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Is there a need for climate model intercomparison projects in the future?

Shuting Yang
DMI

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Is there a need for coupled model intercomparison projects (CMIP) in the future?

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Acknowledgement:
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Jens H. Christensen (Univ. of Copenhagen)

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Outline

- A brief history of CMIP
  - The state of CMIP
  - Lessons learnt from the past CMIP
  - CMIP6 design
- Why CMIP? Why multi-models?
  - A statistic explanation
  - Dealing with climate variability: an example of assessing future sea ice conditions
- Conclusions

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What is Coupled Model Intercomparison Project (CMIP)?

- A project led by WCRP's working group of coupled modelling (WGCM)
- Coordinated climate model experiments involving in multiple modelling teams worldwide since 1995
- Objective:
  - To design coordinated global simulations of the coupled climate system and make available a wide range of model output to **advance understanding of past, present, and future climate** variability and change of the Earth system
- Defines common experiment protocols, forcings, output formats and standards
- CMIP simulations regularly assessed as part of the IPCC Climate Assessment Reports and various national assessments. But CMIP is not done for the IPCC, or run by the IPCC
- Developed in phases, currently phase 6 (CMIP6)

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A brief history of CMIP

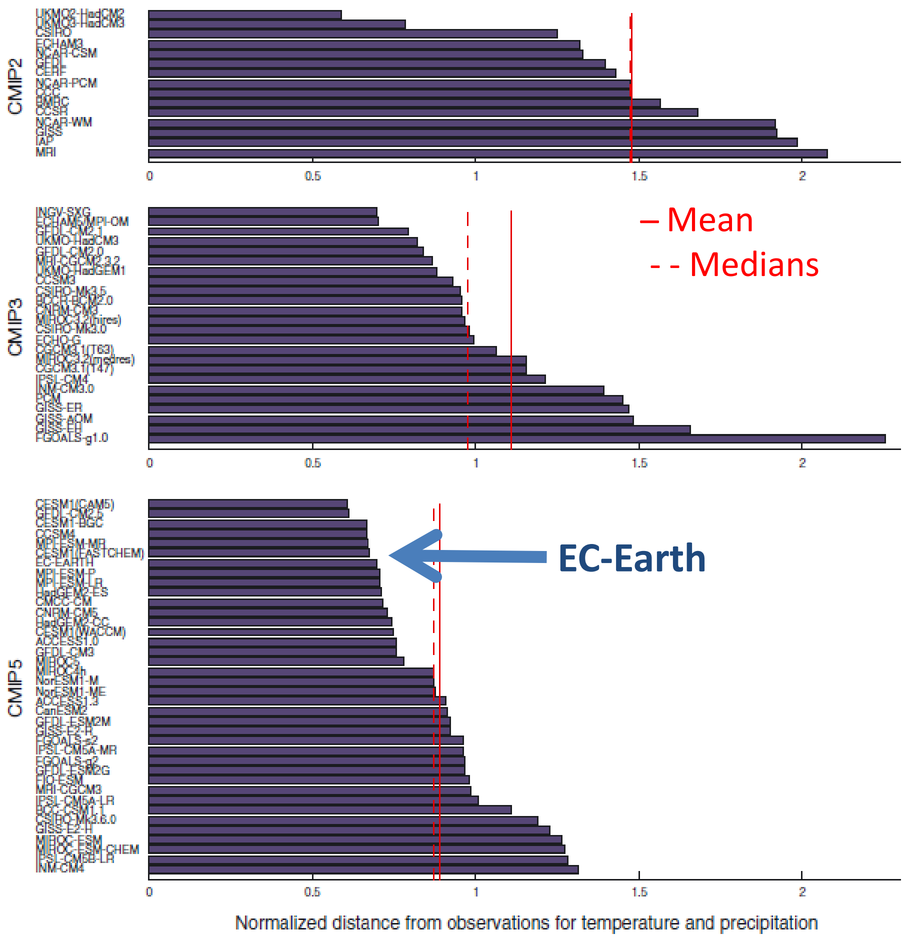
	CMIP 1996 -	CMIP2 1997 -	CMIP3 (2005-2006)	CMIP5 (2010-2011)	CMIP6 (2017-2020)
Number of experiments	**1**	**2**	**12**	**110**	?
Experiment description	present-day ctrl	pd-ctrl & 1pctCO2	Ctrl & 20C & 21C-SRES & AMIP & idealized CO2	Near- and long-term, core + tier 1 + tier 2	DECK + historical run & 21 MIPs
Centres participating	16	18	17	24	32
# of distinct models	**19**	**24**	**25**	**63**	Many model versions, more with higher res.
Total dataset size	1 GB	500 GB	40 TB	2-3 PB	~10 PB

Source: http://www.easterbrook.ca/steve/2012/04/some-cmip5-statistics/
Stouffer, 2015: A retrospective look at CMIP5
Eyring et al, 2017: Overview of CMIP6 experiment design and organization

- More than 1000 CMIP5 acticle recorded in the CMIP website as of Oct. 2015
- ~45% of climate research papers published in 2016 in *J. of Clim.* explicitly cite CMIP5

Evolution of climate model performance

Normalized distance From observations
Surface Temp. & Precip.



Knutti, et al (2013): *GRL*

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Evolution of climate model performance

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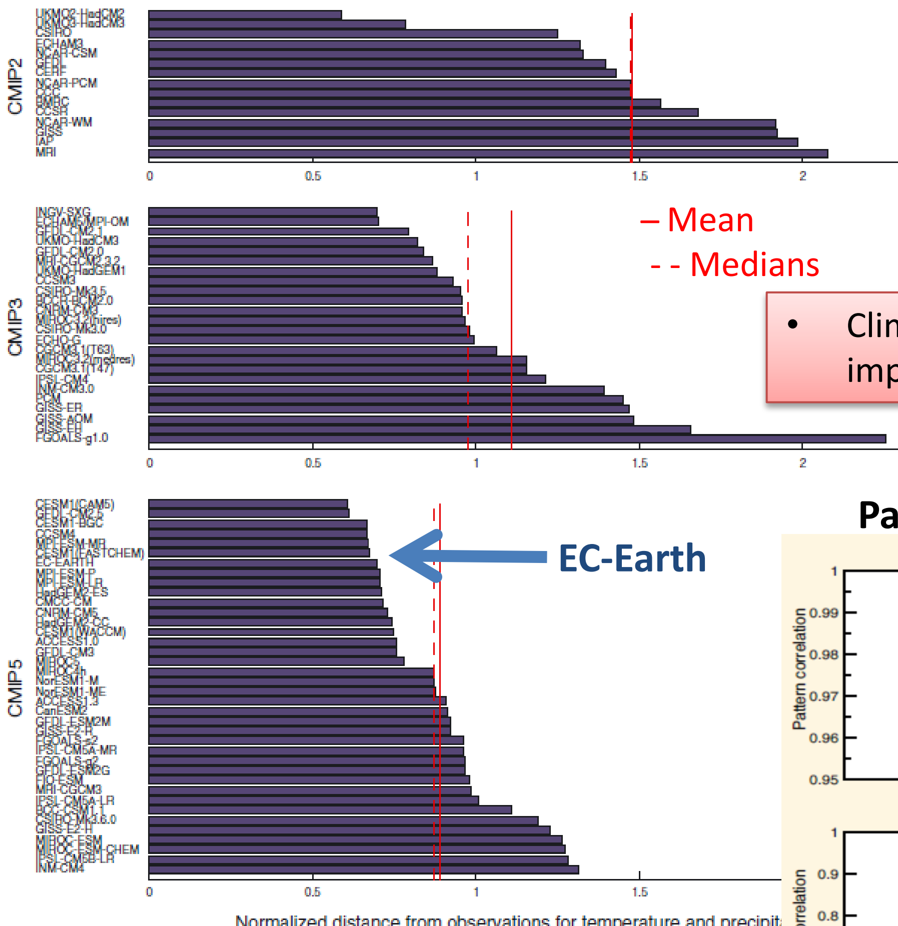

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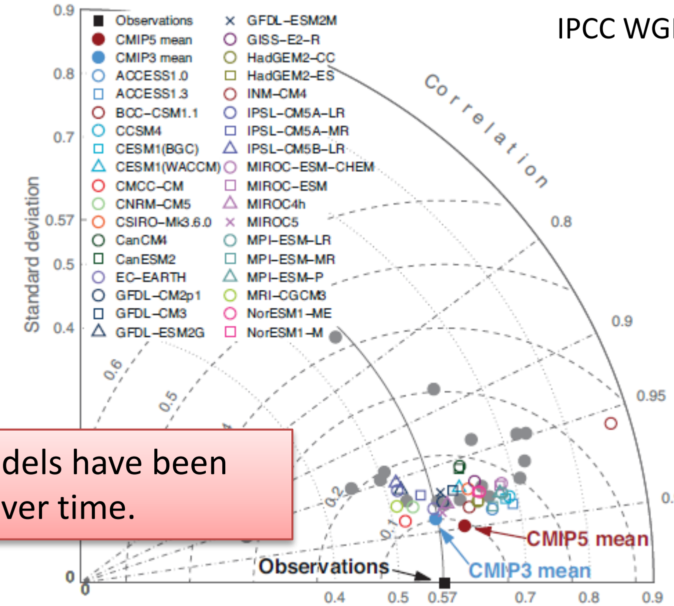
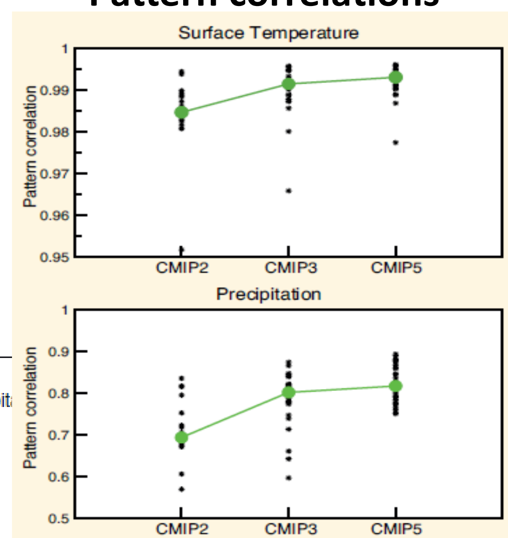
Taylor diagram for dyn. Sea surface height clim.

IPCC WGI AR5

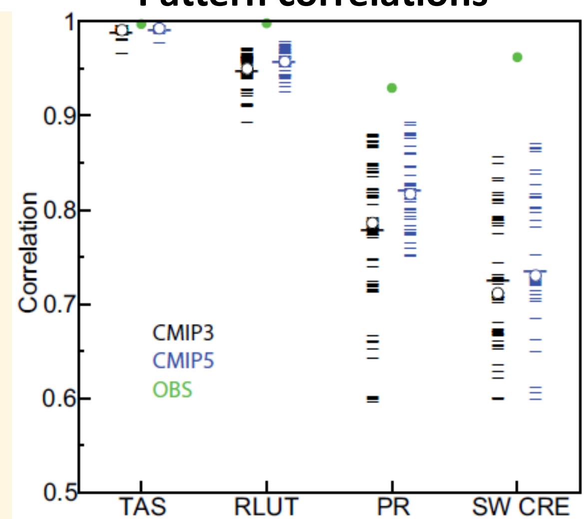


- Climate models have been improved over time.

Pattern correlations



Pattern correlations



IPCC WGI AR5

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Evolution of climate model performance

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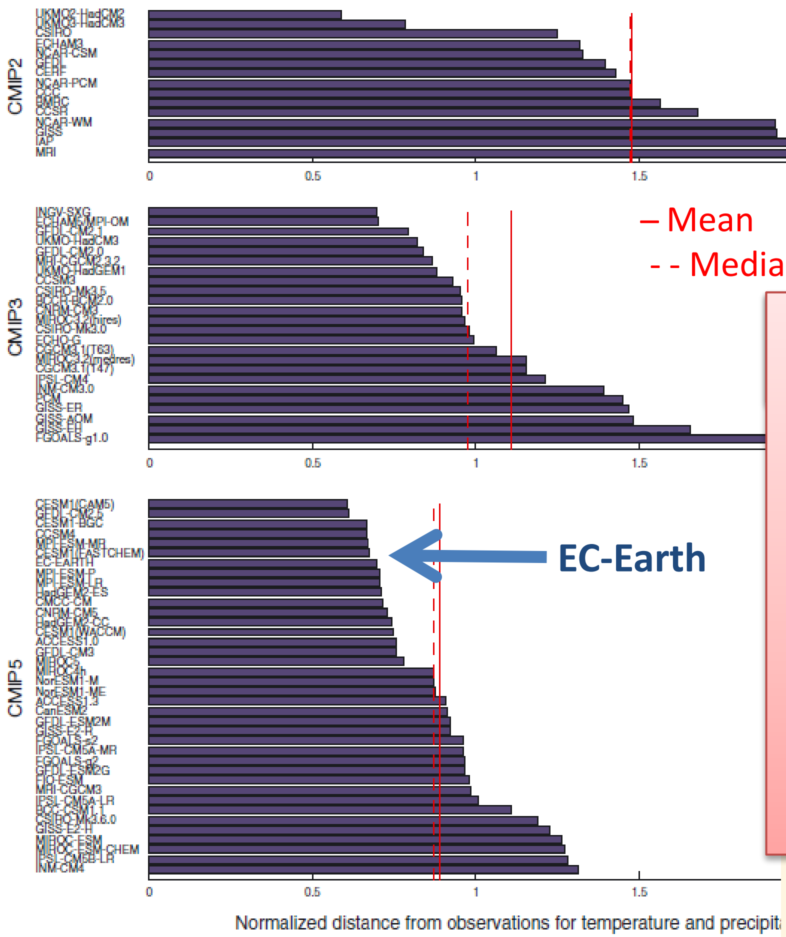

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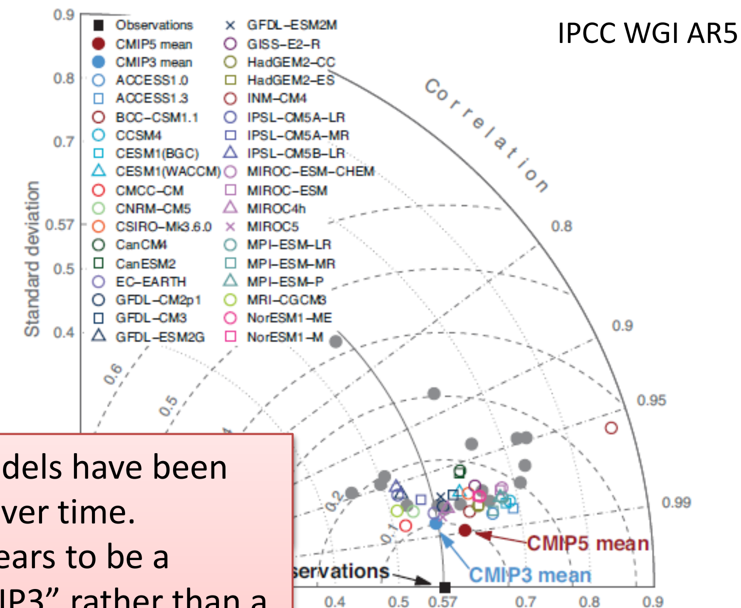
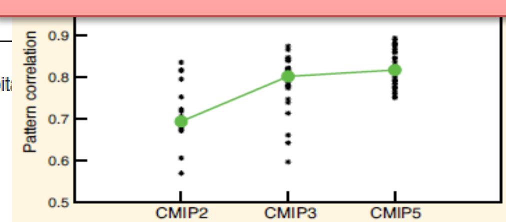
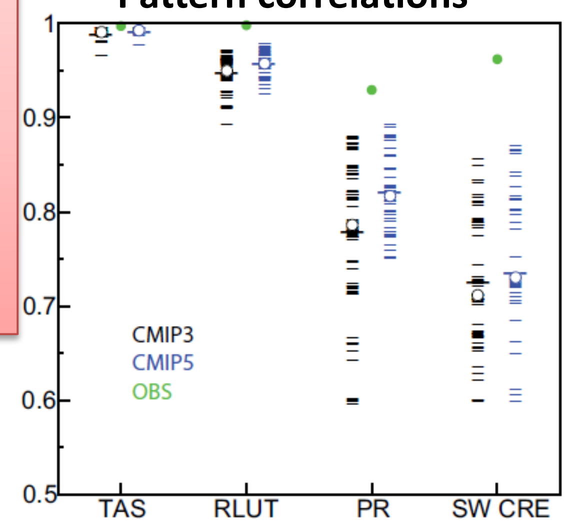


- Climate models have been improved over time.
- CMIP5 appears to be a “better CMIP3” rather than a radically new ensemble.
- Most models are strongly tied to their predecessors. Their strengths and weakness may partly passed on newer version.
- **EC-Earth is a young model with good performance**



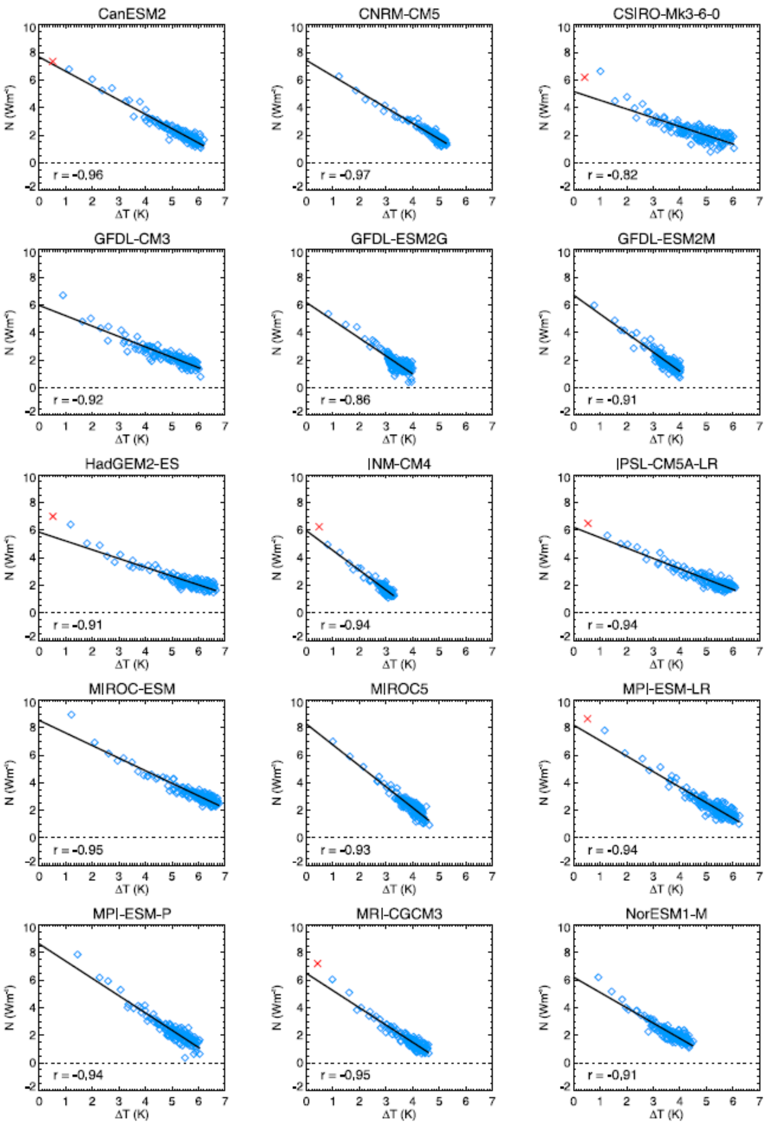
Pattern correlations



IPCC WGI AR5

Scientific gaps in CMIP5

1. How does the Earth system respond to changes in forcing?



- Abrupt 4xCO_2 experiment of 150 years
  N == net radiative flux at the top
  ΔT == global mean surface air temp. changes
- Use to estimate the effective radiative forcing (ERF, ie., Intercept at ΔT=0), the climate feedback parameter (ie., the slope), and the equilibrium climate sensitivity (ECS)
- Large difference in estimates of ERF, and ECS among models

➔ more detailed radiative forcing calculations (eg., multiple radiation runs during model integration) - CFMIP and AerChemMIP

Andrews et al. *GRL* 2012

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Scientific gaps in CMIP5

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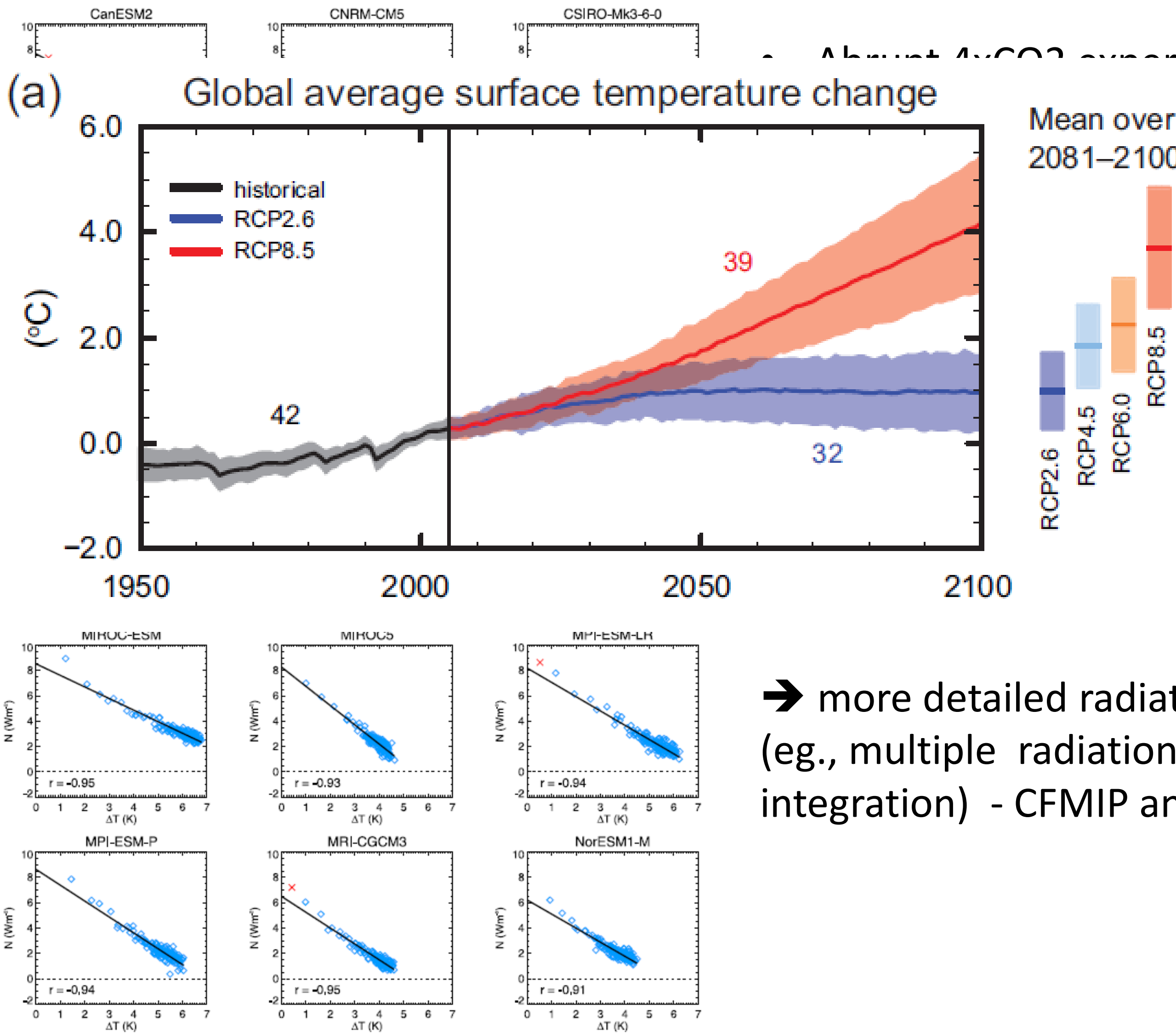

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ensitivity (ECS)

timates of ERF, and ECS

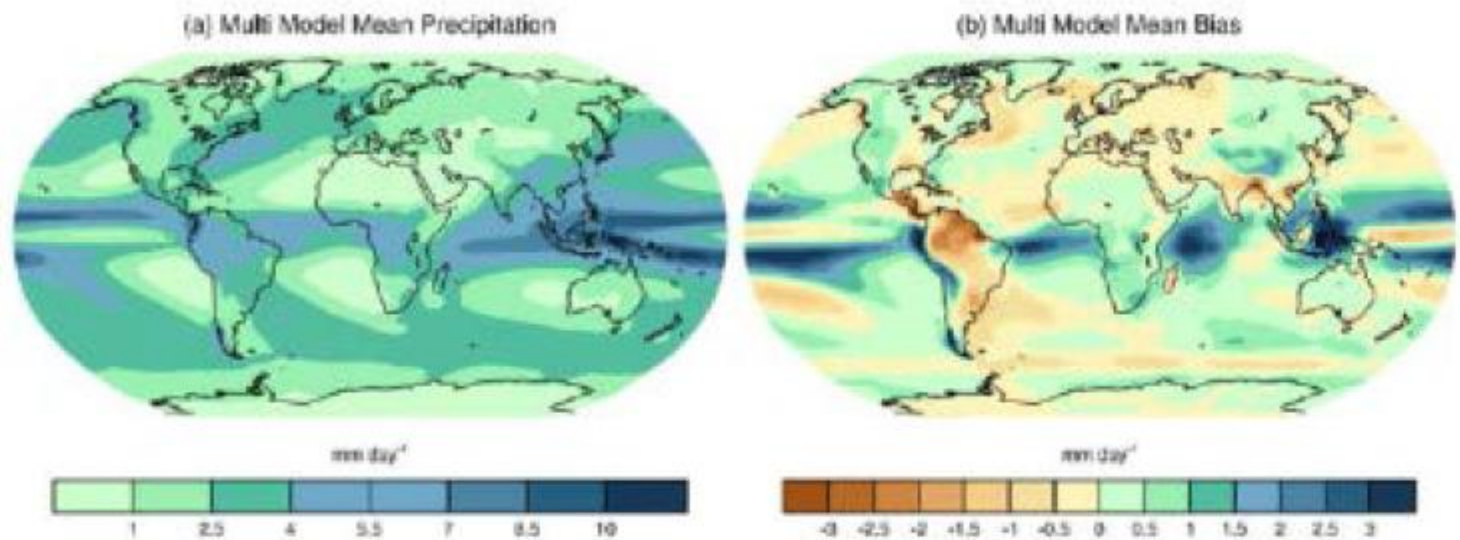
➔ more detailed radiative forcing calculations (eg., multiple radiation runs during model integration) - CFMIP and AerChemMIP

Andrews et al. *GRL* 2012

Scientific gaps in CMIP5

2. What are the origin and consequence of systematic model biases?

Long standing model biases



IPCC AR5

- Double ITCZ – related to dry Amazon?
- poor simulation of tropical and subtropical low clouds
- an overly deep tropical thermocline in ocean
- land surfaces too warm and too dry during summertime
- position of the Southern Hemisphere atmospheric jet
- … …

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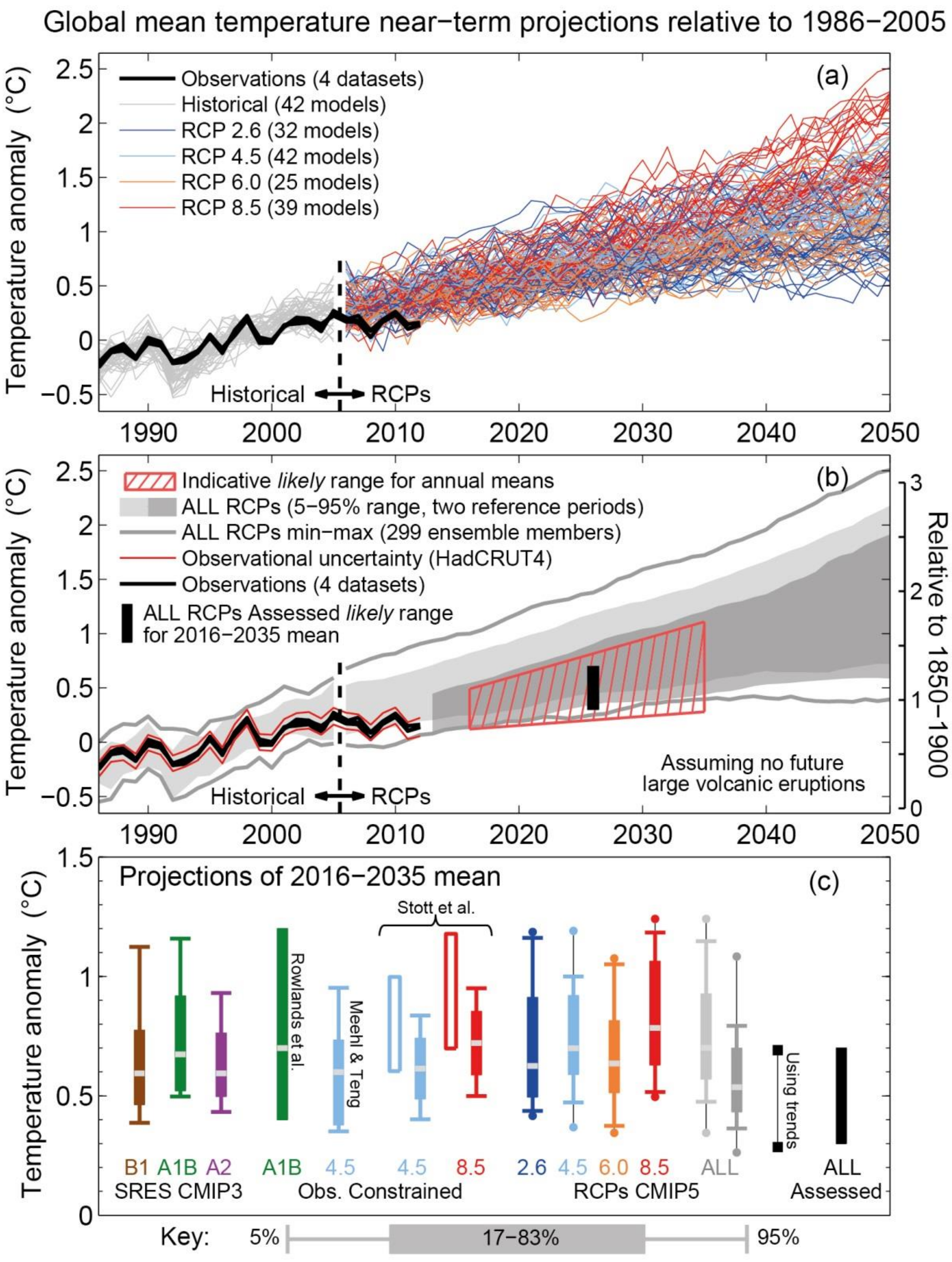
Scientific gaps in CMIP5

3. How can we access future changes given climate variability, predictability and uncertainty



IPCC, WG-I, AR5
Fig. TS.14

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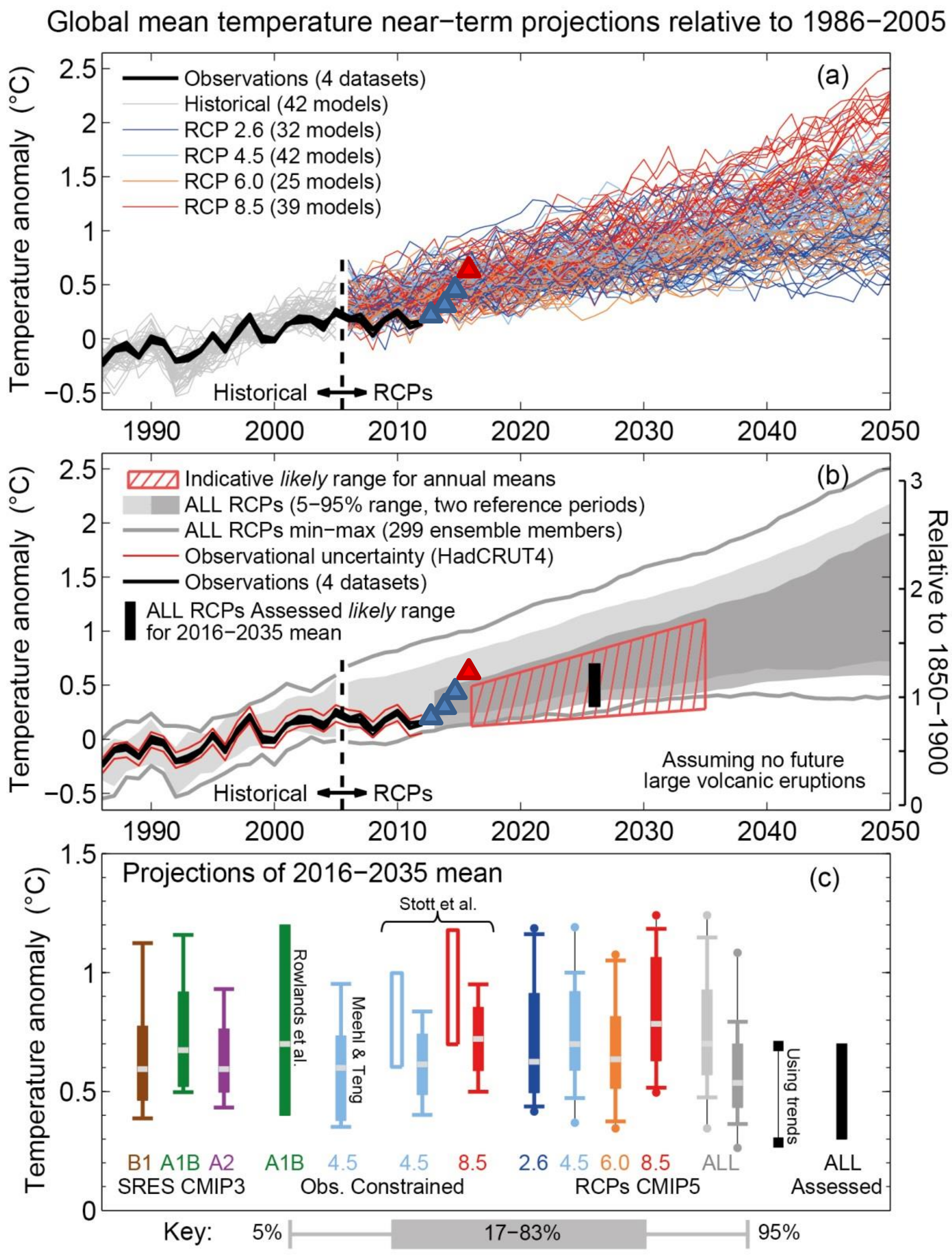
Scientific gaps in CMIP5

3. How can we access future changes given climate variability, predictability and uncertainty



- Natural variability: S/N ratios
- Future scenarios
- Decadal climate predictions: predict the “noise” and forcing signals

IPCC, WG-I, AR5
Fig. TS.14 updated

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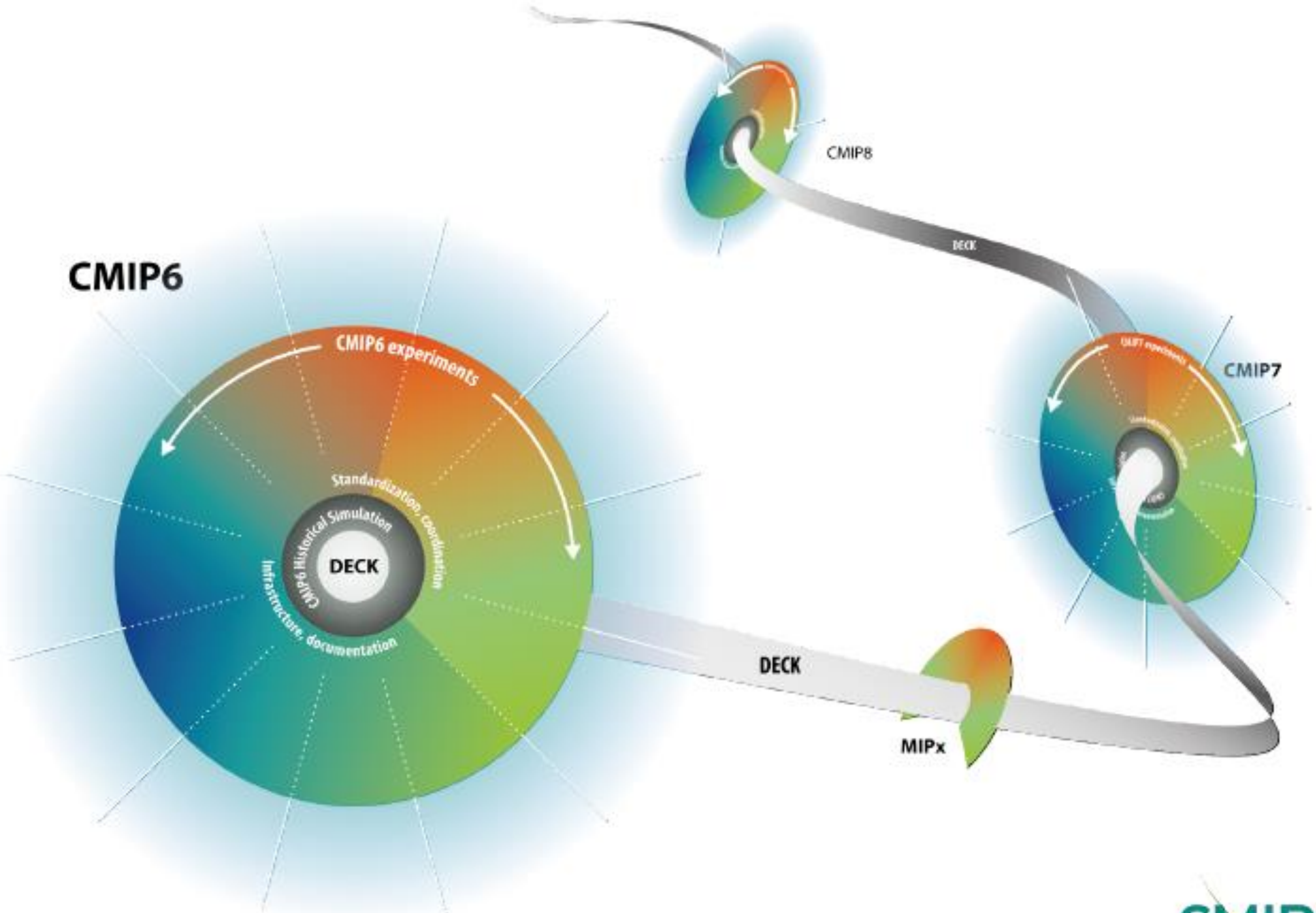
Need for CMIP6: Scientific Focus

- The specific experimental design is focused on **three broad scientific questions**:
  1. How does the Earth System respond to forcing?
  2. What are the origins and consequences of systematic model biases?
  3. How can we assess future climate changes given climate variability, predictability and uncertainties in scenarios?

