

Climate Change 2013: The Physical Science Basis

Working Group I contribution to the IPCC Fifth Assessment Report

Klima-Vorhersagbarkeit und Regionale Klimaprojektionen

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Klima-Zukunft im IPCC AR5

Darstellung im Report: in 2 Kapitel und einem Anhang

- Chapter 11: „near-term future“ (bis 2050)
- Chapter 12: „far-term future“ (zum Teil bis 2300) => Vortrag von Reto Knutti
- Annex I: Atlas => Vortrag von Gian-Kasper Plattner

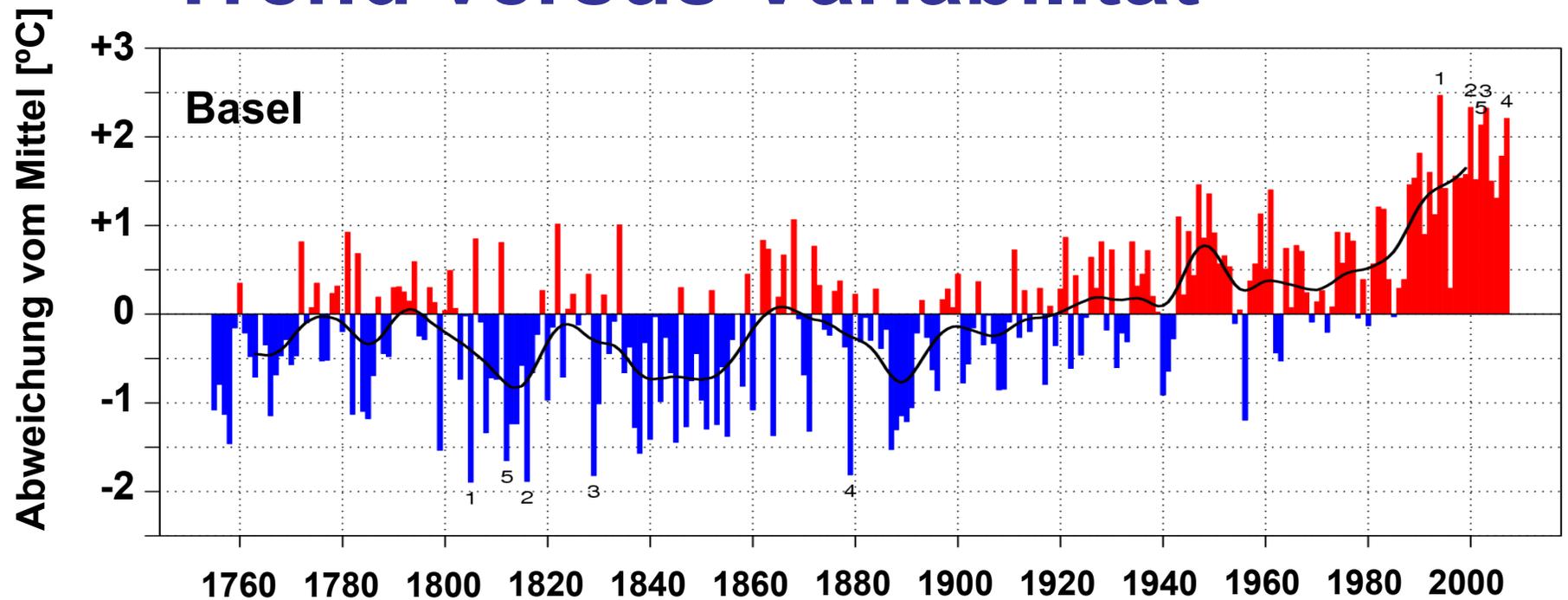
Neue Szenarien (RCPs) =>

Basiert weitgehend auf neuen CMIP5-Simulationen:

- 51 Modellversionen, 138 Modellläufe im Zeitraum 1850-2100
- Durchschnittliche Auflösung deutlich höher als im AR4
- Viele Modelle haben verfeinerte Darstellung von:
Wolken-Mikrophysik, Aerosol, Biogeochemie, Ozon-Schicht
- Validation (Chapter 9) findet Verbesserung gegenüber AR4
- Referenz-Periode: 1986-2005

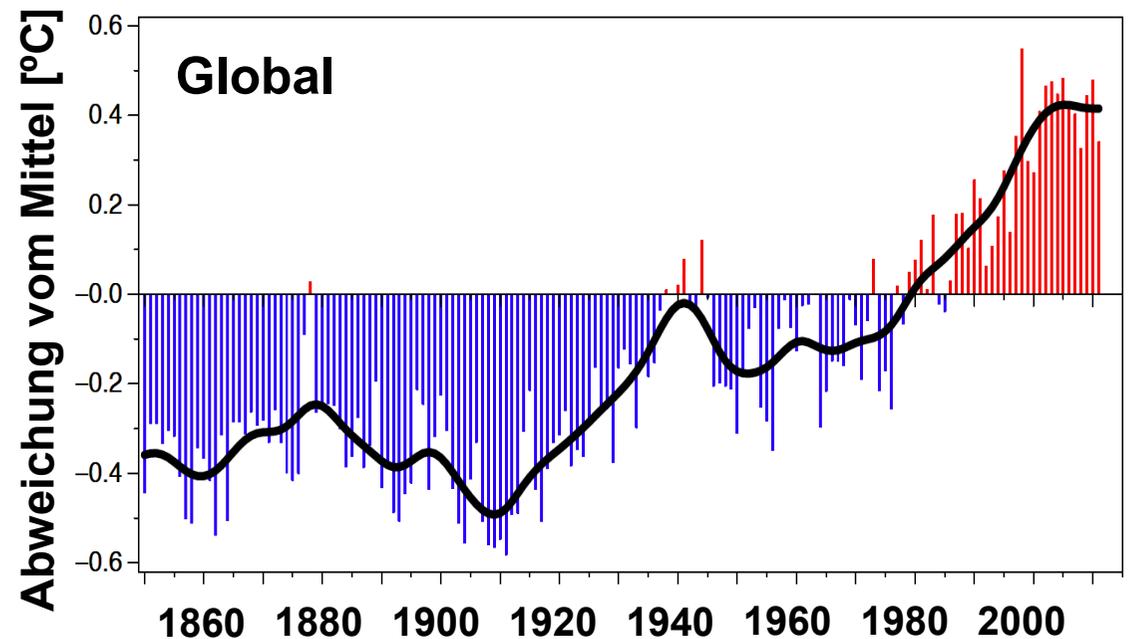
Chapter 11 betrachtet nebst „Projektionen“ auch „Prognosen“

Trend versus Variabilität



Wichtige Frage:
Dominiert
anthropogener Trend
oder natürliche Variabilität?

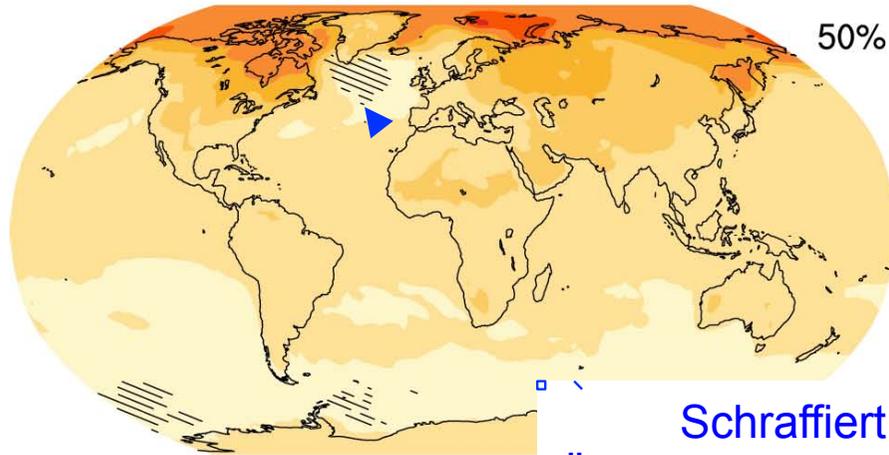
Kurzfristig: Variabilität
Langfristig: Trend



Änderung versus Variabilität

2016-2035

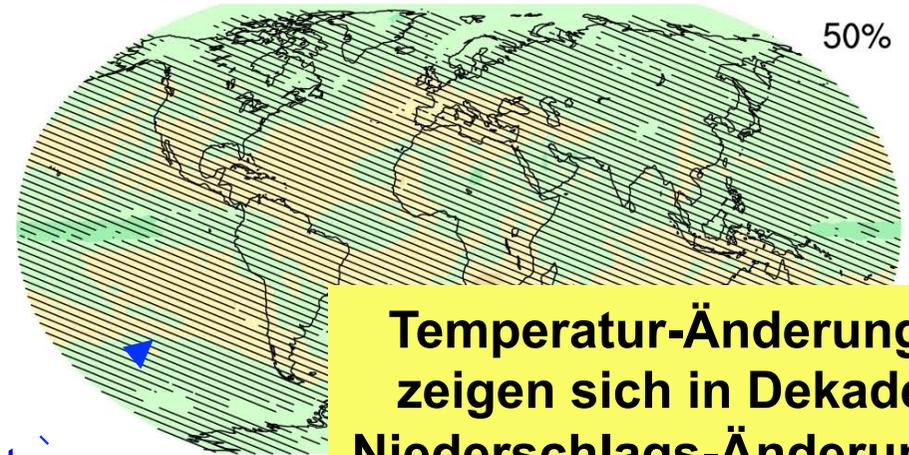
Temperatur Winter [°C]



50%

Schraffiert:
Änderung < Variabilität

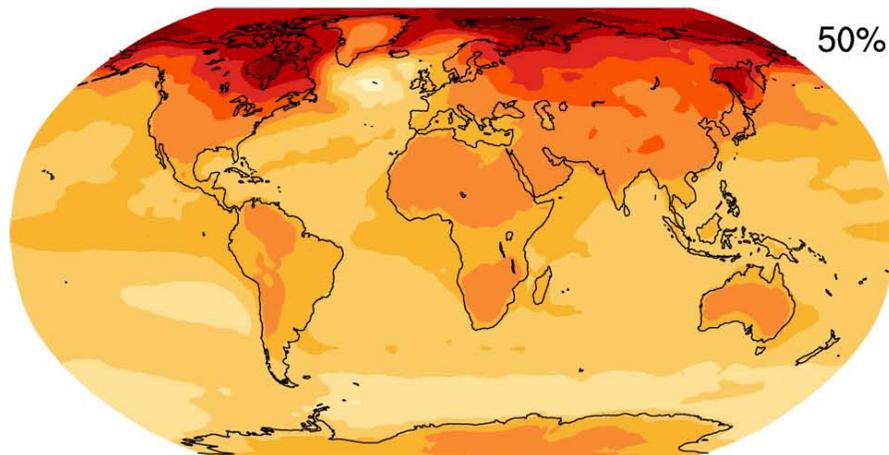
Niederschlag Sommerhalbjahr [%]



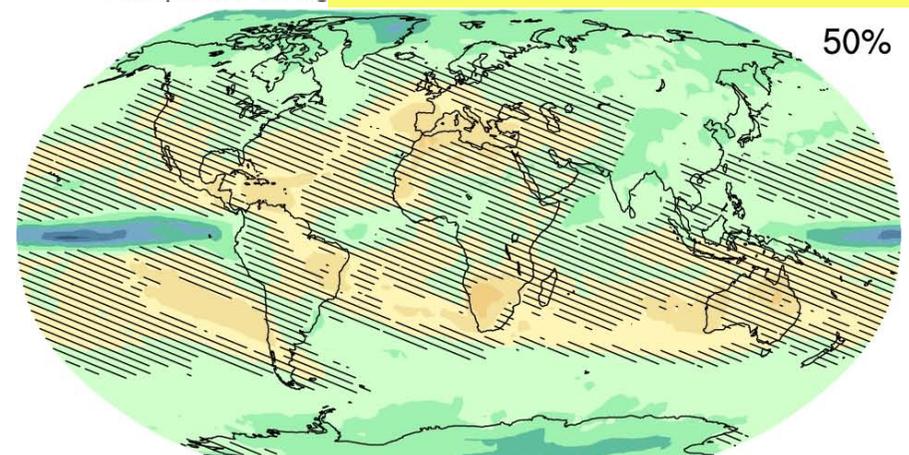
50%

**Temperatur-Änderungen
zeigen sich in Dekaden,
Niederschlags-Änderungen
erst langfristig**

2081-2100



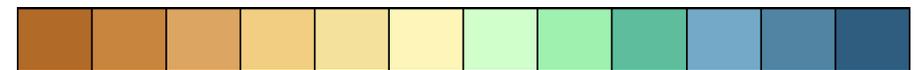
50%



50%



-2 -1.5 -1 -0.5 0 0.5 1 1.5 2 3 4 5 7 9 11



-50 -40 -30 -20 -10 0 10 20 30 40 50

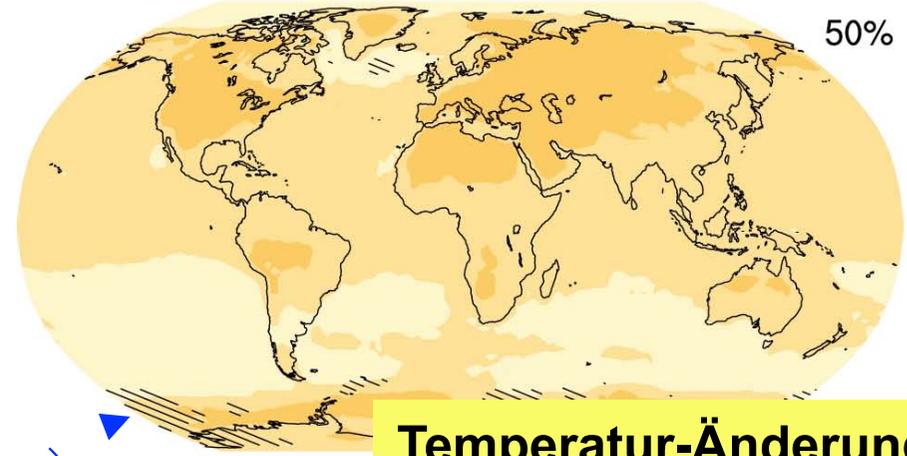
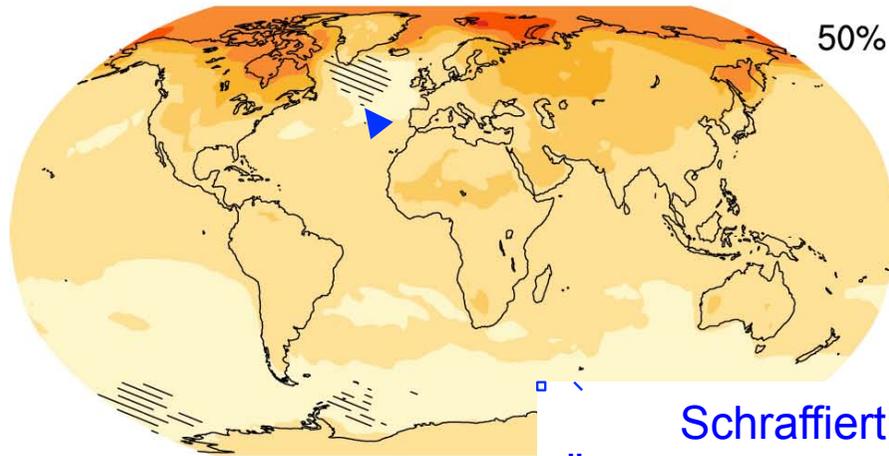
IPCC AR5, Atlas (Annex I), RCP4.5

