The underpinning and crosscutting role and responsibilities of the Instrument and Methods of Observation Programme and CIMO in the context of WIGOS

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The mission of CIMO is to promote and facilitate international standardisation and compatibility of meteorological observing systems used by Members within the WMO Global Observing System. This is to improve the quality of products and services of members. Integration of WMO observing systems is included in the current WMO Operating Plan in order to facilitate the production of more accurate, timely and reliable forecasts and early warnings of weather, climate water and related environmental elements. So, the WMO Integrated Global Observing System (WIGOS) Project was formulated to partner the WMO Information System (WIS) project in late 2007. This allows a start to be made on the path to integration and to demonstrate what Initial Integration Projects could deliver. WIGOS is to be coordinated with the WIS since WIS will be used to transmit the information from WIGOS to users. This paper will try and interpret how these strategic plans can be translated into the work plans of the experts within CIMO who are responding to the requirements of the Instrument and Methods of Observation Programme.

1. Introduction

1.1 Changes in the Management Policy for CIMO

WMO programmes have moved to a results based management system and this requires that CIMO Expert Teams have targets which can be monitored. In practice, this requires the terms of reference for the teams to be transformed into deliverables and key performance targets. This transformation needs to be completed by early 2009. This performance monitoring system is common in the working practices of many modern NMHSs but application of this type of management to experts working on a voluntary basis needs to be done carefully, recognising the voluntary nature of the work required from the expert. This works best if the main work of the expert is related to the work required from the expert by his own NMHS.

There is much to gain from technical experts working together on an international scale. So the strategy of CIMO is to support initiatives which by co-ordinating *collective actions* by Members with respect to observing systems produce *results that exceed* what each Member could produce unilaterally to meet their critical needs.

However, if the funding for this work is to continue, the value of working together has to be recognised in terms of useful outputs for WMO Members and their NMHSs. There has been progress in gaining this recognition for CIMO experts, but this needs to continue, as we are always competing for resources against many other areas where funds are short and whose publicity is better than that available from CIMO. In particular, an Expert Team that does not function or address its terms of reference cannot be overlooked, as might have happened in the past and those responsible for managing CIMO will need to take action to rectify the situation. In planning our work we must be realistic in recognising what resources are available, particularly in terms of available time from our technical experts. This is particularly important when considering changes to the work of CIMO. It would be easy to transfer resources to a new strategic target , but if this then damages the expected ongoing output of the WMO Programmes, then some prioritisation or assessment of the benefits of the new strategy need to be considered.

In activities up till 2011 CIMO instrumentation experts are required to concentrate on the integration of WMO observing systems. Thus, our targets for the expert teams and other activities such as the technical conferences and training events need to be linked to this result. CIMO will still contribute to other strategic expected results. e.g.:-

- “Enhanced capabilities of NMHS in developing countries, particularly least developed countries, to fulfil their mandates”,
- “Enhanced capabilities of members in multi-hazard early warning and disaster prevention and preparedness”,

but CIMO work in these areas is to be recognised and funded as contributing to an improved WMO Integrated Observing System.

One of the themes for this TECO is Integrated Observing. When you look at all the papers and posters submitted under this theme you realise what a wide range of interpretations there are for Integrated Observing, and what was seen as a rather narrow target by the strategic planners leads to a very diffuse target when interpreted at the working level. So, it is my task to try and sharpen up where we are trying to go in the ground based sector of the WMO Global Integrated Observing System, and then hopefully this will allow you to consider where you can contribute to the process of improving the world’s meteorological observing systems.

1.2 WMO Observing programmes, the Instruments of Methods of Observation Programme, and CIMO

In the last year, the structures of the WMO World Weather Watch (WWW) Department dealing with Observations have been revised. A WMO Integrated Global Observing System Branch has been established.

Within this, the WMO Observing Systems Division, currently managed by Dr Miroslav Ondras, is responsible for:-

- WWW Global Observing System Programme
- Instruments and Methods of Observation Programme
- Marine and Oceanographic observations, data management and information
- Aeronautical observations.

Also within the WMO Integrated Global Observing System Branch,

- the Space Programme Office deals with the WMO Space Programme and the Space based Observing Division deals with satellite systems,
- the Global Climate Observing System Joint Planning Office deals with the Global Climate Observing Programme and is the Lead Office for the GCOS Joint Scientific and Technical Committee.

- In addition a WIGOS Planning Office has been established to deal with development and implementation of the WMO Integrated Global Observing System.

The Instruments and Methods of Observation Programme (IMOP) is currently managed by Dr Isabelle Ruedi. Enquiries about participation in future programme work should be made through her.

The purpose of IMOP is to promote development, documentation and the world-wide standardization of meteorological and related geophysical and environmental instruments and methods of observation to meet agreed user needs for data; and to ensure the effective and economic use of instruments and methods of observation under varying working conditions and in differing technical infrastructures, by providing technical standards, guidance material, performance specifications, technology transfer and training assistance.

CIMO is the Technical Commission responsible for matters relating to international standardization and compatibility of instruments and methods of observation of meteorological, related geophysical, and environmental variables, and as such is responsible for IMOP Programme.

The number of technical experts registered with CIMO is large, reflecting the variety and complexity of the instruments and systems with which CIMO deals. CIMO also works with a large number of instrument manufacturers who have interests in the outcomes of CIMO activities. The manufacturers often participate in CIMO calibration, test and comparison activities, they support them financially and also participate in CIMO training and capacity building events. They are represented at WMO by the Association of Hydro-Meteorological Equipment Industry (HMEI).

Historically, CIMO has mainly worked with ground-based equipment, with only very limited occasional involvement with satellite systems. The terms of reference of the Commission will be discussed later under the CIMO WIGOS Pilot Project.

1.3 WIGOS

Detailed planning for the WIGOS project commenced in autumn 2007, leading to the WIGOS Concept of Operations (CONOPS) and the WIGOS Development and Implementation Plan (WDIP). WIGOS is intended to be a comprehensive, coordinated and sustainable system of observing systems managed by WMO, ensuring interoperability between its component systems.

At a strategic level the four objectives of WIGOS have been stated as:-

- To address the needs of the atmospheric, oceanic and terrestrial (including hydrological and cryospheric) domains within the operational scope of a comprehensive integrated system;
- To improve WMO observation management and governance (use of resources, planning, monitoring, etc.).
- To increase interoperability between the various systems with particular attention given to complementarity between the space-based and in situ components;
- To ensure that in broader governance frameworks, WMO relationships with other international entities are respected, sustained and strengthened.

And so the benefits expected from WIGOS for the users of observations are:-

- Improved observation services;
- Increased quality, consistency and access to observations;
- More efficient use of resources in managing observing systems;
- Better preparedness to incorporate new observing systems and to interface with non-WMO systems.

