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ROLLING REVIEW OF REQUIREMENTS AND STATEMENTS OF GUIDANCE

STATEMENTS OF GUIDANCE

SEASONAL & INTER-ANNUAL FORECASTING (SIAF)

(Submitted by Laura Ferranti (ECMWF))

SUMMARY AND PURPOSE OF DOCUMENT

The document provides detailed information on the current status of the Statement of Guidance for Seasonal and Inter-Annual Forecasting (SIAF)

ACTION PROPOSED

The Meeting is invited to note the information contained in this document when discussing how it organises its work and formulates its recommendations.

References: Current versions of the Statements of Guidance
http://www.wmo.int/pages/prog/www/OSY/GOS-RRR.html#SOG

Appendix: **A.** Statement of Guidance for Sub-Seasonal to longer predictions

DISCUSSION

The meeting of the CBS/CCl Expert Team on Operational Predictions from Sub-Seasonal to Longer-Time Scales (ET-OPSLS), which took place in Exeter from 10 to 14 March 2014, discussed the SoG for Seasonal and Inter-Annual Forecast (SIAF) and :

- Expressed the interest of adding an additional paragraph to deal with the observational needs for decadal predictions. If accepted by IPET-OSDE, this will be provided by Dr. Richard Graham (Met. Office., United Kingdom);
- Proposed also to change the name of the Application Area from *“Seasonal and Inter-annual Forecasting (SIAF)”* to *“Sub-Seasonal to longer time scale predictions”* in order to better reflect the content of the SoG since it now includes observational needs for sub-seasonal to longer time scale predictions;
- Proposed that Dr. Yuhei Takaya (Japan) should take over the responsibility of maintaining the SoG on behalf of the ET-OPSLS;
- Discussed and approved the version of the Statement of Guidance provided in Appendix A

APPENDIX A

STATEMENT OF GUIDANCE FOR SUB-SEASONAL TO LONGER PREDICTIONS

(Point of contact: Laura Ferranti, ECMWF)
(Version updated 16 March 2014 by the PoC, and approved by CBS/CCI/ET-OPSLS March 2014)

1. Introduction

The physical basis for seasonal and inter-annual climate prediction lies in components of climate that vary slowly compared with individual weather events, i.e. ocean and land surface (including cryospheric components). The ENSO (El Nino Southern Oscillation) cycle is the most relevant phenomenon with predictability on the seasonal time-scale. ENSO consists of a coherent, large-scale fluctuation of ocean temperatures, rainfall, and atmospheric circulation across the tropical Pacific. It is a coupled ocean-atmosphere phenomenon centred over the tropical Pacific but the scale of the fluctuations is quite vast, with changes in sea-surface temperatures (SSTs), tropical rainfall and winds spanning a distance of more than one-half the circumference of the earth. ENSO represents the dominant source of predictive skill for any seasonal to inter-annual forecasts. It follows that in order to predict seasonal climate by dynamical means, fully coupled ocean-land-atmosphere models are used. Just as in weather prediction, ensemble forecasts using these coupled models give probabilistic risk forecasts of climate events. While empirical and statistical methods are also used to predict climate conditions a season ahead, the present assessment of how well observational requirements are met relates only to the coupled model inputs. It is noted that historical data sets also play an important role in sub-seasonal and longer predictions by supporting calibration and verification activities.

Whilst such forecasting is still subject to much research and development, many seasonal forecast products are now widely available. The complexity of the component models ranges from simple models to full general-circulation-model representations of both the ocean and atmosphere. Coupled model initialization makes use of both atmospheric and oceanic data. There is large variation in the approach to the assimilation of initial data, with some of the simpler models assimilating only wind information while the more complex models usually assimilate sub-surface temperature information and satellite surface topography and temperature data. Indeed, major challenges remain in the development of assimilation techniques that optimize the use of observations in initializing coupled models.

The time and space scales associated with seasonal-to-interannual variability (large scale, low frequency) suggest the key information for forecasts will derive mostly from the slow parts of the climate system, in particular the ocean, but also the land surface. On time scales beyond one or two months, the ocean state has an important role. Land surface conditions play a role during the first two months of the forecast. The models should also include up-to-date radiative forcing (e.g., greenhouse forcing, volcanic aerosol), which are important for maximizing skill in forecasts of land-surface air temperature anomalies relative to recent historical reference-normal periods. Although it is still unclear the exact level of improvement associated with the inclusion of stratospheric processes, some modelling groups are starting to include the stratosphere in their seasonal forecast systems.