Temperatur-Änderung (RCP 4.5)

Winter (DJF)

Sommer (JJA)

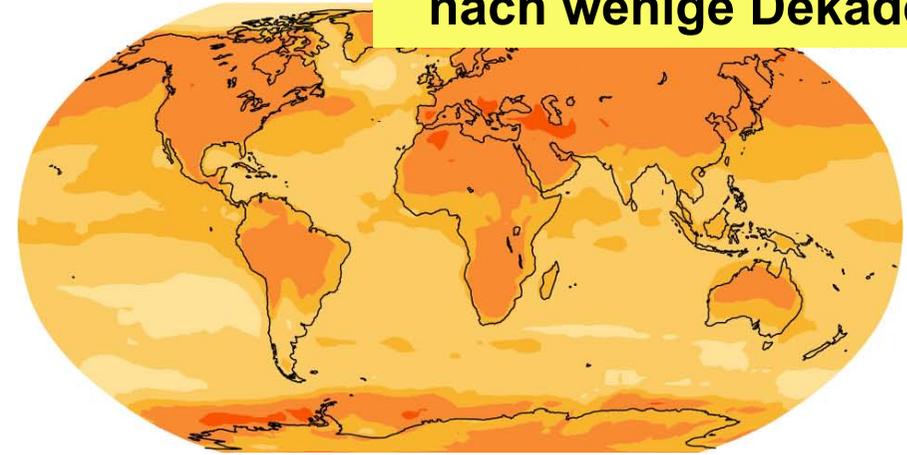
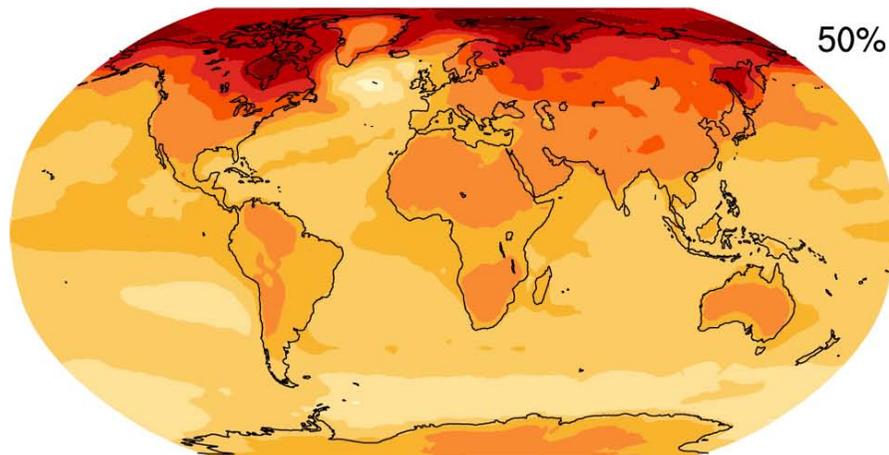
2016-2035



Schraffiert:
Änderung < Variabilität

Temperatur-Änderungen
zeigen sich bereits
nach wenige Dekaden

2081-2100



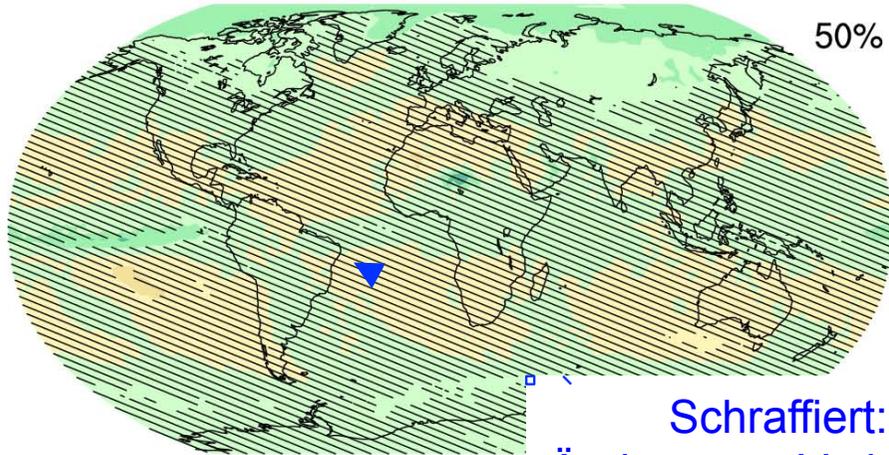
[°C]

Niederschlags-Änderung (RCP 4.5)

Winterhalbjahr (Okt-März)

Sommerhalbjahr (Apr-Sep)

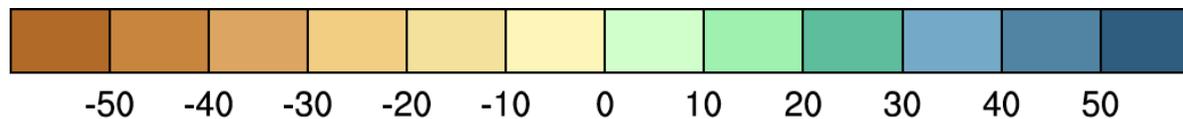
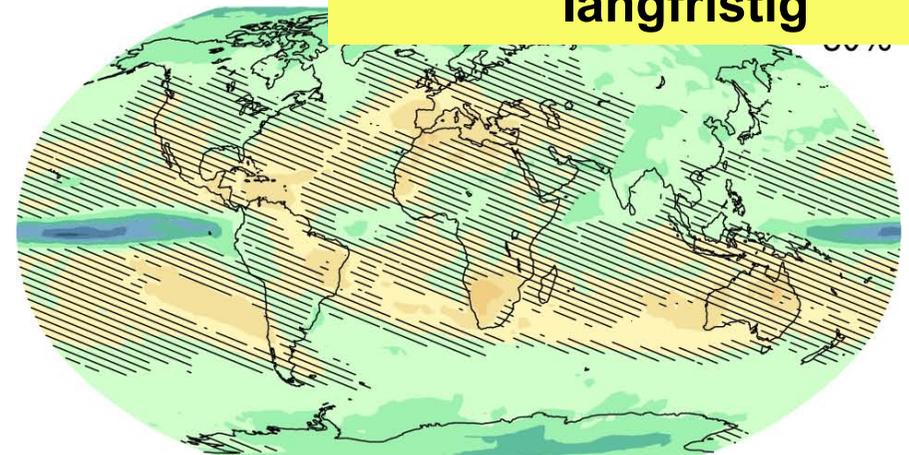
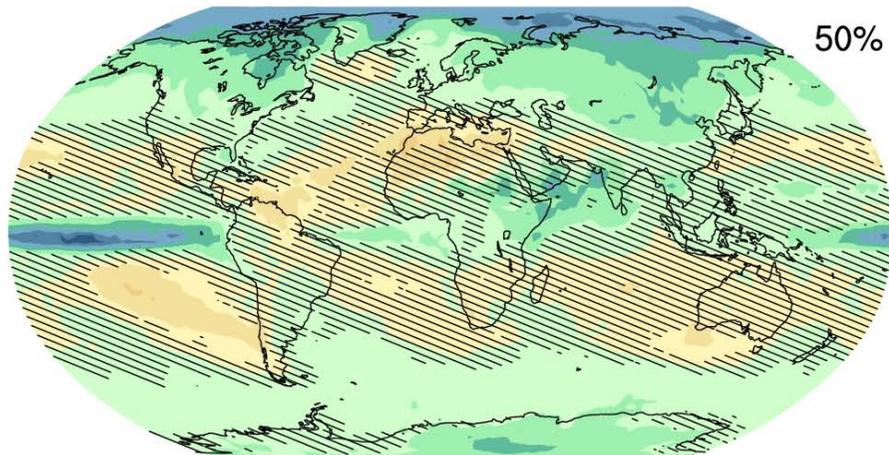
2016-2035



Schraffiert:
Änderung < Variabilität

Niederschlags-Änderungen
zeigen sich erst
langfristig

2081-2100



[%][C]

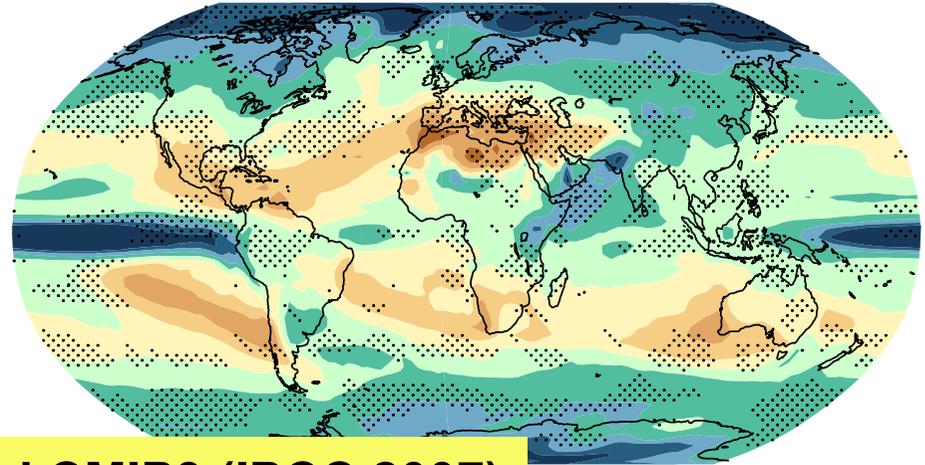
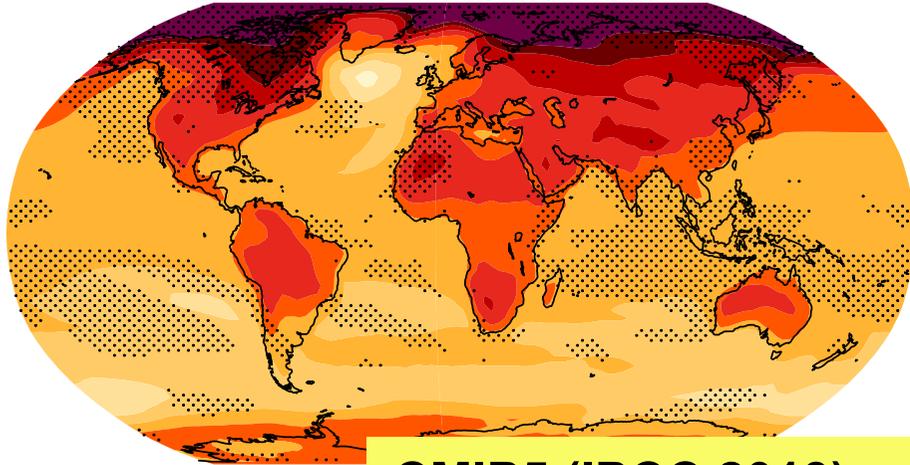
-50 -40 -30 -20 -10 0 10 20 30 40 50

IPCC 2013 versus IPCC 2007

Δ Temperatur (skaliert)

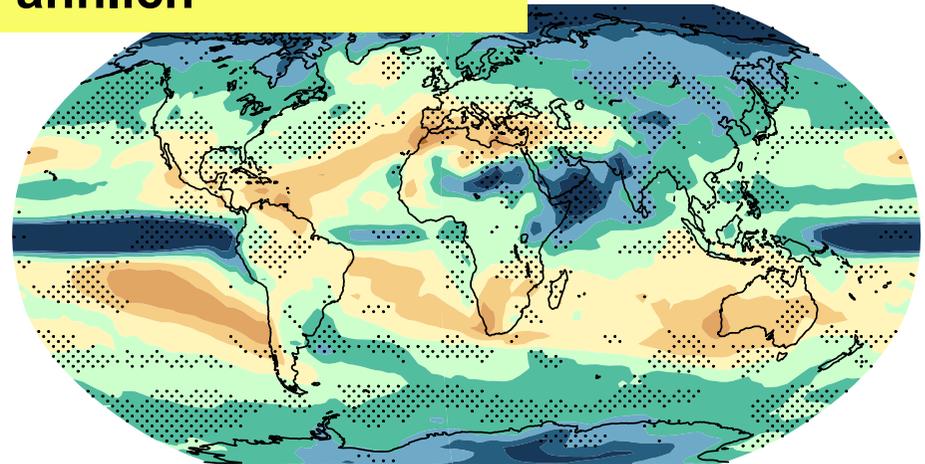
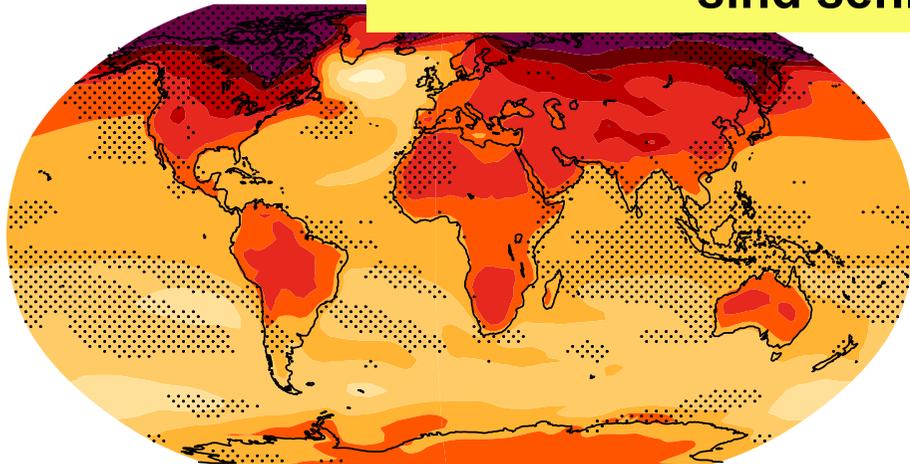
Δ Niederschlag (skaliert)

