Non-Climatic and Climate-Related Nat Cat Modelling in the Insurance Industry

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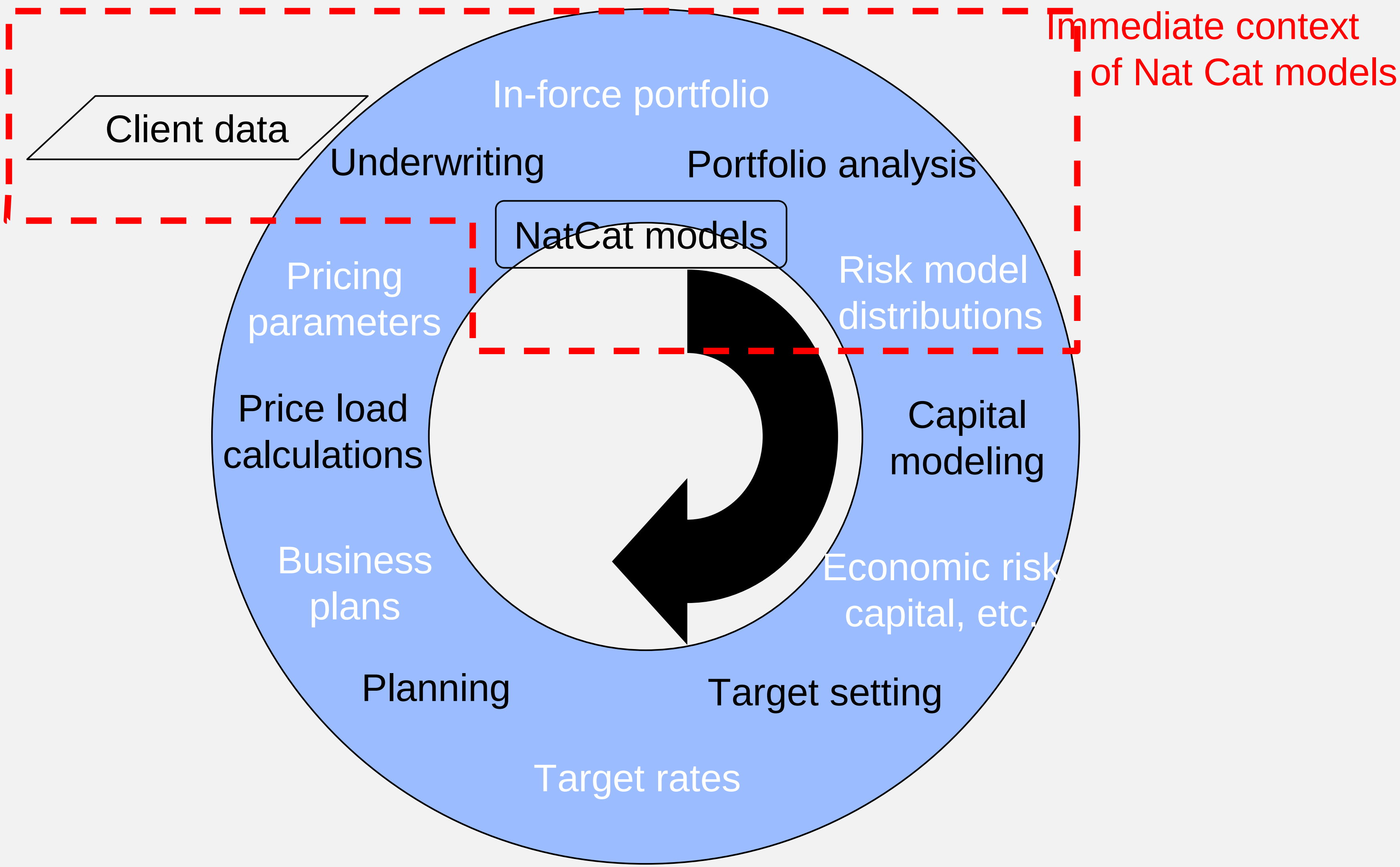
The steering process for Nat Cat (annual scope of risk management)



Dealing with uncertainties…
(annual scope of risk management)

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Basically we are steering our business based on stochastic models

- Uncertainty in terms of *risk based capital allocation* (nat cat) is involved in:
  - the **choice of the appropriate type of model** (e.g. approximation of stationarity)
  - the **estimation of model parameters.**

  Examples: Number and quality of sample data, level of detail (address or zip-code, split buildings and contents), estimate of next year's exposure (accounting for inflation), …

- Uncertainty is also involved in the **contribution of so-called „secondary hazards"** which come along with explicitly modelled primary hazards.
  Example windstorms (extra-tropical and tropical cyclones): storm surge, debris flow / projectiles and inland flooding additionally to peak windspeeds.
  So-called **„large-loss amplification effects"** have to be captured, e.g. demand surge, claims inflation, coverage expansion, disruption of infrastructure and regional economic breakdown, …

- **Difficult** to model **direct business interruption** (due to actual physical damage) and hardly possible to include the effects of **contingent business interrruption** (CBI) in nat cat models.

