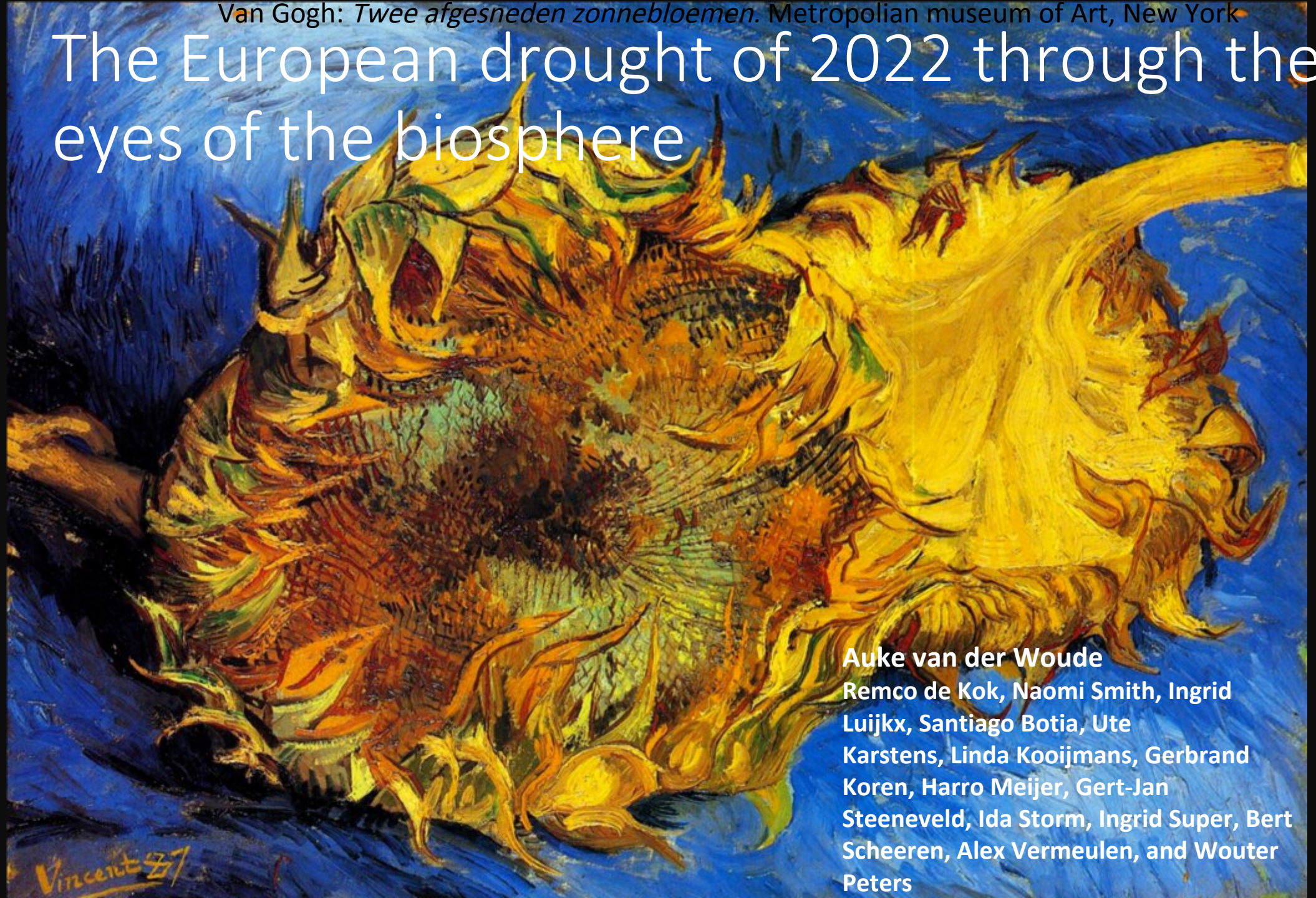
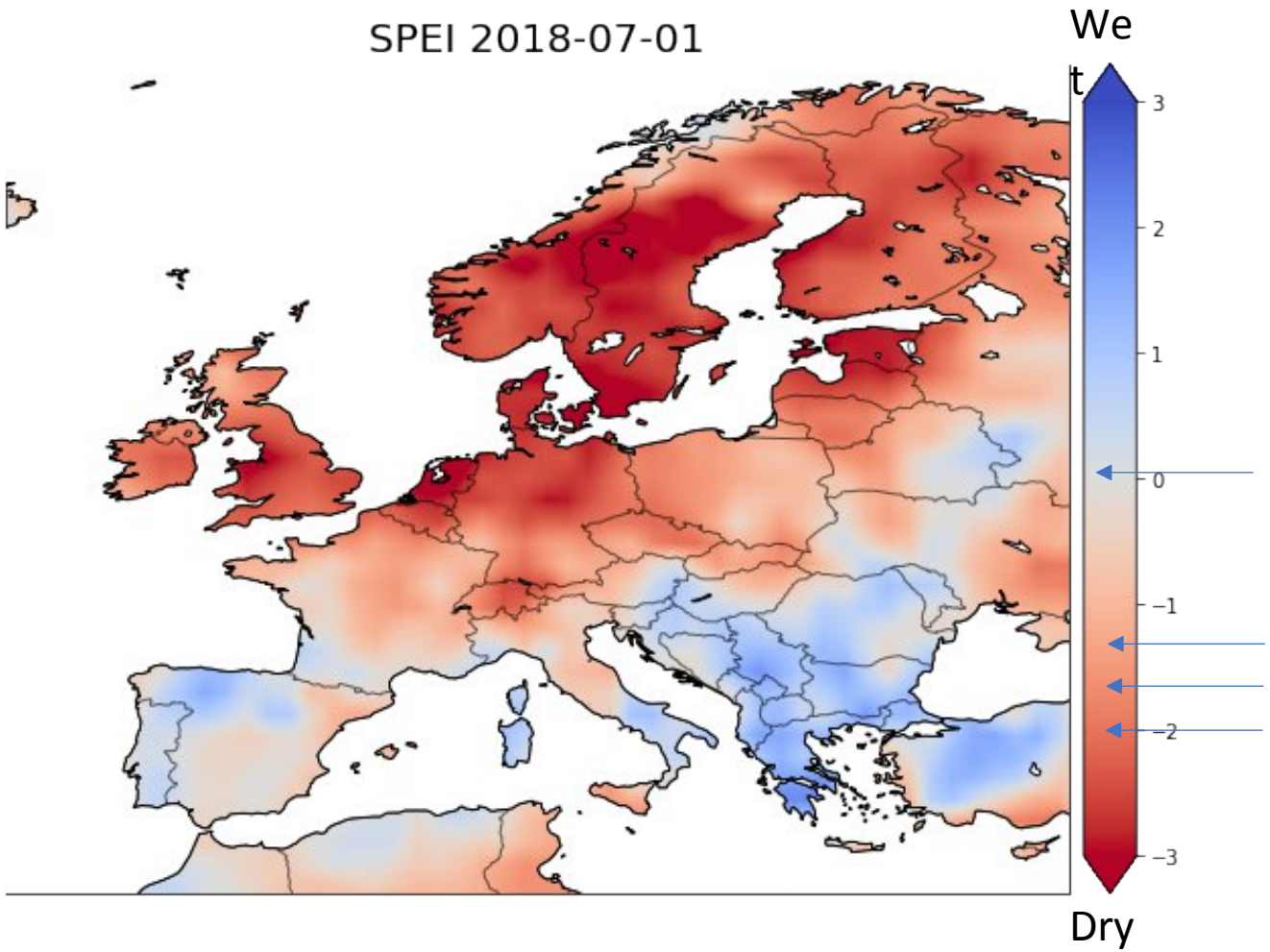
Van Gogh: *Twee afgesneden zonnebloemen.* Metropolian museum of Art, New York

The European drought of 2022 through the eyes of the biosphere



Auke van der Woude
Remco de Kok, Naomi Smith, Ingrid Luijkx, Santiago Botia, Ute Karstens, Linda Kooijmans, Gerbrand Koren, Harro Meijer, Gert-Jan Steeneveld, Ida Storm, Ingrid Super, Bert Scheeren, Alex Vermeulen, and Wouter Peters



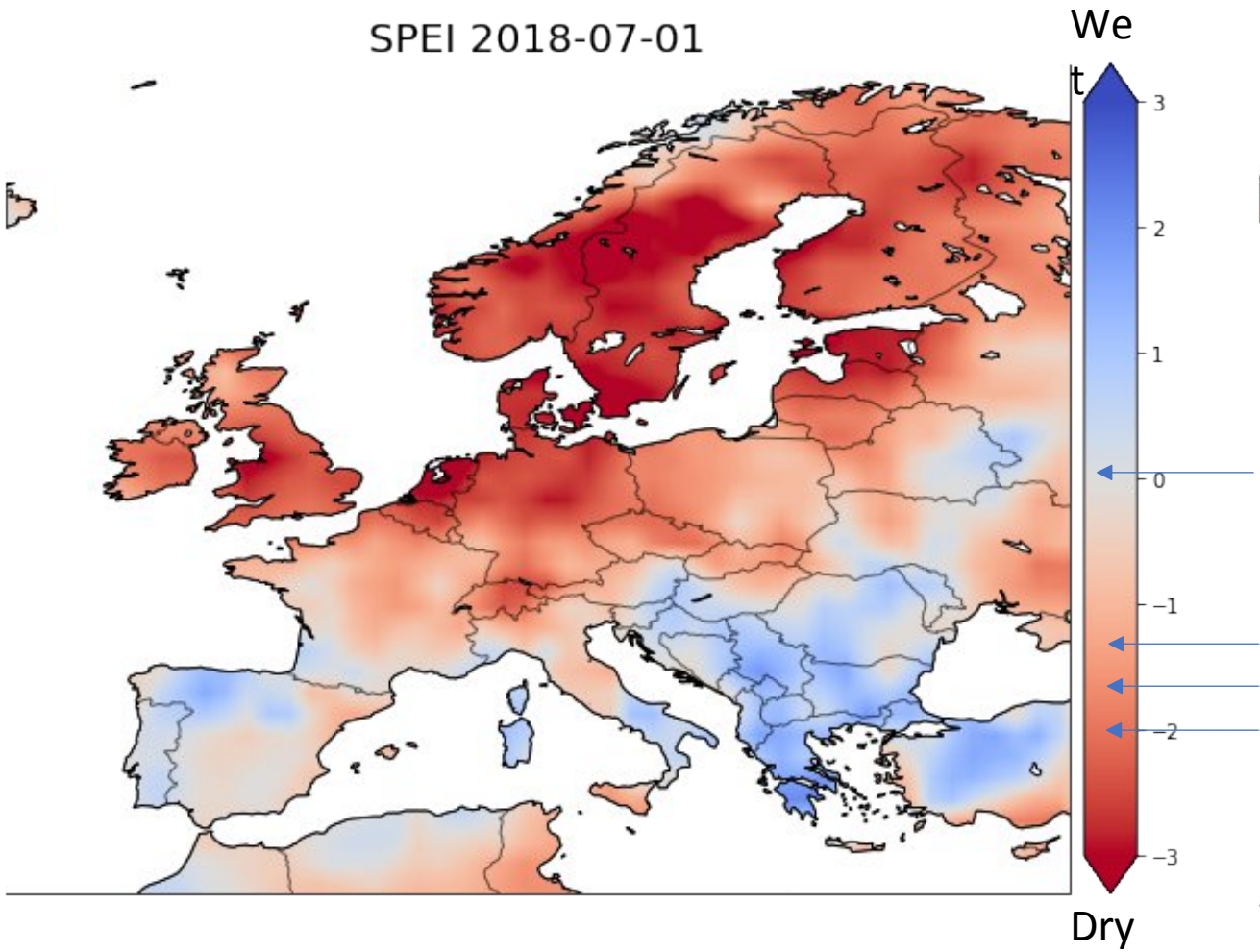
0: normal year

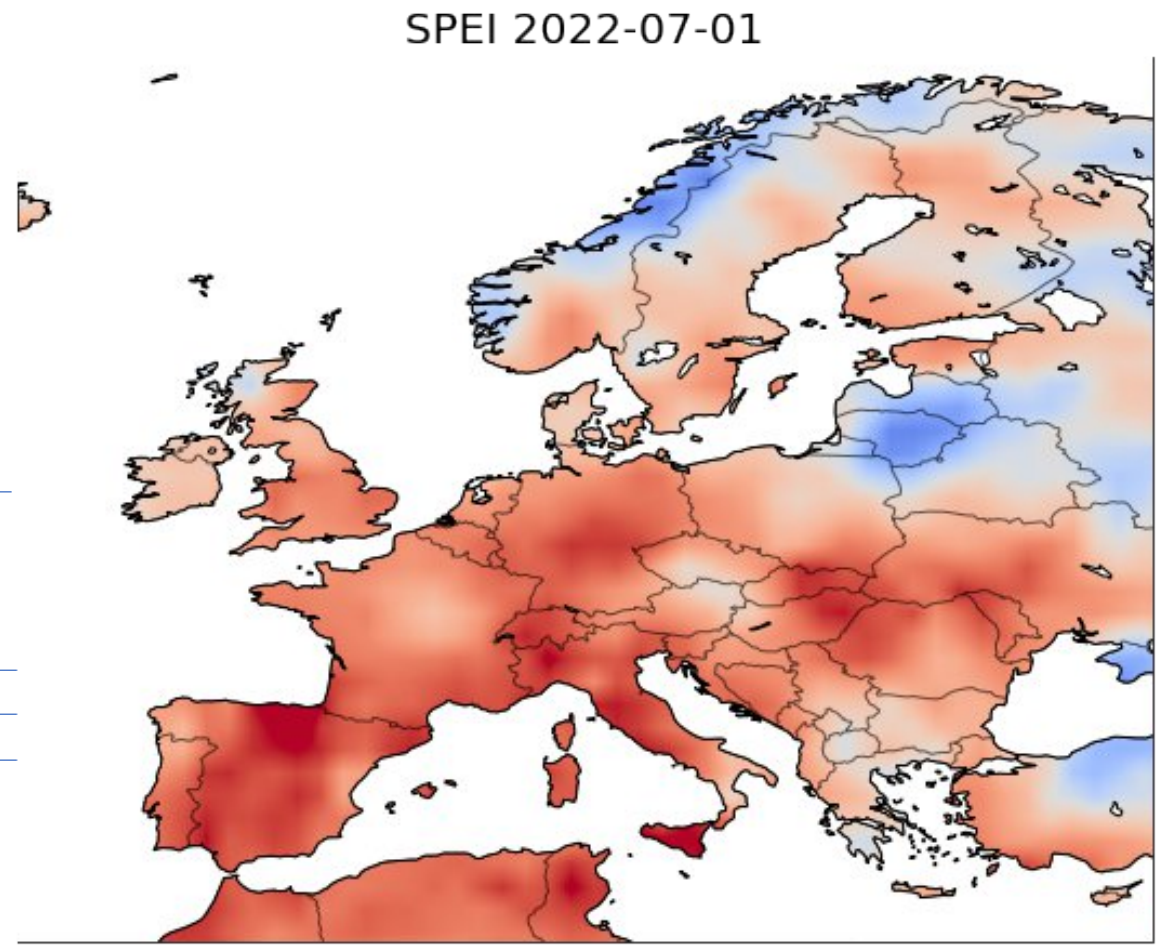
-1.3 - -1.5: Severe drought

-1.6 - -1.9: Extreme drought

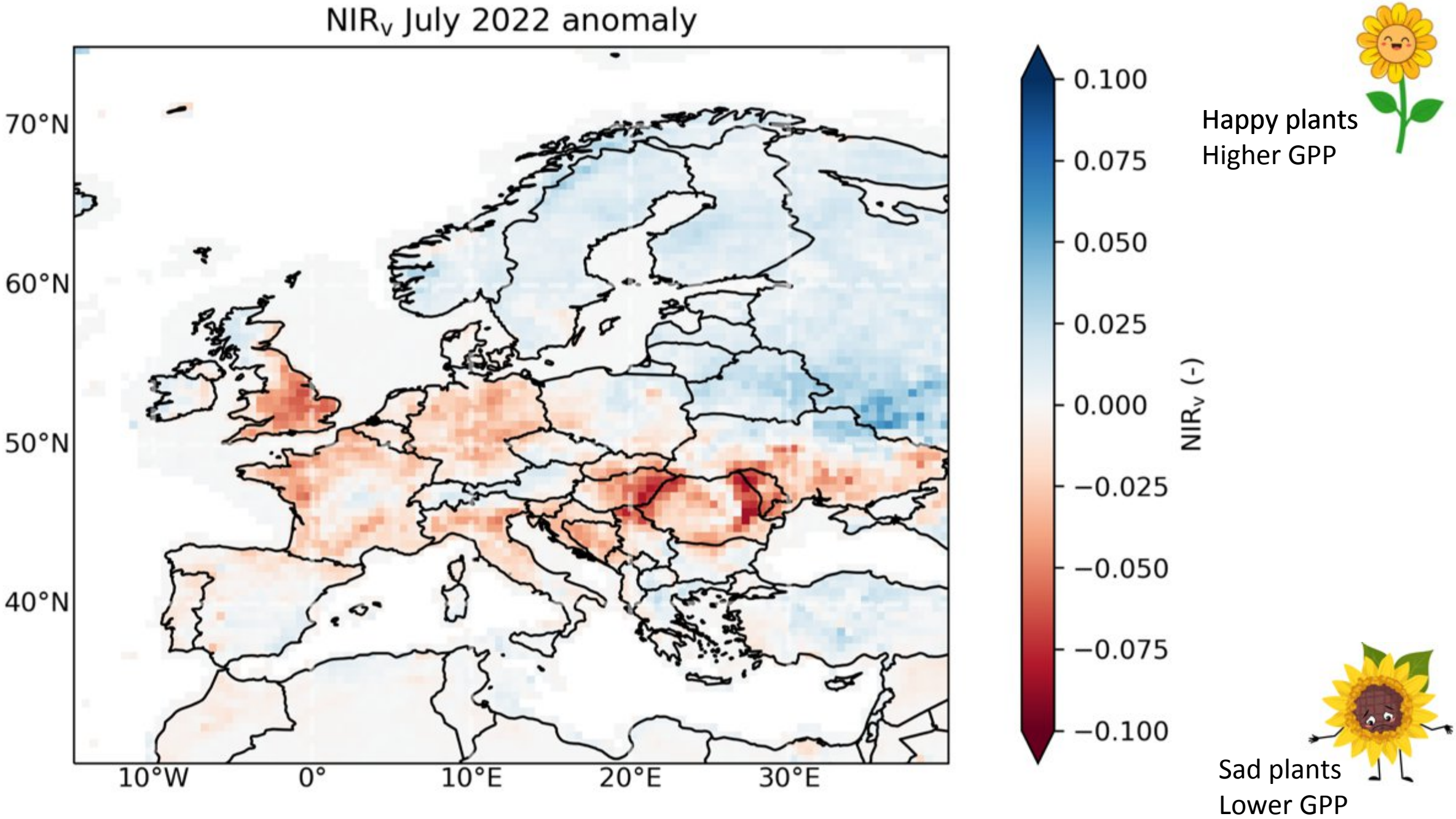
< -2: Exceptional drought

spei.csic.es/



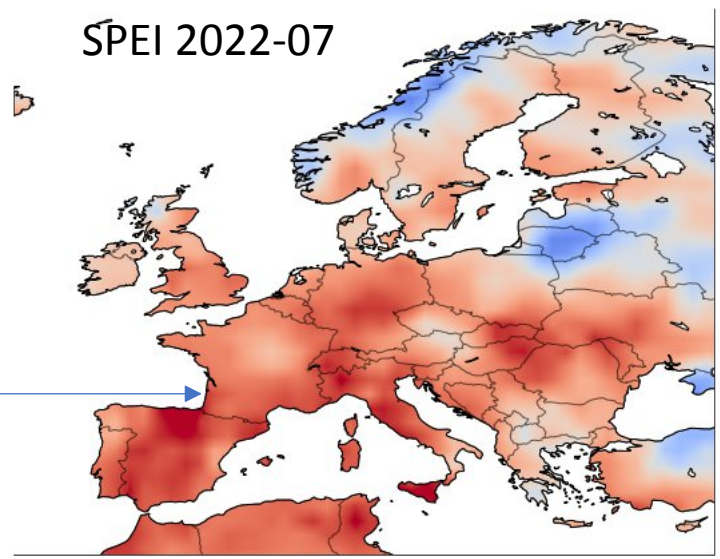


spei.csic.es/



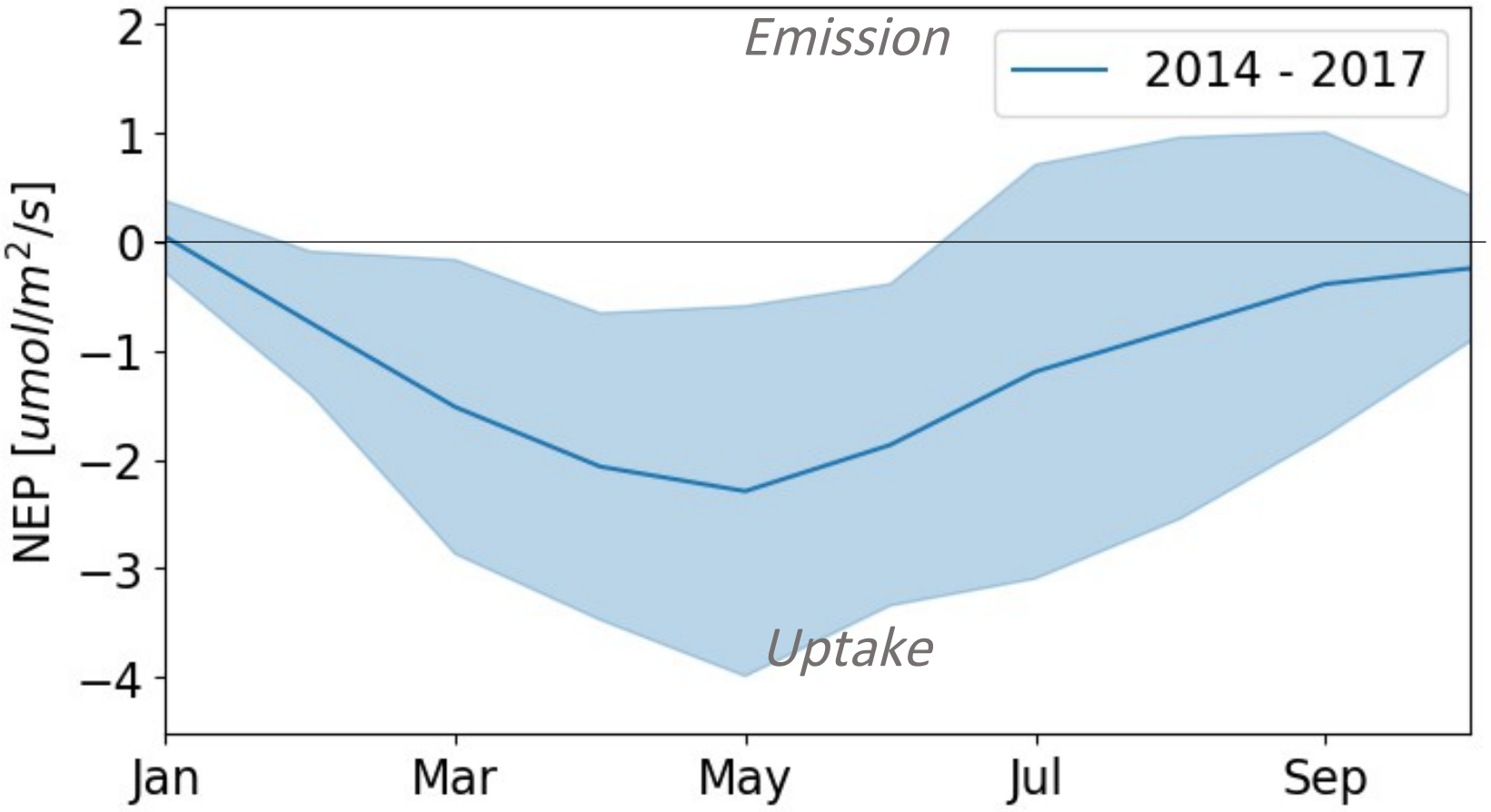
Baseline: 2013-2021 (excl 2018). MODIS data, courtesy of G. Koren

