The WWRP and WCRP Polar Prediction Initiatives

Thomas Jung
Chair of the WWRP Polar Prediction Project
Alfred Wegener Institute for Polar and Marine Research
November 2012

THORPEX
WWRP
WMO
OMM

Outline

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

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...“

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

SG2, Montreal, 27-28. March 2012

- Mikhail Tolstykh
- Paco Doblas Reyes (ex-officio)
- Peter Lemke (ex-officio)
- Neil Gordon (WMO consultant)

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

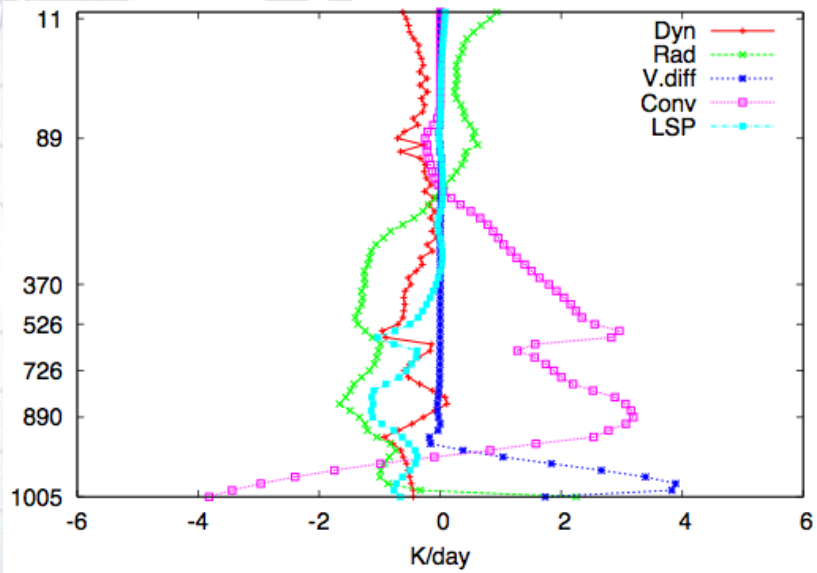
THORPEX

WWRP

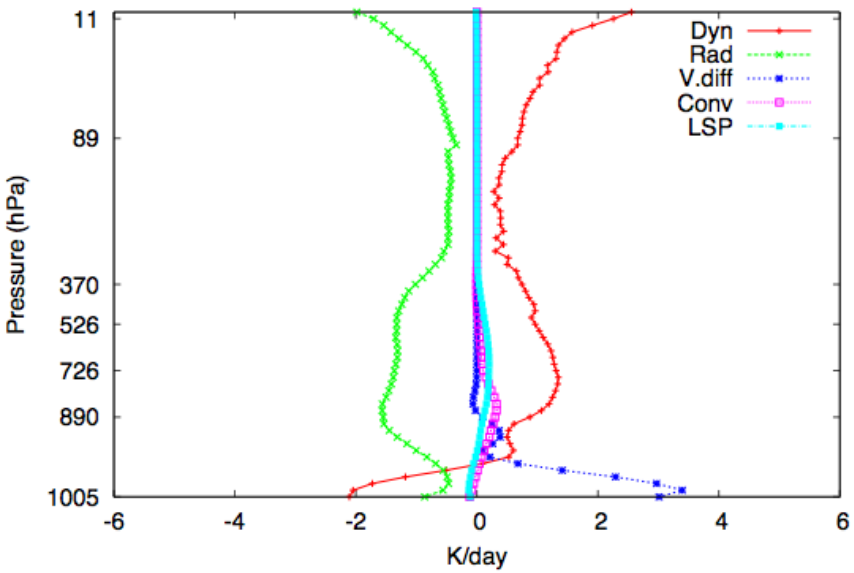
WMO
OMM

Mean temperature tendencies

Tropics: Sea points



Arctic: Sea and sea ice points

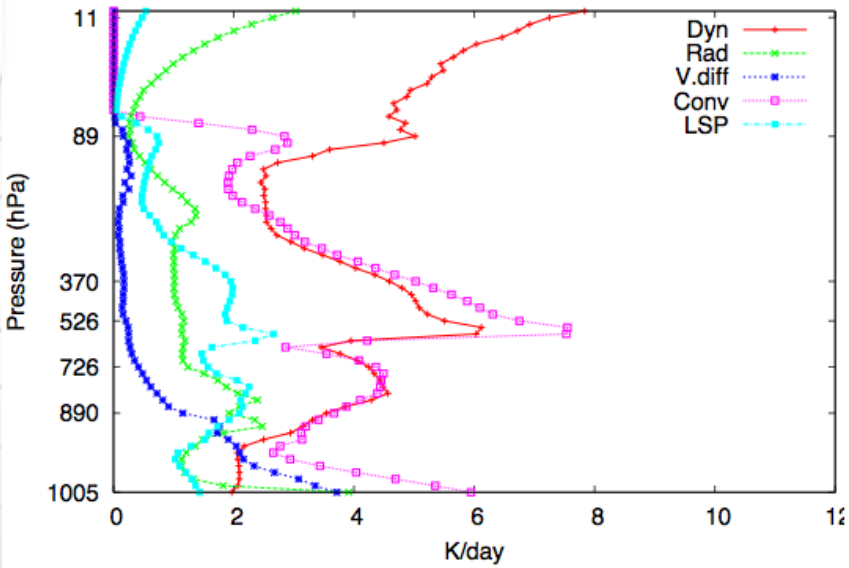


- ECMWF model
- 6-hourly initial tendencies
- 120 forecasts (DJF 1989-2010)

Figure courtesy of S. Serrar (AWI)

Temperature tendencies: Stdev

Tropics: Sea points



Arctic: Sea and sea ice points

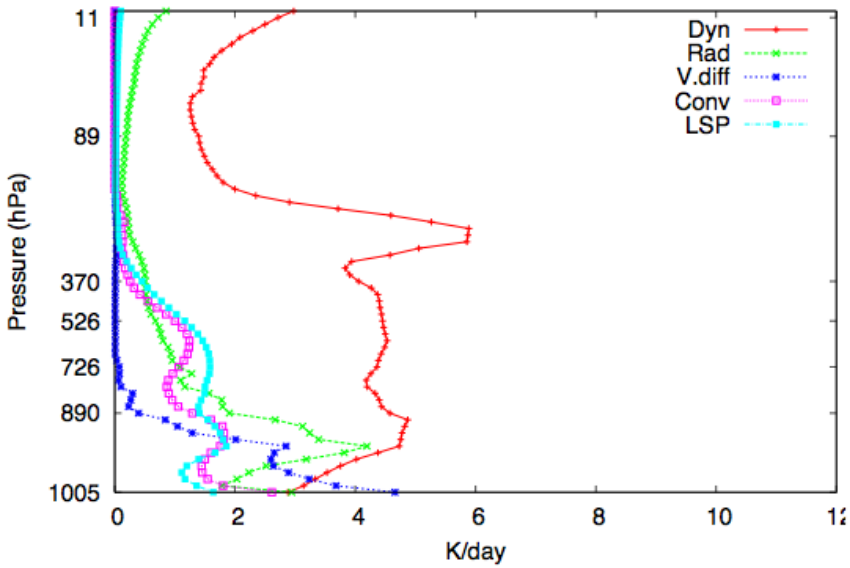


Figure courtesy of S. Serrar (AWI)

New TIGGE Products (cont'd)

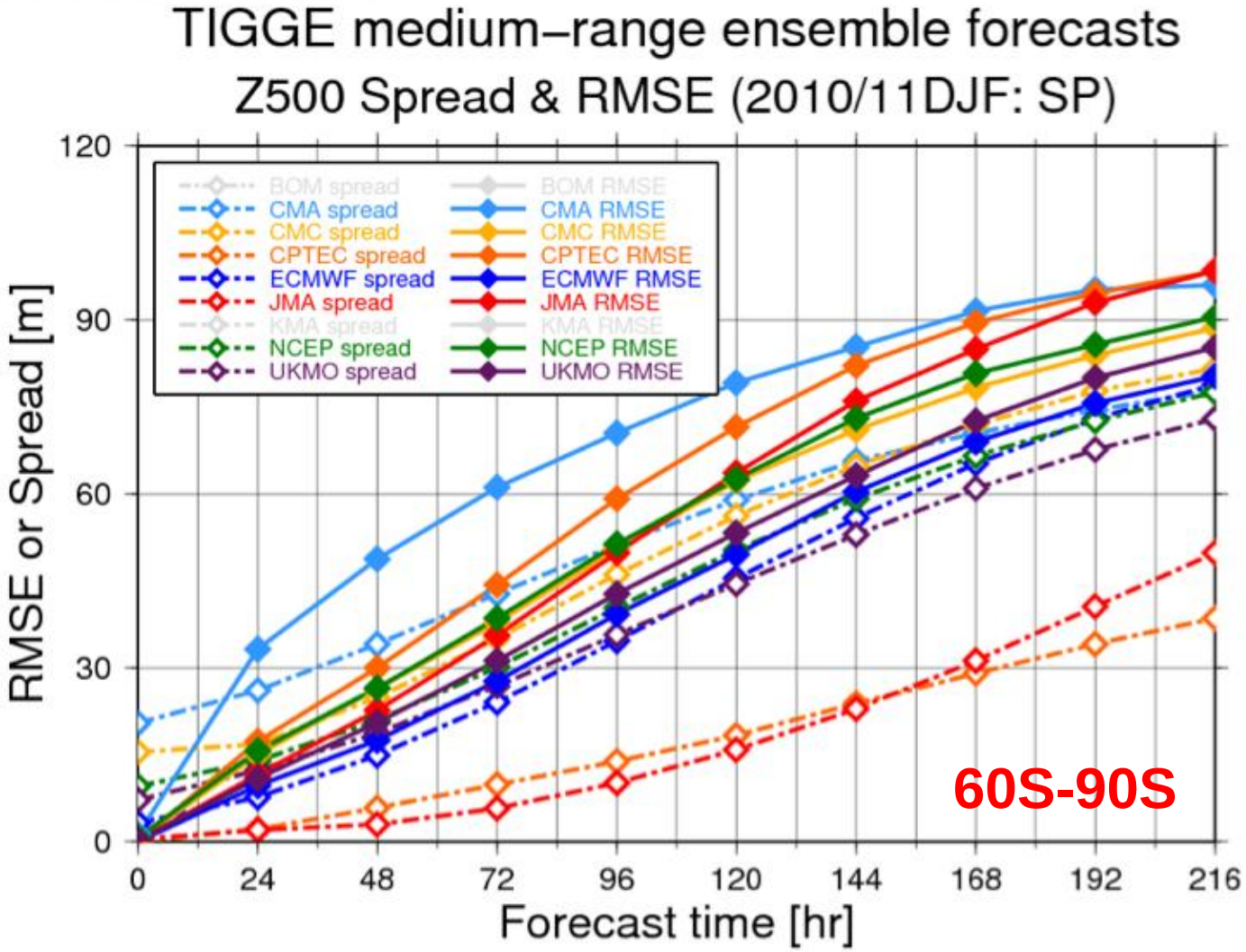


Figure courtesy of Mio Matsueda (Oxford)

Role of Sea Ice in Medium-Range Weather Forecasting

T2m Difference: Observed Minus Persisted Sea Ice

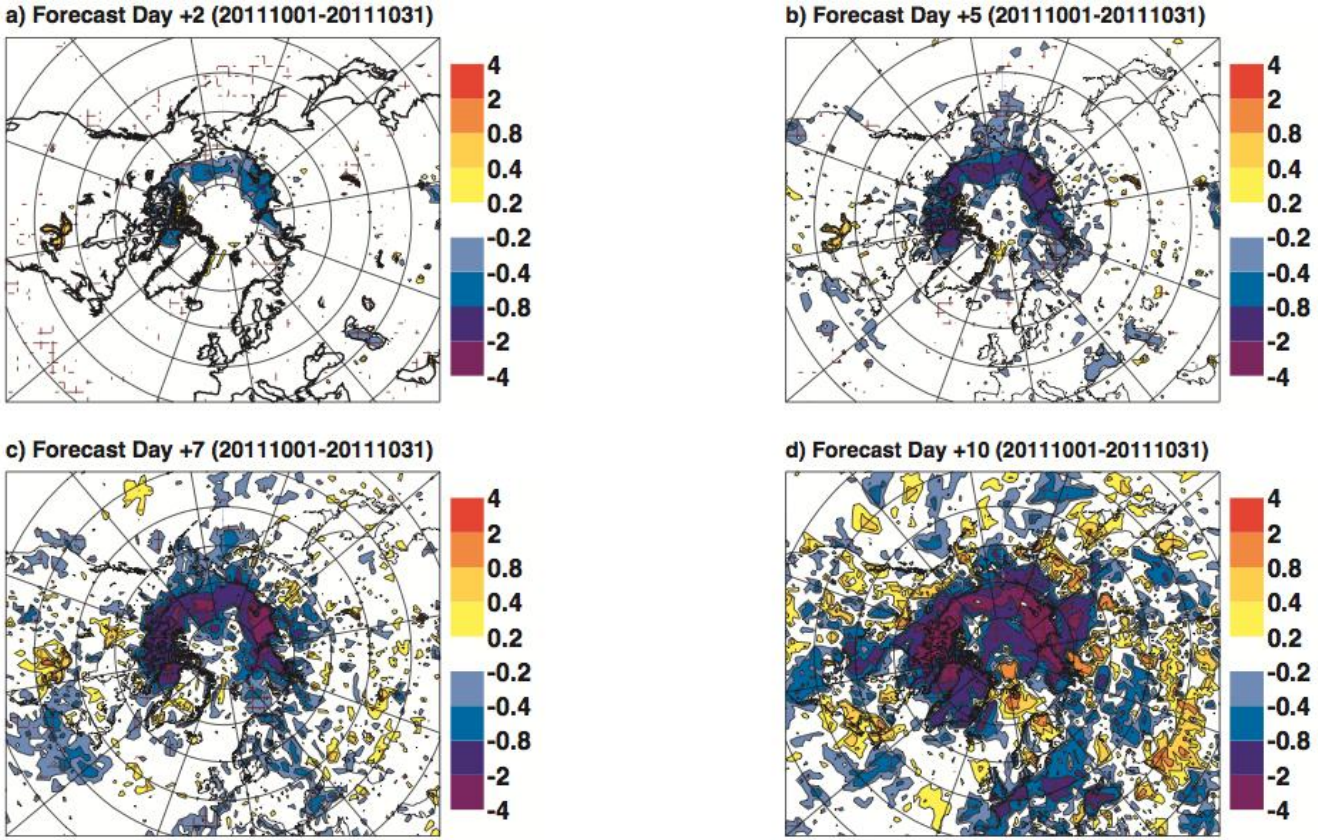
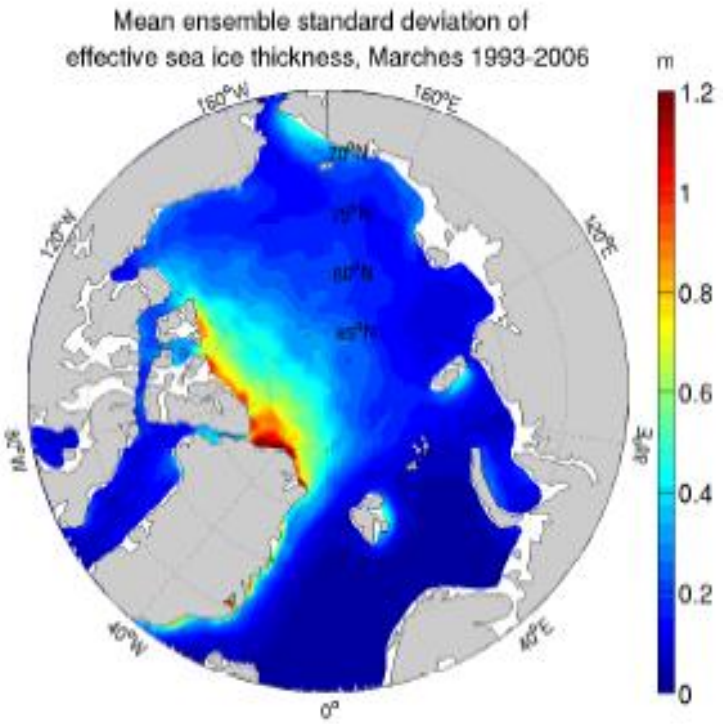


