PPP

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The Polar Prediction Project

and the

Year of Polar Prediction

YOPP and short-range NWP

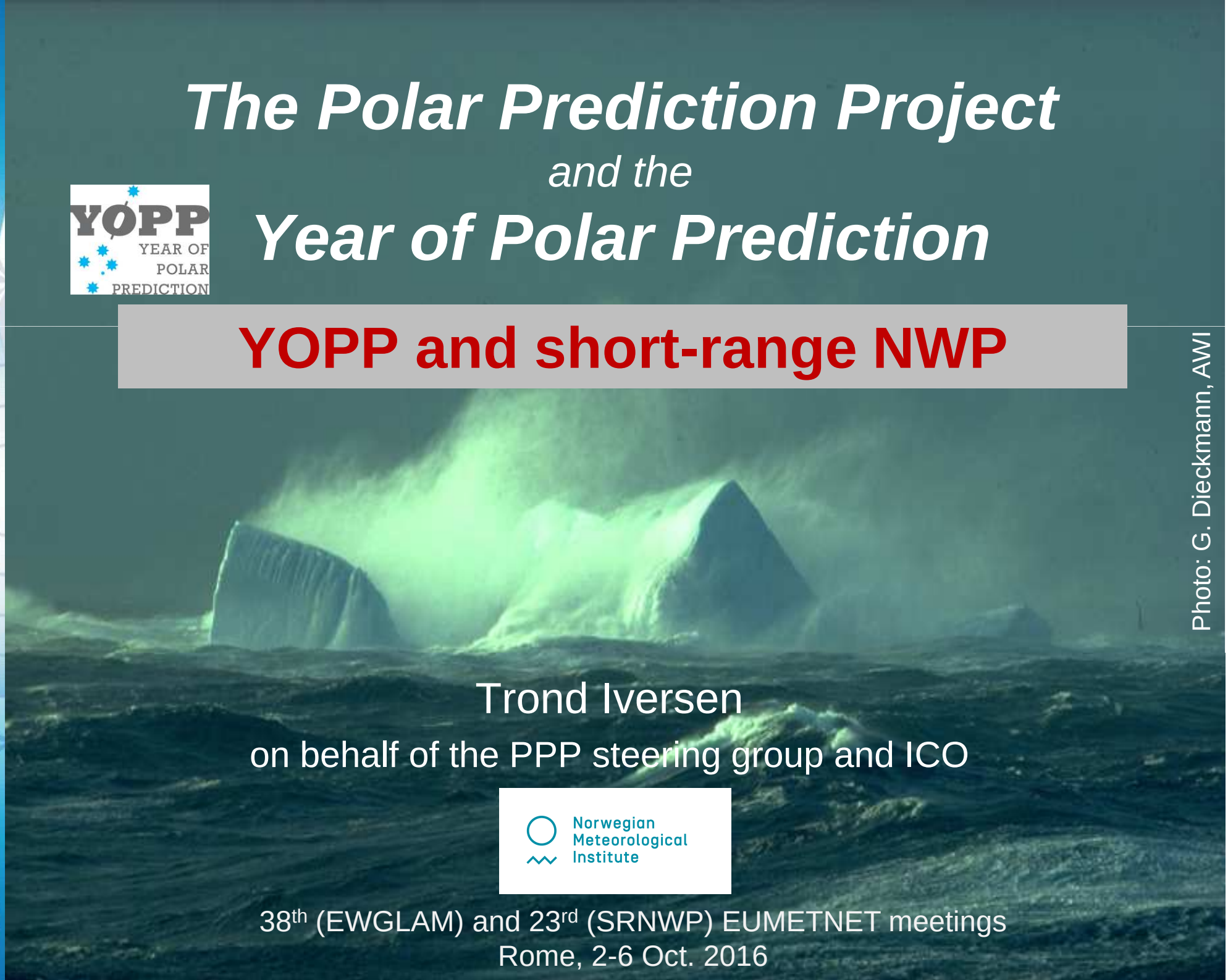


Photo: G. Dieckmann, AWI

Trond Iversen

on behalf of the PPP steering group and ICO

Norwegian Meteorological Institute

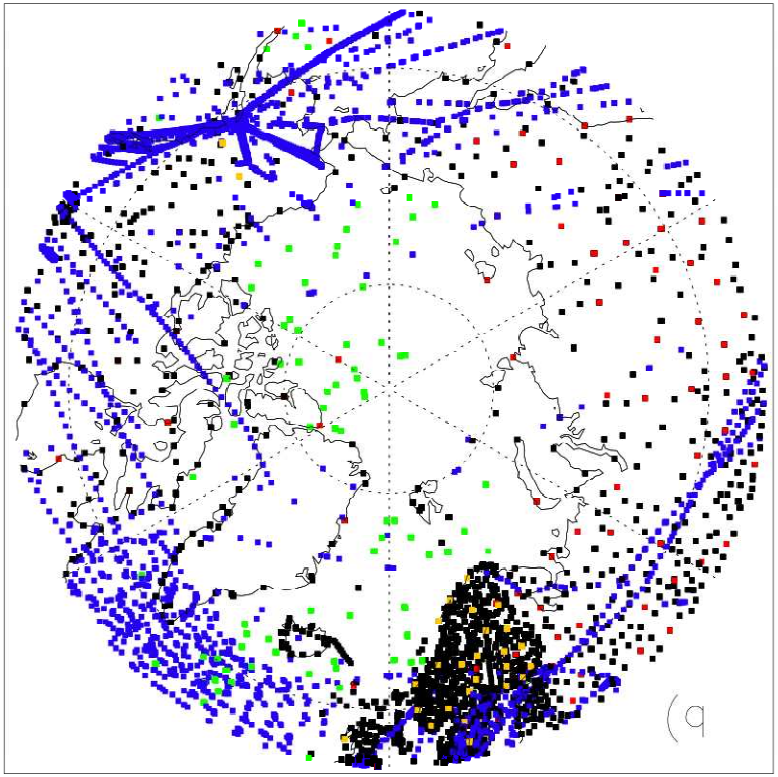
38th (EWGLAM) and 23rd (SRNWP) EUMETNET meetings

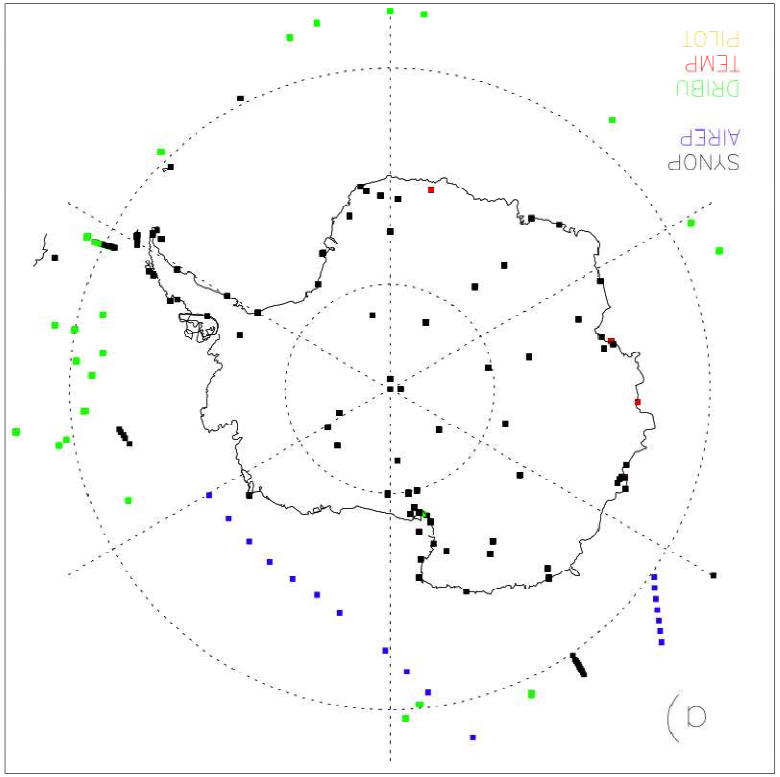
Rome, 2-6 Oct. 2016

Why?

Significant gaps in the polar observing systems

Hard task for data assimilation where (i) observations are rare





Synop, AIREP, DRIBU, TEMP and PILOT

Polar data coverage of conventional observations in the ECMWF operational analysis on 1 January 2012

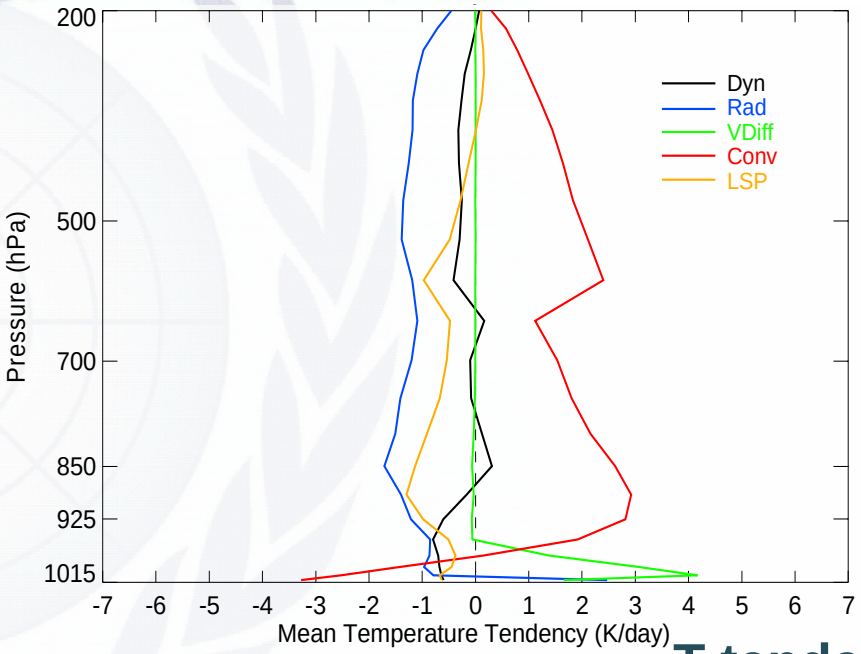
P. Bauer (ECMWF)

Why?

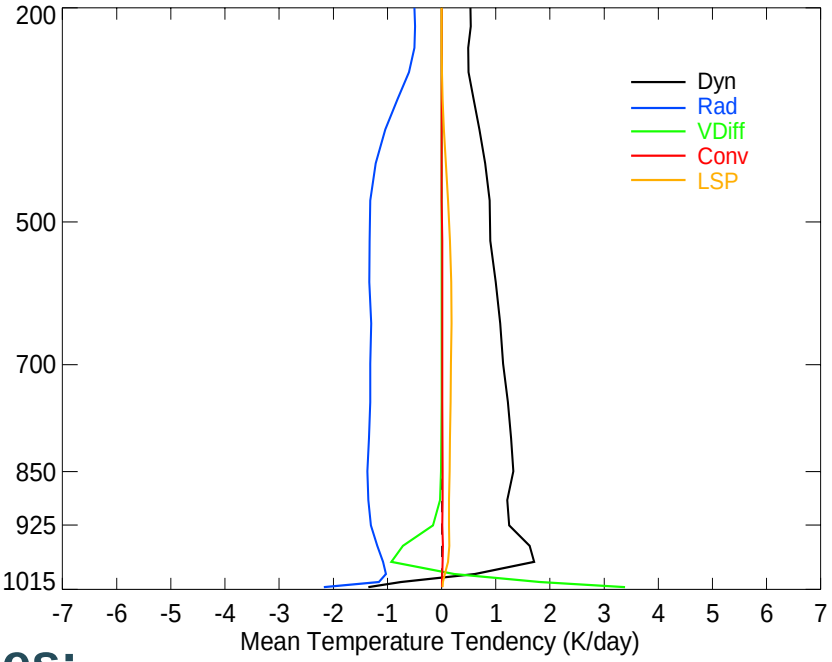
Hard task for data assimilation where (i) observations are rare
and (ii) models are deficient

Strong differences between polar and lower latitudes

Tropics: Ocean-only (DJF)



Arctic: Sea ice-covered ocean (DJF)



T-tendencies:

dynamical cooling by advection and ascent (Dyn); radiative (Rad);
vertical diffusion (VDiff); convective (Conv);
evaporative cooling of large-scale precipitation (LSP);

S. Serrar (AWI)

Model difficulties: - stably stratified boundary layers over sea ice
- mixed-phase clouds
- presence of sea-ice; difficult rheology

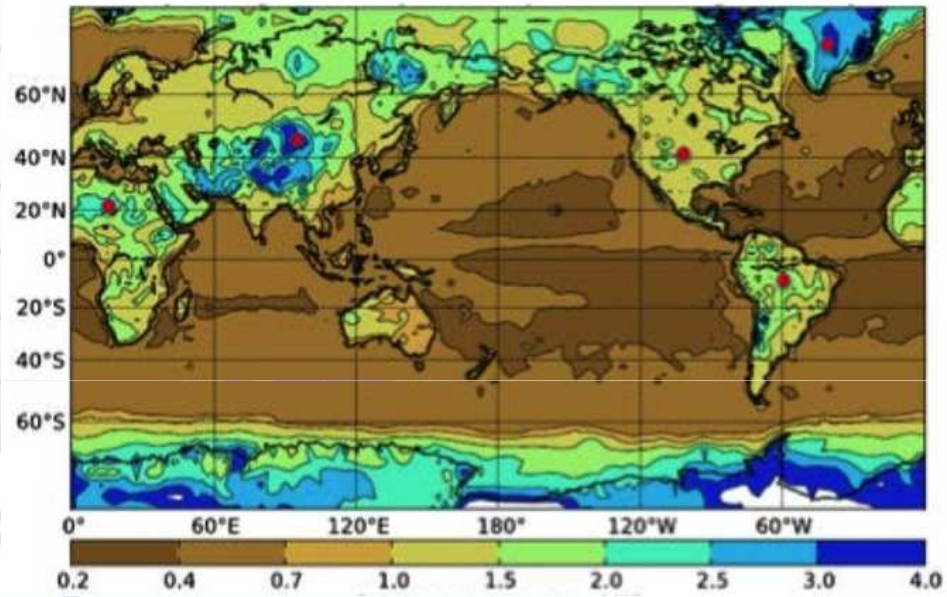
Why?

