Long-term variability of the hail potential in Europe and potential drivers

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Thunderstorm-related hazards…

Large loss potential due to:

Hail

Heavy rain

…furthermore: straight-line winds, tornadoes

Photos: B. Mühr, J. Daniell (KIT)

The problem of scales

Hail event: small-scale phenomenon

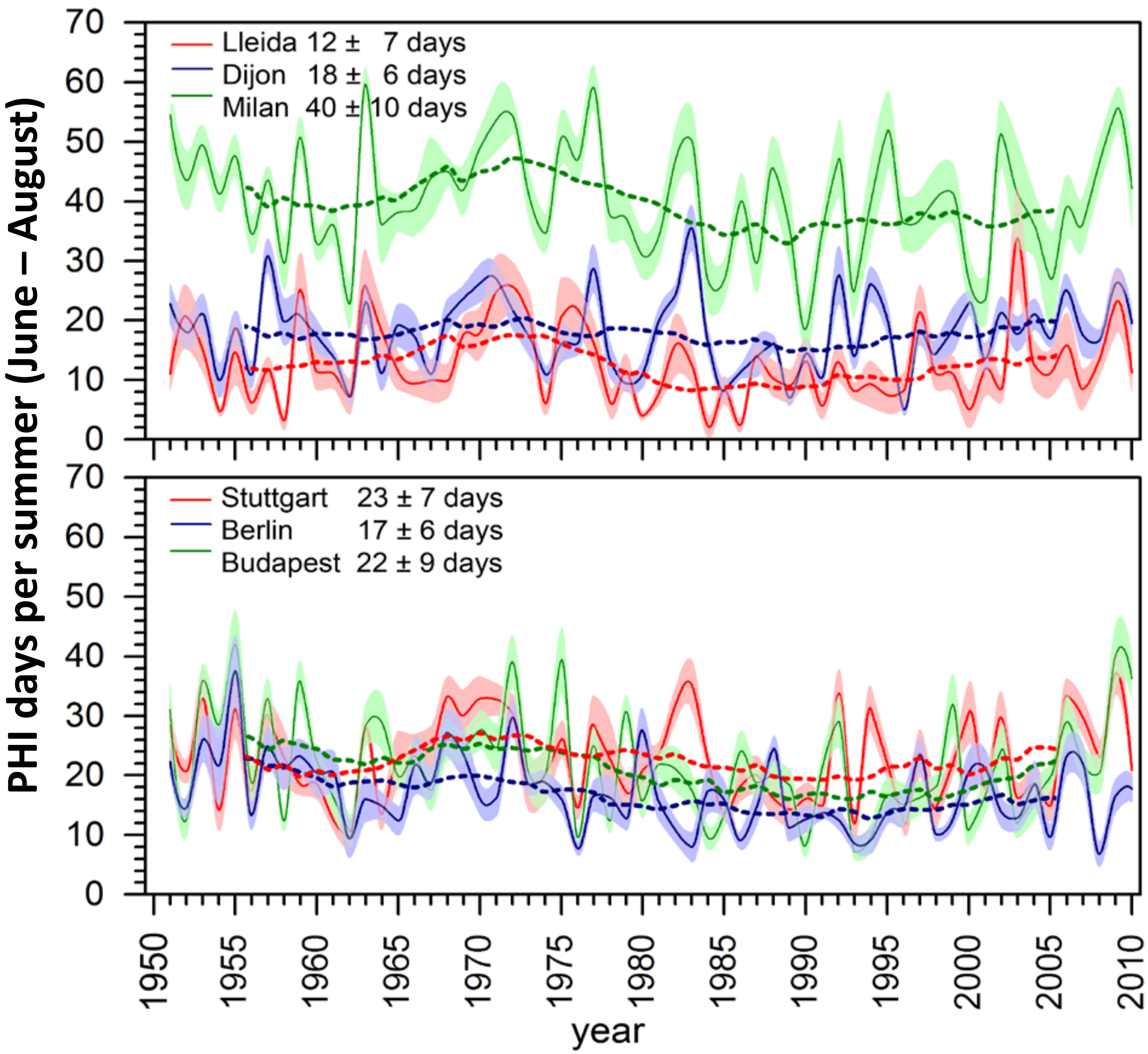
Mechanisms providing favorable pre-convective conditions

Large-scale processes

Key questions

- What is the interannual variability of hail incidence? How does it vary on spatial scales?
- What are potential large-scale drivers?
- Is there any significant relation to atmospheric teleconnections?

