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# REQUIREMENTS FOR OBSERVATIONAL DATA :

# THE ROLLING REVIEW OF REQUIREMENTS

It is a challenging exercise to develop a consensus view on the design and implementation of composite observing systems, in particular where the need and implementation occur on global or regional scales. The WMO Commission for Basic Systems (CBS) has encouraged the development of a process to accomplish this, as objectively as possible. The process is known as the Rolling Review of Requirements (RRR). It applies to each of the application areas covered by WMO programmes. Those currently identified are:

- Global numerical weather prediction (GNWP)
- High-resolution numerical weather prediction (HRNWP)
- Nowcasting and very short range forecasting (NVSRF)
- Seasonal and inter-annual forecasting (SIAF)
- Aeronautical meteorology
- Atmospheric chemistry
- Ocean applications
- Agricultural meteorology
- Hydrology
- Climate monitoring (as undertaken through the Global Climate Observing System, GCOS)
- Climate applications
- Space weather

In addition, requirements for WMO polar activities and the developing Global Framework for Climate Services (GFCS) are also being considered. The observational needs of the former application area "Synoptic meteorology" are now captured and reviewed along with those for NVSRF.

## 1 The Rolling Review of Requirements (RRR) process

The process jointly reviews users' evolving requirements for observations and the capabilities of existing and planned observing systems. As a result, through so-called "Statements of Guidance", experts in each application area address the extent to which the capabilities meet the requirements, and they produce gap analyses with recommendations on how these gaps could be addressed.

For each application area, the process consists of four stages:

(i) a review of *technology-free*[1] users' requirements for observations, within an area of application covered by WMO programmes and co-sponsored programmes;

(ii) a review of the observing capabilities of existing and planned observing systems, both surface- and space-based;

1 Technology-free means that the requirements do not take into account the available technology for making the observations, whether it is surface-based or space-based; they are independent of observing system capabilities as far as is possible.

(iii) a *Critical Review* of the extent to which the capabilities (ii) meet the requirements (i); and

(iv) a *Statement of Guidance* based on (iii).

The aim of the Statement of Guidance is:

- to inform WMO Members on the extent to which their requirements are met by present systems, will be met by planned systems, or would be met by proposed systems. The Statement of Guidance is essentially a gap analysis with recommendations on how to address the gaps. It also provides the means whereby Members, through the Technical Commissions, can check that their requirements have been correctly interpreted.

- to provide resource materials useful to WMO Members for dialogue with observing system agencies regarding whether existing systems should be continued or modified or discontinued, whether new systems should be planned and implemented, and whether research and development is needed to meet unfulfilled aspects of the user requirements.

The RRR process feeds information into two key documents. Based on knowledge of:

- current and planned observing systems,
- the gaps identified by the Statements of Guidance,
- which future observing systems are likely to be feasible and affordable, guidance is provided on the component observing systems to which the WMO community should aspire in:

1. the “Vision for the Global Observing System“ for the coming decade(s).

A plan to achieve this Vision is then elaborated in:

2. the Implementation Plan for the Evolution of Global Observing Systems (EGOS-IP).

These two documents are periodically revised and submitted to the CBS and the Executive Council for approval. Indeed, the whole RRR process is a rolling activity through which all documents are periodically reviewed and updated, as observational requirements change and observing technology progresses. Figure 1 indicates the anticipated interactions with observing system agencies and user groups.