Let’s look at carbon exchange



FR-Bil

Bilos, France



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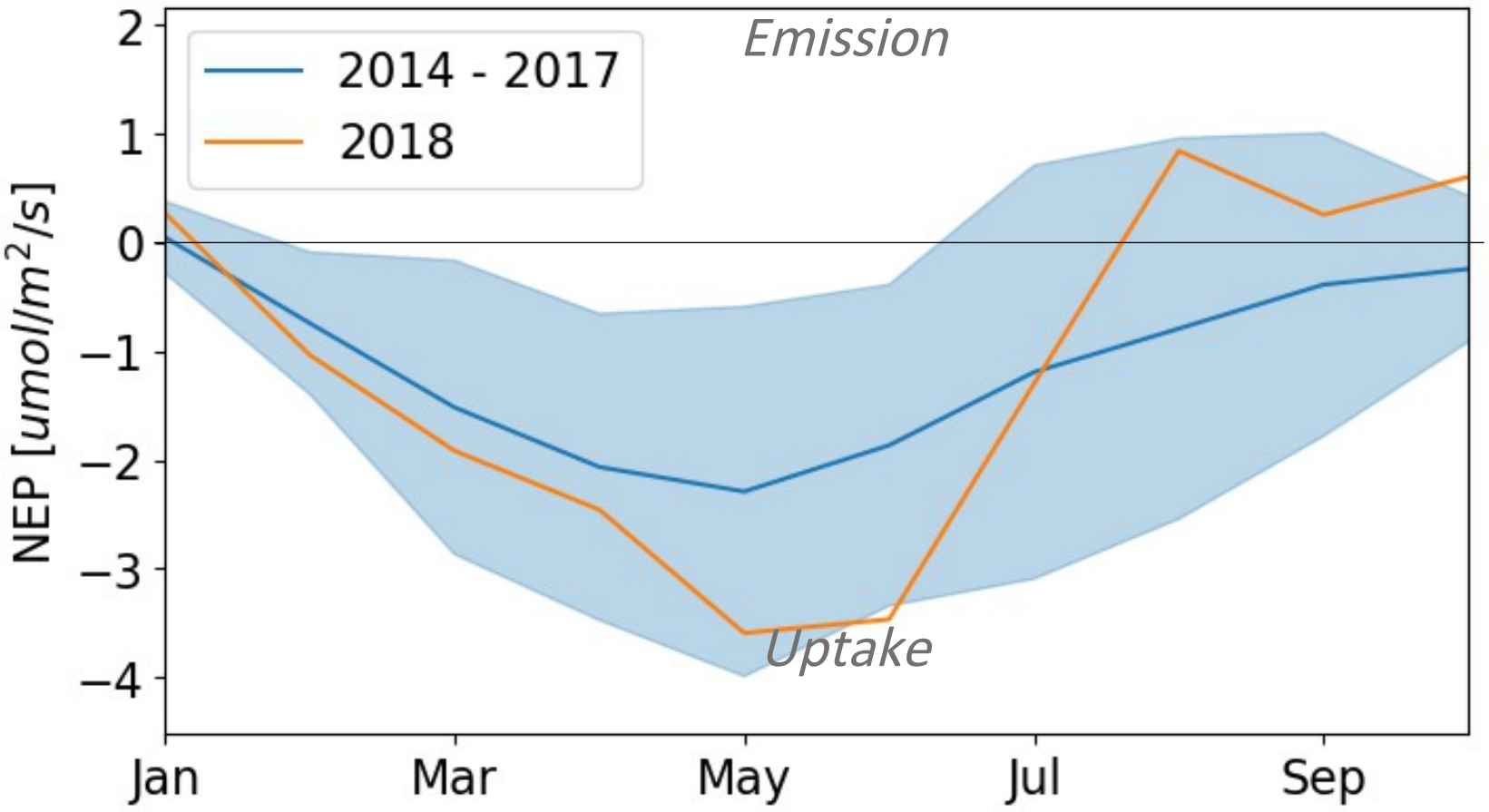
https://hdl.handle.net/11676/_370Gj__i2YoegiuvoCzbtzp

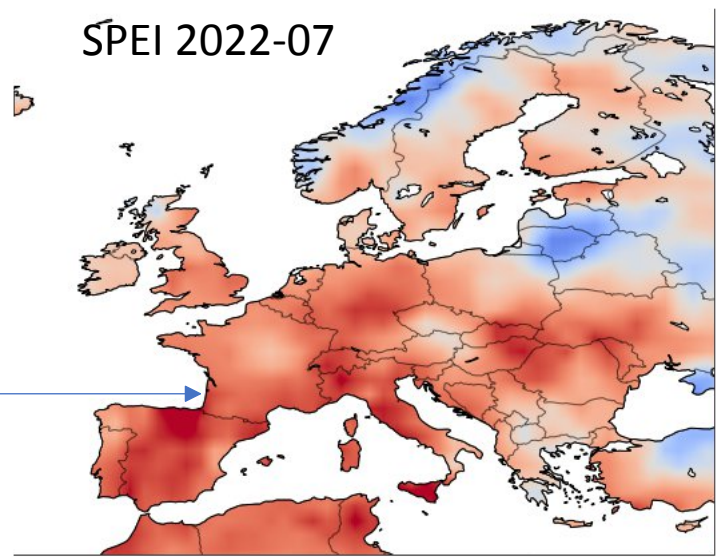
denis.loustau@inrae.fr
Loustau, D., Aluome, C., Chipeaux, C., Denou, J., DEPUYDT, J., Kruszew A., Lafont, S., ICOS RI, 2022

Let’s look at carbon exchange

Bilos, France



SPEI 2022-07



FR-Bil

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https://hdl.handle.net/11676/_370Gj__i2YoegiuvoCzbtzp

ICOS Integrated Carbon Observation System

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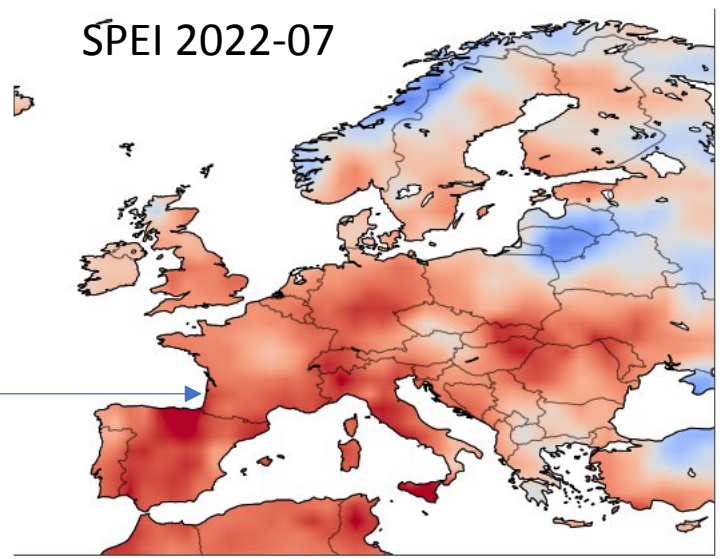
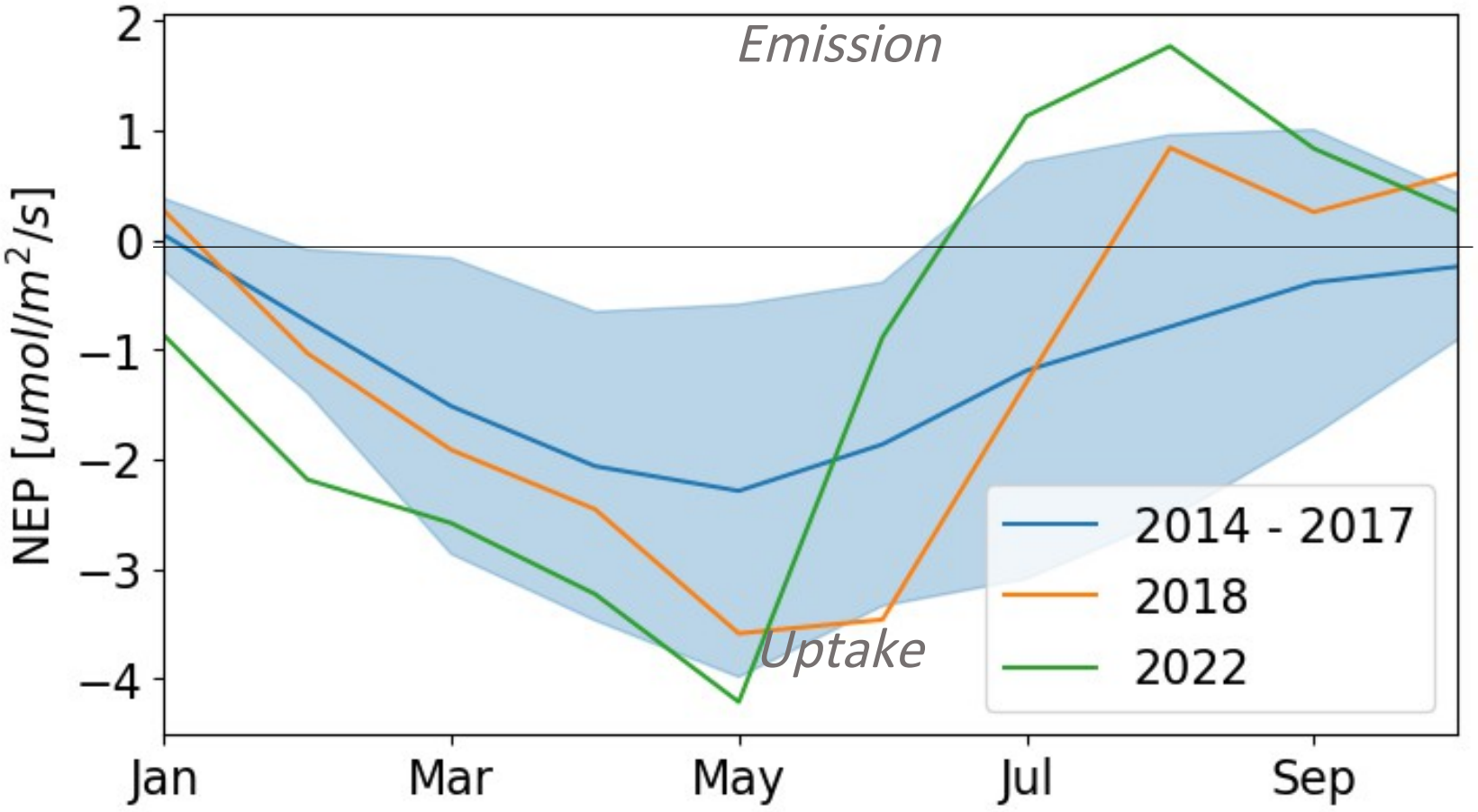
Loustau, D., Aluome, C., Chipeaux, C., Denou, J., DEPUYDT, J., Kruszew A., Lafont, S., ICOS RI, 2022

Let’s look at carbon exchange



FR-Bil

Bilos, France



denis.loustau@inrae.fr
Loustau, D., Aluome, C., Chipeaux, C., Denou, J., DEPUYDT, J., Kruszew A., Lafont, S., ICOS RI, 2022

How about European-wide?

Model results

For 2018:

One contribution of 16 to a theme issue 'Impacts of the 2018 severe drought and heatwave in Europe: from site to continental scale'.

Spring enhancement and summer reduction in carbon uptake during the 2018 drought in northwestern Europe

How about European-wide?

One contribution of 16 to a theme issue 'Impacts of the 2018 severe drought and heatwave in Europe: from site to continental scale'.

Spring enhancement and summer reduction in carbon uptake during the 2018 drought in northwestern Europe

Model results

For 2018:

- 55 TgC spring enhancement
- 68 TgC summer reduction

How about European-wide?

Model results

For 2018:

- 55 TgC spring enhancement
- 68 TgC summer reduction

One contribution of 16 to a theme issue 'Impacts of the 2018 severe drought and heatwave in Europe: from site to continental scale'.

Spring enhancement and summer reduction in carbon uptake during the 2018 drought in northwestern Europe

Naomi E. Smith[1], Linda M. J. Kooijmans[1], Gerbrand Koren[1], Erik van Schaik[1], Auke M. van der Woude[1,2], Niko Wanders[3], Michel Ramonet[4], Irène Xueref-Remy[4], Lukas Siebicke[5], Giovanni Manca[6], Christian Brümmer[7], Ian T. Baker[8], Katherine D. Haynes[8], Ingrid T. Luijkx[1] and Wouter Peters[1,2]

Smith et al., 2020; 2 years!

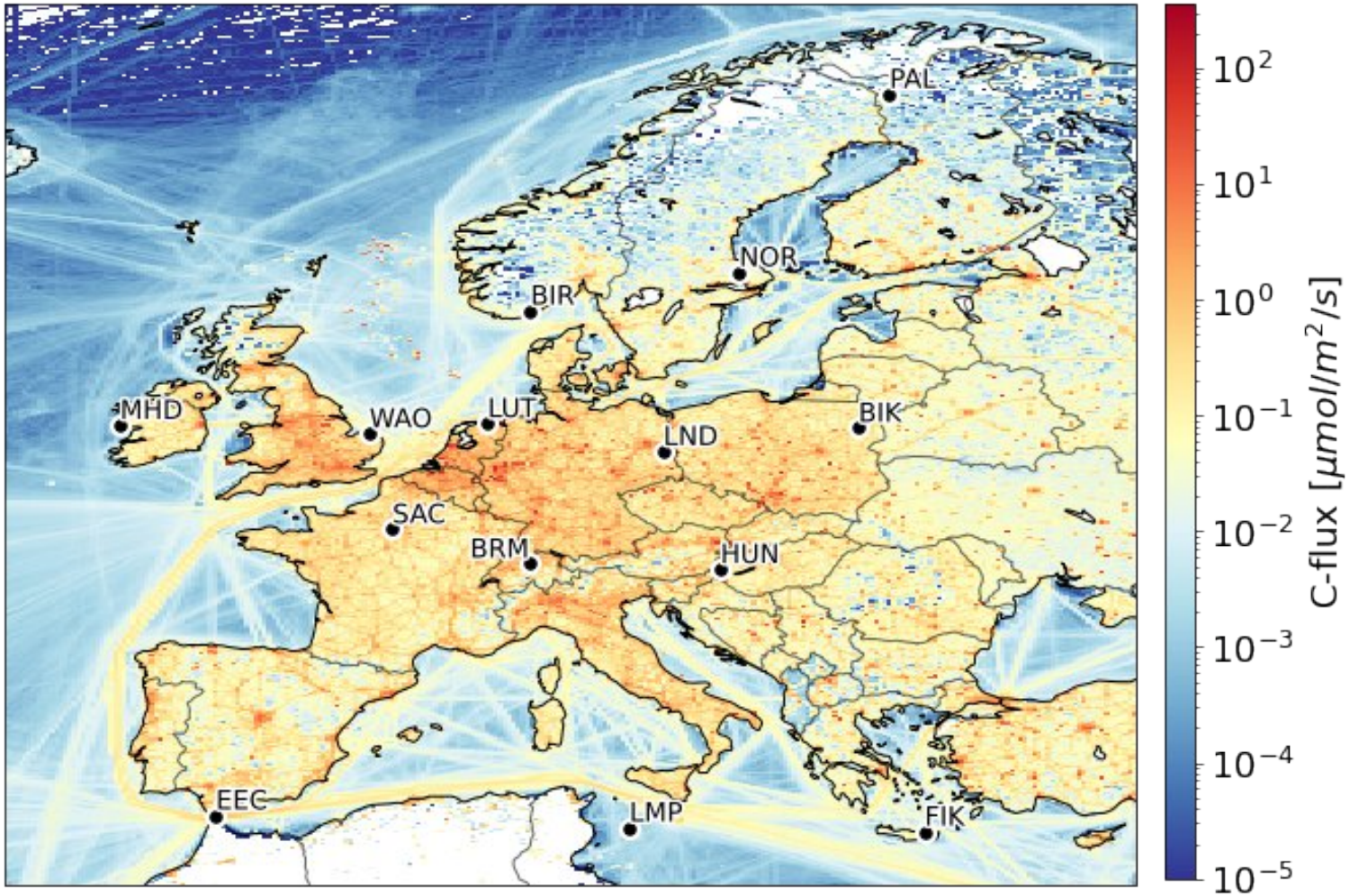
Also Thompson et al, 2020; Rödenbeck et al, 2020; Bastos et al, 2020: Powered by ICOS data

Near real-time

- CTE-HR
  - Biosphere
  - Anthropogenic
  - Fires
  - Ocean
- 2 months behind real-time
- High resolution (0.2°x0.1°)
- Hourly

- Provide people with CO_2 fluxes for atmospheric modelling

Anthropogenic fluxes from CTE-HR for Aug 31, 2022, 12h UTC



rijksuniversiteit groningen

ICOS Integrated Carbon Observation System

WAGENINGEN UNIVERSITY & RESEARCH

Netherlands activates energy crisis plan, removes cap on coal plants

https://www.reuters.com/business/energy/netherlands-activates-energy-crisis-plan-removes-cap-coal-plants-2022-06-20/

Germany's energy U-turn: Coal instead of gas

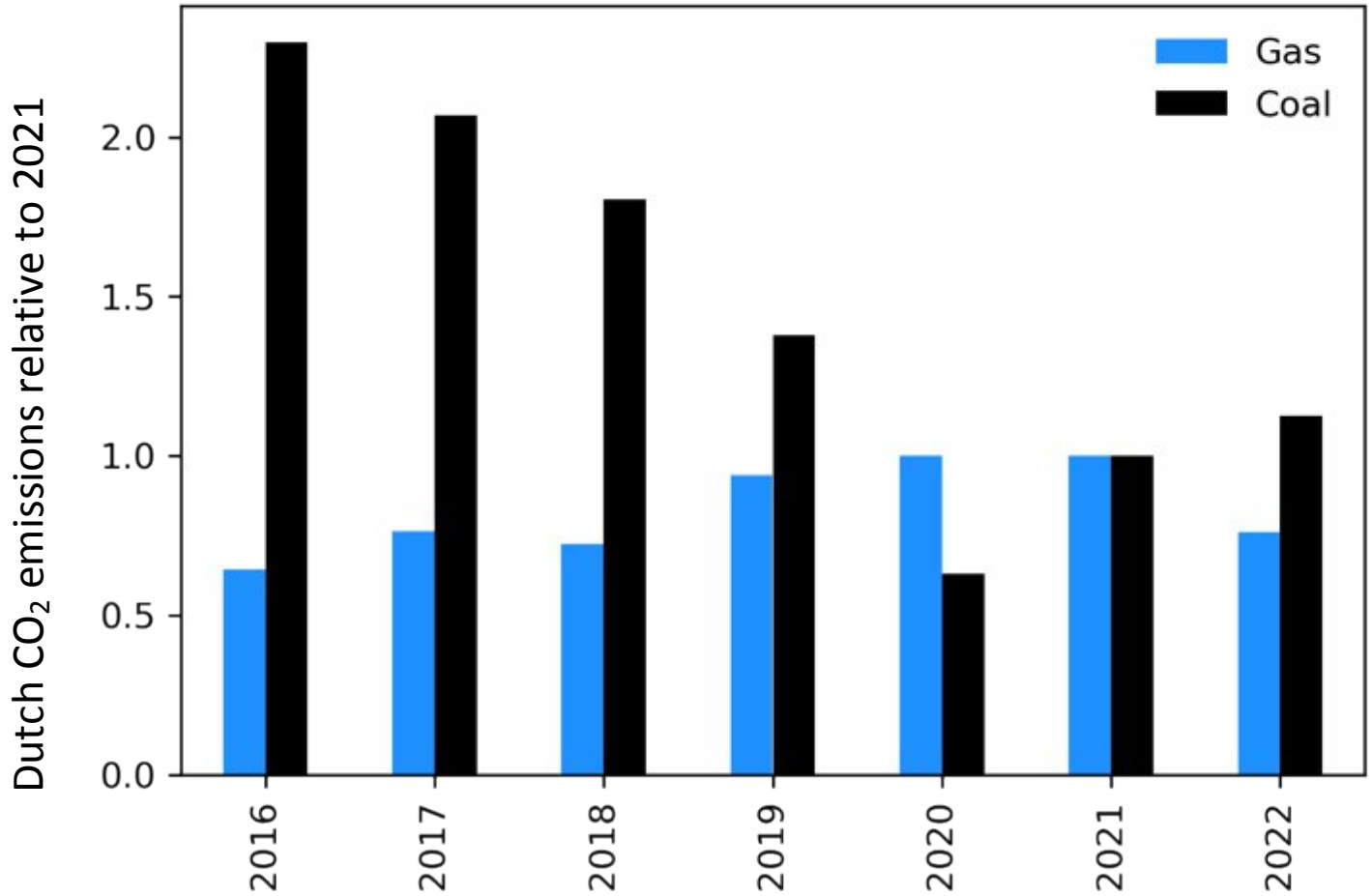
https://www.dw.com/en/germanys-energy-u-turn-coal-instead-of-gas/a-62709160#:~:text=Germany's%20goal%20had%20been%20to,of%20Germany's%20overall%20energy%20mix.

Europe turns back to coal as Russia cuts gas supplies

https://euobserver.com/green-economy/155276

Reduced gas emissions from public power in 2022

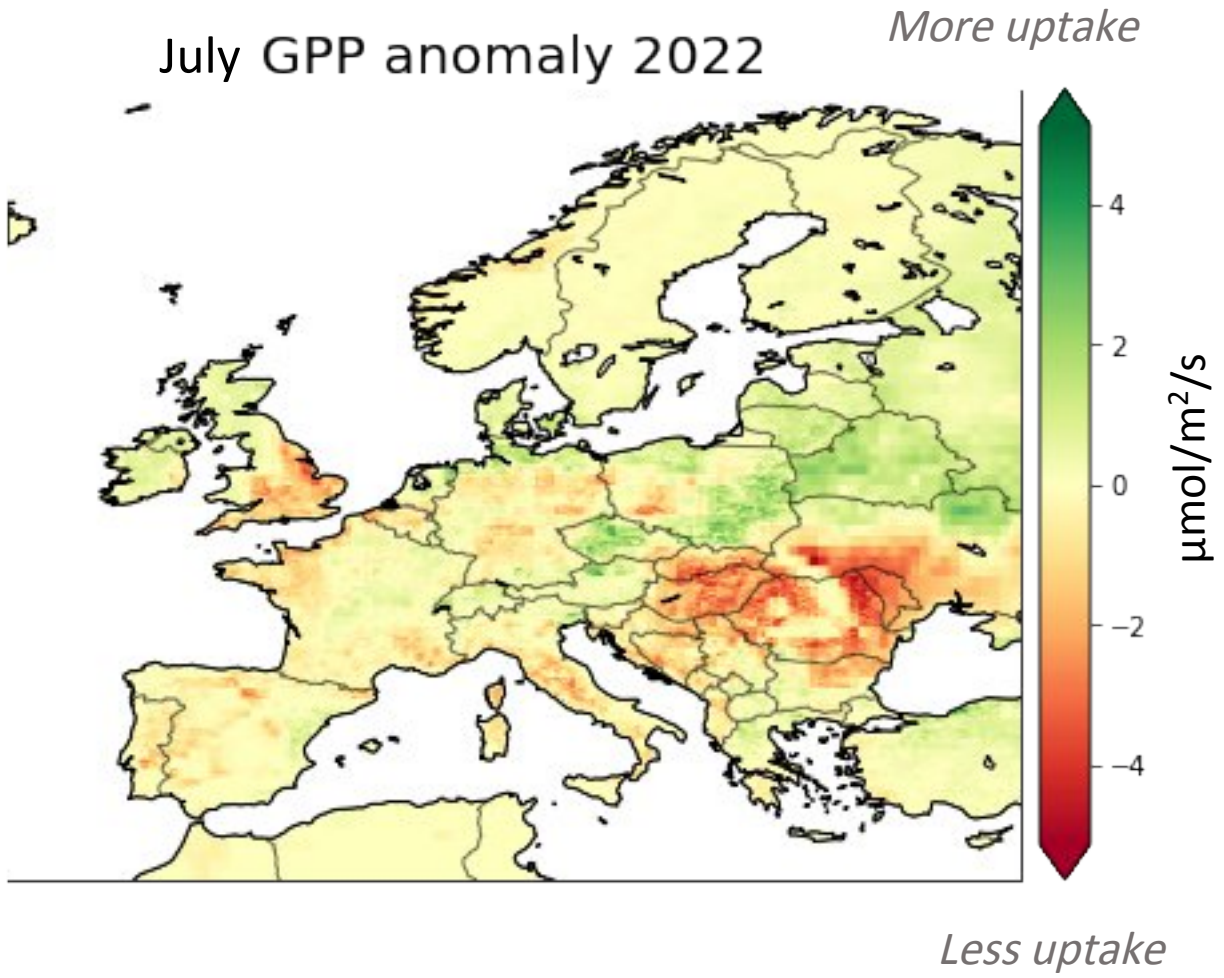
Total CO_2 emissions are similar to 2021



