CONFÉRENCE INTERNATIONALE

LES EAUX SOUTERRAINES, CLÉ DES OBJECTIFS DE DÉVELOPPEMENT DURABLE

PARIS – 18-20 MAI 2022

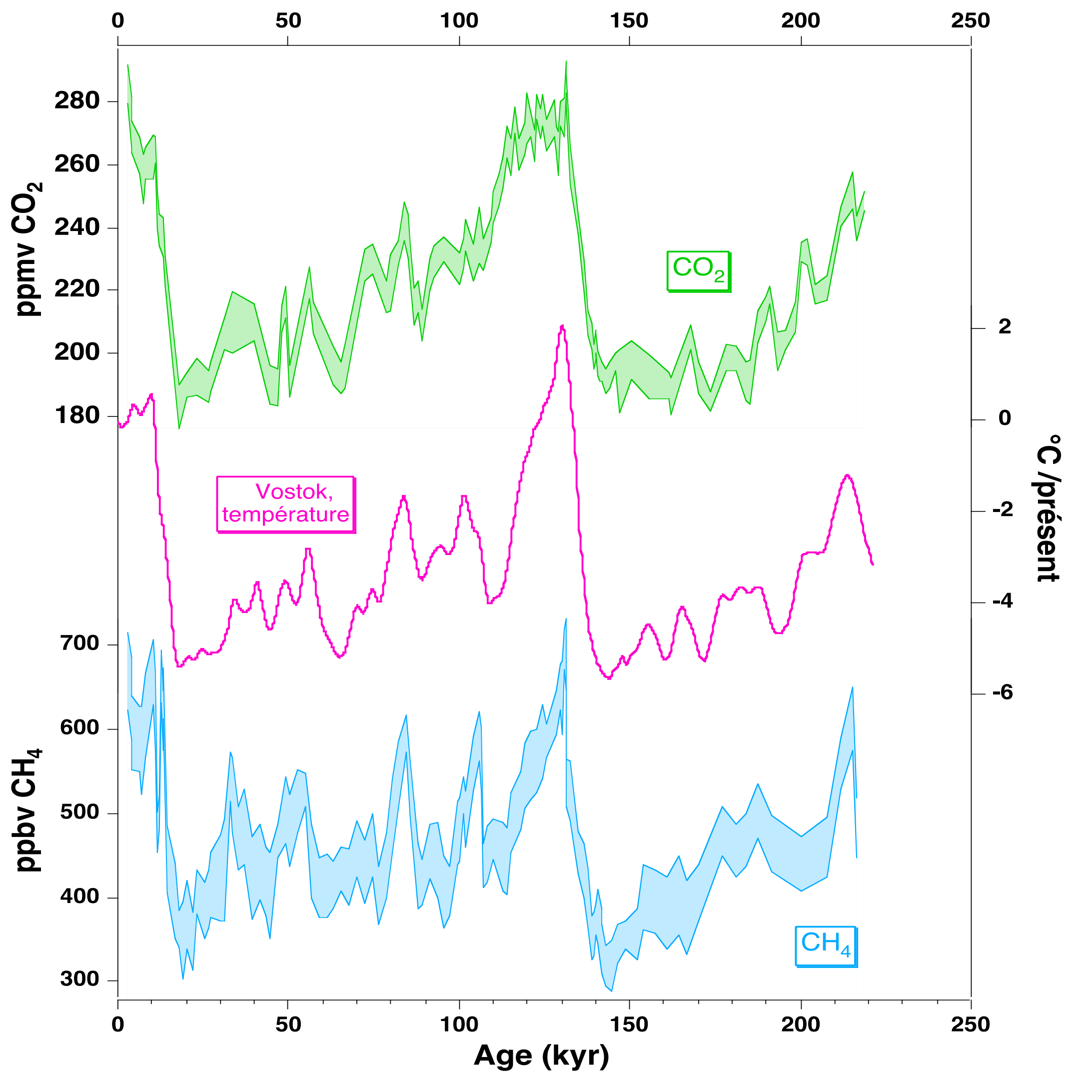
Jean Jouzel

Emeritus Director of Research at CEA LSCE/IPSL

Worldwide rainfall distribution

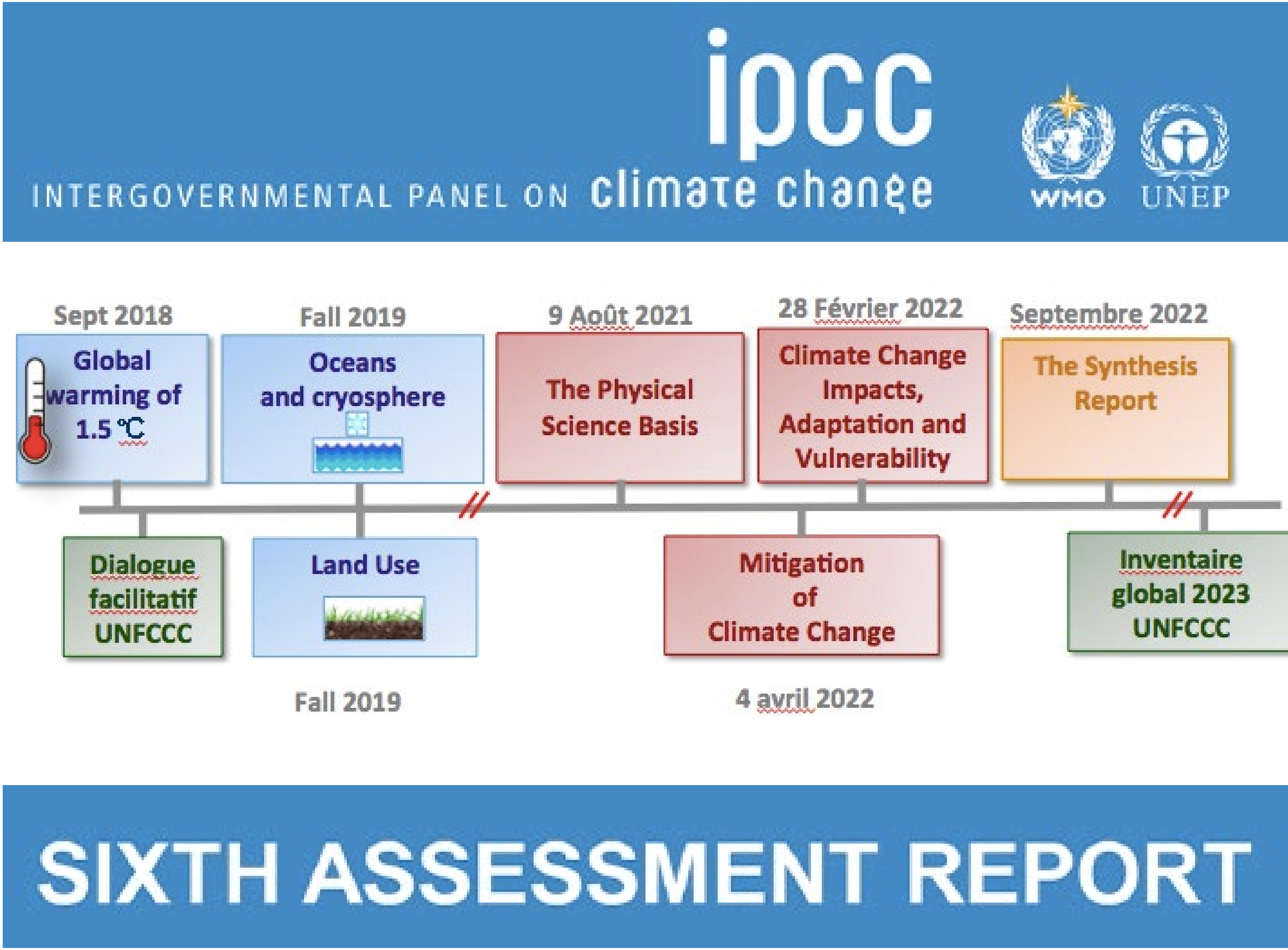
and its evolution in the warming climate context

La prise de conscience date des années 70 et 80 grâce aux modélisateurs du climat : rapport Charney en 1979 : Sensibilité du climat entre 1,5 et 4,5°C (2 fois plus de CO_2)



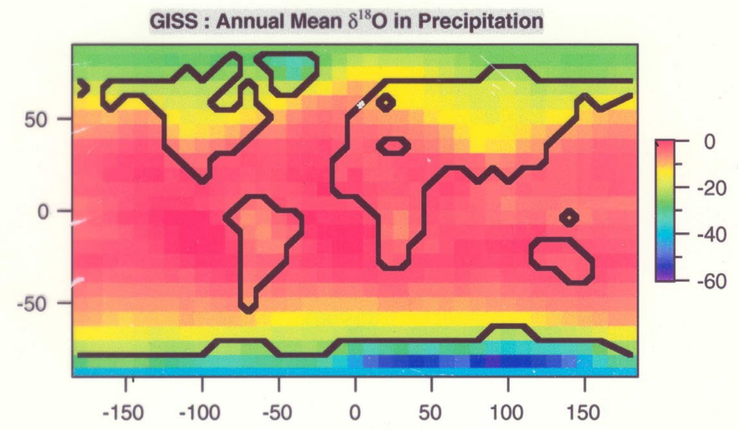
Forage Antarctique de Vostok (1987)

- Confirmation du rôle des changements d'insolation
- Lien entre effet de serre et climat (amplificateur)


ipcc
INTERGOVERNMENTAL PANEL ON climate change
WMO
UNEP
Sept 2018
Global warming of 1.5 ℃
Fall 2019
Oceans and cryosphere
9 Août 2021
The Physical Science Basis
28 Février 2022
Climate Change Impacts, Adaptation and Vulnerability
Septembre 2022
The Synthesis Report
Dialogue facilitatif UNFCCC
Land Use
Fall 2019
Mitigation of Climate Change
4 avril 2022
Inventaire global 2023 UNFCCC
SIXTH ASSESSMENT REPORT

IGCMs provide a potential way to improve the δ interpratation

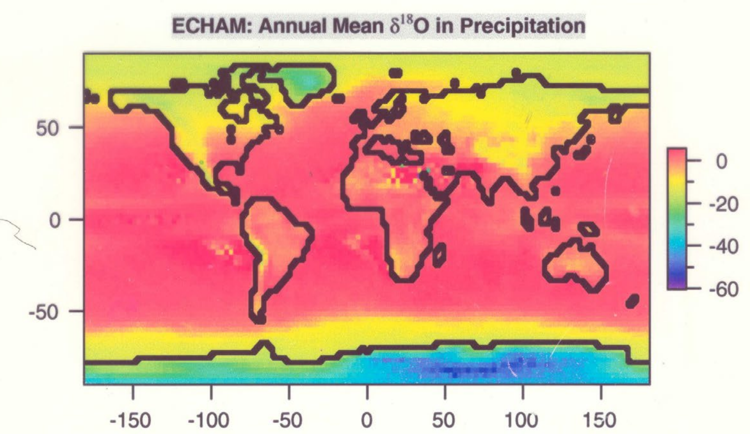
- Isotopic GCM' s (General Circulation Models)
  - Pioneering work (LMD model, Joussaume et al., 1984)
  - NASA GISS isotopic GCM (Jouzel et al. (1987) full seasonal cycle
  - ECHAM Hoffmann et al. (1998)

