# Impact of sub-grid orographic drag on weather forecasts in Iceland

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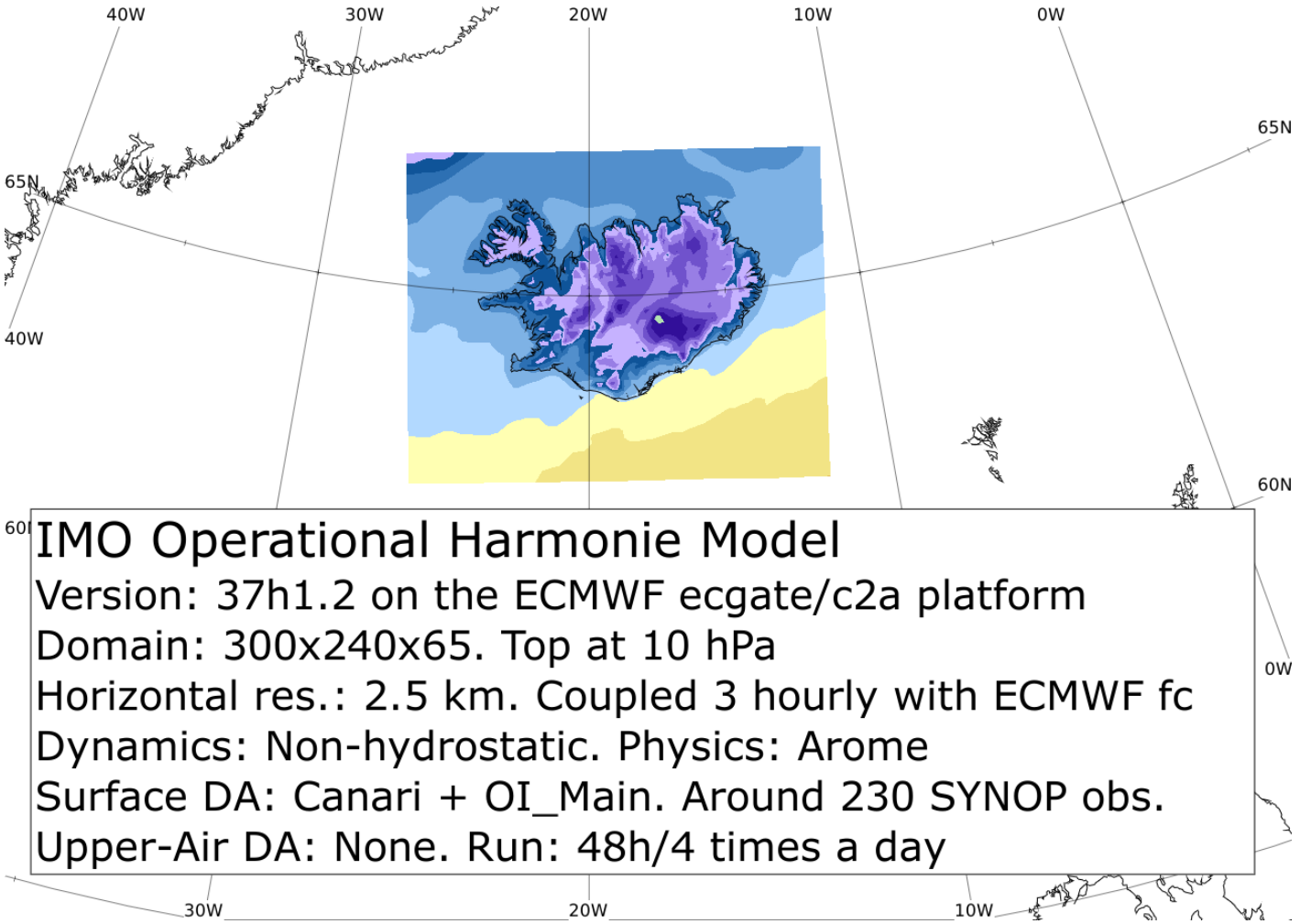
# Introduction

Icelandic Met Office

- **Roughness depends on surface type and each type has its roughness**
- **Damping of surface wind is also due to sub-grid scale orography friction**
- IMO op. Harmonie-37h1.2 forecast system
- Two orographic drag options
- Experimental set-up
- Verification of analysis & forecasts
- Conclusions and plans

# IMO op. Harmonie-37h1.2 forecasting system




IMO Operational Harmonie Model

Version: 37h1.2 on the ECMWF ecgate/c2a platform

Domain: 300x240x65. Top at 10 hPa

Horizontal res.: 2.5 km. Coupled 3 hourly with ECMWF fc

Dynamics: Non-hydrostatic. Physics: Arome

Surface DA: Canari + OI_Main. Around 230 SYNOP obs.

