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Első tapasztalatok a GraphCast időjárás-előrejelző modellel

Leelőssy Ádám, Varga-Balogh Adrienn, Varga László

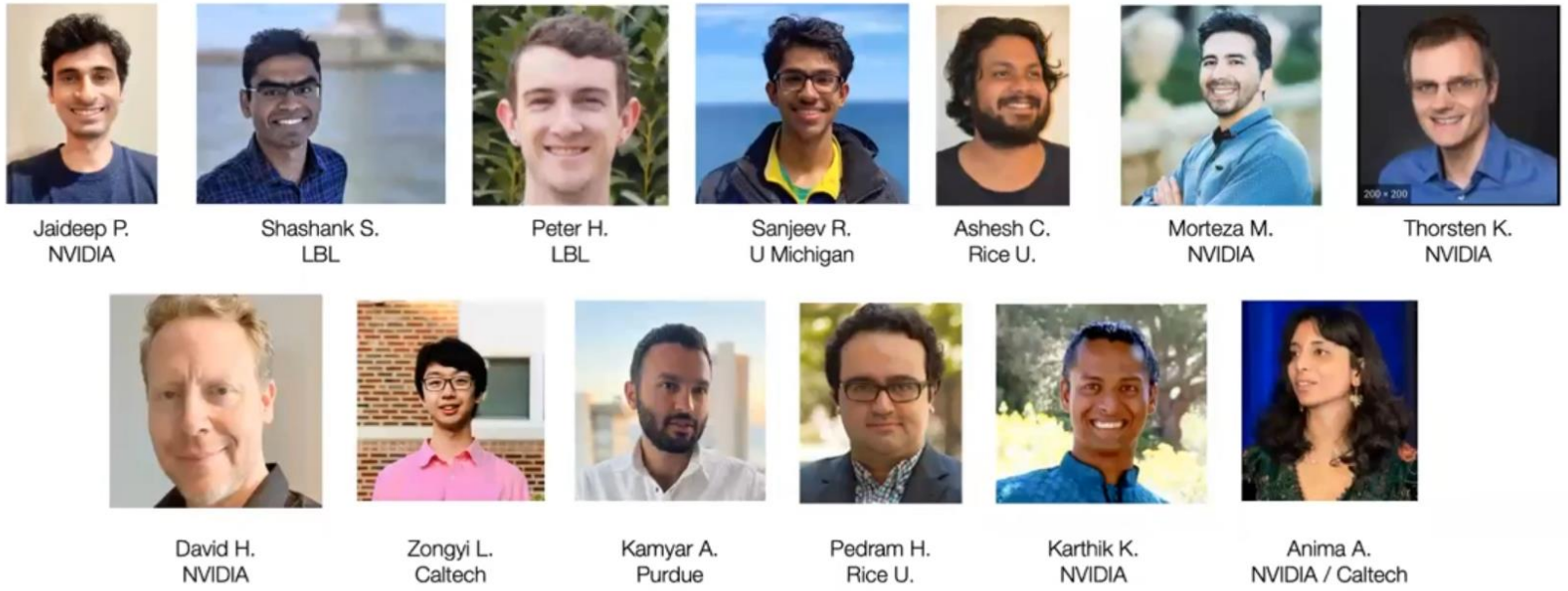
ELTE Meteorológiai Tanszék

NEMZETI LABOR

ELTE | TTK

2022. február 24. – NVidia FourCastNet

Team



Pathak et al. "FourCastNet: A Global Data-driven High-resolution Weather Model using Adaptive Fourier Neural Operators." *arXiv:2202.11214* (2022).

FourCastNet: A Global Data-driven High-resolution Weather Model using Adaptive Fourier Neural Operators

A Preprint

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February 24, 2022

2023. július 5. – Huawei Pangu-Weather

nature

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nature › articles › article

Article | Open access | Published: 05 July 2023

Accurate medium-range global weather forecasting with 3D neural networks

Kaifeng Bi, Lingxi Xie, Hengheng Zhang, Xin Chen, Xiaotao Gu & Qi Tian ✉

Nature **619**, 533–538 (2023) | Cite this article

185k Accesses | **102** Citations | **1678** Altmetric | Metrics

2023. november 14. – Google GraphCast

RESEARCH ARTICLE | WEATHER FORECASTING

Learning skillful medium-range global weather fore-casting

REMI LAM, ALVARO SANCHEZ-GONZ
TIMO EWALDS, ZACH EATON-ROSEN

SCIENCE · 14 Nov 2023 · Vol 382, Issu

181 666 10

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2023. október – ECMWF AIFS

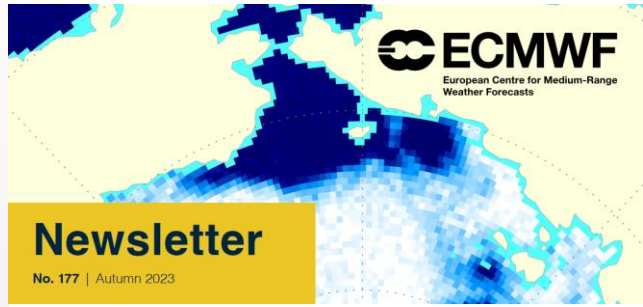
editorial

The AIFS is launched

As I write this editorial, we are launching the Artificial Intelligence/Integrated Forecasting System (AIFS). This is our first forecasting system that is entirely based on machine learning, apart from establishing the initial conditions of forecasts. We are making it public in an alpha version: it has a resolution of approximately one degree (111 km), and it makes predictions for wind, temperature, humidity, geopotential and more. This is just a starting point. The AIFS will be regularly updated to increase resolution and to add fields. It will also be developed into an ensemble syste produce a set of forecasts that include uncertainty inherent in any weather pr

The development of the AIFS does nc abandoning our current physics-base an ensemble-based system, which w

Machine learning is not just making inroads into forecasting but also into establishing the best possible initial conditions for forecasts. One of the articles in this Newsletter looks into the growing role of machine learning in data assimilation. It takes the view that we will make the furthest



AIFS: a new ECMWF forecasting system

Simon Lang, Mihai Alexe, Matthew Chantry, Jesper Dramsch, Florian Pinault, Baudouin Raoult, Zied Ben Bouallègue, Mariana Clare, Christian Lessig, Linus Magnusson, Ana Prieto Nemesio

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...eközben Sanghajban

nature › npj climate and atmospheric science › articles › article

Article | Open access | Published: 16 November 2023

FuXi: a cascade machine learning forecasting system for 15-day global weather forecast

Lei Chen, Xiaohui Zhong, Feng Zhang, Yuan Cheng, Yinghui Xu, Yuan Qi ✉ &

npj Climate and Atmospheric Science **6**, Article number: 190 (2023) | Cite thi

6910 Accesses | **8** Citations | **3** Altmetric | Metrics

| 6 Apr 2023

FengWu: Pushing the Skillful Global Medium-range Weather Forecast beyond 10 Days Lead

A Preprint

Kang Chen [1,2,*] **Tao Han** [1,*] **Junchao Gong** [1,3,*] **Lei Bai** [1,*,†] **Fenghua Ling** [4] **Jing-Jia Luo** [4]

Xi Chen [5] **Leiming Ma** [6] **Tianning Zhang** [1] **Rui Su** [1] **Yuanzheng Ci** [1] **Bin Li** [2]

Xiaokang Yang [3] **Wanli Ouyang** [1]

[*] **Equal Contributions,** [†] **Project Lead, bailei@pjlab.org.cn**

[1] **Shanghai Artificial Intelligence Laboratory** [2] **University of Science and Technology of China**

