



Global meteorological services report

How innovative technology can transform the delivery of meteorological services

Executive summary

Meteorological services rely on new technologies to produce faster, more accurate predictions. Take the first computerized forecasts, in the US in the 1950s, by mathematical models created from current weather conditions. Or how in 1960, the first successful cloud imagery from the United States Television and InfraRed Observation Satellite (TIROS-1) revealed the potential for satellite forecasting. Customized meteorological services accelerated in the 1980s. Machine Learning (ML)-based weather forecasting models, such as [NVIDIA's FourCastNet](#), emerged in this decade. Today we see a democratization of information. Thanks to advanced weather forecasting modelling via services such as Amazon SageMaker Canvas, consumers ranging from farmers planting crops to large enterprises will be able to interact better with weather products and services.

Now, the technological advances behind this accelerated transformation and democratization are themselves rapidly changing. Artificial Intelligence (AI), generative AI, and agentic AI offer opportunities to transform meteorological services and their business models. The new methods complement traditional physics-based [Numerical Weather Prediction \(NWP\)](#) models. They collect and analyze vast datasets far more rapidly. They also learn from past weather patterns to deliver more accurate, detailed, and localized short-term and long-range forecasts. Agentic AI technologies may identify future weather events and patterns beyond human inference and develop appropriate responses.

“AI will enter every segment of the meteorological value chain, from replacing some of the current forecasting instruments to developing new and more effective weather forecasting products and services,” says Klemen Bergant, executive director of [EUMETNET](#), a network of 33 European national meteorological and hydrological services.

This paper explores the potential impact of AI on meteorological services and suggests:

- Users of AI-enabled meteorological services want to know how the weather will impact them, rather than what the weather will be
- Collaboration between public and private sectors is essential to realize the full potential of AI
- Governance of meteorological services requires urgent revision to keep pace with AI-driven innovations

“ AI will enter every segment of the meteorological value chain, from replacing some of the current forecasting instruments to developing new and more effective weather forecasting products and services. ”

—Klemen Bergant

Executive director of [EUMETNET](#)



Section 1

Users of AI-enabled meteorological services want to know how the weather will impact them, rather than what the weather will be

New technology raises user expectations

Expectations of what weather reports could and should deliver have been rising since the advent of computerized and satellite forecasting in the 1950s and 1960s. Their limitations, and confusion between scientific and general vocabulary, created room for misunderstanding, with significant effects. For example, in [October 1987 in the UK](#)ⁱ, a weather forecaster reassured BBC viewers that an approaching storm was not a hurricane. This was scientifically correct. Nonetheless, hurricane-force winds devastated much of southern England a few hours later. In October 2005, there was the perceived failure of the [US National Weather Service \(NWS\) to predict in good time precisely where Hurricane Katrina would make landfall](#)ⁱⁱ. Both examples illustrate how public trust is undermined by the mismatch of expectation and capability. Meteorological agencies face the double challenge of assessing and adopting new technologies' potential while understanding and communicating their limitations.

The risk of inflated expectations about the predictive power of AI-based weather forecasts is real. "Currently, most AI-based models are trained on data reanalysis produced by traditional NWP physics-based models," says Bergant. Nonetheless, AI's potential is pushing public-sector meteorological agencies to change their core understanding of weather forecasting.

"Do people want just a weather forecast, or are they more interested in a forecast that relates to a decision to be made, or an impact that might be felt, or an activity to undertake?" asks Charles Ewen, director of technology at the [UK Met Office](#). Ewen believes what people really want is reliable information on which to base decisions.

Global concern about climate change and extreme weather events creates demand for increasingly accurate short-, medium- and long-range local and general forecasts. Weather forecasting apps that deploy agentic and other AI technologies could help a wide range of users build long-term resilience against climate-change impacts—such as energy providers optimizing power grids, logistics companies organizing supply chains, and

“ Do people want just a weather forecast, or are they more interested in a forecast that relates to a decision to be made, or an impact that might be felt, or an activity to undertake? ”

—Charles Ewen

Director of technology at the UK Met Office

farmers planting crops. For example, [Sencrop](#), an agricultural weather company that uses [AWS to collect and analyze data from local stations across Europe](#), has built an ML-based microclimate app to provide more accurate data to help farmers implement sustainable practices.ⁱⁱⁱ

