

Climate Change - What are the main issues with regard to human activities, climate modeling and land-climate interactions?

Sonia I. Seneviratne

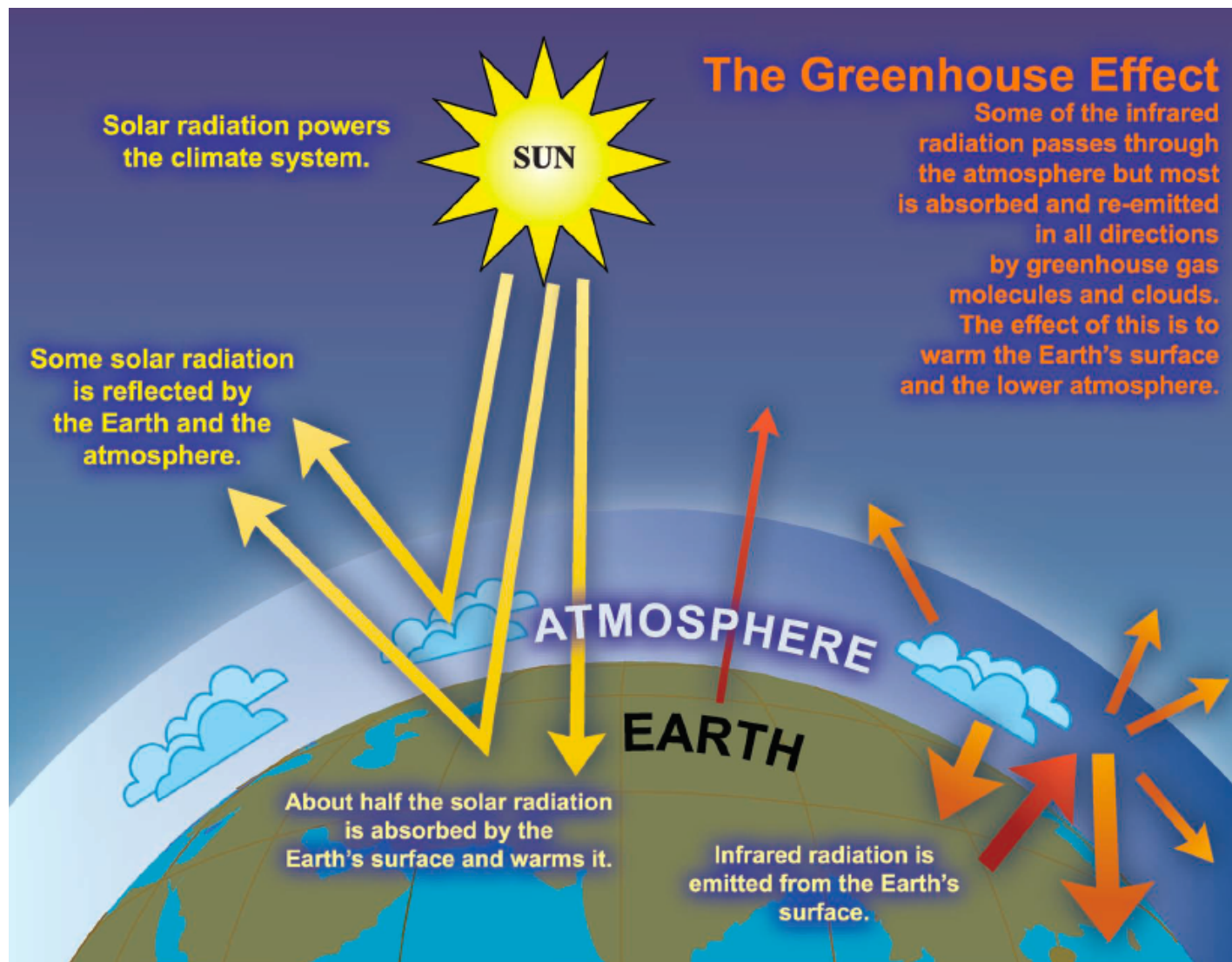
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ÖPG - SPS - ÖGA Annual Meeting, Innsbruck, Austria
September 2, 2009

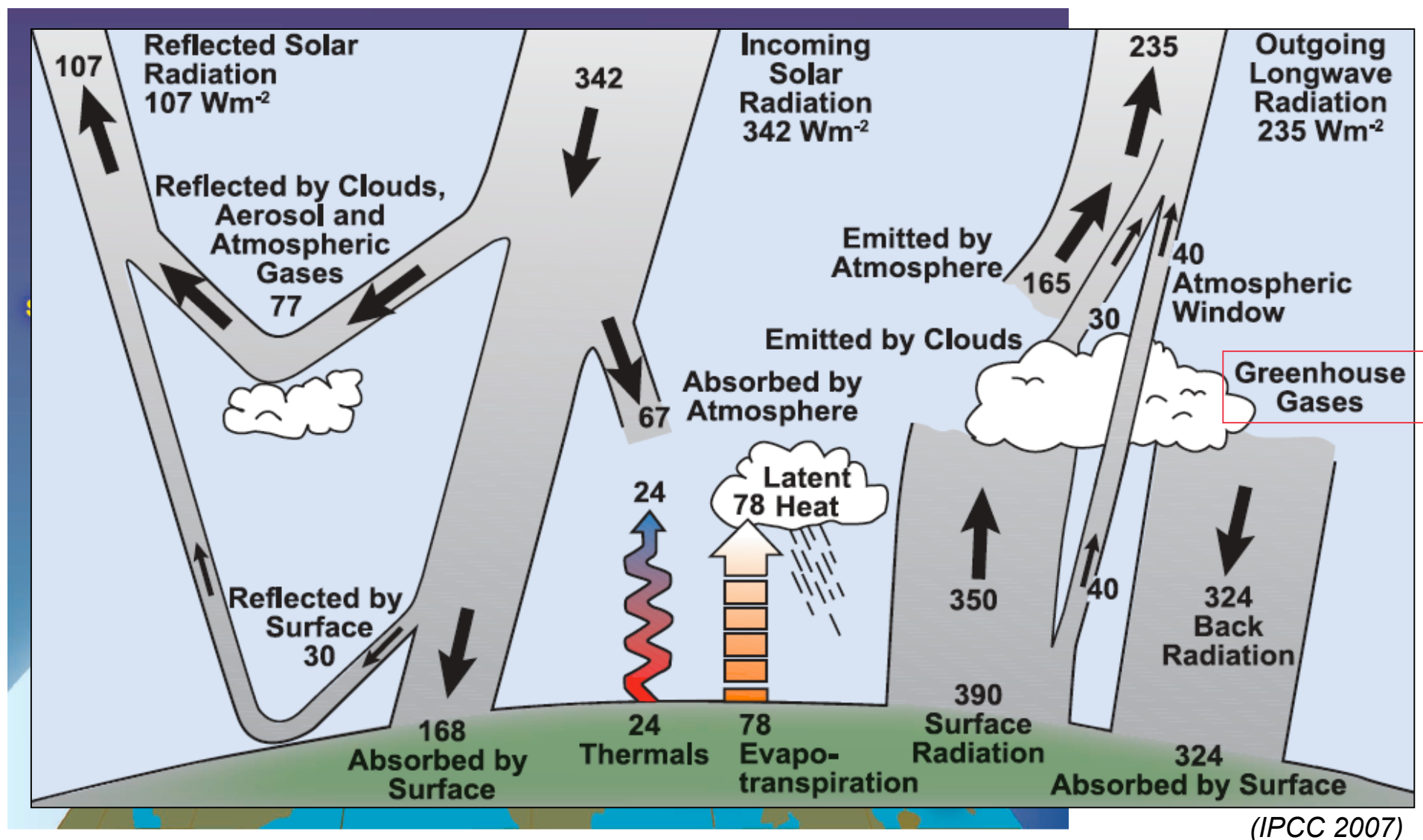
- Introduction
- Evidence from observations and climate model projections
- Current uncertainties
 - Emissions
 - Processes: e.g. land-atmosphere feedbacks
- Conclusions

Climate change

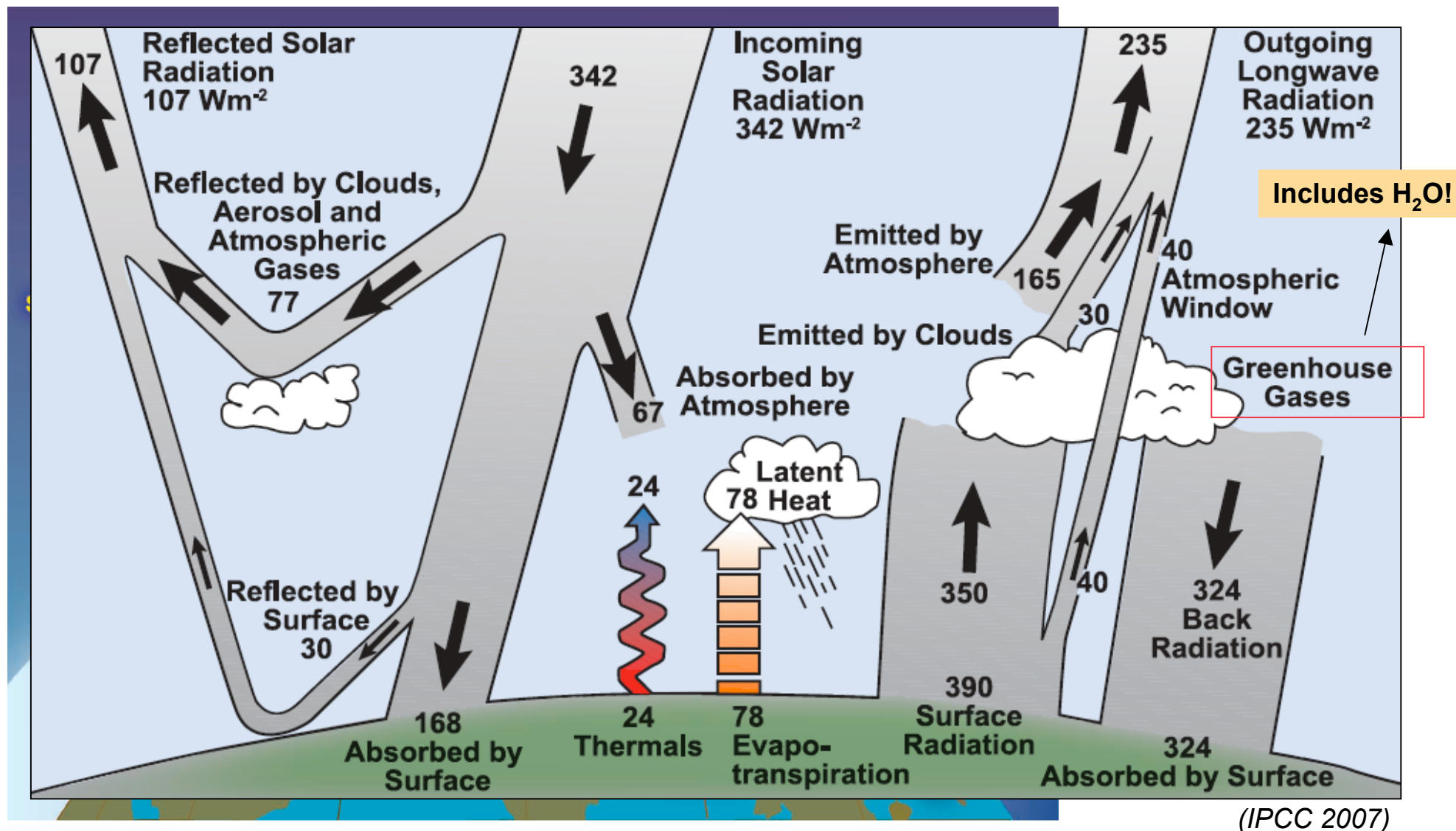


(IPCC 2007)

