The WWRP and WCRP Polar Prediction Initiatives

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September 2012

Outline

- The WWRP Polar Prediction Project
- The WCRP Polar Climate Predictability Initiative
- Collaboration

Part I: The WWRP Polar Prediction Project

Background

- November 2009: CAS recommended establishment of an IPY legacy project
- October 2010: WWRP and WCRP workshops were held in Norway
- September 2011: THORPEX ICSC endorsed polar prediction project
- September 2011: Formation of a steering group
- December 2011: 1st SG meeting (implementation plan)
- March 2012: 2nd SG meeting (implementation and science plan)
- June 2012: WMO-EC „Approves the establishment of a polar prediction project with strong linkages to the WCRP polar predictability initiative...“

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WWRP-PPP Steering Group

- Thomas Jung (chair)
- Peter Bauer
- Chris Fairall
- David Bromwich
- Trond Iversen
- Marika Holland
- Brian Mills
- Pertti Nurmi
- Ian Renfrew
- Gregory Smith
- Gunilla Svensson
- Mikhail Tolstykh
- Paco Doblas Reyes (ex-officio)
- Peter Lemke (ex-officio)
- Neil Gordon (WMO consultant)

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Mission Statement

„Promote cooperative international research enabling development of improved weather and environmental prediction services for the polar regions, on time scales from hourly to seasonal“

An important addition:

„This constitutes the hourly to seasonal research component of the WMO Global Integrated Polar Prediction System (GIPPS)“

Research Areas

Services

Societal and Economic Research Applications (SERA)	Verification

Underpinning research

Predictability and Diagnostics	Teleconnections

Forecasting system development

Observations	Modelling
Data Assimilation	Ensemble Forecasting

Year of Polar Prediction (YOPP)

- Intensive observational *and* modelling period
- Involves different initiatives
- Observations
  - Observing system design
  - Model development
- Numerical experimentation
  - Special data sets (e.g., process tendencies)
  - High-resolution modelling
  - Transpose-AMIP
  - Post-processing of extra fields (SSF data base)
- SERA: Montoring of forecast use in decision making
- Tentatively scheduled for the period 2017-2018

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YOPP: Time line

- Establish planning group
- Carry out YOPP planning workshop
- Develop strategy
- Carry out preparatory research
- ...

- Analysis of YOPP data
- Operational implementation of YOPP findings
- Reanalysis
- ...

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Next steps

Month	Milestone
Sep 2012	Send out draft Implementation Plan
Oct 2012	Feedback from the community
Nov 2012	Finalize implementation plan

Dec 2012	Steering group meeting
	• Launch of International Coordination Office
	• Start of YOPP planning phase
	  ○ Establish international YOPP planning group
	  ○ Organisation of YOPP planning workshop
	  ○ Start work on implementation plan
	• Review of Science Plan

Jun 2013	ECMWF-WWRP Workshop on Polar Prediction

Part II: The WCRP Polar Climate Predictability Initiative

Slides provide by Ted Shepherd

WCRP Polar Climate Predictability Initiative

- Planning meeting was held in Toronto (April 2012), joint with IASC-Atmosphere (~30 participants)
- Outcome:
  - There are important problems to work on
  - There is a community wanting to move forward
  - There is good cooperation with relevant partners (WWRP PPP, IASC, SCAR)
    - Clear role for WCRP: global perspective, global modelling
  - Predictability is not just about the initial-value problem
  - Most people are interested in both poles
- Produced the beginnings of a draft implementation plan (still in very rough form)

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Frontier Questions

- Why are the climates at the two poles changing so differently to each other (with the Arctic changing rapidly, and the Antarctic unevenly), and to global climate?
- Why is the rate of Arctic change at the edge of (or beyond) the distribution of model estimates, with observations on average exceeding the model rate of change? And why is the situation essentially the opposite in the Antarctic?
- What does high latitude climate change mean for lower latitudes?
- Do the ongoing amplified changes in the Arctic have an influence on extremes in the Arctic?
- How predictable is Arctic climate?
- Is the stability of ice sheets changing? What is the probability of catastrophic ice sheet breakdown in the next few decades?

Imperatives

- Reconstruct past climate variations (100+ years)
- Improve reanalysis products for the high latitudes
  - Ocean as well as atmosphere, work towards coupled
- Design optimised sustained observational networks
  - Need for public sharing of data
- Improve the climate models that are used for simulating past and future polar climate
  - Improve process parameterizations
- Assess model performance and inform new model development
  - Assess how much confidence we can place in models
- Define proper use of models to answer frontier questions
- Improve prediction

Suggested Implementation Mechanisms

- A sequence of actions to form a community on Antarctic climate processes, centred on the question of how the jets and non-zonal circulation couple to the rest of the system in the SH
- Synthesis workshop focused on Antarctic climate and its change, as represented in data records, reanalyses and CMIP models
- Workshop to determine the best estimate and uncertainty of old Arctic data
- Workshop to construct metrics that can be used to assess models
- Workshop (with special collection or single consensus paper) to synthesize the polar performance in CMIP5 analysis
- Workshop to assess, understand, and improve predictability experiments (involve WGSIP and YOPP)
- Special session or paper collection to debate Arctic-midlatitude connectivity (linkage with IASC and WWRP)

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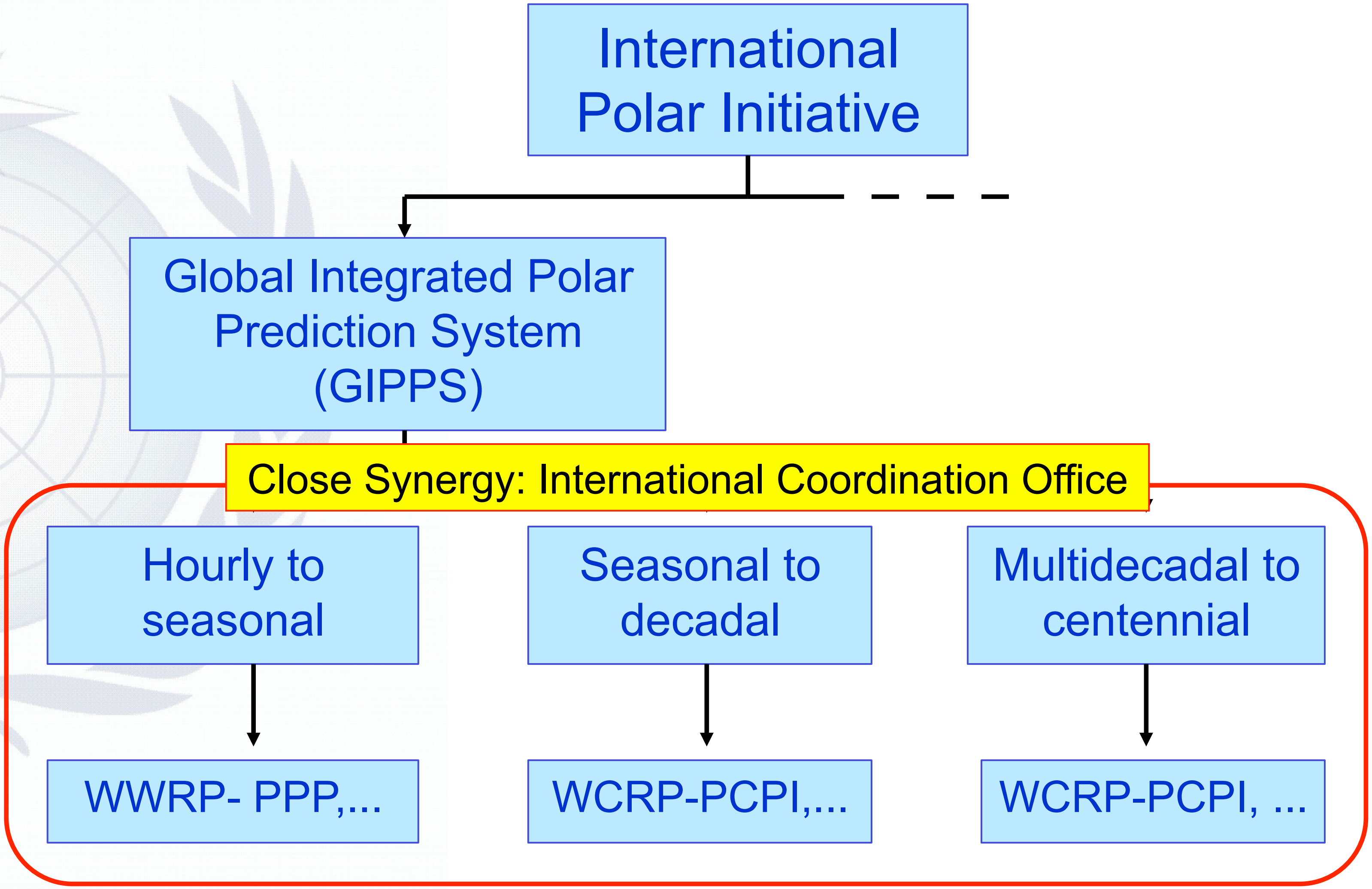
The Way Ahead

- Recommend forming a limited-lifetime PCPI SSG
  - Charge: develop an Implementation Plan and move ahead with specific, targeted activities ranging from focused workshops to coordinated efforts of up to 2-3 years' duration
  - Secretariat support available from SPARC IPO (Dr. Diane Pendlebury, funded by the Canadian Space Agency): will need continued JPS support
- Initiative can be an 'incubator' to generate community research efforts that could be adopted, in the longer term, by more permanent components of the WCRP or of partner organizations
- Whilst good liaison with partner organizations is important, this activity will fail if the SSG consists only of 'representatives'
  - Needs to have a core group of champions who will move it forward

Part III: Coordination

- WWRP was willing to develop joint project from the outset
- No interest in a joint project from WCRP
  - Topics are sufficiently different
  - Different communities (operational vs. research)
- Where are we now?
  - WWRP-PPP steering group consists of members from the weather and climate community (e.g. WGSIP representative)
  - WWRP-PPP suggests to establish an International Coordination Office (in the ToR)

Programmatic Context



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Thank you!

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Strategies to Achieve Research Goals

- Develop strong linkages with other initiatives
- Strengthen linkages between academia, research institutions and operational prediction centres
- Establish linkages with space agencies and other data providers
- Establish and exploit special research data sets
- Promote interactions and collaboration between research and stakeholders
- Foster education and outreach

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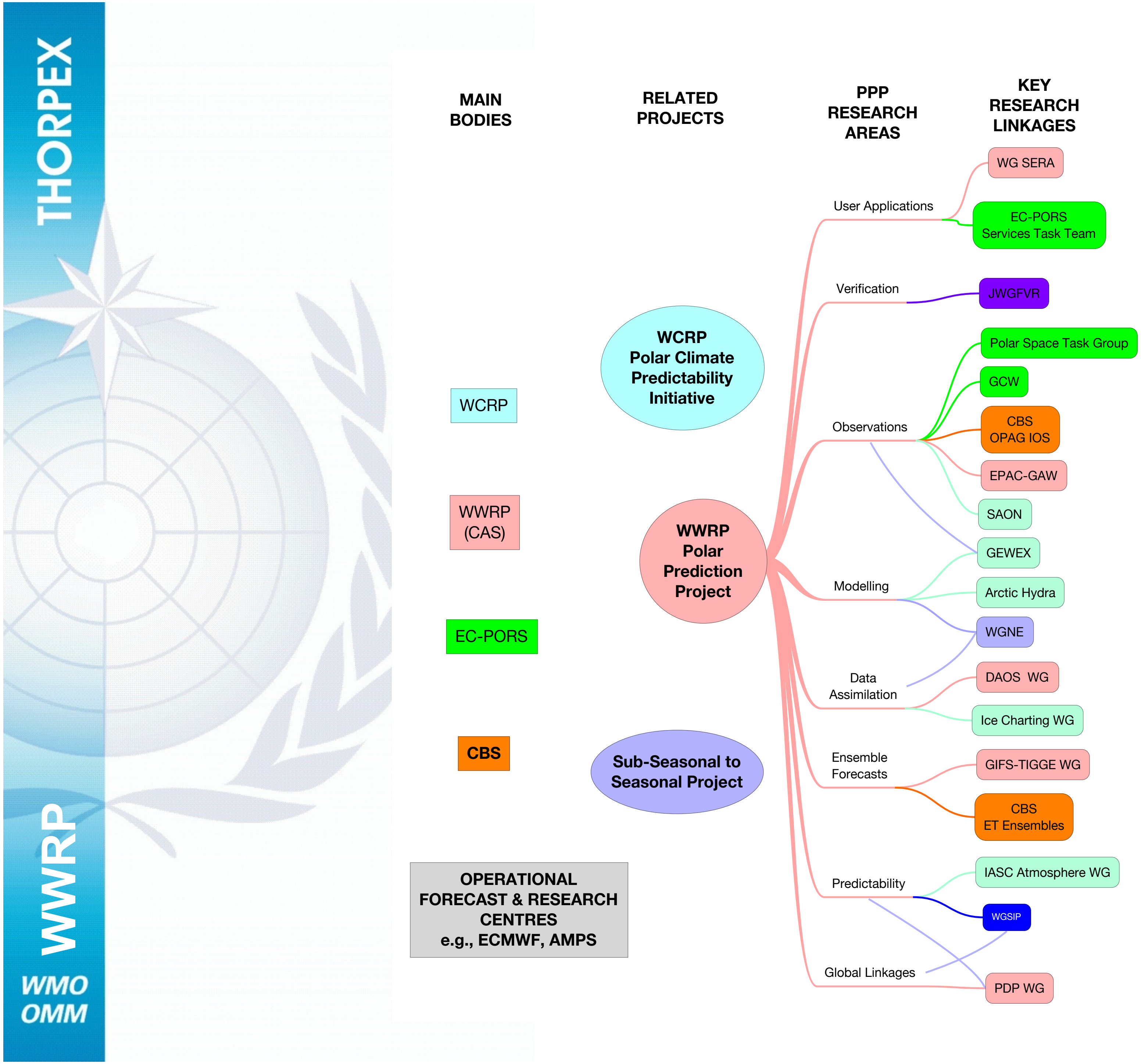