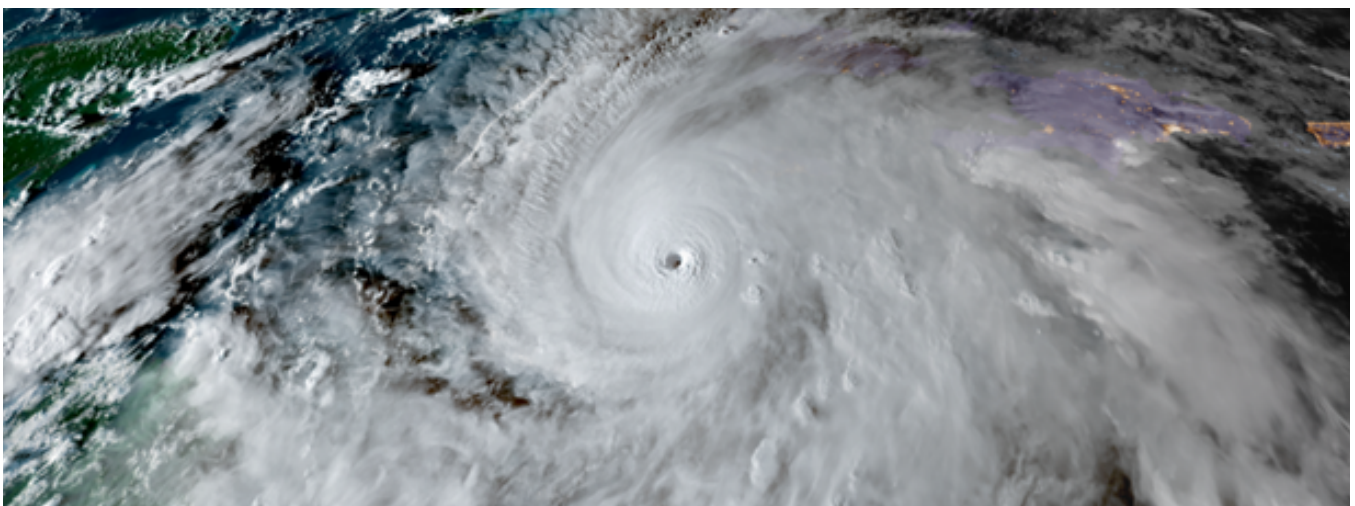
Building an open-access global weather data cache to serve the world's poorest countries

Across the Global South, the delivery of accurate, timely weather forecasts is undermined by lack of access to advanced digital technologies and a shortage of human and capital resources. According to the [United Nations \(UN\)](#), [around one-third of the world's population, concentrated in the least developed countries, is still not protected by early warning systems](#) to alert people to extreme weather events, such as imminent storms or heat waves.^{iv}

In March 2022, [UN Secretary-General António Guterres](#) announced new action “to ensure every person on Earth is protected by early warning systems within five years.” [WMO Information System \(WIS\) 2.0](#), an international collaboration led by the [World Meteorological Organization \(WMO\)](#), will be critical to achieving this goal.^v

WIS 2.0 is a global, open-access online cache of the latest, up-to-the-minute meteorological data around the world, using AI-based forecasting models as well as National Meteorological Service (NMS) models. National and local forecasters in some of the world's poorest countries will be able to access the [cloud-based, serverless cache, built by AWS](#), without the need for substantial investment in computing power and technological expertise.^{vi} Other collaborators on WIS 2.0 include the UK Met Office, the [US National Weather Service \(NWS\)](#) and [Synoptic Data](#), an environmental data platform.

WIS 2.0 was launched in January 2025. It will gradually replace the WMO's current Global Telecommunication System (GTS) meteorological data network, which is due to be decommissioned in 2033.



The business market for AI-enabled weather forecasting

The US is a significant testing ground for commercial weather forecasting tools. There, around one-third of the world's largest economy is directly exposed to weather and climate conditions, according to research published by the [Federal Reserve Bank of Richmond](#).^{vii} The US is the world's leading base for innovating digital meteorological products and services, despite increasing competition from China.

In 2024, the technology investment company [Battery Ventures](#) identified highest value opportunities for meteorological services and products, principally in the US and Europe. They are natural disaster mitigation and preparation; defense mission planning; airline route planning and ground operations; route optimization for logistics companies; energy demand forecasting for utilities; and conditions-based marketing for the travel and leisure industry.^{viii} Green energy is another promising area. For example, [Envision Group](#), a green energy company in China, deploys an [AI-based weather forecasting system](#) to improve the accuracy of predictions about wind and solar fluctuations to store intermittent power more efficiently.^{ix}

How AI weather forecasts could reduce US insurance industry costs and claims for hail damage

Hailstorms typically begin suddenly and are highly localized. A house in one street may have its windows shattered by large hail pellets, while buildings a few blocks away may be unaffected. This extreme short-term unpredictability is a challenge for insurers writing policies and customers assessing their risk from hail-related damage.

