Characteristics of clouds in the Arctic Ocean:

Comparison of Arctic-CORDEX regional model's data with satellite observations

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Introduction

Clouds play one of the key roles in the Arctic climate system by impacting on the regional energy budget and acting in several influential climate feedbacks. The Arctic cloud cover is sensitive to different climatic factors such as sea ice extent and atmospheric circulation indices. Climate and numerical weather prediction models, including regional models, simulate the Arctic cloud cover imperfectly, with non-negligible biases. The models may significantly benefit from inter-comparisons between the observed cloud cover and the corresponding quantities from historical model runs. It is of note, that for the Arctic-CORDEX regional model ensemble such intercomparison has not been performed previously for the entire Arctic.

Data and methods

This paper presents first results of comparative analysis of cloud characteristics, i.e., cloud liquid, ice and total water path (CLWP, CIWP and CTWP, respectively), that based on data from six regional models of the Arctic-CORDEX project. In particular, we used data from CCCma CanRCM4, DMI HIRHAM5, SMHI RCA4, SMHI RCA4–SN, ULg MAR3.6, and UQAM CRCM5-SN models. Model data were compared with the CERES satellite data (the SYN1deg_4.1 product). All data were bilinearly interpolated into the unified 0.25-degree grid cell.

Results

Comparison of cloud characteristics was carried out for different underlying surfaces (open water and sea ice). Distributions of cloud characteristics (Figure 1) and median values (Table 1) for all grid cells over open water and solid-ice regions were intercompared among models and satellite data for the mutual period from 2001 to 2010 for the cold portion of the

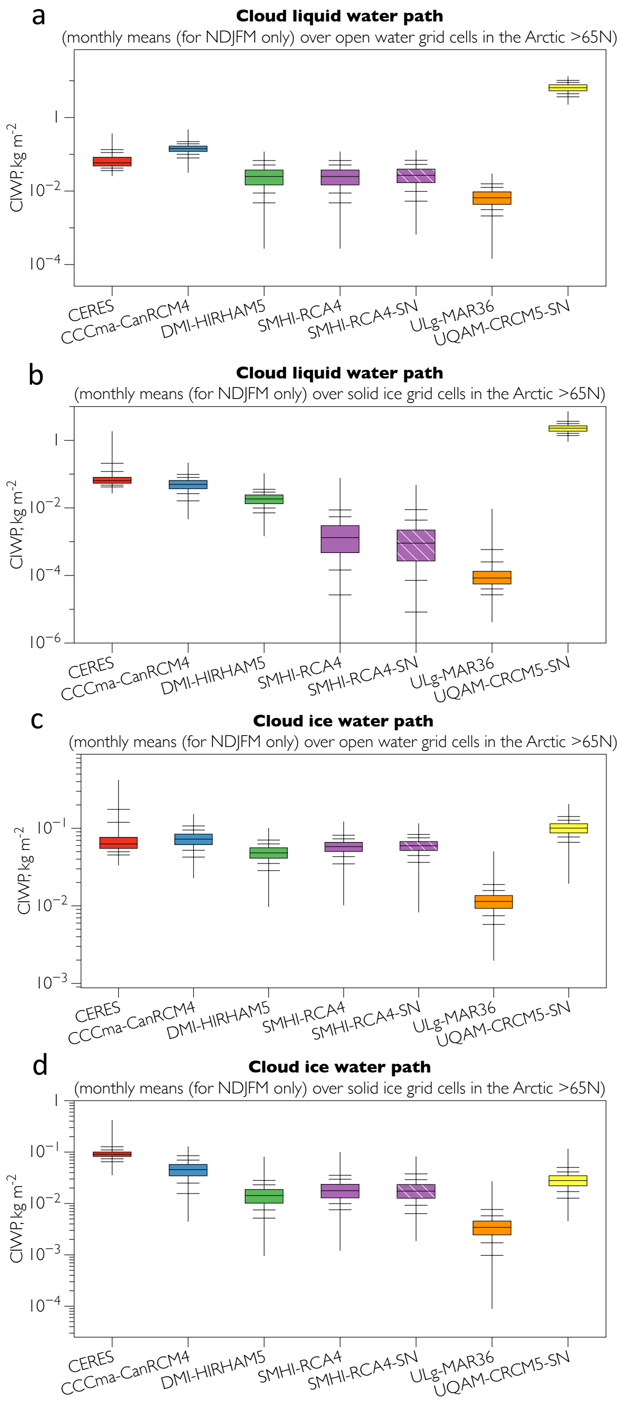

Figure 1. Box-plots for CLWP (a, b) and CIWP (c, d) over open-water (a, c) and solid-ice regions (b, d) for various data. Color boxes show interquartile range, while horizontal ticks stand for 2.5, 10, 90 and 97.5 percentiles.

