ESTIMATING THE COMBINED RISK DUE TO HAIL, CONVECTIVE GUSTS AND TORNADOES

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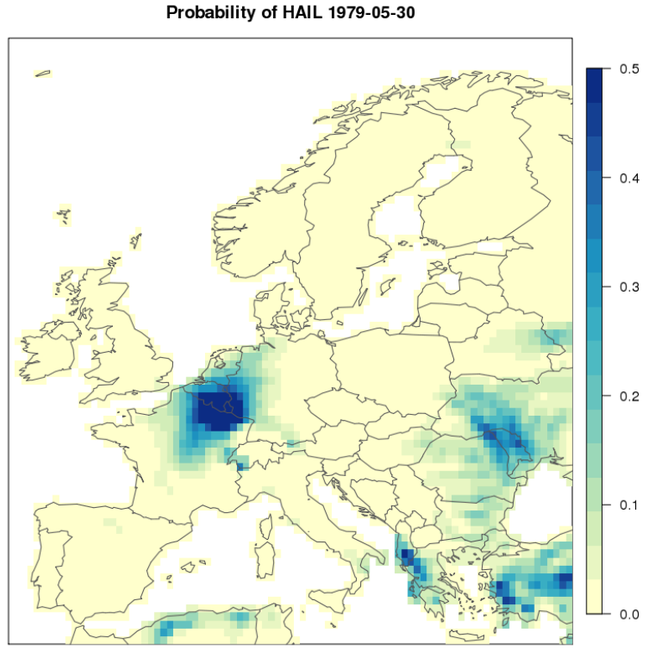
OUTLINE

- AIM: Build a stochastic loss model of European Severe Convective Storm
- Use a logistic regression to inform spatial distribution of SCS occurrence (hail, convective gust, tornado)
- Resample days to produce a three peril, # thousand year event set.

- Logistic regression inputs
  - Convective parameters calculated from reanalysis data
  - European Severe Weather Database (ESWD)
- Logistic regression results
- Hail intensity distribution (Spatial distribution of intensity)



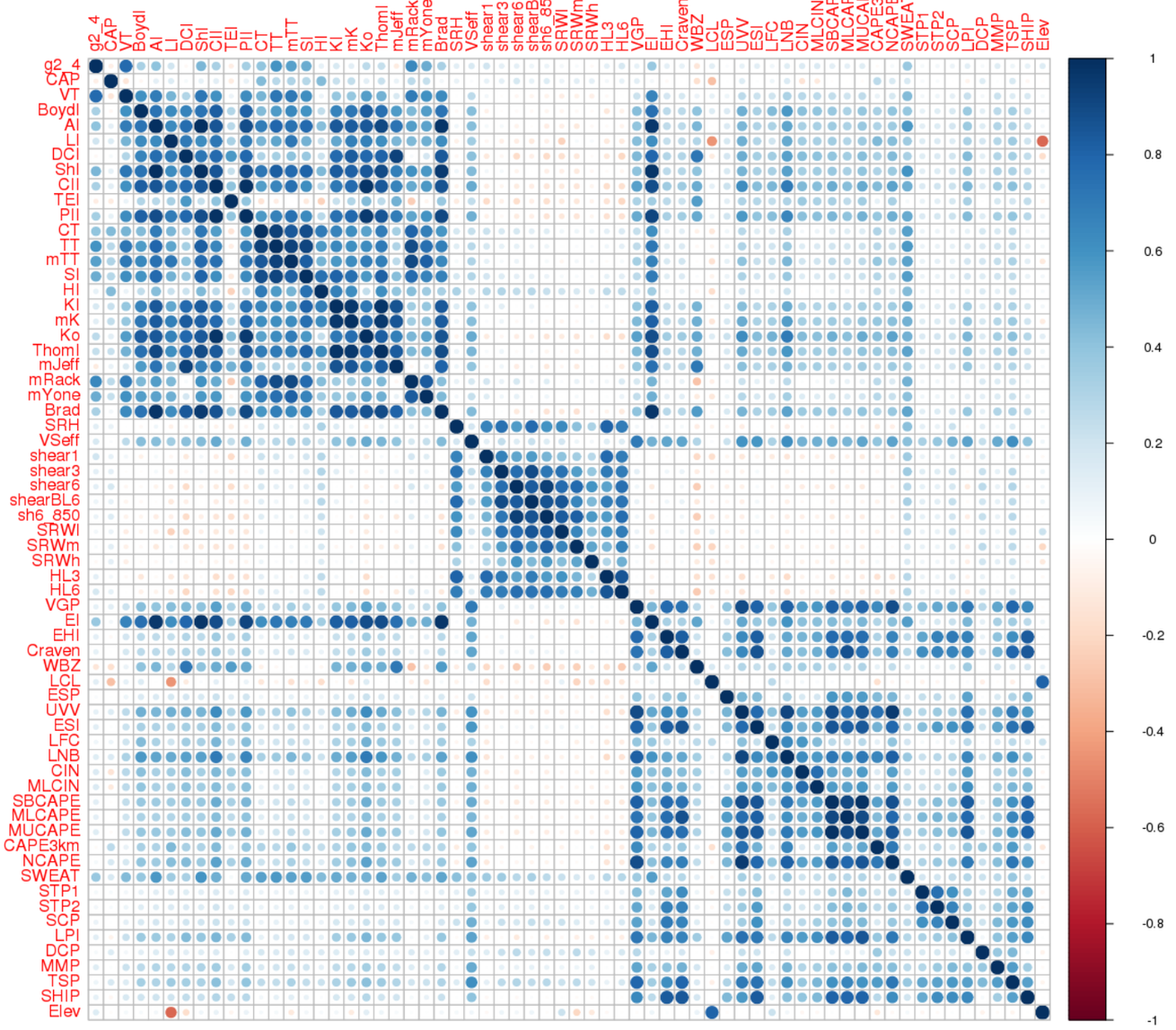
INPUT DATA

CFSR

- Daily convection parameter values for ~70 parameters.
- Calculated from Climate Forecast System Reanalysis 1979-2015
- 0.5 degree grid over Europe
- Converted from 3 hourly to daily

CONVECTION PARAMETERS

- ~70 parameters in three main groups:
  - Temperature and humidity based (individual levels)
  - Wind based (shear)
  - Advanced (involve CAPE)
- Plot shows correlations for all grid cells 2011-2015
- High degree of correlation within each group



