WWRP/THORPEX Workshop on Polar Prediction, ECMWF, 24-27 June 2013

Forecast Verification in a Polar $\frac{\text{(PPP)}}{\text{(YOPP)}}$ Framework

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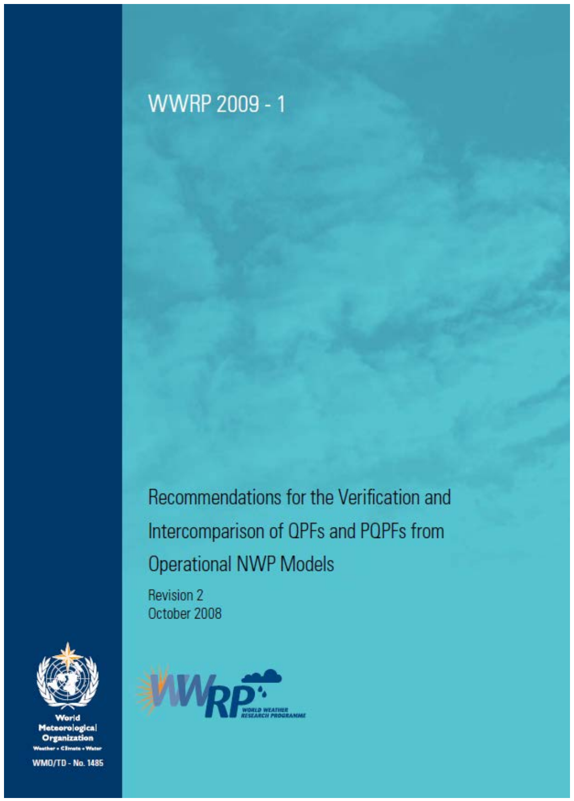
Acknowledgements:
- ✓ *JWGFVR*
- ✓ *ECMWF*
- ✓ *M. Matsueda*

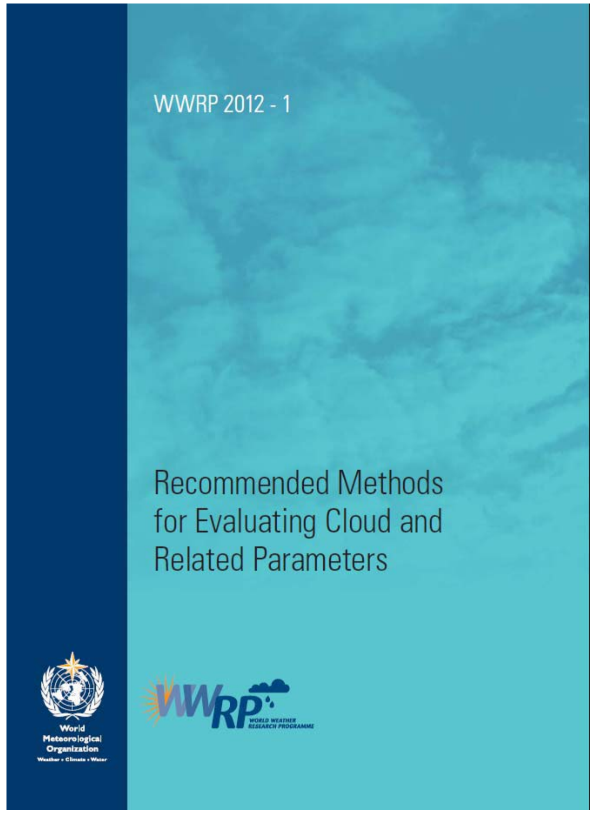
A few words about JWGFVR : Goals & activities

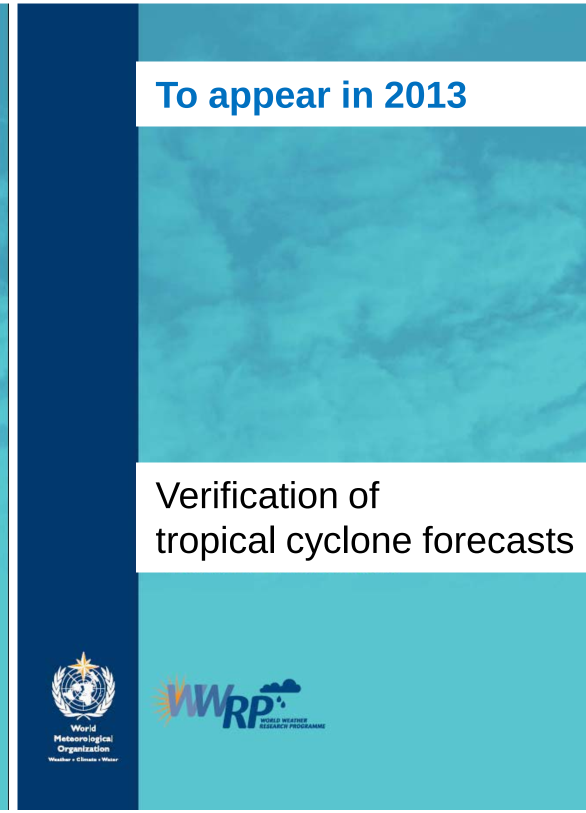
Verification component of WMO WWRP, in collaboration with WGNE, WCRP, CBS

- **Serve as a focal point to develop and promote new verification methods**
- **Promote importance of verification (as vital part of experiments)**
- **Promote collaboration among verification scientists, model developers, forecast providers AND end-users** (customers)
- **Emphasize user-aspects of forecast verification ⇔ Impacts**
- **Provide training on verification methodologies**
  - ✓ ***3 extensive tutorials organized so far ; Next in spring 2014*** ***?***
- **Does** NOT **provide “verification services” per se …**

References ...







8 papers by JWGFVR members in Special Issue (June 2013) of *Met. Apps.*

- incl. a *"lead paper"* Progress and challenges in forecast verification

Our popular website : www.cawcr.gov.au/projects/verification

References : Only few addressing Polar Verification per se

✓ ***Based on survey to find relevant papers covering past c. 10 years :***

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Ref. Implementation Plan

Service-oriented Research

Societal and Economic Research Applications (SERA)	Verification

Modeling perspective ⇔ User perspective !

Underpinning Research

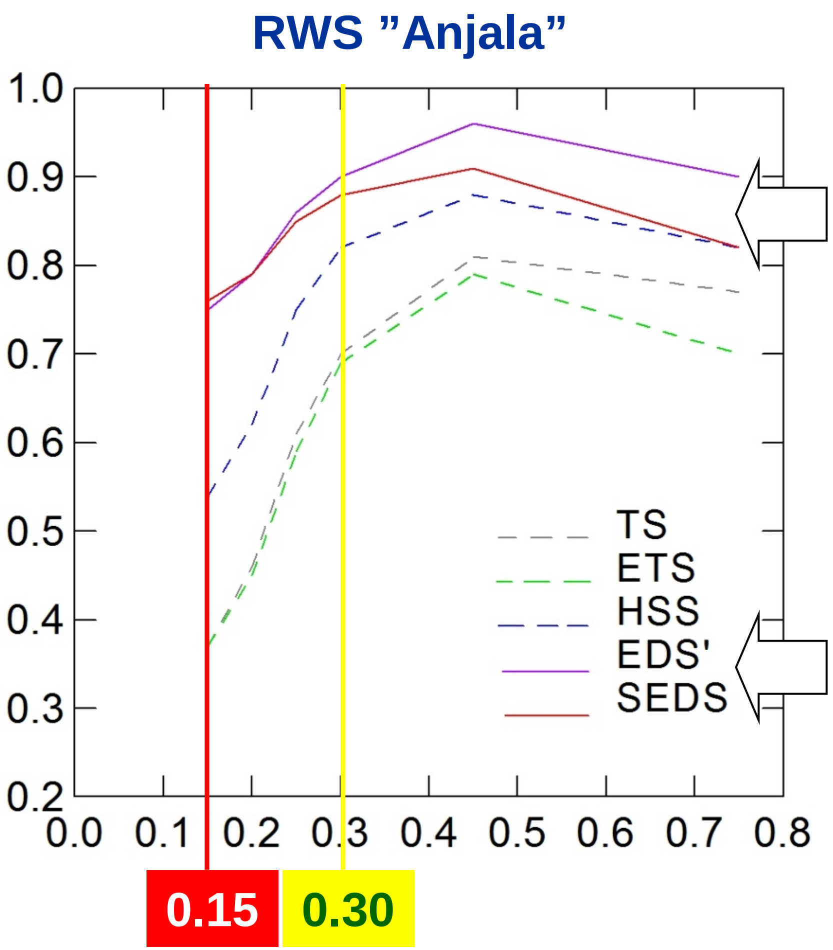
Predictability and Diagnostics	**Teleconnections**

