Commission for Instruments and Methods of Observation (CIMO) best practices and standards in the context of QA4EO

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28 September -1 October 2009

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WIGOS aims to;-

Address in the most cost/effective way all of the WMO Programme observation requirements
[was mostly operational but now change of emphasis to a wider scope]

Facilitate access in real and quasi-real time to all required information 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

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Instruments and Methods of Observation Programme and CIMO [ongoing for many decades]

- IMOP is to promote **development** , **documentation**, and the worldwide standardisation of meteorological and related geophysical and environmental instruments and instruments and methods of observation to meet agreed user needs for data:
- 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**.

and CIMO is responsible

- For matters relating to **international standardisation** and **compatibility of instruments and methods of observation** and hence responsible for the IMOP Programme.

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CIMO Mission

To promote and facilitate international standardisation and compatibility of meteorological observing systems used by Members within the WMO Global Observing System to improve quality of products and services of Members.

CIMO Strategy

- Support initiatives which by coordinating **collective actions** by Members with respect to observing systems produce **results that exceed** what each Member could produce unilaterally to meet their critical needs, e.g. Updating of **WMO Guide to Instruments and Methods of Observation** ;
- Support **capacity building** in developing and least developed countries to close the gap between them and the developed countries;
- Support **development** of new observing equipment, critical to Member's needs, collaborating with members of HMEI , the scientific community and other developers to facilitate a production of reliable instruments that are adequately tested before use.

CIMO and Metrology

- Regional Instrument Centres [six regions, but more than one in most regions]
- Maintain standards for some meteorological variables, which can be linked to international standards
- World and Regional radiation Centres
- Linking national NMHS calibration facilities
- E.g. through work of experts Facilitated by CIMO
- Principles in WMO Guide to Instruments and Methods of Observation
- Links through WMO QMF to set standards with ISO and also with BIPM

Current Key Challenges

- Improving **sustainability** of observing systems;
- **Integrating** remote sensing and in-situ observing systems;
- Monitoring in **severe** weather/climate conditions;
- Improving Weather radar calibration and evaluation of algorithms (**QPF**);
- Development of technical **expertise**.

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Challenges for quality management

- Large numbers of observing systems, deployed in a wide variety of environments [188 countries],
  by people of differing skill levels, by agencies with a wide range of resources [about 60 countries attend CIMO technical conferences]
  supported by a wide range of manufacturers.
  [less than 20 for upper air, but more than 100 for surface measurements]

- Wide range of meteorological variables, not necessarily corresponding to what satellite based systems observe.

- Most conventional systems change more rapidly than in the past, so equipment has much greater capability [e.g. Automatic weather stations] but shorter life cycles.

- Exposure of sensors is critical, so laboratory performance does not equal operational performance.

- Systems nearly always suffer significant damage/degradation with time, from various causes

This means CIMO will have as a priority:

- **Respond to the requirements for standardized and compatible observations, including data content, quality and metadata for all elements of WIGOS.**

- **This requires expansion of the WMO Guide to Meteorological Instruments and Methods of Observation (WMO -No.8 ; seventh edition),**

available on line at

http://www.wmo.ch/pages/prog/www/IMOP/publications/CIMO-Guide/CIMO_Guide-7th_Edition-2008.html

This work is co-ordinated with other technical commissions, for those measurements which are considered mature in terms of development.

PART I: MEASUREMENT OF METEOROLOGICAL VARIABLES

- 1 General
- 2 Measurement of temperature
- 3 Measurement of atmospheric pressure
- 4 Measurement of humidity
- 5 Measurement of surface wind
- 6 Measurement of precipitation
- 7 Measurement of radiation
- 8 Measurement of sunshine duration
- 9 Measurement of visibility
- 10 Measurement of evaporation
- 11 Measurement of soil moisture
- 12 Measurement of upper air pressure, temperature, humidity
- 13 Measurement of upper wind
- 14 Observation of present and past weather; state of the ground
- 15 Observation of clouds
- 16 Measurement of ozone
- 17 Measurement of atmospheric composition

PART II OBSERVING SYSTEMS

- 1 Measurements at automatic weather stations
- 2 Measurements and observations at aeronautical meteorological stations
- 3 Aircraft observations
- 4 Marine observations
- 5 Special profiling techniques for the boundary layer and the troposphere
- 6 Rocket measurements in the stratosphere and mesosphere
- 7 Locating the sources of atmospherics
- 8 Satellite observations
- 9 Radar measurements
- 10 Balloon techniques
- 11 Urban observations
- 12 Road Meteorological Measurements

PART III: QUALITY ASSURANCE AND MANAGEMENT OF OBSERVING SYSTEMS

- 1 Quality management
- 2 Sampling meteorological variables
- 3 Data reduction
- 4 Testing, calibration and intercomparison
- 5 Training of instrument specialists

Appendix List of contributors to the Guide Seventh edition

This means CIMO will be working to:

•Provide advice, studies and recommendations concerning effective and sustainable use of instruments and methods of observations, including quality management procedures such as methods of testing, calibration and quality assurance.

•Conduct and /or coordinate global and regional field intercomparisons and performance 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.

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This means CIMO will be working to :

•Encourage research and development of new approaches in the field of instruments and methods of observation of required variables. [Improve liaison with the scientific research community and with HMEI]

•Promote the appropriate and economical production and use of instruments and methods of observation with particular attention to the needs of developing countries.

•Promote , integration, inter-calibration, compatibility, and interoperability between space –based and surface based (insitu and remote sensing) observations , including conducting test-bed observing experiments.

•Support training and capacity building activities in the area of instruments and methods of observation.

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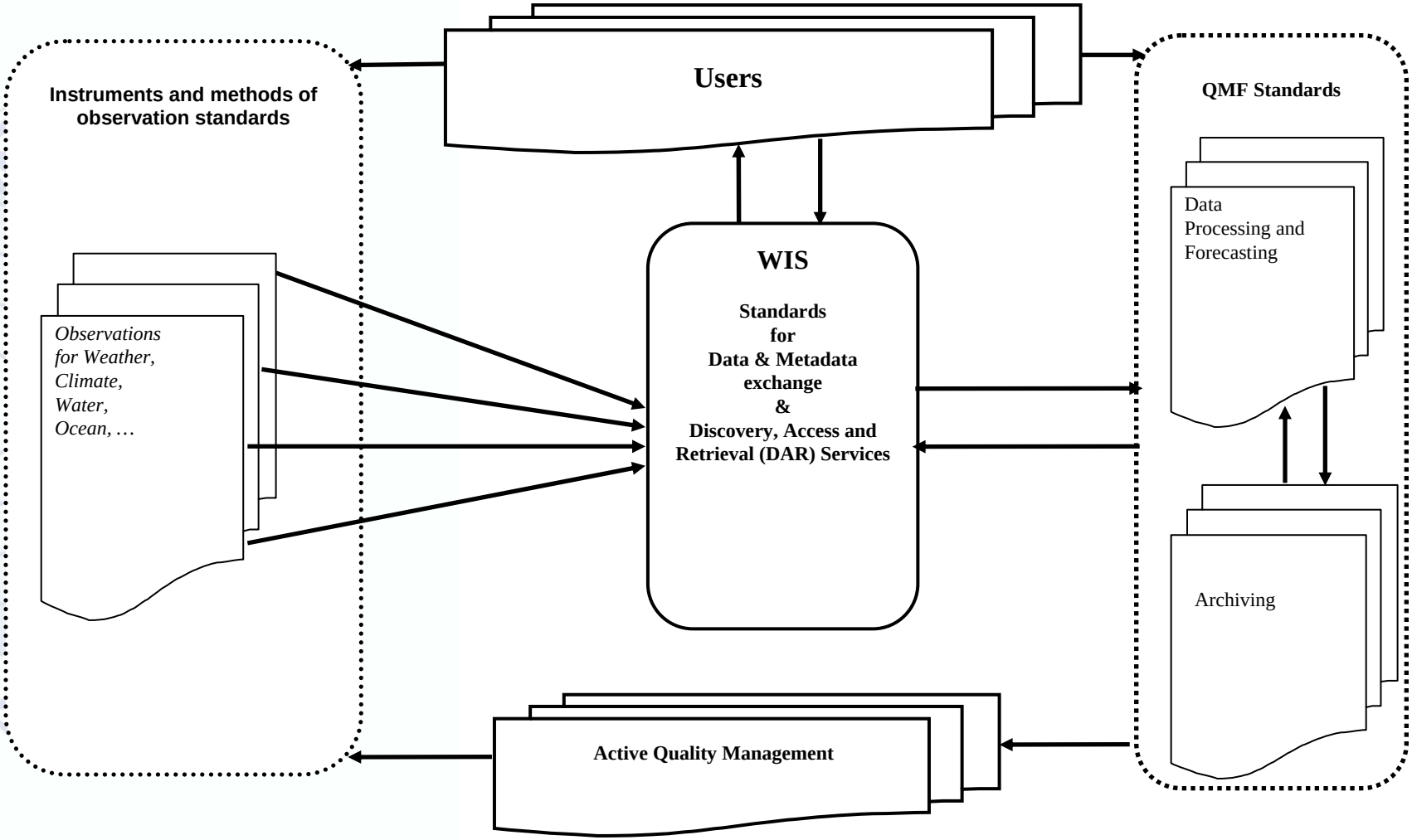
WIGOS Integration Areas

- Three key areas where standards are required:-
  - Measurements and observations, **must ensure component observing systems are functioning correctly and reporting observations in accordance with the known sampling and error characteristics for that type of system**
  - Data exchange, discovery, access and retrieval [**standards imposed by the use of WIS**]
  - End-product quality management, Quality monitoring needs to be associated with organised feedback to improve identified problems with observing systems


Users
Instruments and methods of observation standards
QMF Standards
Data Processing and Forecasting
WIS
Standards for Data & Metadata exchange & Discovery, Access and Retrieval (DAR) Services
Observations for Weather, Climate, Water, Ocean, …
Archiving
Active Quality Management

WMO Standards

- WMO/ISO agreement that WMO can promulgate standards
- CIMO will initially develop standards for priority meteorological variables from the existing documentation

How to transform the concept into an action plan?

