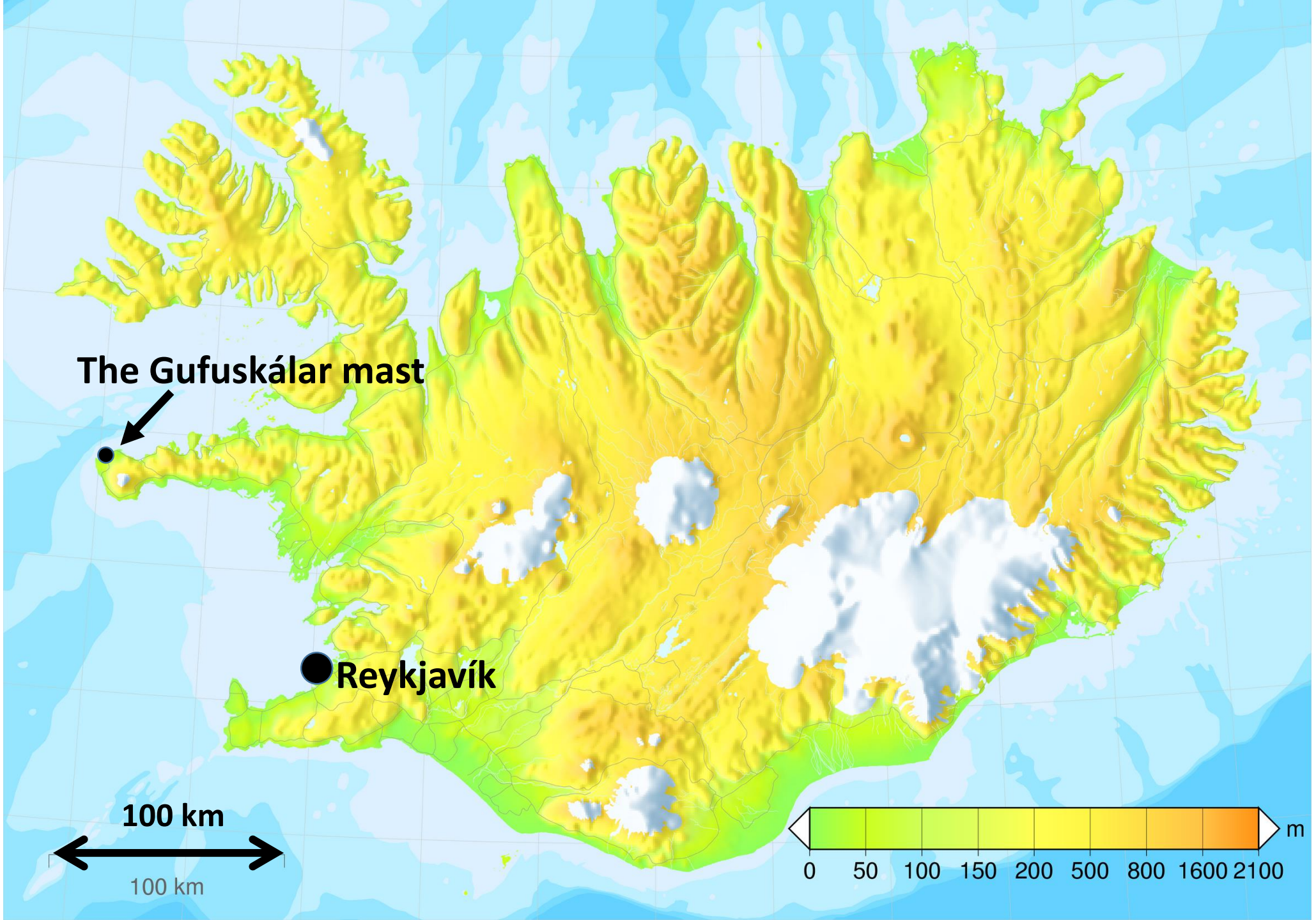
Surface fluxes at the west coast of Iceland

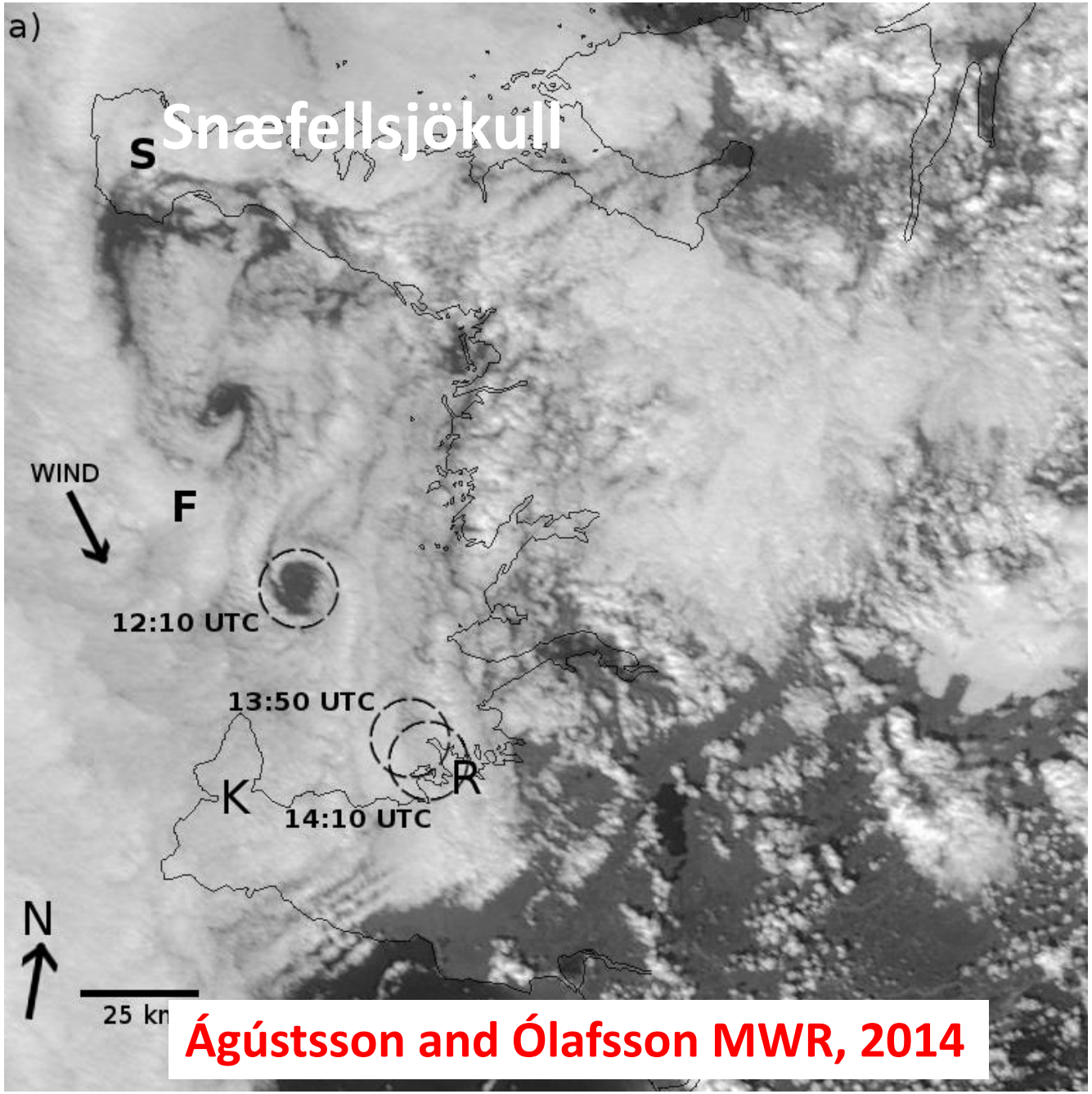
Monitoring the Atmospheric Boundary Layer in the (MABLA)