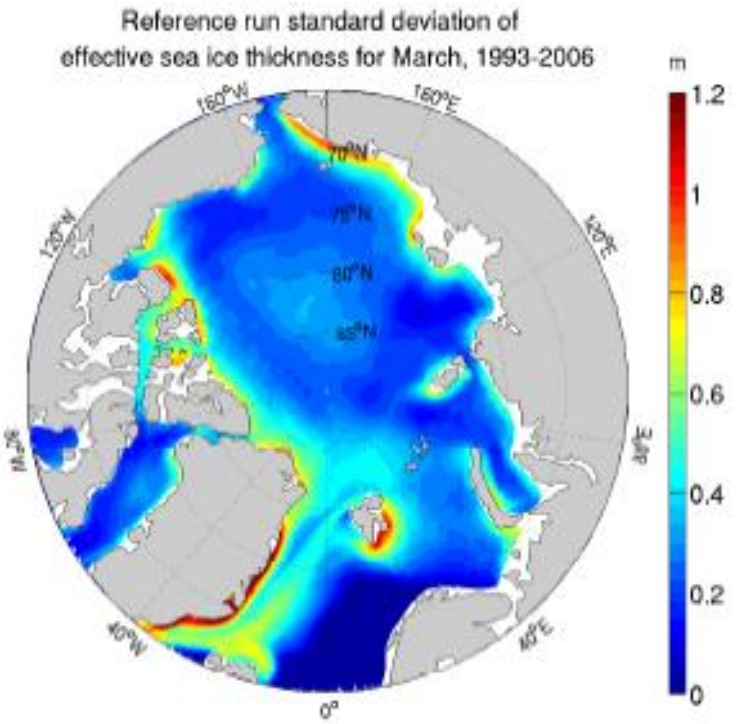
Figure courtesy of P. Bauer (ECMWF)

Stochastic Sea Ice Parametrizations

Ensemble Spread



Interannual variability



Juricke et al., accepted in J. Climate

Year of Polar Prediction (YOPP)

Aim:

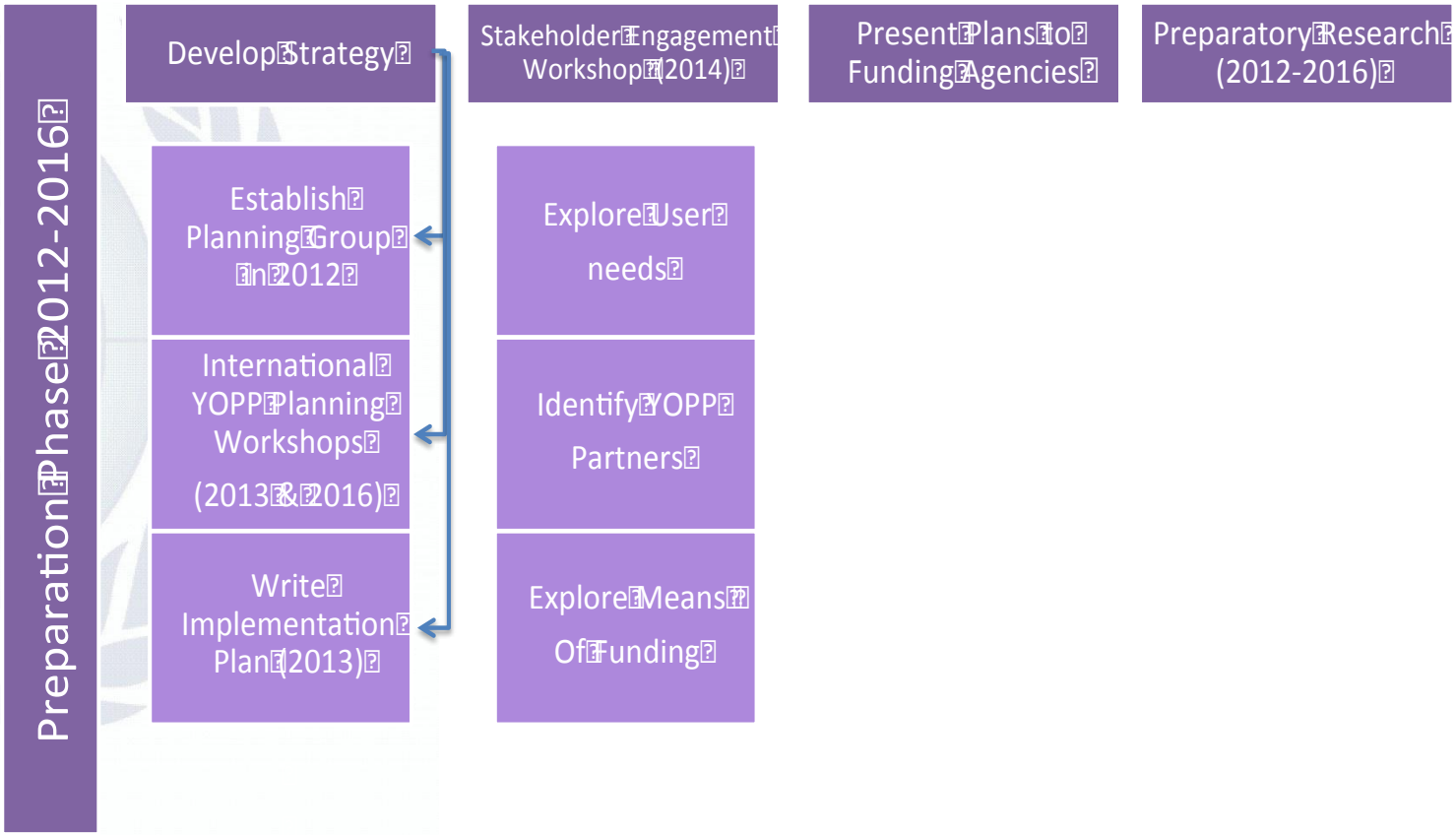
Intensive observational *and* modelling period to advance polar prediction capabilities. This will be augmented by research into forecast-stakeholder interaction, verification and a strong educational component

Important:

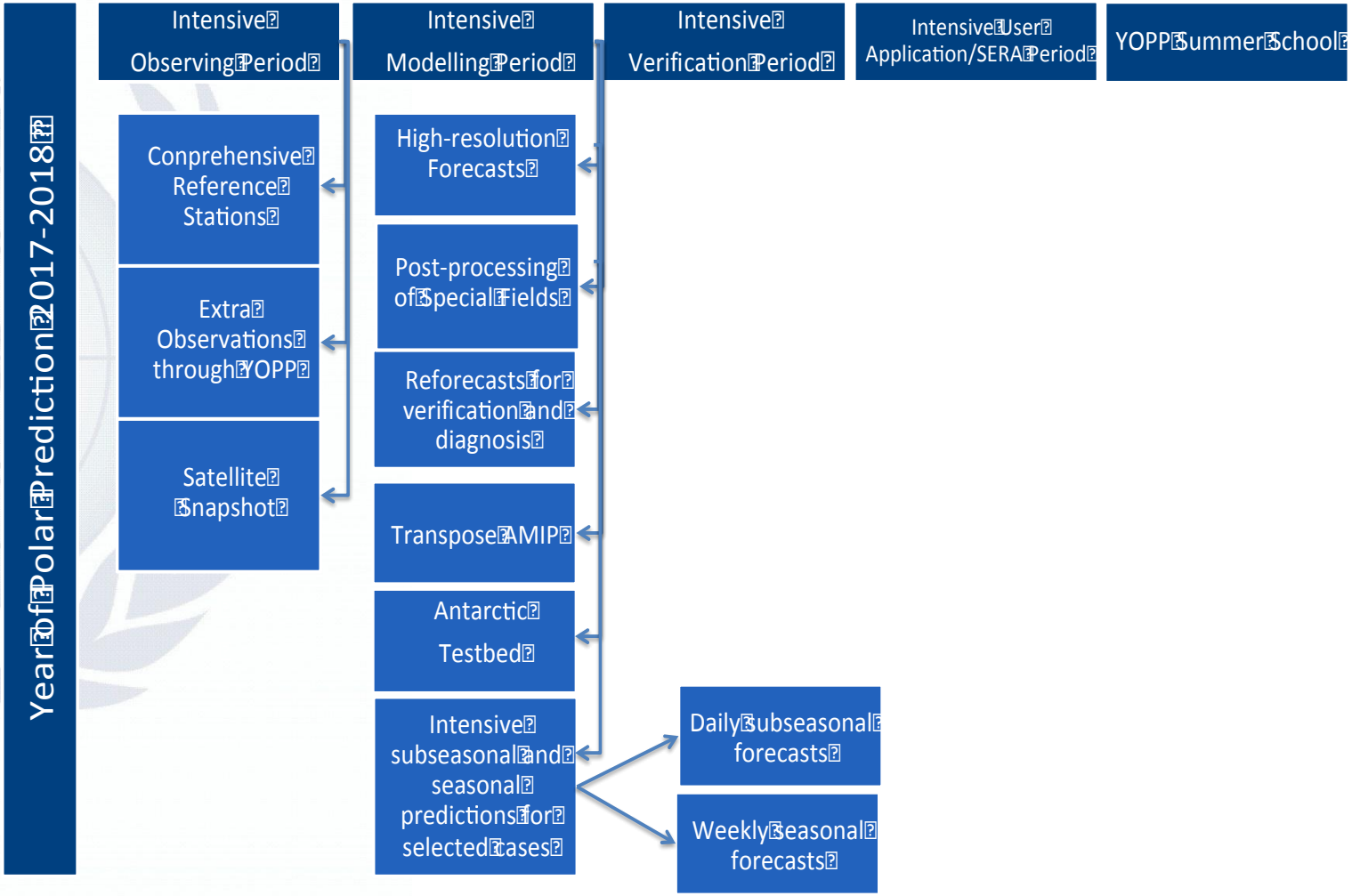
Needs to be aligned with other (planned) activities such as MOSAiC.

YOPP: Time line

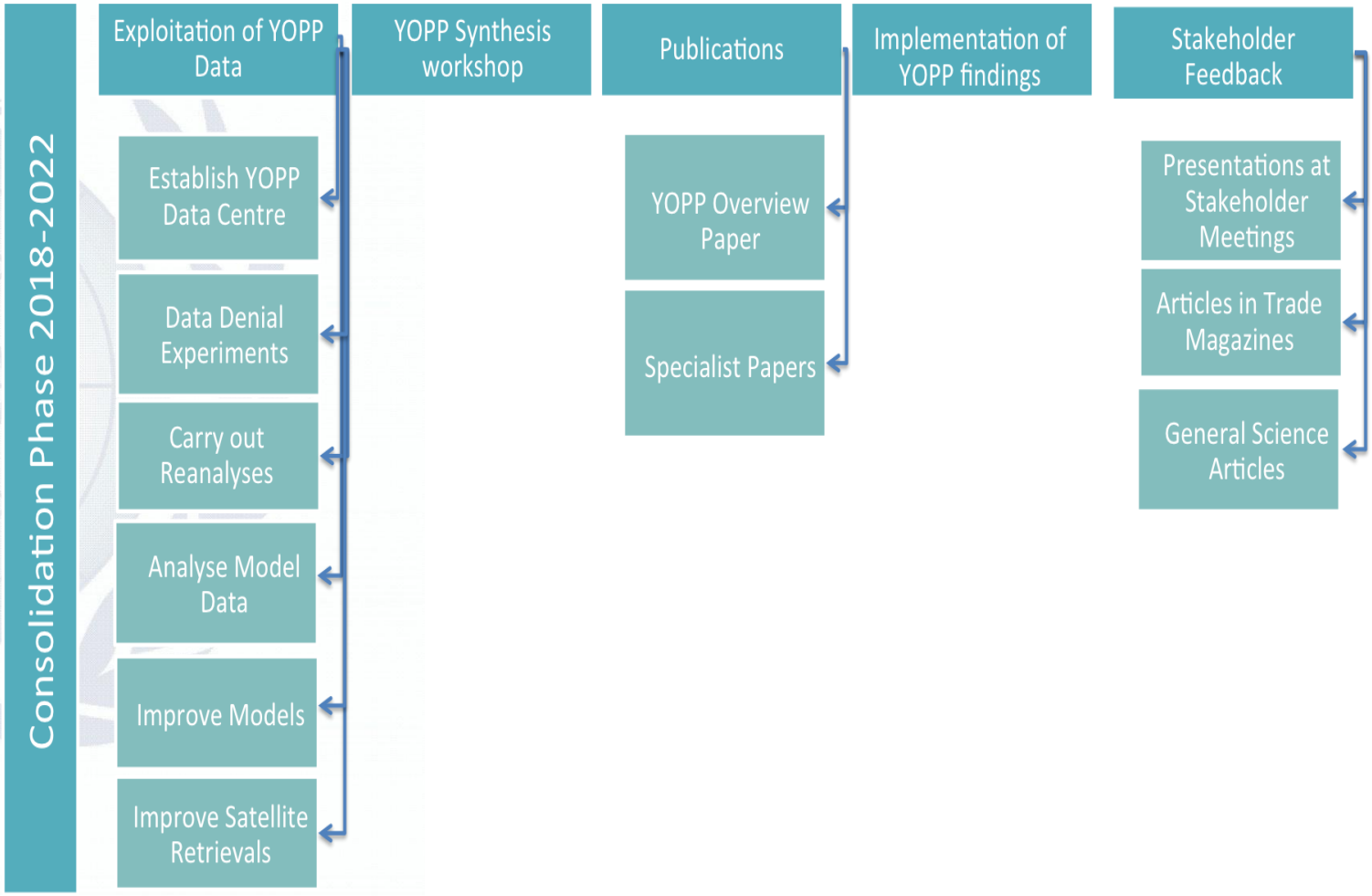
Preparation phase



Year of Polar Prediction



Consolidation phase



Next steps

Month	Milestones
Oct/Nov 2012	Feedback from the community on the Implementation Plan (you are welcome to contribute)

