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Abstract

The interactions between wetlands and the hydrological cycle are well known with increasing attention being focused on environmental flows and the links between surface and ground water. The relationships between the climate and the water regime in wetlands has also been increasingly investigated, including from a methodological side given the uncertainty and variability associated with many past measurements. As there is less clarity about the effect of weather and climate, these terms are explained below within the context of global climate change and the role of wetlands.

Wetlands, Weather, and Climate: Understanding the Terms and Definitions

Jan Pokorný and Hanna Huryna

Contents

Introduction

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Weather – concerns the conditions of the atmosphere prevailing during any particular time and place. It is often referred to by such terms as temperature, humidity, wind velocity, precipitation, barometric pressure, and cloudiness. It is the day-to-day state of the atmosphere, and its short-term variation is minutes to weeks. Weather on Earth occurs primarily in the troposphere, or lower atmosphere, and is driven by energy from the Sun and the rotation of the Earth (The American Heritage Dictionary of the English Language 2011).

Climate – in a narrow sense is usually defined as the average weather conditions of a certain region, including temperature, rainfall, and wind, or more rigorously, as

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the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. Climate, therefore, represents the accumulation of daily and seasonal weather events over a long period of time. The classical period is 30 years, as defined by the World Meteorological Organization (WMO). Climate in a wider sense is the state, including a statistical description, of the climate system. On Earth, climate is most affected by latitude, the tilt of the Earth's axis, the movements of the Earth's wind belts, the difference in temperatures of land and sea, and topography. A simple way of remembering the difference is that "climate is what you expect (e.g., cold winters) and weather is what you get (e.g., a blizzard)" (Glossary of Climate Change Terms 2013).

Global warming – is a gradual increase in the overall temperature of the earth's atmosphere generally attributed to the greenhouse effect caused by increased levels of carbon dioxide, CFCs, and other pollutants (The American Heritage Dictionary of the English Language 2011).

Global climate change – is the periodic modification of Earth's climate brought about as a result of changes in the atmosphere as well as interactions between the atmosphere and various other geologic, chemical, biological, and geographic factors within the Earth system (Encyclopedia Britannica 2008).

Greenhouse effect – is the warming of an atmosphere by its absorbing and emitting infrared radiation while allowing shortwave radiation to pass on through (Ahrens 2011).

Radiation – the Sun with a surface temperature of about 6000 K radiates short wavelength energy (with a peak at 500 nm, corresponding to Planck's and Wien's laws). The atmosphere influences the spectrum of incident light both quantitatively and qualitatively. Shortwave radiation passes through clear atmosphere, and it is trapped by clouds. In the nineteenth century, Arrhenius pointed out that some atmospheric gases absorb longwave radiation, and an increase in their concentration would result in an increase of global temperature on the Earth. The gases mainly responsible for the earth's atmospheric greenhouse effect are water vapor, carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). They are called **greenhouse gases** (GHGs). The surface of the Earth, with its temperature ca. 300 K, emits longwave radiation (with a peak at 10000 nm).

Radiative forcing – is the change in the net radiative flux expressed in W m^{-2} (downward minus upward) at the tropopause or top of atmosphere. It occurs due to a change in an external driver of climate change, such as a change in the concentration of CO_2 or in the output of the Sun. The IPCC (2007) documents the radiative forcing caused by an increase in greenhouse gases in the atmosphere from 1750 as between 1–3 W m^{-2}. In the next 10 years, the radiative forcing is expected to increase by 0.2 W m^{-2}. Radiative forcing cannot be measured; it is calculated (Myhre et al. 2013) (Fig. 2).

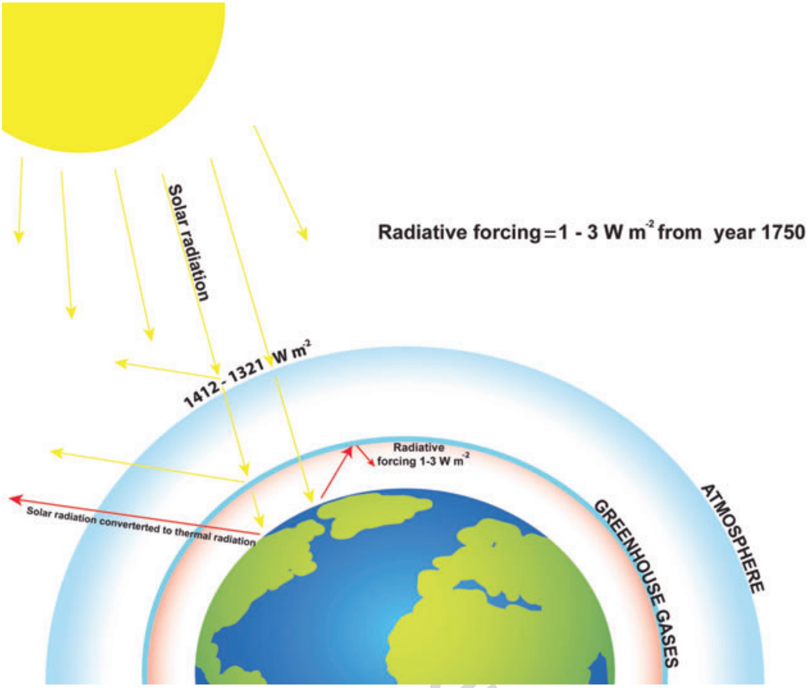

Fig. 1 1412–1321 W m^{-2} of solar energy comes on outer layer of Earth's atmosphere due to its elliptic trajectory. Radiative forcing caused by an increase in greenhouse gases in the atmosphere has risen by 1–3 W m^{-2} from 1750

