



# THE EFFECTS OF CLIMATE CHANGE ON WINTER SERVICE IN GERMANY

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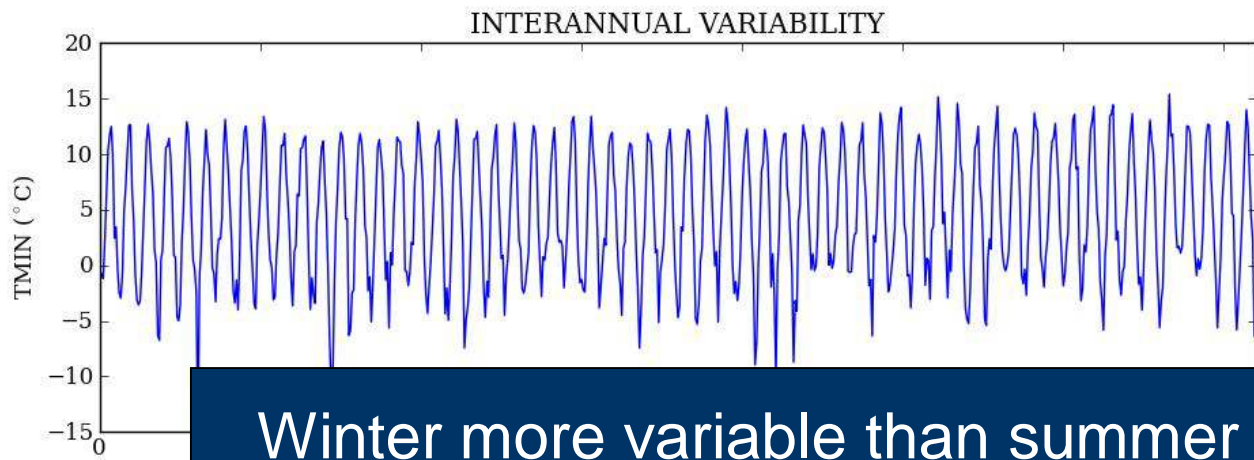
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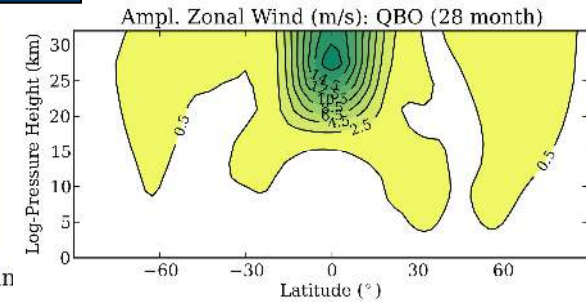
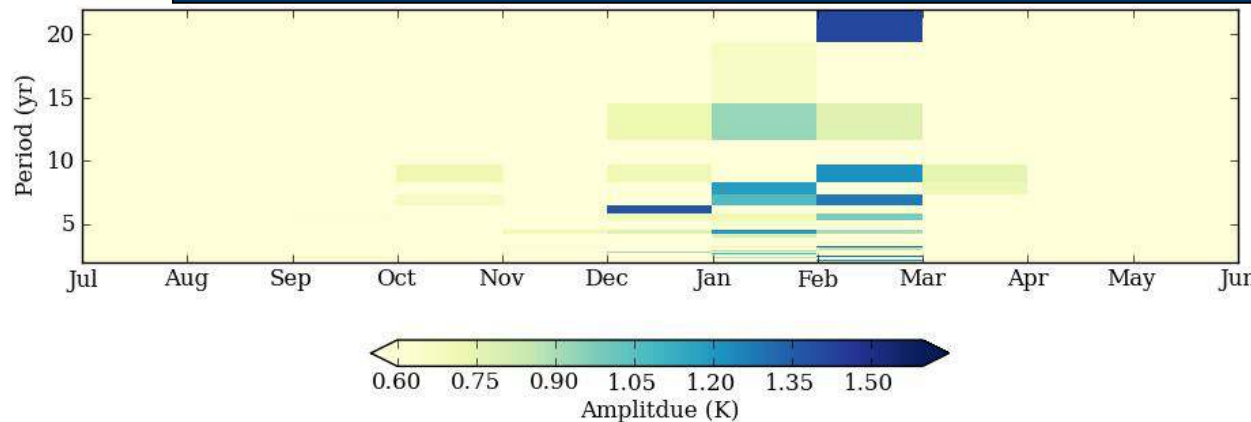
# 1. INTRODUCTION

