



Future changes in frequency and intensity of meteorological and hydrological droughts in Denmark

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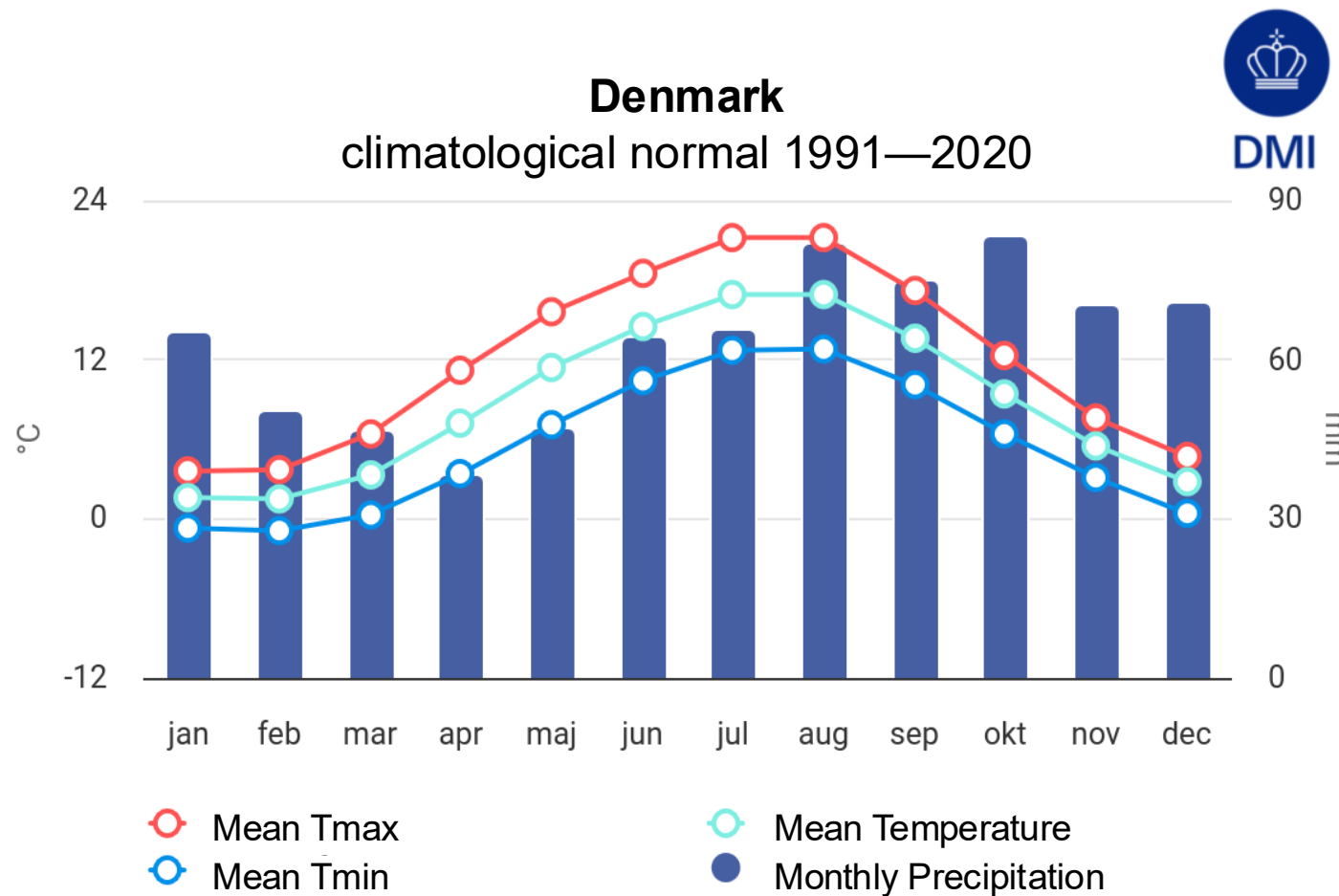
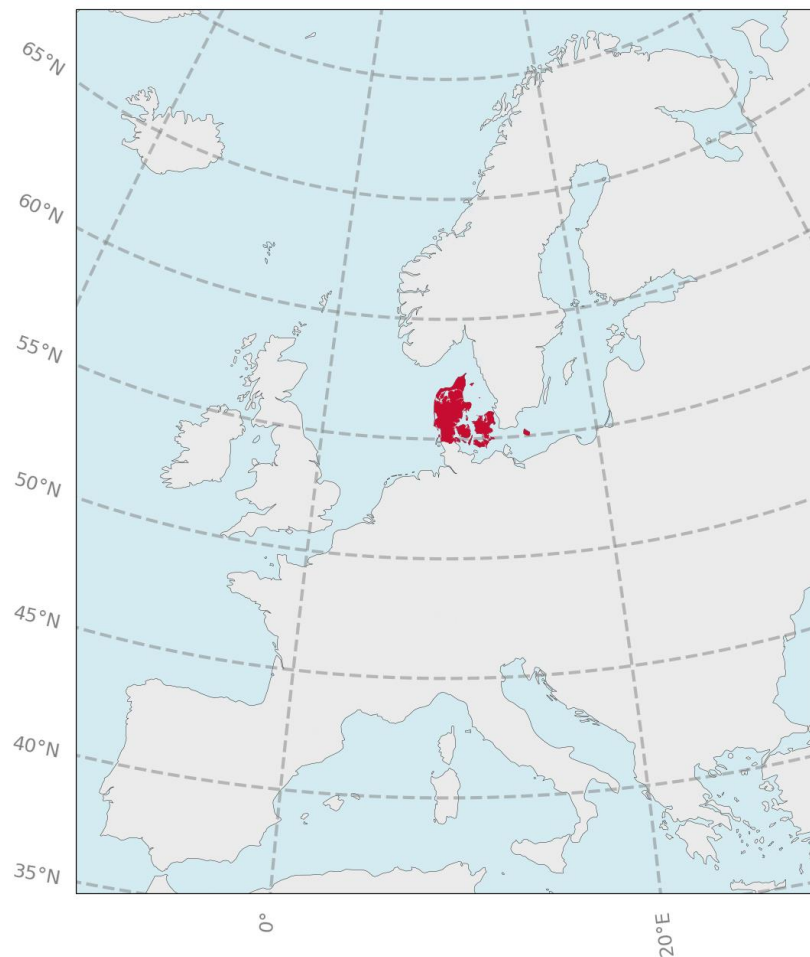
³ Department of Hydrology, Geological Survey of Denmark and Greenland (GEUS)



