Utilising ECMWF seasonal hindcast data from a European windstorm loss perspective

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What I Do

- Work on the boundary between academia and insurance
- Background in Meteorology (Reading PhD, 2000)
- Worked in insurance (catastrophe modelling) for 20 years
- Keen to repurpose climate and forecast model data to create beneficial output for insurance industry (and beyond?)
- Still very much work-in-progress

Why am I doing this?

- The US Hurricane Season is from June-November
  - US-focused insurance contracts are June-June
  - Forecasts can inform underwriting strategy
- The European Windstorm Season is October-March
  - European insurance contracts are January-January
  - Unhelpfully takes in two “half-winters”
- Is there value in moving European windstorm contracts back to, say, October to benefit from any forecast skill?
- It’s interesting

Calculate “Loss” in the style of a Catastrophe Model

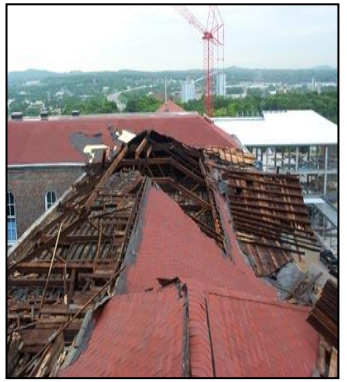
Calculate Hazard

SEAS5 seasonal daily maximum gust forecast

ERA5 daily maximum wind gust

Define portfolio

Population data to weight wind damage



Calculate Damage

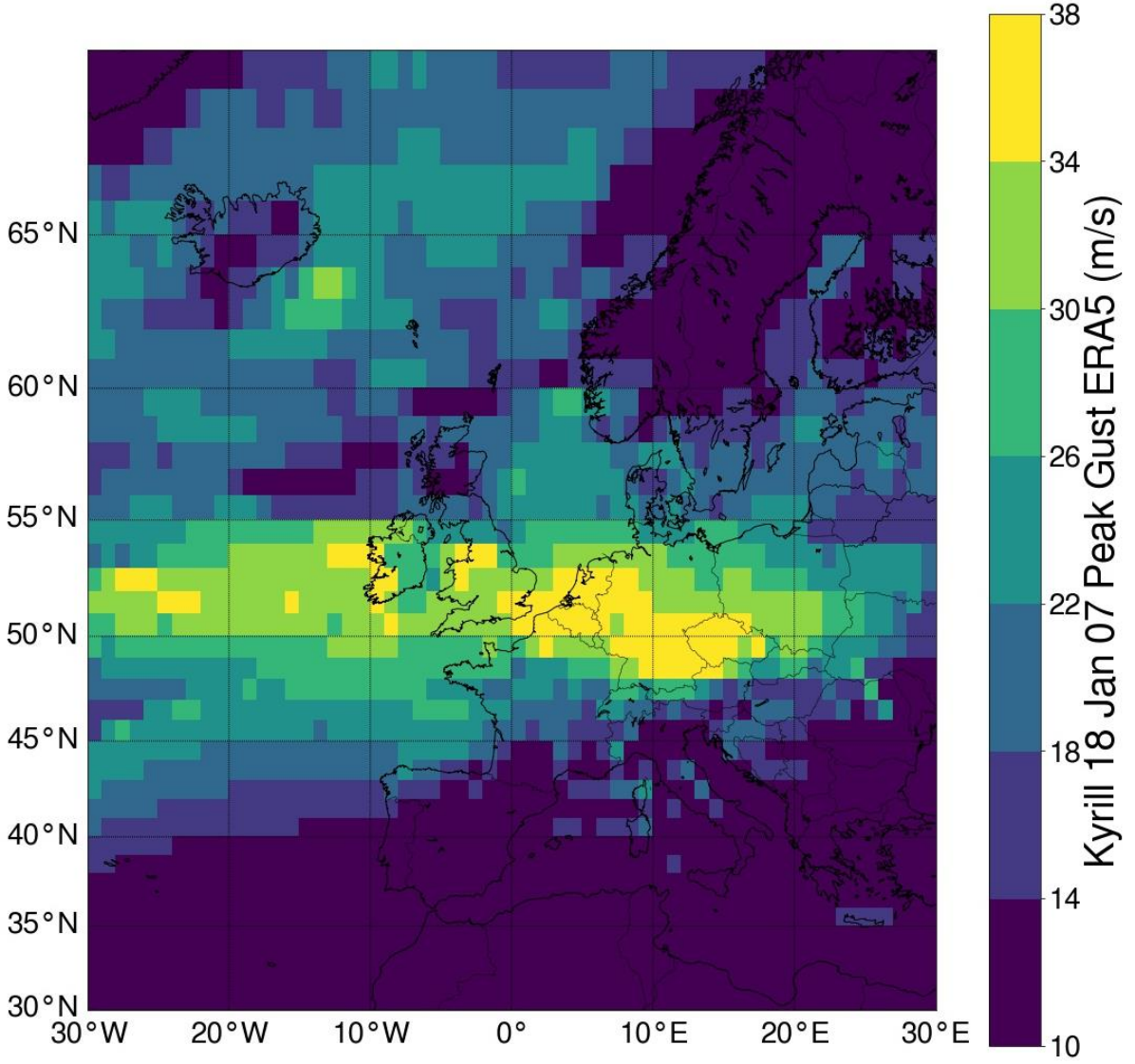
Cube of the wind speed above a threshold

