Marine Climatology from Satellite Remote Sensing

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Australian Defence Force
Overview

• Satellites and Sensors
• Satellite data for Climatology?
• Case Studies
  – Wind Speed
  – Significant Wave Height
  – Atmospheric Moisture and Precipitation
Satellites and Sensors

- **Active Microwave**
  - Transmit ‘ping’ from space, measure returning signal

- **Passive Microwave**
  - Measure microwave energy emitted from earth

- **Passive Visible/Near IR Imaging**
  - Measure visible light and heat reflected off earth

- **Passive Thermal Imaging**
  - Measure ‘black body’ temperature emitted from earth

- **Passive Multi-spectral Imaging**
  - Measure across microwave, visible/NIR and thermal bands
Satellites and Sensors

- **Active Microwave – Radar Imaging**
  - Sensors: SAR, ASAR
  - Returns: image at radar wavelengths
  - Flown on: Radarsat, Envisat
  - Resolution: down to 10 m
  - Parameters: Ice, waves, swell, internal waves
Satellites and Sensors

- **Active Microwave - Scatterometer**
  - Sensors: SeaWinds/Quikscat, ASCAT, (NSCAT)
  - Measures: Backscatter ~ surface roughness ~ wind speed
  - Flown on: QuikBird, Metop, ERS-2 (ADEOS, ERS-1)
  - Resolution: 25km
  - Parameters: Ice, Wind vectors
Satellites and Sensors

- **Active Microwave - Altimeter**
  - Sensors: SSALT, NRA-2, RA-2, GFO RA
  - Measures: time ~ altitude; signal shape ~ wave height; signal scatter ~ wind speed
  - Flown on: Jason, Envisat, GFO (ERS-1, ERS-2, Topex/Poseidon)
  - Resolution: 5 km along track. No swath
  - Parameters: Significant Wave Height, Wind Speed, Ocean Surface Topography, Mesoscale Ocean Features, Derived Geostrophic Currents
Satellites and Sensors

- **Passive Microwave**
  - Sensors: TMI, SSM/I, AMSR, AMSU
  - Measures: Brightness temperatures from surface and atmospheric radiation at multiple wavelengths in microwave spectrum
  - Flown on: TRMM, DMSP, AQUA, MetOp
  - Resolution: 25 km in 1400 km wide swath
  - Parameters: ocean surface wind speed, ice cover and age, integrated columnar water vapor, cloud liquid water, precipitation rate, and sea surface temperature
Satellites and Sensors

- **Passive Visible/NIR/IR Imaging**
  - Sensors: VISSR, MVISR, AVHRR, MODIS, MERIS, ATSR, SEAWIFS ....
  - Returns: Brightness at multiple wavelengths
  - Flown on: Multiple platforms
  - Resolution: From 100s of metres
  - Parameters: cloud incl low cloud/fog, ocean colour, turbidity, dust, aerosols
SEAWIFS (OrbView-2) Images: 04 Oct 2002 – Chlorophyll
The Case for Satellite Climatology

- Global coverage (not just shipping routes)
- Don’t avoid severe weather conditions
- Volume of observations
- Well calibrated against in situ measurements
- Bulk re-processing for new algorithms
- Minimal subjective human interpretation
Limitations and Challenges

- ‘Incomplete’ weather observation
- Affected by severe weather
- Unable to capture some extreme events
- Limited diurnal coverage from sun synchronous satellites
- Limited coastal coverage
- Short observational history unsuitable for long time series, climate change trends etc
Case Studies

- Wind Speed (Quikscat)
- Significant Wave Height (Multiple altimeters)
- Atmospheric Moisture and Precipitation (SSM/I)
- Sea Surface Temperature
- Cloud
- Sea Ice
- Ocean Colour
Wind Speed and Direction

- Sensor: SeaWinds scatterometer on Quikscat
- Data Source: Remote Sensing Systems
- Resolution: 25 km
- Swath Width: 1800 km
- Time Series: ~ 9 years
- Observations: ~ 2.2 billion
- Parameter: Wind speed vectors at 10 m (~ 10 minute averaged)
- Processing: Already QC’d and flagged. Bin on regular grid and calculate statistics
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Significant Wave Height

- Sensors: GFO, Envisat, Topex/Poseidon, Jason, ERS-2
- Data Source: JPL PODAAC, ESA, USN
- Resolution: 5 km
- Swath Width: Nil
- Time Series: ~ 36 satellite years
- Observations: ~ 600 million
- Parameter: Significant Wave Height
- Processing: Extract from geophysical data records, QC, bin on ¼ degree grid, calculate statistics
Standard Deviation of Significant Wave Height (0.25 degree)
Significant Wave Height - January

<table>
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<th>Value</th>
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<tr>
<td>Latitude</td>
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<td>Longitude</td>
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<td>Mean</td>
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Atmospheric Moisture and Precipitation

- Sensor: SSM/I on DMSP and TMI on TRMM
- Data Source: Remote Sensing Systems
- Resolution: 25 km
- Swath Width: ~ 1400 km
- Time Series: ~ 51 satellite years
- Observations: ~ 41 billion
- Processing: Already QC’d and flagged. Bin in regular grid and calculate statistics
SSMI Mean Atmospheric Water Vapour

January

February

March

April

May

June

July

August

September

October

November

December
SSMI Mean Precipitation Rate

January
February
March
April
May
June
July
August
September
October
November
December
What is GPCP?