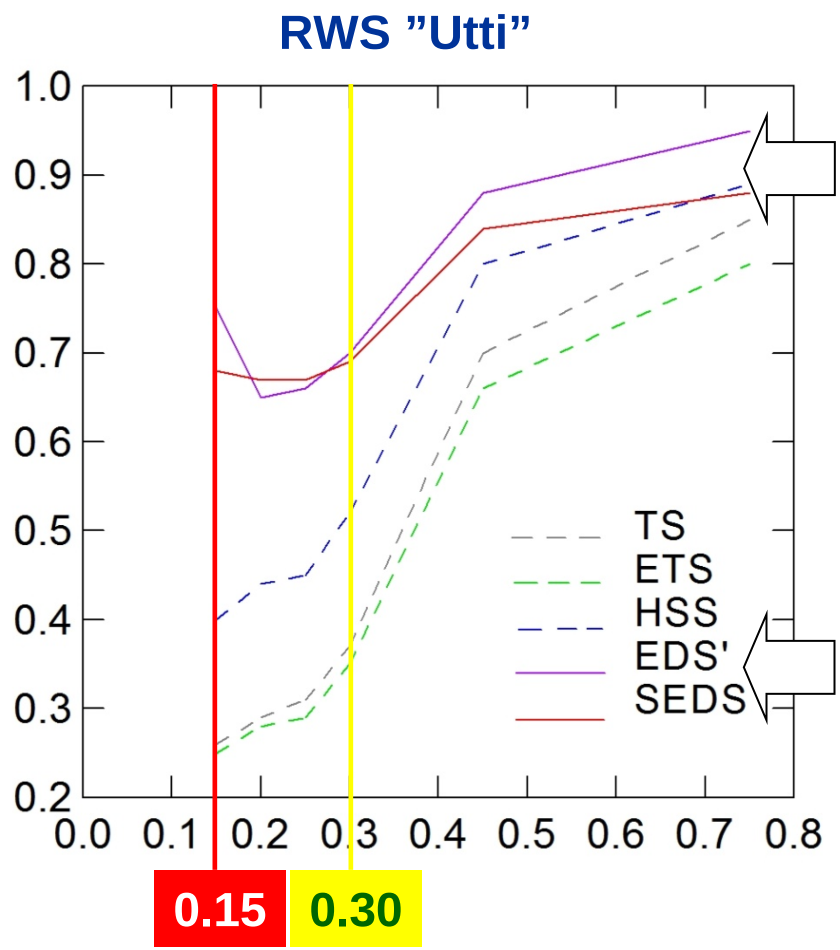
Forecasting System Research

Observations **Data Assimilation**	**Modelling** **Ensemble Forecasting**

User perspective !

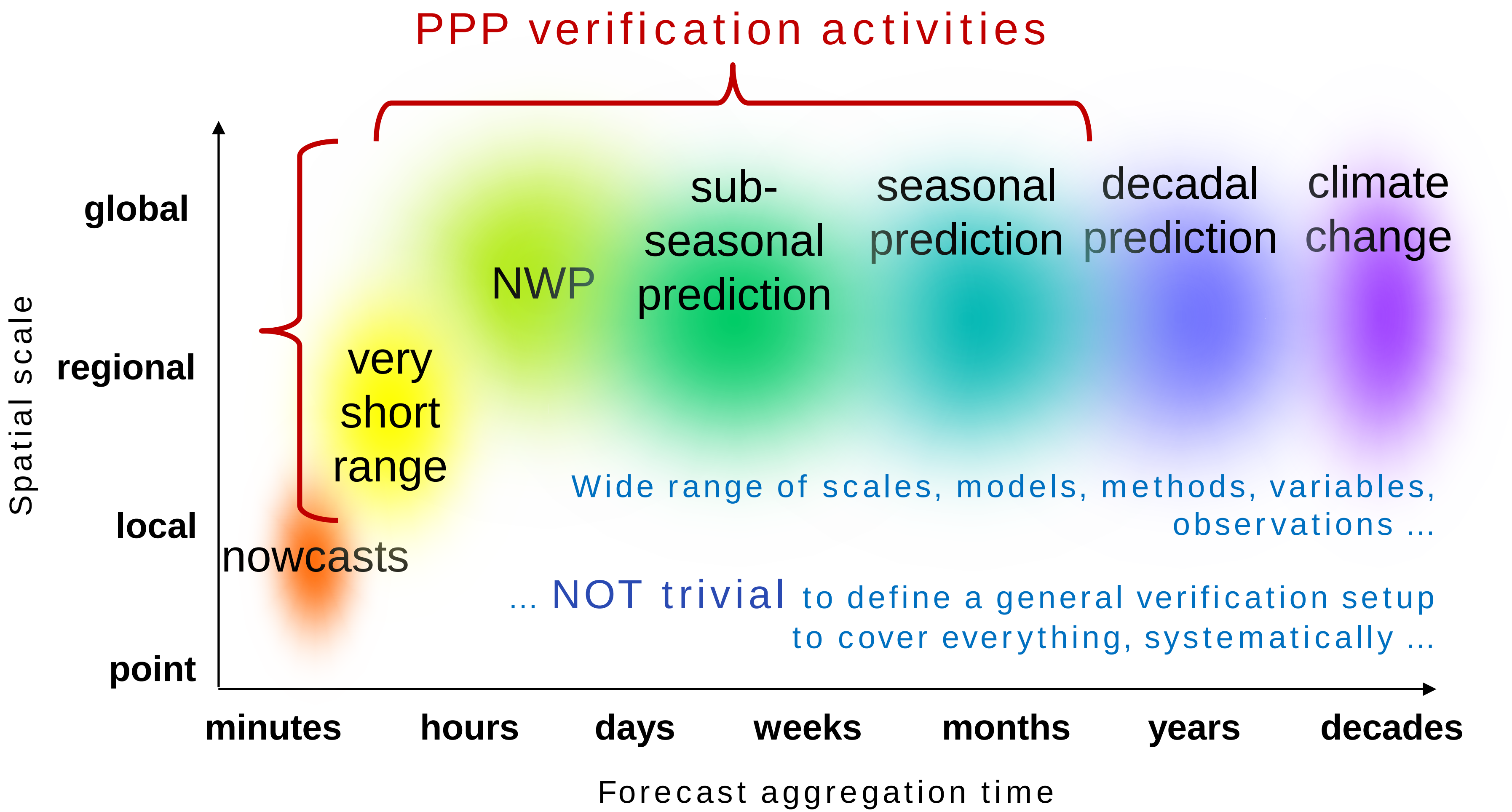
Road surface friction forecast verification on northern roads





Seamless verification ⇔ Seamless forecasting

New Issue : *"Seamless"* or *consistent* verification across all scales ⇔ applying same verification measures to all forecasts, to allow comparison



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A. Observations

- ✓ Identification, definition & establishment of optimal, high-resolution observing networks
- ✓ Utilization of in-situ & remote sensing observations
- ✓ *“Invention”* of new, mobile (?) observing means; cf. road transport
- ✓ Issues with complex terrain + surface properties

B. Raise awareness of the necessity for comprehensive verification

C. Verification methods and metrics

- ✓ Dedicated metrics for dedicated, high-impact polar phenomena
  - *Low cloud, fog, visibility, blizzards, wind, temperature extremes*
- ✓ Verification methods R&D
  - *Exploration of existing vs. new, upcoming verification metrics*
- ✓ Definition and adoption of “seamless verification” to cope with seamless forecasting
- ✓ Address both deterministic and probabilistic forecasts (obviously)

... PPP Goals and Activities : i

Q1: 2013-15 Q3: 2017-19
Q2: 2015-17 Q4: 2019-21

GA 1. Review & examine present verification state-of-the-art — Q1

- ✓ Literature review
- ✓ Applicability to polar specific phenomena and applications
- ✓ All forecast variables and types & all forecast scales : hourly-to-seasonal
- ✓ Seamless applicability, multi-dimensionality

GA 2. Distinguish key user-relevant, high-impact weather elements **(not forgetting sea ice)** — Q1

- ✓ Low cloud, fog, visibility, blizzards, wind, temperature extremes
- ✓ Definition of variables and their temporal and spatial scales, followed by verification specifications for each

GA 3. Try to devise and apply polar-tailored – ***potentially new*** - verification techniques — Q1-3

- ✓ **User-relevance ⇔ Impacts**

Loosely following Implementation Plan

Preparation Phase 2012-2016 | **YOPP 2017-2018** | Consolidation Phase 2018-2022

Q1: 2013-15 Q3: 2017-19
Q2: 2015-17 Q4: 2019-21

GA 4. Carry out polar vs. mid-latitude verification comparison Q1

- ✓ Verification of existing forecasting systems ⇔ Comparison of past and present forecast performance and progress
- ✓ Compare polar vs. non-polar (mid-latitude) forecast performance
- ✓ Systematic comparison between different Forecast Centres
- ✓ Investigation of polar lows
  - Possibly utilize methodology like for tropical cyclones

GA 5. Is there potential / interest to develop ***spatial*** verification techniques for polar areas ? Q1-3

- ✓ Feasibility with lack of data ? Only polar orbiter data available ? Only for cloud verification ? Can we distinguish cloud from ice ? …
- ✓ Needs motivation and commitment ⇔ Potential collaboration with spatial forecast verification methods inter-comparison initiatives and programs

Loosely following Implementation Plan

... PPP Goals and Activities : iii

Q1: 2013-15 Q3: 2017-19
Q2: 2015-17 Q4: 2019-21

GA 6. Define and adopt ***"headline"*** performance measures

Q1-4

- ✓ To monitor polar fc performance throughout the 10-year project lifetime
- ✓ Comparison between different forecasting systems and Centres

GA 7. Devise and perform *user-oriented* verification

Q1-4

- ✓ Distinguish specific (end-) users and their requirements
- ✓ Define & apply *"simplified"* verification metrics addressing end-users
- ✓ Provide guidance to Weather Services to adopt and apply meaningful user-oriented verification measures
- ✓ Forecast value (c/b; C/L) issues addressing impacts ⇔ SERA

GA 8. Analyze present and explore new observation means ⇔ YOPP observation & verification strategy

Q1-3

- ✓ E.g. mobile observation platforms; utilization of non-conventional data; new telecommunication techniques facilitating rapid applicability
- ✓ Observation uncertainties