2007
CMIP3
AR4



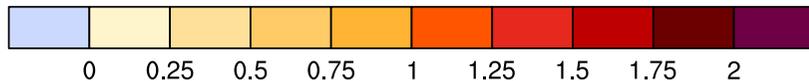
**CMIP5 (IPCC 2013) und CMIP3 (IPCC 2007)
sind sehr ähnlich**

2013
CMIP5
AR5



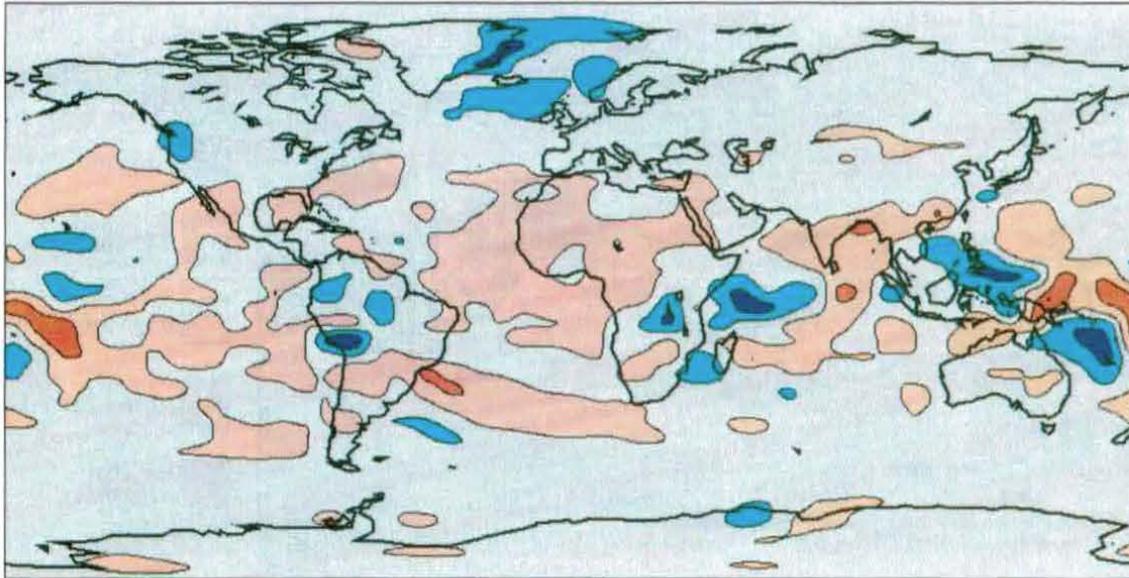
(°C per °C global mean change)

(% per °C global mean change)



Erfreuliche Konsistenz!

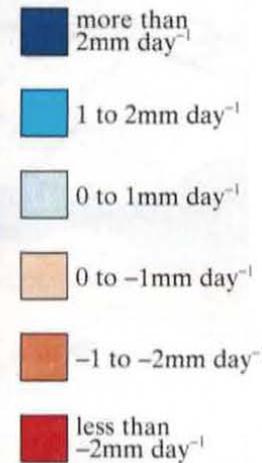
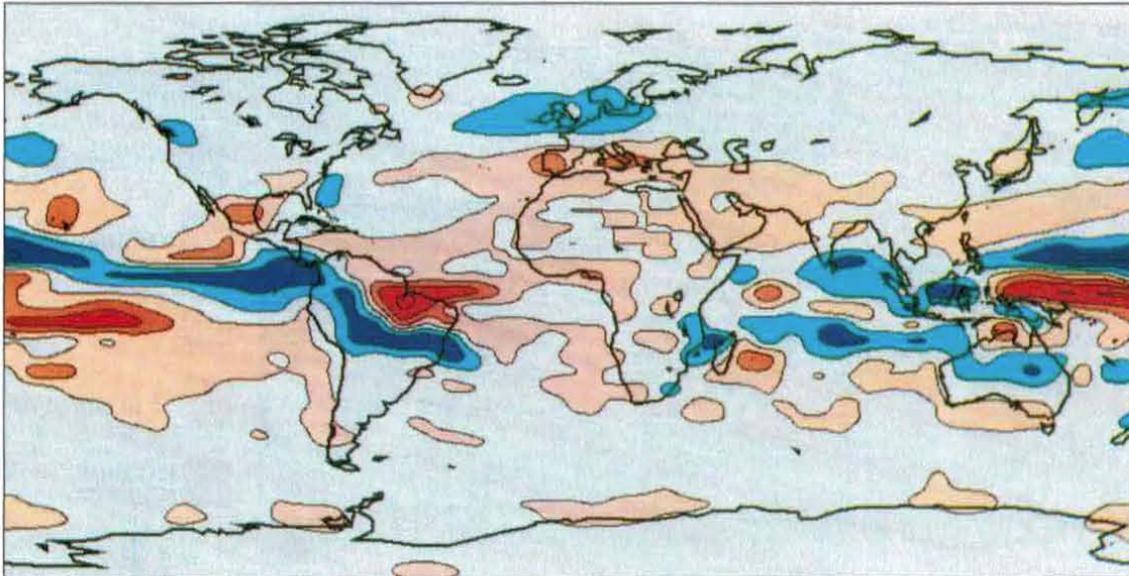
(b) DJF $2\times\text{CO}_2 - 1\times\text{CO}_2$ precipitation: GFHI



Konsistenz zwischen Simulationen und Assessments ist sehr erfreulich!

War bei einigen früheren IPCC Reports nicht der Fall.

(c) DJF $2\times\text{CO}_2 - 1\times\text{CO}_2$ precipitation: UKHI



IPCC Figure 1990 (FAR):

DJF Niederschlags-Änderung zum Zeitpunkt der CO_2 -Verdoppelung für "high-resolution models".

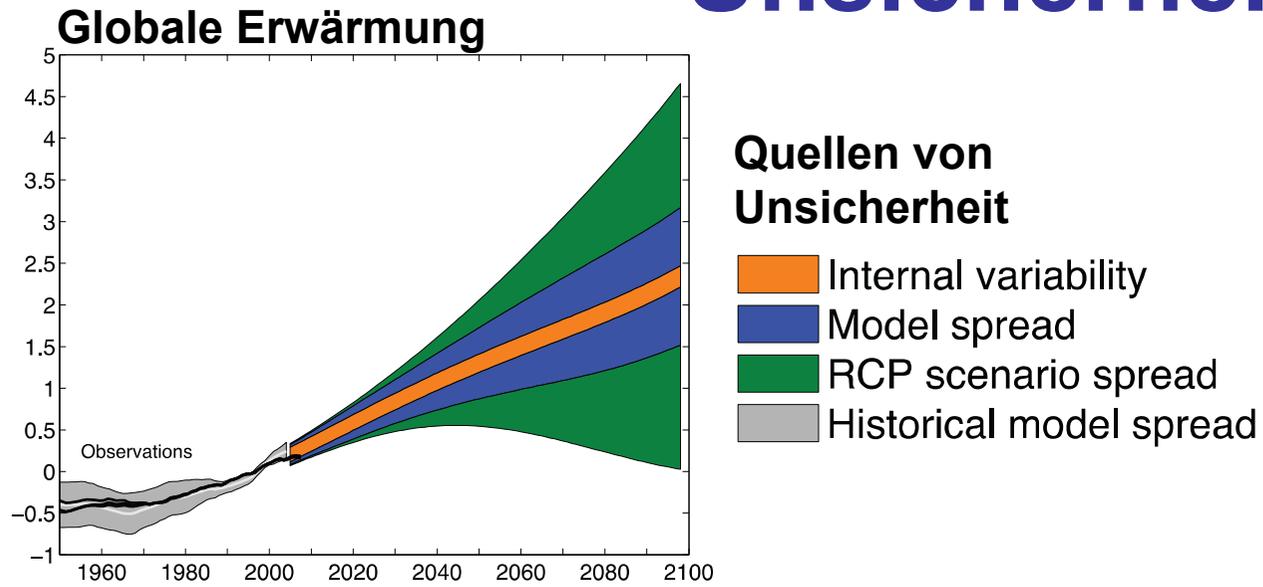
Damals "high resolution":

(a) CCC: T32 (310 km)

(b) GFDL: R30 (330 km)

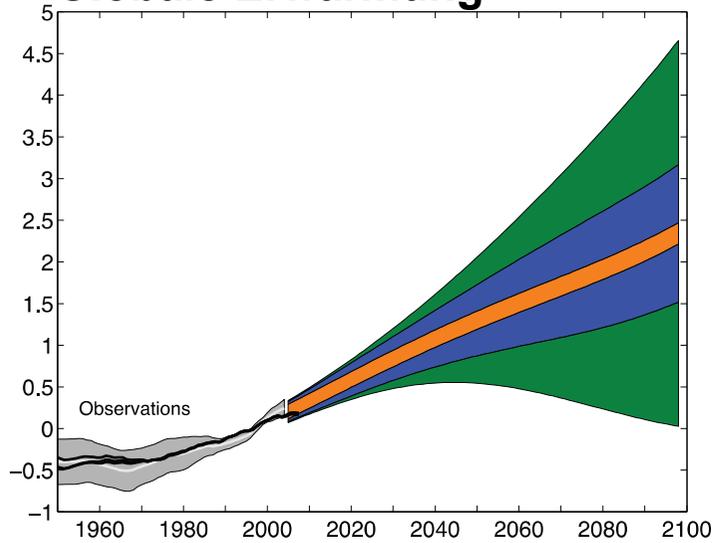
(c) UKMO: $3.75^\circ \times 2.5^\circ$ (300 km)

Unsicherheiten



Unsicherheiten

Globale Erwärmung



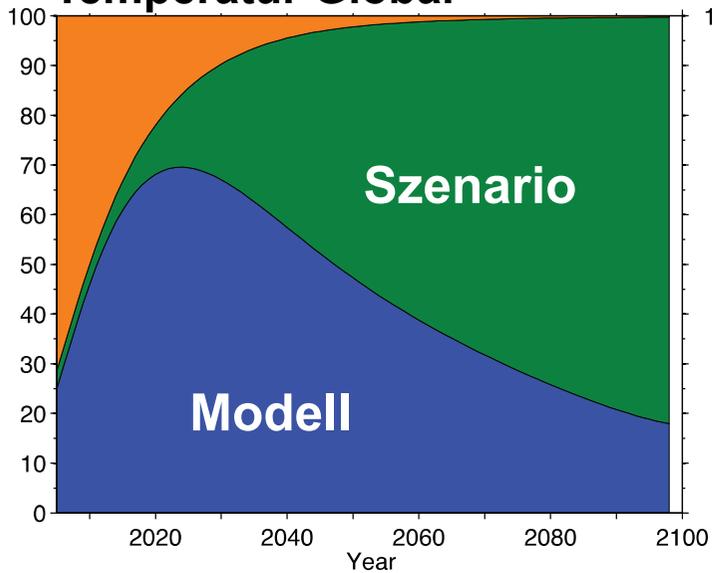
Quellen von Unsicherheit

- Internal variability
- Model spread
- RCP scenario spread
- Historical model spread

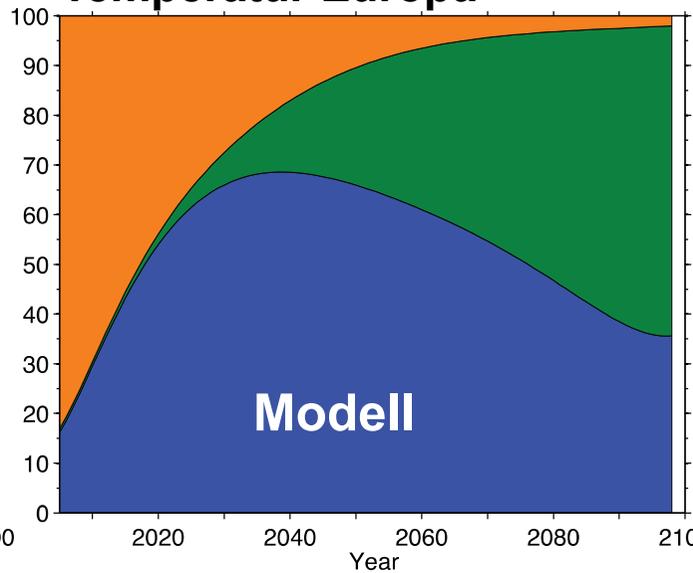
Unsicherheiten sind abhängig von Zeitraum und betrachteter Variabel.

