Waves to Weather

Newsletter Jul/Sep 2018

The primary goal of Waves to Weather is understand the predictability of high impact weather, and in our research highlights this quarter we have important new results on probabilistic predictions of wind storms and the large-scale dynamics leading to heat waves. But a second goal is to develop new methods and tools to explore the atmosphere, and this newsletter also highlights papers on new visualization techniques for forecast sensitivities and for frontal features, as well as an application of deep learning to cumulus parameterization. This last project was initiated by one of our Early Career Scientists (ECS) and developed during a visit overseas that we were able to support. Supporting ECS in advancing their careers is of course our third goal. Happy reading!

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

The **7th Workshop on European Storms** will take place at KIT "Campus South" in Karlsruhe from October 10th – 12th 2018. The workshop is organized by Joaquim Pinto, Florian Pantillon and Patrick Ludwig and is sponsored by W2W. For more information, please visit: http://www.wavestoweather.de/meetings/windstorm-2018

The **4th Annual Meeting of W2W** will take place in Landau (Pfalz) from November 12th – 14th 2018. Information about the program, the venue, keynote speakers, etc. is available here: http://www.wavestoweather.de/meetings/4th-annual-meeting-nov18

The next **Cyclone Workshop** will be organized by W2W and will take place in Seeon (Bavaria, Germany) from September 29th – October 4th 2019. Save the date!
The website of the previous Cyclone workshop is here: http://www.atmos.albany.edu/facstaff/rmctc/cw18

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

Please contact us if you have any questions.

News

The **AMS special collection "W2W"** is online and currently features 11 articles:
https://journals.ametsoc.org/topic/w2w

The article by **Stephan Rasp** and his collaborators from UC Irvine and Columbia University on "Deep learning to represent sub-grid processes in climate models" has been featured online. For more information, visit:
https://phys.org/news/2018-09-ai-climate.html
https://www.uni-muenchen.de/forschung/news/2018/rasp_klimamodelle.html

In the **newsletter** of the **WMO High Impact Weather Project** (HIWeather; issue of September 2018) Brian Golding writes: "As well as the usual entries, this edition includes a list of recent papers from the Waves-2-Weather project in Germany, which is affiliated to HIWeather. Some really impressive progress has been made in several of the focal areas of the Processes and Predictability theme." The AMS Special Collection for W2W and a detailed list of W2W publications are also mentioned.

Research Highlights

Here are some examples of recently published research from W2W.

1. Forecasting wind gusts in winter storms using a calibrated convection-permitting ensemble (F. Pantillon, S. Lerch, P. Knippertz and U. Corsmeier)
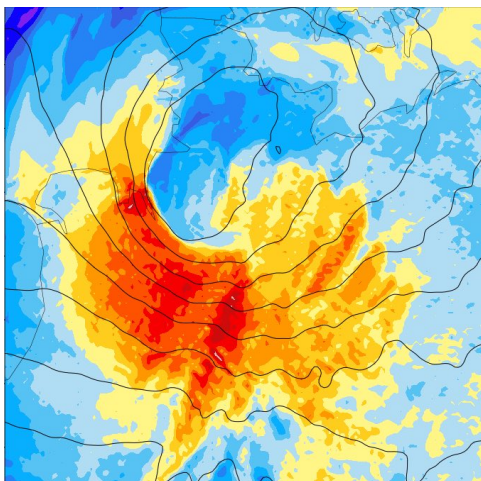
The predictability of wind gusts during winter storms is investigated in a novel 6-year dataset of 21-hour convection-permitting ensemble forecasts over Germany. Post-processing using ensemble model output statistics improves the predicting performance in the whole dataset but also reveals storms with uncharacteristic forecast errors. Reduced predictability is found in cases involving frontal convection, while in other cases it is largely inherited from the synoptic scale, which can lead to high forecast uncertainty even at short range.

