Satellite Oceanography: User’s Perspective
(biased toward ocean color)

Mati Kahru
Scripps Institution of Oceanography/
University of California San Diego
La Jolla, CA 92093-0218
mkahru@ucsd.edu
http://Wimsoft.com
Traditional oceanography from ships: in situ sensors, water sampling, net tows
Traditional oceanography from ships: water sampling (rosette), net tows and in situ measurements (sensors)
Time consuming laboratory analysis (e.g. using radioactive C14 to measure primary production)
Surface Chl-a, SeaWiFS, 1999/01/20, S1999020192603.L2_HMBR.sub
How many samples do we need?

How much does a ship day cost?

$$$$$
Changing in time ...
Notice the changes in only 2 days
How many ships do we need?
Not enough ships to sample the oceans!
Global oceans drastically under-sampled. Solution? Satellite oceanography!
• Satellite remote sensing is a powerful method for studying the global ocean
• Methods have improved significantly since the beginning of the SeaWiFS era (Sept. 1997)
• Chl-a concentration has been the main variable but additional water constituents and variables can be derived
• Standard ocean color algorithms work well in Case-1 waters
  SeaWiFS-derived surface chlorophyll $a$ for 1998

…compositing due to cloud cover needed
• Check out a NOAA visualization of satellite orbits (in Course\0\NOAA\satellitesAndOrbits.htm).
• Earth Observation (EO) satellites are either on **polar orbits** (often sun-synchronous) or **geostationary orbits**
• Polar orbiting satellites (polar orbiters) (~700-800 km above ground). **Orbit repeat cycle** can be ~16 days. However, sensors with wide swath (SeaWiFS – 2806 km, MODIS-Aqua – 2330 km) ~2 day **revisit time**. High-res sensors with narrow swath have revisit time equal to repeat cycle ~14-16 days.
• Open Images\SeaWiFS\L3\Daily\S2000061.L3m_DAY_CHL_chlor_a_9km.hdf
Images\MERIS\L3\Daily\Chl1\*.hdf, mean – convert to byte, overlay coastlines, explain the origins (3) of the white areas.
• Geostationary satellites (~35,786 km or 22,240 miles above ground) are looking at the same ground spot, e.g. GOES.
• S Korea, GOCI – 1st geostationary ocean color satellite -2010
The Electromagnetic Spectrum, visible light spectrum: 400-750 nm (nm = m⁻⁶)
A sketch of the history...

Satellite Oceanography (Ocean color, SST and altimetry) has been around for ~30 years

- CZCS 1978-1986 (ocean color), AVHRR 1979-…(SST), SeaSat 1978 (altimetry), Landsat MSS (visible imagery),…
- Fundamentally, ocean color sensors have not changed from 1978 (more bands, more bits/pixel, better algorithms)
- Similarly, the principal technology behind SST and altimetry has not changed from about 1978
- Fundamental change in data access (PC, Internet!)

- Necessary components for satellite oceanography:
  1. Hardware (antenna, computer, display) ***
  2. Software
  3. Imagery (data)
  4. Cloud-free weather for visible and infrared imagery; microwave & scatterometry penetrates clouds
1. Hardware

• Then: Receiving stations (antenna, etc.): Scripps, Dundee, Tromsö
  • Manually directed horn-antenna in Stockholm University

• Now: Don’t need the antenna! Loads of data available through internet for free!
1. Hardware, continued

- Then: Dedicated and expensive computers
  - 15-20 yrs ago ~ $500,000… $1 million VAX, HP, etc., specialized hardware (video monitors)

- Now the minimum what is needed is a ~$500 PC and fast internet connection

VAX 11/780, 6.2 m wide
2. Software

- **Then:** Tailored for the specific hardware, very complicated and expensive

- **Now:** generic, using high-level software layers (MS Windows, X-Windows), high-level file formats (HDF), inexpensive or free
  - WIM on Windows
  - SeaDAS on Linux, SunOS, MacOS
  - Matlab, IDL, ENVI, beam, etc.
3. Data (imagery)
   • Then:
     • Hard to get without owning a receiving station, stored and distributed on bulky tapes. Expensive!
   • Now:
     • Mostly freely downloadable. Need fast internet and lots of storage (disk space)

4. Cloud-free weather for visible and infrared
   • All-weather microwave sensors (passive, active)
   • Some areas very cloudy (e.g. Gulf of Alaska, Hong Kong) ~ single clear pass per month.
   • Gulf of California, Eastern Mediterranean – some of the clearest areas in the world

2/28/2012
• Then:

• Now: + $$$

•Let’s get + started!!!

Don’t need to be computer programmer or “rocket-scientist”! No radiative transfer calculations or complex formulas. Mostly point and click!
Proposed Schedule:

Day 1  Overview of the course

Introduction to satellite oceanography, emphasis on ocean color

*Practical exercises using WIM*

Basics of digital image analysis using WIM

*Practical exercises using WIM*

Day 2  Available satellite imagery/Level 2 data/Level 3 data

*Practical exercises using WIM and WAM*

Time series of ocean color and SST images

*Practical exercise: creating a time series from images*

Day 3  MODIS: Global moderate resolution (250 m) imagery at no cost

*Practical exercise: creating 250-m quasi true-color (RGB) images*

2/28/2012