Earth Syst. Dynam. Discuss., 4, C90–C94, 2013
www.earth-syst-dynam-discuss.net/4/C90/2013/

Earth System Dynamics Discussions

ESDD
4, C90–C94, 2013

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

Received and published: 2 March 2013

Subject: Comparison of my paper with Dessler (2013) raises some doubts about using conventional linear regression for studying feedbacks

Since the submission of my discussion paper a new paper addressing the value of the climate feedback parameter has appeared, Dessler (2013). The purpose of this short comment is a comparison of the results in the two papers. My results raise some doubts regarding some aspects of the use of linear regression for studying feedback in Dessler (2013).

General comments

While my paper only deals with the net radiative flux anomalies and how to determine the climate feedback parameter Dessler (2013) has a much broader scope. The main aim is a detailed study of how the feedbacks change the TOA net energy balance in response to changes in surface temperature and comparing results from observations with climate model simulations. The author writes:

> *Ideally, we would estimate the magnitude of the feedbacks from observations of long-term warming covering decades or even centuries. Unfortunately, accurate global measurements of the parameters of interest for feedbacks (particularly atmospheric water vapor, temperature, and clouds) are only available for about a decade. And over this time, the dominant climate variations were from the El Niño-Southern Oscillation (ENSO). In this paper, I will analyze the feedbacks over the period March 2000 to December 2010 in response to ENSO and compare the results to control simulations of coupled GCMs, whose climate is also dominated by internal climate variability. These results will then be compared to feedbacks in simulations of long-term warming in order to assess how these feedbacks differ from those in response to internal variability.*

The TOA all sky net radiative flux anomaly in Dessler (2013) was decomposed into its feedback constituents due to Planck response and lapse rate, water vapor, surface albedo and clouds using the radiative kernels of Soden et al. (2008) (except for clouds requiring special treatment). Each partial feedback parameter was then determined separately by linear regression against the surface temperature anomaly as illustrated in Fig. 1 in that paper. The results were compared to the corresponding global average feedbacks in models.

The part of Dessler (2013) that may be most directly compared to my discussion paper

ESDD

4, C90–C94, 2013

Interactive Comment

is section 7 on thermal damping rate that is another name for the climate feedback parameter. The climate feedback parameter was determined from observations by linear regression of the total net radiative flux anomaly against the surface temperature anomaly.

The basic assumption used by Dessler (2013) is that the TOA net flux anomaly is a linear function of the temperature anomaly, i. e. corresponding to Eq. (3) in my paper:

$$N(t) = F(t) - \alpha \Delta T(t)$$

The radiative flux changes were assumed to be dominated by the feedback term and by random variations canceling in the calculations. The radiative forcing term was assumed to be a known function of time increasing with a rate of 0.2 $\mathrm{W\,m^{-2}}$ over the 2000-2010 period (Solomon et al. 2011). Such a rate of change in F is very small and is in fact illustrated by the red line in Fig. 3b in my paper.

However, the phase plane plot in Fig. 2a in my paper suggests that F according to that equation may vary considerably more than as described above during the studied period. The variations in F are seen by noting the N values for the same ΔT values, for example at $\Delta T = 0.4$ K where F varies between -0.7 and 0.3 $\mathrm{W\,m^{-2}}$.

After plotting N and ΔT as time series according to Fig. 1 in my paper it was found that the big loop in Fig. 2a corresponds to the time period mid-2006 to mid-2011 where both N and ΔT show oscillations. Such oscillations may occur by chance in a smoothed time series. However, because the oscillations in N and ΔT are coherent such an explanation is very unlikely. The coherent oscillations of N lagging the oscillations in ΔT with around seven months strongly suggest that what we are seeing is the feedback changes in the radiative flux in response to the changes in surface temperature.

This suggests that the feedback of the net radiative flux in response to changes in surface temperature comes with a lag and that Eq. (5) in my paper should describe the TOA net flux instead of Eq. (3):

ESDD

4, C90–C94, 2013

Interactive Comment

$$N(t) = F(t) - \alpha \Delta T\,(t - t_{\text{lag}})$$

Phase plane plots and linear regressions based on that equation are shown in Fig. 3. It is further observed in my paper that there appears to be a change of state in the climate system in mid-2006. During the period 2003 to mid-2006 the relations between N and ΔT are such that no linear model may be satisfied (unless the climate feedback parameter would be almost equal to zero).

According to those results in my paper it is doubtful if a linear regression of flux anomalies against surface temperature anomalies over the whole time interval, as applied in Dessler (2013), is likely to give reasonable results. The regression is carried out over a time interval with at least one change of climate state affecting the conditions for linear regression. Also the feedback in the radiative flux seems to have a lag which must be considered.

A linear relationship as needed for linear regression seems to be valid only in some parts of the time interval. It is possible that the climate feedback parameter may have much different values in different time intervals with different climate states. In order to use the linear regression method for studying feedbacks it seems important at first to identify in what time intervals a linear regression model is valid and to determine what value of the time lag that should be used in that time interval.

Specific comments

1. While in my paper CERES EBAF TOA net radiative flux data and temperature anomalies from HadCRUT3 were used, Dessler (2013) has used reanalyzed data from ERA-Interim and MERRA. However, that difference should not be important in this context.

ESDD

4, C90–C94, 2013

2. An especially important point in this context is that the phase plan plot in Fig. 2a in my paper is not consistent with the assumptions about small variations in F compared to the variations in $\alpha \Delta T$ that are necessary for using linear regression. After introduction of the hypothesis of a time lag based on the coherent oscillations seen in Fig. 1 in my paper the new phase plane plot in Fig. 2b is consistent with that assumption, but only for certain time intervals. Figure 3 in my paper shows a phase plane plot and two linear regressions for one such time interval, mid-2006 to mid-2011.

3. A remarkable agreement between my paper and Dessler (2013), although possibly a coincidence considering uncertainties in the data, concerns the rate of change of the radiative forcing. In the linear regressions in Dessler (2013) a rate of change in the radiative forcing of 0.2 $\mathrm{W\,m^{-2}}$ over the 2000-2010 period according to Solomon et al. (2011) was used that is around 0.02 $\mathrm{W\,m^{-2}\,a^{-1}}$. The linear regression shown in Fig. 3b in my paper, using the model equation $N(t) = F + bt - \alpha \Delta T\,(t - t_{\mathrm{lag}})$, gave a rate of change in the radiative forcing of $b = 0.025 \pm 0.030\,\mathrm{W\,m^{-2}\,a^{-1}}$.

Reference

Dessler, A. E., 2013: Observations of climate feedbacks over 2000–10 and comparisons to climate models. J. Climate, 26, 333–342.

Interactive comment on Earth Syst. Dynam. Discuss., 4, 25, 2013.