M. Hermann presenting in person at EGU

Updated abstract & new co-author.

Analysis of multi-seasonal meteorological storylines to reduced forest $NDVI$ in Europe in 2000–2020

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Abstract: Forest productivity is strongly influenced by meteorological conditions imposed by seasonal variations of temperature, $T2m$, and precipitation, P. This study quantitatively investigates anomalous characteristics of the three-year meteorological storyline preceding low forest productivity events in Europe's temperate and Mediterranean forests in the phase space of seasonal-mean anomalies of $(T2m, P)$. A specific focus is on the amplitude, persistence, and co-variability of these anomalies. A pragmatic approach serves to identify low forest productivity events at the 50 km scale in Europe in June to August 2000—2020, based on remote sensing observations of normalized difference vegetation index $NDVI$. An independent forest disturbance data set is used to qualitatively validate the identified more than 1'500 low $NDVI$ events. These events occur in summers with particularly dry and hot conditions but their meteorological storylines feature significant anomalies during multiple seasons preceding the events, with clear differences between the two biomes. In the Mediterranean biome, the anomalously dry conditions persist over more than 1.5 y prior to the events, whereas $T2m$ is anomalously warm only during the last 0.4 y. In contrast, in the temperate biome, $T2m$ is anomalously large during most of the 2.5 y prior to the events and, most interestingly, the winter preceding the events is characterized by anomalously wet and warm conditions. These anomalies potentially induce a negative legacy on the following summer drought. The seasonal-mean anomalies of P are strongly determined by synoptic scale weather systems, such that long dry periods are characterized by a deficit of cyclones and an excess of anticyclones. A final analysis investigates the peculiarities of low $NDVI$ events that occur in two consecutive summers and the potential role of drought legacy effects. In the temperate biome, the second event summer of an event sequence has less hot and less dry anomalies than during a single event. In summary, detailed investigations of the multi-annual meteorological storyline of low forest productivity events provided clear evidence that anomalies of surface weather and synoptic-scale weather systems over time periods of up to 2.5 y can negatively impact European forests, with important differences between the temperate and Mediterranean biomes.

This presentation participates in OSPP

Outstanding Student Poster & PICO Contest

Multi-seasonal meteorological storylines of reduced forest $NDVI$ in Europe in 2000–2020

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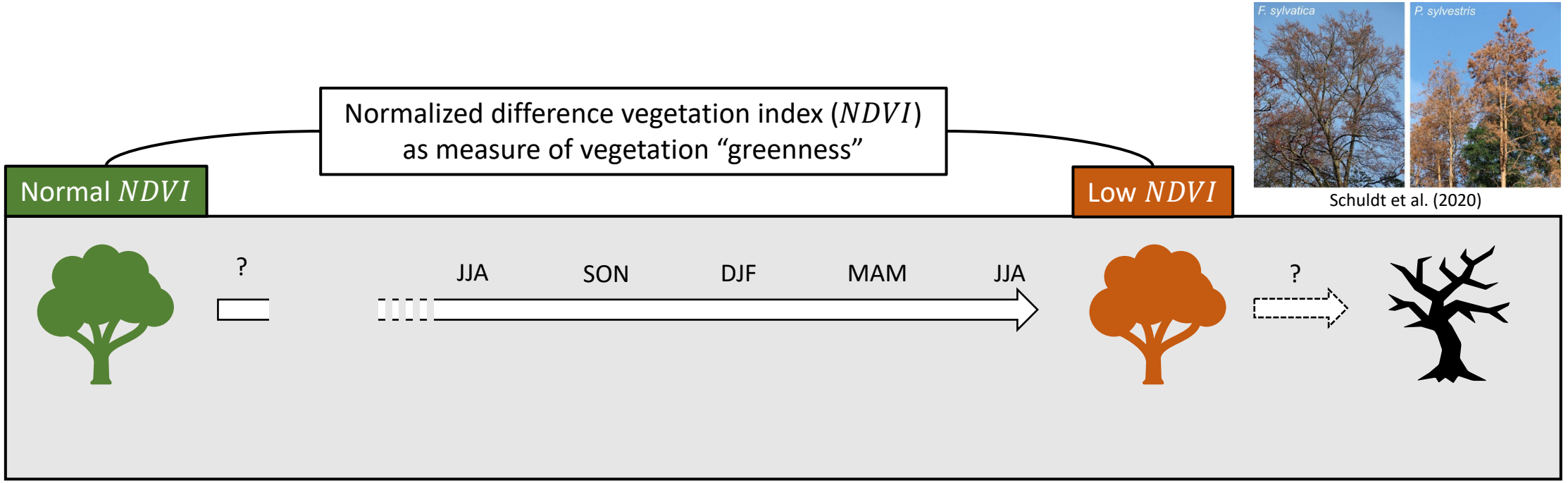
Importance of a longer-term meteorological storyline



