



# **GABLS4 models intercomparison experiment: presentation of the case and first results with LMDZ5 model**

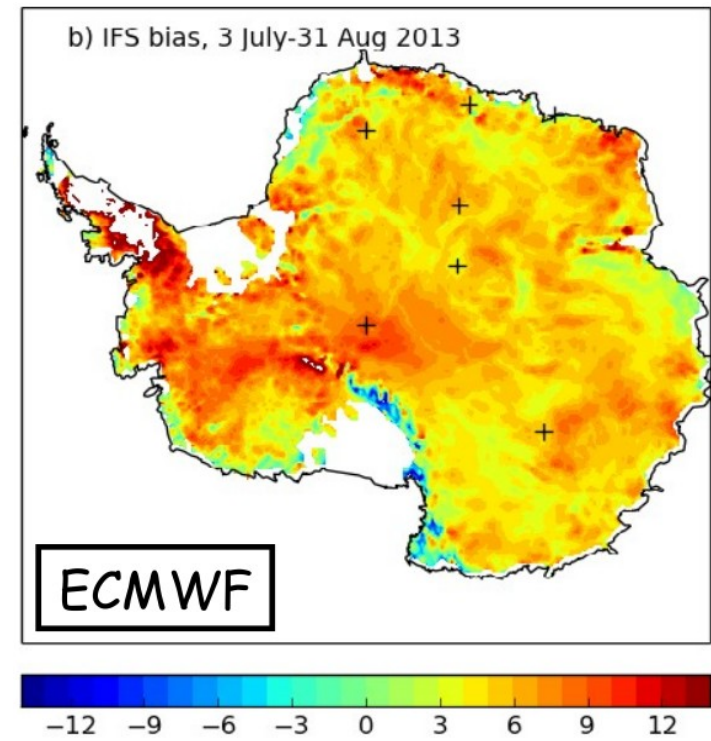
**E. Vignon, E. Bazile, F. Couvreur, P. Le Moigne, C. Genthon, O. Traullé, H. Barral,  
G. Canut, A.A.M. Holtslag, G. Svensson, T. Vihma, M. P. Lefebvre and F. Hourdin**

**10th AMOMF Workshop  
17-19th June 2015**

**This work is supported by the french national programme LEFE/INSU**

# Motivations

- Under strongly stable stratifications GCM/NWP models still have an excess of mixing or strong decoupling with the surface (Holtslag et al 2013)
- Warm or cold biases (Holtslag et al 2013)
- Parametrization of turbulence in models ?  
Surface/air coupling ?



*ECMWF surface temperature biases compared to Modis data, Freville et al 2014*



## What is GABLS4 ?

- « Gewex Atmospheric Boundary Layer Study 4 »
- Single column models (SCM), Land surface models (LSM) and LES intercomparison at Dome C, Antarctic plateau
- Launched at the GEWEX conference in July 2014 by CNRM-GAME and LGGE



**1/ To study a diurnal cycle of the atmospheric boundary layer with very stable conditions during the night .**

**2/ Interactions air/snow surface**

# Why Dome C ?

- flat, homogeneous snow desert
- A.B.L. experiences strong nocturnal temperature inversions and a clear diurnal cycle in summer



# Why Dome C ?

- flat, homogeneous snow desert
- A.B.L. experiences strong nocturnal temperature inversions and a clear diurnal cycle in summer
- meteorological instruments setting of Concordia station :



45m tower, 6 levels of measurements

sonic anemometers



Young 05103 aerovanes



PT100 thermometers





# Why Dome C ?

- flat, homogeneous snow desert
- A.B.L. experiences strong nocturnal temperature inversions and a clear diurnal cycle in summer
- meteorological instruments setting of Concordia station :

Young 05103 aerovanes



sonic anemometers



PT100 thermometers



45m tower, 6 levels of measurements

Thermometers in mechanically ventilated shields

# Why Dome C ?

- flat, homogeneous snow desert
- A.B.L. experiences strong nocturnal temperature inversions and a clear diurnal cycle in summer
- meteorological instruments setting of Concordia station :



45m tower, 6 levels of measurements

sonic anemometers



Young 05103 aerovanes



PT100 thermometers



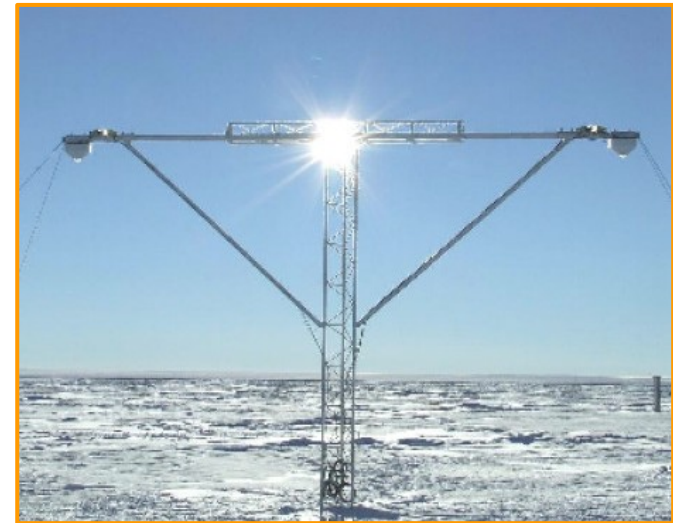
+ HMP155 thermo-hygrometers (biased at night!)

# Why Dome C ?

- flat, homogeneous snow desert
- A.B.L. experiences strong nocturnal temperature inversions and a clear diurnal cycle in summer
- meteorological instruments setting of Concordia station :



BSRN network





# Why Dome C ?

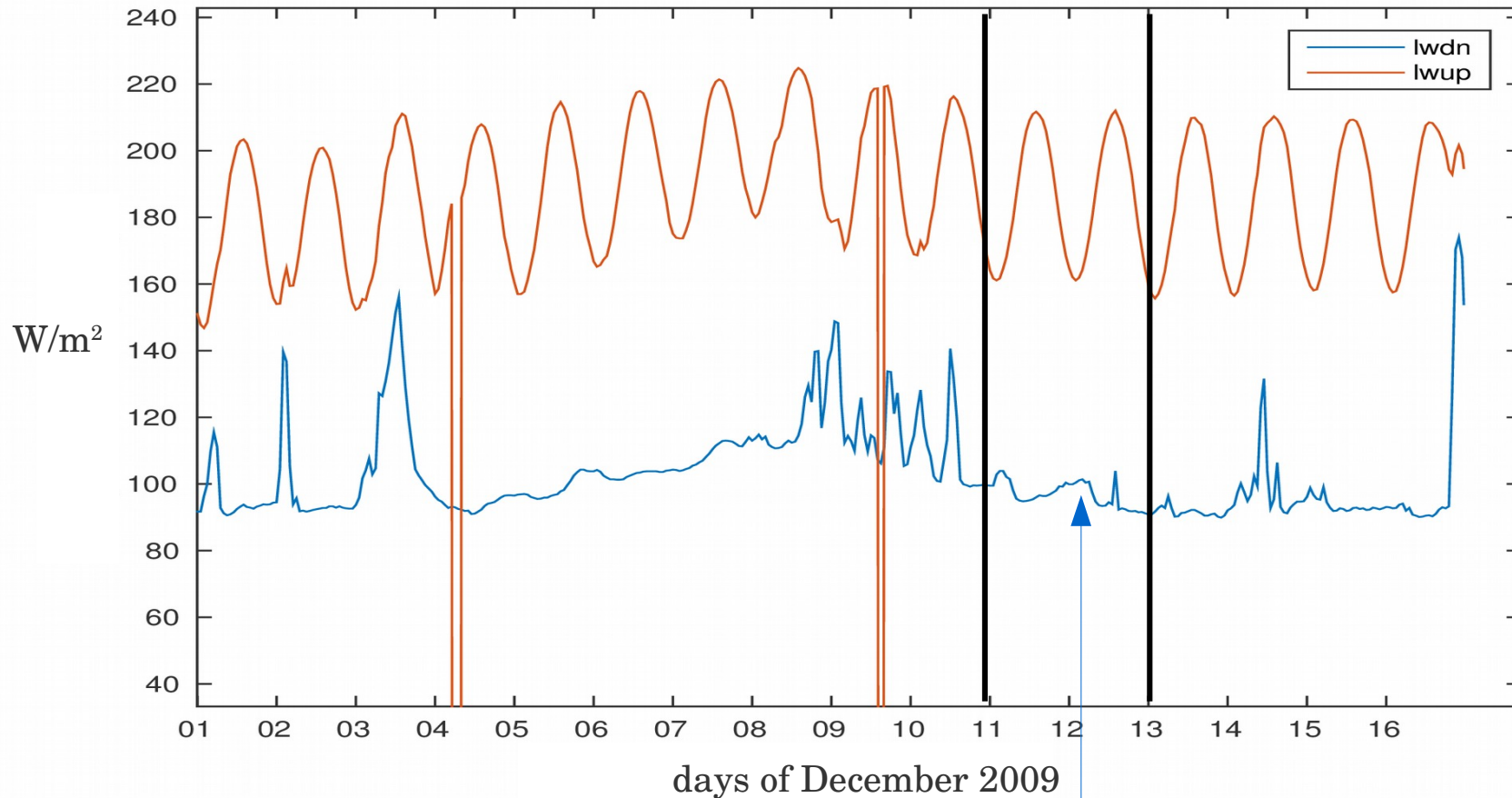
- flat, homogeneous snow desert
- A.B.L. experiences strong temperature inversions and a well-marked diurnal cycle in summer
- meteorological instruments setting of Concordia station :