Upper-Air DA: None. Run: 48h/4 times a day

# Two orographic drag options

Icelandic Met Office

$$drag_{Z01D} = \rho^2 \left(\frac{0.4}{\ln\frac{H}{Z_0}}\right)^2 U; \quad Z_0 = \min\left(Z_0, \frac{H}{XFRACD}\right)$$

$Z_0$ is orographic roughness length; ρ is density; U is wind speed. H is height of the atmospheric forcing level.
XFRACD is chosen to minimize the bias and RMSE.
See Y. Seity, C. Lac, V. Masson: About orographic drag options in SURFEX. Tech. Report.

$$drag_{BE04} = 2 \propto \beta C_{md} C_{corr} C_a S_{st}^2 H^{-1.2} \left(e^{-H/1500}\right)^{1.5} U$$

H is the altitude; $S_{st}$ is the subgrid orography standard deviation; Other variables are constants.
See A. C. M. Beljaars, A. R. Brown, N. Wood 2004: A new parameterization of turbulent orographic form drag. QJRMS

# Experimental set-up
## Impact of sub-grid orographic friction

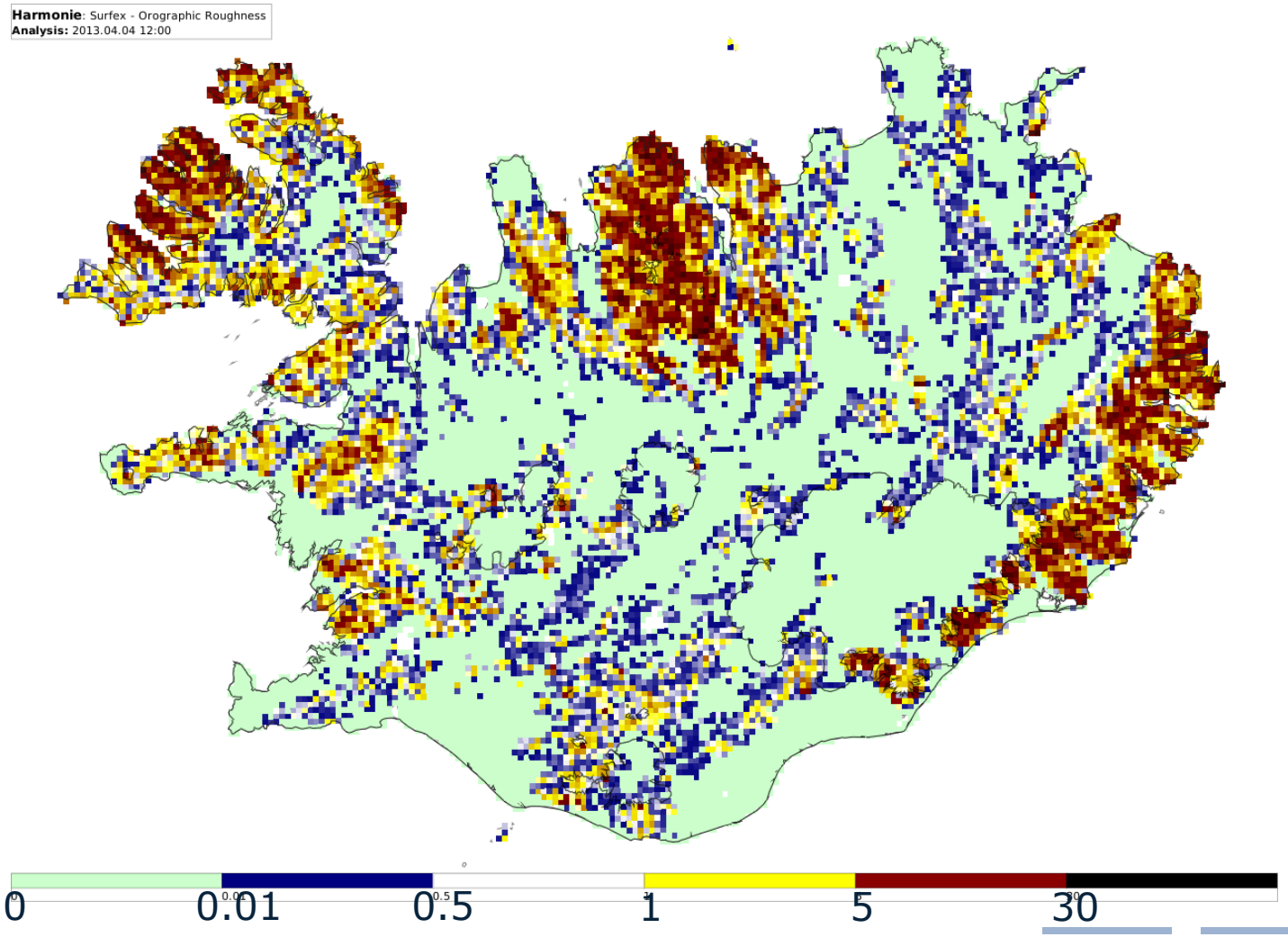
Icelandic Met Office

**Two parallel exp. for November 2012 and July 2012**

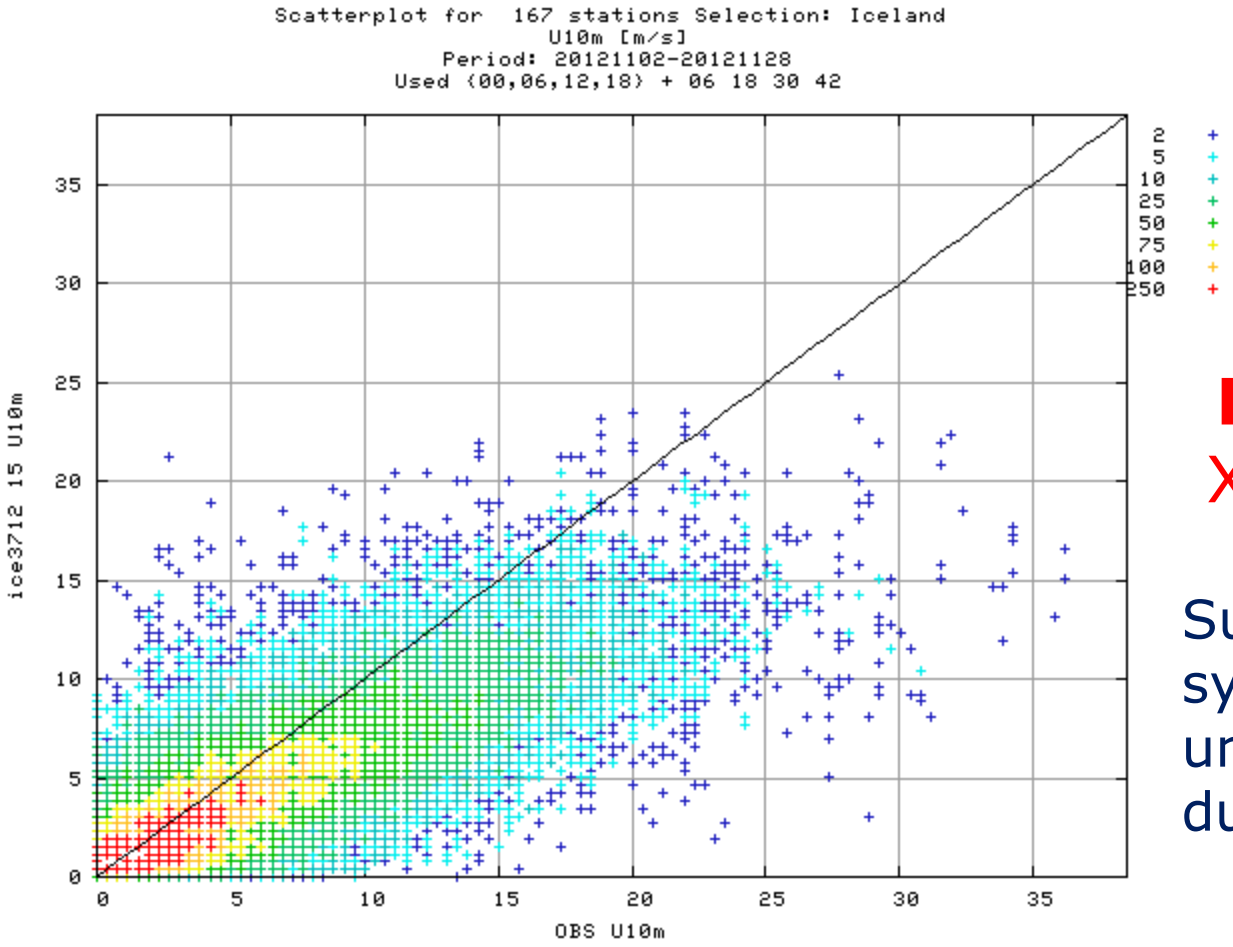
- Value of XFRACD is chosen to minimize the bias and RMSE
- Lateral boundary conditions from 6 h old ECMWF forecasts and all SYNOP observations except snow depth sent externally from IMO in a 6 h cycle.
- Observaions time window +/- 3 h intermittent DA cycle
- At 00 and 12 UTC 48 h forecasts were launced

