The DISCOVER Passive Microwave Data Available for Climate Study

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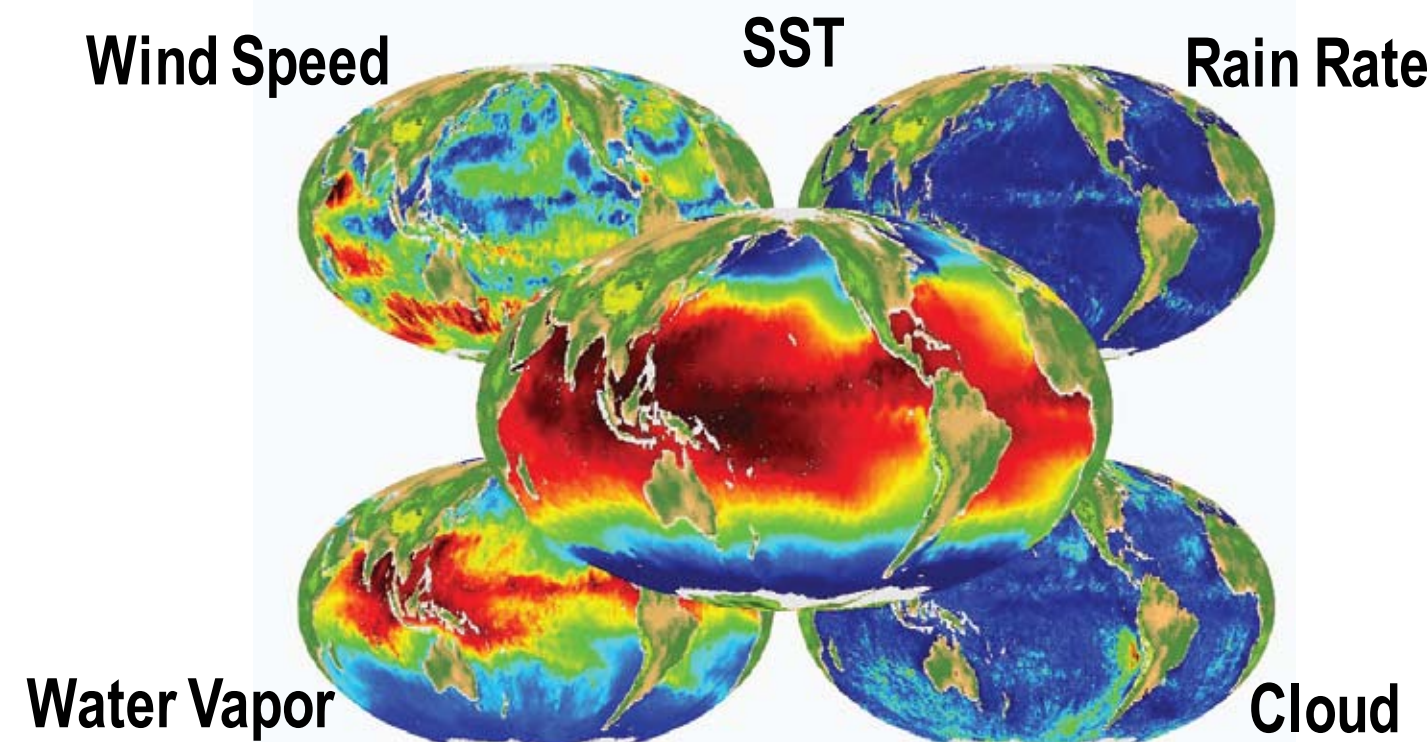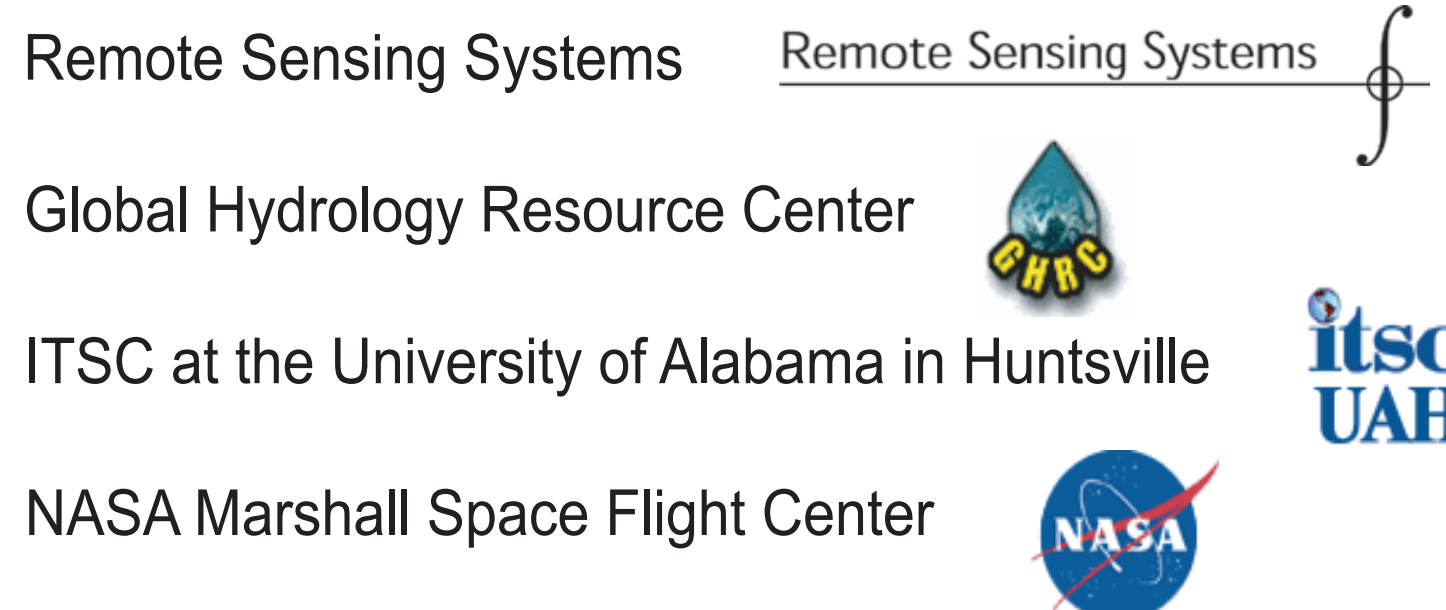
Remote Sensing Systems
www.remss.com

