REPORT OF WORKING GROUP 6

THE FEASIBILITY OF AN ERS-1 ORIENTED, BUT SCIENTIFICALLY AUTONOMOUS, INTERNATIONAL EXPERIMENT CAMPAIGN

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1. TERMS OF REFERENCE

The main task of the Working Group was to investigate the feasibility of making use of international experimental field programmes dependent on ERS-1 to obtain useful in-situ data or other support for the validation and calibration of the ERS-1 instruments. Since this hinges critically on the way in which the interaction between the ERS-1 programme and large-scale international scientific field programmes is developed, the Working Group placed this question in the focus of its discussion.

2. EXISTING PROGRAMMES

The ERS-1 flight will coincide with a number of important scientific research programs addressing problems of global dynamics, weather and climate.

The WG considers it an important matter to coordinate the research activities connected with ERS-1 with other ongoing research.
The World Climate Research Programme (WCRP) with its several components can contribute significantly to the calibration and validation of ERS-1; principal among these are WOCE and TOGA. Other experimental programmes being planned include SATLANT, SAVE, WAM, COST43 and several Arctic and Antarctic programmes.

At this time the ensemble of large-scale international scientific programmes which could make useful contributions to ERS-1 instrument validation and calibration is so large and encompasses such a broad range of activities that the Working Group did not see a need to propose any additional new autonomous scientific programmes.

This report will address the question of establishing the requiredscientific and technical interfaces with these existing programmes to ensure mutual benefits in data validation, sensor performance assessment and enrichment of scientific research programmes by collaboration and data exchange.

3. INTERFACING WITH OTHER PROGRAMMES

The WG recognises the need to establish interfaces and liaison with research programmes not directly related to ERS-1, with agencies and institutions in countries that launch and operate Earth-observing satellites, and with international organisations and projects. While many of the needed links do exist, it will benefit the scientific efforts related to ERS-1 to identify existing links and to establish new links as needed.

Specific satellite systems and projects that need to be considered are the following:

- ERS-1
- NROSS
- MOS-2
- EOS and other polar platforms
- ARGOS
- TOPEX-POSEIDON
- DMSP
- SIR-C

In the process of setting up such liaison programmes, the WG suggests that the guiding principle be to establish direct contact between active research groups and between teams engaged in system validation, data interpretation and data communication; the WG also suggests that the charge to the liaison links be broad and that the ultimate purpose continuously be kept in mind, namely the furthering of understanding of the global system and the operational needs of forecasting and assessment.

In order to establish effective links to strengthen the ERS-1 instrument validation and calibration programme, the role of this particular activity within the framework of the overall ERS-1 programme and the parallel international scientific programmes must be kept clearly in mind.

It is an essential characteristic of the contribution of scientific programmes to the ERS-1 instrument calibration and validation that this is a spin-off contribution which cannot be separated from the overall scientific programme planning.

The relation between ERS-1 instrument calibration and validation, similar activities for other satellites (N-ROSS, TOPEX/POSEIDON, MOS-2), the various scientific field programmes, other sources of data such as the World Weather Watch and IGOSS, and data assimilation and modelling activities, is indicated in fig. 6.1. The interfaces and

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comunication links between the different sub-systems of this end-to-end system need to be carefully planned if a mutually beneficial cross-interaction between the ERS-1 programme and the various international scientific programmes - all of which have their own complex internal organisational structures - is to develop fruitfully.

We discuss organisational mechanisms to achieve the necessary communication links and the scientific and technical questions to be addressed in the coordination of the various component activities shown in fig. 6.1 in the next section.

As background for this discussion it is useful to first give a brief review of the activities involved in the different components of the end-to-end system (paragraph numbers below cross-refer to the boxes in fig. 6.1).

1. For TOGA and WOCE the data from satellite are regarded as a central part of the observational system. Satellite data will be used, in particular, for:

   - sea surface topography (altimeter from TOPEX/POSEIDON ERS-1, MOS-2(?) Geosat will also be considered if data are available in the extended mission).

   - wind forcing (scatterometer, wind velocities and altimeter wind speeds from - NSCATT (NROSS) - ERS-1 - MOS-2

   In both of these experiments in-situ measurements will be implemented in two ways:

   a) as part of the extensive observational network designed to provide the basic oceanic data sets of the experiments to constrain the modes (direct scientific objectives)
   b) as part of the process of calibration and validation of the satellite data. The objectives of these measurements are identical to the long-term calibration and validation activity of the ERS-1 programme.

