Global NWP Statement of Guidance for the EUCOS region

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In 2018, WMO completed a rolling requirement review (RRR) process for Global NWP which delivered: 1) an updated record of user requirements listed in the WMO's Observing Systems Capability Analysis and Review database (OSCAR database); 2) a critical analysis to assess the gaps by comparing capabilities versus requirements, a workshop in 2016 on Impact Studies (Global NWP session chaired by John Eyre from Met Office and Carla Cardinali then ECMWF; 3) and finally an analysis (led by Erik Anderson, then ECMWF and chair of Obs-SET) to produce a gap analysis and a Statements of Guidance (SoG) for WMO for the Global NWP Application Area. This SoG was developed to guide the evolution of networks (both ground-based and space-based) on a global scale and therefore does not necessarily represent the priorities for EUMETNET members for the EUCOS region. Following on from this WMO RRR process, the EUMETNET Observations Programme led a similar exercise in collaboration with the EUMETNET Observation Programme Science Expert Team (Obs-SET) to develop a SoG for Global NWP for the EUCOS region.

The SoG captures the most important observation gaps that users wish to be addressed in order to help tackle some high priority challenges in NMHS's service delivery. The SoG does not provide a record of all user requirements; these are documented in the WMO OSCAR database which has been used to inform the SoG. The consensus view from Global NWP is that the EUCOS region is the best observed region on a global scale; nevertheless, the EUCOS and NMHS observing networks are not currently fulfilling Global NWP requirements, with significant weakness particularly but not limited to oceans regions. The starting assumption for this SoG is that existing networks should be maintained, forming the basis on which enhanced capabilities are introduced in an optimal manner to enhance the overall performance of composite network over the EUCOS region.

EUMETNET Global NWP community includes DWD, ECMWF, Meteo-France, and the UK Met Office. Most of these global centres produce short- and medium range weather forecasts (1-15 days), typically at a horizontal resolution between 9-15km, at a vertical resolution 50-100m in the boundary layer and 0.5–2km in the stratosphere. Ensembles are commonly used to derive estimates of uncertainty for analyses and forecasts. Forecasters use NWP output as guidance to issue forecasts. Ensemble system output is used to predict the uncertainty of the forecast, often with special emphasis on the risk of extremes/severe weather events. All four EUMETMET Global NWP centres are also using ensembles to estimate flow dependent background errors in the data assimilation process. The ensembles represent the model uncertainties, and the observation uncertainties for analyses ensembles. Finally, Global NWP models also provide boundary conditions for a variety of regional limited area models. The boundaries transfer important information from model fields and observations outside the area.

In general, all Global NWP centres report that adding more observations to the assimilation almost always lead to a positive impact on the forecast skill, either due to improvement in the quality or quantity of observations or to improvement of the assimilation process. The highest impact observational dataset to Global NWP are primarily provided by satellite systems but also include radiosonde and aircraft as part of the observing systems contributing most to positive impact on the forecast skill.

Obs-SET Members identified the top 5 Global NWP challenges within the EUCOS region relating in part to gaps in EUCOS networks currently are (in order or priorities):

- Forecast of sudden deepening and heavy precipitation associated with Tropical cyclones in the Caribbean and ex-tropical storms reaching Europe: Lack of wind profile observations in the Tropics
- Forecast of strong cyclogenesis and associated high impact weather systems: Lack of humidity profiles or IWV (Integrated Water Vapour) data to observe atmospheric rivers (large scale driver of heavy precipitation and local intensification of wind gusts). Note also that IWV have lower information content and pose more challenges for assimilation than humidity profiles.
- The large scale drops of forecast skill, typically at 7 – 9 days: it is unclear if this is due to lack of observations or issues with the assimilation of the data or the quality of the forecast model. However, experience suggests that loss of forecast skills is often due to lack of observations to describe the initial conditions accurately enough. Forecast errors over Europe can often be traced back to the baroclinic regions in the North Atlantic and North Pacific, and to the Arctic region (particularly in the winter) where there is a severe lack of in-situ observations. Severe convective events over North America are also difficult to analyse and forecast, primarily due to model errors. These deficiencies are affecting Global NWP's ability to forecast the beginning and the end of blocking situations for example. In addition, the position of the jet stream can be affected by the lack of snow cover/depth observations that play an important role in determining the model surface temperatures, leading to significant errors in the global circulation prediction.
- The need to maintain and increase the number of high-precision, 'anchor' observations: an increase in the volume of (bias corrected non-anchored) observations available for assimilation risks impacting the overall balance of the global observing system. The lack of available unbiased observations to anchor satellite data is limiting the best use of this increasing data source; globally radiosonde observations are too few in number, particularly over the ocean, to ensure anchoring. GPS radio occultations provide an important anchor observing system.
- The increasing resolution of Global NWP to 5km (during the next decade) will drive higher resolution observation requirements – Short-Range NWP observation requirements today will become Global NWP requirement tomorrow.

Based on these Global NWP challenges and the observation gaps, the following statements were selected and prioritised to guide the evolution of the EUCOS networks; Global NWP centres would benefit from increased:

- wind profiles at all levels, particularly in the Tropics via increasing the number of vessels included in E-ASAP and via increasing the number of ascent and descent reported from aircraft via E-AOB in tropical regions. Note: the ESA Earth Explorer Aeolus mission is providing (yet uncalibrated) wind profiles from space, but likely only until mid-2021;
- humidity profiles at all levels over Europe and surrounding seas via a hybrid network comprised of a range of technology or techniques at various level of maturity (e.g. radiosonde, AMDAR, Raman or DIAL lidar, ZTD from GNSS, weather radar refractivity, microwave radiometer…etc). R&D studies (i.e. instrumental trials and

impact studies) are required to understand the optimum synergy between these technologies in order to deliver a cost-effective network for humidity profiling;

- in-situ surface observations off-shore from North America and in the Arctic region via additional deployment of buoys in those areas, ideally through collaboration with other international organisations;
- snow cover and depth via enhancing best practice to report these variables through-out the EUCOS regions and via identifying and filling the gaps in this observing capability;
- enhancing the provision of unbiased observations to anchor satellite data via identifying why aircraft temperature measurements are biased and try to improve the measurement practices for meteorological instrumentation, first on a selected number of long-haul aircraft.

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