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OBSERVING SYSTEMS

EUCOS operational programme

(Submitted by Mr S.J. Caughey, the EUCOS Programme Manager)

Summary and Purpose of the Document

The document contains information on the EUCOS operational programme.

ACTION PROPOSED

The meeting is invited to consider the information on the EUCOS operational programme given in the document.

THE EUCOS OPERATIONAL PROGRAMME

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ABSTRACT

EUCOS (Eumetnet Composite Observing System) is an initiative to improve Numerical Weather Prediction (NWP) products on the regional (European) scale. An outline is provided of the development and structure of the programme which is expected to lead to progressively improved observational data sets by 2006. The main programme components include upper air data from commercial shipping (ASAPs) and aircraft (AMDAR) as well as territorial and surface marine networks. Some elements are being integrated and progressively funded on a GNI basis by the 18 member National Met Services[1] and a single programme manager appointed. It is intended that EUCOS will evolve to form an optimised component of the total space-terrestrial observing system. In addition the contribution of targeted observations in sensitive areas (predicted by NWP schemes) is being investigated.

1. INTRODUCTION

EUMETNET is an informal grouping of 18 National Met Services which provides a framework for collaboration and co-operation. EUCOS is a EUMETNET programme in the field of observing systems aimed at improving numerical weather predictions on the regional scale for 1-3 days ahead and introducing (where appropriate) integrated management and joint funding of programme elements. The EUCOS area of interest is, broadly speaking, the area from which observations impact on NWP, in the short range (Fig. 1). EUCOS can also be regarded as a larger scale network across Europe and the surrounding sea areas which provides a framework for smaller scale networks (designed for very short range forecasting and nowcasting over national territories) and also contributes to medium range weather prediction over the globe. It can also be considered as an optimised regional component of the World Weather Watch of the WMO.

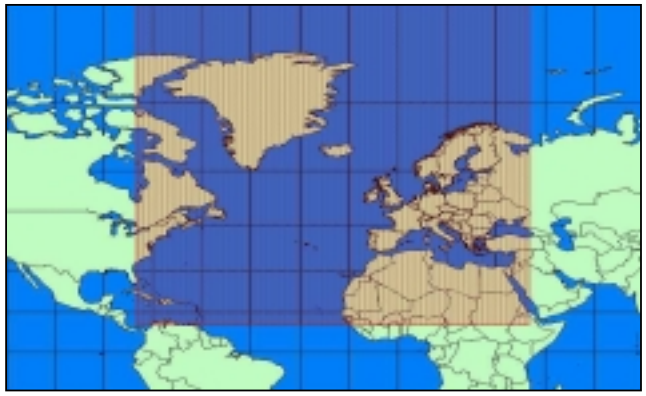

Figure 1: The EUCOS Area of Interest (70W-40E, 10N-90N)

2. PROGRAMME STRUCTURE

It was clear at the outset that more upper air observations were needed upstream if the goal of improved NWP was to be realised. The Atlantic and Mediterranean areas are data sparse but generate damaging cyclones across Europe. On the other hand observational coverage across mainland Europe on the larger scale is generally fairly good. This implies that some resource transfer may be justified – from rather well to poorly observed areas. During the Implementation Phase of the programme (1999-2002) design studies were conducted leading to overall development strategies for the various components. These were then finalised taking into account issues of affordability. The current EUCOS operational design Ref (1) is summarised in (Fig. 2). Most effort at the present time is involved in implementing this design and completing definitions where necessary as the system evolves and develops out to 2006.

