HIGH RESOLUTION STORM FOOTPRINTS FOR THE INSURANCE SECTOR

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AXA - MetOffice
2018

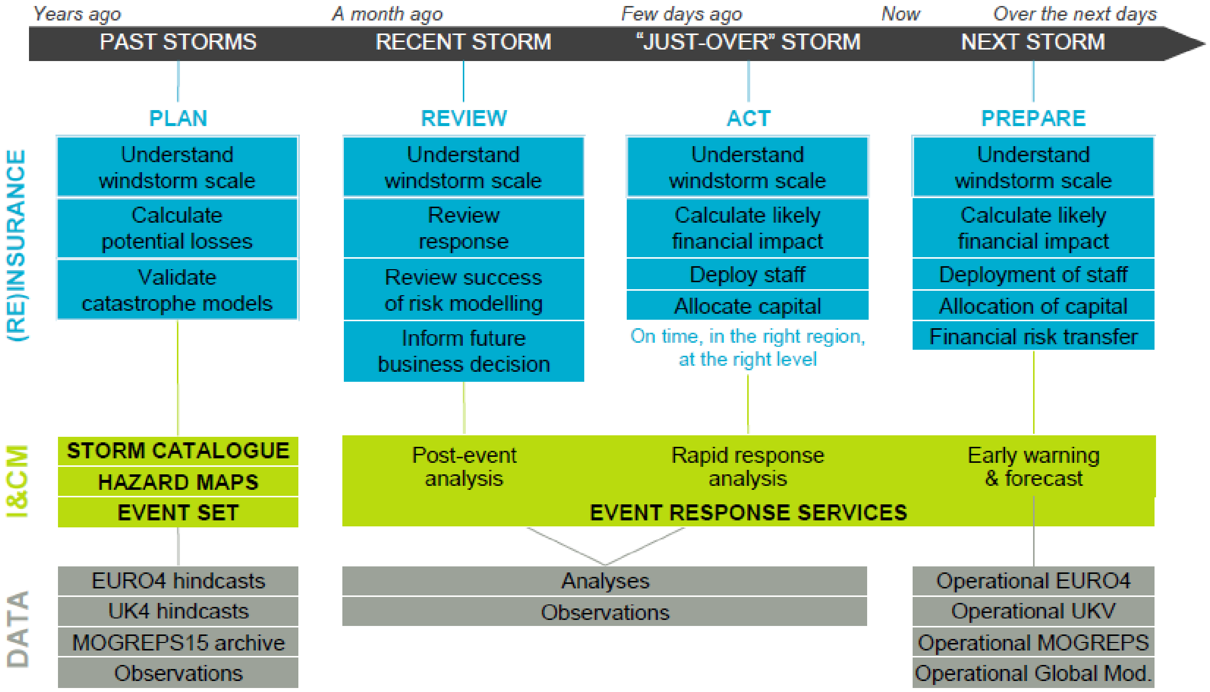
INTRODUCTION

- According to MunichRe, 59% of insured losses in Europe (1980-2009) are related to storms
- From 1970 to 2008, of the 40 global natural and man-made catastrophes with the highest insurance losses, 7 were European winter storms causing 11.2% of the total losses (Enz et al., 2009)

- AXA has a significant market share in Europe
- Windspeeds of winterstorms are relatively low but they maintain their strength over land
  - → **Potential for significant AXA losses (typically through many relatively small claims)**

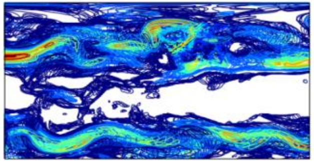
- New tools (XWS catalogue, WISC, OASIS) and lots of data (regional reanalysis, ensemble simulations) are developing
- Resolution of dynamical models are improving
  - → **Can we improve AXA knowledge of windstorm risk in Europe ?**
  - → **Which AXA tools can be improved thanks to these high-resolution footprints ?**

PRODUCT & ACTIVITIES - METOFFICE



WINDSTORM INFORMATION SYSTEM

- Downscaling ERA/real-time surface footprints (SFP)



Global 6-hourly lowest model level wind (example IC)
For(cing) the global UM to provide boundary conditions for the nested 4 km model

	-- recent hist.		-- event response
Timeline:	1979-2014	|	2015 - 2018
Resolution:	4km	|	4km
Model:	UM	|	UM
Forcing:	ERA-I	|	UM-DA

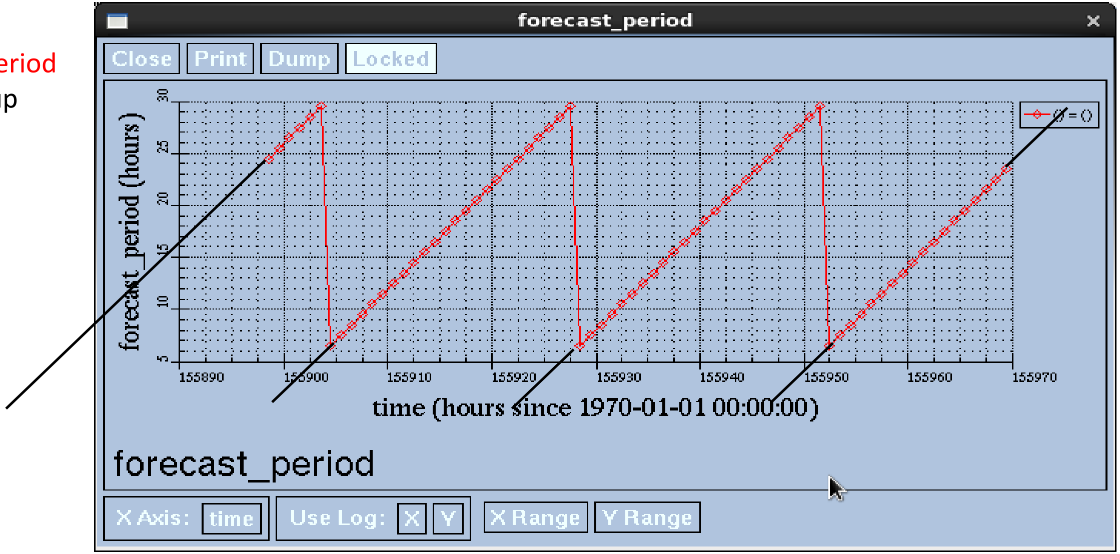
Storms identified by tracks or by date

★Existing:
- ★Selection from Met Office 4km Windstorm catalogue
- ★Real time forecasts since 2015

★Also available:
- ★UPSCALE (5 members) 1985-2011 (for the event set)

FOOTPRINTS METHODOLOGY

Red: a 6hr foot print period
Black: discarded spin-up



★Repeat 4 times a day
★Remove 'spin-up' period (ST to ST+3)
★Use 4 to 9 hours forecasts

★Concatenate into 72-hour footprint → maximum wind gust
★Output as appropriate (currently geo-referenced and NetCDF)

CREATE REAL-TIME STORM FOOTPRINTS

What?