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ESWD

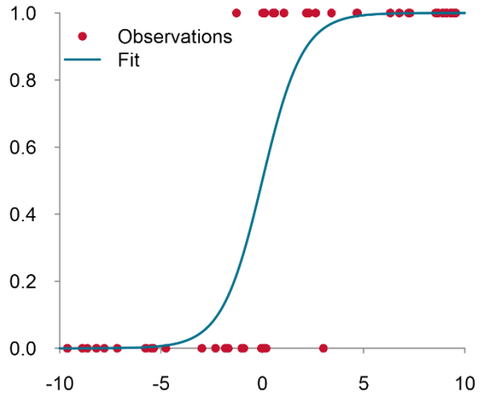
- European Severe Weather Database reports for hail, convective gust and tornado
- Assigned to CFSR grid as daily occurrence flag
- Smooth occurrence by also counting reports from 8 surrounding cells

Daily convection parameters from CFSR

Training area

ESWD peril reports

Stepwise Logistic regression to get N parameter fit



Europe
1979-2015
13,514 daily probability distributions

Aggregate

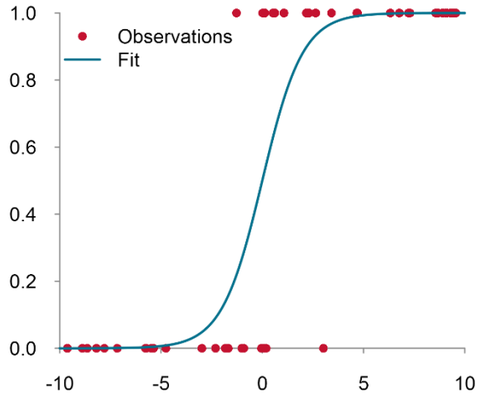
Climatology
Seasonality

Daily convection parameters from CFSR

HAIL
AT-CH-DE-IT
2011-2015
494 cells x 1826 days

ESWD peril reports

Stepwise Logistic regression to get N parameter fit



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RESULTS

- Fit GLM to AT-CH-DE-IT hail observations between 2011-2015
- 5 parameter stepwise fit

  $\eta \sim -LI + rh_{700} - ShI + BoydI - HI$
- As with other studies lifted index and humidity key

- Lifted Index, LI
- $700hPa$ relative humidity, rh_{700}
- Showalter Index

  ShI = Lifted index for $850hPa$ parcel
- Boyden Index

  $BoydI = 0.1(z_{700} - z_{1000}) - T_{700} - 200$
- Humidity Index

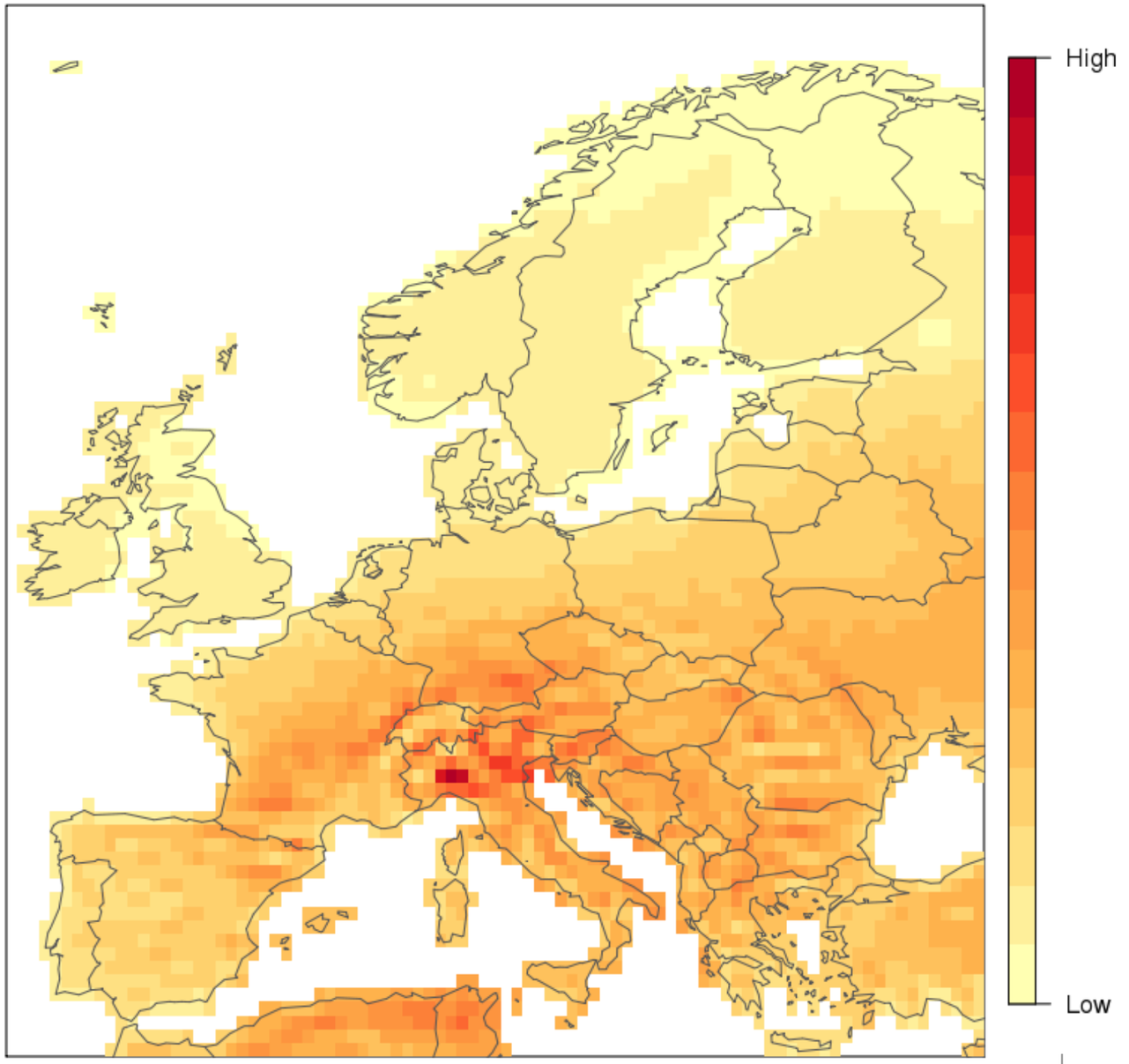
  $HI = T_{\{850,700,500\}} - T_{d,\{850,700,500\}}$

HAIL CLIMATOLOGY

- Expected number of hail events per grid cell 1979-2015 using 5 parameter stepwise fit

$$\eta \sim -LI + rh_{700} - ShI + BoydI - HI$$

- Event rates will be imposed separately
- Hotspots North and South of the Alps well represented.
- Some grid level features of CFSR data visible.



