Comparison of ERA-20C and ERA INTERIM reanalysis datasets

Zita Krisztina Balázs (zit.krisztina.balazs@gmail.com) - Department of Meteorology, Eötvös Loránd University, Budapest, Hungary

István Ihász (ihasz.i@met.hu) - Hungarian Meteorological Service, Budapest , Hungary

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Introduction

Reanalyses are mainly used for monitoring climate change, but another goal is to observe how the development of forecast systems affect the accuracy of the forecast itself. Only real and selected data is used for producing a reanalysis dataset supported by the measurements of diving buoys, airplanes, geostationary and quasi-polar satellites.
The aim of our study is to examine the two most modern ECMWF reanalysis datasets (ERA INTERIM, ERA-20C) and to recognise the strengths and weaknesses by comparing them. It can have a great benefit to all the reanalysis users, like climate researchers, and the developers of climate modelling and reanalysis, because as our results point out these miscalculations and uncertainties, it supports the development of new reanalysis products. Which is the key of making trustworthy forecasts, and getting precise results of global climate models as well.

The two datasets

ERA-Interim is a global atmospheric reanalysis from 1979, continuously updated with a two-month delay. It was produced with 4-dimensional variational analysis (4D-Var) with a 12-hour analysis window. The spatial resolution of the data set is approximately 80 km on 60 vertical levels from the surface up to 0.1 hPa. ERA INTERIM has the best possible spatial resolution, which leads to its usage in a wide area of fields.

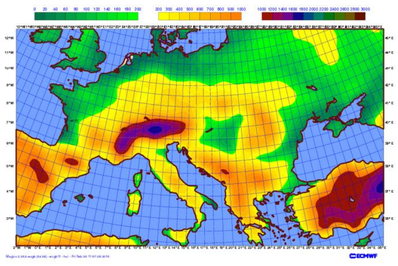

Fig. 1. Model orography for Central-Europe by ERA INTERIM

ERA-20C is ECMWF's first atmospheric reanalysis of the 20th century, for the period 1900-2010. The assimilation methodology is 24-hour 4D-Var analysis. The reanalysis describes the spatio-temporal evolution of the atmosphere on 91 vertical levels, between the surface and 0.01 hPa. The horizontal resolution is approximately 125 km. The analyses provide the initial conditions for subsequent forecasts that serve as backgrounds to the next analyses.

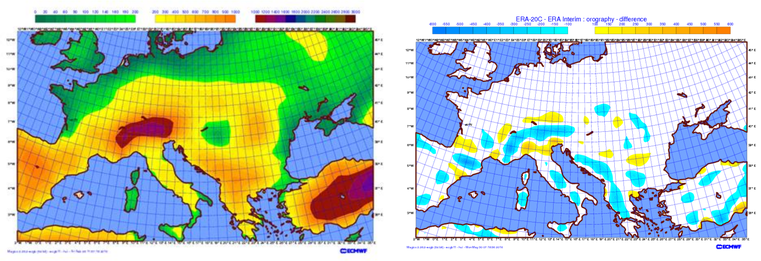

Fig. 2. Model orography for Central-Europe by ERA-20C and field of difference

Study of mean sea level pressure

In the first part of our study we assigned three periods of ERA-20C (1901-2000, 1901-1950 and 1951-2000) where we examine several selected parameters. In the following parts monthly average values are presented for the whole 20th century.

In the first place mean sea level pressure values are exhibited for January, April, July and October. We can notice that Icelandic low action centre is obviously detecable in the winter, such as Azores high action centre in the summer.

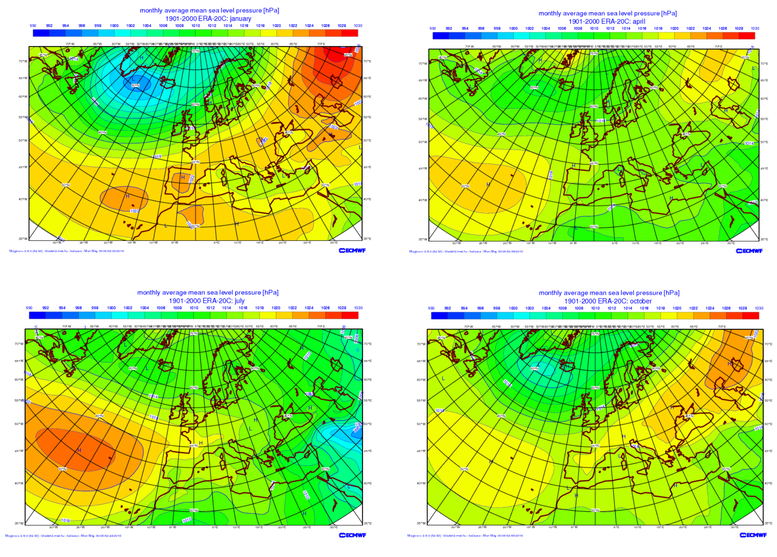

Fig. 3. Monthly average mean sea level pressure fields by ERA-20C in the period 1901-2000

