Part 4

The Archive and Data Base

by
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4.1 Introduction

The requirement to collect, check and make readily available to the scientific community the data measured during the Fronts and Atlantic Storm-Track Experiment is important to achieving the scientific objectives.

The FASTEX Core Steering Group (CSG) gave the Météo-France/Centre National de Recherches Météorologiques (CNRM) the responsibility for the design of the FASTEX Data Archive in October 1995. CNRM, in consultation with the FASTEX scientific community, recorded the Specialised Data Archives who take responsibility in the dissemination of the raw data and developed a Central Archive (FCA) to provide the community with a large part of the quality controlled measurements that are easily accessible, via the Internet, to all interested investigators.

This part of the report shows the original elements of this archive, which made possible the availability of some data sets in March 97, two weeks after the end of the field phase, and describes the different services and data sets available from the FASTEX Data Archive. Section 4.2 explains the FASTEX Data Archive design, with the locations of the Specialised Data Archives. Documentation and graphics available on-line on the FCA are described in section 4.3. The FCA building processes are described in section 4.4, and its technical design in section 4.5. Information on data set availability is given in section 4.6 and FCA checking procedures in section 4.7. A summary of the radiosonde quality control conducted by the University Corporation for Atmospheric Research/Joint Office for Science Support (UCAR/JOSS) is included in section 8.

4.2 FASTEX Data Archive overview

FASTEX leadership made a strong commitment to provide timely and efficient access to all special data sets collected during the field phase of the program. The primary point of contact and repository of archived data is the FASTEX Central Data Archive (FCA). Other organisations and agencies, however, also maintain subsets of FASTEX data. Collectively all of these data centres are referred to as the FASTEX Data Archive (FDA). The FCA Internet address is (see Fig. 4.1):

http://www.cnrm.meteo.fr/fastex/

and its Email address is:

fastex-dba@cnrm.meteo.fr.

The FCA contents include technical documentation about the measurements made during FASTEX, the on-line field catalog built during the field season and the locations of the specialised data bases. Many graphics are available, such as maps from the Météo-France operational forecast model, and images and products from satellites. On-line data access is provided through a client/server configuration based on a World Wide Web (WWW) Interface.

The main function of the FCA is to provide processed data, in geophysical units. The main part of the data sets processed from the raw data archived in the specialised data bases are available in the FCA. Some processed data sets are only available in the FCA. When it is possible, the measurements from several instruments are provided in the same format. Some raw data sets are also retained on the FCA for long-term archival.

Figure 4.1: *The FASTEX Home Page on the INTERNET and its address.*

The main function of the specialised data bases is to provide the scientific community with raw data from the research instruments involved in FASTEX. Some qualified data sets processed from the archived raw data, and provided in the specialised data bases own format, could be available from the specialised data bases.

The list of the specialised data bases is in section 4.2.3.

4.2.1 Data Policy for the FASTEX Experiment

Data Access

Access to the FASTEX Data Archive is consistent with World Meteorological Organisation (WMO) Resolution 40. Accordingly, use of the FASTEX Data Archive is unrestricted for scientists who utilise the data for research and educational purposes. The use or redistribution of data for commercial purposes may engender certain restrictions that vary depending on the source and type of data under the guidelines of WMO Resolution 40.

The FASTEX Data Archive sites provide a "best" effort in data validation. However, data sets are provided "as is" without warranty of any kind.

Data Attribution

In all cases, proper acknowledgements should be given in publications that utilise FASTEX data to specific scientists and institutions that made the collection of data possible.

Where appropriate, all authors considering publication of FASTEX related research results should offer co-authorship to investigators that had a primary role in the collection of data utilised in the study.

4.2.2 Requirements for the FASTEX Central Archive

Requirements for the FCA call for:

- Facilitated access to selected data of interest to the international FASTEX scientific community. All FASTEX data are not available on the FCA, but a large subset of the data collected during the field phase are on the FCA.
- The long-term archival of the original FASTEX data.
- A catalog of available data, in the general FASTEX Data Archive.

Archive data validation

The FCA takes no responsibility in the FASTEX data validation. This is the data provider's responsibility. The data providers are the best persons to provide scientists with well validated data sets. However, the FCA takes a global view from all the data collected. It is also the first contact between FASTEX data users and data providers. The FCA can perform a global check when a scientist informs it of a possible problem. The FCA can also compare different data sets. The technical design of the FCA (section 4.5) make this checking easier.

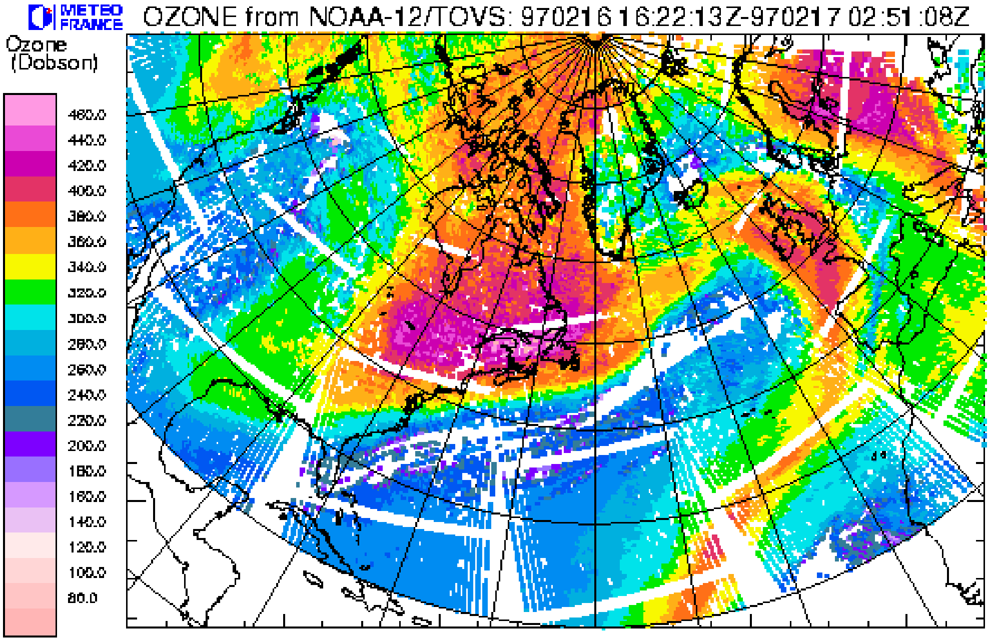
For each problem appearing, the FCA informs the data provider. The data provider sends a new data set, well validated, to the FCA, or, for easy corrections, accepts that the FCA modifies the data set. The new data set replaces the older, and is quickly available for all the FCA users. The FCA always gives users access to the most recent versions of validated data sets.

4.2.3 The specialised data bases

The specialised data bases take responsibility in the raw data distribution for the instruments involved in FASTEX. They are specialised in the data processing and can also distribute validated data sets. Some specialised data bases maintain WWW sites. Here is the list of the specialised data bases:

- NCAR/RAF (P.O. Box 3000, Boulder, Colorado 80307-3000, USA) for all NCAR aircraft data (Electra and Lear 36)
- NOAA/NSSL (3450 Mitchell Lane, Boulder, Colorado 80301-2260, USA) for all NOAA aircraft data (Gulfstream IV and WP-3D). The on-line documentation site: http://mrd3.mmm.ucar.edu/FASTEX/FASTEX.html provides informations about the coordinated operations in the Mesoscale Sample Area with the turboprop aircraft (NCAR Electra, NOAA WP-3D, UK-C130).
- DERA/Meteorological Research Flight (Farnborough, Hants GU14 6TD, UK) for the UKMO aircraft data (UK-C130).
- University of Reading/JCMM (Whiteknights Road, PO Box 240, Reading RG6 6FN, UK) for the UKMO aircraft dropsondes. The on-line documentation site: http://www.met.rdg.ac.uk/FASTEX/ offers an overview of the Intensive Observational Period during FASTEX.
- INSU/CETP (10-12 avenue de l'Europe, 78140 Vélizy, France) for the airborne radar data (NOAA WP-3D and NCAR Electra)
- UCAR/JOSS (P.O. Box 3000, Boulder, Colorado 80307, USA) for the high resolution soundings. The sounding data set and the FASTEX on-line field catalogue are available at the following address: http://www.joss.ucar.edu/fastex/

Figure 4.2: *Total Ozone content from NOAA-12/TOVS for 16 February, 1997*



- Météo-France/CMS (B.P.147, 22302 Lannion Cedex, France) for NOAA 12 & 14 HRPT, Meteosat and GOES-EAST Imagery.
- The Hurricane Center for the US Air Force aircraft data (USAF C130). Data and operation reports are available on the WWW site: http://www.hurricanehunters.com .

4.3 FASTEX Central Archive overview

In the FASTEX Central Archive, documentation and/or data can often be reached in two ways: by instrument, or by data set. Instrument refers to all data collected by the same aircraft, ship or site. Data set refers to the same kind of measurements. Some instruments made the same kind of measurements. For example, six aircraft involved in FASTEX dropped sondes. All the ships, as well as radiosounding ground stations, launched soundings. When several instruments provided the same type of measurements, all the data are available in the same format and form a data set.

4.3.1 The technical documentation

A description of the instruments involved in FASTEX, including for each instrument a summary of the instrumentation, the period of measurements, and measurements reports, is available on the WWW site. The data provider is also noted, and when it is possible, WWW sites with technical documentation are linked. This documentation provides an overview of the measurements made during FASTEX by a particular instrument, aircraft or ship. A list of the data sets including measurements of this particular instrument is provided.

The documentation of the data sets available or planned to reside at the FCA, with a list of the different instruments which provided these measurements, provide information about data format, checks and control procedures applied.

A detailed description of the data available, listed as data sets as well as instruments, is updated when new data are available, or when some data are corrected. Information about the data number and position, and the state of qualification of the data are available. All past data updates are mentioned.

Some technical documents, such as the “FASTEX Operations Plan” (D. Jorgensen *et al.* 1996), are available in postscript format.

4.3.2 The FASTEX On-Line “Real-Time” Field Data Catalog

The Daily Operations Summaries, the forecasts, scientist logs and summaries, were included daily during the FASTEX field phase in an on-line catalog provided by the FASTEX Operations Coordination Team at Shannon (Ireland). This catalog also included special imagery or graphics such as the GOES-EAST/Meteosat Infrared imagery mosaic, 6 hourly winds deduced from GOES-EAST by the University of Wisconsin (Velden *et al* 1997), forecast maps from the Ireland Model HIRLAM, the daily consensus forecast, and the sea state forecast for the FASTEX ships. Built and updated daily by UCAR/JOSS during the field phase, this catalog is available both on the UCAR/JOSS WWW site and on the FCA site.

4.3.3 The graphical documentation

The graphical documentation collected during the field phase in the “Real-Time” Field Data Catalog was updated in delayed time on the FCA site. New satellite products and many charts from the ARPEGE Model were included. A new interface, with animation capability, was developed.

Satellite Imagery and products

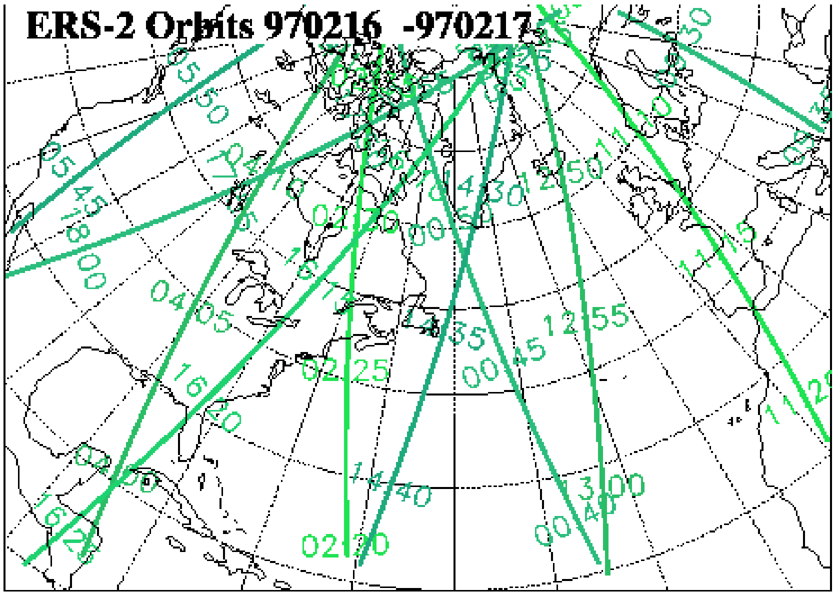
The 6 hourly mosaic imagery from the infrared channel of the GOES-EAST and METEOSAT geostationary satellites are available for each day of the FASTEX field phase. The domain is the North Atlantic ocean. The main part of these images were provided in real-time to the field Catalog by Météo-France. The remaining part was processed in delayed time, from the data files available in the FCA.

The SSMI Imagery provided by NOAA/NESDIS in support of the FASTEX Experiment, and available in real time on its site, was archived at the FCA and is now available on the FCA site. This imagery included, on the North Atlantic domain and each 2 hours, the most recent data from the SSMI Imagers aboard the three DMSP polar satellites. Available products are rain rate, rain, water vapour and wind speed (Hollinger *et al* 1987).