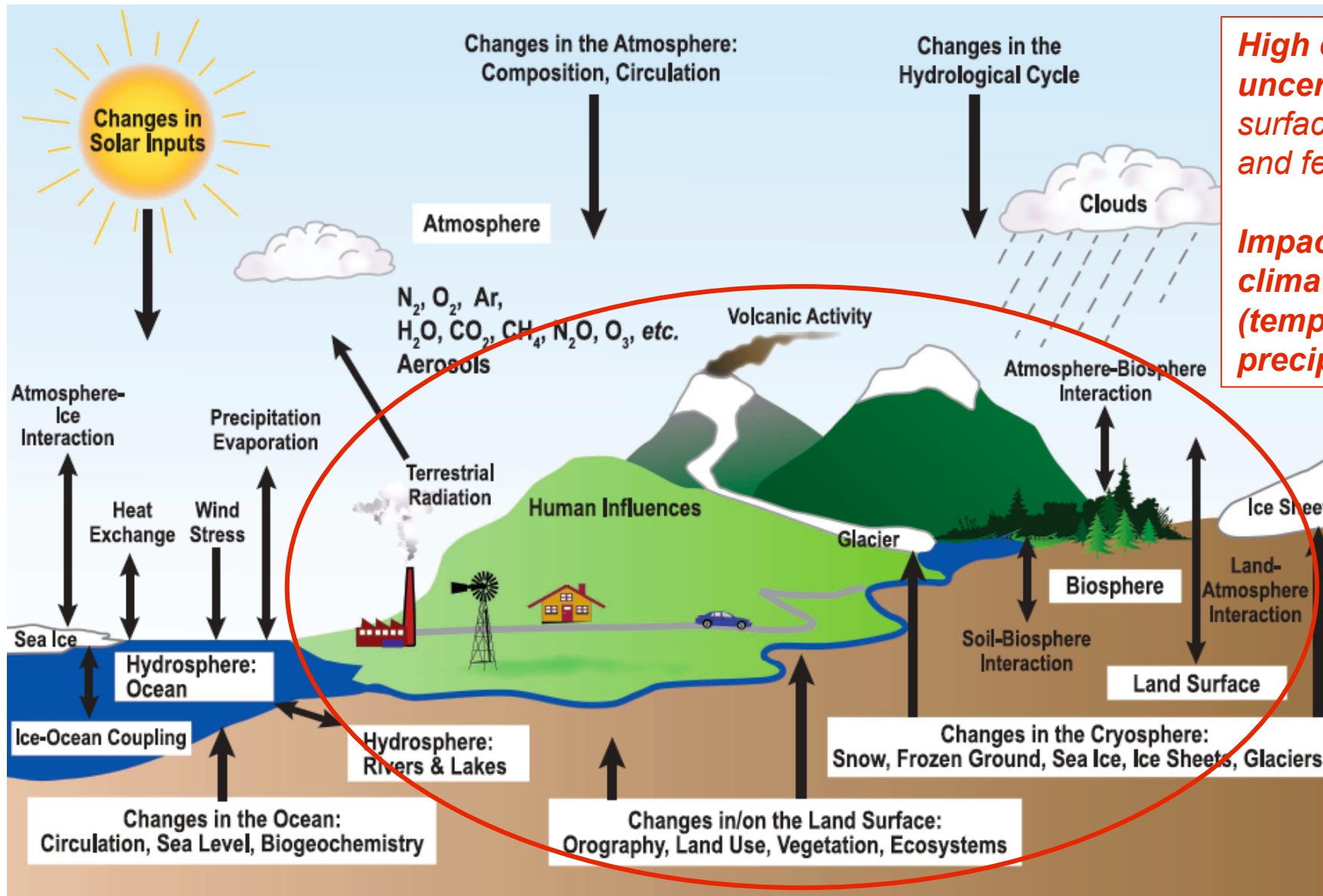
Climate change



Climate change



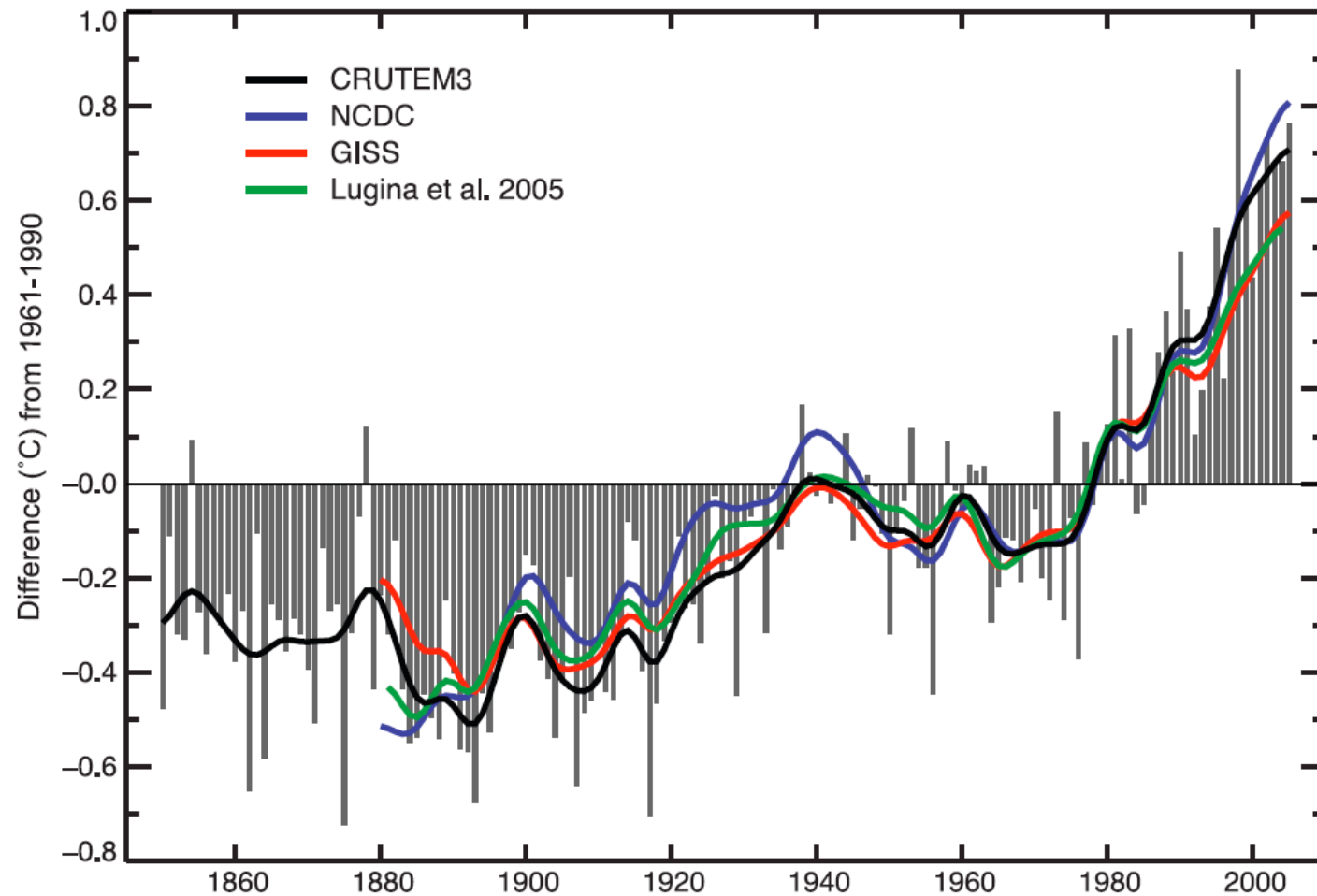
The climate system and climate change



High complexity & uncertainty of land surface processes and feedbacks!

Impacts regional climate response (temperature, precipitation)

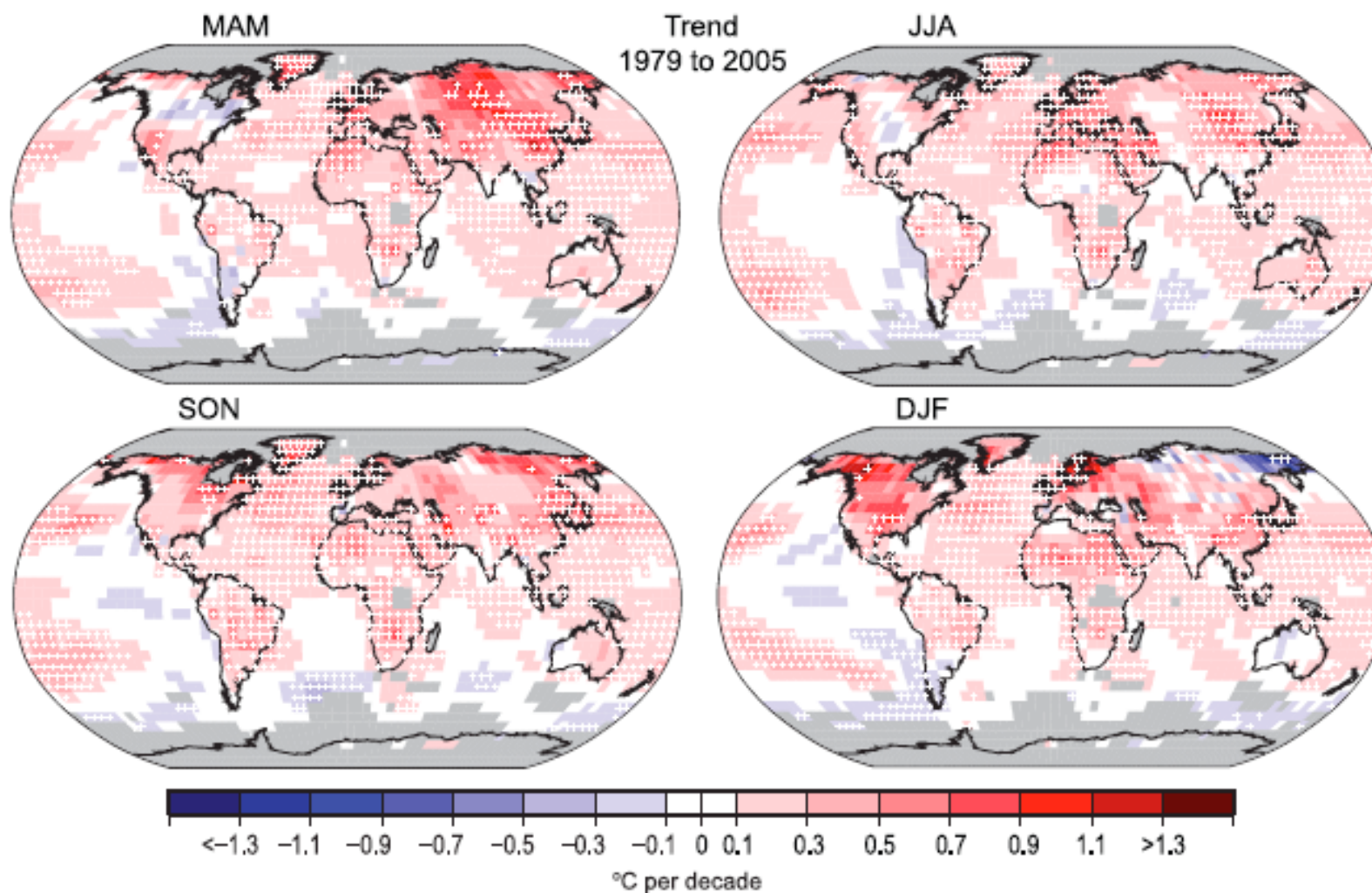
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Global temperature trends

Figure 3.1. Annual anomalies of global land-surface air temperature (°C), 1850 to 2005, relative to the 1961 to 1990 mean for CRUTEM3 updated from Brohan et al. (2006). The smooth curves show decadal variations (see Appendix 3.A). The black curve from CRUTEM3 is compared with those from NCDC (Smith and Reynolds, 2005; blue), GISS (Hansen et al., 2001; red) and Lugina et al. (2005; green).