Loss

Damage * population data summed over each winter

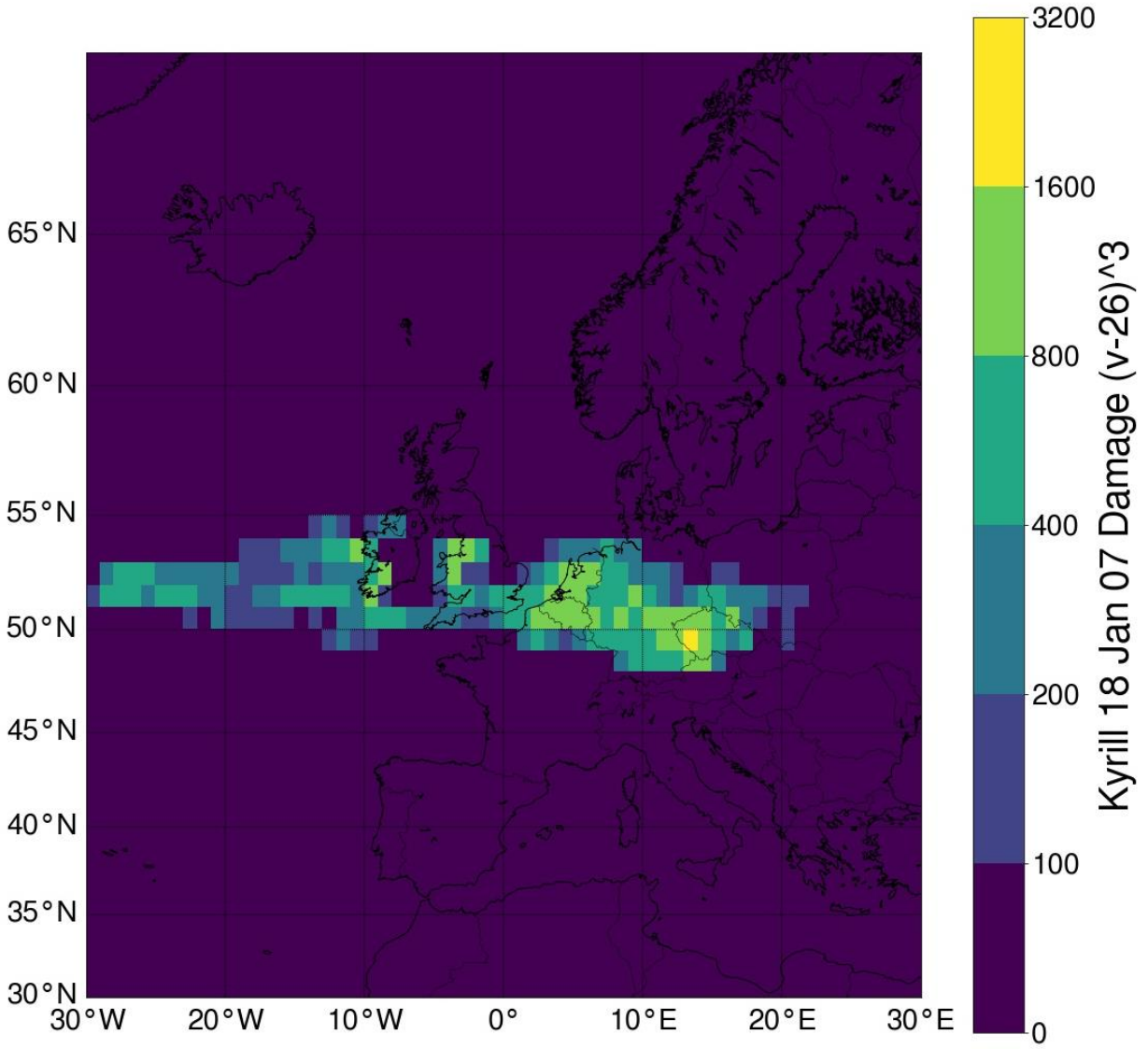
Hazard – Damage – Population – Loss

- Wind snapshot from a single day
- Kyrill in ERA5
- Interpolation to same grid at SEAS5 on C3S website (1 deg)



