Potential Application of Ocean Color Remote Sensing in Malaysia

Welcome to the world of
ocean color remote sensing

Outline

1. What is ocean color remote sensing?
2. Past and latest sensor
3. Recent research of ocean color in Malaysia and regional
4. Potential application
5. Problem and limitation
6. Future development of sensor and research direction and application

What is ocean color remote sensing?

- “Color" of the ocean is determined by the interactions of incident light with substances or particles present in the water
- The most significant constituents are phytoplankton, organic and inorganic particulates.
- Phytoplankton contain chlorophyll, which absorbs light at blue and red wavelengths and transmits in the green.
- Particulate matter can reflect and absorb light, which reduces the clarity (light transmission) of the water

What is ocean color remote sensing?

- The net result of these optical interactions is light radiating from the ocean surface -- the water-leaving radiance.
- Radiometers are instruments that measure the radiance intensity
- The measured radiance may then be quantitatively related to various constituents in the water column that interact with visible light, such as chlorophyll.
- The concentration of chlorophyll, in turn, may be used to calculate the amount of carbon being produced by photosynthesis, which is termed primary productivity.

Three Main in-water Components

1. Phytoplankton

This component is taken to include phytoplankton and other microscopic organisms. Major contribution on optical properties.

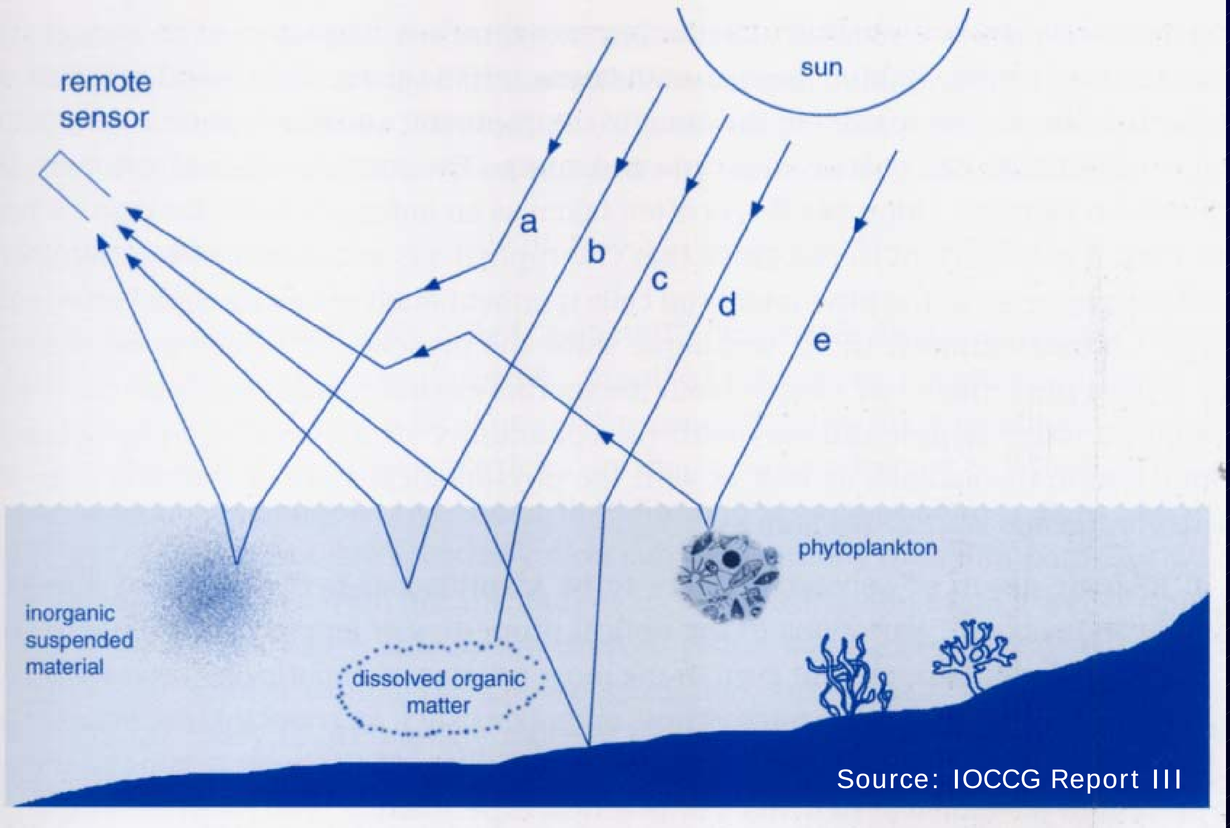
2. Suspended material (inorganic)

Suspended material of inorganic nature.

3. Yellow substances

These are coloured,dissolved,organic substances (CDOM), which generally has absorption characteristic.