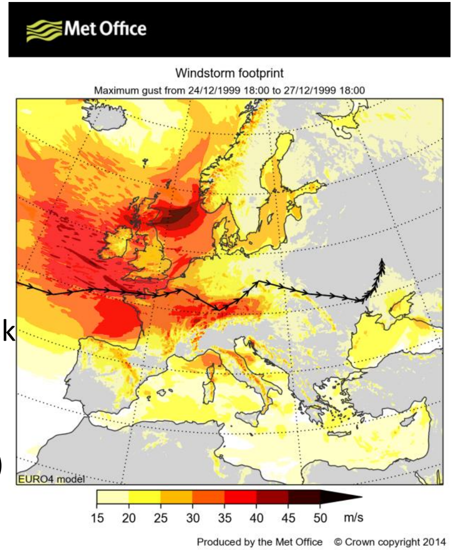
- Succession of short range NWP forecasts during recent storms
- Max gusts

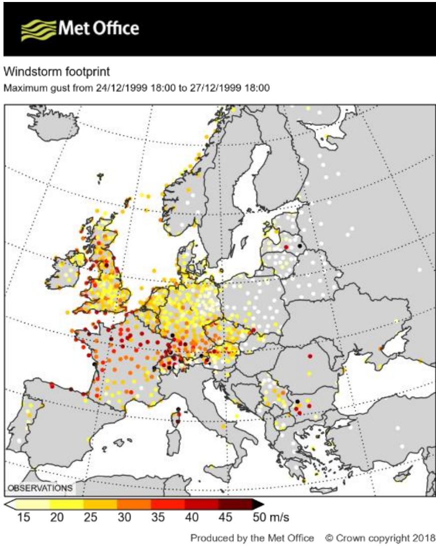
Why?

- Give real time guidance on recent events
- Associated impacts data is useful for quantifying risk

How?

- Run regional NWP model at high resolution (4.4km)





CREATE HISTORICAL CATALOGUE OF STORMS

What?

- Catalogue of potentially 100s of historical storms

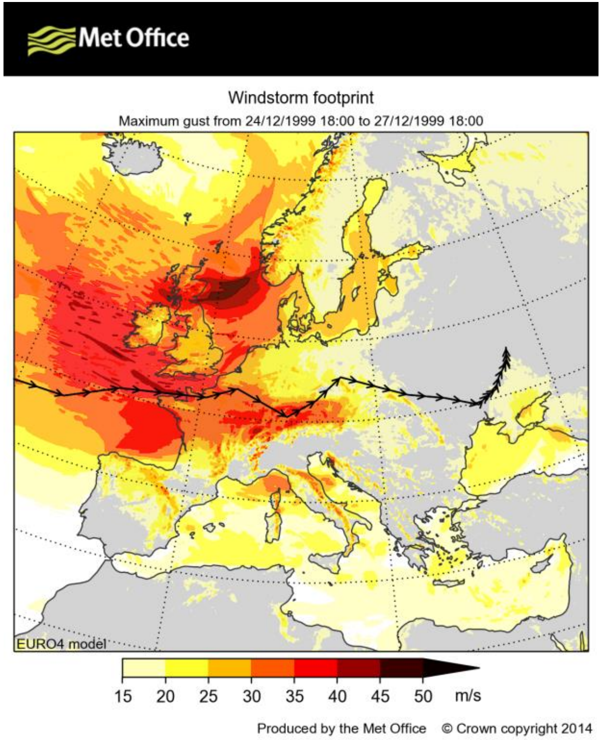
Why?

- Give historical context to current storms; Understand factors influencing these events
- Associated impacts data is useful for quantifying risk

How?

- Downscaled reanalysis data (e.g. ERA Interim/ERA-20c) (from 80km to 4.4km)

  - Verify against: point observations!
  - Very expensive,
  - High resolution, complete, spatially coherent



HIGH-RESOLUTION WIND FOOTPRINTS ARE WORTH FOR THE INSURANCE INDUSTRY

- Calibration of in-house CAT model (1)
  - Calibration of vulnerability
- Real-time estimations of losses using *METAXA* – claims management (2)
  - Overview of 2017/2018 winterstorms in France
  - Estimation of total losses, main regions impacted, etc.
- Estimations of losses for historical events (3)
  - An improvement of knowledge related to windstorm risk in Europe for AXA
  - Magnitude of maximum and aggregated yearly losses

VULNERABILITY (1.1)
CALIBRATION BASED ON AXA CLAIMS AND METOFFICE FOOTPRINTS

- Vulnerability module is a key component of a CAT model: the aim is to quantify the relationship between the hazard at a given location and the resulting loss
- Vulnerability module and hazard module are dependant

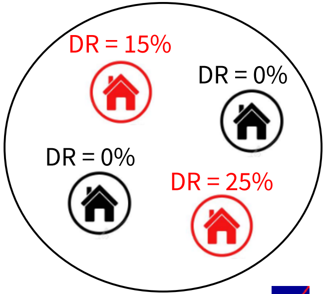
$$\boxed{DR = \frac{claims\_amount}{insured\_value}}$$

- AXA has a large number of claims related to windstorm damages in Europe with relatively good geocoding
  - → High resolution footprints help us to extract a maximum information from these claims data
- Two-steps vulnerability functions are developed and calibrated against MetOffice wind gusts

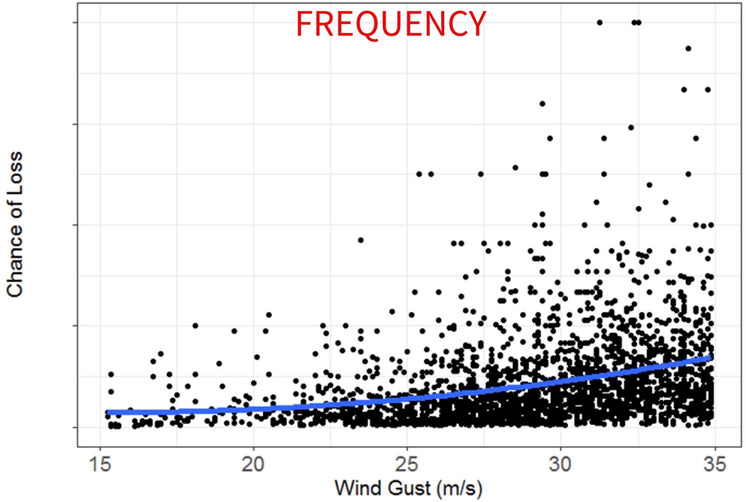
SEVERITY FREQUENCY

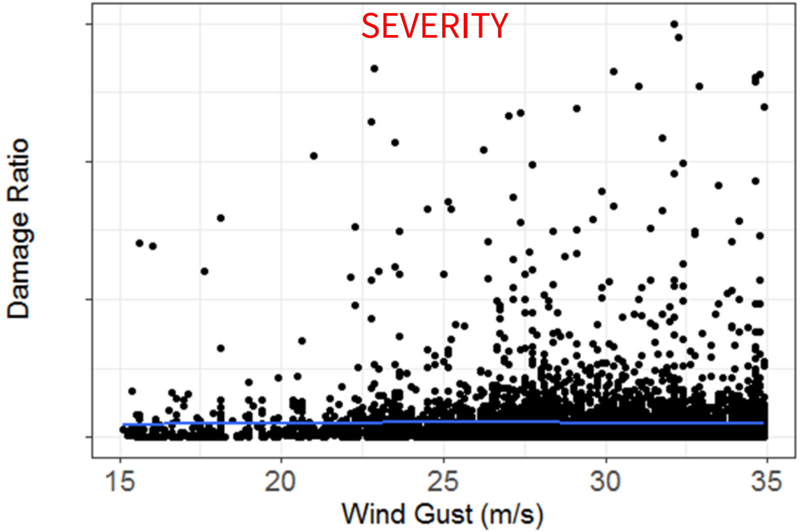
Conditional_DR x Chance_of_Loss = Mean_DR

