Evénements extrêmes et incertitudes

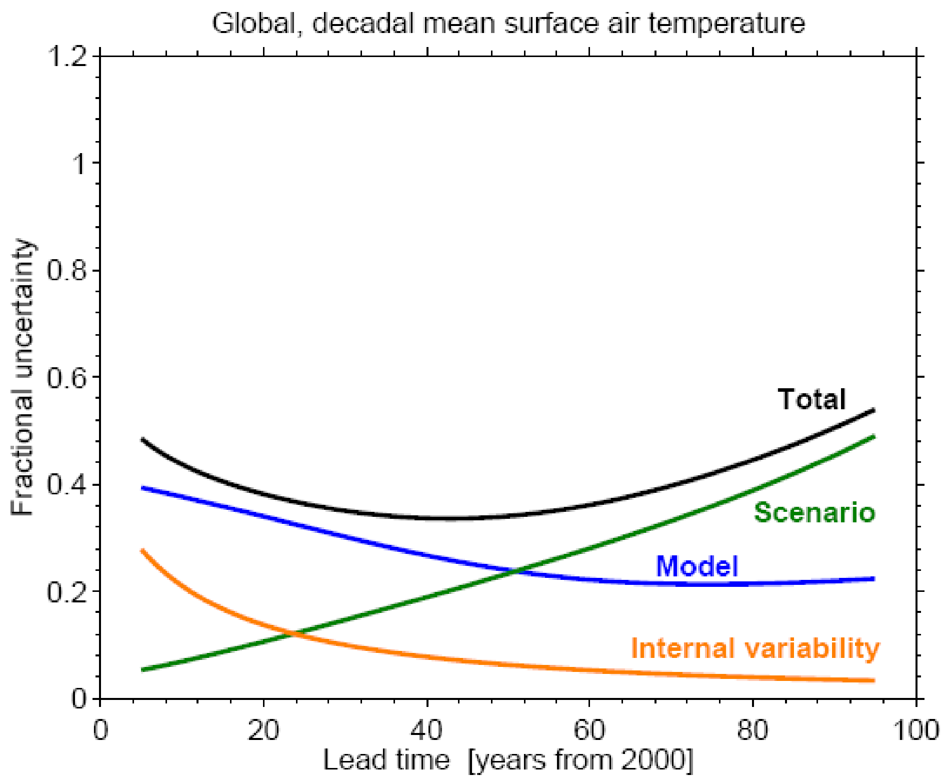
Robert Vautard

LSCE IPSL

Sources « classiques » d'incertitude dans les cénarios climatiques

- Variabilité climatique, particulièrement inter-décennale
- Scénario de développement
- Modélisation

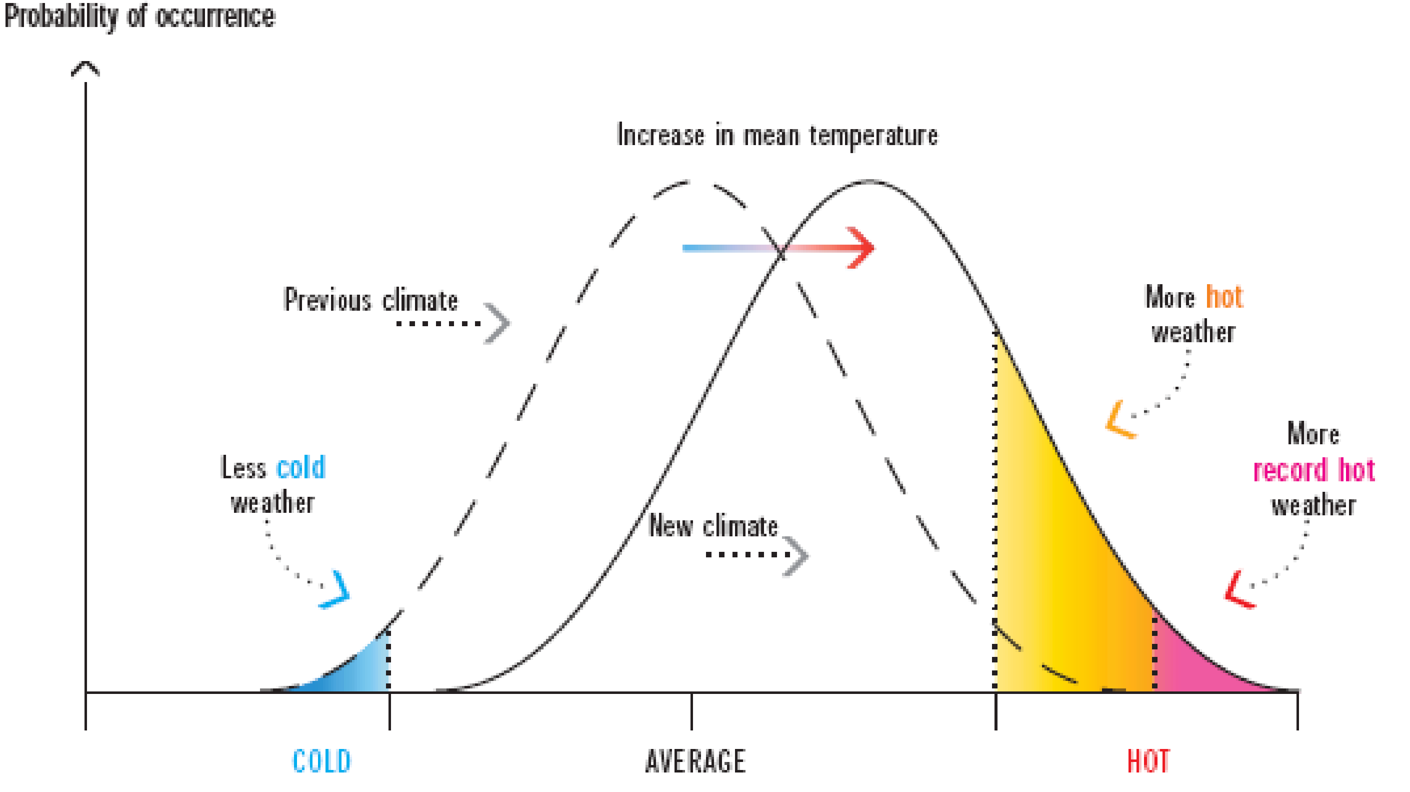
→Incertitude structurelle, limite des connaissances



Hawkins and Sutton 2009

Sources spécifiques liées aux extrêmes sensibilité aux changements de distribution

Fig. 2. Changes in the probability of extreme weather events



Source: Houghton et al. (2001).