In recent years, US insurers have experienced steep rises in losses for hail claims. In 2022, insurance company [State Farm](#) reported that [payouts for hail claims had increased year-on-year by around \\$1 billion, to \\$3.5 billion](#).^x Reasons for the spike in the volume and value of claims are complex and range from the higher prevalence of hailstorms in midwestern US states to price rises in building materials. Faster, more accurate, highly-localized hail forecasts would give more homeowners and businesses more time to take preventive action to mitigate, or even avoid, hail damage before the storm arrived.

The daily [Hail Outlooks](#) issued by the US National Weather Service (NWS) are too broad in scope to be an effective early-warning system for when and where individual hailstorms might break out. By contrast, AI-based weather forecasting models can potentially issue localized hail predictions as often as every 10 minutes, according to [Excarta](#), one of a growing number of specialist US hail-prediction services.^{xi}

It's too early to tell whether AI-enabled hail forecasts can help reduce US hail insurance claims and losses. Nonetheless, the market for these forecasts has strong potential if vendors can demonstrate proof of concept.

Section 2

Collaboration between public and private sectors is essential to realize the full potential of AI

The first private-sector weather forecasting companies were founded shortly after the end of the Second World War in 1945, when several [former US military meteorologists independently established forecasting businesses for weather-exposed industries](#).^{xii} In the late 20th century, specialized meteorological services companies were concentrated in the US. Meanwhile, the delivery of weather forecasts and related services and products remained largely the preserve of the US National Weather Service (NWS) and a few other large, well-funded national and regional agencies, such as the UK Met Office and the [European Centre for Medium-Range Weather Forecasts \(ECMWF\)](#).

Since then, the development of innovative weather forecasting models, tools, and apps has disrupted the balance between public and private sectors. Resource and skills are as big a challenge for public sector organizations as they have ever been.

The UK Met Office is among the taxpayer-funded agencies that see public-private partnerships (PPPs) as the solution, where both sides benefit from collaboration on AI-related projects and ventures.



How new and emerging AI technologies could improve the UK Met Office Shipping Forecast

The [UK Met Office](#) wants to translate its Numerical Weather Prediction (NWP) data into text-based products whose quality is consistently high and easy to understand and scale. They worked with AWS on a project to explore the potential of generative AI tools (especially LLMs) to allow users to interact with weather products and services. [The UK Met Office's shipping forecast](#)^{xiii} was selected to contextualize the challenge because it has strict format and length requirements, plus a combination of various atmospheric and ocean datasets.

The Met Office worked with AWS to develop two complementary approaches to automate forecast generation. The first is a large language model (LLM) approach that achieves 62 percent accuracy, using [Amazon Nova Pro](#) and [Claude Sonnet](#) models. The second is a novel vision language model (VLM) approach, reaching 52 percent accuracy, using [Amazon Nova Customization on SageMaker AI](#). The project balanced experimentation with cost and used lowlight models and though these numbers are relatively low as a result, the prototype established the route to greater accuracy.

Both approaches process meteorological data through text descriptions. The VLM approach also converts numerical weather predictions into video format for direct visual processing. It does this with [Amazon Nova Customization on SageMaker AI](#) to fine tune Nova Lite vision models. The Met Office used these approaches in model predictions for all 31 sea areas covered by its shipping forecast, up to 24 hours in advance.

The Shipping Forecast project highlights how advanced GenAI technologies on AWS could be applied more widely. As a result, the UK Met Office is now on a path to modernize many more of its 300 text-based products and services. AI tools could be used to help with the initial drafting and staff can focus expertise where it can have more impact.

[Watch the project team describe their work.](#)^{xiv}

In February 2025, the United Nations' (UN) network on climate and weather for member states, the World Meteorological Organization (WMO), published fresh guidelines for public-private engagement. [The WMO cited "scientific and technological innovation" as the primary reason for the update.](#)^{xv}

What the public sector needs most from PPPs: capital and expertise

The [UK government announced](#) in February 2020 that it would invest £1.2 billion (\$1.6 billion) to develop a supercomputer, which would unleash the potential weather and climate data in the UK and help drive AI integration across all Met Office operations.^{xvi} "Skills related to AI, information technology, data analysis, and computing resources are becoming more and more important," says Bergant. "Being in the public sector, it's challenging for national meteorological services to attract experts in these fields."