1. INTRODUCTION

DISCOVER
www.discover-earth.org

Distributed **I**nformation **S**ervices for **C**limate and **O**cean Products and **V**isualizations for **E**arth **R**esearch

We provide multi-sensor, multi-platform highly accurate, long-term satellite microwave data products suitable for Earth research applications via easy-to-use display and data access tools.

We are funded by the NASA MEaSUREs Project and are a Federation Type-II ESIP member. We are a collaboration between:

Remote Sensing Systems

Global Hydrology Resource Center

ITSC at the University of Alabama in Huntsville

NASA Marshall Space Flight Center

Wind Speed   SST   Rain Rate
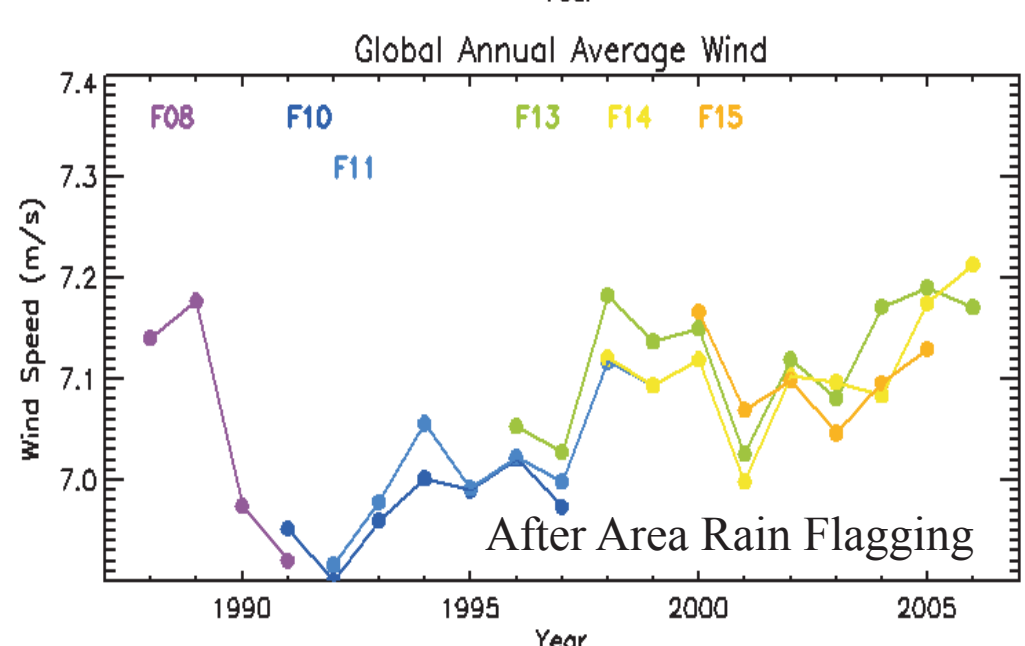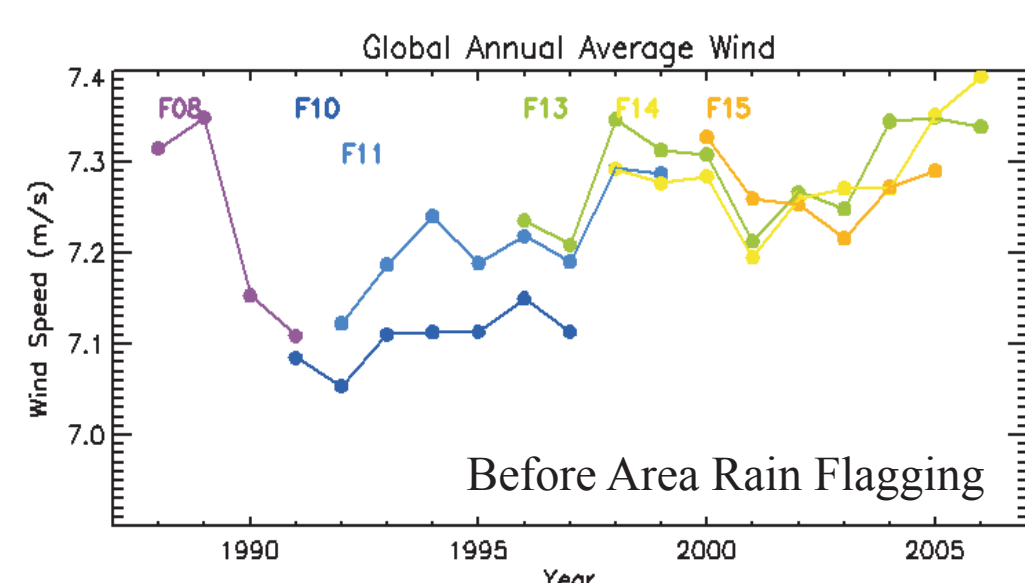
Water Vapor   Cloud

Satellite microwave radiometers have been operating since 1987 in polar orbits around the earth on a succession of DMSP satellites. When consistently processed and inter-calibrated to a precision of 0.1K, the data from these instruments result in a long-term high-quality ocean climate data set of surface winds, atmospheric water vapor, cloud liquid water, rain rates, and sea surface temperatures. (See Wentz poster in this same poster session for more information on the inter-calibration process).

