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Evaluation of air stagnation periods using regional climate models over Europe

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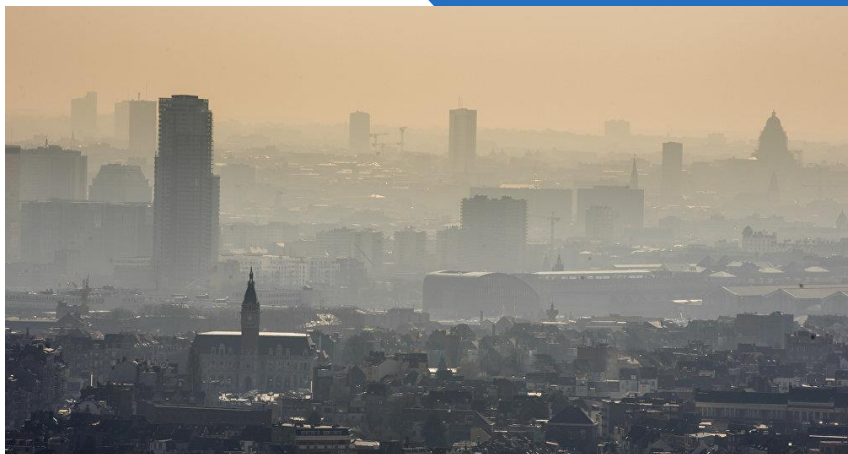
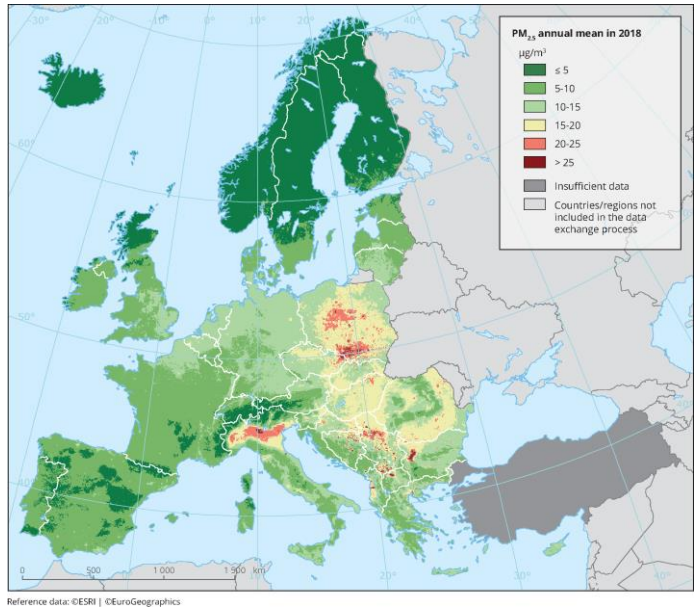


Air pollution & stagnation

- Despite strong legislation Europe is still subject to a high degree of air pollution due to its high population density and strong industrialization.
- Particulate matter, for instance, is held responsible for more than 400.000 premature deaths during 2018 (EEA report, 2020) and 55.000 attributable to NO2.
- Known relations between AQ and weather conditions
- Air pollution peaks often occur during stagnant atmospheric conditions.

What will be impact of climate change on these stagnation periods?



EEA 2018, PM2.5

Data used

Reference data:

- **CAMS** reanalysis (2003-2019) - 3-hourly for NO, NO_2, ozone and PM*
- Meteorological reference data: **ERA5** reanalysis (1979-present)

Daily model data **EURO-CORDEX** 0.11°, 0.22° & 0.44° resolution:

- Evaluation: 25 RCMs period (1979-2013)

Method

Simple index quantifies air stagnation: Horton Air Stagnation Index (**H-ASI,** see Horton & Diffenbaugh, 2012).

