

The European climate anomaly in 2006 as seen by the Geostationary Earth Radiation Budget instrument.

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Abstract

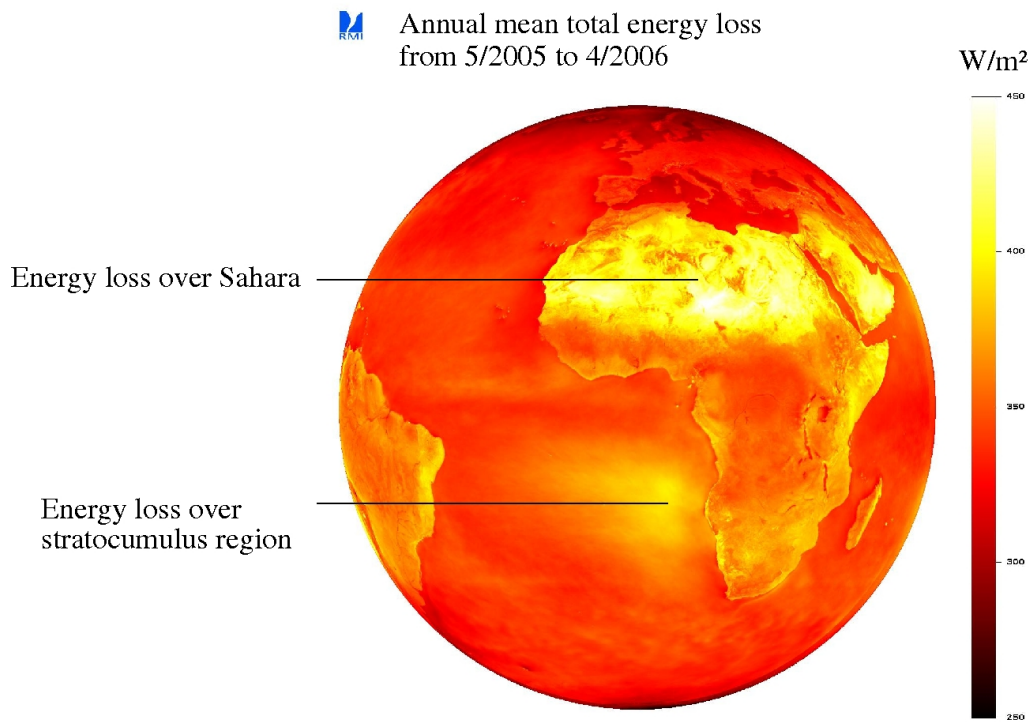
In the summer of 2006 there was a sudden increase of temperature over Europe, with e.g. in Belgium record warm July and September months followed by record warm autumn, winter and spring seasons. Such a temperature increase must be due to the input of extra energy in the form of radiation at the top of the atmosphere. This extra energy input was measured by the dedicated Geostationary Earth Radiation Budget (GERB) [Harries et al.(2005)] instrument on board of Meteosat 8, verifying for the first time the energy conservation equation during a period of a major climate anomaly. We use GERB data over the two year period from May 2005 to April 2007. We present the components of the radiation budget over the Meteosat disc during the first year, and the interannual change in the radiation budget for the second year.

Instantaneous GERB data are processed in the RMIB GERB Processing system and are available from <http://gerb.oma.be> [Dewitte et al.(2007)]; monthly mean GERB data are processed in the EU-METSAT Climate Monitoring Satellite Application Facility and are available from <http://www.cmsaf.eu> [Caprion et al.(2004)].

