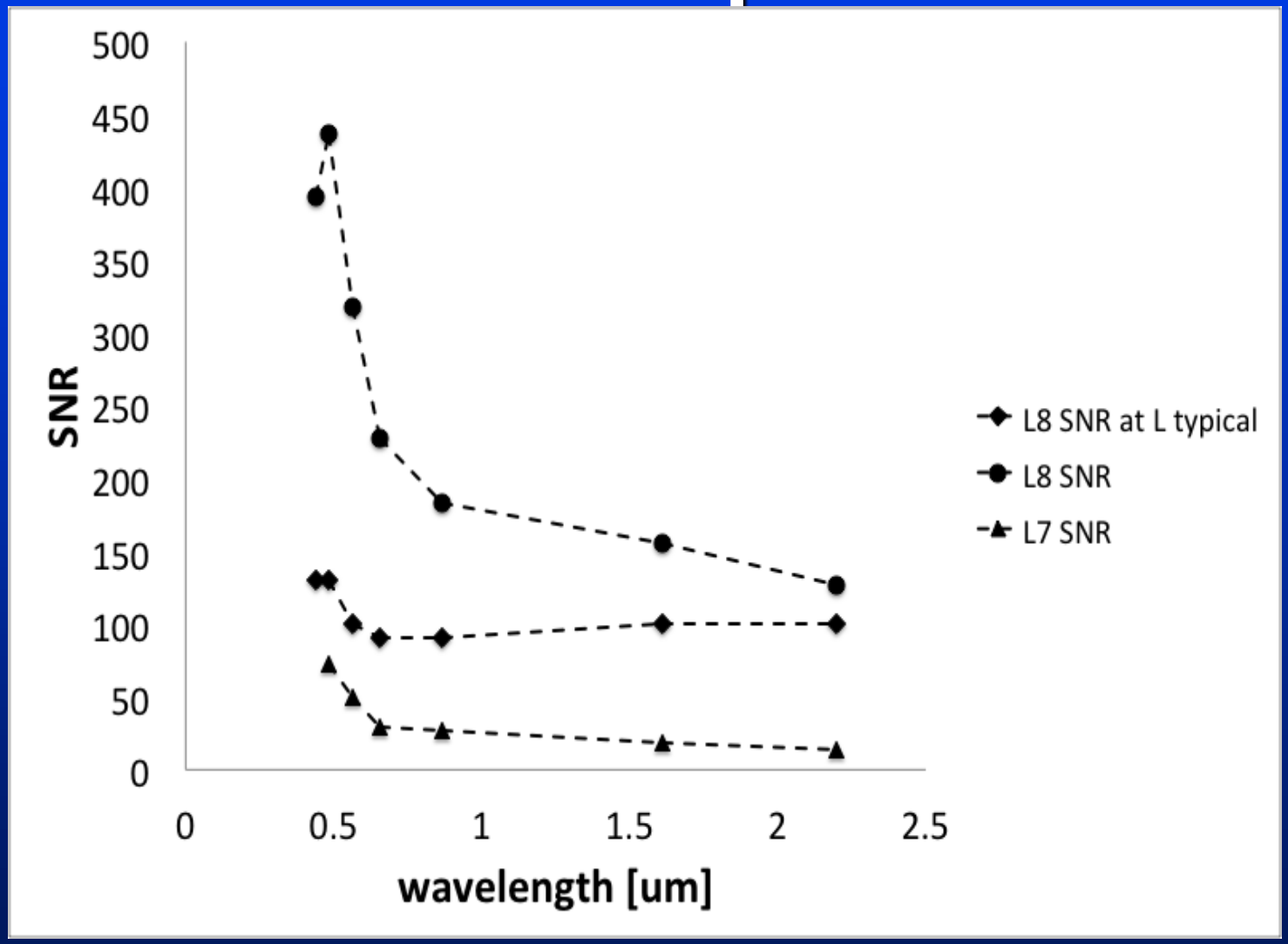
SNR Margins


SNR Margin @ L_typ
200%
180%
160%
140%
120%
100%
80%
60%
40%
20%
0%
C/A
Blue
Green
Red
NIR
SWIR 1
SWIR 2
Pan
Cirrus

Results: Perfect atmospheric compensation



Observed SNR Landsats 7 and 8 vs. L8 spec

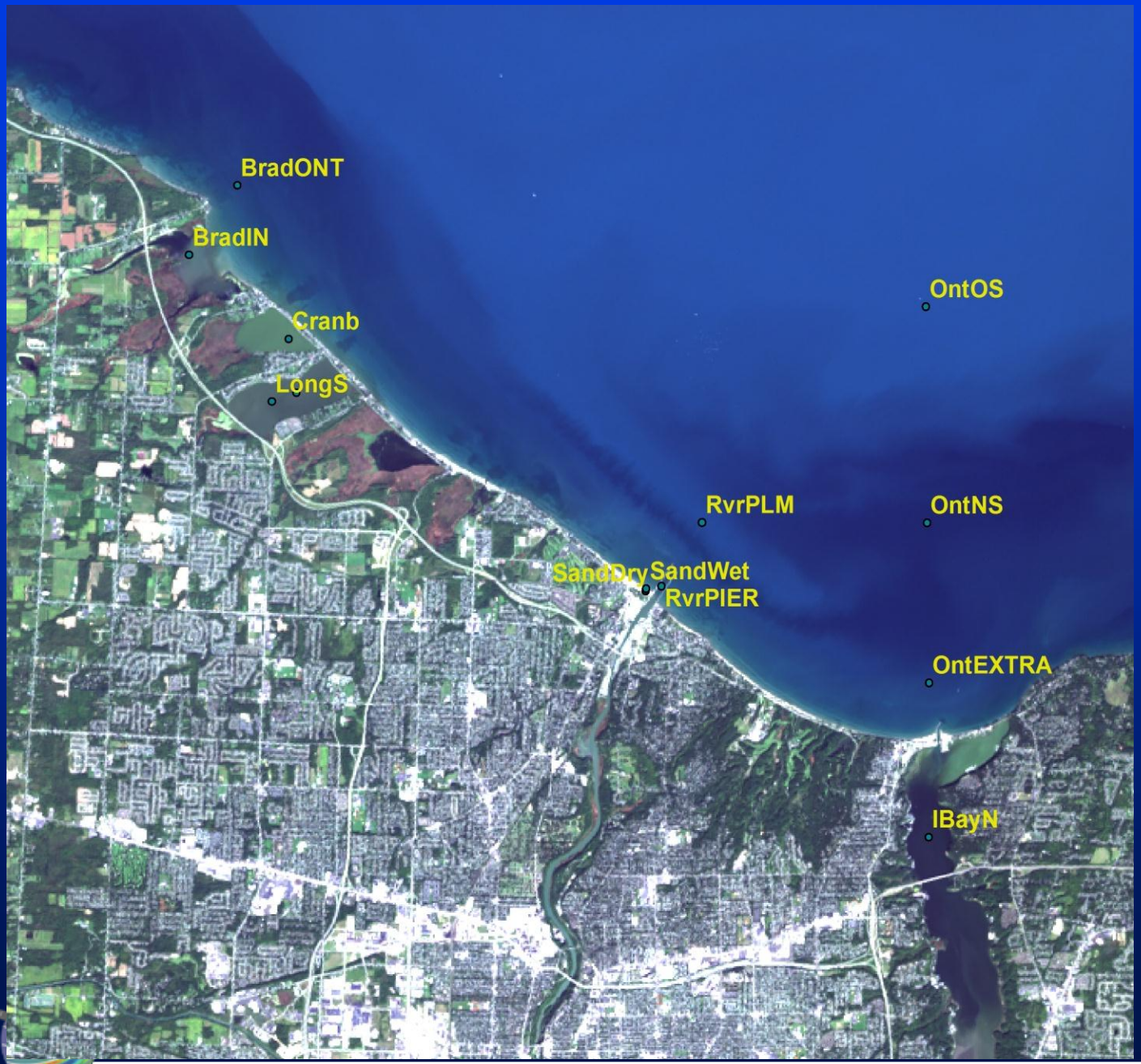


Signal to Noise Ratio for uniform water regions extracted for a region of uniform brightness in the Red Sea from Landsat 8(circle) and Landsat 7(triangle), along with the specified Signal to Noise Ratio for Landsat 8 at typical radiance levels (diamond).

RIT Ground Truth Collection Summary

- April 8: Practice Water Sample Collection
- June 15: Full Collect, Clouds
- June 22: Collect, Clouds
- July 1: Collect on Ponds, Samples to County Lab, Clouds
- August 2: Collect Sand Spectra, Clouds
- August 25: Collect on Ponds, Mostly Clear
- Sept 19: Full Collect Ponds & Lake Ontario, CLEAR
- Sept 26: Mostly Clear some cirrus and cumulus present
- October: ?

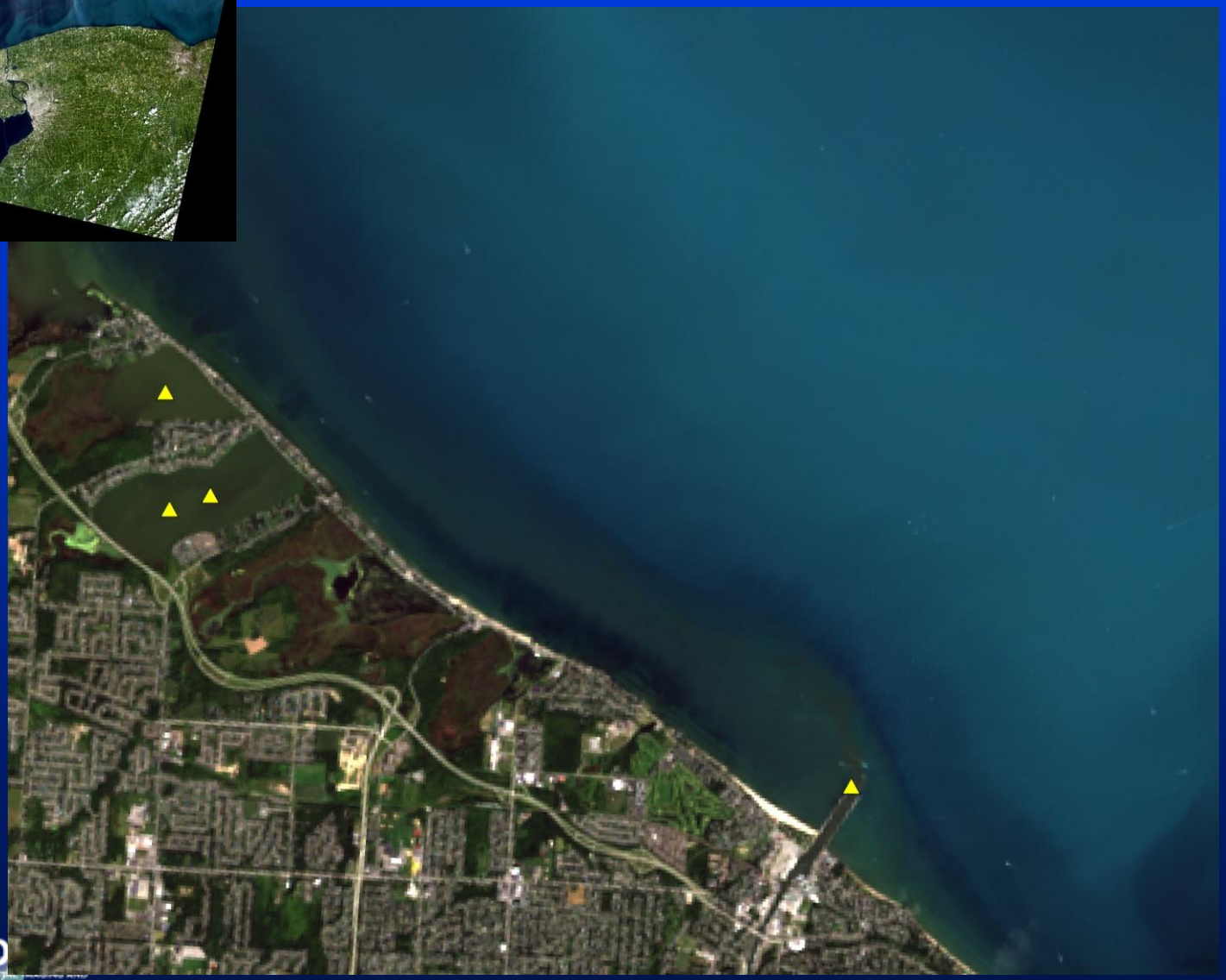
Sept 19th Ground Truth Collect



- Water collection
  - Tss, Chlorphyll, CDOM
- Spectral Meas.
  - on LO Boat
- HydroScat
- Thermistor