Upwelling Light



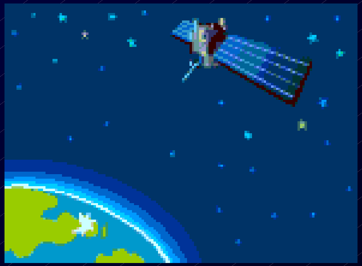
a – upward scattering by inorganic suspended material
b - upward scattering from water molecules
c – absorption by the yellow substance
d – reflection from bottom
e - upward scattering from phytoplankton component

Classification of Oceanic Waters

- **CASE 1**
  - About 90% of the world ocean
  - Phytoplankton dominant
  - Easier to analyze, model and derive the chlorophyll *a* concentration
- **CASE 2**
  - Support 60% human population, 90% world fish catch
  - Several other factors mixed together to create their optical characteristics
    - Phytoplankton
    - Suspended material
    - Yellow substance
  - Complexity in the optical properties make chlorophyll *a* prediction difficult

Two Types of Satellite

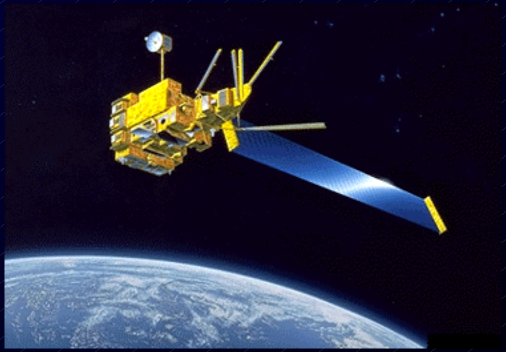
- **Polar Orbiting / Sun-synchronous**
  - Operate at an altitude of around 700-800 km
  - Revisit time of 2-3 days
  - Covered entire earth
  - Most of the Ocean Color sensors



- **Geostationary**
  - Placed in orbit 36,000 km above the equator
  - Moving in the same direction that the Earth is turning
  - Continuously views the same portion of the surface of the earth.
  - Large area observation and images can be obtained more frequently

Ocean Color Sensors

- Historical Sensors
  - **Coastal Zone Color Scanner (CZCS)**
    - First instrument to collect scientific data on the color of the ocean
    - 1978 – 1986
    - NIMBUS-7 satellite
  - **Ocean Colour and Temperature Scanner (OCTS) & POLDER**
    - ADEOS I, Japan
    - 1996 – 1997



Ocean Color Sensors

Current Sensors

- Modular Optoelectric Scanner (MOS)
- Sea-viewing Wide Field-of-view Sensor (SeaWiFS)
- Ocean Colour Imager (OCI)
- Ocean Colour Monitor (OCM)
- Moderate Resolution Imaging Spectroradiometer (MODIS – Terra)
- Multi-angle Imaging SpectroRadiometer (MISR)
- Ocean Scanning Multispectral Imager (OSMI)
- Medium Resolution Imaging Spectrometer (MERIS)
- MODIS-AQUA
- MVISR
- Chinese Ocean Color and Temperature Scanner (COCTS)
- Global Imager (GLI)
- POLDER-2

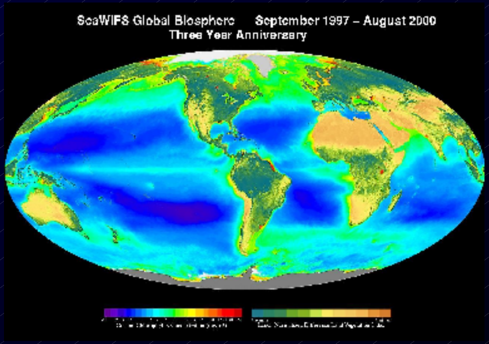
Sensor that Applicable for Monitoring in Malaysian Waters

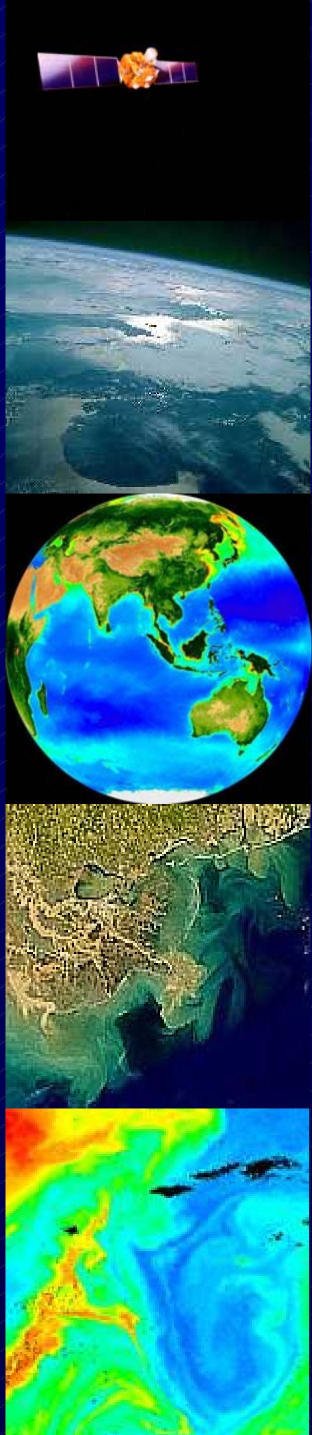
Name	Launched	Platform	No. of Band	Resolution
SeaWiFS	1 August, 1997	OrbView-2 (USA)	8	1100m
OCI	27 Jan, 1999	ROCSAT-1 (Taiwan)	6	825m
OCM	26 May, 1999	IRS-P4 (India)	8	350m
MODIS-Terra	18 Dec, 1999	Terra (USA)	36	1000m
MERIS	1 March, 2002	ENVISAT-1 (Europe)	15	300/ 1200m
MODIS-Aqua	4 May, 2002	Aqua (EOS-PM1)	36	1000m
MVISR	15 Oct, 1999	FY-1C (China)	10	1100m
MVISR	15 May, 2002	FY-1D (China)	10	1100m
COCTS	15 May, 2002	HY -1 (China)	10	1100m
GLI	14, Dec, 2002	ADEOS-II (Japan)	36	250/ 1000m

