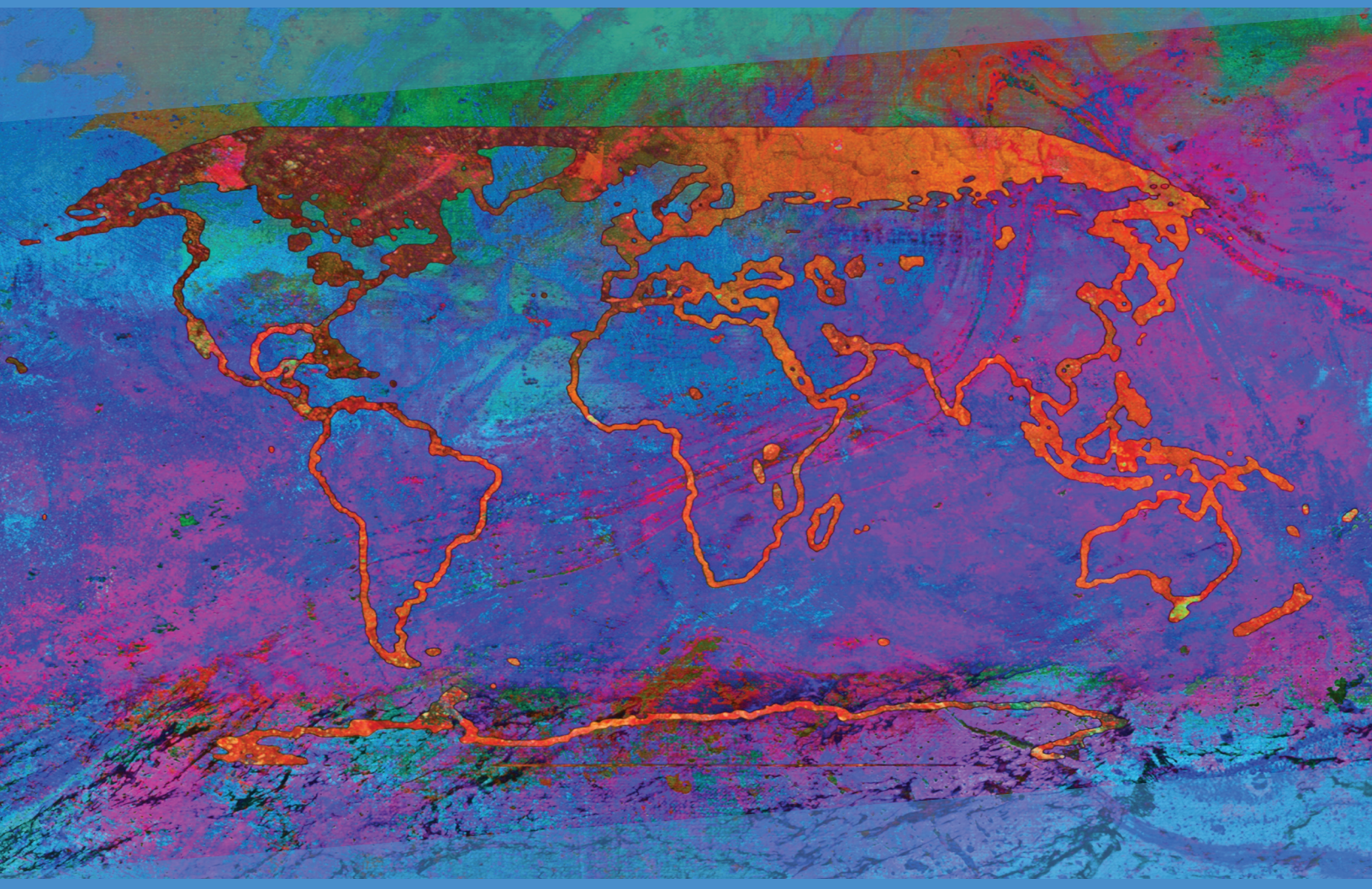
ipcc

INTERGOVERNMENTAL PANEL ON climate change

Climate Change 2021

The Physical Science Basis



WGI

Working Group I Contribution to the
Sixth Assessment Report of the
Intergovernmental Panel on Climate Change

WMO UNEP

Emergence (of the climate signal) Emergence of a *climate change* signal or trend refers to when a change in *climate* (the 'signal') becomes larger than the amplitude of natural or internal variations (defining the 'noise'), This concept is often expressed as a 'signal-to-noise' ratio and emergence occurs at a defined threshold of this ratio (e.g., S/N > 1 or 2). Emergence can refer to changes relative to a historical or modern baseline (usually at least 20 years long) and can also be expressed in terms of time (*time of emergence*) or in terms of a global warming level. Emergence is also used to refer to a time when we can expect to see a response to reducing *greenhouse gas (GHG)* emissions (emergence with respect to *mitigation*). Emergence can be estimated using observations and/or model simulations. See also *Time of emergence (ToE)*.