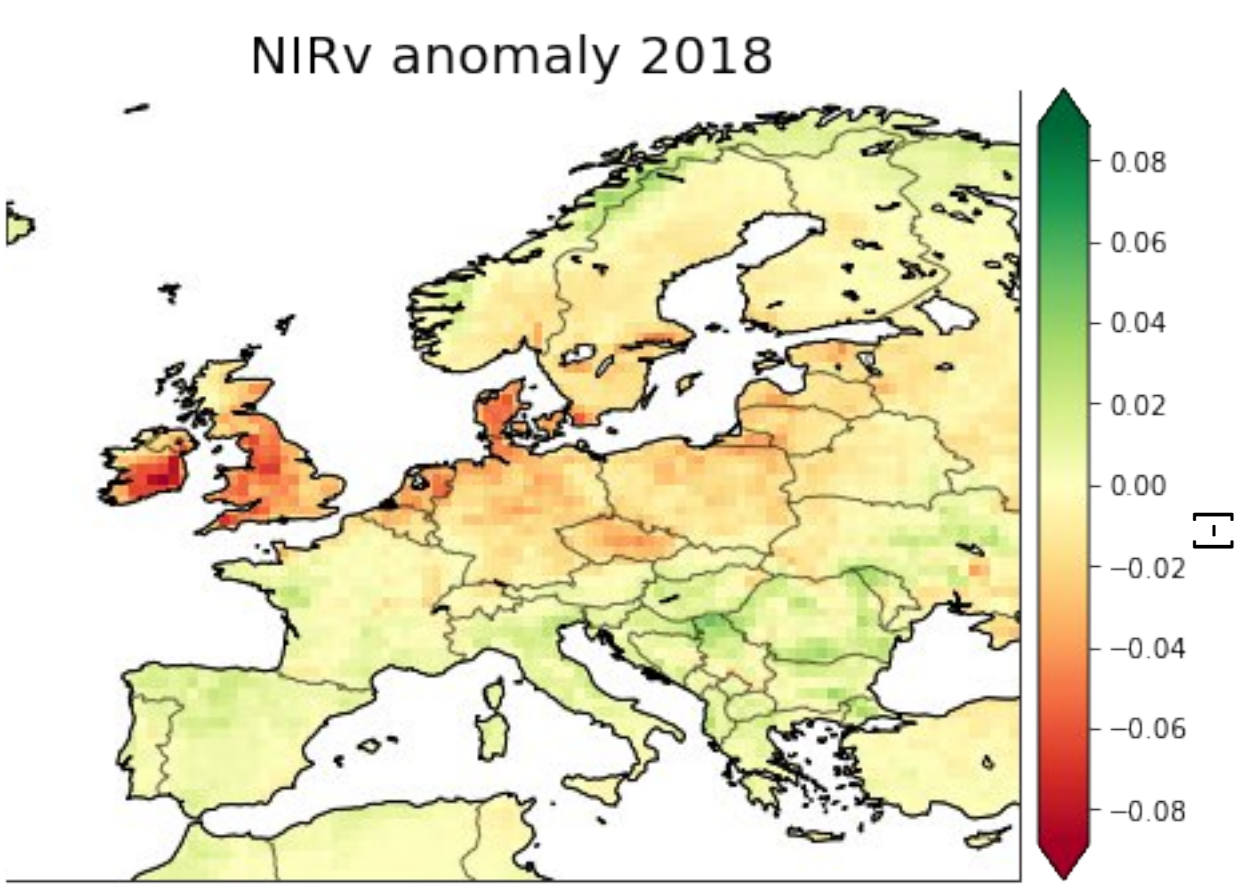
CTE-HR 2022 biosphere drought response

- SiB4 biosphere model
- ERA5 meteorology
- Downscaled based on Land-use type

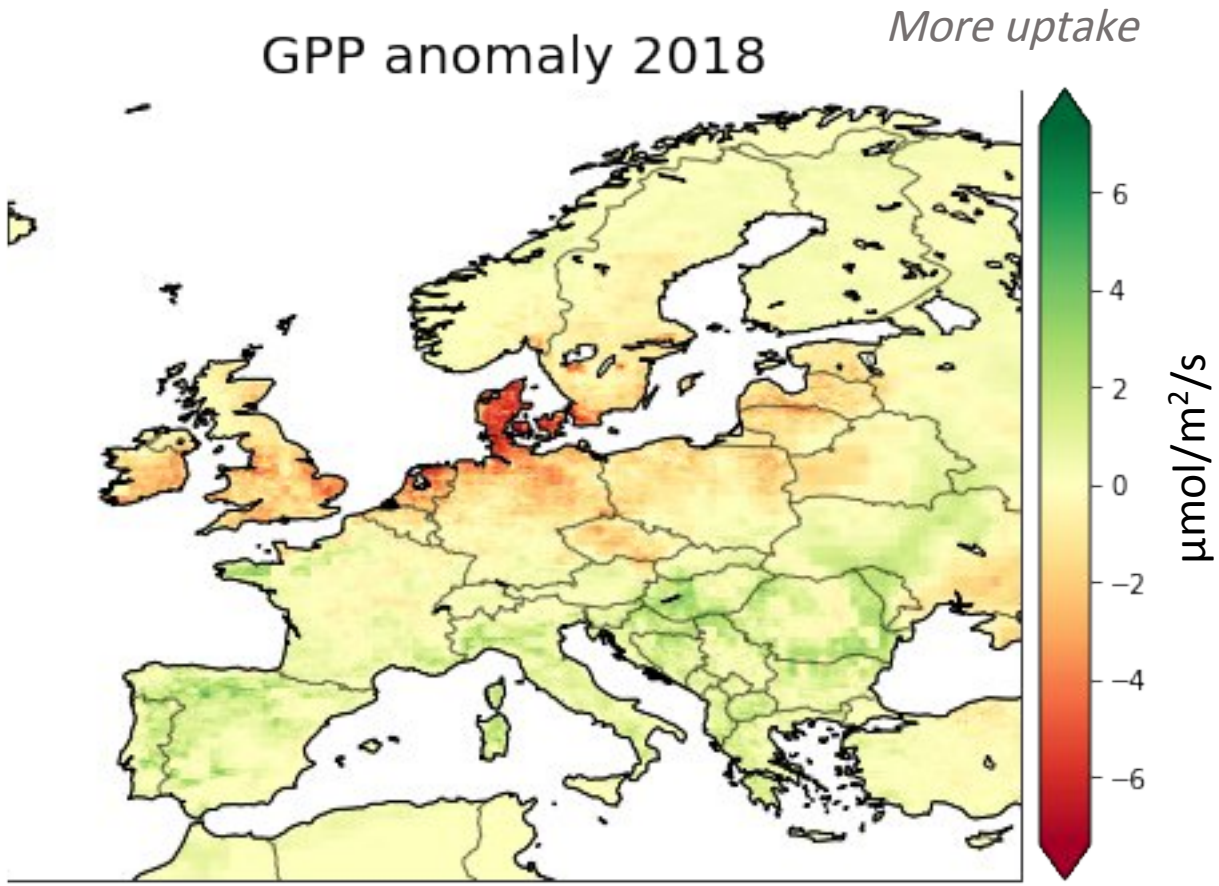
- Can we trust this?



CTE-HR 2022 biosphere drought response



More uptake

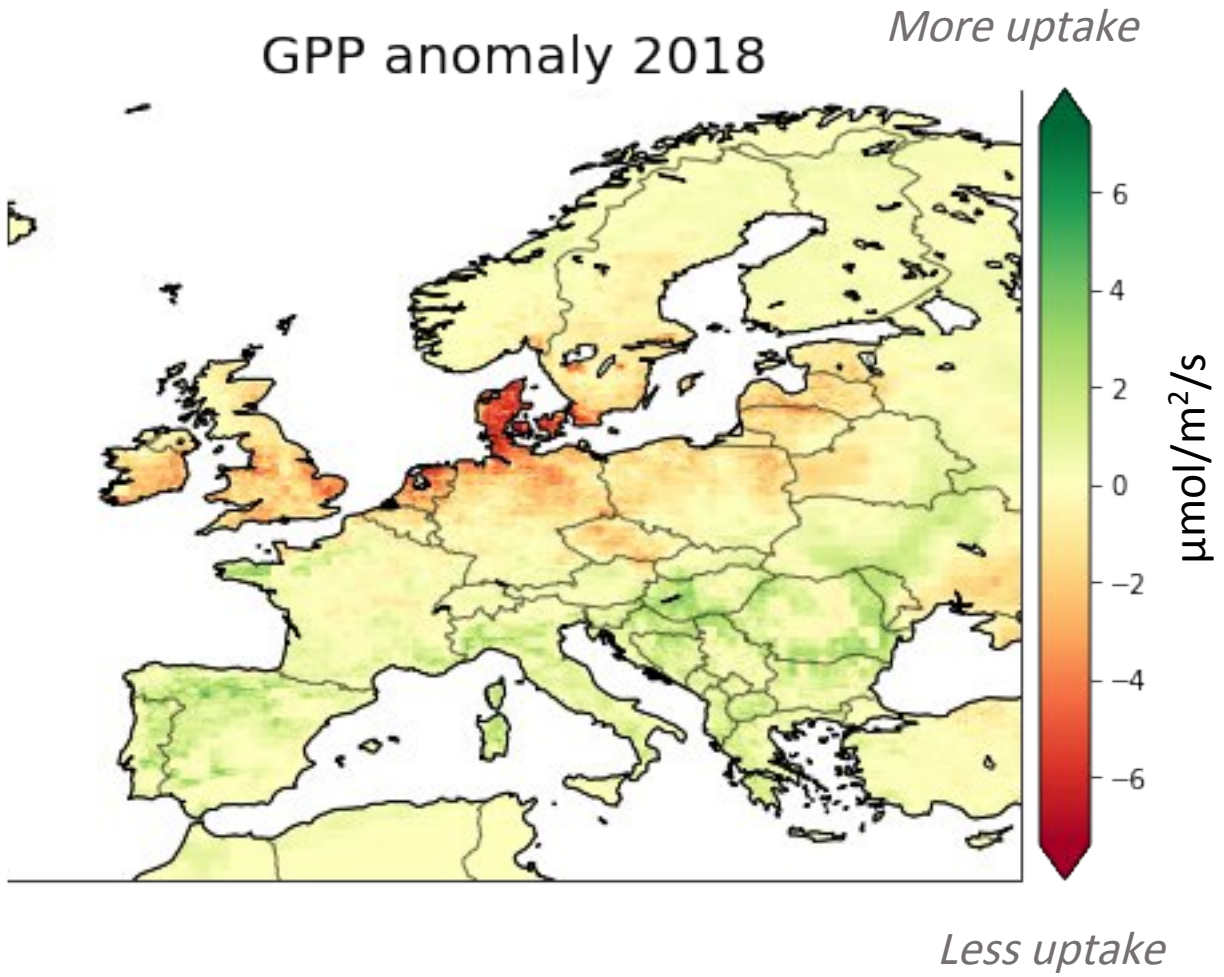


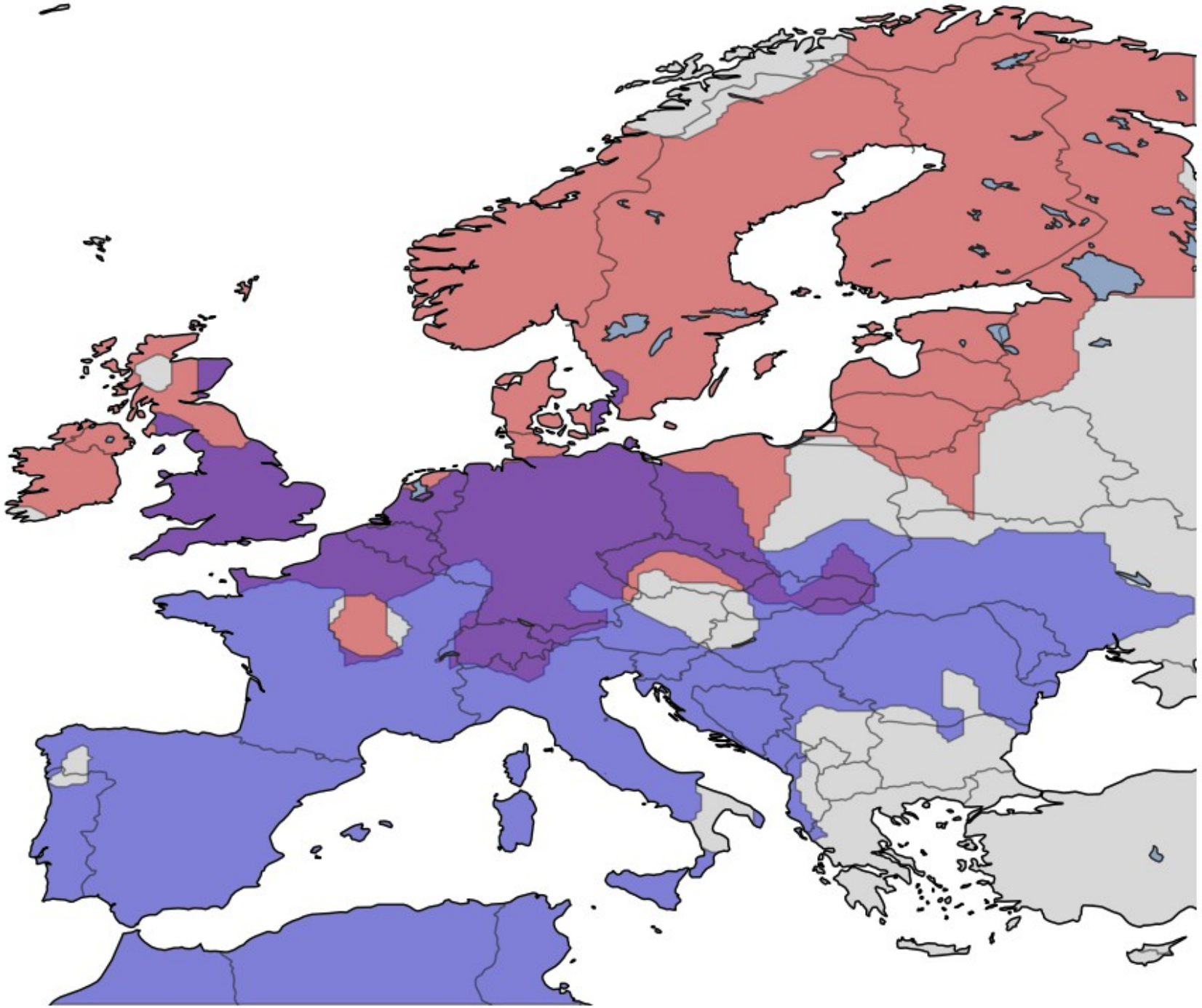
Less uptake

July anomalies, reference period 2016 - 2022

CTE-HR 2022 biosphere drought response

- SiB4 biosphere model
- GPP response similar to NIRV
- Validated in
  - Smith et al, 2020
  - Van der Woude et al., (in rev.)
- 2022 validation ongoing
- Let’s look at some droughts



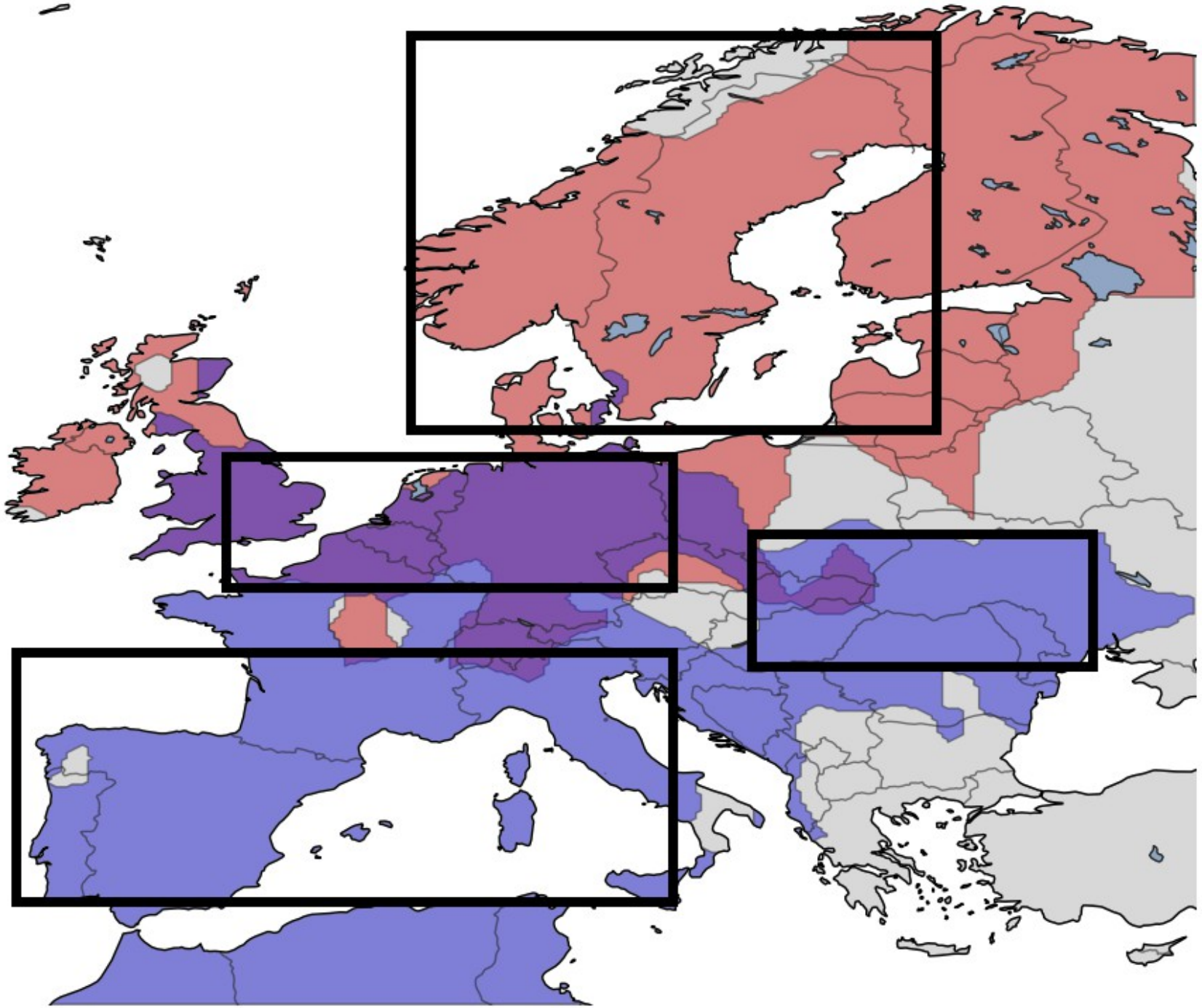


We are interested in the drought-affected area

Over drought region
(SPEI < -1.5)

2018: 3.1 x 10^6 km^2

2022: 3.4 x 10^6 km^2



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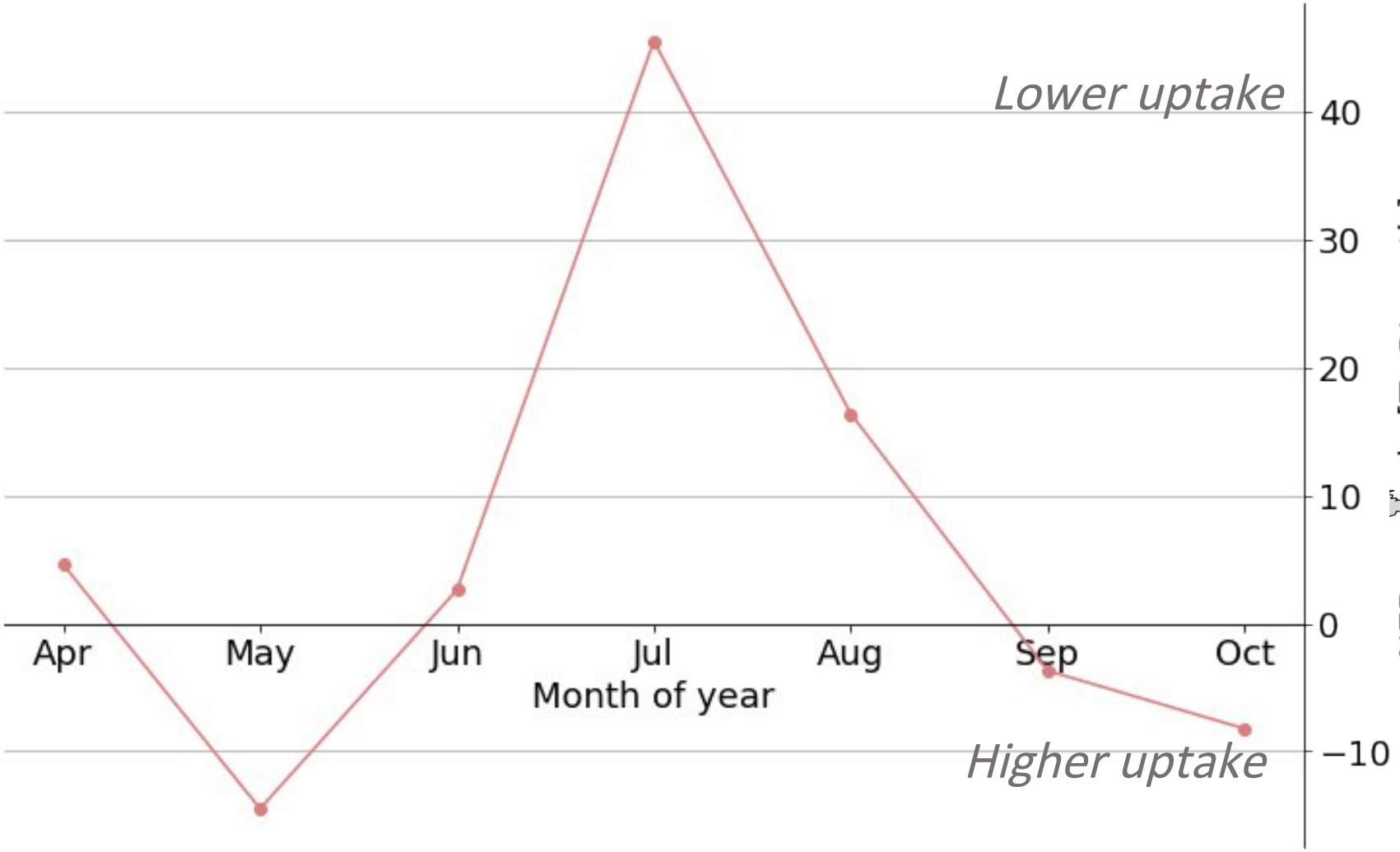
Droughts are different



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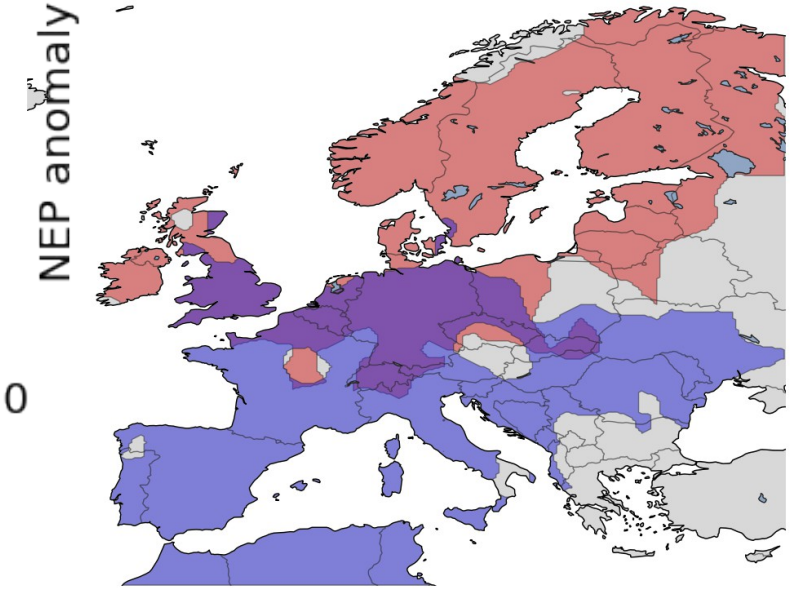