- The scientific backdrop for CMIP6 is the **WCRP Grand Science Challenges**:
  - Melting ice and global consequences
  - Clouds, circulation and climate sensitivity
  - Carbon feedbacks in the climate system
  - Understanding and prediction weather and climate extremes
  - Water for the food baskets of the world
  - Regional sea-level change and coastal impacts
  - Near-term climate prediction

CMIP Continuity

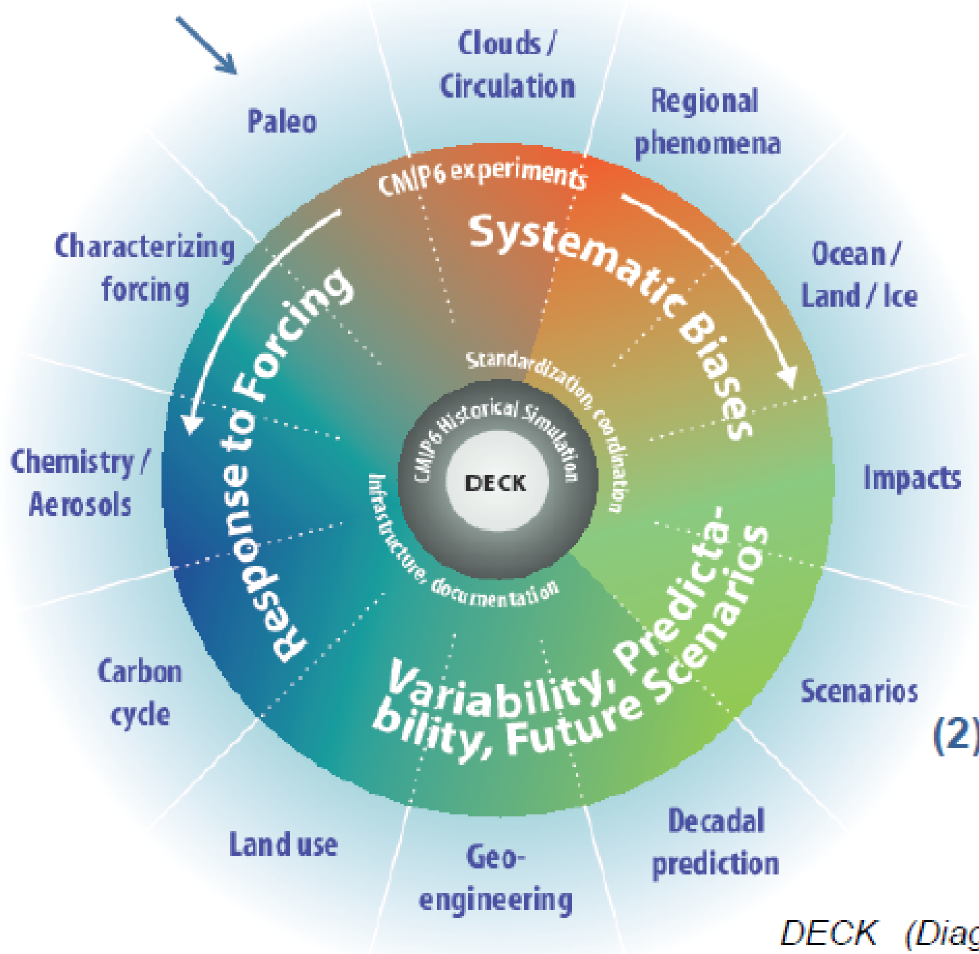
A common suite of experiments for each phase of CMIP provides an opportunity to construct a multi-model ensemble using model output from various phases of CMIP



Eyring et al., CMIP6 Experimental Design and Organization, GMD, 2016

CMIP: a More Continuous and Distributed Organization

(3) CMIP-Endorsed Model Intercomparison Projects (MIPs)



(1) A handful of common experiments

DECK (entry card for CMIP)

i. AMIP simulation (~1979-2014)
ii. Pre-industrial control simulation
iii. 1%/yr CO_2 increase
iv. Abrupt 4xCO_2 run

CMIP6 Historical Simulation (entry card for CMIP6)

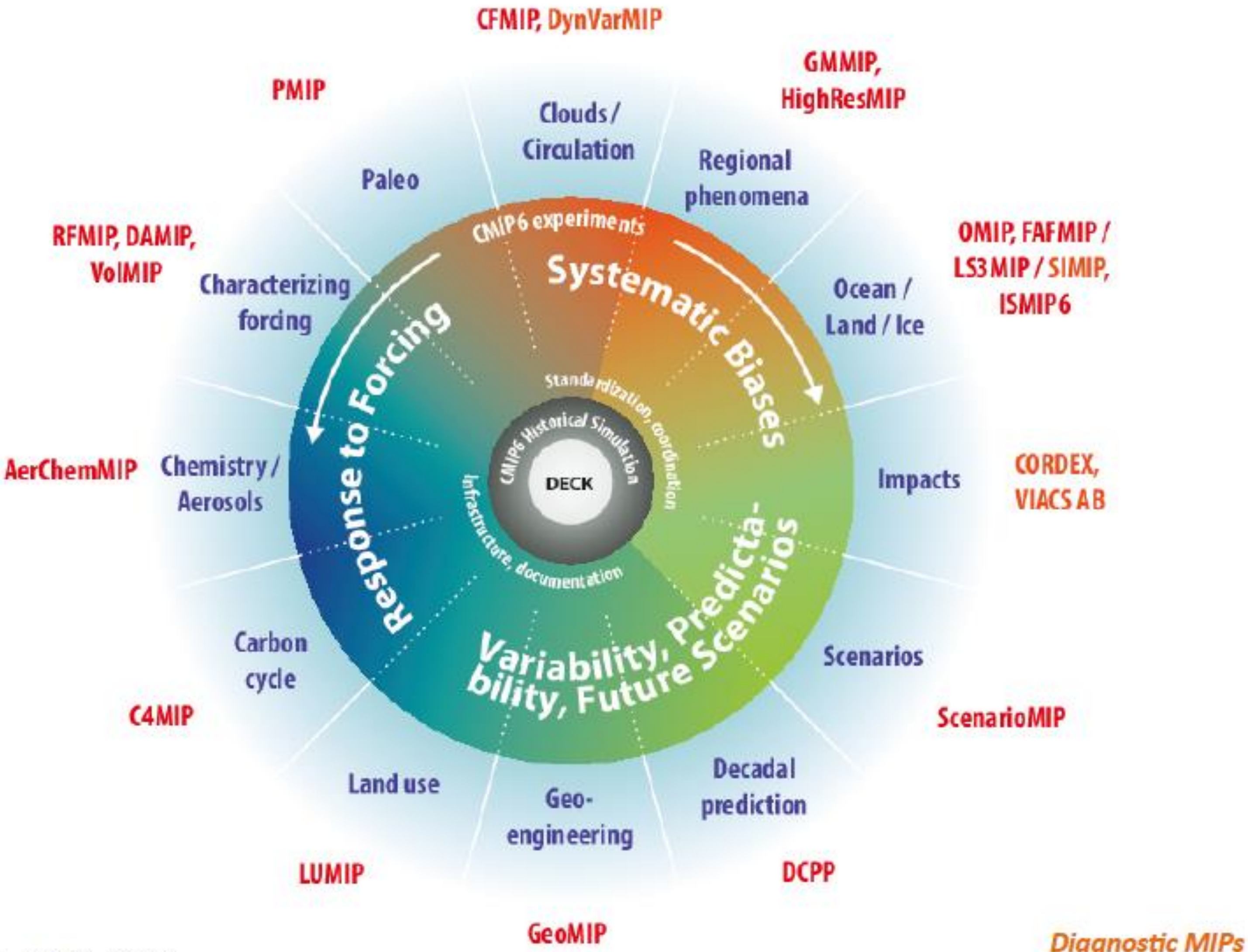
v. Historical simulation using CMIP6 forcings (1850-2014)

(2) Standardization, coordination, infrastructure, documentation

DECK (Diagnosis, Evaluation, and Characterization of Klima) & CMIP6 Historical Simulation to be run for each model configuration used in CMIP6-Endorsed MIPs

Eyring et al., GMD, 2016

21 CMIP6-Endorsed MIPs



Eyring et al., GMD, 2016

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Why CMIP? Why multi-model?

– A statistic explanation

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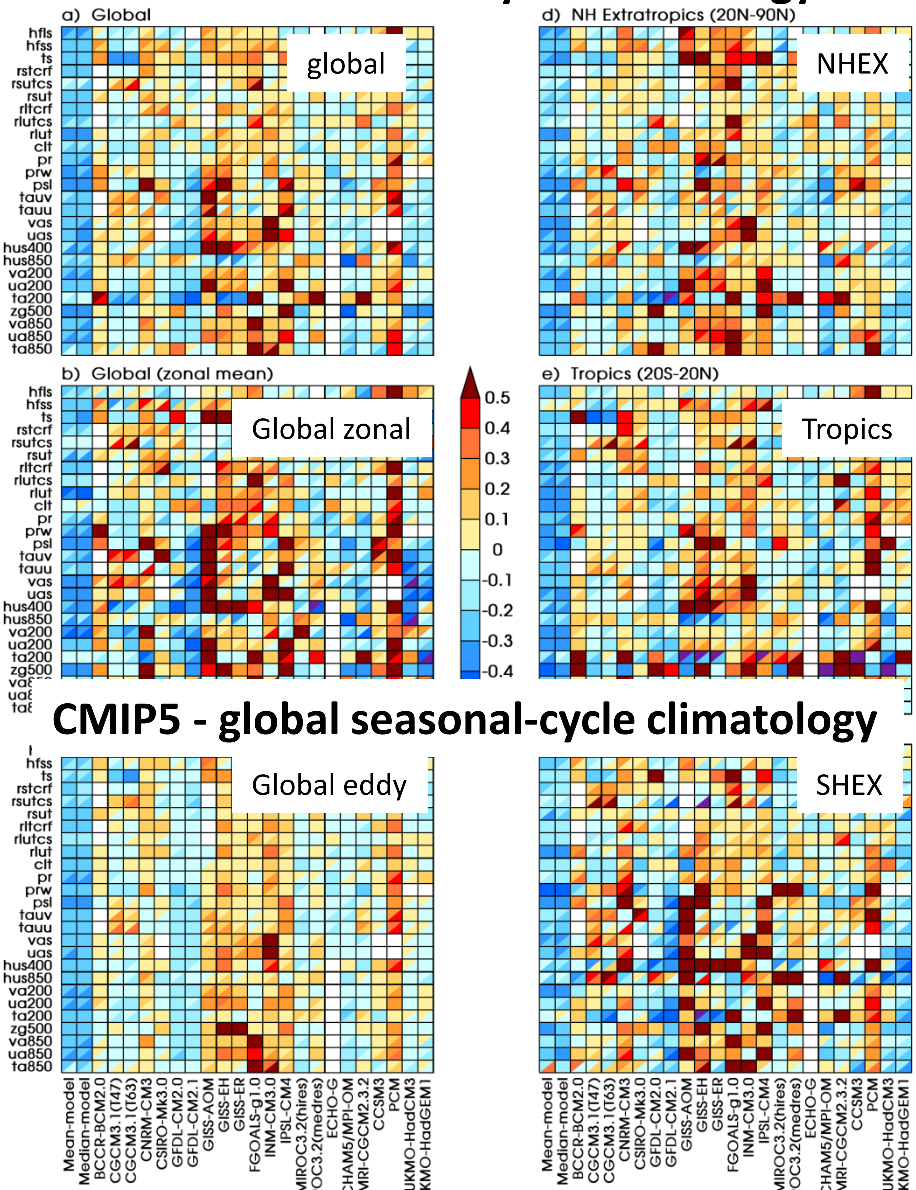
The advantage of multi-model ensemble

CMIP3 – seasonal-cycle climatology



Gleckler et al 2008

- **Relative error** of CMIP3 and CMIP5 models based on seasonal-cycle climatology (1980-2005) from the historical experiments.
- The error measure is a space-time root-mean-square error (RMSE) portrayed as a relative error by normalizing the result by the median error of all model results.
- For example, a value of 0.20 indicates that a model's RMSE is 20 % larger than the median CMIP5 error for that variable, whereas a value of -0.20 means the error is 20 % smaller than the median error.
- **The ensemble mea is often better than individual ensemble members, and the relative errors are about 30% smaller**

The advantage of multi-model ensemble

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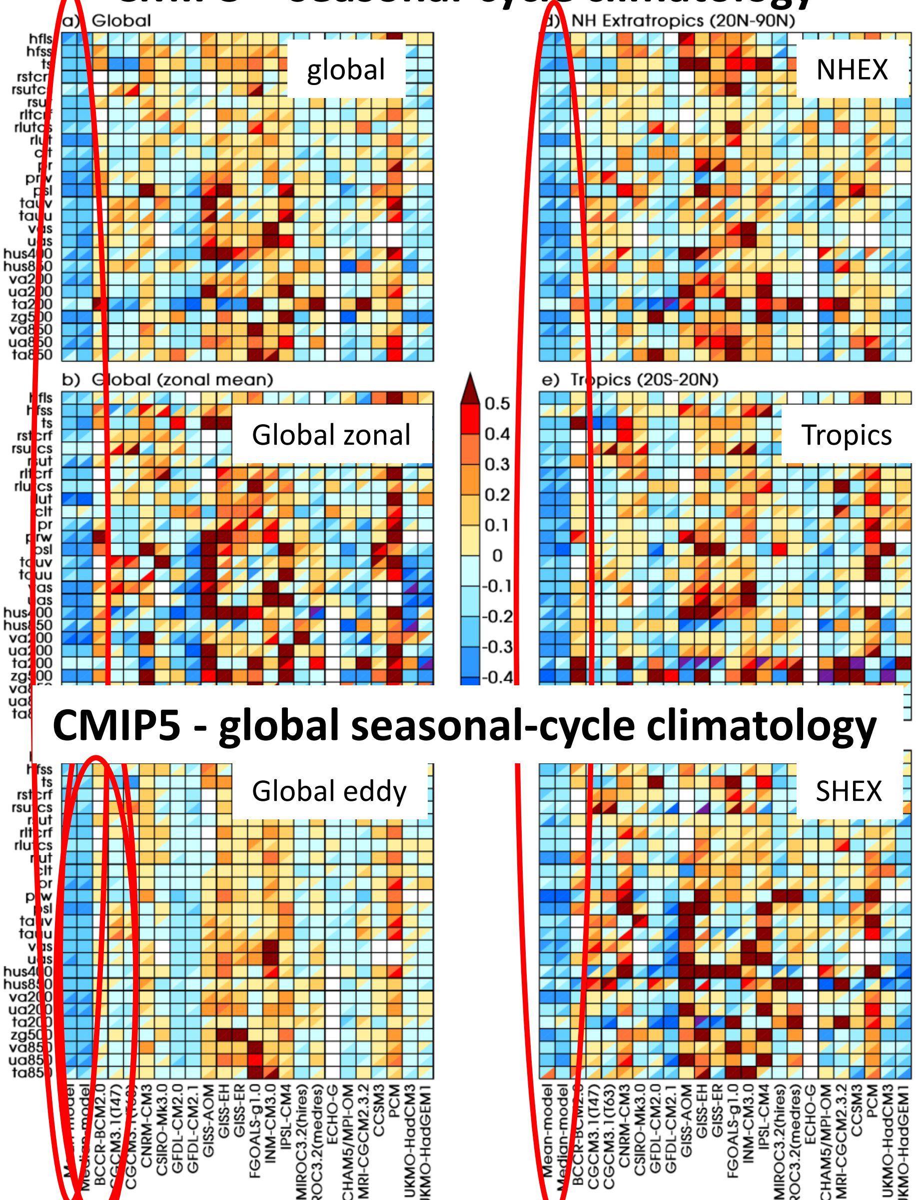
CMIP3 – seasonal-cycle climatology



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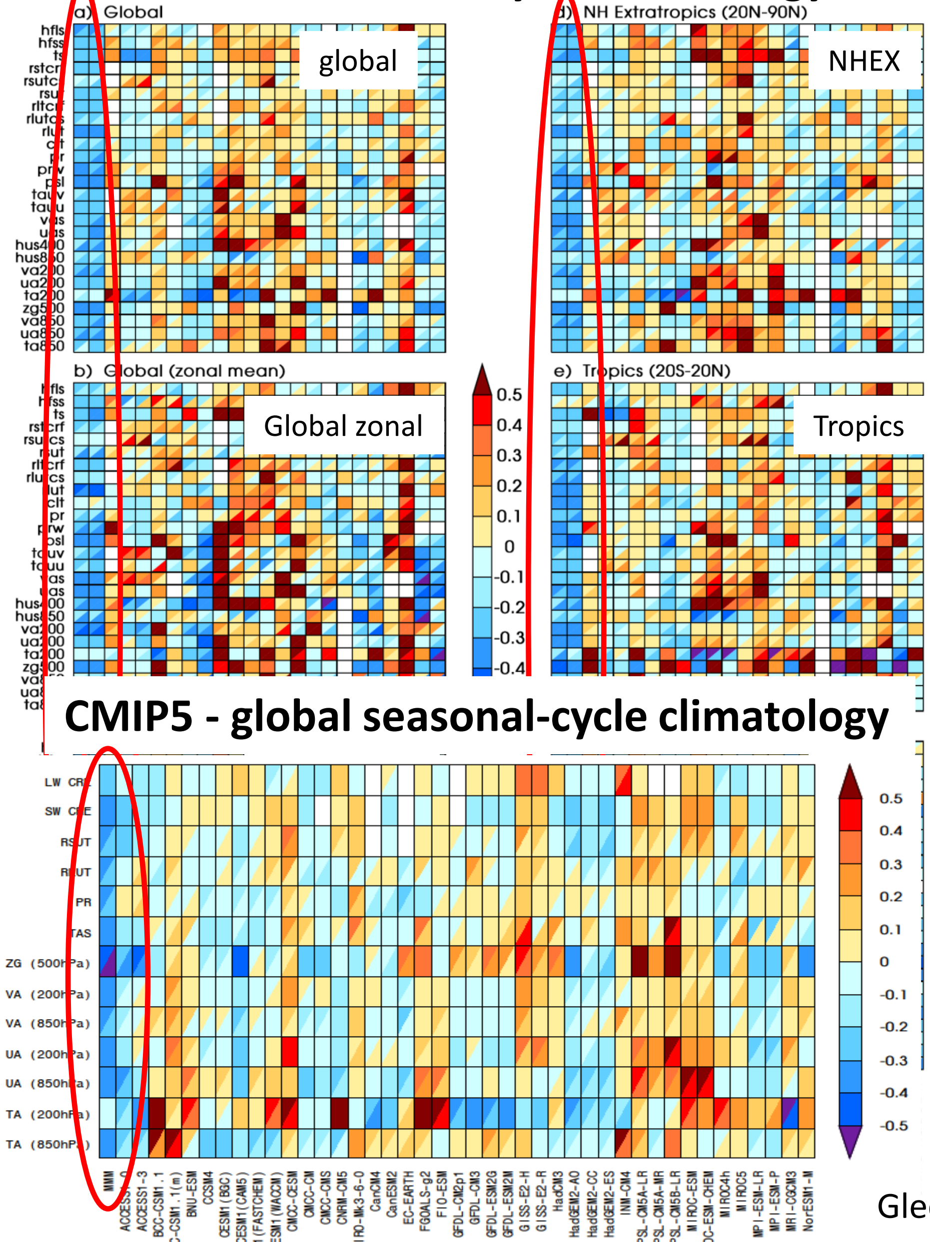

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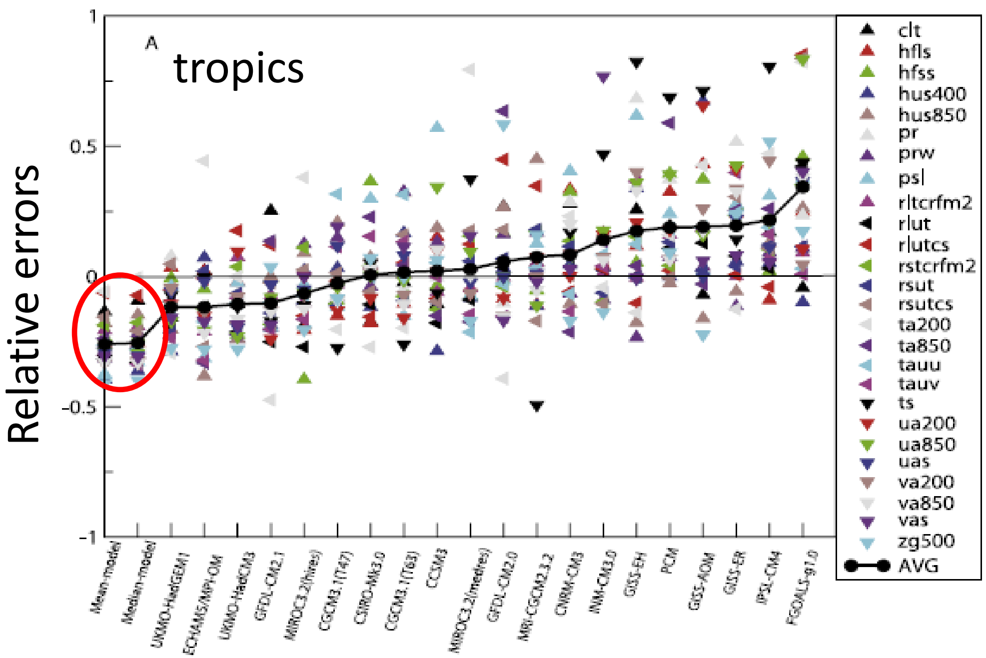
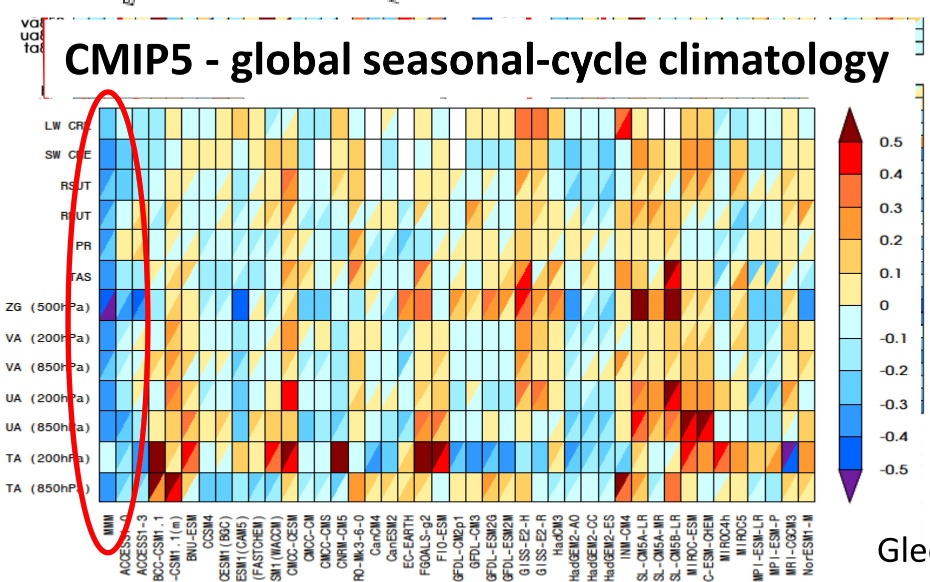
The advantage of multi-model ensemble

CMIP3 – seasonal-cycle climatology



CMIP5 - global seasonal-cycle climatology



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Gleckler et al 2008

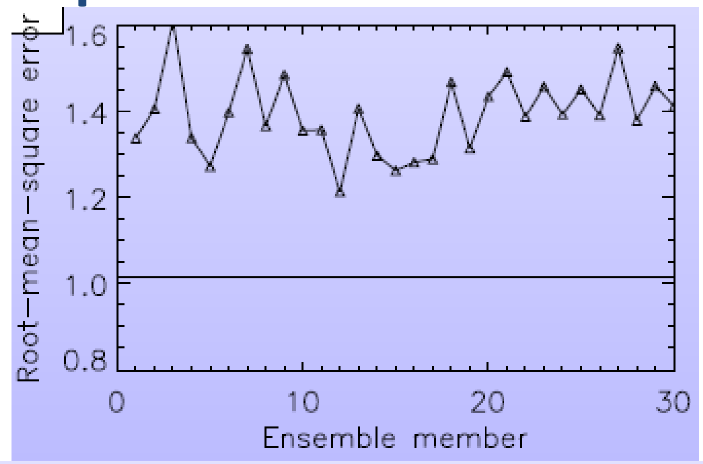
The relative ensemble error is often almost 30% smaller then individual members

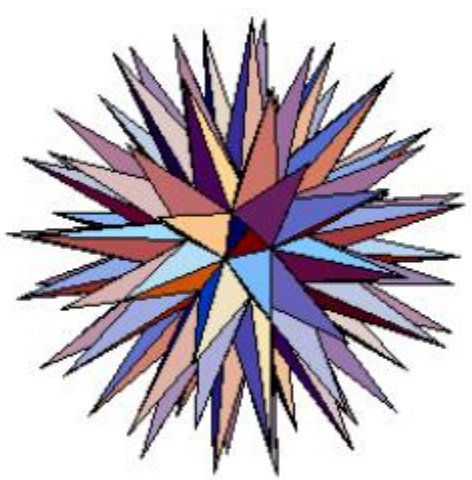
B. Christiansen, 2017: Ensemble averaging and the curse of dimensionality. Submitted to *J. Clim.*, In review

A simple example

```
N=100                          ; # of dimensions
K=30                           ; # of models

;  Draw random numbers
models=randomn(seed,[K,N])
obs=randomn(seed,N)

; Calculate model mean
mean_model=mean(models,dimension=1)

; Calculate errors
err_models=dblarr(K)
for ii=0,K-1 do err_models[ii]=sqrt(mean((models[ii,*]-obs)^2))
err_mean=sqrt(mean((mean_model-obs)^2))

; Plot errors
plot,err_models
oplot,[0,K],[err_mean,err_mean]
```

“Observations “and “models” drawn from same distribution





- This is because of the general features of high dimensional spaces and do not require any other assumptions. These features are:
  - ⋆ In high dimensions random points will almost always be the same long distance from the center.
  - ⋆ Two random vectors are almost always orthogonal.
  - ⋆ The model mean is positioned close to the center and is therefore special.
  - ⋆ The distance between the observation and a ensemble member will therefore be $\sqrt{2}$ longer than the distance between the observation and the model mean.
- Relative error of model mean:

$$\frac{\epsilon - \sqrt{2}\epsilon}{\sqrt{2}\epsilon} = \frac{1-\sqrt{2}}{\sqrt{2}} \approx -0.29$$

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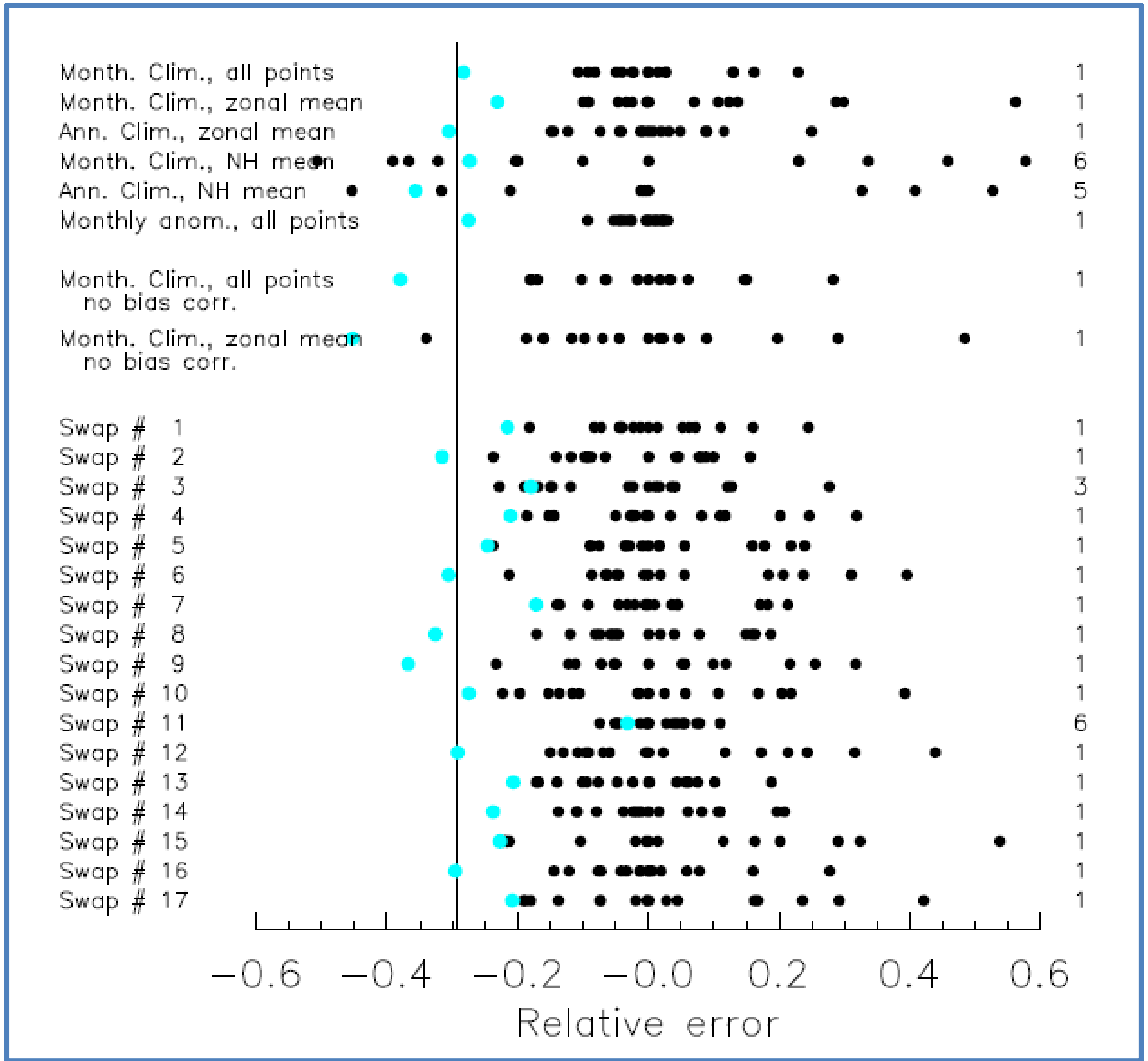
The relative ensemble error is often almost 30% smaller then individual members

B. Christiansen, 2017: Ensemble averaging and the curse of dimensionality. Submitted to *J. Clim.*, In review

Testing CMIP5 ensemble for seasonal cycle of SSTs



17 CMIP5 models

- ACCESS1.0
- BCC-CSM1.1
- BNU-ESM
- CanCM4
- CMCC-CESM
- EC-EARTH
- FGOALS-g2
- FIO-ESM
- GFDL-CM3
- GISS-E2-R-CC
- HadGEM2-ES
- INM-CM4
- IPSL-CM5A-LR
- MIROC-ESM
- MIROC5
- MPI-ESM-MR
- NorESM1-M

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Why CMIP? Why multi-model?

– An example of dealing with uncertainty in future Arctic sea ice condition

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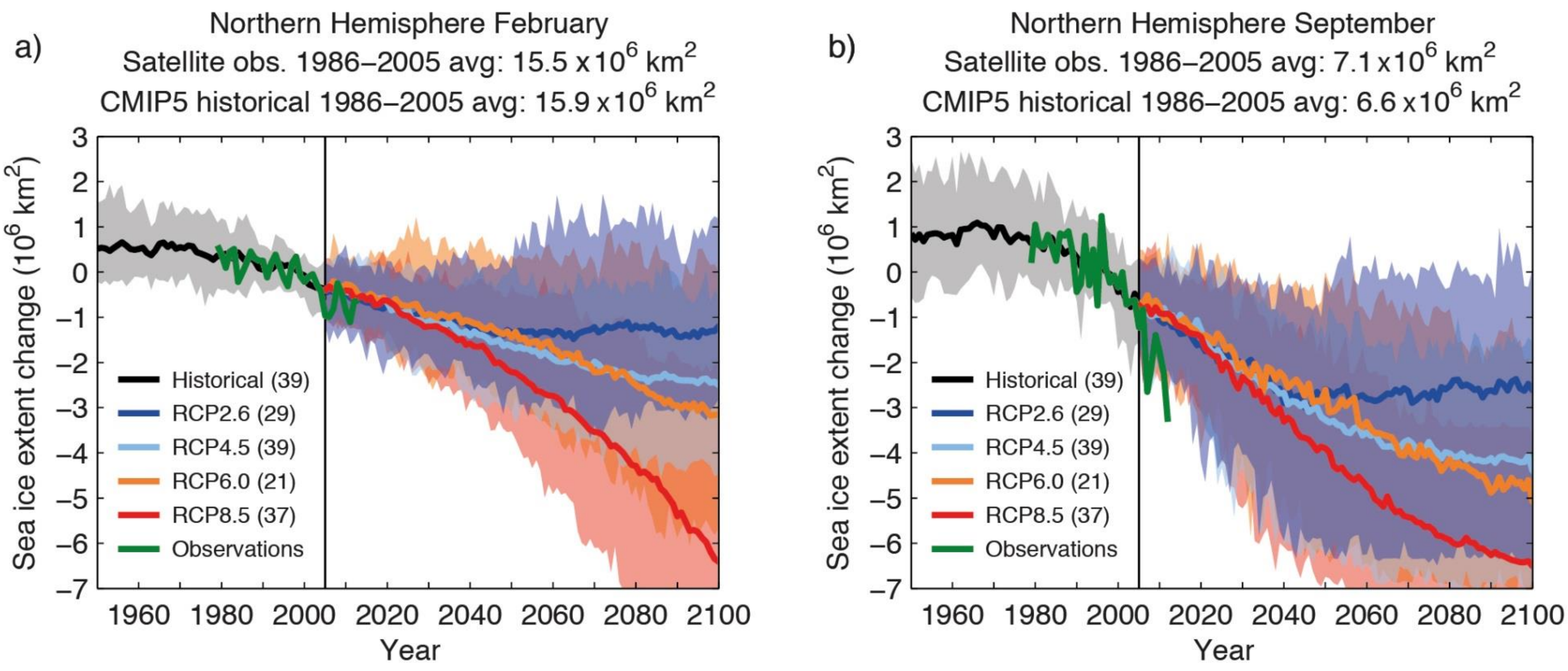
CMIP5 and sea ice projections



IPCC AR5

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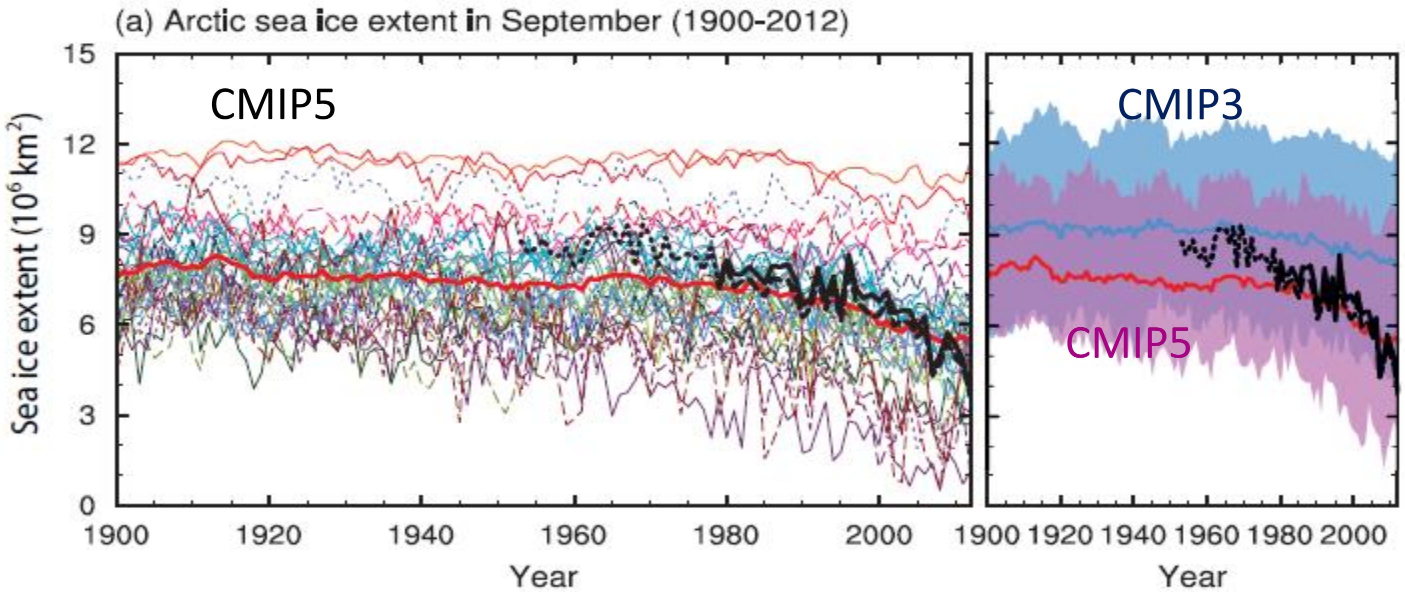
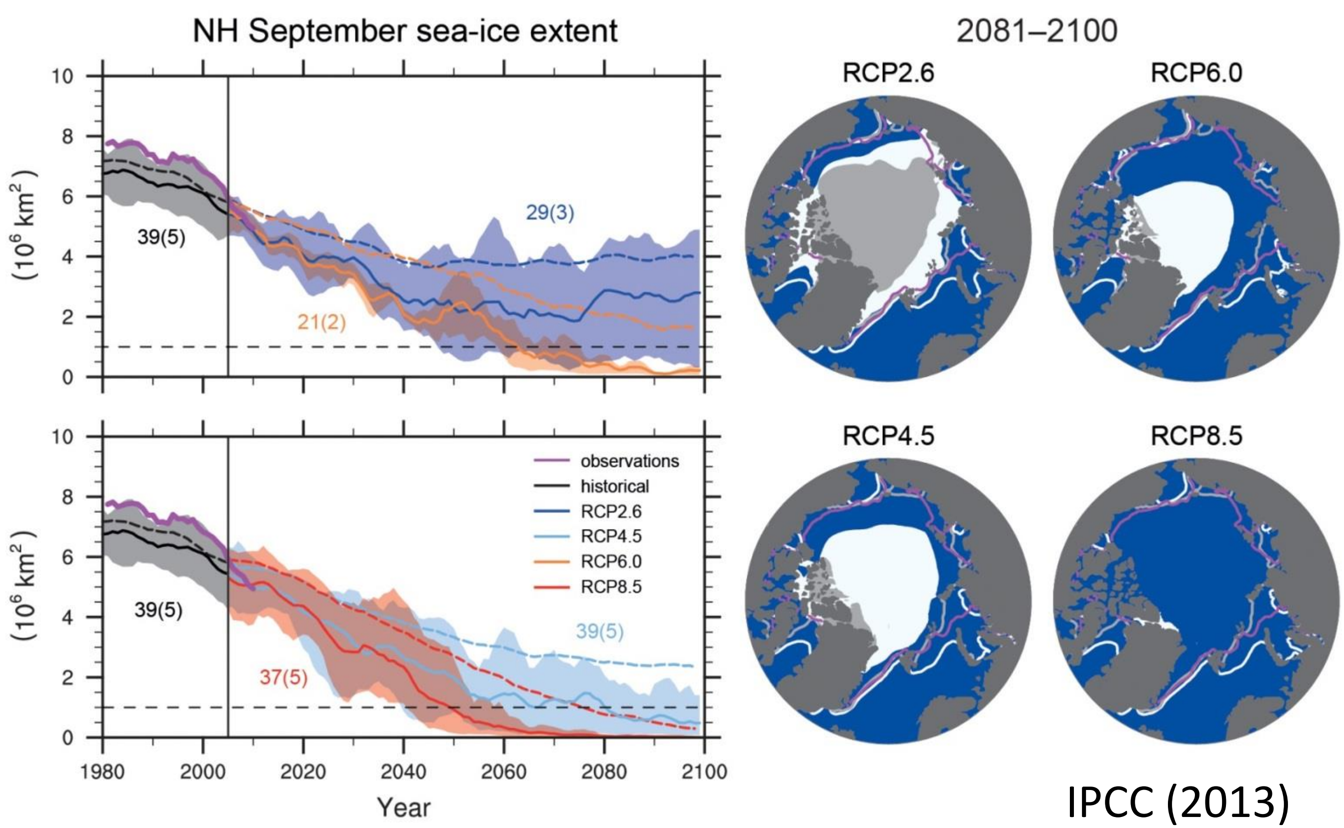
Selecting models

Only look at a subset of models that match observed climatology and trends





IPCC (2013)

