CGMS-XXVIII
WMO WP-7
Prepared by WMO
Agenda item: E.1

STATEMENT OF GUIDANCE AND THE FEASIBILITY OF MEETING WMO REQUIREMENTS

(*Submitted by the WMO)*

Summary and purpose of document

This document informs CGMS of the status in the preparations of Statements of Guidance and of the Feasibility of Meeting WMO Requirements.

ACTION PROPOSED:

CGMS Members to note the results of the second iteration for the Preliminary Statement of Guidance and of the Feasibility of Meeting WMO Requirements.

Appendices:

A. Summaries of the Statements of Guidance on Global NWP, Regional NWP, Nowcasting and VSRF, Aeronautical Meteorology and Seasonal and inter-annual forecasts;
B. Draft Observational Requirements for Seasonal and Inter-Annual Forecasting;
C. Requirements for Aeronautical Meteorology.

DISCUSSION

1. The CBS OPAG IOS Expert Team on Observational Data Requirements and Redesign of the Global Observing System has met twice since CGMS-XXVII. The Expert Team has continued to follow the CBS-approved Rolling Review of Requirements process (Requirements, Expected Performances, Critical Review and Statement of Guidance). A second iteration of the Statement of Guidance based only on space-based expected performances has been finalized and distributed as WMO TD/No. 992 (SAT-22) (See WMO WP-08). The database of expected instrument performances has been greatly expanded to contain information related to all *in situ* observing systems within the surface-based Global Observing System. A third iteration of the Statement of Guidance is in preparation that is based on both space-based and *in situ* expected performances. Draft observational data requirements for Seasonal and Inter-Annual (SIA) Forecasting and Aeronautical Meteorology have been prepared and are under review by appropriate Technical Commissions. Finally, a new technical document is under preparation describing candidate observing system for consideration in the redesign of the Global Observing System.

Observational Requirements

Seasonal and Inter-Annual Forecasting

2. The second session of the CBS OPAG IOS Expert Team on Observational Data Requirements and Redesign of the GOS noted that Seasonal and Inter-Annual (SIA) forecasting has observational requirements that go beyond those represented by Global NWP. While climatology was not included in the initial set of WMO Programme applications areas in the draft Statement of Guidance, SIA forecasts, climate change detection and attribution, and climate impact assessments were all application areas highly dependent on the extent, scope and quality of observational data. The second session agreed that the development of guidance on the adequacy of observational input, related to objective SIA forecasts could be included in its work as part of the critical review procedure. With respect to climate change detection and attribution, the meeting noted that the Report of the Adequacy of the Global Climate Observing Systems (GCOS-48) contains an appraisal of enhancements of the observational systems that were needed. Additionally a detailed requirement for data in support of research on climate processes already existed.

3. The second session noted that it was planned the critical review of SIA would follow the assembly of requirements for observational data in support of Global NWP and ocean modelling, which provided the basis for objective SIA forecasts. It was noted that it was necessary to secure advice from centres producing SIA forecasts, on amendments or additions to these requirements for observations, related to optimization of the quality of NWP-based SIA forecasts. The following action resulted from this discussion at the second session. CBS in consultation with CCI and CAS would secure advice on amendments or additions to the user requirements in the application area of SIA forecasts. The aim was to create a preliminary set of user requirements that have been subjected to a preliminary expert review. It was noted that this action was compliant with a decision of a recent meeting on the infrastructure needed to support SIA forecasting.

4. The third session noted the activities during the inter-sessional period towards the development of SIA observational requirements. Based on discussions with relevant NWP centres, draft observational requirements for Seasonal and Inter-Annual Forecasts were agreed upon at the third session as shown in Appendix B. A review of the requirements contained in Appendix B is continuing.

Aeronautical Meteorology

5. The third session also recalled that at its first session it had suggested that the Commission for Aeronautical Meteorology (CAeM) should review requirements in the existing application areas that could meet its needs and consider further new requirements as necessary. The first session further suggested that such new aeronautical meteorology requirements should be quantified as to their horizontal and vertical resolutions, accuracy, observing cycles, and delay of availability.