ROBUSTNESS

Climatology relatively unsensitive to changes in inputs:

a) 2 parameter fit: 13% change

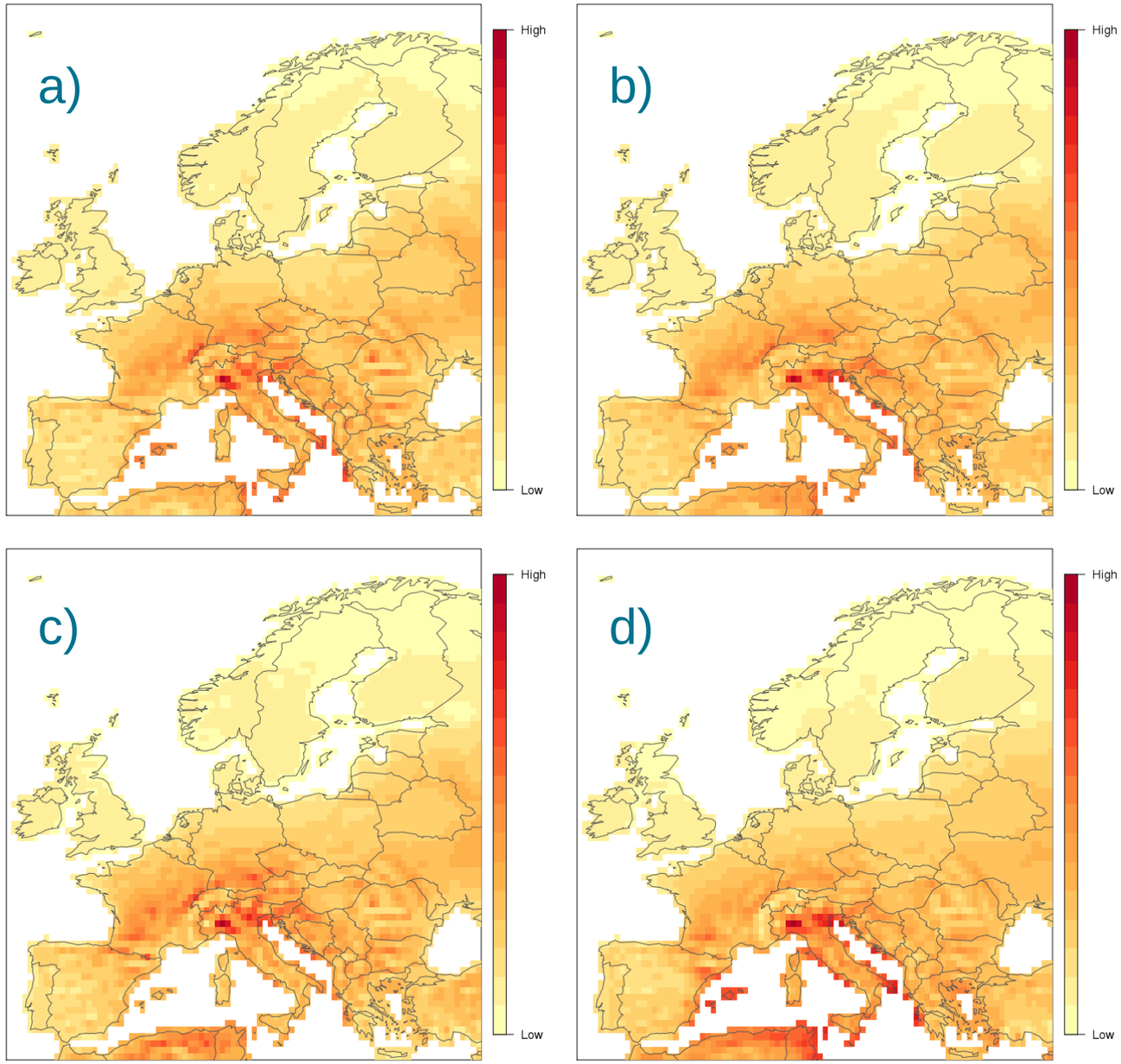
b) 2009-2010 fit: 12%

c) Unsmoothed ESWD: 9%

d) AT-DE fit: 17%

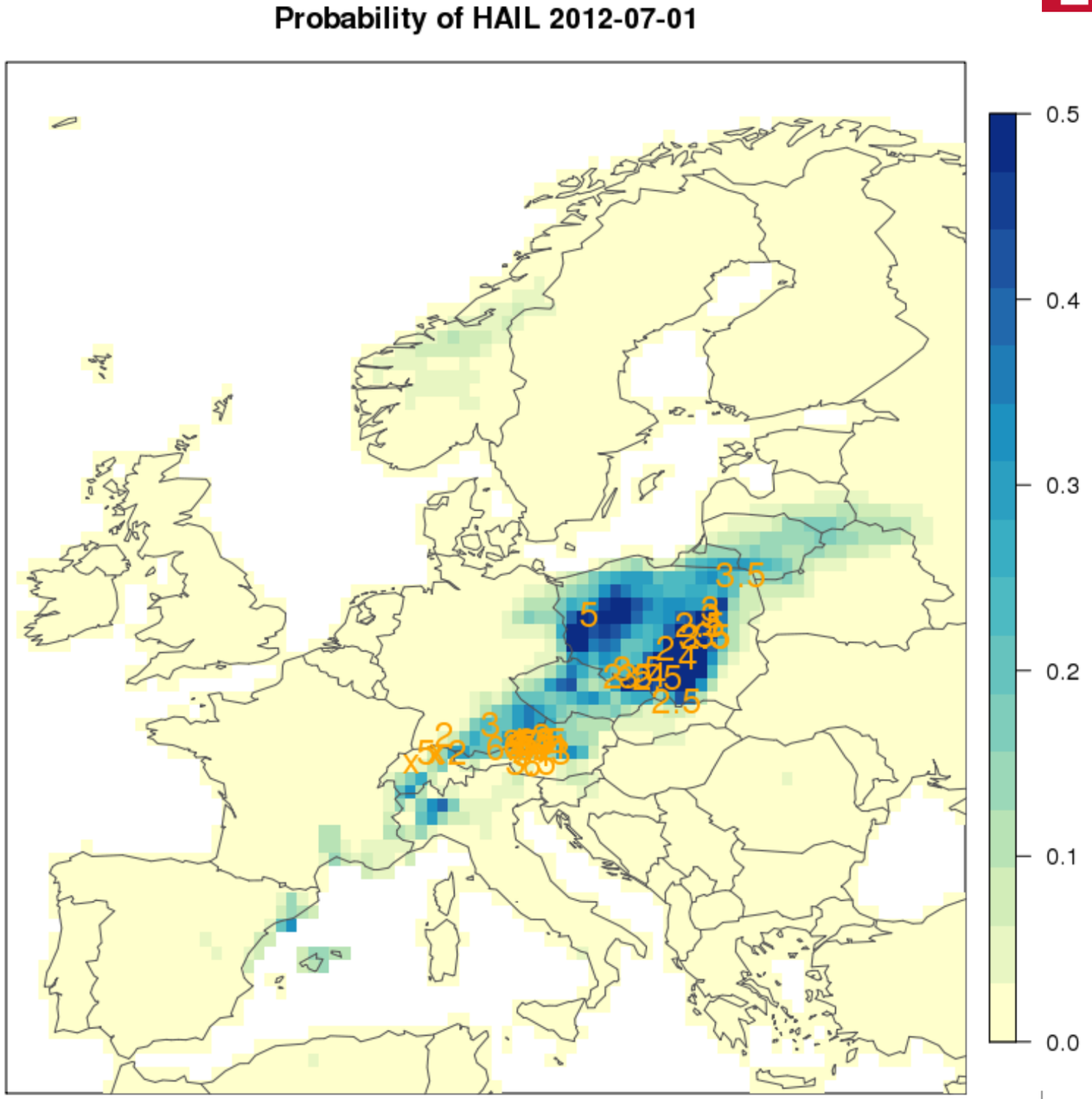
Achieve similar results using DE claims at Cresta level.

