



HOW DO HIGH-RESOLUTION MODELS IMPROVE THE REPRESENTATION OF PAST EUROPEAN WINDSTORMS?

**Julia Lockwood, Galina Guentchev, Erika Palin (Met Office),
and the PRIMAVERA team**

Insurance focused webinar, 19/03/2019



STRUCTURE OF WEBINAR

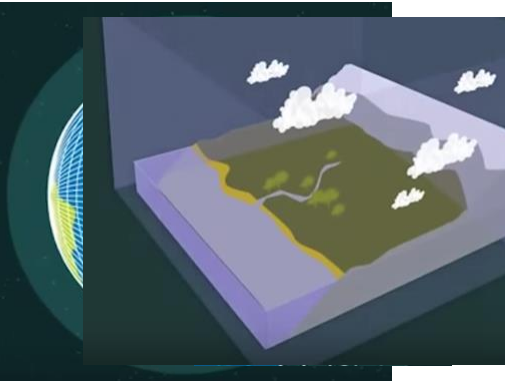
- The PRIMAVERA project
 - Model simulations and user engagement (insurance)
- Windstorms analyses
 - Track density
 - Intensity
 - Temporal clustering
- Ongoing / future work (windstorm footprints)
- Questions and discussion

THE PRIMAVERA PROJECT

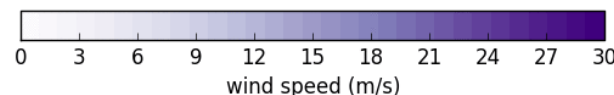
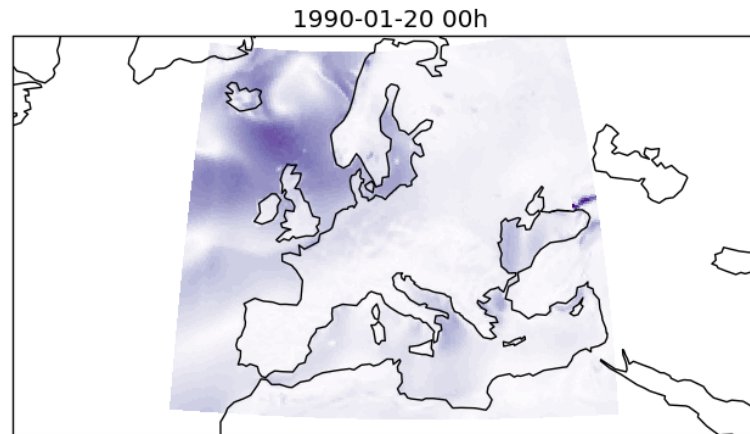


- **PR**ocess-based climate **sI**mulation: **AdV**ances in high-resolution modelling and **Eu**ropean climate **R**isk **Assessment**

*PRIMAVERA is a European Commission-funded project about designing and running **new high resolution global climate models**, assessing their ability to simulate **societally important processes**, to **support climate risk assessment** activities across Europe.*



Animation of wind storm Daria at $0.22^\circ \times 0.22^\circ$



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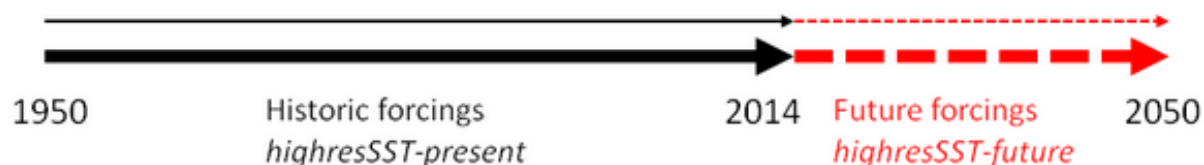
MODEL SIMULATIONS

MODEL SIMULATIONS

Atmosphere-land-only, 1950-2014 (→ 2050)

Forced by observed SST and sea-ice and historic forcings (→ projected)

highresSST-present (→ highresSST-future)

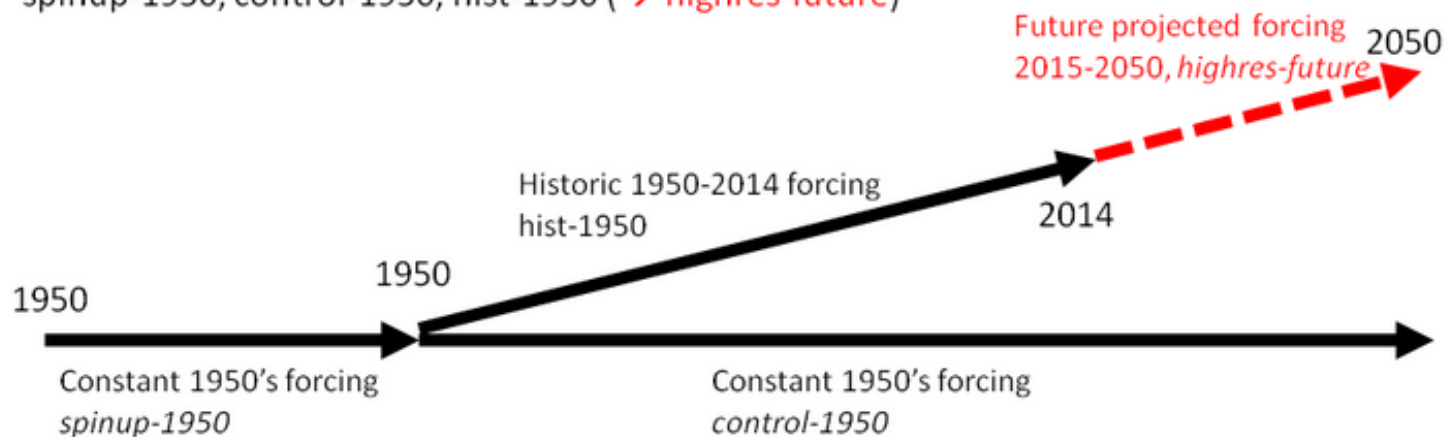


Coupled climate, 1950-2014 (→ 2050)

Forced by constant 1950 and historic forcings (→ projected)

