Warum bedeutet ein wärmeres Klima stärkere Extremereignisse?

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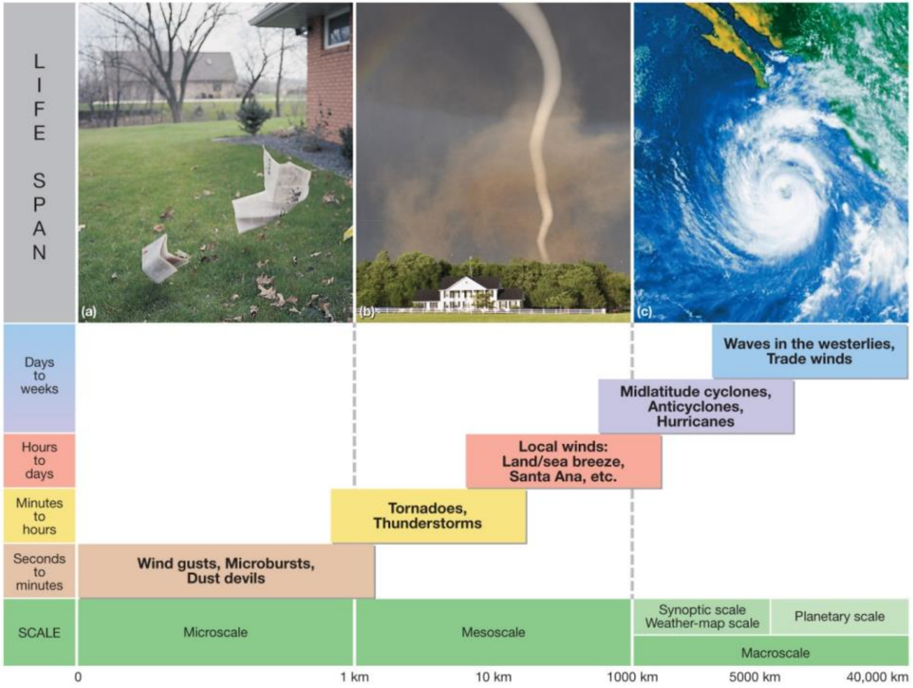
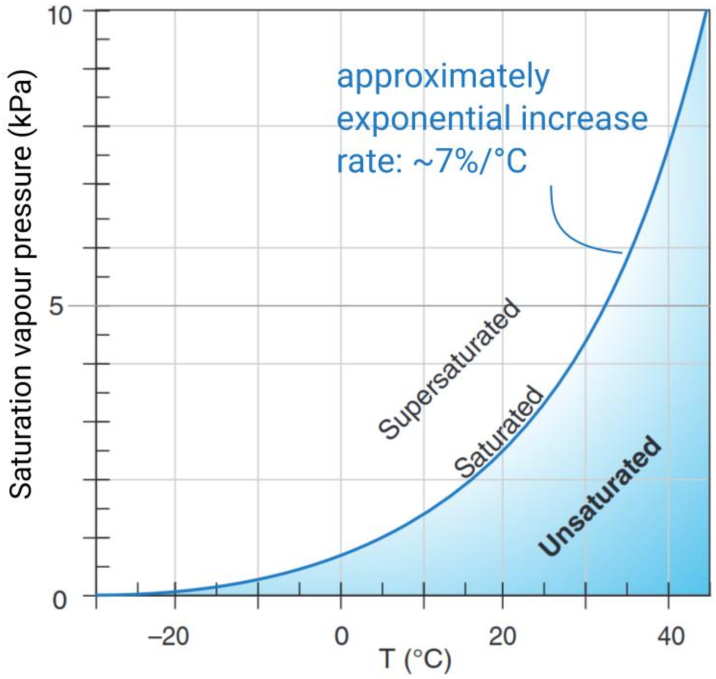
@rnd.de Ahr flooding 7-2021 Schuld

Skalen in der Meteorologie, Clausius-Clapeyron

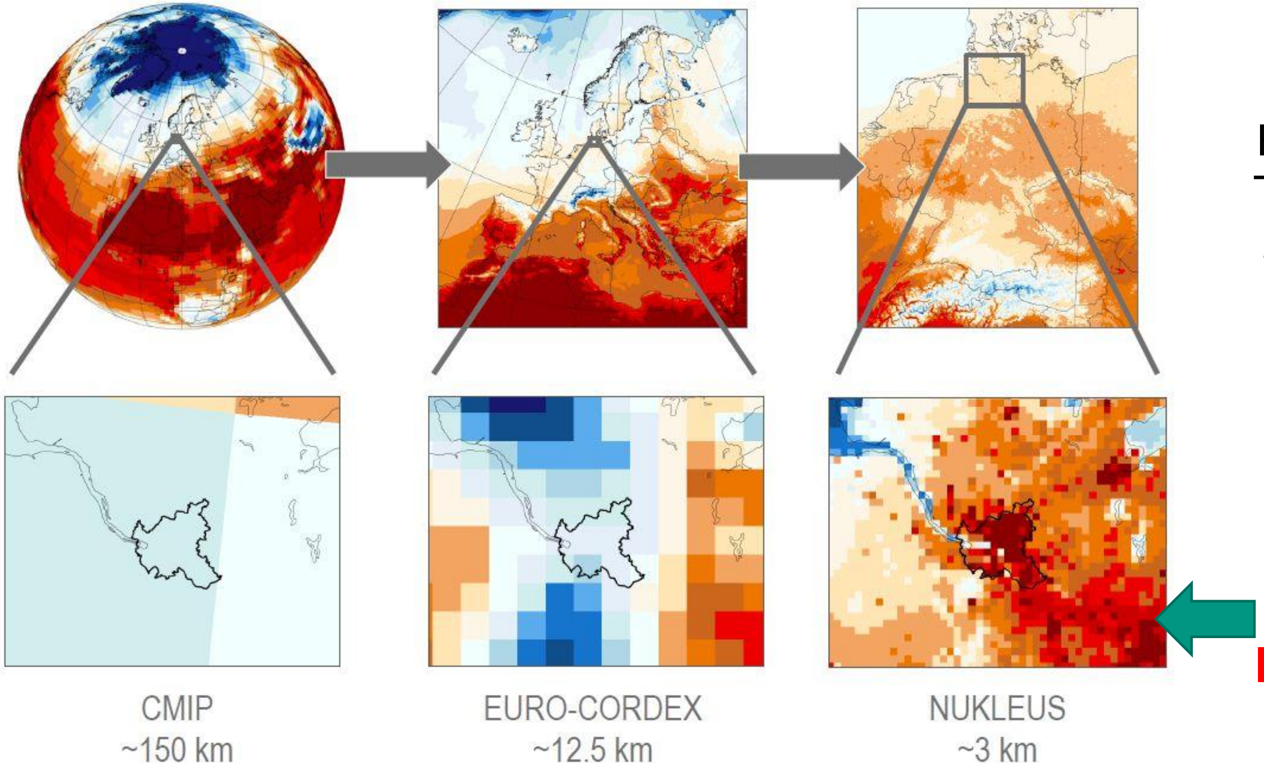


Sättigungsdampfdruck



Quellen: Lutgens and Tarbuck (2013); Stull (2015), angepasst.

