WORLD METEOROLOGICAL ORGANIZATION

Distr.: RESTRICTED
CBS/OPAG-IOS (ODRRGOS-4)/Doc. 7, REV.
(15.I.2002)

COMMISSION FOR BASIC SYSTEMS
OPEN PROGRAMME AREA GROUP
ON INTEGRATED OBSERVING SYSTEMS

ITEM: 6

EXPERT TEAM ON OBSERVATIONAL DATA REQUIREMENTS
AND REDESIGN OF THE GLOBAL OBSERVING SYSTEM

Original: ENGLISH

FOURTH SESSION

GENEVA, SWITZERLAND, 28 JANUARY-1 FEBRUARY 2002

Re-design of the Global Observing System: Some implications of the Statements of Guidance (SOGs) for global and regional NWP

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Summary and Purpose of Document

On the basis of the ET deliberation “Statement of guidance regarding how well observing system capabilities meet WMO user requirements in several application areas” published as SAT-26, WMO TD No.1052, 2001, gaps between user requirements for global and regional NWP and present/planned observing system capabilities have been identified and expressed in terms of tentative proposals relevant to the re-design or evolution of the Global Observing System (GOS) and for the distribution and use of data from the GOS. Specific results of the above review are presented in the Appendix to this document.

ACTION PROPOSED

The meeting is invited to take into consideration the information contained in this document when discussing implications of SOGs for redesign of the GOS.

Appendix: **Some implications of the Statements of Guidance (SOGs) for global and regional NWP**

1. INTRODUCTION

The Report of ET-RR, “Statement of guidance regarding how well observing system capabilities meet WMO user requirements in several application areas” (SAT-26, WMO TD No.1052, 2001), has been reviewed. Gaps between user requirements for global and regional NWP and present/planned observing system capabilities have been identified and expressed in terms of tentative proposals relevant to the re-design or evolution of the Global Observing System (GOS) and for the distribution and use of data from the GOS.

This version of the paper is in draft form, appropriate for discussion within ET-RR.

2. THE OBSERVING SYSTEM

2.1 General

2.1.1 More frequent observations – one or more per hour – will be necessary in support of regional NWP. For contributions from the space-based GOS, this implies observations from GEO satellites.

2.1.2 A baseline system of in situ observations is needed for “tuning” some components of satellite data assimilation systems (e.g. radiative transfer models). A detailed study of the optimal characteristics of such a system is required, including the applicability of the GUAN to serve as the baseline.
[Is this what we mean? Or is an ARM-like system the baseline?]

2.2 3D wind field

2.2.1 AMDAR technology can/should provide more ascent/descent profiles, with improved vertical resolution.

2.2.2 Radiosondes
Network design studies are encouraged, to optimise use of available resources. Networks should be reviewed in light of:
- increasing numbers of ascent/descent wind and temperature profiles from commercial aircraft, noting that significant numbers of moisture sensors aboard commercial aircraft are not likely for several more years,
- potential for semi-automated releases of sondes from containers aboard ships,
- increasing impact of satellite data over land.

[Contribution to GUAN to be noted.]

2.2.3 Satellite technology
Global coverage requires satellite technology. Current satellite winds have restricted spatial coverage (horizontal and vertical). Improvements offered by new technologies are:
- Advanced IR geostationary sounders (e.g. GIFTS) – winds at more levels with improved height assignment.
- Doppler wind lidars – technology is very demanding and options for an operational system need to be studied. Research demonstration missions (e.g. ADM) are encouraged.

2.2.4 Wind-profiling radar

Systems have already been implemented over some land regions. Frequency of observation, accuracy and high vertical resolution are major advantages, if deployment is affordable. Mixes of boundary-layer and full tropospheric profilers should be considered. The planetary boundary layer (PBL) is less well observed than the upper troposphere wherever there is commercial air traffic. Wind profiling is now possible from ships and buoys.

2.2.5 Scanning Doppler radar

These systems provide an excellent source of boundary-layer wind information. Frequency of observation and high spatial resolution are major advantages. These data are more valuable for short-term mesoscale forecasts than for longer range synoptic scale forecasts. Systems are expensive but can be cost-effective for providing warnings of severe weather near large population centres. In the less sensitive operational radar systems, precipitation is required to provide the necessary tracers for the Doppler wind measurements.

As these observations are not formally part of the GOS, requirements for international exchange of these data need to be presented.