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[1] EUMETNET Members: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom

		2001 (RBSN, COSNA)	2006 (EUCOS)
Oceanic Segment	Ocean platforms	OWS "M" (4 RW/day) and Ekofisk rig (2RW/day) (2190 TEMP/yr)	
	ASAP units	10 operated by Members and E-ASAP, producing 3000 TEMPSHIP/yr	18 units operated by E-ASAP producing a Minimum of 6300 TEMPSHIP/ year
	Data Buoys	Yearly deployment of approx. 50 drifting buoys operated under EGOS	To be defined pending Assessment under stage 1 of EUCOS Surface Marine Programme
	Moored buoys	EGOS buoys off the Continental shelf	
	Ships	Approximately 1700 VOS	
Aeronautic Segment	AMDAR units	140 units operated by Members 10 000 000 msgs/yr	13 000 000 AMDAR observations/yr. Profiles from 140 European Airports and level flight data throughout the EUCOS area
Territorial Segment	Radiosonde Stations	69 stations 19 with 4 RW/day 63 510 TEMP/yr	46 stations 34 with 4 RW/day 59130 TEMP/yr
	Surface Stations	359 RBSN stations	Selected surface synoptic stations (list currently subject to approval)
Observation Targeting	ASAP, AMDAR, BUOYS		Season and area variable Deployment and activation
	Other systems		To be defined according to the results from the studies programme

Figure 2: The EUCOS Operational Design

The programme consists of a series of elements as outlined in (Fig 3). A brief review is now given of the main programme components and the expected evolution out to 2006.

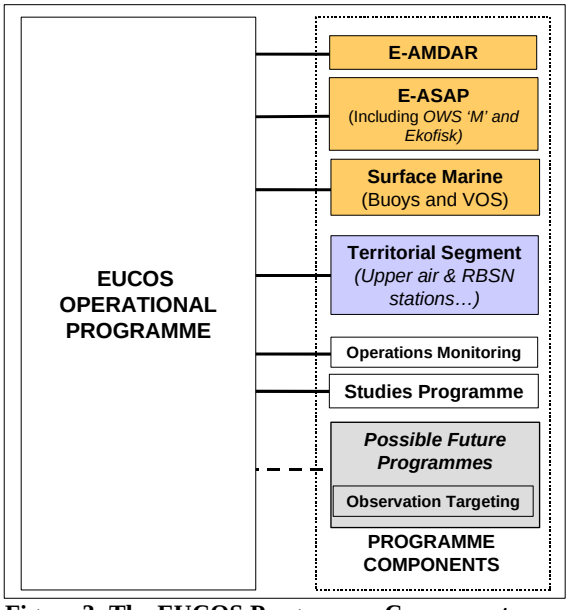

Figure 3: The EUCOS Programme Components

3. OCEANIC UPPER AIR SEGMENT (E-ASAP)

This encompasses upper air data from both commercial shipping and Ocean Weather Ship 'Mike' together with the Ekofisk platform in the North Sea. It forms an 'integrated' element of EUCOS which means that Members contribute on a GNI basis to the programme costs. The Programme Management is the responsibility of the Deutscher Wetterdienst (DWD) - the Programme Manager is Klaus Hedegaard (e-mail Klaus.Hedegaard@dwd.de). The main programme objectives can be summarised as follows:

- reach a total of 18 ASAP ships providing 6,300 soundings per year by 2006.
- optimise the overall system – to provide homogeneous coverage (as far as possible) and appropriate temporal sampling.
- reduce the average cost of each profile through efficiency measures.
- maintain and (if necessary) replace major equipment components
- contribute to the WWW of the WMO through the ASAP Panel

A typical coverage map from the ASAP programme is shown in Fig (4) for Feb 2003. A total of around 3000 ascents are expected to be generated in 2003.