R·I·T

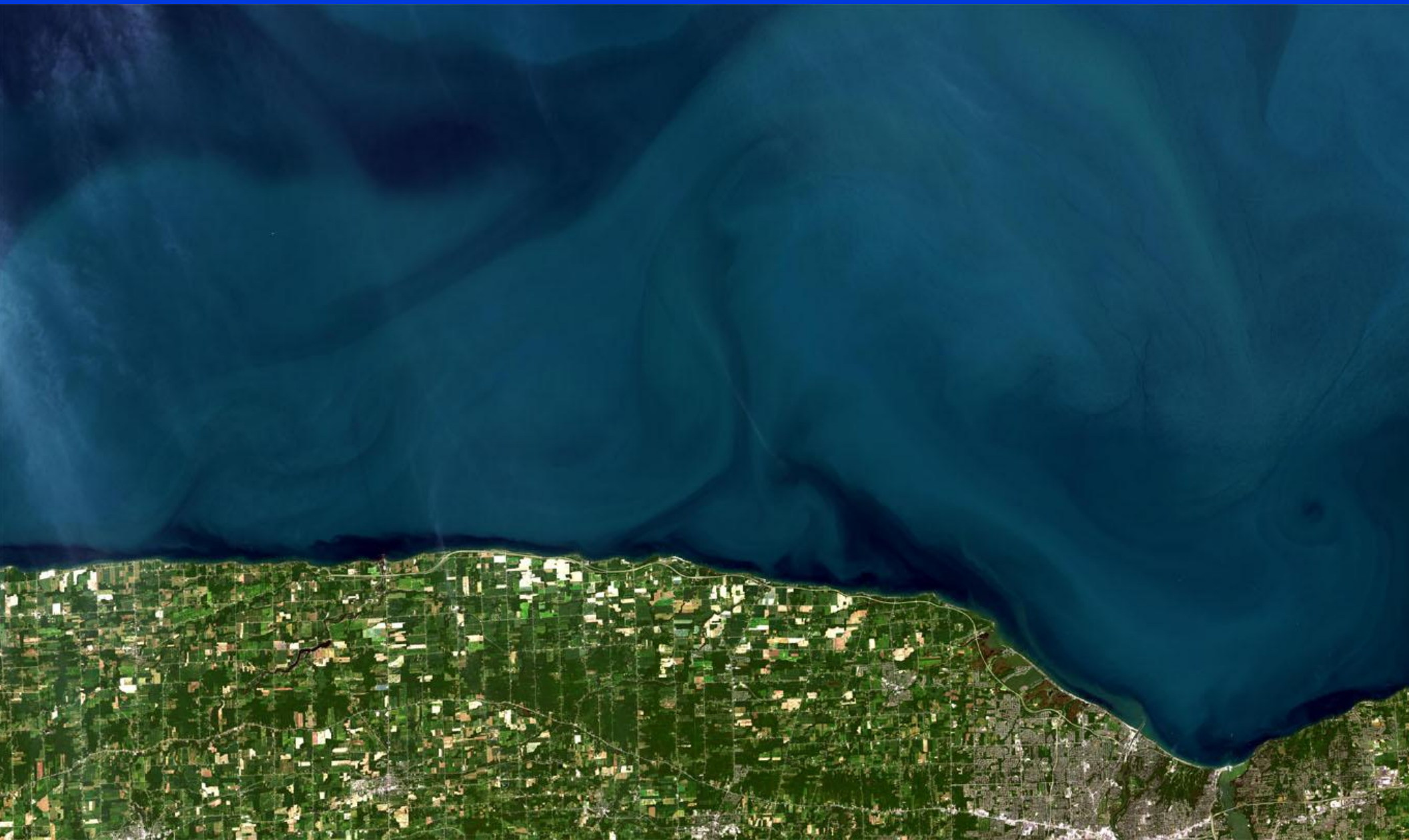
Aug 25th Ground Truth Collect



- Water collection
  - Tss, Chlorphyll, CDOM
- HydroScat
- Ponds only

Aug 25th Ground Truth Collect

- During Whiting Event

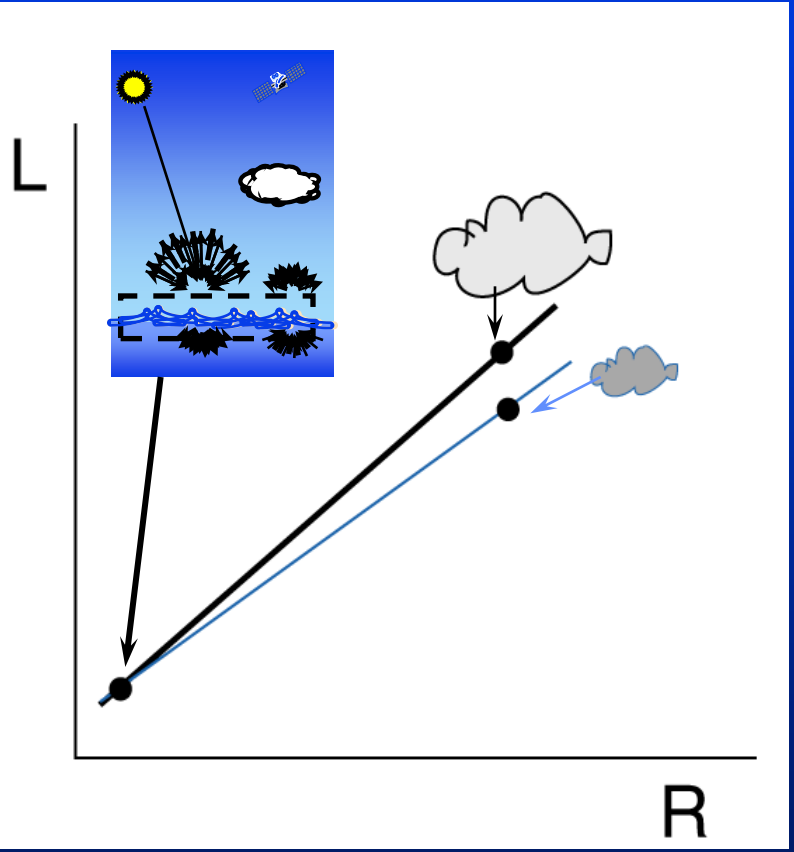


Sept 26th Ground Truth Collect

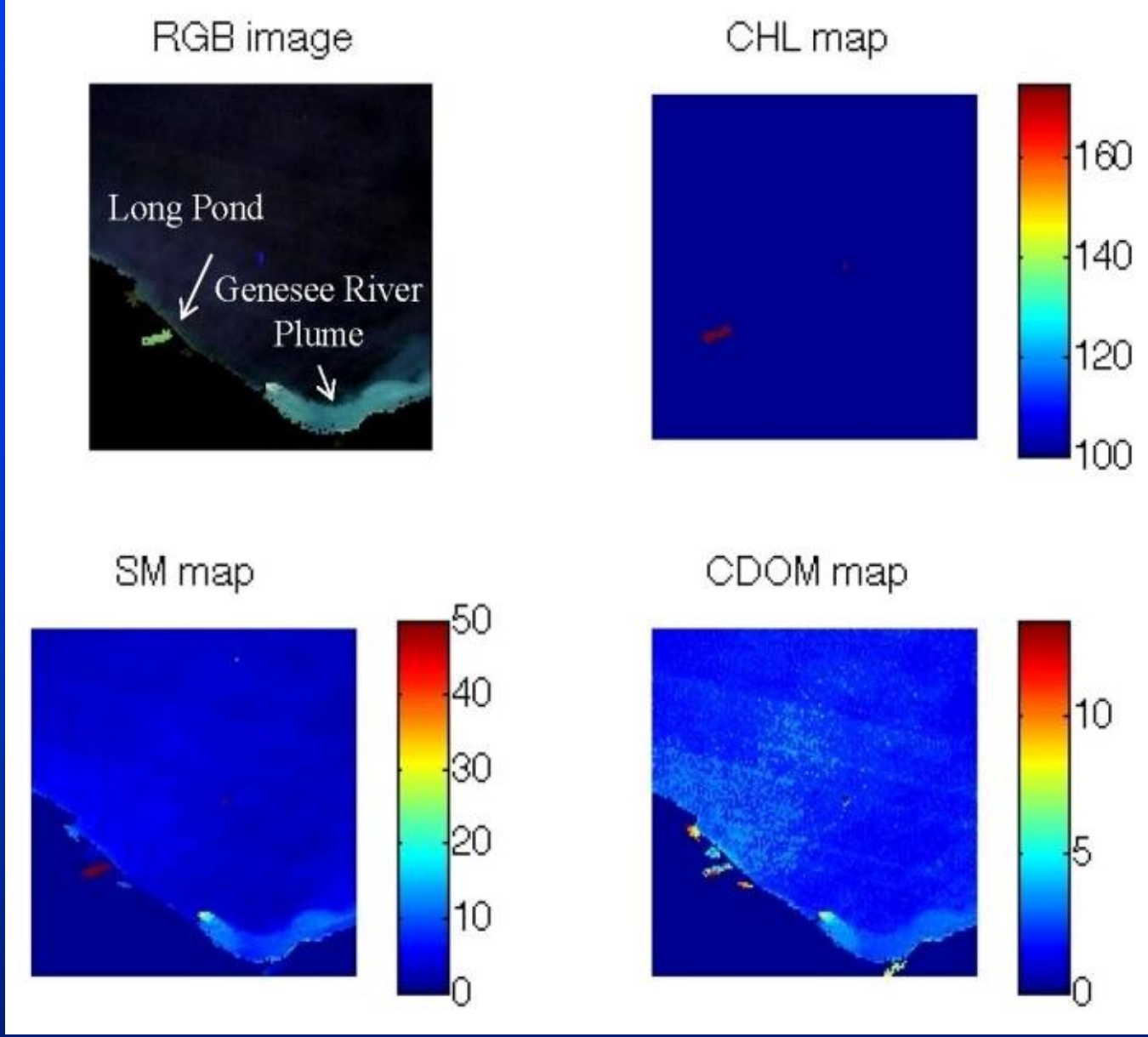
- Water collection
  - Tss, Chlorphyll, CDOM
- Spectral Meas.
  - on LO Boat
- HydroScat
- Thermistor

Model based ELM

- Bright target is urban from reflectance product. Estimate water constituents in clear water (use ground truth if available) to predict R using Hydrolight for the specific conditions under study
- Perform Linear transform of Radiance to reflectance, L=mR+b
- NB accounts not only for atmos-phere, but for any first order model-atmosphere-sensor mismatch

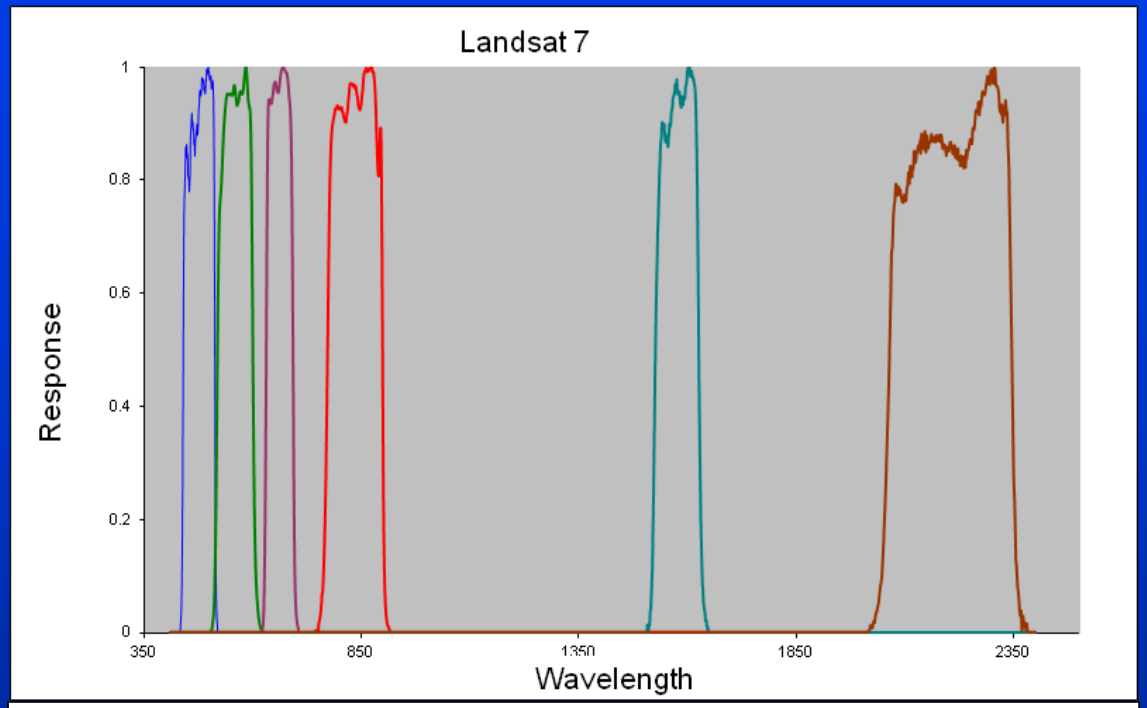


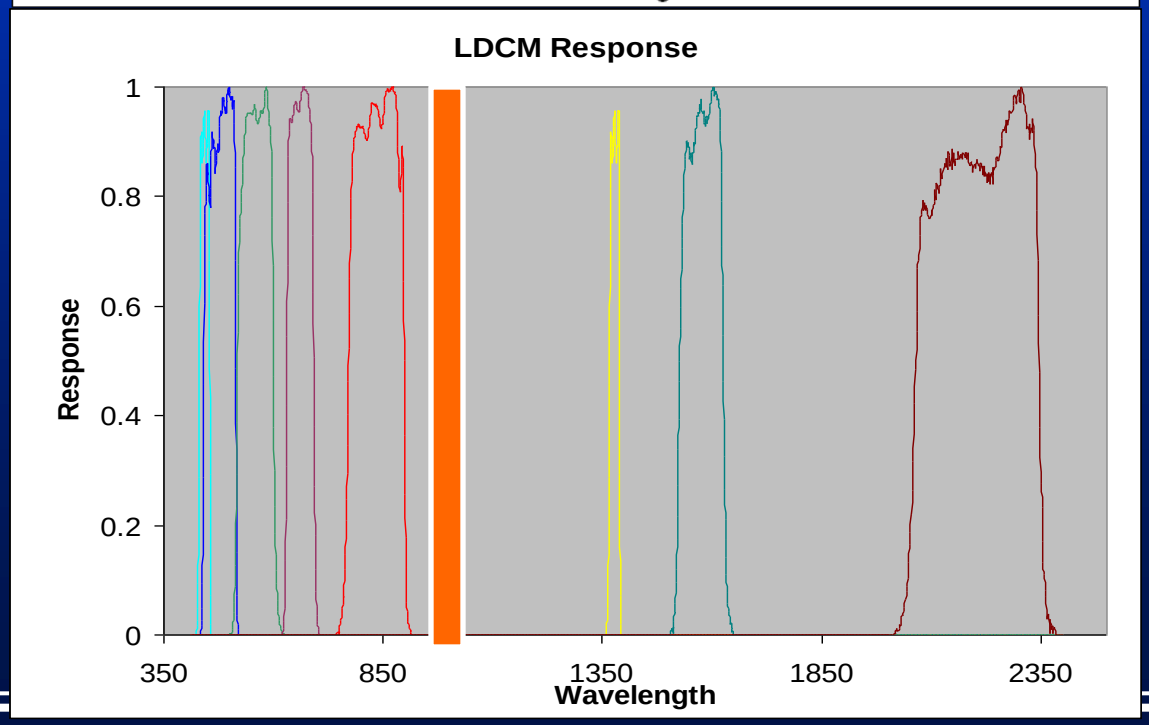
PIF mask – more conservative



Portion of a true color Landsat 5 image of Lake Ontario (top left) and derived concentration/absorption maps of chlorophyll (CHL), suspended material (SM) and colored dissolved organic material (CDOM).