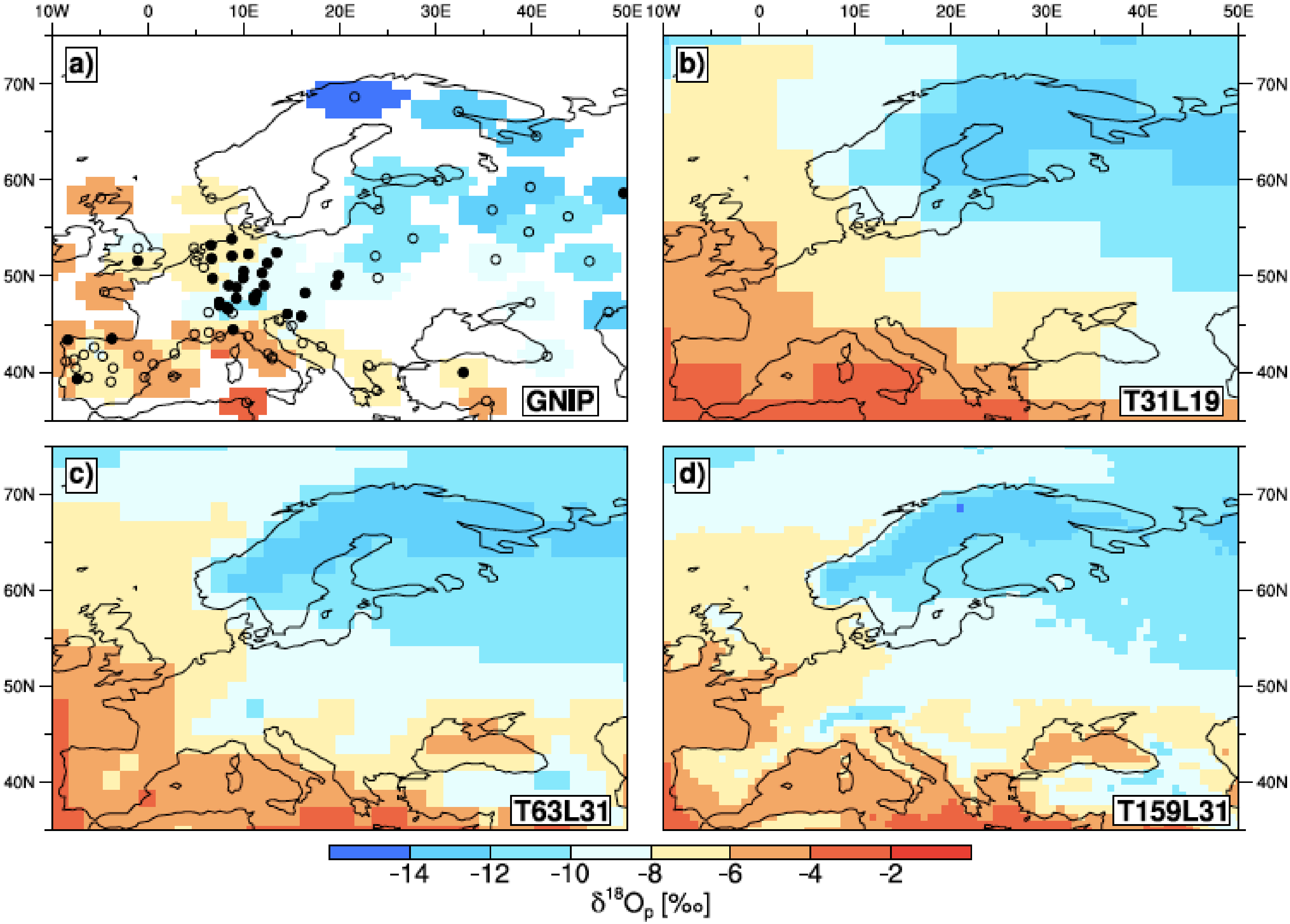


GISS (8*10)

2b

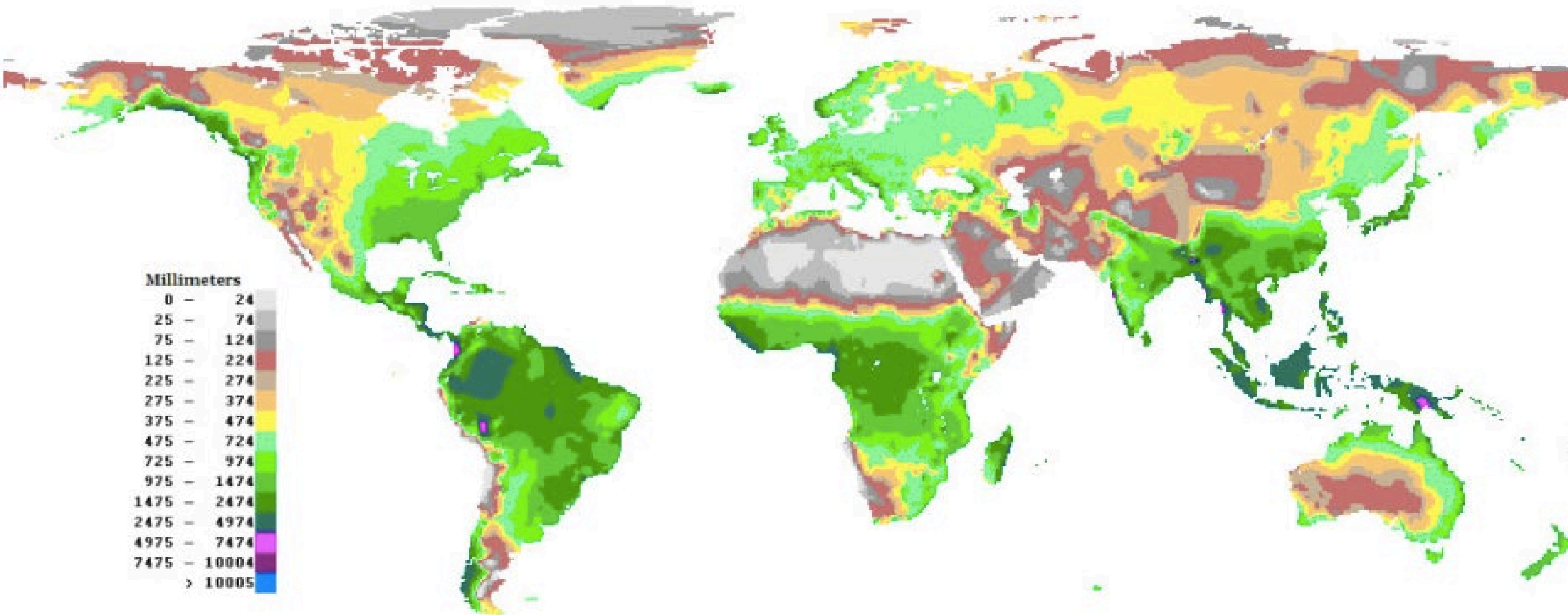
ECHAM (T42)





Recent simulations (higher resolution) : ECHAM 5 (Werner et al., 2011)

