ATMOSPHERIC FORCING

Atmospheric forcing is the hypothesis that variations in the composition of certain minor atmospheric gases (water vapor, carbon dioxide and methane in particular) can bring about climate change. The physical theory behind this hypothesis is well established; and many atmospheric scientists favor it to one degree or another.

The major gases in the atmosphere—those that make up more than 99% of the gaseous atmosphere—do not significantly absorb either incoming solar radiation (shortwave) or outgoing terrestrial radiation (longwave). Therefore, they play almost no role in either heating or cooling the Earth. Instead, it is left to the minor gaseous constituents plus clouds and particulates to perform that role.

The table shows how these atmospheric components absorb both shortwave incoming solar radiation and longwave ambient atmospheric and terrestrial radiation.[1] Note that water vapor is far and away the most important of these absorbing gases. When combined with the liquid and solid phases of water found in atmospheric clouds, water completely dominates the atmospheric heat budget.

Nevertheless, each of the absorbing gases has its scholarly proponents who claim that the role of their favorite in heating and cooling the Earth is grossly underestimated. The IPCC (International Panel on Climate Change), of course, very vigorously argues for the primacy of carbon dioxide (carbon-forcing), even to the point of claiming that no other climate-forcing factor is significant in explaining the current (since 1750) global warming.

[1] Terrestrial radiation rarely gets more than a few hundred meters from the Earth's surface before being more or less completely absorbed by the so-called "greenhouse" gases, low clouds, and atmospheric particulates. Therefore, most of the longwave radiation absorbed by any particular volume of air comes primarily from the surrounding air, and not from the surface.

ABSORPTION OF RADIANT ENERGY BY THE ATMOSPHERE

ATMOSPHERIC COMPONENT	ATMOSPHERIC ABUNDANCE	SHORTWAVE ABSORPTION	LONGWAVE ABSORPTION	TOTAL ABSORPTION	TOTAL PERCENT
	Parts per billion	Watts per square meter	Watts per square meter	Watts per square meter	
Water Vapor (H_2O)	4,000,000	64	128	192	52
Clouds[2]	-	19	59	78	21
Total Of All Water	-	83	187	270	73
Carbon Dioxide (CO_2)	390,000	<1	53	53	14
Ozone (O_3)	3.5	19	17	36	10
Methane (CH_4)	1,790	<1	9	9	2
Nitrous Oxide (N_2O)	300	<1	2	2	1
Total		102	268	370	100

Table data modified from: Kiehl, J. T. and Trenberth, K. E.: "Earth's Annual Global Mean Energy Budget", *Bulletin of the American Meteorology Society*, Vol. 78, No. 2, February 1997.

[2] Includes water droplets, ice crystals, dust, pollen, and other atmospheric particulates.

Let's take a look at some of those hypotheses.

Carbon-forcing – Carbon-forcing is the hypothesis that changes in the carbon dioxide content of the atmosphere can bring about global climate change. This is the climate change hypothesis that has been adopted and vigorously promoted by the IPCC.

The evidence that supports this hypothesis consists of the correlation between temperature increases since pre-industrial times and increases in atmospheric carbon dioxide concentrations during that same time. In pre-industrial times, the atmospheric carbon dioxide concentration was roughly 280 parts per million by volume. Today, the atmospheric concentration is roughly 390 parts per million and increasing. This post-industrial increase in carbon dioxide concentration has added some 14 Watts per square meter to the Earth's heat budget.

Since pre-industrial times (the Little Ice Age), the global climate has been warming overall. The IPCC argues that global temperatures increased by 0.9°C (1.4°F) from 1906 through 2005.

Arguments and counter-arguments against carbon-forcing tend to fall into three main categories:

1. There is no historical record of carbon-forcing ever bringing about any previous change in global climate. True, but not logically compelling. There has to be a first time for everything. The IPCC argues that the current level of atmospheric carbon dioxide is also unique in modern times.[3]

2. The increase in carbon-forcing over the past century (14 Watts per square meter) is not physically sufficient to bring about a global warming of 0.9°C during that same time. True. The IPCC argues that carbon-forcing has had a "triggering" effect on other greenhouse gases, specifically water vapor. They argue that the combined effect is, in fact, sufficient.

