

Changes in Net Ecosystem Exchange over Europe During the 2018 Drought

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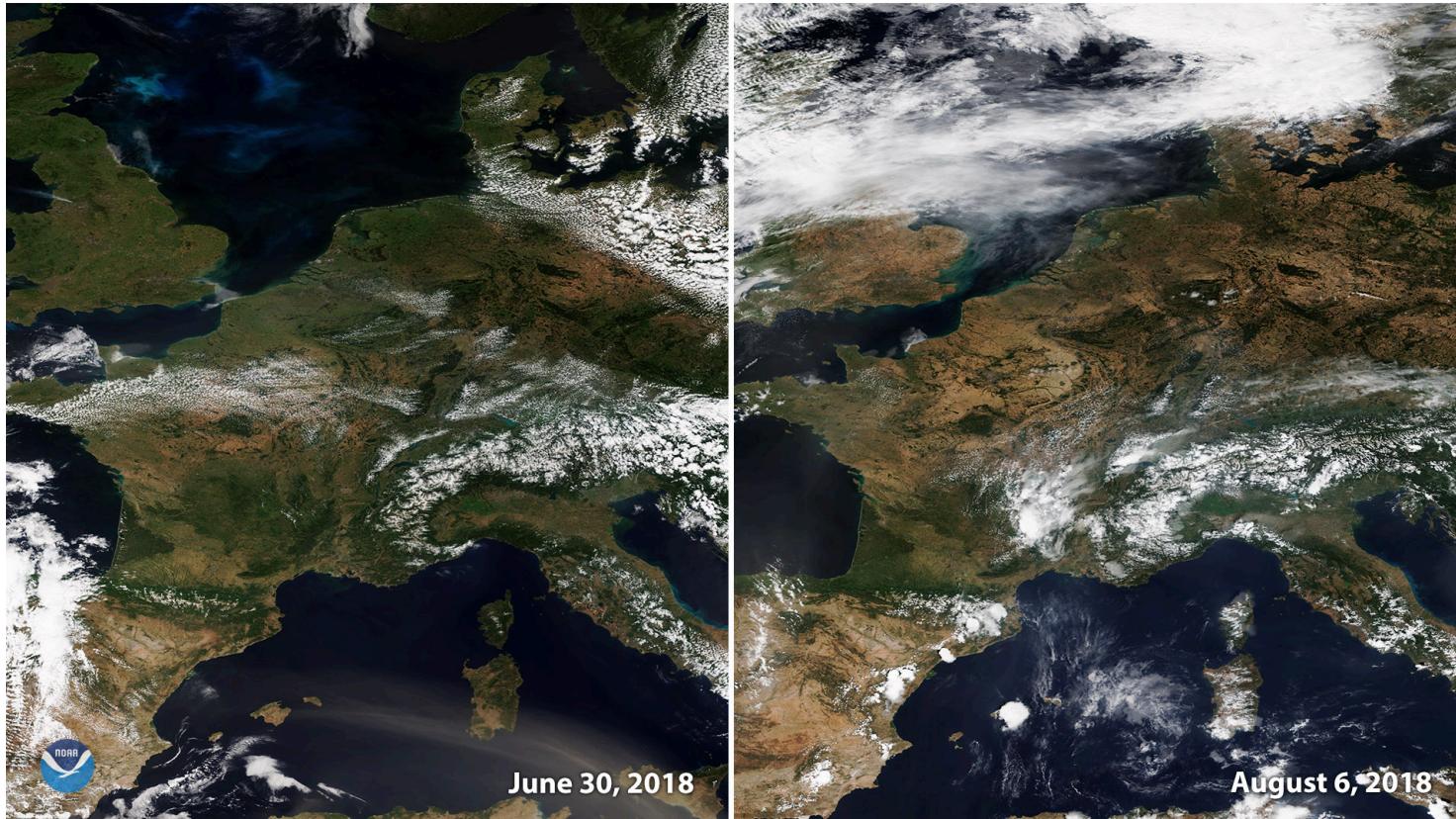
Introduction

- In 2018 Europe experienced a severe heatwave and drought
- Expect extreme meteorological conditions to impact NEE
- Used atmospheric CO₂ observations with models of atmospheric transport to estimate NEE over Europe
- Compared NEE in 2018 with the past 10 years

*ICOS special issue in Phil Trans Roy Soc:
Thompson et al., Phil Trans Roy Soc, 2020*