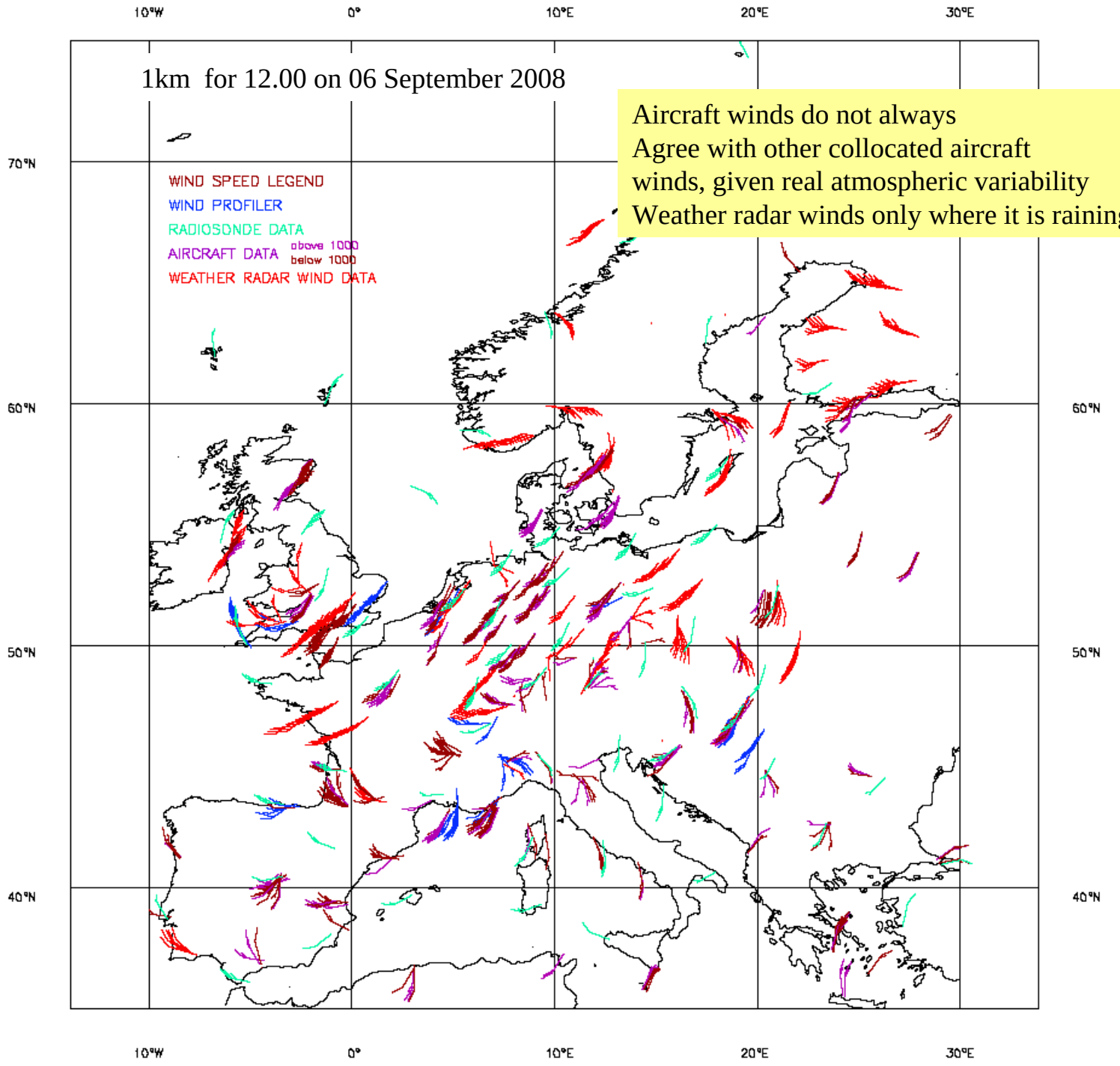
- Different types of observing system require different approaches, e.g. satellites or ground based observing systems
- CIMO activities fundamental to 1st and third areas and in contributing information to the Metadata for the second area
- Documentation required so that users know how to link surface and space based observations to produce interoperable products for each meteorological variable.

