The impact of snow microphysics on the simulation of the ABL and snowdrift over polar ice sheets

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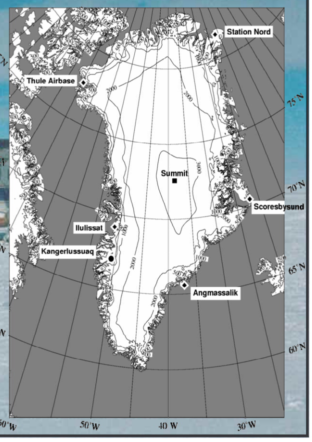
The IGLOS campaign 2002 at Summit (Greenland)

(*Investigation of the **G**reenland boundary **L**ayer **O**ver **S**ummit*)

Experiment: 29 June - 25 July 2002
Research aircraft "Polar2" based in Kangerlussuaq (West Greenland)



SUMMIT station (3250m)

Surface conditions at SUMMIT are very homogenous, similar to the Antarctic plateau

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ETH 50m tower

- Temperature, humidity, wind at 8 levels
- Turbulence at 4 levels
- Incoming and outgoing radiation fluxes at 4 levels

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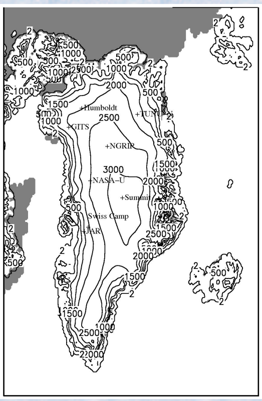
Ultrasonic Anemometer

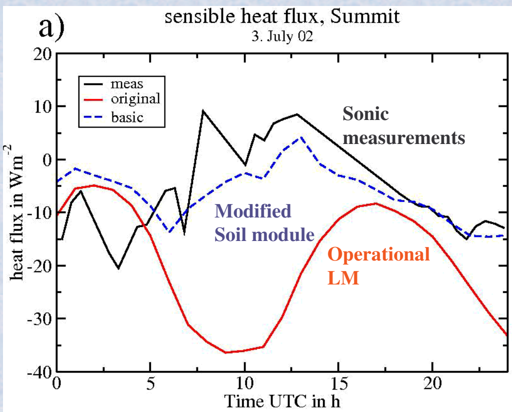
Simulations: non-hydrostatic mesoscale model LM



LM (COSMO)
14 km
180x240
35 levels

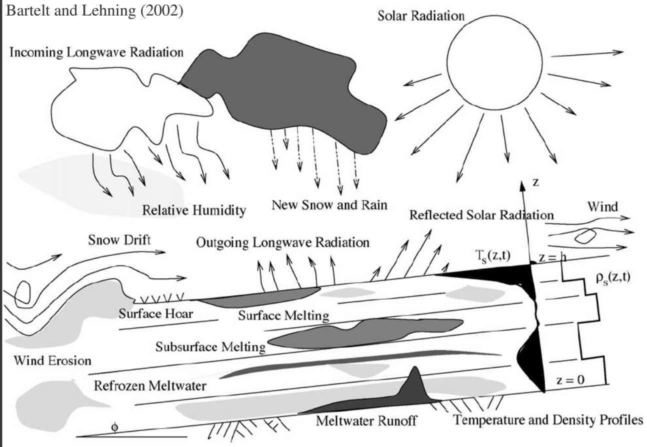
7 July 2002
06 UTC

Improvement of the representation of snow properties in the LM of the German Meteorological Service



Important physical processes in snowpack modelling

Bartelt and Lehning (2002)



Snow microphysis model SNOWPACK (SLF, Lehning et al. 2002)

Snow is treated as a three component system (ice, air, water), finite element, Lagrangian model

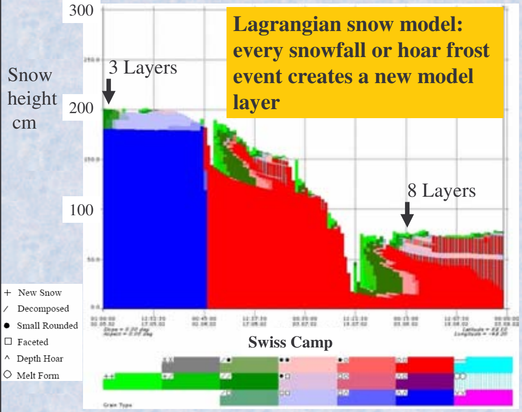
Simulation of snow microphysics:
Intergranular bonding, grain size, dendricity, sphericity

Computation of
heat conductivity, albedo, snow drift, ...
as a function of the snow microphysics