Dec 2012	Steering group meeting
	• Revision of the Implementation Plan
	• Prepare launch of the International Coordination Office
	• Start of the YOPP planning phase
	  ○ Establish international YOPP planning group
	  ○ Organisation of a YOPP planning workshop
	  ○ Start work on YOPP implementation plan

Jan 2013	Official launch of WWRP Polar Prediction Project
Jun 2013	ECMWF-WWRP Workshop on Polar Prediction

Part II: The WCRP Polar Climate Predictability Initiative

Based on input 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
- WCRP-PCPI accepted as a sub-initiative within the WCRP's Grand Challenge on the Cryosphere
- Document from the Toronto workshop has been written and distributed

Key Scientific 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 are climate models generally unable to capture the observed behaviour in polar regions?
- 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?

Specific Initiatives

- Improve knowledge and understanding of past polar climate variations (100+ years)
- Assess reanalyses in polar regions
- Improve understanding of polar climate predictability on seasonal to decadal timescales
- Assess performance of CMIP5 models in polar regions
- Develop methods to calibrate long-term predictions of polar climate change
- Improve understanding how jets and non-zonal circulation couple to the rest of the system in the Southern Hemisphere

Implementation

- PCPI will be a sub-initiative within the ‘Cryosphere in a Changing Climate’ WCRP Grand Challenge
  - Overall responsibility with CliC
  - SPARC responsibility for the development of SPARC
- PCPI Steering Committee should be formed (it should not be a “committee of representatives”)
- Actvities
  - Coordinated efforts of up to 2-3 years
    - Coordinated model experiments
    - Assessment of data sets
  - Focussed small workshops and meetings
- Secretariat support: see below

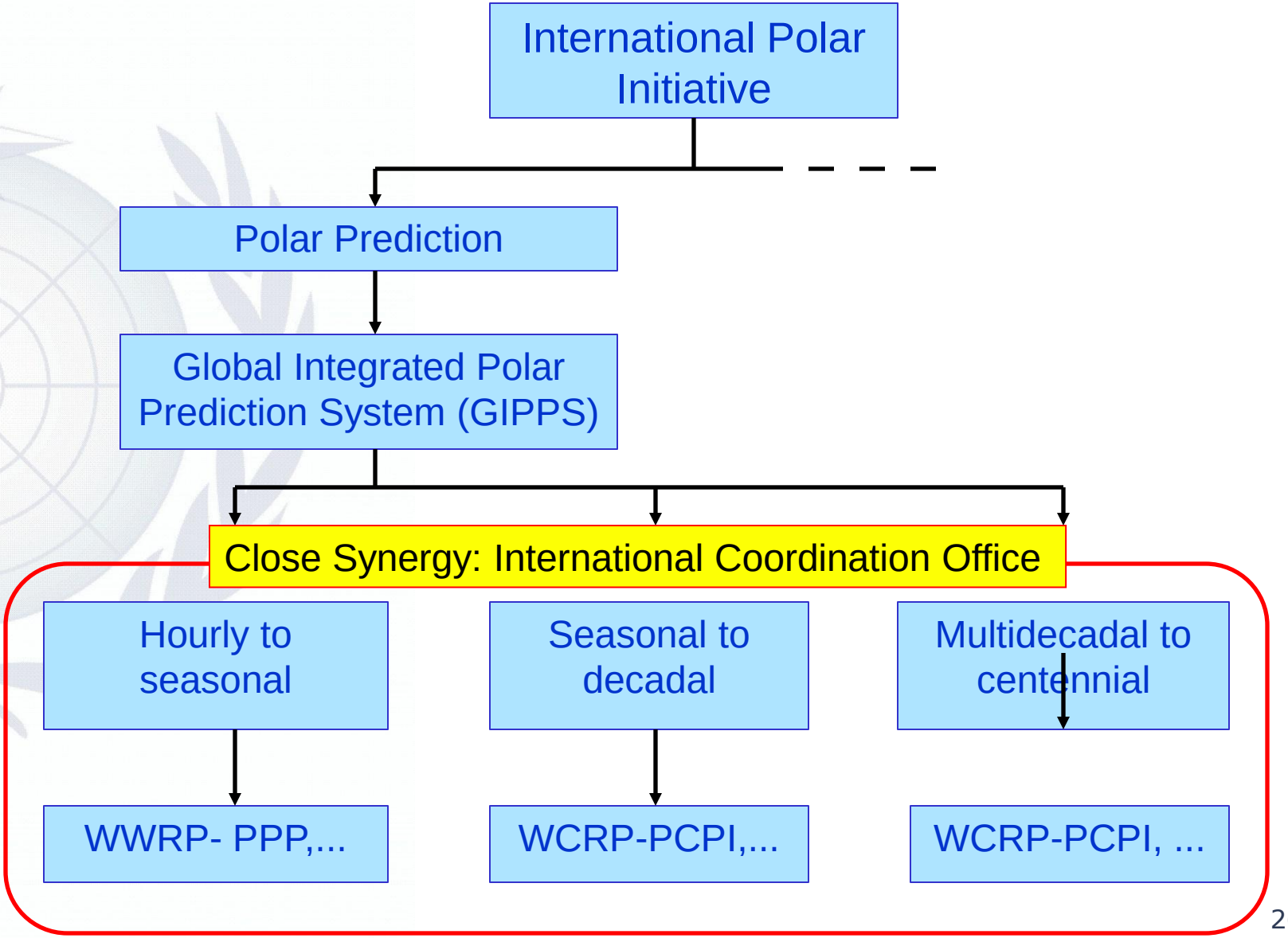
The Way Ahead

- 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
- WCRP in favour of two separate projects
  - 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



THORPEX

WWRP

WMO
OMM

Thank you!

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


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
WG SERA
EC-PORS Services Task Team
Verification
JWGFVR
Observations
Polar Space Task Group
GCW
CBS OPAG IOS
EPAC-GAW
SAON
GEWEX
Modelling
Arctic Hydra
WGNE
Data Assimilation
DAOS WG
Ice Charting WG
Ensemble Forecasts
GIFS-TIGGE WG
CBS ET Ensembles
Predictability
IASC Atmosphere WG
WGSIP
Global Linkages
PDP WG

SERA

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

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

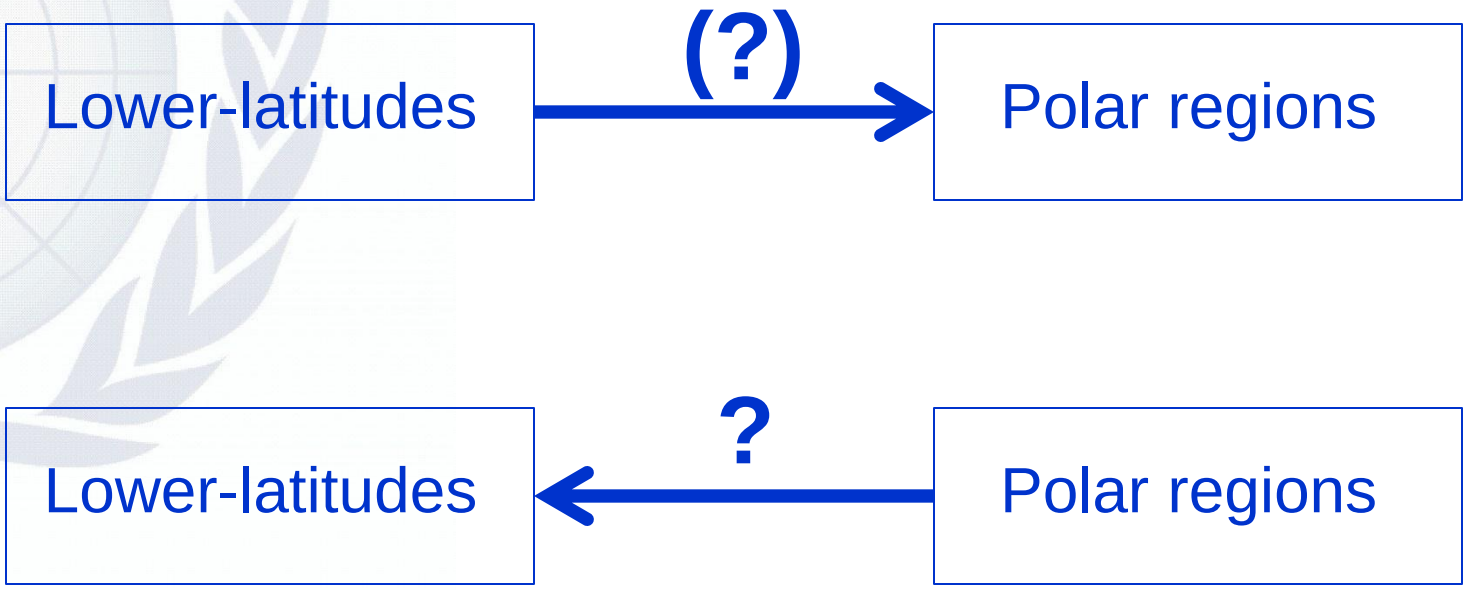
Predictability and Diagnostics

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

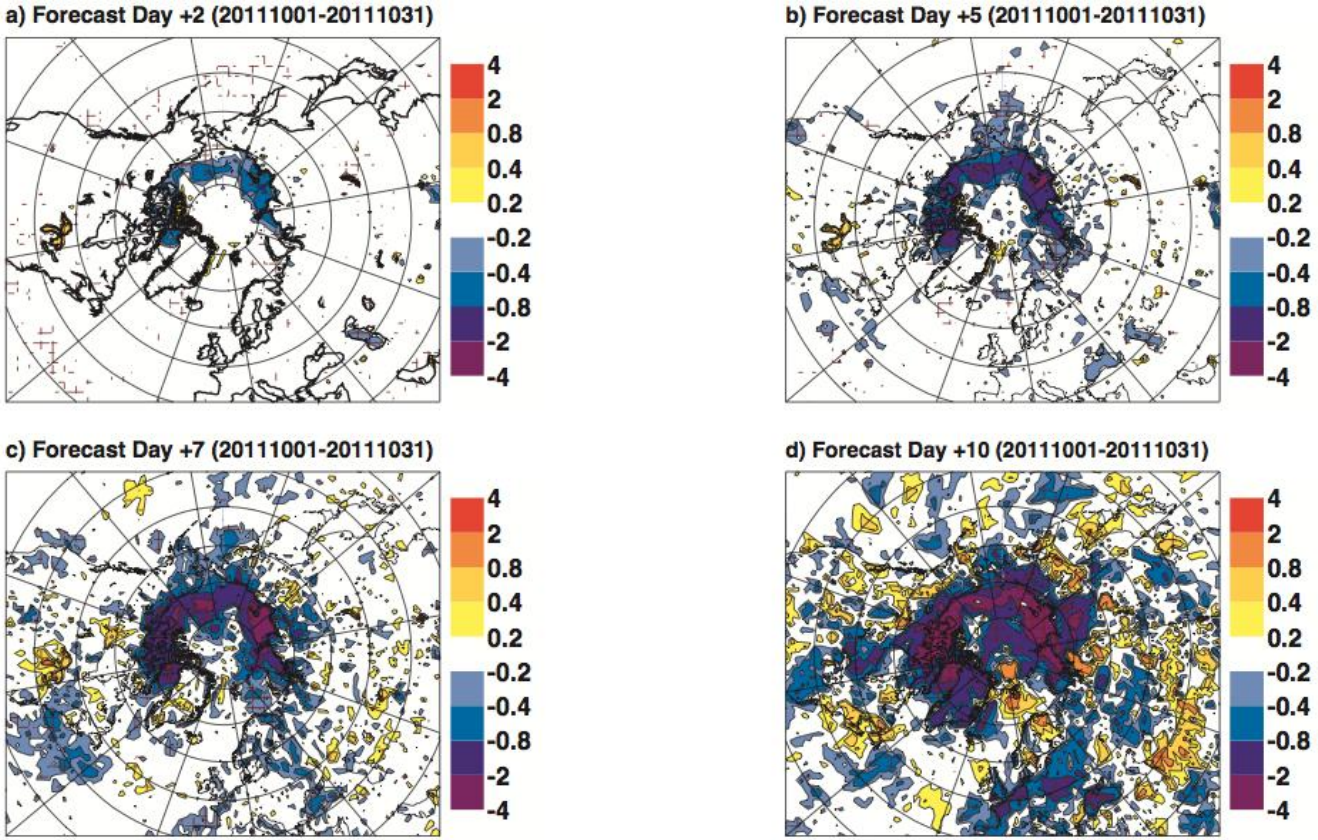


Figure courtesy of P. Bauer (ECMWF)

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

New TIGGE Products

Raise awareness: there are low hanging fruits...