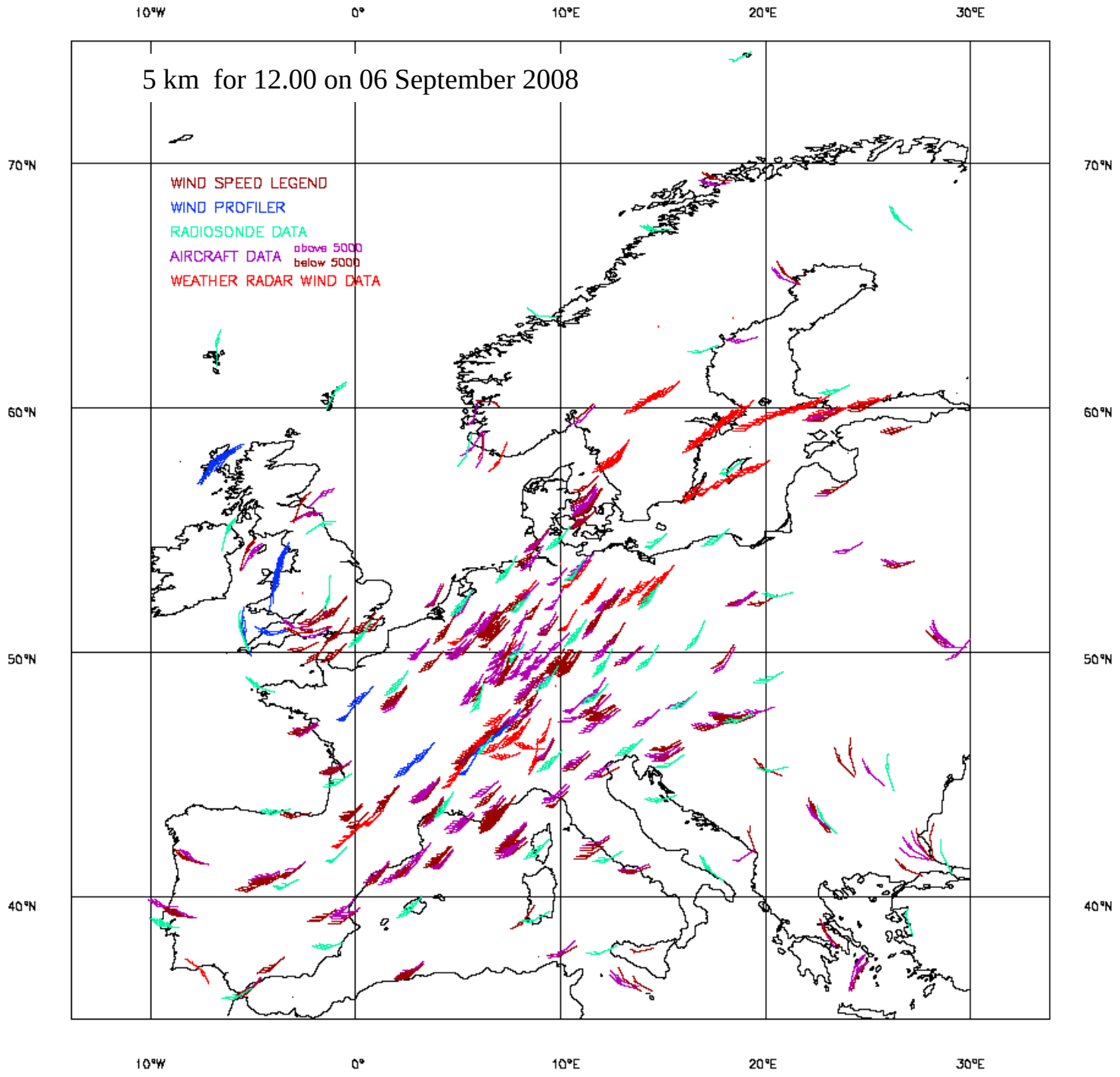
Example of the upper wind network

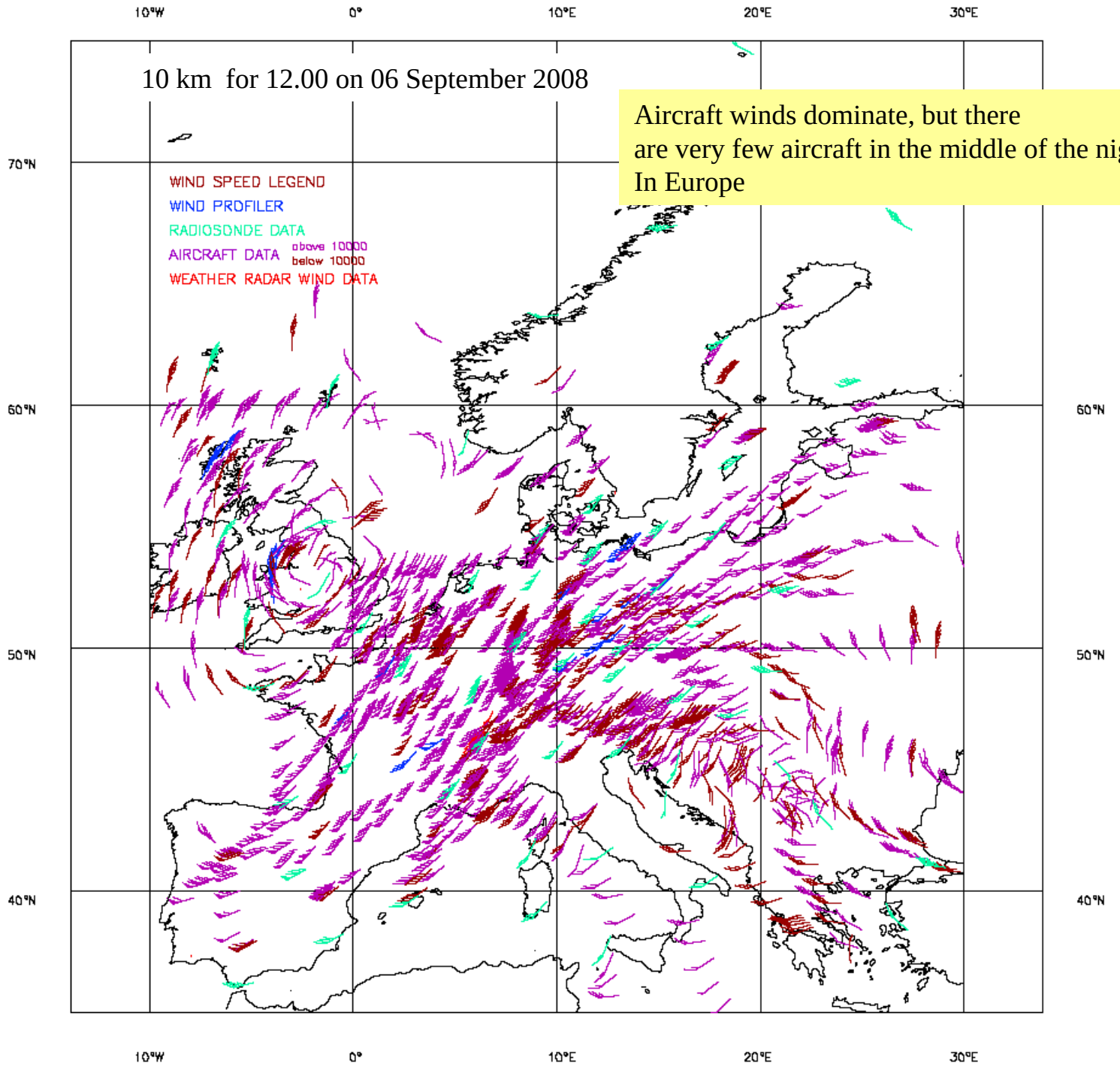
- Only functions well if a variety of systems are used together.
- In these examples two insitu systems radiosondes and aircraft take snapshots over a specified path for a short time. The characteristic errors of these two types of measurements are different, although often of similar magnitude. The atypical errors that occasionally occur are quite different for the two systems.

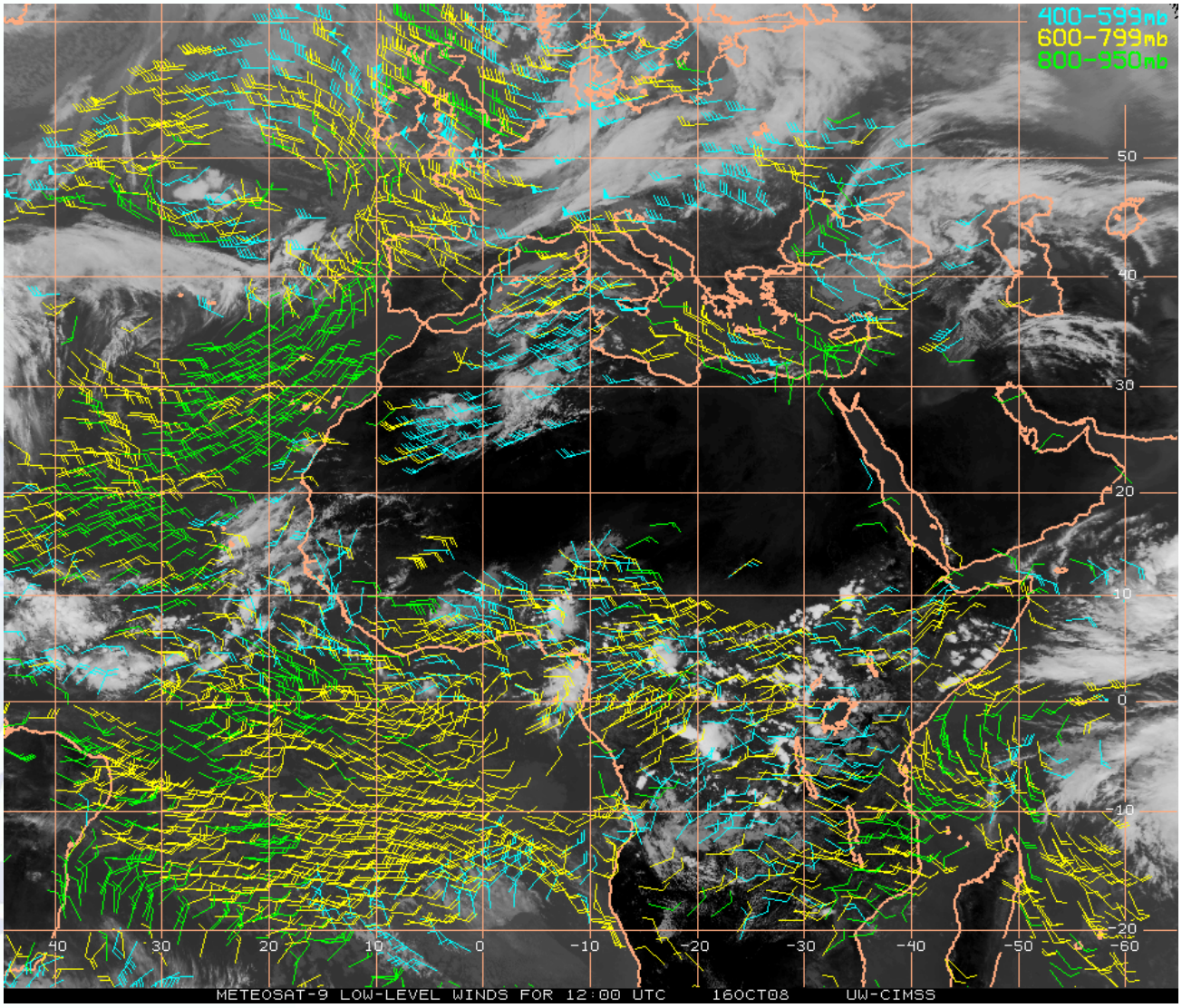
- Wind profiler winds are often integrated for 30 minutes over a cross section of diameter of about 1km at 2 km ,and 5 km at 10 km.

- Weather radar winds are derived around a cone of wider diameter, e.g. 7.5 km at 2 km and 5 km at 20 km, and will be usually sampled over a much shorter time period than the wind profiler winds.