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MAIN BODIES
RELATED PROJECTS
PPP RESEARCH AREAS
KEY RESEARCH LINKAGES
WCRP
WWRP (CAS)
EC-PORS
CBS
OPERATIONAL FORECAST & RESEARCH CENTRES e.g., ECMWF, AMPS
WCRP Polar Climate Predictability Initiative
WWRP Polar Prediction Project
Sub-Seasonal to Seasonal Project
User Applications
Verification
Observations
Modelling
Data Assimilation
Ensemble Forecasts
Predictability
Global Linkages
WG SERA
EC-PORS Services Task Team
JWGFVR
Polar Space Task Group
GCW
CBS OPAG IOS
EPAC-GAW
SAON
GEWEX
Arctic Hydra
WGNE
DAOS WG
Ice Charting WG
GIFS-TIGGE WG
CBS ET Ensembles
IASC Atmosphere WG
WGSIP
PDP WG

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Goal: Understand and evaluate the use of enhanced prediction information and services in polar regions

- Link with forecast user community (two-way)
- Communication of risk, opportunity and uncertainty across user types
- Estimation and analysis of historic and current use
  - Develop/test framework to define and assess *expected* polar and lower-latitude benefits in relation to cost
  - Monitor/evaluate *actual* decision-making behaviour, costs and benefits

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Verification

Goal: Establish and apply verification methods appropriate for polar regions

- Verify existing forecasting systems in the polar regions
- Develop key performance headline measures with polar relevance to monitor progress
- Devise methods that can be used to verify user-relevant key weather and climate phenomena in polar regions (e.g. blizzards and fog-visibility)
- Define an observation strategy to meet forecast verification requirements
- Develop forecast verification in observation space using, for example, satellite data simulators

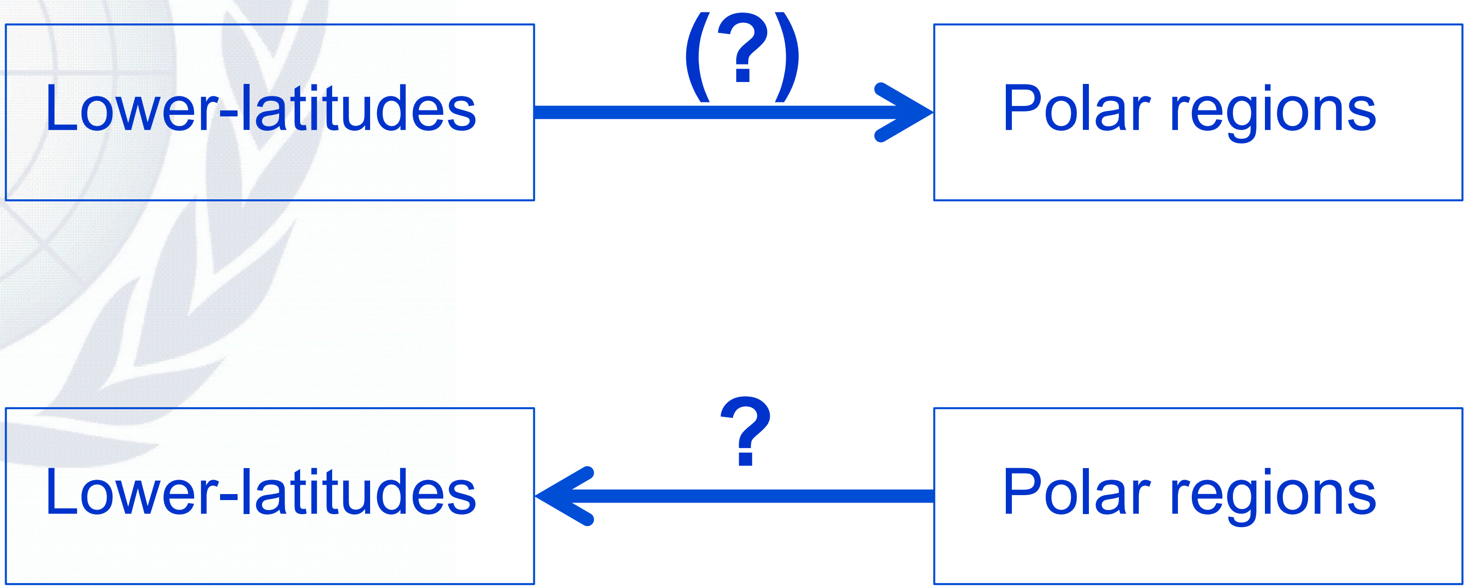
Predictability and Diagnostics

Goal: Determine predictability and identify key sources of forecast errors in polar regions

- Determine
  - mechanisms providing predictability
  - Instabilities of the polar climate system
  - Structure of imperfections (analysis and model error)
- Apply/develop diagnostic techiques that help to understand model error at the process level
- Central: Explore the role of sea ice (time scales from days to seasonal)

Teleconnections

Goal: Improve knowledge of two-way teleconnections between polar and lower latitudes, and their implications for polar prediction



Modelling

Goal: Improve representation of key processes in models of the polar atmosphere, land, ocean and cryosphere

- Improve representation of key dynamical and physical processes (e.g. PBL, sea ice rheologies)
- Develop stochastic parametrizations
- Explore the role of horizontal and vertical resolution
- Develop coupled model systems across all forecast ranges

Role of Sea Ice in Medium-Range Weather Forecasting

T2m Difference: Observed Minus Persisted Sea Ice

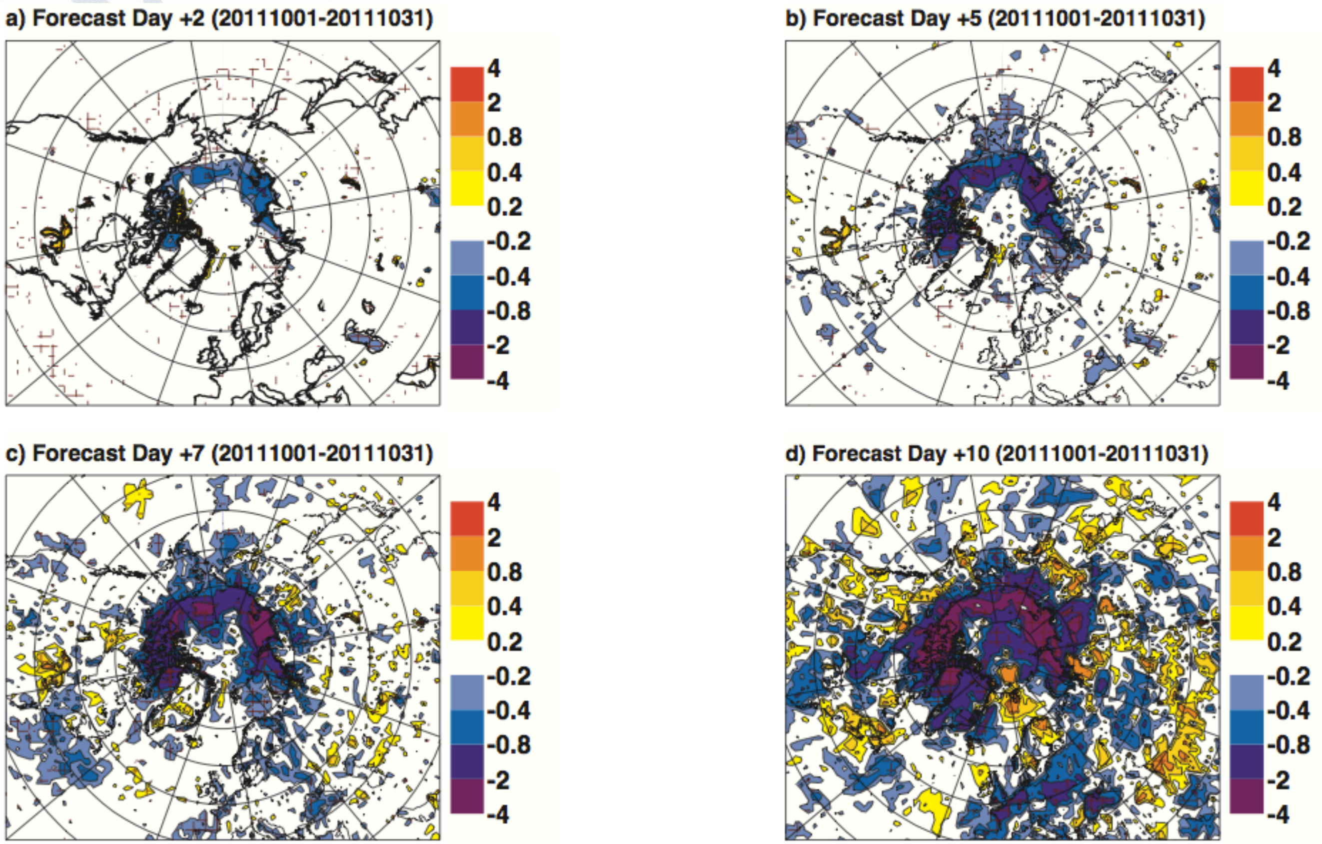


Figure courtesy of P. Bauer (ECMWF)

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Ensemble forecasting

Goal: Develop and exploit ensemble prediction systems with appropriate representation of initial and model uncertainty for polar regions

- Assess performance of existing EPSs and LAM-EPSs in polar regions
- Improve initial perturbation methods for the atmosphere
- Develop initial perturbation methods for sea ice, ocean and land surface models
- Develop methods to account for model uncertainty
- Monitor probabilistic prediction skill of high-impact weather and climate events in polar regions

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New TIGGE Products

Raise awareness: there are low hanging fruits...

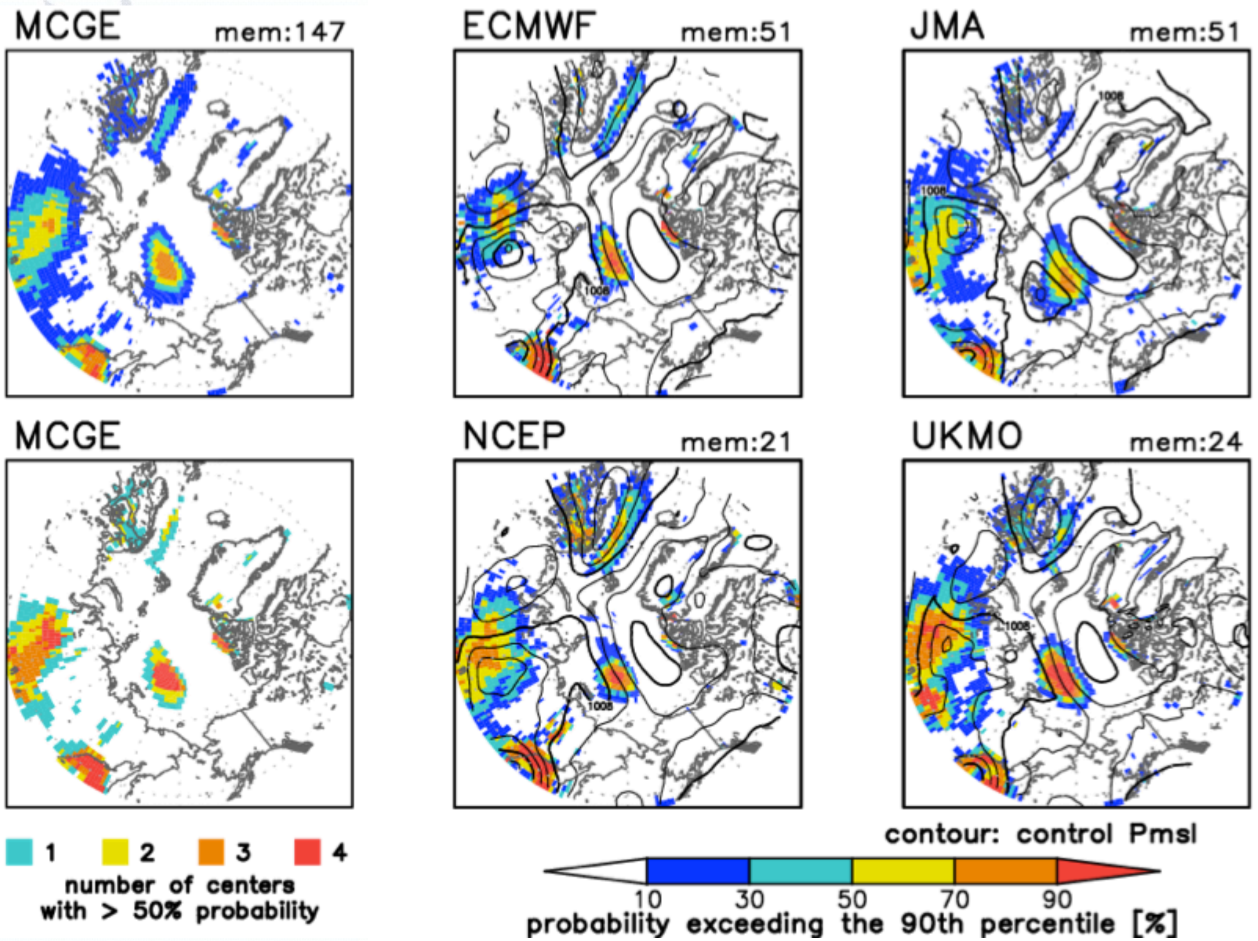

Figure courtesy of Mio Matsueda (Oxford)