Globale und regionale Klimamodellierung



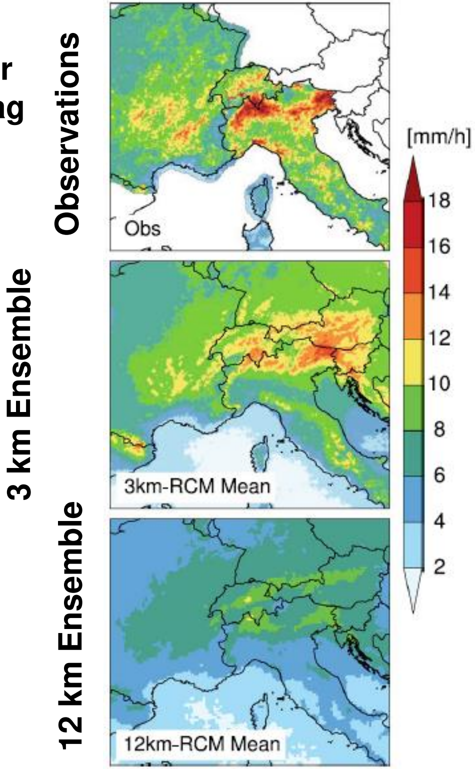
Ex: 2 Meter Temperatur, 2 Juli 1995

Konvektions auflösende Modellierung (2-3 km)

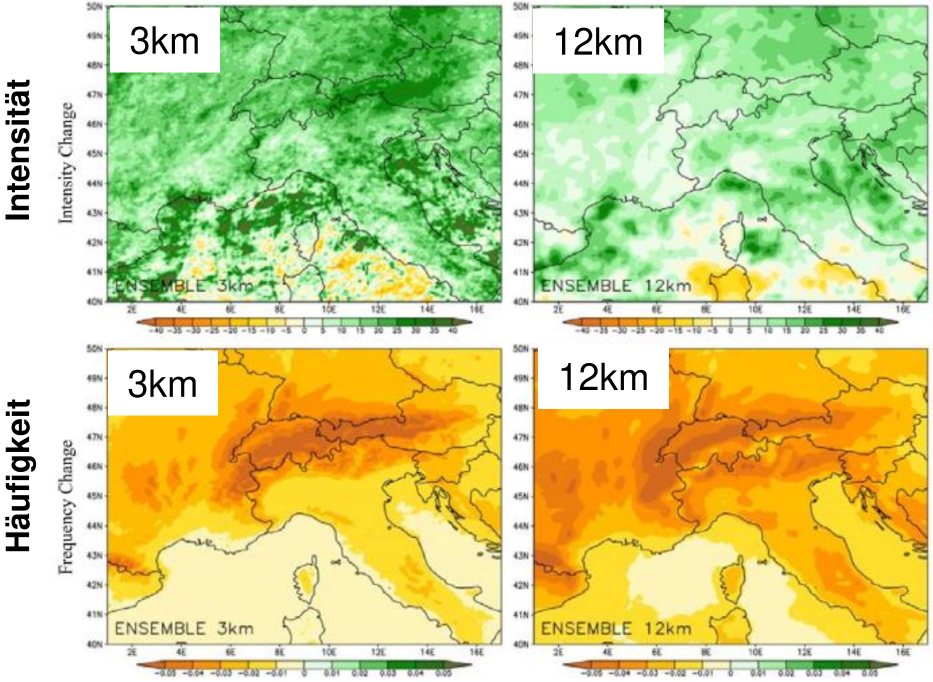
Quelle: BMBF RegIKlim NUKLEUS Project; Kevin Sieck

Extremniederschläge - FPS Convection

Stündlicher Niederschlag 99.9th p. (JJA)



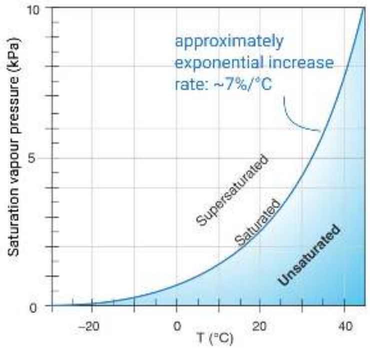
Klimaänderungssignal, stündlicher Niederschlag, 99.9th p. (JJA)



Multi-RCM Ensemble, 2090 – 2099 vs. 1996 – 2005

Quellen: Ban et al. (2021); Pichelli et al.(2021)

Extremniederschläge

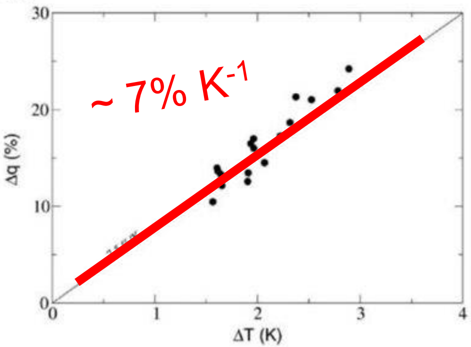


Sättigungsdampfdruck

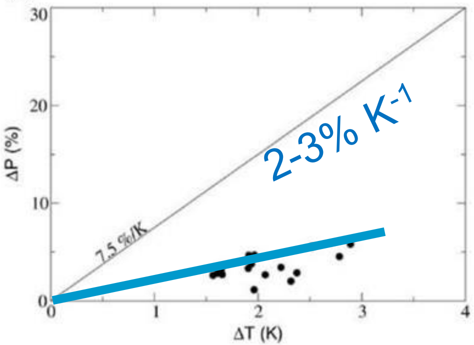
Luft mit 20°C kann doppelt so viel Wasserdampf halten wie mit 10°C