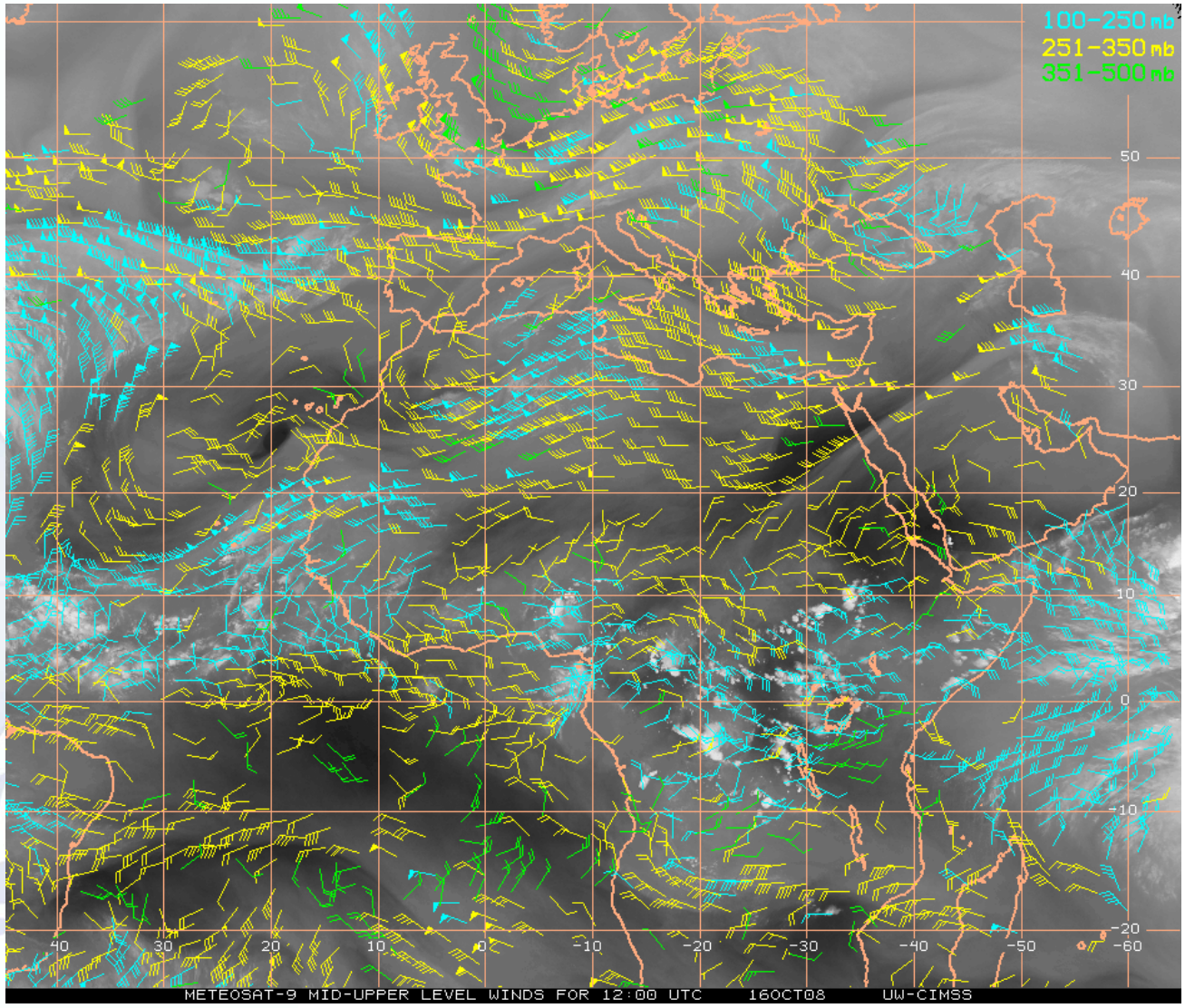

1km for 12.00 on 06 September 2008
Aircraft winds do not always
Agree with other collocated aircraft
winds, given real atmospheric variability
Weather radar winds only where it is raining
WIND SPEED LEGEND
WIND PROFILER
RADIOSONDE DATA
AIRCRAFT DATA above 1000 below 1000
WEATHER RADAR WIND DATA
10°W
0°
10°E
20°E
30°E
70°N
60°N
50°N
40°N


5 km for 12.00 on 06 September 2008
10°W
0°
10°E
20°E
30°E
70°N
60°N
50°N
40°N
WIND SPEED LEGEND
WIND PROFILER
RADIOSONDE DATA
AIRCRAFT DATA
above 5000
below 5000
WEATHER RADAR WIND DATA


10 km for 12.00 on 06 September 2008
Aircraft winds dominate, but there
are very few aircraft in the middle of the night
In Europe
WIND SPEED LEGEND
WIND PROFILER
RADIOSONDE DATA
AIRCRAFT DATA above 10000 below 10000
WEATHER RADAR WIND DATA
10°W
0°
10°E
20°E
30°E
70°N
60°N
50°N
40°N

