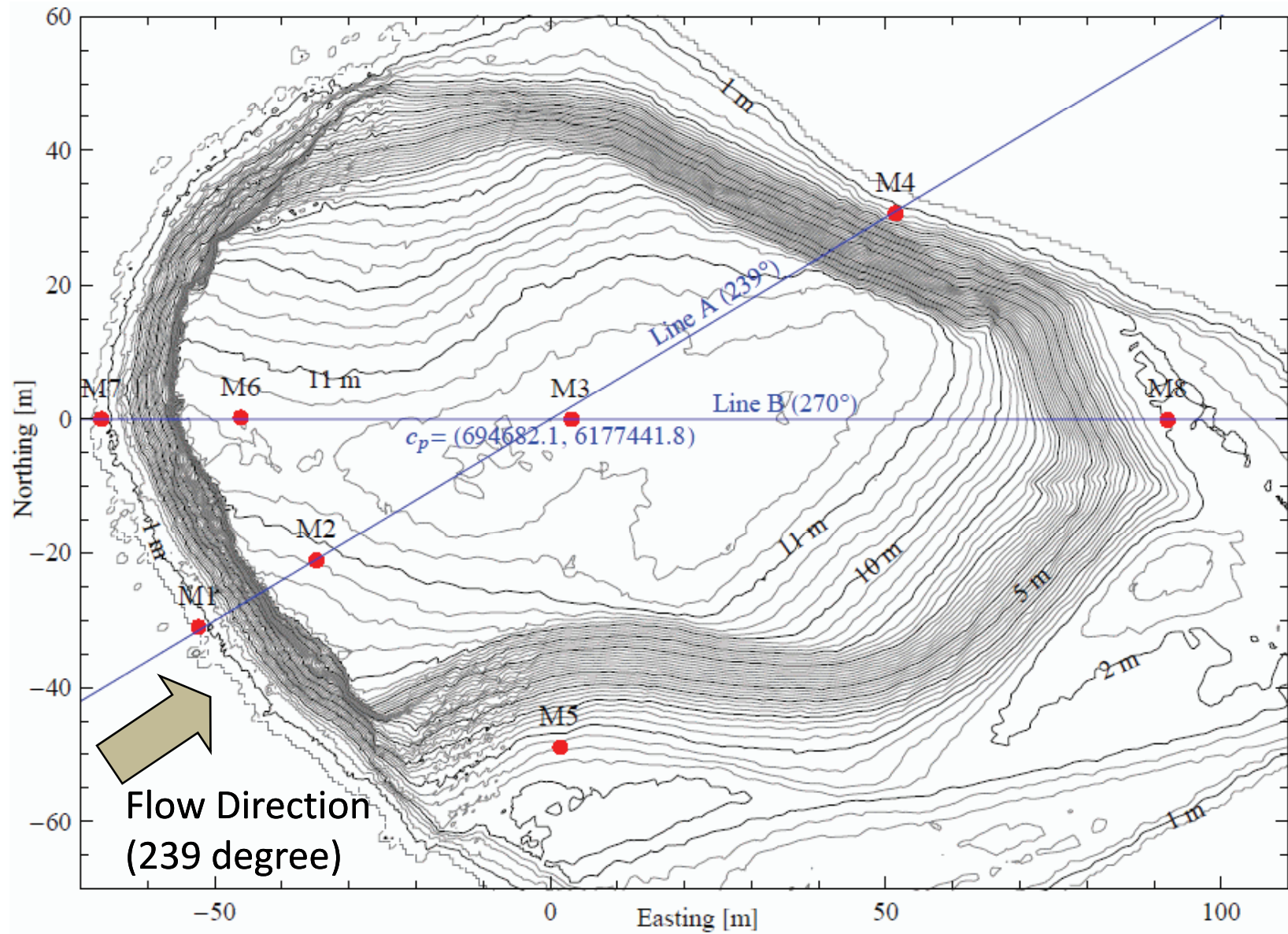


Validation - Bolund Hill Wind Tunnel Experiment