H-ASI

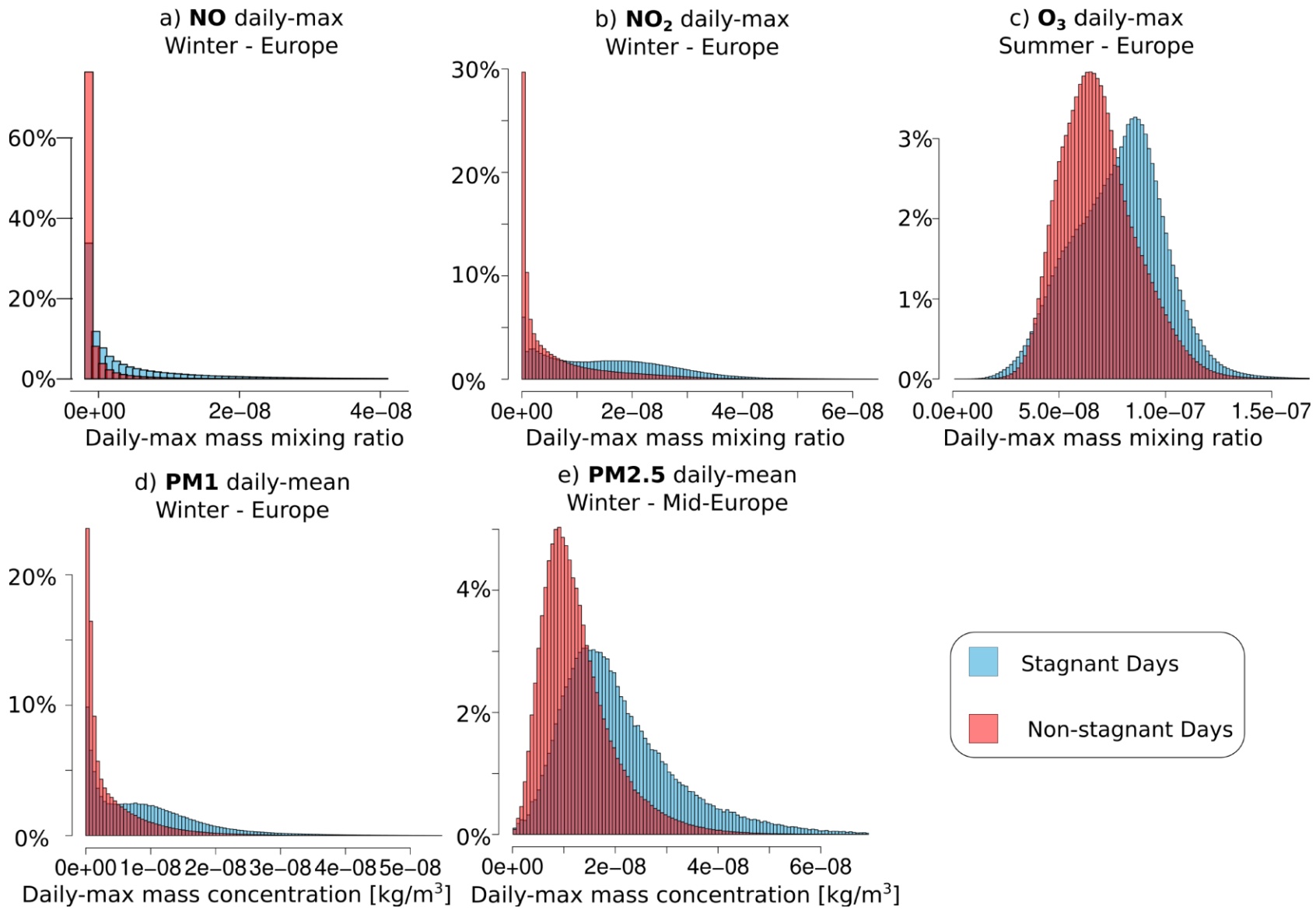
1) Daily mean precipitation accumulation $< 1 \frac{mm}{day}$

