On the Sunny Side of the Planet

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The Earth's temperature and climate are kept in equilibrium by the balancing flows of solar or shortwave radiation (inward), and terrestrial or longwave radiation (outward). For the past decade or two, much of Atmospheric Science has been focused on the longwave side of this equation, as the unrelenting build-up of greenhouse gases will almost certainly shift the planetary temperature balance.

It may then come as a surprise to find that there are also major uncertainties on the solar side of this balance sheet. Starting around ten years ago, a number of groups decided to fly aircraft fitted with radiometers above and below cloud layers. By their measurements, these clouds were absorbing a significant amount of the incident solar radiation. Yet all atmospheric radiation models say that there is virtually nothing inside a cloud capable of absorbing solar radiation (apart from water vapour).

Initially the fingers were pointed at the measurements. A total of four radiometers was required, looking upwards and downwards on two planes. These are quite difficult instruments to construct properly, and also to calibrate accurately. The planes had to fly straight and level to high precision. Then there were the clouds. Horizontally homogeneous cloud layers might exist in text books, but not in the atmosphere. Some of the "lost" light might well be leaking out the sides somewhere.

So someone decided to make similar measurements in a cloud free environment, and surprisingly again found energy losses which could not be explained. By this time the matter was becoming heated, with some scientists refusing to discuss the issues with certain 'pig headed' colleagues. More accurate measurements were undertaken, which seemed to reduce the deficit somewhat, but it was still larger than the error bars.

Why is this such a cause for concern? Several reasons. First, if we don't understand the Physics of solar radiation in the atmosphere, what don't we know about the flow of terrestrial radiation – and hence the greenhouse effect? Second, the atmospheric energy budget is actually 'closed' by a latent heat term. Water evaporating from the world's oceans takes with it latent heat, which it then leaves behind when it later precipitates. The amount of latent heat needed to balance the books then tells us directly the amount of evaporation/precipitation taking place globally. But if more solar radiation is being absorbed in the atmosphere, less latent heat will be required – and less global rainfall. So we don't even understand the hydrological cycle!

The American Geophysical Union responded to this crisis by arranging a Chapman Conference on "Atmospheric Absorption of Solar Radiation", at Estes Park, Colorado, August 13-17. I was the only southern hemisphere representative. (In one of life's little ironies, George W. happened to be visiting the area one day, proving his environmentalist credentials by chopping down a few trees – as you do. Just as well he didn't call in on our discussions, or his views of atmospheric physicists might well have hit nadir.)

The Conference was jointly convened by Al. Arking, V. Ramanathan, and Susan Solomon. (Susan's designated role was to separate the protagonists whenever it became necessary, which she did with her usual tact.) Approximately 80 of the scientific leaders in both measurement and modelling of solar radiation attended, with most giving papers. There was also a significant amount of free time for 'off-line' discussion.

We heard a number of papers on the recent "ARESE II" experiment, in which a number of instrumented aircraft overflew a well characterized site in Oklahoma, mostly above clouds. Analysis of such measurements is complex, due to the large variability of the cloud layers, which raises all sorts of sampling/statistical issues. We also heard papers on the latest measurements of atmospheric spectroscopy, including the spectrum of the O_4 'molecule' – the fleeting embrace of two O_2 molecules. Of most interest to me were the papers on atmospheric aerosols, and the amount of energy they might absorb.

Is there now a consensus? It would be unfair to suggest that everyone left happy, but the gaps do appear to be narrowing. The atmosphere absorbs somewhere between 20% (the text book value) and 25% (which a few measurements are suggesting) of incoming solar energy. The true value is almost certainly at the lower end. In my own opinion, the role of aerosols, and especially sooty aerosols, is still underestimated. Our measurements here in Sydney suggest that they can make up a sizeable fraction of the particulate matter in the atmosphere, and are very efficient absorbers of sunlight – that, after all, is why they are black.