Observations and modelling of drifting snow occurrences in coastal East Antarctica

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AGU Fall meeting - December 2017

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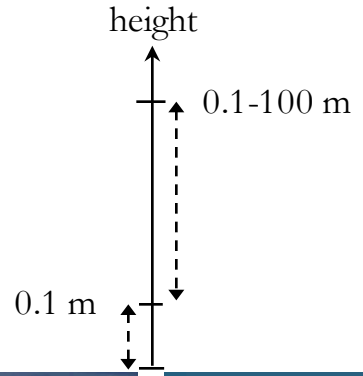
Aeolian transport modes



Saltation

Video. Real-time movie showing saltation of snow near Dumont d'Urville, Adélie Land, January 26th 2013.

Suspension

Video. Time lapse showing suspension of snow during a snow storm near Dumont d'Urville, Adélie Land, April 18th 2013.

Methods

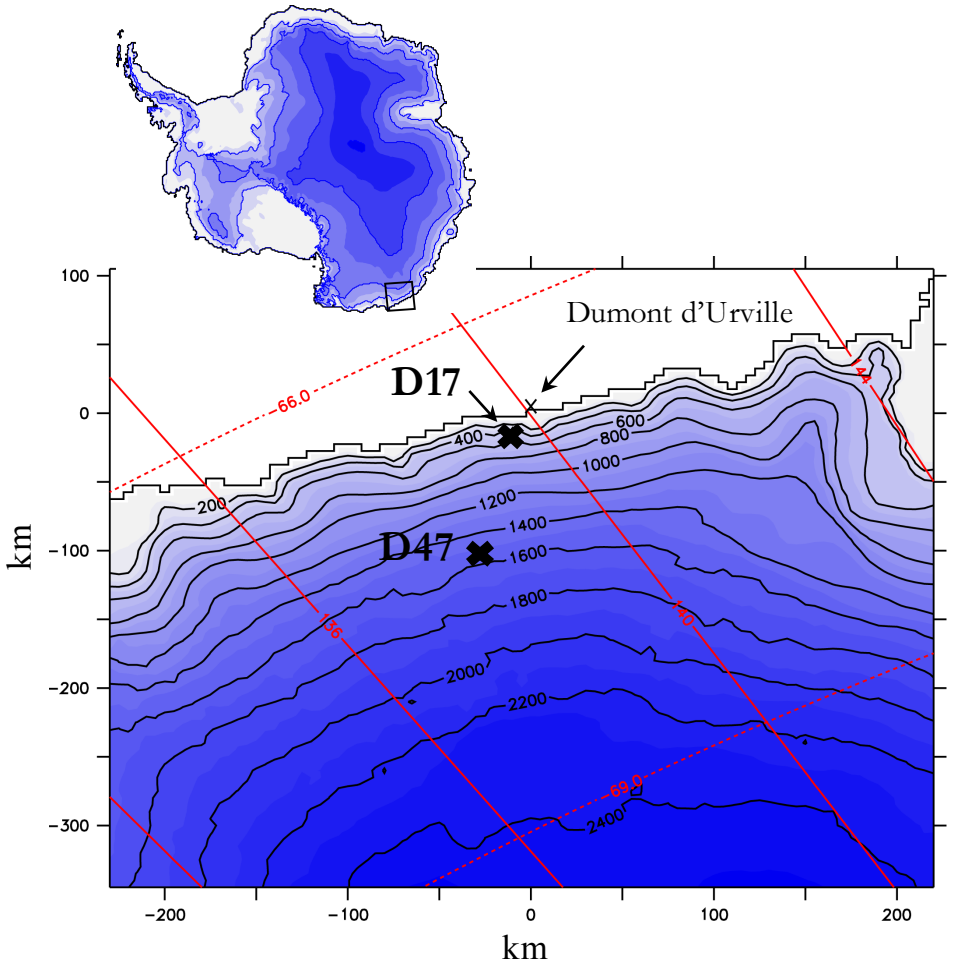
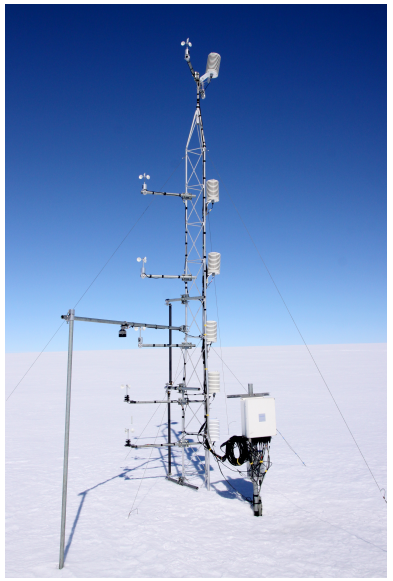
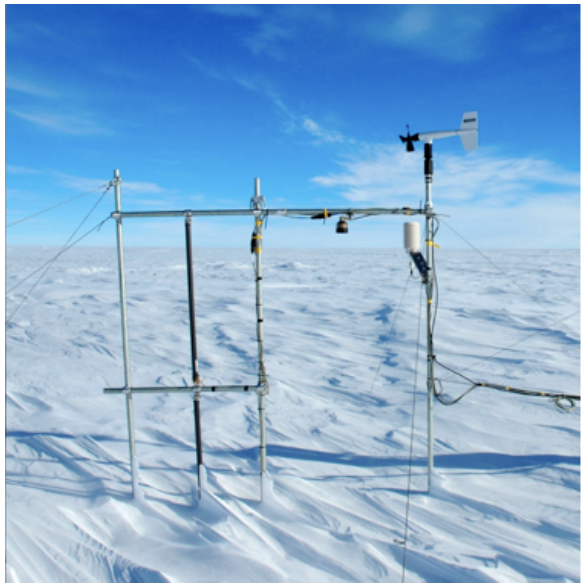


Fig. Topographic map of coastal Adélie Land.

D17 (2010-2016)



D47 (2010-2012)



Model MARv3.8

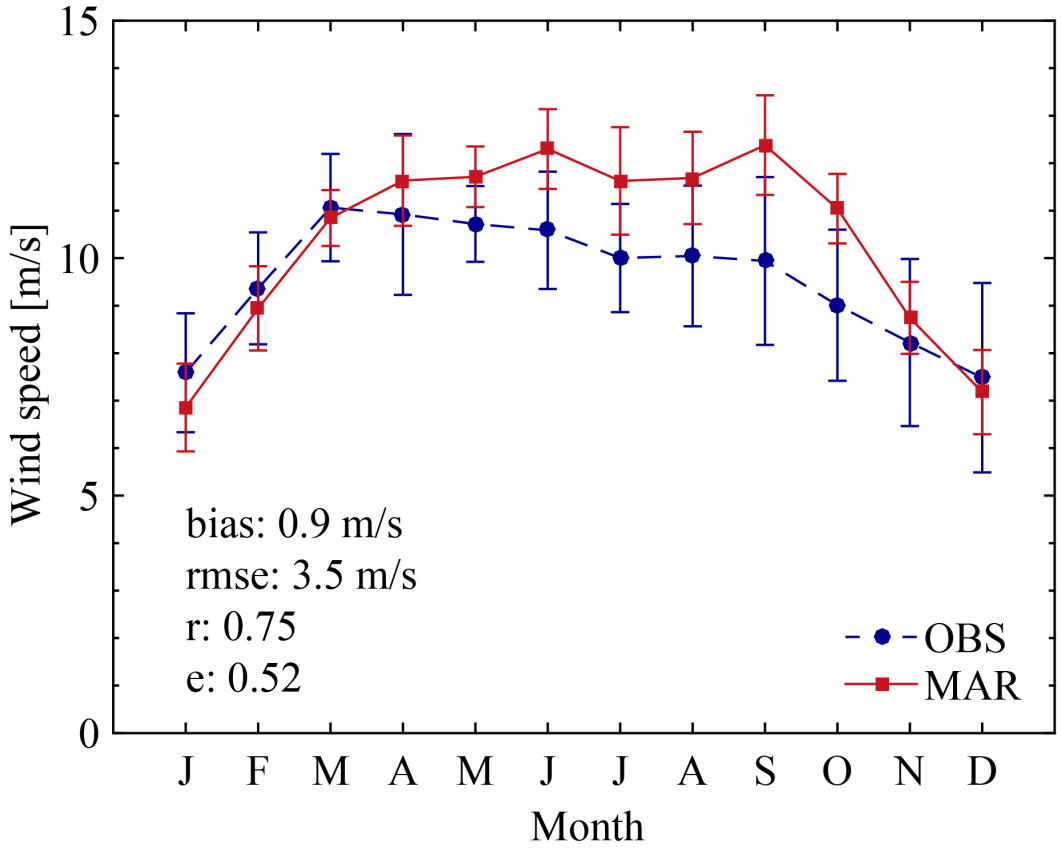
Specificities Developed for polar regions:

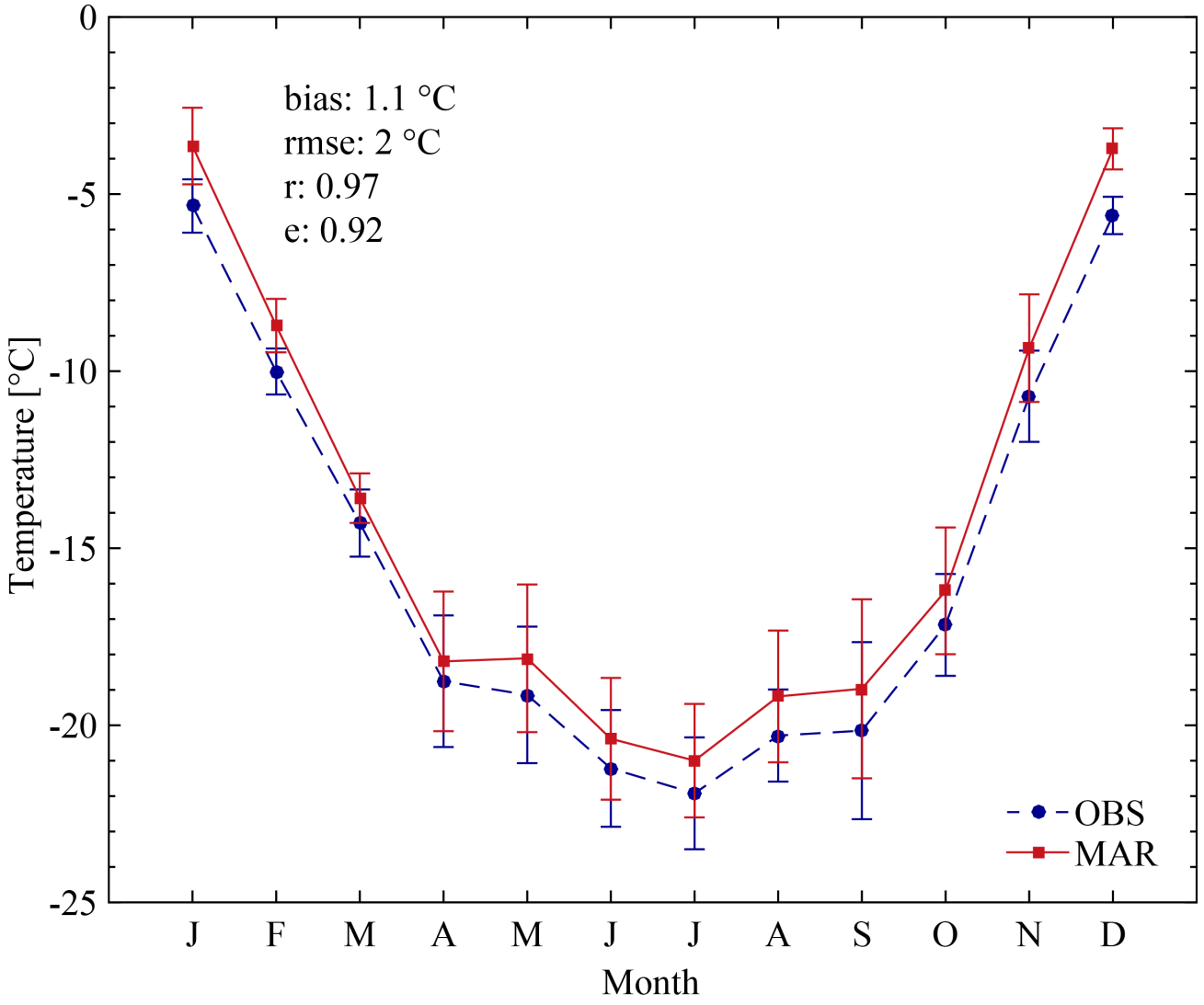
- Drifting snow routine
- Interactive snowpack model
- Stable boundary layer physics

