# A SATELLITE DATA PRIMER

Prepared for the NOAA ocean satellite data course at OSU/CIOSS, August 22-24, 2006 to provide a ***very simplified*** summary of the available satellite data for oceanic uses. The weather and/or atmospheric applications of different satellites are not covered here. For more complete information see the Martin textbook "An introduction to Ocean Remote Sensing", or the powerpoint presentations given during the course.


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# Data Websites

The NOAA Ocean Satellite Course focused on accessing data through the following websites, or using OpenDap delivery protocol which accessed the datasets served on these websites. We strive to offer "one-stop shopping" on these websites, with multiple satellite datasets available, in a range of different formats. Most of the datasets mentioned in this document are served on our browsers, however there are some that we do not yet serve such as microwave SST and sea ice. Other websites serving satellite datasets are also mentioned in this document on the dataset pages.

CoastWatch West Coast Regional Node OceanWatch browsers
http://coastwatch.pfeg.noaa.gov/coastwatch/CWBrowser.jsp (US West Coast only)
http://coastwatch.pfeg.noaa.gov/coastwatch/CWBrowserWW360.jsp (global)
http://coastwatch.pfeg.noaa.gov/coastwatch/CWBrowserWW180.jsp (global for ArcGIS)
http://coastwatch.pfeg.noaa.gov/coastwatch/CWBrowserAK.jsp (Alaska)
http://coastwatch.pfeg.noaa.gov/coastwatch/CWBrowserSA.jsp (South America)

OceanWatch Live Access Server (LAS) at ERD
http://oceanwatch.pfel.noaa.gov/

A list of all the datasets served on the above sites, along with documentation (temporal coverage, spatial resolutions how to access directly from your computer using OpenDap, etc.) can be found at:
http://oceanwatch.pfeg.noaa.gov:8081/thredds/catalog.html

Dataset documentation is also available via the "Data Set Info" links on the Coastwatch browsers.

# Orbital Configurations

Satellites orbit the earth in either polar or geostationary orbit (see Fig. 1). Those in polar orbit continually circle over the poles and achieve global coverage in roughly a week. Satellites in geostationary orbit stay in a fixed position relative to the earth. Geostationary satellites have a much higher sampling frequency for a particular area than polar orbiting satellites, allowing better sampling of cloudy areas. However geostationary satellites can't get global coverage, and they do not sample high latitudes regions very well because of the oblique angle between the earth's surface and the satellite sensor. Because of the high orbit of gesostationary data it's more challenging to obtain the high spatial resolution of data from polar orbiting satellites. Most environmental satellite data comes from satellites in polar orbit, however geostationary SST data is available, and there might be an ocean color sensor on a GOES-R (estimated launch date of 2014).

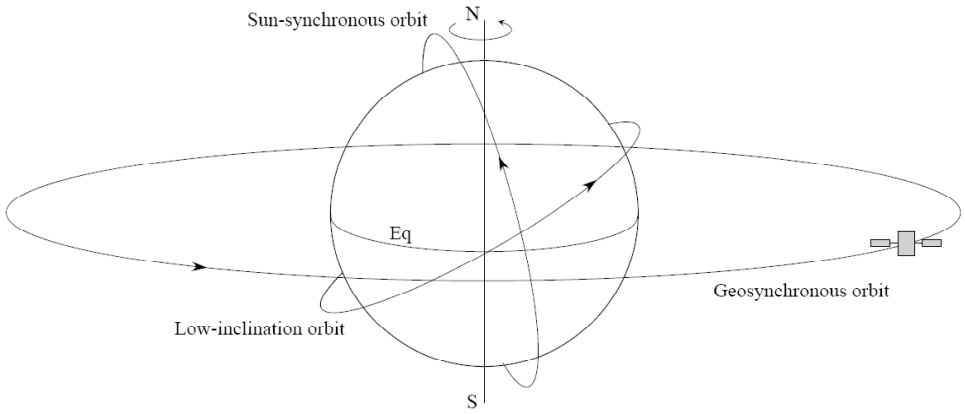


Fig. 1. Examples of sun-synchronous (polar-orbiting), geosynchronous and low-inclination orbits. Geosynchronous (also called geostationary) satellites orbit at ~36,000 km, while polar-orbiting satellites are at ~800 km altitude. Figure from Martin textbook "An Introduction to Ocean Remote Sensing" (Fig. 1.3).

# Sea-Surface Temperature (SST)

**Brief Description:** SST measurements can be made from both IR and passive microwave, and from both polar-orbiting and geostationary orbit. The highest spatial resolution (~ 1 km) datasets are from polar-orbiting IR measurements using the AVHRR.