2) Daily mean near-surface wind speed $< 3.2 \frac{m}{s}$

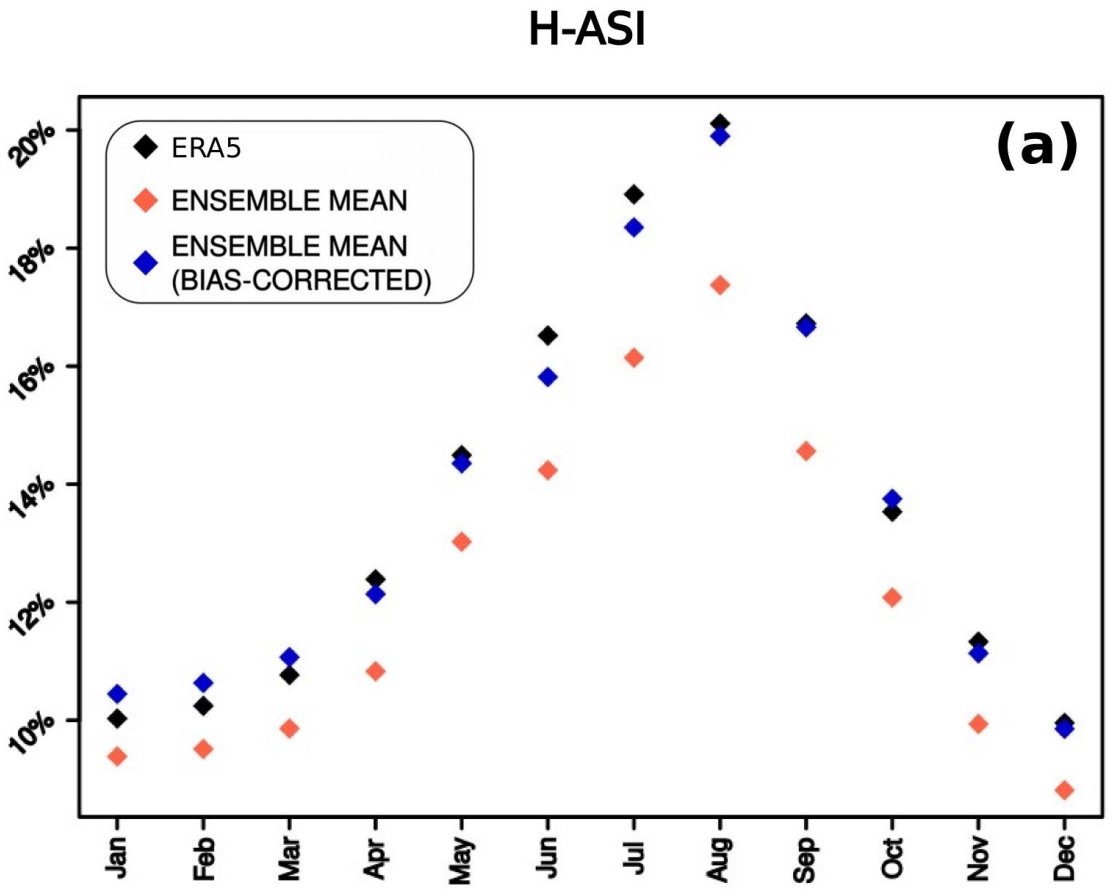
3) Daily mean mid-troposheric (500 hPa) wind speed $< 13 \frac{m}{s}$

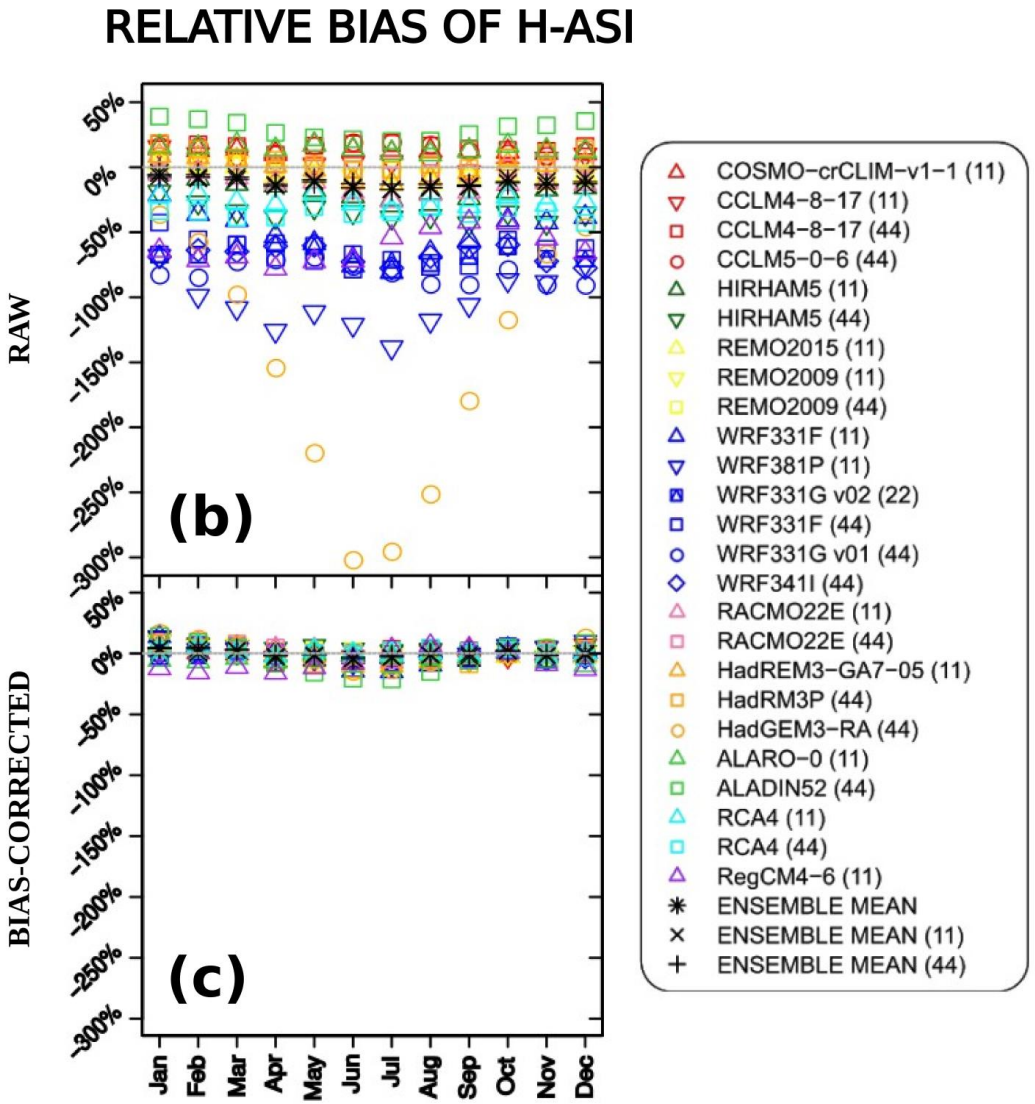
Bias correction done by adjusting these thresholds as done in quantile mapping