Read the full article: https://rmets.onlinelibrary.wiley.com/doi/abs/10.1002/qj.3380

2. Visual Analysis of the Temporal Evolution of Ensemble Forecast Sensitivities (A. Kumpf, M. Rautenhaus, M. Riemer and R. Westermann)
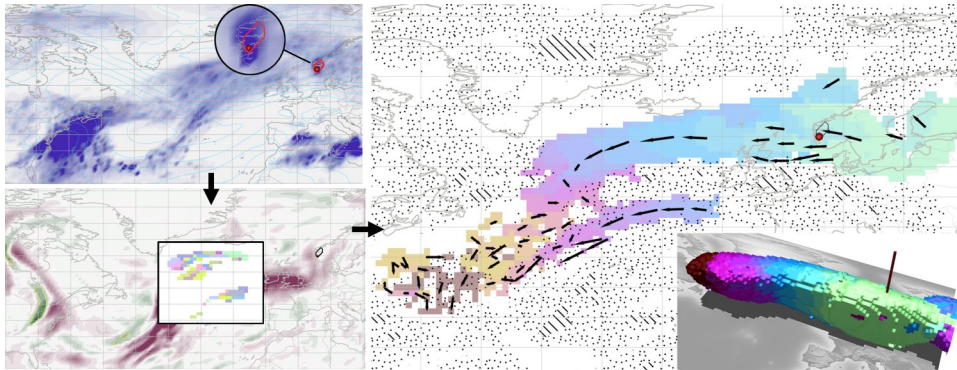
Ensemble sensitivity analysis (ESA) can be used to determine the sensitivity of a scalar forecast metric J computed over a region to changes in another model variable at a different model state. However, the outcome depends heavily on a suitable region selection for the metric J. In our workflow, we propose "correlation cliques", an automated approach to find statistically coherent regions based on pairwise correlations. Further, our system automatically tracks sensitive regions over time by using optical flow based tracking in forward and backward direction. It provides overview plots depicting paths and split-merge events of structures, and analyzes the statistical stability of selected regions. We apply the workflow to investigate sensitivities related to the extratropical transition of tropical cyclone "Karl" in late September 2016.

Read the full article: https://doi.org/10.1109/tvcg.2018.2864901

3. Interactive 3D Visual Analysis of Atmospheric Fronts (M. Kern, T. Hewson, A. Schäfler, R. Westermann and M. Rautenhaus)
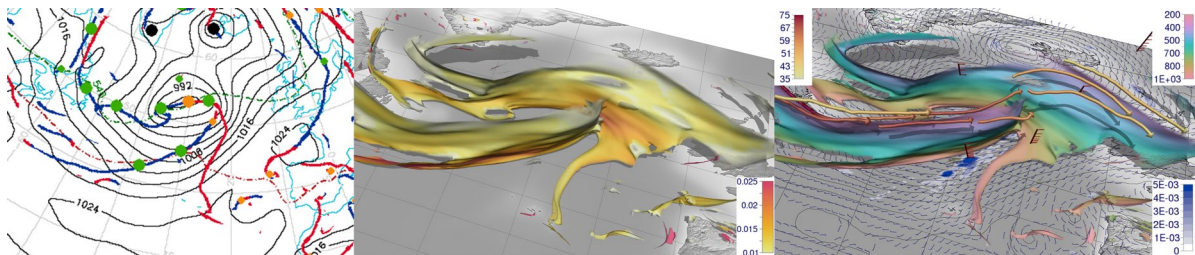

The objective detection of atmospheric fronts is essential in weather forecasting, as fronts are associated with significant weather activities ranging from temperature changes to severe weather events. Although there are conceptual models describing the 3D-structure of fronts, existing methods only focus on the frontal structure in 2D. Building upon these 2D detection methods, we present a new approach to objectively detect atmospheric fronts as 3D surfaces and techniques to visualize the frontal surface and frontal zone. We also compute the distribution of atmospheric variables within this zone and demonstrate the results and benefit of our approach with two real-world cases using NWP data.