Geoffroy Dumont
Haraldur Ólafsson
Guðrún Nína Petersen
Joan Cuxart
Hálfdán Ágústsson
Ólafur Rögnvaldsson
Joachim Reuder


The Gufuskálar mast
Reykjavík
100 km
100 km
0 50 100 150 200 500 800 1600 2100
m

NW-winds: 0,4 km from the sea
SE-winds: 20 km from the sea

SW-winds: 1-13 km from the sea
NE-Winds: 1-6 km from the sea



Ágústsson and Ólafsson MWR, 2014

Mean gust factors in complex terrain

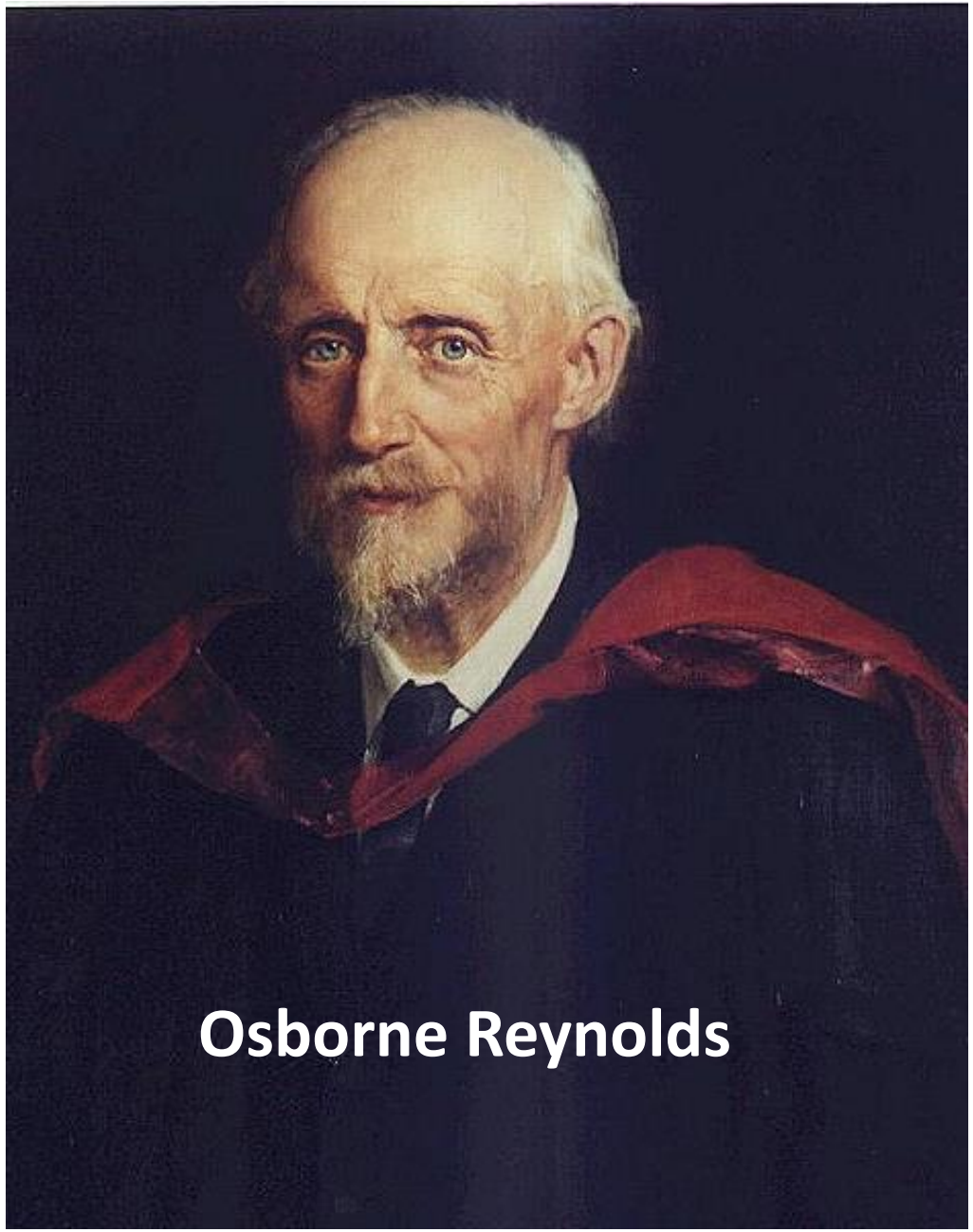
HÁLFDÁN ÁGÚSTSSON* and HARALDUR ÓLAFSSON