Danish Meteorological Institute



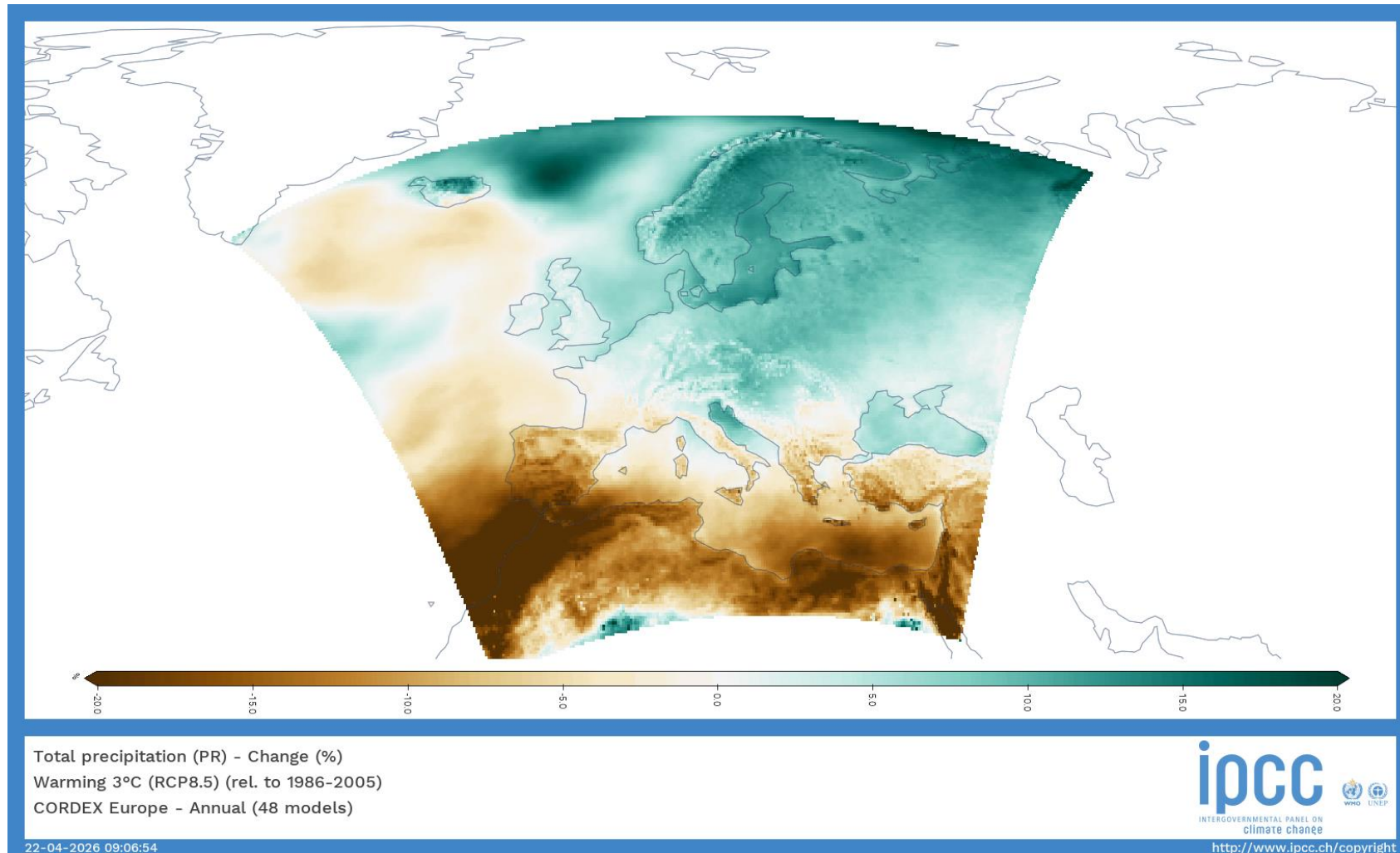
Introduction – Denmark



Source: <https://www.dmi.dk/vejrkiv/normaler-danmark>



Introduction – Precip. Change

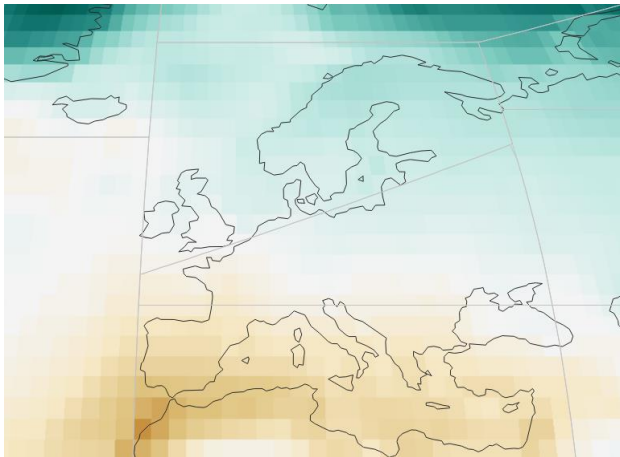


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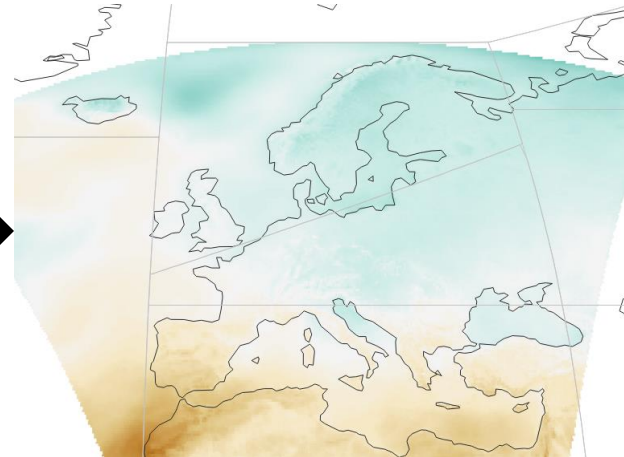
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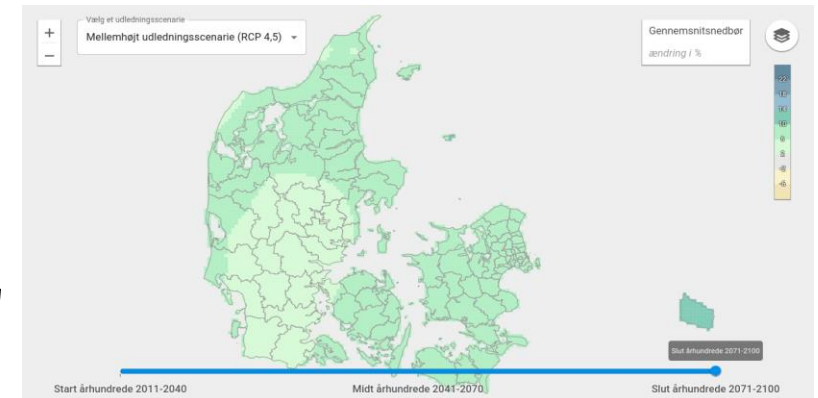
CMIP5



Euro-CORDEX

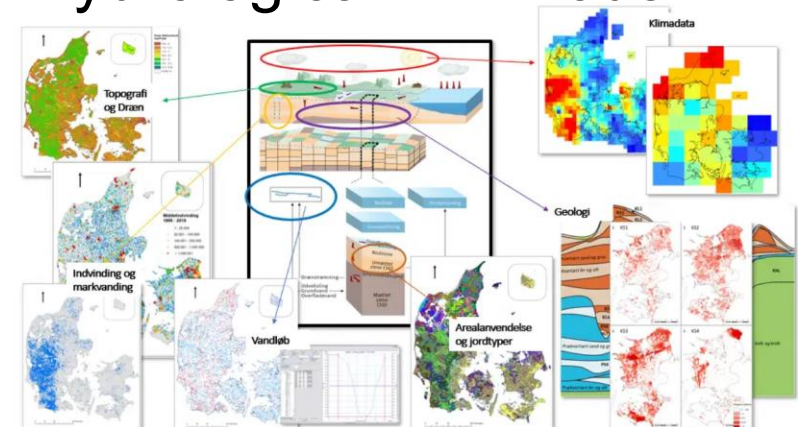


Danish Climate Atlas



Source: <https://www.dmi.dk/klima-atlas/data-i-klima-atlas>

Hydrological DK-Model



Source: <https://denationalehydrologiskemodel.dk/om-den-nationale-hydrologiske-model-dk-modellen>

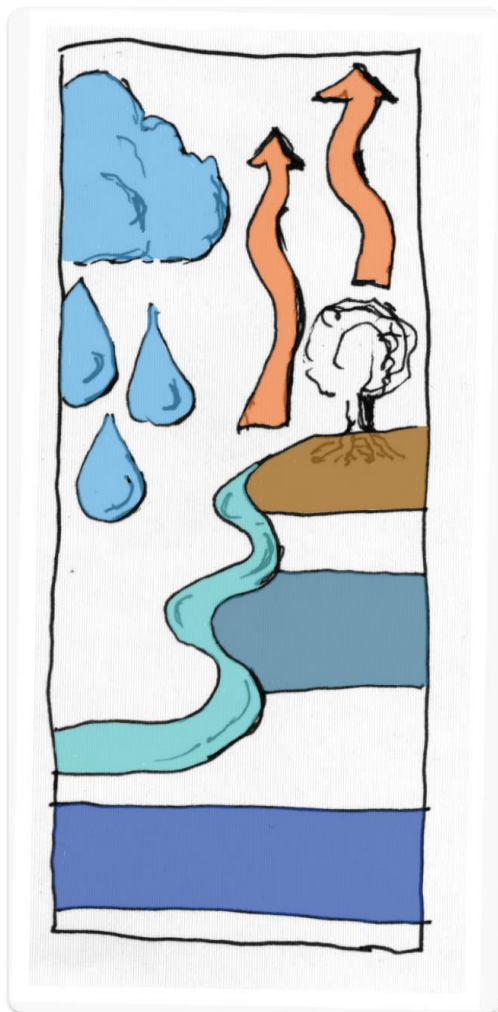
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Standardised indices