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Data Assimilation

Goal: Develop data assimilation systems that account for the unique character of the polar regions

- Evaluate existing analysis and reanalysis data sets
- Develop improved background error covariance matrices for the polar regions (PBLs, sea ice, ...)
- Develop coupled data assimilation schemes
- Develop data assimilation schemes with representation of model uncertainty
- Improved models for simulating surface emissivity in infrared and microwave spectral range for snow, sea-ice, frozen ground, vegetation etc.

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Observations

Goal: Provide guidance on optimizing polar observing systems, and coordinate additional observations to support modelling and verification

- Provide observations for
  - forecast initialization
  - model development activities
  - forecast verification
- Assess the sensitivity of analysis and forecast accuracy to observation data usage and error formulations (OSE, adjoint sensitivities)
- Understand potential of future observational capabilities (OSSEs)

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Implementation Plan

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Discussion

- How much and what can be influenced in the coming years (10-yr project)?
  - Sea ice remote sensing (concentration thickness, age drift etc.)
  - Active radars/lidars for polar clouds (aerosols)
  - What are important developments we should be aware of?
- Improved usage of existing data
  - Improved models (eg, radiative transfer-snow, ice and clouds)
  - Improved representation of model error in data assimilation
- How can we strengthen linkages with satellite community (PSTG)?
- Any contribution of the satellite community to YOPP?

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International Collaboration

- Forecasting brings together different communities!
- Consultation on the Implementation Plan will increase collaboration
- Cross-membership (e.g. WWRP-PPP and EC-PORS)
- Incentives
  - YOPP
  - Special data sets (establishment and use)
- Workshops, conference meetings and summer schools
- International project office (AWI happy to host!)

Strengthening Linkages Between Academia, Research Institutions and Operational Centres

- Modify funding schemes following UK, USA and Canadian examples (e.g. researchers are required to spend time at operational centres)
- Provision of computing time, experimental support and special data sets by operational centres
- Ensure continual near-real-time availability (e.g. GTS) of future operational and experimental campaign observations
- Committee work

Establish and Exploit Special Research Data Sets

- Inventory of existing data sets: TIGGE, YOTC, reforecasts, DEMETER, Athena etc.
- Formulate special requirements and devise special experiments together with other working groups (e.g. WGNE and SG Subseasonal and Seasonal Prediction)
- Limited value from case studies!
- Need for long sustainable, openly accessible data sets
- High-resolution reanalysis

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Others Strategic Issues

- Write BAMS paper about WWRP Polar Prediction Project
- Prepare WWRP-PPP brochure for funding agencies and stakeholders
- Linkages with space agencies and data providers
  - Liaise with WMO Polar Space Task Group
- Promote interaction and communication between researchers and stakeholders
  - Identification of stakeholders: NMHS, Arctic Council, private sector companies etc.
  - Organize meetings to bring communities together
- Education and outreach (collaboration with APECS)

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Mean T Ensemble Forecast Spread

Ensemble Spread | **RMS An Increment**

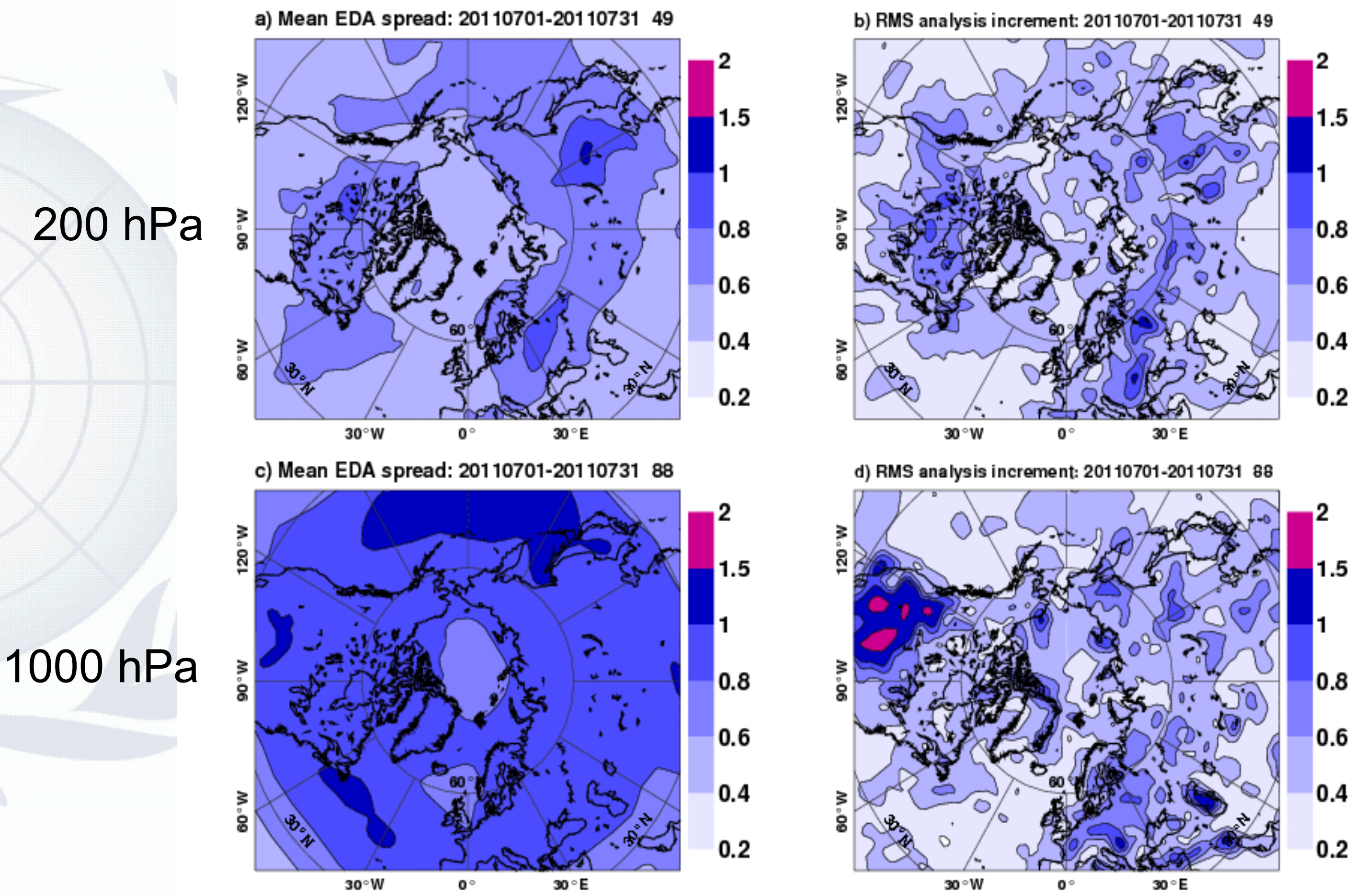

Figure courtesy of P. Bauer (ECMWF)

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Implementation Plan

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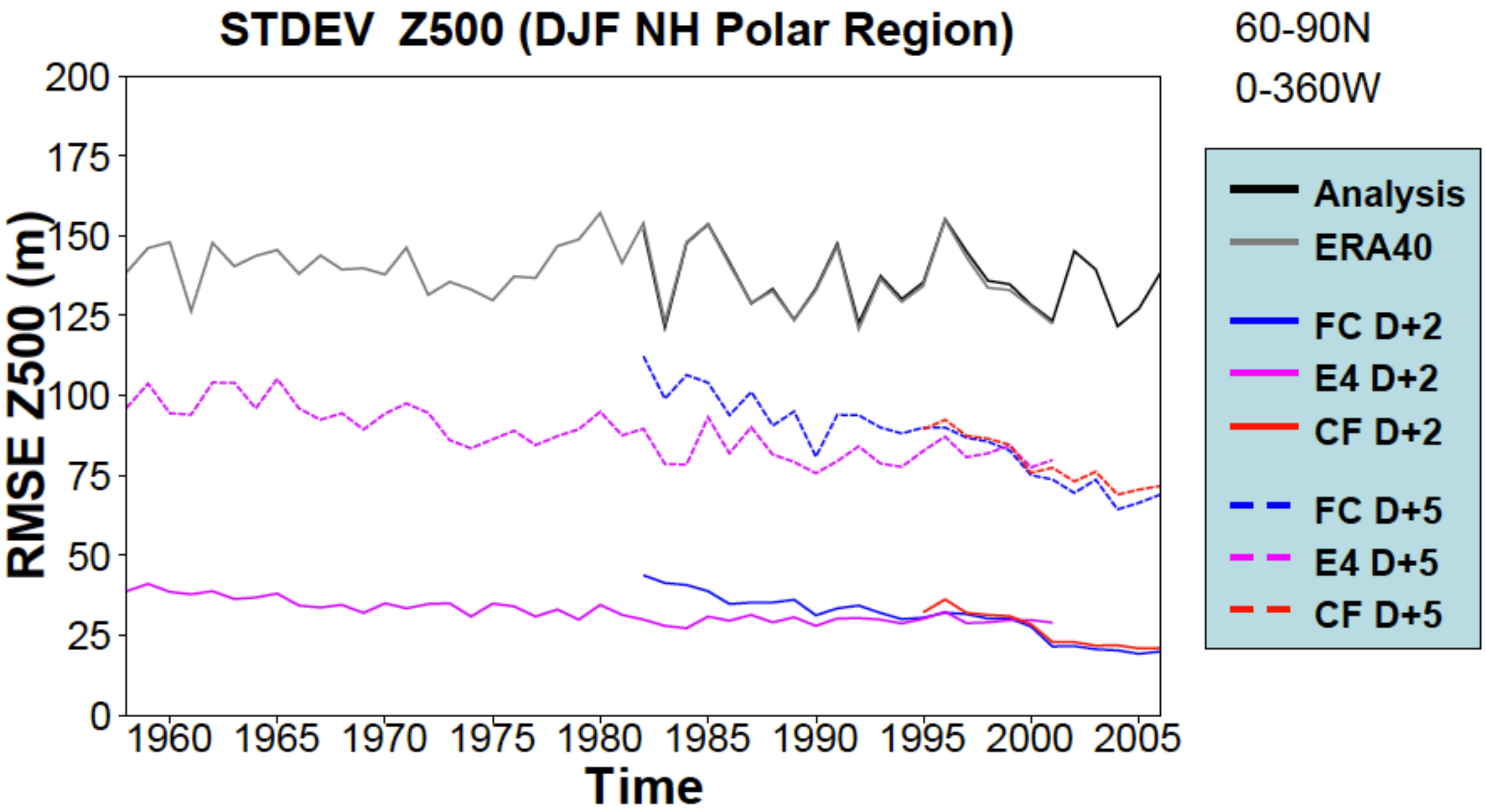
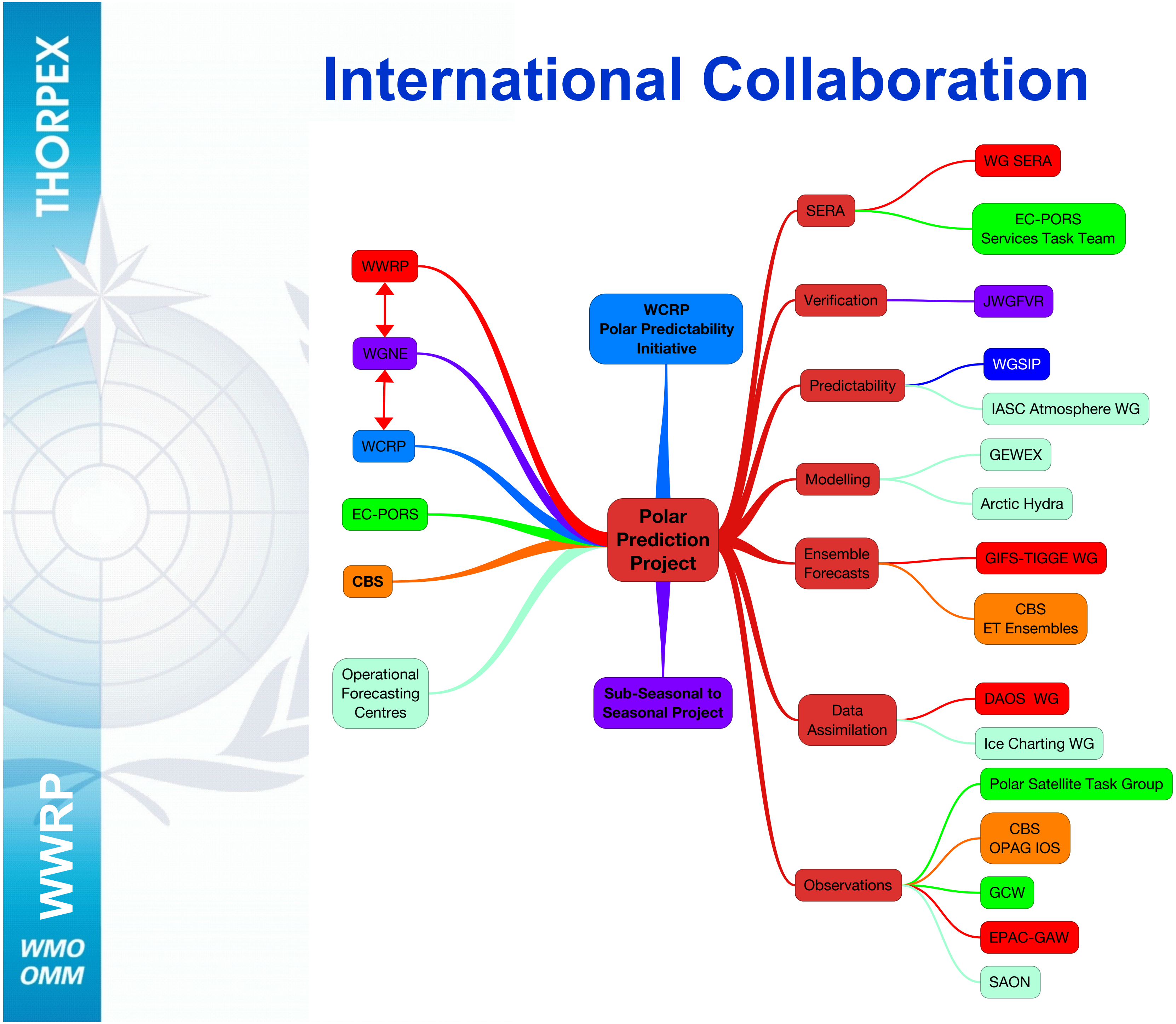
Deterministic Skill: Z500 Arctic