*Available for download from internet

International Organization and Project

- UNESCO/IOC/WESTPAC
- International Geophere-Biosphere Programme (IGBP)
- The Global Ocean Observing System (GOOS)
- Committee on Earth Observation Satellites (CEOS)
- International Ocean Colour Coordinating Group (IOCCG)
- Sensor Intercomparison and Merger for Biological and Interdisciplinary Oceanic Studies (SIMBIOS)
- Asian I-LAC



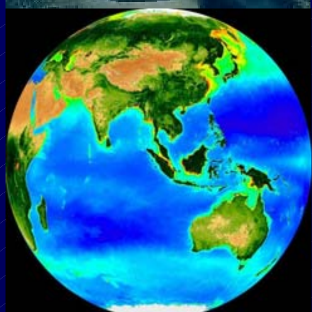


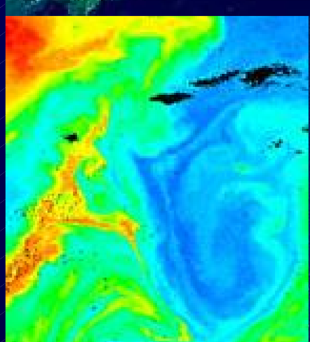
Potential Application

Uses for satellite ocean-colour data can be categorized within three broad thematic areas:

- Quantifying ocean carbon flux, understanding how it is controlled and why it varies from year to year;
- Providing a synoptic, observational link between the development of the ocean biology and upper ocean process ; and
- Assisting with the scientific analysis and management of the coastal zone, including fisheries management.

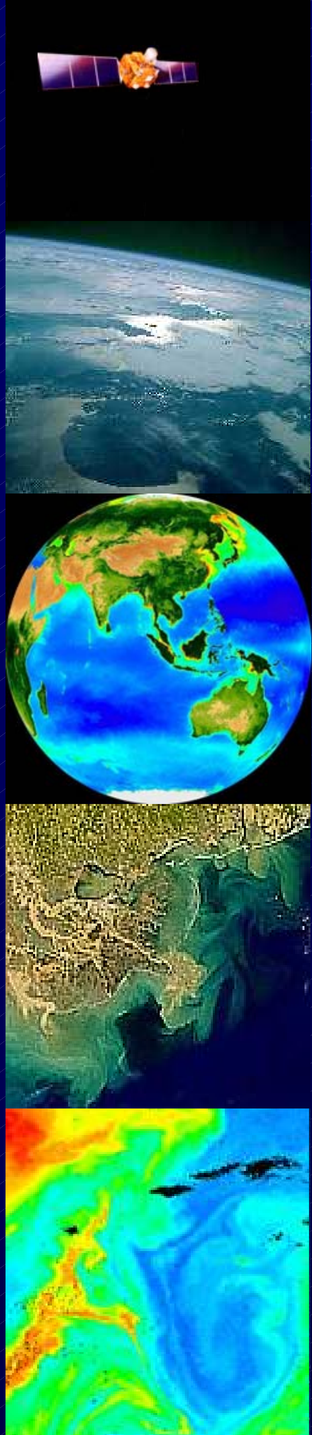






Potential Application:
Ocean Carbon Flux

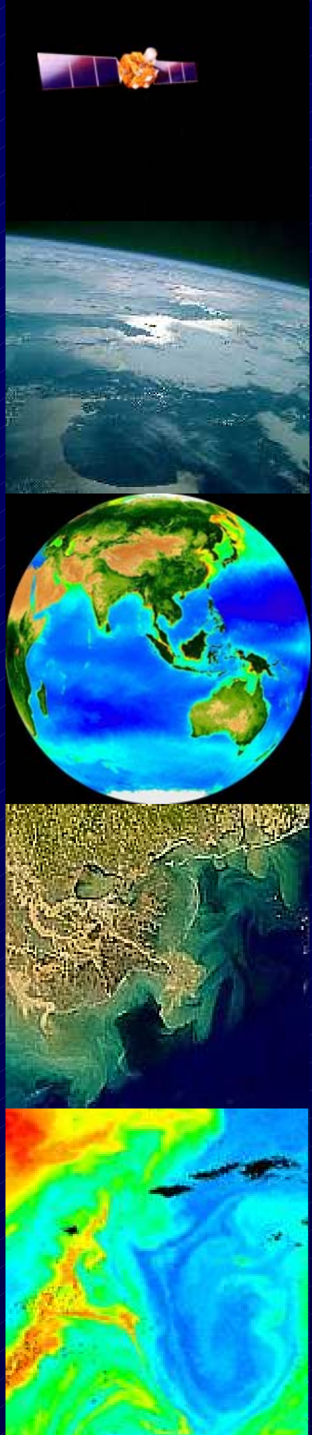
- Study the global change, especially the global carbon cycle
- Long-term data sets, including satellite data sets, to quantify the effects of periodic climate phenomena such as El Niño, and to separate the periodic effects from those that may be occurring in response to human-induced changes to the ocean environment, including permanent climate changes.
- Emphasize the importance of both biological and physical processes for determining oceanic CO_2 uptake during the next century and its relation to global warming