Analysis and forecast quality

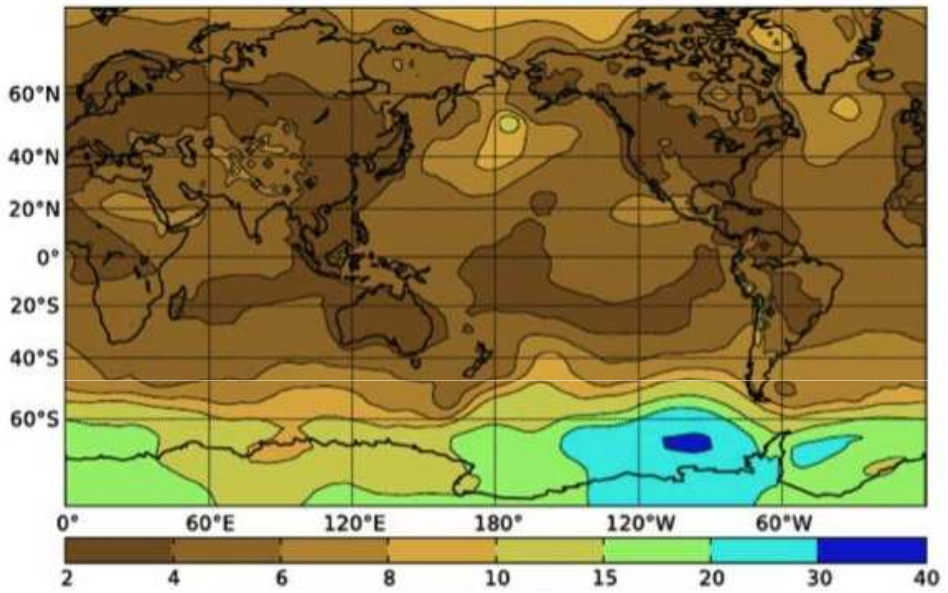
TIGGE* analysis spread (Oct-Nov 2010)

* UKMO, ECMWF, NCEP, CMC, CMA

2-meter temperature (K)



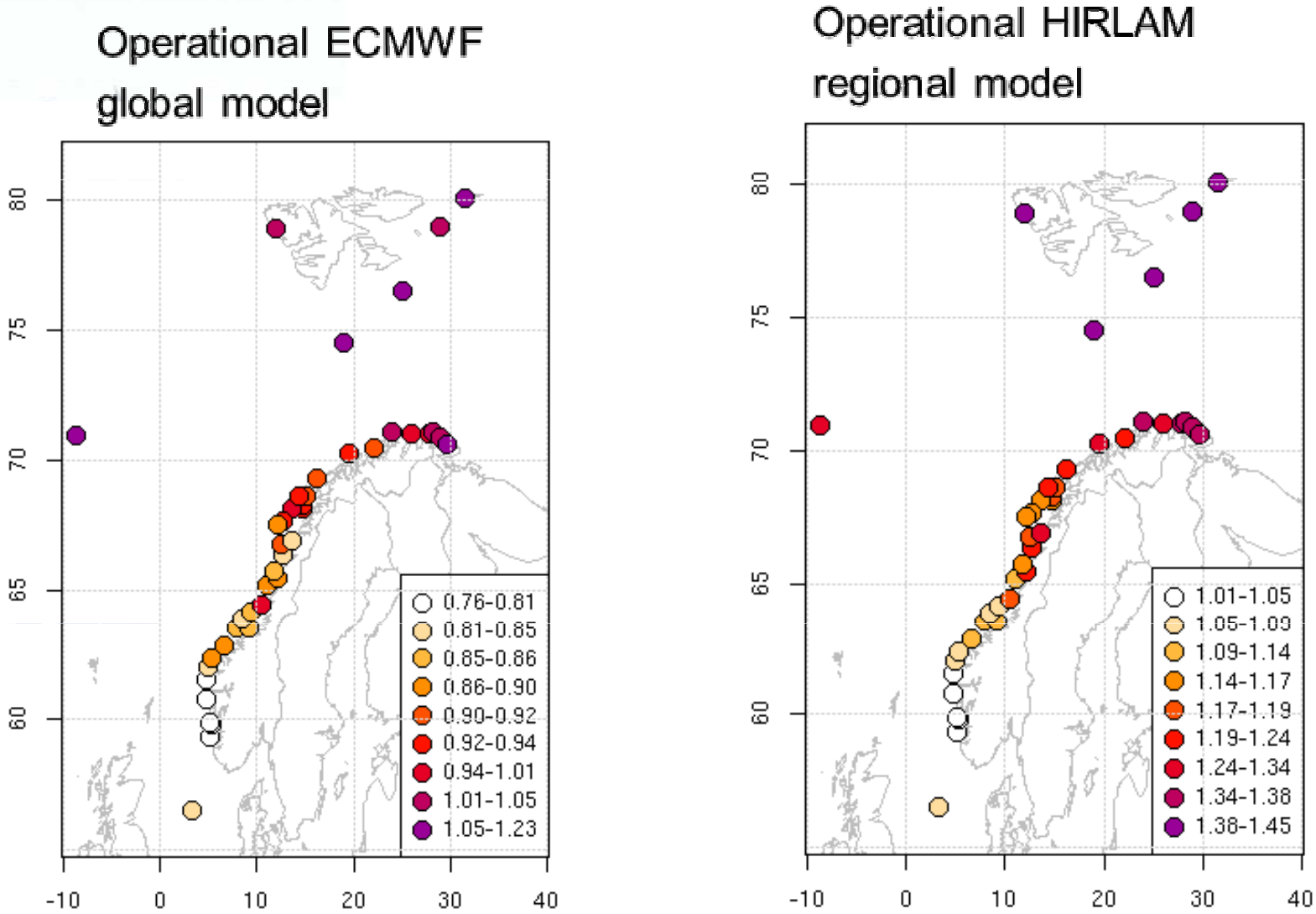
500hPa geop. height (m)



Hamill 2012, (pers. comm.)

Forecast accuracy decreases towards the North

RMS errors in pressure (vs observations) for forecasts from 18 to 42 hours



Schyberg, Nipen, Randriamampianina (2013)→EU_ACCESS

PPP

YOPP
YEAR OF POLAR PREDICTION

Year of Polar Prediction

a period of intensive observing, modelling, prediction, verification, user engagement and education activities

MOSAiC

Preparation Phase 2013 to mid-2017	YOPP mid-2017 to mid-2019	Consolidation Phase mid-2019 to 2022
Community engagement	Intensive observing periods & satellite snapshot	Data denial experiments
Alignment with other planned activities	Dedicated model experiments	Model developments
Development of Implementation Plan	Coupled data assimilation	Dedicated reanalyses
Preparatory research	Research into use & value of forecasts	Operational implementation
Summer school Workshops	Intensive verification effort	YOPP publications
Fundraising & Resource mobilization	Summer school	YOPP conference

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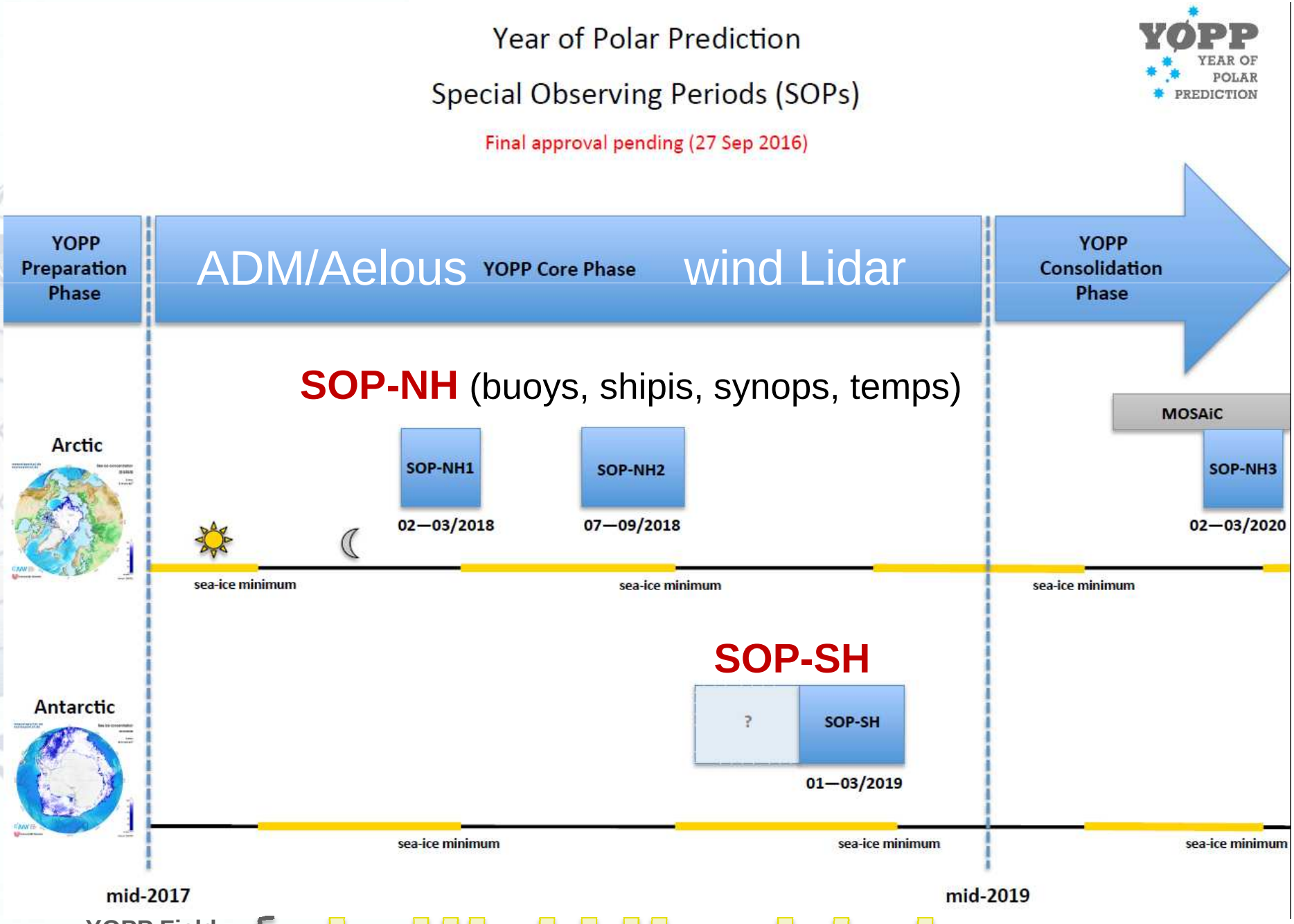
The YOPP-Observational Component



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The YOPP Modeling Component

- **Identify polar specific scientific issues that require addressing in NWP systems to advance predictive skill**
- **Devise numerical experiments that provide guidance on how to implement improvements**

How do we diagnose/quantify this?

Model forecasts:

- **Observation impact**: contribution of observations to predictive skill (FSOI, OSE, OSSE)
- **Ensemble diagnostics**: sensitivity of forecasts to location/magnitude of initial perturbations
- **Relaxation experiments**: sensitivity of forecasts to 'accurate' states in selected areas, linkages

Analysis/initial conditions:

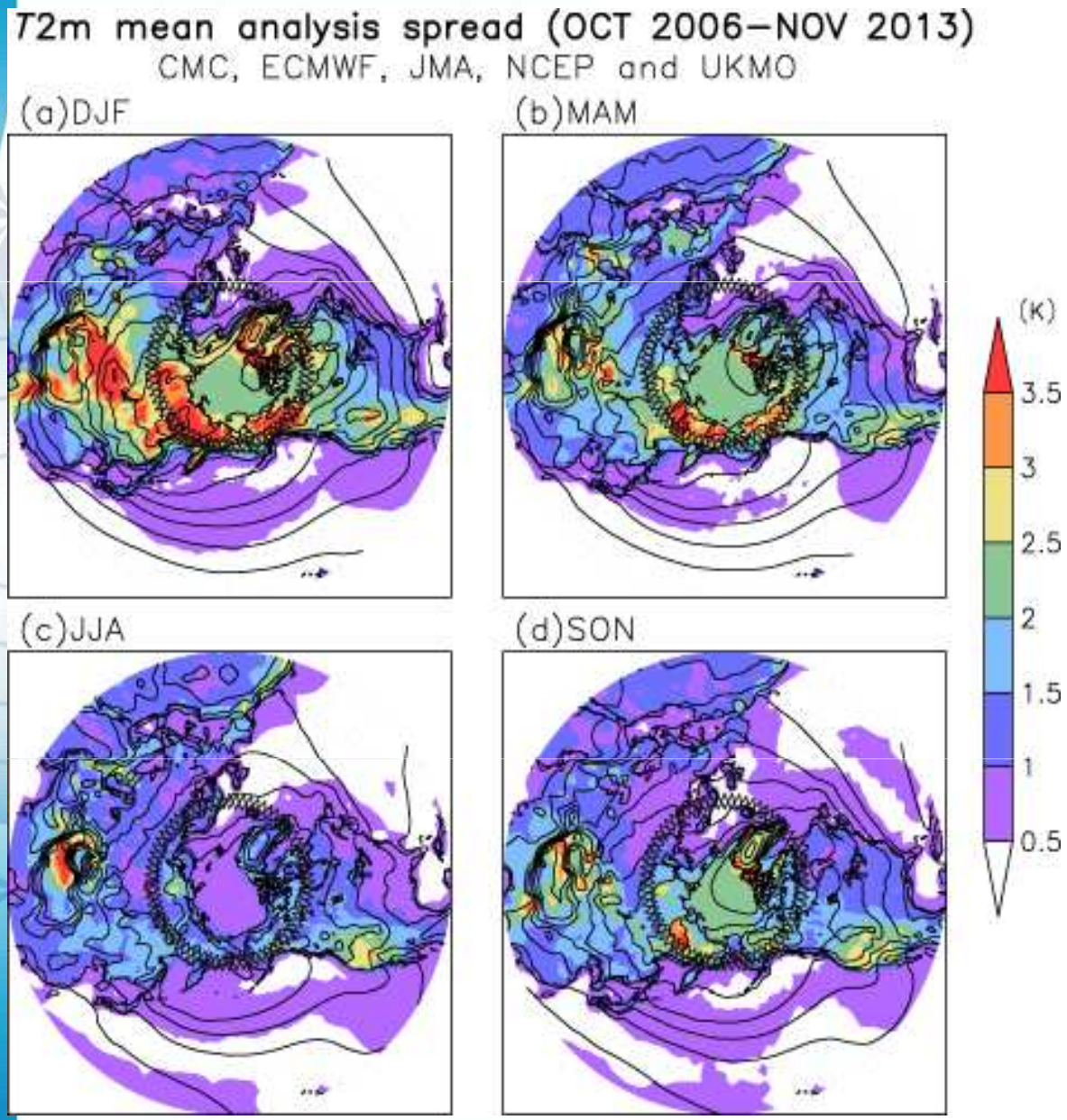
- **Observation impact**: contribution of observations to analysis (DFS, increments)
  - **Ensemble diagnostics**: consistency of uncertainty definition in analysis
- **Tendency diagnostics**: contribution of processes to tendencies, error growth
  - **Reanalyses**: representation of trends, budgets (incl. most of the above!)