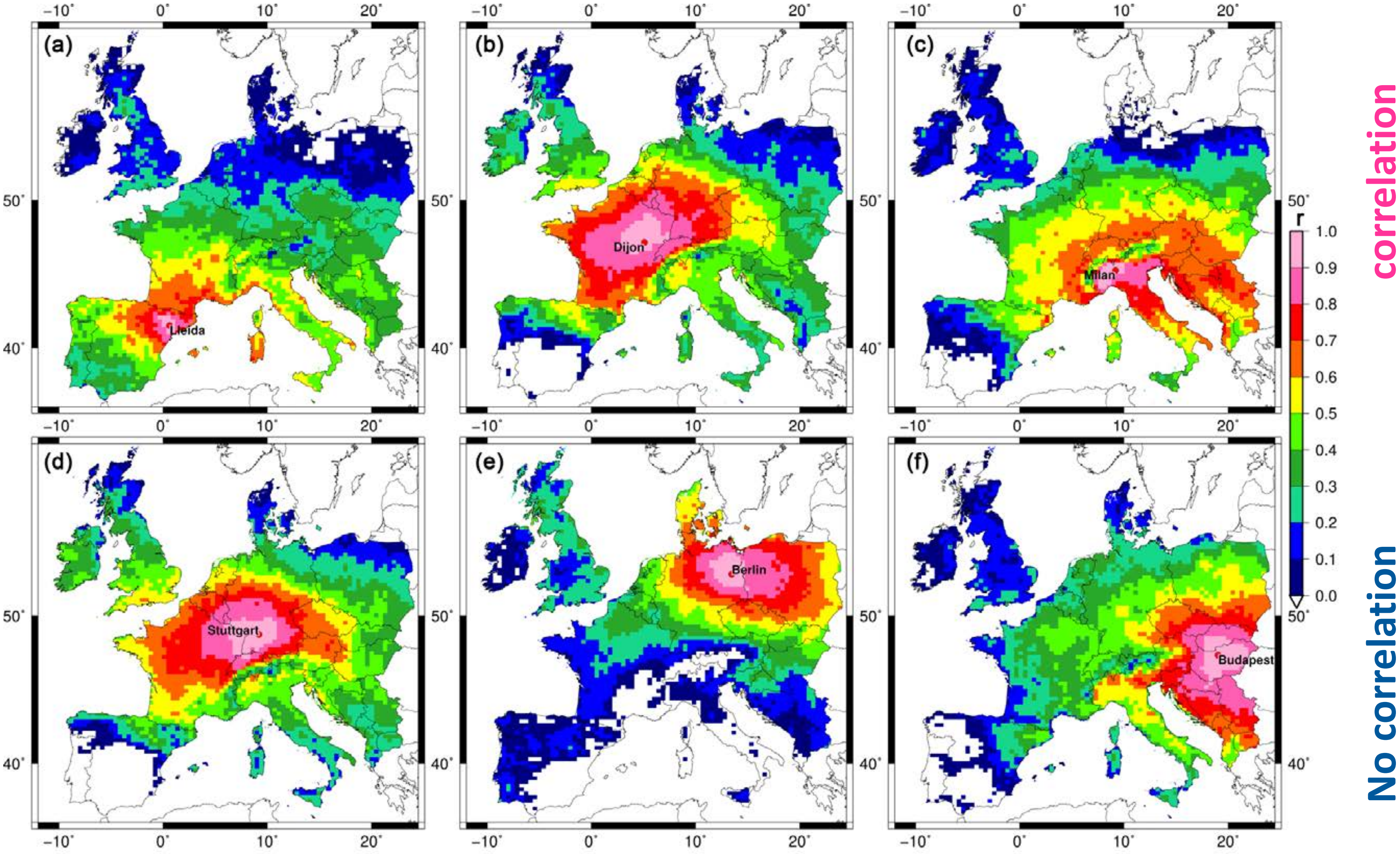
Interannual variability of hail potential



PHI
1951 – 2010
JJA

(Mohr et al., GRL, 2015b)

Interannual variability: correlation maps



(Mohr et al., GRL, 2015b)