1 radiosounding/day



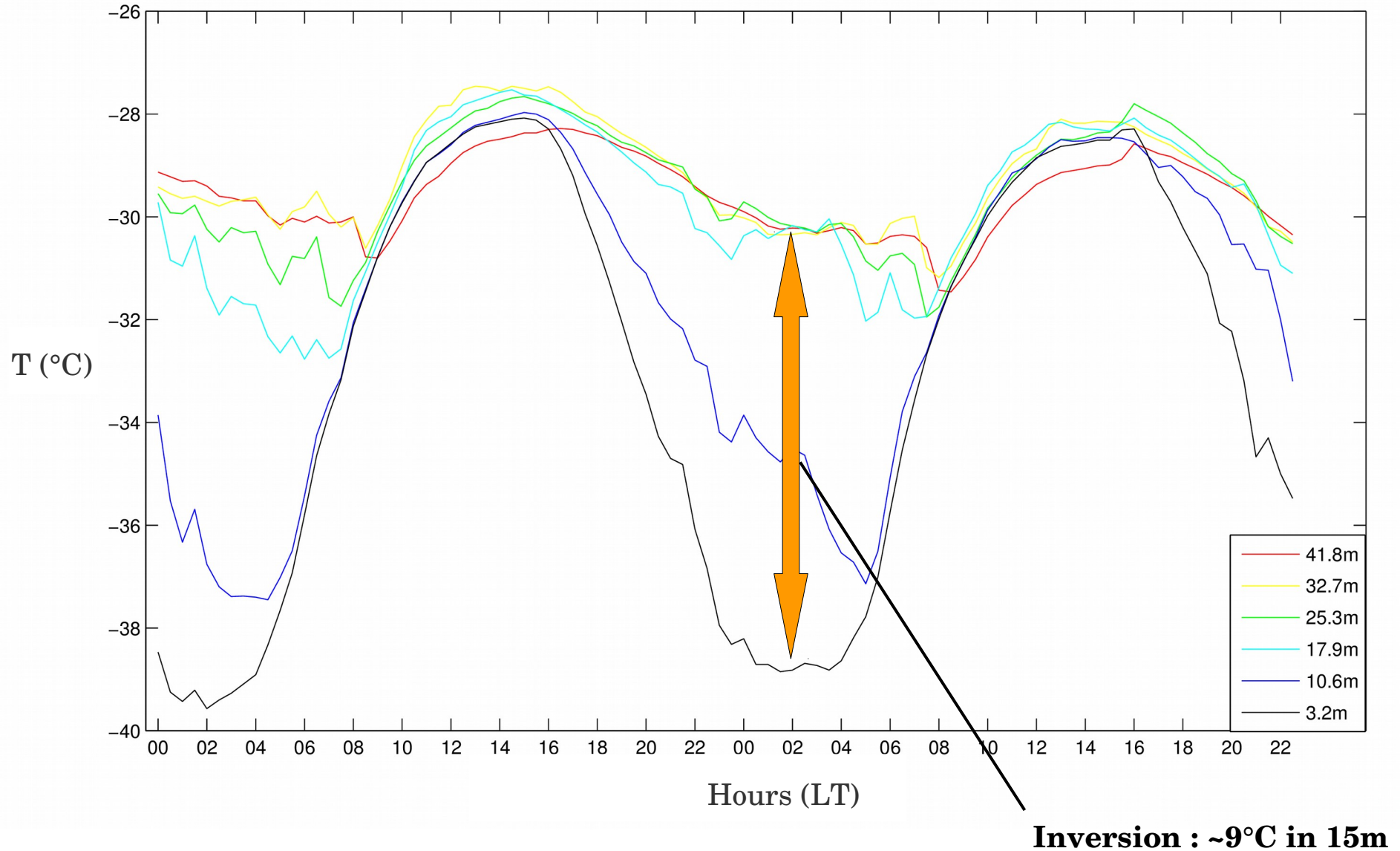
# Which period ?

December 2009, end of the Concordiasi campaign, 2 radiosoundings/day



Clear sky days  
+ no gap in the  
meteorological data

# Temperature at the different levels of the tower 11-12 december 2009



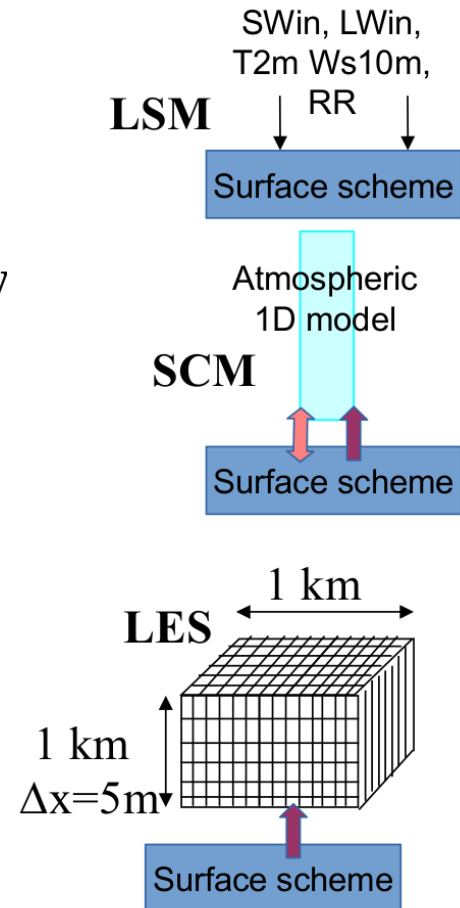


# GABLS4 experiment

## Stages :

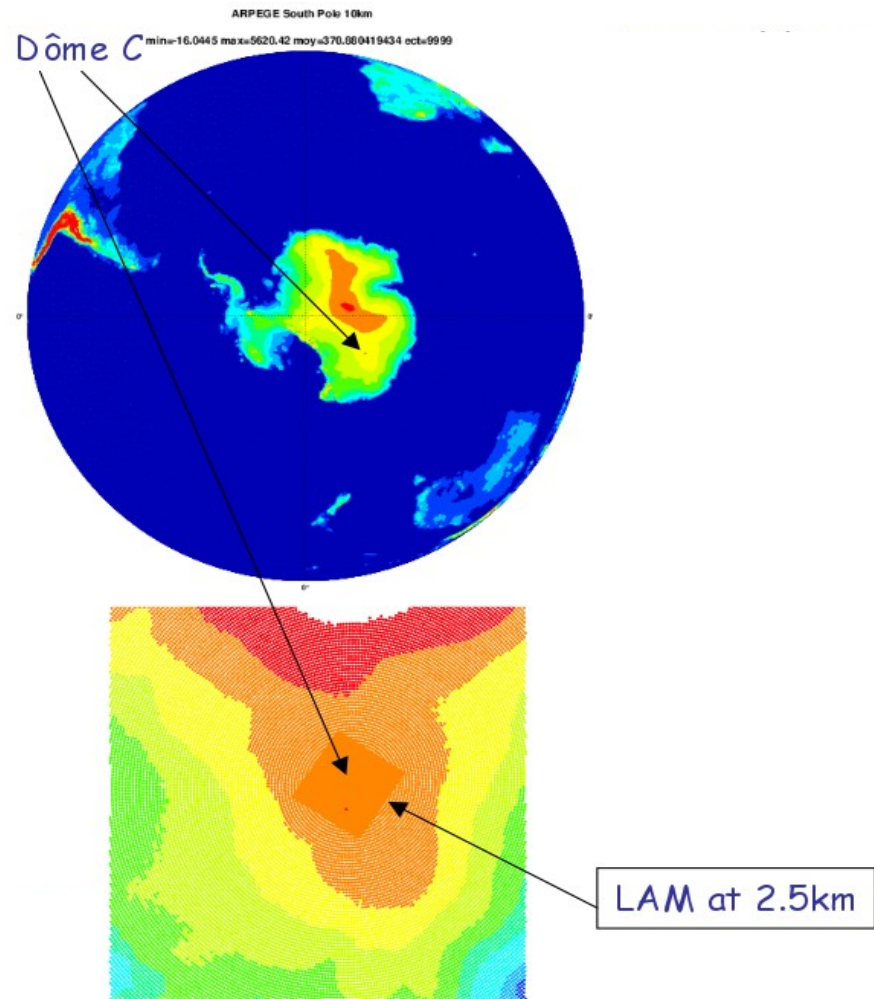
- Stage 0 : Land/snow surface model driven by observations from 1/12/2009 up to 15/12/2009.
- Stage 1 : Single column atmospheric models coupled with Land/snow model from the 11 december 2009 00UTC → the 12 december 2009 12UTC (=36h).
- Stage 2 =Stage 1 but the surface temperature is prescribed
- Stage 3 = Ideal GABLS4 (easier for LES community)  
= Stage 2 without radiation and humidity  
+ constant geostrophic wind

- 7 institutes for LSM, 11 for SCM and 7 (+2) for LES.
- 1 st Workshop 20-22 May 2015 in Toulouse

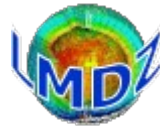


# Atmospheric forcings

- From limited area models (AROME, 2.5km\*2.5km)
- Lateral conditions from ARPEGE 4DVar reanalyses (validated by radiosoundings).