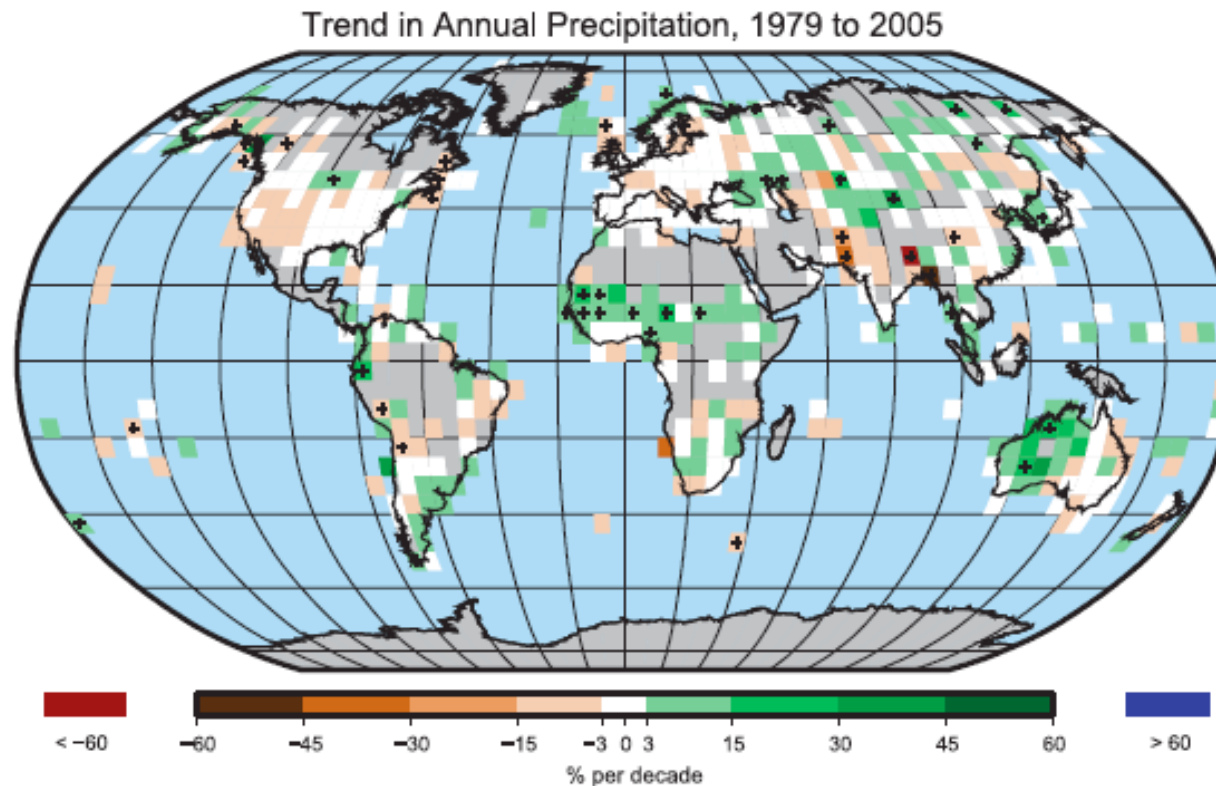
(IPCC 2007)



Regional and seasonal variations

Figure 3.10. Linear trend of seasonal MAM, JJA, SON and DJF temperature for 1979 to 2005 (°C per decade). Areas in grey have insufficient data to produce reliable trends. The minimum number of years required to calculate a trend value is 18. A seasonal value is available if there are two valid monthly temperature anomaly values. The dataset used was produced by NCDC from Smith and Reynolds (2005). Trends significant at the 5% level are indicated by white + marks.

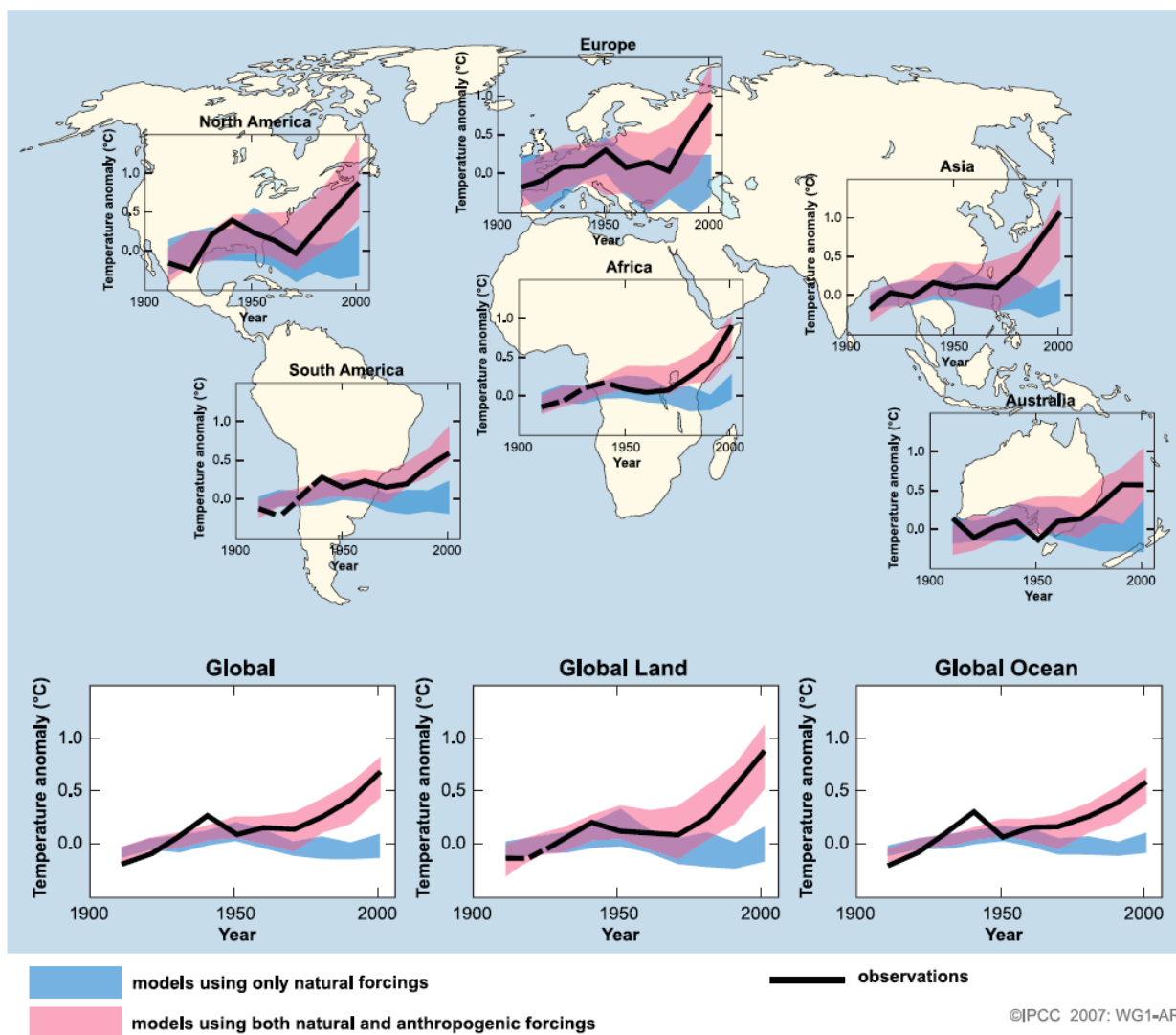
(IPCC 2007)



**Less robust
trends for
precipitation**

Figure 3.13. Trend of annual land precipitation amounts for 1901 to 2005 (top, % per century) and 1979 to 2005 (bottom, % per decade), using the GPCP precipitation data set from NCEP. The percentage is based on the means for the 1961 to 1990 period. Areas in grey have insufficient data to produce reliable trends. The minimum number of years required to calculate a trend value is 66 for 1901 to 2005 and 18 for 1979 to 2005. An annual value is complete for a given year if all 12 monthly percentage anomaly values are present. Note the different colour bars and units in each plot. Trends significant at the 5% level are indicated by black + marks.

(IPCC 2007)

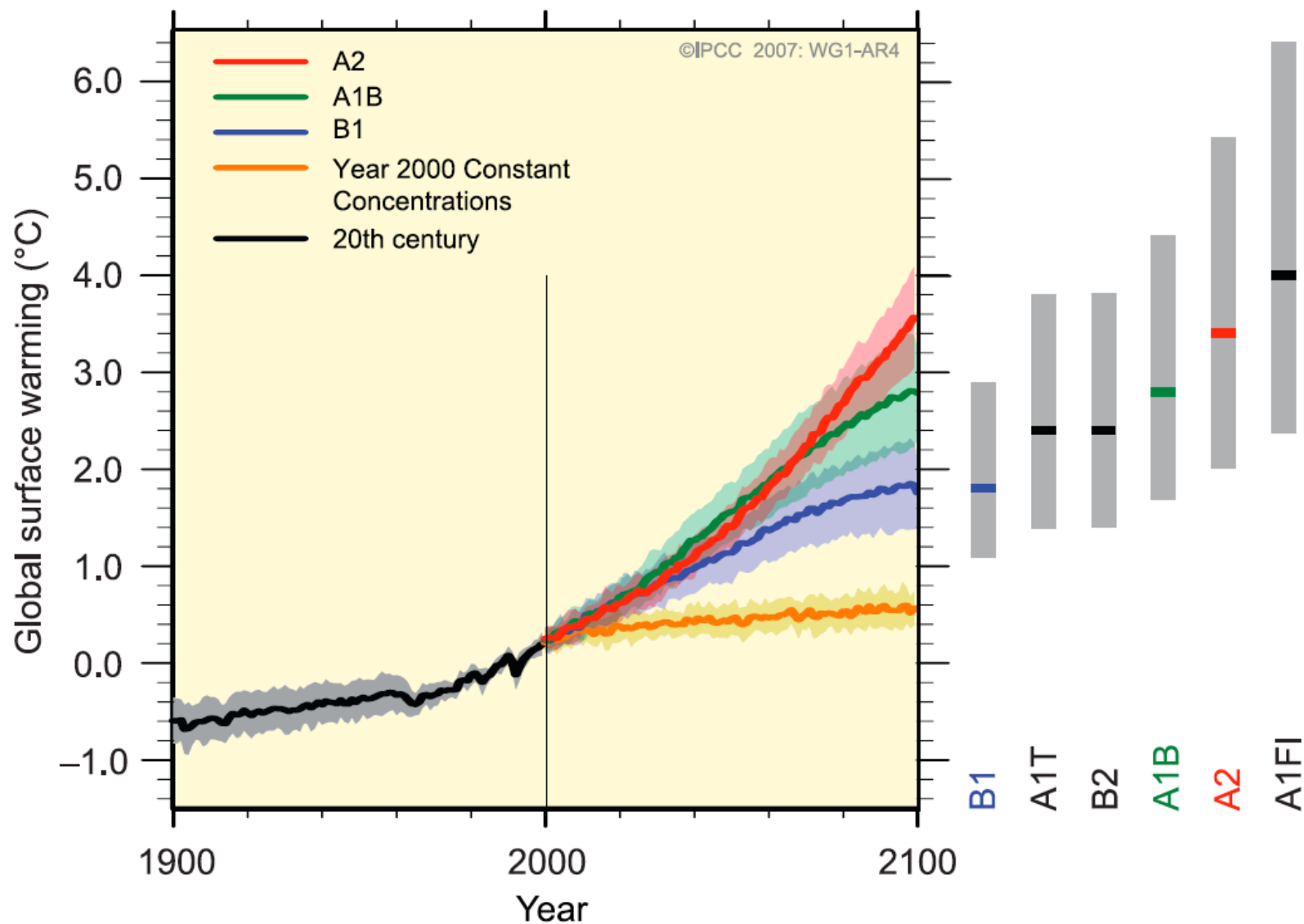


FAQ 9.2, Figure 1. Temperature changes relative to the corresponding average for 1901-1950 (°C) from decade to decade from 1906 to 2005 over the Earth's continents, as well as the entire globe, global land area and the global ocean (lower graphs). The black line indicates observed temperature change, while the coloured bands show the combined range covered by 90% of recent model simulations. Red indicates simulations that include natural and human factors, while blue indicates simulations that include only natural factors. Dashed black lines indicate decades and continental regions for which there are substantially fewer observations. Detailed descriptions of this figure and the methodology used in its production are given in the Supplementary Material, Appendix 9.C.