Loosely following Implementation Plan

Preparation Phase 2012-2016 | YOPP 2017-2018 | Consolidation Phase 2018-2022

... PPP Goals and Activities : iv

Q1: 2013-15 Q3: 2017-19
Q2: 2015-17 Q4: 2019-21

GA 9. YOPP - Polar test bed(s) — Q2-3

- ✓ Enhanced verification utilizing comprehensive "Verification Toolboxes"
- ✓ Potentially build up a Real-Time Forecast Verification System (RTFVS)
- ✓ YOPP impact studies and post-YOPP consolidation

GA 10. Identify data needs, organize data collection, storage and access ⬄ YOPP data centre (ref. TIGGE) — Q1-4

- ✓ Common data formats & platforms to ease access and encourage use

GA 11. Set up & launch a centralized verification effort — Q3-4

- ✓ Many Centres, possibly, apply own differing non-uniform metrics
- ✓ Seek for potentially interested host Meteorological Service(s)

GA 12. Set up a dedicated verification expert team — Q1-4

- ✓ PPP expert team members enforced by verification "enthusiasts"
- ✓ Lead Centres of verification; WMO meso-scale working group etc…

Loosely following Implementation Plan

Preparation Phase 2012-2016 → YOPP 2017-2018 → Consolidation Phase 2018-2022

Desirable specific <u>properties</u> for a verification measure :

- ✓ **Dependency on the verification, or analysis, grid should be minimised**
- ✓ **Dependency on spatial and temporal scales and sampling of observation data should be minimised**
- ✓ **Behaviour should not depend on the base value, i.e.**
  on the magnitude of verified quantity
- ✓ **Behaviour should not depend on the base rate, i.e.** *climatology*
- ✓ **Should remain useful for rare events:**
  Most conventional measures become unusable beyond c. 90 percentile
- ✓ **Should converge quickly for relatively small samples**
- ✓ **Should be accompanied by estimates of uncertainty - error bars**
- ✓ **Should take both hits and false alarms into account, for categorical fcs**
- ✓ **Should be** *"proper"*, *"equitable"* **and not reward** *"hedging"*

⇨ No currently available metrics satisfy all these !!!

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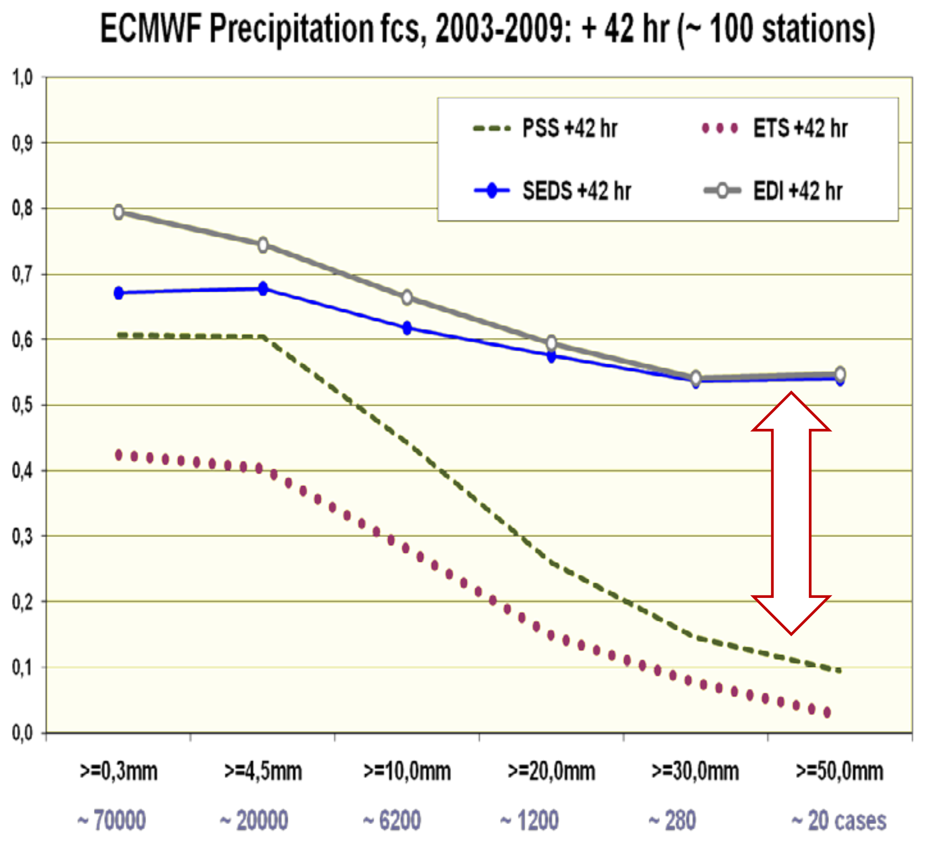
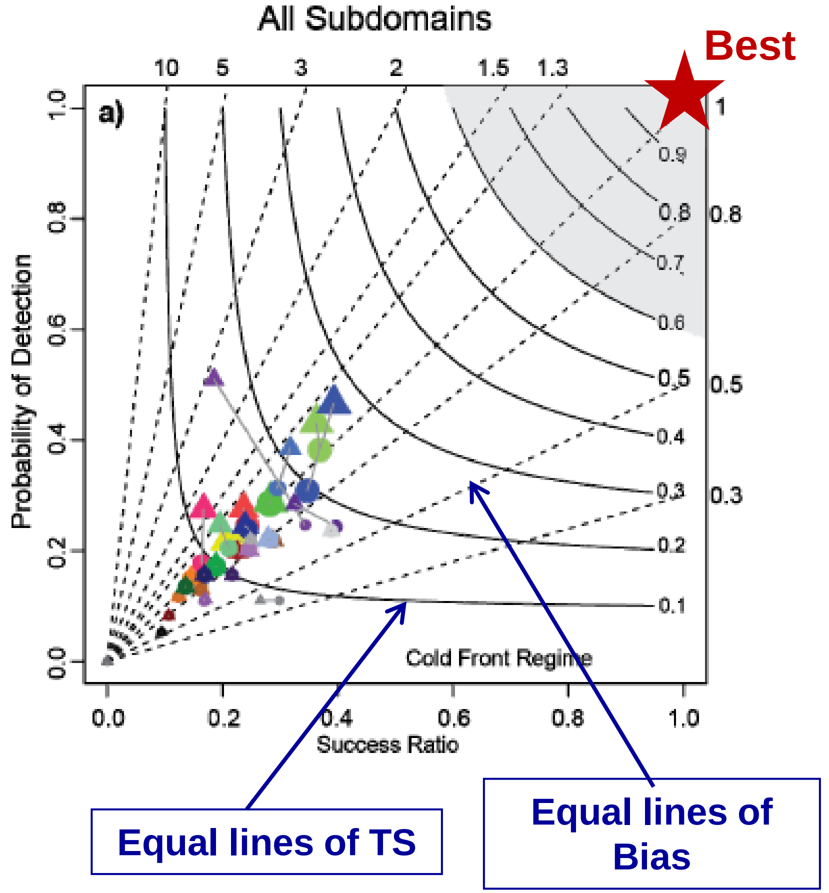
Examples of some relatively new verification metrics / methods

"Traditional" scores tend to zero with the rarity of the event, i.e. are highly dependent on base rate (i.e. local climatology) !



Looking at multiple scores at one time
Only need to plot POD and 1-FAR (Success Ratio)



(From Roberts et al. 2011; after Roebber 2009 and C. Wilson 2008)