20% *50%* *10%*



VULNERABILITY (1.2)
CALIBRATION BASED ON AXA CLAIMS AND METOFFICE FOOTPRINTS





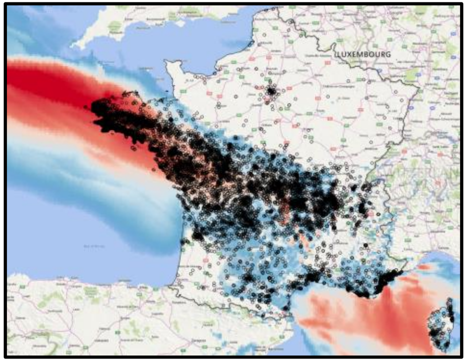
- A large part of losses due to windstorms in Europe occur at relatively low wind speeds
- Losses related to windstorms are associated to an increased claims frequency

AN ACCURATE AND QUICK ESTIMATION OF TOTAL LOSSES (2.1)

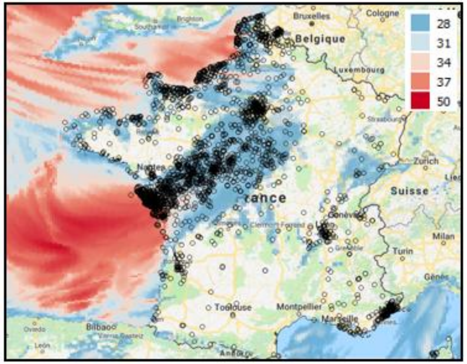
- The METAXA CAT model gives slighlty better results than actuarial methods and estimations are available very quickly during the event

TOTAL AXA LOSSES	ZEUS 6-7 Mar 2017	ANA 10-11 Dec 2017	ELEANOR 2-4 Jan 2018
Actuarial Methods	-25%	-9%	*few days*: -37% *few weeks*: -27%
METAXA Cat Model	+22%	+6%	*forecast* : -12% *analysis* : +3%

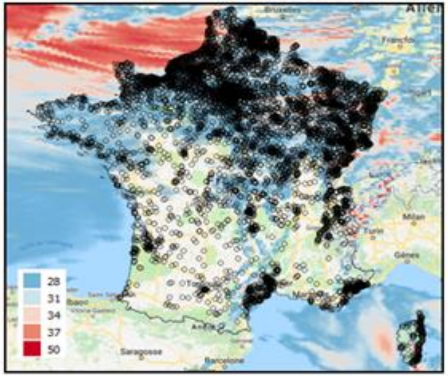
ZEUS – 6-7 Mar 2017



ANA – 10-11 Déc 2017



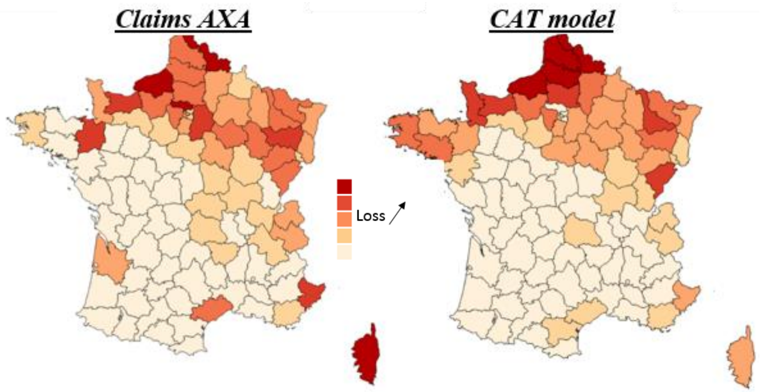
ELEANOR – 2-4 Jan 2018



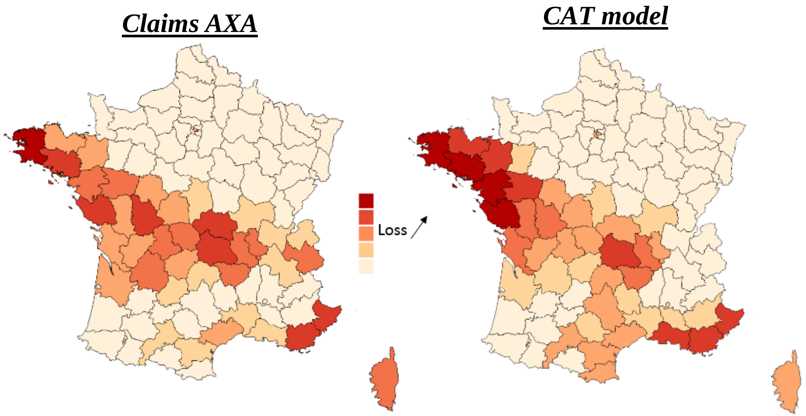
MAIN IMPACTED REGIONS AGREE BETWEEN METAXA AND CLAIMS (2.2)

- Accurate estimation of main regions impacted is worth for claims management
  - → Where do I need to send claims experts ?
  - → Where do I need to send general agents for helping my customers ?

ELEANOR – Jan 2018



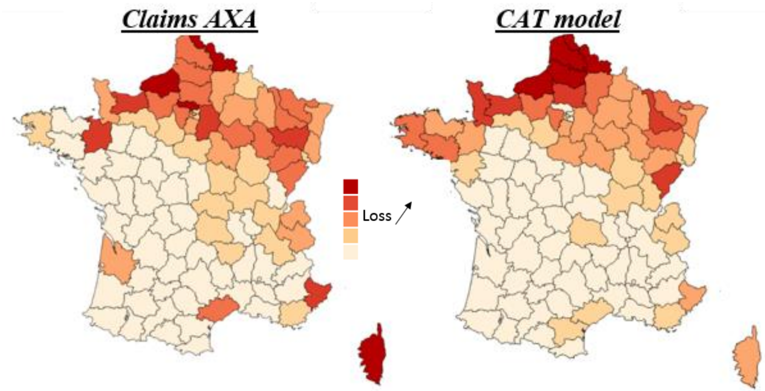
ZEUS – Mar 2017



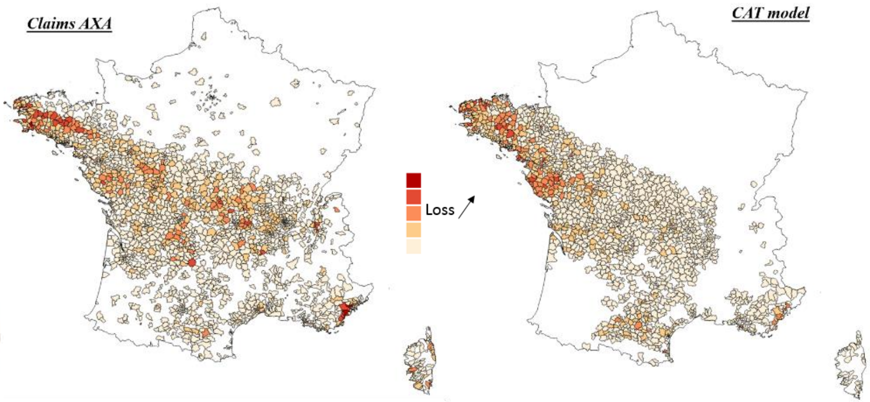
MAIN IMPACTED REGIONS AGREE BETWEEN THE MODEL AND CLAIMS (2.3)

- Accurate estimation of main regions impacted is worth for claims management
  - → Where do I need to send claims experts ?
  - → Where do I need to send general agents for helping my customers ?

