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Comprehensive, Up-to-Date Climate System Change Indicators, Trends and Interactions

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Abstract : Comprehensive climate change indicators and trends inform the state of the climate (system) with respect to present and future climate change scenarios and the urgency of mitigation and adaptation. With data records now going back for many decades, indicator trends can complement model projections. They are provided as datasets by several climate monitoring centers, reviewed by state of the climate reports, and documented by the IPCC assessments. Up-to-date indicators are provided here. Rates of change are instructive, as are extremes. The indicators include greenhouse gas (GHG) emissions (natural and synthetic), cumulative CO2 emissions, atmospheric GHG concentrations (including CO2 equivalent), stratospheric ozone, surface ozone, radiative forcing, global average temperature increase, land temperature increase, zonal temperature increases, carbon sinks, soil moisture, sea surface temperature, ocean heat content, ocean acidification, ocean oxygen, glacier mass, Arctic temperature, Arctic sea ice (extent and volume), northern hemisphere snow cover, permafrost indices, Arctic GHG emissions, ice sheet mass, sea level rise, and stratospheric and surface ozone. Global warming is not the most reliable single metric for the climate state. Radiative forcing, atmospheric CO2 equivalent, and ocean heat content are more reliable. Global warming does not provide future commitment, whereas atmospheric CO2 equivalent does. Cumulative carbon is used for estimating carbon budgets. The forcing of aerosols is briefly addressed. Indicator interactions are included. In particular, indicators can provide insight into several crucial global warming amplifying feedback loops, which are explained. All indicators are increasing (adversely), most as fast as ever and some faster. One particularly pressing indicator is rapidly increasing global atmospheric methane. In this respect, methane emissions and sources are covered in more detail. In their application, indicators used in assessing safe planetary boundaries are included. Indicators are considered with respect to recent published papers on possible catastrophic climate change and climate system tipping thresholds. They are climate-change-policy relevant. In particular, relevant policies include the 2015 Paris Agreement on “holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels” and the 1992 UN Framework Convention on Climate change, which has “stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.”

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