

Simulations over Greenland with the LM and the snow model SNOWPACK

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Modelling with LM and SNOWPACK



Overview

Introduction

Turbulence Paramerisation in LM

Sensitivity Studies & Comparison with Measurements

SNOWPACK results

Conclusions and Outlook



Modelling with LM and SNOWPACK



Introduction

–Arctic often stable stratified

–> representation of stable boundary layer shows deficiencies in LM

–turbulence parameterisation:

–> local mixing length

–> scalar roughness length

–snow accumulation due to snow drift –> influence on mass balance

Turbulence Parameterisation in LM

–following Louis; constant mixing length

–> erroneous for stable situations

–> local mixing length $m_1 = \sqrt{\frac{2}{3} \text{TKE}} / N$

–scalar roughness length = roughness length for momentum

–> erroneous over ice and snow

–> scalar roughness length, parameterised after Andreas (2002)

(Andreas, 2002: Parameterizing Scalar Transfer over Snow and Ice: A Review. Journal of Hydromet.)



Modelling with LM and SNOWPACK



Scalar roughness length over ice and snow

$$\ln(z_T/z_0) = b_0 + b_1(\ln Re_*) + b_2(\ln Re_*)^2$$

–coefficients b_0 , b_1 , b_2 depend on stability

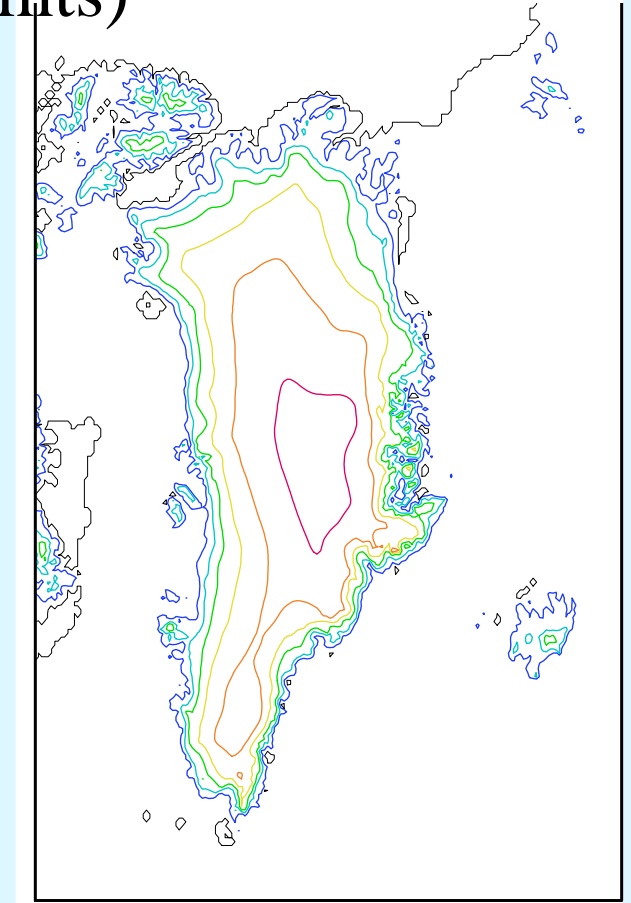
– Re_* is roughness Reynoldsnumber ($u_* z_0 / \nu$)

	$Re_* \leq 0.135$	$0.135 < Re_* < 2.5$	$2.5 \leq Re_* \leq 1000$
b_0	1.25	0.149	0.317
b_1	0	-0.55	-0.565
b_2	0	0	-0.813

(Table from Andreas (2002))

Simulations

- 3rd till 12th July 2002, entire Greenland area
- resolution: horizontal ~14km (180x240 grid points)
vertical: 35 levels, 20 below 500m
- 48h simulation, using day 2
- snow albedo from MODIS
- prognostic TKE, diffusion coefficients min. 0
- basic case plus two sensitivity studies:
 - > local mixing length approach (ml)
 - > scalar roughness length (z0)



Comparison with Measurements

–available measurements:

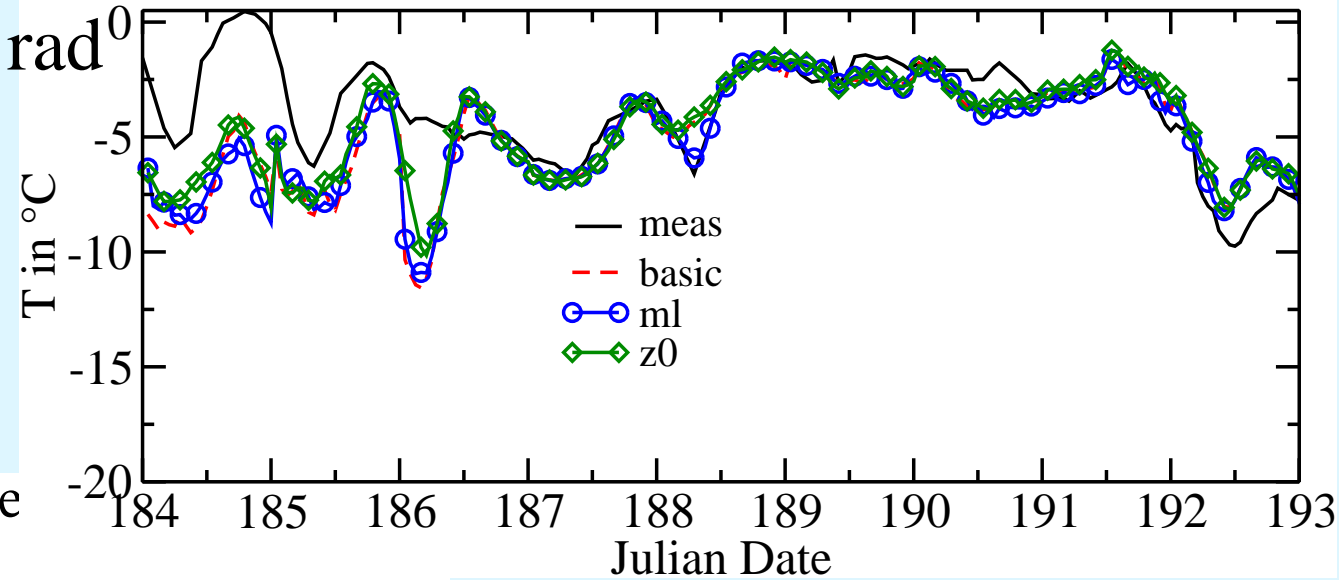
- > 8 PARCA–stations over whole Greenland (T, ff, P, radiation)
- > ETH–mast at Summit (T, ff in 5 levels; TKE in 4 levels)
- > radiosonde ascents from Summit (T, ff averaged to LM levels)
- > Solar Tracker at Summit (radiation at the ground)
- > Sonic Anemometer near Summit (sensible heat flux at the ground)