Cartes des pluies dans le monde, carte du monde



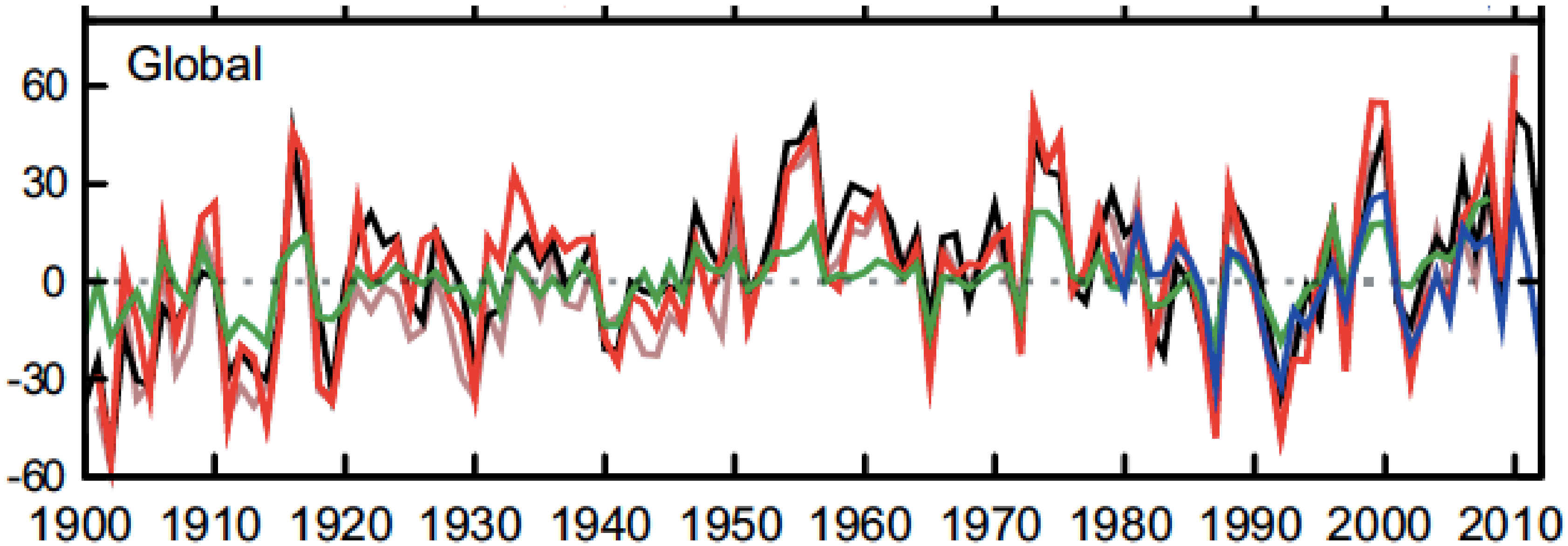
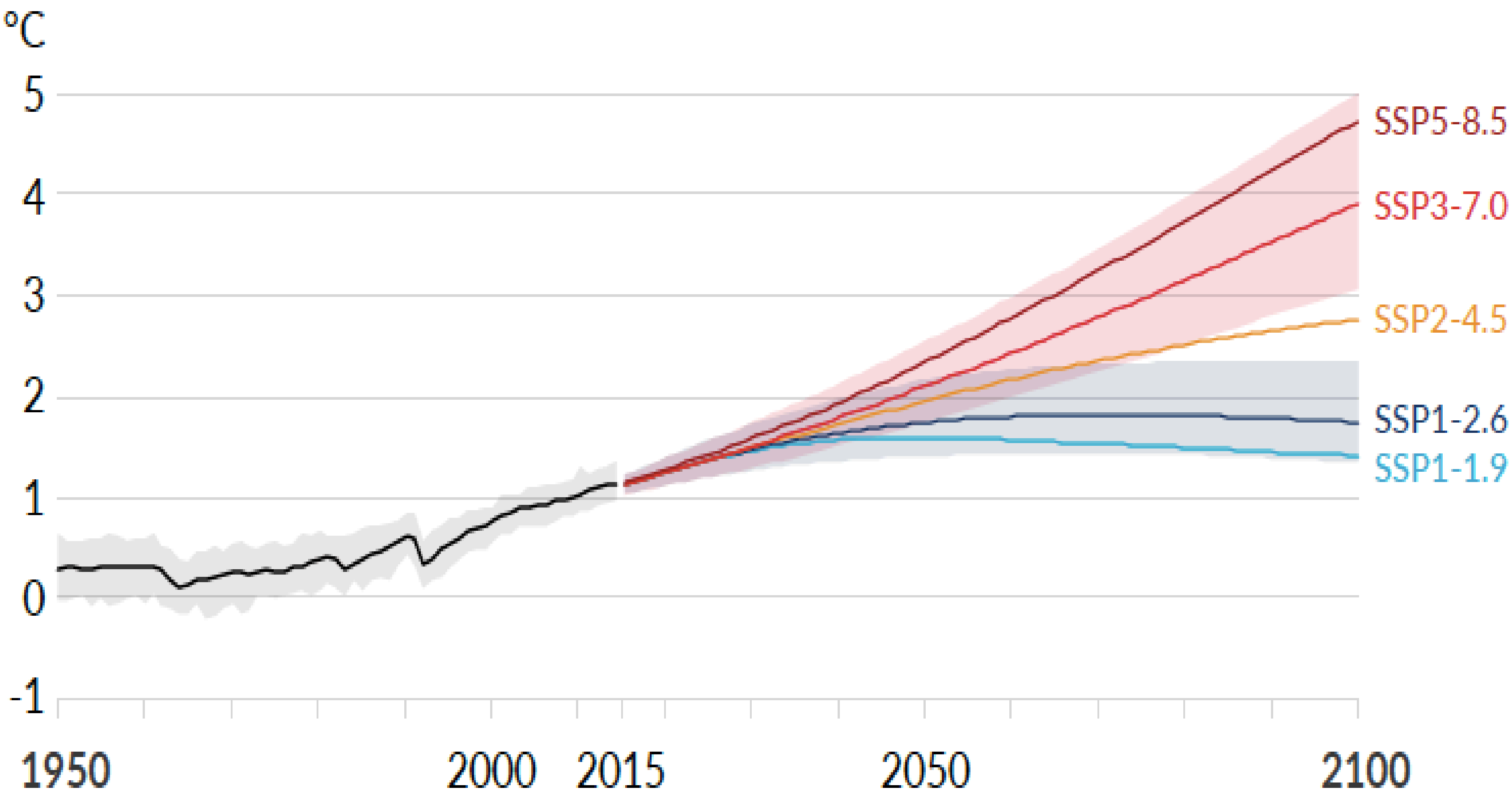


Figure 2.28 | Annual precipitation anomalies averaged over land areas for four

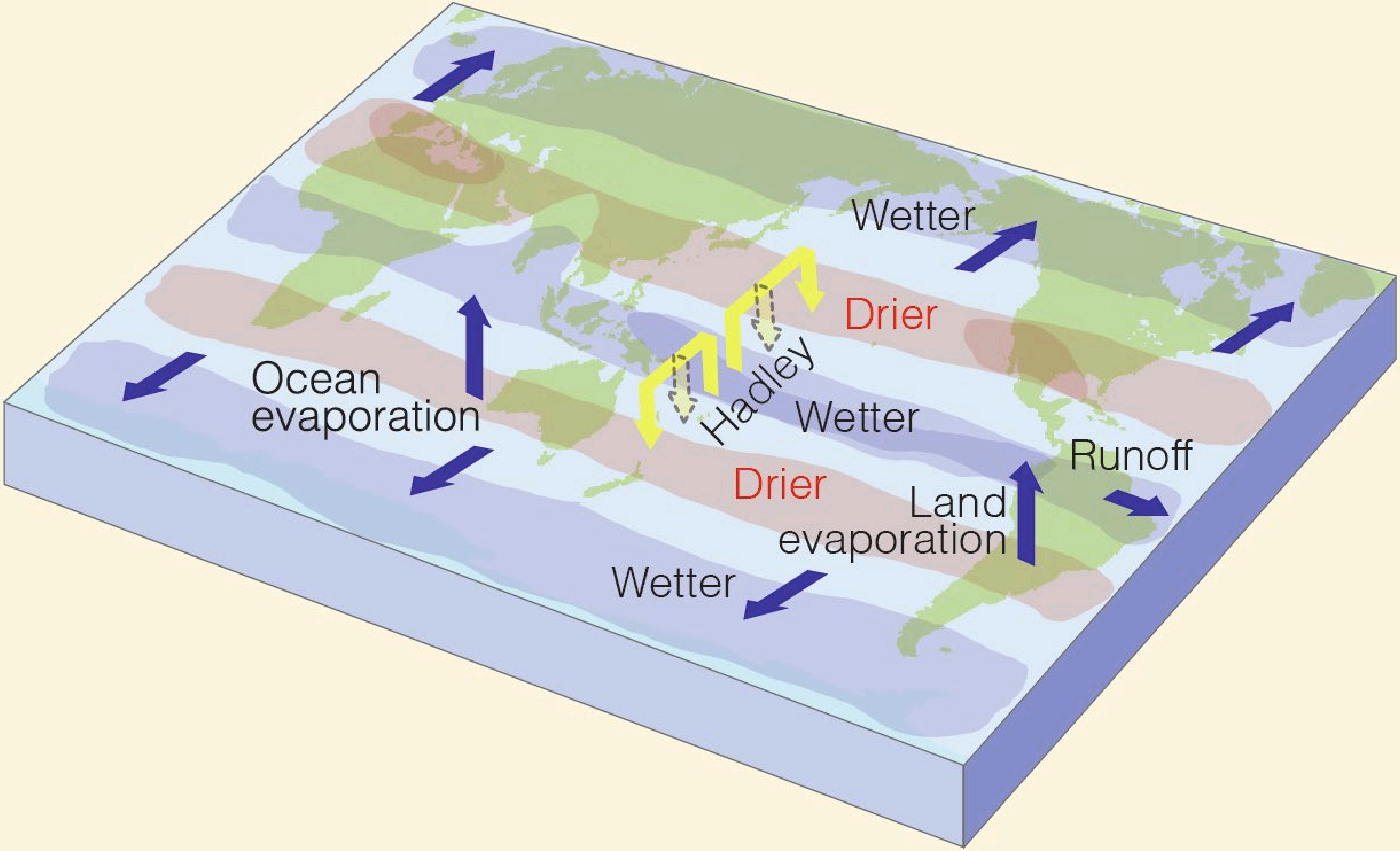
Table 2.9 | Trend estimates and 90% confidence intervals (Box 2.2) for annual precipitation for each time series in Figure 2.28 over two common periods of record.

Data Set	Area	Trends in mm yr^{-1} per decade	
		1901–2008	1951–2008
CRU TS 3.10.01 (updated from Mitchell and Jones, 2005)	Global	2.77 ± 1.46	–2.12 ± 3.52
GHCN V2 (updated through 2011; Vose et al., 1992)	Global	2.08 ± 1.66	–2.77 ± 3.92
GPCC V6 (Becker et al., 2013)	Global	1.48 ± 1.65	–1.54 ± 4.50
Smith et al. (2012)	Global	1.01 ± 0.64	0.68 ± 2.07

