Validation of atmospheric reanalyses against tethersonde data from the central Arctic Ocean in spring and summer 2007

AT-23

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1. INTRODUCTION

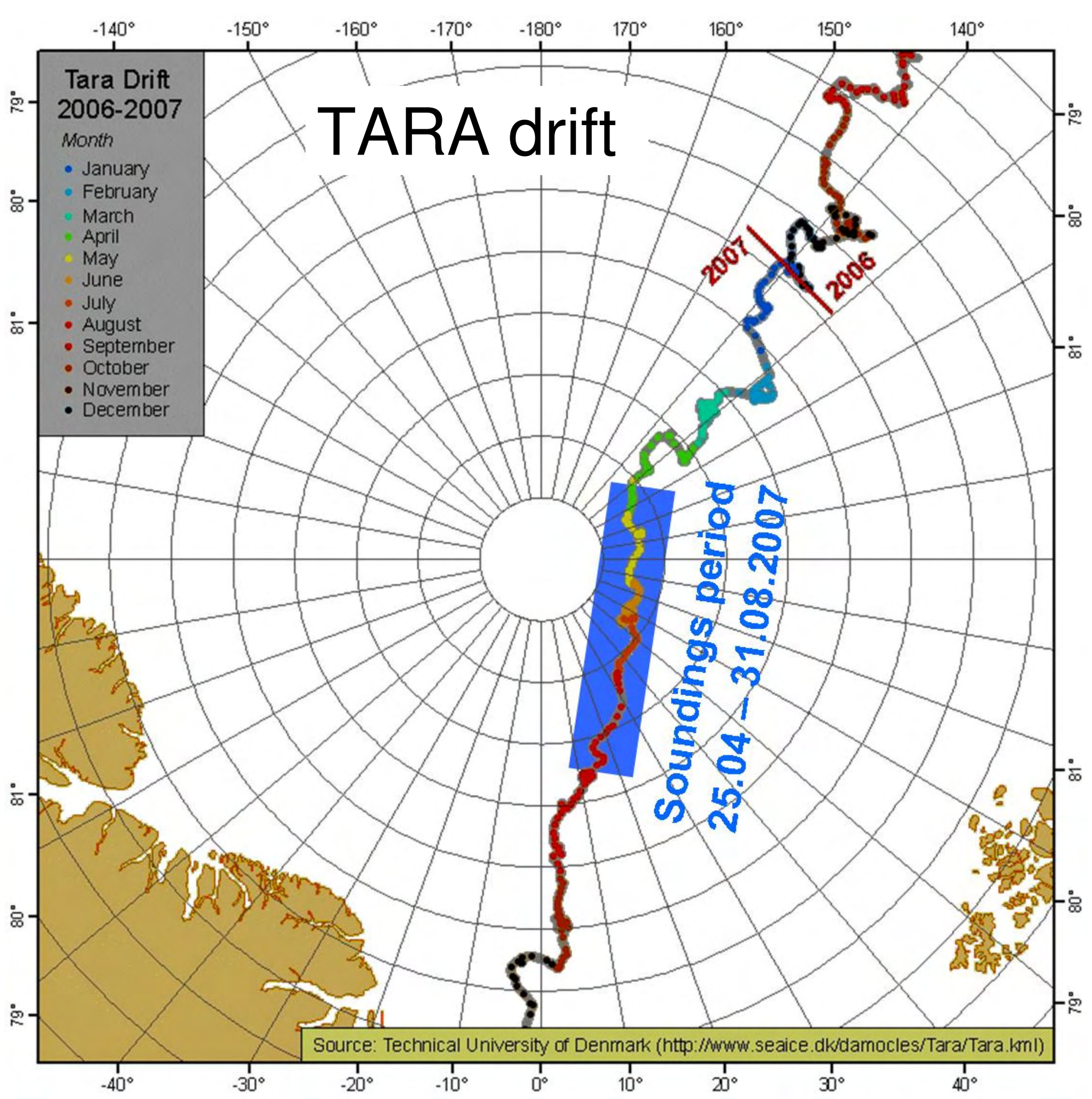
The structure and processes in the atmospheric boundary layer (ABL) over the ice-covered Arctic Ocean is quantitatively not well known. Detailed observations have been made only during ship and aircraft campaigns and ice stations. At the drifting ice station TARA, from 25 April to 31 August 2007, total of 95 tethersonde soundings during 39 sounding days were made. A Vaisala DigiCORA Tethersonde System was used to measure the vertical profiles of the air temperature, relative humidity, wind speed, and wind direction up to the height of 2 km. The average top height of the soundings was 1240 m. For this study, 29 profiles up to 890 m were selected.