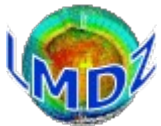


# First results with LMDZ5 model





# 1D simulations with LMDZ5/Orchidee



## LMDZ :

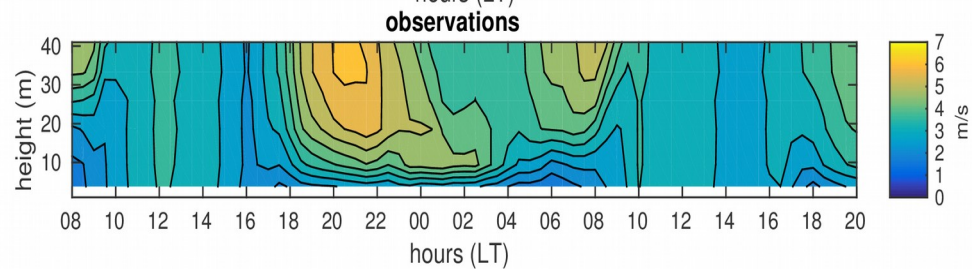
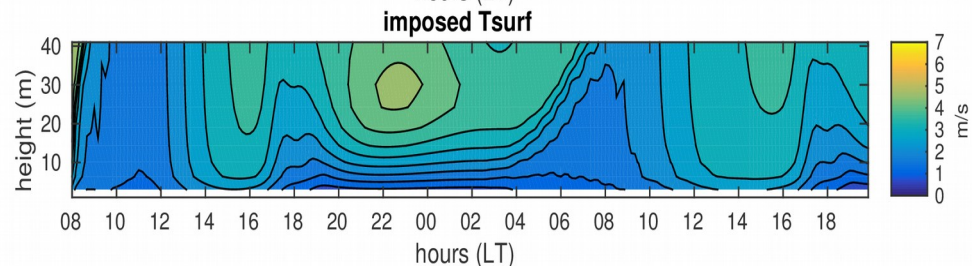
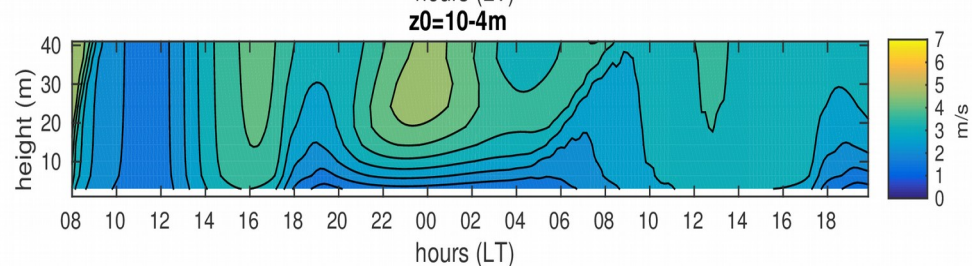
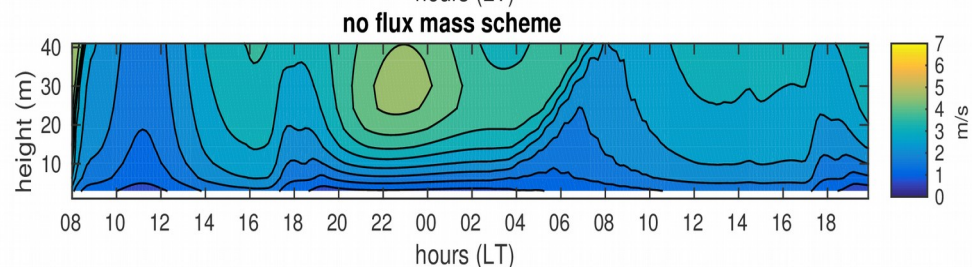
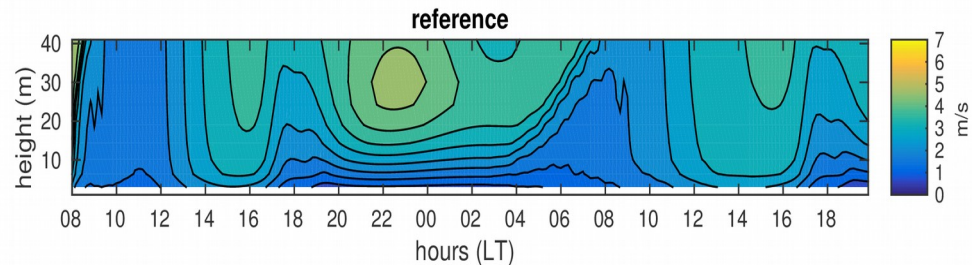
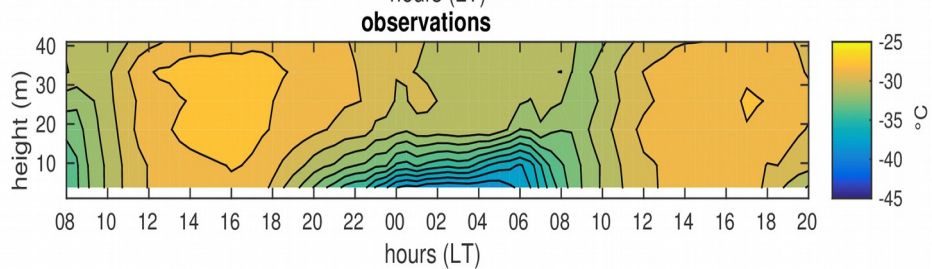
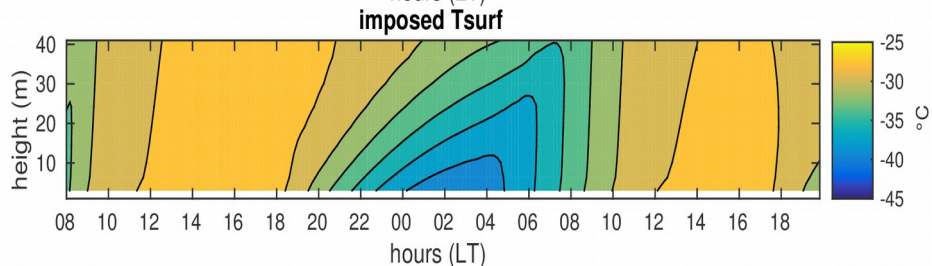
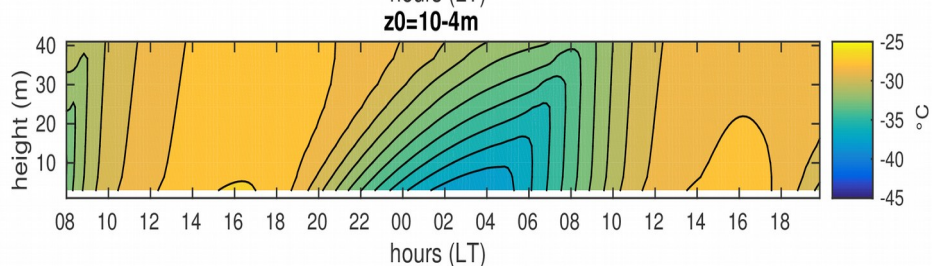
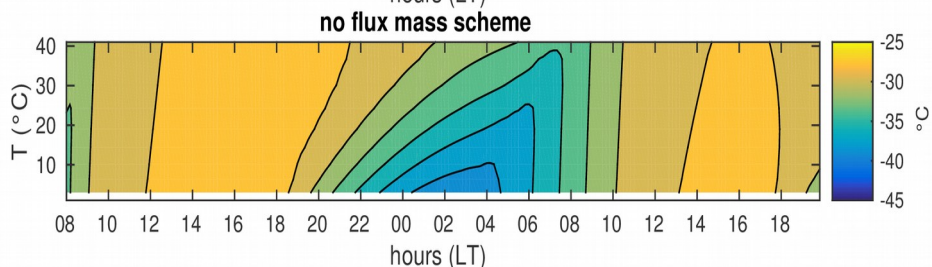
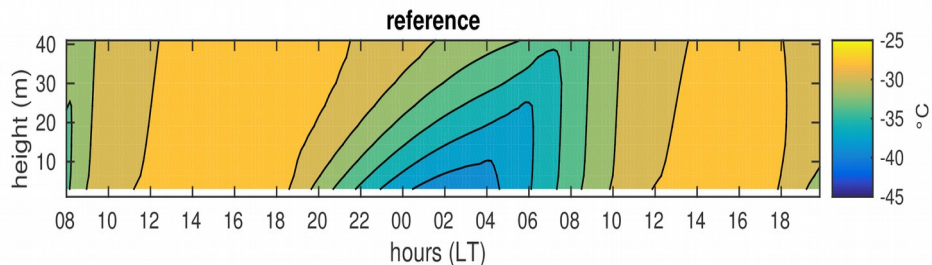
- Global atmospheric circulation model of the IPSL-CM5 model (used for CMIP5 simulations). Not particularly tuned for polar regions.
- Turbulence scheme : K-profile + TKE-1 :  
*Mellor, G. L. and Yamada, T., 1982: Development of a turbulence closure model for geophysical fluid problems. Rev. Geophys. Space Phys. 20, 851-875*  
*Yamada, T 1983: Simulations of Nocturnal Drainage Flows by a  $q^2$  Turbulence Closure Model, JAS, 40, 91-10*
- Mass-flux scheme :  
*Rio et al 2010: Resolved Versus Parametrized Boundary-Layer Plumes. Part II: Continuous Formulations of Mixing Rates for Mass-Flux Schemes, BLM, 135, 469-483*
- 79 vertical levels, 9 within the first 50m