a) Global surface temperature change relative to 1850-1900

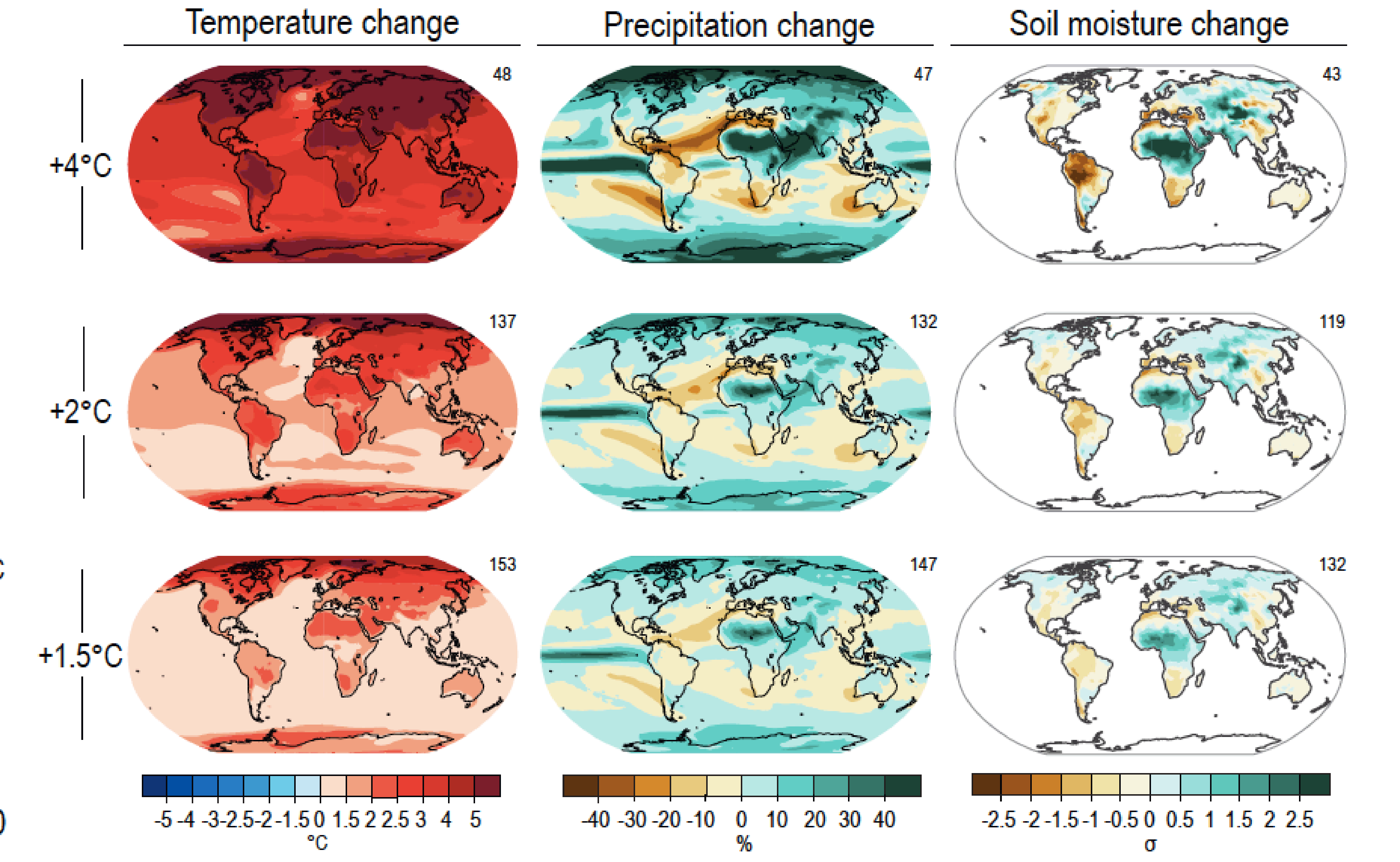


SSP	2.6	4.5	8.5
AR5	1.6	2.4	4.3
AR6	1.8	2.7	4.4

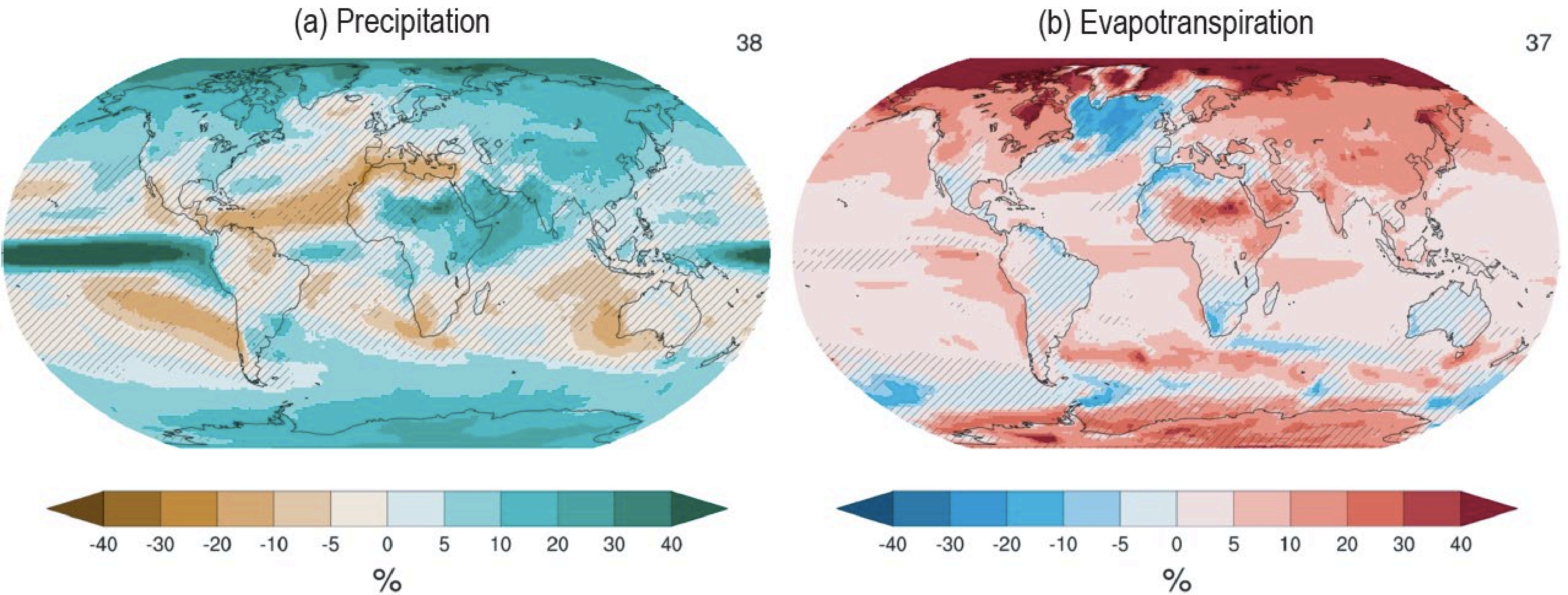


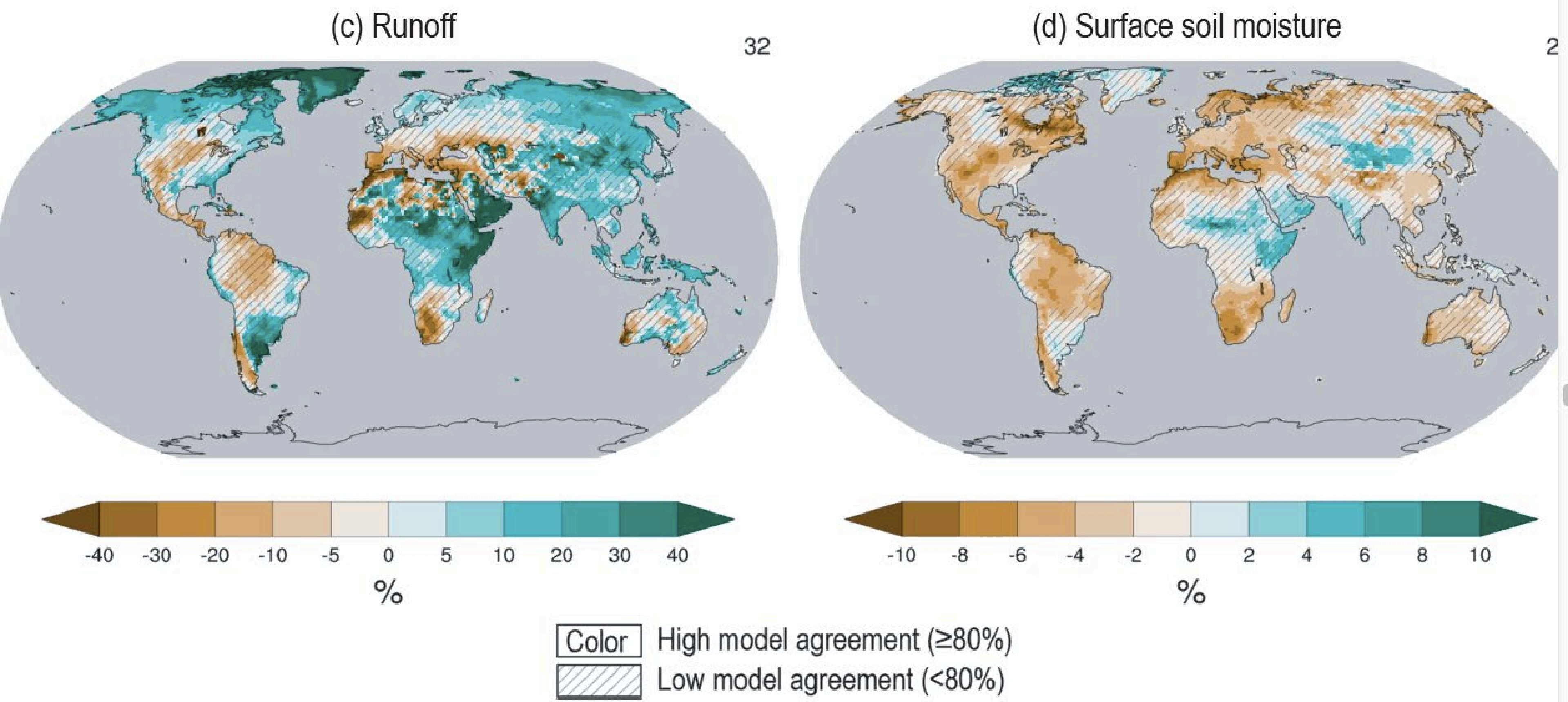
- **Model projections indicate that the Hadley Circulation will shift its downward branch poleward in both the Hemispheres, with associated drying.**
- **Wetter conditions are projected at high latitudes.**

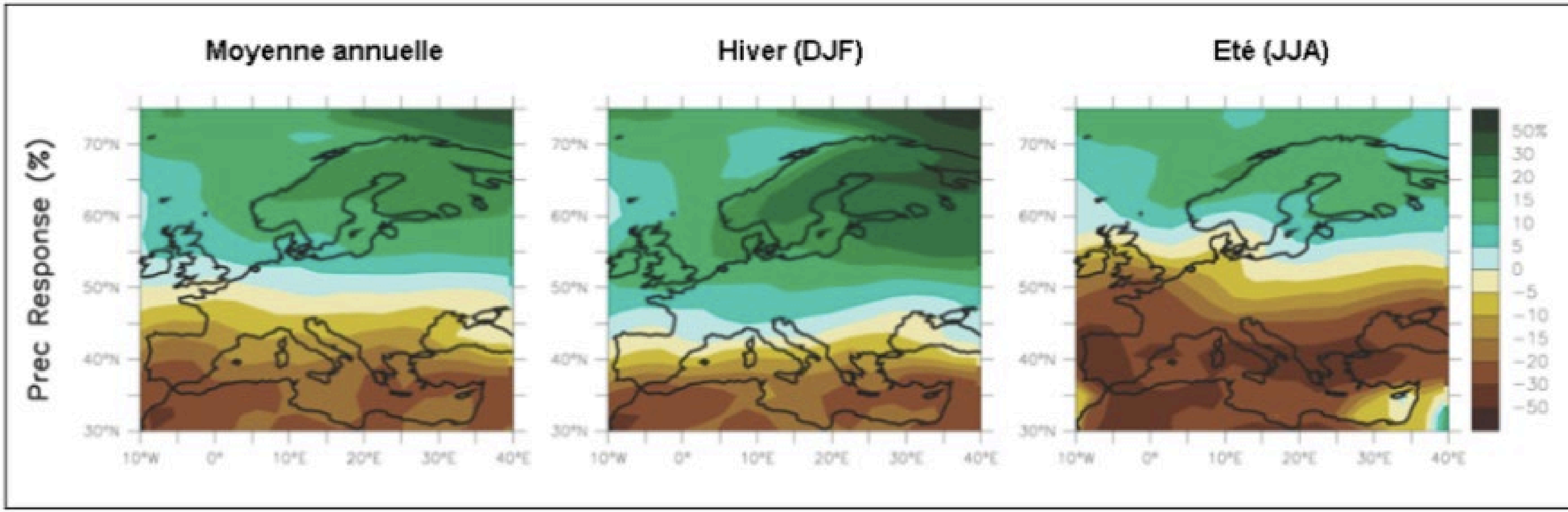
(b) Patterns of change in near-surface air temperature, precipitation and soil moisture