Exemple de la sensibilité: effet d'un décalage de $+1\sigma$

- Hypothèse: décalage d'une distribution normale sans changement de variance

$+2\sigma \rightarrow +1\sigma$: 2.3% → 16%

$+3\sigma \rightarrow +2\sigma$: 0.13% → 2.3%

Pour ces derniers événements on passerait d'un temps de retour de 800 ans à 43 ans

Evolution de la couverture spatiale des températures extrêmes

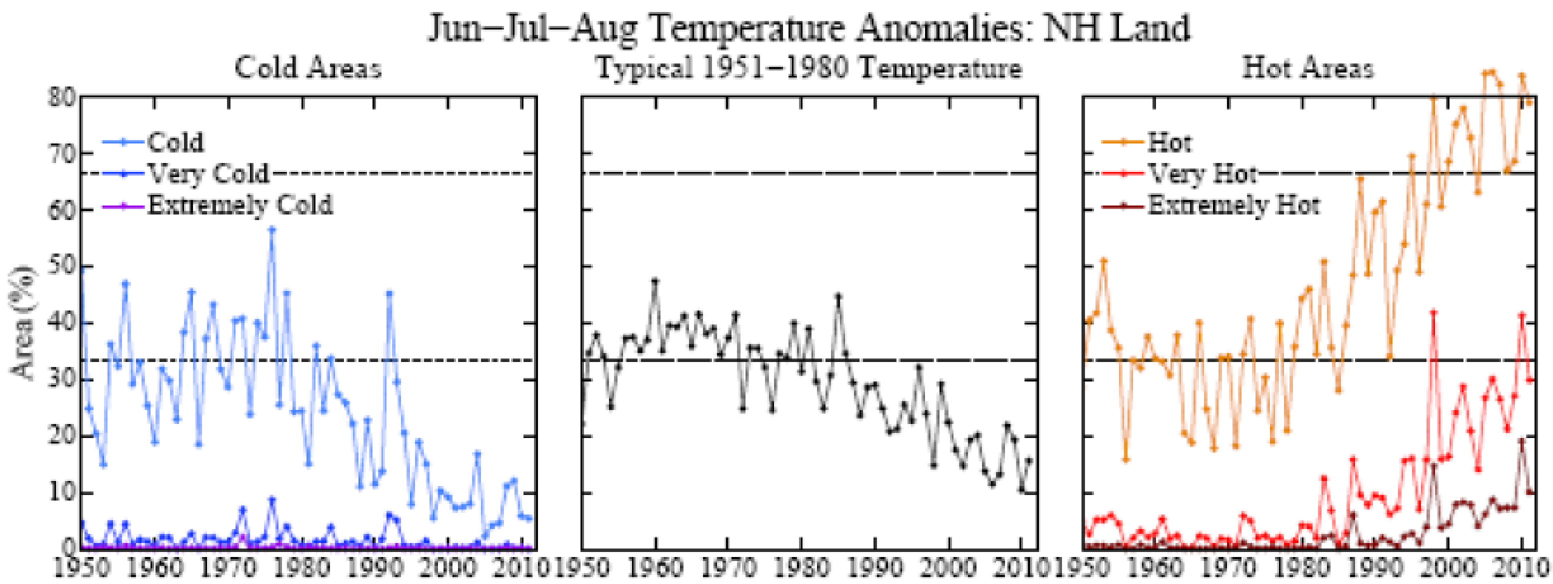


Fig. 5. Area of the world covered by temperature anomalies in the categories defined as hot (> 0.43σ), very hot (> 2σ), and extremely hot (> 3σ), with analogous divisions for cold anomalies. These anomalies are relative to 1951-1980 climatology with σ from the detrended 1981-2010 data, but results are similar for the alternative choices for standard deviation.

Pour les événements à +3σ: passage de <1% à 10%

D'après un article de Hansen et al. 2012
http://www.columbia.edu/~jeh1/mailings/2012/20120105_PerceptionsAndDice.pdf