Anfangs dominiert interne Variabilität, in 100 Jahren oft Szenario-Wahl

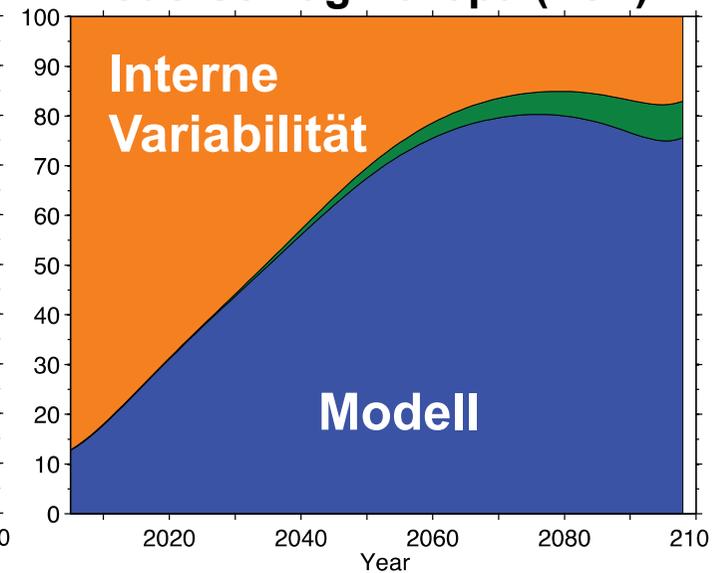
Temperatur Global



Temperatur Europa

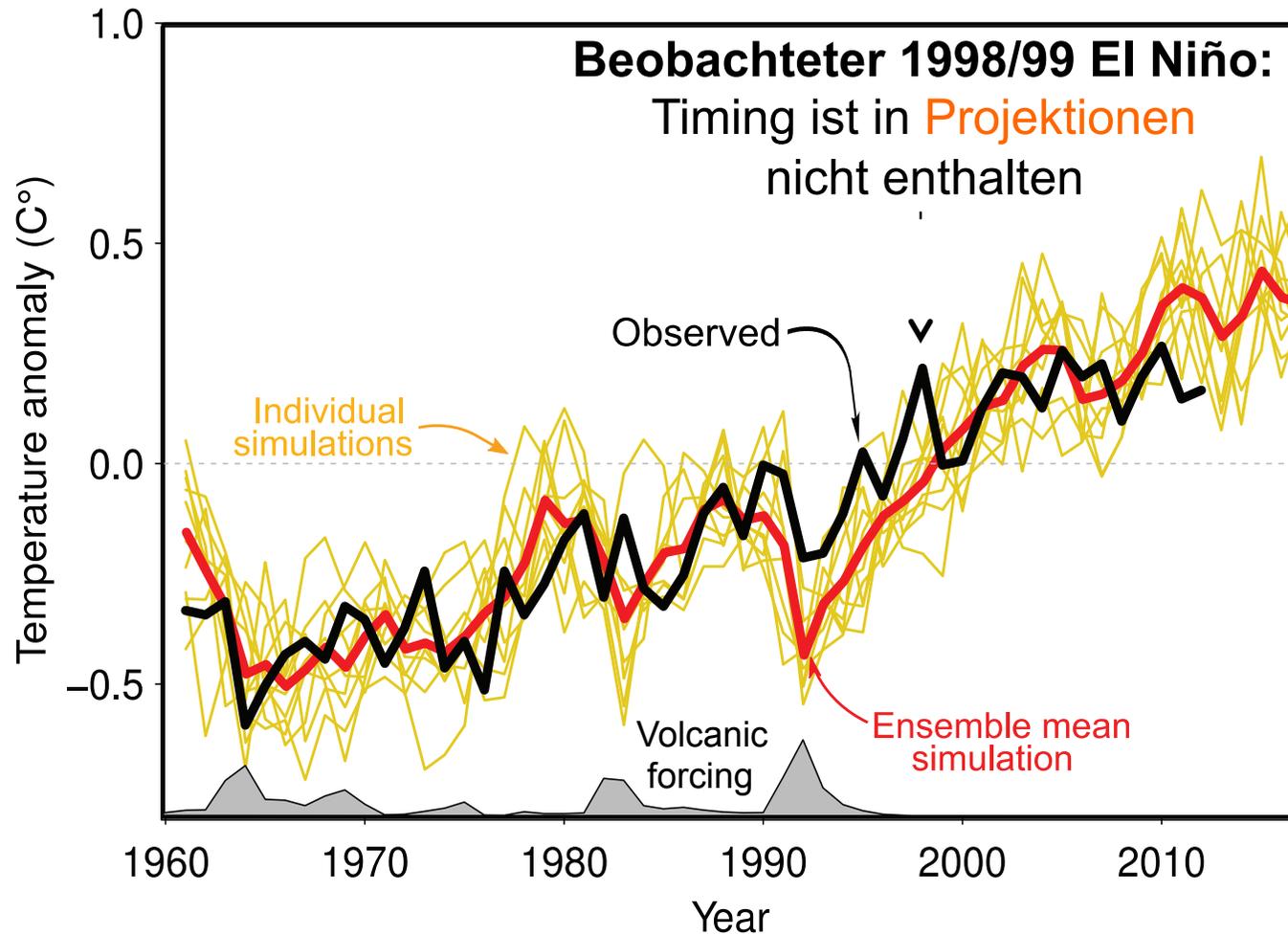


Niederschlag Europa (DJF)



Projektion versus Beobachtungen

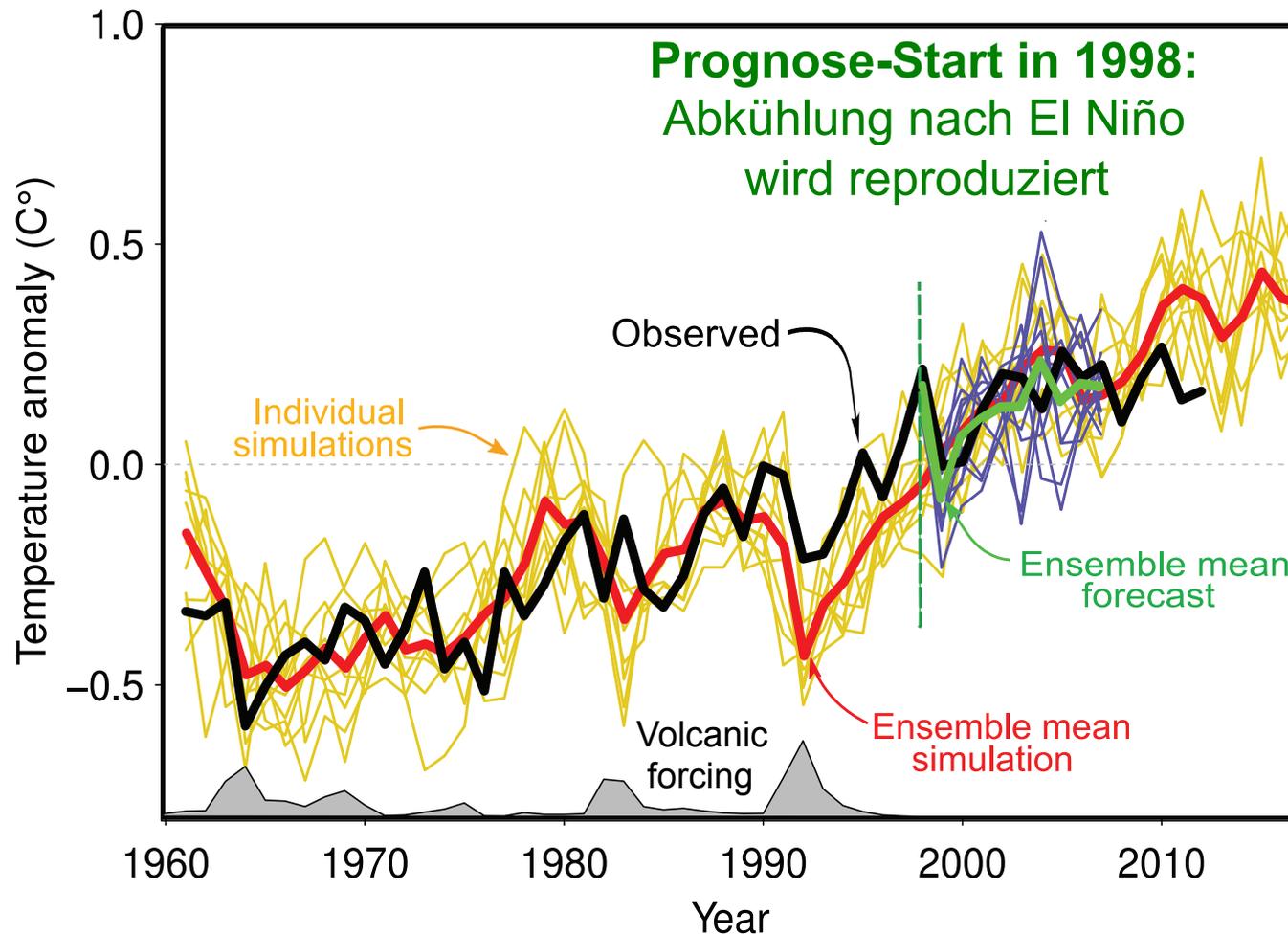
Interne Variabilität in
Projektionen enthalten,
aber keine Prognose



Projektion versus Prognose

Interne Variabilität in
Projektionen enthalten,
aber keine Prognose

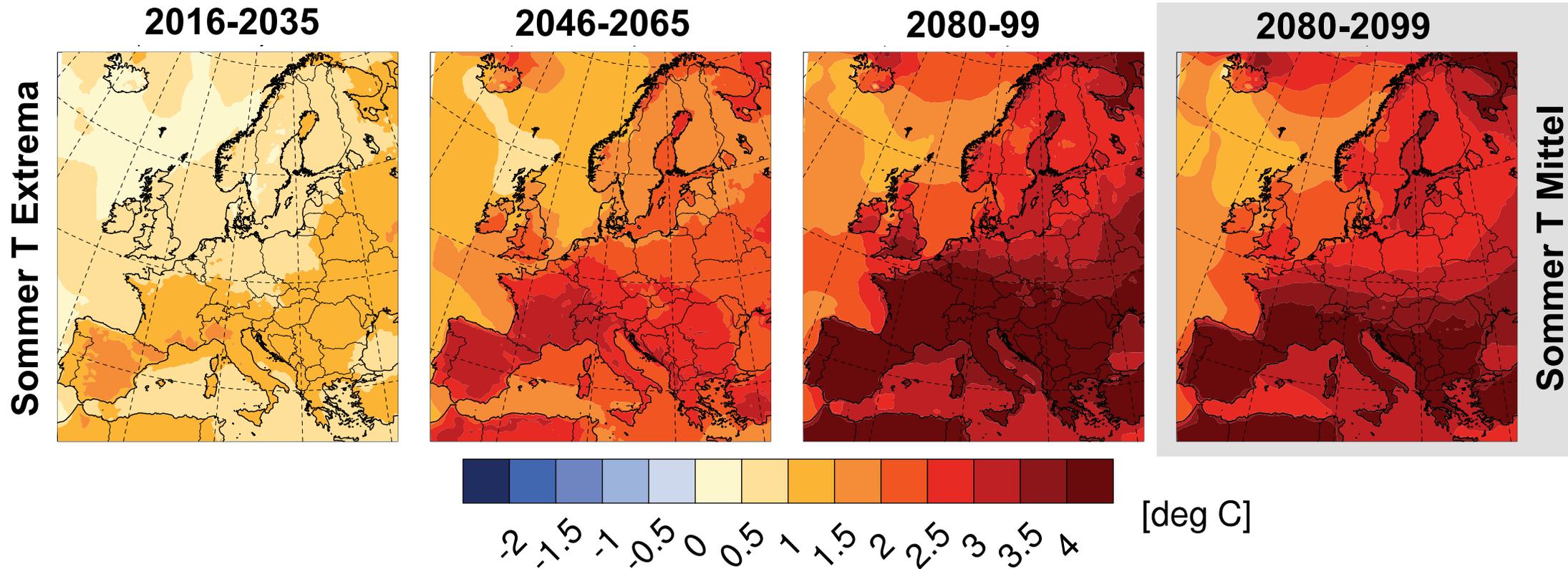
Interne Variabilität wird
über einige Jahre
vorhergesagt



Prognose hat
kurzfristig einen
besseren Skill als
Projektion.

Hinweise auf
beträchtliches
Potential (bis zu ca
10 Jahren).

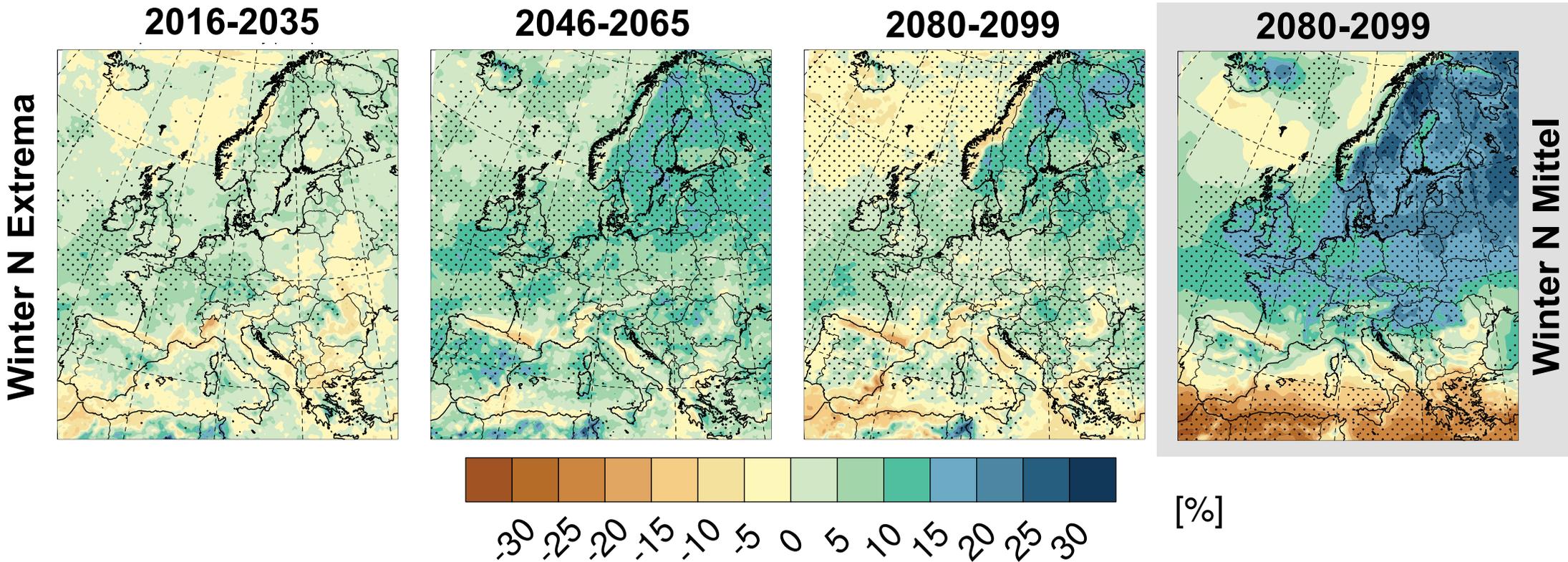
Extrema der Sommer-Temperaturen



Änderung der Temperatur-Extrema im Sommer (Tmax, 90%-Perzentil)

- Statistisch signifikant in ganz Europa
- Stärkste Zunahme in Südeuropa
- Deutliche Zunahme im Laufe des Jahrhunderts
- Stärker als Zunahme der Mitteltemperaturen

Extrema der Winter-Niederschläge



Änderung der Niederschlags-Extrema im Winter (95%-Perzentil der täglichen N)

- **Langsame Zunahme in Nordeuropa (nur signifikant wo gepunktet)**
- **Starke dekadische Variabilität, verursacht durch Zirkulationsänderungen**
- **Zunahme teilweise langsamer als bei mittleren Niederschlagsmengen**

Wichtigste Aussagen

Die neuen Simulationen im IPCC AR5 zeigen hohe Konsistenz untereinander, und mit vorangehenden Resultaten im IPCC AR4.