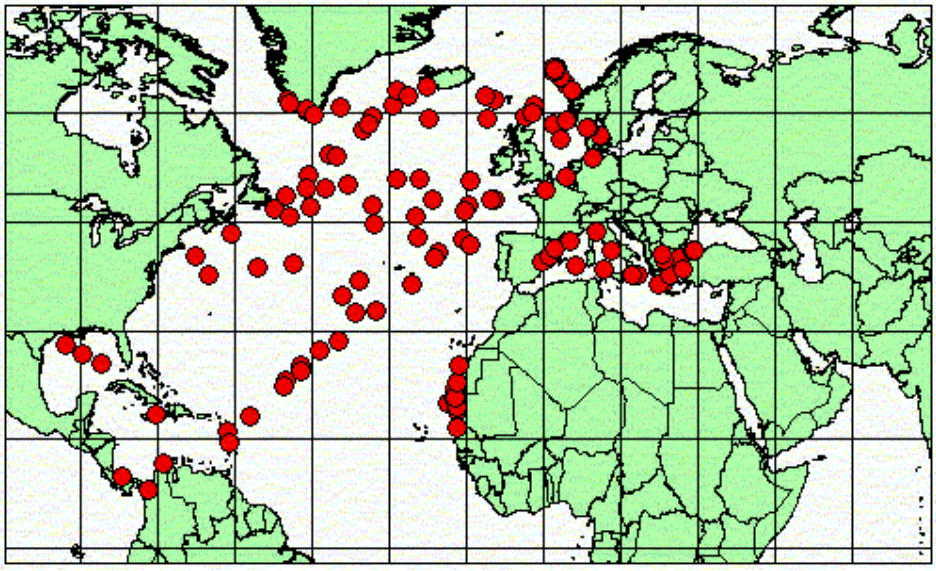

Figure 4: ASAP Soundings, Feb 2003

The expected deployment of the 18 ASAP units by 2006 is set out in the Table below:

Number of ASAP Ships	Route
2	Europe – Greenland
3	Channel - French West Indies / Caribbean
1	Between the Canary Islands – Spain
1	Iceland - Eastern seaboard of Canada / US
1	Greece/Turkey - NW Europe
1	Egypt – Italy
3	Channel – Charleston
3	Malta (mid. & west Mediterranean) – Newark
2	Channel – Montreal
1	Research vessel (WWW contribution)

4. AERONAUTICAL SEGMENT (E-AMDAR)

This element provides profiles of wind and temperature data from aircraft from the ascent and descent phase as well as en-route observations (as desired). Data costs are a fraction of those from traditional radiosondes and although humidity measurements are not yet available they provide a lower cost alternative. During the implementation phase EUCOS conducted an upper air OSE which showed that 700-800 AMDAR profiles per day could largely offset a significant reduction in radiosonde ascents across Europe Ref (2). This work enabled a less dense more uniform EUCOS radiosonde network to be defined and offered NMSs the opportunity to re-design national networks to release resources for investment in improving coverage in data sparse areas.

In broad terms the objectives are:

- to provide 3 hourly profiles over Europe
- generate en-route and profile data over data sparse/sensitive areas
- procure data in support of the WWW
- achieve data capture of around 13 million messages per year.
- enable Members to procure additional data for national purposes beyond the EUCOS requirement.

The expected growth of the programme between 2003 and 2006 is outlined in the Table below.

Description	2003	2004	2005	2006
Number of Airports observed daily (within EUCOS area)	100	110	125	140
'3 hourly' locations (Configured to complement EUCOS radiosonde stations)	25	28	32	35
Number of Profiles (within EUCOS area)	560	620	680	740
Data Over Sensitive EUCOS Areas (Percentage of resources devoted)	15%	19%	24%	30%
WWW Contribution (Resources devoted to data acquisition outside of the EUCOS area)	5%	7%	9%	10%
AMDAR Observations (Annual Total)	8 million	9.5 million	11 million	13 million

By 2006 approximately 740 soundings within the EUCOS area/day should be provided i.e. the level needed to implement the EUCOS upper air design. The network has developed rapidly in recent years. Figures (5a) and (5b) show a comparison between the coverage in October 1999 and June 2003. It is hoped to improve coverage in data sparse areas and achieve better coverage during the period 00-06 UTC.