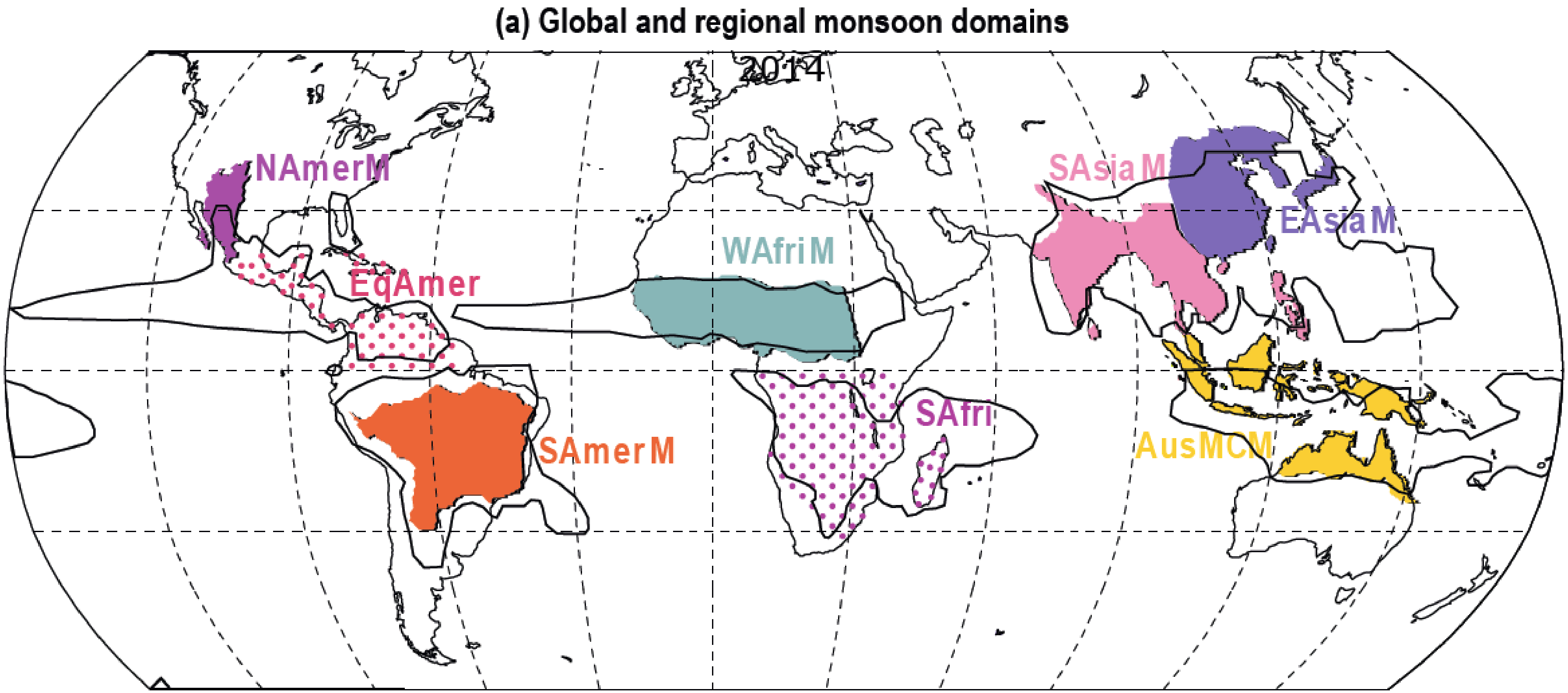


Long-term water cycle variables changes for SSP2-4.5 (2081–2100 vs 1995–2014)

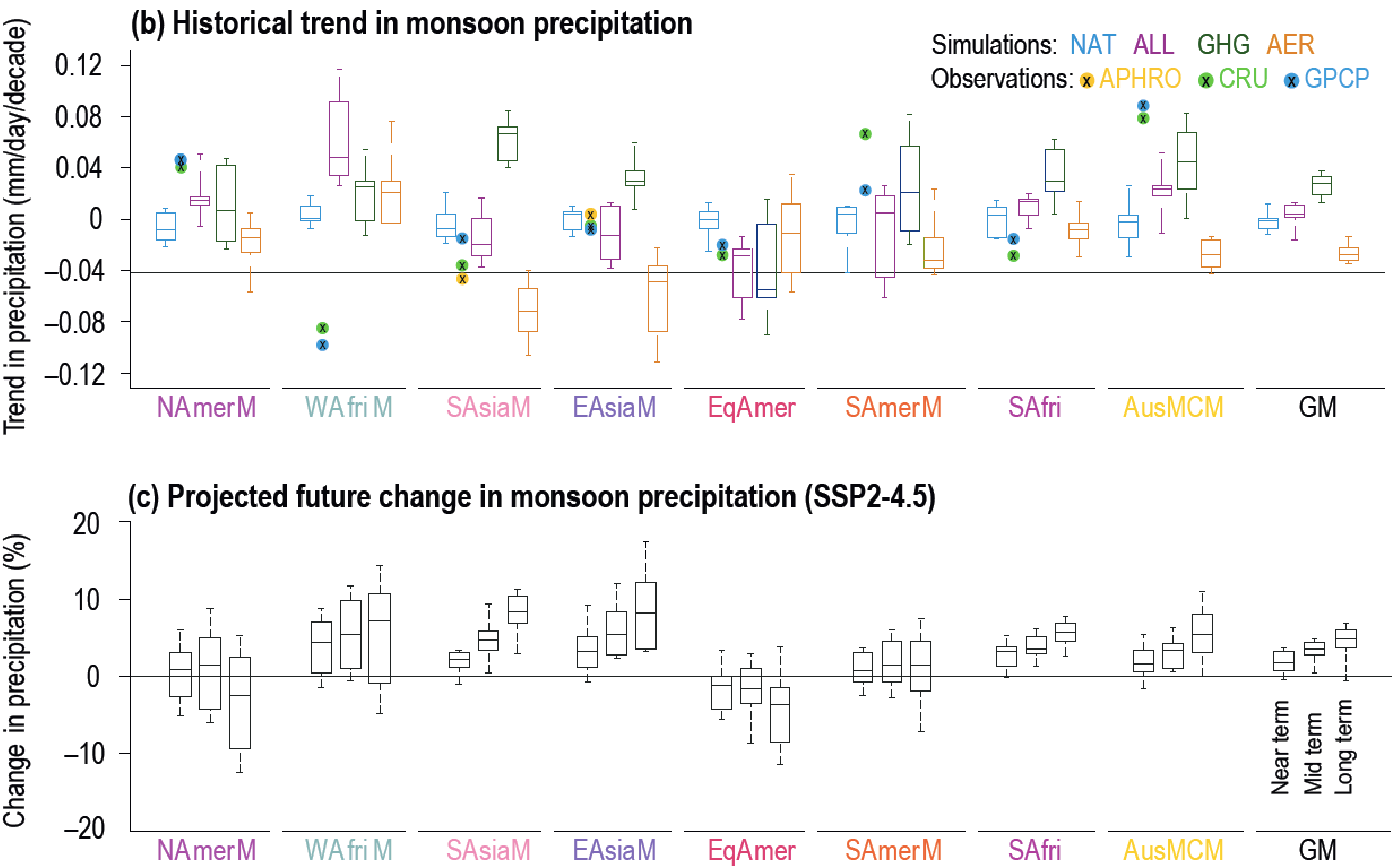



(c) Runoff
32
-40 -30 -20 -10 -5 0 5 10 20 30 40
%
(d) Surface soil moisture
-10 -8 -6 -4 -2 0 2 4 6 8 10
%
Color High model agreement (≥80%)
Low model agreement (<80%)


Moyenne annuelle
Hiver (DJF)
Eté (JJA)
Prec Response (%)
70°N
60°N
50°N
40°N
30°N
10°W
0°
10°E
20°E
30°E
40°E
50%
30
20
15
10
5
0
−5
−10
−15
−20
−30
−50



(a) Global and regional monsoon domains
2014
NAmerM
EqAmer
SAmerM
WAfriM
SAfri
SAsiaM
EAsiaM
AusMCM

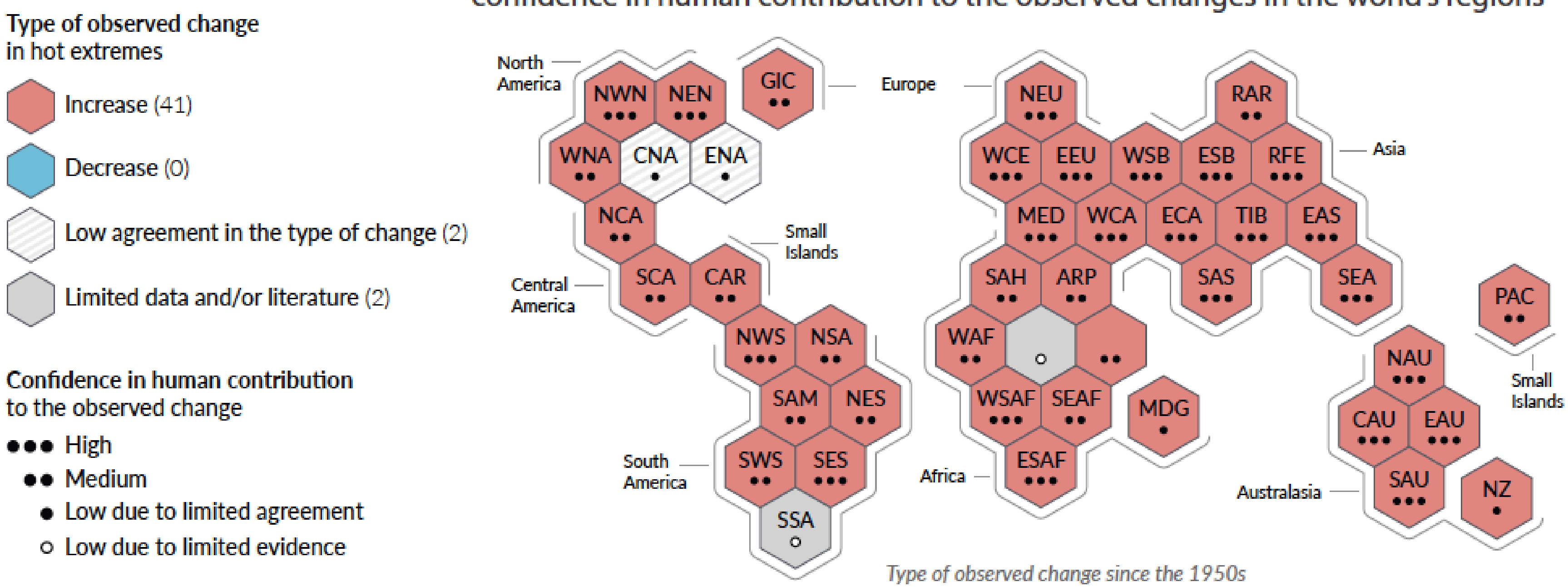


(b) Historical trend in monsoon precipitation
Simulations: NAT ALL GHG AER
Observations: APHRO CRU GPCP
Trend in precipitation (mm/day/decade)
0.12
0.08
0.04
0
−0.04
−0.08
−0.12
NAmerM
WAfriM
SAsiaM
EAsiaM
EqAmer
SAmerM
SAfri
AusMCM
GM
(c) Projected future change in monsoon precipitation (SSP2-4.5)
Change in precipitation (%)
20
10
0
−10
−20
Near term
Mid term
Long term
NAmerM
WAfriM
SAsiaM
EAsiaM
EqAmer
SAmerM
SAfri
AusMCM
GM