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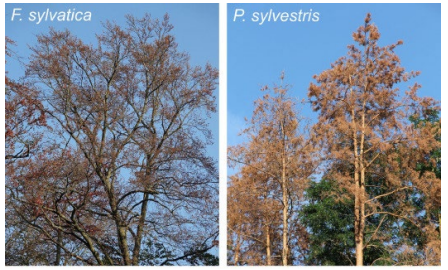

Schuldt et al. (2020)

Normalized difference vegetation index ($NDVI$) as measure of vegetation "greenness"

Normal $NDVI$ | Low $NDVI$

?

JJA SON DJF MAM JJA

?

previous drought(s) + secondary disturbances

early snow melt

early growth

drought

secondary disturbances

Anderegg et al. (2015,2020)
Bose et al. (2020)
Schuldt et al. (2020)

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Buras et al. (2020)…

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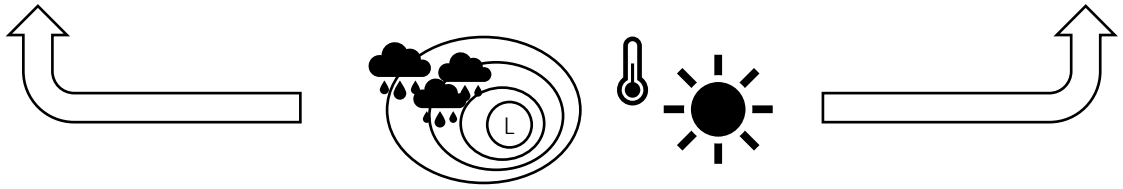
Jakoby et al. (2019)



Study focus and outline

Main research question: What is the systematic meteorological storyline (three preceding years) that is characteristic to low $NDVI$ events in Europe in summer 2000–2020. Which time periods / time scales are particularly important?

Data in 2000–2020:

- ERA5 meteorological reanalyses at 50 km ($T2m_{90d}$, P_{90d}, weather systems) Hersbach et al. (2020)
- NASA MODIS Terra $NDVI$ at 5 km Acker & Leptoukh (2007)
- Landsat forest cover at 30 m in 2000 Hansen et al. (2013)