Initial coupled spin-up period ~ 30-50 years from 1950 EN4 ocean climatology

spinup-1950, control-1950, hist-1950 (→ highres-future)



MODEL GROUPS AND MODEL RESOLUTIONS

Institution Model components resolution	Met Office, U Reading, NERC (United Kingdom)			EC-Earth, KNMI, SHMI, BSC, CNR (Netherlands)		CERFACS (France)		MPI-M (Germany)		AWI (Germany)		CMCC (Italy)		ECMWF (Europe)	
Model name	HadGEM3 GC3.1			EC-Earth3		CNRM-CM6		MPIESM-1-2		AWI-CM 1.0		CMCC-CM2		ECMWF-IFS	
Atmosphere only resolution (CMIP6), km	250	100	50	100	50	250	50	100	50	250	100	100	25	50	25
Atmosphere only – grid spacing at 50deg N, km	135	60	25	71	36	142	50	67	34	129	64	64	18	50	25
Ocean resolution, km	100	25	25	100	25	100	25	40	40	50	25	25	25	100	25

USER ENGAGEMENT

USER ENGAGEMENT

■ WP 10 – Climate Risk assessment; Case studies

- Insurance
- Energy
- Transport
- Agriculture
- Health
- Water



■ WP 11 – User engagement and dissemination

- Video (>450 views)
- Initial user survey (>80 replies)
- Interviews (~50)
- User Interface platform
 - <http://uip.primavera-h2020.eu>
- Factsheets
- Conferences
- Webinars
- Workshops

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INSURANCE/FINANCE INTERVIEWS

- Previous webinar in Nov 2017 with overview of all interviews (June 2017)
- **Interview included questions on:**
 - Which weather/climate hazards most important to your work?
 - On what timescales are you interested in weather and climate data?
 - Importance of climate change to your work
 - How do you use weather and climate data?
 - Gaps in climate/weather knowledge and data

INSURANCE/FINANCE INTERVIEWS

- Most important hazards for Europe – **windstorms and flooding**.
- Sector is already very knowledgeable about weather and climate.
- Risk assessed using catastrophe models → hazard ‘footprints’.
- **Mostly interested in present day risk, or <10 years into the future.**
- General interest in climate change and how it affects risk, but some mentioned difficulty of implementing this information.
- **Gaps in knowledge/data:**
 - **Not enough data to assess present day risk**
 - Limits of storm severity?
 - Trends – climate change vs natural variability
 - Storm clustering
 - Impacts of climate change on max winds/rainfall/river flows.
 - How to downscale to very small scales (km/metres/buildings).

INSURANCE/FINANCE INTERVIEWS

- **PRIMAVERA** can help
- Data can be used to generate event sets for present day (and future) risk.
- Focus on event set of European **windstorms** (extra-tropical cyclones).
- First need to **assess model performance...**

WINDSTORMS - TRACK DENSITY

WINDSTORMS – TRACK DENSITY

■ DATASETS

- REANALYSIS: ERA Interim (~80km resolution), MERRA2 (~50km)
- GCMs – present day AMIP runs – PRIMAVERA and CMIP5 counterparts