ELEANOR – Jan 2018

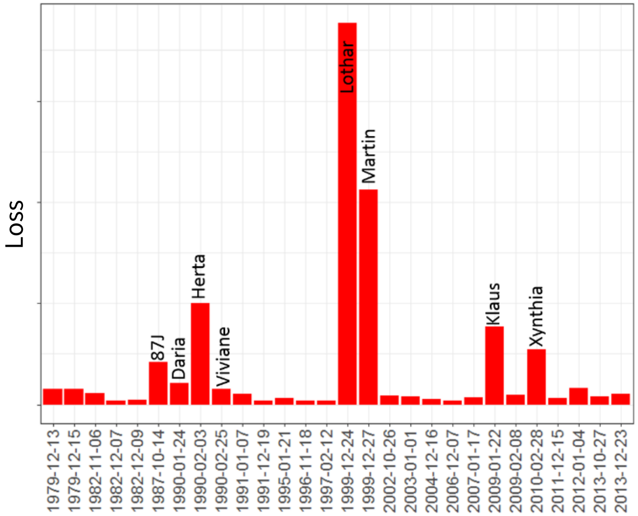


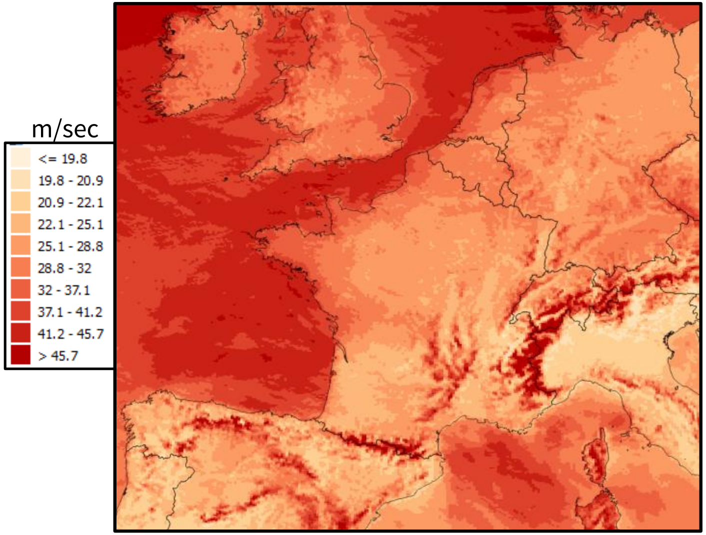
ZEUS – Mar 2017



HISTORICAL REANALYSIS (3.1)
A BETTER KNOWLEDGE OF WINDSTORM RISK

- Knowledge of total losses for recent storms: better understanding of windstorm risks
  - Lothar, Martin and Hertha are the top 3 losses in France since 1980
  - No trend detected
  - Spatial view of windstorm risk over Europe





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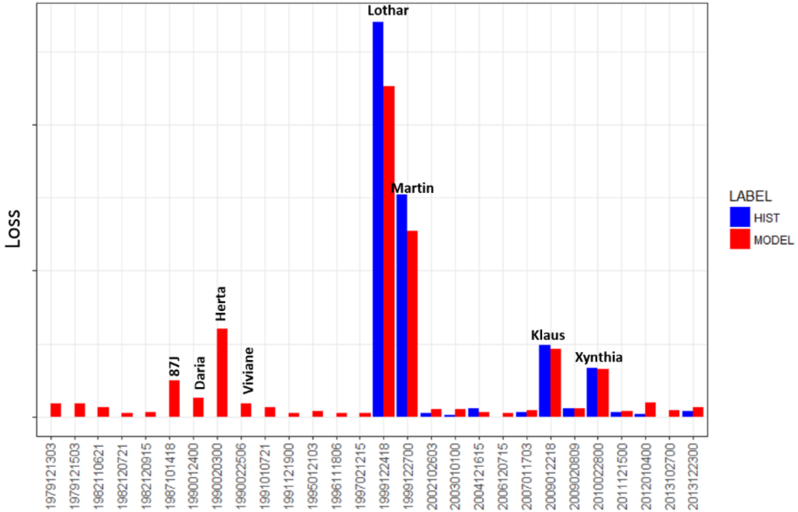
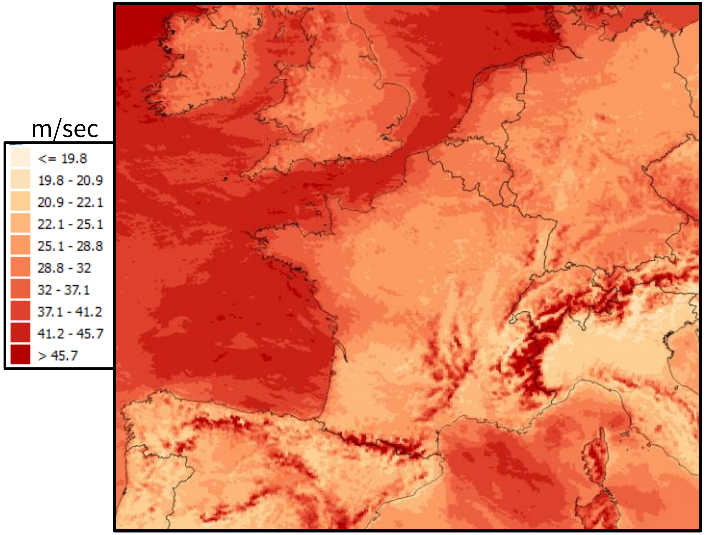




CONCLUSIONS & NEXT STEPS

- High-resolution footprints from the MetOffice gave us the opportunity to:
  - → Leverage large amount of claims data for the development of vulnerability curves
  - → Have an accurate view of the impacts of historical storms for AXA portfolios
  - → Estimate the impact of real-time storms few hours after the event

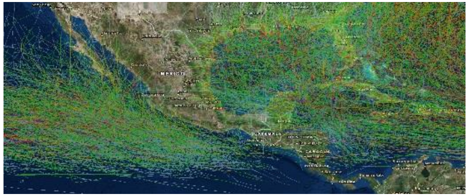
- Next steps:
  - → Creation of an event set based on ensemble climate simulations and statistical methods
  - → Build a view of risk at higher return periods
  - → QQ mapping, feature learning, scale filtering, orographic adjustment, etc.

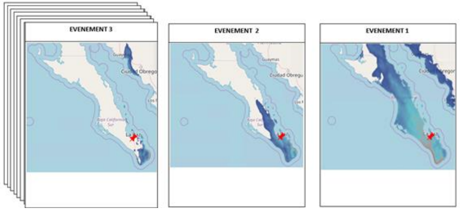
ADDITIONNAL SLIDES

DESCRIPTION OF A CAT MODEL

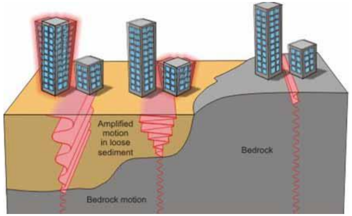
« A CAT model is a computerized system that generates a robust set of simulated events and estimates the magnitude, intenisty, and location of the event to determine the amount of damage and calculate the insured loss as a result of a catastrophic event such as a hurricane or an eathquake. »