Relation between stagnation and polution

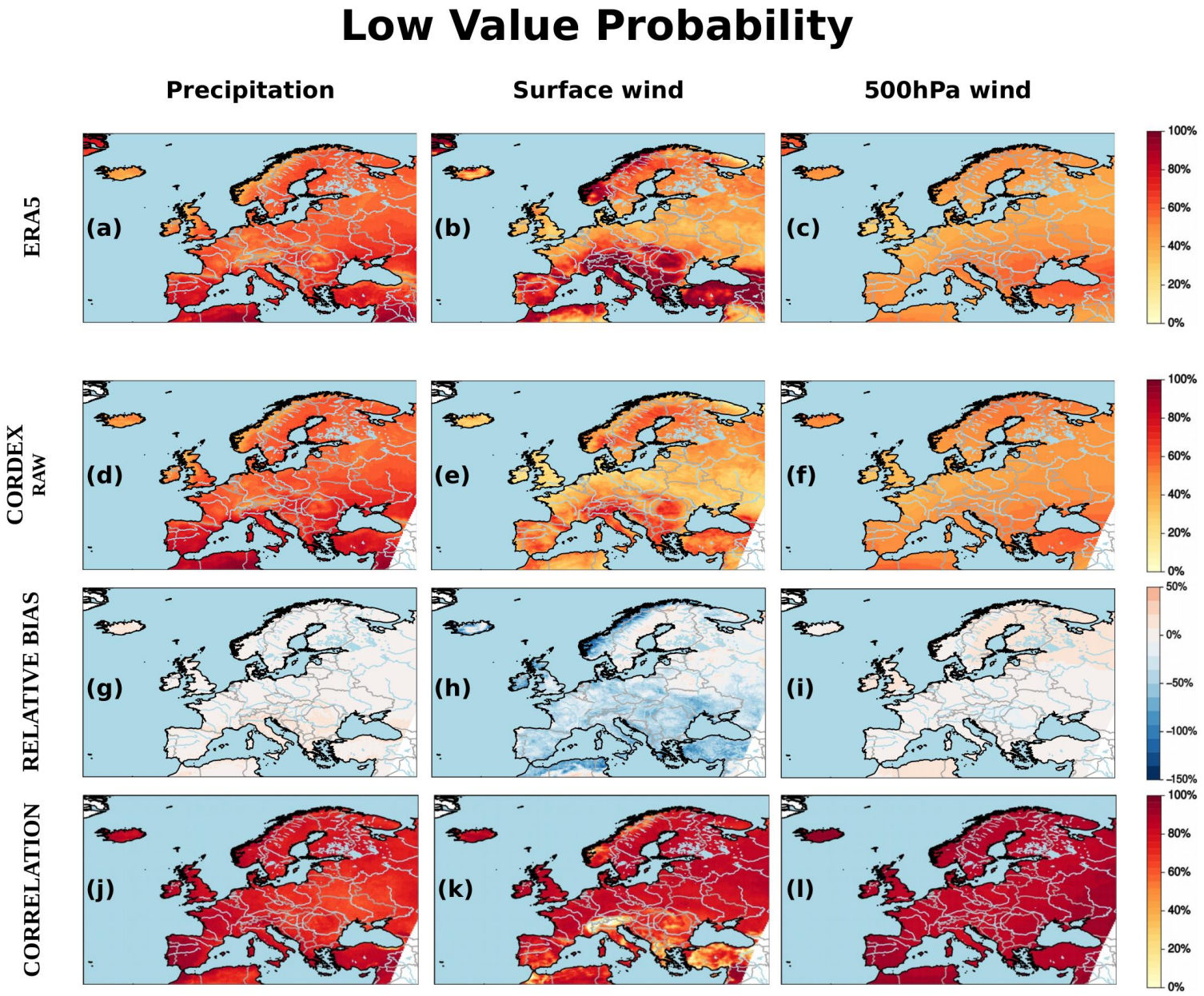


Annual cycle of H-ASI and its bias





Horton Air Stagnation Index (H-ASI)



