

Responses to reviewers' comments

We would like to thank the reviewers for their careful readings of our manuscript and the detailed comments. The major changes in the revision are the following:

- Added comparison with the independent sea ice thickness from buoy observations from autonomous ice mass balance (IMB; <http://imb.erdcdren.mil>) shown in Fig. 7 of the revised manuscript.
- Equations from (1) to (5) are modified or changed their orders in the text.
- Modifications of figures of 1, 4, and 5 as the suggestions.

The detailed responses are listed one by one as following:

Reviewer #2:

(1) Page 2, line 6: “winter season” should be “cold season”.

Reply: We agree with the reviewer, and also change throughout the manuscript.

(2) Page 2, line 13, the full name of TOPAZ should be given in the Abstract.

Reply: The origin of the name TOPAZ is from a European project (***Towards an Operational Prediction system for the North Atlantic European coastal Zones***). However time has passed and we now consider TOPAZ as a brand name and no longer as an acronym.

(3) Page 2, line 20, should “contents” be corrected to “contains” ?

Reply: Thanks. It is replaced by “contains”.

(4) Page 2, line 28, the “Keywords” should be revised, e.g., a lot of readers do not know “OSE” and “DFS”.

Reply: These words are replaced by “Observing System Experiment” and “Degrees of Freedom for Signal”.

(5) Page 3, line 22, “draft” should be “freeboard”.

Reply: Thanks. This mistake is corrected by freeboard.

(6) Page 4, line 13: Yang et al. (2015) should be (2014).

Reply: Thanks. The reference is corrected by Yang et al. (2014).

(7) Page 4, line 14: “LSEIK” should be defined.

Reply: It is defined by with the Localized Singular Evolutive Interpolated Kalman filter (LSEIK, ref. Nerger et al., 2005).

(8) Page 4, line 26, “Xie et al., 2016” is frequently referred in this MS, this should be corrected, as it has not been accepted, the authors even have not tell us the journal they submitted to.

Reply: Xie et al. (2016) was submitted to *Ocean Science discussion* at the moment, and is available online as doi:10.5194/os-2016-38. <http://www.ocean-sci-discuss.net/os-2016-38/>

(9) Page 7, line 15, is “TOPAZ equivalent ice thickness” “TOPAZ model mean ice thick- ness”?

Reply: This statement is modified as “The TOPAZ ice thicknesses shown in Fig.2 are at the same locations and times as the observations.”

(10) Page 7, line 17, “RMSD” is not defined here.

Reply: Thanks. This definition is added.

(11) Page 7, line 29, you only assimilate the SMOS data less than 0.40 m, why not 0.50 m? As you referred, “the penetration depth into sea ice is about 0.5 m”. Although you mentioned that “the effect of ice melting may lead to a saturation thickness of less than 0.4 m”, but for this paper, you run the experiments in the cold season, basically there is no melting in the sea ice surface. If you increase the upper limit, more SMOS observation data is available, thus stronger influence/correction to the TOPAZ system is expected. In Yang et al. (2014), they use an upper limit of 1.0 m.

Reply: It is correct that by raising the threshold to 1 m we would increase the influence of the observation. However the observation error becomes very large above 0.4 m, so we do not expect that we are losing much information (see also Fig. A in the answer to Reviewer #1). The main motivation for rejecting the observation above this threshold is that there is an obvious bias between model and observation beyond this threshold. Data assimilation with bias is problematic because the correction of the bias may be transferred to

other variables via the multivariate updates of the scheme. We have therefore taken a cautious approach and decided not to use the data > 0.4 m for the moment. The word “multivariate” is added on p. 8, l. 8

(12) Page 8, line 3, 4, 7: “thick” should be “thickness”?

Reply: Here, it means the sea-ice thickness simulated by the model is too thick relative to the SMOS-Ice data. We want to keep the indication of the sign of the bias (too thick instead of too thin).

(13) Page 8, line 19, y_{smos} is not defined.

Reply: Thanks. The definition is added in the revision.

(14) Page 9, line 10: “SMOS-Ice” is forgotten in Table 1.

Reply: Table 1 lists the observations assimilated in the present TOPAZ system. This is clarified in the revision.

(15) Page 11, line 1: In the Beaufort Sea, there are some sea ice draft measurements from Beaufort Gyre Exploration Project (BGEP) by upward-looking sonar (ULS) moorings located in the Beaufort Sea (<http://www.who.edu/beaufortgyre>). Also, there are some sea ice thickness data obtained from autonomous ice mass balance (IMB; <http://imb.erd.c.dren.mil>). I would suggest the authors to use these data as the independent ice thickness observations in the evaluation of their model results.

Reply: Thanks. The two buoys from the IMB have been used to validate the sea ice thickness as the Fig. 7 in the revision. As the buoys are far away from assimilated observation, the impact is small. Still there is a slight improvement.

(16) Page 12, line 32, an “a” is missing before “slight”. (17) Page 13, line 24, should be “In addition”.

Reply: Thanks. It is added in the revision.