Comparison with PARCA-data

- good agreement for p and rad
- problems for $T > 0^{\circ}\text{C}$

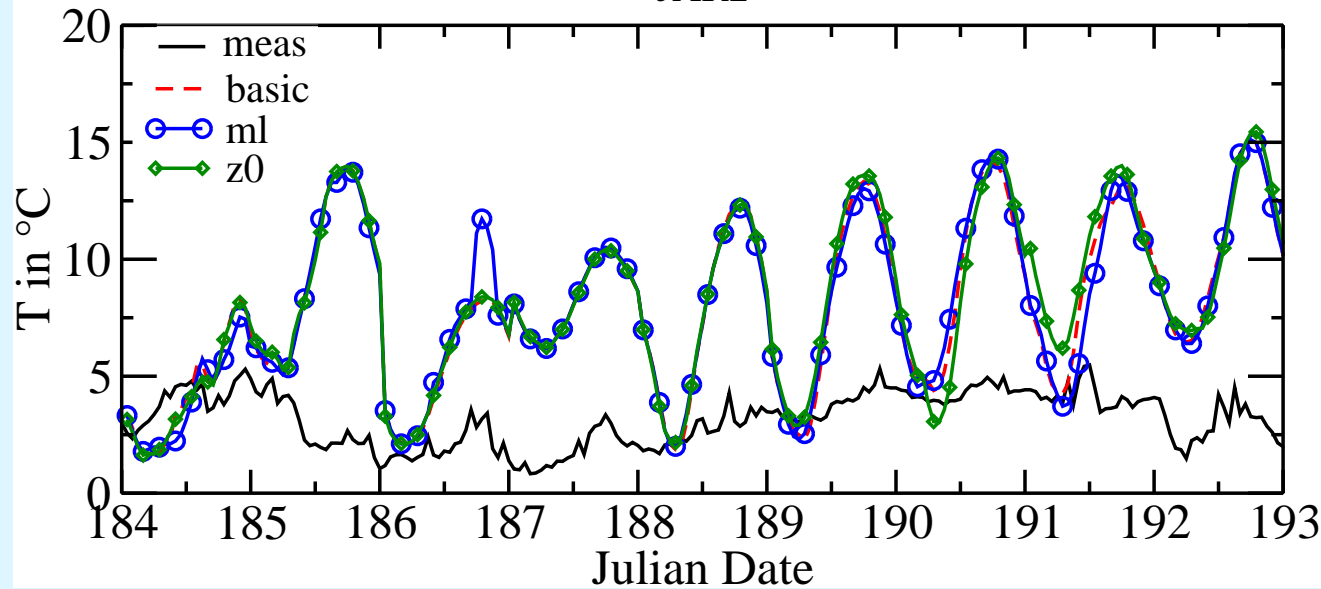
Air Temperature

GITS



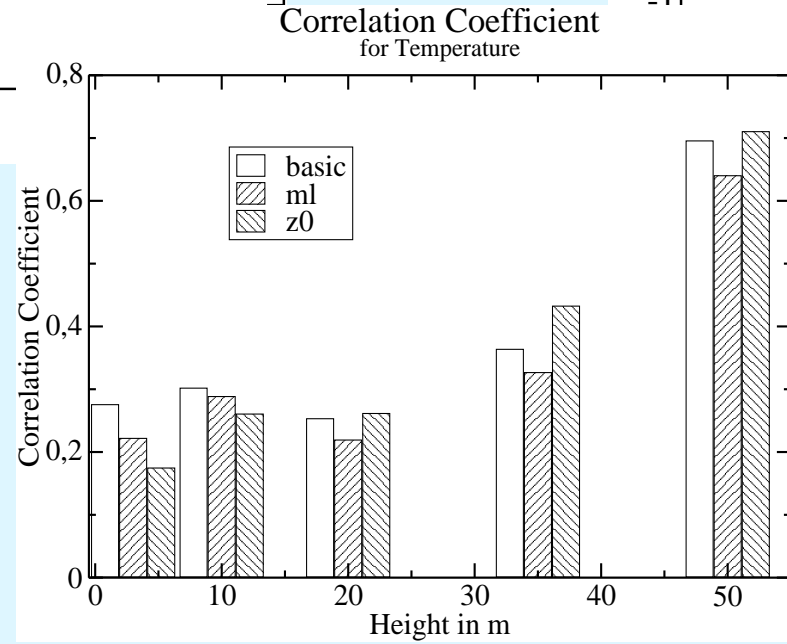
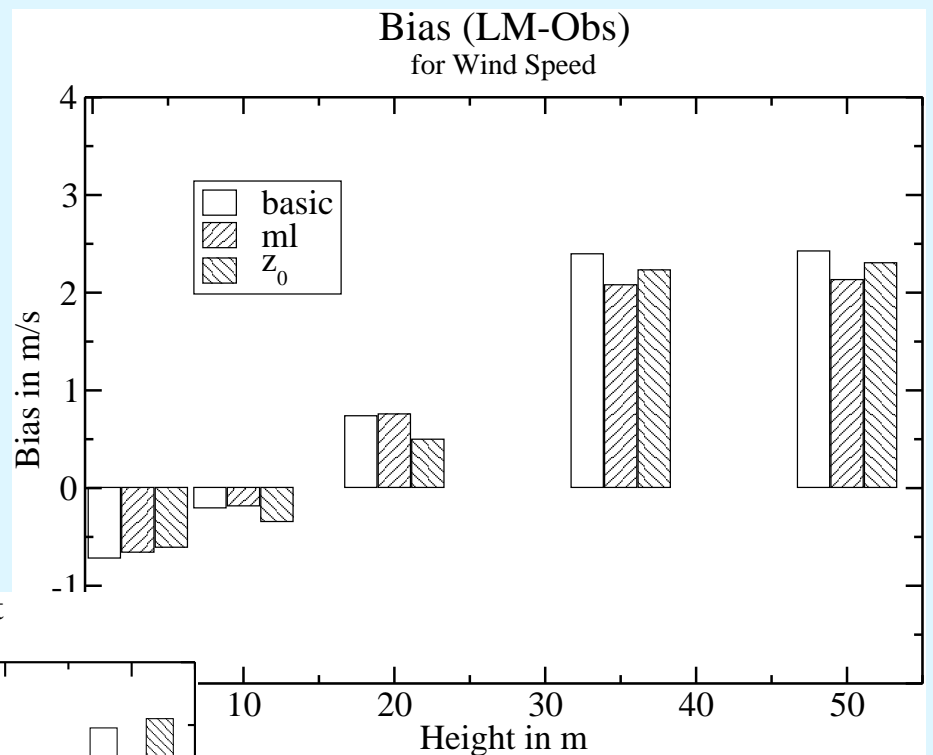
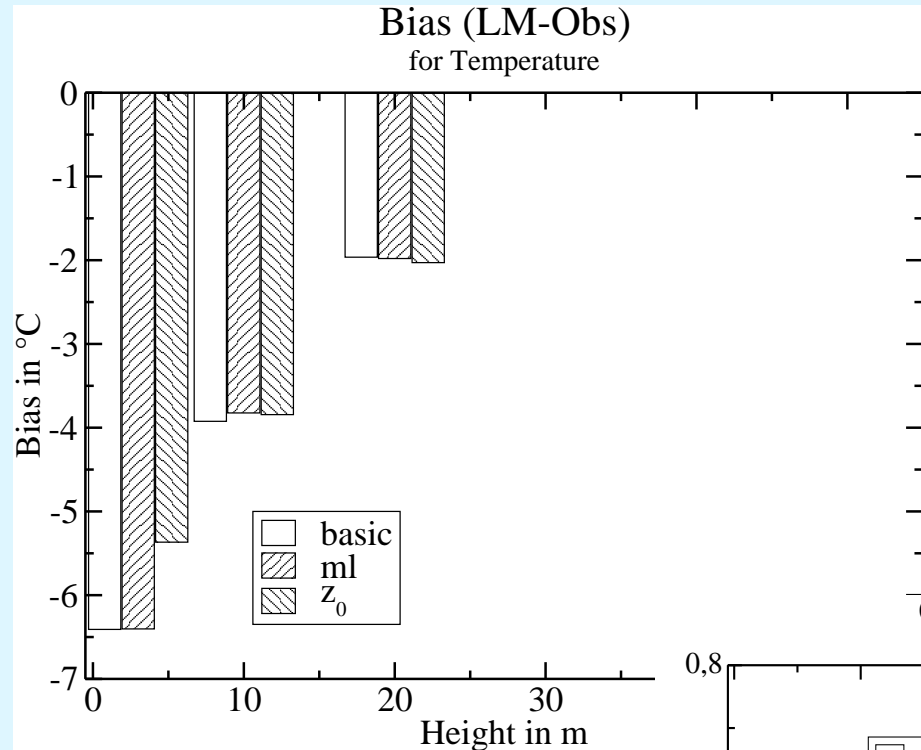
Air Temperature

