Consistency of recently observed trends over the Baltic Sea basin with climate change projections

Hans von Storch, Armineh Barkhordarian, Juan J. Gómez-Navarro

7th Study Conference on BALTEX
10-14 June 2013, Sweden

Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research

Introduction

Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research

In this study we investigate the consistency of observed trends with climate change projections.

The principle aim of “consistency” method is to tackle the question, whether the recent change is a plausible harbinger of future change that is, we examine to what extent the observed climate trends are already an indication of the conditions described by the climate change scenarios (A1B) at the end of this century.

Jonas Bhend and Hans von Storch (2008) Consistency of observed winter precipitation trends in northern Europe with regional climate change projections. **31**,17-28.

Jonas Bhend and Hans von Storch (2009) Is greenhouse gas forcing a plausible explanation for the observed warming in the Baltic Sea catchment area? Boreal Environment Research. **14**, p81.

Data

Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research

Parameters and observed datasets used:

- 2m Temperature — CRUT
- Precipitation — CRU, GPCC6, GPCP
- Mean Sea-level pressure — HadSLP2
- 500 hPa Geopotental height — NCEP/NCAR
- Specific and relative humidity — HadCRUH
- Cloud cover — CRU
- Surface solar radiation — MFG Satellites

Models:

- 10 simulations of RCMs are used from ENSEMBLES project

Estimating natural variability:

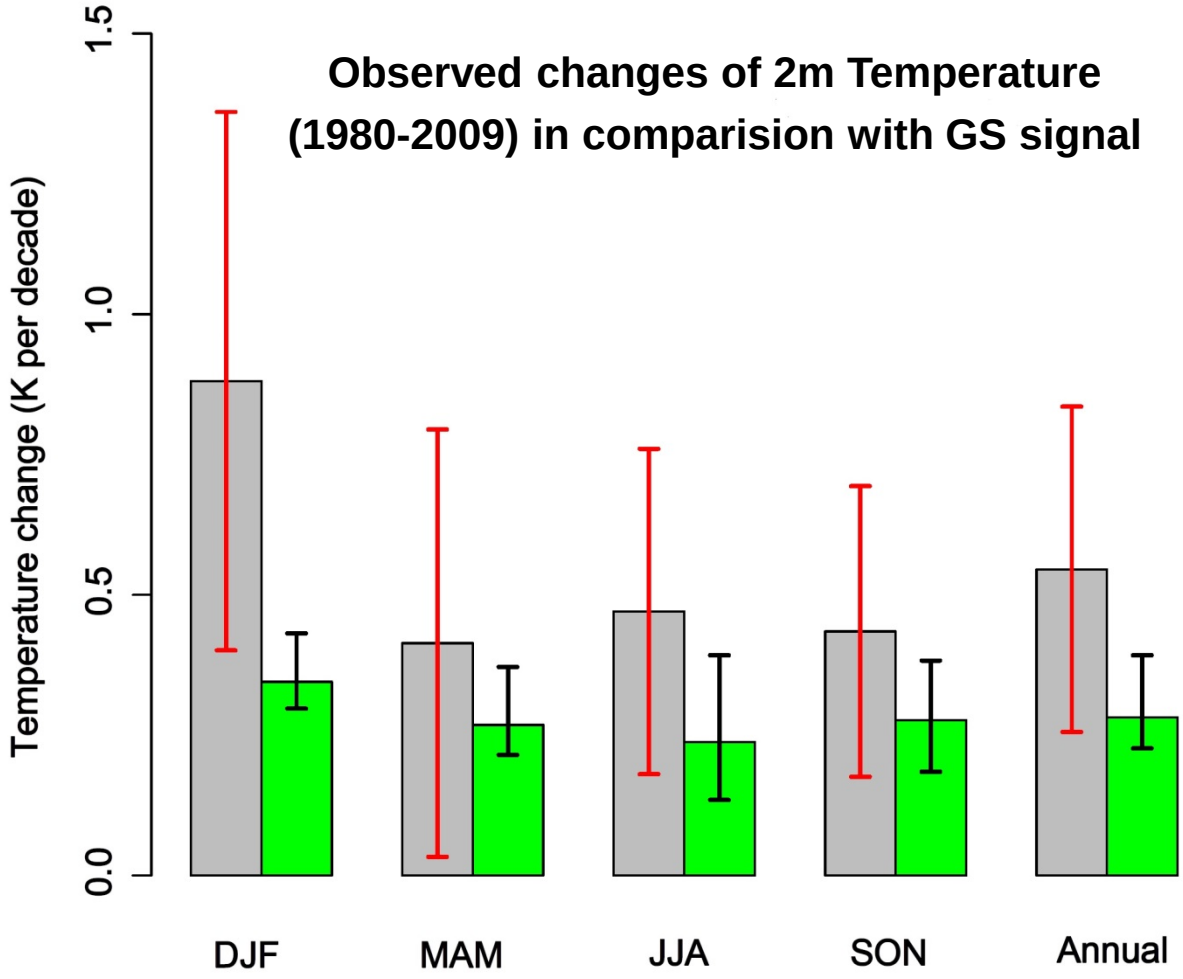
- 2,000-year high-resolution regional climate Palaeosimulation is used to estimate natural (internal+external) variability.