In the long-term WIGOS has ambitious aims to:-

- Address in the most cost-effective way all of the WMO Programme observation requirements
- Facilitate access in real and quasi-real time to all required observations through WIS, both for WMO Programmes and related international Programmes and eventually to all users
- Facilitate archiving of the data
- Assure quality of the data to published standards
- Ensure Metadata required by the Programmes is provided through WIS
- Encourage technological innovation in observing systems, working with scientific institutions and instrument manufacturers
- Work with manufacturers in testing the next generation observation instruments

In terms of the surface-based observing systems, WIGOS should incorporate:-

- Weather observing networks (e.g. WWW/GOS, AMDAR, ASAP etc);
- Atmospheric composition observing networks (e.g. Global Atmospheric Watch, GAW);
- Radiation observing networks (e.g. BSRN);

- Marine meteorological networks and arrays (e.g. VOS, drifting and moored buoy arrays etc.);
- Hydrological observing networks (e.g. observing components of WHYCOS etc.);
- The climate components of various atmospheric, oceanographic and terrestrial observing systems contributing to GCOS

2. Integration in the context of WIGOS

2.1 Proposed Basic Strategy

It is proposed that there should be three levels of integration (see Fig.2.1) where standards should be implemented to facilitate integration of the observing processes between different systems:-

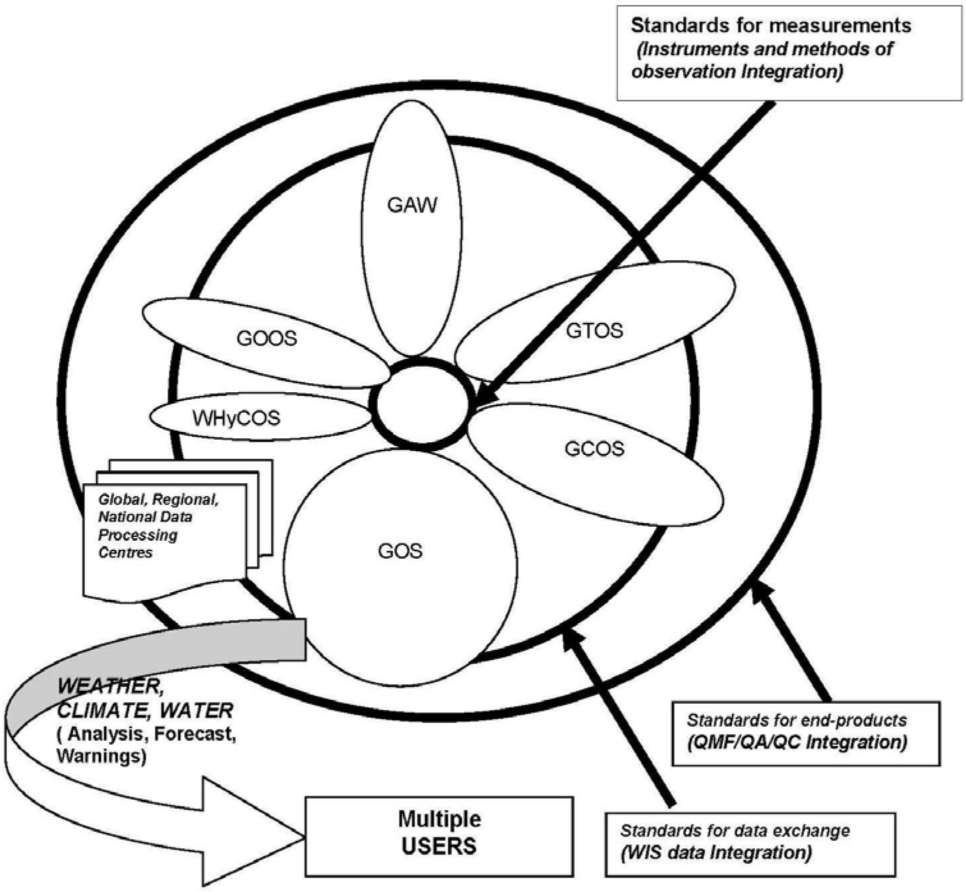

Fig. 2.1 The three levels of integration among the WMO-sponsored and co-sponsored observing systems contributing to WIGOS: standardization of instruments and methods of observation, common information infrastructure; and end product quality assurance. In particular, within the 1st level of integration **(***inner circle***)**: a sustained, optimized, end-to-end WMO Integrated Global Observing System should encompass homogeneity, interoperability, compatibility of observations from all WIGOS constituent observing systems. This should be achieved through meeting the requirements on instruments and methods of observations established by CIMO/networks including tests, calibration and intercomparisons. In the 2nd level of integration **(***middle circle***)**: Data and information generated by all WIGOS constituent networks should meet a comprehensive, standardized set of WIS data presentation and exchange requirements for all WMO Programmes. In the 3rd level of integration **(***outer circle***)**: Various end-products generated on the basis of observations/measurements by all WIGOS constituent observing systems and exchanged through WIS should meet quality management framework requirements to ensure the best possible products to be delivered to end users.

The first set of standards needs to ensure that the component observing systems in the WIGOS ***are functioning correctly and reporting observations in accordance with the known sampling and error characteristics for that type of system.*** If this is the case then the users should be readily able to exploit the data for numerical weather forecasting or whatever type of scientific study they would like to conduct, as the quality of the different measurements should be readily recognized.

The practical problem to be overcome is that many observing systems produce much poorer information than expected from the type of system, e.g.:-

- Poorly calibrated observations, not traceable to international standards.
- Complex automated observations where the system has degraded with time and this has not been recognized, from visibility observing systems and laser ceilometers, to weather radars and wind profilers.
- Basic faults in observing system design that produce poor quality observations which in some cases are too poor for the users to exploit.
- Observing systems that do not function well in conditions when the observations are critical for the users, e.g. when there is severe weather.

Whilst CIMO experts have a lot of experience in dealing with these sorts of issues, the outcomes in the past have not always been successful. The second theme for the conference deals with automatic weather stations, partly as a response to Members' problems in running these systems successfully in long term operation. However, in practice, not much is reported, because some of the problems are embarrassing to both the manufacturers and the NMHS instrumentation experts. Successful integration requires honesty and a willingness to admit mistakes so others can learn for the future.

The second set of standards is to be associated with interoperability of the reported values as delivered to the users. This is to be obtained through using the standards agreed upon by the WMO Information System (WIS). This Information System should circulate all the observations from the WIGOS with their relevant Metadata.

The third set of standards is to be applied in the WIGOS Quality management/Quality Assurance/Quality end-product integration. As far as I am aware, quality monitoring of observations that is effective is nearly always based on comparisons with the output of numerical models or can also be established [consuming larger resources] by comparing with measurements from a high quality observing system with known error characteristics deployed to check the monitoring results. In any case, this latter area of standards needs the involvement of at least some of the user groups. The user groups need to accept the responsibility of generating monitoring statistics and then providing these through effective feedback mechanisms to those operating the observing systems.

This feedback needs to be organized, for example as performed on the GUAN radiosonde network, by an expert employed to fulfil the task. Just relying on publishing the monitoring results and expecting people to take action, without any remedial action does not seem to usually work, particularly where there are persistent problems.

Whilst quality management documentation and standards are useful, the desired common measurements with known errors are only obtained if the quality management set up is effective. Examples where the quality management framework has not produced the desired results initially and needs to be improved are not difficult to find. This area will require significant development if measurable improvements in quality are to be achieved. In any case, it seems that certain types of observation need to be targeted first since to try and do this for the whole range of observations does not seem feasible, especially before successful outcomes for the targeted observations have been achieved. (Note: for more detailed information on WIGOS concept, see WMO web page: http://www.wmo.int/pages/prog/www/wigos/index_en.html).

2.2 Example of what needs to be achieved based on upper wind observations

One of the problems in planning WIGOS is that it is relatively simple to produce strategic plans talking about standardization. CIMO is being tasked to make a large contribution to the standardization process. How is this to be translated into an action plan at working level? This is not straightforward and different types of observing system will require different approaches. The standardization processes for satellite observations are not going to be the same as for surface based measurements. In addition, information will have to be provided and documented as to how the different types of observation [space-based, surface-based] may be linked together to produce interoperable products for the users for each meteorological variable.

