Waves to Weather

Newsletter Jul/Sep 2023

Welcome to the final W2W newsletter. On behalf of everyone in the W2W community, I would like to thank you for your interest and support over the nine years of the program. We are very proud of the science that we have been able to do and we will continue to report this in conferences and journals. The most important software tools and data sets that we developed will be published, where this has not already happened, and the website will be updated from time to time until the final project end on 30 June 2024. On a personal note, it has been an honor to work with such a creative and collaborative team of scientists, and I look forward to continuing to work with the community that we have built up in W2W.

George Craig

Contents

If you have any questions or comments about this newsletter or W2W in general, we would be happy to hear from you!

Upcoming events

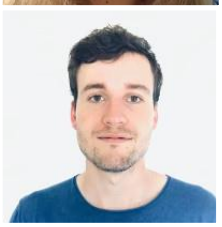
- A joint **SPARC DynVar - SNAP meeting on "The Role of Atmospheric Dynamics for Climate and Extremes"** will take place from 9-13 October 2023 at the LMU in Munich. It is co-organized by Thomas Birner and Hella Garny (W2W).
  For more information, visit:
  https://www.wavestoweather.de/meetings/sparc-snap-2023
- The final **W2W Annual Meeting** will take place on 27-28 November 2023 in Landau. The keynote speakers will be the three W2W Fellows: Linus Magnusson (ECMWF), Daniel Kirshbaum (McGill University) and Juliana Dias (NOAA). For more information about this meeting, visit:
  https://www.wavestoweather.de/meetings/w2w-ann-meet-2023

Additional information on upcoming events can be found here:
http://www.wavestoweather.de/meetings

News

Kirsten Tempest (A6) defended her PhD on 10 July 2023. Congratulations, and good luck with your next endeavours!

Congratulations, **Lea Eisenstein** (C5) for defending your PhD on 14 July 2023! Good luck, and have fun in your new position at KIT!



Congratulations, **Maurus Borne** (B6) for defending your PhD on 21 July 2023! We wish you all the best for your next career steps.

Seraphine Hauser (A8) defended her PhD on 21 July 2023. Congratulations, and good luck with your new endeavors!

Dear **Uğur Cayoglu**,
It has been a pleasure to get to know you and to work with you to prepare the third phase of W2W. We wish you all the best in your new endeavours!

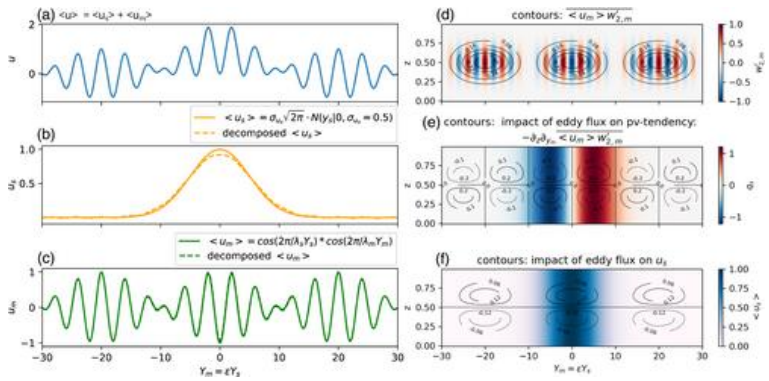
Lena Frey (B1) will leave W2W early October to go in the industry. We wish you all the best for this new chapter of your professional life!

Audine Laurian (Z1) will leave W2W early October to coordinate the Hanz-Ertel Zentrum für Wetterforschung (HErZ). Looking forward to the new challenges at DWD and staying in contact with some of the W2W community!

Research Highlights

Here are some examples of recently published research from W2W.

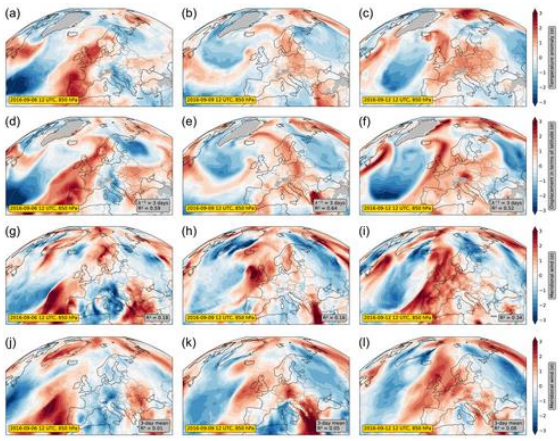
1. Scale interactions between the meso- and synoptic scales and the impact of diabatic heating (M. Hirt, G. Craig and R. Klein)