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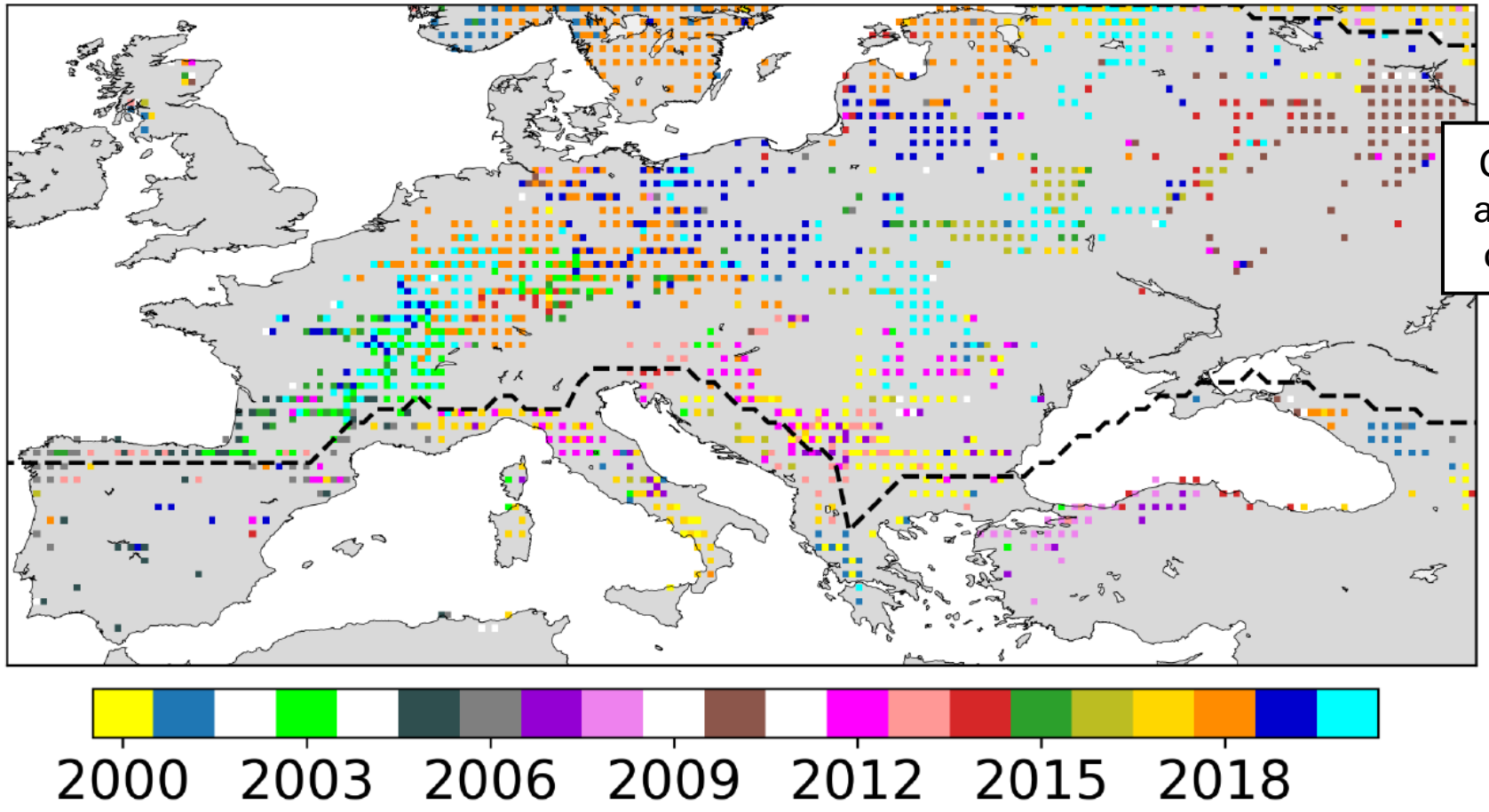
Meteorological storyline: normalized anomalies of 90-day mean 2-meter temperature $T2m_{90d}$ and precipitation P_{90d}

1. Uni-variate evolution ⟸ shown today
2. Persistence of dry and warm periods
3. Bi-variate evolution
4. Link to weather system frequencies

Low $NDVI$ events at 50 km (from 5 km $NDVI$)



Only evaluated at mostly forest covered pixels

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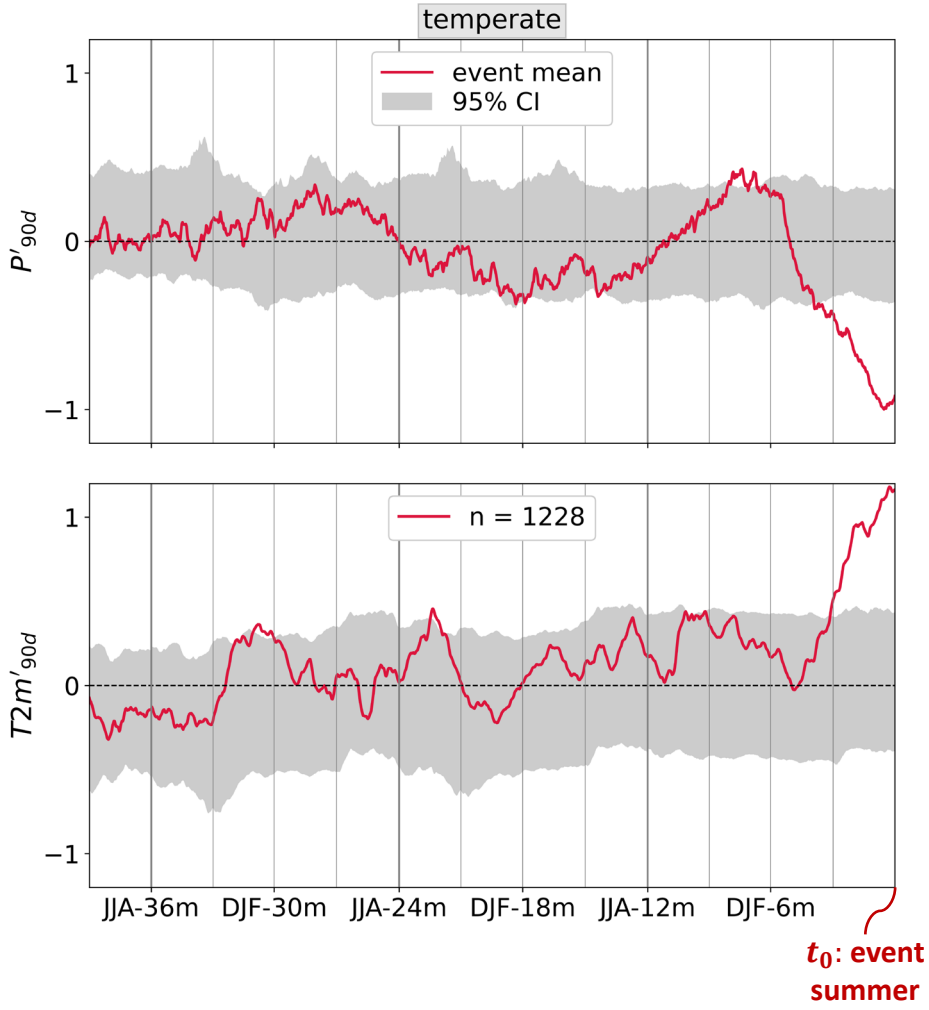
Meteorological storyline in the temperate biome (all events)