## Natural Variability

Germany

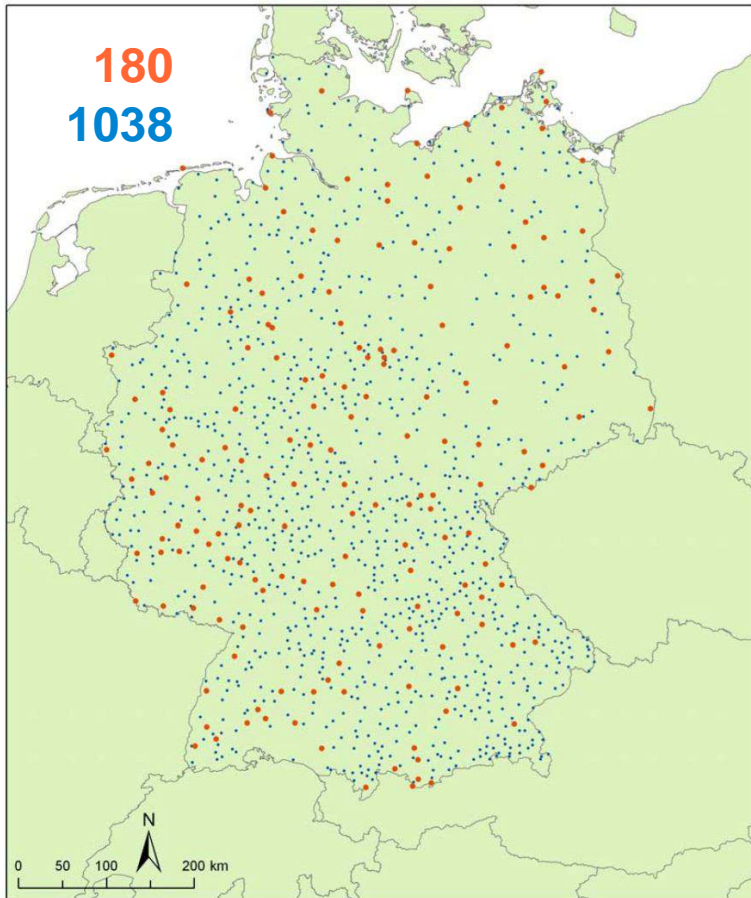


monthly means



## 2. Meteorological Data and Model

### Climate Station Network



### Maintenance Areas



## 2. Meteorological Data and Model

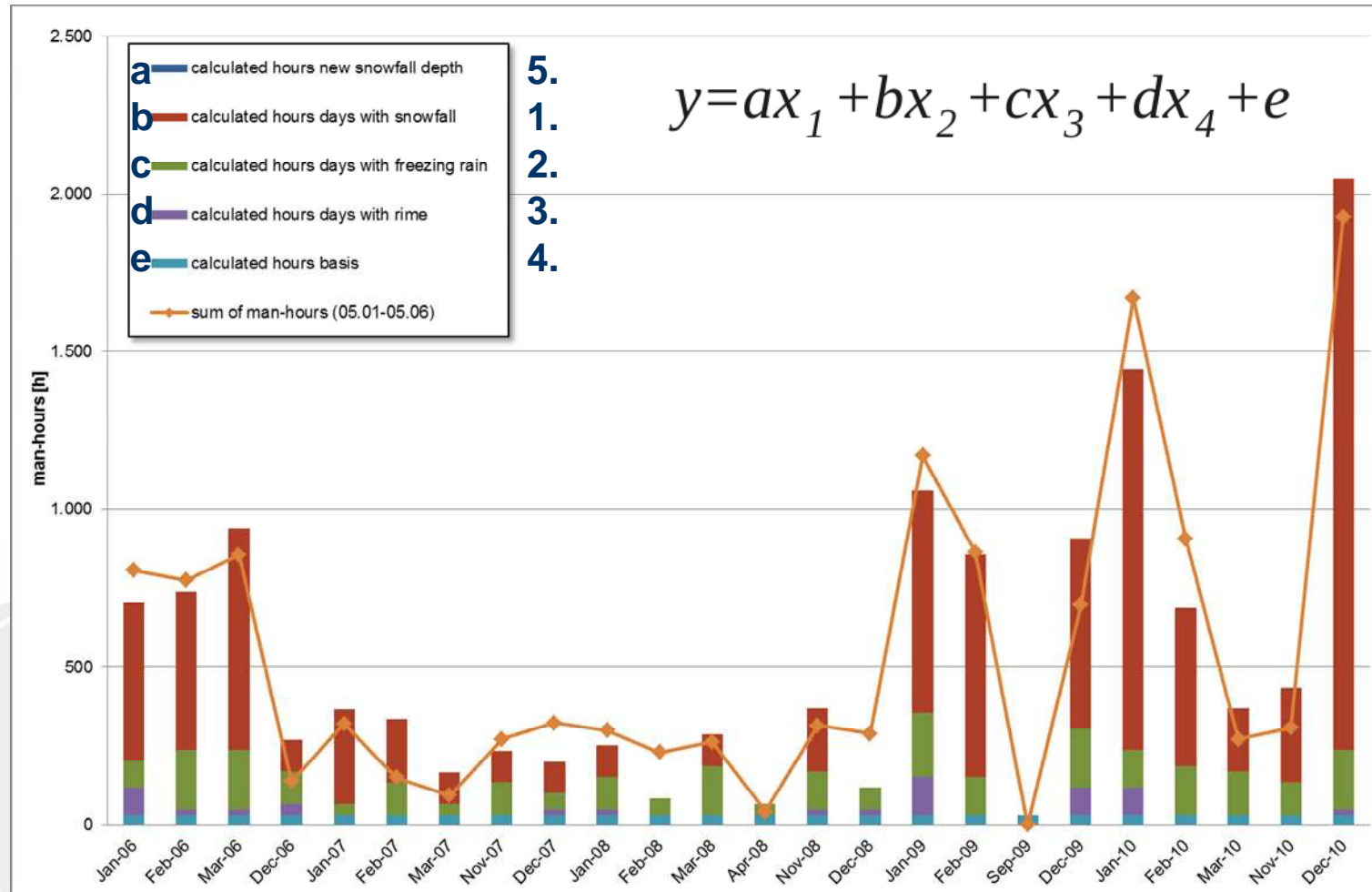
### Winter Climate Parameters

Primary parameter				Unit
daily minimum temperature			Tmin	°C
daily sum of precipitation			RR	mm
relative humidity			RF	%
new snowfall height			SN	cm
snow height			SH	cm
Secondary parameter			Combinations of primary parameters	Unit
sum of new snowfall depth	$x_1$	<b>SSD</b>	SN > 0 cm	cm
days with snowfall	$x_2$	<b>NSF</b>	SN > 0 cm	d
days with freezing rain	$x_3$	<b>NFR</b>	Tmin < 0 °C & RR > 0 mm	d
days with rime	$x_4$	<b>NRM</b>	Tmin < 0 °C & RR = 0 mm & RF > 90 %	d