Emergent constraint An attempt to reduce the uncertainty in *climate projections*, using an ensemble of *Earth system models (ESMs)* to relate a specific feedback or future change to an observation of the past or current *climate* (typically some trend, variability or change in variability).

Emission factor/Emissions intensity A coefficient that quantifies the emissions or removals of a gas per unit activity. Emission factors are often based on a sample of measurement data, averaged to develop a representative rate of emission for a given activity level under a given set of operating conditions.

Emission pathways See *Pathways*.

Emissions See *Cumulative emissions*, *Anthropogenic emissions*, *Fossil fuel emissions*, *Non-CO_2 emissions and radiative forcing* and *Negative greenhouse gas emissions*. See also *Emissions scenario* (under *Scenario*), and *Emission pathways.*

Emulation Reproducing the behaviour of complex, process-based models (namely, *Earth system models, ESMs*) via simpler approaches, using either *emulators* or *simple climate models (SCMs)*. The computational efficiency of emulating approaches opens new analytical possibilities given that ESMs take a lot of computational resources for each simulation. See also *Emulators* and *Simple climate model (SCM)*.

Emulators A broad class of heavily parametrized models ('simple climate models'), statistical methods like neural networks, genetic algorithms or other artificial intelligence approaches designed to reproduce the responses of more complex, process-based *Earth system models (ESMs)*. The main application of emulators is to extrapolate insights from ESMs and observational constraints to a larger set of *emission scenarios*. See also *Emulation* and *Simple climate model (SCM)*.

Energy balance model (EBM) An energy balance model is a simplified climate model that is typically used as an emulator of climate to analyse the energy budget of the Earth to compute changes in the *climate*. In its simplest form, there is no explicit spatial dimension, and the model then provides an estimate of the changes in globally averaged temperature computed from the changes in radiation. This zero-dimensional energy balance model can be extended to a one-dimensional or two-dimensional model if changes to the energy budget with respect to latitude, or both latitude and longitude, are explicitly considered.

Energy balance The difference between the total incoming and total outgoing energy. If this balance is positive, warming occurs; if it is negative, cooling occurs. Averaged over the globe and over long time periods, this balance must be zero. Because the *climate system* derives virtually all its energy from the Sun, zero balance implies that, globally, the absorbed *solar radiation*, that is, *incoming solar radiation* minus reflected *solar radiation* at the top of the *atmosphere* and *outgoing longwave radiation* emitted by the *climate system* are equal.

Energy budget (of the Earth) The Earth is a physical system with an energy budget that includes all gains of incoming energy and all losses of outgoing energy. The Earth's energy budget is determined by measuring how much energy comes into the Earth system from the Sun, how much energy is lost to space, and accounting for the remainder on Earth and its *atmosphere*. *Solar radiation* is the dominant source of energy into the Earth system. Incoming solar energy may be scattered and reflected by clouds and *aerosols* or absorbed in the atmosphere. The transmitted radiation is then either absorbed or reflected at the Earth's surface. The average *albedo* of the Earth is about 0.3, which means that 30% of the incident solar energy is reflected into space, while 70% is absorbed by the Earth. Radiant solar or shortwave energy is transformed into sensible heat, latent energy (involving different water states), potential energy, and kinetic energy before being emitted as *infrared radiation*. With the average surface temperature of the Earth of about 15°C (288 K), the main outgoing energy flux is in the infrared part of the spectrum. See also *Sensible heat flux* and *Latent heat flux*.

Enhanced weathering A proposed method to increase the natural rate of removal of *carbon dioxide (CO_2)* from the *atmosphere* using silicate and carbonate rocks. The active surface area of these minerals is increased by grinding, before they are actively added to soil, beaches or the open *ocean*. See also *Carbon dioxide removal (CDR)* and *Anthropogenic removals*.

Ensemble A collection of comparable datasets that reflect variations within the bounds of one or more sources of *uncertainty* and that, when averaged, can provide a more robust estimate of underlying behaviour. Ensemble techniques are used by the observational, *reanalysis* and modelling communities. See also *Climate simulation ensemble*.

Equilibrium and transient climate experiment An equilibrium climate experiment is a *climate model* experiment in which the model is allowed to fully adjust to a change in *radiative forcing*. Such experiments provide information on the difference between the initial and final states of the model, but not on the time-dependent response. If the forcing is allowed to evolve gradually according to a prescribed *emissions scenario*, the time-dependent response of a climate model may be analysed. Such an experiment is called a transient climate experiment.

Equilibrium climate sensitivity (ECS) See *Climate sensitivity*.

Equilibrium line The spatially averaged boundary at a given moment, usually chosen as the seasonal *mass budget* minimum at the end of summer, between the region on a *glacier* where there is a net annual loss of ice mass (ablation area) and that where there is a net annual gain (*accumulation* area). The altitude of this boundary is referred to as equilibrium line altitude (ELA).