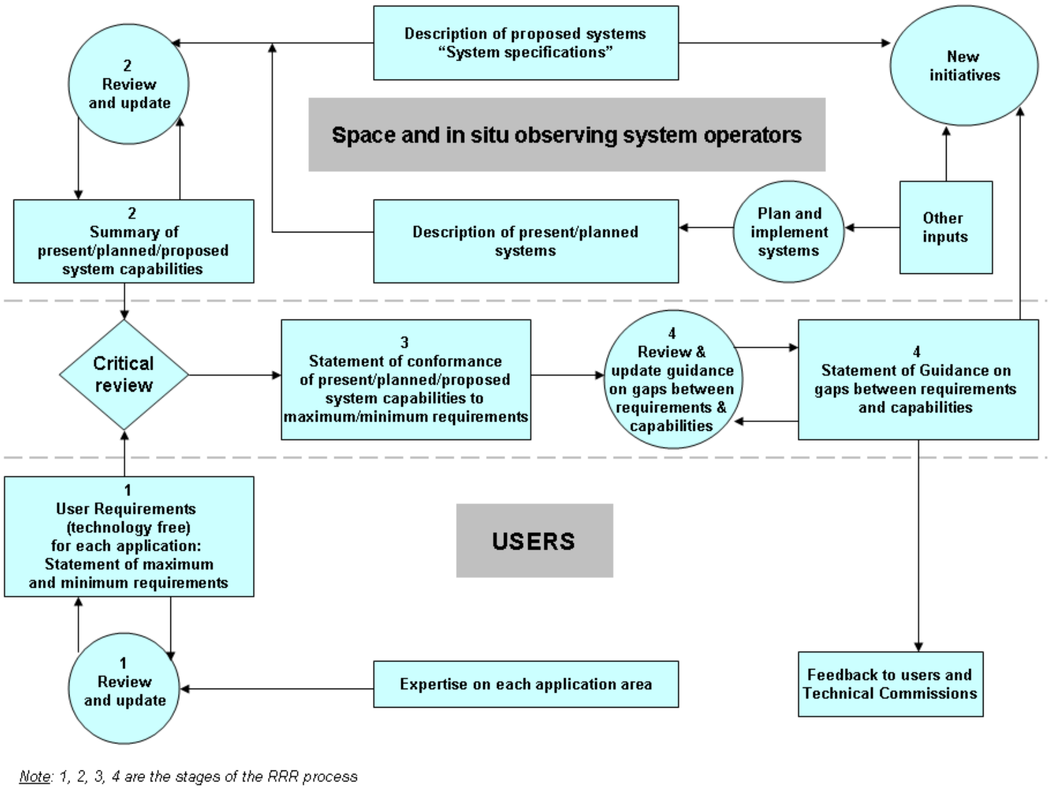


**Figure 1**: Anticipated interactions within the Rolling Review of Requirements

## 2 The Database on User Requirements and Observing System Capabilities

To facilitate the RRR process the Observing and Information Systems Department of the WMO Secretariat collects the requirements for observations to meet the needs of all WMO Programmes, and also catalogues the current and planned provision of observations. The resulting database is called the Database on User Requirements and Observing System Capabilities and is accessible via the WMO website through the Observing Systems Capability Analysis and Review Tool (OSCAR)[2]. For example, Annex I, extracted from this database, tabulates a part of the observations required currently for GNWP (more up to date requirements are available from OSCAR[2]).

### 2.1 User requirements

The user requirements are not system-dependent; they are intended to be technology-free. No consideration is given to what type of measurement characteristics, observing platforms or data processing systems are necessary (or even possible) to meet them. The requirements are aimed at the *GOS Vision*[3] time frame. The database has been constructed in the context of a given application (use). The requirements for observations are stated quantitatively in terms of five criteria, which are horizontal and vertical resolution, frequency (observation cycle), timeliness (delay in availability), and uncertainty (acceptable RMS error and any limitations on bias). For each application, there is usually no abrupt transition in the utility of an observation as its quality changes; improved observations (in terms of

2 http://www.wmo.int/oscar
3 The Vision of the GOS for the coming decade(s) is provided on the following website: http://www.wmo.int/pages/prog/www/OSY/gos-vision.html

resolution, frequency, accuracy, etc.) are usually more useful while degraded observations, although less useful, are usually not useless. Moreover, the range of utility varies from one application to another. Therefore, for each of these criteria, the requirement includes three values determined by experts: the “goal“, the “threshold“, and the “breakthrough“.

- The “goal” or “maximum requirement“ is the value above which further improvement of the observation would not cause any significant improvement in performance for the application in question. The cost of improving the observations beyond the goal would not be matched by a corresponding benefit. The goals are likely to evolve as applications progress and develop a capacity to make use of better observations.

- The “threshold” or “minimum requirement“ is the value that has to be met to ensure that data are useful. Below this minimum, the benefit derived does not compensate for the additional cost involved in using the observation. Threshold requirements for any given observing system cannot be stated in an absolute sense; assumptions have to be made concerning which other observing systems are likely to be available.

- Within the range between threshold and goal requirements, the observations become progressively more useful. The “breakthrough” is an intermediate level between “threshold” and “goal“ which, if achieved, would result in a significant improvement for the targeted application.

### 2.2 Observing system capabilities

For the capabilities of space-based observing systems, each of the contributing space agencies has provided a summary of the potential performances of their instruments, expressed in the same terms as the user requirements, together with sufficiently detailed descriptions of the instruments and missions to support evaluation of the performances. Assessment of service continuity is based on the programmatic information supplied. Particular care has been taken to establish a common language, in the form of agreed definitions for the geophysical variables for which observations are required / provided and agreed terminology to characterise requirements and performances. The space-based capabilities are accessible through the Satellite component of OSCAR[2] (i.e. OSCAR/Space).

The performance of elements of surface-based observing systems are to be characterised in a similar manner, and accessible via the Surface component of OSCAR[2] (i.e. OSCAR/Surface), taking into account their uneven distribution on a global basis. While the development of OSCAR/Space is well advanced and now operational, OSCAR/Surface is yet to be specified and implemented.

## 3 Cost-benefit considerations

User requirements are expressed in a technology-free manner, and therefore cost-free also. However, decisions on design and implementation of observing systems must take account of cost. The relationship between user requirements, as defined by the RRR process, and decisions on design and implementation of observing systems based on cost-benefit considerations is therefore important. The cost-benefit curve for a single observing system, in the context of a single application, is illustrated schematically in Figure 2 below. It is assumed that "benefit" can be estimated quantitatively and also that it can be expressed in financial terms. The cost-benefit curve has the following generic characteristics:

- A significant cost must be incurred before any significant benefit is derived. Beyond this point (B), additional cost then results in increasing benefit. However, a point (A) is reached beyond which additional cost does not bring any significant benefit;
- The "maximum" and "minimum" requirements of the CBS method map on to points A and B respectively.;
- The cost-benefit curve will (normally) first cross the line of equal cost-benefit at the "break even" point. It represents the point above which we can make a (business) case for implementing the system.
- The optimal point, representing the highest ratio of benefit to cost, is also shown.