At every $t_0 - \Delta t$ when the red curve lies outside the grey shaded area, the meteorological storyline is significantly linked to the low $NDVI$ events at t_0.

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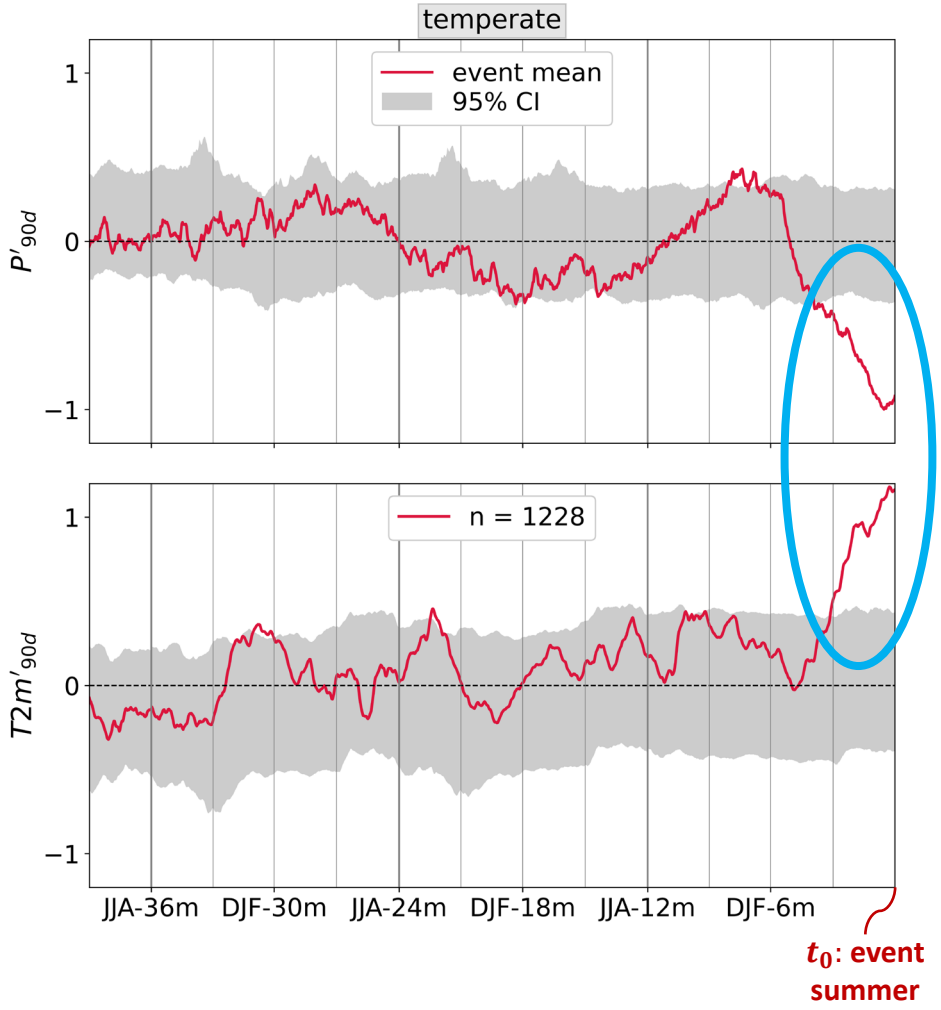