Unsicherheiten abhängig von Zeitraum und betrachteter Variabel:

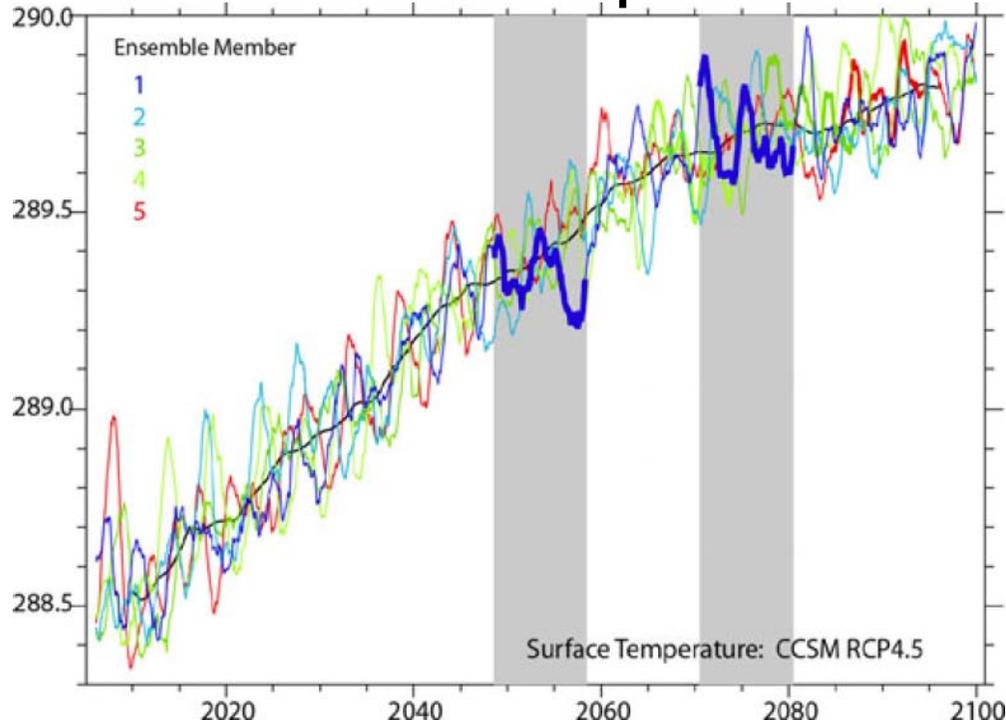
- interne Variabilität: dominiert in nächsten Jahrzehnten
- Modell-Unsicherheit: wichtig langfristig und beim Wasserkreislauf
- Szenario-Unsicherheit: dominiert langfristig

Die initialisierten Prognosen haben kurzfristig einen besseren Skill als die gängigen Projektionen. Studien belegen signifikantes Potential für <10 Jahre, gegenwärtig noch nicht voll ausgeschöpft.

Resultate für Europa (Temperaturen, Niederschlag, Extreme) konsistent mit älteren Szenarien (IPCC AR4 und SREX, ENSEMBLES, CH2011).

Dekadische Variabilität

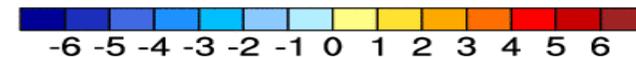
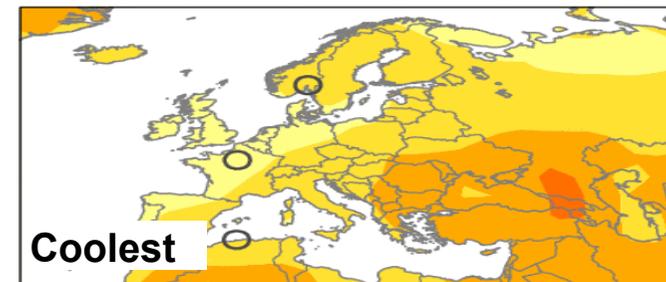
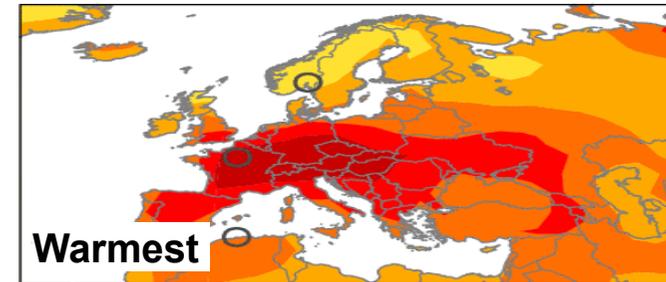
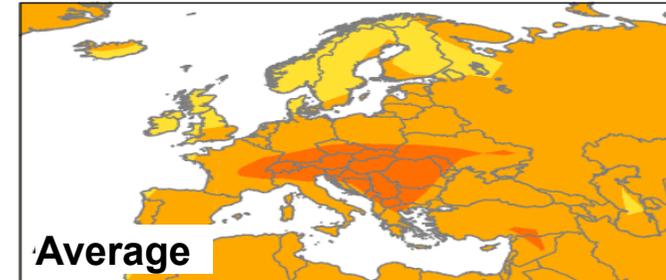
Globale Temperatur



**Simulationen zeigen
Phasen mit globaler
Abkühlung.**

Trenberth and Fasullo (2012)

Temperatur Trend 2005-2060



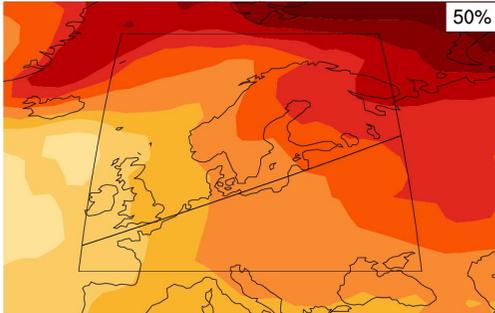
**Ensemble (50 members) zeigt
grossen Spread in Erwärmung**

(Deser et al. 2012,
Europa-Update von Reto Knutti)

Projektionen Europa (RCP4.5) 2081-2100 versus 1986-2005

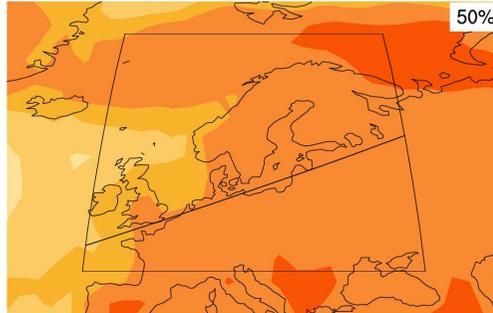
Winter

Temperature change RCP4.5 in 2081-2100: December-February



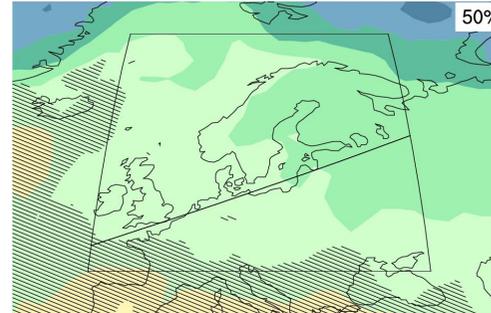
Sommer

Temperature change RCP4.5 in 2081-2100: June-August



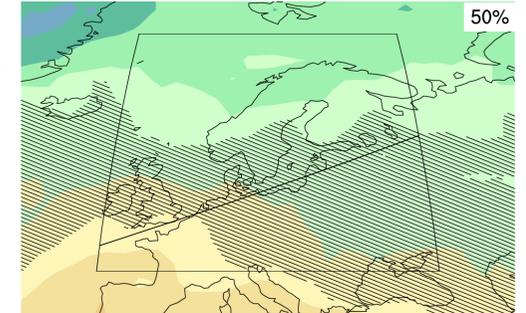
Winterhalbjahr

Precipitation change RCP4.5 in 2081-2100: October-March

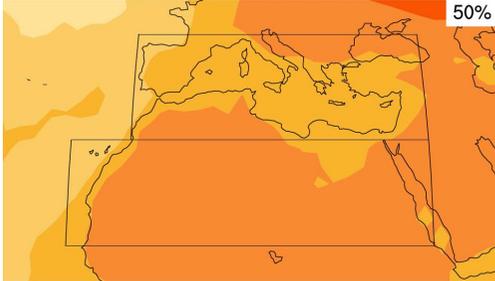


Sommerhalbjahr

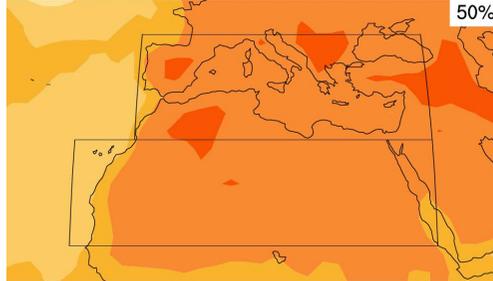
Precipitation change RCP4.5 in 2081-2100: April-September



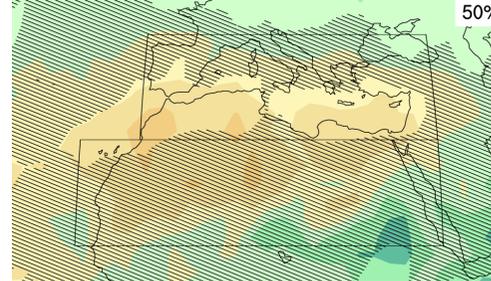
Temperature change RCP4.5 in 2081-2100: December-February



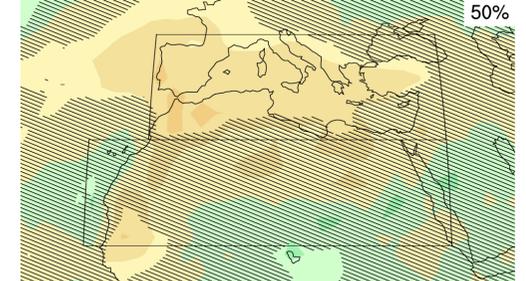
Temperature change RCP4.5 in 2081-2100: June-August



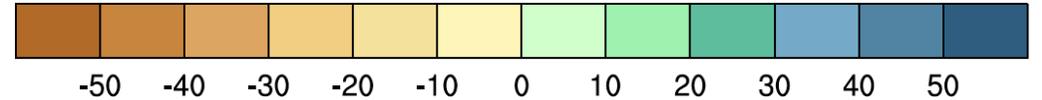
Precipitation change RCP4.5 in 2081-2100: October-March



Precipitation change RCP4.5 in 2081-2100: April-September



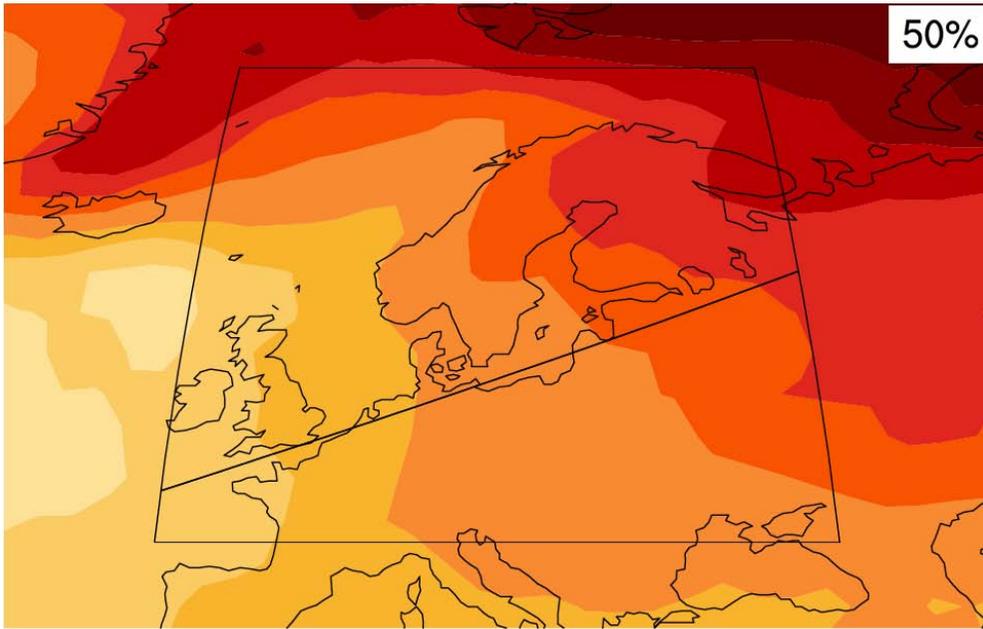
Temperatur-Änderung [°C]



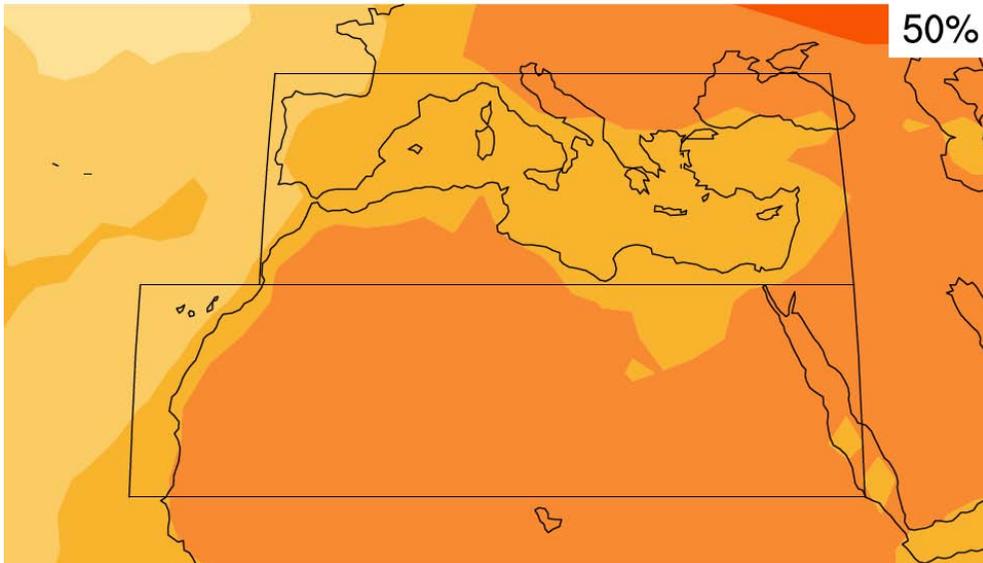
Niederschlags-Änderung [%]

