



EXTREME PRECIPITATION ESTIMATION

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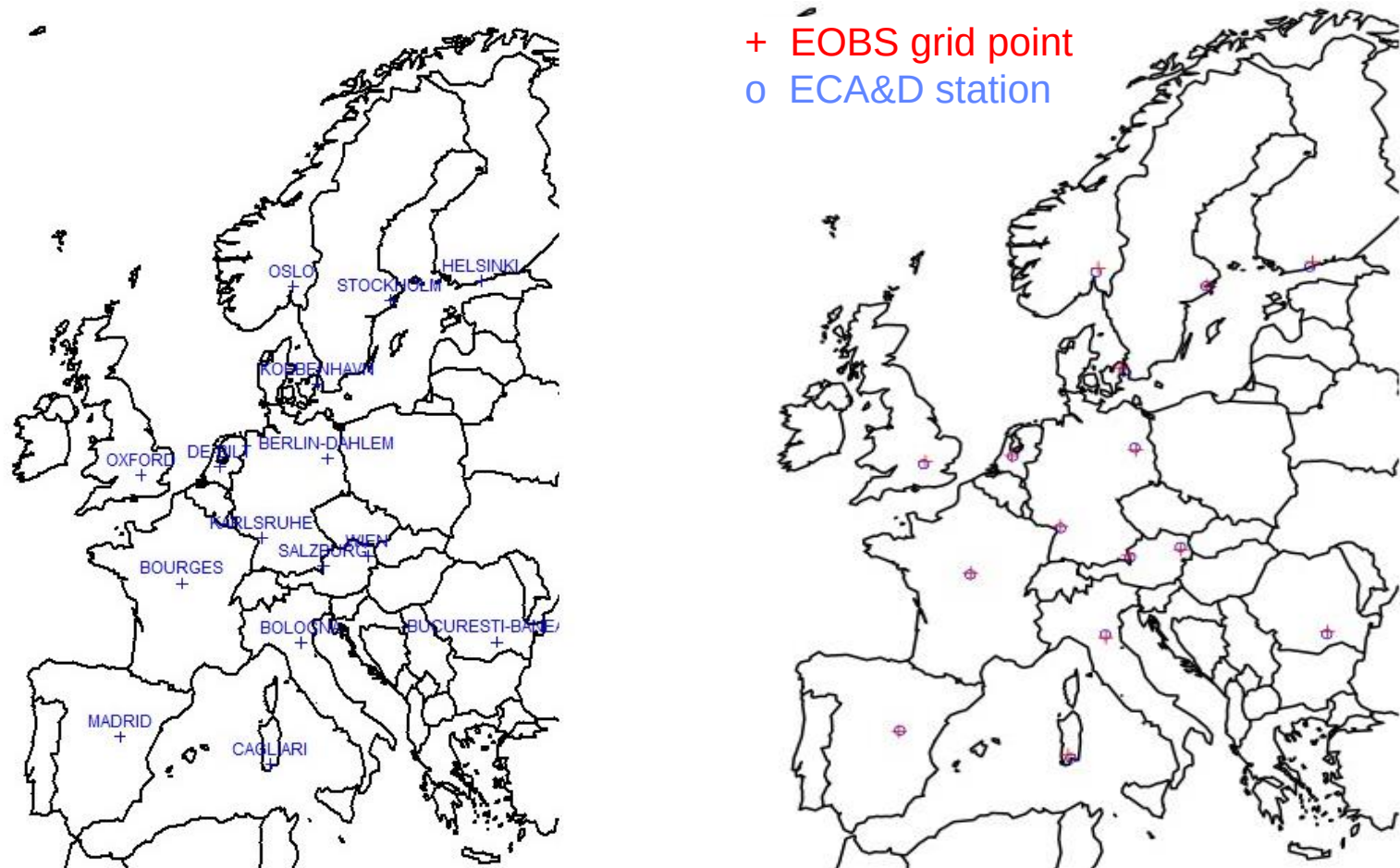


CONTEXT AND OUTLINE

- 1. THE ADAPTATION OF INDUSTRIAL ASSETS TO CLIMATE CHANGE NEEDS AN ESTIMATION OF HAZARDS INTENSITY IN THE FUTURE AT A LARGE SPATIAL SCALE (EUROPE, OR EVEN GLOBAL)**
- 2. EXAMPLE HERE: HEAVY DAILY RAINFALL AMOUNTS**
- 3. AVAILABLE DATASETS: STATIONS / GRIDDED**
- 4. DESCRIPTION OF THE METHODOLOGY**
- 5. COMPARISONS**
- 6. CONCLUSION AND PERSPECTIVES**