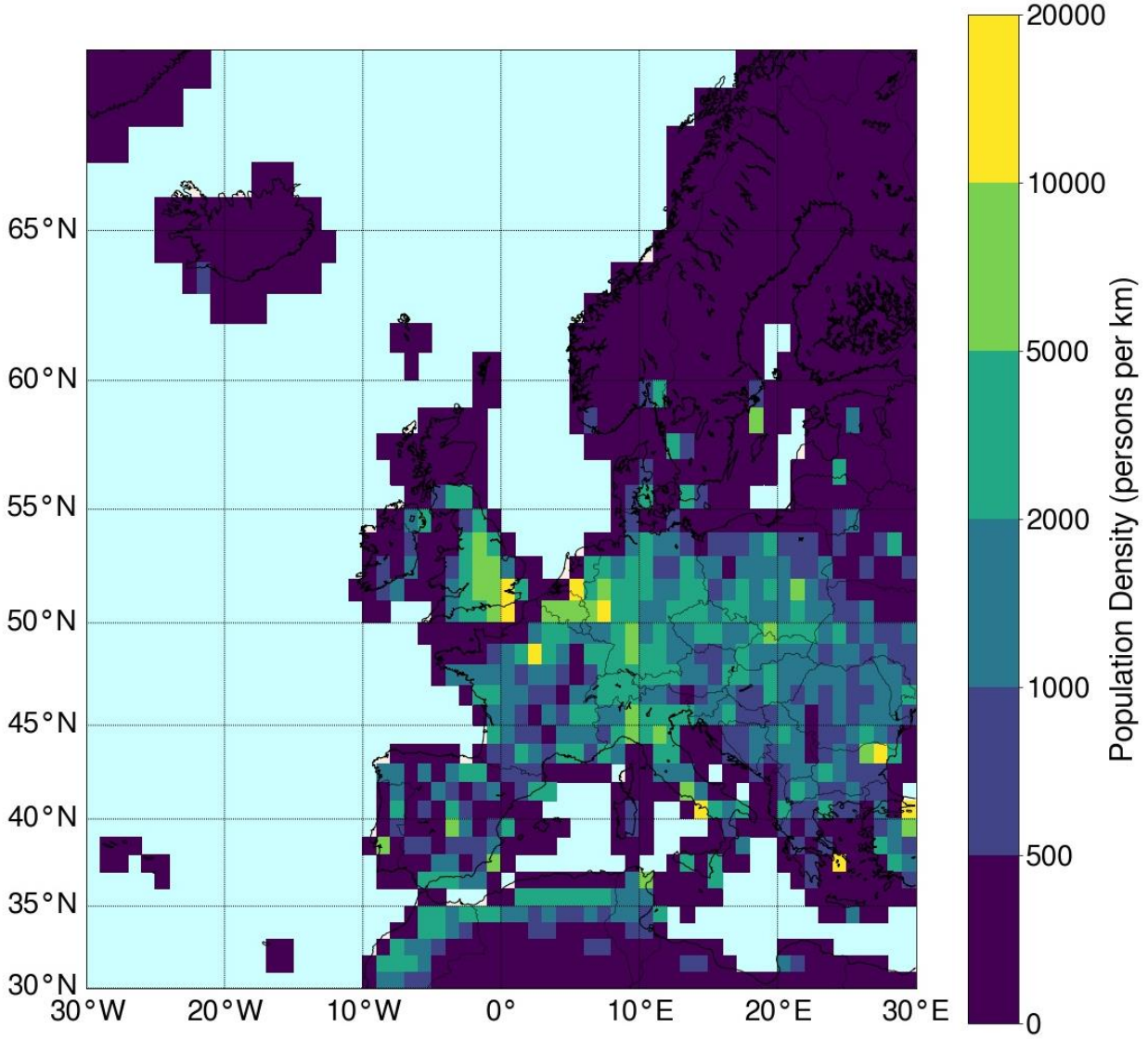
Hazard – Damage – Population – Loss

- Convert winds to “damage”
- Using (v-26)^3
  - Have also seen 20 m/s used, not tested here
- Shows central core of strong winds where damage is possible



