

Response to Editor's comment

It is great to see improvements for sea ice volume when you assimilate sea ice concentration. I wonder whether the choice of sea ice concentration product has an impact on the sea ice volume changes? Can you give some reasons why thickness errors remain high in certain areas and improve more in other areas. A short discussion about this would be enlightening.

Reply: Thank you very much for pointing this out. We have added two paragraph to discuss the effect of SIC assimilation on the SIT and SIV at the end of the section, as follows:

When combining the seasonal evolution of the SIC and SIT fields (Figs. 4 and 6), we can see that the effect of the SIC assimilation on the SIT is the most significant during the summer period. The LAON assimilation effectively corrected the large bias in the spatial distribution of the SIC, particularly in the Arctic shelf seas. Such a correction not only rectifies the summer SIT bias in these areas, but also provides an open ocean condition close to the observations for the later new ice development during the freezing period. By contrast, the persistent large overestimate in the MYI suggests that the SIC assimilation tends to have limited SIT improvement for the ice that survives through the melt season. Such a mechanism is unanimously applicable to the LAON SIC assimilation when using other SIC products, although the improvement may differ due to the variations in the SIC values and uncertainties.

The effect of the SIC assimilation on the SIT implies that the LAON SIC assimilation would also improve the SIV using any reasonable SIC products, with the largest improvements in the melt season and from new seasonal sea ice formed during the freezing period. While the improvement in the surviving MYI is generally limited, such MYI is expected to transport out of the Arctic in several years. It is therefore anticipated that, after several years' SIC assimilation, the SIT spatial distribution and the SIV would have an overall improvement. Nevertheless, a direct SIT assimilation would be more effective and prompt.

We also changed the corresponding conclusion as follows,

The LAON assimilation of SIC improves the simulation of SIT and SIV, with the largest improvements in the melt season and from new seasonal sea ice formed during the freezing period. In the present study, the spatial pattern of the simulated SIT is noticeably improved after a one-year LAON assimilation. The LAON assimilation also reduces the overestimate of SIV, with the bias in the second year being less than 3000 km³ compared with over 4000 km³ in the Free_run simulation (Fig. 7). However, the LAON assimilation of SIC generally has limited improvement in the surviving MYI, and it may take several years of assimilation to reach a notable improvement. Therefore, a direct assimilation of the SIT is highly needed.

(In addition to the above paragraph, Fig. 7a is updated in which the previous SIV calculation missed to multiply the grid area. The volumes in the text have also been corrected.)