Mesoscale modelling of cold-air outbreaks in the Arctic: the effect of spatial resolution and numerical filtering on ocean-atmosphere energy exchange

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Motivation and goals

Problem: GCMs and RCMs – large bias with observations in the Arctic, especially with regards to surface turbulent fluxes (Chapman and Walsh 2007; Tjernström et al 2005)

Possible reason: coarse spatial resolution

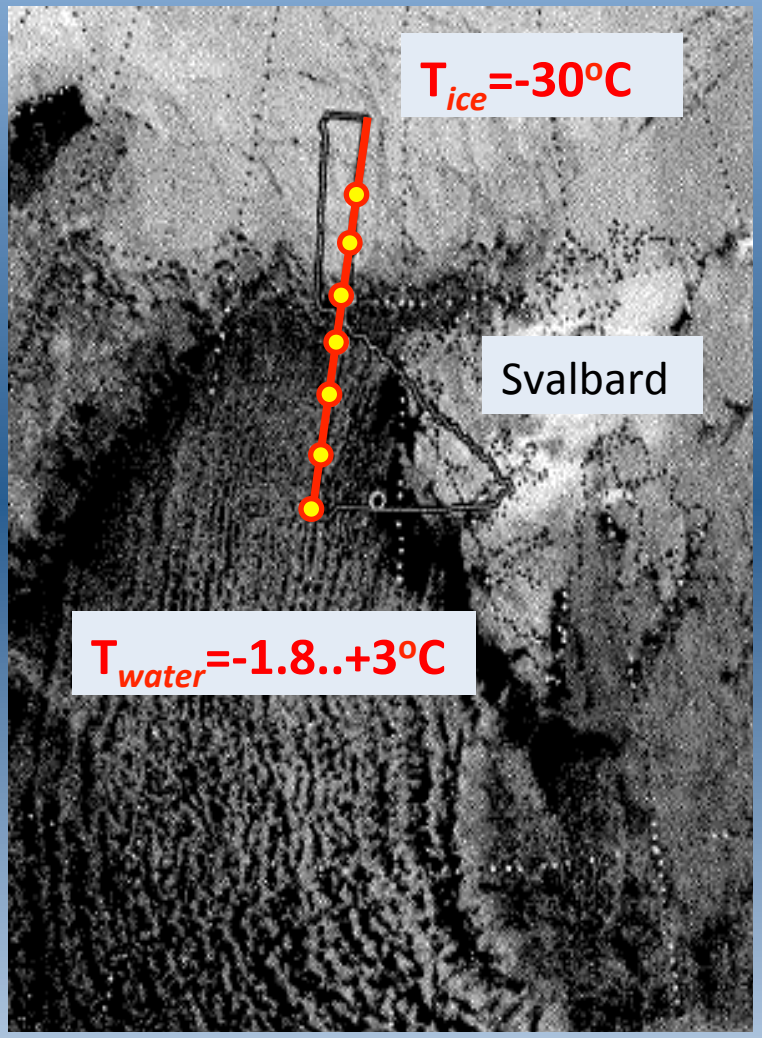
- Large horizontal gradients in the Arctic - MIZ
- Off-ice flow - typical meteorological regime for MIZ

Questions addressed in the research:

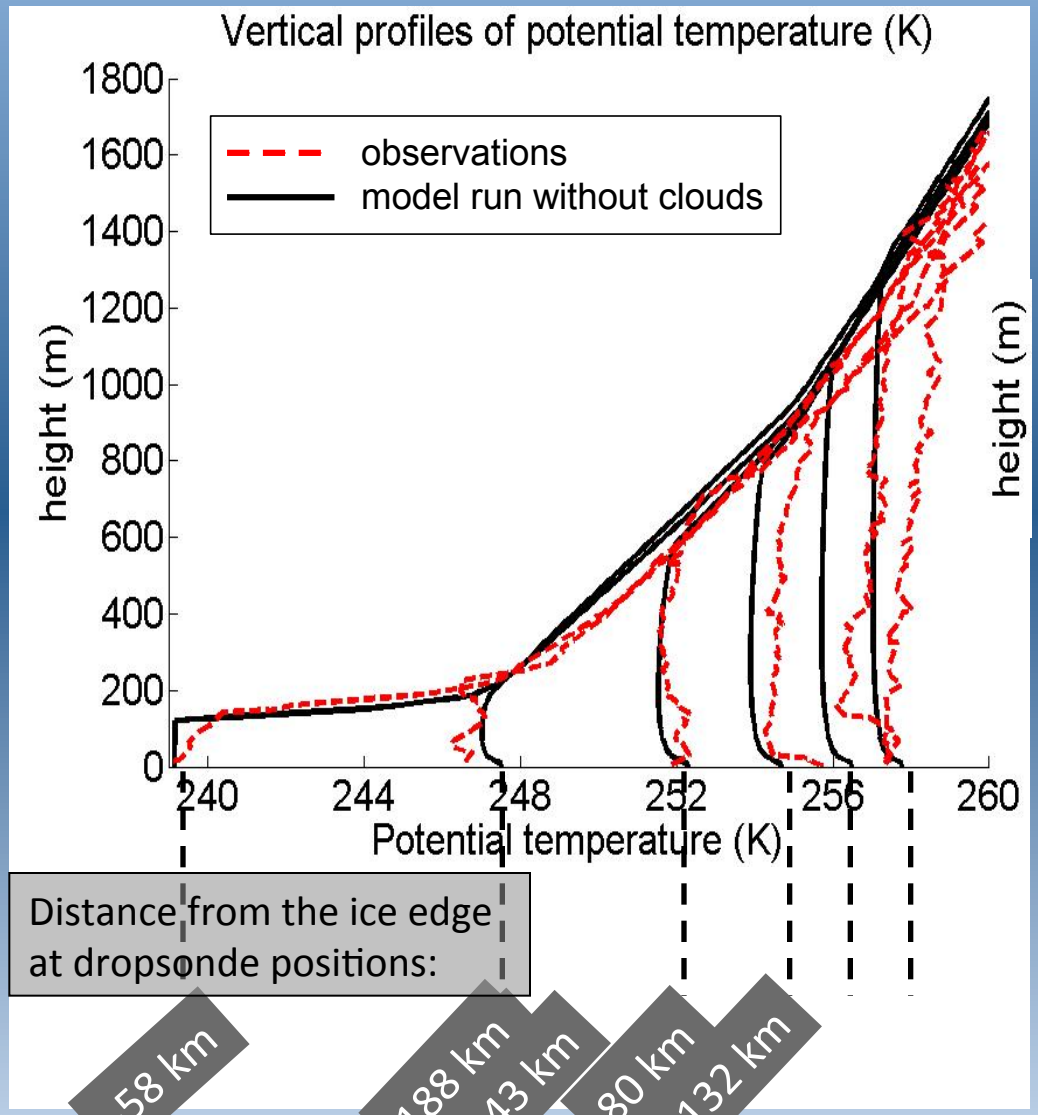
1. Does horizontal resolution, used in GCMs and RCMs, affect surface fluxes during off-ice flows?
2. If YES, then HOW MUCH?