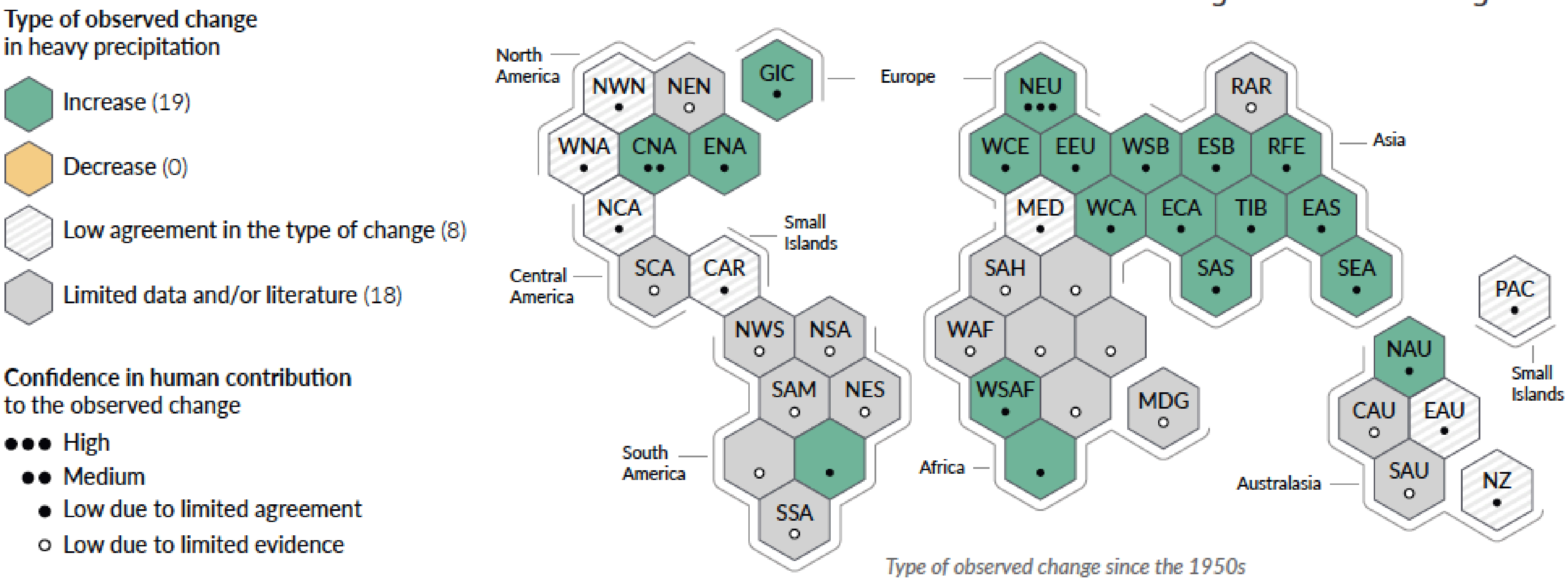
Phenomenon and direction of trend	Likelihood of further changes	
	Early 21st century	Late 21st century
Warmer and/or fewer cold days and nights over most land areas	Likely	Virtually certain
Warmer and/or more frequent hot days and nights over most land areas	Likely	Virtually certain
Warm spells/heat waves. Frequency and/or duration increases over most land areas	Not formally assessed[b] {11.3}	Very likely
Heavy precipitation events. Increase in the frequency, intensity, and/or amount of heavy precipitation	Likely	Very likely
Increases in intensity and/or duration of drought	*Low confidence*[g] {11.3}	Likely
Increases in intense tropical cyclone activity	*Low confidence* {11.3}	*More likely than not* in the Western North Pacific and North Atlantic[j] {14.6} *More likely than not* in some basins *Likely*
Increased incidence and/or magnitude of extreme high sea level	Likely	Very likely

Climate change is already affecting every inhabited region across the globe, with human influence contributing to many observed changes in weather and climate extremes

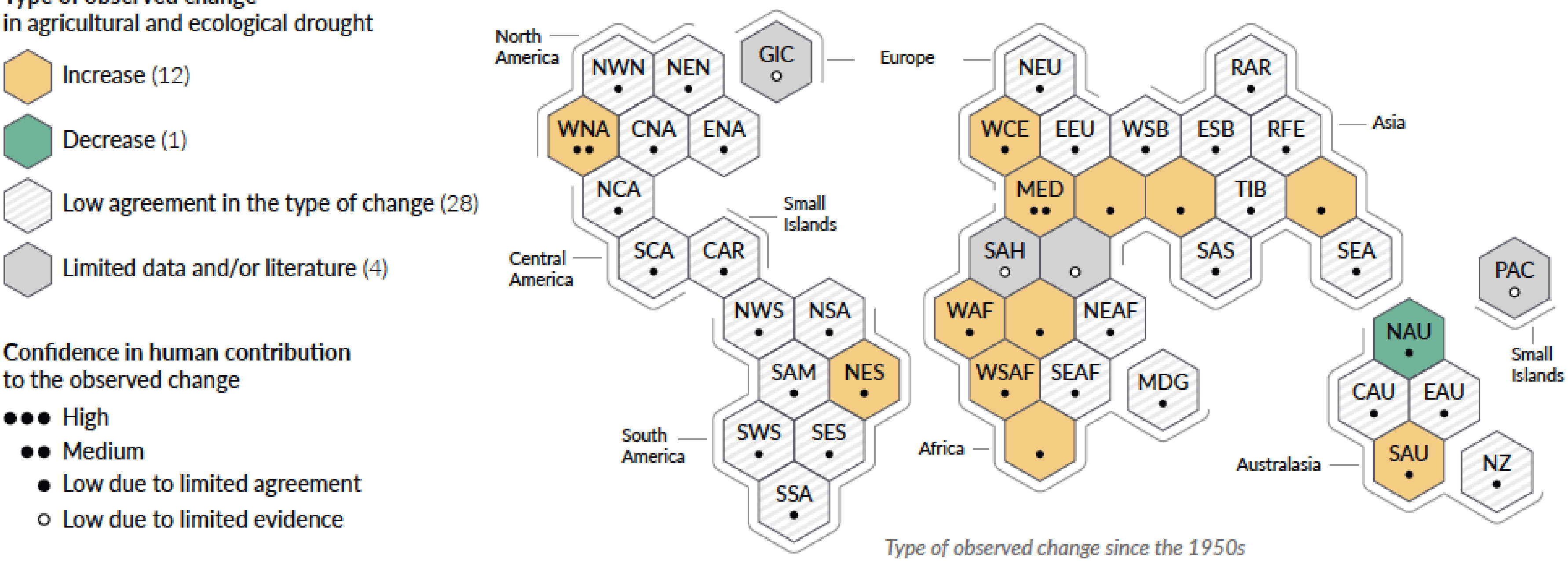
(a) Synthesis of assessment of observed change in **hot extremes** and confidence in human contribution to the observed changes in the world's regions

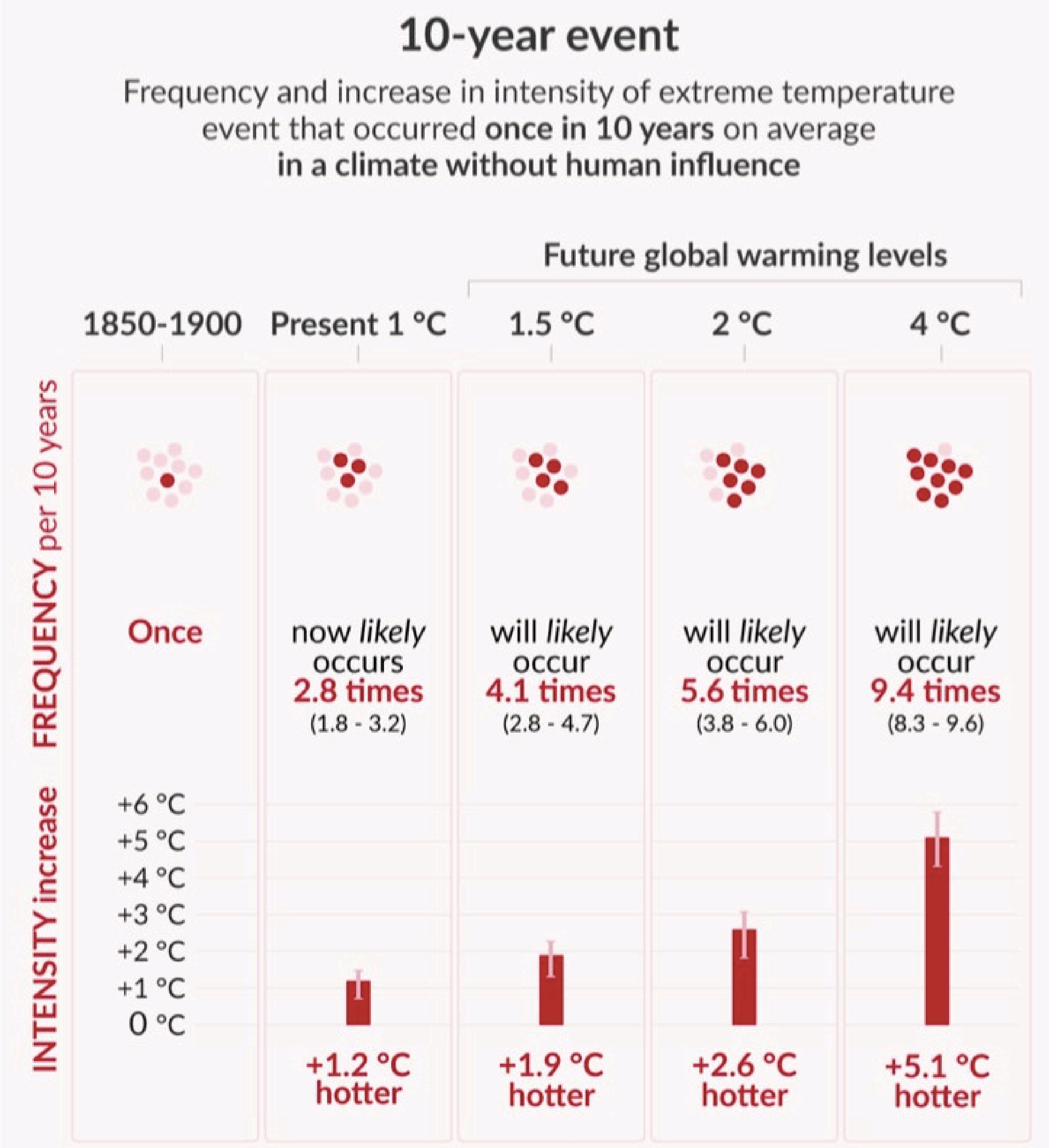


(b) Synthesis of assessment of observed change in **heavy precipitation** and confidence in human contribution to the observed changes in the world's regions