6. The representative from CAeM at the third session noted that an interim and preliminary review of existing data requirements under Global NWP, Regional NWP, and Nowcasting & VSRF with regard to their applicability for Aeronautical Meteorology had been conducted. The Commission had found that requirements for global/regional NWP for aviation were congruent with those for general NWP and included shorter cycle times to reflect plans for an increase in the number of forecast runs per day. Higher vertical resolution of humidity, wind and temperature fields were found essential for the development and verification of turbulence and icing algorithms. The requirements for aeronautical nowcasting and meteorological watch purposes were found to include additional parameters with higher spatial and temporal resolution. These parameters include liquid water and ice content and estimates of drop size distribution for icing forecasts, cloud ceiling height and visibility for route and terminal area forecasts, wind shear in the boundary layer and high-resolution vertical profiles of wind and temperature in mountainous regions for gravity wave prediction, including information on the depth of boundary layer in complex terrain.

7. With regard to the need for volcanic ash information, the third session noted that it has grown during the past decades due to threats to the safety of flights that volcanic ash hazards have caused. The third session noted a number of issues related to volcanic ash monitoring. These included data resolution requirements, derived product specifications and observational frequencies already recommended by the Committee on Earth Observing Satellites (CEOS) Volcanic Hazards Team and endorsed by the third meeting of the ICAO Volcanic Ash Warning Study Group (VAWSG) held in Brisbane, Australia, from 2 to 5 May 2000. It was felt that although requirements for horizontal and vertical resolution in the detection of position and extent of ash cloud could be given, the estimates of required precision for the concentrations of ash and gaseous components should be regarded as preliminary.

8. The third session agreed with a draft list of observational requirements unique to aeronautical meteorology as contained in Appendix C. The third session further noted that the draft list would be reviewed by CAeM.

9. The third session also discussed the relationship between WMO user requirements for observations and cost-effective observing systems. The discussion included a cost benefit curve that illustrated the notions that (a) significant cost must be incurred before any significant benefit is derived, (b) the equal cost benefit slope should be exceeded for cost effective systems, (c) optimum cost benefit occurred before maximum requirements would be met, and (d) considerable cost could be incurred in moving from optimum cost benefit to meeting maximum user requirements. The second session felt that systems should be focused on achieving optimum and not maximum benefit such that a level representing diminishing returns at the high end of the benefit curve could be avoided (see Fig. 1).

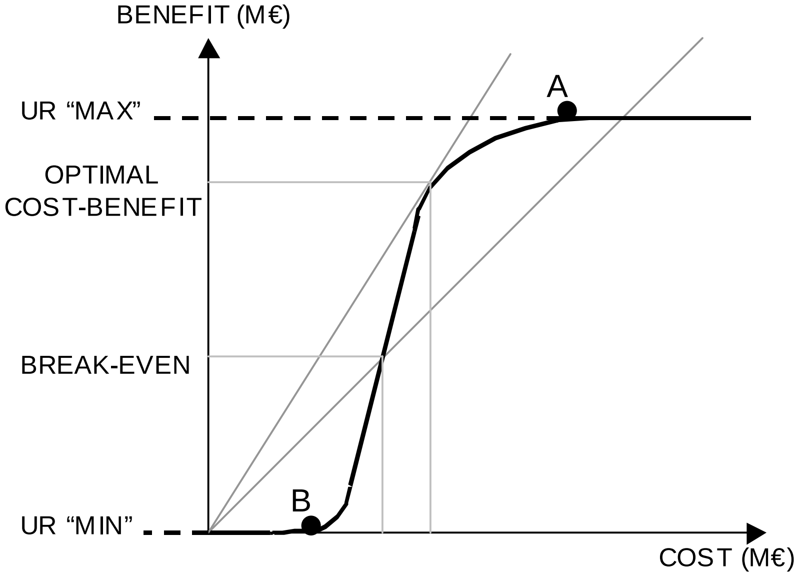

Figure 1. Cost-benefit curve for an observing system

In situ expected performances

10. The third session reviewed the process utilized during the second session in preparing expected performances for *in situ* observing systems. In order to refine the expected performances for use at the third session, it had been decided to use the results of the WMO Special MTN Monitoring (SMM) for October 1999. Additionally, an extra data-set was used to supplement the data obtained from SMM to provide more detailed buoy data.

