Atmos. Chem. Phys. Discuss., 14, C5816–C5827, 2014
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Atmospheric Chemistry and Physics Discussions

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Interactive Comment

Interactive comment on "Atmospheric winter conditions 2007/08 over the Arctic Ocean based on NP-35 data and regional model simulations" *by* M. Mielke et al.

M. Mielke et al.

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Received and published: 13 August 2014

Answers to anonymous referee 1

Atmospheric winter conditions 2007/08 over the Arctic Ocean based on NP-35 data and regional model simulations by Mielke et al.

We thank the reviewer for his careful reading and useful comments.

Major comments/questions:

1. As suggested by the reviewer, we computed area-averaged values for a selected

rectangle region over the Arctic Ocean indicated by white lines for December 2007 until February 2008 and the 3 different time scales 1-3, 2-10 and 10-20 days and show and explain them in the new Fig. 16. We recomputed the Figs. 13-15 by including the HIRHAM f12 simulations.

We described these results in the text as follows. “The increased vertical stability in the model simulations does not show an influence on synoptical time scales 1-3 days, but leads to reduced planetary-scale variability on time scales of 2-10 and 10-20 days in all winter months.”

New Fig. 13. Pan-Arctic distribution of synoptic-scale variability on time scales from 1–3 days expressed as filtered temporal standard deviation of 6 hourly mean sea level pressure (hPa) for November 2007 (upper row) until March 2008 (lower row) and December, January and February in between. From left to right ECMWF operational analyses, HIRHAM f12 simulations, HIRHAM clima simulations with b = 5, and HIRHAM b10 with b = 10.

New Fig. 14. Pan-Arctic distribution of baroclinic-scale variability on time scales from 2–10 days expressed as filtered temporal standard deviation of 6 hourly mean sea level pressure (hPa) for November 2007 (upper row) until March 2008 (lower row) and December, January and February in between. From left to right ECMWF operational analyses, HIRHAM f12 simulations, HIRHAM clima simulations with b = 5, and HIRHAM b10 with b = 10.

New Fig. 15. Pan-Arctic distribution of baroclinic-scale variability on time scales from 10–20 days expressed as filtered temporal standard deviation of 6 hourly mean sea level pressure (hPa) for November 2007 (upper row) until March 2008 (lower row) and December, January and February in between. From left to right ECMWF operational analyses, HIRHAM f12 simulations, HIRHAM clima simulations with b = 5, and HIRHAM b10 with b = 10.

New Fig. 16. Area mean (rectangle indicated by white lines in new Figs. 13-15) of the synoptic and planetary-scale variability on time scales 1-3 days, 2-10 days and 10-20 days for December 2007 (left), January (middle) and February 2008 (right). The results are based on filtered standard deviation of 6 hourly mean sea level pressure (hPa). Red column-ECMWF, Grey column-HIRHAM f12, Green column-HIRHAM clima with b5, Blue column-HIRHAM b10.

2. We changed the sentences on page 11871, lines 8-16: "The model simulations show deficits in reproducing the observed temporal near-surface temperature changes especially in January, when the temperature differences between observations and model simulations near the surface can reach up to 15 K. These large temperature differences are connected with overestimated vertical mixing in the stable ABL, but deficits in the modelled cloud feedbacks still play a role"

We changed the sentence on page 11871, lines19-24: "As a result of the strong temperature bias near the surface, HIRHAM simulates too many and too strong near surface inversions and too less temperature inversions in the lowest 400 meters. Above 400 meters HIRHAM simulates too many elevated inversions compared to the NP-35 data, which could be connected with the poor simulations of clouds."

We changed the sentence on page 11872, lines 6-7: "This feedback changes the baroclinic-scale variability on time scales from 2-10 days and impacts through baroclinic-barotropic interactions on the planetary scale variability and the large-scale planetary wave patterns."