# Sub-grid Orographic Roughness length in Harmonie-37h1.2

Icelandic Met Office



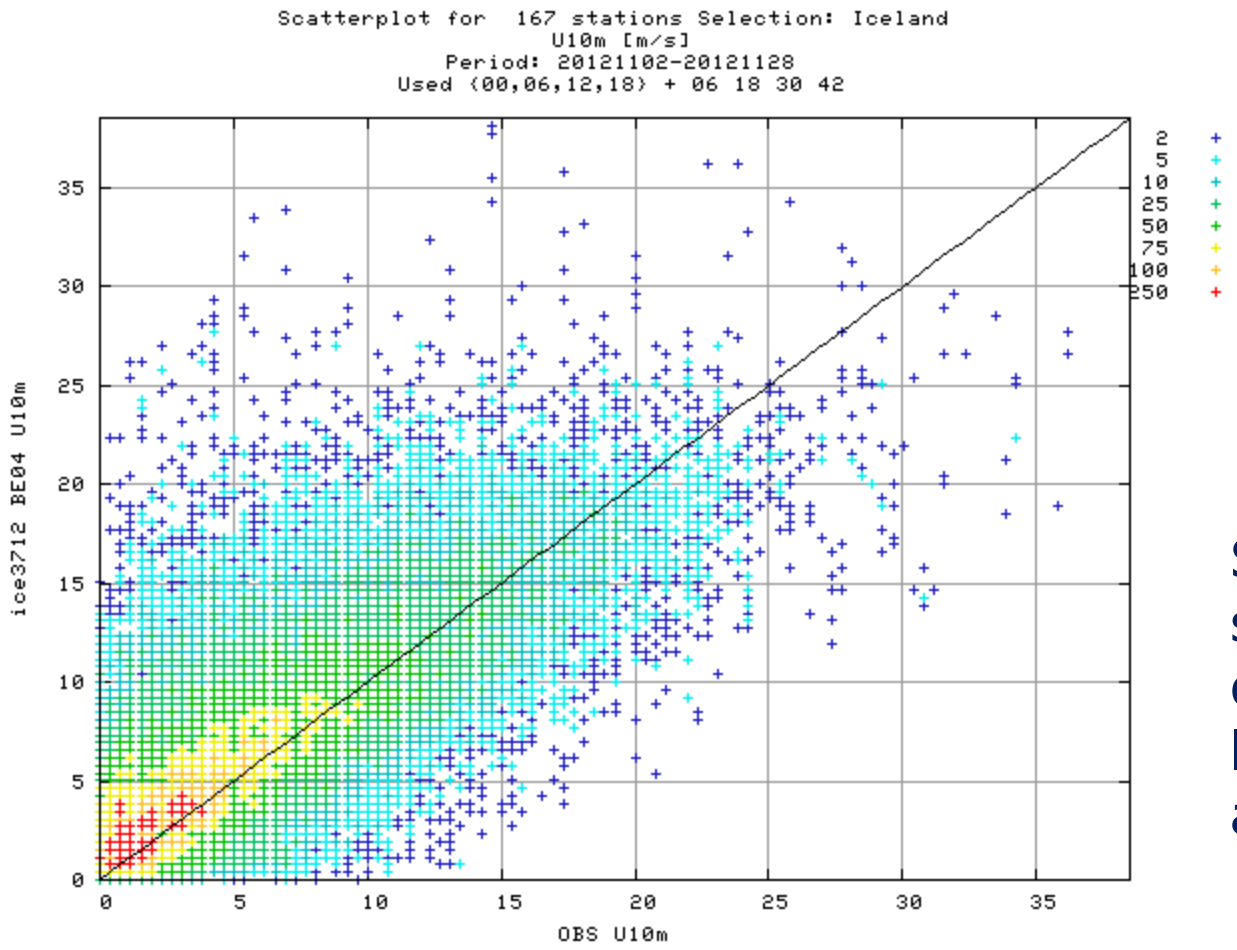
# Validation of drag winter




**Default $z_0$**
XFRACD=15

Surface winds are systematically underestimated during windstorms

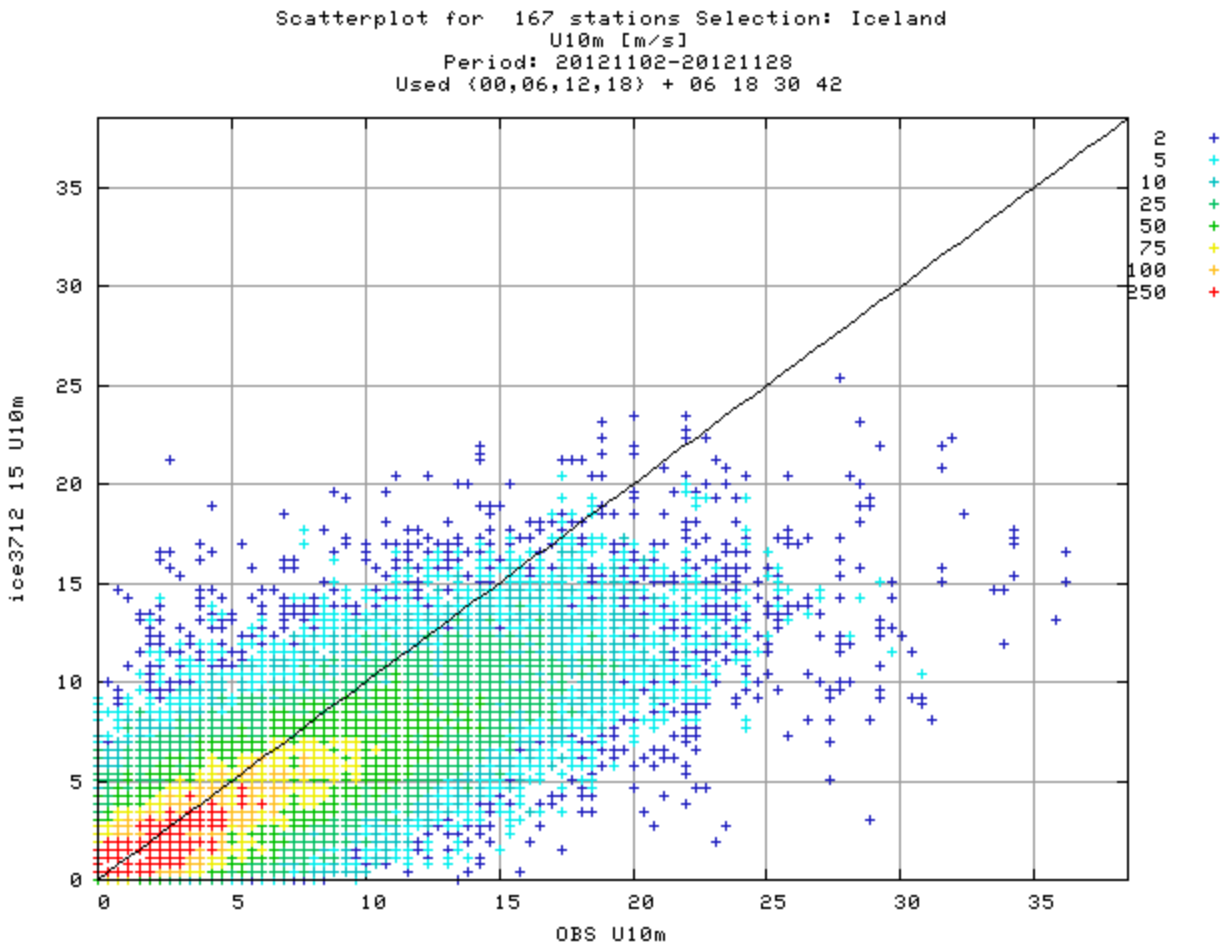
# Validation of drag winter (cont.)