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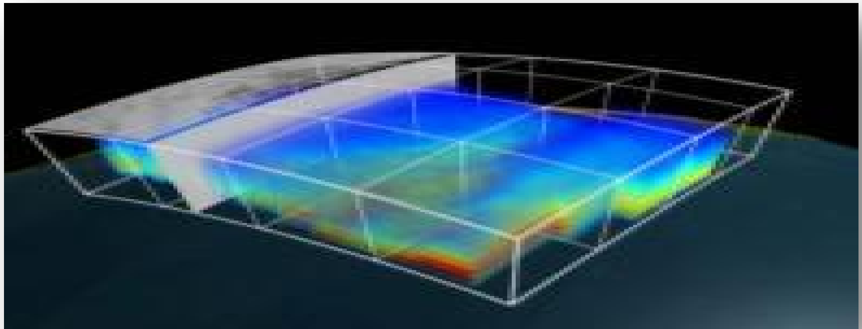
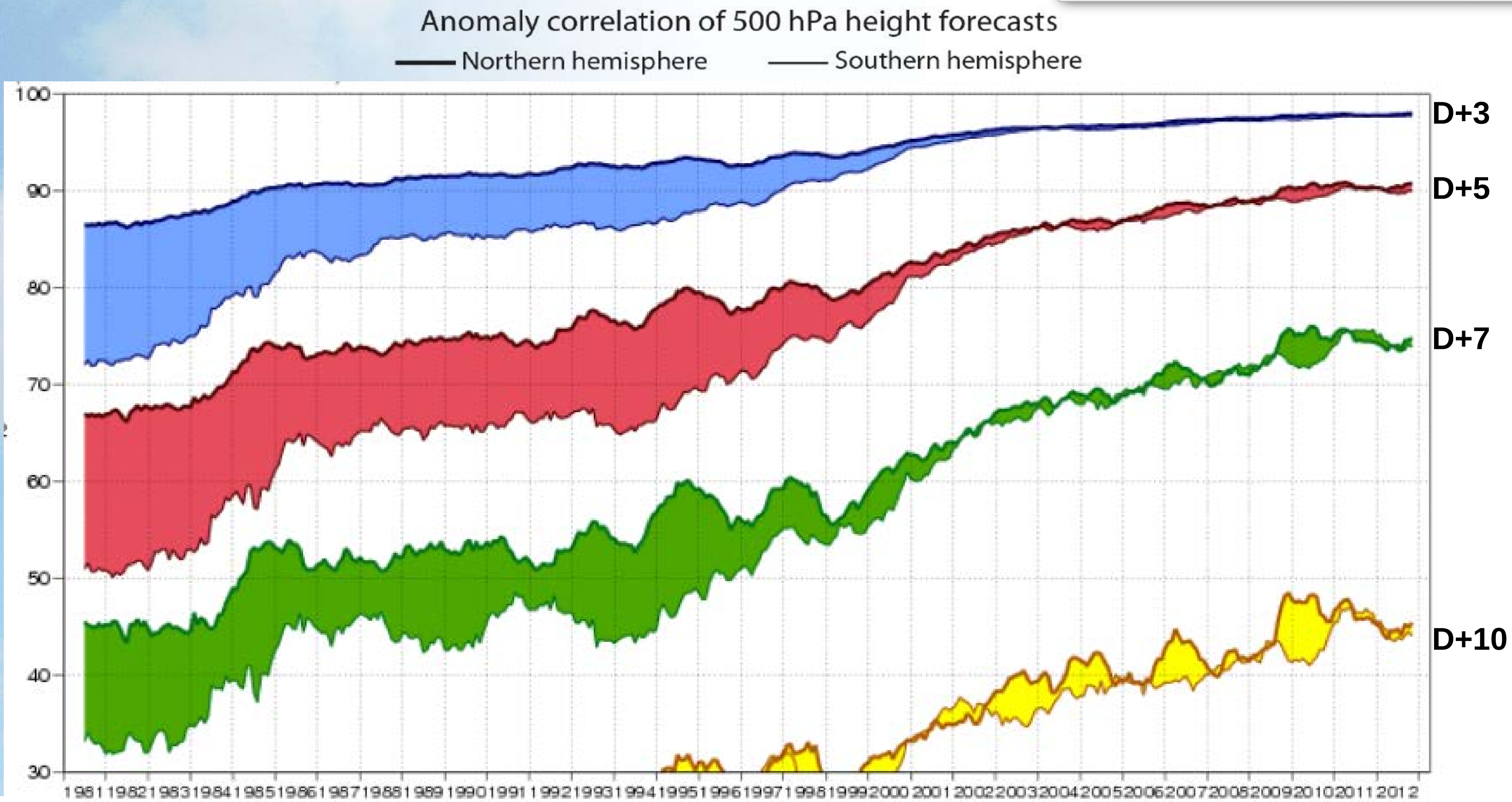
Spatial verification

- Lots of activity during past – **and probably during coming several years**
- Designed to diagnose spatial structures like precipitation areas, fronts …
  ⇔ Cover different scales
- Provide information on error in physical terms
- Account for uncertainties in location and timing
- Typically utilize remote sensing satellite and/or radar data
- **Would require a high density observation network !**
- Neighborhood methods, Fractions Skill Score, Feature-based methods, CRA, SAL, MODE, etc…
- Starting to penetrate to ensemble forecast verification



Evolution of ECMWF scores comparison northern and southern hemispheres

... but how about polar prediction forecast quality?



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GA-4, GA-11

Welcome to the TIGGE museum!

http://tparc.mri-jma.go.jp/TIGGE/index.html © Dr. Mio Matsueda

Daily scores for TIGGE

running mean:
- 365-day
- 91-day
- 31-day

Areas:
- Hemispheres
- Polar regions
- Midlatitudes

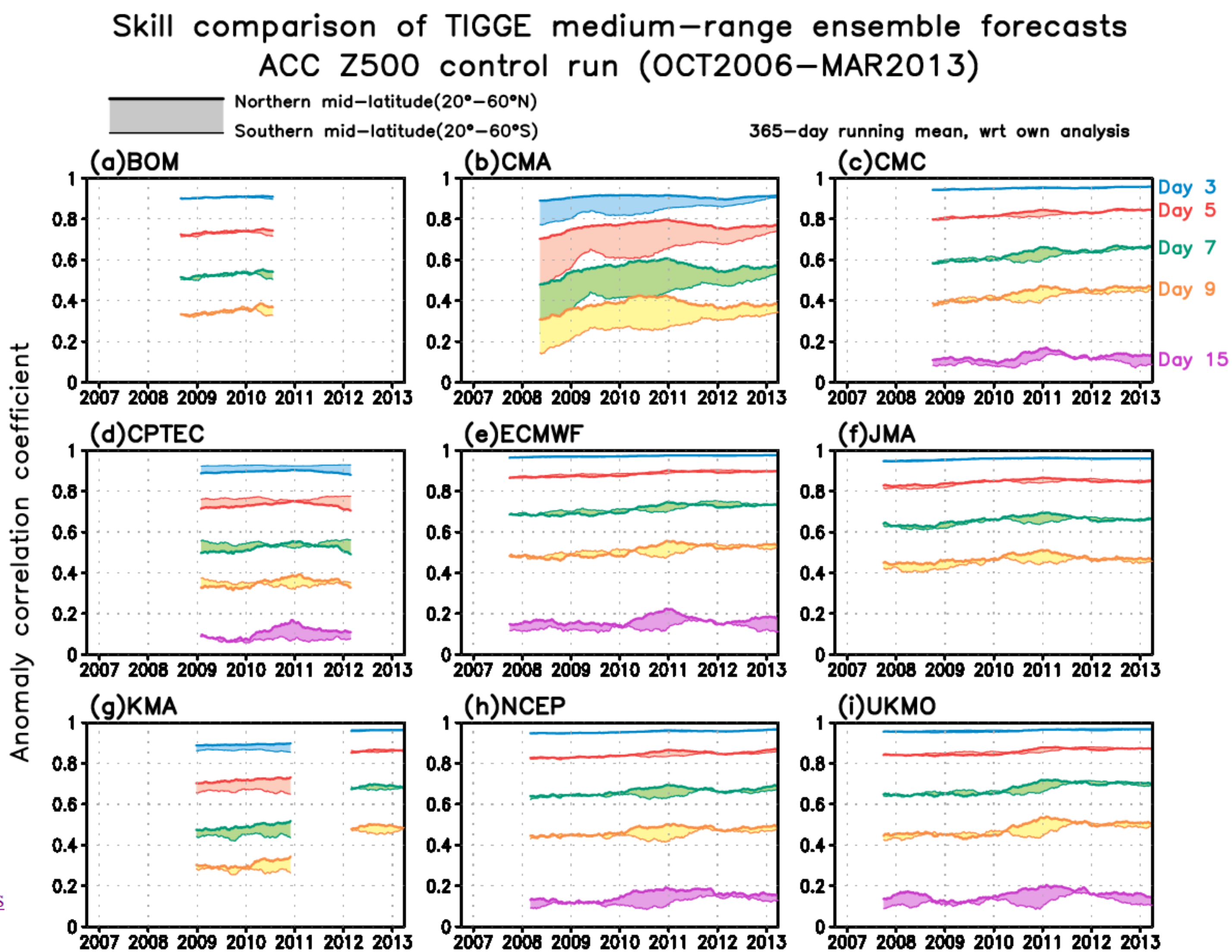
Scores:
wrt own analysis:
- ACC (control run)
- ACC (ensemble mean)
- RMSE (control run)
- RMSE (ensemble mean)

wrt ERA-Interim:
- ACC (control run)
- ACC (ensemble mean)
- RMSE (control run)
- RMSE (ensemble mean)
- RPSS