“ Skills related to AI, information technology, data analysis, and computing resources are becoming more and more important. Being in the public sector, it's challenging for national meteorological services to attract experts in these fields.”

—Klemen Bergant
Executive director of [EUMETNET](#)

To illustrate the competition for skills, investment in weather-dependent markets and businesses by hedge funds rose by 23 percent in 2024 versus 2023, according to UK executive search firm Proco Group. [Average pay packages rose by 18 percent, reaching \\$750,000 and \\$1 million per year for some.](#)^{xvii} The median salary for atmospheric scientists, including meteorologists, in the [US was \\$97,450 in 2024, according to data compiled by the U.S. Bureau of Labor Statistics.](#)^{xviii}

Ewen suggests that PPPs offer the best solution to this challenge. “Scaling up, getting the expertise, and recruiting people is incredibly expensive,” he says. “We simply can’t do it, so there is a role there for the private sector.”

What private-sector companies gain from PPPs: data and trust

The earliest US private weather forecasters in the 1940s relied on meteorological data compiled and published by public-sector agencies. This is still largely true today. “It is important to note that the private sector relies on the vast amount of open data that the scientific community and public entities, such as the weather services, provide for free,” said Nicolas Gruber, professor of environmental physics at [ETH Zürich](#), in a November 2024 [report on ML-based weather forecasting by Pictet Asset Management](#). “Without those data, the training of these data-based models would not have been possible.”^{xix}

ERA5, the fifth generation of a global time series that began in January 1940, illustrates the scope, scale, and granularity of atmospheric, land and oceanic variables that is publicly available. The dataset, produced by the [ECMWF’s Copernicus Climate Change Service \(CS3\)](#), provides hourly estimates of a wide range of variables through analysis of the atmosphere at [137 levels from the earth’s surface up to a height of 80 kilometers.](#)^{xx} Data-collection points for variables—such as ozone levels, snow depths, and ocean surface winds—range from satellites operated by the [U.S. National Aeronautics and Space Administration \(NASA\)](#), to land stations, and moored and floating buoys.^{xxi}

Generative AI (GenAI) weather forecasting models have the potential to create new datasets by developing likely future weather scenarios from historic data, then re-analyzing the newly generated data to predict scenarios further forward in time. Developers are running comparative tests on early-stage models and outcomes are reportedly delivering

“Scaling up, getting the expertise, and recruiting people is incredibly expensive. We simply can’t do it, so there is a role there for the private sector.”

—Charles Ewen

Director of technology at the UK Met Office

positive results in terms of accuracy and customization for specific clients. For example, Dan Margulies, chief information officer at [The Weather Company](#), a global forecasting and meteorological services company that uses [Amazon SageMaker](#) and [Amazon Bedrock](#) for foundation model training and inference, says “[Generative AI allows us to hit different segments of the market with more accurate information that’s just in time for their use case.](#)”^{xxii}

Trust in meteorological service providers’ forecasts, whether private or public sector, will remain critical as new AI-enabled technologies are adopted. “Who will you blame if the AI output in a forecast provides you with information that leads you to make a wrong decision?” asks Bergant. Factors that have the potential to erode public trust in AI-based forecasting include the [risk of cyberattacks and a lack of high-quality, comprehensive meteorological data in poorer countries and regions to train AI models.](#)^{xxiii}

Some reassurance comes from the ambition of leading technology companies to protect and support open-source AI-based weather and climate data with a range of initiatives and projects. AWS and many other technology companies that develop AI-based weather forecasting models, apps, and services have publicly committed to maintain open, free access to their source codes, training data, and other relevant information. In 2024, for example, [IBM and NASA released an open-source AI model](#) for weather and climate use cases.^{xxiv} Similarly, in 2025, [Microsoft launched Aurora](#) as an open-source AI weather forecasting model.^{xxv}

Trustworthiness is one of the intangible assets that make public-sector meteorological agencies and networks such as the Met Office and EUMETNET attractive collaborators for private companies. “We work really, really hard to be trusted,” says Ewen, pointing to the Met Office’s heritage as a weather forecaster that exists to serve the public.