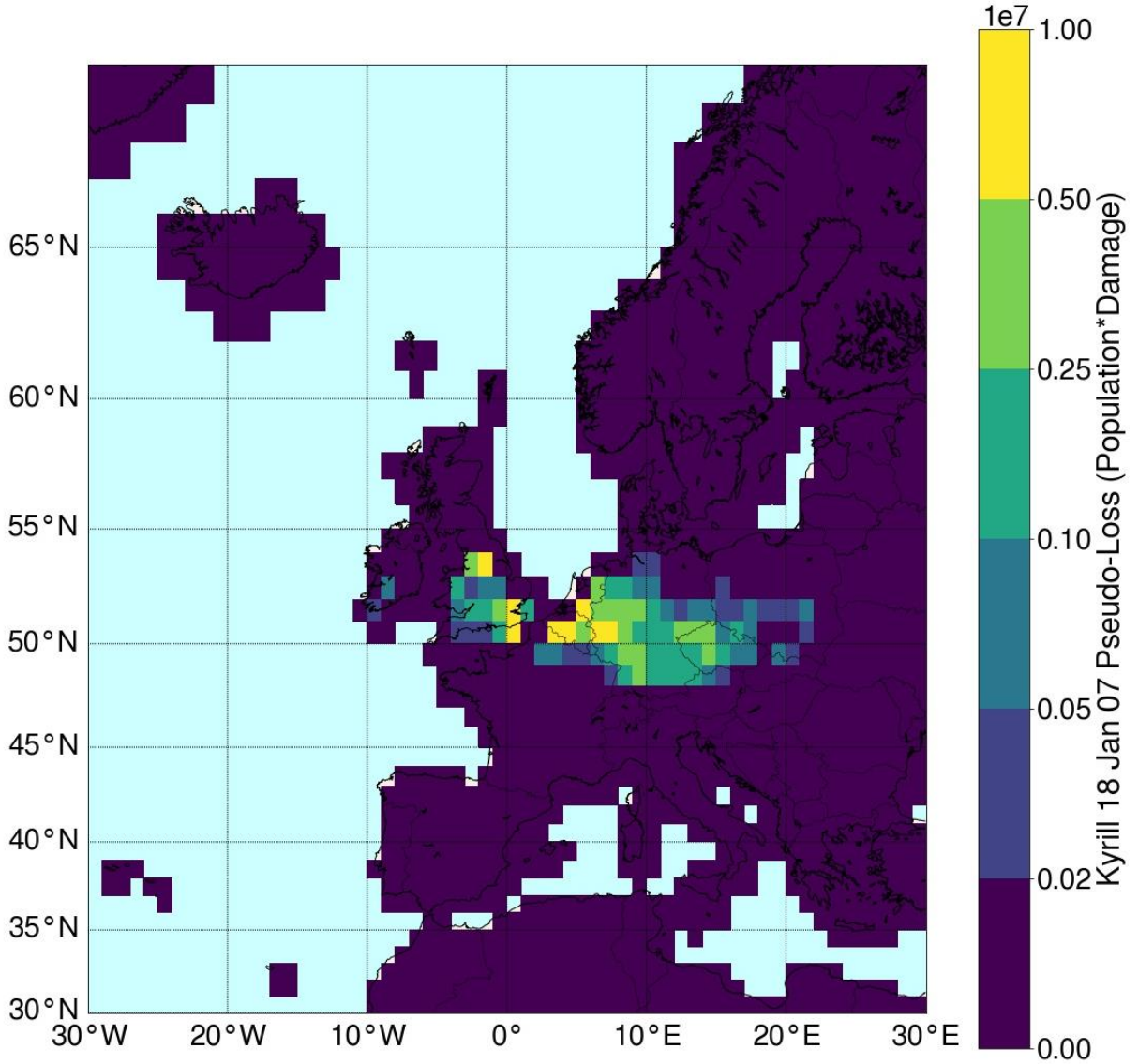
Hazard – Damage – Population – Loss

- We can also “importance-sample” the damage
- Find where damage co-locates with the population data
- Data here from SEDAC (NASA) interpolated to SEAS5 1-degree grid



Hazard – Damage – Population – Loss

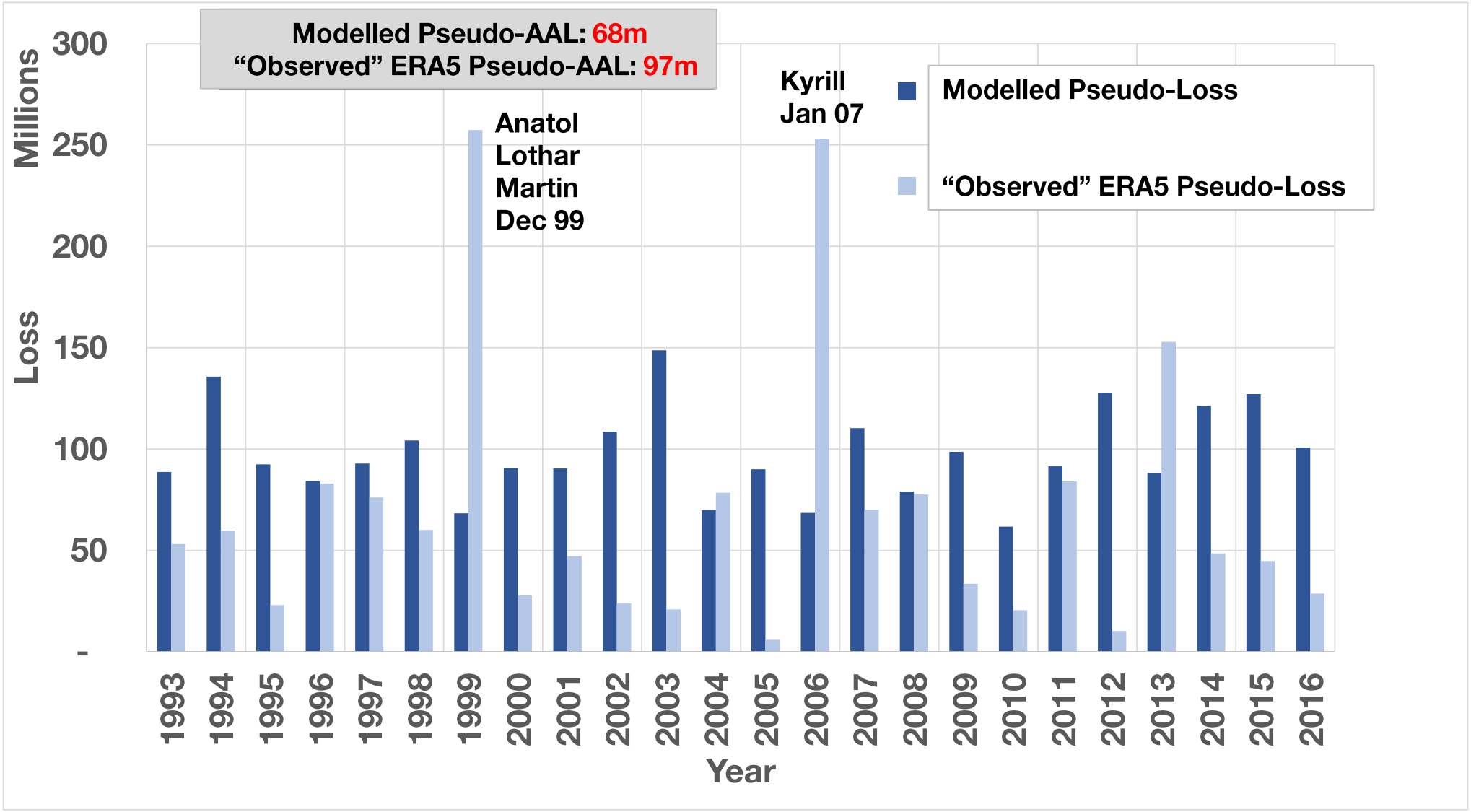
- Daily values of “loss”
- Loss = damage * population
- Summed by the day across the winter
- Double-counting caveat here as storms can stretch across two days