For both the meso- and synoptic scales, reduced mathematical models give insight into their dynamical behaviour. For the mesoscale, the weak temperature gradient approximation is one of several approaches, while for the synoptic scale the quasigeostrophic theory is well established. However, the way these two scales interact with each other is usually not included in such reduced models, thereby limiting our current perception of flow-dependent predictability and upscale error growth. Here, we address the scale interactions explicitly by developing a two-scale asymptotic model for the meso- and synoptic scales with two coupled sets of equations for the meso- and synoptic scales respectively.

Read the full article: https://doi.org/10.1002/qj.4456

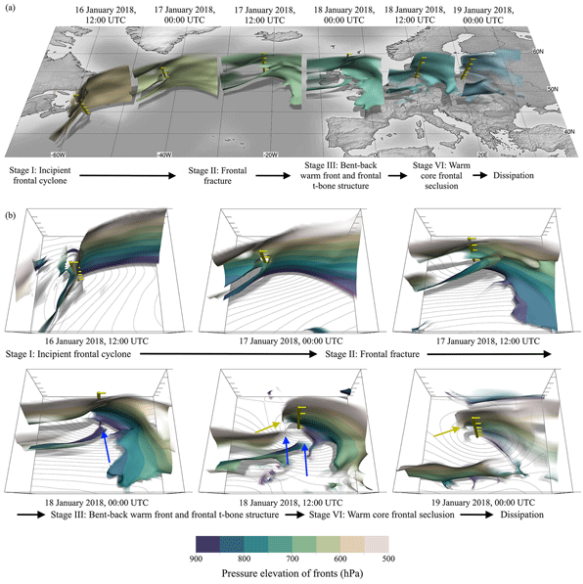
2. Lagrangian description of the atmospheric flow from Eulerian tracer advection with relaxation (A. Mayer and V. Wirth)



This article proposes an Eulerian method that allows one to extract Lagrangian information about the atmospheric flow. The method's utility is demonstrated on the basis of a few examples, which relate to cloud formation and the development of temperature anomalies. The examples highlight that the method provides a convenient diagnostic of parcel-based changes, paving an intuitive way to explore the physical processes involved.

Read the full article: https://doi.org/10.1002/qj.4453

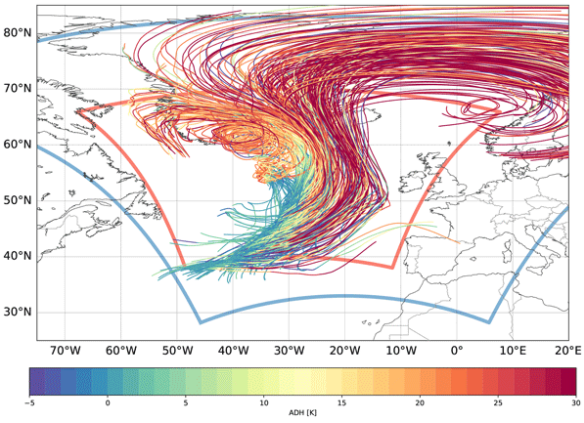
3. The three-dimensional structure of fronts in mid-latitude weather systems in numerical weather prediction models (A. Beckert, L. Eisenstein, A. Oertel, T. Hewson, G. Craig and M. Rautenhaus)



We investigate the benefit of objective 3-D front detection with modern interactive visual analysis techniques for case studies of extra-tropical cyclones and comparisons of frontal structures between different numerical weather prediction models. The 3-D frontal structures show agreement with 2-D fronts from surface analysis charts and augment them in the vertical dimension. We see great potential for more complex studies of atmospheric dynamics and for operational weather forecasting.