NB: Climate change may hamper statistical calibration of extremes

YOPP Model Dataset Categories

Core Datasets:	Main modelling datasets produced primarily to support YOPP. Covering YOPP core period (mid-2017 to mid-2019) but could be extended to cover MOSAiC period
Supplementary Datasets:	Outside YOPP, but providing valuable resources to support YOPP scientific studies.
Experimental Datasets:	Experiments running during YOPP aimed at studying and improving model performance for polar prediction. This will include contributions from a wide range of YOPP scientists.

Example: Analysis Uncertainty



Large spread in the analysis of T2m in regions of sea ice and snow
– **except summer** when the ice temperature is close to melting.

Jung et al. 2014

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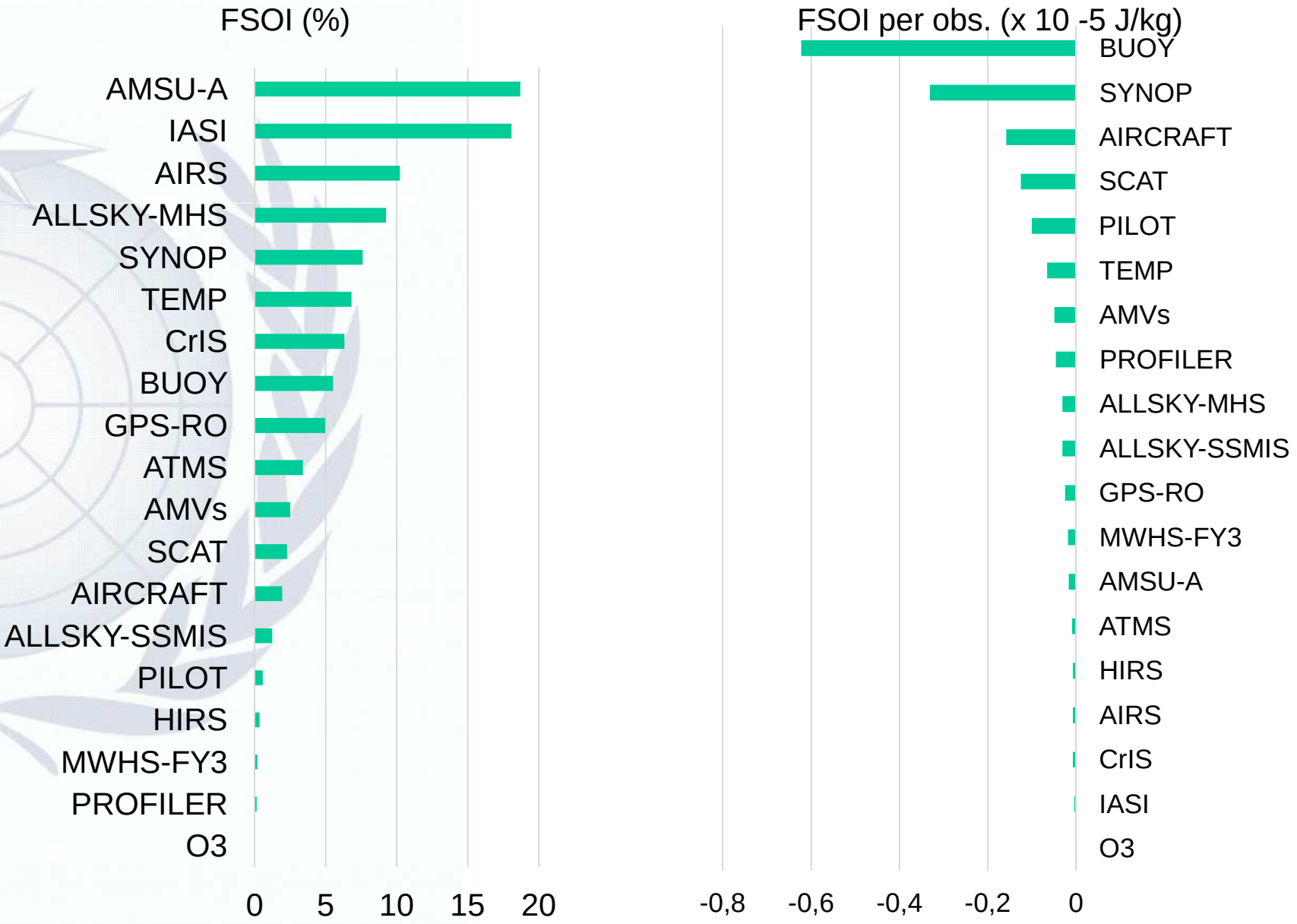
Forecast sensitivity to the observing system within the Arctic (>68N) –Winter (S. Keeley, ECMWF)

Adjoint sensitivity tool (FSOI = Forecast Sensitivity to Observations Impact)

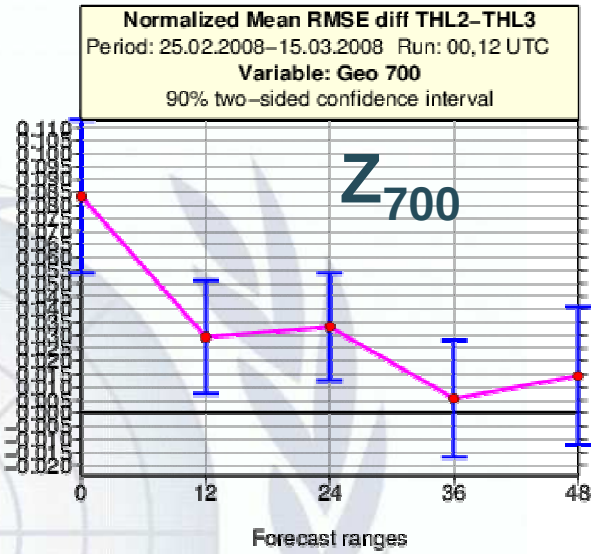


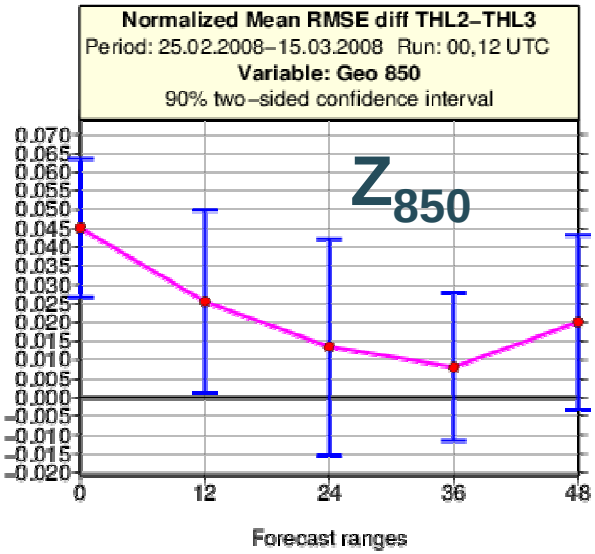
41r1 for 1st November 2015 – 28 February 2016

Examples from short-range NWP:

OSE – Impact of remote radiosonde stations

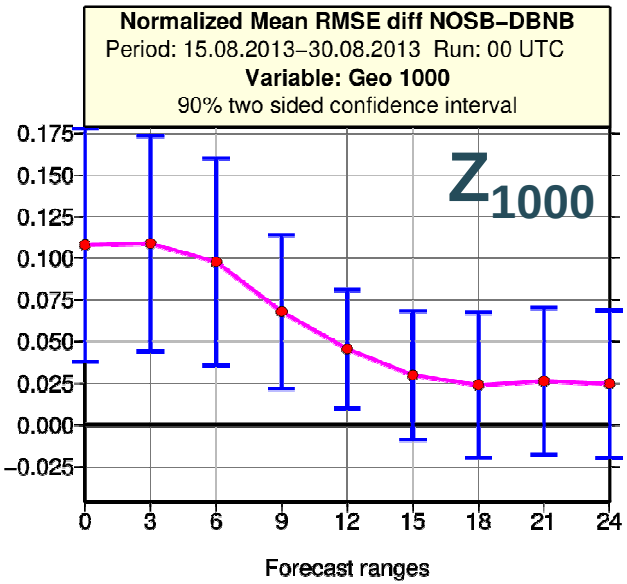
IPY-THORPEX study (March 2008) Randriamampianina et al. (2011)

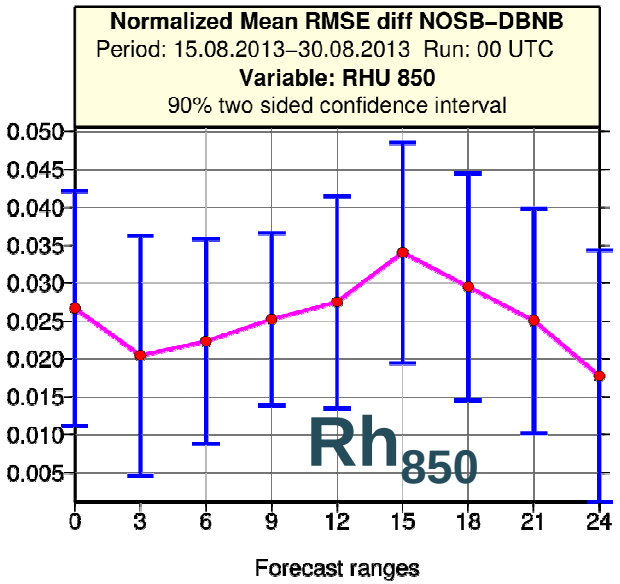




OSSE – impact of more ~24 (x2) BUOYs

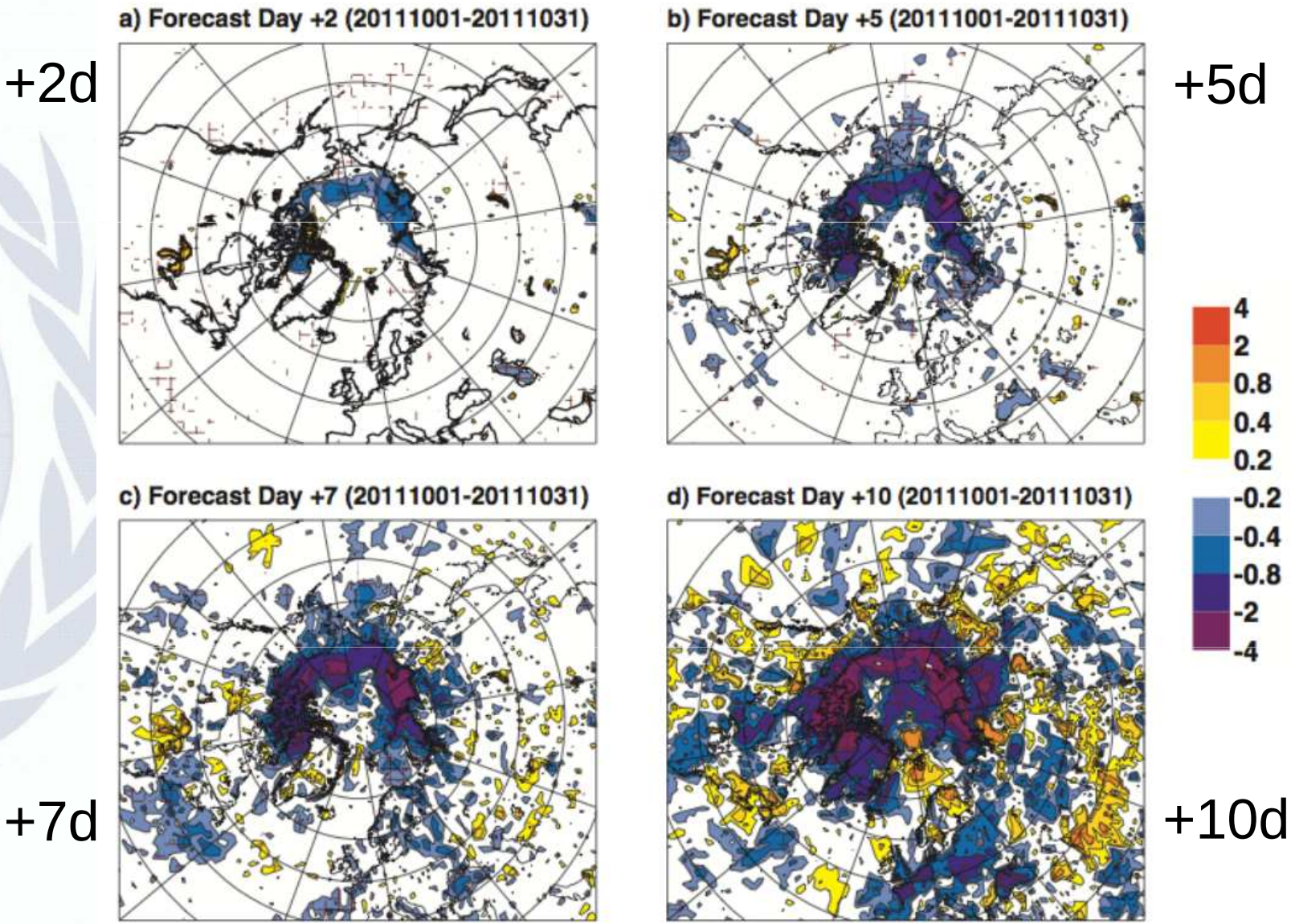
EU FP7 ACCESS study (August 2013) Randriamampianina & Schyberg (2014)