Nat Cat loss distributions for the capital model after accounting for non-modeled hazards and white spots

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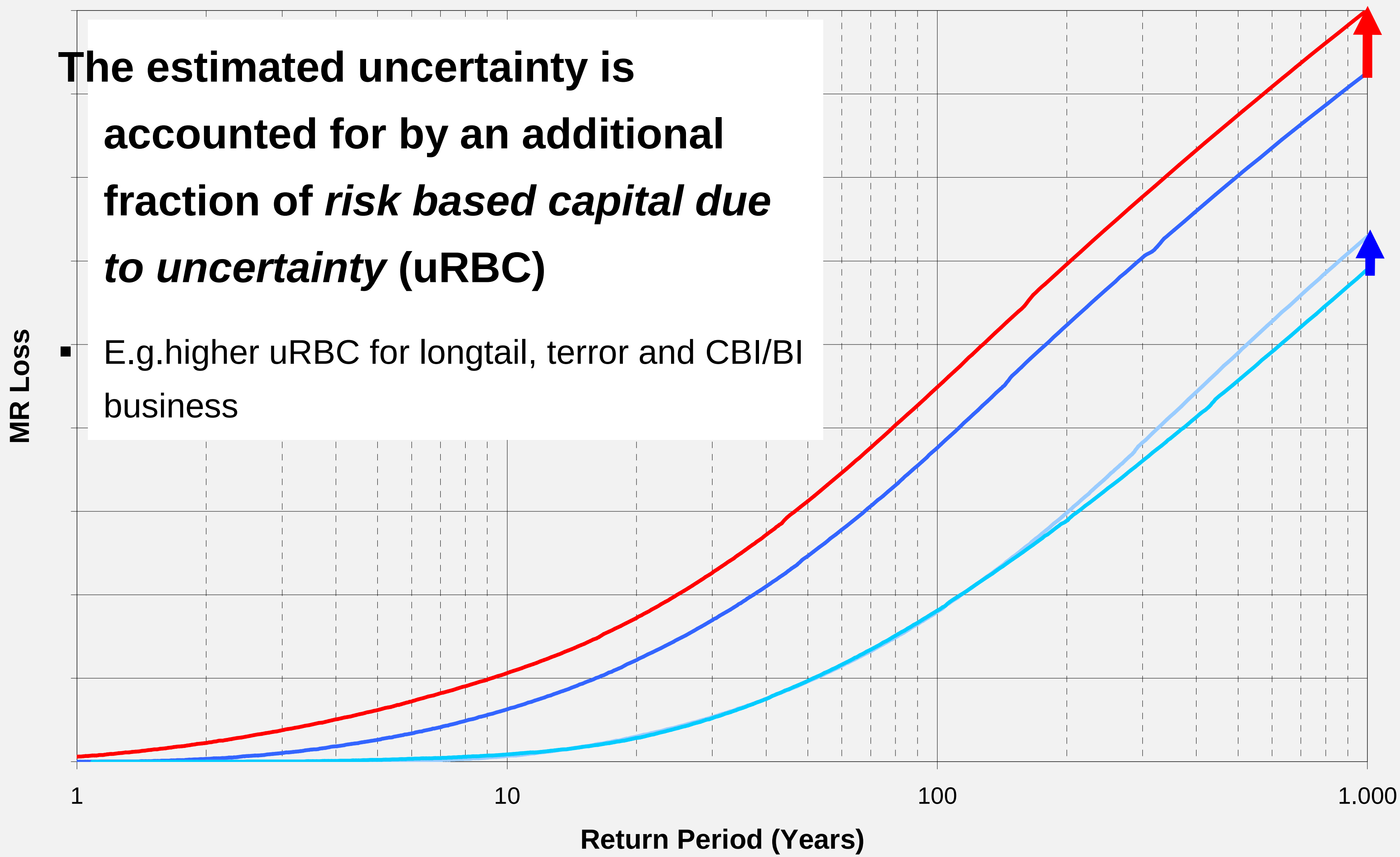
The estimated uncertainty is accounted for by an additional fraction of *risk based capital due to uncertainty* (uRBC)

