BREAKING THE ICE

ECCC’s contribution to an international effort at improved environmental predictions

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Coordinated by the World Meteorological Organization (WMO)

Period: mid 2017 – mid 2019  
(Launch: 15th May 2017)

• **Goal:** Improving predictions of weather and environmental conditions in polar regions and beyond

• International collaboration between academia, operational forecasting centres, and stakeholders

• Improving the polar observing system, as well as weather and environmental prediction models in polar regions
# YOPP Timeline

## Preparation Phase
2013 to mid-2017

- Community Engagement
- Alignment with other Planned Activities
- Development of Implementation Plan
- Preparatory Research
- Summer School Workshops
- Fundraising & Resource Mobilisation

## Core Phase
mid-2017 to mid-2019

- Intensive Observing Periods & Satellite Snapshot
- Dedicated Model Experiments
- Coupled Data Assimilation
- Research into Use & Value of Forecasts
- Intensive Verification Effort
- Summer School & Workshops

## Consolidation Phase
mid-2019 to 2022

- Consolidating YOPP Research
- From Research to Operations and Services
- YOPP Legacy
- Determining Success of YOPP
- Outreach & Communication
- Coordination
YOPP Observations – Arctic

- Satellite snapshots
- Extra modelling
- Field campaigns
- Special observing periods
  - SOP1: Feb-Mar
  - SOP2: Jul-Sep
  - SOP3: Feb-Mar

Extensive buoy coverage

Core modelling & prediction

MOSAiC

Preparing Phase

YOPP Core Phase

YOPP Consolidation
YOPP Endorsement

59 endorsed projects (28 August 2017)
Canada's interest in YOPP

- Close to a third of Canada is North of the Arctic Circle
- YOPP objectives align with Canada’s Arctic Policy Framework (science, sovereignty, safety)
- Builds on Canada’s leadership and investments to respond to METAREAS XVII and XVIII responsibilities
- Builds on ECCC’s leadership in Atmosphere-Ocean-Ice coupled prediction
  - CCMEP was the first centre with a short-range atmosphere-ice-ocean coupled system (GSL) and is now first with a global coupled medium-range atmosphere-ice-ocean forecasting system (GDPS) in operations
- Co-benefits further plans Government of Canada has recently funded such as OPP and CIOOS
ECCC YOPP activities

• Increased coverage of Arctic observations during YOPP Special Observing Periods (SOPs).

• Operating Supersites in Iqaluit and Whitehorse, and carrying out in situ snow and ice monitoring in other locations.

• Producing new environmental prediction systems and products, including monthly probabilistic sea ice forecasts and high-resolution pan-Arctic atmosphere-ice-ocean coupled forecasts.
  – Forecasts disseminated both nationally and internationally on public datamart server

• Standard WMO style verifications and new experimental metrics such distance measures of ice edge

• Regional Forecasting Offices and the Canadian Ice Service will share their evaluations of available prediction systems and collect valuable user feedback
**Additional Arctic Observations**

- Supersites in Iqaluit and Whitehorse
- Additional radiosonde launches during SOPs

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**10 Largest Radiosonde Impacts**

- Alert
- Eureka
- Hall Beach
- Inuvik
- Cambridge Bay

Doyle et al. (2019)

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**06Z and 18Z Radiosondes and Dropsondes (July 2018)**
Historical lack of buoy coverage in Eurasian basin
ECCC – (non GTS) Observations

• Supersites at Iqaluit and Whitehorse
  – Precipitation and particle classification from Ka- and X-band radar
  – Aerosol, water vapour and wind vertical distribution from LIDAR
  – Validating Earth Observations from NASA GPM and ESA Aeolus

• Ice stress measurements off the Labrador Coast
  – Study of interaction between the land fast ice and mobile ice pack and the formation of the Stamukhi region

• Measurements of snow distribution and microstructure for snow remote sensing validation and modelling
  – in concert with UkMet FAAM aircraft campaign out of Inuvik

• Validating ice thickness retrievals from IceSat2 in collaboration with NASA Ice Bridge
ECCC Polar Forecasts