3. We added the following sentences to explain better what is new in the results: "Boundary layer processes over the ice covered Arctic Ocean during winter are investigated by comparing the unique observations from the Russian drifting station NP-35 and a set of sensitivity experiments with the regional model HIRHAM in the climate and forecast mode. Sensitivity experiments for the parameterization of the stable boundary layer and its interaction with synoptic scale processes are presented."

4. We incorporated the impact of varying sea ice thickness on simulated surface and

tropospheric temperatures. In the current model setup there is no snow layer on sea ice on page 11864, LN 9: "A reduction of sea ice thickness from 2m to 1m reduces the temperature correlation coefficient between model simulations and the NP-35 observations at 1000 hPa from 0.58 to 0.55 and at 500 hPa from 0.74 to 0.66."

Detailed comment:

Page 11856: L13: This sentence was changed to: "The impact of internally generated dynamical changes on the temporal development of atmospheric surface processes and vertical profiles of temperature, wind and relative humidity has been estimated trough ensemble simulations by varying the initial atmospheric conditions."

Page 11857: L16-19: "To understand the complex feedbacks between turbulence and mixing processes in the stable stratified ABL over the Arctic Ocean, baroclinic cyclones and the planetary-scale atmospheric circulation, more reliable observational data are needed. The combined use of data and model studies might help to reduce the current uncertainties in Arctic climate models."

Page 11858, L15: Corrected to: small-and meso-scales features

P11858, L16-18: "A regional climate model (RCM) generates from lower-resolution lateral boundary conditions, dynamically consistent high resolution atmospheric fields. Laprise (2008) showed in ensemble simulations with a RCM, that beside the forced component as a result of prescribed sea-surface and lateral boundary conditions, departures from the ensemble mean, the so called free component appears on spatial scales below 1100 km due to internally generated variability. In this way, RCMs are capable of generating regional and meso-scale features absent in the driving fields. This is the added value of the presented HIRHAM simulations on climate time scales. Prescribed sea-surface and lateral boundary conditions determine the forced ensemble mean component in a regional climate model, but departures from the ensemble mean can appear on spatial scales below ca 1100 km due to internally generated variability. This internally generated free component depends on the RCM domain size and can

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be rather strong in the applied large Arctic integration domain as shown by Rinke and Dethloff (2000)."

P11859, L6-7: "As part of observations during the International Polar Year (IPY) the Russian sea ice drifting station "North Pole-35" was built by the Arctic and Antarctic Research Institute (AARI) St. Petersburg. From 21 September 2007 (81°27' N 115°19' E) until 13 July 2008 (81°15'N 029°15'E) NP-35 drifted on a sea-ice flow across the Arctic Ocean."

P11860, L1: "Near-surface meteorological parameters: was added.

P11860, L9-14: "The upper air measurements have been carried out twice daily at 00:00 and 12:00 UTC with the sounding system Vaisala Digicora III and RS-92 type probe (Vaisala, Finland)."

P11861, L14: We agree with the reviewer.

P11862, L17: The HIRHAM convention differs between radiative and turbulent fluxes. Downward turbulent fluxes are positive and upward fluxes are negative.

P11863, L10-14: "At NP-35 relative humidity measurements has been carried out with the sensor HMP45 DX from Saliva. Its accuracy in temperature range -20 +60 degrees is: $\pm$ 2% (RH 0 - 90%) and $\pm$ 3% (RH 90 - 100%). Dew point temperatures has been calculated with Vaisala software and not measured independently."

P11864. L6-9: We incorporated in Table 2 the specific humidity results as requested.

P11864, L19: We changed the wording to planetary scale to avoid the word transient.

P11865, L25-26: We changed these sentences as suggested "differ for stronger turbulence, when z0 is large. This dependency is not taken into account in the HIRHAM model."

P11866, L4-5: We added the following sentence. "The inversion top heights are much lower than the winter statistics presented in Serreze et al. (1992) and a result of the

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very cold winter temperatures in this single year 2007/08."

P11866, L12: Based on Fig. 6, the across-ensemble scatter for temperature, wind speed and relative humidity, described by the $\pm$ 1 standard deviations in the HIRHAM ens varies during the winter.

