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Interactive comment on "Quality assessment of the TOPAZ4 reanalysis in the Arctic over the period 1991–2013" *by* Jiping Xie et al.

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Referee #2 The manuscript provides a detailed description of the results of the 23-year reanalysis of the Arctic computed with the TOPAZ4 model system. 1. The manuscript appears more like a report than a scientific paper tackling a scientific or methodological issue. The model system is described elsewhere and has undergone very little changes with respect to previously published information. The assessment of the quality of the products uses a rather elementary approach.

Reply: The paper by Sakov et al. (2012) was a proof of concept that an EnKF-based assimilation system can be used with a coupled ocean and sea ice for long reanalysis. This study does not propose new methodological development but it verifies that the proof of concept holds when applied for a longer period (23 years are more relevant

to the community than 6 years) with a more heterogeneous observation network (spatially, temporally and various data sources). The main purpose of the manuscript is to present and validate the official Copernicus CMEMS product for the Arctic region. The proposed reanalysis is unique (see table below extracted from Chevalier et al. 2016) as it proposes a long high-resolution dynamical reconstruction of the ocean and sea ice, and assimilates a complete set of observations available in the Arctic region with an advanced ensemble data assimilation method and with strongly coupled data assimilation between ocean and sea-ice. We have tried to present this achievement in a concise manner, with a primary focus to inform the end-user about the strength and weaknesses of our data set. As a response to the recommendation of the first reviewer (and your following comment), we will extend the current validation with the an analysis of the ensemble reliability, and asses whether our system manage to provide a dynamical reconstruction that falls within the uncertainty of the different observational data sets that are assimilated. We believe that this will increase the scientific value of our manuscript as it would confirm or infirm the underlying assumptions on model and observation errors.

2. The results discussed in the manuscript can be useful as a support of further studies using the reanalysed fields but, as it stands, the manuscript is merely descriptive. Also, little information is given about the ensemble and this information is not used to assess the quality of the reanalysis: only the ensemble mean are used for this purpose.

Reply: We agree and this will be investigated using the ensemble statistics at assimilation time. See also our answer to the other reviewer.

3. The quality of the reanalysis obtained using TOPAZ4 could also be compared with the quality of similar other products.

Reply: We think that such comparison is beyond the scope of our paper and, for the sake of diplomatic correctness, is better undertaken in a separate collaborative initiative (The ongoing Ocean Synthesis COST action, a follow-up of the ORA-IP Arctic paper by Chevallier et al.). A primary comparison of the ocean part of our analysis has been compared with other existing systems (Lien et al. 2016, cited in the manuscript).

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Table 1 System configuration and selected parameters

Name	C-GLORS05	CNRM	ECCO-v4	ECDA	GloSea5	G2V3	MERRA Ocean	MOVE-CORE	MOVE-G2	ORAP5	UR025.4	G2V1	ERAL	ERAN
Institution	CMCC	CNRM-GAME	JPL/NASA, MIT, AER	GFDL/NOAA	UK Met Office	Mercator Océan	GSFC/NASA/GMAO	MRI/JMA	MRI/JMA	ECMWF	University of Reading	Mercator Océan	ECMWF	ECMWF
Nominal horizontal resolution	0.5°	1°	0.4°–1.0°	1°	0.25°	0.25°	0.5°	0.5° × 1°	0.3–0.5° × 1°	0.25°	0.25°	0.25°	1°	1°
Ocean–sea ice model	NEMO3.2-LIM2	NEMO3.2-GELATO5	MITgcm	GFDL-MOM4.4.1-SIS	NEMO3.2-CICE4.0	NEMO3.1-LIM2 (EVP)	MOM4.1-CICE4.0	MRI. COM3-Mellor & Kanta + CICE4.0	MRI.COM3-Mellor & Kanta + CICE4.0	NEMO3.4-LIM2	NEMO3.2-LIM2	NEMO3.1-LIM2 (EVP)	NEMO3.2-LIM2	NEMO3.2-LIM2
Time period	1979–2011	1990–2010	1992–2010	1961–2014	1993–2012	1993–2011	1979-present	1948–2007	1993–2012	1979–2012	1989–2010	1993–2009	1990–2011	1990–2011
Source of atmospheric forcing data	ERA-Interim	ERA-Interim	ERA-Interim	Coupled run constrained to NCEP/NCAR-NCEP/DOE	ERA-Interim	ERA-Interim	Coupled run constrained to MERRA	CORE	JRA55	ERA-Interim	ERA-Interim	ERA-Interim	ERA-Interim	ERA-Interim
Vertical discretization	2 ice + 1 snow	9 ice + 1 snow	1 ice + 1 snow	2 ice + 1 snow	1 ice + 1 snow	2 ice + 1 snow	4 ice + 1 snow	1 ice + 1 snow	1 ice + 1 snow	2 ice + 1 snow	2 ice + 1 snow	2 ice + 1 snow	2 ice + 1 snow	2 ice + 1 snow
Thickness categories	1	8	1	5	5	1	5	5	5	1	1	1	1	1
Dynamics	EVP	EVP	VP	EVP	EVP	EVP	EVP	EVP	EVP	VP	VP	EVP	VP	VP
P* (N/m)/ Cf (–)	$P^* = 2.0 \times 10^4$	$P^* = 2.75 \times 10^4$	$P^* = 2.754 \times 10^4$	$P^* = 2.5 \times 10^4$	Cf = 17	$P^* = 2 \times 10^4$	$P^* = 2.75 \times 10^4$	$P^* = 2.75 \times 10^4$	$P^* = 2.75 \times 10^4$	$P^* = 1.50 \times 10^4$	$P^* = 1 \times 10^4$	$P^* = 2 \times 10^4$	$P^* = 1.5 \times 10^4$	$P^* = 1.5 \times 10^4$
Drag air–ice (10-3)	1.63	1.63	2.00	1.21	1.63	1.50	1.63	3.00	1.00	1.63	1.63	1.50	1.63	1.63
Drag ocean–ice (10-3)	10.00	5.00	1.00	3.24	5.36	10.00	5.36	5.50	5.50	10.00	5.00	10.00	5.00	5.00
DA sea ice system	Linear nudging	None (SST)	Adjoint	None (SST)	3DVAR	2D local analysis SEEK filter	EnOI	None (SST)	None (SST)	3DVAR-FGAT	OI	None (SST)	Linear nudging	Flow-dependent nudging
DA sea ice data	NSIDC	–	NSIDC	–	OSI-SAF	CERSAT	NSIDC	–	–	OSTIA	OSI-SAF	–	NCEP-OIv2	NCEP-Oiv2
Analysis window	7 days	10 days	20 years	1 day	1 day	7 days	5 days	1 month	1/3 month	5 days	5 days	7 days	1 day	1 day

P* and Cf are parameters for the ice strength formulations following respectively Hibler (1979) and Rothrock (1975)

DA data assimilation, *VP* viscous-plastic, *EVP* elastic–viscous–plastic, *SST* sea surface temperature

Fig. 1.