## 2. Meteorological Data and Model

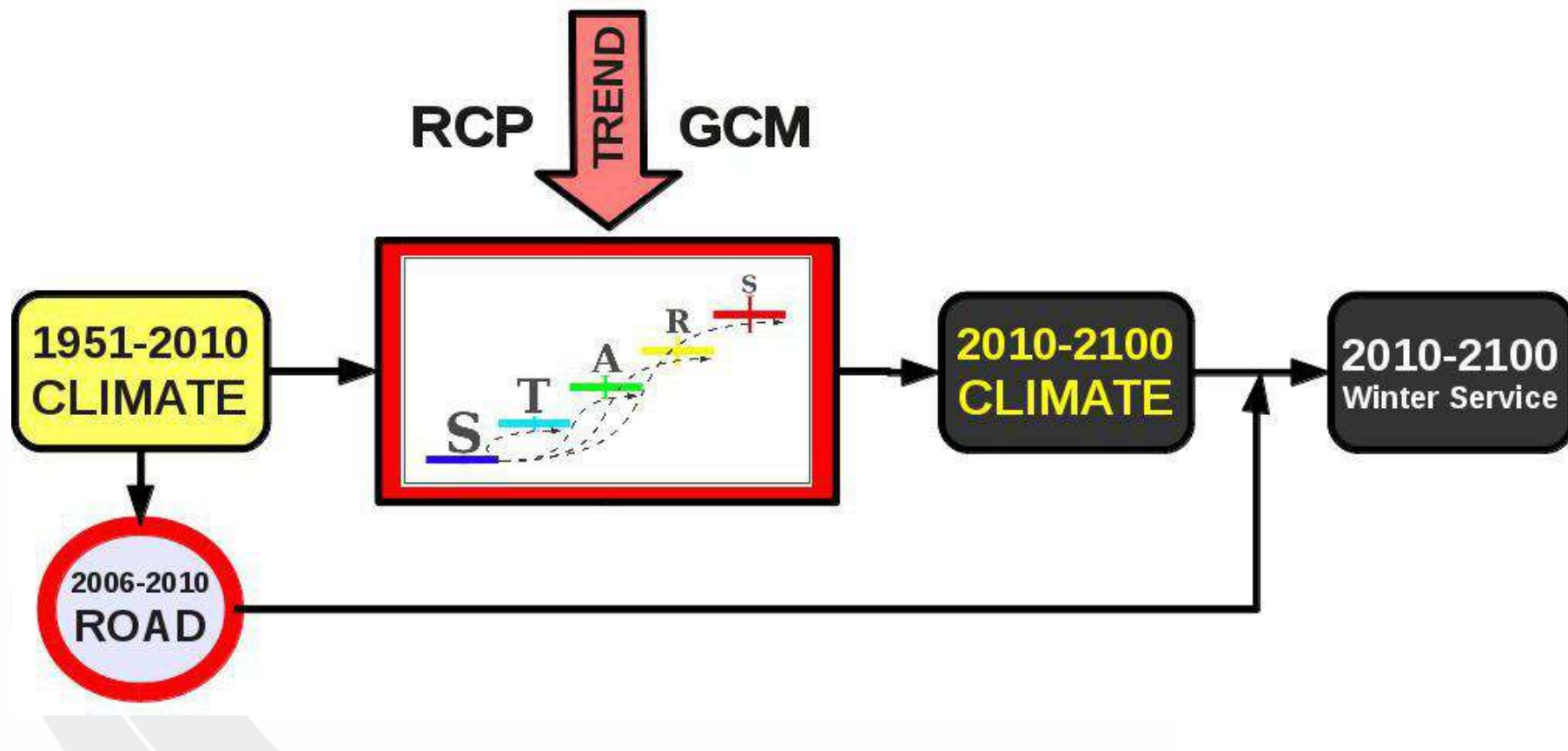
### Winter Service Parameters



## 2. Meteorological Data and Model

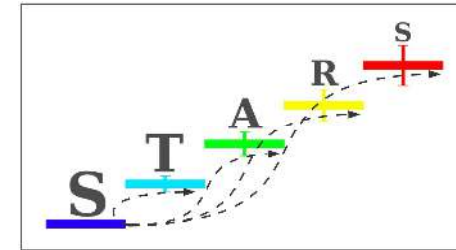
About climate projections

External Forcing:



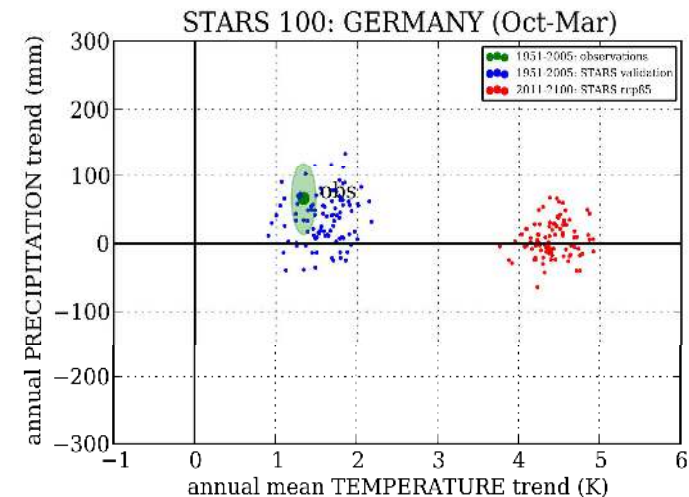
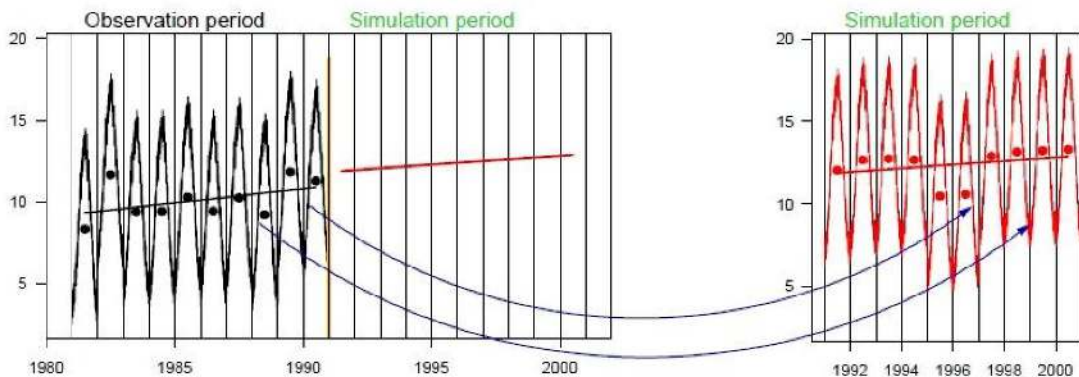
## 2. Meteorological Data and Model

### The statistical climate model



### STatistical Analogue Resampling Scheme:

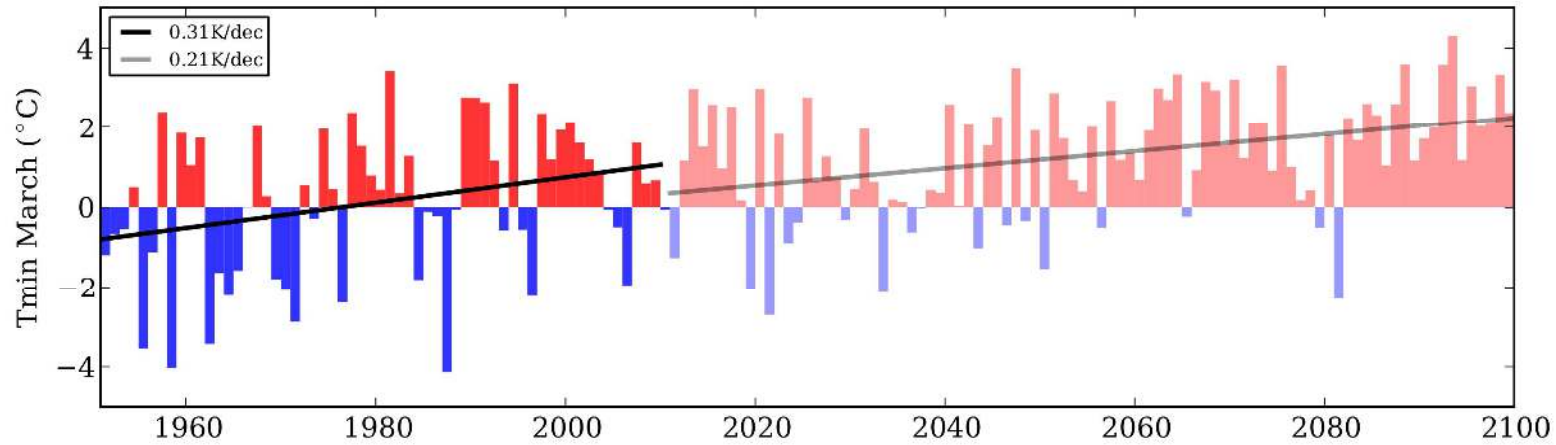
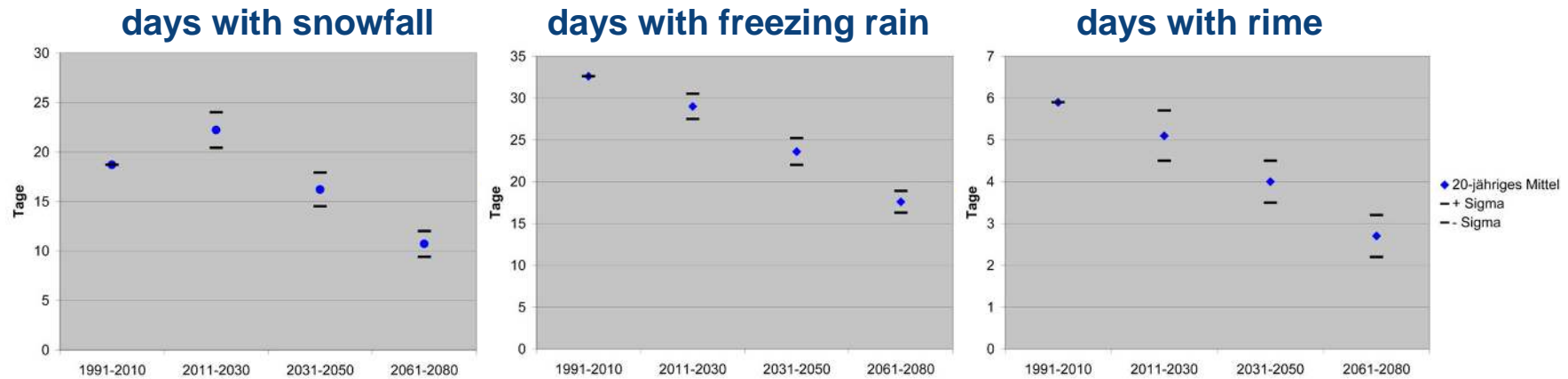
- observed weather situations will very likely recur in the similar way
- mean temperature is a very robust signal
- annual means of the simulated time series have to match the given linear trend for the simulation time period
- Blocks of 12 days are replaced