Study of sea ice in the Arctic regions

On the other hand we study the ice coverage in the Arctic regions. As one of the most important climate factors it is significant to examine how the extent of Arctic sea ice is changing with time.

Below the variance fields of ice coverage is presented in the Arctic regions for January, April, July and October in the 20th century by ERA-20C. This series of maps shows exactly how delay appears in the maximum and minimum extent of Arctic sea ice.
In addition dark areas represent the areas of uncertainties, the more it is dark the smaller likelihood is there to be ice coverage in the period of the year. Moreover it seems evident that in the time scale of 100 years the centre of the Arctic regions are more and more melted in summer and especially in autumn.

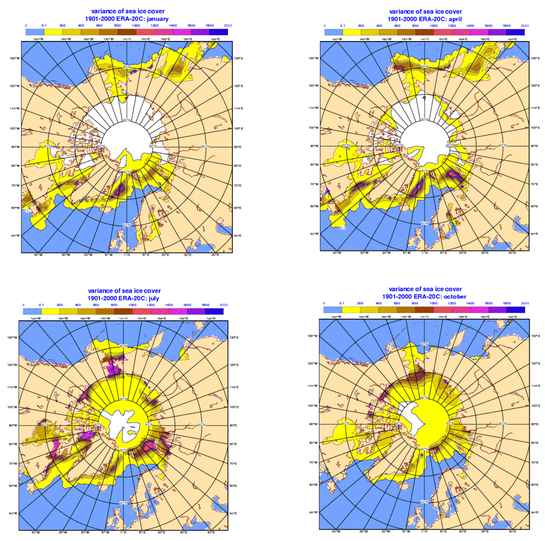

Fig. 4. Monthly average sea ice coverage variance fields by ERA-20C in the period 1901-2000

Comparative study between the two datasets

Besides all above we assigned a common period from both ERA INTERIM and ERA-20C (1981-2010). In this part of our study we examine various parameters, such as 850 hPa temperature, mean sea level pressure or the altitude of 500 hPa. Below the monthly mean sea level pressure fields are presented based on the correlation between ERA-20C and ERA INTERIM for the period 1981-2010.

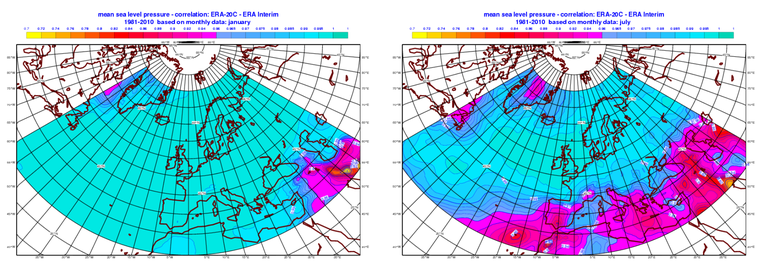

Fig. 5. Monthly mean sea level pressure fields based on the correlation between ERA-20C and ERA-Interim in the period 1981-2010

Our main matter in the statistical part is to examine the spatial structure of the correlation field calculated from the pairs of average-fields from every period of 30 months. Also we study the similarities and differences between the months of the year and the also between the different parameters.
Accordingly we can find here a comparison between the monthly mean sea level pressure fields (above) and the monthly 850 hPa temperature fields (below), which are presented for January and July based on the correlation between ERA-20C and ERA INTERIM for the period 1981-2010.

First of all this series of maps shows that ERA-20C is more reliable in the mean sea level, in turn it gives a lot of uncertainties in the upper level of the atmosphere. That is why a lower correlation is given in the case of the 850 hPa fields (another reason is the lack of data from the Atlantic region). ERA INTERIM definitely has a better resolution than ERA-20C, so it is more reliable in connection to the surface measurements.