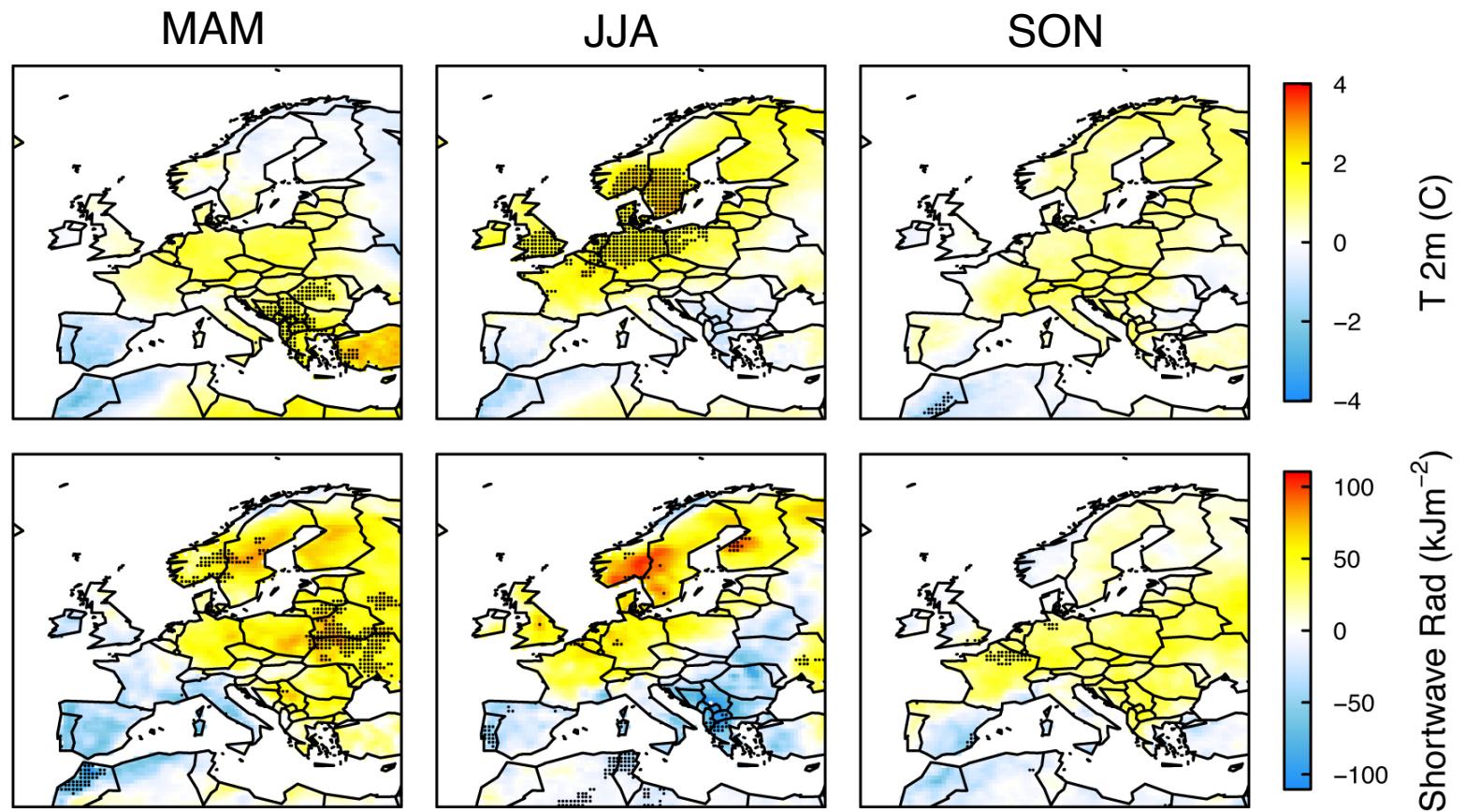
Background

NOAA-20 satellite's VIIRS instrument on 30 June and 6 August 2018 show the browning of western Europe after several weeks of hot, dry weather