JAR2

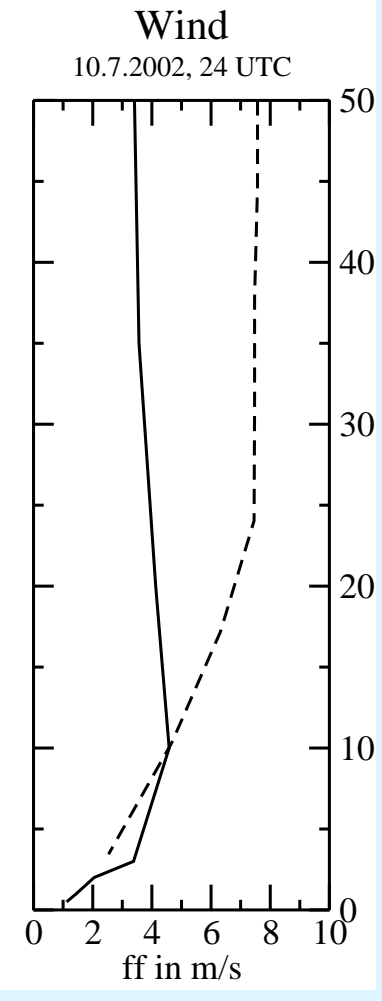
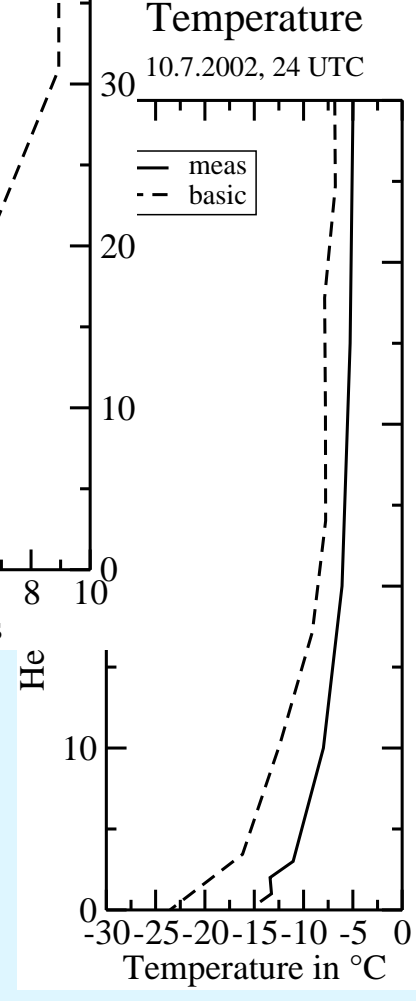
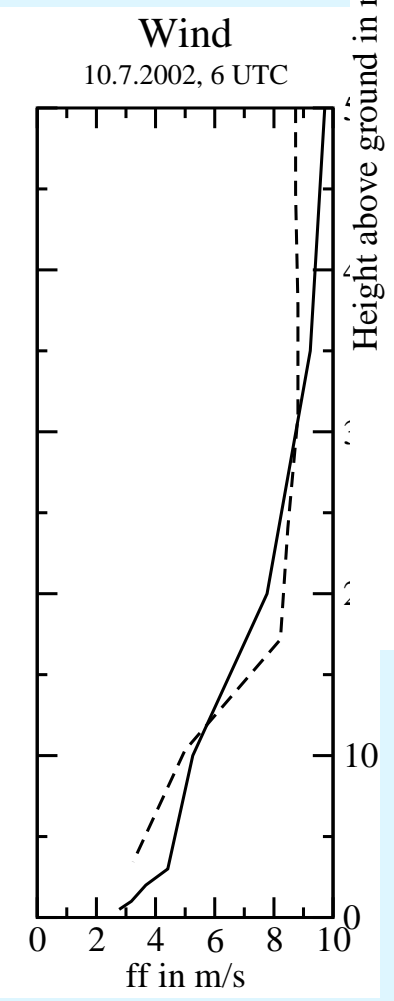
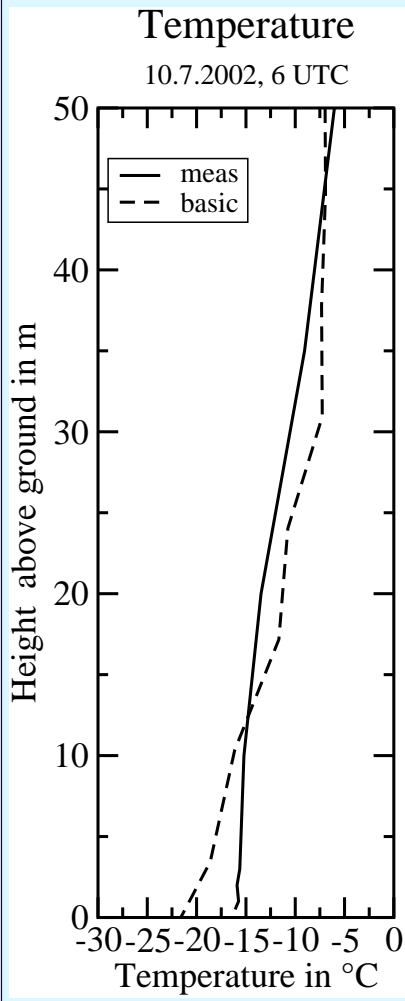
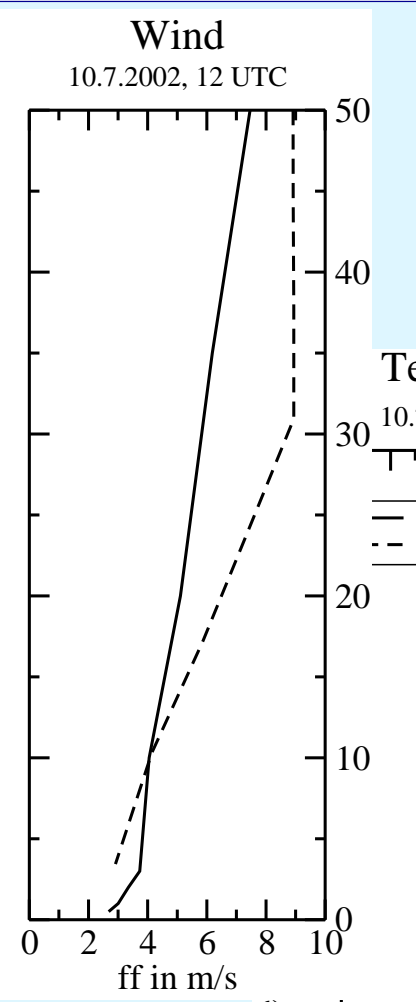
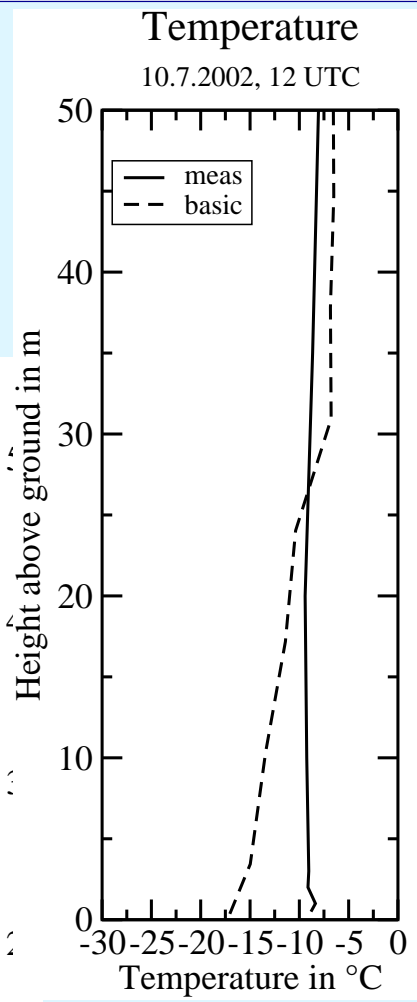