**Caveats:** SST from IR measurements can not measure through clouds. SST data from passive microwave measurements can see through clouds but have a lower spatial resolution than IR measurements. Passive microwave SST measurements are not possible within a ~75 km band next to land, or in times of heavy rainfall. Geostationary measurements of SST can alleviate cloud coverage problems because of their frequent sampling. Geostationary measurements do not sample high latitudes regions very well because of the oblique angle between the earth's surface and the satellite sensor.

## Current Platforms/Datasets

**AVHRR Pathfinder** dataset has science-quality data from 1985 onward from the AVHRRs on NOAA's polar orbiting satellites. The latest version (version 5) has a spatial resolution of 4 km, an improvement from the previous version which was 9 km.

**MODIS SST** from Terra (10/00 onward) and Aqua (12/02 onward) is available at 4km and 9km resolution

**GOES** (geostationary) SST data is available from 5/03 onward at a resolution of 6 km for the region between 45°S-60°N and 180°-30°W

**TMI** on **TRMM** provides microwave SST between 40°S-40°N, at ~25 km spatial resolution from 12/97 onward.

**AMSR-E** on **Aqua** provides microwave SST between 40°S-40°N, at 38 km and 56 km spatial resolution from 12/02 onward.

## Derived or related products

Frontal products are derived from SST by measuring the spatial temperature gradient.

## Additional websites with data or further information

Pathfinder 4km website:
http://www.nodc.noaa.gov/sog/pathfinder4km

JPL's PO DAAC (Physical Oceanography Distributed Active Archive Center):
http://podaac.jpl.nasa.gov/sst

POET, JPL's PO.DAAC Ocean ESIP Tool (POET) for plotting ands subsetting data
http://poet.jpl.nasa.gov

Remote Sensing Systems, specializes in microwave satellite measurements
http://www.ssmi.com

GODAE's High Resolution SST Pilot Project
http://www.ghrsst-pp.org

# Sea-Surface Height (SSH)

**Brief Description:** Altimeters use active radar to measure the surface elevation of the ocean, relative to a reference level (the mean geoid). Satellite SSH data provides information about the ocean circulation, integrated surface height content, eddy movement, geostrophic currents and changes in global sea level. Measurements of SSH are not affected by cloud coverage. They can not be retrieved within ~15 km of land.

### Past and Current Platforms

| | |
|---|---|
| GEOSAT | 3/85-1/90 |
| TOPEX/Poseidon | 8/92 onward |
| JASON-1 | 12/01 onward |
| ERS-1 | 7/91-6/95 |
| ERS-2 | 4/95 onward |
| Envisat | 3/02 onward |

### Planned Future Platforms

JASON-2 to be launched in 2008 (NOAA)

### Derived or related products

**Geostrophic currents** can be derived from the slope of SSH.

### Additional websites with data or further information

JPL's Ocean Surface Topography from Space page
http://sealevel.jpl.nasa.gov

JPL's PO DAAC (Physical Oceanography Distributed Active Archive Center):
http://podaac-www.jpl.nasa.gov/ost

POET, JPL's PO.DAAC Ocean ESIP Tool (POET) for plotting and subsetting data
http://poet.jpl.nasa.gov

AVISO (France)
http://www.aviso.oceanobs.com

NOAA's OSCAR (Ocean Surface Current Analyses – Real time) site
http://www.oscar.noaa.gov

# Ocean Color (Chlorophyll)

## Brief Description

Chlorophyll-a concentration is calculated from the normalized water-leaving radiances at several different visible wavelengths. The number of wavelengths varies between different sensors (CZCS had 5, SeaWiFS 8, and MODIS 9). The algorithm is optimized for open-ocean (case-I) water, and the presence of sediments and colored dissolved organic material (CDOM) can affect the accuracy of the measurements in coastal (case-II) waters. Cloud coverage prevents the ability to measure chlorophyll remotely.

## Past and Current Platforms

| | |
|---|---|
| CZCS: | 11/78-6/86 (incomplete global coverage) |
| SeaWiFS: | 9/97 onward* |
| MODIS/Terra: | 2/00 onward (calibration problems with chlorophyll) |
| MODIS/Aqua: | 6/02 onward |

*SeaWiFS is owned commercially by GeoEye (formerly OrbImage) and they limit the degree to which this data can be distributed. There is a two-week embargo on viewing data, and while data older than 2 weeks can be freely obtained from the NASA DAAC for research purposes, other sites are not allowed to distribute data until it is 60 months old, although the distribution of images is allowed.

## Planned Future Platforms

VIIRS on NPP (2010) an NPOESS (2013)
HES-CW on GOES-R (2014)

## Derived or related products

**Primary productivity** can be derived from chlorophyll using PAR, SST and day length. The most widely-used algorithm is that of Behrenfeld and Falkowski, 1997. (Limnol. Oceanogr., 42, 1479-1491). This product is served on the CoastWatch West Coast Regional Node thanks to R&O funding from NOAA/NESDIS.