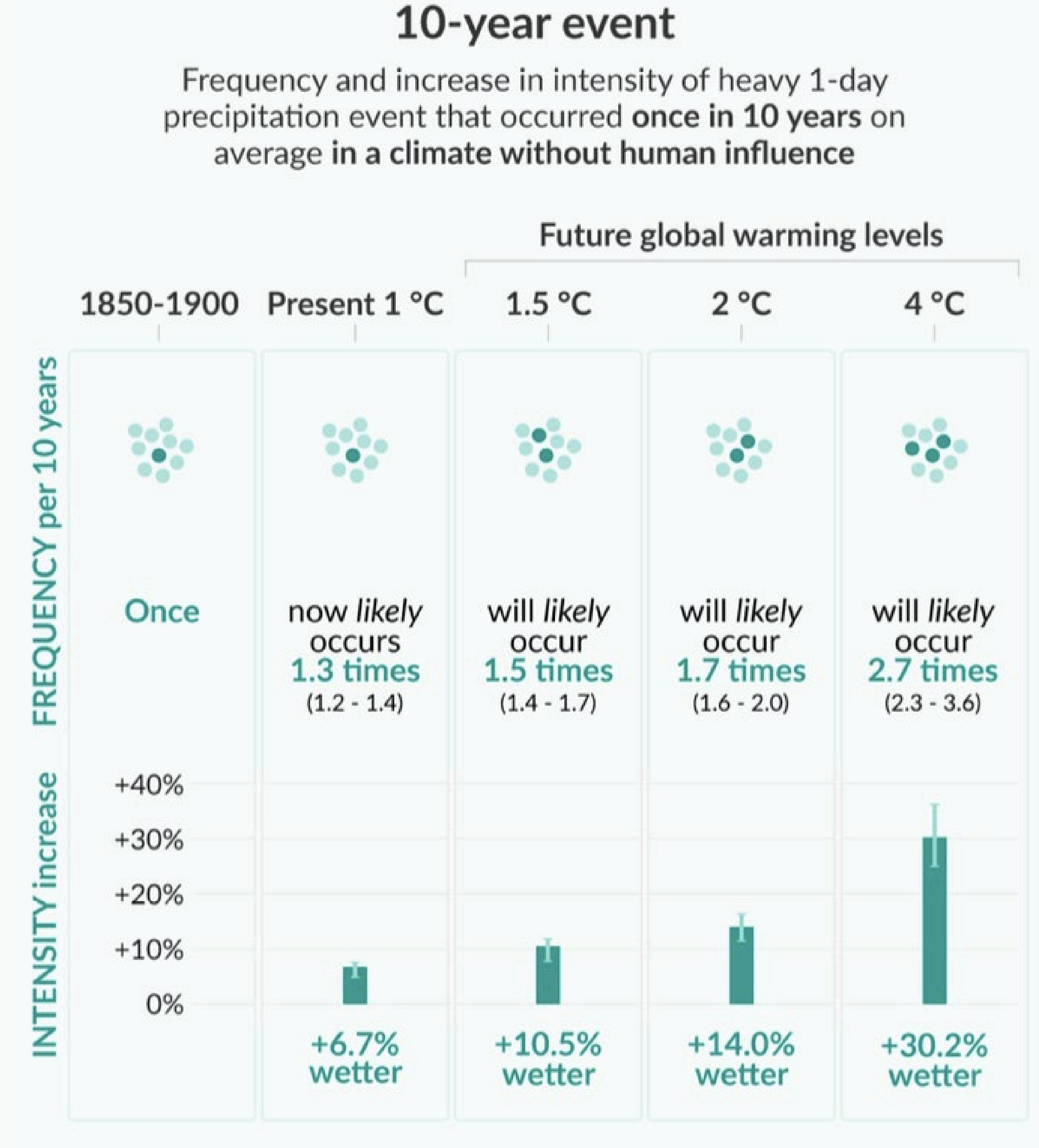


(c) Synthesis of assessment of observed change in **agricultural and ecological drought** and confidence in human contribution to the observed changes in the world's regions




10-year event
Frequency and increase in intensity of extreme temperature event that occurred once in 10 years on average in a climate without human influence
Future global warming levels
1850-1900
Present 1 °C
1.5 °C
2 °C
4 °C
FREQUENCY per 10 years
Once
now likely occurs 2.8 times (1.8 - 3.2)
will likely occur 4.1 times (2.8 - 4.7)
will likely occur 5.6 times (3.8 - 6.0)
will likely occur 9.4 times (8.3 - 9.6)
INTENSITY increase
+6 °C
+5 °C
+4 °C
+3 °C
+2 °C
+1 °C
0 °C
+1.2 °C hotter
+1.9 °C hotter
+2.6 °C hotter
+5.1 °C hotter

Heatwaves



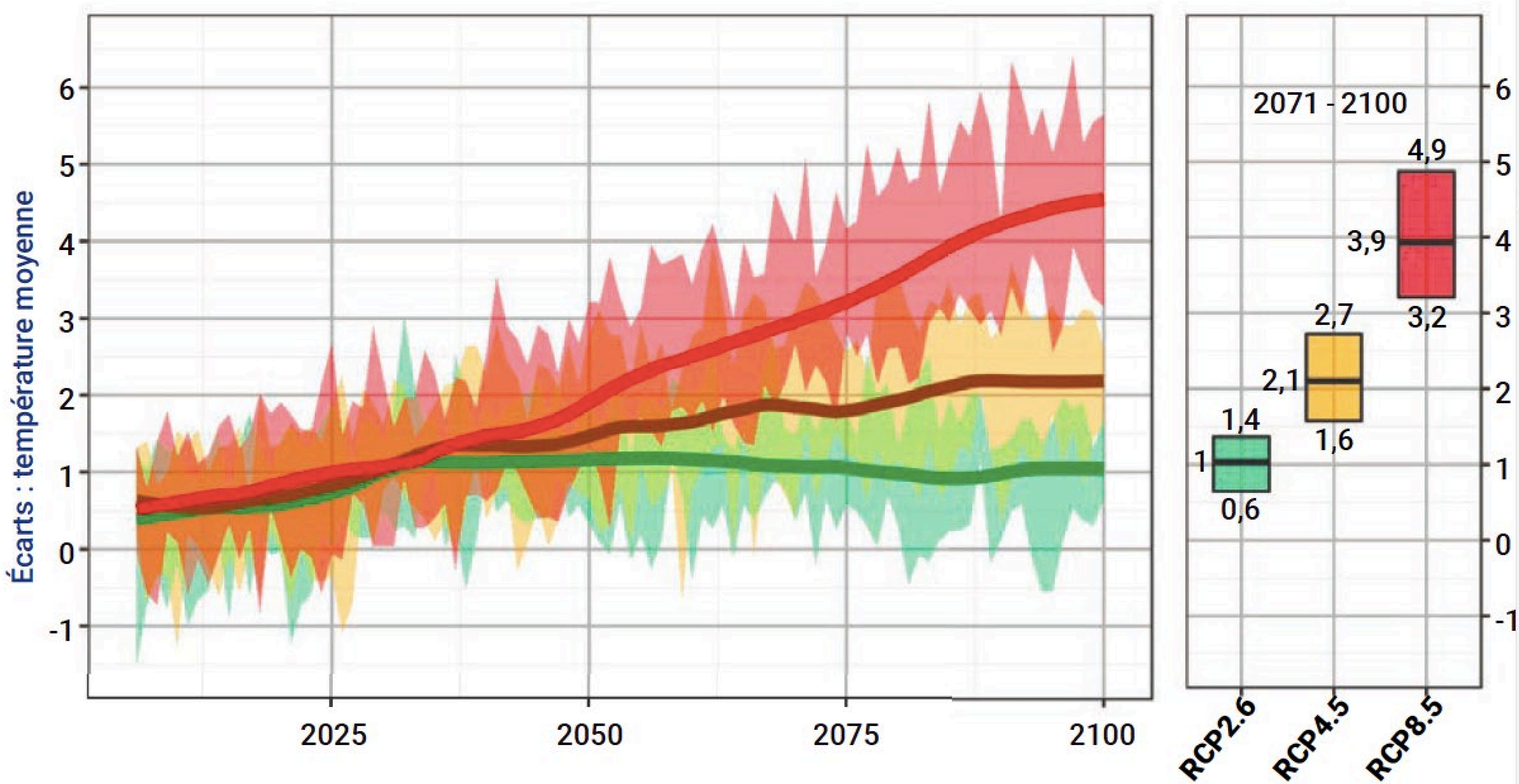
Heavy precipitation

RÉPUBLIQUE FRANÇAISE
Liberté
Égalité
Fraternité

LES NOUVELLES PROJECTIONS CLIMATIQUES DE RÉFÉRENCE **DRIAS 2020** POUR LA MÉTROPOLE

METEO FRANCE

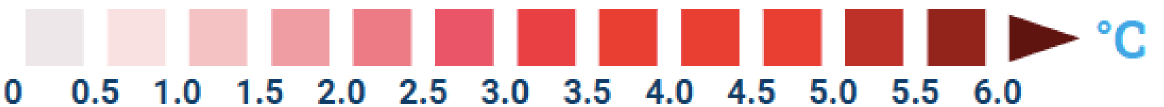
Température moyenne : écarts des moyennes annuelles



