Intro to Instrumentation and Field Measurements in Remote Sensing

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Presented for 2015 Intersession Term

Outline

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1. Introduction
2. Background
3. Taking Measurements

Course Goals

- Learn the importance of field measurements
- Learn how to take field measurements
- Learn about DIRS instruments

Course Description

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- Friday: Introduction
- Monday: Introduction (con't) and DIRS instruments exhibition
- Tuesday: Lab: Reflectance measurements
- Wednesday: Lab: LIDAR measurements

Definitions

Field Measurements or Groundtruth:

"Observations or measurements made at or near the surface of the earth in support of remote sensing."

Remote Sensing:

"Remote sensing is the science of obtaining information about objects or areas from a distance, typically from aircraft or satellites."

Motivation

Why is it important?

- Validation
- Calibration
- Correction

Motivation
Examples

Include:
Javier's example (over water mea.)
Paul's example (LIDAR and trees?)

Field Data Collection
Area of Study

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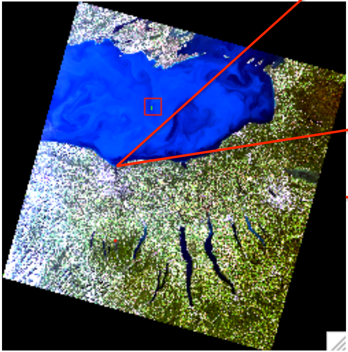
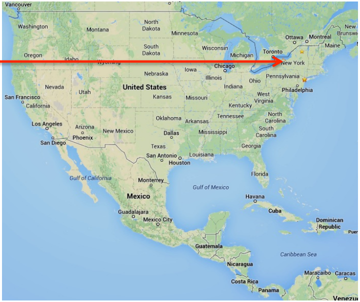
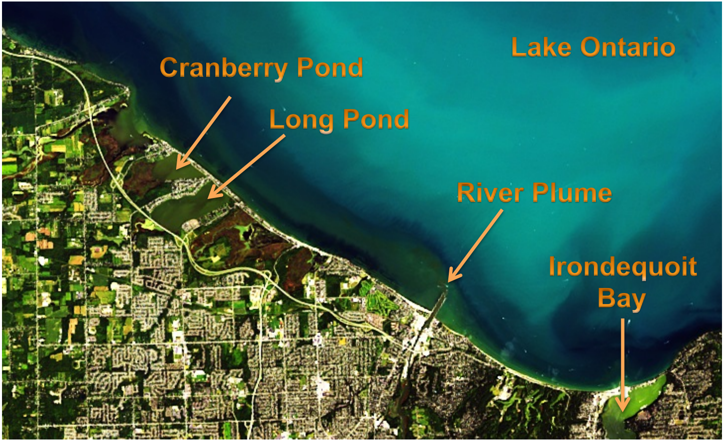
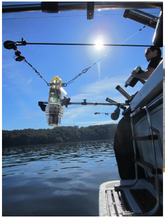




Field Data Collection (con't)
Area of Study

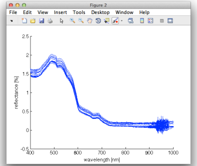


Field Data Collection (con't)



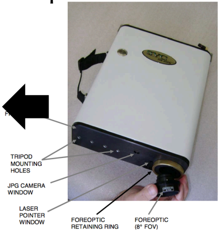
Water Samples

Lab Analysis



Water Leaving Reflectance

Spectroradiometer



Backscattering

Field Data Collection (con't)
Lab Measurements

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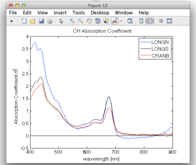
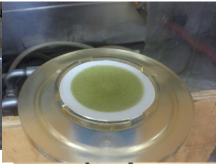
Spectrophotometer

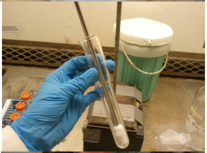


IOPs

Hydrolight



Filtration and Spectrophotometric Analysis



Concentrations

Field Data Collection (con't)

2013 and 2014 Seasons

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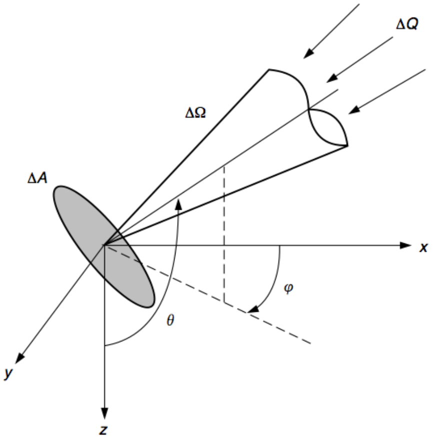
		IOPs		Concentrations		Reflectances		Backscattering	
Date		Ponds	Lake	Ponds	Lake	Ponds	Lake	Ponds	Lake
2013	25-Aug	✔	✗	✔	✗	✗	✗	✗	✗
	19-Sep	✔	✔	✔	✔	✗	✔	✔	✔
	26-Sep	✔	✔	✔	✔	✗	✔	✗	✔
2014	17-May	✔	✗	✔	✗	✔	✗	✔	✗
	02-Jun	✗	✔	✗	✔	✗	✔	✗	✔
	11-Jul	✔	✔	✔	✔	✔	✔	✗	✔
	28-Aug	✗	✔	✗	✔	✗	✗	✗	✗
	29-Sep	✔	✔	✔	✔	✔	✔	✔	✔