Conclusion: Governance of meteorological services requires urgent revision to keep pace with AI-driven innovations

In June 2021, the [World Bank published a research paper on *Creating Value in the Global Weather Enterprise*](#).^{xxvi} The title indicates the degree to which advances in technology have turned meteorological services into products that may be marketed worldwide, even as the core function of publicly funded agencies continues to be the delivery of reliable weather forecasts to national users. The World Bank paper noted that “the governance of national meteorological services may... establish clear operating principles under which commercial activity could or should be undertaken.” Approaches differ from country to country. “Some EUMETNET members are required by their governments to earn revenue from added-value products, while others are forbidden from competing with the private sector,” says Bergant.

AI-enabled weather forecasting and meteorological services raise governance and regulation issues such as those found in traditional NWP-based weather and climate prediction. In July 2025, an article posted on the specialist supply-chain technology blog [Procurement Insights](#) itemized several ways that AI, GenAI, and agentic AI weather forecasting models prompted the same “obstacles and concerns” as previous models. They included “inaccuracy,” “disconnect from users”, and “lack of transparency.”^{xxvii} For example, the author Jon Hansen noted that AI-enabled forecasts were just as prone as traditional forecasts to be issued “without clear explanation of confidence and uncertainty levels.”

National regulators, public-sector meteorological agencies, and private-sector companies are just beginning to address these complex issues. This partly reflects the speed with which innovative AI-based technologies and models are being developed and launched. Yet it’s already clear that the current fusion between NWP and AI will continue for the foreseeable future, creating a need for governance and regulation that reflects this reality.

“ML models have not yet been rigorously tested over a meaningful time period across mission-critical use cases,” noted Battery Ventures in 2024. “The prevailing view among experts we surveyed is that the likely end-state will be hybrid approaches that combine deep learning with hard-earned insights of physics-based NWP.”^{xxviii}

AI-enabled weather forecasting and meteorological services raise governance and regulation issues such as those found in traditional NWP-based weather and climate prediction.

Nonetheless, from climate scientists working for hedge funds, to traditional government weather forecasters, it's universally agreed that AI is transforming the sector at an accelerating pace. This is due to increasingly advanced ML-based models, and Agentic AI and GenAI applications enabling faster, more precise, and customized analysis of vast data sets.

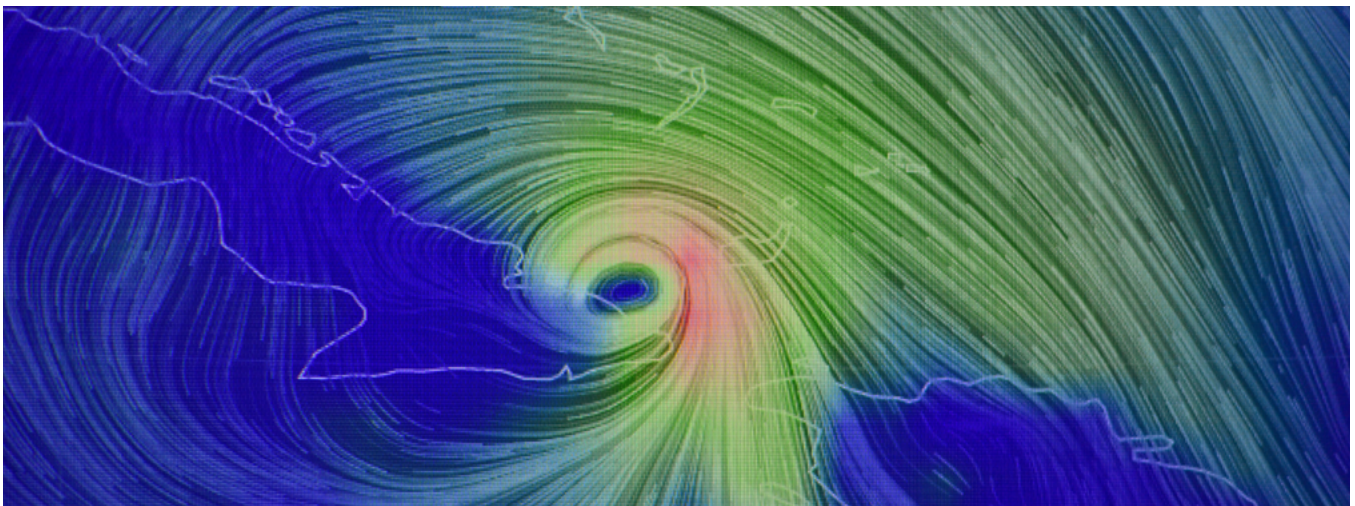
Collaboration between public and private meteorological service providers will be essential to realize the full potential of this AI-driven transformation. "We need to learn how to work better with private-sector and tech companies to deliver composite value chains," says Ewen. At the same time, Ewen and Bergant believe this value chain must preserve a traditional public service ethos that reinforces the commitment of technology companies to maintain free, open access to their forecasting models and apps. "We have to strive for greater impact and efficiency, but profits should not be our main driver," says Bergant.