- solid lines – mean of selected models
- dashed lines - mean of all models

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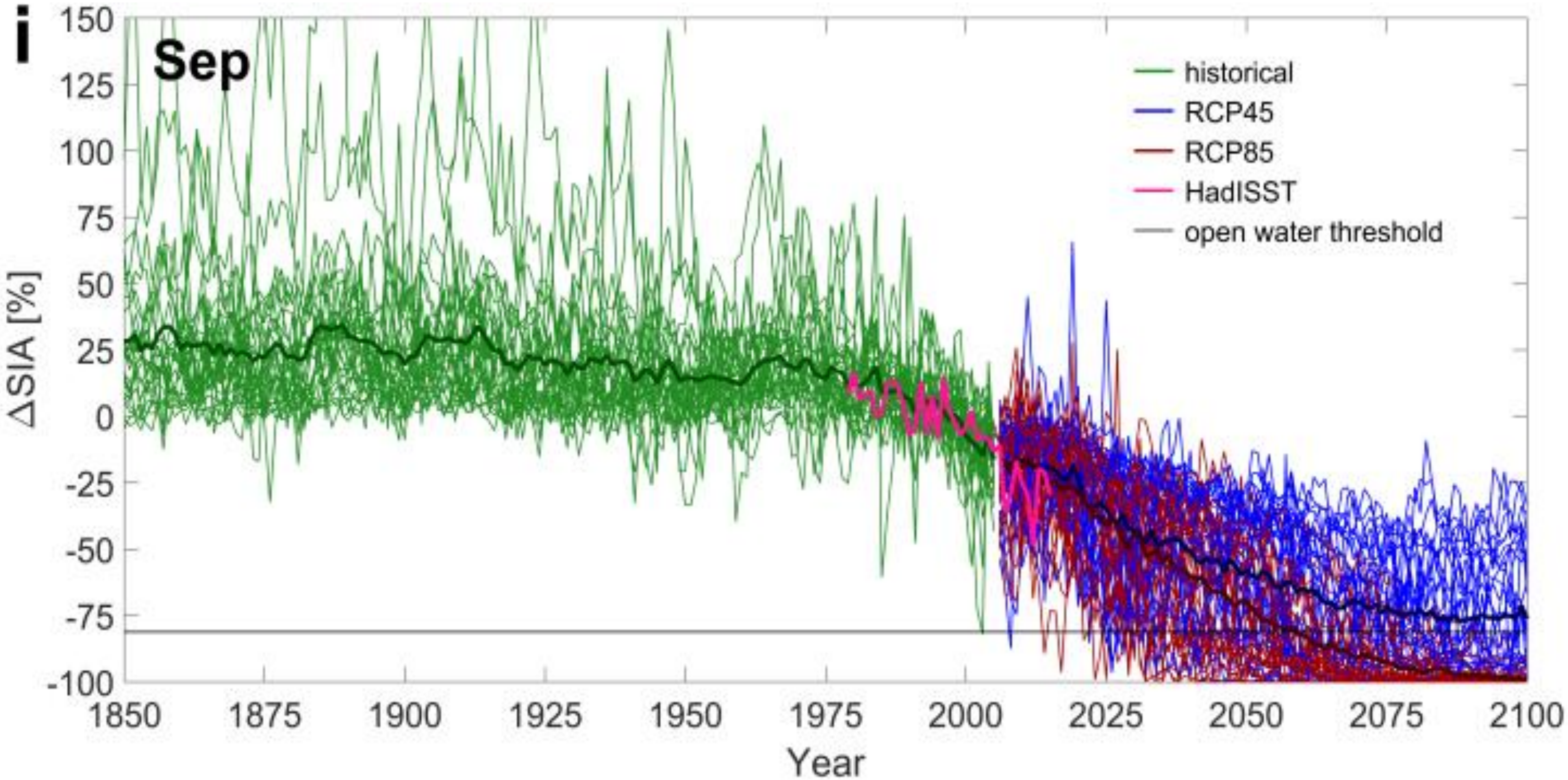
Using relative change



- A source for model spread comes from the large difference of the modelled baseline state.
- This motivates inspections of the **relative changes of sea ice area** (ΔSIA) rather than the absolute SIA.
- Models seem to lie in the range of observed variability during the satellite era (1979-present)

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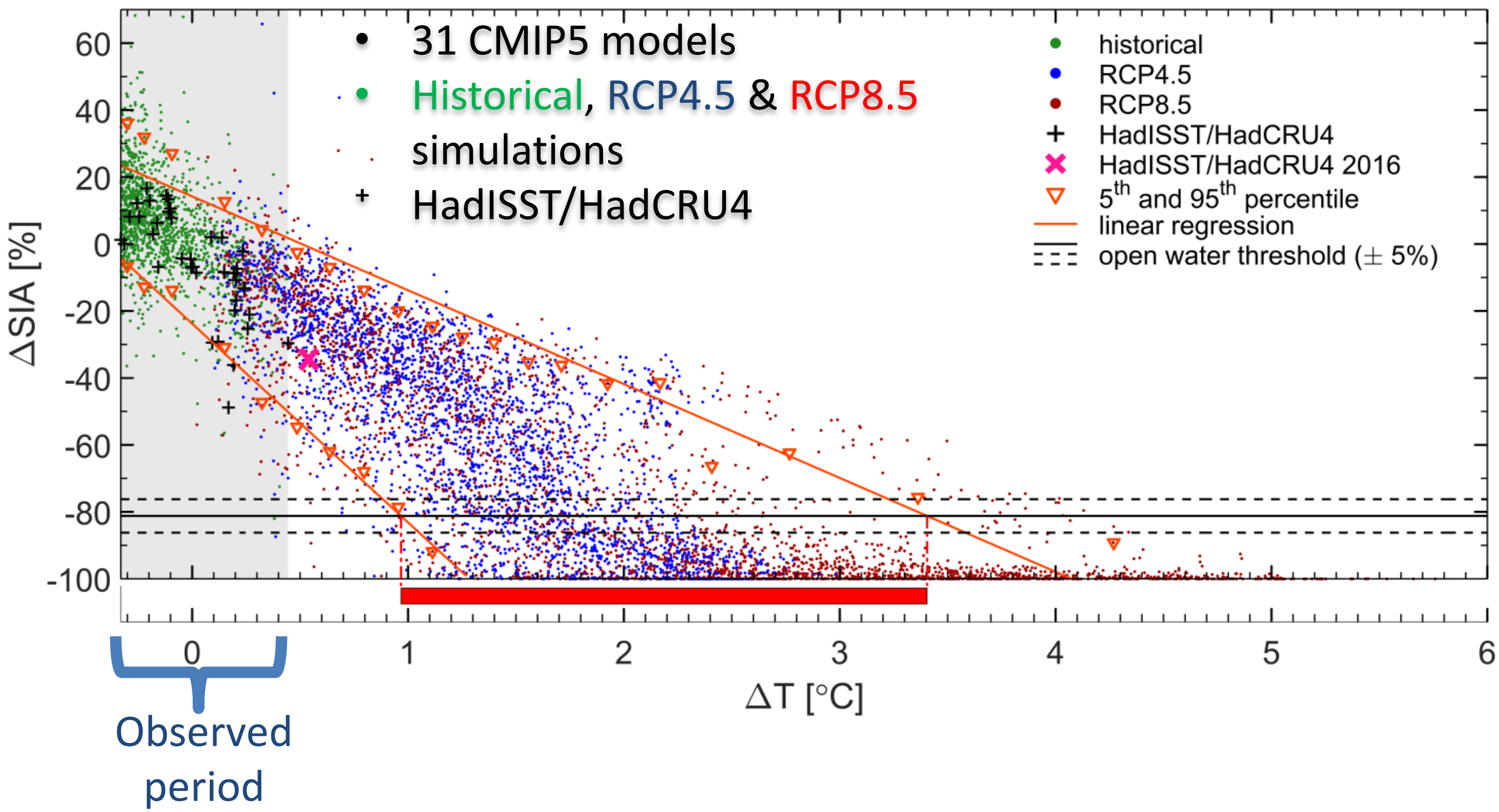
Combining all models and observations wrt. 1986-2005



1. **Are modelled and observed sea ice changes drawn from the same population?**
2. **Are modelled and observed sea ice change wrt. Global mean temperature change (ΔSIA/ΔT) drawn from the same population?**

The observed period

1. Are modelled and observed sea ice changes drawn from the same population?

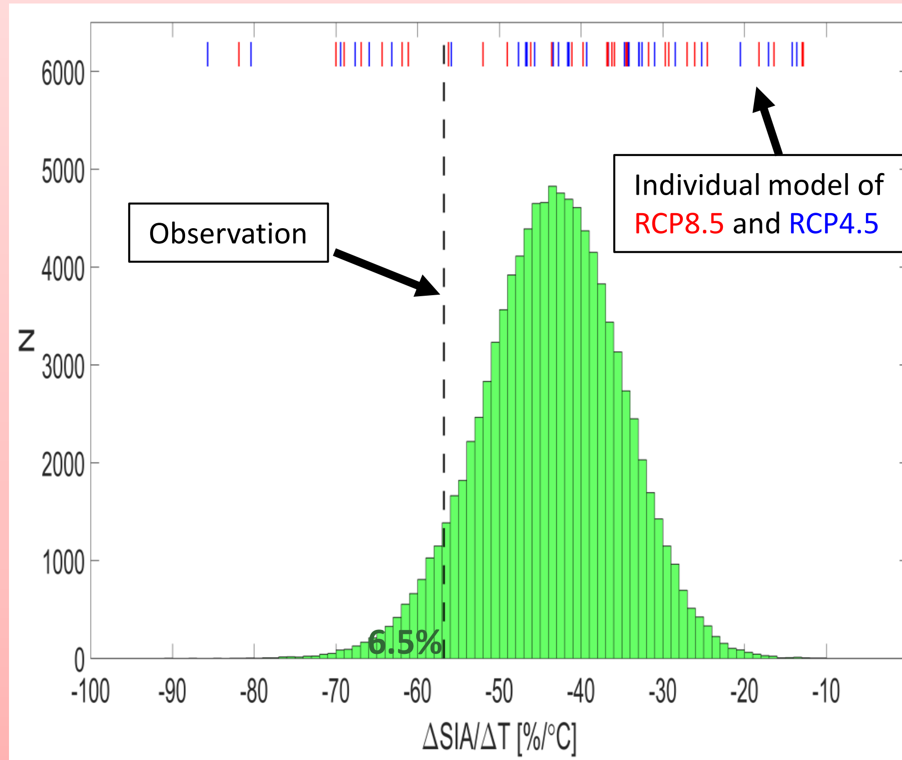
Kuiper test

Month	***p***
January	0.133
February	0.193
March	0.373
April	0.027*
May	0.272
June	0.758
July	0.858
August	0.121
September	0.467
October	0.300
November	0.272
December	0.229

- The ***p*** values are larger than 0.05 for all months except April (marked with an asterisk),
- Indicating that for these months we cannot, with 95% confidence, reject the Null hypothesis of the modelled and the observed sea ice changes being drawn from the same population

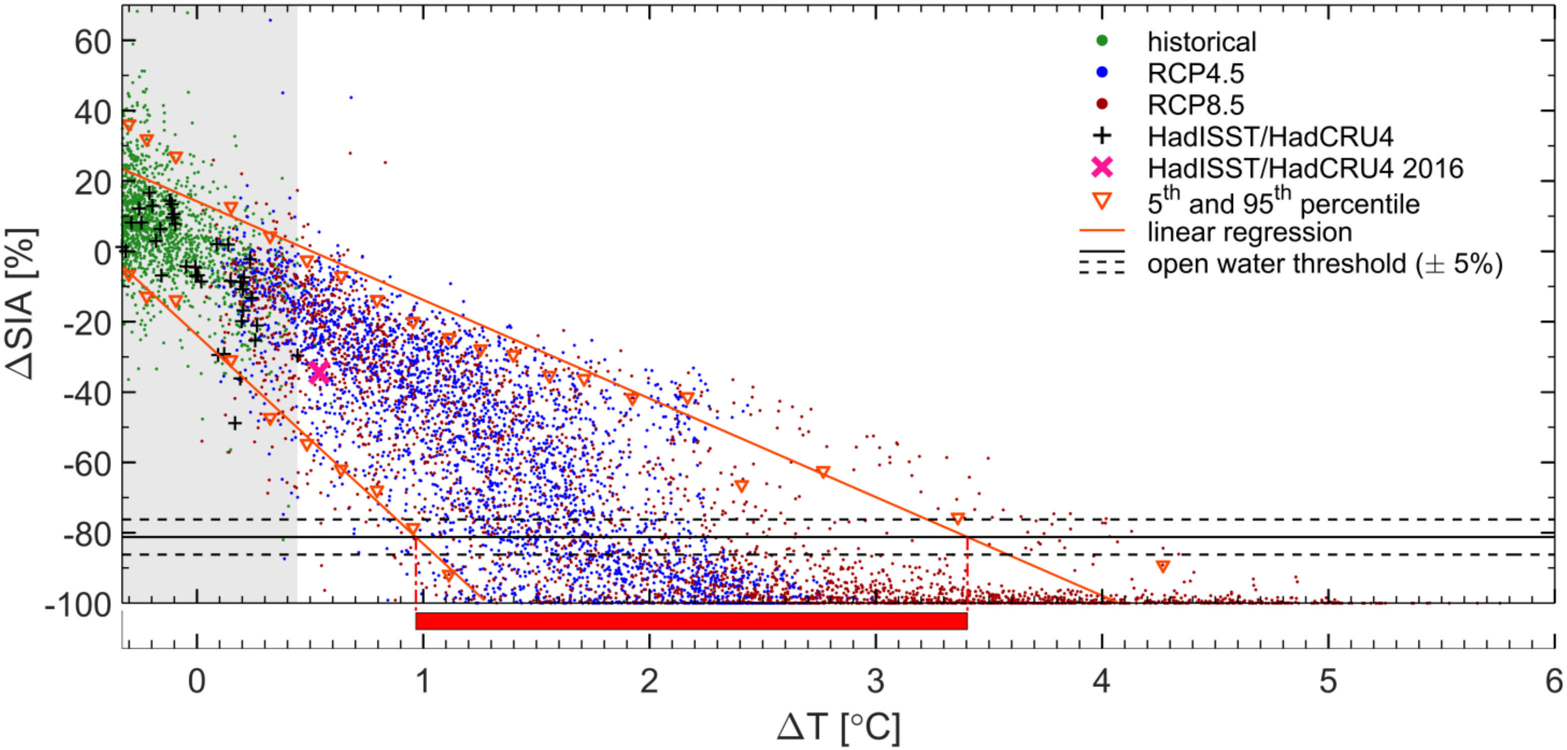
2. Are modelled and observed slope (ΔSIA/ΔT) drawn from the same population?

Slope from bootstrapped data {ΔSIA, ΔT}



- 6.5% of model slopes are MORE negative than observed – we cannot, at the 5% level, rule out that the observed slope is drawn from the same distribution as the model slopes.

Combining all models and observations wrt. 1986-2005



- Models and observations agree remarkably well on sea ice conditions throughout the year
  - when accounting for model biases (global mean temperature and sea ice conditions)
- Taken together all model projections imply that summer time ice free conditions are likely when ΔT exceeds 0.97°C wrt. 1986-2005, ie., 1.58°C above pre-industrial period

Yang et al, 2017, submitted to *Scientific Reports*

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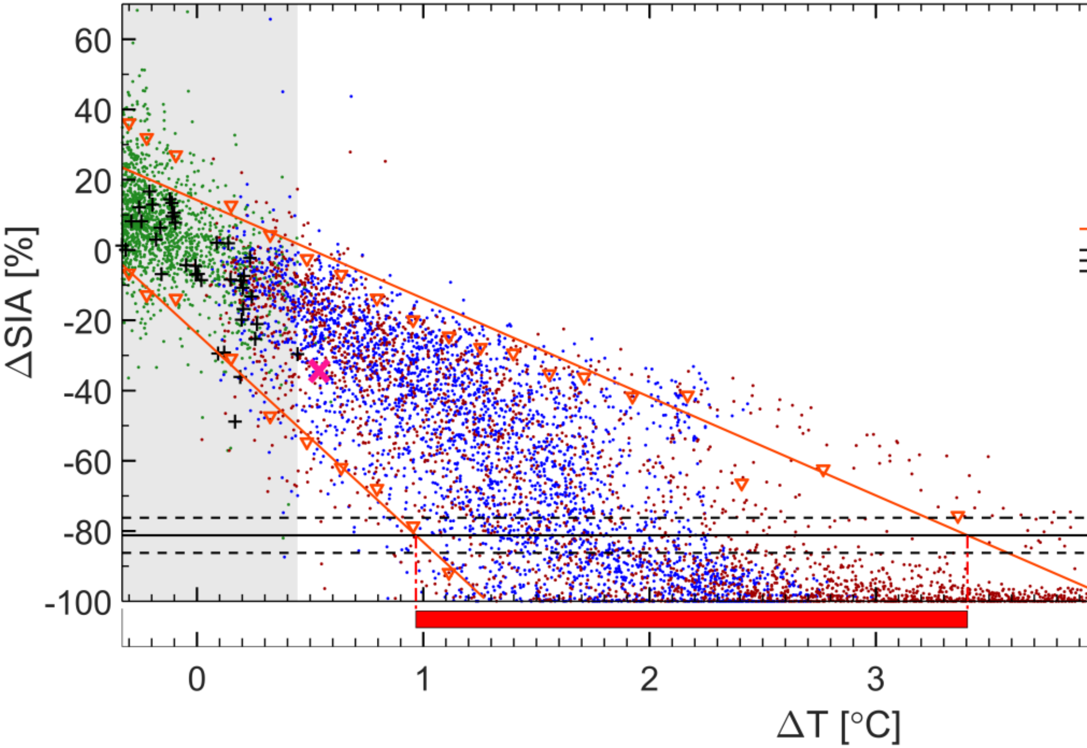
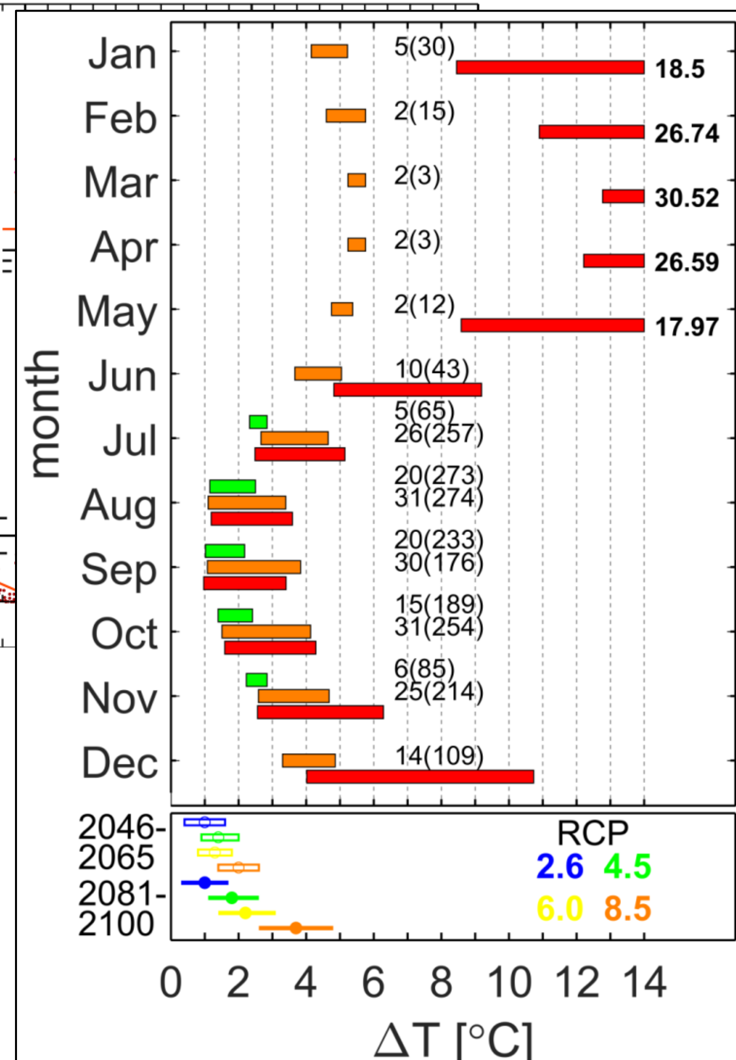
Combining all models and observations wrt. 1986-2005





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Summary

- CMIP has made a success over the last 20+ years
  - Made state-of art climate model simulations directly available to a broad international communities of climate scientists and impacts researchers
  - Analysis of CMIP multi-model database have formed the basics for the past IPCC assessment reports and various national assessments
- **Is there a need for coupled model intercomparison projects (CMIP) in the future? – Yes!**
  - Multi-model ensemble mean is an effective way to reduce errors and improve the assessment of future changes in comparison with estimates from individual models
  - Scientific questions need to be addressed – Coordinated experiments involving in large number of models and modelling groups have helped and will continue to improve our understanding of climate variability and changes
  - Climate models became more and more complex with more components incorporated in, which may potentially increase the uncertainty in model results
- Lessons learnt from past CMIP has led to new CMIP6 experiment design. "**Future CMIP efforts should focus more strongly on specific science questions while continuing to make model output available to a broad scientific community**." (Stouffer et al., *BAMS*, 2017)


Thank you!

CORDEX: a short walk through of how we got to where we are today

Colin Jones
University of Leeds & Rossby Centre

SMHI

WCRP CORDEX

A short walk through (my impression) of how we got to where we are today

Colin Jones

Head of UK Earth System Modelling

Previously somewhat involved in CORDEX

Where is CORDEX now ?

Pan-CORDEX Conferences and Workshops

Pan-CORDEX conferences:

- **CORDEX2011**, Trieste, about 150 participants
- **CORDEX2013**, Brussels, about 450 abstracts and more than 500 attendees
- **CORDEX2016,** Stockholm, more than 300 participants

- Regular CORDEX session at EGU, AGU etc
- Many regional workshops for specific CORDEX domains

CORDEX Management and Coordination

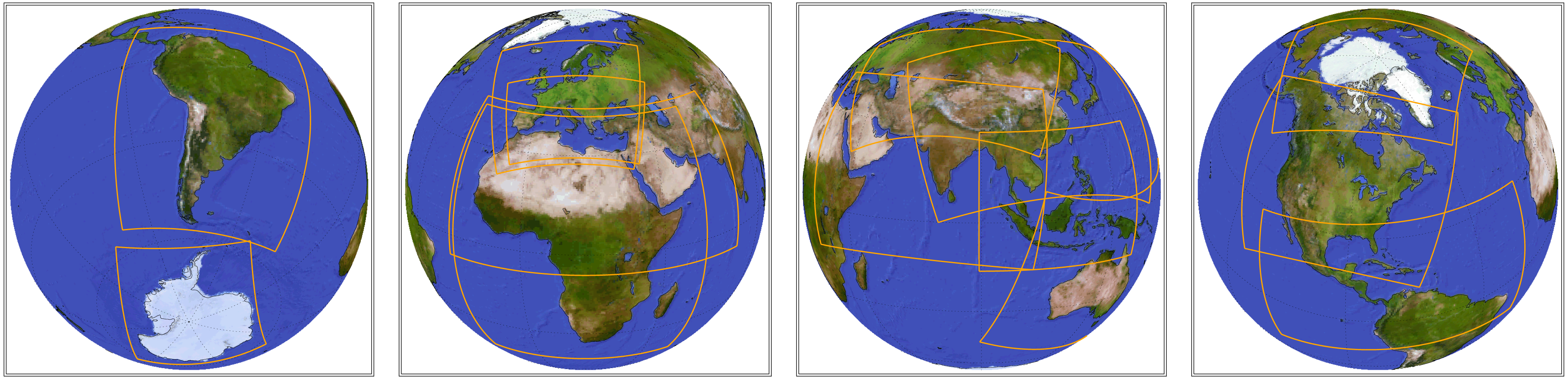
- CORDEX (WCRP project) has been running since 2009
- CORDEX **Science Advisory Team** (SAT), 12 members

- **International Project Office for CORDEX** (IPOC) hosted by SMHI since January 2015 (Irene Lake)
- Each CORDEX domain has 2-3 Points of Contacts (POCs)
- CORDEX archiving is coordinated by IS-ENES

CORDEX Phase I

- focus on downscaling of the CMIP5 results
- both dynamical (RCM) and statistical downscaling (ESD)
- RCM: about 40 groups in the CORDEX RCM list (+ 30 unregistered)
- ESD: 13 groups registered for the 1st ESD experiment (+ 30)

14 CORDEX domains

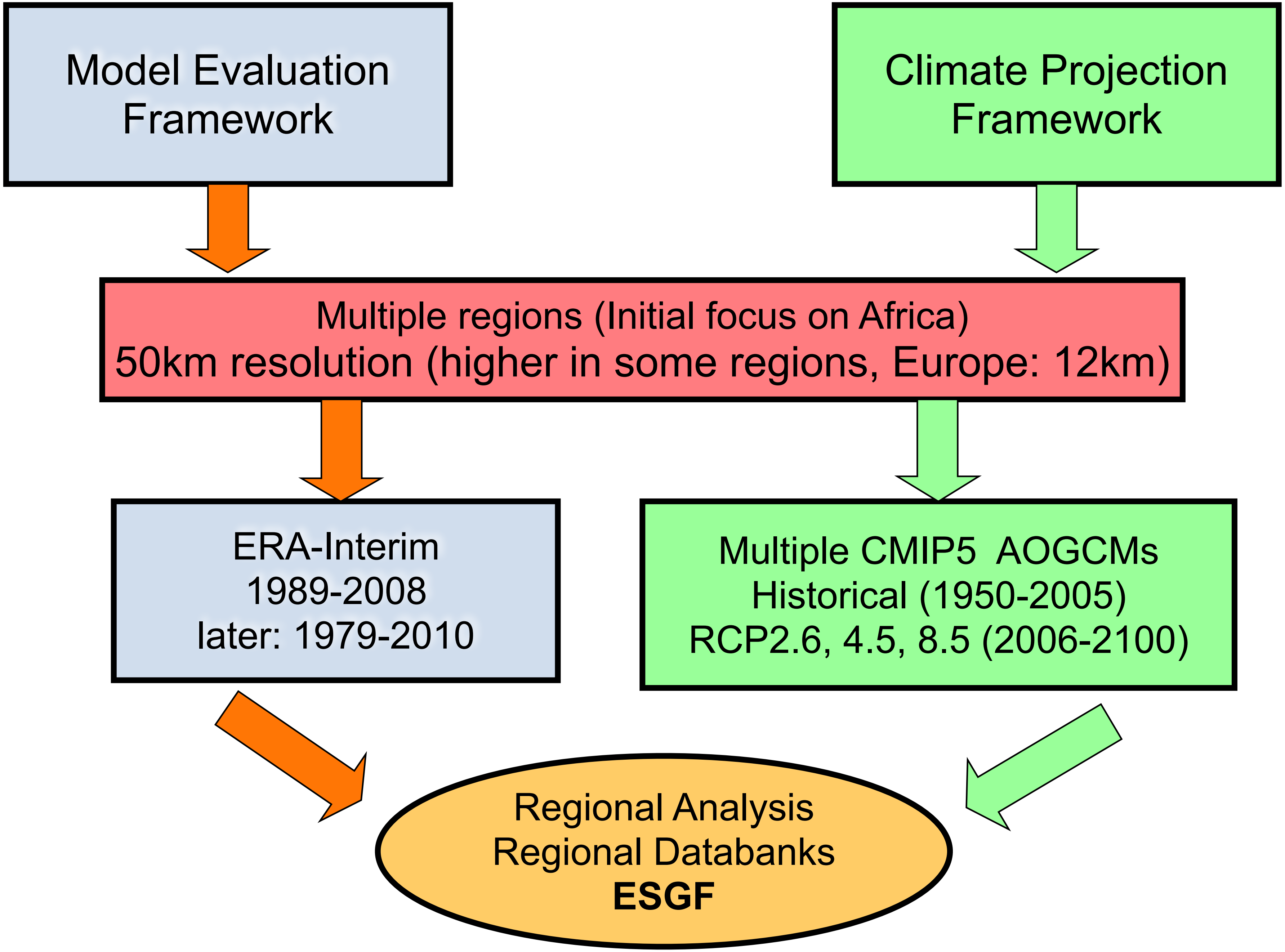


CORDEX simulations can be accessed using:

1. **Earth system Grid Federation (ESGF)**
2. **Data Portals (Med-CORDEX, South/East Asia, North America)**

- **CORDEX-Adjust:** bias-adjusted simulations on ESGF (Oct 2016)

CORDEX Phase I experiment design



CORDEX goals and vision

- To better understand relevant regional/local climate phenomena, their variability and changes, through downscaling.
- To evaluate and improve regional climate downscaling models and techniques
- To produce coordinated sets of regional downscaled projections for (land) regions worldwide
- To foster communication and knowledge exchange with users of regional climate information

The CORDEX vision is to advance and coordinate the science and application of regional climate downscaling through global partnerships

CORDEX Regional Training Workshops

- CORDEX Africa Analysis Campaign Phase 1: 4 training workshops (2011-2012)
- CORDEX Africa Analysis Campaign Phase 2: 2 workshops (2015/ 2016) and 4 upcoming workshops in 2017-2018
- 1st and 2nd WCRP CORDEX South Asia Training Workshops (Oct 2012 and Aug 2013)
- 1st and 2nd CORDEX Latin America and the Caribbean (LAC) training workshops (Sep 2013 and Apr 2014)
- SEACLID: South East Asia group formed and delivering data and training for SE Asia countries

Large interest in regional training workshops is very large and the long-term benefits are very significant. **Funding** as usual is a big problem

Looking back to how things developed

1st attempts at Regional Climate Downscaling

A regional climate model for the western United States

R.E. Dickinson, R. Errico, F.Giorgi and G. Bates: Climatic Change 1989

A numerical approach to modeling climate on a regional scale is developed whereby large-scale weather systems are simulated with a global climate model (GCM) and the GCM output provides boundary conditions needed for high-resolution mesoscale model simulations over the region of interest.

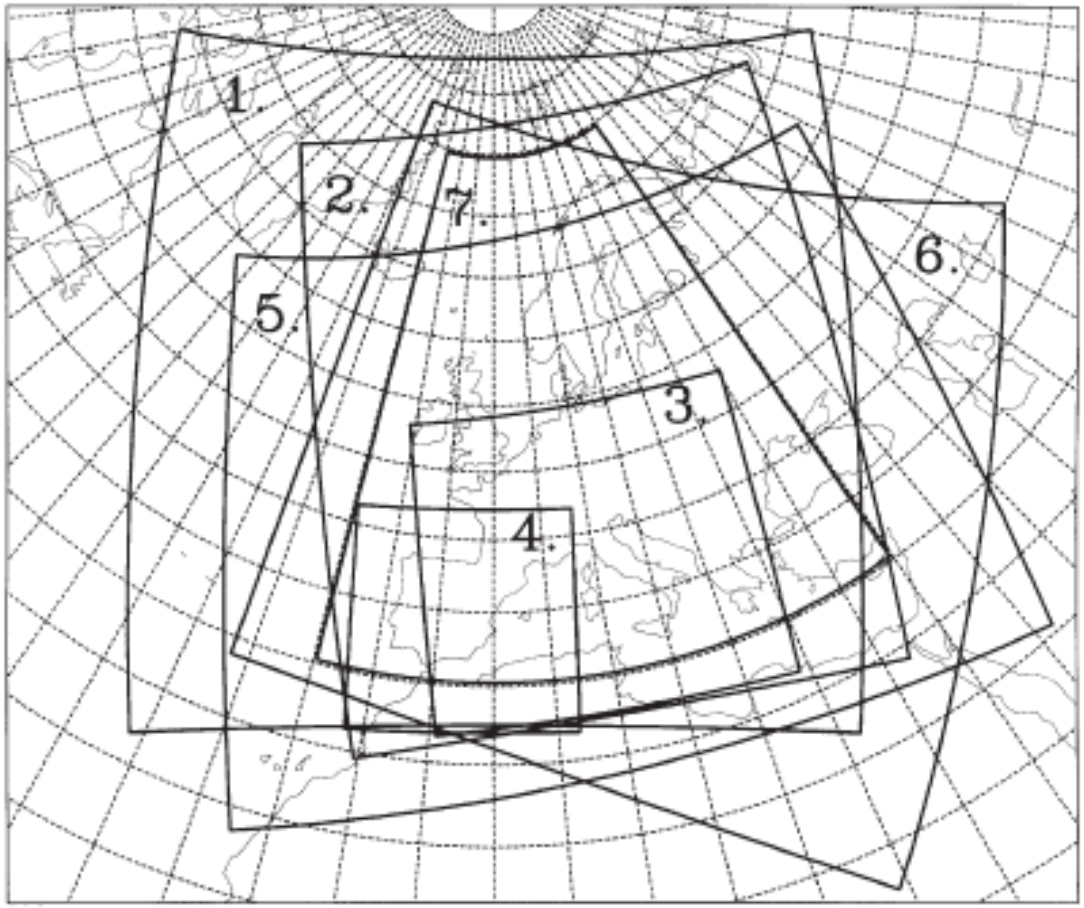
We simulate global climate for three years with CCM1/BATS and describe the January climatology over western U.S. Precipitation patterns are unrealistic because of the smooth topography. Selecting five January CCM1 storms over the western U.S. with a total duration of 20 days for simulation with the MM4, we demonstrate that the mesoscale model provides much improved wintertime precipitation patterns.

European Regional Climate Modelling started to develop in the 1990's

Validation of present-day regional climate simulations over Europe: LAM simulations with observed boundary conditions

J. H. Christensen, B. Machenhauer, R. G. Jones, C. Schär, P. M. Ruti, M. Castro, G. Visconti

Climate Dynamics 1997 : **No Swedish presence yet.**



Important milestones along the way to CORDEX Phase 1

- SWECLIM/Rossby Centre starts 1997: Development of RCA and RCAO

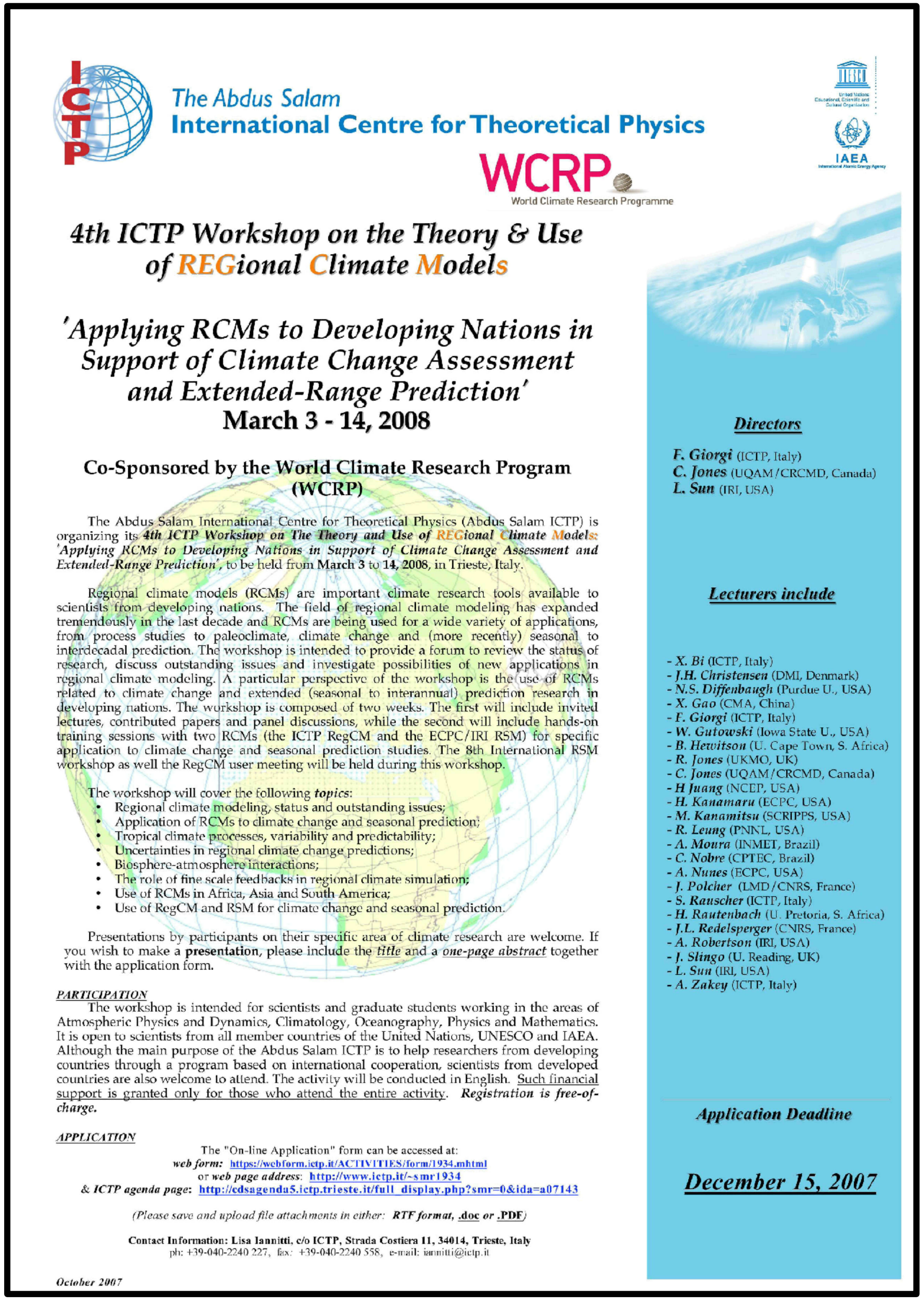
- EU project PRUDENCE 2001-2004 *(DMI, Jens Christensen coordinates)*
  Coordinated European RCM simulations sampling a matrix of GCMs and RCMs

- NARCCAP: *North American version of PRUDENCE*

- EU FP6 ENSEMBLES 2004 -2009
  GCMs and RCMs in the same project developing a matrix of GCM-RCM simulations targeting European climate change projections

- 1st and 2nd Lund Regional Climate scale workshop 2004 & 2009
  Representation of Regional modelling on the WGNE panel
  Ad-hoc WGNE panel of regional modelling

- 12th WGCM Paris Sept 2009 CMIP5 experiment protocols developed
  WGCM/CMIP5 agree to provide boundary condition data from key experiments for Regional climate downscaling: start of CORDEX activities.


The Abdus Salam
International Centre for Theoretical Physics

WCRP
World Climate Research Programme

IAEA

4th ICTP Workshop on the Theory & Use of REGional Climate Models

'Applying RCMs to Developing Nations in Support of Climate Change Assessment and Extended-Range Prediction'
March 3 - 14, 2008

Co-Sponsored by the World Climate Research Program (WCRP)

The Abdus Salam International Centre for Theoretical Physics (Abdus Salam ICTP) is organizing its ***4th ICTP Workshop on The Theory and Use of REGional Climate Models: 'Applying RCMs to Developing Nations in Support of Climate Change Assessment and Extended-Range Prediction'***, to be held from **March 3** to **14, 2008**, in Trieste, Italy.

Regional climate models (RCMs) are important climate research tools available to scientists from developing nations. The field of regional climate modeling has expanded tremendously in the last decade and RCMs are being used for a wide variety of applications, from process studies to paleoclimate, climate change and (more recently) seasonal to interdecadal prediction. The workshop is intended to provide a forum to review the status of research, discuss outstanding issues and investigate possibilities of new applications in regional climate modeling. A particular perspective of the workshop is the use of RCMs related to climate change and extended (seasonal to interannual) prediction research in developing nations. The workshop is composed of two weeks. The first will include invited lectures, contributed papers and panel discussions, while the second will include hands-on training sessions with two RCMs (the ICTP RegCM and the ECPC/IRI RSM) for specific application to climate change and seasonal prediction studies. The 8th International RSM workshop as well the RegCM user meeting will be held during this workshop.

The workshop will cover the following ***topics***:

- Regional climate modeling, status and outstanding issues;
- Application of RCMs to climate change and seasonal prediction;
- Tropical climate processes, variability and predictability;
- Uncertainties in regional climate change predictions;
- Biosphere-atmosphere interactions;
- The role of fine scale feedbacks in regional climate simulation;
- Use of RCMs in Africa, Asia and South America;
- Use of RegCM and RSM for climate change and seasonal prediction.

Presentations by participants on their specific area of climate research are welcome. If you wish to make a **presentation**, please include the *title* and a *one-page abstract* together with the application form.

PARTICIPATION

The workshop is intended for scientists and graduate students working in the areas of Atmospheric Physics and Dynamics, Climatology, Oceanography, Physics and Mathematics. It is open to scientists from all member countries of the United Nations, UNESCO and IAEA. Although the main purpose of the Abdus Salam ICTP is to help researchers from developing countries through a program based on international cooperation, scientists from developed countries are also welcome to attend. The activity will be conducted in English. Such financial support is granted only for those who attend the entire activity. ***Registration is free-of-charge.***

APPLICATION

The "On-line Application" form can be accessed at:
web form: https://webform.ictp.it/ACTIVITIES/form/1934.mhtml
or ***web page address***: http://www.ictp.it/~smr1934
& ***ICTP agenda page***: http://cdsagenda5.ictp.trieste.it/full_display.php?smr=0&ida=a07143

(Please save and upload file attachments in either: ***RTF format, .doc or .PDF****)*

Contact Information: Lisa Iannitti, c/o ICTP, Strada Costiera 11, 34014, Trieste, Italy
ph: +39-040-2240 227, fax: +39-040-2240 558, e-mail: iannitti@ictp.it

October 2007

Directors

F. Giorgi (ICTP, Italy)
C. Jones (UQAM/CRCMD, Canada)
L. Sun (IRI, USA)

Lecturers include

- *X. Bi* (ICTP, Italy)
- *J.H. Christensen* (DMI, Denmark)
- *N.S. Diffenbaugh* (Purdue U., USA)
- *X. Gao* (CMA, China)
- *F. Giorgi* (ICTP, Italy)
- *W. Gutowski* (Iowa State U., USA)
- *B. Hewitson* (U. Cape Town, S. Africa)
- *R. Jones* (UKMO, UK)
- *C. Jones* (UQAM/CRCMD, Canada)
- *H Juang* (NCEP, USA)
- *H. Kanamaru* (ECPC, USA)
- *M. Kanamitsu* (SCRIPPS, USA)
- *R. Leung* (PNNL, USA)
- *A. Moura* (INMET, Brazil)
- *C. Nobre* (CPTEC, Brazil)
- *A. Nunes* (ECPC, USA)
- *J. Polcher* (LMD/CNRS, France)
- *S. Rauscher* (ICTP, Italy)
- *H. Rautenbach* (U. Pretoria, S. Africa)
- *J.L. Redelsperger* (CNRS, France)
- *A. Robertson* (IRI, USA)
- *J. Slingo* (U. Reading, UK)
- *L. Sun* (IRI, USA)
- *A. Zakey* (ICTP, Italy)

Application Deadline

December 15, 2007

Regions around the globe need to feel and actually have “ownership” of climate scenarios produced for their regions.