Experiment

- How does the SEAS5 model predict our “loss” metric?
- 25 ensemble hindcasts, 1993-2016
- Calculate seasonal damage across 25 simulations
  - October forecast, using Nov 1 to end of 7-month forecast
- Compare to ERA5 output interpolated on to SEAS5 grid
  - Interpolation done online using Copernicus CDS API

ERA5 Pseudo-Loss versus Mean Ensemble Pseudo-Loss



Ranked Ensemble Loss vs Observed Loss

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Loss Rank	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
							257							253										
1	277	470	192	334	331	257	165	367	238	550	678	143	254	235	350	174	314	369	248	551	380	283	364	225
2	168	239	187	333	235	195	157	218	187	468	386	135	245	167	249	162	186	145	190	400	168	272	271	207
3	165	203	180	173	208	170	139	118	179	187	344	133	170	112	197	158	155	97	164	278	148	271	250	189
4	162	201	159	108	141	170	105	112	166	163	311	119	166	88	171	128	147	93	141	208	138	232	245	189
5	160	192	159	105	134	167	102	109	148	157	181	119	161	85	169	122	138	84	135	170	107	166	205	184
6	136	191	128	98	116	145	93	108	142	128	156	112	159	81	167	106	133	74	127	149	102	164	197	160
7	107	167	125	87	109	144	86	100	141	107	135	100	139	80	143	102	127	68	121	114	91	150	178	127
8	95	160	114	81	105	132	73	97	139	107	133	93	123	79	140	100	127	67	103	114	91	142	158	126
9	88	154	101	76	97	125	67	95	116	106	131	84	114	70	132	100	119	60	103	113	86	132	142	120
10	85	151	101	72	87	123	65	89	107	100	118	82	80	59	124	99	117	53	101	113	84	121	136	110
11	84	145	92	70	82	109	61	80	93	86	116	62	68	55	119	84	114	48	99	112	83	119	130	100
12	81	139	81	68	69	100	61	72	82	66	110	61	60	55	114	74	108	42	88	105	79	114	109	89
13	76	137	80	57	67	88	58	69	61	60	109	59	52	55	109	74	94	40	84	104	72	112	108	87
14	76	125	77	56	56	80	55	69	59	56	108	56	49	52	97	63	90	40	68	99	66	110	107	72
15	65	104	77	56	54	79	52	65	54	54	102	51	49	51	65	62	70	39	68	87	63	102	81	70
16	64	88	61	55	52	74	50	62	54	49	93	51	48	50	62	59	54	38	64	75	60	74	80	68
17	54	86	61	49	49	74	49	62	46	46	77	48	48	47	60	46	52	37	63	70	54	72	79	63
18	48	82	59	38	49	70	49	60	46	35	67	40	44	47	51	42	52	25	62	62	53	69	72	55
19	42	74	53	38	49	54	42	57	43	35	63	34	42	46	51	39	46	23	59	54	50	66	52	53
20	35	64	50	35	45	54	33	55	40	33	59	34	37	45	40	39	45	22	45	53	46	65	51	51
21	33	61	43	32	44	52	33	53	36	33	58	32	33	41	34	37	44	22	37	51	45	61	45	49
22	31	59	42	24	43	50	32	48	31	25	55	30	32	34	33	33	40	17	35	43	43	49	41	40
23	30	51	40	21	33	49	29	35	17	23	47	27	31	28	32	29	34	16	33	28	41	32	27	31
24	29	29	29	20	33	30	26	35	17	21	43	27	29	25	27	24	33	14	31	23	34	27	26	27
25	26	21	20	18	31	14	26	29	17	17	38	17	19	25	19	17	24	10	18	19	20	26	23	24
								28			21		6							10				

Reflecting on these results

- Not one October ensemble forecast was within 40% of “loss” for 1999/2000 winter
- 2006/7 also struggled to pick up the losses from that year
- Is forecasting an increased likelihood of often single tail hazard events in a winter simply too much of an ask?
- Would things improve with a shorter lead time for 1999?

Ensemble Loss and Lead Time: Dec '99

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- Showing Sept, Nov, Dec forecasts for Dec 1999 as well as Oct from previous slide
  - ERA5 Dec loss index was 238m
- Would expect Dec forecast to be higher; first storm was 3rd December
- What about comparing to Sept-Dec forecasts for December from climatology?