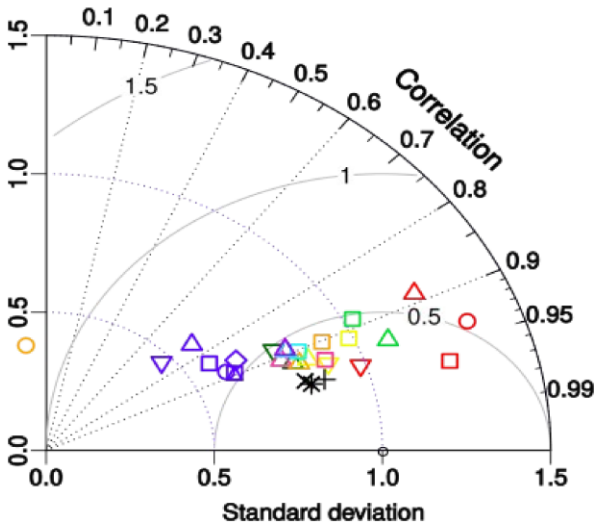
For the low-value exceedance probabilities:

- Bias largest for surface wind
- Correlation lowest for surface wind in some regions

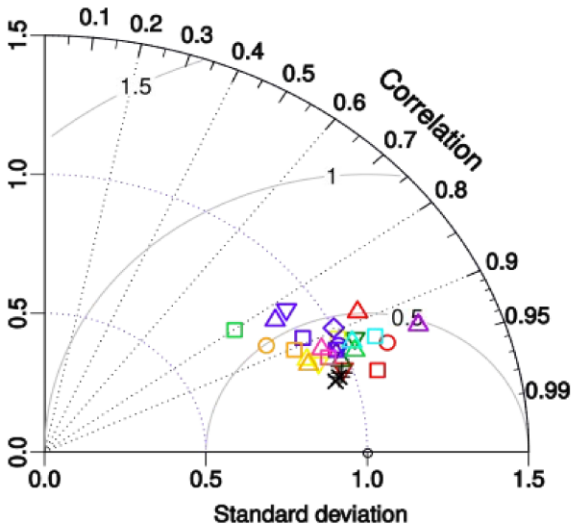
Taylor diagrams of stagnation index

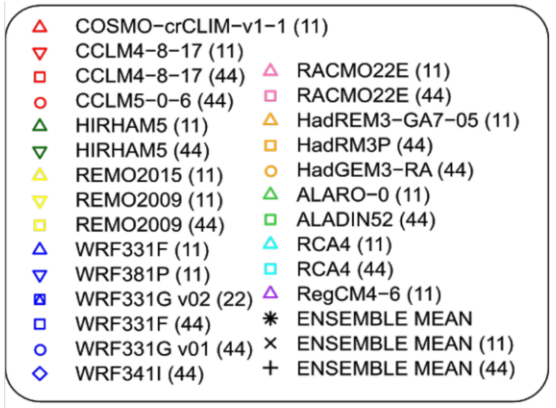
H-ASI

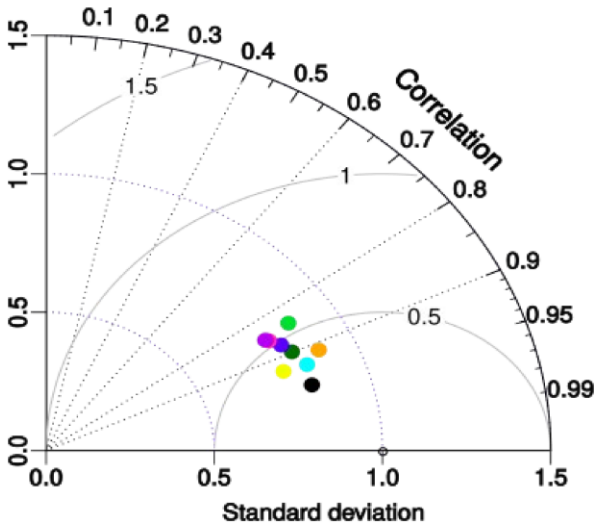
RAW