Potential Application:

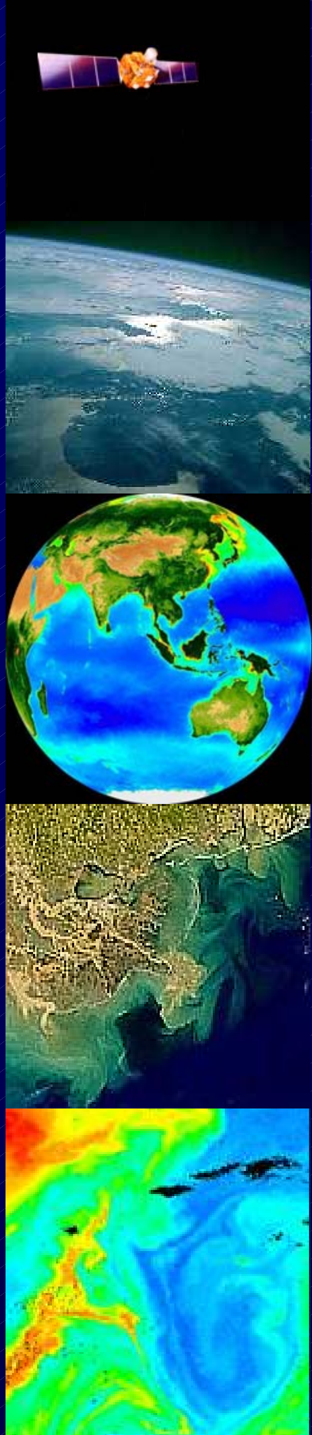
Ocean biology and upper ocean process

- Ocean heat budgets, upper ocean heat flux calculations modeling
- Observe the effects of climate and other large-scale phenomena
- Augments and enhances *in situ* observation programmes, eg. the 1997/98 El Niño
- Effects of human activity to the environment
    - Human-induced transfer of nitrogen from the land, through rivers and the atmosphere, is a significant source of new nitrogen in the ocean.
    - Over decadal time scales, this nitrogen flux to the ocean may have observable effects on the productivity and biomass of coastal and open-ocean phytoplankton.



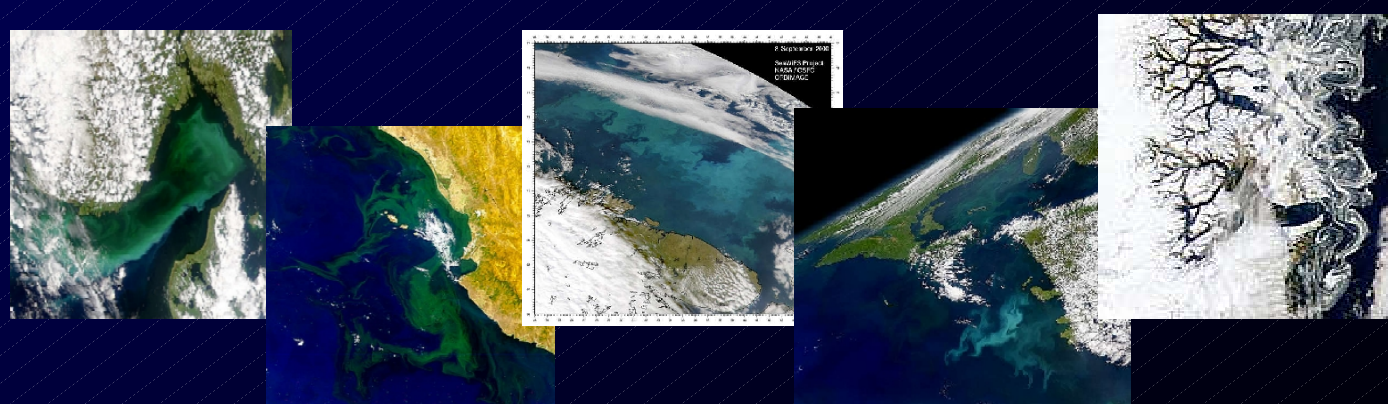
Potential Application:
Coastal Zone Application

- Impact of Human-induced activities
  - Urban/industrial expansion
  - Tourism
  - Fisheries-aquaculture
  - Agriculture
  - Pollution
- Natural events
  - Eutrophication
  - Harmful Algae Bloom (HAB)
  - Erosion/ sediment transportation
- Coastal/Resource monitoring
  - Information on water-quality parameters
  - Fishery information
  - Bottom depth, benthic reflectance and habitat
  - Water column primary production