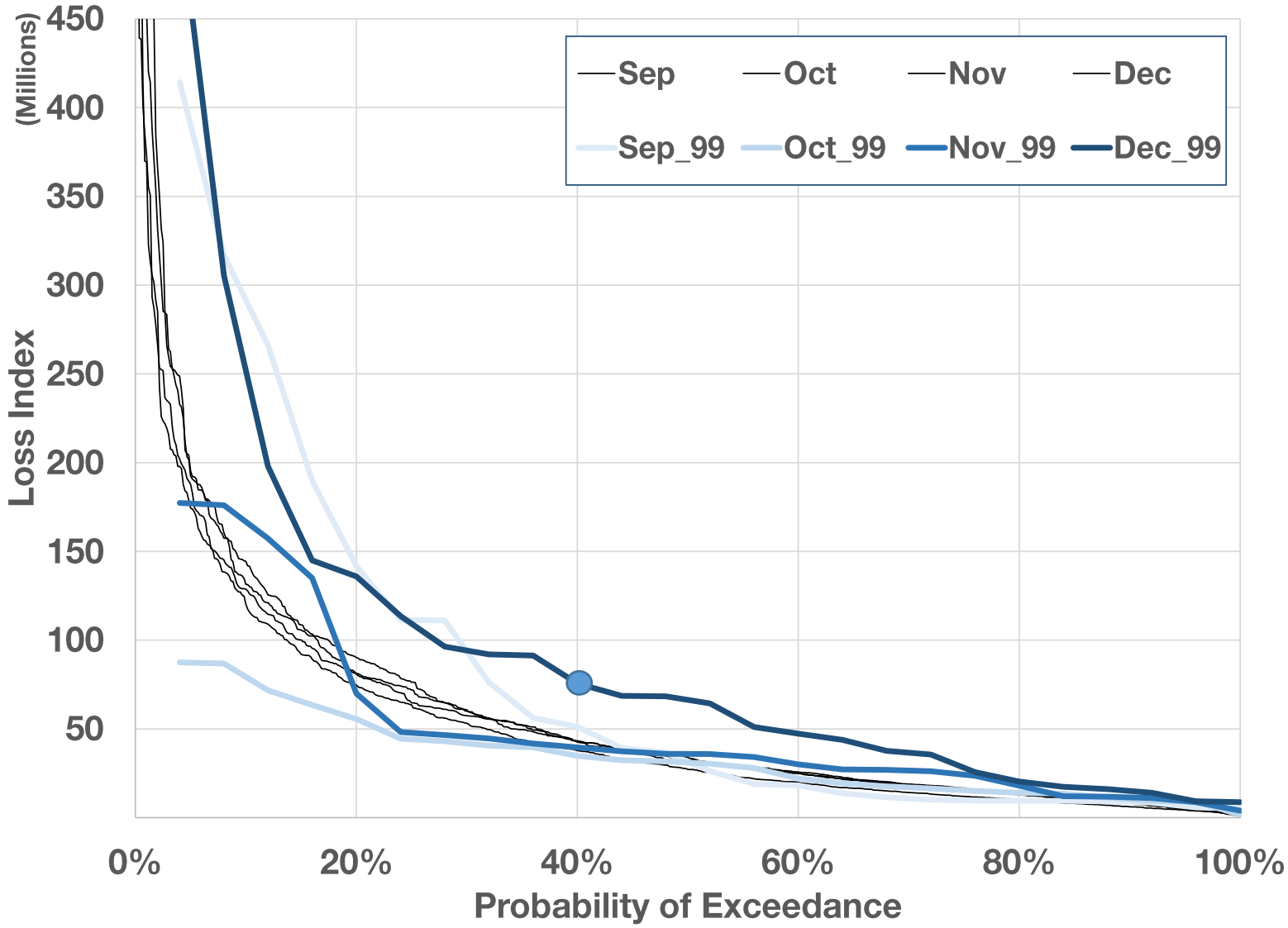
Rank	Sep-99	Oct-99	Nov-99	Dec-99
1	414.3	87.4	177.3	509.2
2	316.8	86.8	176.0	305.5
3	266.1	71.7	157.3	197.9
4	189.8	63.4	134.9	144.9
5	141.7	55.6	69.8	135.9
6	111.3	44.4	48.3	113.5
7	111.1	43.1	46.5	96.3
8	76.2	40.6	44.5	92.0
9	56.2	39.5	41.8	91.3
10	51.2	34.8	39.5	75.5
11	39.2	32.3	37.3	68.6
12	36.7	31.7	35.9	68.4
13	26.2	30.3	35.8	64.3
14	18.9	27.9	34.2	51.1
15	18.1	22.0	30.0	47.3
16	13.8	19.5	27.2	43.8
17	11.4	17.6	26.9	37.6
18	10.1	16.5	26.2	35.5
19	9.6	15.1	23.6	25.7
20	9.5	14.1	18.0	20.3
21	9.5	13.4	12.1	17.3
22	9.1	11.3	11.8	16.0
23	8.5	9.4	11.0	14.0
24	5.7	9.1	8.7	9.2
25	5.2	1.5	4.0	8.7
MEAN	78.7	33.6	51.1	91.6

Exceedance Probability Curve of Loss
1999 Forecasts versus 1993-2016 climatology

- Thin black lines: 600 Sep-Dec hindcasts for Dec 1993-2016
- Coloured lines: 25 Sep-Dec hindcasts for December 1999

- Probability of Exceedance "X % chance that loss will exceed Y value"

