

# La sécheresse 2022 est-elle une conséquence du changement climatique ?

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# Context – Attribution of Single Extreme Events

## Describing the relationship between an extreme event and climate change

- Usually no deterministic (necessary) causality.  
(e.g., the event was *possible* without climate change)
- Climate change potentially affects the probability of the event,  
(considering a given threshold)
- Climate change potentially affects the intensity if the event,  
(considering a given occurrence probability)

## Recent progresses (IPCC WG1 AR6 Ch.11, 2021)

*“there have been important new developments and knowledge advances on changes in weather and climate extremes, in particular regarding human influence on individual extreme events, on changes in droughts, ...”*

# Temperature

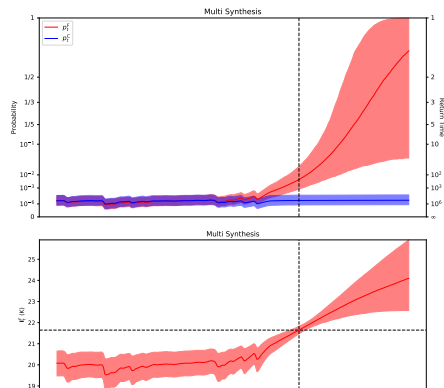
**IPCC AR6:** Heatwaves increase in frequency and intensity.

## 12–25 July Heatwave:

- Event: +3°C; 14 days.
- Change in frequency: x8 [x4 to x20],
- Change in intensity: +2 [+1.4 to +2.6] °C,
- Probability (curr. climate): 25%.

## May to August Heat:

- Event: +3.8°C; 4 months.
- Change in frequency: x500 [x50 to x10.000],
- Change in intensity: +1.5 [+1.1 to +2] °C,
- Probability (curr. climate):  $5 \cdot 10^{-3}$  [ $10^{-3}$  to 2%].



Attribution of May–August heat.

Top: change in probability (red: factual world, blue: counterfactual, i.e., no human influence). Bottom: human-induced increase in intensity.

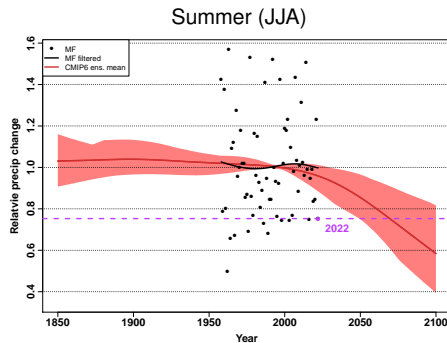
# Precipitation

**IPCC AR6:** Expected increase in maximum consecutive dry days.

No formal attribution study...

**June – August rainfall:**

- not so rare ( $p \sim 15\%$ ),
- normal in late 21C.



France avg rainfall vs CMIP6 models

histSSP5-8.5 scenario

Adapted from Ribes et al. (2022)

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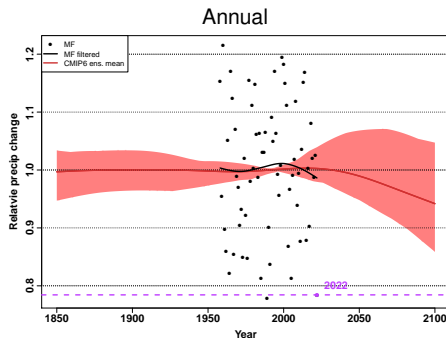
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## June – August rainfall:

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## Full 2022 rainfall:

- rare event ( $p \sim 3\%$ ),
- long-term trend unclear,
- some models simulate substantial drying.



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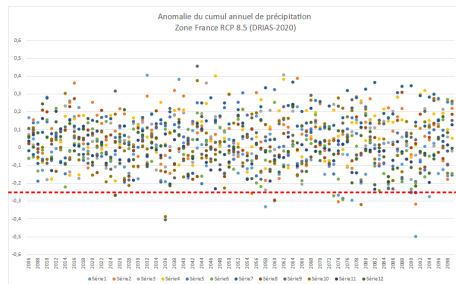
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### Annual



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RCP8.5 scenario

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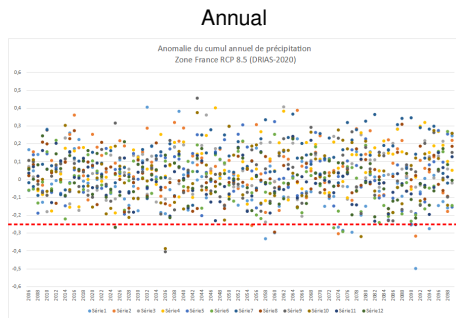
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**Early 2023 rainfall deficit?**