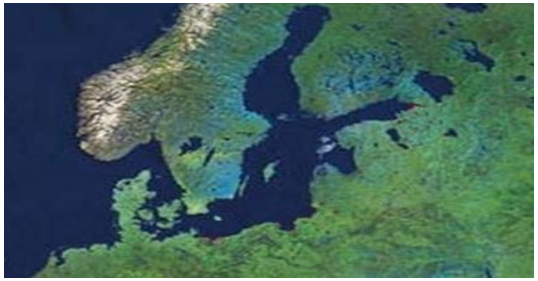
(Gómez-Navarro, J. J., Montávez, J. P., Wagner, S., and Zorita, E.: A regional climate palaeosimulation for Europe in the period 1500–1990 – Part 1: Model validation, Clim. Past Discuss., 9, 1803-1839, 2013)

2m Temperature (1980-2009)

Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research

Observed changes of 2m Temperature (1980-2009) in comparision with GS signal





Observed trends in 1980-2009

Projected GS signal, A1B scenario
10 simulations, ENSEMBLES

95th-%tile of „non-GHG“ variability,
derived from 2,000-year palaeo-simulations

The spread of trends of 10 RCM simulations

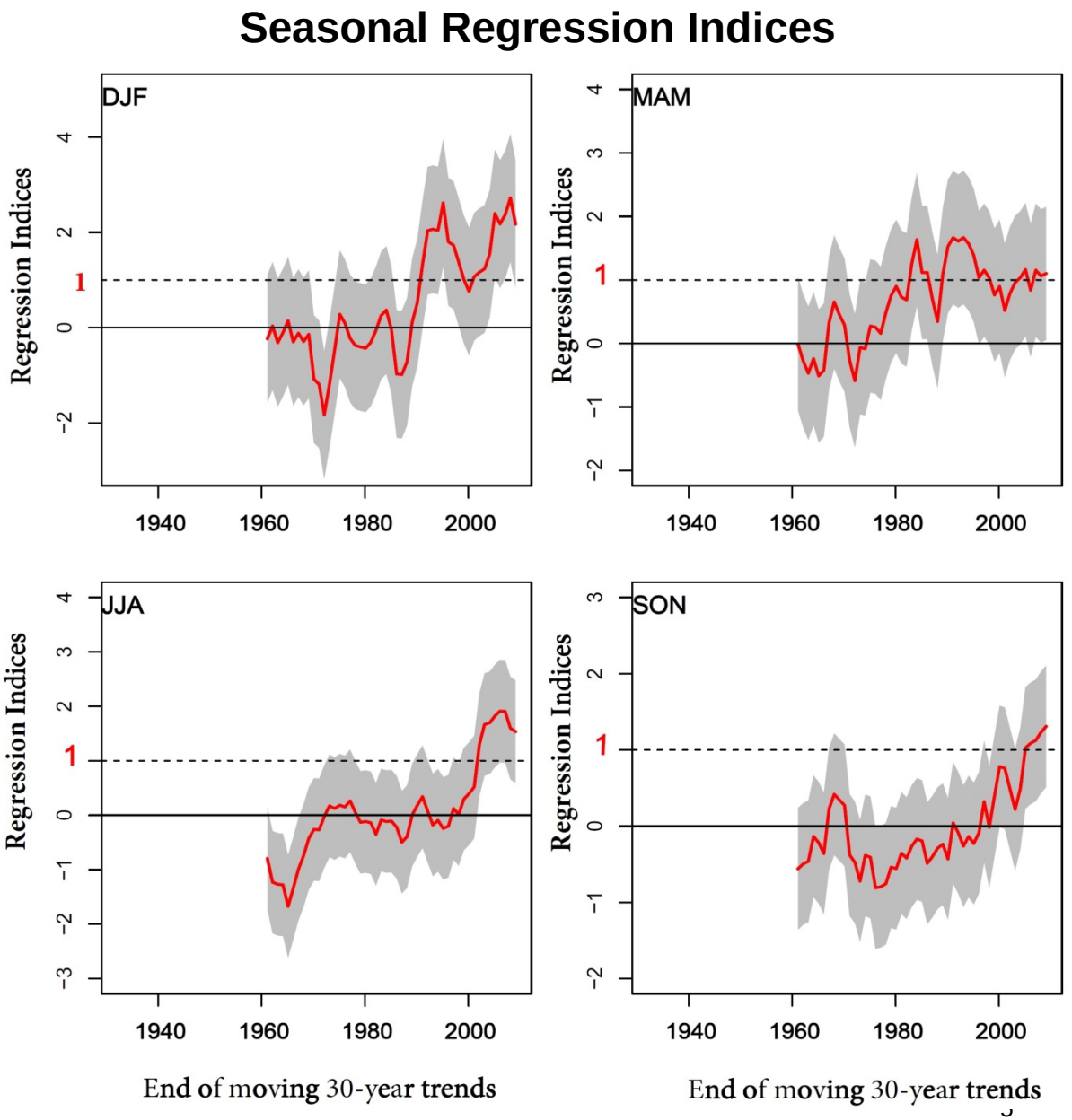