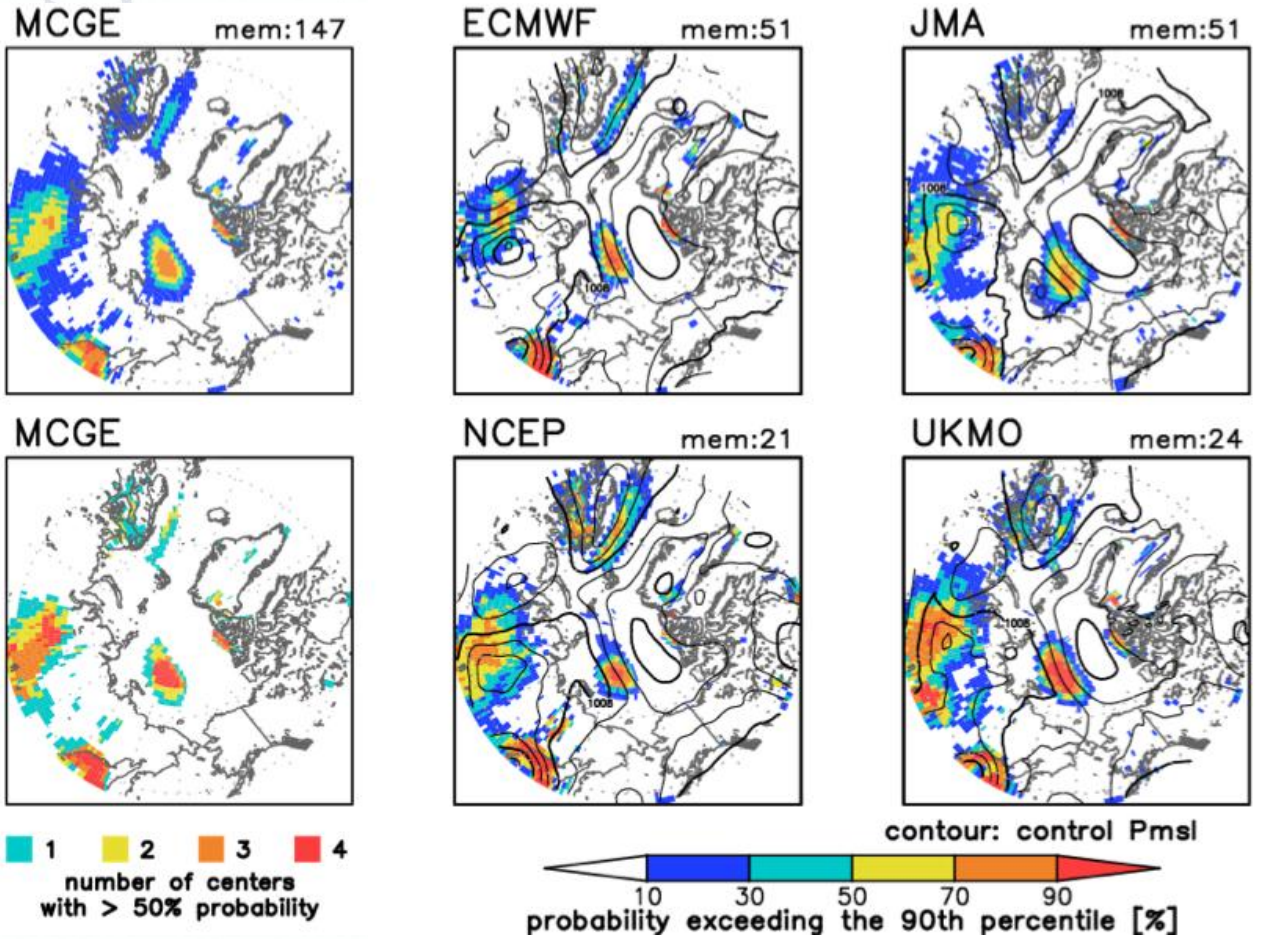


Figure courtesy of Mio Matsueda (Oxford)

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.

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)

Implementation Plan

Table of Contents

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?

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

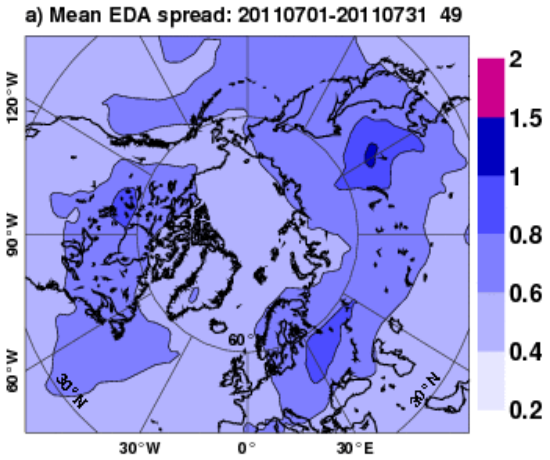
Others Strategic Issues

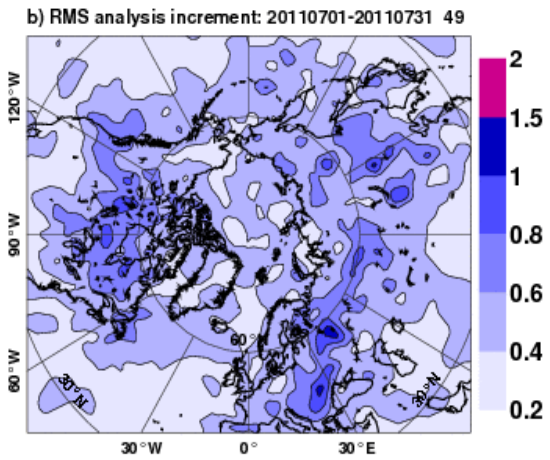
- Write BAMS paper about WWRP Polar Prediction Project
- Prepare WWRP-PPP brochure for funding agencies and stakeholders
- Linkages with space agencies and data providers
  - Liaise with WMO Polar Space Task Group
- Promote interaction and communication between researchers and stakeholders
  - Identification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

Mean T Ensemble Forecast Spread

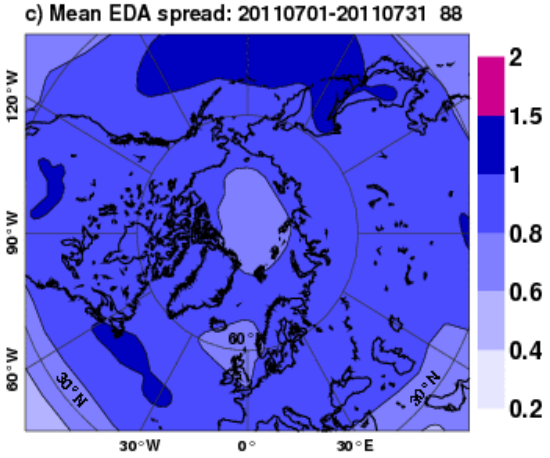
Ensemble Spread | **RMS An Increment**

200 hPa





1000 hPa



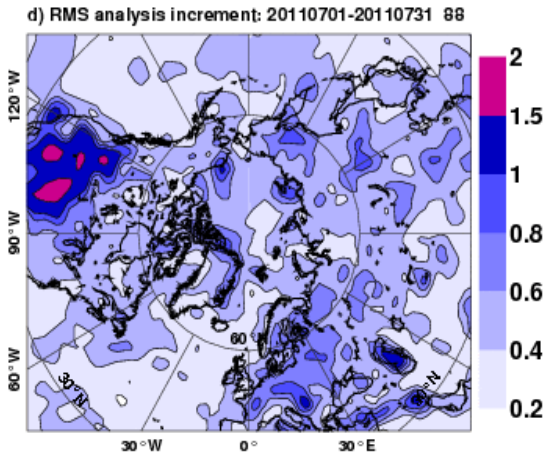


Figure courtesy of P. Bauer (ECMWF)

