ISSN: 0001-5113 AADRAY	ACTA ADRIAT., 47 (Suppl.): 113 - 131, 2006	UDC: 551.501(450)(262.3) 551.46.06

The S1 buoy station, Po River delta: data handling and presentation

Giovanni BORTOLUZZI [1*], Franca FRASCARI [1], Patrizia GIORDANO [1], Mariangela RAVAIOLI [1], Giuseppe STANGHELLINI [1], and Alessandro COLUCCELLI [2]

[1]Istituto di Scienze Marine (ISMAR-CNR), Sede di Bologna - Geologia Marina, Via Gobetti 101, 40129 Bologna, Italy

[2]Istituto Nazionale di Geofisica e Vulcanologia (INGV) – Sezione di Bologna, Via Donato Creti 12, 40129 Bologna, Italy

Corresponding author, e-mail: g.bortoluzzi@ismar.cnr.it

The technical setting of the mete-oceanographic buoy at site S1 south of the Po River delta is presented. The station was deployed by Istituto di Scienze Marine (ISMAR) of CNR of Bologna, in cooperation with the local Regional Government and Environmental Agencies (ARPA) of E. Romagna, and ADRICOSM. The buoy mooring and data flow architecture is discussed, with some emphasis on the WWW data presentation. The possible integration with other remote stations, data and mete-oceanographic operational activities is also proposed.

Key words: buoys, data handling, web sites

INTRODUCTION

In the framework of a coooperative research project between ISMAR-CNR, Emilia Romagna regional government agencies (ARPA SOD and SIM) and ADRICOSM, a meteorological and oceanographic M4 buoy (Fig. 1) was installed at the S1 site (Fig. 2). It is located south of the Po River delta (North Adriatic Sea, Italy), at 22 m water depth, in the mainstream of the Po River discharge, off the mouth of Po di Goro.

The S1 area has been intensively studied by ISMAR for decades both collecting abiological and biological data in the water column and the sediment, and investigating the water and sediment interactions. The area was therefore thought to be a key monitoring point for studying the interactions between the Adriatic basin and the Po River.

The buoy was installed for a 30 day test at the end of 2003, and deployed for data acquistion in April 2004 (GIORDANO *et al*., 2005). During March 2005 the buoy was recovered, refurbished onshore and redeployed. Standard meteorological and oceanographic parameters are available at selectable sampling and transmission rates. The

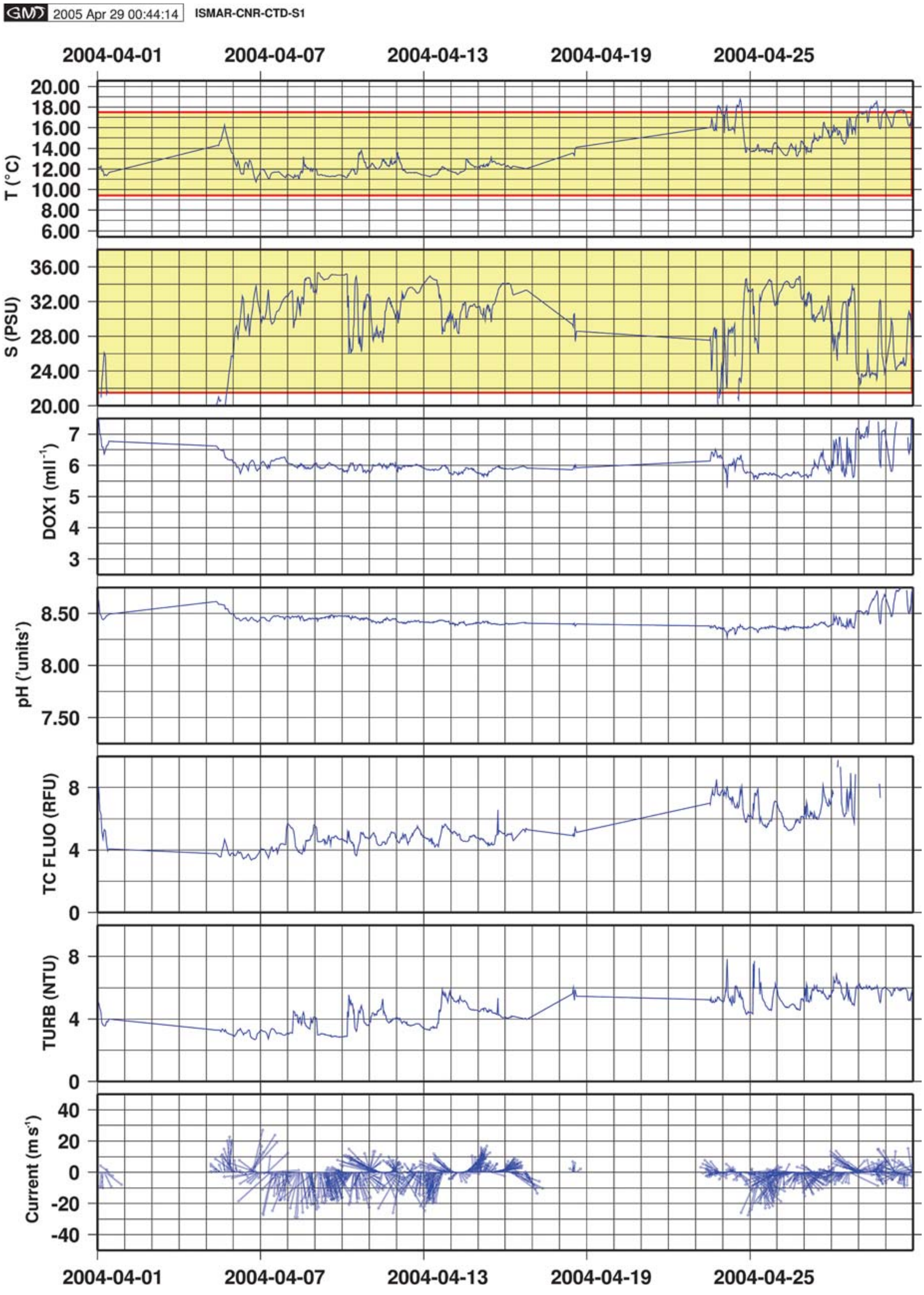

Fig. 1. Buoy M4, Communication Technology, Cesena

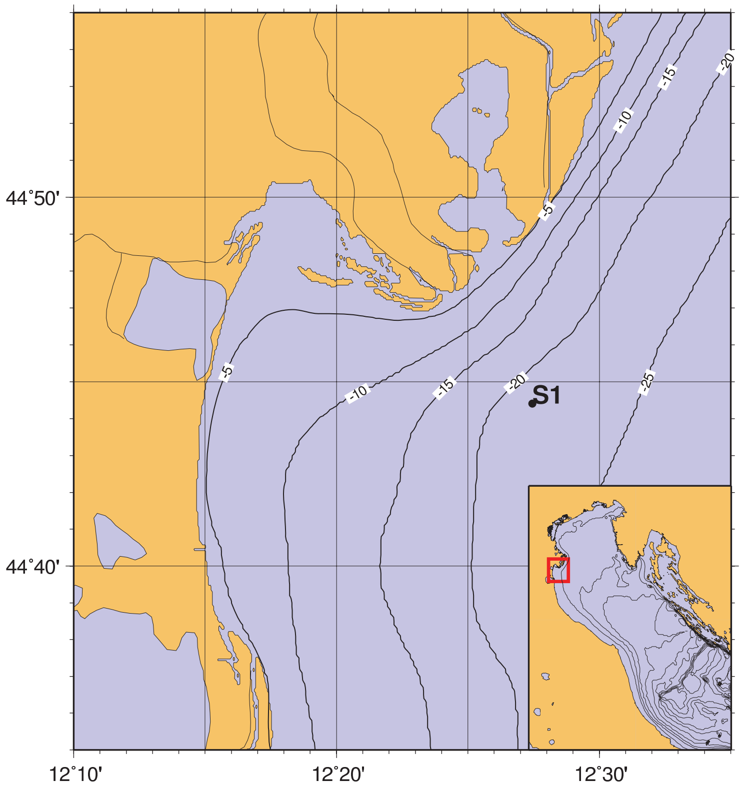

Fig. 2. S1 station position

received data are delivered on the Internet and deposited in a data bank at ISMAR in Bologna, which is updated continuously by automated procedures. To provide the scientific community with a tool for data visualization and delivery, a WWW site was created, in which the buoy data are shown for different time frames. Circulation (AREG, ADRICOSM) or Meteorological Model Data produced by operational activities, or other time series data (tide, river discharge), can be plotted together with the buoy data to help in the data analysis.

METHODS

M4 buoy

The M4 buoy (Fig. 3) was provided by Communication Technology of Cesena, Italy. The device is used for short and long period data acquisition of oceanographic and meteorological parameters and consists of: (a) a surface buoy carrying the data-logger, batteries, solar-panels, a suite of modular meteorological sensors, a GPS receiver and bi-directional communication system via GSM or satellite, and (b) a sub-surface modular pack of oceanographic sensors, that are serially connected to a hose system where water flows is driven by a pump. The shore-controlled Intelligent System Control supervises the operations.

At the S1 site the buoy is moored by a ballast chain and a wire rope fixed to an anchor, allowing the buoy to move freely and follow the wind and wave directions.