This will increase uptake of such information by regional planners and policymakers

Requires production of regional climate projections for all land regions on the globe.

With active involvement and leadership from scientists local to and working in each region.

- Feb 2009: Workshop on Evaluating/Improving Regional Projections, Toulouse
  International RCM groups agree to target a 1st coordinated set of projections for Africa.

- Summer 2009 CORDEX project formally started under WCRP auspices
  CORDEX Science Advisory Team formed to guide planning (Giorgi & Jones co-chair)

- June 2010: WCRP Regional Climate Workshop: Lille
  1st CORDEX experiment protocol developed and LBC request to CMIP5 agreed

- March 2011: 1st International CORDEX Conference, Trieste
  1st CORDEX experiments (length, domains, resolution etc) agreed
  Agreement to produce common diagnostics in common file format (CMIP5 standards)
  Begin discussing distributing CORDEX data via the Earth System Grid Federation (ESGF)
  is-ENES project coordinates CORDEX ESGF efforts: DKRZ, IPSL, BADC, SMHI-LiU

- Late 2011 onwards: 1st CORDEX downscaling of CMIP5 projections made

- Late 2012 onwards: 1st CORDEX data becomes available on the ESGF

- Sept 2013 : 2nd CORDEX conference in Brussels
  CORDEX becomes "of interest" to IPCC

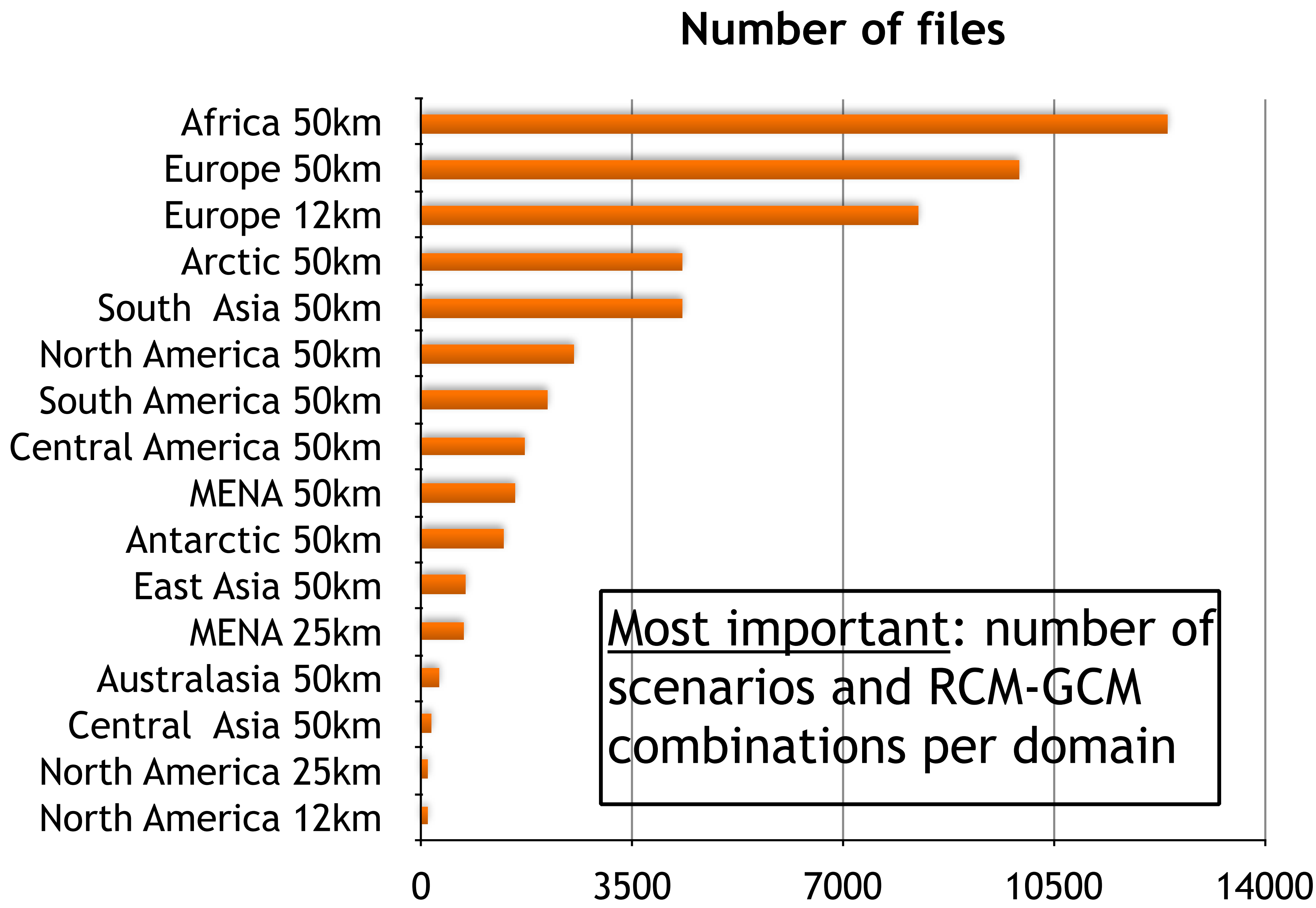
CORDEX ESGF nodes

Distributing quality-controlled, standardised simulation data

CORDEX ESGF nodes

SMHI-NSC, Sweden, DMI, Denmark, DKRZ, Germany
BADC, UK, IPSL, France, University of Cantabria, Spain
IITM, India, KMA Korea ?

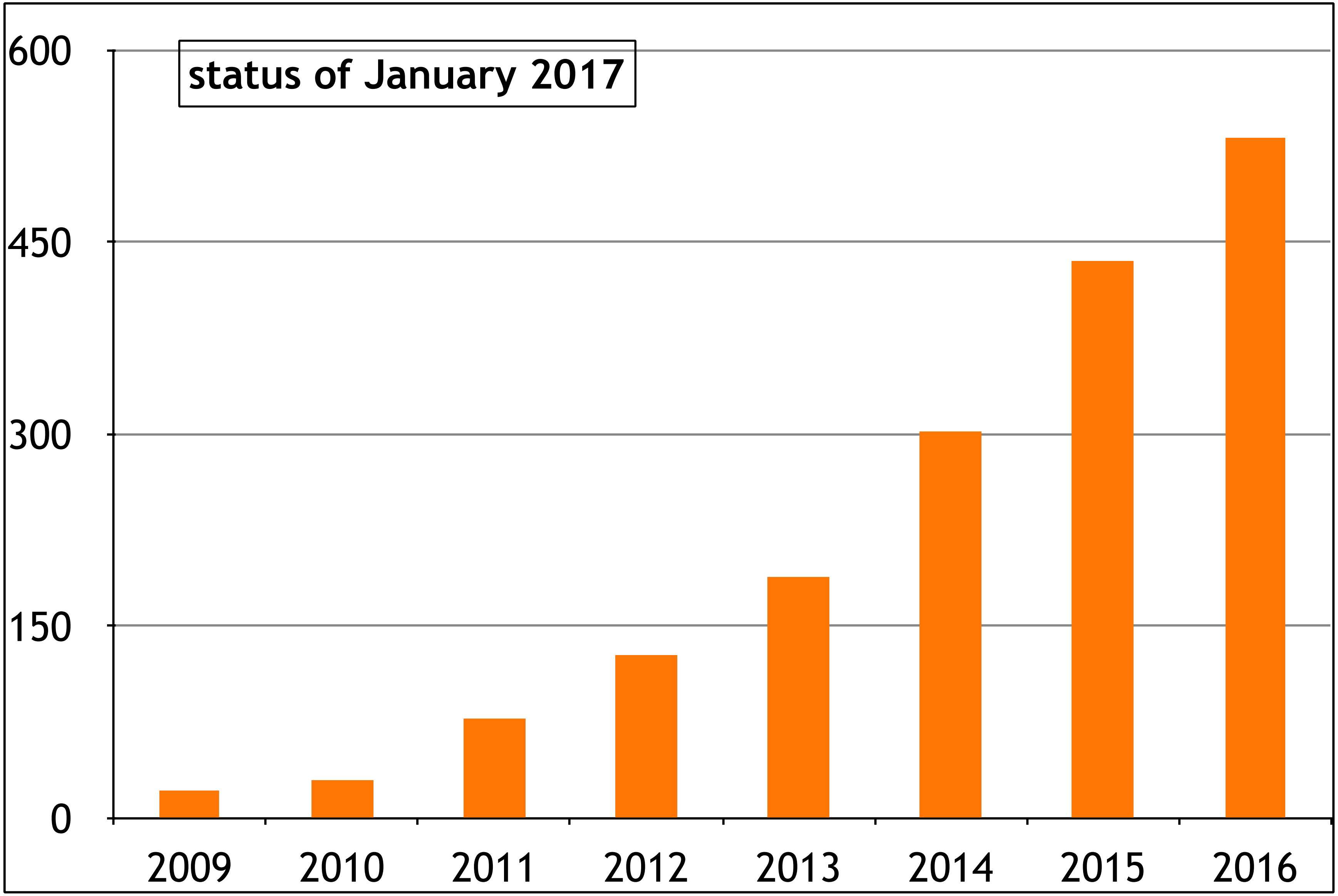
CORDEX data on ESGF



provided by DKRZ (Jan 2017)

CORDEX-related articles

searching for CORDEX & RCM & climate in Google Scholar



CORDEX going forwards ?

- **CMIP6 diagnostic MIP**
  New ESM data for new Regional Climate Downscaling
- **CORDEX FPS**
  Convection resolving, coupled RCMs, Regional Environmental models
- **Continue capacity building**
  Data, training, interaction, information for/with developing countries

Rossby Centre 20 År
13-14 SEPT 2017
NORRKÖPING, SVERIGE

Experiences from supporting development of climate services in Finland

Hilppa Gregow
FMI

SMHI

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FINNISH METEOROLOGICAL INSTITUTE

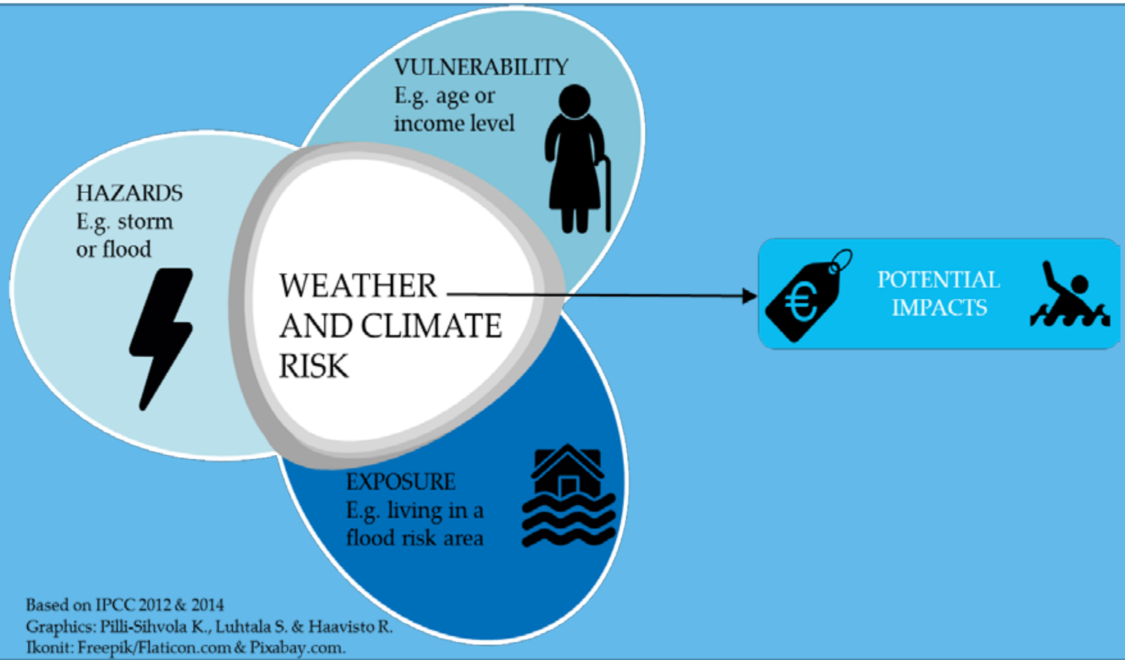
Experiences from supporting development of climate services in Finland

Rossby Center 20 year jubileum 14.9.2017 Norrköping

Dr. Hilppa Gregow

Head of Unit, Climate Service Centre (2014 -> 2017)

Head of Unit, Weather and Climate Change Impact Research (2018 -> 2021)



Outline

1. Some reflections from past years
2. Highlights from where we are now
3. Future emphasis – where new collaboration could form?

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Climate and Energy Systems - CES (http://en.vedur.is/ces/project/) kick-off at Dynamicum Helsinki 29.5.2007

Ari Venäläinen and Grigory Nikulin
Riederalp 2009 Workshop (ENSEMBLES)

PRUDENCE, Toledo, v. 2004 e.g.,
Kirsti Jylhä, Erik Kjellström and Lars Bärring

Collaboration moments within climate research: FMI and Rossby Centre

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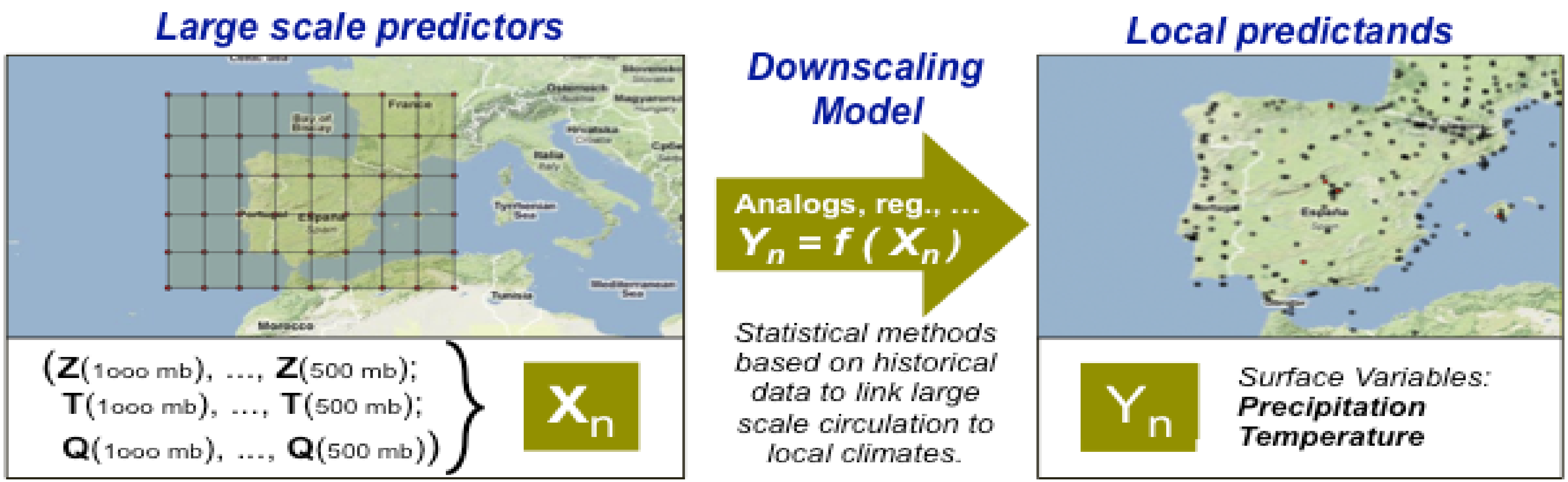
Lund 2011: Statistical downscaling was much discussed in SARMA WS



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FINNISH METEOI

Nordic Energy Rese

Conference on Future Climate and Renewable Energy: Impacts, Risks and Adaptation

31 May - 2 June 2010
Soria Moria Hotel and Conference Center, Oslo, Norway

Conference proceedings

INTERNATIONAL
JOURNAL OF CLIMATOLOGY

Tellus SERIES A DYNAMIC METEOROLOGY AND OCEANOGRAPHY
ED BY THE INTERNATIONAL METEOROLOGICAL INSTITUTE IN STOCKHOLM

Tellus SERIES A DYNAMIC METEOROLOGY AND OCEANOGRAPHY
PUBLISHED BY THE INTERNATIONAL METEOROLOGICAL INSTITUTE IN STOCKHOLM

Tellus (2011), 63A, 41–55

TELLUS

Evaluation and future projections of temperature precipitation and wind extremes over Europe in an ensemble of regional climate simulations

By GRIGORY NIKULIN*, ERIK KJELLSTRÖM, ULF HANSSON, GUSTAV STRANDB
and ANDERS ULLERSTIG, *Rossby Centre, SMHI, SE 60196 Norrköping, Sweden*

(Manuscript received 28 October 2009; in final form 28 April 2010)

ABSTRACT

Temperature, precipitation and wind extremes over Europe are examined in an ensemble of RCA3 regional climate model simulations driven by six different global climate models (ECHAM5, CCSM3, HadCM3, CNRM, BCM and IPSL) under the SRES A1B emission scenario. The extremes are expressed in terms of the 20-yr return values of annual temperature and wind extremes and seasonal precipitation extremes.

The ensemble shows reduction of recurrence time of warm extremes from 20 yr in 1961–1990 (CTL) to 1–2 yr over southern Europe and to 5 yr over Scandinavia in 2071–2100 (SCN) while cold extremes, defined for CTL, almost

INTERNATIONAL JOURNAL OF CLIMATOLOGY
Int. J. Climatol. **32**: 1834–1846 (2011)
Published online 2 August 2011 in Wiley Online Library
(wileyonlinelibrary.com) DOI: 10.1002/joc.2398

RMetS
Royal Meteorological Soci

Changes in the mean and extreme geostrophic wind spee in Northern Europe until 2100 based on nine global climate models

Hilppa Gregow,* Kimmo Ruosteenoja, Natalia Pimenoff and Kirsti Jylhä
Finnish Meteorological Institute, Helsinki, Finland

ABSTRACT: This study aims at analyzing the mean and extreme geostrophic wind speeds in Northern Europe. T analyses are based on nine global climate models and the Special Report on Emission Scenarios (SRES) A1B, A2 and I scenarios. The time frames studied consist of the baseline 1971–2000 and the future periods 2046–2065 and 2081–210 The SRES scenarios are considered both separately and combined. The extremes are calculated for the September–Ap period for various return periods. The analysis is done by applying the program R and the Generalized Extreme Val -methodology.

All projections indicate that both the mean and extreme geostrophic wind speeds will increase in the southern a eastern parts of Northern Europe and decrease over the Norwegian Sea in September–April. The change over the ocean pronounced already in 2046–2065, over the continents in 2081–2100. For the model mean, the smallest change (2–6 was projected under the B1 and the largest (4–10%) under the A1B and A2 scenarios. However, spread among t individual global circulation models (GCMs) was fairly large.

The ratios between the return level estimates for various return periods and the annual maximum wind speeds we found nearly homogeneously independent of the time frame studied. For the baseline and future periods, the extreme win

Highlights from where we are now

CCA and DRR expert support and research especially in developing countries

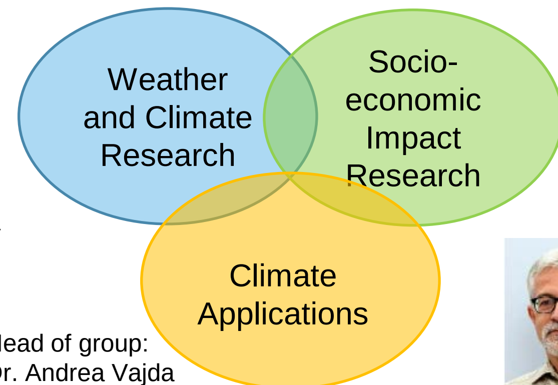
On-going   In preparation   Scientific research

Finalised cooperation and consultation project

Research and Service Unit: Climate service centre was established in 2014

1. We do MULTIDISCIPLINARY climate change research
2. We investigate the economic benefits of weather and climate services
3. We focus on improving scientific communication
4. We develop monthly to seasonal forecast products
5. Our main sectorial focus: energy and infrastructure, construction, agriculture, forestry, water and education – health is emerging

Head of group:
Dr. Antti Mäkelä



Head of group:
Dr. Heikki Tuomenvirta

CLIMATE-GUIDE

Head of group:
Dr. Andrea Vajda

Head of unit:
Dr. Hilppa Gregow

Research Professor:
Dr. Adriaan Perrels

http://en.ilmatieteenlaitos.fi/climate-service-centre

One example of multidisciplinary work: soils, forests, weather and climate.

Roundwood removals

Frozen soil with estimate
By using soil temperature
and air temperature

Yesterday we got news that this poster has been given the EMS2017: Outstanding Poster Award

18.9.2017

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FINNISH METEOROLOGICAL INSTITUTE

Luke NATURAL RESOURCES INSTITUTE FINLAND

HELSINGIN YLIOPISTO HELSINGFORS UNIVERSITET UNIVERSITY OF HELSINKI

UNIVERSITY OF EASTERN FINLAND

High-resolution projections for soil frost conditions in Finland with regard to timber harvesting and transport availability

Ilari Lehtonen[1], Ari Venäläinen[1], Juha Laitila[2], Mikko Strahlendorff[1], Matti Kämäräinen[1], Juha Aalto[1,3], Andrea Vajda[1], Hilppa Gregow[1] and Heli Peltola[4]

[1] Finnish Meteorological Institute, Helsinki, Finland
[2] Natural Resources Institute Finland, Joensuu, Finland
[3] Department of Geosciences and Geography, University of Helsinki, Helsinki, Finland
[4] School of Forest Sciences, University of Eastern Finland, Joensuu, Finland

Sprruce and clay soils
Pine and sandy soils

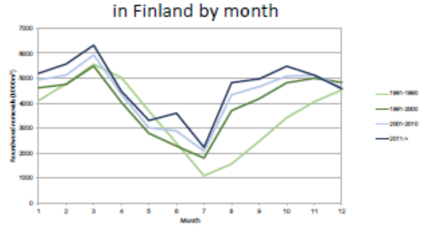


Fig. 1. Average industrial roundwood removals in Finland by month during the periods 1981–1990, 1991–2000, 2001–2010 and 2011 onwards.

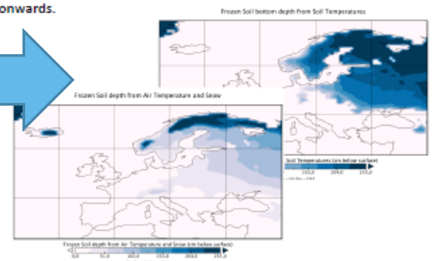
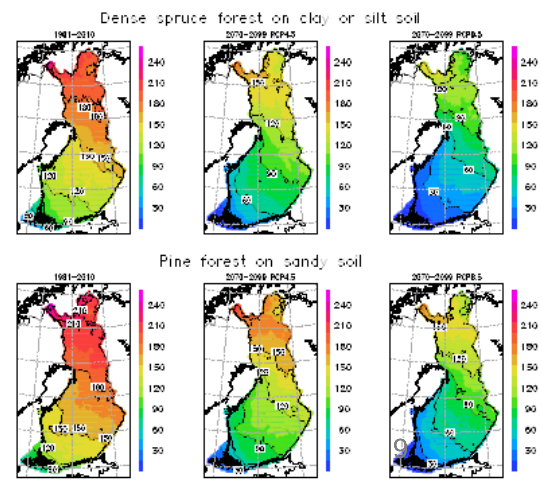


Fig. 3. An example of frozen soil depth on 20 Mar 2006 derived directly from the ERA-Interim soil layer temperatures (top) and calculated with a simple soil frost model by using the ERA-Interim air temperature and snow data (bottom).

Background

- Timber has been traditionally harvested in Finland mainly in wintertime.
- This is partly due to historical reasons; in countryside agriculture has been traditionally practised in summer and forestry in winter.
- Nowadays, approximately 60% of logging in Finland is carried out while the soil is frozen, although logging in late summer and early autumn has increased during recent decades (Fig. 1).
- Bearing capacity of frozen soil enables the use of heavy forest harvesters.
- Small forest truck roads having light foundations do not bear heavy timber trucks in wet road sections unless the soil is frozen.
- Climate or numerical weather prediction models do not capture the freezing of the soil correctly. Freezing in the model soil layers is typically too intense (Fig. 3).

Fig. 2. Poor bearing conditions decrease the efficiency of forest harvesting operations.



Motivation

- Climate change is expected to have a negative impact on timber harvesting and transport conditions due to reduced soil frost depth and shorter duration of soil frost period.

Materials and methods

- We used a soil frost model (Rankinen *et al.* 2004; Jungqvist et al. 2014)

Another example from multidisciplinary research

www.nature.com/scientificreports

SCIENTIFIC REPORTS

OPEN

Increasing large scale windstorm damage in Western, Central and Northern European forests, 1951–2010

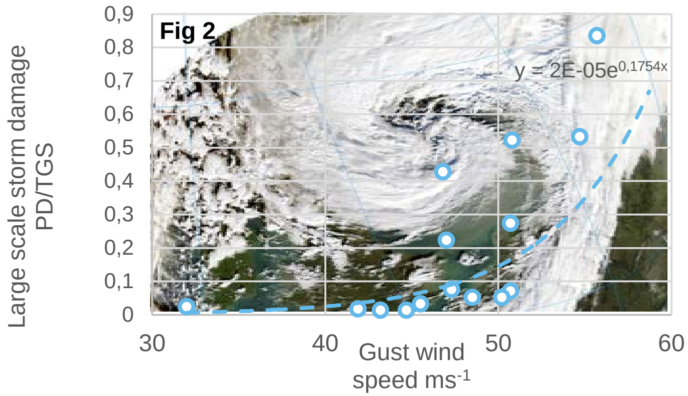
Received: 27 July 2016
Accepted: 17 March 2017
Published: 12 April 2017

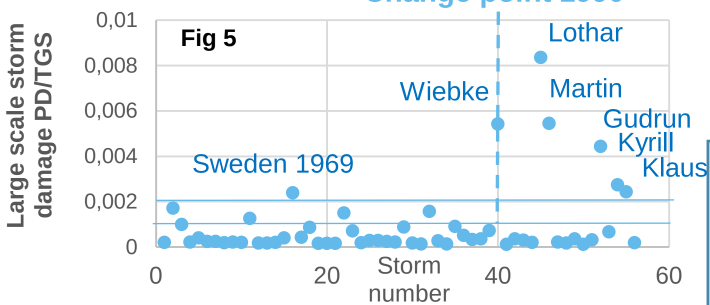
H. Gregow[1], A. Laaksonen[1,2] & M. E. Alper[1]

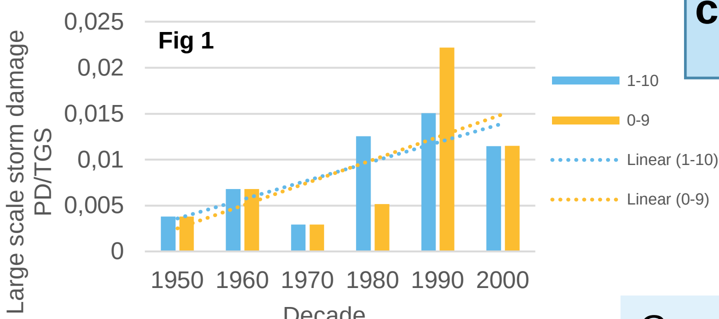
Using reports of forest losses caused directly by large scale windstorms (or primary damage, PD) from the European forest institute database (comprising 276 PD reports from 1951–2010), total growing stock (TGS) statistics of European forests and the daily North Atlantic Oscillation (NAO) index, we identify a statistically significant change in storm intensity in Western, Central and Northern Europe (17 countries). Using the validated set of storms, we found that the year 1990 represents a change-point at which the average intensity of the most destructive storms indicated by PD/TGS $>$ 0.08% increased by more than a factor of three. A likelihood ratio test provides strong evidence that the change-point represents a real shift in the statistical behaviour of the time series. All but one of the seven catastrophic storms (PD/TGS $>$ 0.2%) occurred since 1990. Additionally, we detected a related decrease in September–November PD/TGS and an increase in December–February PD/TGS. Our analyses point to the possibility that the impact of climate change on the North Atlantic storms hitting Europe has started during the last two and half decades.

Increasing intensities of catastrophic storms hitting Europe in 1951-2010 (AMS 2017)

Dr. Hilpa Gregow[1], Prof. Ari Laaksonen[1,2], Dr. Muzaffer Ege Alper[1] Finnish Met Institute[1], Uni. Eastern Finland[2]

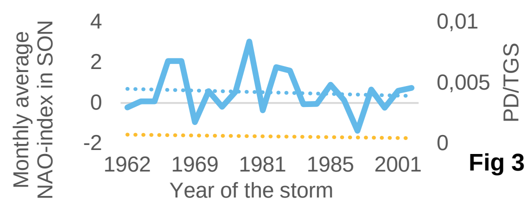


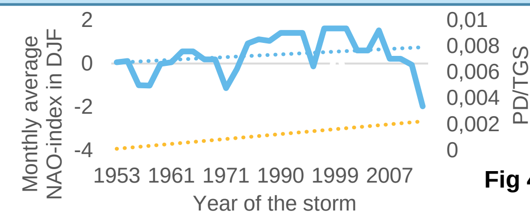




1. We used forest damage reports (PD) of FORESTSTORMS database.
2. We constructed total growing stock (TGS) statistics for Western, Central and Northern Europe based on TGS reports from 17 countries.
3. We homogenized the datasets as PD/TGS for the period 1951-2010.
4. We analyzed 56 large scale storms (**Fig1**)
5. Out of 56 storms 15 were assessed also with the gust wind speeds (**Fig2**), namely storms from 1981, 1984, 1986, 1987, 1990 (4 storms), 1999 (3 storms), 2005, 2007, 2009, 2010.
6. We further compared storm intensity to NAO-index during SON (decrease in both) (**Fig3**) and DJF (increase in both) (**Fig4**)
7. We divided the storm distribution to destructive (PD/TGS < 0.08%), highly destructive (0.08% ≤ PD/TGS ≤ 0.2%), and catastrophic storms (PD/TGS > 0.2%). (**Fig5**)
8. We performed a change point-analysis of the full time-series (**Fig5**).

Our conclusions are: Storm intensity of the catastrophic storms in Europe has increased by a factor of 3,5. NAO is not driving the change but most probably Arctic climate change is. More research is needed.





Gregow et al. 2017. https://www.nature.com/articles/srep46397

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FINNISH METEOROLOGICAL INSTITUTE

One example of adaptation research

The ELASTINEN project 2015-2016 aimed to answer the following questions:

1. How can the **tools for the assessment and management of climate risks** be developed and updated?
2. What are the **changes in regional climate variables**, especially with regard to changes in the water resources and heavy precipitation events?
3. How are the **costs and benefits of risk management** measures assessed?
4. What are the **cross-border effects** of climate change in Finland?

Project web page: http://fmi.fi/elastinen

2016-2025	2025-2050	2050-2100
Short-term < 10 yrs	Mid-term 10-30 yrs	Long-term > 30 yrs

ELASTINEN-project: Policy recommendations and measures to improve the management of weather and climate risks and support adaptation to climate change

Lead Hilppa Gregow
34 experts from:

ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

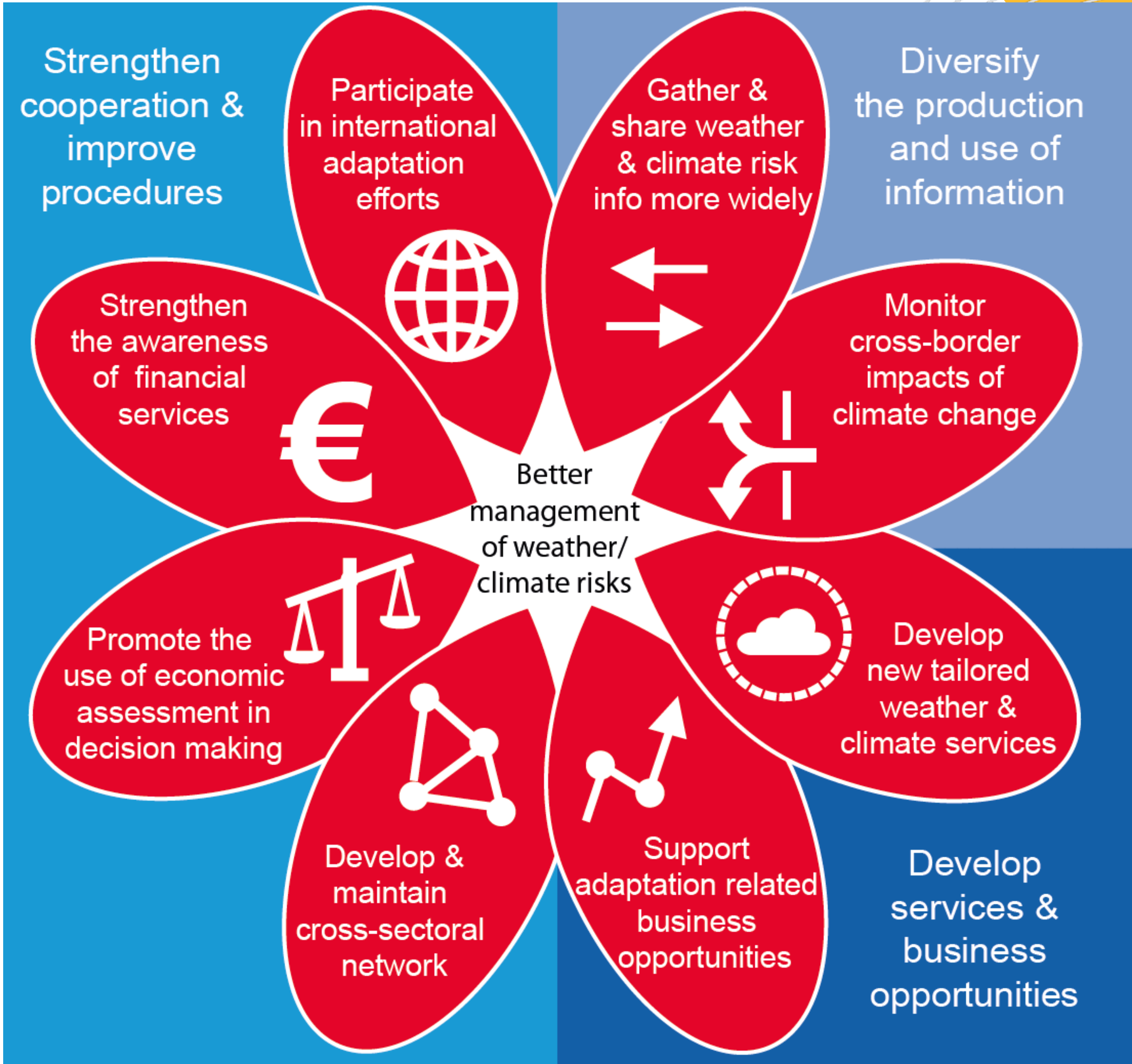
SYKE

UNIVERSITY OF HELSINKI

gaia

Luke NATURAL RESOURCES INSTITUTE FINLAND

NATIONAL INSTITUTE FOR HEALTH AND WELFARE FINLAND



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More information

- **Project web page:** http://fmi.fi/elastinen

- **Final report**: Gregow, H. et al. 2016. Keinot edistää sää- ja ilmastoriskien hallintaa. (*Measures to promote the management of weather and climate related risks. Abstract in English*.) Valtioneuvoston selvitys- ja tutkimustoiminnan julkaisusarja 47/2016. 36 s. http://tietokayttoon.fi/julkaisu?pubid=15406

- Harjanne, A, et al. 2016. Sää- ja ilmastoriskien hallinta ja tietolähteet Suomessa. (*Management of weather and climate risks and the use of related information sources in Finland. Abstract in English*.) Ilmatieteen laitoksen julkaisusarja 2016:6. 111 s. http://hdl.handle.net/10138/168693

- Pilli-Sihvola, K. et al. 2016. Taloudellisesti tehokkaampaa sää- ja ilmastoriskien *hallintaa Suomessa. (*Efficient weather and climate risk management in Finland. Abstract in English.) Valtioneuvoston selvitys- ja tutkimustoiminnan julkaisusarja 45/2016. 68 s. http://tietokayttoon.fi/julkaisu?pubid=15404

- Hildén, M. et al. 2016. Ilmastonmuutoksen heijastevaikutukset Suomeen. (*Crossborder effects of climate change in Finland. Abstract in English*.) Valtioneuvoston selvitys- ja tutkimustoiminnan julkaisusarja 46/2016. 62 s. http://tietokayttoon.fi/julkaisu?pubid=15405

- Luhtala, S. et al. 2017. Kuntien sää- ja ilmastoriskit kuriin riskien arvioinnilla ja hallinnalla. Policy Brief. Valtioneuvoston selvitys- ja tutkimustoiminnan artikkelisarja 2/2017. 4 s. http://tietokayttoon.fi/julkaisu?pubid=18801

Availability of good quality data is the key

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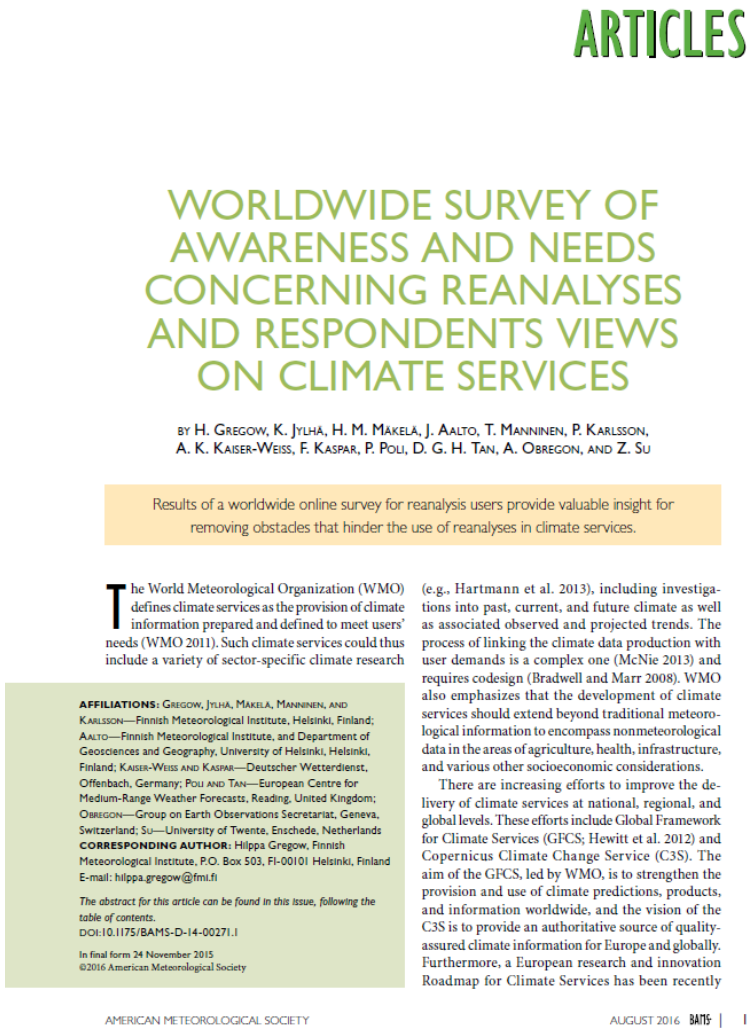
FMI and development of reanalyses to support climate services: EU-CORE-CLIMAX 2013-2015


ARTICLES

WORLDWIDE SURVEY OF AWARENESS AND NEEDS CONCERNING REANALYSES AND RESPONDENTS VIEWS ON CLIMATE SERVICES

BY H. GREGOW, K. JYLHÄ, H. M. MÄKELÄ, J. AALTO, T. MANNINEN, P. KARLSSON, A. K. KAISER-WEISS, F. KASPAR, P. POLI, D. G. H. TAN, A. OBREGON, AND Z. SU

Results of a worldwide online survey for reanalysis users provide valuable insight for removing obstacles that hinder the use of reanalyses in climate services.