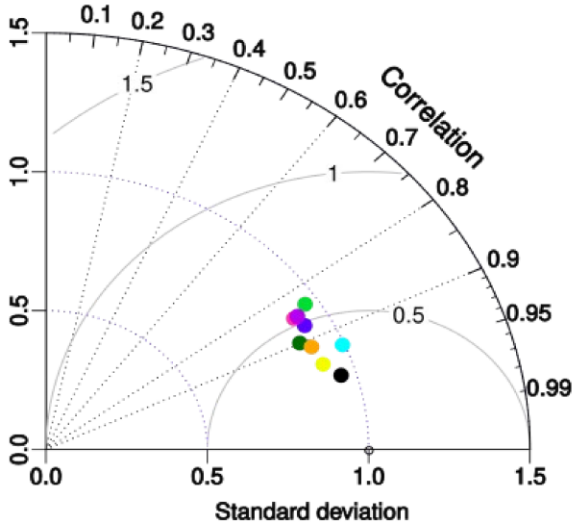


BIAS-CORRECTED

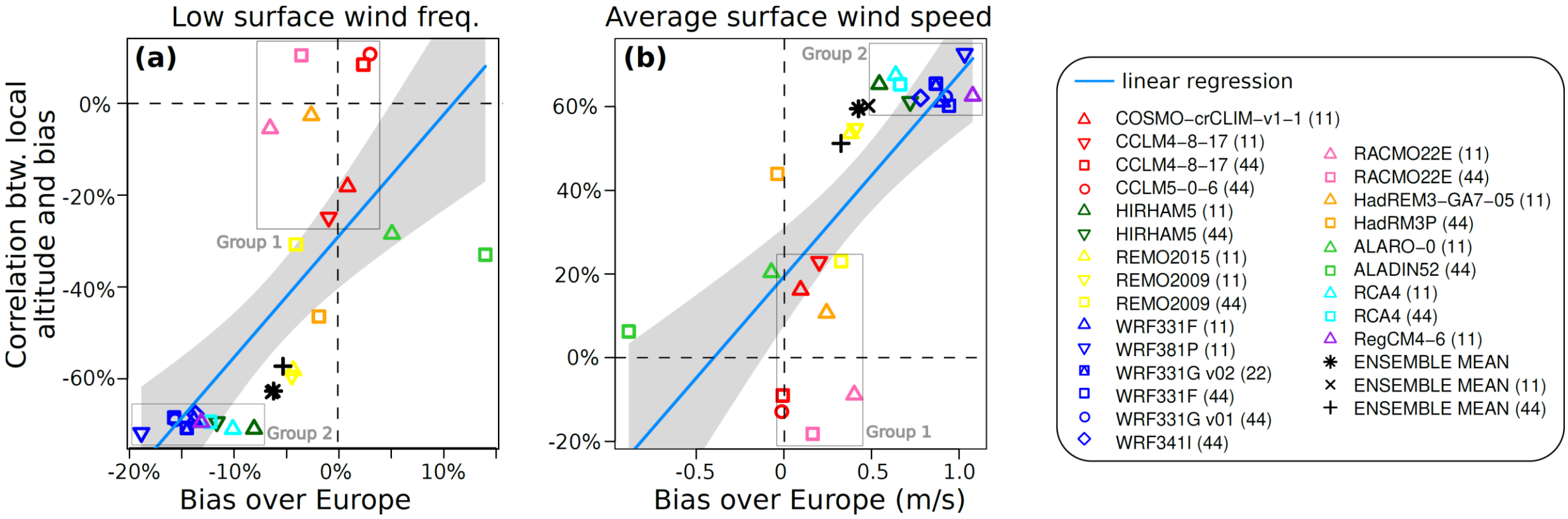




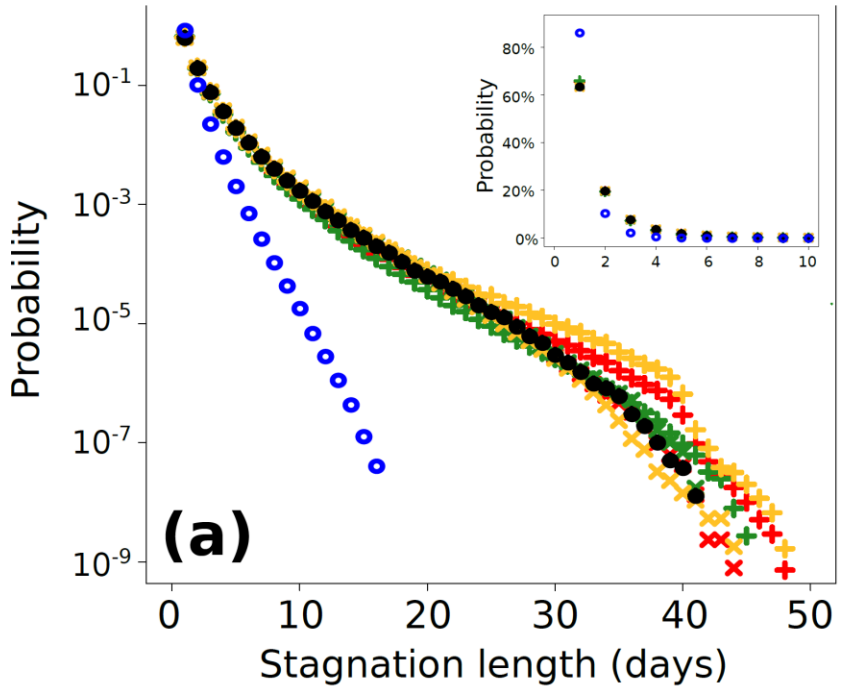


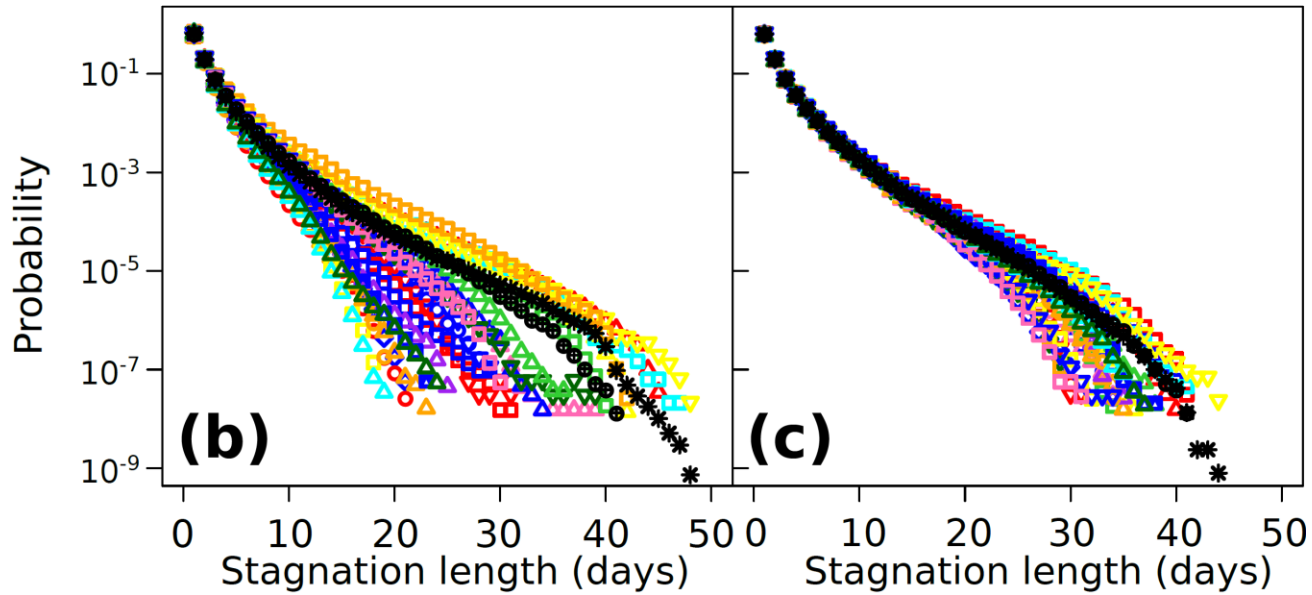


Relation altitude & surface wind bias



Stagnation-period statistics





ENSEMBLE MEAN
ENSEMBLE MEAN BIAS CORRECTED
ENSEMBLE MEAN EUR–11
ENSEMBLE MEAN EUR–11 BIAS CORRECTED
ENSEMBLE MEAN EUR–44
ENSEMBLE MEAN EUR–44 BIAS CORRECTED
ERA5
BINOMIAL DISTRIBUTION

COSMO–crCLIM–v1–1 (11)
CCLM4–8–17 (11)
CCLM4–8–17 (44)
CCLM5–0–6 (44)
HIRHAM5 (11)
HIRHAM5 (44)
REMO2015 (11)
REMO2009 (11)
REMO2009 (44)
WRF331F (11)
WRF381P (11)
WRF331G v02 (22)
WRF331F (44)
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Conclusion

