Seasonal and subseasonal forecasts

The World Climate Service, operated by Prescient Weather, provides long-lead forecasting tools supported by the best science available

Scientists have used computers since the late 1950s to model the physics of the atmosphere and oceans and predict future patterns and events. While weather forecasts have improved in recent decades, the requirements for processing and combining very large data sets have increased to successfully prepare and communicate the forecasts.

Long-lead weather and climate prediction today is a Big Data application which involves accessing large data volumes created by government organisations and adding value to the data with sophisticated calibration techniques. This difficult task is accomplished by the World Climate Service (WCS).

The subseasonal challenge

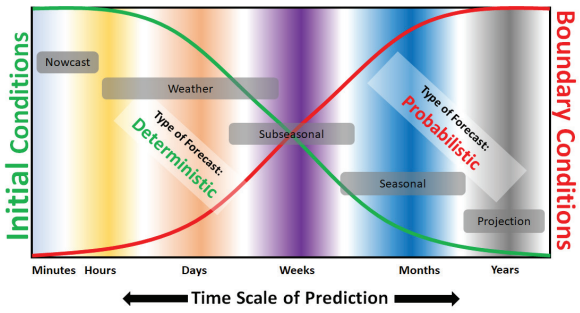
Until recently, forecasts with leads longer than 14 days but less than a month or season were thought to be nearly impossible. Short-term weather forecasts are derived primarily from atmospheric initial conditions while for seasonal climate forecasts, boundary conditions such as tropical sea surface temperatures are most important.

Subseasonal forecasts, spanning approximately three to six weeks in the future, are based on information from both initial conditions and boundary conditions, but neither provide a strong basis for predictability – leaving subseasonal forecasts in a 'no man's land' of predictability.

Despite this challenge, recent scientific advances in both climate modelling and statistical techniques have enabled regular, skillful subseasonal forecasts to be issued by governments and commercial entities, such as the WCS. International efforts, including the WMO S2S Prediction Project and NOAA's Subseasonal Experiment, have recently expanded scientific understanding of subseasonal forecasting.

Successful subseasonal to seasonal (S2S) prediction requires foreseeing the likely future state of the climate system based on several independent sources of forecast information. Two of the most important are dynamical models of the atmosphere and statistical or analog models based on comparisons of present and past conditions.

Both require regularly downloading a substantial volume of data for post-processing as well as advanced knowledge of the statistical techniques required to convert the raw data into useful forms.



The importance of initial and boundary conditions with forecast lead time

This task is challenging for NMHSs and forecasting organisations with limited or unreliable digital bandwidth and insufficient computing power.

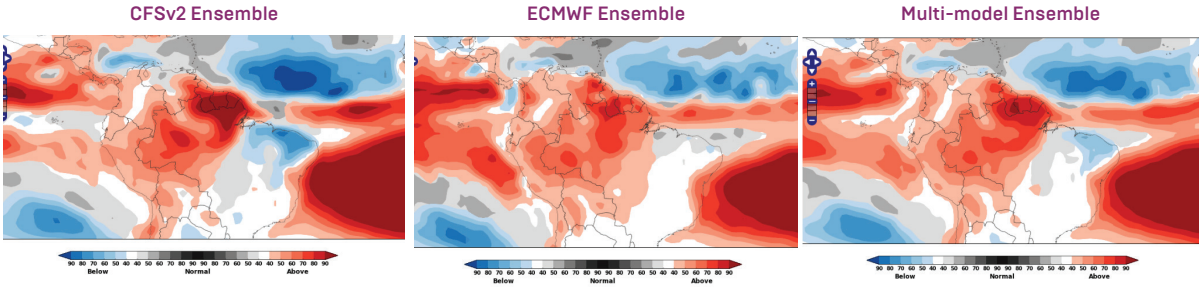
Two well-known dynamic models are the NOAA Climate Forecast System Version 2 (CFSv2) and the European Centre for Medium-Range Weather Forecasts extended ensemble (ECMWF). Both provide ensemble forecasts for several weeks to months and seasons.