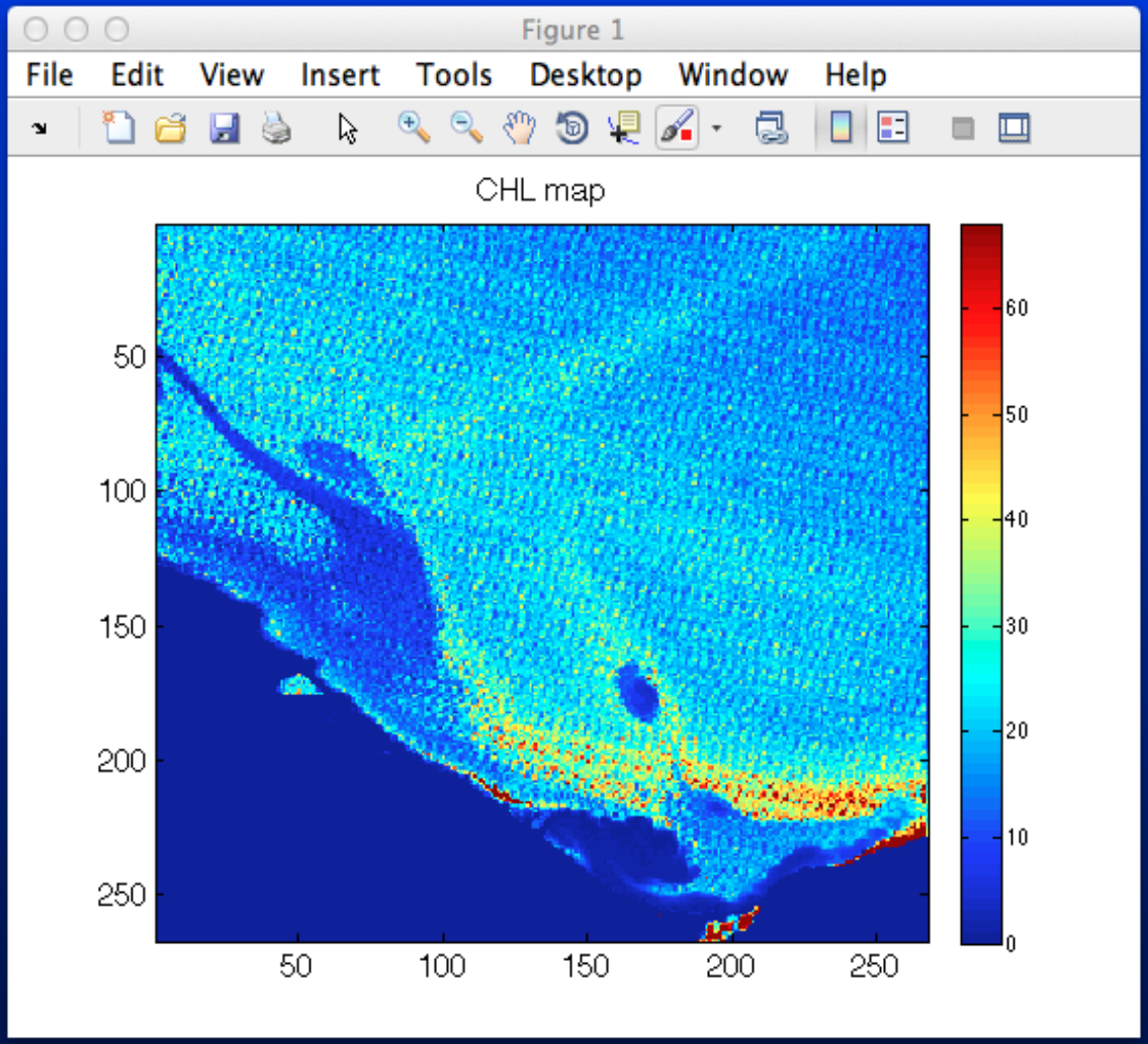
LDCM Features: New bands
Landsat 9 atm comp band for water