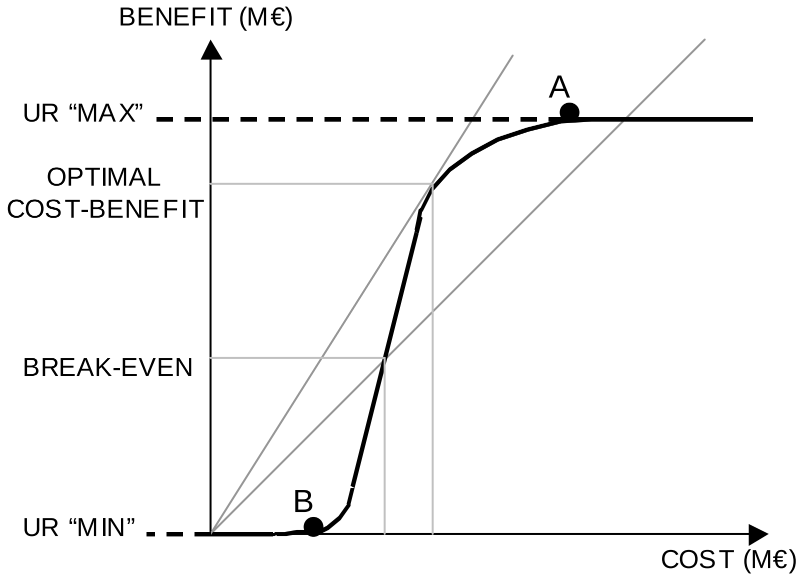


**Figure 2**. Generic cost-benefit curve for an observing system.

Note that the point of optimal cost-benefit represents a benefit (and cost) that is, in general, lower than the point of "maximum requirement". This is important; it is often assumed that we should be striving to meet the maximum requirement. Whereas this analysis shows that a system meeting "maximum" requirements is likely to deliver a level of benefit in a region of diminishing returns. Also a system's performance must exceed the "minimum" requirement before it is likely to be cost-effective.

## 3 The Critical Review

The comparison of requirements to capabilities utilizes the database. As the database changes to reflect more effectively the user requirements as well as existing and planned observing capabilities, the RRR must be performed periodically.

The process compares user requirements with the observing system capabilities and records the results in terms of the extent to which the capabilities of present, planned and proposed systems meet the stated requirements. In some cases, impact studies are conducted using Observing System Experiments (OSEs) and Observing System

Simulation Experiments (OSSEs) and other assessment tools. The critical review is a challenging process which should ideally meet the following criteria:

- The presentation must be concise and attractive, and understandable to senior managers and decision makers, whilst retaining sufficient detail to represent adequately the full range of observation requirements and observing system capabilities;

- The presentation of user requirements must be accurate; although it is necessarily a summary, it must be recognizable to experts in each application as a correct interpretation of their requirements;

- The presentation of the observing system capabilities must be accurate; although it is also a summary, it must be recognizable to expert data users as a correct interpretation of the systems' characteristics and potential;

- The results must accurately reflect the extent to which current systems are useful in practice, whilst drawing attention to those areas in which they do not meet some or all user requirements; and the process must be as objective as possible.

## 4 Statements of Guidance

The role of a Statement of Guidance (SoG) is to provide an interpretation of the output of the critical review as a gap analysis, to draw conclusions, and to identify priorities for action. The process of preparing such a statement is necessarily more subjective than that of the critical review. Moreover, whilst a review attempts to provide a comprehensive summary, a Statement of Guidance is more selective, drawing out key issues. It is at this stage that judgements are required concerning, for example, the relative importance of observations of different variables.

The following terminology has been adopted in the SoGs. "Marginal" indicates minimum user requirements are being met, "Acceptable" indicates greater than minimum but less than maximum requirements (in the useful range) are being met, and "Good" means close to maximum requirements are being met.

Since the preliminary Statements of Guidance were published in 1998, several updates and additions have been completed in order to extend the process to new application areas, to take into account the evolving nature of requirements, and to include the capabilities of surface-based sensors. The latest statements of guidance can be found on the WMO website[4].

## 5 The Vision for the GOS

The “Vision for the GOS“ provides high-level goals to guide the evolution of observing systems in the coming decades. These goals are intended to be challenging but achievable. The Vision considers that future observing systems will build upon existing sub-systems, both surface- and space-based, and capitalize on existing, new and emerging observing technologies not presently incorporated or fully exploited. Incremental additions to observing systems will be reflected in better data, products and services from the National Meteorological and Hydrological Services (NMHSs), including for developing countries and Least Developed Countries (LDCs).

4 http://www.wmo.int/pages/prog/www/OSY/GOS-RRR.html#SOG

The Vision for the GOS is proposed by the CBS following wide consultation with experts in the user and observational communities, taking into account the Statements of Guidance and foreseen technological developments, both in terms of future application areas' requirements and observational technology evolution, both surface- and space-based.

The Vision for the GOS is available from the WMO website[5].

## 6 The Implementation Plan for the Evolution of Global Observing Systems (EGOS-IP)

Responding to the Vision for the GOS and the WMO Integrated Global Observing System (WIGOS) needs, the Implementation Plan for the Evolution of Global Observing Systems (EGOS-IP) is a key document providing Members with clear and focused guidelines and recommended actions, in order to stimulate cost-effective evolution of the observing systems and to address in an integrated way the requirements of WMO programmes and co-sponsored programmes.