Variables:
- Z500
- T850
- T2m
- U850
- V850
- U200
- V200

Go to scores for NCEP GEFS

Go to the main page



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GA-4, GA-11

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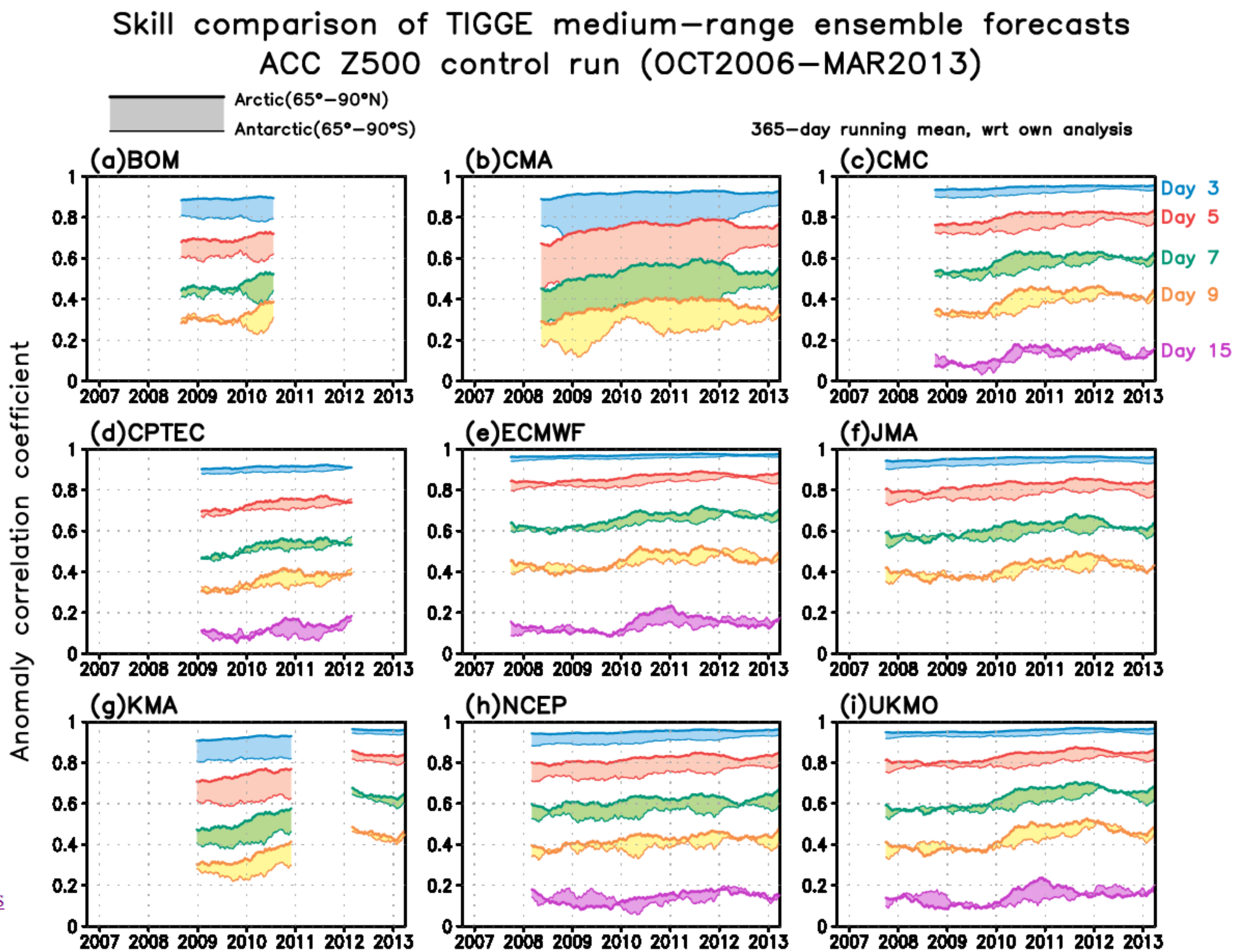

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Welcome to the TIGGE museum!

GA-4, GA-11

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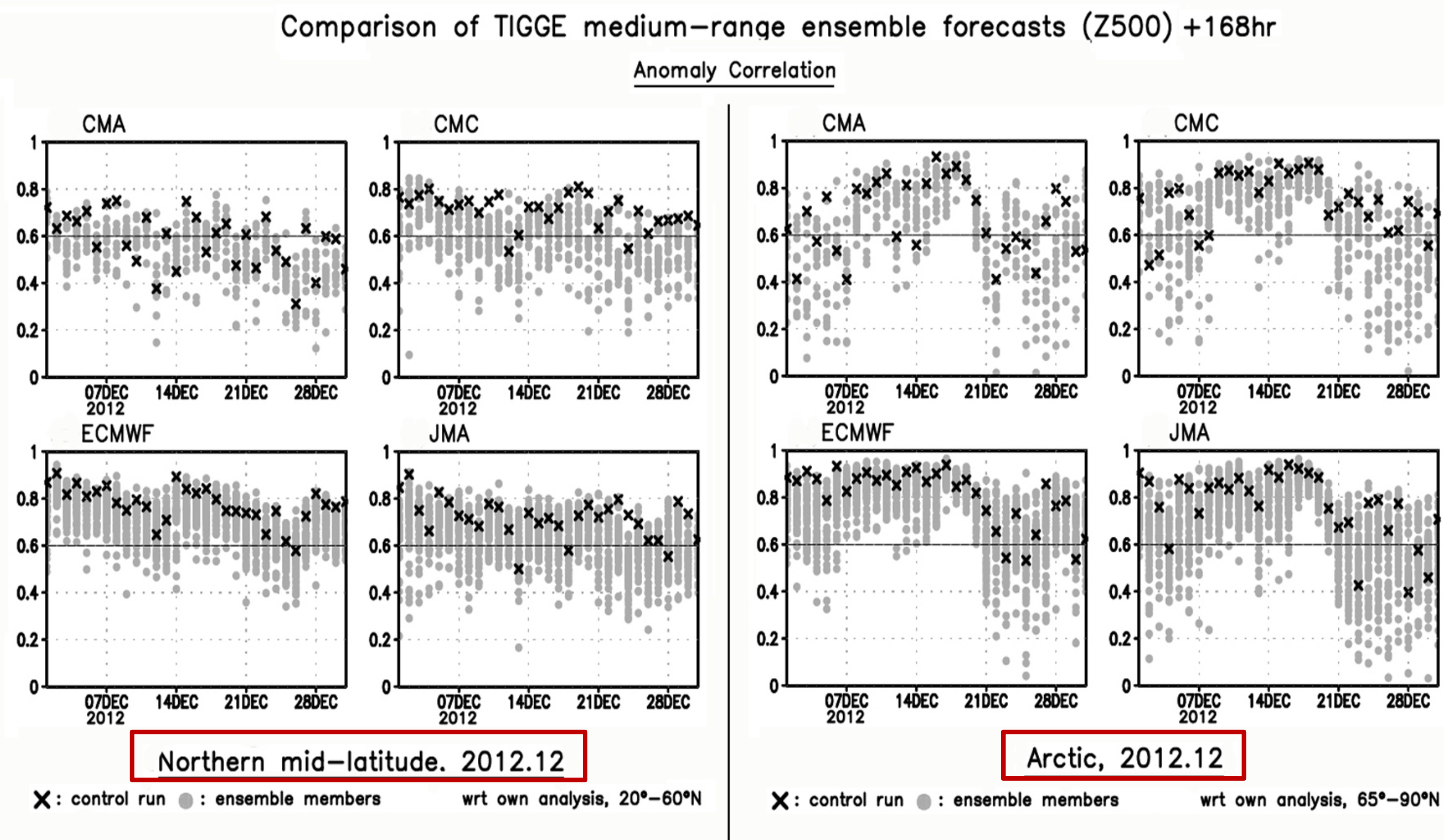
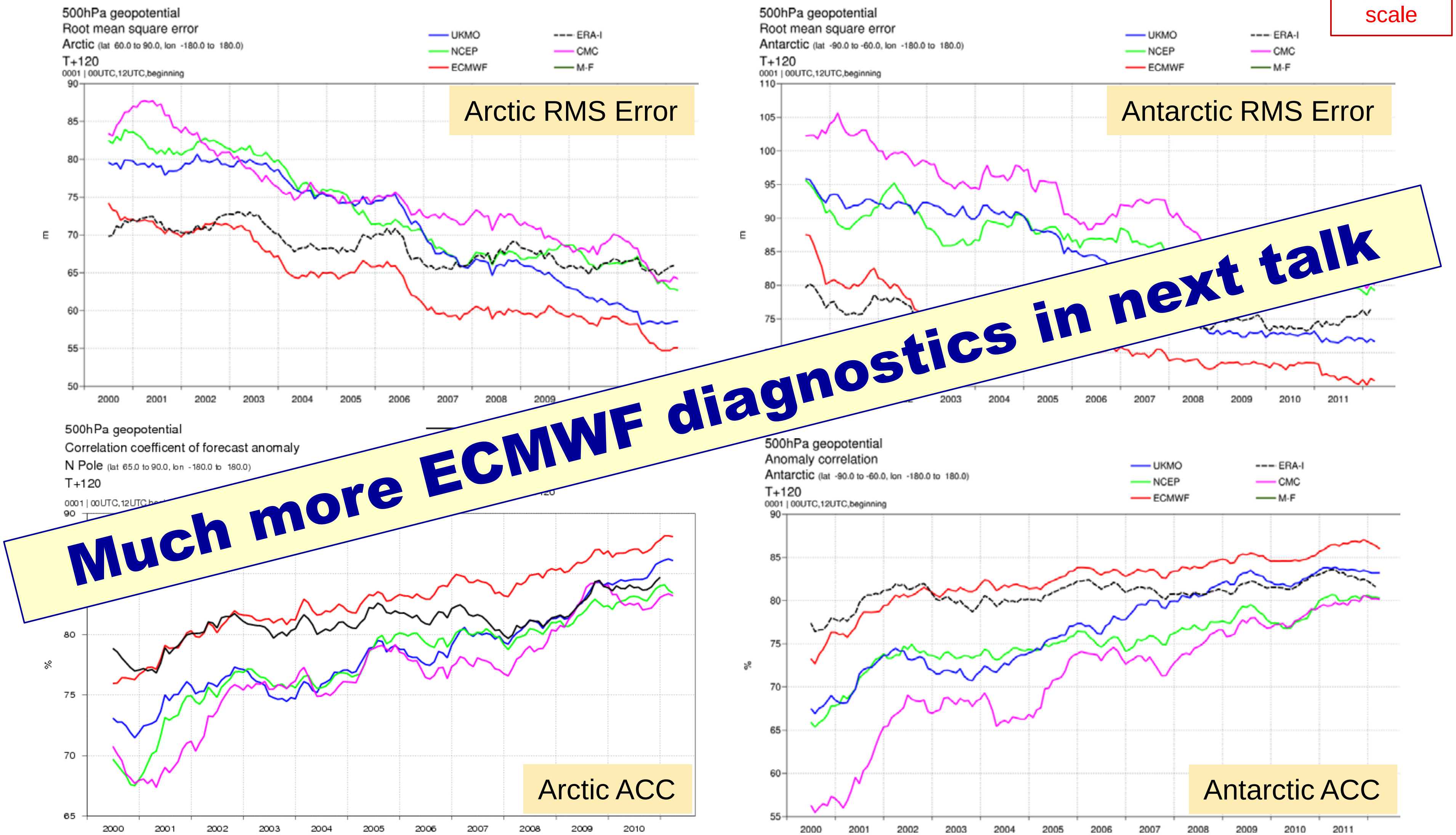
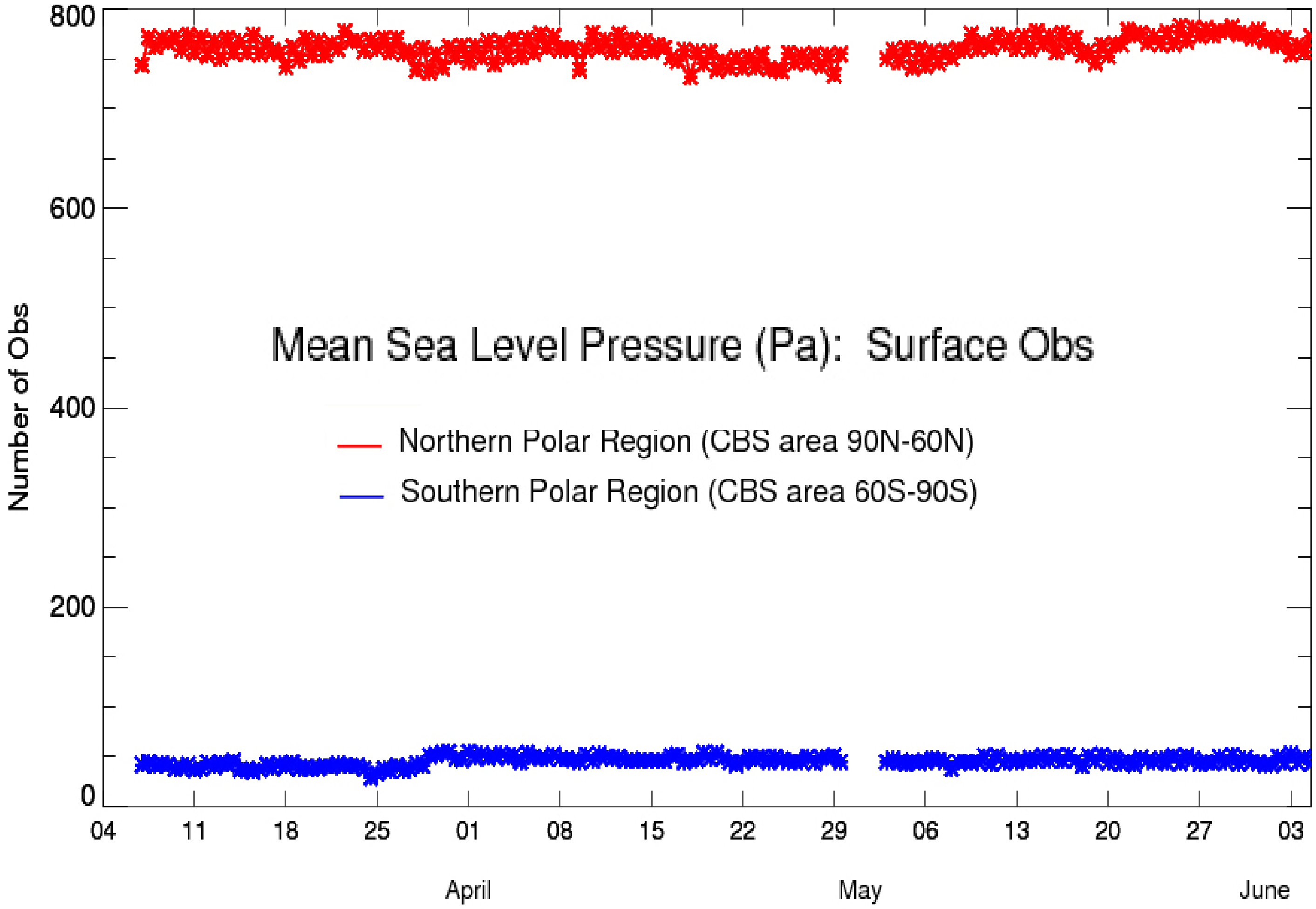