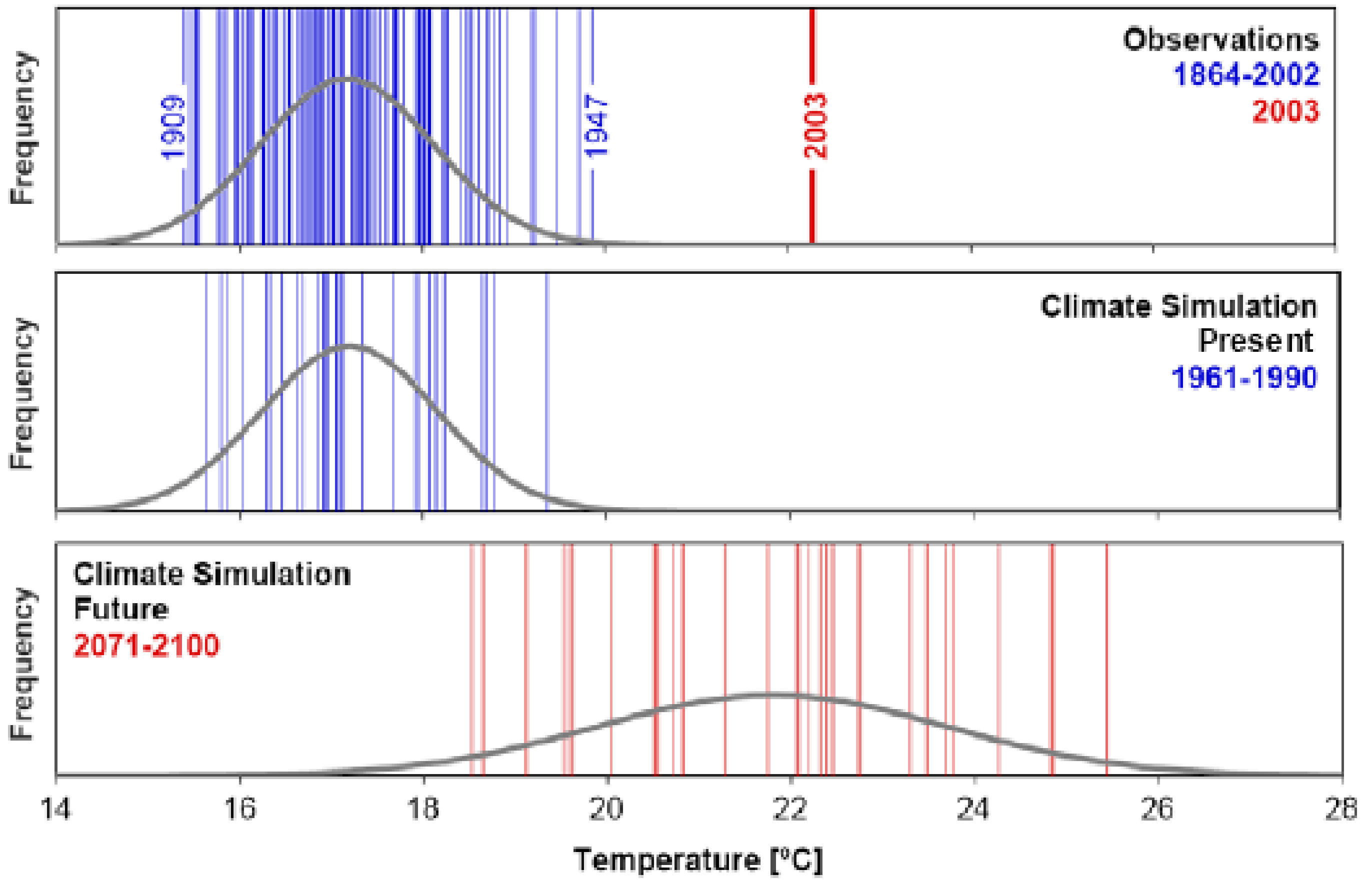
Les sources « physiques » d'incertitude

Rétroactions

Non-linéarités

Exemple des vagues de chaleur

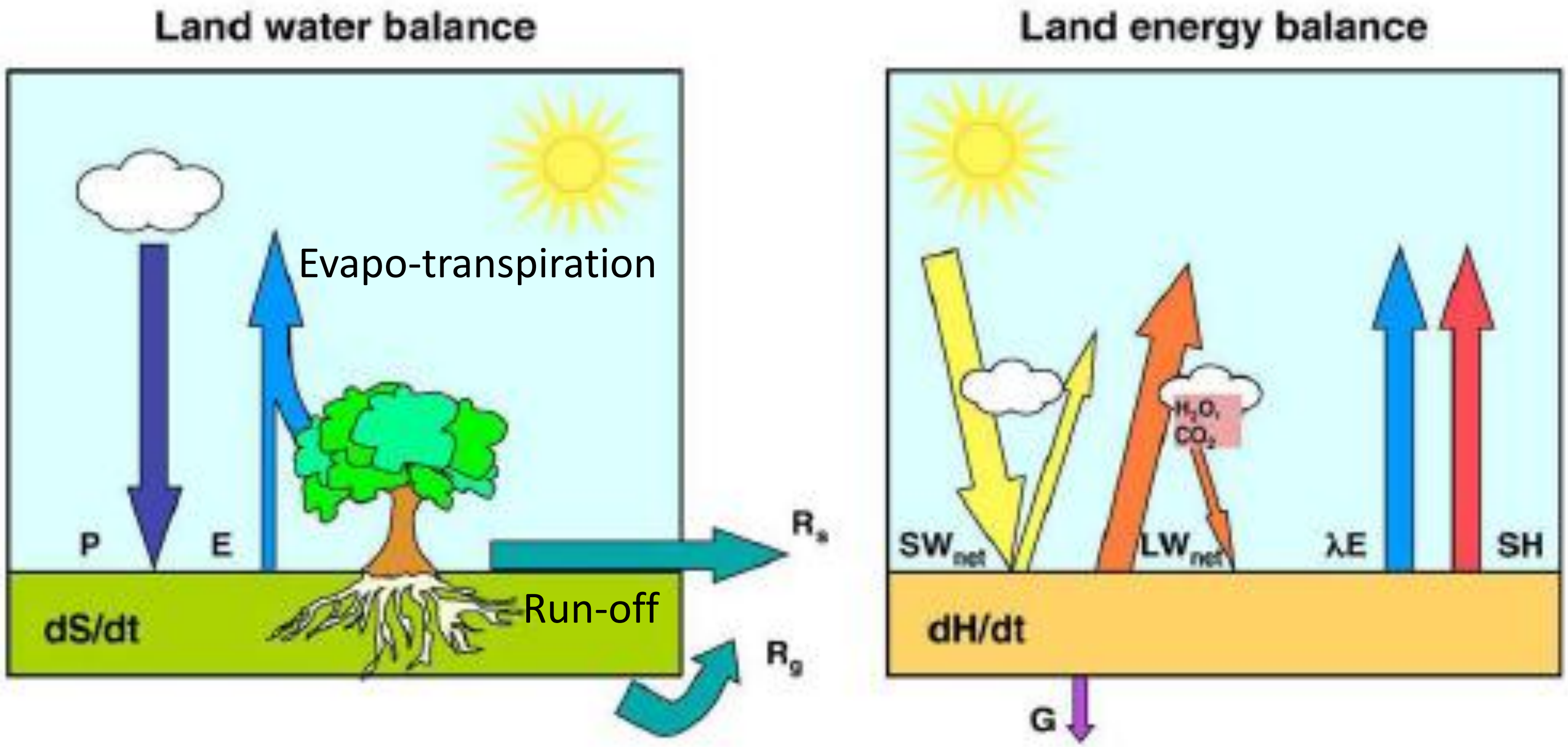
Eté 2003 et étés futurs



Eté 2003
(Suisse)
Schär et al 2005

→Nouvelles situations sans précédent à attendre

Bilan d’eau et d’énergie en surface



$$\frac{dS}{dt} = P - E - R_s - R_g$$

$$\frac{dH}{dt} = R_n - \lambda E - SH - G$$

Seneviratne et al., 2010

Contrôle de l'évapo-transpiration

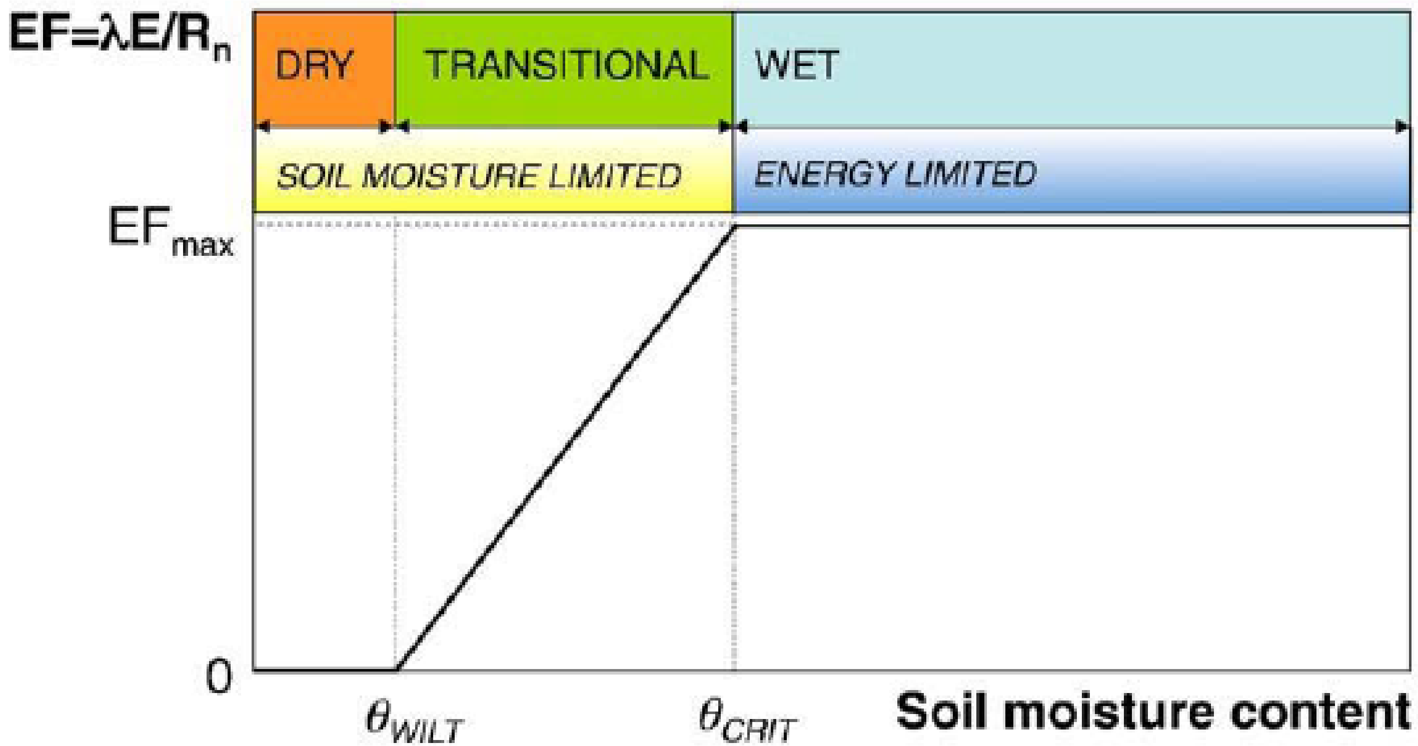


Fig. 5. Definition of soil moisture regimes and corresponding evapotranspiration regimes according to framework described in Section 4.1. *EF* denotes the evaporative fraction, and EF_{max} its maximal value.

