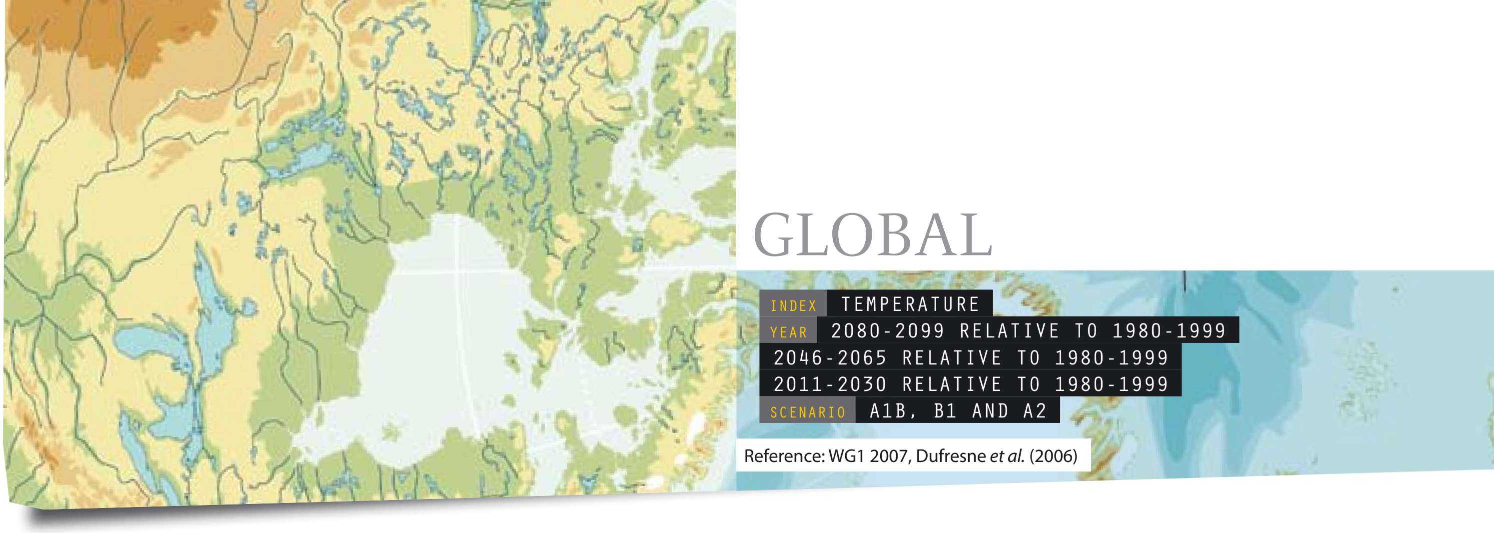


GLOBAL

INDEX TEMPERATURE
YEAR 2080-2099 RELATIVE TO 1980-1999
2046-2065 RELATIVE TO 1980-1999
2011-2030 RELATIVE TO 1980-1999
SCENARIO A1B, B1 AND A2