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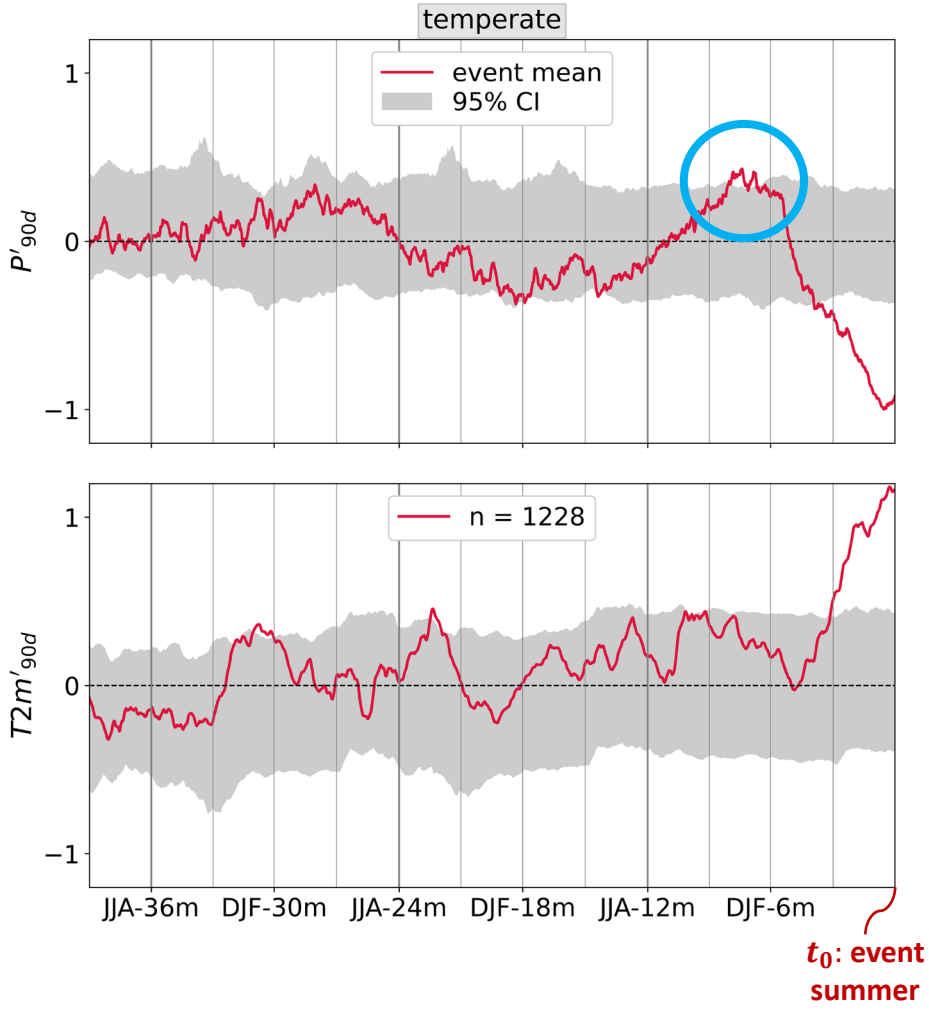