2.2.1 Introduction to an integrated upper wind network

The upper wind network consists of observations from four sources, aircraft and radiosonde winds, both in situ observing systems and weather radars and wind profilers, both ground based remote sensing systems. The coverage of observations over Europe at 1 km and 5 km can be compared with that at 10 km .see Figures 2.2.1, 2.2.2 and 2.2.3. At 1 km and 5 km the coverage in the horizontal is similar, with a resolution better than a 100km spacing only available in very limited areas of the network At 10 km the large numbers of dispersed cruise level aircraft wind measurements provided measurements at a horizontal resolution of about 50 km over much but not all of Europe. 12.00 UTC is the time of day when most aircraft observations are available in Europe. The problem is that these densities of aircraft measurements are not available for much of the rest of the day, particularly during the night. So the final network design for Europe needs to ensure that enough wind measurements are available from other sources for the rest of the day. Investment in these other systems might need to be higher than originally imagined.

Upper winds are fundamental for numerical weather prediction, so how this part of the observing system works is important, not a luxury. There are some locations where only one type of data is available, in some places the radiosonde measurements, many places the aircraft measurements, some only weather radar and some only wind profiler, with the two types of radar and radiosondes seeming to be more important at night when there are very few if any aircraft measurements. Thus, this is an integrated observing system, but up till now it is only on the CWINDE wind profiler monitoring site, that you can see how the system functions as a whole.

How would the first set of WIGOS standards be applied to the four observing systems shown here? There are two types of in situ observing system, radiosondes and aircraft and two remote sensing systems, weather radar and wind profiler. What is required is that all the observing systems considered should produce observations consistent with the expected error characteristics and sampling strategies associated with the type of observing system, and this will not be the same for each observing system.

2.2.2 Differences in sampling strategies
a) In situ measurements and ground based remote sensing

All four types of observing system have different sampling strategies.

Both radiosonde and aircraft wind measurements are essentially snapshots performed over a specific path for a short time, rarely lasting for longer than a few minutes. The potential errors in the movement of balloon or aircraft relative to the air are different. The turbulent wake around a balloon causes the balloon to oscillate relative to the true air motion, but for larger balloons these errors are small enough to be overlooked for normal operations. During some flight manoeuvres the aircraft may have a tendency to slip in flight relative to the air motion, and measurements under these circumstances may have significant errors and need to be excluded by the on-board software. The observed wind profile from a balloon lifting the radiosonde tends to follow the motion of the weather near the launch site, whereas the aircraft may travel several hundred km in a direction opposite to the wind flow in measuring the wind profile. In the wind plots shown here in Figs. 2.2.1 to 2.2.3, the winds have been reported where they were measured, so the motion of the radiosonde in the horizontal has been compensated and similarly the position of the aircraft winds shifted to be in the correct position relative to the weather systems as observed at 12.00 UTC.

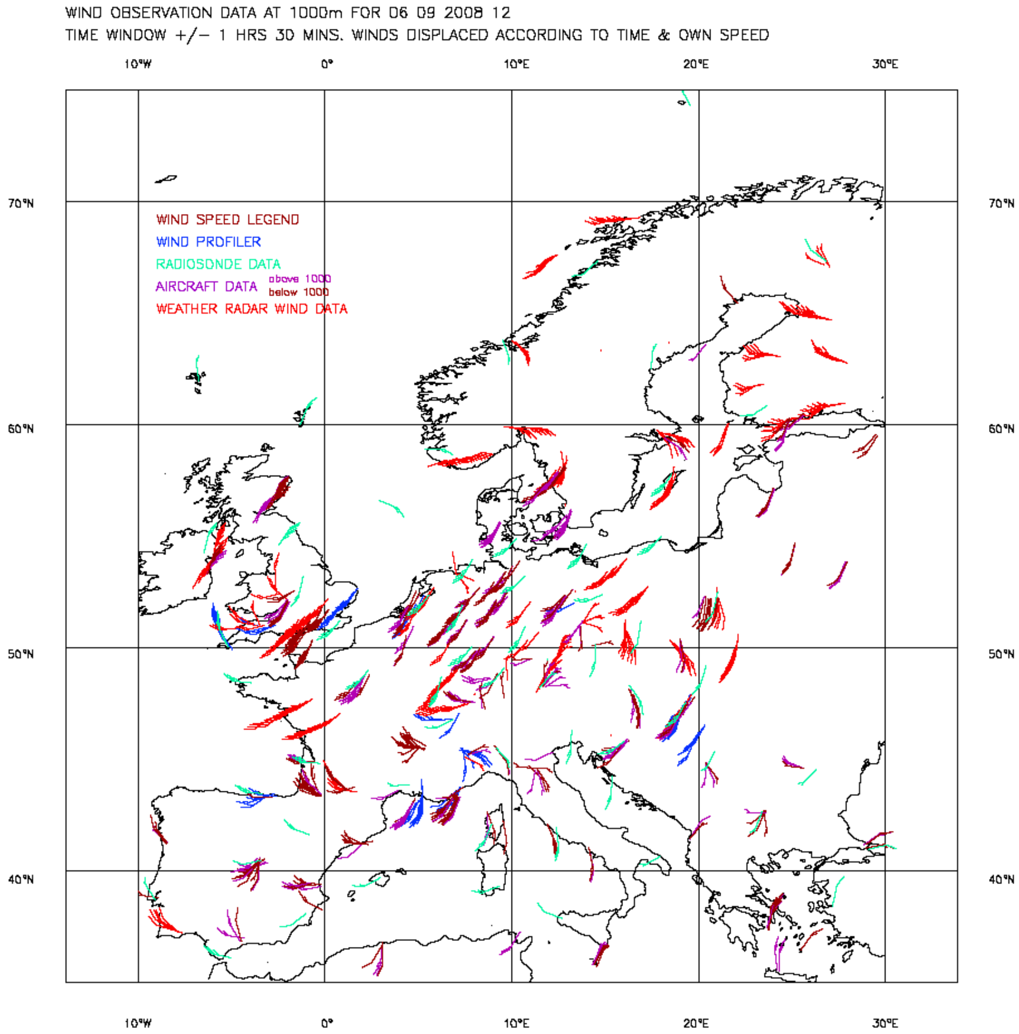

Figure 2.2.1a Upper wind measurements available between 10.30 and 13.30 UTC on 06 September 2008 at 1 km

Wind profiler winds are likely to be integrated over half an hour, over an area of cross section with diameter 1 km at 2km and 5 km at 10 km. typically radar winds would be derived around a cone of wider cross section, say 7.5 km at 2 km and 20 km at 5 km, with a shorter integration time than the wind profiler. The sampling details would have to be defined in the Metadata for the given radar type. Radar winds are mostly available when there is precipitation, but in some cases winds may be obtained in clear air conditions from scattering from insects.

Thus some of the very small scale structure sampled on an individual radiosonde flight might not be present in the wind profiler measurements using volume sampling and longer integration times. The differences that are found from the different sampling techniques need to be quantified by testing and the users informed. In many cases the differences will not be large, if the equipment is functioning correctly. The CIMO documentation in this area needs to be examined and perhaps revised so that it is easier for users to understand, and shall be the considered opinion of a range of technical experts. In an integrated environment the discussion of observing characteristics must be soundly based on facts and not anecdote.