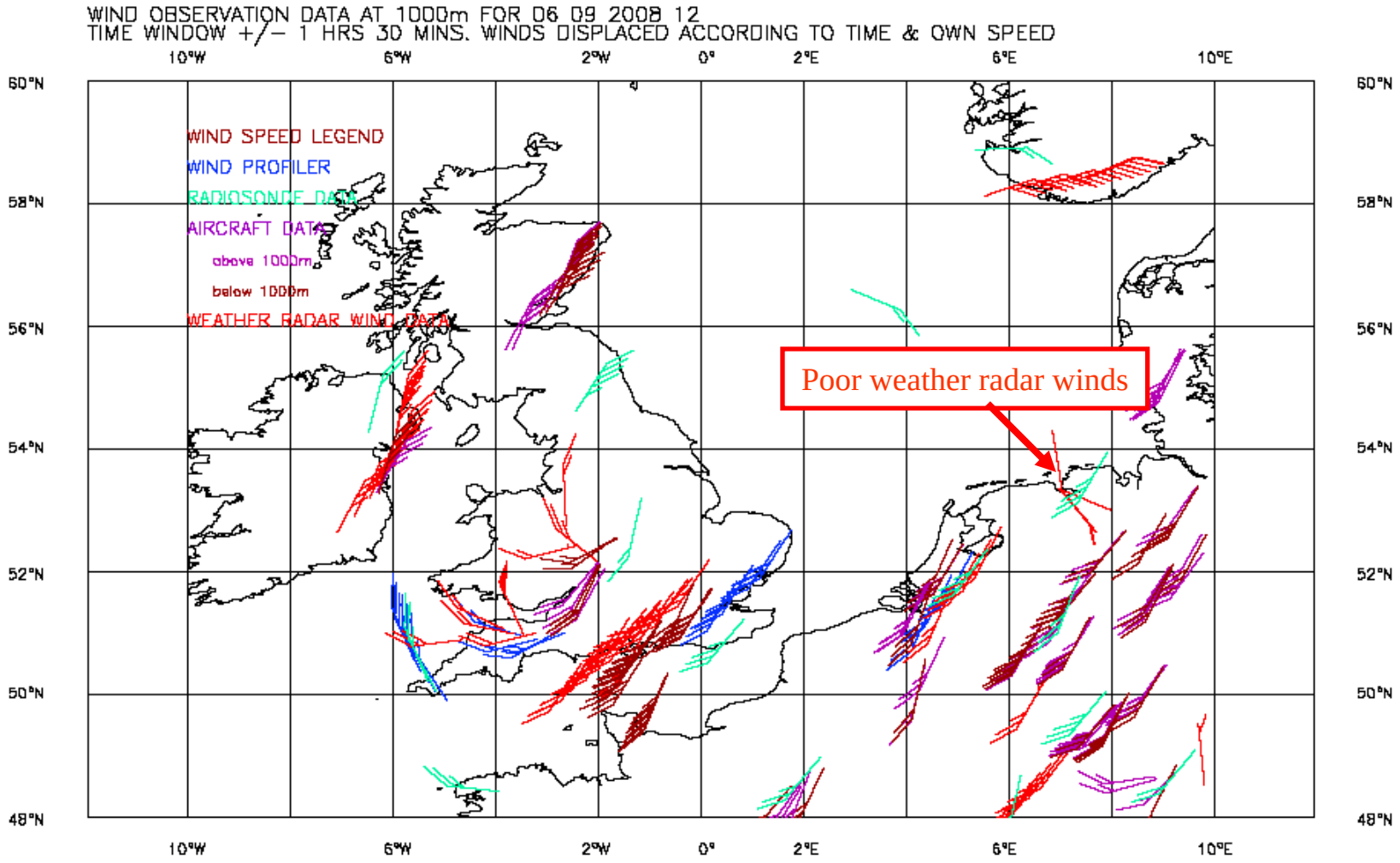


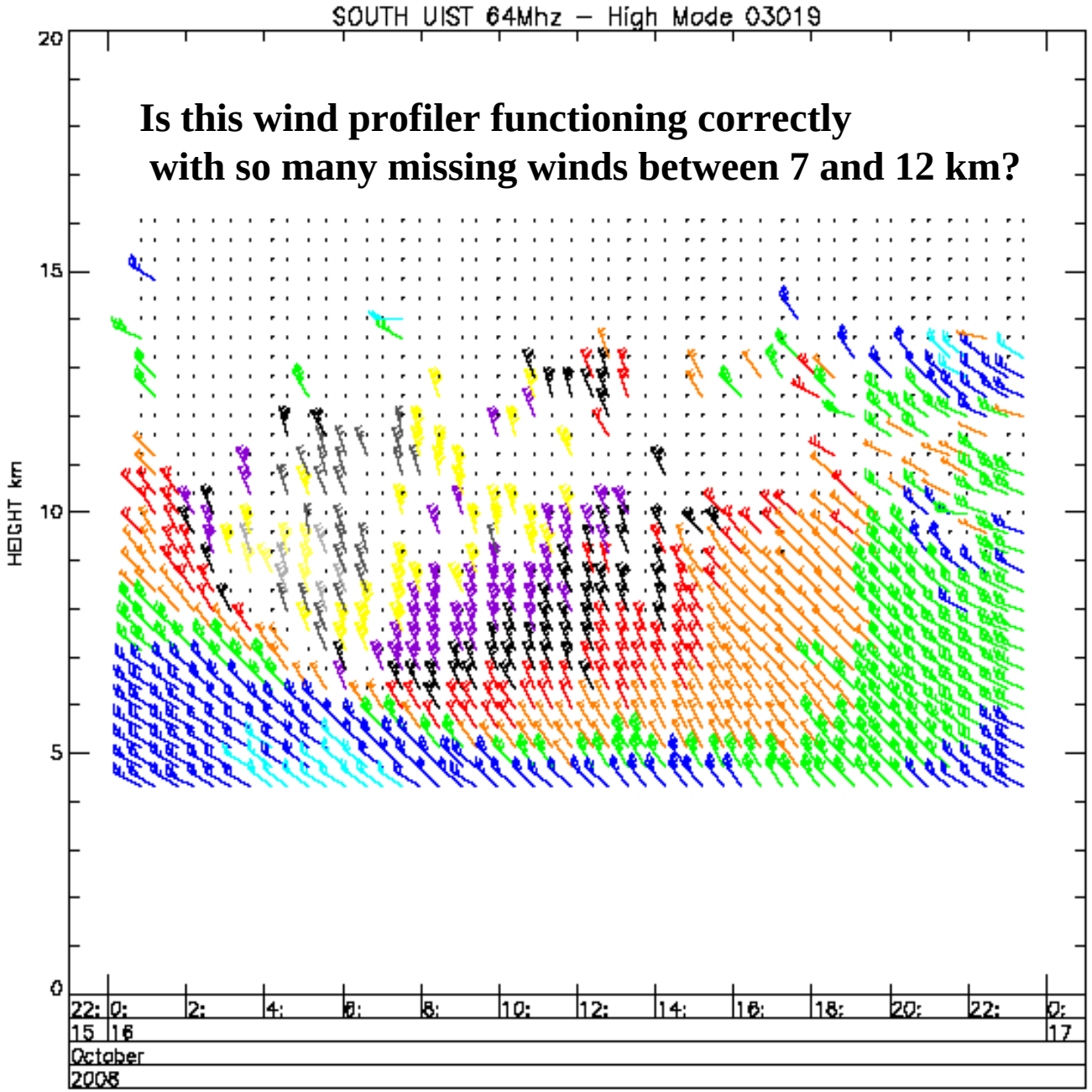
Lower and middle troposphere. Satellite winds from tracking cloud and water vapour structure. Sampling is for much deeper layers than the ground-based systems/aircraft.
Comparison with NWP fields is essential to eliminate false winds, before values are reported



Upper troposphere. Satellite winds from tracking cloud and water vapour structure.
Sampling is for much deeper layers than the ground-based systems/aircraft.
. Are the height assignments correct?

Looking in more details at surface measurements reveals some suspicious measurements that probably should have been quality controlled




SOUTH UIST 64Mhz – High Mode 03019
Is this wind profiler functioning correctly
with so many missing winds between 7 and 12 km?
HEIGHT km
20
15
10
5
0
22:
0:
2:
4:
6:
8:
10:
12:
14:
16:
18:
20:
22:
0:
15
16
17
October
2008