Skill Scores of 30 to 40%

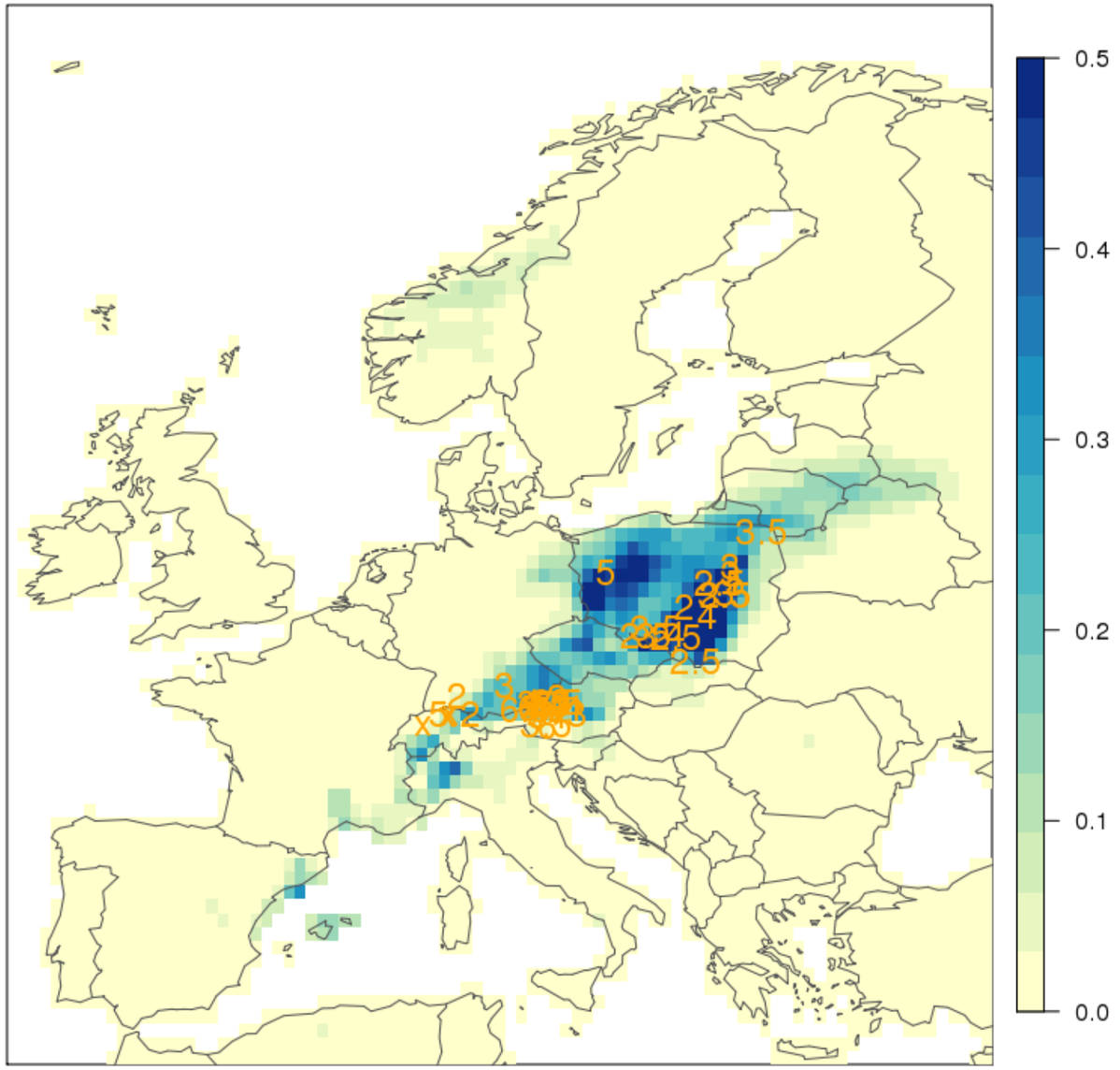


HAIL DAY

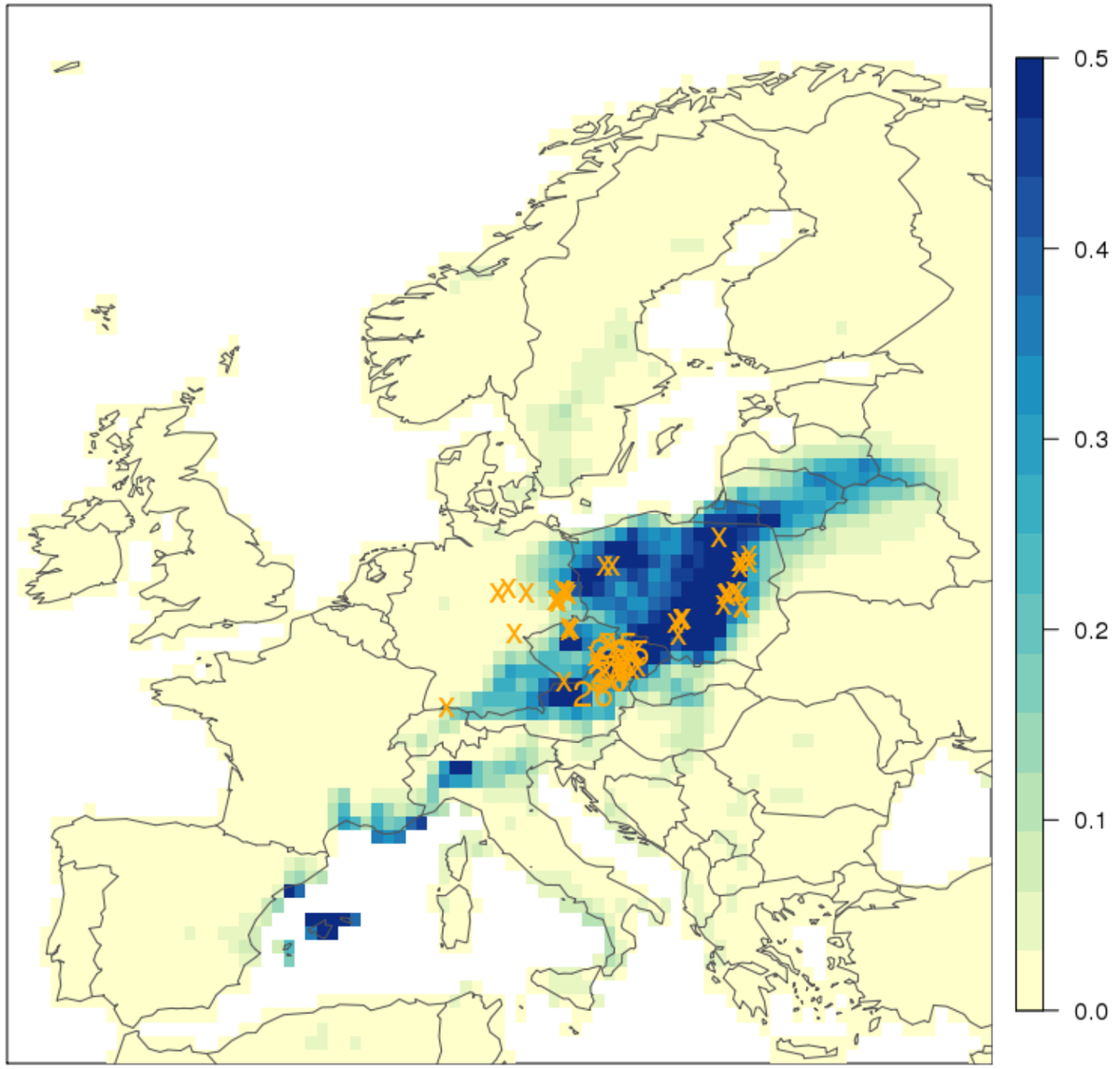
- Probability of hail for 2012-07-01
- Agrees relatively well with ESWD observations (hailstone diameter in cm)
- Resample day to obtain multiple different realisations.
- Can compare with other perils…