Jung and Leutbecher (2007)

International Collaboration



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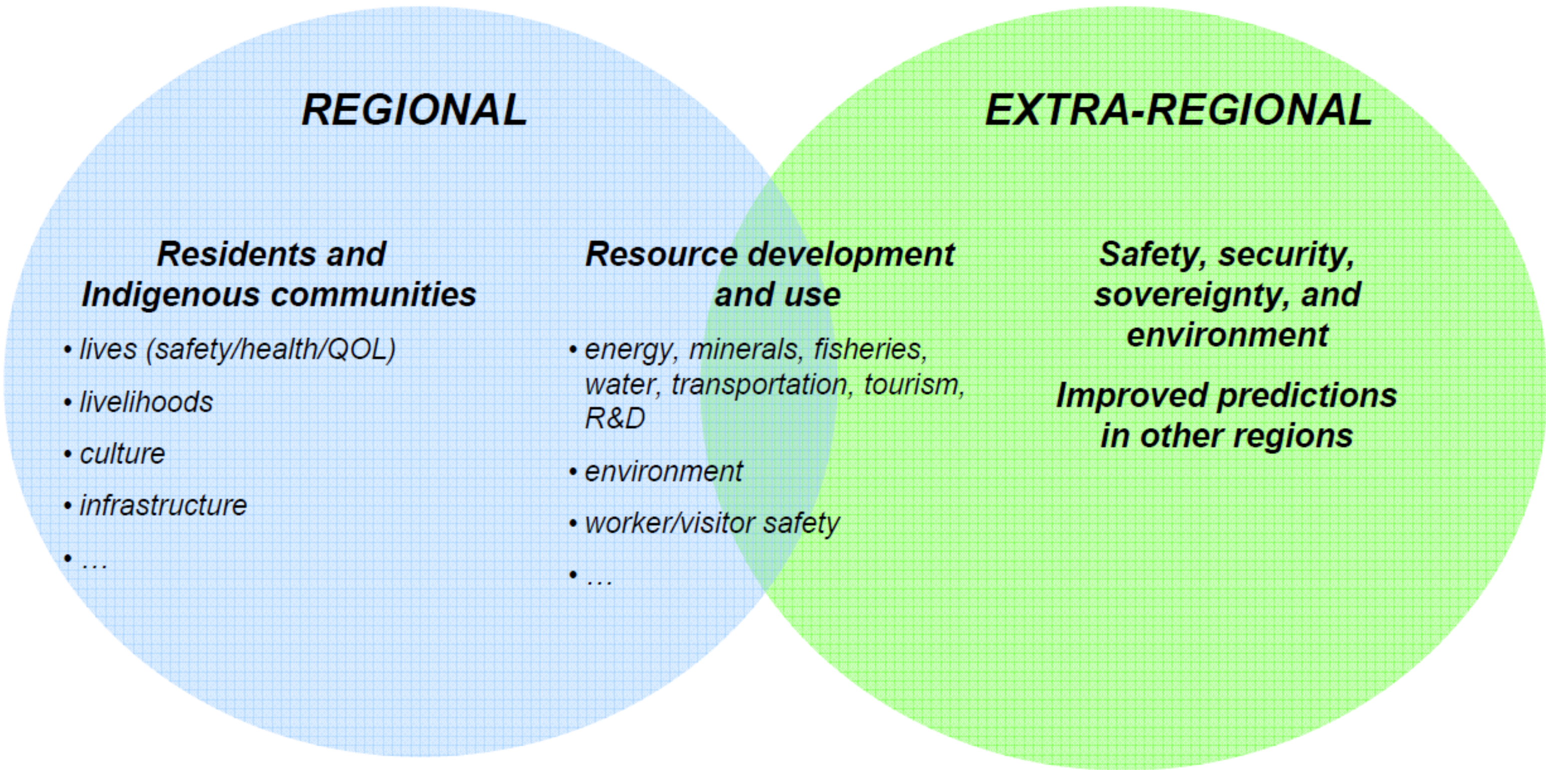
Benefit Areas



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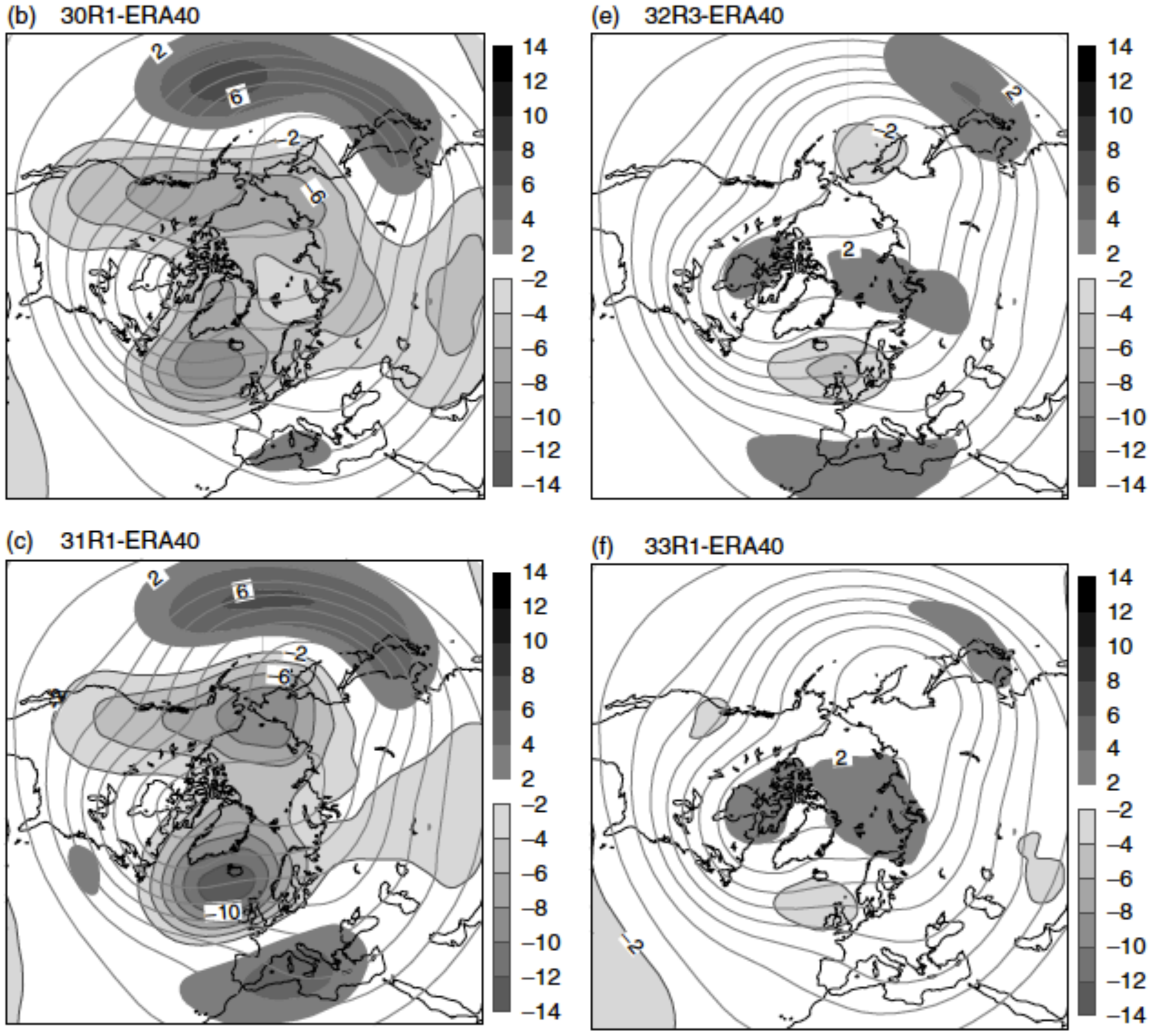
Benefit Areas (cont‘d)

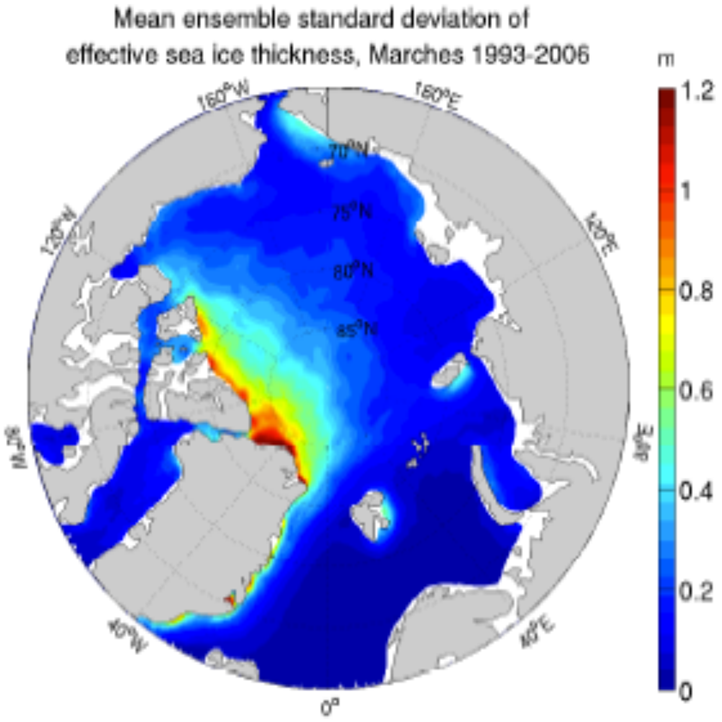


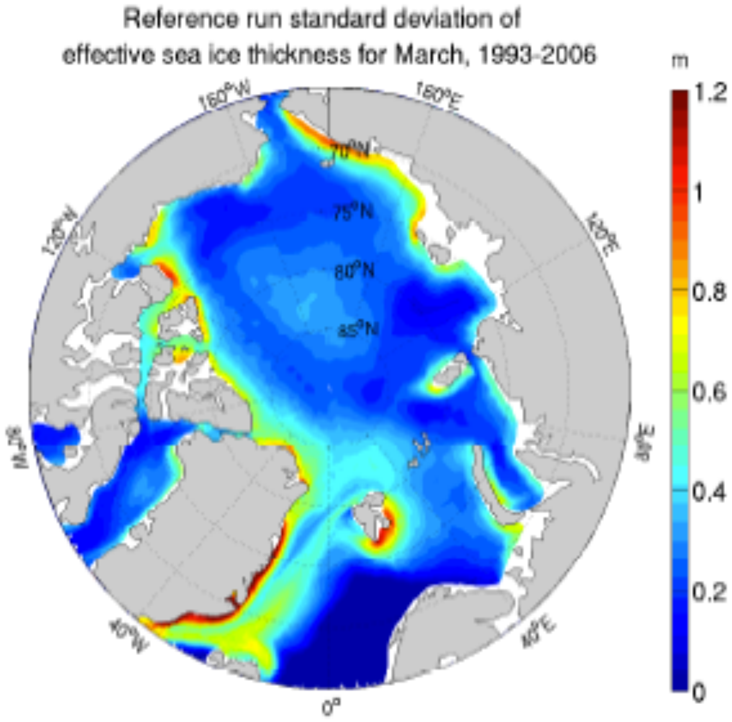
Jung et al. (2010)

