The water vapor continuum effect on the surface transmitted irradiance at 8 – 12 μm atmospheric window

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ABSTRACT

This study aims to present an estimate of the global annual mean surface transmitted irradiance (STI, in Wm^{-2}). Irradiances were calculated based on the state-of-the-art line-by-line radiation model; 12-year climatological dataset from ECMWF reanalyzes and clouds from the International Satellite Cloud Climatology Project (ISCCP). Results show that the global annual mean surface transmitted irradiance at the top of the atmosphere is around 65 Wm^{-2} for clear sky, and decreases to 22 Wm^{-2} due to clouds, which is almost half of the actual values presented in the literature.

1 - MOTIVATION

The **surface transmitted irradiance** (**STI** Fig.1, in red circle) represents the radiation that is emitted by surface and transmitted through the atmosphere to space. Kiehl and Trenberth (1997, hereafter KT1997) showed that STI is around 40 Wm^{-2}. The present study show that such surface contribution to OLR is seems to be overestimated, because water vapor and clouds absorb considerable the surface emitted radiation.

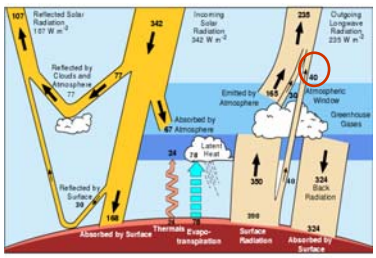


Figure 1–Earth's global annual mean energy budget from Kiehl and Trenberth (1997).

2 - METHODS

Clear sky surface transmitted irradiance is calculated by using the line-by-line model Reference Forward Model version 4.22 – RFM (Duhia, 1997) and assuming spatial resolution of 10 degrees of latitude and longitude. Pressure, water vapor and temperature have been derived from the European Centre for Medium-Range Weather Forecasts (ECMWF) monthly mean reanalysis dataset averaged over a 12 year period (1980-91). Clouds are represented in the radiative transfer according to ISCCP climatology.

3 - THE CONTINUUM WATER VAPOR EFFECT ON STI

The water vapor continuum has strong effect in the infrared atmospheric window and reduces almost 30% the surface transmitted irradiance.

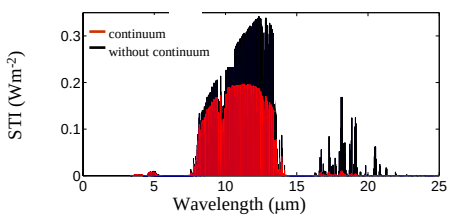
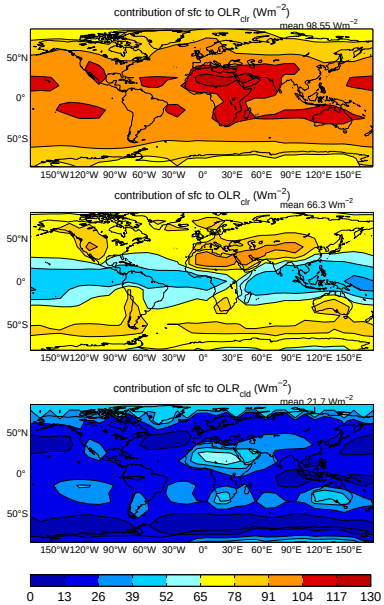


Figure 2 – Clear sky STI calculated using RFM and the global annual mean vertical profile. Red bars represent irradiance with continuum while black bars are without continuum effect.

4 - SURFACE CONTRIBUTION TO ANNUAL MEAN OLR

The water vapor continuum absorbs more than 60% of the clear sky surface transmitted irradiance at the tropics, around 20% at mid-latitudes and around 7 % at the poles (Fig. 3b). The stronger effect on the lower latitudes is because self-broadened continuum absorption is proportional to the square of the partial pressure of the water vapor. Global annual mean STI is 66 Wm^{-2} for clear sky (Fig. 3b), an it reduces to 22 Wm^{-2} due to clouds (Fig. 3c).



a) Clear sky STI without water vapor continuum:

98 Wm^{-2}.

b) Clear sky STI with water vapor continuum:

66 Wm^{-2}.

c) Cloudy sky STI with water vapor continuum:

22 Wm^{-2} .

Figure 3 – Clear and cloudy sky global annual mean STI

5 - CONCLUSION

The amount of the surface radiation transmitted unimpeded through the atmosphere is found to be 22 Wm^{-2} under cloudy. This value is almost half of the value of 40 Wm^{-2} obtained by KT1997. Assuming that less infrared radiation from the surface escapes to space, the results of present study imply that more radiation is available to heat the atmosphere. Future study will analyze the continuum effect on atmospheric window in terms of satellite signal.

6 - REFERENCES

Dudhia, A., Reference Forward Model v3 Software User's Manual. ESA Document PO-MA-OXF-GS-003, Department of Atmospheric Oceanic and Planetary Physics, Univ. of Oxford, United Kingdom, Oxford.

Kiehl, J.T. and K.E. Trenberth, Earth's annual global mean energy budget. Bulletin of the American Meteorological Society, 78(2): 197-208, 1997.

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