(IPCC 2007)

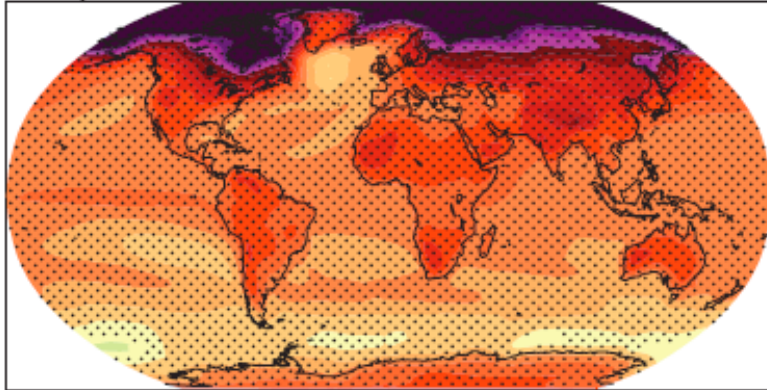
Projections of global temperature changes

MULTI-MODEL AVERAGES AND ASSESSED RANGES FOR SURFACE WARMING

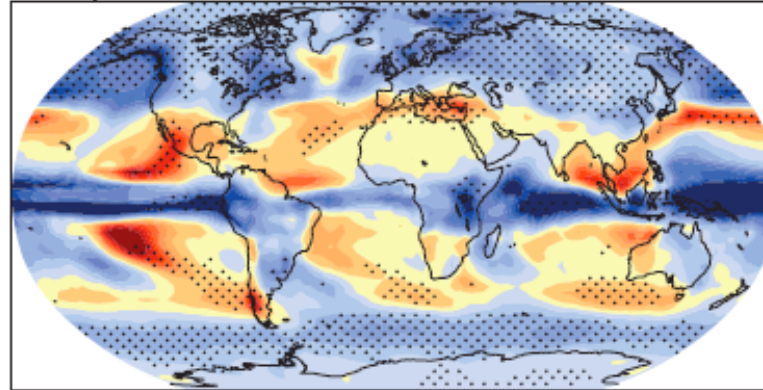


(IPCC 2007)

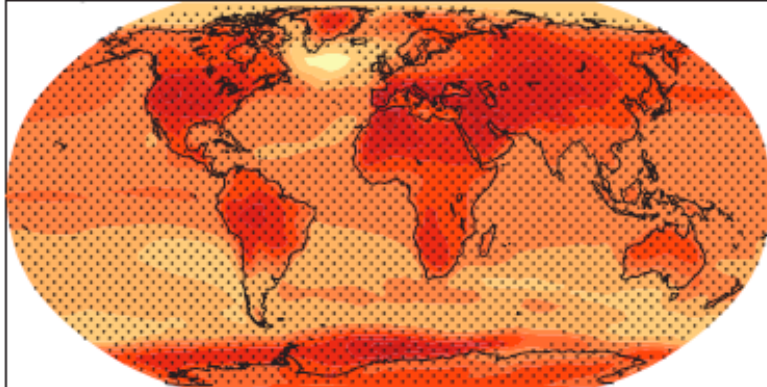
Temperature A1B: 2080-2099



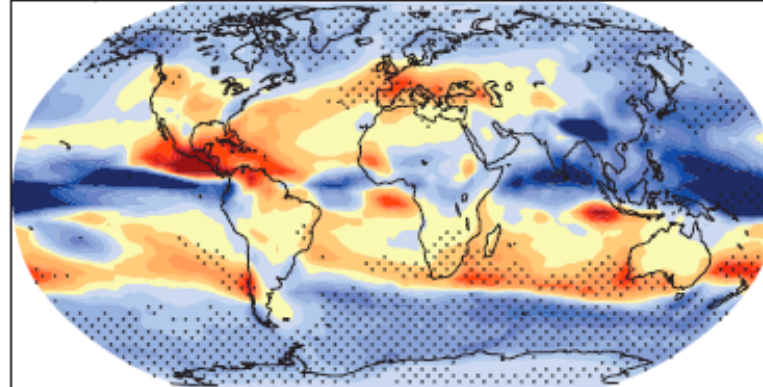
DJF Precipitation A1B: 2080-2099



Temperature A1B: 2080-2099



JJA Precipitation A1B: 2080-2099



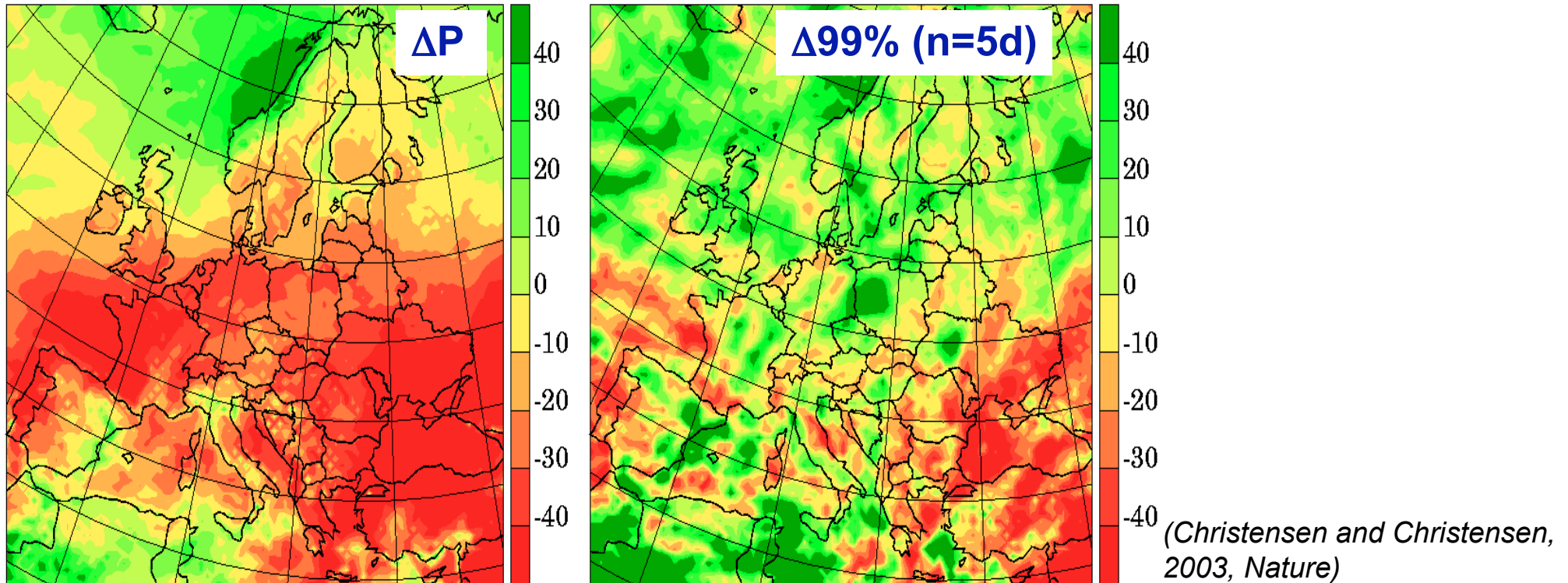
Projected changes in temperature and precipitation (2080-2099) vs (1980-1999)

Regional changes are distinct from global mean changes

(IPCC 2007)

Europe: Changes in climate extremes (precipitation)

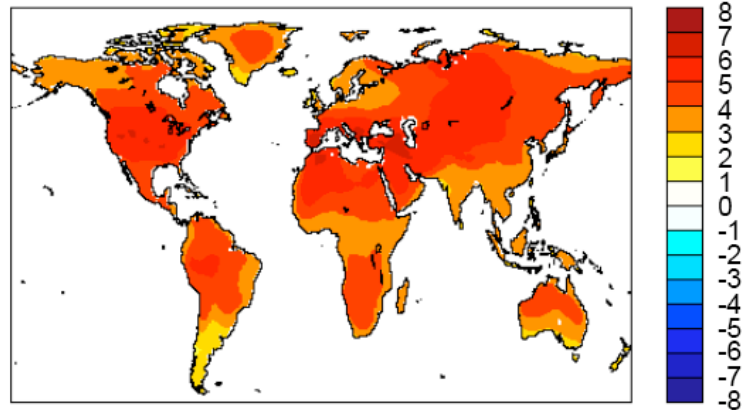
(JAS, 2071-2100 vs 1961-1990)



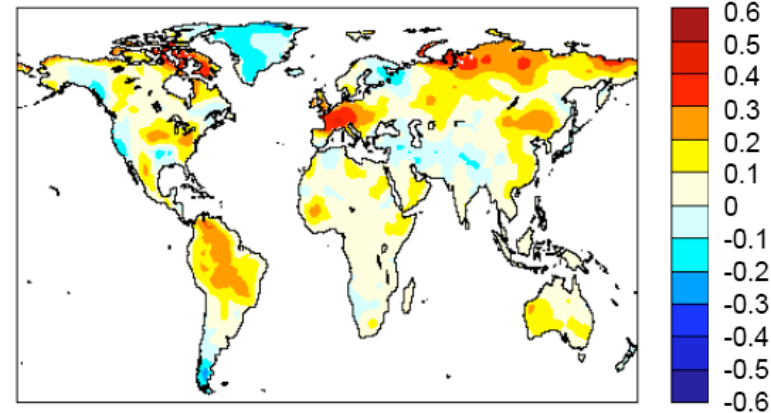
- In Europe, climate models project both a **decrease** of mean precipitation (enhanced drought) and **increase** of precipitation extremes

Europe: Changes in climate extremes (temperature)