[3] Some five-hundred million years ago, atmospheric carbon dioxide levels were some twenty times as high as at present. During the Jurassic era, they were usually four to five times higher that present levels.

3. From 1940 through 1977 and from 1999 through the present year, global temperatures of the IPCC's own global temperature model actually decreased or failed to rise. During these same periods, atmospheric carbon dioxide concentrations rose significantly. Carbon-forcing fails to explain these phenomena. True and this is probably the greatest challenge to the carbon-forcing hypothesis.

   The IPCC has argued that industrial pollution muted the 1940-1977 carbon-forcing and sulfate particulates are responsible for the more recent failure. These arguments have some merit, but the weight of the current scientific evidence is unconvincing.

Virtually all professional atmospheric scientists agree that mankind's activities have added to the concentration of carbon dioxide in the Earth's atmosphere. The evidence is overwhelming. Virtually all professional atmospheric scientists agree that this anthropogenic carbon-forcing contributes to this current episode of global warming. The evidence is overwhelming.

Very real disagreements exist as to how much of this global warming is due to carbon-forcing and how much is due to other global climate-forcing factors. Here, the weight of scientific evidence is by no means overwhelming. And it is here that scientific objectivity most often falls victim to political considerations.

Water vapor forcing – Water vapor forcing is the hypothesis that changes in the water vapor content of the atmosphere can bring about global climate change. This hypothesis is supported by the fact that water vapor is the most important of all the greenhouse gases by a wide margin. Its effect on the Earth's heat budget (192 Watts per square meter) is greater than that of all of the other greenhouse gases put together (100 Watts per square meter). When you consider the effects of clouds (water in its liquid and solid phases), you add another 78 Watts per square meter.

Globally, the total annual precipitation increased by some 2% in the period from 1900 to 1980 [Dai et al, 1997]. Since water vapor's average residence time in the atmosphere is only a matter of some nine days, water vapor concentration is thus thought to be increasing. A 2% increase would thus have added at least 9 Watts per square meter to the Earth's heat budget over the past century.

Forcing by other minor gases – Forcing by other minor gases (ozone, methane, nitrous oxide, etc.) is not thought to be a global factor. They are present in only relatively small amounts, generally have short residence times, and are often chemically unstable, breaking down easily (ozone becomes ordinary oxygen, and methane become water vapor and carbon dioxide).

Summary – Atmospheric forcing is the leading edge of the climate change controversy. Every new bit of scientific evidence, every scientific study—no matter how irrelevant or insignificant—is seized upon are scrutinized for possible ammunition in the battle between the supporters of carbon-forcing and everyone else.

The effect on the scientific community has often been demoralizing. Scientists can no longer be completely objecting and impartial—they are expected to be activists instead. They are continually pressured to take one side or the other. The position that "if you are not for us, you are against us" is unfortunately becoming the norm. This is a sad thing.

REFERENCES

Kiehl, J. T. and Trenberth, K. E., 1997: "**Earth's Annual Global Mean Energy Budget**", *Bulletin of the American Meteorology Society*, Vol. 78, No. 2, February 1997.

Spencer and Braswell, **On the Misdiagnosis of Surface Temperature Feedbacks from Variations in Earth's Radiant Energy Balance**, *Remote Sensing*, July 2011.

"**Climate, History and the Modern World**"; Hubert H. Lamb; Second Edition, 1997; Routledge, New York, NY.

R D Cess et al: **Uncertainties in Carbon Dioxide Radiative Forcing in Atmospheric General Circulation Models**; *Science*, November 1993.

Robert D Cess: **Atmospheric Science. Water Vapor Feedback in Climate Models**; *Science*, November 2005.

Wikipedia: **Gaseous Composition of Dry Atmosphere**: retrieved 28/02/2011. http://en.wikipedia.org/wiki/Atmosphere_of_Earth .

C D Keeling and T P Whorf: **Atmospheric Carbon Dioxide Record from Mauna Loa**; Oak Ridge National Laboratory; 2005.

USEPA: **Greenhouse Gases and Global Warming Potential Values**; April 2002.