The Total Ozone content data was processed by Météo-France/CNRM from the raw data files of the NOAA 12 & 14 TOVS sounders (Lefèvre *et al* 1991). Data files, as well as maps, are available in the FCA. Two different maps sets are available: the first set shows all the measurement from a satellite during 12 hours (Fig. **??**), the second shows the measurements for each satellite pass.

The satellites ephemerides were provided during the field phase by the CNES (France) and the Air Force Institute of Technology (USA). The ground trace was calculated for the NOAA 12 & 14, ERS-2, DMSP 10,11 & 13 and TOPEX/POSEIDON satellites. Daily graphics are available for each satellite (Fig. 4.3).

Figure 4.3: *ERS-2 Ground trace for 16 February, 1997*



The Maps from the analysis of the ARPEGE Meteorological Model

Special outputs of the analysis of the Météo-France ARPEGE Meteorological Model were processed during the FASTEX Experiment. The following 6 hourly fields are available on the North Atlantic domain: mean sea level pressure, temperature and wind at the surface and at the 500 hPa level, geopotential height at the 500 and 300 hPa levels, and vertical motion at the 500 hPa level. (Fig. 4.4)

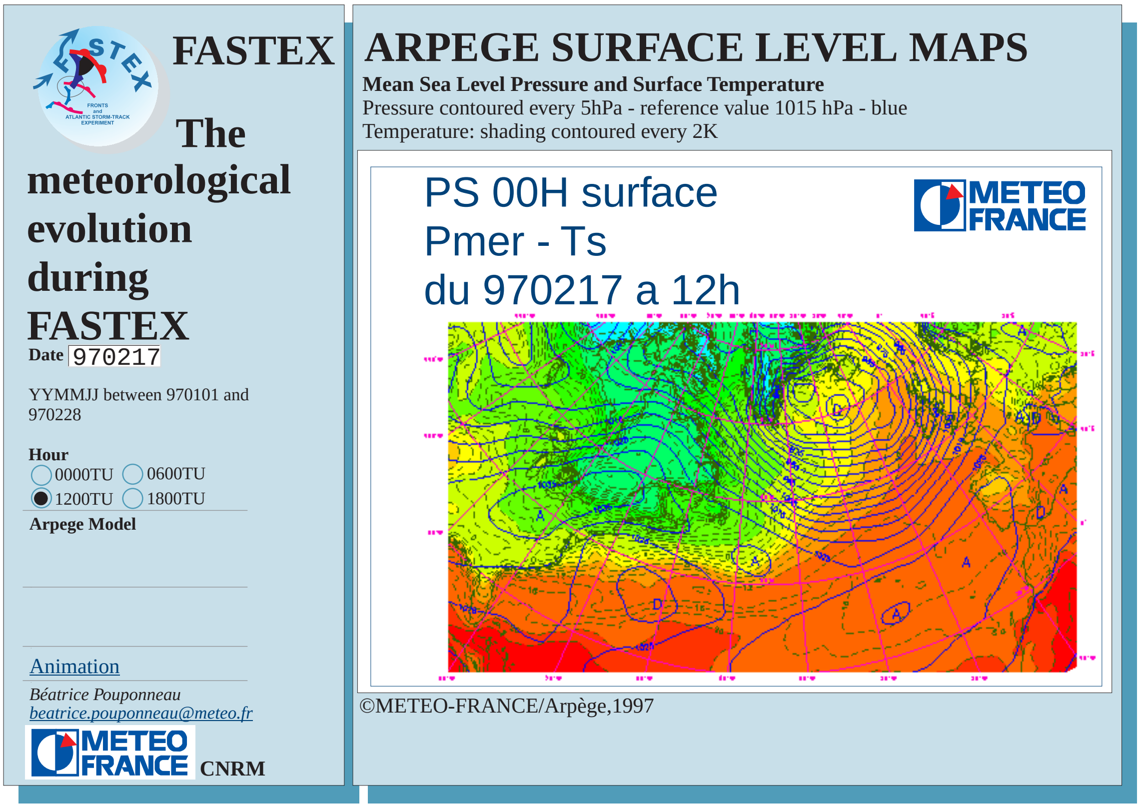
4.3.4 The data distribution

The data may be ordered on-line, through a WWW client/server configuration. The files requested are extracted from the FCA and put on an FTP server in near real-time. This provides the FASTEX scientists access to the up-to-date version of the data. CD-ROMs will be edited when the Archive content includes mainly validated data sets.

Through the data selection interface, both the instrument type or/and the specific data sets can be selected. The time and position windows can be specified. The FCA site returns information about the number and the location of the data selected. The choices can then be modified interactively. At the first request of data, the new user must subscribe to the FCA, and to state his agreement with the FASTEX data policy.

The data requests are automatically processed within 30 minutes after the end of the data selection process. Fields are extracted from the FCA Database Management System or copied from the FCA storage disks, and sent with a documentation to the FTP server. An email is sent to the FASTEX user with information about the location of the files extracted.

Figure 4.4: *The WWW page for ARPEGE map access*



The main part of the data are sent in ASCII format, which is easily readable for the major part of the users. Some data sets, such as the model fields or the satellite imagery, are stored in WMO GRIB format. Some very specialised data sets, such as the Electra in-situ measurements or some satellites products, are sent in its original form, along with a method to read them.

The documentation sent with the data includes information about the data origin, the data processing and eventually the corrections made, rights to be applied for these data and format description.

4.4 History

To design the FASTEX archive, lessons of the past were provided by the data management of previous experiments, and particularly the Tropical Ocean Global Atmosphere Coupled Ocean Atmosphere Response Experiment (TOGA-COARE, Webster and Lukas 1992) and the PYRenean EXperiment (PYREX, Bougeault *et al* 1990). These experiments are not comparable in term of size of the data archive, or by the number of laboratories and countries involved in. The design of the TOGA-COARE and PYREX archives are different. However, a significant effort in data management, validation and delivery was done for these two archives. We retain from the TOGA-COARE data management the use of specialized centers for data validation,

Table 4.1: *Steps of the FASTEX Central Archive Construction*

FASTEX Archive building	
Summer 95	Project defined
Fall 95	Project accepted by the FASTEX Scientific Steering Group
Spring 96	Agreement for the satellite products delivery The satellite Imagery to be processed at Météo-France/CMS is defined Contacts with the scientific teams who provide data Definition of the FASTEX data bases requirements
Summer 96	FCA Computer and Software Installation FCA WWW site is opened FASTEX Data Policy is written
Fall 96	Contacts with the meteorological services which provide the high resolution sounding data sets Software Interface between the Météo-France operational archive and the FCA for GTS data sets is written Software Interface between the FCA Users and the FCA is written
FASTEX Experiment Field Phase	
January - February 97	Operational data received through the GTS are included in the FCA High resolution sounding data are sent by the meteorological services to the FCA Beginning of the inclusion, and the checking, of the high resolution sounding data in the FCA Satellite Ephemerides are archived SSMI images from NOAA/NESDIS are archived
Data availability on FCA	
March 97	The FCA is opened, some data sets received from the GTS are available to the FASTEX community, consistent with the WMO Resolution 40
Spring 97	High resolution soundings from the ground sites participating in FASTEX Operational Surface measurements and high resolution soundings from the 4 FASTEX ships High resolution soundings from the ASAP ships participating in FASTEX Low resolution dropsonde data set from FASTEX aircraft
Summer 97	Full satellite Imagery ARPEGE analysis fields High resolution soundings from the R/V Knorr during LabSea Experiment
Fall 97	1s in-situ measurements from US Research aircraft (Electra, WP-3D, Gulfstream IV) Reflectivity Composite images from aircraft Radar (WP-3D) First data set of the high resolution US dropsonde High resolution UK-C130 dropsonde data set during some IOPs
Winter 97	Full High resolution sounding data set, including UCAR/JOSS QC flags EGOS buoy data set validated by Météo-France/CMM R/V Knorr 15 min and 1 hour surface measurements validated data set R/V Le Suroît 1 min surface measurements validated data set Total Ozone Content from NOAA/TOVS TOPEX/POSEIDON Wind/Wave product Surface measurements from some World Weather Watch principal ground stations
Spring 98	Full High resolution UK-C130 dropsonde data set Real Time profilers data set from the R/V Knorr and the R/V Le Suroît Corrected High resolution US dropsonde data set
Summer 98	ERS-2 Wind product Profilers data set from the European network

specialized data bases for raw data distribution, on-line access and a primary point of contact. From the PYREX experiment, a central point for processed data archive and delivery, the necessity of a dialog between the archive manager and the data providers, and between archive users and archive manager to point out and correct erroneous data, the delivery of up-to-date data sets.

In another connection, a major problem appears after the field phase of meteorological experiments: scientists wish to work quickly with the data collected, but the data providers need time to validate the data sets. Data exchange between scientists during the field phase, or just after, force the scientists to work with real time data sets. Fairly often, validated data sets, when they are available, are not in the same format. These practices bring difficulties in the use of validated data sets.

Following these observations, the FCA was planned to provide timely and efficient access to special data sets collected during the field phase of the FASTEX experiment. The FCA was planned a long time before the field phase. The Internet facilities were largely used, before the field phase for the preparation of the archive, and during and after the field phase for sending the data to the archive, and to provide efficient access to the data. Table 4.1 presents a summary of the steps of the FASTEX Central Archive construction.

The FASTEX Archive was designed eighteen months before the field phase. The plan was presented and accepted during the first FASTEX Scientific Steering Group meeting in October 1995.

During the year 1996, the agencies which provide data were contacted in order to establish collaboration. In particular, satellite agencies and data providers for satellite products were contacted, as were meteorological agencies which provided the high resolution soundings from ground stations and Atmospheric Sounding Automated Program (ASAP) ships. In the Météo-France service, several teams were contacted and proposed their collaboration for data retrieved through the Meteorological Global Telecommunications System (GTS), imagery computing and buoy supervising. The Central Archive hardware and software technical environments were installed. The WWW site, with data sets and instruments documentation, was opened in summer 96. The software for data archival was written. Figure 4.6 presents a schematic of the important components of the FCA architecture.

During the field phase, many data were processed and archived:

- The Météo-France/Centre de Météorologie Spatiale (Lannion, France) processed the imagery received in real-time from METEOSAT and GOES-EAST. The remaining part of the METEOSAT imagery, sent by EUMETSAT to the CMS, was also processed. The HRPT from NOAA 12 & 14 for the CMS coverage zone was received and processed.
- Data from the World Weather Watch and some FASTEX data, received through the GTS at Météo-France, were decoded and archived in the FCA. This includes a fair amount of the dropsondes.
- Some high-resolution soundings from ground stations were verified by the Meteorological services and sent to the FCA.

The FCA data archives were open 2 weeks after the end of the field phase. Many data sets received from the GTS have been available since this date for the FASTEX community:

- sounding data from TEMP and TEMPSHIP messages
- real-time buoy data from BUOY messages

- surface data from commercial ships and some data from the FASTEX ships (SHIP messages)
- Commercial aircraft data (AIREP, ACARS and AMDAR messages)

The complete satellite imagery , many fields from the ARPEGE model analysis, and low resolution data from the FASTEX dropsondes were available 4 months after the field phase.

Some FASTEX measurements were quickly validated by the data providers. The high resolution sounding data from FASTEX ships, ASAP ships and ground stations were available between 2 and 6 months after the field phase. The in-situ measurements from NOAA and NCAR aircraft (WP-3D, Gulfstream IV and Electra) were available 6 months after the field phase.

The complete high resolution sounding data set, verified both by FCA and UCAR/-JOSS has been available since the winter 97-98 with the UCAR/JOSS quality control flags.

During the year 1998, many data sets were included in the archive, or replaced by validated data.

The FASTEX Archive will be in its final form during the year 1999.

4.5 FASTEX Central Archive Technical Constitution

4.5.1 A data base built around a Database Management System

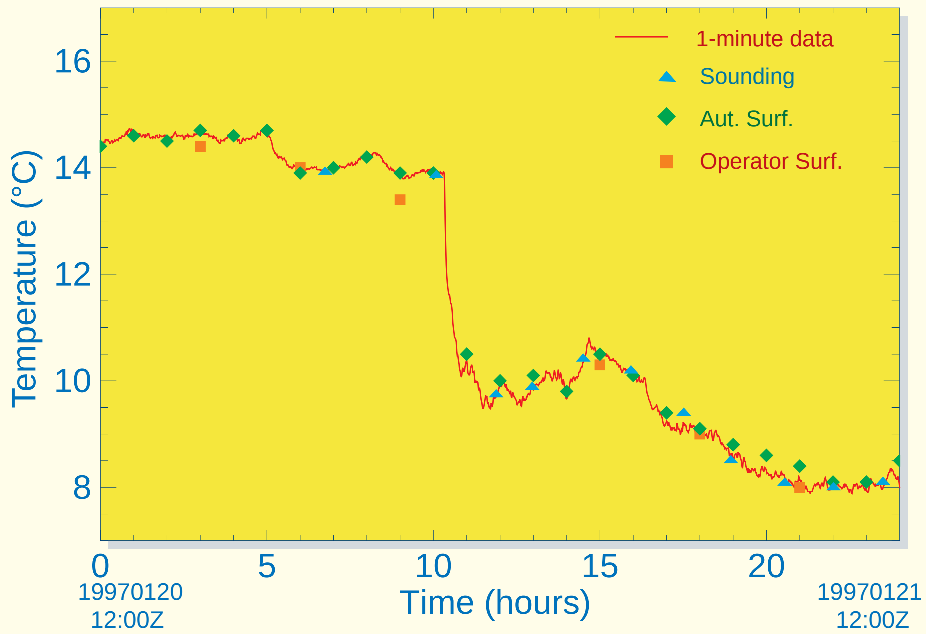
The FASTEX Central Archive was designed with these main ideas:

- exactness for the data management
- easiness for the data checking
- facility for data sets cross validations
- uniqueness for the accessible archive
- easiness to insert new data sets
- interactive access to all the available data sets
- quickly sending the available data sets, without human interaction

All data bases have to establish a catalog of the data archived; usually, this catalog is maintained by a Database Management System (DMS). This is also the case for the FASTEX Central Archive. The FCA DMS catalog is interfaced with the WWW server, and produces for each request exact and up-to-date information of the available data.

