The Impact of Marine Cloud Brightening (MCB) on the Meridional Heat Flux (MHF)

Ben Parkes[1], Alan Gadian[1] and John Latham [2,3]

[1] NCAS, SEE, University of Leeds, [2] SOEAS University of Manchester, [3] MMM, NCAR.

Introduction

Marine cloud brightening (MCB) will increase the albedo of selected stratocumulus clouds with the aim of increasing the reflected component on incoming solar radiation. Modelling results have been suggested that MCB reduces the polar temperatures significantly (Latham et al. 2008 & Rasch et al. 2010) . A reduction in the atmospheric / oceanic Meridional Heat Flux (MHF) is postulated as a mechanism for this cooling.

Method

To calculate the radiative MHF the radiative balance at the top of the atmosphere is found calculated as in Fig 1. (a) , (b). The radiative balance is multiplied by the area in its latitude band as in Fig 1. (c) ,(d). These latitude weighted fluxes are accumulated from the South pole to the North pole to give the total MHF Fig 1.(e) , (f). The dotted lines also show the results from the North polar to the South pole. Figures on the left from (Wunsch 2005) and the right from HadGEM1.

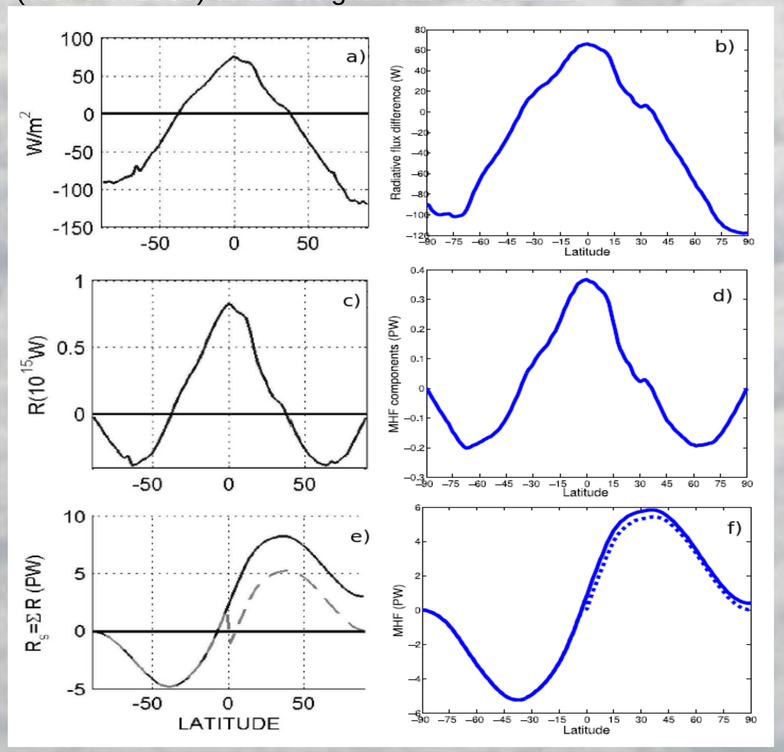

Figure 1 Plots of the radiative balance and MHF in Wunsch (2005) and values from the HadGEM1 climate model. (Martin et al, 2006)

Surface temperature results

Increasing carbon dioxide concentrations leads to a warming of polar regions all year round Fig. 2 (a),(b) with significant heating during the winter months Fig. 2(b). Three region MCB seeding Fig. 2(c),(d) prevents this warming in both seasons and redistributes the energy balance. All sea MCB Fig. 3. (e),(f) cools to less than control levels but appears to set up dipoles of warming South of Greenland and West of Japan.