Tasks of the NASA MEaSUREs-funded DISCOVER project include the **intercalibration**, **consistent processing**, **validation**, **distribution** and **support** of satellite Microwave Radiometer Ocean Geophysical and Climate Data Records. We provide high-quality data products to Users and the public through our web and ftp servers. Examples of the data are shown below.

2. DISCOVER DATA PRODUCT DETAILS

The DISCOVER products are available since 1987 when the first SSM/I was launched and are available as day and night (or morning/evening) swaths mapped to 0.25 deg grids. In addition, we provide 3-day, weekly and monthly average maps. Merged products are also available and include Daily Optimum Interpolated Sea Surface Temperatures and 4x-Daily Water Vapor and Wind Speeds.

These data are also used to produce value-added products by other scientists. For example:
1. Cross-Calibrated, Multi-Platform Ocean Surface Winds produced by Ardizzone/Atlas at NASA Goddard and available from JPL PODAAC. This product uses DISCOVER wind speeds in a 4-D variation analysis model to produce ocean surface wind vectors on a 0.25 degree grid.
2. Blended Sea Winds produced by Zhang at NOAA NCDC (see Zhang et al, 2006) This method uses optimum interpolation to combine DISCOVER winds and produce a 0.25 degree/ 6-hourly product.
3. Cloud Climatology produced by O'Dell at University of Wisconsin (see O'Dell, 2008). This 1-degree diurnally corrected cloud climatology uses DISCOVER cloud data from 1988 to 2005.