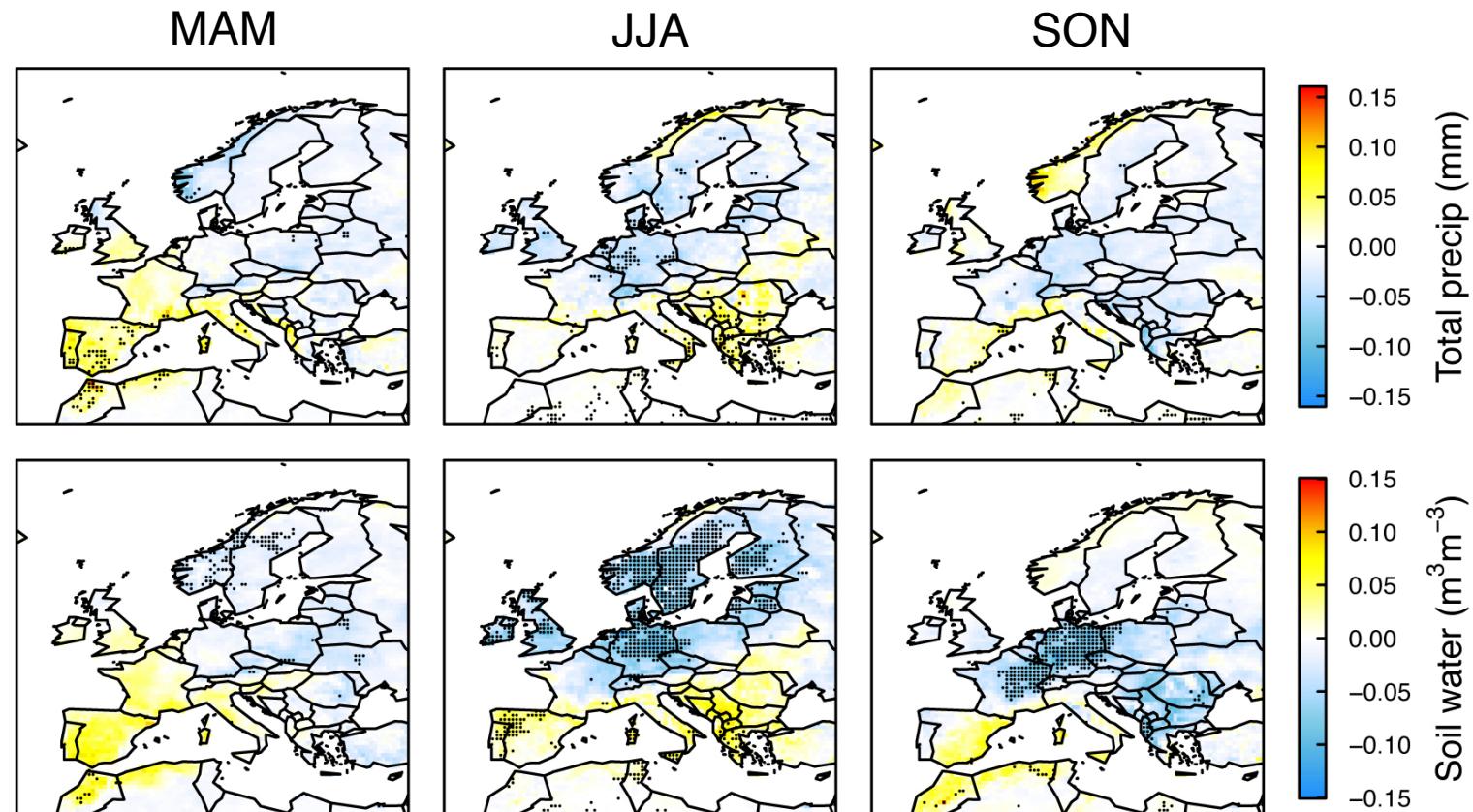
Background

Anomalies in 2m temperature and shortwave radiation compared to 2009-2018 mean (ECMWF ERA5)



Background

Anomalies in precipitation and soil water content compared to 2009-2018 mean
(ECMWF ERA5)