- **GHG forcing allows for reconstructing the recently observed warming over the Baltic Sea area (with less than 5% risk of error)**
- **None of the 10 regional climate projections capture the observed warming, which is pronounced in winter (DJF).**

2m-Temperature (1930-2009)

Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research

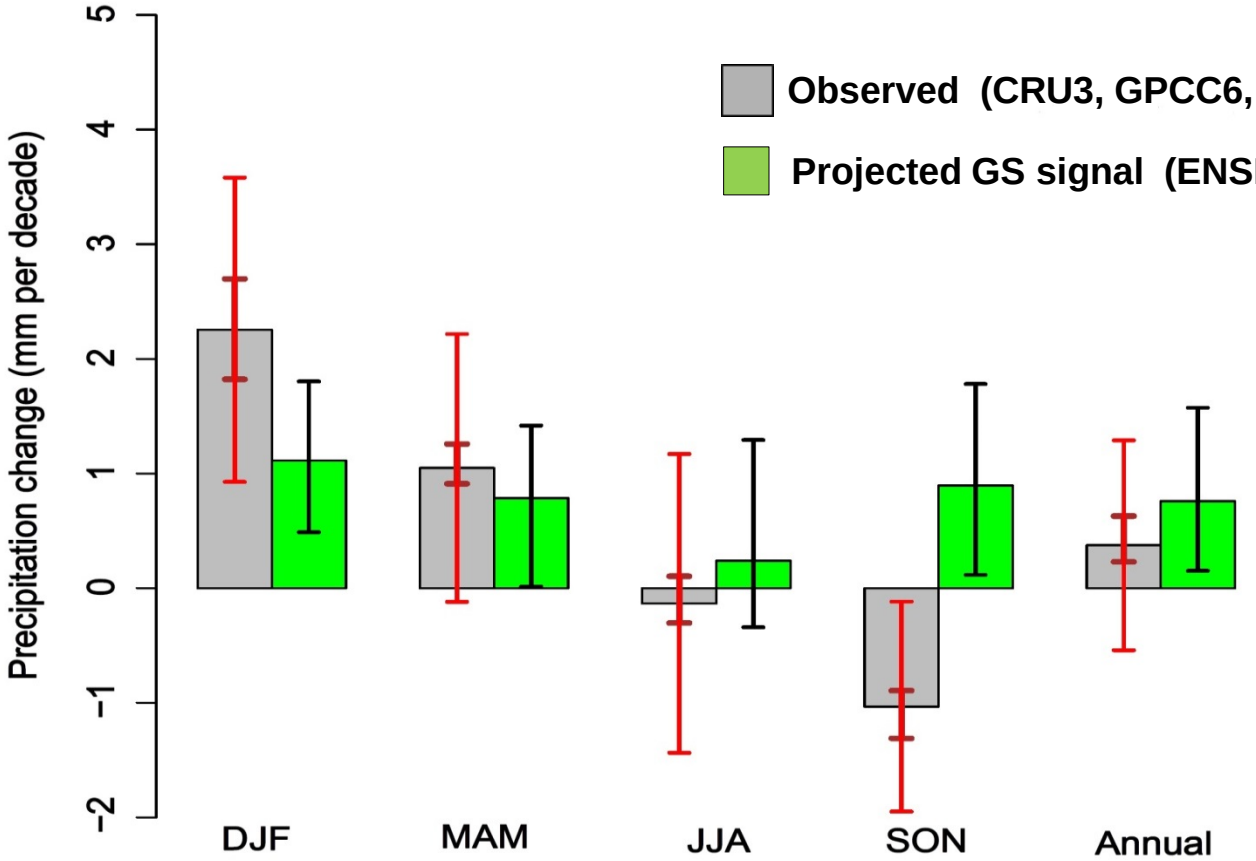
Seasonal **regression indices** of observed moving 30-year trends based on CRUT onto the multi-model mean GS (Greenhouse gas and Sulfate aerosols) signal. The gray shaded area indicates the 95% uncertainty range of regression indices, derived from fits of the regression model to 2,000-year palaeo-simulations.