## ORCHIDEE :



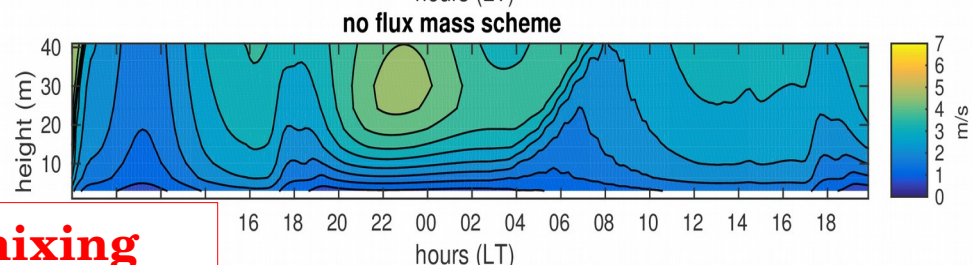
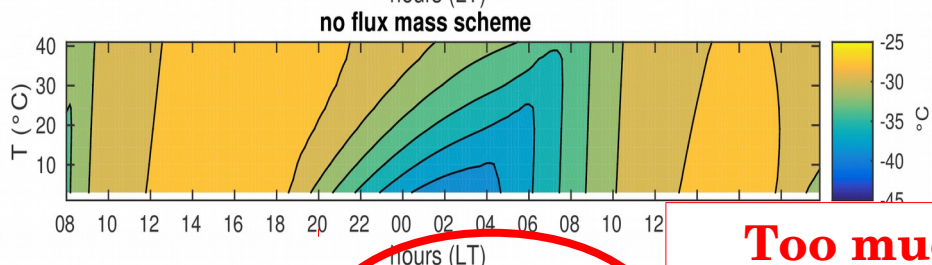
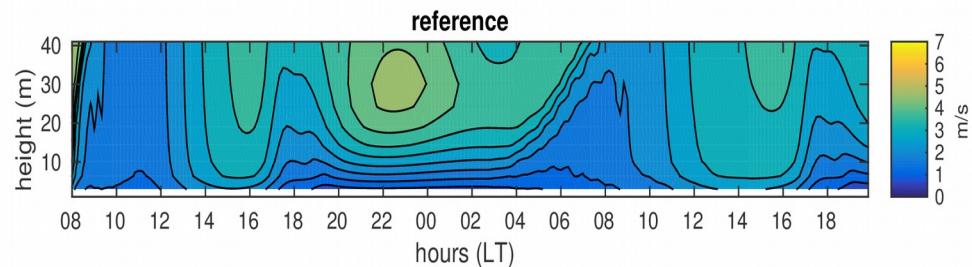
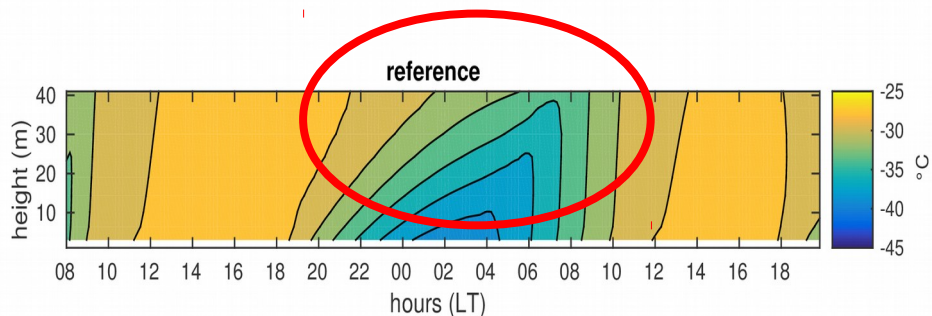
- Land surface model  
prognostic variables : snow albedo, soil water content, soil temperature

# 1D simulations with LMDZ5/Orchidee

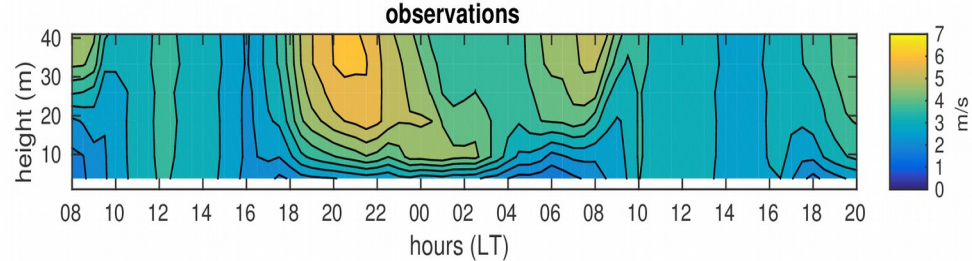
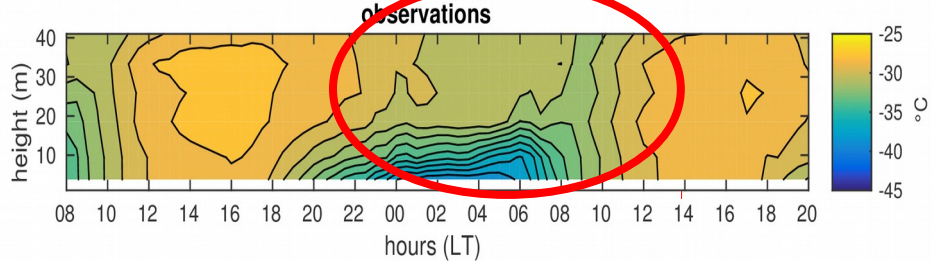
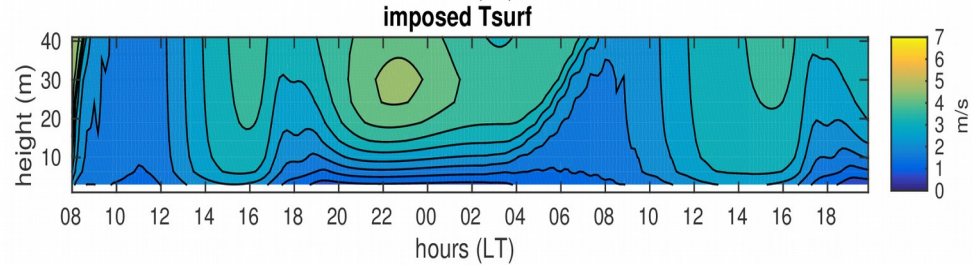
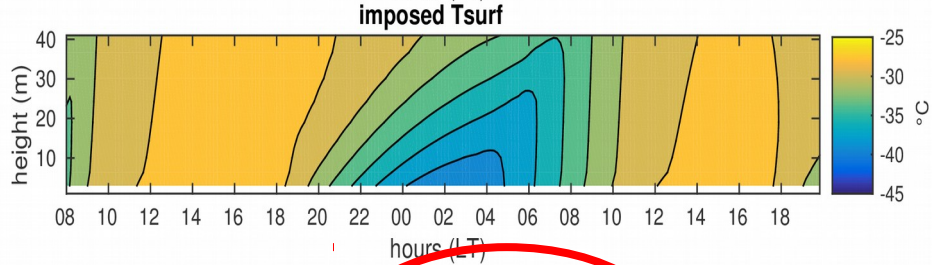
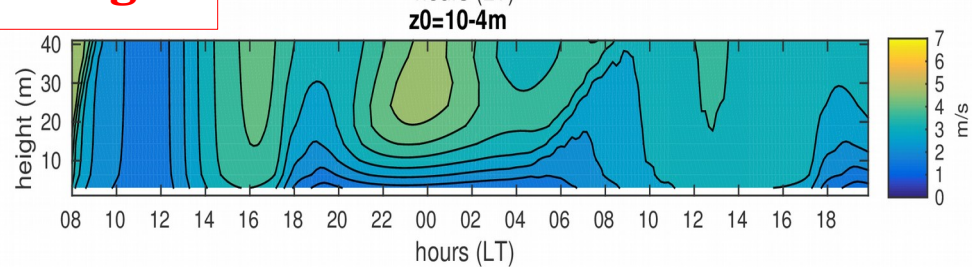
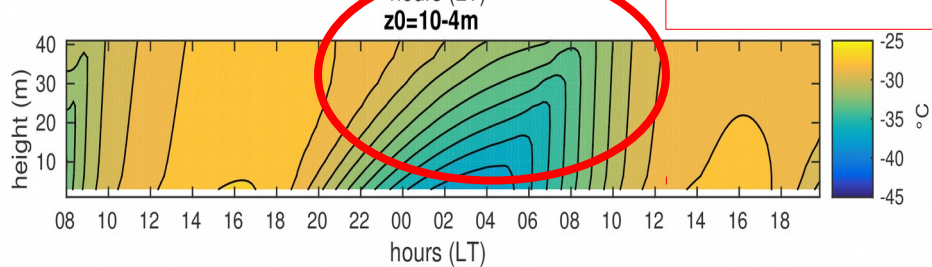