Figure 5a: European AMDAR coverage Oct 1999

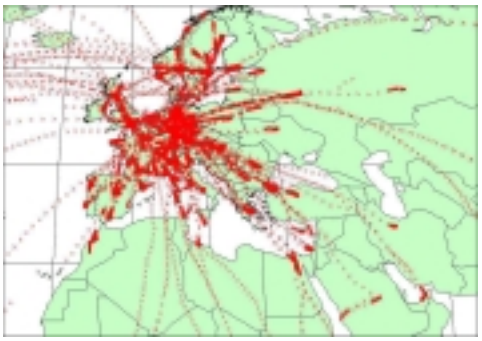

Figure 5b: European AMDAR coverage June 2003

The programme has established data optimisation and quality control procedures which enable selection of particular aircraft and routes as required. Further automation and development is envisaged to give greater flexibility to commission the data required on a day to day basis by selection across the entire 600 aircraft fleet. At the beginning of 2003 responsibility for this programme transferred to the Swedish Meteorological and Hydrological Institute. The manager is Ture Hovberg (e-mail ture.hovberg@smhi.se)

5. SURFACE MARINE PROGRAMME (E-SURFMAR)

This is a relatively new activity within the EUCOS framework and is currently supported by 15[(2)] of the 18 NMSs. It seeks to establish the EUCOS requirement for surface marine data from Voluntary Observing Ships, drifting buoys and moored buoys in the context of the other elements of the total system (especially space data). A study will be conducted across the next two years to develop an optimised design, following which is envisaged a period of progressive implementation as resources allow. This work proceeds in close co-operation with the European Group on Ocean Stations (EGOS). Meteo France have been given responsibility for this programme. Pierre Blouch is the programme manager (e-mail pierre.blouch@meteo.fr)

One of the first actions will be to introduce a technical group to establish effective liaison in VOS matters in Europe. This group is expected to meet in the autumn of 2003. E-SURFMAR will maintain close links with relevant WMO/IOC activities in this area.

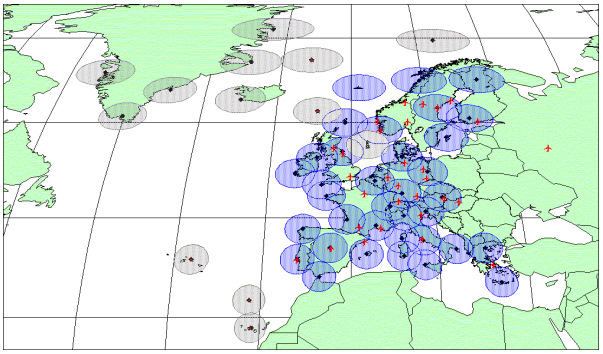

Figure 6: EUCOS Upper Air Design

6. TERRITORIAL NETWORKS

As noted earlier the EUCOS upper air design relates closely to the expected growth of AMDAR data and monitoring at airport sites across Europe. A relatively homogeneous network of stations about 500 km apart was chosen as illustrated in Fig. (6). (The shaded areas indicate the 500km region around the station)

Most of these stations are expected to eventually perform 4 soundings per day (shown in blue, grey indicates 2 soundings per day). However, this network is now under review to take into account

- wider availability of AMDAR data than originally envisaged

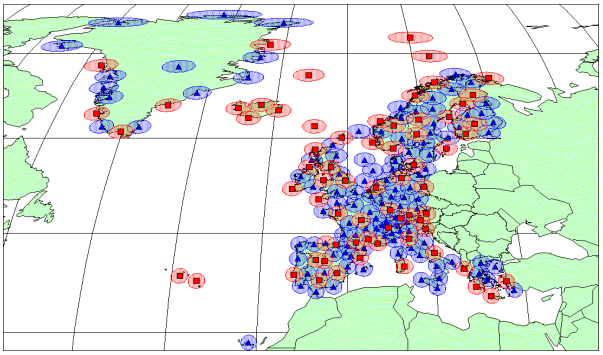

Figure 7: Preliminary Surface Network

[2] SurfMar Participants: Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, United Kingdom.