The World Meteorological Organization (WMO) defines climate services as the provision of climate information prepared and defined to meet users' needs (WMO 2011). Such climate services could thus include a variety of sector-specific climate research (e.g., Hartmann et al. 2013), including investigations into past, current, and future climate as well as associated observed and projected trends. The process of linking the climate data production with user demands is a complex one (McNie 2013) and requires codesign (Bradwell and Marr 2008). WMO also emphasizes that the development of climate services should extend beyond traditional meteorological information to encompass nonmeteorological data in the areas of agriculture, health, infrastructure, and various other socioeconomic considerations.

There are increasing efforts to improve the delivery of climate services at national, regional, and global levels. These efforts include Global Framework for Climate Services (GFCS; Hewitt et al. 2012) and Copernicus Climate Change Service (C3S). The aim of the GFCS, led by WMO, is to strengthen the provision and use of climate predictions, products, and information worldwide, and the vision of the C3S is to provide an authoritative source of quality-assured climate information for Europe and globally. Furthermore, a European research and innovation Roadmap for Climate Services has been recently

AFFILIATIONS: GREGOW, JYLHÄ, MÄKELÄ, MANNINEN, AND KARLSSON—Finnish Meteorological Institute, Helsinki, Finland; AALTO—Finnish Meteorological Institute, and Department of Geosciences and Geography, University of Helsinki, Helsinki, Finland; KAISER-WEISS AND KASPAR—Deutscher Wetterdienst, Offenbach, Germany; POLI AND TAN—European Centre for Medium-Range Weather Forecasts, Reading, United Kingdom; OBREGON—Group on Earth Observations Secretariat, Geneva, Switzerland; SU—University of Twente, Enschede, Netherlands
CORRESPONDING AUTHOR: Hilppa Gregow, Finnish Meteorological Institute, P.O. Box 503, FI-00101 Helsinki, Finland
E-mail: hilppa.gregow@fmi.fi

The abstract for this article can be found in this issue, following the table of contents.
DOI:10.1175/BAMS-D-14-00271.1

In final form 24 November 2015
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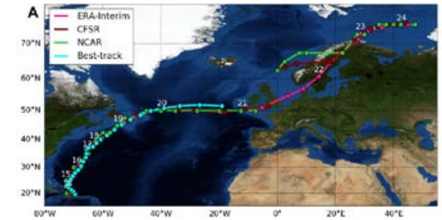
AMERICAN METEOROLOGICAL SOCIETY AUGUST 2016 BAMS | 1

Using three reanalyses and intercomparing the hurricane Debby 1982 transitioning into storm Mauri (22.9.1982)



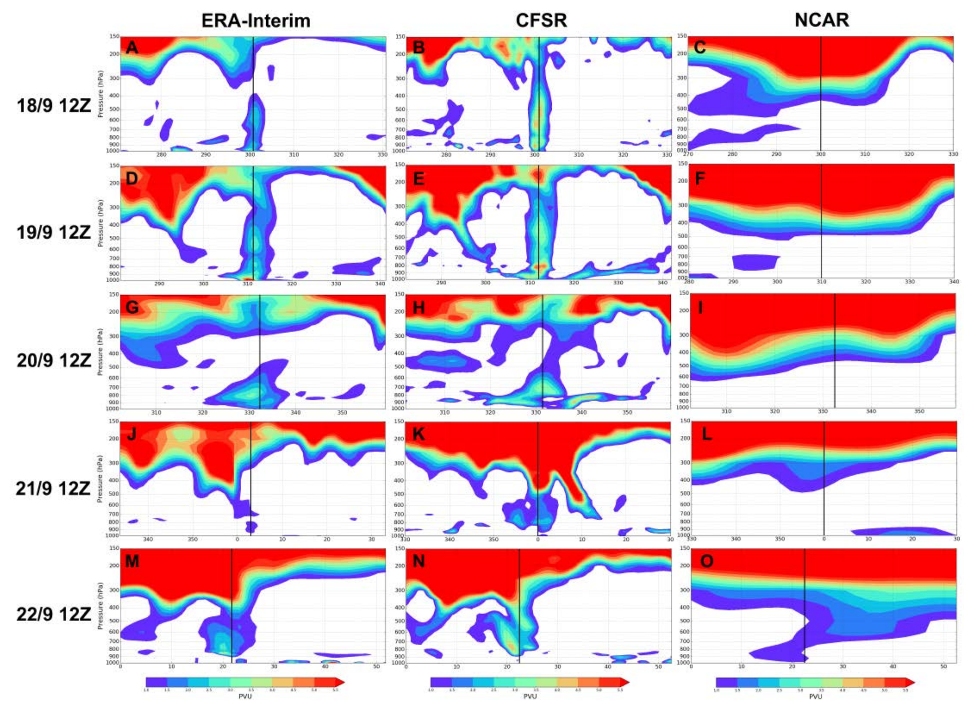


FIG. 6. Vertical cross sections of potential vorticity (colors, PVU, 1 PVU = 10^{-6} m^{-2} s^{-1} K kg^{-1})) calculated from ERA-Interim (left), CFSR (middle) and NCAR (right) at 12 UTC on the 18-22 September 1982. Black vertical line denotes the location of the cyclone center at the surface. Each vertical cross section is taken along

Laurila et al (submitted)

Climate Change

Data Evaluation for Climate Models (DECM) 1.8.2016-31.12.2018

C3S_51_Lot4

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DECM – Data Evaluation for Climate Models

- DECM **maps and analyses user requirements, assesses data availability and applicability and identifies the gaps that need filling**
- We need to make sure that the climate model data is delivered to the different end-users in the best way
- DECM project examines the climate model data according to these requirements and provides the recommendations for its Evaluation and Quality Control (EQC) framework.
- The data will also be part of the C3S Climate Data Store (CDS).
- https://decm.climate.copernicus.eu/

FMI has
7 subcontractors:
GERICS
DMI
MetNo
OMSZ
CSC Finland
UH
ABHL France

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Climate modelling and evaluation needs networks and high level research expertise

HARMONIE-CLIM offers new possibilities in Climate Services

Copernicus Europe's eyes on Earth | Climate Change Service

ABOUT C3S | NEWS & MEDIA | EVENTS | TENDERS | PRODUCTS | SERVICES | HELP & SUPPORT

Search

Data Evaluation for Climate Models

home

The **Data Evaluation for Climate Models** project assesses user requirements, data catalogue and scientific gaps in the delivery of climate model data (CMIP and CORDEX). It will rely on contributions from multiple providers who maintain their own climate model systems. The project is part of the Evaluation and Quality Control (EQC) block of the Copernicus Climate Change Service (C3S).

The outcomes of the project relate to the applicability of climate model data in:

- user requirements,
- data inventory,
- scientific assessment and gap analysis,
- requirements for the Climate Data Store (CDS), and
- recommendations of climate model data for the EQC framework.

Activities in this p
make recommenc

Both current and
voluntary champi
the design of the

The work is imple
Meteorological In

Contact Dr. Hilpp

FMI is supported

- University
- Helmholz-Z

NEWS

03 Mar 2017
#OpenDataHack @ECMWF - explore creativ
uses of open data

03 Mar 2017
C3S holds its inaugural General Assembly

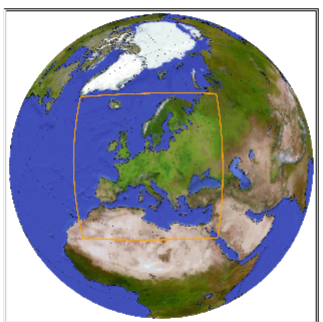
26 Jan 2017
Copernicus at the 4th International Conferen
on Energy & Meteorology (ICEM)

06 Dec 2016
Report Reassesses Variations in Global Warr

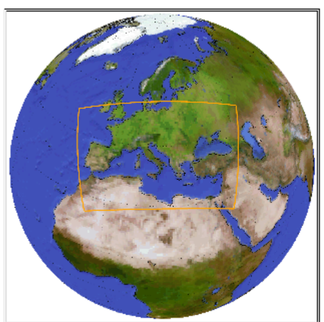
EUR-44	RCM-GCM chains																	
	CNRM-CM5	CNRM-CM5	MPI-ESM-LR	EC-EARTH	EC-EARTH	HadGEM2-ES	CanESM2	CNRM-CM5	CSIRO-Mk3-6-0	EC-EARTH	IPSL-CM5A-MR	MIROC5	HadGEM2-ES	MPI-ESM-LR	NorESM1-M	GFDL-ESM2M	MPI-ESM-LR	IPSL-CM5A-MR
Output frequency	ALADIN52	ALADIN53	CCLM4-8-17	HIRHAM5	RACMO22E		RCA4										REMO2009	WRF331F
3-hourly																		
6-hourly																		
daily	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
monthly	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
seasonal	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
invariant (fx)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

EUR-11	RCM-GCM chains														
	CNRM-CM5	CNRM-CM5	EC-EARTH	HadGEM2-ES	MPI-ESM-LR	EC-EARTH	EC-EARTH	HadGEM2-ES	CNRM-CM5	EC-EARTH	IPSL-CM5A-MR	HadGEM2-ES	MPI-ESM-LR	MPI-ESM-LR	IPSL-CM5A-MR

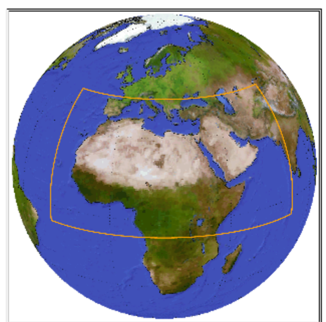
EURO-CORDEX



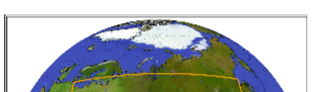
MED-CORDEX



MENA-CORDEX



Central Asia CORDEX



Arctic-CORDEX

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RAIN PROJECT

This project is funded by the European Union

Risk management in support of Climate Adaptation Impacts on critical infrastructure

Heavy snowfall, blizzard, snow load and freezing rain can affect different type of critical infrastucture

Railways

Freezing rain, Feb 2014, Slovenia

Heavy snowfall, Feb 2013, Romania

(AP Photo/Vadim Ghirda)

Road infrastructure

Heavy (coastal effect) snowfall, 2 Feb 2012, Finland

Blizzard, March 2013, Hungary

Freezing rain, Feb 2014, Slovenia

Energy & telecommunication infrastructure

Feezing rain, Dec 2010, Moscow

Heavy snow load, Nov 2005, Germany

Freezing rain, Feb 2014, Slovenia

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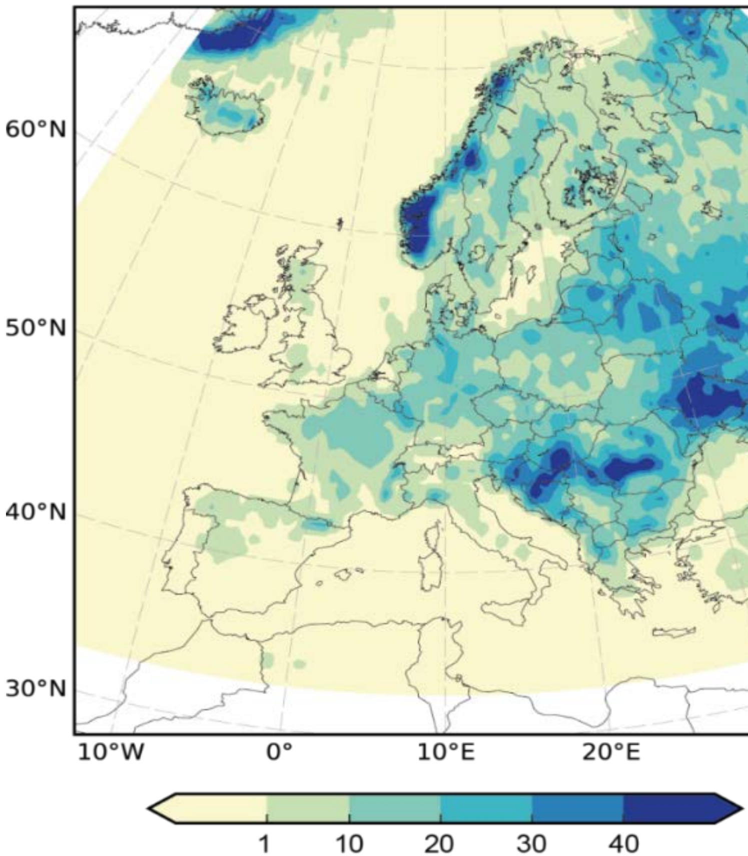
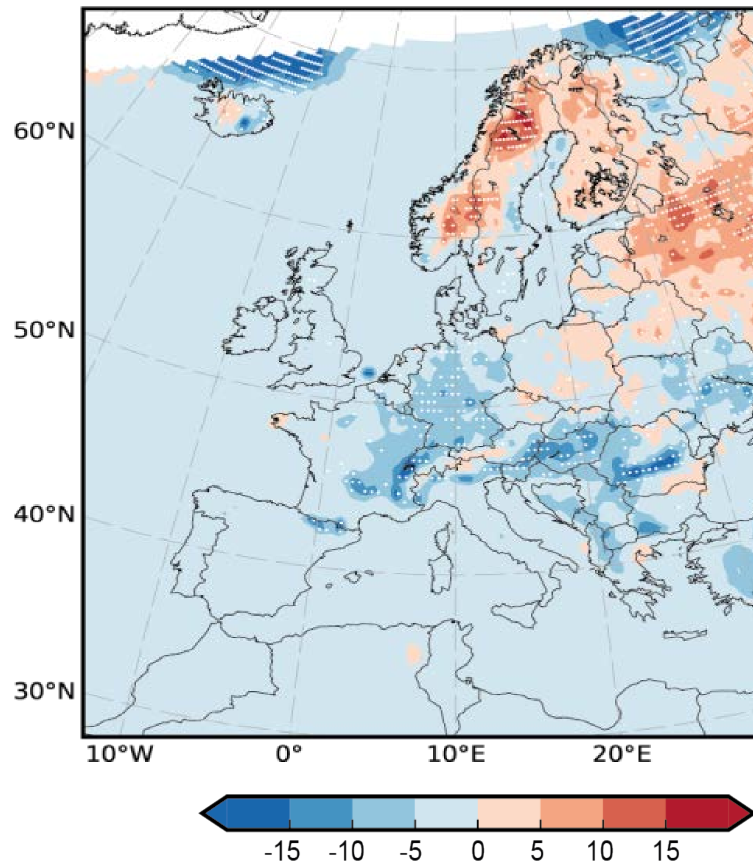
Freezing rain, annual

Annual probabilities
> 5 mm / day



Change by 2071-2100
> 5mm/day



RAIN PROJECT
This project is funded by the European Union

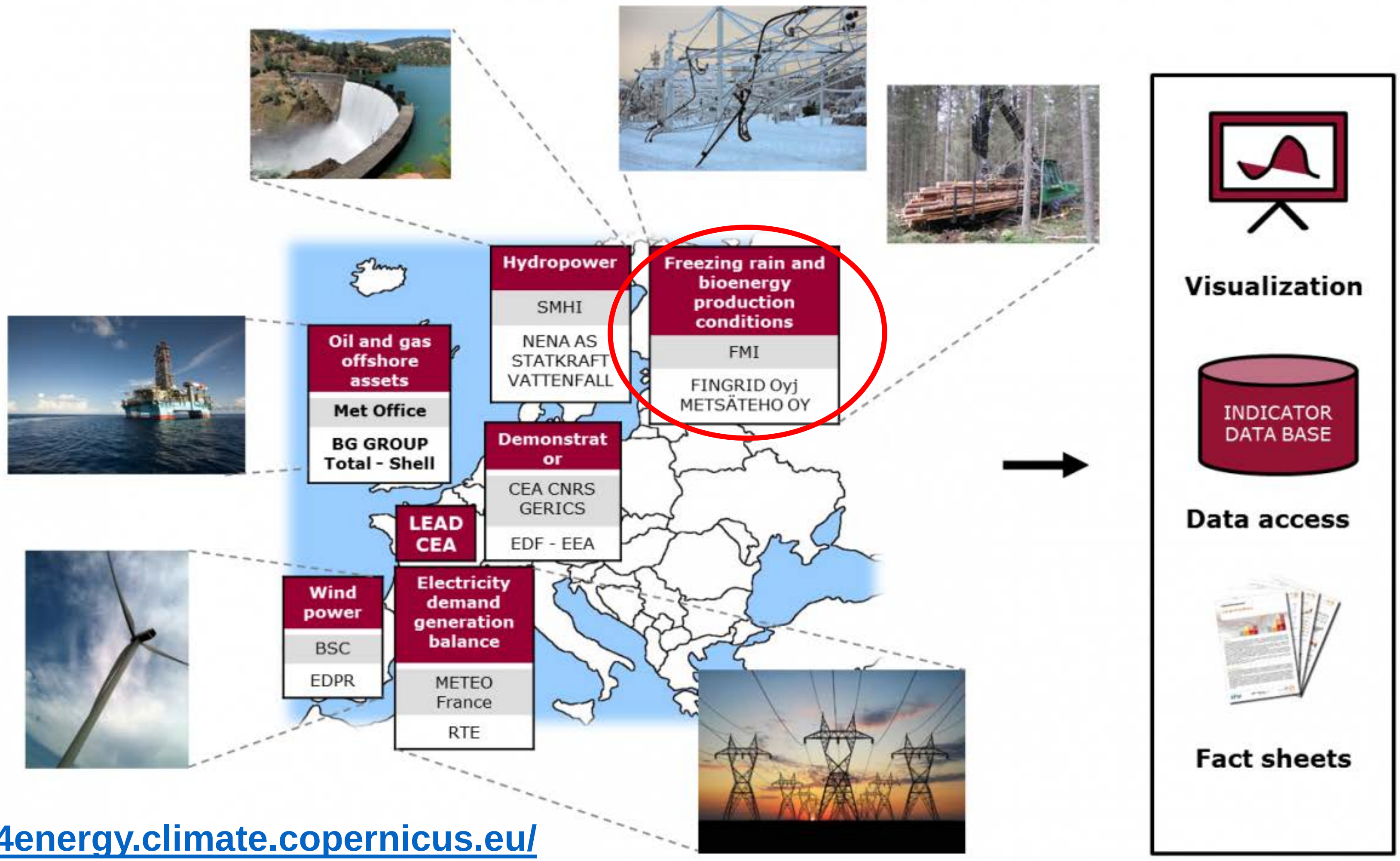
Service development

9 energy-relevant pan-European indicators of climate trends and variability

CLIM4ENERGY

2016-2018

A co-designed approach to develop a portfolio of products for the energy sector



http://clim4energy.climate.copernicus.eu/

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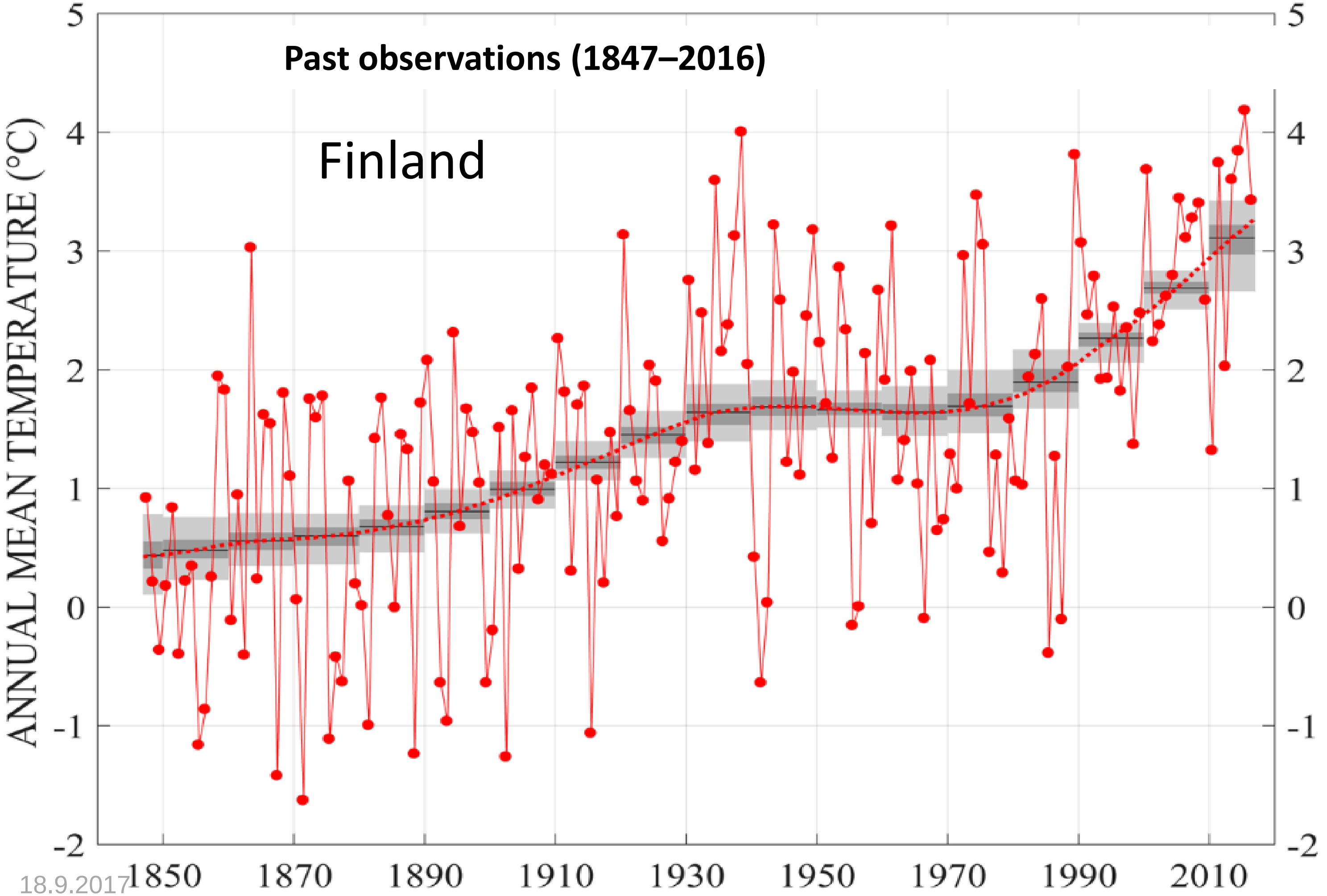
Monitoring climate change propagation is important



Experimentation in tailoring the LRF products

Local Winter Type Forecasting Based on Frost Sum and NAO-index Regression Analysis

Hilppa Myllys, Ari Venäläinen: Finnish Meteorological Institute, Erik Palmen place 1, 00101 Helsinki, Finland
hilppa.myllys@fmi.fi, ari.venalainen@fmi.fi

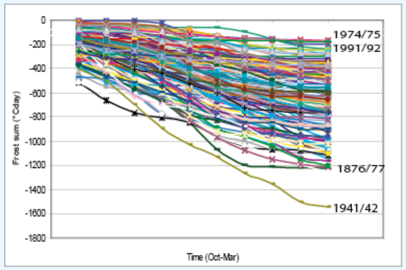


Fig.1. Distribution of all frost sums during October-March in Helsinki 1844-2001. The mean value for frost sum is -657. Coldest winter took place in 1941/42 and mildest in 1974/75.

BACKGROUND

Frost sum is a good predictor for the development of sea ice thickness and extent of ice cover. The idea of studying frost sum climate and frost sum's dependence on NAO-index became acute as after the mild 1990's winters we experienced more difficult conditions and e.g. during winter 2002/2003 ice conditions in Gulf of Finland caused severe problems for sea traffic. There were for example discussions which kind of oil tankers can be used during thick ridged ice conditions. Based on preliminary studies utilizing time series of air temperature data from Helsinki we found out that based on statistical methods it is possible to estimate the development of frost sum (and ice conditions). The method was further developed by combining NAO-index to the frost sum estimate and the results of this study are presented here.

DATA AND METHODS

Frost sum was calculated using Helsinki air temperature measurements made during winter seasons 1844/1845 - 2000/2001 (Fig. 1). Years 1844/1845 - 1950/1951 were used for searching of best fitting regression equation and rest of the dataset was used for testing the equations. Both linear and polynomial equations were defined. Polynomial equations represent those winters when the development of frost sum is faster than in case of winters described by linear equations. Same method was used to predict the sum for NAO-indices (NOAA Climate Prediction Center). Years 1950/1951-1969/1970 were used for the definitions of regression equations and years 1970/1970-2000/01 were used for testing of the developed equations.

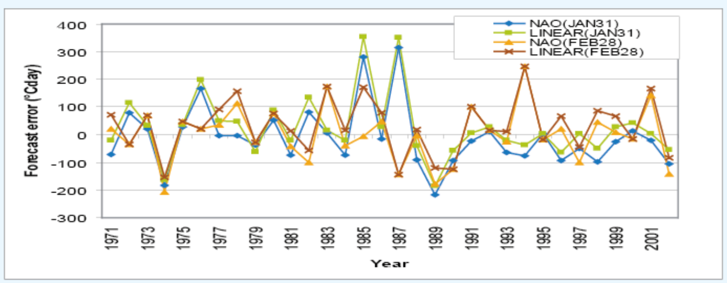


Fig 2. The errors of frost sum forecasts beginning on the 1st of Jan and 1st of Feb being valid in the the of each month are shown here in degrees Celsius. The blue line represents the NAO based and the green line LINEAR January forecast error. The orange and brown lines show errors of NAO based and LINEAR February forecasts during1971-2001.

RESULTS

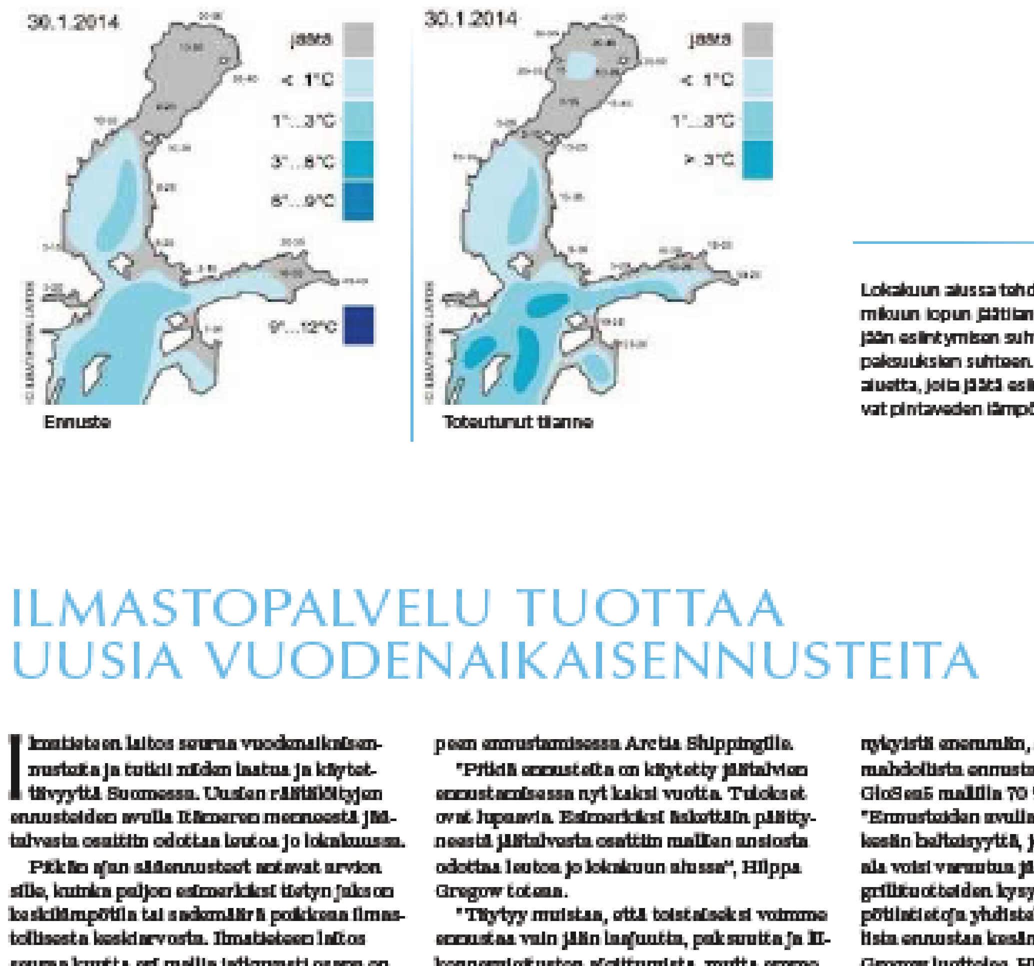
Correlation between linearly forecasted 10-30 days frost sums in January and February and the true frost sum varies between 0,7 and 1. According to independent data (years 1971-2001) the inclusion of NAO-index improves the frost sum estimates (Fig.2 and Table 1) by approximately 5 % in case of 20 and 30 days January forecasts. Is this improvement significant depends on the user's requirements. In February the improvement is less and clearly insignificant.

Table 1. Summary of frost sum errors of 10-30 days forecasts in January and February 1971-2000.

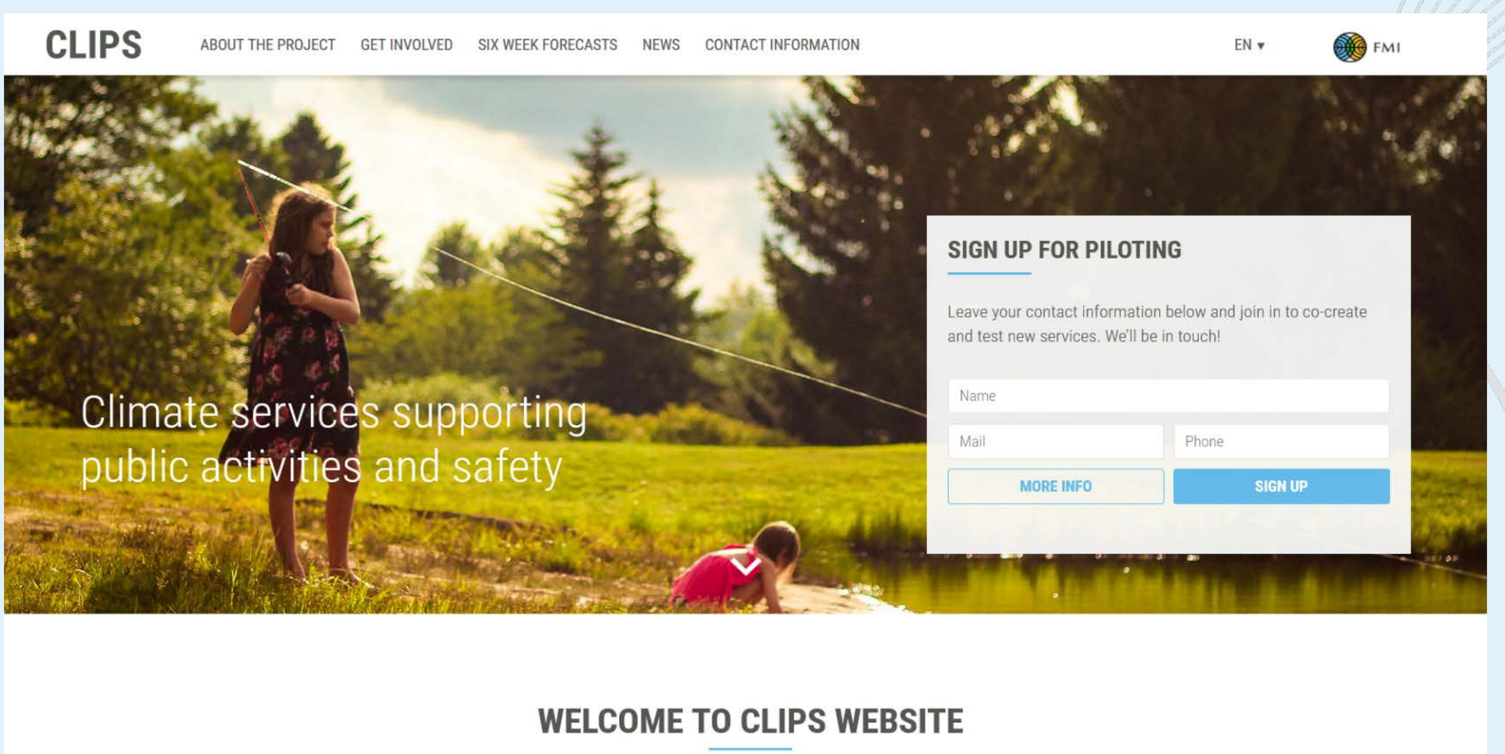
	Forecast length					
	10 days		20 days		30 days	
Type of forecast	NAO	LINEAR	NAO	LINEAR	NAO	LINEAR
January						
Mean bias error	10,6	12,2	3,6	12,9	-11,4	24,4
RMSE	46,6	47,6	80,2	85,2	109,2	114,8
February						
Mean bias error	6,2	9,1	-1,9	19,9	-0,8	30,0
RMSE	44,2	45,5	77,8	78,9	98,8	100,6

During 2011-2012 we were experimenting the operationally delivered sea ice forecasts and sea ice management support service

Arctia Shipping has been pleased: *”The skill in the forecast has developed positively and we benefit from the forecast much before the winter as we assess the need for ice breakers e.g., in the Baltic Seas region.”*



CLImate service supporting Public activities and Safety



Hilppa Gregow, Andrea Vajda, Otto Hyvärinen, Terhi Laurila, Tiina Ervasti, Juha A. Karhu, Hadassa Hovstadt, Natalia Korhonen, Antti Mäkelä

EMS 2017

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What kind of work do we do?

- ✓Test and improve impact forecasting of average and extreme conditions using the ERF (six week forecasts) of ECMWF
- ✓Design and co-design products (within the technical boundaries)
- ✓Set up automatic operational services through FMI Ilmanet portal
- ✓Continuously collect feedback and make surveys
- ✓Support and guide users
- ✓Evaluate and verify in parallel
- ✓Write news and scientific papers
- ✓Supervise master thesis and PhDs

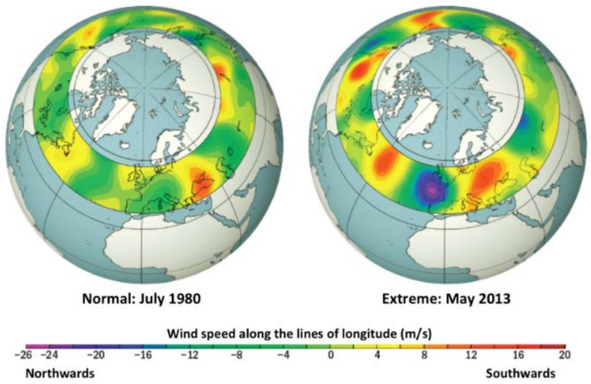

Image: Michael Mann / Penn State

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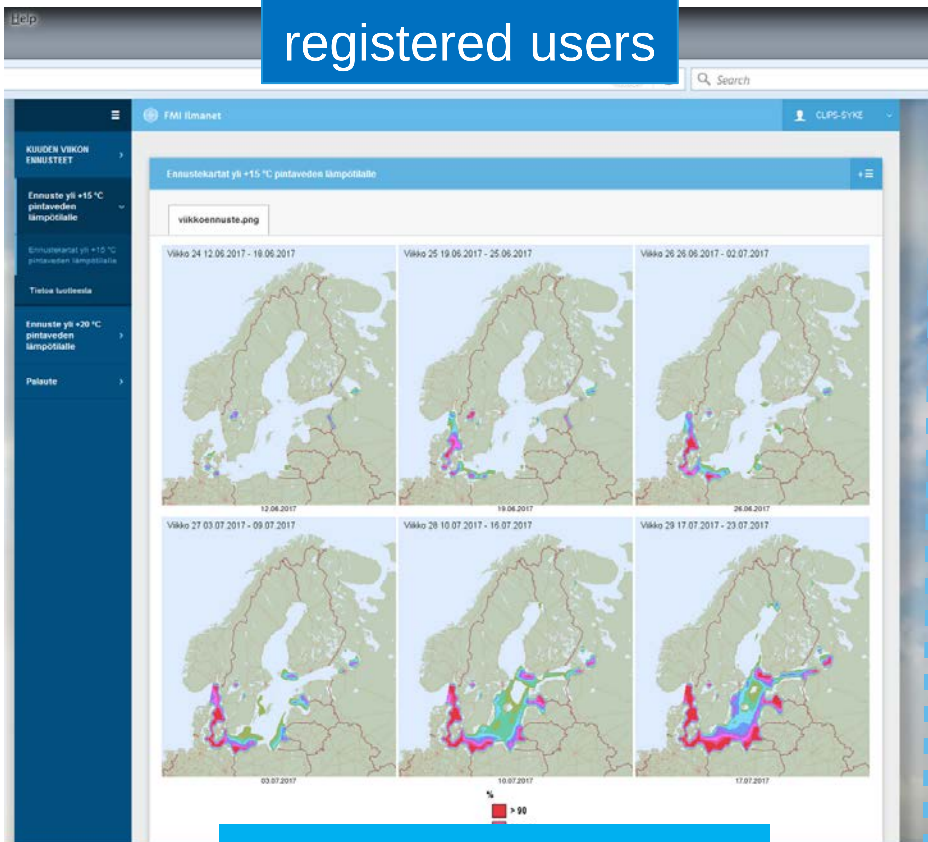
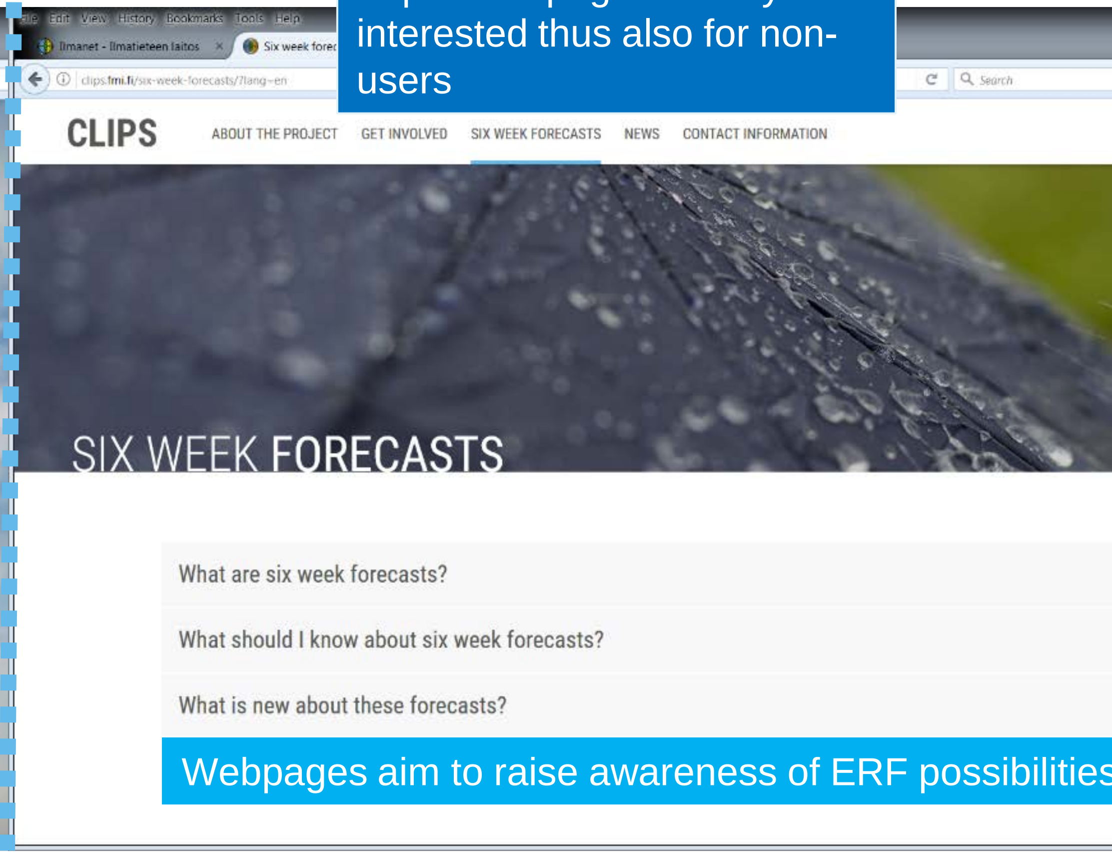
To build the service – CLIPS example http://clips.fmi.fi/?lang=en

ILMANET for registered users



This is the blue algae product

Clips.fi.fmi pages for anyone interested thus also for non-users



Webpages aim to raise awareness of ERF possibilities

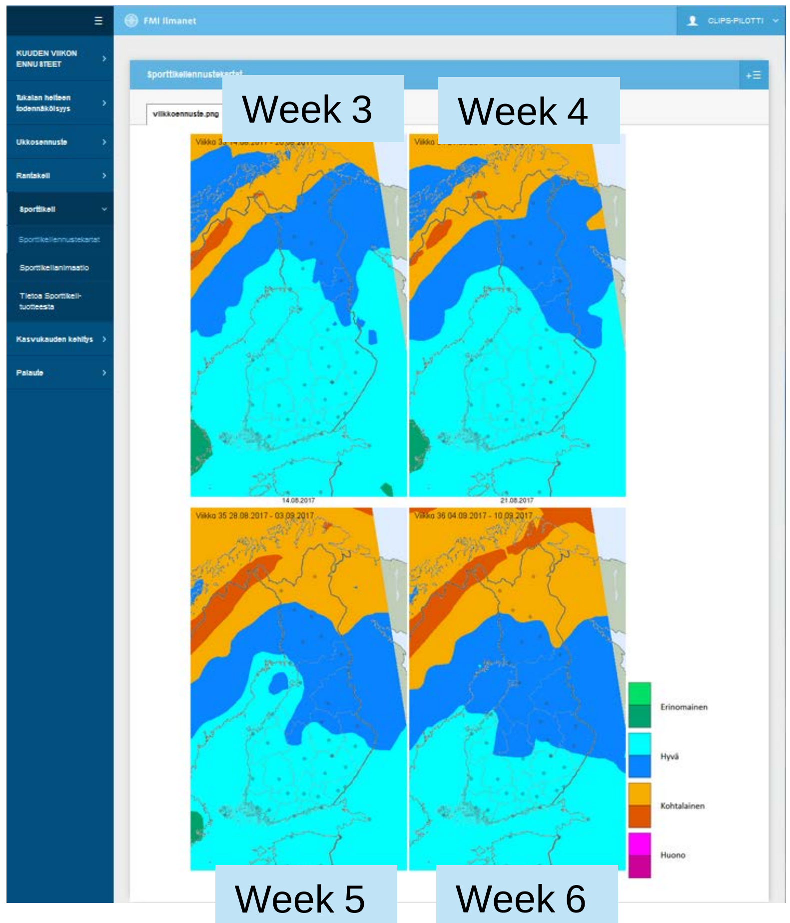
We do not overlap with the first two week weather forecasts!