OBSERVATION DATASETS CONSIDERED

- Daily rainfall amounts 1951-2018
- Selection of 15 ECA&D time series across Europe
- Associated grid points from the gridded EOBS 0.25°C dataset



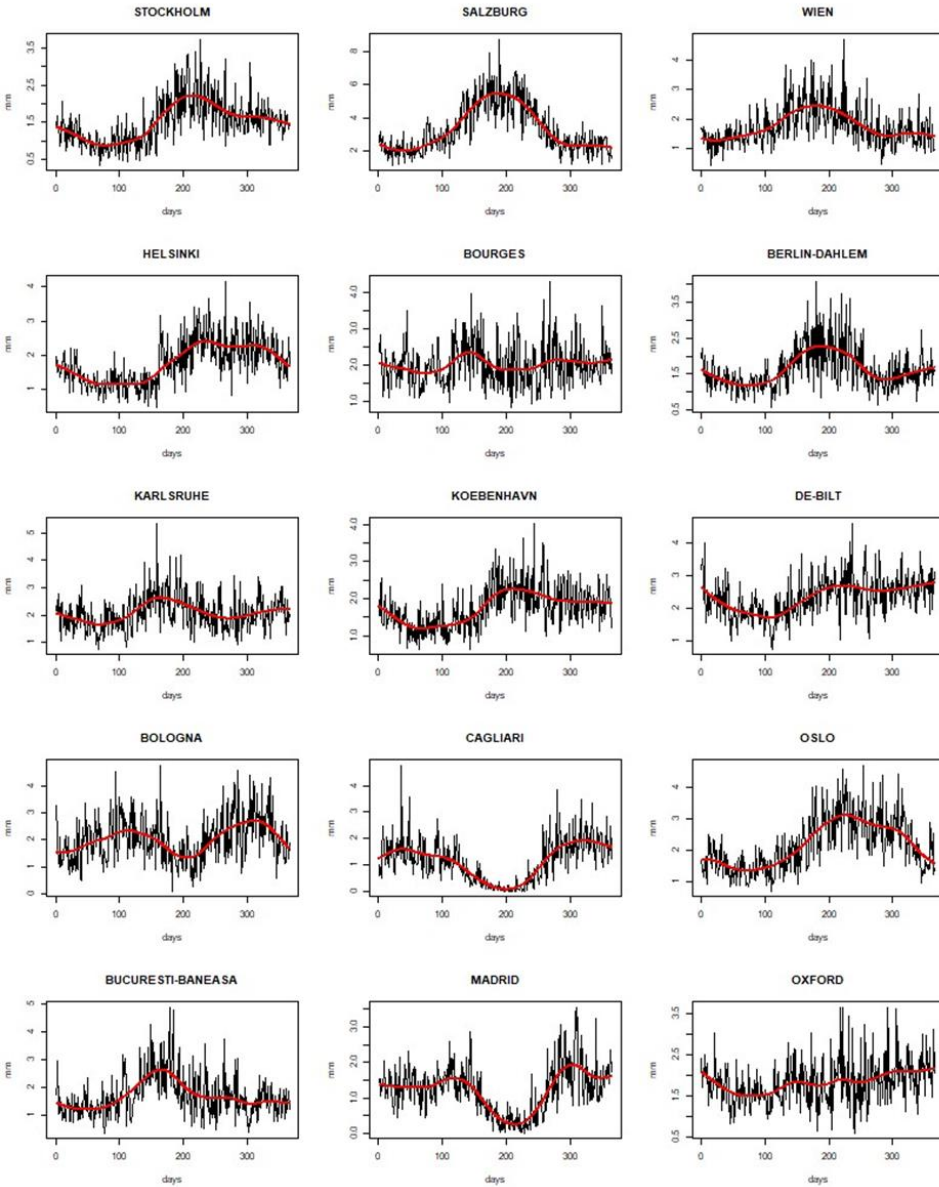
BASIC STATISTICS: TAIL OF THE DISTRIBUTIONS