Optimally Interpolated SSTs

4x daily Merged Water Vapor

Daily Cumulative Rain Rate

TMI & AMSR-E SSTs Merged into One Product

TMI   AMSR-E

Combined Product
September 26,2002

Essential Steps for the Creation of Inter-Calibrated, Multi-Instrument Data Records

- Start with original instrument counts
- Apply consistent quality control procedures
- Adjust geolocation / satellite attitude problems
- Correct for any along-scan biases
- Correct any hot load or antenna emissivity problems
- Intercalibrate instruments at brightness temperature level
- Apply a uniform algorithm to obtain geophysical retrievals
- Correct for sun glitter or radio frequency interference
- Test for product consistency over time and instruments
- Validate with other data sources, "truth"
- Merge geophysical data accounting for diurnal variability

3. HOW TO USE DISCOVER DATA FOR CLIMATE STUDY

DISCOVER data are produced for many types of users, therefore, to use the DISCOVER data for climate studies, it is necessary to follow these guidelines:
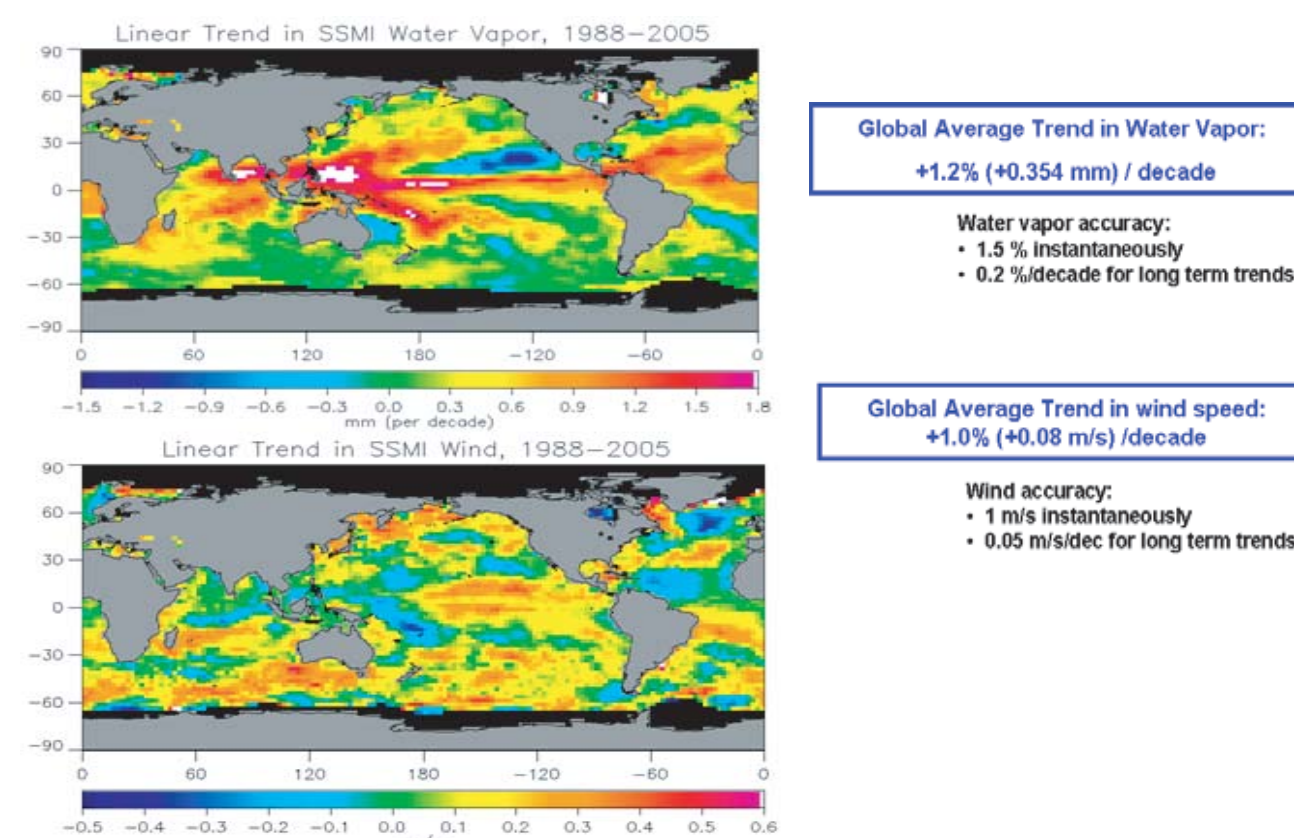
- **Begin with daily data.** The monthly averaged data provided by DISCOVER have some rain included and there is no threshold for the number of counts per cell which contributes to errors.