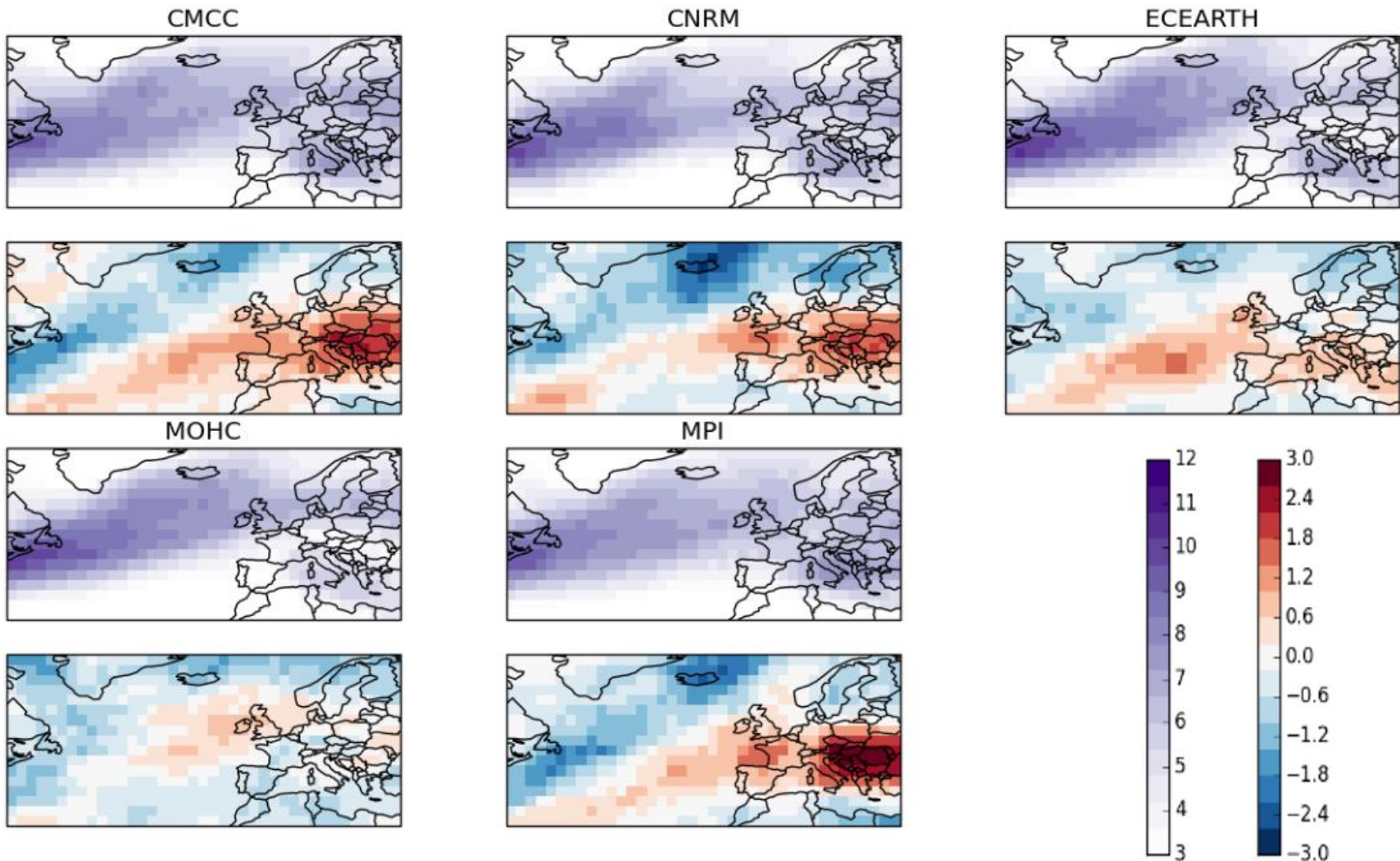
■ METHOD

- TRACK (Hodges 1995)
 - Tracks last at least 2 days; travel >1000km; have a maximum relative vorticity $>10^{-5} \text{ s}^{-1}$
 - ERA Interim tracks were provided by Kevin Hodges and Robert Lee
 - MERRA2 tracks were provided by Malcolm Roberts
- Period 1980-2008
- TRACK DENSITY
 - counting the number of storms each month passing within a 6.3° radius of each grid point of a template grid

Modelling centre	PRIMAVERA model analysed	CMIP5 model analysed
CMCC	CMCC-CM2-HR4 (100km)	CMCC-CM (70km)
CNRM	CNRM-CM6-1-HR (45km)	CNRM-CM5 (100km)
ECEARTH	ECEARTH3-HR (25km)	ECEARTH (80km)
MOHC	HadGEM3-GC31-HM (25km)	HadGEM2-A (90km)
MPI	MPI-ESM-1-2-XR (50km)	MPI-ESM-MR (130km)
ECMWF	ECWMF-IFS-HR (25km)	Unavailable