The EGOS-IP is produced by the CBS following wide expert review through the RRR process, looking at Statements of Guidance for all WMO Applications Areas, taking overall cost-effectiveness into account, as well as WMO priorities.

The EGOS-IP is available from the WMO website[6].

## 7 Feedback from stakeholders

The databases of user requirements and of observing system capabilities are living documents, which are regularly updated. Similarly, the Statements of Guidance are periodically reviewed and updated. Also, the progress against actions in the EGOS-IP is regularly reviewed and, when necessary, actions are revised or added.

These activities are managed within CBS, and efforts are made to involve appropriate contacts (applications experts and observing technology experts) to ensure that the information is accurate and relevant. Nevertheless, the information will only be as good as the inputs received and the extent to which the key documents of the RRR process have been reviewed by external experts and stakeholders.

CBS encourages feedback from Members, Regions, other Technical Commissions and other stakeholders. The RRR process is intended to be comprehensive, covering all application areas of WMO programmes and co-sponsored programmes. Therefore it should cover applications, whether global, regional or national. It is important that any deficienieces in this respect are reported back to CBS so that they can be considered and corrected. Members and Regions are also encouraged to adopt the concepts of the RRR process when considering observing system developments specific to their own country or region.

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5 http://www.wmo.int/pages/prog/www/OSY/gos-vision.html
6 http://www.wmo.int/pages/prog/www/OSY/gos-vision.html#egos-ip

## ANNEX I

## EXAMPLE OF USER REQUIREMENTS FROM THE WMO DATABASE[7]

### *(Global Numerical Weather Prediction – as of 22 October 2012)*

| Variable | Layer | UN[8] Goal | UN[8] BT[9] | UN[8] TH[10] | HR[11] Goal | HR[11] BT[9] | HR[11] TH[10] | VR[12] Goal | VR[12] BT[9] | VR[12] TH[10] | OC[13] Goal | OC[13] BT[9] | OC[13] TH[10] | Avail.[14] Goal | Avail.[14] BT[9] | Avail.[14] TH[10] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Accumulated precipitation (over 24 h) | Surface | 0.5 mm | 2 mm | 5 mm | 10 km | 30 km | 100 km | 0 N/A | 0 N/A | 0 N/A | 60 min | 3 h | 12 h | 24 h | 5 d | 30 d |
| Aerosol column burden | TC | 10% | 20% | 50% | 15 km | 50 km | 250 km | 0 N/A | 0 N/A | 0 N/A | 60 min | 6 h | 24 h | 6 min | 30 min | 6 h |
| Aerosol mass mixing ratio | HS&M | 10% | 20% | 50% | 15 km | 50 km | 250 km | 0.2 km | 3 km | 3 km | 60 min | 6 h | 24 h | 6 min | 30 min | 6 h |
| Aerosol mass mixing ratio | HT | 10% | 20% | 50% | 15 km | 50 km | 250 km | 0.2 km | 3 km | 3 km | 60 min | 6 h | 24 h | 6 min | 30 min | 6 h |
| Aerosol mass mixing ratio | LS | 10% | 20% | 50% | 15 km | 50 km | 250 km | 0.2 km | 3 km | 3 km | 60 min | 6 h | 24 h | 6 min | 30 min | 6 h |

7 Please go to the database at http://www.wmo.int/oscar for more up to date user requirements
8 UN: Uncertainty
9 BT: Breakthrough
10 TH: Threshold
11 HR: Horizontal Resolution
12 VR: Vertical Resolution
13 OC: Observing Cycle
14 Avail: Availability (i.e. data timeliness, delay after observation)

| Variable | Layer | UN[8] Goal | UN[8] BT[9] | UN[8] TH[10] | HR[11] Goal | HR[11] BT[9] | HR[11] TH[10] | VR[12] Goal | VR[12] BT[9] | VR[12] TH[10] | OC[13] Goal | OC[13] BT[9] | OC[13] TH[10] | Avail.[14] Goal | Avail.[14] BT[9] | Avail.[14] TH[10] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aerosol mass mixing ratio | LT | 10% | 20% | 50% | 15 km | 50 km | 250 km | 0.2 km | 3 km | 3 km | 60 min | 6 h | 24 h | 6 min | 30 min | 6 h |
| Air pressure (at surface) | Over land | 0.5 hPa | 1 hPa | 1 hPa | 15 km | 100 km | 500 km | 0 N/A | 0 N/A | 0 N/A | 60 min | 6 h | 12 h | 6 min | 30 min | 6 h |
| Air pressure (at surface) | Over sea | 0.5 hPa | 1 hPa | 1 hPa | 15 km | 100 km | 500 km | 0 N/A | 0 N/A | 0 N/A | 60 min | 6 h | 12 h | 6 min | 30 min | 6 h |
| Air specific humidity (at surface) | Surface | 2% | 5% | 10% | 15 km | 50 km | 250 km | 0 N/A | 0 N/A | 0 N/A | 60 min | 3 h | 12 h | 6 min | 30 min | 6 h |
| Air temperature (at surface) | Surface | 0.5 K | 1 K | 2 K | 15 km | 50 km | 250 km | 0 N/A | 0 N/A | 0 N/A | 60 min | 6 h | 12 h | 6 min | 30 min | 6 h |
| Atmospheric temperature | HS&M | 0.5 K | 3 K | 5 K | 50 km | 100 km | 500 km | 0.3 km | 1 km | 3 km | 60 min | 6 h | 24 h | 6 min | 30 min | 6 h |
| Atmospheric temperature | HT | 0.5 K | 1 K | 3 K | 15 km | 100 km | 500 km | 0.3 km | 1 km | 3 km | 60 min | 6 h | 24 h | 6 min | 30 min | 6 h |
| Atmospheric temperature | LS | 0.5 K | 1 K | 3 K | 15 km | 100 km | 500 km | 0.3 km | 1 km | 3 km | 60 min | 6 h | 24 h | 6 min | 30 min | 6 h |
| Atmospheric temperature | LT | 0.5 K | 1 K | 3 K | 15 km | 100 km | 500 km | 0.3 km | 1 km | 3 km | 60 min | 6 h | 24 h | 6 min | 30 min | 6 h |
| Cloud base height | 2D | 0.2 km | 0.5 km | 1 km | 5 km | 15 km | 50 km | 0 N/A | 0 N/A | 0 N/A | 60 min | 3 h | 12 h | 6 min | 30 min | 6 h |

