The origin and the early days of ECMWF

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A legitimate question to ask at the outset: Why was ECMWF so successful?

- **The timing was perfect**

- There was a strong need for a European cooperation. Many of leading individuals in the 1970s had experienced war during their formative years and wanted something different.
- A fundamental understanding of atmospheric circulation and predictability had developed in previous decades
- The on-going Global Atmospheric Research Programme GARP) where on its way to establish a global atmospheric observational system for weather and climate.
- A breakthrough in large scale computing was on its way including the Cray supercomputer.

Note on Cooperative Research Projects
C.-G. Rossby, July 1951, Tellus

- .....
- After more than twenty years of work with such research groups in the United States the author of this note feels a deep gratitude for the escape from pomposity and for the opportunity to intellectual development that work with an imaginative and intellectually courageous American team brings with it.
- ….
- This does not mean that the European science, with its long and valuable traditions, should be blindly americanized. The European chinashop is a delicate one and must be handled with great deal of care if we want to avoid serious damage to its antiques.
- ….
- It seems more desirable to set up one or several regional institutions with rotating, overlapping staffs, to which scientific workers from different countries may be sent or invited for participation, over limited periods of time, in certain broad scientific projects.

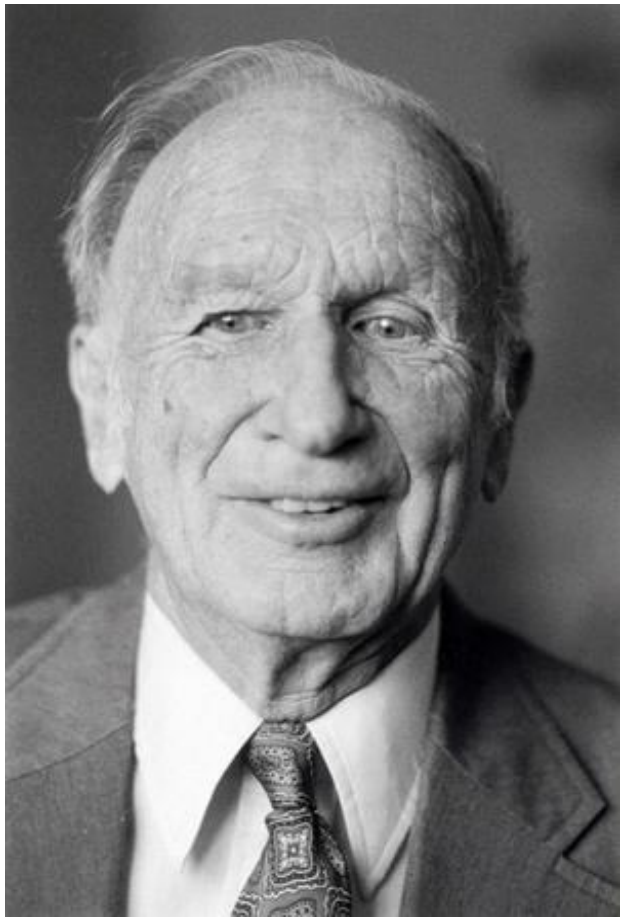
- With the help of the institutions from which the collaborating scientists are sent, such a system of rotating scientists would reduce the cost of operations and would further eliminate the otherwise very real danger that the institution be looked upon as a comfortable place of retreat.
-

John Von Neumann 26 October 1955

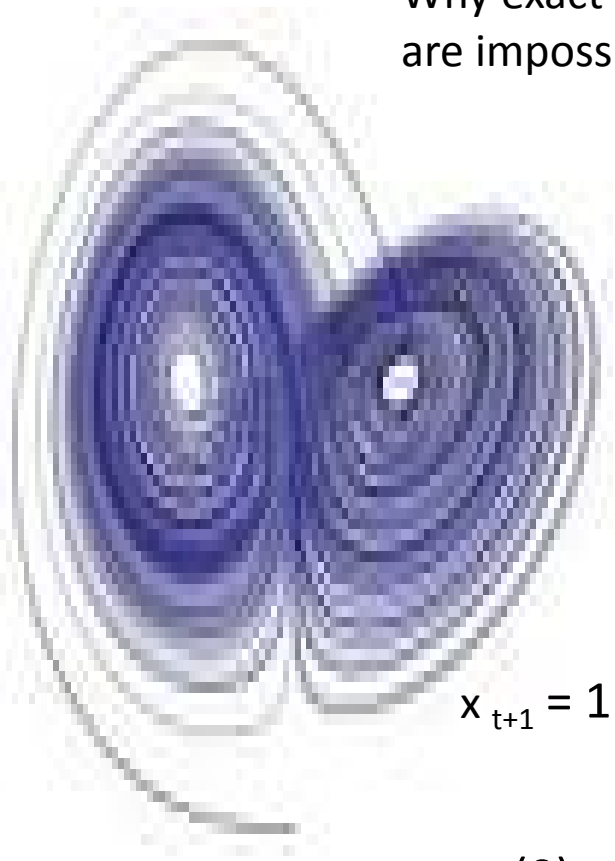
Conference on numerical integration techniques to the problem of the general circulation, in Dynamics of Climate (1959)

