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Interactive comment on "How reversible is sea ice loss?" *by* J. K. Ridley et al.

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Thanks for the detailed assessment of the paper.

1. This work was completed many years ago and has been presented at various conferences since, but is finally now written up. The welcome Armour et al (2011) paper came out after submission to The Cryosphere, and complements the work of this paper. I have included reference to it in the discussion. The thrusts of the very interesting Winton paper and comprehensive Eisenman et al paper are not overly well aligned with this paper and, for the sake of simplicity of argument, are not referred to here. However, they are pertinent to a follow-on paper (under review) which addresses the performance of sea ice in our AR5 climate model, HadGEM2-ES.

2. Although Armour et al used CO2 as the medium of reversibility, I use global mean temperature as the temperature response to CO2 is different across models. Thus to

assist in model intercomparison global temperature is used here (after all it is temperature that sea ice is responding to), and reversibility is defined as such in section 2 and section 3.1. I have now added further clarification in the text. The lag in SH sea ice response to global temperature, a function of ocean heat uptake, is a form of hysteresis. This is where this paper differs from that of Armour et al as we allow CO2 to stay high for 1000 years and yet global temperatures have not reached equilibrium - the cause for the hysteresis. I have added to the discussion, to point out that this behaviour may be different across models due to variations in ocean heat uptake and consequently transient climate sensitivity (Raper et al., 2002).

3. it is true that the stabilisation at 1xCO2 is not run for sufficiently long to definitively state that there is no bistability. The trajectory is towards the start point. However, since the follow-on paper which does a more comprehensive analysis of the Antarctic reversibility for our new model, HadGEM2-ES, does show bistability, I have added a caveat in the discussion to this effect. Unfortunately, since the model discussed in this paper, HadCM3, is quite an old one, the capability of conducting further simulations no longer exists.

4. It is true that there is some influence of the sea ice on the temperature, since the 1.5m temperature is dependent on the immediate surface characteristics of that grid cell. However, we consider here only annual mean temperatures and sea ice area and the regions selected do not contain sea ice year round (indeed, none in the Arctic for a while). The point of this analysis is to show that despite the partial autocolloration, there were a bistability it would exhibit itself in the local temperatures (sst), even when the sea ice covers a small fraction of the area the area vs temperature trajectories are reversible. The poleward heat transports are thus reversible.

5. Global temperature was used as this is considered is cross model tool for defining the temperature sensitivity of sea ice that is independent from the polar amplification in the models (Gregory et al., 2002; Ridley et al., 2007; Winton et al., 2011). However, because of the prolonged stabilisation at high CO2 and consequent ocean heat uptake,

it may be unsuited to this experiment. Even so, the paper illustrates the cause of this failing through the inter-hemisphere temperature differences. A comment has been included in the discussion to this effect.

Minor points

1. Fair point. Have added to the method section "The two scenarios, fast and slow, are considered idealised extremes which bracket the range of policy-relevant scenarios."

2. Done.

3. Thanks for catching this. These numbers refer to figure 4 which had was previously not referenced to until the end of the paragraph. This is now corrected.

4. Ref to Stouffer included.

5. Clarified with some reference to Stouffer. It is the diapycnal mixing scheme in low resolution models which continues to mix downwards and beacuse of the greater depth of the Southern ocean results in a slower expression of heat to the surface.

6. Arctic ocean response now included descriptively is the results section, although it does not merit a further diagram.

7. Figure 1 adjusted accordingly

8. Figure 1 adjusted to match the model times and caption amended on figure 5.

Interactive comment on The Cryosphere Discuss., 5, 2349, 2011.