Read the full article: https://gmd.copernicus.org/articles/16/4427/2023/

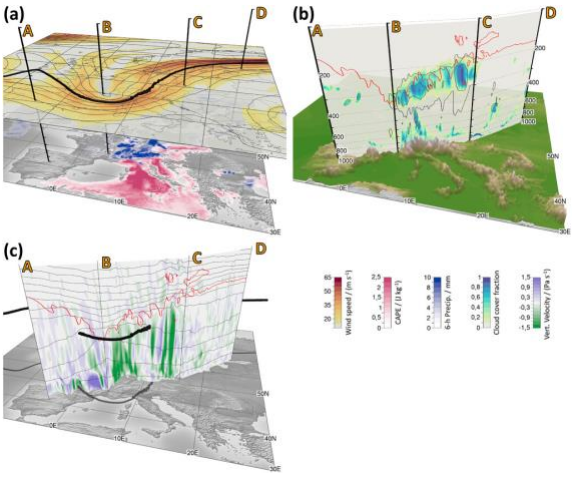
4. Interaction of microphysics and dynamics in a warm conveyor belt simulated with the ICOsahedral Nonhydrostatic (ICON) model (A. Oertel, A. K. Miltenberger, C. M. Grams and C. Hoose)



Warm conveyor belts (WCBs) are cloud- and precipitation-producing airstreams in extratropical cyclones that are important for the large-scale flow and cloud radiative forcing. We analyze cloud formation processes during WCB ascent in a two-moment microphysics scheme. Quantification of individual diabatic heating rates shows the importance of condensation, vapor deposition, rain evaporation, melting, and cloud-top radiative cooling for total heating and WCB-related potential vorticity structure.

Read the full article: https://doi.org/10.5194/acp-23-8553-2023

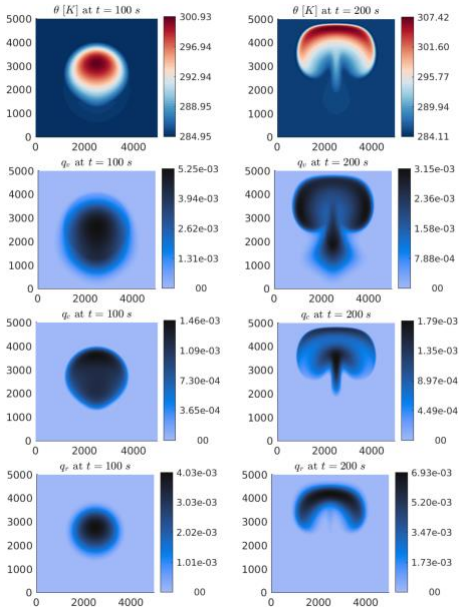
5. Interactive 3D Visual Analysis of Weather Prediction Data Reveals Midlatitude Overshooting Convection during the CIRRUS-HL Field Experiment (A. Schäfler and M. Rautenhaus)



We describe the use of 3D tropopause and cloud visualizations during a convective event over the Alps, which became one of the Cirrus High Latitude (CIRRUS-HL) airborne field campaign observation targets. The example presented provides a novel 3D perspective of convective overshooting in a global NWP model and its impact on the tropopause and lower stratosphere. The case study shall encourage the atmospheric science community to further evaluate the use of modern 3D visualization capabilities for NWP analysis.

Read the full article: https://doi.org/10.1175/BAMS-D-22-0103.1

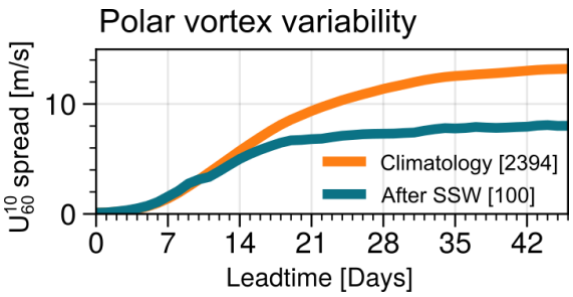
6. Comparison of uncertainty quantification methods for cloud simulation (T. Janjić, M. Lukáčová-Medviďová, Y. Ruckstuhl and B. Wiebe)



Quantification of evolving uncertainties is required for both probabilistic forecasting and data assimilation in weather prediction. We explore the so-called stochastic Galerkin (SG) method, which integrates uncertainties forward in time using a spectral approximation in stochastic space.