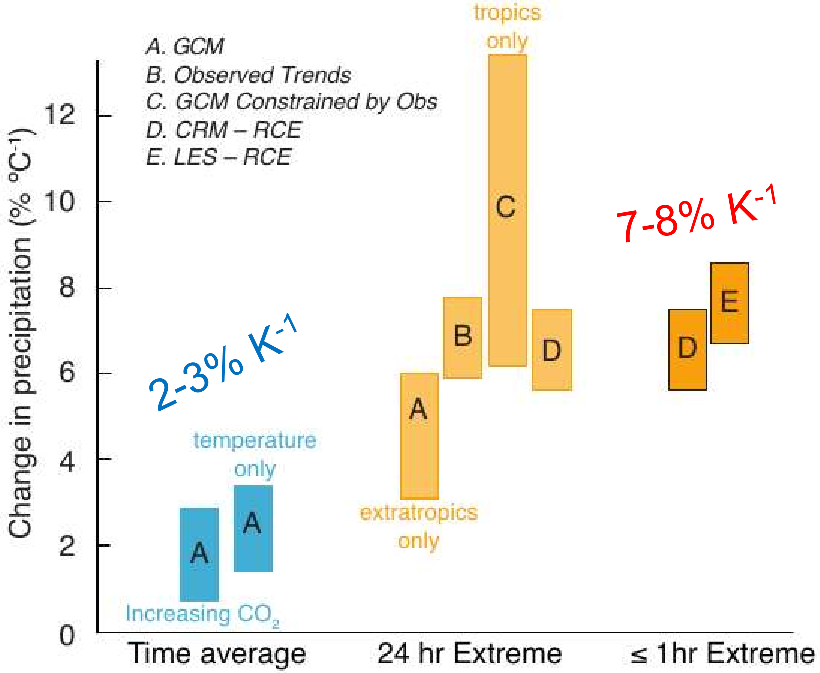
AR4, 2000-2020 vs 2080-2100

(a) Wasserdampf



Globaler, jährlicher Niederschlag

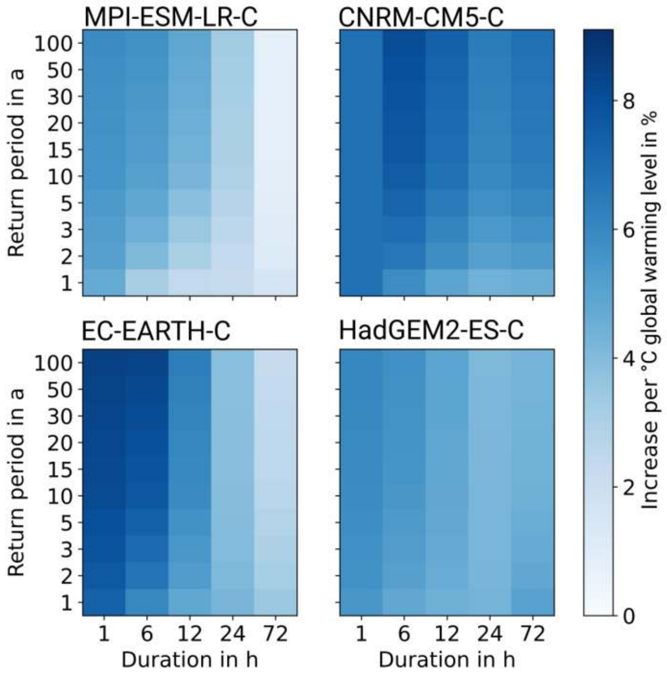


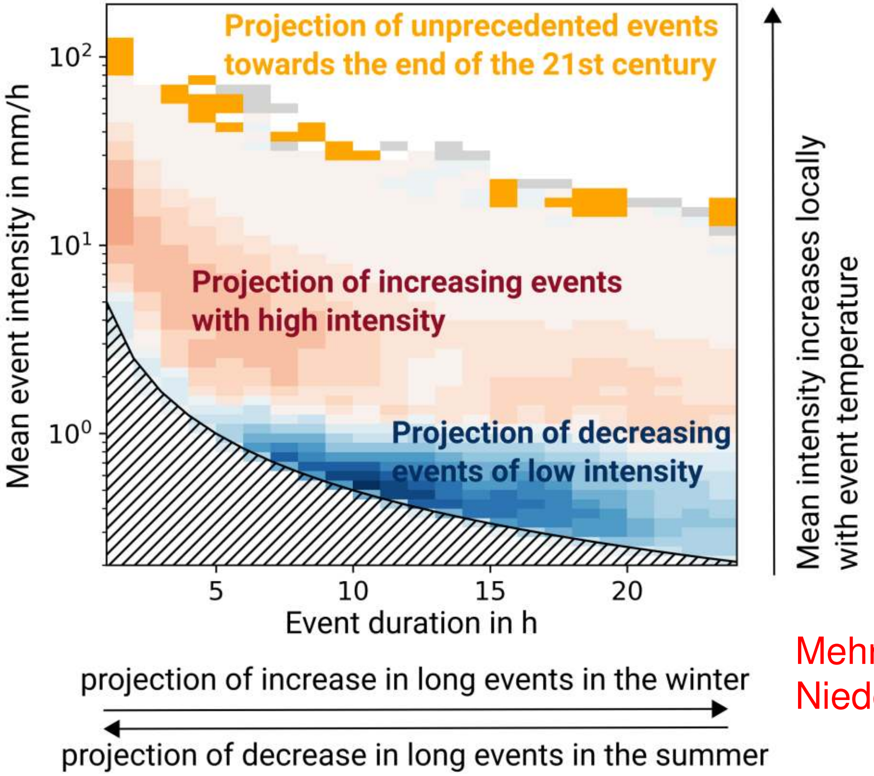


Quellen: Stull (2015), angepasst. Held and Soden (2006); IPCC (2013)

