Earth Syst. Dynam. Discuss., 4, C48–C52, 2013
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Earth System Dynamics Discussions

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Interactive Comment

Interactive comment on "Estimation of the climate feedback parameter by using radiative fluxes from CERES EBAF" *by* P. Björnbom

Pehr Björnbom

pehrbjor@kth.se

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Subject: Hypotheses and estimated parameter value are supported by generally accepted ENSO theory

From the comments on my discussion paper so far it seems to me that all my points have not been well understood by the reviewers. The purpose of this comment is to try to improve the explanations of the hypotheses and the lines of evidence used in my discussion paper.

General comments

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Interactive Discussion

Discussion Paper

My discussion paper reports some interesting new discoveries in the CERES EBAF net radiative flux data seen in especially Fig. 1 and Fig. 2 in that paper. According to new hypotheses a modification is proposed of the linear TOA net radiative flux model Eq. (3) in the discussion paper by including a time lag to obtain Eq. (5) in that paper.

The hypotheses proposed in the discussion paper are based on ENSO theory as described for example by Neelin et al. (1998) and Trenberth et al. (2002). For the ENSO driven periods discussed it is assumed that heat fluxes between the surface ocean and lower layers of the ocean are the main controlling factors for variations in the global surface temperature anomaly. A further important assumption is that the variations in the TOA net radiative flux anomaly are dominated by radiative feedback while variations in radiative forcing are almost negligible.

There are some highlights:

1. There is a change of state around mid-2006 clearly seen in Fig. 1 in the discussion paper. During the period 2003 to mid-2006 the temperature anomaly shows clear oscillations but no corresponding oscillations are found in the net radiative flux anomaly. On the other hand during the period mid-2006 to mid-2011 the temperature anomaly oscillations continue with an increased amplitude followed by coherent oscillations in the net radiative flux anomaly with a time lag.

2. During the period mid-2006 to mid-2011 the climate feedback parameter according to Eq. (5) in the discussion paper equals around 6 $\mathrm{W\,m^{-2}\,K^{-1}}$. There are three lines of evidence for that: From the ratio of the y-axis scales in Fig. 1 in the discussion paper, from the linear regressions according to Fig. 3 in that paper and by calculating the ratios of the amplitudes of the two curves in Fig. 1 in that paper (see the interactive comment “Reply to Troy CA”).

3. A justification that the five year period mid-2006 to mid-2011 may give a

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reasonable value of the climate feedback parameter was arrived at by comparison with climate model simulations by Gregory et al. (2004). They simulated $2{\times}CO_2$ and $4{\times}CO_2$ step change experiments where the radiative forcing is constant after the initial perturbation. In both their and my cases there is a varying imbalance between incoming and outgoing radiative flux at the TOA. Since the variations in the radiative forcing are comparatively negligible this imbalance in both cases varies only through variations in the radiative feedback due to the variations in the temperature anomaly. The simulations by Gregory et al. (2004) suggest that a five year period may give a reasonable climate feedback parameter value by linear regression.

Specific comments

During the second period mentioned above according to the highlights, mid-2006 to mid-2011, the fluxes of heat and radiation may be described as in Fig. 1 in this comment. The oscillating heat flux between the surface ocean and lower layers of the ocean, shown by green arrows, has a key role for controlling the global surface temperature anomaly during this ENSO driven period. Some of those oscillations in the oceanic heat flux are spread through the troposphere both as latent and sensible heat (shown by blue arrows) and after a considerable lag cause the observed oscillations in the net radiative flux anomalies (shown by red arrows).

Those oscillations in net radiative flux anomalies mainly consist of radiative feedback while variations in radiative forcing are almost negligible. This may be explained according to the following hypotheses.

1. The net heat flux, O, oscillating between the lower layers of the ocean and the surface ocean controls the global surface temperature. This is because

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according to the energy balance analysis by Dessler (2011) the variations in the global temperature depend on the variations in net radiative heat flux, N, and on the variations of the ocean heat flux. Dessler's calculations show that during ENSO events $\sigma_N < 1$ W m^{-2} while $\sigma_O \approx 10$ W m^{-2} giving that $\sigma_N \ll \sigma_O$.

2. The net radiative flux anomaly is assumed to be described by the radiative forcing, F, and the radiative feedback, H, giving that $N = F - H$. The radiative feedback varies proportionally to the global temperature anomaly with a lag such that $H = \alpha \Delta T \left(t - t_{\text{lag}}\right)$.

3. During this time period, mid-2006 to mid-2011, the variations in radiative forcing are much less than the variations in the radiative feedback as may be expressed such that $\sigma_F \ll \sigma_H$. As a consequence the net radiative flux anomaly as a function of the surface temperature anomaly according to Eq. (5), $N(t) = F - \alpha \Delta T \left(t - t_{\text{lag}}\right)$, approaches a straight line in the lagged phase plane plot of $-N(t)$ versus $\Delta T \left(t - t_{\text{lag}}\right)$ (see Fig. 2B and Fig. 3 in the discussion paper). This is also the reason that variations in $-N(t)$ are proportional to variations in $\Delta T \left(t - t_{\text{lag}}\right)$ since $\Delta(-N(t)) \approx \alpha \Delta \left(\Delta T \left(t - t_{\text{lag}}\right)\right)$ (see Fig. 1 in the discussion paper).

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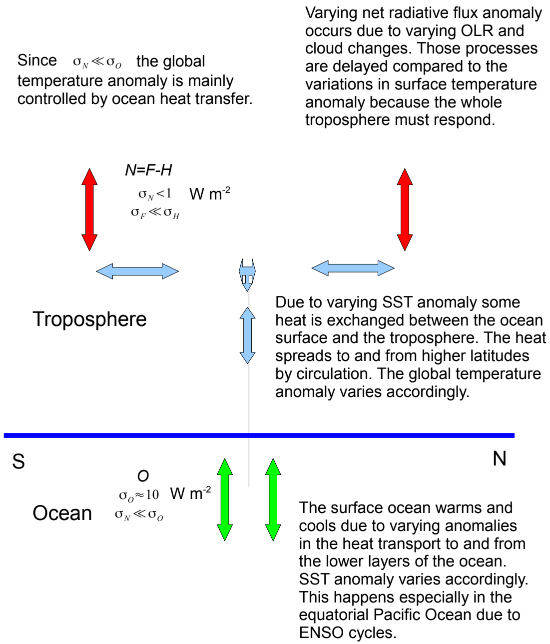

Fig. 1. An outline of the assumed heat and radiative fluxes during the time period mid-2006 to mid-2011

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