Input:
- meteorological data (T, RH, ff, radiation, clouds)
- initial snow profile

SNOWPACK simulations driven with PARCA Swiss camp May- Sept. 2002

Snow height cm

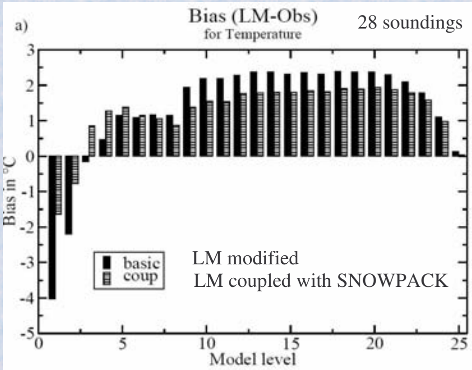


Grain type

IGLOS: initial snow profile from Summit, 14 layers

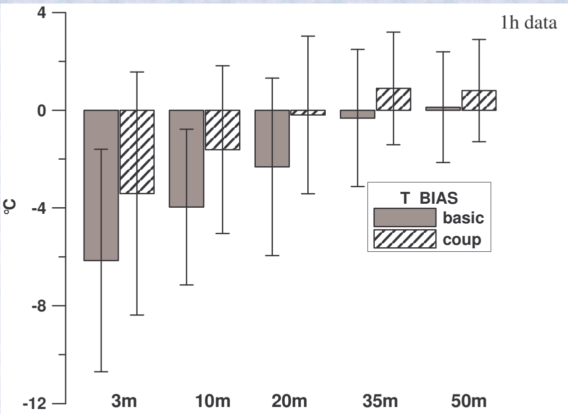
Comparison LM with radiosondes at Summit 3-12 July 2002

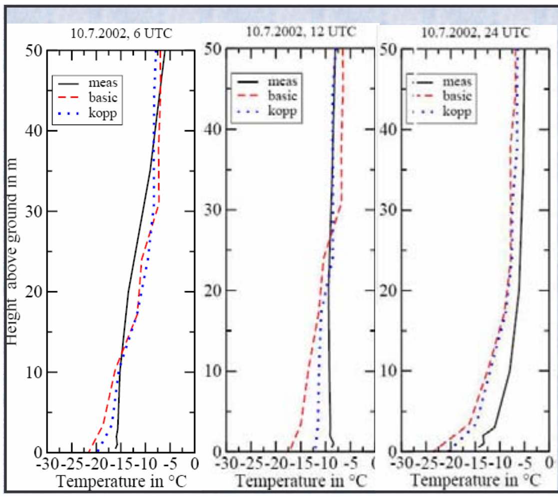
48h forecast runs, day 2 used for comparison



Height levels: 1: 3 m, 5: 30 m, 10: 90 m, 25: 1900 m.