Buoy data

The buoy records meteorological and CTD data at the selected sampling rate (see Table 1 and 2). The data stored on the internal data logger are transmitted ashore at scheduled intervals. The onboard GPS (accuracy 10-15 m) provides information useful for detecting mooring problems or buoy release. The CTD data are measured at a depth of 1 m. Other CTD sensors and ADCP, for current and water level measurements, are scheduled for deployment

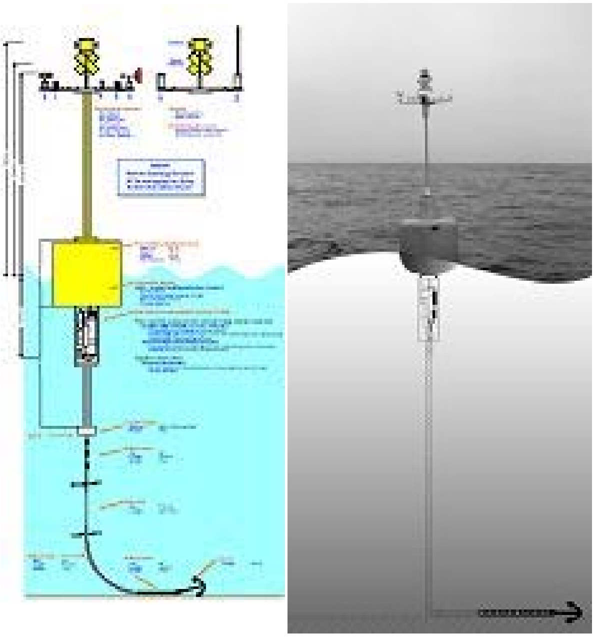

Fig. 3. Buoy M4, Communication Technology, Cesena

Table 1. M4 buoy CTD measured parameters

Parameter	Name	Units
Temperature	temp	° C
Conductivity	cond	Sm^{-1}
Pressure	pres	dbar
Oxygen	oxyg	mll^{-1}
pH	ph	pH
Redox	orp	mV
Salinity	sal	PSU
Density	dens	kgm^{-3}
Fluorimetry	fluo	RFU
Temp.Corr. Fluorimetry	tcfluo	RFU
Turbidity	turb	NTU
Temperature	stemp	° C
Current Speed	currspeed	cms^{-1}
Current Direction	currdir	°
Temperature	dtemp	° C
Current Compass	currcompass	°
Current x,y	currtx,currty battery	cms^{-1} V

at other depth levels during 2005. The data are transmitted ashore at programmable rates (10 min to hours, depending on battery status and available data links) by a GSM or satellite terminal to a computer that encodes them in an e-mail message that is sent to authorized addresses.

Model data and other time-series data

The high-resolution field data analysis can benefit from the comparison with model data, i.e. for Quality Control (QC). Conversely, these latter can use the field data as a check and for finer tuning. Other data sources can provide model or time series data. Among these may be included the AREG circulation model (described below), the ECMWF and the ARPA-SIM regional meteorological models, the tide station and the Po River discharge data.

Within the ADRICOSM project an operational marine forecasting system was implemented for the Adriatic Sea on a basin-scale. The model is the Adriatic regional model (AREG, an implementation of the Princeton Ocean Model (BLUMBERG & MELLOR, 1987)) with 5 km horizontal resolution and 21layers. A complete description of the model set-up is given by ODDO *et al.* (2006).

Table 2. M4 buoy surface meteorological measured parameters

Parameter	Name	Units
Wind speed average,gust	windspeed, windgust	ms^{-1}
Wind Direction	winddir	°
Wind True Direction	twinddir	°
Temperature	airtemp	° C
Pressure	airpres	hPa
Rel.Humidity	relhum	%
Net Radiance	netrad	Wm^{-2}
N Heading	heading	°
Attitude	pitch,roll	°
Latitude, longitude	gps lat,long battery	ddmmxx V

The model is forced by the atmospheric forcing fields from the European Center for Medium-Range Weather Forecast (ECMWF), from which the surface heat and momentum fluxes are computed. The Po River runoff is included as the daily mean as measured by ARPA Emilia Romagna at the Pontelagoscuro station.

The AREG domain is nested into the Mediterranean model at the 1/8° horizontal resolution of the Mediterranean Forecasting System (MFSTEP) project and the temperature, salinity and velocity fields are included at the lateral boundary below the Otranto Channel, following the scheme proposed by ZAVATARELLI & PINARDI (2003). Every week on Wednesday the operational forecasting system releases a 7-day simulation of the past week and a 9-day forecast for the next week. Within this schedule a subset of the produced fields, centered to include the S1 position, is extracted and automatically encoded in a e-mail message with a Subject ID suitable unique parsing by a standardized processing sequence. Temperature, salinity and velocity fields from AREG together with the ECMWF atmospheric fields are then passed to the S1 site for visualization and comparison with the buoy data.

Data handling

The data flow (remote stations, model data, Fig. 4) has been loosely synchronous and rather unpredictable. Therefore, we designed timely automated procedures to control this at the server side, trying to achieve as much automatization as possible, yet leaving room for manual handling. These procedures poll the data sources at selected intervals, although at rates that must be the fastest data source sampling and transmission rate. The main unpredictability source was found to be related to remote station transmission problems, whilst others, such as network problems or server-side problems, should have a lesser impact since they can be planned and managed by a proper data dissemination and delivery path design.

The procedures described above are built by Shell, Perl and GMT scripts, and are designed to filter the data and insert them in a relational database (RDBMS). Once in the database data may be retrieved, processed and plotted. The database structure is such that queries by buoy ID, date, time and depth are possible using SQL statement either directly on the server or by using front-ends (in this case Perl DBI).

The buoy data (CTD and METEO) and the other data sources are encoded (BASE64) in an

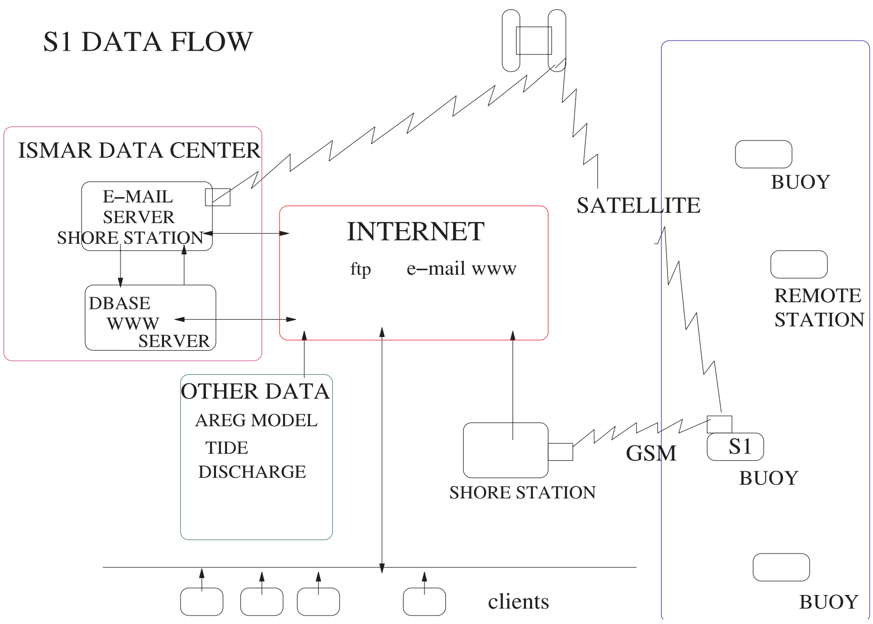

Fig. 4. Data flow and handling

email message with unique subject information and sent to mailbox s1 (buoy id) of the domain bo.ismar.cnr.it on the e-mail server of ISMAR.

A scheduled, automated procedure on another ISMAR server carries out the following:

– checks the presence of coded data on the remote mailbox
– decodes data if coded (header and data) messages were found
– copies and renames messages and data on both servers (first stage backup)
– processes buoy data, inserting them in the RDBMS with unique buoy ID's, model data such as the ADRICOSM AREG, ECMWF or local meteorological data, and other data (tide station or river discharge data, etc.)
– updates user downloadable data files and 'custom' data for authorized access by www, ftp, e-mail or other Internet services
– updates the daily, weekly and monthly maps and publishes them on the INTERNET
– logs and sends messages to system administrators and to the project responsibles.

This sequence is therefore able to make publicly available the buoy data within 5-10 minutes from the delivery of the e-mail message from the on-shore receiving station.

The WWW server

The WWW server s1@bo.ismar.cnr.it displays the ongoing buoy data, and provides the user with additional control for data display and authorized download. The server is built by a Perl script (including the CGI.pm (STEIN, 2004) and DBI (BUNCE, 2004)) modules that interfaces whit the SQL RDBMS that produces static or dynamic HTML code which is handled by mod Perl modules of an Apache server.

The site home page provides some administrative information and shows the daily data flowing from the buoy (normally 2-3 hour averaged). The data are retrieved from the database, thus giving information on the health of the data link and of the buoy performance. The other sections show plots, maps and documentation, such as:

– weekly and monthly buoy time-series and TS/density diagrams (this latter aggregates the yearly buoy data with the daily and weekly data, as an aid in the interpretation of the data set)
– daily AREG model data maps and daily and monthly time-series model versus buoy data
– technical documentation
– messaging
– password protected data access.