- It seems quite plausible from general experience that in any mathematical problem it is easiest to determine the solution for shorter periods, over which the extrapolation parameter is comparatively small. The next most difficult problem to solve is that of determining the asymptotic conditions – that is the conditions that exist over periods for which the extrapolation period is very large, say near infinity. Finally, the most difficult is the intermediate range problem, for which the extrapolation parameter is neither very small nor very large

Edward Lorenz and understanding of predictability 1917 -2008



Why exact predictions are impossible.



$x_{t+1} = 1.9 - x_t^2$

set: $x(0) = 0.5 + 10^{-8}$.

GARP and the Global Weather Experiment or FGGE

- The objective was to organize a geophysical experiment to explore the Earth's global atmosphere with the objective to improve weather prediction. **The planning work lasted for more** than a decade and the main experiment was finally carried out in 1979.
- The main components of the experiment were:
- 1) to create an integrated observing system including geostationary and polar orbiting satellites,
- 2) to develop a system for data collection, analysis and prediction and
- 3) to explore global weather systems such as the El-Nino phenomenon and the way they interacted

The steps towards ECMWF

- November 1967: Longer range weather forecasting and research using a very large European computer installation.
- May 1970: European Meteorological Computing Centre (EMCC)
- November 1971: European Centre for Medium-Range Weather Forecasts (ECMWF)

- January 1974: Appointment of Wiin-Nielsen as Interim Director

- November 1, 1975: ECMWF Convention into Force.

Project Study Group on EMCC
(European Meteorological Computing Centre)
Set up in May 1970

- **H Reiser, Germany** (Chairman)
- L Bengtsson, Sweden
- D J Bouman, Netherlands
- K Cehak, Austria
- J van Isacker, Belgium
- E Knighting, UK
- J Labrousse, France
- **S Palmieri, Italy**
- R Pone, France
- L La Valle, Italy
- (Later also D Söderman, Finland)

Letter to Aksel Wiin-Nielsen 22 March 1973 from Lennart Bengtsson

- Dear Aksel

- I would like let you know that I have now been informed that the Senior Officials have decided that ECMWF will be placed in Reading (UK). Hörsholm in Denmark was the other alternative, which naturally was strongly supported by us. ….
- As we see it now, it is even more important to get a forceful and naturally highly qualified director of the Institute.
-
- The next step will now be to elect a director for the Institute and proposals from the different countries will be sent to the secretariat before the 15th of April….
- There is a general opinion among the meteorologists in Scandinavia to see you as a director for the institute…
- I you are interested in the matter, which I hope you are, please contact Vuorela or Nyberg as soon as you can. Curriculum vitae should be submitted.
-
- I am leaving Monterey tomorrow and will be in Suitland (NMC) Monday and Tuesday next week. If there is anything more you would like to know you can reach me in John Browns office….

Key science challenges in the early 1970s

- Were predictions 10-days ahead at all feasible?
- Where integrations methods possible to handle non-linear interactions?
- What were the best ways to realistically handle moist convection and precipitation processes?
- How to obtain global observations, analyze them in three-dimensions and determine a globally valid initial state?
- What were the best ways to handle satellite observations?

