Chapter 3. Climate classification

Introduction

The purpose of any classification system is to obtain an efficient arrangement of information in a simplified and generalized form. Climate statistics can be organized in order to describe and delimit the major types of climate in quantitative terms. Obviously, any single classification can serve only a few purposes satisfactorily and many different schemes have therefore been developed. Many climatic classifications are concerned with the relationships between climate and vegetation or soils and rather few attempt to address the direct effects of climate on humans.

Only the basic principles of generic classifications related to plant growth or vegetation are summarized here.

3.1 Generic classification related to plant growth or vegetation

Numerous schemes have been suggested for relating climate limits to plant growth or vegetation groups. They rely on two basic criteria – the degree of aridity and of warmth. Aridity is not simply a matter of low precipitation, but of the 'effective precipitation' (i.e., precipitation minus evaporation). The ratio of rainfall/temperature is often used as an index of precipitation effectiveness, since higher temperatures increase evaporation. W. Köppen developed the pre-eminent example of such a classification. Between 1900 and 1936, he devised several classification schemes that involve considerable complexity in their full detail. The system has been used extensively in geographical teaching. The key features of Köppen's approach are temperature criteria and aridity criteria.

3.1.1 Temperature criteria

Five of the six major climate types are based on monthly mean temperature values.

1. Tropical rainy climate: coldest month >18°C. \
2. Dry climates.
3. Warm temperate rainy climates: coldest month between –3° and +18°C, warmest month >10°C.
4. Cold boreal forest climates: coldest month <–3°, warmest month >10°C. Note that many American workers use a modified version with 0°C as the C/D boundary.
5. Tundra climate: warmest month 0–10°C.
6. Perpetual frost climate: warmest month <0°C.

3.1.2 Aridity criteria

The criteria imply that, with winter precipitation, arid (desert) conditions occur where $r/T < 1$, semi-arid conditions where $1 < r/T < 2$. If the rain falls in summer, a larger amount is required to offset evaporation and maintain an equivalent effective precipitation.

Subdivisions of each major category are made with reference, first, to the seasonal distribution of precipitation. The most common of these are:

f = no dry season; *m*= monsoonal, with a short, dry season and heavy rains during the rest of the year; *s* = summer dry season; *w* = winter dry season. Second, there are further temperature criteria based on seasonality. Twenty-seven subtypes are recognized, of which 23 occur in Asia. The ten major Köppen types each have distinct annual energy budget regimes, as illustrated in Figure 3.1.

