Testing the new ice model for the global NWP system GME of the German Weather Service

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A new ice model (Mironov and Ritter 2003) for the global NWP system GME (Majewski et al. 2002) of the German Weather Service has been tested through parallel experiments including data assimilation. The main features of the new GME ice model are briefly outlined as follows. The model accounts for thermodynamic processes only, i.e. no ice rheology is considered. The heat transfer through the ice is treated using the integral, or bulk, approach. It is based on a parametric representation (assumed shape) of the evolving temperature profile within the ice and the integral heat budget of the ice layer. Simple thermodynamic arguments are invoked to compute the ice thickness. The result is a system of two ordinary differential equations for the two time-dependent quantities, the temperature $T_i(t)$ at the air-ice interface and the ice thickness $H_i(t)$. No snow over the ice is considered at present (although provision is made to account for the snow layer). As regards the horizontal distribution of the ice cover, the ice model is obedient to the GME data assimilation scheme. If a GME grid box has been set ice-free during the initialisation, no ice is created over the forecast period. If observational data indicate open water conditions for a given grid box, residual ice from the model forecast is removed and the water surface temperature is set to the observed value. At present, no fractional ice cover is considered. The GME grid box is treated as ice-covered once the assimilation scheme has detected an ice fraction greater than 0.5. The newly formed ice has the thickness of 0.5 m. Prognostic ice thickness is limited by a maximum value of 3 m.

Results from numerous test runs have shown that the ice surface temperature is rather sensitive to the cloud cover, particularly during winter, and that the ice albedo with respect to the short-wave solar radiation, α, plays a major part in forecasting $T_i(t)$, particularly during summer. The following formulation is proposed for use in GME: $\alpha = \alpha_{max} - (\alpha_{max} - \alpha_{min}) \exp[-C_\alpha (T_{f0} - T_i)/T_{f0}]$. Here, $\alpha_{max} = 0.65$ and $\alpha_{min} = 0.40$ are maximum and minimum values of the ice albedo, and $C_\alpha = 95.6$ is a fitting coefficient. The above formulation is meant to implicitly account (in a crude way) for the seasonal changes of α. During summer, when the ice surface temperature is close to the fresh-water freezing point $T_{f0} = 273.15$ K, a decrease of the area-averaged albedo occurs due to the presence of meltwater ponds and leads (see e.g. Ebert and Curry 1993). A minimum value of $\alpha_{min} = 0.40$ is close to the estimates of the wavelength-intergrated albedo reported by Ebert and Curry (1993) and Perovich et al. (2002). This value is typical of the summer months in the Arctic.

Figure 1 shows the two-metre temperature in the Arctic, as computed by GME with the new ice model and by ECMWF, versus observations. Recall that the ECMWF ice model solves a finite-difference analogue of the one-dimensional heat transfer equation for the ice slab of fixed depth. The two simulations show a somewhat different spatial temperature structure. The overall agreement of both simulations with data is satisfactory, considering possible uncertainties and sparsity of available observational data. The ice thickness in the Arctic computed with the new GME ice model is illustrated in Fig. 2. The ice thickness distribution looks reasonable. This is difficult to verify quantitatively, however, for lack of observational data.

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Figure 1. The two-metre temperature in the Arctic at 12 UTC on 5.12.2003: left panel – GME analysis using the new ice model, right panel – ECMWF analysis. Numbers show computed minus observed two-metre temperature difference (in K).

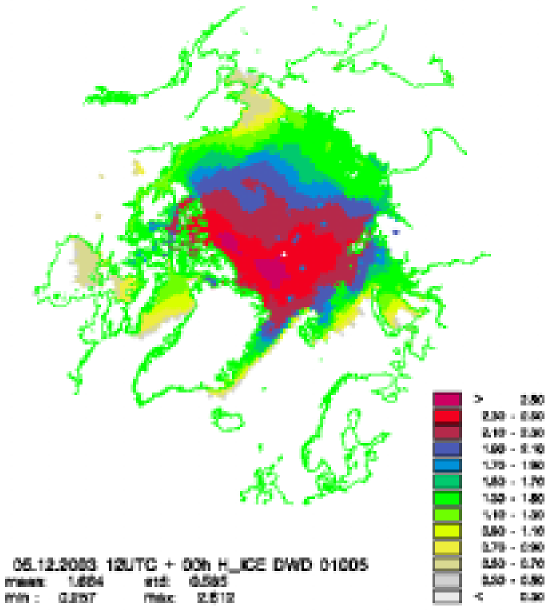

Figure 2. The ice thickness H_i in the Arctic at 12 UTC on 5.12.2003 computed with the new ice model.

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