➢ **In winter (DJF), summer (JJA) and autumn (SON) the gray shaded areas exclude zero line but include unit scaling for 30-year trends ending in 2000 and later, indicating the emergence of a detectable GS influence (with less than 5% risk of error).**



Precipitation (1979-2008)

Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research



In **winter (DJF)** non of the 59 segments derived from 2,000 year palaeo-simulations yield a positive trend of precipitation as strong as that observed. There is less than 5% probability that observed positive trends in winter be due to natural (internal + external) variability alone (with less than 5% risk).

In **spring (MAM)**, **summer (JJA)** and **Annual** trends externally forced changes are not detectable. However observed trends lie within the range of changes described by 10 climate change scenarios, indicating that also in the scenarios a systematic trend reflecting external forcing is not detectable (< 5% risk).

In **autumn (SON)** the observed negative trends of precipitation contradicts the upward trends suggested by 10 climate change scenarios, irrespective of the observed dataset used.

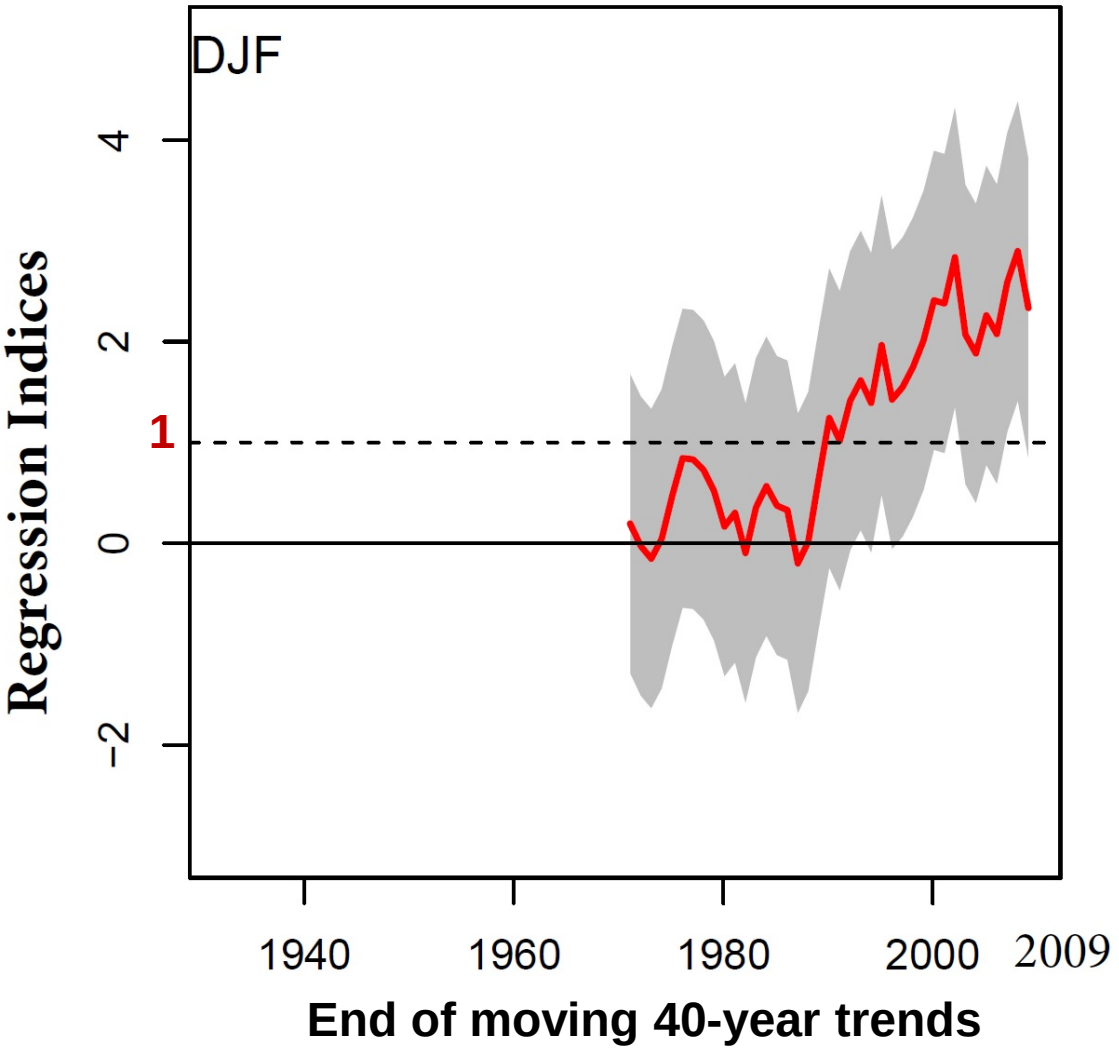
Winter-time precipitation (1930-2009)

Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research

Regression indices of observed moving 40-year trends of precipitation in DJF onto the multi-model mean GS signal. The gray shaded area indicates the 95% uncertainty range of regression indices, derived from fits of the regression model to 2,000-year palaeo-simulations.