• Canadian Arctic Prediction System (CAPS)
  – Pan-Arctic high-resolution coupled forecasts
• Coupled Global Medium-range Deterministic System
  – GDPS-GIOPS (now operational)
  – fully-coupled A-I-O, 15km(A)-1/4deg(IO), 10day
• Monthly Ice-Ocean Ensemble Forecasts
  – EnsGIOPS, Global, 1/4deg, 20 member, 32day
• Seasonal Predictions (CanSIPS)
  – CanCM3/4 with improved sea ice, and
  – Also including GEM-NEMO-CICE
    ▪ Global, 1deg, 20 member

Outputs available on MSC Datamart
For sharing nationally and internationally
Monthly Ensemble Ice-Ocean Forecasts

Running in real-time (every Thursday) since June 2016

- Developed for use by Canadian Ice Service
- Forced by Global Ensemble Prediction System (50km)
  - EnKF Atmospheric analysis, daily 15d forecasts, 32d forecast 1/week
  - 21 members with perturbed analyses and different model physics
- Subjective evaluation by CIS found significant value for long-range forecasts
- Finalizing implementation of Coupled A-I-O Ensemble Forecasting System

Anomaly 2017-07-06+504 hours

3-week forecast

Canadian Ice Service Regional Analysis
Canadian Arctic Prediction System (CAPS)

High-resolution coupled atmosphere-ice-ocean prediction system

- **In support of:**
  - Weather prediction for northern Canada
  - EC METAREAs Services
  - Marine emergency response

- **Coupled atmosphere-ice-ocean model**
  - GEM (3.0 km)
    - Predicted particle properties microphysics
  - NEMO-CICE (3-8 km)
    - Tides, landfast ice
  - 48 h forecasts (2/day)
  - Uncoupled since Jan. 24, 2018
  - Coupled since Jun. 28, 2018
  - Available at: http://dd.alpha.weather.gc.ca/yopp
CAPS Configuration

Coupled GDPS-GIOPS

Coupled CAPS-RIOPS
Impact of small-scale coupled atmosphere-ice-ocean interactions in CAPS

- Orographic features better represented
  - Flow through fjords
  - Potential impact on local ice drift
- Imprint of small-scale features on surface fluxes
  - Boundary layer interactions in marginal ice zone
  - Coastal polynyas and leads in sea ice

Surface Air Temperature

Forecast for 2017-01-01

Ice Concentration
Impact of model resolution on forecast skill

CAPS, Regional forecasts (RDPS), Global forecasts (GDPS) over Northern N. America

Verification against Surface Stations – Jul/Aug/Sep 2018

Casati et al. (2019)

See Køltzow et al. (2019) for comparison with forecasts from Met.no, Meteofrance and ECMWF
New products: Internal Ice Pressure

IcePressure (w wind vectors) on 2018031800_000

Lemieux et al. (2019)
New products

- Internal ice pressure
- Tendency of internal pressure
- Shear rate

F. Labelle
**ICE-X: ICE STRAIN AND FRACTURING RISK**

**Fracturing Risk Code**

- 4/01 00Z: GREEN
- 4/02 00Z: GREEN
- 4/03 00Z: GREEN
- 4/04 00Z: YELLOW
- 4/05 00Z: YELLOW
- 4/06 00Z: RED

**Ice Strain**

- GOFS Ice Openings Strain Rate
- Valid 00Z 01 April 2017

**Fracturing Risk Code Guide**

- **GREEN**
  - Low risk of new fractures: No sign of ice strain in environmental conditions AND model data.

- **YELLOW**
  - Moderate risk of new fractures: Environmental conditions indicate ice strain developing OR model data suggests elevated ice strain.

- **RED**
  - High risk of new fractures: Environmental conditions AND model data indicate high ice strain.

- **ACTIVE FRACTURING**
  - Fracturing imminent or underway: Environmental conditions AND model data indicate fracturing OR fracturing has been observed.

**Analyst Notes**

Current winds are light (below 15kts) and generally NE over monitored floes. This is a mildly compressive scenario for the pack ice and represents a low risk of new fractures. Forecast calls for strong high pressure by mid-week and model data indicates increasing ice strain. Expect moderate fracturing risk beginning Tue as winds shift to E/SE. Long term shows active fracturing may be expected through the weekend.