| Variable | Layer | UN[8] Goal | UN[8] BT[9] | UN[8] TH[10] | HR[11] Goal | HR[11] BT[9] | HR[11] TH[10] | VR[12] Goal | VR[12] BT[9] | VR[12] TH[10] | OC[13] Goal | OC[13] BT[9] | OC[13] TH[10] | Avail.[14] Goal | Avail.[14] BT[9] | Avail.[14] TH[10] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cloud cover | TC | 5% | 10% | 20% | 5 km | 15 km | 50 km | 0 N/A | 0 N/A | 0 N/A | 60 min | 3 h | 12 h | 6 min | 30 min | 6 h |
| Cloud drop effective radius | Cloud-top | 1 N/A | 2 N/A | 5 N/A | 5 km | 15 km | 50 km | 0 N/A | 0 N/A | 0 N/A | 60 min | 3 h | 12 h | 6 min | 30 min | 6 h |
| Cloud ice | HT | 20% | 50% | 100% | 5 km | 15 km | 50 km | 0.2 km | 1 km | 2 km | 60 min | 3 h | 12 h | 6 min | 30 min | 6 h |
| Cloud ice | LT | 20% | 50% | 100% | 5 km | 15 km | 50 km | 0.2 km | 1 km | 2 km | 60 min | 3 h | 12 h | 6 min | 30 min | 6 h |
| Cloud ice (total column) | TC | 5 $g/m^2$ | 10 $g/m^2$ | 20 $g/m^2$ | 5 km | 15 km | 50 km | 0 N/A | 0 N/A | 0 N/A | 60 min | 3 h | 12 h | 6 min | 30 min | 6 h |
| Cloud liquid water | HT | 20% | 50% | 100% | 5 km | 15 km | 50 km | 0.2 km | 1 km | 2 km | 60 min | 3 h | 12 h | 6 min | 30 min | 6 h |
| Cloud liquid water | LT | 20% | 50% | 100% | 5 km | 15 km | 50 km | 0.2 km | 1 km | 2 km | 60 min | 3 h | 12 h | 6 min | 30 min | 6 h |
| Cloud liquid water (total column) | TC | 10 $kg/m^2$ | 20 $kg/m^2$ | 50 $kg/m^2$ | 5 km | 15 km | 50 km | 0 N/A | 0 N/A | 0 N/A | 60 min | 3 h | 12 h | 6 min | 30 min | 6 h |
| Cloud top height | 2D | 0.2 km | 0.5 km | 1 km | 5 km | 15 km | 50 km | 0 N/A | 0 N/A | 0 N/A | 60 min | 3 h | 12 h | 6 min | 30 min | 6 h |
| Cloud type | 2D | 0 Class | 0 Class | 0 Class | 0.99 km | 1 km | 5 km | 0 N/A | 0 N/A | 0 N/A | 60 min | 3 h | 12 h | 6 min | 30 min | 6 h |