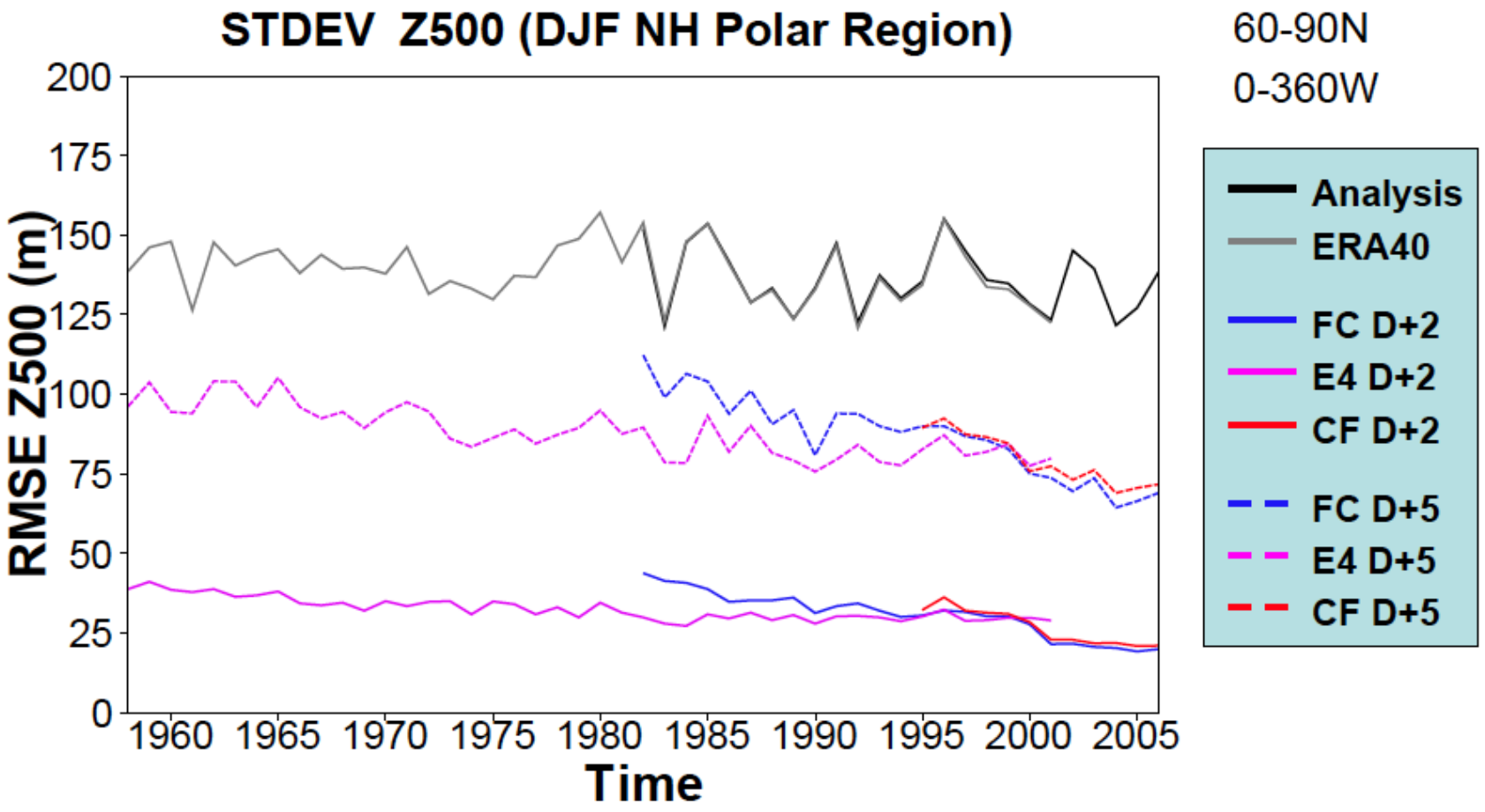
WWRP-PPP Steering Group

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

Implementation Plan

Table of Contents

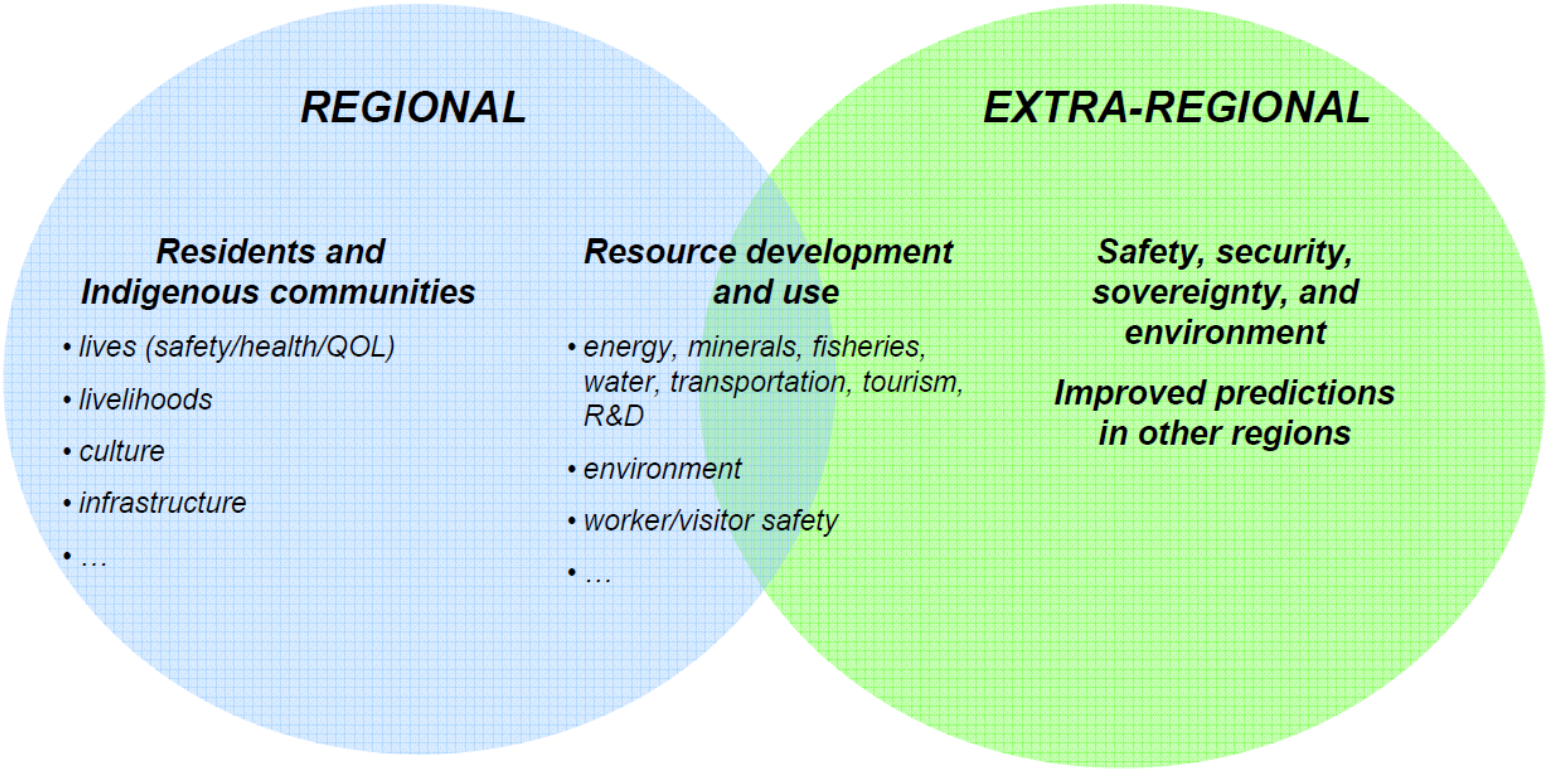
Deterministic Skill: Z500 Arctic



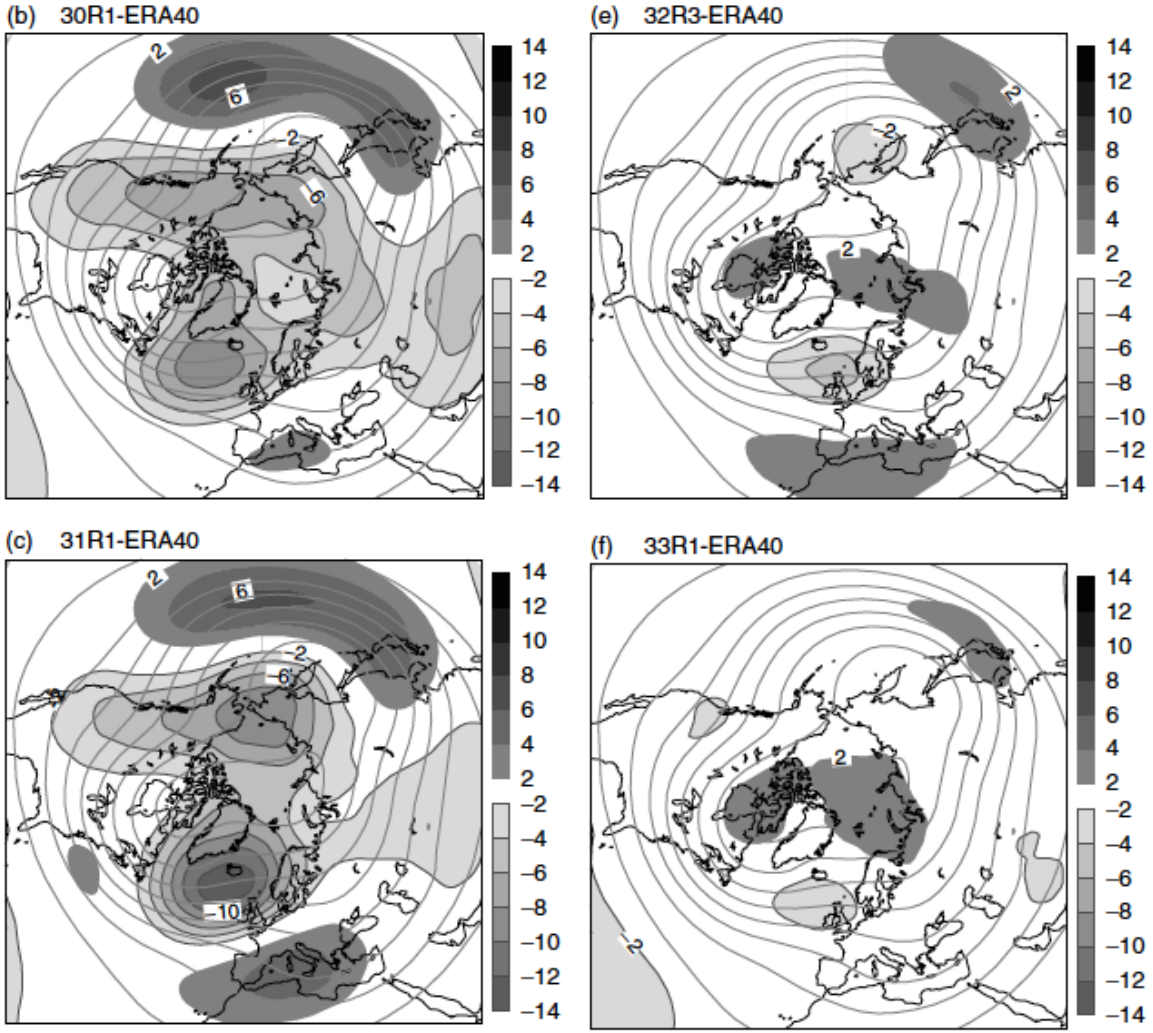
Jung and Leutbecher (2007)

International Collaboration

Benefit Areas



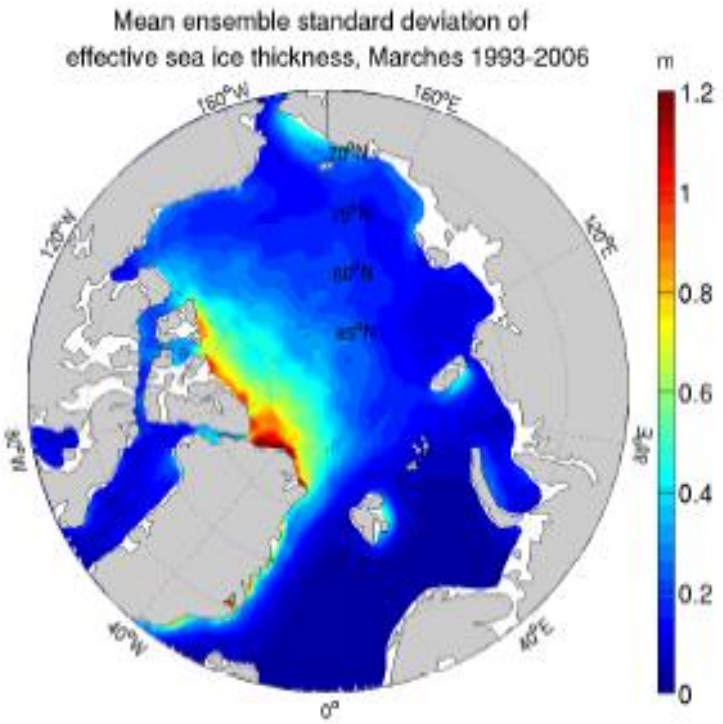
Benefit Areas (cont‘d)



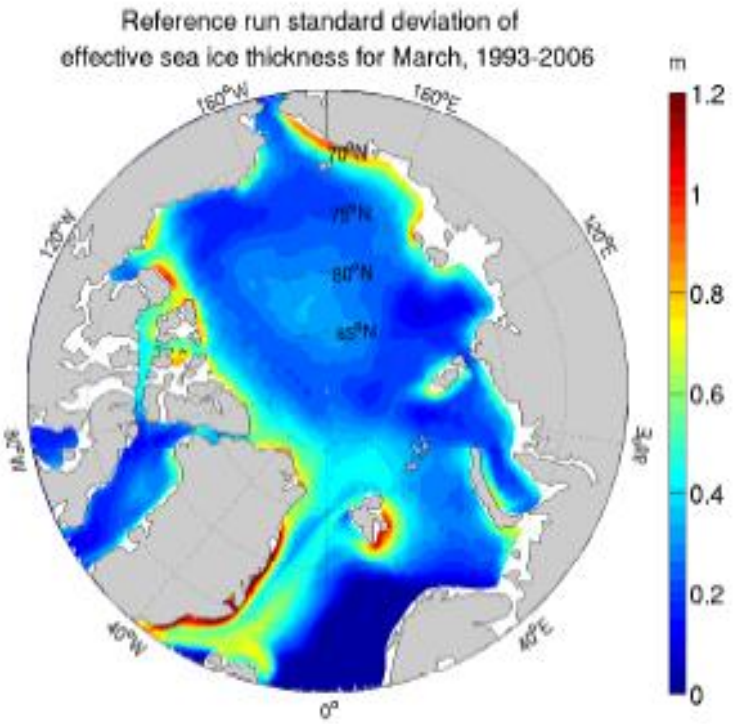
Jung et al. (2010)

Stochastic Sea Ice Parametrizations

Ensemble Spread



Interannual variability



Juricke et al., in preparation

New TIGGE Products (cont'd)

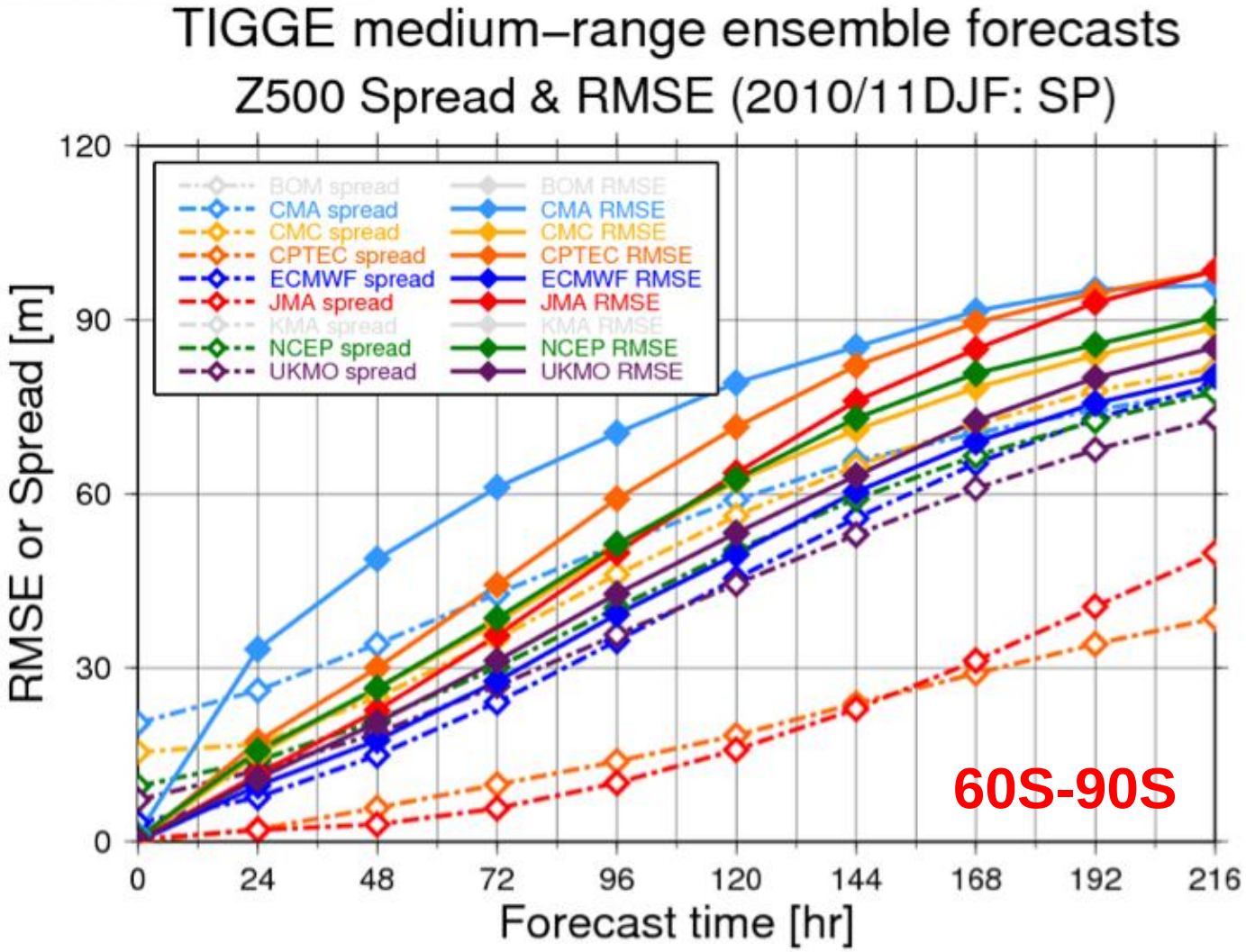
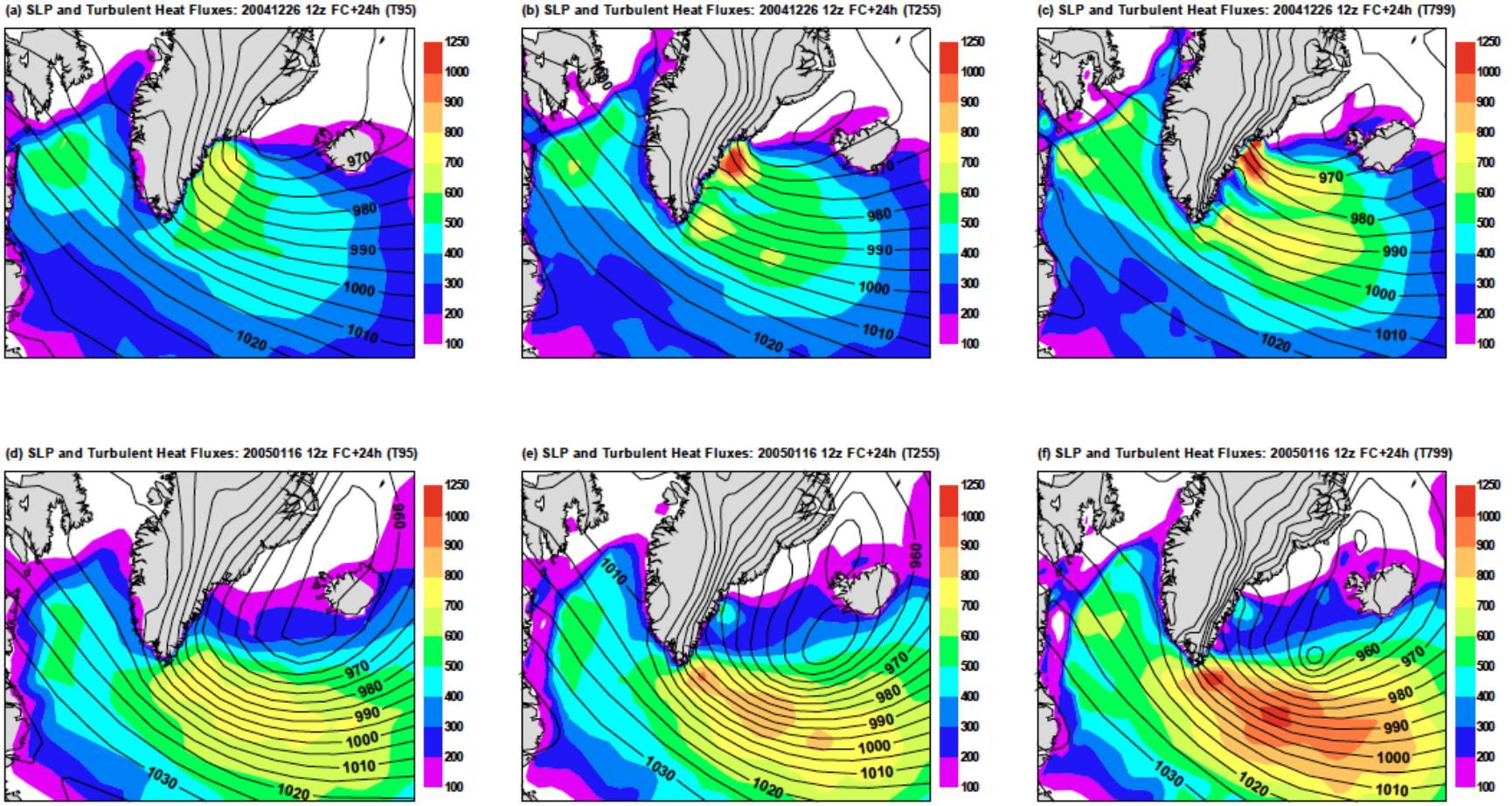