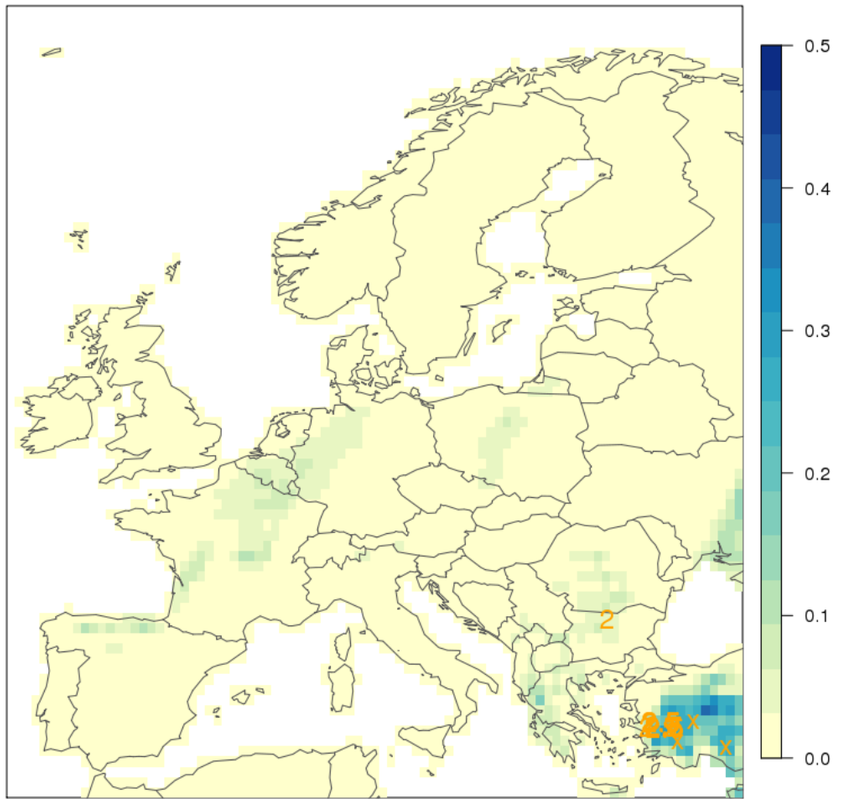
Probability of HAIL 2012-07-01



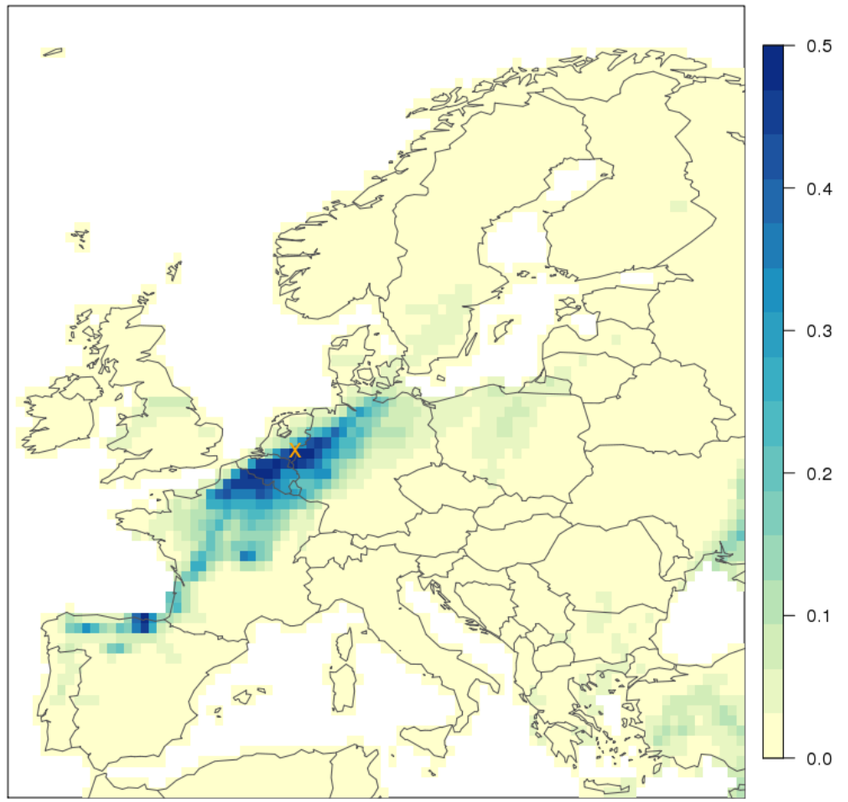
Probability of WIND 2012-07-01



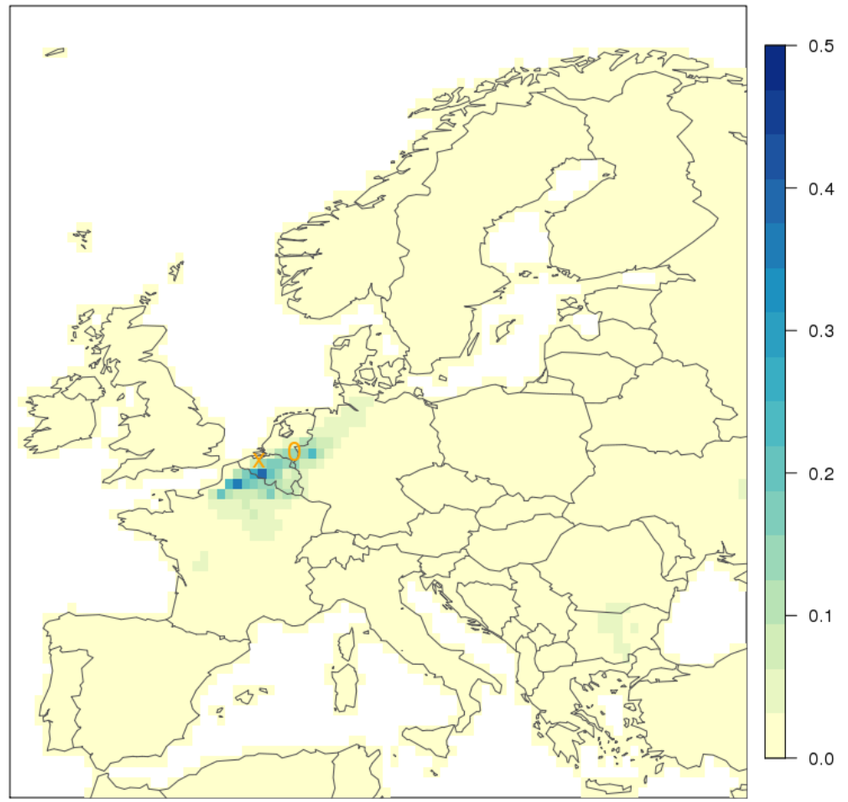
Probability of HAIL 2012-05-10



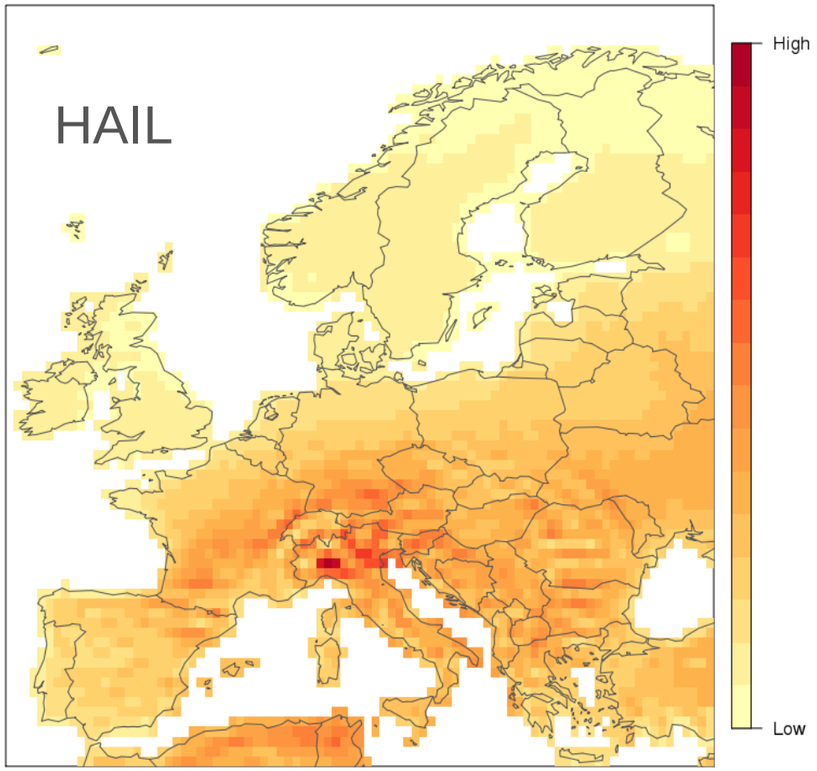
Probability of WIND 2012-05-10