Comparison with other centres (2000-2012)

Note diff. y-axis scale



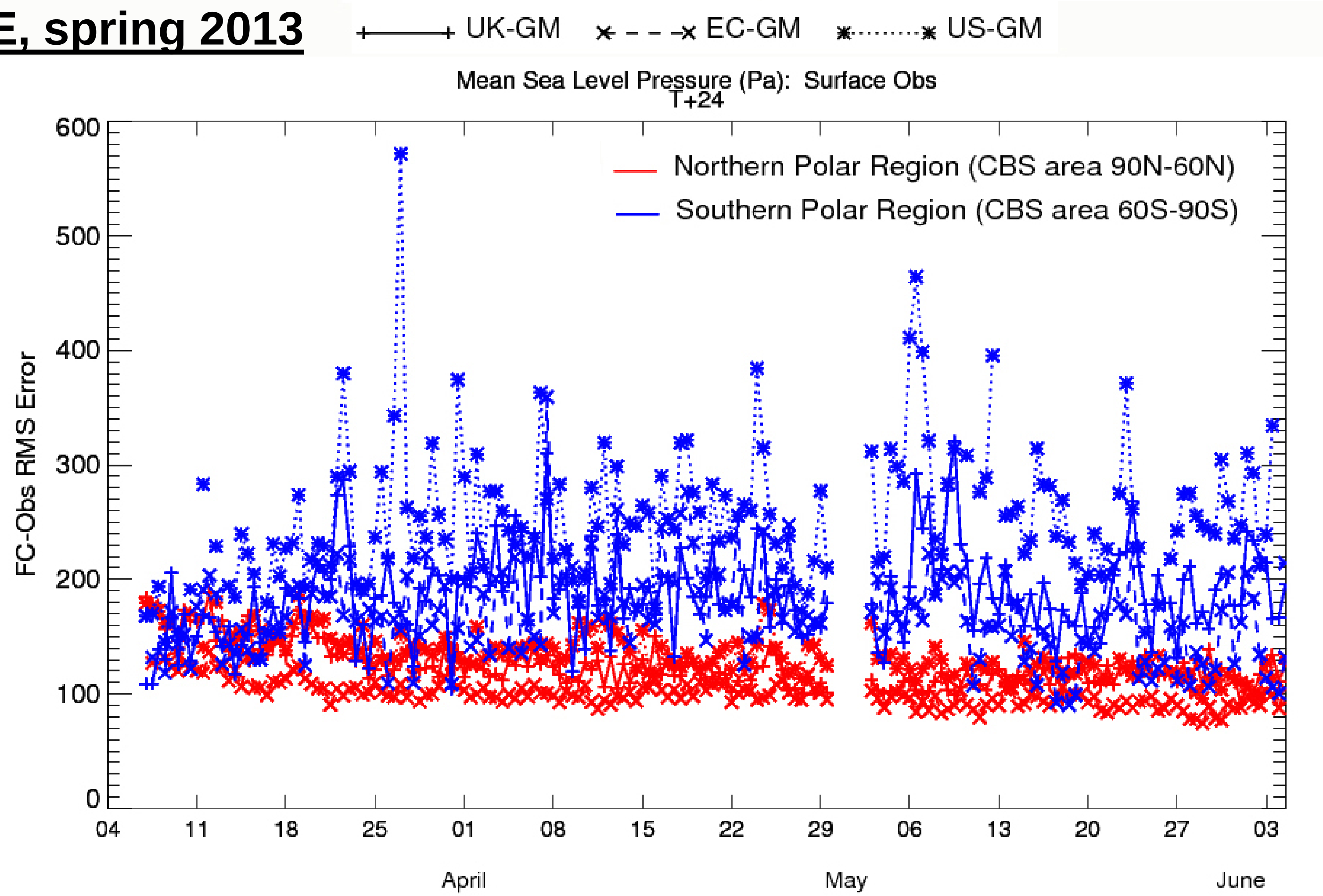
Obs availability, spring 2013



(Acknowledgement: Marion Mittermaier)