The buoy and model T and S time-series have the climatology ± 2σ superimposed (MONTANARI *et al*., 2005), as kindly provided by S.SIMONCELLI, as an aid for QC and data interpretation. A section is provided for the launch of Tellus, ISMAR's Java™ interactive tool that browses geographical and oceanographic station databases. Tellus is a program that retrieves and displays data coming from an SQL server, serving client calls over the Internet with an SQL compatible language. It deals preferably with georeferenced data as it is able to display their locations on a map, allowing the user to select them as well as set filters to limit the amount of data retrieved. It is also able to display some types of retrived data in graphical form. The queried databases must be described with a configuration file that sets all important parameters needed for extraction, among which include database name, key table names, password used for connections etc. This makes the software highly portable for different and currently implemented georeferenced databases. The application is entirely written inside Sun's Java™ environment, is fully multi-platform and supports the Web Start™ protocol for easy client download and is run via a http link.

The application can be used as a complement to web interfaces accessing databases, as well as a stand-alone application, connecting and retrieving data from SQL databases.

RESULTS AND DISCUSSION

Hereafter, we briefly describe the structure of the S1 web site, giving some examples to explain how to visualize and handle the available data. Fig. 5 shows the homepage. The right-hand section shows the hourly averaged data of the day. The navigation bar at the top of this gives user choice (typically by date) between some different visualization:

– time-series of the last week of data (meteorological and CTD) (Figs. 6 and 7)
– time-series of the last month of data (meteorological and CTD) (Figs. 8 and 9)
– TS (density) diagrams (Fig. 10); the user can select YEAR and MONTH - the initial plot shows the aggregated yearly data and the last week and day of data with different color and symbol sizes
– daily plots of the AREG data against the S1 data (Figs. 11 and 12), and contour maps of the daily AREG model data
– monthly plots of the AREG-ADRICOSM data against the S1 data (Fig. 13).

The left-hand panel provides a navigation bar for the selection of documentation and other more general information. One of the buttons launches the Tellus program that gives the user a geographically interactive access to the ATOS-ABCD database (ARTEGIANI *et al.*, 1997a, b), including the zoom and display of single station data profiles. Figs. 14 and 15 show some snapshots.