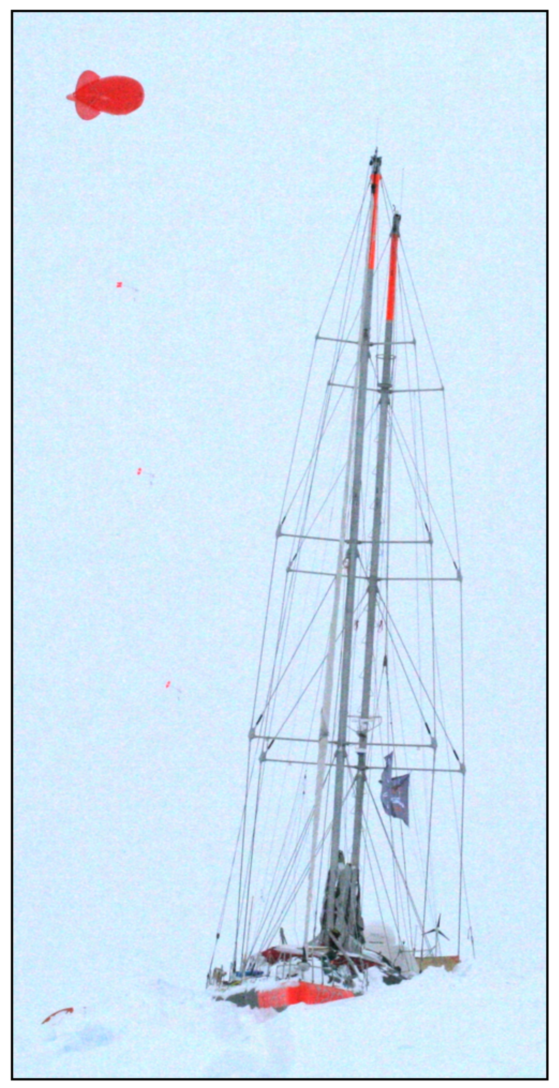
2. DATA

Tara tethersonde sounding data were not sent to the GTS network of the WMO. The data therefore provides a rare possibility for validation of atmospheric model reanalyses against an independent data set. The following reanalyses were validated against TARA sounding data:

- **ERA-Interim;**
- **JCDAS JMA;**
- **NCEP-DOE;**
- **NCEP-CFSR;**
- **NASA-MERRA.**

The reanalysis products were horizontally linearly interpolated to TARA sounding sites. In the vertical, the reanalysis results were linearly extrapolated from the model levels (from 2 levels of NCEP-DOE to 9 levels of ERA-Interim) to the sounding levels. In addition, the reanalysis products for 2 m temperature and humidity and 10 m wind speed were validated.





3. RESULTS

Single modelled profiles varied from the measured profiles a lot: in temperature single profile errors reached to 15°C, in specific humidity to 3 g kg^{-1}, and in wind speed to 5 m s^{-1}.

None of the reanalyses was successful in capturing the shape of the temperature profile. ERA-Interim and MERRA performed very well above 200 m, but had a significant warm bias of up to 2.0°C at lower levels. NCEP-CFSR was very good in the lowermost 200 m layer, but had a significant cold bias above 400 m, whereas NCEP-DOE yielded a strong surface-based inversion, with a large significant warm bias peaking at the height of 100 m. Upward of the lowest prognostic model level, JCDAS yielded a linear temperature gradient of –5°C km^{-1}, which strongly deviates from observations.

Among the reanalyses, basically only ERA-Interim reproduced the shape of the specific humidity profile, but with a significant moist bias of 0.3 to 0.5 g kg^{-1} throughout the profile. The observed mean specific humidity profile was best captured by NCEP-CFSR, with mostly dry insignificant biases of up to 0.3 g kg^{-1}.

ERA-Interim and JCDAS yielded statistically significantly too strong 10 m wind speed, whereas higher than 30 m MERRA and NCEP-CFSR had significantly too low wind speed. The mean wind speed profile was best captured by ERA-Interim and JCDAS. NCEP-CFSR and MERRA, however, outperformed the other reanalyses for the 10 m wind speed.