	ECA&D station					EOBS grid point				
	75%	90%	95%	98%	max	75%	90%	95%	98%	max
Stockholm	1.5	6.3	10.8	18.3	59.8	1.8	6.2	10.4	16.4	53.9
Salzburg	5.9	15.2	22.1	32.0	135.0	6.4	14.8	20.6	29.2	109.7
Wien	1.2	6.7	12.1	21.4	78.1	2.2	6.8	10.8	17.3	53.3
Helsinki	1.6	6.8	11.6	18.5	79.3	2.2	6.9	11.1	17.0	62.4
Bourges	1.2	6.3	10.8	18.1	75.3	2.1	6.5	10.1	15.1	50.9
Berlin	1.7	6.2	10.3	17.8	106.0	2.0	5.9	9.5	15.1	114.1
Karlsruhe	2.2	7.6	11.9	18.3	76.5	2.8	7.1	10.8	15.6	66.4
Koebenhavn	1.8	6.6	11.0	17.5	135.4	2.6	6.1	9.1	13.9	54.4
De Bilt	2.6	8.5	12.9	19.0	66.2	3.1	8.0	11.6	17.1	59.2
Bologna	0.6	7.7	15.6	27.4	114.6	2.3	9.7	16.4	25.4	78.5
Cagliari	0.6	4.2	9.0	17.2	109.0	0.3	6.7	11.9	19.3	87.1
Oslo	2.7	9.3	14.7	21.7	72.8	3.6	10.2	15.5	21.6	59.9
Bucuresti	0.3	5.8	12.9	23.7	126.4	0.0	6.1	11.2	18.1	90.3
Madrid	0.2	4.8	9.9	17.6	87.0	0.0	5.5	8.9	12.9	39.9
Oxford	1.3	5.6	9.7	16.4	87.9	2.3	5.8	8.7	13.2	54.9

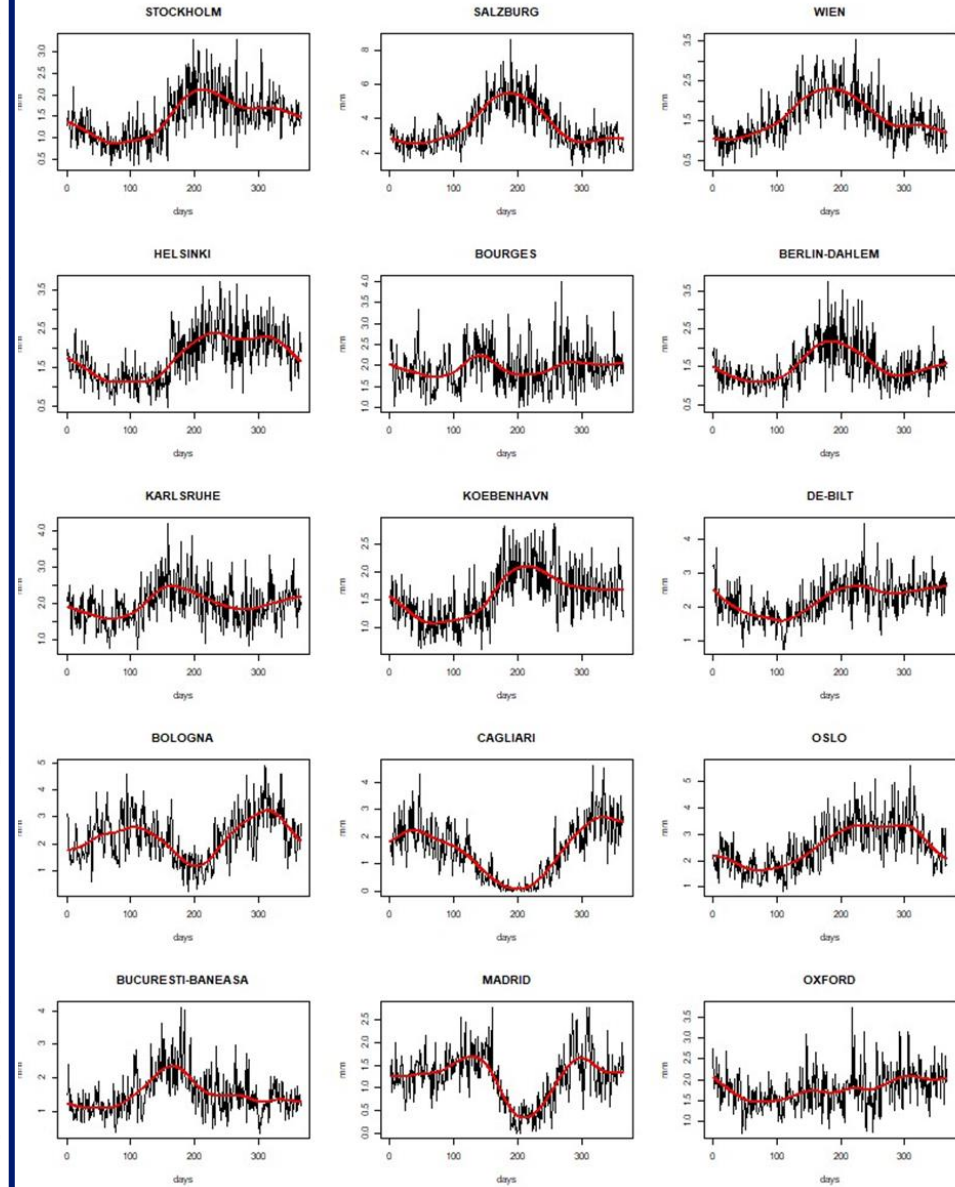
The highest values are much lower in EOBS