Example: Relaxation experiments

Atmosphere model coupled with observed SSTs



T2m Difference: Observed Minus Persisted Sea Ice; Nov. 2011 (ECMWF)

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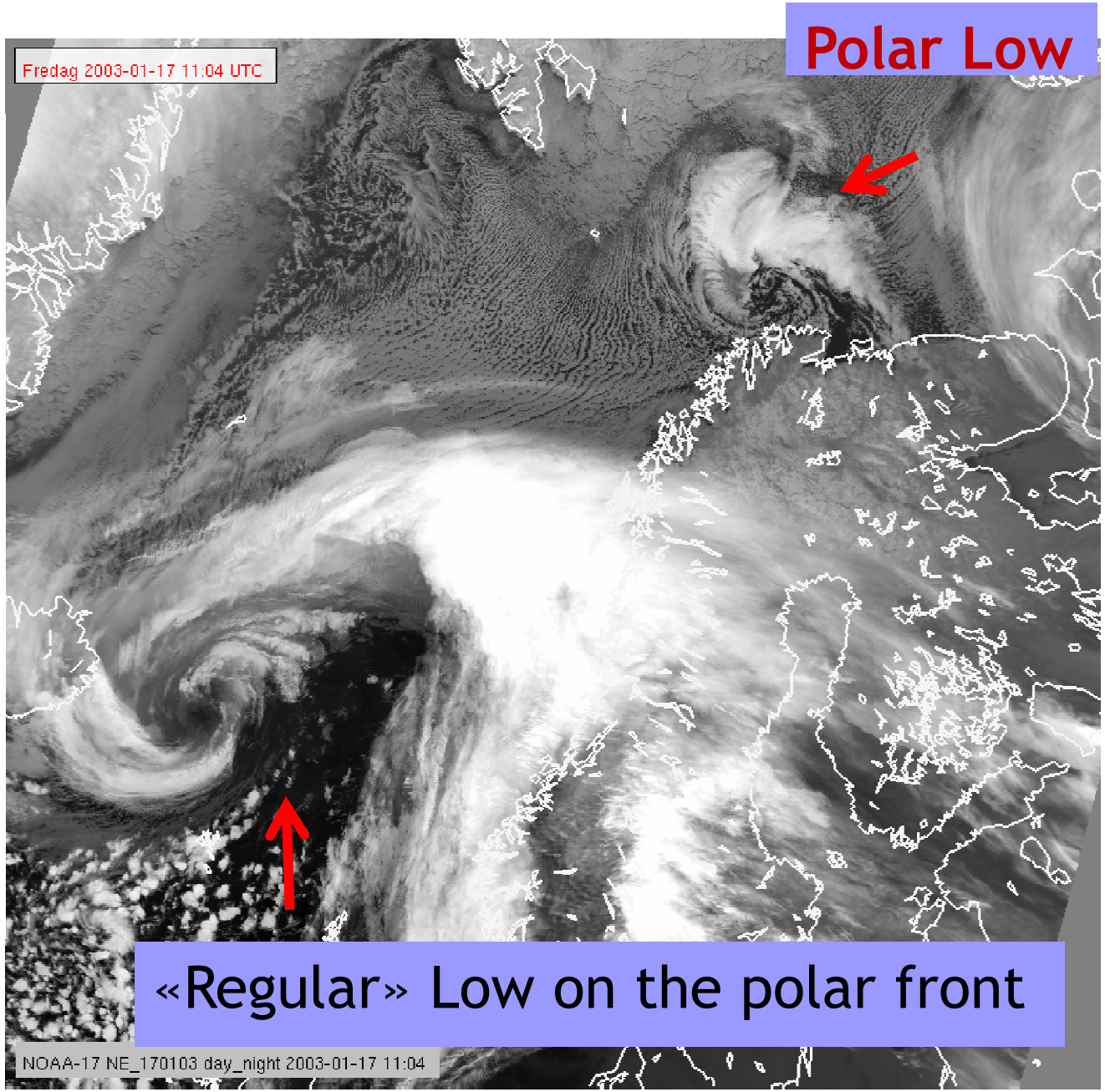
Polar lows:

- A small-scale, rapidly developing and fairly intense cyclone over ice-free ocean
- October - May
- Rapidly changing weather
- Gale or storm force winds
- Severe snow intensity



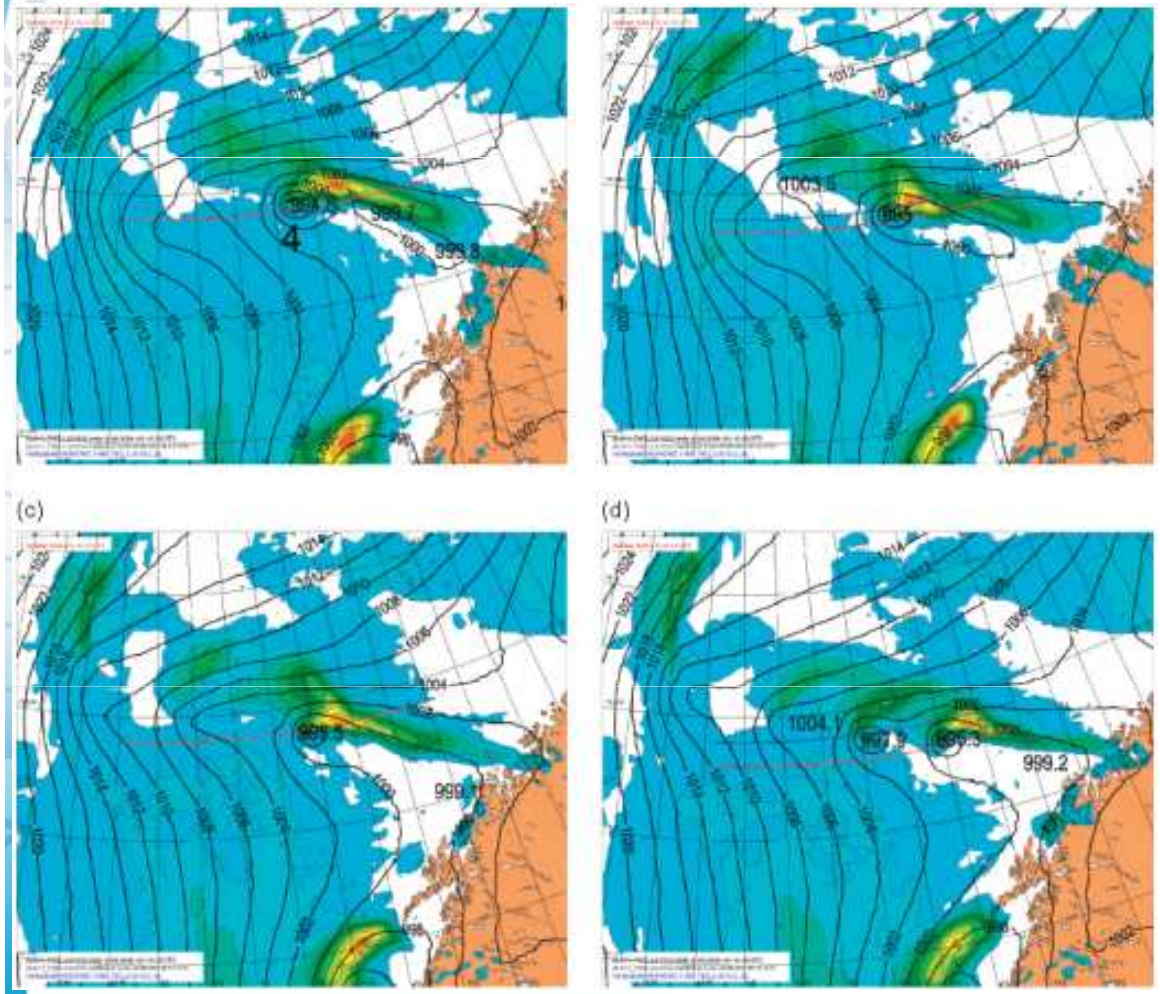
Example from IPY Thorpex

Randriamampianina, Iversen and Storto **2011, Q.J.R.M.S.** DOI:10.1002/qj.838

24h forecast, valid at 16.03.2008 12 UTC

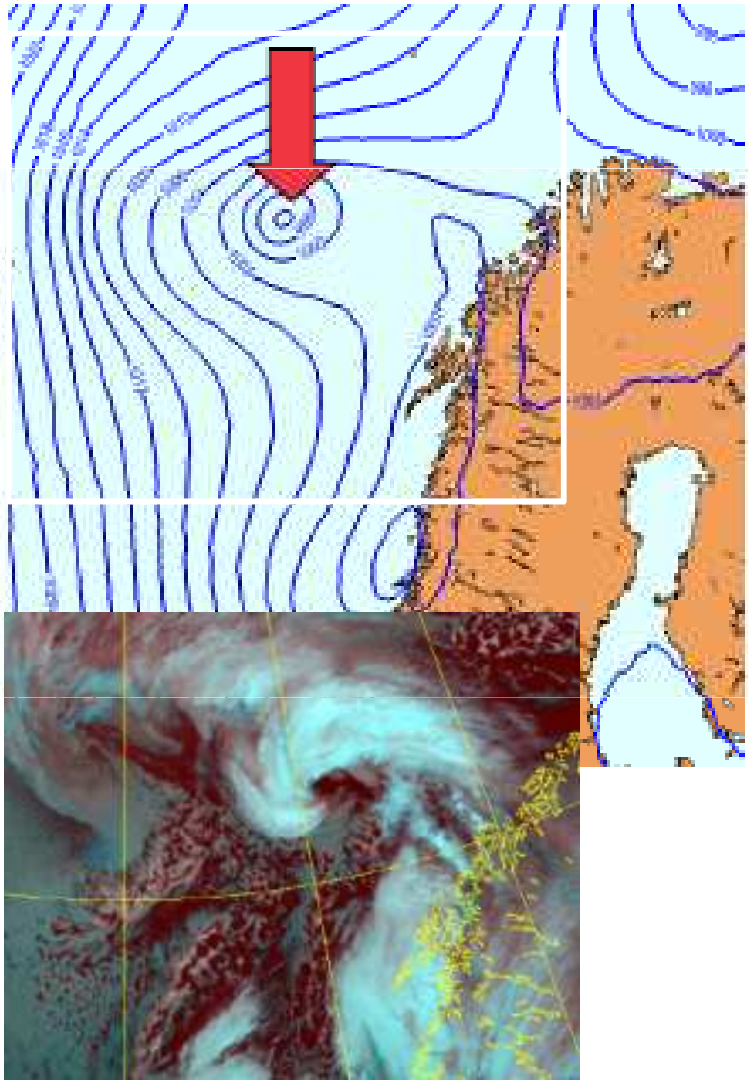
IASI-data

No IASI-data



20080316 12 UTC

HARMONIE verifying analysis
16.03.2008 12 UTC
IASI & campaign data employed



NOAA-18, 16.03.2008 09:26

Campaign observations + IASI ➔improved forecast

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Campaign in-stu -data

No campaign in-stu -data

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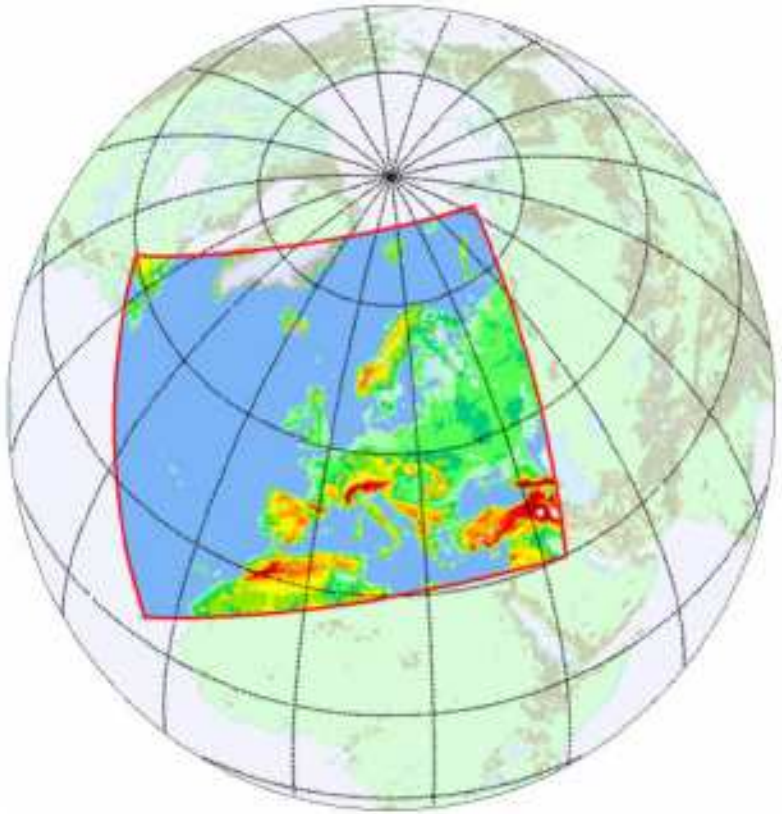
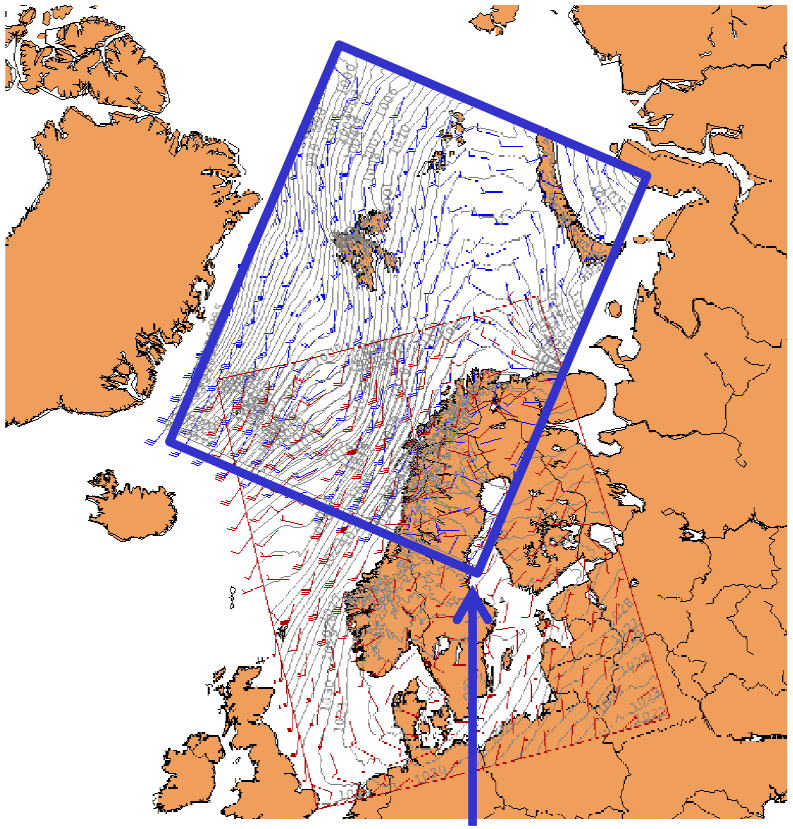
Operational short-range NWP with Arctic cover



CLAMEPS

Multi-model, pan-European EPS ~8 km resolution
Forecast range: 54h 48 +4 ensemble members
Four times a day (00, 06, 12 and 18 UTC)



AROME-Arctic

Categorical (deterministic) 60h convective scale (2.5km) atmosphere model coupled to simplified sea-ice model

Also a candidate for re-analysis

Other European Systems are welcome!