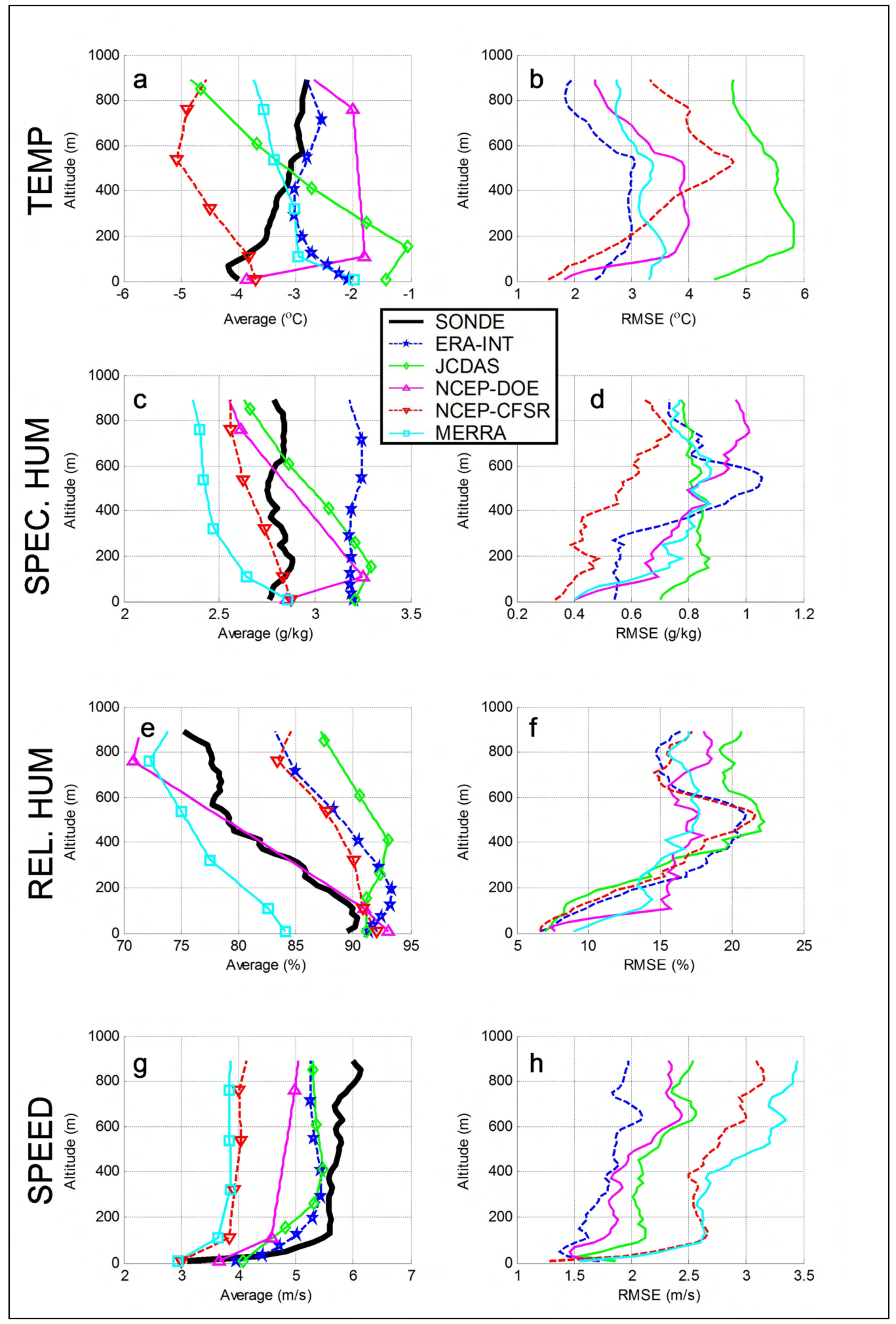
Vertically averaged values of the magnitude of bias, RMSE, and correlation coefficient of air temperature, specific humidity, relative humidity, and wind speed. The best reanalyses is ranked by 5 points and the worst by 1 point.