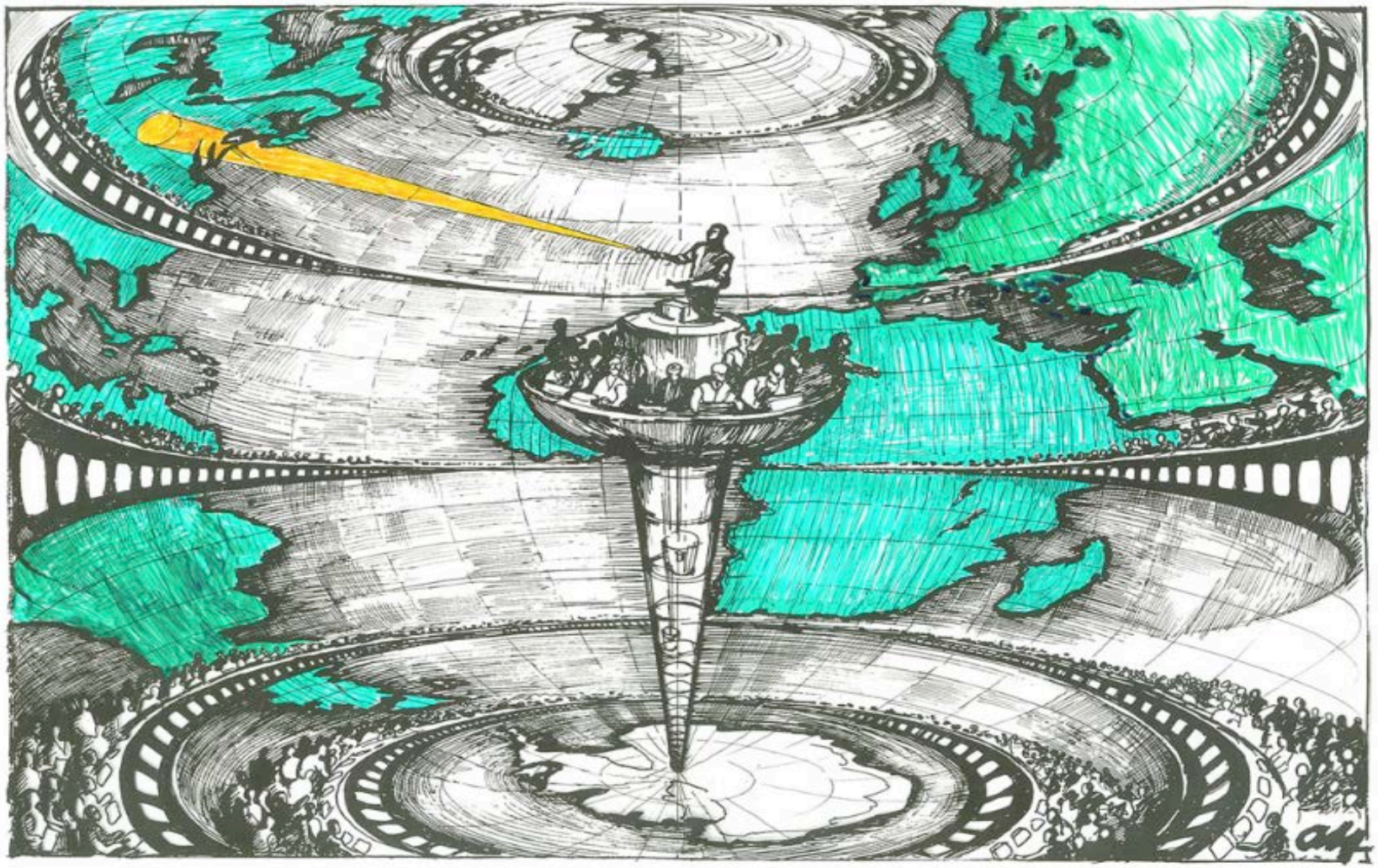
(Figure courtesy, Norman Phillips)