Method: mesoscale modelling with different spatial resolution

Model NH3D validation against observations

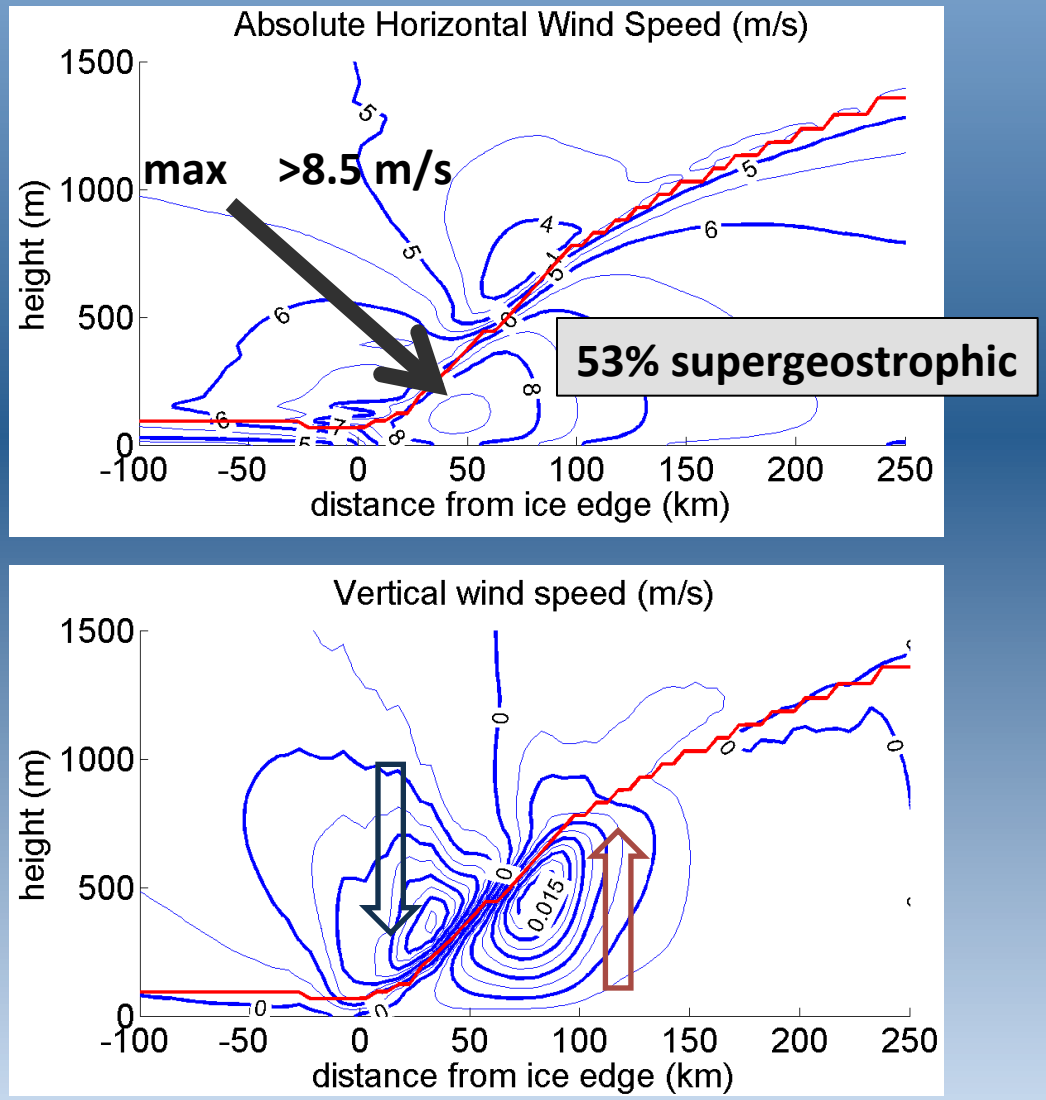


4th of March 1993, REFLEX II campaign