North - South Comparison

RMSE, spring 2013

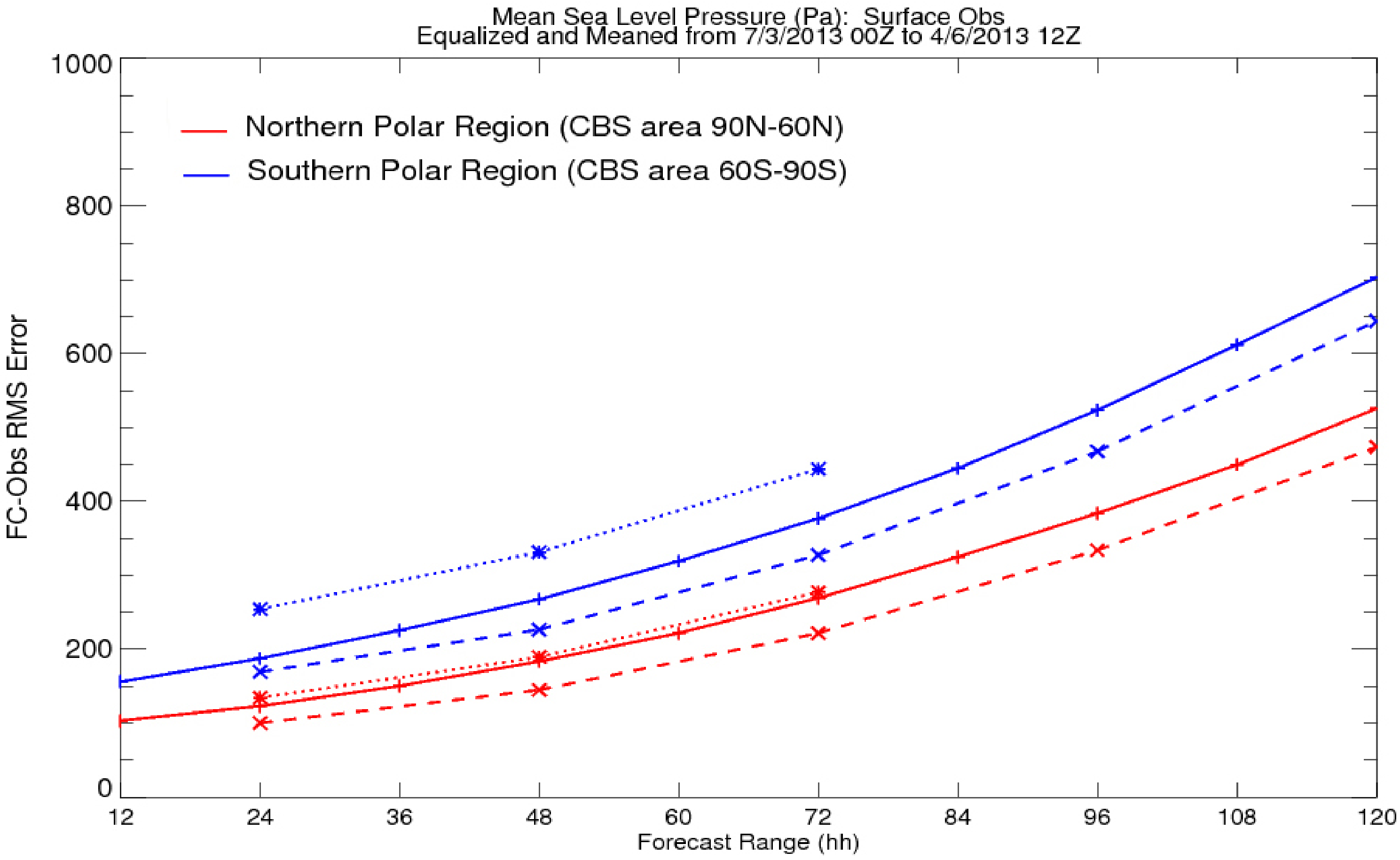


NB: UK @ full resolution; EC & US @ coarser CBS grip resolution

(Acknowledgement: Marion Mittermaier)

North - South Comparison

RMSE, spring 2013 UK-GM EC-GM US-GM **3-month mean**



NB: UK @ full resolution; EC & US @ coarser CBS grip resolution

(Acknowledgement: Marion Mittermaier)

- ✓ **No such thing as observed *"truth"***
  - Regardless how good your observations, they are always estimates !
  - Forecast verification would require knowing the "truth", however
- ✓ **Observational uncertainty need to be taken into account**
  - E.g., how well do nearby observations match each other?
  - Quality checking of observations
    - o Removal of gross errors, instrument and reporting errors; biases
- ✓ **Observations generally are *"more true"* than model analyses**

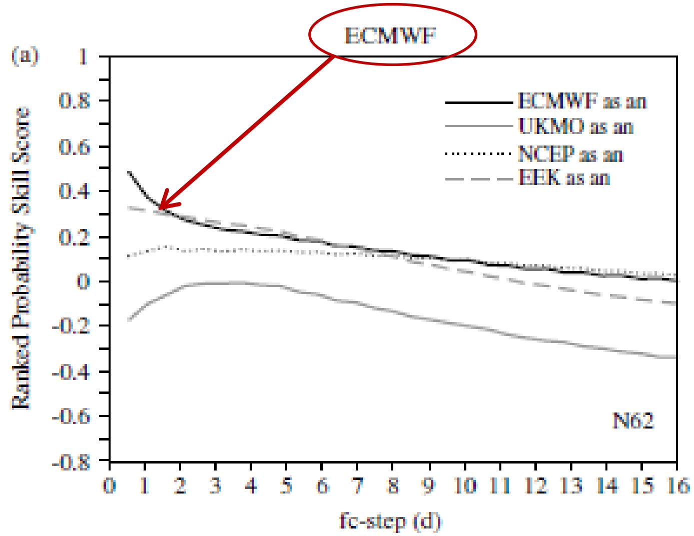
⬄ Utmost care if using model analysis as verifying *"truth"*

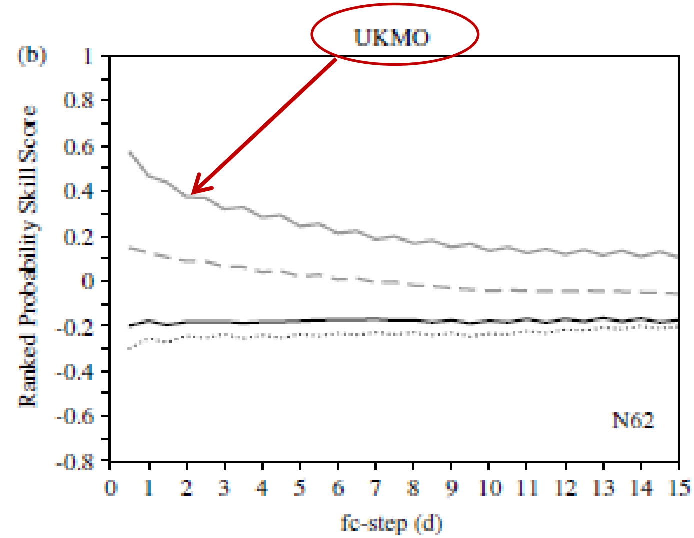
⬄ **Analyses typically are highly model dependent!**

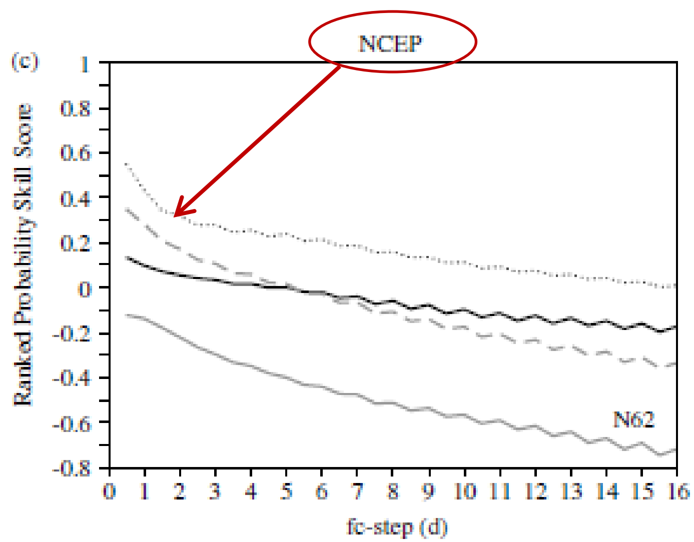
✓ **Especially so in polar regions with lack of observations**

⬄ Analyses suited for comparison between versions of same model - e.g. operational vs. experimental suite – rather than comparing different models against each other

Observations are THE cornerstone of forecast verification !







RPSS for 850 hPa temperature in the tropics (TIGGE data)
(from Park et al, 2008)

You always get best verification scores when using your <u>own</u> analysis

- ✓ Own model climatology brings advantage
- ✓ Differences largest in the tropics and at low levels

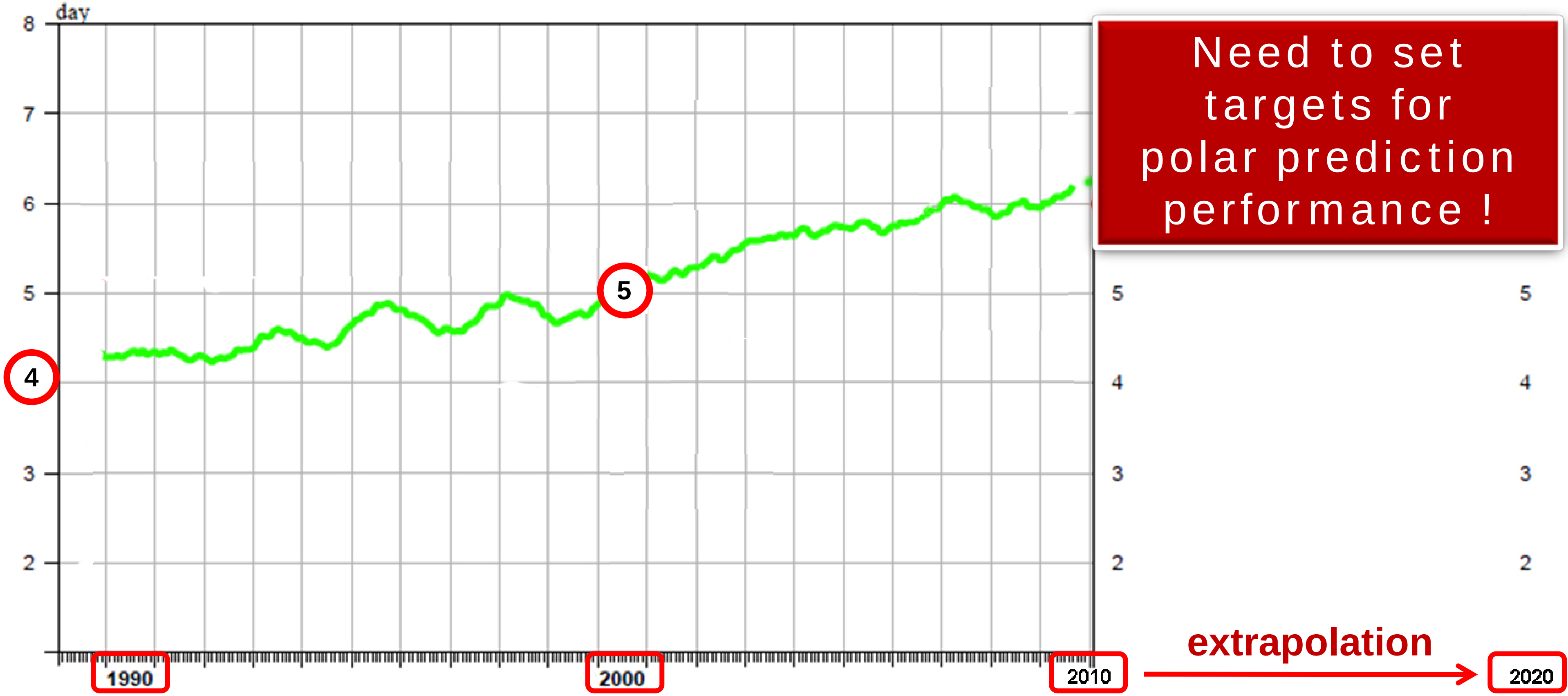
Repeat this kind of experiment for the Polar regions