2.2.6 Aerosondes

This is a potentially valuable source of targeted observations. A fleet of them would probably be needed to cover targeted area well, especially if they make only in situ measurements and do not drop sondes. The size of the fleet and other aspects of their deployment needs further study.

2.2.7 High-altitude balloons

It will be several years before convincing demonstration is possible. Stratospheric balloons can probably be kept within a reasonably narrow latitude belt, at least at lower latitudes. They could drop sondes to make a variety of measurements in the atmosphere and ocean. Too early to make recommendations.

2.2.8 Requirement for higher accuracy and resolution in PBL in support of regional NWP.

The North American Observing System Program is involved in an effort to design a mesoscale observing system for North America that will improve mesoscale weather services, both from the standpoint of subjective uses in forecast offices and objective use in NWP. The planning group agrees that the greatest unmet need for observations *supporting mesoscale weather services lies in the atmospheric boundary layer, and it recommends measurement of the standard parameters, especially moisture.*

*[Is this appropriate for an ET-*RR *recommendation, or is it just a NAOS matter?]*

2.3 Surface pressure and wind (over ocean)

2.3.1 Satellite data

Satellites provide surface wind vectors (scatterometers) and surface wind speed (microwave imagers). NWP data assimilation schemes can make effective use of wind speed only, if wind direction is not available. Vectors are likely to become more important for defining small-scale surface wind features in regional NWP and for providing accurate mean vectors to force ocean models. Demonstration is planned of a polarimetric passive microwave system (Windsat/Coriolis) to provide both speed and direction information.

2.3.2 Ocean buoys (surface pressure)
Satellites can provide surface wind information at high horizontal resolution. This information is related to the surface pressure gradients. An adequate network of ocean buoys is needed to provide “tie points” for the surface pressure analysis. The requirements and potential capabilities for direct surface pressure observation from space merits further study.

2.3.3 Ships
[Any points to be made?]

2.4 Surface pressure and wind (over land)

2.4.1 Surface mesonets
These are proliferating in many parts of the developed world because of the need to monitor pollutants and to provide detailed information for agriculture and power generation. For the most part, these mesonets are not being developed in a coordinated way. It is recommended that WMO conducts a census of such systems with national weather services and promotes agreements with the owners of the data for central collection. The owners would be required also to provide metadata about their instruments: make, manufacture, exposure, maintenance (if any), data formats, and communications protocol. The owner could prohibit further distribution of data by the weather service. The owner would presumably benefit from better local forecasts make possible, in part, by the additional data.

2.4.2 Automation issues
Wireless technology is being considered for the collection of observations from meso-networks, either permanently or temporarily deployed, for example, in the vicinity of a forest fire. In many cases, automation brings increased temporal observing capabilities but also raises quality control issues that need close attention (though no specific ones in the case of surface pressure and wind).
[? Move this para to “General” category ?]

2.5 3D temperature field

2.5.1 AMDAR data
See 3D wind field (2.2.1).

2.5.2 Radiosondes
See 3D wind field (2.2.2).

2.5.3 Satellites
Planned advanced IR sounders on polar satellites will provide improved vertical resolution / accuracy except in cloudy areas. GPS radio occultation could supply observations of high vertical resolution and accuracy, including in cloudy areas; implementation is needed. Its application is more promising for global NWP than for regional NWP, because of its limited horizontal resolution. Advanced IR sounders on geostationary satellites could provide

improved frequency of coverage; a proof-of concept mission (i.e. NASA's GIFTS mission) is planned.

2.6 3D humidity field

2.6.1 AMDAR
Enhanced instrumentation is needed. The second-generation Water Vapour Sensing System (WVSS-2) employs a laser diode to measure the absorption by water vapour of energy in the laser beam over a short path length. This is an absolute measurement of water vapour content that is expected to be accurate from the ground to flight altitudes. The development and testing of this sensor on aircraft should be carefully watched.

2.6.2 Radiosonde
See 3D wind field (2.2.2).

2.6.3 Satellites
IR sounders. See 3D temperature field (2.5.3).

2.6.4 Ground-based GPS
These systems could provide useful data for regional NWP.

2.6.5 Ground-based lidars, radiometers and spectrometers
These instruments have an existing and planned role in the calibration and validation of other systems. Although many trial sites now exist, where studies are being undertaken to establish potential contributions to an integrated observing network, their ultimate operational utility is not yet clear.

2.7 Snow

2.7.1 Satellites
Planned capabilities for snow cover monitoring and good, but adequate capability for snow equivalent water measurement has not yet been demonstrated.