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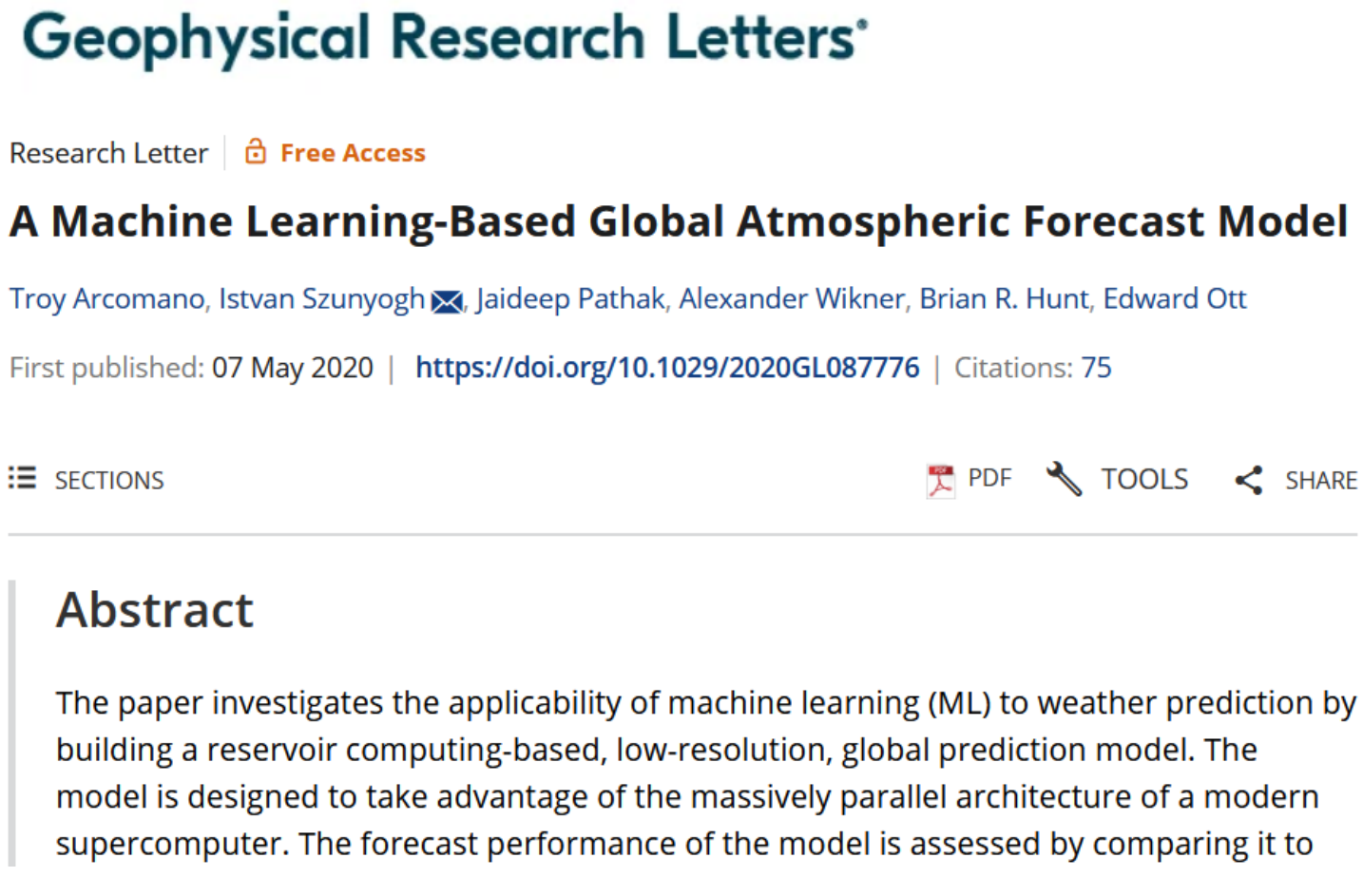
...mindenhol van egy magyar



Geophysical Research Letters

Research Letter | Free Access

A Machine Learning-Based Global Atmospheric Forecast Model

Troy Arcomano, Istvan Szunyogh, Jaideep Pathak, Alexander Wikner, Brian R. Hunt, Edward Ott

First published: 07 May 2020 | https://doi.org/10.1029/2020GL087776 | Citations: 75

SECTIONS PDF TOOLS SHARE

Abstract

The paper investigates the applicability of machine learning (ML) to weather prediction by building a reservoir computing-based, low-resolution, global prediction model. The model is designed to take advantage of the massively parallel architecture of a modern supercomputer. The forecast performance of the model is assessed by comparing it to

GraphCast

Google DeepMind – ECMWF, 2023

- **Tanítás**
  - Tanító halmaz: 1979–2017 ERA5
  - Tanítási idő: kb. 4 nap
- **Futtatás**
  - Kiindulási mező: ECMWF IFS analízis
  - kb. 1 perc / 10 nap futási idő, Google TPU v5
  - 0,25° / 1°, 6 óra felbontás
  - Operatív futtatás: ECMWF, 2x/nap
  - ECMWF grib kimenet, nyílt forráskód,
  - Python csomag, Google Colab

Változók

- Hőmérséklet,
- Szél
- Geopotenciál
- Specifikus nedvesség
- Feláramlás
- 37 nyomási szint
- 2 m hőmérséklet, 10 m szél, tengerszinti légnyomás, csapadékösszeg

Az előrejelzések beválása

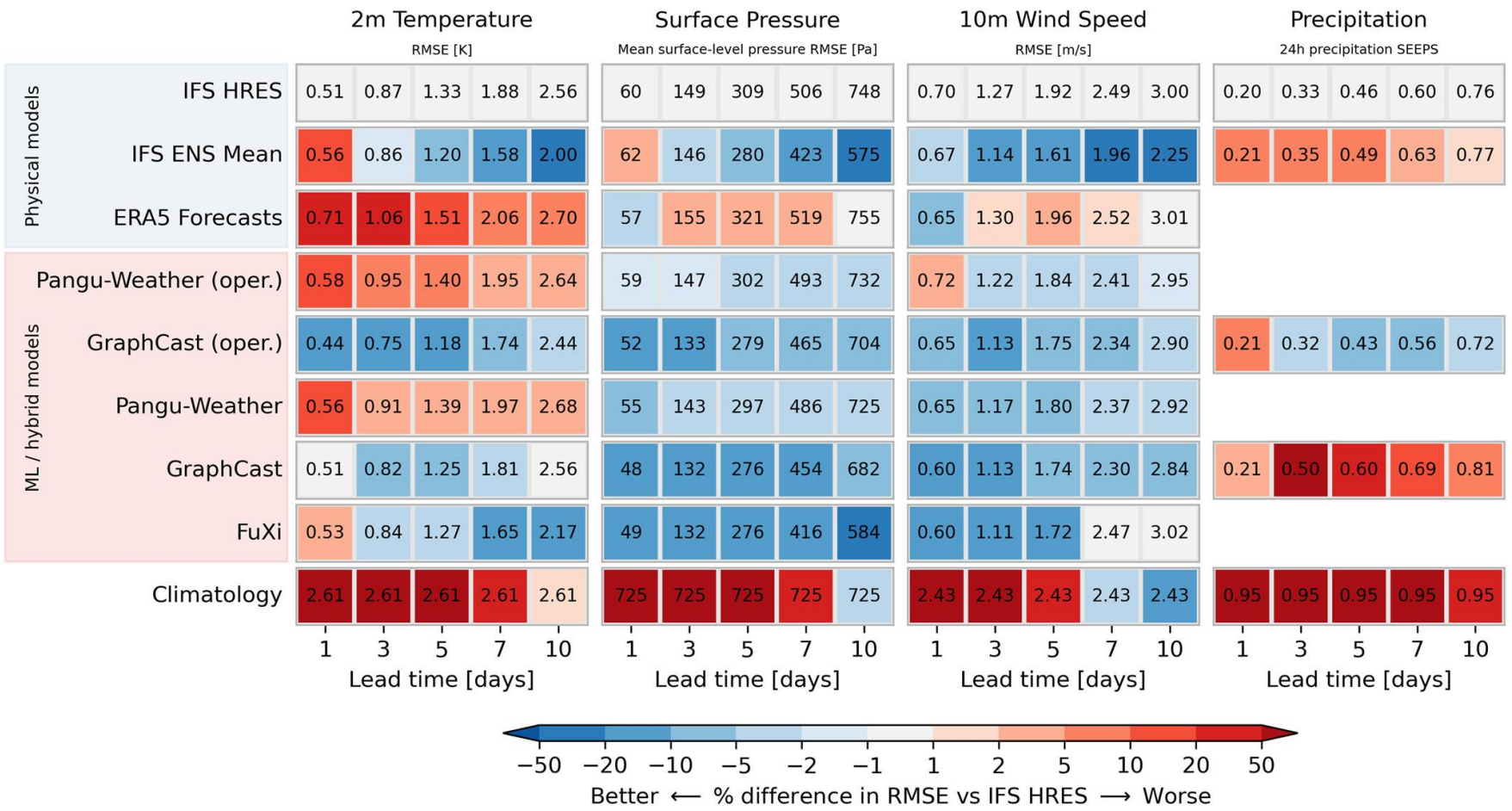
JAMES | Journal of Advances in Modeling Earth Systems