ff: spikes in LM values
(not shown)

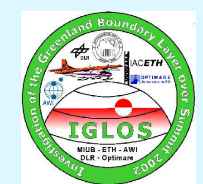
Comparison with mast measurements



Comparison with mast profiles of T and ff

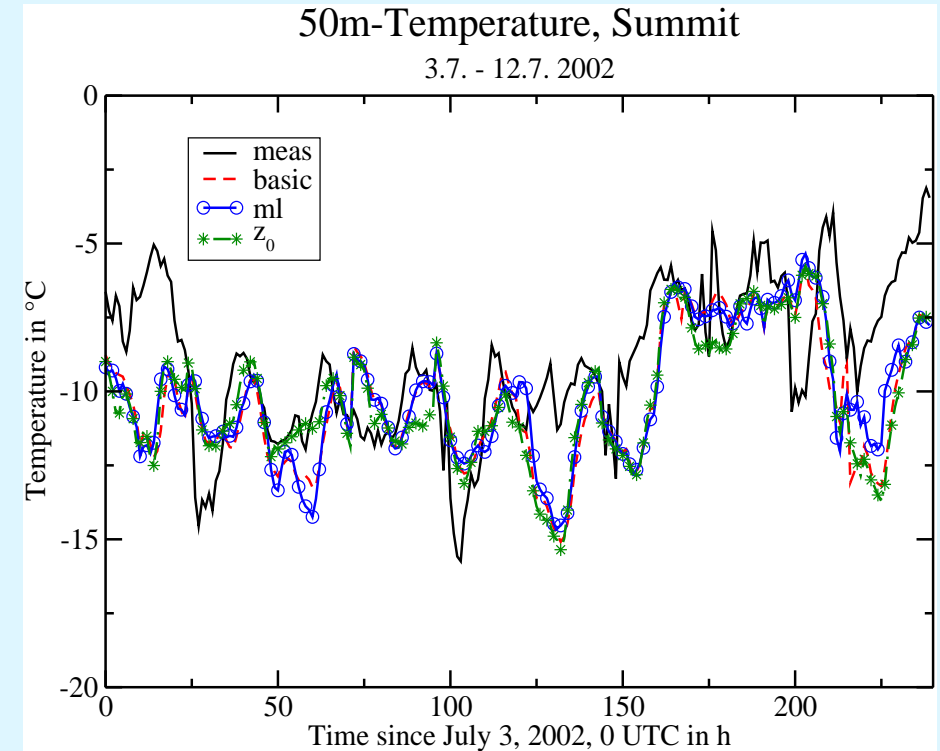
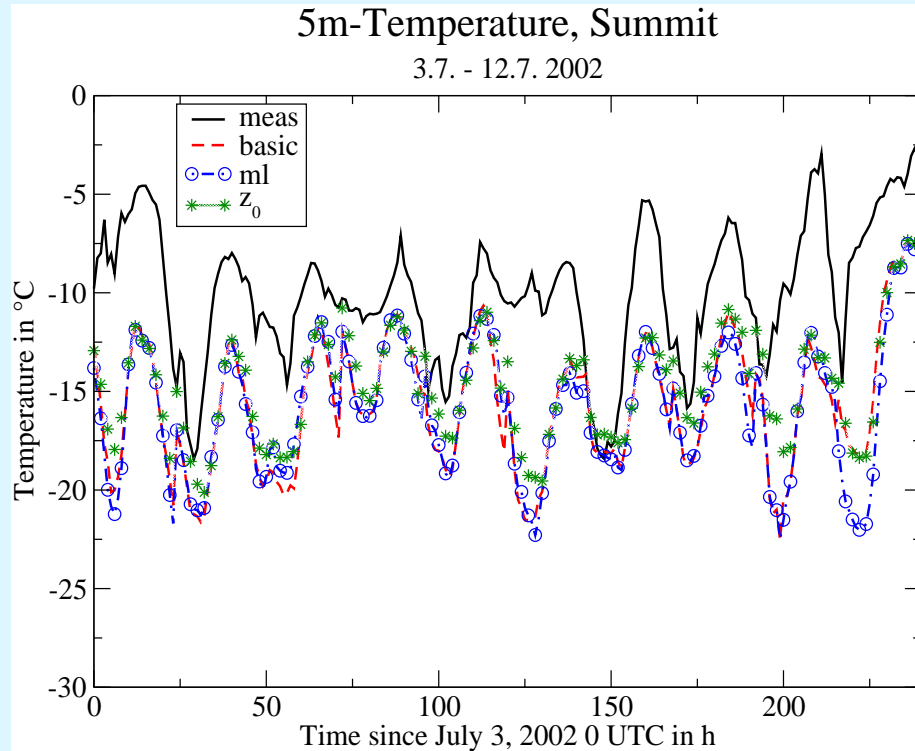


