What are the challenges and priorities for improved prediction and climate monitoring of the Arctic?

Irina Sandu

Weather forecasts experienced a quiet revolution

Global NWP systems of today, i.e. ECMWF ten-day fc ~ 9 km, 137 levels

COMBINED advances in NWP key ingredients:
- science (physics, numerics, data assimilation)
- Utilisation of observations
- Supercomputing

Anomaly correlation geopotential height 500hPa – NH/SH (ECWMF)
Weather forecasts experienced a quiet revolution – and so did modern reanalysis

Much better representation of Sudden Stratospheric Warming events, due to changes in the Semi-Lagrangian scheme (Diamantakis, 2014)

Modern reanalysis, i.e. ERA5 ~ 32km, 137 levels

Great tools for climate monitoring of the Arctic

Linear trends in 2m temperature (K/decade) for 1979-2017

(f) ERA5 analysis

T. McNally, A. Simmons
Yet, forecast skill remains lower in the Arctic

Challenges related to:
- physical processes, wide range of scales, coupling
- use of observations
- data assimilation techniques
- ensemble prediction
Modelling challenges – one example: Arctic air mass transformation

- Stable boundary layers
- Mixed phase clouds
- Atmosphere-sea ice coupling
- Sea ice
- Snow over sea-ice
- Wide range of scales

Pithan et al. (2018, 2016)
Challenges in data assimilation techniques

We know observations and models are not perfect:
1. As long as observations and background forecast uncertainty are properly specified, we should produce an optimal analysis
2. As long as initial condition and model uncertainty are properly specified, we should produce a reliable ensemble forecast
Challenges in data assimilation techniques

In lower-troposphere & upper-stratosphere, the adjustments observations can make to the short-range forecasts in the Arctic during the assimilation are now limited.
Challenges in the use of observations

Less conventional data above 70N than Northern mid-latitudes

Also larger model errors & too much confidence in the model in the lower-troposphere

H. Lawrence
Challenges in the use of observations

- better coverage from polar orbiting satellites than anywhere else
- more challenges with their use (model errors, radiative transfer modelling)
- more data rejected for tropospheric channels in winter

NOAA-15
AMSU-A channel 5 (peaks 500-700hPa)
YOPP Modelling & Forecasting Datasets

**ECMWF YOPP dataset**
- EPS control coupled forecasts 15 days (18 km)
- Process tendencies provided
- [http://apps.ecmwf.int/datasets/data/yopp/](http://apps.ecmwf.int/datasets/data/yopp/)

**ECCC YOPP datasets**
- CAPS-RIOPS (A:3 km, IO: 3-8 km, 2 days)
- GDPS-GIOPS (A: 25km, IO: 1/4°, 10 days)
- GIOPS ensemble (32 days, 20 members)
- Seasonal predictions (1°, 20 members)
- Available through World Mapping Service (WMS)

Data availability and further information [http://polarprediction.net](http://polarprediction.net)
Example application:
Contrasting mean tendencies in different regions

Jung et al. (2016)
YOPPsiteMIP - YOPP supersite Model Inter-comparison Project

- **Process based forecast evaluation** at YOPP supersites: fixed and floating, range of surface & climate types
- IASOA/NOAA producing Merged Observatory Data Files (MODFs) for YOPP SOPs, hosted by MetNo
- Modelling contributions from ECMWF, UK Met Office, Russian Hydromet, ECCC, Met No., Univ. Stockholm.
Example of diagnostic analysis at the Sodankyla supersite (Finland)

Targeted diagnostics & model evaluation inform model development

Temperature profile for Jan-Feb 2017

- Obs
- Single layer snow
- Multi layer snow

J. Day & G. Arduini
Coupled (atm/ocean/sea-ice) modelling and process understanding

Specific dynamic & thermodynamics coupling challenges in NWP
- Initialization
- Temporal and spatial scales

Hartung et al. (2018)
Model comparison for the first YOPP SOP
(Feb-March 2018)

Temperature when forecasts and observed calm winds (< 2m/s)

ECMWF IFS overestimates very cold temperatures in calm wind conditions, AROME(s) better
Observing System Experiments (OSEs)

Remove (satellite and conventional) observations at \( \text{lat}>60\text{N} \) and \( \text{lat}<60\text{N} \):

3 months winter (including YOPP 1\textsuperscript{st} SOP)

3 months summer

Analyse the increase in forecast error when observations are removed from the Arctic

H. Lawrence et al., in preparation
Degraded forecast skill in the North Pole and Northern Mid-latitudes

Summer:
- Microwave
- Conventional
- Infrared
- GPSRO, AMVs

Winter:
- Conventional
- Less impact overall from each observation type

H. Lawrence et al., in preparation
Impact on the midlatitudes & Arctic – midlatitude linkages

Day 4

13-01-2018
(MW most important)

24-02-2018
(Conventional most important)

Jung et al, 2014

J. Day et al, in preparation
Specific challenges in the Arctic:

- Coupled model errors are large & the range of scales to cover is wide;
- The Arctic is sparse in term of conventional observations but very rich in terms of satellite observations;
- Satellite observations are more difficult to use (i.e. radiative transfer modelling);
- Background error representation in data assimilation systems.

Concerted effort in YOPP in:

- enhanced coupled modelling;
- data assimilation methods (including initialization of new components & coupled data assimilation) ;
- effective use of observations in the numerical weather prediction systems.
- Artic-mid-latitude linkages