A new proxy for high thunderstorm risk

Objective Weather Types (DWD)

↓

optimized with respect to convection

↓

4 variables relevant for convection

↓

weighted spatial mean

$$\theta_e = T\left(\frac{p_0}{p}\right)^{\kappa} \exp\left(\frac{Lr_s}{c_p T}\right)$$

$$PW = \frac{1}{\rho_w g} \cdot \int_0^{p_{max}} r\, dp$$

SLI

$w \sim -\omega$

Reference area can be chosen freely

↓

Determination of 2 thresholds

→ evaluation based on HSS / BSS (reference: lightning data)

Result: 81 weather types, including:

- 2 convection-favoring
- 2 convection-inhibiting

} **Proxies**

Data

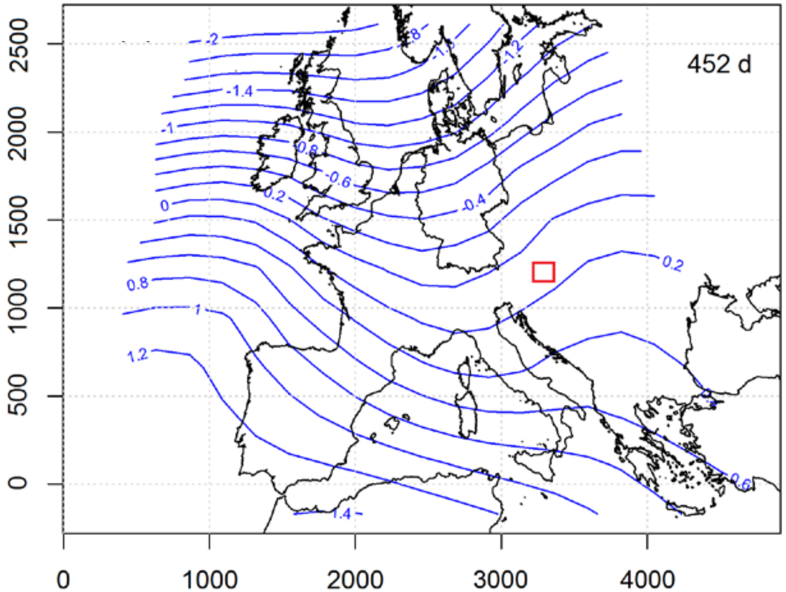
$\theta_e = T\left(\frac{p_0}{p}\right)^{\kappa} \exp\left(\frac{Lr_s}{c_p T}\right)$ ||