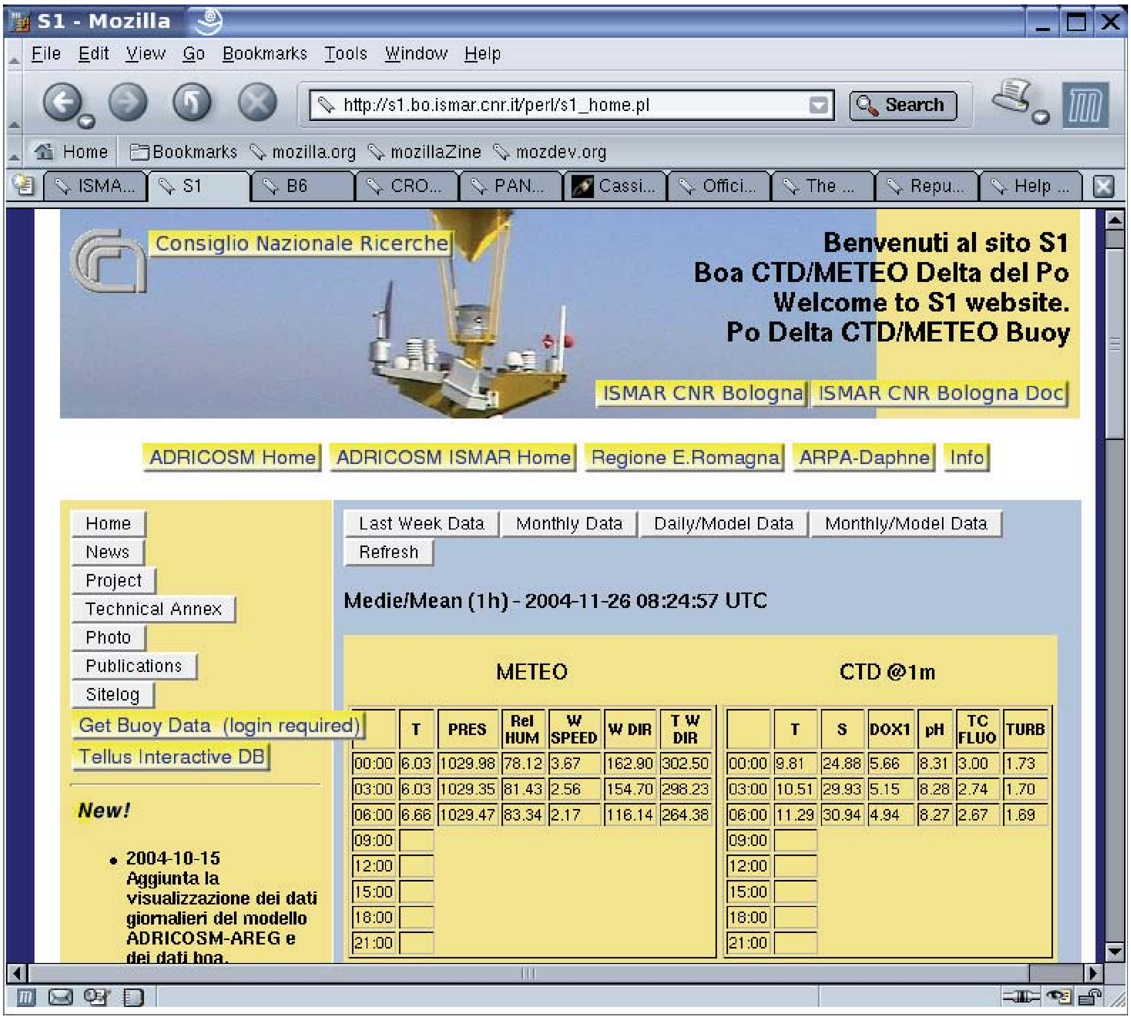

Fig. 5. Home page of the www site s1.bo.ismar.cnr.it

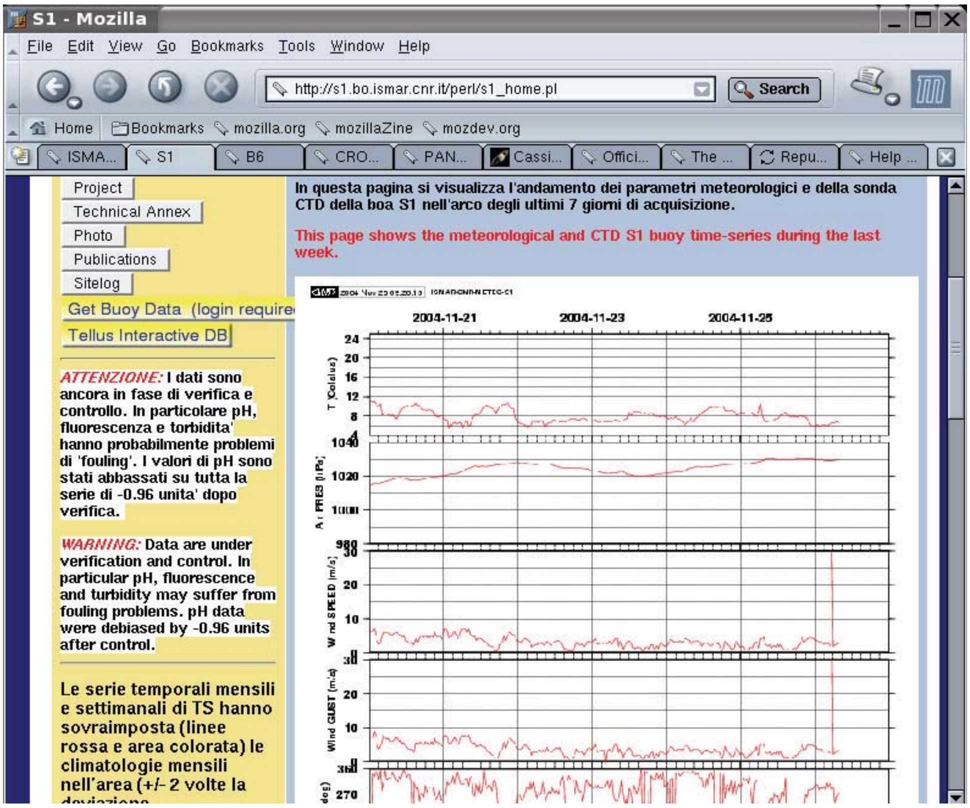

Fig. 6. Meteorological data of the last week

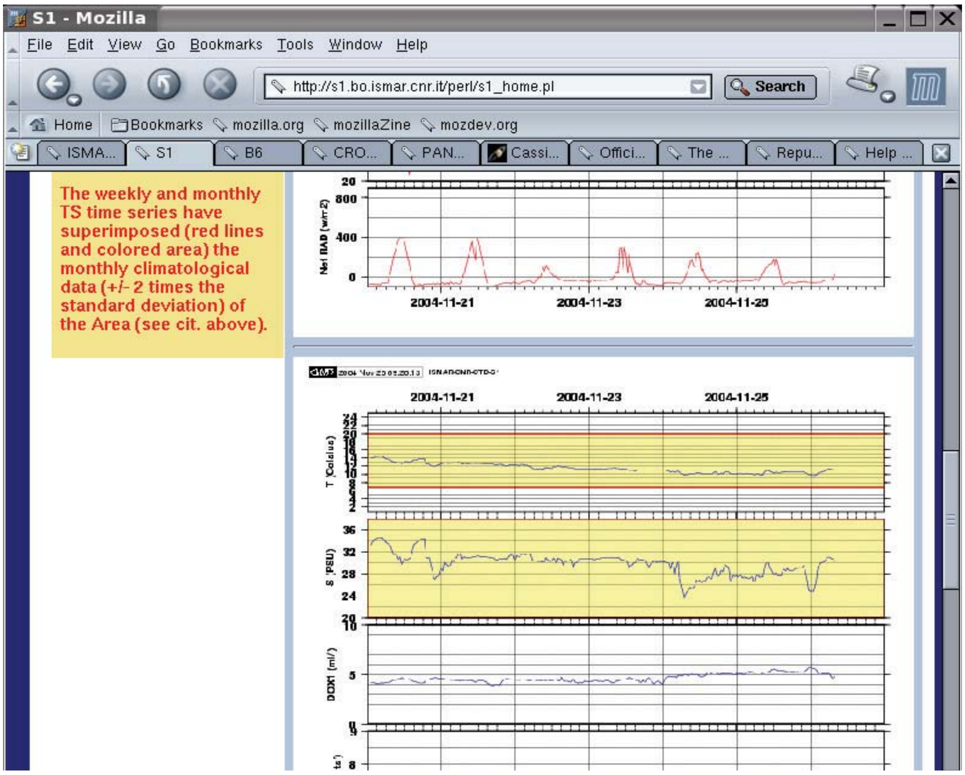

Fig. 7. CTD data of the last week

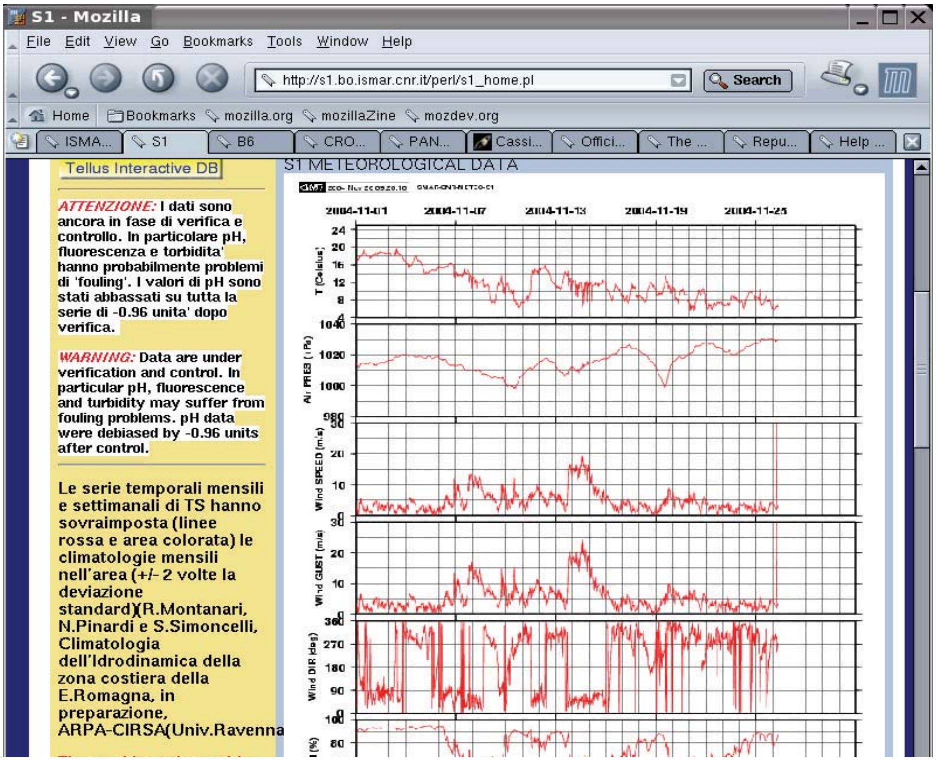

Fig. 8. Monthly meteorological data

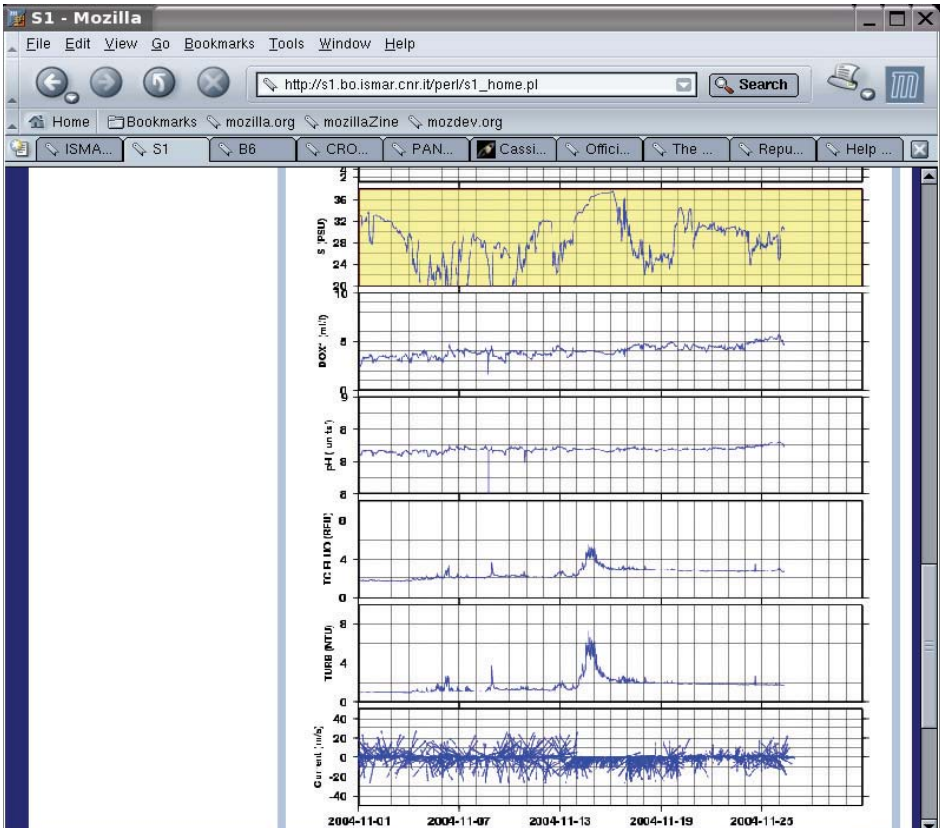

Fig. 9. Monthly CTD data

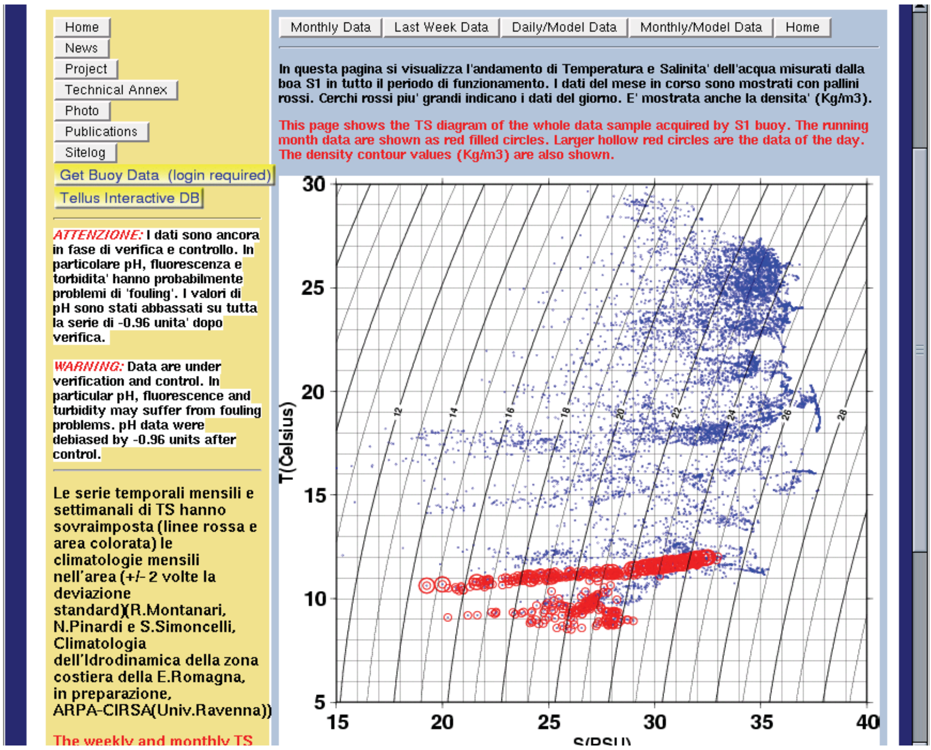

Fig. 10. TS and density diagram. On this page, the T and S buoy data of the whole sample are presented (blue). Data of the ongoing month are shown in red. Bigger red circles indicate the data of the ongoing day The density contours are superimposed (kgm^{-3})