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Possible (Nordic) short-range contributions to the YOPP modelling plan:

- **Core datasets**
  - AROME-Arctic forecast data sets with additional variables
  - Re-analysis with AROME-Arctic
- **Supplementary datasets**
  - GLAMEPS forecast data
- **Experimental Set-ups**
  - Data-denial experiments with AROME-Arctic
  - Experiments with GLAMEPS (possibly)
  - High-resolution coupled model system experiments

YOPP
YEAR OF POLAR PREDICTION

NB: To obtain YOPP endorsement of projects
→http://apps3.awi.de/YPP/

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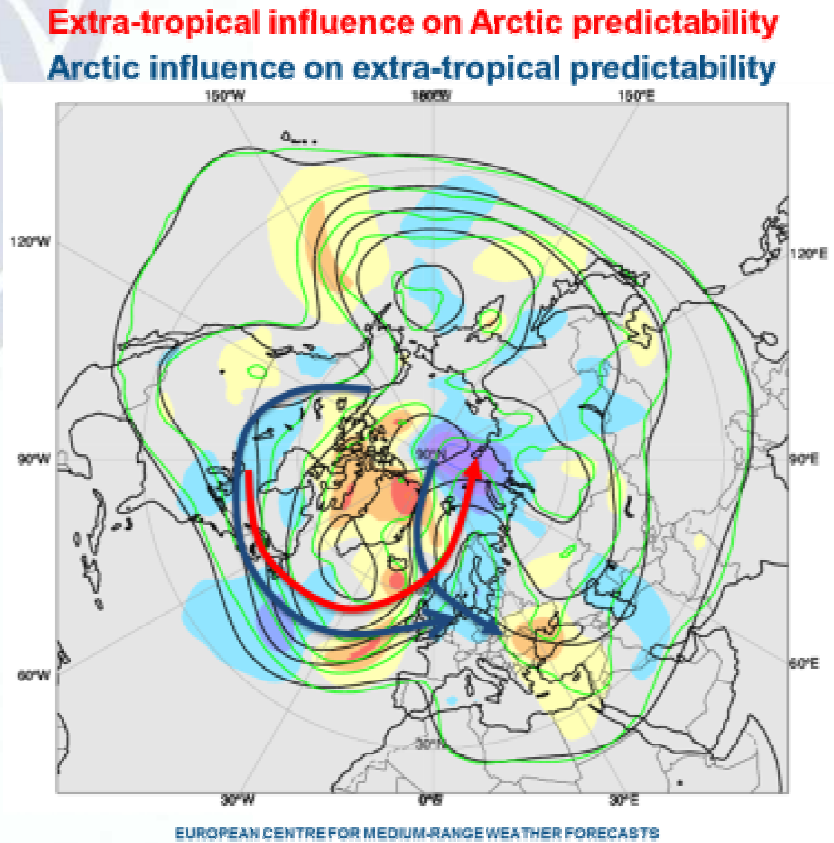
Arctic-specific phenomena can be relevant for NWP at mid-latitudes, e.g.:

- Stable ABL,
- Fog & Stratus-clouds;
- Mesoscale storm systems (Mediteranean «hurricanes»)
- Weather systems associated with strong surface contrasts
- Linkages:

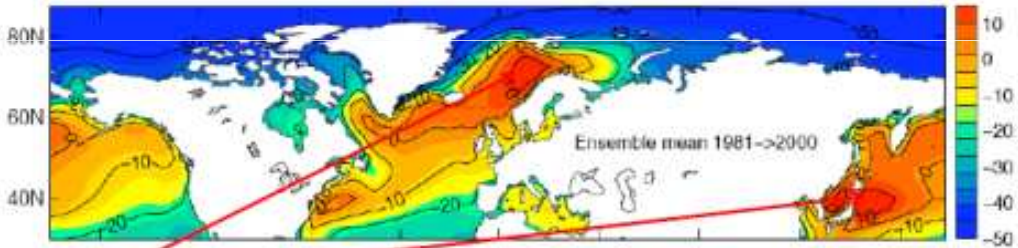


Should SRNWP address potential C.C.-induced NWP-challenges?

Climate Change: Profoundly new extremes (?)

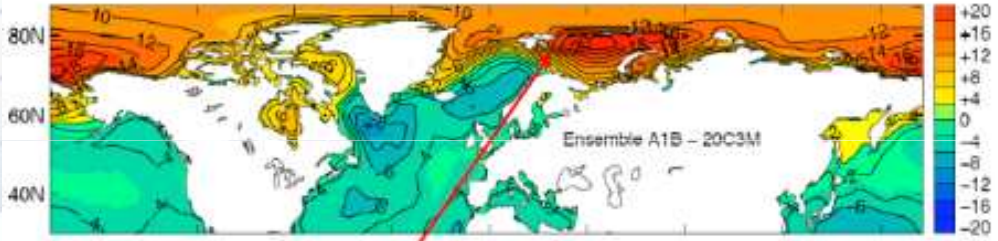
Kolstad and Bracegirdle, 2007, Clim Dyn:

Where do we find polar lows today?



Red: Marine cold air outbreaks => polar lows

Polar Lows in the Future

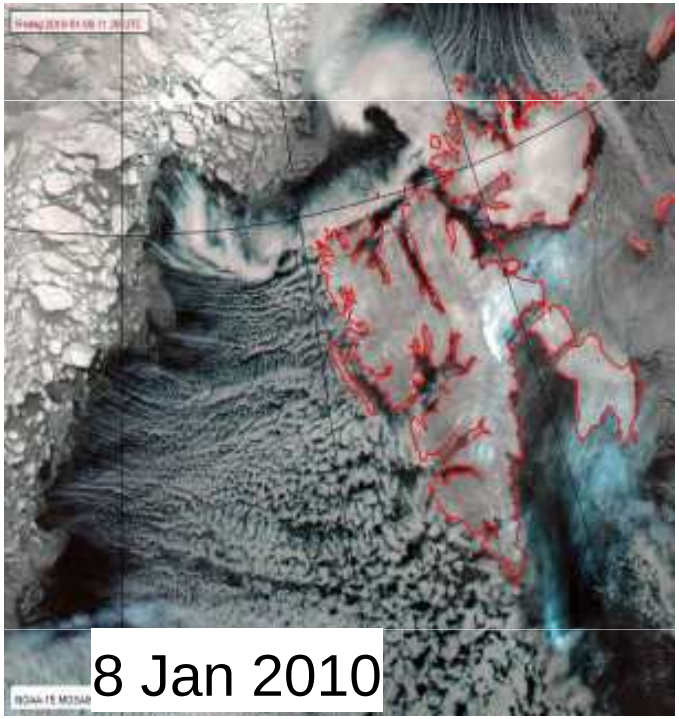


Blue: Fewer polar lows than now

Red: More numerous polar lows than now

Note increase in the Barents Sea

IPCC AR4



First PL North of Svalbard

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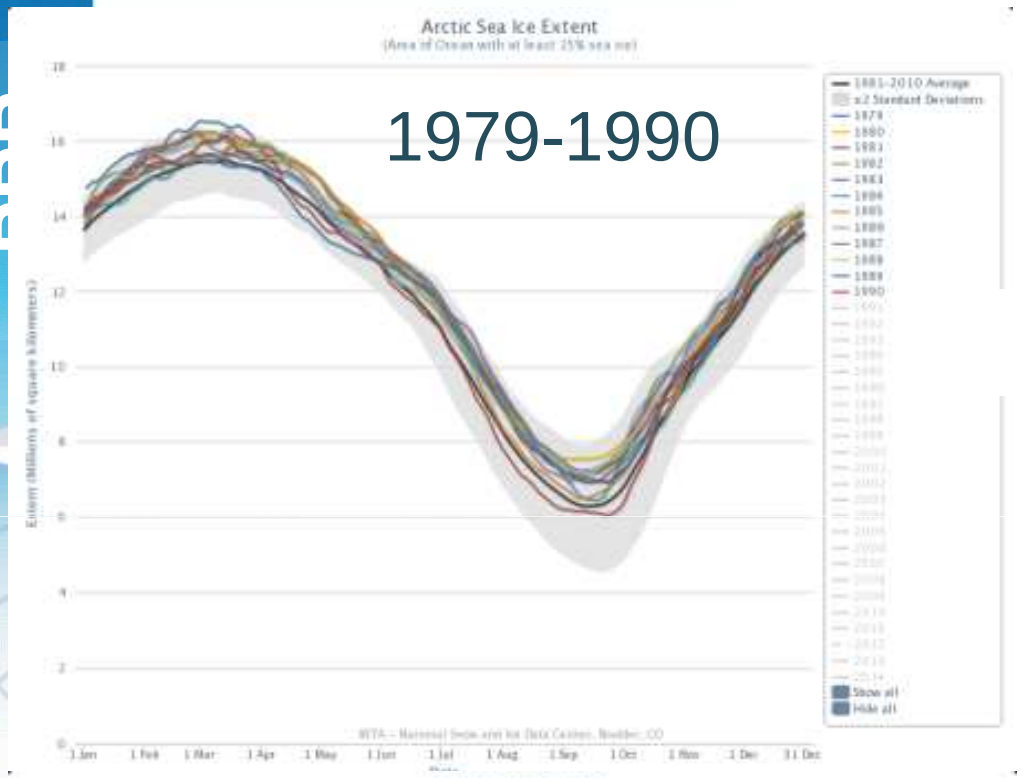
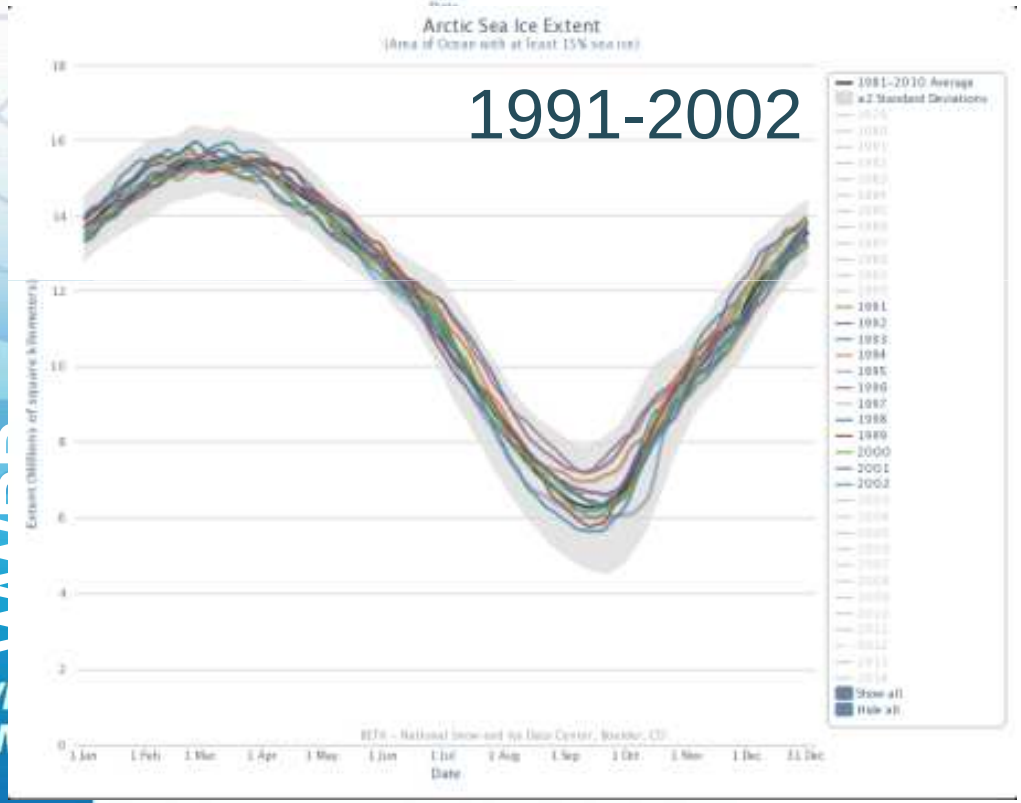
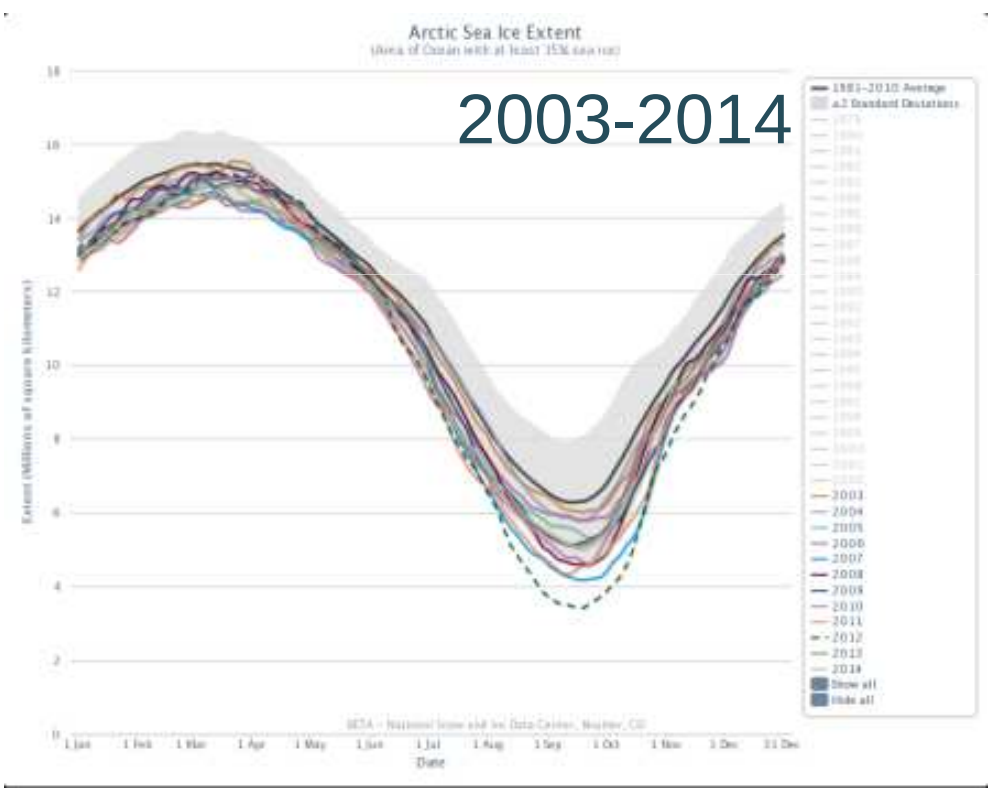
National Snow and Ice Data Center