| Variable | Layer | UN[8] Goal | UN[8] BT[9] | UN[8] TH[10] | HR[11] Goal | HR[11] BT[9] | HR[11] TH[10] | VR[12] Goal | VR[12] BT[9] | VR[12] TH[10] | OC[13] Goal | OC[13] BT[9] | OC[13] TH[10] | Avail.[14] Goal | Avail.[14] BT[9] | Avail.[14] TH[10] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | es $^{-1}$ | es $^{-1}$ | es $^{-1}$ | | | | | | | | | | | | |
| Dominant wave direction | Surf-sea | 10 degrees | 15 degrees | 30 degrees | 15 km | 50 km | 250 km | 0 N/A | 0 N/A | 0 N/A | 60 min | 3 h | 12 h | 6 min | 30 min | 6 h |
| Dominant wave period | Surf-sea | 0.25 s | 0.5 s | 1 s | 15 km | 50 km | 250 km | 0 N/A | 0 N/A | 0 N/A | 60 min | 3 h | 12 h | 6 min | 30 min | 6 h |
| Downward short-wave irradiance at Earth surface | Surface | 1 W/m² | 10 W/m² | 20 W/m² | 10 km | 30 km | 100 km | 0 N/A | 0 N/A | 0 N/A | 60 min | 3 h | 12 h | 24 h | 5 d | 30 d |
| Downward long-wave irradiance at Earth surface | Surface | 1 W/m² | 10 W/m² | 20 W/m² | 10 km | 30 km | 100 km | 0 N/A | 0 N/A | 0 N/A | 60 min | 3 h | 12 h | 24 h | 5 d | 30 d |
| Earth surface short-wave bidirectional reflectance | Surface | 1 % | 2 % | 5 % | 10 km | 30 km | 100 km | 0 N/A | 0 N/A | 0 N/A | 60 min | 3 h | 12 h | 24 h | 5 d | 30 d |
| Fraction of Absorbed PAR (FAPAR) | Surf-land | 5% | 10% | 20% | 2 km | 10 km | 50 km | 0 N/A | 0 N/A | 0 N/A | 24 h | 5 d | 10 d | 3 h | 24 h | 10 d |
| Land surface temperature | Surf-land | 0.5 K | 1 K | 4 K | 5 km | 15 km | 250 km | 0 N/A | 0 N/A | 0 N/A | 30 min | 3 h | 6 h | 6 min | 30 min | 6 h |
| Leaf Area Index (LAI) | Surf- | 5% | 10% | 20% | 2 km | 10 | 50 | 0 N/A | 0 N/A | 0 N/A | 24 h | 5 d | 10 d | 3 h | 24 h | 10 d |

| Variable | Layer | UN[8] Goal | UN[8] BT[9] | UN[8] TH[10] | HR[11] Goal | HR[11] BT[9] | HR[11] TH[10] | VR[12] Goal | VR[12] BT[9] | VR[12] TH[10] | OC[13] Goal | OC[13] BT[9] | OC[13] TH[10] | Avail.[14] Goal | Avail.[14] BT[9] | Avail.[14] TH[10] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | land | | | | | km | km | | | | | | | | | |
| Long-wave Earth surface emissivity | Surf-land | 0.50 % | 1% | 3% | 5 km | 15 km | 50 km | 0 N/A | 0 N/A | 0 N/A | 24 h | 5 d | 30 d | 24 h | 5 d | 30 d |
| Normalised Difference Vegetation Index (NDVI) | Surf-land | 5% | 10% | 20% | 2 km | 10 km | 50 km | 0 N/A | 0 N/A | 0 N/A | 24 h | 5 d | 10 d | 3 h | 24 h | 10 d |
| O3 | HS&M | 5% | 10% | 20% | 15 km | 100 km | 250 km | 1 km | 3 km | 10 km | 60 min | 6 h | 12 h | 6 min | 30 min | 6 h |
| O3 | HT | 5% | 10% | 20% | 15 km | 100 km | 250 km | 1 km | 2.2 km | 10 km | 60 min | 6 h | 12 h | 6 min | 30 min | 6 h |
| O3 | LS | 5% | 10% | 20% | 15 km | 100 km | 250 km | 1 km | 2.2 km | 10 km | 60 min | 6 h | 12 h | 6 min | 30 min | 6 h |
| O3 | LT | 5% | 10% | 20% | 15 km | 100 km | 250 km | 1 km | 2.2 km | 10 km | 60 min | 6 h | 12 h | 6 min | 30 min | 6 h |
| O3 (Total column) | TC | 5 DU | 10 DU | 20 DU | 15 km | 100 km | 250 km | 0 N/A | 0 N/A | 0 N/A | 60 min | 6 h | 12 h | 6 min | 30 min | 6 h |
| Ocean salinity | Upper oc | 0.1 psu | 0.2 psu | 0.3 psu | 5 km | 100 km | 250 km | 1 m | 2 m | 10 m | 24 h | 30 d | 60 d | 3 h | 24 h | 5 d |
| Ocean temperature | Upper oc | 0.3 K | 0.5 K | 1 K | 5 km | 100 km | 250 km | 1 m | 2 m | 10 m | 24 h | 2 d | 30 d | 3 h | 24 h | 5 d |