P11866, L24: We connect this to the higher horizontal resolution.

P11867, L2: We reformulated this sentence: Temperature inversions close to the surface are an essential feature of the Arctic atmosphere.

P11867-11868: We added the following sentence: These problems in simulating LLJs are very similar to those reported by Tastula et al. (2013).

P11868, L8-9: We added the following sentences: The wavelet analyses of 10 m wind measurements at NP-35 (Fig. 4) indicated pronounced variability on time scales from 5 to 25 days and points to the important role of air mass advection through synoptical disturbances during winter which could impact on the surface energy balance. We therefore computed in Fig. 10 the observed and simulated frequency distribution of surface net LW radiation with respect to the NP-35 drift. The NP-35 extended winter observations indicate two different radiative-turbulent states below and above 30 Wm-2. These states are similar to the two different synoptically driven atmospheric circulation states detected by Stramler et al. (2011) for the winter of the SHEBA year 1997/98.

P11868, L12-18: We added the following sentences: The HIRHAMf12 simulations apply a nudging to the operational ECMWF analyses every 12 hours and it seems that beside the accurate initial states internally generated variability on monthly time scales is essential for the development of the two different radiative-turbulent circulation states. As shown by Stramler et al. (2011) the cold and warm circulation anomalies connected with these radiative-turbulent states often persist for days to weeks.

P11869, L20: The sentences were changed to: Figure 12 displays ... from the bulk

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parameterization of Zilitinkevich (1970) only applied for both atmospheric circulation states from November 2007 until March 2008. As shown by Makshtas et al. (2012) these results are not sensitive to the selected parameterization." Makshtas A.P., Ivanov B.V., Timachev V.F., 2012, The comparison of turbulent energy-mass exchange parameterizations in stable stratified atmospheric surface layer. Problems of the Arctic and Antarctic, 3, 93, 5 – 18, in Russian.

P11869, L20: The sentence was changed to: Turbulent mixing is determined by the surface roughness, the thermal stratification and the vertical wind shear.

P11870, L15-17: The following sentence was added: The transient cyclones include also spatial scales larger than 400 km.

Table 2: We removed the RMS error of the observations from this table. This was a mistake.

Figure 4: We added the following sentences: The colours describe the local wavelet power normalized by 1/(σxσ) in the different frequency bands. The edge effects are due to finite-length time series.

Figure 5: The legend was rewritten: Pan-Arctic distribution of monthly mean sea level pressure (hPa) from November 2007 (uppermost row) until March 2008 (lowermost row) for the operational ECMWF analyses (left column). The second column displays the "ECMWF analyses minus HIRHAMf12", the third column the "ECMWF analyses minus HIRHAM ens", the fourth column the "ECMWF analyses minus HIRHAM clima" and the last column the "ECMWF analyses minus HIRHAM b10". The NP-35 position is indicated by the black rectangles.

Figure 7: We replotted this Figure with different colour bars.

New Fig. 7.

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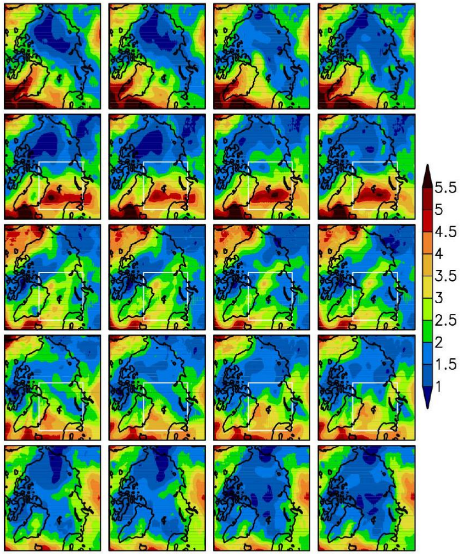

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Fig. 1.