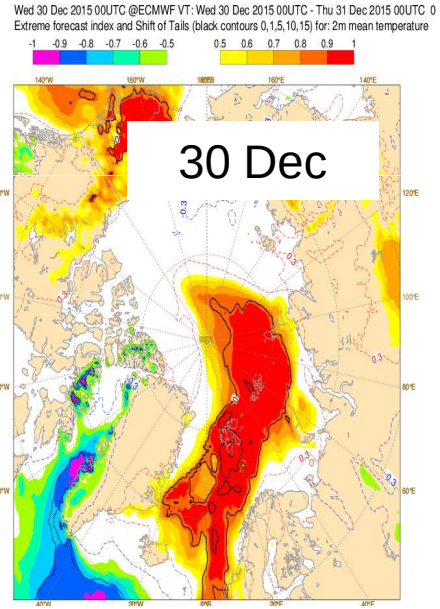
Reduced Arctic Sea-ice extent

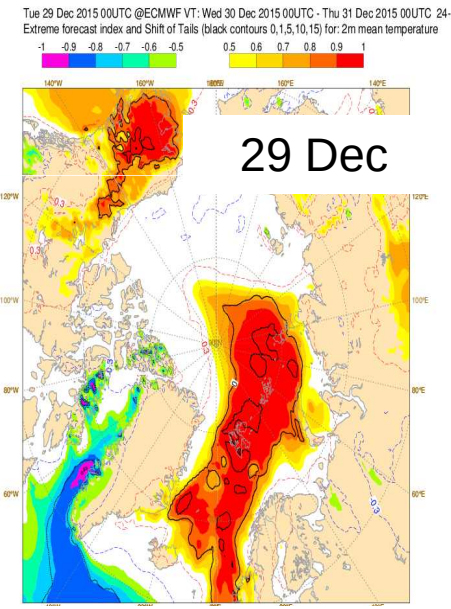


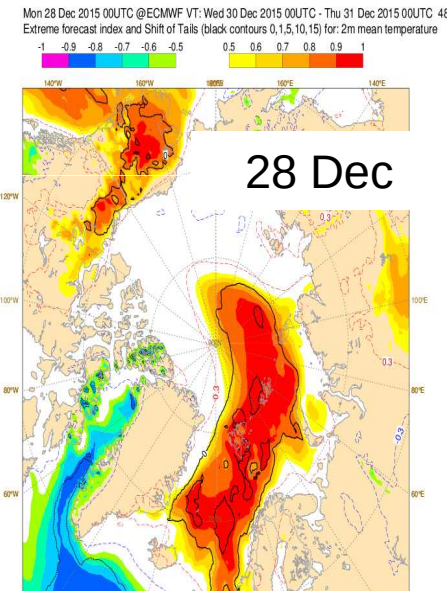


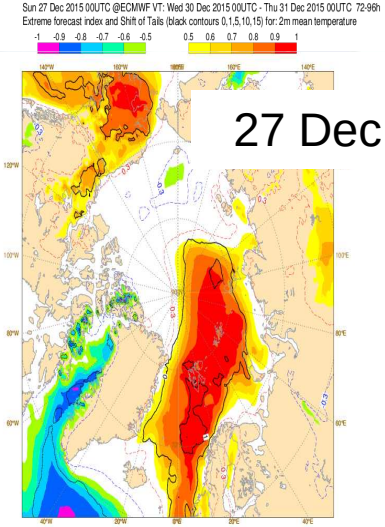
Predicting extremes in the Arctic
Extreme Forecast Index (EFI) for T2m; 30 Dec. 2015

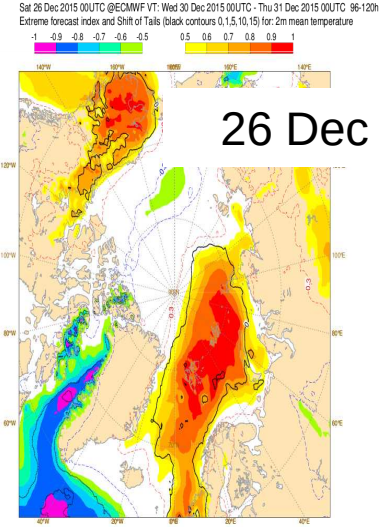
L. Magnusson; E C M W F

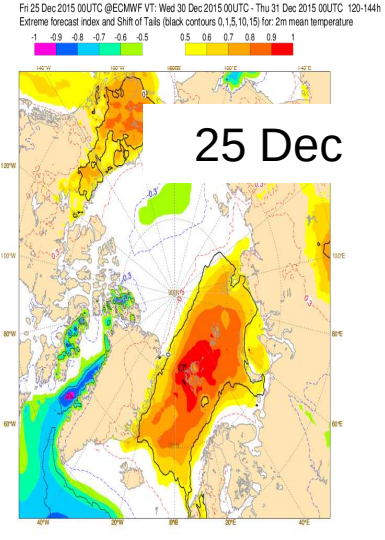


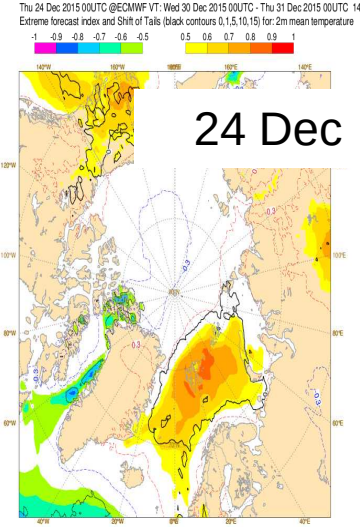












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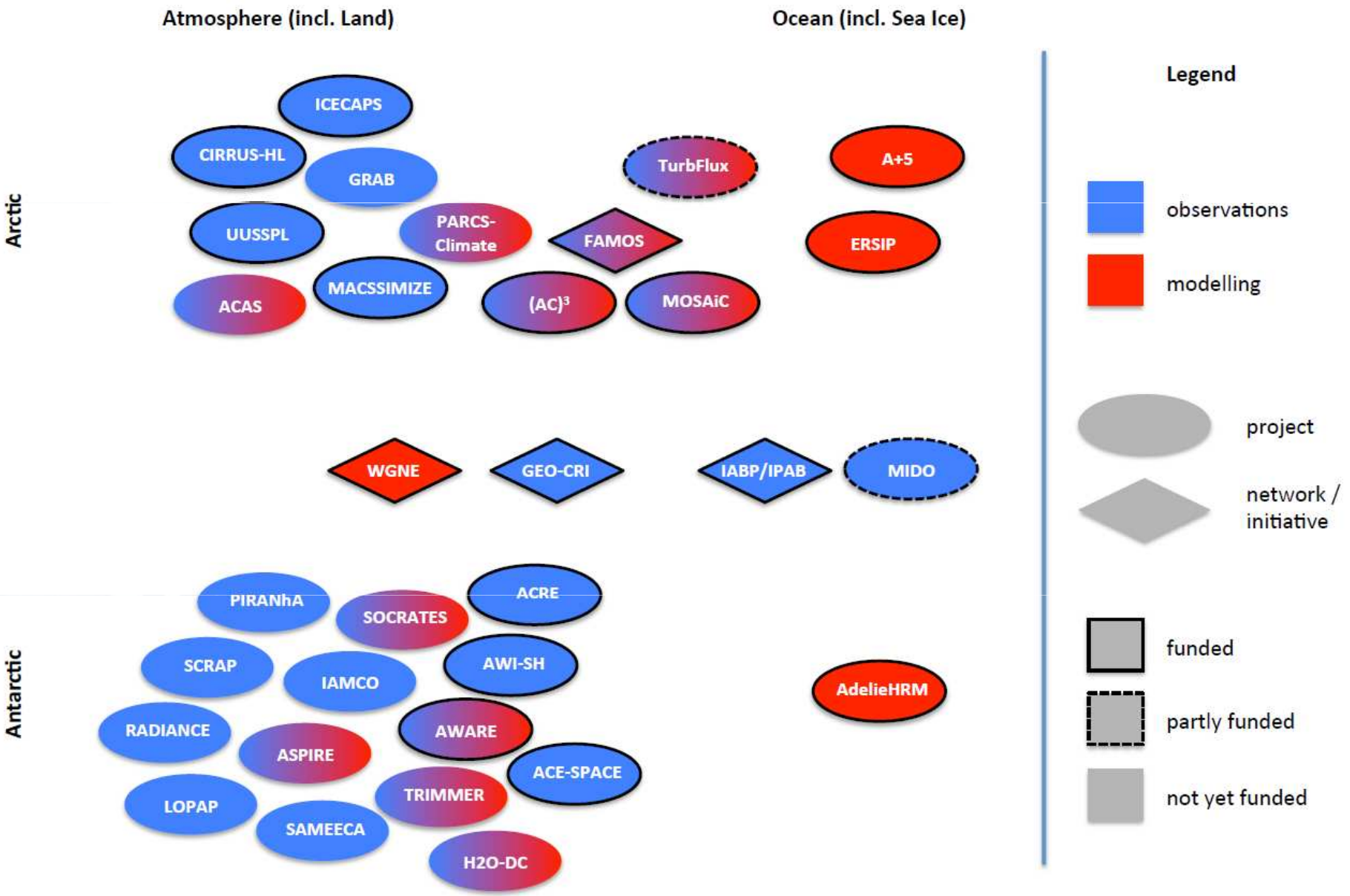
YOPP-endorsed projects & initiatives