1 GERB annual mean energy loss

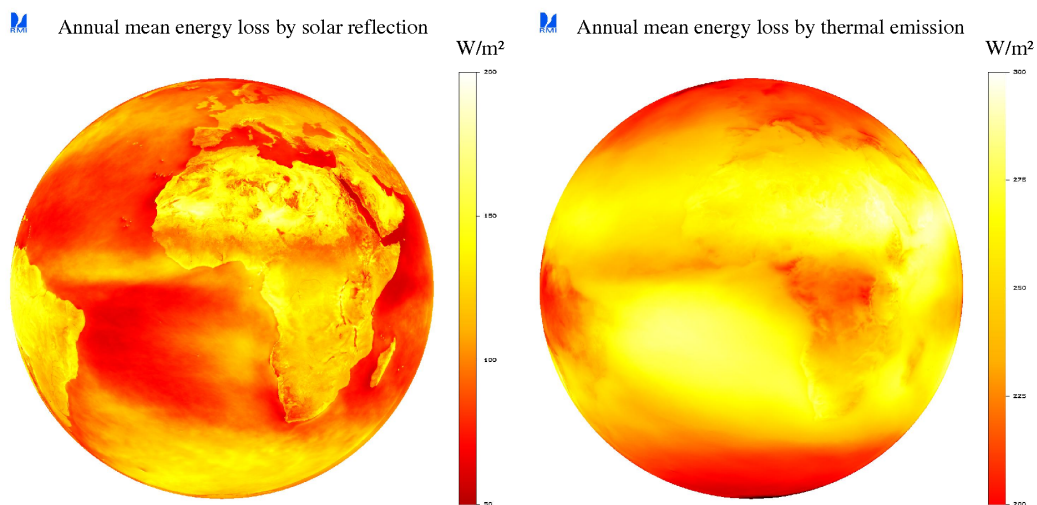
1.1 Total energy loss

The GERB annual mean energy loss for the year from May 2005 to April 2006 is shown below. Regions with particularly high energy loss are the Sahara and the stratocumulus region of the West coast of Southern Africa. These regions of strong cooling correspond to the descending branches of the Hadley cells, with the ascending branches near the equator, where the heating by incoming solar radiation (not shown here) is maximum. The energy loss in these regions has a strong diurnal cycle justifying the high temporal resolution measurement from a geostationary orbit. The link between the radiative energy input/output and the Hadley circulation shows a direct influence of the radiation on the dynamics of the atmosphere, on an annual mean timescale.



1.2 Energy loss by solar reflection and thermal emission

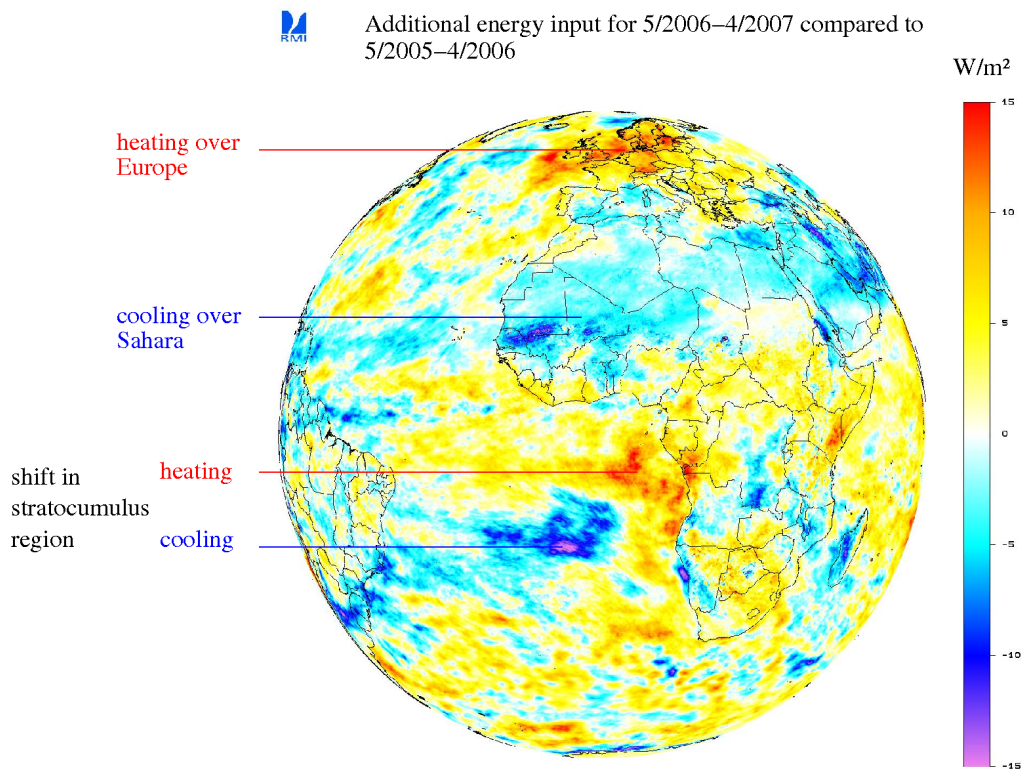
The separate components of energy loss by reflection of solar radiation (left) and emission of thermal radiation (right) are shown below. The regions with low thermal emission correspond to high cold clouds; they show a strong reflection, and no marked effect on the total energy loss; hence there is an approximate compensation of the heating and cooling effects of clouds. The stratocumulus clouds are an exception. They have no marked thermal emission effect since they are low and warm, hence they have a pure cooling effect through the reflection of solar radiation.