C.-G. Rossby

Jule Charney

J. von Neumann

Richardson‘s dream



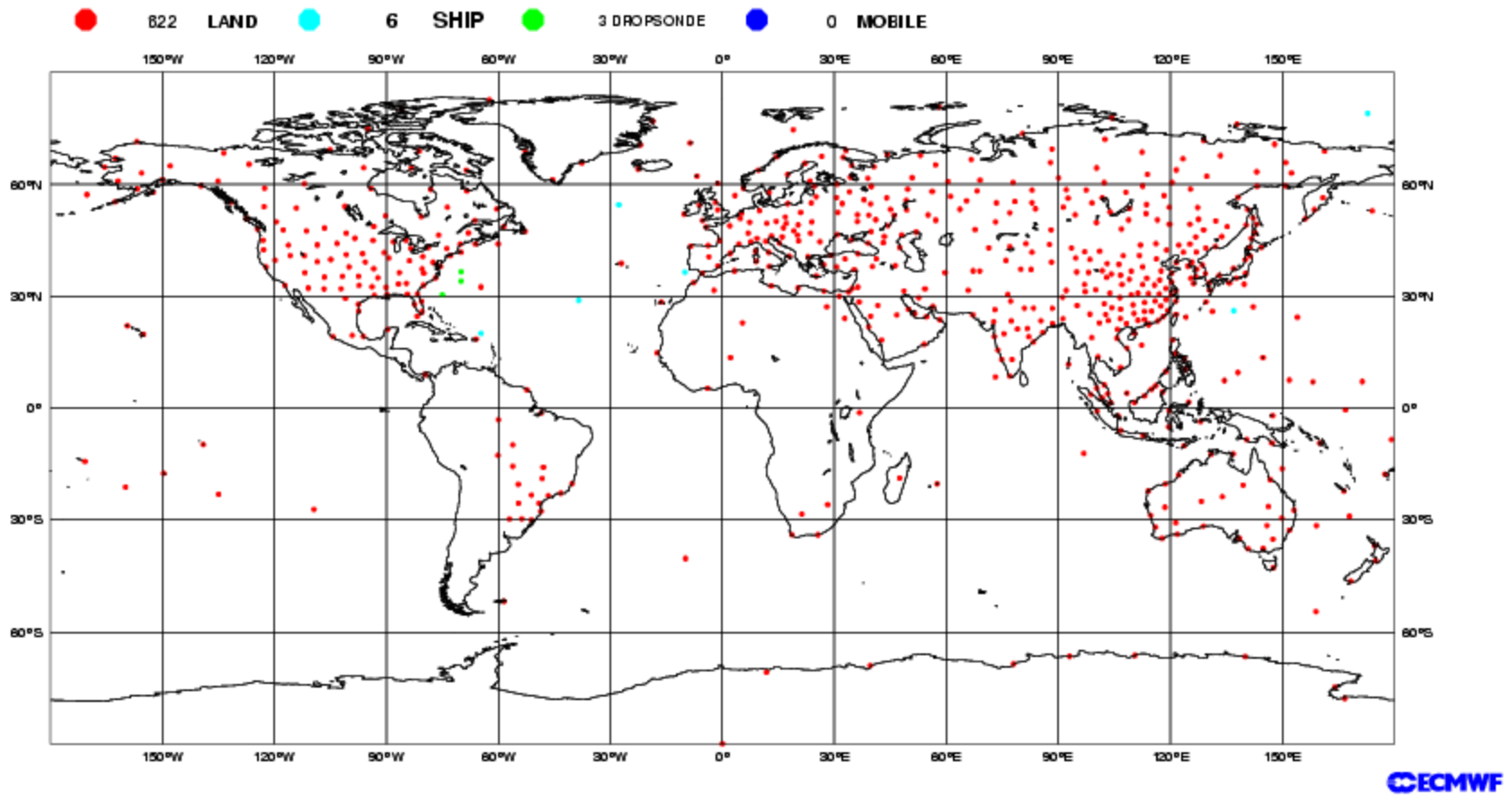
How to obtain global observations, analyze them in three-dimensions and determine a globally valid initial state?

- Data-assimilation for a global domain and the initialization of a global model had to be developed by ECMWF.

- This was finally solved by filtering methods worked out by Bennert Machenhauer, Clive Temperton and Dave Williamson

- We explored the possibility to obtain SH- analysis from Melbourne. For some time we actually used “subjective” information from satellite pictures by meteorologists as fictive “soundings”
- The importance of data-assimilation can be seen from the ECMWF re-analyses. This was first explored in 1978/79.

Radiosondes



What were the best ways to handle satellite observations?

- Vern Suomi: How to unscramble an egg?
- Answer: Feed another chicken!
- This finally gave rise to 4D-Var

The building of a ECMWF
The technical, administrative and social challenges

- Start building the Centre and waiting for the Convention to be ratified that required 80% of the financial contribution and 2/3 of the countries. Finally this took place 1 November 1975.
- Preparing for the new headquarter
- Preparing for the main computer and telecommunication system.
- Building a social community of young Europeans

ECMWF Staff 1 November 1975

The technical challenges

- To find a suitable super computer
- To obtain and process the initial data
- To distribute the results of the forecasts to the member states
- We decided to be digital from the outset. That was not common 40 years ago. We also decided to fully automate the complete forecast cycle . Also a very bold decision.
- **These turned out to be crucial decisions**