| Variable | Layer | UN[8] Goal | UN[8] BT[9] | UN[8] TH[10] | HR[11] Goal | HR[11] BT[9] | HR[11] TH[10] | VR[12] Goal | VR[12] BT[9] | VR[12] TH[10] | OC[13] Goal | OC[13] BT[9] | OC[13] TH[10] | Avail.[14] Goal | Avail.[14] BT[9] | Avail.[14] TH[10] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Precipitation intensity at surface (liquid or solid) | Surface | 0.1 mm/h | 0.5 mm/h | 1 mm/h | 5 km | 15 km | 50 km | 0 N/A | 0 N/A | 0 N/A | 60 min | 3 h | 12 h | 6 min | 30 min | 6 h |
| Precipitation intensity at surface (solid) | Surface | 0.1 mm/h | 0.5 mm/h | 1 mm/h | 5 km | 15 km | 50 km | 0 N/A | 0 N/A | 0 N/A | 60 min | 3 h | 12 h | 6 min | 30 min | 6 h |
| Sea surface salinity | Surf-sea | 0.1 psu | 0.2 psu | 0.3 psu | 5 km | 100 km | 250 km | 0 N/A | 0 N/A | 0 N/A | 24 h | 30 d | 60 d | 3 d | 24 d | 120 d |
| Sea surface temperature | Surf-sea | 0.3 K | 0.5 K | 1 K | 5 km | 15 km | 250 km | 0 N/A | 0 N/A | 0 N/A | 3 h | 24 h | 5 d | 3 h | 24 h | 5 d |
| Sea-ice cover | Surf-sea | 5% | 10% | 20% | 5 km | 15 km | 100 km | 0 N/A | 0 N/A | 0 N/A | 3 h | 24 h | 5 d | 3 h | 24 h | 5 d |
| Sea-ice surface temperature | Surf-sea | 0.5 K | 1 K | 4 K | 5 km | 15 km | 250 km | 0 N/A | 0 N/A | 0 N/A | 60 min | 3 h | 12 h | 6 min | 30 min | 6 h |
| Sea-ice thickness | Surf-sea | 20 cm | 50 cm | 100 cm | 15 km | 50 km | 250 km | 0 N/A | 0 N/A | 0 N/A | 24 h | 5 d | 30 d | 24 h | 5 d | 30 d |
| Sea-ice type | Surf-sea | 0.25 Classes $^{-1}$ | 0.333 Classes $^{-1}$ | 0.5 Classes $^{-1}$ | 10 km | 25 km | 100 km | 0 N/A | 0 N/A | 0 N/A | 3 h | 24 h | 5 d | 3 h | 24 h | 5 d |
| Short-wave cloud reflectance | Cloud-top | 1% | 3% | 10% | 10 km | 30 km | 100 km | 0 N/A | 0 N/A | 0 N/A | 60 min | 3 h | 12 h | 24 h | 5 d | 30 d |

| Variable | Layer | UN[8] Goal | UN[8] BT[9] | UN[8] TH[10] | HR[11] Goal | HR[11] BT[9] | HR[11] TH[10] | VR[12] Goal | VR[12] BT[9] | VR[12] TH[10] | OC[13] Goal | OC[13] BT[9] | OC[13] TH[10] | Avail.[14] Goal | Avail.[14] BT[9] | Avail.[14] TH[10] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Significant wave height | Surf-sea | 0.1 m | 0.3 m | 0.5 m | 15 km | 50 km | 250 km | 0 N/A | 0 N/A | 0 N/A | 60 min | 3 h | 12 h | 6 min | 30 min | 6 h |
| Snow cover | Surf-land | 10% | 20% | 50% | 5 km | 15 km | 100 km | 0 N/A | 0 N/A | 0 N/A | 3 h | 24 h | 5 d | 3 h | 24 h | 5 d |
| Snow water equivalent | Surf-land | 2 mm | 10 mm | 20 mm | 5 km | 15 km | 100 km | 0 N/A | 0 N/A | 0 N/A | 3 h | 24 h | 5 d | 3 h | 24 h | 5 d |
| Soil moisture at surface | Surf-land | 0.01 $m^3/m^3$ | 0.02 $m^3/m^3$ | 0.05 $m^3/m^3$ | 5 km | 15 km | 100 km | 0 N/A | 0 N/A | 0 N/A | 3 h | 24 h | 5 d | 3 h | 24 h | 5 d |
| Specific humidity | HT | 2% | 5% | 10% | 15 km | 50 km | 250 km | 0.5 km | 1 km | 3 km | 60 min | 6 h | 12 h | 6 min | 30 min | 6 h |
| Specific humidity | LT | 2% | 5% | 10% | 15 km | 50 km | 250 km | 0.3 km | 1 km | 3 km | 60 min | 6 h | 12 h | 6 min | 30 min | 6 h |
| Specific humidity (Total Column) | TC | 1 $kg/m^2$ | 2 $kg/m^2$ | 5 $kg/m^2$ | 15 km | 50 km | 250 km | 0 N/A | 0 N/A | 0 N/A | 60 min | 6 h | 12 h | 6 min | 30 min | 6 h |
| Upward short-wave irradiance at TOA | TOA | 5 $W/m^2$ | 10 $W/m^2$ | 20 $W/m^2$ | 10 km | 30 km | 100 km | 0 N/A | 0 N/A | 0 N/A | 60 min | 3 h | 12 h | 24 h | 5 d | 30 d |
| Upward spectral radiance at TOA | TOA | 0.05 $SNR^{-1}$ | 0.1 $SNR^{-1}$ | 0.2 $SNR^{-1}$ | 10 km | 30 km | 100 km | 0 N/A | 0 N/A | 0 N/A | 5.8 min | 18 min | 5 d | 24 h | 5 d | 30 d |
| Upward long-wave irradiance at TOA | TOA | 5 $W/m^2$ | 10 $W/m^2$ | 20 $W/m^2$ | 10 km | 30 km | 100 km | 0 N/A | 0 N/A | 0 N/A | 60 min | 3 h | 12 h | 24 h | 5 d | 30 d |

