The Ignored Horizontal Energy Balance

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Introduction

Almost exclusive focus on CO_2 distracts from essential research and understanding of far more important processes. For example, water vapor is by far the most important greenhouse gas but receives very little attention or research. Indeed, a majority of the public are unaware it is the most important greenhouse gas. Most people have heard about the Greenhouse Effect, but few understand how it works. Far too many people claiming expertise are unaware of a multitude of other far more important parts of the climate system. One of these is the horizontal energy balance and its control over so many major weather and climate patterns that in the short and medium term are far more important for flora, fauna and thereby humans.

Energy Balance

Every year solar energy, usually abbreviated from (in)coming (sol)ar radi(ation) to insolation, enters the atmosphere and warms the Earth's surface. The earth returns the heat to space at a different wavelength known as IR (Infrared) radiation that moves up through the atmosphere to space.

Over time there is a balance between the amount of insolation coming in and the IR going out. A great deal of focus is placed on this vertical energy balance because it constitutes part of the Greenhouse debate. It receives far too much attention to the detriment of equally important parts of the global energy balance that have profound implications for global circulation, snow cover, major wind patterns, vegetation zones and severe weather.

Horizontal Energy Balance

Primarily because of the tilt of the Earth from the plain of its orbit around the sun each point on Earth receives a varying amount of insolation over the year. The angle at which the insolation strikes a surface determines the amount of energy imparted as shown in this Figure1.

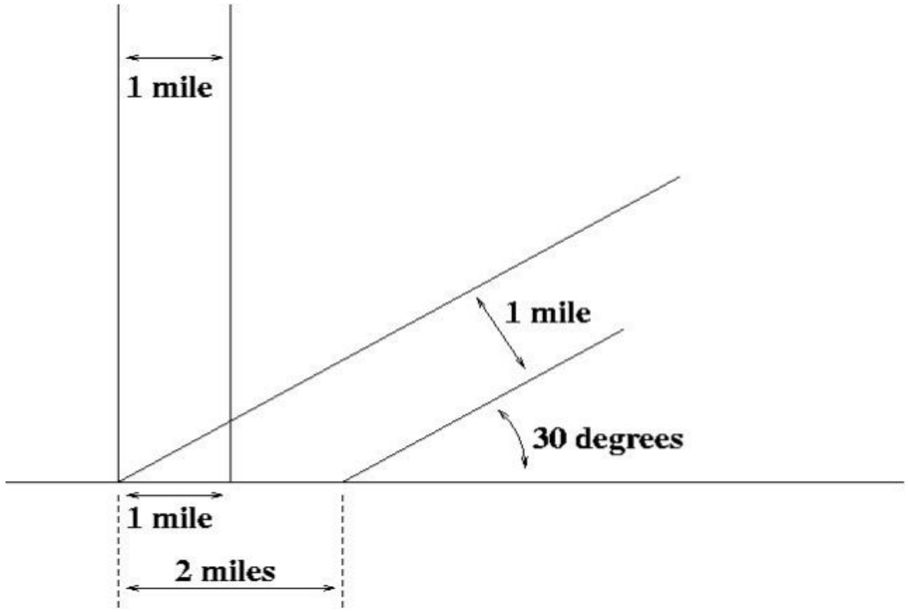

Figure 1: The same amount of energy in each column is spread over twice as big an area at 30° angle of incidence as at 90°.
Source: Wikipedia.

Because of the general balance between incoming and outgoing energy the amount of outgoing also changes over the year. If we plot the average annual pattern of incoming against outgoing energy by latitude we have diagram A in Figure 2.