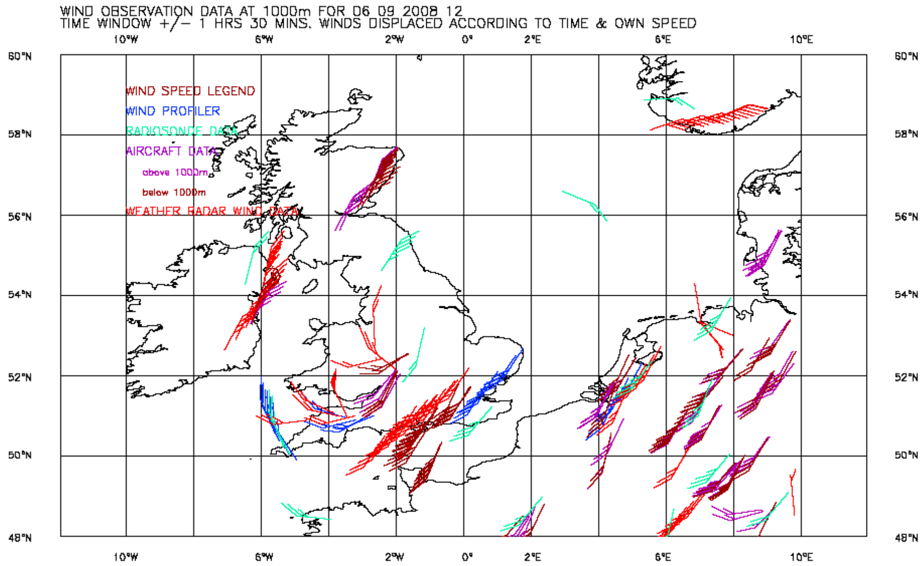

Figure 2.2.1b Upper wind measurements available between 10.30 and 13.30 UTC on 06 September 2008 at 1 km in northwest Europe

In Fig.2.2.1a where several aircraft reports are available from a given airport, there is quite a wide variation in the direction of the wind, indicating that in these cases wind direction is really varying quite a lot with time. So in similar locations, a radiosonde snapshot wind could also be significantly different in direction to the true average for over an hour at that location. This does not happen at all airports on this day and the aircraft wind directions associated with the main areas of precipitation in Fig. 2.2.1b are more consistent, indicating that the representativeness errors in the snapshot samples may not be the same in all circumstances. By plotting all the winds together in this fashion, it is possible to pick out some suspect winds. For instance, in Fig.2.2.1b, the winds measured by the weather radar near 53º N, 7ºE look too small.

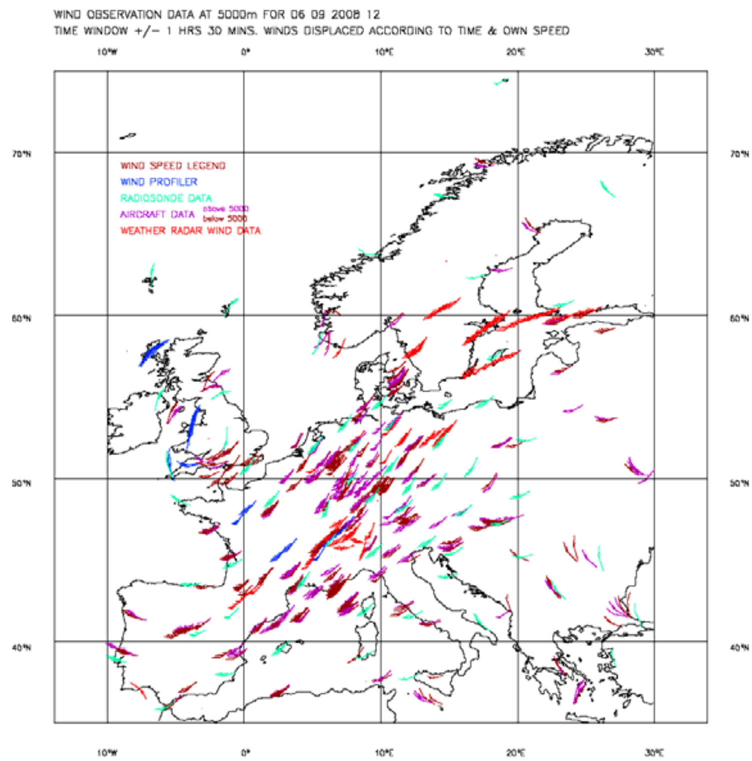

Figure 2.2.2 Upper wind measurements available between 10.30 and 13.30 UTC on 06 September 2008 at 5 km

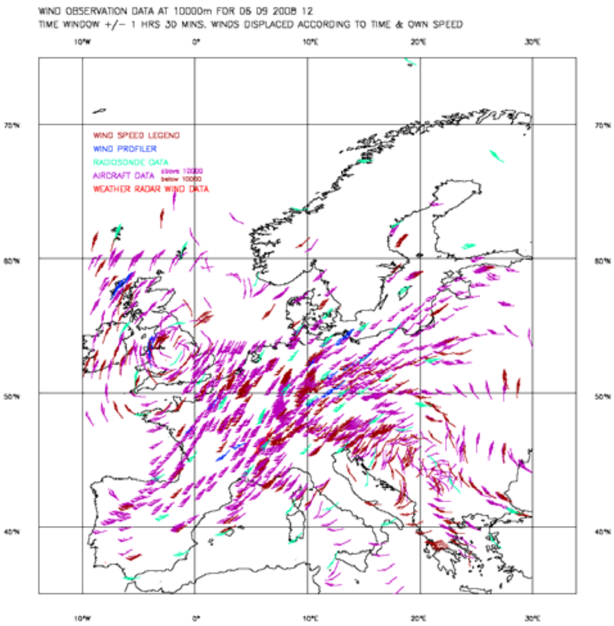

Figure 2.2.3 Upper wind measurements available between 10.30 and 13.30 UTC on 06 September 2008 at 10km

2.2.3 Wind measurements from geostationary satellites

When winds are produced by geostationary satellites from tracking cloud and water vapour structure, the effective sampling is not for discrete levels in the vertical but over deeper layers. In some cases the cloud or water vapour structure does not move with the wind at all but is locked to topographical features and so part of the reporting process is to eliminate false winds by comparison with background fields from an NWP model.

The type of coverage available from satellite winds over Europe are shown in Fig. 2.2.4a for low and mid-level winds in the troposphere, and in Fig. 2.2.4b for upper level winds in the troposphere and lower stratosphere.