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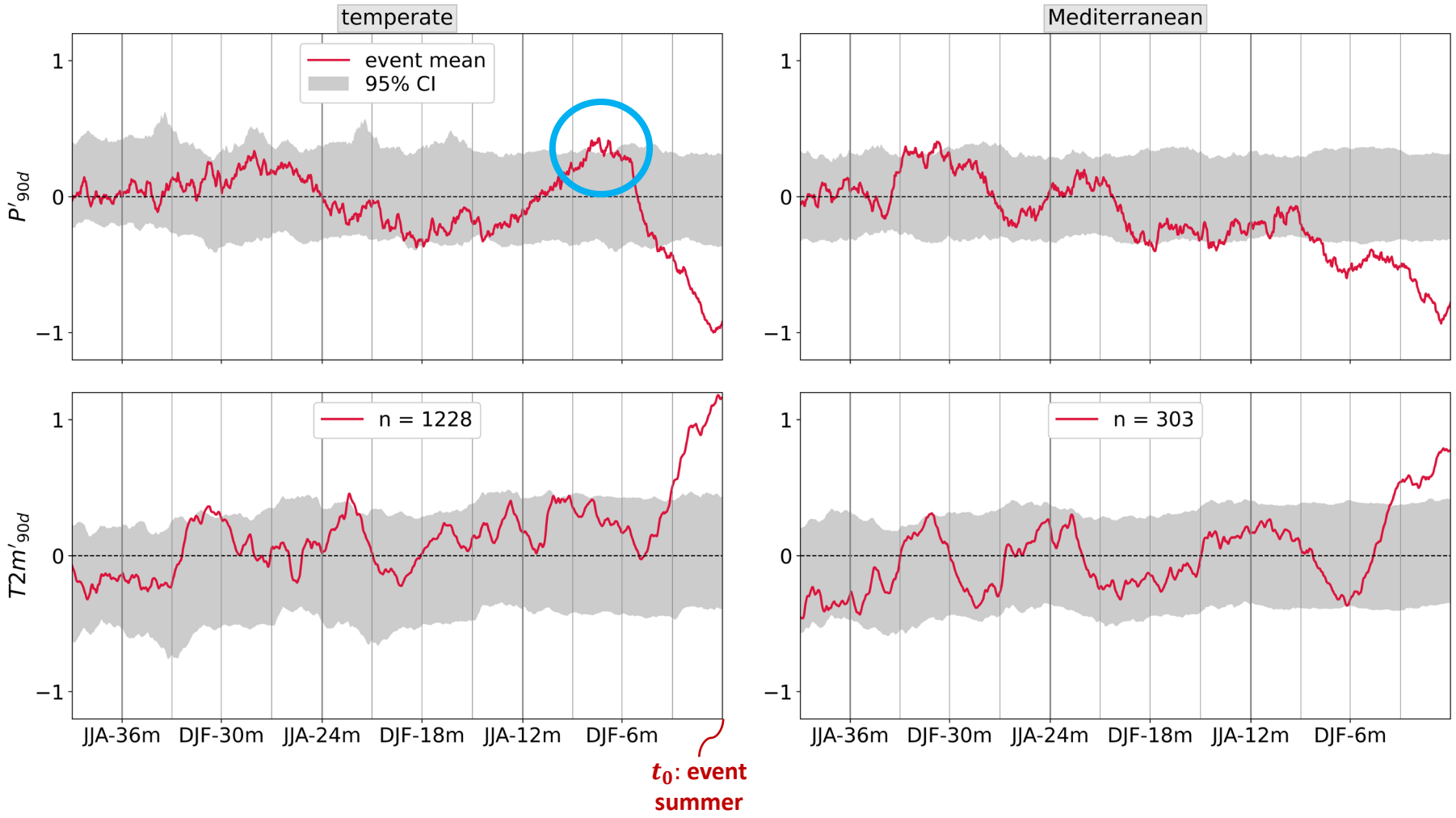
Important differences between the two biomes