Signing for the Cray 1 contract, 22.6.1977

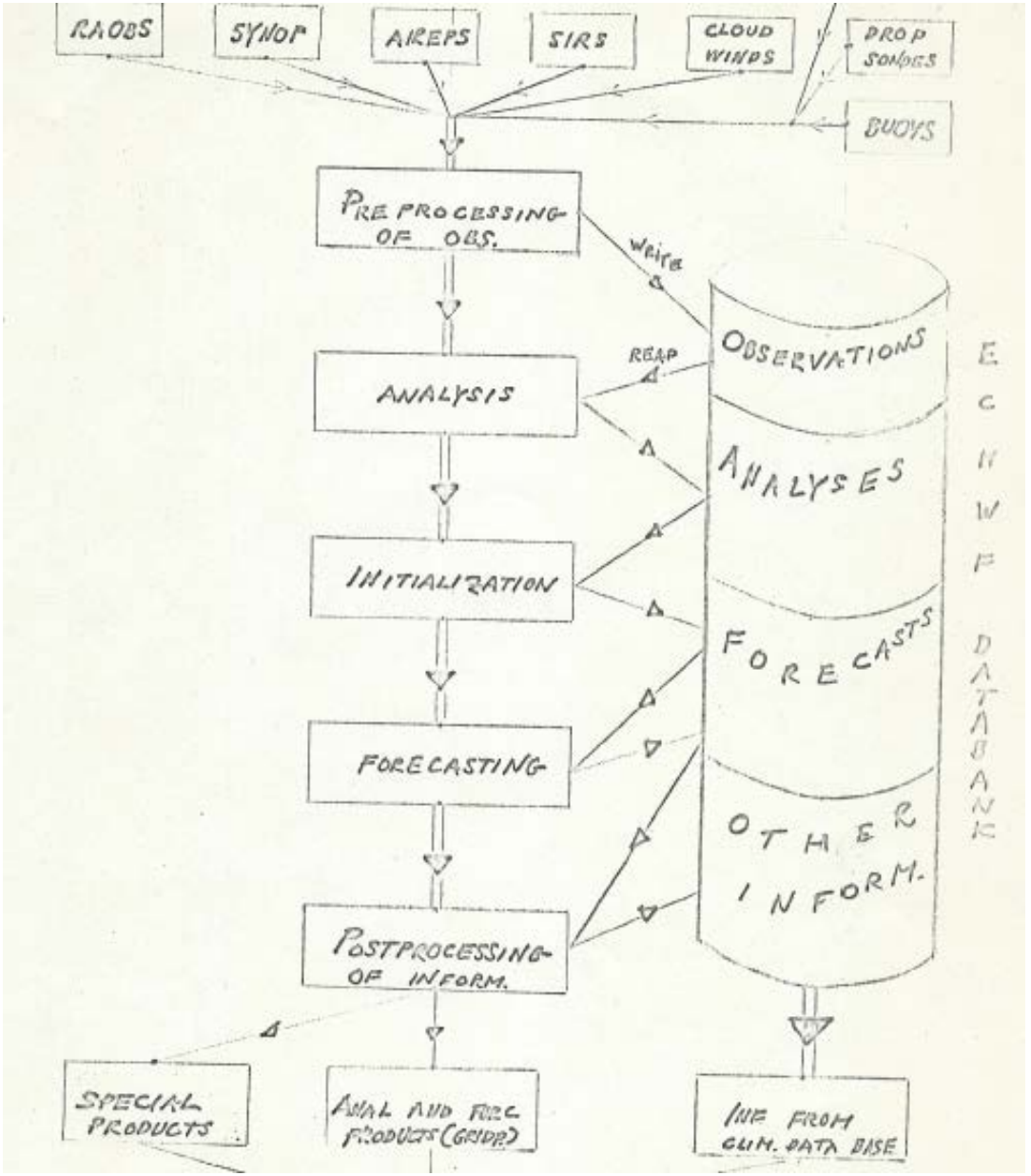
Cray 1

Where integrations methods possible to handle non-linear interactions? (sometimes very strong feelings!)

- Arakawa's finite difference grids
- What grid to be used, C- or E-grid?
- Was a semi-implicit integration acceptable?
- Spectral –transform methods or grid point integrations?

How to set up an operational forecasting system?

From a planning document prepared 23 september 1974



From a RD planning document 3 March 1975

Performance comparison using GCM with real data.

ECMWF should try to get copies of some GCM to be transformed to either CDC 6600 (in the configuration we are going to have) or for IBM 360/195 where that is necessary. The following three models should be studied :

(a) project P3301 GFDL - fine mesh model (N40-N80) Tony

(b) project P3302 UCLA - new model Sadourny

(c) project P3303 UKMO - 11 layer model.

One ECMWF staff member or consultant will be responsible for any of the 3 models. The work will consist of :