Extremniederschläge - Projektionen

Wiederkehrperiode in Jahren vs Dauer

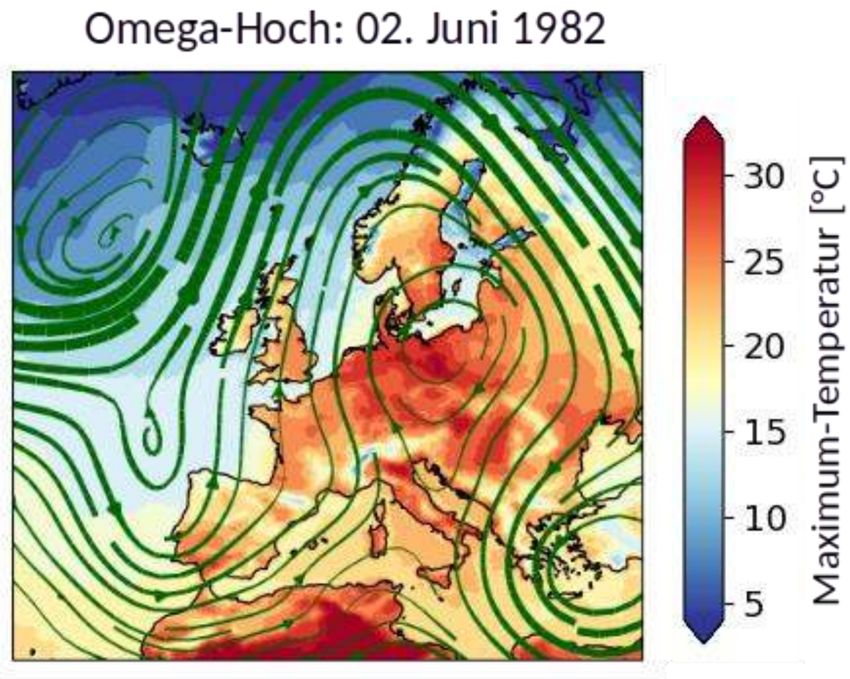


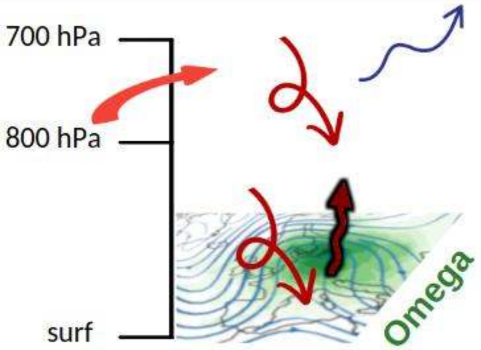


Mehr konvektive Niederschlag

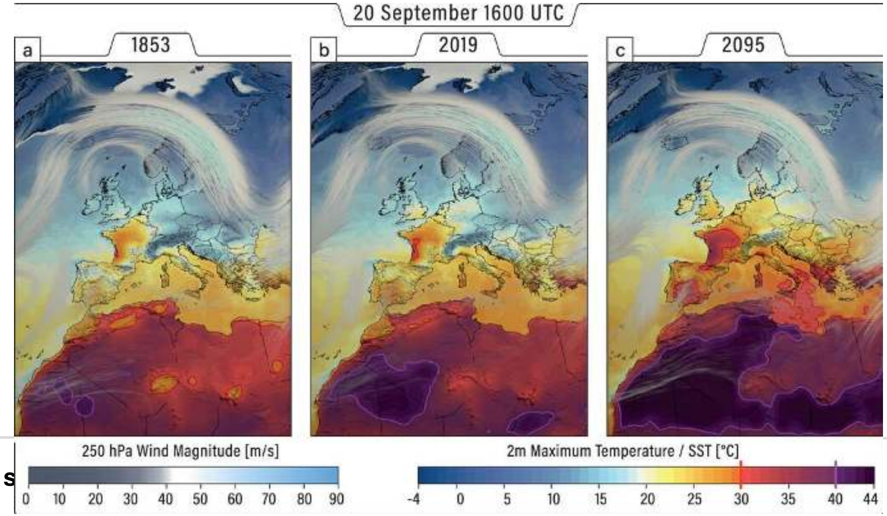
Quelle: Hundhausen et al. (2025)

Hitzewellen – Prozesse und Storylines



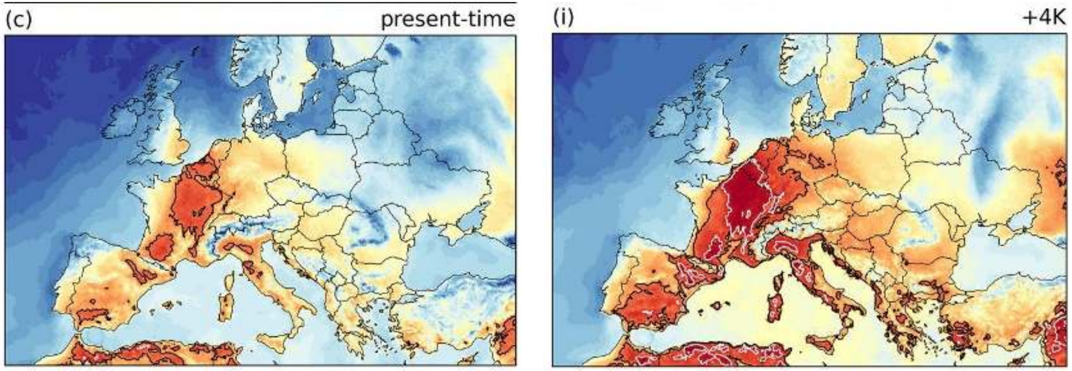


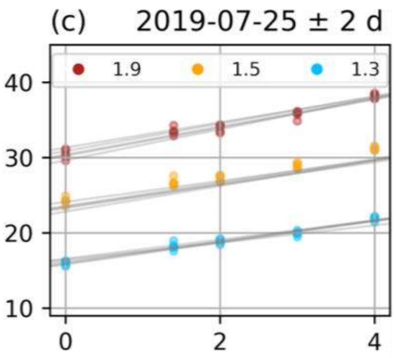
Advektion
Adiabatische Erwärmung (absinken)
Diabatische Erwärmung (Wärmeflüsse)
Diabatische Abkühlung (Strahlung)



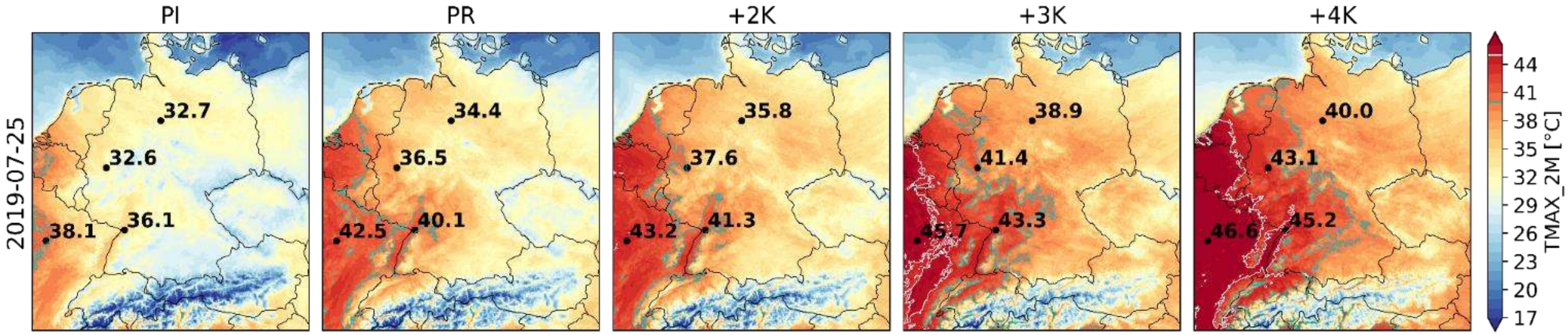
Quellen: Lemburg et al. (2025); Sanchez-Benitez *et al. (2022)*