Outline

Kind of Measurements

- reflectance
- concentration
- location

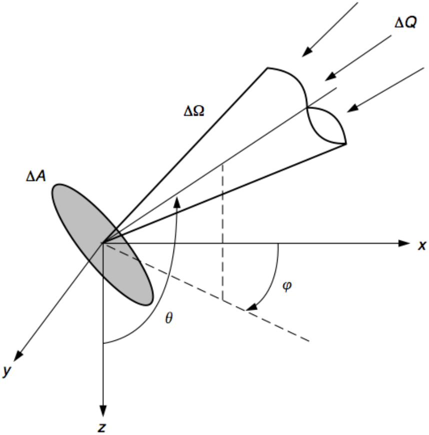
Radiometric Quantities: Radiance



ΔQ: radian energy incident
Δt: time interval
ΔA: surface area at location (x,y,z)
$\Delta\Omega$: solid angle in direction (θ,φ)
$\Delta\lambda$: photons wavelength interval

$$L(x,y,z,t,\theta,\varphi,\lambda) \equiv \frac{\Delta Q}{\Delta t \Delta A \Delta\Omega \Delta\lambda} \quad \left[Js^{-1}m^{-2}sr^{-1}nm^{-1}\right] \qquad (1)$$

Radiometric Quantities: Radiance



ΔQ: radian energy incident

Δt: time interval

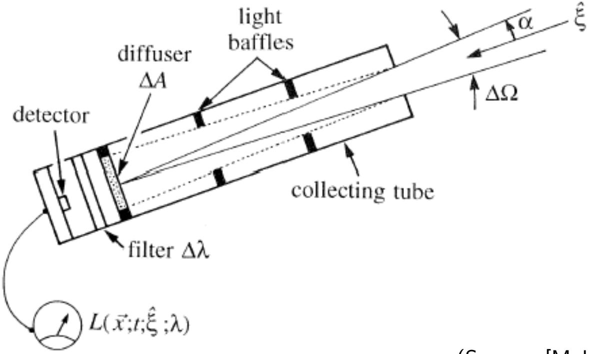
ΔA: surface area at location (x,y,z)

$\Delta\Omega$: solid angle in direction (θ,φ)

$\Delta\lambda$: photons wavelength interval

$$L(x,y,z,t,\theta,\varphi,\lambda) \equiv \frac{\partial^4 Q}{\partial t \partial A \partial \Omega \partial \lambda} \quad \left[Js^{-1}m^{-2}sr^{-1}nm^{-1}\right] \tag{1}$$

Radiance Sensor



(Source: [Mobley, 2010])

Radiometric Quantities: Irradiance

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Spectral downwelling scalar irradiance at depth z:

$$E_{od}(z,\lambda) = \int_{2\pi_d} L(z,\theta,\varphi,\lambda)d\Omega \quad \left[Wm^{-2}nm^{-1}\right] \tag{2}$$

Spectral upwelling scalar irradiance at depth z:

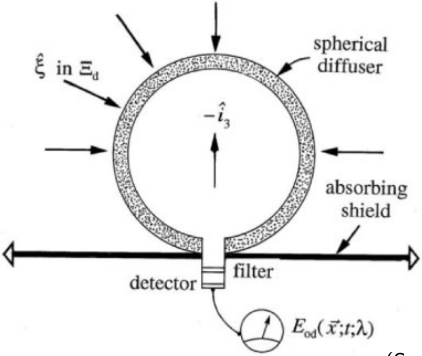
$$E_{ou}(z,\lambda) = \int_{2\pi_u} L(z,\theta,\varphi,\lambda)d\Omega \quad \left[Wm^{-2}nm^{-1}\right] \tag{3}$$

Spectral scalar irradiance at depth z:

$$E_{o}(z,\lambda) \equiv E_{od}(z,\lambda) + E_{ou}(z,\lambda) \tag{4}$$

$$= \int_{4\pi} L(z,\theta,\varphi,\lambda)d\Omega \tag{5}$$

Scalar Irradiance Sensor



(Source: [Mobley, 2010])

Radiometric Quantities: Irradiance

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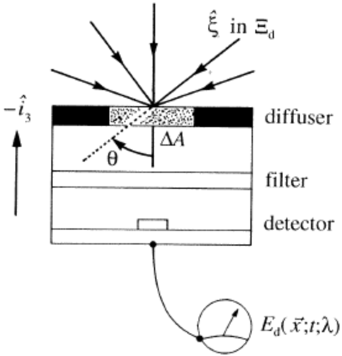
Spectral downwelling plane irradiance at depth z:

$$E_d(z,\lambda) = \int_{2\pi_d} L(z,\theta,\varphi,\lambda)|cos\theta|d\Omega \quad \left[Wm^{-2}nm^{-1}\right] \qquad (6)$$