Seneviratne et al., 2010

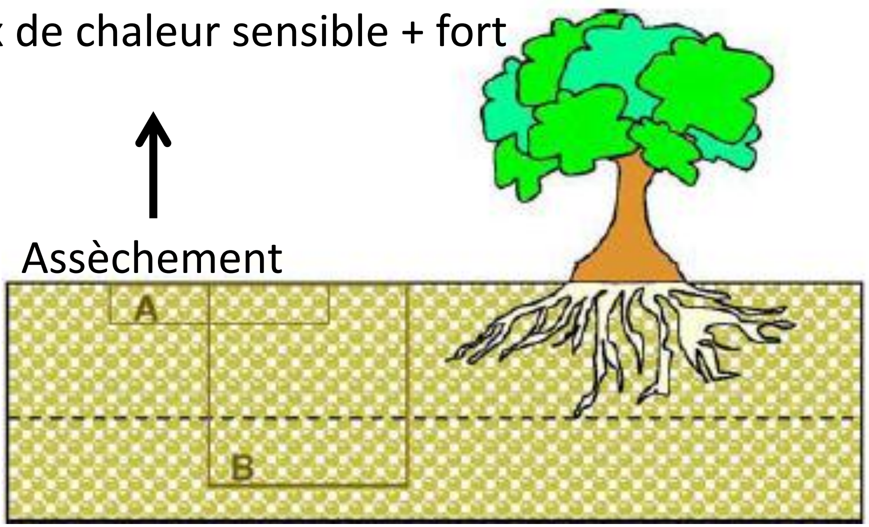
Rétroaction due aux échanges sol-atmosphère (régime « sec »)

T augmente → RH diminue

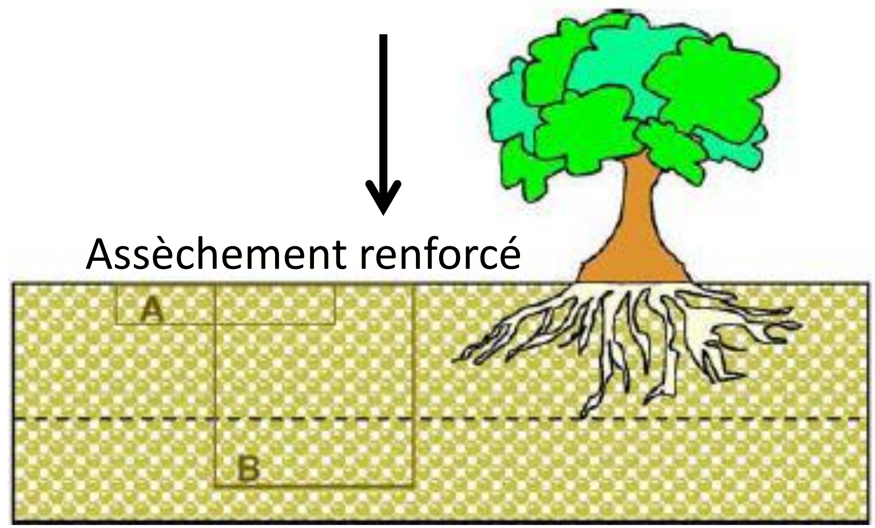
Flux de chaleur latente + faible
Flux de chaleur sensible + fort

Demande évaporative + forte

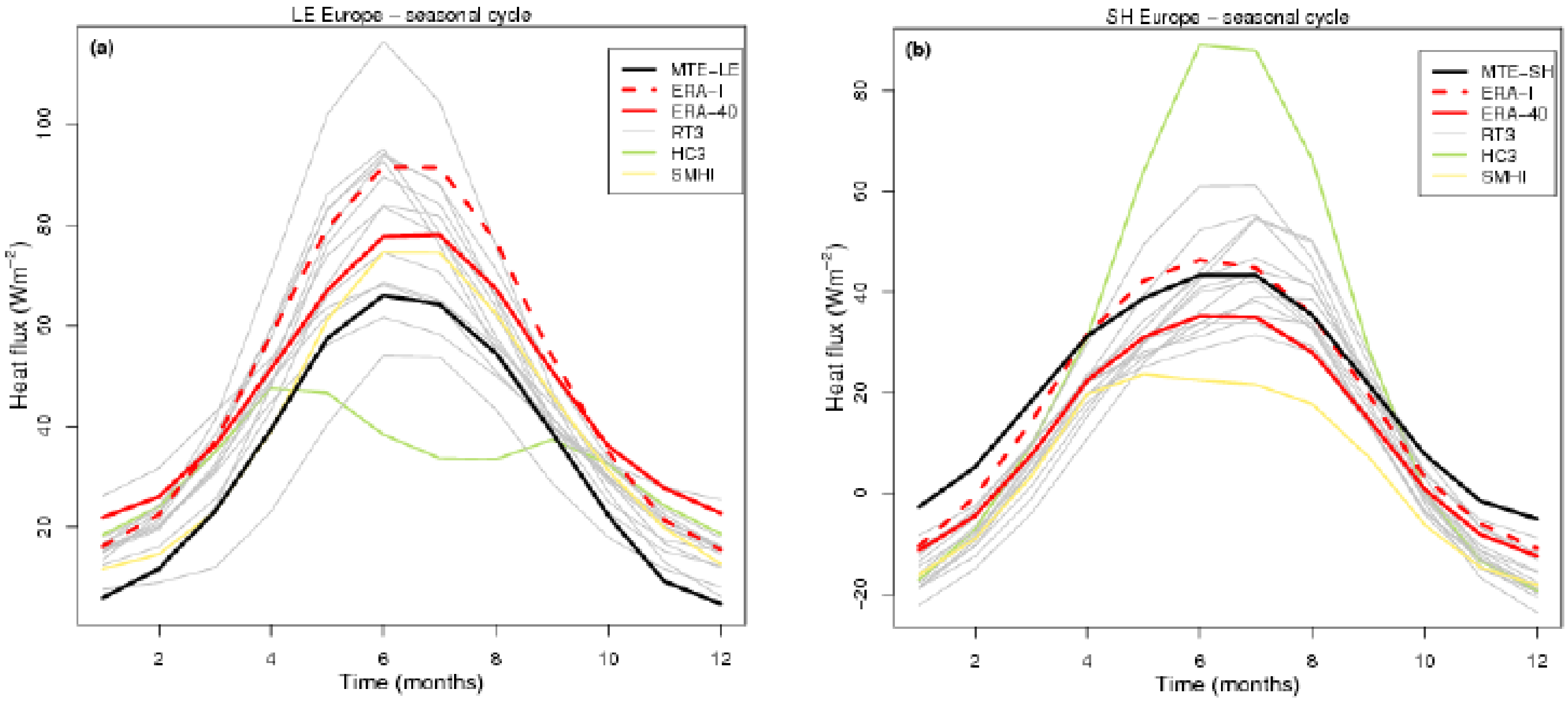
Assèchement



Assèchement renforcé



Dispersion des modèles pour les flux de chaleur



Stegehuis et al., 2012, Clim. Dyn., submitted

Evolution avec le changement climatique

IPCC SREX

A retenir : concernant la température IPCC SREX 2012

- It is **very likely** that there has been an overall decrease in the number of cold days and nights, and an overall increase in the number of warm days and nights

- It is **virtually certain** that increases in the frequency and magnitude of warm daily temperature extremes and decreases in cold extremes will occur in the 21st century at the global scale.