Hitzewellen - Storylines



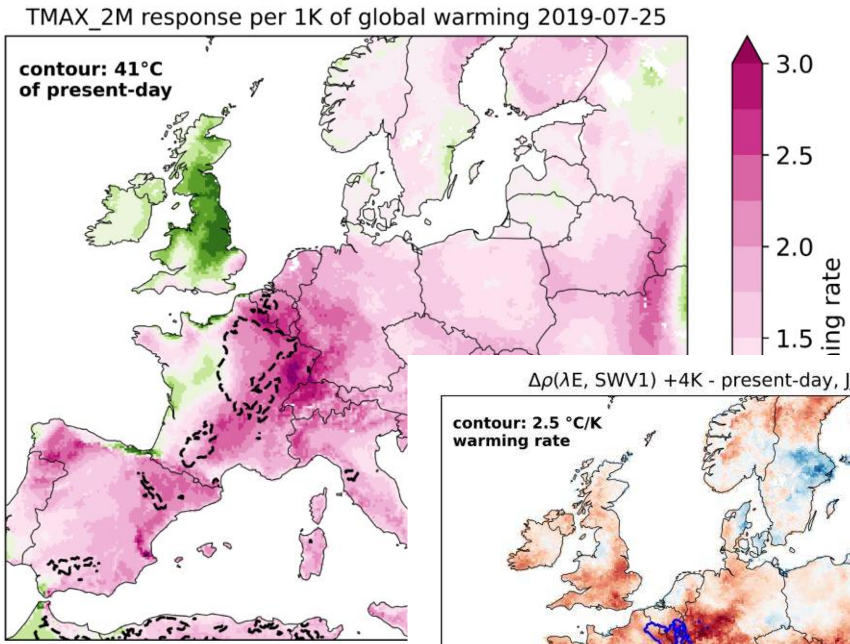


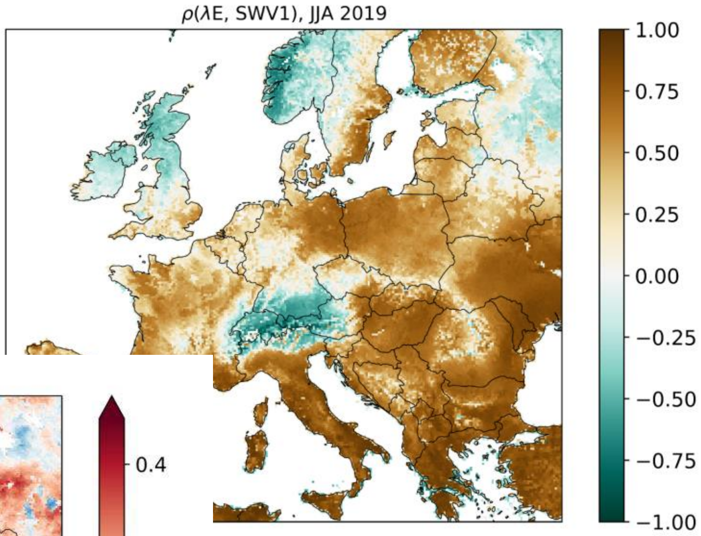
Erwärmungsraten (K)



Quelle: Klimiuk et al. (2025)

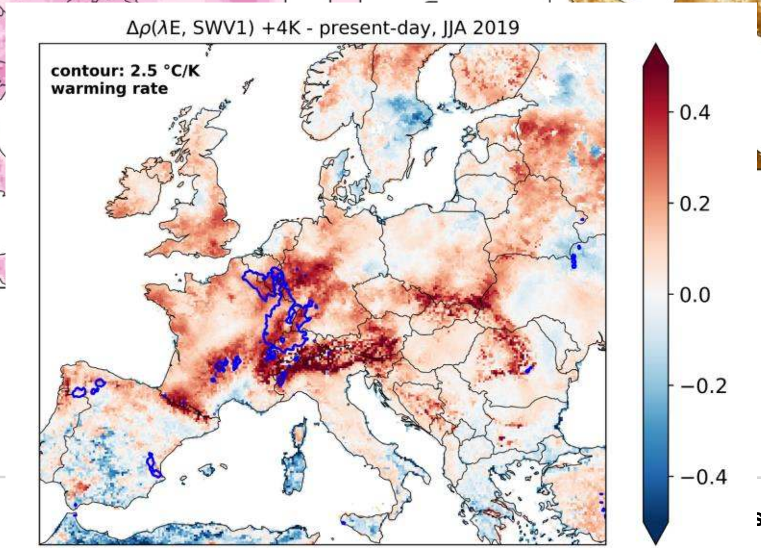
Hitzewellen: Erwärmungsraten und Feedbacks