- availability of new technology such as GPS, profilers and doppler radar

During the next year EUCOS will seek to develop a revised design taking these additional data sources into account.

A preliminary surface network design Fig. (7) has been developed using WMO recommendations for surface observations in regional NWP (the red circles denote GCOS Surface Network Stations). A 250-km spacing has been used and a requirement for hourly observations agreed. Individual station lists for the national territories of the 18 NMSs are in the process of being finalised.

7. OPERATIONS

The EUCOS network became 'operational' on the 1 January 2003. At this time routine monitoring of individual elements against agreed performance standards (mainly quality and timeliness) commenced. Other fault correction and change control procedures have been developed and introduced. The broad aim is to ensure that the components of the system perform in an increasingly effective way as time progresses. More exacting standards will be introduced as information about actual performance becomes available. Information and feedback to participants of the programme are made available through the EUCOS web-site. Bruce Truscott bruce.truscott@metoffice.com is the EUCOS Operations Manager and Jacqui Rogers jacqui.rogers@metoffice.com is the Technical Co-ordinator.

A brief summary of the results of operational monitoring from January-June 2003 is shown below. These results have highlighted a number of issues that must now be considered

(i) adjust initial targets to reflect current performance, particularly those for data timeliness which have been comfortably achieved.
(ii) Complete the set of data availability targets.
(iii) Introduce additional measures that will help monitor specific aspects of performance.

Although most of the EUCOS components have experienced minor problems during the period, these have been rapidly resolved and are not therefore considered serious. There are, however, some continuing concerns about some radiosonde stations and the availability and height coverage of some ASAP profiles. These are being addressed as a matter of priority.

EUCOS Component	Data Availability	Data Timeliness	Data Quality
AMDAR	E-AMDAR statistics show performance is on target	Target exceeded	Good
ASAP	*Fewer than expected soundings were received, although steadily improving.*	On target (and improving)	*Some problems reaching 100hPa level but improving*
OWS M and Ekofisk	On target	Target exceeded	Good, Ekofisk below target (Burst height) but now improving.
Radiosonde	*Some stations not achieving the minimum requirement (2 launches per day by HH+120)*	Target exceeded	Good
RBSN	On target	Target exceeded	3- 6% of observations show a pressure bias > 1 hPa
VOS	Consistent throughout period, on target. Duplication of data has been noted	Target exceeded	Automatic VOS: Good *Manned VOS: Approximately 10% of ships show a pressure bias > 1 hPa*
Moored and Drifting Buoys	Drifting buoys: on target *Moored buoys:dropped below target late in period*	Moored buoys: exceed the target. *Drifting buoys: below target.*	Good

8. THE STUDIES PROGRAMME

As noted earlier the evolution of EUCOS is guided by a Studies Programme – overseen by a Scientific Advisory Team chaired by ECMWF and comprising representatives from the main NWP centres in Europe. The 2003 activities include

- Observing System Experiments (OSEs)
- technology demonstrations
- network reviews

The three OSEs given priority in 2003 are

- high frequency AMDAR data
- additional surface marine data from climatologically sensitive areas in the Atlantic (Ref 3)
- targeted observations (in conjunction with THORPEX – the 2003 North Atlantic Thorpex Regional Campaign).

The AMDAR OSE involves capturing profiles across Europe at a roughly hourly rate compared to the present 3-hourly requirement. Fig. (8) shows the increase in data achieved in the first special observing period (SOP) which ran from 5th March to 15th April 2003. The impact of these additional data on regional and smaller scale NWP models will be investigated by a number of NWP centres. The marine OSE is intended to assist with the design study noted earlier and will consider case studies of selected events in the key sensitive areas of interest. It involves deployment of 20 additional drifting buoys in key climatologically sensitive areas of the Atlantic.