Research Article | Open Access

WeatherBench 2: A Benchmark for the Next Generation of Data-Driven Global Weather Models

Stephan Rasp, Stephan Hoyer, Alexander Merose, Ian Langmore, Peter Battaglia, Tyler Russell, Alvaro Sanchez-Gonzalez, Vivian Yang, Rob Carver ... See all authors

First published: 18 June 2024 | https://doi.org/10.1029/2023MS004019 | Citations: 2



Színskála: előrejelzés minősége az ECMWF IFS modellhez képest.

Számértékek: RMSE (csapadék esetében SSE) az ERA5-höz viszonyítva.

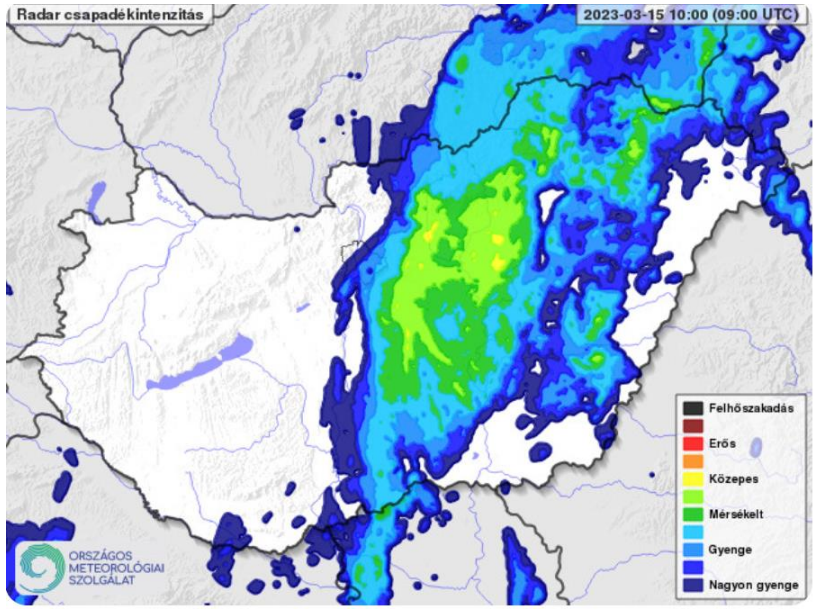
2020-as év globális átlaga.

Forrás: WeatherBench2, Rasp et al. (2024)

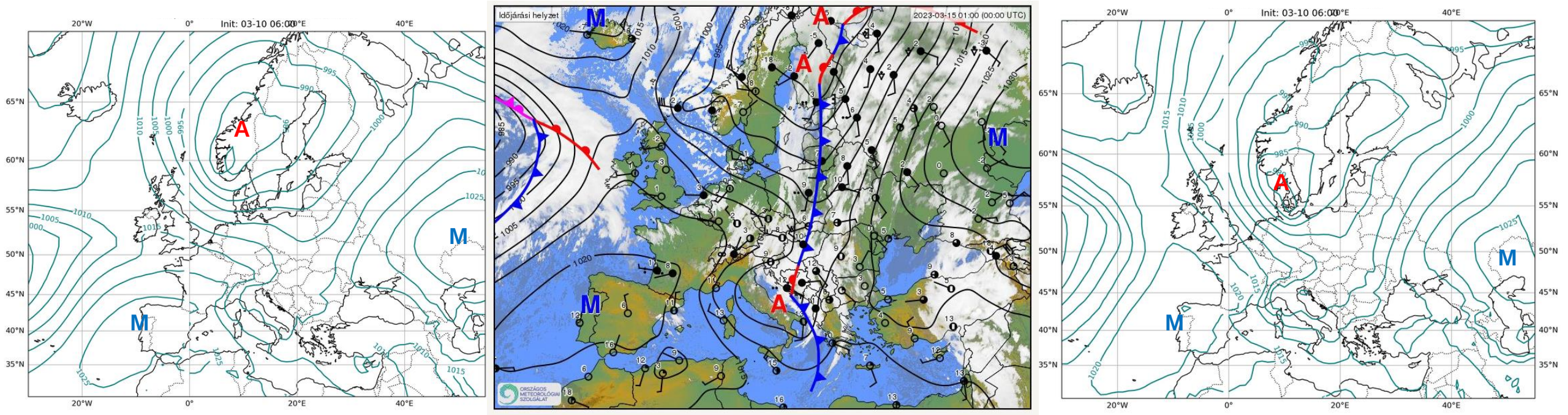
GraphCast futtatás az ELTE-n

Research supported with Cloud TPUs from Google's TPU Research Cloud (TRC)

- 1°, 6 óra felbontás
- Google Cloud (kb. 1 perc / nap futási idő)
- 10 napos előrejelzési időtáv
- Hindcast 2020–2023
- Esettanulmány: 2023. március 15.



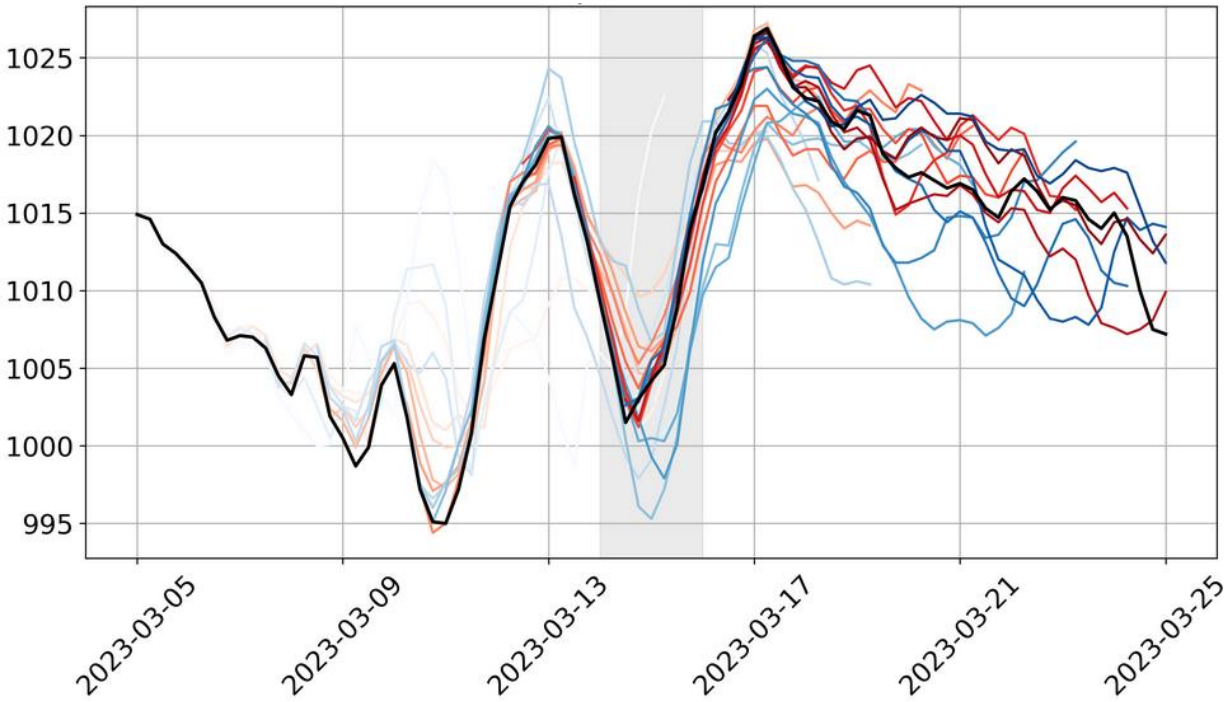
2023. március 15.