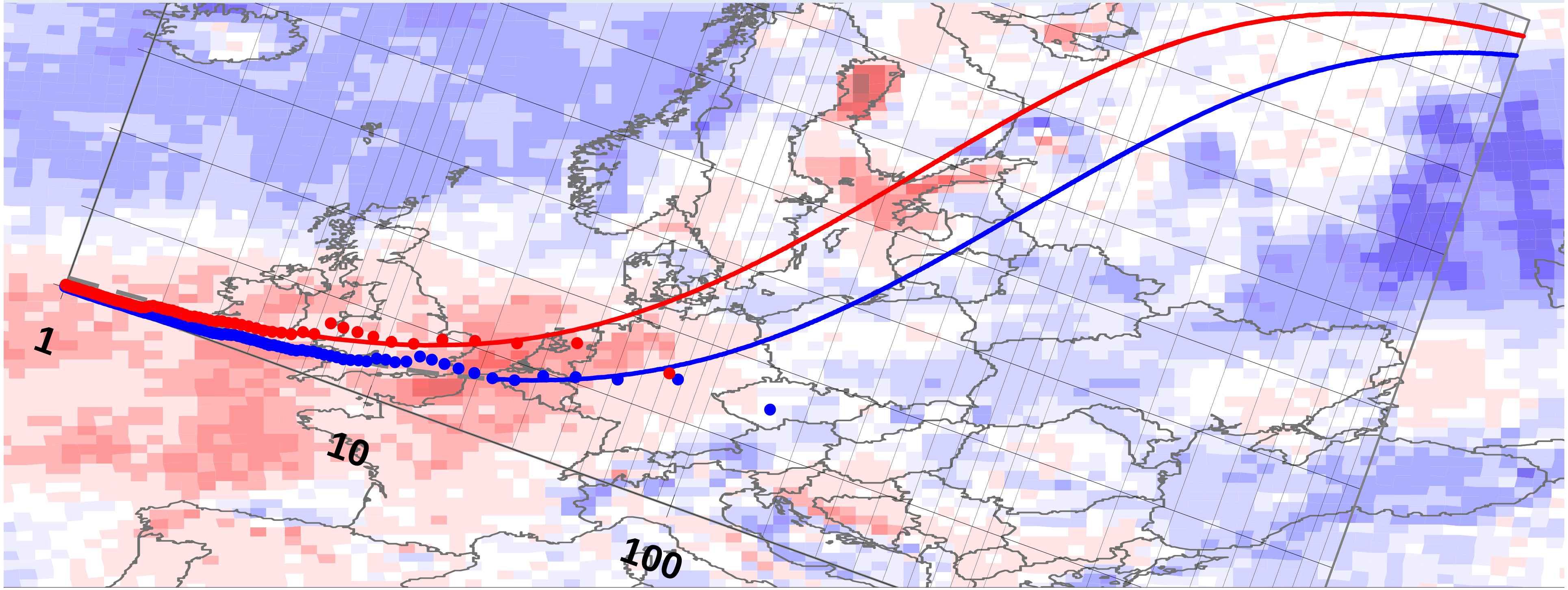
- E.g.higher uRBC for longtail, terror and CBI/BI business



Climate Change related nat cat modelling in the insurance industry – example European winter storm

Scope: strategic perspectives on business development based on climate change effects over the 21st century

Overview over 4 projects



1 Association of British Insurers (ABI), June 2005: Report on Financial Risks of Climate Change

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European windstorm

Scenario		Annual average insured loss	Annual average total loss	Insured loss with chance of occurring once every 100 years	Insured loss with chance of occurring once every 250 years
Current observed baseline[a]	-	$1.5 bn	$3.0 bn	$30 bn	$35 bn
	Frequency increase in top 5% of storms windspeed	Loss increase relative to baseline			
Potential impact of climate change[b,c]	20%	+ 35%	35%	+ 5%	+ 5%

Source: Association of British Insurers, Financial Risks of Climate Change, Summary Report, June 2005

- **First pioneering study on quantification of climate change risks from the perspective of a national association of insurers.**
- **Limitations from today's perspective**: Rather coarse approach via increasing the frequency only of the upper 5% storms by 20%, without accounting for other features of change (e.g. shift in storm track, change in contribution from less intense and much more intense storms).

2 Winter storm impacts on West Germany under climate change – a statistical-dynamical downscaling approach (1)

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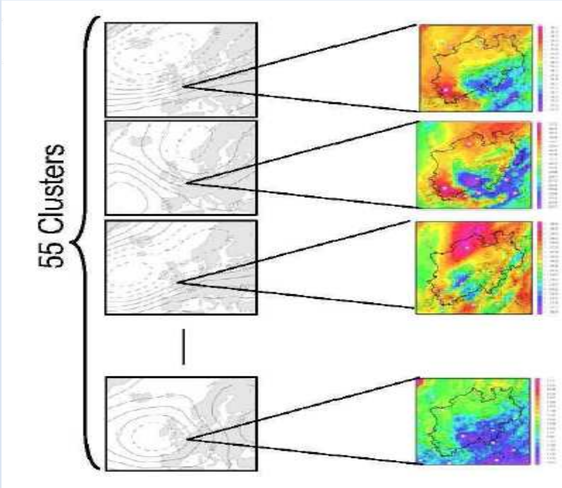
Project cooperation between **University of Cologne** and **public insurers** in North-Rhine Westphalia, started under SFB 419 in 2000, first results in 2003.

Derivation of a wind gust climatology for North-Rhine Westphalia

① 55 spatio-temporal weather clusters (patterns) at the synoptic scale (coarse resolution).

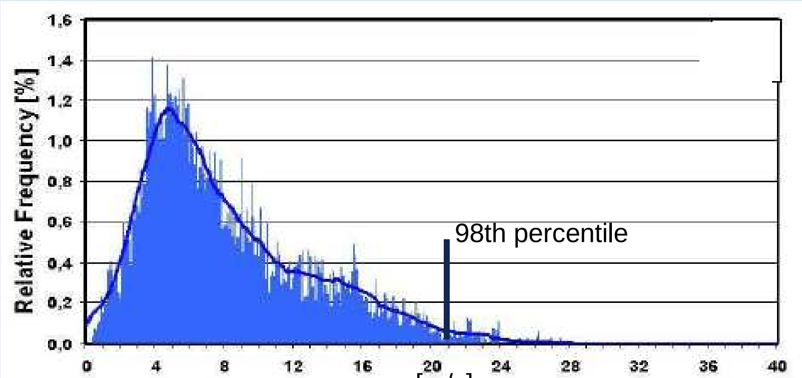
Storm-prone clusters: ca. 5%

Clusters associated with an ensemble of representative high-resolution storm realisations, calculated via a regional dynamical model.