- It is **very likely** that the length, frequency, and/or intensity of warm spells or heat waves will increase over most land areas.

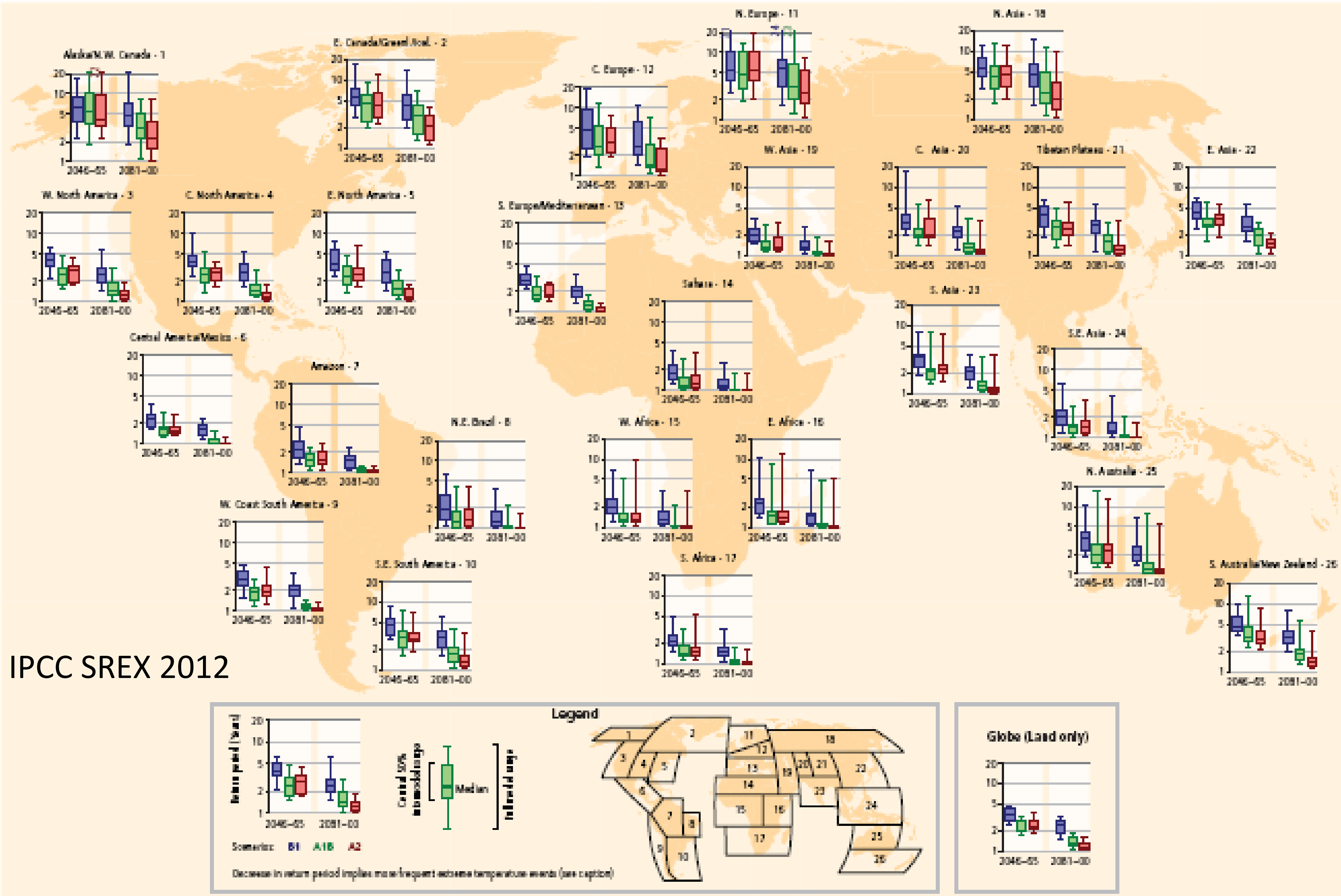


Figure SPM.4A | Projected return periods for the maximum daily temperature that was exceeded on average once during a 20-year period in the late 20th century (1981–2000). A decrease in return period implies more frequent extreme temperature events (i.e., less time between events on average). The box plots show results for regionally averaged projections for two time horizons, 2046 to 2065 and 2081 to 2100, as compared to the late 20th century, and for three different SRES emissions scenarios (B1, A1B, A2) (see legend). Results are based on 12 global climate models (GCMs) contributing to the third phase of the Coupled Model Intercomparison Project (CMIP3). The level of agreement among the models is indicated by the size of the colored boxes (in which 50% of the model projections are contained), and the length of the whiskers (indicating the maximum and minimum projections from all models). See legend for defined extent of regions. Values are computed for land points only. The 'Globe' inset box displays the values computed using all land grid points. [3.3.1, Figure 3-1, Figure 3-5]