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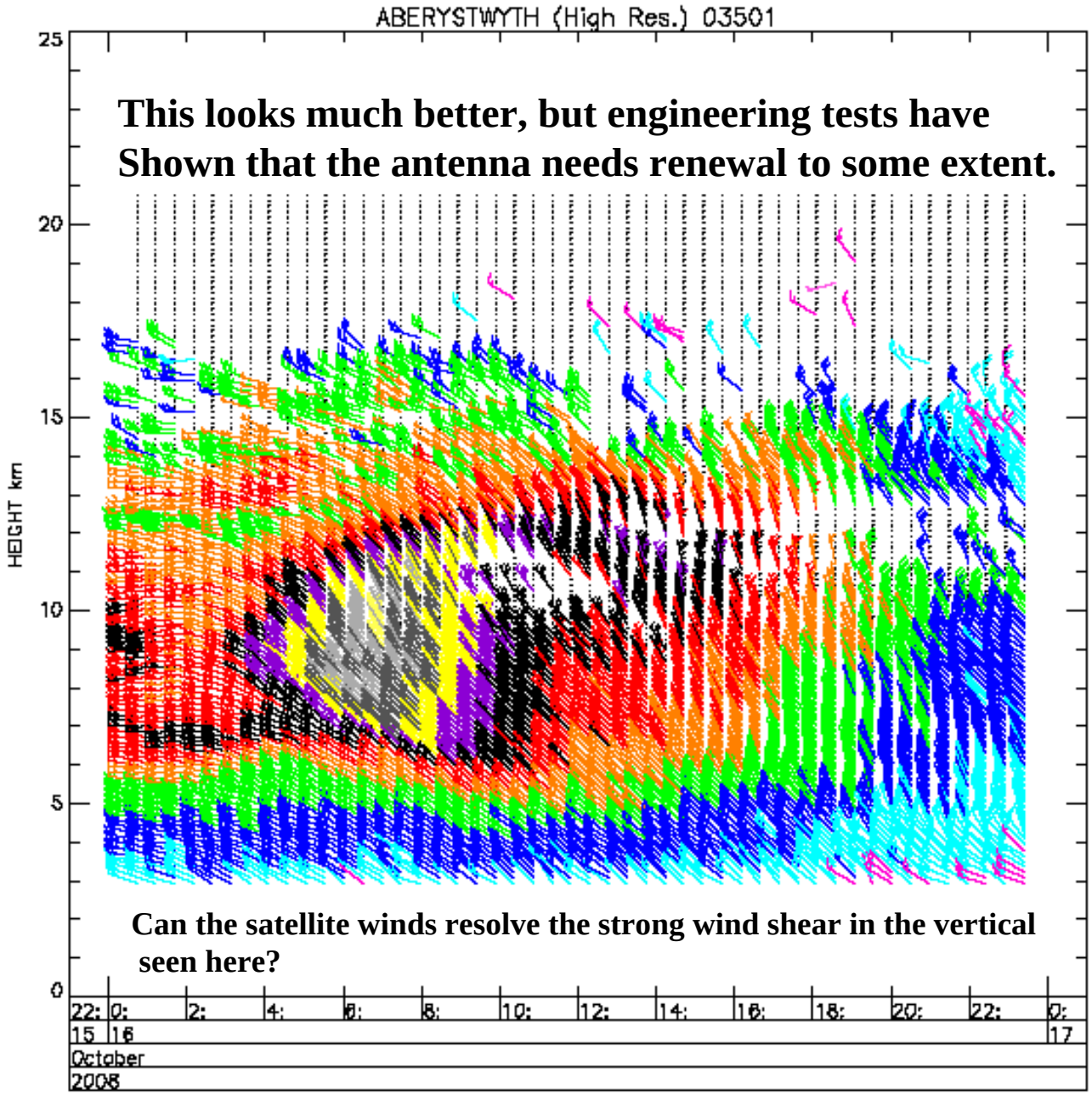
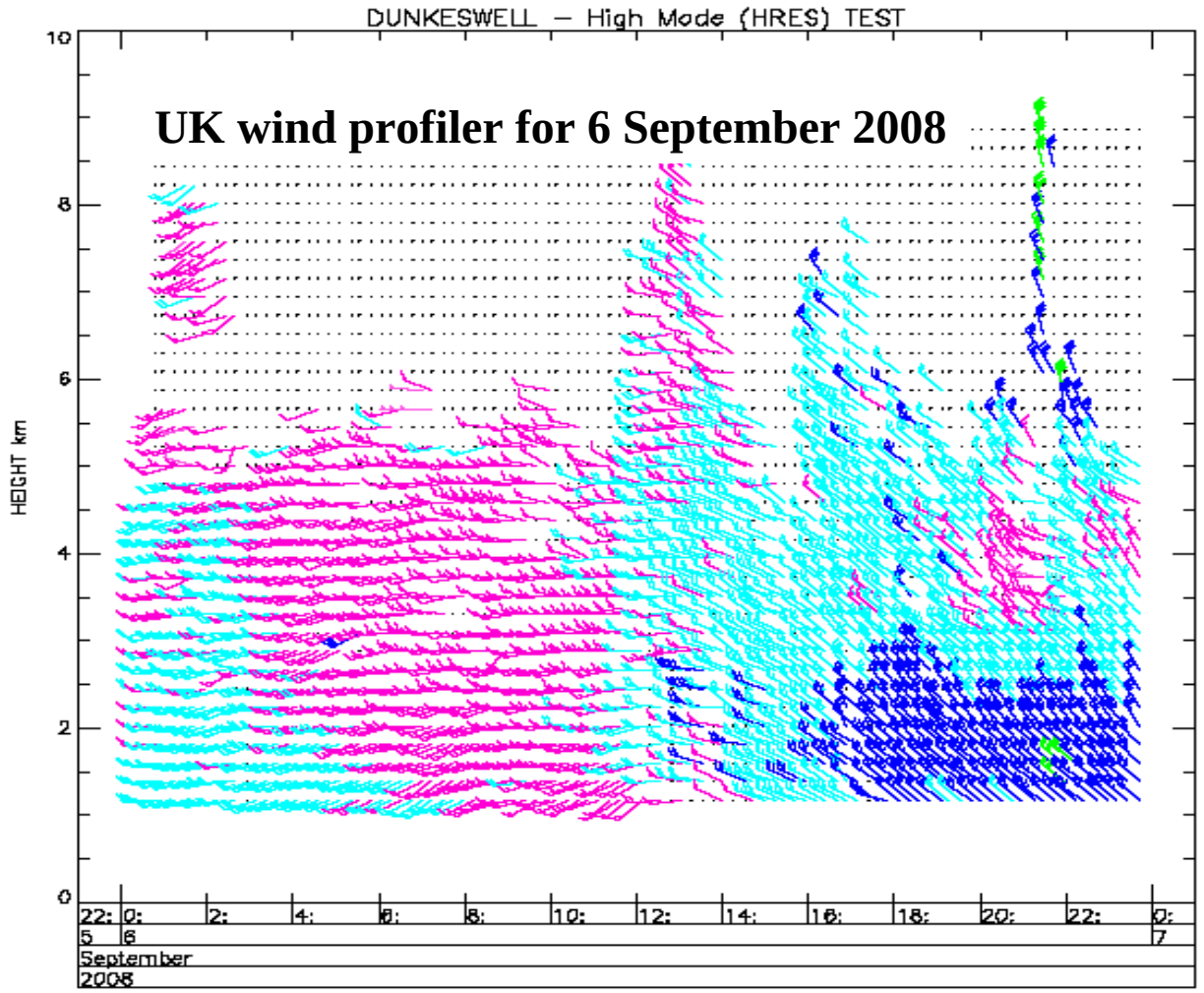
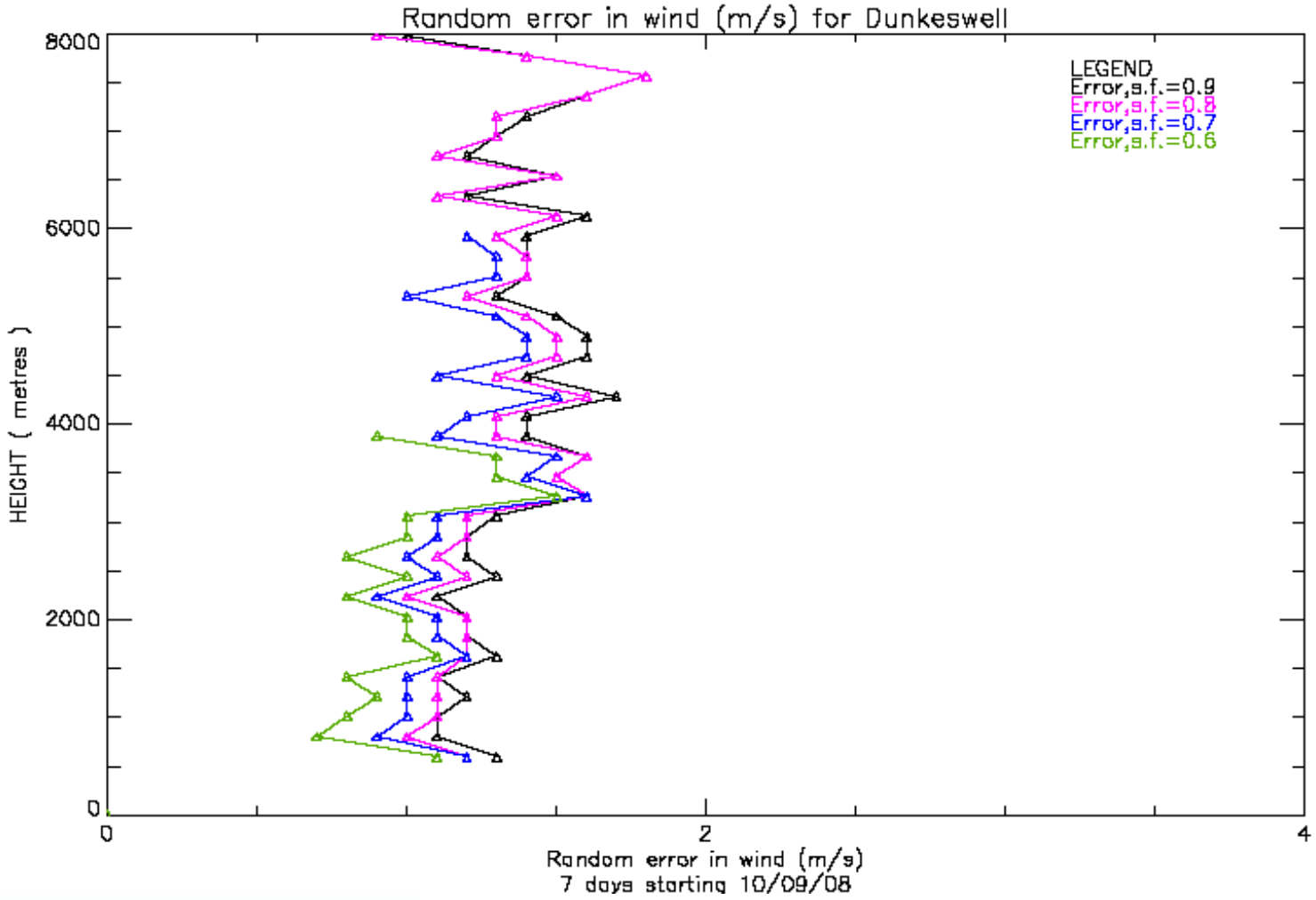

ABERYSTWYTH (High Res.) 03501
This looks much better, but engineering tests have
Shown that the antenna needs renewal to some extent.
HEIGHT km
25
20
15
10
5
0
Can the satellite winds resolve the strong wind shear in the vertical
seen here?
22:
0:
2:
4:
6:
8:
10:
12:
14:
16:
18:
20:
22:
0:
15
16
17
October
2008

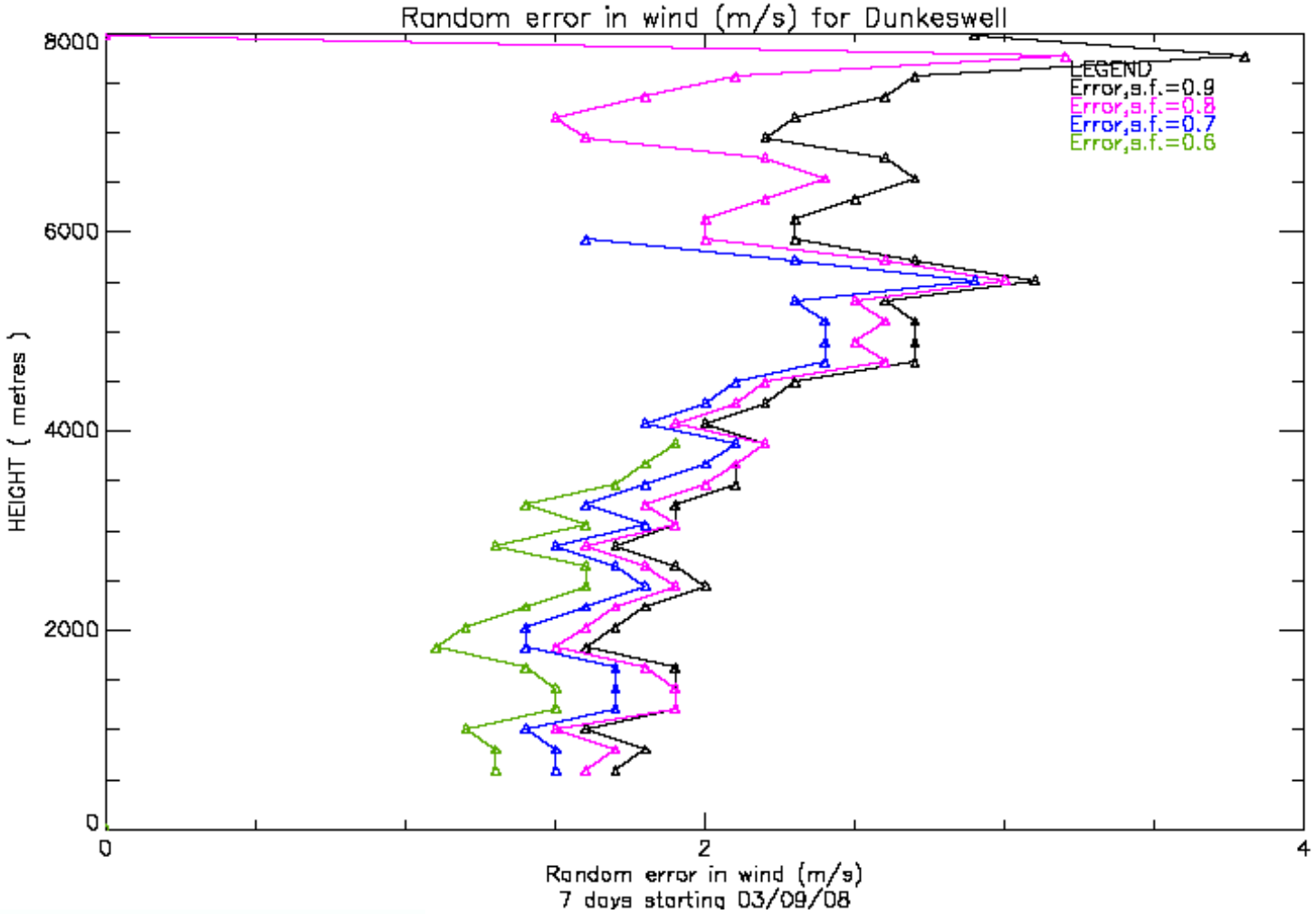
Time series of measurements allows identification of atypical errors