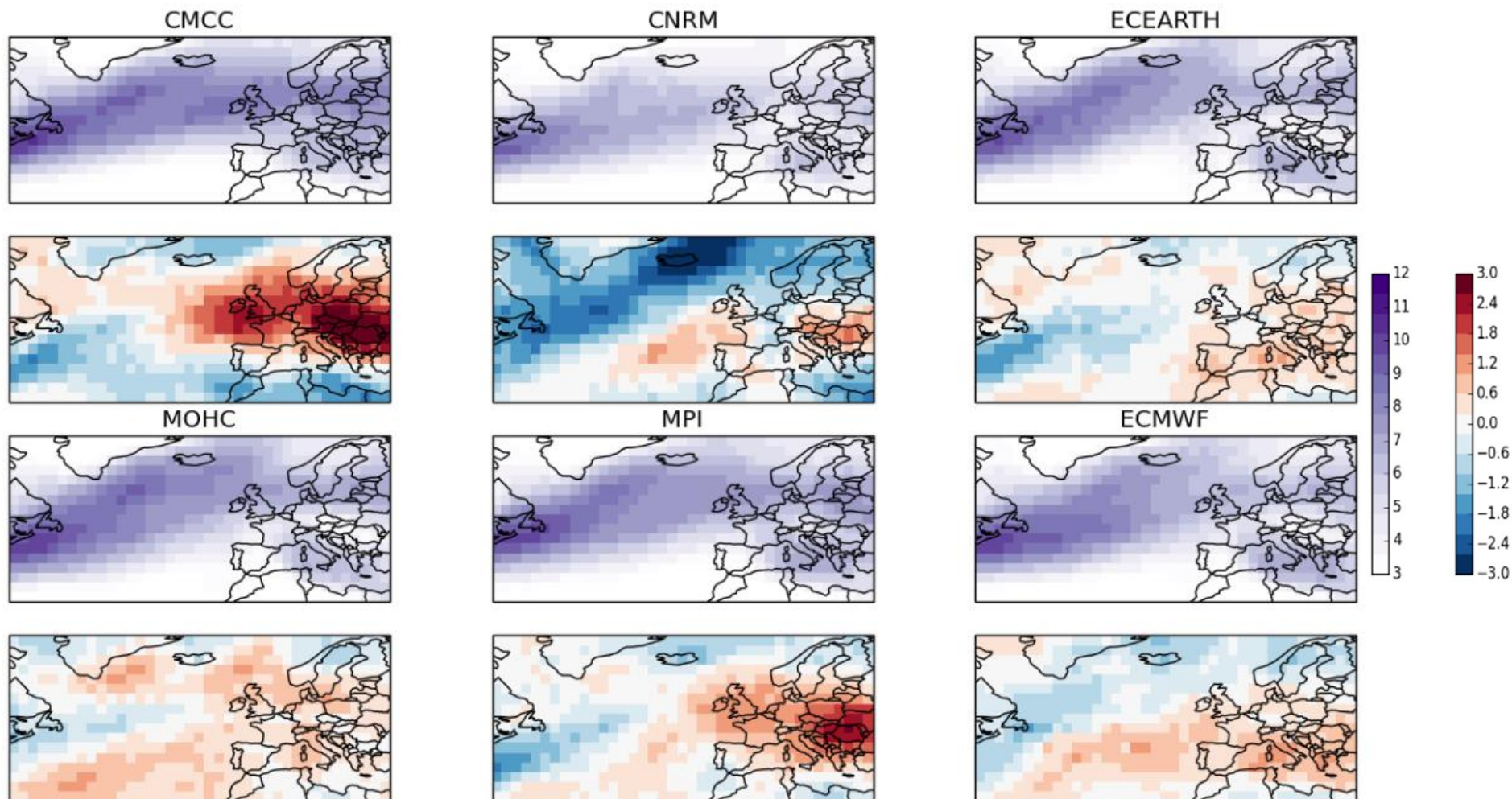
TRACK DENSITY – CMIP5 models

Comparison vs ERA Interim



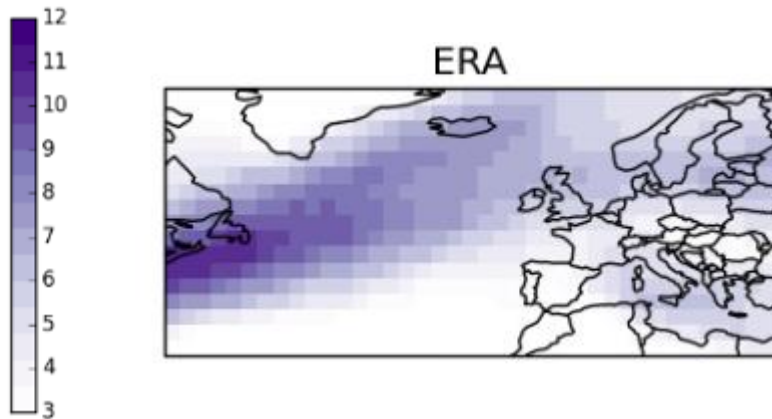
TRACK DENSITY – PRIMAVERA models

Comparison vs ERA-Interim



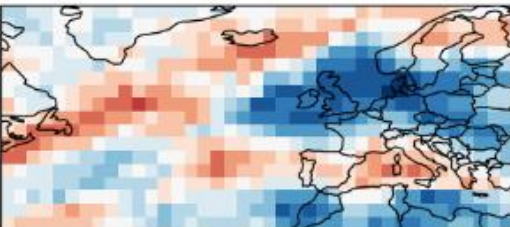
TRACK DENSITY – CMIP5 vs PRIMAVERA

Comparison vs ERA Interim – Change in bias between CMIP5 and PRIMAVERA

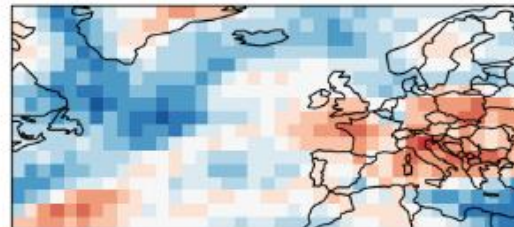


- PRIMAVERA models are characterized by **smaller biases** overall compared to the CMIP5 models

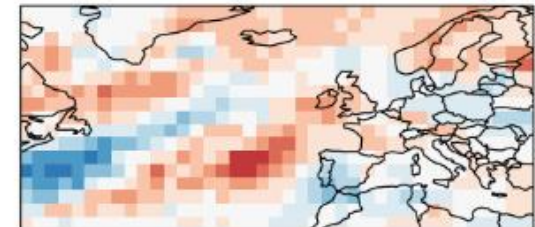
CMCC



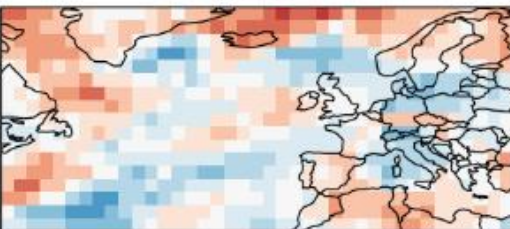
CNRM



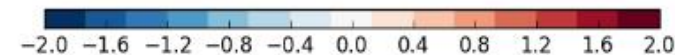
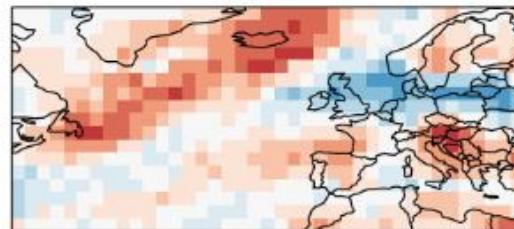
ECEARTH



MOHC



MPI



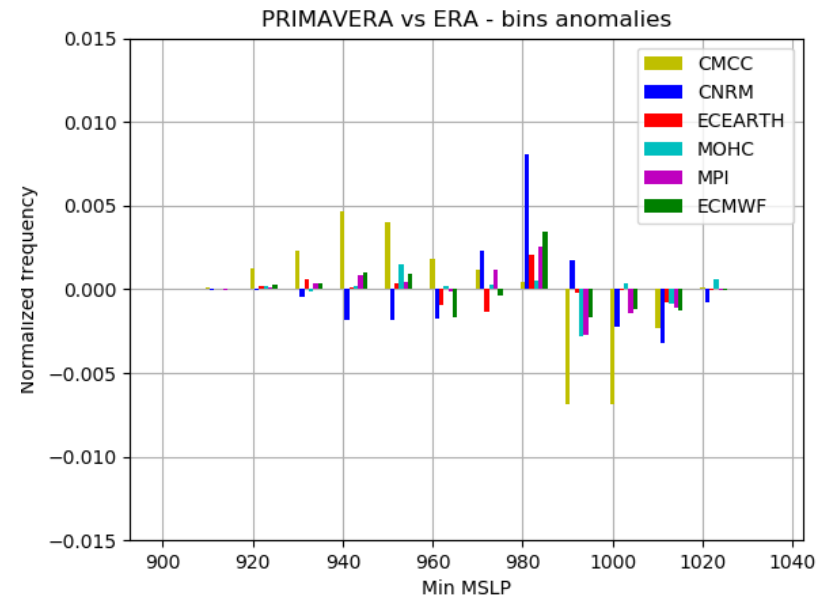
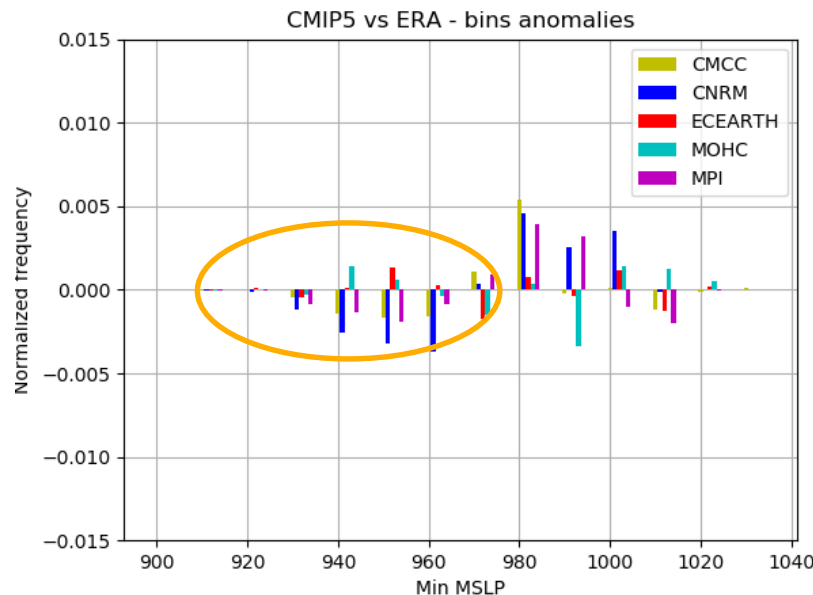
Change in storm track bias between CMIP5 and PRIMAVERA ($|\text{CMIP5 bias}| - |\text{PRIMAVERA bias}|$), as compared to ERA Interim
Red areas (reduction in bias) show where there is improvement