- Air stagnation over Europe well reproduced by RCMs
- Largest error source of H-ASI (both bias and correlations) stems from surface wind
- Overestimation of surface wind speed correlates with elevation
- Bias correction on underlying variables strongly improves H-ASI
- Stagnant-period statistics well reproduced by (bias-corrected) RCMs

DANK U

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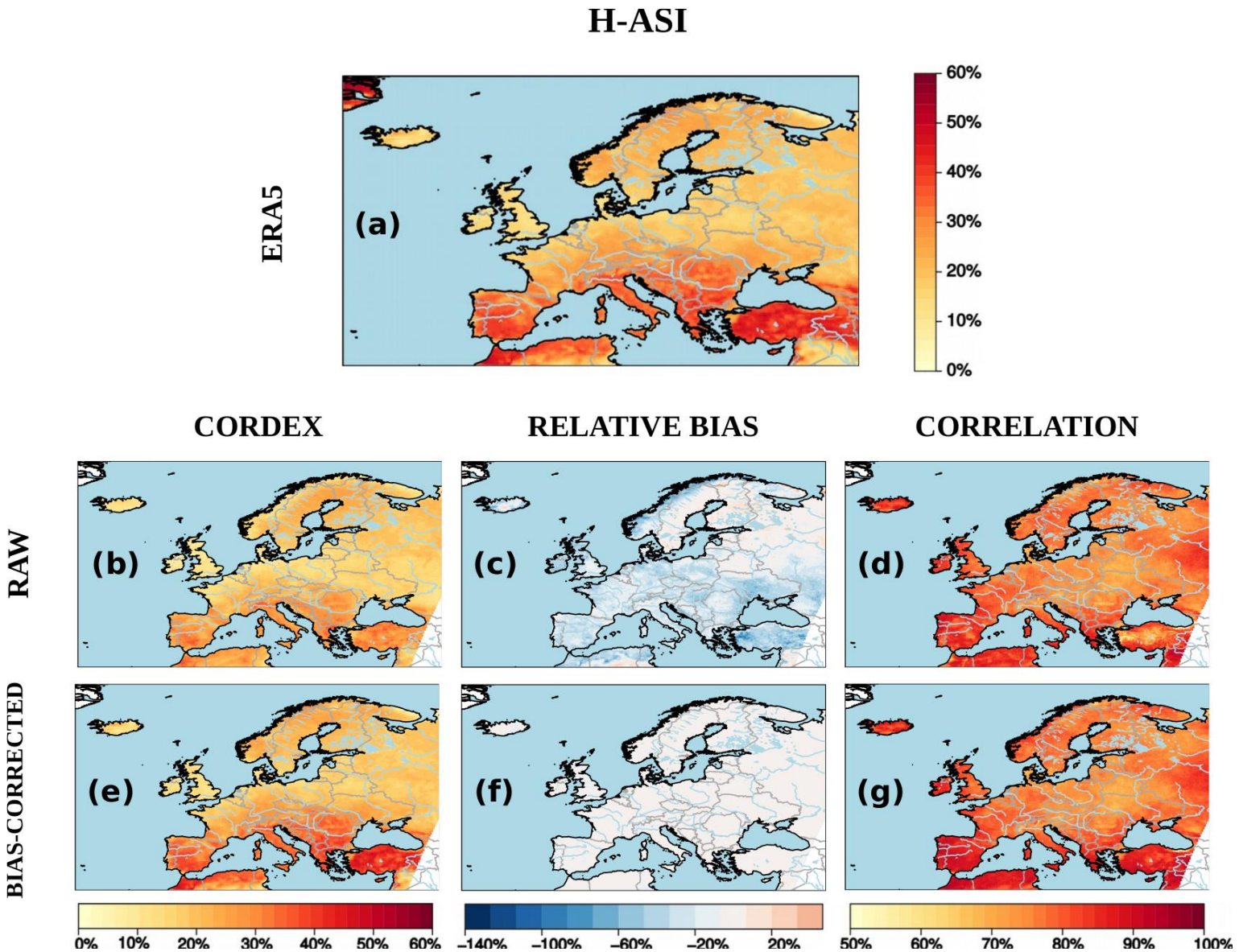
H-ASI bias


H-ASI
ERA5
(a)
60%
50%
40%
30%
20%
10%
0%
CORDEX
RELATIVE BIAS
CORRELATION
RAW
BIAS-CORRECTED
(b)
(c)
(d)
(e)
(f)
(g)
0% 10% 20% 30% 40% 50% 60%
−140% −100% −60% −20% 20%
50% 60% 70% 80% 90% 100%

Relation H-ASI & air pollution