# 1D simulations with LMDZ5/Orchidee

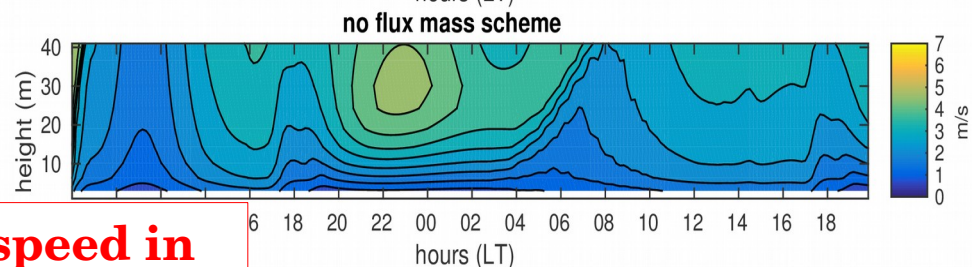
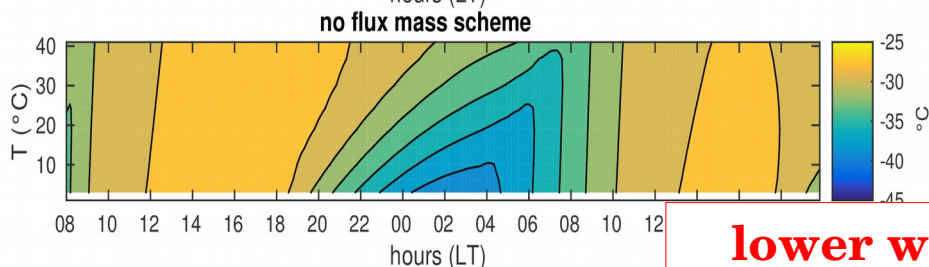
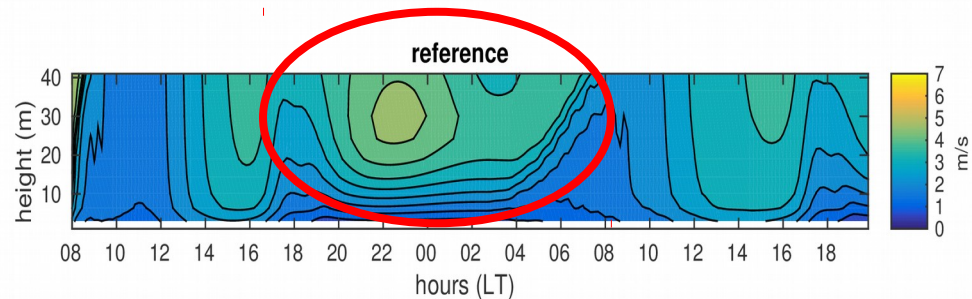
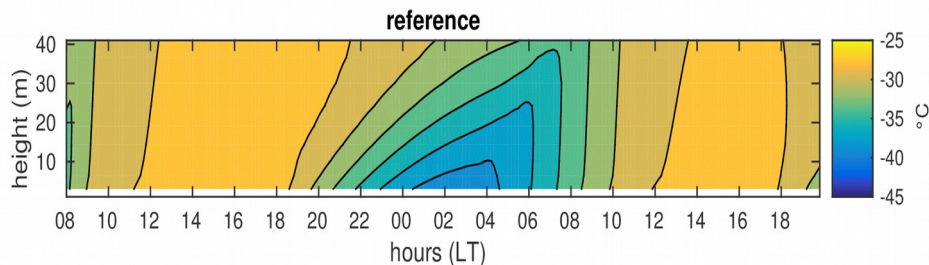


**Too much mixing**

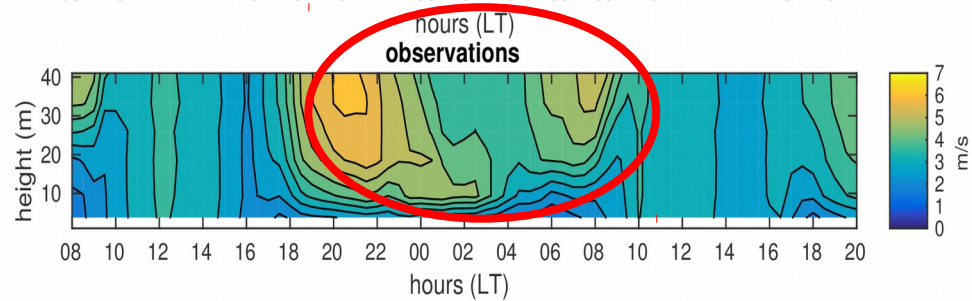
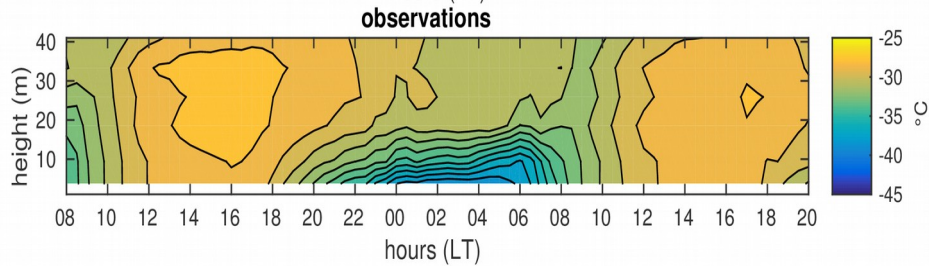
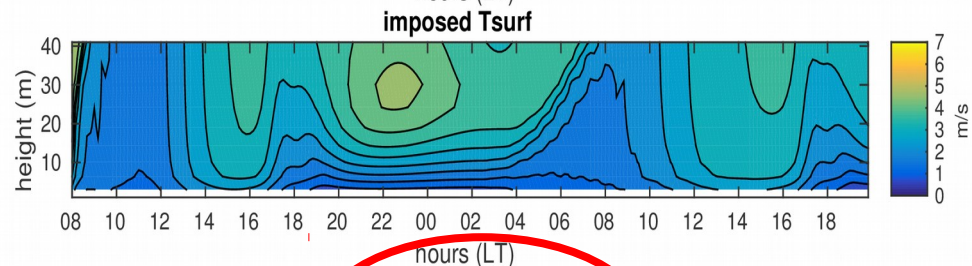
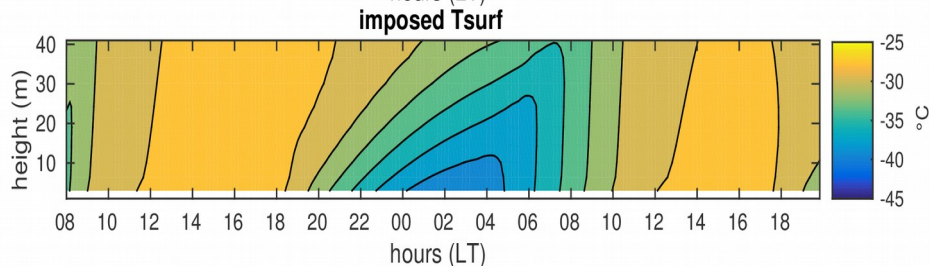
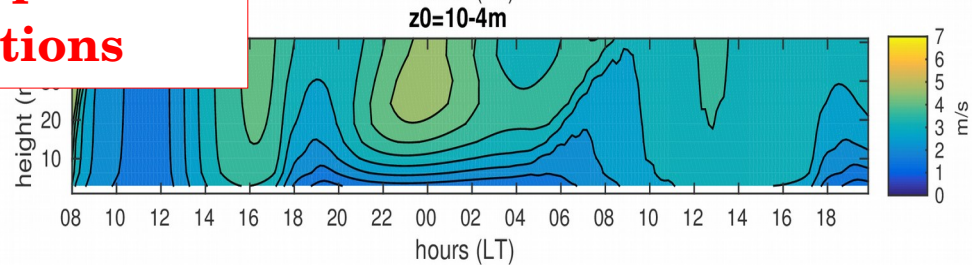
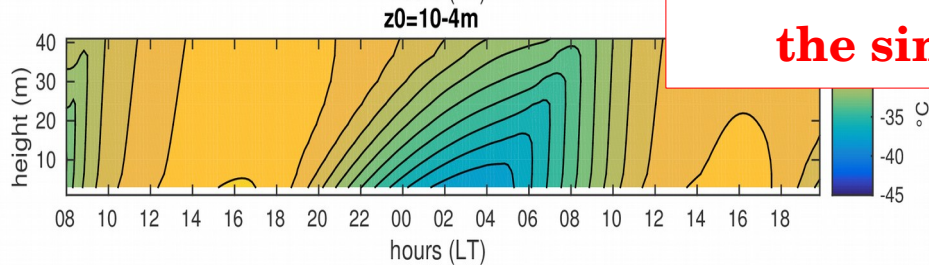