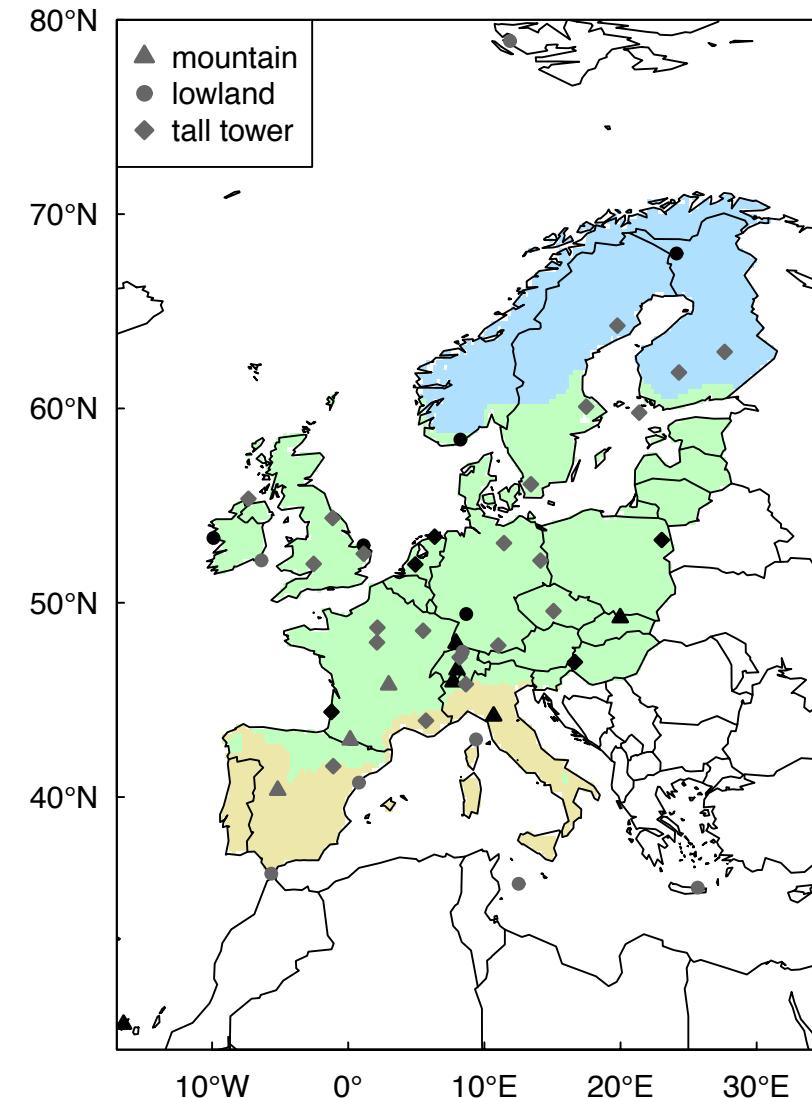


Inversion frameworks

	Carboscope Regional	FLEXINVERT	LUMIA	NAME-HB	PyVAR- CHIMERE
Transport model	STILT	FLEXPART	FLEXPART	NAME	CHIMERE
Meteo	ECMWF IFS	ECMWF IFS	ECMWF EI	UK Met	ECMWF IFS
Optimization	Variational	Variational	Variational	Metropolis Hastings	Variational
Resolution	$0.5^\circ \times 0.5^\circ$	$0.5^\circ \times 0.5^\circ$	$0.5^\circ \times 0.5^\circ$	$0.23^\circ \times 0.35^\circ$	$0.5^\circ \times 0.5^\circ$
Temporal	3 hours	12 hours	1 month	6 hours	6 hours

Atmospheric network

- Total of 48 in-situ measurement sites
- Selected 16 sites with quasi-continuous records for 2009-2018 for reference inversion (black points)
- Europe split into Northern, Temperate and Mediterranean regions (based on Koeppen-Geiger climate regions)



Prior fluxes

	Carboscope Regional	FLEXINVERT	LUMIA	NAME-HB	PyVAR CHIMERE
NEE	VPRM	SiBCASA	LPJ-Guess	LPJ-Guess	VPRM
Fossil fuel*	EDGARv4.32	EDGARv4.32	EDGARv4.32	EDGARv4.32	EDGARv4.32
Ocean	Mikaloff- Fletcher et al. 2007	SOCATv1.6	SOCATv1.6	Takahashi et al. 2009	zero (optimized)
Biomass burning	None	GFEDv4.1s	None	None	None