Reanalysis (HZG), driven by **NCEP–NCAR 1**

Time range

1958-2014

Convection-favoring flow types



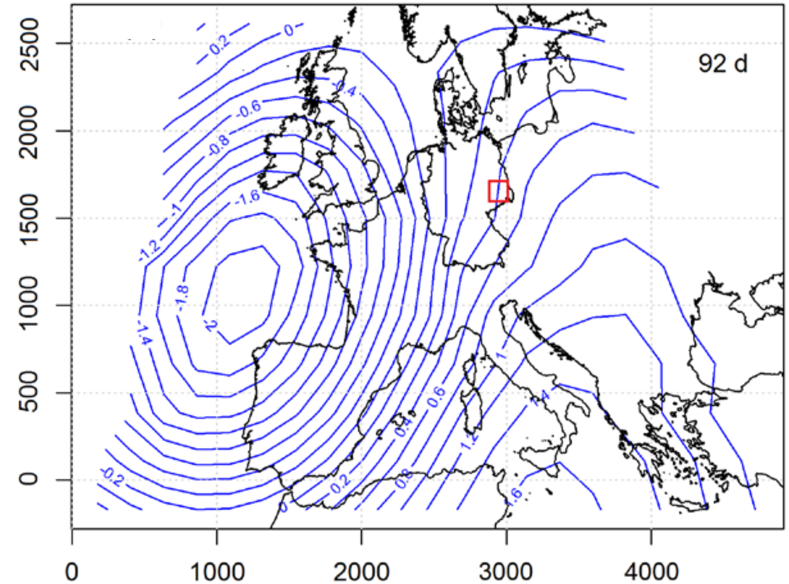
Short, small-amplitude trough

Dominant: southwesterly types, but …

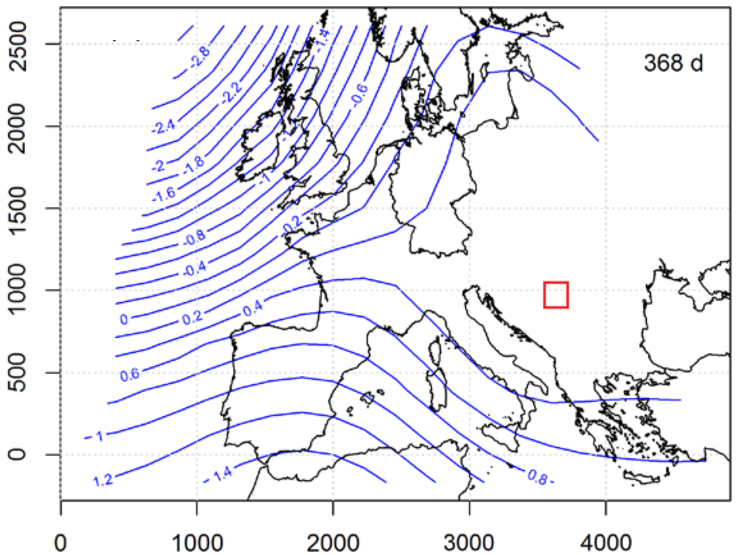
Long, large-amplitude trough

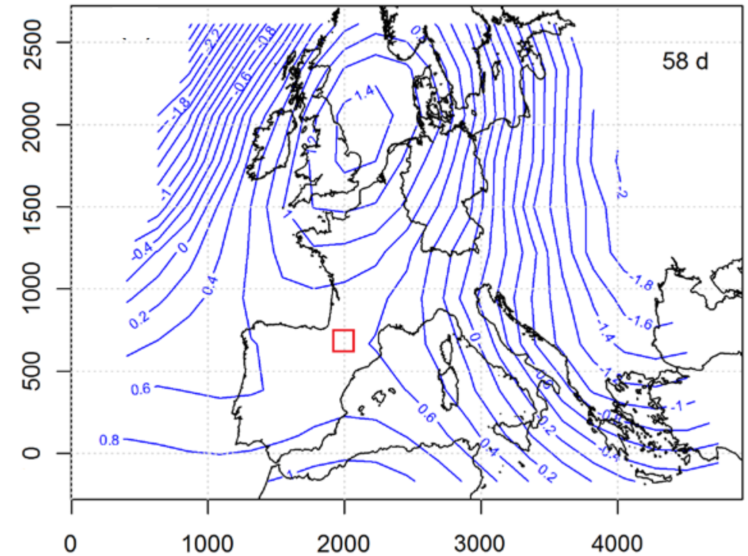
Principal component analysis (T-Mode) with *oblimin*-rotation

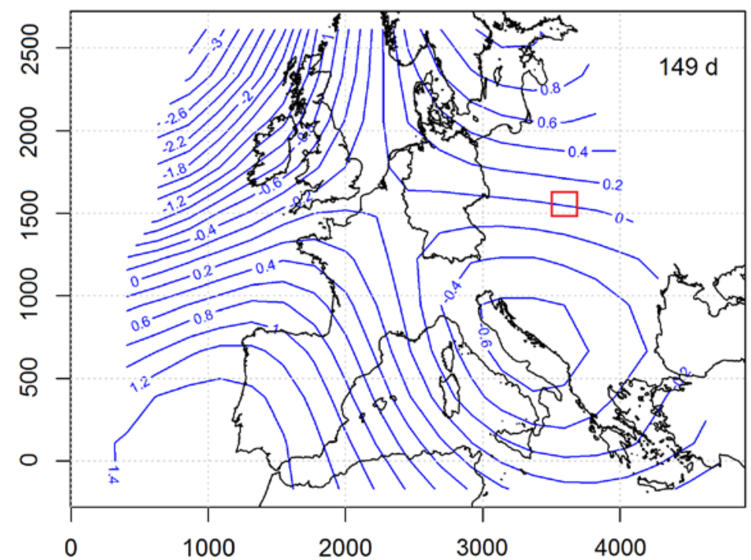
Input data:
Geopotential at 500 hPa, 12 UTC (NCEP-NCAR1)