SPI

SDI



SPEI

ESSMI

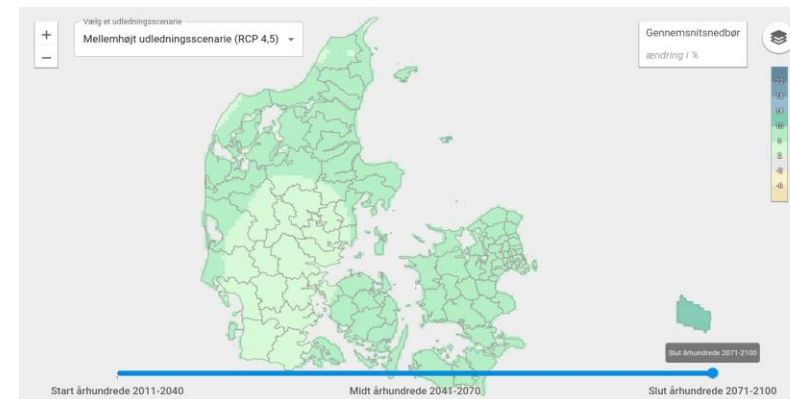
SGDI

SGDIda

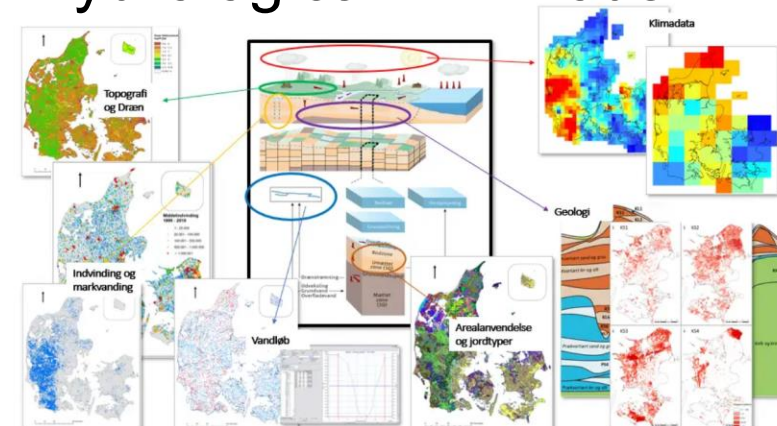
27 x RCP2.6
22 x RCP4.5
72 x RCP8.5

5 x RCP4.5
17 x RCP8.5

Danish Climate Atlas

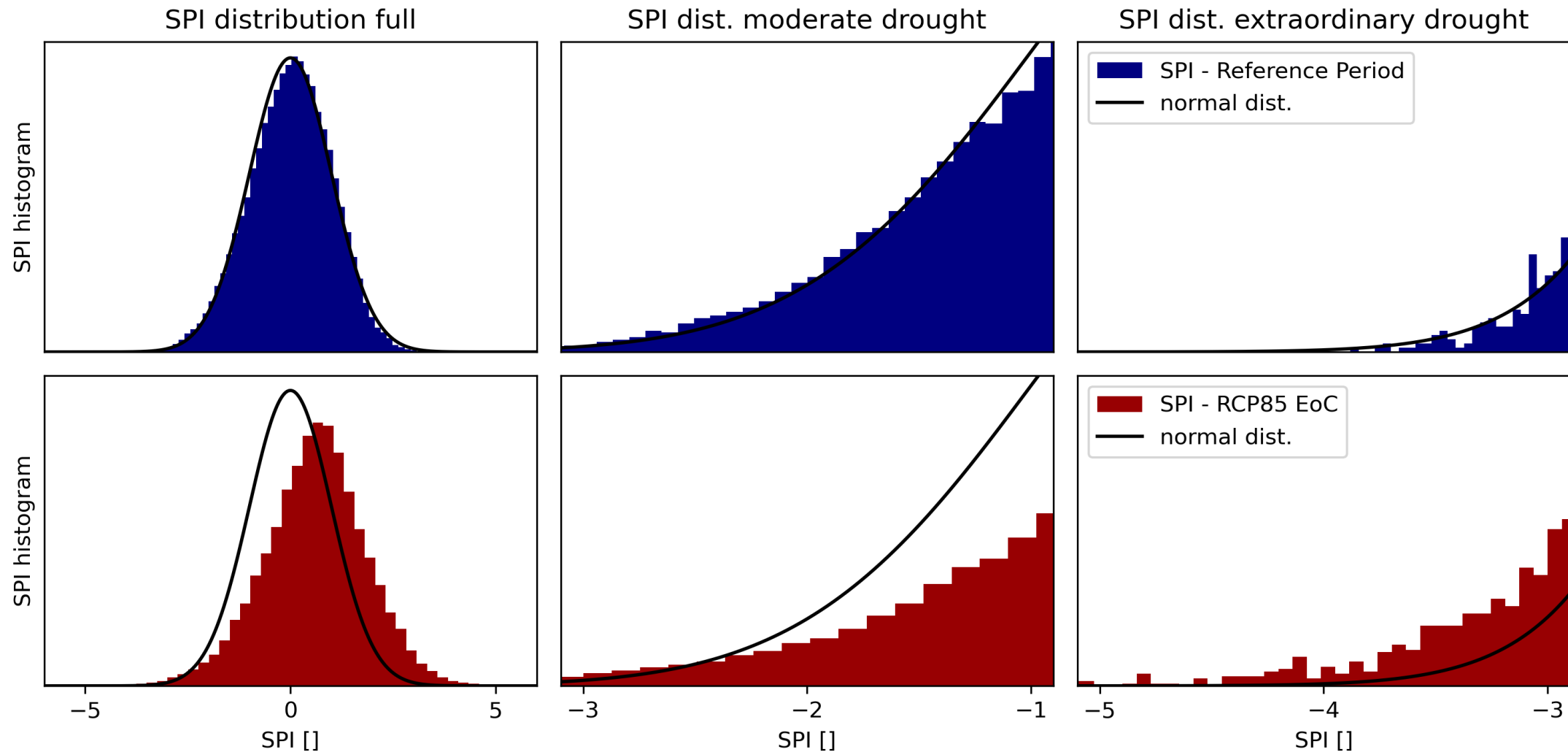


Hydrological DK-Model



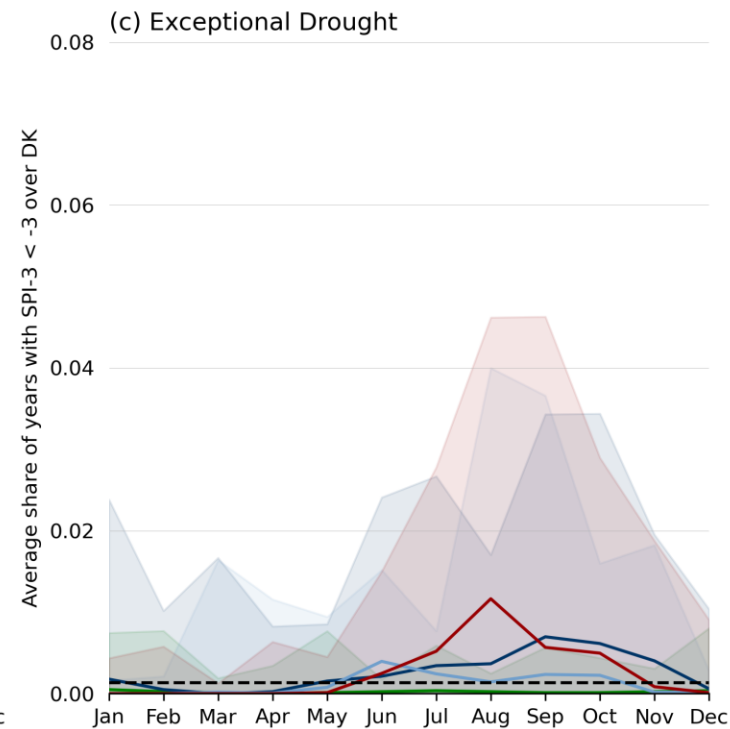
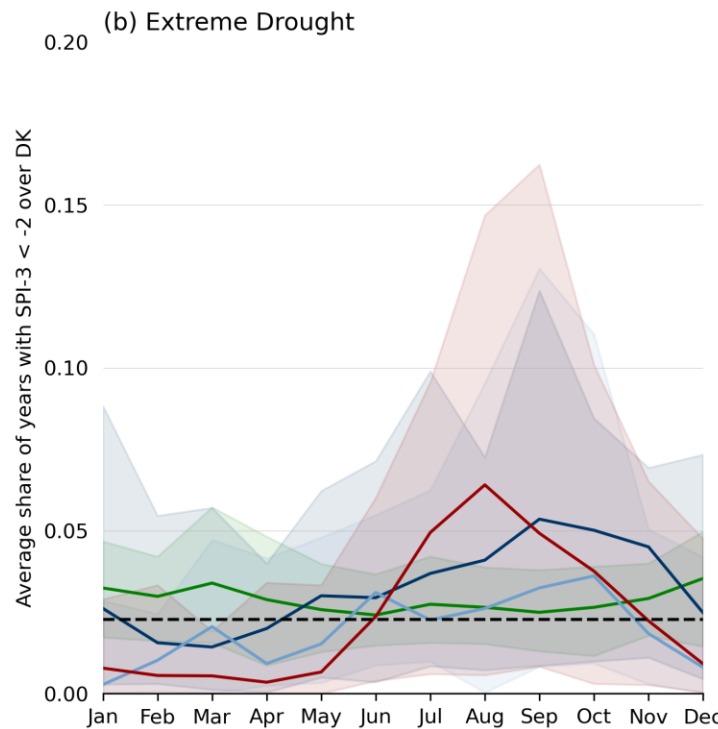
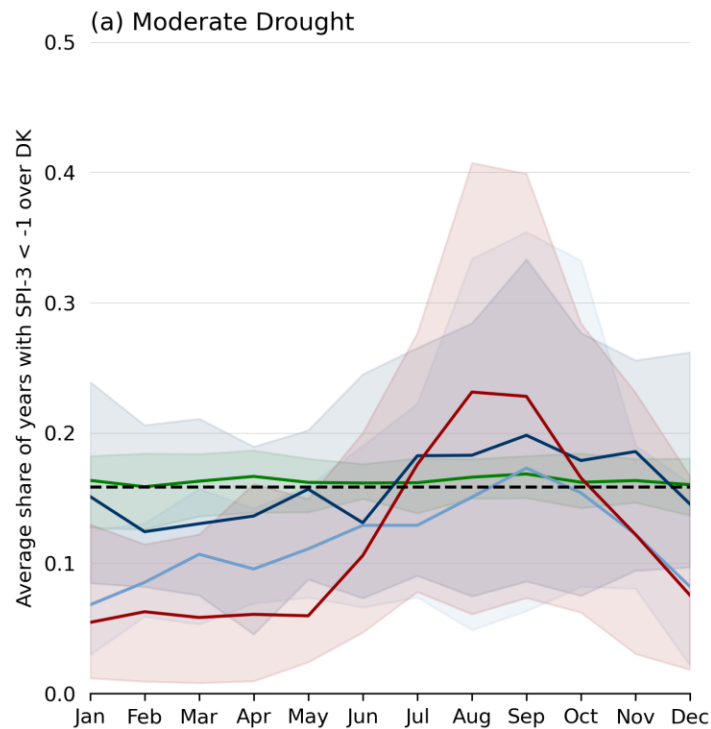
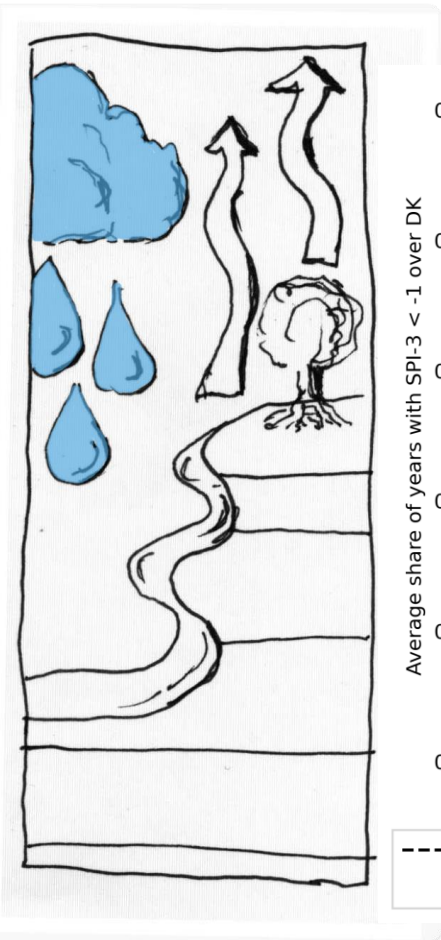


Multi-Threshold Method





Results SPI-3

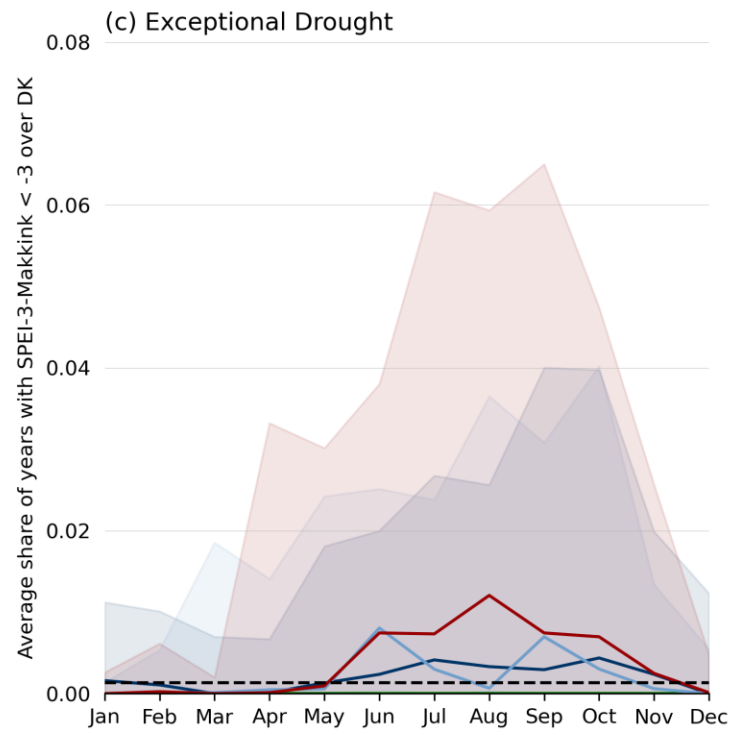
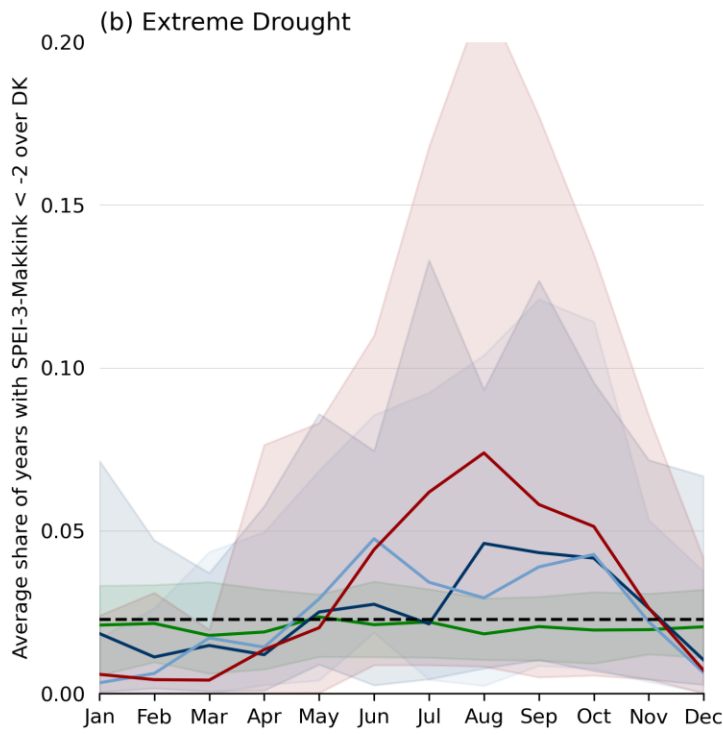
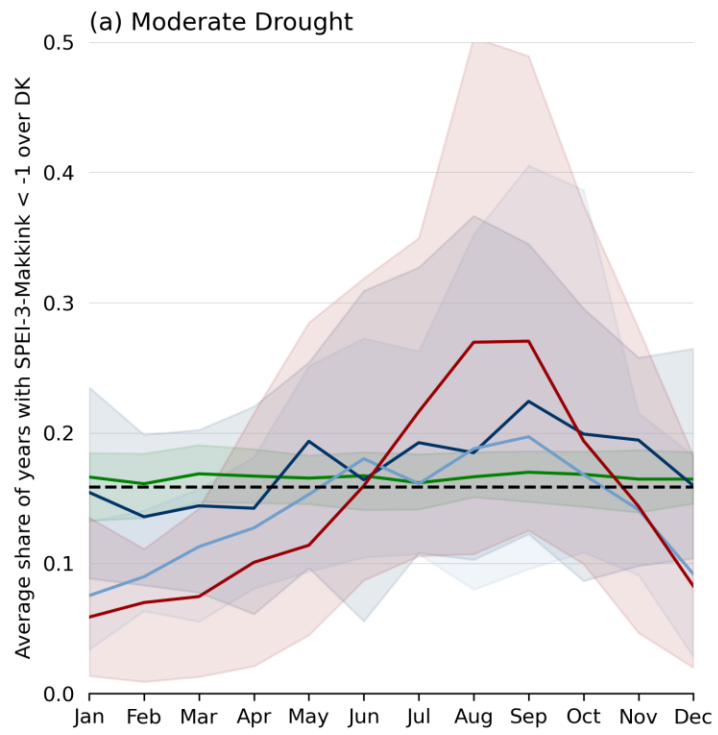
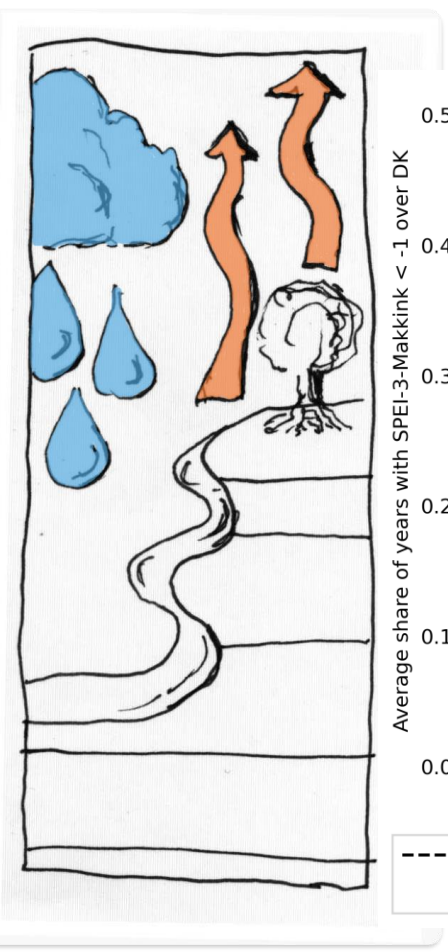