Read the full article: https://ieeexplore.ieee.org/document/8440076

4. Deep learning to represent sub-grid processes in climate models (S. Rasp, M. S. Pritchard and P. Gentine)
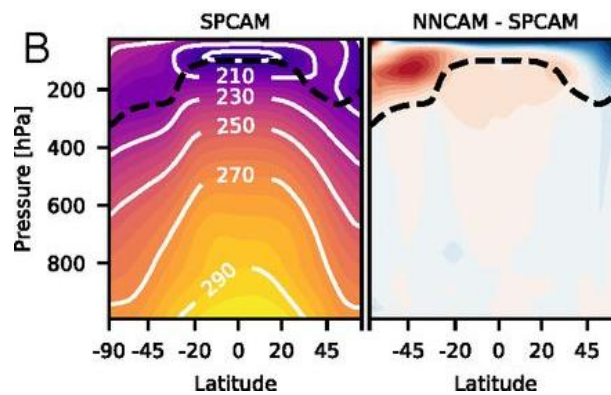
Current climate models require the parameterization of many of the atmosphere's most important processes. However, imperfections in these parameterizations, especially for clouds, have impeded progress toward more accurate climate predictions for decades. Cloud-resolving models alleviate many of the gravest issues of their coarse counterparts but will remain too computationally demanding for climate change predictions for the foreseeable future. Here we use deep learning to leverage the power of short-term cloud-resolving simulations for climate modelling. Our data-driven model is fast and accurate, thereby showing the potential of machine-learning–based approaches to climate model development. The figure shows that the tropospheric temperature of the deep learning model (NNCAM) only differs slightly from the high-resolution reference (SPCAM).

Read the full article: http://www.pnas.org/content/early/2018/09/05/1810286115

5. Large-scale Rossby wave and synoptic-scale dynamic analyses of the unusually late 2016 heat wave over Europe (P. Zschenderlein, G. Fragkoulidis, A. H. Fink, and V. Wirth)
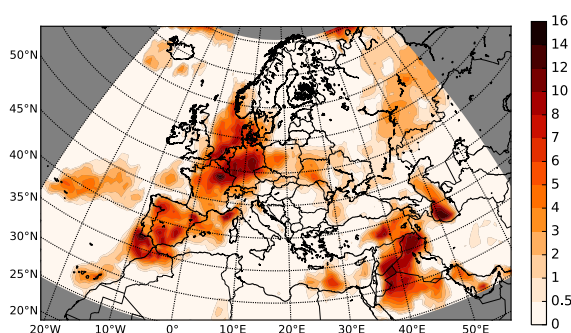
Parts of Europe were affected by a heat wave in the late summer of 2016 with record-breaking temperatures for this time of the year. The heat wave was associated with successive Rossby wave packets, which originated in western North America. During the heat wave, subsidence and ensuing adiabatic compression in the free atmosphere in combination with boundary layer processes rather than temperature advection were instrumental in the explanation of the extreme temperatures at the three selected surface stations.

Read the full article: https://doi.org/10.1002/wea.3278

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

Past activities

Kompaktseminar Numerik workshop

From September 12th – 14th 2018 the numerical analysis working group of JGU-Mainz organized the Kompaktseminar Numerik workshop, which was attended by several members of W2W, including people from JGU-Mainz and LMU-Munich. The main goal of the workshop was to focus on interdisciplinary aspects of W2W with a strong focus on mathematical details. Among the participants was Markus Bachmayr (https://www.numerik.mathematik.uni-mainz.de/bachmayr/) who has been appointed on September 1st 2018 as a new colleague at the mathematics department of JGU. Markus is an expert in uncertainty quantification and he contributed a lot of insights during the discussions at the workshop.

The topics of the individual talks were ranging from questions of existence and uniqueness of differential equations that occur in cloud physics, convergence of finite volume methods for the Euler equations, parameter estimation techniques using Kalman type filters, to the detection of coherent air streams in tropical storms, and to mathematical models for homogeneous ice nucleation. Further talks on stochastic Stokes equations, stochastic Galerkin methods for cloud simulations, and uncertainty quantification of cloud models demonstrated that some W2W projects have already applied uncertainty quantification techniques, and the corresponding people are faithfully looking forward to further improve their results and to benefit from discussions with Markus.

The meeting took place at the small village Kaub in the center of the romantic Rhine valley, not far from the famous Loreley. We gratefully acknowledge the financial support from W2W, and we hope to organize a similar workshop in two years.