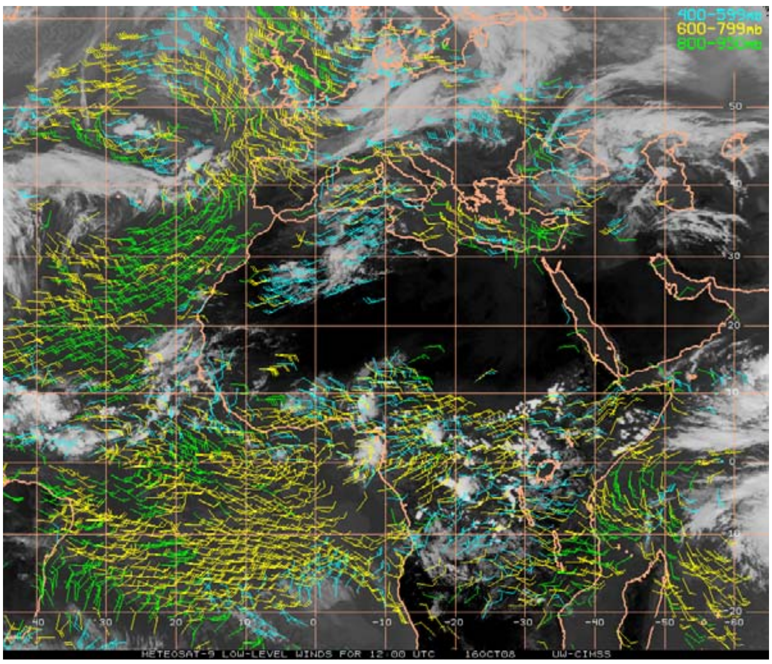

Fig. 2.2.4a Satellite winds over Europe and Africa from Meteosat, lower and middle troposphere at 12.00 UTC on 16 October 2008

In the case of the measurements over the UK, the available winds shown are consistent with the measurements of the two VHF wind profilers in the UK, South Uist and Aberystwyth, see Figure 2.2.4c and 2.2.4d, but the profilers show much more detail about the vertical structure. During part of the day the winds do not vary very much in the vertical, but at other times there is strong wind shear in the vertical and at these times the satellite technique is unlikely to be as reliable as when there is little vertical shear. The wind profilers also show how rapidly the wind fields change and why it is necessary to have an integrated network that can resolve both the spatial and temporal variations.

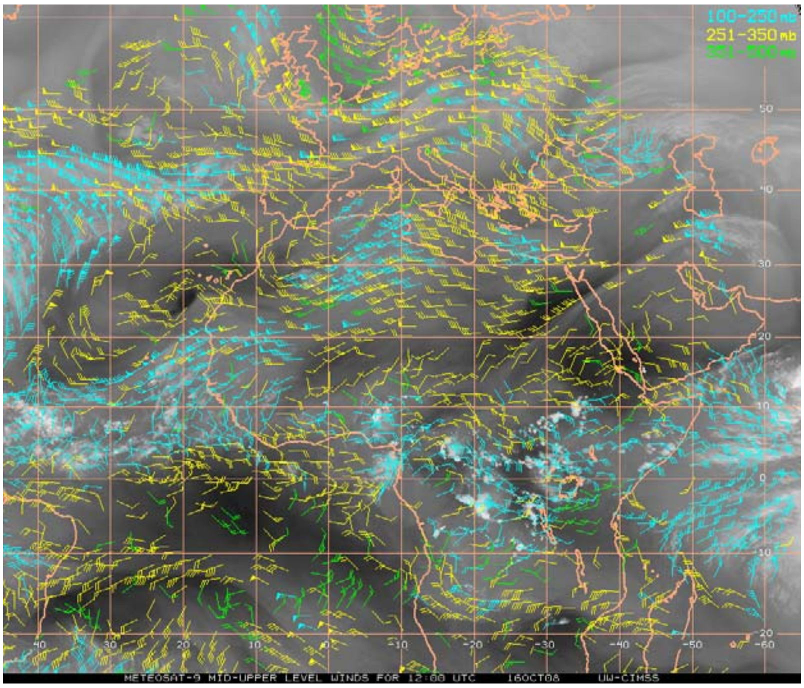

Fig. 2.2.4b Satellite winds over Europe and Africa from Meteosat, upper troposphere and lower stratosphere at 12.00 UTC on 16 October

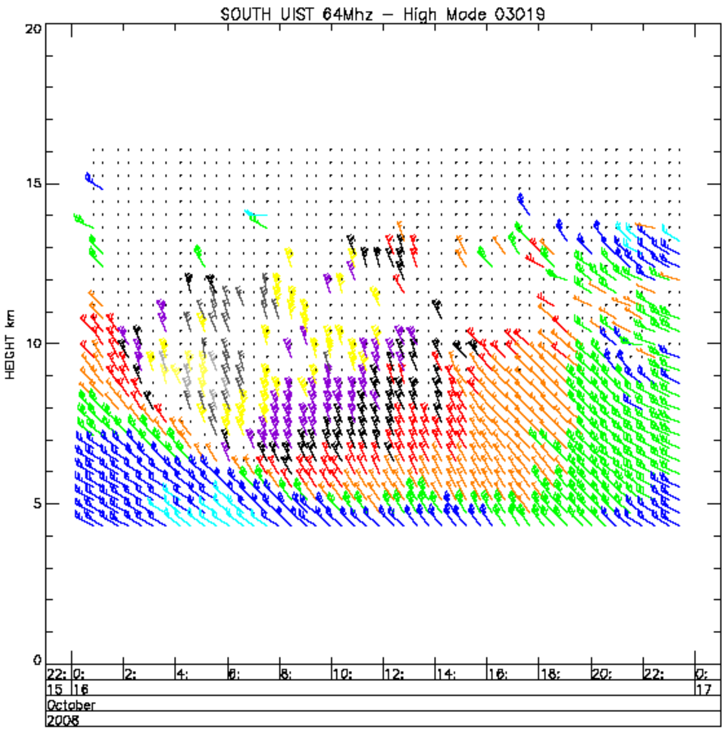

Fig. 2.2.4c 24-Hour summary of winds from South Uist VHF wind profiler on16 October 2008. Is this wind profiler functioning correctly with so many missing winds at upper levels?

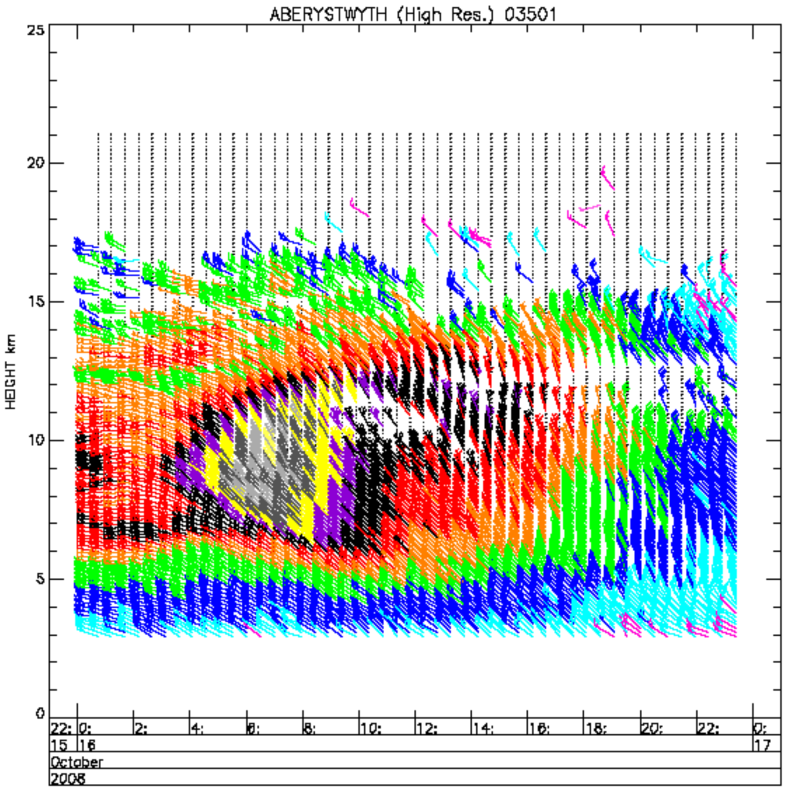

Fig. 2.2.4d 24-Hour summary of winds from Aberystwyth VHF wind profiler on16 October 2008.