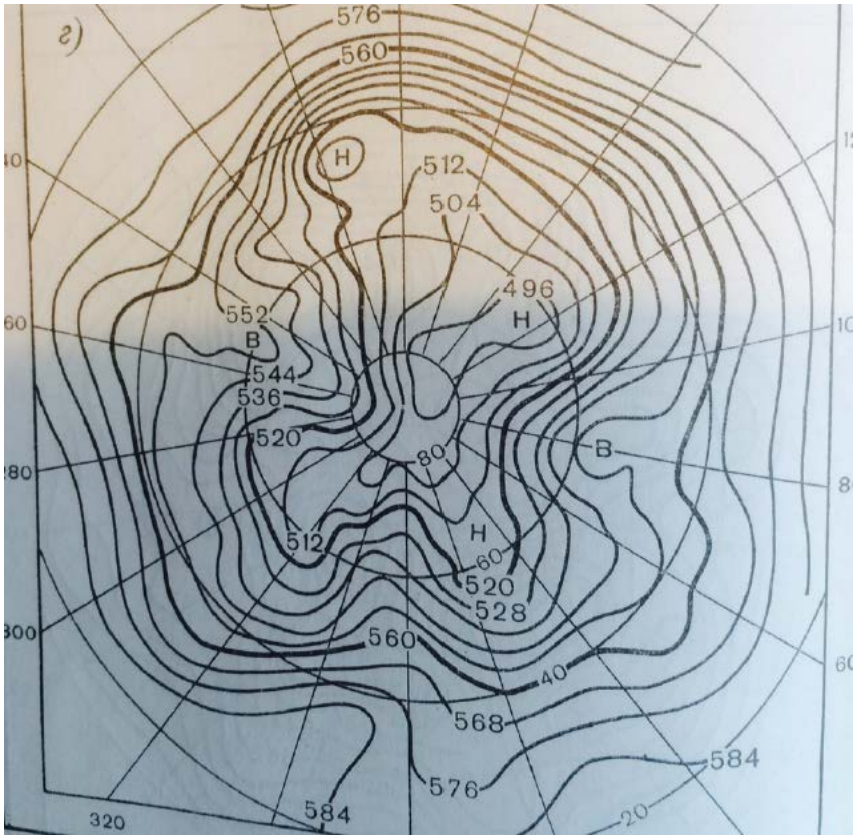
4.2.1 A documentation of the model carried out in the same way for each of the models and done very similar to the RAND.R-877-ARPA-report: "A documentation of the Mintz-Arakawa two-level atmospheric general circulation model".

The very first 10-day forecast!

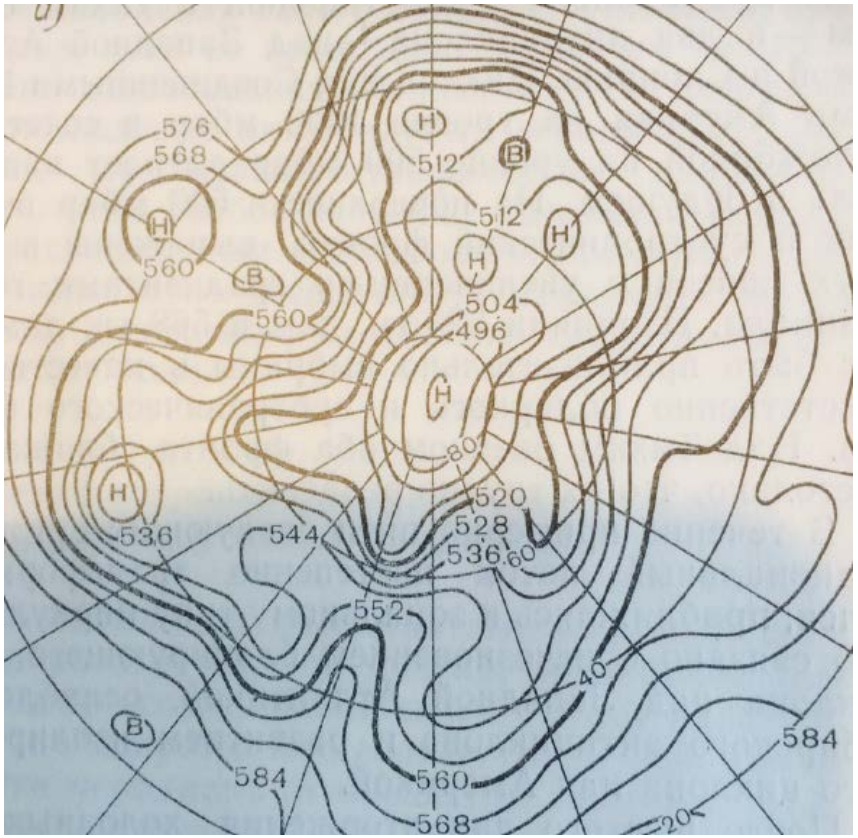
- Tony Hollingsworth was sent to GFDL, Princeton for the model developed by Miyakoda and coworkers
- Robert Sadourny was sent to UCLA for a version of the Mintz-Arakawa model
- Back in Bracknell the models were tested by our own CDC 6600 and at the UK Met Office IBM 360/195
- The collected know how was used to develop our own global model that was led by Dave Burridge