Read the full article: https://doi.org/10.1002/qj.4537

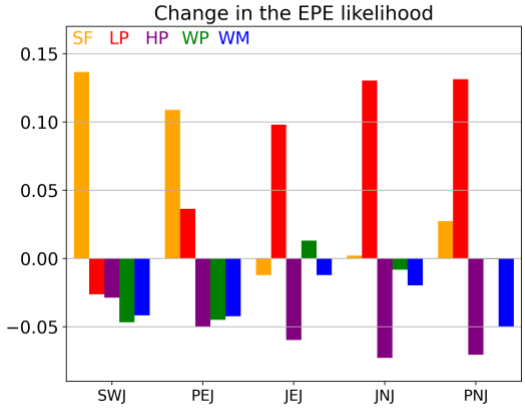
7. Enhanced Polar Vortex Predictability Following Sudden Stratospheric Warming Events (P. Rupp, J. Späth, H. Garny and T. Birner)



Sudden stratospheric warming (SSW) events can form a window of forecast opportunity for polar vortex predictions on subseasonal-to-seasonal time scales. Analyzing numerical ensemble simulations, we quantify the associated enhanced predictability due to reduced upward planetary wave fluxes during the mostly radiatively driven recovery phase following SSWs.

Read the full article: https://doi.org/10.1029/2023GL104057

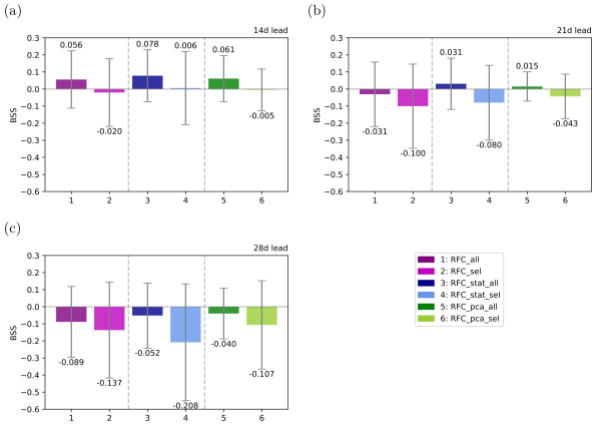
8. Regional extreme precipitation events in wintertime Japan facilitated by East-Asian large-scale flow patterns (T. Matsunobu, J. F. Quinting, C. M. Grams and M. Matsueda)



Synoptic weather is more predictable and often dominates a local extreme precipitation event (EPE). This study investigates the statistical and dynamical link between East-Asian weather patterns and local EPEs during winter in Japan. We find that two out of five weather patterns increase the likelihood of EPEs, but their respective contributions vary between regions due to differences in moisture transport facilitated by synoptic flow. This study has implications for the use of synoptic weather patterns in the forecasting of local extreme events.

Read the full article: https://doi.org/10.2151/sola.2023-033

9. Can Machine Learning Models be a Suitable Tool for Predicting Central European Cold Winter Weather on Subseasonal to Seasonal Timescales? (S. Kiefer, S. Lerch, P. Ludwig and J. G. Pinto)



Forecasting extremes on subseasonal to seasonal timescales is very challenging as the information from initial conditions is gradually lost. Here, Quantile Regression Forests (QRFs) and Random Forest Classifiers (RFCs) are used for probabilistic forecasting of Central European wintertime mean 2m temperatures and cold wave days at lead times of 14, 21 and 28 days. ERA5-reanalysis meteorological predictors are used as input data for the machine learning models. All used machine learning models are able to learn pattern in the data beyond climatology. A more detailed analysis using Shapley Additive Explanations suggest that both Random-Forest (RF) based models are able to learn physically known relationships in the data.

Read the full article: https://doi.org/10.1175/AIES-D-23-0020.1

Additional publications relevant to W2W are listed here:
http://www.wavestoweather.de/publications

Past activities

Daniel Kirshbaum (McGill University; W2W Fellow) visited the Institute of Meteorology and Climate Research at KIT on 3-6 July, and the Institute for Atmospheric Physics in Mainz on 7-11 July 2023. His hosts were Christian Keil (LMU), Christian Barthlott (KIT) and Annette Miltenberger (JGU). Read more about his visit here:
https://www.wavestoweather.de/guest/dan-kirshbaum