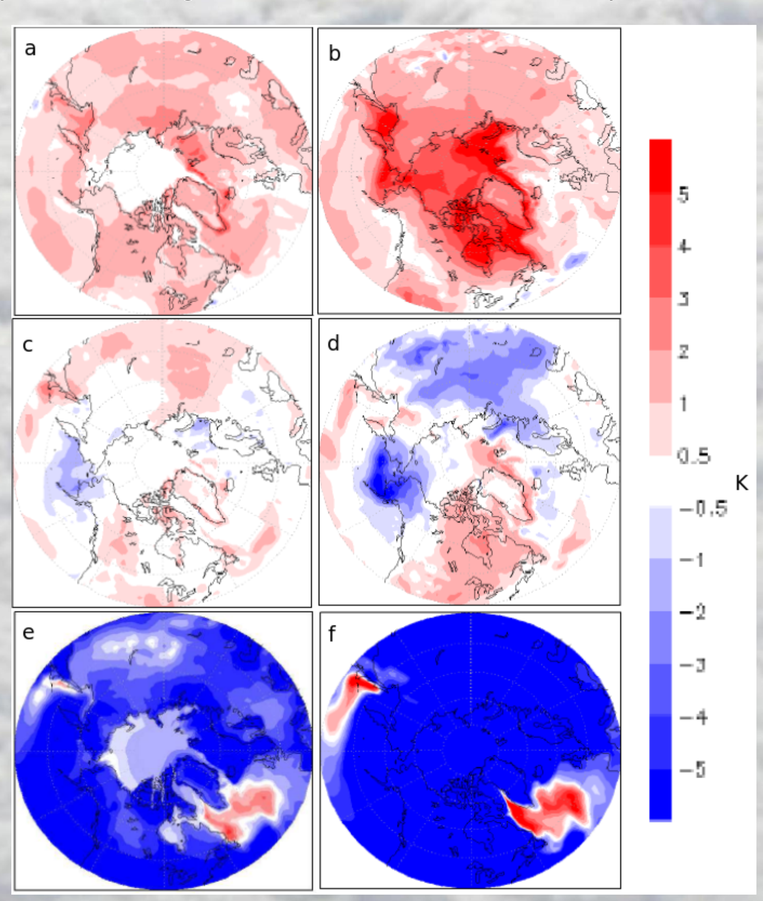

Figure 2. Plot showing the change in surface temperature (K) for summer (left panels) and winter (right panels). Top panels show the difference between a double preindustrial carbon dioxide atmosphere and a control atmosphere. Middle panels show difference between a double preindustrial carbon dioxide atmosphere with three region MCB and a control. The bottom panels show difference between a double preindustrial carbon dioxide atmosphere with all sea MCB and control.

References

Lathaam et al, 2008. “Global Temperature Stabilisation via controlled albedo enhancement” Phil Trans Roy Soc, 466, 3969-3987

Martin, G. et al.. 2006 , “The physical properties of the atmosphere in the new hadley centre global environmental model (hadgem1)” , Journal Of Climate , Vol. 19,pp. 1274–1301.

Rasch, P. J., et. al. 2010 , “Geoengineering by cloud seeding: influence on sea ice and climate system”, ERL, 4, 045112.

Wunsch, C. 2005, “The total meridional heat flux and its oceanic and atmosphericpartition”, JoC , 18, p. 4374–4380.

Conclusions

We find that the HadGEM1 (Martin et al 2006) model is suitable for use to calculate the radiative MHF. The model is used to simulate surface temperatures at the Arctic which is more susceptible to warming than the Antarctic. We have shown that doubling preindustrial carbon dioxide levels leads to significant warming and that seeding three tropical regions ameliorates this warming. Changes in the MHF are postulated as a mechanism to explain how seeding stratocumuli in sub topical regions affects the temperatures in the polar regions and that MCB is able to recover values of MHF close those in the control run.

MHF Results

It can be seen that the double carbon dioxide simulation increases the maximum MHF. The MCB three region seeding is capable of reducing this increase. The all sea seeding reduces the MHF to 4.0 PW from 5.8 PW in the Control run.

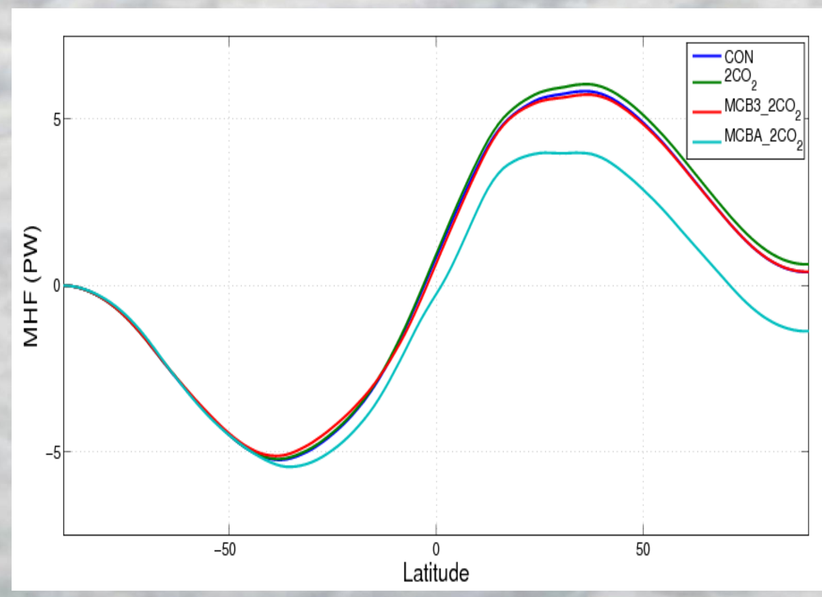

Figure 3. Plot showing the MHF for four geoengineering simulations in HadGEM1.

Acknowledgements.

This work made use of the facilities of HECToR, the UK's national high-performance computing service, which is provided by NCAS / NERC supercomputing facility. Support for elements of this research was provided by the Fund for Innovative Climate and Energy Research, FICER, at the University of Calgary. This does not constitute endorsement of deployment in any form of Cloud Albedo Modification by the funding agency.