Evolution en Europe

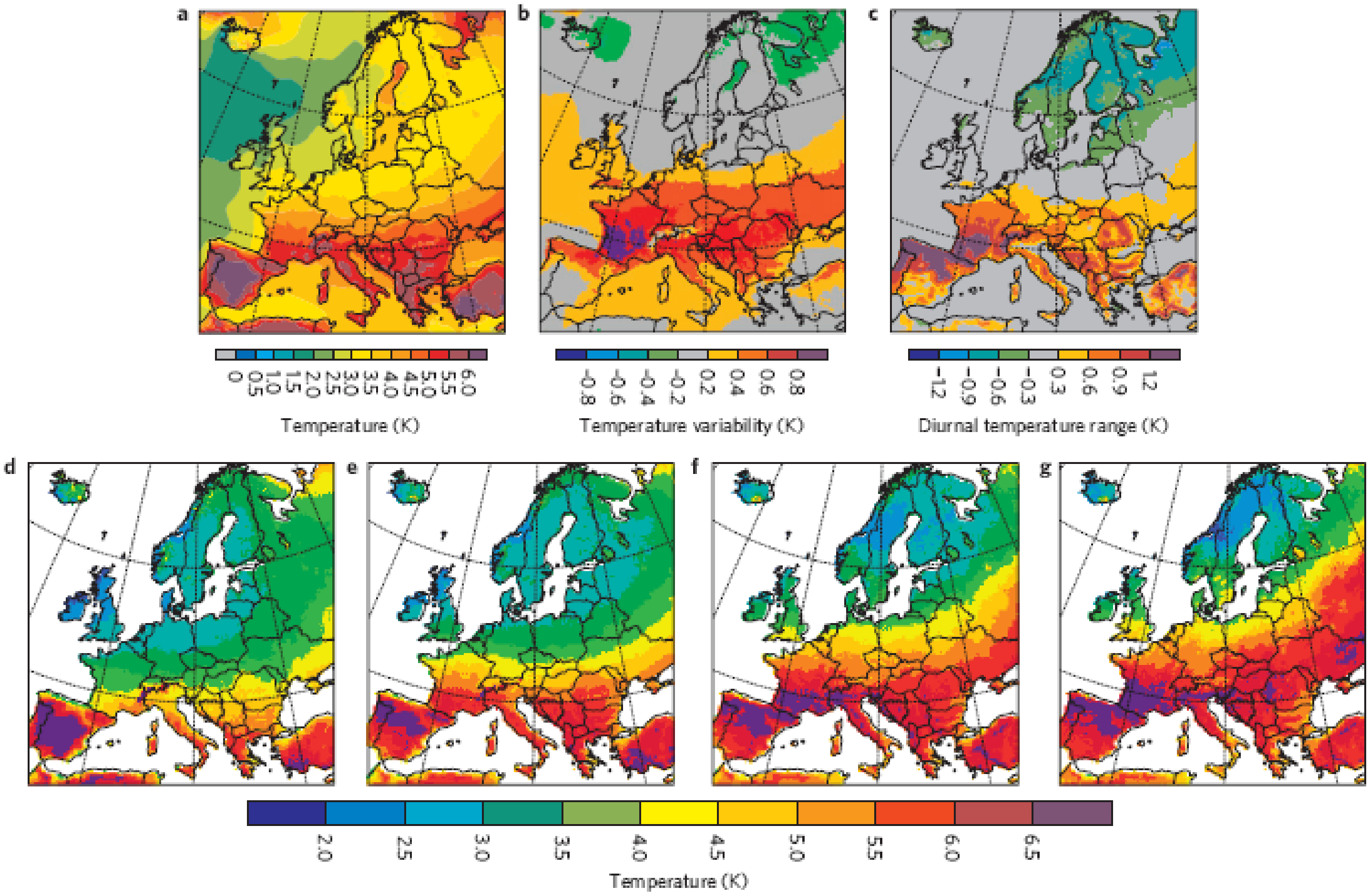
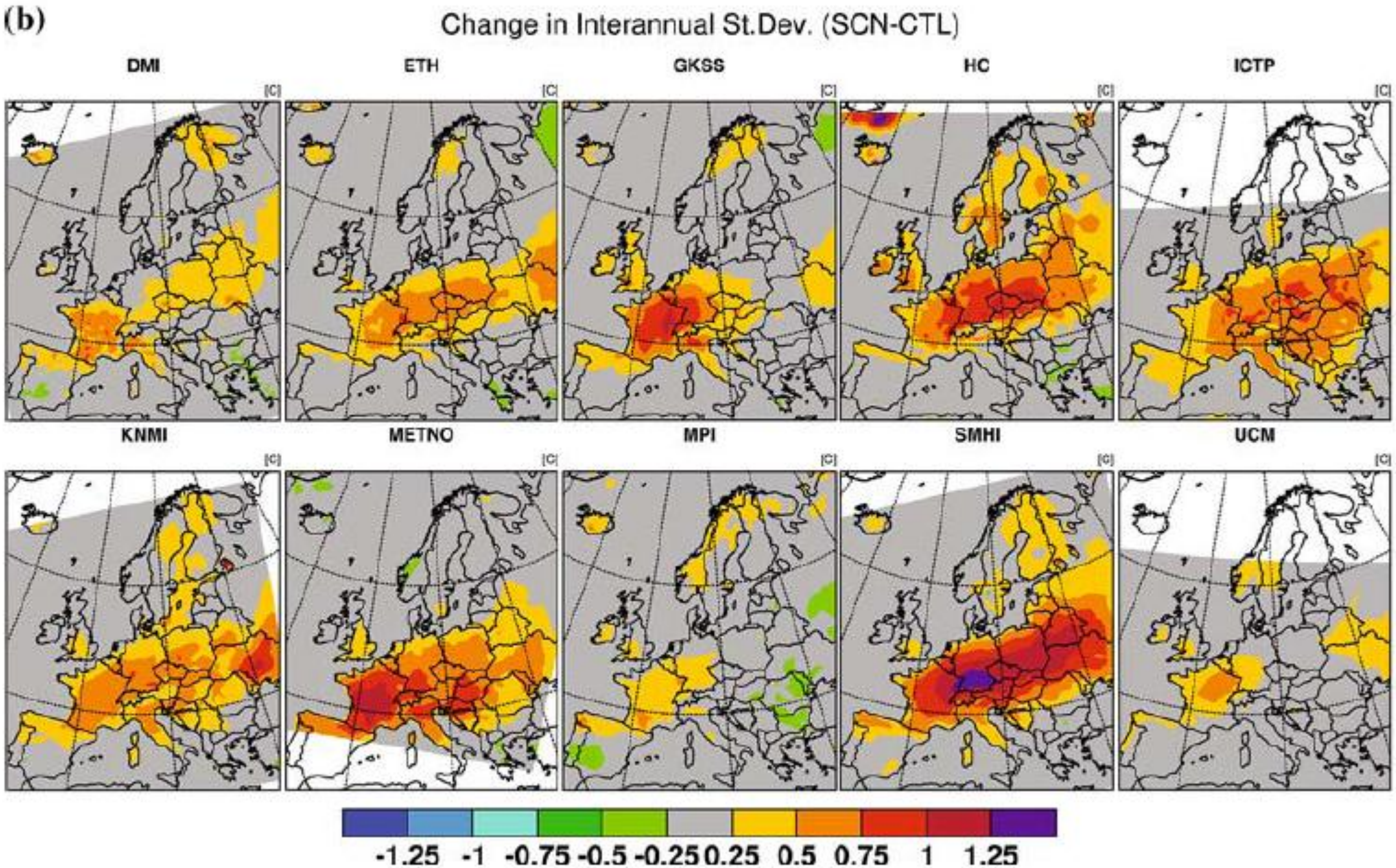


Figure 1 | Climate-change scenarios for daily summer temperature statistics. Projected ensemble mean changes in summer (JJA) for six simulations of the ENSEMBLES project for 2071–2100 with respect to 1961–1990. **a**, Mean temperature. **b**, Daily temperature variability (standard deviations of all summer days). **c**, Diurnal temperature range. **d–g**, The same as in **a**, but for 10th (**d**), 50th (**e**), 95th (**f**) and 99th (**g**) percentiles of daily maximum temperatures.

Fischer and Schär, 2010

Incertitude sur la variabilité (expérience PRUDENCE)



Fischer et al., 2009

A retenir: concernant le cycle de l'eau IPCC SREX 2012

- There have been statistically significant trends in the number of heavy precipitation events in some regions. It is **likely** that more of these regions have experienced increases than decreases, although there are strong regional and subregional variations in these trends.

- It is **likely** that the frequency of heavy precipitation or the proportion of total rainfall from heavy falls will increase in the 21st century over many areas of the globe

- There is **medium confidence** that droughts will intensify in the 21st century in some seasons and areas, due to reduced precipitation and/or increased evapotranspiration.

- Projected precipitation and temperature changes imply **possible changes** in floods, although overall there is **low confidence** in projections of changes in fluvial floods.