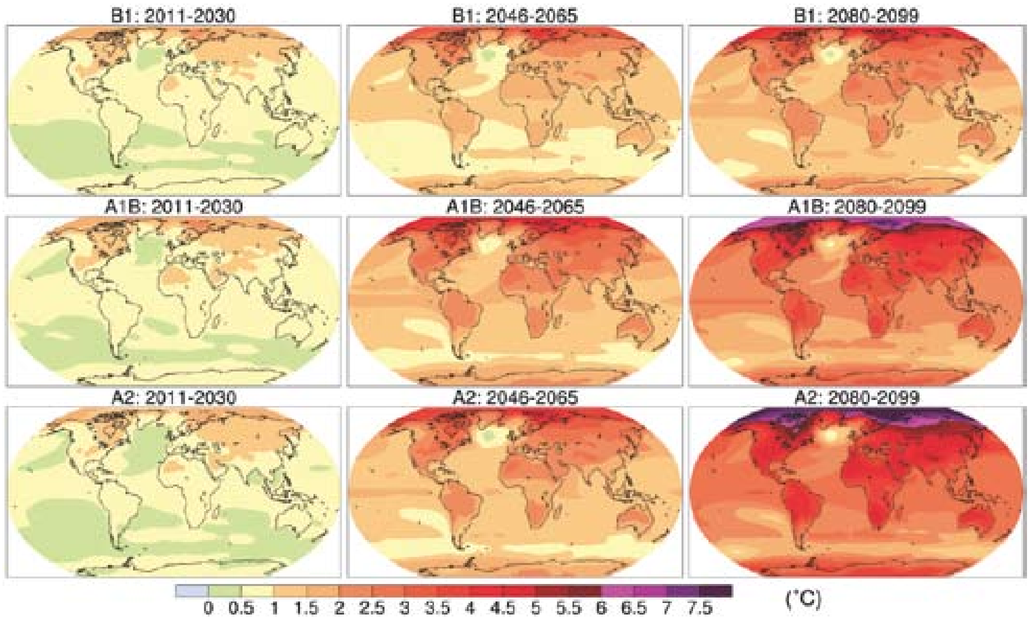
Reference: WG1 2007, Dufresne *et al.* (2006)

1 The major trends in temperature

1.1 The factors influencing temperature

The temperature change caused by the increase in atmospheric CO_2 concentration results from the direct CO_2 response, and from the different feedbacks[1] that modify water vapour, snow cover, clouds and oceanic and atmospheric circulation. An increase in atmospheric CO_2 first contributes to a positive radiative forcing[2] due to absorption of infrared radiation in the atmosphere ("enhanced" greenhouse effect). The associated temperature rise increases the water-holding capacity of the atmosphere and modifies a number of physical processes. In general, the direct greenhouse gas forcing and the radiative effects linked to the different feedbacks (positive or negative) control the surface temperature of the Earth.

Two main physical reasons explain these temperature changes in a given place. First, the total energy of a given air particle is modified by the balance between radiation fluxes (incoming solar and outgoing infrared radiation), sensible heat flux (heat conduction) and latent heat flux (associated with water phase transition). Its temperature varies according to different thermodynamic processes. Second, the air particle temperature is also influenced by heat advection, particularly by horizontal winds that can increase or counterbalance local warming.



MODIFIED AND BASED ON WORKING GROUP I CONTRIBUTION TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007: THE PHYSICAL SCIENCE BASIS. FIGURE 10.8. CAMBRIDGE UNIVERSITY PRESS.

FIGURE 1 Multi-model mean of annual mean surface warming (surface air temperature change, °C) for the scenarios B1 (top), A1B (middle) and A2 (bottom), and three time periods, 2011 to 2030 (left), 2046 to 2065 (middle) and 2080 to 2099 (right). Stippling is omitted for clarity. Anomalies are relative to the average of the period 1980 to 1999.

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[1] Positive feedbacks amplify the initial disturbance; negative feedbacks dampen it.

[2] See section 2 of the "using climate IPCC models" sheet for further information.

1.2 Characteristics of temperature changes

FIGURE 1 indicates that for the next decade, the global temperature increase due to human activity is in line with the considerable pertubation in greenhouse gas concentration (high scenario, A2, compared to the low scenario, B1). From a general viewpoint, the continents warm more than the oceans (which cover two thirds of the planet).

In tropical regions, this result is partly explained by changes in evaporation (Dufresne *et al.,* 2006). Lose of heat flux during water evaporation cools the surface. In the oceans, the quantity of water available is not limited, whereas it is limited on the continents by the soil water content, which is itself linked to the total amount of precipitation. Thus, cooling is limited on continents, but not in the oceans over the oceans. In the mid- and high latitudes, the small increase in ocean temperature is also due to its own thermal inertia, partly due to (1) heat transport from the surface to the ocean depths (by ocean dynamics), but also (2) the slow rate of heat penetration in the ocean.

In and around the Arctic Basin, the very high increase in temperature is partly due to feedback between the albedo (surface reflectivity of solar radiation) and the temperature. For example, in summer, when the temperature increases, the snow and sea ice cover decrease, which reduces the surface albedo and tends to amplify the initial temperature increase.