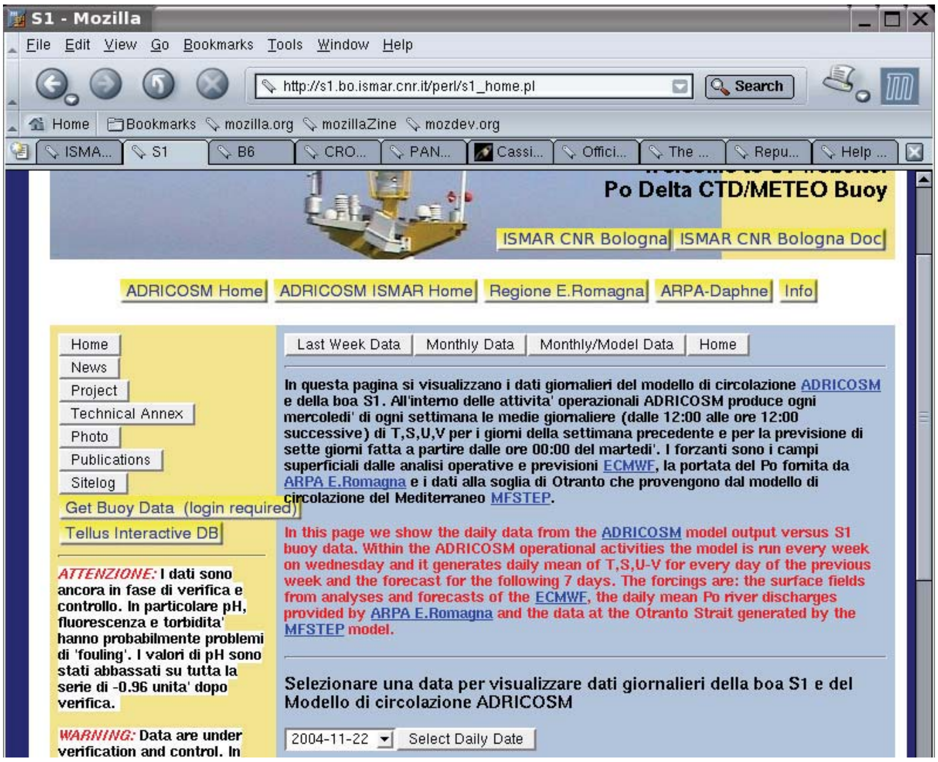

Fig. 11. Section on model/buoy data

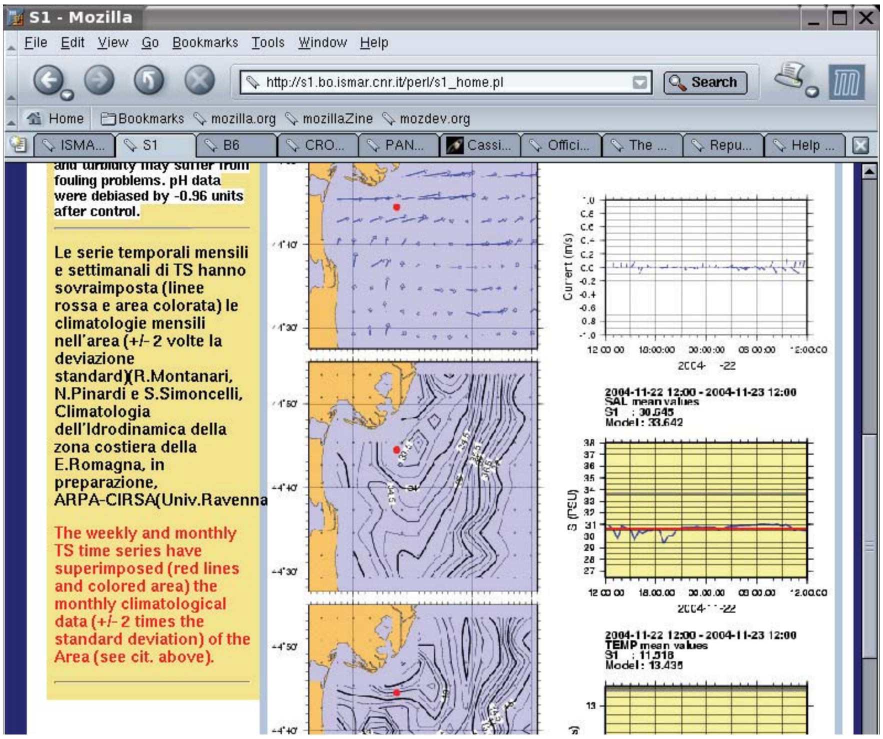

Fig. 12. Example of daily model versus buoy data

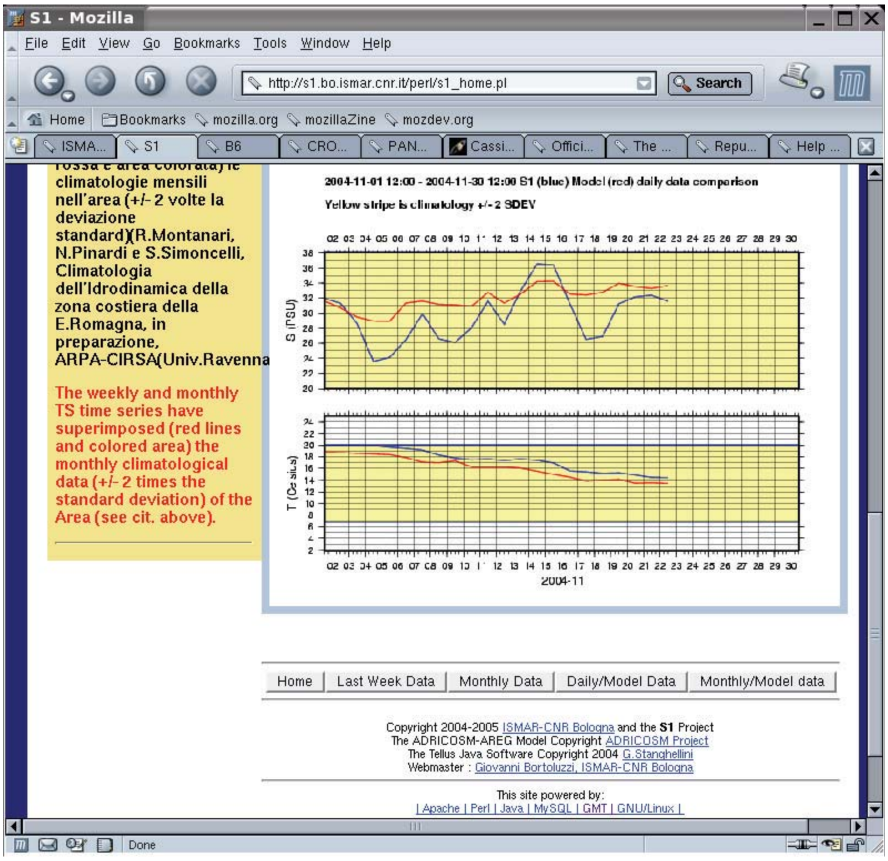

Fig. 13. Example of monthly model versus buoy data

As regards quality, we have noticed problems in some sensors (pH and O2), that presented some offsets and erratic behaviour. A check against the end deployment calibration will hopefully let us recalibrate the data series.

The buoy data show the high variability of the hydrological conditions at the S1 station (Figs. 20 and 21), together with the relationship with meteorological data. Further insight will be provided by concurrent analysis with river