Temperature DJF

Temperature change RCP4.5 in 2081-2100: December-February



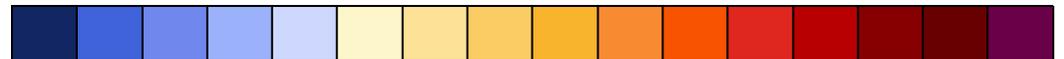
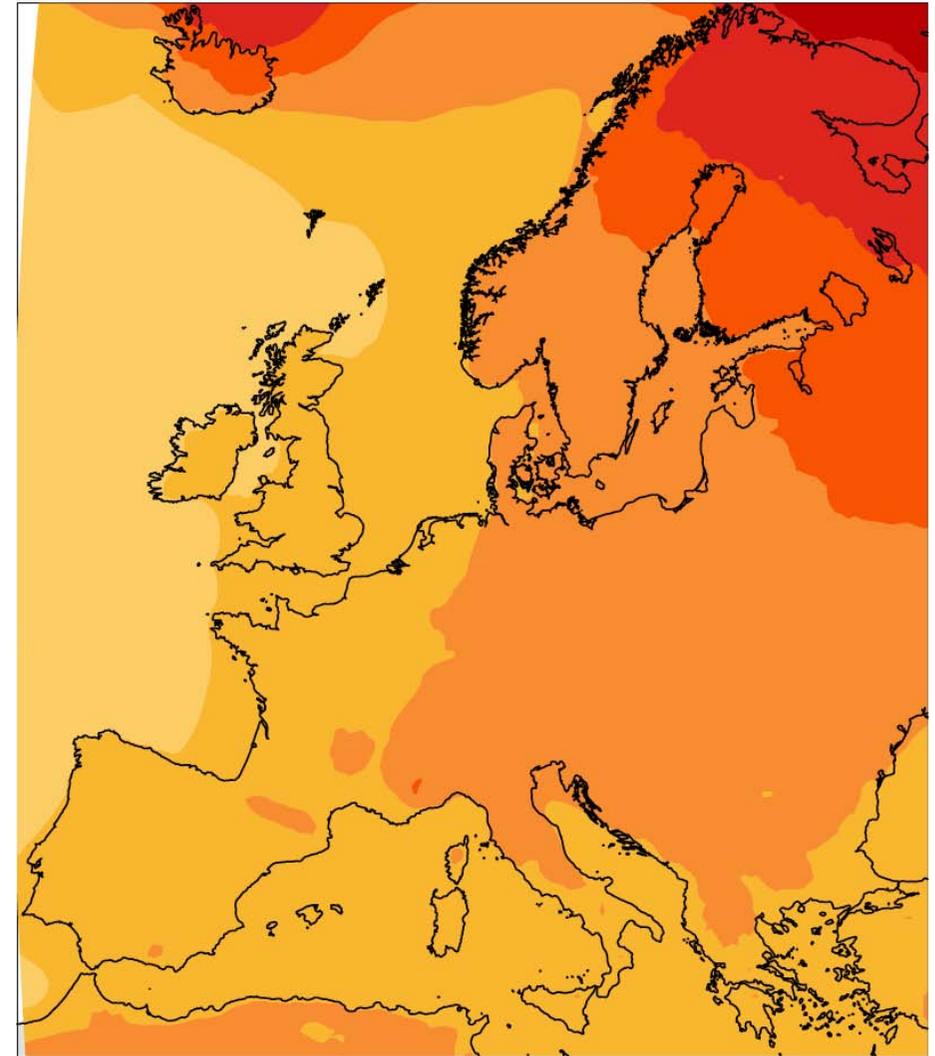
Temperature change RCP4.5 in 2081-2100: December-February



Temperature

ENSEMBLES A1B mean

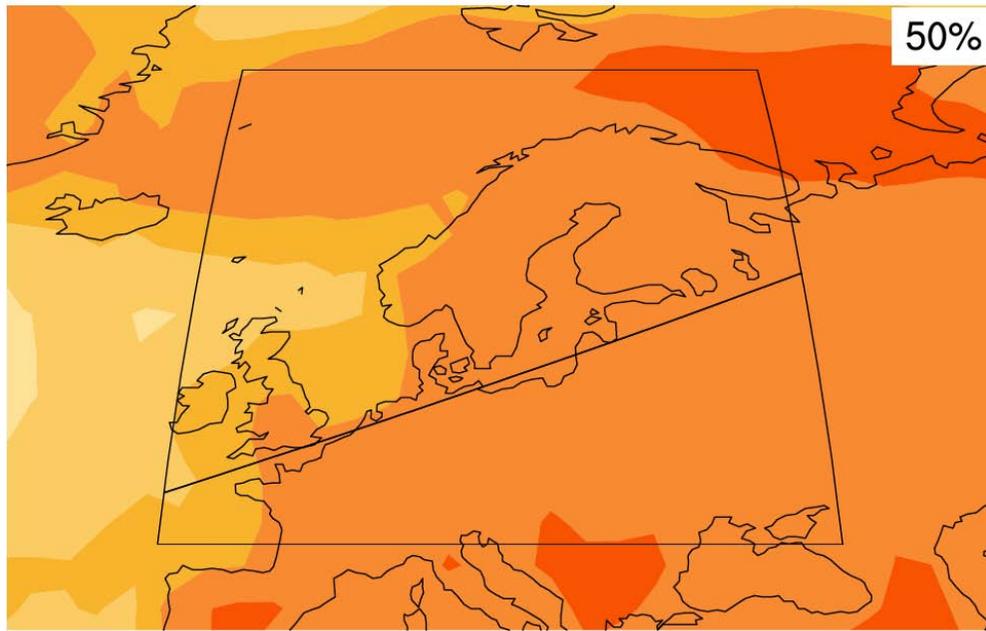
DJF 2080-2099



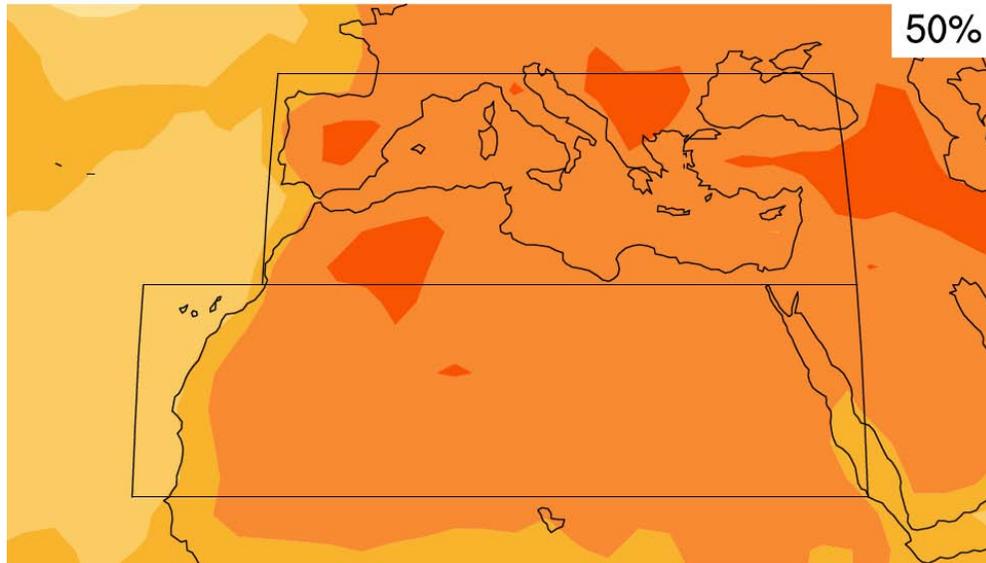
Temperature Change [°C]

Temperature JJA

Temperature change RCP4.5 in 2081-2100: June-August



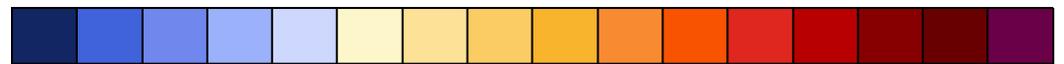
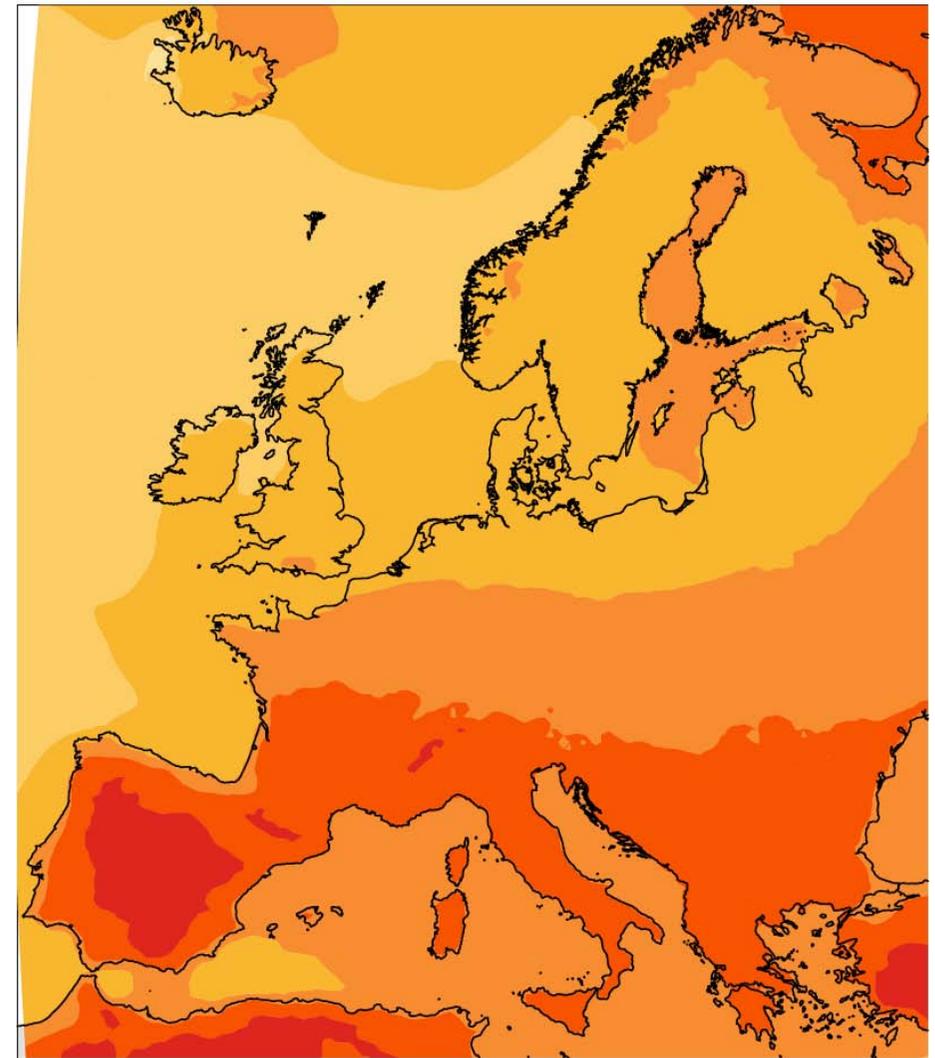
Temperature change RCP4.5 in 2081-2100: June-August



Temperature

ENSEMBLES A1B mean

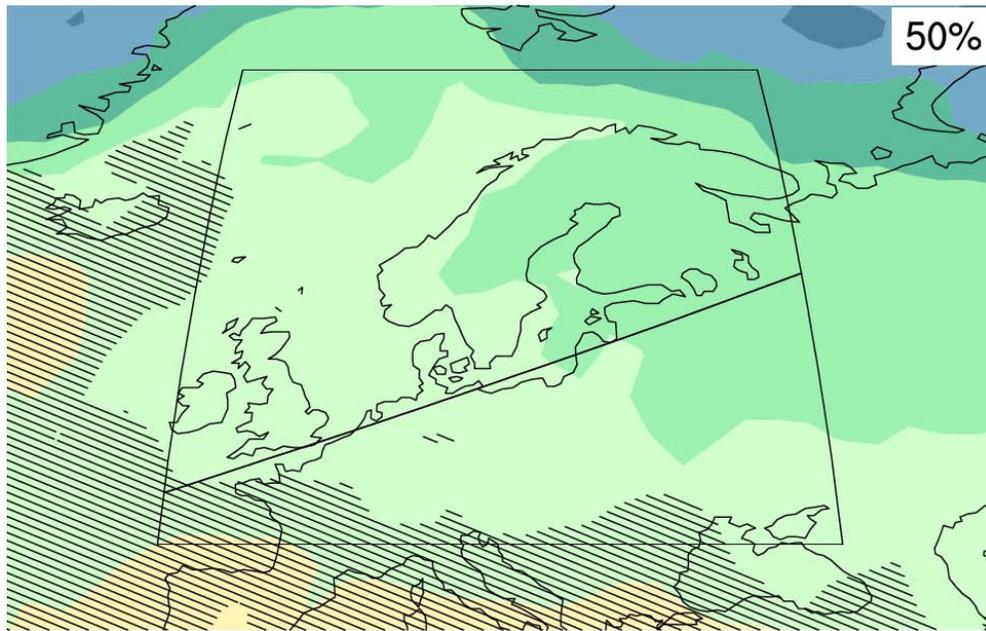
JJA 2080-2099



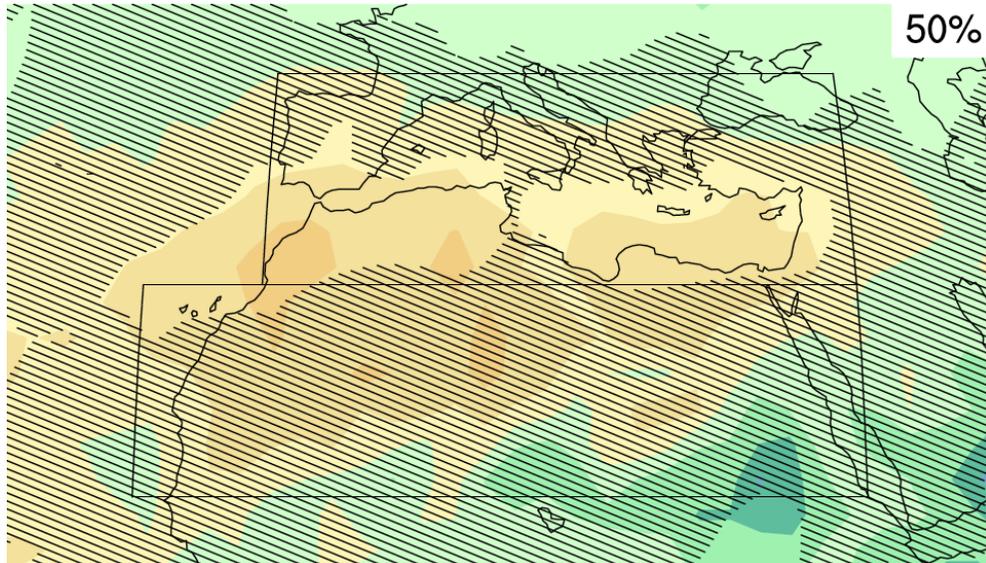
Temperature Change [°C]