11. The third session noted that the CEOS/WMO database was populated with expected performances derived from the WMO/SMM for each parameter measured by an observing system. Based on the new expected performances, selected Critical Review charts for each geophysical parameter in six application areas (Global NWP, Regional NWP, Atmospheric Chemistry, Hydrology, Synoptic Meteorology and Nowcasting & Very Short Range Forecasting (VSRF)) were prepared. The Critical Review charts were used in the preparation of the Statements of Guidance as discussed below.

12. The third session also noted that the last full review of user estimates of expected observational performances found in the CEOS/WMO database was performed in 1997. It proceeded, therefore, to review all user estimates of expected observing system performances as contained in the CEOS/WMO database. Changes and amendments to the database were made. The meeting also agreed that additional available data particularly from ocean areas would be included. Data describing the microwave sounder (ATMS) and multi-spectral imager (VIIRS) anticipated for NPOESS would be added when available. It was also noted that a review of the database manual was required in order to add the names, definitions and unit descriptions for geophysical parameters not contained in the database.

Statement of Guidance on Feasibility of Meeting Requirements by Satellite and *In-Situ* Systems

13. The third session reviewed draft Statements of Guidance for Global NWP, Regional NWP, Nowcasting & VSRF, and Seasonal and Inter-Annual Forecasts and made a number of proposals to improve the content of each of the Statements. Summaries of the Statements of Guidance on Global NWP, Regional NWP, Nowcasting & VSRF, Aeronautical Meteorology and Seasonal and Inter-Annual Forecasts are given in Appendix A. The third session agreed that the completed Statements of Guidance should be published as a WMO Satellite Activities Technical Document (See WMO WP-8).

Candidate Observing Systems

14. The third session recalled that it had reviewed recommendations from a Technical Conference on Integrated Upper-air Observing (Karlsruhe, September 1998) during its second session. During its second session, the Expert Team had also agreed to review, on an annual basis, a report on "Candidate Observing System Technologies and Their Use".

15. The third session reviewed the first update of the report on "Candidate Observing System Technologies and Their Use". It noted the content and comprehensiveness of the report that included sections on:

- *In situ* upper air measurements, which provided information on AMDAR and ASDAR, ASAP, GPS, radar system development, radiosonde system modernization, radiosonde substitutes, profiling systems, radio acoustic sounding systems, lidar aerosol detection and lightning detection;

- *In situ* surface measurements, including drifting buoy systems, ice buoys, moored buoys, sub-surface floats and ship based systems;

- Satellite measurements (this brief summary will be expanded); and,

- Adaptive strategies for specific events supporting NWP and the Basic Climate Monitoring Network.

16. The third session believed that the information contained in the report could benefit many potential users. It proposed a number of additions to the text to improve the homogeneity of the contents and suggested that the report also include a summary of the components of the present GOS. The updated report will be published as a WMO Technical Document in the future.

SUMMARIES OF THE STATEMENTS OF GUIDANCE ON:

- Global NWP
- Regional NWP
- Nowcasting and VSRF
- Aeronautical Meteorology
- Seasonal and inter-annual forecasts

Summary of Statement of Guidance regarding Global NWP

- Global Numerical Weather Prediction (NWP) models are used to produce short and medium-range forecasts of the state of the troposphere and lower stratosphere. Observations of the 3-D field of wind, temperature and humidity, and of surface pressure and wind are of primary importance, with a growing role for observations of other surface variables and of cloud and precipitation;

- Global NWP centres make use of the complementary strengths of *in-situ* and satellite-based observations. In the Northern Hemisphere *in-situ* data from radiosonde, aircraft and surface observations have the larger impact on forecast skill but satellite data now provide comparable benefit, particularly in the medium range; in the southern hemisphere and Tropics satellite data have the dominant impact;

- Recent enhancements in available satellite data (such as AMSU, SSM/I and scatterometer data) have shown a positive impact;

- Recent advances in 4-D data assimilation systems are allowing benefits to be derived from more frequent measurements (e.g., from geostationary satellites, aircraft and surface observations) and from measurements of cloud, precipitation and ozone;

- Global NWP centres are preparing to take advantage of data from high spectral resolution satellite sounders (such as IASI, AIRS and CrIS);

- They could also benefit from increased coverage of aircraft data, particularly from ascent/descent profiles;

- Critical atmospheric/surface variables that are not adequately measured by present or planned observing systems are:

  - wind profiles at all levels (over oceans and sparsely-inhabited areas);
  - surface pressure (over oceans and sparsely-inhabited areas);
  - snow equivalent water content;
  - precipitation; and
  - soil moisture.