## Default BE04

Surface winds are systematically overestimated for lower wind speed and has pos. bias

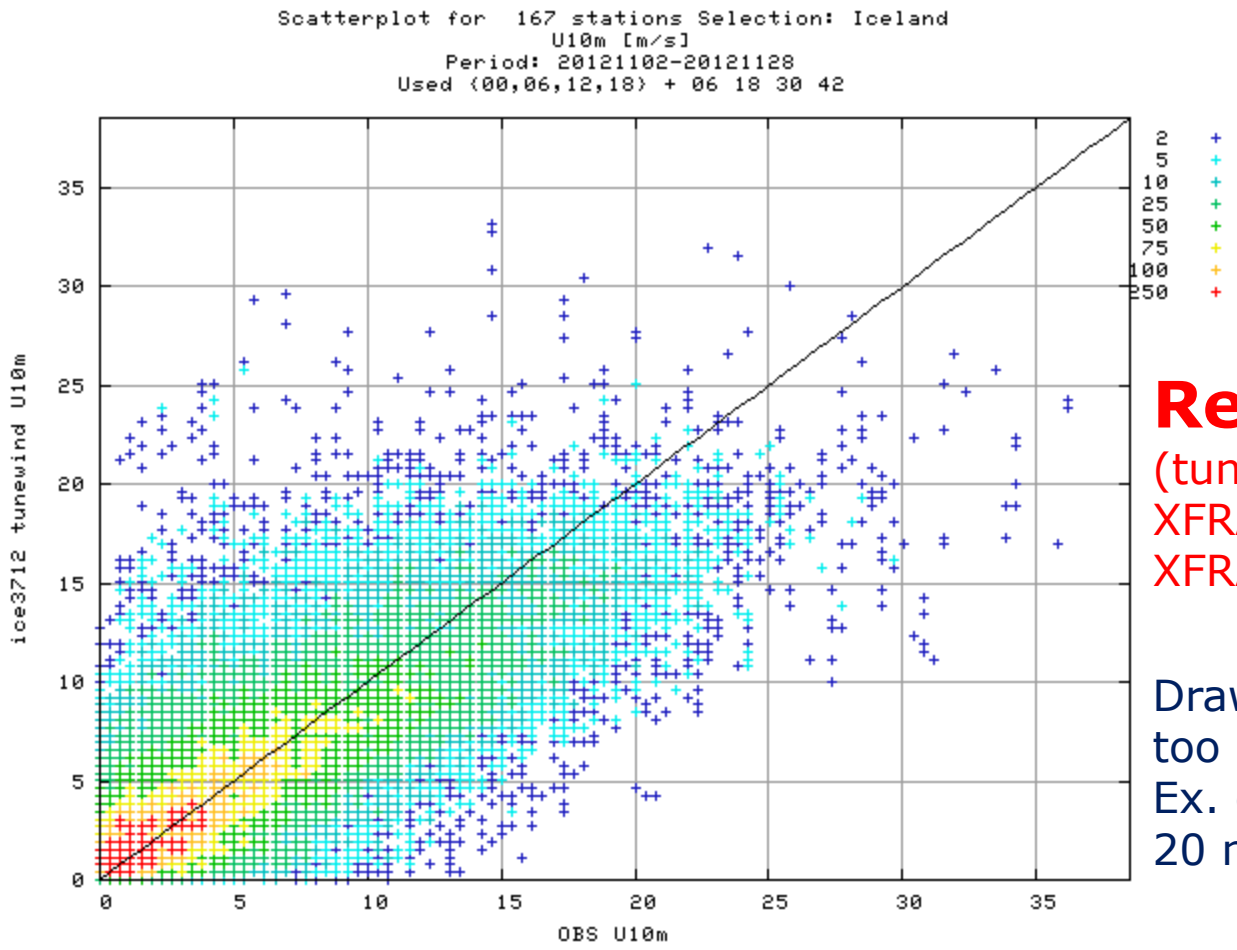
# Validation of drag winter (cont.)