WINDSTORMS - INTENSITY

INTENSITY – Minimum Sea level Pressure

Comparison vs ERA - Interim

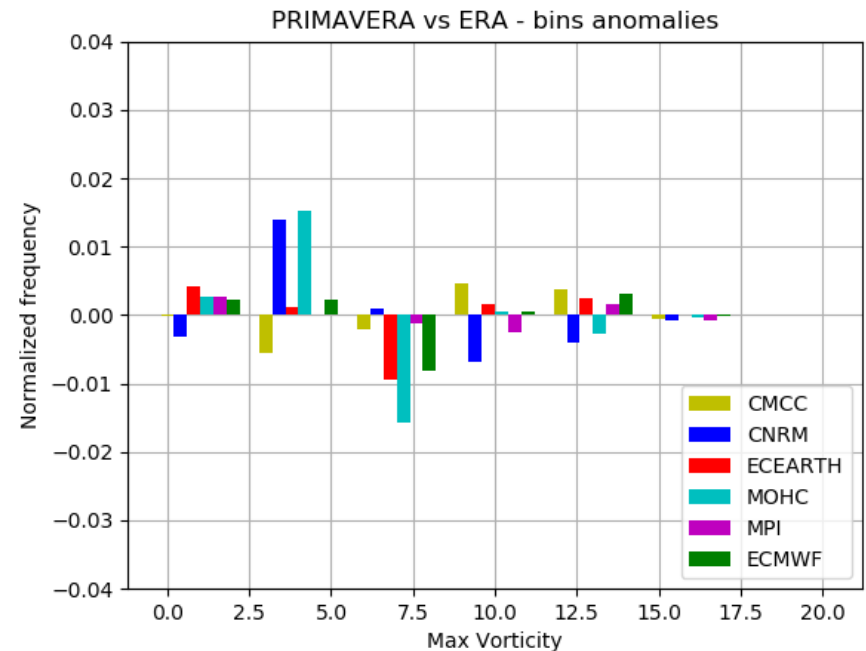
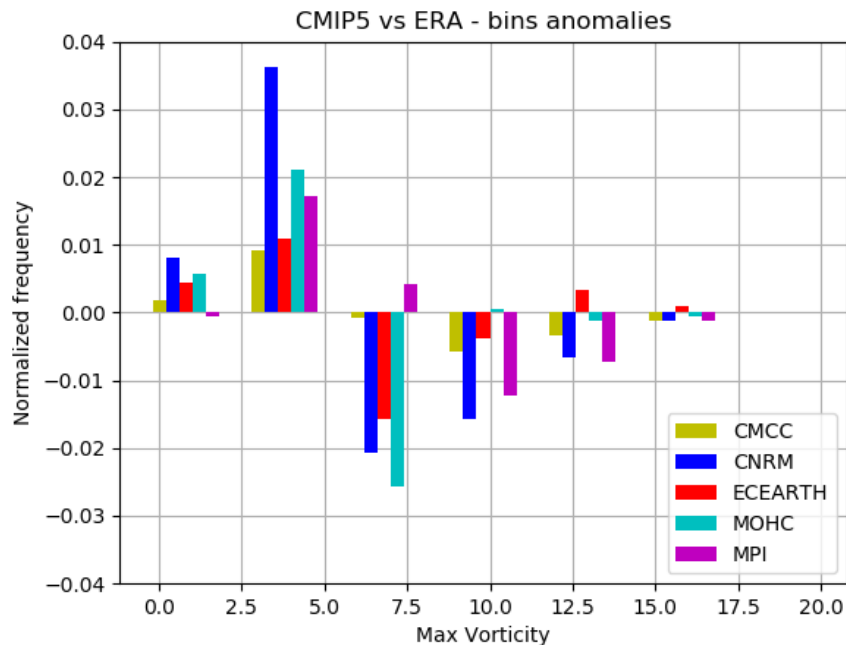
- Some CMIP5 models underestimate the number of extreme storms with lower min MSLP and **overestimate the number of less intense storms**
- Some of the PRIMAVERA models overestimate slightly the number of storms with low min MSLP (below 980 hPa), especially the CMCC model, but **fewer models underestimate the number of intense storms**, which is an **improvement** compared to the CMIP5 models.
- The PRIMAVERA models underestimate the number of weaker storms.