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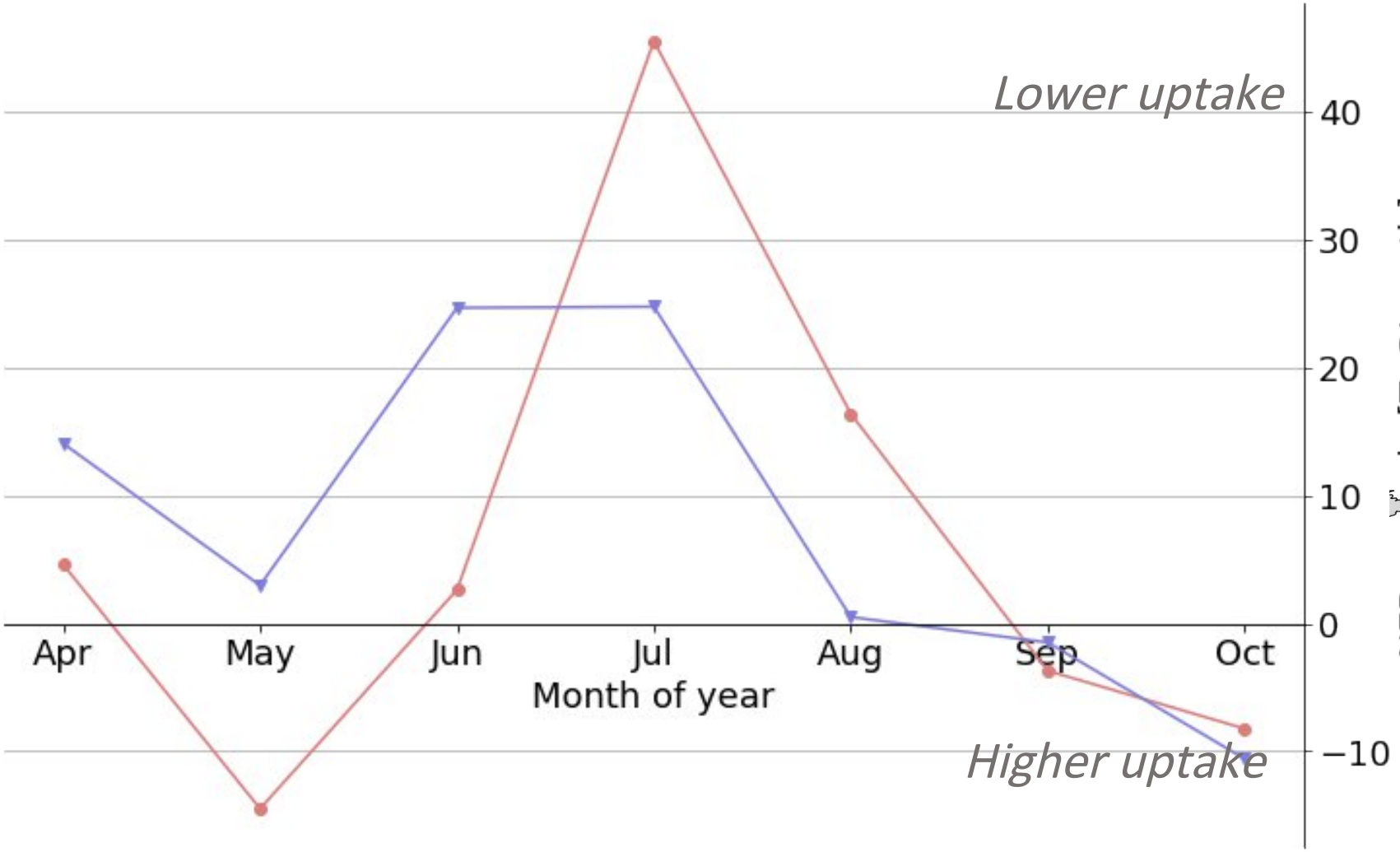

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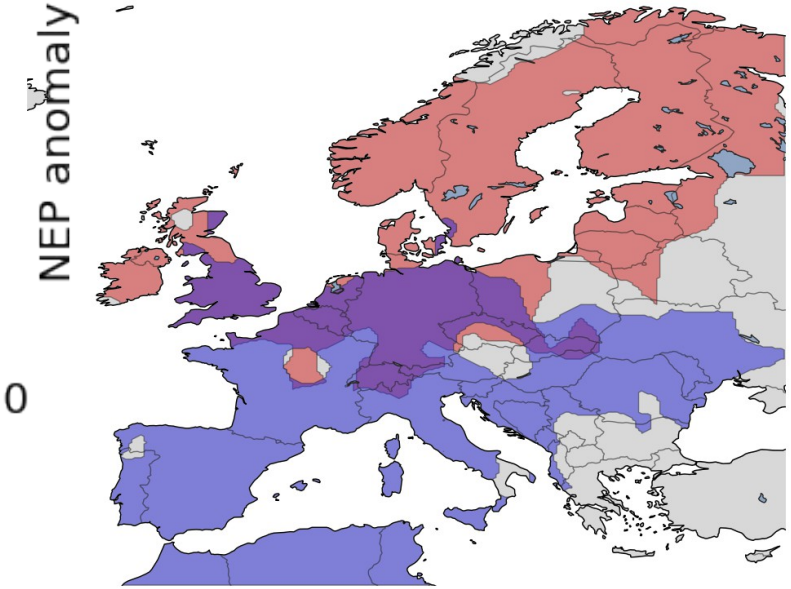

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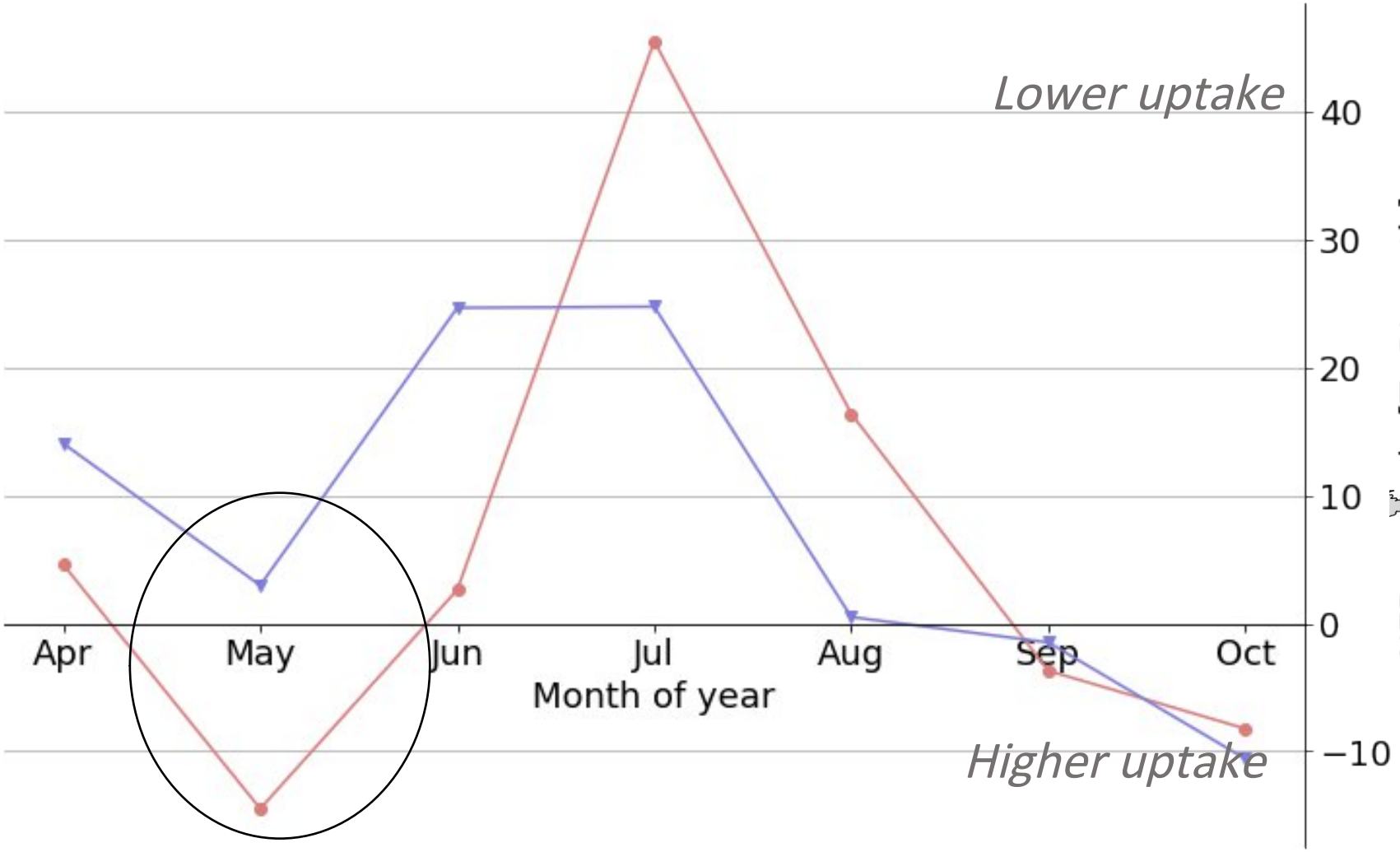

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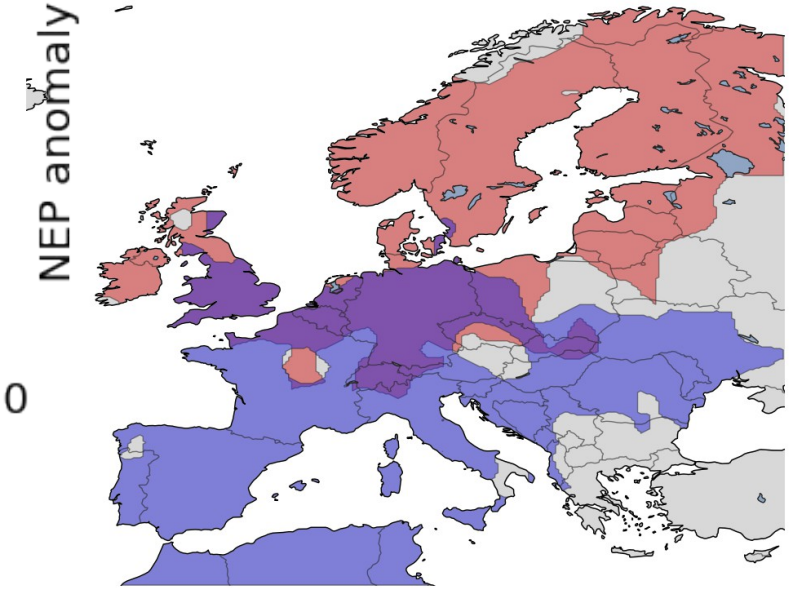
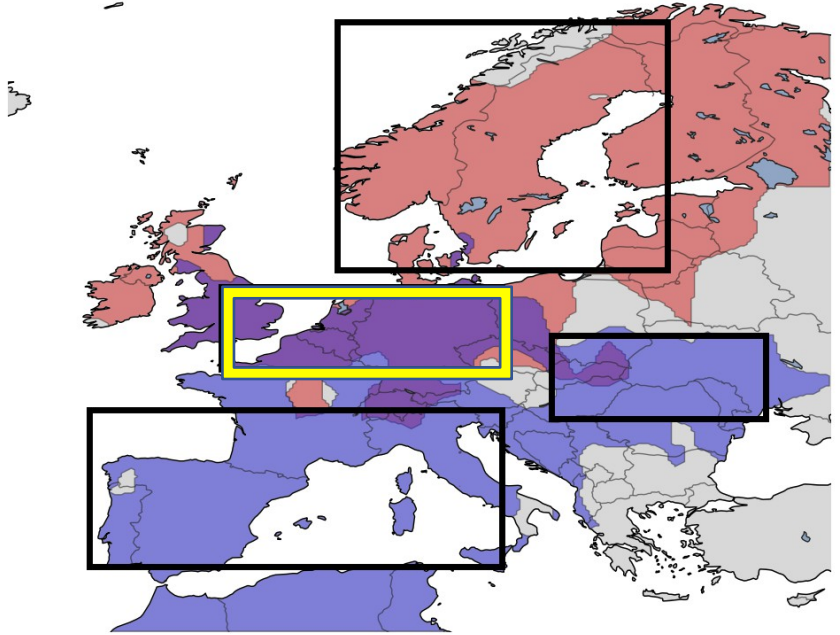
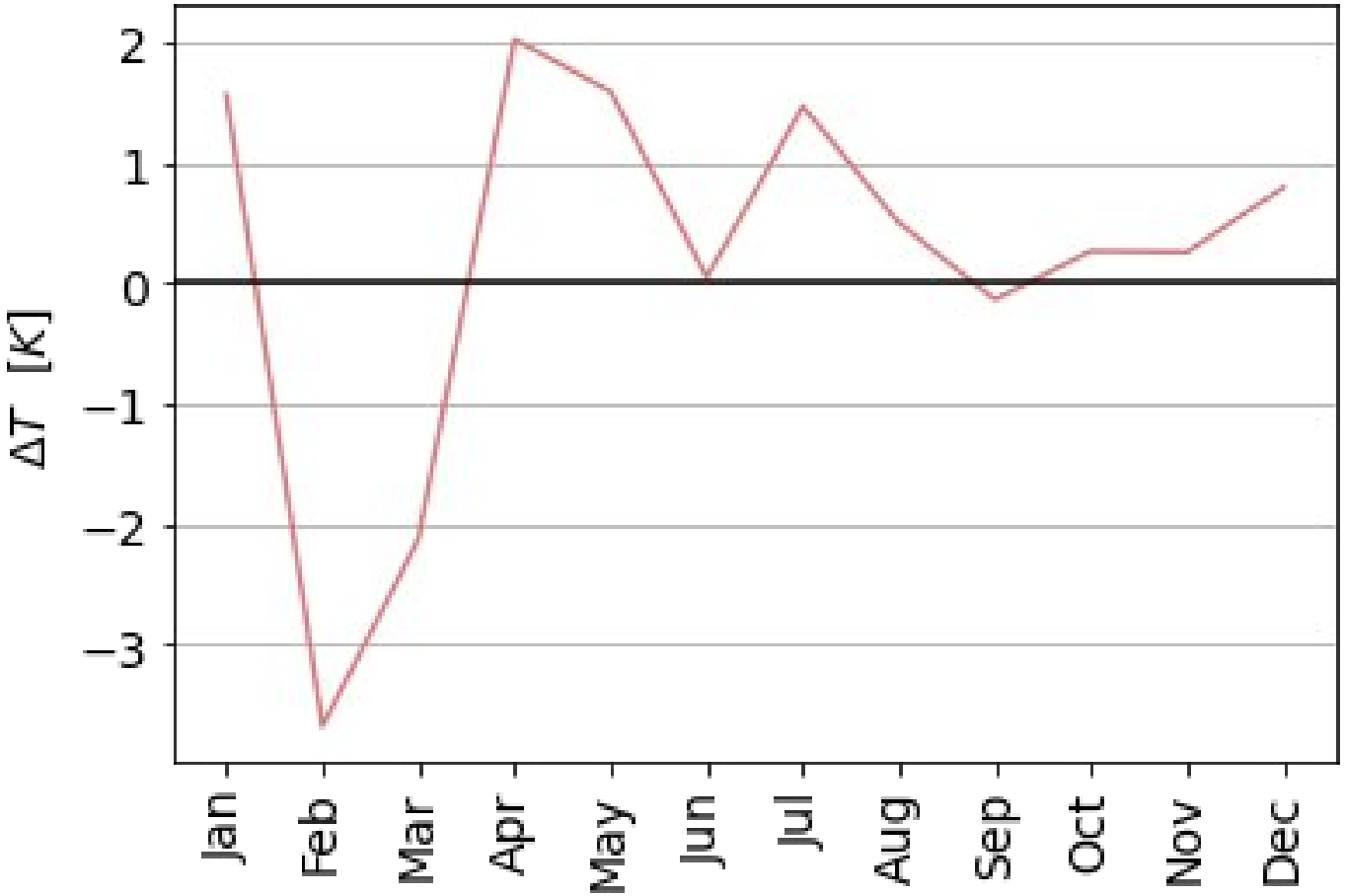
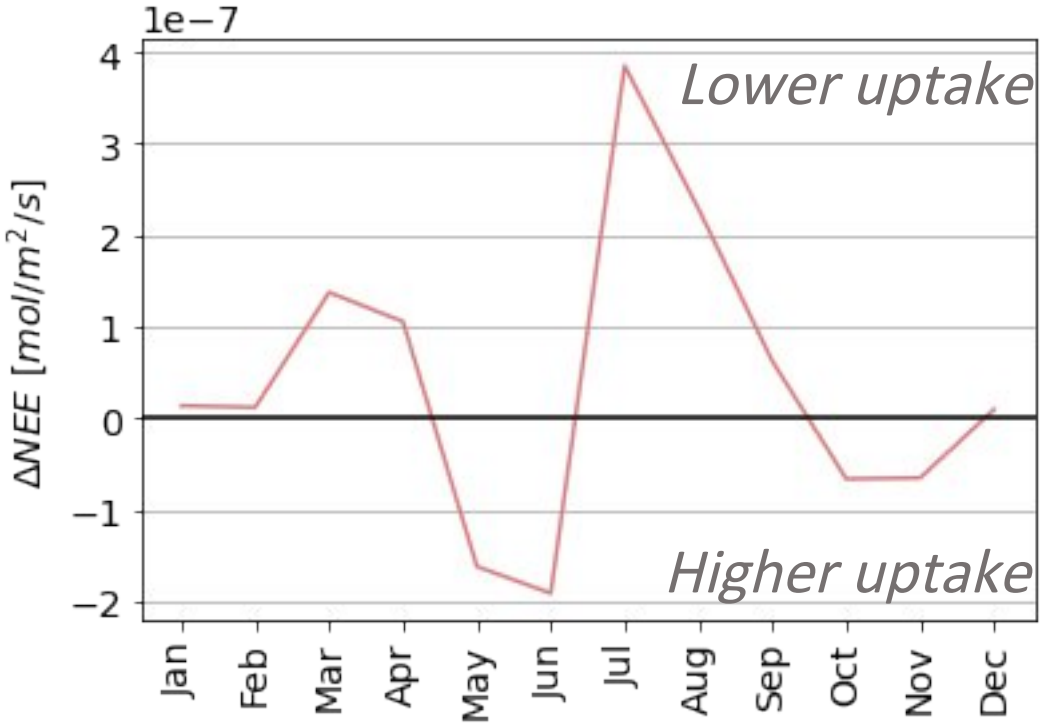