Meteorol. Z., 2004

Forecasting wind gusts in complex terrain

H. Ágústsson[1,2], H. Ólafsson[2,3,4]

Meteorol. Atmos. Phys., 2009



Wind components: u,v,w

V = V(mean in time) + v´

T = T(mean in time) + T´

The turbulent fluxes

- Turbulent heat flux:

$$H = \rho C_p \overline{w'\theta'}$$

(Potential) temperature

- The stress tensor:

$$\tau = \rho \sqrt{(\overline{u'w'})^2 + (\overline{v'w'})^2}$$

Wind components (instantaneous deviation from the mean)

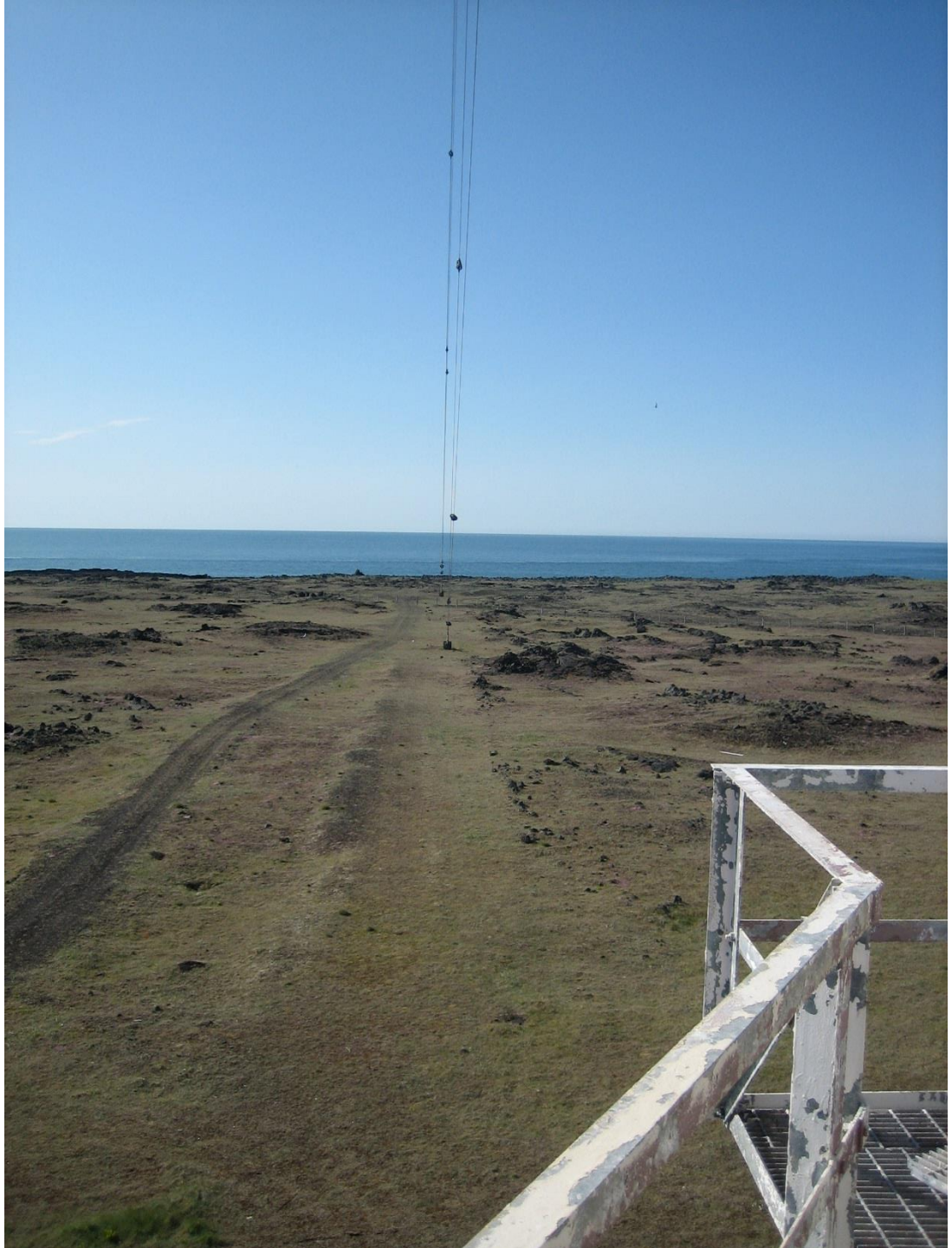
Terms of vertical, turbulent fluxes of horizontal momentum

$$\frac{\partial V}{\partial t} + \nabla \cdot \nabla V = -\frac{1}{\rho}\nabla P - f\, k \times V - \frac{\partial (u'w')}{\partial z} - \frac{\partial (v'w')}{\partial z}$$

gh 2008

What do we (think we) know

- The ocean is usually warmer than the air
- Winds are often strong
- NWP models tend to underestimate strong winds
- The airmasses are quite different, ranging from subtropical, statically stable and humid air to cold convective arctic outflow.