**PAR** (Photosynthetically available radiation) measurements from SeaWiFS provide the amount of incoming radiation from the sun between 400-700 nm.

**Fluorescence Line Height** from MODIS instruments on Aqua and Terra provides information on the phytoplankton health.

**K490** is diffuse attenuation coefficient data at 490 nm wavelength available from the MODIS instruments on Aqua and Terra and from SeaWiFS. It is a good measure of water clarity.

## Additional websites with data or further information

NASA's OceanColor Web
http://oceancolor.gsfc.nasa.gov

NASA's Ocean Color Time-Series Online Visualization and Analysis System
http://reason.gsfc.nasa.gov/Giovanni/
International Ocean-Colour Coordinating Group
http://www.ioccg.org

# Surface Vector Winds (SVW)

**Brief Description:** A scatterometer is a high frequency microwave radar designed specifically to measure ocean near-surface wind speed and direction.

### Past and Current Platforms

**NSCAT** flew 9/96-6/97 on ADEOS

**SeaWinds** on **QuikScat** launched 6/99 and still operating providing near-surface wind speed and direction at a 25 km resolution.

**SeaWinds** on **ADEOS-II** launched 12/02. ADEOS-II lost power 10/03.

### Planned Future Platforms

**ASCAT** on **METOP-A** to be launched 10/06 by ESA

### Derived or related products

**Wind stress** is derived from wind speed and direction and provides an indication of the amount of work done by the wind to the ocean
**Wind stress curl** provides a measure of the pattern of the wind field. Areas of strong curl cause divergence in the surface layer and result in upwelling
**Ekman upwelling** is a measure of the vertical movement of water as a result of wind-driven horizontal water movement at the ocean surface

### Additional websites with data or further information

JPL's Winds Page
http://winds.jpl.nasa.gov

JPL's PO DAAC (Physical Oceanography Distributed Active Archive Center):
http://podaac-www.jpl.nasa.gov/ovw

POET, JPL's PO.DAAC Ocean ESIP Tool (POET) for plotting ands subsetting data
http://poet.jpl.nasa.gov

Remote Sensing Systems, specializes in microwave satellite measurements
http://www.ssmi.com

NOAA's OSCAR (Ocean Surface Current Analyses – Real time) site
http://www.oscar.noaa.gov

# Sea Ice

**Brief Description:** Passive microwave instruments such as ESMR, SMMR and SSM/I, and radar such as ERS-1, ERS-2, and RADARSAT provide the main data sets used for sea ice studies because of their nighttime and all-weather capabilities.

Passive microwave data provides measurements of the ice edge, sea ice concentrations, and classification of different types of sea ice types. Passive microwave imagery is available from late 1978 through the present. Earlier but less reliable data from the ESMR are available from late 1972 to 1976.

### Past and Current Platforms

| | |
|---|---|
| ESMR | Flew 12/72-12/76 |
| SMMR | Flew 10/78-8/87 |
| SSM/I | 6/87 onward |
| AMSR-E | 4/02 onward |
| GLAS | launched 1/03 on ICESat to discern changes in ice volume (mass balance) over time |

### Additional websites with data or further information

Alaska CoastWatch browser (sea ice data will be available here in 9/06)
http://coastwatch.pfeg.noaa.gov/coastwatch/CWBrowserAK.jsp

National Snow and Ice Data Center
http://nsidc.org

# Names & Acronyms

Satellite data products are usually referred to by their sensor name, when the same instrumentation is on different satellites, they are distinguished by the name of the satellite (ie MODIS sensors on the Terra and Aqua satellites).

There is also a longer list of acronyms in the front of the Martin textbook and there is also a good list at http://www.noc.soton.ac.uk/lso/acronyms.php that has sensors and satellites listed separately, and has better international coverage than given here.