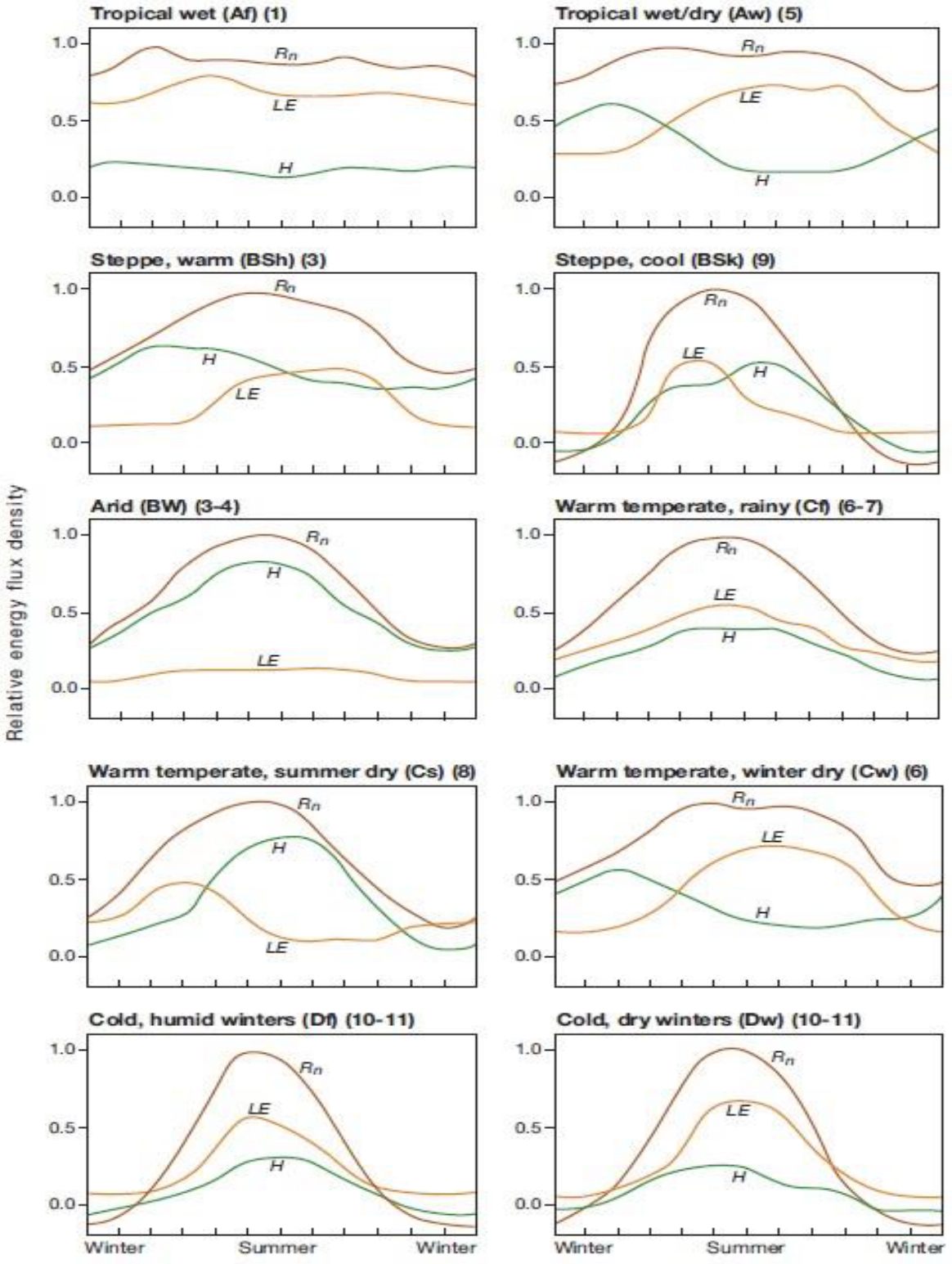
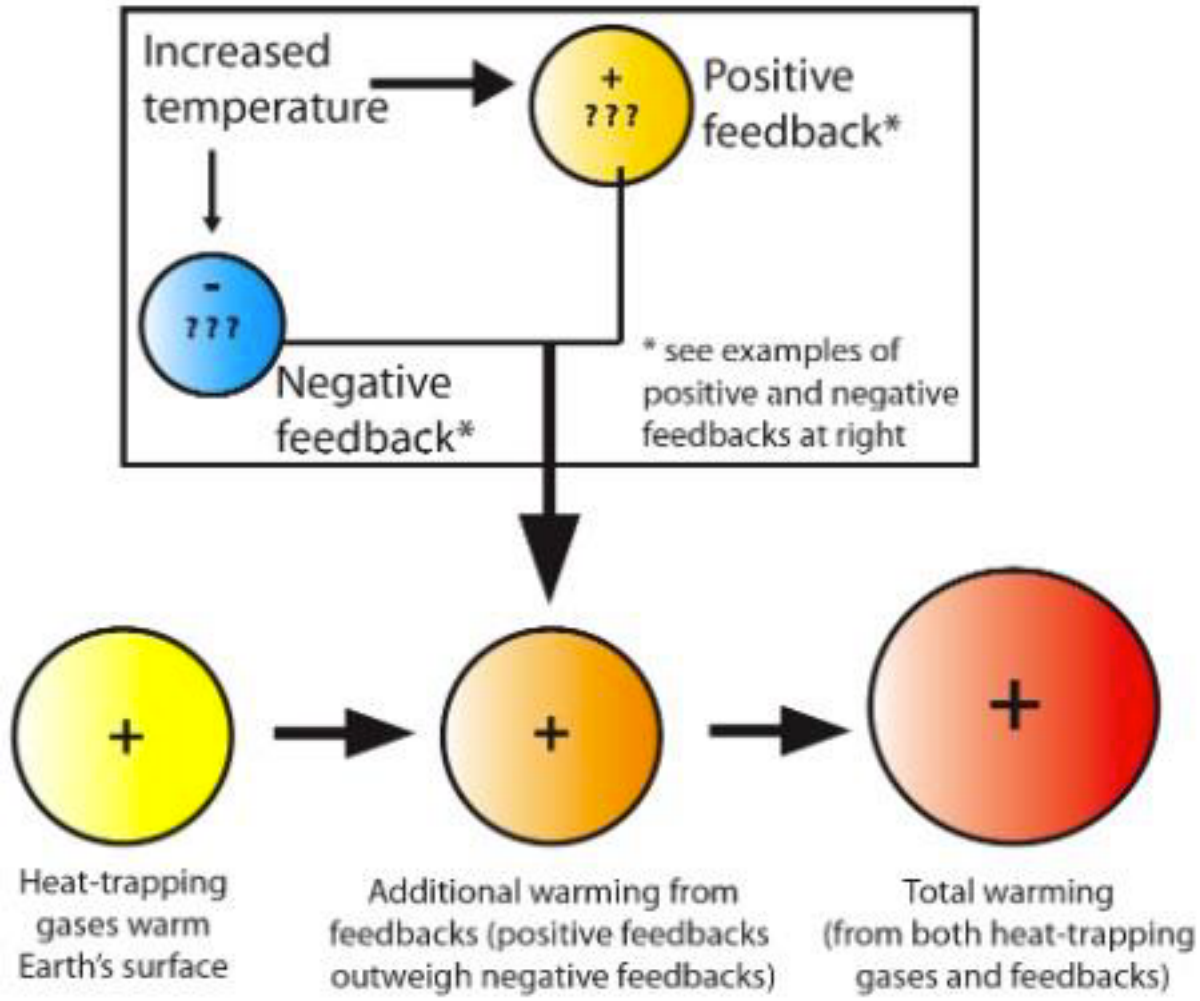