Ensemble modelling

An ensemble forecast consists of many runs of the same forecast model with perturbed initial conditions. A primary objective of ensemble modelling is to sample the uncertainty of initial conditions and their impact on the forecast. Probabilities of specific weather and climate events, such as above or below normal temperatures, can be estimated by analysing the ensemble forecasts. However, this process must adequately address the systematic and random errors that arise from the uncertainty of the initial conditions, limited model grid resolution, and model physics approximations; these post-processing efforts are referred to as model calibration.

Long-lead dynamical forecast models should be calibrated to remove bias and improve forecast performance. The modelling centres producing dynamical S2S forecasts also produce retrospective forecasts ('reforecasts'), which are long histories (up to 40 years) of ensemble forecasts created in an identical framework to the operational forecasts.

The reforecasts allow scientists to study and correct for model biases and improve estimated event probabilities; in particular, it is desirable to ensure that the predicted probability of events



Example of Week 3 (Subseasonal) lead time calibrated probabilistic tercile temperature forecast

corresponds to the observed frequency of events. Model calibration, however, is a significant processing effo rt because of the volume of data (more than 125TB is required to prepare operational S2S forecasts similar to the WCS) and the sophistication of the statistical techniques.

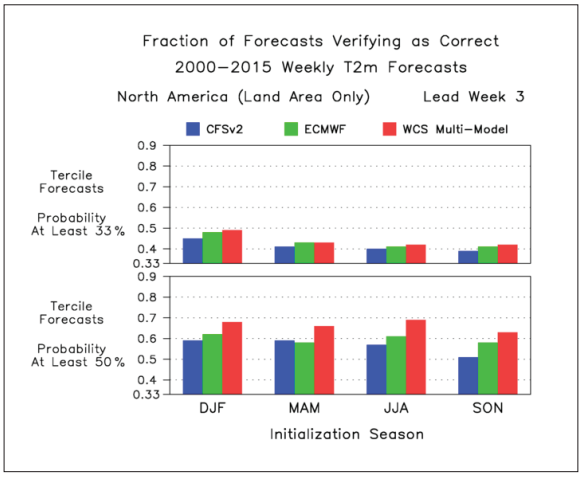
While the use of a single ensemble model provides useful forecast information, a combination of two or more models can significantly increase forecast skill at all lead times. The chart below demonstrates this for tercile forecasts of probabilities of greater than 50% in particular, and shows that while the ECMWF model is generally better than the CFSv2, the multi-model ensemble is better than either model.

It also demonstrates that "high confidence" forecasts (indicating higher probabilities of specific events) tend as expected to verify correctly more often than "low confidence" forecasts. The calibration process helps to ensure that the probability predicted for specific events corresponds to the frequency at which the event is observed.

Analog forecasts and climate index tracking

Other sources of information are important for enhancing the predictability of S2S events, but are also data intensive. There is growing interest in purely statistical prediction, and even simple analog analysis often provides valuable independent guidance for subseasonal and seasonal lead times.

An analog technique finds earlier states of the atmosphere or oceans that are similar to the present state and then uses the evolution of those earlier states as the forecast. Analogs provide value because they accurately represent the earth system's physical processes, unlike dynamical models. However, because there are many degrees of freedom in the climate system it is difficult to find analogs fully representative of all aspects of a climate pattern.



Fraction of tercile temperature, land-only, 3 week lead forecasts verifying as correct for winter (DJF), spring (MAM), summer (JJA), and autumn (SON) for calibrated CFSv2, ECWMF, and a multi-model ensemble of the two

Some climate indexes, such as the El Niño – Southern Oscillation, indicate that certain patterns or events may be expected and thus can be used in S2S forecast preparation. The WCS provides easy-to-use analog forecast tools for both subseasonal and seasonal time scales.