The FCA has to meet several conditions. The FCA has to send data, coming from several instruments but belonging to the same data set, in the same format. These data sets have to be verified, and sometimes replaced by a qualified data set. Any user could have access at any time to the best available data sets. The format must not change, as the data set is replaced. To satisfy all these requirements, the Database Management System does not only manage the data catalog, but also manages a large part of the data sets. Every parameter of a measurement is stored in its physical unit. So, to compare and compute the same parameter coming from different instruments or data sets is easily done. For example, the temperature measurements aboard the R/V Le Suroît during one day in IOP5, coming from the automatic station, the

Figure 4.5: *An example of the comparison of measurements coming from different data sets and instruments. The temperature measurements are from the R/V Le Suroît: 1-minute data, from research instrumentation (continuous line), operational surface measurements provided by the Météo-France automatic station Batos (rhombs) and the routine messages sent by the crew (squares), potentiel temperature at the surface pressure calculated with the first sonde measurement (10 s after launch) and the sounding ground pressure (triangle).*



operator measurements, and the soundings at low levels are compared to the 1-minute surface data on figure 4.5.

Each data set is introduced in one or several DMS tables. As an example, the ship surface measurements data set, archived from the SHIP messages, is inserted in a table named 'SHIPS'. The 'SHIPS' table is composed of as many columns as informations informed in a SHIP message. The informations from each message are inserted in a row of the 'SHIPS' table. The pressure measurement, in hPa, is inserted in the 'Pressure' column, the temperature one, in degrees C, is inserted in the 'Temperature' column, etc...

The DMS functionalities are used to verify, when it is possible, the uniqueness of each measurement and to apply the gross-limit checks. A measurement inserted in the DMS must satisfy all the specifications. As an example, each measurement in the 'SHIPS' table has a site identifier, a date and time, and a location in latitude and longitude. These specifications are unique, and the date and location are bounded. All the measures are bounded numbers, or are coded as a chain of characters as defined in the WMO codes. If one of the specification rules is not satisfied, the measurement is rejected. Human intervention is necessary, to verify the measurement, correct it (or the software) if it is possible, or reject definitively the information. Many anomalies were detected in this manner, in the data sets sent to the FCA.

When a new measurement is inserted, each measure can be selected independently. The statistics tools and group selection possibilities of the DMS are used for validation. The quality control procedures applied to each data set are described in section 4.7.

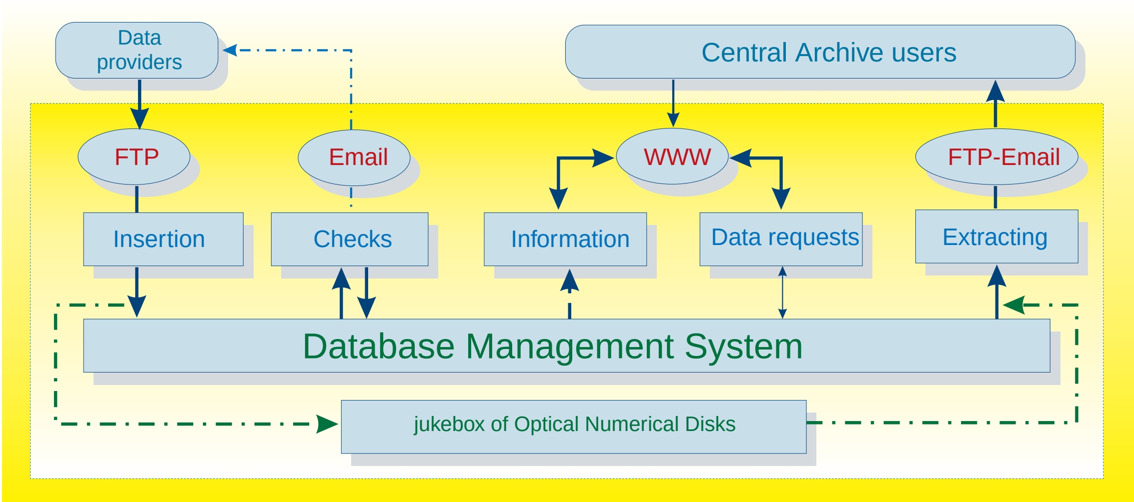


Figure 4.6: *FASTEX Central Archive Structure*

The DMS functionalities are also used for data updates. Uniqueness and gross-limit checks are automatically applied for each update. The DMS functionalities for updating independently each row/column are very useful to minimise the human errors. For example, these functionalities are used to modify the quality flags without data modification. A timestamp is updated for each line when a column is updated. This information is useful to verify if a new data set, well validated, includes all the data previously inserted in the DMS. The timestamp is sent with the data for each request, so, any user is informed of the date of the last update.

As soon as a measurement is inserted (or updated) in the DMS, it is available for all the FCA users.

The data requests are defined through a WWW form. The WWW server sends the request to the DMS. The DMS responses allow the user to adjust, interactively, the request to the data actually available. When the request is definitely written, it is archived in the DMS. Some minutes after, typically 30 minutes, an automatic process asks the DMS, the data requested are extracted from the DMS, and the files are written. The files are put on an FTP server and an email is sent to the user.

Data extracted from the DMS are written in ASCII files, each measure in physical units. The data extracting from the DMS is done for each request. The typing format was defined when the data set table(s) is(are) defined, and stored in the DMS. This allows any user to have access to the up-to-date data sets at any time, and every time in the same format.

4.5.2 The data sets structure

Measurements stored in the FCA are classified according to the measurement method and/or the processing method. The method used to build the PYREX data base (Bougeault *et al* 1993) was extended to all the FASTEX data sets. For example, the surface measurements received from the ground stations (SYNOP messages) are not included in the same data set as the surface measurements received from the ships (SHIP messages). Parameters are not exactly the same, and the site location is fixed in the SYNOP messages, not in the SHIP messages. The sounding measurements are included in two different data sets, according to the data processing. The high-resolution data, sent by the FASTEX participants, are included in the 'high-resolution sounding data set'. The soundings processed as per WMO conventions, in standard and significant levels, are included in the 'low-resolution sounding data set'. This data set includes soundings received from the GTS (TEMP messages) and soundings provided by the FASTEX participants. A type identifier is attributed to each class measurement.

The archive structure is not the same for all the measurements:

- For measurements in a single point, data set identifier, site identifier, and date assume the uniqueness of the measurement. The data set is stored in one table of the DMS.
- For profile measurements, to add a level identifier is necessary to assume the uniqueness of the measurement. This level identifier depends on the data set: it is time for high resolution soundings data, pressure for low resolution soundings data, and altitude for profilers data. Two tables are necessary to store the data set: one table includes profile informations, like site identifier, date, and comments, another table include the measurements, a row for each level. The two tables are linked by a foreign key.
- For the two-dimensional fields, and special data, the FCA distribute these data, with no validation. Files provided to the FCA are stored in a juke box of Optical Numerical Disks. The DMS includes only the file catalog, not the measurements.

Three DMS tables are used to summarise the information:

- The description of each data set, including name, identifier, tables used for the catalog or data storage, are stored in a table
- The description of each site measurement, including name, site identifier, position (for fixed site), data set type and data provider information are stored in a table.
- A table summarises the relation between instruments and data sets.

4.6 Data available in the FASTEX Central Archive

4.6.1 The FASTEX instruments measurements

The research aircraft

Seven aircraft participated in FASTEX. The Lear 36 and two US Air Force C130 were based at St John's (Newfoundland,Canada) to document the "Far Upstream Area". The NOAA Gulfstream IV, based at Shannon (Ireland), documented, depending on the Intensive Observational Period (IOP), one of the three FASTEX sampling areas: the "Far Upstream Area" near St John's, the "Near Upstream Area" centered about 35°W longitude, or the "Multiscale Sampling Area" near Shannon. The two turboprop aircraft with Doppler radar, the NOAA WP-3D and the NCAR Electra, based at Shannon, and the UKMO C130 turboprop,based at Lyneham (UK), operated coordinated flights in the "Multiscale Sampling Area". See Joly *et al.* (1997) for the description of the observing strategy and Joly *et al.* (1999) for a summary of operations and cases.

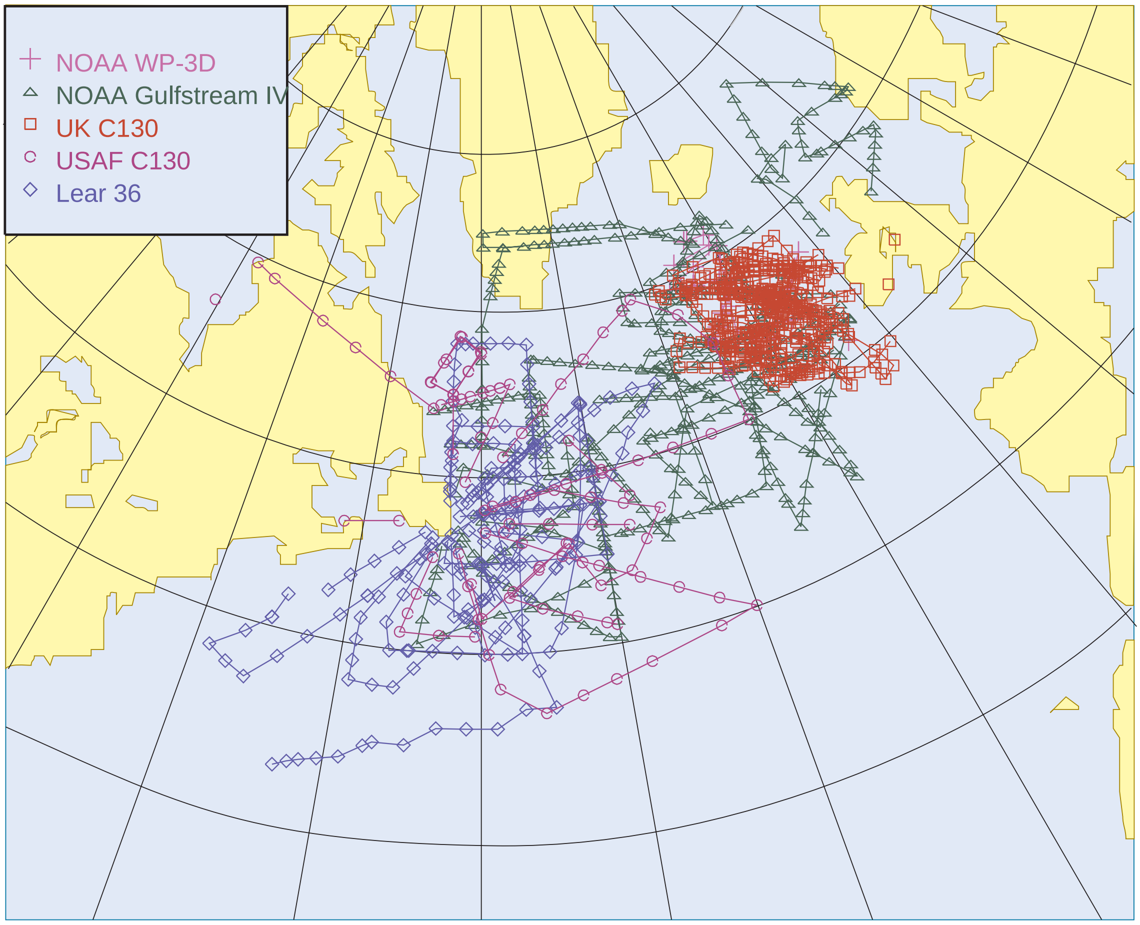
The raw aircraft measurements are available in the specialised data bases. The 2s and low-resolution dropsonde data sets are available in the FCA, as well as the 1s

Table 4.2: *Summary of the FASTEX aircraft measurements available in the FCA*

	LEAR jet	USAF C130	NOAA Gulfstream IV	UK-C130	NOAA WP-3D	NCAR Electra
Number of flights	13	9	16	11	12	7
Number of available dropsonde measurements	220	108	498	439	31	
Number of hours of in-situ meteorological measurements		78h	60h	101h+	138h	57h
Composited images from aircraft radar					All flights	
Dynamical fields from Doppler radars					+	+

+: planned

Figure 4.7: *Dropsondes location resulting from all the flights performed during the fiel phase*



meteorological measurements of the Gulfstream, the WP-3D and the Electra. The composite images of reflectivity from the WP-3D radar are also available. Selected 3-D analysed wind and reflectivity fields and PERL profiles computed from the airborne Doppler radars will be available when provided by PIs, following formal publication of results. Measurements available or planned for each aircraft are indicated on Table 4.2. The dropsonde locations are on Fig. 4.7.