Figure 3.1 *Characteristic annual energy balances for ten different climatic types (Köppen symbols and Strahler classification numbers shown).*

3.2 Feedback in climate system

As human activities increase the concentration of heat-trapping gases in the atmosphere, Earth's surface warms. This initial warming causes many changes in the atmosphere, on land, and at sea. These changes, in turn, may cause additional warming (positive feedbacks) or reduce the rate of warming (negative feedbacks). The actual rate of warming of Earth's surface is determined by the warming caused by heat-trapping gases, plus the effects of the feedbacks to this warming.

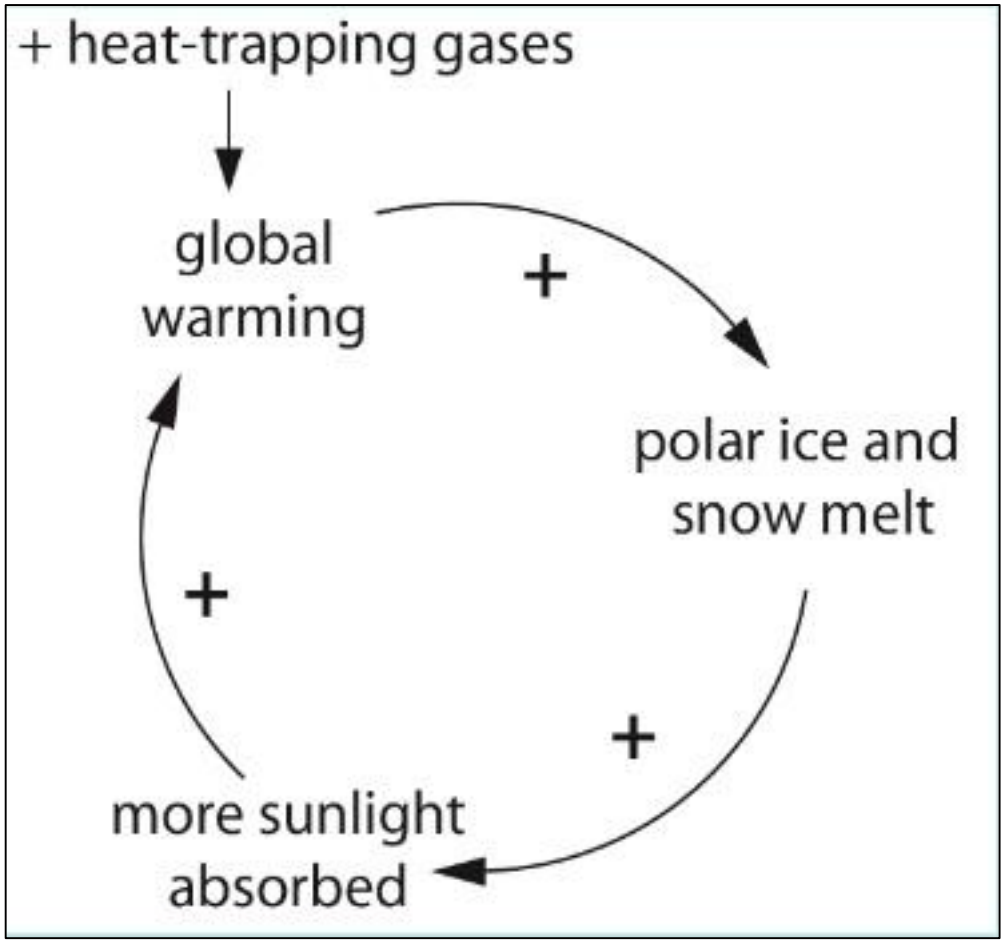
Positive feedbacks to warming are expected to outweigh negative feedbacks, leading to additional warming. Scientists estimate that feedbacks may increase warming by 15 – 78% over this century.



