On the integration of weather and climate prediction

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Introduction

The question of the predictability of weather and climate is a fundamental issue that must be considered with more stringency than often is the case. And from time to time it may be pertinent to seriously reflect whether such a complex system as the Earth's system at all can be understood accurately enough to make useful predictions for longer period of times. In addressing such an issue, we must first clarify what we *mean by climate* and also what, we *intend to achieve* by the use of a climate model. I believe Edward Lorenz has made this point in a concise way by introducing the concept of *climate predictability* (to be clearly separated from weather predictability) as the predictability of the statistics of climate including a comprehensive set of statistical measures (mean values, standard deviations, extremes etc.) and this for different times of the year and for different parts of the world. A suitable time average for defining climate is in the order of 30-100 years.

We have several reasons to believe that the many climate projections, which have been produced in recent years, may well indicate a typical range of credible climate statistics for the whole 21st century. However, what information can we provide for the next few decades? Assume for the sake of argument that we are in 1956 instead of 2006 and produce say a 30 year climate prediction, covering a period of the 1960s and 70s when several climatologists, some well known, claimed that the climate of the Earth was approaching a long cold period. The media spoke even of a coming ice age! Nevertheless I am sure that the climate projection in 1956 even using models of today would have indicated a minor warming trend and certainly not the observed cooling trend.
We have now good reasons to believe that the typical climate anomalies during the 20th century were natural climate fluctuations superimposed on a slow warming trend (FIG) and as such not predictable, except in a statistical sense. However, such a climate projection would not have been particularly useful for those who have to cope with the many problems due to the many cold climate episodes, which occurred in the 20th century. And furthermore I have reasons to believe that this property of the climate, which we may call the unpredictable part, has not been well understood by the laymen to say the least. And many scientists have perhaps also created a false hope by the laymen that such anomalies are predictable.

How can we best approach this dilemma? Firstly, I believe it is essential to identify what is the useful content of a climate prediction. This include for example the risk of extreme events, such as powerful hurricanes, excessive precipitation and long periods of draught. Secondly, to provide information to the users which is consistent with what is predictable. This will have to include the risk of specific harmful weather events. It is the consequence of this approach, which I intend to outline in this talk.

Development in weather prediction

Significant developments have taken place in weather prediction in recent decade or so. Firstly, this has included the use of models at higher resolution and more accurate treatment of physical processes. Secondly, by the introduction of ensemble prediction is has been possible to assess potential predictive skill as well as obtain warnings for adverse weather. (FIG) As the forecasts are extended in time they will gradually be transformed into a summary of climate average information as presently developed for example by IRI.

Development in climate prediction

Climate modeling has developed into a broad range of applications, but I will here concentrate on modeling with the emphasis on prediction. The same trends as in weather modeling towards higher resolution and towards ensemble prediction can also be seen here. The use of resolutions of around 50 km and less are now being done, indicating spectacular achievements to handle smaller scale dynamical systems such as extreme tropical and extra-tropical storms. (FIG). These results are highly encouraging as they indicate the potential to predict possible changes in extreme events in a future climate, which would be of large practical value even if such event may not be predicted per se, but only in its probability distribution. Given a model that can mimic the present climate (and we are now actually approaching such a state) there will be an increasing rational to develop feasible ensemble prediction systems. To develop ensemble prediction with poor models is much less useful and should instead be focus on advanced climate models. Example of such projection can be seen in FIG

A strategy for climate prediction in Europe

Based on the observations above I suggest that climate prediction shall be undertaken on a more organized and systematic basis. I also believe that we now have reached a time when climate modeling shall be considered jointly in a similar way as medium range prediction at ECMWF. Ensemble climate prediction can then be undertaken on a regular basis with a least a set of multi-decadal predictions once a year. Such a projection should include a significant number of ensemble members and should be done at a resolution sufficient to resolve extreme weather on a synoptic time scale, requiring a resolution of at least 25-50 km
The European climate community could and should be heavily involved in such an undertaking, both in model development and in the assessment of the climate projections.

A prediction system on such a scale including suitable systems for data-assimilation would require a central team of scientific and technical expertise as well as having suitable computer resource including data handling and communication. As communication today is so flexible it is no problem to use a central resource from outside and consequently the scientist in Europe interested in model development can then work

together with the central staff towards such an objective. I also anticipate that copies of the system are available locally for more specific type of experiments.
However, the major work for external scientist would be to assess the performance of the predictions for an almost infinite range of application and studies and compare it with observations.

To continue the present arrangement in Europe with a range of different models is probably not a sensible long-term strategy as any given country is not likely to find the resources in staff and computers in order to effectively compete with USA, Japan and China. To concentrate climate modeling in Europe around a joint centre (partly virtual) would make very much sense as Europe has a common policy for climate change strongly supported by public opinion. It is now, I believe, the right time to start to consider such a development as ECMWF presently is changing its convention making such an undertaking formally feasible.