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year (months from November to March) for the Arctic Ocean (north of 65N).

Cloud characteristics	CLWP, kg m^2		CIWP, kg m^2		CTWP, kg m^2	
Underlying surface	Solid ice	Open water	Solid ice	Open water	Solid ice	Open water
models						
CCCma CanRCM4	0.050	0.142	0.046	0.072	0.095	0.217
DMI HIRHAM5	0.018	0.080	0.014	0.048	0.033	0.129
SMHI RCA4	0.001	0.025	0.018	0.058	0.019	0.083
SMHI RCA4–SN	0.001	0.027	0.017	0.059	0.018	0.088
ULg MAR3.6	0.001	0.007	0.003	0.011	0.004	0.018
UQAM CRCM5-SN	*2.288*	*6.457*	0.028	0.100	*2.317*	*6.558*
Observations						
CERES	0.064	0.058	0.091	0.063	0.155	0.121

Table 1. Median values of cloud characteristics for different regions of the Arctic Ocean in November-March. Suspicious values that should be checked are shown in italics.

In general, values of CIWP and CLWP among models vary substantially, especially those for CLWP with the revealed difference for several orders. We found better agreement between models and satellite observations for both CLWP and CIWP over open water and lower agreement over solid-ice regions. When comparing contribution of liquid and ice water path to CTWP, part of models shows higher values for CIWP (i.e., SMHI RCA4, SMHI RCA4-SN, ULg MAR3.6), while other models show the opposite. It is of note that data for CLWP (and for CTWP respectively) for UQAM CRCM5-SN model should be checked since it is suspiciously two order higher than the one for other datasets.

The CERES data displays higher values for CLWP than for CIWP (the ratio CIWP/CLWP is around 0.7 over solid-ice regions and around 0.92 over open-water regions). In general, CERES data display higher values of CTWP over solid-ice regions while models show the opposite.

It is of note that while models display a substantial difference for CLWP and CIWP values, they agree well in surface downward longwave radiation (Figure 2). Presumably, this should imply different relationship between cloud emissivity (that associated with cloud water path) and surface downward longwave radiation in each model. This finding has to be evaluated properly in future.

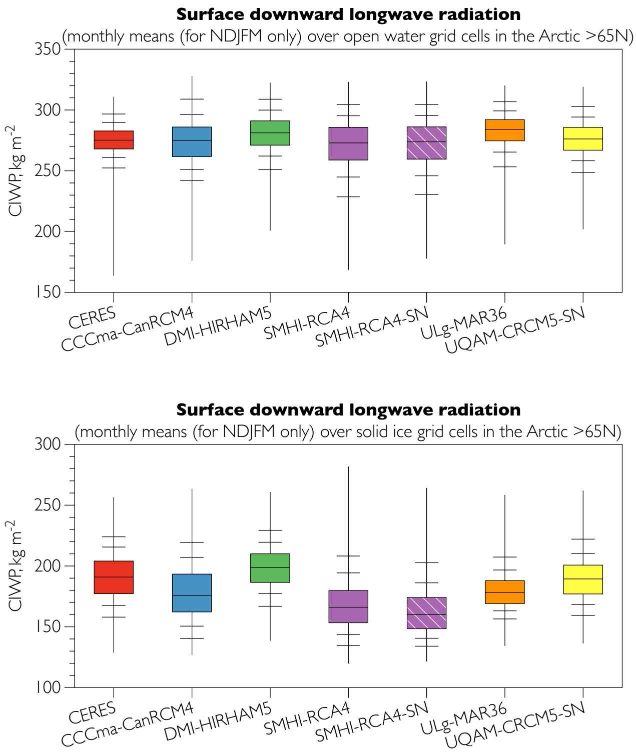

Figure 2. The same as for Figure 1 but for surface downward longwave radiation.