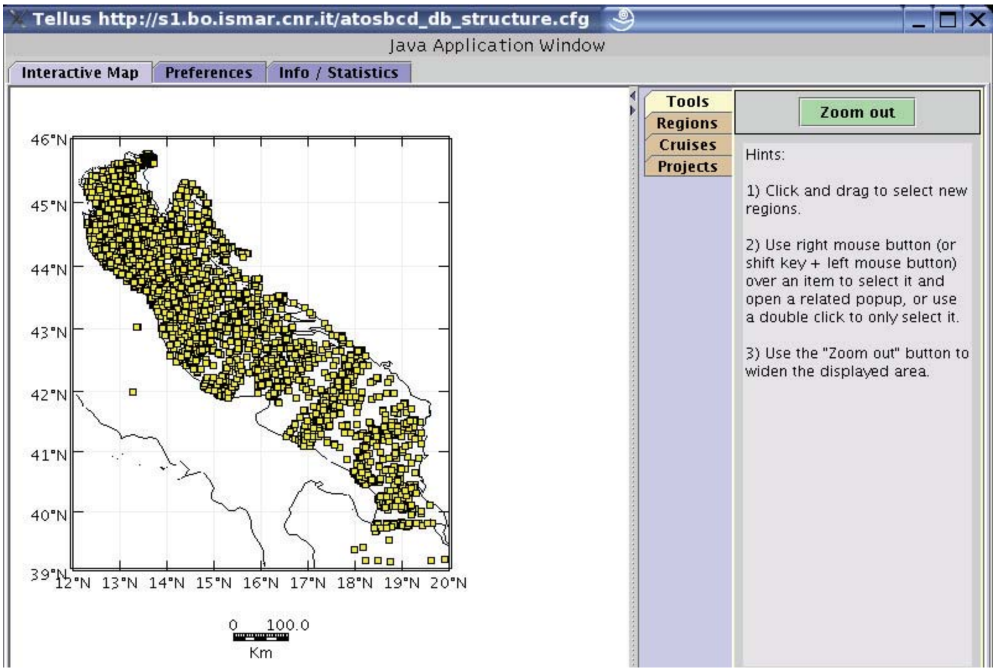

Fig. 14. The ATOS-ABCD database visualized by Tellus

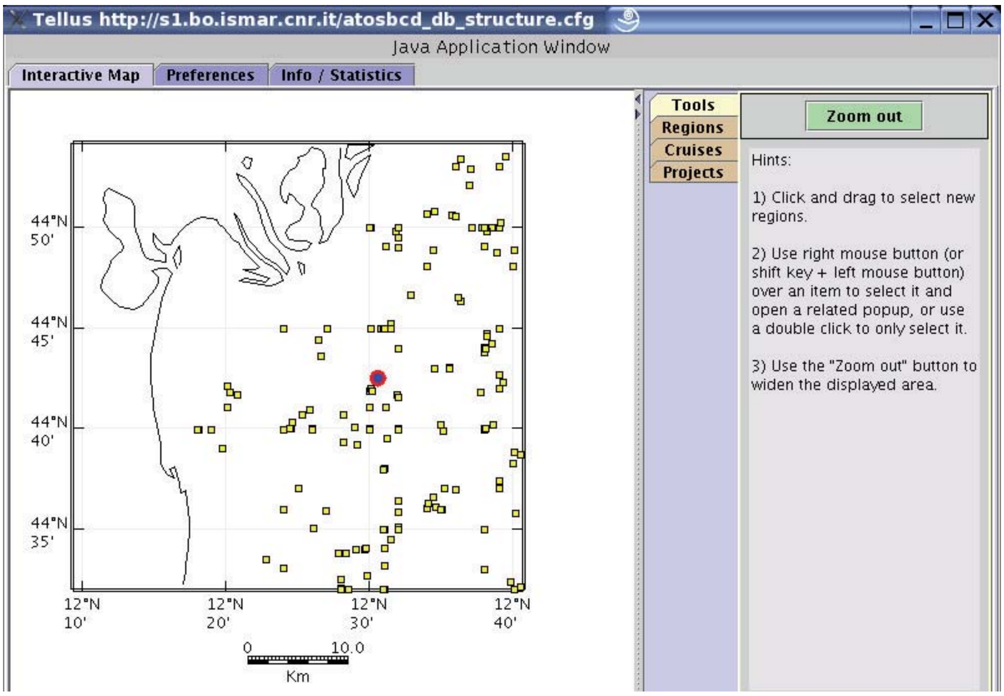

Fig. 15. The ATOS-ABCD database visualized by Tellus, local zoom

discharge and tide data. Figs. 16, 17, 18 and 19 present the comparison of the buoy data in April 2004 and 2005. The data of 2005, in particular, give evidence of very high biogeochemical activity, as depicted by the pH, oxygen and fluorescence curves and that appear to have a close relationship with the fresh river water input, tide pulsation and light availability.

