THE AQUARIUS SALINITY SATELLITE/ IN-SITU DATA COMPARISON PROCESSING SYSTEM – A DEMONSTRATION

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1. ABSTRACT

The Aquarius/SAC-D satellite mission, scheduled to launch in 2010, will utilize various types of near-real time *in situ* data to validate the satellite remote sensing sea surface salinity (SSS) measurements.

The objectives of the Aquarius Validation Data System (AVDS) are to collect appropriate *in situ* surface salinity data for comparison with Aquarius/SAC-D satellite SSS measurements and to make this data available to the user community at large. The AVDS data will be matched up with associated satellite data by the Aquarius Data Processing System at Goddard Space Flight Center which will be incorporated back into the AVDS for processing and evaluation.

A web-based data base management system will allow the user community to review and evaluate the data and validation processing.

2. INTRODUCTION

The present status of *in situ* data collection in the ocean has evolved into a global network of data transmitted by satellite and available in near real-time by various data centers via the Internet. The Aquarius/SAC-D Salinity Satellite mission will use this broadly sampled data for validation of the remotely sensed sea surface salinity. The validation measurements will consist of *in situ* surface salinity (SSS) and temperature (SST) data obtained from moored and drifting buoys, Volunteer Observing Ships (VOS) and the automated ARGO profiling buoy array.

The Aquarius Validation Data System (AVDS) will access data from the various sources, select the values optimal for comparison with the surface salinity and reformat and transmit the data to Goddard Space Flight Center for matching with the appropriate satellite data. Subsequently the satellite data will be processed to select the values for comparison with the *in situ* values.

A data server at Earth and Space Research in Seattle will provide the means for the user community to review data, chosen within selectable parameters, such as time, location and environmental parameters, for evaluation of the satellite sensor performance.

3. THE AQUARIUS PROGRAM

The Aquarius/SAC-D Mission is designed to provide monthly, global 150-km resolution, SSS maps. Briefly, the Aquarius instrument measures the brightness temperature (T_B) of the sea surface at L-band, 1413 MHz, with three separate radiometers with ellipsoid footprints ranging in width from 94 to 156 km for a total beam width of 390 km (Fig. 1).

These data, in combination with coincident sea surface temperatures, radar scatterometer measurements, and other ancillary data, are used to estimate SSS. Ancillary data are acquired from sources other than the Aquarius instrument and are used to correct or geo-locate instrument measurements. The Aquarius instrument will be hosted with a number of other science instruments on the SAC-D service platform, built by CONAE, the Argentine government's space agency.

4. AVDS ROLE

All applicable oceanographic data will be routinely collected from the various sources and assembled in the AVDS data server at ESR. The validation system will deliver the quality controlled data to the Aquarius Data Processing System (ADPS) at Goddard Space Flight Center in a specified format for efficient use in calibrating and validating the Aquarius measurements.

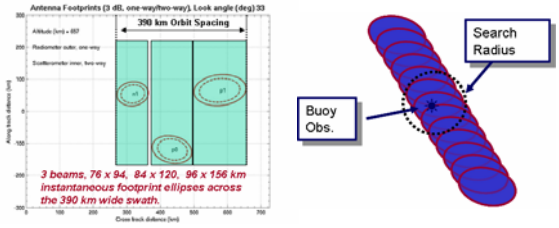

Figure 1. The graphic on the left shows the approximate orientation of the three radiometer footprints from Aquarius aligned across the orbit track. The right graphic is a schematic showing the alignment of one of the radiometer footprints and the location of an in situ point used for validation with an appropriate search radius super imposed.

These data will undergo careful scrutiny, quality control and evaluation to screen spurious values, check for

oceanographic consistency and examination for calibration drift of the surface sensors. Salinity sensors are typically prone to calibration drift and must be tended to carefully to ensure the highest quality surface information for validating the Aquarius satellite measurements. This will entail considerable time and effort working with the various scientific groups who are making these observations, evaluating the calibration procedures they use and documenting the quality of the instruments and accuracy, and understanding the other aspects of the measurements (such as depth below the surface, wind and wave conditions, temperatures, etc.)