In the recent years the capabilities in sub-seasonal predictions have developed substantially. By sub-seasonal predictions we mean predictions beyond 10 days but not extending to a full season, usually averaged and expressed as a departure from climate values for that period. Monthly prediction is a sub-sample of the sub-seasonal predictions. A report of a joint WWRP/THORPEX/WCRP Workshop held at UK Met Office (1- 3 December 2010) has reviewed the predictive skill on the sub-seasonal time scale and concluded that there is potentially useful predictability at sub-seasonal timescales. These timescales are intermediate between NWP and seasonal ones. Among the main outcomes of the workshop there are recommendations for the establishment of an international research project on sub-seasonal prediction and proposal for operational collaboration in sub-seasonal prediction. Forecasting in the intermediate range between medium and seasonal range is difficult as the importance of initial conditions wanes and the effect of slower boundary conditions such as sea surface temperature increases. Although such predictions could be done without coupling to an ocean, the preferred tool is a fully coupled atmosphere ocean model as for the seasonal predictions. It follows that the observational data requirements for sub-seasonal forecasts are the same as the ones for seasonal and interannual forecasts.

In this list of observation needs, the requirements for sub-seasonal to longer forecasts are based on a consensus of the coupled atmosphere-ocean modelling community. It builds on the requirements for Global NWP and represents in addition those variables that are known to be important for initialising models or for testing and validating models. There is some attempt to capture the impacts aspects; that is, those variables that are needed for downscaling and/or regional interpretation.

2. Data Requirements

2.1 Sea-surface temperature

Accurate SST determinations, especially in the tropics, are important for SIA forecast models. Ships and moored and drifting buoys provide observations of good temporal frequency and acceptable accuracy, but coverage is marginal or worse over large areas of the Earth. Instruments on polar satellites provide information with global coverage in principle, good horizontal and temporal resolution and acceptable accuracies (once they are bias-corrected using in situ data), except in areas that are persistently cloud-covered (which includes significant areas of the tropics). Geostationary imagers with split window measurements are helping to expand the temporal coverage by making measurements hourly and thus creating more opportunities for finding cloud-free areas and characterising any diurnal variations (known to be up to 4 degrees C in cloud free regions with relatively calm seas). Microwave measurements provide acceptable resolution and accuracy and have the added value of being able to ’see through’ clouds. Blended products from the different satellites and in-situ data can be expected to be good for SIA forecasts. Observation of the diurnal cycle is becoming increasingly important, for which present and planned geostationary satellites offer a capability.

There is a requirement for high quality, fast delivery SST (ideally with accuracy < 0.1 deg C on 100 km spatial scale and < 0.25 deg C on 10 km spatial scale, available within 24h (by SST we mean e.g., bulk temperature at 2m depth).

2.2 Ocean wind stress

Ocean wind stress is a key variable for driving ocean models. It is important to recognise the complementarity between surface-wind and surface-topography measurements. Current models use winds derived from Numerical Weather Prediction (NWP), from specialist wind analyses or, in some cases, winds inferred from atmospheric models constrained by current SST fields. The tropical moored buoy network has been a key contributor for surface-winds over the last decade, particularly for monitoring and verification, providing both good coverage and accuracy in the equatorial Pacific. Fixed and drifting buoys and ships outside the tropical Pacific provide observations of marginal coverage and frequency; accuracy is acceptable.

Satellite surface-wind speed and direction measurements are now the dominant source of this information. Currently their data reach SIA models mostly through the assimilated surface wind products of NWP, where their positive impact is acknowledged. Overall, a two-satellite scatterometer system, or its equivalent, would provide good coverage and acceptable frequency, and it would complement the ocean-based systems. At this time, continuity and long-term commitment are a concern. Improved integration of the data streams and operational wind stress products from NWP and other sources will be needed to achieve acceptable or better coverage, frequency and accuracy.

High-quality scatterometer winds are the best products available at the moment and need to be maintained operationally.

2.3 Sub-surface temperature

Many, but not all, SIA forecast models assimilate sub-surface temperature and salinity data, at least in the upper ocean (down to ~500 m depth). The Tropical Atmosphere Ocean (TAO) / TRITON moored buoy network provides data of good frequency and accuracy, and acceptable spatial resolution, of sub-surface temperature for the tropical Pacific, at least for the current modeling capability. The tropical moored network in the Atlantic (PIRATA) is better than marginal but does not yet have the long-term resource commitments and stability. The RAMA array provides coverage over the Indian Ocean. The Ships-Of-Opportunity Programme (SOOP) provides data of acceptable spatial resolution over some regions of the globe but the temporal resolution is marginal. It is noted that SOOP is evolving to provide enhanced temporal resolution along some specific lines. The ARGO Project is providing global coverage of temperature and salinity profiles to ~2000 m, mostly with acceptable-to-good spatial resolution, but only marginal temporal resolution in the tropics. In all cases the accuracy is acceptable for SIA purposes.

Moorings at and near the equator are important. It is crucial that the current coverage over the Pacific (e.g TAO) is sustained.