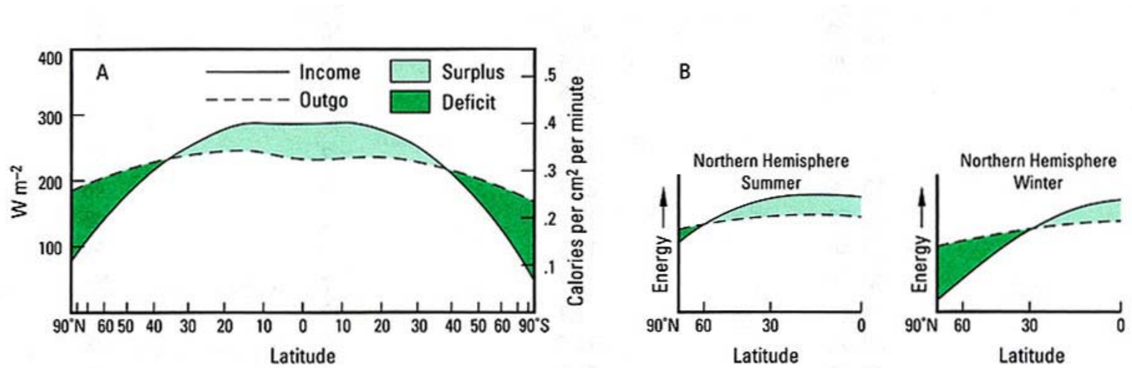

Figure 2: Latitudinal energy distribution A) Global annual average, B) Seasonal shift for Northern Hemisphere summer, C) Seasonal Shift for Northern Hemisphere winter.
Source: Smithson, Briggs, Ball et al.

On average the zone of energy surplus, that is more incoming in than outgoing, extends from 38°N to 40°S. The difference is due to the different land/water ration between the hemispheres. Where the incoming equals outgoing you have a point of zero energy balance (ZEB). This is a point in the diagram, but in reality a very critical line around the globe. As the season progresses the point of ZEB migrates north in the summer to approximately 65° N and south in the winter to 30°N (B in Fig 2). These average seasonal positions coincide with critical boundaries for flora and fauna and thereby humans.

The implications for climate

1. The northern and southern boundaries of the Taiga, (called the boreal forest in North America) is the largest biome (single unit biological zone) in the world. These boundaries coincide with the seasonal latitudinal limits of the ZEB.

Figure 3: The extent of the Taiga in the Northern Hemisphere.
Source: Wikipedia.

2. The snow line also migrates with the seasonal movement of the ZEB. In the energy deficit region there is not enough energy to melt the snow. North of 65°, which is in energy deficit year round the snow cover is essentially permanent. Changes in the movement of the ZEB result in changes in the extent of seasonal snow cover, which has implications for the Earth's albedo, which is a measure of the amount of sunlight reflected back to space without heating the Earth.
3. The ZEB marks the boundary between cold polar air and warmer tropical air generally known as the Polar Front. The cold air forms a shallow dome over the poles that expands and contracts with the seasons. This dome represents the area of deficit energy. (Figure 4)

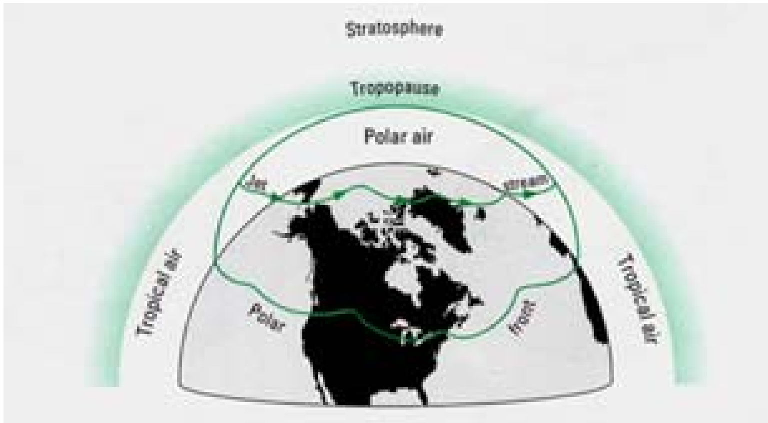

Figure 4: A simplified three-dimensional diagram of the dome of cold polar air over the North Pole. A similar dome exists over the South Pole.
Source: Briggs, Smithson, Ball et al.

4. The strongest winds occur when the temperature contrast is the greatest. This occurs above the surface at the boundary between the cold polar air and warm tropical air. Although labeled “Jet Stream” in Figure 4 it is properly called the Circumpolar Vortex and the Jets Stream is only that portion with winds above a certain speed.
5. At the surface along the Polar Front is where major mid-latitude cyclones develop. These bring the heavy rainfalls that cause flooding in the spring and the fall; the tornadoes during summer and the blizzards in winter. As the Polar Front migrates, these storms systems move with them.

Discussion

Because of the politicizing of climate science almost total attention has focused on CO_2 and the Greenhouse Effect. As a result extremely important mechanisms that have great impact on all life on the planet are ignored. The horizontal distribution of energy and the major patterns it creates are a major example. When you understand this you can see how a slight change in the tilt of the Earth has significant implications. Sadly, the tilt as part of the larger Milankovitch Effect are not even included in the IPCC computer models.

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