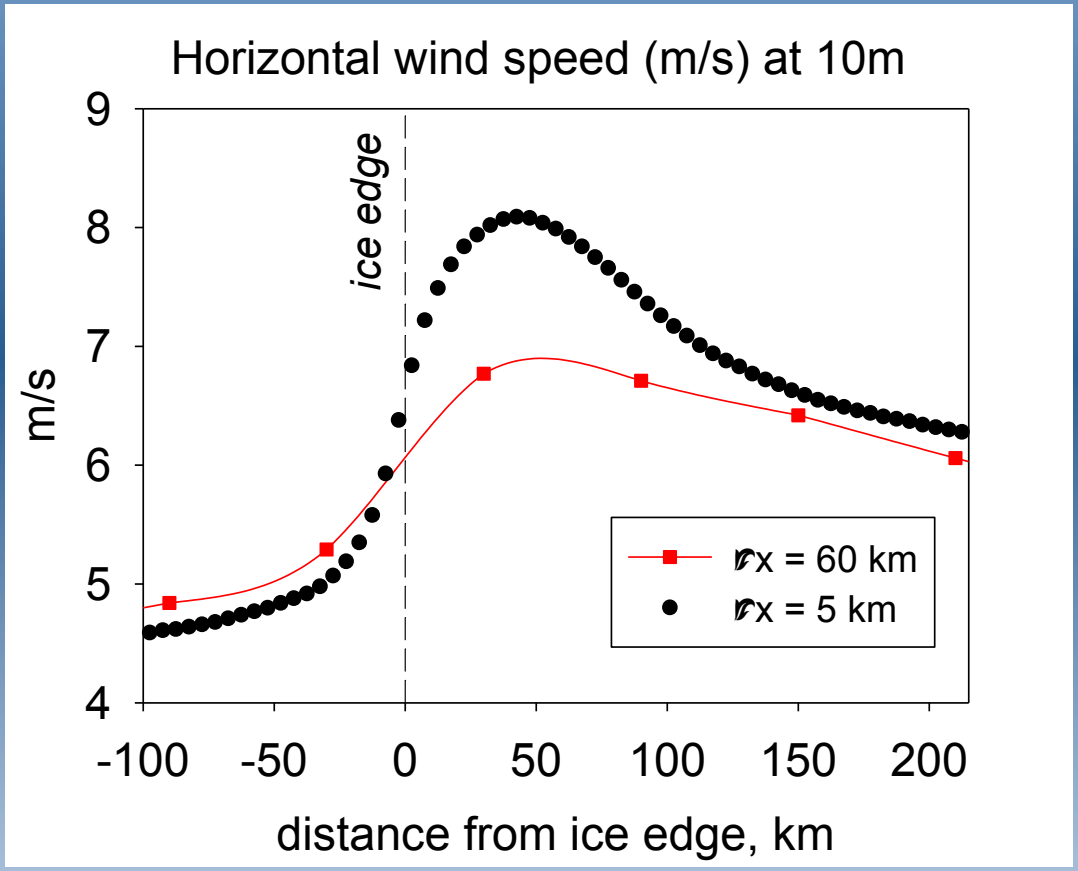


Mesoscale circulation

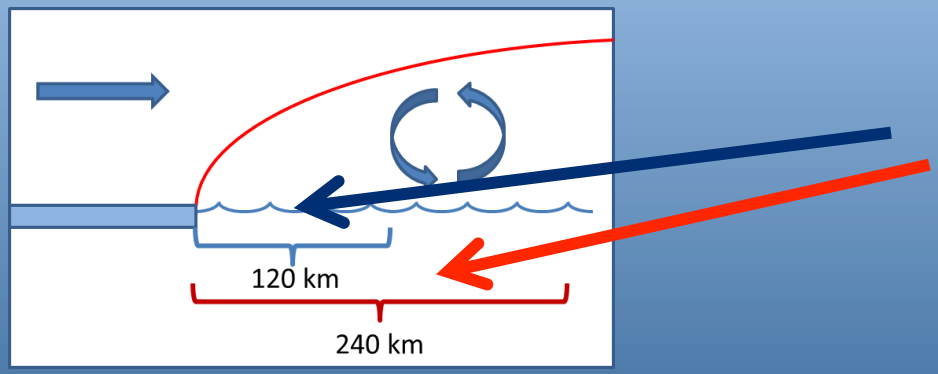
Geostrophic wind speed : U_{geos} = - 3.1; V_{geos} = - 4.7