Convection-favoring flow types

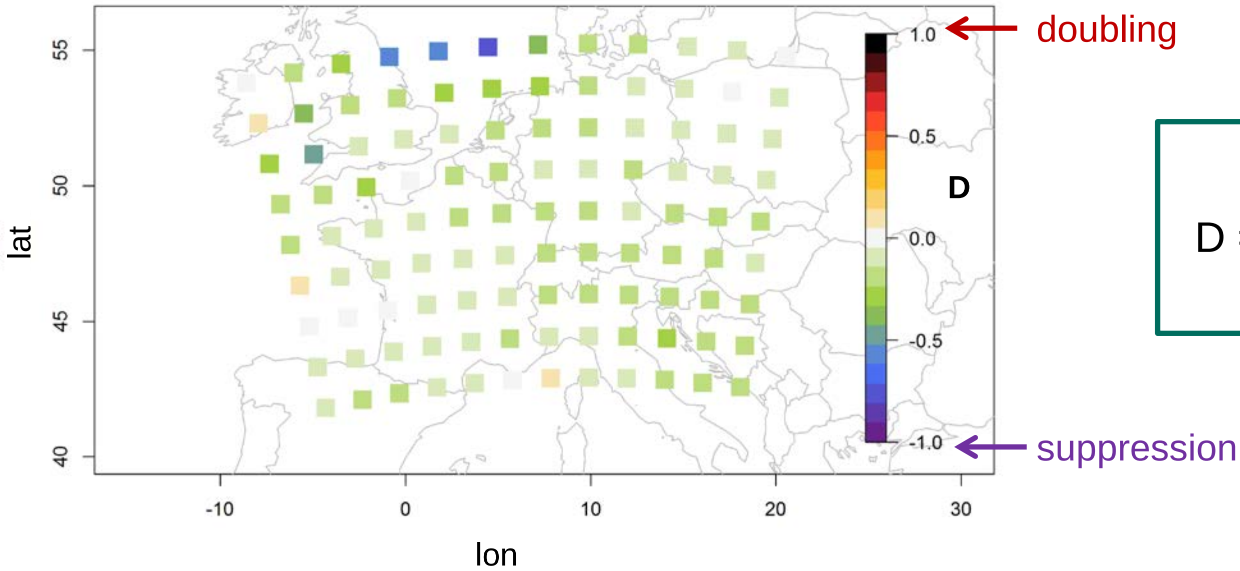






… regionally, further circulation patterns relevant

Teleconnections: East Atlantic Pattern (EA)