**Default $z_0$**
XFRACD=15

We chosed to tune up Z01D rather than tune down BE04

# Validation of drag winter (cont.)




## Reduced $Z_0$

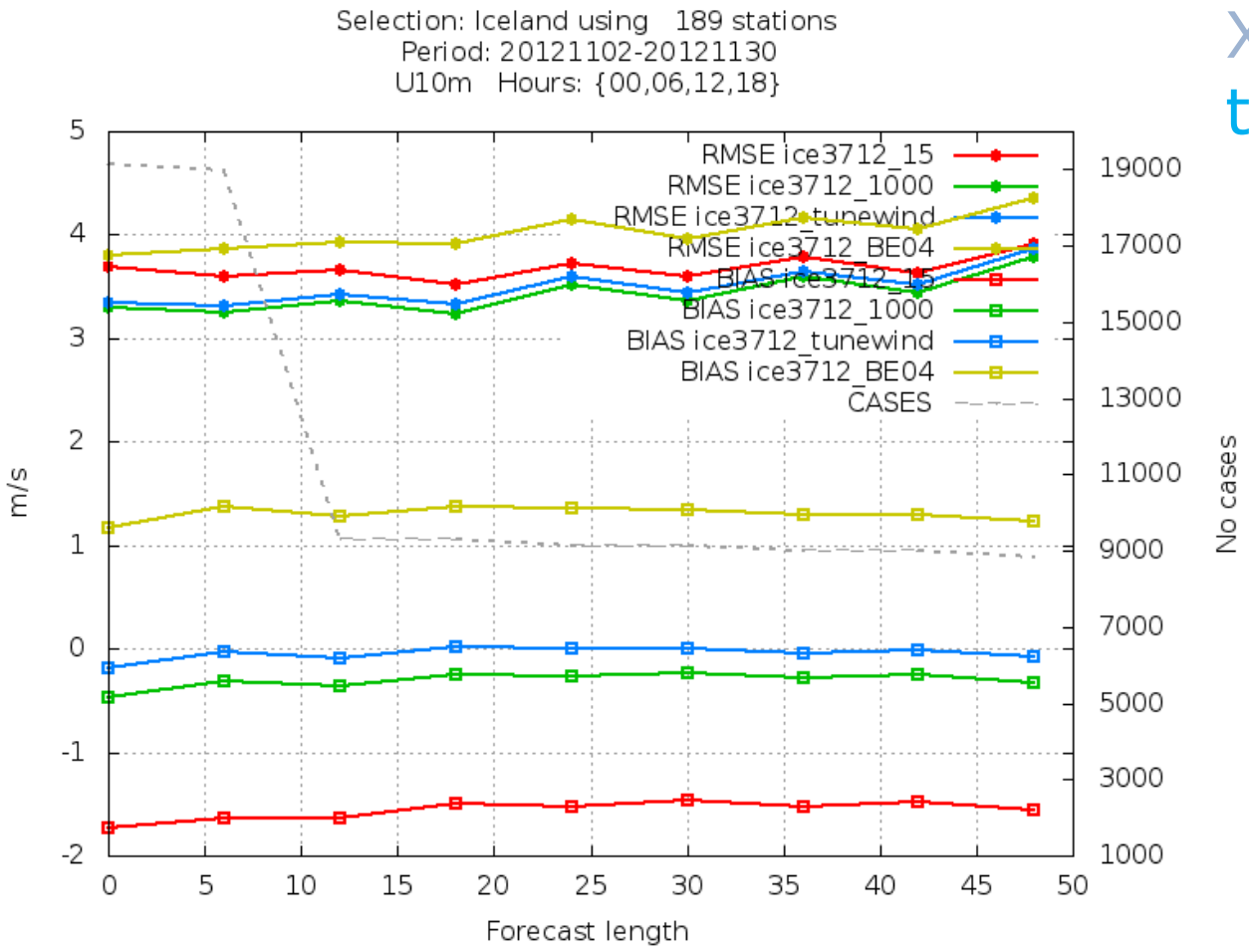
(tunewind)

XFRACD=2500 for f<13 m/s

XFRACD=10000 for f>13 m/s

Drawback: Reducing $Z_0$ gives too strong winds at $f_{obs}$< 3 m/s. Ex. obs. 5 m/s when forecasted 20 m/s is not good

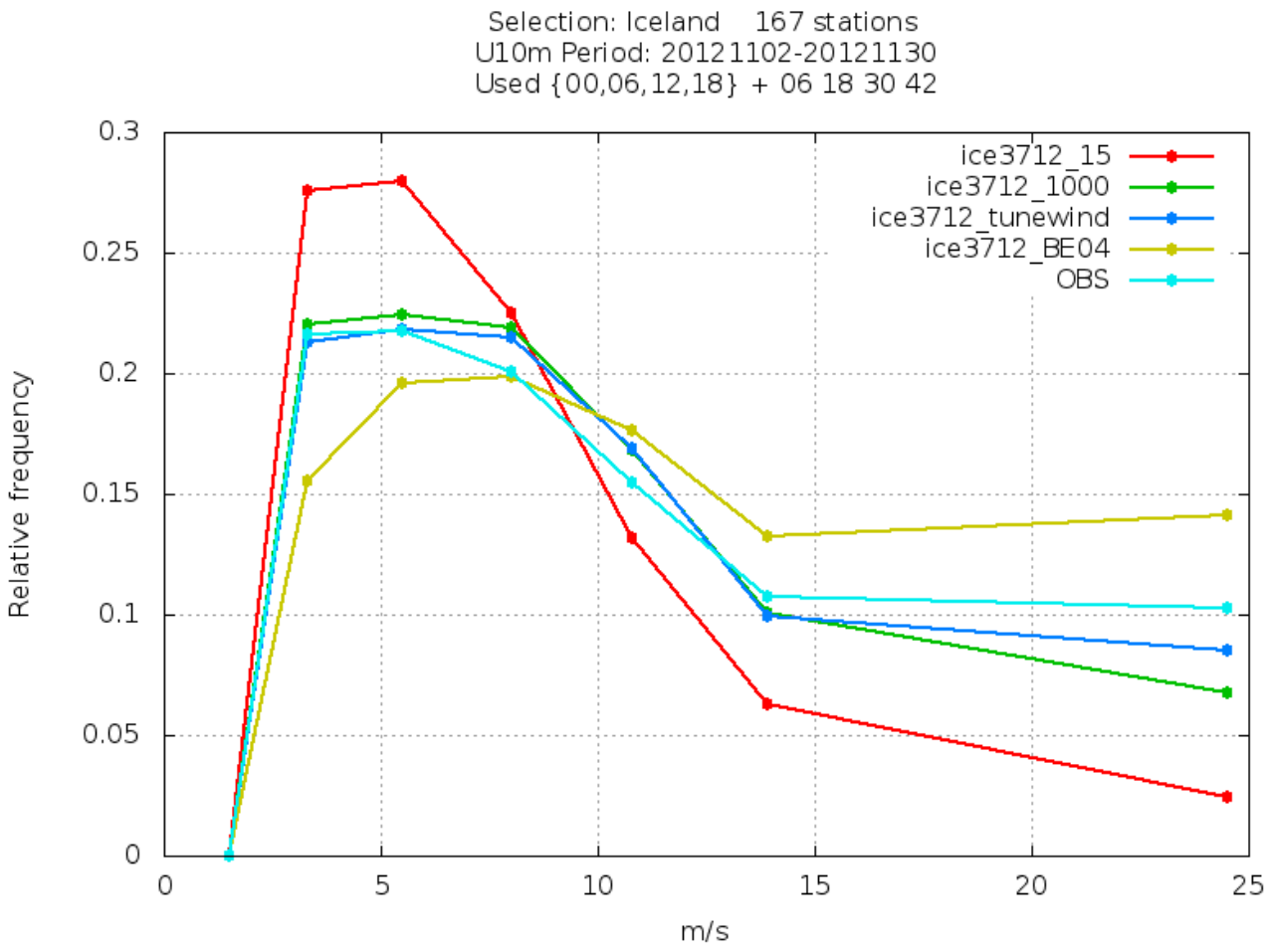
# Validation of drag winter (cont.)