2.4 Salinity

Salinity is becoming an important parameter. Some models are starting to make use of such data in the ocean data assimilation. The ARGO is a major source of salinity observations. It provides global coverage of temperature and salinity profiles to ~2000 m, mostly with acceptable-to-good spatial resolution, but only marginal temporal resolution in the tropics. Valuable data also comes from the tropical moorings although data coverage is too limited. Surface salinity will be measured by satellite in the forthcoming research mission. There will be a need for continuity of those measurements. There is large uncertainty in the fresh water flux (precipitation, evaporation and river runoff), affecting the surface salinity and mixed layer properties. It is probably the largest source of uncertainty in the estimation of salinity in the upper 100m. Information about Sea Surface Salinity (SSS) from either in-situ measurements close to the surface and from satellite (Aquarius or SMOS) can be useful.

2.5 Ocean topography

Ocean altimetry provides a measure of the sea surface topography relative to some geoid (or mean sea-surface position) that in turn is a reflection of thermodynamic changes over the full-depth ocean column. In principle, the combination of altimetry, tropical mooring and ARGO will provide a useful system for initialising the thermodynamic state of SIA models. Long-term commitments for satellite altimetry are required. Research satellites are providing a mix of data with acceptable accuracy and resolution and data with good spatial resolution (along the satellite tracks) but marginal accuracy and frequency. The "synoptic" global coverage, particularly beyond the tropical Pacific, is an important requisite. Ocean altimetry data can currently only be used to look at variability in the sea-state. Information about the geoid and the mean state of the oceans can be derived indirectly from gravity missions such as GRACE (Gravity Recovery and Climate Experiment) and, in the near future, GOCE (Gravity field and steady-state Ocean Circulation Explorer).

2.6 Surface heat and freshwater fluxes

There are a few sites in the tropical ocean where the data on surface heat flux are of value for validation and are required at a number of sites in the tropical oceans. NWP products (derived from analysis from short-range forecast), in principle, have good resolution but the accuracy is at best marginal. Satellite data provide prospects for several of the components of heat flux, particularly shortwave radiation, but at present none is used on a routine basis for SIA assimilation. Precipitation estimates are important for validation because of the fundamental role of the hydrological cycle in SIA impacts. They also have importance in initialisation because of the links to salinity. However, there remain significant uncertainties in estimates of rainfall over the oceans. In addition the fresh water run off information from rivers (large estuaries) will become important in coastal areas and regional parts of the oceans (e.g., the Gulf of Bengal). Additional data would always be useful. For example, data to allow better estimates of heat-fluxes and P-E (precipitation minus evaporation) could help give a better definition of the mixed layer structure.

2.7 Ocean current data

Models generally do not currently assimilate ocean current data, perhaps in part because data is limited. However, because of the central importance of dynamics and advection, current data are important for testing and validation. For example, experimental fields of surface current for the tropical Pacific and Atlantic are now being produced routinely by blending geostrophic estimates from altimetry with Ekman estimates from remotely-sensed wind observations. Inferred surface currents from drifting buoys are acceptable in terms of accuracy and temporal resolution but marginal in spatial coverage. Satellite altimetry is also being used to infer the distribution of ocean currents. Moored buoys are good in temporal coverage and accuracy, but marginal otherwise.

2.8 In-situ sea level

In-situ sea level measurements provide an additional time-series approach (good temporal resolution and accuracy; marginal spatial coverage), particularly for testing models and validating altimetry.

2.9 Land-surface

Snow cover and depth are important, particularly at short lead times (intraseasonal-to-seasonal). Snow depth observations are marginal.

Soil moisture is a crucial element in the sub-seasonal and seasonal forecast performance in mid-latitudes Spring / Summer. Due to its extended memory, the relevant quantity to initialise is the soil water in the root layer (a soil layer with a depth of about 1 m). Low frequency microwave imagery and scatterometer data are sensitive to surface wetness with an insufficient penetration depth. At present only the Soil Climate Analysis Network (SCAN) provides a network of real-time vertical profiles of soil moisture covering the all area of the United States. A network of similar measurements covering the global domain would be very useful.

2.10 Sea-ice

Sea-ice cover is important for high latitudes. It is implicitly included in the leading SST products (e.g. OSTIA). Sea ice concentration products like the EUMETSAT OSI SAF, derived from SSMIS brightness temperatures, are valuable. Sea-ice thickness is important for fluxes and for initialisation. CryoSat, through use of a satellite in low Earth orbit, monitors variations in the extent and thickness of polar ice.

2.11 Aerosol and Ozone

As for the NWP models, the use of aerosols data and stratospheric ozone concentration data has been recently introduced in several SIA systems.

2.12 Atmospheric data

Similar to the NWP models, the atmospheric component of several SIA systems is initialized by an accurate analysis of the state of the atmosphere and earth’s surface. Therefore the observational requirements are similar to those for global NWP (see SoG for global NWP). However, because of the extension of biases in the long range forecasts, calibration is needed. Typically a set of hind-cast integrations going back 20 years or more in the past is used to calibrate the SIA systems.

The hind-cast initialization relies on the capability of the re-analysis in providing consistent time series of data covering a sufficient long period of years. In this respect a general requirement for SIAF is the availability of consistent historical observational data sets as well as a continuous provision of accurate observational data in the future.