Creating the best possible subseasonal and seasonal forecasts for a country or a region requires processing significant volumes of data and applying tailored statistical methods to extract value. Likewise, forecasters must have access to appropriate tools, such as the WCS, which provide calibrated multi-model dynamical forecasts and analog or statistical guidance to support local long-lead forecast preparation. ✢

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World Climate Service

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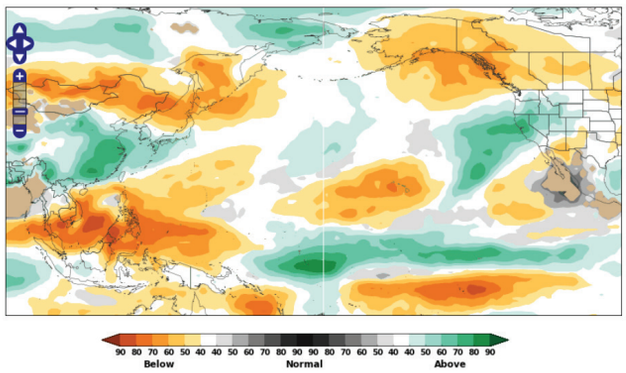
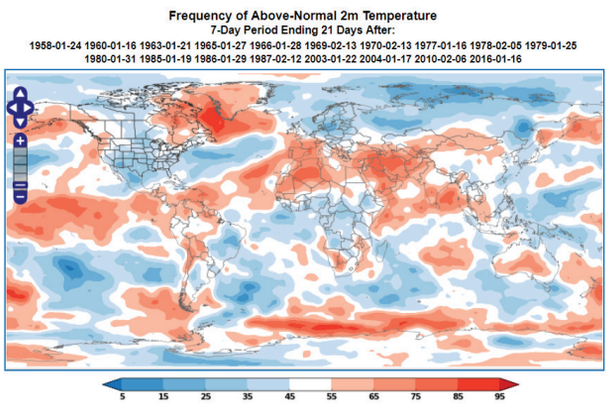
CLIMATE ANALYSIS, MONITORING, AND PREDICTION

Ensemble Model Probability Forecasts

1. GEFS, CFSv2, ECWMF, Multi-Model
2. Subseasonal, Monthly, Seasonal
3. Calibrated for accurate probabilities
4. Multiple variables
5. Trend analysis
6. Skill Statistics





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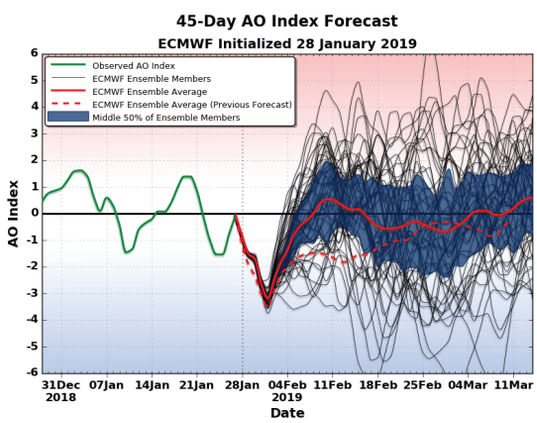
1. Seasonal and subseasonal climate driver analysis
2. Create your own custom analog scenarios with a flexible interface
3. Explore back to 1950

Index Forecast Tools

1. Monitor important modes in subseasonal, monthly, and seasonal climate timeframes
2. Analyze index impact on surface climates
3. Includes: ENSO, QBO, AMO, PDO, IOD NAO, AO, WPO, EPO, PNA, Sunspots SCAND, EA/WR, MJO, SSW, etc



Benefits: World Climate Service

1. **Comprehensive Information:** Improve long lead forecasts
2. **Save time:** Single source for subseasonal and seasonal climate prediction
3. **Be confident:** Calibrated ensembles ensure tuned, accurate probabilities
4. **Ease of use:** Web interface simplifies access to ensemble models and reanalysis data
5. **Global Coverage:** WCS provides forecasting information for the entire globe
6. **Experience:** Expert team with decades of forecasting experience

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