Table 4.3: *FASTEX ship measurements*

	FASTEX ships				ASAP ships		
	R/V KNORR	R/V Le SUROÎT	Victor BUGAEV	ÆGIR	4 French	2 Danish	1 Swedish Icelandic
Days with measurements	52	53	50	44	109	75	26
Number of soundings	282	271	283	264	208	219	81
Operational Surface measurement frequency	6h	1h	1h	3h/1h	6h	3h	3h
Research Surf. and Oceano. measurements	15min avg /33 days	1min avg /52 days					
Flux measurements	+	+					
Profilers	25 days	50 days					

+: planned

The FASTEX and ASAP ships participating in FASTEX

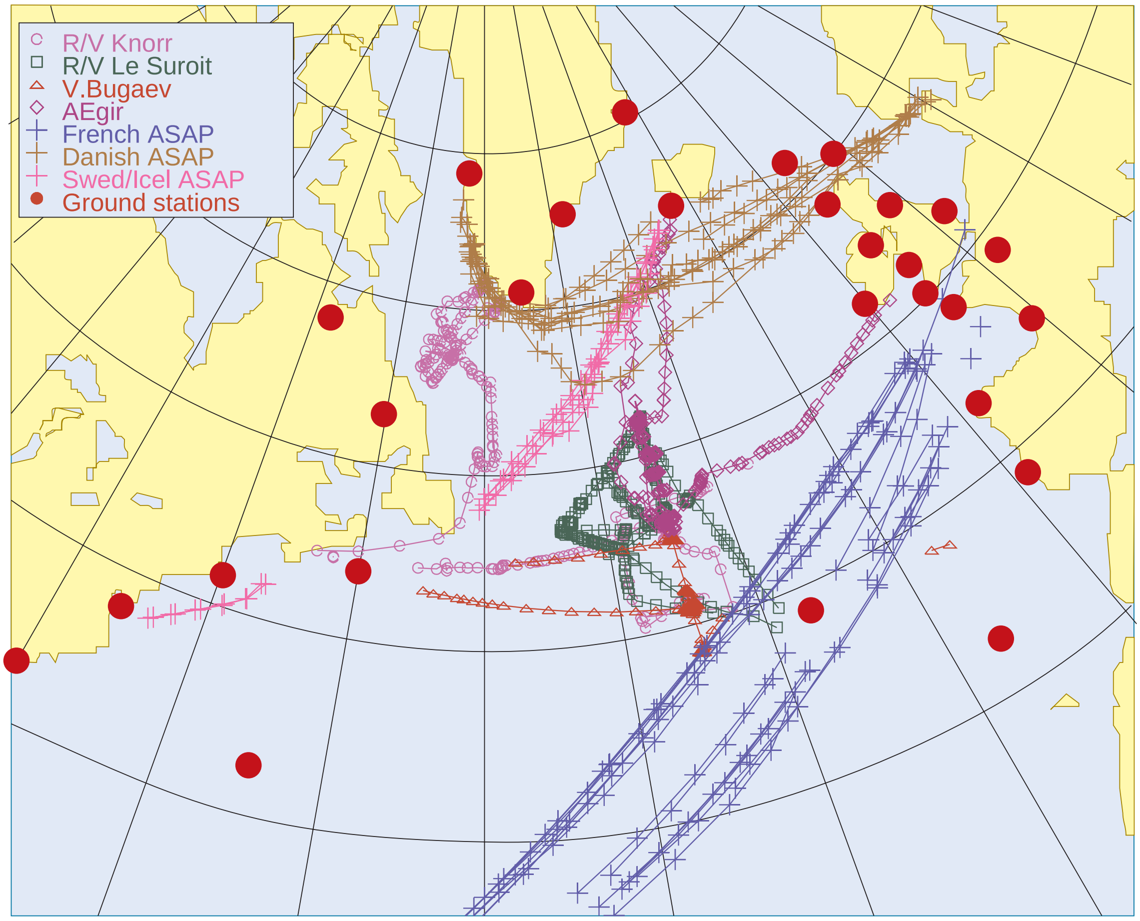
The FASTEX ships are two research vessels, the R/V Knorr from NOAA and the R/V Le Suroît from IFREMER (France), a Ukrainian Meteorological Vessel, the Victor Bugaëv, and an Icelandic Coast Guard ship, the Ægir. The four FASTEX ships were approximately aligned on 40W longitude between 40N and 55N latitude. All routinely performed operational surface measurements and 6 hourly soundings. During IOPs, they performed more frequent soundings, up to every 90 minutes for 18 hour periods.

An air-sea interaction program was conducted by the two research vessels, the R/V Knorr and the R/V Le Suroît, using a 915 MHz Wind Profiler and in-situ atmospheric and oceanic instruments. Measurements made by the R/V Le Suroît are documented in L.Eymard *et al.* (1999). The R/V Knorr participated in FASTEX, in the middle of the North Atlantic Ocean, during January 97. During February 97, she participated in the LabSea Experiment, in the Labrador Sea. The LabSea PIs have provided the high resolution data from the soundings performed by the R/V Knorr to the FCA.

Seven commercial ships equipped with radiosounding equipment (ASAP), performed routine 12 hour soundings and participated in FASTEX by taking soundings each 6 hours during IOPs. The four French ASAP ships cross the Atlantic between Le Havre (France) and the French West Indies. The two Danish ASAP ships operate between the Denmark and Godthaab, on the Greenland West Coast. The Swedish - Icelandic ASAP ship crosses the North Atlantic between Reykavik (Iceland) and Norfolk (Virginia, USA). The Icelandic, Danish and French meteorological services sent, in delayed time to the FCA, the high-resolution data from the soundings performed by the ASAP ships.

Table 4.3 summarises the ship measurements and Fig. 4.8 provides the location of soundings performed by each of these ships.

Figure 4.8: *Locations of the high resolution soundings released from FASTEX and ASAP ships and ground sites participating in FASTEX*



The radiosounding ground stations participating in FASTEX

Twenty nine ground sites performed more frequent soundings during FASTEX. The meteorological services have sent the high resolution data set, validated, to the FASTEX Archive. Table 4.4 summarises the location, frequency and measurement method at each site. The location of these sites are in Fig.4.8.

The buoy network

The European Group of Oceanic Stations (EGOS) maintains an operational network of buoys in the North Atlantic. The coverage of this network was maximised during the two months of the experiment. Additional buoys were deployed by the FASTEX ships: the R/V Knorr deployed six EGOS buoys, the R/V le Suroît eight, and the Ægir four NOAA/EGOS buoys.

All the measurements from the EGOS buoys with pressure measurements, when they were located in the North Atlantic, were validated by Météo-France / Centre de Météorologie marine (CMM) at Brest (France). The CMM processed the raw data files, from the Argos archive, of 53 buoys. The measurement location is interpolated

Table 4.4: *Radiosounding ground stations participating in FASTEX*

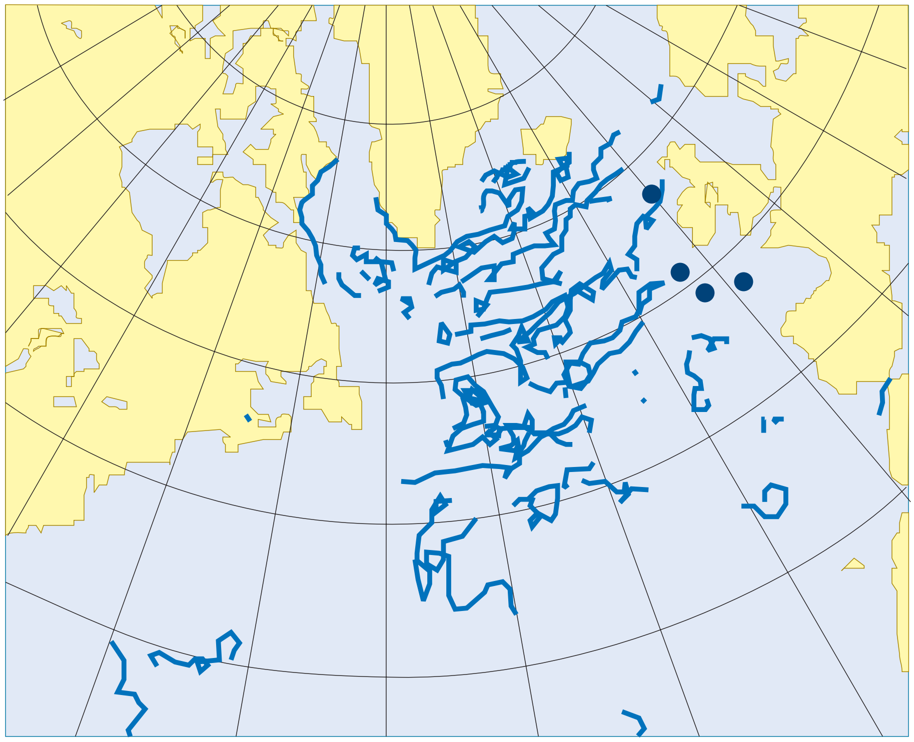
Site	WMO code	Lat	Long	Alt (m)	System	Sounding Frequency	Vertical resolution	Number
Greenland	Staff: DMI							
Egedesminde	04220	68.70N	52.87W	40	RS80-N/Omega	4/day	10 s	234
Narssarssuaq	04270	61.18N	45.44W	4	RS80-N/Omega	4/day	10 s	248
Scoresbysund	04339	70.50N	22.00W	68	RS80-N/Omega	4/day	10 s	229
Angmagssalik	04360	65.62N	37.65W	51	RS80-N/Omega	4/day	5/10 s	215
Denmark	Staff: DMI							
Thorshavn	06011	62.02N	06.77W	55	RS80-N/Omega	4/day	10 s	238
France	Staff: Météo-France							
Brest	07110	48.45N	04.42W	98	RS80-L/LoranC	4/day IOP: 8/day	10 s	289
Trappes	07145	48.77N	02.02E	168	RS80-L/LoranC	4/day IOP: 8/day	10 s	219
Bordeaux	07510	44.82N	00.68W	48	RS80-L/LoranC	4/day IOP: 8/day	10 s	242
Iceland	Staff: IcMS							
Keflavic	04018	63.97N	22.60W	38	RS80-N/Omega	4/day	5/10 s	230
Ireland	Staff: IrMS							
Valentia	03953	51.93N	10.25W	14	RS80-N/Omega	4/day IOP: 8/day	2 s	313
Portugal	Staff: INMG							
Lajes	08508	38.73N	27.07W	112	RS80-N/Omega	4/day (Jan:2/day)	variable	173
Lisboa Gago	08579	38.77N	09.13W	104	RS80-N/Omega	2/day	2 s	
Funchal	08522	32.63N	16.90W	56	RS80-N/Omega	4/day	2 s	233
Spain	Staff: INM							
La Coruna	08001	43.37N	08.42W	67	RS80-N/Omega	4/day	10/30 s	206
United King.	Staff: UKMO							
Lerwick	03005	60.13N	01.18W	84	RS80-L/LoranC or VIZ/LoranC	4/day IOP: 8/day	2 s or VIZ wind 20 s	285
Stornoway	03026	58.22N	06.32W	13	RS80-L/LoranC	4/day IOP: 8/day	2 s	302
Boulmer	03240	55.41N	01.6W	23	RS80-L/LoranC	4/day IOP: 8/day	2 s	266
Hemsby	03496	52.68N	01.68W	14	RS80-L/LoranC	4/day IOP: 8/day	2 s	268
Aberporth	03502	52.13N	04.57W	121	RS80-L/LoranC	4/day IOP: 8/day	2 s	277
Camborne	03808	50.22N	05.32W	88	RS80-L/LoranC	4/day IOP: 8/day	2 s	312
Hillsborough	03920	54.48N	06.10W	38	RS80-L/LoranC	4/day IOP: 8/day	2 s	304
Canada	Staff: AES							
Sable Island	71600	43.93N	60.02W	4	RS80-L/LoranC	4/day	10 s	240
St Johns	71801	47.62N	52.73W	140	VIZ/LoranC	4/day	variable wind 1 mn	206
Goose Bay	71816	53.32N	60.36W	38	RS80-L/LoranC	4/day	5 s	212
Kuujjaq	71906	58.10N	68.42W	60	RS-80/Omega or RS-80/CommVLF	4/day	10 s	215
USA	Staff: NOAA							
Charleston	72208	32.9N	80.03W	15	VIZ/Radiotheodolite	2/day IOP: 4/day	6 s	146
Wallops Isl.	72402	37.93N	75.48W	12	VIZ/Radiotheodolite	2/day IOP: 4/day	1.2 s wind 1 mn	170
Chatam	74494	41.67N	69.97W	14	VIZ/Radiotheodolite	2/day IOP: 4/day	6 s	169
Bermuda	Staff: USNavy							
Kindley	78016	32.36N	64.68W	6	RS80-N/Omega	4/day	10 s	236

when the meteorological measurements and Argos locations have different times. If necessary, recalibration based on the buoys monitoring statistics is applied to the meteorological measurements.