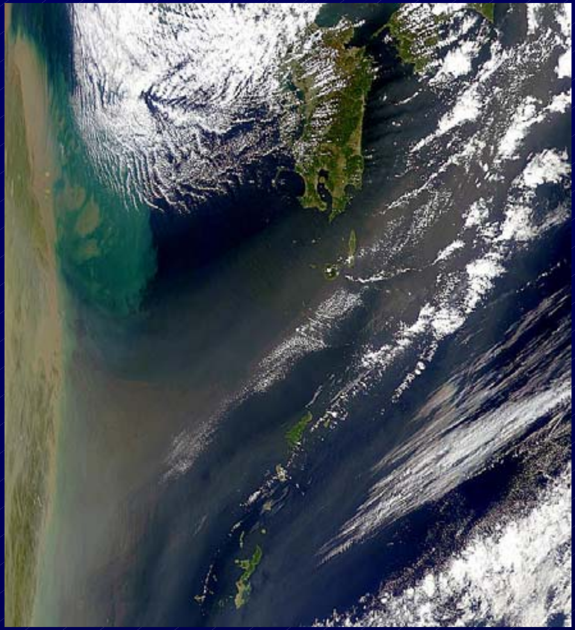
Others Potential Application

- Identify physical dynamics
  - various circulation features including river plumes, fronts, unstable meanders, filaments, coherent dipole and monopole eddies and jets etc.
- Pollutant dispersion
  - Suspended sediments and contaminants → particle bound contaminants
  - Trans-boundaries pollution, eg. haze, sand dust etc.

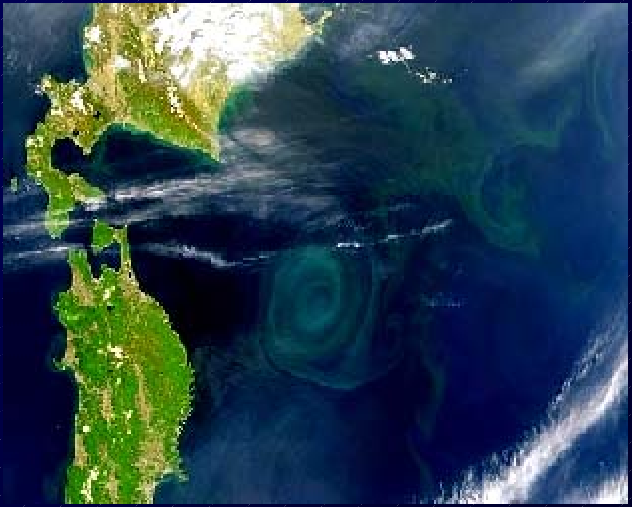


Example of Satellite Images

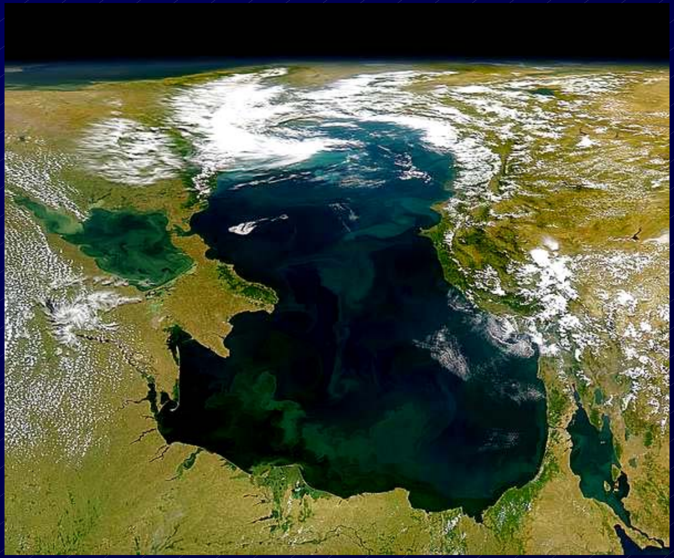
SeaWiFS - Sediment loading at Adaman Sea