2.2.2 Characteristic errors

Each observing system when functioning correctly will have a measurement error related to limiting factors in the technology. For instance, basic wind measurements from a GPS radiosonde should be reproducible to better than 0.2 ms^{-1} in each orthogonal horizontal wind component. The value reported to the user may not be so accurate because of the limitations in the reporting code, and as indicated earlier the motion of the balloon relative to the air will also limit the accuracy of the sample, but in any case the reproducibility of the operational measurement should be better than 1 ms^{-1}. However, in assimilating into most numerical weather prediction models the radiosonde wind measurement would be attributed with a larger error than this, caused by the inability of the model to represent all the scales of motion affecting the radiosonde measurement. This representativeness error will vary according to the spatial resolution of the numerical weather prediction model considered.

Aircraft wind measurements are not inherently as reproducible as the radiosonde wind measurements since the reported winds are the difference between the velocity of the aircraft and the air velocity relative to the aircraft. In practice, the difference in reproducibility between the two systems is not large enough to cause a significant problem for most users.

With wind profiler radars and to some extent Doppler weather radars, the continuity of a time series of observation s at a given height allows the random errors in the measurements to be estimated independently.
A 24 hour summary of the data available from the Cobbacombe weather radar at about 51º N, 3ºW on 6 September is shown in Fig.2.2.5a and a similar sample from the UHF wind profiler at Dunkeswell , just over 20 km away is shown in Fig.2.2.5b. Fig.2.2.5c shows the results of estimates of the random error in the wind profiler measurements at Dunkeswell, taken from the CWINDE internal monitoring. On this occasion the random errors do not vary in the vertical by very much, but often the random errors increase significantly in the vertical, see Fig.2.2.5d.

For both VHF and UHF wind profilers the performance of the observing systems depends on the scattering conditions in the atmosphere. So there is natural variability in the observing system performance day to day, which has nothing to do with system malfunction. Where the performance of the system depends on the atmospheric conditions, another layer of complexity is added to describing the performance of a particular observing system in terms of standards. So for this type of system the quality management becomes much more difficult. For instance in Fig. 2.2.4c it is unclear whether the data missing between 8 and 12 km were caused by poor scattering conditions or poor radar performance.

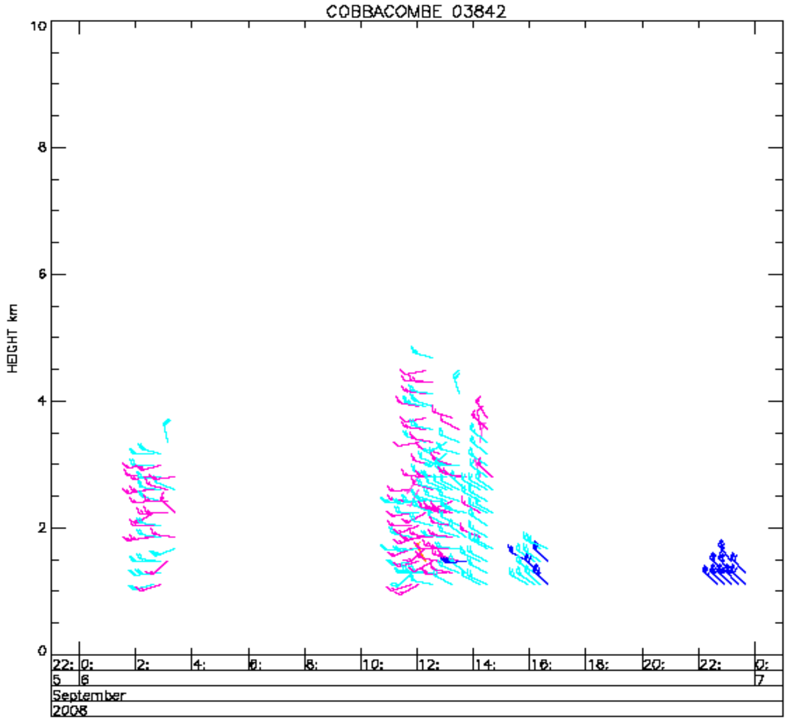

Fig. 2.2.5a 24 hour summary of winds measured by the Cobbacombe weather radar on 06 September 2008

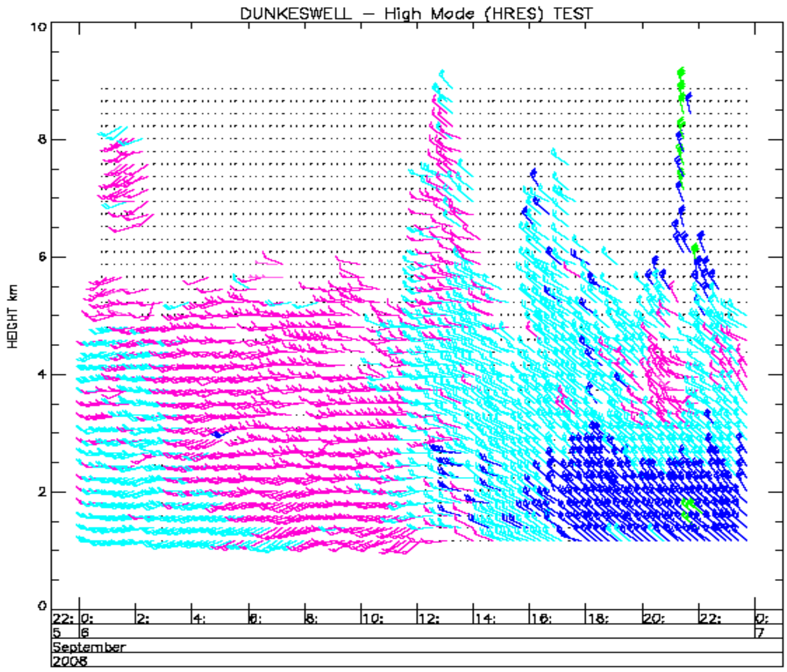

Fig. 2.2.5b 24 hour summary of winds measured by the Dunkeswell wind profiler radar on 06 September 2008, just over 20 km from the Cobbacombe radar.

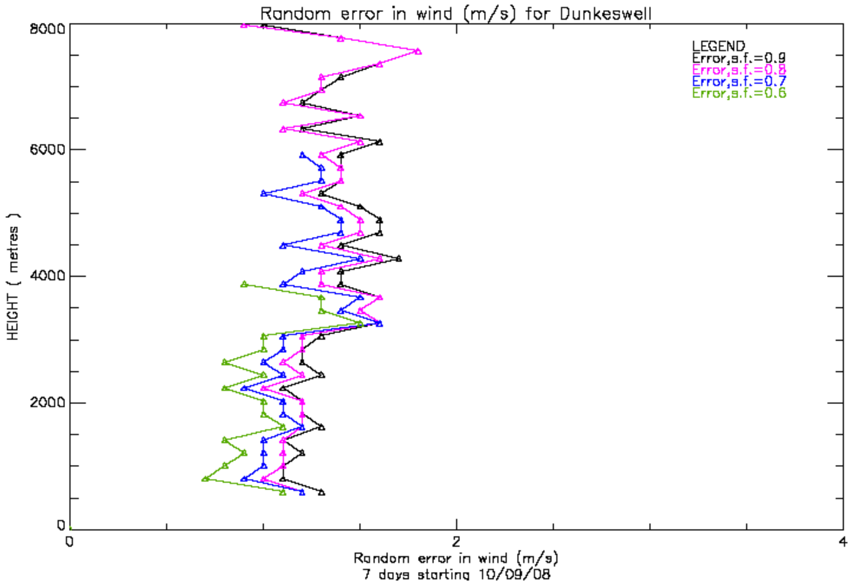

Fig.2.2.5c Estimates of random error in wind profiler wind measurements at Dunkeswell centred on the week including 06 September 2008, http://www.metoffice.gov.uk/corporate/interproj/cwinde/, blue or purple structure functions most likely to be correct.