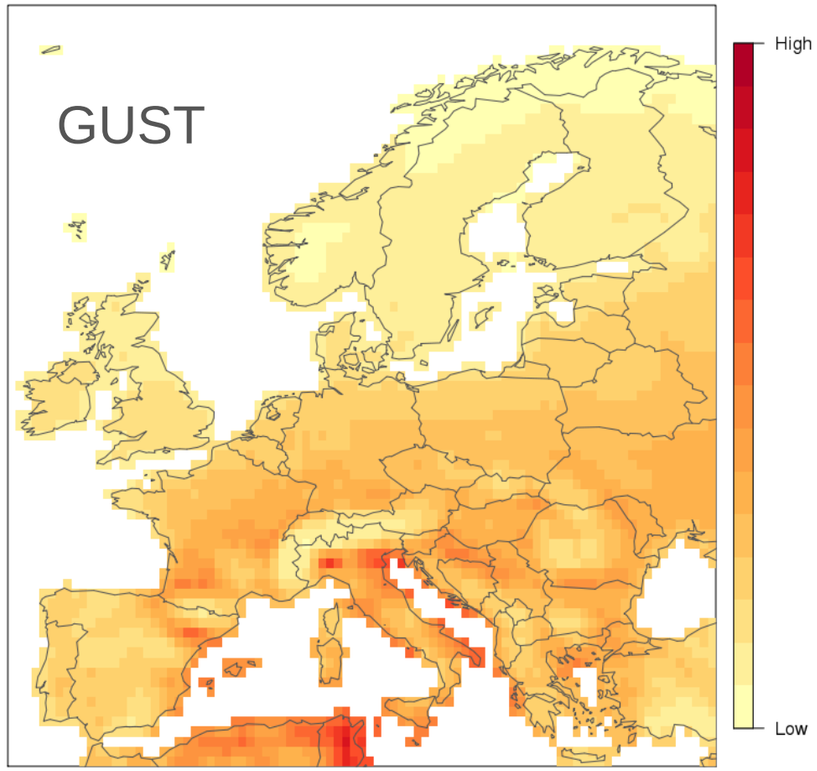
Probability of TORNADO 2012-05-10



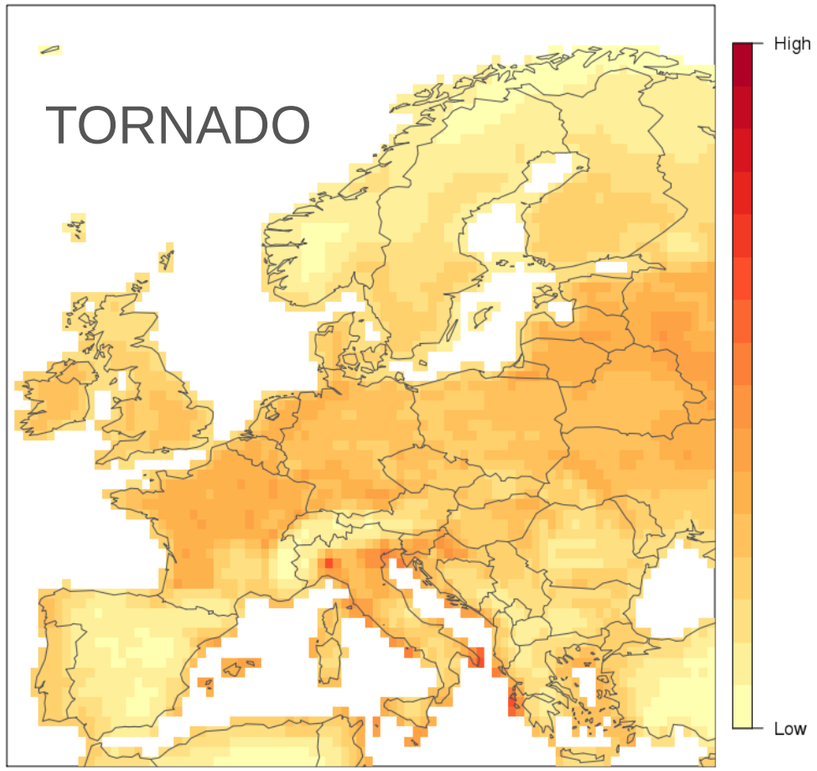
CLIMATOLOGY COMPARISON



$$\eta \sim -LI + rh700 - ShI + BoydI - HI$$



$$\eta \sim mKI + TSP + shear1 + BoydI + LPI$$



$$\eta \sim -LI + shear1 * CAPE3 - HI - LCL - VT$$

MAXIMUM HAILSTONE SIZE