Resolution 10 km (z_{min} = 1 m)

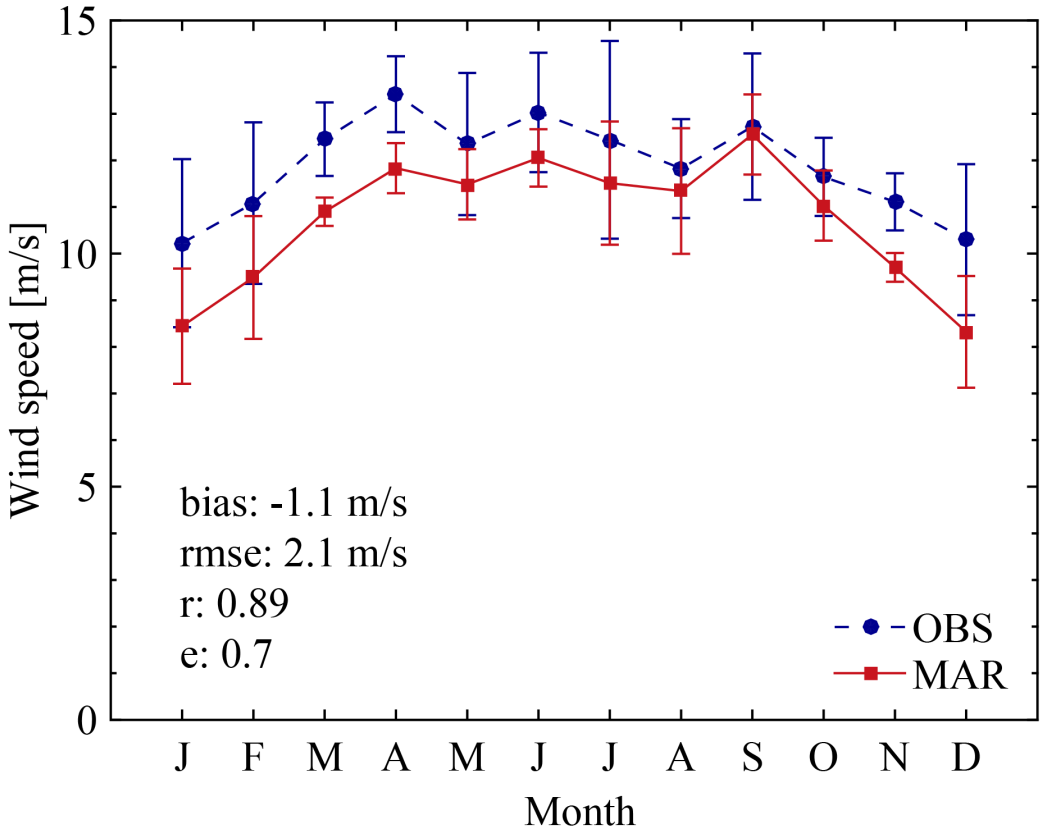
Forcing Era-Interim

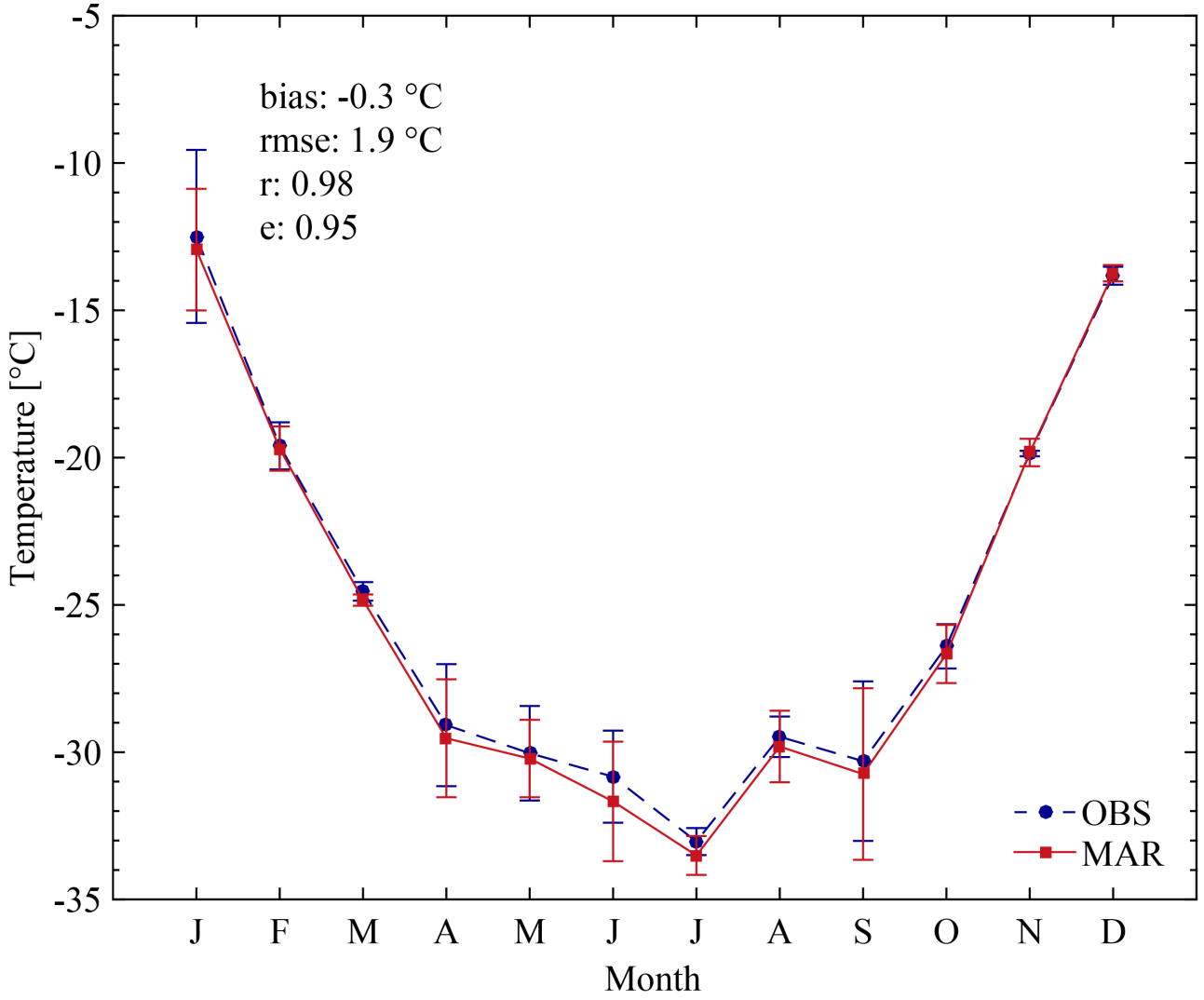
Near-surface climate (D17)