2.8 Soil moisture

Satellite capability is needed; a proof-of-concept mission is planned (ESA's SMOS mission).

2.9 Clouds

Satellites provide very good information on cloud cover, cloud top height and their evolution. They do not provide cloud base height. Nor do they provide accurate cloud optical thickness (which controls SW radiation at the surface). Therefore, enhancements of automated surface networks should be considered to provide these for regional NWP. Cloud base height is available from ground-based instruments. Laser cloud base recorders (LCBRs) are widely used for this purpose. Sparse networks of pyranometers exist in various parts of the world. Pyranometers give a very good indication of cloud optical thickness. It is probably too expensive to make pyranometers part of the standard surface instrument package, but data from existing sites could be collected for NWP.

Satellite microwave imagers can provide estimates of total cloud liquid water.

Cloud profile information will require active microwave technologies, either from satellites or from the ground. Satellite technology is currently very demanding and expensive. Ground-based radars operating at millimeter wavelengths can deliver reliable cloud profiles.

2.10 Precipitation

2.10.1 Ground-based radar.
Many hourly precipitation observations are made but not distributed internationally. Because of their growing utility for global NWP, it is recommended that the status of these observations is changed so that they become part of the GOS, and their distribution improved accordingly.
[Also, need to consider any recommendations for regional NWP]

2.10.2 Satellite passive microwave
Higher temporal frequency is required. The Global Precipitation Mission (GPM), if implemented, will address this deficiency.

2.10.3 Satellite active microwave.
In order to improve the interpretation of passive microwave measurements in terms of surface rain rates, measurements are needed of the vertical distribution of precipitation within precipitating clouds. This requires active technology, i.e. rain radars; such systems have been demonstrated on TRMM and are planned as an important component of the GPM.

2.11 Visibility

Visibility information is most valuable for air and highway transportation, but it is also useful for calibrating algorithms that estimate visibility on the basis of precipitation type and intensity. Similarly one can verify forecasts of fog and low clouds or even air quality. Visibility is a part of SYNOP and METAR reports, but the source of information varies widely. The human observer assesses visibility with reference to landmarks at known distances. Accuracy tends to be less at night than during the day. Automated measurements rely on the extinction of light in a beam between a transmitter and a receiver, and this is converted to a measure of visibility. Remote cameras (e.g., CCTV) give some measure of visibility, but the information is difficult to quantify.
[What should be our recommendation? Visibility has always been important for public weather services, and it is becoming increasingly important for air quality, both for health and aesthetic reasons. Automated measurements of extinction are probably the answer, but they need to be referred to some standard that traces back to what the human eye perceives, for visibility is in the eye of the highway driver or the pilot, and these people are involved in the accidents.]

3. DISTRIBUTION AND USE OF DATA

3.1 Radiosondes offer information of very high vertical resolution. Some of the information that could be used by modern NWP systems is lost through use of out-dated character-code messages. Data processing and distribution should be upgraded to prevent this.

3.2 Global and regional NWP systems are becoming increasingly capable of extracting information from sequences of observations at high temporal frequency. This implies:

- For ground-based systems, many hourly observations are made (e.g. local meso-networks) but not distributed internationally. More widespread data distribution should be encouraged.
- For data from aircraft, sub-hourly collection and distribution would benefit regional NWP.

3.3 Some surface observations are made available in METAR code. Collaboration between WMO and ICAO is needed to obtain more widespread distribution of hourly data, and to improve and exchange the metadata required to allow exploitation of these data in NWP (e.g. station heights).

3.5 For global NWP, near real-time data collection (2-3 hours delay) is usually sufficient. However for regional NWP more timely data are required (< 1 hour delay). For polar satellite data, this implies that appropriate data distribution systems must be implemented – either by direct reception from the satellite (in addition to being stored on board and down-linked once per orbit) or via communications satellites.

3.6 Effective use of observations in NWP requires appropriate interfaces between observations and NWP systems. This is particularly problematic for remotely-sensed data where the relationship between the measured variable (e.g. radiance) and the variables carried by the NWP model is complicated, requiring complex instrument-specific pre-processing code and assimilation modules. Particularly important are accurate and computationally efficient forward models to estimate the observed quantities from model variables, and the adjoints of these forward models. They are needed for each observation type. Enhanced collaboration is required between observation providers and users to generate this software and share it within the community.

3.7 Advances in data assimilation techniques are likely to provide significant improvements in exploitation of information from the current observing system, e.g. dynamical information assimilated directly from sequences of visible/IR imagery.