INTENSITY – Maximum vorticity

Comparison vs ERA - Interim

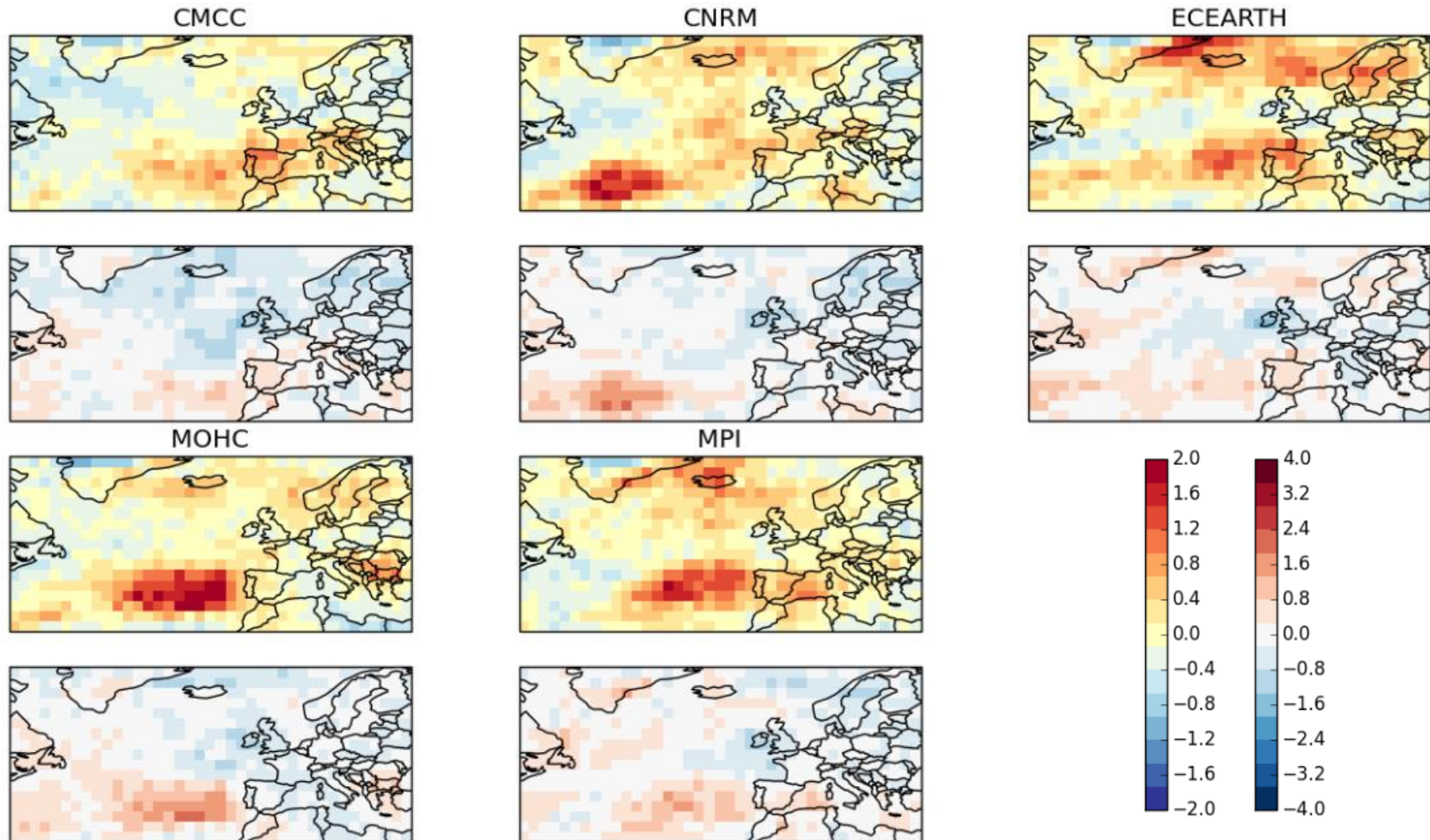
- The CMIP5 models underestimate the frequency of more extreme storms with higher vorticity, while **overestimating the frequency of lower vorticity storms**
- **These biases are reduced** to a great extent in the PRIMAVERA models especially regarding the underestimation of the stronger storms with higher vorticity