Errors estimated from the time series vary from week to week, see next slide as well



Errors estimated from the time series vary from week to week, so scattering conditions in the atmosphere affect the wind profiler performance. Periods of poorer performance need to be flagged to the users, but this does not happen now.



Some conclusions for upper winds integration

Uniformity of performance relies on:-

- Thorough testing of systems before large scale deployment
- System maintenance regimes that maintain 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
- Most systems need to generate error estimates in real time, which does not currently happen.

Relationship to QA4EO

- CIMO/WMO ’s work on quality needs to be linked to fit with the general principles of QA4EO, but the framework must recognise where the complexity of insitu measurements requires a different approach.

- It is not possible to make some satellite based products interoperable with some insitu measurements since they do not measure the same variables with the same vertical resolution.

- A product [e.g. 3-D atmospheric temperature or humidity structure] which can be used by any user without specialist knowledge needs to be generated by an additional process.

Strategic background

GEOSS: seamless & continuous delivery of information products to meet needs of societal **benefit areas**

Goal

Interoperability **among diverse** sources of EO data

Key principles

Harmonization of practices

Data suitability

Data accessibility

Strategy

Strategy
Establish a set of guidelines …etc.

Theme areas

Data quality

Documentation

Data Management

Guiding principle

Data or products must have a QI based on a documented assessment of their traceability to an agreed reference.

Sound and harmonized doc management

Data and metadata sharing protocols and principles

Guidelines

Comparisons

Procedures

Reference standards

Document identification and maintenance

Data delivery

Metadata content

Data / metadata format

Implementation enabler

Outreach & education

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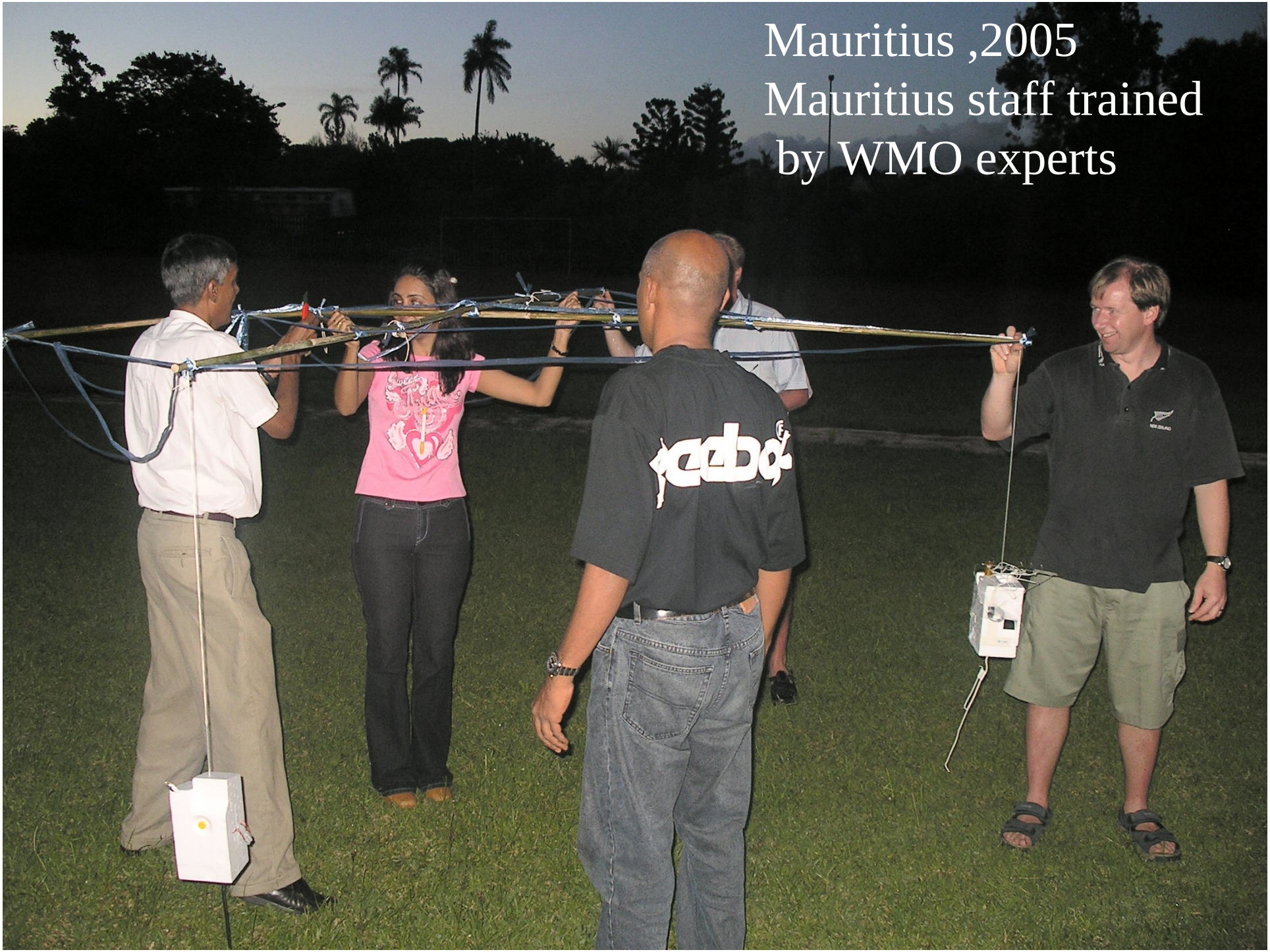
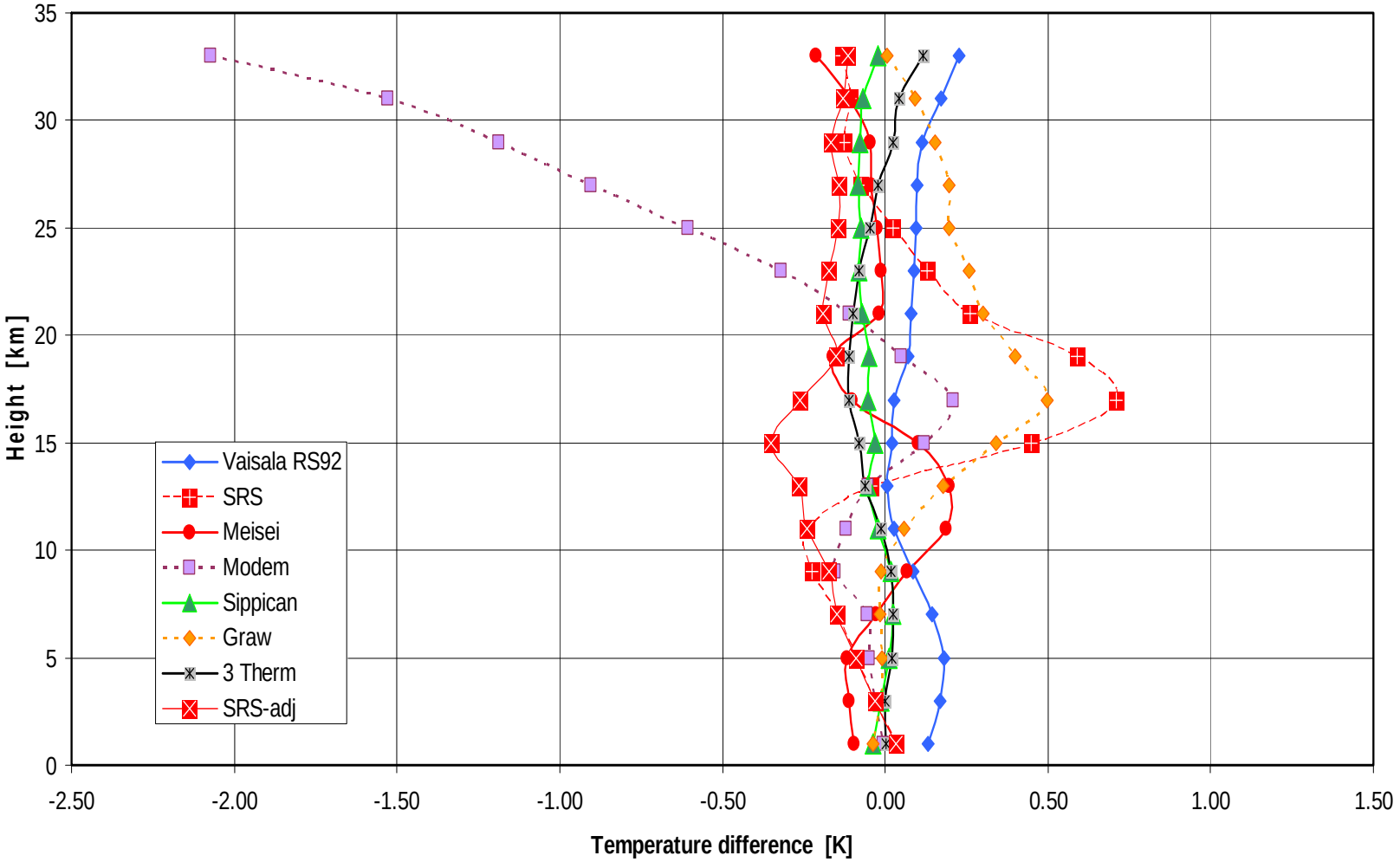
Preparing for the Future, 2007 In China