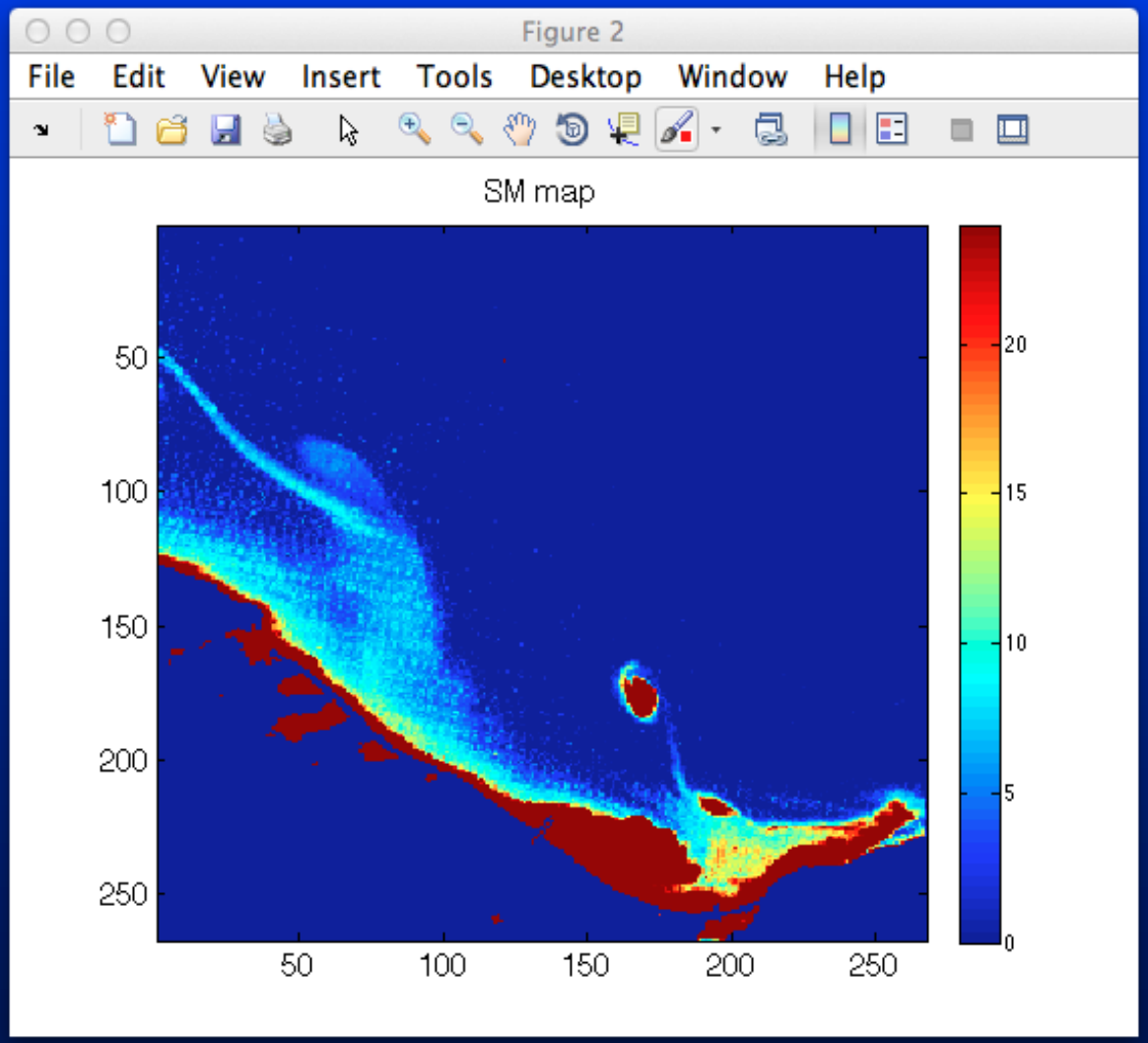


Backup

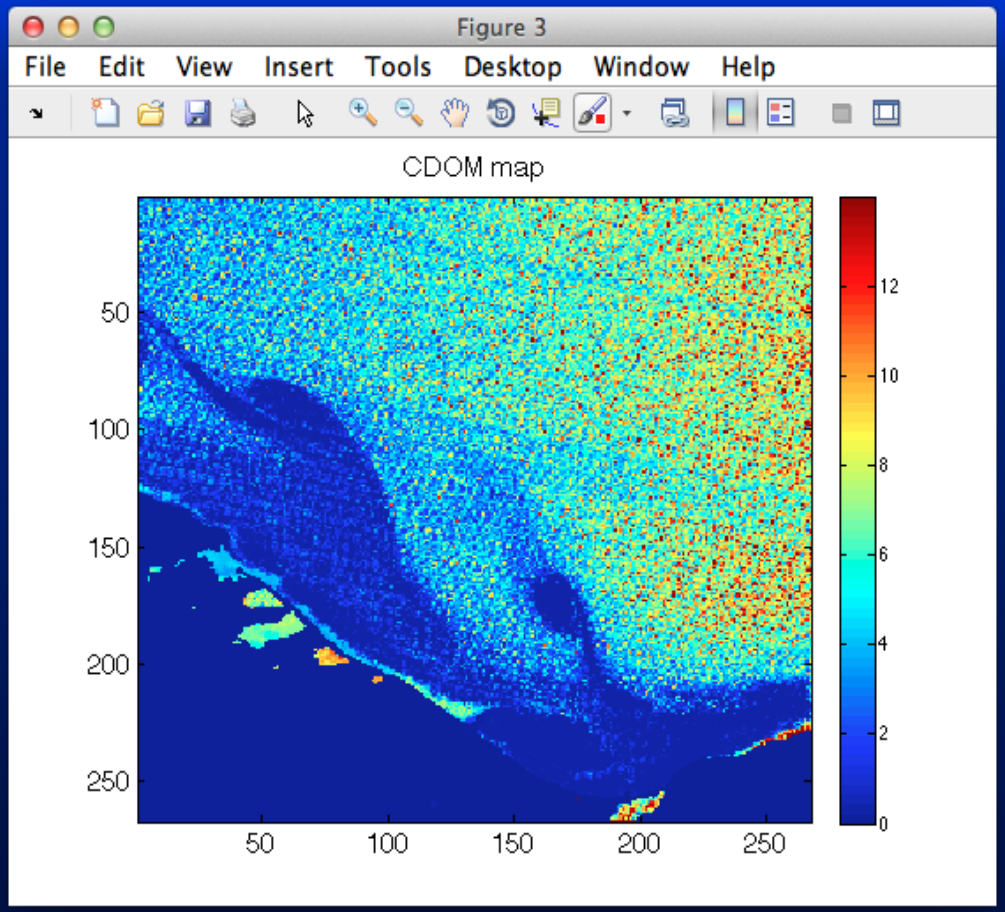
Landsat 5 Chl map



Landsat 5 SM map

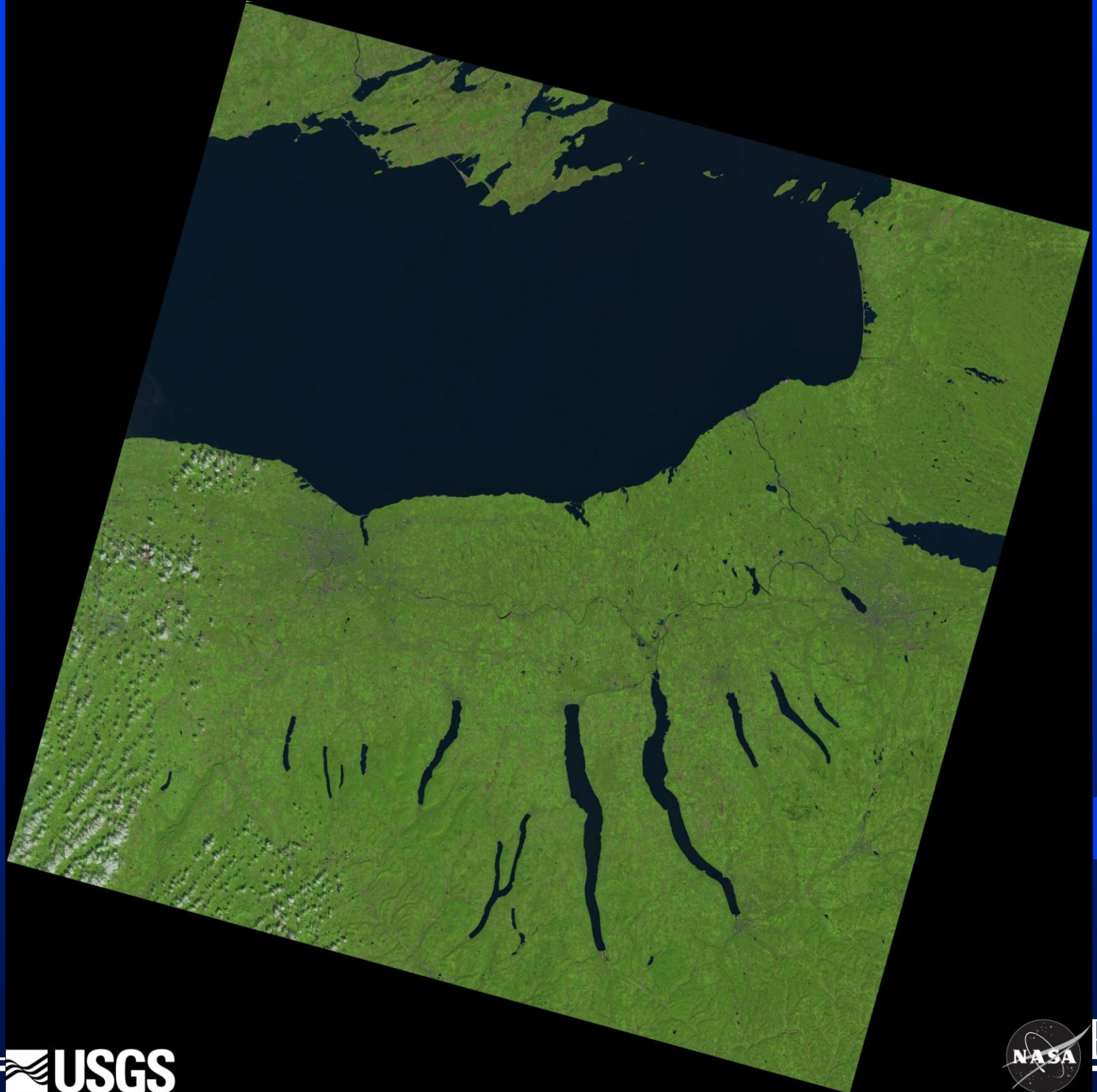


Landsat 5 CDOM map



Sept 26t

Path17Row30
June 6 - Sept 1



Sept 19

Path16Row30
April 12-Sept 19

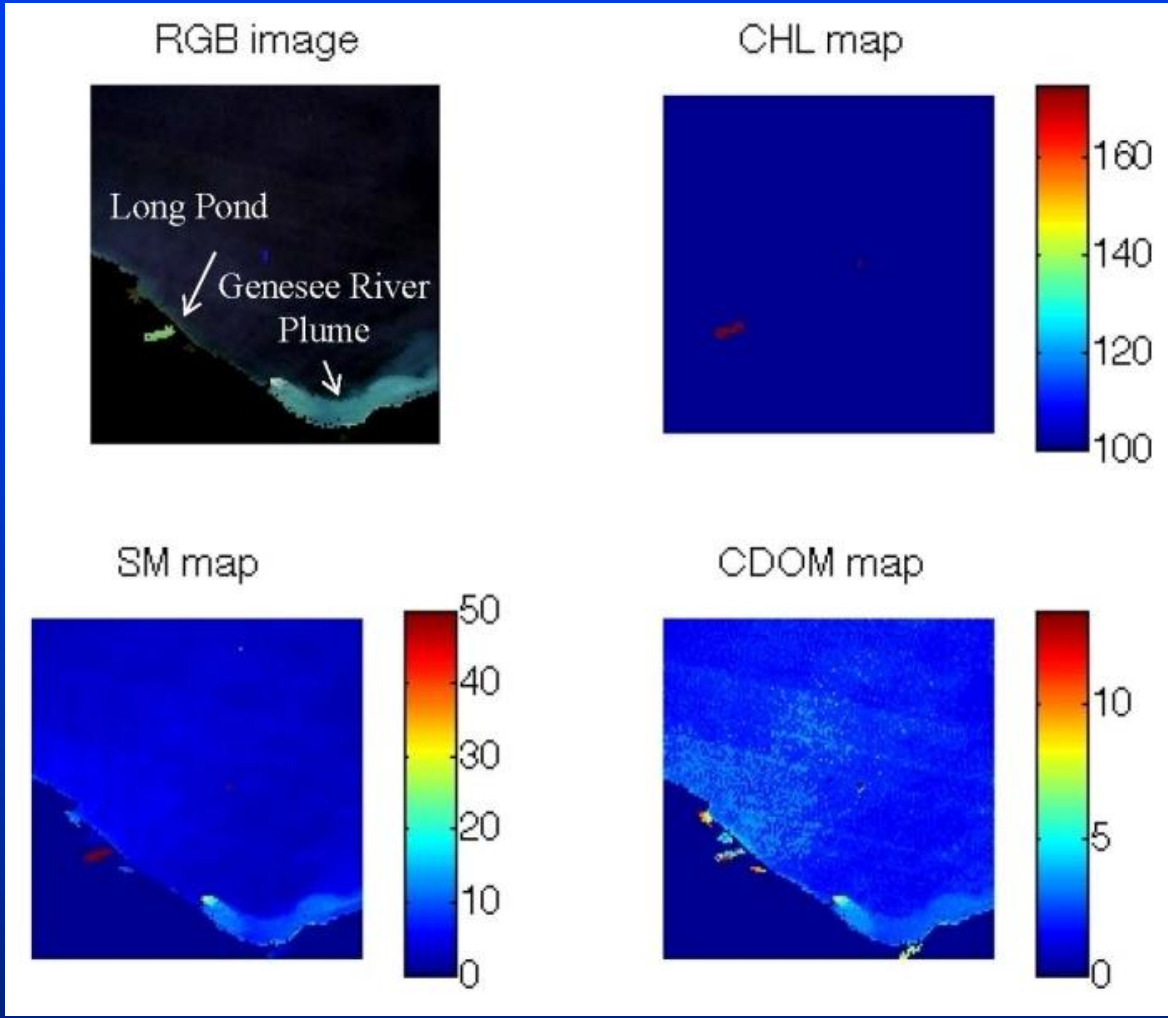


Figure 2: Portion of a true color Landsat 5 image of Lake Ontario (top left) and derived concentration/absorption maps of chlorophyll (CHL), suspended material (SM) and colored dissolved organic material (CDOM).

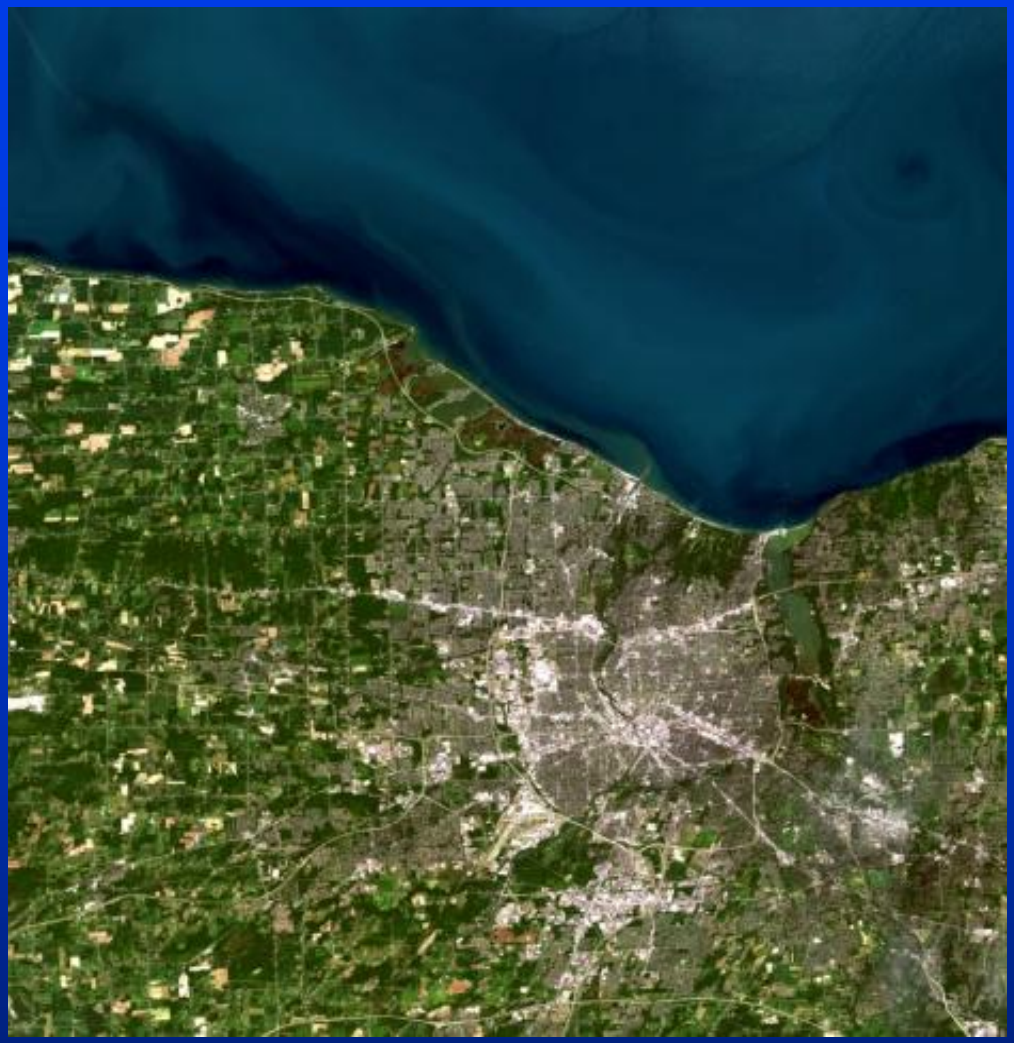
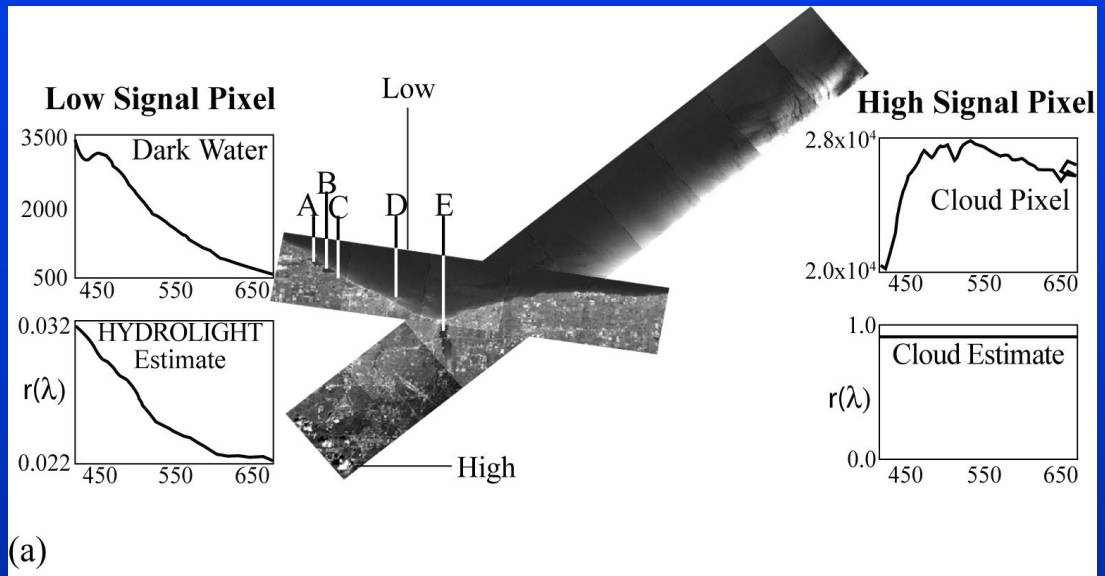
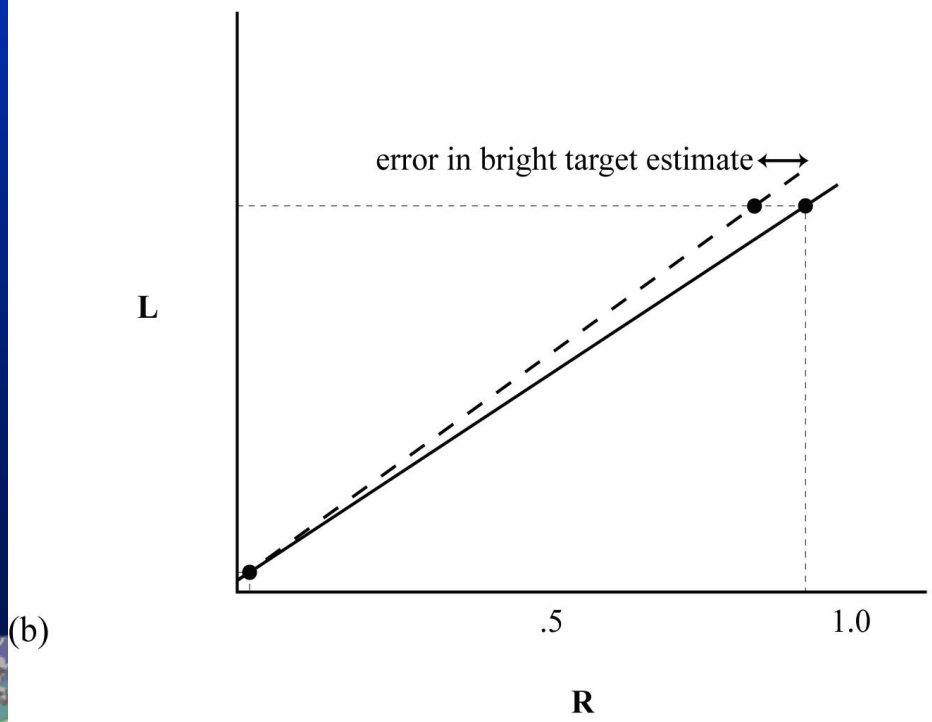


Figure 3: Landsat 8 image acquired on 8/25/13 showing a whiting event on Lake Ontario.