--- Statistical Value
 — Ref. Period 80% Range
 — RCP26 80% Range
 — RCP45 80% Range
 — RCP85 80% Range
— Reference Period Median
— End of Century RCP26 Median
— End of Century RCP45 Median
— End of Century RCP85 Median

End of Century = 2071-2100



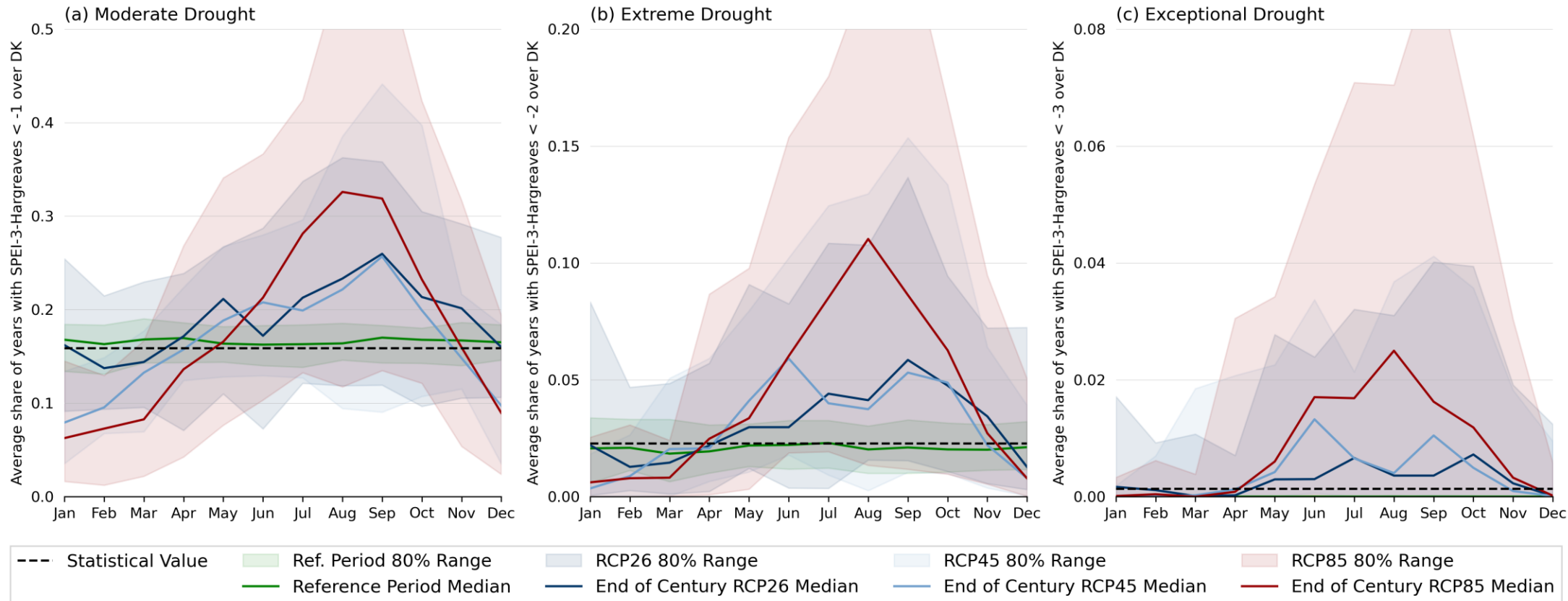
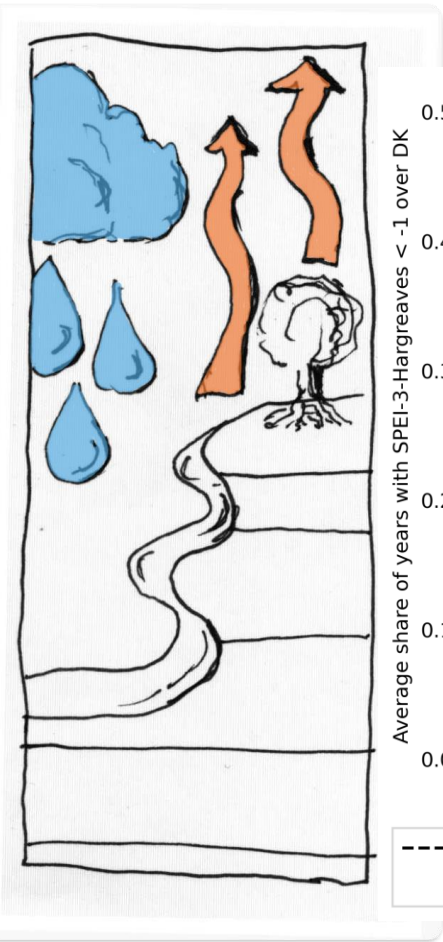
Results SPEI-3 (PET-Makkink)



--- Statistical Value
 — Ref. Period 80% Range
 — RCP26 80% Range
 — RCP45 80% Range
 — RCP85 80% Range
— Reference Period Median
— End of Century RCP26 Median
— End of Century RCP45 Median
— End of Century RCP85 Median

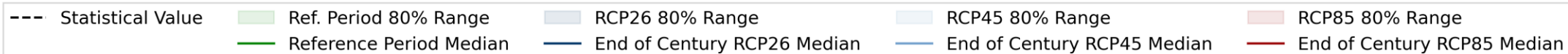
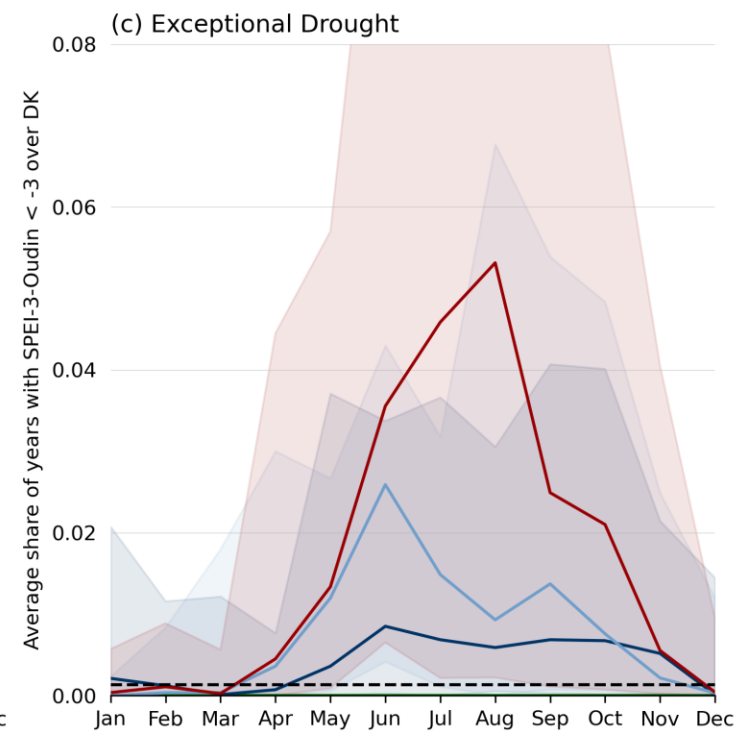
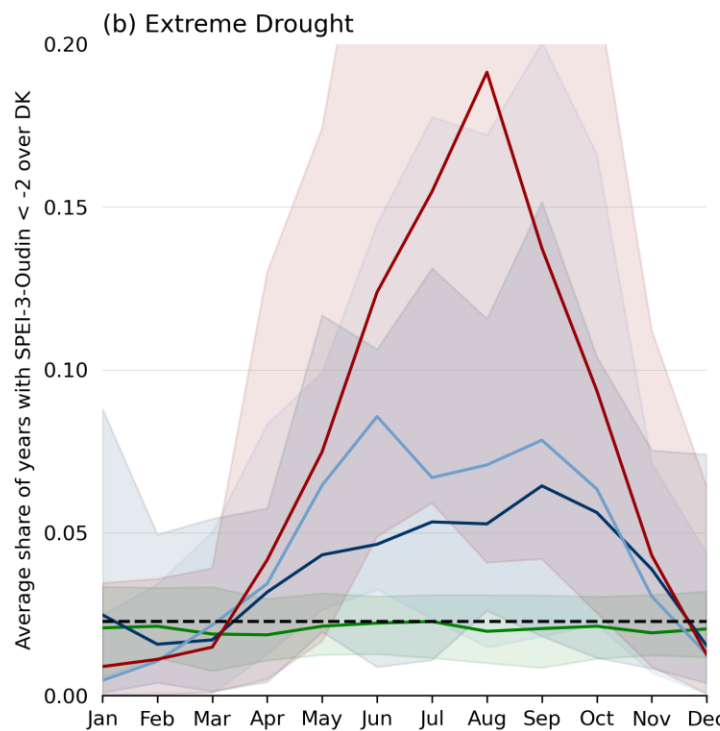
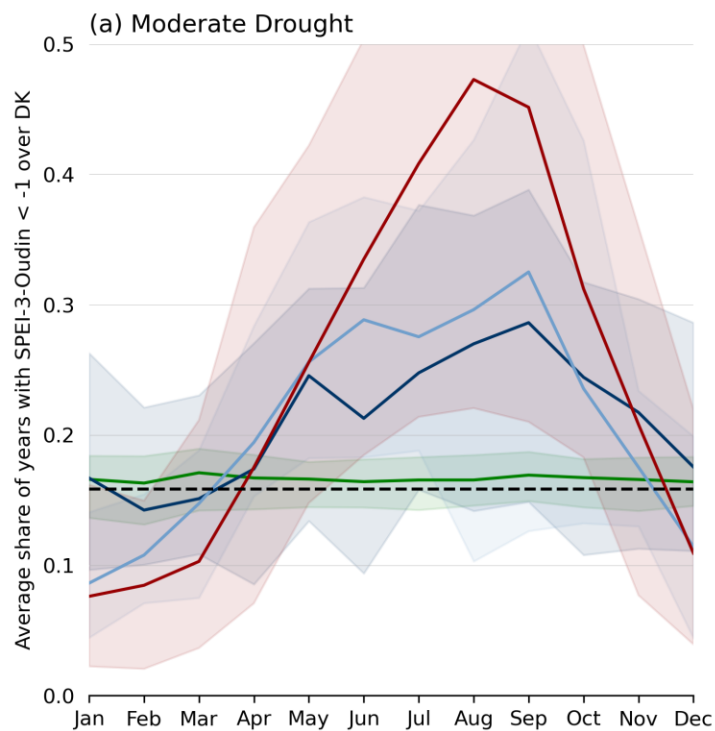
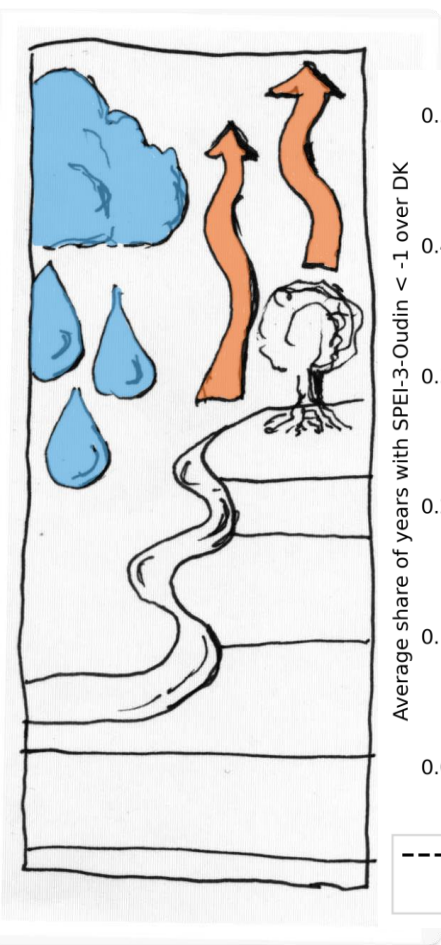