SeaWiFS - Sediment loading and Sand Dust from China

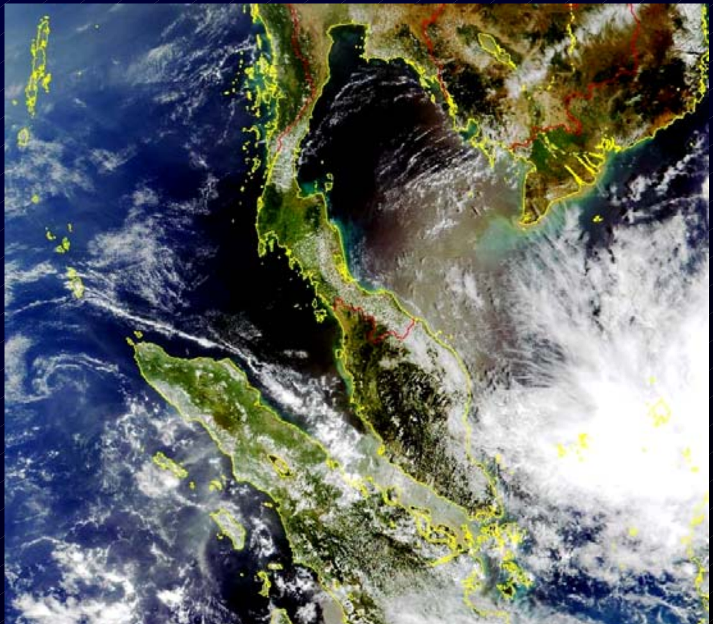


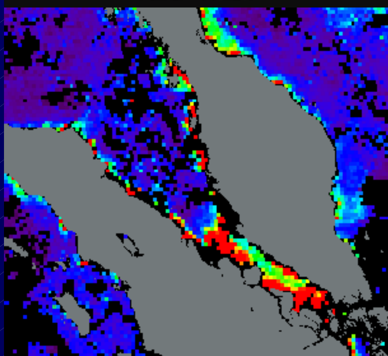
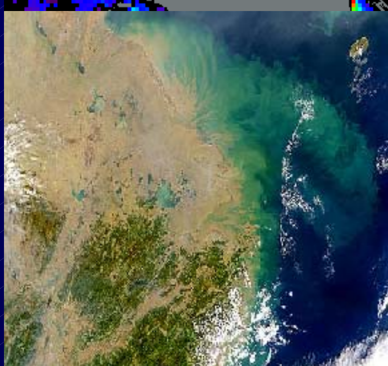
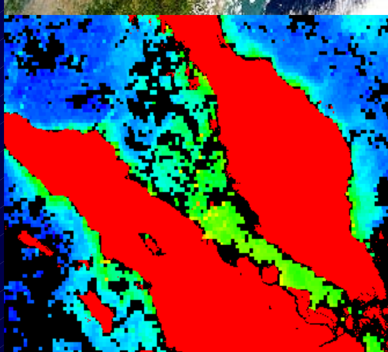
SeaWiFS – Large gyre at the east of Japan



SeaWiFS – Algae bloom at Great Lake

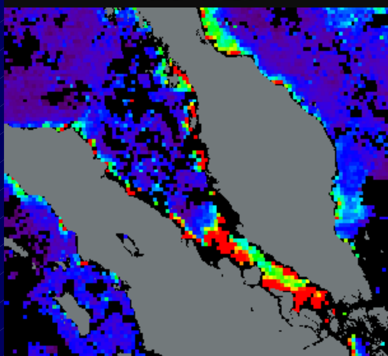
MODIS – Peninsular Malaysia

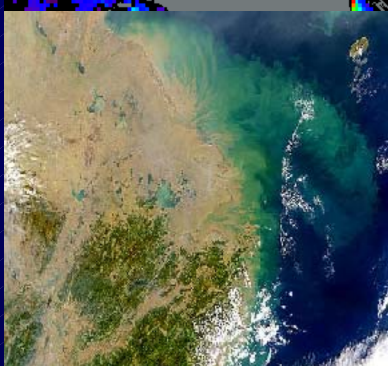


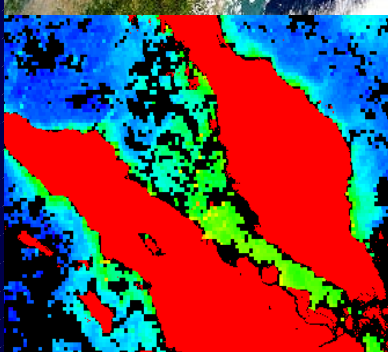





Problems and Limitations

- **Accuracy for coastal water**
  - Coastal water optical properties dominated by three major component phytoplankton, CDOM and SS.
  - Lack of long term (seasonal) *in-situ* data for the accuracy assessment
  - Problem of atmospheric correction
  - Difficulties in developing local algorithm, non-linear modeling
- **Cloud cover**

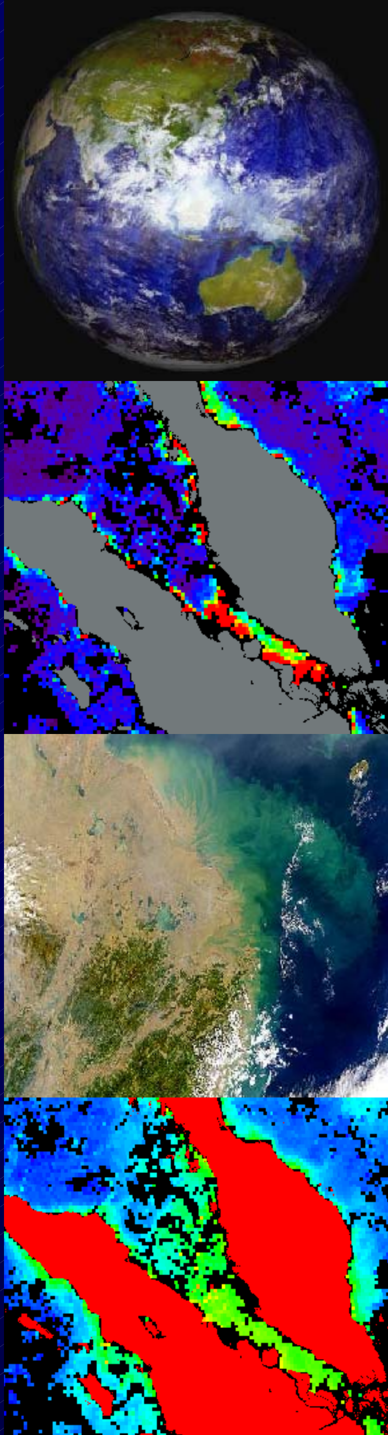






Problems and Limitations

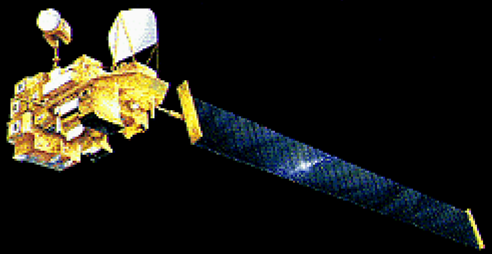
- **Limited spatial resolution for coastal process monitoring**
  - Coastal monitoring need better spatial resolution, etc 30m
  - HAB event occurring at small scale will not be able to detect using 1km resolution
- **Lack of experienced researcher and research project**
  - Complexity of ocean color remote sensing, which integrating physical ocean optics, biochemistry, marine biology etc.
  - Unawareness of the ocean color sensor usage and potential application
  - Difficulties of processing ocean color images eg. specific software, hardware requirement