Stochastic Sea Ice Parametrizations

Ensemble Spread

Interannual variability





Juricke et al., in preparation

New TIGGE Products (cont‘d)

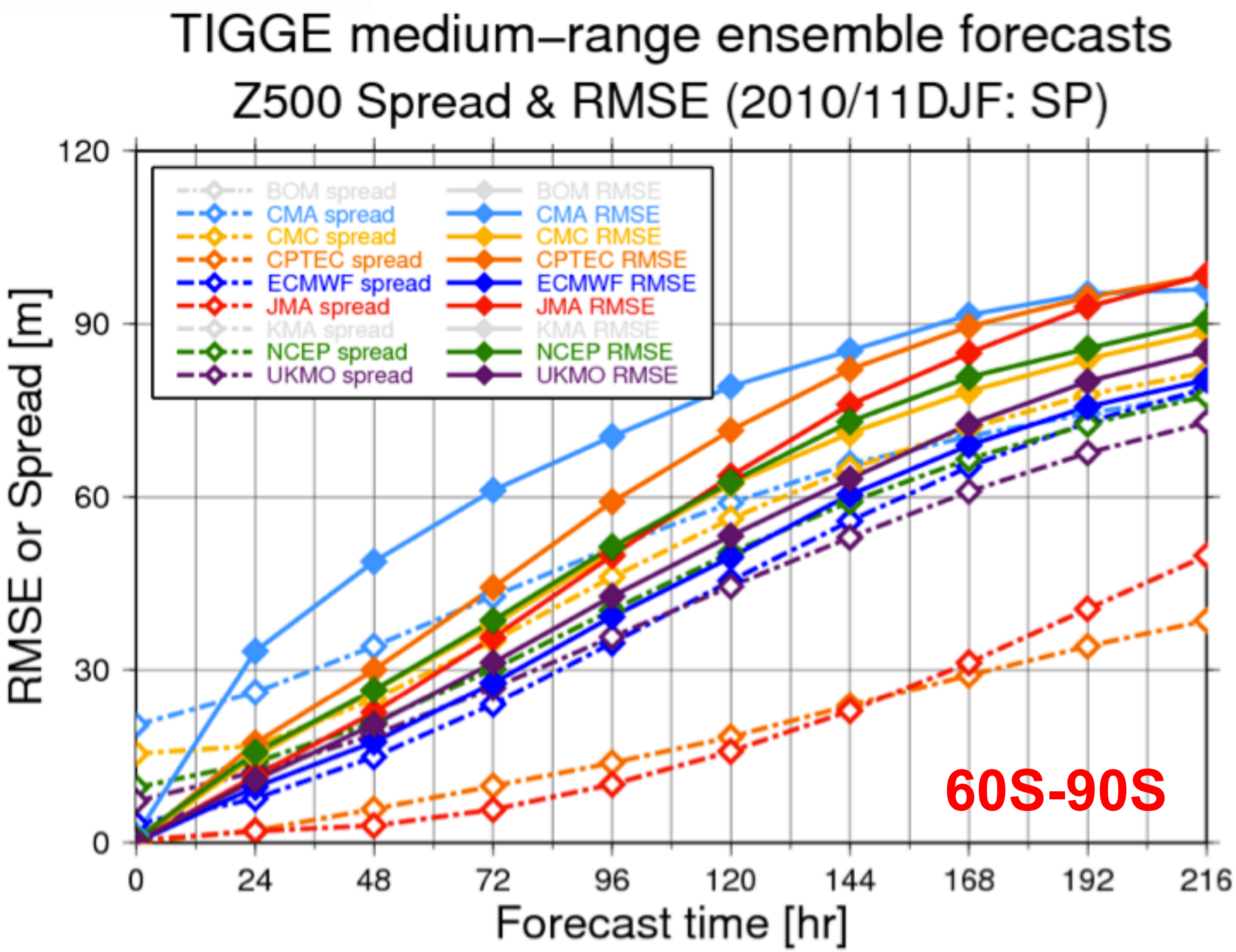


Figure courtesy of Mio Matsueda (Oxford)

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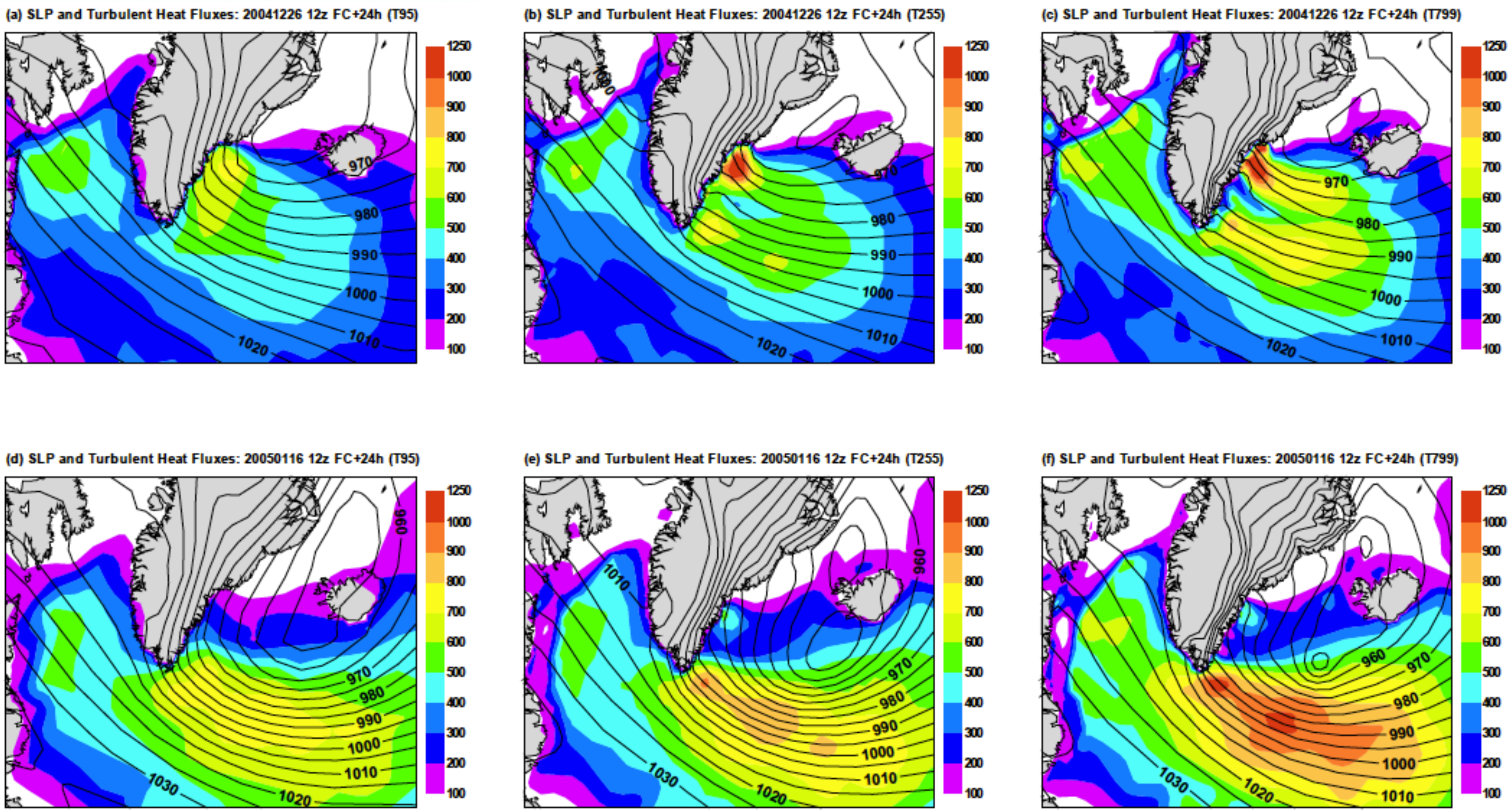
Topograhic Jets and Resolution



Jung and Rhines (2007)

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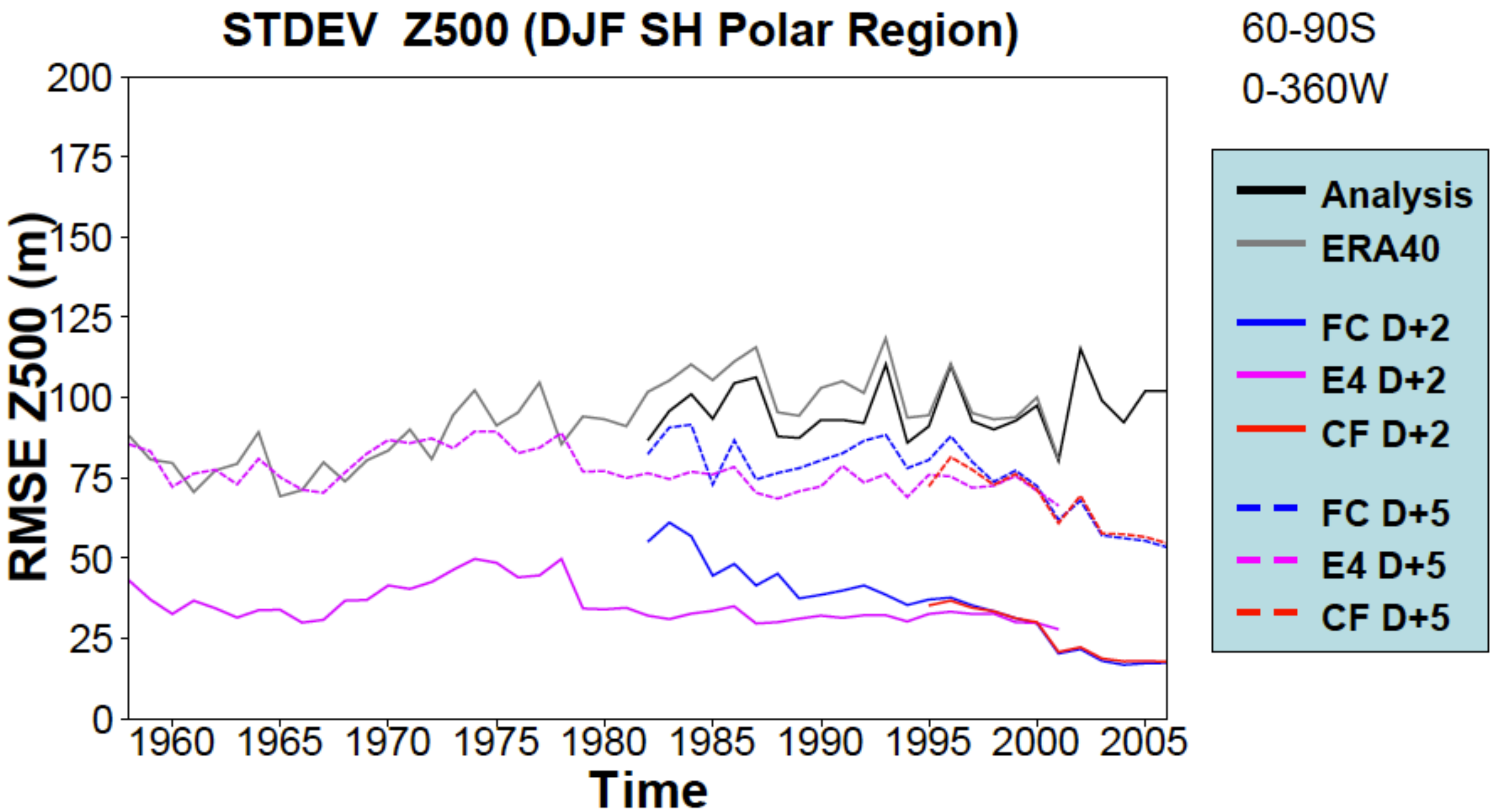
Deterministic Skill: Z500 Antarctic