**Courtesy of R. Allard (NRL)**
Third Session of the Pan-Arctic Regional Climate Outlook Forum (PARCOF-3), Rovaniemi, Finland, May 2019

Consensus Statement for the Arctic Summer 2019 Season Outlook

**Figure 8:** Forecast for the 2019 spring break-up where break-up is defined as the date when the ice concentration drops below 50%. Left: anomaly (difference from normal) based on the 2009-2017 period and right: the historical skill defined as the detrended anomaly correlation coefficient based on the 1981-2010 period.

**Figure 9:** September 2019 probability of sea ice at concentrations greater than 15% from CanSIPS (ECCC). Ensemble mean ice extent from CanSIPS (black) and observed mean ice extent 2009-2017 (green).

Dirkson et al., J. Clim (2019); Sigmond et al., GRL (2016)
Shared Metrics for Sea Ice Verification

Integrated Ice Edge Error (IIEE) and Spatial Probability Score (SPS)

Forecast error in predicting the Arctic sea ice edge

Zampieri et al., GRL (2018)
Goessling et al., QJRMS (2018)
Sea Ice Drift Forecast Experiment (SIDFEx)

- SIDFEx is a community effort to collect and analyze Arctic sea-ice drift forecasts at lead times from days to a year.
- Currently, 10 groups participating with 16 forecast products.
- Forecasts are made with various methods for drifting sea-ice buoys and, ultimately, the trans-Arctic MOSAiC drift campaign.

> 37, 000 SIDFEx forecasts to date!

10-day forecasts for one buoy from two systems, daily initial times between 14 February and 20 April 2018.

Top: Observed (grey) and forecast (coloured) trajectories.
Bottom: Drift speed and angle relative to observations.

Goessling et al. (2019)

All the details at www.polarprediction.net/yopp-activities/sidfex
Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC)

- Over-wintering of Polarstern icebreaker
  - Starting Sep. 2019
  - Largest central Arctic expedition ever
- Intensive observatory:
  - buoys, ice-tethered profilers, remote meteorology stations, underwater drifters, unmanned aerial systems, aircraft
- Improved process-level understanding
- Contribute to improved modeling of global climate and weather, and Arctic sea-ice predictive capabilities

Shupe et al. (2018)
YOPP Consolidation Phase

6 key elements

Consolidating YOPP Research
- Observing system experiments
- Process understanding
- Forecasting system development
- YOPP reanalysis
- Verification
- Special Services Periods

From Research to Operations and Services
- Recommendations for an advanced polar observing systems
- Operational implementation of research

Coordination
- Define YOPP Task Teams for relevant activities
- Community engagement
- Ensure effective coordination by members of PPP Steering Group and International Coordination Office

Outreach and Communication
- Promote YOPP findings
- Community engagement
- Ensure acknowledgement of YOPP and WMO WWRP
- Train next generation of scientists

YOPP Legacy
- Define activities to be continued past YOPP
- Identify critical partners
- Ensure availability of YOPP data past 2022
- Maintain central hub of information (website)

Determining Success of YOPP
- Identify success measures for YOPP
- Evaluate achievements
- Define remaining gaps
- Provide recommendations for future research

Revised Chapter on Consolidation in YOPP Implementation Plan version 3.0
Available on Polarprediction.net
Summary remarks

Outcomes from the YOPP Core phase
• Putting together modelling and observational data sets for process understanding
• Improved performance of environmental prediction systems in polar areas
• Improved sea ice verification and user-relevant products

Key challenges for consolidation phase
• Increased understanding of polar dynamic and physical processes to allow improved formulation of environmental prediction models and parameterization schemes in the polar regions
• Recommendations for an optimized Arctic and Antarctic observing system to benefit predictions in polar regions and beyond.
Adapting to user needs….

Did anyone check the sea ice forecast this morning?

13.71 M km²!

AN EXAMPLE FROM THE QUÉBEC WINTER CANOE RACE

Courtesy Corinne Bourgault-Brunelle
Thank you!

ECCC Forecasts available at:
dd.weather.gc.ca
dd.alpha.weather.gc.ca
navigator.oceansdata.ca
More info: Polarprediction.net