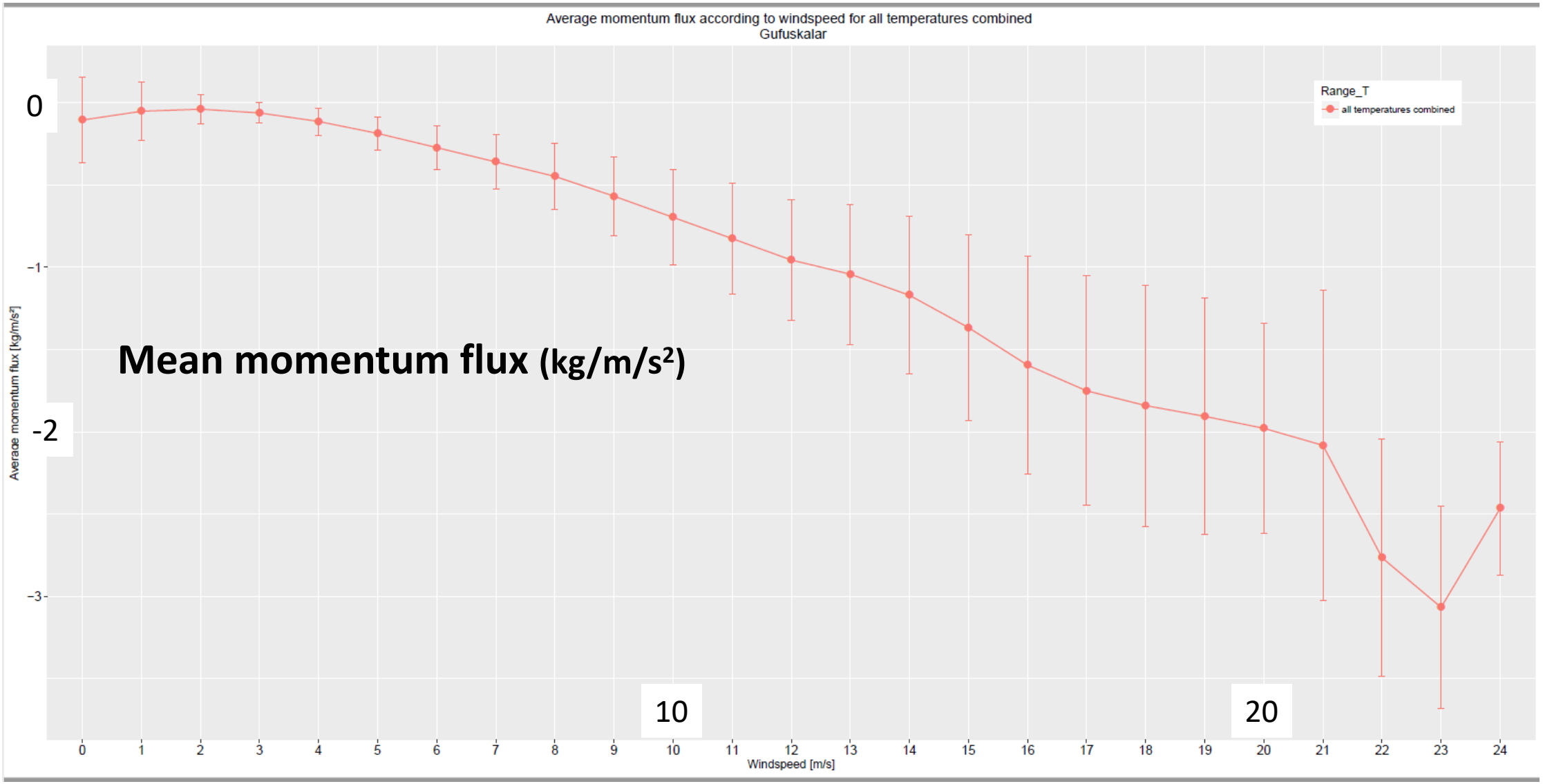


Summer: stable from land (SE), yet the land is warm (or not?)

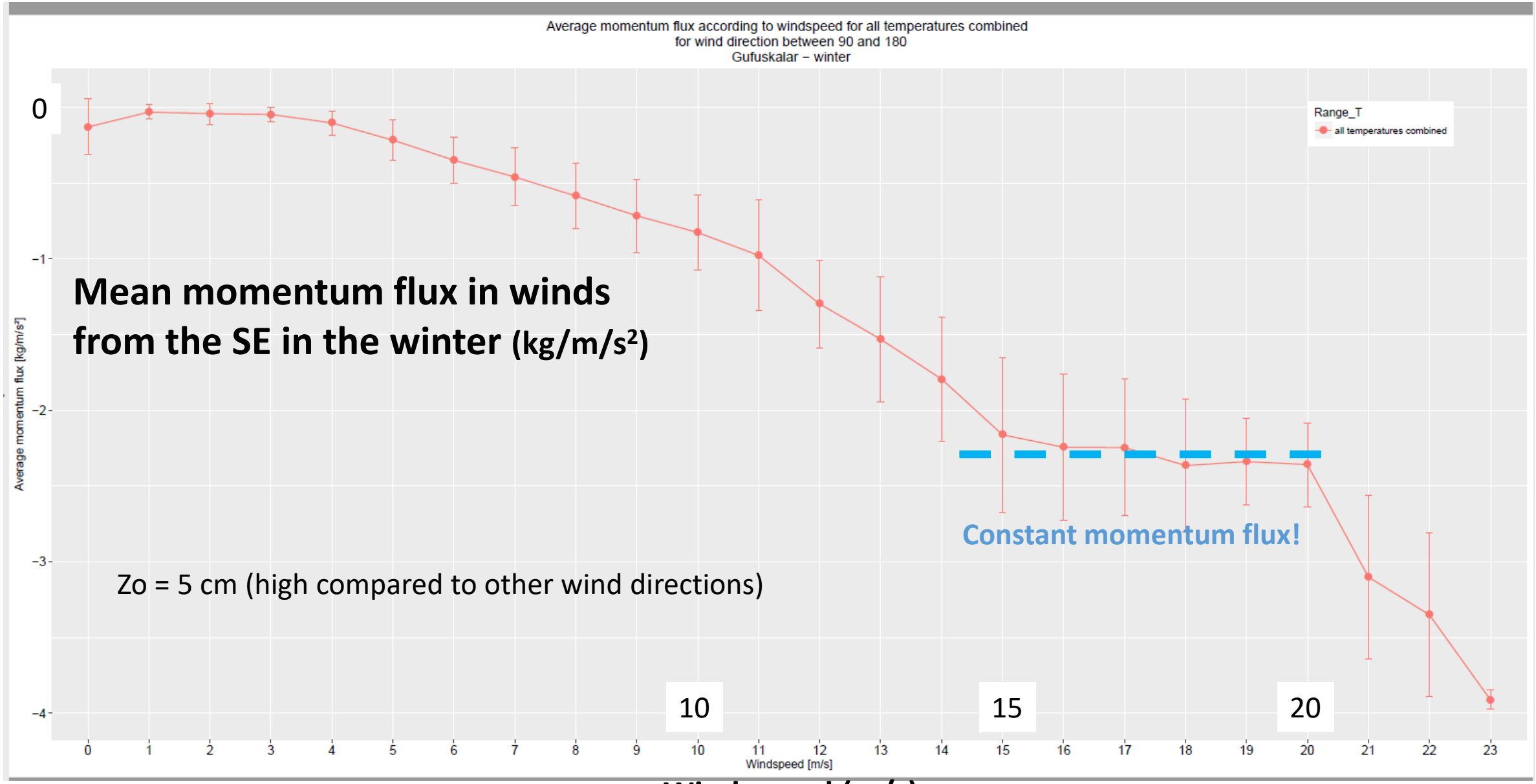
Direction	To	YEAR		JJA		SON		DJF		MAM		
	Stable	Instable	Stable	Instable	Stable	Instable	Stable	Instable	Stable	Instable	
0°-360°	71,0%	29,0%	41,9%	58,1%	83,7%	16,3%	93,1%	6,9%	59,5%	40,5%	ALL
0°-90°	70,7%	29,3%	40,7%	59,3%	86,9%	13,1%	94,7%	5,3%	46,3%	53,7%	NE
90°-180°	86,5%	13,5%	70,7%	29,3%	86,5%	13,5%	94,1%	5,9%	94,2%	5,8%	SE
180°-270°	76,4%	23,6%	47,8%	52,2%	78,0%	22,0%	97,1%	2,9%	72,7%	27,3%	SW
270°-360°	27,9%	72,1%	11,8%	88,2%	26,6%	73,4%	62,4%	37,6%	21,9%	78,1%	NW