Results SPEI-3 (PET-Hargreaves)



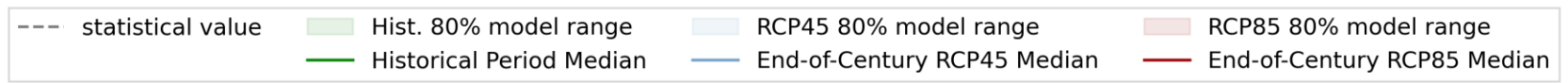
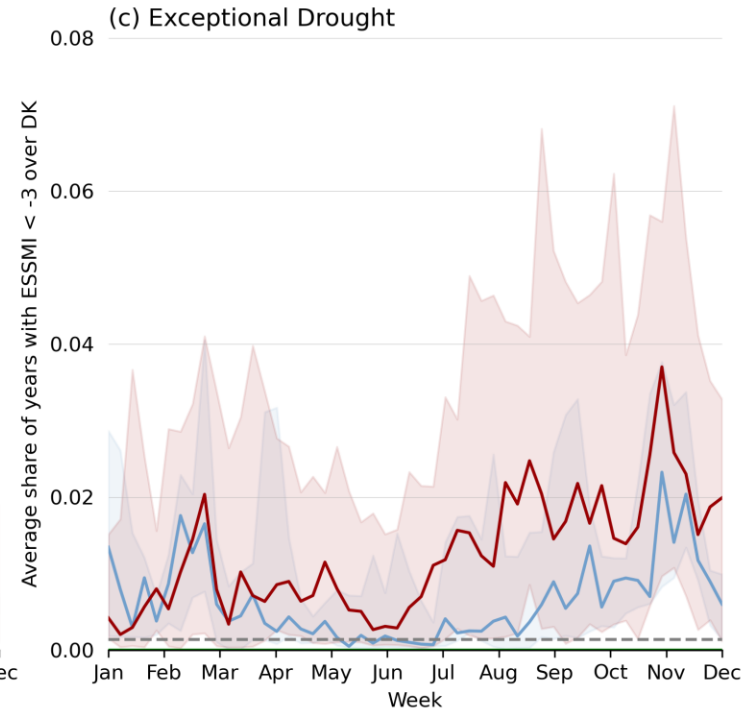
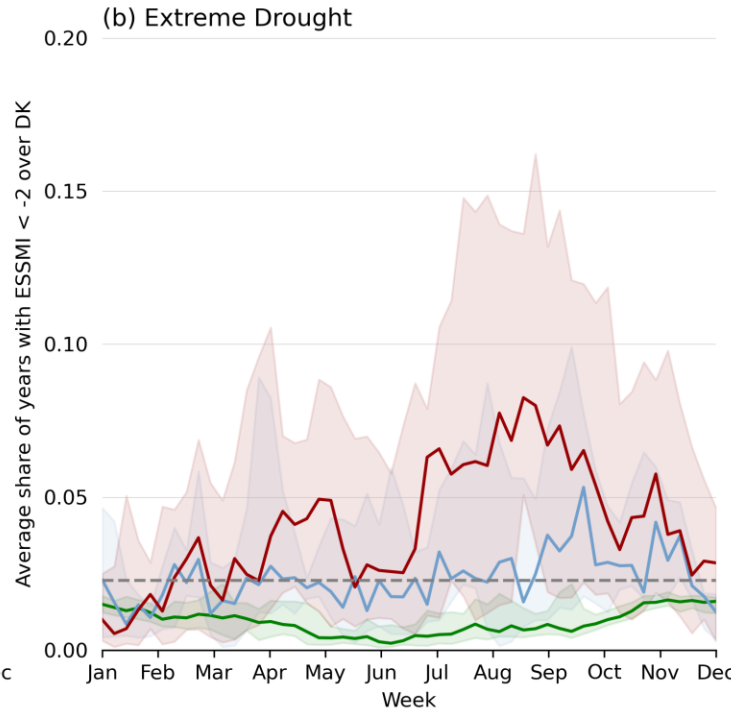
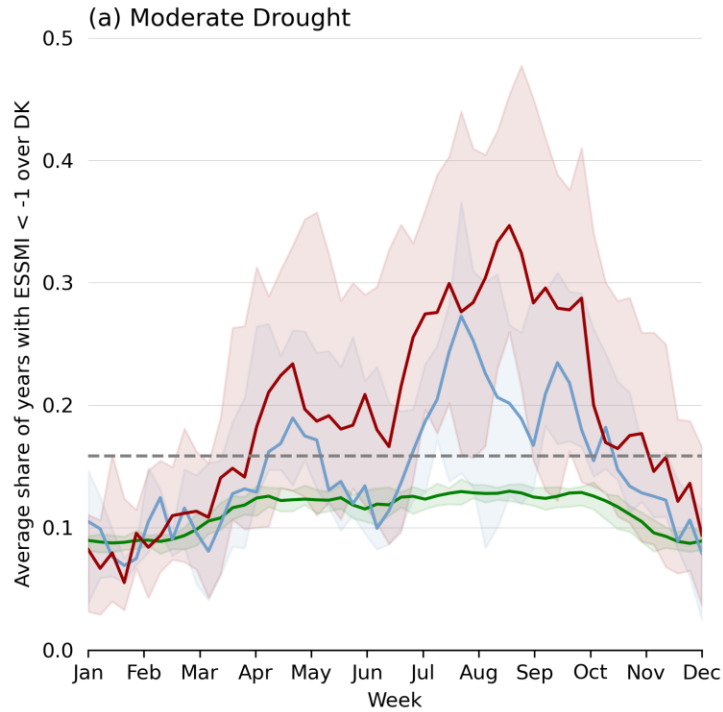
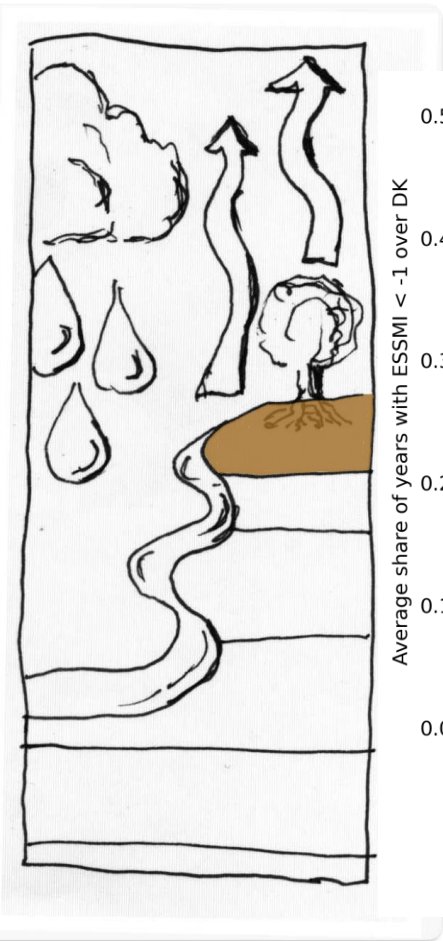


Results SPEI-3 (PET-Oudin)



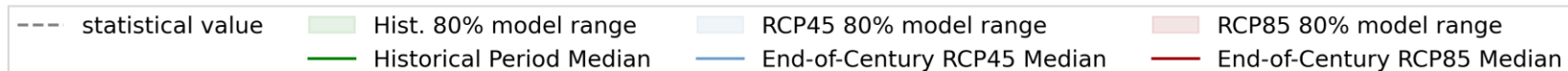
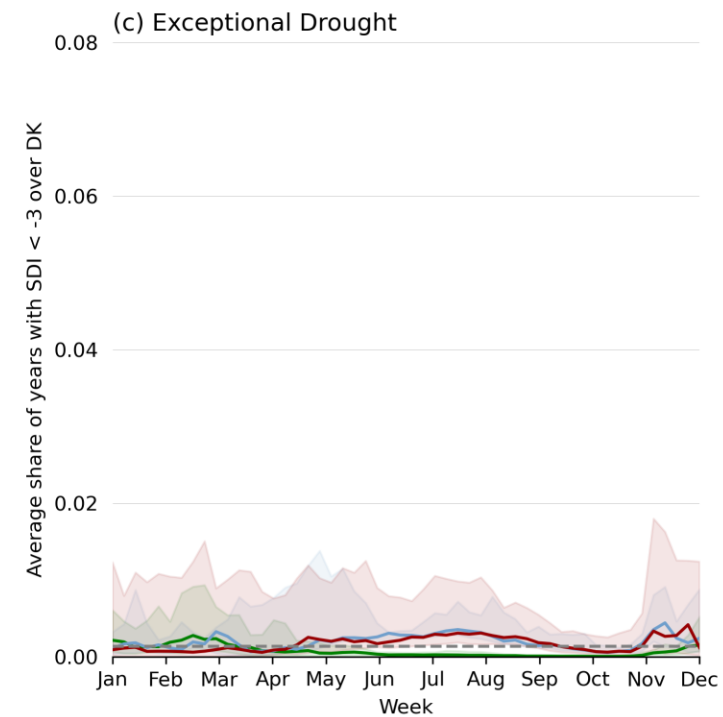
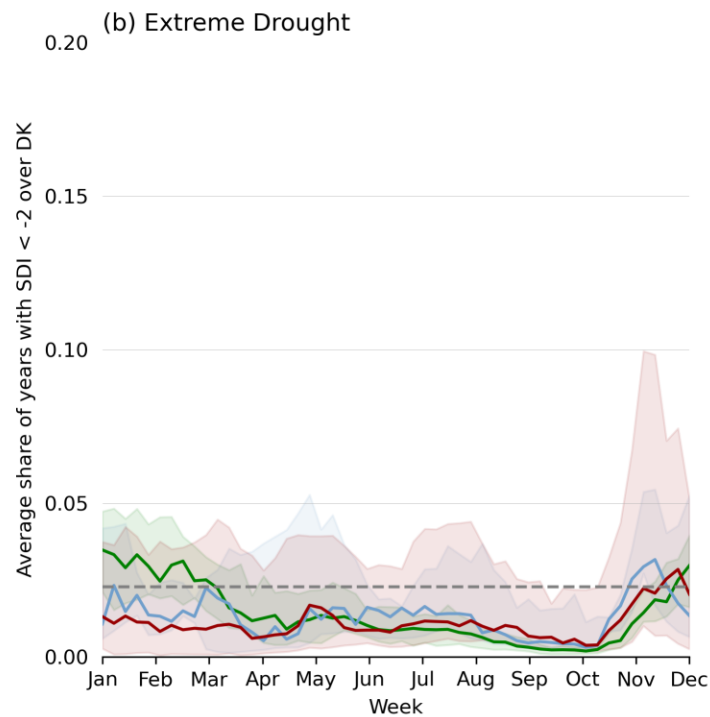
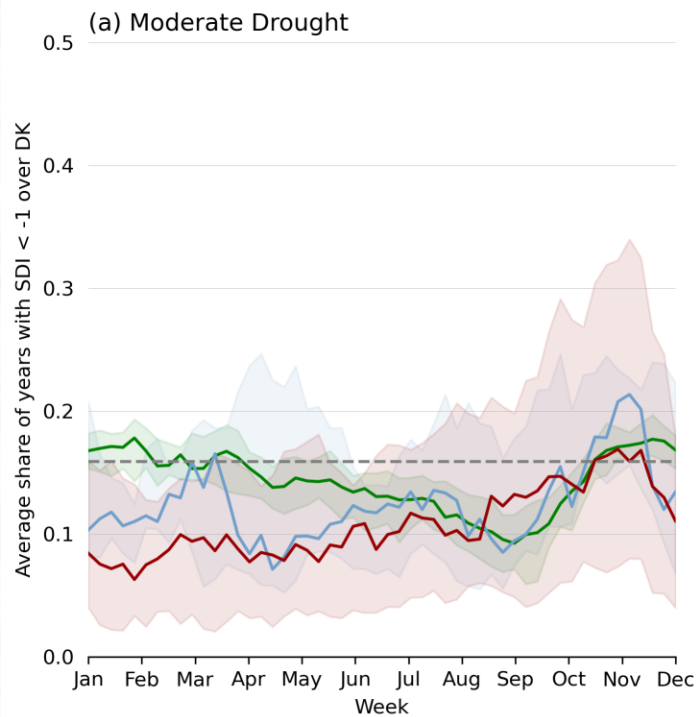
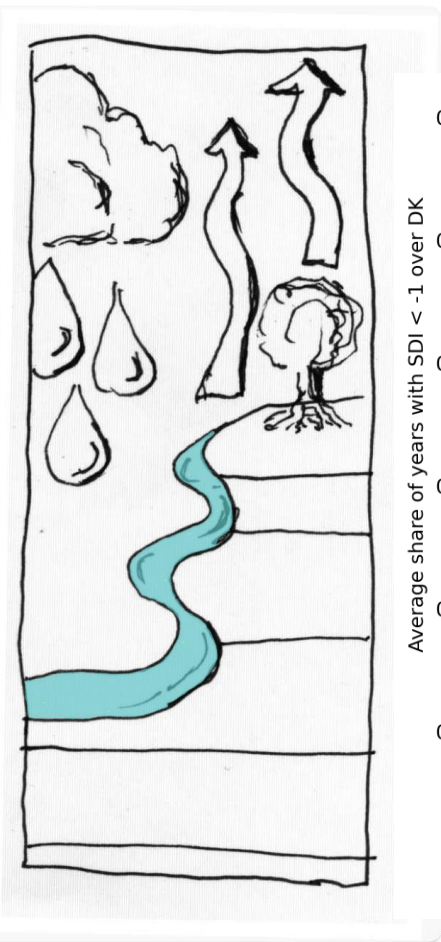