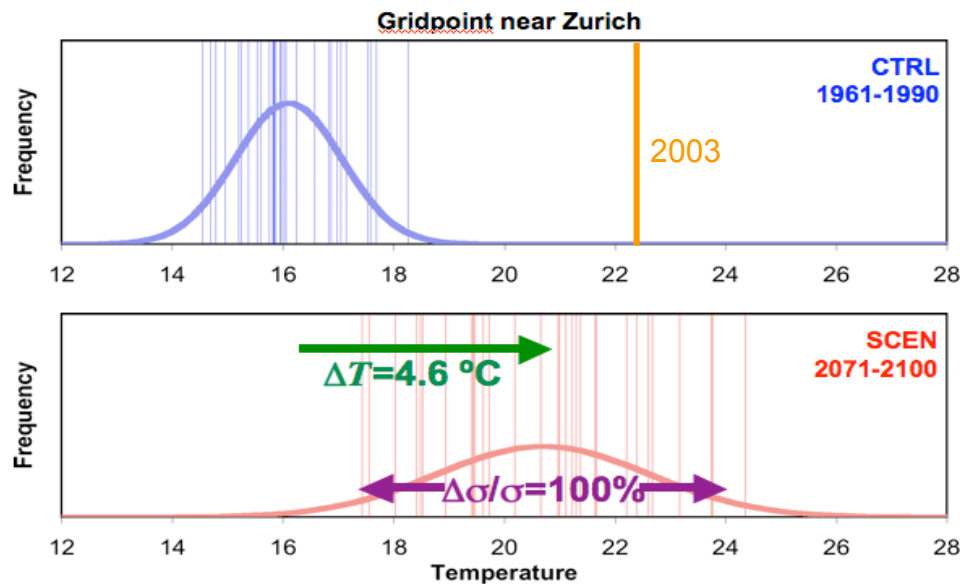
ΔT_{2M} [°C], IPCC scenarios (A2-20c3m), JJA



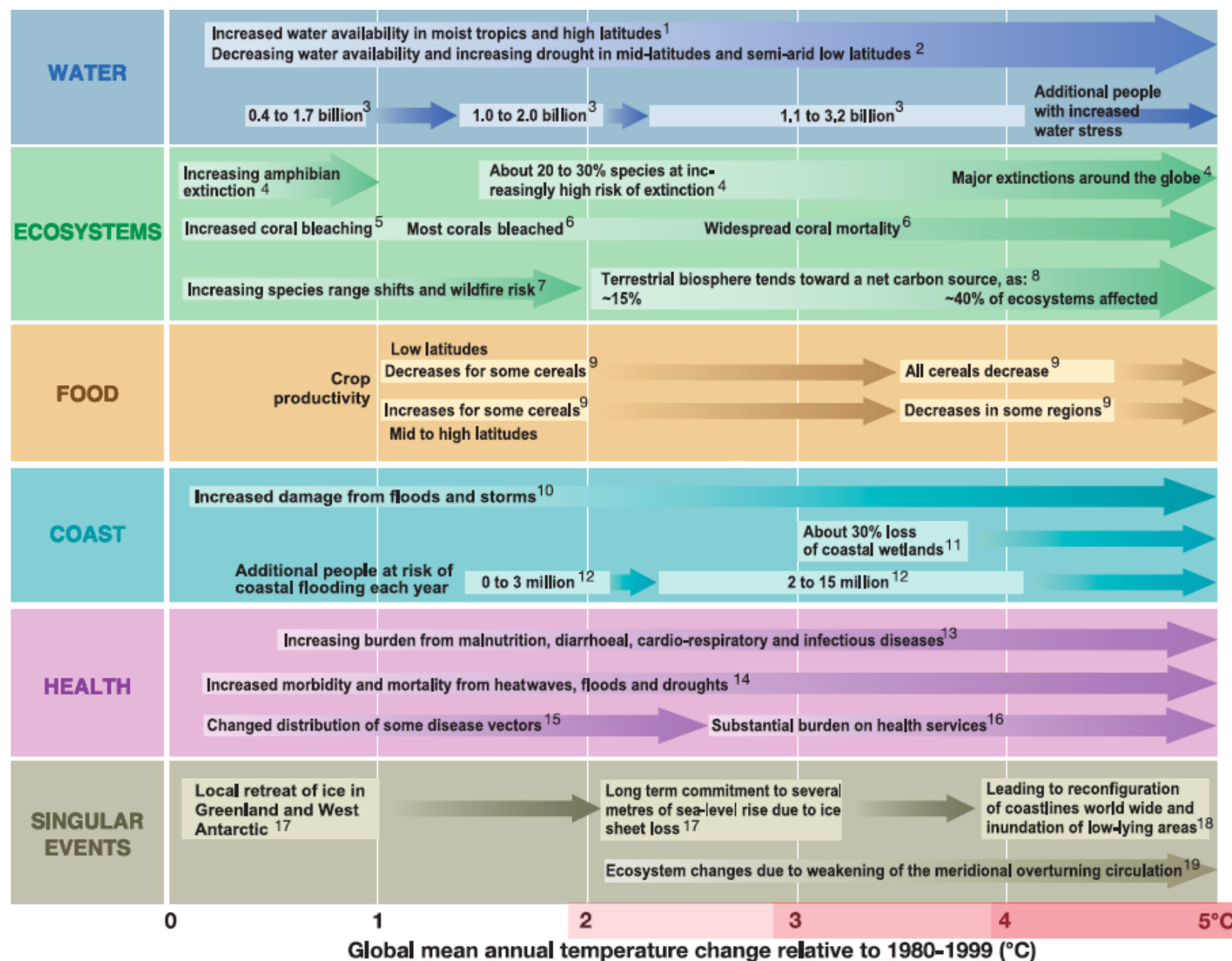
$\Delta \text{Stdev}(T_{2M})$ [°C], IPCC scenarios (A2-20c3m), JJA



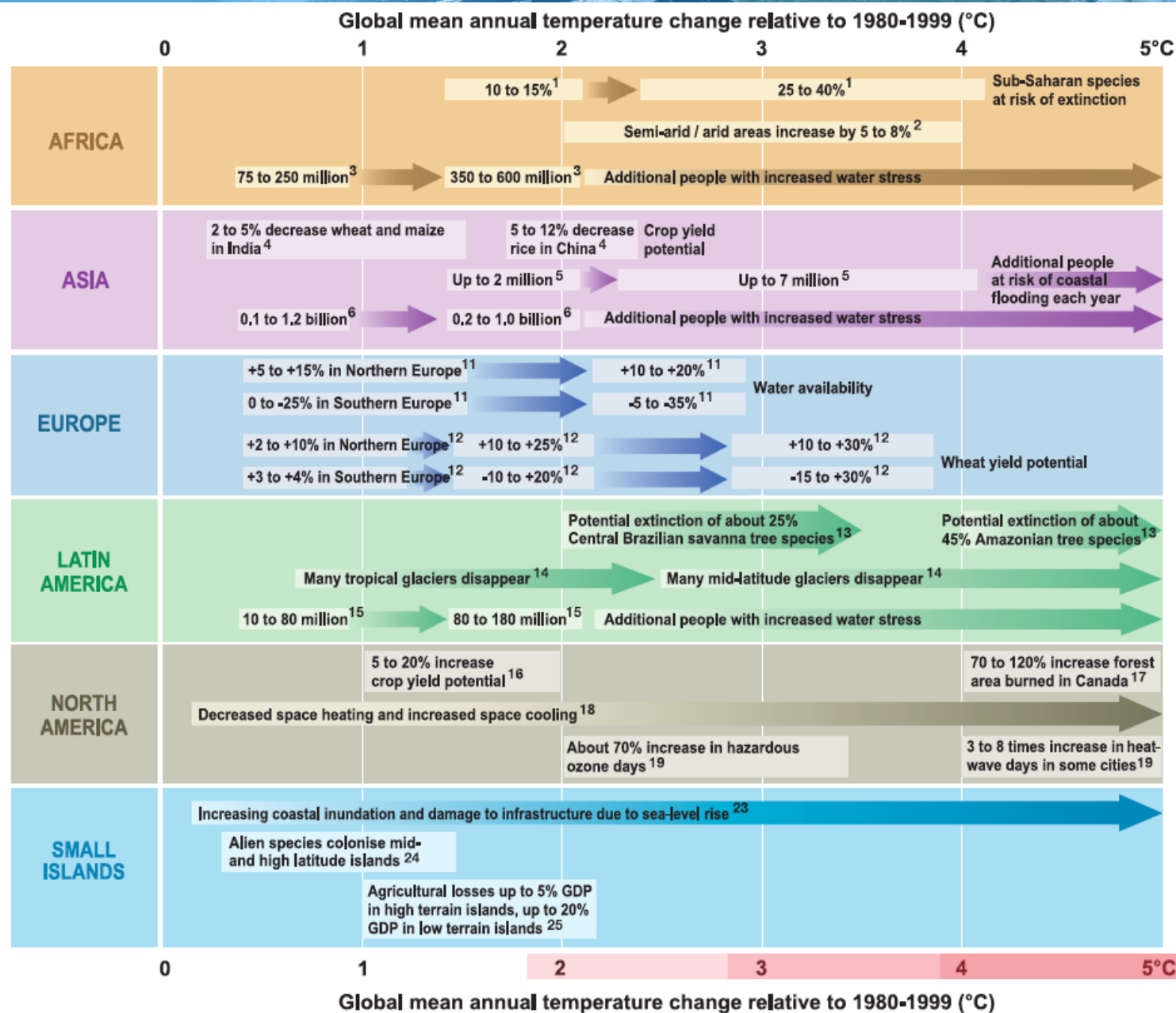
(Seneviratne et al. 2006, Nature)



(Schär et al. 2004, Nature)



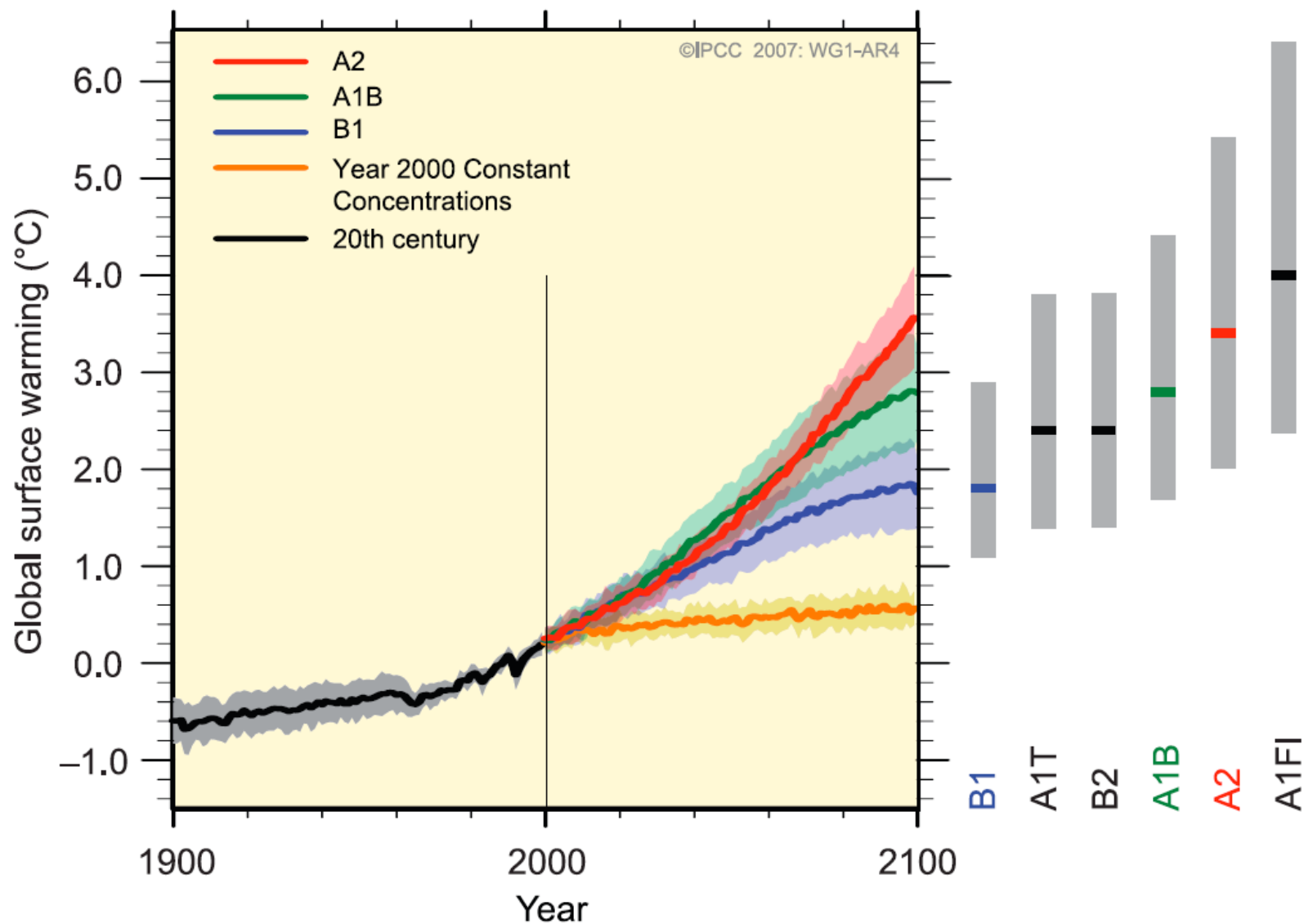
(IPCC 2007)