| Variable | Layer | UN[8] Goal | UN[8] BT[9] | UN[8] TH[10] | HR[11] Goal | HR[11] BT[9] | HR[11] TH[10] | VR[12] Goal | VR[12] BT[9] | VR[12] TH[10] | OC[13] Goal | OC[13] BT[9] | OC[13] TH[10] | Avail.[14] Goal | Avail.[14] BT[9] | Avail.[14] TH[10] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Upward long-wave irradiance at Earth surface | Surface | 1 W/m² | 10 W/m² | 20 W/m² | 10 km | 30 km | 100 km | 0 N/A | 0 N/A | 0 N/A | 60 min | 3 h | 12 h | 24 h | 5 d | 30 d |
| Vegetation type | Surf-land | 0.055 Classes -1 | 0.08 Classes -1 | 0.11 Classes -1 | 2000 m | 10000 m | 50000 m | 0 N/A | 0 N/A | 0 N/A | 7 d | 15 d | 30 d | 24 h | 2 d | 7 d |
| Wind (horizontal) | HS&M | 1 m/s | 5 m/s | 10 m/s | 50 km | 100 km | 500 km | 1 km | 2 km | 3 km | 60 min | 6 h | 12 h | 6 min | 30 min | 6 h |
| Wind (horizontal) | HT | 1 m/s | 3 m/s | 8 m/s | 15 km | 100 km | 500 km | 0.5 km | 1 km | 3 km | 60 min | 6 h | 12 h | 6 min | 30 min | 6 h |
| Wind (horizontal) | LS | 1 m/s | 3 m/s | 5 m/s | 15 km | 100 km | 500 km | 0.5 km | 1 km | 3 km | 60 min | 6 h | 12 h | 6 min | 30 min | 6 h |
| Wind (horizontal) | LT | 1 m/s | 3 m/s | 5 m/s | 15 km | 100 km | 500 km | 0.5 km | 1 km | 3 km | 60 min | 6 h | 12 h | 6 min | 30 min | 6 h |
| Wind (vertical) | HS&M | 1 cm/s | 5 cm/s | 5 cm/s | 15 km | 200 km | 500 km | 0.5 km | 2 km | 3 km | 60 min | 6 h | 12 h | 6 min | 30 min | 6 h |
| Wind (vertical) | HT | 1 cm/s | 5 cm/s | 5 cm/s | 15 km | 200 km | 500 km | 0.5 km | 2 km | 3 km | 60 min | 6 h | 12 h | 6 min | 30 min | 6 h |
| Wind (vertical) | LS | 1 cm/s | 5 cm/s | 5 cm/s | 15 km | 200 km | 500 km | 0.5 km | 2 km | 3 km | 60 min | 6 h | 12 h | 6 min | 30 min | 6 h |

| Variable | Layer | UN[8] Goal | UN[8] BT[9] | UN[8] TH[10] | HR[11] Goal | HR[11] BT[9] | HR[11] TH[10] | VR[12] Goal | VR[12] BT[9] | VR[12] TH[10] | OC[13] Goal | OC[13] BT[9] | OC[13] TH[10] | Avail.[14] Goal | Avail.[14] BT[9] | Avail.[14] TH[10] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wind (vertical) | LT | 1 cm/s | 5 cm/s | 5 cm/s | 15 km | 200 km | 500 km | 0.5 km | 2 km | 3 km | 60 min | 6 h | 12 h | 6 min | 30 min | 6 h |
| Wind speed over the surface (horizontal) | Over land | 0.5 m/s | 1.5 m/s | 2 m/s | 15 km | 100 km | 250 km | 0 N/A | 0 N/A | 0 N/A | 60 min | 6 h | 12 h | 6 min | 30 min | 6 h |
| Wind speed over the surface (horizontal) | Over sea | 0.5 m/s | 1.5 m/s | 2 m/s | 15 km | 100 km | 250 km | 0 N/A | 0 N/A | 0 N/A | 60 min | 6 h | 12 h | 6 min | 30 min | 6 h |
| Wind vector over the surface (horizontal) | Over land | 0.5 m/s | 2 m/s | 3 m/s | 15 km | 100 km | 250 km | 0 N/A | 0 N/A | 0 N/A | 60 min | 6 h | 12 h | 6 min | 30 min | 6 h |
| Wind vector over the surface (horizontal) | Over sea | 0.5 m/s | 2 m/s | 3 m/s | 15 km | 100 km | 250 km | 0 N/A | 0 N/A | 0 N/A | 60 min | 6 h | 12 h | 6 min | 30 min | 6 h |

## ANNEX II

## ACRONYMS

| | |
|---|---|
| CBS | Commission for Basic Systems (WMO) |
| EGOS-IP | Implementation Plan for the Evolution of Global Observing Systems |
| GCOS | Global Climate Observing System (WMO, IOC, UNEP, ICSU) |
| GFCS | Global Framework for Climate Services |
| GNWP | Global Numerical Weather Prediction |
| GOS | Global Observing System (WMO) |
| HRNWP | High-resolution numerical weather prediction |
| ICSU | International Council for Science |
| IOC | Intergovernmental Oceanographic Commission of UNESCO |
| LCD | Least Developped Country |
| NMHS | National Meteorological and Hydrological Service |
| NVSRF | Nowcasting and Very Short Range Forecasting |
| OSCAR | Observing Systems Capability Analysis and Review Tool |
| OSE | Observing System Experiment |
| OSSE | Observing System Simulation Experiment |
| RMS | Root Mean Square |
| RRR | Rolling Review of Requirements |
| SIAF | Seasonal and Inter-Annual Forecasting |
| SoG | Statement of Guidance |
| UN | United Nations |
| UNEP | UN Environment Programme |
| UNESCO | UN Educational, Scientific and Cultural Organization |
| WIGOS | WMO Integrated Global Observing System |
| WMO | World Meteorological Organization |