XFRACD 15 1000
tunewind BE04

Reduced $Z_0$ leads to improved BIAS and RMSE fit to U10m data

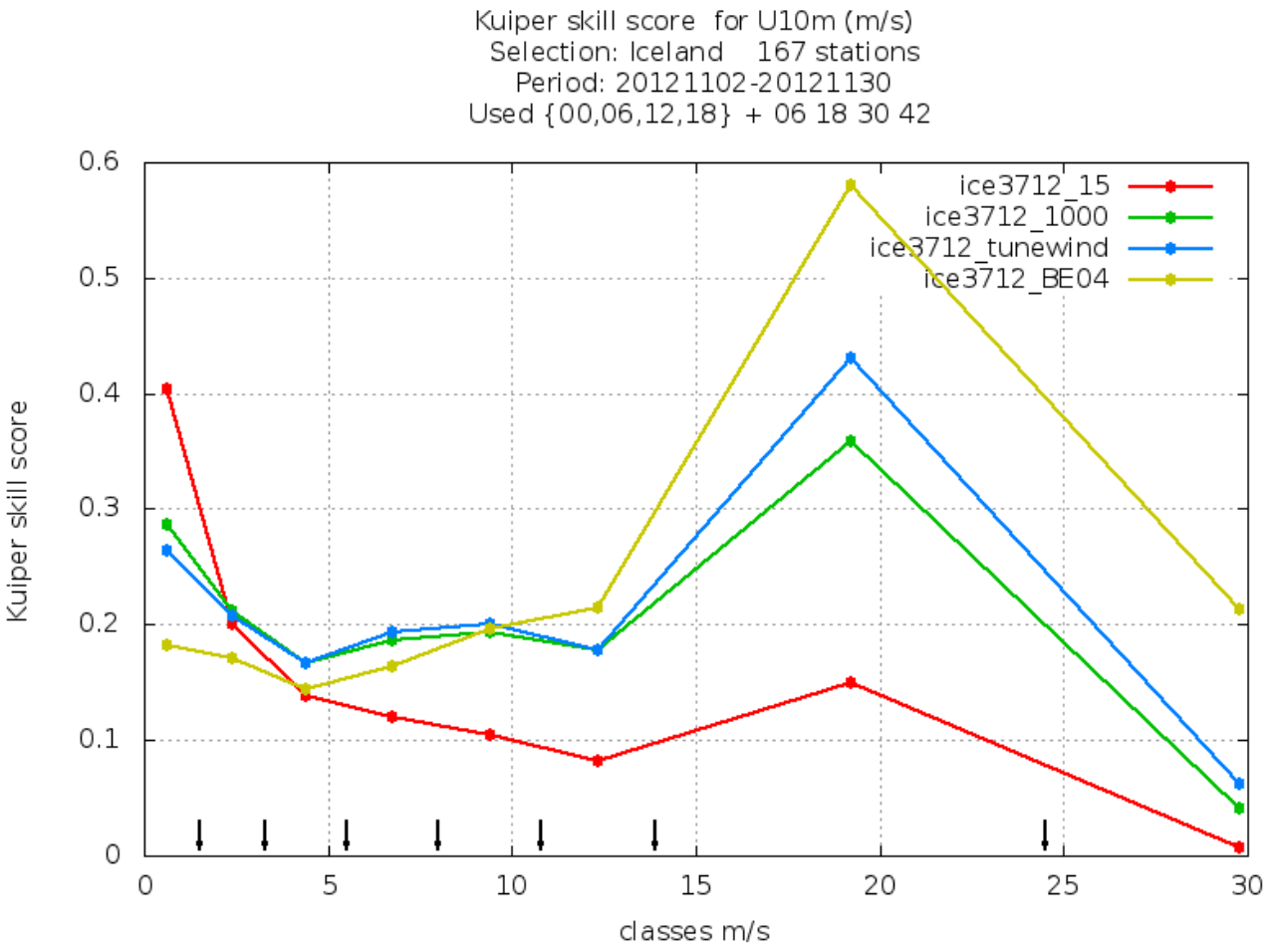
# Validation of drag winter (cont.) frequency distribution