# 1D simulations with LMDZ5/Orchidee



**lower wind speed in  
the simulations**



# Conclusions about LMDZ simulations

- Too much mixing in the nocturnal boundary layer in LMDZ even with a low  $z_0$ 
  - problem in the turbulence scheme itself
  - comparison with MAR physics with a TKE- $\epsilon$  turbulence scheme (in progress)
  - implementation of an EFB turbulence scheme (*Zilitinkevich 2013*) in the future months
- Strong dependency of the surface fluxes on the roughness length and on the stability function during night time (not shown here).
  - implementation of different surface layer schemes (in progress)
- Bad diurnal cycle of the snow albedo in Orchidee (not shown here)

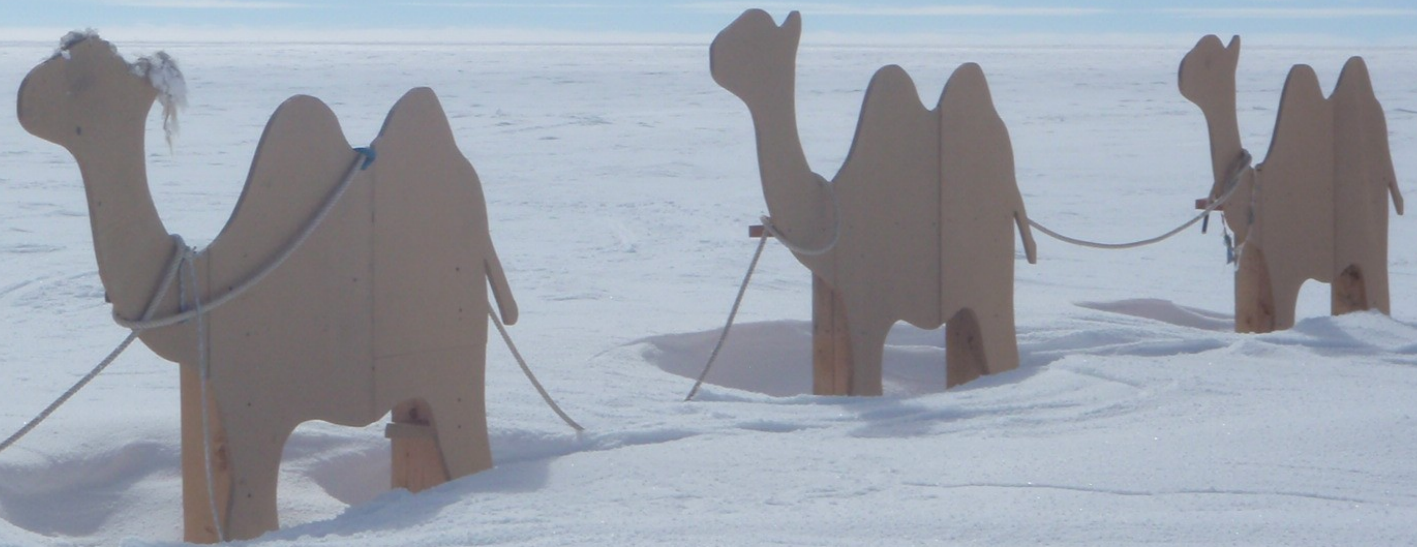
# Perspectives for GABLS4

## after the workshop 20-22 May 2015:

- Reference simulations for stages 1, 2 and 3 :
  - albedo = 0.81
  - $z_{0m} = 0.001$  m
  - $z_{0h} = 0.0001$  m
  - prescribed vertical grid
  - given snow density and thickness
- To draw the best comparison of the turbulence schemes between models
- To look at moist processes (cold microphysics...)
- Stage 4 : no turbulence, balance between radiation and conduction
  - Turbulence cut-off during the night ?






*Thank you for your attention !*



<http://www.cnrm.meteo.fr/aladin/meshtml/GABLS4/GABLS4.html>

Project leader : [eric.bazile@meteo.fr](mailto:eric.bazile@meteo.fr)

GABLS 1 - 2003	GABLS 2 - 2005	GABLS 3 - 2008
		
LES as reference	Observations (CASES99)	LES and Observations (CABAUW)
Academic setup	Idealized forcing	Observed forcing
Prescribed Ts	Prescribed Ts	Full coupling with surface
No radiation	No radiation	Radiation
Turbulent mixing	Diurnal cycle	LLJ+transition
<i>Cuxart et al. (2006)</i>	<i>Svensson et al. (2011)</i>	<i>Bosveld et al. (2014)</i>

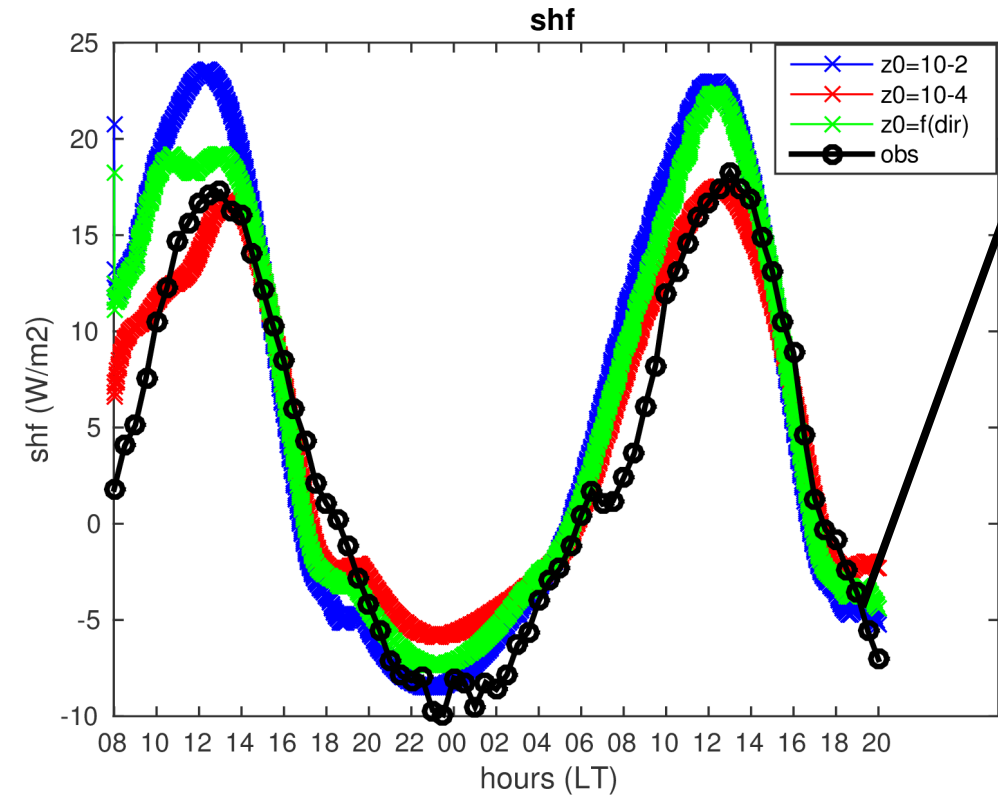
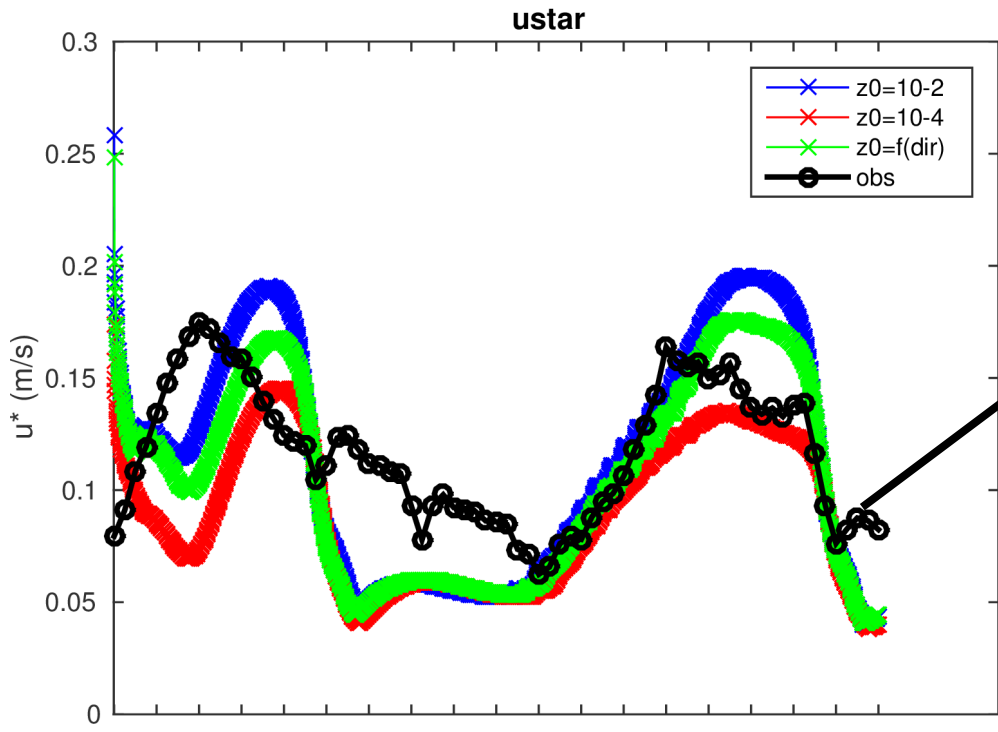
From Holtslag et 2014