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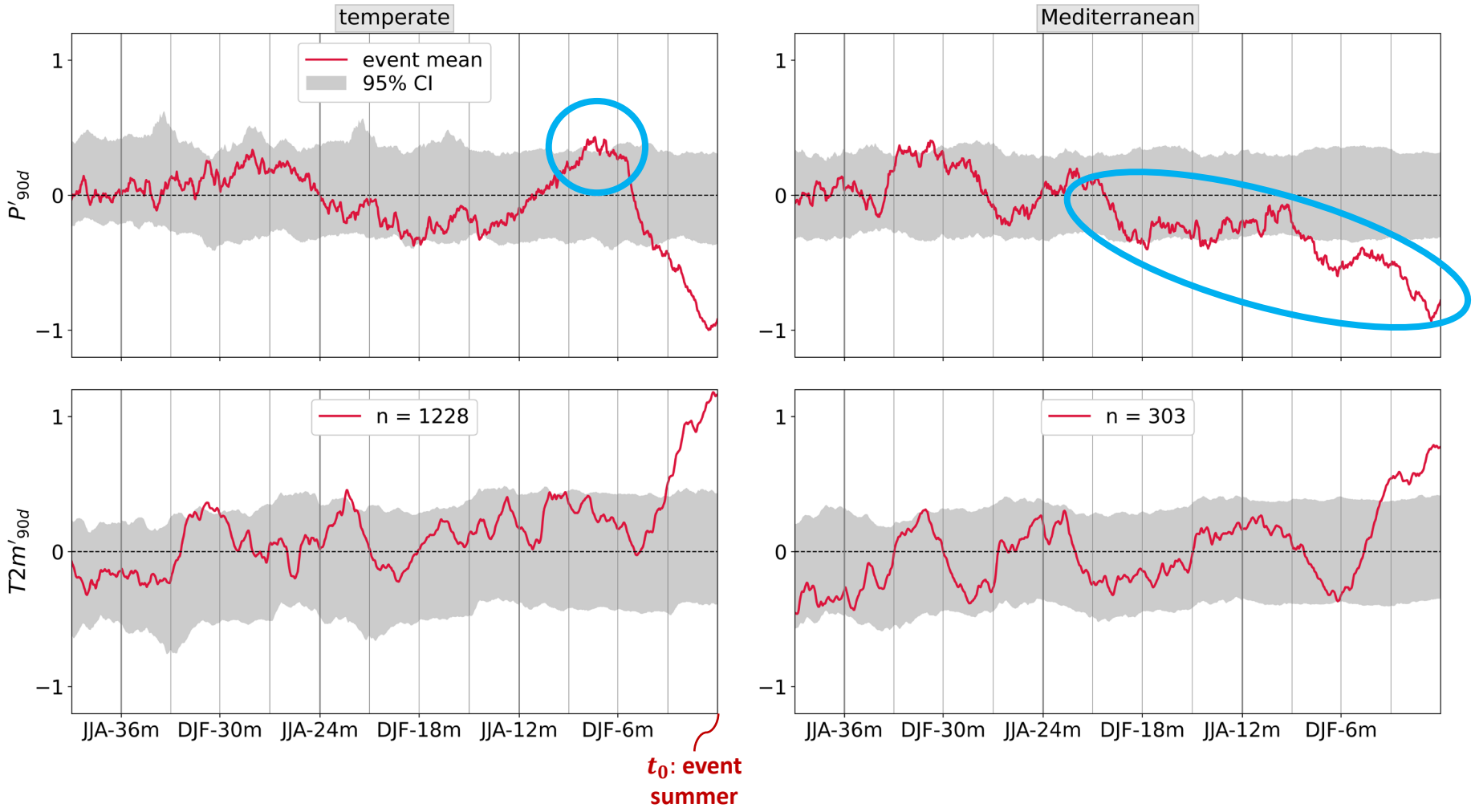