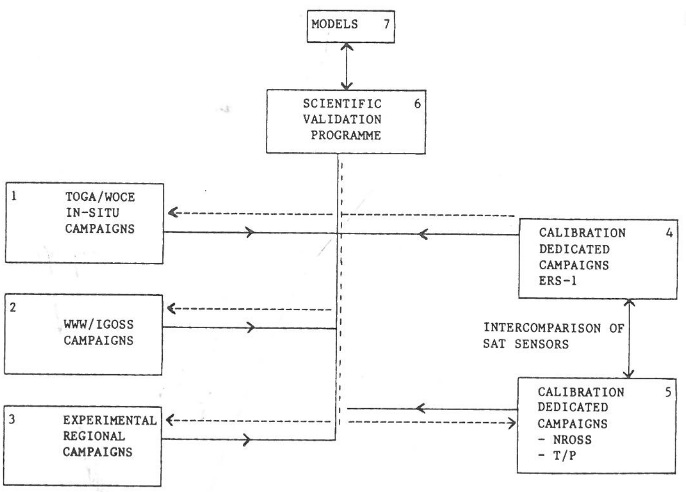

FIG. 6.1

2. Both WOCE and TOGA will lean heavily on the ongoing data collection provided by the WWW and IGOSS. These data will also be useful in conjunction with the continual comprehensive data assimilation operation planned for WOCE and TOGA (and required also for various other applications of ERS-1 data, for example, for real time weather and wave forecasting) to validate and calibrate ERS-1 data.

3. Besides WOCE and TOGA there are other campaigns planned to collect in-situ data, generally in regional areas. On the average there is a lag of 2-3 years between the proposal and/or decision and the implementation of such experiments. Thus it will still be possible for the ERS-1 programme planning to impact on these campaign plans.

4/5 The various satellite projects will carry out calibration activities during commissioning phases (a few months)

- to assess the accuracy of the instruments (within given specifications)

- to give a preliminary evaluation of geophysical parameters.

However, because of the limited time frame, this calibration can have only limited objectives and cannot guarantee the value of the geophysical parameters e.g. in various conditions of sea state.

An important feature of the calibration and validation activities during the commissioning phase is that they will need to be synchronised with the launch date. Since this cannot be precisely determined in advance, this implies that the programme will need to be very flexible. This requirement will generally be in conflict with the field programme and data collection activities of the components 1, 2 and 3. Nevertheless, the value of the calibration and validation campaigns during the commissioning phase to the scientfic programmes, and the possibility of augmenting these activities through supplementary in-situ measurements from the scientific field programmes, should be investigated.

6. The scientific validation programme represents the central activity of all scientific programmes. It is concerned with the application of models (component 7 of fig. 6.1) to the data coming in from all component streams 1-5, to test the physical concepts which are the object of the scientific programmes.

   A basic output of the validation programme will be complete reconstruction of all geophysical fields for which sufficiently dense data coverage is available. This includes particularly thesea surface properties measured by satellites. A continuous data assimilation system of this form, in which the satellite data are combined with all other available data sources, provides an excellent long-term instrument calibration and validation tool. Thus in the planning of the calibration/validation programme, attention should be given to this aspect, as well as to the standard in-situ intercomparison techniques.

Time Scale

Both TOGA and WOCE are long term programmes and are expected to span the full life time of the oceanographic satellites.
TOGA has already started and will certainly still be operational during the lifetime of ERS-1. Significant deployment of in-situ measurements is planned but will be limited primarily to tropical areas.

The current planning for WOCE is to start the experiment in the early 90's. The time scale is based upon the expected launch time of NROSS (NSCAT), TOPEX/POSEIDON and ERS-1. The possible shift in the launch of ERS-1 (end of 89) relative to the launch of the other satellites (mid 91) will have disadvantages.

The timing of most of the other campaigns is also matched to the operation periods of the satellites. However, any advantage gained by extending the total period of satellite coverage, may be partially off-set by reducing the common operation period.

4. ORGANISATIONAL ASPECTS

In setting up both the inter-governmental and working level interactions between ESA and the international campaigns, the following approach, illustrated in figure 6.2, should be followed:

1. The ERS-1 Science and Applications Working Team (ESAWT), whose membership will be determined primarily by the response to the ERS-1 Announcement of Opportunity, shall provide inputs to ESA for the establishment of agreements with the organisations responsible for major international scientific experiments and campaigns of interest to the ERS-1 mission.