Testing problems with early GPS radiosondes, 2001, Brazilian staff advised by CIMO experts


Mauritius ,2005
Mauritius staff trained
by WMO experts


Quality based on training in methods of observation, Tanzania

Systematic differences in nighttime temperature
referenced to the average of Graw, Meisei, Sippican, SRS-adjusted and Vaisala
WMO High Quality Radiosonde Comparison Test, Mauritius 2005



Results incorporated into CIMO Guide- becoming basic documentation for future

Harmonization/Standardization?

- If errors identified correct the problem and inform users
- Cannot make everything the same…even if all use the same equipment.
- But ensure characteristic measurement stays within certain limits of the typical performance measured
- Inform users of quality through observation report
- Many systems would benefit from real time estimates of error, e.g. if radiosonde is faulty, don't pretend it is usual quality.
- Space-based and surface based measurements rarely similar, so interoperability has to be sought through products, e.g. output from NWP model rather than through direct comparisons??
- So users/ data centres in standardisation diagram have important function, but are these joined up efficiently at present.

WMO quality policy statement and strategy

Quality policy: WMO is dedicated to ensuring optimum affordable quality for all meteorological, climatological, hydrological, marine and related environmental data, products and services, especially those supporting the protection of life and property, safety on land, at sea and in the air, sustainable economic development and protection of the environment.

Does this ensure observations are fit for purpose?

In any case do we need several standards to make observations affordable?

***Strategy:* WMO will endeavor through a process of continuous improvement, efficient management and good governance to:**

•ensure that increasingly accurate and reliable warnings of severe events related to weather, water and climate are delivered to users in a timely and useful manner;

•specify and enhance provision of user-oriented weather, water, climate and related environmental services of identified quality to the public, governments and other users and customers;

•ensure that observations, records and reports on weather, water resources, climate and related natural environment, operational forecasts, warning services and related information are of **identified quality for international exchange** through the WMO coordinated systems and relevant joint standards with other international organizations;

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Questions & answers

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Implementation

- Process needs to be described to Members in a better fashion
- Do members know the quality of their measurements?
- Do members take any pride in their observing systems?
- How can standards managed by WMO be chosen and sustained in reality?
- Requires project approach, with central staff (seconded by members?)
- Coordinated through TCs and Regional associations

- How this serves crosscutting activities of Climate, Disaster reduction, etc needs to be explained.

Instruments and Methods of Observation Programme and CIMO

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- To ensure the 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**.

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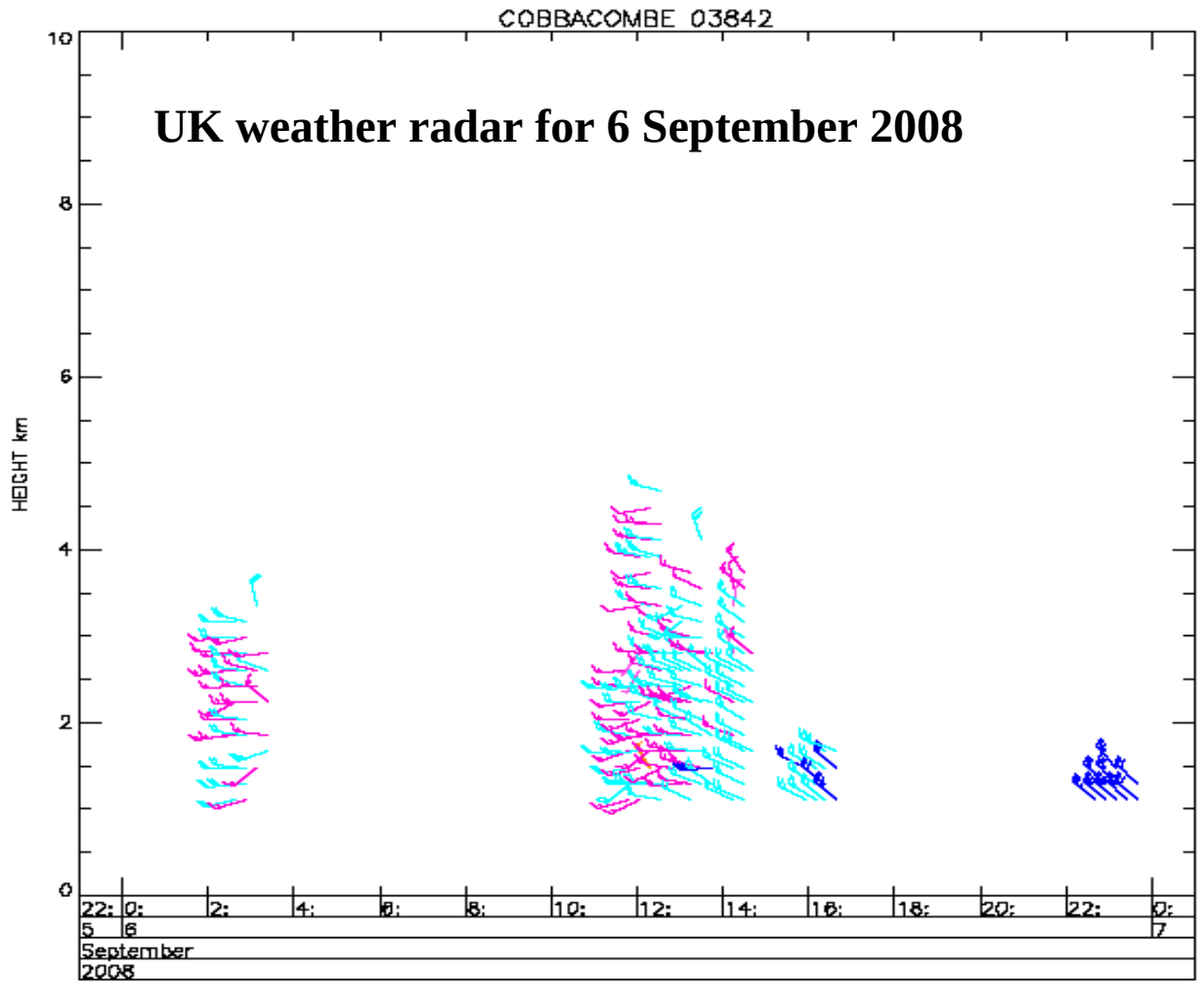
A new challenge

Expected Results, Key Performance Targets for CIMO [1]

- For activities to receive financial support in future, WMO Members must see useful outputs from the activities of CIMO.
- I would prefer that the usefulness of CIMO is measured in terms of outcomes achieved.
- An expert team that does not function can no longer be tolerated.
- Outputs must be more than useful discussions between experts, especially if these discussions do not represent any progress from the previous intersessional period.

Time series of measurements also allows identification of atypical errors

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Aim of CIMO intercomparisons

- To improve the **quality** and **cost-effectiveness** of surface based and upper air observing systems by exploiting existing national tests and performing global intercomparisons;
- To provide recommendations on **system performance**, **improvements** of instruments and methods of observation, suitable working **references** to WMO Members and instrument manufacturers.

Witness of earlier CIMO activities in Brazil,

Waiting for chicken remains from the cookhouse!

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***Strategy:* WMO will endeavor through a process of continuous improvement, efficient management and good governance to:**

- address the need to enhance the capabilities of Members to deliver services to users and customers with best available technology and assist to improve cooperation and collaboration between Members in the implementation of quality management systems;

- address the need to enhance the capabilities of Members with comprehensive capacity building activities that include training, through the development of partnerships and technology transfer.