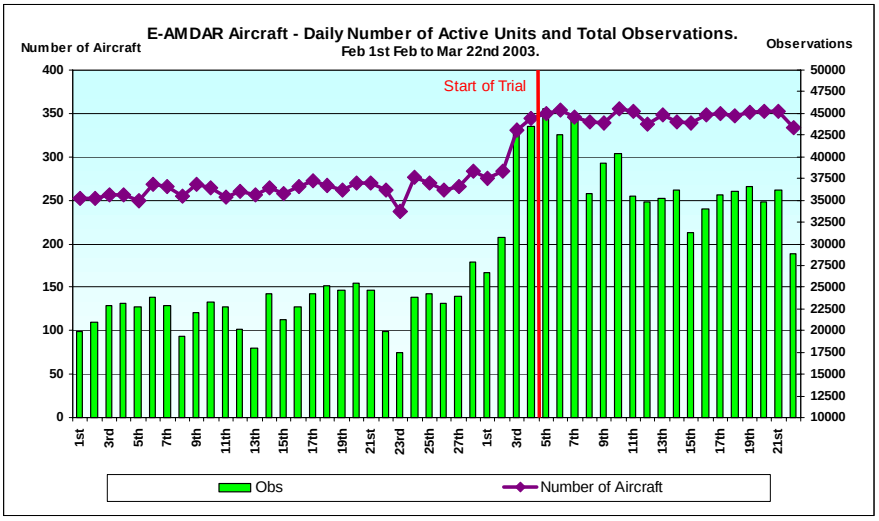

Figure 8: AMDAR Network Performance during the first SOP (March – Mid April 2003)

The targeted observations work follows on from earlier EUCOS studies and links closely to THORPEX observational objectives. Several NWP centres will prepare predictions of "sensitive areas" (ie zones where additional observations are expected to have a significant impact on NWP quality). These will then be 'targeted' by EUCOS and US/Canadian observational assets (including ASAP, AMDAR, additional upper air data, extra satellite data and data from research aircraft). Selected events will then be studied by NWP Centres including ECMWF. These studies if successful may lead to progressively greater dynamic interaction between NWP schemes and observing networks. This overall activity is known as

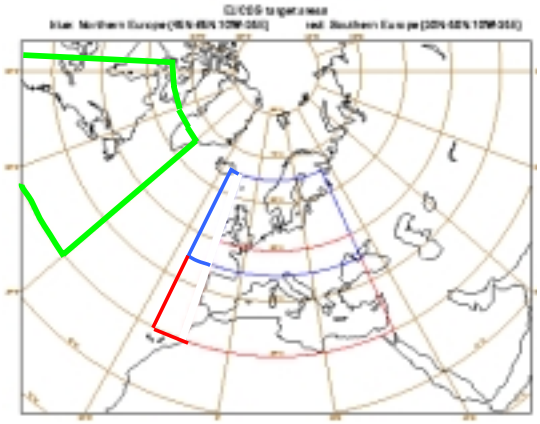

Figure 9: TOST Verification

the North Atlantic – THORPEX Regional Campaign (NA-TReC). The forecast verification regions comprise N. and S. European zones and the eastern area of N. America (see Figure 9). A summary of the observing systems expected to participate in the TOST are illustrated below.

EUROPEAN	
Observing System	**Operator**
AMDAR Aircraft	EUMETNET-AMDAR Programme
ASAP Ships	EUMETNET-ASAP Programme
Selected Radiosonde	EUCOS
Moored and Drifting Buoys	EUMETNET Surface Marine Programme (under EGOS)
Research Aircraft	Falcon - DLR
Meteosat 6 (@ 10 deg E)	EUMETSAT (Rapid scan winds 10 min)
MSG	EUMETSAT (Some early products may be available during commissioning)

NORTH AMERICAN / CANADIAN	
Observing System	**Operator**
Radiosonde	US National Weather Service
	Met. Service Canada (MSC)
Research Aircraft	NOAA G-IV: NOAA
	Convair 580: Met. Service Canada
	DLR Falcon: DLR
	Citation : UND
	NASA ER-2: NASA
	NOAA P3s (2 aircraft): NOAA
Other aircraft	US Air Force
Driftsonde	NCAR (1 site: 2 to 3 flights)
TAMDAR	NASA
MDCRS (AMDAR)	NOAA/FSL
Satellite	GOES rapid scan winds