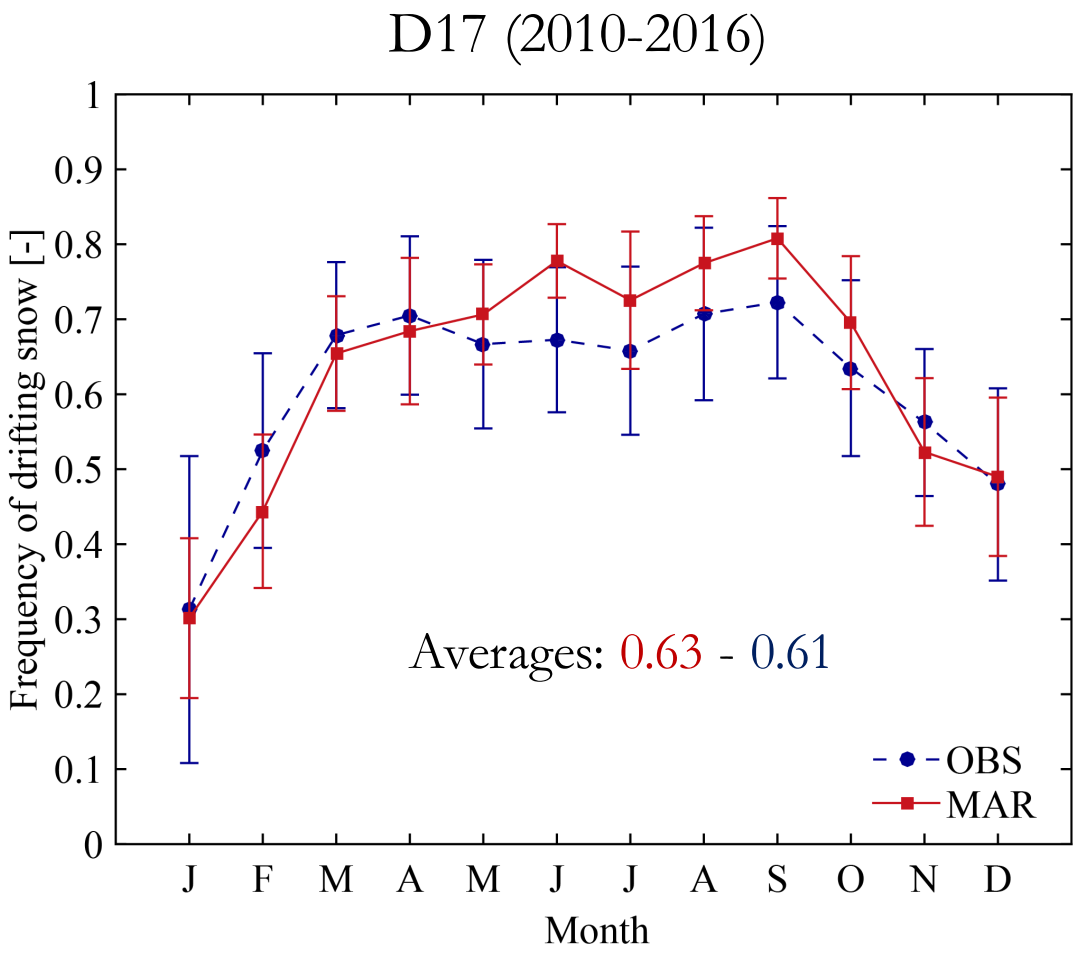


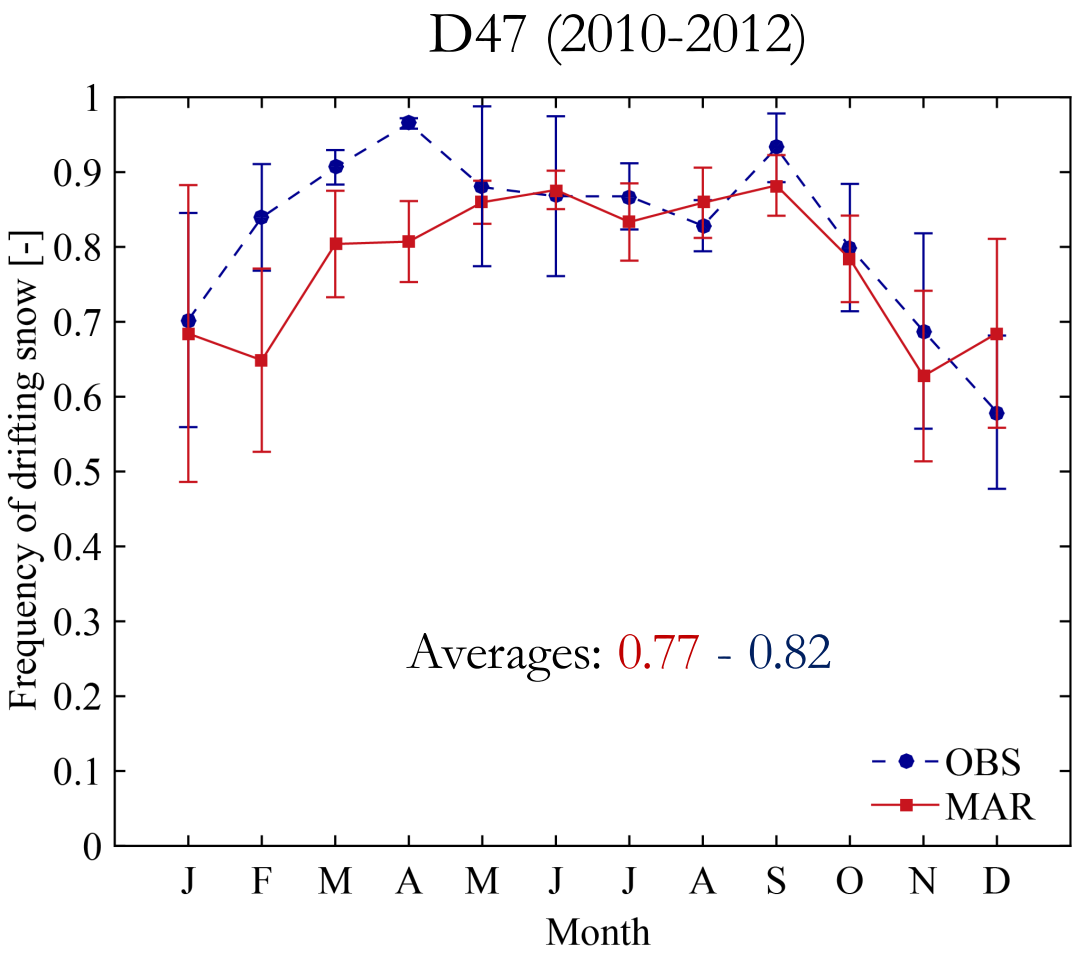
Near-surface climate (D47)





Intra-annual variability of DSF





- Detection threshold set to 10^{-3} kg/m^2/s
- Low inter-annual variability (not shown) but a strong seasonal cycle

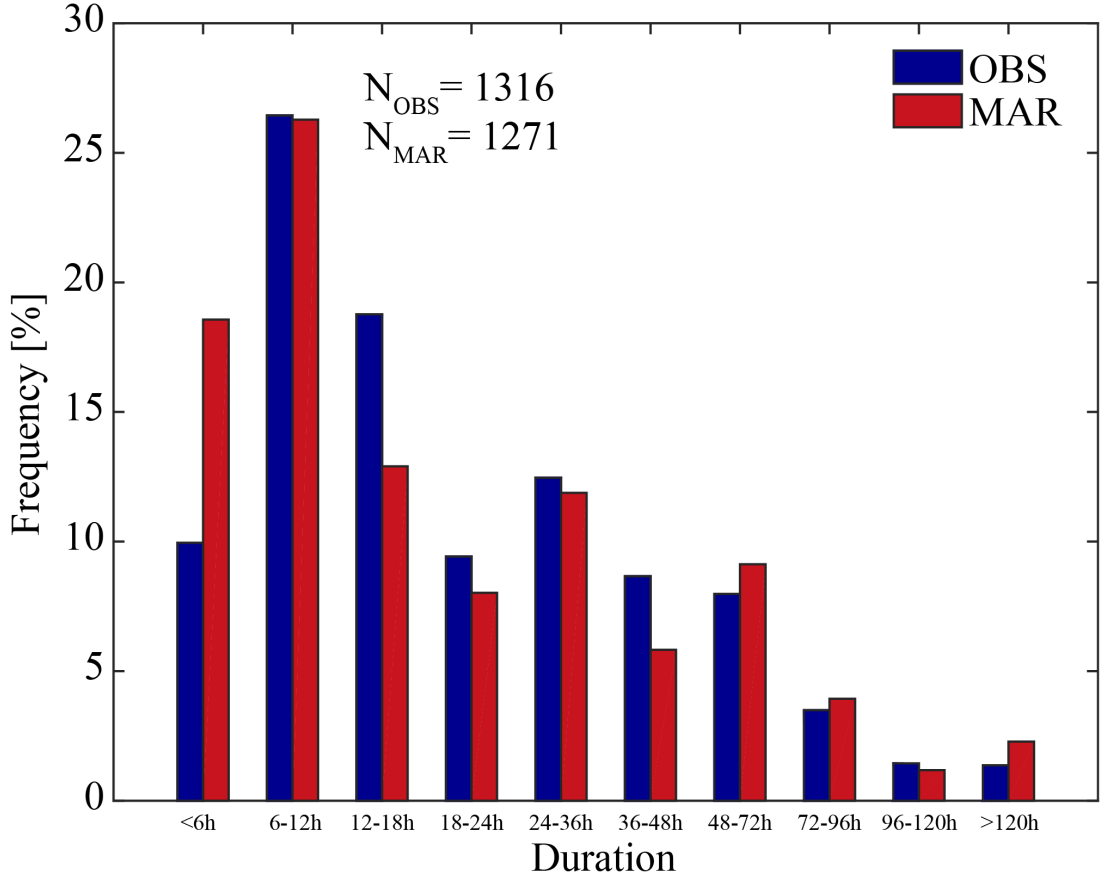
Duration of drifting snow events

➢ Minimum duration set to 4 hours

D17 (2010-2016)

Mean duration: 26 h (OBS&MAR)

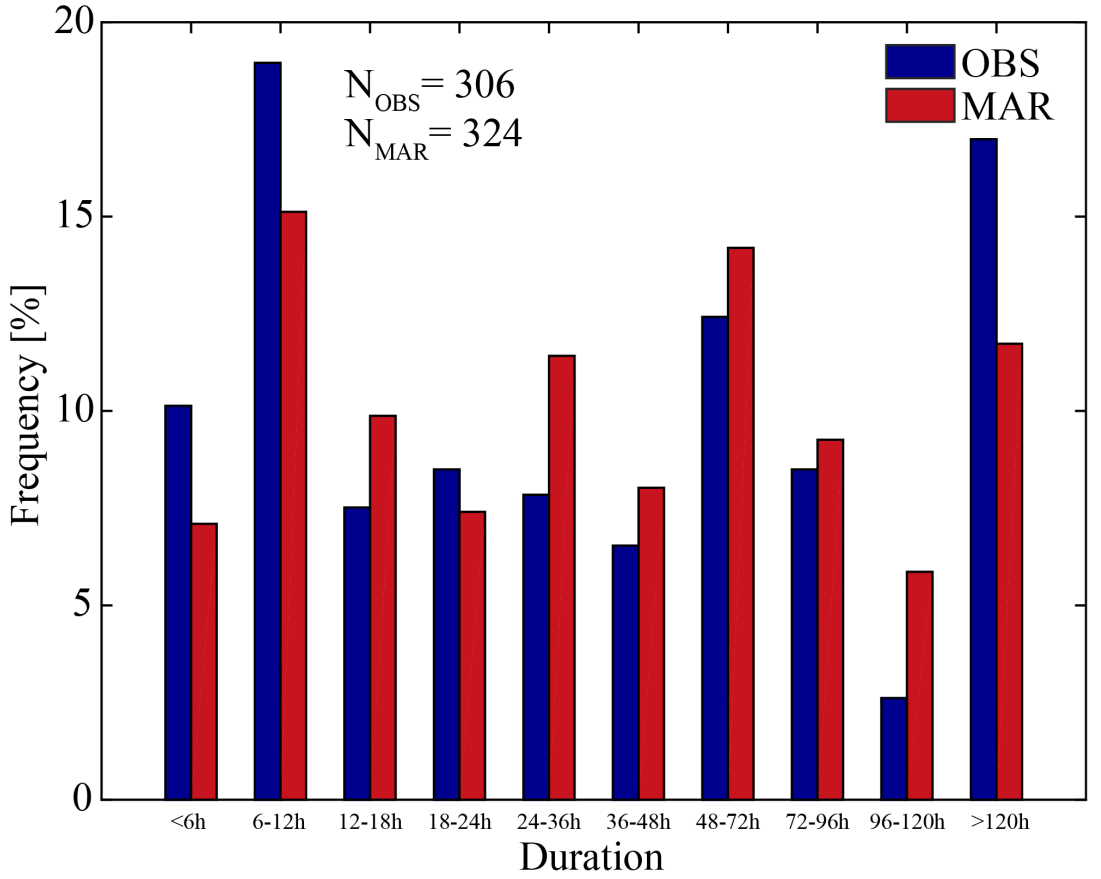
Max. duration: 10 days (OBS&MAR)



D47 (2010-2012)

Mean duration: 67 h (OBS) / 56 h (MAR)

Max. duration: 26 days (OBS) / 17 days (MAR)