Feuchte limitiert

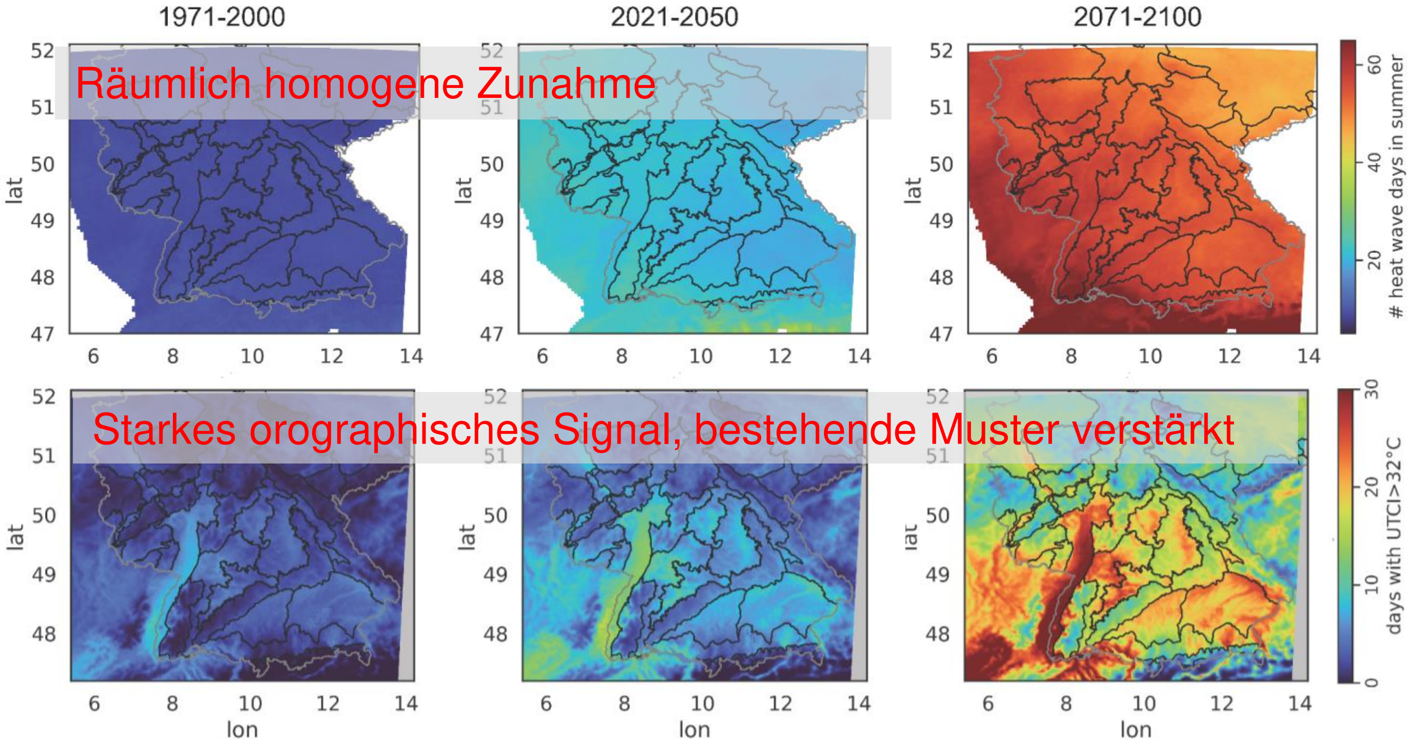
Energie limitiert



Zunahme der Feuchte-Limitierung bei +4K vs Erwärmungsrate

ρ(λE, SM): Zusammenhang zwischen latentem Wärmefluss und Bodenfeuchte

Klimaprojektionen für Hitzewellenindizes



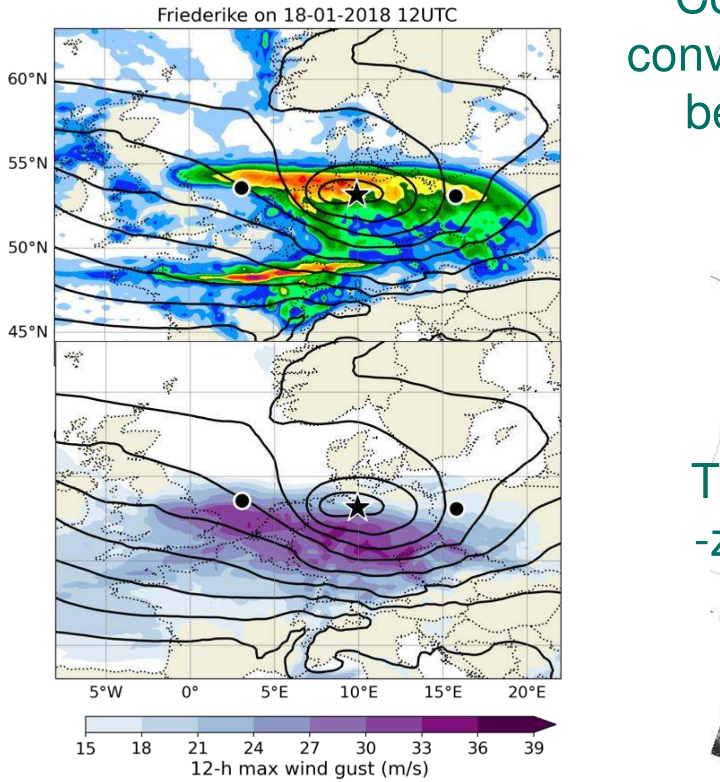
Anzahl Hitzewellentage im Sommer (HWMId)

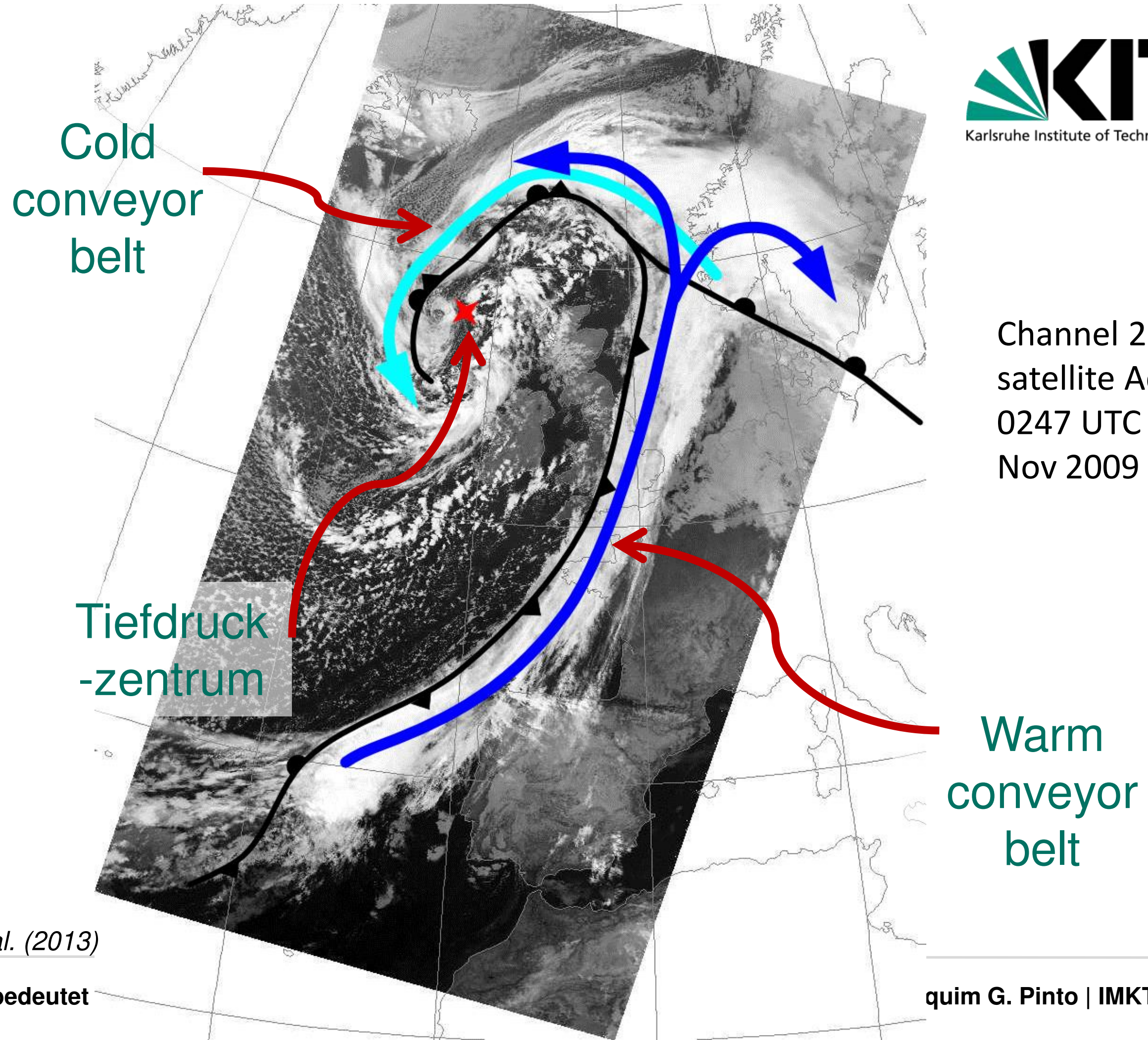
Anzahl Tage mit UTCI > 32°C (starker Hitzestress)