Section 11.2.2 Model Matching Applied to Water Quality Parameter Retrieval



(a)



(b)

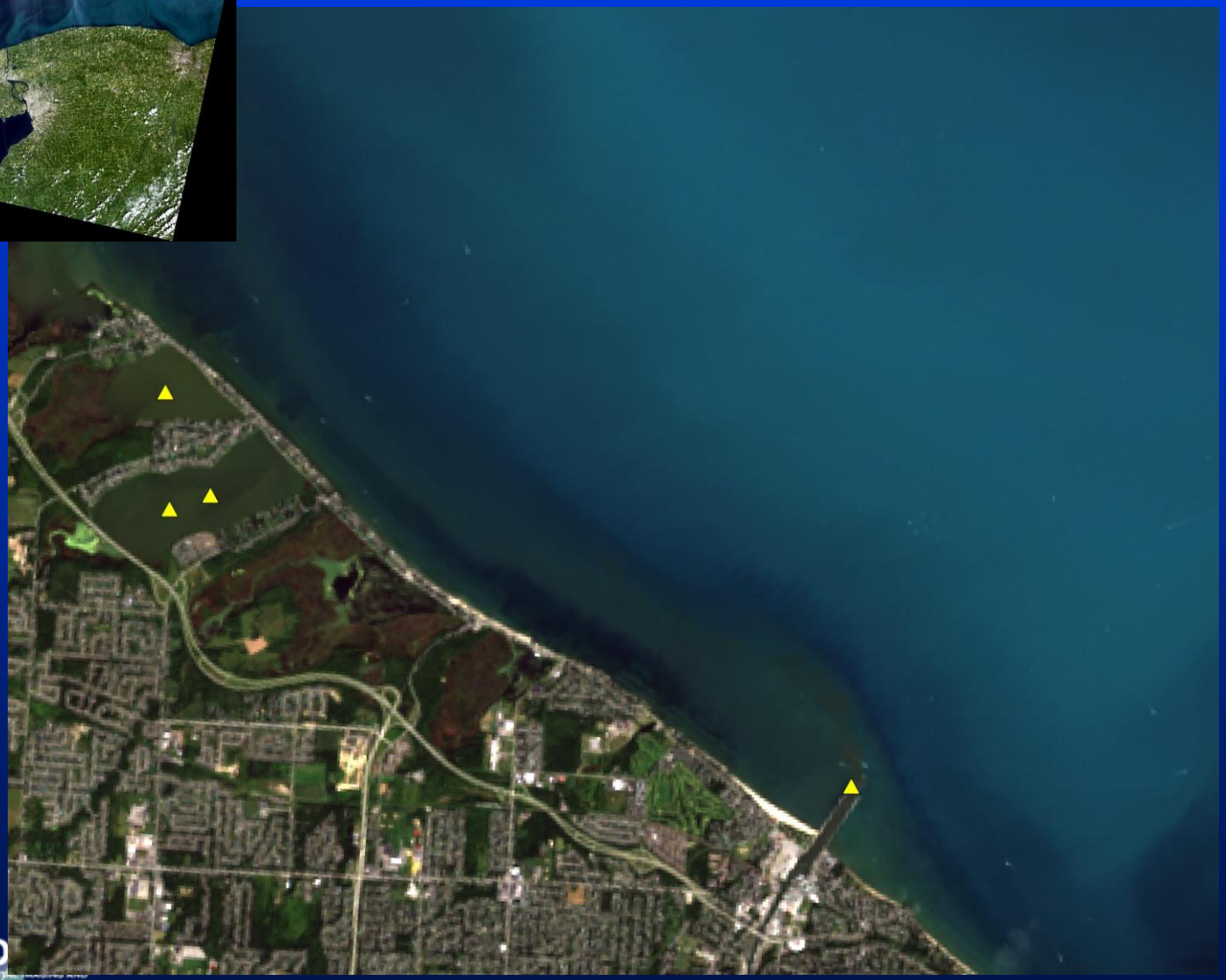
Figure 11.10

Illustration showing:

(a) two AVIRIS flight lines over Lake Ontario shoreline along with sample points and spectra used in ELM based atmospheric compensation and

(b) An example ELM fit in one band is shown as the solid line. The dashed lines show how little error is introduced for low reflectance targets by a large error in the estimate of the bright targets reflectance.

Aug 25th Ground Truth Collect



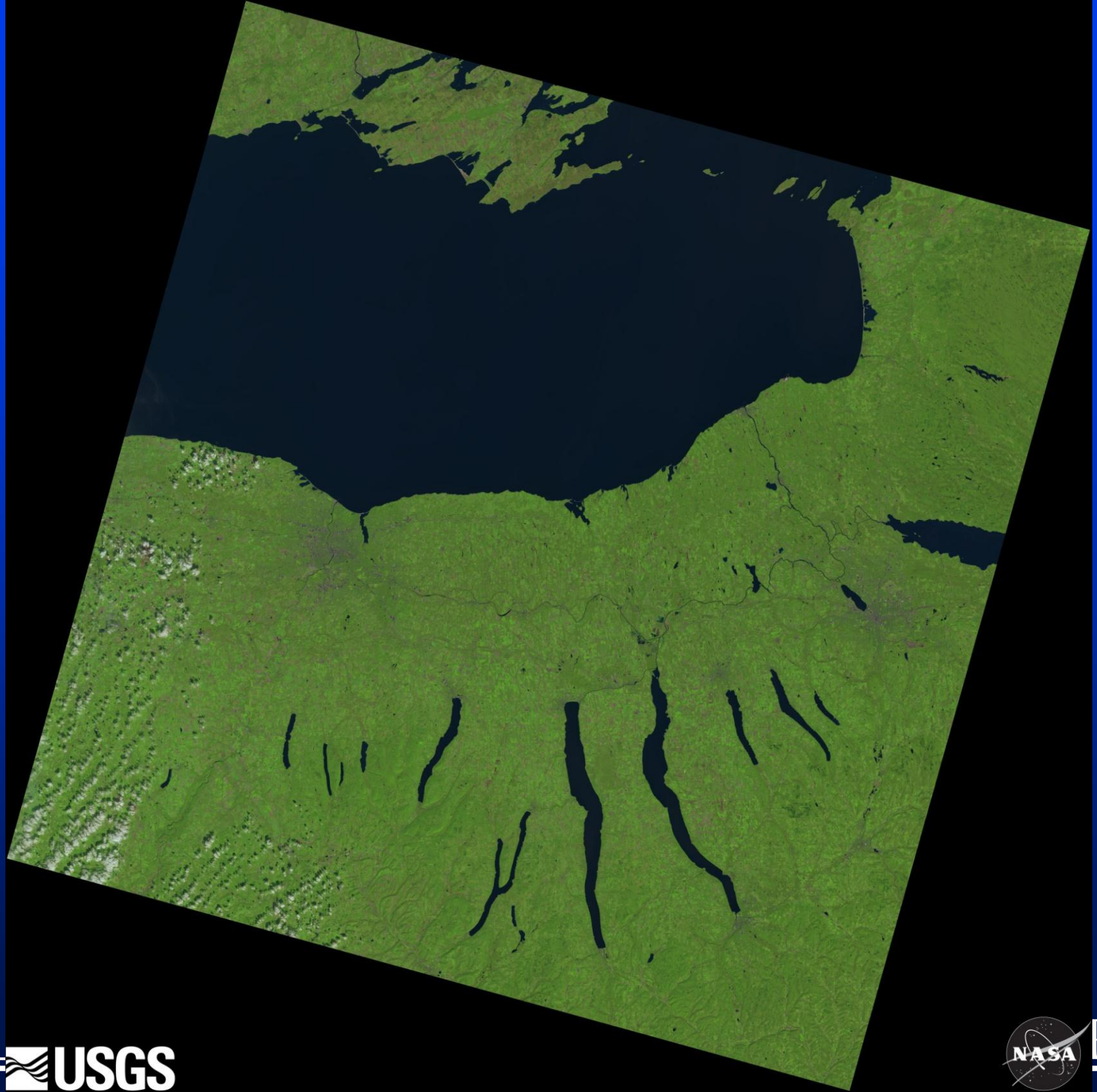
- Water collection
  - Tss, Chlorphyll, CDOM
- HydroScat
- Ponds only

RIT Ground Truth Collection Summary

	IOPs		Concentrations		Reflectances		Backscattering	
Date	Ponds	Lake	Ponds	Lake	Ponds	Lake	Ponds	Lake
25-Aug	✔	✗	✔	✗	✗	✗	✗	✗
19-Sep	✔	✔	✔	✔	✗	✔	✔	✔
26-Sep	✔	✔	✔	✔	✗	✔	✗	✔

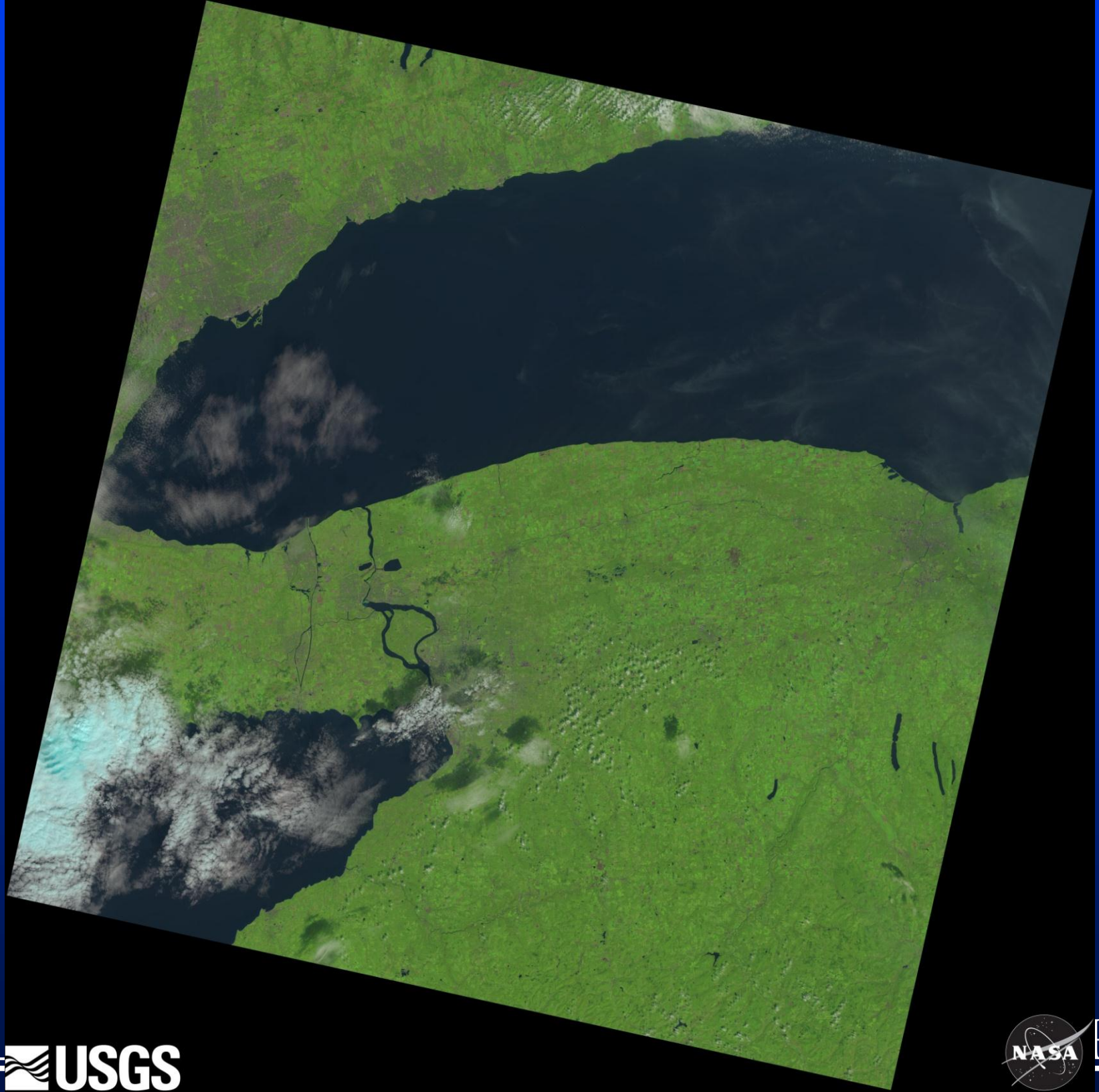
RIT Ground Truth Collection Summary

- April 8: Practice Water Sample Collection
- June 15: Full Collect, Clouds
- June 22: Collect, Clouds
- July 1: Collect on Ponds, Samples to County Lab, Clouds
- August 2: Collect Sand Spectra, Clouds
- August 25: Collect on Ponds, Mostly Clear
- Sept 19: Full Collect Ponds & Lake Ontario, CLEAR