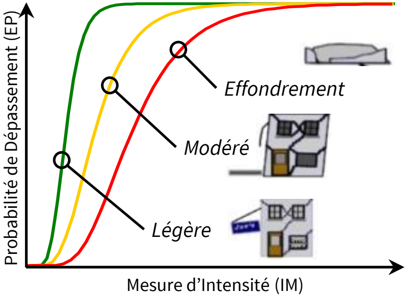
HAZARD



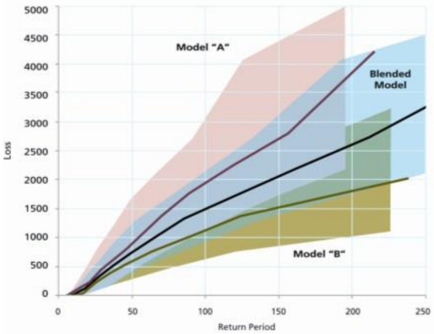


VULNERABILITY





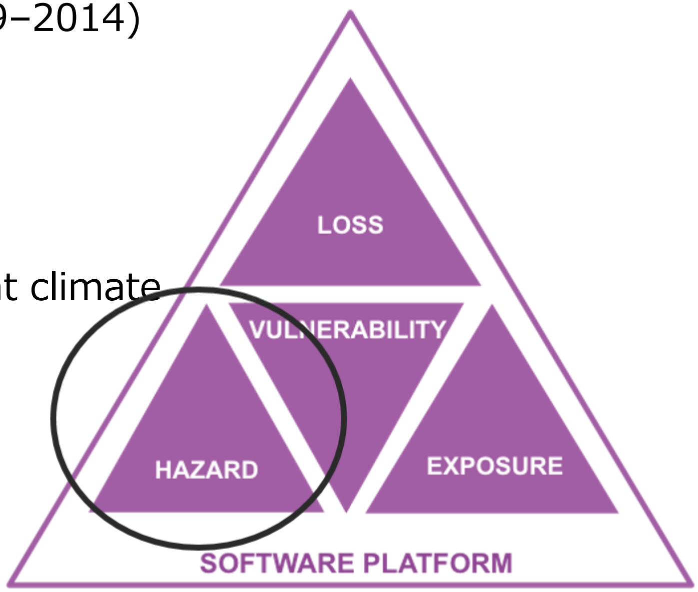
FINANCIAL

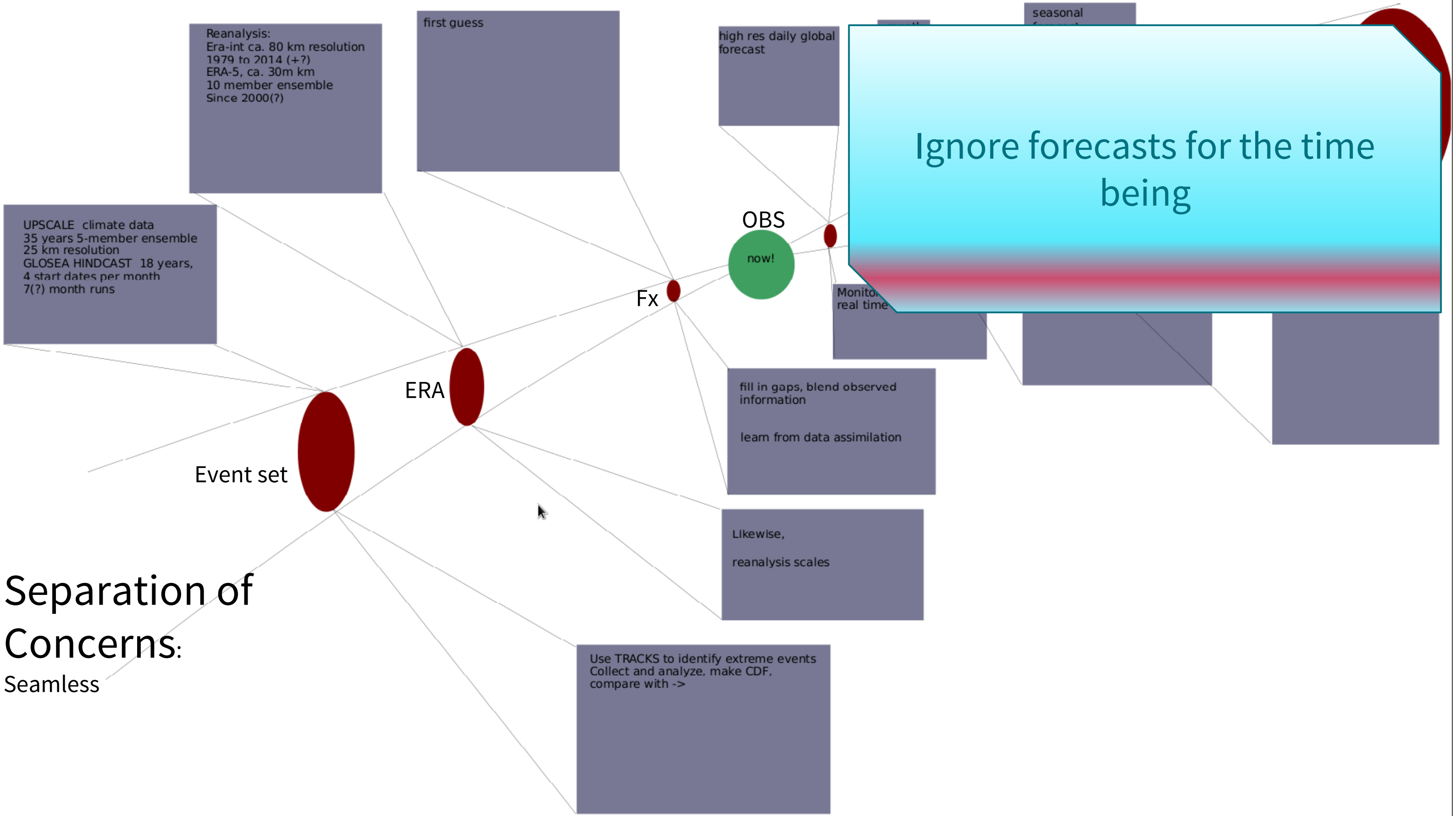


METHODOLOGY for a better Hazard model

- History :
- XWS: ERA-I downscaled using UM to 25 km (1979–2010)
- Met Office: Further downscaled to 4 km (1979–2014)
- Euro4 forecast footprints (2014-present)
- Extend data period backwards

- Objectives:
- Delivery Europe-wide hazard model for current climate
- Develop vulnerability curves





Separation of Concerns:

Seamless

Create Event Set

What?

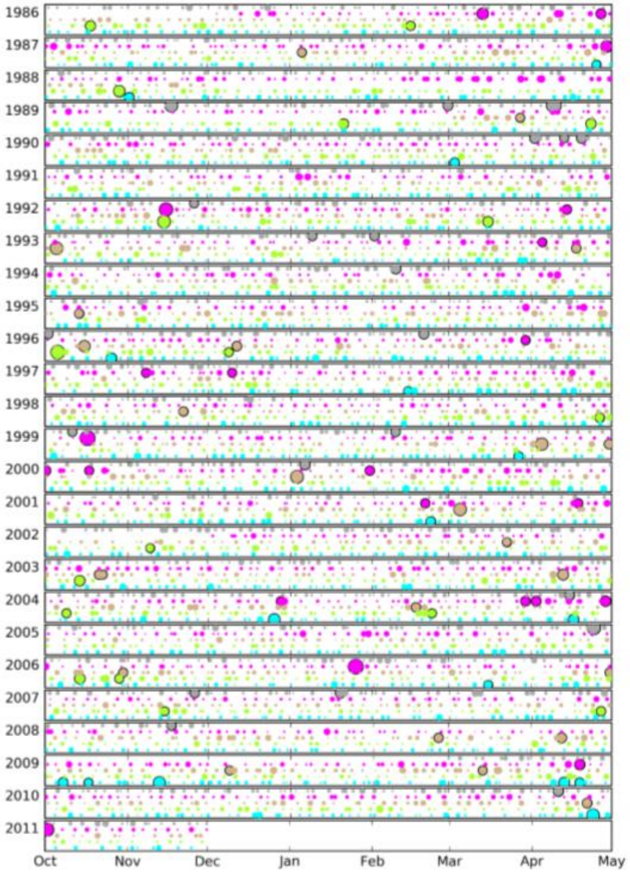
- Potentially 1000s of dynamically plausible cyclones/wind storms

Why?

