Christmas Challenge 2017
Drag coefficient of Suzanne

Andras Horvath
Rheologic GmbH
Vienna

Cd of a smooth sphere

- We assume that Suzanne behaves similar to a sphere or at least somewhat like it
- If we can accurately predict Cd of a smooth sphere we can predict Cd of Suzanne
- The region from laminar to turbulent is covered from Re=100 to Re=100000 in x10 steps
- Re > 100000 is left out due to computational cost
- Re < 100 is left out because it's booooring
- The model with closest match to experimental data is chosen and applied to simulation of Suzanne (without doing too much fitting!)
- Relative offset from experimental results (average from two sources) for the smooth sphere is applied to monkey simulation as correction factor

Results 1|2

Drag coefficient Cd of a smooth sphere in OpenFOAM-5.0

Re (1)	Boundary layer	Transient	Turb.model	Cd (1)	Error vs Exp. (%) Cd source [1]	Error vs Exp. (%) Cd source [2]
1e2	coarse	no	n.a./laminar	0.82	- 19.6	- 25.4
1e3	coarse	no	n.a./laminar	0.47	<+ 4.0	~+ 4.0
1e4	high Re	no	k-omega SST	0.47	+ 14.6	+ 17.5
1e4	low Re	yes	LES Smagorinsky	0.44	+ 7.3	+ 10.0
1e5	high Re	no	k-omega SST	0.31	- 20.5	- 24.3
1e5	low Re	yes	LES Smagorinsky	0.44	- 13.6	+ 7.3

Drag coefficient Cd of *Suzanne* in OpenFOAM-5.0

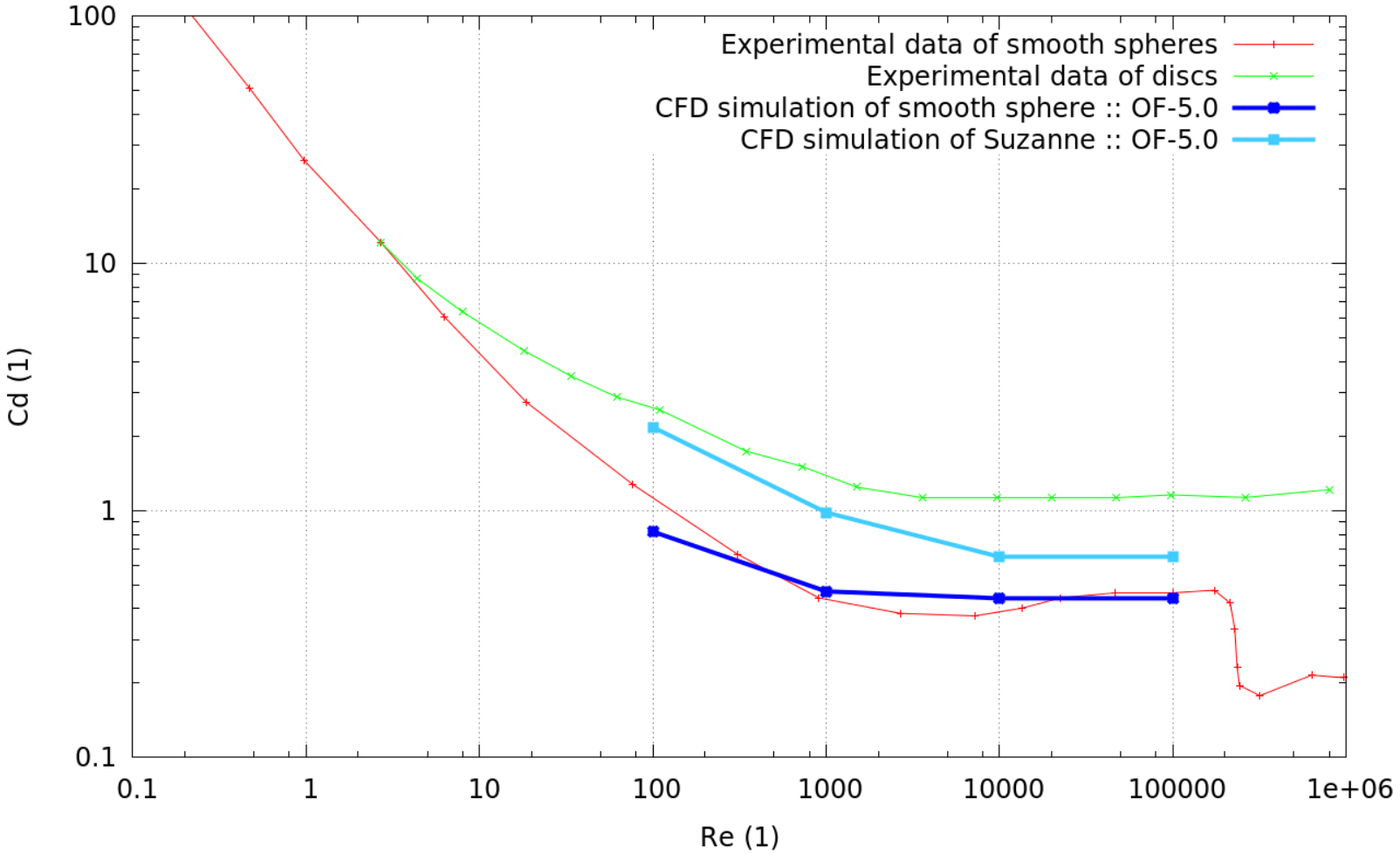
Re (1)	Boundary layer	Transient	Turb.model	Cd (1)	Cd (1) corr. Avg [1], [2]
1e2	coarse	no	n.a./laminar	1.77	2.17
1e3	coarse	no	n.a./laminar	0.98	0.98
1e4	low Re	yes	LES Smagorinsky	0.67	0.65
1e5	low Re	yes	LES Smagorinsky	0.67	0.65

lowRe means y+<1 (fully resolved boundary layer) highRe means y+>1

[1] R. Clift, J. R. Grace and M.E Weber: Bubbles, Drops and Particles, p.110, Academic Press (1978)

[2] https://i.stack.imgur.com/axAi7.png (visited 11/07/2017)

Results 2|2


Experimental data of smooth spheres
Experimental data of discs
CFD simulation of smooth sphere :: OF-5.0
CFD simulation of Suzanne :: OF-5.0
Cd (1)
Re (1)
100
10
1
0.1
0.1
1
10
100
1000
10000
100000
1e+06

Frontal wind ...

Instantaneous velocity contours after flow field stabilisation of LES Smagorinsky Model on semi-transparent central cut are shown below