Températures

- De 2,1 et 3,9°C (RCP 4,5)
- De 2,7 et 4,9°C (RCP 8,5)
- Plus fort l'été (jusqu'à 6°C)
- Gradient sud-est / nord-ouest (1°C)
- Réchauffement plus marqué en montagne

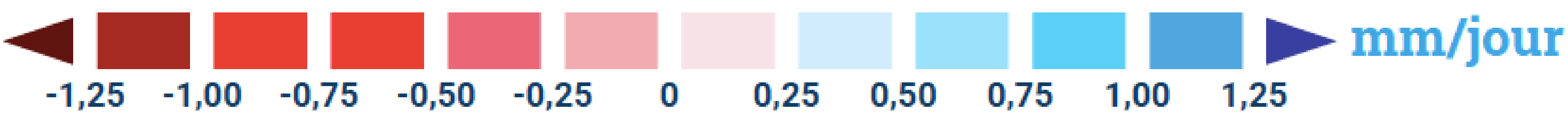
Scénario 8,5 ; 2041 - 2070



Précipitations

- Moyennes annuelles en hausse (2 à 6%)
- Hausse systématique en hiver de 10 jusqu'à 40% (RCP 8,5)
- Baisse en été de 10 à 20% (jusqu'à 50% RCP 8,5)
- Hausse plus marquée dans la moitié nord et baisse sur certaines régions de la moitié sud
- Pluies plus intenses
- Evénements méditérranéens

Scénario 8,5 ; 2041 - 2070

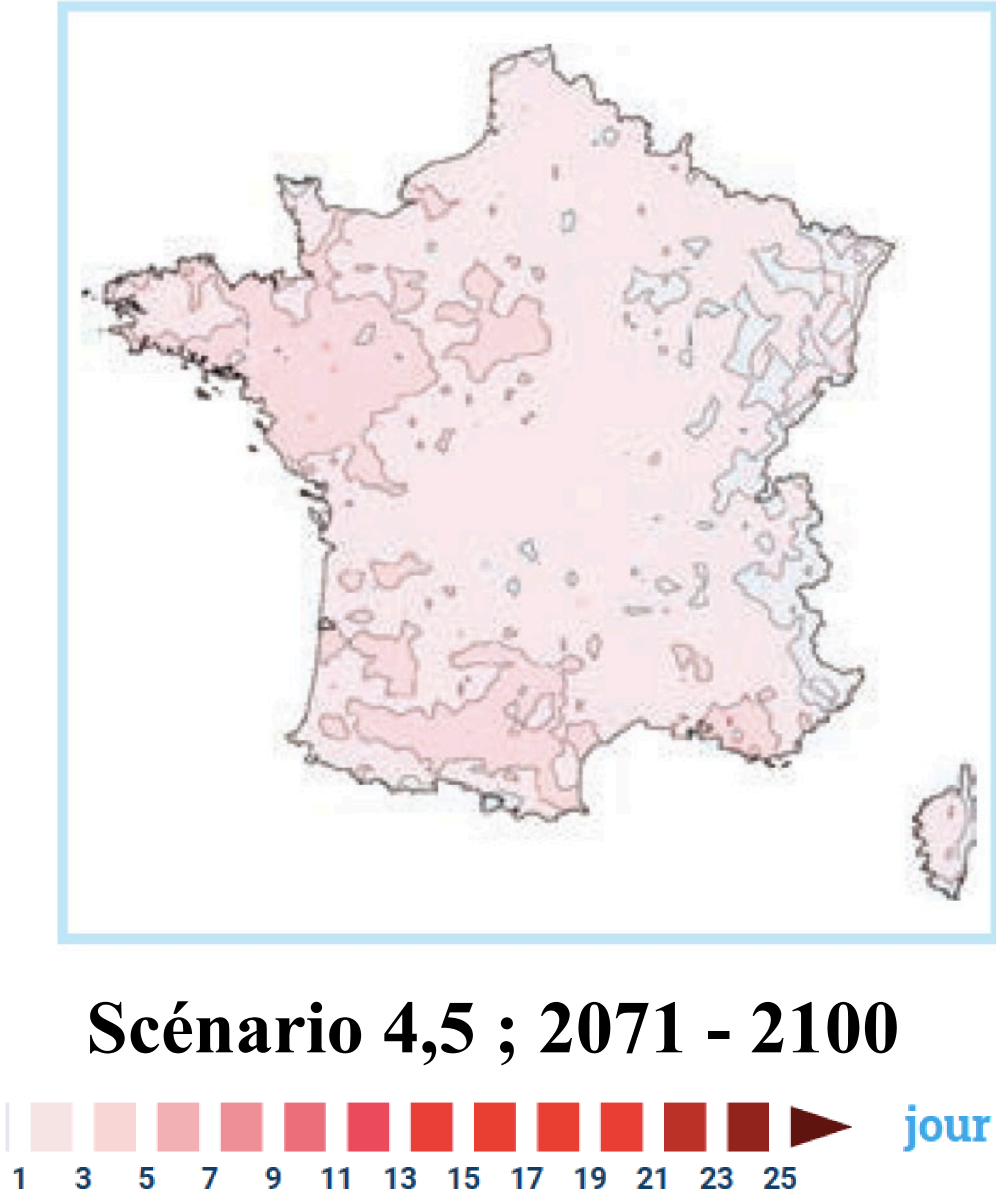


Cartes des écarts de cumul annuel de précipitation pour le RCP8.5

Sécheresses Météorologiques

- Augmentation de 5 à 10 jours soit 30 à 50% (sauf RCP 2.6)

- Sud-ouest du pays notamment sur le pourtour méditerranéen, bassin aquitain et ouest de la France (Bretagne, Pays de Loire)



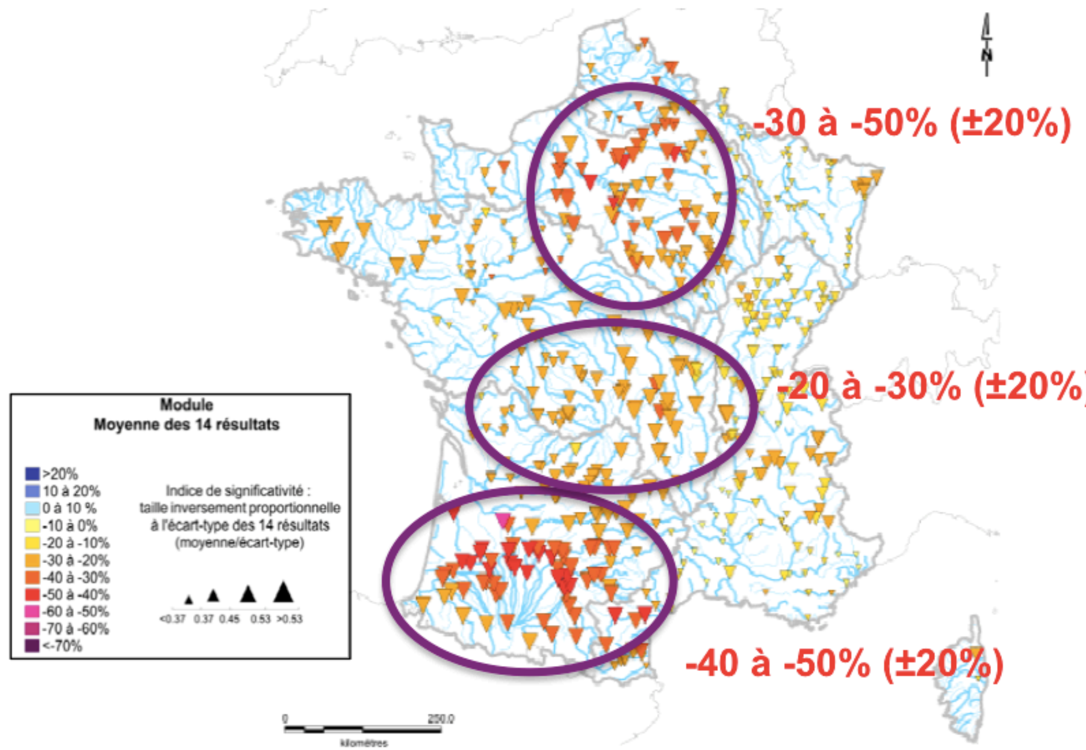
écarts du nombre maximum de jours secs consécutifs en été

Les enjeux liés à l'eau

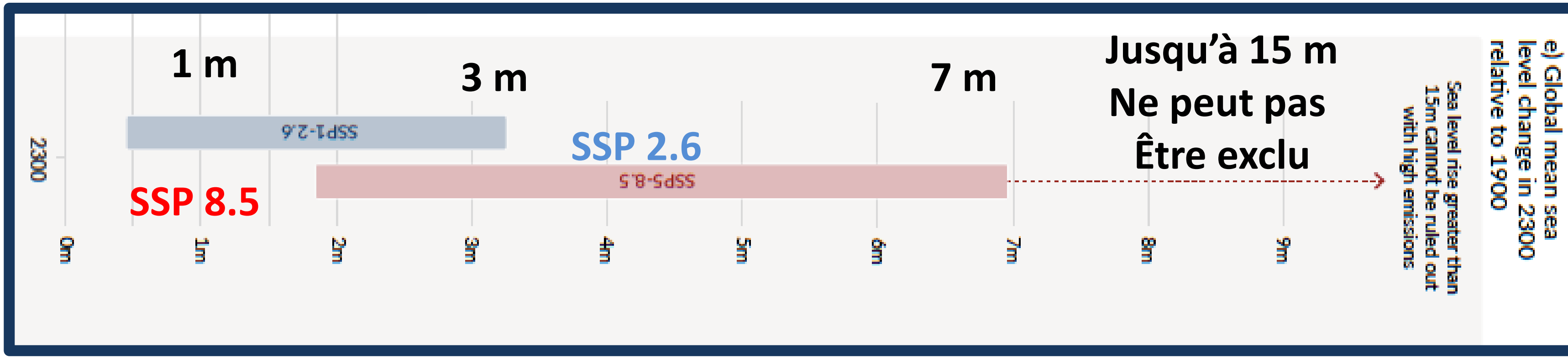
- Aléas plus fréquents et plus intenses.

Etude Explore 2070 :

- Diminution significative globale des débits moyens annuels et des débits d'étiage.
- Baisse quasi-générale de la piézométrie, associée à une diminution de la recharge des nappes.



2300



Sur 2000 ans

1.5°C	2 à 3 m
2.0°C	2 à 6 m
5°0 C	19 à 22 m