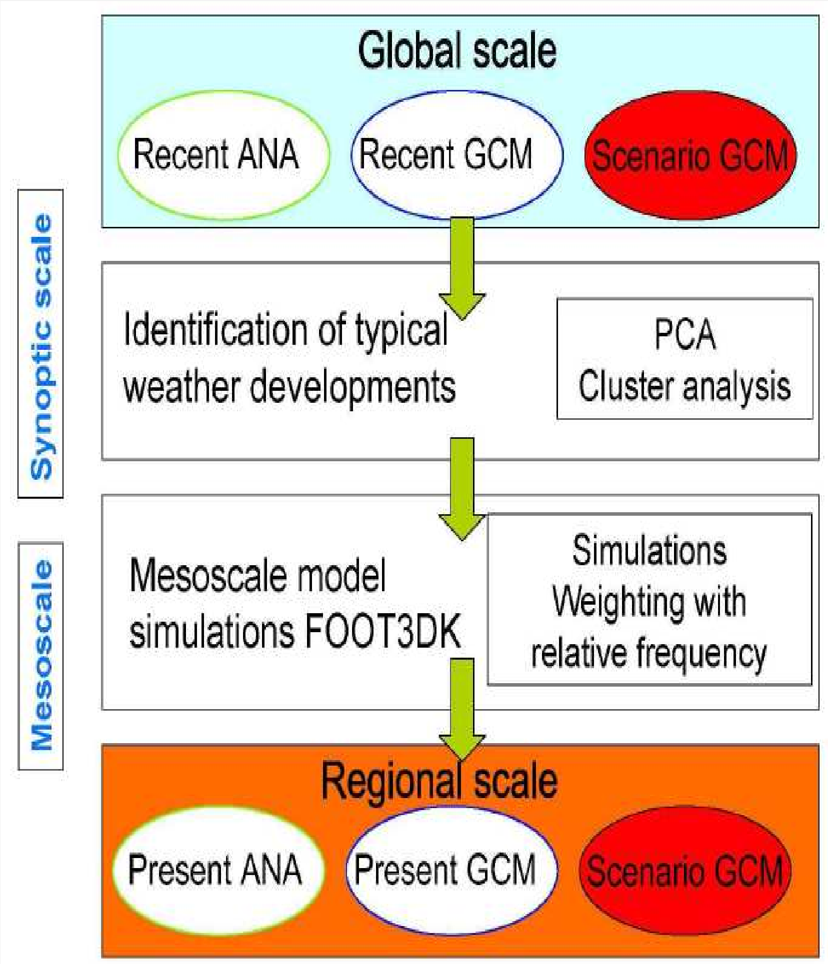
② Full distribution of wind gusts for an individual grid point:

Sum of gust frequencies from all high-resolution regional storm simulations (sampling intervall: 30 minutes) weighted with the relative frequency of the associated cluster.



Source: Pinto, J. et al. (2009), submitted to Tellus A

2 Winter storm impacts on West Germany under climate change – a statistical-dynamical downscaling approach (2)



Source: Pinto, J. et al. (2009), submitted to Tellus A

Two future scenarios (SRES **A1B** and **A2**) and associated relative cluster frequencies inferred from global climate model runs (ECHAM 5/MPI-OM1).

Assumption: adaptation of building stocks to current local wind climate, i.e. **losses start with gusts exceeding the local 98th percentile**.

Transfer functions for **relative losses (loss ratios)** inferred from loss data of two regional public insurers. Basis: wind gust values normalised by the local 98th percentile.

Changes in the period 2060-2100 relative to 1960-2000 for North-Rhine Westphalia (no adjustment of building stocks to the changed wind climatology):

Average annual loss ratio for North-Rhine Westphalia increases by **8% (A1B)** and **19% (A2).**