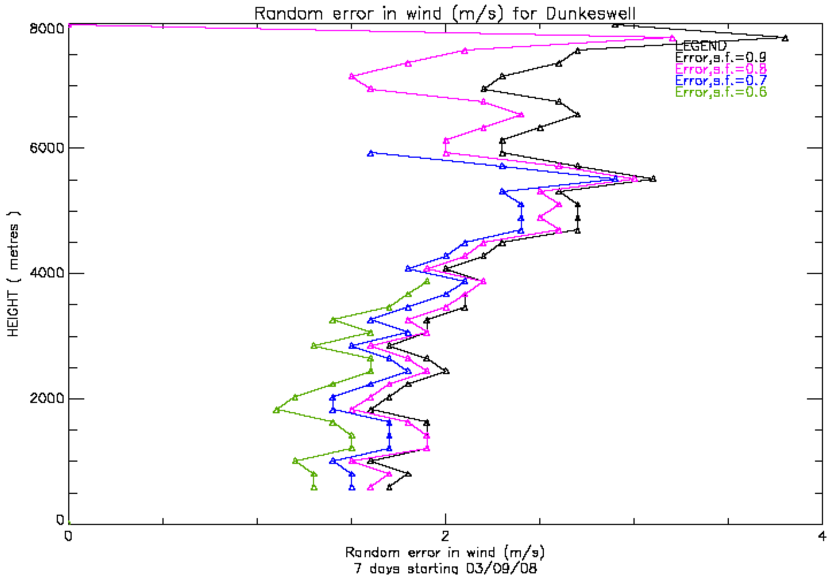

Fig.2.2.5d Estimates of random error in wind profiler wind measurements at Dunkeswell centred on the week before 06 September 2008, http://www.metoffice.gov.uk/corporate/interproj/cwinde/, blue or purple most likely to be correct.

2.2.3 Sources of atypical errors

As noted earlier the process of standardization should try and eliminate the atypical errors from an observing system.

Atypical errors in the radiosonde winds are most likely if a given radiosonde malfunctions in flight, for instance giving poor signal reception at the ground. Thus implementation of the quality standard requires that the system software/operator is able to identify malfunction and suppress the measurements from being reported at source. If it is a prototype radiosonde system, errors may arise because the software has not been fully tested. Here it is vital that the testing service has the necessary skills to identify the faults, and CIMO would like to propose that only nominated CIMO test centres are used for this work. So assuring the observation quality requires testing the system not only when everything works well, but also when there are problems. Evaluations of this type have relied heavily on certain countries having the expertise to perform this type of evaluation, and WIGOS would need to ensure that the resources are available in future as radiosonde designs continue to evolve. As far as the radiosonde operators are concerned, training needs to be provided based on suitable technical documentation, which may need to be more specific than is currently found in the Guide to Meteorological Instruments and Methods of Observation (WMO-No. 8).

Atypical errors in aircraft wind measurements could arise when the motion of the aircraft becomes relatively unstable relative to the atmospheric motion, e.g. when certain aircraft are banking in ascent or descent. This is usually dealt with in the wind processing software, but not all aircraft have the same characteristics, so some specialized testing/ evaluation might be necessary to ensure the software is adequate as the aircraft in use change.

Testing of the observing system in a wide range of conditions is essential for winds from both types of radar, if atypical errors are to be minimised. The effects of ground clutter, unwanted returns [e.g. birds or aircraft for wind profilers], interference either external or internal, or inadequacy of a given sample [incomplete signals in showery situations for radar VAD scans, differences in vertical velocity between different beams in variable precipitation for a wind profiler] rely on software optimised to deal with the problems and this is only obtained by very thorough prototype testing. Rectification of flaws may require liaison with the manufacturers if appropriate, plus detailed monitoring of output at some selected locations as variants of the software are tested.

2.2.4 Limitations of quality monitoring

Most of the upper wind measurements need to be monitored by comparison with the background forecasts of numerical weather prediction models. This technique seems quite sensitive when looking for systematic bias in wind speed and wind direction measurements. However, the random errors in the background forecast for orthogonal wind components are usually in the range 2 to 4 ms^{-1}, so that only radiosondes systems with abnormally large random errors can be identified from random error in the difference between the background fields and the observations.

Similarly, it has been found that wind profiler radars often deteriorate quite significantly before changes in system performance are noted in comparison to background fields. So it proves helpful to check the functioning of the wind profiler from time to time, e.g. check that the signal power in the different beams is similar to check for correct switching between beams.

2.2.5 Conclusions

Standardisation of observing systems is a complex process and will require different activities depending on the type of observing system.

For upper winds uniformity of performance relies on:-

- thorough testing of the systems before large scale deployment,
- system maintenance regimes that maintains the performance of the system to the expected levels,
- quality management that is effective and can detect anomalies and report them back to the system operators. In some cases, monitoring will have to be performed on the internal functioning of the observing system as well as on the reported products.
- Detailed evaluation of system performance from specialized tests and from the various monitoring methods.

For this to be performed on a global scale , then documentation and training must be provided, so that operators understand how to obtain reliable performance from their observing systems and manufacturers are informed of unresolved deficiencies in their products. One of the problems with the CIMO Guide is that it is not actively used or perhaps understood by those that it is intended to guide. Now that the Guide is available in electronic form, every effort must be made to publicise its use. Efforts must also be made to improve those areas where the Guide is unclear or does not currently address the requirements of Integration noted here, e. g. compatibility between different types of observations, ground-based versus satellite based, for instance.

So clearly CIMO has a very strong responsibility for setting and developing the necessary standards, and the current activities of CIMO do encompass these requirements as noted here, but CIMO only has limited resources and we need to check that we are addressing the most urgent issues at the moment. For instance is CIMO doing enough to support weather radar operations?

In the particular example chosen here, traceability to known measurement standards is not so important, but for variables such as surface pressure or temperature or relative humidity, this becomes critical. How can such standards be sustained on a global scale, or even between different agencies in one country? Do all observations have to be to the same standard? As these problems need to be examined carefully, the WIGOS Project has planned a variety of pilot activities and these will be described in the next section.

3. Underpin and crosscut in WIGOS?

From the example of upper winds we can see that a whole range of activities, much more than just creating more comprehensive documentation, is required by the principle of standardization which has been seen as central to WIGOS. As the WMO Technical Commission responsible for standardization activities for some of the WIGOS observing systems, it was decided to see whether CIMO could rise to the challenge of expanding its area of influence as requested by the WIGOS planners.