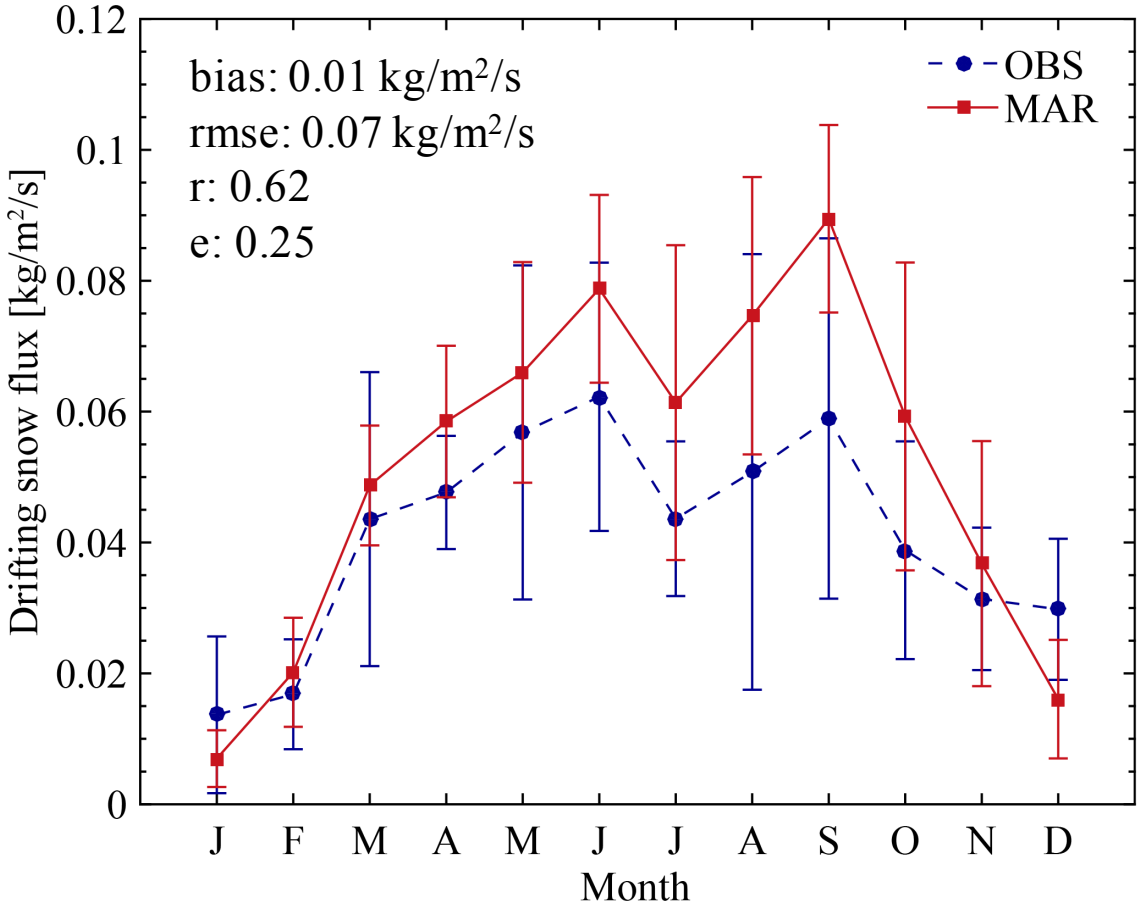
Comparison of occurrences (30 min)

MAR / OBS	D17		D47	
	DS	nDS	DS	nDS
DS	49.1%	12.3%	68.3%	12.6%
nDS	14.3%	24.3%	8.6%	10.5%

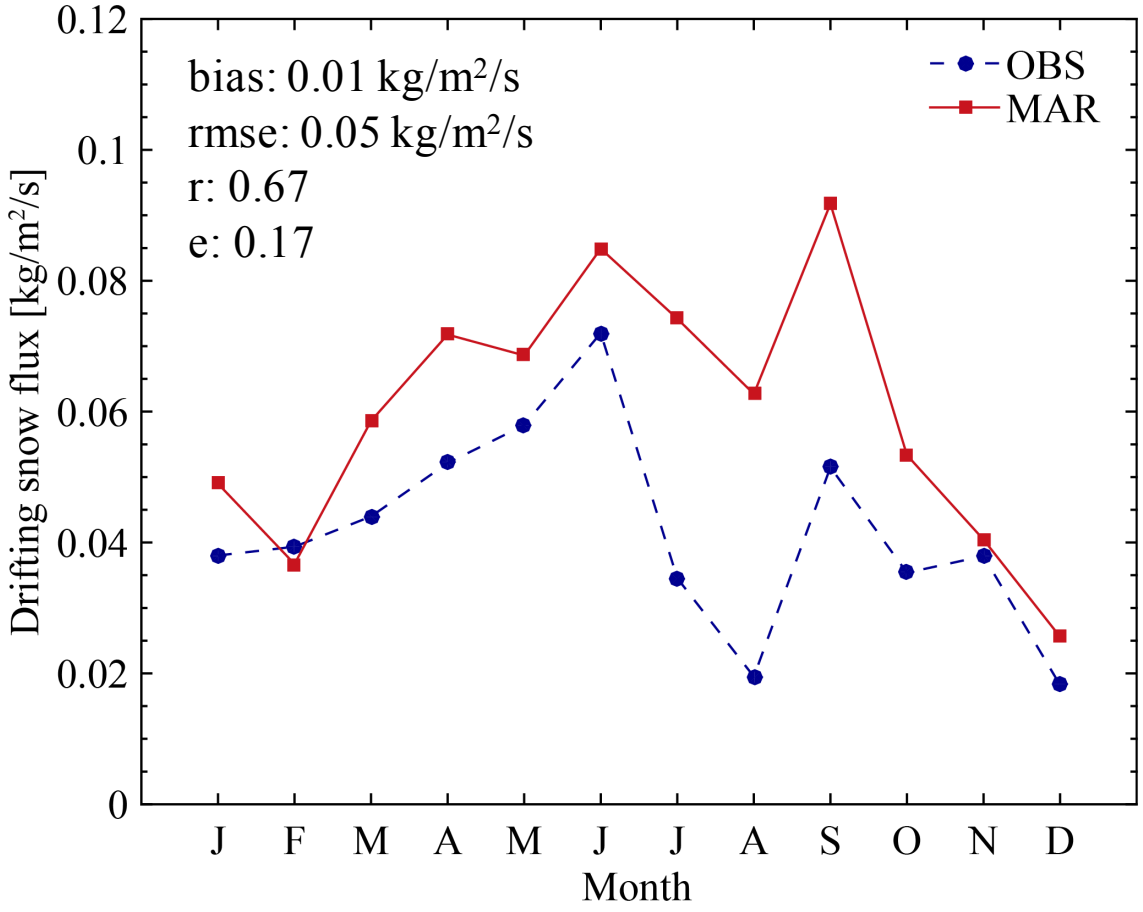
Location	POD	FAR	HSS
D17	80	22.5	0.43
D47	84.4	11.1	0.36

Snow mass flux

D17 (2010-2016)



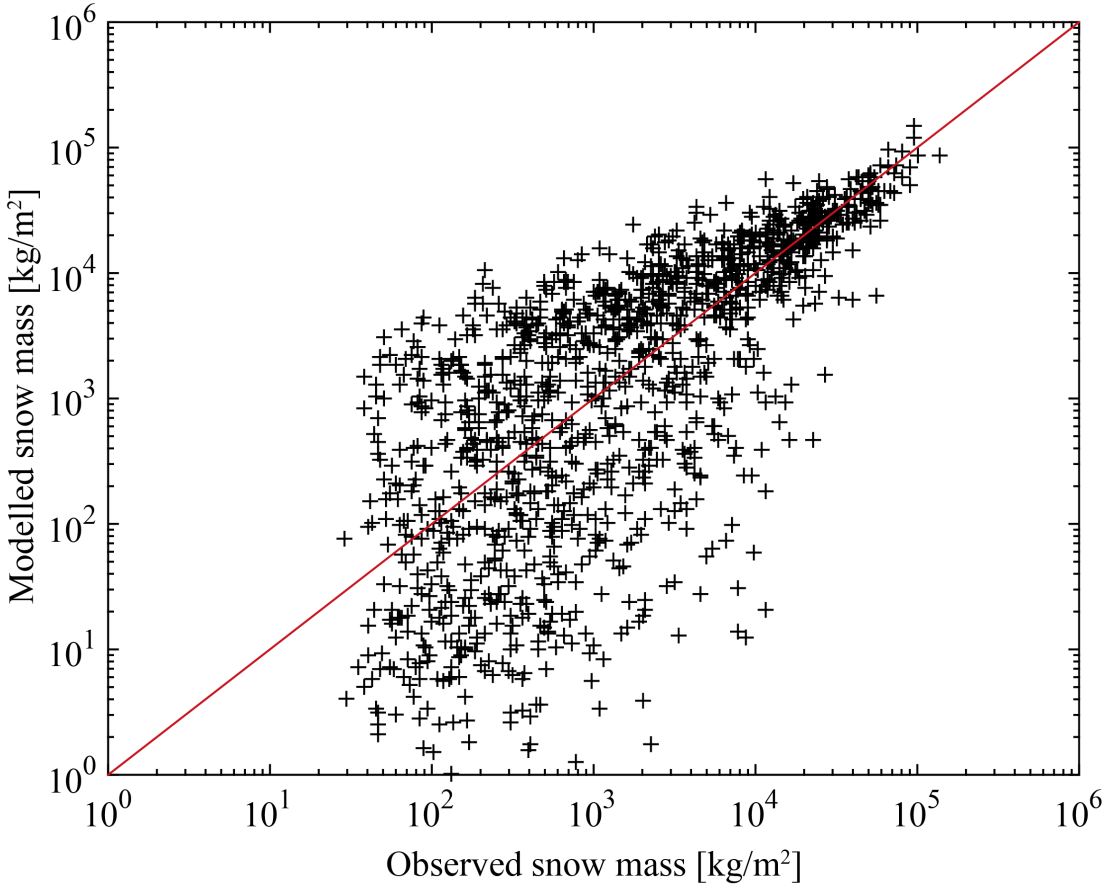
D47 (2010-2011)