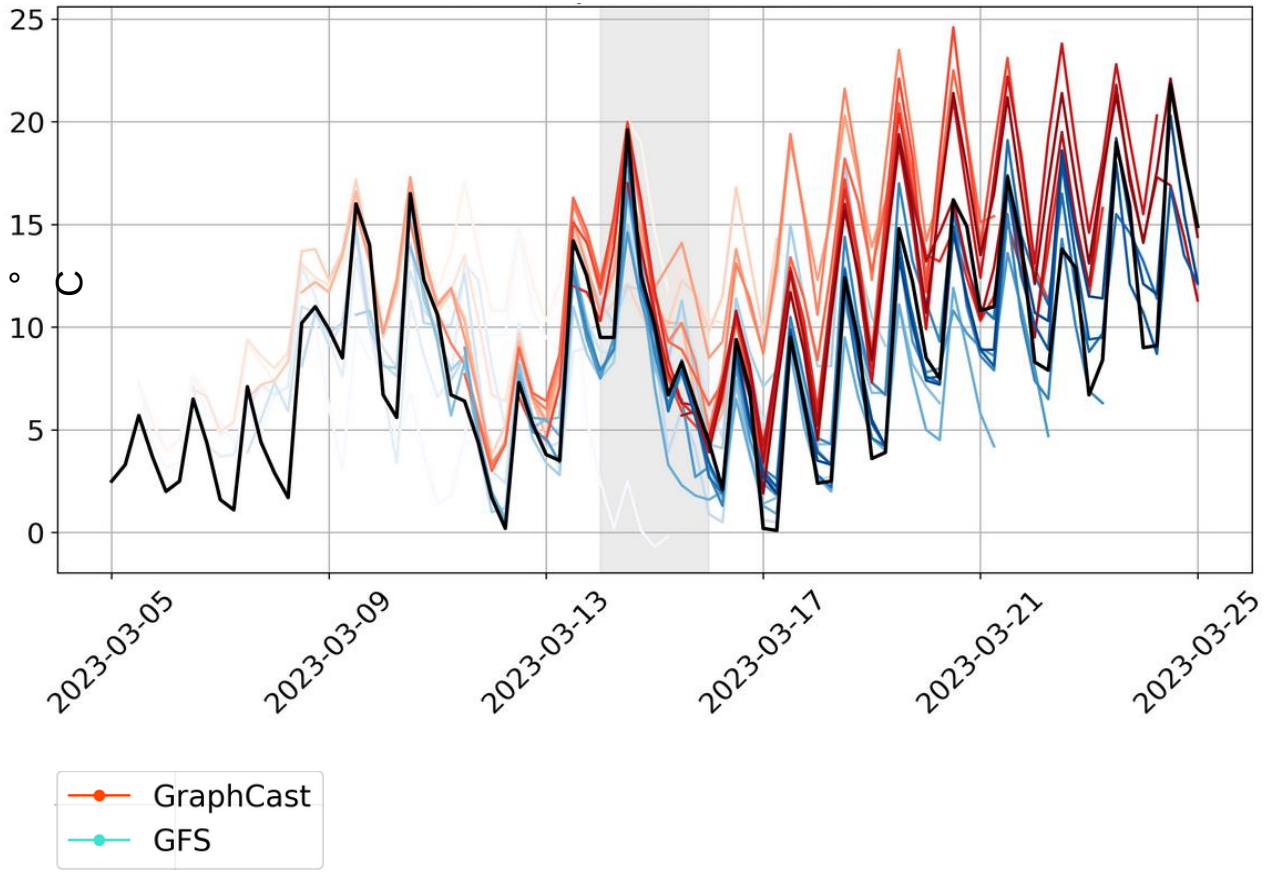


Légnyomástérkép 2023. március 15. 0 UTC-kor, és annak 5 napos előrejelzése (03.10-i indítással) a GraphCast és a GFS modellből.

2023. március 15.

Légnyomás- és hőmérséklet-előrejelzés Budapestre
Fekete: mérés
Piros: GraphCast 1°
Kék: GFS 0,25°





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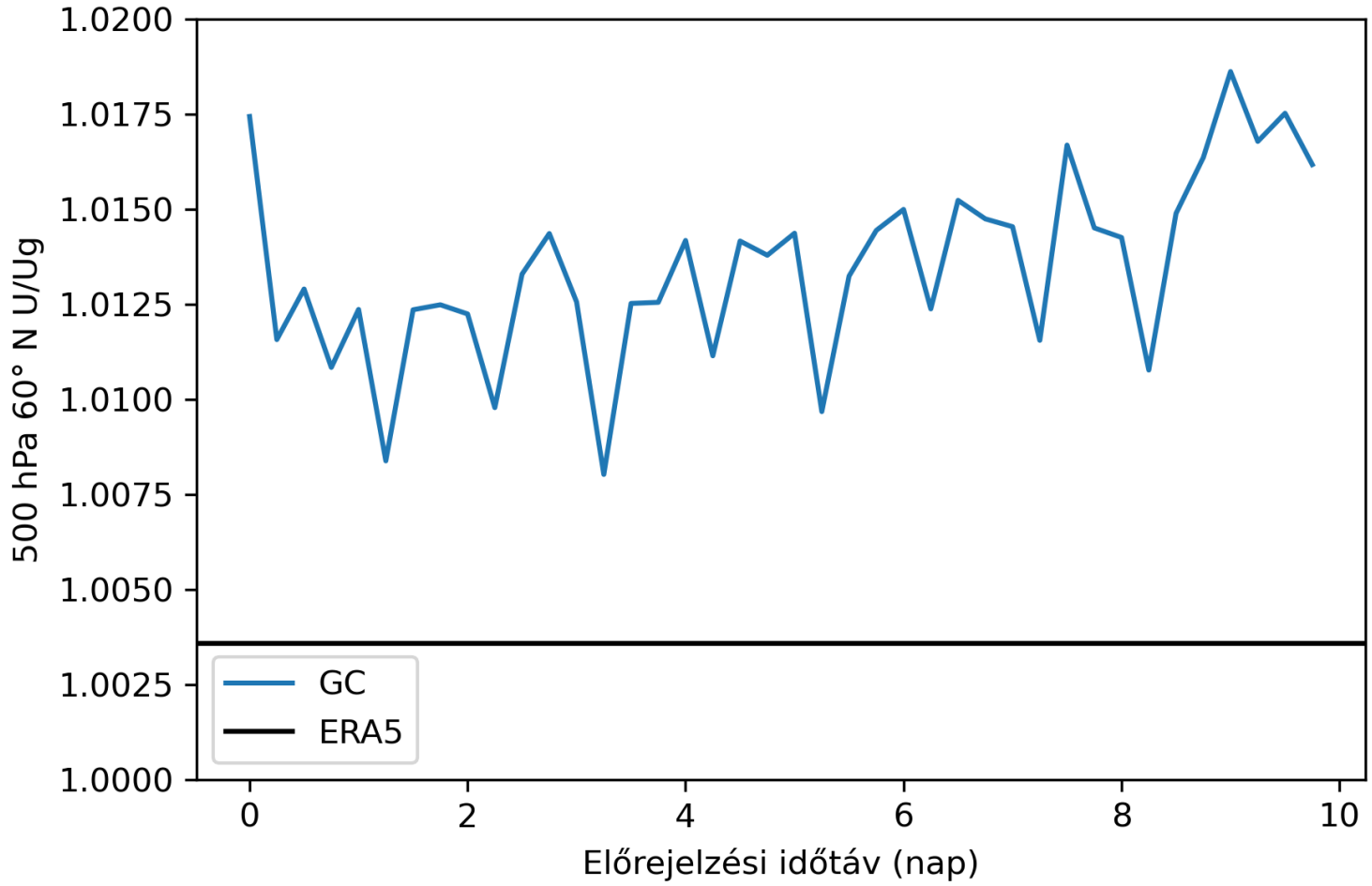
Fizikai törvények?