2 Winter storm impacts on West Germany under climate change – a statistical-dynamical downscaling approach (3)

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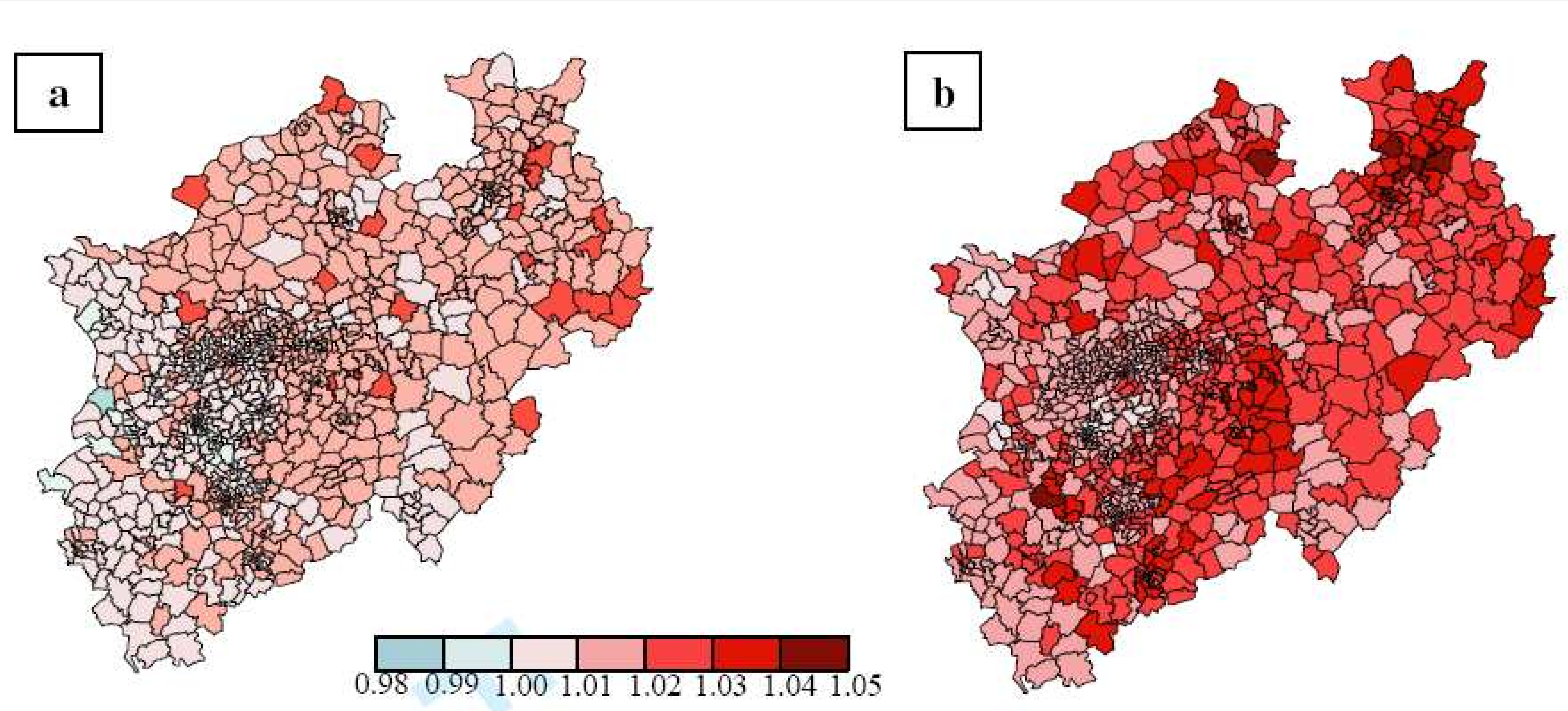

Source: Pinto, J. et al. (2009), submitted to Tellus A

Relative changes [given as factor] of the 98th wind gust percentile for future climate (2060-2100) relative to present (1960-2000) based on 2 ECHAM5 simulations (**left:** A1B, **right:** A2).

2 Winter storm impacts on West Germany under climate change – a statistical-dynamical downscaling approach (4)

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First study to explicitly infer changing properties of *insured winter storm losses* under climate change for a particular region *from global climate model runs*.
Start of project: 2000.
First results: 2003 (proprietary mode and not published at that time).

Limitations (among others):

- **Single GCM approach** as opposed to an ensemble approach:
  not able to capture uncertainties involved in sub-scale parametrisations and deficiencies in the numerical representation of dynamical and physical processes in the GCM and the regional model (RCM)
- **Clusters may change** in temporal and spatial properties in a future climate.

3 Winter storm impacts on Europe under climate change – a dynamical downscaling approach (1)

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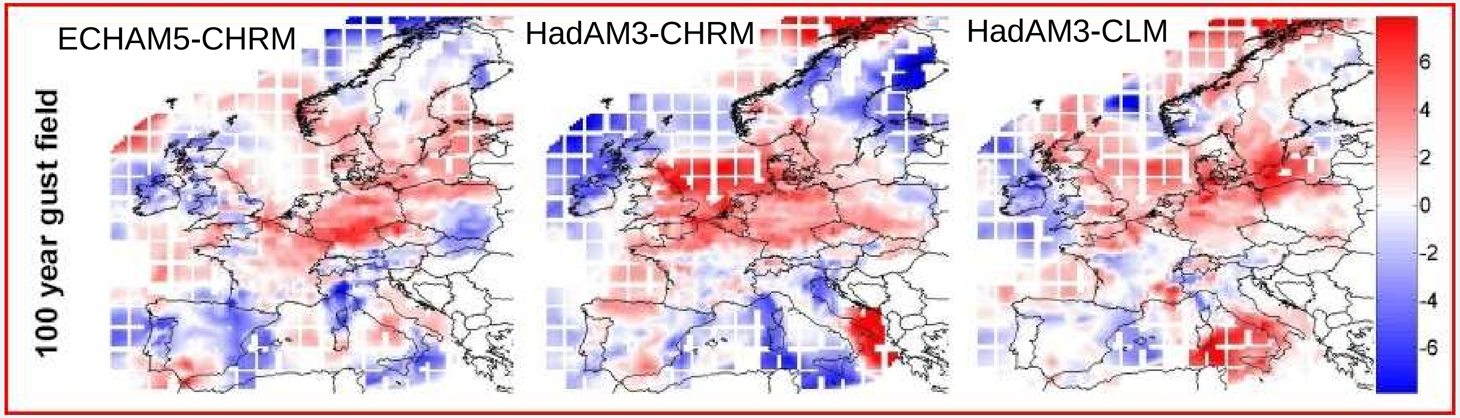
Winter storm losses in Europe and European countries under climate change (2071-2100) as compared to present climate (1961-1990). **Project cooperation** of **ETH Zurich** and **Swiss Re**.

- **2 global climate models** (HadAM3, ECHAM5, scenario A2),
  combined with **2 regional climate models** (CHRM, CLM) for downscaling purposes
  → **3 model chains** (ECHAM5 – CHRM, HadAM3 – CHRM, HadAM3 – CLM).