### 3. Results

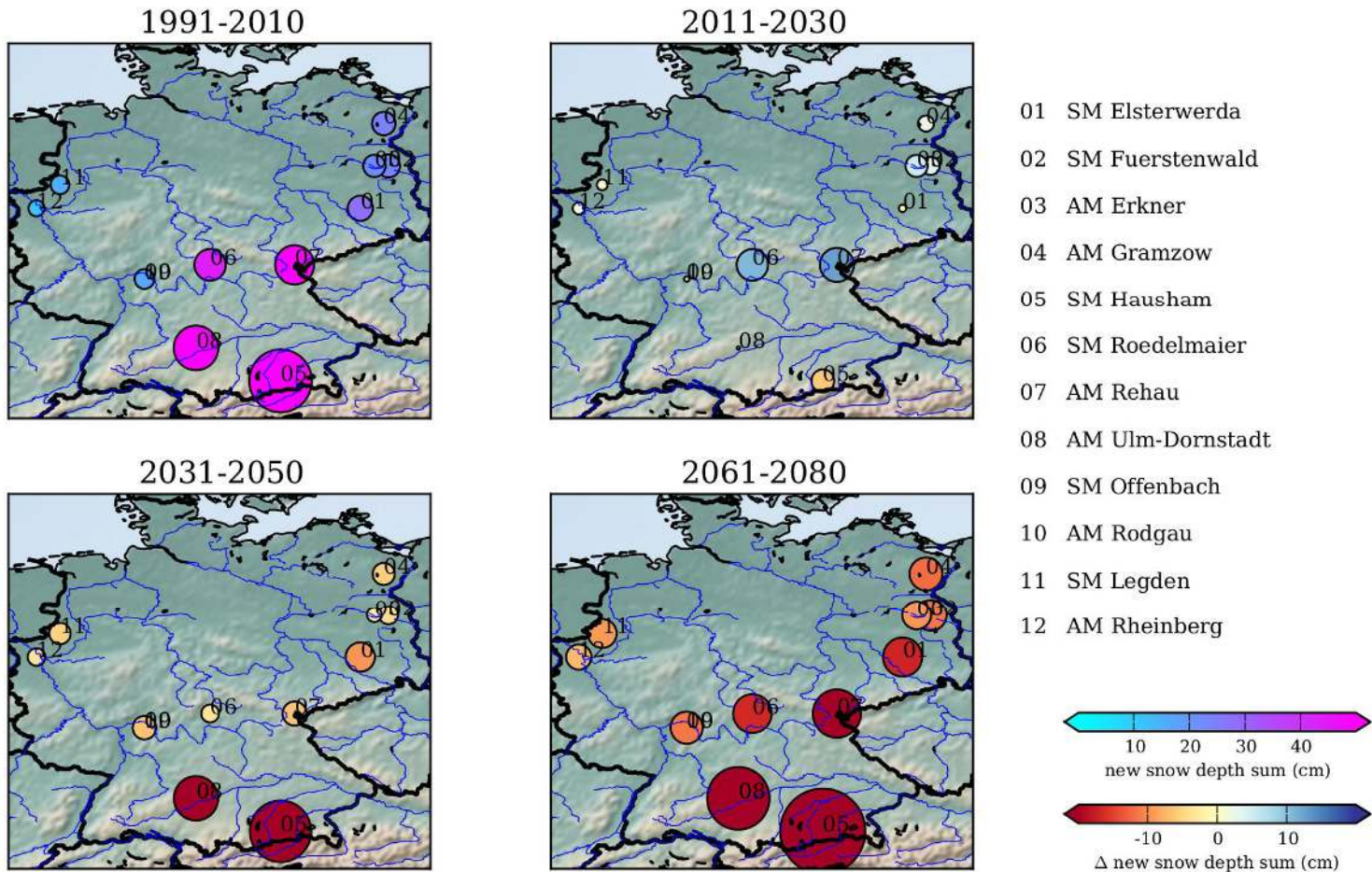
## Projection of Winter Climate Change



### 3. Results

#### Regional Characteristics

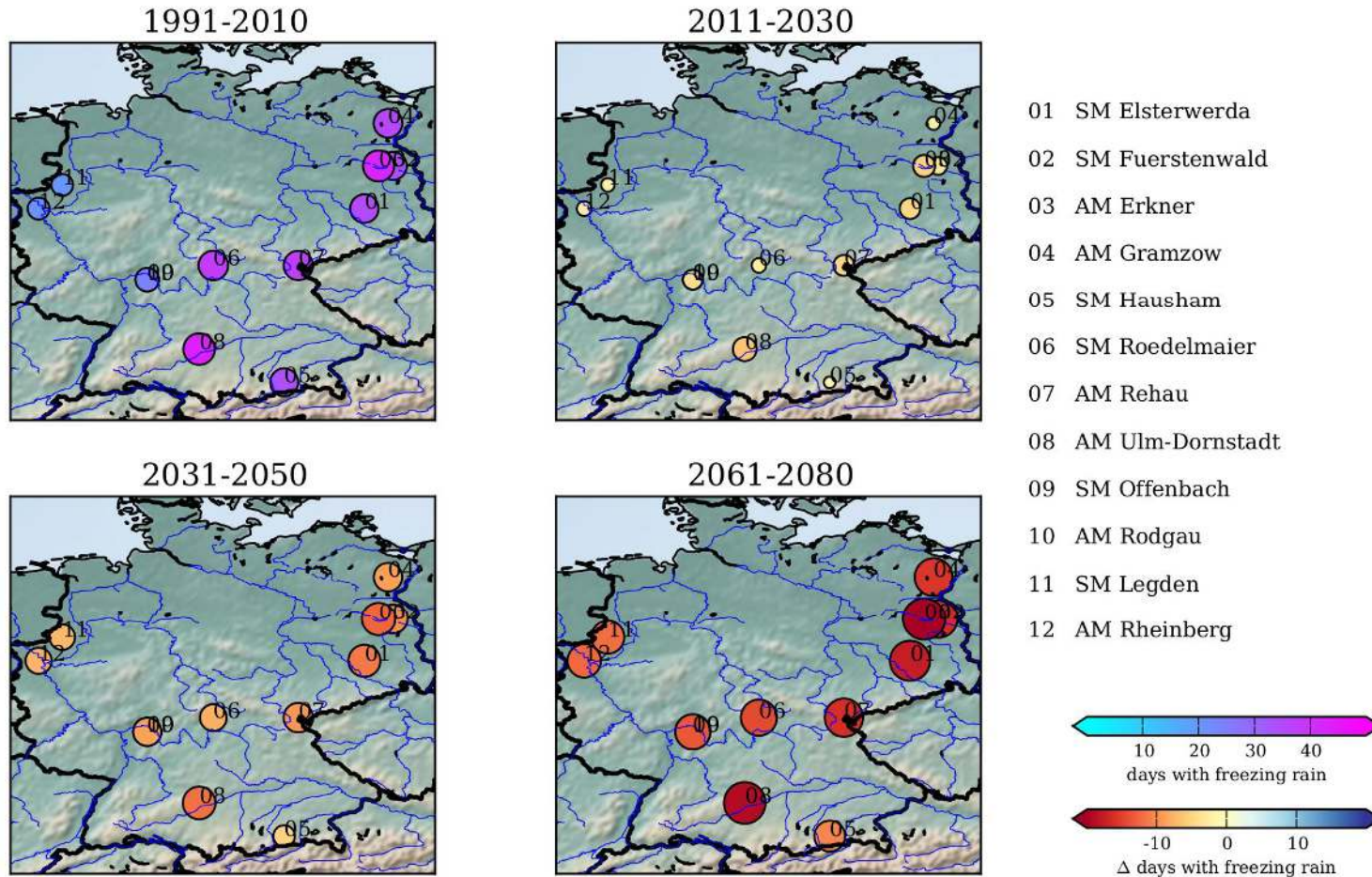
Parameter:  
New Snow Depth Sum



