WEATHER CLIMATE WATER
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AI for Weather (AI4WX) Task Team

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World Meteorological Organization
Organisation météorologique mondiale

Overview

- Motivation for the Task Team: A snapshot of the current state of AI/ML for Wx, challenges
- Scope of the TT
- Progress to date
- Next steps

ML/AI forging ahead

From 2022 - "First generation": GraphCast, FourCastNet, Pangu-Weather, ClimaX…

- ➢ By tech companies, single member, blurry, needs reanalysis to run

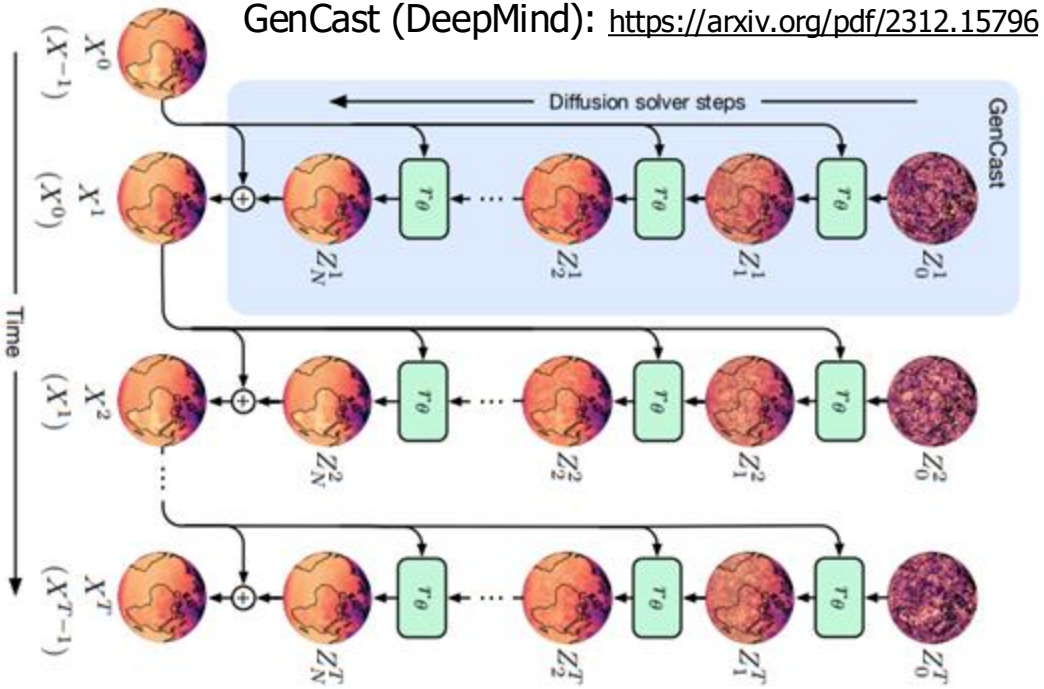
Last ~1 year - "Second generation": AIFS-V2, NeuralGCM, Aurora, Aardvark, Gencast, FuXi variants, …

- ➢ More met agencies involved (ECMWF a clear leader), more physics-informed, more specialized, less blurry, ensembles, ...

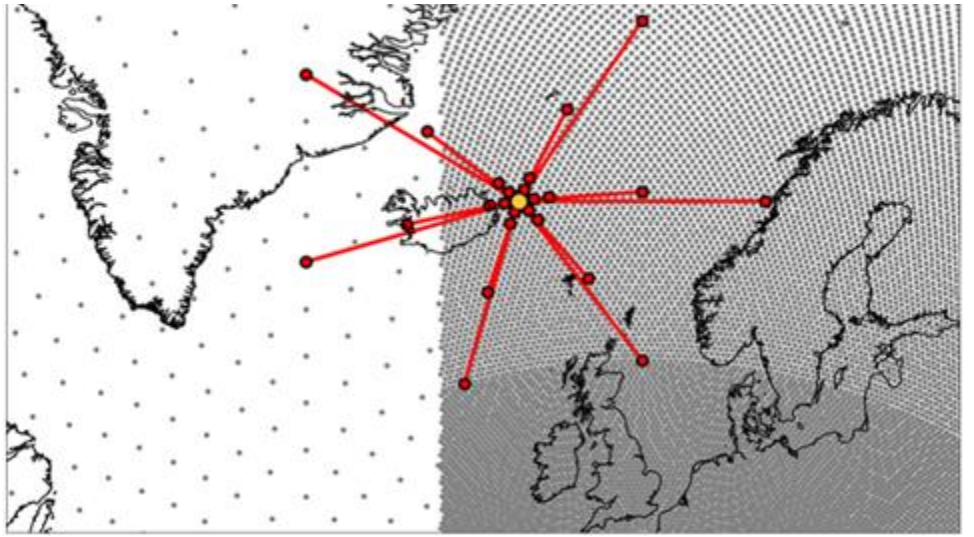
What's next?