Summer: unstable from the sea (NW), yet the sea is cold

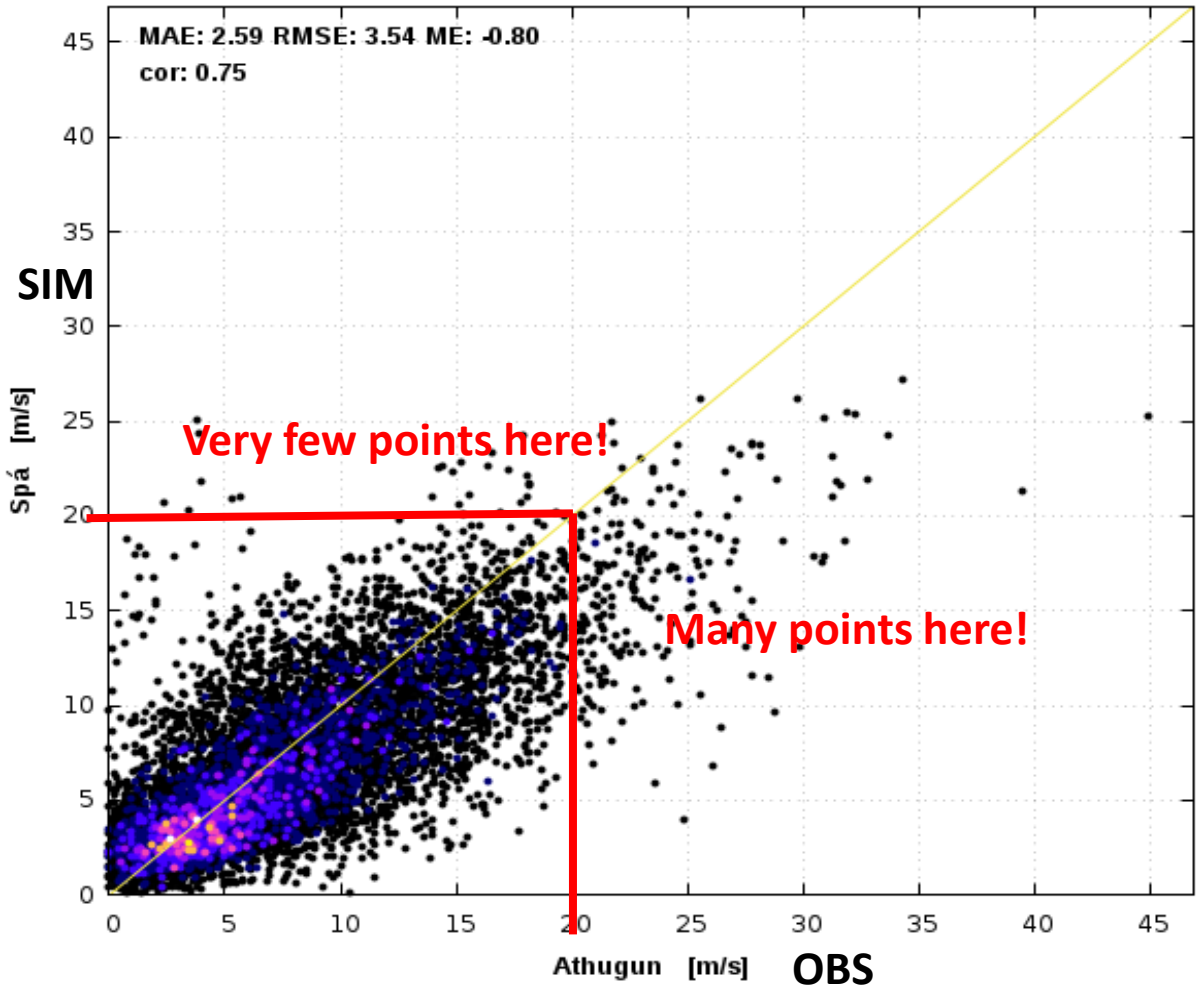
Usually stable, except if the wind is from the sea (NW)



Wind speed (m/s)