First ECMWF prediction 1975
1 March 1965 +5 days

1.3.1965 + 5 days GFDL mod.
N48 = 250 km resolution

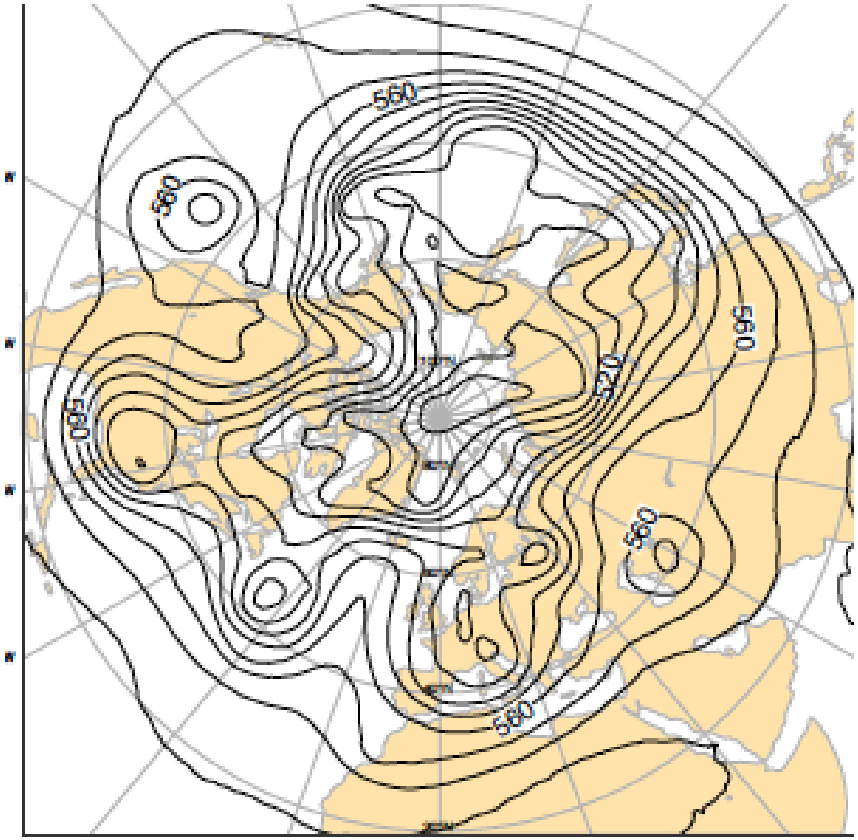


NMC analysis 6.3. 1965

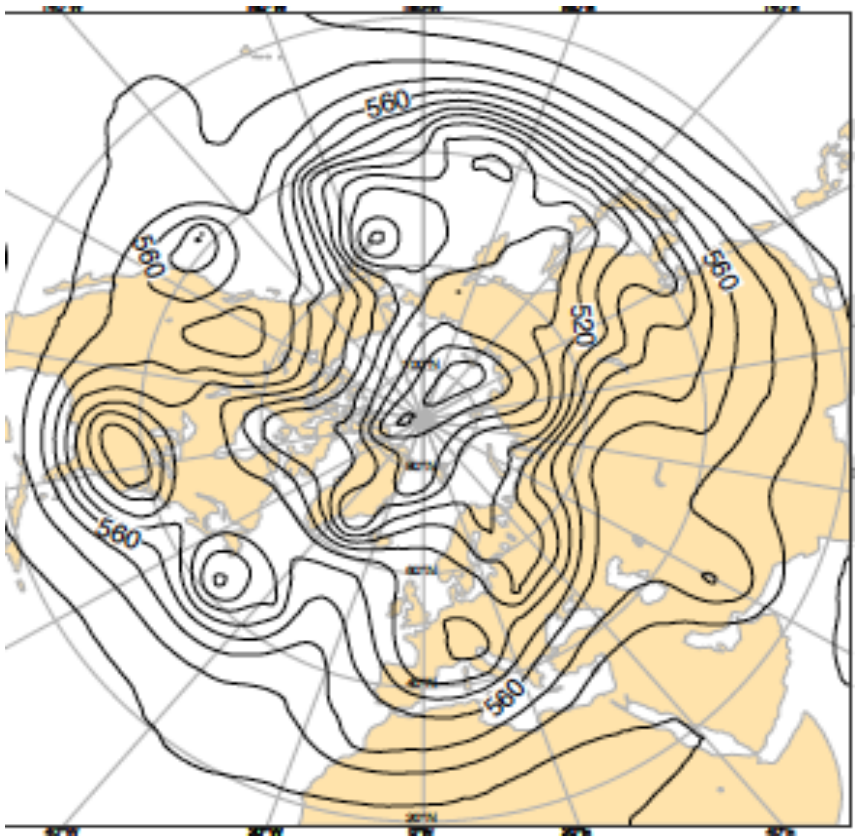


Forecast with the ECMWF model June 2015 using the CERA re-analysis, credit Patrick Laloyaux