Sportweather outlook example for 14.08.-10.09. issued on 1.8.2017

Animation:
Shows the same but animated.

About the product
Explains which parameters are used and with which weights.

Colours on the map indicate the conditions:
Poor (Pink)
Moderate (Orange)
Good (Blue)
Excellent (Green)



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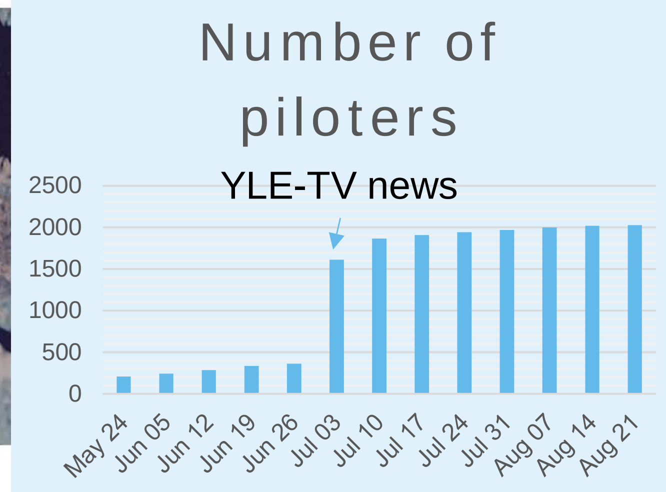
CLIPS ABOUT THE PROJECT | GET INVOLVED | SIX WEEK FORECASTS | NEWS | CONTACT INFORMATION | EN ▾ | FMI



We have more than 2000 piloters!

JOIN IN TO CO-CREATE

CLIPS invites citizens to co-design and test new services, come along! In the CLIPS project the six week forecasts are developed together with the users. Finnish citizens, stakeholders, decision makers, enterprises, students, etc. are welcome to participate in testing and commenting the services. You can sign up here to test the novel, experimental products we are developing.

SIGN UP FOR PILOTING

Leave your contact information below and join in to co-create and test new services. We'll be in touch!

Name

Mail | Phone

SIGN UP

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FALL – WINTER –SPRING OUTLOOKS are under development

FALL e.g.,

1. Skiing conditions
2. Biking conditions
3. Sailing conditions
4. Road conditions
5. Cottage conditions
6. Stormwinds

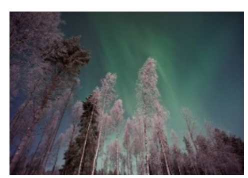
WINTER e.g.,

1. Skiing conditions
2. Skating conditions
3. Biking conditions
4. Sweater weather
5. Cottage conditions
6. Road conditions
7. Storm paths

SPRING e.g.,

1. Running conditions
2. Road conditions
3. Air quality conditions
4. Cottage conditions
5. Growing season starting point
6. Bush and forest fire risk




Future emphasis – from where new collaboration could form?

On Friday 24.3.2017 very many FMI researchers got good news. FMI was granted five important ERA4CS climate service projects.

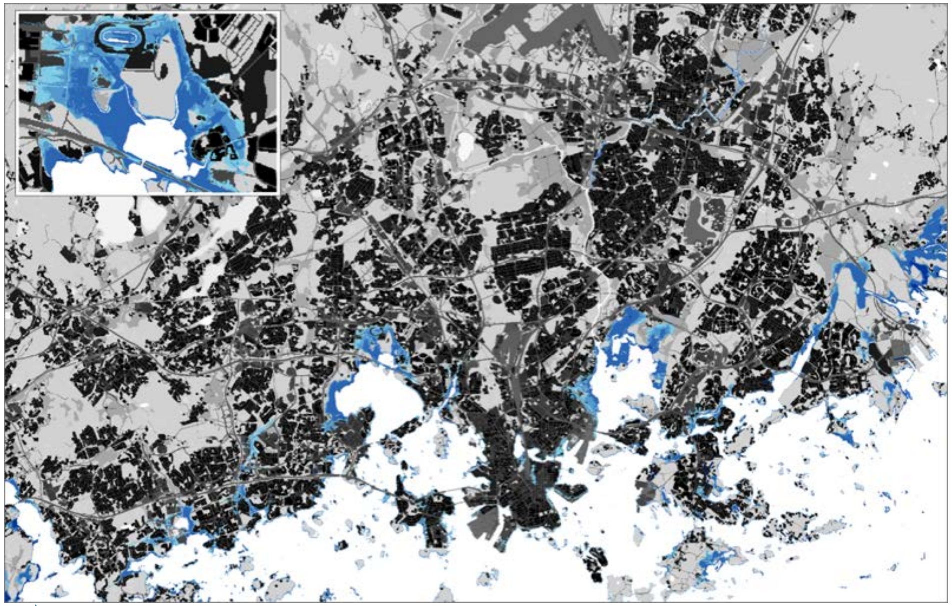
JPI Climate

The ERA4CS received altogether 12 proposals. These were reviewed by an international 19-member Panel of Experts.

- **DustClim:** Dust Storms Assessment for the development of user-oriented Climate Services in Northern Africa, Middle East and Europe. **Lead Dr. Sara Basart, BSC Spain.**
- **INDECIS:** Integrated approach for the development across Europe of user oriented climate indicators for GFCS high-priority sectors: agriculture, disaster risk reduction, energy, health, water and tourism. **Lead Dr. Enric AGUILAR, C3-URV Spain.**
- **SERV_FORFIRE:** Integrated services and approaches for Assessing effects of climate change and extreme events for fire and post fire risk prevention. **Lead Dr. Rosa Lasaponara, CNR Italy.**
- **URCLIM:** URban CLIMate services. **Lead Dr. Valéry Masson, Météo France France.**
- **WINDSURFER:** WIND and wave Scenarios, Uncertainty and climate Risk assessments for Forestry, Energy and Reinsurance. **Lead Dr. Len Shaffrey, UREAD UK.**

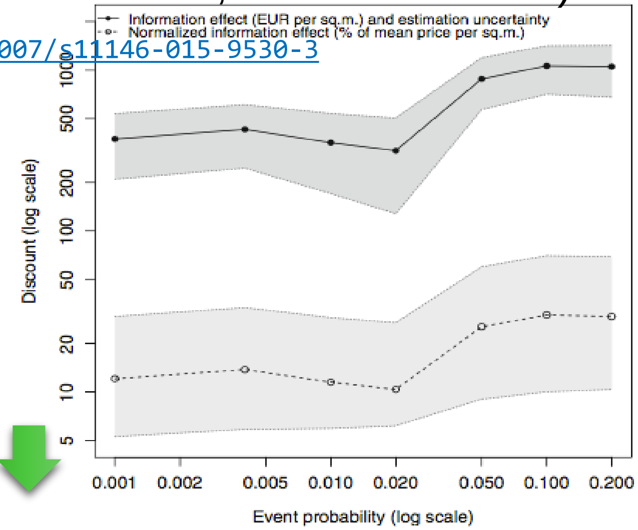
Related to e.g., URCLIM: Flood risk assessment, hazard management & adaptation policy work

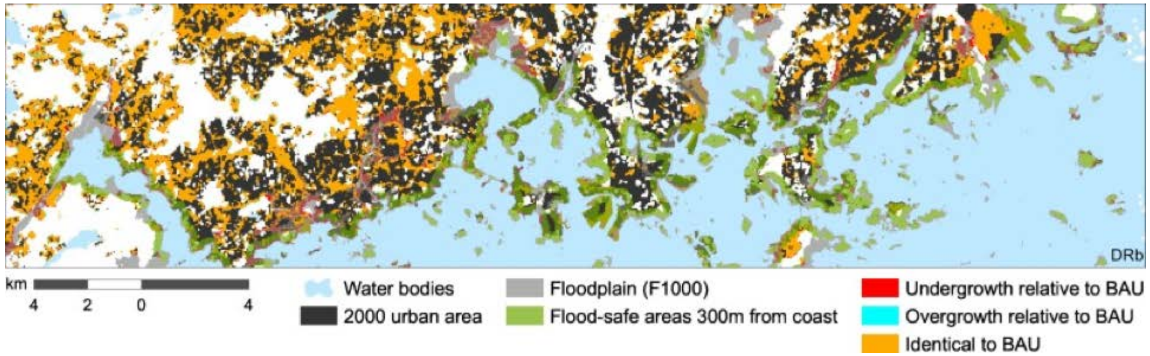
Public release of flood risk information – how to assess its effectivity?



1. Response of housing markets to flood probabilities
(spatial econometrics, treatment effects)

doi.org/10.1007/s11146-015-9530-3





2. Effects of flood risk management policies on urban growth in the floodplain

(simulation of urban spatial dynamics)

doi.org/10.1016/j.compenvurbsys.2017.04.005

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EU·macs

Context: EU-MACS

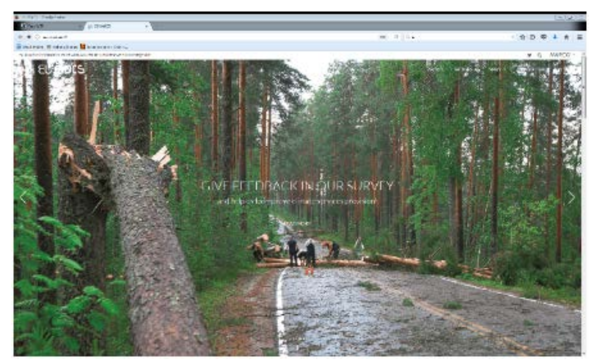
European Market for Climate Services

Co-ordinator: Prof. Adriaan Perrels, FMI

- Towards **better matching** of supply options and user needs
- Exploring engagement protocols with stakeholders from **finance, tourism and urban planning**

Issues:

- User orientation at the core of quality control
- Towards viable CS business models
- What are key innovations for better uptake?
- What legislation is upcoming / needed?



Contact: adriaan.perrels@fmi.fi
web-site: http://eu-macs.eu/#


iSCAPE
H2020 iSCAPE
Home
About
Research approach
Results
Media
News
• Passive control systems for climate change
• Together with the citizens, for the citizens!
Project at a glance
The iSCAPE project works on integrating and advancing the control of air quality and carbon emissions in European cities in the context of climate change through the development of sustainable and passive air pollution remediation strategies, policy interventions and behavioural change initiatives.
https://www.iscapeproject.eu/

Big congrats to Rossby Centre for the succesful 20 years!

Thank you for listening!

- WMO EXTRANET -

e-book

WORLD METEOROLOGICAL ORGANIZATION

WEATHER CLIMATE WATER

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http://public.wmo.int

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World Climate Services Programme
Climate Applications and Services

Programmes > WCP > WCASP / CLIPS > RCC - Polar Regions

GFCS GLOBAL FRAMEWORK FOR CLIMATE SERVICES

RCC implementation in the Polar Regions

The World Meteorological Organization (WMO) Executive Council through its Panel of Experts on Polar and High Mountain Observations, Research and Services (EC-PHORS) (renamed from EC-PORS to EC-PHORS by EC-67) is developing a concept for the establishment of Regional Climate Centres (RCCs) for the Polar Regions.

The WMO Executive Council, at its 65th Session (2013), agreed that EC-PORS, the Global Cryosphere Watch (GCW), the Commission for Climatology (CCl), the Commission for Basic Systems (CBS) and the concerned regional associations should work in close cooperation to develop the Polar RCCs (PRCCs).

Other groups have launched relevant initiatives such as the International Ice Charting Working group (IICWG), the World Weather Research Programme (WWRP), the World Climate Research Programme (WCRP) and the Arctic-HYCOS project led by the WMO Commission for Hydrology. Following the fifth session of EC-PORS in 2014, its Services Task Team (STT) began consultations on the implementation strategy for PRCCs, including definition of their priority functions based on user requirements in the Polar Regions.

- WCASP Home
- CLIPS
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- Publications
  - WCASP Series
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Related Links

Thematic Pages

- Climate Services
- RCCs
- GPCs
- RCOFs
- Climate Watches

More work for us
In the Arctic!

Rossby Centre 20 År
13-14 SEPT 2017
NORRKÖPING, SVERIGE

Developing climate services in Norway: experiences, successes and challenges

Stefan Sobolowski
UniResearch & Bjerknes Centre for Climate Research

SMHI

Developing Climate Services in Norway: Experiences, Successes and Challenges

Stefan Sobolowski
Uni Research Climate & the Bjerknes Centre for Climate Research

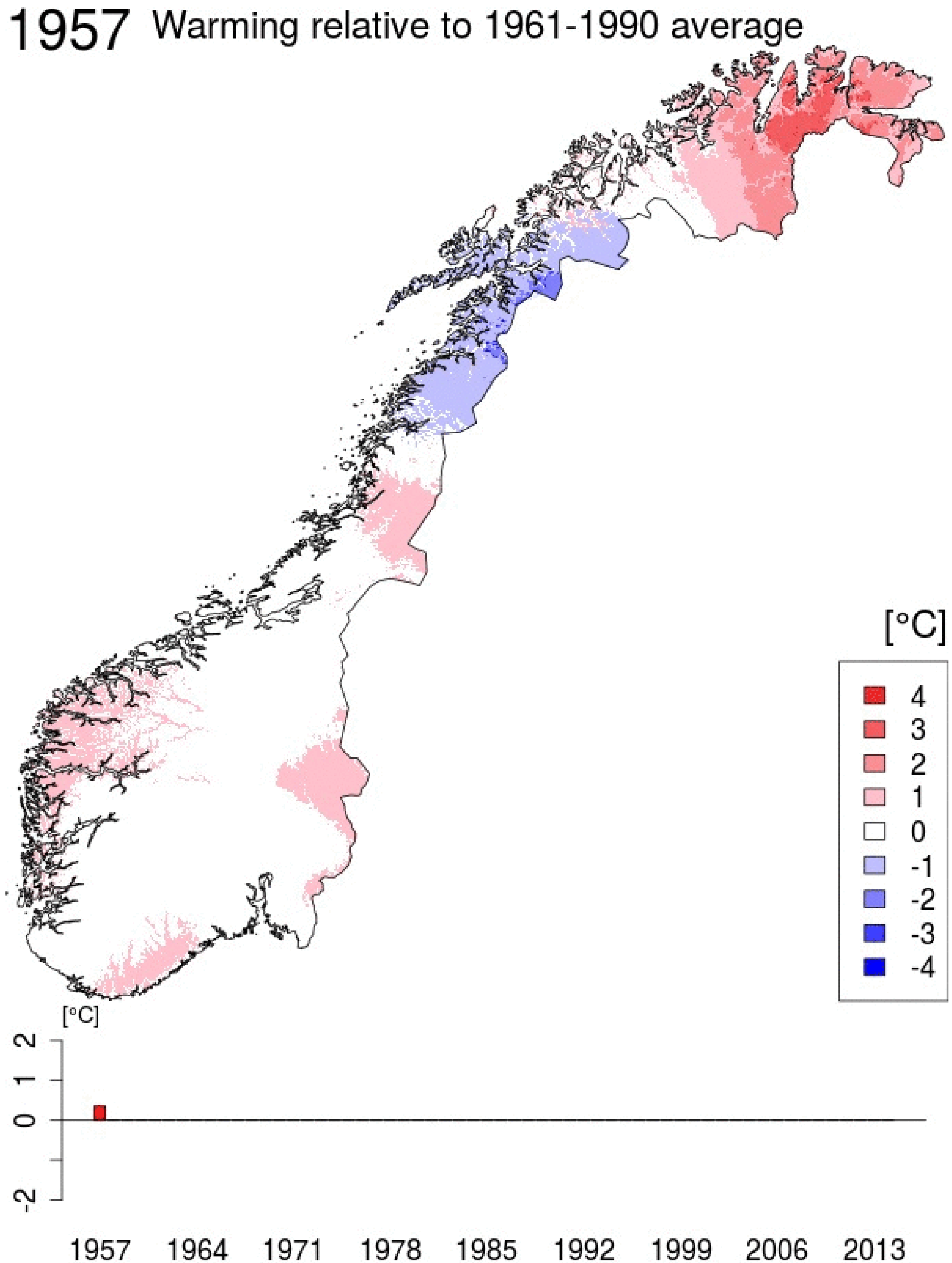
Rossby Centre 20yr Sept. 13-14, 2017

Uni Research

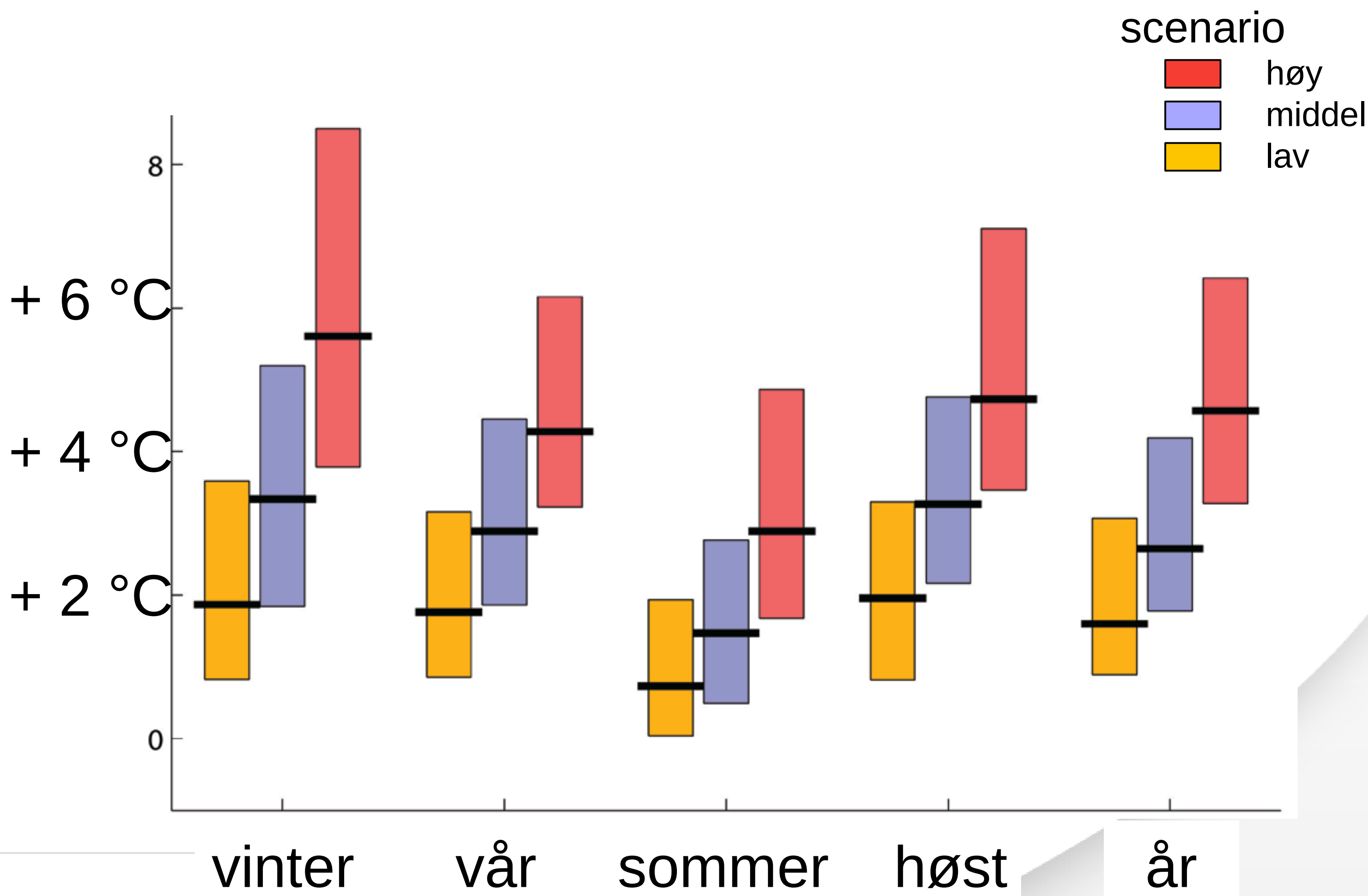
NVE

Norwegian Meteorological Institute

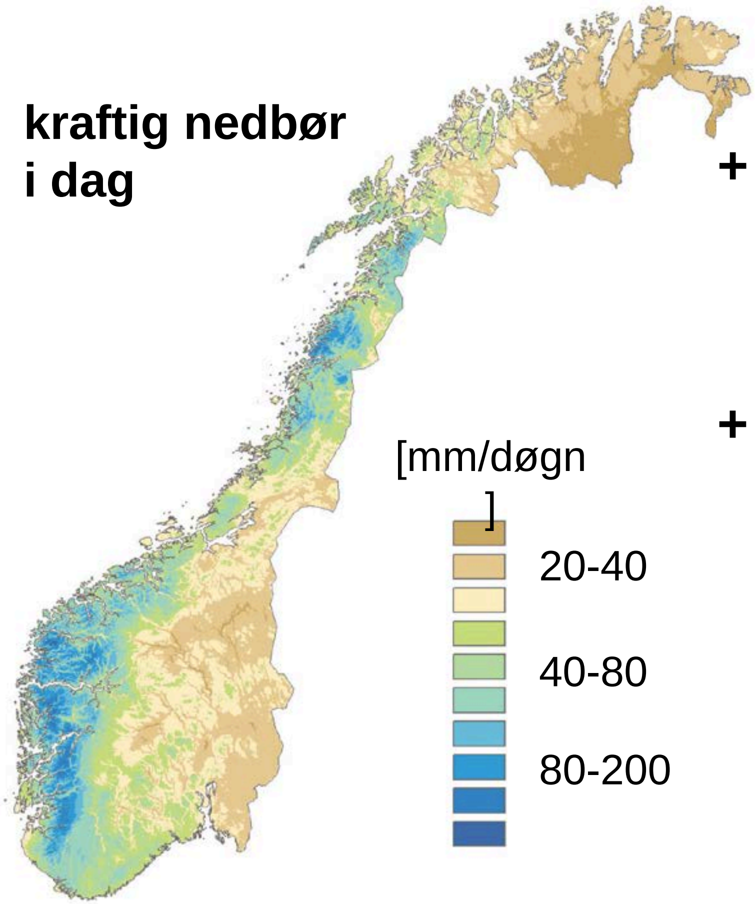
BJERKNES CENTRE for Climate Research

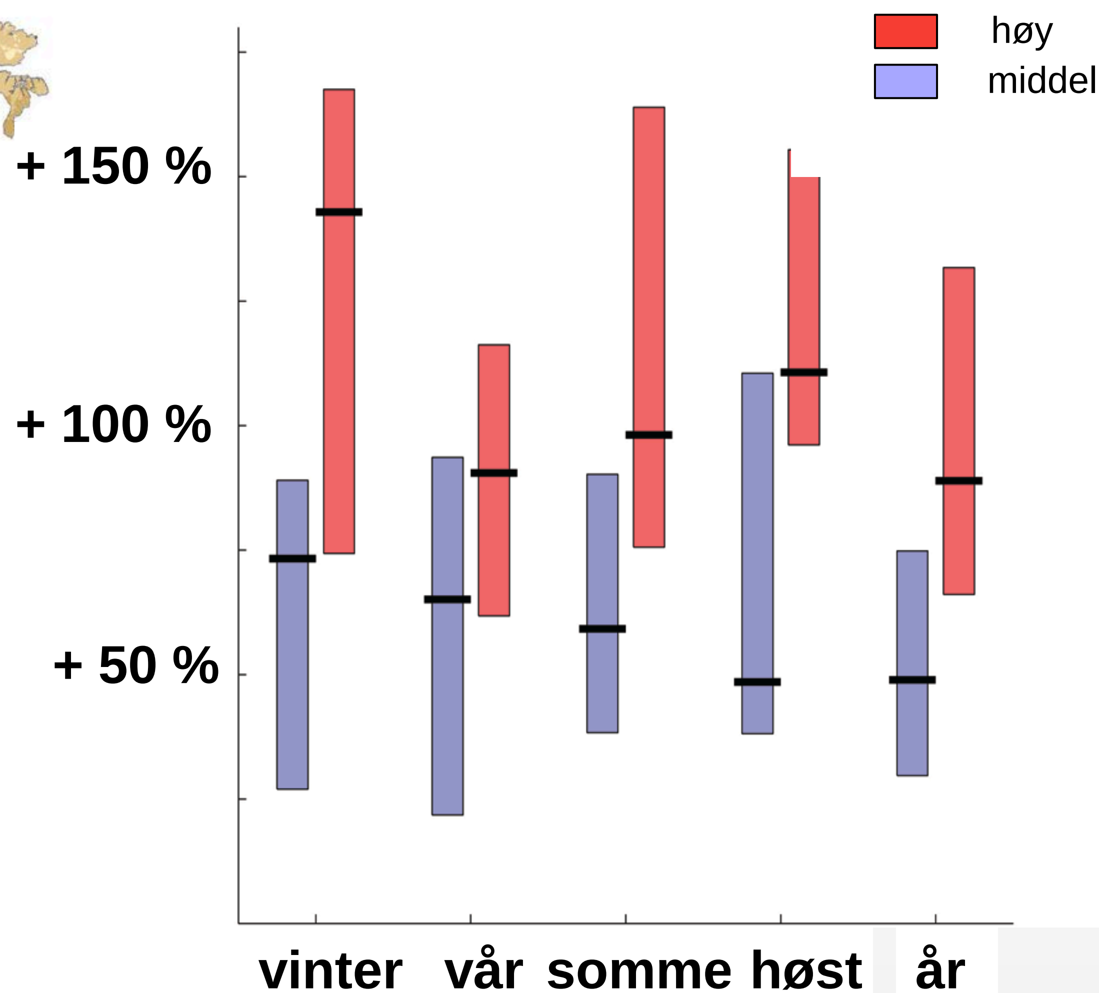

1957 Warming relative to 1961-1990 average
[°C]
4
3
2
1
0
-1
-2
-3
-4
[°C]
2
1
0
-2
1957
1964
1971
1978
1985
1992
1999
2006
2013

Endring i temperatur



Endring i antall dager med kraftig nedbør





High interest around local scale implications (present & future)

- Hydropower and other industries
- Planning for flood mitigation/adaptation
- Urban planning/zoning/drainage
- How best to provide information that's fit for purpose (i.e. decision-relevant)

Figure: Massive flooding in Odda western Norway in October, 2014. *credit: Hommedal, Marit NTB/SCANPIX*

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Outline for rest of the talk

- Background of the NCCS
- Current products (both released and in development)
- Research & engagement
- Challenges, lessons learned & the way forward (IMHO)

The Norwegian Centre for Climate Services (NCCS) is a cooperation between

- **Norwegian Meteorological Institute**
- **Norwegian Water Resources and Energy Directorate (NVE)**
- **Bjerknes Centre for Climate Research**
- **Uni Research**

- **The Norwegian Environment Agency is represented in the board**

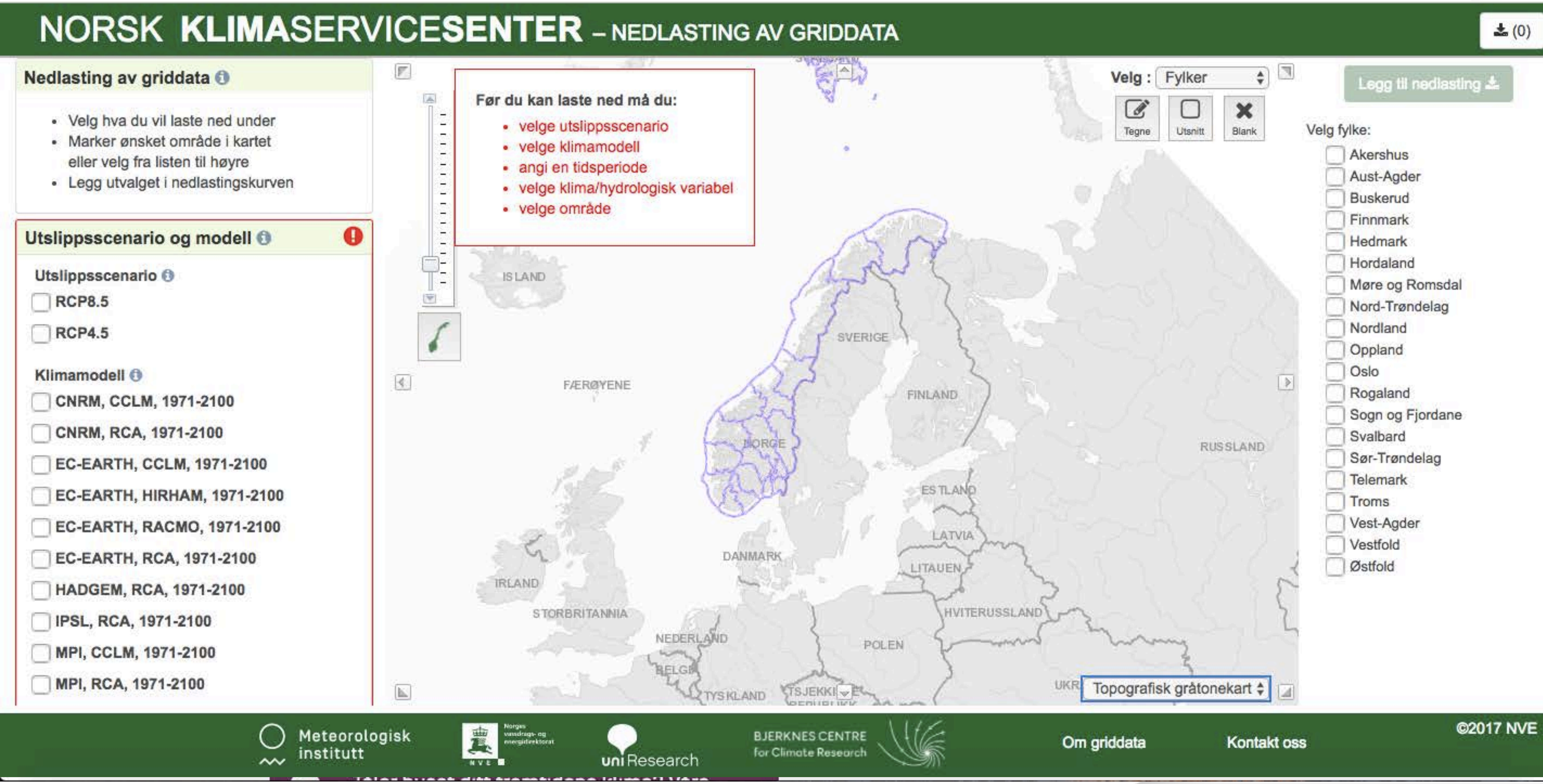
Background for establishing NCCS:

- Official Norwegian Reports NOU 2010:10
- White paper on climate adaptation in Norway: «Stortingsmelding 33 (2012-2013)»
- Funding ~4million NOK/yr from Environment ministry
- Partnership managed by Meteorological Institute
- Leadergroup of representatives from each partner

Mission for NCCS:

Provide decision makers in Norway with information relevant for climate adaptation - in a changing climate

Web-pages: //klimaservicesenter.no



NORSK KLIMASERVICESENTER

Meteorologisk institutt

Norges vassdrags- og energidirektorat

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“Climate in Norway 2100”

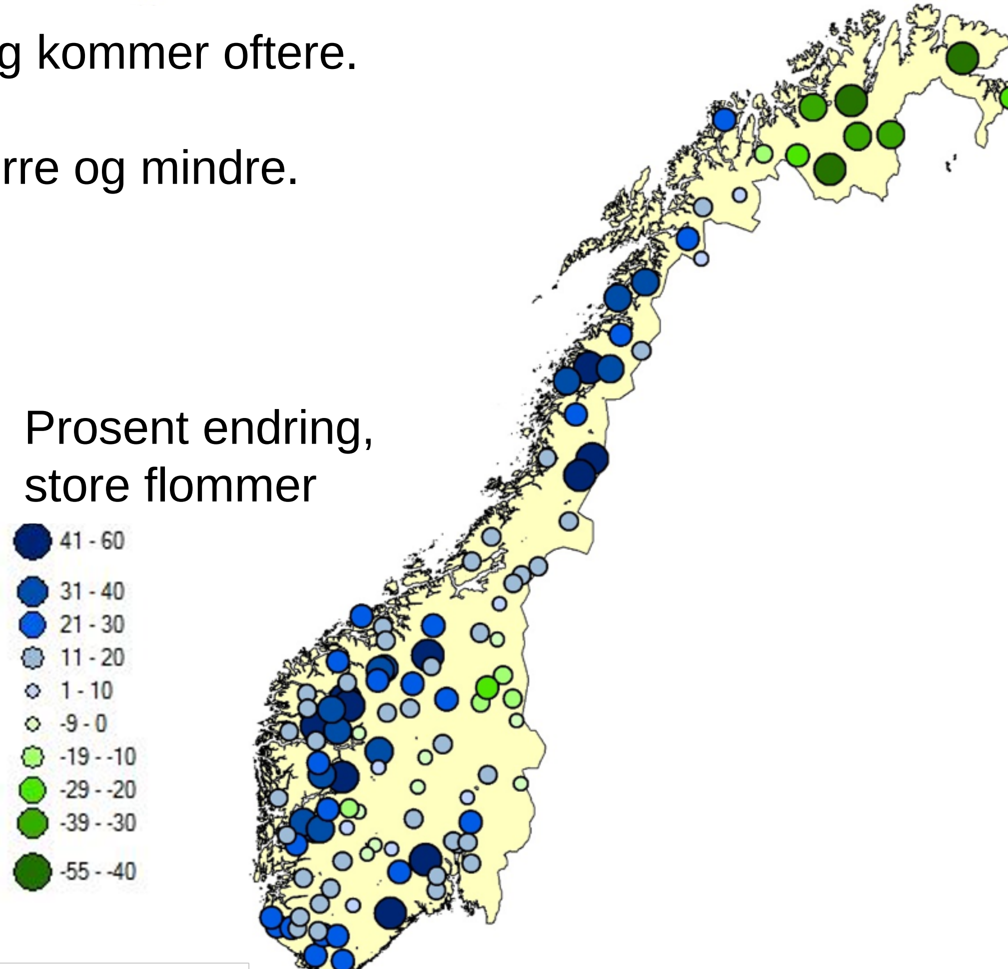
- Report on past, present and future climate in Norway (200 pp)
- Published in 2015, based upon CMIP5, Euro-CORDEX
- A knowledge base for climate adaptation
- 37 authors from 7 institutions
- English short version is now available (50 pp)

Flommene blir større her og mindre der

Regnflommene blir større og kommer oftere.

Snøsmelteflommene blir færre og mindre.

Prosent endring, store flommer



“Climate factsheets”

Based upon the report: 8-page “climate-factsheets” for all counties

Summary, «Climate factsheets»:

INCREASED PROBABILITY

- Kraftig nedbør
- Regnflom
- Jord-, flom- og sørpeskred
- Stormflo

POSSIBLY INCREASED PROBABILITY

- Tørke
- Isgang
- Snøskred

UNCHANGED OR REDUCED PROBABILITY

- Snøsmelteflom

UNCERTAIN

- Sterk vind
- Kvikkleireskred
- Steinsprang og steinskred
- Fjellskred

Research project "PostClim" (2016 – 2019)

"…will focus on further development and evaluation of post-processing techniques (...) in order to bridge the gap between the output from global and regional climate models and the needs of key stakeholders."

Research project "PostClim" (2016 – 2019)

- Research partners:
- Involved users: Municipalities and the agriculture sector
- Work packages:
  - WP1: Communication with users and dissemination of results
  - WP2: Post-processing of climate model output (i.e. bias adjustment)
  - WP3: Hydrological modelling
- Publications: Report on user needs


Norwegian Centre for Climate Services

User needs for post processed climate data

A survey of the needs for output from the research project PostClim

NCCS report no. 2/2017

Authors

Inger Hanssen-Bauer, Hans Olav Hygen, Hanne Heiberg, Eirik Førland and Berit Nordskog

Photo: Hans Olav Hygen

Research Project: Relevant, reliable and robust local climate projections for Norway (R3)

Stefan Sobolowski – Principal Investigator

Uni Research Klima/Klimaservice

R3: Three main areas of inquiry

- Aspects regarding downscaling/regional climate modelling
- Aspects regarding decision-making and implementation of new knowledge among users (both public and private)
- Aspects regarding co-creation of knowledge, how stakeholders can productively contribute

Figure: Photo from the flooding in Voss, fall 2015. This camping area with many permanent trailer homes is right on the flood plain.

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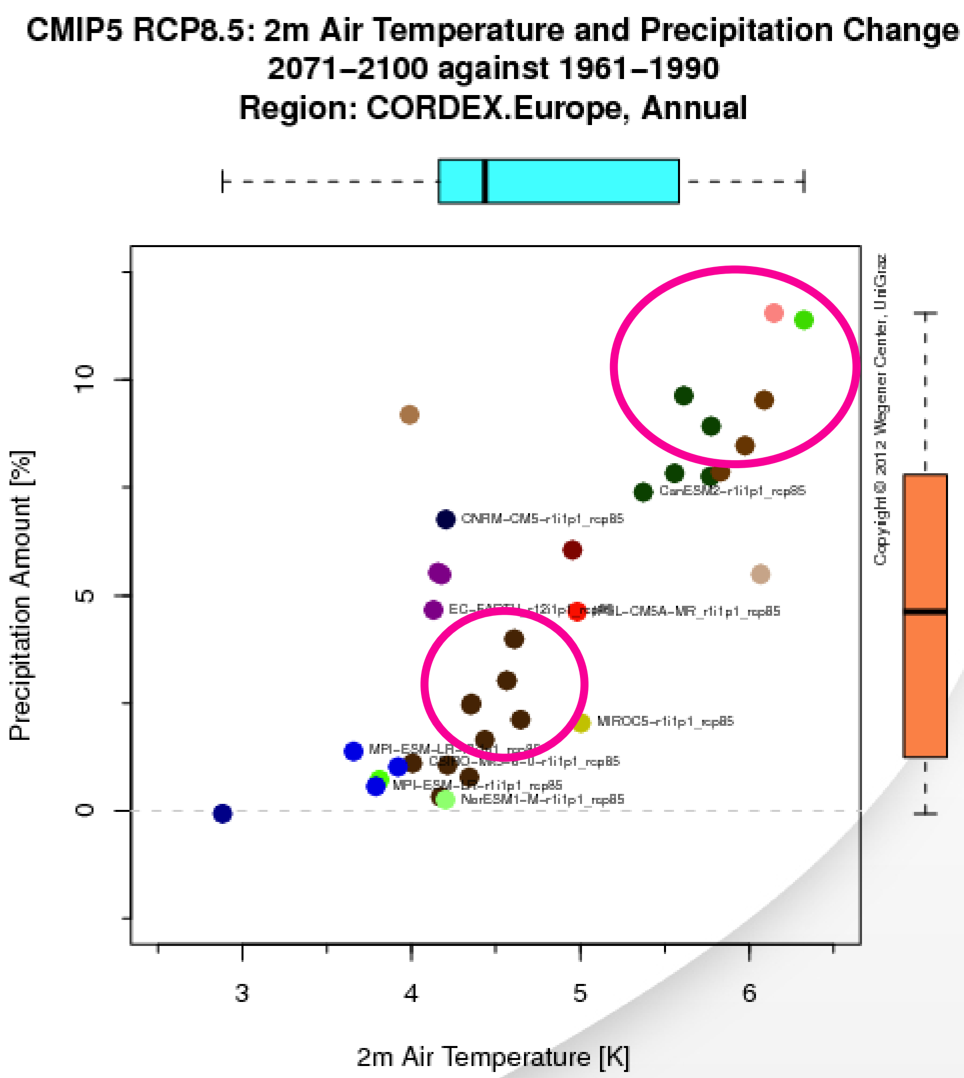
Robust

- Current backbone of all climate services undersamples range of possibilities
- The issue is exacerbated at local scales
- ‘Brute force’ solutions are not tractable
- Can we devise inexpensive solutions to obatin local information across a range of possiblities?