WINDSTORMS - TEMPORAL CLUSTERING

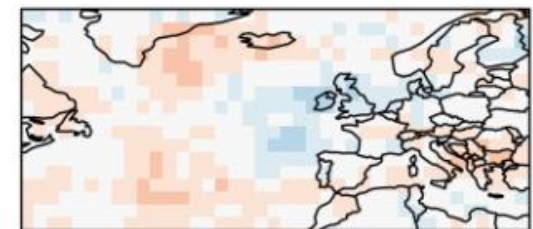
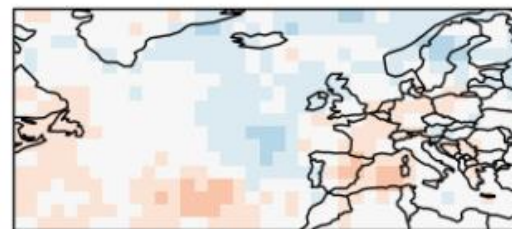
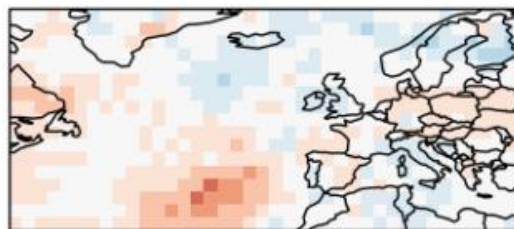
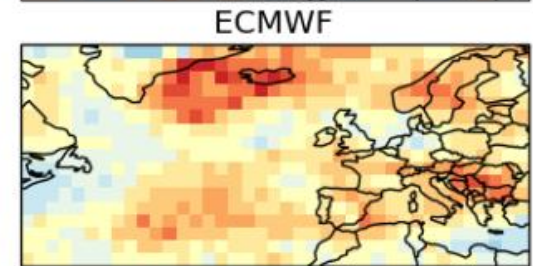
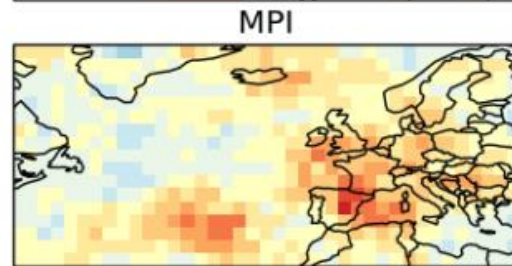
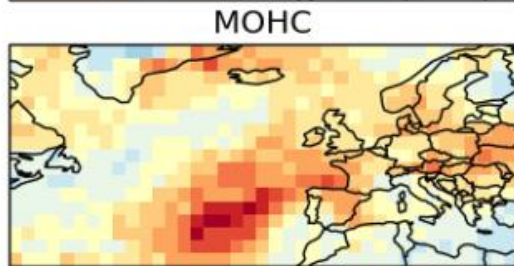
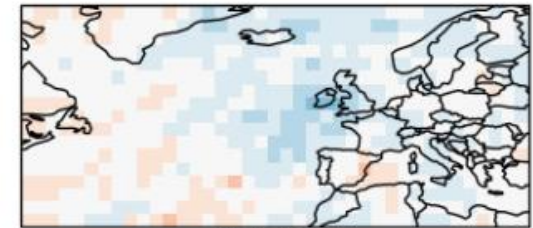
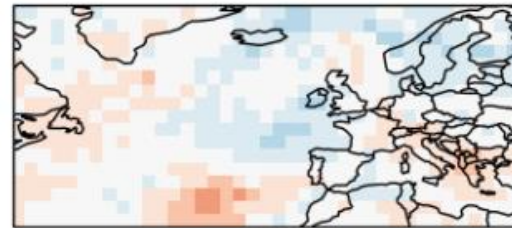
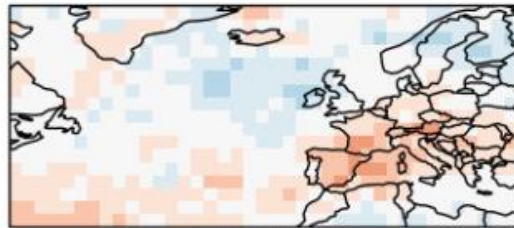
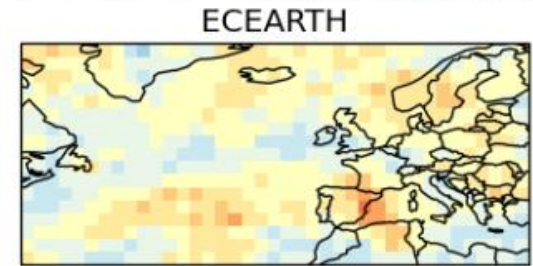
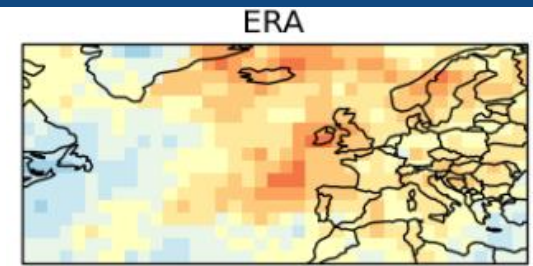
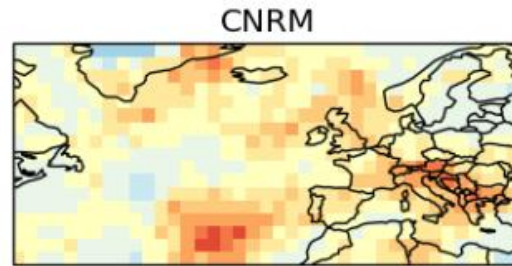
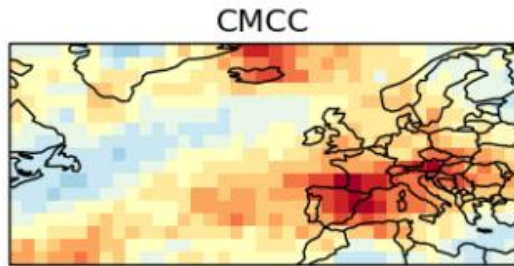
TEMPORAL CLUSTERING – CMIP5 MODELS

- **TEMPORAL CLUSTERING** – using the dispersion (ratio of variance to mean) of the December–February counts of North Atlantic storms, following Economou et al. 2015
- The CMIP5 models **overestimate** clustering **to the south**



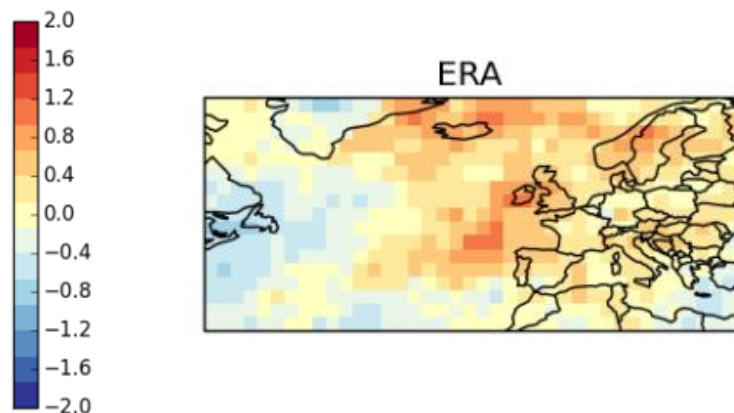
TEMPORAL CLUSTERING – PRIMAVERA models

- The **PRIMAVERA models** represent the temporal clustering of windstorms with somewhat **smaller biases** compared to the CMIP5 models



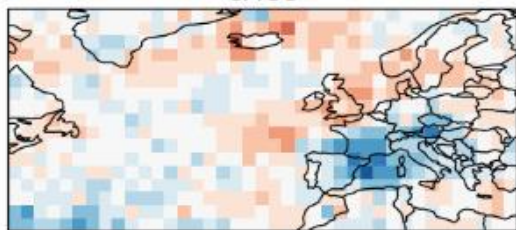
TEMPORAL CLUSTERING – CMIP5 VS PRIMAVERA

Comparison vs ERA Interim – Change in bias between CMIP5 and PRIMAVERA

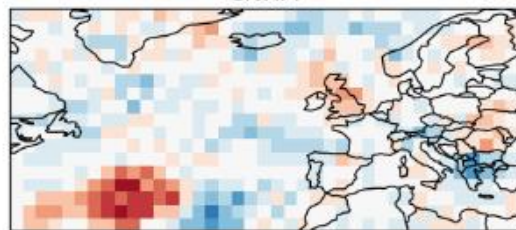


- PRIMAVERA models are generally characterized by somewhat **smaller biases especially in the southern sections** compared to the CMIP5 models