- ➔ Coupled models (DLWP-HPX etc.), longer leads
- ➔ Nested regional modelling (ECMWF work on AIFS-V2)
- ➔ More physically-informed approaches?
- ➔ Combining longer lead approaches (transformer, GNN, SFNO…) with sharper approaches (diffusion, generative modelling, …)
- ➔ More foundation models? Zero shot (AtmoRep) vs few-shot (Aurora)?

GenCast (DeepMind): https://arxiv.org/pdf/2312.15796



From the ECMWF AIFS Blog: https://www.ecmwf.int/en/about/media-centre/aifs-blog/2024/data-driven-regional-modelling



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The challenges

Lots of unanswered questions

- Physicality/realism
- Trustworthiness
- Accessibility
- Unsolved application needs (ensembles, longer leads, more variables etc.)
- …

Lots of uncertainty, confusion

- Keeping up with new developments is a full time job
- Still a lot of churn - where does one start?
- Shortage of AI/ML expertise
- Lack of tooling/infrastructure
- …

Changing paradigms

- Fasttrack to experimental mode: Timeline between R&D on a given ML system and its potential operational/experimental deployment happens in a matter of months rather than years

- Cost of running inference is drastically smaller than current physical systems
  - Implications for smaller centres
  - Lower bar computationally
  - Where's the bar at technically?
  - Major consideration for the TT

- Increased emphasis on observations (not just reanalyses), and aspects related to completeness, such as consistent coverage in space and time

- A constant: Open data (and systems) remain critical

Motivation for the Task Team

- WMO has a role to play in supporting members in facing these challenges
  - Especially true for members with fewer resources

- The Task Team convenes representatives of key WMO bodies and ML experts (SERCOM, INFCOM, SAP, WWRP, WCRP, GAW, …)
  - Coordinate existing efforts and capacities
  - Identify immediate support the WMO can provide
  - Inform longer-term planning

- The Task Team will provide improved visibility, insights and capabilities to members.

Scope

AI4Wx is a short duration, rapid pace TT (meets fortnightly)

1. Generate a list of existing activities within WMO programs and regional associations
2. Review activities which can be expanded with limited resources to include AI/ML systems
3. Identify main science gaps and science questions of immediate relevance
4. Identify other key needs of members (infrastructure, open data advocacy, training and knowledge dissemination, ….)
5. Develop a report on the above including recommendations on immediate actions

AI4WX draft plan

Activities informing model readiness and best practices:

- Systems comparison and performance (NMHSs AI/ML systems; private sector AI/ML systems); System evaluation and evaluation standards

Pilots: applicability in nowcasting, countries with low data density

- Nowcasting, Low density data regions, ICPAC, United Nations and Google.org early warning systems project in Eastern Africa

Scientific advances

- Monitor and communicate AI/ML advances and their relevance ; Communication & outreach of capabilities and tools

Data infrastructure

- Development environments for ML models; Data Study group on Future Data Infrastructure; Anemoi and other systems

Training Initiatives

- Explore training initiatives to bridge the understanding gap; Leverage training curriculum for use of AI-based models and products

Strategic impact

- Analyze AI Replacement Risks: Analyze risks and opportunities for AI as part of production chain

Progress so far

- ToR endorsed by RB (including scope of deliverables)
- Links to other AI4XX activities established
- TT members surveyed for AI/ML activities under their WMO affiliations - ongoing process
- TT members surveyed for AI/ML science priorities
- Short-term activities to support member awareness and education have been canvassed:
  - Living database of noteworthy AI/ML publications, existing or planned guidelines on best practice with AI/ML

A first glance at AI in Weather in WMO activities

Integration of AI/ML in program activities

- **WGNE** yearly update of members' NWP and related activities includes AI
- **WWRP**: promotion on AI inclusion in all new projects, ML DA work on-going
- **WCRP:** Digital Earth Lighthouse activity

Knowledge sharing

- **United in Science 2024 -** chapter "AI and ML: revolutionizing weather forecasting"
- **WWRP/WIPPS Nowcasting**: AI guidelines and good practices document to be developed
- **RA-IV seminar** – July 2024
- **WIPPS** – Beijing workshop Nov2024
- **TT**: Living database of noteworthy AI/ML publications

Hydrology

- **WIPPS and SERCOM**: Planned Pilot on global riverine and flood prediction including Google participation (**PPE**)
- **SC-HYD** : AI is part of ongoing pilot studies in four countries with NHMS, using Google Flood Hub and other global models

Data sharing infrastructure / WIS

- **SG-FIT** workshop on future technologies (Sept 23-25) including use of AI for data sharing and data needs for AI/ML development and use

Intercomparisons and Analyses

- **WIPPS**: considering Pilot project incl. verification, forecaster testing
- **WIPPS** - exploring AI model archive (TIGGE-like) supported ECMWF
- **WGNE** – exploring extension of systematic error evaluations to AI
- **WWRP & WGNE**: verification with joint working group

Nowcasting AINPP

- AI for Nowcasting **WIPPS-WWRP Pilot Project** (co-leads DJ Gagne (NCAR) and Kai Dan (CMA): Launch in 2024
- **Collaboration with ITU Global Initiative:** AI for Nowcasting testbed/intercomparisons will be hold in Asia, Africa, and Latin America