Jung and Leutbecher (2007)

Importance of sea ice forecasts

Scale dependent predictability

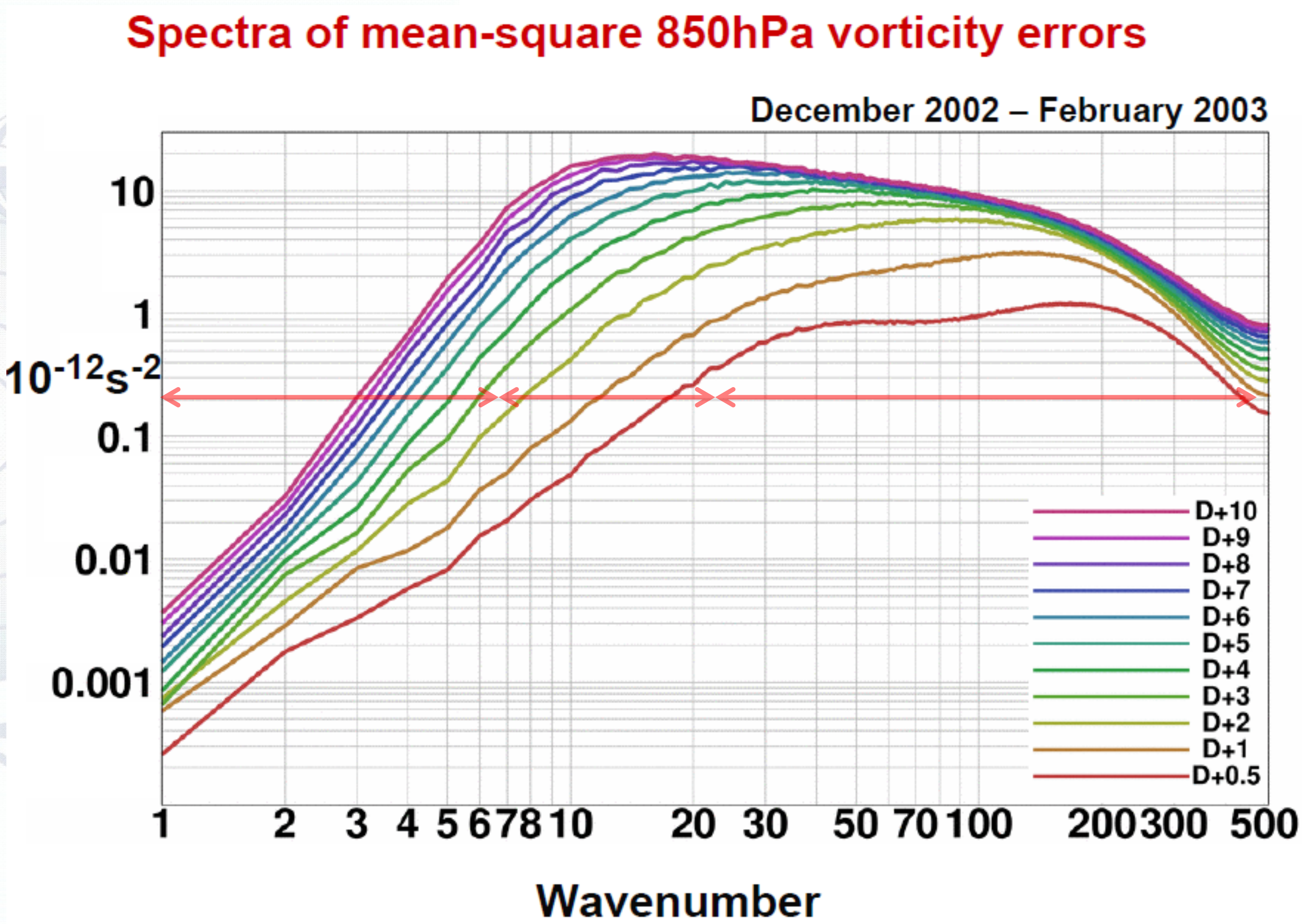
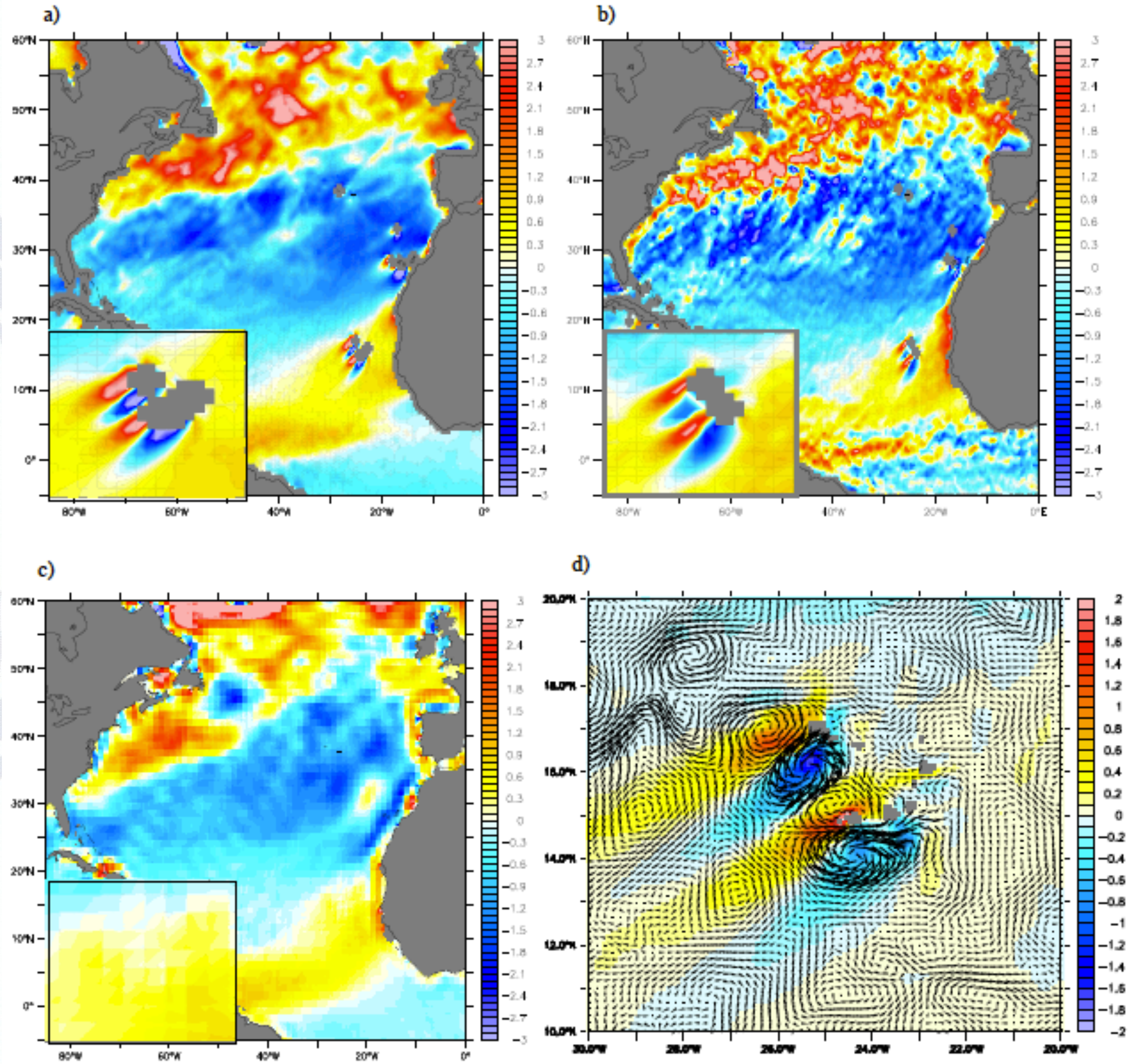


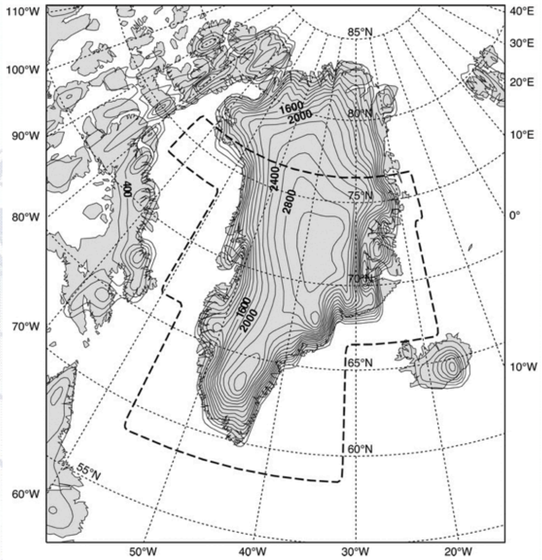
Figure courtesy of A. Simmons (ECMWF)

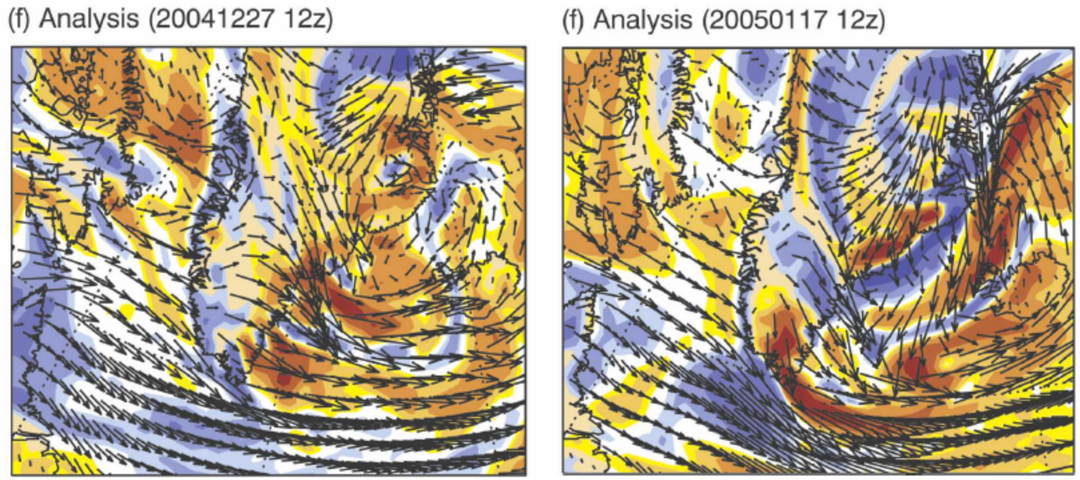
Oceanic response to high-resolution atmospheric forcing

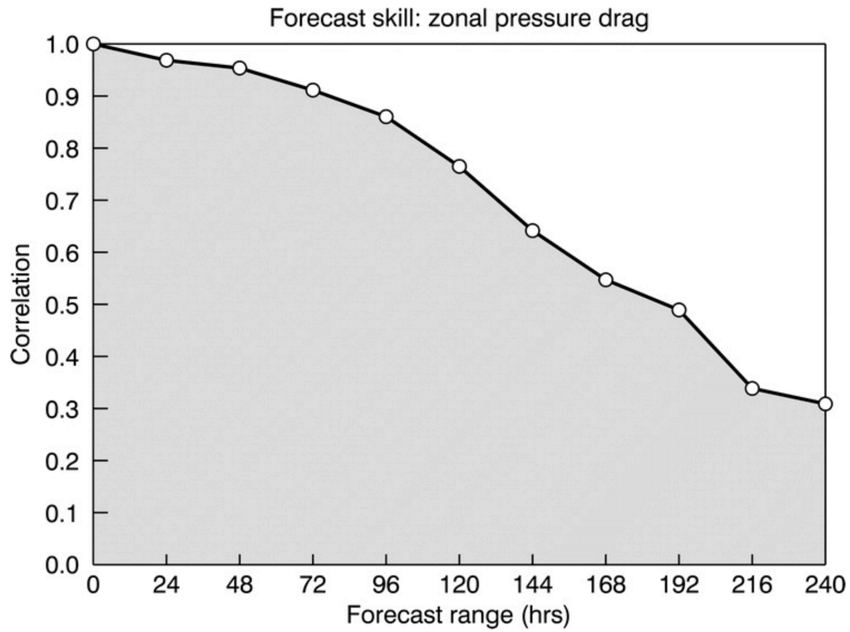


Eden and Jung (2006)