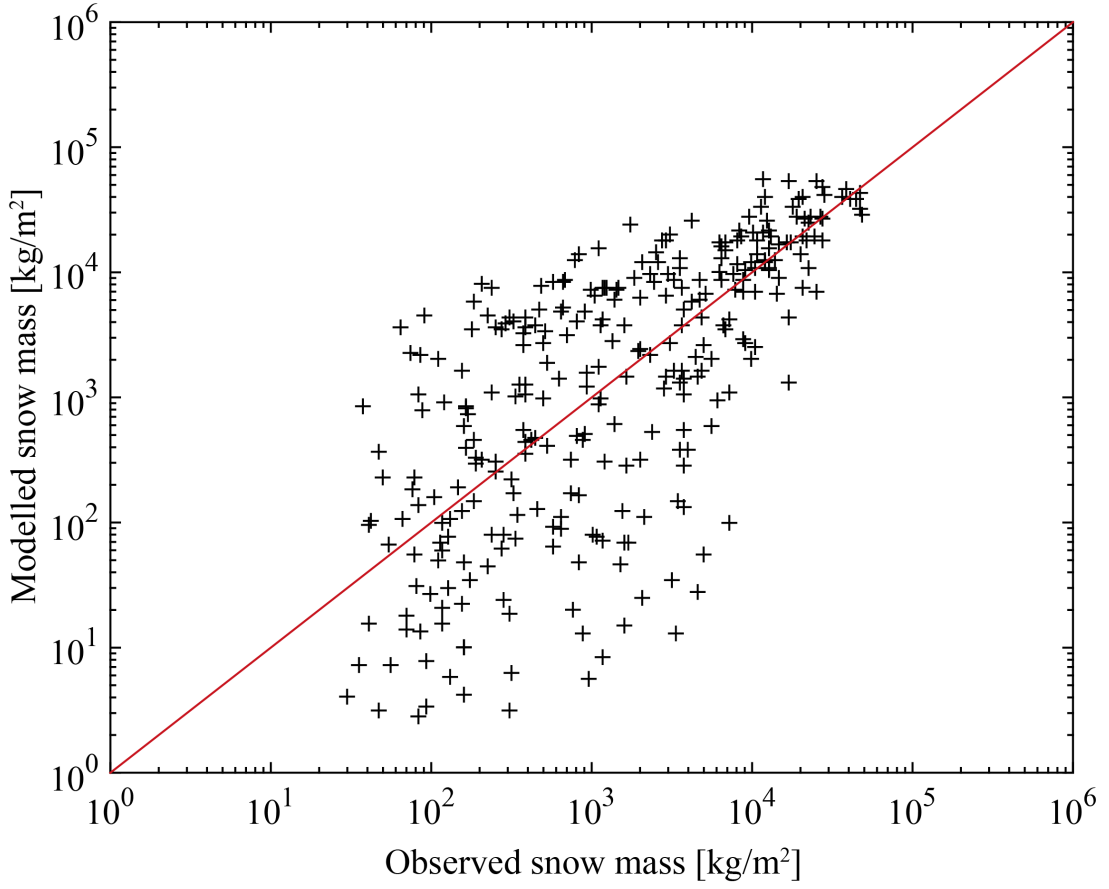
➢ Mean anomaly of 18 10^{-3} kg/m²/s (D17) and 54 10^{-3} kg/m²/s (D47)

Mass transport per event

D17 (2010-2016)



D47 (2010-2011)



➢ Overestimation by a factor of 3 on average

Total horizontal snow mass transport

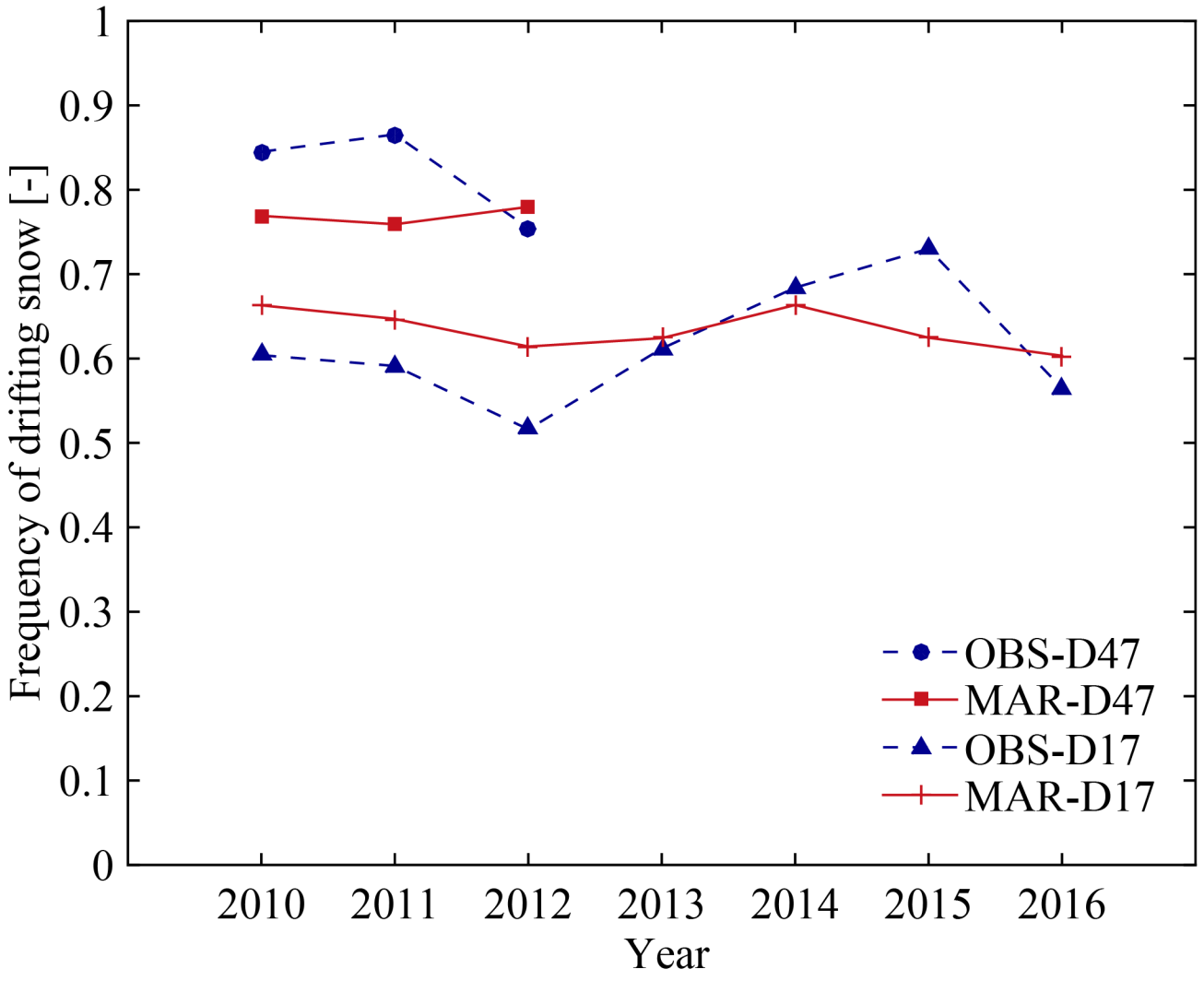
Location	D17		D47	
Period	2010-2016		2010-2011	
	OBS	MAR	OBS	MAR
Horizontal snow mass transport [kg m^{-2}]	9.05 10^6	11.34 10^6	2.61 10^6	3.75 10^6

- Total horizontal snow mass transport overestimated by ~30% at both locations
- 8% (D17) and 3% (D47) simulated during false alarms

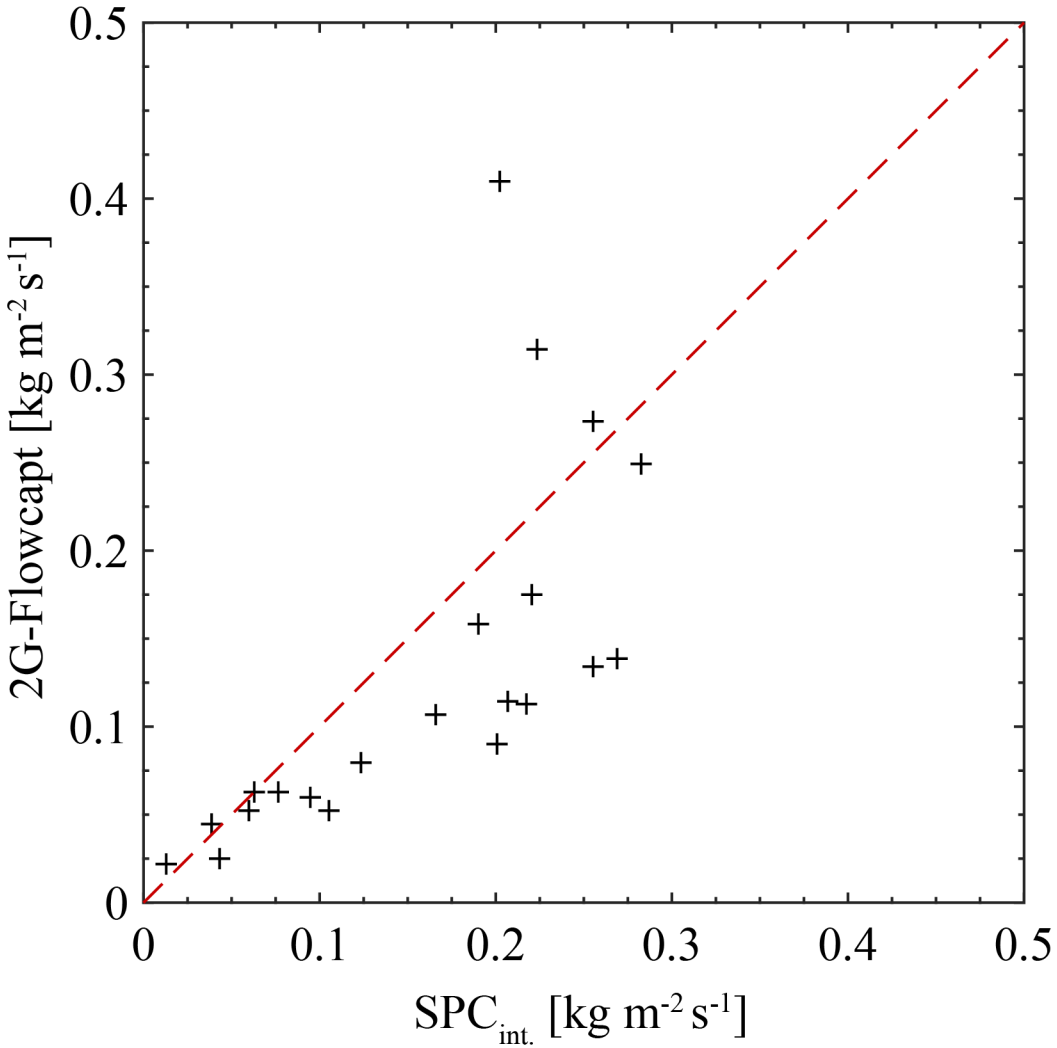
Summary

- Production of a drifting snow dataset for model evaluation
- High DFS values of 0.61 (D17) and 0.83 (D47) with a strong seasonal cycle and a low inter-annual variability
- MAR is able to reproduce realistic drifting snow characteristics and their spatial variability over long time periods
- MAR overestimates mass transport per event (x3) and total mass transport (30%) compared to underestimated OBS
- Continental-scale SMB and climate studies…?