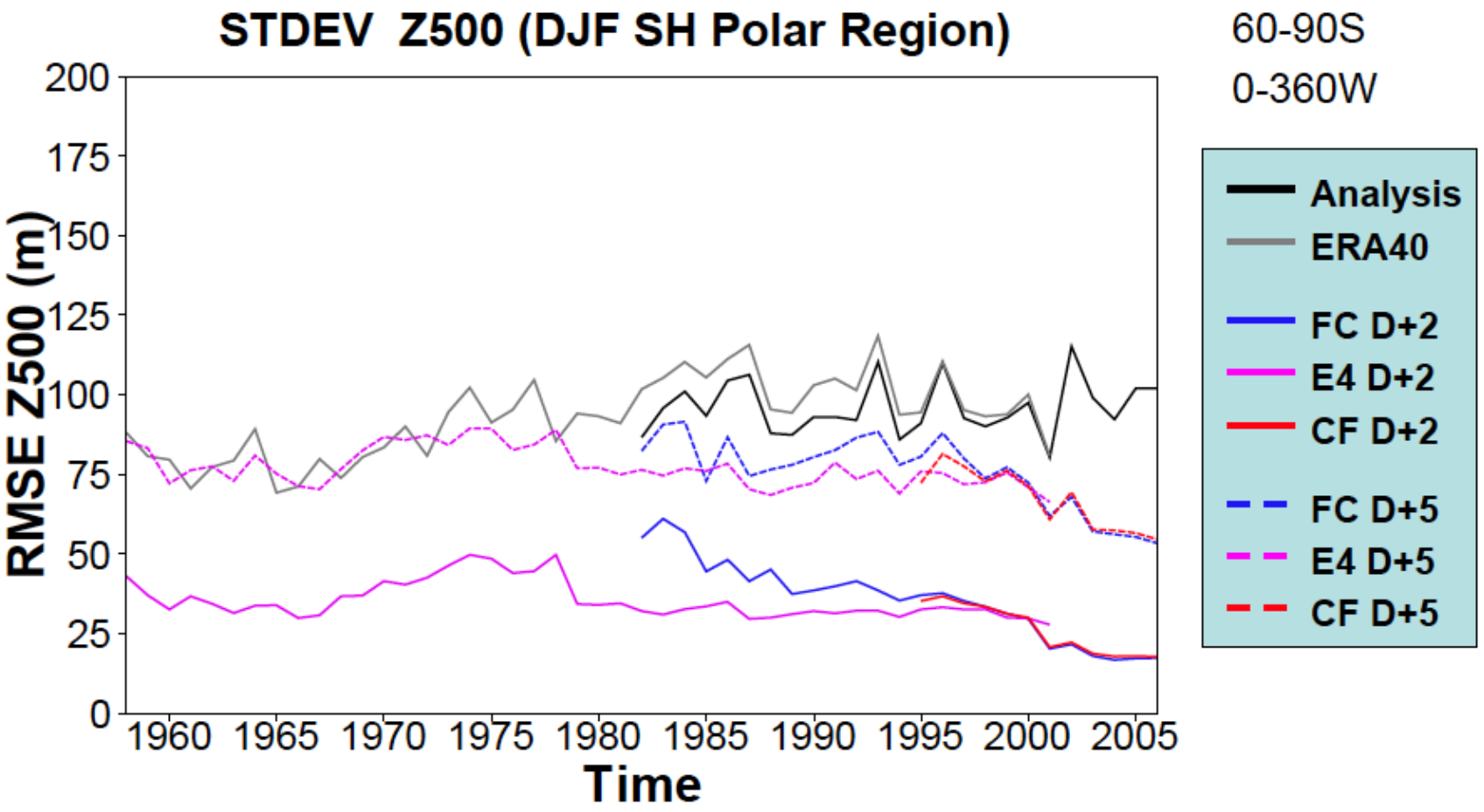
Figure courtesy of Mio Matsueda (Oxford)

Topograhic Jets and Resolution



Jung and Rhines (2007)

Deterministic Skill: Z500 Antarctic



Jung and Leutbecher (2007)

Importance of sea ice forecasts

Scale dependent predictability

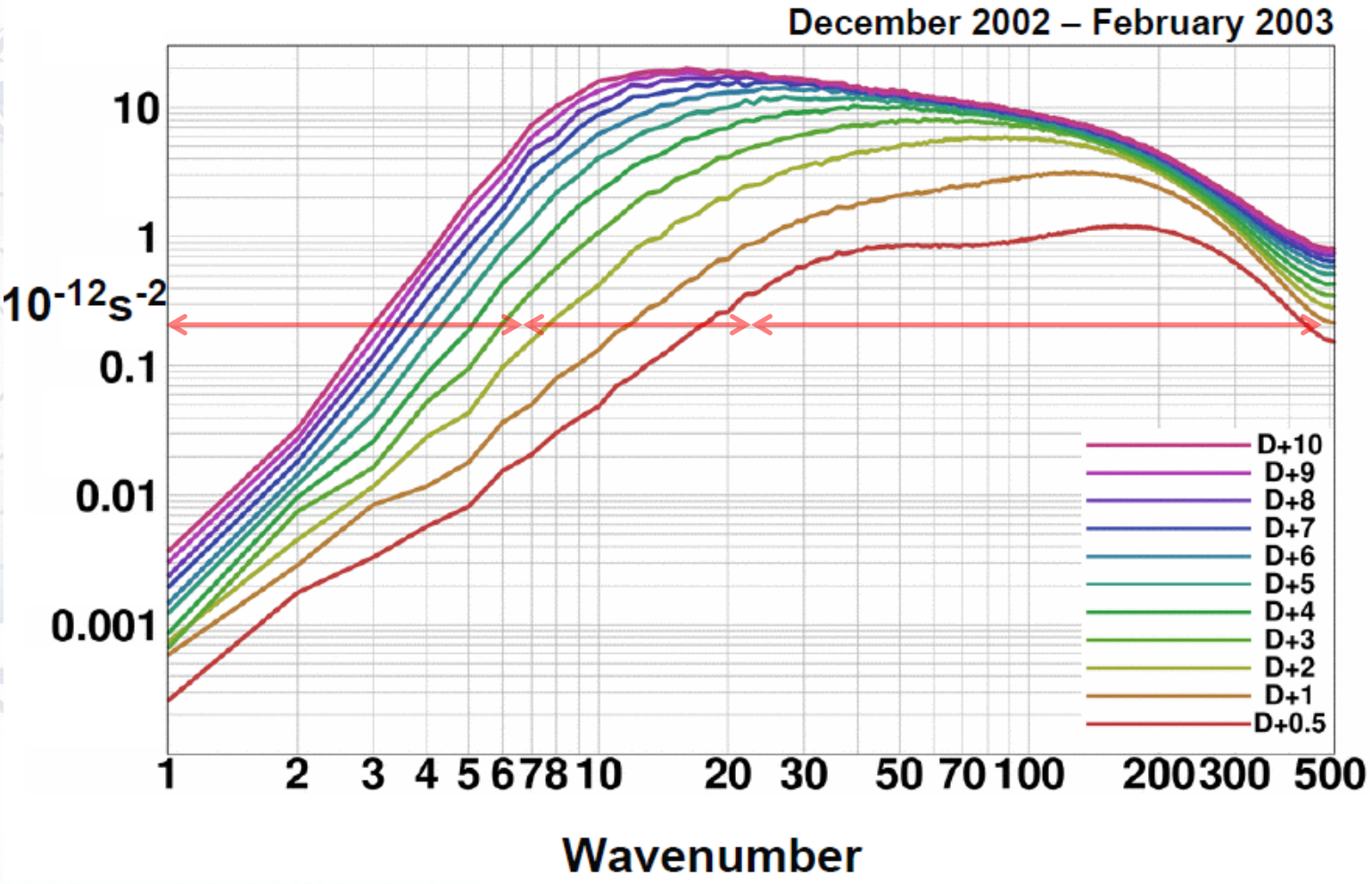
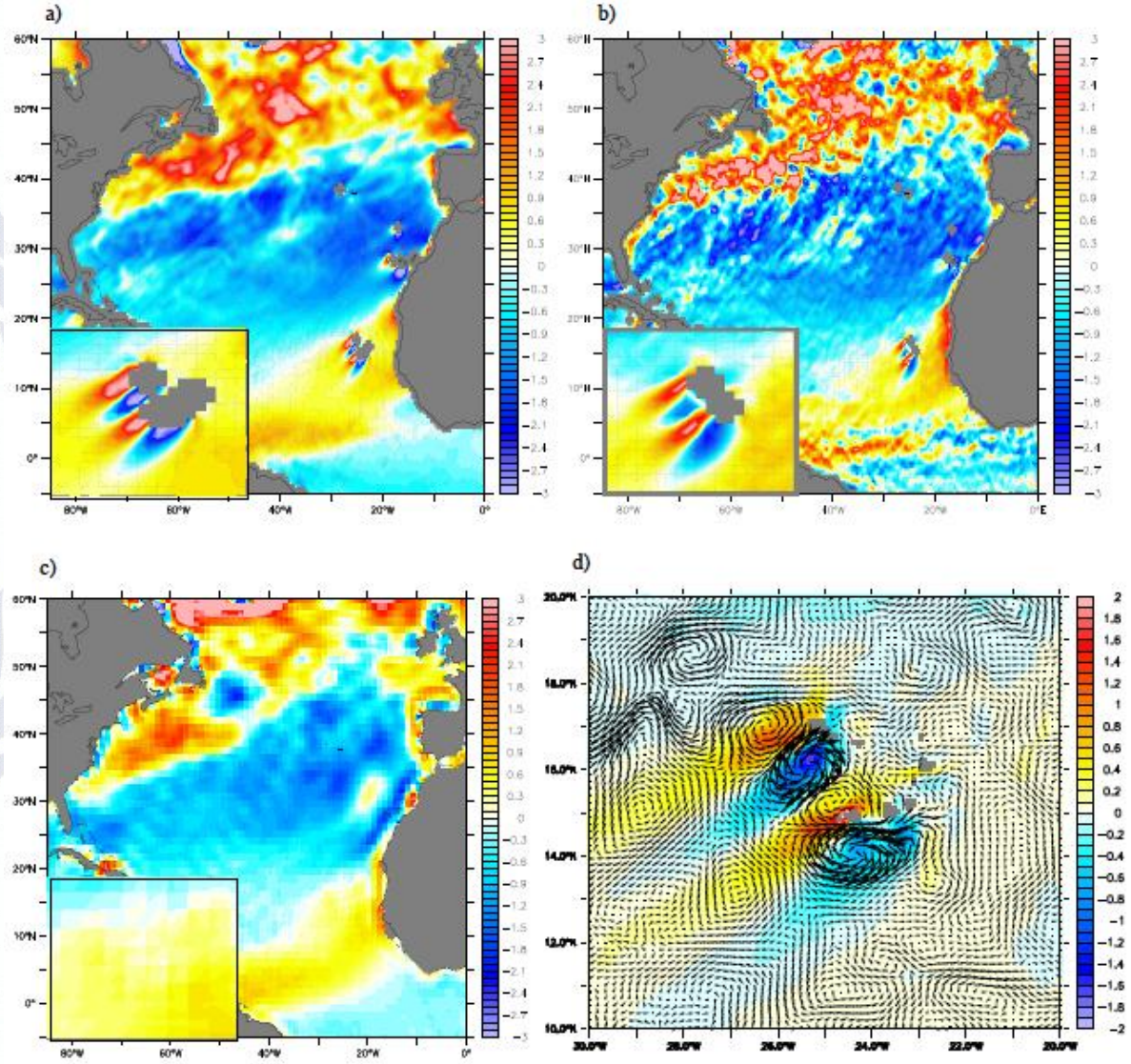


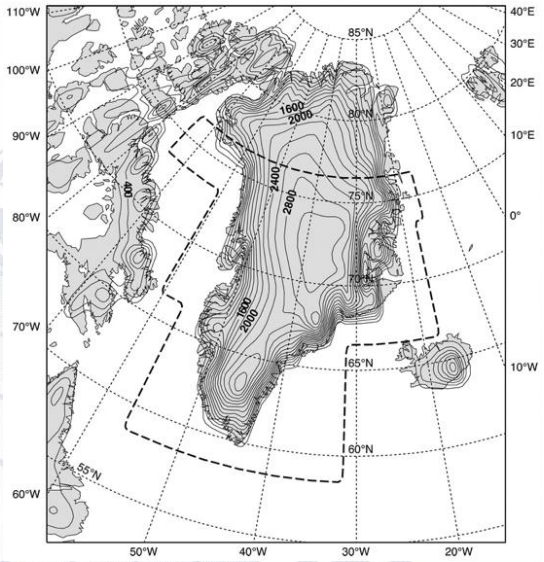
Figure courtesy of A. Simmons (ECMWF)