Linus Magnusson (ECMWF; W2W Fellow) visited KIT in Karlsruhe and the Johannes-Gutenberg University in Mainz from 19-23 June 2023, as a part of the fellowship in the W2W project. He gave a colloquium at both universities on the subject "Understanding forecast errors". To help to understand how different errors should be tackled, ongoing work to split forecast errors into different categories was discussed. The forecast errors can, as a first step, be divided into systematic (bias) and non-systematic errors. The systematic part can then be split into biases present already at short lead-times (12-24 hours) and growing biases with increased lead time (model drift). If verifying model data against observations, representativeness errors (sometimes referred to as observation errors) need to be included as well as the observation and model represents different scales and local conditions. Finally, a category about interpretation errors was added, to include errors that appears after the NWP forecast is produced until in it understood by the user. However, when making an error decomposition the sample should optimally be stratified according to location, weather regime, etc. as many of the errors are conditional. The aim of the division is to better understand how a forecast error should be approached in the forecast system development.
In the past year, a lot of developments has been seen in the field of medium-range forecasts based on machine learning, and the presentations also included some evaluation of ML models against ECMWF forecasts. ECMWF is running several of the available ML models and apply the operational verification tools to them. The presentation mainly focused on the PanguWeather model with both statistical evaluation and cases of extreme weather. Updated results are available in the links below.
During both visits, different predictability problems related to W2W were discussed such as weather regime predictions, predictability barriers, and error growth in general. With the developments of ML models, it is an open question how these can be used in predictability studies. If the models are capturing the relevant error growth, it can open up for a new type of forecast experiments to understand error propagation.

References to evaluation of machine learning models:

- https://doi.org/10.48550/arXiv.2307.10128
- https://www.ecmwf.int/en/newsletter/176/news/exploring-machine-learning-forecasts-extreme-weather

Seminars and guest program

Simon H. Lee (Columbia University) will give a special seminar at KIT on **17 October 2023** on "A New Year-Round Weather Regime Classification for North America". This hybrid event is organized by Seraphine Hauser (A8 project, KIT). Simon Lee has expertise on subseasonal prediction, climate variability and change, and stratosphere-troposphere coupling. He will visit KIT-IMK from 16 to 18 October 2023.

Read about the **W2W Fellows program** here:
https://www.wavestoweather.de/guest

Information about previous **guest scientists** invited by W2W is posted here:
http://www.wavestoweather.de/guest

Past and upcoming **W2W seminars** are listed here:
http://www.wavestoweather.de/seminars

Most seminars and colloquium are broadcasted live. If you would like to receive a link to listen to the presentation, please contact us.