Scale dependent predictability



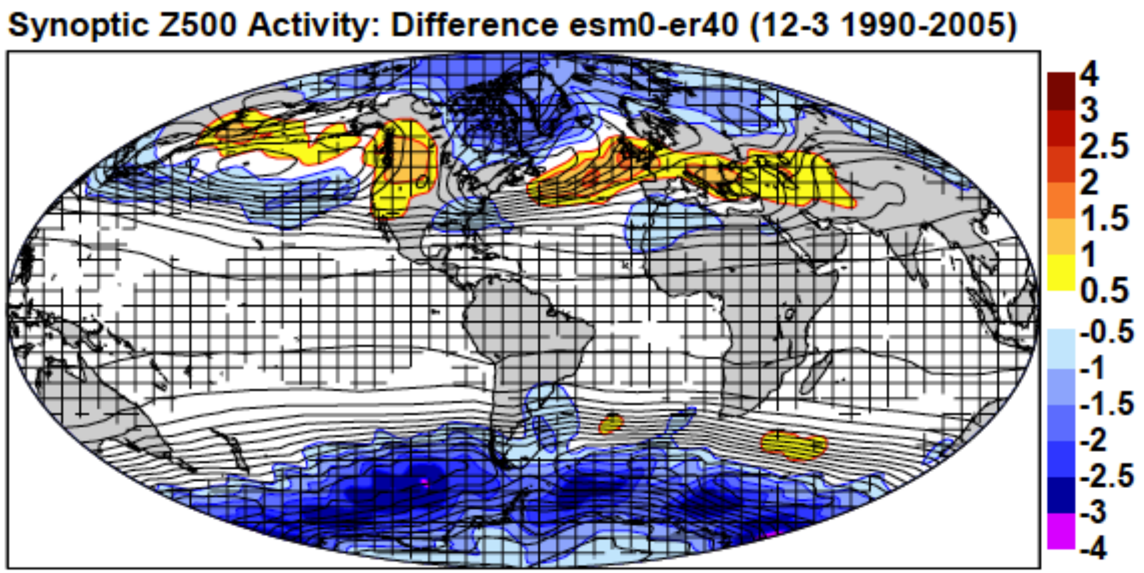




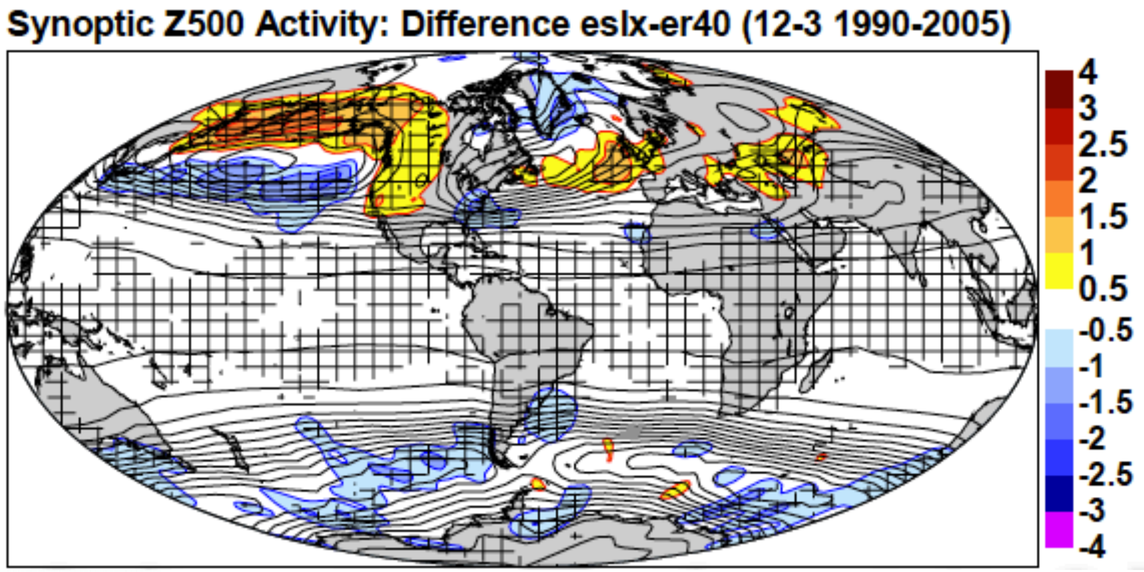
Jung and Rhines (2007)

Synoptic eddy activity and resolution

T95-ERA40



T511-ERA40



Jung et al. (2006)

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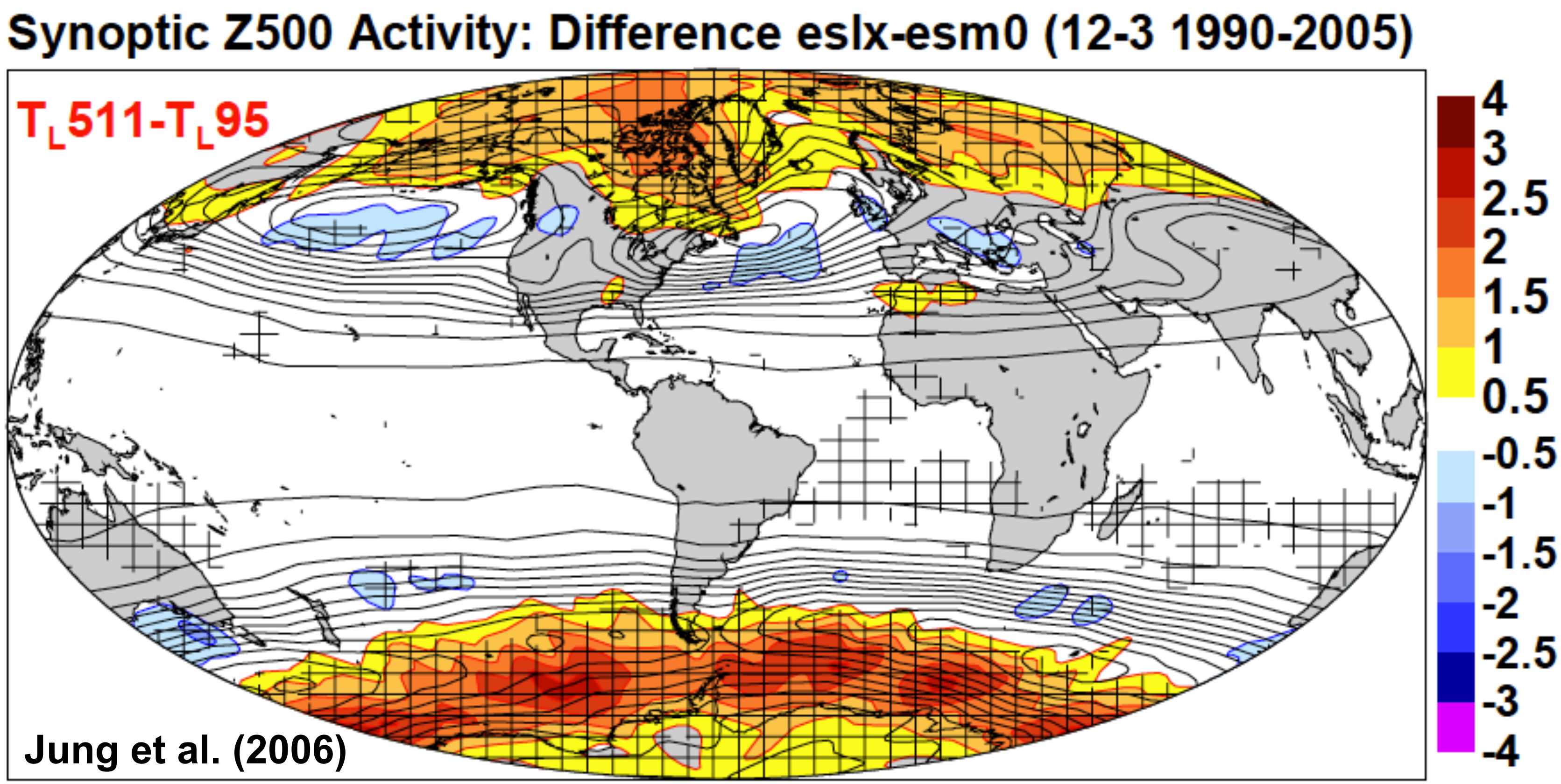
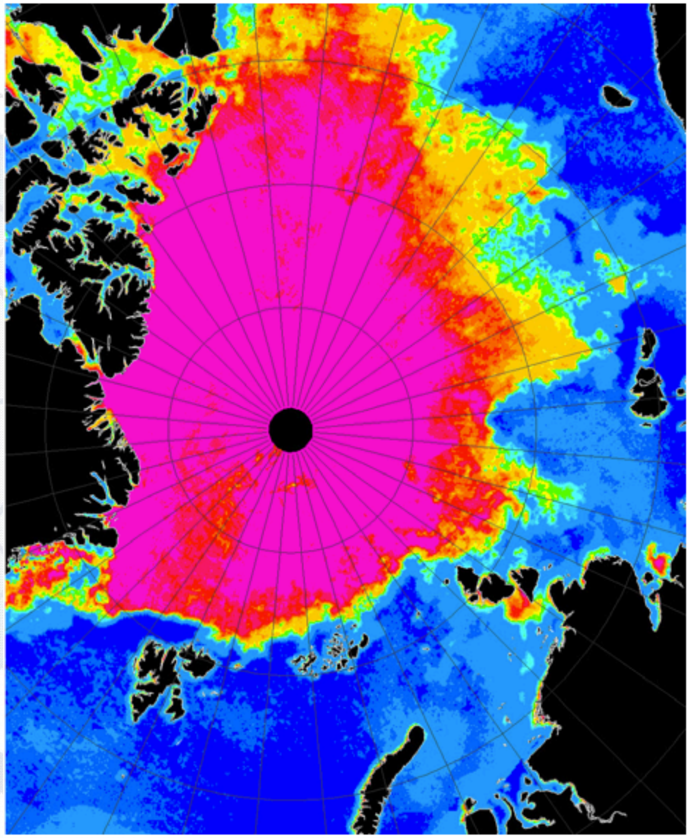
Synoptic eddy activity and resolution



Predictability of sea ice anomalies

24. August 2005



23. August 2006

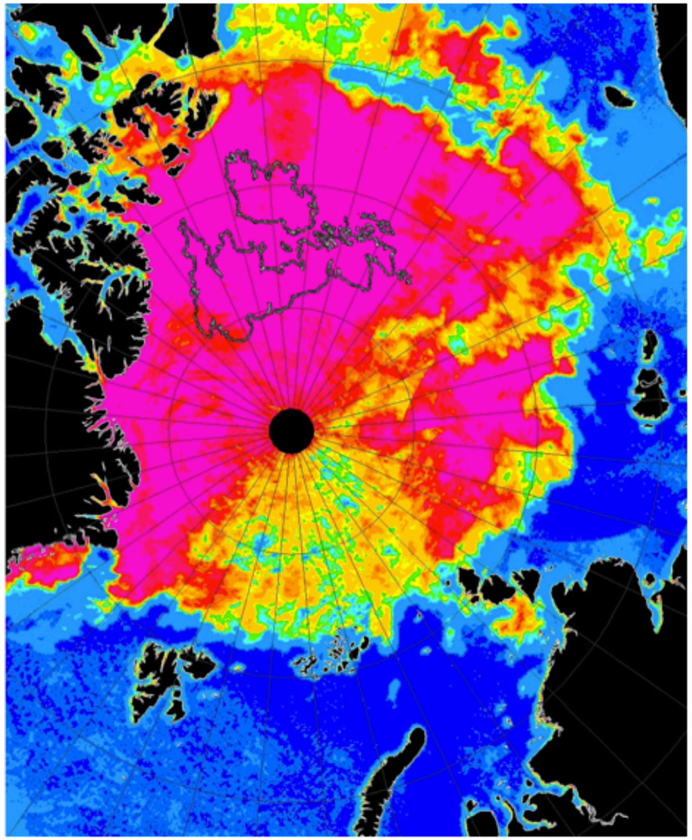
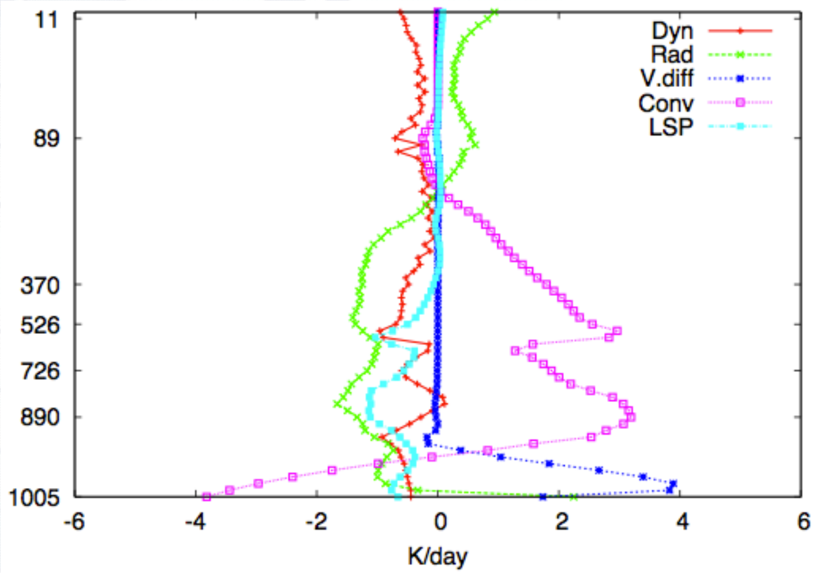