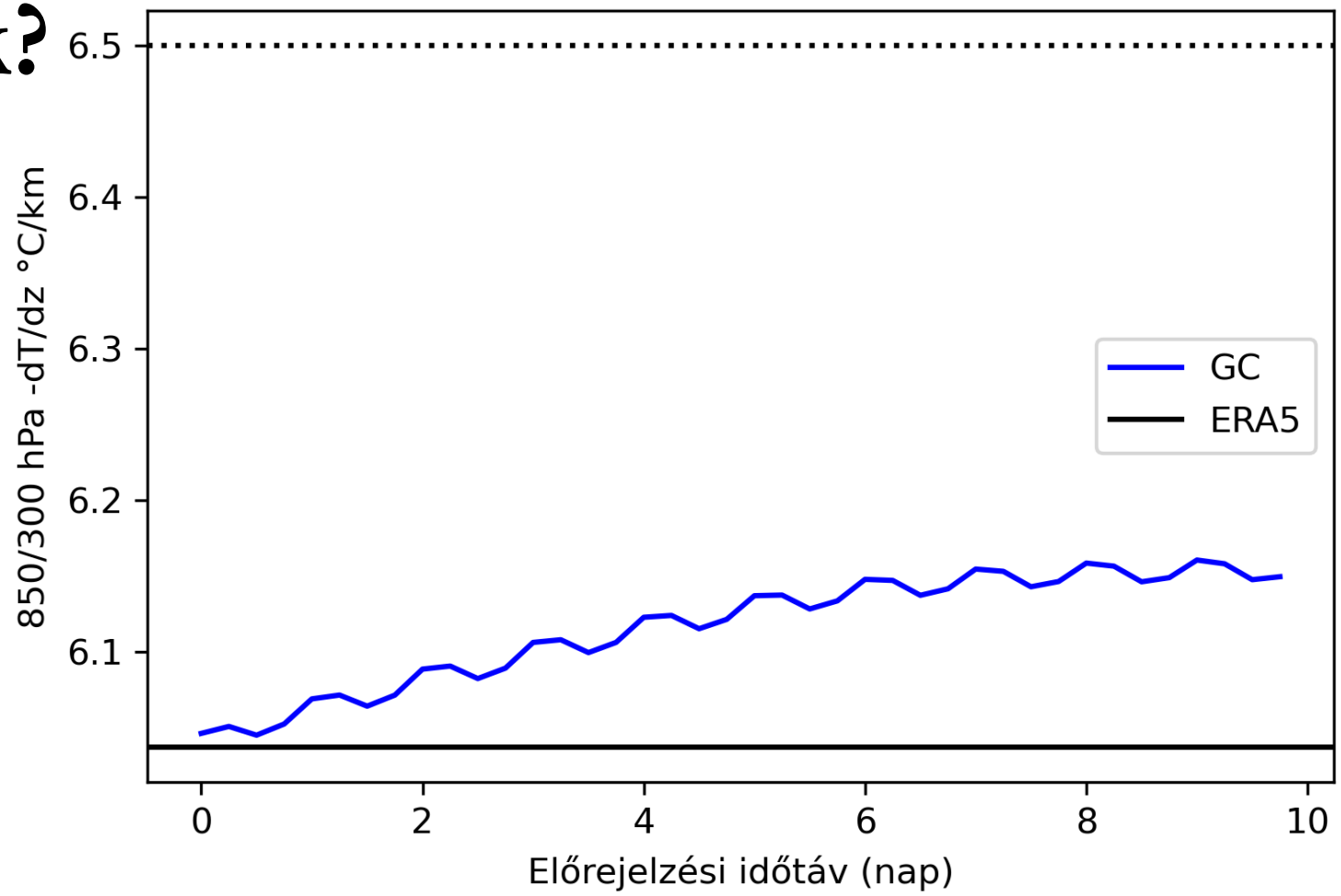
- **Geosztrófia**



É.sz. 60°, 500 hPa szélsebesség a geosztrofikus szélsebesség arányában, zonális és négyéves (2020-2023) átlag

Fizikai törvények?