- **Area rain flag the data** - The radiometer footprint is larger than the 0.25 deg grid cell and therefore can be affected by nearby rain. Removal is necessary for climate study.

- **Extend land and ice buffers** - Instrument side lobes and reduced sampling along boundaries result in poorer quality data at land and ice edges. For best quality, omit cells next to land and ice.

- **Do not use F15 SSM/I data past August 2006** - A radcal beacon was turned on August 2006 that produces a 10K mean brightness temperature offset for the 22GHz F15 SSM/I observations as described in Hilburn, 2008b. We have implemented a correction that works well for wind and vapor, but is too poorly characterized for cloud and rain to used in climate work. It is unknown at this time if the correction is stable over time.

- **Apply adjustments to rain** - As described in Hilburn, 2008a, latitudinal band adjustments are necessary to account for snow which can not be measured by radiometers.

- **Apply adjustments to wind** - As described in Wentz, 2007 supplementary online material, characteristic biases were found between radiometer winds and buoy winds. One small (< 0.1 m/s) yearly correction is applied to SSM/I data to bring the winds into better agreement with the buoys. This process also brings the SSM/I and scatterometer winds into better agreement.
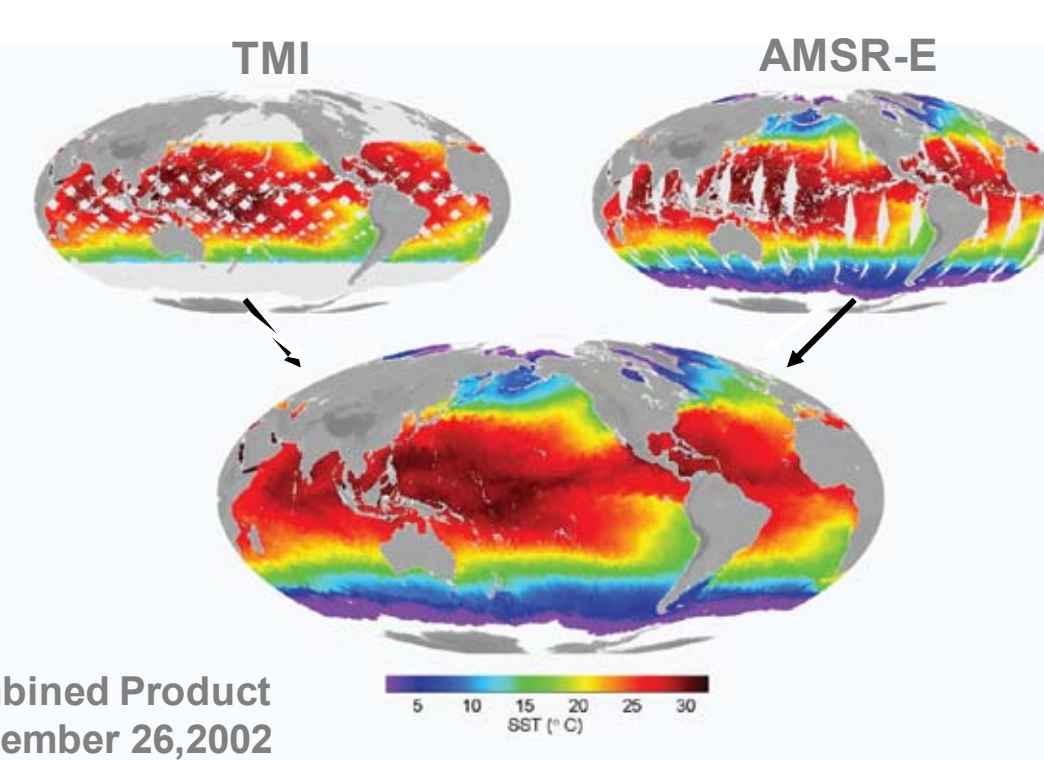
Global Annual Average Wind
Before Area Rain Flagging

Global Annual Average Wind
After Area Rain Flagging

DISCOVER data products have contributed to instrument validations, field campaigns, synoptic scale studies and global climate analyses. Since 2006 when the data were reprocessed, the data have contributed to a better understanding of climate. For example, the Wentz et al 2007 study showed agreement between SSM/I derived evaporation, precipitation and water vapor trends. These results are in contrast to those from climate models.