Figure courtesy of Leif Toudal Pedersen

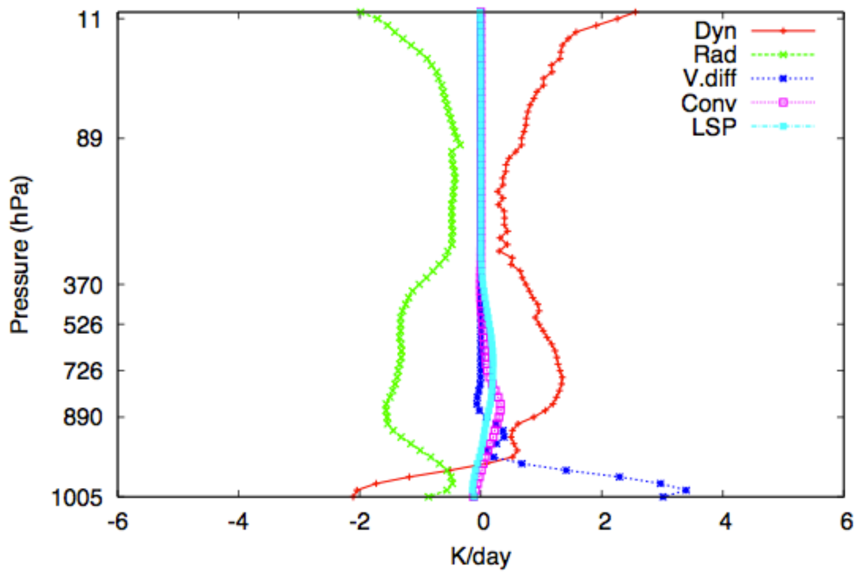
EOS Aqua AMSR-E ice concentration

Mean temperature tendencies

Tropics: Sea points



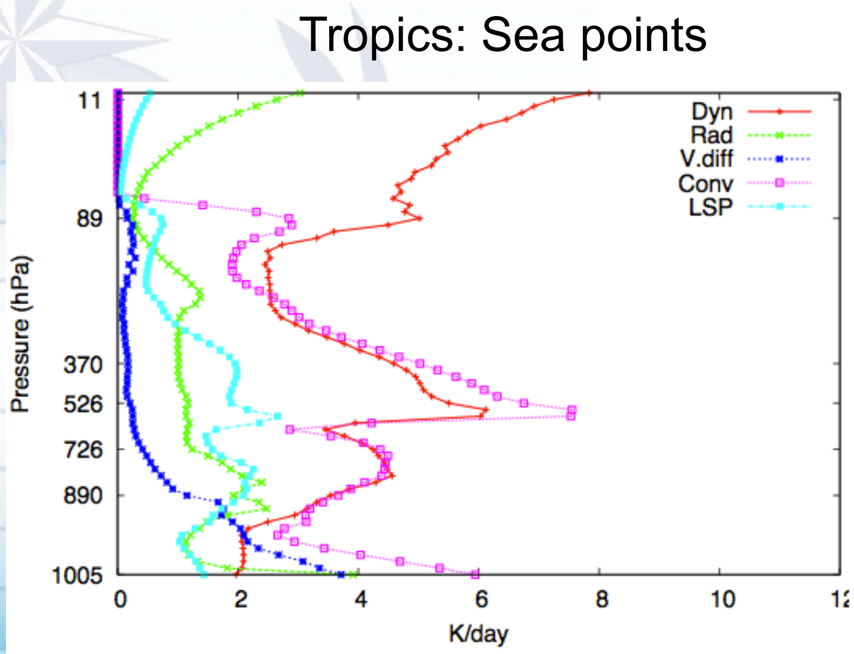
Arctic: Sea and sea ice points



- ECMWF model
- 6-hourly initial tendencies
- 120 forecasts (DJF 1989-2010)

Figure courtesy of S. Serrar (AWI)

Temperature tendencies: Stdev



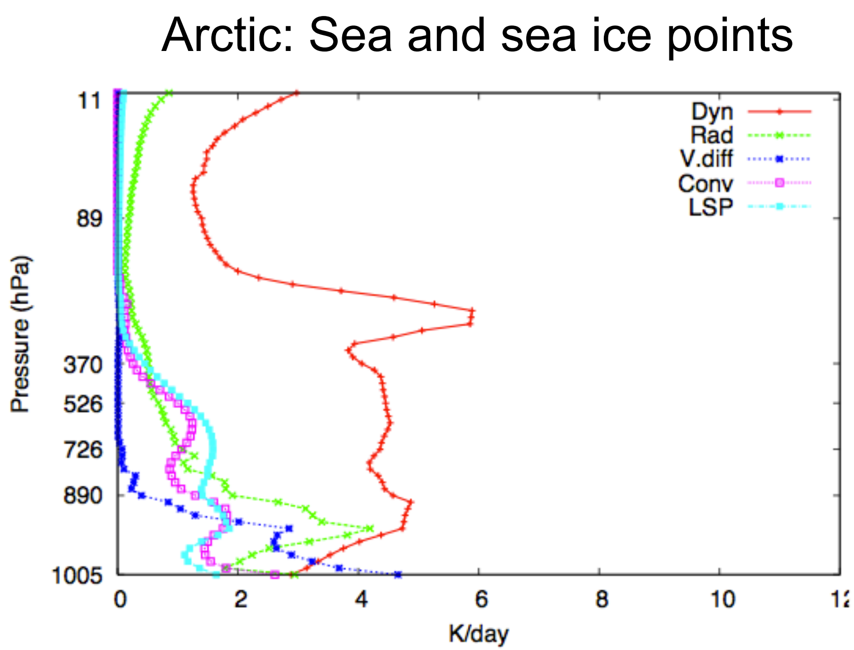
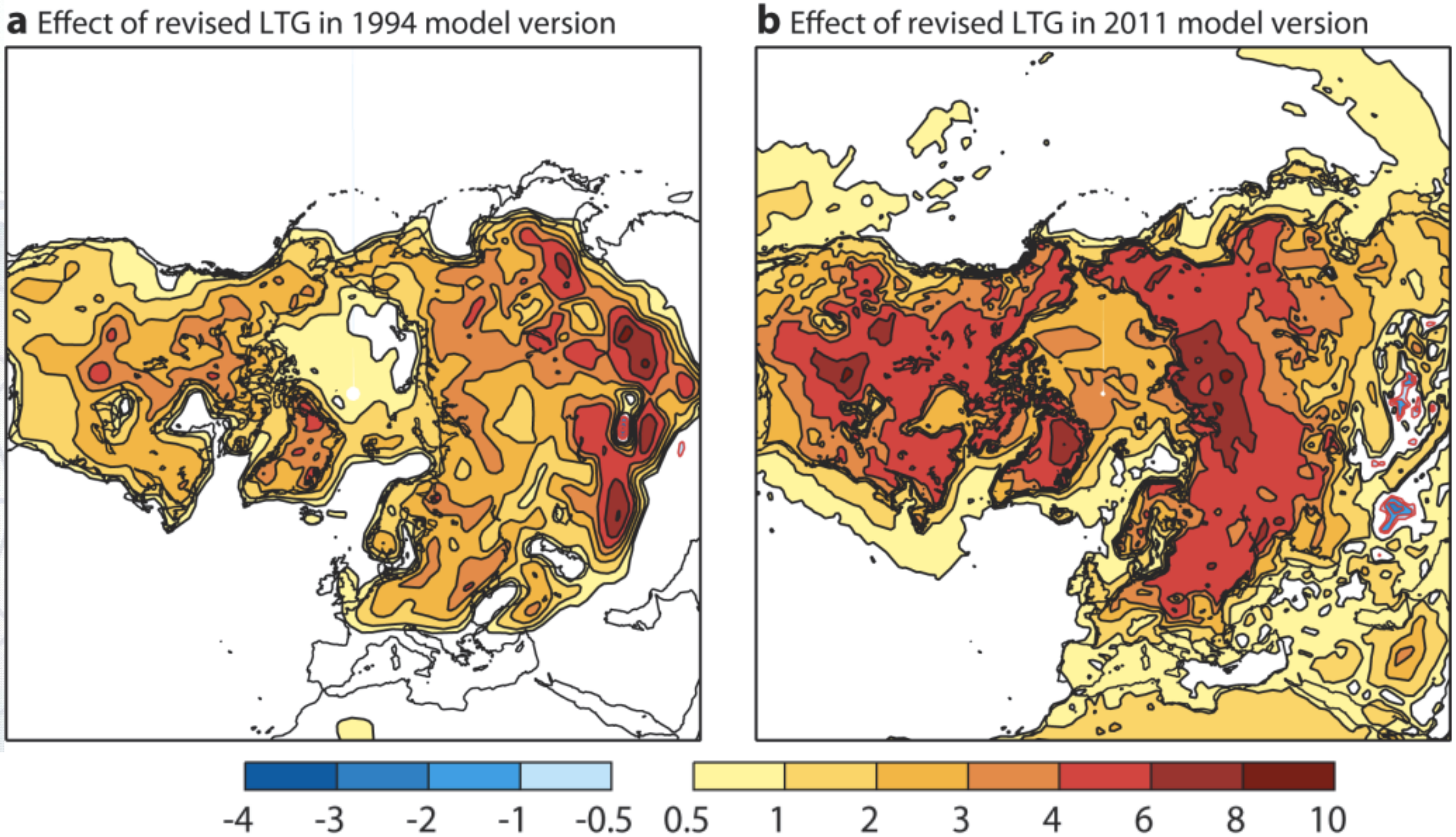


Figure courtesy of S. Serrar (AWI)

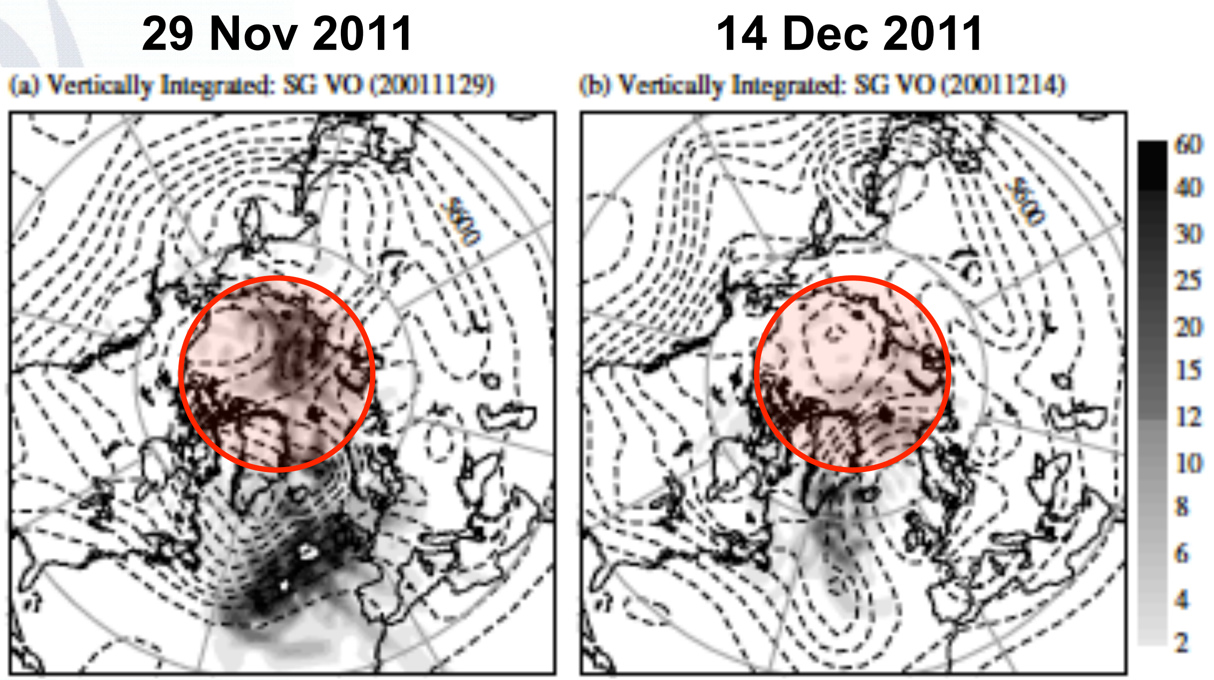
Sensitivity to Model Formulation



Effect of revised diffusion in PBL scheme on averaged January 1996 temperature. These sensitivity experiments were performed by starting a long integration from 1 October 1995 and applying relaxation to the 6-hourly operational analyses above 500 m from the surface. This is an efficient way of doing "deterministic" seasonal integrations without constraining the stable boundary layer.

Beljaars (2012)

D+2 Forecast Sensitivity to Initial Perturbations



Jung and Leutbecher (2007)