2. The ESA ERS-1 team, with the assistance of the ESAWT, shall maintain close links with the Scientific Steering Groups (SSG's) of the various major international campaign organisations. The working group underlined the convenience of overlapping membership between the ESAWT and SSG's.

3. ESA, with the support of the ESAWT, shall set up ad hoc task groups of limited lifetime to address specific issues such as the initial planning arrangements for bilateral or multilateral data exchange, for data processing and interpretation, the deployment of in situ measurement equipments etc.

4. ESA shall ensure that direct scientific and technical links are made at working level in order that the recommendations of the ESAWT, endorsed by the ERS-1 programme, are fully implemented in practice.

The inter-relationship between ESA and the parent organisation(s) responsible for the campaign(s) as well as the proposed procedures by which campaign data should be collected is as follows:

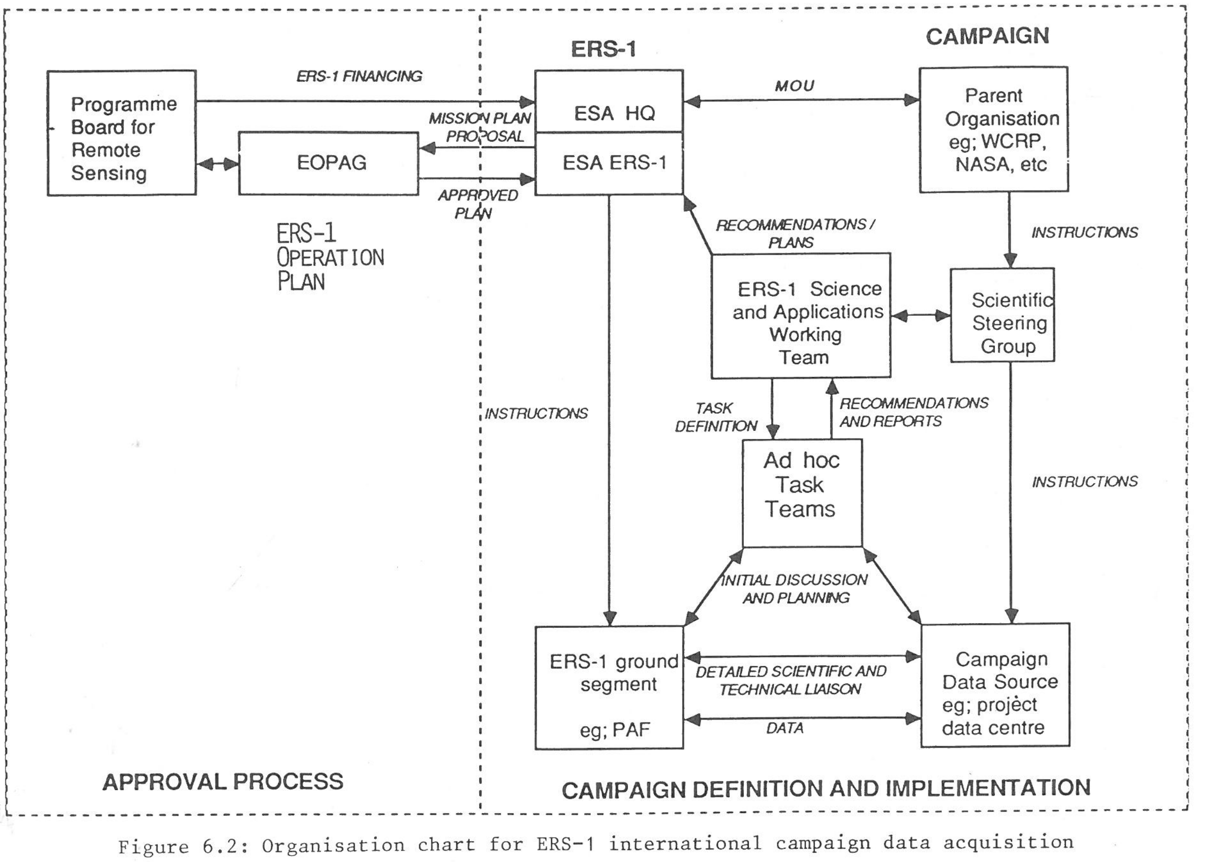

Figure 6.2: Organisation chart for ERS-1 international campaign data acquisition

a) The ESAWT shall assist ESA in the formulation of a plan for interaction with a given appropriate international campaign based on the results of discussions with the Scientific Steering Group of that particular international campaign and on a report of an ad hoc group which will have carried out a preliminary assessment of the detailed technical issues at working level (i.e. discussions with potential providers and receivers of data).
b) Following the analysis of technical, operational and financial implications, ESA shall enter into a dialogue with the parent organisation of the campaign, maintaining discussion with the ESAWT, and culminating in the signing of an Agreement/Memorandum of Understanding (MOU).
c) At the working level, scientific and technical liaison will take place between the teams collecting or generating the campaign data and the ESA teams and associated entities (e.g. ERS-1 PAF's) whose task is to assimilate the data for the purpose of ERS-1 sensor calibration and data validation.

The organizational structure for these activities is shown in Fig. 6.2. Note that the responsibility for the final decisions concerning the ERS-1 mission lies with the Remote Sensing Programme Board (PB-RS), the ESA delegate body responsible for Earth Observation matters, assisted by the ERS-1 Operation Plan Advisory Group (EOPAG) for those aspects related to the mission operation plan.

5. COORDINATION TASKS

A number of problems affecting the coordination of the ERS-1 calibration/validation programme and the scientific field programmes will need to be addressed by the various inter-acting groups described in fig. 6.2.
In particular, the Working Group expressed its concern that existing planned campaigns may be limited in scope and may not address all of the necessary requirements for calibration and validation. Therefore, the following were identified as possible gaps, which should be taken into account:

5.1 The identification of measurements (wind and waves) planned for WOCE, TOGA and other campaigns.

Such measurements can be used:
- to validate ERS-1 instruments