Precipitation October-March

Precipitation change RCP4.5 in 2081-2100: October-March



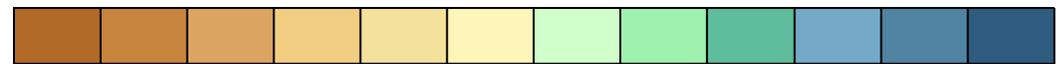
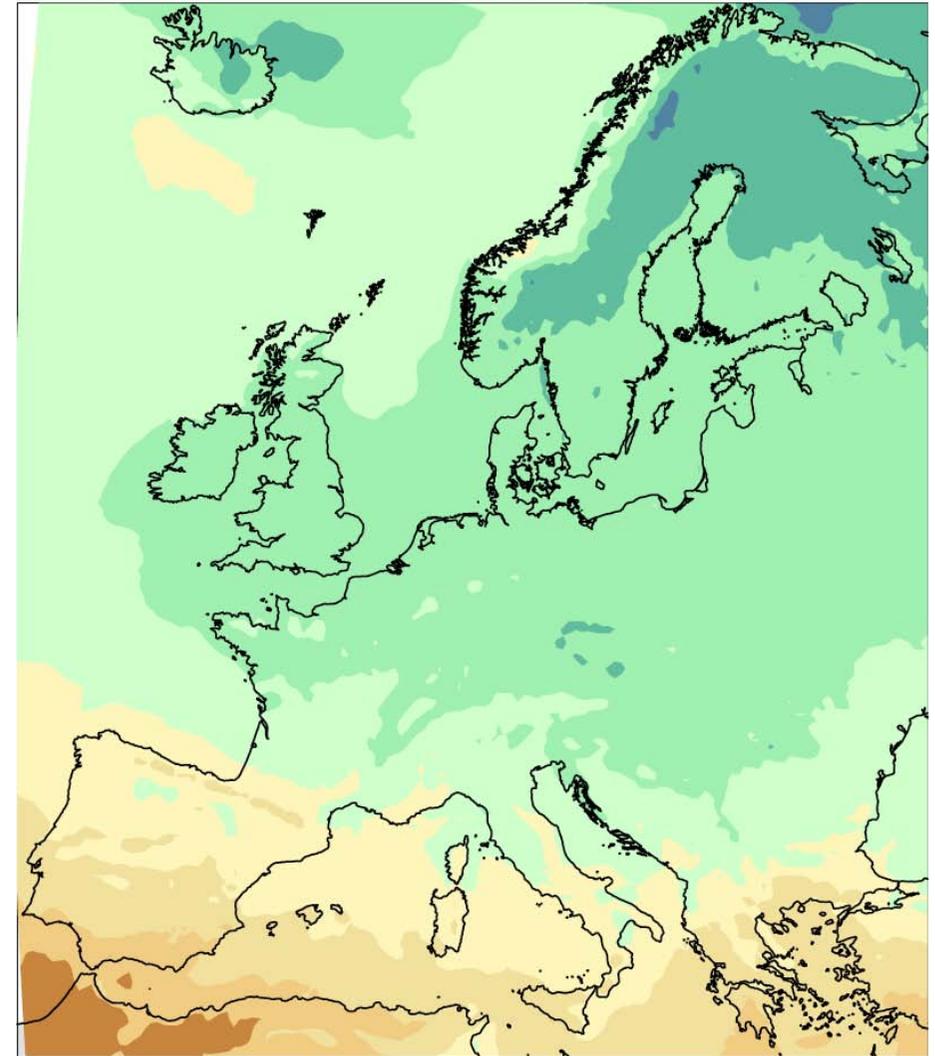
Precipitation change RCP4.5 in 2081-2100: October-March



Precipitation

ENSEMBLES A1B mean

ONDJFM 2080-2099

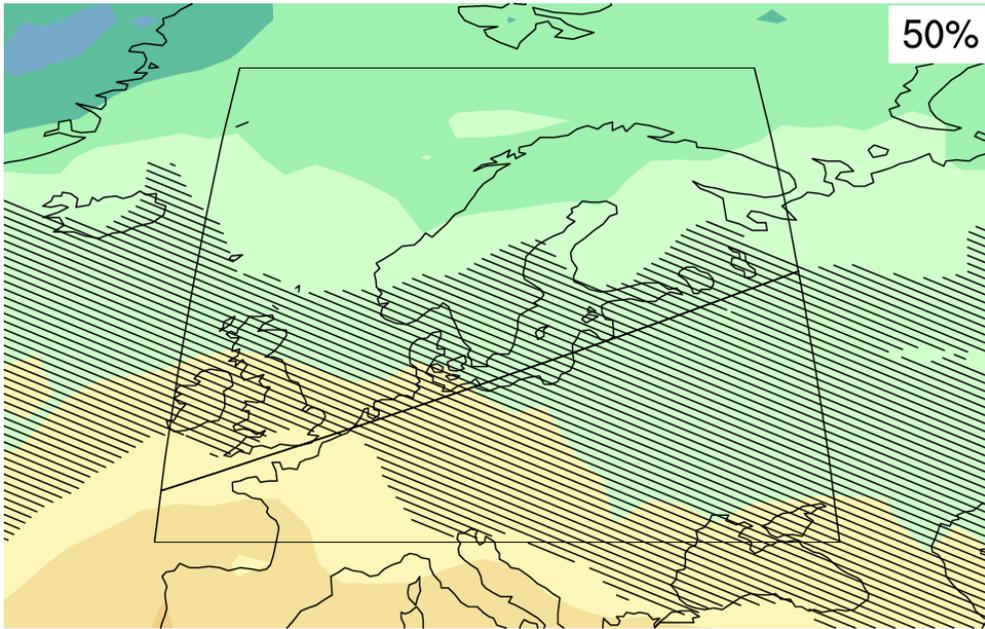


-50 -40 -30 -20 -10 0 10 20 30 40 50

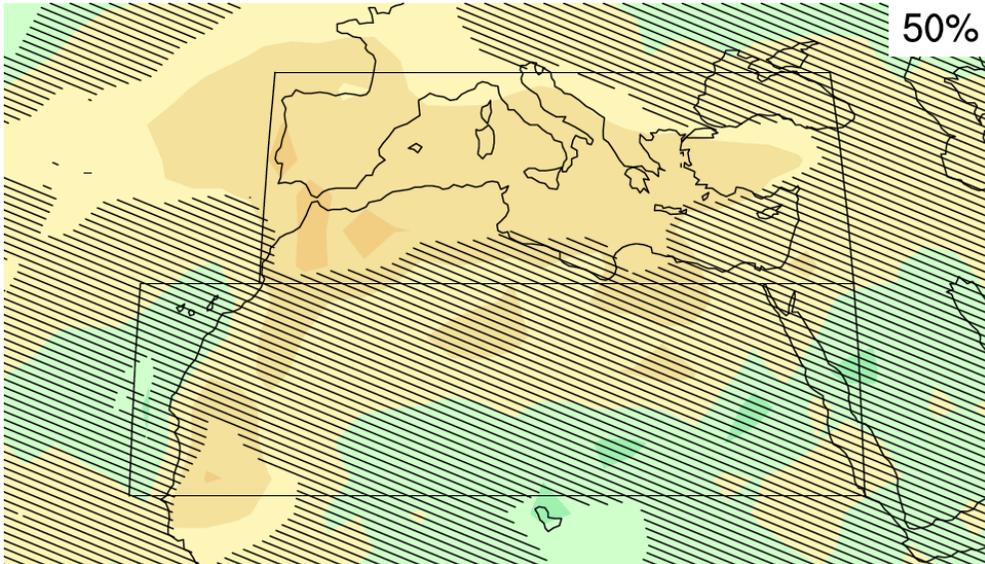
Precipitation Change [%]

Precipitation April-September

Precipitation change RCP4.5 in 2081-2100: April-September



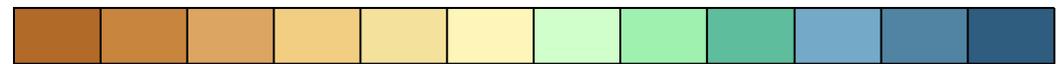
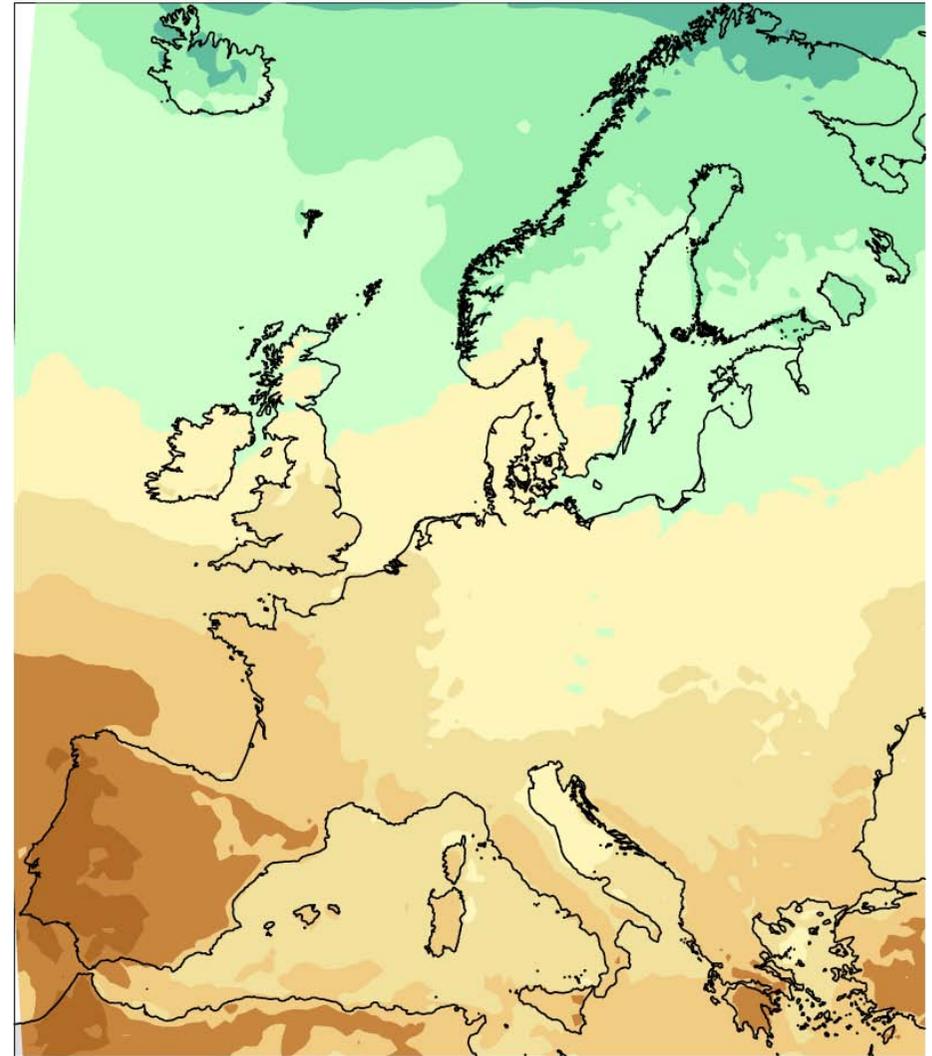
Precipitation change RCP4.5 in 2081-2100: April-September



Precipitation

ENSEMBLES A1B mean

AMJJAS 2080-2099

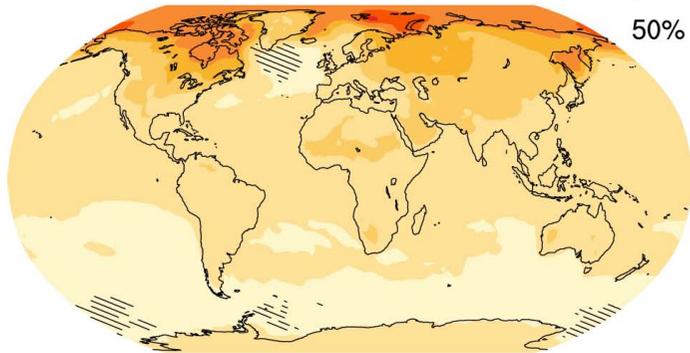


-50 -40 -30 -20 -10 0 10 20 30 40 50

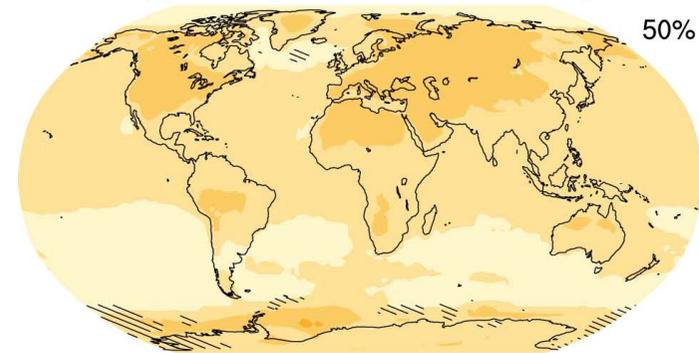
Precipitation Change [%]

Temperatur-Änderung

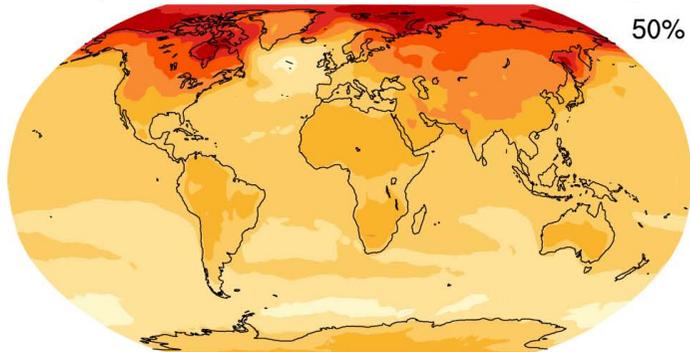
Temperature change RCP4.5 in 2016-2035: December-February



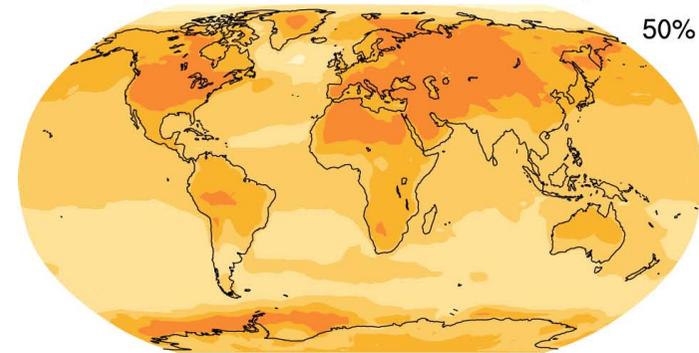
Temperature change RCP4.5 in 2016-2035: June-August