Predictability - Free atmosphere

Predictability ⇔ ECMWF "headline" measure

ACC of Z 500 remains above 80 %

- ✓ **1990 ⇔ 4 days**
- ✓ **2000 ⇔ 5 days**
- ✓ **2010 ⇔ 6 days** ⇔ Expected increase ⇔ 1 day / decade



Need to set targets for polar prediction performance !

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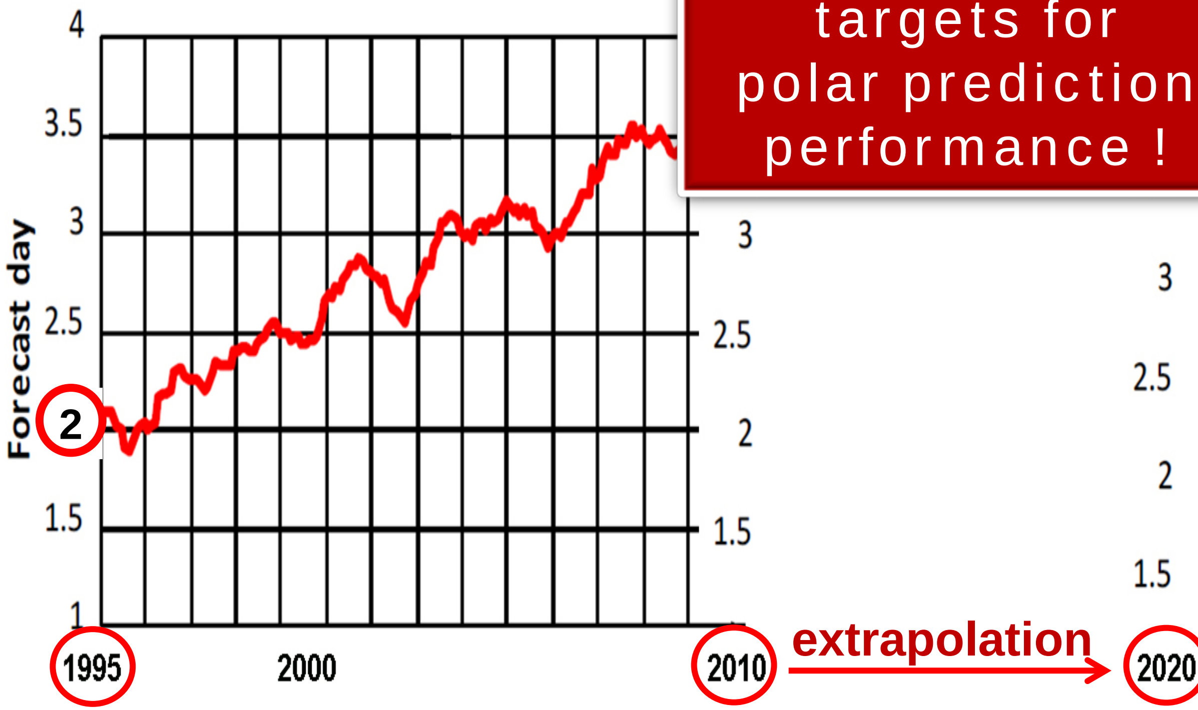
Predictability - Surf. weather ⇔ End-user perspective

Predictability ⇔ ECMWF "headline" measure

"1 – SEEPS" of 24 hr precipitation remains above 45 %

- ✓ **1995 ⇔ 2 days**
- ✓ **2010 ⇔ 3.5 days** ⇔ Expected increase ⇔ 1 day / decade

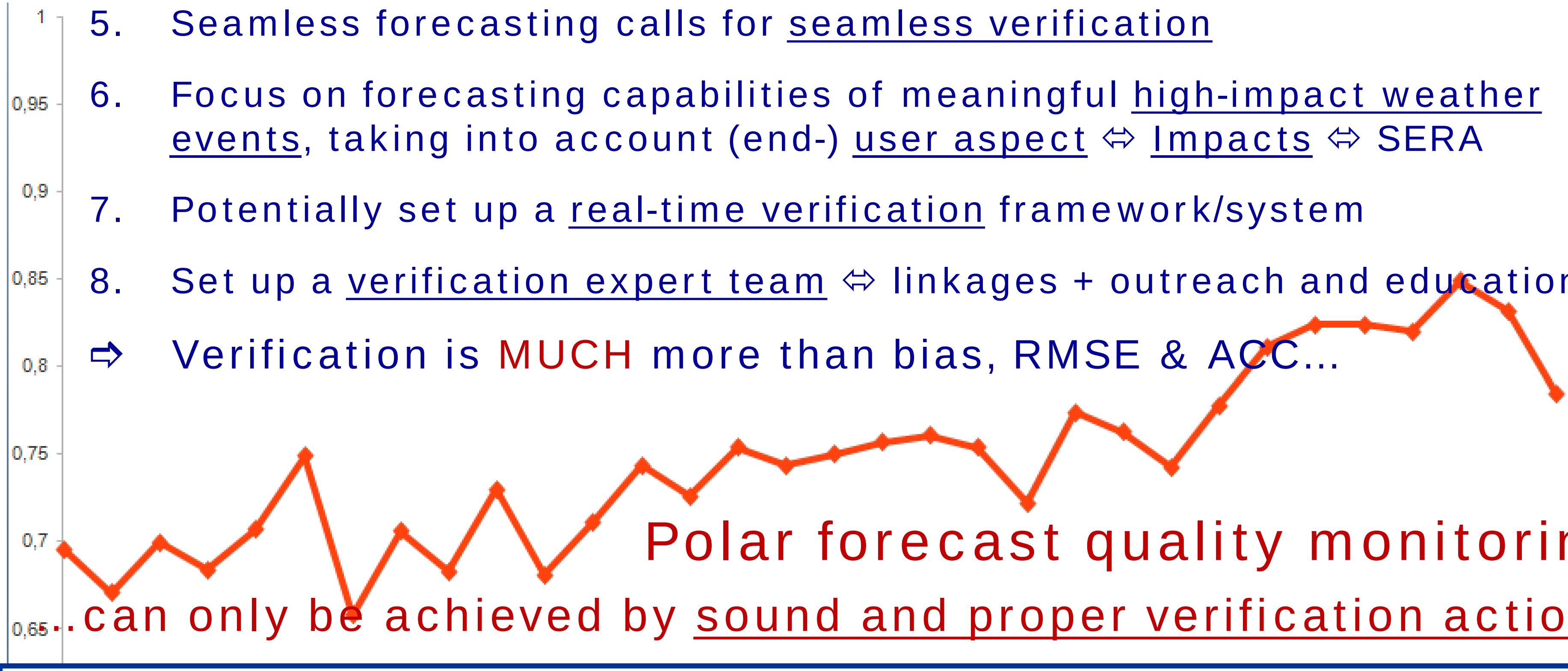
Need to set targets for polar prediction performance !



“ Summary “

1. Investigate and test present and new, upcoming verification measures
2. Utilize verification as a means to assist observing system design - YOPP
3. Agree on **(at some stage)** a common set of verification metrics **(for YOPP)**
4. YOPP data centre ⇔ Include a verification module
5. Seamless forecasting calls for seamless verification
6. Focus on forecasting capabilities of meaningful high-impact weather events, taking into account (end-) user aspect ⇔ Impacts ⇔ SERA
7. Potentially set up a real-time verification framework/system
8. Set up a verification expert team ⇔ linkages + outreach and education

⇨ Verification is MUCH more than bias, RMSE & ACC...



Polar forecast quality monitoring

...can only be achieved by sound and proper verification actions

Interest in polar region dedicated verification has clearly increased since the initiation of PPP !


Preparation Phase
2012-2016
YOPP
2017-2018
Consolidation
Phase
2018-2022
JWGFVR
thanks
You
Pertti
Laurie
Beth
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