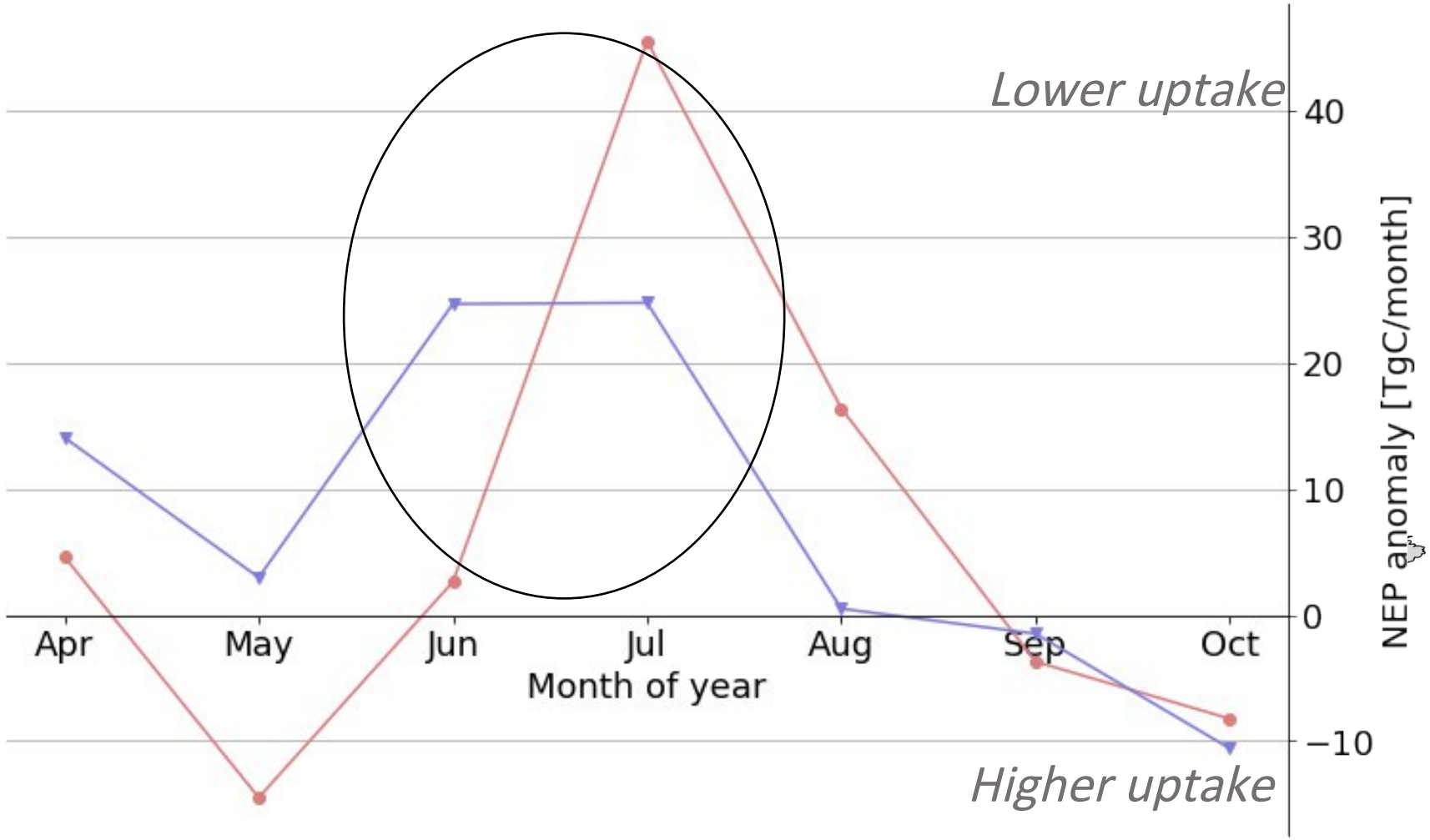
Spring in central Europe







Droughts are different



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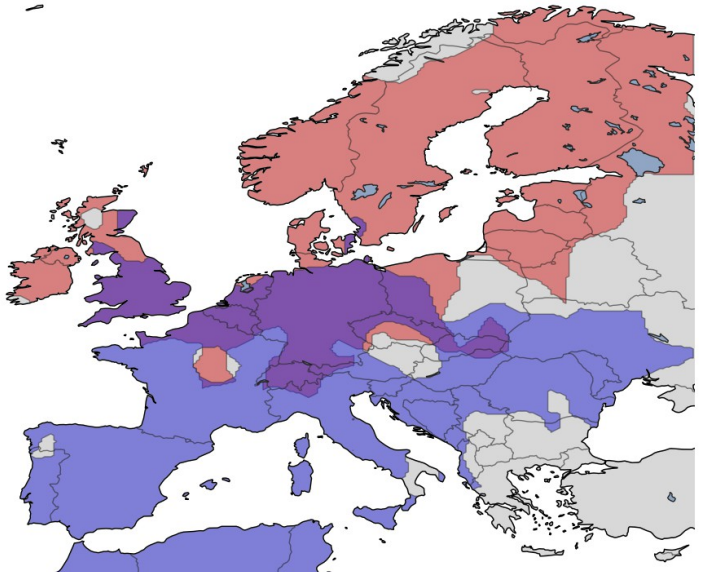
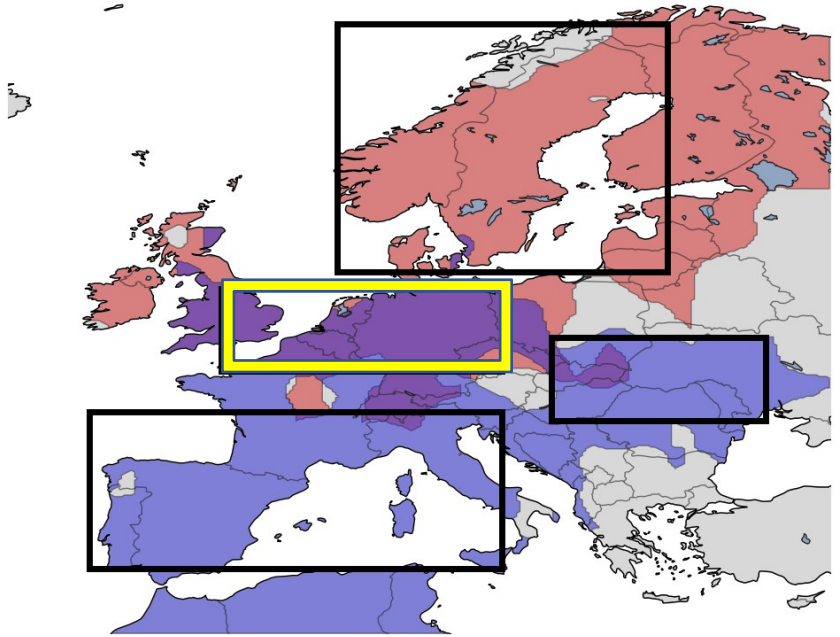
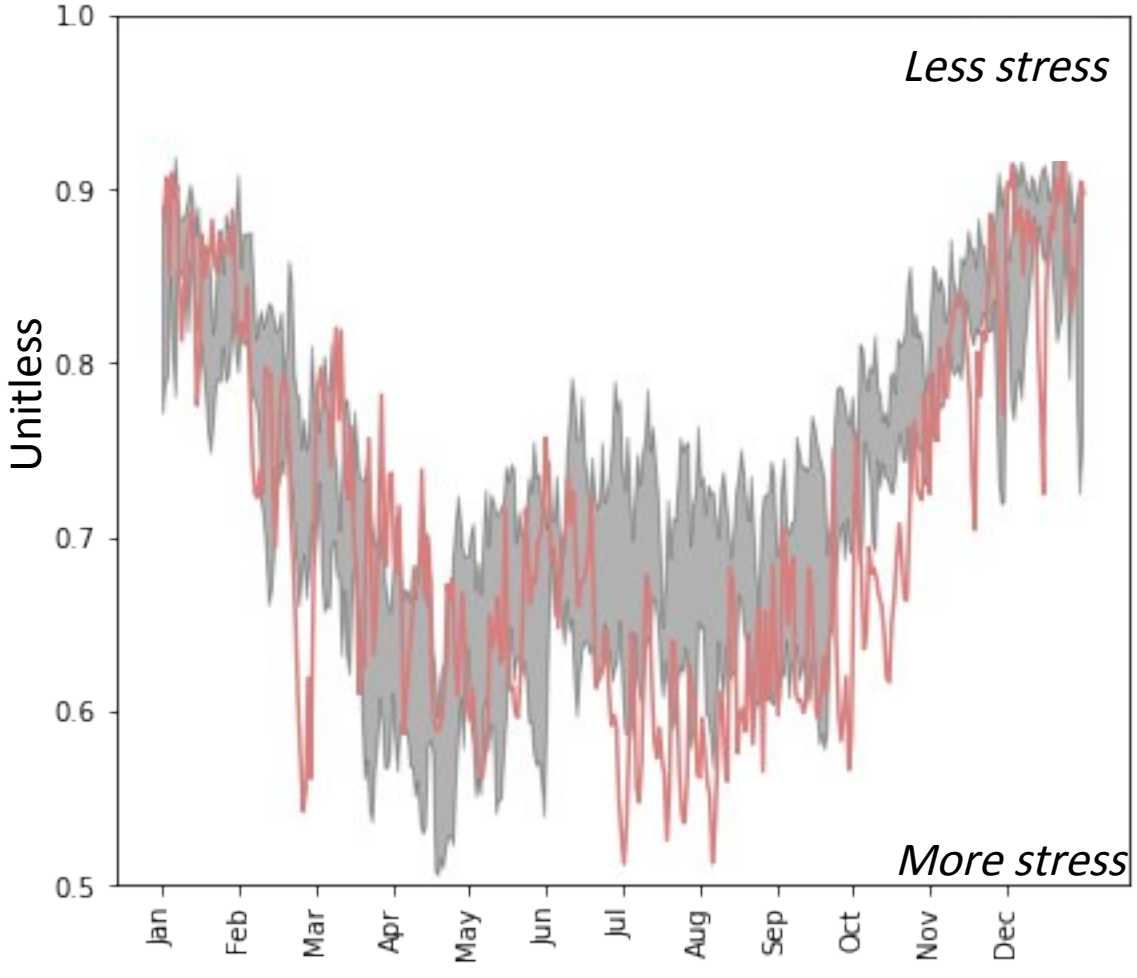
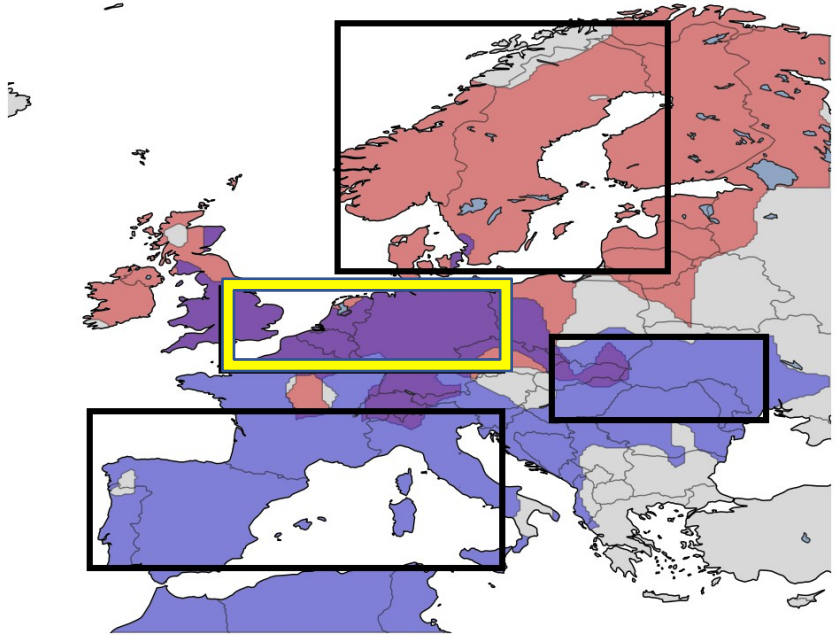


Central Europe – VPD stress

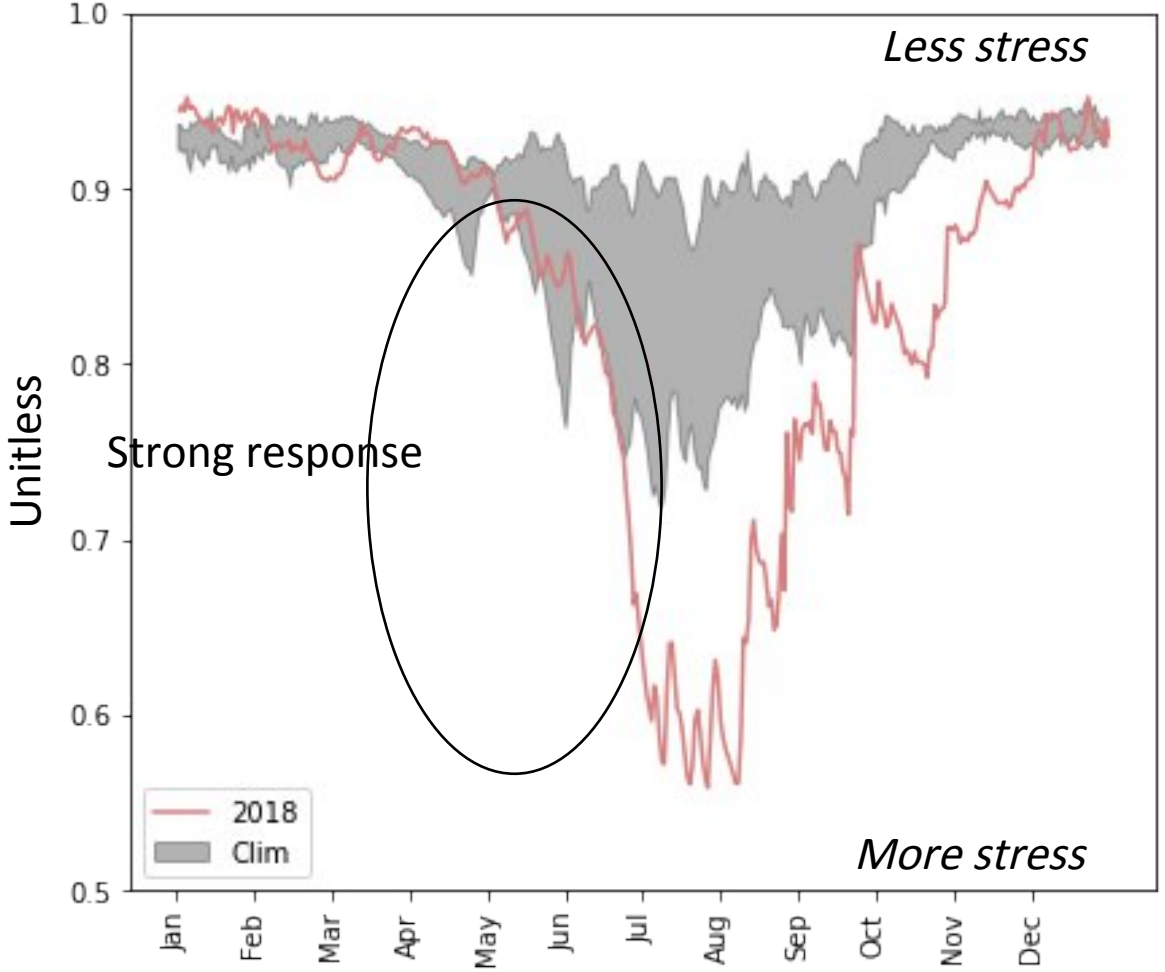


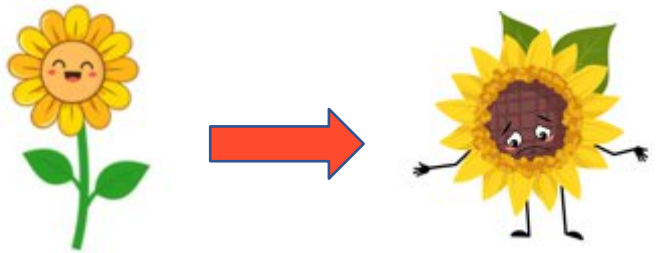


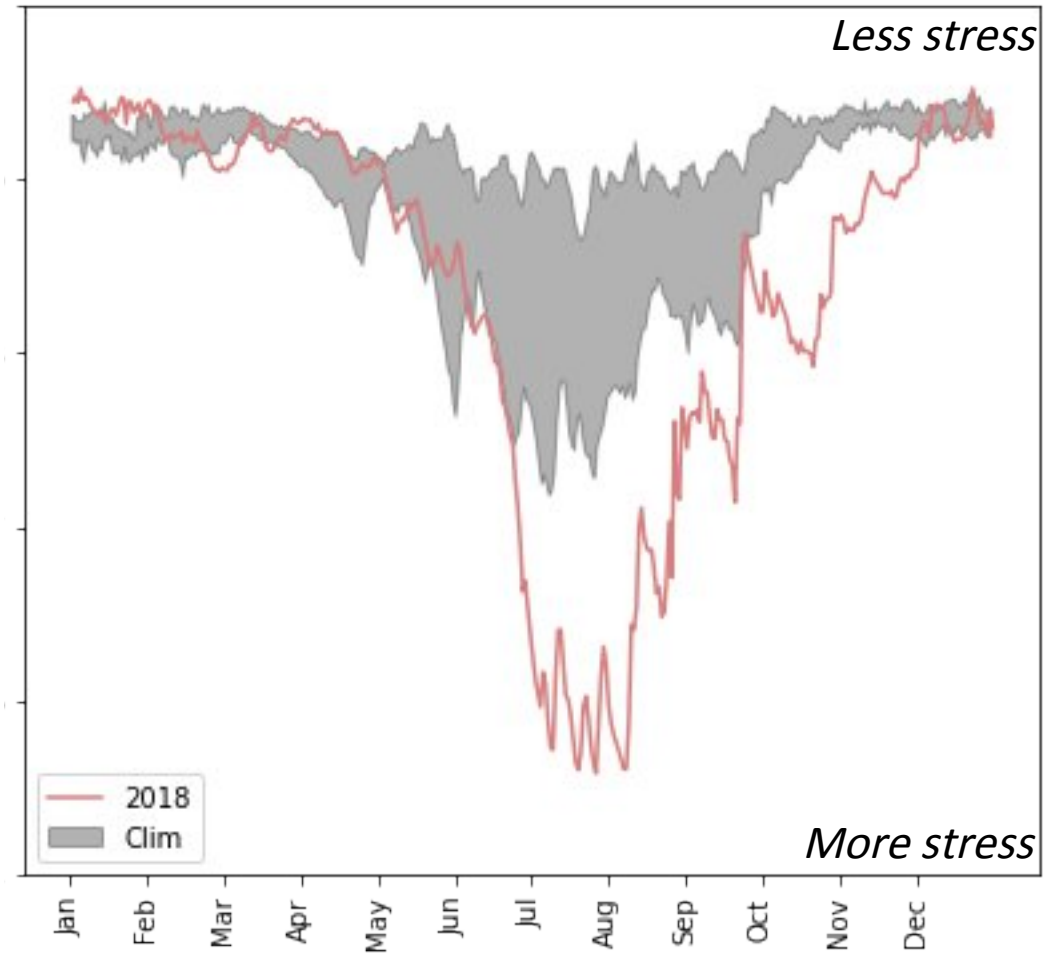
Central Europe – Soil moisture

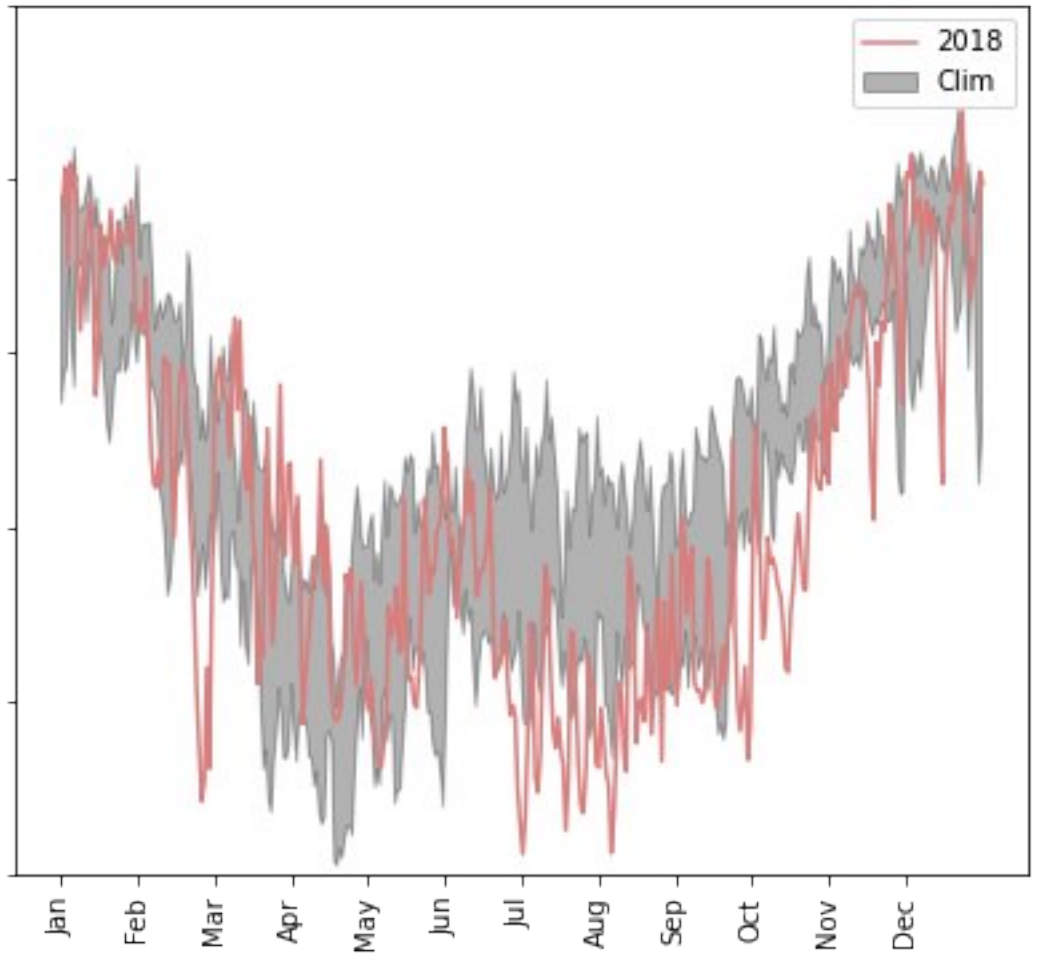


Soil moisture stress:



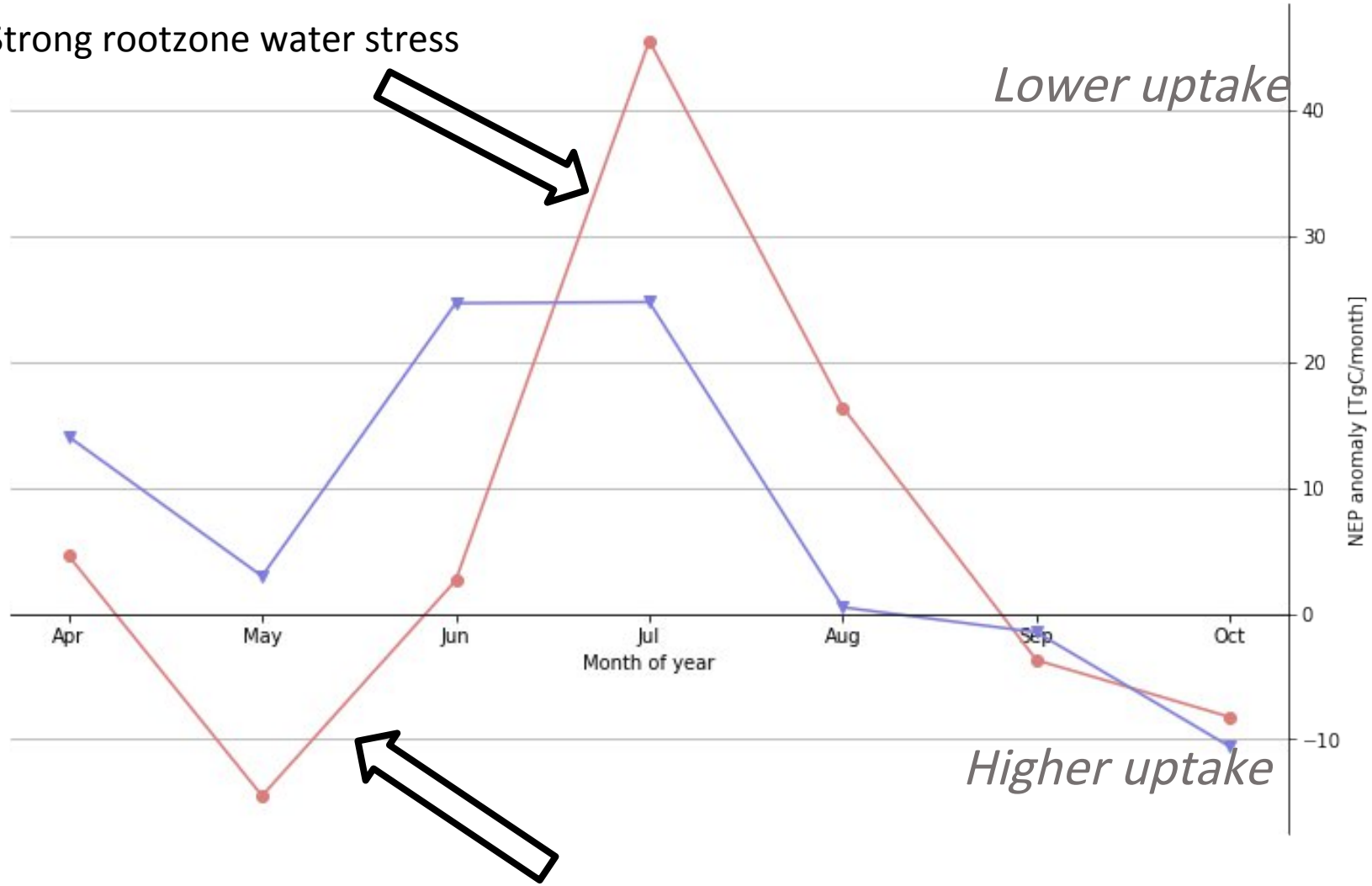


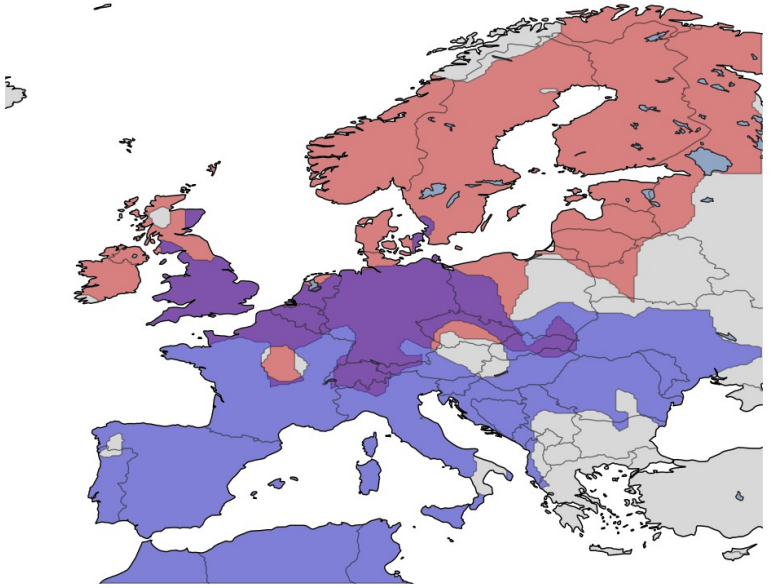




Rootzone water stress

Strong rootzone water stress

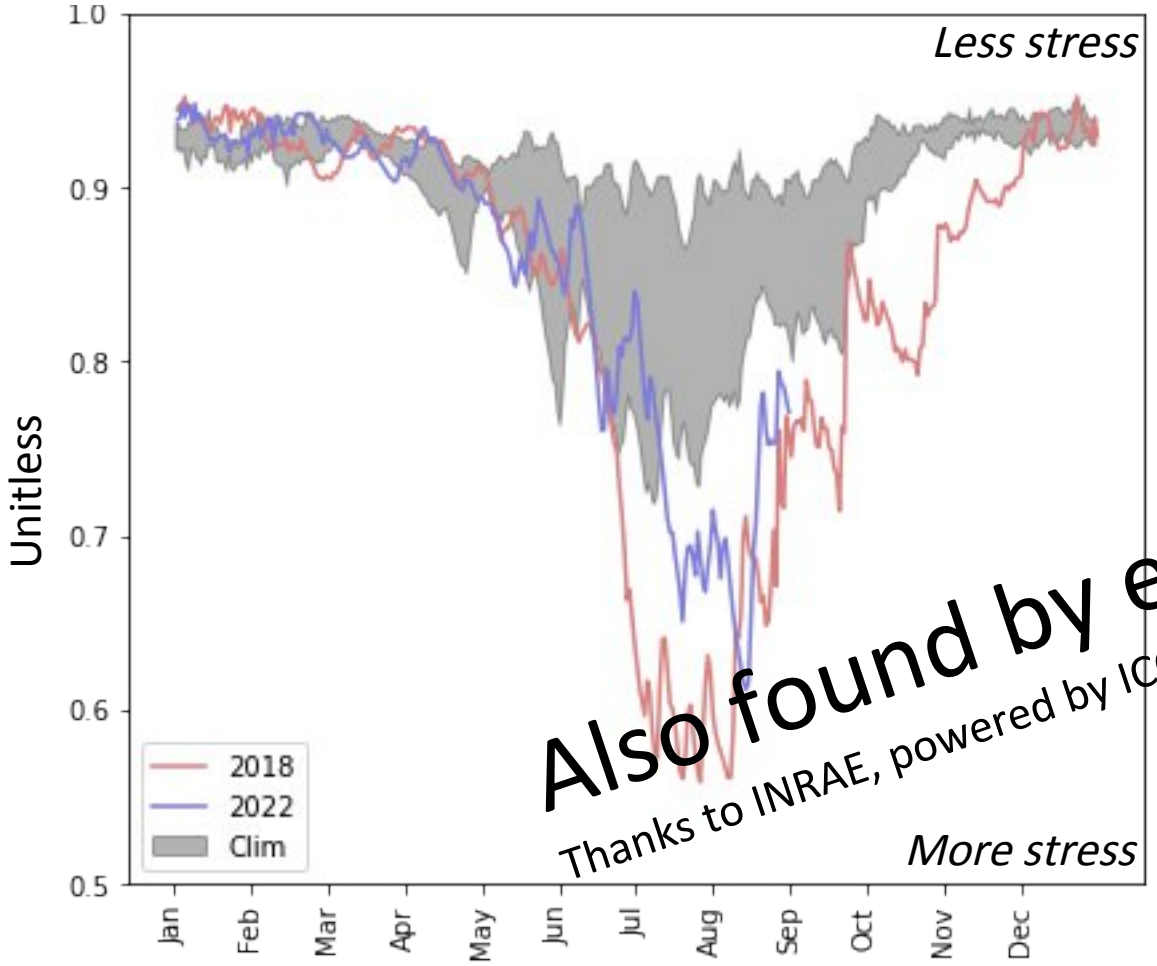




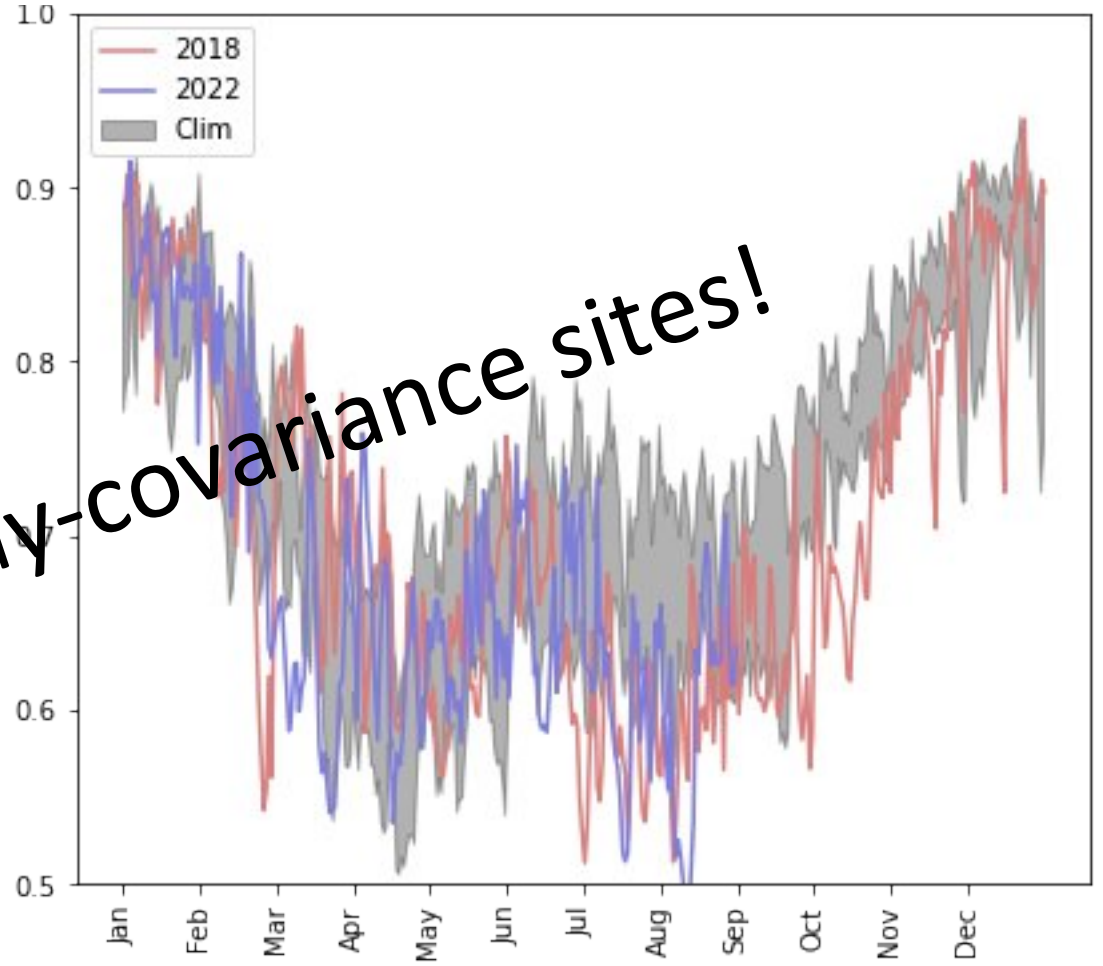
But what about 2022?