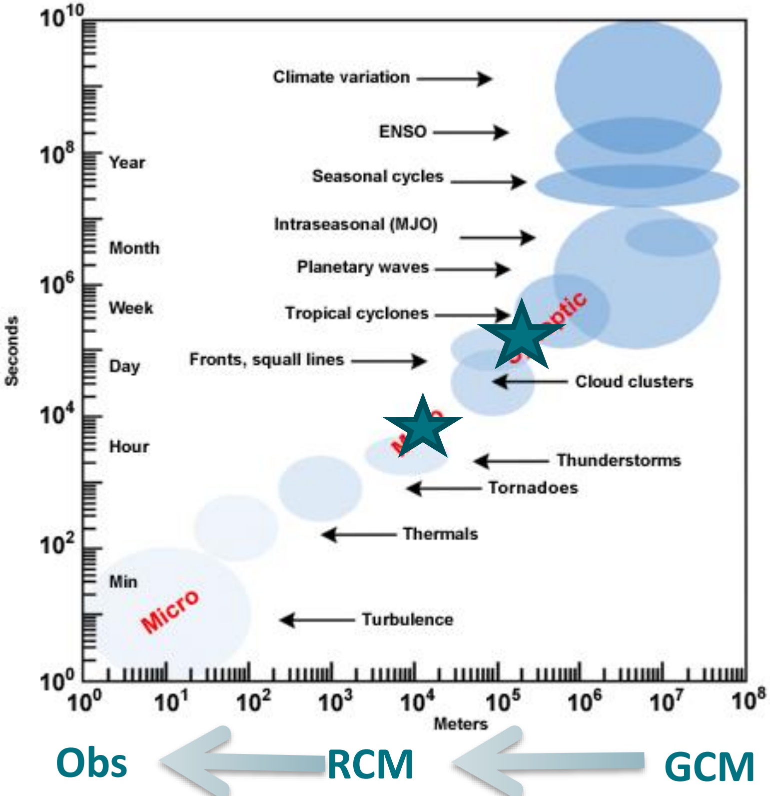
- Allows for analysis of possible but not observed extremes (Black Swans)

How?

- An ensemble of weather-resolving climate model data (25km resolution)

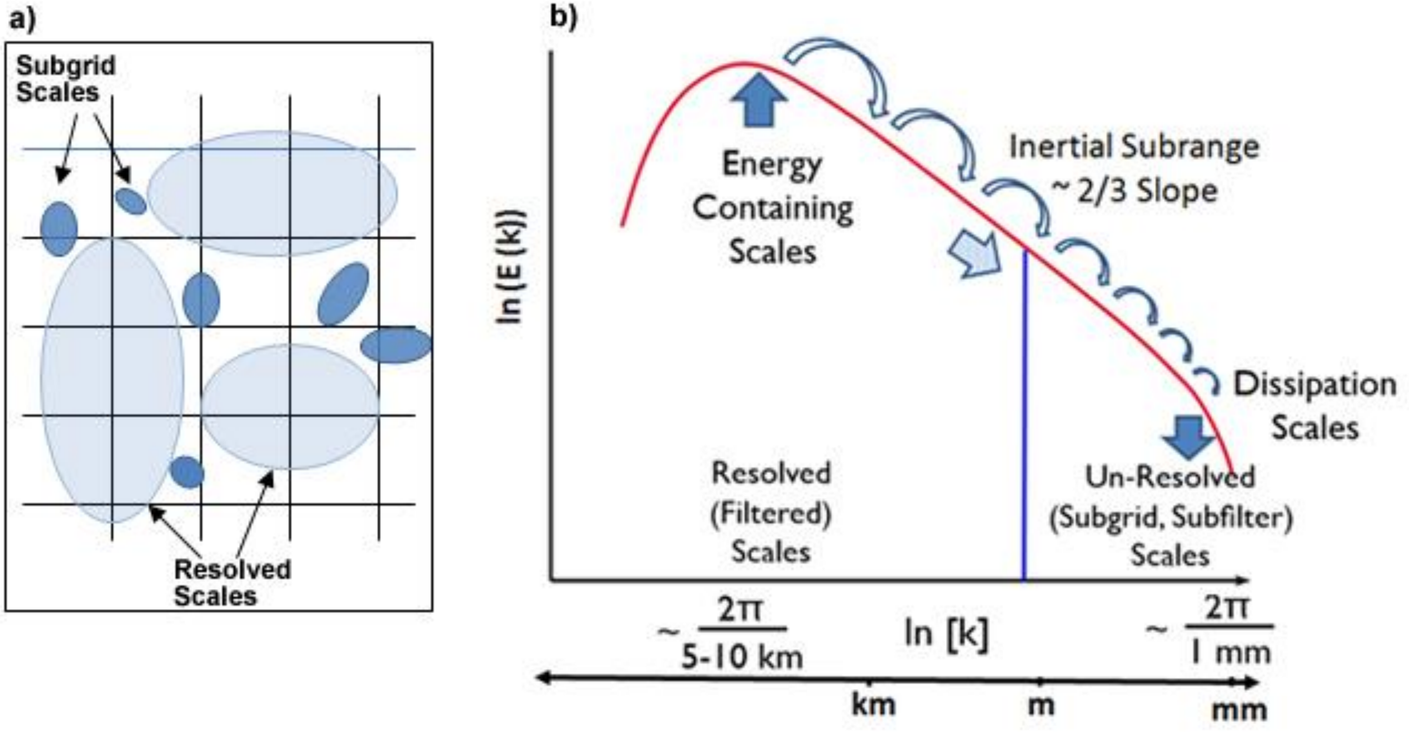


Snag: Scale discrepancy



Resolved and Subgrid Scales

Spectrum of Turbulent Kinetic Energy and Energy Cascade



Patton/NCAR/ The COMET Program

Bridge the scale gap!

Between:

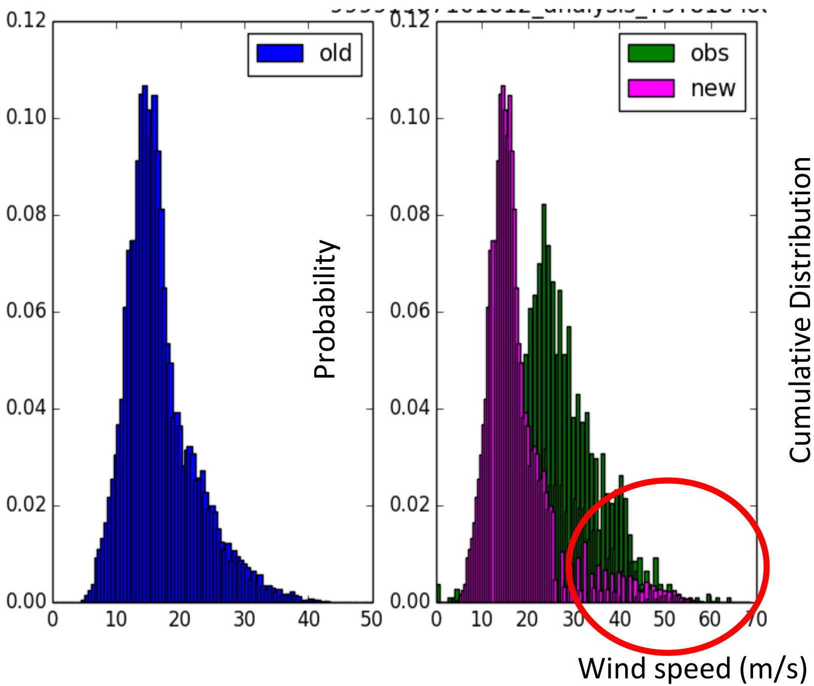
- model gridded wind gust storm footprints (SFP)