Participants of the Kompaktseminar Numerik 2018 in Kaub

More information about the workshop can be found here:
http://www.wavestoweather.de/meetings/kompaktseminar-numerik-2018

Early Career Scientists workshop on Machine Learning and Neural Networks
In recent years computational techniques, such as Neural Networks and other Machine learning methods have become increasingly fashionable also for meteorological applications. Due to the high interest in the topic and to exploit its potential, the Early Career Scientists felt the need to be further trained in these methods. They organized a workshop on Machine Learning and Neural Networks from September 24th – 26th 2018 at the Schneefernerhaus on the Zugspitze (Bavaria). The 22 participants and 3 instructors found perfect study conditions in the calm mountain atmosphere.

Together with the invited guest Martin Felder (Zentrum für Sonnenenergie und Wasserstoff-Forschung Baden-Württemberg), Stephan Rasp (W2W) and Sebastian Lerch (W2W) designed a very dense and highly instructive program. A mixture of basic and advanced lectures and well explained hands-on exercises lead to a stimulating environment. Starting with basic linear regression models, the ECS learned to apply highly complex techniques such as random forests, embedded neural networks, and convolutional neural networks with multiple hidden layers using the python libraries "keras" and "scikit_learn". At the end of each of the 6 hands-on sessions, the ECS had sufficient time to apply their own ideas based on the techniques learned. To increase the motivation, they evaluated their results in a competition using a web application, where they fought for the first places, i.e. the best trained models.

Furthermore, the ECS learned about the research performed at the Schneefernerhaus during a guided tour, they enjoyed lunch, sunny weather, and panoramic views on the Zugspitz-summit, and finally went sledding on Zusgspitzplatt together.

To read more about the workshop:
http://www.wavestoweather.de/meetings/workshop_neural_networks_sep18

Seminars and guest program

Shira Raveh-Rubin (Weizmann Institute of Science, Israel) will be a W2W guest during the summer semester 2019. She will give a talk at the IMK-Colloquium at KIT and will also visit the meteorological institutes in Mainz and in Munich.
Her homepage: http://www.weizmann.ac.il/EPS/raveh-rubin/home

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

The seminars and colloquium are broadcasted live using **Adobe Connect**. If you would like to receive a link to listen to the presentation, please contact us.

Recent outreach and equal opportunity activities

Interview
George Craig gave an interview on September 15th 2018 for the **Nürnberger Zeitung**.
To read more, visit: http://www.wavestoweather.de/outreach

"Mädchen machen Technik" summer program
A few ECS in W2W and at the meteorological institute at the LMU offered a workshop called "Wind, Wetter und Klimawandel" for the summer program "Mädchen machen Technik". On September 3rd– 4th 2018 ten schoolgirls between 12 and 14 years old got a taste of the complex atmospheric processes by learning about the water cycle and the formation of precipitation using a marble run model. They performed experiments to learn about temperature, pressure and convection. For example, they constructed their own thermometer and produced clouds in a glass. After taking part in lab experiments to simulate and explain the Föhn winds, the schoolgirls learned about where data comes from by visiting the weather station at the institute. This first day was a nice introduction to better understand the challenges of weather and climate forecasting, which were presented on the second day. After a weather briefing, the schoolgirls experienced the challenges of weather forecasting by producing their own numerical weather prediction (see *Charlton-Perez and Dacre* 2011). In the afternoon, the forecast horizon was extended to climate predictions. The participants learned about the challenges of long-range forecasting and took part in the great challenge of climate negotiations during a role play.
The program was fully booked and the participants were highly motivated and interested. Their feedback was very positive. They especially enjoyed the experiments and were very happy to talk to the volunteers about studying meteorology at the university and the everyday life at the institute.

Top left: numerical weather forecasting – the Forecast Factory for real. Top right: role play on climate negotiations. Bottom left: group of participants and some volunteers. Bottom right: the "egg in the bottle" experiment

More information about this event:

- http://www.wavestoweather.de/equal_opportunity/activities/maedchenmachentechnik2018
- Charlton-Perez, A. and Dacre, H., 2011: Lewis Fry Richardson's forecast factory - for real, *Weather*, **66 (2)**, 52-54, doi: https://doi.org/10.1002/wea.670
- https://www.climateinteractive.org

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

Past issues of this newsletter are available here:
http://www.wavestoweather.de/outreach/quarterly_newsletter

Summer's highlight

Thunderstorm close to Passau, Germany, in the late afternoon on June 24th 2016 (photo: Volkmar Wirth)

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