XFRACD 15 1000 tunewind BE04 OBS

The reduced $Z_0$ follow best the frequency distrib. of the obs

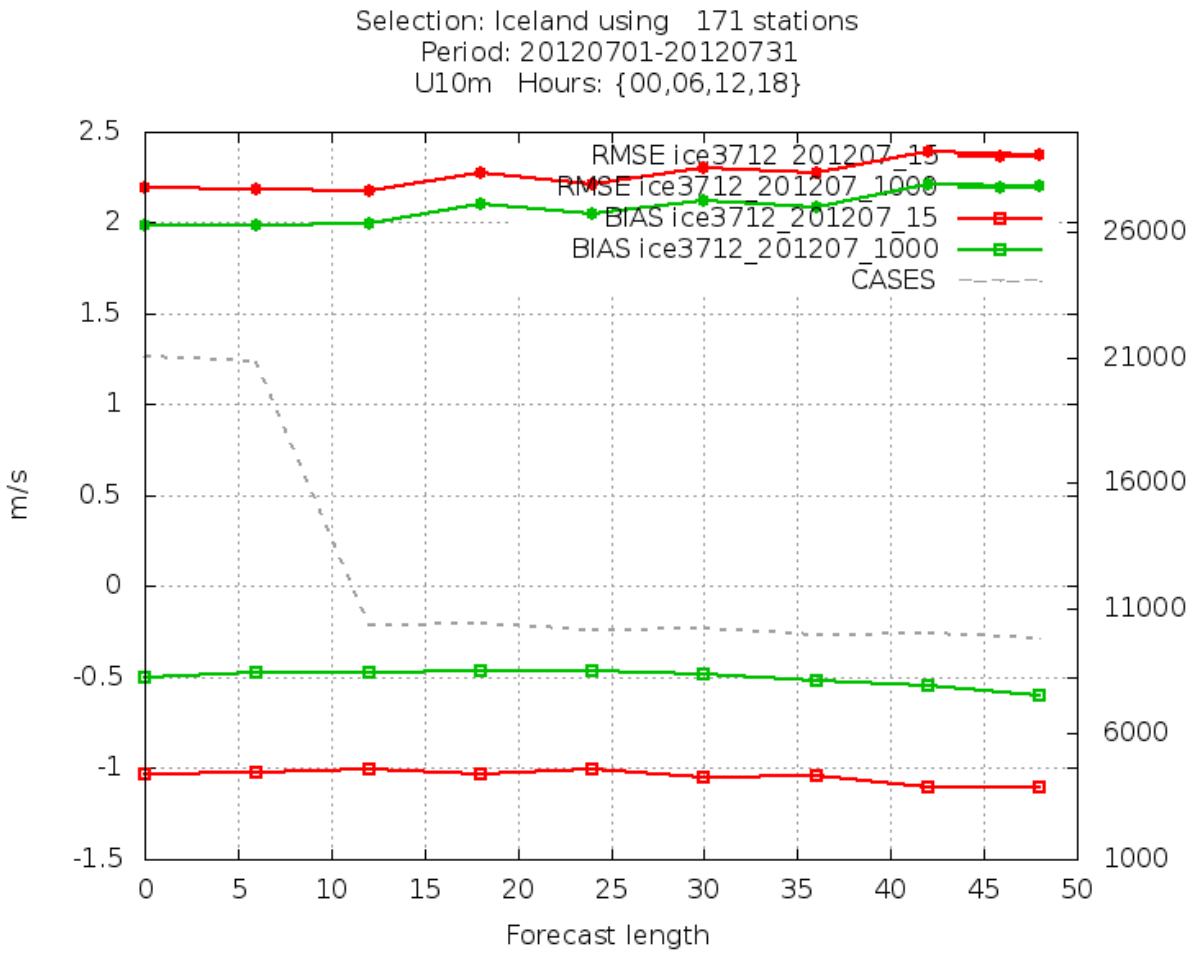
# Validation of drag winter (cont.) Kuiper Skill Score




XFRACD 15 1000
tunewind BE04

Drawback: Reducing $Z_0$ gives too strong winds at $f_{obs}$ < 3 m/s

# Validation of drag summer




XFRACD 15 1000

Reduced $Z_0$ leads also to improved BIAS and RMSE fit to U10m obs. in summer

# Conclusions and plans

Icelandic Met Office

- **Harmonie SA system has been set up for use with two orography drag options and varying value of surface roughness and evaluated for one summer and one winter period**
- **For one case the surface roughness takes values which are functions of model wind speed**
- **The results indicate that it is important to reduce the orography drag roughness in the Icelandic runs.**
- **Future roughness experiments with Harmonie 2.5 km will also evaluate the roughness for different surface types as well as the sub-grid orography drag**