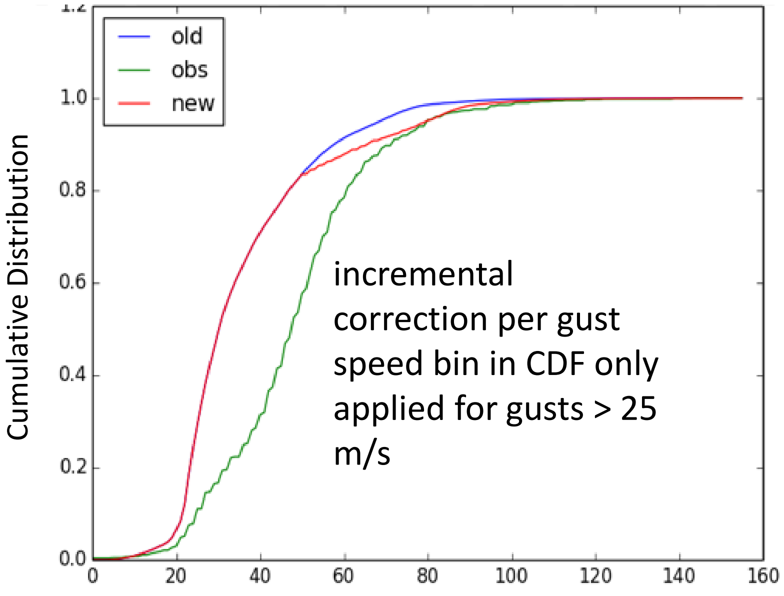
and

- observed point measurement based SFPs

- QQ mapping, feature learning, scale filtering, orographic adjustment etc.

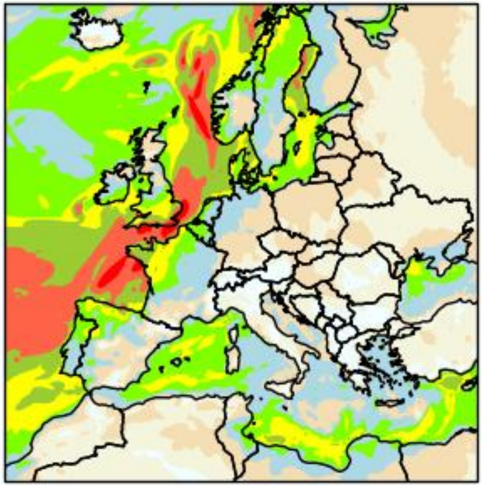
(Incremental) quantile mapping



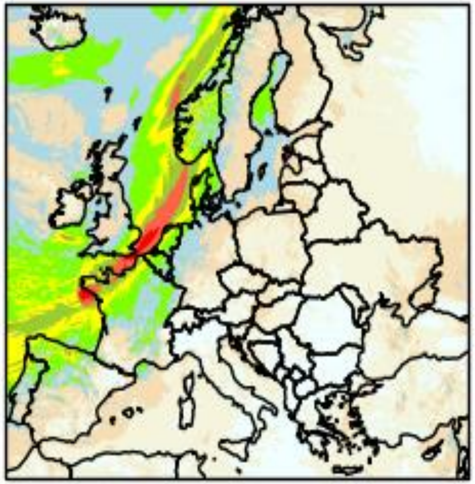


Quantile Matching e.g. for one storm

25km

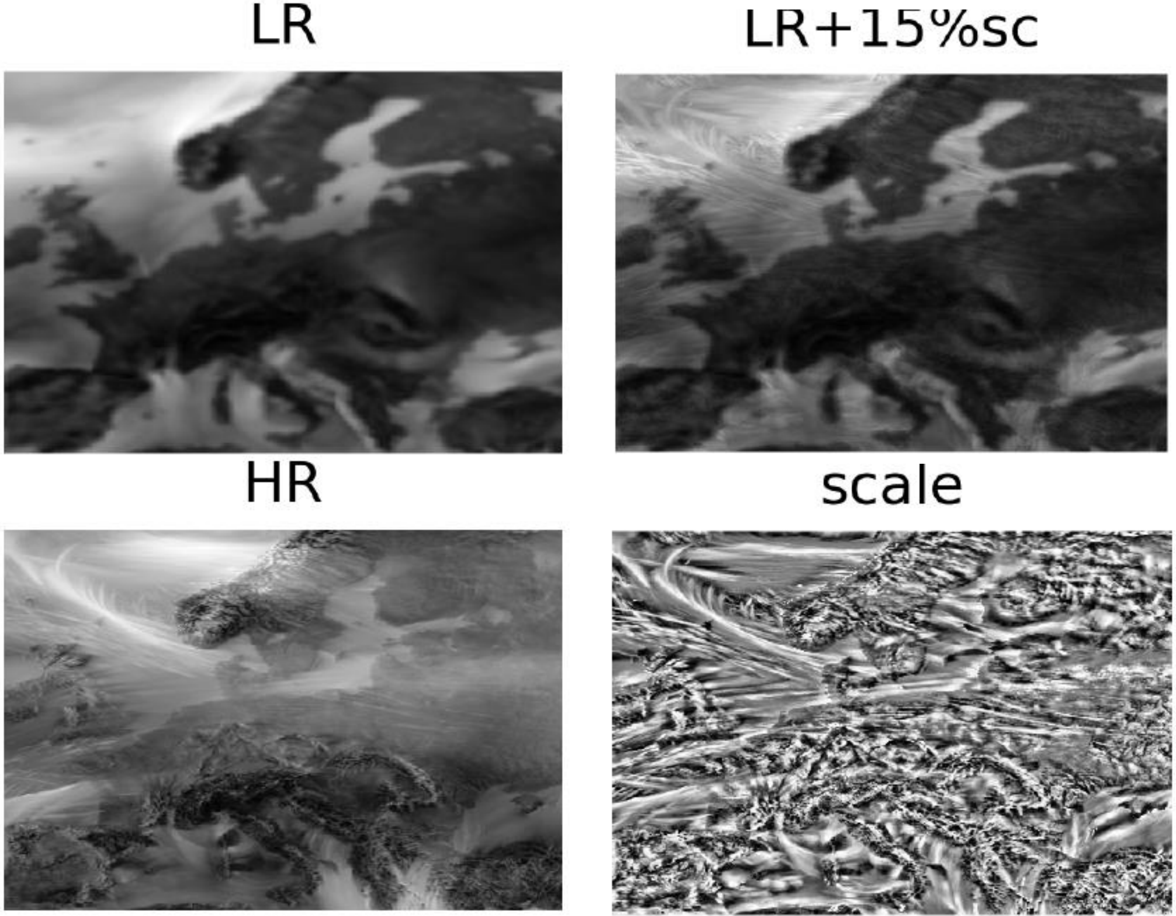


4km



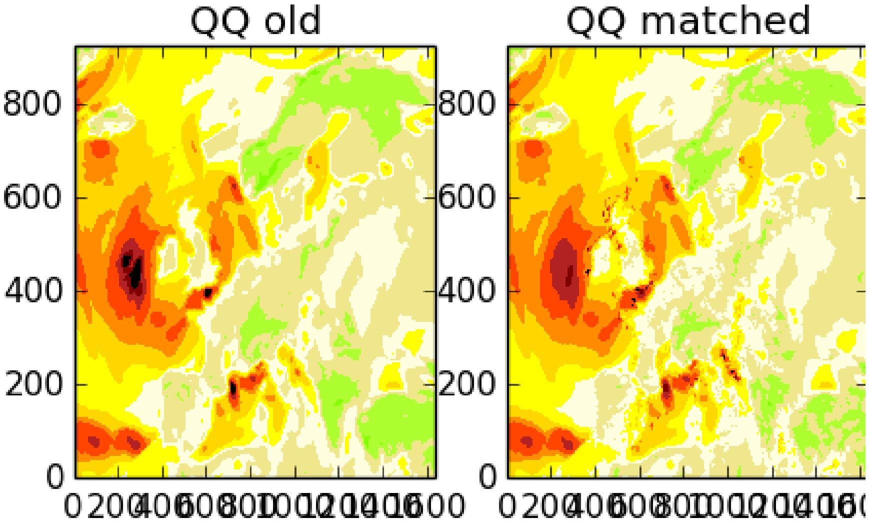
Matching value range but pattern still lacking "gustiness"