Modelling with LM and SNOWPACK



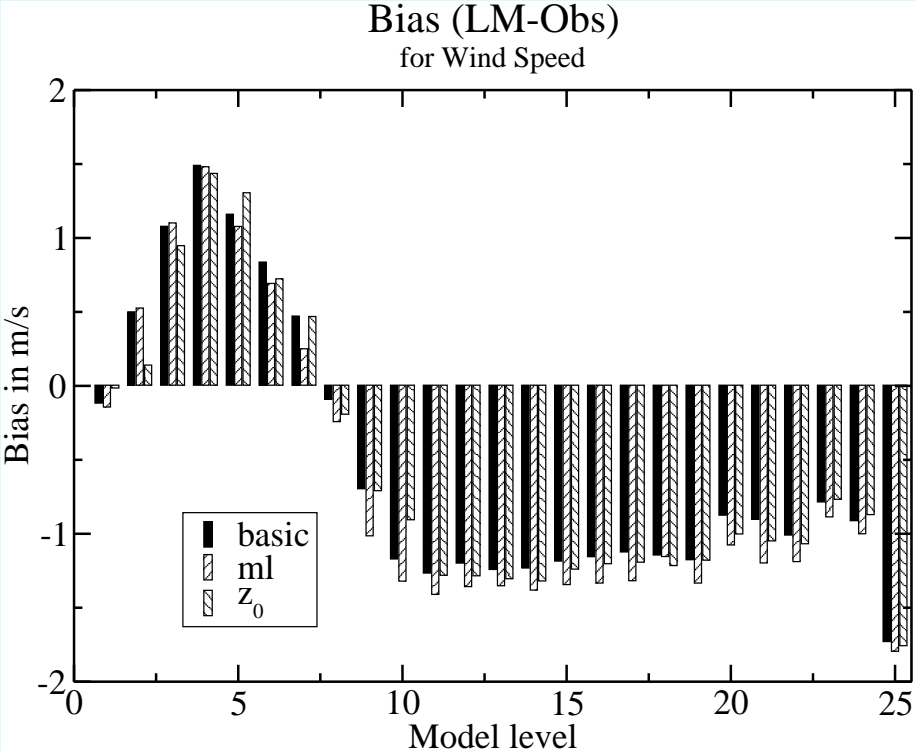
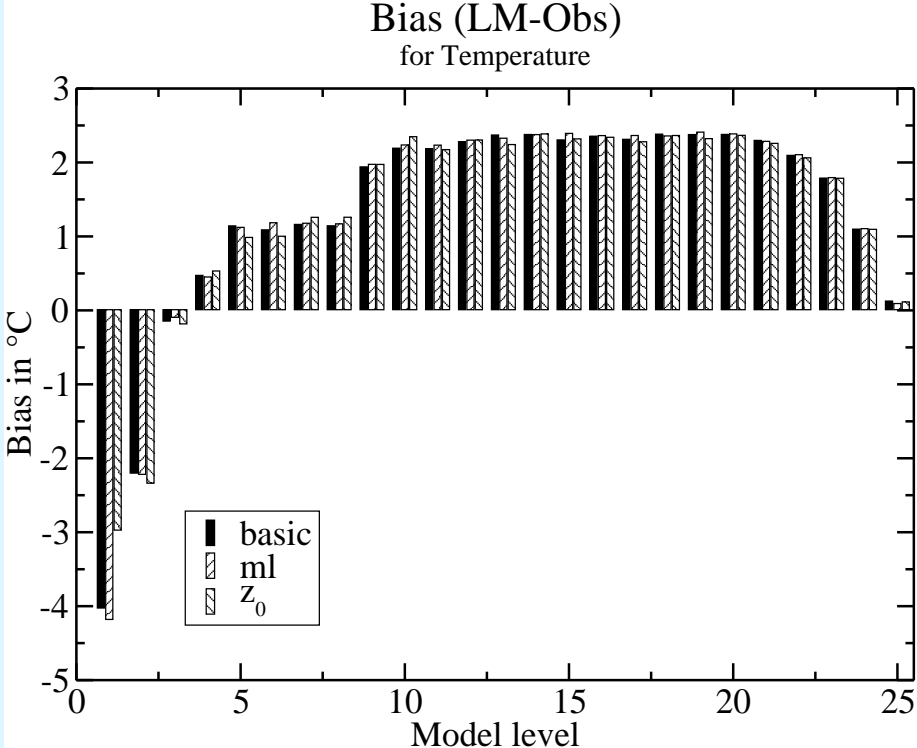
Comparison with mast measurements

Time series of Temperature at 5m and 50m height



Rad. (basic): corr. coeff.: 0.94 (sw) 0.77 (total) 0.55 (lw)
bias: -10.65 Wm^{-2} -21.78 Wm^{-2} -11.1 Wm^{-2}