- Global NWP centres can now make use of high-frequency *in situ* observations, and their availability should be extended.

Summary of Statement of Guidance regarding Regional NWP

Regional (mesoscale) NWP is motivated by a desire to provide enhanced weather services to large population centres and is aided by the availability of comprehensive observations. Oceanic areas are included in the geographical domain for regional weather prediction primarily as a buffer zone upstream from populated land areas, where accuracy is most important. Lateral boundary conditions supplied by global models eventually govern the forecast in the interior of the domain except for locally forced events.

Where observational and computational resources support regional prediction, the following is true:

- NWP centres rely rather more on surface-based and in situ observing systems than on space-based systems;

- Weather radars supply the highest resolution information, but the coverage is spatially limited, vertically and horizontally;

- Satellites supply information at high horizontal resolution; infrared sounding coverage is limited primarily by clouds;

- Accurate estimates of moisture flux are critical for good mesoscale forecasts, especially of clouds and precipitation; the forecasts thus rely heavily upon wind and humidity observations;

- Lower boundary conditions can quickly affect a mesoscale forecast; observations of screen-height temperature (2m air temperature), dew point, wind, and pressure are often good to adequate in coverage and frequency whereas observations of surface conditions, for example, soil moisture, are not;

- In many cases, mesoscale observations are not fully exploited in mesoscale prediction, e.g., radar reflectivity, cloud images, and microwave sounders;

- This is more a problem in data assimilation than in the character or distribution of the observations.

The greatest observational needs for regional prediction are:

- More comprehensive wind and moisture observations, especially in the planetary boundary layer. Enhancement of the AMDAR data collections and the addition of moisture sensors aboard aircraft are recommended. Numerous ground-based GPS receivers need only the addition of simple surface observations to be able to deliver estimates of integrated water vapour. Wind profiles are needed at closer spacing;

- More accurate and frequent measures of surface and soil properties, in that these influence surface fluxes strongly. More accurate estimates of precipitation are sorely needed.

More comprehensive observations of cloud base, cloud thickness, and other cloud properties.

Summary of Statement of Guidance regarding Nowcasting & VSRF

- Nowcasting & VSRF and VSRF consists of analyzing primarily observational data to make forecasts from 0 to a few hours. It addresses phenomena of tens of kilometres in size lifetimes from a few minutes to a few hours;

- Nowcasting & VSRF and VSRF can be applied to many phenomena including severe weather, but is most frequently used to forecast:

    - convective storms with attendant phenomena;

- mesoscale features associated with extratropical and tropical storms;
- fog and low cloud;
- locally forced precipitation events;
- sand and dust storms;

- Key Nowcasting & VSRF and VSRF parameters for which observation data are required are:

  - Clouds and precipitation;
  - Surface variables; pressure, wind, temperature, present wx, visibility and precipitation accumulation;
  - 3-D wind field;
  - 3-D humidity field;
  - 3-D temperature field;

- Well defined high spatial and temporal resolution multispectral imagery from space will provide important immediate benefit to nowcasting phenomena such area as cloud, fog and severe weather monitoring;

- While few in number, scanning weather radar (especially Doppler) provide excellent information critical to improving Nowcasting & VSRF/VSRF of convective, stratiform and local precipitation events with their attendant potential for flash flooding, tornadoes, hail, low ceilings and visibility and high winds;

- In the intermediate term, the most efficient way of improving the analysis of 3-D wind, humidity and temperature fields important for Nowcasting & VSRF/VSRF is the expansion of AMDAR equipped aircraft providing high resolution wind, humidity and temperature data;

- Doppler wind profilers have proven valuable for Nowcasting & VSRF because they provide high vertical and temporal resolution as a complement to other upper air observing systems;

- Rapid imaging (on the order of minutes) is critical for nowcasting, but it is not yet provided by all geostationary satellites. With some systems, the rapid scan for small areas competes with broader coverage;

- Reliable precipitation estimates still remain elusive, however they will benefit from continuing enhancements to satellite measurement capabilities.