2 Uncertainties

2.1 The mean state

FIGURE 3 indicates that the climate models agree on the increase in winter and summer temperatures across the globe, except for southern Greenland. Temperature is a variable that can be considered linea; as a consequence its future projection is relatively reliable. Furthermore, **FIGURE 3** shows that the mean state for temperatures is consistently represented between the different models, whatever the horizontal scale considered (at the local and global levels).

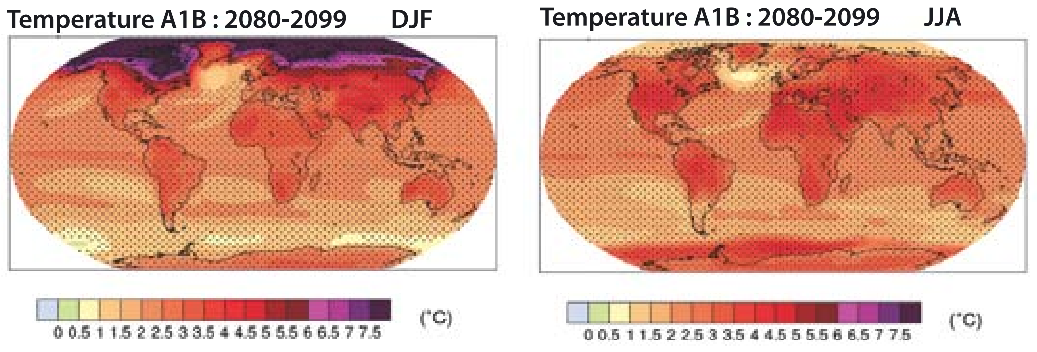

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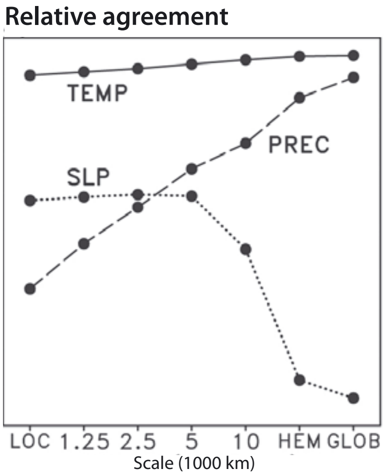
FIGURE 2 Multi-model mean changes in surface air temperature (°C) for boreal winter (DJF, left) and summer (JJA, right). Changes are given for the SRES A1B scenario, for the period 2080 to 2099 relative to 1980 to 1999. Stippling denotes areas where the magnitude of the multi-model ensemble mean exceeds the inter-model standard deviation.

2.2 Variability

The change in variability is far more difficult to quantify than the mean state. Improvements have been made in model representation of phenomena such as El Niño (periodic anomaly in atmospheric circulation that disturbs surface waters in the Pacific Ocean), and the North Atlantic Oscillation (north-south oscillation in the air over the arctic and Icelandic regions towards the subtropical belt near the Azores and the Iberian Peninsula), but few converge on the results of projections. The dispersion between models comes mainly from physical parameterisations used in each model.



MODIFIED AND BASED ON WORKING GROUP I CONTRIBUTION TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007: THE PHYSICAL SCIENCE BASIS. FIGURE 10.27. CAMBRIDGE UNIVERSITY PRESS.

FIGURE 3 Statistics of annual mean responses to the SRES A1B scenario, for 2080 to 2099 relative to 1980 to 1999, calculated from the 21-member AR4 multi-model ensemble using the methodology of Räisänen (2001). Results are expressed as a function of horizontal scale on the x axis ('Loc': grid box scale; 'Hem': hemispheric scale; 'Glob': global mean) plotted against the y axis showing the relative agreement between ensemble members, a dimensionless quantity defined as the square of the ensemble-mean response (corrected to avoid sampling bias) divided by the mean squared response of individual ensemble members. Values are shown for surface air temperature, precipitation and sea level pressure. The low agreement in SLP changes at hemispheric and global scales reflects problems with the conservation of total atmospheric mass in some of the models. However, this has no practical significance because SLP changes at these scales are extremely small.