UTCI = gefühlte Temperatur

Quelle: Hundhausen et al. (2023)

Winterstürme





Channel 22, satellite Aqua 0247 UTC 25 Nov 2009

Quellen: Knutzen et al., 2025 ;Martinez-Alvarado et al. (2013)

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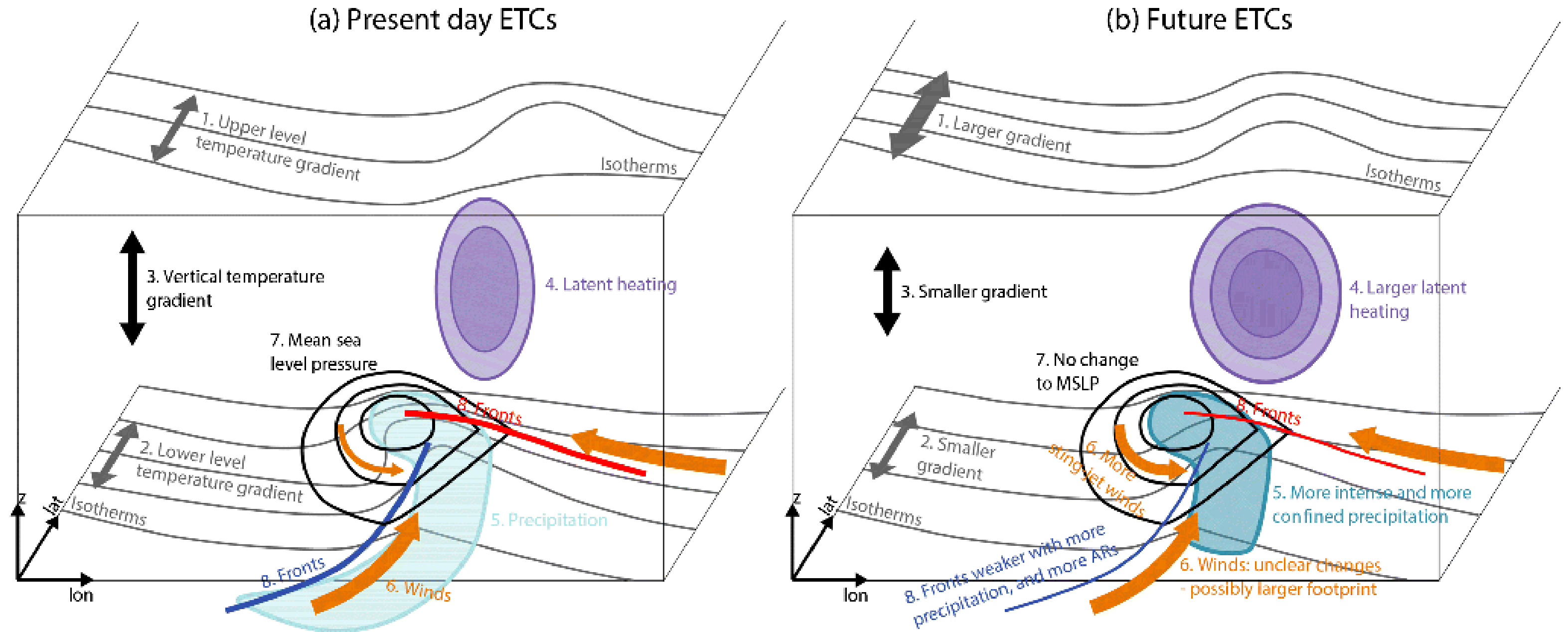
Winterstürme - Prozesse

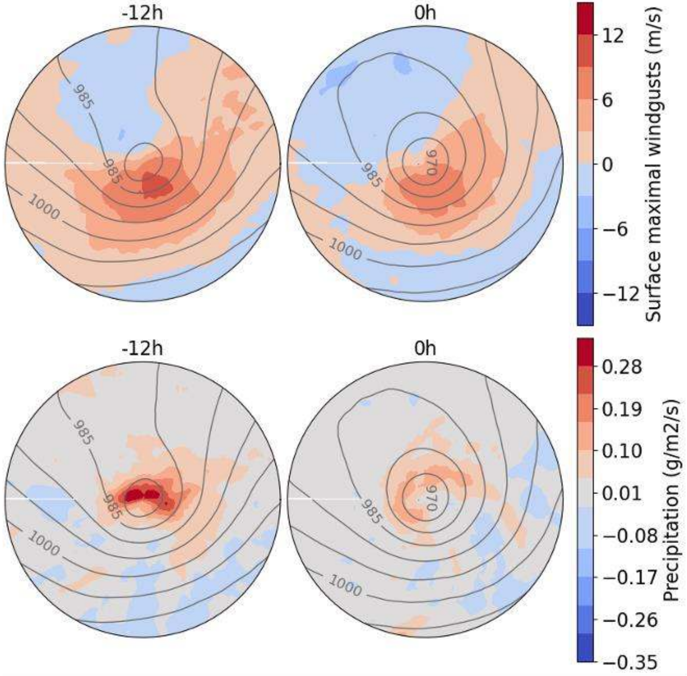


Feature	1	2	3	4	5 (intensity)	5 (extent)	6	7	8
Confidence	High	High	High	High	High	Low	Low	Medium	Low