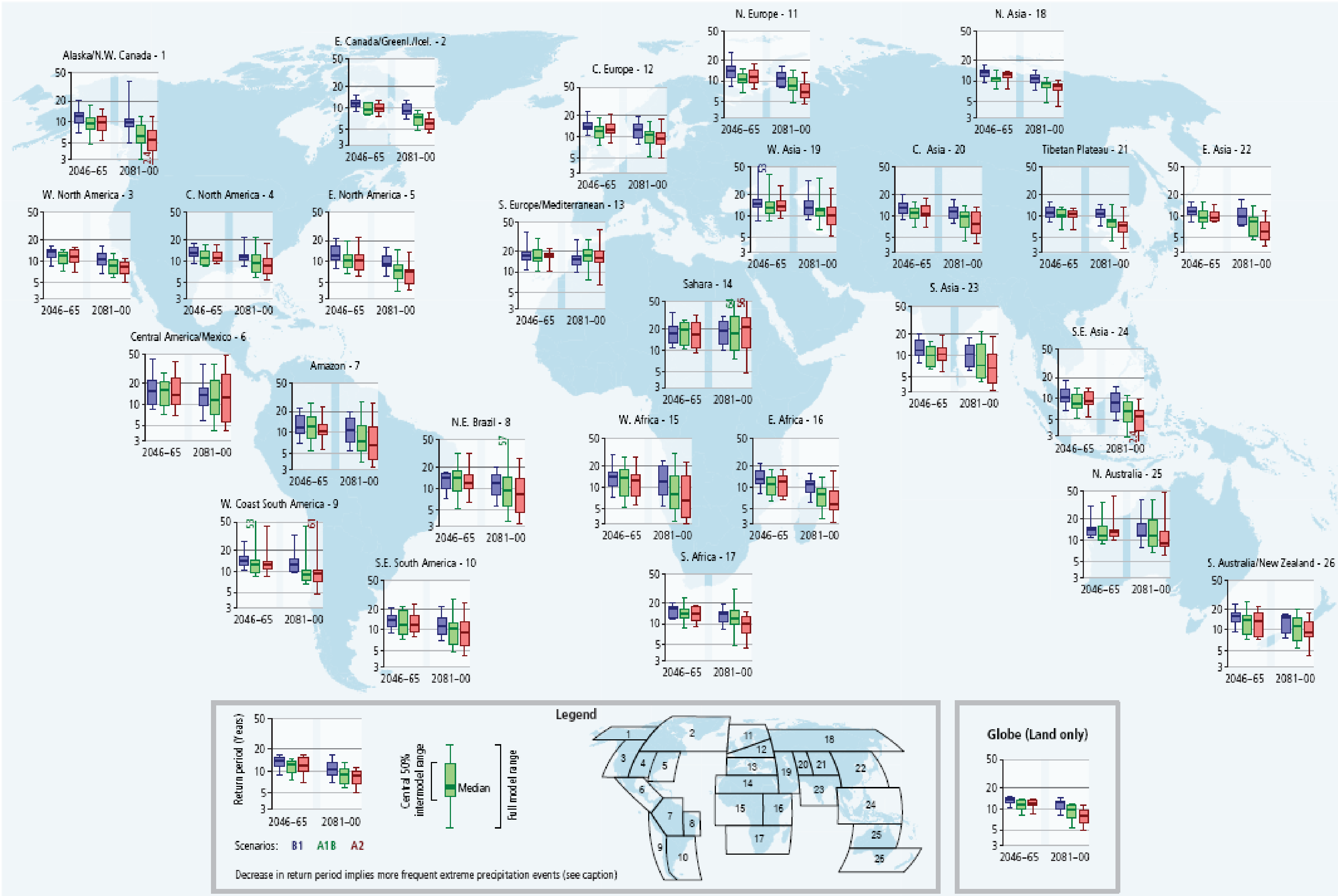
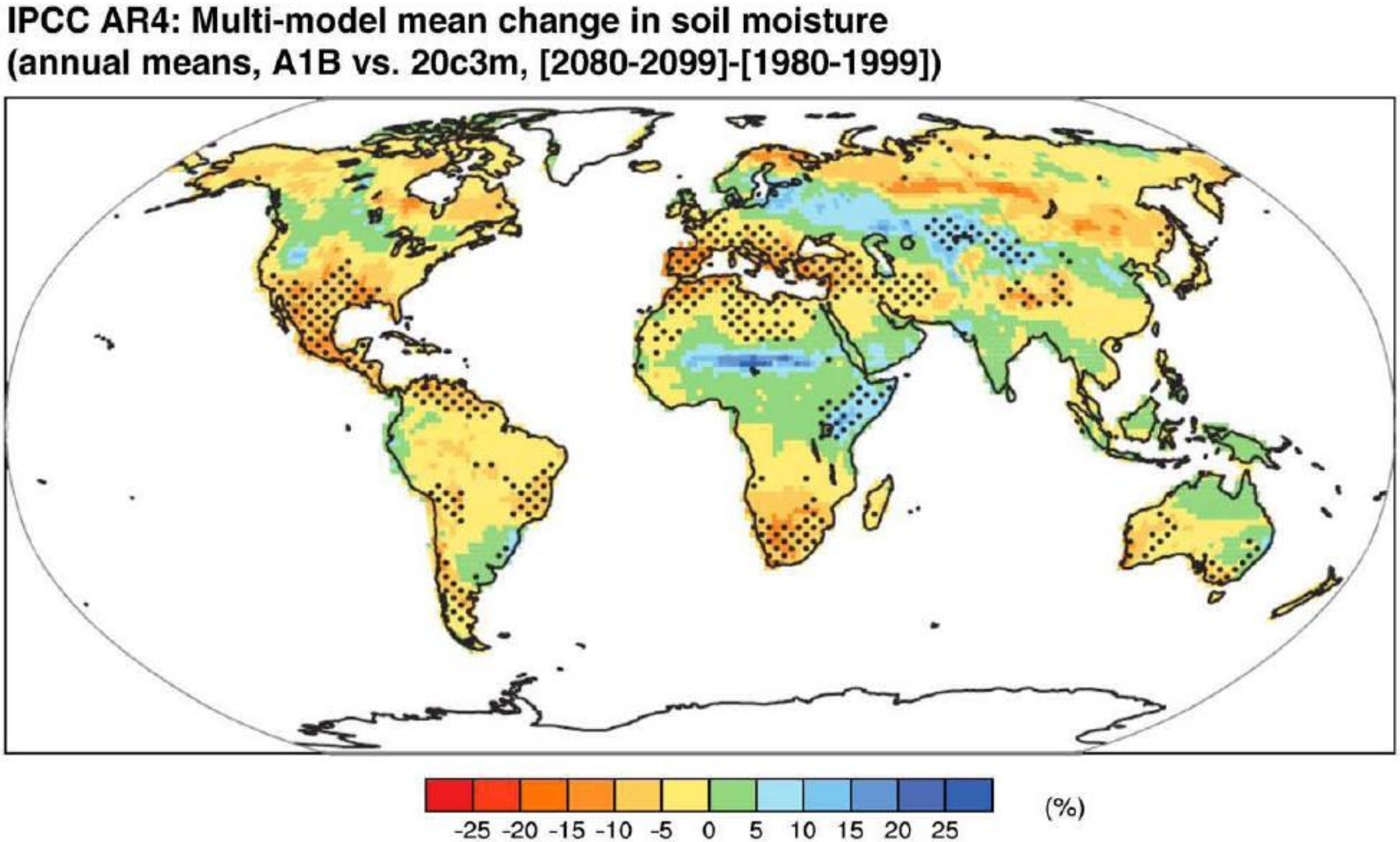


Figure SPM.4B | Projected return periods for a daily precipitation event that was exceeded in the late 20th century on average once during a 20-year period (1981–2000). A decrease in return period implies more frequent extreme precipitation events (i.e., less time between events on average). The box plots show results for regionally averaged projections for two time horizons, 2046 to 2065 and 2081 to 2100, as compared to the late 20th century, and for three different SRES emissions scenarios (B1, A1B, A2) (see legend). Results are based on 14 GCMs contributing to the CMIP3. The level of agreement among the models is indicated by the size of the colored boxes (in which 50% of the model projections are contained), and the length of the whiskers (indicating the maximum and minimum projections from all models). See legend for defined extent of regions. Values are computed for land points only. The 'Globe' inset box displays the values computed using all land grid points. [3.3.2, Figure 3-1, Figure 3-7]

Evolution avec le changement climatique



Seneviratne et al., 2010

A retenir : concernant le vent IPCC SREX 2012

- There is **low confidence** in any observed long-term (i.e., 40 years or more) increases in tropical cyclone activity (i.e., intensity, frequency, duration), after accounting for past changes in observing capabilities. It is **likely** that there has been a poleward shift in the main Northern and Southern Hemisphere extratropical storm tracks.