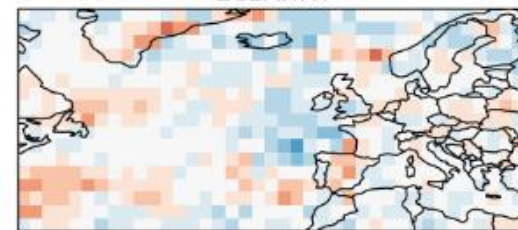
CMCC



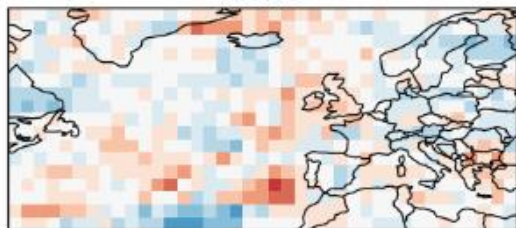
CNRM



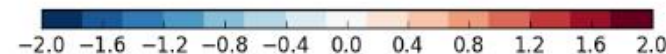
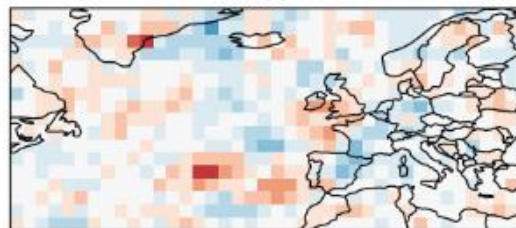
ECEARTH



MOHC



MPI



Change in temporal clustering bias between CMIP5 and PRIMAVERA ($|\text{CMIP5 bias}| - |\text{PRIMAVERA bias}|$), as compared to ERA Interim
Red areas (reduction in bias) show where there is improvement

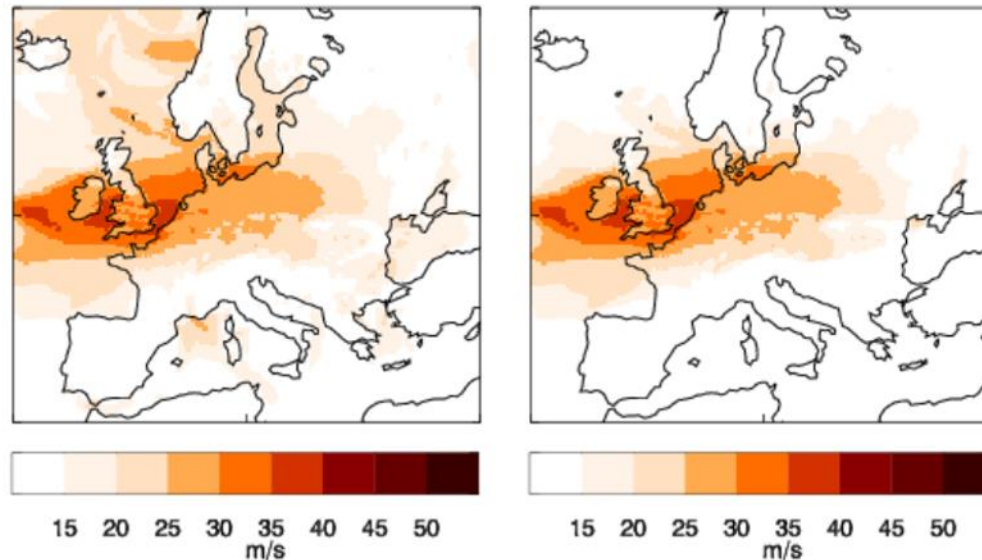
CONCLUSIONS FOR RESULTS TO DATE

- **PRIMAVERA** generation of **models** are an **improvement over the CMIP5 models** with regards to:
 - intensity represented by maximum vorticity and lowest mean sea level pressure
 - track density representation
 - temporal clustering

ONGOING / FUTURE WORK

WINDSTORM FOOTPRINTS/EVENT SET

- Currently constructing windstorm event set from atmosphere only, present day models.
- Use same method as XWS project (www.europeanwindstorms.org): 72 hour max gust/wind centred on time of max 925hPa wind speed over land
- Analysis will include comparison of footprint properties across resolutions and models (may be able to include more – discuss at end?).



WINDSTORM FOOTPRINTS/EVENT SET

- How many years of data?

Institution Model components resolution	Met Office, U Reading, NERC (United Kingdom)	EC-Earth, KNMI, SHMI, BSC, CNR (Netherlands)	CERFACS (France)	MPI-M (Germany)	AWI (Germany)	CMCC (Italy)	ECMWF (Europe)
Model name	HadGEM3 GC3.1	EC-Earth3	CNRM-CM6	MPISM-1-2	AWI-CM 1.0	CMCC-CM2	ECMWF-IFS
Atmosphere only – grid spacing at 50deg N, km	135 x3 60 x3 25 x3	71 36	142 50	67 34	129 64	64 x2 18 x2	50 25

- Present day atmosphere only runs (1950-2014):

- High res, max gusts only:
 - 64 yrs * 4 runs = 256 yrs
- High res, max gusts or winds (at least daily):
 - 64 yrs * 9 runs = 576 yrs
- All resolutions, daily winds:
 - 64 yrs * 21 = 1344 yrs

- Include coupled runs?
- Future runs?

DATA AVAILABILITY

- All PRIMavera **raw data** will be made available via ESGF (<https://esgf-node.llnl.gov/projects/cmip6/>)
- ETC and TC **tracks** will be made available on CEDA data archive (<http://www.ceda.ac.uk/>)
- **Event set/footprints** can be shared during project but currently no permanent place to store (possibility of putting them on Copernicus Climate Data Store).
- For now contact julia.lockwood@metoffice.gov.uk if you're interested in obtaining footprints once they've been generated.

THANK YOU!

QUESTIONS?

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🐦 [@PRIMAVERA_H2020](https://twitter.com/PRIMAVERA_H2020)

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DISCUSSION

- Comments on the presented track analysis? Are there other storm parameters that you would be interested for us to analyse?
- Would anyone be interested in using this data?
- What research questions would you like investigated? (trends vs natural variability, limits to storm severity....?)
- Make only max gust footprints, or include max wind ones? For comparability, just make footprints from max daily winds (even when 1/3/6hrly max winds/gusts available)?
- Keep footprints at native resolution? Convert to make whole set uniform (at ~25km? At <10km?)
- Interest in lower resolution footprints?
- Just atmosphere only runs? Or include couple models, future, constant 1950s forcings...?
- Format – netcdf? csv?
- **More questions? Email** julia.lockwood@metoffice.gov.uk,
galia.guentchev@metoffice.gov.uk, primavera_inquiries@bsc.es