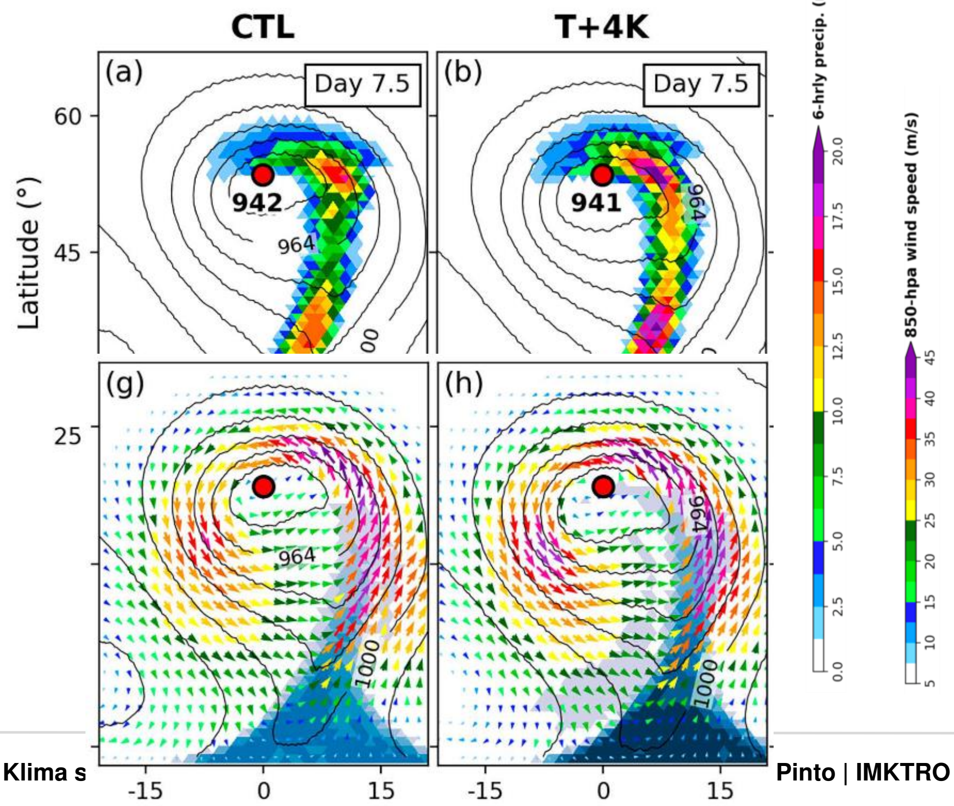
Quelle: Catto et al., 2019

Winterstürme – Veränderungen Niederschlag, Wind(böen)

Diabatische – Nicht-diabatische Zyklonen



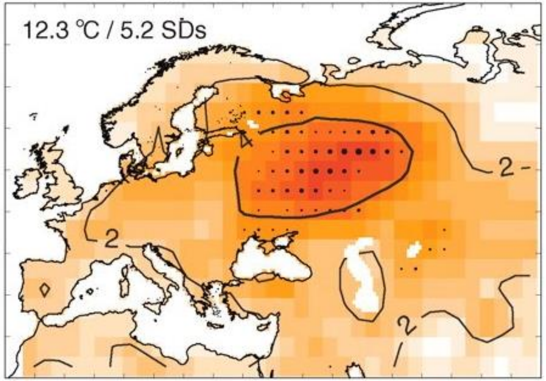
Heute vs 4K-wärmeres Klima (2095)



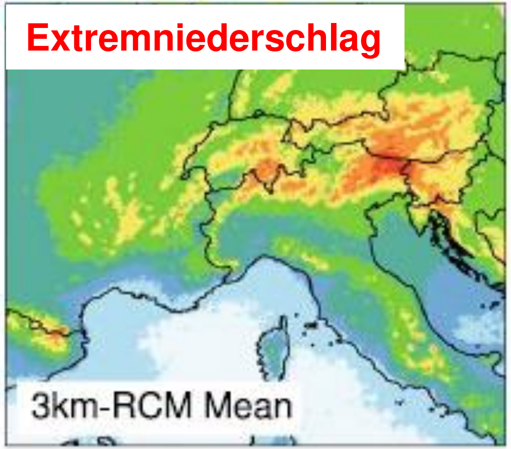
Quellen: Christ et al., 2025; Chen et al., 2024

Zusammenfassung

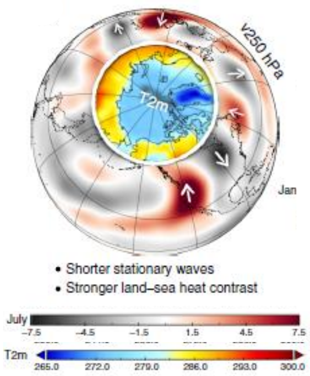
Hitzewellen und Trockenheit



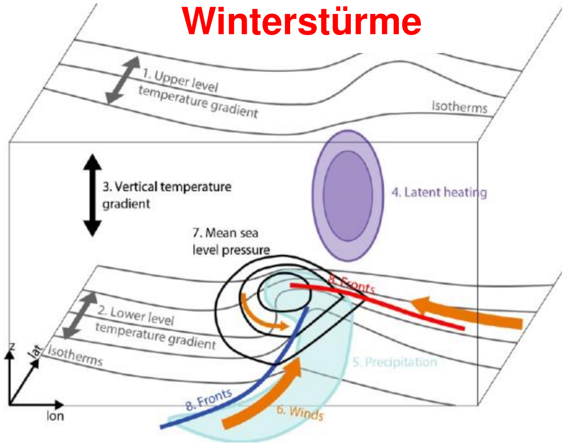
Extremniederschlag



Atmosphärische Zirkulation und Thermodynamik sind beide wichtig, um rezente und zukünftige Veränderung zu verstehen



Winterstürme



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