Results ESSMI



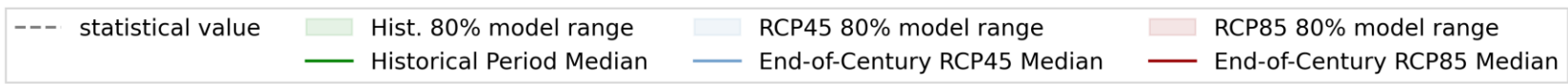
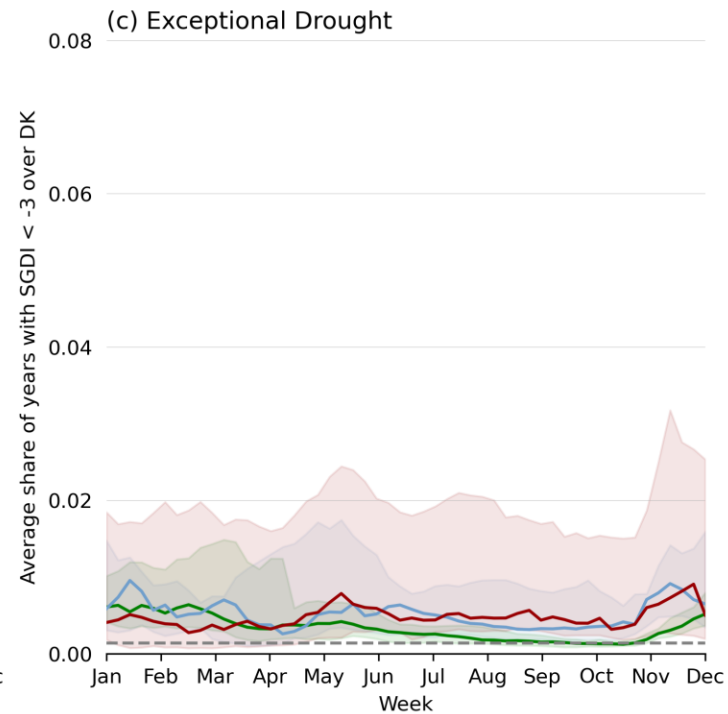
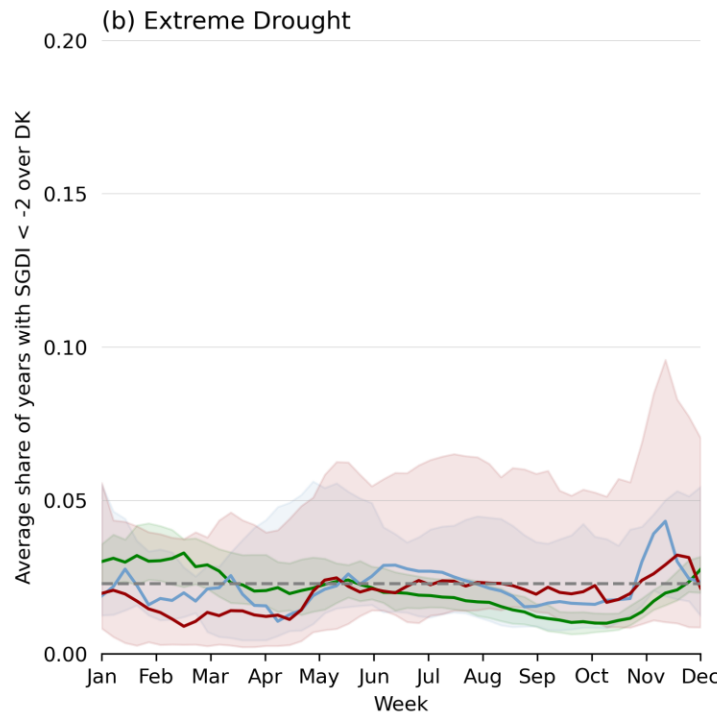
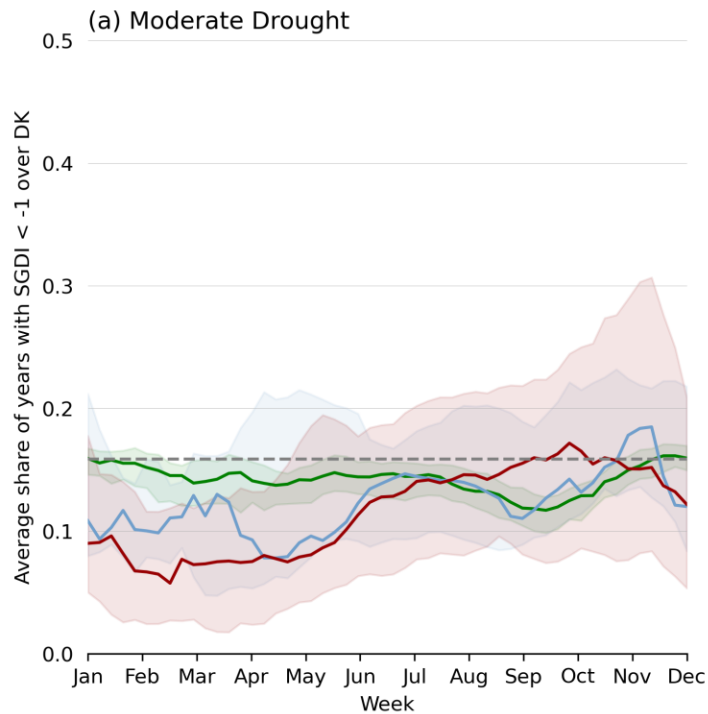
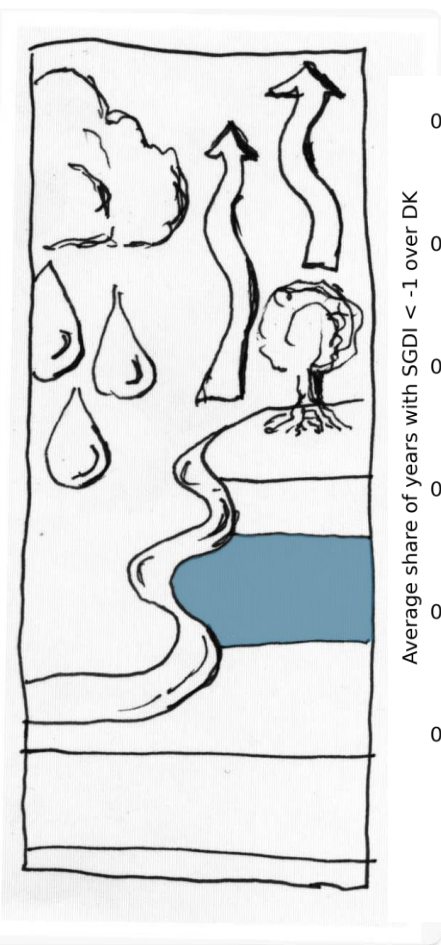