Measurements from nine NOAA buoys, retrieved from the GTS, were validated by CMM. CMM also validated the data from five UKMO moored buoys, from the raw Argos files.

The location and the meteorological measurements were drawn and visual checks were performed for each of these 67 buoys. The location of buoys with pressure measurements is shown in Fig. 4.9.

Figure 4.9: *Location of buoys with pressure measurements. large dots: UKMO moored buoys validated by CMM*



European COST-76 Wind Profiler Network

Eleven wind profilers in Europe performed hourly profiles during FASTEX. Some of these are operational profilers, the others are research ones. Table 4.5 summarises their characteristics. Measurements from the three French profilers are described in W. Klaus (1998). The data from all the profilers are available in the FCA.

4.6.2 Measurements from the World Weather Watch and commercial aircraft

A large subset of the measurements done during the FASTEX field phase (January and February 1997) and received from the GTS is available in the FCA. Data archived are included in a large domain centered on the North Atlantic: 20N-90N,140W-40E. Messages were decoded and geophysical measurements and significant WMO codes

Table 4.5: *European Wind Profilers*

Site	WMO Code	Lat	Lon	Alt (m)	Frequency (MHz)	Staff	Type
Aberystwyth (UK)	03501	52.42N	4.00W	50	46.5	UKMO	operational
Camborne (UK)	03807	50.13N	5.10W	88	40.3	UKMO	research
Brest (France)	07113	48.45N	4.42W	15	1238.0	Ets.Degreane	research
Lannemezan (France)	07114	43.08N	0.21E	597	45.0	CNRS/LA	research
La Ferté Vidame (France)	07112	48.61N	0.87E	244	52.0	Météo-France	operational
Toulouse (France)	07115	43.56N	1.36E	158	45.0	Météo-France	research
Hamburg (Germany)	10999	54.00N	9.50E	20	1240.0	Met.Obs.	research
Lindenberg (Germany)	10394	52.21N	14.13E	101	482.0	Met.Obs.	research
Lindenberg (Germany)	10394	52.21N	14.13E	101	1290.0	Met.Obs.	research
Cabauw (Netherlands)	06348	51.95N	4.88E	0	1290	KNMI	research
Payerne (Switzerland)	06610	46.82N	6.95E	491	1290.0	Swiss.Met.I.	research
Bilbao (Spain)	08025	43.37N	3.03W	60	1290.0	Univ.of Bilbao	research

are available in ASCII files. This allows easy access on these measurements to the whole scientific community. Data sets available include commercial aircraft data sets, from AMDAR, AIREP and ACARS messages, surface measurements from ground principal stations (SYNOP messages) and ships (SHIP messages), soundings from TEMP and TEMPSHIP messages, sea measurements from ships (BATHY messages) and buoy measurements (BUOY messages).

All the data sets are provided with quality control flags. These flags were calculated by the operational service of Météo-France, according to the WMO recommendations, when the data were received. If a validated data set replaces the GTS data set, or if manual checking is done by the FCA, the quality control flags values are updated.

Surface measurements from ships have a great interest for FASTEX analysis. This data set was validated by the FCA. Control procedures are described in section 4.74.7.2. The geographic coverage of this data set is shown in Fig. 4.10.

4.6.3 Satellite Imagery and products

Satellite Imagery

Météo-France/CMS provided the imagery from the geostationary satellites METEOSAT and GOES-EAST, and the polar orbiting satellites NOAA 12 & 14, for all the channels of the imagers. Special computations were made from FCA requests. The data from the four satellites are in the same geographical projection. The domain is shown in Fig. 4.11. The image resolution choosen for the satellite imagery is higher or close to the imager resolution at 45 degrees latitude, and allows for the easy use of several channels of the same satellite, and for the use of imagery from several satellites (see Table 4.6).

Thirty minute data from the 5 channels of the GOES-EAST Imager were received in real time at CMS. Thirty minute data from the 3 channels of the METEOSAT imager were partly received in real-time at CMS, and partly in delayed time, sent by the EUMETSAT Archive Service. The EUMETSAT Archive Service provided full resolution visible data and some Infrared and Water Vapor slots which were not disseminated in real time in full domain. The HRPT NOAA 12 & 14 data were received in real time at CMS (Eastern domain) and at the Canadian Atmospheric Environment Service (AES) in Halifax (Western domain). The CMS computed all

Figure 4.10: *Location of the operational surface measurements from commercial and FASTEX ships during FASTEX*

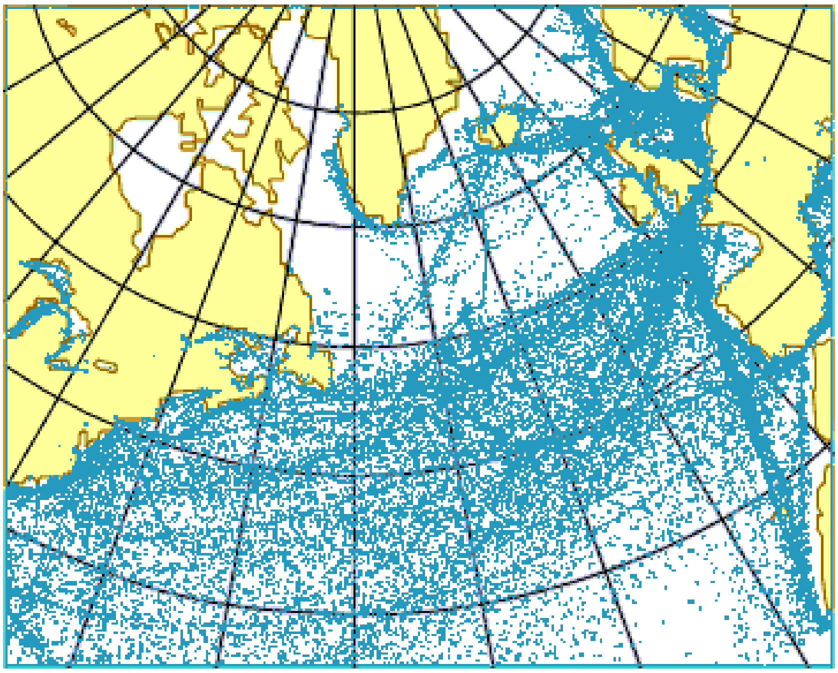


Table 4.6: *Satellite imagery specifications*

Satellite	Channels	Size (km) X(km)	Size (km) Y(km)	Resolution x(km)	Resolution y(km)	Size(pixels) columns	Size(pixels) rows
GOES-EAST	1,2,4,5	7875	6750	7.5	7.5	1050	900
GOES-EAST	3	7875	6750	15.0	15.0	525	450
METEOSAT	VIS	6000	6750	5.0	5.0	1200	1350
METEOSAT	IR, WV	6000	6750	7.5	7.5	800	900
NOAA	all	5000	6000	2.0	2.0	2500	3000

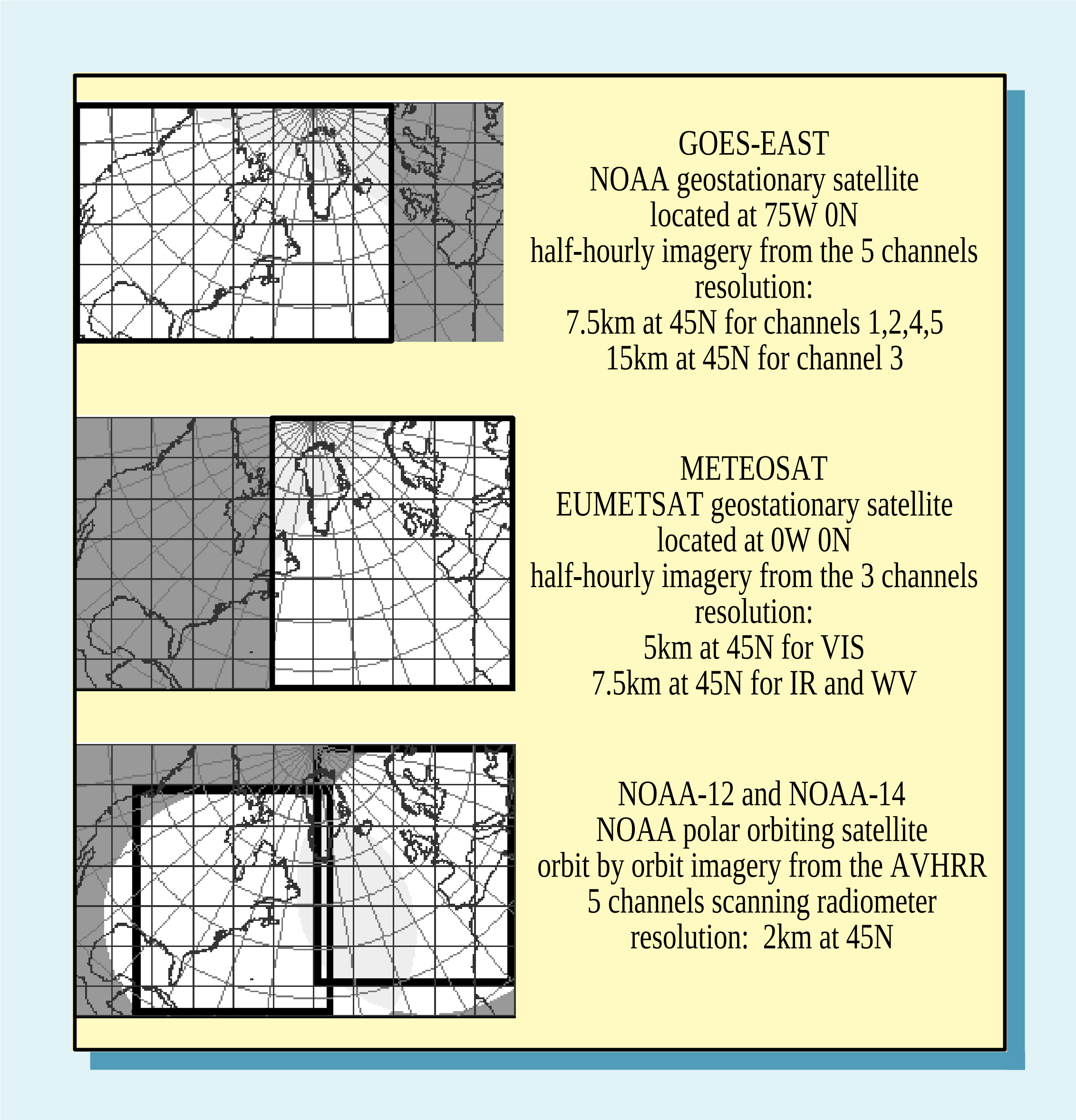
the imagery received at Halifax and Lannion for the 5 channels. There is one data file per orbit scan and channel.

The satellite products

The NOAA/TOVS Total Ozone Content was prepared by Fernand Karcher (Météo--France) from the NOAA/TOVS raw data (level-1b files) produced by the NOAA/-NESDIS for the 2 satellites (Lefèvre *et al.* 1991). This product is provided at the spatial resolution of the sounder, that is 17x17km at nadir and 59x30 km at the end of the scan. The geographical domain is the FASTEX domain (20N-90N,140W-40E).

The significant wave height and the average surface wind speed, both at a resolution of 5x5km, are computed from the TOPEX-POSEIDON Altimeter data. The TOPEX-POSEIDON WIND/WAVE product was prepared by the CLS/AVISO Operations Center, Ramonville St-Agne (FRANCE). The product is provided along the altimeter trace, when it is in the FASTEX domain.

Figure 4.11: *Geographical coverage of the satellite imagery*



The following other products are also available:

- the GOES cloud drift winds product prepared by Chris Velden from the raw data of the NASA geostationary satellite GOES-East (Velden et al., 1997),
- the 30 km resolution SATEM prepared by CMS from the HRPT NOAA data received at CMS and AES (Lavanant et al., 1997),
- the 25 km resolution speed and direction of the surface wind from the ERS-2 scatterometer data prepared by CERSAT.

4.6.4 The ARPEGE model analysis fields

Analyses are performed with the operational data assimilation and forecasting model ARPEGE/IFS at Météo-France. Since 1987, Météo-France and the European Center for Medium Range Weather Forecasts (ECMWF) have developed a new forecast system called ARPEGE/IFS (Courtier *et al.*, 1991). At the time of the experiment, the ARPEGE/IFS model was running with a semi- Lagrangian semi-explicit scheme. The resolution was T149, 27 levels with stretching 3.5. Time step: about 600s. The average resolution over the Atlantic is (roughly) equivalent to T300, T400 and more over western Europe (the pole is over France). The six hourly ARPEGE analyses are the outcome of the data assimilation suite run by Météo-France in Toulouse during the field phase. This data set was obtained from the operational analyses and covers entirely the two months of the FASTEX experiment. They incorporate the extra-FASTEX data that have been transmitted in real time to Toulouse. The analysis scheme was an optimal interpolation followed by digital filter initialization. The idea is to provide a self-contained data set enabling:

- the study of the model simulation, global or in limited area, and
- the computation of diagnostics from the analyses with good precision on spatial derivatives.