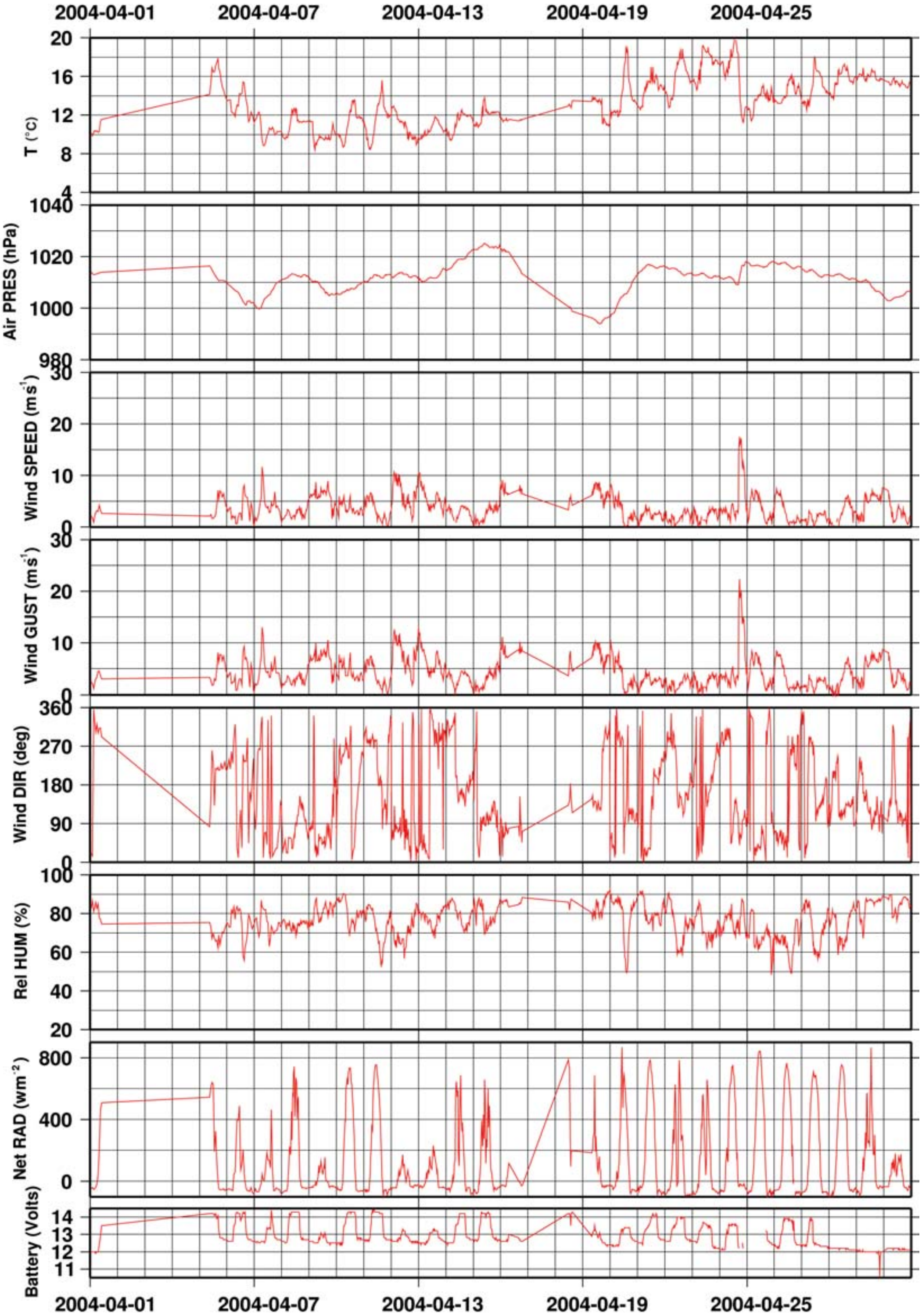

Fig. 16. Meteorological data, April 2004

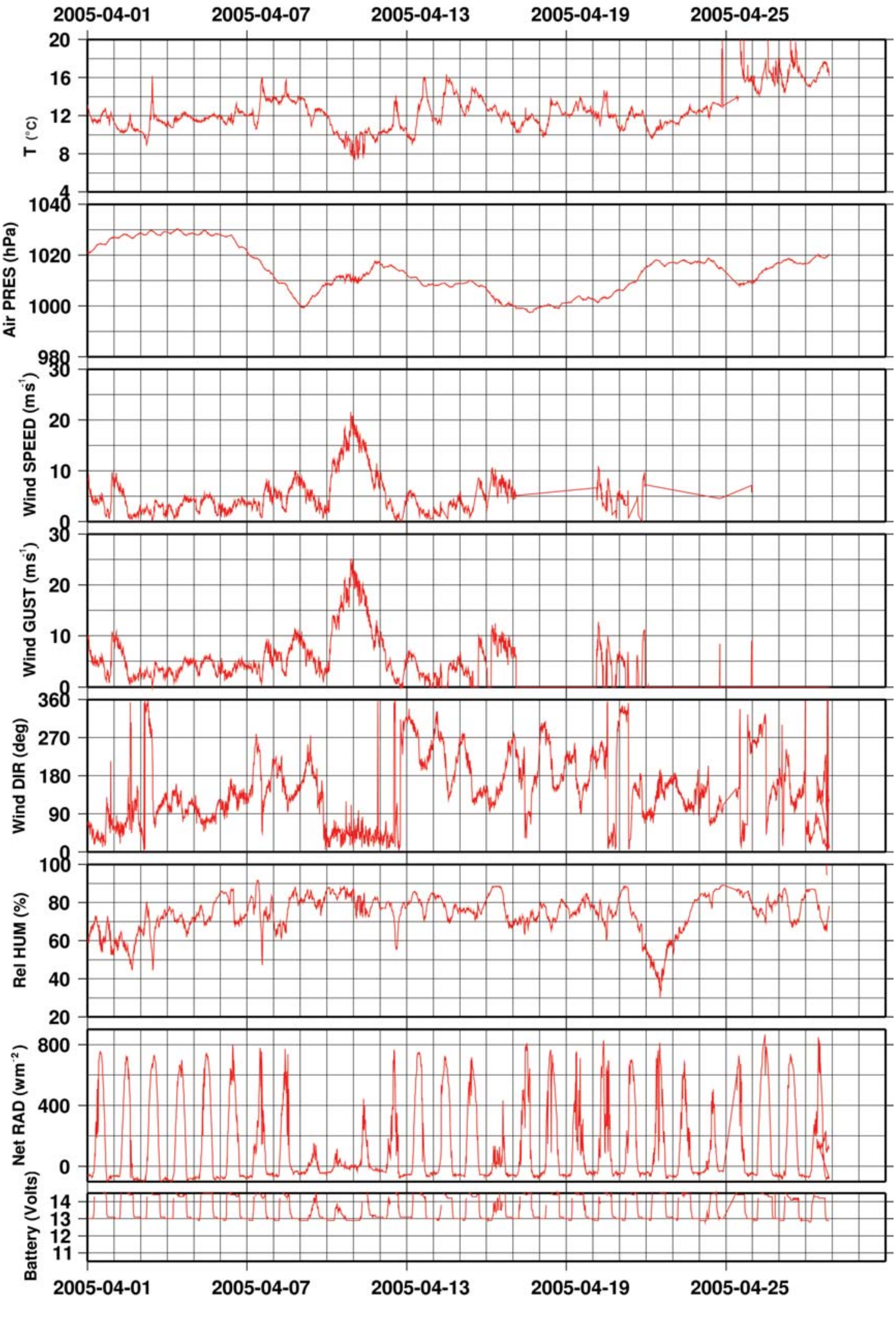

Fig. 17. METEO data, April 2005

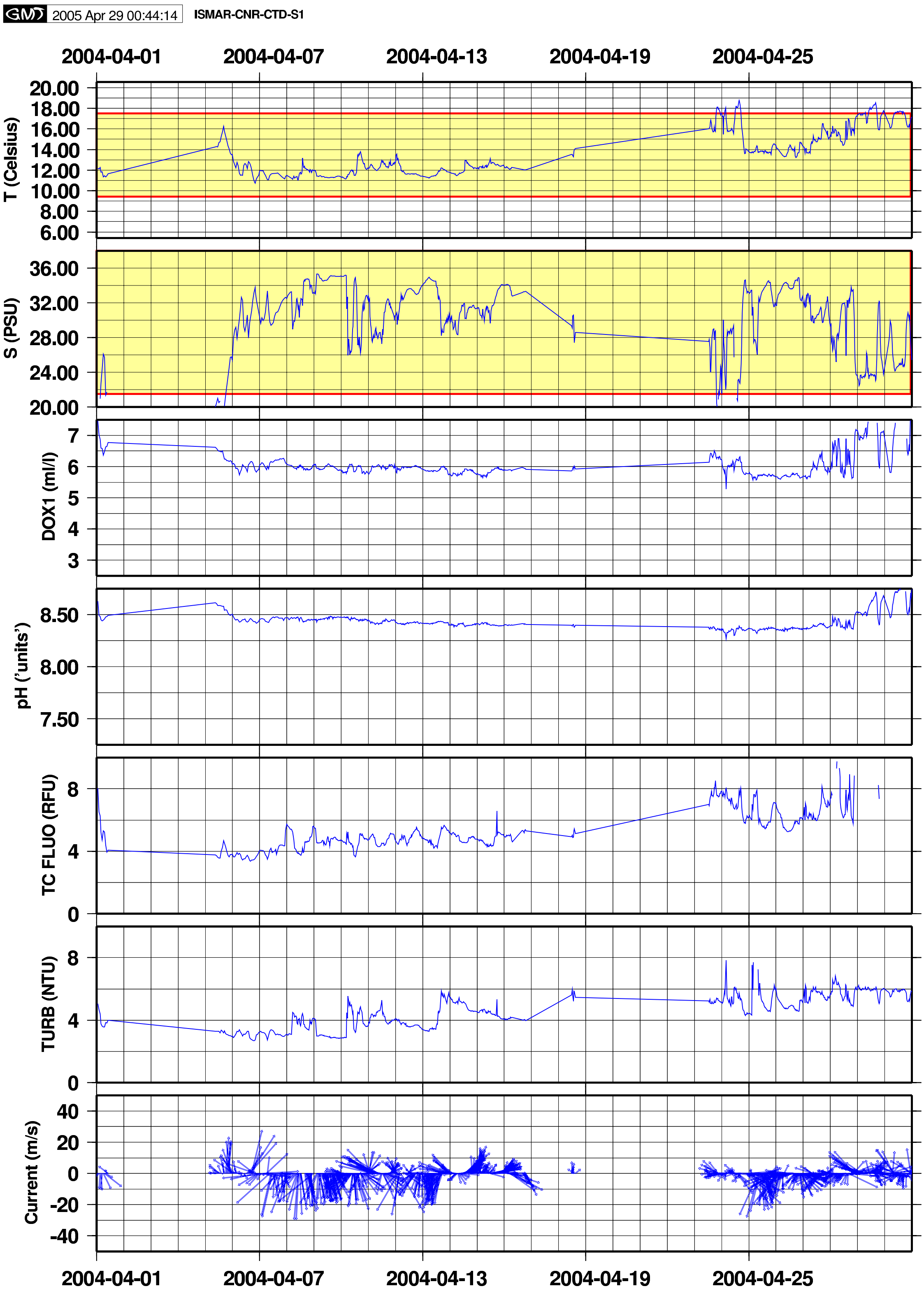

Fig. 18. CTD data, April 2004

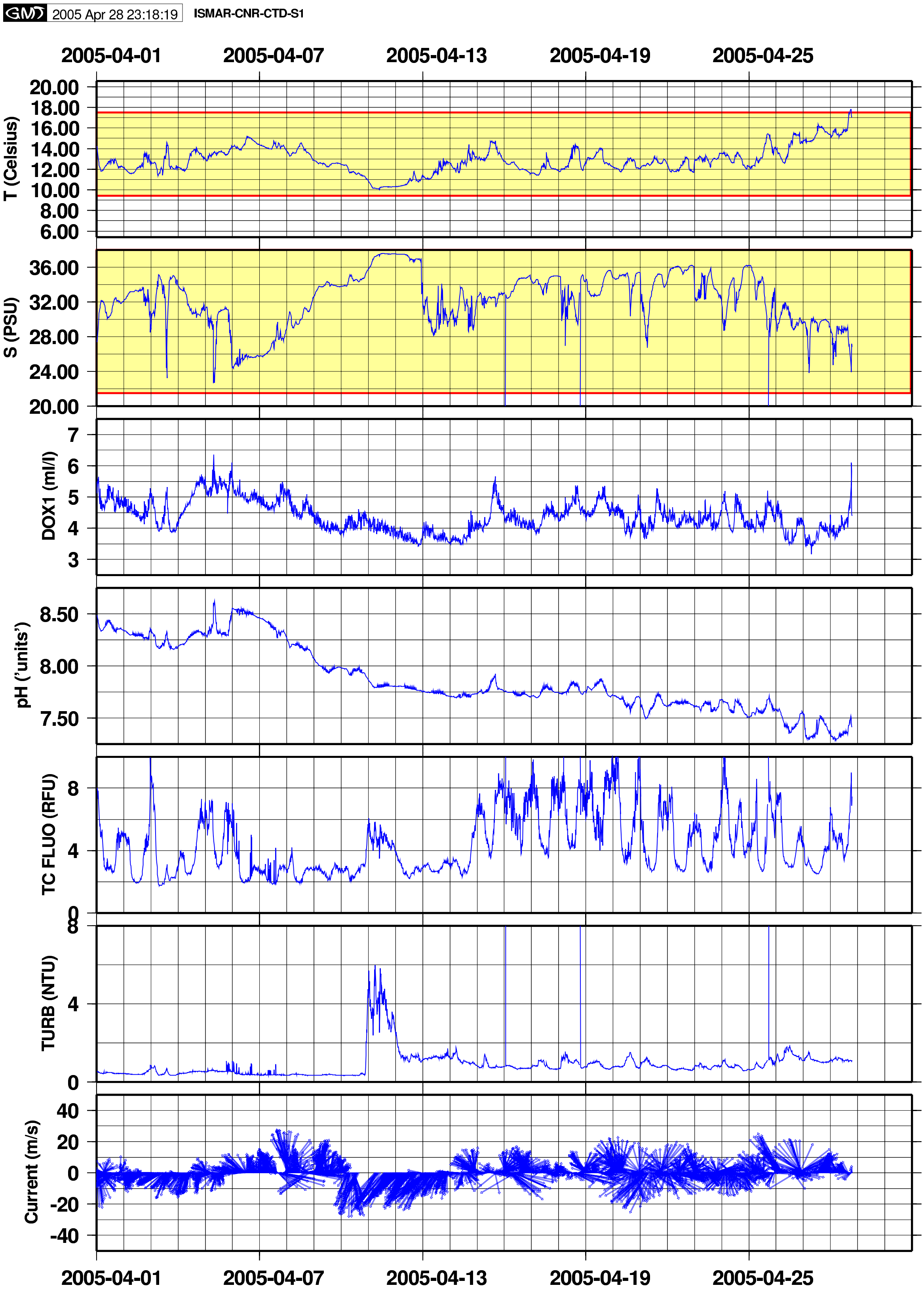

Fig. 19. CTD data, April 2005

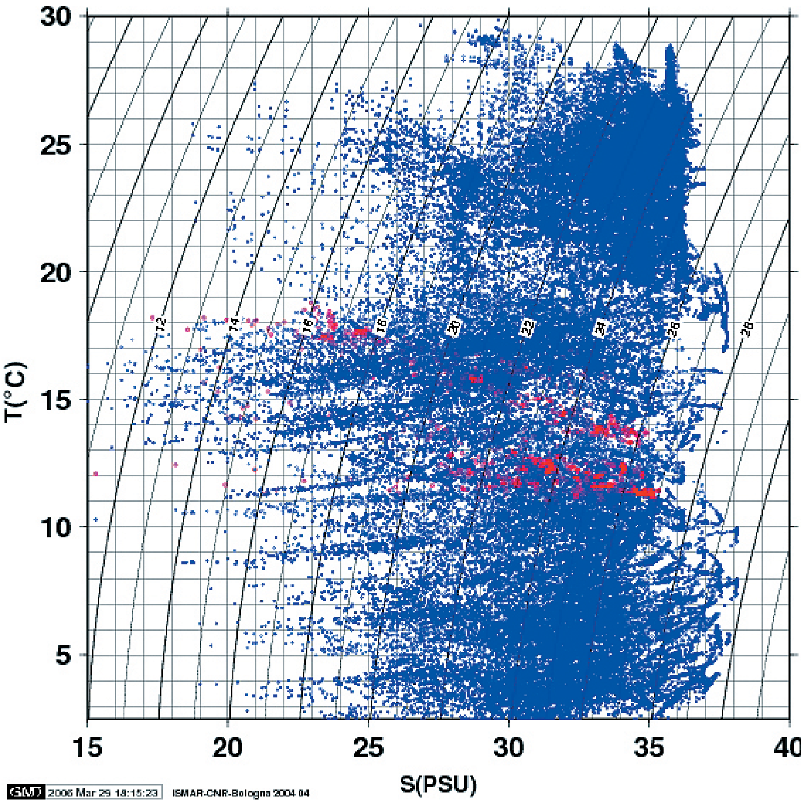

Fig. 20. TS diagram, April 2004

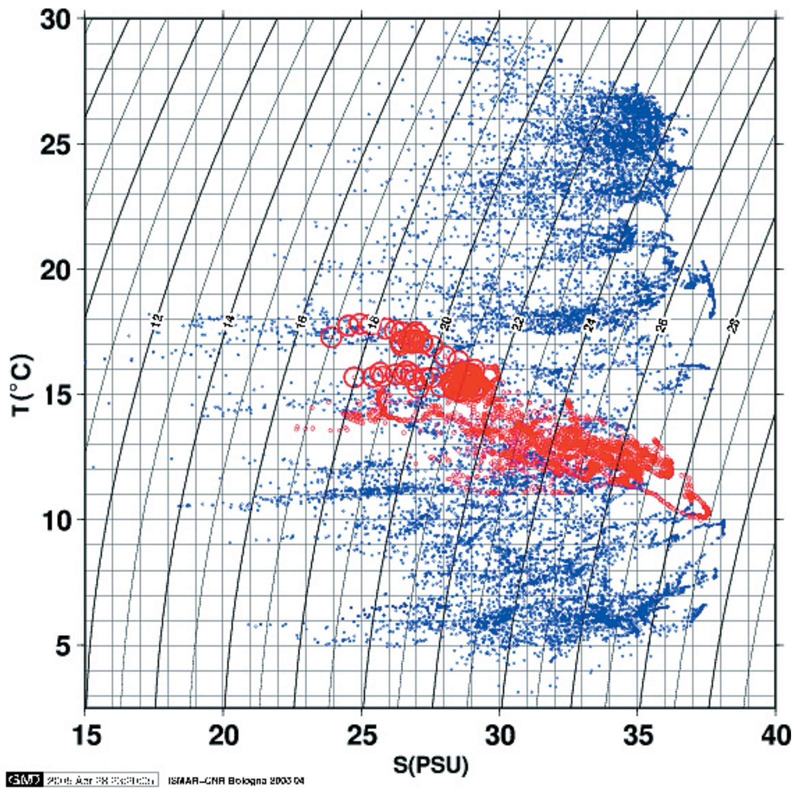

Fig. 21. TS diagram, April 2005

CONCLUSIONS

Jointly with the continuous field work controling and maintaining the S1 buoy site, including tests and new instrument deployment plans, the WWW system we have presented here has served on the Internet the S1 buoy data for a year since April 2004 with a minimal effort required for its maintenance.

Further work is being designed in order to standardize the procedures for:

A) handling of other data sources (delivery, coding of information, etc.) and their processing and input to database

B) data presentation (time series, plots, etc.) and delivery (QC, known formats etc.)

C) possible integration between different WWW servers and database servers

D) backup and mirroring of the system, in order to provide high availability services.

Points A and B are the most important and critical ones, requiring coordination at different levels, while points C and D may be easily addressed, when the software architecture conforms to well known standards.

ACKNOWLEDGEMENTS

Work funded by CNR, E.Romagna ARPA SOD and ADRICOSM. We thank N. PINARDI for continuous help and suggestions, and S. SIMONCELLI for the climatological data in the S1 area. At the ISMAR, the S1 data flow relies on free Open Source software in a non-proprietary hardware and software environment, such as the WWW server Apache and the programming language Perl, and the GMT package, integrated in a GNU/Linux box. We are indebted to the huge number of individuals that have created and keep going this fruitful and open-minded cooperative model.

REFERENCES

ADRICOSM. http://www.bo.ingv.it/adricosm.

ARPA E. ROMAGNA. SOD, Servizio Operativo Daphne, http://www.arpa.emr.it/daphne.

ARPA E. ROMAGNA. SIM, Servizio Idro. Meteorologico, http://www.arpa.emr.it/sim/pagine/home/index.

ARTEGIANI, A., D. BREGANT, E. PASCHINI, N. PINARDI, F. RAICICH & A. RUSSO. 1997a. The Adriatic Sea general circulation. Part I: Air-sea interactions and water mass structure, J. Phys. Oceanogr. 27: 1492-1514.