The Global Precipitation Climatology Project (GPCP) is an element of the Global Energy and Water Cycle Experiment (GEWEX) of the World Climate Research Programme (WCRP). It was established by the WCRP in 1986 with the initial goal of providing monthly mean precipitation data on a 2.5°×2.5°latitude-longitude grid. Monthly mean precipitation estimates are being produced beginning in 1979 and planned to go through 2005.

more about this......

The GPCP Quarterly/Semi-Annual Reports

The GPCP citation list

How to access the data?

These data are available from the WDCA.

How is the GPCP organized?

The GPCP is organized as follows.

- IR Component
- Microwave Component
- In Situ Component
- Merge satellite and Gauge Data
The Blended Sea Winds contain globally gridded, high resolution ocean surface vector winds and wind stresses on a global 0.25° grid, and multiple time resolutions of 6-hourly, daily, monthly, and 11-year (1995-2005) climatological monthlies. The period of record is 9 July 1987 - present. The wind speeds were generated by blending observations from multiple satellites (up to six satellites since June 2002; Figure 2). The wind directions came from two sources depending on the products: for the research products the source is the NCEP Reanalysis 2 (NRA-2) and for near-real-time products the source is the ECMWF NWP. The wind directions were interpolated onto the blended speed grids.
Blended SeaWinds

- NCDC Project
  - Sensors: SSM/I F13, F14, F15; AMSR-E; TMI; Quikscat
  - 21 year, 6 hourly, 0.25° dataset (6 satellites since 2002)
  - [http://www.ncdc.noaa.gov/oa/rsad/seawinds.html](http://www.ncdc.noaa.gov/oa/rsad/seawinds.html)
  - Local diurnal variability?
Other Satellite Climatology Resources

- GHRSST
- ISCCP
- Sea Ice
- Ocean Colour
Integrated SST Data Products.

The Global High-Resolution Sea Surface Temperature (SST) Pilot Project (GHRSSST-PP) provides a new generation of global high-resolution (<10km) SST products to the operational oceanographic, meteorological, climate and general scientific community.

Every day, GHRSSST-PP global processing systems combine several complementary satellite and in situ SST data streams together and deliver integrated SST products with supporting data in a common netCDF format.

Data Access

GHRSSST PP data products are freely available in real time every day through various delivery services more >

Applications

A variety of applications are now using GHRSSST-PP products and services more >

Documents

Project reference documents provide a detailed description of the plans and activities "globally" GHRSSST.

Calendar

Meetings, workshops and key dates for the GHRSSST-PP Regional/Global Task Group.
GHRSST-PP

- Multi-sensor, multi-platform foundation SST
- Geostationary and sun-synchronous platforms
- Microwave and thermal imaging sensors
- Near real-time swath (L2P) products
- Re-mapped (L3) products
- Optimally interpolated gridded regional and global (L4) analyses to 5 km and 6 hourly resolution
- Best copy re-analysis datasets for climate studies
ISCCP

- 8 km, 3 hourly geostationary satellite brightness temperature in all channels
- Covers 28 satellites since 1978
- Cloud type determined by reflectance and temperature from pairs of IR and VIS/NIR images
The NSIDC DAAC archives and distributes brightness temperature data, polar atmosphere data, satellite imagery, sea ice data, snow cover data, and ice sheet data.

**Visible Infrared:** NSIDC distributes visible and infrared data from the TIROS Operational Vertical Sounder (TOVS) suite of instruments, the MODIS instruments, and the AVHRR instrument.

**LIDAR:** NSIDC distributes laser data from the GLAS instrument.

**Passive Microwave:** NSIDC distributes passive microwave data from the AMSR-E instrument, the AMSR instrument, the SSMR instrument, and the SSM/I instrument.

**Active Microwave:** NSIDC distributes active microwave data from the RADARSAT instrument, scatterometer instruments, and radar altimeters.
Antarctic Sea Ice Extent (Quikscat)

Jul 99

May 08
Welcome to the Ocean Color Time-Series Online Visualization and Analysis System! This system is based on the GES-DISC Interactive Online Visualization and ANalysis Infrastructure (Giovanni) which was developed by the GES DISC DAAC to provide users with an easy-to-use, Web-based interface for the visualization and analysis of the Earth Science data.

The Ocean Color Time-Series Project (REASoN CAN, Dr. Watson Gregg, PI) currently employs Giovanni for the visualization and analysis of SeaWiFS ocean color data, and MODIS Aqua ocean-color and SST data processed by the Ocean Biology Processing Group (OBPG). In the future, merged (multiple mission) data products will be added.

### Ocean Color Time-Series Online Visualization and Analysis

<table>
<thead>
<tr>
<th>Product Description</th>
<th>Java Link</th>
<th>Non-Java Link</th>
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<td>OBPG MODIS-Aqua Monthly Global 9-km Products</td>
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Mean Chlorophyll 2003 – 2006 (MODIS and SEAWIFS)

January

April

July

October
Summary

- Satellite sensors provide a massive volume of quality data that can be used to develop climatologies of some variables also measured by in-situ observations.
- These data are already in the public domain (USA) or available to researchers (Europe).
- We cannot ignore them, but
- Which is the right JCOMM group to exploit them?
- What products should be developed?
Questions