### 3. Results

#### Regional Characteristics

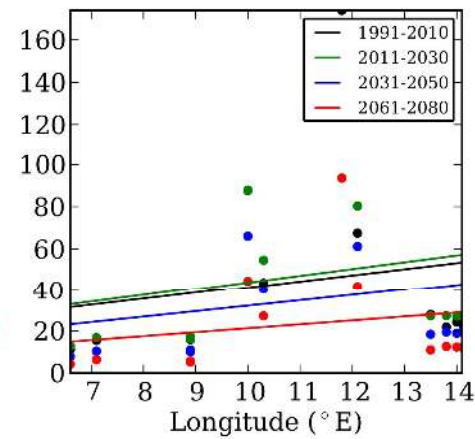
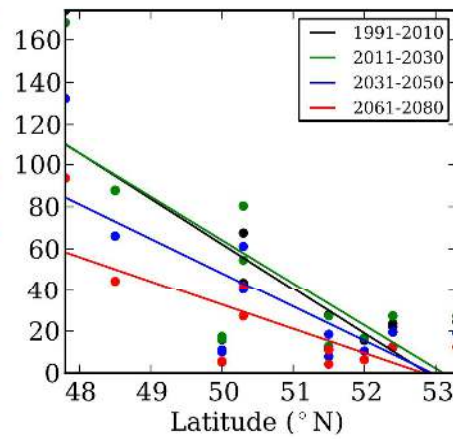
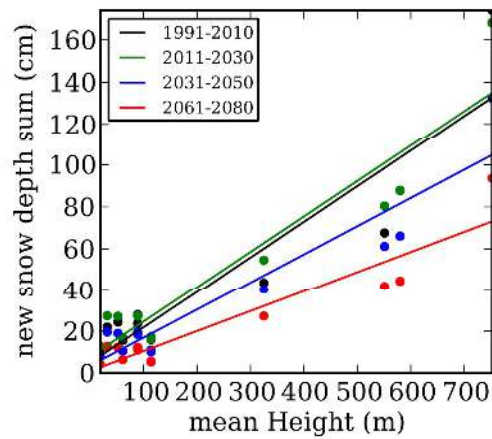
Parameter:  
Days with Freezing Rain