AI-based meteorological products and services do not represent a break with the past. The effectiveness of even the most advanced new weather-prediction technologies depends on the users' trust, and belief in the provider's integrity.

“ We need to learn how to work better with private-sector and tech companies to deliver composite value chains. ”

—Charles Ewen

Director of technology at the
UK Met Office



Source references

- ⁱ<http://news.bbc.co.uk/1/hi/magazine/7042220.stm>
- ⁱⁱ<https://www.sciencenews.org/article/hurricane-katrina-anniversary-prepared>
- ⁱⁱⁱhttps://aws.amazon.com/solutions/case-studies/sencrop-case-study/?did=cr_card&trk=cr_card
- ^{iv}<https://wmo.int/activities/early-warnings-all/wmo-and-early-warnings-all-initiative>
- ^v<https://wmo.int/media/news/early-warning-systems-must-protect-everyone-within-five-years>
- ^{vi}<https://aws.amazon.com/blogs/publicsector/building-the-wis-2-0-global-weather-cache-on-aws/#:~:text=Just%2024%20hours%20warning%20of,global%20weather%20cache%20on%20AWS>
- ^{vii}https://www.richmondfed.org/publications/research/economic_brief/2018/eb_18-08
- ^{viii}<https://www.battery.com/blog/future-of-weather-forecasting/>
- ^{ix}<https://global.chinadaily.com.cn/a/202508/06/WS6892c33ba3108a99c1905746.html>
- ^x<https://newsroom.statefarm.com/state-farm-reports-increase-in-hail-claim-costs/>
- ^{xi}<https://www.excarta.io/>
- ^{xii}David. B. Spiegler, 'A History of Private Sector Meteorology', in Historical Essays on Meteorology 1919-95, ed. James Rodger Fleming (American Meteorological Society), 1996, pp.417-441, https://link.springer.com/chapter/10.1007/978-1-940033-84-6_15
- ^{xiii}<https://weather.metoffice.gov.uk/specialist-forecasts/coast-and-sea/shipping-forecast>
- ^{xiv}<https://www.youtube.com/watch?v=VLjzP9n63mA>
- ^{xv}https://library.wmo.int/viewer/57344/download?file=WMO-1258-2024_en.pdf&type=pdf&navigator=1
- ^{xvi}<https://www.gov.uk/government/news/12-billion-for-the-worlds-most-powerful-weather-and-climate-supercomputer>
- ^{xvii}https://www.linkedin.com/posts/weareprocogroup_hedge-funds-paying-up-to-1-million-for-weather-activity-7309934759437058049-c1ax
- ^{xviii}<https://www.bls.gov/ooh/life-physical-and-social-science/atmospheric-scientists-including-meteorologists.htm>
- ^{xix}<https://am.pictet.com/nl/en/mega/2024/ai-weather-modelling>
- ^{xx}<https://www.ecmwf.int/en/forecasts/dataset/ecmwf-reanalysis-v5#:~:text=ERA5%20is%20the%20fifth%20generation,land%20and%20oceanic%20climate%20variables>
- ^{xxi}<https://confluence.ecmwf.int/display/CKB/ERA5%3A+data+documentation#ERA5:datadocumentation-Observations>
- ^{xxii}<https://www.youtube.com/watch?v=pmpZqbJkBhw>
- ^{xxiii}<https://unfccc.int/news/ai-and-climate-action-opportunities-risks-and-challenges-for-developing-countries>
- ^{xxiv}<https://arxiv.org/abs/2409.13598>
- ^{xxv}<https://www.nature.com/articles/s41586-025-09005-y>
- ^{xxvi}<https://documents1.worldbank.org/curated/en/464731623345298700/pdf/Creating-Value-in-the-Global-Weather-Enterprise.pdf>
- ^{xxvii}<https://procureinsights.com/2025/07/05/what-does-the-weather-have-to-do-with-procurement-and-ai/>
- ^{xxviii}<https://www.battery.com/blog/future-of-weather-forecasting/>