(IPCC 2007)

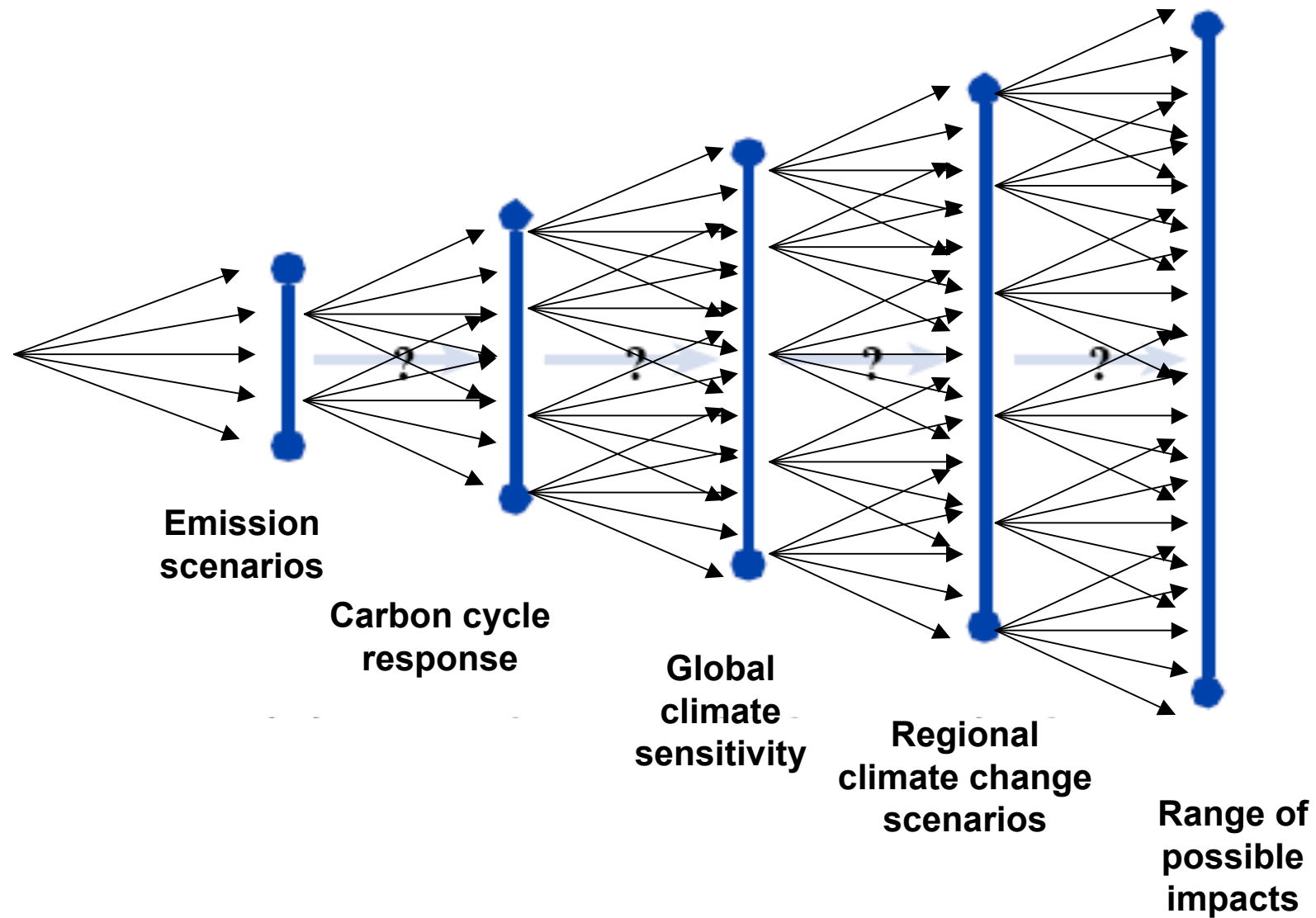
Projections of global temperature changes

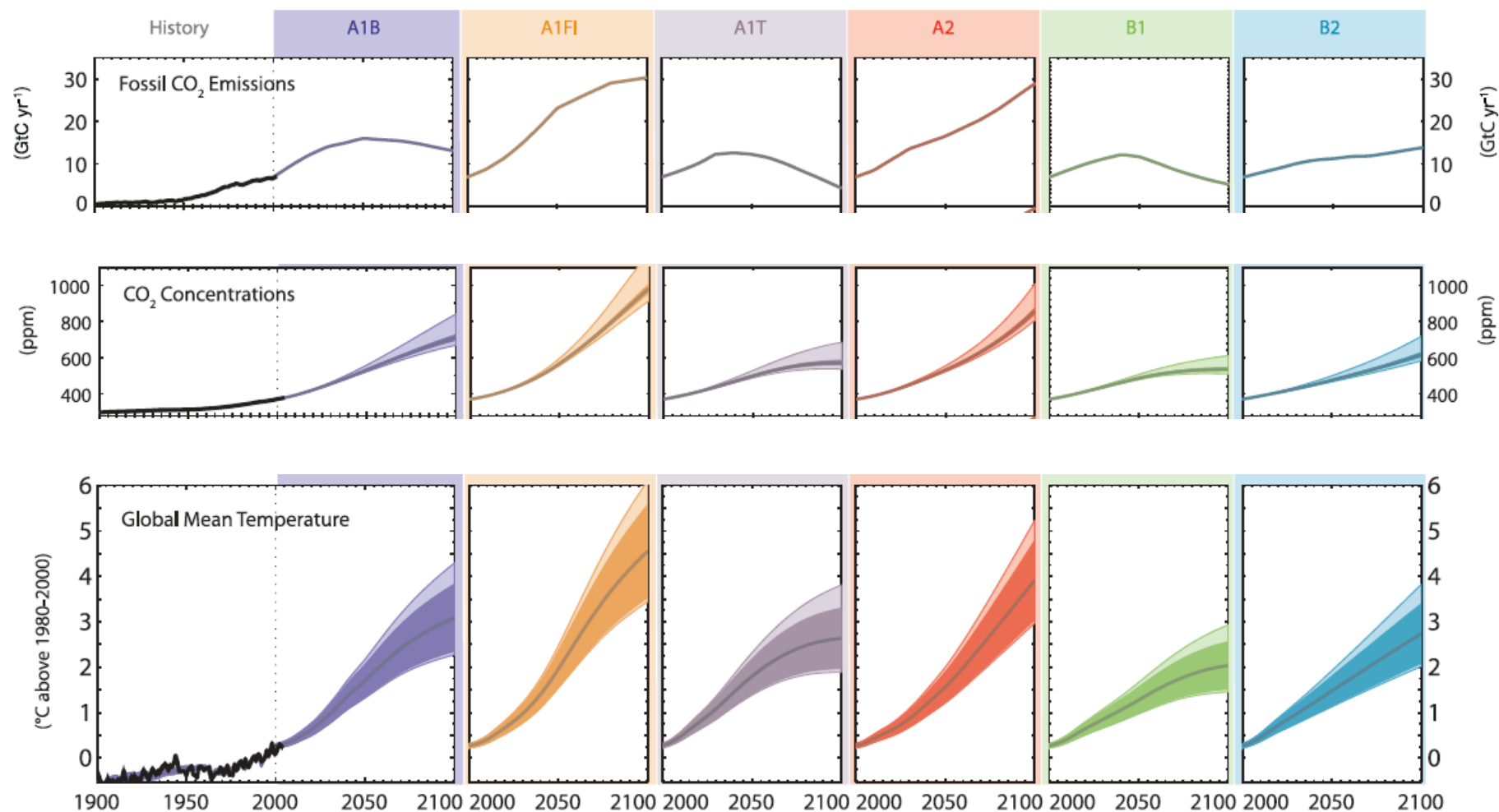
MULTI-MODEL AVERAGES AND ASSESSED RANGES FOR SURFACE WARMING

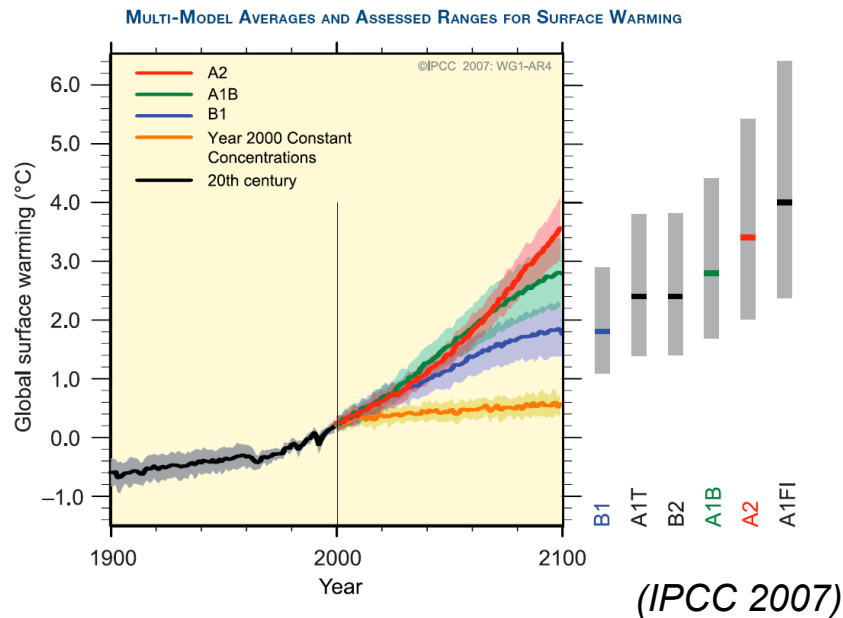


(IPCC 2007)