Solar Energy Flux Between Sun and Earth

For a mean distance between the Sun and the Earth, the intensity of solar radiation incident upon a surface perpendicular to the Sun's rays measured above the atmosphere is approximately 1367 W m^{-2}. This quantity is called the **solar constant**. The actual direct solar irradiance at the top of the Earth's atmosphere fluctuates during a year from 1412 W m^{-2} to 1321 W m^{-2} due to the Earth's varying distance from the Sun (Kopp et al. 2005). The maximum irradiance on Earth's surface commonly lies between 800 W m^{-2} and 1000 W m^{-2} in the tropics and subtropics and during the growing season in temperate zones. This indicates that approximately 25–40 % of energy incident on the upper layer of the atmosphere is reflected, scattered, or absorbed in the atmosphere and does not reach the Earth's surface (Fig. 1). AU3

The amount of incoming energy differs significantly with weather conditions. The difference between the amounts **of incoming radiation on a clear day** (e.g., 8.5 kWhm^{-2} and maximum flux 1000 W m^{-2}) can be an order of magnitude higher than the amount of incoming radiation **on an overcast day** (e.g., 0.78kWhm^{-2}, maximum flux 100 W m^{-2}). Part of the energy is reflected straight away after incidence.

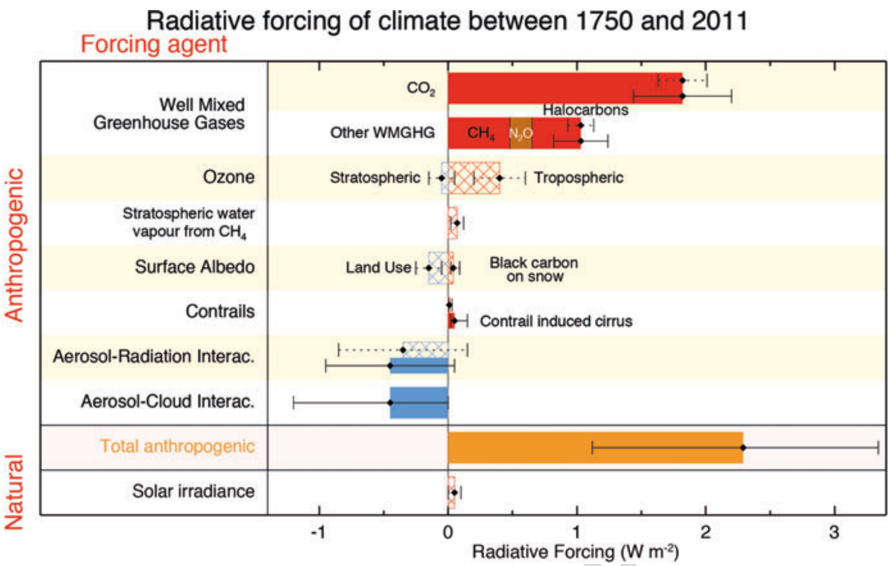

Fig. 2 Radiative forcing of climate caused by individual agents and total radiative forcing between 1750 and 2011 (Myhre et al. 2013). Total RF is less than 2.3 W m^{-2} with standard deviation 1.1 W m^{-2}

The ratio of reflected to incident radiation is called **albedo**. Dark surfaces such as water, wet soil, and wet vegetation absorb solar radiation whereas light surfaces like snow or sand are more reflective. The sum of incoming radiation minus all outgoing radiation across a unit area of the plane is called **net radiation**.

Main Fluxes of Solar Energy in Landscape

There is a big difference between the distributions of net radiation in functioning natural ecosystems of high plant biomass well supplied with water (such as wetlands) versus dry, nonliving physical surfaces. In ecosystems, net radiation (Rn) is divided in varying proportion into following four parts: latent heat flux (LE), sensible heat flux (H), ground heat flux (G), and storage of energy (S).

Latent heat flux represents the energy that is released or absorbed from the surface during phase transition process. Transition of liquid into a gas phase consumes energy and thus local cooling accompanies it. Latent heat flux is generally referred to as evapotranspiration, which describes the total evaporation from land surface and transpiration by plants. **Evapotranspiration** from wetlands use several hundred W m^{-2} on a sunny day.

Sensible heat flux represents the sum of all heat exchanges between the surface of landscape and its surroundings by conduction and convection. The proportion of sensible heat in the energy balance of an ecosystem increases when water is not present, since the capacity for evaporative cooling by latent heat is diminished. On dry surfaces, the sensible heat flux may reach values of several hundreds of W m^{-2} at a sunny day (Huryna et al. 2014).

Ground heat flux is positive when the ground is warming, normally being positive during the day and negative at night. During the plant-growing period in daylight hours, G can reach up to 100 W m^{-2}.

The **energy stored** in vegetation is the smallest part of R_n. There are two energy sinks within a plant stand: metabolic sink (**photosynthesis** with consequent biomass production) and a physical sink (**heating of the plant material** itself). Energy stored flux is a maximum of 30 W m^{-2} on a sunny day, i.e., several percent of $R_{n.}$

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