Summary of Statement of Guidance regarding Aeronautical Meteorology

- For upper level temperature and wind forecasts the SOG for global NWP apply for operational forecast production, locally higher vertical resolution is required for development and verification of turbulence forecast algorithms;

- For Meteorological Watch purposes, Satellite imagery, and higher-level products such as multi-spectral images, provide good guidance for location and intensity of convection, but only scanning radars in networks combined with lightning detection systems only have the cycle times of less than 10 minutes required for air traffic control;

- For turbulence and gravity wave prediction, current *in-situ* instruments have acceptable vertical resolution, but are not available in sufficient density for all areas of the globe. AMDAR is a data source with a high potential to fill existing data gaps in the medium term;

- For forecasts and warnings in the terminal area, in-situ and ground-based remote sensor technology has the potential to meet requirements, but its high cost inhibits global availability;

- For en-route forecasts for VFR flights, ground based observations are not meeting the required data coverage except for some densely populated areas. Satellite imagery and specialised products have acceptable horizontal resolution, but lack the information on ceiling height for low cloud;

- For the detection of volcanic ash clouds and eruptions, satellite remote sensing has significantly improved the lack of information in this field. Sonic data from the CTBT agreement are being investigated as a data source for immediate detection of volcanic eruptions.

Summary of Statement of Guidance regarding Seasonal and Inter-Annual Forecasting

The following key points summarize the SIA forecast SOG. Seasonal to Inter-annual forecasts:

- Show useful skill in regions where there is clearly an atmospheric response to ocean temperature fluctuations such as the El Niño cycle;

- Require complementary atmospheric and oceanic observing systems;

- Have benefited substantially from the input of sub-surface ocean measurements in the tropics (e.g., from the TOGA buoys), and require continued sampling of temperature and salinity profiles on an operational basis;

- Will benefit from improved accuracy of sea surface temperature measurement in the tropics;

- Would benefit from the use of available satellite data on vegetation type and cover (instead of climatology), and on wind stress;

- Would benefit from continued topography measurements by altimetry;

- Require further development of assimilation schemes to accept the additional data.

In addition to those listed in the guidance statement on global NWP, the following critical parameter is likely to be measured by *in situ* sensors in the foreseeable future:

- Upper oceanic profiles of temperature and salinity.

In addition to those listed for global NWP, the critical parameters that are likely to be improved by satellite system measurements are:

- Sea surface temperature;
- Wind stress (surface);
- Ocean surface topography;
- Vegetation type and cover;
- Cryospheric (snow and ice) variables;
- Atmospheric liquid water and cloudiness.

It is important to note that the existing *in situ* measurements of these parameters have calibration and validation value, in addition to their model input value.

The key observational problems affecting improvements in seasonal to inter-annual forecasting are:

- The transition of research networks and outputs to operational status;
- The timely operational acquisition of data from research and non-governmental systems/sources.