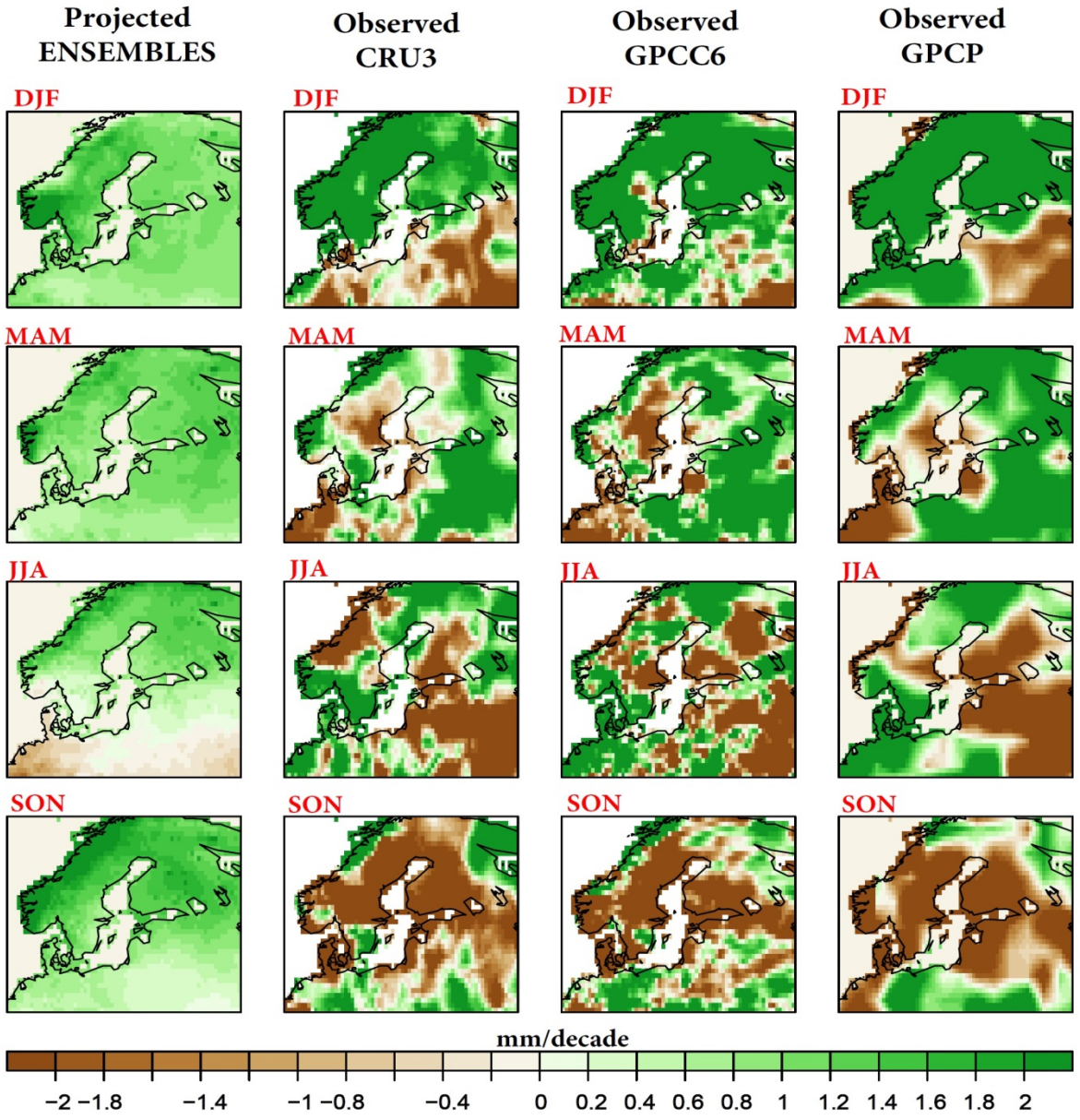
- **The gray shaded area exclude the zero line but includes unit scaling for 40-year trends ending in 1995 and later, indicating the concerted emergence of the GS signal in the late 20th and 21st century.**
- **Obtained results are insensitive to the removal of NAO fingerprint**

Regression indices of Winter-time precipitation (1930-2009)