- Simulated future winter storm climatologies are converted to **probabilistic event sets (expansion of samples) as input for an insurance loss model** and **relative change in loss properties** calculated (annual expected loss, 10-year loss, 30-year loss, 100-year loss).



- Changes of 100-year gust fields in the period 2071-2090 relative to 1961-1990 per climate model chain.

Source: Schwierz, Cornelia et al. (2007), submitted to Climatic Change

3 Winter storm impacts on Europe under climate change – a dynamical downscaling approach (2)

Winter storm losses over Europe and European countries under climate change (2071-2100) as compared to present climate (1961-1990).

Results:

Individual Countries:	United Kingdom:	+ 35%
	Germany:	+ 114%
	Denmark:	+ 116%
	France:	+ 47%
All of Europe:	Annual expected loss:	+ 44%
	10-year loss:	+ 23%
	100-year loss:	+ 104%

Progress: **Ensemble approach** in order to capture GCM and RCM uncertainties;
But: Global climate model differences dominate the overall differences between climate model chains and their results.

4 Winter storm impacts on Europe under climate change – a GCM ensemble approach (1)

Research by University of Cologne and Freie Universitaet Berlin:

Pinto, J.G. et al. (2007): Changing European storm loss potentials under modified climate conditions according to ensemble simulations of the ECHAM5/MPI-OM1 GCM, NHESS 7

Leckebusch, G.C. et al. (2007): Property loss potentials for European midlatitude storms in a changing climate, GRL 34.

Starting from 3-member ensemble under A1B forcing and 3-member ensemble under A2 forcing of the GCM (ECHAM5/MPI-OM1) , periods 1960-2000 and 2060-2100 compared.

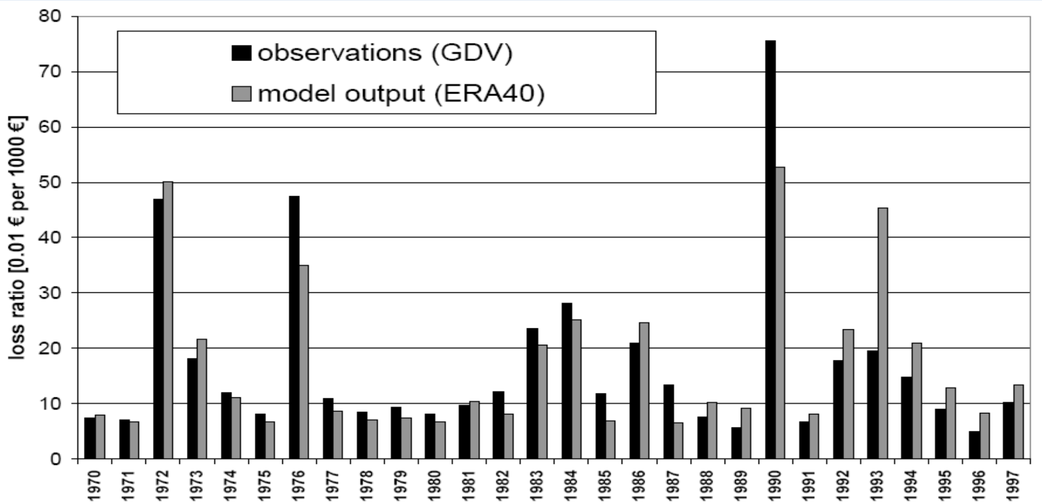
Focus: estimate the sensitivity of the results against the GCM's internal variability.

Loss transfer function
(loss threshold: local 98th percentile)

$$\text{loss(area)} \propto \text{pop(area)} \cdot \underbrace{\left(\frac{v\,\text{(area)}}{v_{98}\,\text{(area)}} - 1\right)^3}_{=\text{ loss index}}$$

Good match of observed (GDV) and modelled (ERA 40) annual aggregate losses
(r = 0.87).

Also: present climate GCM run close to ERA40-based modelled loss (within 10%).
(0.17 vs.0.185 permil)



4 Winter storm impacts on Europe under climate change – a GCM ensemble approach (2)

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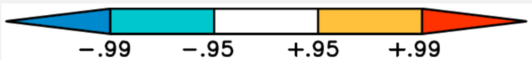
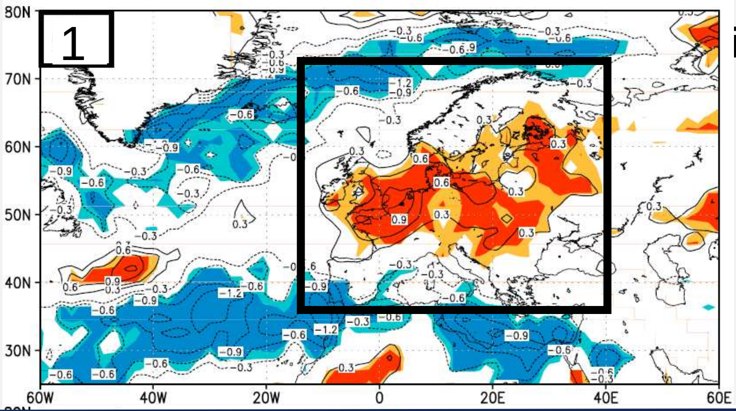
Results for 98th percentile of near-surface daily maximum wind speed (interval: 0.3 m/s)