Each of the organisations responsible for operating elements of the observing system are expected to consider and if possible respond to requests from the relevant Observations Centre which will be responsible for:

- setting up the necessary systems and processes required to co-ordinate their components of the targeted observing system
- delivering the data requested by the Operations Centre;
- Monitoring data returns and the providing feedback to the Operations Centre

Other aspects of the studies programme involve evaluation of TAMDAR (Tropospheric AMDAR) units being developed by NASA and driftsonde – a targeted observing technology developed by NCAR that involves release of dropsondes from a gondola attached to a stratospheric balloon.

Based on a paper (see Annex 1) prepared by the EUCOS Scientific Advisory Team discussions have taken place between ECMWF, EUMETSAT and EUCOS to consider an appropriate way ahead in developing a fully integrated space-terrestrial observing system for the future. The work would involve a longer-term, comprehensive study of the relative contributions of the different components of the total system to eg NWP quality. It would start with assessments of the current system and develop to include new types of data eg MSG/Metop (when available) as well as new elements of the terrestrial

system. From this recommendations may emerge to guide future evolution of the total system. ECMWF have undertaken to prepare a proposal for a specific programme of work that could be jointly funded by EUCOS and EUMETSAT.

References

1. EUCOS Detailed Design by Francois Gerard. EUCOS-PRG-010. September 2001

2. EUCOS Impact Study by Carla Cardinali. EUCOS-REP-029. September 2000

3. EUCOS Sensitivity Study by Gert-Jan Marseille and Francois Boultier. EUCOS-REP-030.

Evolution of the Space and Terrestrial Observing Systems for NWP EUCOS proposals for co-ordinated research

Prepared by EUCOS Scientific Advisory Team (E-SAT)[1]

1. Summary

A terrestrial network of observations is required for the calibration and verification of satellite observations. However, such a network will not be sufficient to meet the future requirements of NWP as specified in WMO (2001). The shorter term question to be asked is: what terrestrial observations are needed in terms of type, quality, distribution and frequency, in addition to the current and planned observations taken from space, to meet future requirements for regional NWP? In the longer term, of course, both terrestrial and space components should evolve to meet overall requirements in the most cost-effective way through a truly optimised system.

These questions were addressed by E-SAT at a meeting held in Oxford, England on 9-10 October 2002. E-SAT consists of expert scientists from European National Meteorological Services and advises the EUCOS Programme Manager on the implications for Numerical Weather Prediction of modifications to the European-funded observing network, including observations taken in the North Atlantic. The meeting agreed:

- an ongoing programme of research should be initiated to determine the optimal mix of space and terrestrial observations from the perspective of Numerical Weather Prediction for Europe; the research should focus on Observing System Experiments (OSEs) designed to determine which terrestrial observations add value to those currently provided by satellites
- the impact of new space instruments should be assessed through OSEs
- consideration should be given to performing Observing System Simulation Experiments (OSSEs) to investigate the likely impact of possible future space and terrestrial observations
- the programme should be jointly funded by EUCOS and EUMETSAT.

2. Latest recommendations from WMO

The latest work on the future evolution of the terrestrial component of the GOS has been presented in WMO (2002). It 'takes into account known upgrades to current satellite systems and entirely new space-based instrumentation to be deployed by 2015'. The changes are based on greater utilisation of existing systems and development of a few relatively new systems.

The recommendations are based on results from recent OSEs at different centres. Although the OSEs address global NWP, they provide useful up-to-date guidance on the impact of different observation types using the latest assimilation schemes and forecast models.