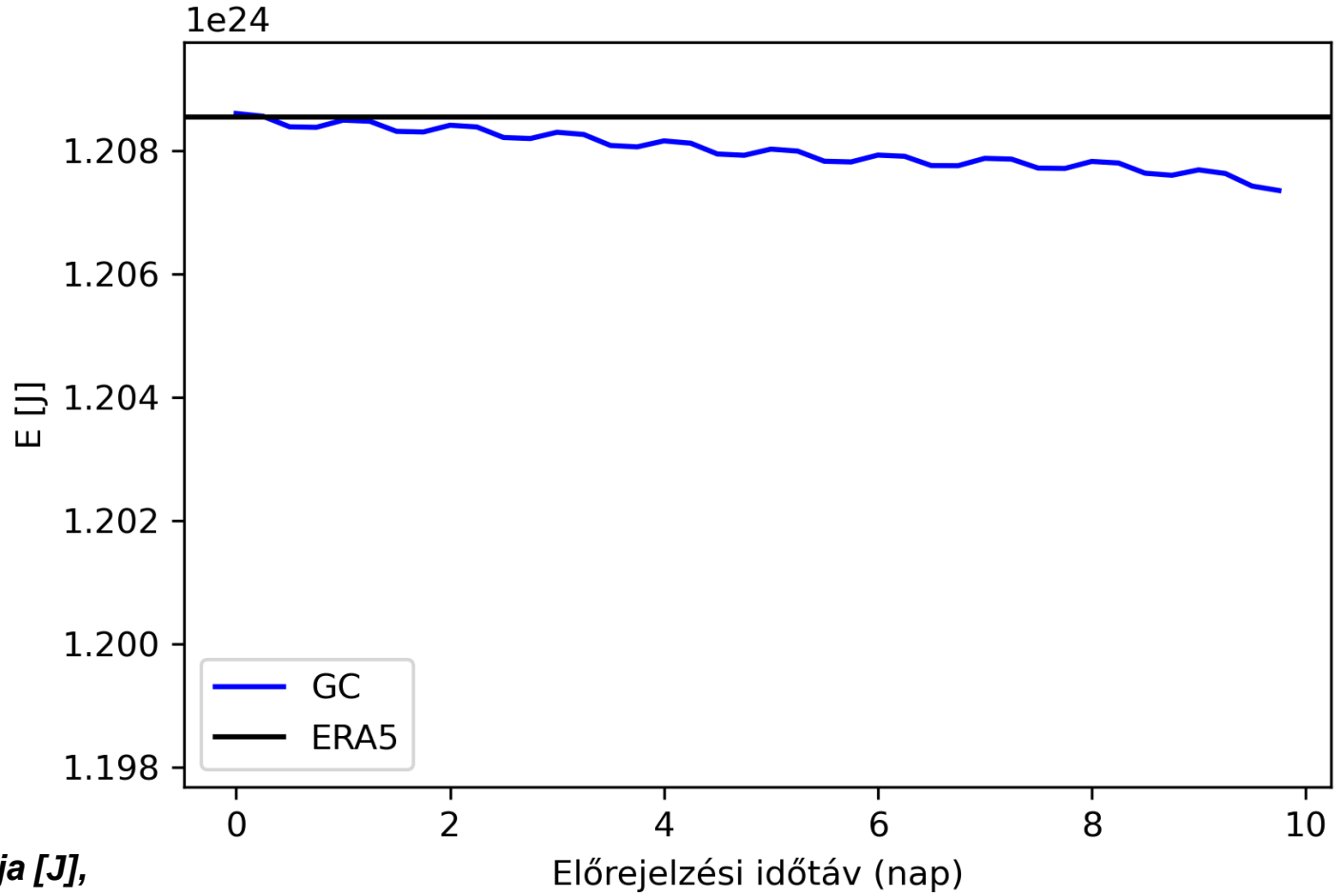
- Geosztrófia
- **Stabilitás**



Globális átlagos 850-300 hPa hőmérsékleti gradiens, °C/km, 2020 – 2023 átlag

Fizikai törvények?

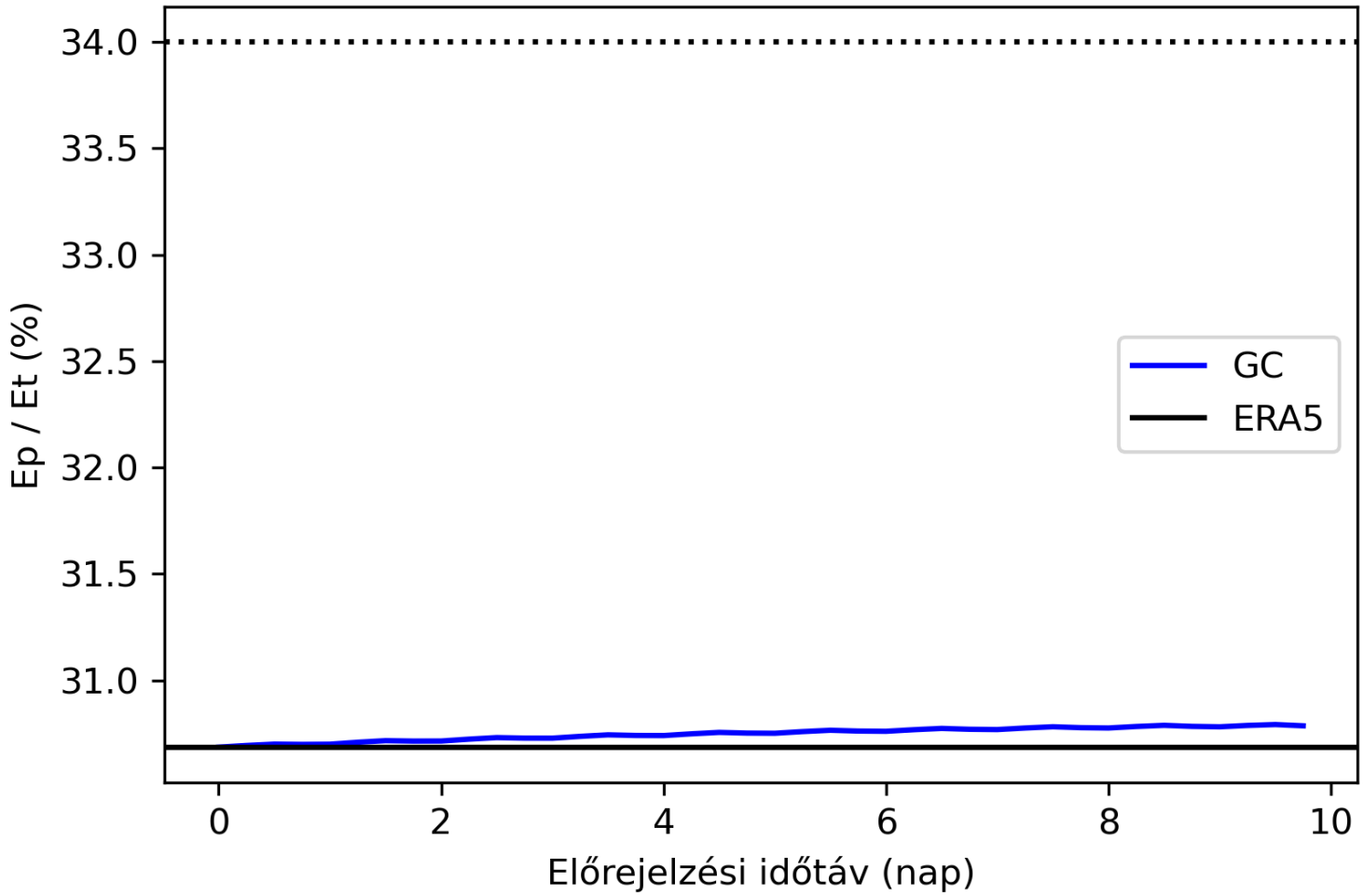
- Geosztrófia
- Stabilitás
- **Energia**



A légkör összenergiája [J], (helyzeti+belső+mozgási) 2020 – 2023 átlag

Fizikai törvényeki

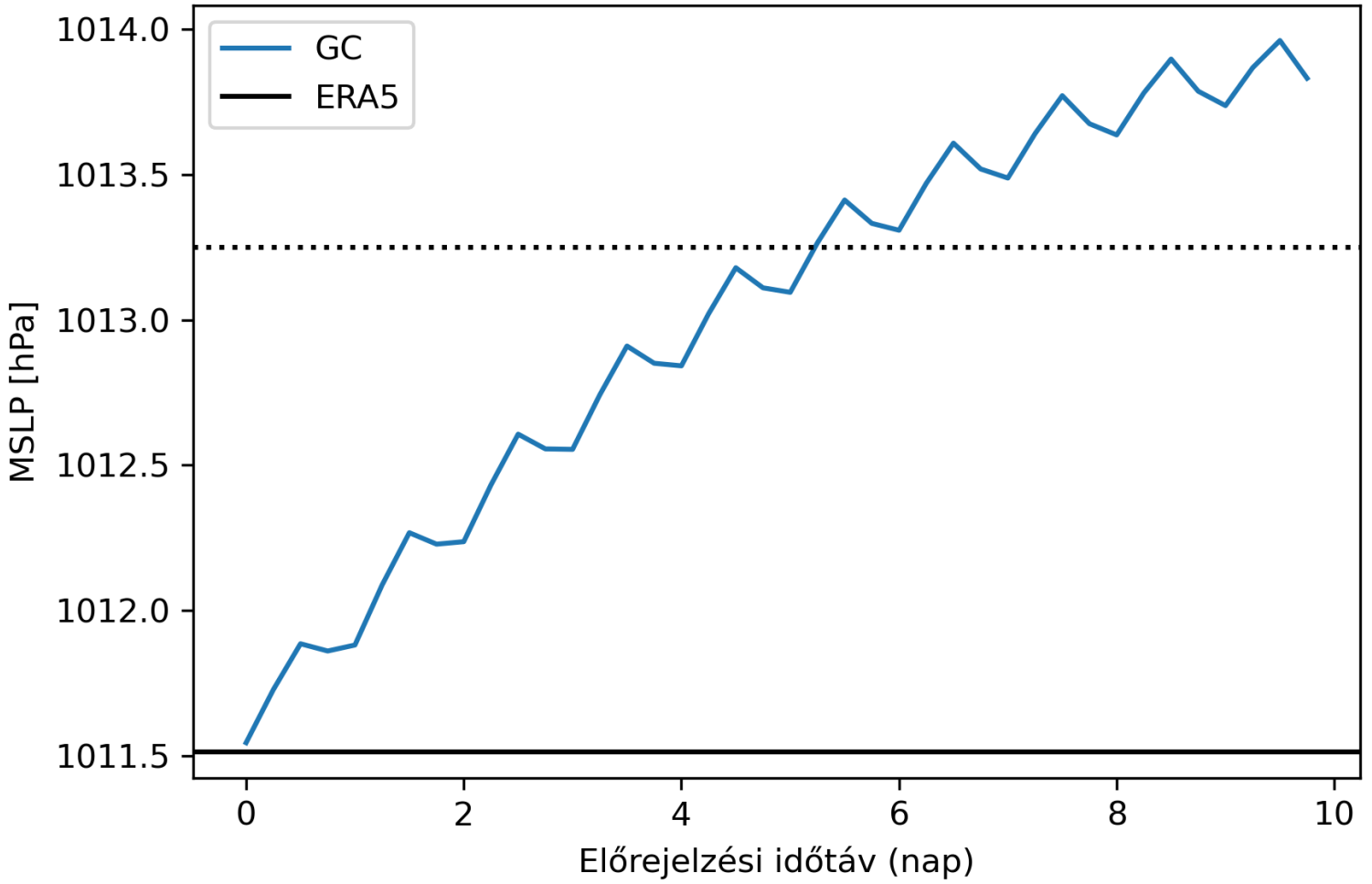
- Geosztrófia
- Stabilitás
- Energia
- **Hidrosztatika**