state 27 September 2016

YOPP YEAR OF POLAR PREDICTION

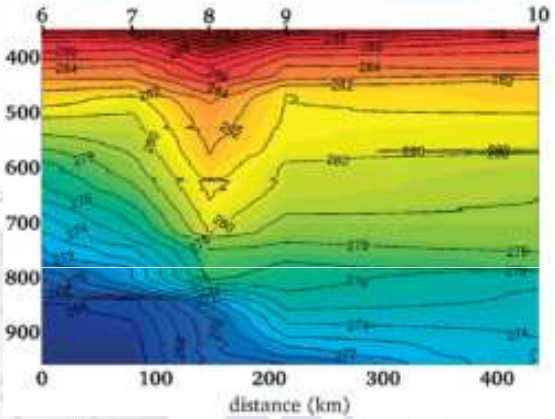


→http://apps3.awi.de/YPP/

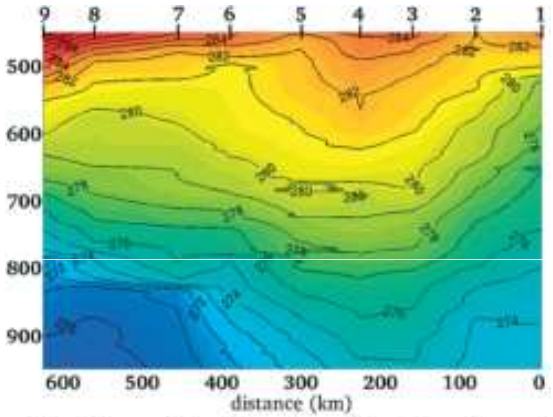
Føre et al, 2011, (IPY Thorpex) QJRMS

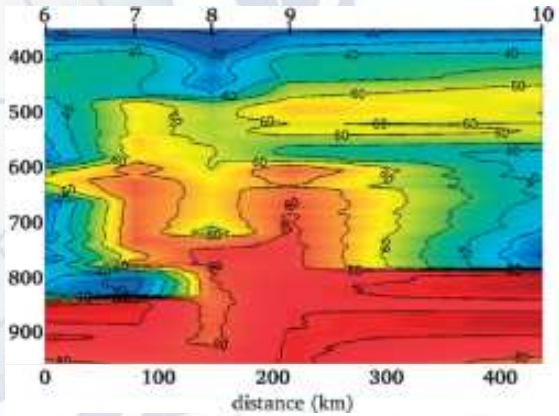
16:01 UTC on 3 March

11:28 UTC on 4 March

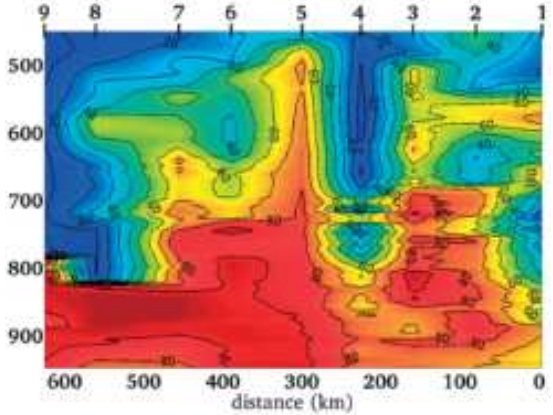


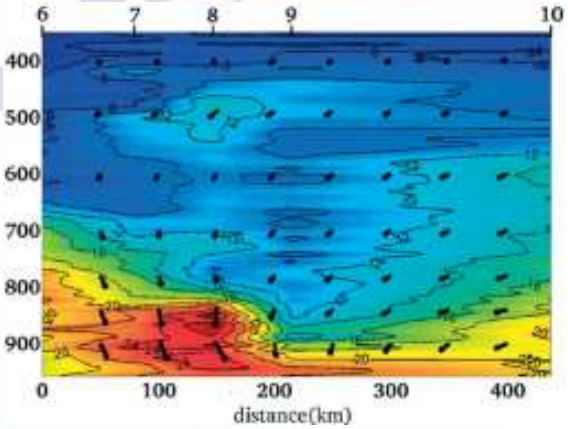
Pot Temp



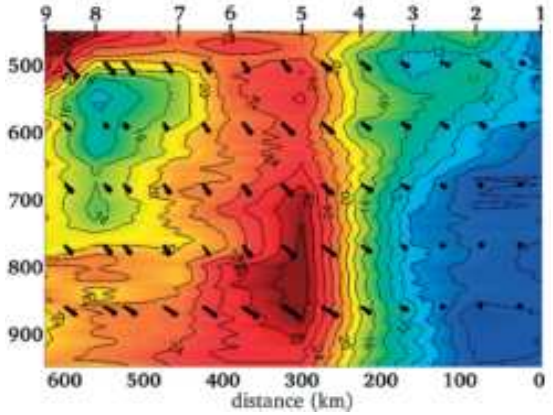


Rel Hum





Wind



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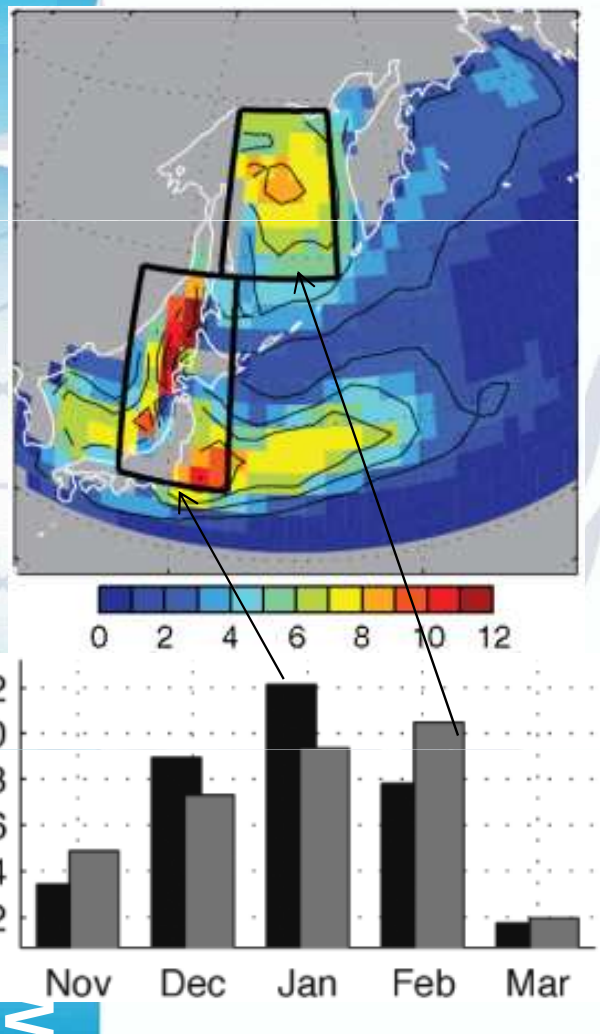
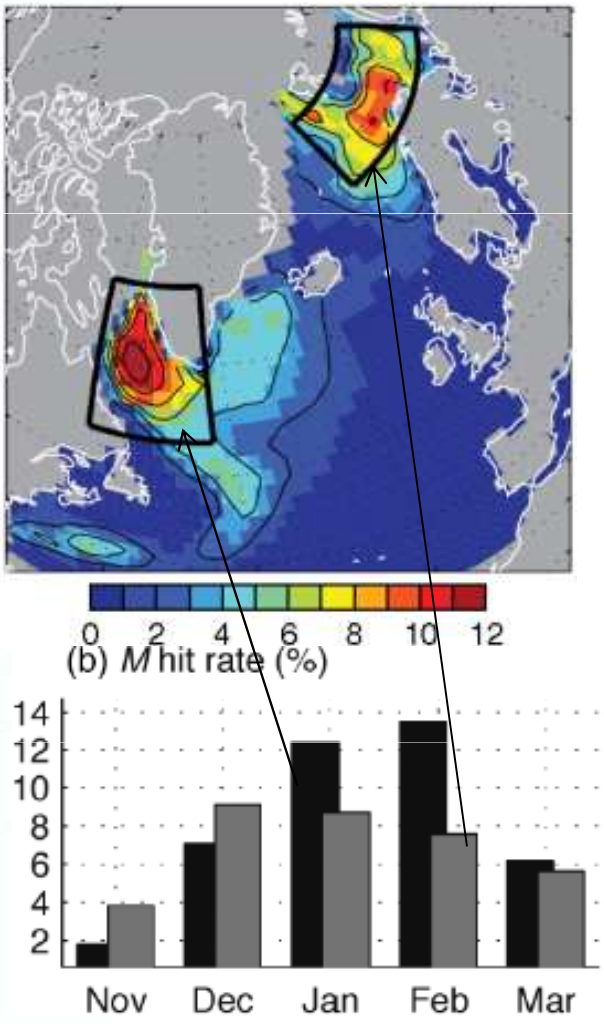
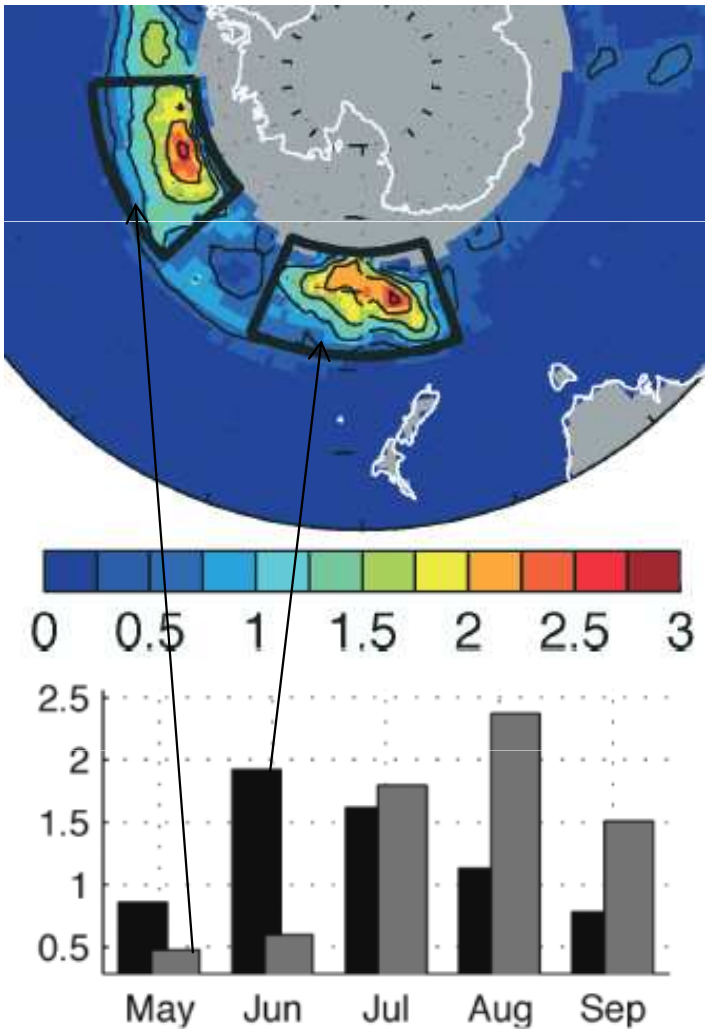
Kolstad, 2011, QJRMS, 137

MCAO (M>3.4)-Hit Rate 1989-2010, ERA Interim

$$M = \frac{L}{Z}(\ln\ \theta_S - \ln\ \theta_{700}) \qquad L = 7 \times 10^5\ \mathrm{m}$$







Additional requirement are needed for PLs to actually occur:
E.g.: upper-level PV anomaly: p_{2pvu} > 470 hPa

The YOPP-Observational Component

- Purpose: Comprehensive observational „snapshot“ for
  - Improved initial conditions
  - Model development
  - Forecast verification
- Selected Elements
  - Mobile systems (buoys, ships etc.) →SOPs
  - Extra observations from existing sites →SOPs
  - Supersites → model grid box (e.g., MOSAiC and SIOS)
  - Satellite snapshots
  - YOPP field campaigns (aircraft etc.)
  - User relevant data → verification
  - Data availability (GTS, data sharing)

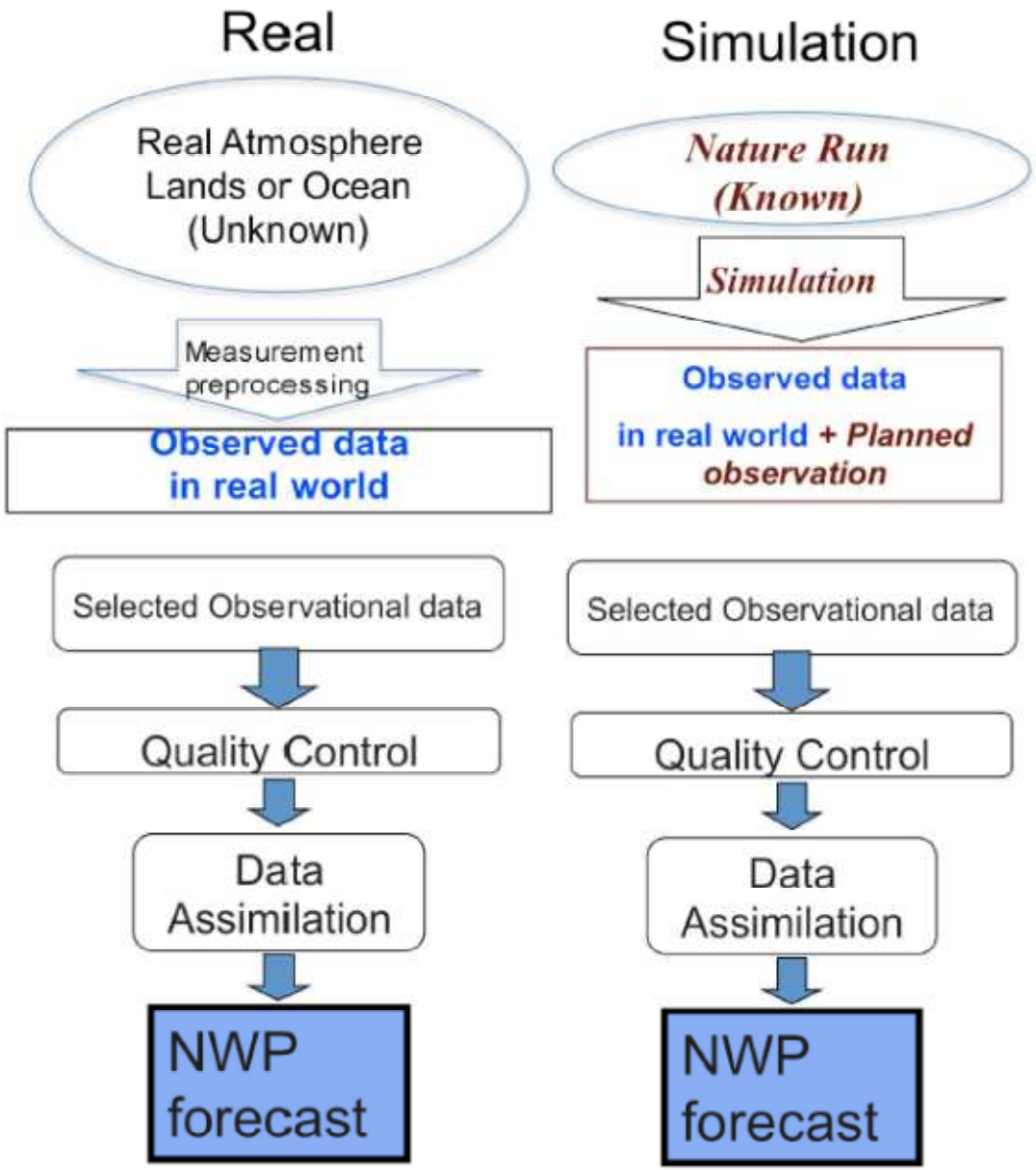
Example for experiments: OSE and OSSE

What: quantify improvement of analysis/forecast contributed by (simulated) observations

How: perform experiments with existing and simulated observations (needs calibration)

