Comparison of air-sea latent heat fluxes from HadGAM1 and the NOC climatology.

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1. Abstract

Both the ECMWF, and the Met Office's HadGAM1 atmosphere models (Martin *et al.*, 2004) are known to overestimate ocean latent heat losses when compared to bulk formula fluxes. We investigate the reasons for this by comparing latent fluxes derived from HadGAM1, with fluxes derived from ship data and the bulk formulae by Josey et al. (their unadjusted fluxes, 1998), and show that the differences between the fluxes in the north Atlantic are correlated with differences in the atmospheric humidity assumed in the flux calculations.

2. Introduction

Accurate air-sea heat flux climatologies are needed for driving and validating ocean and atmosphere forecast models, but errors in these datasets are known to be still on the order of 30 Wm^{-2}. This error is significant since it has an impact on atmospheric forecasts that is several times larger than that of doubling atmospheric CO_2.

Here, we investigate the reasons for the errors in the latent heat flux by comparing fluxes derived from an atmosphere model (the Met Office's HadGAM1) and from ship data and the bulk formulae by Josey et al. (1998, called NOC). We chose to use this earlier data set since it has not been altered by comparison with ocean heat transport estimates, and is therefore a more direct test of bulk formula fluxes.

3. HadGAM and NOC latent heat fluxes

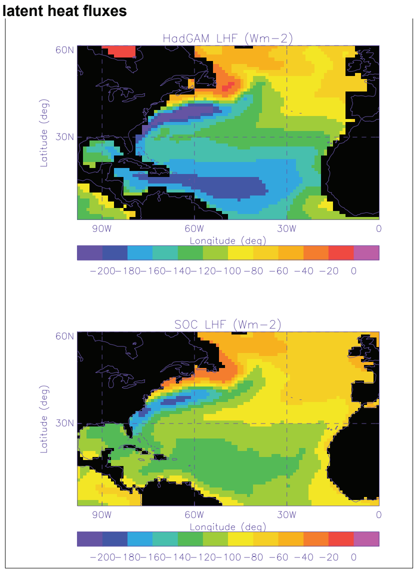

Figure 1a-b. The HadGAM and NOC annual average latent heat flux (Wm^{-2}). The blue areas are where the ocean is losing the most heat.

Figure 1a shows the annual ocean latent heat loss over the north Atlantic derived from the Met Office's HadGAM1 model. The heat losses are largest over the Gulf Stream where cold winter winds from the American continent blow over warm sea, and in the tropics (excluding the InterTropical Convergence Zone, ITCZ). Figure 1b shows the fluxes from the NOC climatology, derived using the bulk formula and data from Voluntary Observing Ships. The model's heat losses (1a) are typically 50 Wm^{-2} larger than those derived from the bulk formula (1b). Taylor et al. (2001) similarly found that HadAM3 (a precurser to HadGAM1) over-estimated the latent flux by 50 to 100 Wm^{-2} when compared with buoys in the western Pacific and Arabian Sea.

4. Results: HadGAM minus NOC latent heat fluxes

We now investigate the causes of these differences. Figures 2a shows the difference between the annually averaged latent heat flux from HadGAM1 and NOC over the north Atlantic. This is effectively Figure 1a minus Figure 1b. The ocean latent heat losses from HadGAM1 are much greater (the blue areas) in the tropics, and in the Gulf Stream at 60^oW.

Figure 2b shows the differences between the HadGAM1 relative humidity at 10m height (which was derived from data at 20, 50 and 80m height by downwards linear extrapolation) and the NOC humidity at 10m height (as given in the dataset). The blue areas are where the HadGAM1 atmosphere is drier than NOC.

There is a strong correlation of -0.82 between the fields in Fig. 2a and 2b in the north Atlantic (although this correlation is only -0.3 when calculated for the whole globe). This suggests that differences in atmospheric humidity may be responsible for the differences in the fluxes.

For comparison the correlation between the flux differences and the annual wind stress differences (HadGAM1-NOC) was -0.56. The correlation with SST differences was -0.66.

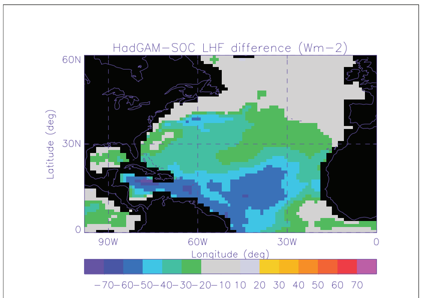

Figure 2a. The extra latent heat flux in HadGAM1. The blue areas mean that the ocean is losing more heat.

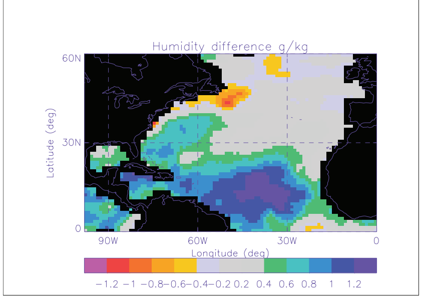

Figure 2b. The humidity difference (g/kg) between HadGAM and NOC. The blue areas mean that the HadGAM air at 10m is drier.

5. Discussion

Figure 2b shows that either the NOC climatology is too humid, or the HadGAM climatology is too dry. The latter is more likely since HadGAM1 has also been found to be too dry compared to the new GSSTF2.0 climatology (J.M. Edwards, pers. comm). For a discussion of GSSTF2 see Chou *et al*. (2003).

6. Conclusions

Annual average ocean latent heat losses in HadGAM1 are 50 Wm^{-2} greater than those in the unadjusted NOC climatology in the tropical north Atlantic (excluding the ITCZ) and in the Gulf Stream area. A correlation coefficient of 0.82 was found between these differences in the latent flux and the differences between the humidity at 10m height in the climatologies.

This implies that in these areas either the NOC atmosphere is too moist at 10m height or HadGAM1 is too dry. HadGAM1 is known to overestimate latent heat fluxes, and its humidity is known to be low when compared with the new GSSTF2 climatology (as well as NOC). This implies that HadGAM1 is too dry in the tropics, and over the Gulf Stream.

References

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