A légkör helyzeti és belső energiájának aránya.
Hidrosztatikus érték: 40%. Valós érték: ~34%
2020 – 2023 átlag

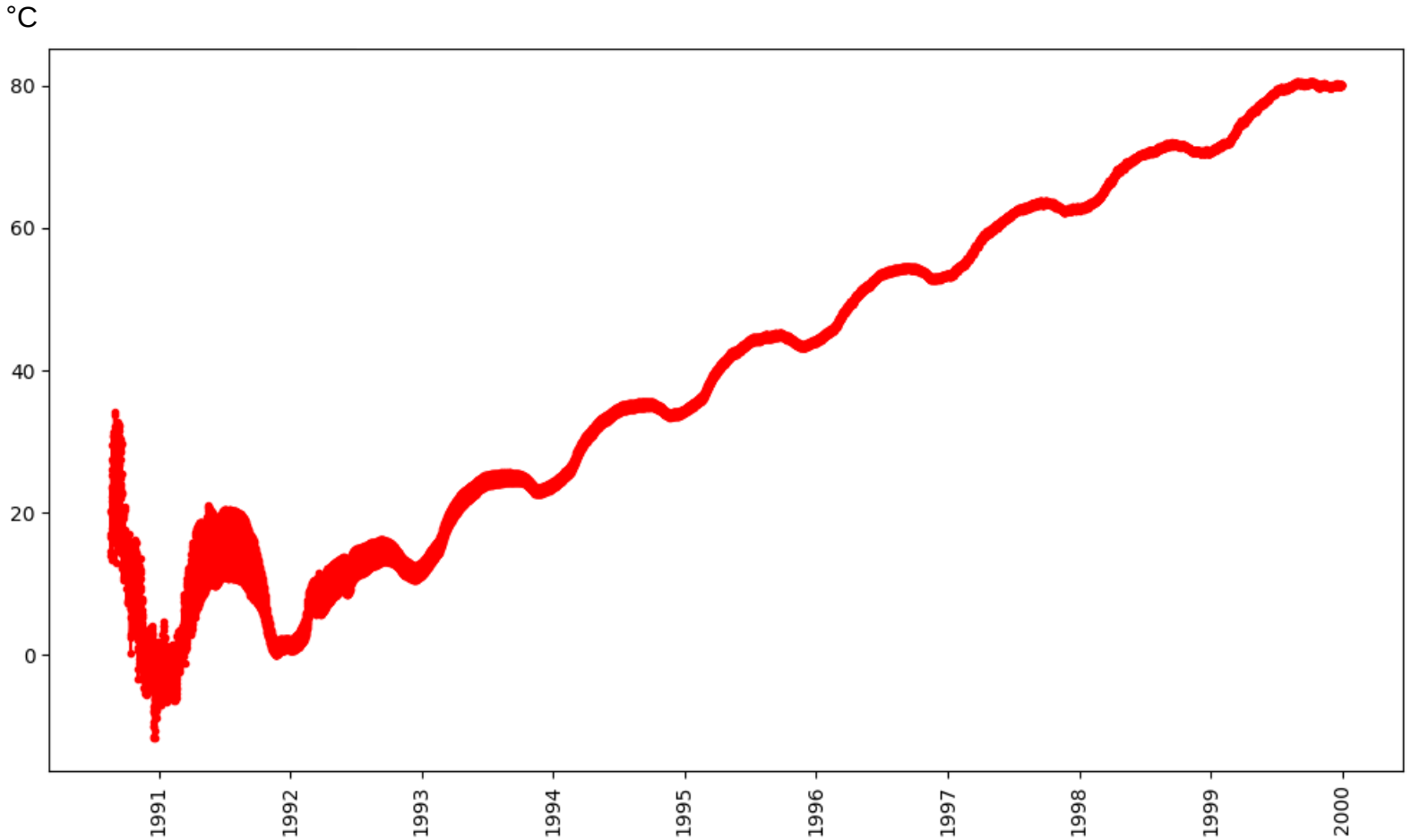
Fizikai törvények?

- Geosztrófia
- Stabilitás
- Energia
- Hidrosztatika
- **Tömeg**



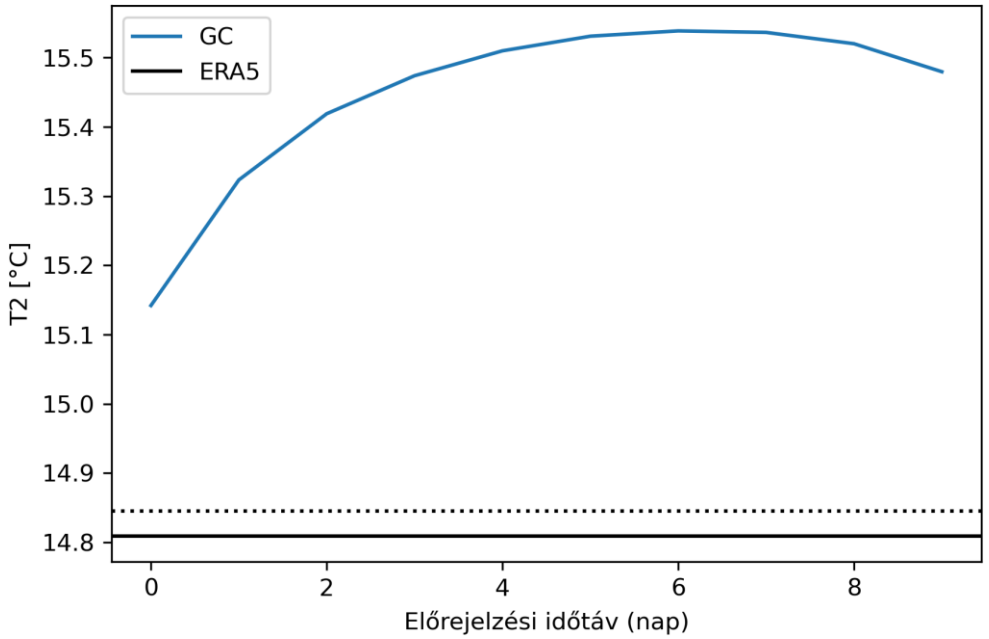
Globális átlagos tengerszinti légnyomás [hPa]
2020 – 2023 átlag

Modellklíma?