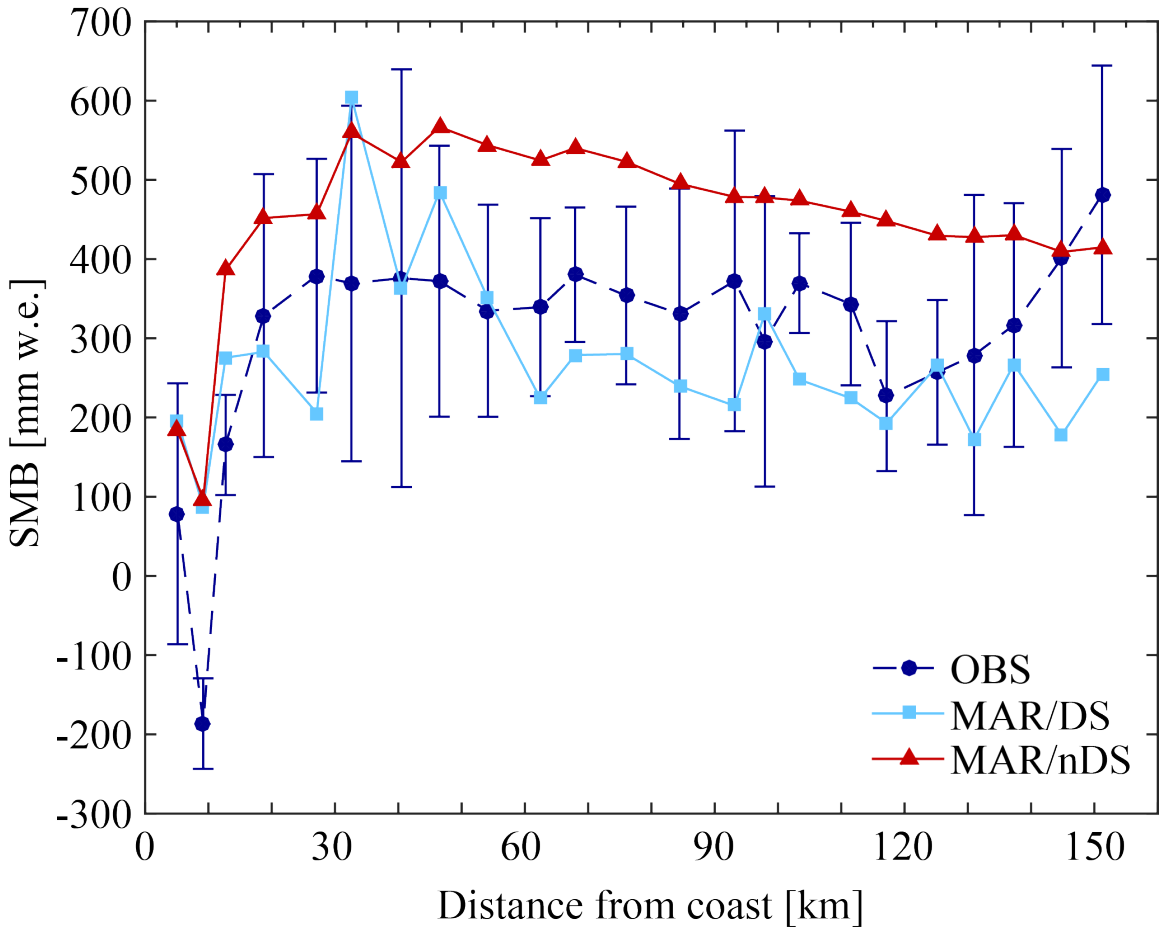
Inter-annual variability of DSF



SPC vs 2G-Flowcapt™



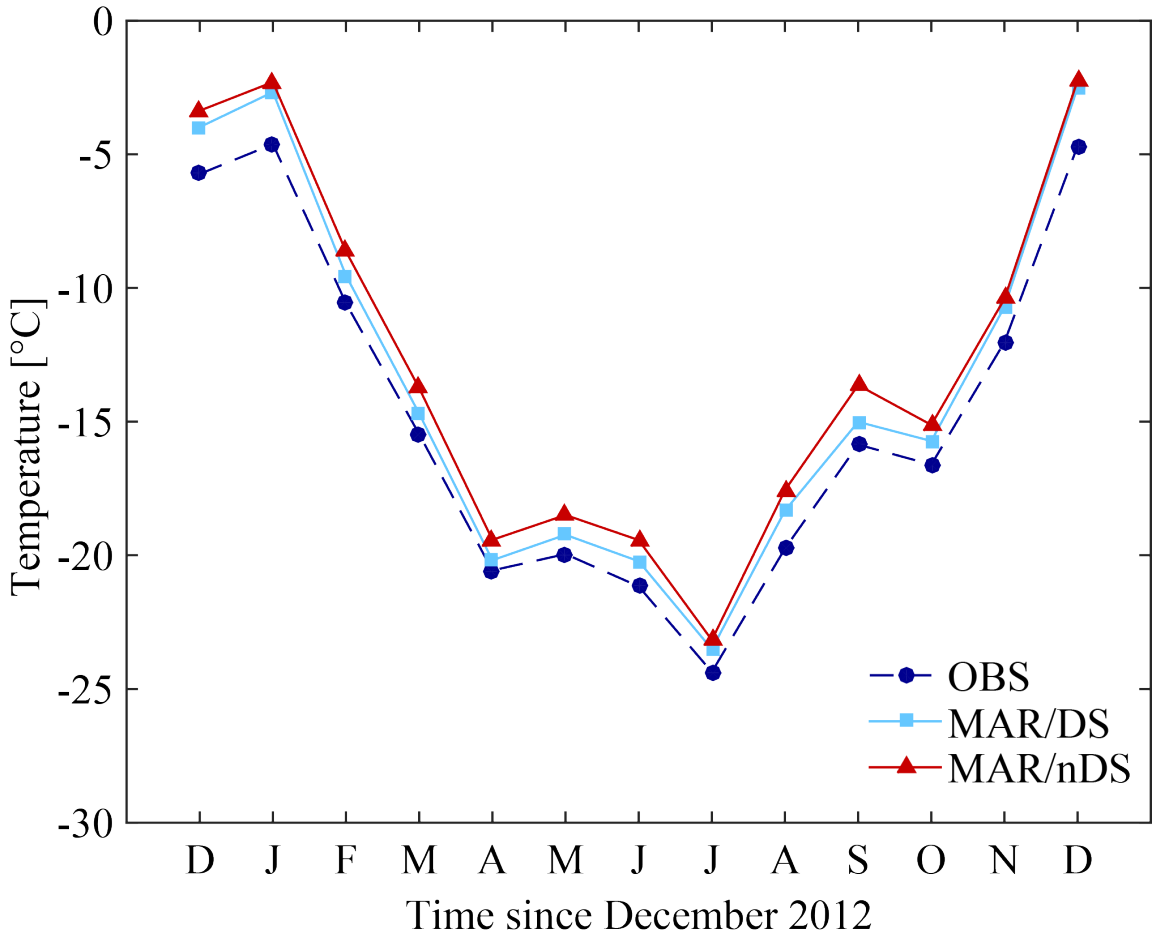
Surface mass balance

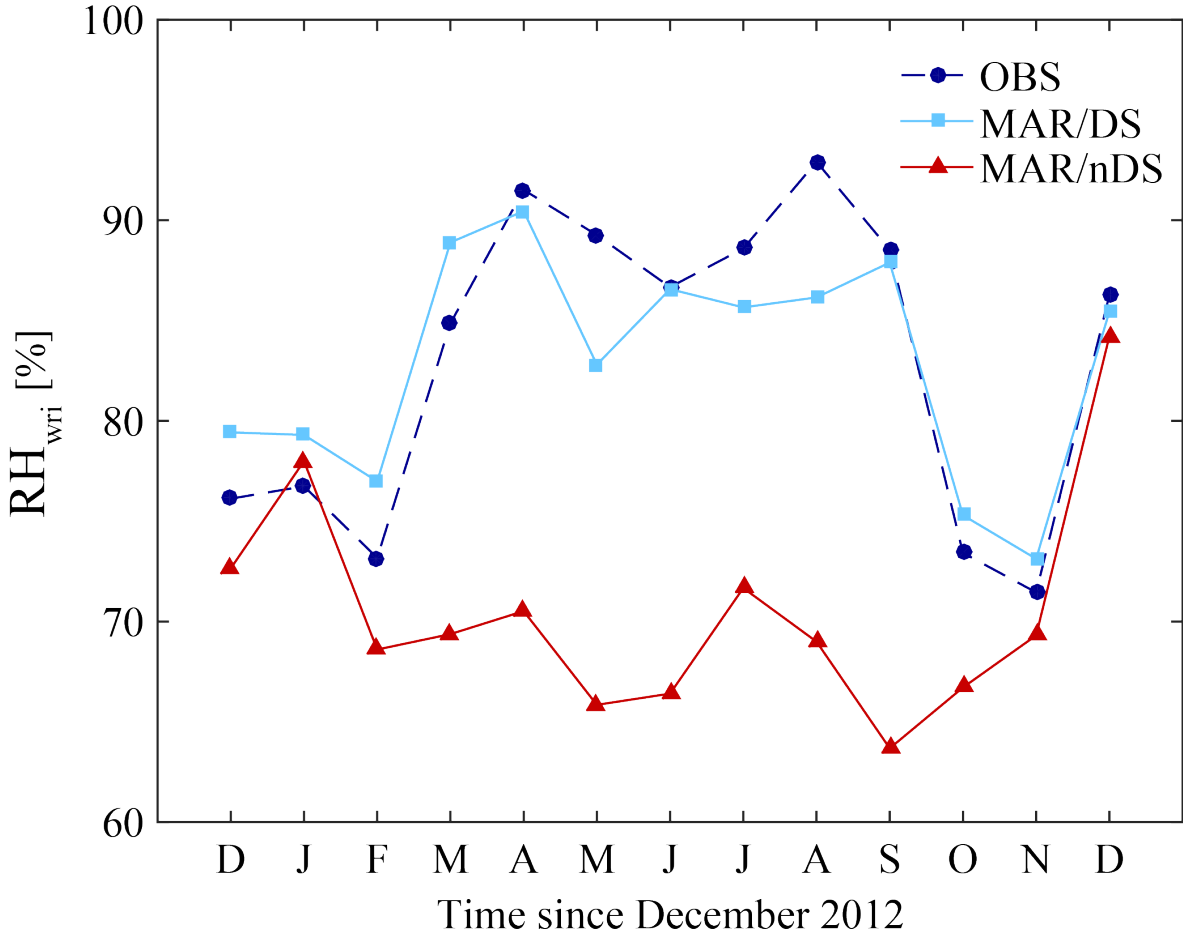


	OBS	MAR/DS	MAR/nDS
D17 Drifting snow frequency [-]	0.59	0.6	-
D17 Snow mass transport [kg m^{-2}]	1.54 10^6	1.72 10^6	-
SMB [mm w.e.]	303	270	445