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Challenges: Quality Control

- How to balance scientific rigor and ethical responsibilities with expectations and demands?

2013(Fall)
- Discussions around developing an updated climate report for Norway

2014(Spring)
- Report on bias correction intercomparison; decisions on ensembles and analyses

2014(Fall)
- Official request for report from Environment Directorate; writing teams determined

2015(Winter-Summer)
- Writing, production, stress

2015(Fall)
- Report released 22.09.2015

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Euro-CORDEX Models in KiN

A.5.1 Klimamodeller

Institutt	Global klimamodell	Ensemble medlem	Regional klimamodell
Climate Limited-area Modelling Community (CLM-Community)	CNRM-CERFACS-CM5	r1i1p1	CCLM4-8-17
Swedish Meteorological and Hydrological Institute (SMHI), Rossby Centre	CNRM-CERFACS-CM5	r1i1p1	RCA4
SMHI	IPSL-CM5A-MR	r1i1p1	RCA4
Royal Netherlands Meteorological Institute (KNMI)	ICHEC-EC-EARTH	r1i1p1	RACMO22E
Danish Meteorological Institute (DMI)	ICHEC-EC-EARTH	r3i1p1	HIRHAM5
SMHI	ICHEC-EC-EARTH	r12i1p1	RCA4
CLM-Community	ICHEC-EC-EARTH	r12i1p1	CCLM4-8-17
SMHI	MPI-ESM-LR	r1i1p1	RCA4
CLM-Community	MPI-ESM-LR	r1i1p1	CCLM4-8-17
SMHI	MOHC-HadGEM2-ES	r1i1p1	RCA4

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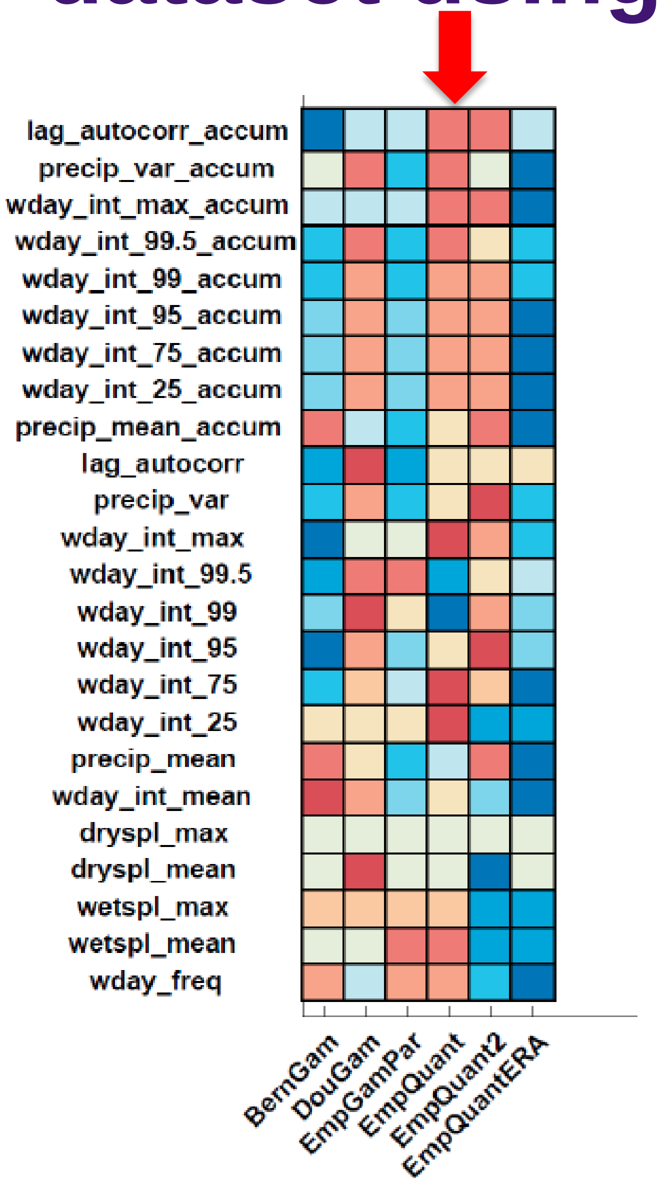
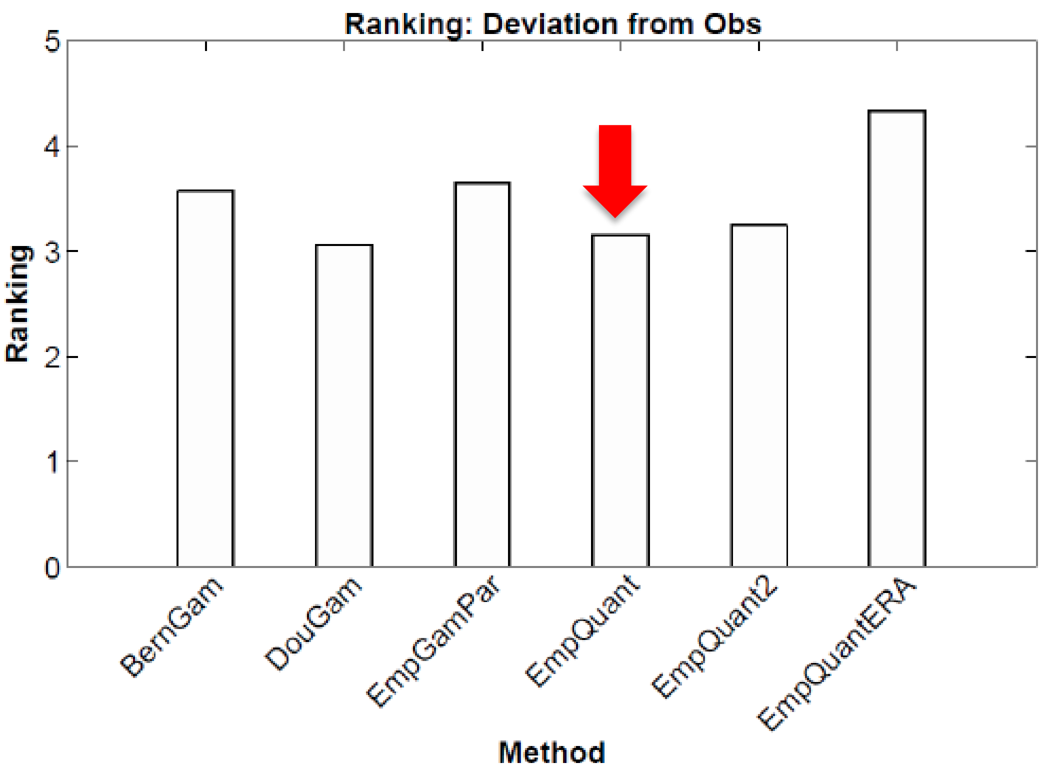
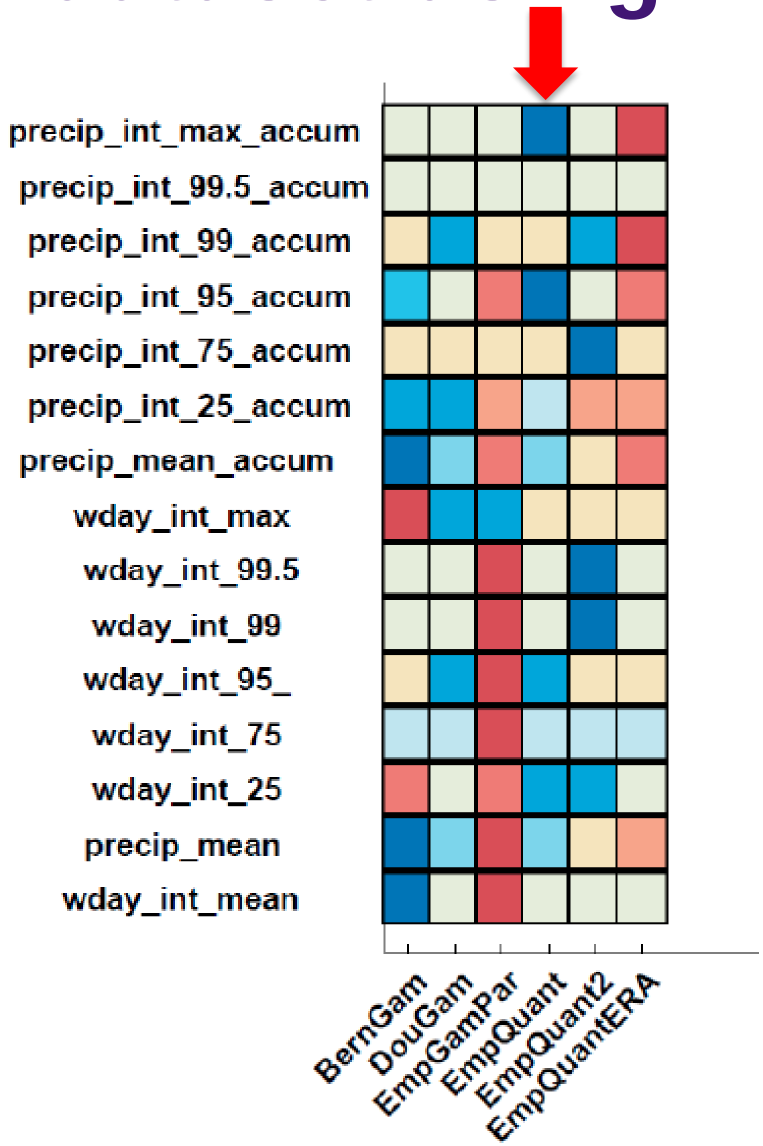
From 12x12km to 1x1km gridded dataset using EQM & interpolation



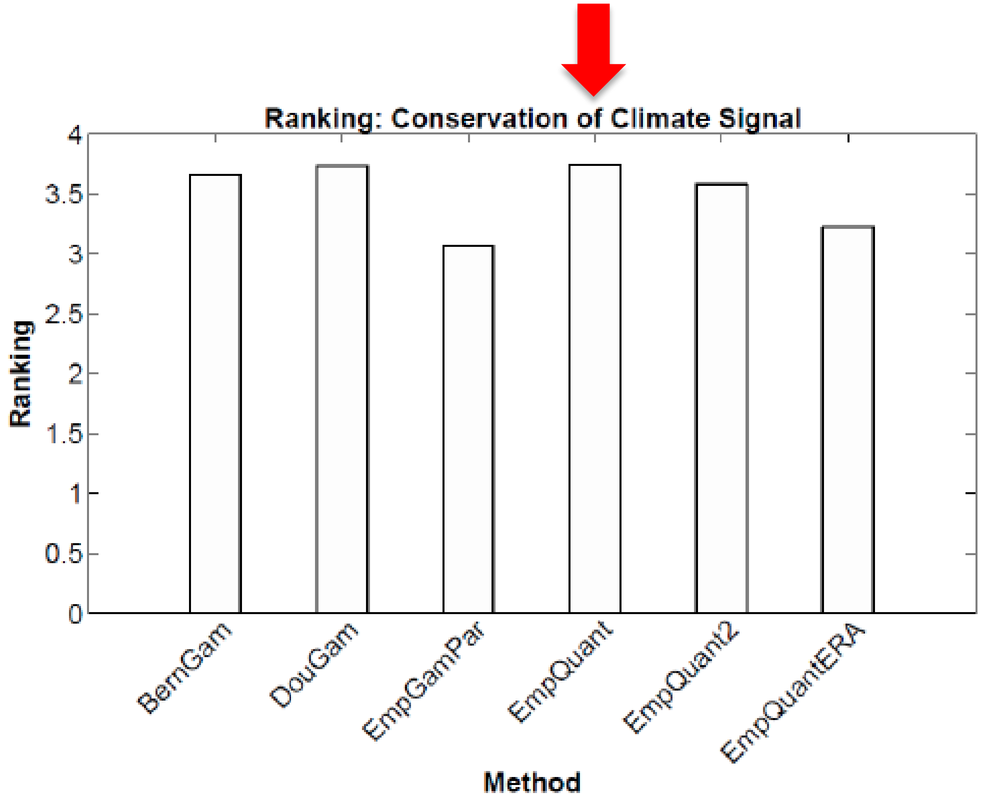
How well do various methods match obs?



From 12x12km to 1x1km gridded dataset using EQM & interpolation



How well do various methods preserve climate change signal?



Challenges: Evaluation Frameworks?

- Are we fulfilling the mission statement?
- Are products actually used?
- Currently no evaluation metrics/criteria or frameworks in place
- Who are the appropriate actors?

102 WEATHER, CLIMATE, AND SOCIETY VOLUME 9

TABLE 1. Proposed indicators for evaluating coproduced climate science.

Components	Indicators
Inputs	I1. Necessary scientific disciplines are included on research team (research capacity maps to research question).
	I2. Significant research time is devoted to project (% of FTE yr^{-1} allocated to the project)
	I3. Research team works collaboratively among themselves.
	I4. Target agency indicated commitment through contribution of services, funds, time, and a specific point person.
	I5. Target agency representatives on the project can articulate a need for this research (i.e., they have a problem they want to solve through this research project).
	I6. Target agency representative perceives a path to use/application of the research findings (i.e., does manager see barriers to implementation?)
	I7. Proposal includes a clear plan for communication, engagement, and/or collaboration between research and management team
	I8. Total funding for project compared to total amount allocated for engagement/collaboration activities (if discernable).
	I9. Research team has training or experience in collaborative research approaches.
	I10. Research team's motivations for participating in the project (i.e., their goal is actionable science).
	I11. Research team and agency representative have preexisting working relationship.
Process	P.1. Point at which host/target agency enters or participated in the project: vision, problem definition, research question articulation, research design, data collection, data analysis, knowledge/meaning making, testing results, dissemination of knowledge, evaluation of project.
	P.2. Frequency and medium of communication between research and management teams.
	P.3. Participants perceive they had equitable opportunities to participate in project meetings, workshops, etc. (observe interactions when possible).
	P.4. Target agency representative is satisfied with the level of engagement.
	P.5. Researchers are satisfied with the level of engagement.
	P.6. Challenges within project are resolved in mutually agreeable ways.
	P.7. Researchers are aware of whether/how information was used or not used by agency.
Outputs	OP.1. Number of peer-reviewed articles.
	OP.2. Number of technical reports/gray literature.
	OP.3. Workshops or meetings to disseminate findings.
	OP.4. Final report is delivered directly to agency representative(s) or made easily accessible via another format.
	OP.5. Findings are delivered in a timely manner (meet agency's decision calendar or timeline).
	OP.6. Other outputs (media reports, websites, other products created by the project).
Outcomes	OC1. Project goals have been achieved (both objective assessment by evaluator and researcher and agency representative perceptions with regard to completion of goals).
	OC2. Participants perceive science as credible.
	OC3. Findings/outputs meet the standard the agency applies to "usable" information for action.
	OC4. Agency participants perceive the science as salient to their needs/problems.
	OC5. Participants perceive that the process of producing the science was legitimate (i.e., all participants had opportunities to contribute).
	OC6. Mutual interest in longer-term collaboration (i.e., both teams express interest in working together again).
Impacts	IM.1. "Enlightenment" use of information (agency representative perceives self to be better informed about an issue).
	IM.2. "Problem Understanding" use of information (more specific than Enlightenment, better comprehension of particular problems).
	IM.3. "Instrumental" use of information (agency representative finds out what to do and how to do something; gained new skills).
	IM.4. "Factual" use of information (provision of precise data, for example).
	IM.5. "Confirmational" use of information (previous information was verified).
	IM.6. "Projective" use of information (agency gained better understanding of possible future scenarios).
	IM.7. "Motivational" use of information (encouraged someone to keep going (or not) on search for information).
	IM.8. "Personal or Political" use of information (helped a person gain control of a situation or avoid a bad situation).
	IM.9. Findings from study are explicitly used in agency planning, resource allocation, or policy decision.
	IM.10. Findings contribute to successful climate change adaptation action.

Table of 45 indicators for evaluating climate services from Wall et al., 2017 https://doi.org/10.1175/WCAS-D-16-0008.1

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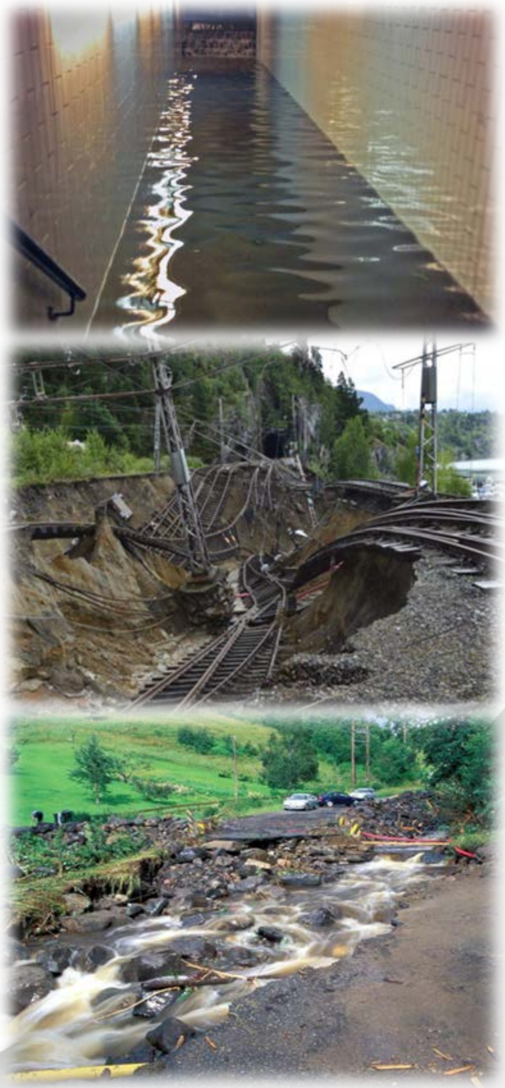
Challenges: Structure and roles

- Currently very “top down” and project oriented (time limited)
- Lack of a stable organizational framework for knowledge development and exchange
- Preferences are not clear-cut or predefined (multi-disciplinarity can be a problem)
- Actor participation is fluid; temporality is a constraint



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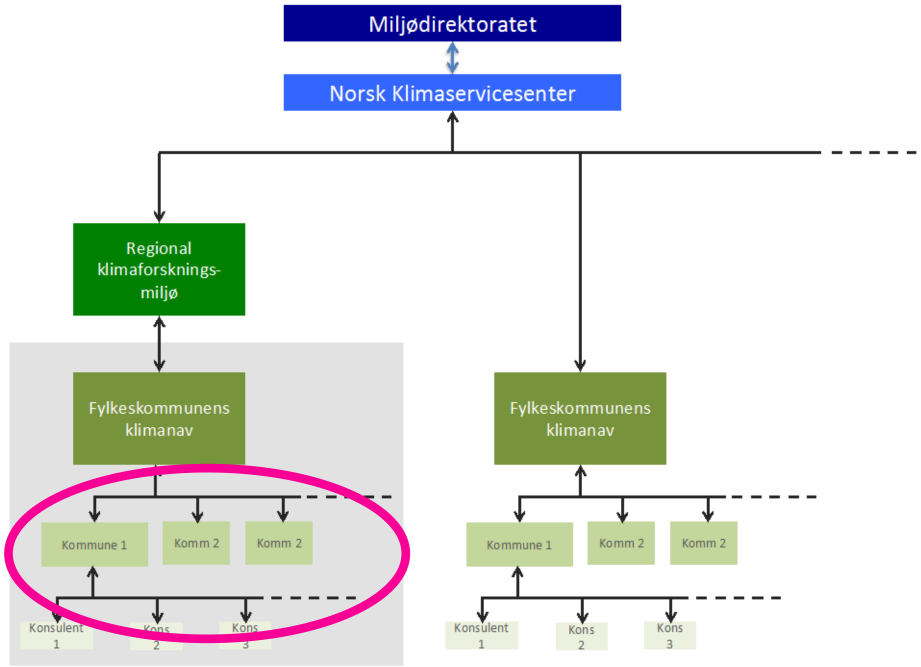
Challenges: Engagement

- Climate services need to be integrated into existing decision-making processes.
- Each municipality has very local climate needs even within similar climate zones.
- Need for sustained local engagement to determine needs & communicate local-based expertise and knowledge
- This requires considerable investment

There is need for more bottom up engagement!



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Conclusions and the way forward

- Different mandates, preferences, constraints of providers must be reconciled
- Scientific rigor critical establish trust and helps establish voice of authority (see mission)
- Need stronger and more sustained engagement and guidance; requires input from other disciplines
- Stronger pan-Nordic collaboration at national level climate services

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Thank You!

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+2, 4 or 6 °C? International collaboration on temperature targets

Gustav Strandberg
Rossby Centre, SMHI

SMHI

SMHI

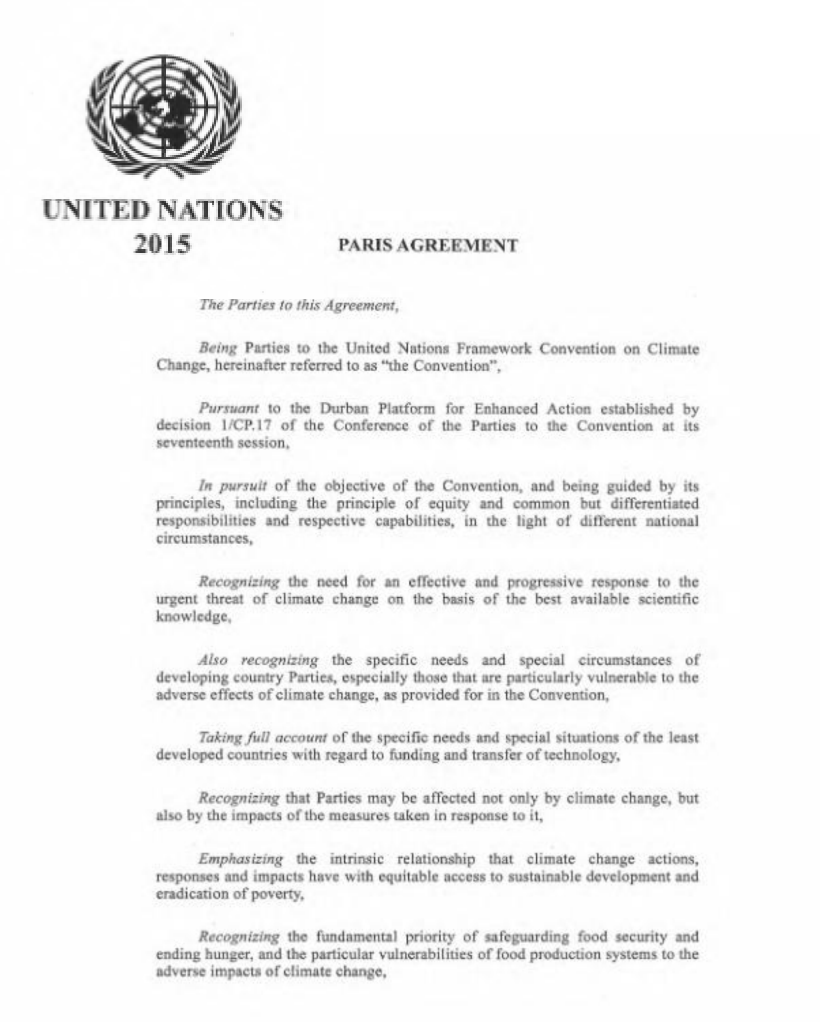
+2, 4 or 6 °C? International collaboration on temperature targets

Gustav Strandberg with Lars Bärring, Erik Kjellström, Grigory Nikulin

IMPACT2C

helix
www.helixclimate.eu

The Paris Agreement


UNITED NATIONS
2015

PARIS AGREEMENT

The Parties to this Agreement,

Being Parties to the United Nations Framework Convention on Climate Change, hereinafter referred to as "the Convention",

Pursuant to the Durban Platform for Enhanced Action established by decision 1/CP.17 of the Conference of the Parties to the Convention at its seventeenth session,

In pursuit of the objective of the Convention, and being guided by its principles, including the principle of equity and common but differentiated responsibilities and respective capabilities, in the light of different national circumstances,

Recognizing the need for an effective and progressive response to the urgent threat of climate change on the basis of the best available scientific knowledge,

Also recognizing the specific needs and special circumstances of developing country Parties, especially those that are particularly vulnerable to the adverse effects of climate change, as provided for in the Convention,

Taking full account of the specific needs and special situations of the least developed countries with regard to funding and transfer of technology,

Recognizing that Parties may be affected not only by climate change, but also by the impacts of the measures taken in response to it,

Emphasizing the intrinsic relationship that climate change actions, responses and impacts have with equitable access to sustainable development and eradication of poverty,

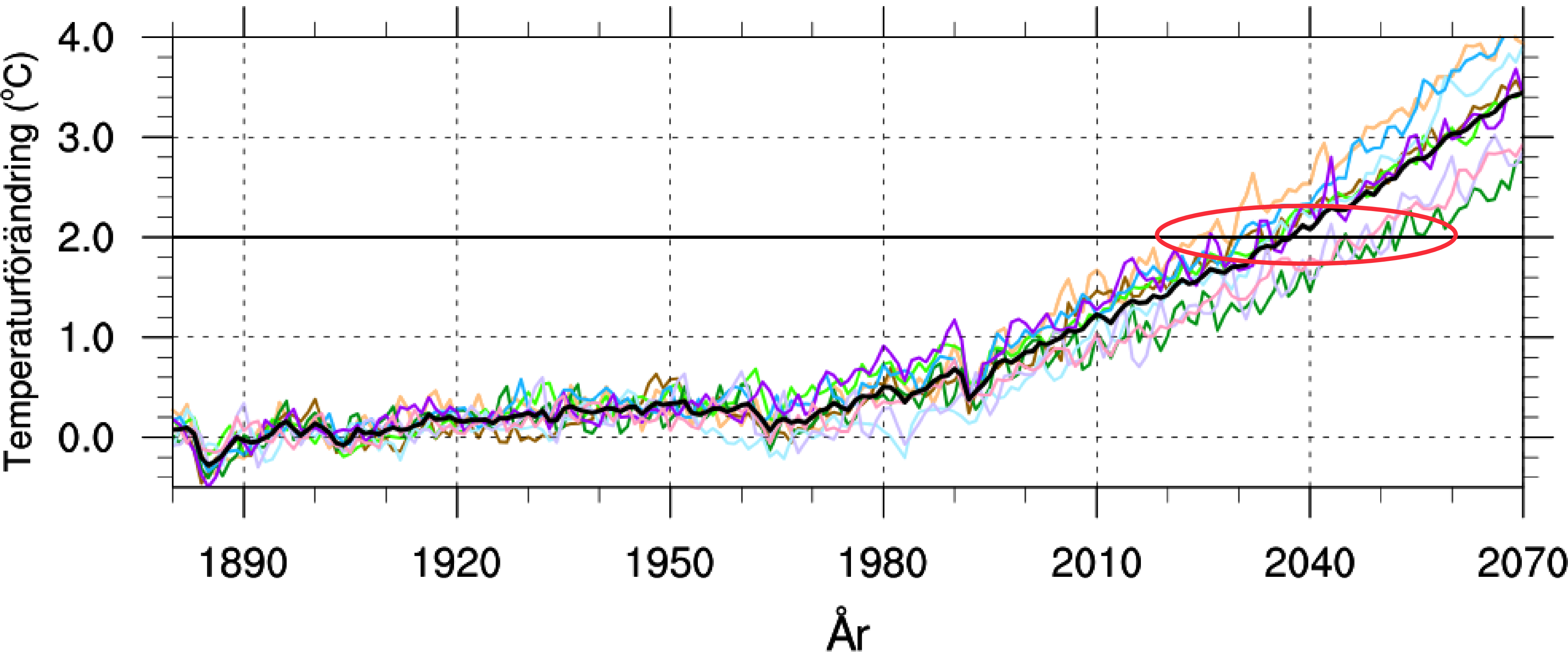
Recognizing the fundamental priority of safeguarding food security and ending hunger, and the particular vulnerabilities of food production systems to the adverse impacts of climate change,

Aim to keep "a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels" (UNFCCC, 2015).

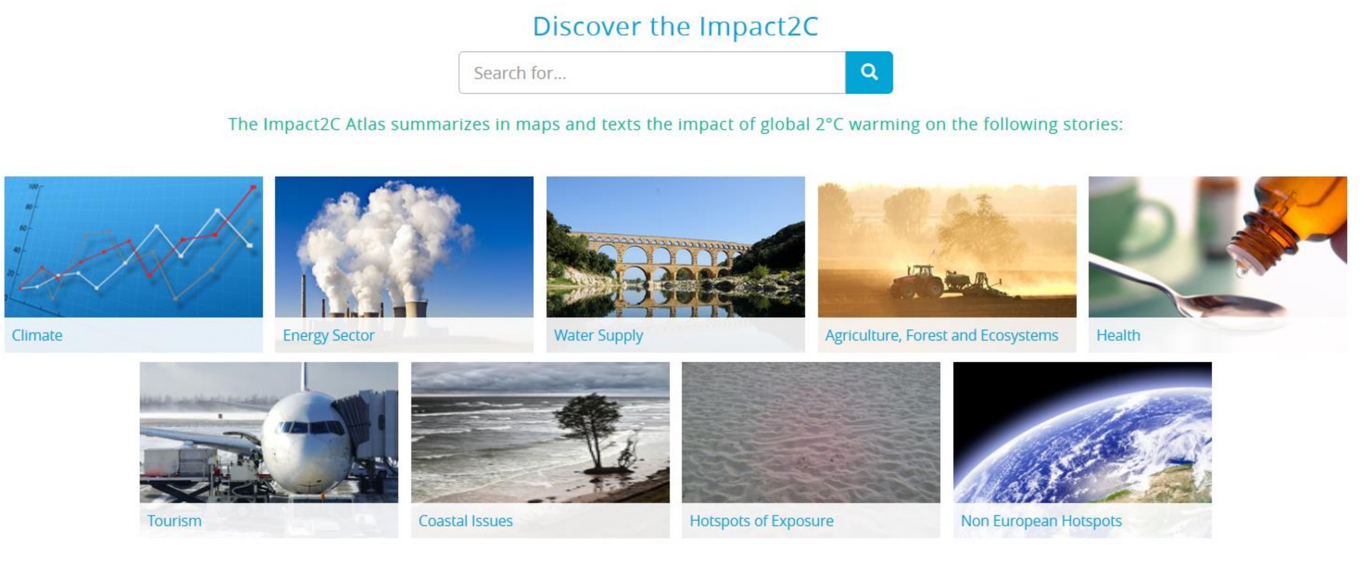
"The two degree target"

SMHI

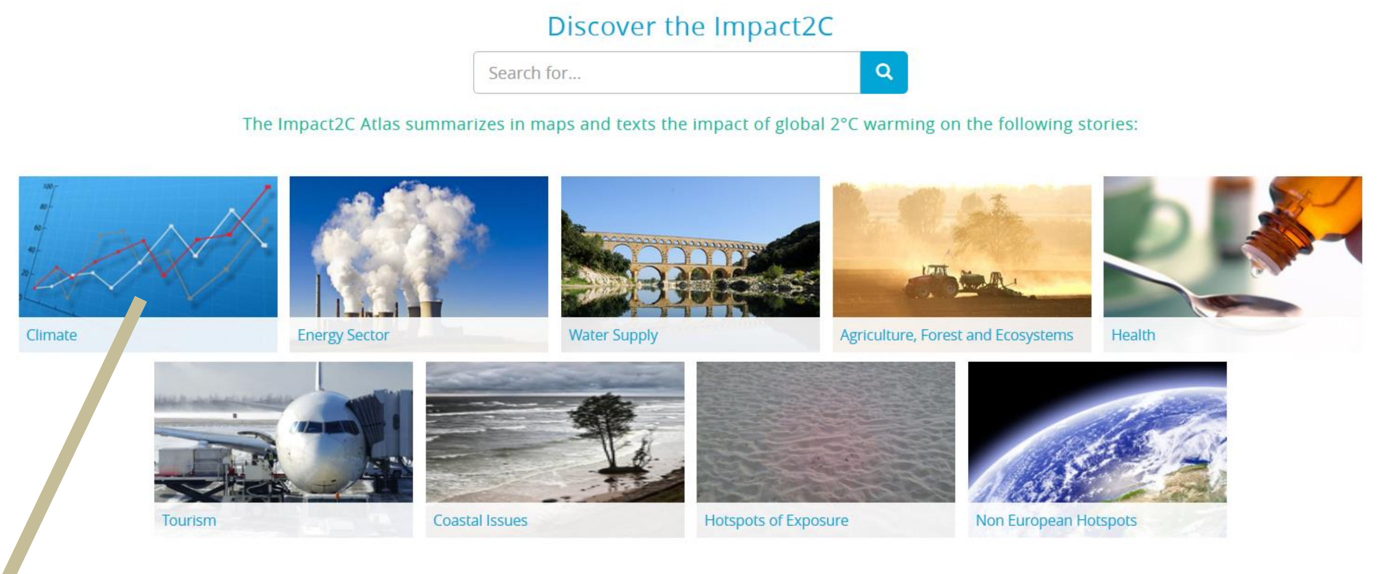
What does two degrees warming mean?

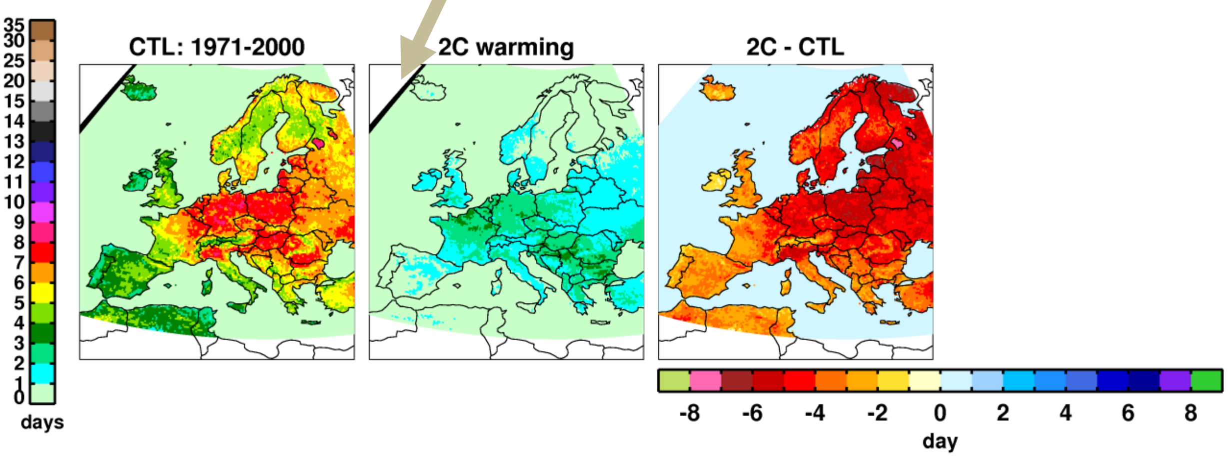


Impact2C project

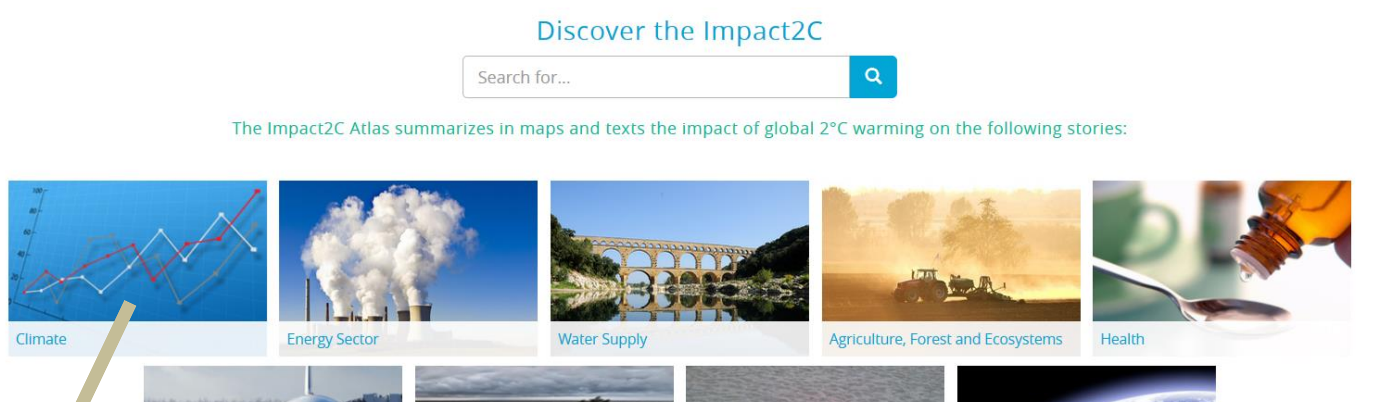


Impact2C project





Impact2C project



Key messages

i) cold spell duration strongly decreases across Europe under a 2C warming
ii) cold spells duration is reduced more than twice or almost disappear
iii) shorter cold spells have a positive impact on the human society in Europe

Why is the content of this map important?

Cold spells are abnormal long-lasting cold periods when temperature drops much below the climatological norm. They have strong negative impact on the human society including health and infrastructure.

Which sectors are affect by this result?

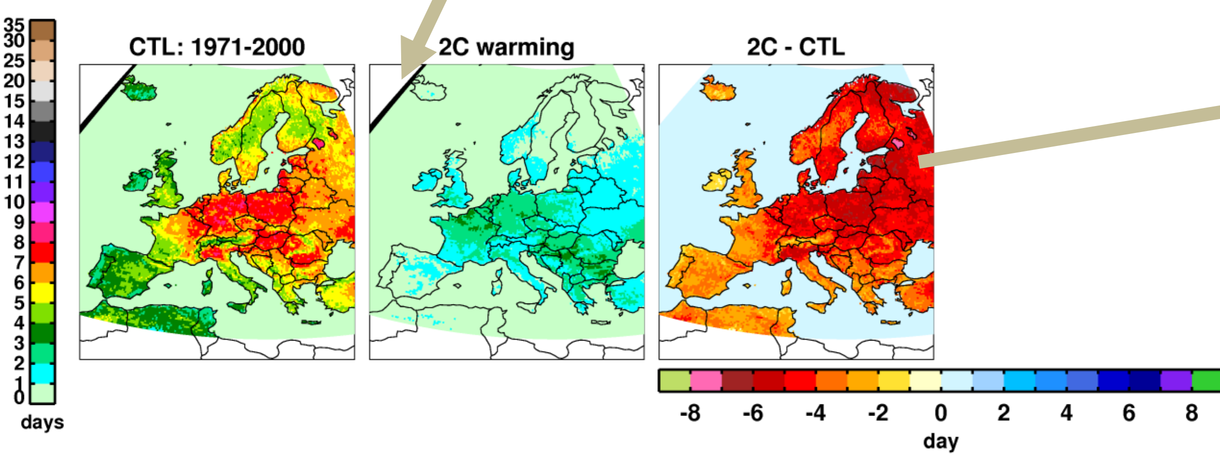
Heart/respiratory diseases and strokes increase during cold spells. Consumer demand for electrical power rises. This can lead to overloads that can result in a cold-weather outage. Transport infrastructure may partly collapse in case of extremely strong and long cold spells.

What is shown in the maps

The 1971-2000 period shows that cold spell duration varies from 3 to 9 days across Europe with maximum up to 10 days over central and eastern Europe. When the global mean temperature increases by 2C duration of cold spells is strongly reduced. Cold spells which are typical for 1971-2000 almost completely disappear in Scandinavia and Iberian Peninsula. In central and eastern Europe cold spell duration is strongly reduced by more than twice: from 6-8 days to 2-4.