HEAVY RAINFALL SEASONS

ECA&D stations



EOBS grid points



50-YEAR RETURN LEVEL ESTIMATIONS

- Use of the statistical Extreme Value Theory (EVT), threshold exceedances
- Need: climate change impact

■ Methodology (Acero et al. 2017)

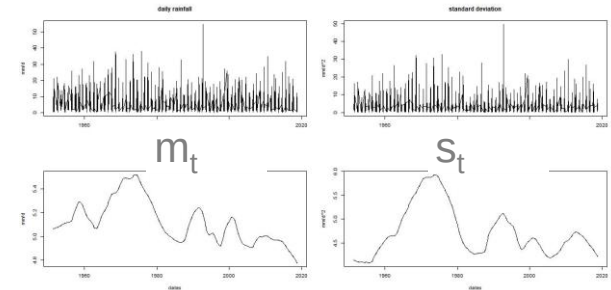
- Consideration of rainy days only in the heavy rainfall season

- Calculation of a reduced variable:
$$Y_t = \frac{X_t - m_t}{s_t}$$

- Test of the stationarity of the extremes of $Y(t)$

- Estimation of a future Return Level:

- $Y_t > v \Rightarrow X_t > w$ with $w = s_F * v + m_F$, m_F and s_F being the mean and standard deviation of the rainfall amounts in the desired period for the Return Level estimation
- The extreme value distribution parameters for X_t are linked to those of Y_t :
 - Same shape parameter ξ
 - Scale parameter: $\sigma_X = s_F * \sigma_Y$
 - Threshold exceedance frequency: $I_w = I_{rv} * nb_F / n$ with nb_F the mean number of rainy days per season in the desired period and n the number of days in the heavy rainfall season
- Thus a future Return Level can be obtained from the Return Level of Y_t and the future mean and standard deviation of the rainy days and the future number of rainy days in the heavy rainfall season



COMPARISON OF 50-YEAR RETURN LEVELS: 1951-2018

	ECA&D station		EOBS grid point	
	Direct estimation	Use of Y_t	Direct estimation	Use of Y_t
Stockholm	58,7 [52,8 ; 64,6]	55,8	51,3 [46,2 ; 56,3]	49,7
Salzburg	142,3 [90,0 ; 194,7]	132,0	111,3 [77,9 ; 144,8]	108,1
Wien	79,7 [71,2 ; 88,2]	78,7	56,4 [50,5 ; 62,2]	53,4
Helsinki	56,7 [51,2 ; 62,1]	56,4	50,3 [45,6 ; 55,1]	50,2
Bourges	63,9 [57,3 ; 70,4]	62,2	45,8 [41,3 ; 50,2]	44,3
Berlin	89,2 [60,7 ; 117,7]	72,7	75,1 [53,7 ; 96,5]	72,2
Karlsruhe	70,9 [52,1 ; 89,8]	70,4	60,0 [42,1 ; 78,0]	56,4
Koebenhavn	83,7 [58,5 ; 109,0]	83,2	44,2 [39,9 ; 48,6]	43,7
De Bilt	57,4 [52,1 ; 62,7]	58,1	48,7 [44,3 ; 53,1]	48,6
Bologna	94,3 [82,7 ; 105,8]	87,9	78,2 [68,6 ; 87,7]	79,5
Cagliari	102,9 [60,9 ; 144,9]	71,4	67,4 [59,0 ; 75,7]	66,3
Oslo	64,1 [58,0 ; 70,1]	64,0	60,0 [54,5 ; 65,5]	60,2
Bucuresti	90,1 [80,4 ; 99,7]	87,0	78,8 [55,7 ; 101,8]	69,1
Madrid	59,4 [52,2 ; 66,6]	57,5	34,3 [30,6 ; 38,0]	33,3
Oxford	74,3 [55,1 ; 93,5]	75,9	42,5 [38,4 ; 46,7]	41,4