Draft Observational Requirements for Seasonal and Inter-Annual Forecasting

22-Jun-00

Application

Requirement	Hor		Vert		Obs		Delay		Acc		Confidence	Remarks
		Res	Min	Res	Min	Cycle	Min	avail		Min		Min
S & I A												
Aerosol profile - Higher troposphere (HT)	50 km	500 km	1 km	5 km	6 h	168 h	12 h	168 h	10 %	20 %	Tentative	
Aerosol profile - Lower stratosphere (LS)	50 km	500 km	1 km	10 km	6 h	168 h	12 h	168 h	10 %	20 %	Tentative	
Aerosol profile - Lower troposphere (LT)	50 km	500 km	0.1 km	1 km	1 h	168 h	1 h	168 h	10 %	20 %	Tentative	
Aerosol profile - Total column	50 km	500 km			1 h	168 h	1 h	168 h	10 %	20 %	Tentative	
Air pressure over land surface	50 km	250 km			1 h	12 h	1 h	4 h	0.5 hPa	2 hPa	Firm	
Air pressure over sea surface	50 km	250 km			1 h	12 h	1 h	4 h	0.5 hPa	2 hPa	Firm	
Air specific humidity (at surface)	50 km	250 km			1 h	12 h	1 h	4 h	5 %	15 %	Reasonable	
Air temperature (at surface)	50 km	250 km			1 h	12 h	1 h	4 h	0.5 K	2 K	Reasonable	
Atmospheric temperature profile - Higher stratosphere & mesosphere (HS & M)	50 km	500 km	1 km	3 km	1 h	12 h	1 h	4 h	0.5 K	5 K	Reasonable	
Atmospheric temperature profile - Higher troposphere (HT)	50 km	500 km	1 km	3 km	1 h	12 h	1 h	4 h	0.5 K	3 K	Firm	
Atmospheric temperature profile - Lower stratosphere (LS)	50 km	500 km	1 km	3 km	1 h	12 h	1 h	4 h	0.5 K	3 K	Firm	
Atmospheric temperature profile - Lower troposphere (LT)	50 km	500 km	0.3 km	3 km	1 h	12 h	1 h	4 h	0.5 K	3 K	Firm	
Cloud base height	50 km	250 km			1 h	12 h	1 h	4 h	0.5 km	1 km	Tentative	
Cloud cover	50 km	250 km			1 h	12 h	1 h	4 h	5 % (Max)	20 %	Reasonable	
Cloud drop size (at cloud top)	50 km	250 km			1 h	12 h	1 h	4 h	0.5 µm	2 µm	Speculative	
Cloud ice profile - Higher troposphere (HT)	50 km	250 km	1 km	10 km	1 h	12 h	1 h	4 h	5 %	20 %	Tentative	
Cloud ice profile - Lower troposphere (LT)	50 km	250 km	0.3 km	5 km	1 h	12 h	1 h	4 h	5 %	20 %	Tentative	
Cloud ice profile - Total column	50 km	250 km			1 h	12 h	1 h	4 h	10 g/m2	20 g/m2	Tentative	
Cloud imagery	1 km	50 km			0.5 h	6 h	1 h	4 h			Firm	
Cloud top height	50 km	250 km			1 h	12 h	1 h	4 h	0.5 km	1 km	Firm	
Cloud water profile (< 100 µm) - Higher troposphere (HT)	50 km	500 km	1 km	10 km	1 h	12 h	1 h	4 h	5 %	20 %	Tentative	
Cloud water profile (< 100 µm) - Lower troposphere (LT)	50 km	500 km	0.3 km	5 km	1 h	12 h	1 h	4 h	5 %	20 %	Tentative	
Cloud water profile (< 100 µm) - Total column	50 km	500 km			1 h	4 h	1 h	4 h	10 g/m2	50 g/m2	Tentative	
Cloud water profile (> 100 µm) - Higher troposphere (HT)	50 km	500 km	1 km	10 km	1 h	12 h	1 h	4 h	5 %	20 %	Tentative	