HR scales (random) super imposed on coarse SFP: many combinations possible, matching “similar” HR with LR footprint first may be beneficial

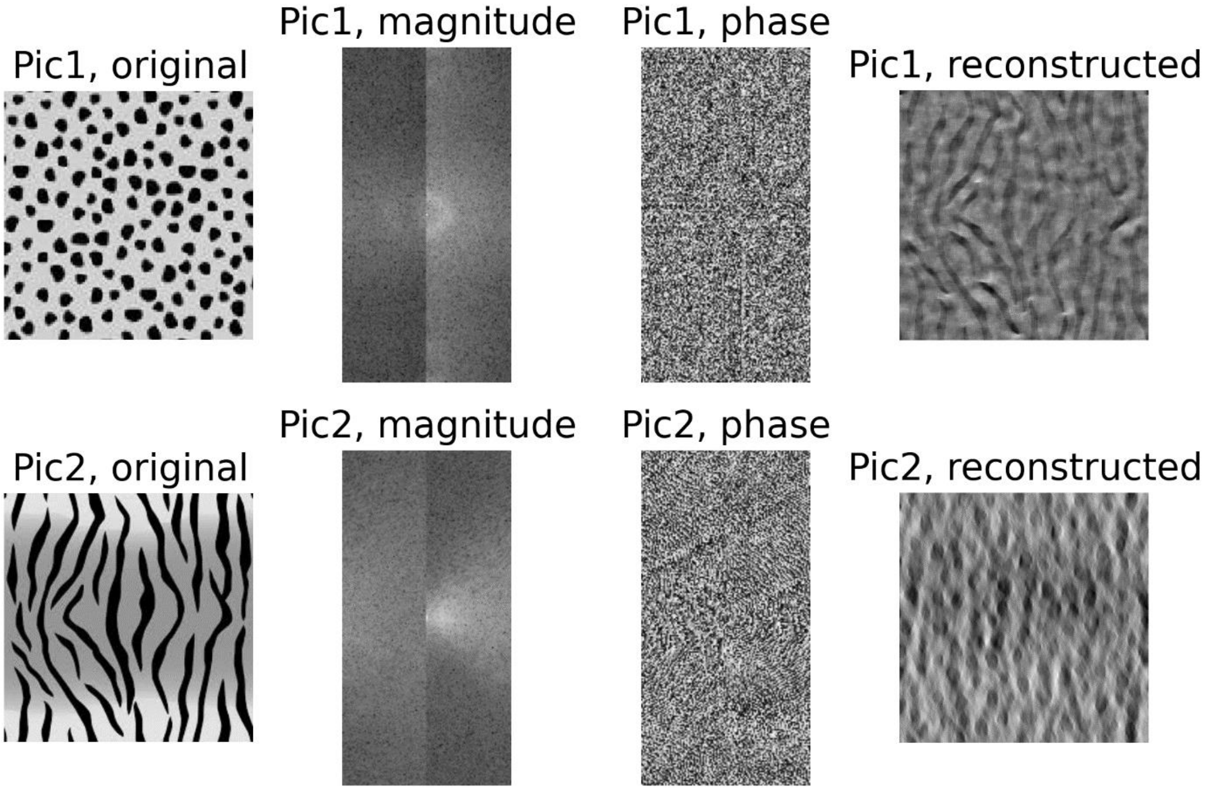


Orography effects

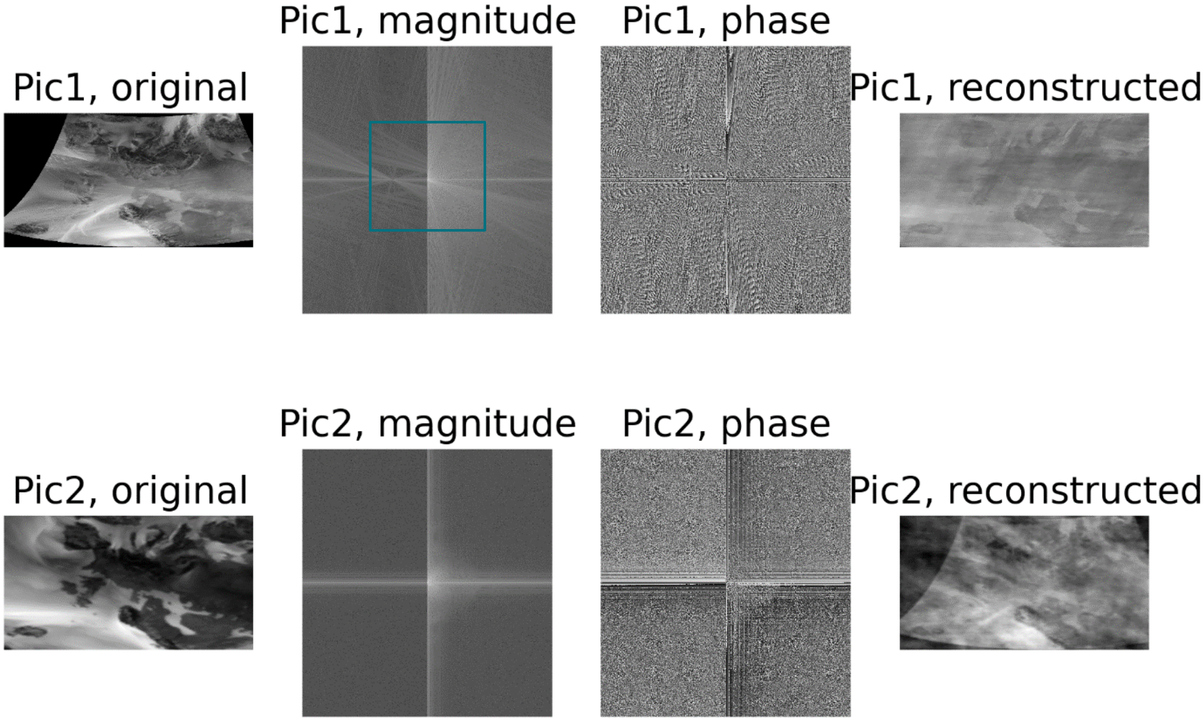
- SFP "lifted" to same value range as the 4.4 km data by QQ but still very broad features, lack of map detail. No indication of "gustiness" in the foot print.
- Add gustiness due to difference in model orography between the high and the low resolution:



Fourier analysis and image merging



Fourier analysis and image merging: needs tuning (select “ribbons”)



CONCLUSIONS

- With a tool kit addressing the scale gap between gridded model and observed point data, it may be possible to combine dynamically consistant SFPs from varying resolutions in a statistical downscaling suite.
- From O(100K) low resolution climate SFP combined with O(1k) high resolution SFPs and quantile mapping with observed gust data and with orographic adjustment at extremely high resolution (100m) a dynamically consistent and statistically potent (O 10^6) event set may be built to form the basis for future European windstorm risk assessments.
- The method is transferable to other regions and to other perils.

HISTORICAL REANALYSIS (3.1)
A BETTER KNOWLEDGE OF WINDSTORM RISK

- Knowledge of total losses for recent storms: better understanding of windstorm risks
  - Aggregated yearly losses: 1999 and 1990
  - Spatial view of windstorm risk over Europe