	ERA-Interim		NCEP-DOE		NCEP-CFSR		MERRA		JCDAS	
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
Ta |bias|	0.51	5	1.17	3	1.36	2	0.63	4	1.42	1
Ta RMSE	2.61	5	3.31	3	3.53	2	3.15	4	5.3	1
Ta Correl	0.74	4	0.79	5	0.7	2	0.74	3	0.63	1
Qa |bias|	0.4	1	0.2	4	0.14	5	0.33	2	0.25	3
Qa RMSE	0.75	4	0.81	2	0.54	5	0.75	3	0.81	1
Qa Correl	0.56	4	-0.17	1	0.58	5	0.33	2	0.47	3
RH |bias|	6.89	2	2.35	5	5.82	3	5.26	4	8.68	1
RH RMSE	15.7	3	15.9	2	15.3	5	15.4	4	16.8	1
RH Correl	0.41	3	0.48	4	0.29	2	0.52	5	0.23	1
V |bias|	0.43	5	0.9	3	1.69	2	1.85	1	0.47	4
V RMSE	1.8	5	2.03	4	2.7	2	2.91	1	2.2	3
V Correl	0.71	5	0.59	4	0.44	2	0.28	1	0.52	3
Total points		46		40		37		34		23

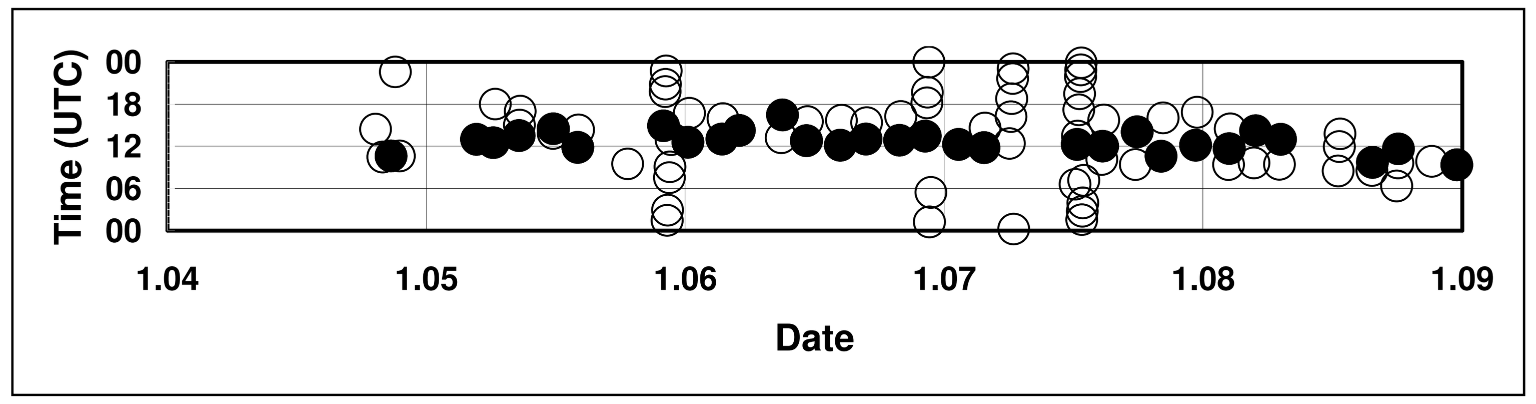
4. CONCLUSIONS

There is no model that performs best in all variables and layers:

- ERA-Interim got the highest overall ranking, but suffered, however, from a warm bias of up to 2°C in the lowermost 400 m layer and a moist bias of 0.3 to 0.5 g kg^{-1} throughout the 890 m layer.
- Both NCEP reanalyses and MERRA outperformed the other reanalyses with respect to 2 m air temperature and specific humidity and 10 m wind speed. This is an important result for those who apply reanalyses to provide atmospheric forcing for sea ice models in retrospective simulations. If one reanalysis should be selected, NCEP-CFSR is recommended on the basis of this study.
- JCDAS suffered from poor temperature and humidity inversions with close to moist-adiabatic temperature profile.
- The observed biases in temperature, humidity, and wind speed are in many cases comparable or even larger than the climatological trends during the latest decades. This calls for caution when applying reanalysis data in climatological studies.



From 29 single profiles calculated: a) average temperature, b) RMSE (root mean square error) of temperature, c) average specific humidity, d) RMSE of specific humidity, e) average relative humidity, f) RMSE of relative humidity, g) average wind speed, h) RMSE of wind speed.



Temporal distribution of Tara tethersoundings; filled circles mark the soundings that were included in this study.

Jakobson, E., T. Vihma, T. Palo, L. Jakobson, H. Keernik, and J. Jaagus (2012), Validation of atmospheric reanalyses over the central Arctic Ocean, *Geophys. Res. Lett.*, 39, LXXXXX, doi:10.1029/2012GL051591 (in press)