Measurement standards and quality assurance and management are clearly areas where CIMO should aim to underpin the integration activities. The crosscutting comes from the need to liaise with experts in other Technical Commissions to deal with a wider range of observing systems, than has currently been addressed in CIMO activities. Historically, CIMO has always served other Technical Commissions, but whilst some CIMO expert teams have members nominated from other Commissions, this does not happen on a large scale, and interaction with those responsible for running the networks in CBS only seems to happen by chance if a person who is a CIMO expert is also incorporated into a CBS expert team.

Cg-XV proposed five Pilot Projects which involve coordination between a variety of Technical Commissions, and CIMO has been asked to support all these Pilot Projects as requested. The Pilot Projects which have been initiated are:-

- Integration of WWW/GOS and GAW into WIGOS (CBS/CAS)
- Initiation of a Global Hydrological network in the context of WIGOS (CHy)
- Integration of AMDAR into WIGOS (CBS/AMDAR Panel)
- Elaborating the underpinning/crosscutting role and responsibilities of the Instruments and Methods of Observation Programme in the context of WIGOS.(CIMO)
- Integration of marine meteorological and other appropriate oceanic observations into WIGOS (JCOMM)

In addition, some Members have volunteered to run national Demonstration Projects that will allow the practicality of WIGOS concepts to be tested out before 2011. Those who have submitted plans for demonstration projects include Brazil, Morocco, Republic of Korea, and the USA. In several cases these proposals involve trying to improve the national surface networks of observations, particularly by trying to standardize observations between the NMHS and the other national agencies involved in making surface observations. The USA proposal is larger and is looking at a wide range of observing networks on a Regional scale. In Europe, the UK will propose a testbed experiment which will look at the use of ground-based remote sensing and other upper air observing systems to satisfy future user requirements.

3.1 CIMO WIGOS Pilot Project

First, I wish to bring some basic information about the CIMO Pilot Project.

The project is concerned with defining the role that IMOP should play within WIGOS/WIS and demonstrating this within as many as is practical of the other Pilot and Demonstration projects.

The actual terms of reference of CIMO cannot be change before the next WMO Congress in 2011, so any proposed change to CIMO's role at this stage is to provide evidence as to how the role of IMOP needs to be strengthened in future.

CIMO is challenged to demonstrate what it can do in the context of WIGOS, and the results of this challenge are likely to have serious consequences for the long term organisation and funding of the work in IMOP. So we cannot assume that current working structures will persist and we must be very clear about what it is we are trying to achieve. Our efforts and resources need to be focused on the outcomes we think are essential for the future of technical work associated with IMOP.

Given this is the case, the CIMO Management Committee and the first meeting of the ad-hoc working group on the CIMO WIGOS Pilot Project on CIMO decided to expand the scope of the potential CIMO role to:-

Responsibility for matters relating to international standardization, compatibility and sustainability of instruments and methods of observation of meteorological, climatological, hydrological, oceanographic and related geophysical and environmental variables.

This responsibility underpins all observations within WIGOS and will be carried out in close collaboration with relevant WMO Partner organizations, e.g. JCOMM. This scope was presented at the Meeting of Presidents of Technical Commissions and it was agreed that CIMO should attempt to demonstrate that during the Pilot Project it could perform this function in at least some of the areas where at the moment it has not made significant contributions.

In particular CIMO should in the long term:-

- For all elements of WIGOS address the requirements for standardized and compatible observations, including data content, quality and metadata.
- Provide advice, studies and recommendations concerning effective and sustainable use of instruments and methods of observation, including methods of testing, calibration and quality management consistent with the WMO Quality Management Framework.
- Conduct and /or coordinate global and regional field intercomparisons and functional testing of instruments and methods of observation.
- Promote the development of measurement traceability to recognized international standards, including reference instruments and effective hierarchy of world, regional, national and lead centres for instrument calibration, development and testing.
- Promote integration, inter-calibration, compatibility, and interoperability between space – based and surface based (in situ and remote sensing) observations , including conducting test-bed observing experiments
- Encourage research and development of new approaches in the field of instruments and methods of observation of required variables.
- Promote the appropriate and economical production and use of instruments and methods of observation with particular attention to the needs of developing countries.
- Support training and capacity building activities in the area of instruments and methods of observation.

So between 2009 and 2011, CIMO needs to work with selected WIGOS Pilot Projects and Demonstration Projects which will allow it to demonstrate the future roles suggested for CIMO. Whilst senior members of CIMO may participate in the steering groups for the various pilot projects it also needs members of expert teams willing to take on some of the activities required, for instance testing relative humidity sensors in the AMDAR project, or defining best practices and standards to be used amongst the meteorological and oceanographic communities, advising on operational methods of observation suitable for real time hydrological networks, or suitable for delivery of real time observation so of ozone or aerosol from GAW sites.

The issue of the suitable standards for use in cost effective surface observations will need to be addressed for some of the national Demonstration Projects. Most countries cannot afford to have all surface observations of the highest quality, and how should the acceptable and minimum standards of quality be defined in relation to the best standards.

Testbed experiments combining remote sensing and in situ measurements are also required, to optimize the combination of the two types of observing system and to identify the limitations of the different types of observation.

So what we need are volunteers who are willing and committing to take work forward. We are happy for new experts to join in with the work, but we are looking for a commitment over several years so that we gain some return on the time taken to train a national expert in the international arena.

3.1 Conclusions

CIMO has no choice but to underpin operational observing systems, but the range of areas where this has to happen is now expected to be much larger than before.

In some cases, the work fits naturally with some existing CIMO activities, but this is not true in all the areas which have been listed.
For CIMO/IMOP to be taken seriously, CIMO has to deliver good quality work, advice and documentation. The existing CIMO Guide is a good basis, but may not be adequate in its current form for all that needs to be done.

For instance, what documentation might be necessary for a given observing system?

- Description of a typical good quality system
- Sampling strategy for the system
- Calibration strategy for the system or integrated network, including traceability to national and international standards.
- Typical errors of the system
- Potential anomalies/problems/ limitations of the system, including exposure issues
- Essential methods of observation for the system
- Recommendations on the preparation of Metadata for the system.
- Quality monitoring techniques and the limitations of the these techniques
- Recommendations on maintenance to sustain operational standards in the long term.
- Recommendations on engineering/ instrumentation tests necessary to ensure system does not degrade with time.
- Recommendations on basic testing to ensure that the system works correctly on installation.
- Results from international testing of the system
- Results of the studies of representativeness errors.
- Results of compatibility studies with other observing systems measuring the same variable.
- Description of where cheaper instrumentation may be used, and which lower standards may be acceptable for some sites in an integrated network

This list illustrates the complexity of all the issues surrounding integration, but IMOP is not starting without significant experience in many of these topics.

Crosscutting seems to be raised as a desirable quality to counterbalance the perception that instrument experts just address issues that interest them and not the full range of requirements from the customers. The actual problem is the reverse of what is perceived. Most good instrumentation experts are so busy with the work required by their employers that there is little time left for collaboration or developing interests outside their main area of work, or for addressing specialised issues not of immediate interest to their employers. We cannot do much crosscutting if our employers do not allow us time to deal with these issues, or if WMO does not pay for the work rather than rely on volunteers. For WMO to pay our employers have to recognise that there is a problem and make the funding available. So we should not exaggerate the situation, but the reality is that most of the work of CIMO is done by very few people, and many of these are reaching retirement age, so where will the continuity of personnel for this work listed here be found? Who will continue to organise the WMO Technical Conferences which I believe are of large value to those who attend and are an investment for the future of instrumentation science?