- Highlights tail risk that existed in the Sept and Dec forecast for Dec
  - Oct / Nov not so successful



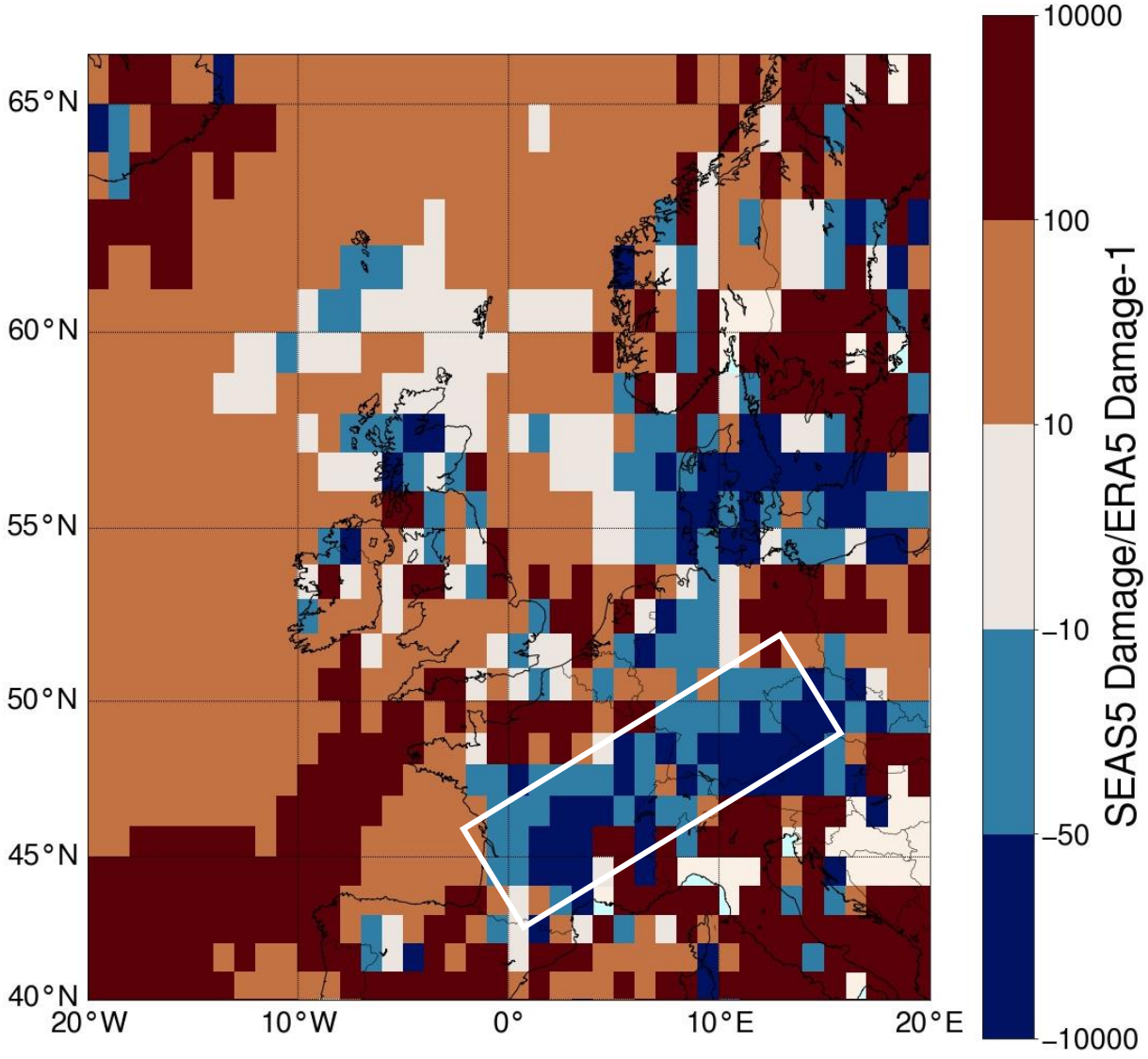
SEAS5 Mean Damage versus ERA5 Mean Damage