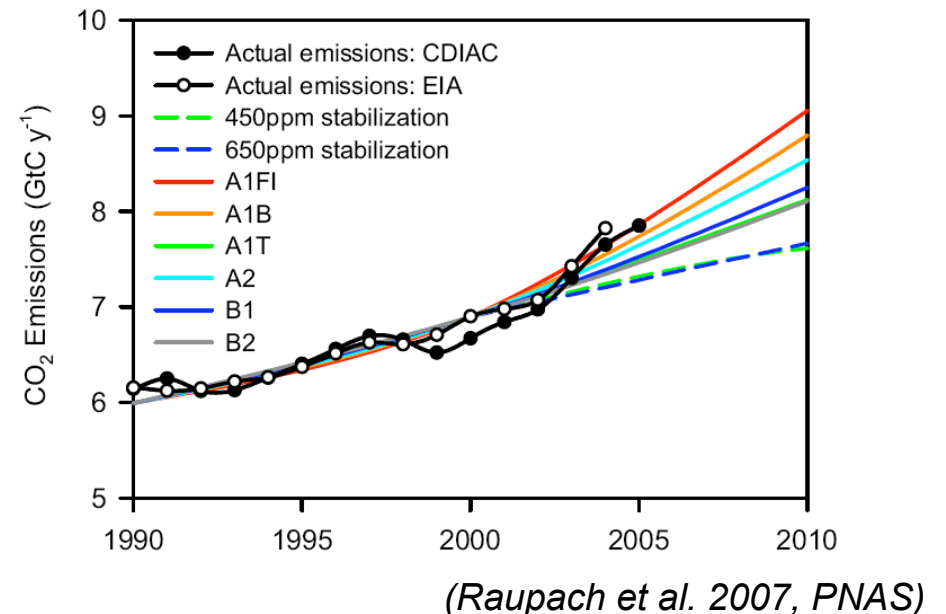
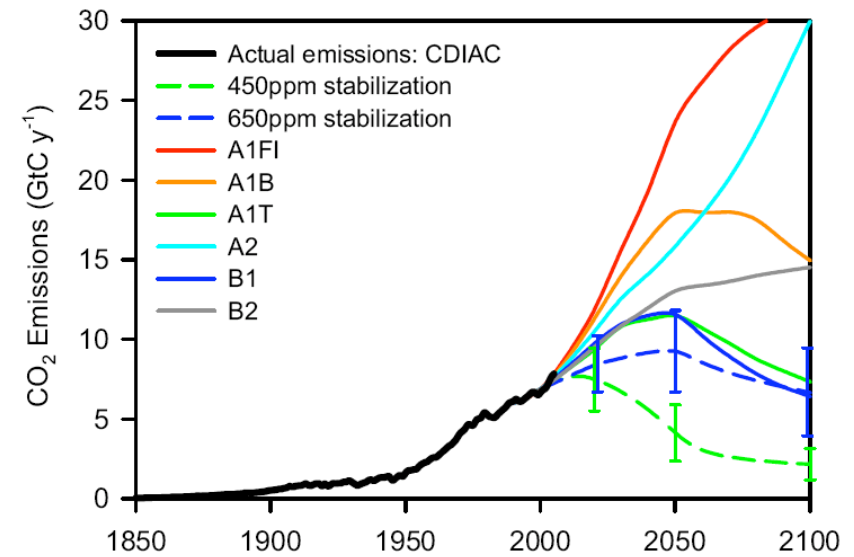
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- Conclusions



*(IPCC 2007)*



- Current emissions follow highest IPCC scenarios!
- Stabilisation of CO₂ concentrations is only possible if emissions are very significantly reduced compared to present



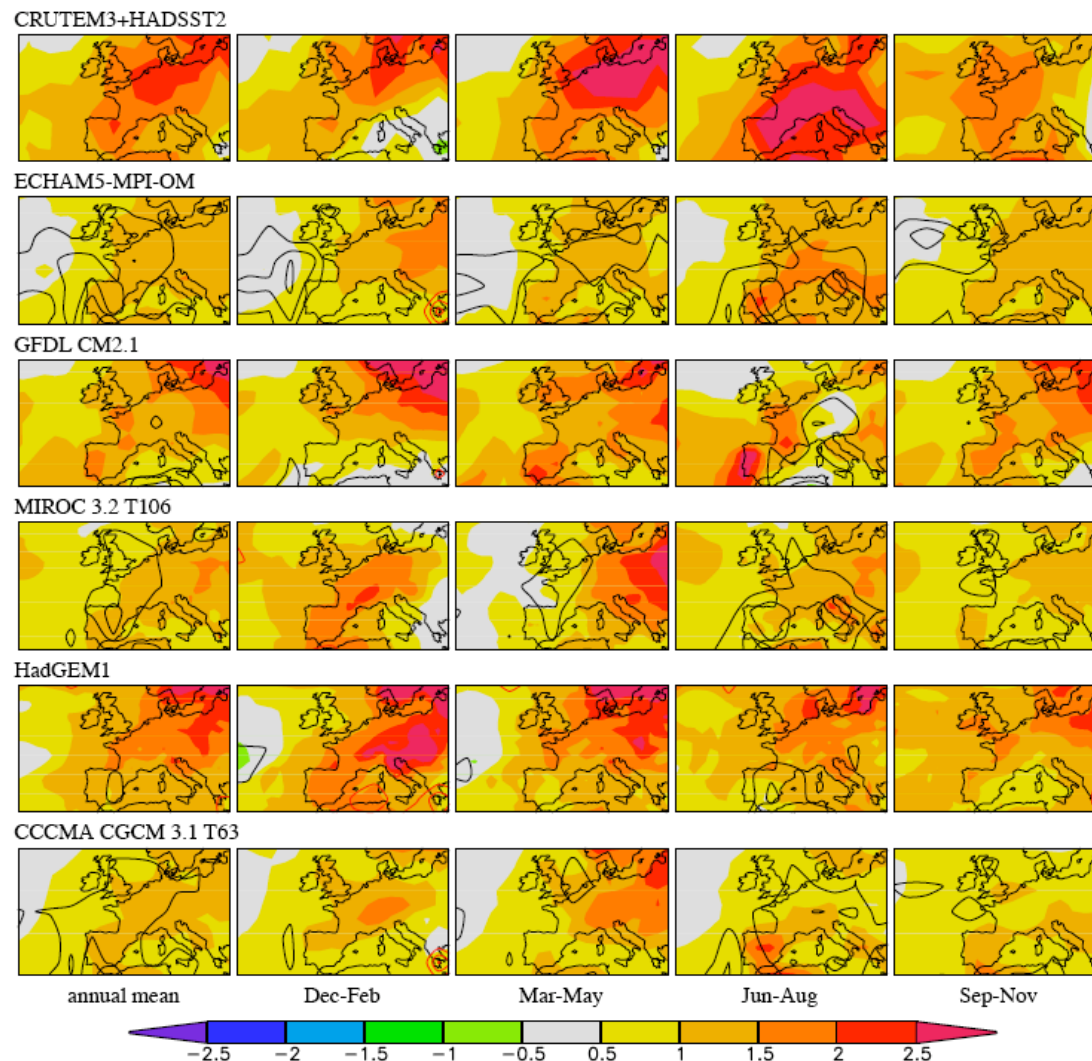
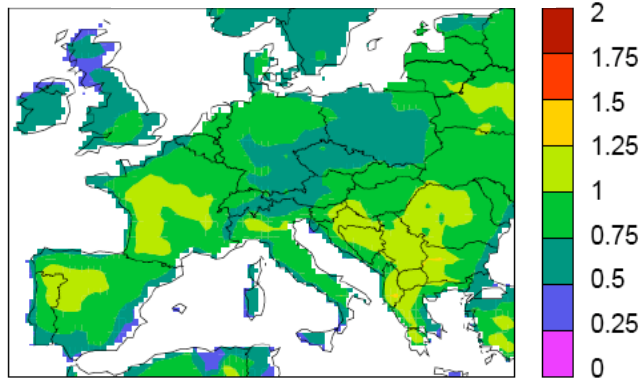


Fig. 3. The trends in temperature in western Europe as the regression against global mean temperature [K/K] in the observations and the GCMs with the most realistic mean circulation in Europe over 1950–2007. The contours denote the number of standard errors between the observed and modelled trends starting at $z=2$ (black) and $z=-2$ (red).

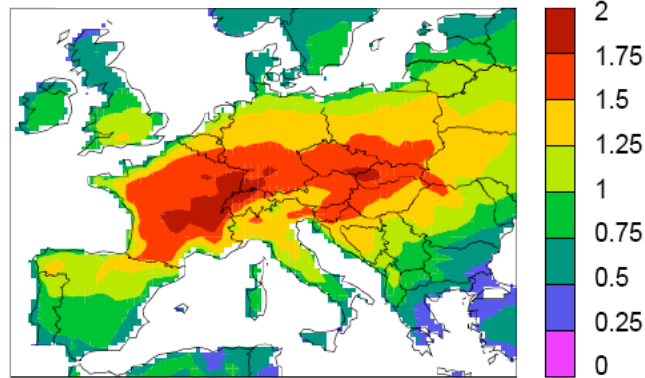
(van Oldenborgh et al.,
Clim. Past, 2009)

Changes in interannual variability of summer temperature (Standard deviation of the summer (JJA) temperature)

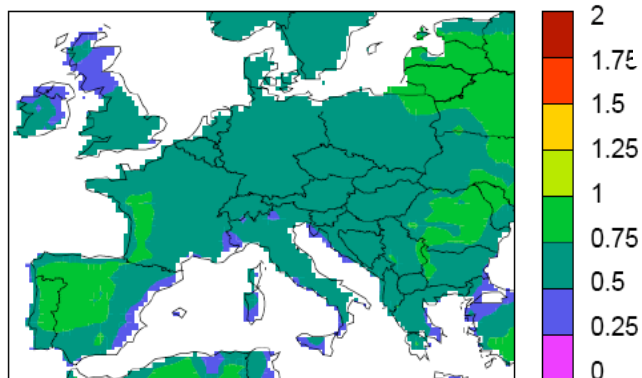
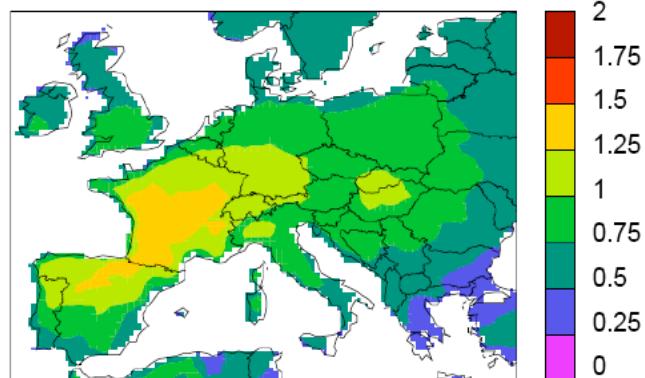
CTL (1970-1989)



SCEN (2080-2099)