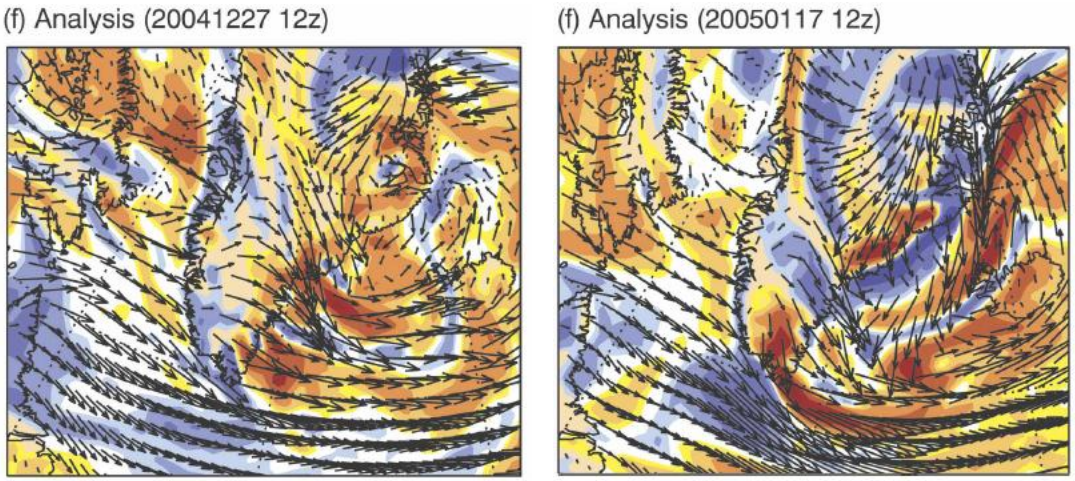
Oceanic response to high-resolution atmospheric forcing

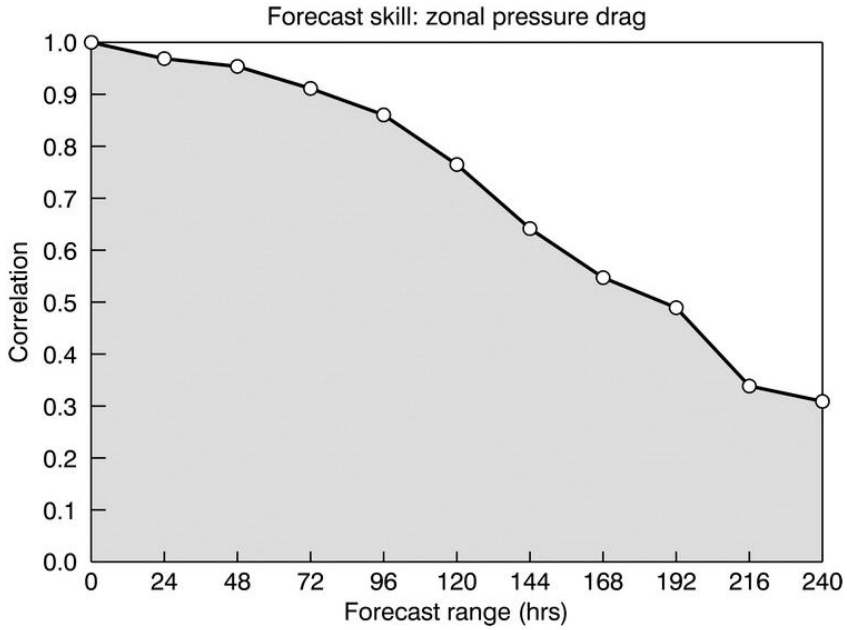


Eden and Jung (2006)

Scale dependent predictability



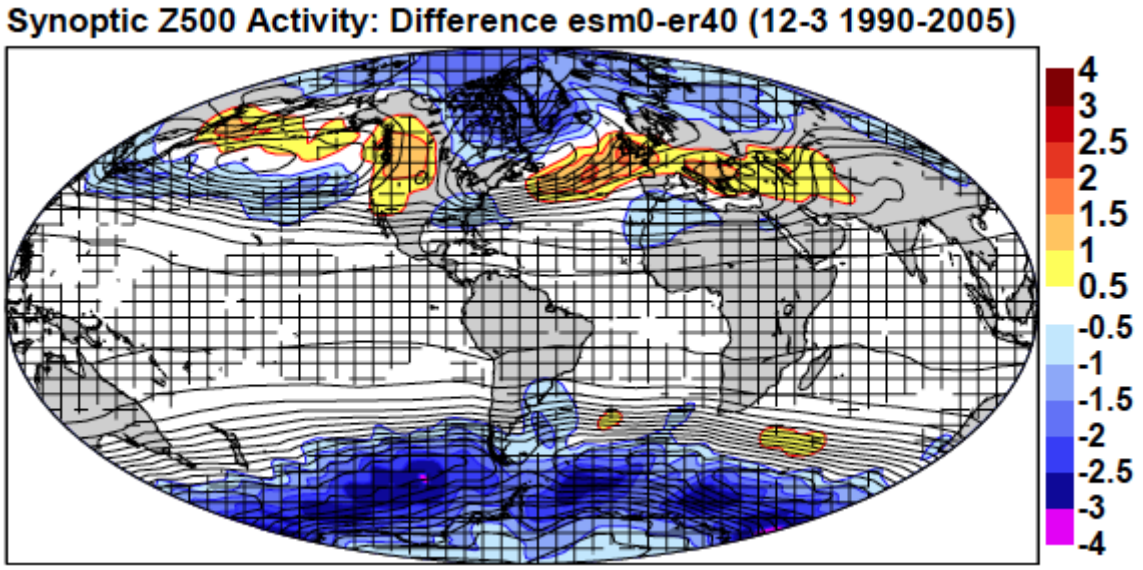




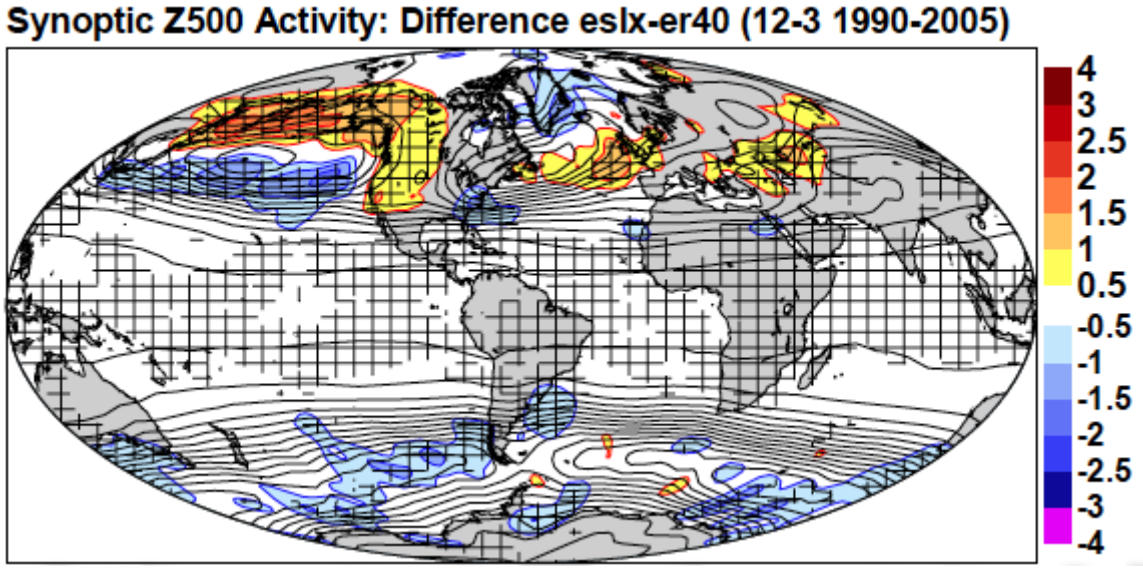
Jung and Rhines (2007)

Synoptic eddy activity and resolution

T95-ERA40

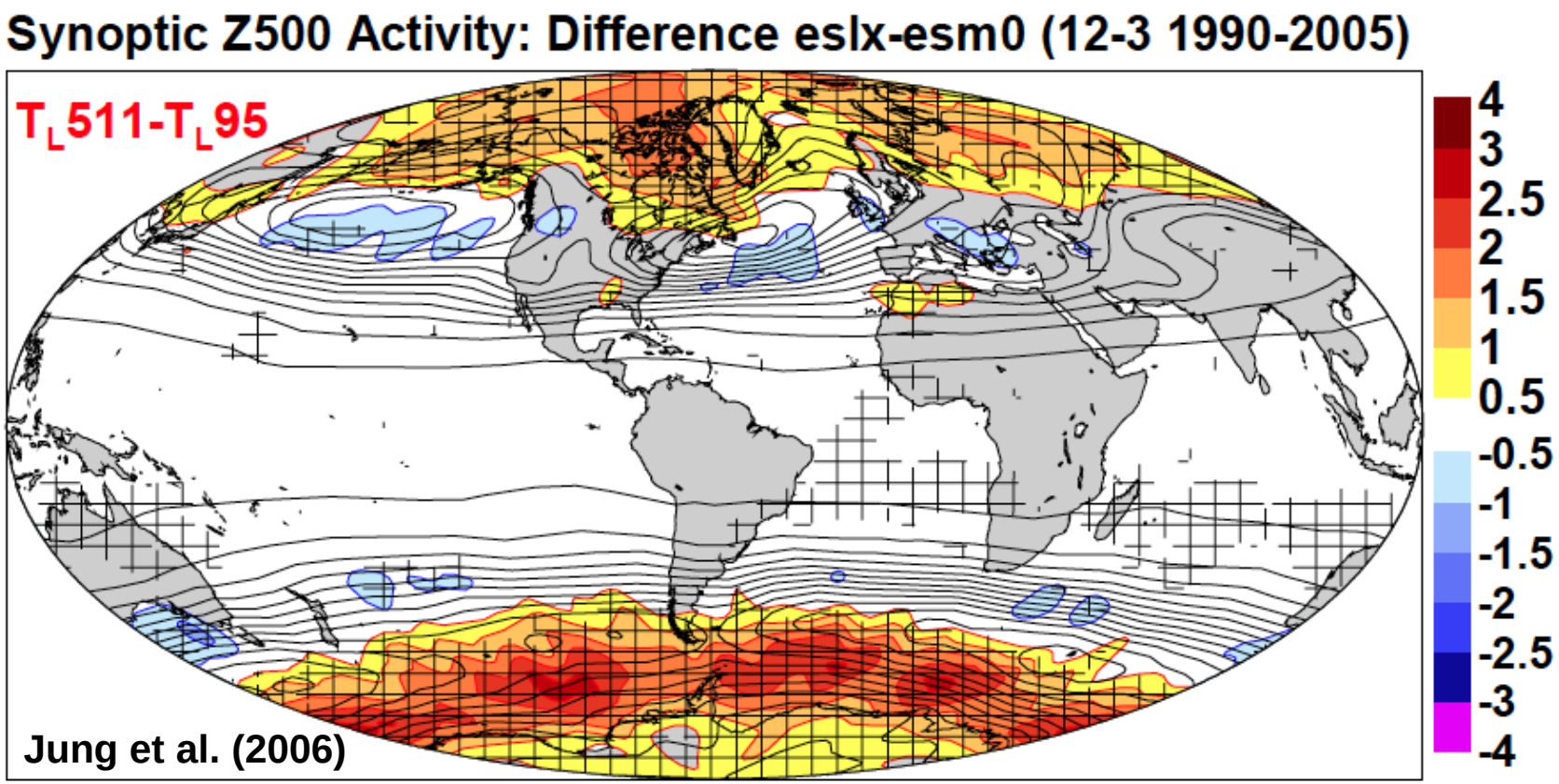


T511-ERA40



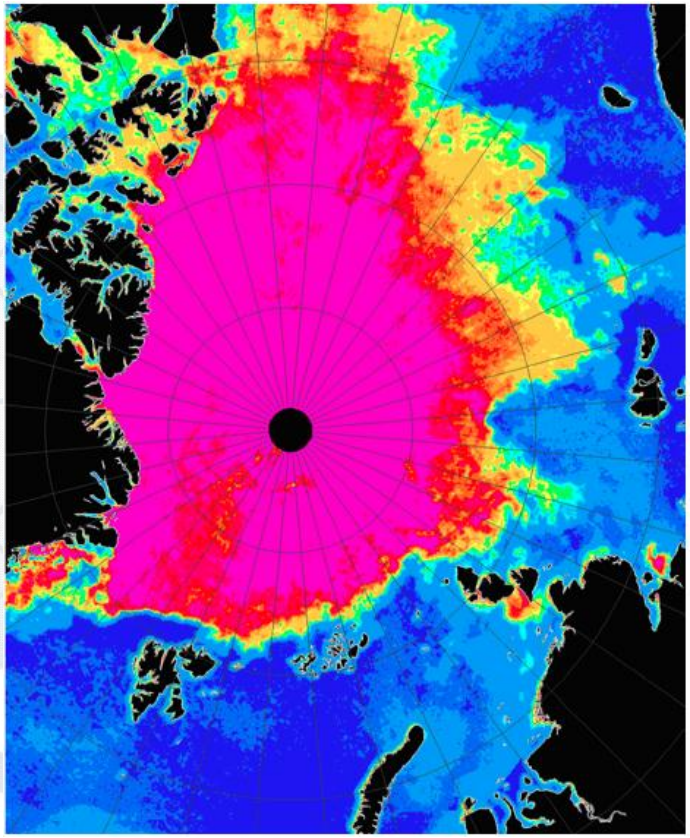
Jung et al. (2006)