RL estimated through Y_t : coherent with the application of EVT to the observed rainfall time series

Underestimation of the RL with EOBS



Orange shading: EOBS RL not included in the station Confidence Interval

CROSS VALIDATION

- In order to validate the proposed methodology for the estimation of future extremes, a test in a cross validation setting has been designed:
 - Division of the whole observation period in 2 sub-periods:
 - 1951-1984 1985-2018
 - Calculation of Y_t over the first sub-period (1951-1984)
 - Estimation of the 50-year RL over the second sub-period from:
 - The 50-year RL of Y_t
 - mean, standard deviation and number of rainy days in period 1985-2018 obtained through:
 - These quantities over period 1951-1984
 - Their projected changes between 1985-2018 and 1951-1984 according to 17 CMIP5 climate model projections
- For all estimations: test whether the shape parameter is significantly non zero. If not, an exponential distribution is fitted instead of the Generalized Pareto Distribution

RESULTS WITH THE ECA&D STATION DATA

	EVT applied over 1985-2018	Climate model range		EVT applied over 1985-2018	Climate model range
Stockholm	60,4 [53,0 ; 67,9]	48,4 – 65,7	De Bilt	58,3 [51,9 ; 64,7]	50,9 – 62,6
Salzburg	89,2 [79,4 ; 99,1]	94,4 – 110,7	Bologna	95,5 [81,5 ; 109,4]	81,9 – 109,5
Wien	78,0 [68,2 ; 87,7]	69,8 – 84,8	Cagliari	88,7 [51,6 ; 125,8]	59,8 – 111,0
Helsinki	59,0 [52,2 ; 65,8]	51,0 – 63,0	Oslo	66,3 [58,8 ; 73,8]	57,3 – 68,8
Bourges	65,8 [57,6 ; 73,9]	57,7 – 67,9	Bucuresti	119,5 [67,3 ; 171,7]	66,3 – 98,1
Berlin	87,2 [50,8 ; 123,6]	66,7 – 81,1	Madrid	57,5 [48,9 ; 66,1]	48,0 – 67,2
Karlsruhe	74,8 [48,8 ; 100,8]	49,8 – 62,6	Oxford	51,2 [45,2 ; 57,3]	99,2 – 127,2
Koebenhavn	91,4 [57,1 ; 125,6]	50,1 – 62,7			

DISCUSSION

- The approach is valid: the values obtained by use of the reduced variable extreme and the changes in mean, standard deviation and number of rainy days fall inside the confidence interval of the same RL estimated from the observations
- One exception: Oxford
 - Difference in the shape parameter between period 1951-1984 (significantly positive) and 1985-2018 (zero)
 - If the EOBS grid point is considered instead: the RL is much lower, but the shape parameter is the same for each period

Oxford	38,2 [33,9 ; 42,5]	38,6 – 47,2
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- Problem in the ECA&D time series, sub period length insufficient for a reliable estimate of the shape parameter or real change in the tail of the distribution?

CONCLUSION AND FUTURE WORK

- **For the estimation of extreme levels, the choice of the database matters!**
 - It seems better to use the best possible observation time series than a gridded dataset, which underestimates the highest values (probably because of the spatial interpolation)
 - EOBS 0.1° could be better (this could be further investigated), but calculations at the whole European spatial scale would become more computationally demanding
 - Preferred approach:
 - Locate the assets for which the estimations are required
 - Look for the best locally observed time series
 - If no available observation time series, then use gridded data, knowing that it may underestimate the risk
- **The proposed methodology for the estimation of future extremes seems to be valid**
- **Further work:**
 - Investigate further the behavior identified for Oxford
 - Impact of the test of the shape parameter against 0
 - If not, it is slightly positive in 1985-2018, but not enough to make the RLs more compatible
 - Is it worth testing the nullity of the shape parameter?
 - Impact of the time series length on the estimation of the shape parameter
 - Use of nearby station data to see if some change in the tail behavior can be identified

Thanks