- Average tropical cyclone maximum wind speed is **likely** to increase, although increases may not occur in all ocean basins. It is **likely** that the global frequency of tropical cyclones will either decrease or remain essentially unchanged.

- There is **medium confidence** that there will be a reduction in the number of extratropical cyclones averaged over each hemisphere.

- There is **medium confidence** in a projected poleward shift of extra-tropical storm tracks.

A retenir: autres phénomènes

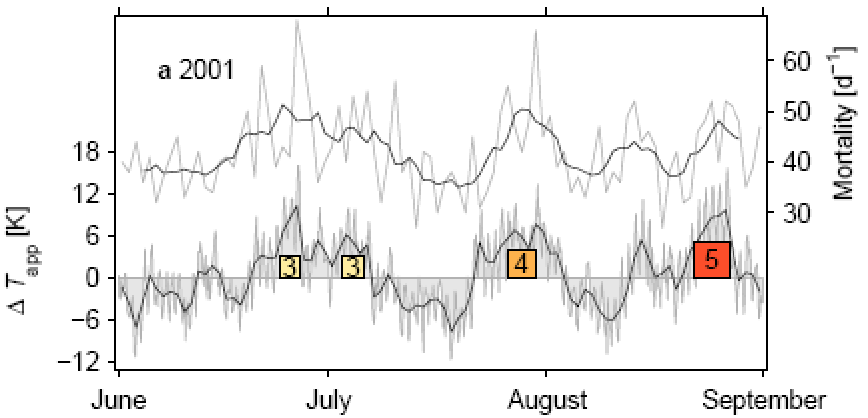
- It is **very likely** that mean sea level rise will contribute to upward trends in extreme coastal high water levels in the future.

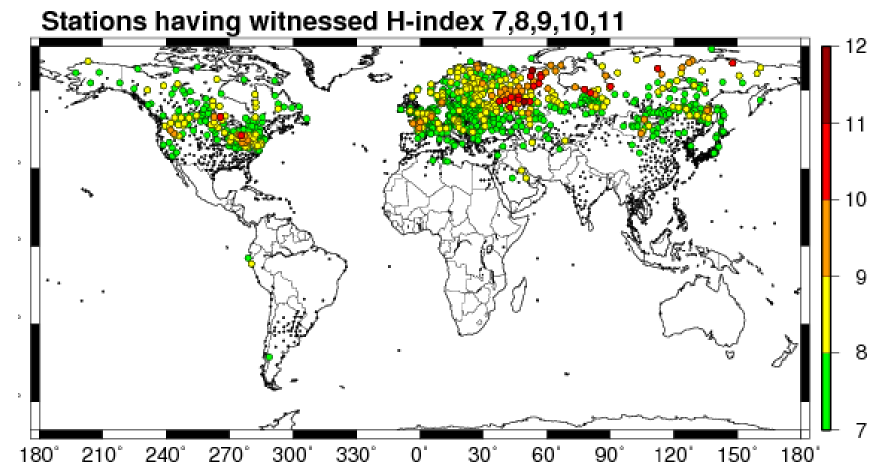
- There is **high confidence** that changes in heat waves, glacial retreat, and/or permafrost degradation will affect high mountain phenomena such as slope instabilities, movements of mass, and glacial lake outburst floods

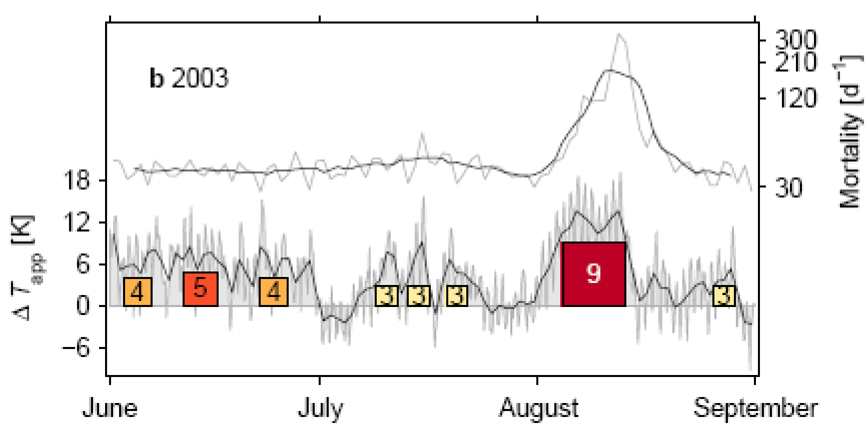
Conclusions

- Incertitudes: des questions encore largement à l’étude, sur la méthodologie et les résultats
- De meilleures observations de long terme permettront de réduire les incertitudes sur les processus
- Une meilleure compréhension des phénomènes possibles de rupture est indispensable
- Autres: incertitudes sur les impacts, les mesures d’adaptation: nécessite des index pour comparer les événements

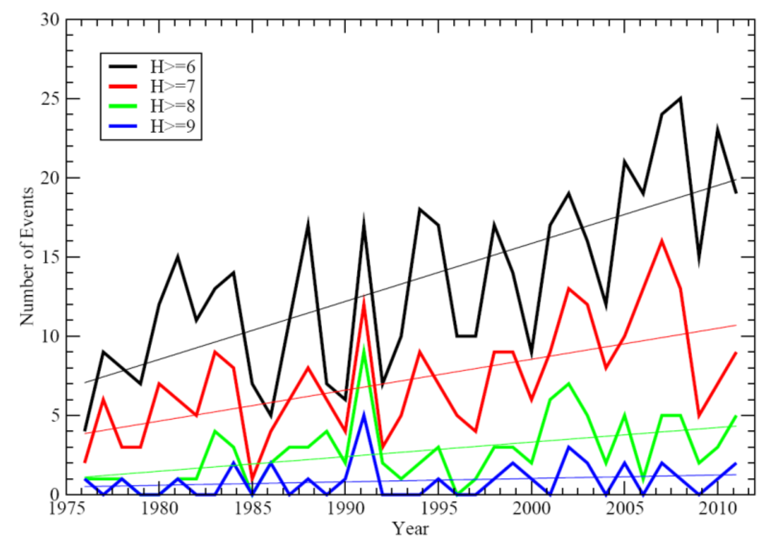
Exemple : un H-index pour les vagues de chaleur ?







a) Number of Heat Waves Events



Teuling and Vautard, 2012, GRL, submitted