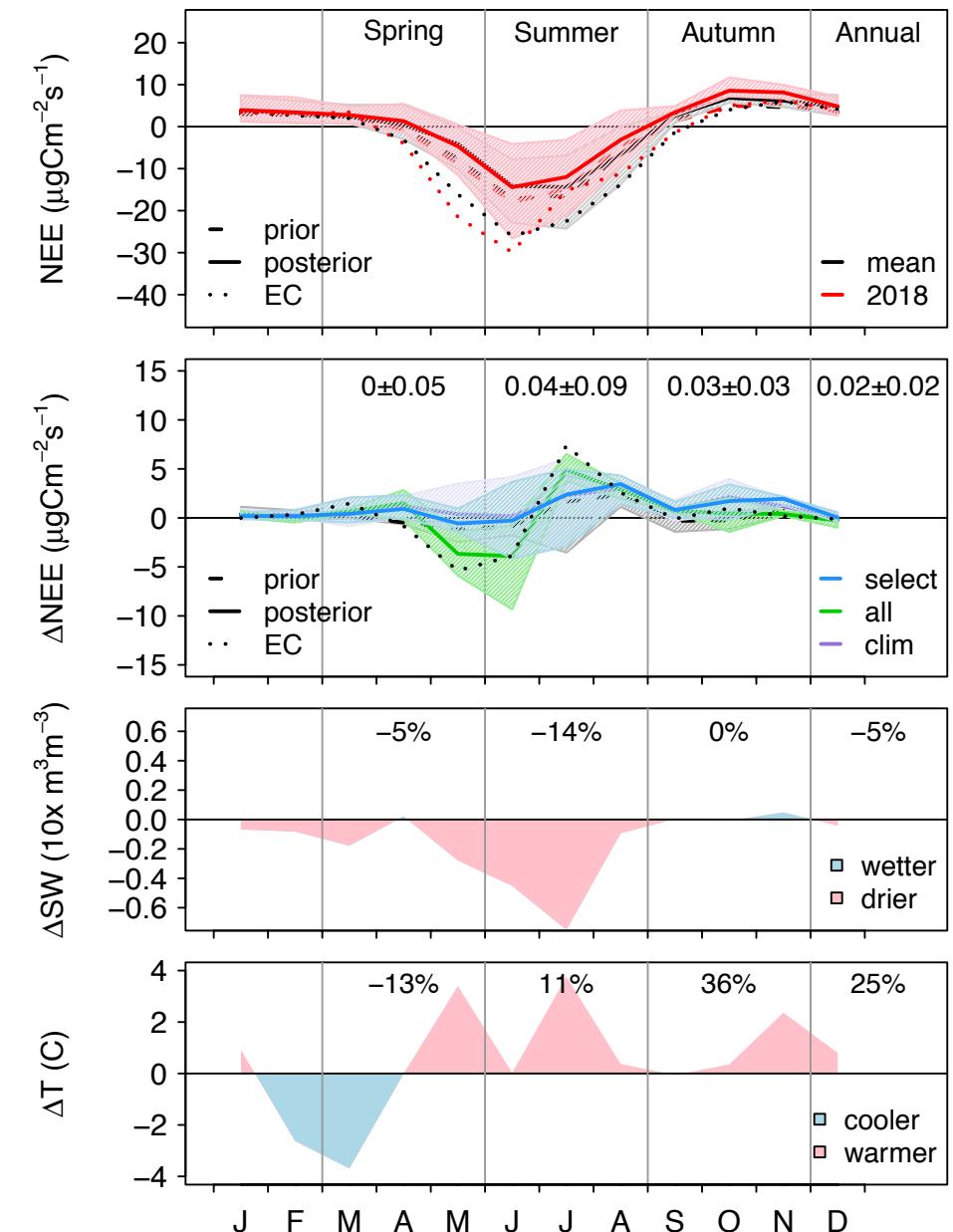
*Fossil fuel data extrapolated to 2019 using BP Statistical Review of World Energy 2019 and temporally disaggregated to hourly using sector-specific activity factors

Inversion cases

Case	Description	Purpose	Inversion frameworks
SELECT	Selected 16 sites with quasi-continuous observations	Same uncertainty reduction in posterior fluxes every year	Carboscope, FLEXINVERT, LUMIA, NAME
ALL	No selection - can use up to 48 sites	Maximum observational constraint	Carboscope, LUMIA, PyVAR
CLIM	As in “SELECT” but used a climatological prior NEE estimate	Inter-annual variability in NEE driven solely by observations	Carboscope, FLEXINVERT, LUMIA, NAME