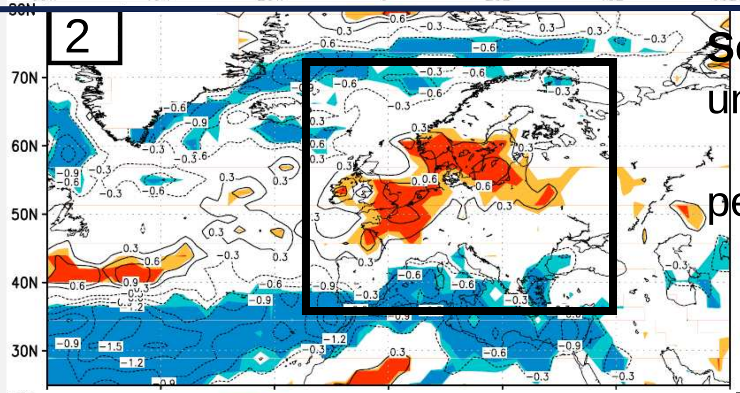
ignificance level





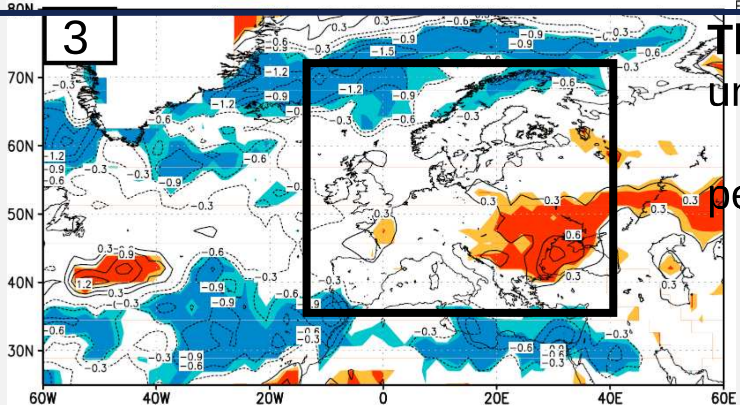
irst run of ECHAM5 under the **A2** scenario:

period 2060-2100 minus period 1960-2000



Second run of ECHAM5 under the **A2** scenario:

period 2060-2100 minus period 1960-2000



Third run of ECHAM5 under the **A2** scenario:

period 2060-2100 minus period 1960-2000

4 Winter storm impacts on Europe under climate change – a GCM ensemble approach (3)

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Loss ratio results

ETH, C. Schwierz: +114%

ETH, C. Schwierz: +35%

ETH, C. Schwierz: +47%

ETH, C. Schwierz: +16% (NOR) +95% (SWE)

	ECHAM5 (ensemble averages)									
region	Germany		U.K.		France		Portugal / Spain		Norway / Sweden	
scenario	A1B	A2	A1B	A2	A1B	A2	A1B	A2	A1B	A2
mean with adaption	+6%	+13%	+8%	-4%	+3%	+34%	+8%	+10%	+1%	+4%
mean no adaption	+40%	+49%	+43%	+24%	+11%	+44%	-5%	-5%	+7%	+10%
standard deviation with adaption	+50%	+74%	+37%	+19%	+25%	+132%	+74%	+36%	+29%	+66%
standard deviation no adaption	+112%	+137%	+119%	+85%	+37%	+156%	+63%	+11%	+58%	+89%

- **Substantial differences to other studies.**
- **High internal GCM variability under identical forcing.**
- **Limitations from today‘s perspective**: No change in socio-economic factors; calibration only to German loss data; good performance only for annual aggregate losses.

Conclusions

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- Over the last decade insurance industry along with climate science started to apply climate models to infer changing loss properties under future climate change.
- All approaches **vary climate** (radiative forcing) while **keeping today's socioeconomic parameters constant** (exposures, vulnerability, population).
- Increasingly **model ensembles** (GCMs, RCMs) were used in order to estimate uncertainties in parametrisations and in the numerical representation of dynamical and physical processes.
- All climate model **results pertain to the end of the 21st century** and indicate changes in annual loss properties relative to the end of the 20th century.
- Given the evident uncertainties, it is **more save to infer that there will likely be an increase in annual winter storm losses** in Western and Central Europe over the coming 100 years **than to quantify the change**. In particular the intense storms can increase in frequency, which renders a disproportionate increase in losses associated with high return periods possible and can **increase dramatically the volatility / variability of nat cat business.**

Conclusions (cont.)

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Implications for business decisions (on an extended time horizon)

- Prepare for a **higher demand for nat cat covers**.
- Prepare for **enhancement of the balance sheet‘s stability by diversification** through inclusion of non-correlated insurance cover(s) in an object‘s insurance covers (in Germany: e.g. flood insurance EEV in addition to windstorm)
- Prepare for **regional and sectoral diversification** (portfolio management)
- Prepare for introduction of **deductibles** (product management)
- Prepare for loss-reduction incentives such as **tariffing according to customer‘s loss experience**
- Prepare for **adequate reinsurance covers**
- Prepare for **transfer of risks into the capital market** (insurance linked securities).

Outlook

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Move on to more business-relevant time horizons spanning the coming decades (as opposed to all of the 21st century).