1.3.1965+ 5 days, CERA model
T1259 = 12 km resolution

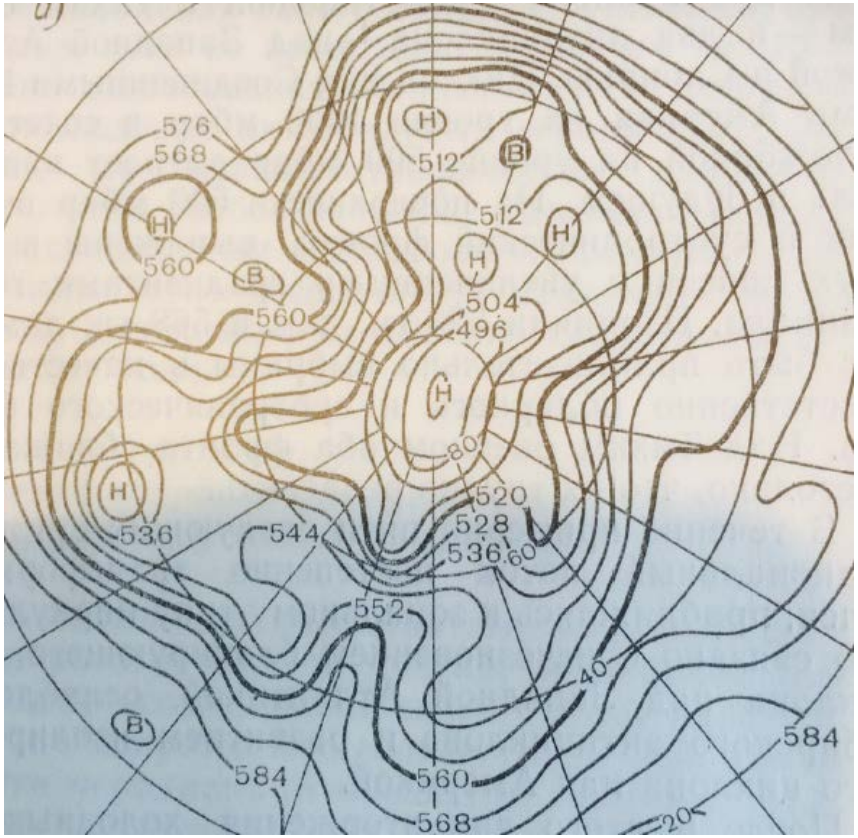


CERA analysis 6.3.1965

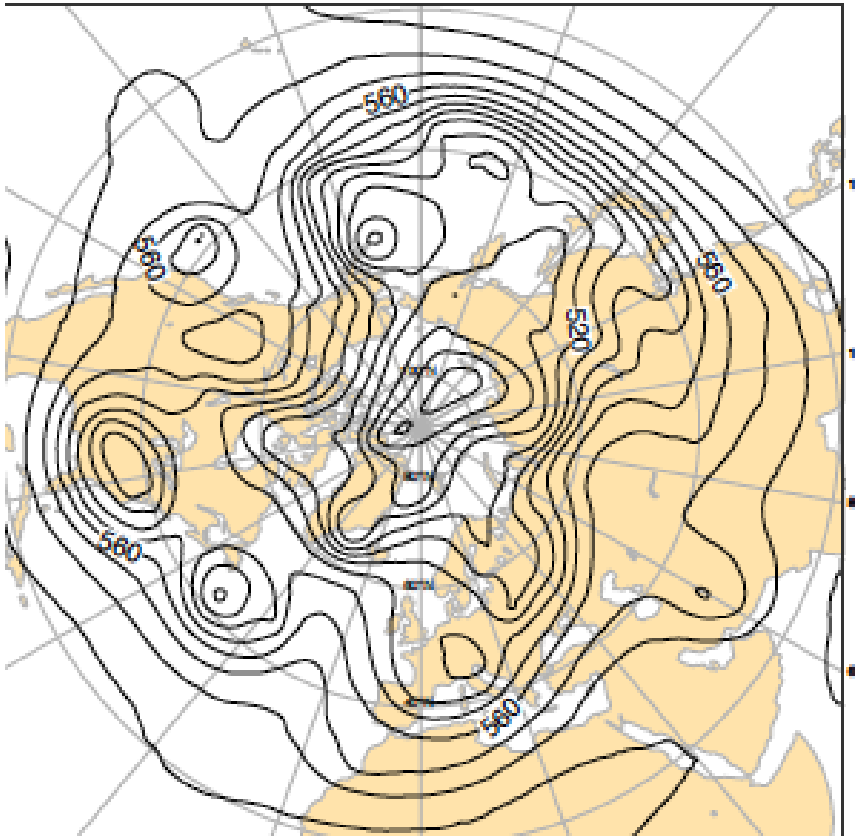


Analyses for 500 hPa height 50 years apart

NMC analysis 6.3.1965



CERA analysis 6.3.1965



END

With all my thanks to all those who devoted their strength, energy and creativity in building ECMWF and in particular to those that have left us forever.

We will always remember you.