Strategic considerations

SAP with TT input

- Implications on the roles and responsibilities of NMHSs
- Role of the private sector
- WMO role in ensuring ongoing emphasis on open data and models

Intercomparisons –Additional

- **ECMWF**: Visual intercomparison of AI models e.g. https://charts.ecmwf.int/?query=pangu
- **NOAA** AI weather model intercomparison: https://aiweather.cira.colostate.edu

AI model development infrastructure:

- Anemoi https://github.com/search?q=topic%3Aanemoi+org%3Aecmwf&type=repositories
- NCAR: MILES-GUESS ML uncertainty quantification framework
- CREDIT: AI numerical weather prediction model and community system
- EDIT: AI model data pipelining, training and inference tool

To be added: GAW, slower variables such as ocean / seasonal / climate, downscaling

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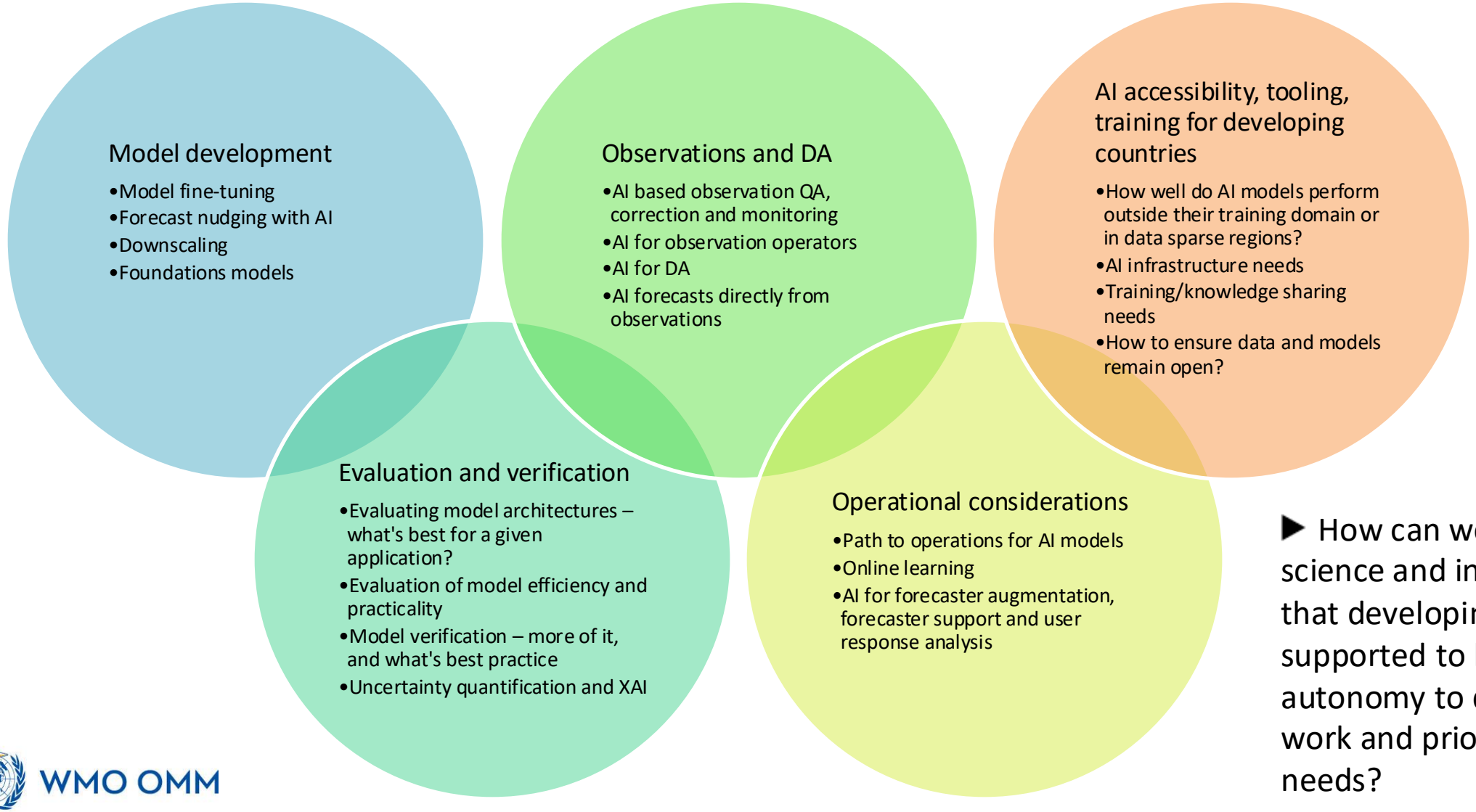
A first pass at science (and other) priorities



▶ How can we progress science and infrastructure such that developing countries are supported to have the autonomy to do their own work and prioritize their own needs?

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Next steps

- Continue to meet fortnightly
- Continue surveying for existing AI/ML activities within WMO programs and regional associations
- Review identified science gaps and priorities
- Identify immediate community needs beyond the TT (more guidelines, training etc.)
- Begin drafting final report

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Thank you

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