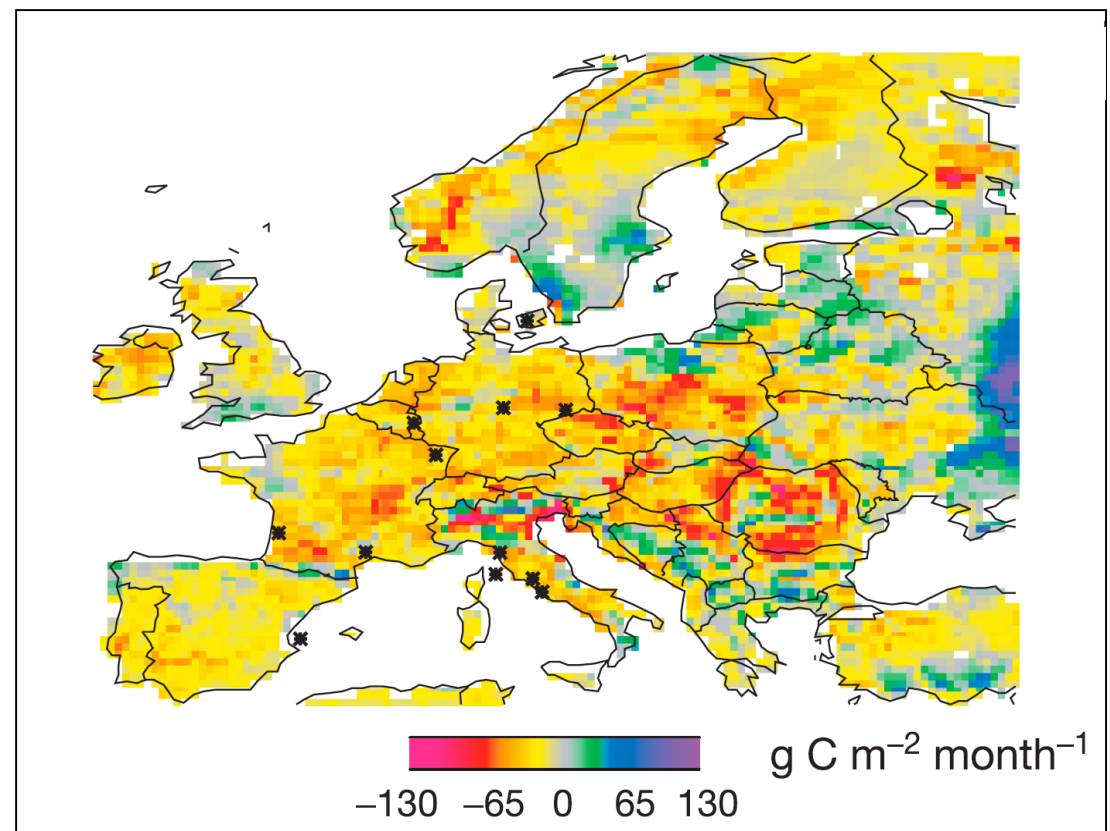
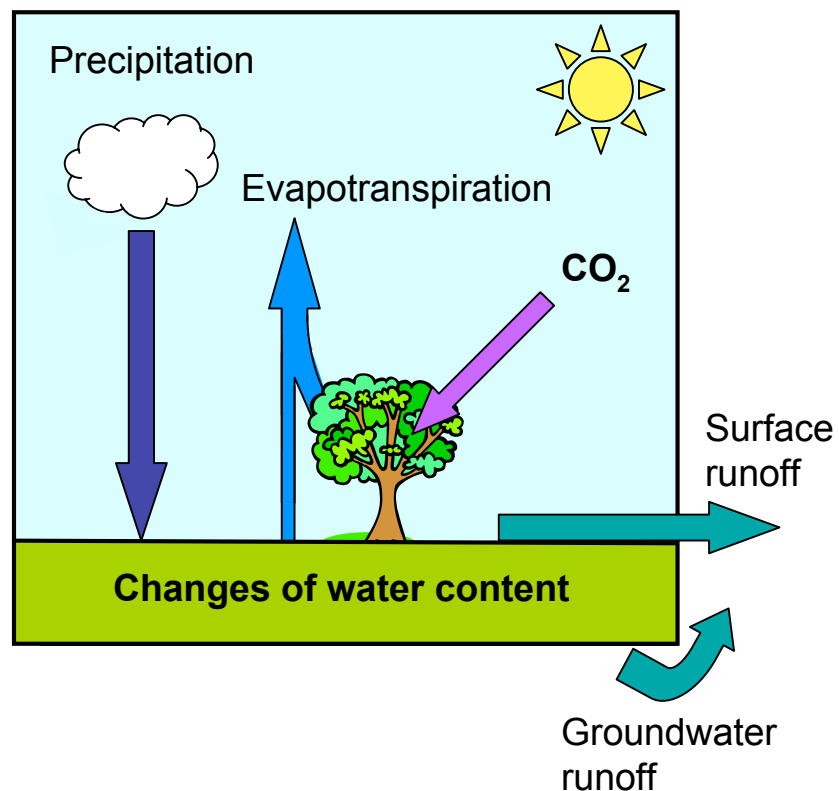
Large decrease of T° variability when effect of soil moisture is removed

CTL_{UNCOUPLED}SCEN_{UNCOUPLED}

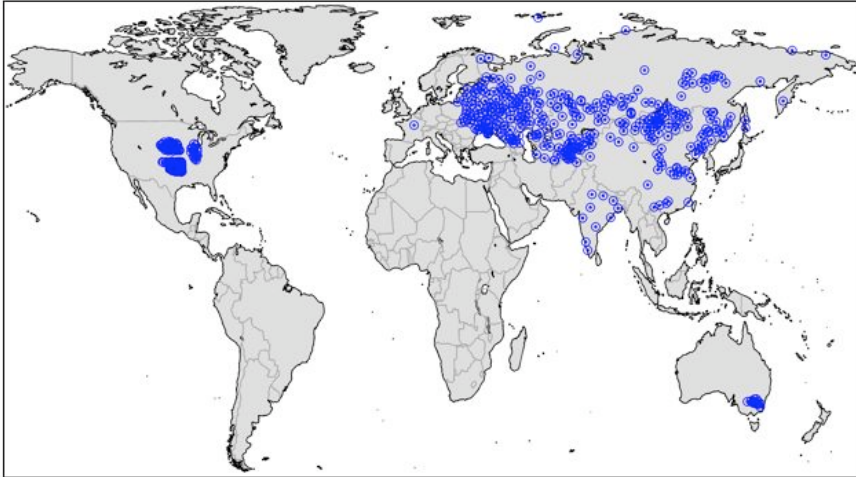
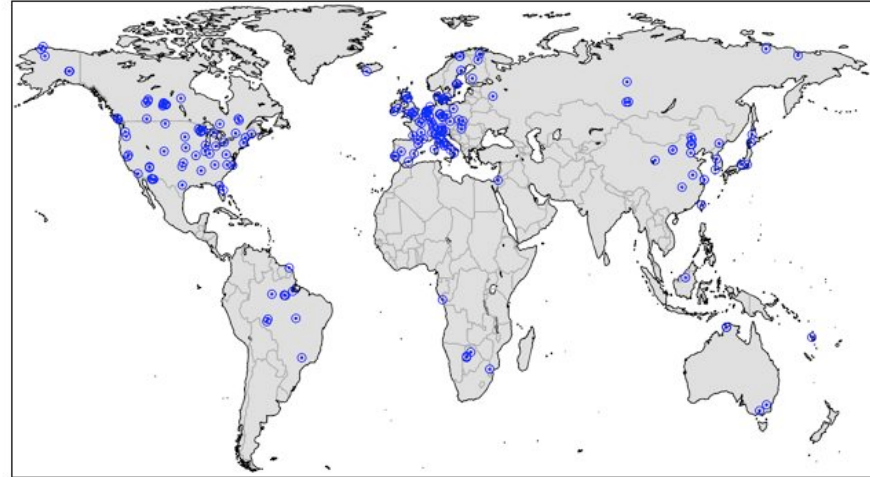
(Seneviratne et al. 2006, Nature)

Soil moisture - CO₂ interactions

Europe transformed in carbon source in summer 2003 (heatwave/drought)



(Ciais et al., Nature, 2005)

(a) Global Soil Moisture Data Bank**(b)** FLUXNET LaThuile Synthesis Dataset

(Seneviratne et al. 2009,
Earth-Science Reviews, submitted)

Issue: Lack of land surface observations in many areas of the world

Difficulties to validate key feedbacks such as those associated with soil moisture content...

SwissSMEX: Swiss Soil Moisture Experiment (2008-2011; SNF)

ETH Zurich, IAC: S.I. Seneviratne (PI), H. Mittelbach, I. Lehner, A.J. Teuling, K. Schrott

Agroscope ART: J. Fuhrer (co-PI), C. Ammann

MeteoSwiss: M. Rotach (co-PI), Y-A. Roulet



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LESERKOMMENTARE

23.08.08 TB: Interesting results

21.08.08 Nachbarschaft: Trotzdem Toleranz-Niveau

Klimaforschung

Der Bodenfeuchte auf den Grund gehen

Wie feucht ein Boden ist, hat grossen Einfluss auf das Regionalklima. Doch die Klimawissenschaft hat wenig Ahnung, wie gross dieser Beitrag wirklich ist. Ein neues, dichtes Messstellennetz in der Schweiz wird die dazu nötigen Daten liefern.

Das Testfeld vor Oensingen ist topfeben. Ausgedehnte Wiesen bis zum nächsten Hügel am Horizont und zur Autobahn A1, ein paar Gehölzstreifen. Die höchsten Erhebungen im Umkreis von einem halben Kilometer sind mehrere Erdhaufen, die auf der Wiese auf blauen Planen lagern. Drei Tonnen Material, schwerer lehmiger Gley-Boden aus zwei 1,20 Meter tiefen Gruben. Alles von Hand ausgehoben.

Doktorandin Heidi Mittelbach richtet eine Messstelle ein zur Erfassung von Bodenfeuchtigkeit und -temperatur. (mehr Bilder)

Blaue Erde

Irene Lehner, Postdoktorandin am Institut für Atmosphäre und Klima sowie die Doktorandin Heidi Mittelbach stehen in Gruben und stecken in regelmässigen Abständen Messsonden in den lehmigen Boden. Noch am Vorabend haben die Forscherinnen ein 100jähriges Niederschlagsereignis über einem Quadratmeter simuliert, das Wasser blau, mit Lebensmittelfarbe eingefärbt, um bevorzugte Fliesswege zu erkennen. Die Schollen sind noch immer blau, die Schuhe, und die Hosensäume von Mittelbach ebenso. Dafür erkennt sie nun im Aushub, wo das Wasser versickert ist, das Bodenprofil sieht aus wie ein Marmorkuchen. Unter Einsatz ihres Körpergewichts lässt Mittelbach die Sonden vor allem in den braunen Stellen verschwinden.

In jeder Grube stecken die Forscherinnen in sechs verschiedenen Tiefen Sonden in den Erdboden, um die Bodentemperatur zu messen oder um den Wassergehalt festzuhalten. Alle zehn Minuten senden die Sonden Daten an ein Aufzeichnungsgerät, den Logger, der in einem Gehäuse über Boden eingebaute ist.

SCIENCE

Klimawandern mit der Maus

Ein Haus für die Zukunft

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CAMPUS

Visionäres Forschungsinstitut feiert Jubiläum

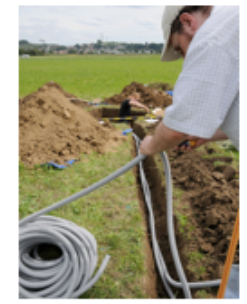
Wahrzeichen fürs Weltpublikum

weitere Artikel aus Campus

ETH-INTERN

Vom Bleistift bis zur Fruchtfliege

Projektleiter verlässt Science City



- Introduction
- Evidence from observations and climate model projections
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- **Climate change is happening** and is due for the most part to anthropogenic greenhouse gas emissions
- **Associated impacts are of strong concern** for most regions of the world; **we are committed to some level of warming**, but by reducing emissions, **we can still reduce risks of extreme climate impacts**
- **In Europe, very strong changes are projected:** increase of temperature variability and occurrence of heat waves, decrease of mean precipitation, increase of precipitation extremes; *observed changes appear to follow the higher-end scenarios*
- **Uncertainties remain** regarding realistic emission scenarios, resulting CO₂ concentrations, global climate sensitivity and in particular regional impacts; **the reduction of current scenario uncertainties is crucial for the development of adequate adaptation strategies**