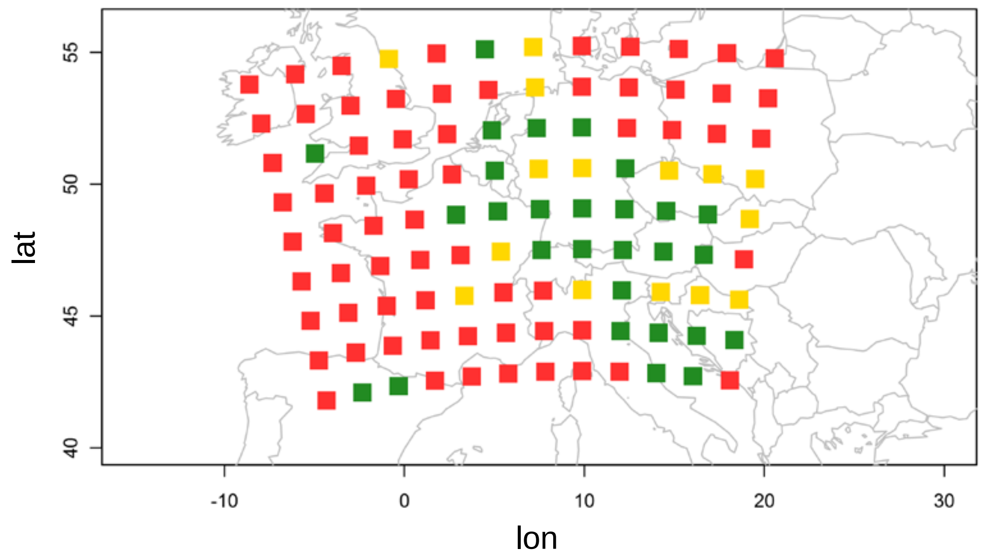


$$D = \frac{\#(Yes \mid EA < -0.5) - \#(Yes)}{\#(Yes)}$$

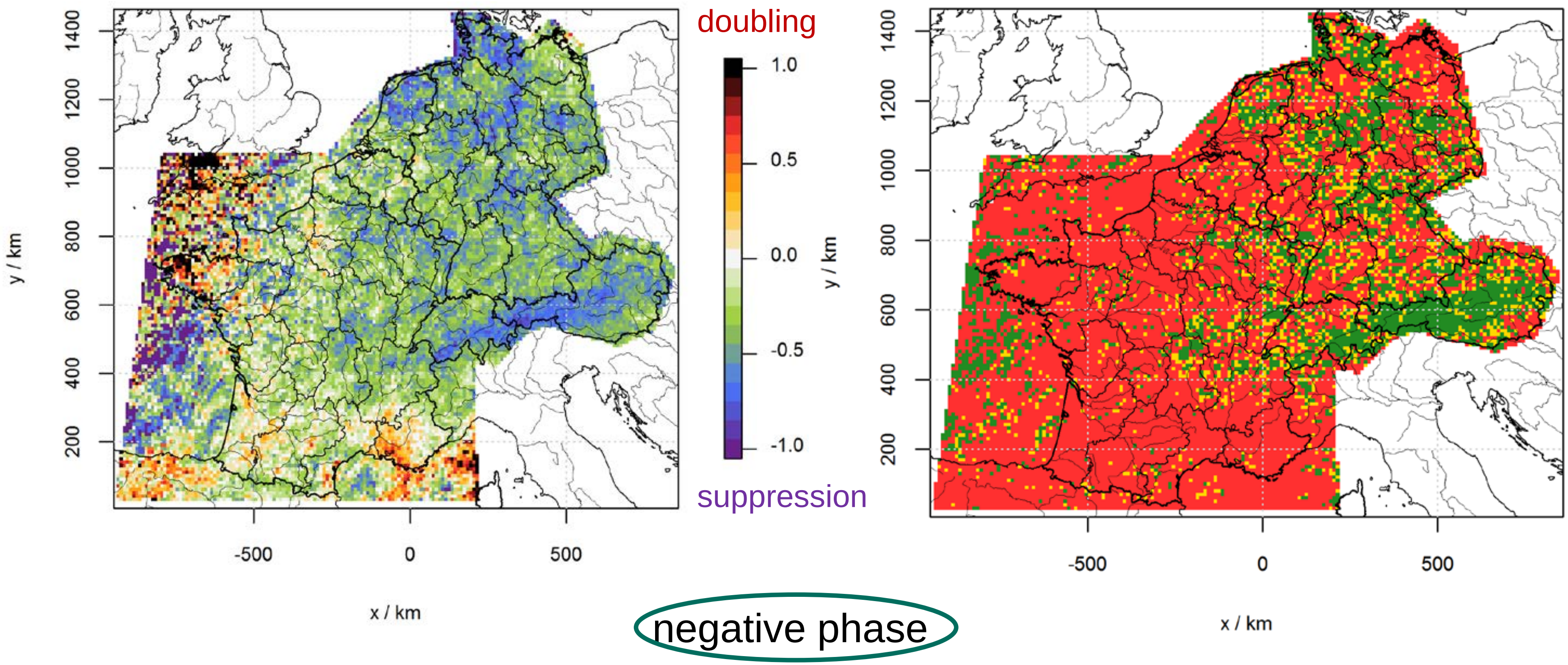
negative phase

Two-sided bootstrap-test:

green: significant (Si = 95%)
yellow: significant (Si = 90%)



… and with respect to lightning data (2001 – 2014)



$$D = \frac{\#(\text{thunderstorm days} \mid EA < -0.5) - \#(\text{thunderstorm days})}{\#(\text{thunderstorm days})}$$

Statistical significance :
green: significant (Si = 95%)
yellow: significant (Si = 90%)

Conclusions

- Large interannual variability of hail incidence
- Substantial spatial coupling
- Proxy for lightning activity: Modified Objective Weather Type Classification
  convection-favouring ⟷ convection-inhibiting classes
- Favorable flow patterns: predominantly southwesterly, but distinctly different patterns appear in some regions
- Significant impact of teleconnection patterns on convection (e.g. EA)