Observational Requirements in the Context of AI prediction Systems (ORCAS)

A PCAPS Task Team

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The PCAPS ORCAS task team is part of the WMO's World Weather Research Programme (WWRP)'s PCAPS (Polar Coupled Analysis and Prediction for Services) project.

PCAPS aims at improving the **fidelity**, **actionability**, **and impact** of forecasting for human and environmental well-being in the Arctic and Antarctic regions.

- **PCAPS SERVICES:** Enhance environmental services. => **Actionability**
- **PCAPS SUSTAINABILITY:** Enable informed decision-making to enhance human safety and mitigate environmental risk. => **Impact**
- **PCAPS PREDICT:** Provide more accurate and reliable analyses and predictions. => **Fidelity**

Sustained actionability, impact & fidelity via:

- **PCAPS PARTNERSHIPS:** Strengthen partnerships through transdisciplinary coordination and cooperation.
- **PCAPS INCLUSIVITY:** Facilitate inclusivity and capacity development.

Want to get involved in PCAPS?

Website: www.wwrp-pcaps.net
Newsletter: https://www.wwrp-pcaps.net/contact
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PCAPS ORCAS Task Team

Our Task Team members include experts in machine learning applications for sea ice prediction and specialists in polar observing systems, including field campaigns and satellite observations

Open Call to join PCAPS Task Teams!

- PCAPS ORCAS is a community effort to **enhance forecasting capabilities** by exploring the potential of new AI techniques and leveraging data and collaborations from field programs.
- We will evaluate AI model performance to determine optimal **observational requirements** for future prediction systems
- We will assess the **physical consistency of AI prediction systems to build trust** among the scientific community and stakeholders

Strengthened observing systems for training, initialisation and validation of data-driven polar forecasts.

Sharing is encouraged

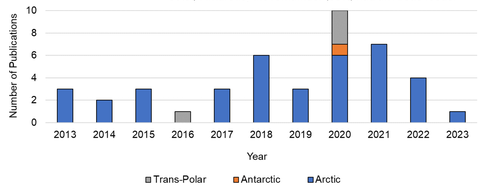
1 User needs in polar environments

Heinrich et al., 2024
Weather, Climate, and Society 16, 3; 10.1175/WCAS-D-23-0105.1

Word frequency count examining title, abstract, and keywords from the literature review. Dominant focus on **sea ice** research and **Arctic** users.

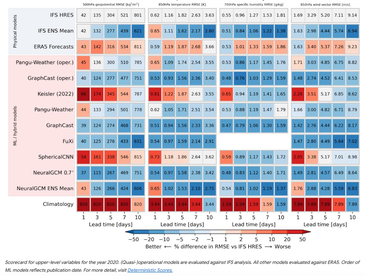
Number of publications by year during the PPP decade (n = 43).

Four discussed both Arctic and Antarctic regions and one was solely Antarctic, the remainder (88%) had an Arctic focus.



Most polar weather, water, ice and climate (WWIC) users do not have access to tailored products, decision-support services, or a local meteorologist / knowledge broker.

2 AI revolution in weather forecasting



Scorecard for upper-level variables for the year 2020. (Quasi-)operational models are evaluated against IFS analysis. All other models evaluated against ERA5. Order of ML models reflects publication date. For more detail, visit Deterministic Scores.

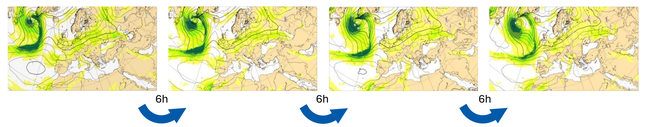
Recent advances in artificial intelligence are transforming sea-ice forecasting, with AI models demonstrating comparable or superior performance to traditional physics-based approaches while requiring significantly fewer computing resources.

These advantages could enable **more frequent and timely predictions**, benefiting stakeholders.

WeatherBench 2

3 On the design of ML models

TRAINING: ML models learn from several years of a high-quality dataset (e.g., ECMWF's ERA5 reanalysis), progressing from one analysis state to the next



For **FORECASTING**, we autoregressively step the trained model 6h into the future $x_n = f(x_{n-1})$

State variables and not fluxes are simulated

High-quality coupled reanalyses become central to train ML models

4 The use of observations

... in "traditional" numerical models:

- process understanding
- parameterisation development
- data assimilation for **initial conditions**
- forecast verification and model validation

... in data-driven models:

- process understanding
- parameterisation development
- data assimilation for **reanalysis and initial conditions**
- forecast verification and model validation

Certain observations are better suited to interact with current AI systems
(e.g., remote sensing)

Others less so
(e.g., campaign-style observations)

KOPRI 극지연구소 Korea Polar Research Institute
AAPP Australian Antarctic Program Partnership
The Ohio State University
University of Oslo
ECMWF
Australian Government Department of Climate Change, Energy, the Environment and Water Australian Antarctic Division
Australian Antarctic Program
Norwegian Meteorological Institute
GFDL
AWI

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