This data set is available for the period from 1 January 1997 0Z to 28 February 1997 18Z, with a frequency of 6 hours. The data set is projected on a global grid, latitude × longitude, with a resolution of 1.5 degrees. Vertically, the atmosphere is described through 24 pressure levels. Parameters available are geopotential height, the zonal and meridional wind components plus the zonal and vertical derivatives, the horizontal wind divergence and the vertical component of vorticity, the temperature and its 3 derivatives, and the specific humidity and its 3 derivatives. Six surface fields are also available: pressure, orography used for vertical interpolation, surface temperature including analysed Sea Surface Temperature, soil temperature and water content. The format used is WMO GRIB. The ECMWF software to read GRIB files can be provided by the FCA on special request.

4.7 Quality Control Procedures applied by the FCA

The measurements from the research instruments were processed by scientists or organisations participating in FASTEX. Checks applied by the FCA included:

- all the files are read,
- the uniqueness of each measurement is checked,
- average, minimal and maximal values for each parameter are computed,
- some samples are drafted to verify spatial and time consistency.

The data provider was informed if a problem appeared, and correction, or new release, or comment for documentation, was provided.

The data sets retrieved from the GTS are provided with Quality Control (QC) flags on the observation, and on some measurements like position, pressure, temperature, humidity and wind. These QC flags were calculated when the BUFR messages were decoded. The tests have been settled from controls made at the ECMWF, which have in general been extracted from the WMO guide on data processing (WMO 1982) . For each type of message, there are 3 different steps of control:

1. Unconditional checks when parameters can take only some defined values.
2. Gross limit checks for air, dew point and sea temperatures, pressure and its tendency, wind speed, geopotential height , etc...
3. Internal consistency checks between some parameters of an observation, like wind speed and direction, pressure and its tendency, and vertical wind shear for soundings.

The quality controls are presented in a Météo-France/SCEM note (1996). An english version is available on the FCA WWW site.

Some real-time data sets, retrieved from the GTS, were replaced by validated data sets. This was the case for EGOS buoys, UKMO moored buoys, and surface measurements from ships. When a data set is replaced, QC values are updated.

The surface measurements from the commercial ships data set contains precious informations on the meteorological environment of the FASTEX measurements. The FCA has done a best effort for quality control of this data set, which was not operationaly controlled by an international committee, as the buoys were.

Careful attention was given to verifying the location of the FASTEX and ASAP ships. A reference position data set was provided by the FASTEX ship data providers. The FCA used it to update the measurement locations in all the data sets, including the low resolution sounding one. The ASAP ship location from the surface measurement data set and the low and high resolution sounding data sets were compared. The ASAP ship velocity deduced from the ASAP ship positions, was calculated. Suspect positions were manually verified and corrected.

The FCA had in its charge to collect and to transpose in the same format the high resolution sounding data sets from the 29 ground stations, the 7 ASAP and the 4 FASTEX ships. The dropsonde from the 6 FASTEX aircraft were put in the same format as the radiosoundings. UCAR/JOSS was responsible for the Quality Control of the entire dropsounding and radiosounding data set. The methods used at UCAR/JOSS and at the FCA to verify the data set were slightly different. The method used at the FCA is explained below, the method used at UCAR/JOSS to attribute the QC flags is described in section 4.8. Table 4.7 summarises the QC procedures applied to the data sets available in the FCA.

4.7.1 FCA verifications on the sounding data set

Each data set was verified by the data provider before it was sent to the FCA. At Toulouse, each sounding was plotted and visually verified. The data insertion in the Data Management System allowed the assumption of the uniqueness of each measure identified by the sounding site, the launch date and time, and the time passed from the launch time. Errors dues to transmission, writing or reading the data, were detected first during the data insertion, and after when the minimum and maximum values for each sounding and each parameter were computed. For each problem, a dialog between the data provider and the FCA allowed its correction. Sometimes a new data set was provided, sometimes the data set was corrected at the FCA. The European meteorological services provided the FCA with the soundings launched in Europe and aboard the ASAP ships. UCAR/JOSS provided the FCA with the soundings launched in Canada and USA.

All soundings provided, except those from Lajes (Azores), are archived operationally by the Meteorological Services. The measurements were included without change in the FASTEX Archive. The Lajes data set was hand entered at the site by the Portuguese Weather Service (INMG). Due to the lower resolution of these data in the upper levels, the FCA included data from the TEMP (GTS) messages within the high resolution data set.

When all the soundings from a site were included in the DMS, the complete data set was sent to UCAR/JOSS. UCAR/JOSS applied its Quality Controls Procedures (see Section 4.8) on each sounding and initialized the QC flags for each measurement line. The data set was sent back to the FCA, where the available data set was updated. The soundings data set is available in the same version and in the same format (JOSS quality control format) both in the FCA and in the UCAR/JOSS database.

The very good collaboration of the meteorological services has to be noted. They sent the data very quickly - many of them sent the data during the field phase - and answered additional questions with efficiency and efficacy.

The sounding data set from the FASTEX ships was also provided very quickly after the experiment, by Météo-France/GMEI (R/V Le Suroît, V.Bugaëv and Ægir) and NOAA/ETL and US-Navy/NPS (R/V Knorr).

8391 soundings compose this data set, 6785 soundings were launched by the ground stations, 406 soundings were launched by the ASAP ships, and 1100 by the FASTEX ships. The full high resolution sounding data set, validated and controlled, has been available since winter 97-98.

The same controls were applied to the dropsonde data set. The UK-C130 dropsonde measurements were processed and validated by the JCMM/University of Reading (UK), and quality controlled by UCAR/JOSS. The dropsondes launched by the US Air Force C130 were processed by the US Air Force, and validated and controlled by UCAR/JOSS. UCAR/JOSS processed and controlled the measurements from the NCAR GPS dropsondes (Lear jet, Gulfstream IV and WP-3D). See section 4.8 for a complete discussion of UCAR/JOSS sounding processing.

4.7.2 SHIP Message Quality Control

The automatic QC procedures, proposed by WMO and applied by Météo-France, allow the elimination of the major part of the wrong or doubtful measurements, before the data assimilation in an operational forecast system. For meteorological experiments analyses, and especially for case studies, a measurement could be very important in the interpretation. The validation of the surface measurements from the commercial ship data set is not internationaly organized, as the buoy data set validation is. So, the validation was done by the FCA. The procedures applied to the surface measurements done by the commercial ships during FASTEX allowed the cleaning of this data set, and sometimes the correction of the data.

The measurement, coding and transmission of the surface data aboard ships are often made in hard conditions, sometimes by people with little experience. Errors in this data set are due to different possibilities and can add up. The measurement errors are difficult to correct, whereas coding errors can be sometimes corrected. Some transmission problems can induce difficulties or errors in the automatic decoding of the message, sometimes to a duplication of messages, complete or not.

Checks are done on:

- the doubtful ship WMO codes,
- the location and the trajectory of each ship,
- the pressure and pressure tendency measurements,
- the temperature measurements.

Table 4.7: *Quality Control procedures applied to the data sets available in the FCA*

Dataset	Provenance	Checking
Commercial Aircraft Data	GTS (AIREP, AMDAR, ACARS messages)	WMO checks
Bathythermal Data	GTS (BATHY messages)	WMO checks
Buoy Data	EGOS Buoys: Météo-France/CMM from Argos raw files	CMM
	9 USA/GDC SVP drifters in the North Atlantic: GTS (BUOY messages)	CMM
	Other Buoys: GTS (BUOY messages)	WMO checks
Sea Temperature and Salinity from BUOY	3 EGOS Buoys: Météo-France/CMM from Argos raw files	CMM
	Other Buoys: GTS (BUOY messages)	WMO checks
SYNOPs Surface in-situ Data	GTS (SYNOP messages)	WMO checks
SHIPS Surface in-situ Data	R/V Le Suroît, V.Bugaëv, Ægir: GTS + ship archive	CNRM/GMEI
	Other ships: GTS (SHIP messages)	WMO checks + FCA checks
Average meteorological and Oceanic data from Research Vessels	R/V Le Suroît: Météo-France/CNRM/GMEI processing	CNRM/GMEI
	R/V Knorr: NOAA/ETL processing	NOAA/ETL
High resolution radiosonde Data	Data providers	data provider + FCA + UCAR/JOSS
Low resolution radiosonde Data	R/V Le Suroît, V.Bugaëv, Ægir: GTS + ship archive	WMO checks
	Other sites: GTS (TEMP, TEMPSHIP messages)	WMO checks
High resolution dropsounding Data	Lear36, NOAA Gulfstream IV, NOAA WP-3D: UCAR/JOSS processing	UCAR/JOSS
	USAF C130: USAF processing	UCAR/JOSS
	UKMO C130: JCMM processing	JCMM + UCAR/JOSS
Low resolution dropsounding Data	GTS + aircraft archive	WMO checks
Profiler on the FASTEX ships	ship measurements	real-time data set
Aircraft in-situ Meteorological Data	NOAA Gulfstream IV, NOAA WP-3D: NOAA/NSSL processing	NOAA/NSSL
	NCAR Electra: NCAR/RAF processing	NCAR/RAF
	USAF C130 : USAF processing	USAF
Composited images from Aircraft radar	NOAA WP-3D: NOAA/NSSL processing	NOAA/NSSL
Satellite Imagery	GOES-EAST, METEOSAT, NOAA-12, NOAA-14: Météo-France/CMS processing	CMS
Others Satellite products	Data provider processing	
Model analyzed fields	Météo-France ARPEGE Model	

A total of 164,000 GTS messages were received, validated and archived by FCA from ships other than the four FASTEX ships. The FASTEX ship measurements were validated by the data providers.

The unusual or doubtful ship WMO codes

The ship WMO codes usually use 4 to 8 letters. A long code could be erroneous. Also, a transmission problem could transform a WMO code into an unusual one. The WMO code attributed to a ship which broadcasted less than 5 messages during the 2 months of the experiment may be doubtful. Some messages come with the date or the name 'SHIP' instead of the WMO code. Some codes are not referenced in the WMO list of ships. All of these messages were considered to have doubtful codes. For each doubtful code, the message was compared to the other messages received in a spatio-temporal window of ± 12 hours and ± 3 degrees in latitude and longitude. The message was also compared to the messages sent by ships with closely related WMO codes. 820 messages were suppressed due to duplicated transmissions. 451 messages, with doubtful codes, were attributed without any uncertainty to another WMO code ship. The unknown codes of 2137 messages were replaced by the code 'SHIP'. 954 messages, from 306 unusual codes, could not be reattributed; the original code was maintained. 1.8 % of the received messages have a doubtful or unknown code.

Checks on ship location and trajectory

The successive locations of each ship were used to calculate its average speed. If this average speed and the ship course speed difference is greater than 12 km/h, the location is doubtful. When the ship course speed is not included in the message, an average speed greater than 50 km/h is doubtful. The ship locations were also compared to the locations calculated with the ship course heading and speed. When the distance between these two locations is greater than a limit value, the ship locations, heading and speed are checked. This limit value depends on the ship speed, the time between two successive observations and the heading steadiness, and also includes the lack of precision due to the WMO coding itself. Each doubtful location was edited. Typical code errors (latitude and longitude inversion, transposed figures in latitude or longitude value, erroneous coding of negative longitude) were corrected if possible. When this kind of error could not be corrected the quality code flag was set to doubtful or bad.

One of the automatic QC procedures applied at Météo-France is to compare the ship location with a land/sea mask. The land/sea mask, from the US-Navy, had a resolution of 10 minutes. If the four grid points surrounding the position of the ship are all land points, then the ship is considered to be over land. This procedure is effectual on the high sea or on the continents, but not for ships located on estuaries or on narrow rivers. A more accurate land/sea mask was used, calculated from the USGS Microwave databank II coastlines, lakes and islands at 0.1 degrees resolution, which is the precision of the ships location. The location of the ships considered to be over land by the automatic QC procedure were checked with this new land/sea mask. If 4 or more of the 8 points surrounding the position of the ship are water points, then the ship is considered to be over water. This procedure is more accurate than the automatic one, but again eliminates ships on some narrow rivers. The locations of these ships were checked with a geographical atlas. Some coding errors were corrected. There remain 681 measurements with a doubtful or bad location, that is 0.4% of the available measurements.

Pressure and pressure tendency measurements

Some of the usual errors done in coding pressures higher than 1000 hPa (in hPa instead of in decimal hPa, allowing pressure values greater than 1060 hPa) were checked (1065 hPa instead of 1006.5 hPa). The doubtful pressure values were compared to the neighbouring pressure measurements when they exist, or to the sea level pressure field from the ARPEGE analysis.