5. DETAILS OF THE *IN SITU* DATA

The AVDS data sources will include freely available SSS data from the Climate Variability (CLIVAR), Global Ocean Observing System (GOOS) and other observing programs, including but not limited to, the following; ARGO, GOSUD, GTSPP, Global Lagrangian Drifter Program, TAO, PIRATA, RAMA and NDBC surface moorings. The approach to building up the database will be to develop the AVDS software using the ARGO profile data, which we anticipate will be the largest and most appropriate data set for validation, and then incrementally add the other data sources during the final year of system testing, applying the strengths of each type of data to the validation task. The data will be accessed daily.

ARGO is an international program of freely drifting profiling floats, presently numbering over 3000 distributed over the global ocean, which measure the temperature and salinity in the upper 2,000 m of the ocean providing ~100,000 T/S profiles and reference velocity measurements per year. The buoys drift at depth and surface at 10-day intervals transmitting a profile of temperature and salinity to be incorporated in the global data base. Thus, on average, ~300 profiles will be available each day. Eventually, a subset of these profilers will be outfitted with separate sensors to measure the upper surface layer salinity and temperature.

Data are accessed through two Global Data Assembly Centers (GDAC); one in California (www.usgodae.org) and the other in France (www.coriolis.eu.org). Data format information is available through the ARGO program and documented on the Program web site as well as those of the individual GDACs.

The Global Ocean Salinity Underway Data project (www.gosud.org,) seeks to collect, process, archive and disseminate, in both real time and delayed mode, sea surface salinity and other variables collected underway by research and "ships of opportunity". The data is collected from a multitude of organizations via both GTS in near real-time and in delayed mode. The underway data is sampled using shipboard thermosalinographs, which sample at approximately 5 meters depth. The submitting organizations vary, so sample rates, averaging, calibration, duration, etc. are all subject to considerable variability. GOSUD provides basic range and quality checks on the data (applying the same algorithm used for ARGO data) and formats them in a well documented format. Because of the unique nature of this data it is the only source of detailed along track salinity information in the upper layer of the open ocean, and will be very helpful in evaluating Aquarius data.

The TAO/TRITON array (formerly the TOGA/TAO/TRITON array, prior to 1 January 2000) consists of approximately 70 moorings in the Tropical Pacific Ocean, telemetering oceanographic and meteorological data to shore in real-time via the Argos satellite system. The PIRATA array, consisting of approximately 15 moorings, studies ocean-atmosphere interactions in the tropical Atlantic. NOAA's National Data Buoy Center (NDBC) is a part of the National Weather Service (NWS). NDBC designs, develops, operates, and maintains a network of data collecting buoys and coastal stations. A subset of the moorings in these programs has surface salinity sensors. TAO, for example, has approximately 95% coverage. RAMA is a growing instrumentation program of surface moorings in the Indian Ocean.

The Global Drifter Program (GDP) maintains an array of approximately 1250 satellite-tracked drifting buoys to measure mixed layer (near-surface) currents, sea surface temperature, air pressure, and winds. Some portion, on the order of 100-200 buoys, are planned to measure SSS.

GTSPP is a cooperative international program designed to develop and maintain a global ocean T-S resource with data that are as up-to-date, and of the highest quality possible.

6. AVDS RELATIONAL DATABASE STRUCTURE

The goal of the AVDS is to match up *in-situ* and satellite data in a manner which allows comparison between the two types of data to evaluate and validate the performance of the satellite surface salinity sensors. As part of this process, data from the above *in situ* data programs will be converted into a consistent format and made accessible to the user community for analysis and review (Fig. 2).

The data source programs provide data in different formats, each with unique data retrieval requirements. For example, the ARGO profile data used will be the

upper-most values in the profile whereas data from fixed surface moorings will be averaged to produce a representative surface value for comparison with the satellite data. Since the ARGO profile data has the largest number of floats and the most extensive coverage, it will be incorporated first and the structure and lessons learned during that effort will be applied to subsequent data program assimilation software development.