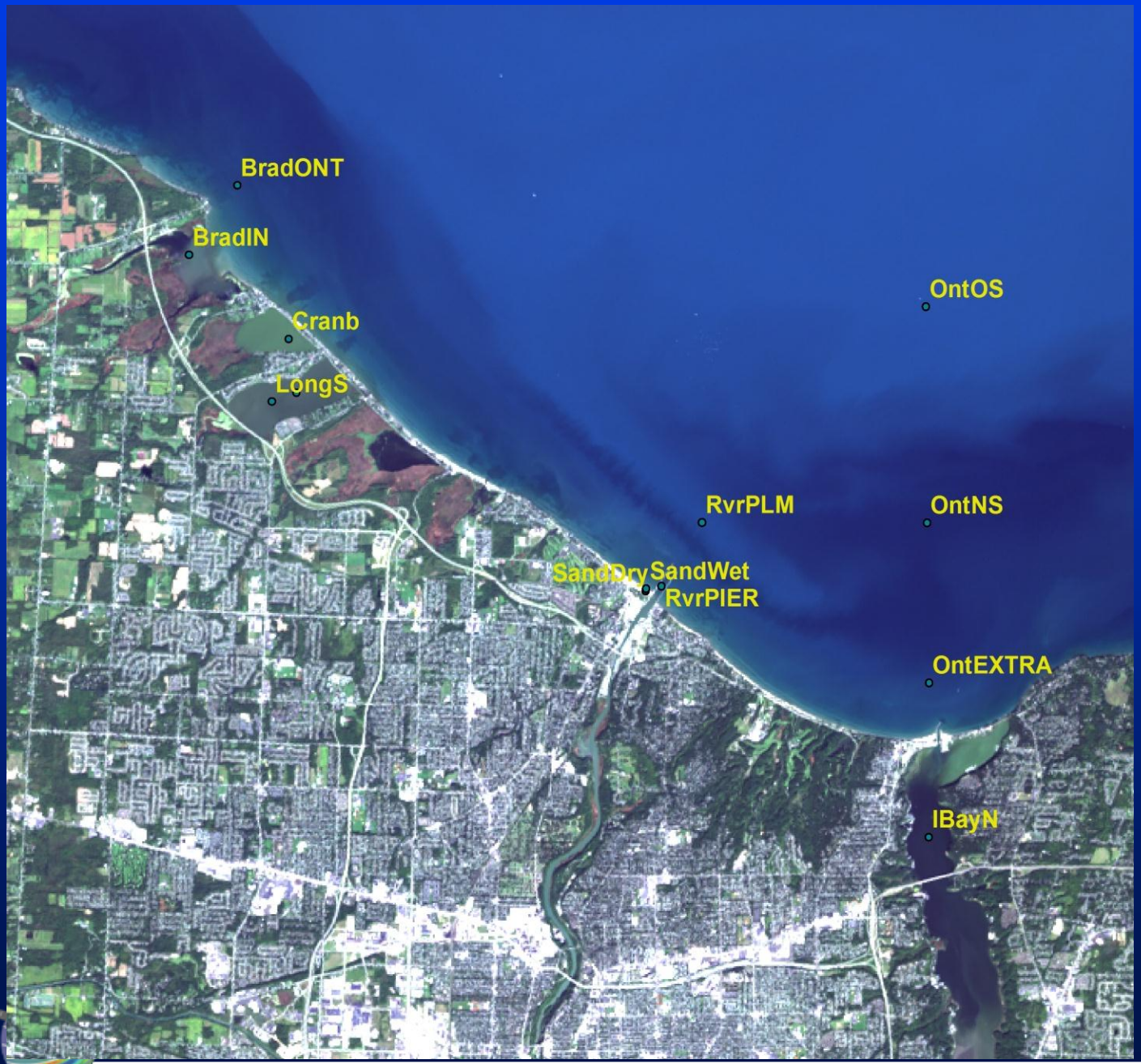
Sept 19

Path16Row30
April 12-Sept 19



Path17Row30
June 6 - Sept 1

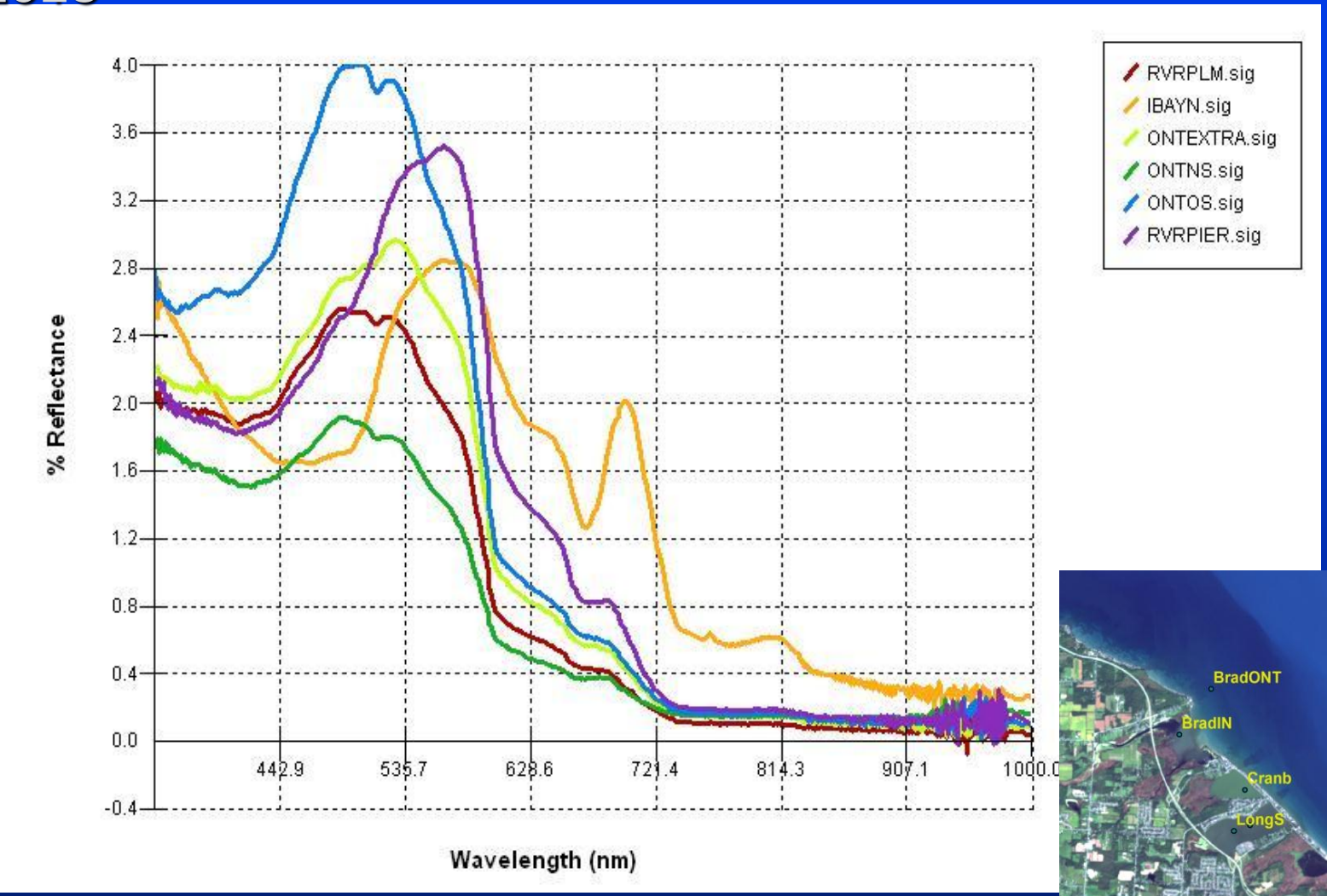
Sept 19th Ground Truth Collect

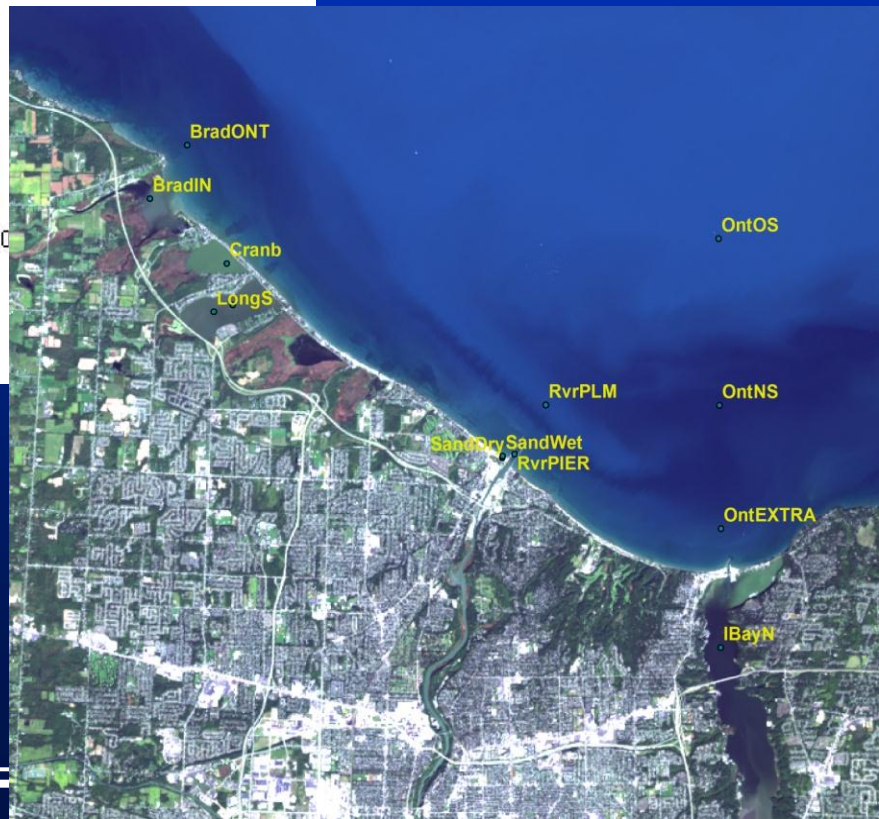


- Water collection
  - Tss, Chlorphyll, CDOM
- Spectral Meas.
- HydroScat
- Thermistor