Higher temperature; more sunlight, enough water

Centre



Rootzone water stress

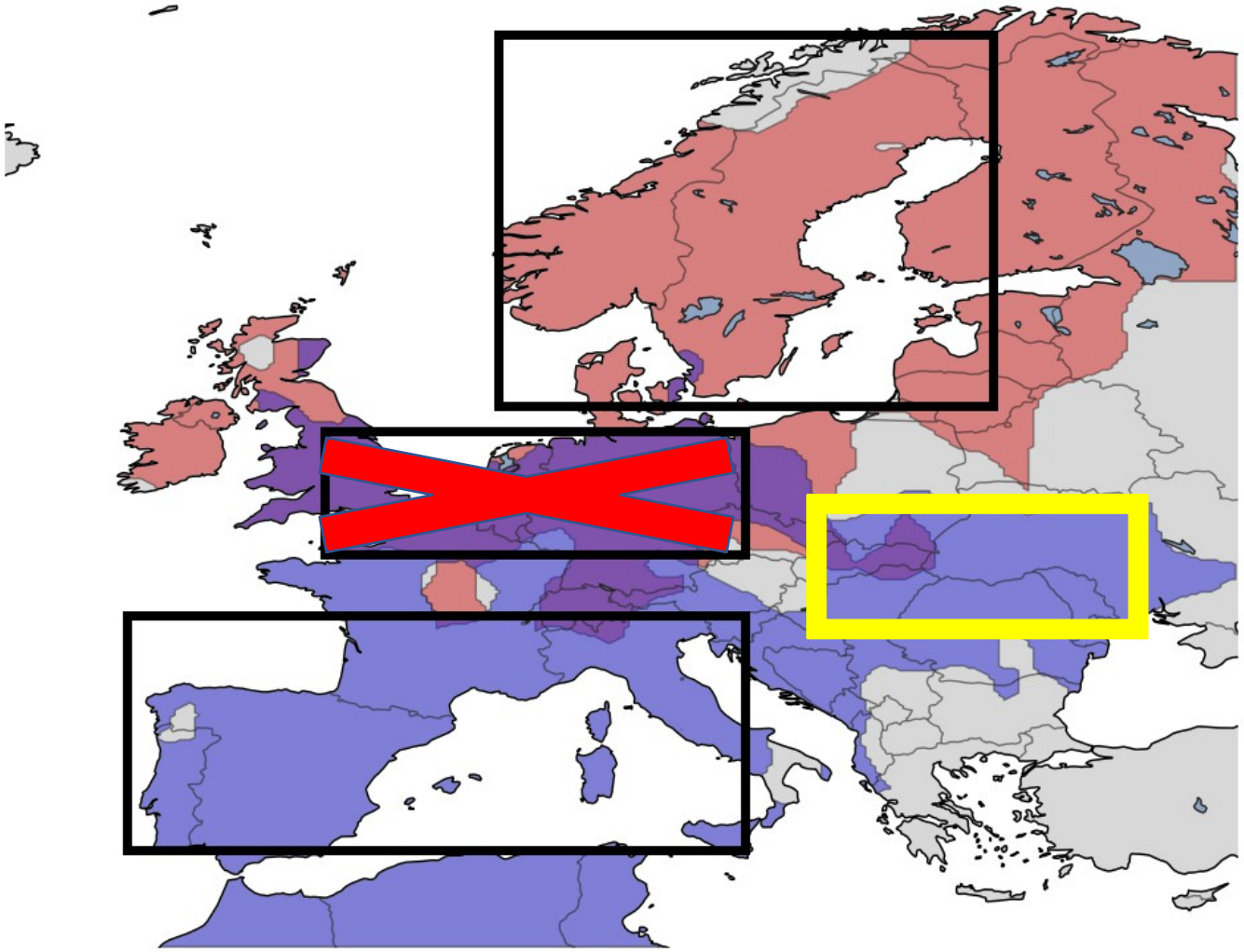


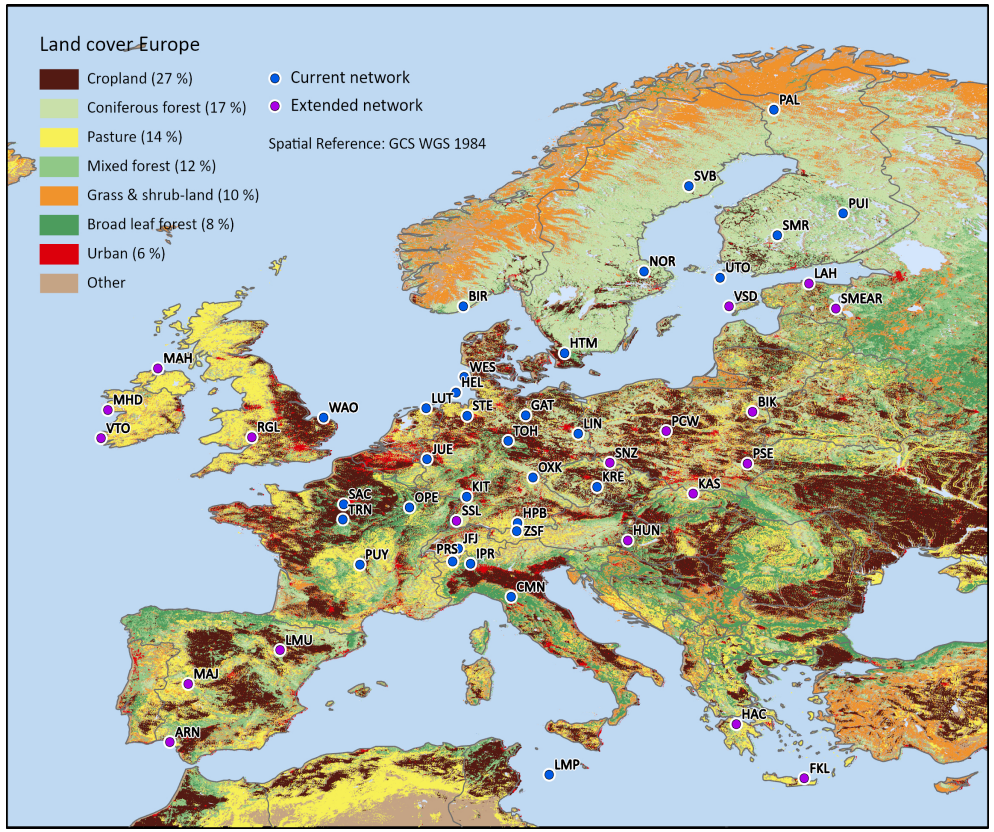
Leaf humidity stress

Also found by eddy-covariance sites!

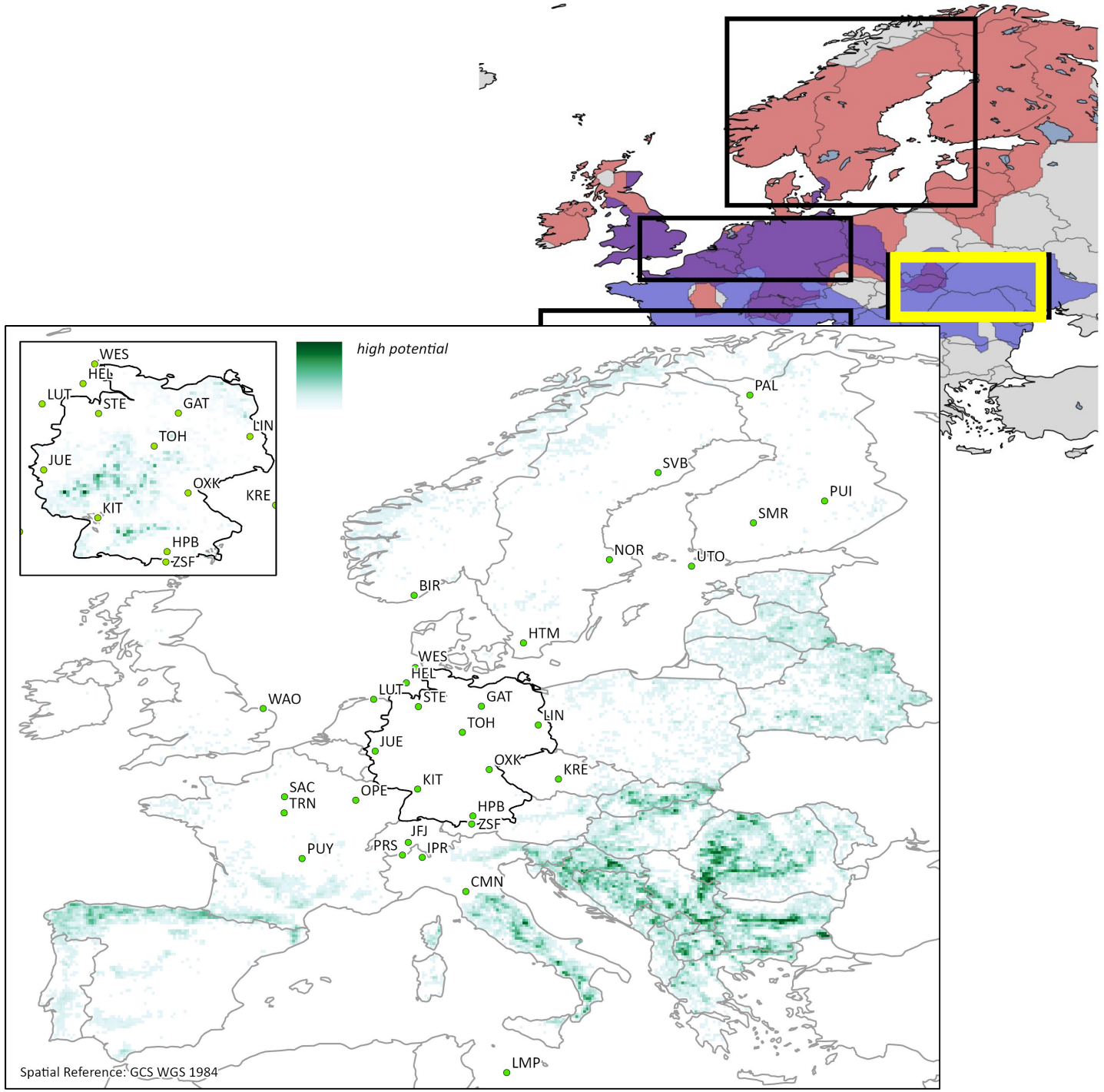
Thanks to INRAE, powered by ICOS

’New’ region: East



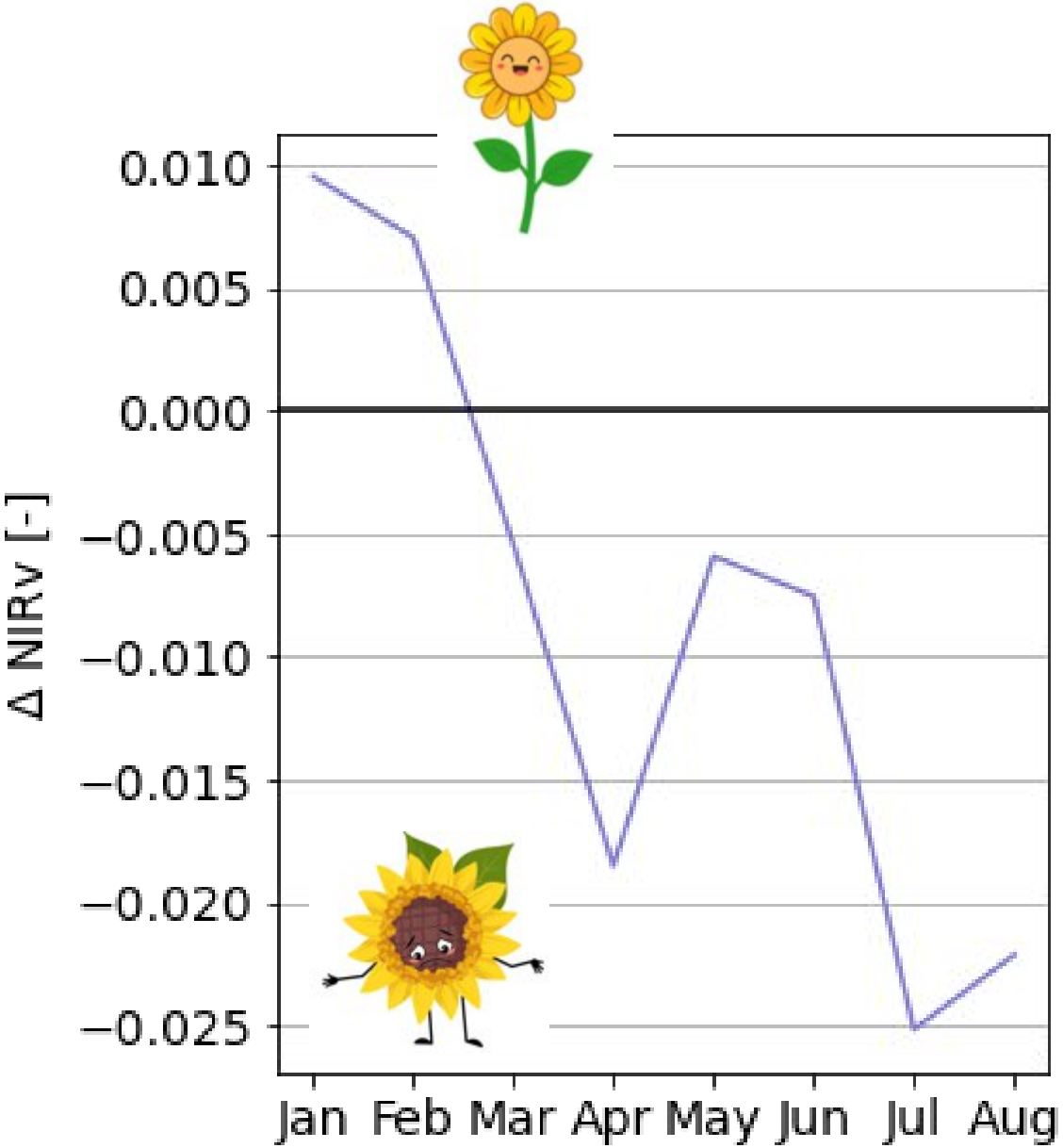


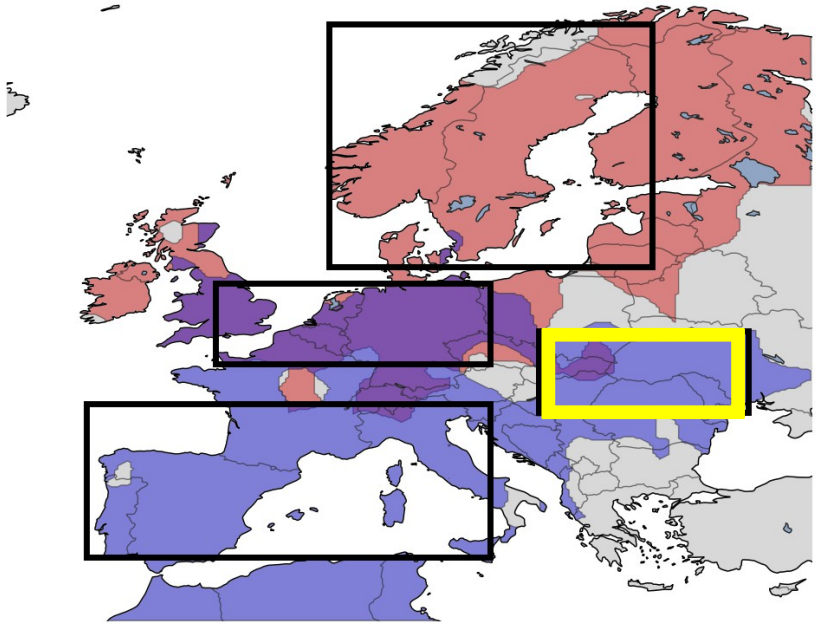
Land use type

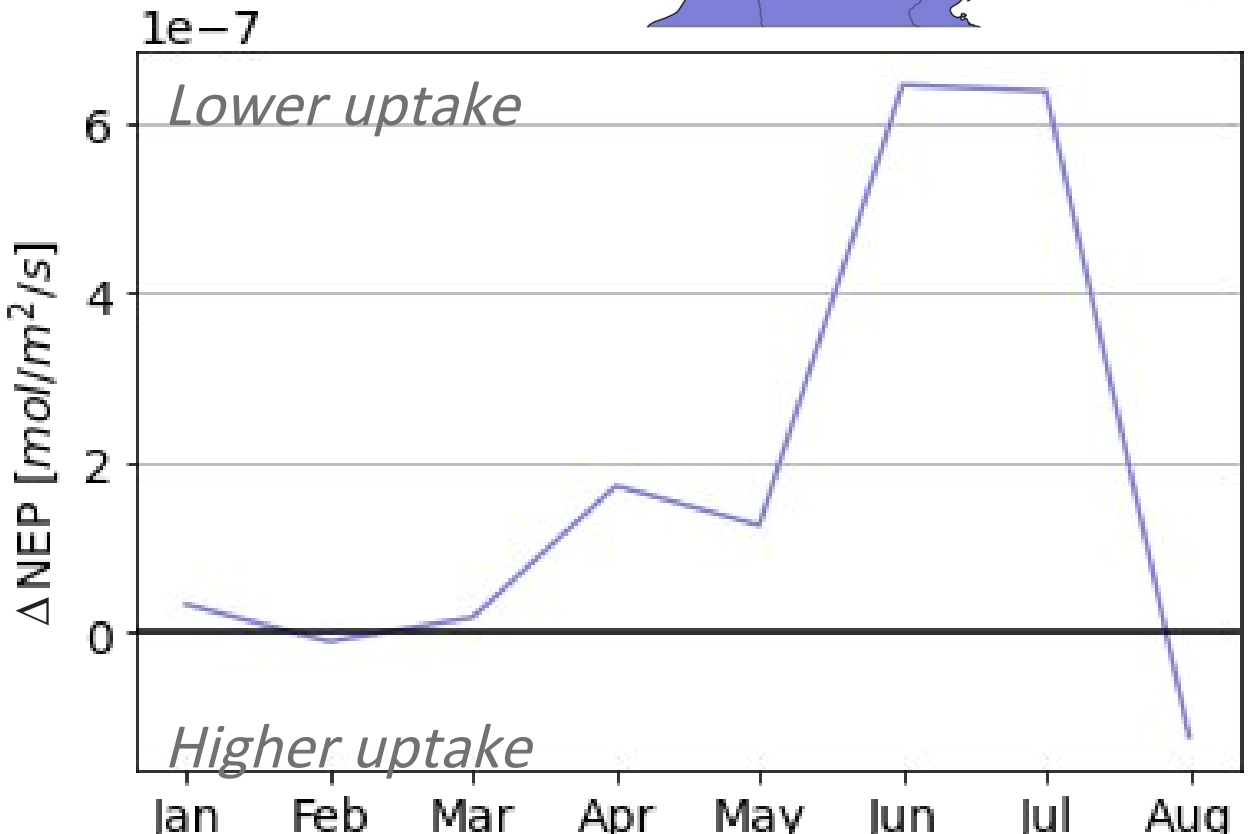


Monitoring potential for broadleaved forest fluxes

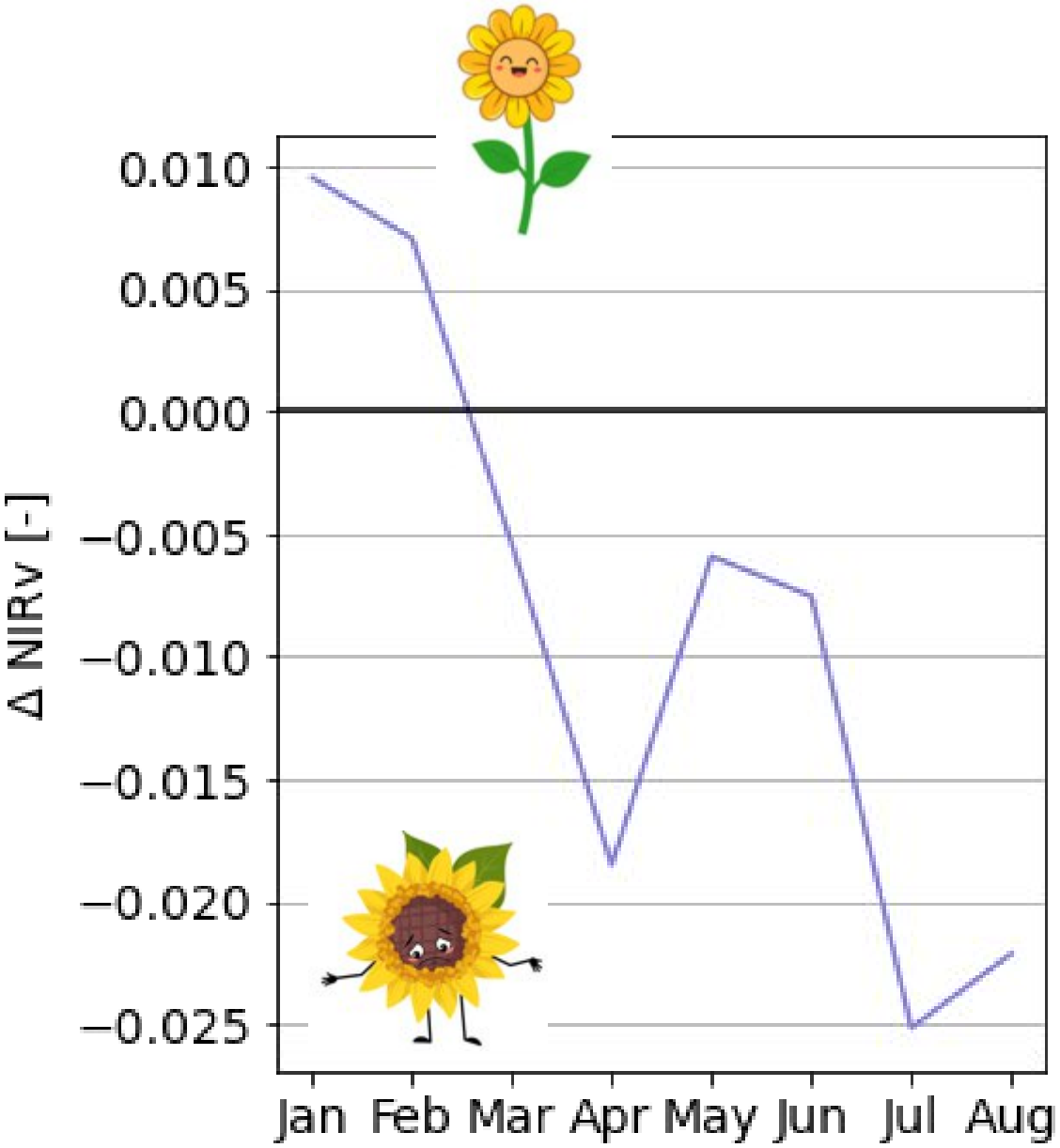
Storm et al., in prep.