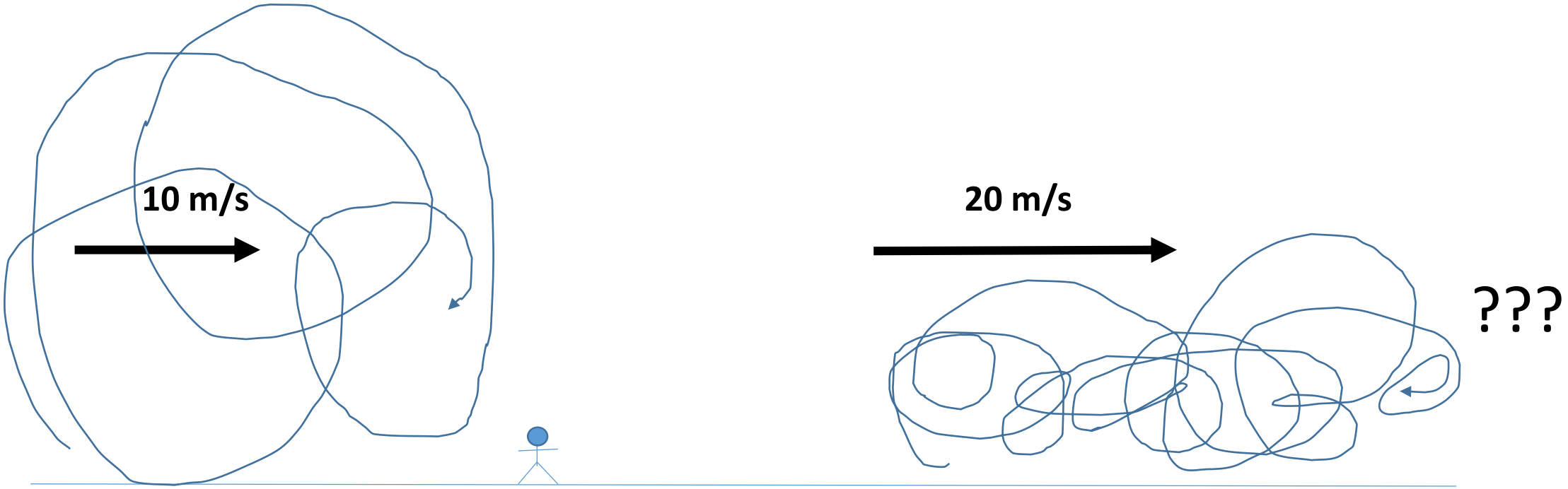

Average momentum flux according to windspeed for all temperatures combined
for wind direction between 90 and 180
Gufuskalar – winter
Range_T
all temperatures combined
Average momentum flux [kg/m/s²]
0
−1
−2
−3
−4
Windspeed [m/s]
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Mean momentum flux in winds from the SE in the winter (kg/m/s²)
Constant momentum flux!
Zo = 5 cm (high compared to other wind directions)
10
15
20
Wind speed (m/s)