<b>Organization</b>	<b>Model</b>	<b>Snow layers</b>	<b>People</b>
METOFFICE	Jules	19	John M. Edwards
Meteo-France	ISBAES	19	Patrcik Le Moigne
	CROCUS	19	
	D95	1	
	ARP	1	
Langley Research Center (LARC)	CLM4	5	Anning Cheng
NCEP	NOAH	1	Weizhong Zheng
CMC	GDPS4	1	Ayrton Zadra
LGGE	LMDZ	19	Etienne Vignon
ECMWF	CHTESSEL	1	Emanuel Dutra, Irina Sandu

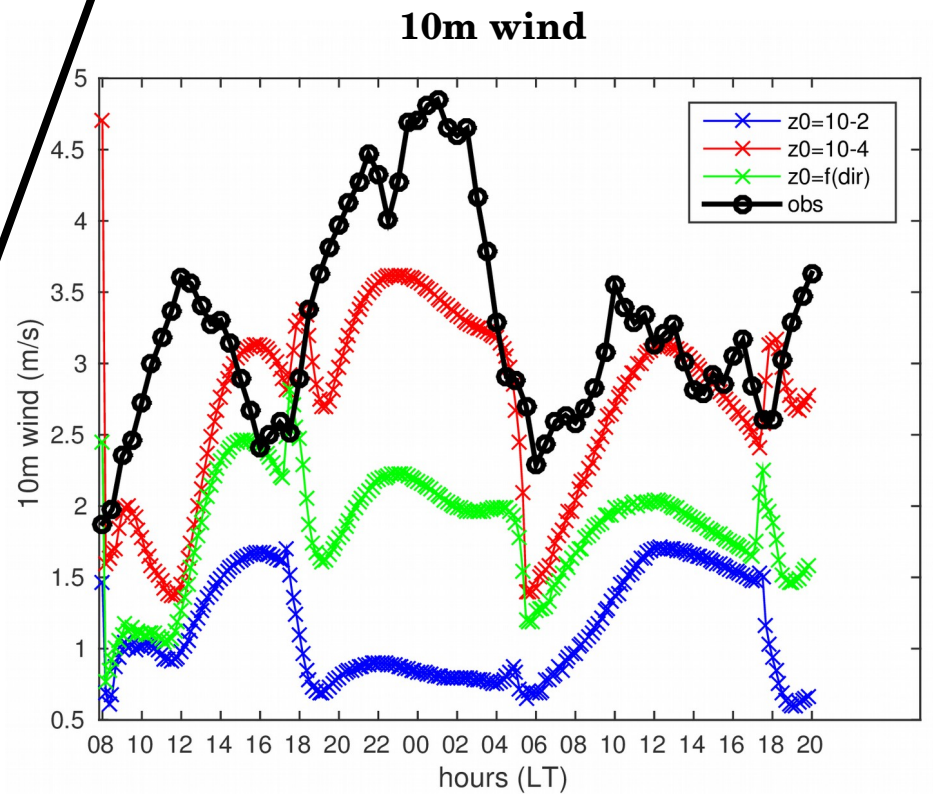


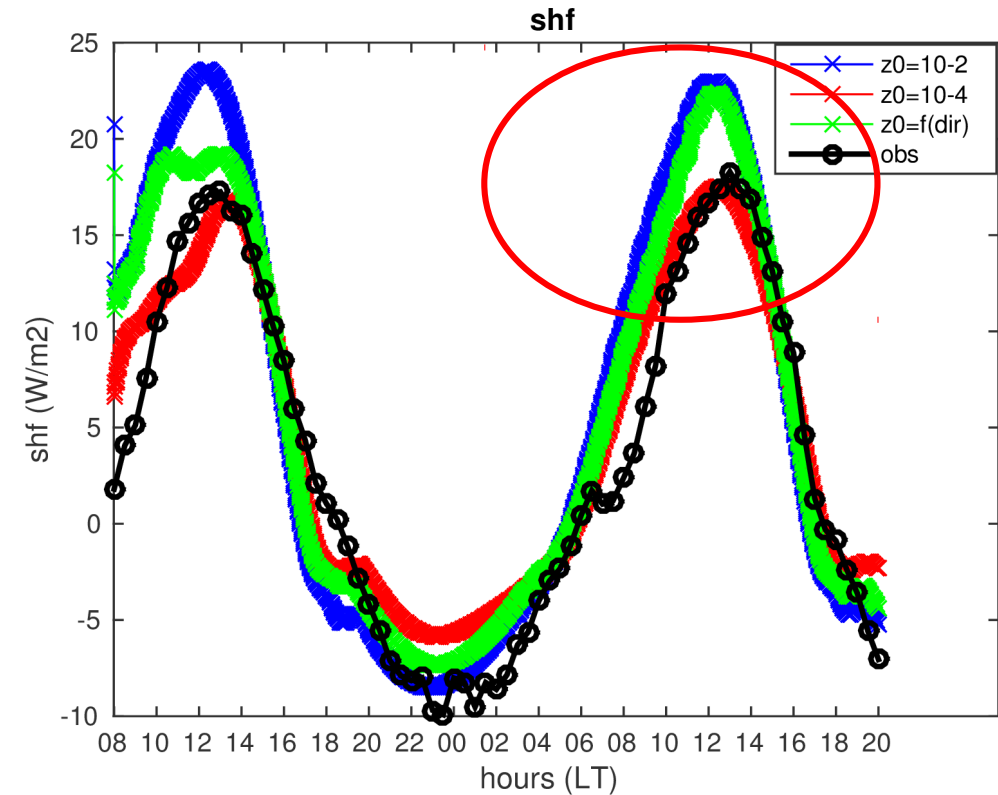
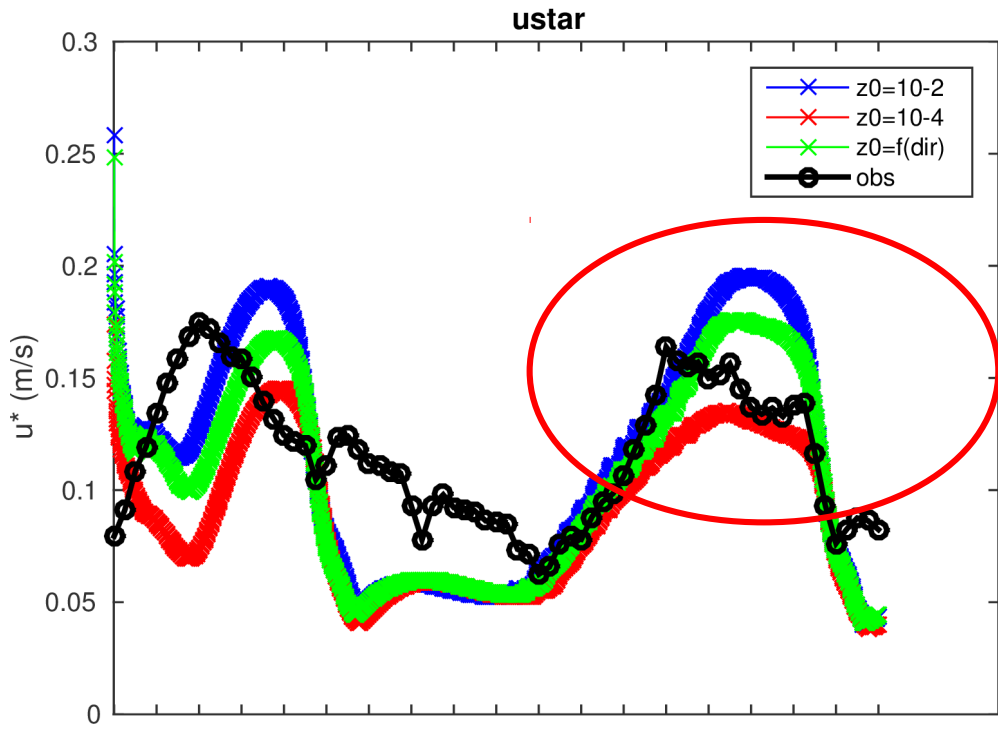
Organization/model 1D	Stage1 (01/2015)	Stage2 (04/2015)	Stage3 (04/2015)	People
METOFFICE (Unified Model)	1a STD 1b STD, SHRP, R150	Not Yet	Not yet	John M. Edwards (MO_UM)
Météo-France AROME ARPEGE ARPEGE-EFB ARPEGE-CLIMAT	1a, 1b 1a, 1b 1a, 1b 1a, 1b	2= dz 3= dz 2= dz Not Yet	2= dz 3= dz 2= dz Not Yet	Eric Bazile = = Isabelle Beau
LaRC-NASA CAM5-IPHOC	oper, dz, alb	oper, dz, alb	oper, dz	Anning Cheng
NOAA NCEP /GFS	1a,1b	std	std	Weizhong Zheng, Michael Ek
CMC (Global version)	1a + 3=phys & 1b	L79, L117	L79, L117	Ayrton Zadra
ECMWF / IFS (38r2)	1a + 2=surf + TKE + 1b	ref + TKE	Not Yet	Irina Sandu, Emanuel Dutra, G. Balsamo
CIRES/NOAA WRF	1b 2*2 =phys/surf	2*2= phys/surf	Not Yet	Wayne Angevine
FMI HARMONIE-AROME	1b Ref + TTE	Not Yet	Not Yet	Carl Fortelius
LMD/LGGE (France) LMDz	1a, 1b+ 4=surf	std	std	Etienne Vignon (LGGE), M-P Lefebvre (LMD)
U. of Delaware WRF	1b 3= dz	3= dz	Not Yet	Dana Veron, Alexander Schroth
Univ. Illes Balears / Méso-Nh	1a, 1b , std	std	std	Maria A. Jimenez

