Computing and Weather Prediction

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In 1904 V. Bjerknes considered weather prediction as a problem of physics and formulated the basic idea of a forecasting process by solving the Navier-Stokes Equations taking the initial state from observations. But he concluded that this was a utopic vision that could never be realized with the available tools. Few years later Lewis Fry Richardson developed the first numerical weather forecast model without having any idea on computers we have available today and published in 1922 in his book “Weather Prediction by Numerical Process” a complete documentation of his model including all the physical and numerical approximations together with a numerical solution on which he worked together with his wife for more than two years. Richardson proposed a parallel computing environment with human calculators working in a large hall, coordinated by a conductor, and using a program formulated in spreadsheets. Unfortunately Richardson’s solution was unrealistic caused by observational errors in the data he used as initial values. However his concept has been used in many numerical weather prediction systems until today. Deutscher Wetterdienst operates since January 2015 his new weather forecast model ICON using the full compressible Navier-Stokes equations numerically approximated on a triangular grid with the special feature of local grid refinement.

During the last 40 years many efforts have been spent to develop maximum likelihood estimations of the initial state from observations, consistent to the forecast model, to the available observations including those from space and gathered at different times. For this variational problems have to be solved to determine the initial state for all degrees of freedom of the forecast model. These data assimilation schemes are formulated so that they are applied in a cycle so that they accumulate also the information from the past wit the technical challenge that this cycle must never be broken e.g. due to computer failures.

The actual challenge most forecast centres are working on is the prediction of the limited predictability of weather following Lorenz’s (1963) approach to provide probabilistic weather forecasts by using ensembles of 50 or 100 forecasts with corresponding demands on computing resources.