The temporal evolution of the pressure was compared to limit values depending of the time between the two measurements. Limit values used were: 6 hPa per 1 h, 13 hPa per 3 h, 20 hPa per 12h, 30 hPa per 12h and 40 hPa per 24 h. When the pressure tendency was present, the temporal evolution of the pressure was compared to the pressure tendency. When the difference was greater than $3hPa$ per 6 hours, the pressure was visually checked. Measurements where corrected when an obvious coding error appeared. In other cases, the QC pressure flag was set to doubtful or bad.

2 % of the pressure measurements were flagged as doubtful or erroneous.

Temperature measurements

The temporal evolution of the temperature was calculated. When it was greater than a limit value depending of the time between the two measurements, the data were edited. Measurements were corrected when an obvious coding error appeared. In other cases, the QC temperature flag was set to doubtful or bad. Limit values used were: 6 degrees for 1h, 8 degrees for 3 h, 12 degrees for 12h, 15 degrees for 12h and 18 degrees for 24 h.

2 % of the temperature measurements were flagged as doubtful or erroneous.

4.8 Quality Control of High Resolution Sounding Data by UCAR/JOSS

UCAR/JOSS was given responsibility for the quality control (QC) of the FASTEX high resolution sounding data from the aircraft dropsondes (see Table 4.2), ships (see Table 4.3) and ground stations (see Table 4.4). The sounding QC procedures for FASTEX were based on those used by JOSS for the Tropical Ocean Global Atmosphere Coupled Ocean-Atmosphere Response Experiment (TOGA COARE; Loehrer *et al.* 1996). There were four processing steps used to QC the over 9000 soundings from FASTEX. The first process was the conversion of all data to a single, easily used format. The second process was the application of a series of automated internal consistency checks. The third process was a visual examination of every sounding. Finally, a special examination was conducted on the data from the aircraft dropsondes. This took the form of intercomparisons between the various aircraft dropsondes as well as between the dropsondes and the upsondes released from the FASTEX ships.

4.8.1 Format conversions

Each data provider had its own format(s) for its sounding data. In order to make the data easily useable by the scientific community UCAR/JOSS and Météo-France converted all soundings to a single ASCII format that both agencies agreed upon, the UCAR/JOSS quality control format (QCF). For a complete description of this format and an example please see Loehrer *et al.* (1996) . JOSS QCF has 15 data fields for measured and derived parameters and six additional fields for QC flags (see Loehrer *et al.* 1996 for the JOSS QCF flagging conventions). For the purpose of conducting a consistent QC methodology for the entire FASTEX data set, JOSS ignored any flags provided by the provider agencies.

The format conversion process also included the calculation of some derived parameters not initially available in the raw data. These were most often simple calculations (i.e. dew point, wind components, ascent rate of the radiosonde, and latitude/longitude position of the radiosonde). However, in the case of US National Weather Service (NWS) radiosondes, both wind speed and direction were calculated from the azimuth and elevation angles and the altitudes provided in the data set. This is a complex process due to the presence of oscillations within the measured angle data which can lead to oscillations in the winds. For complete information on the evolution of the UCAR/JOSS processing of high resolution winds in the US NWS radiosonde data see Williams *et al.* (1993) and Williams *et al.* (1998) .

The very high resolution dropsonde data from the Lear 36, Gulfstream IV, and NOAA WP-3D were reprocessed by UCAR/JOSS during this format conversion process. These data arrived to JOSS as 0.5 s vertical resolution data files with the data beginning prior to release of the dropsonde from the aircraft. Two modifications to the raw data set were made. First, JOSS determined the actual release point and started the data files about 20 s after that time, in order to allow for the acclimation of the dropsonde instrument package to the environment outside the aircraft. Second, JOSS developed 2 s vertical resolution data files from the 0.5 s data. This was done due to the presence of significant amounts of “bad” data within the 0.5 s data files. JOSS conducted a loosened version of its automated quality control processes on the 0.5 s data files to determine “bad” data points. These “bad” data points were then removed from the recalculation of the 2 s data files.

4.8.2 Automated internal consistency checks

UCAR/JOSS has for several years used an evolving set of automated internal consistency checks on high resolution sounding data from a variety of field programs (Loehrer *et al.* 1998) . These checks provide a quick and consistent test on every data point, thereby alerting users to potential problem areas within soundings. This process also helps to ensure that all format conversions were properly completed. All checks are applied from the surface up through the profile.

There are four types of automated checks used by UCAR/JOSS. They are:

1. inclusion of only numerical values
2. values within QCF format limits
3. values within reasonable climatology limits (see Table 4.8)
4. vertical consistency within a sounding/dropsonde (see Table 4.9)

The first two groups of checks typically do not result in flags being applied in the final version of the data but are used to verify the format conversion process. The third group of checks ensure that the values are within reason for the North Atlantic region climatology during winter and use a set of gross limits (Table 4.8). The flags are automatically applied within the data file to the affected data point. No flags are changed to the "good" value during this procedure. The checks for dropsondes varied slightly from those applied to the upsondes, the maximum allowable descent rate was 30 m s^{-1} due to the quicker rate of dropsonde descent versus radiosonde ascent. These gross limit checks (except the dew point ≤ -99.9°C check) affected a very small segment of the data with only 0.44% of data points flagged by these checks. Most of those flags were applied via the ascent rate checks. About 1% of all data points were flagged using the dew point ≤ -99.9°C check.

Table 4.8: *Gross limit checks applied to the FASTEX high resolution sounding data set.*

Parameter	Gross Limit Check	Parameter(s) Flagged	Flag Applied
Pressure	$<$ 0 hPa or $>$ 1050 hPa	p	B
Altitude	$<$ 0 m or $>$ 40000m	p , T , RH	Q
Temperature	< -80°C or $>$ 30°C	T	Q
Dew Point	< -99.9°C or $>$ 25°C	RH	Q
	$>$ Temperature	T , RH	Q
Relative Humidity	$<$ 0% or $>$ 100%	RH	B
Wind Speed	$<$ 0ms^{-1} or $>$ 100 ms^{-1}	u , v	Q
	$>$ 150 ms^{-1}	u , v	B
u Wind Component	< -100ms^{-1} or $>$ 100 ms^{-1}	u	Q
	< -150ms^{-1} or $>$ 150 ms^{-1}	u	B
v Wind Component	< -100ms^{-1} or $>$ 100 ms^{-1}	v	Q
	< -150ms^{-1} or $>$ 150 ms^{-1}	v	B
Wind Direction	$<$ 0°or $>$ 360°	u , v	B
Ascent Rate	< -10 ms^{-1} or $>$ 10 ms^{-1}	p , T , RH	Q

p = pressure, T = temperature, RH = relative humidity.
u = zonal wind component, v = meridional wind component.
B = bad, and Q = questionable.

The final group of automated checks examined for vertical consistency within each sounding (Table 4.9). These were the most stringent checks applied during the processing. Again, these checks were applied beginning at the surface and were applied to neighboring data points except in a few cases where (for the purposes of QC only) some averaging of the data was employed. Again, the dropsonde checks varied slightly from those used for upsondes. In this case, the pressure (altitude) was checked to ensure it increased (decreased) with time. Over the entire FASTEX data set 1.33% of data points were flagged by these checks. Most of the flags were due to large inversions (some of which were deemed valid during the visual quality control procedure), large changes in ascent rates, and superadiabatic layers.

In summary, out of the about 9.5 million data points contained within the FASTEX high resolution data set there were about 265 000 reported "errors" (or about 2.8%). However, different checks can often find different errors affecting the same data points so the actual percentage of flagged data points is somewhat less. In comparison with other field programs, the FASTEX data set has a smaller proportion of flagged data points. This is mostly due to less frequent occurrence of superadiabatic layers than in the tropics, as would be expected in mid-latitude winter.

Table 4.9: *Vertical consistency checks applied to the FASTEX high resolution sounding data set.*

Parameter	Vertical Consistency Check	Parameter(s) Flagged	Flag Applied
Time	decreasing/equal	None	None
Altitude	decreasing/equal	p, T, RH	Q
Pressure	increasing/equal	p, T, RH	Q
	$>$ 1hPas^{-1} or < -1 hPas^{-1}	p, T, RH	Q
	$>$ 2hPas^{-1} or < -2 hPas^{-1}	p, T, RH	B
Temperature	< -15°Ckm^{-1}	p, T, RH	Q
	< -30°Ckm^{-1}	p, T, RH	B
from surface to 850 hPa:	$>$ 25°Ckm^{-1}	p, T, RH	Q
	$>$ 40°Ckm^{-1}	p, T, RH	B
for 275 hPa $< p <$ 800 hPa	$>$ 5°Ckm^{-1}	p, T, RH	Q
	$>$ 30°Ckm^{-1}	p, T, RH	B
Ascent Rate	change of $>$ ($<$) ($-$)3 ms^{-1}	p	Q
	change of $>$ ($<$) ($-$)5 ms^{-1}	p	B

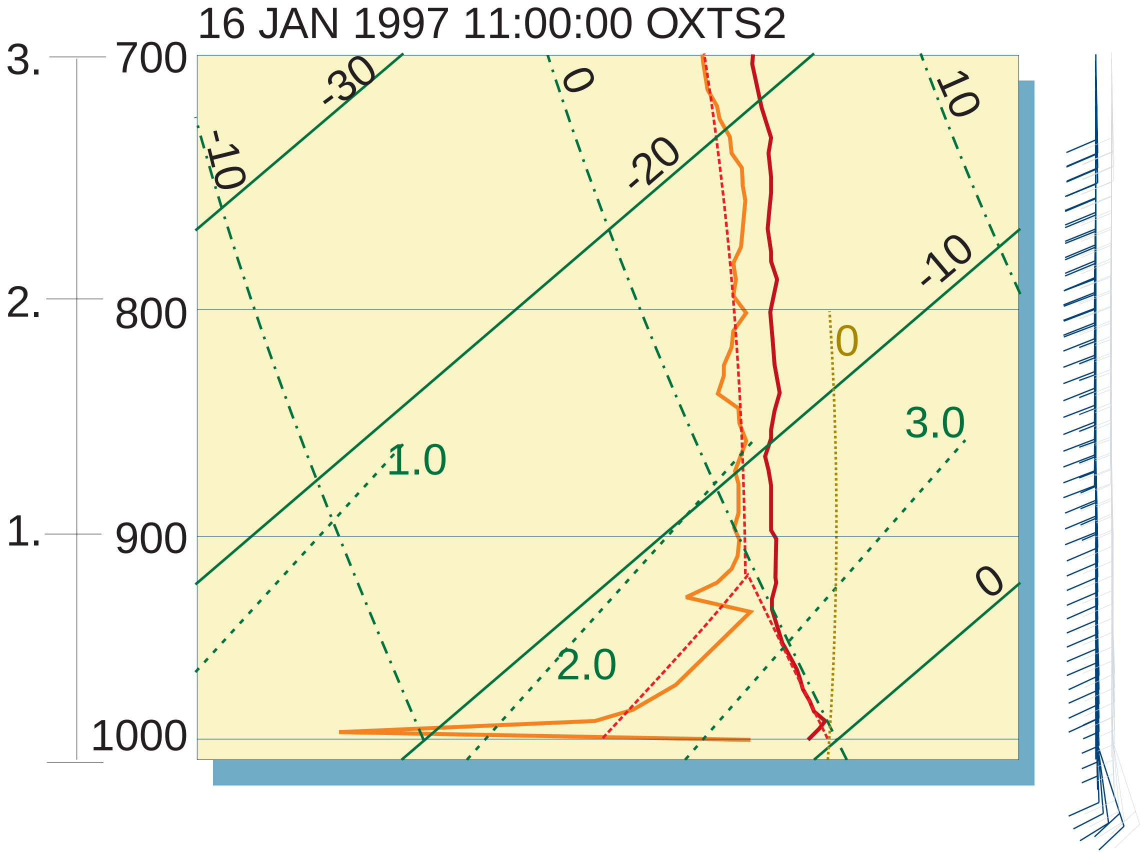
p = pressure, T = temperature, RH = relative humidity.
u = zonal wind component, v = meridional wind component.
B = bad, and Q = questionable.

4.8.3 Visual examination

The next process in the UCAR/JOSS QC for FASTEX was the visual examination of each sounding. This process permitted a closer examination of the humidity and wind data. This QC step was identical to that undertaken by JOSS for TOGA COARE and the full details on this process can be found in Loehrer *et al.* (1996) . JOSS has developed an interactive skew T-log p diagram plotting routine which allows the scientist to automatically change the quality control flags within the sounding data file based on their knowledge of sounding structure. The severity of the flags can be increased or decreased by the scientist, so if the automated procedure flags a feature that upon visual examination appears to be an accurate representation of the atmospheric conditions, that flag can be decreased in severity from what the automated procedure provided. In the case of FASTEX, many large inversions that were flagged by the automated procedure were determined to be realistic features during the visual examination.