Synoptic eddy activity and resolution



Predictability of sea ice anomalies

24. August 2005



23. August 2006

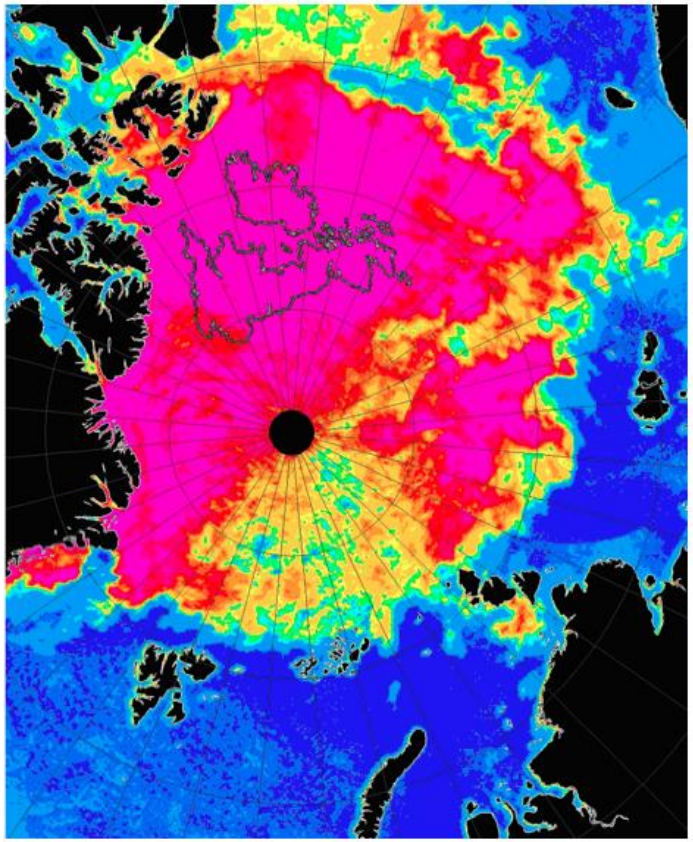


Figure courtesy of Leif Toudal Pedersen

EOS Aqua AMSR-E ice concentration

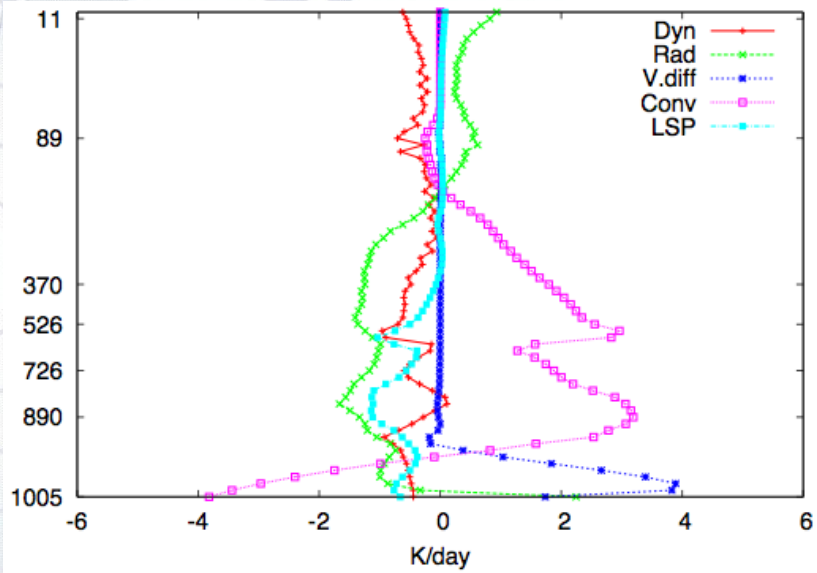
THORPEX

WWRP

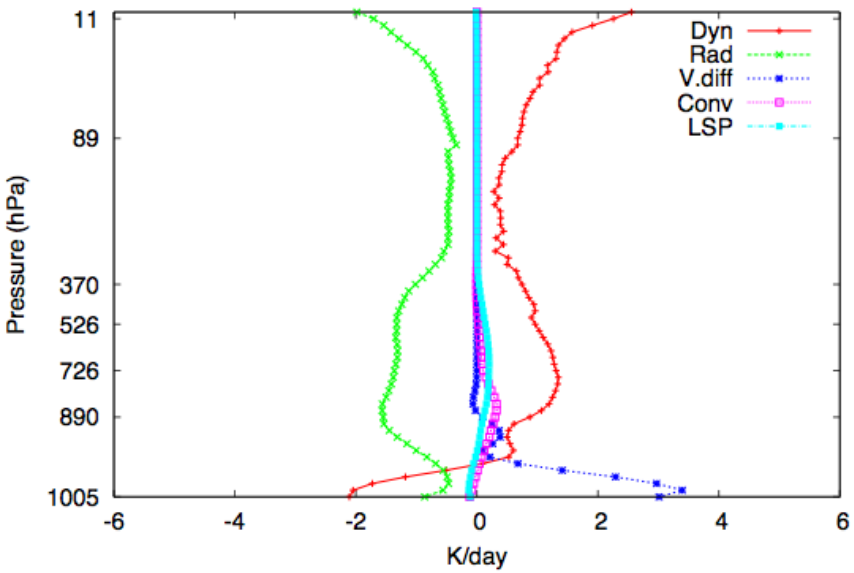
WMO
OMM

Mean temperature tendencies

Tropics: Sea points



Arctic: Sea and sea ice points

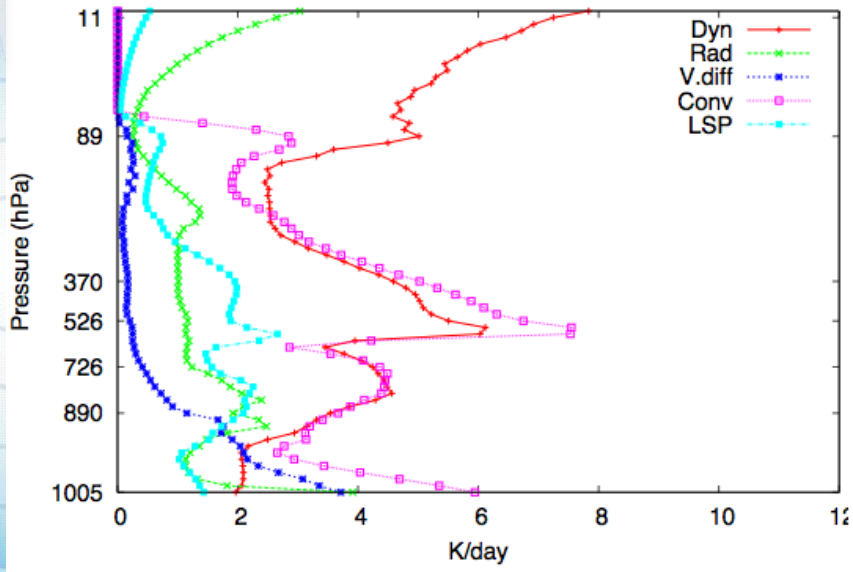


- ECMWF model
- 6-hourly initial tendencies
- 120 forecasts (DJF 1989-2010)

Figure courtesy of S. Serrar (AWI)

Temperature tendencies: Stdev

Tropics: Sea points



Arctic: Sea and sea ice points

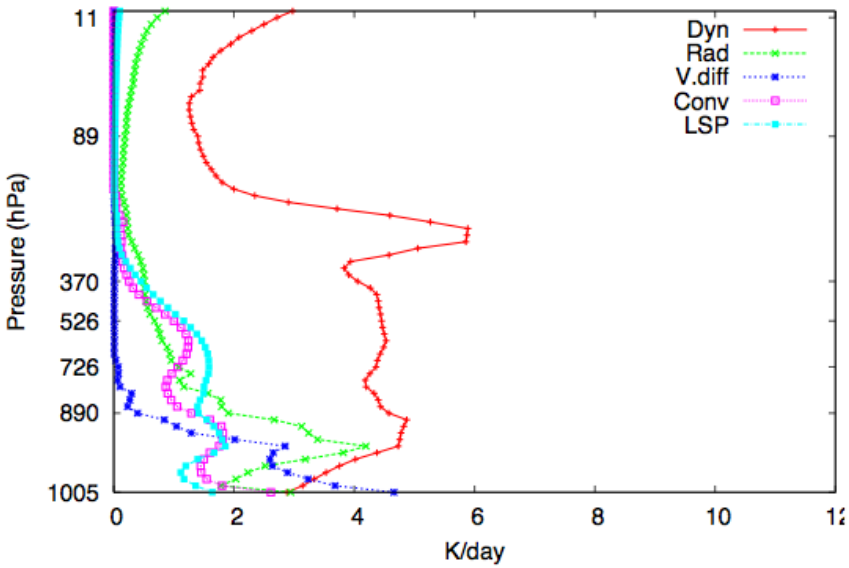
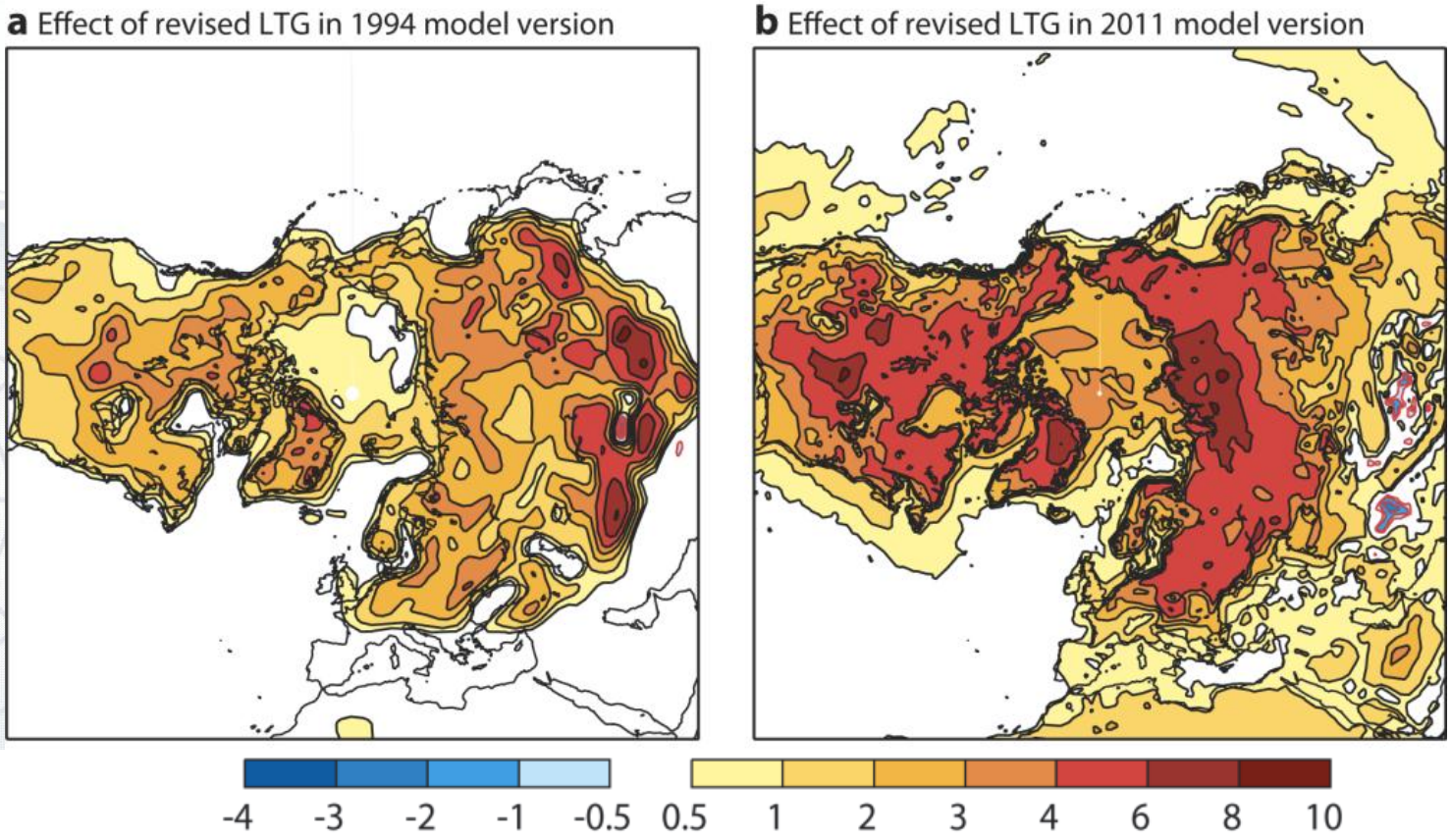


Figure courtesy of S. Serrar (AWI)

Sensitivity to Model Formulation

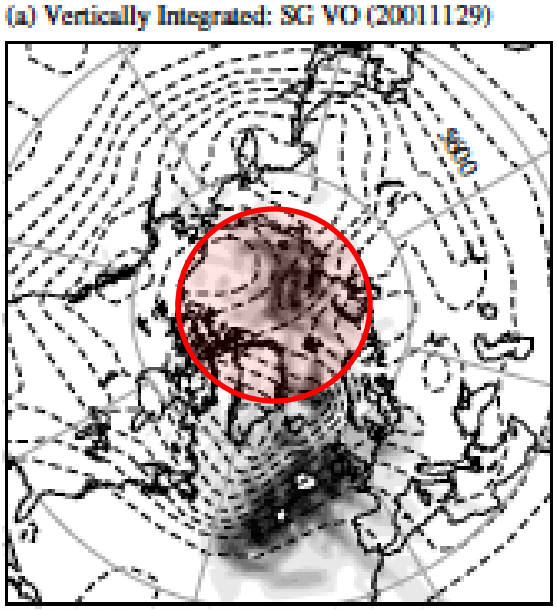


Effect of revised diffusion in PBL scheme on averaged January 1996 temperature. These sensitivity experiments were performed by starting a long integration from 1 October 1995 and applying relaxation to the 6-hourly operational analyses above 500 m from the surface. This is an efficient way of doing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

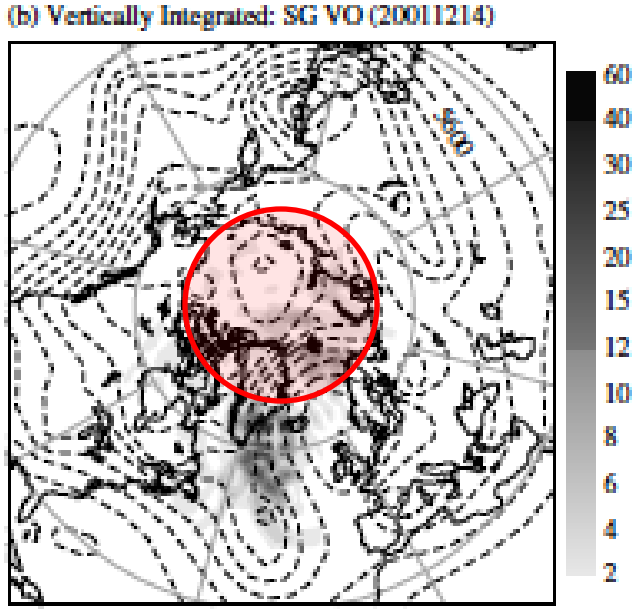
Beljaars (2012)

D+2 Forecast Sensitivity to Initial Perturbations

29 Nov 2011



14 Dec 2011



Jung and Leutbecher (2007)