Problems and Limitations

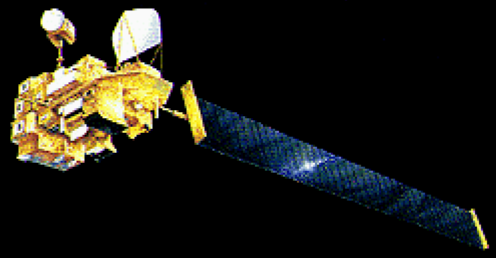
- Lack of Facilities
  - No local receiving station and coordination
  - Highly depends on foreign country for data acquisition (1km HRPT data)
  - Unable to access to real-time data
  - Singapore CRISP stop receiving SeaWiFS images
- Lack of Coordination

Development of Ocean Color Remote Sensing



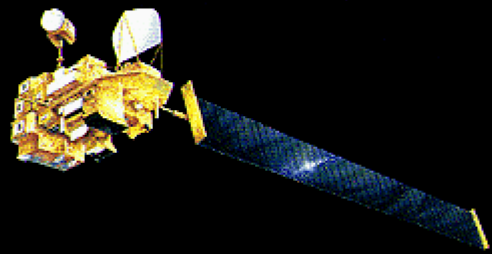
- New generation sensors
  - MERIS, GLI, SGLI
  - Better spectral resolution (more bands)
  - Able to extract more parameters, eg. SS, CDOM, Phytoplankton flourosence etc.
  - Better sensor calibration and atmospheric correction
- More Satellites and Sensors
  - Able to have more coverage daily
  - Able to monitor dynamic oceanography features
  - Minimize the effect of cloud cover
  - Near Equatorial Low Earth Orbit (NEqO) satellites

Development of Ocean Color Remote Sensing

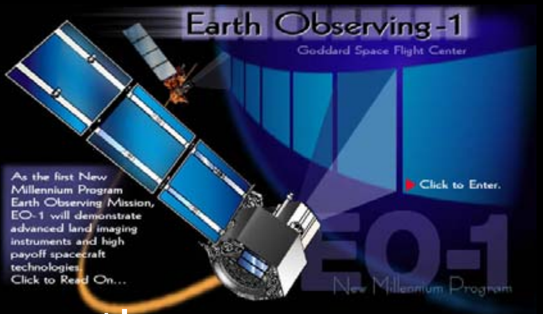


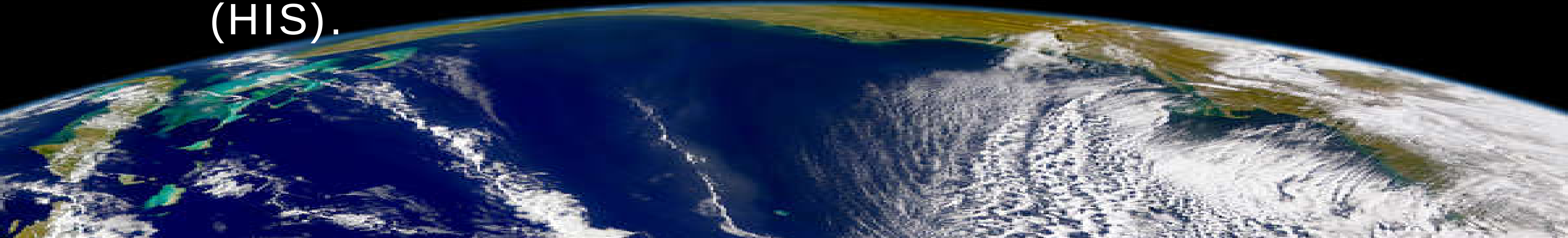
- Geostationary Sensor
  - High frequency observation/ Continuous monitoring
  - Higher resolution
  - Cloud-free mosaicing
  - Detecting, monitoring, and predicting noxious or toxic algal blooms of notable extension
  - Initializing and validating coastal circulation models
  - Assessing the geological and biological response to storm and other short-term events (dust or smoke plumes, for instance)
  - Monitoring biotic and abiotic material in transient surface features, such as extended river plumes and tidal fronts
  - Tracking hazardous materials, such as oil spills