Errors for DISCOVER products are on the order of:

SST	0.5 deg C
Wind	1.0 m/s
Vapor	1.0 mm
Rain Rate	3%

Global Average Trend in Water Vapor:
+1.2% (+0.354 mm) / decade

Water vapor accuracy:
- 1.5 % instantaneously
- 0.2 %/decade for long term trends

Global Average Trend in wind speed:
+1.0% (+0.08 m/s) /decade

Wind accuracy:
- 1 m/s instantaneously
- 0.05 m/sec for long term trends

4. EXAMPLES OF DISCOVER DATA USE

Ocean Imaging (www.oceani.com) uses DISCOVER TMI and AMSR-E SSTs blended with MODIS IR SSTs in their SeaView Sport and Commercial fish-finding tool. Customers use the 4x/daily refreshed SST images to save them fuel, time and money. SSTs are combined with plankton levels, ocean current data, sea surface height estimates and weather information to help clients operate at sea.
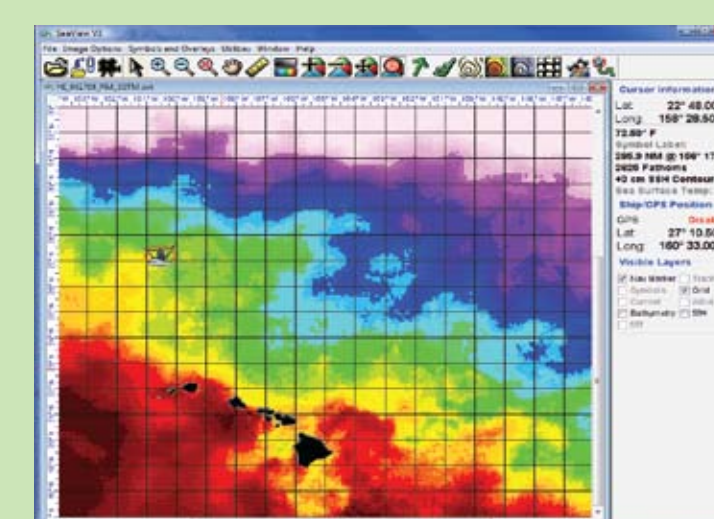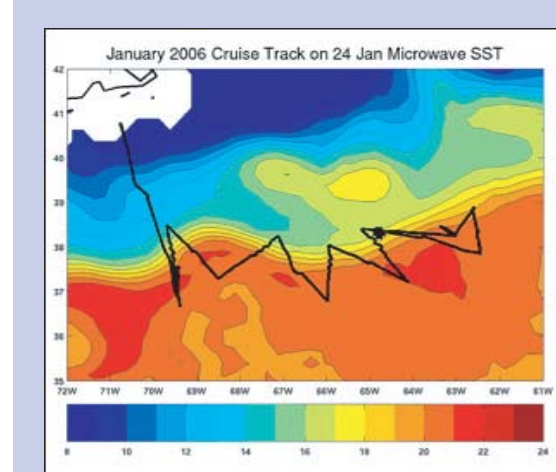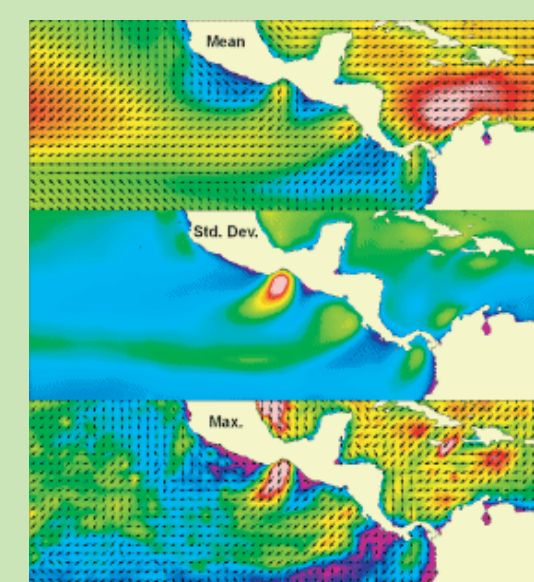
Tagging of Pacific Predators, TOPP, researchers have tagged over 2000 animals and monitor their travels in the Pacific Ocean. They include DISCOVER SSTs in their web displays and research to connect animal travel patterns with ocean temperatures, currents, plankton counts and weather patterns.
The DISCOVER SSTs are included in the TOPP near-real time web site showing tagged animal locations (see images at right).