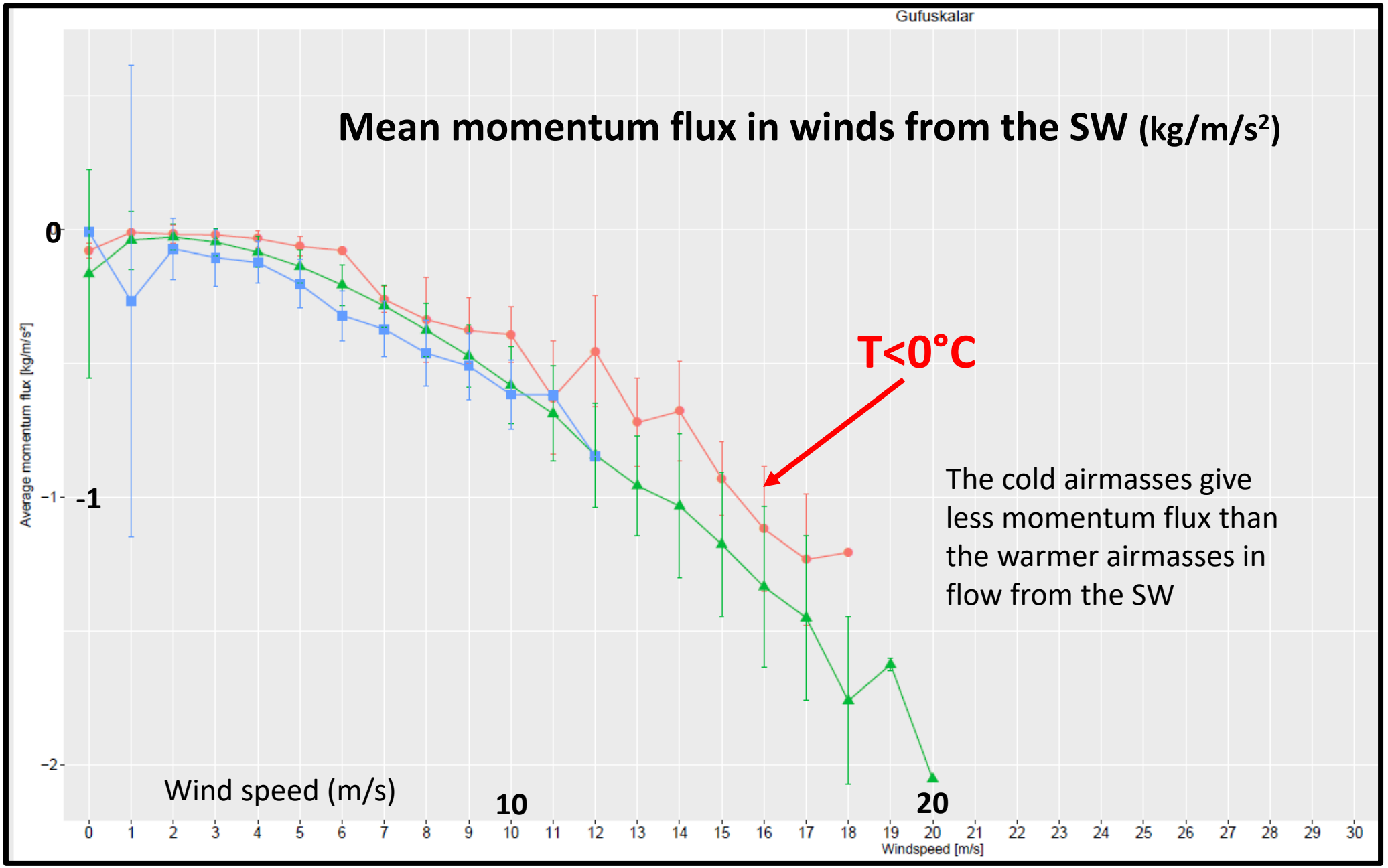
Observed and simulated winds



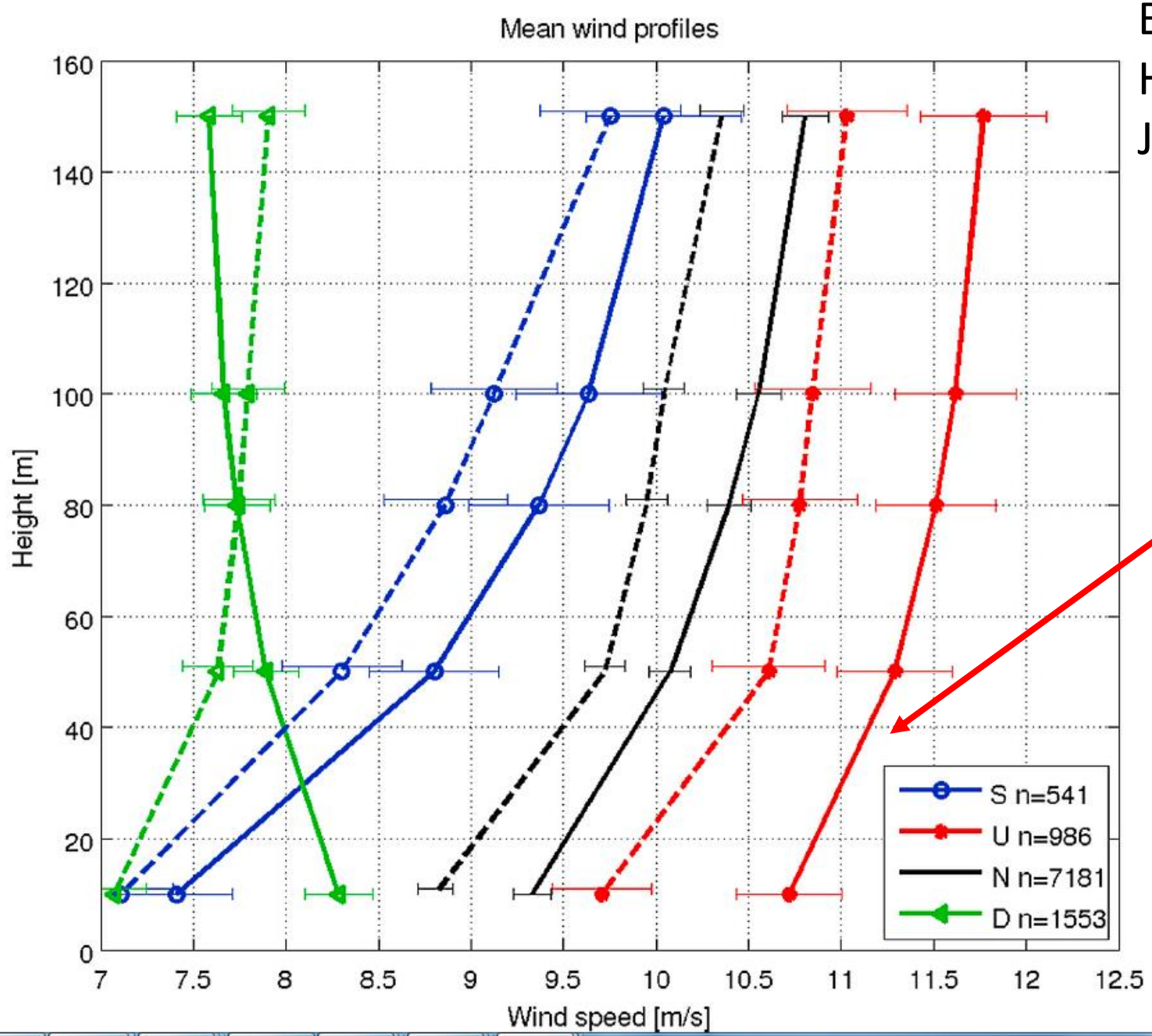
Underestimation of strong surface winds is a known problem in numerical simulations

What happens for winds > 17 m/s?




Gufuskalar
Mean momentum flux in winds from the SW (kg/m/s²)
T<0°C
The cold airmasses give less momentum flux than the warmer airmasses in flow from the SW
Average momentum flux [kg/m/s²]
0
-1
-2
Wind speed (m/s)
10
20
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Windspeed [m/s]