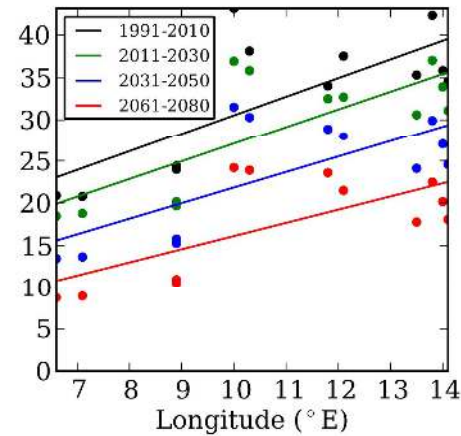
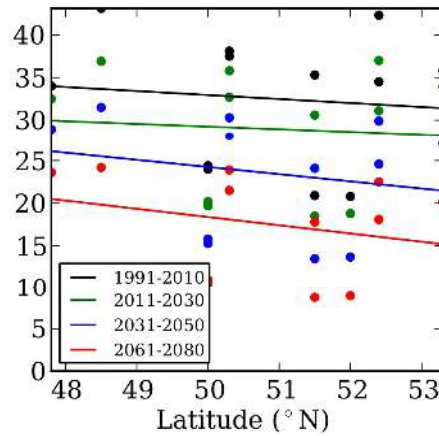
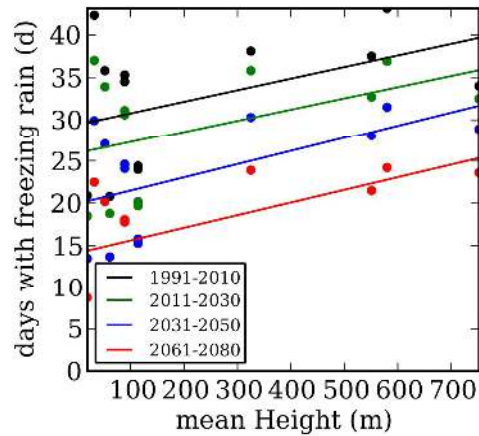
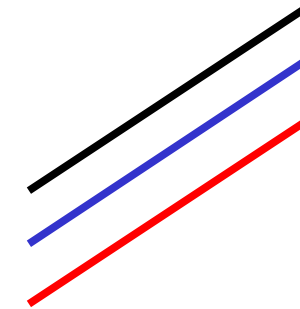