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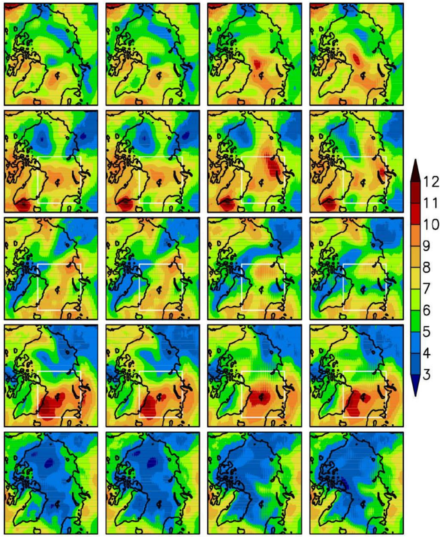

New Fig. 14. Pan-Arctic distribution of baroclinic-scale variability on time scales from 2–10 days expressed as filtered temporal standard deviation of 6 hourly mean sea level pressure (hPa) for November 2007 (upper row) until March 2008 (lower row) and December, January and February in between. From left to right ECMWF operational analyses, HIRHAM f12 simulations, HIRHAM clima simulations with b = 5, and HIRHAM b10 with b = 10.

Fig. 2.

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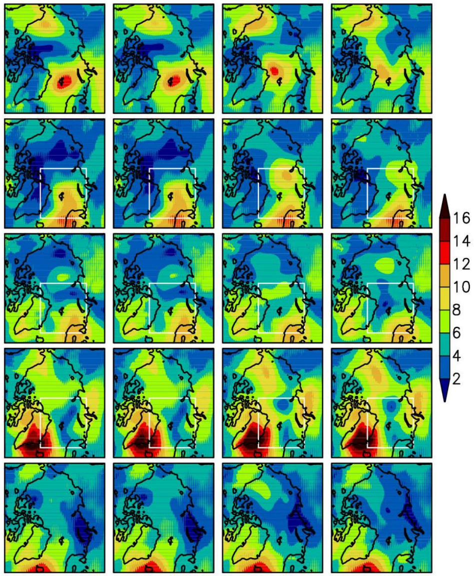

New Fig. 15. Pan-Arctic distribution of baroclinic-scale variability on time scales from 10–20 days expressed as filtered temporal standard deviation of 6 hourly mean sea level pressure (hPa) for November 2007 (upper row) until March 2008 (lower row) and December, January and February in between. From left to right ECMWF operational analyses, HIRHAM f12 simulations, HIRHAM clima simulations with b = 5, and HIRHAM b10 with b = 10.

Fig. 3.

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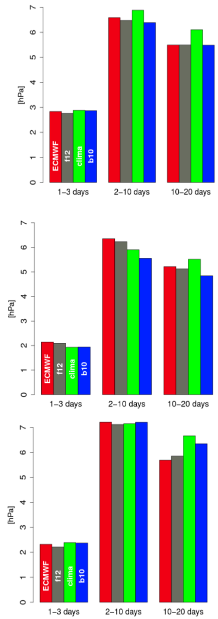

New Fig. 16. Area mean (rectangle indicated by white lines in new Figs. 13-15) of the synoptic and planetary-scale variability on time scales 1-3 days, 2-10 days and 10-20 days for December 2007 (top), January (middle) and February 2008 (bottom). The results are based on filtered standard deviation of 6 hourly mean sea level pressure (hPa). Red column-ECMWF, Grey column-HIRHAM f12, Green column-HIRHAM clima with b5, Blue column-HIRHAM b10.

Fig. 4.

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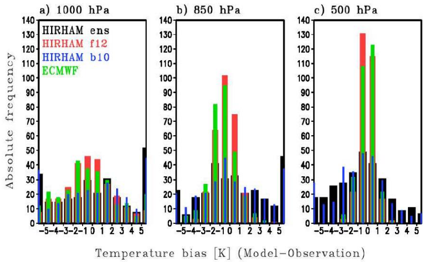

New Fig. 7.

Fig. 5.

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