- to help to cross-calibration of ERS-1 instruments and other satellites NSCAT/NROSS, TOPEX/POSEIDON, GEOSAT

A detailed discussion is needed with respect to the
. type of measurement (sensors, platforms)
. accuracy of measurements
. sampling problems
. areas of specific interest

5.2 Plans for other satellites

This will enable the optimal use of the specific validation and calibration campaigns of ERS-1, and other satellites, in the design of the planned scientific campaigns during the 1990 - 1995 period.

5.3 Sampling of high winds and waveheights by in-situ measurements

Major oceanographic and atmospheric processes of scientific and operational interest are associated with extreme wind and wave situations. This means that the full dynamic range of the satellite instruments must be evaluated, implying in-situ observations to be taken in areas and at times when extreme weather is most likely to occur. On the large scale, this is between 40 - 60° N during winter and throughout the year in some parts of the Southern Ocean.

There are some technical problems to be overcome with the in-situ measurement of extreme wind and wave conditions. Airborne measurements may be assistance.

5.4 Coverage of a broad SST Range

There is some evidence that radar backscatter depends not only on surface roughness but also on sea surface temperature (Freilich, these proceedings). Such behaviour should be taken into account in the calibration and validation of both scatterometer and altimeter winds and for this comparison data sets should be obtained at a variety of SST's. Within the high wind speed regions of mid-latitudes there is rather little variation in SST. In order to obtain measurements covering a reasonable range of wind and wave conditions at high SST the western portion of the Trade winds should be considered e.g. Caribbean where temperatures exceed 25°C.

5.5 Inclusion of Frontal Regions

Atmospheric and oceanic fronts are of interest in air-sea interaction because they are often associated with significant fluxes and they induce vertical motion coupling boundary layer processes with the free atmosphere and ocean. It is therefore important that wind and wave parameters should be accurately retrieved in such regions and the calibration/validation should incorporate possible effects of rapidly changing thermo/dynamic stability (i.e. air-sea temperature difference) and sea-state.

5.6 Inclusion of adequate wave spectra variability

The discussion under 5.3 also holds for obtaining waveheight measurements which span a wide range. However, the same locations may not provide an adequate variation of wavelength and direction. In-situ data should be gathered over a range of conditions varying from those dominated by long swell to a wind generated sea. This may necessitate the use of open ocean and coastal sites with limited fetch and depth. Wind retrieval algorithms may differ for the two cases, however, we must remember the limit of near coastal scatterometer wind retrievals due to the large footprint. It is also known that SAR imaging of ocean waves depends on the orientation of wave direction with respect to the radar look angle. Therefore calibration/validation should encompass the whole range of this parameter.