Photosynthetic available radiation, **PAR**:

$$PAR(z) \equiv \int_{350nm}^{700nm} \frac{\lambda}{hc} E_o(z,\lambda)d\lambda \quad \left[photons\ s^{-1}m^{-2}\right] \qquad (7)$$

Planar Irradiance Sensor



(Source: [Mobley, 2010])

Reflectance

- **Irradiance reflectance:**

$$R(z,\lambda) \equiv \frac{E_u(z,\lambda)}{E_d(z,\lambda)} \tag{8}$$

- **Remote sensing reflectance (water):**

$$R_{rs}(\theta,\varphi,\lambda) \equiv \frac{L_w(\theta,\varphi,\lambda)}{E_d(\lambda)} \quad \left[sr^{-1}\right] \tag{9}$$

where L_w is the **water-leaving radiance**

- **Bidirectional Reflectance Distribution Function (BRDF):**

$$r_{BRDF} = \frac{L(\theta_o,\phi_o)}{E(\theta_i,\phi_i)} \quad \left[sr^{-1}\right] \tag{10}$$

Outline

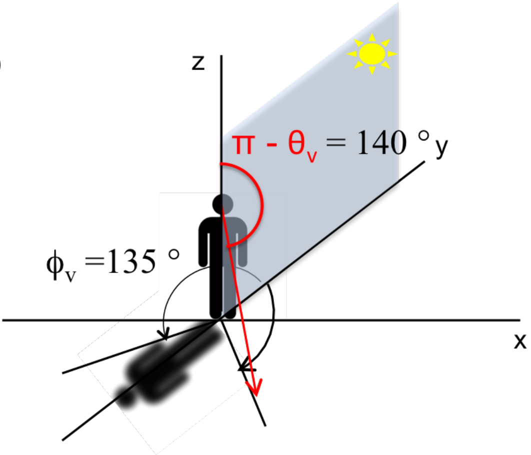
Remote-Sensing Reflectance

- 3 measurements:
  - L_g (spectralon)
  - $L_t = L_r + L_w$ (water)
  - L_{sky}
- Remote-sensing reflectance:

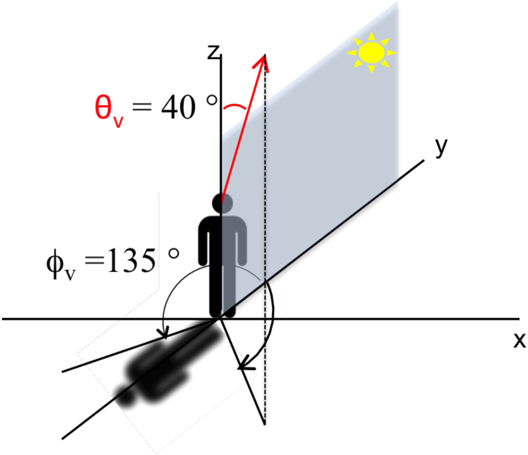
$$R_{rs} = L_w / E_d$$
$$= (L_t - L_r)/E_d$$

with $L_r = 0.028 * L_{sky}$

- $E_d = L_g * \pi$
- ϕ : azimuthal angle
- θ : zenith angle



L_{sky}



Diffuse white reference panel (Spectralon)

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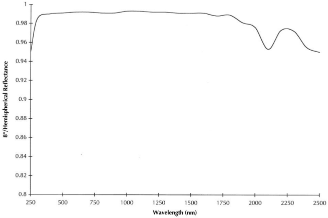
- For a Lambertian surface:
  $L = \frac{E_d r}{\pi} \Rightarrow E_d = \frac{L\pi}{r}$
- For spectralon $r \approx 1$
  ($\approx$ 100%)
  $\Rightarrow E_d = L\pi$



Thanks for your attention!

QUESTIONS?

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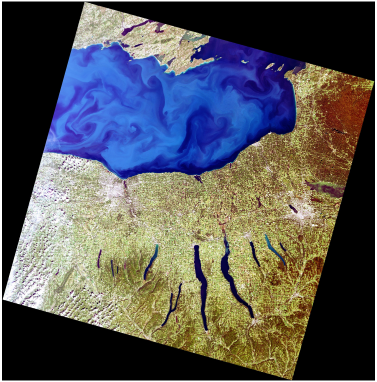

(09/19/2013)

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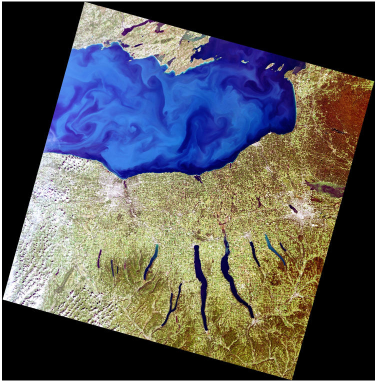

(09/19/2013)

References

[[Mobley, 2010]]Mobley, C. D. (2010).
Ocean optics web book.
http://www.oceanopticsbook.info/.