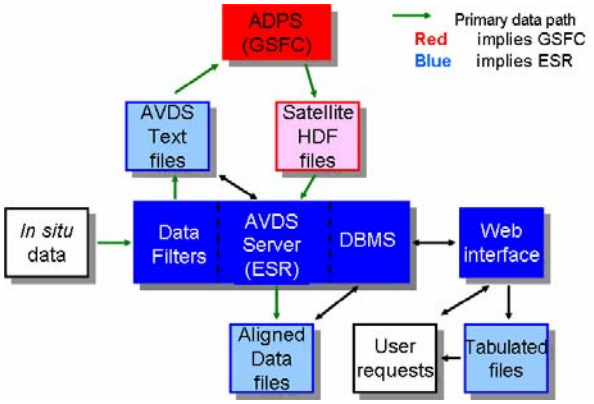

Figure 2. The flow of data in the AVDS DBMS. The in situ data is reviewed and sent to GSFC to be matched up with appropriate satellite data which is sent back to the ESR server. These files are analyzed to provide comparative data and made available to the user community via an interactive web interface which allows creation of subsets of the data within specific user defined criteria.

Each program data server will be queried daily for data associated with a particular target date, prior to the current date. A transfer file will be prepared for all the *in situ* data collected on that target date and it will be made available to the ADPS at GSFC for satellite data match-up. HDF structured data files (http://hdf.ncsa.uiuc.edu) will be returned with the appropriate satellite data within specified time and spatial limits. This data will then be processed to choose appropriate satellite derived surface salinities, unique to each radiometer, which can be compared to the *in situ* value. These data matches will be stored in a relational data base and made available to the user community via an Internet web interface that allows the user to create subsets of the data selectable by time, location and other pre-defined limits of associated data. Metadata associated with each data match up will be sufficient for users to acquire and download the original native *in situ* and satellite data, if desired, for verification purposes.

Defining a pass as the sequence of Level 2 Aquarius data from a particular radiometer beam, a match up file for a particular *in situ* record will often contain multiple passes or orbits. The AVDS match up processing will evaluate these and tabulate each pass with each *in situ* record as a unique match up.

Each pass within a match up file contains a sequence of Aquarius samples along the beam ground track. The AVDS match up processing should identify the closest point of approach (CPA) between the geographic path of the Aquarius boresight and the geo-location of the *in situ* record. The sample at or closest to the CPA shall be identified. The processing shall also perform a weighted average of the pass data centered on the CPA. The weighting function shall be Gaussian with an e-folding scale of half the Aquarius beam width; unless a better weighting function is determined through subsequent analyses.

The AVDS matchup processing shall process, filter and tabulate matchup data to provide a set of unique pairs between *in situ* records and the filtered and unfiltered Aquarius pass data at the CPA.

7. USER INTERFACE

Data access to the AVDS data base will be via web-based interface similar to the SeaBASS system [http://seabass.gsfc.nasa.gov/]. The interface (data server and web site) will be run on a data server at ESR.

The AVDS data will be available to the Science Team as well as the general public. In order to monitor the activity, a user registry shall be maintained by requesting input of the user's name, affiliation, mailing address, email and phone number as a requirement for issuing a user access name and password. It is anticipated that this registration function as well as the technical nature of the web interface may focus the user base on the scientific community and those of the public interested in the problem of Surface Salinity but there will be no prerequisite for participation.

The AVDS Data Base Management System (DBMS) will be accessed via multiple web pages that enable users to conduct various searches and data retrievals. Users will specify a variety of pre-defined limiting parameters and the DBMS will provide matches with the *in situ* data and matched up satellite salinities, as well as other satellite parameters. Searches will be possible by time, geo-location, observing platform, measurement depth, measurement platform type, platform name and/or serial number, and other relevant metadata. Original ADPS-provided matchup files as well as processed and tabulated match ups will be retrievable with searches driven by the same criteria. Depending on data volumes generated, the results of such searches, particularly for the original data, will be provided as an HDF sequential data file.