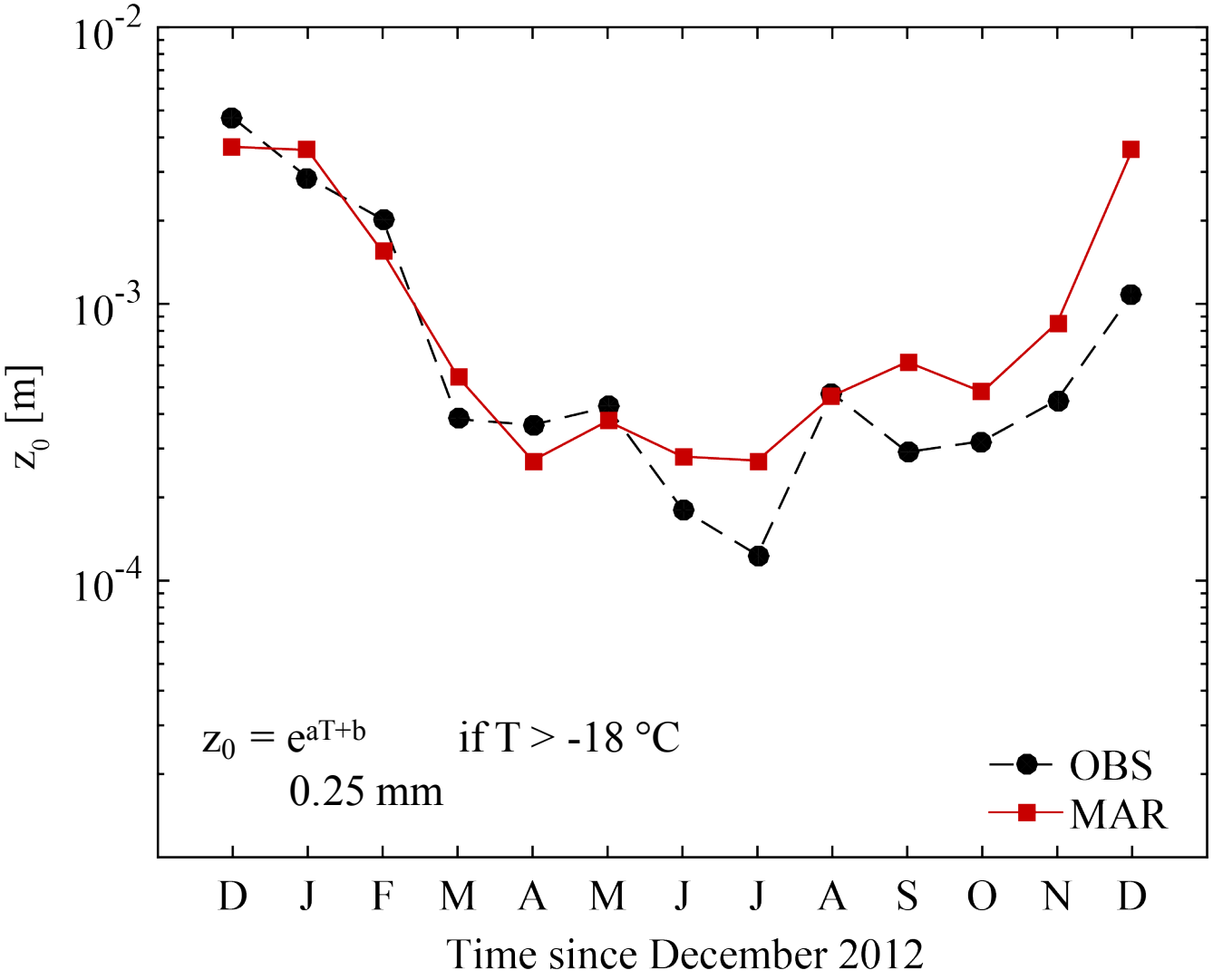
- Horizontal snow mass transport overestimated by 12%
- SMB overestimated by 50% if drifting snow is switched off
- SMB underestimated by 10% if drifting snow is switched on