- **Precondition:** account for **low-frequency natural climate variability** (which might have a larger amplitude on decadal timescales than anthropogenic climate change).
- **Change operational mode** of climate models from scenario into prediction: from **boundary value problem** to **initial value problem.** Data assimilation (initial values) in particular with respect to the slow changing components of the climate system *ocean, cryosphere and soil moisture.*
- Might enable us to know about the future development of important climate modes like AMO, NAO, PDO, ….
  … and infer hazard statistics over the coming 1 – 3 decades which are dependend on natural climate variability and anthropogenic global warming.

Concluding example:
Importance of low-frequency natural variability
In US hurricane losses

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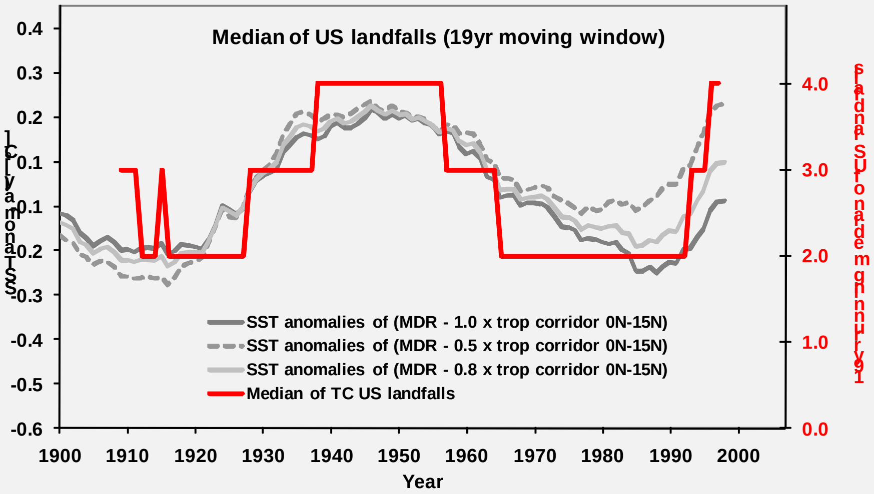

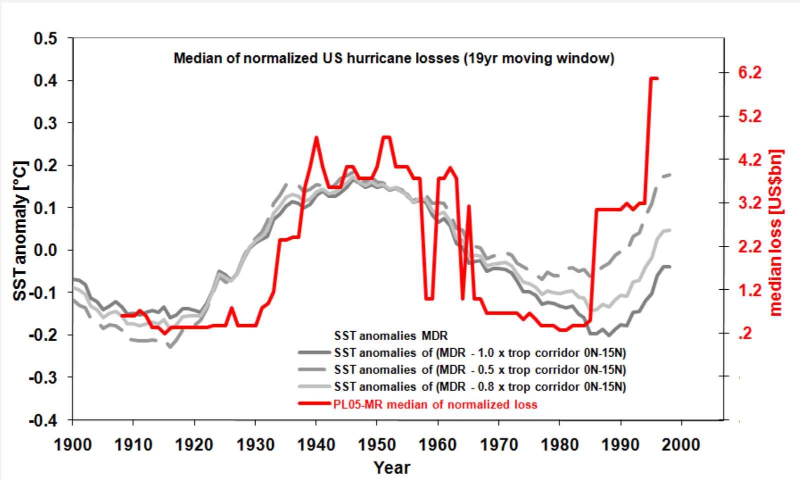

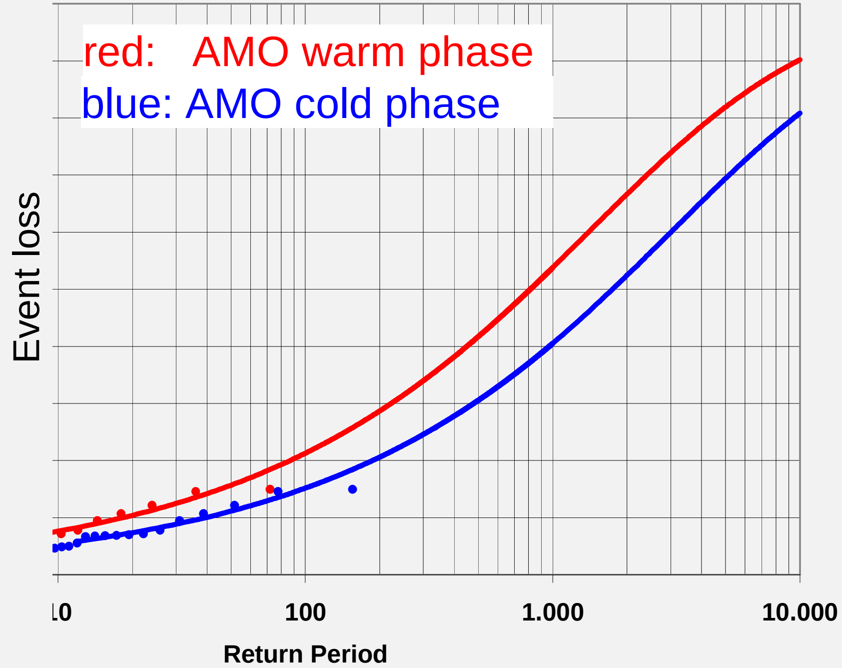

PML curve specific to AMO warm phase
(enhanced hurricane activity) since 1995

Thank you for your attention!

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