Communication

Dissemination

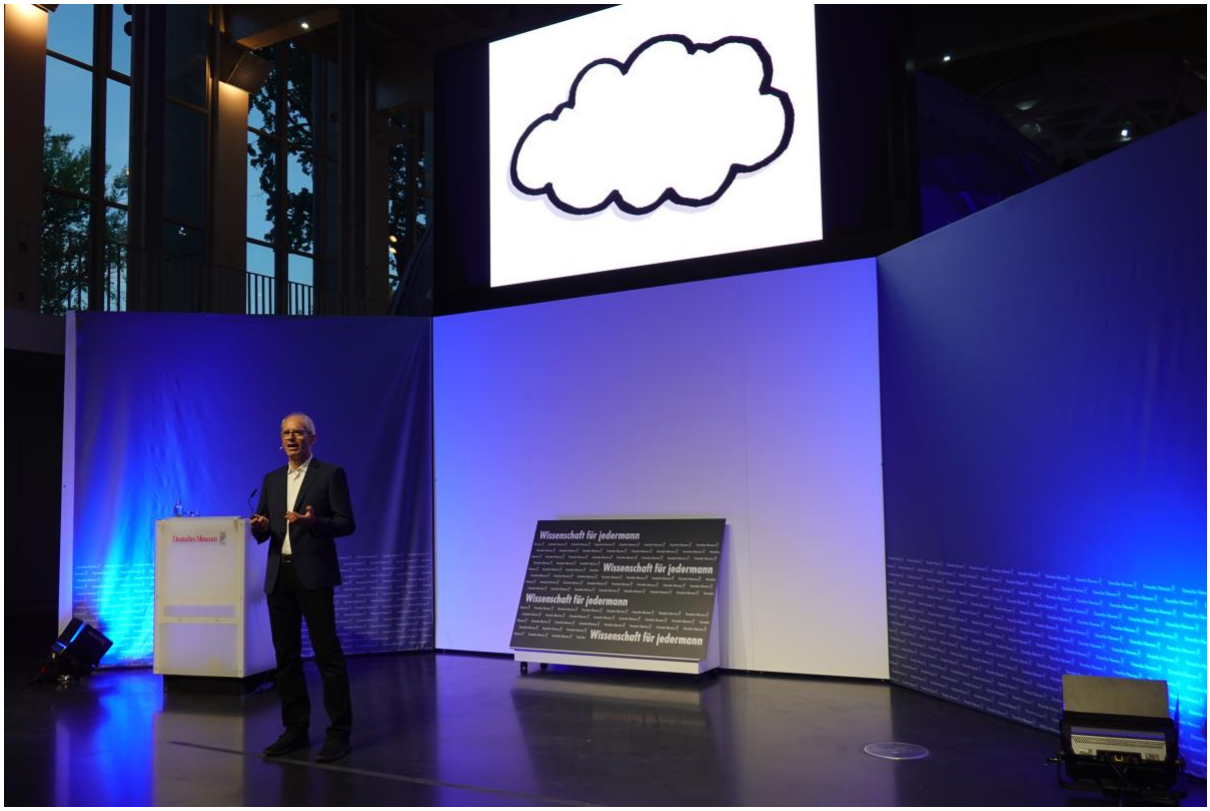
Past issues of the newsletter

Past issues of this newsletter are available here:
https://www.wavestoweather.de/communication/dissemination-activities/publications/quarterly_newsletter

Outreach

Presentation in the Deutsches Museum

Bernhard Mayer gave a presentation about clouds within the seminar series "Wissenschaft für jedermann" at the Deutsches Museum in Munich on 20 September 2023. The auditorium was fully booked with ca. 100 listeners of all ages and backgrounds, and about 250 interested people joined the event online. The presentation gave an overview of the different clouds, how they form, how they influence our weather and climate, and the challenges associated with clouds for the scientific community. A friendly discussion concluded the evening.



Bernhard Mayer at the Deutsches Museum on 20 September 2023

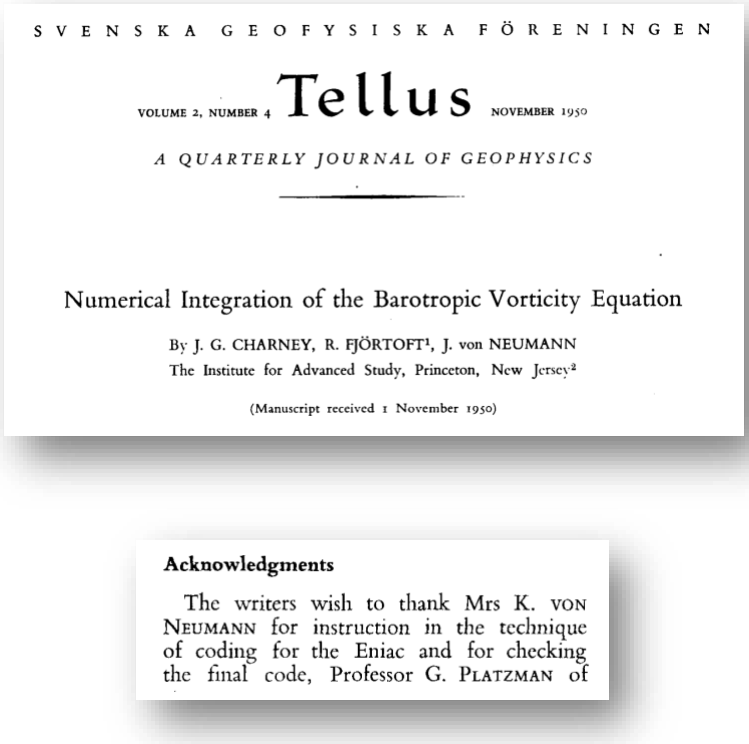
You can watch the presentation online, here:
https://www.youtube.com/watch?v=6QIO95gn6B8

For more information visit: https://www.wavestoweather.de/communication/outreach-activities/presentations-general-public/deutsches-museum-sep-2023

Equal opportunity (EO) activities

Klára Dán von Neumann's role in numerical weather forecasts – Text by Corinna Hoose

In 1950, Jule Charney, Ragnar Fjørtoft, and John von Neumann published a now-famous paper in Tellus, reporting about the first successful numerical weather forecast (Charney et al., 1950, see Fig. 1). The acknowledgements start with an interesting sentence: "The writers wish to thank Mrs. K. von Neumann for instruction in the technique of coding for the Eniac and for checking the final code […]". The Eniac, short for Electronic Numerical Integra-tor and Computer, was the world's first programmable general-purpose digital computer. But who is K. von Neumann and what was her role in this seminal work? I stumbled upon her story in the fantastic podcast "Lost Women of Science" (Hafner, 2022), and here is a short summary.