Cloud water profile (> 100 µm) - Lower troposphere (LT)	50 km	500 km	0.3 km	5 km	1 h	12 h	1 h	4 h	5 %	20 %	Tentative		
Cloud water profile (> 100 µm) - Total column	50 km	500 km			1 h	12 h	1 h	2 h	10 g/m2	50 g/m2	Tentative		
Dominant wave direction	50 km	250 km			1 h	12 h	1 h	4 h	10 degrees	20 degrees	Firm		
Dominant wave period	50 km	250 km			1 h	12 h	1 h	4 h	0.5 s	1 s	Firm		
Fractional Photosynthetically Active Radiation (FPAR)	50 km	500 km			7 d	30 d	1 d	30 d	5 % (Max)	10 %	Firm		
Geoid		100 km	500 km			20 y	30 y	12 y	24 y	1 cm	5 cm	Firm	
Ice thickness	15 km	250 km			1 d	7 d	1 d	7 d	0.5 m	1 m	Speculative		
Land surface temperature	50 km	250 km			1 h	12 h	1 h	4 h	0.5 K	4 K	Firm		
Leaf Area Index (LAI)	50 km	100 km			7 d	30 d	1 d	7 d	5 % (Max)	20 %	Tentative		
Long-wave Earth surface emissivity	15 km	250 km			24 h	720 h	24 h	720 h	1 % (Max)	5 % (Max)	Tentative		
Normalized Differential Vegetation Index (NDVI)	50 km	100 km			7 d	30 d	1 d	7 d	1 % (Max)	5 % (Max)	Tentative		
Ocean chlorophyll	25 km	100 km			1 d	3 d	1 d	3 d	0.1 mg/m3	0.5 mg/m3	Firm		
Ocean salinity	100 km	250 km			30 d	60 d	9 d	120 d	0.1 ‰	0.3 ‰	Reasonable		
Ocean suspended sediment concentration	100 km	500 km			1 d	6 d	30 d	90 d	Missing	Missing	Speculative		
Ocean topography	25 km	100 km			7 d	30 d	2 d	15 d	1 cm	4 cm	Firm		
Ocean yellow substance	100 km	500 km			1 d	6 d	30 d	90 d	Missing	Missing	Speculative		
Outgoing long-wave radiation at TOA	50 km	250 km			1 h	1 h	240 h	720 h	5 W/m2	10 W/m2	Firm		
Outgoing short-wave radiation at TOA	50 km	250 km			1 h	6 h	240 h	360 h	5 W/m2	10 W/m2	Firm		
Ozone profile - Higher troposphere (HT)	50 km	500 km	1 km	10 km	1 h	12 h	1 h	4 h	5 %	20 %	Tentative		
Ozone profile - Lower stratosphere (LS)	50 km	500 km	1 km	10 km	1 h	12 h	1 h	4 h	5 %	20 %	Tentative		
Ozone profile - Lower troposphere (LT)	50 km	500 km	1 km	5 km	1 h	12 h	1 h	4 h	5 %	20 %	Tentative		
Ozone profile - Total column	50 km	100 km			1 h	6 h	1 h	4 h	5 DU	20 DU	Reasonable		
Precipitation index (daily cumulative)	50 km	250 km			1 h	12 h	24 h	720 h	0.5 mm/d	5 mm/d	Reasonable		
Precipitation rate at the ground (liquid)	50 km	100 km			1 h	12 h	1 h	4 h	0.1 mm/h	1 mm/h	Tentative		
Precipitation rate at the ground (solid)	50 km	100 km			1 h	12 h	1 h	4 h	0.1 mm/h	1 mm/h	Tentative		
Sea surface temperature	50 km	250 km			3 h	12 h	3 h	24 h	0.1 K	0.5 K	Firm	Tropical ocean most important	
Sea-ice cover	15 km	250 km			1 d	15 d	1 d	7 d	5 % (Max)	50 %	Firm		
Sea-ice surface temperature	15 km	200 km			1 h	7 h	1 h	4 h	0.5 K	4 K	Reasonable		
Significant wave height	100 km	250 km			1 h	12 h	1 h	4 h	0.5 m	1 m	Firm		
Snow cover		15 km	250 km			0.5 d	7 d	0.5 d	1 d	10 % (Max)		50 %	Reasonable
Snow water equivalent	50 km	500 km			1 d	7 d	1 d	7 d	5 mm	20 mm	Tentative		
Soil moisture	50 km	500 km			1 d	7 d	1 d	7 d	10 g/kg	50 g/kg	Reasonable		
Specific humidity profile - Higher troposphere	50 km	250 km	1 km	3 km	1 h	12 h	1 h	4 h	5 %	20 %	Firm	Accuracy 5% in RH	
Specific humidity profile - Lower troposphere	50 km	250 km	0.4 km	2 km	1 h	12 h	1 h	4 h	5 %	20 %	Firm	Accuracy 5% in RH	
Specific humidity profile - Total column	50 km	500 km			1 h	12 h	1 h	4 h	1 kg/m2	5 kg/m2	Firm		
Vegetation type	50 km	500 km			7 d	30 d	1 d	7 d	18 classes	9 classes	Firm		
Wind profile (horizontal component) - Higher troposphere (HT)	50 km	500 km	1 km	10 km	1 h	12 h	1 h	4 h	1 m/s	8 m/s	Firm		
Wind profile (horizontal component) - Lower stratosphere (LS)	50 km	500 km	1 km	10 km	1 h	12 h	1 h	4 h	1 m/s	5 m/s	Firm		