One problem that was found during this visual examination process during FASTEX was the existence of some significant "mismatches" between the independent surface humidity measurements and the initial radiosonde humidity measurements. This was especially true on some of the ships. A particularly severe example of this can be seen in Figure 4.12. Here, in the case of the ASAP ship *Irena Arctica*, the first several data points from the radiosonde show much drier conditions than the independently measured surface humidity. The radiosonde values then appear to recover to values that appear to be more representative. This problem has been noted to a significant degree in association with the soundings from TOGA COARE (Cole 1993 and Loehrer *et al.* 1996) as well as from other programs (Loehrer *et al.* 1998) . There have been many suggested causes for these problems, but in this case the problem appears to lie in not allowing the radiosonde to properly acclimate itself to the environment prior to its release. For most of the FASTEX sites, this problem occurred rarely, with $\leq 1\%$ of soundings affected. However, the ASAP ships *Nuca Arctica* ($\sim 20\%$) and *Godafoss* ($\sim 10\%$) had significant numbers of soundings affected. Also, *Godafoss* had another ∼ 10% of soundings where the independently measured surface humidity value was significantly drier (≥ 5°C dew point difference) than the radiosonde values.

Figure 4.12: *An example of a mismatch problem between the surface and initial radiosonde data. The sounding is from the ASAP ship Irena Arctica at 1200 UTC on 16 January, 1997. Note the reduced pressure scale.*



Another problem that needs to be noted occurs in US NWS soundings from Chatham, MA, USA and Charleston, SC, USA. As was mentioned previously, the calculation of the winds at these sites was complicated by the presence of oscillations in the measured angle data. As described in Williams *et al.* (1998) , JOSS applies a scheme that includes outlier removal, smoothing, as well as the application of a notch filter. JOSS focuses the notch filter to the periods most often seen in the oscillations (90 to 190 s). This is done to allow the removal of the effect of the majority of the oscillations, but still keep the mesoscale wind features in the wind profile. However, the tight focus of the notch filter allows some oscillations to remain within the wind data. The problem is particularly still present in conditions that lead to elevation angles ≤ 15^o (i.e. strong winds). This was the case in ∼ 6% of soundings from Charleston, SC and ∼ 5% of soundings from Chatham, MA.

In summary, the visual examination in FASTEX often led to a decrease (∼ 0.5%) in the number of temperature and pressures flagged as "questionable" or "bad" due to occasional over flagging by the automated QC in the case of large inversions. These parameters have little additional flagging done in visual examination due to the overall good performance of the automated QC, which identifies most problems involving these parameters adequately.

In the case of the winds, at most sites the additional flags applied during this process were quite small $\leq 1\%$. However, some sites (i.e. US NWS, French operational, and dropsondes) had from 3-5% of all winds flagged during visual examination.

The relative humidity from the surface to about 350 hPa again had few additional flags applied during this process ($\leq 1\%$). From 350 hPa to 50 hPa (the highest point checked in the visual examination) the amounts of humidity data points flagged could be very high ($\geq 10\%$). The humidities flagged were typically in regions of the sounding that were very cold ($\leq -40^oC$) and dry ($\leq 15\%$) where humidity measurements become difficult and filled with problems. Often the humidity sensor becomes frozen and on a skew T-log p diagram the dew point curve mirrors the temperature curve. Also, at sites which report the relative humidities only to the nearest whole percent, at low humidities the dew point values change large amounts with small changes in relative humidity, which leads to an erratic appearance.

4.8.4 Dropsonde intercomparisons

One of the important and unique aspects of the FASTEX data collection strategy was the use of dropsondes released from aircraft to specifically target and/or document cyclones or areas of potential development. These data are critical to achieving a primary objective of FASTEX concerning forecast improvement. As the initial processing and quality control of nearly 1300 dropsonde launches from the research aircraft platforms progressed, some problems arose that required special attention. Specifically, inconsistencies were found in the measurement of humidity made by several groups using different types of dropsonde expendables. At the time of publication some of these issues are still being examined. However, the authors felt it important that the community be aware of these problems and take them into consideration when dropsonde data are used in analyses.

The known problems with the dropsonde data sets include:

- Incorrect temperature was used to correct humidity. This problem was discovered during processing and has been corrected.
- Contamination of the capacitive sensor's dielectric material by outgassing products from the radiosonde's case and some of the bonding agents. This typically leads to a "dry bias" in the humidity measurement. A resolution to this problem is still being considered.
- Wetting of the humidity sensor during descent causing saturation during most of the profile. This problem remains under investigation.
- Possible effects of heating the humidity sensor on the latest model of expendable package used. This potential problem remains under investigation.

We have identified corrections, if any, that have been made to the data sets that are available from the FCA and JOSS. The first problem concerns the initial calculation of relative humidity (RH) and its adjustment for changing environmental conditions as required by the manufacturer. The Vaisala humicap humidity sensor has a temperature coefficient that is applied in the calibration equation to correct the humidity measurement. It was determined by the data provider that the internal radiosonde package temperature was used to adjust the humidity rather than the ambient outside temperature. This problem existed for the Gulfstream IV, Lear 36 and WP-3D data sets. It has now been corrected.

The next problem concerns contamination of the humidity sensor by outgassing from the resin impregnated radiosonde case and from some of the sealant and bonding products used in the manufacture of the expendable package. A portion of this problem was discovered during FASTEX (i.e. resin impregnated case material) so some of the dropsondes used by the Gulfstream IV and Lear 36 were modified to eliminate that portion of the problem. However, other outgassing problems were discovered after FASTEX and those problems will affect the FASTEX dropsonde data and remain unresolved. An error correction curve has been established but it can only be applied on a sensor by sensor basis. In addition, the amount of time the sensor is stored, and therefore exposed to the outgassing products has an impact on the magnitude of the measurement error. It is clear that the measurement error introduces a dry bias to the humidity observation. Any sort of "correction" process will be both tedious and risky especially if there is no corroborating in-situ humidity measurement. The possibility of making a correction for the dry bias is still being considered but can only be done on soundings exhibiting a known reference condition (e.g. saturation in cloud) (Cole, personal communication).

As JOSS continued its processing and quality control of the sounding data set, it was deemed useful to do some simple comparisons between dropsondes and upsondes, sensor types, and temperature and humidity regimes. Tables 4.10 and 4.11 provide a general summary of these intercomparisons. Table 4.10 provides the percent occurrence (regardless of temperature) of binned RH values in the lower levels (surface to 700 hPa) of the dropsonde data from the Gulfstream IV, Lear 36 and UK C-130 and the upsondes from the *Ægir*. The *Ægir* is taken to be representative of all four of the FASTEX ships (see Table 4.3) as they all had similar sounding statistics and instrumentation. The *Ægir* used a Vaisala RS80-18 Global Positioning System (GPS) radiosonde, the Lear 36 and Gulfstream IV used a Vaisala RD93 GPS dropsonde which uses Vaisala's most recently developed module which has dual humidity sensors that can be heated, and the UK C-130 used a Vaisala RD82 GPS dropsonde. The Aegir and the UK C-130 use the same single humidity sensor which does not have any heating capability. There are two extremes obvious from Table 4.10. The dropsondes from the UK C-130 had $\sim 64\%$ of all data points at these levels with RHs $\geq 90\%$, while the Gulfstream IV and especially the Lear36 had significantly lower occurrences of $\sim 25\%$ and $\sim 10\%$ respectively. The FASTEX ships fell between the extremes at $\sim 30\%$. The humidity sensor used by the UK C-130 was not heated, and there is some evidence here that once the dropsonde was deployed from the aircraft and the humidity sensor reached saturation, there was a tendency for it to remain saturated for the remainder of the flight (e.g. sensor got wet). This problem is currently being investigated by JCMM. Investigators should consider this fact and contact JCMM when using these data in their analysis efforts. Also in Table 4.10, the occurrence of very low RH values at these sites was quite varied. In this case, however, the Lear 36 is quite different from all of the others, including the Gulfstream IV. The Lear 36 had $\sim 16.4\%$ of all data points with RHs $< 20\%$ while the Gulfstream IV and Ægir were $\sim$ 5-6% and the UK C-130 only 1.8%.

Table 4.11 provides the percent occurrence of radiosonde reported saturated conditions for temperatures $\leq 0^oC$ and $> 0^oC$ for the same sites as in Table 4.10. The differences here are dramatic. The same general pattern appears here as in Table 4.10, i.e. a very moist UK C-130 data set, much drier Lear 36 and Gulfstream IV data sets and the *Ægir* data set between the extremes. Note, however, that there is a difference in the occurrence of reported saturated conditions in different temperature

Table 4.10: *Percent occurrence (regardless of temperature) of binned relative humidity values for data points from the surface to 700 hPa for the Gulfstream IV, Lear 36 and UK C-130 dropsondes and the FASTEX ship Ægir upsondes.*

RH %	Gulfstream IV %	Lear 36 %	UK C-130 %	*Ægir* %
$\geq$ 100	3.5	2.9	33.6	12.5
90–99	20.7	8.0	30.4	19.9
80–89	26.9	22.7	13.3	18.1
70–79	18.0	18.1	7.7	15.2
60–69	10.0	12.6	4.5	11.1
50–59	5.8	8.8	3.4	7.8
40–49	3.3	4.2	2.3	3.7
30–39	2.8	2.6	1.7	3.0
20–29	3.0	3.6	1.5	3.2
10–19	2.9	6.9	1.1	3.2
0–9	3.2	9.5	0.7	2.3

Table 4.11: *Percent occurrence of reported saturated conditions for data points with temperatures $\leq$ 0°C and $>$ 0°C (regardless of pressure) for the Gulfstream IV, Lear 36 and UK C-130 dropsondes and the FASTEX ship* Ægir *upsondes. Relative humidity (RH) is related to liquid water*

Site	$\leq$ 0°C, $RH = 100\%$	$>$ 0°C, $RH = 100\%$
Ægir	9.4	17.5
UK-C130	20.4	51.1
Lear 36	1.3	10.3
Gulfstream IV	1.6	8.5

regimes depending on the radiosonde type. The two sites that used an unheated humidity sensor (the UK C-130 and *Ægir*) had about a factor of two higher reported saturated conditions in the warmer temperatures versus the colder temperatures. However, the two sites that used a heated humidity sensor (Lear 36 and Gulfstream IV) reported saturated conditions a factor of five and eight (respectively) higher in the warmer temperatures versus the colder temperatures. Thus while the sites using the heated sensors reported fewer saturated conditions in general (i.e. regardless of temperature) than those sites using the unheated sensors, the effect becomes even more pronounced when temperatures are below 0C. It has already been noted above that there is a known dry bias based on the contamination of the sensor by outgassing by-products from sealant materials. In addition, there may be some effect by the cyclic heating of the humidity sensor during descent. This analysis of the heated sensor has not occurred as of this publication.

4.9 The FASTEX Data Base: Conclusion

The data collected during FASTEX are archived in the FASTEX Data Archive. The raw data are available from specialised data bases. The main part of processed data from FASTEX measurements, in geophysical units, are available from the FASTEX Central Archive at Météo-France. Its Internet address is:

http://www.cnrm.meteo.fr/fastex/.

Operational meteorological measurements in the FASTEX area, as well as the satellite imagery and some satellite products, and fields from the meteorological model ARPEGE analysis are also available in the FCA. The data sets diffused are the up-to-date qualified ones. The high resolution soundings data set, which is one of the most important FASTEX data set, was quality controlled by UCAR/JOSS. The FASTEX Central Archive is open to the whole scientific community, for research and educational purposes. It is planned to diffuse a large part of the FASTEX data sets on CD-ROMs when the major part of the data is in their final form.

The planning for a data management strategy to support the FASTEX project began two years before the field experiment. There is a very important lesson that projects must consider as they prepare for the field. As the scientific objectives and measurement strategies are being developed and finalized so should the policies, procedures and tools needed to handle the data sets be considered and implemented. Meteo France provided the central nucleus of manpower and resources to develop the FCA, reach agreement with national and international data centers for vital project related data sets, and help participants to organize and submit data for archival. This has permitted a rich and varied data set to be readily accessible at the FCA via the WWW.

4.10 Acknowledgments

Many people in Météo-France provided a great help to the FCA: Jean-Paul Guillou, Pascal Brunel and Bertrand Kerdraon (CMS) processed the satellite imagery, Joelle Breuil and Hugo Vandeputte (SCEM) provided the interface to the GTS data, Pierre Blouch and Michel Tremant (CMM) validated the buoys data, Béatrice Pouponneau (CNRM) formated the ARPEGE fields.

Thanks to the persons who processed the FASTEX data and sent it to the FCA, for their collaboration: Andy Macallan (JCMM), Paul Bergue, Guy Caniaux, Emmanuel Gizard (Météo-France/CNRM), Krista Laursen (NCAR/RAF), Ola Persson (NOAA/ETL) and Peter Guest (USnavy/NPS), John Daugherty (NOAA/NSSL), Jon Talbot (USAF).

A special thanks to our correspondants for the high resolution soundings in the European meteorological services: Cesar Belandia (Spain), François Bonnardot (France), Lars Handersen (Denmark), Torfi Karl (Iceland), Gerry Murphy (Ireland), Tim Oakley (UK), and Victor Prior (Portugal).

Also a thanks to the Canadian and US contacts: Dave Steenbergen (Canada), Michael DiVecchio (US), Frank Perry (Chatham), Dave George (Charleston), and Sam West (Wallops).

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