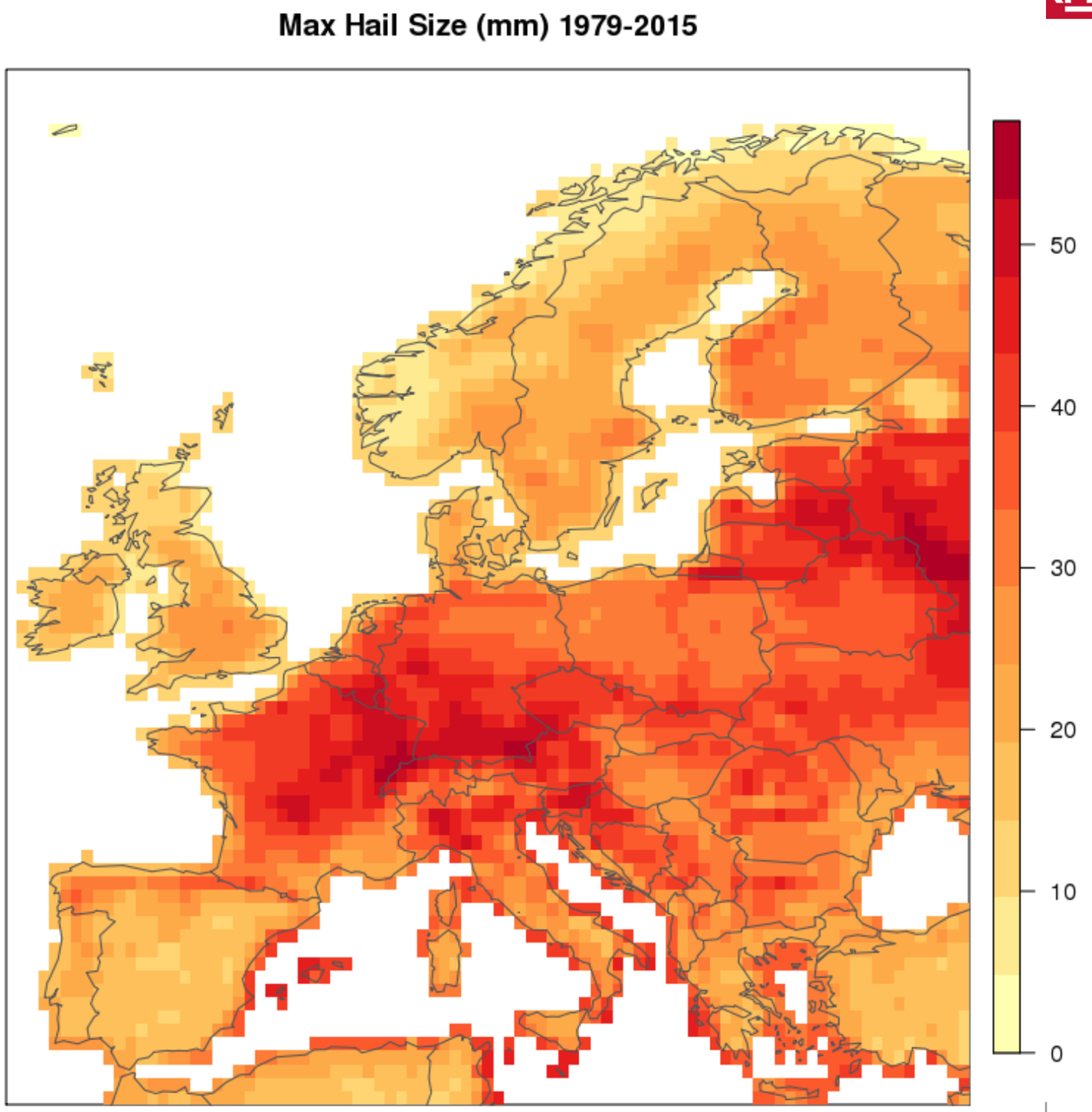
- Need a spatial distribution for hail intensity. Hail is less frequent in Scotland than Italy but is it also smaller on average?
- Construct a simplified model to gain insight.
- Calculated maximum hailstone diameter that can be supported by CAPE updraft.