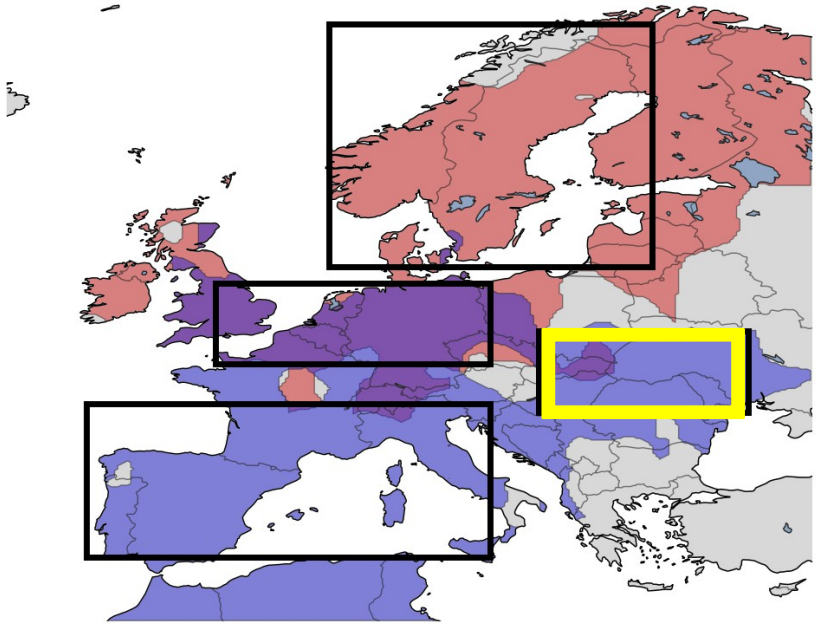






Reference years: 2016 - 2022



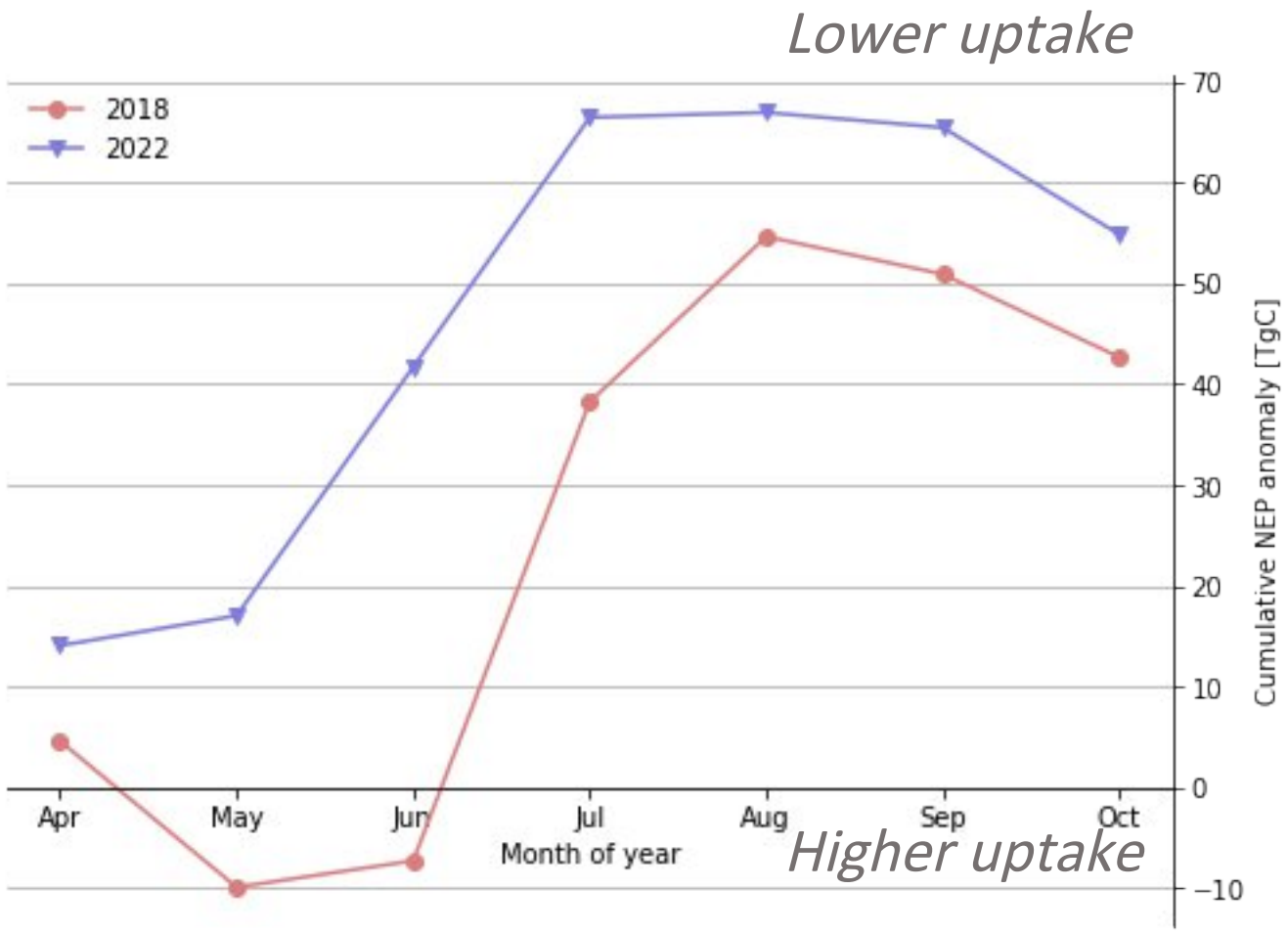


SM stress, but leaf RH stress dominant

Reference years: 2016 - 2022

Current status

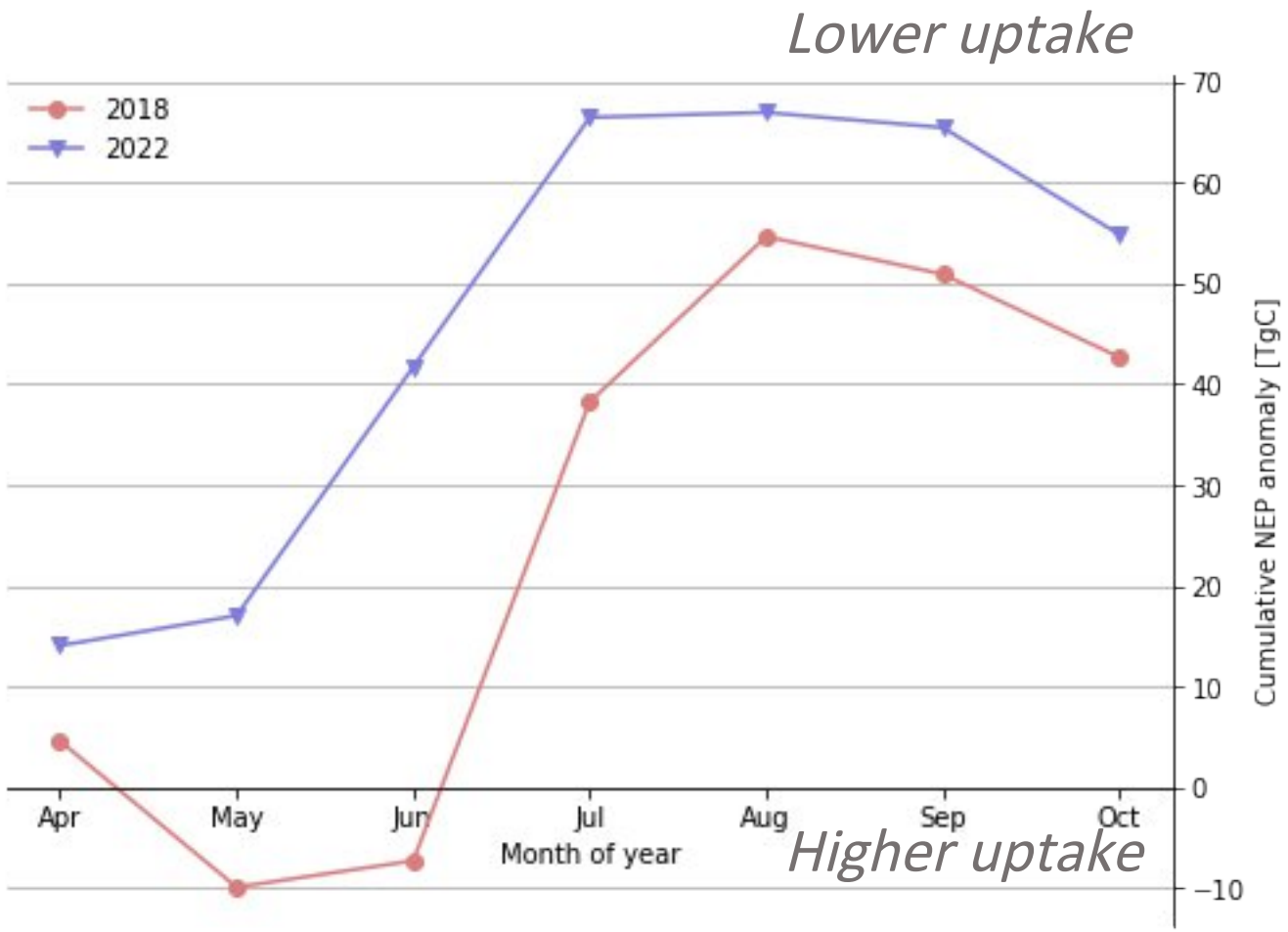
- Biosphere took up 55TgC less
- Eastern Europe important
- Fall enhancement?
- Fires more intense than 2018 (~5 TgC)



Current status

- Biosphere took up 55TgC less
- Eastern Europe important
- Fall enhancement?
- Fires more intense than 2018 (~5 TgC)

- Note: only one model; preliminary data



Conclusions

- Drought of 2022 likely worse than 2018
  - no enhanced spring uptake
  - Soil moisture vs leaf humidity stress
  - Fires
  - Research ongoing

- Gas crisis shows in our data

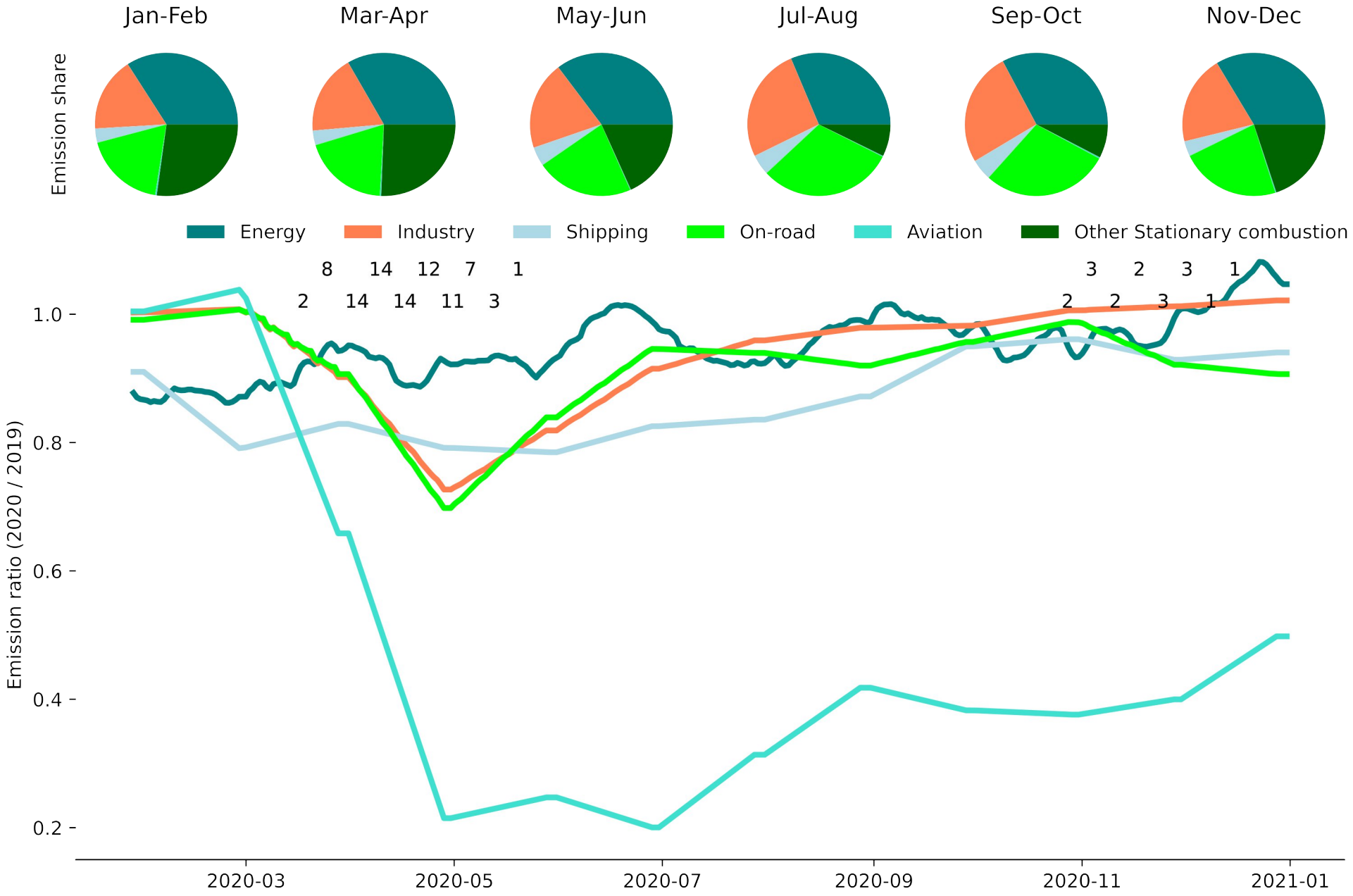
Download at the ICOS Carbon Portal:
https://doi.org/10.18160/20Z1-AYJ2
(And also fossil fuels, ocean and fire fluxes-)

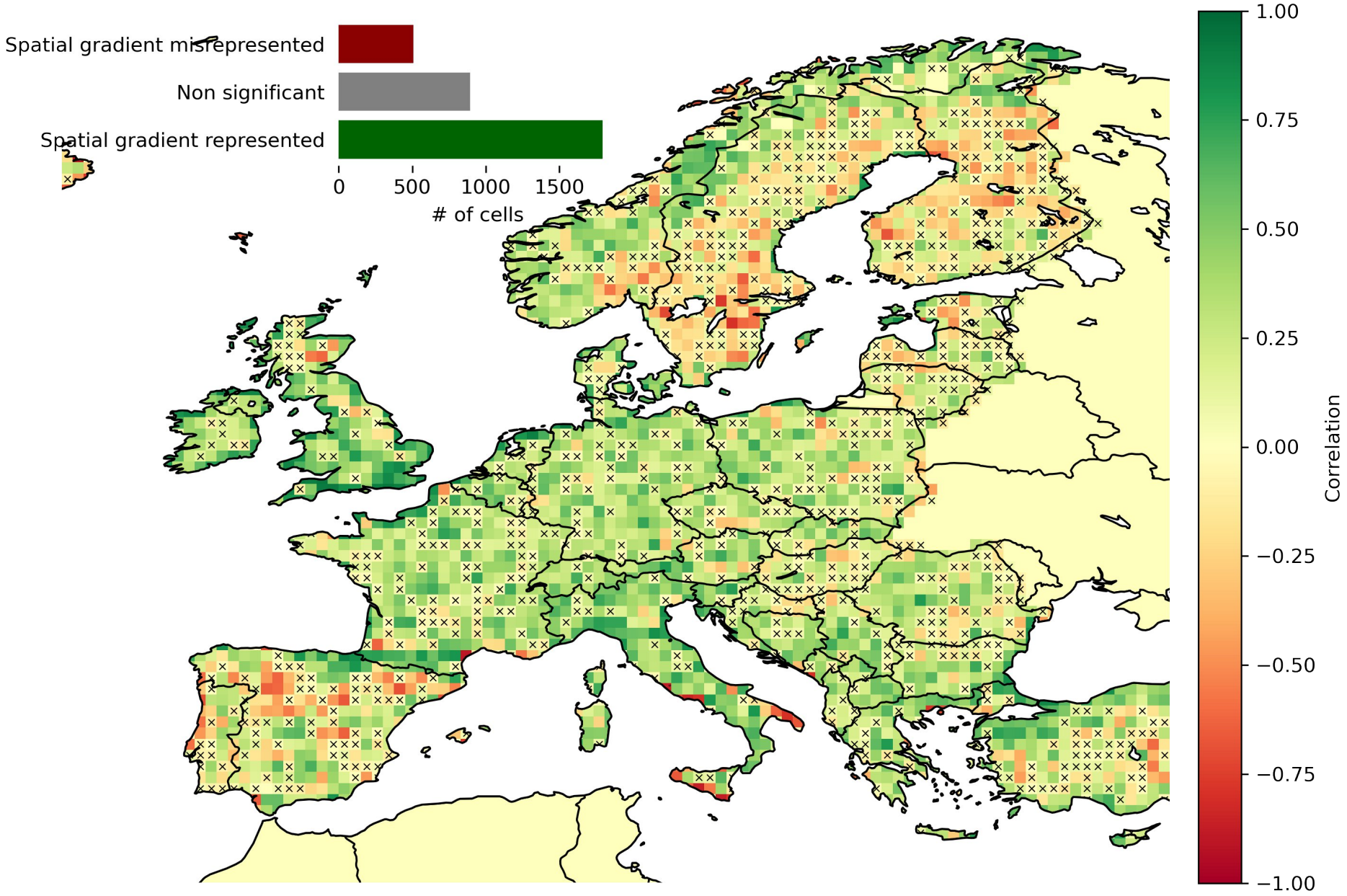
More details: https://doi.org/10.5194/essd-2022-175

rijksuniversiteit groningen

ICOS Integrated Carbon Observation System

WAGENINGEN UNIVERSITY & RESEARCH


Jan-Feb
Mar-Apr
May-Jun
Jul-Aug
Sep-Oct
Nov-Dec
Emission share
Energy
Industry
Shipping
On-road
Aviation
Other Stationary combustion
8 14 12 7 1
2 14 14 11 3
3 2 3 1
2 2 3 1
Emission ratio (2020 / 2019)
1.0
0.8
0.6
0.4
0.2
2020-03
2020-05
2020-07
2020-09
2020-11
2021-01

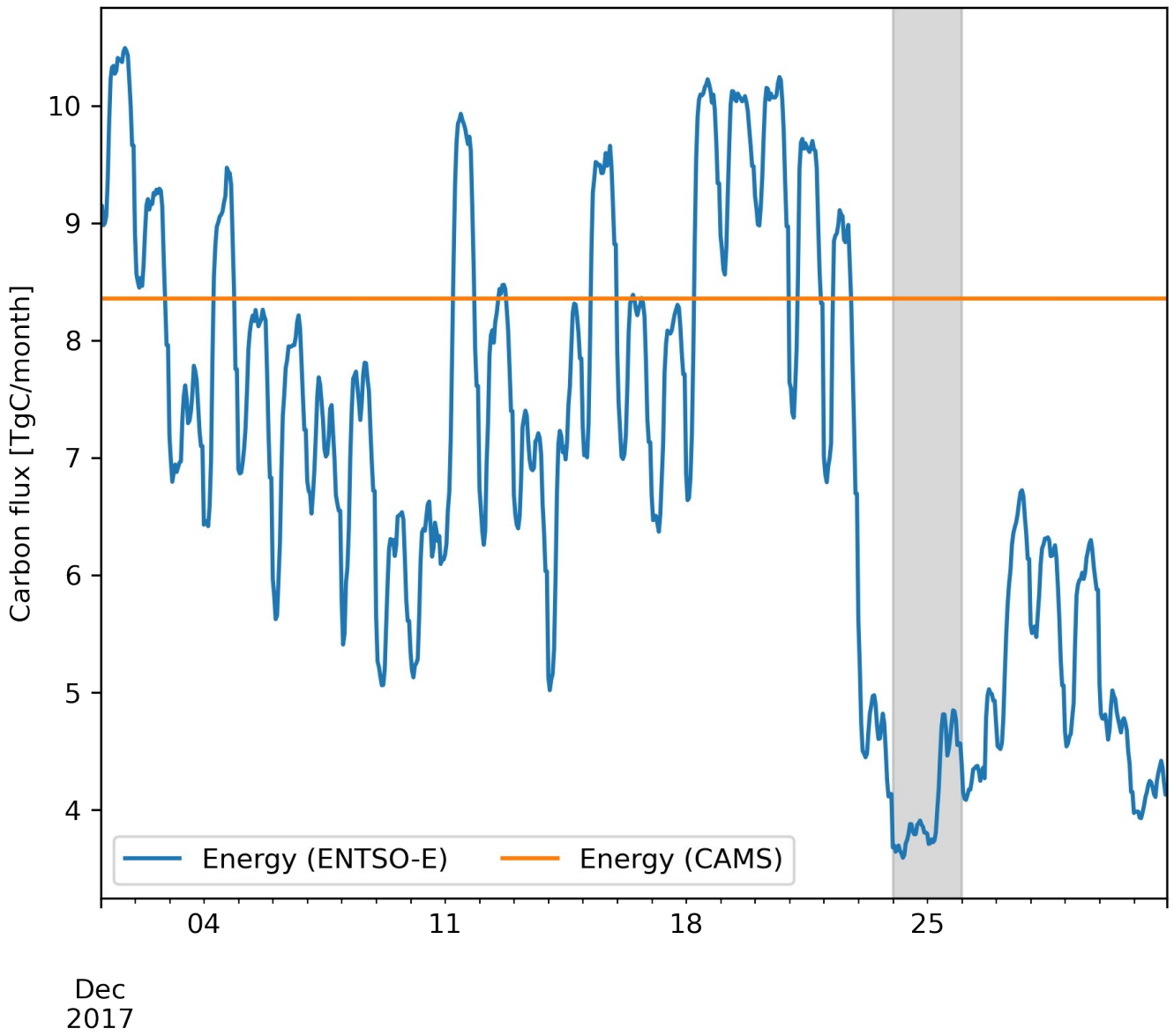

Spatial gradient misrepresented
Non significant
Spatial gradient represented
0
500
1000
1500
# of cells
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00
Correlation

RH stress: $F_{LH} = \frac{H_2Os}{H_2Oi}.$

SM stress: $F_{RZ} = \frac{(1 + wssp)\frac{w_{column}}{w_{max}}}{wssp + \frac{w_{column}}{w_{max}}}$

where *wcolumn* is water in the column in excess of wilt point (kg), *wmax* is the maximum possible excess of water in the column (field capacity less wilt point, kg), and *wssp* is a water stress curvature parameter, currently set to 0.2.