Comparison (LM-OBS) with 50m tower at Summit 3-12 July 2002

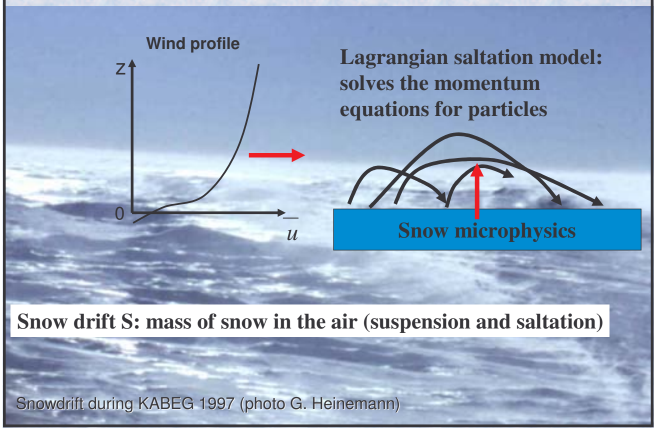


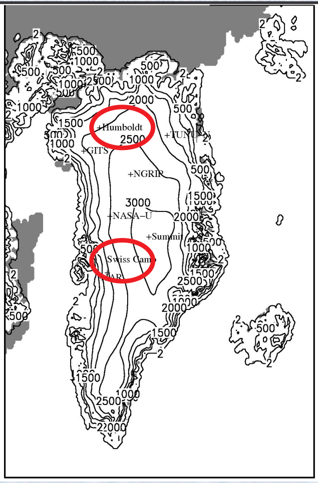


Case study 10 July 2002

Kopp = coupled

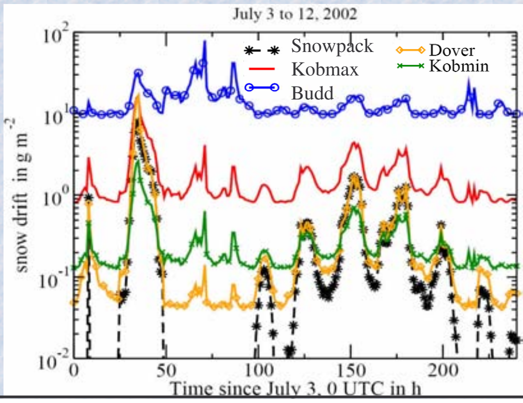
Snowdrift



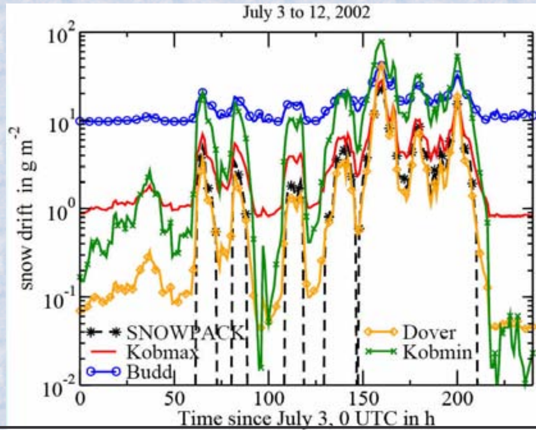


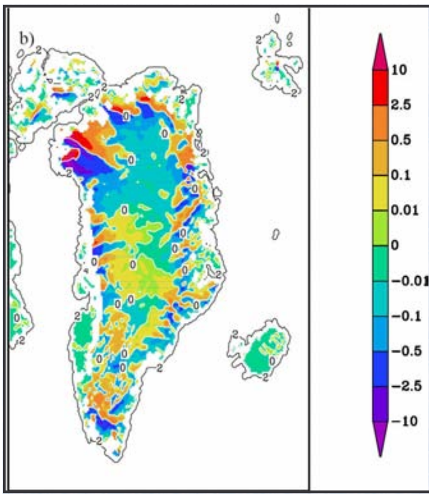
Comparison of snow drift parameterizations with LM/SNOWPACK: SWISS Camp

Snow drift S: mass of snow in the air (suspension and saltation)



Comparison of snow drift parameterizations with LM/SNOWPACK: Humboldt



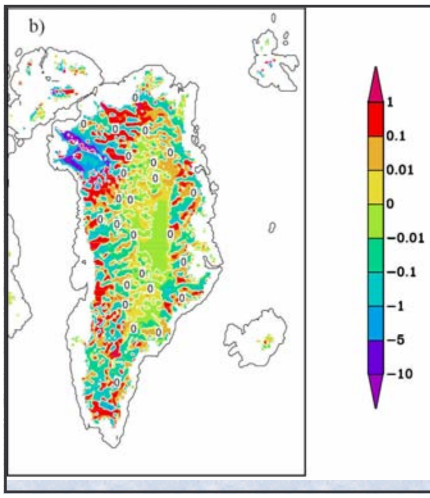


Snow drift S

$$Acc = -\vec{\nabla} \bullet (\vec{v}_H S)$$

10d accumulation by snow drift (kg/m²) LM14+SNOWPACK 3-12 July 2002

Hebbinghaus and Heinemann (2006)



Ratio snow drift/sublimation LM14+SNOWPACK 3-12 July 2002

Conclusions

LM/SNOWPACK

Largest effect for new snow and melting
Snow drift is overestimated by snow drift parameterizations

Full coupling:
better representation of the SBL
decrease in snow drift (data for verification needed)

Computing time (32 node LINUX cluster, 16 CPUs used):
Uncoupled: 2h CPU for 48h forecast
Coupled: 100h CPU for 48h forecast

Publications

Peer reviewed

Hebbinghaus, H., Heinemann, G., 2006: LM simulations of the Greenland boundary layer, comparison with local measurements and SNOWPACK simulations of drifting snow. ***Cold regions science and technology*** 46, 36-51.

Drüe, C., Heinemann, G., 2007: Structures of intermittent turbulence in the upper stable boundary layer over Greenland during IGLOS. ***Boundary-Layer Meteorol.***, in print.

Non-reviewed

Drüe, C., Heinemann, G., 2003: Investigation of the Greenland atmospheric boundary layer over Summit 2002 (IGLOS). ***Reports on Polar and Marine Research*** 447, Alfred-Wegener-Institute for Polar Research, Bremerhaven, Germany, 81pp.