ARTEGIANI, A., D. BREGANT, E. PASCHINI, N. PINARDI, F. RAICICH & A. RUSSO. 1997b. The Adriatic Sea general circulation. Part II: Baroclinic circulation structure, J. Phys. Oceanogr., 27: 1515-1532.

BLUMBERG, A. F. & G. L. MELLOR. 1987. A description of a three-dimensional coastal ocean circulation model, In Three-Dimensional Coastal Ocean Models, N. S. Heaps (Editor), 1-16. American Geophysical Union, Washington, DC.

BUNCE, T. 2004. Perl DBI, http://perl/dbi.org .

COMMUNICATION TECHNOLOGY. http://www.comm-tec.com, Cesena, Italy.

ECWMF. http://www.ecmwf.int.

GIORDANO, P., G. BORTOLUZZI, M. RAVAIOLI, F. FRASCARI. 2005. ISMAR ADRICOSM Project Final Report, Bologna.

MFSTEP. http://www.bo.ingv.it/mfstep.

MONTANARI, R., N. PINARDI & S. SIMONCELLI. 2005. Climatologia dell'idrodinamica della zona costiera della E. Romagna (Climatology of the hydrodynamics of the E. Romagna coastal zone), in preparation, ARPA-CIRSA (Univ. Ravenna).

ODDO P., N. PINARDI, M. ZAVATARELLI & A. COLUCCELLI. 2006. The Adriatic basin forecasting system. Acta Adriat., 47 (Suppl.): 169-184.

POM. http://www.aos.princeton.edu/WWWPUBLIC/htdocs.pom.

STEIN, L. 2004. CGI.pm, a Perl5 CGI Library, http://stein.cshl.org/WWW/software/CGI/cgi docs.html.

WESSEL, P. & SMITH W. H. F. 1995. New version of the Generic Mapping Tool released, EOS Trans. AGU, p. 329, see also URL: gmt.soest.hawaii.edu.

ZAVATARELLI, M. & N. PINARDI. 2003. The Adriatic Sea modeling system: a nested approach, Ann. Geophys., 21: 345-364.

S1 stanica, rijeka Po: rukovanje podacima i prikaz podataka

Giovanni BORTOLUZZI [1*], Franca FRASCARI [1], Patrizia GIORDANO [1], Mariangela RAVAIOLI [1], Giuseppe STANGHELLINI [1], i Alessandro COLUCCELLI [2]

[1] Institut za istraživanje mora, sjedište u Bolonji - pomorska geologija, (ISMAR-CNR), Via Gobetti 101, 40129 Bolonja, Italija

[2] Nacionalni institut za geofiziku i vulkanologiju (INGV) - Odsjek u Bolonji, Via Donato Creti 12, 40129 Bolonja, Italija

**Kontakt adresa, e-mail: g.bortoluzzi@ismar*

SAŽETAK

U radu je predstavljen tehnički postav meteorološko-oceanografske plutače na položaju S1 južno od delte rijeke Po. Stanicu su postavili ISMAR CNR iz Bolonje, u suradnji s lokalnom agencijom za zaštitu okoliša (ARPA) iz pokrajine Emilia-Romagna i ADRICOSM-om. Diskutirana su sama struktura plutače i arhitektura tijeka podataka s naglaskom na prikaz podataka na web-u. Predložena je, također, i moguća integracija s ostalim postajama, izvorima podataka i ostalim operativnim meteorološko-oceanografskim aktivnostima.

Ključne riječi: plutače, obrada podataka, web stranice