5.7 Establishment of continuously monitoring stations

After the initial calibration/validation period there will be need for continuous in-situ data to check possible drift or minor failures in the satellite instrument performance. This can be obtained in near real time from platforms of opportunity such as buoys, research vessels, weather ships and oil rigs. In addition, if the satellite retrievals are interactively used in operational atmospheric and wave models, any "bad" data will soon be discovered.

5.8 Measurements near the ice edge

Wind and waves are extremely important in determining marginal ice zone (MIZ) processes, and the MIZ is a generation area for polar lows. Since this is the area where, in general, the coldest surface water is found, some calibration points should be obtained here to check the SST sensitivity (see 5.4) of the satellite retrievals near 0°C. As mentioned in 5.6), due to the large footprint of the scatterometer the wind velocity retrievals are limited to a certain distance from the ice edge and must, therefore, be coupled with an atmospheric model. Another important limitation in these areas is the sometimes sudden formation of a very thin layer of grease ice over large areas, having similar effect as oil or micro-organisms by the dampening of capillary and small gravity waves.

5.9 The Establishment of combined data sets for real-time operational forecasting

Most of the planned large-scale international experimental programmes are directed towards problems of climate or long-term ocean dynamics. To our knowledge there exist at present no specific scientific programmes designed to exploit the data provided by ocean satellites, and in particular by ERS-1, for real-time forecasting operations (although some centres, such as ECMWF, are making efforts to investigate how these data can be included in their future operations). Such programmes could provide a valuable feedback into the validation problem.

The assimilation of oceanographic satellite data poses a number of non-trivial scientific questions which will need to be addressed by a concerted collaborative effort of the scientific community and operational forecast centres.

There is a strong interest of the climate community and other researchers concerned with long time scale processes that these questions are resolved and ocean satellite data are routinely assimilated and used by operational forecasting centres. For it is only through such an operational real-time activity approval that continuous gridded data can be generated for other research applications. In addition to these considerations, however, it should be recognised that ocean satellites will also open up unique new opportunities in the field of real-time forecasting itself.

The scientific community should attempt to develop the methodology to make use of these new forecasting possibilities in collaboration with forecasting centres. These concern, for example, the prediction of sea ice, wind fields and surface waves in the marginal ice zones, the interaction of currents and waves in frontal zones or the possibilities of extended range weather forecasting using coupled atmosphere/ocean models. A closer analysis of these problems could well lead to the definition of additional experimental programmes designed to augment the ocean satellite data with data from conventional instruments, which could then also provide useful data for instrument validation.

5.10 Investigation of the space time variability and its implications for calibration/validation

Satellites and in-situ instruments provide very different views of the sea-surface, one giving a spatial average over footprints as large as a few thousands of km^2, the other time series at single locations. The space time variability inherent in wind and wave fields will affect the choice of appropriate averaging of both the in-situ and the satellite data. It will also help determine the weighting to be applied to data from platforms that are not coincident with ERS-1 sensor footprints. Aircraft offer the possibility of relating the two types of measurements. The study of such variability is of scientific interest and emphasis should be placed on this aspect in the design of any ERS-1 oriented experiment. For example, wind and wave instruments on ships, buoys and aircraft could be deployed in arrays spanning scales of kilometres to tens of kilometres. It is important that all surface-based and aircraft sensors be carefully inter-calibrated and such activities should form part of any experiment plan.

6. RECOMMENDATIONS

In addition to the organisational recommendations in 4 the following, more general, points emerged.

(i) The Group endorses the recommendation that the positioning of the 3-day repeat ground tracks should be decided soon as it could influence the location of scientific measurement programmes.

(ii) We note the uncertainty in data reception on three of the ERS-1 orbit tracks during the commissioning phase. In view of the requirement for global satellite date in many of the planned scientific programmes and that these orbits include critical regions such as the Drake Passage and the Southern Ocean near South Africa, we recommend that every effort be made to ensure that global coverage is possible.

(iii) We recommend that calibration of the AMI wind and wave modes using scientific programmes in coastal regions should be made possible through appropriate harmonisation with the operation of the SAR imaging mode.

(iv) We recommend that ESA should bring the general requirements noted in sections 5.1 - 5.10 to the Scientific Steering Groups of relevant experiments.