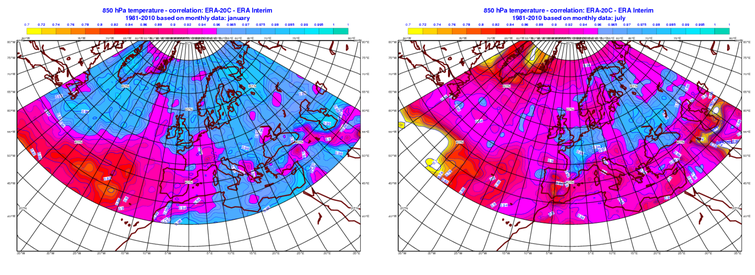

Fig. 6. Monthly 850 hPa temperature fields based on the correlation between ERA-20C and ERA-Interim in the period 1981-2010

Case study of rapid cyclones

In addition to all the applications mentioned before, reanalyses are also used to study extreme weather situations. That is why we feel the urge to study rapid cyclones as well, by examining the frequency and spatial localization of these events.
We find really important to mention that in order to get reliable results the examination of several cases is needed. Due to the space limitation here we only present one rapid cyclone.

As a case study we brought a rapid cyclone from January 2007, called Kyrill. It was originally formed above Newfoundland on 15 January, and after moving across the Atlantic Ocean had a great affect on Western Europe from 17 to 19 January. Kyrill was a multi-center rapid cyclone which caused widespread damage, bringing hurricane-strength winds and heavy rains.

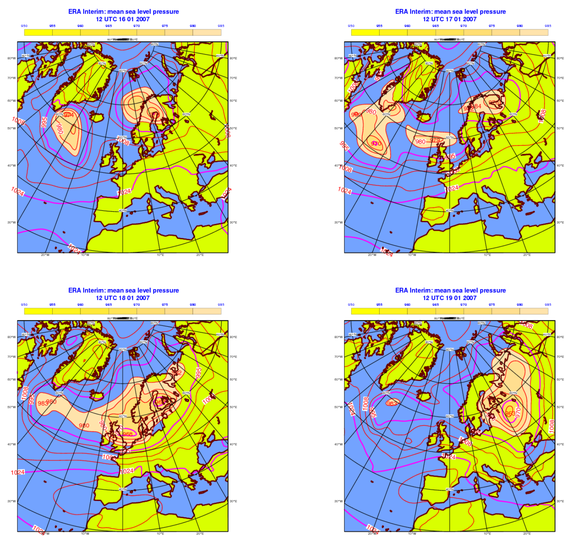

Fig. 7. Mean sea level pressure based on ERA INTERIM between 16-19 January 2007

Above mean sea level pressure is exhibited by ERA INTERIM for the period 16-19 January 2007. By 18. January the multi center type of the Kyrill is clearly seen.

Below mean sea level pressure fields are presented based on the difference between the two reanalyses on the 16. and 19. January. Huge differences can occur because the cyclone is not entirely equally placed on the map by the two reanalyses.

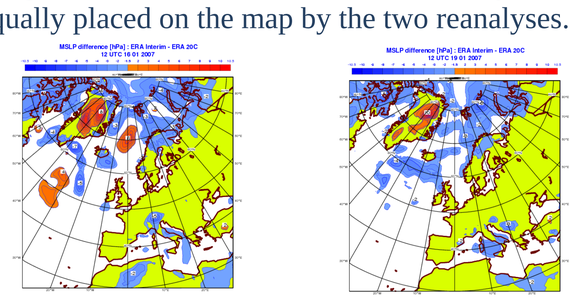

Fig. 8. Mean sea level pressure fields based on the difference between ERA INTERIM and ERA-20C for 16. and 19. January 2007

Conclusion and future plans

To meet user needs further development of reanalysis datasets are necessary. By getting an increasingly precise picture of the atmosphere, scientists will be able to monitor as precisely as possible the potential scenarios of the future, which is a key step to battle climate change.
In our further work emphasis is placed on making case studies related to other rapid cyclones. According to the increased number of this phenomena it becomes more and more obvious that nowadays rapid cyclones affect not only West-Europe but Middle –and East-Europe as well. Therefore it is really important to examine these events, and deepen our knowledge in their characteristics and how they develop over time.
Besides after the appearance of ERA-5 (in the end of 2017) we also plan to make a comparison between ERA-5 and ERA INTERIM. Because of the higher resolution of ERA-5 it would be a really interesting study to work on.

References

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