$$v_T = \sqrt{\frac{4\rho_h g}{3\rho_a C_d}}\sqrt{d} \qquad w_x = \sqrt{2CAPE}$$

$$v_T = w_x \qquad \Rightarrow \qquad d_x = \frac{3\rho_a C_d CAPE}{2\rho_h g}$$

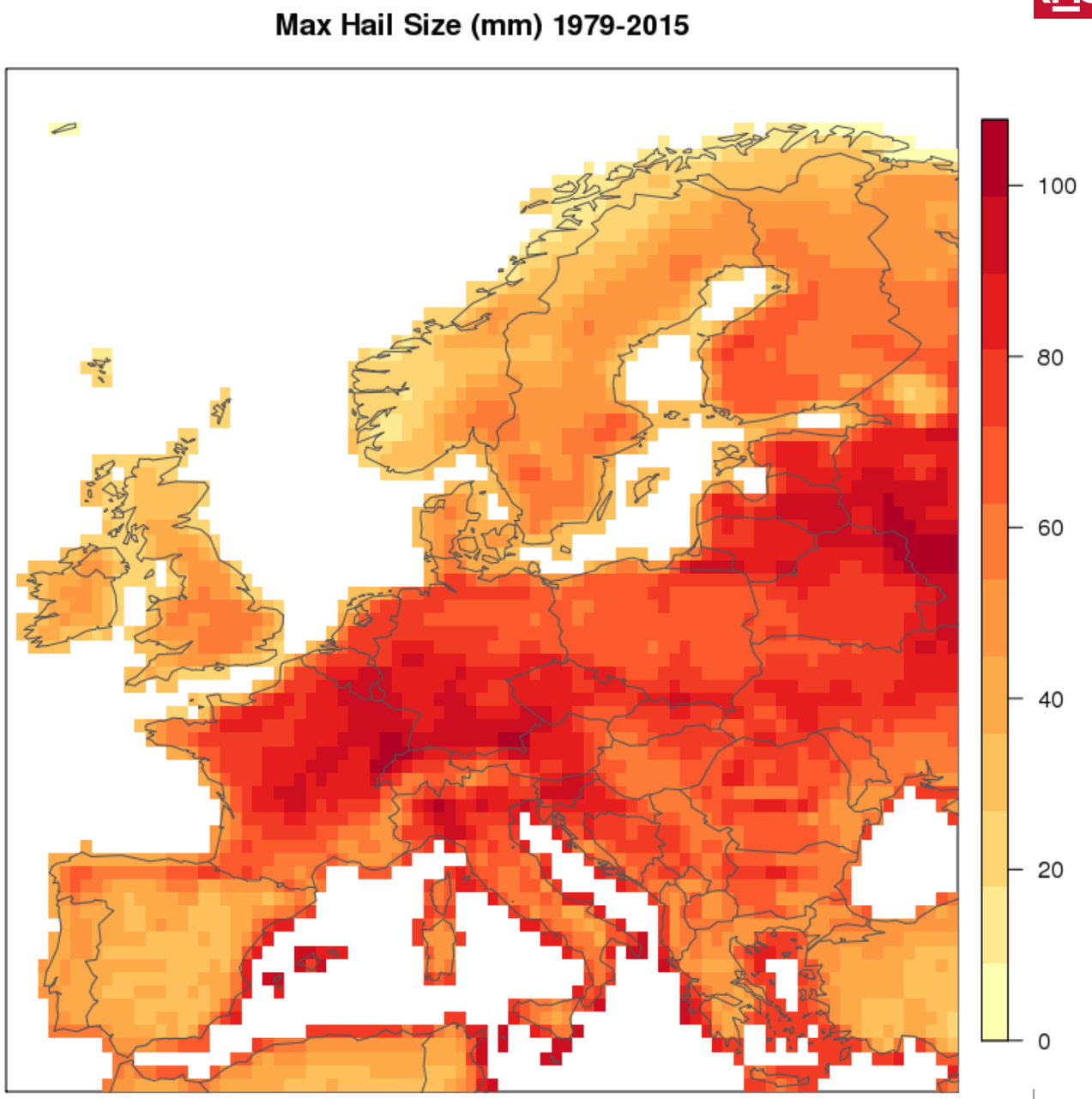
MAX HAILSTONE SIZE

- Calculated maximum hailstone diameter that can be supported by SBCAPE updraft.
- Compute daily values for each grid cell and take probability weighted average to get expected hail size for each location.
- Hope to use results to inform the spatial allocation of hail size (No large hail in Scotland?)
- Less interested in absolute values



MAX HAILSTONE SIZE

- Additionally allow hailstone to fall through cloud, gaining water as it does so.
- Significant change in absolute values (x2) but little change in spatial distribution.
- Similar story if we also allow the hail to melt below zero degree height.



SUMMARY

- Given an SCS event, daily probability maps can be used to distribute hail streaks/wind swaths/tornadoes.
- Probabilities give a good representation of where something can occur but don’t necessarily capture whether something will occur (triggering).
- This can be a positive as we wish to resample days/years to obtain a larger event set.
- Event frequency, size and severity distributions are imposed independently.

- Can also use CFSR data to inform spatial distribution of intensity.

FIND OUT MORE

- **Today 14:30-16:00**
  - Modelling Hail Impact, part 1: How many hail stones of what size?
    Juergen Grieser
  - Modelling Hail Impact, part 2: From hazard to loss
    Marc Hill
- **Thursday 14:30-16:00**
  - Spatial characterisation of hailstorms in Europe using radar data
    Mutahar Chalmers, Sarah Hartley
- **Yesterday ☹**
  - Modelling Straight-Line Wind Impact in Europe
    Mark Dixon