Cold and unstable flow from the SW

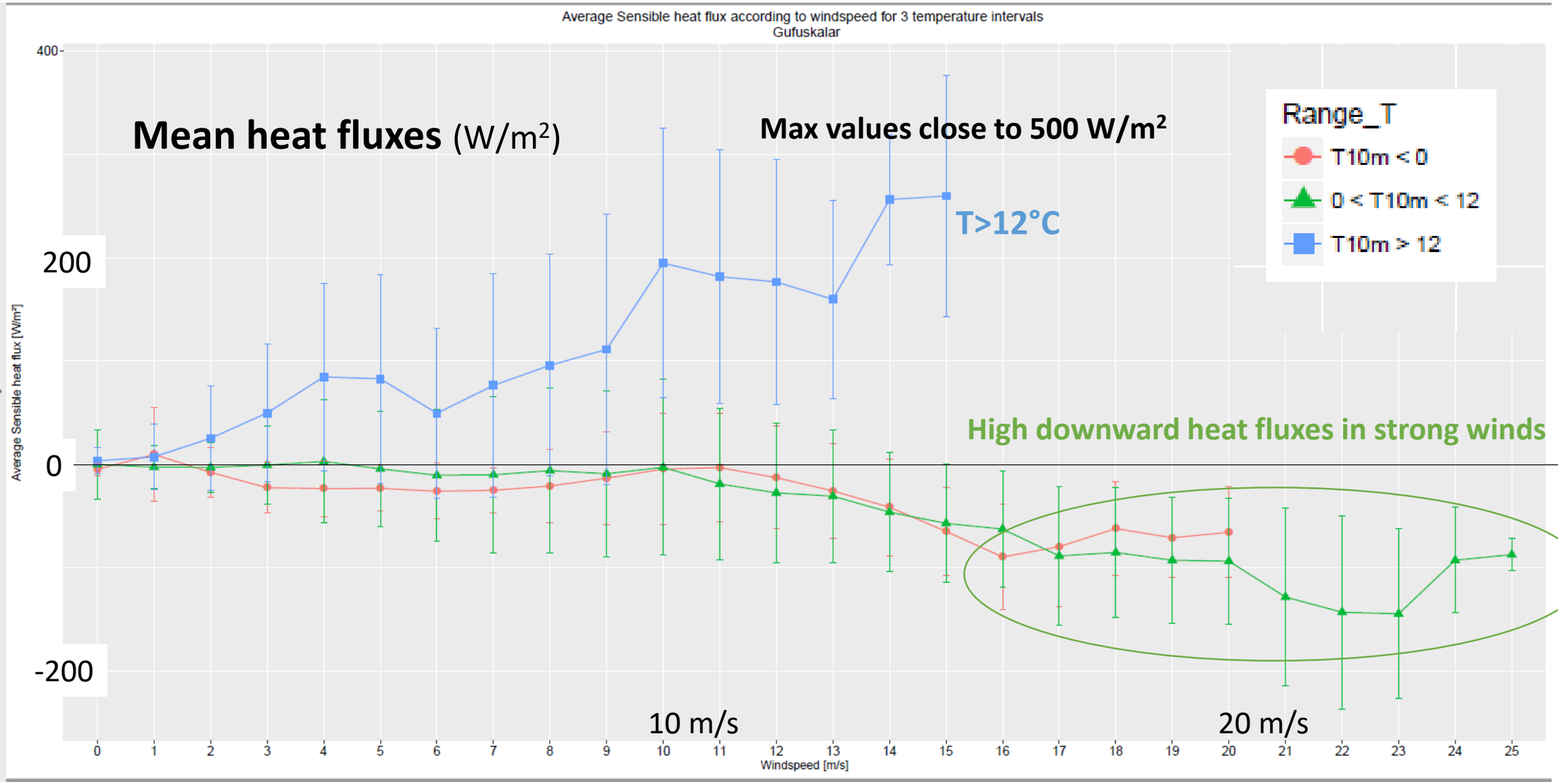


Birgitte Furevik and Hilde Haakenstad
JGR, 2012

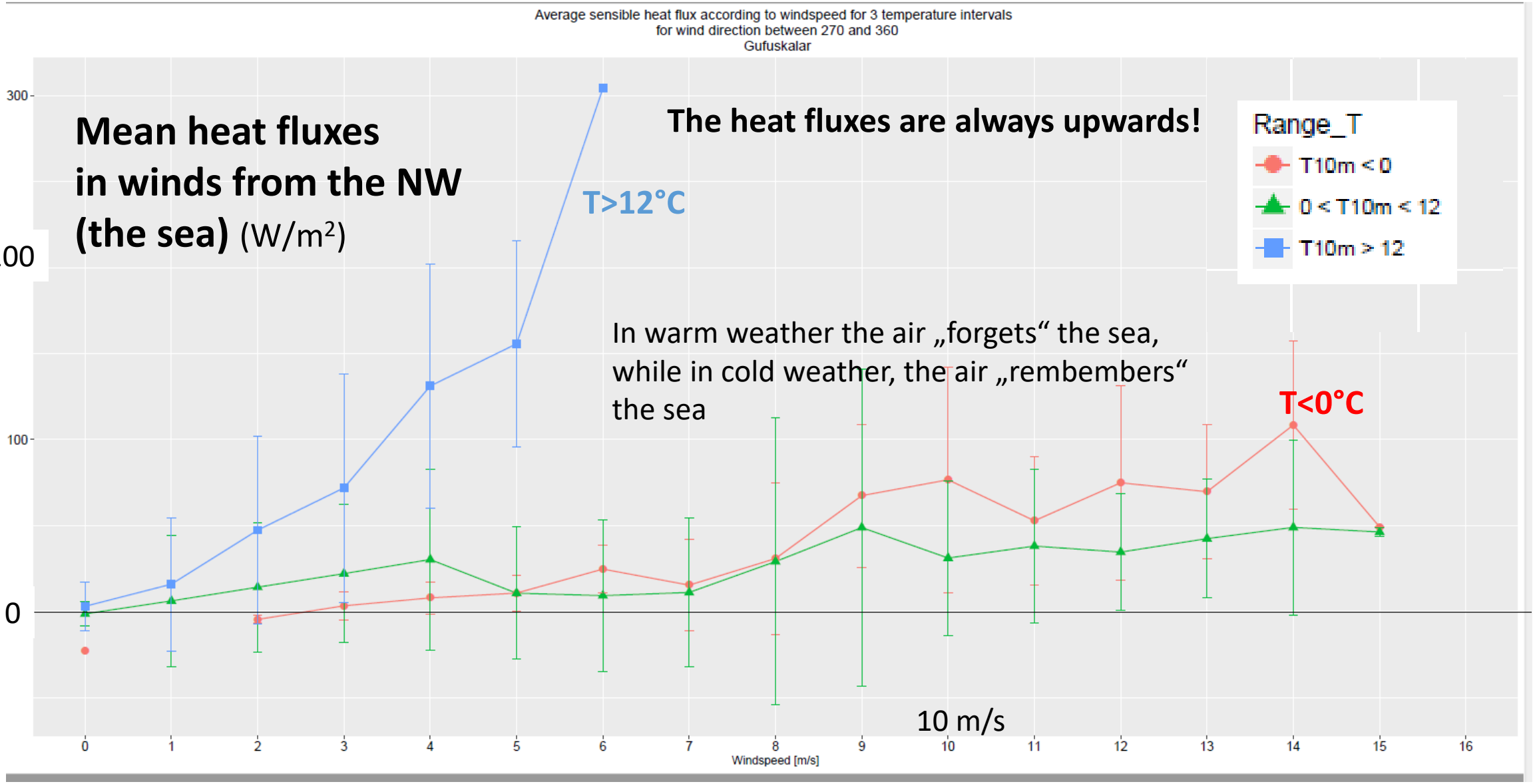
Radiosondes & simulations

Unstable airmasses have low mean vertical windshear

u´ is low – even great mixing does not lead to great vertical transport of horizontal momentum


Average Sensible heat flux according to windspeed for 3 temperature intervals
Gufuskalar
Mean heat fluxes (W/m²)
Max values close to 500 W/m²
T>12°C
High downward heat fluxes in strong winds
Range_T
T10m < 0
0 < T10m < 12
T10m > 12
Average Sensible heat flux [W/m²]
400
200
0
-200
10 m/s
20 m/s
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Windspeed [m/s]

Wind speed


Average sensible heat flux according to windspeed for 3 temperature intervals
for wind direction between 270 and 360
Gufuskalar
Mean heat fluxes
in winds from the NW
(the sea) (W/m2)
The heat fluxes are always upwards!
T>12°C
In warm weather the air „forgets“ the sea,
while in cold weather, the air „rembembers“
the sea
T<0°C
10 m/s
Range_T
T10m < 0
0 < T10m < 12
T10m > 12
300
200
100
0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Windspeed [m/s]

Wind speed

Some highlights and next steps

- Heat fluxes:
  - High maximum values
  - High values in warm weather, even in winds blowing from the sea for only a few hundreds of metres
  - The cold air „remembers“ the sea better than warm air
  - High downward mean fluxes for strong winds
- Momentum fluxes:
  - Very little increase in mean fluxes for winds above 17 m/s
  - Relatively low momentum flux in unstable airmasses
- Next steps:
  - Observing at several levels, up to 400 metres – building a unique dataset of the ABL