EXPERIMENTAL PRODUCT
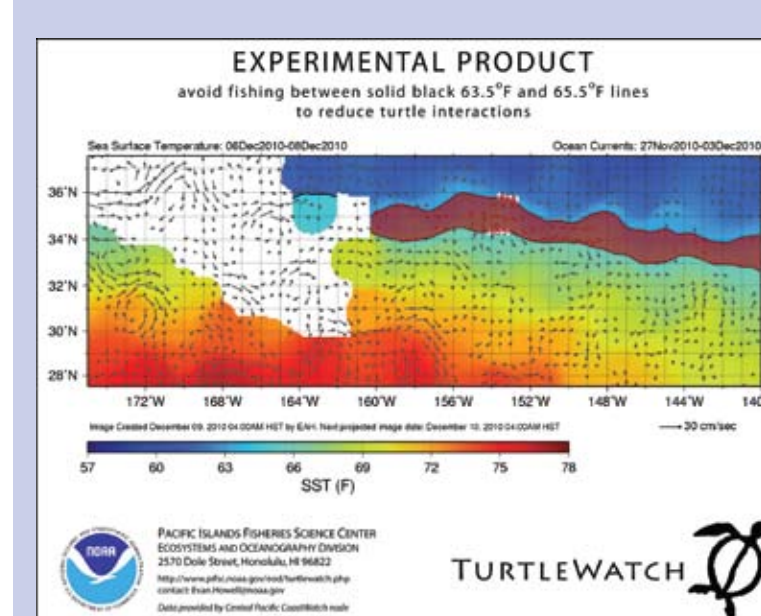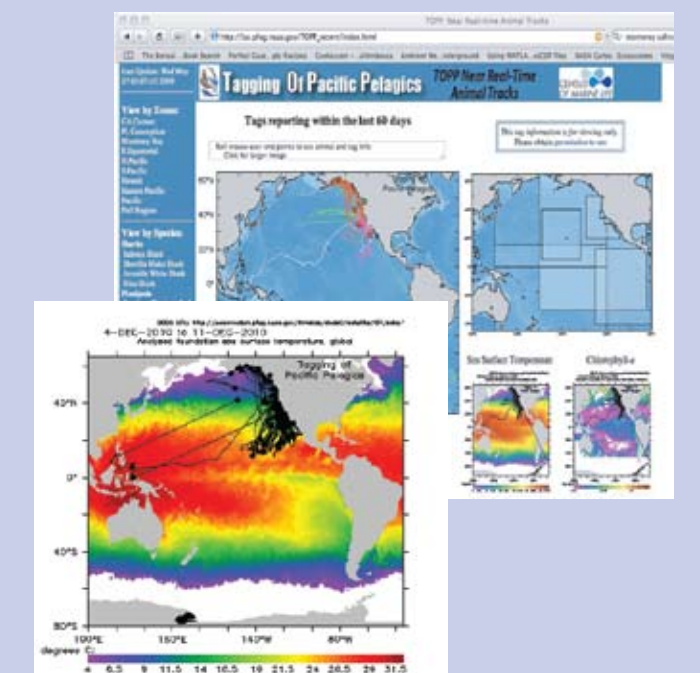
TurtleWatch is an up-to-date thermal habitat map of Pacific Ocean north of the Hawaiian Islands. It is an experimental NRT product by NOAA to help reduce inadvertent interactions between Hawaii-based longline fishing vessels and loggerhead turtles. The map displays DISCOVER SST products combined ocean current conditions and the predicted location of waters preferred by the loggerhead turtles.

DISCOVER wind speeds from SSMI, TMI, SSMIS and AMSR-E are included in merged wind products created by scientists at both NASA and NOAA. The CCMP (Bob Atlas and Joe Ardizonne) uses a 4-dimensional variational analysis method to combine satellite winds with in situ and model data. The Blended Sea Winds (Hui-Ming Zhang) uses an optimal interpolation scheme. Both products are available online, but are not NRT products. The CCMP at PO.DAAC, Blended Sea Winds through NCDC.

The Royal Australian Navy uses remote sensing satellite data for decision making. DISCOVER near-real time data are used in Rapid Environmental Assessment which is the acquisition, processing, compilation, production and dissemination of relevant environmental information to military planners, decision makers and operational and tactical forces in a coordinated, synoptic and timely manner. DISCOVER data are automatically delivered to the Navy's servers where the Geo Database is populated. Web services allow users to zoom to a specific area and query information.