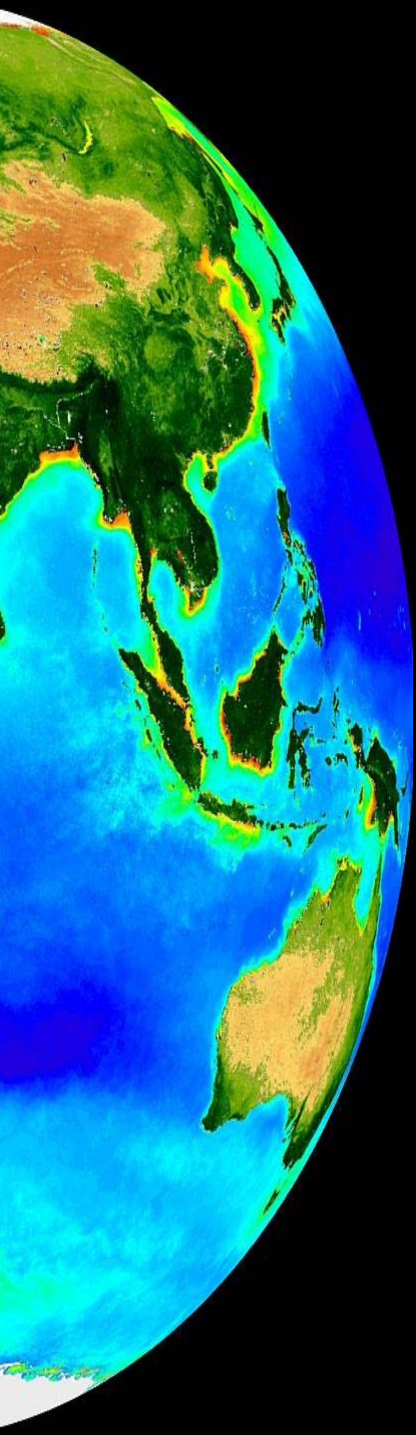
Development of Ocean Color Remote Sensing



- Hyperspectral Sensor
  - Hyperion on EO-1 (US) launched 21 Nov 2000
  - 220 bands, High resolution 30m
  - New algorithm, more product can be derived, better accuracy data
  - Suitable for coastal scientist and manager
  - Pigment and phytoplankton identification
  - HAB monitoring
  - Water quality monitoring
  - New dimension of space remote sensing
  - Many remote sensing tasks which are currently impractical or impossible with broad-band remote-sensing systems will be accomplished with Hyperspectral Imaging (HIS).

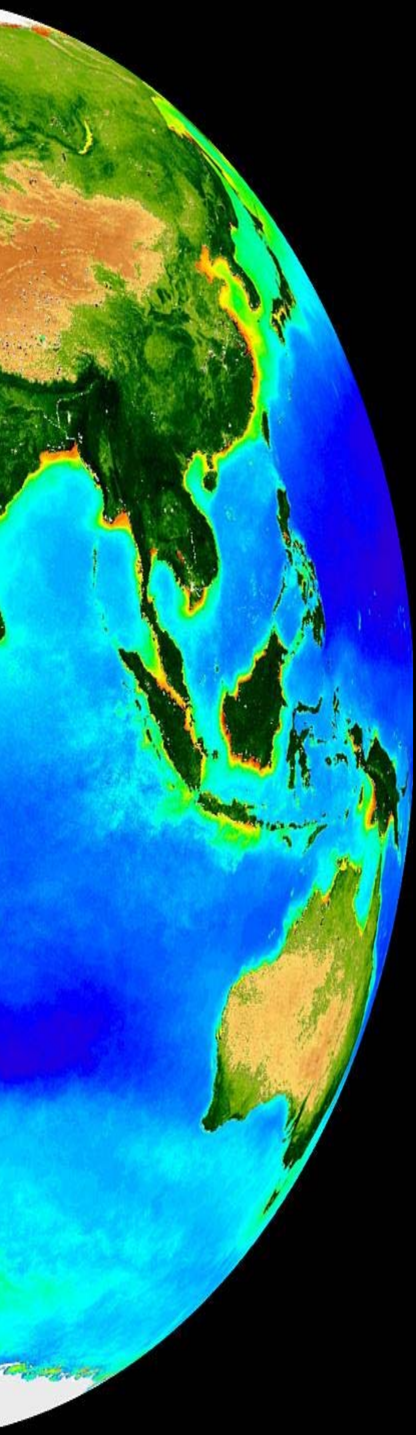






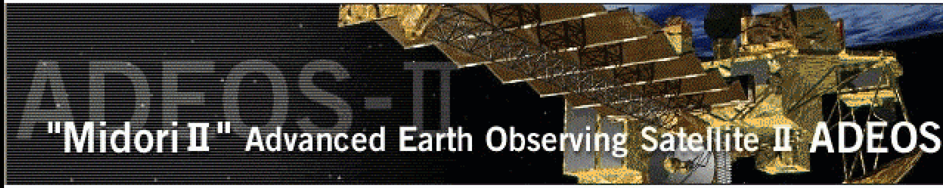
Conclusion

- Ocean color remote sensing has great potential for various applications in Malaysia
- The global usage of ocean color data has rapidly increase these days, however, we are a few steps behind from the development.
- Remote sensing technology will assists and enhances the traditional *in-situ* measurement techniques
- Besides, it provide new opportunities to understand more about our planet



Conclusion

- There are some limitations for ocean color remote sensing in tropical and coastal area up to this stage.
- However, with the further development of this technology and knowledge, the problems and limitations now will offer new dimension of research in the near future.
- More attention and research need to be carry out for Malaysian water
- Creating a regional ocean color network to promote the corporation and monitoring of regional waters.


ADEOS-II
"Midori II" Advanced Earth Observing Satellite II ADEOS-

Thank You