Wind profile (horizontal component) - Lower troposphere (LT)	50 km	500 km	0.4 km	5 km	1 h	12 h	1 h	4 h	1 m/s	5 m/s	Firm
Wind profile (vertical component) - Higher troposphere (HT)	50 km	500 km	0.5 km	10 km	1 h	12 h	1 h	4 h	1 cm/s	5 cm/s	Speculative
Wind profile (vertical component) - Lower stratosphere (LS)	50 km	500 km	0.5 km	10 km	1 h	12 h	1 h	4 h	1 cm/s	5 cm/s	Speculative
Wind profile (vertical component) - Lower troposphere (LT)	50 km	500 km	0.5 km	5 km	1 h	12 h	1 h	4 h	1 cm/s	5 cm/s	Speculative
Wind speed over land surface (horizontal)	50 km	250 km			1 h	12 h	1 h	4 h	0.5 m/s	3 m/s	Reasonable
Wind speed over sea surface (horizontal)	50 km	250 km			1 h	12 h	1 h	4 h	0.5 m/s	3 m/s	Firm
Wind vector over land surface (horizontal)	50 km	250 km			1 h	12 h	1 h	4 h	0.5 m/s	5 m/s	Reasonable
Wind vector over sea surface (horizontal)	50 km	250 km			1 h	12 h	1 h	4 h	0.5 m/s	5 m/s	Firm

New requirements to be added to the database

Ocean salinity profile (UO)	50 km	500 km	5 m	20 m	24 h	720 h	12 h	72 h	.1 PSU	.5 PSU	
Wind stress	50 km	250 km			1 h	12 h	3 h	24 h	1 %	10 %	
Ocean temperature profile (UO)	50 km	500 km	5 m	20 m	24 h	360 h	12 h	72 h	.1 K	.5 K	

Note: UO (0 – 500 metres) upper ocean

Requirements for Aeronautical Meteorology

22-Jun-00

Application

Requirement Remarks	Hor		Vert		Obs		Delay			Acc		Confidence
		Res	Min	Res	Min	Cycle	Min	avail		Min	Min	
Aero Met												
Atmospheric temperature profile - Lower convection, near troposphere (LT)	50 km	100 km	0.15		0.6 km	1 h	3 h	1 h	2 h	2 K	5 K	Firm Only in steep topography, deep inversions and jet streams
Cloud drop size (at cloud top) near	50 km	100 km			1 h	3 h	1 h	2 h	15 µm	30 µm	Firm	Only in steep topography, deep convection, inversions and jet streams
Cloud ice profile - Higher stratosphere & near mesosphere (HS & M)	50 km	100 km	0.15	0.6 km	1 h	3 h	1 h	2 h	10 %	25 %	Firm	Only in steep topography, deep convection, inversions and jet streams
Cloud ice profile - Higher troposphere (HT) near	50 km	100 km	0.15	0.6 km	1 h	3 h	1 h	2 h	10 %	25 %	Firm	Only in steep topography, deep convection, inversions and jet streams
Cloud ice profile - Lower troposphere (LT) near	50 km	100 km	0.15	0.6 km	1 h	3 h	1 h	2 h	10 %	25 %	Firm	Only in steep topography, deep convection, inversions and jet streams
Cloud water profile (< 100 µm) - Lower near troposphere (LT)	50 km	100 km	0.15	0.6 km	1 h	3 h	1 h	2 h	10 %	25 %	Firm	Only in steep topography, deep convection, inversions and jet streams
Cloud water profile (> 100 µm) - Lower near troposphere (LT)	50 km	100 km	0.15	0.6 km	1 h	3 h	1 h	2 h	10 %	25 %	Firm	Only in steep topography, deep convection, inversions and jet streams
Specific humidity profile - Lower near troposphere (LT)	50 km	100 km	0.15	0.6 km	1 h	3 h	1 h	2 h	5 %	10 %	Firm	Only in steep topography, deep convection, inversions and jet streams
Wind profile (horizontal component) - Higher near	50 km	100 km	0.15	0.6 km	0.083	0.16 h	1 h	2 h	2 m/s	5 m/s	Firm	Only in steep topography, deep convection,

troposphere (HT)										inversions and jet streams
Wind profile (horizontal component) - Lower near stratosphere (LS)	50 km	100 km	0.15	0.6 km	0.083	0.16 h 1 h	2 h	2 m/s	5 m/s	Firm	Only in steep topography, deep convection, inversions and jet streams
Wind profile (horizontal component) - Lower near troposphere (LT)	50 km	100 km	0.15	0.6 km	0.083	0.16 h 1 h	2 h	2 m/s	5 m/s	Firm	Only in steep topography, deep convection, inversions and jet streams

New requirements to be added to the database

Radar reflectivity
Doppler velocities
Visibility
Lightning detection
Ceilings
Volcanic ash
Turbulence
Icing
Gravity waves