OSE

Data denial experiments using real observation



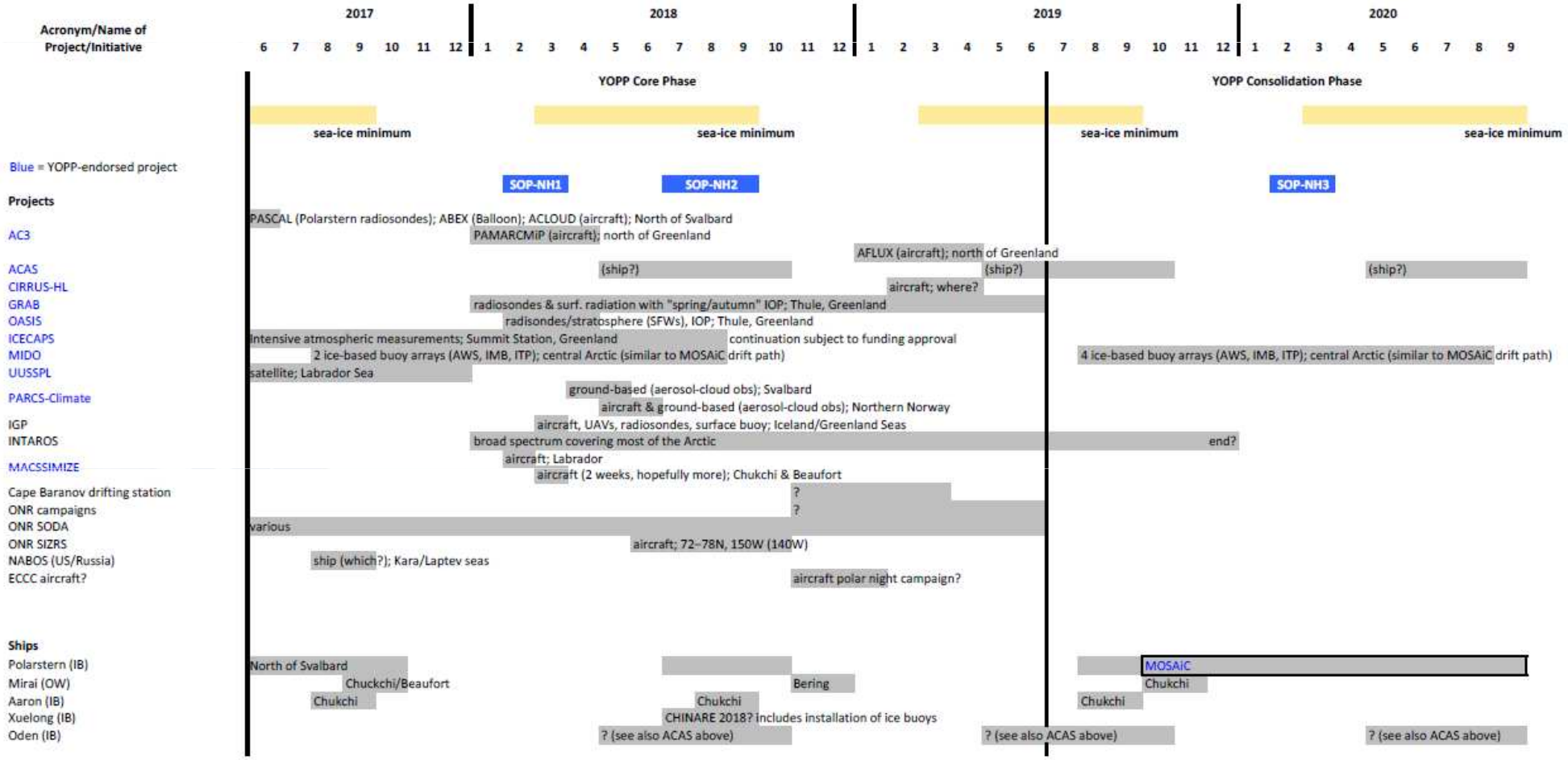
OSSE

Data denial and *adding* experiments with simulated observation

Truth is available for verification.

YOPP Arctic Observations – Timelines

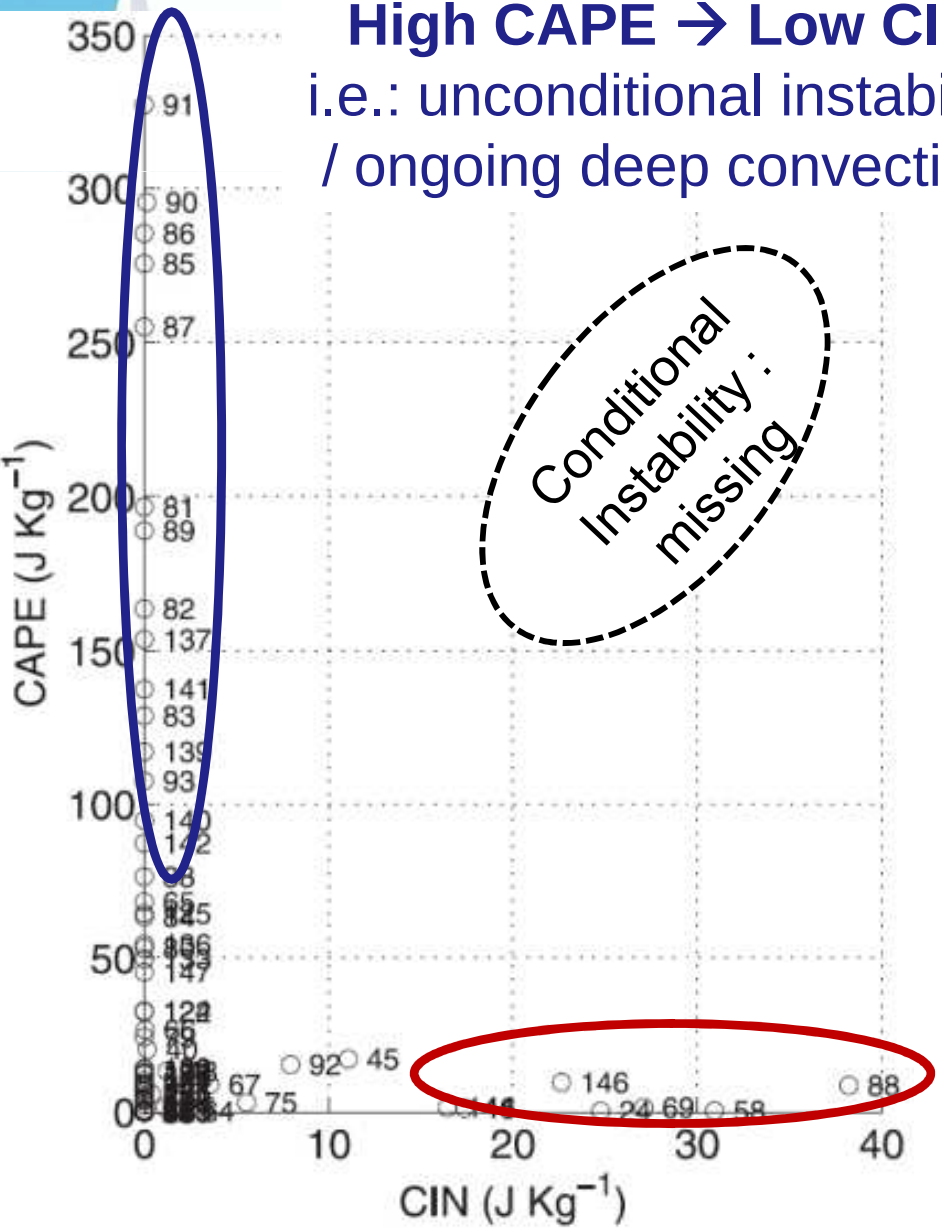
state 27 September 2016



Growth mechanism: consequence of ABL contrasts specific for the Arctic

Linders and Sætra, 2010, J.A.S.

High CAPE → Low CIN
i.e.: unconditional instability / ongoing deep convection



t_{CAPE}<1h; t_{PL}~>1d
There is no CAPE-reservoir for PL kinetic energy.

Plausible energy source: Continuously replenished turbulent surface fluxes

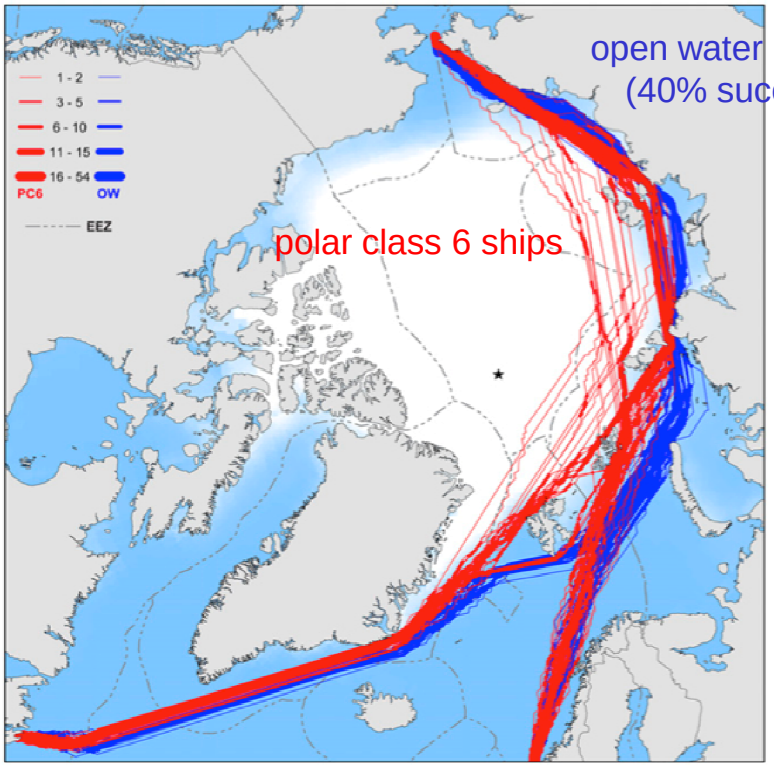
High CIN → Low CAPE
Stably capped, unstable ABL, i.e. during cold air outbreaks

Why?

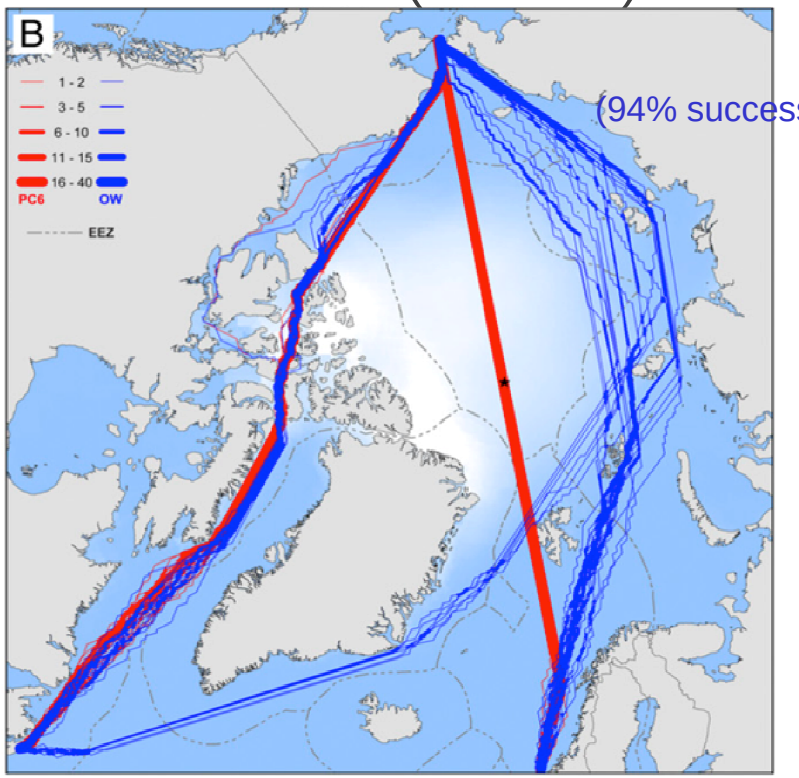
Climate change: Arctic opening and increased activity

Optimal Arctic shipping routes

1979-2005



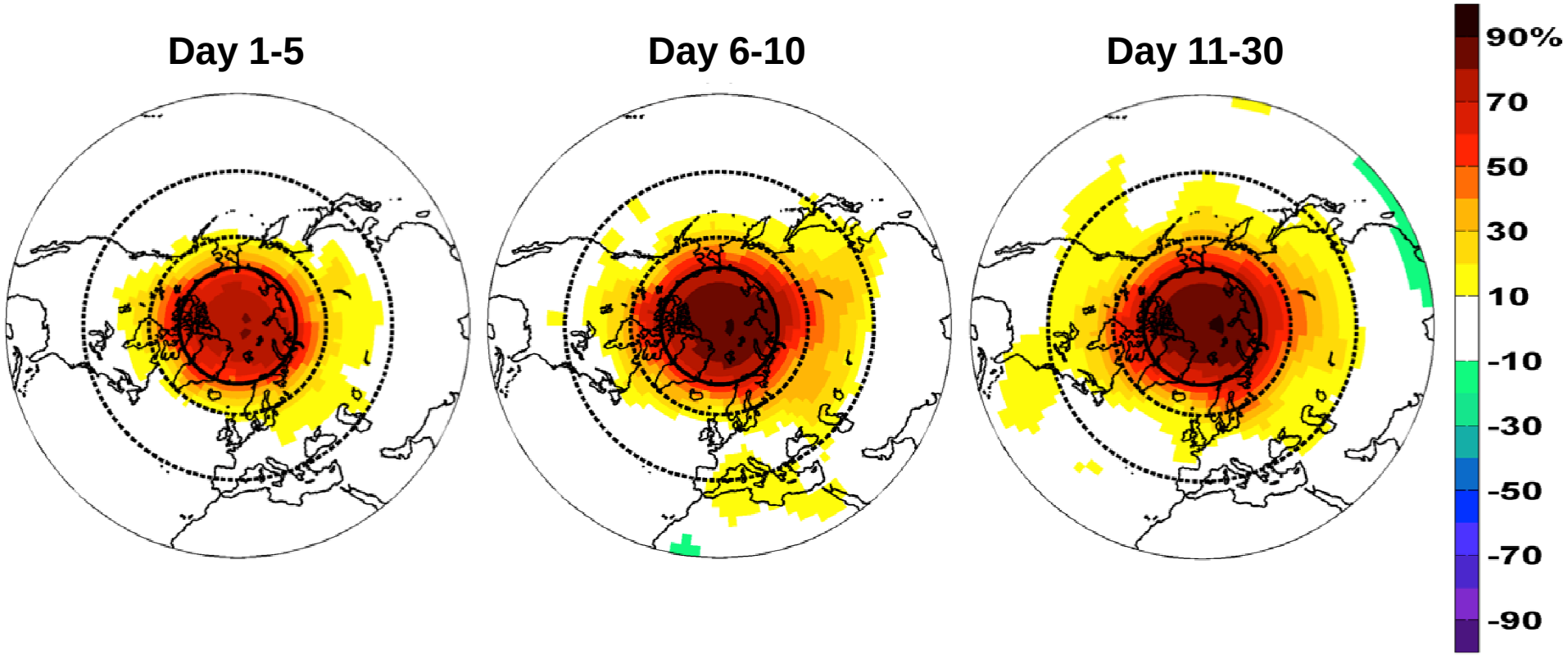
2040-2059 (RCP 4.5)



Smith and Stephenson (2013)

Why?

Linkages: Potential for improved predictions in middle latitudes



Jung et al. (2014), Geophys. Res. Lett.