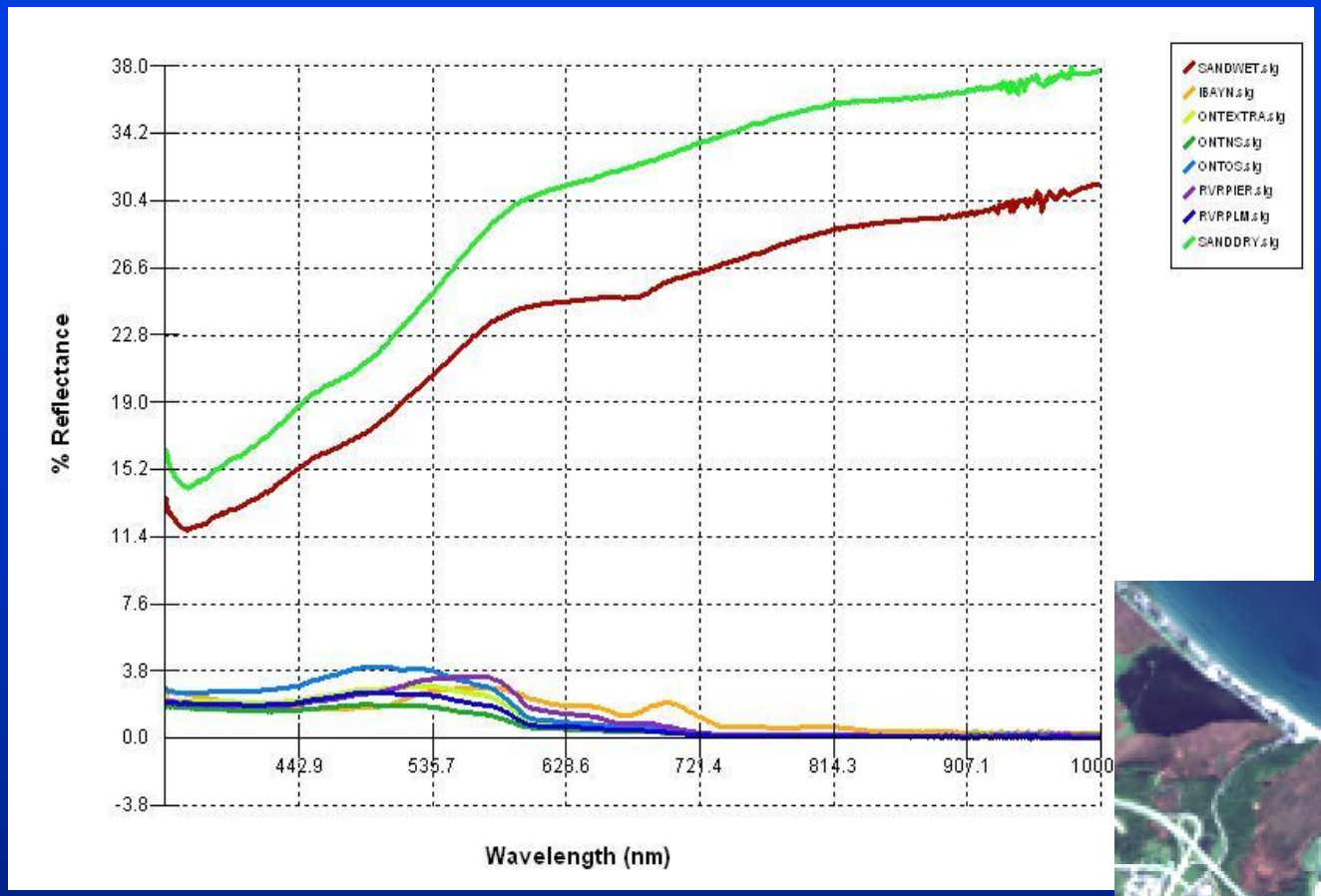
R·I·T

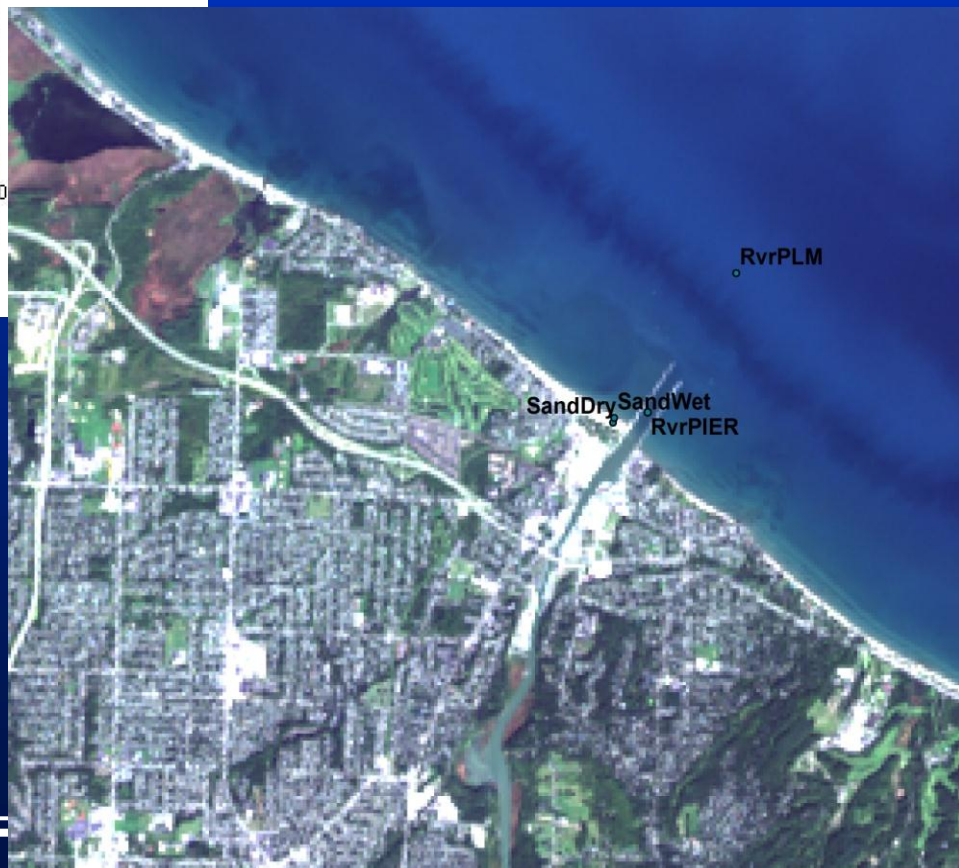
ectra taken with SVC HR1024i
2013





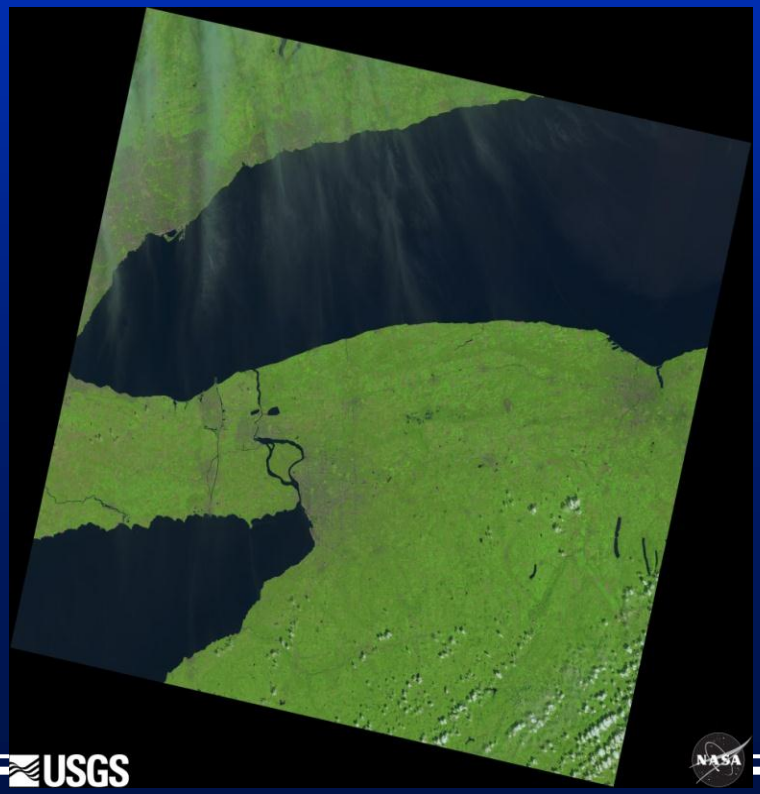
ectra taken with SVC HR1024i
2013





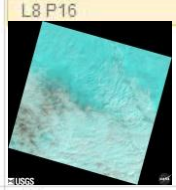
Aug 25th Ground Truth Collect

- **insert map of Aug 25th GT effort**
- **sample measurements**
- **hydroscat, ...**

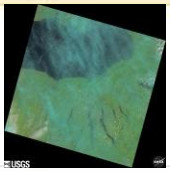


- Water collection
  - Tss, Chlorphyll, CDOM
- HydroScat
- Ponds only

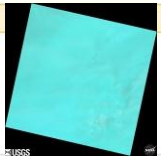
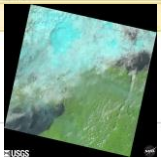
Today | April 2013 | Day | Week | Month | 4 Days | Agenda | More

Sun	Mon	Tue	Wed	Thu	Fri	Sat
31	Apr 1	2	3 L8 Path17 *not imaged*	4	5	6
7	8 Water Sample Collection	9	10	11	12 L8 P16 	13
14	15	16	17	18	19 L8 Path17 *not imaged*	20
21	22	23	24	25	26	27
28 L8 P16 	29	30	May 1	2	3	4

Today | May 2013 | Day | Week | Month | 4 Days | Agenda | More

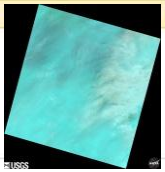
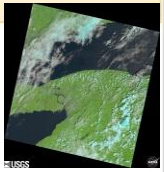
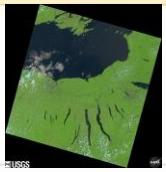
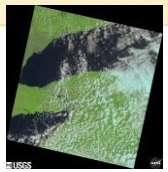
Sun	Mon	Tue	Wed	Thu	Fri	Sat
28 L8 P16	29	30	May 1	2	3	4
5 L8 Path17 *not imaged*	6	7	8	9	10	11
12	13	14 L8 P16 	15	16	17	18
19	20	21 L8 Path17 *not imaged*	22	23	24	25
26	27	28	29	30 L8 P16 	31	Jun 1

Today | June 2013 | Day | Week | Month | 4 Days | Agenda | More

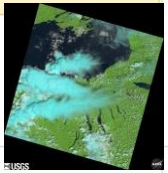
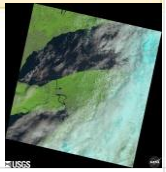
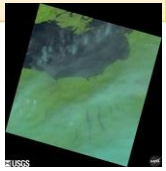
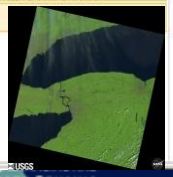
Sun	Mon	Tue	Wed	Thu	Fri	Sat
26	27	28	29	30 L8 P16	31	Jun 1
2	3	4	5	6 L8 Path17 	7	8
9	10	11	12	13	14	15 Full Collect - clouds L8 P16
16	17	18	19	20	21	22 Collect but clouds L8 Path17 
23	24	25	26	27	28	29
30	Jul 1 Javier Nina Ponds only L8 P16	2	3	4	5	6

R·T·T

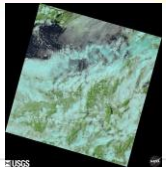
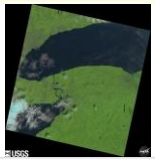
Today | July 2013 | Day | Week | Month | 4 Days | Agenda | More

Sun	Mon	Tue	Wed	Thu	Fri	Sat
30	Jul 1 Javier Nina Ponds only L8 P16 	2	3	4	5	6
7	8 L8 Path17 	9	10	11	12	13
14	15	16	17 L8 P16 	18	19	20
21	22	23	24 L8 Path17 	25	26	27
28	29	30	31	Aug 1	2 L8 P16	3

Today | August 2013 | Day | Week | Month | 4 Days | Agenda | More

Sun	Mon	Tue	Wed	Thu	Fri	Sat
28	29	30	31	Aug 1	2 Collect Sand Spectra L8 P16 	3
4	5	6	7	8	9 L8 Path17 	10
11	12	13	14	15	16	17
18 L8 P16 	19	20	21	22	23	24
25 CLEAR Javier Aaron Ponds L8 Path17 	26	27	28	29	30	31

Today | September 2013 | Day | Week | Month | 4 Days | Agenda | More

Sun	Mon	Tue	Wed	Thu	Fri	Sat
Sep 1	2	3 L8 P16 	4	5	6	7
8	9	10 L8 Path17 	11	12	13	14
15	16	17	18	19 Full Collect RIT, Mon, StJ Samples L8 P16 	20	21
22	23	24	25	26 L8 Path17	27	28
29	30	Oct 1	2	3	4	5 L8 P16

Today | October 2013 | Day | Week | Month | 4 Days | Agenda | More

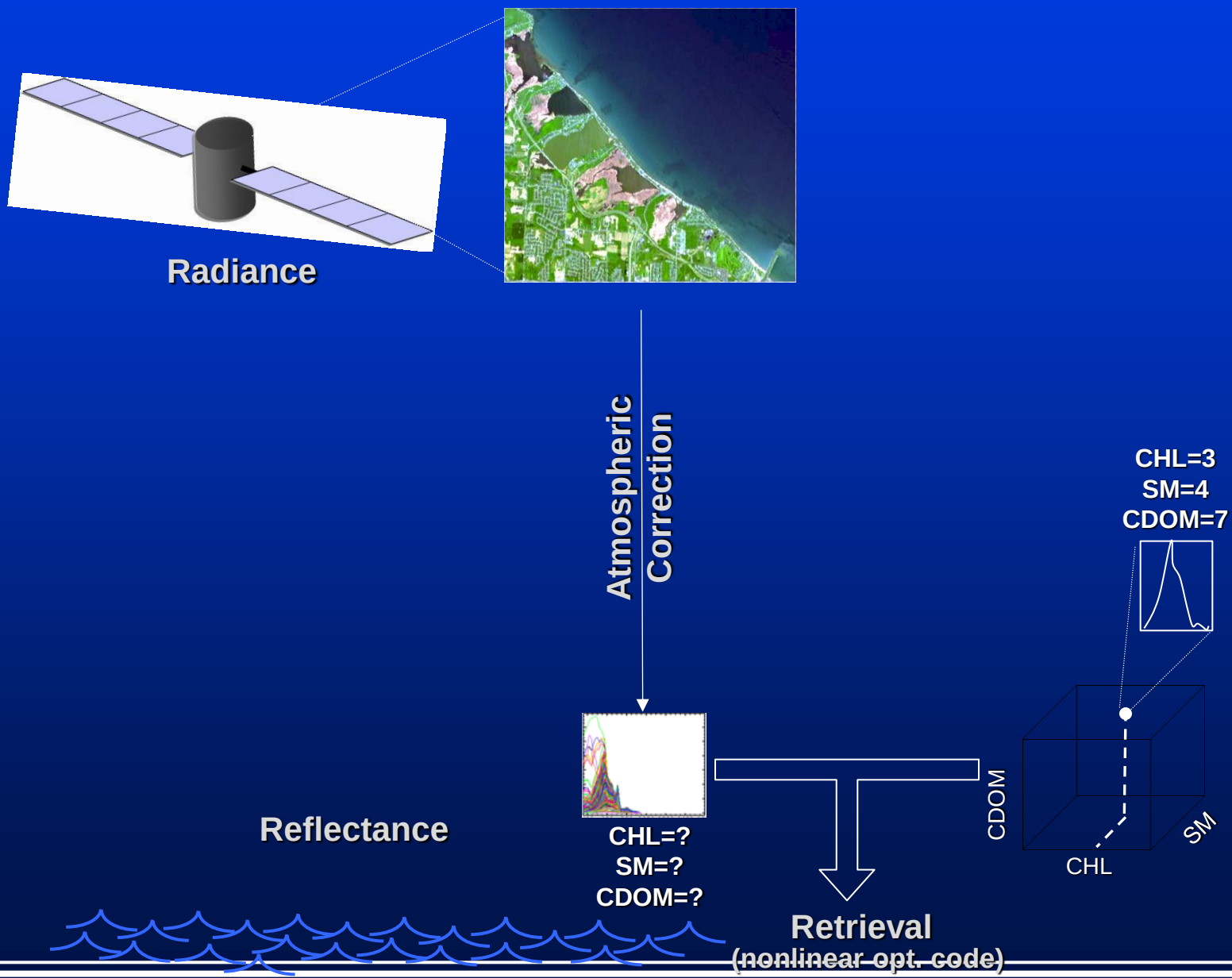
Sun	Mon	Tue	Wed	Thu	Fri	Sat
29	30	Oct 1	2	3	4	5 L8 P16
6	7	8	9	10	11	12 L8 Path17 Nina Not Available
13	14	15	16	17	18	19
20	21 L8 P16	22	23	24	25	26
27	28 L8 Path17	29	30	31	Nov 1	2