Precipitation (1979-2008)

Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research



- We further examine the possibility that the inconsistency of observed precipitation trends in autumn (SON) with regional climate change projections may be related to trends in large-scale circulations.

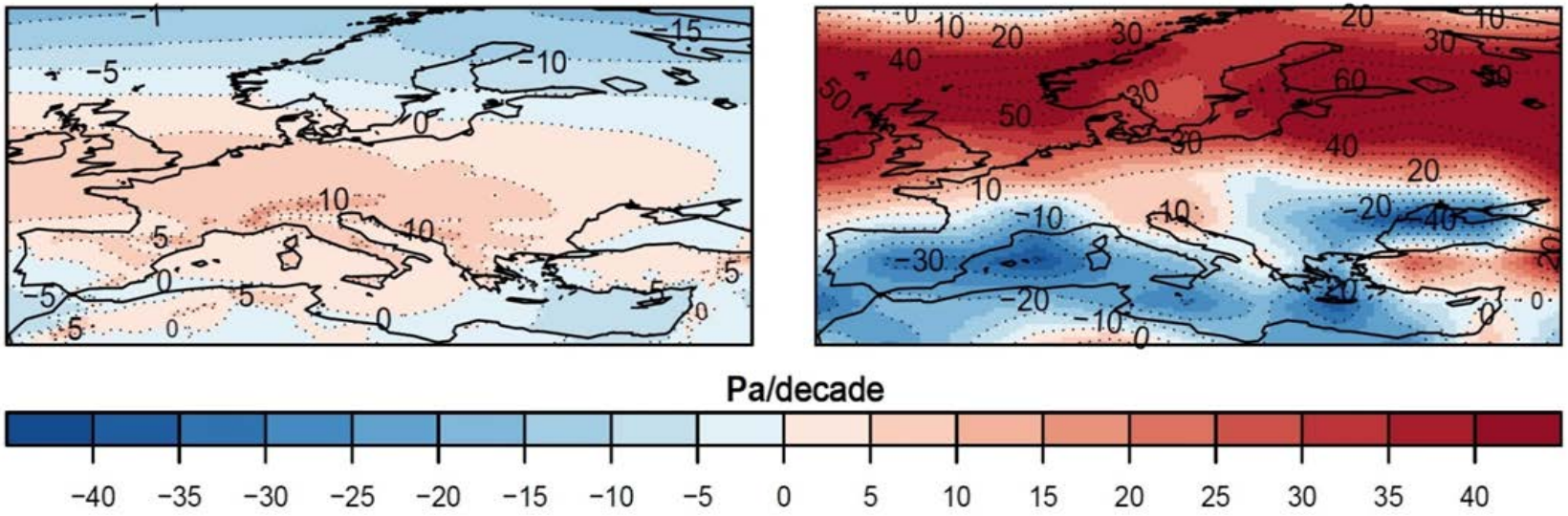
Changes in Large-scale circulation (SON)

Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research

Mean Sea-level pressure (SON)

Projected GS signal pattern (RCMs)

Observed trend pattern (1978-2009)



- Observed trend pattern shows areas of decrease in SLP over the Med. Sea and areas of increase in SLP over the northern Europe. Observed trend pattern of SLP in SON contradicts regional climate projections.

- **The mismatch between projected and observed precipitation in autumn is already present in the atmospheric circulation.**

Summary Table 1

Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research

Parameters	Season	Observed Trend	GS response	Forced changes detected	Risk of error	Anthropogenic (GS) influence detected	Observed trends harbinger for future
Temperature	DJF	+	+	YES	< 5%	With all models	YES
	MAM	+	+	YES	< 5%	Non	YES
	JJA	+	+	YES	< 5%	With all models	YES
	SON	+	+	YES	< 5%	With all models	YES
Surface Specific Humidity	DJF	+	+	NO	> 5%	X	YES
	MAM	+	+	NO	> 5%	X	YES
	JJA	+	+	YES	< 5%	With all models	YES
	SON	+	+	NO	> 5%	X	NO
Surface Relative Humidity	DJF	+	+	NO	> 5%	X	YES
	MAM	-	+	NO	> 5%	X	NO
	JJA	-	-	NO	> 5%	X	YES
	SON	+	+	NO	> 5%	X	YES

Summary Table 2

Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research

Parameters	Season	Observed Trend	GS response	Forced changes detected	Risk of error	Anthropogenic (GS) influence detected	Observed trends harbinger for future
Precipitation	DJF	+	+	YES	< 5%	With all models	YES
	MAM	+	+	NO	> 5%	X	YES
	JJA	-	+	NO	> 5%	X	YES
	SON	-	+	YES	> 5%	X	NO
Cloud Cover	DJF	+	+	NO	> 5%	X	NO
	MAM	-	+	NO	> 5%	X	NO
	JJA	-	-	NO	> 5%	X	NO
	SON	-	-	NO	> 5%	X	NO
Solar Radiation	DJF	-	-	YES	< 5%	Non	NO
	MAM	+	-	YES	< 5%	Non	NO
	JJA	+	-	YES	< 5%	Non	NO
	SON	+	-	YES	< 5%	Non	NO

Conclusions

Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research

Temperature:

- Anthropogenic (Greenhouse gas and Sulfate aerosols, GS) forcing has a detectable influence in the recently observed seasonal and annual warming trends over the Baltic Sea area.
- However, in terms of magnitude of change, regional climate change projections underestimate the observed warming.

Precipitation:

- The influence of GS signal is detectable in winter-time precipitation. However, in autumn observed negative trends contradicts the upward trends projected by 10 regional climate change projections, irrespective of the observed datasets used.
- Obtained results are insensitive to the removal of NAO fingerprint.
- The analysis of large-scale circulation patterns, in terms of mean sea-level pressure and geopotential height at 500 hPa, confirms the inconsistency detected for precipitation in autumn.

Similar analysis for Mediterranean region (see publications Barkhordarian et al) - with similar results, including the inconsistency in SON, but this time more precip in the past with expected reduction.