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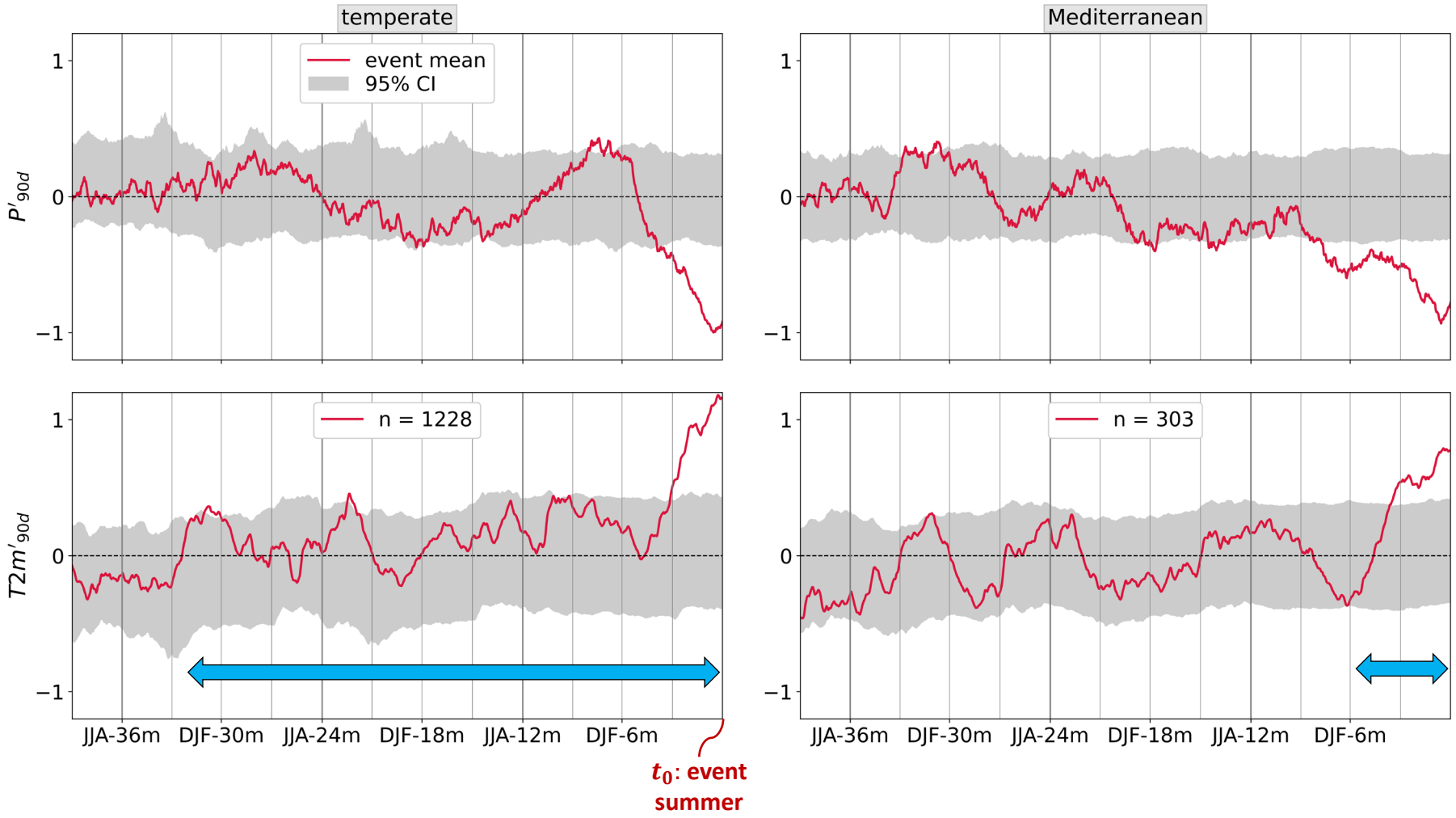

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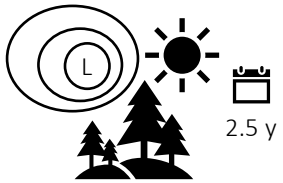
Main conclusions on summer low $NDVI$ events



Surface meteorology and synoptic-scale weather systems:
- Negative impacts on European forest $NDVI$ on time periods of up to 2.5 y
- Important differences between temperate and Mediterranean forests

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Mediterranean forests:
- Low precipitation persist over 1.5 y prior to low $NDVI$ events
- $T2m$ is anomalously warm only during the last 0.4 y

Temperate forests:
- Anomalously warm most of the 2.5 y prior to events
- The preceding winter is anomalously wet (negative legacy on dry summer)
- Unusually many dry periods over the preceding 2 y

Indications of drought legacy effects (only) in temperate forests:
The second event summer of a two-year event sequence has less hot and less dry anomalies than the first summer.

Feedback?

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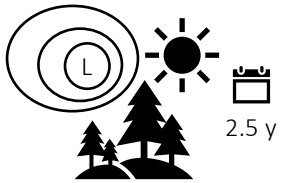
Biogeo-sciences

Main conclusions on summer low $NDVI$ events



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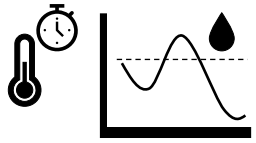

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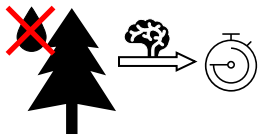

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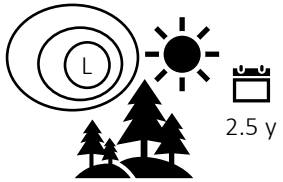

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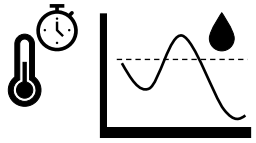

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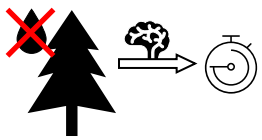

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