Comparison with radiosonde measurements



Comparison

with

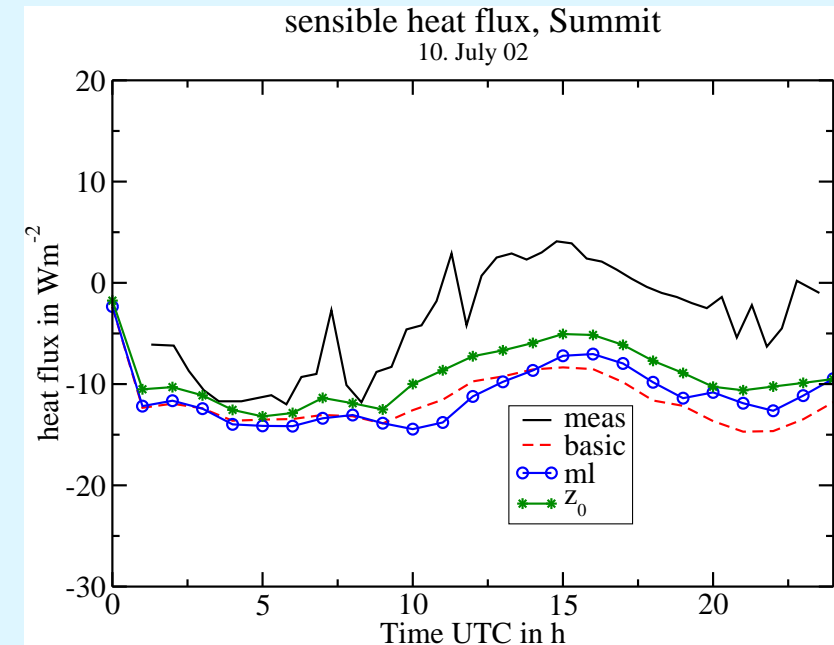
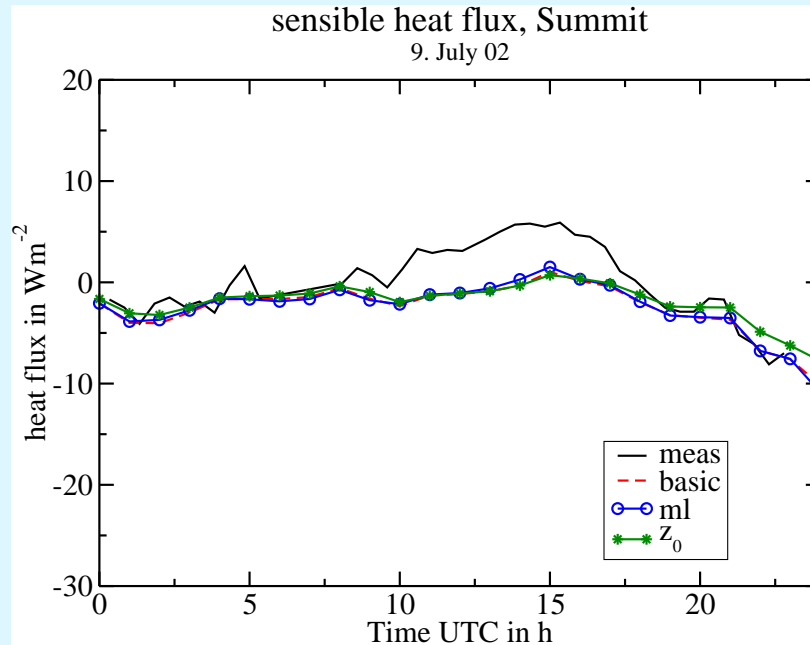
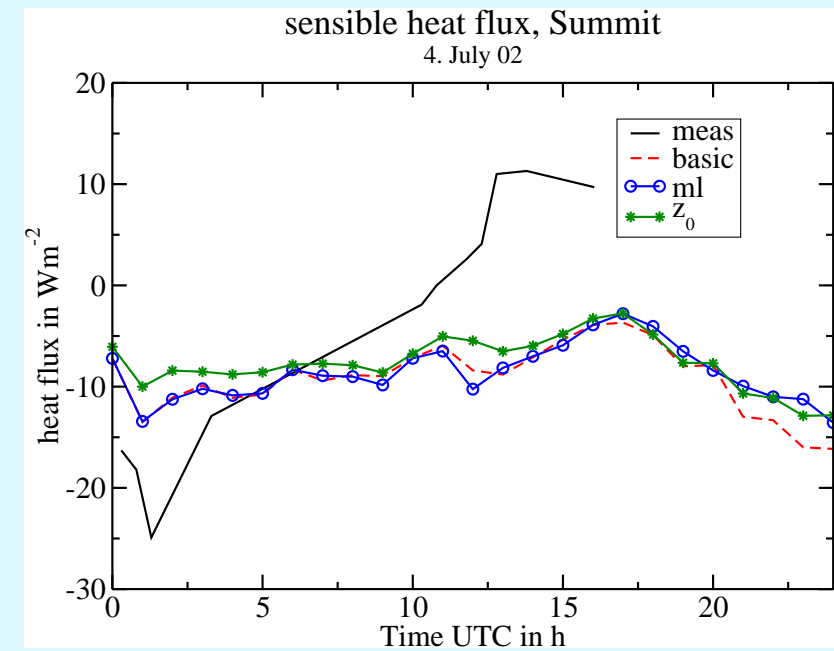
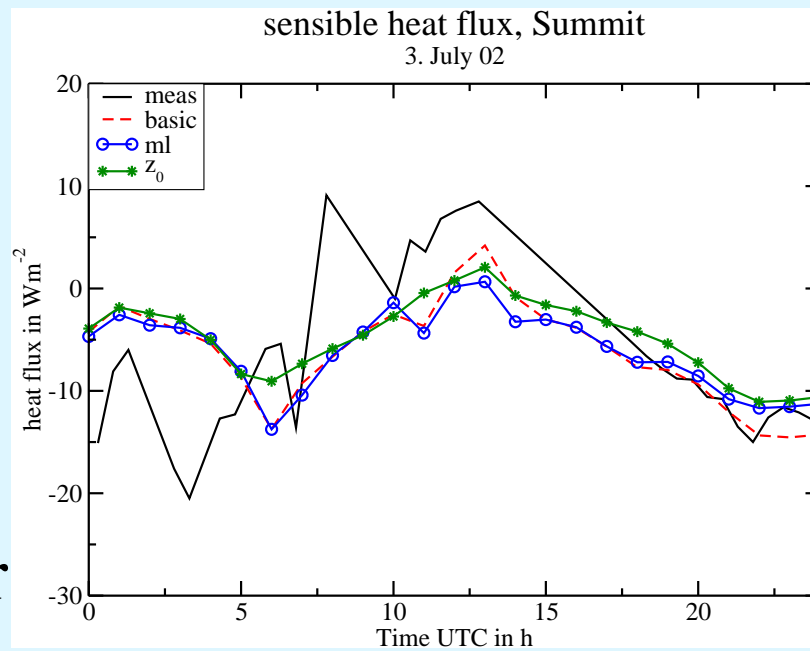
turbulent data :

sens. heat flux

near Summit for

July 3rd, 4th,

9th and 10th



Comparison

with

turbulent data:

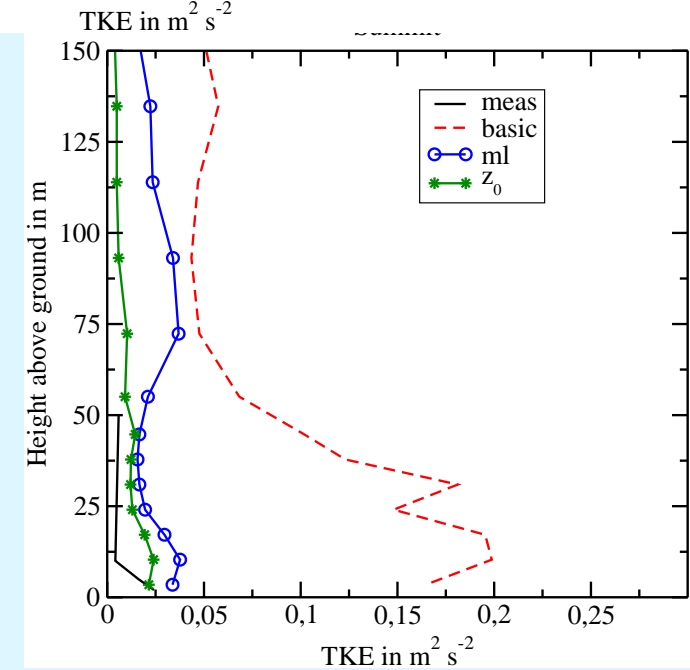
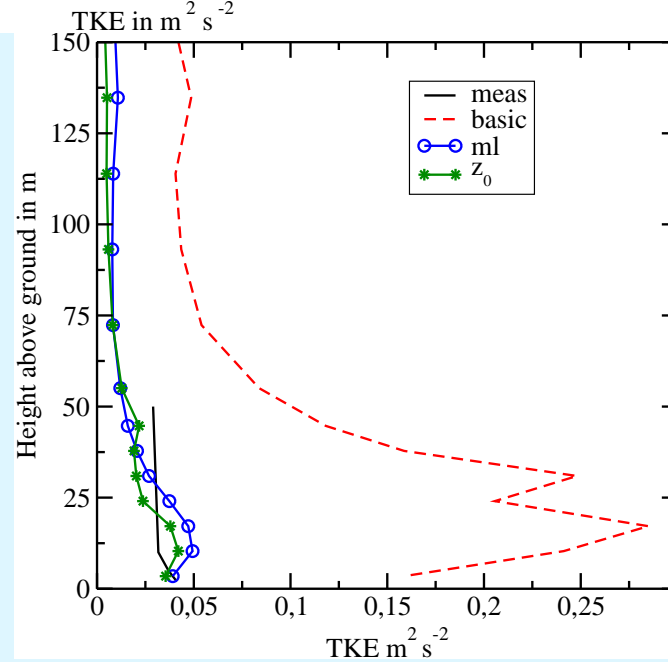
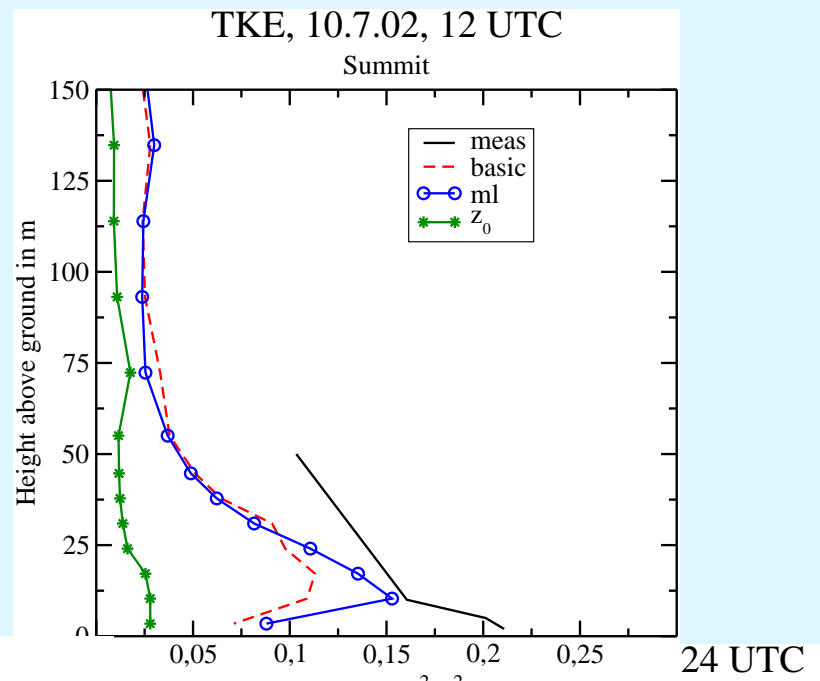
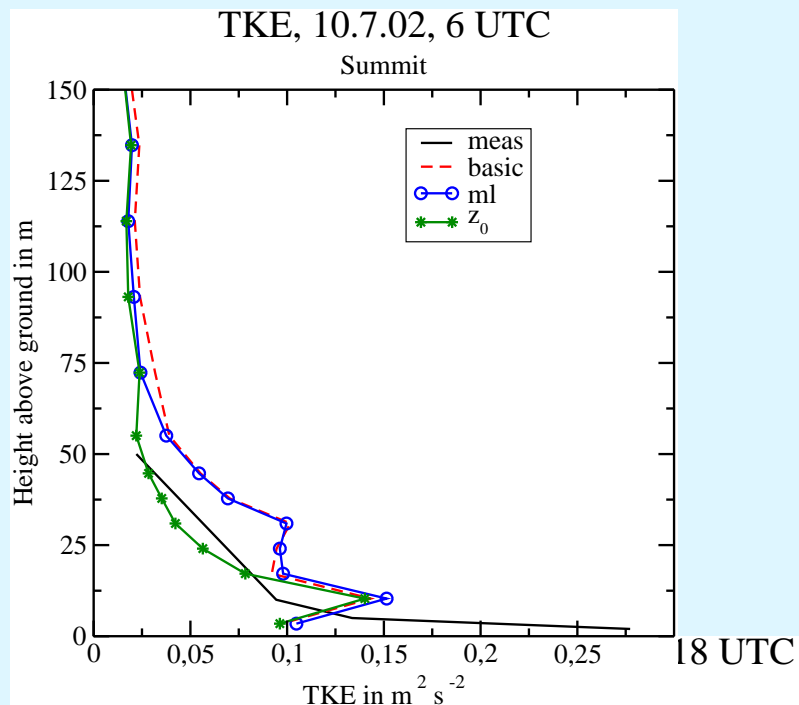
TKE at

Summit for

10th July

6, 12, 18

& 24 UTC



Summary of comparison:

- good agreement for large–scale values (pressure and radiation)
- problems for near–surface values (T and ff), esp. $T > 0^{\circ}\text{C}$
- no clear preference in turbulence parameterisations
- larger deviations for turbulent values between parameterisations
- > heat flux: z0 slightly better
- > TKE: ml and z0 better agreement with measurements
- modified turbulence parameterisations yield better agreement for turbulent structures
- representation of near–surface values of T and ff still problem

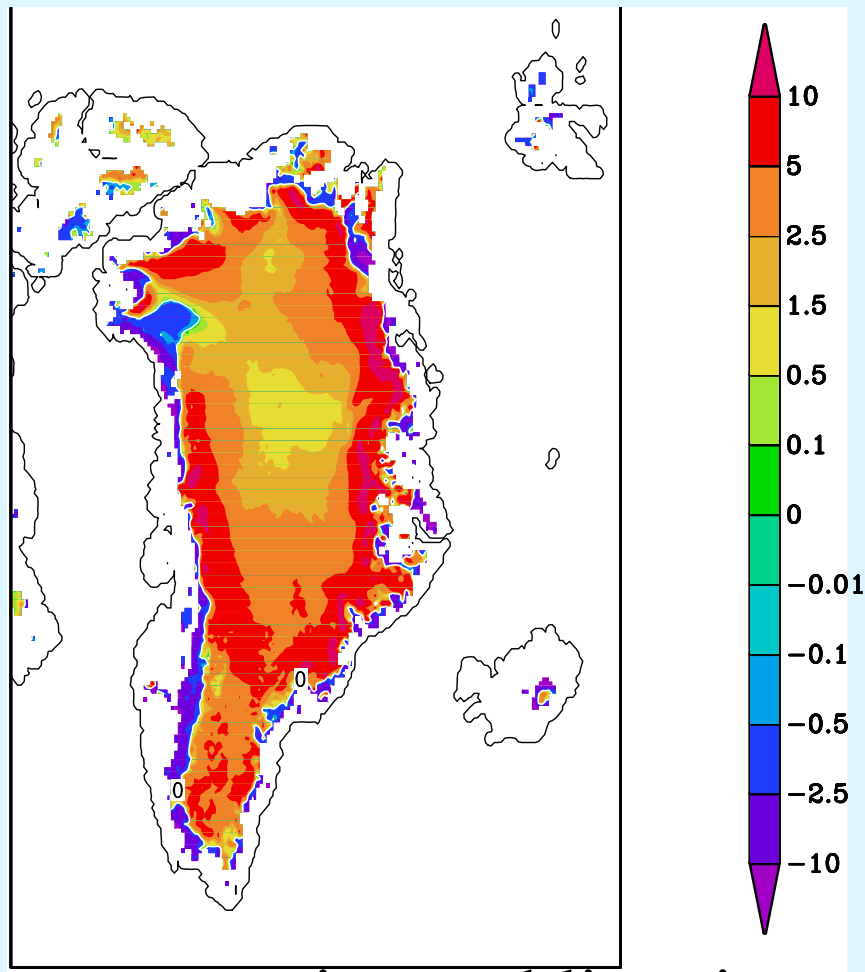
SNOWPACK

- 1d–model of snow from SLF in Davos
- snow = porous 3 component system (ice, liquid water and air)
- driven by meteorological data: T, RH, ff, radiation, cloud cover,
precipitation
- simulating snow microstructure in several snow layers
- output: snow field and meteorological data (snow drift, albedo)

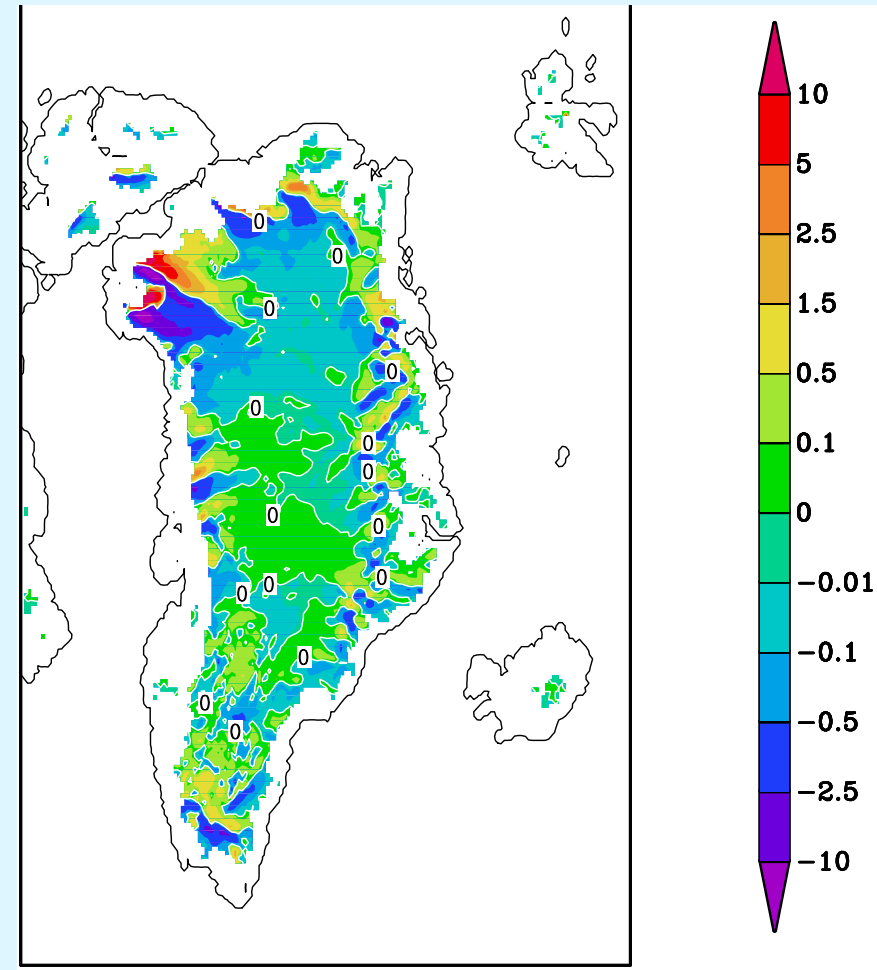
SNOWPACK Results

- 10–day simulation, driven by LM results (basic case)
- yield snow drift fields as well as accumulation of snow due to:
 - snow drift divergence and convergence
 - evaporation and sublimation of the snow field
 - precipitation
- hourly results as well as sum over any or all days

SNOWPACK Results – accumulation in kg/m^2 for whole time period



evaporation+sublimation



snow drift

Conclusions and Outlook

- modified turbulence parameterisation: better results for turbulence
- no strong influence for T, ff, P and radiation
- deficiencies in near–surface values of T and ff
- accumulation due to snow drift about factor 10 smaller than evap.
- but same magnitude at coastal regions (katabatic winds)
- yet no feedback between snowpack and atmosphere
- > coupling of SNOWPACK and LM