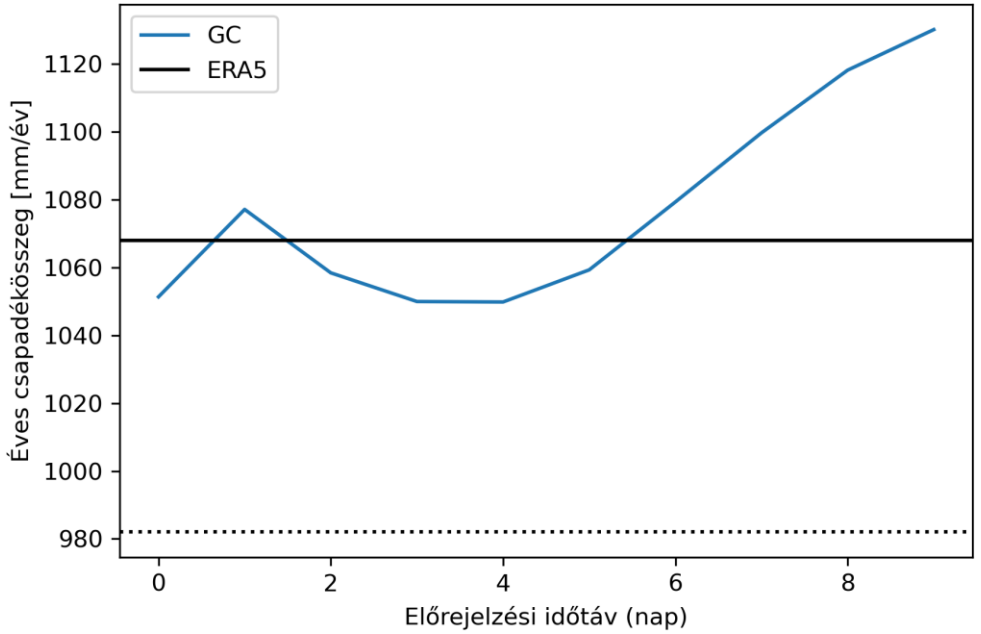


2 m hőmérséklet az É.sz.47°, K.h. 20° rácspontban.
GraphCast 10 éves futtatás alapján.

Modellklíma



Globális átlagos 2 m hőmérséklet
2020 - 2023



Globális átlagos éves csapadékösszeg
2020 - 2023

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2024. május 2. – GenCast ensemble

°C

Google DeepMind

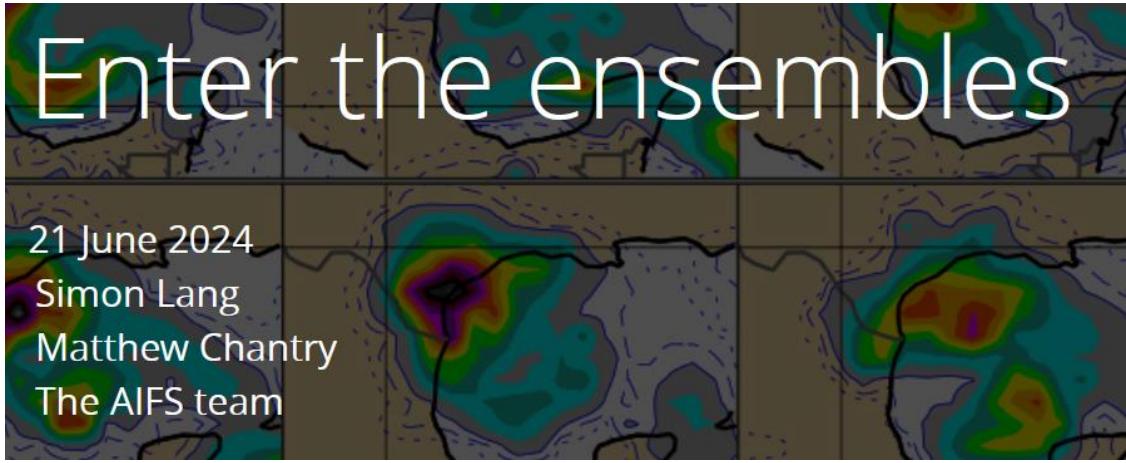
2024-5-2

GenCast: Diffusion-based ensemble forecasting for medium-range weather

Ilan Price[*,1], Alvaro Sanchez-Gonzalez[*,1], Ferran Alet[*,1], Tom R. Andersson[1], Andrew El-Kadi[1], Dominic Masters[1], Timo Ewalds[1], Jacklynn Stott[1], Shakir Mohamed[1], Peter Battaglia[1], Remi Lam[1] and Matthew Willson[1]

[*]Equal contribution, [1]Google DeepMind

Weather forecasts are fundamentally uncertain, so predicting the range of probable weather scenarios is crucial for important decisions, from warning the public about hazardous weather, to planning renewable energy use. Here, we introduce GenCast, a probabilistic weather model with greater skill and speed than the top operational medium-range weather forecast in the world, the European Centre for Medium-Range Forecasts (ECMWF)'s ensemble forecast, ENS. Unlike traditional approaches, which are based on numerical weather prediction (NWP), GenCast is a machine learning weather prediction (MLWP) method, trained on decades of reanalysis data. GenCast generates an ensemble of stochastic 15-day global forecasts, at 12-hour steps and 0.25° latitude-longitude resolution, for over 80 surface and atmospheric variables, in 8 minutes. It has greater skill than ENS on 97.4% of 1320 targets we evaluated, and better predicts extreme weather, tropical cyclones, and wind power production. This work helps open the next chapter in operational weather forecasting, where critical weather-dependent decisions are made with greater accuracy and efficiency.



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2024. június 16. – DWD AI-VAR

AI-BASED DATA ASSIMILATION: LEARNING THE FUNCTIONAL OF ANALYSIS ESTIMATION

A PREPRINT

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ABSTRACT

The integration of observational data into numerical models, known as data assimilation, is fundamental for making Numerical Weather Prediction (NWP) possible, with breathtaking success over the past 60 years (Bauer et al. [2015]). Traditional data assimilation methods, such as variational techniques and ensemble Kalman filters, are basic pillars of current NWP by incorporating diverse observational data. However, the emergence of artificial intelligence (AI) presents new opportunities for further improvements. AI-based approaches can emulate the complex computations of traditional NWP models at a reduced computational cost, offering the potential to speed up and improve analyses and forecasts dramatically (e.g. Pathak et al. [2022], Bi et al. [2023], Lam et al. [2023], Bouallegue et al. [2023]). AI itself plays a growing role in optimization (e.g. Fan et al. [2024]), which offers new possibilities also beyond model emulation.

In this paper, we introduce a novel AI-based variational data assimilation approach (AI-Var) designed

Deutscher Wetterdienst
június 17. ·

Durchbruch des DWD bei der Forschung mit #KI bei #Wettervorhersagen und Klimaanalysen: Erstmals weltweit ist es gelungen, Wetterbeobachtungsdaten ausschließlich mit Hilfe von KI in Vorhersagemodelle und Analyseprozesse einzuspeisen. Details: http://dwd.de/presse

"Der Deutsche Wetterdienst hat damit erneut bewiesen, dass er zu den wissenschaftlich und technisch führenden Wetterdiensten weltweit gehört und zurecht frühzeitig auf die umfassende Nutzung von #KI gesetzt hat", so DWD-Präsidentin Prof. Sarah Jones. Dr. Jan Keller, Leiter DWD-Datenassimilation: „Diese Technologie ist ein entscheidender Baustein für die derzeitige Revolution der Wettervorhersage durch KI. Sie bereitet den Weg für künftig vollständig datengetriebene #Vorhersagesysteme."

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Köszönöm a figyelmet!

2024. november 14.

A kutatás az RRF-2.3.1-21-2022-00014 Éghajlatváltozás Multidiszciplináris Nemzeti Laboratórium támogatásával valósult meg.

MTA