3.2.1 Positive feedback

Warming leads to positive feedbacks by:

Reducing ice and snow cover , exposing soil or ocean Water . Ice reflects much more solar radiation than soil or water . Loss of ice and snow means Earth's surface absorbs more energy , increasing global warming. See below:



Increasing soil respiration rates Causing permafrost to melt . permafrost, the frozen soil commonly found in Earth's coldest regions, could release large amounts of CO2 and methane if it thaws.

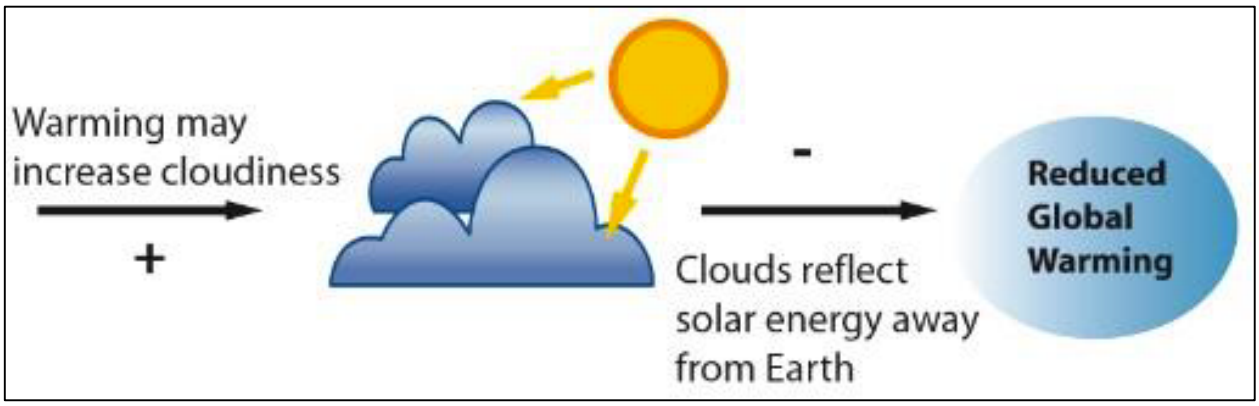
Increasing water vapor concentrations. Warmer weather leads to more evaporation. Water vapor is a powerful greenhouse gas.

Positive feedbacks act to destabilize the climate system.

3.2.2 Negative feedback

Warming leads to negative feedbacks by:

Increasing cloud cover. Warming leads to more evaporation, which can increase cloudiness. Clouds reflect solar radiation and decrease warming. However it is uncertain if cloud production will increase or decrease with warming. Overall, scientists believe that clouds will act as a negative feedback.



Increasing plant growth. As warming and increasing CO2 stimulate plant growth, carbon storage on land may increase.

Negative feedbacks act to stabilize the climate system.

Examples of possible positive and negative feedback in physical systems

1. As carbon dioxide levels in the atmosphere rise:

- Temperature of Earth rises

As Earth warms:

- the rate of photosynthesis in plants increases
- more carbon dioxide is therefore removed from the atmosphere by plants, reducing the greenhouse effect and reducing global temperatures

Positive or Negative? Answer: Negative

2. As Earth warms:

- Ice cover melts, exposing soil or water
- Albedo decreases
- More energy is absorbed by Earth's surface
- Global temperature rises
- More ice melts

Positive or Negative? Answer: Positive.

3. As Earth warms, upper layers of permafrost melt, producing waterlogged soil above frozen ground:

- Methane gas is released in anoxic environment
- Greenhouse effect is enhanced
- Earth warms, melting more permafrost

Positive or Negative? Answer: Positive

4. As Earth warms, increased evaporation:

- Produces more clouds
- Clouds increase albedo, reflecting more light away from Earth
- Temperature falls
- Rates of evaporation fall

Positive or Negative? Answer: Negative

5. As Earth warms, organic matter in soil is decomposed faster:

- More carbon dioxide is released
- Enhanced greenhouse effect occurs
- Earth warms further

- Rates of decomposition increase

Positive or Negative? Answer: Positive

6. As Earth warms, evaporation increases:

- Snowfall at high latitudes increases
- Icecaps enlarge
- More energy is reflected by increased albedo of ice cover
- Earth cools
- Rates of evaporation fall

Positive or Negative? Answer: Negative