Haynes et al., 2020
https://mountainscholar.org/bitstream/handle/10217/200691/FACFATMS_sib4_tech_2020.pdf?sequence=1


Carbon flux [TgC/month]
10
9
8
7
6
5
4
Energy (ENTSO-E)
Energy (CAMS)
04
11
18
25
Dec
2017

Ukraine crisis

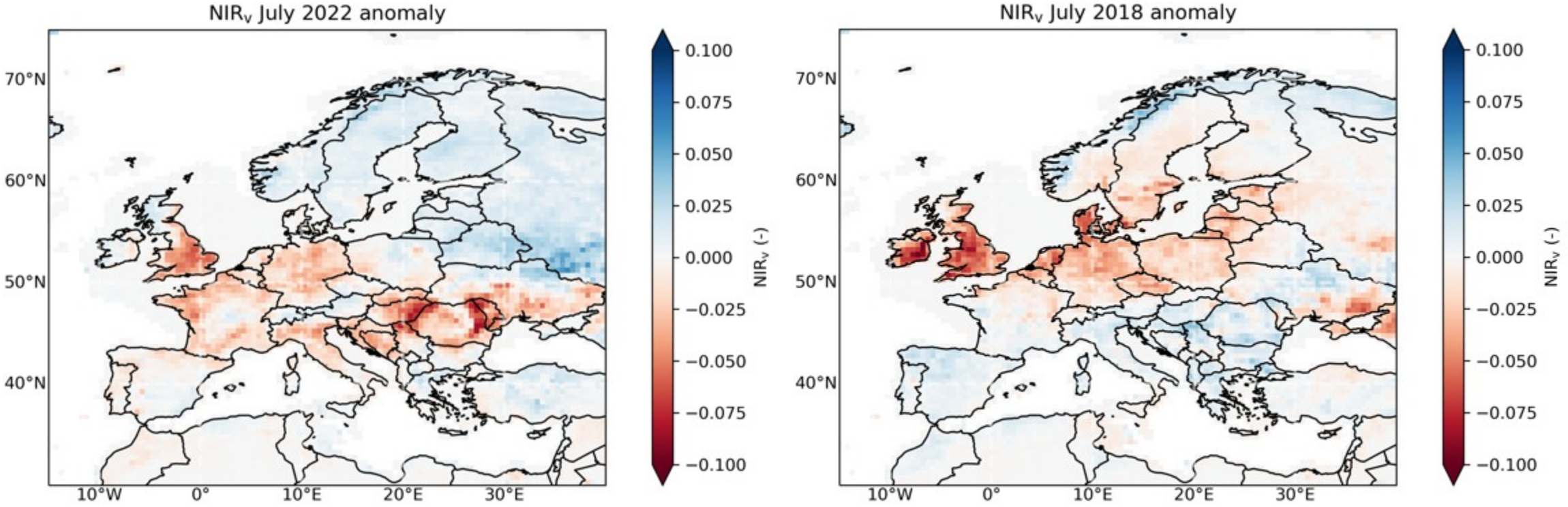
CO_2 emissions from public power, relative to 2021

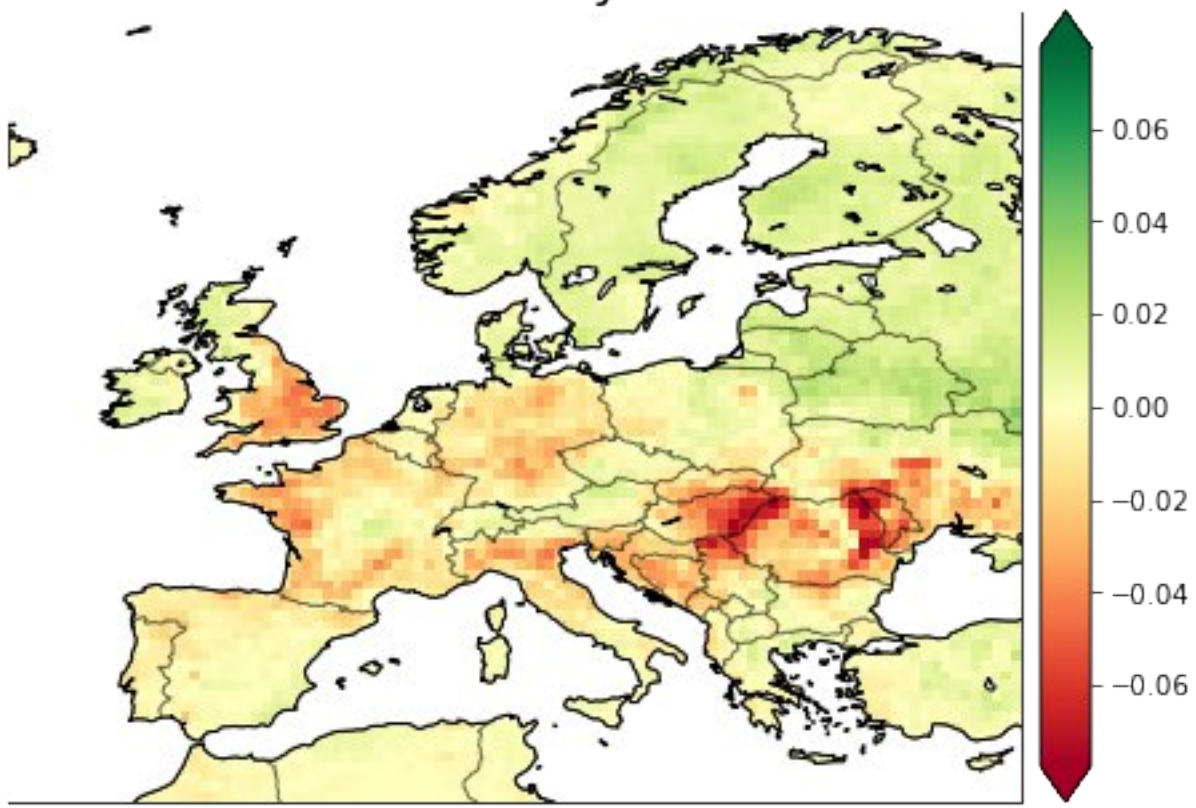
Year	Gas	Coal
2016	0.51	1.83
2017	0.76	2.07
2018	0.72	1.80
2019	0.94	1.38
2020	1.01	0.63
2021	1.00	1.00
2022	0.76	1.12

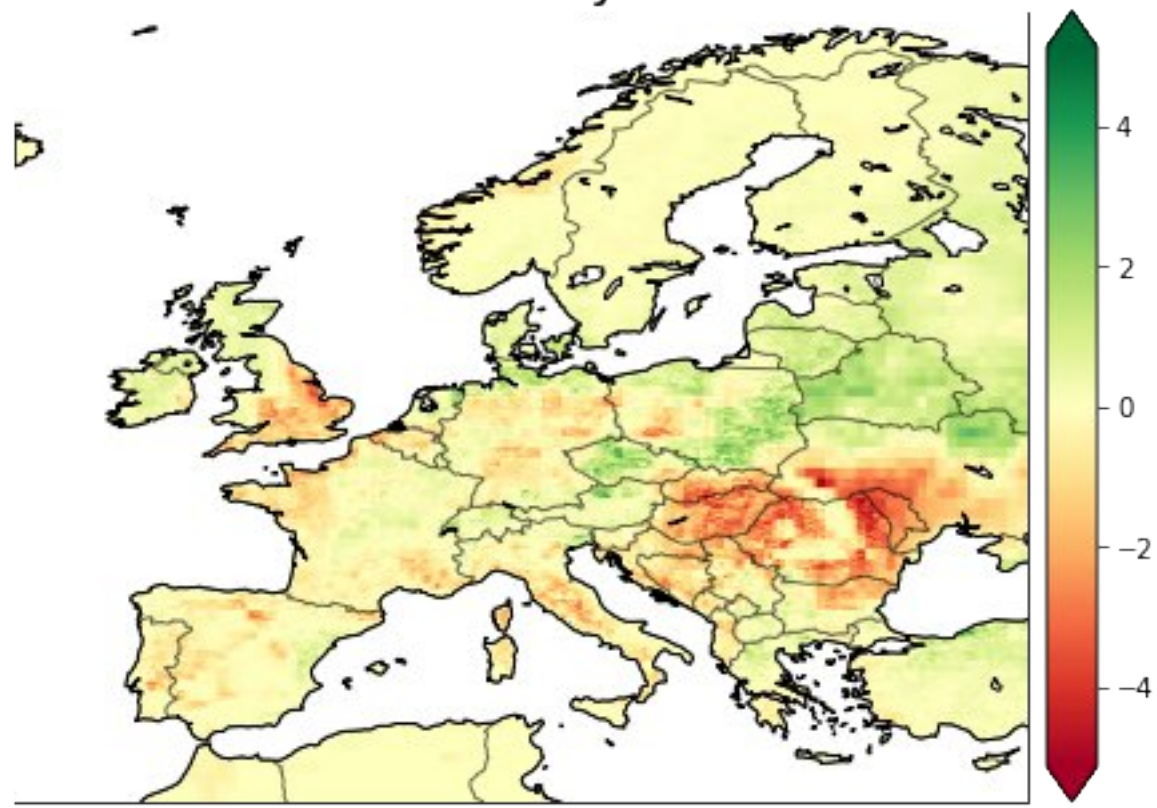
Total CO_2 about the same

Fires (negative means more emission)

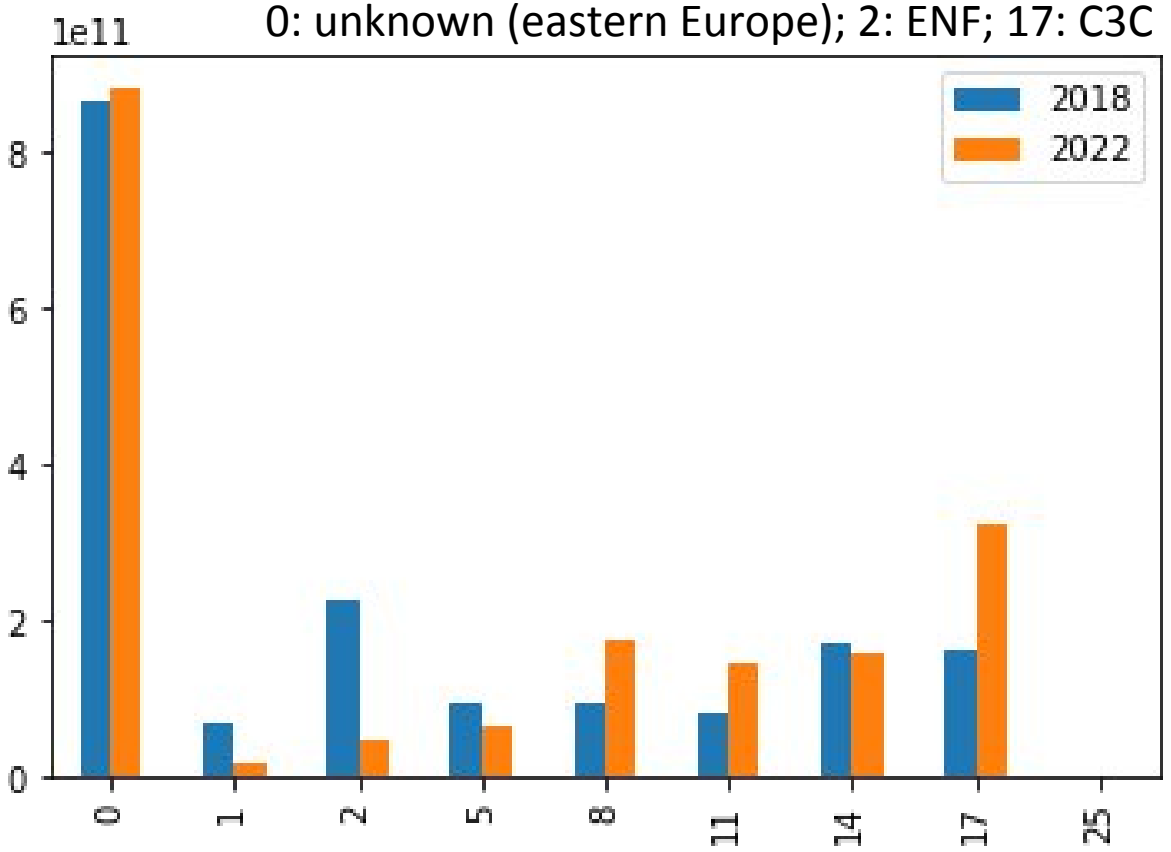
NIRv


NIRv July 2022 anomaly
70°N
60°N
50°N
40°N
10°W
0°
10°E
20°E
30°E
0.100
0.075
0.050
0.025
0.000
−0.025
−0.050
−0.075
−0.100
NIRv (-)
NIRv July 2018 anomaly
70°N
60°N
50°N
40°N
10°W
0°
10°E
20°E
30°E
0.100
0.075
0.050
0.025
0.000
−0.025
−0.050
−0.075
−0.100
NIRv (-)


NIRv anomaly 2022
0.06
0.04
0.02
0.00
−0.02
−0.04
−0.06

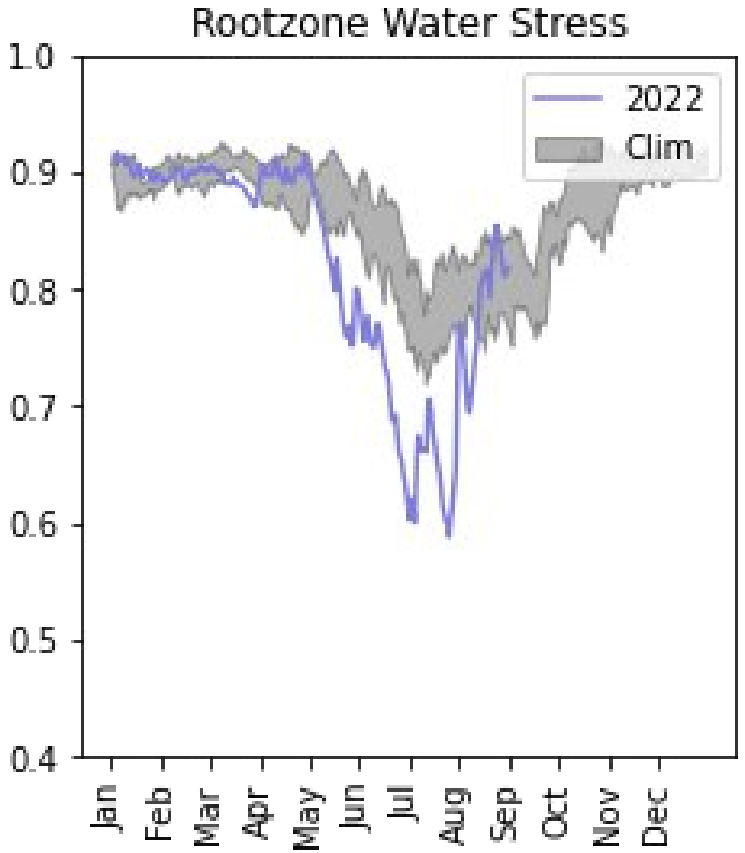

GPP anomaly 2022
4
2
0
−2
−4

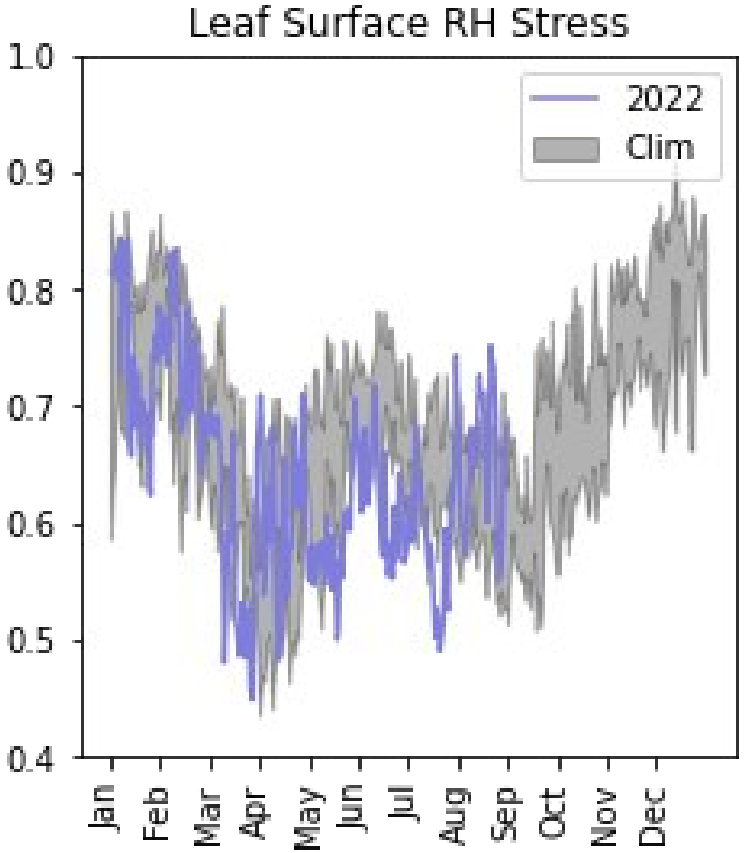
Drought-struck area per land-cover.
0: unknown (eastern Europe); 2: ENF; 17: C3C

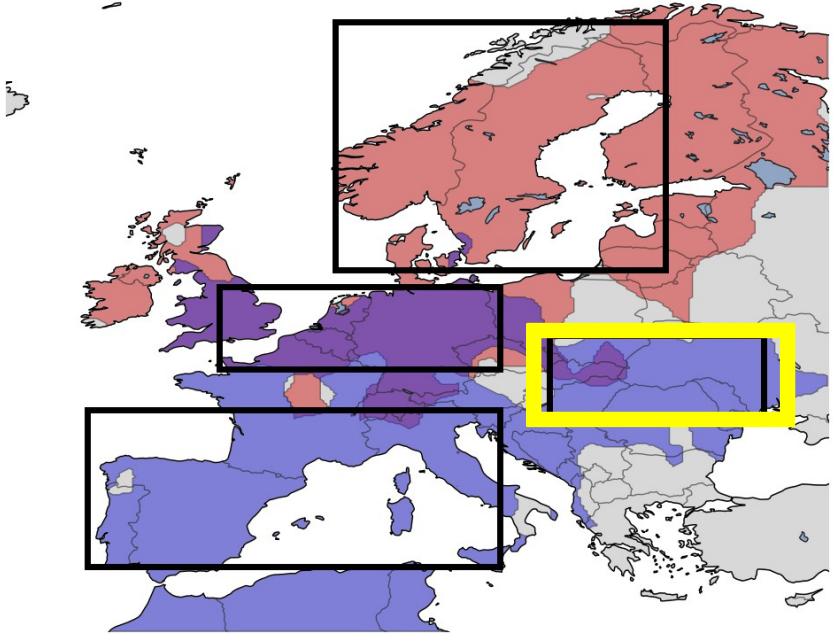


Eastern Europe

- Drought started from March!

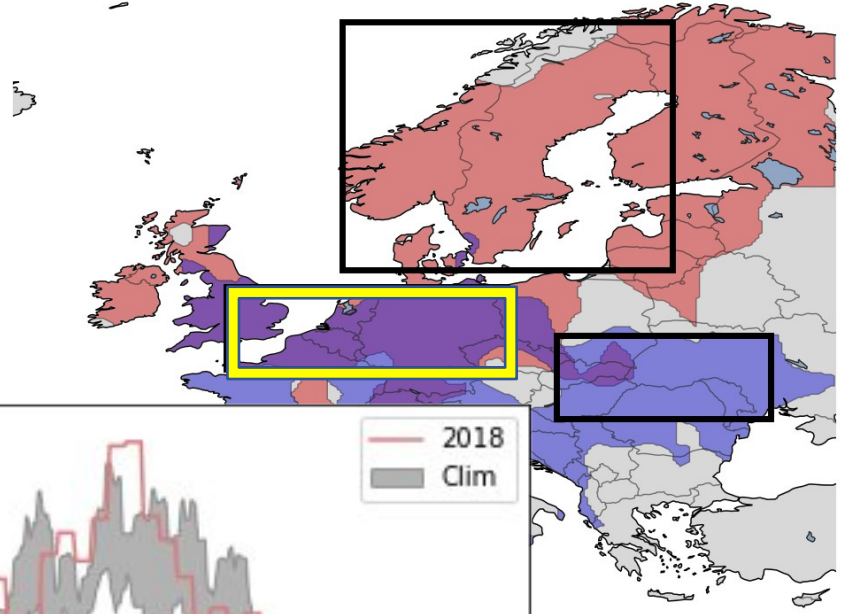


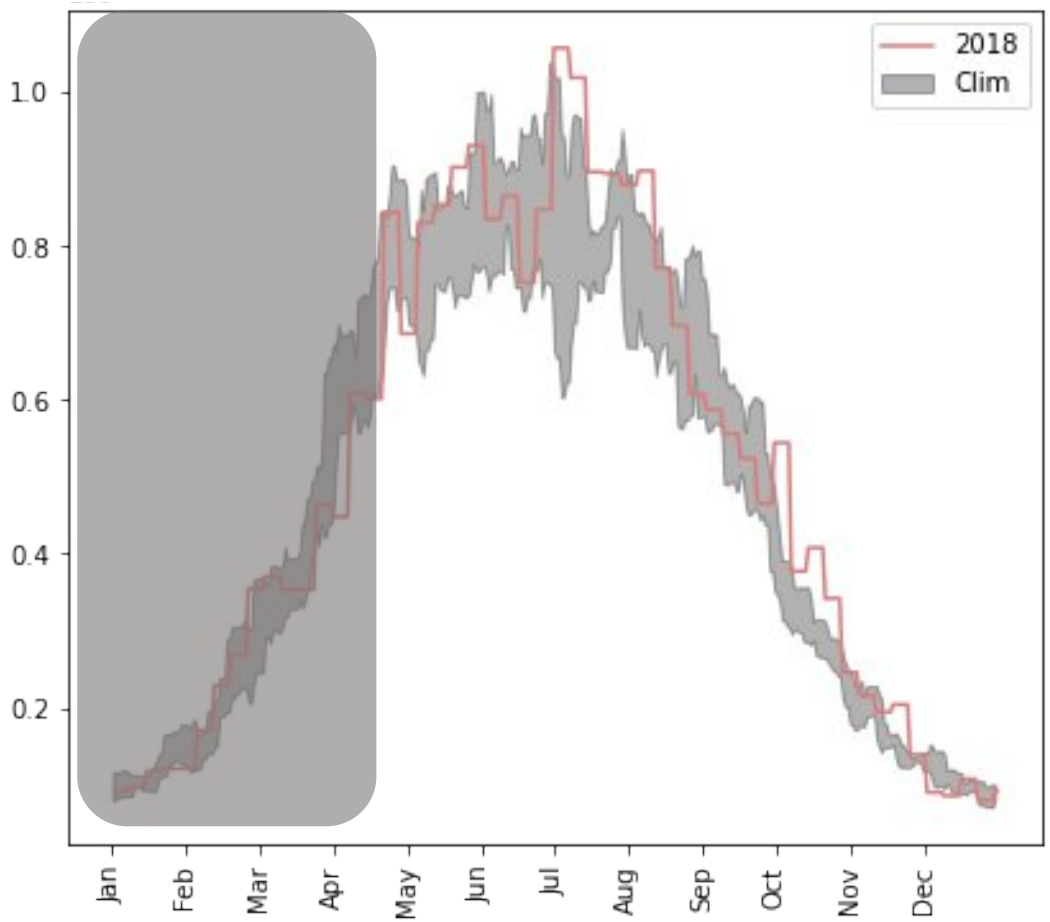




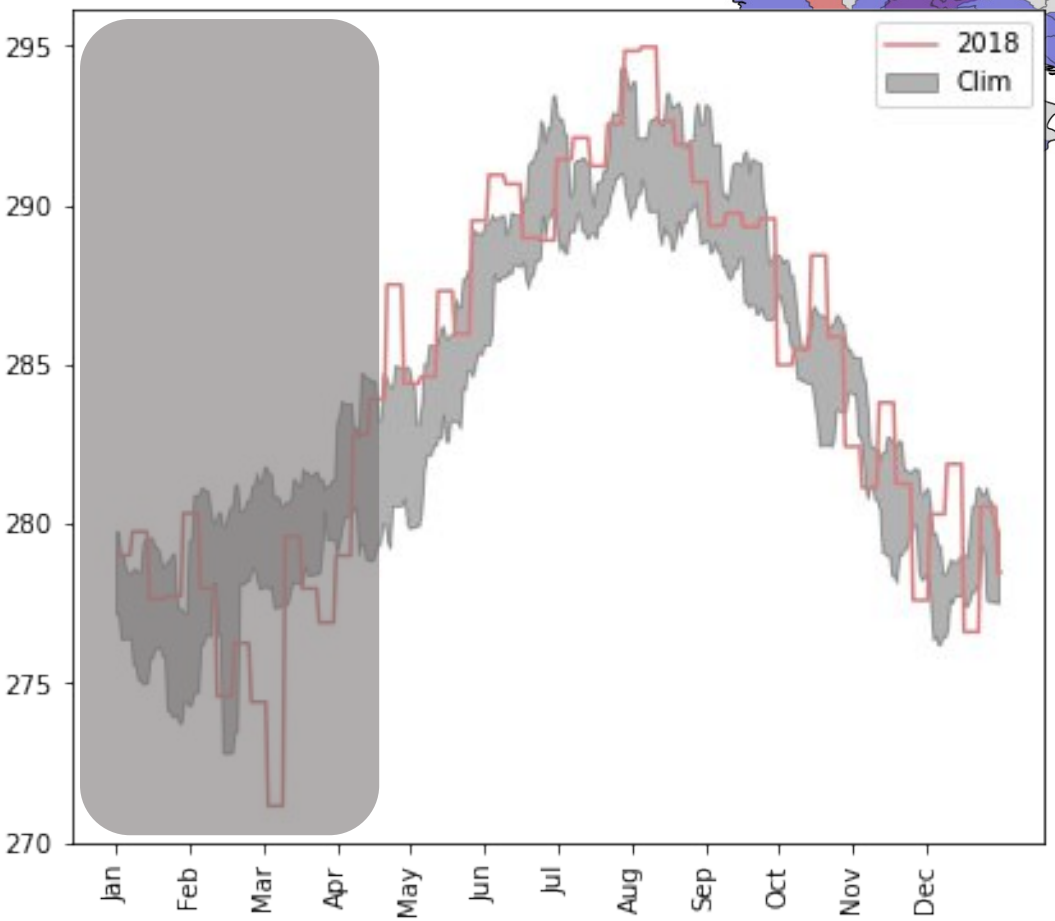
No stress before soil moisture?

Spring in ‘Centre’





Incoming solar radiation



Temperature