### 3. Results

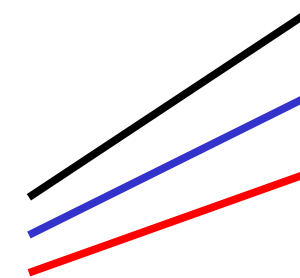
#### Regional Characteristics



Change: no

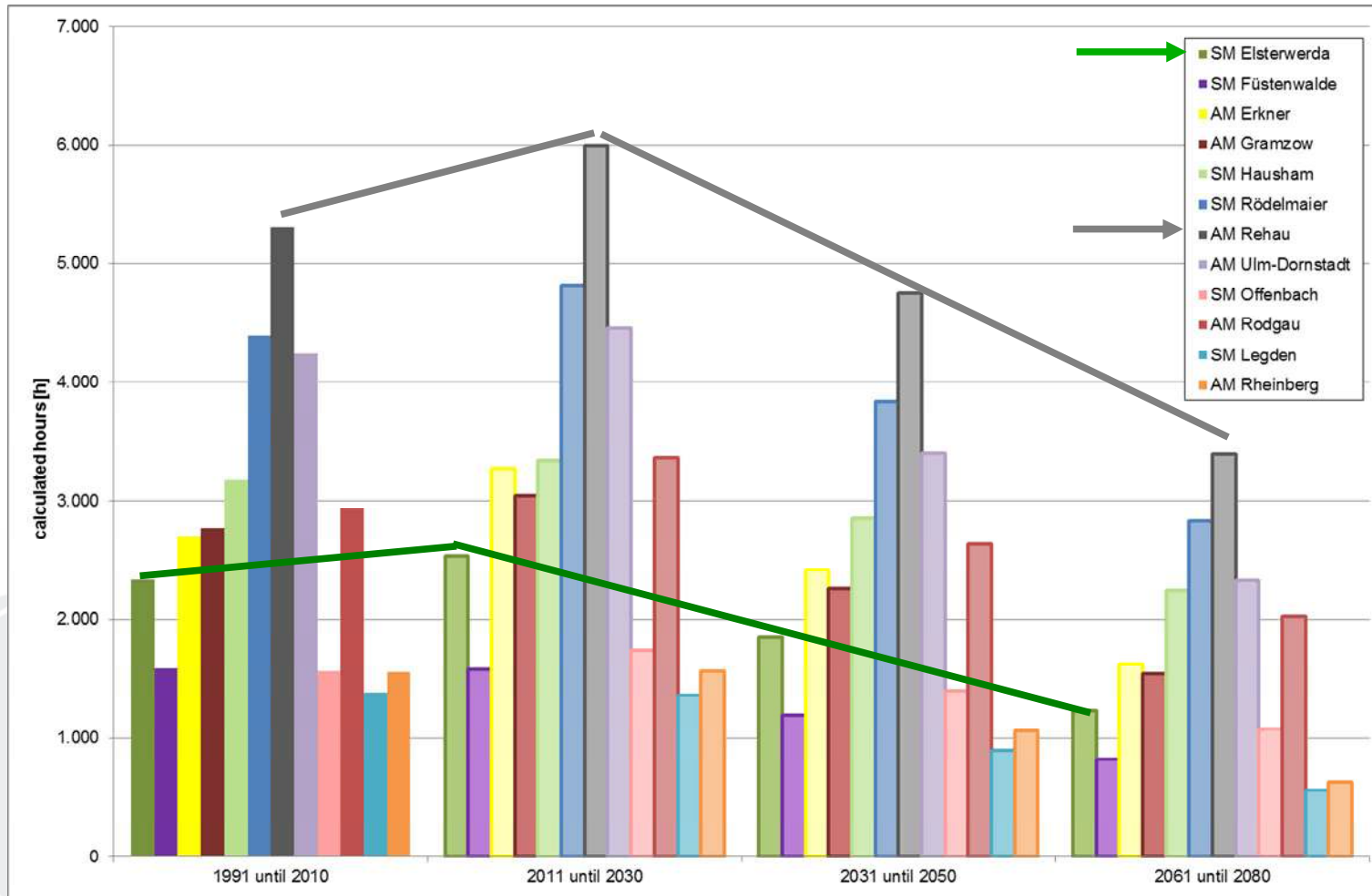


Change: yes



### 3. Results

#### Effects on the Road Winter Service





## 4. Conclusions

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- **scenario:** RCP8.5 („high-end“), moderate specification
- **model:** a statistical approach, resampling scheme
- **ensemble:** 100 realisations
- **uncertainty:** only model-based
- **resolution:** high-regional characteristics
  
- **winter service:** near future (↑), far future (↓)
- **cold waves:** reduced, but still likely (interaction to low-freq. Oscill.)
  
- **vision:** robust ensemble combining dyn. & statistical models
- **update:** every 5-10 yr

The End

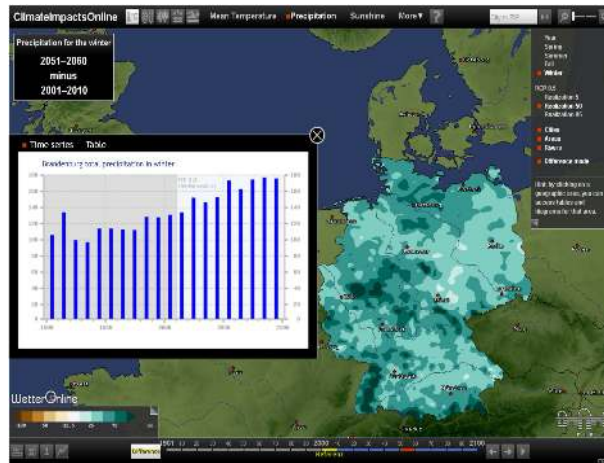
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**THANK YOU  
FOR ATTENTION !**

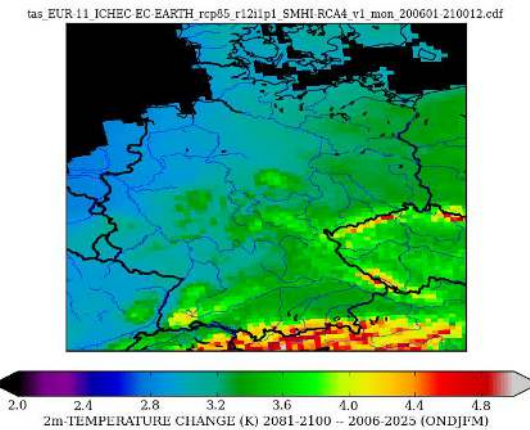


# Additional Material

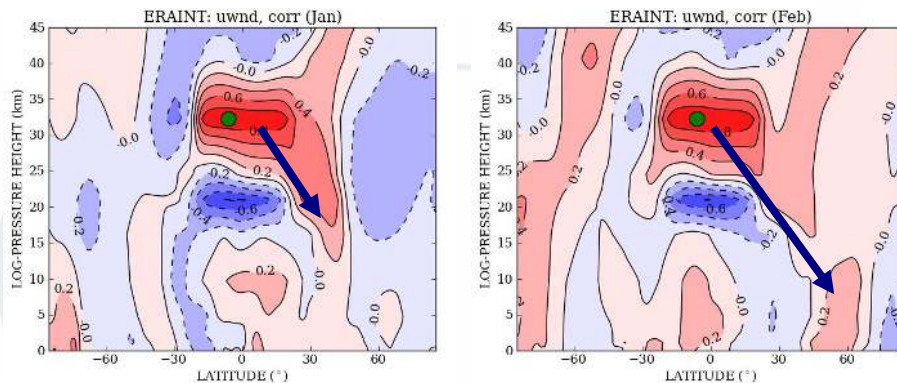
## ClimateImpactsOnline



## Dynamical Downscaling: EURO-CORDEX



## Quasi-Biennial Oscillation



## CMIP5 Ensemble