Organization/model 1D	Stage1 (01/2015)	Stage2 (04/2015)	Stage3 (04/2015)	People
Météo-France / Méso-NH/LES	Yes	Yes	Yes	Fleur Couvreur
Univ. Hannover / PALM	No	No	Yes	Bjorn Maronga, Maria Chinita
UCLA LES	No	No	Yes	Gorgios Matheou
Univ. of Praha / CLMM	?	?	Yes	Vladimir Fuka
SAM-IPHOC, Nasa	No	No	Yes (100m & 5m)	Anning Cheng
MPI LES & DNS	No	No	Yes	Bart van Stratum & Chiel van Heerwaarden
North California State Univ.	No	Not yet	Yes	Sukanta Basu
Linner FLOW Center KTH Stockholm Exp. Algebraic	No	No	Not yet	G. Brethouwer W. Lazeroms
Univ. of Eindhoven / DNS	No	No	Not Yet	B.J.H. van de Wiel
Russian Academy of Sciences	?	?	?	Andrey Glazunov

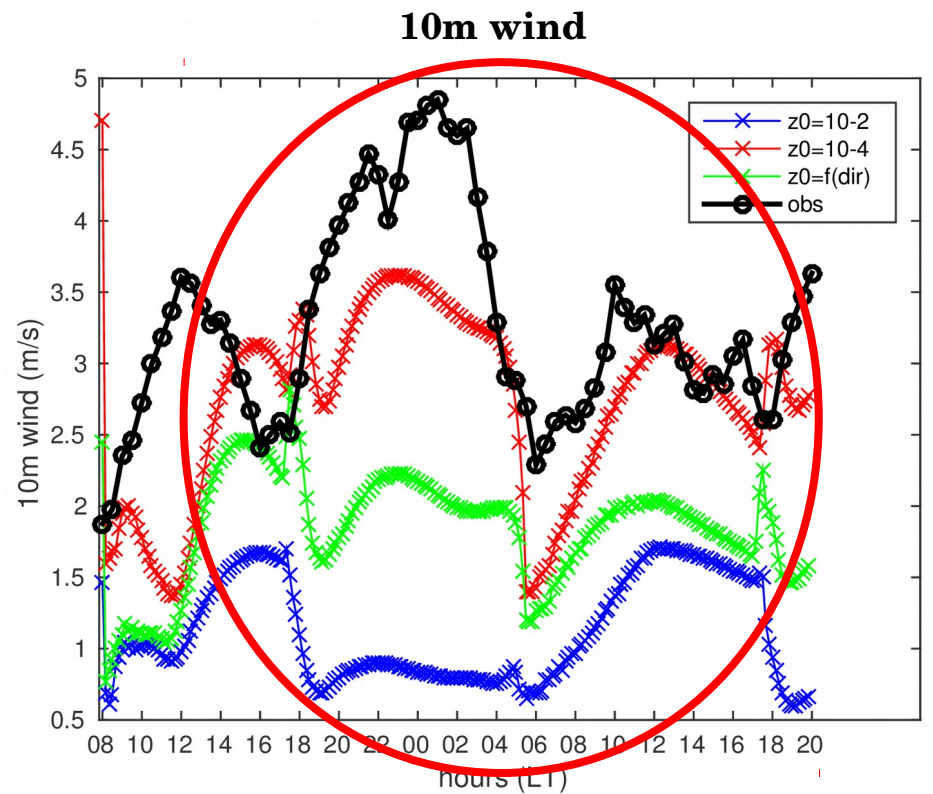


**Estimated from the profiles method  
(based on the Monin-Obukhov similarity theory)**

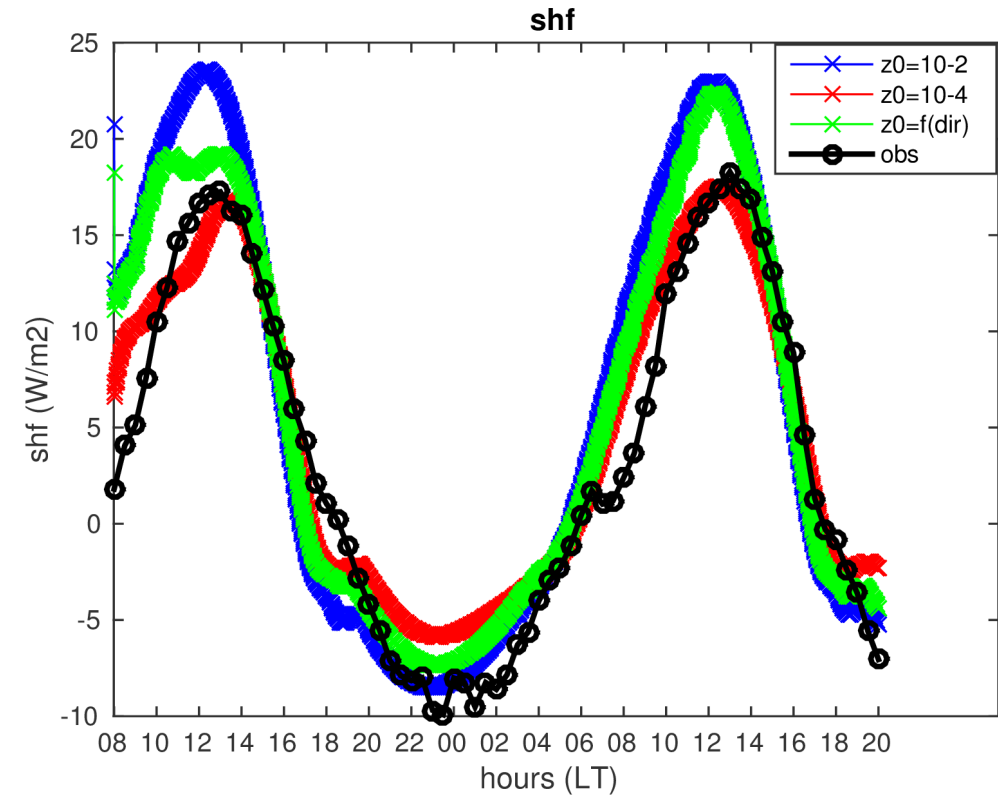
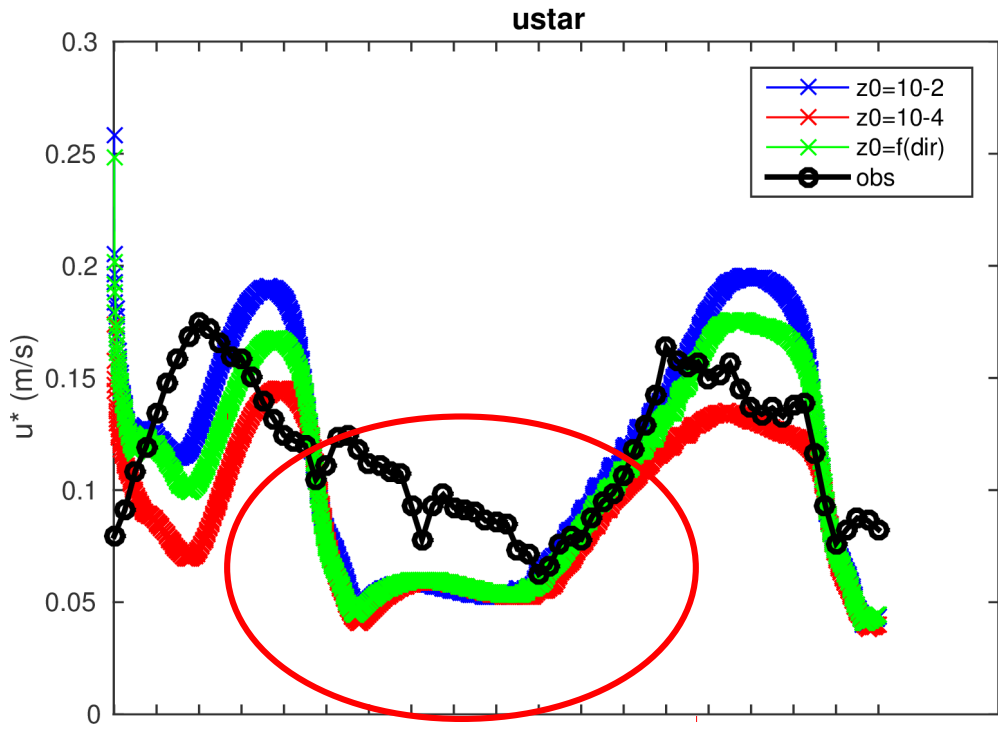




Strong dependence on the roughness length, particularly during daytime







Which stability function in stable stratification ?