| | |
|---|---|
| ADEOS | **AD**vanced **E**arth **O**bserving **S**atellite, ADEOS-1 flew 8/96-6/97, ADEOS-2 was launched in 12/02 but lost power 10/03 (Japan) |
| AMSR | **A**dvanced **M**icrowave **S**canning **R**adiometer (Japan) on ADEOS-2 |
| AMSR-E | **A**dvanced **M**icrowave **S**canning **R**adiometer-**E**OS (Japan) on Aqua |
| Aqua | NASA satellite flying multiple sensors (MODIS sensor. Launched 4/02. Part of EOS. |
| Aquarius | Sea-surface salinity satellite to be launched 2012 by NASA |
| ASCAT | **A**dvanced **Scat**terometer to be launched on MetOp in 2006 by ESA |
| AVHRR | **A**dvanced **V**ery **H**igh **R**esolution **R**adiometer measures SST. The first AVHRR instrument was launched by NOAA in 1978. |
| CZCS | **C**oastal **Z**one **C**olor **S**canner, measures chlorophyll. Flew from 1978-1986 (NASA) |
| GOES | **G**eostationary **O**perational **E**nvironmental **S**atellites (NOAA). Named by letters pre-launch, and numbers post-launch. Collect primarily weather data, but geostationary SST available from 5/03 onward. GOES-R (2012 launch) might measure ocean color via the HES-CW. |
| ESMR | **E**lectrically **S**canning **M**icrowave **R**adiometer, flew 12/72-12/76 |
| EnviSat | **Envi**ronmental **Sat**ellite, follow-on to ERS-1 and ERS-2 (ESA) |
| EOS | **E**arth **O**bserving **S**ystem mission including a series of satellites |
| ERS | **E**uropean **R**emote **S**ensing satellites. ERS-1 7/91-6/95, ERS-2 launched 4/95 |
| ESA | **E**uropean **S**pace **A**gency satellites |
| GAC | **G**lobal **A**rea **C**overage |
| GCOM | **G**lobal **C**hange **O**bservation **M**ission, ADEOS-II follow on (Japan) |
| GCOM-C | **G**lobal **C**hange **O**bservation **M**ission-**C**arbon, 2011 launch (Japan) |
| GCOM-W | **G**lobal **C**hange **O**bservation **M**ission-**W**ater, 2010 launch (Japan) |
| HES-CW | **H**yper-**E**nvironmental **S**uite-**C**oastal **W**ater Imager<br>Ocean color imager that might be launched on GOES-R in 2014 (NOAA) |
| IceSat | Ice, Cloud, and Land Elevation Satellite, launched 1/03 (NASA) |

| | |
|---|---|
| JASON | altimeter for SSH launched 2001 (JASON-1), JASON-2 due to be launched 2008. |
| K490 | Diffuse attenuation coefficient data at 490 nm wavelength from MODIS instruments on Aqua and Terra |
| GLAS | **G**eoscience **L**aser **A**ltimeter **S**ystem on ICESat (NASA) |
| LAC | **L**ocal **A**rea **C**overage |
| MetOp | **Met**eorological **Op**erational satellite programme, MetOp-A due for launch 10/06 (ESA) |
| MODIS | **Mod**erate Resolution **I**maging **S**pectroradiometer (NASA) measures chlorophyll and SST, instruments on two different satellites: Aqua and Terra. Chlorophyll from MODIS/Terra has calibration issues. |
| NESDIS | **N**ational **E**nvironmental **S**atellite, **D**ata and **I**nformation **S**ervice (NOAA) |
| NPOESS | **N**ational **P**olar-orbiting **O**perational **E**nvironmental **S**atellite **S**ystem (a NOAA, NASA, and DOD project) |
| NPP | **N**POESS **P**reparatory **P**roject |
| OCTS | **O**cean **C**olor and **T**emperature **S**canner (Japan). On ADEOS-1 8/96-6/97. |
| OCM | **O**cean **C**olor **M**onitor (India) |
| OSCAR | **O**cean **S**urface **C**urrent **A**nalyses – **R**eal time (NOAA) |
| PAR | **P**hotosynthetically **A**vailable **R**adiation (PAR) |
| Pathfinder | Science-quality 4-km resolution SST product going back to 1985 |
| POES | **P**olar **O**perational **E**nvironmental **S**atellites (NOAA) |
| QuikScat | satellite flying the first SeaWinds scatterometer, launched 6/99 (NASA) |
| SeaWiFS | **Sea**-viewing **Wi**de **F**ield-of-view **S**ensor, measures ocean chlorophyll. Launched in Aug 1997 by NASA, but commercially owned by GeoEye (formerly OrbImage) |
| SeaWinds | scatterometer on QuikScat and ADEOS-2 satellites |
| SSH | **S**ea-**S**urface **H**eight |
| SMMR | **S**canning **M**ultichannel **M**icrowave Radiometer, 10/78-8/87 |
| SSM/I | **S**pecial **S**ensor **M**icrowave/**I**mager |
| SST | **S**ea-**S**urface **T**emperature |
| Terra | NASA satellite flying a MODIS sensor. Launched 2/00. Part of EOS. |
| TMI | **T**RMM **M**icrowave **I**mager, microwave SST sensor on TRMM satellite |
| TRMM | **T**ropical **R**ainfall **M**easuring **M**ission satellite (NASA), launched 11/97 |
| TOPEX/Poseidon | altimeter for SSH launched 8/92 (NASA, jointly with the French) |
| VIIRS | **V**isible **I**nfrared **I**mager/**R**adiometer **S**uite to be flown on NPOESS to measure ocean color and SST |