DISCOVER data are an important part of climate reports. For example, DISCOVER rain, wind, cloud and vapor data were included in the 2009 and 2010 NCDC State of the Climate Reports, an annual report published as a supplement to BAMS. DISCOVER scientists and data have contributed to the IPCC Fourth Assessment Report, published by the WMO. The vapor data were used by Trenberth et al. in section 3.2. MSU/AMSU temperatures were used by Fu in sections 3.17, 3.18, and 3.19.
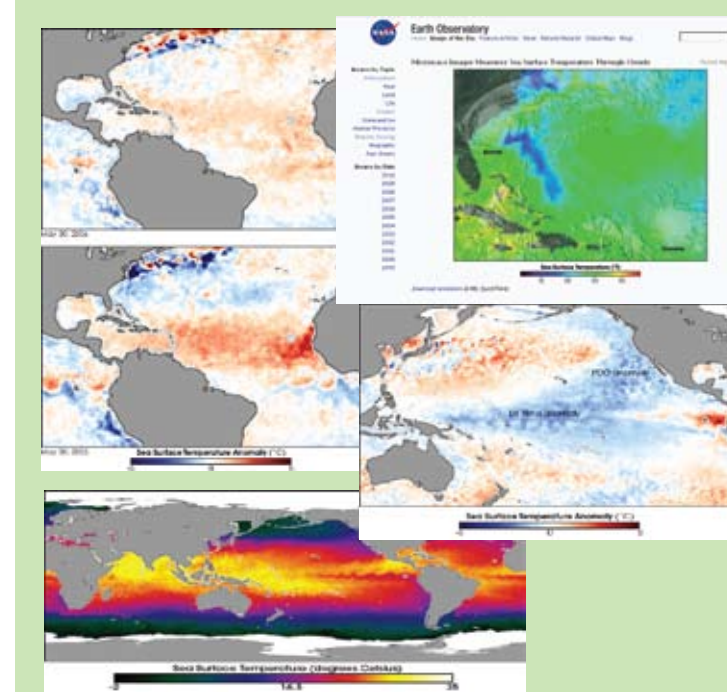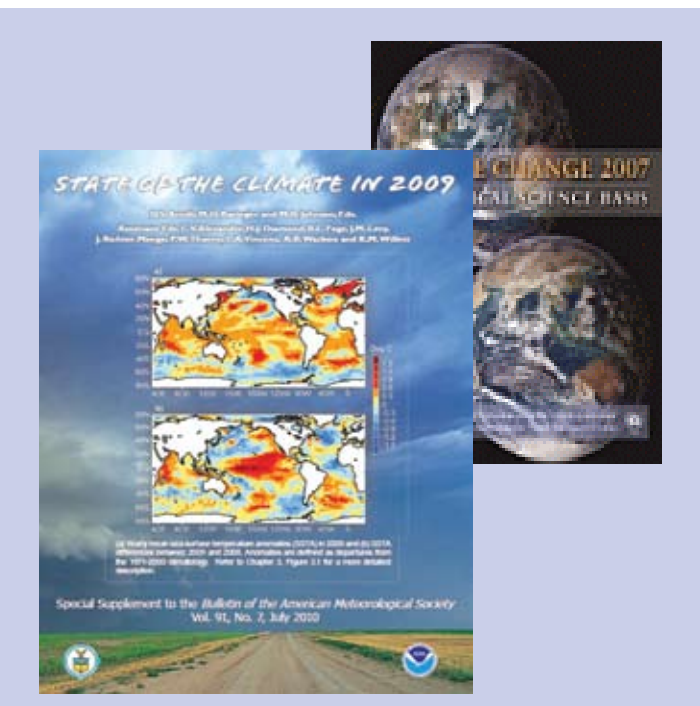
DISCOVER wind and SST products are used by field research programs to provide guidance on instrument deployment and travel plans. Some examples include CLIMODE (pictured left which studied the air-sea exchange and cross-frontal mixing in the wintertime Gulf Stream.
Another example cruise, Cirene, studied the air-sea interaction in the Indian Ocean. Scientists onboard the research ship used DISCOVER SST and wind speeds in both cruise planning and post-cruise data analysis.

DISCOVER data are used by many journalists. A most frequent user is the NASA Earth Observatory, published online by the NASA EOS Project Science Office. At this web site, DISCOVER data are used to show SSTs in the Atlantic during hurricane season, SSTs in the Pacific showing onset of El Nino, AMSR-E data, TMI rain rates, and other applications of DISCOVER data. Some examples are shown at left.