Results SDI



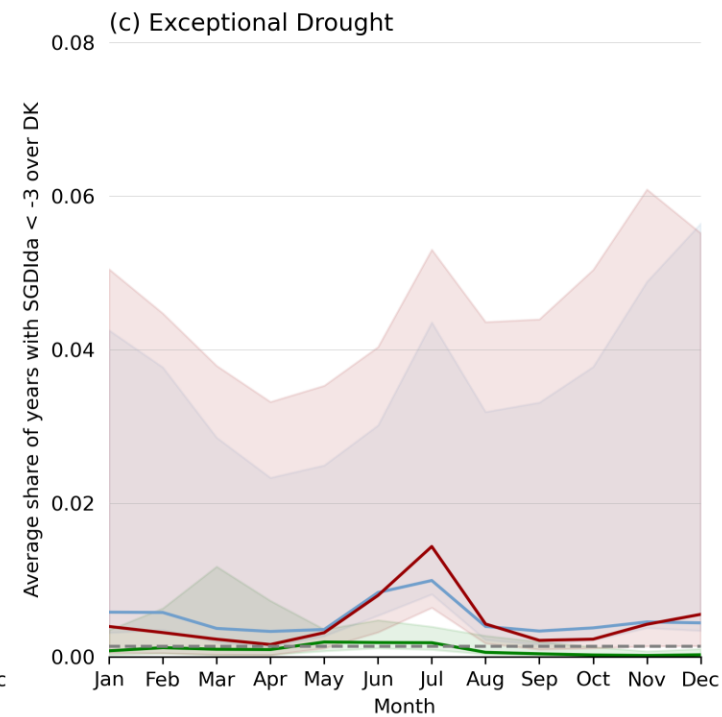
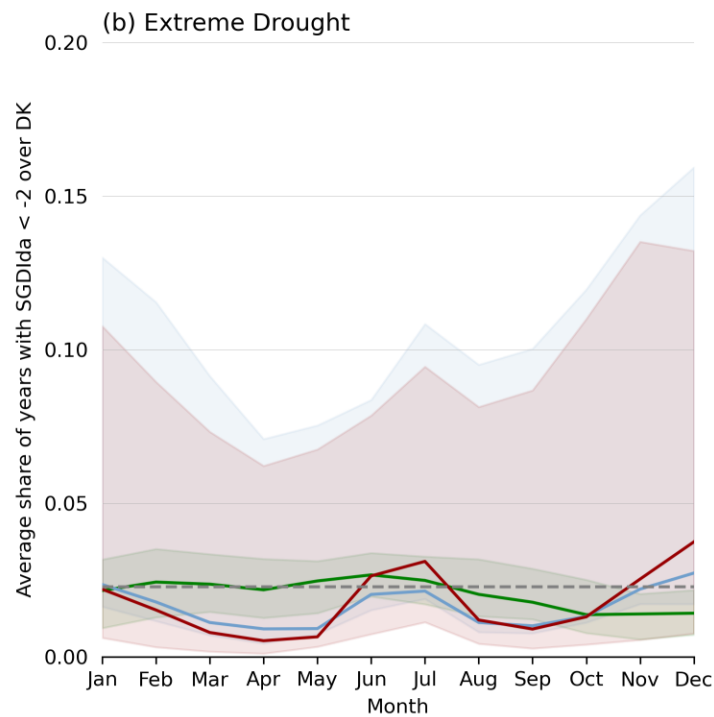
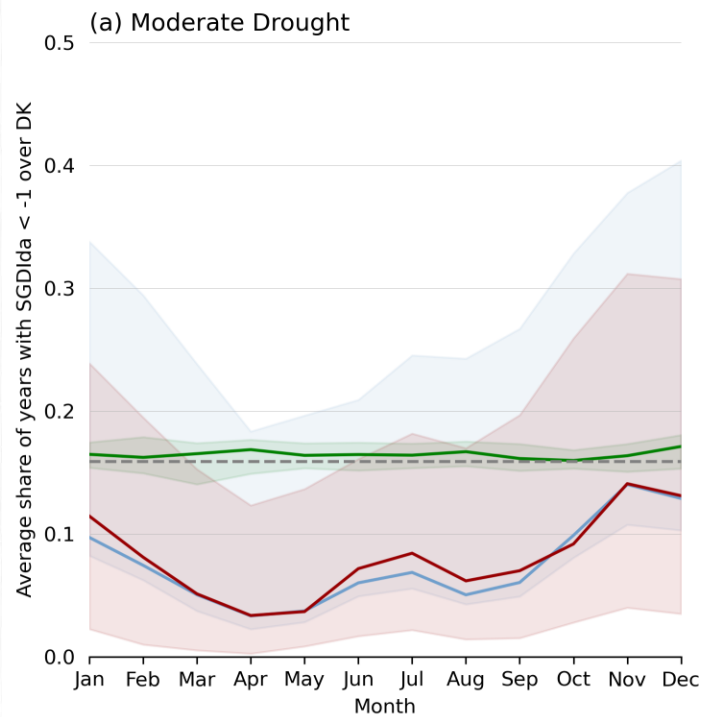
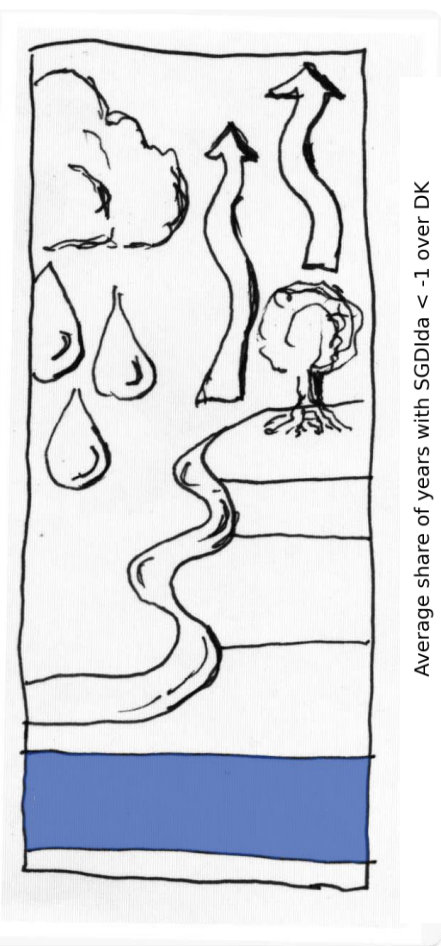


Results SGDI



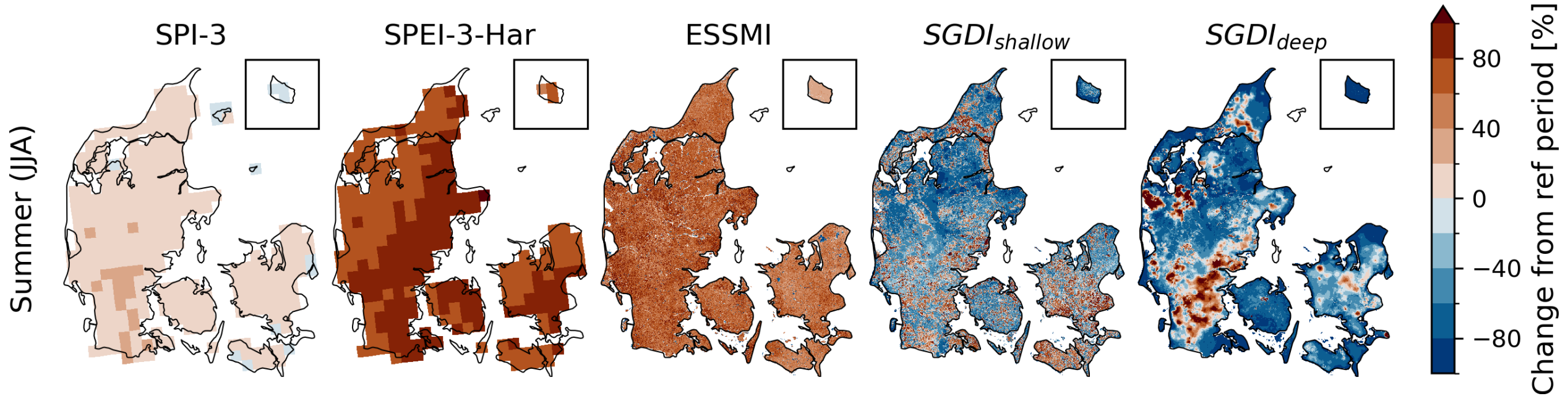
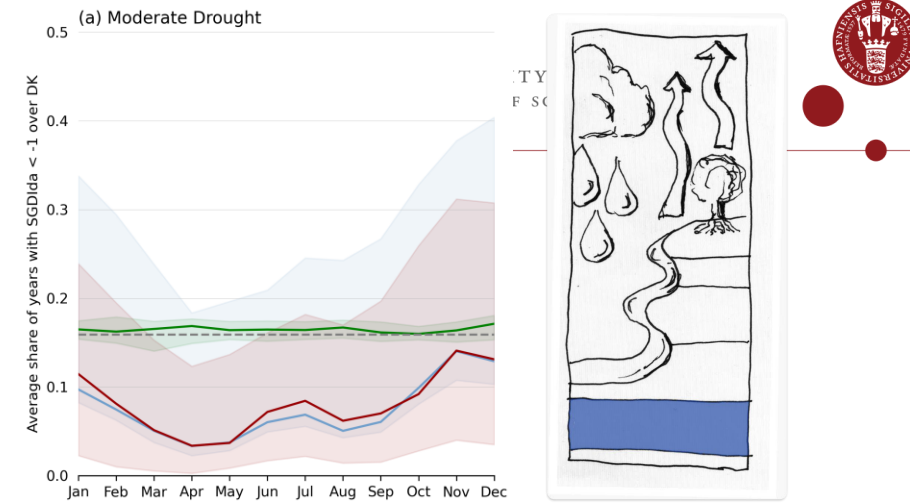


Results SGDIda



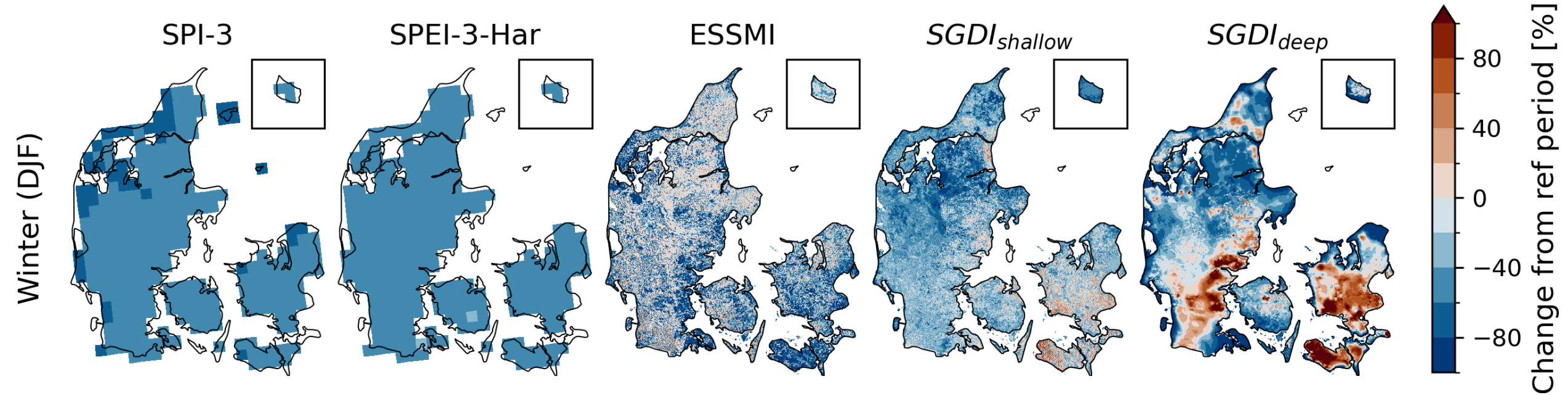
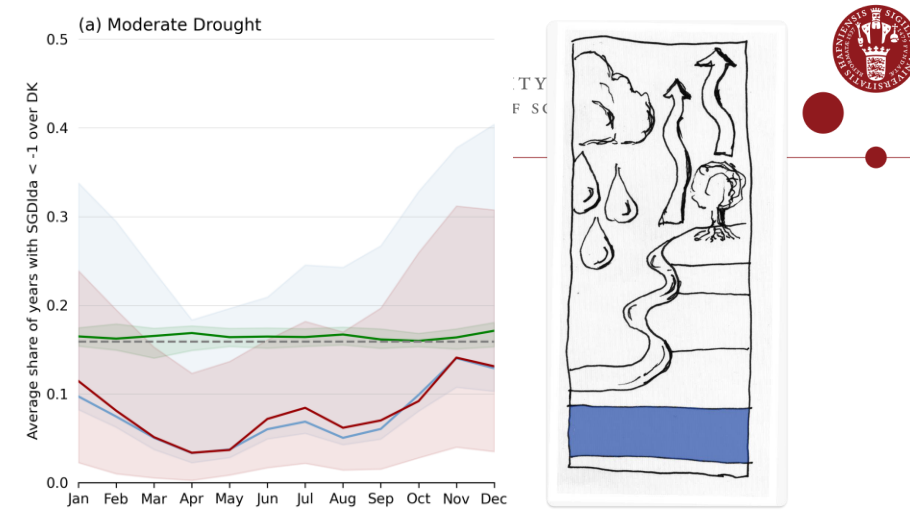
--- statistical value
 ■ Hist. 80% model range
 ■ RCP45 80% model range
 ■ RCP85 80% model range
— Historical Period Median
— End-of-Century RCP45 Median
— End-of-Century RCP85 Median

Is future GW fine then?