The greatest observational needs for 'Regional NWP' (which is the main focus for EUCOS) include more comprehensive upper wind and moisture observations (e.g. from AMDAR, GPS), more frequent and accurate measures of surface and soil properties, more accurate

[1] E-SAT members - experts from NMSs of Denmark, France, Germany, Italy, Spain, Switzerland and UK plus ECMWF (chair)

estimates of precipitation and more comprehensive observations of cloud (e.g. base, thickness).

Selected related considerations are as follows:

(i) There is no prospect in the next 20 years of measuring from space profiles of temperature with high vertical resolution, or any profiles of wind, in areas with total cloud cover at high altitudes. Because it has been shown that these areas are some (though not all) of the important synoptically "sensitive" areas for NWP (McNally, 2000), there is a need for other means of observing them. The following two lines of enquiry (and probably others) need to be pursued:

- targeted, in situ observations (emphasised in THORpex[2])
- assimilation of imagery sequences (i.e. inferring through 4D-data assimilation the underlying dynamical fields given frequent images of the evolving pattern of the cloud top and associated upper tropospheric water vapour field).

(ii) In cloud layers and below cloud-base, the new satellite instruments will have poor resolution. THORpex has been initiated partly to evaluate *in-situ* observing systems, designed to improve analyses in cloudy, sensitive regions. (Shapiro & Thorpe, 2002).

(iii) Good quality horizontal wind data to estimate vertical air motions appear to be the principal ingredient for improved initial conditions for global and regional-scale weather patterns (e.g. Carbone, 2000).

3. Assessing the current space/terrestrial mix of observations

The recommendations referred to in Section 2 are not based on a numerical investigation tailored to the question posed in Section 1. It is therefore proposed that a project specifically designed to evaluate the evolution of the terrestrial component be set up, using as a framework:

- the projected availability of satellite data in the next few years,
- projected upgrades in assimilation and model properties e.g. resolution.

Observing System Experiments (OSEs) should be carried out to assess forecast impact using different observational scenarios. The aim would be to establish the impact in the European context of selected terrestrial data, of varying density, over and above that from current space-based data by sequentially adding, e.g. AMDAR, radiosonde (including ASAP) and surface data.

Results would provide guidance on the optimum composition and density of the terrestrial network, which can then be re-evaluated as new assimilation and modelling techniques are developed.

Suggested observational scenarios for testing are:

(i) all current satellite radiance observations used in NWP plus the minimum network of surface-based observations required for calibration and validation (e.g. the GUAN network)
(ii) as (i) plus all satellite AMV (upper wind) data
(iii) as (ii) plus all other satellite data (e.g. surface winds, ozone)
(iv) as (iii) plus all surface (SYNOPs, ships, buoys) data
(v) as (iv) plus all aircraft data

[2] THORpex - **TH**e **O**bserving-system **R**esearch and **p**redictability **ex**periment

(vi) as (v) plus all radiosonde data.

For rigorous testing of each scenario, several months of data assimilation will be required including sampling periods from different seasons. Taking these requirements into account, it should be noted that testing the scenarios specified above is likely to take several man-years of effort plus considerable computing resources.

4. Assessing the future space/terrestrial mix of observations

It is recommended that the experiments are repeated every few years as and when new data sources are available or proposed and when major numerical model or data assimilation upgrades are made. OSEs could be used to assess the impact of data from new and near-term satellites (Aqua, MSG, Metop, MTSAT-1R, CloudSat, and ADM-Aeolus) as the data becomes available.

OSSEs, although complex and costly to perform, should be considered for assessing the impact on NWP of new data from future satellites (such as post MSG and Metop, future ESA Earth Explorer) and terrestrial observations. It should be noted that OSSEs need to be done thoroughly, to be worth doing at all. A well-resourced activity (~3my/y) involving at least two centres over several years is needed to make such an approach worthwhile. Thus a European OSSE framework would need to be built up and supported accordingly. Carrying out OSSEs can be regarded as 'cheap' relative to the costs of space-borne systems under investigation, and more cost-effective than a cut-price attempt to get the same results.

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