SVENSKA GEOFYSISKA FÖRENINGEN

VOLUME 2, NUMBER 4 **Tellus** NOVEMBER 1950

A QUARTERLY JOURNAL OF GEOPHYSICS

Numerical Integration of the Barotropic Vorticity Equation

By J. G. CHARNEY, R. FJÖRTOFT[1], J. von NEUMANN
The Institute for Advanced Study, Princeton, New Jersey[2]

(Manuscript received 1 November 1950)

Acknowledgments

The writers wish to thank Mrs K. VON NEUMANN for instruction in the technique of coding for the Eniac and for checking the final code, Professor G. PLATZMAN of

Figure 1: Title page and beginning of the Acknowledgements of Charney et al. (1950)

Klárá Dán von Neumann (Fig. 2) was a remarkable woman with an eventful life. Born in Budapest in 1911, she was Hungarian national champion in figure skating at the age of 14. She received a very good high school education, but never attended university (except for enrolling for one course in calculus in 1947, when she was already employed as Head of the Statistical Computing group in Princeton). At the age of 27, she married John von Neumann, already then a famous mathematician, as her third husband, and emigrated with him to the US to escape the prosecution of Jews in Europe. She self-trained to work as mathematician and engineer and worked at the Office of Population Research in Princeton, while John von Neumann moved to Los Alamos to join the Manhattan project, playing a central role in the development of the atomic bomb. After the end of the second world war, Klárá Dán von Neumann also was employed in Los Alamos and became one of the first computer programmers.

Figure 2: Klárá Dán von Neumann. Source: wikipedia.com

There were no instructions available on how to operate the first computers - Klárá Dán developed the methods together with her (mostly female) colleagues and wrote the instructions herself. In particular, Klárá Dán von Neumann coded the first Monte Carlo simulations in 1948, which were used to predict processes inside exploding nuclear weapons (Haigh et al., 2014). There is no record of Klárá Dán von Neumann's personal opinion on how she ethically evaluated her contribution to the development of mass extinction weapons, but a re-cent book (Bennes, 2022) explores the connection between the development of modern computers, nuclear weapon research, and Klárá Dán von Neumann's life. She also taught others about the implementation of computer code. Her exact role in the first numerical weather forecast, however, is not fully clear. Some news articles see her as the "woman behind the weather forecast" and go as far as accusing Charney et al. of bad scientific practice for denying co-authorship to Klárá Dán von Neumann. However, in-depth research by Katie Hafner and colleagues for the "Lost Women of Science" podcast reveals that this appears to be a myth, and that while Klárá Dán von Neumann's contributions to the development of modern coding paradigms and methods for the Eniac machine are eminent, she was most likely not directly involved in running the first weather forecast, except for general technical assistance. The two programmers who actually ran the simulation were (Mrs.) Homé McAllister and (Mr.) Clyde Hauff (Hafner, 2022).

References

Charney, J.G., Fjörtoft, R. and Von Neumann, J. (1950), Numerical Integration of the Barotropic Vorticity Equation. Tellus, 2: 237-254. https://doi.org/10.1111/j.2153-3490.1950.tb00336.x

T. Haigh, M. Priestley and C. Rope, "Los Alamos Bets on ENIAC: Nuclear Monte Carlo Simulations, 1947-1948," in IEEE Annals of the History of Computing, vol. 36, no. 3, pp. 42-63, July-Sept. 2014, doi: 10.1109/MAHC.2014.40.

Bennes, C. (2022), Klara and the Bomb, Wilco Art Books (NL), ISBN 978-94-92051-82-0.

Hafner, K. (2022), Lost Women of Science. A Grasshopper in Very Tall Grass. https://www.lostwomenofscience.org/season-2

EO measures in W2W

- Read about the EO committee: http://www.wavestoweather.de/equal_opportunity/contact
- Read about the EO measures offered in W2W: http://www.wavestoweather.de/equal_opportunity/eo_measures
- Read about the EO measures and activities already implemented: http://www.wavestoweather.de/equal_opportunity/activities

Summer's highlight

Ettlingen, September 2022. Photo: Behrooz Keshtgar

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