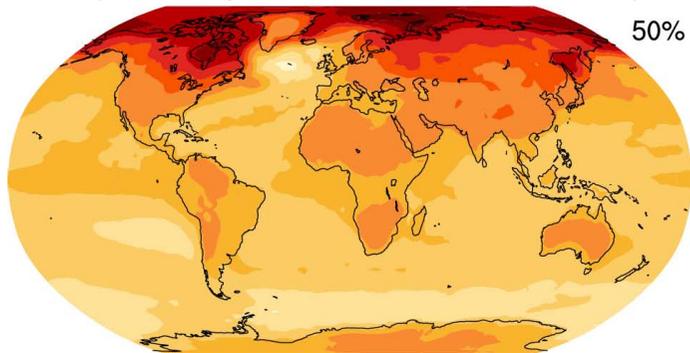
Temperature change RCP4.5 in 2046-2065: December-February



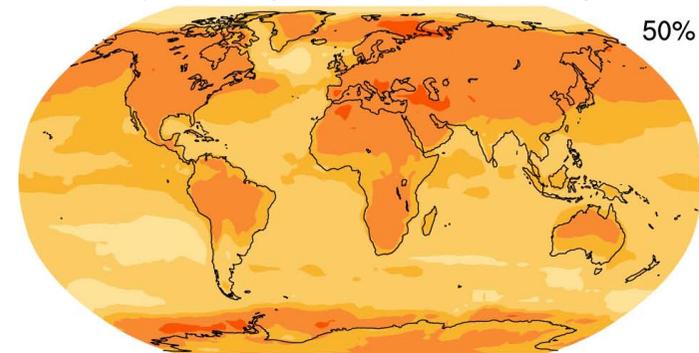
Temperature change RCP4.5 in 2046-2065: June-August



Temperature change RCP4.5 in 2081-2100: December-February



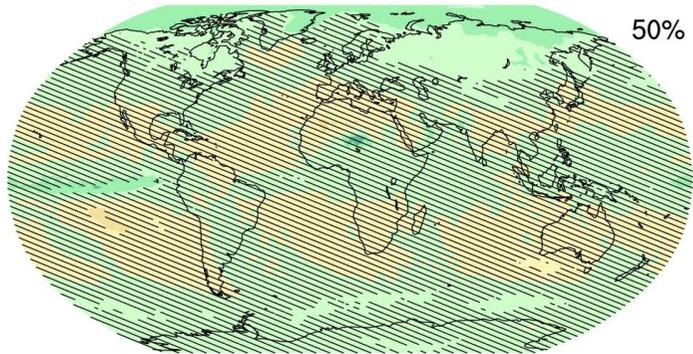
Temperature change RCP4.5 in 2081-2100: June-August



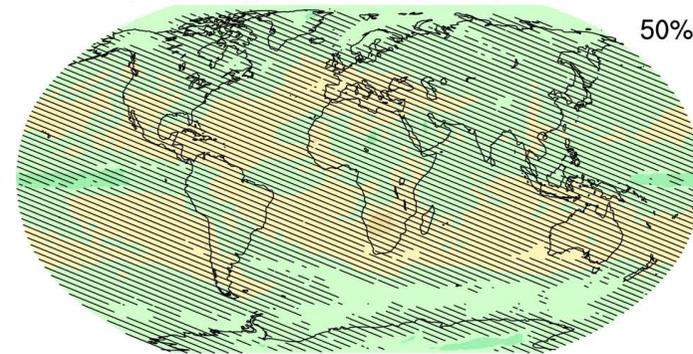
[°C]

Niederschlags-Änderung

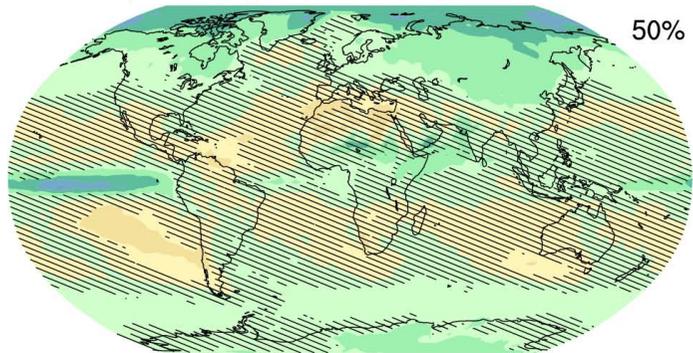
Precipitation change RCP4.5 in 2016-2035: October-March



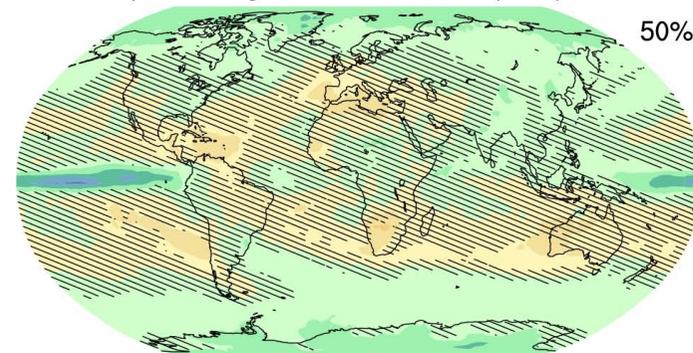
Precipitation change RCP4.5 in 2016-2035: April-September



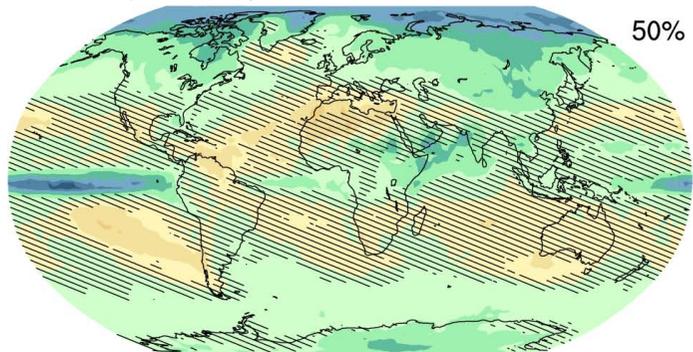
Precipitation change RCP4.5 in 2046-2065: October-March



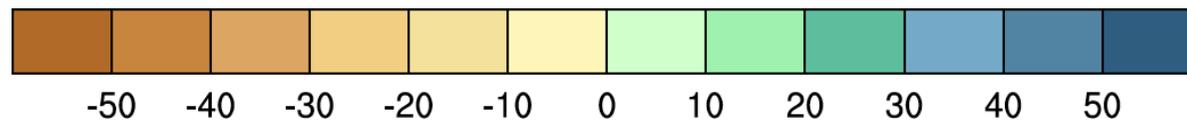
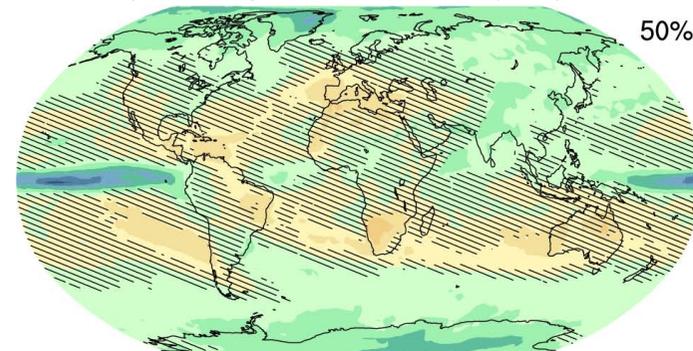
Precipitation change RCP4.5 in 2046-2065: April-September



Precipitation change RCP4.5 in 2081-2100: October-March



Precipitation change RCP4.5 in 2081-2100: April-September

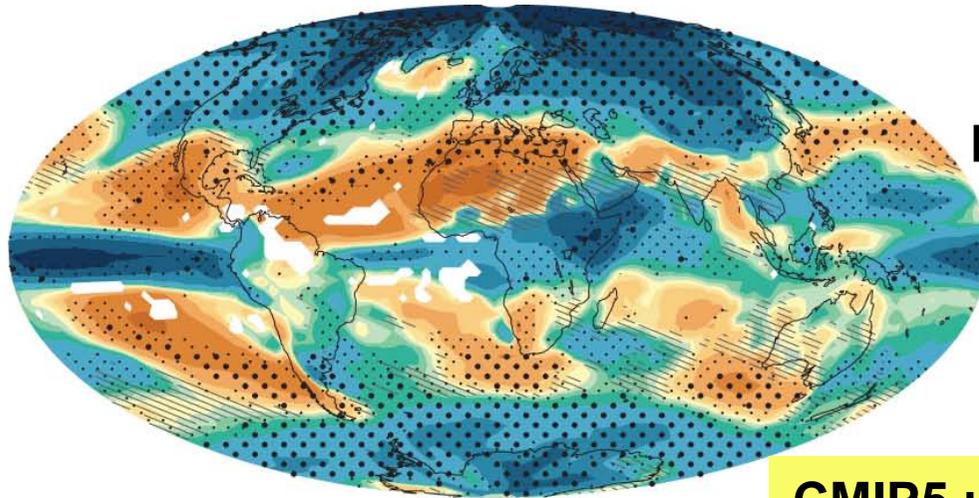


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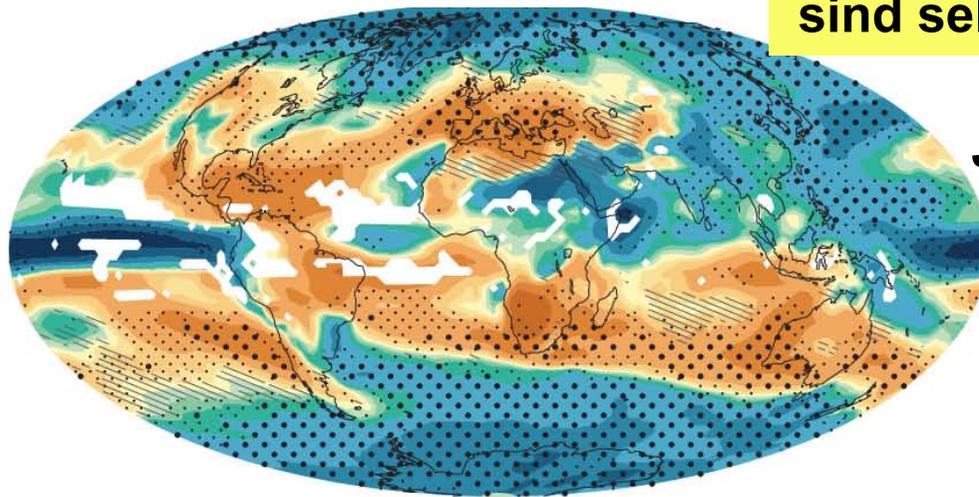
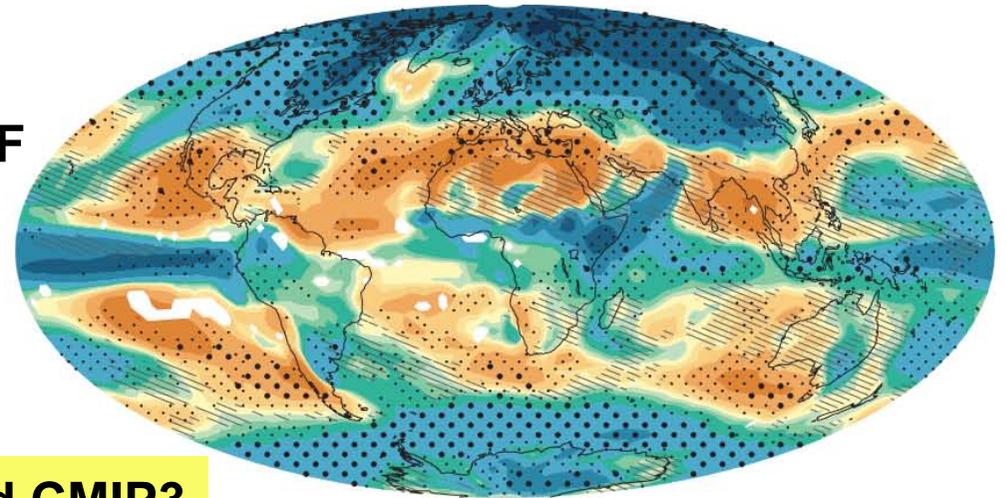
Vergleich CMIP5 versus CMIP3

CMIP5 (AR5), Szenario RCP8.5

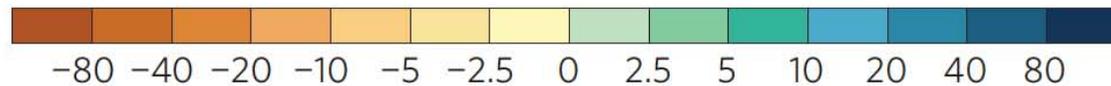
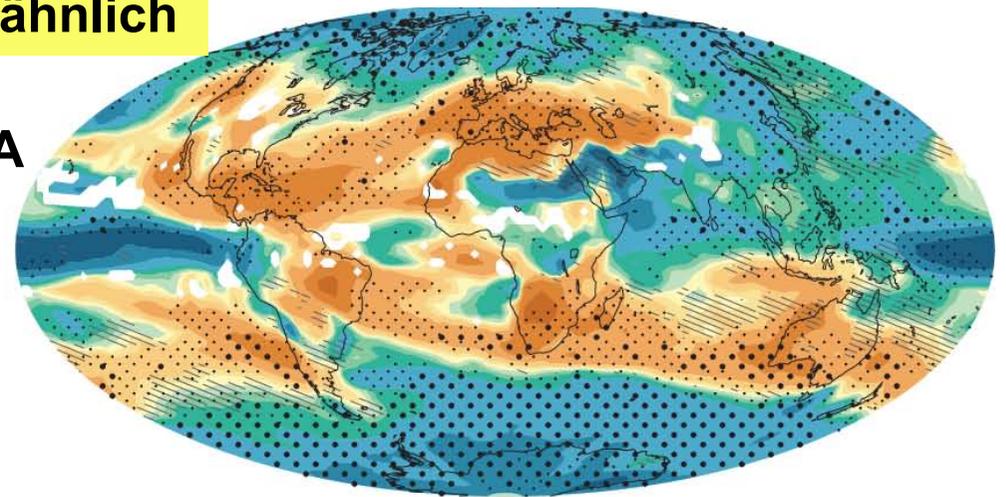
CMIP3 (AR4), Szenario SRES A2



DJF



JJA



Δ Niederschlag [%]