Near-surface climate

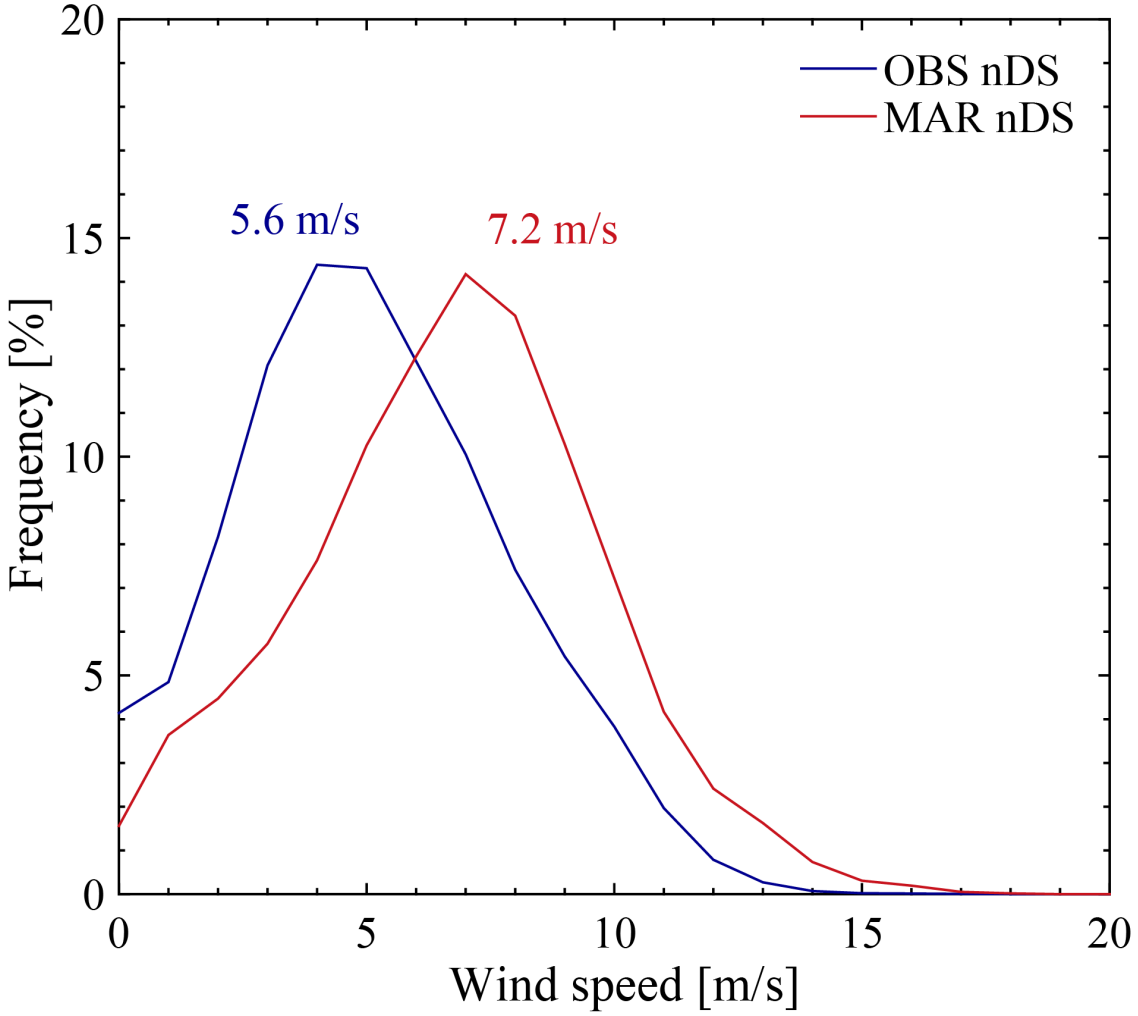


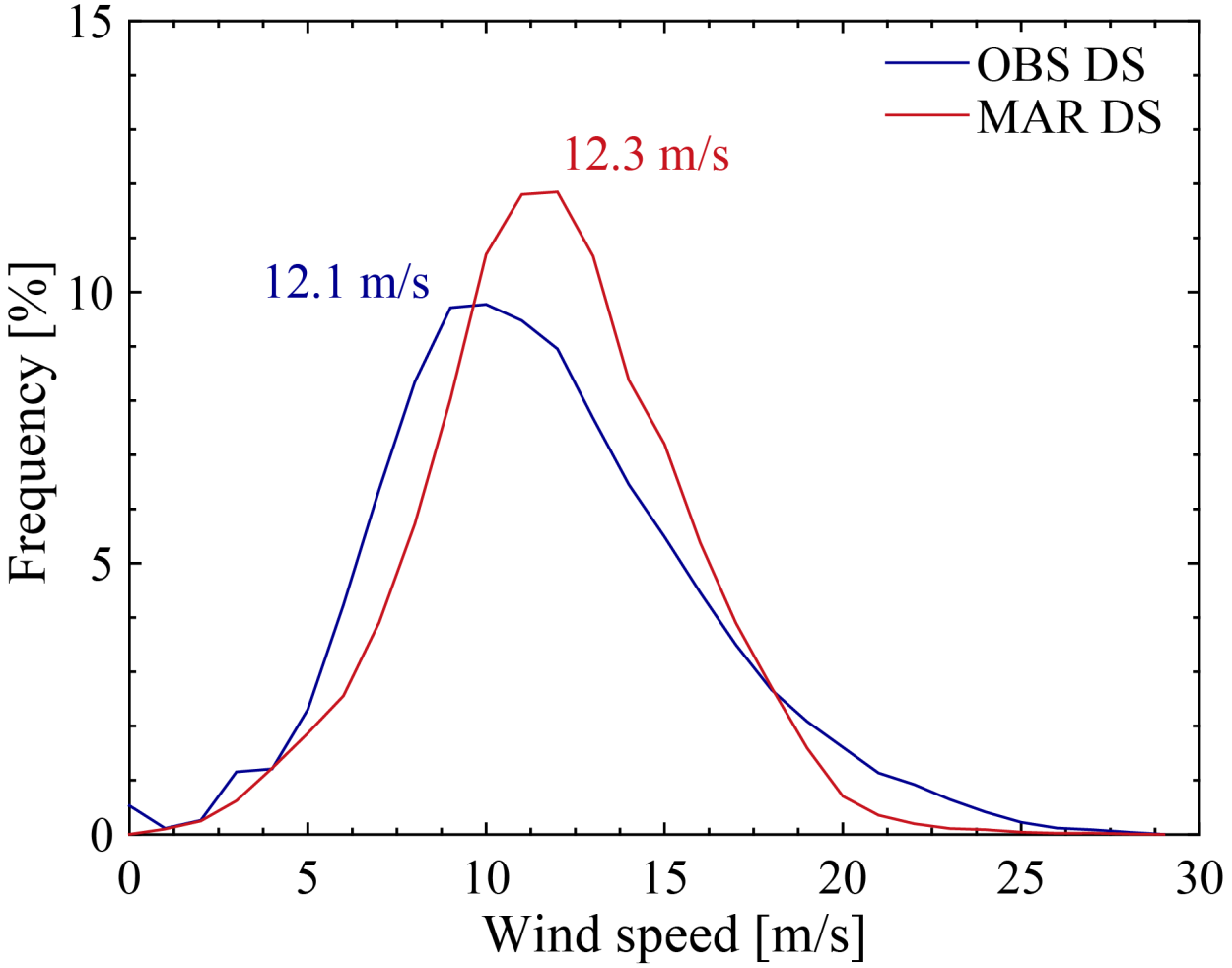


Empirical parameterization for surface roughness

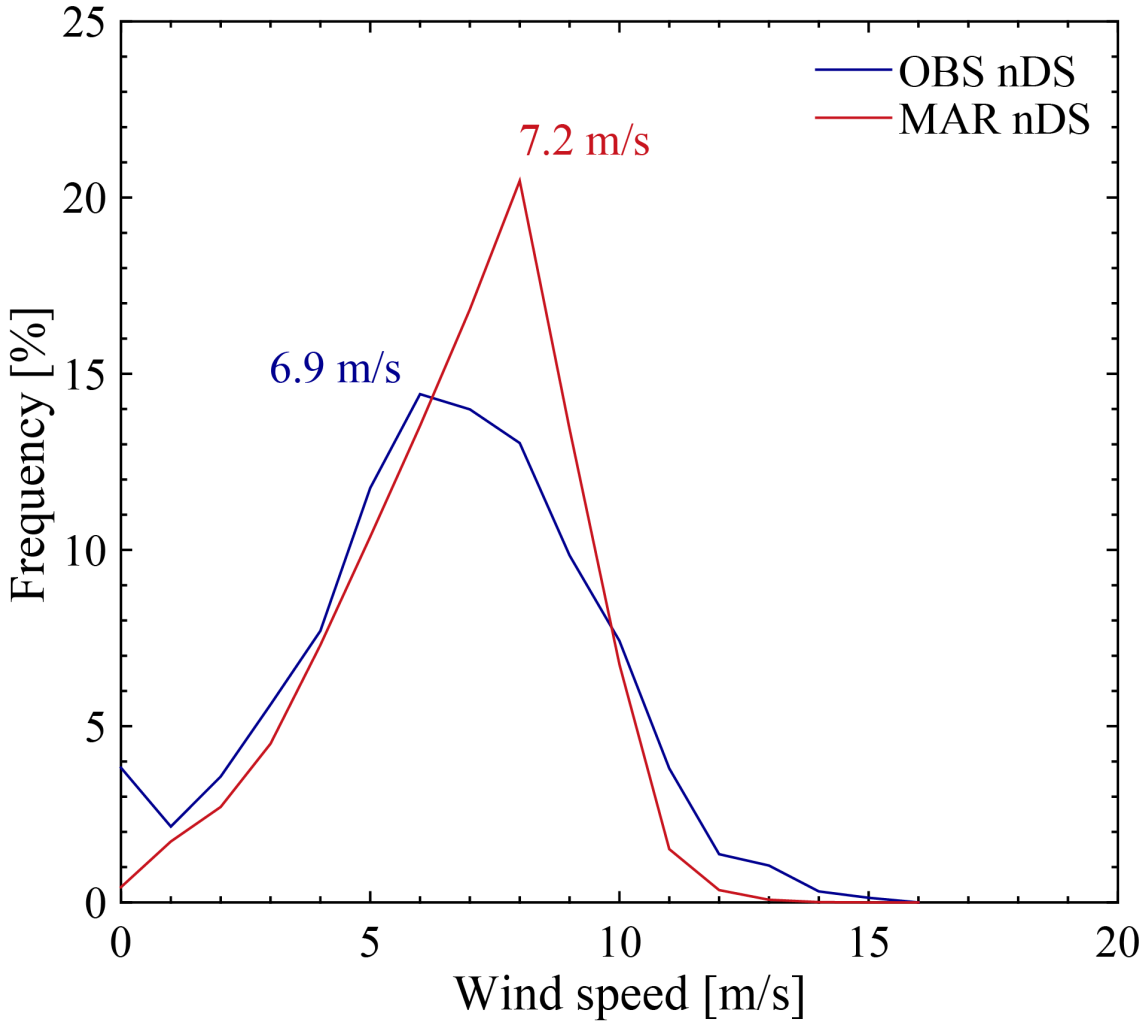


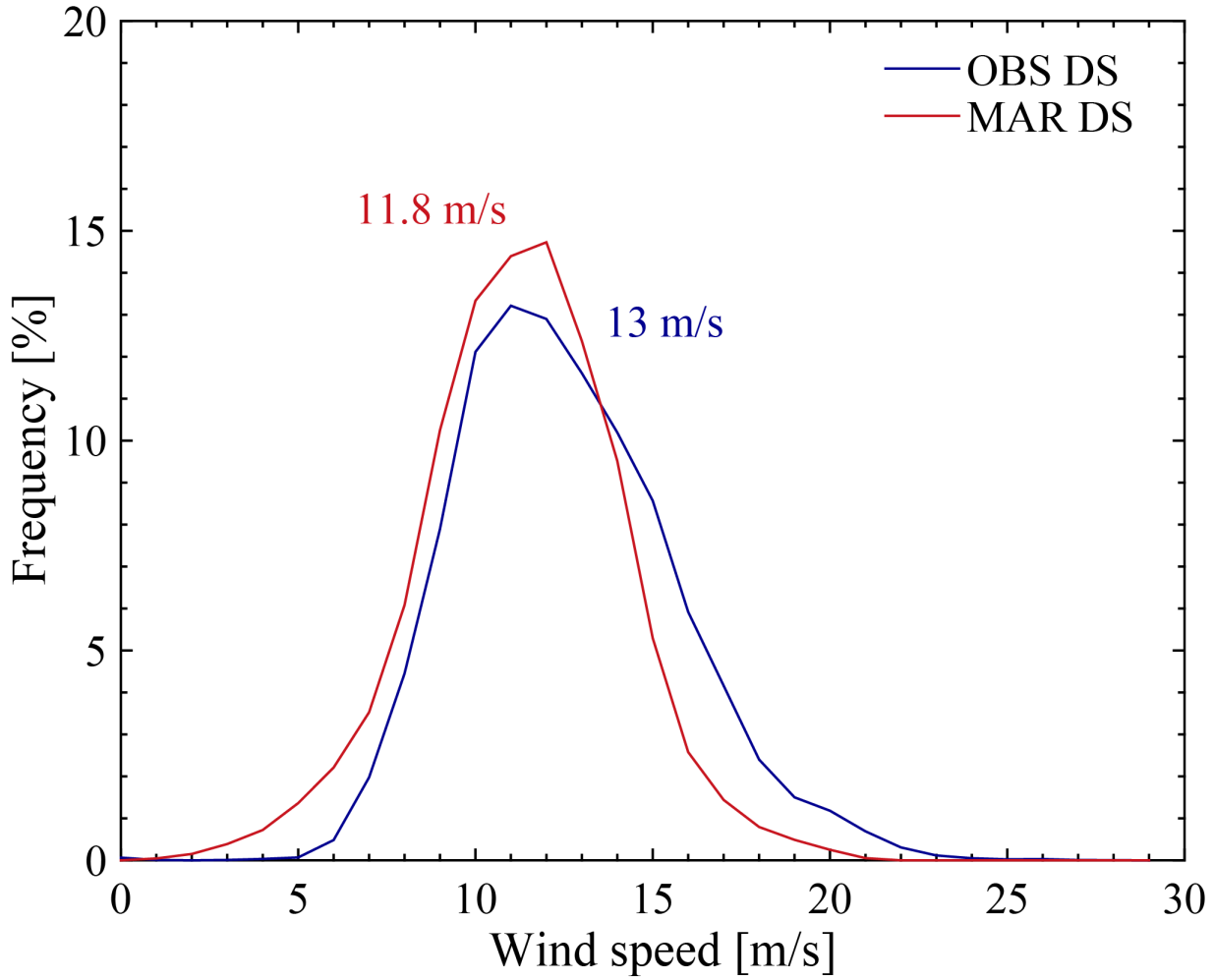
Distribution of wind speeds (D17)



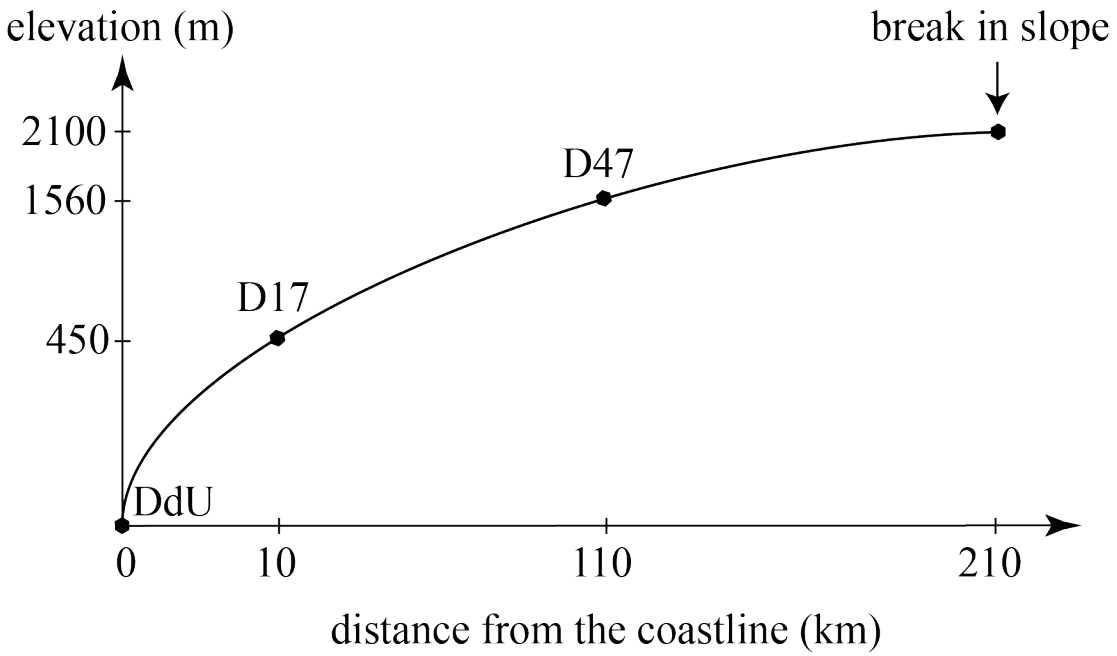


Distribution of wind speeds (D47)





Climatological settings



Location	**D17**	**D47**
Wind speed [m/s]	9.6	11.9
Temperature [°C]	-15.7	-25
Relative humidity w.r.i. [%]	84.1	90.6
Wind direction [deg]	154	158
Directional constancy	0.92	0.95

Model set-up

$n_x \times n_y$	dx	n_z	z_{min}	n_{snow}	Forcing
80 × 80	10 km	24	1 m	30	ERA-Int

- Advection of snow part. by the microphysical scheme
- Drifting snow stabilization effects considered
- u_{*t} = f(snow properties)
- $\rho_{fresh\ snow}$ = f(U,T_{air})
- z_0 = f(T_{air})

Sensitivity to fresh snow availability

- Inhibition of snowfall
- DSF of 0.11 (D17) and 0.23 (D47)

MAR	D17		D47	
OBS	DS	nDS	DS	nDS
DS	9.2%	52.2%	19.5%	61.4%
nDS	1.9%	36.7%	3.8%	15.3%

Location	POD	FAR	HSS
D17	10.2	64.5	0.08
D47	17	79.7	0.02