RCP8.5 - Moderate drought levels

Winter droughts



RCP8.5 - Moderate drought levels



Conclusion

- Do not exclude seasonal signals!
- More summer droughts are projected in the future in Denmark
- Extreme droughts become (much) more likely
- GW droughts are more affected by geology and soils than precipitation

Changes in streamflow, shallow GW or the influence of different PET methods?

- Manuscript will be submitted soon
- Get in touch through email (ruben.haeberli@nbi.ku.dk), or LinkedIn:



Questions



Appendix





Acknowledgments & Contact Information

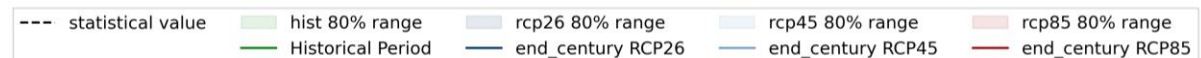
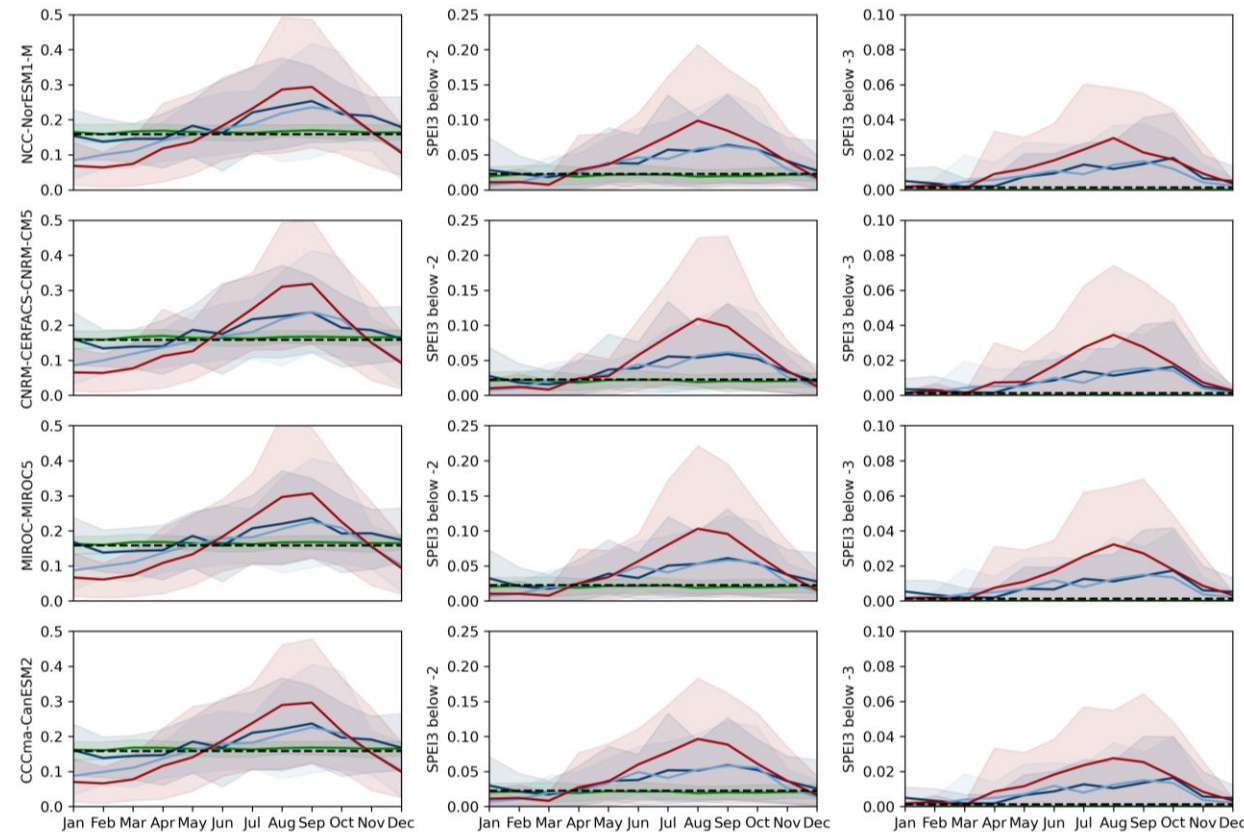
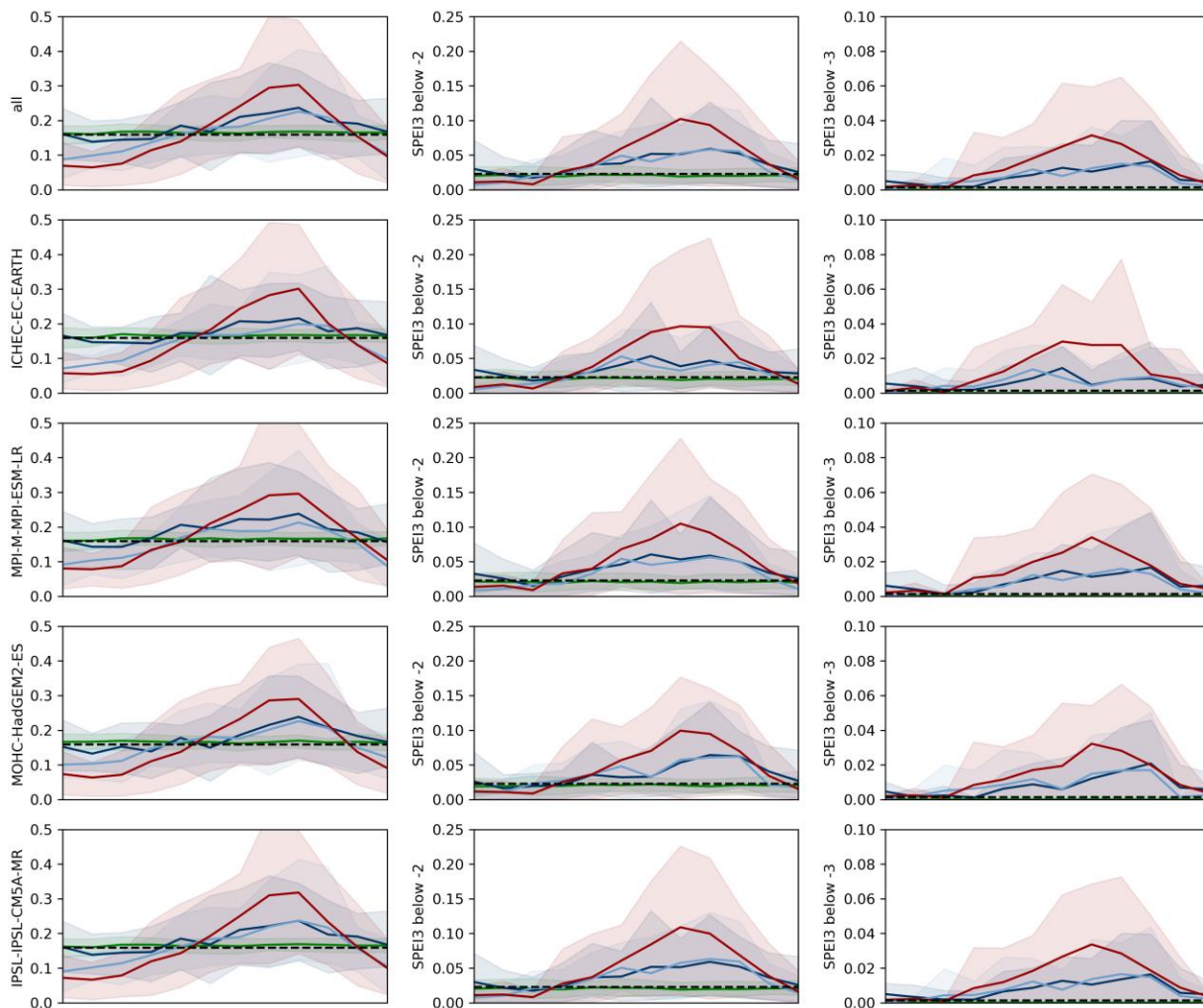
We gratefully acknowledge the effort from the colleagues at DMI and GEUS that made this research possible.

Contact: ruben.haeberli@nbi.ku.dk

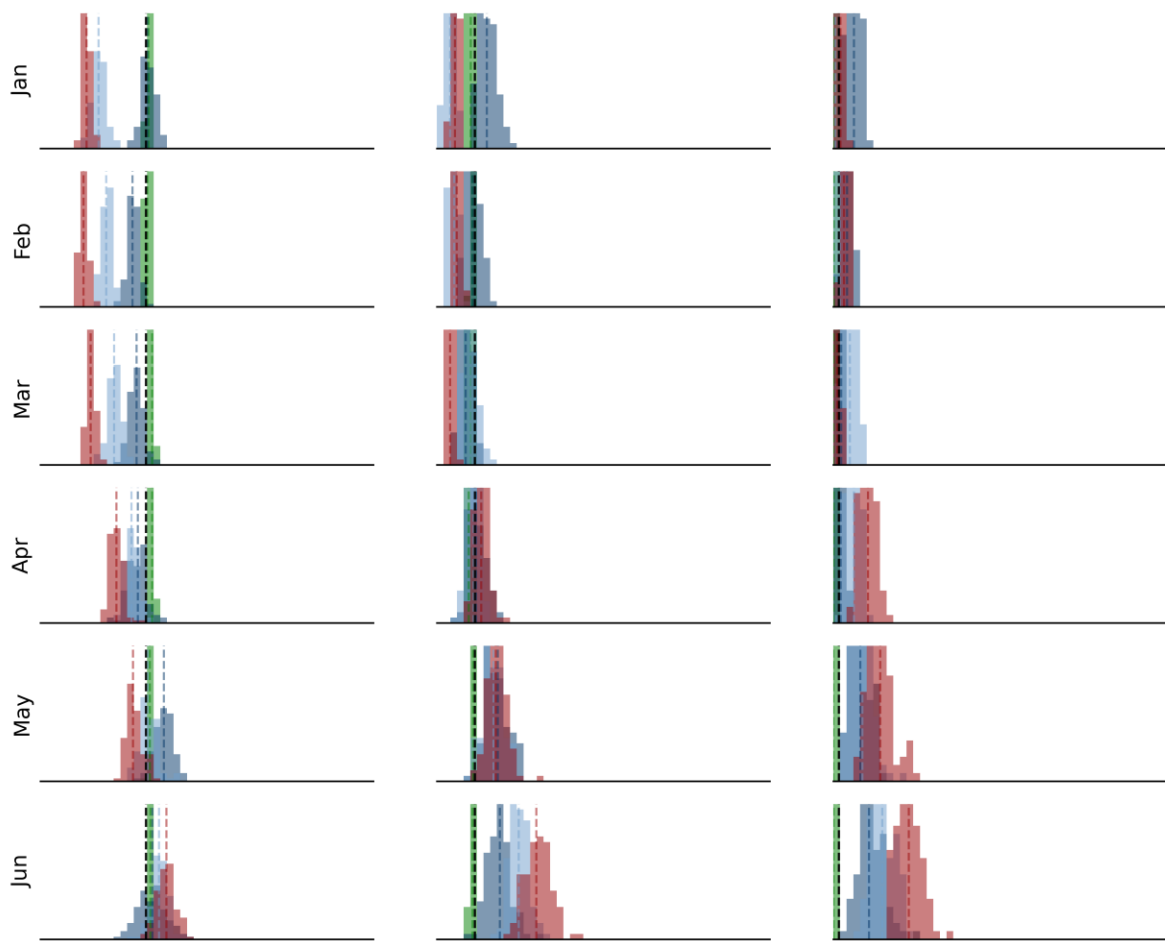




GCM influence



Resampling



SPEI-3 Hargreaves