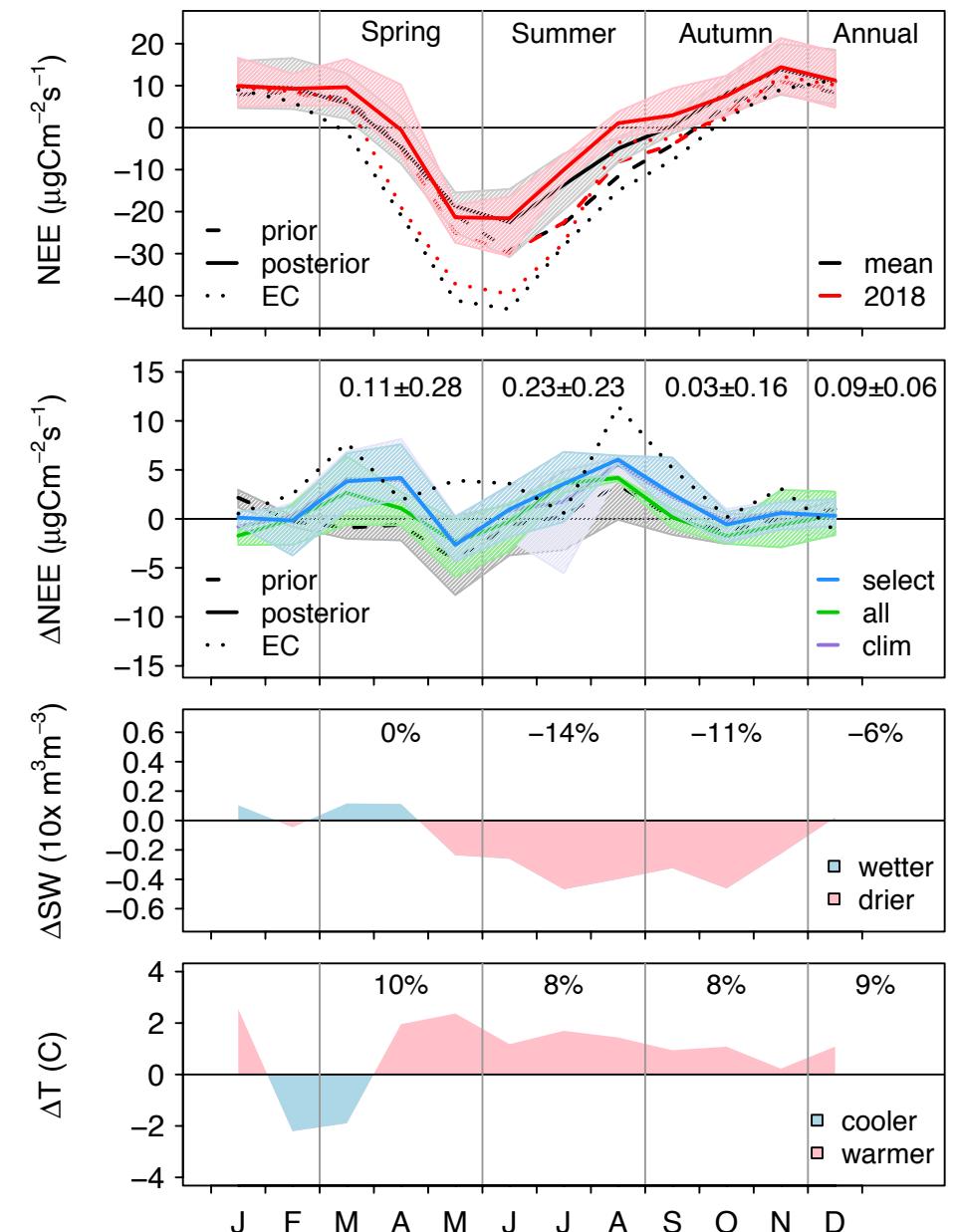
North Europe

- All cases show positive NEE anomaly (decreased uptake) for July-August
- Prior models VPRM and LPJ-Guess also positive anomaly (but not SiBCASA)
- Summer SW 14% less than 2009-2018 mean