Effect of horizontal resolution

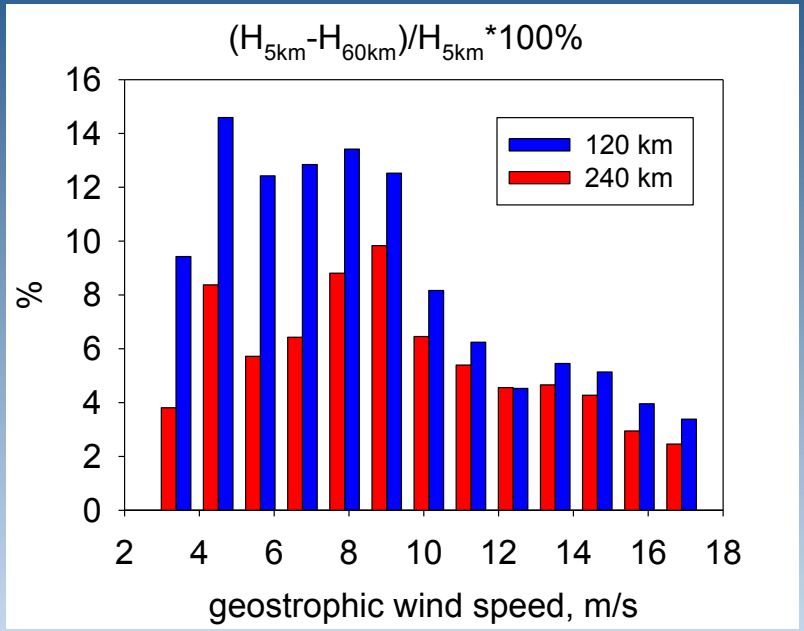


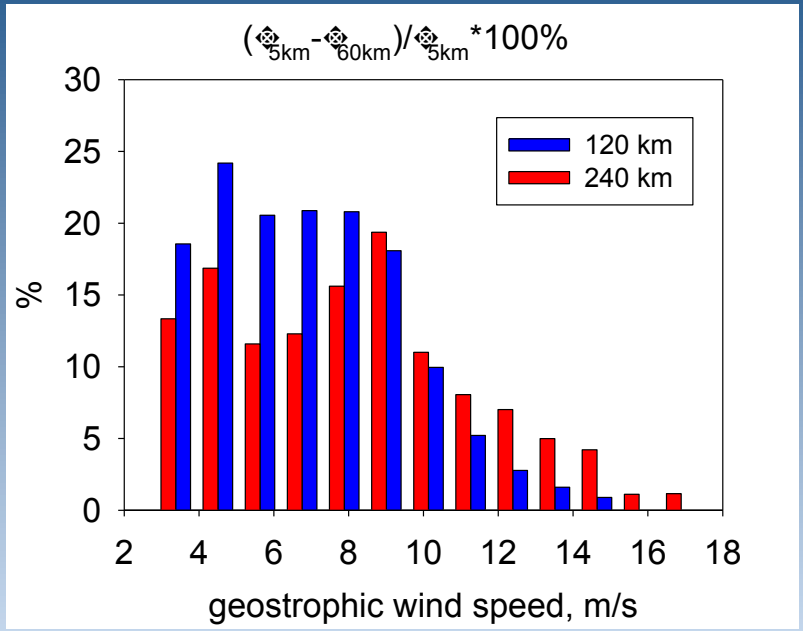
Different geostrophic wind speed



Surface fluxes are averaged for the areas of open water of 120 and 240 km long

The difference of results 60km resolution run and 5km resolution run for heat flux and momentum flux in % from 5km run:



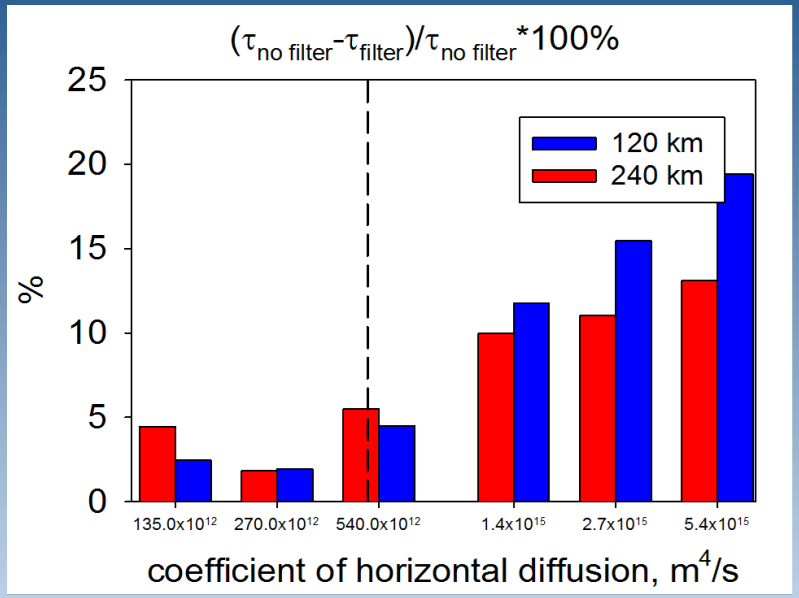


Effect of horizontal numerical smoothing

Forth order horizontal diffusion is typically used in regional models as a numerical filter in order to suppress numerical noise:

$$\frac{\partial \psi}{\partial t} = \kappa \nabla^2 \psi$$

where κ is diffusion coefficient



Results

1

Heat flux is 5-15% underestimated at coarse resolution

Momentum flux is 5-20% underestimated at coarse resolution

2

The effect of coarse resolution on fluxes is largest:

- at moderate geostrophic wind speed: <10 m/s
- when surface temperature difference T_{water}-T_{ice} is large
- When the ice edge is sharp

3

Reasons for flux underestimation at coarse resolution:

1. Mesoscale circulation is not well resolved
2. BL modification close to the ice edge is not resolved

4

Horizontal numerical filtering has an effect on surface fluxes at coarse resolution. The use of a typical for regional climate models coefficient of diffusion leads up to 5% underestimation of surface fluxes

Thank you!