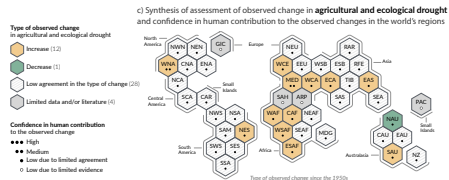


France avg rainfall vs DRIAS models  
RCP8.5 scenario

# Soil moisture

**IPCC AR6:** Increase of drought frequency and severity (regions: WCE, MED).

Climate change is already affecting every inhabited region across the globe with human influence contributing to many observed changes in weather and climate extremes



IPCC WG1 AR6 SPM, Fig SPM.3



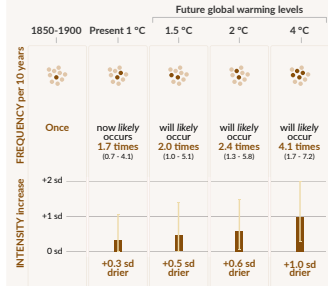
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## Agricultural & ecological droughts in drying regions

### 10-year event

Frequency and increase in intensity of an agricultural and ecological drought event that occurred once in 10 years on average across drying regions in a climate without human influence

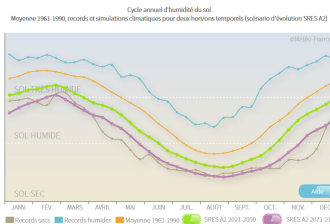
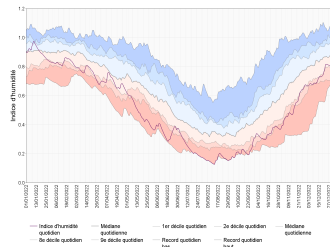


IPCC WG1 AR6 SPM, Fig SPM.6

# Soil moisture

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## Expected soil drying



Soil moisture response in RCP8.5 scenario vs year 2022.

# Soil moisture

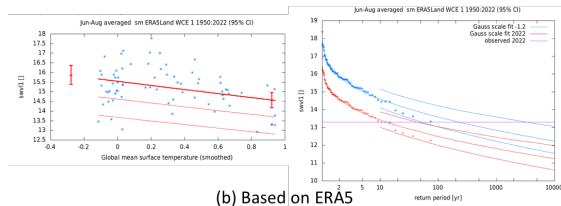
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## Expected soil drying

**WWA study** (Schumacher et al., not yet published)

- Root zone soil moisture drought  $\sim 3\text{--}4$  times more likely now,
- Larger trends in obs than models,
- see also Douville & Plazotta (2017, GRL).

(a) Based on ERA5-Land



(b) Based on ERA5

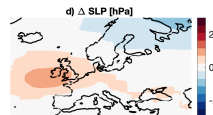
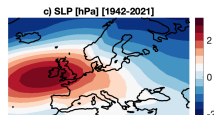
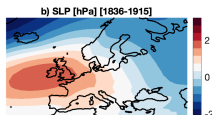
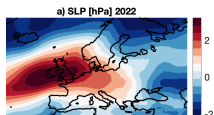
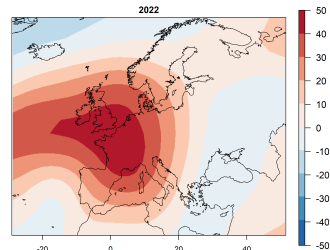
From Schumacher et al. (WWA), Fig 4.

# Circulation

Is the 2022 recurrence of high pressure over France related to the human influence?

**IPCC AR6:** No strong conclusion.

Faranda et al. (2023): Analog evidence suggests *maybe*



Analogues of the 2022 SLP over 1836–1915 and 1942–2021.

# Conclusion

Consistent with IPCC conclusions, the human influence is found to be:

- extremely clear on temperature ; some features of 2022 are not extreme in today's climate,
- pretty clear on low soil moisture and summer (lack of) rainfall,
- uncertain on annual (lack of) rainfall.

*There is high confidence that concurrent heatwaves and droughts have increased in frequency over the last century at the global scale due to human influence (IPCC AR6, 2021).*

Research on event attribution to continue (MF, IPSL, Drias, PEPR TRACCS).

# References

- Douville, H., Plazzotta, M. (2017). Midlatitude Summer Drying: An Underestimated Threat in CMIP5 Models? *Geophysical Research Letters*, 44(19), 9967–9975. <https://doi.org/10.1002/2017GL075353>
- Faranda, D., Pascale, S., Bulut, B. (2023). Persistent anticyclonic conditions and climate change exacerbated the exceptional 2022 European-Mediterranean drought. *Environmental Research Letters*. <https://doi.org/10.1088/1748-9326/acbc37>
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- Schumacher, D. L., Zachariah, M., Otto, F., Barnes, C., Philip, S., Kew, S., Vahlberg, M., Singh, R., Heinrich, D., Arrighi, J., van Aalst, M., Thalheimer, L., Raju, E., Hauser, M., Hirschi, M., Gudmundsson, L., Rodell, M., Li, S., Yang, W., Seneviratne, S. I. (s. d.). High temperatures exacerbated by climate change made 2022 Northern Hemisphere soil moisture droughts more likely.