Details and further information:

Cold spell duration is defined accordingly to recommendations from the Expert Team on Climate Change Detection and Indices (ETCCDI). They are estimated as a number of days when daily minimum temperature is below its climatological 10th percentile for at least 6 consecutive days. In the 2C future warming period the 10th percentile for 1971-2000 is used as a reference. Cold spell duration is calculated annually for each year and when averaged over 30-year periods can be less than 6 days. This simply means that cold spells occur only in some years but not every year.



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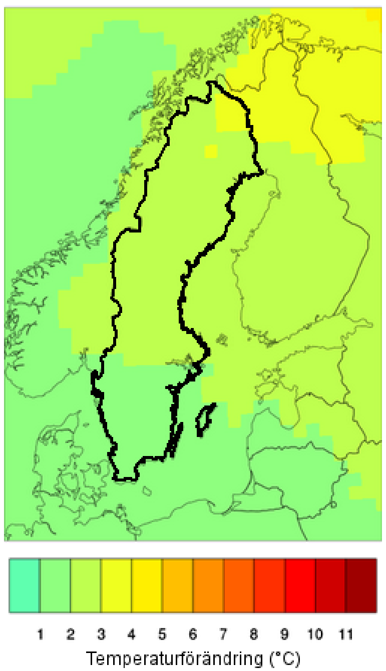
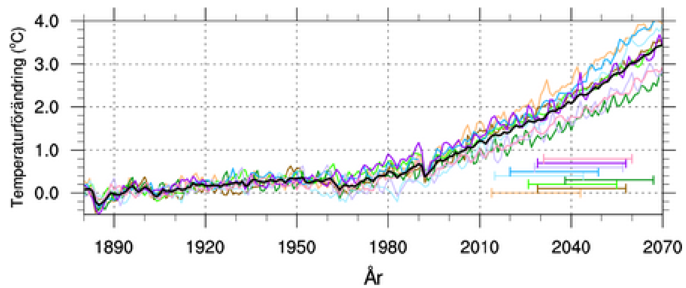
+2C at smhi.se

Change in annual mean temperature in Sweden at 2°C global warming, according to scenario RCP8.5



Calculated change in annual mean temperature (°C) compared to 1971-2000 at the period for 2°C global warming according to scenario RCP8.5



Global temperature increase compared to 1881-1910 according to nine different climate models according to scenario RCP8.5 (coloured lines) and the average of the model ensemble (black line). The thirty year period representing two degrees warming are show as horizontal lines of the same colours as the respective models.

Internationally there is an ambition to limit the increase in global average temperature to below two degrees compared to pre-industrial levels. Since the global temperature increase of two degrees is just an average it is interesting to look at the temperature increase at regional scale in Europe and Sweden (read more).

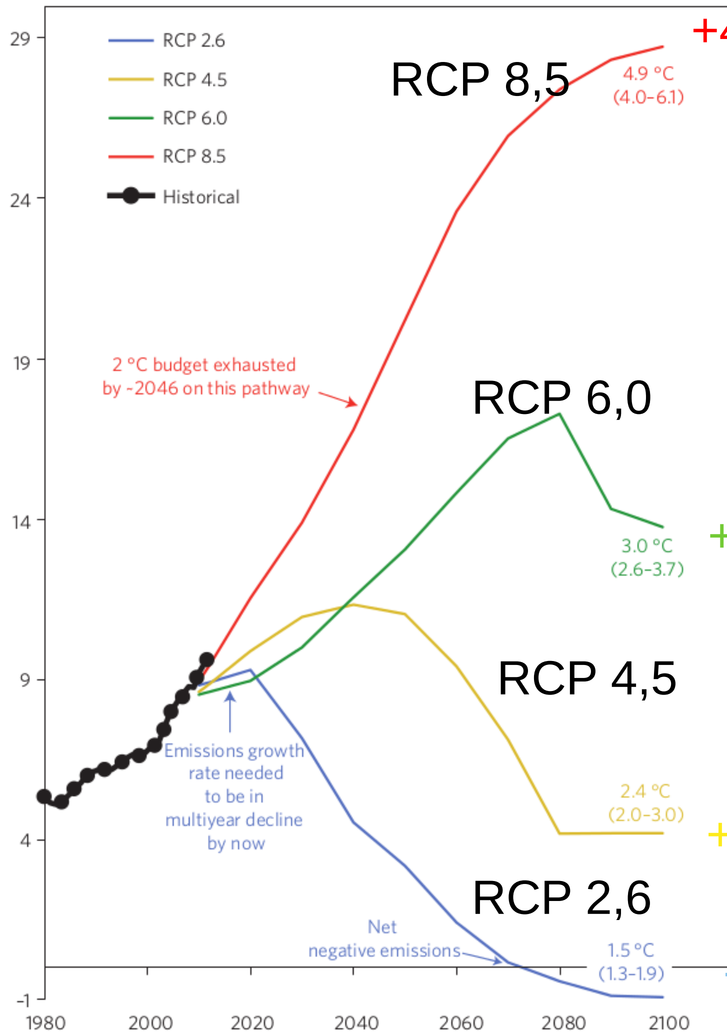
Enlarge image

www.smhi.se/klimat/framtidens-klimat/klimatscenarier/

Where are we heading?

CO_2 emissions, billion tonnes C/year

(Pg C/year)



+4,9 °C

+3,0 °C

+2,4 °C

+1,5 °C

Current policy +3,6 °C

With pledges +2,7 °C

+2 °C

Sanford et al., 2014

År

Climateactiontracker.org

SMHI

Helix project

Aim to provide a set of credible, coherent, global and regional views of different worlds at 2, 4 and 6°C, and now 1.5°C.

Focus on delivering the knowledge needs of Northern Sub-Saharan Africa, South Asia and Europe.

SMHI

Questions

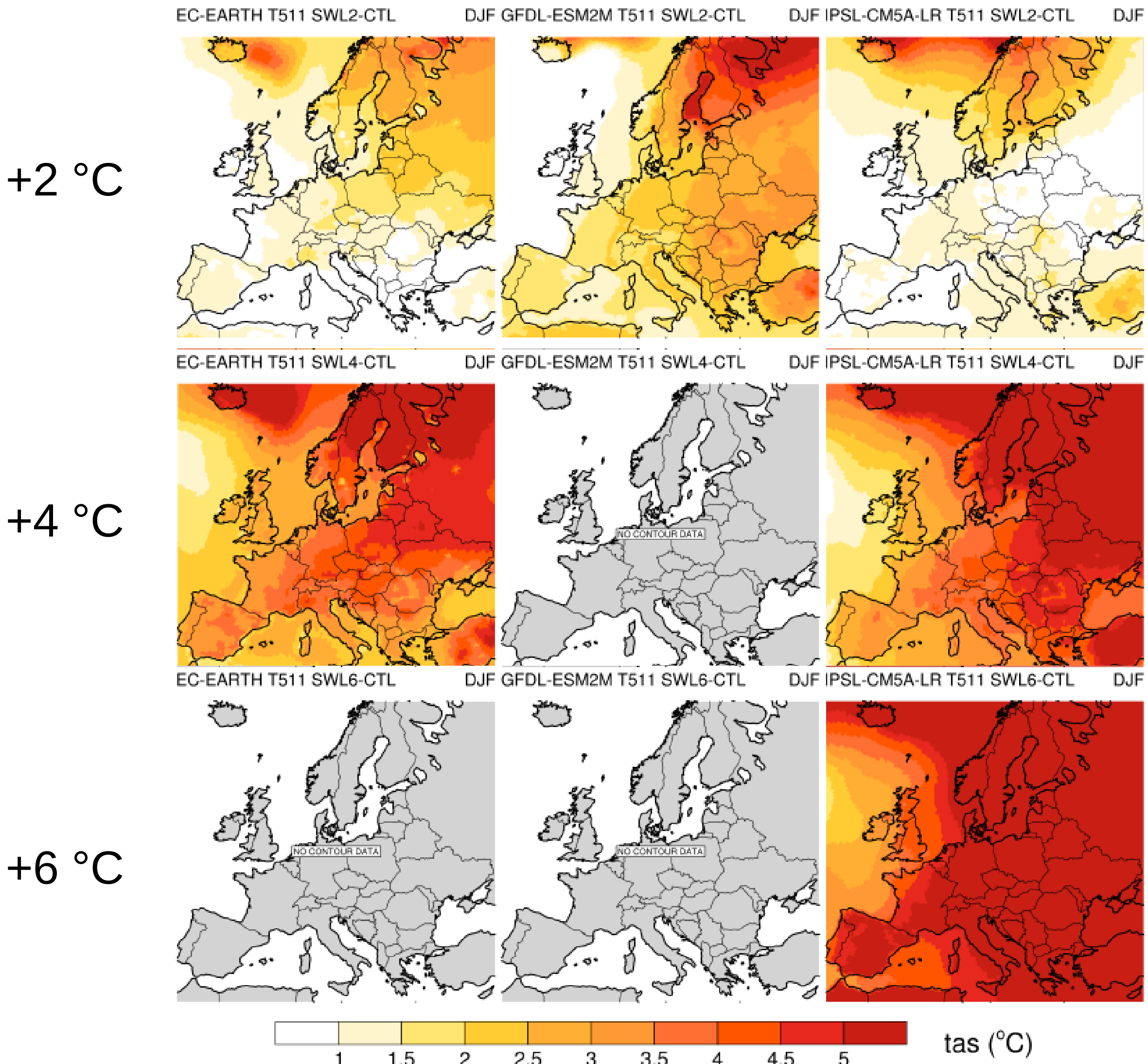
Climate change in Europe at +2C and +4C based on results from EURO-CORDEX and HELIX.
Compare with the CMIP5 data base. Specifically, we address the questions:

i) What will the regional climate look like in Europe at different warming levels?

ii) Will the warming exceed that of the global mean?

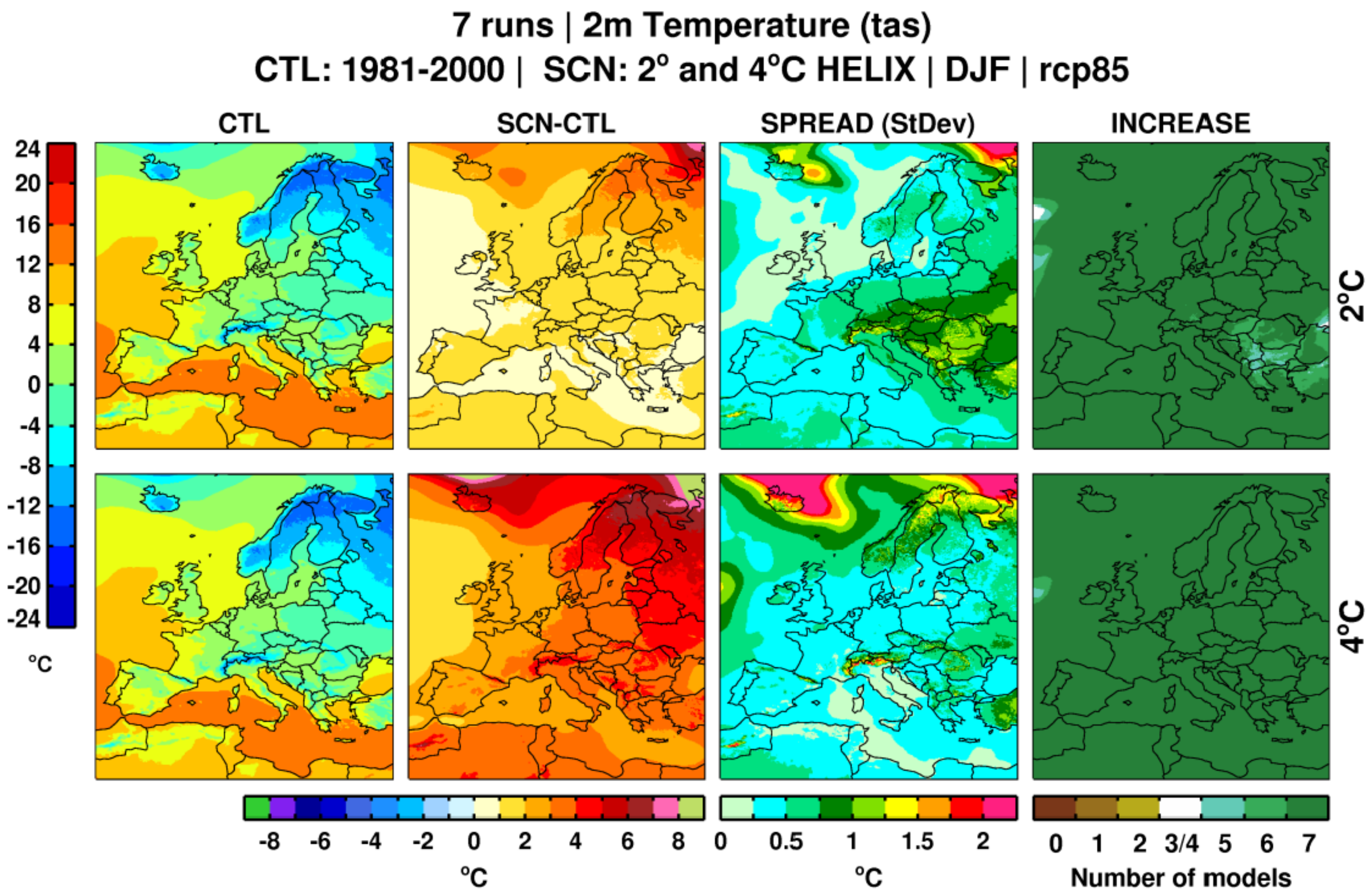
iii) Will the resulting climate change signal based on a subset of CMIP5 GCMs be similar to that of the larger ensemble of all CMIP5 GCMs or will the subset be a misrepresentation?

Future winter temperature

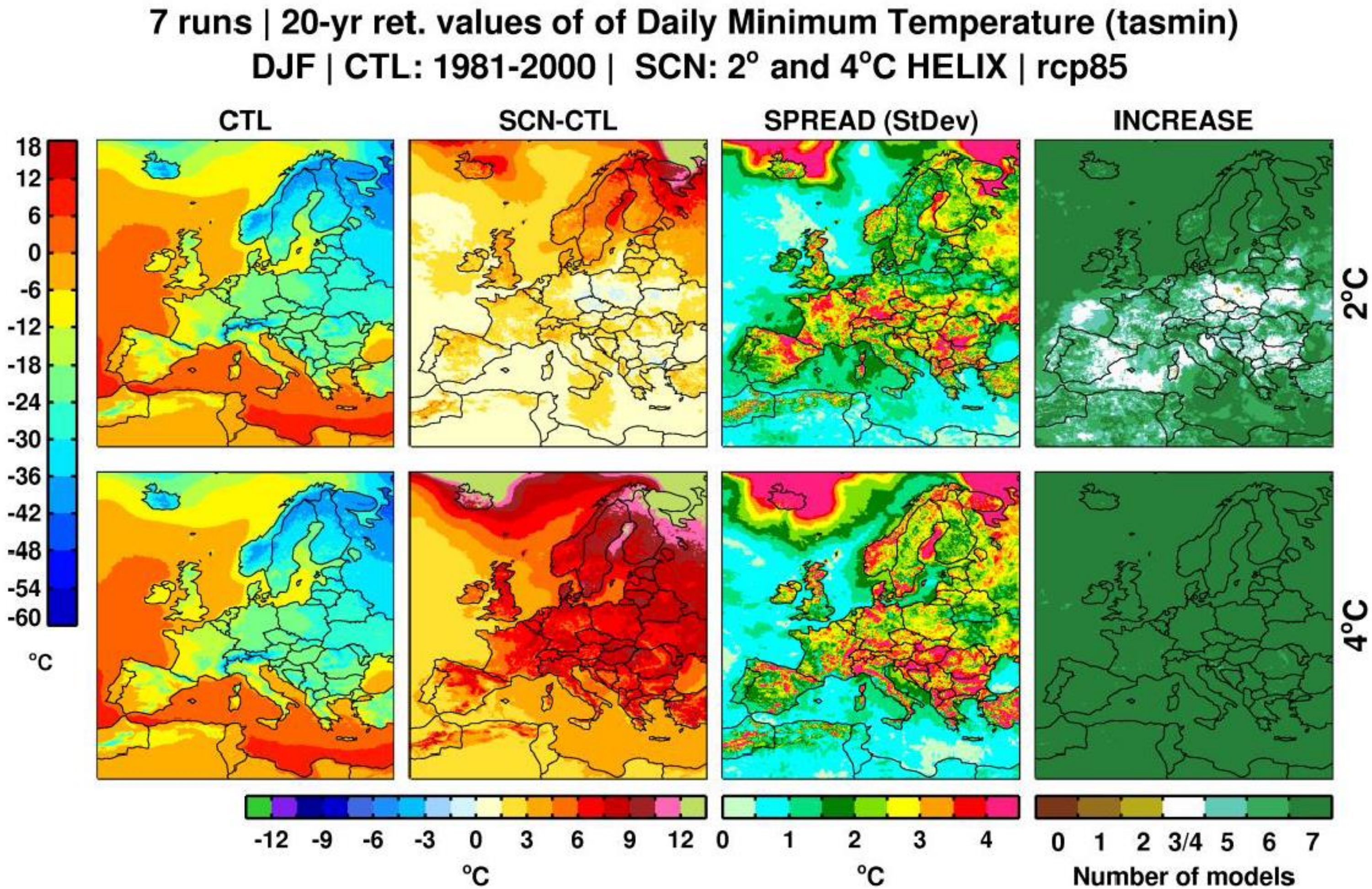


EC-EARTH atmosphere at resolution T511 ≈ 40 km

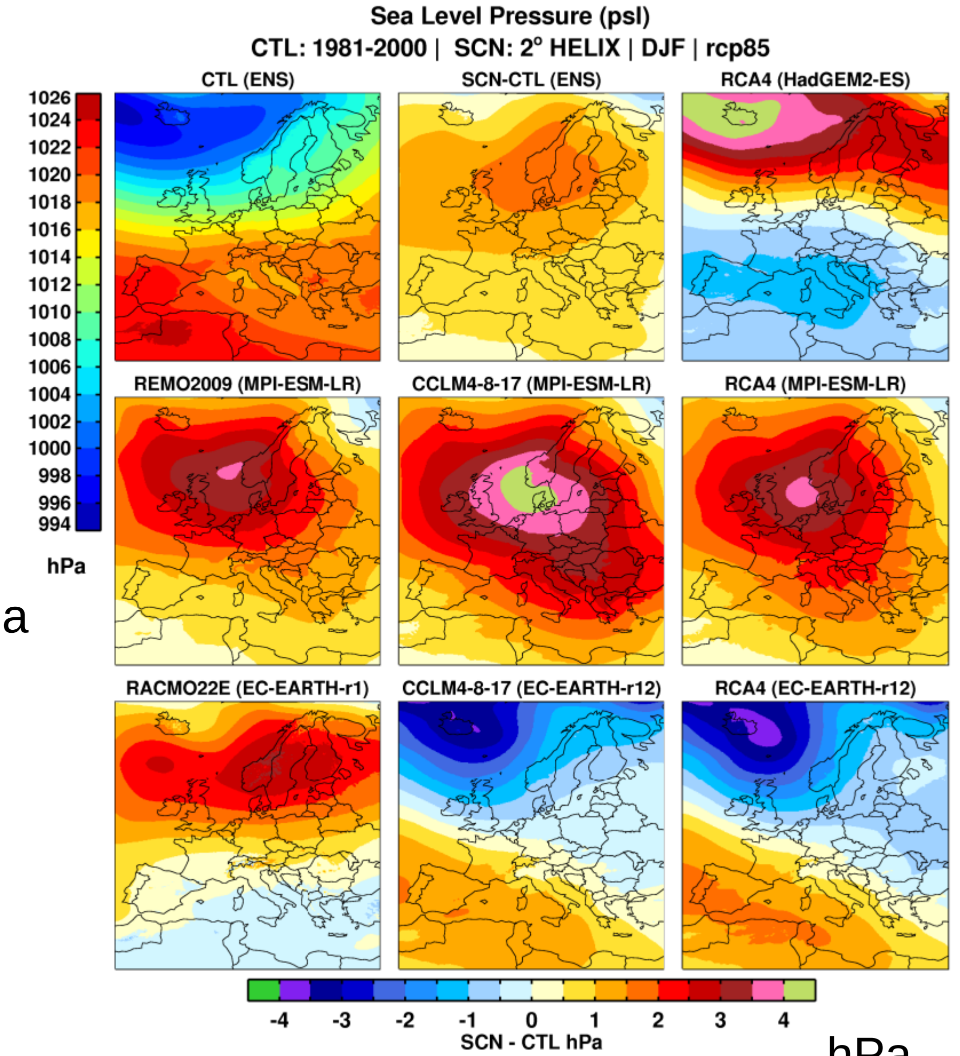
Future winter temperature



20yr return values of winter temperature



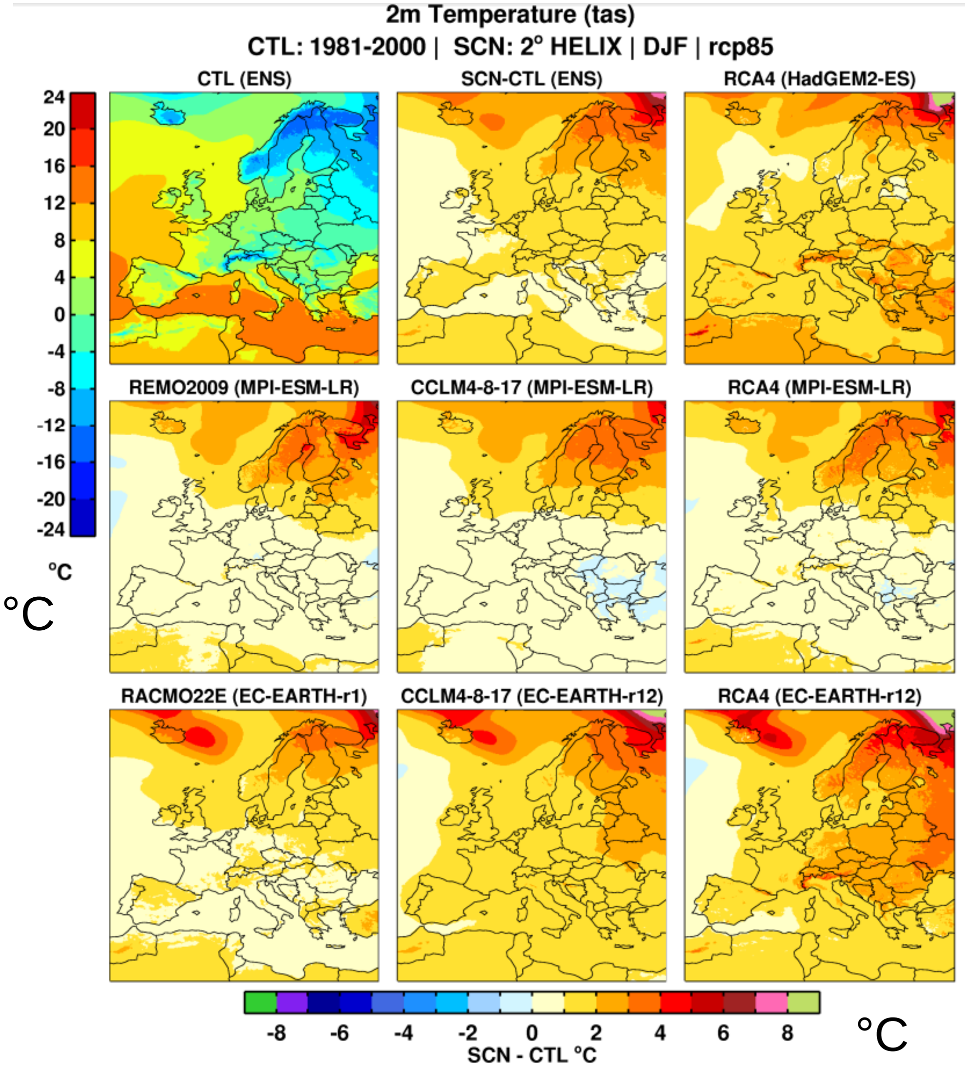
Individual RCM response – winter MSLP



hPa

hPa

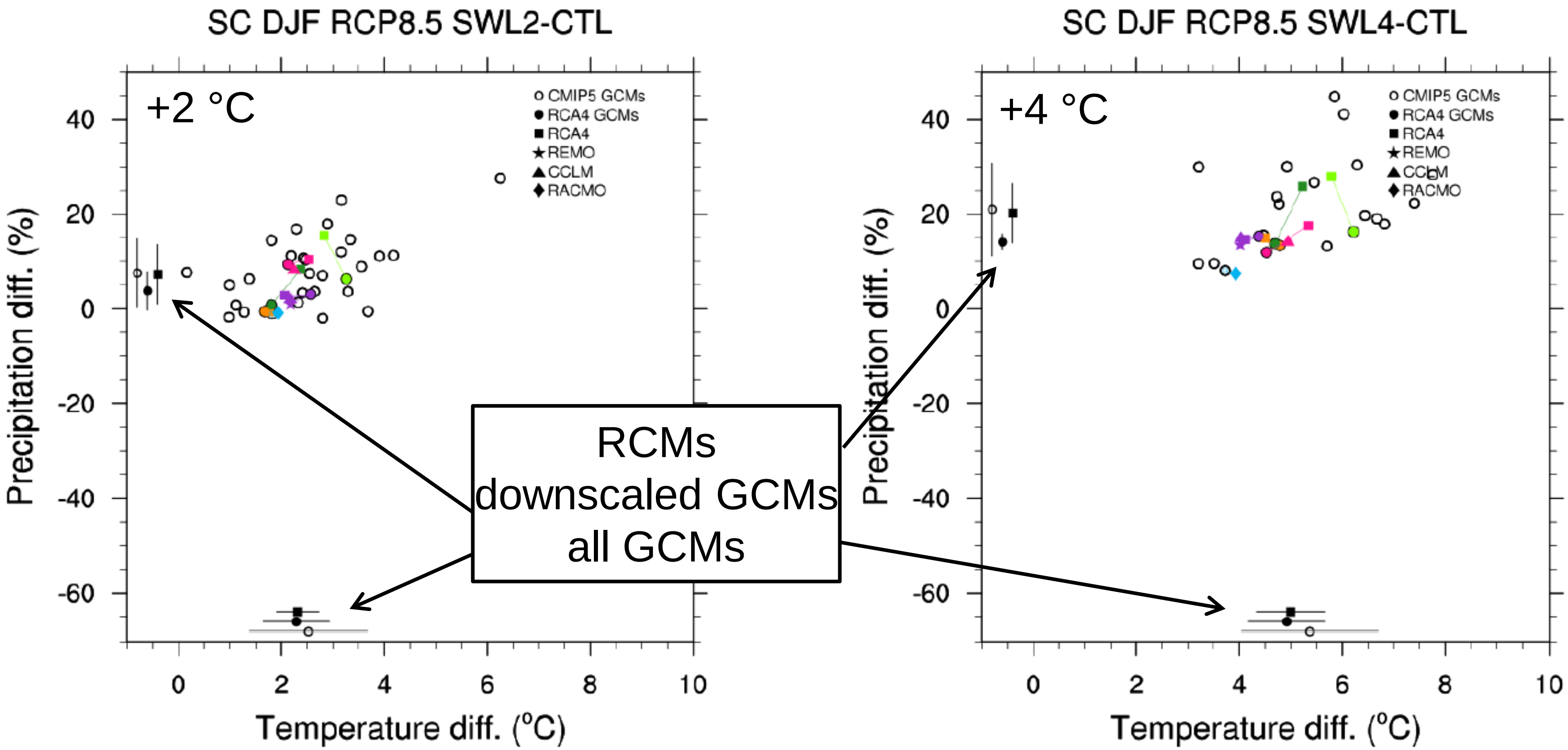
Individual RCM response – winter temperature



°C

°C

The results in a wider context



i) neither the subsample of GCMs nor the RCMs do represent the full variability
ii) the RCMs change the climate change signal compared to the GCMs
iii) the RCM ensemble is mostly within the range of the wider CMIP5 ensemble

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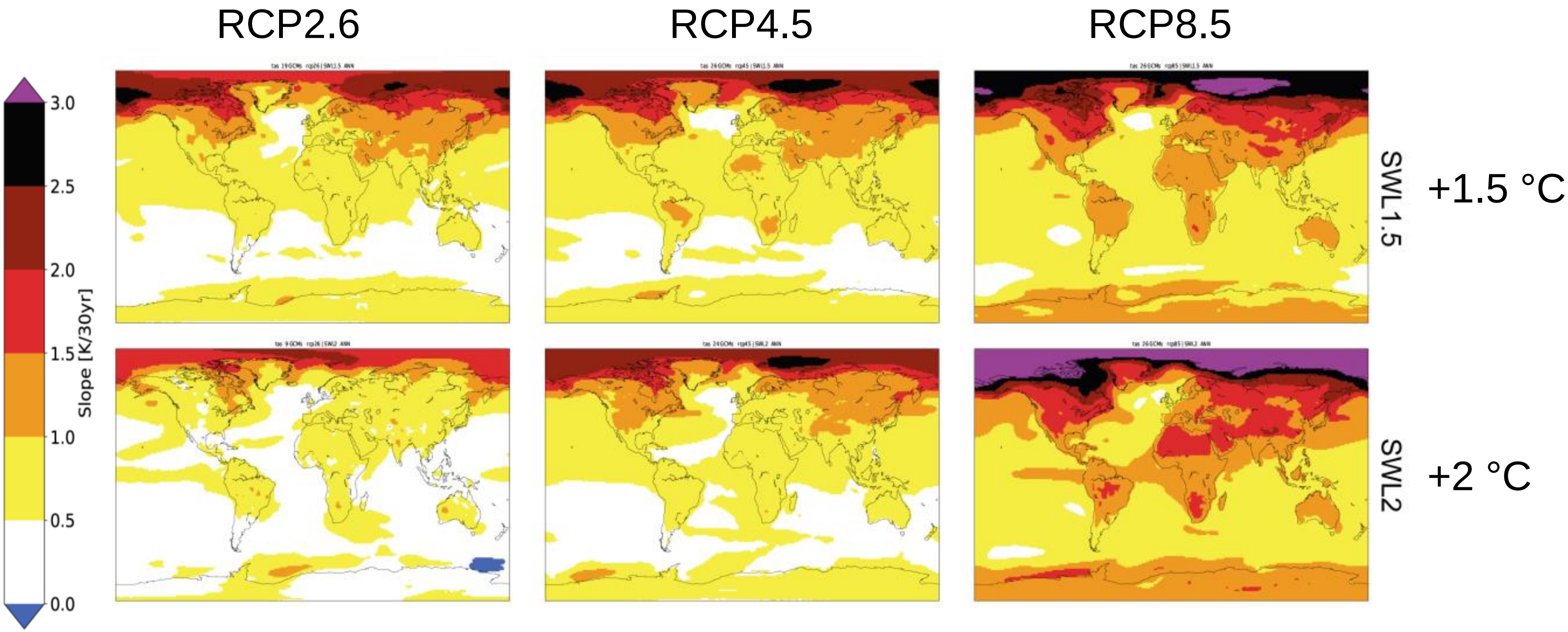
Can RCPs represent temperature levels?



30 year trend in temperature (K/30 years) att different warming levels

Summary

- Stronger warming than on a global mean scale is found for Europe (and other parts of the world)
- Stronger changes in extremes compared to means
- Impact of large-scale circulation sometimes large (notably in DJF and at +2C)
- Limited ensemble size undersamples CMIP5 range
- RCMs are mostly within the CMIP5 range but it is clear that RCMs change GCM results
- If we meet the “two degree target” it will not be along any of the RCPs -> need for stabilisation scenarios

Urban SIS: climate information for European cities

Petter Lind
Rossby Centre, SMHI

SMHI

Urban SIS: Climate information for European cities

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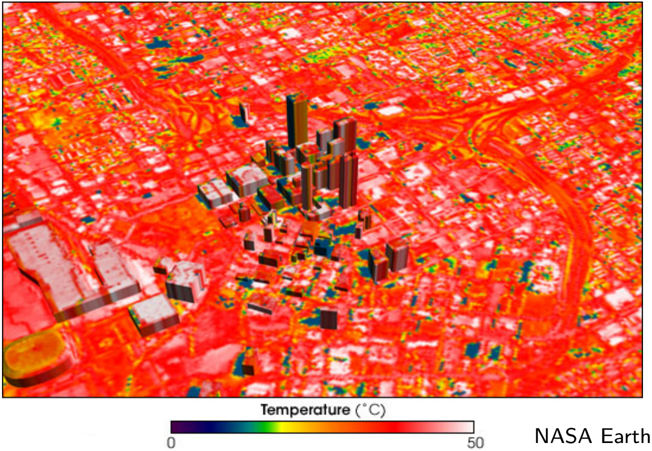
Swedish Meteorological and Hydrological Institute
Rossby Centre

2017-09-14

Urban modeling



NASA Earth Observatory

SMHI

Lim et. al., 2017

Urban SIS

- Urban SIS is a Copernicus funded project and part of the C3S programme.
- Copernicus Climate Change Service (C3S): provide quality-assured climate information for past, present and future states at temporal and spatial scales relevant to European sectors.
- Urban SIS runs from October 2015 to December 2017.

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Partners:

Urban SIS – Concept & Goals

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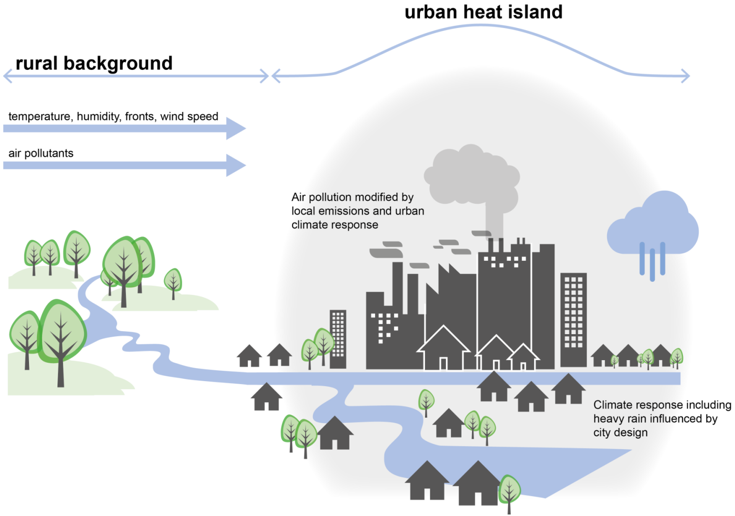
- Urban SIS will offer climate and impact information on the urban scale ($\sim 1\,\text{km}^2$) for major cities, with focus on health and infrastructure sectors.
- Three pilot cities: Stockholm, Amsterdam-Rotterdam and Bologna.



Urban SIS – Concept & Goals

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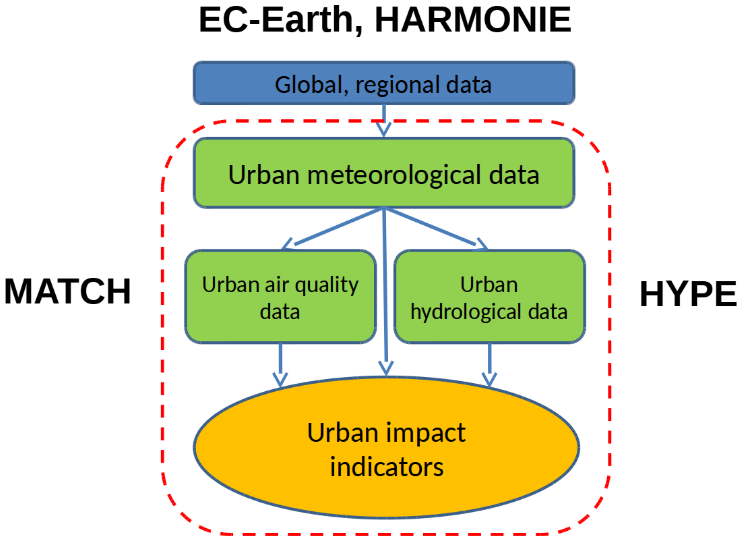
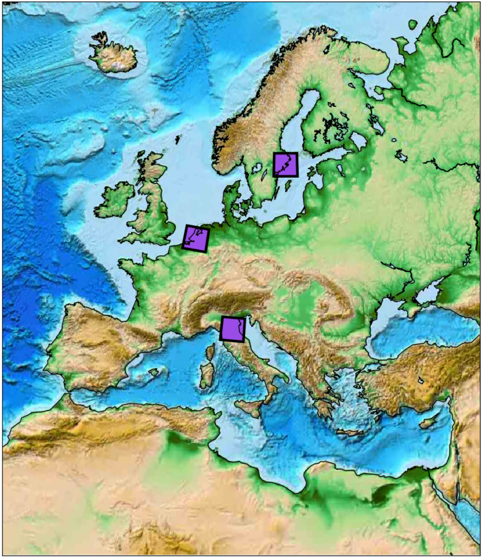
Essential Climate Variables (ECVs)

- ECVs for urban downscaling:
  - o Precipitation and water vapor
  - o Urban temperature
  - o Wind speed and direction
  - o Surface radiation budget
  - o Regional concentrations of NO_2, O_3, PM_{10}, $PM_{2.5}$.
  - o Regional scale soil moisture and river charge
- Statistical indicators (time averages, frequency, return period etc.) are calculated for present and future conditions.
- User-friendly impact indicators specified by the infrastructure and health sectors.

Urban SIS – Method



Urban SIS – Method



Climate simulations

- UERRA re-analysis, 11 km, Europe
  –> HARMONIE-AROME (1 km, 5 years)
- EC-Earth
  Global ∼ 80 km, RCP8.5
- HARMONIE-ALARO
  Regional 20 km, Europe:
  2 × 30 years
- HARMONIE-AROME
  1 km city domains
  (240×240 grid points):
  5 history + 5 scenario years per city = 30 years total.

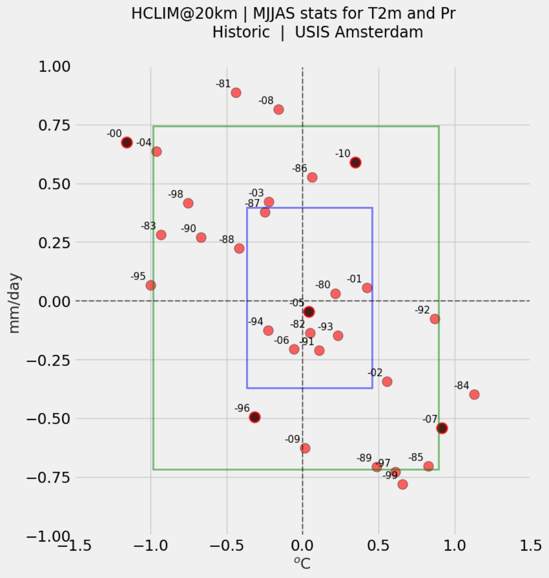
Urban SIS – Method

Selection of time windows

- How do we select years that are interesting for the end user (heat waves, flash floods), and at the same time representative for the climate (present or future)?

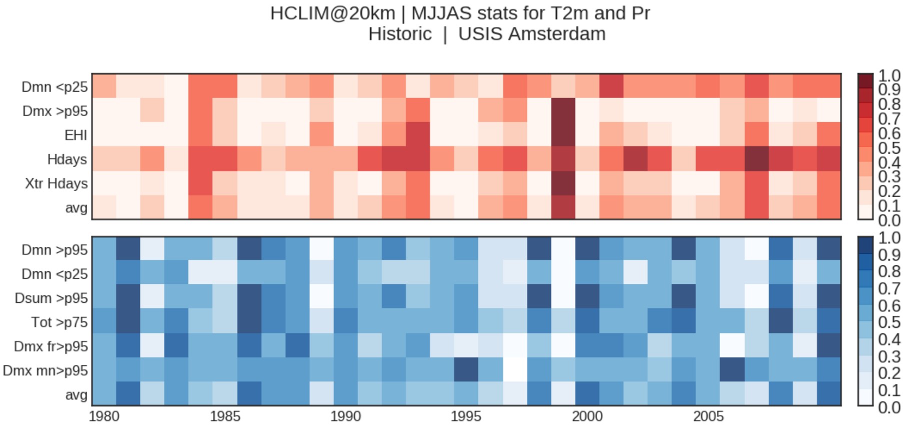
Urban SIS – Method

- Identify "extreme" years ...



Urban SIS – Method

- Joint, multi-index, comparisons provide more information of ”extremeness”.



Urban SIS – Product portal

- Visualisation, selection and download of the Urban SIS data.
- Data is stored as NetCDF following convention CF-1.6.
- http://urbansis.climate.copernicus.eu/