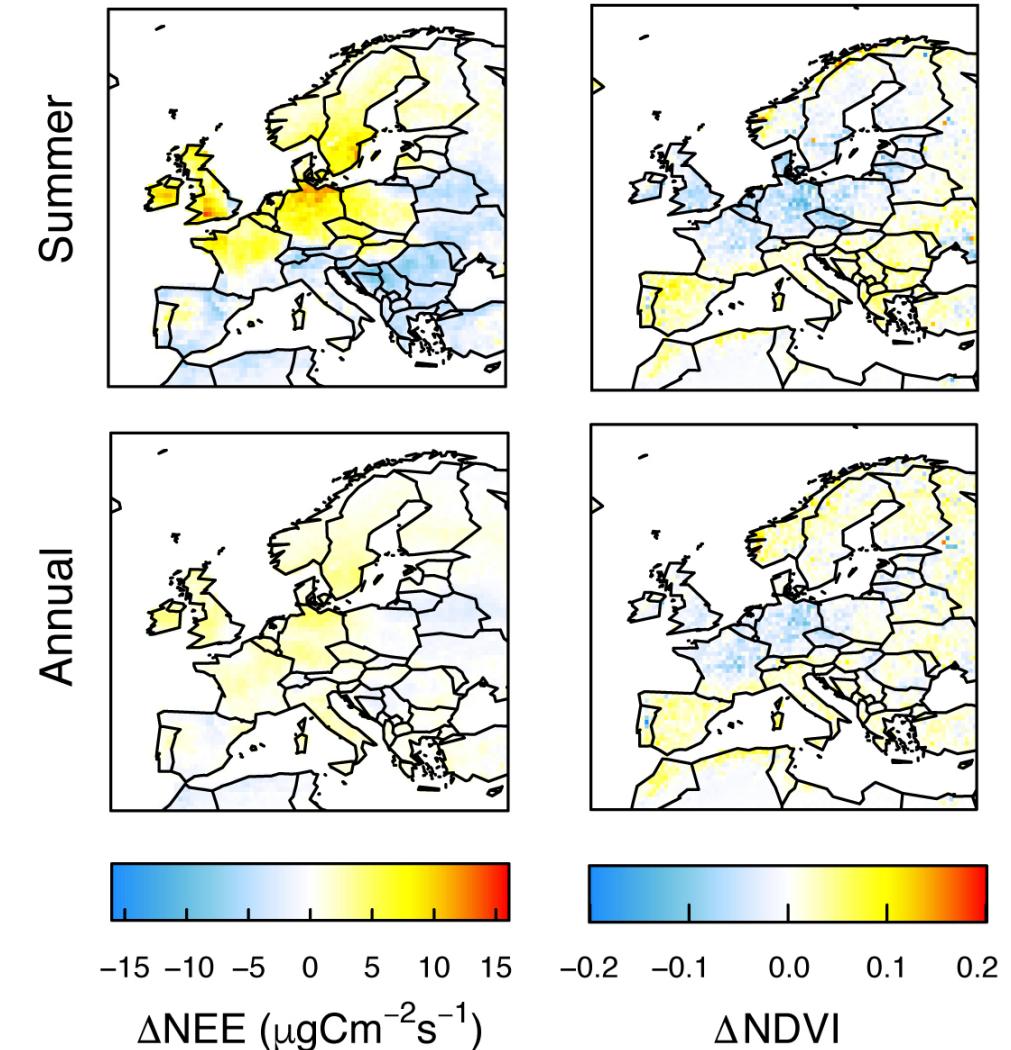
Temperate Europe

- All cases found positive NEE anomaly in summer
- Cases “select” and “all” also found positive anomaly in spring
- Generally consistent with EC data
- Summer SW 14% less than 2009-2018 mean



Comparison NEE and NDVI anomalies

- Summer NEE anomaly corresponds closely to negative NDVI anomaly
- Discrepancy over Scandinavia: positive annual NEE and NDVI anomalies
- NDVI not perfect indicator for NEE (not all absorbed PAR used for photosynthesis)



Summary of main results

NEE ensemble mean and standard deviation (PgC y^{-1})

		North	Temperate
Summer	Mean 2009-2018	-0.33 ± 0.19	-1.11 ± 0.69
	Anomaly	0.04 ± 0.09	0.23 ± 0.25
Annual	Mean 2009-2018	-0.04 ± 0.05	-0.08 ± 0.17
	Anomaly	0.02 ± 0.02	0.09 ± 0.06

Conclusions

- European drought of 2018 was exceptional for the last 10 years
- Annual NEE anomaly in 2018 for Temperate Europe of $0.09 \pm 0.06 \text{ PgC/y}$ making the region close to carbon neutral
- Annual NEE anomaly in North Europe of $0.02 \pm 0.02 \text{ PgC/y}$ making it also close to carbon neutral
- Decrease in C-uptake in summer likely driven by a soil water deficit