2 Interannual change

The change in the net energy input for year 2 - extending from May 2006 to April 2007 - compared to year 1 - extending from May 2005 to April 2006 - is shown hereafter. The change in incoming solar radiation has been evaluated from [Mekaoui Dewitte(2007)], and has been neglected compared to the change in outgoing radiation measured by GERB.

The most marked features are an increased heating (red color) over Europe and a differential heating/cooling (dark blue-purple colors) in the stratocumulus region, indicating a geographical shift of the stratocumulus region. There also is a weak but geographically extended general cooling (light blue color) over the Sahara desert.

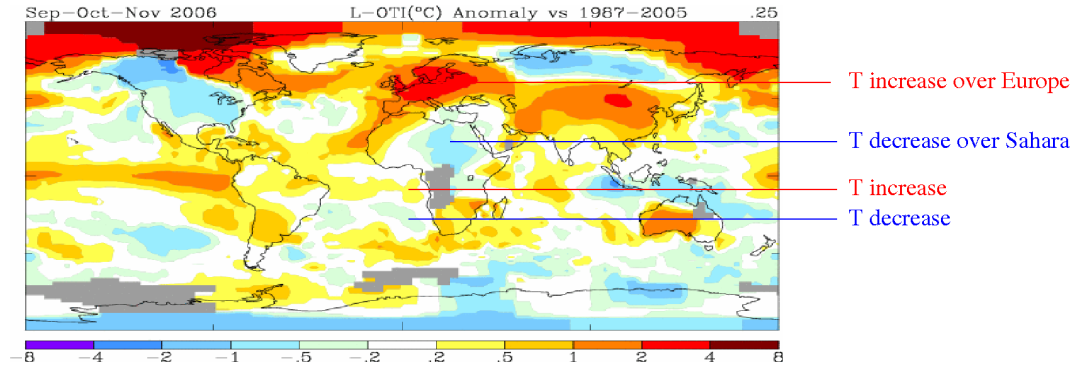


3 Temperature change

The analysis of the long term temperature increase in Ukkel, Belgium, reveals that the temperature increase is rather stepwise than continuous, with discrete temperature increases in 1909 and 1987, of respectively 0.8 and 1.2 ° C. The 12 month average temperature from July 2006 to June 2007 was 2.1 ° C higher than normal. This is the highest temperature anomaly observed since the start of the measurements in 1833. It is too early to judge whether this high temperature anomaly is the initiation of a third temperature step.

The map below shows the temperature increase for the months Sep-Oct-Nov for 2006 compared to the climatology from 1987 to 2005. The map was produced from the NASA GISS website <http://www.nasa.giss.gov>. The temperature increase map shows a remarkable correlation with the map of the change of energy input shown above; in particular the temperature increase over Europe after the summer of 2006 seems to be caused by the increased heating measured by GERB. Also the differential temperature changes in the stratocumulus region, and the temperature decrease over the Sahara seem to be caused by corresponding changes in the energy input. A causal relation from energy input to temperature change is to be expected from the energy conservation

equation.



4 Conclusions and outlook

By chance a strong climate anomaly in the form of a temperature increase appears to have taken place over Europe during the first two years of GERB climate measurements which have been used in the present study. This change has been captured by the GERB instrument, allowing to verify the fundamental energy conservation equation. The energy conservation equation predicts a dependency of the temperature distribution on the energy input. A relation in the other direction can also be expected, as the energy input depends on the state of the atmosphere, which depends in turn on the temperature distribution. The interaction between the radiative energy input and the temperature distribution can be studied from a more detailed analysis of longer time series of GERB data. Likely the Hadley circulation and its descending branches over the Sahara and the stratocumulus region of the coast of Africa will play a key role. The consequences for climate monitoring and climate change predictability are yet to be explored.

References

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- [Caprion et al.(2004)] , CAPRION, D. and BERTRAND, C. and CLERBAUX, N. and DE PAEPE, B. and DEWITTE, S. GONZALEZ, L. and IPE, A., Initial operation of the CM-SAF TOA flux products. *Eumetsat meteorological satellite proceedings*, 395–400,2005.
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