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Interactive Comment

Interactive comment on "ENSO surface shortwave radiation forcing over the tropical Pacific" *by* K. G. Pavlakis et al.

K. G. Pavlakis et al.

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General Comments

We agree with the referee that the ENSO eastern and western Pacific anomaly patterns for many parameters (i.e. SST, SLP, OLR, thermocline depth) have been well documented in the literature. The DSR anomaly patterns presented in our paper are in good agreement with the variations of the other parameters, as the referee points out. But, the aim of this paper was not only to show the DSR-A patterns but also to quantify the DSR variations during the ENSO oscillation. A critical parameter for understanding the ENSO evolution is the SST field. Many factors, well investigated, can influence the SST, like changes in wind speed that affect evaporative heat loss, or wind stresses that create Ekman drifts. Another important mechanism that affects SST is a change in cloud amount that influences the solar radiation that reaches the Earth's surface. DSR anomalies may be important in the western Pacific, where small SST changes are sufficient to induce a change from a warm to a cold ENSO event (western Pacific oscillator mechanism). This is the first paper that shows DSR-A during the development of an ENSO event.

In order to strengthen the paper, as both referees have suggested, we have included more discussion on the physical connection between DSR and ENSO in sections 4.1, 5 and in the conclusions.

Specific Comments

1) We agree with the referee that in some ENSO models, as in the coupled Zebiak-Cane model, surface heat flux does not enter explicitly. However, variations in surface heat flux are both a cause and consequence of variations in sea surface temperature. Thus, we have changed lines 9-12 on page 6701 to: "Specifically, the net heat flux into the ocean plays a key role in ENSO evolution through its effect on SST which is a significant variable in models that have been developed to make ENSO predictions".

2) Our north subtropical region (7N-15N, 150E-170E) has a high overlap with the Niño 6 region (8N-16N, 140E-160E) defined by Wang et al. (1999, JGR). We have changed the name of our north subtropical region in the paper to "off-equatorial western Pacific region". Weisberg and Wang (1997, GRL) proposed the "western Pacific oscillator" as a mechanism for the oscillatory nature of ENSO. This mechanism emphasizes the role of the western Pacific in the development of ENSO. According to this mechanism condensation heating due to convection in the central equatorial Pacific induces a pair of off-equator cyclones. The one in the northern hemisphere is developed over the "off-equatorial western Pacific region". A signal of the off-equator cyclones is the negative DSR anomalies shown in Fig 3a of our paper north and south of the equator. We have added a discussion on the connection between the "western Pacific oscillator" mechanism and the DSR-A in section 4.1 of our paper.

3) We make a figure that shows the correlation coefficient between the Niño-3.4 index

ACPD

8, S4198–S4201, 2008

Interactive Comment

time series and the average 3-monthly smoothed DSR-A time series as a function of leading and lagging months (from -12 to 12 months), as the referee suggested (it is available upon referee request). The SST in the central Pacific doesn't lead the DSR anomalies as the correlation coefficient for -6 month shift takes it's maximum value of 0.13. Thus we think it is not necessary to replace figure 9c in the paper with this one. It is clear that the DSR anomalies in the off-equatorial western Pacific lead the SST anomalies in the central and eastern Pacific by 7 months. This is an indication that the off-equatorial cyclone developed in the western Pacific, through the reduction of DSR, may initiate the reduction of SST there. Additionally, the rise of the thermocline there, via Ekman pumping, results in a further decrease in SST and a rise in sea level pressure (SLP). Low off-equatorial SSTs and high SLP, as shown by Wang et al. (1999, JGR), cause equatorial westerly winds in the central Pacific that contribute to the development of an El Niño towards its mature phase and equatorial easterly wind anomalies in the far western Pacific. As these easterly wind anomalies evolve during the El Niño mature phase, they provide a negative feedback on the ocean-atmosphere system. We have included more discussion on the physical connection between DSR and ENSO in section 5 of our paper.

Technical Comments

1: Although it might appear that there are many acronyms in the paper, in fact only two main variables are used (see table 1 in the paper). The one is "DSR", the downward shortwave radiation at surface with subscripts EN, LN or NE to specify whether El Niño, La Niña or neutral conditions prevail, respectively. The other variable is the widely used DSR-A, i.e. the DSR anomaly with respect to the long-term average where we have also added the subscripts LN or NE when we wanted to distinguish between the two extreme phases of ENSO (El Niño and La Niña) or between ENSO (El Niño or La Niña) and neutral conditions, respectively.

2: Professor Vardavas, who is an Australian, has checked the English.

ACPD

8, S4198–S4201, 2008

Interactive Comment

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