Annual Report: The Use of Landsat 8 for Monitoring of Fresh and Coastal Water

By Javier A. Concha

09-18-13

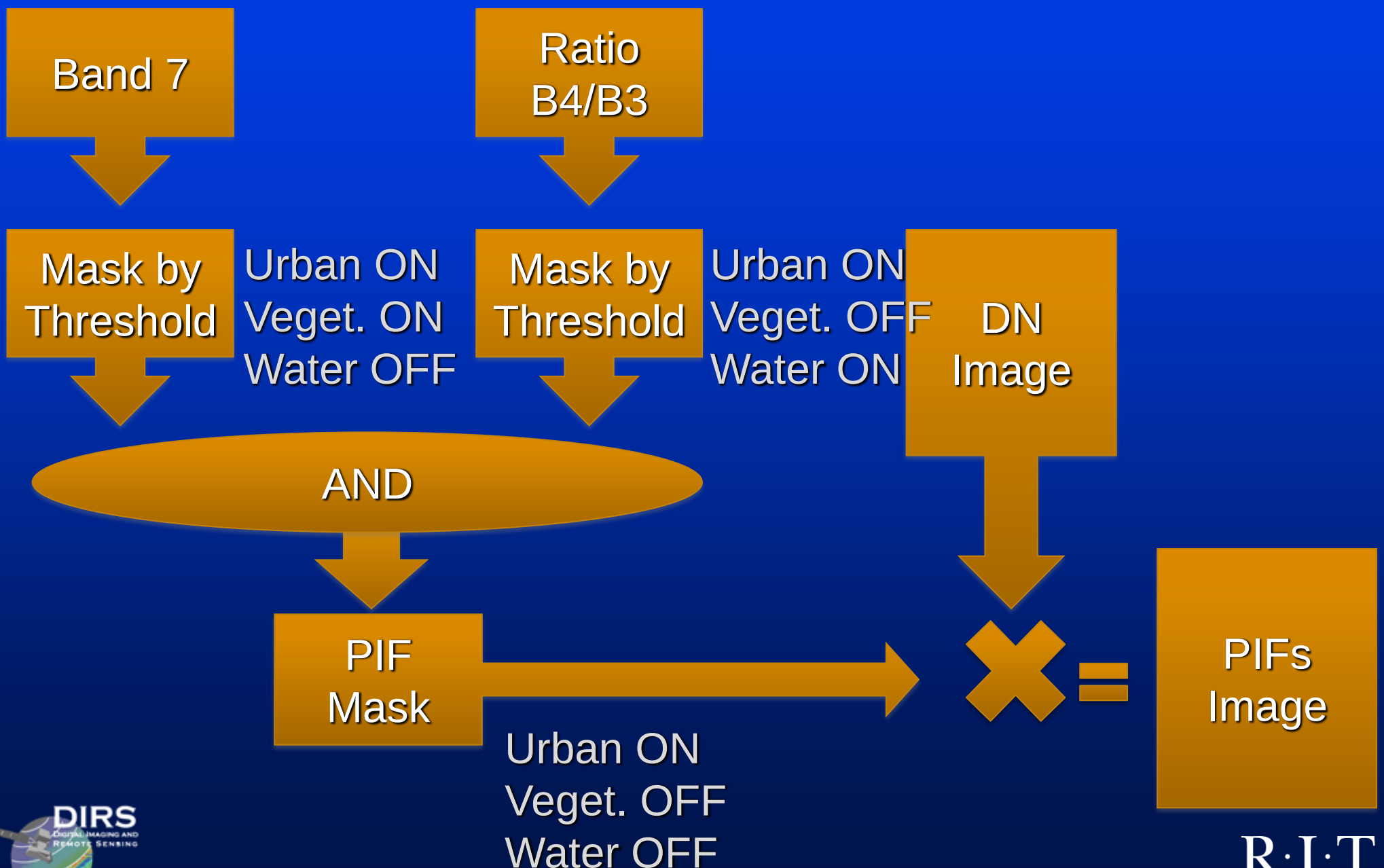
Retrieval Process



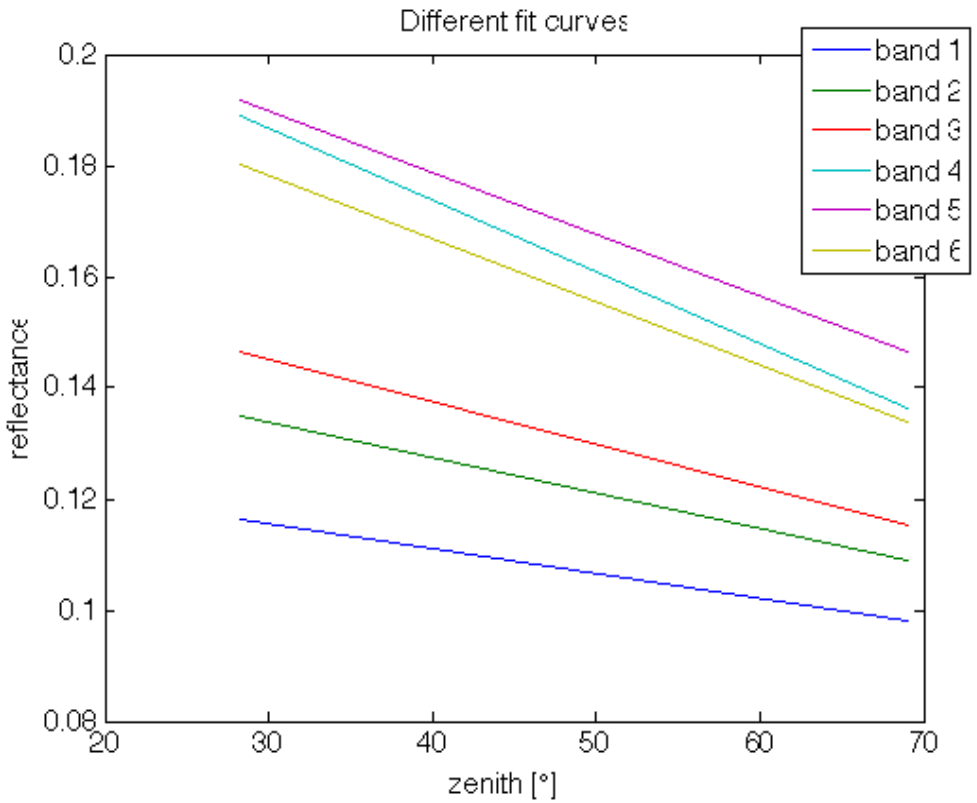
Atmospheric Correction

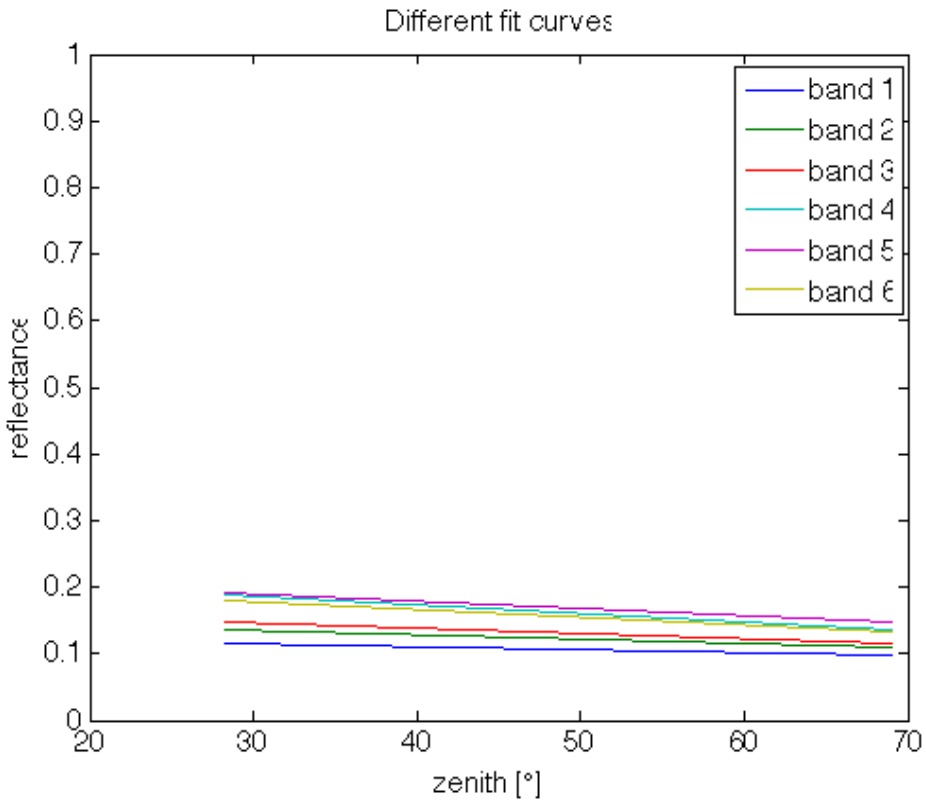
- A Model Based Empirical Line Method (ELM) Atmospheric Correction Method
  - Bright pixel :
    - » Radiance (Data Spectra): Pseudo Invariant Features (PIF) from L8 image
    - » Reflectance (Field Spectra): PIF from Landsat reflectance product (CDR)
  - Dark pixel:
    - » Radiance (Data Spectra): water ROI from L8 image
    - » Reflectance (Field Spectra): HydroLight (estimated concentration)

PIF for L5


Band 7
Ratio B4/B3
Mask by Threshold
Urban ON
Veget. ON
Water OFF
Mask by Threshold
Urban ON
Veget. OFF
Water ON
DN Image
AND
PIF Mask
Urban ON
Veget. OFF
Water OFF
PIFs Image

Reflectance vs Solar Zenith angle for ALL bands

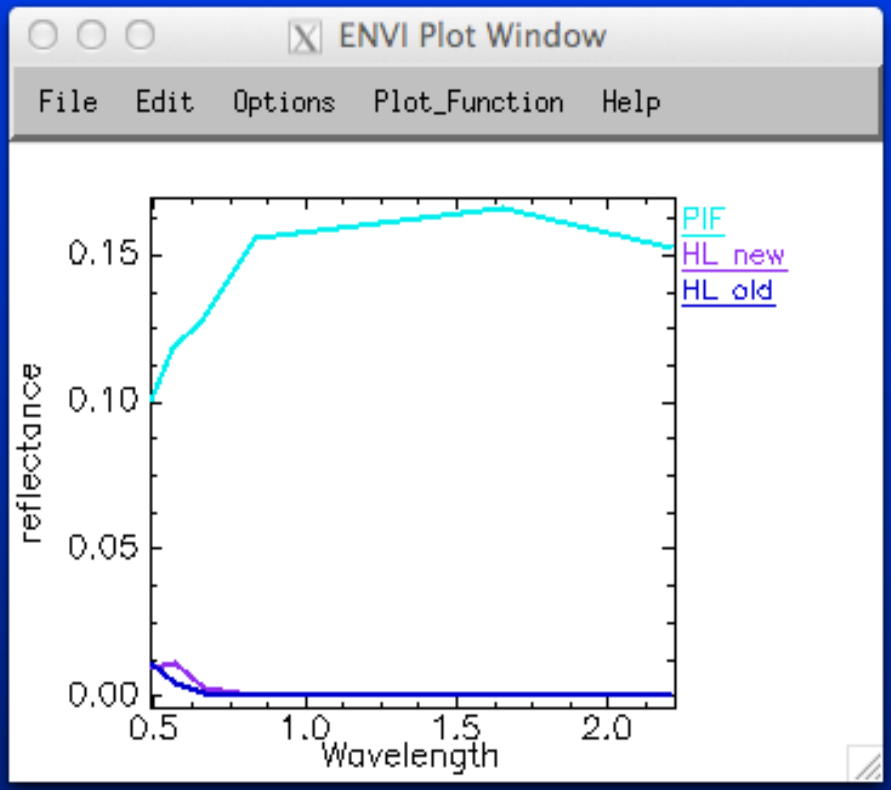




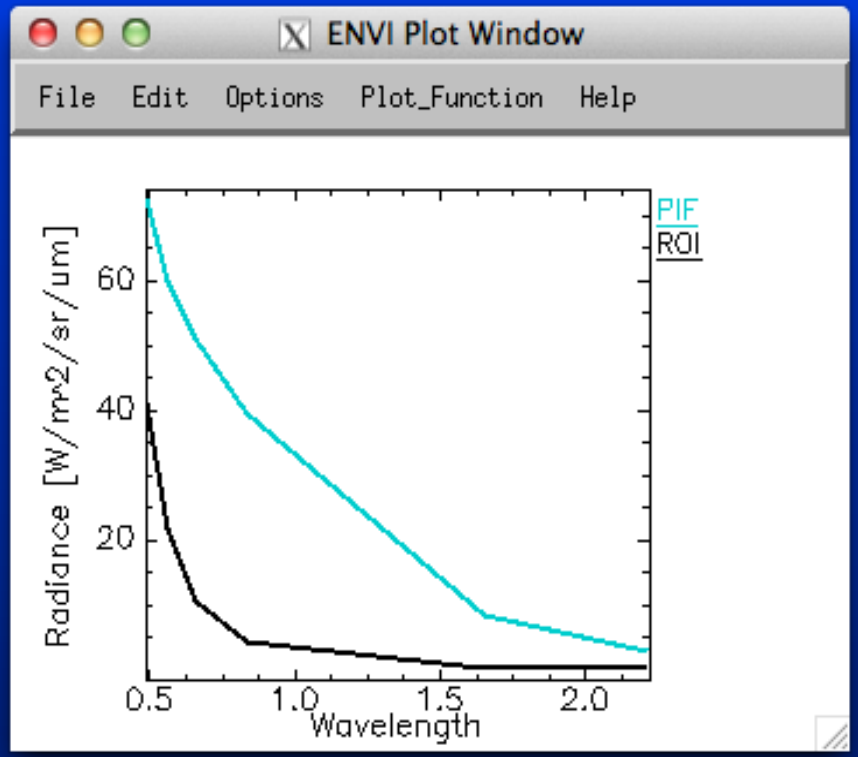
Linear regression parameters

	p(1)	p(2)	r-sq	rmse
Band 1	-0.000443	0.128742	0.93812	0.001818
Band 2	-0.00064	0.153118	0.915764	0.003099
Band 3	-0.000767	0.168112	0.967777	0.002235
Band 4	-0.001289	0.225136	0.897167	0.00697
Band 5	-0.001111	0.222973	0.874089	0.006733
Band 6	-0.001135	0.212046	0.90633	0.005831

ELM



Field Spectra



Data Spectra

Collection Data

- Spring and Summer 2013:
  - When Landsat 8 passes over Rochester
- IOPs and concentration of water main components from Lab

Aug 25th Ground Truth Collect

During Whiting Event

R·I·T