- ERA5 Average Annual Loss: 68.3m
- SEAS5 Average Annual Loss: 97.4m

- Showing <u>percentage</u> difference:
  - (SEAS5 / ERA5) – 1

- Broadly higher for UK, N France, N Scandinavia

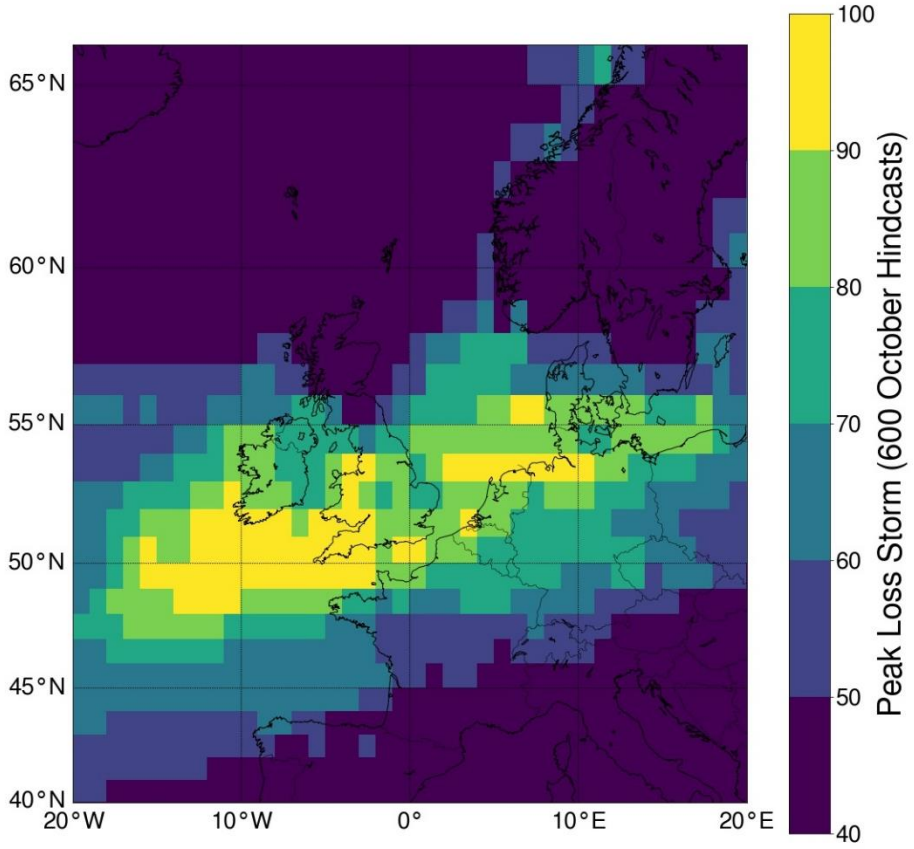
- Lower over S France and Germany
  - Have found this issue in another study with 60km GCM
  - Or is history from 1993-2017 unique?



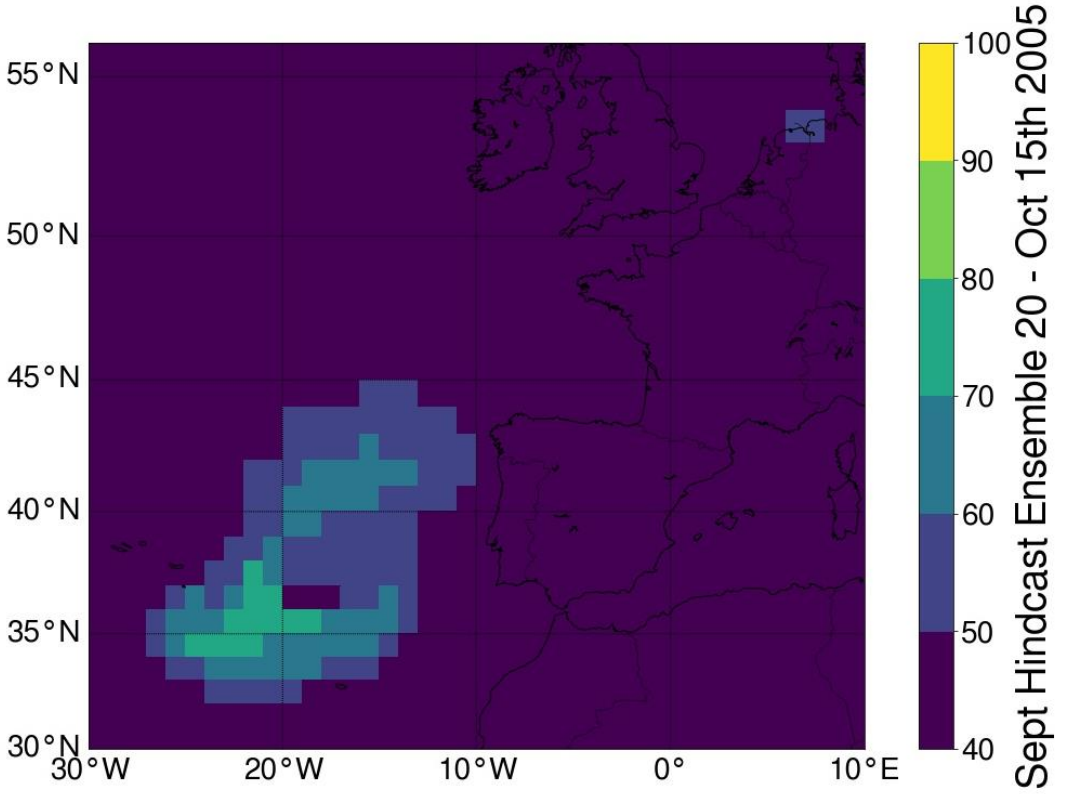
Lots more to do / understand

- Currently doesn't look promising to use SEAS5 for loss forecasts
- Further work on Sept-Dec winter forecasts and lead time
- Used 1 degree SEAS5 resolution. Potential to use raw T319 data?
  - Have also got a better insurance dataset to use
- Risk in France
  - Is "our history" (Lothar, Martin, Xynthia & Klaus) in 1999-2010 a freak?
  - Are GCMs missing something in the southern extent of their storm tracks?

Other Future Work



- **Understanding tail events**
  - **Size and shape of strongest events by country**



- **Early-season events**
  - **Ophelia-style hurricane season overlap in the tail**

Thank You

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