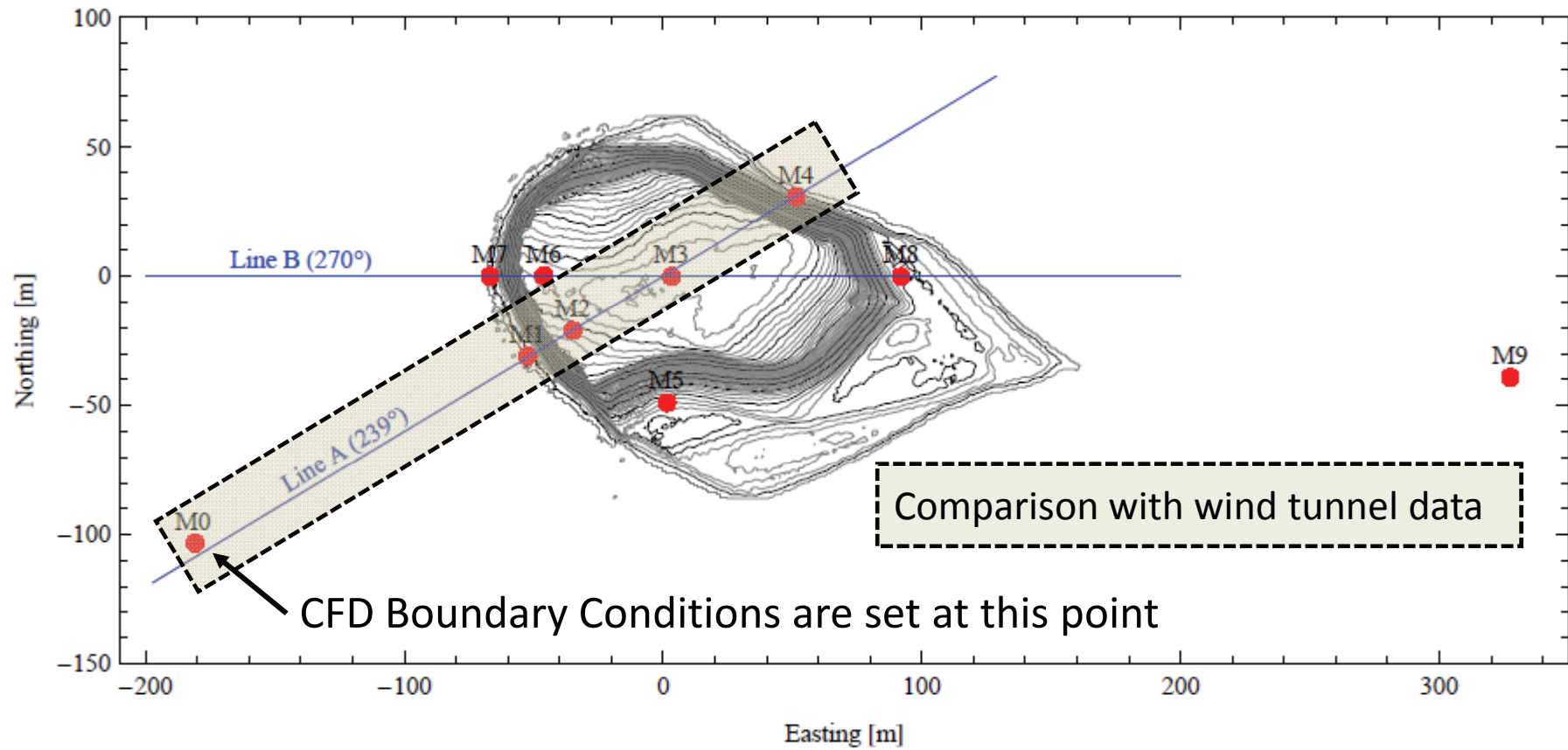
2011 • 12 • 16



Calculation Domain



Calculation Domain



Calculation Domain

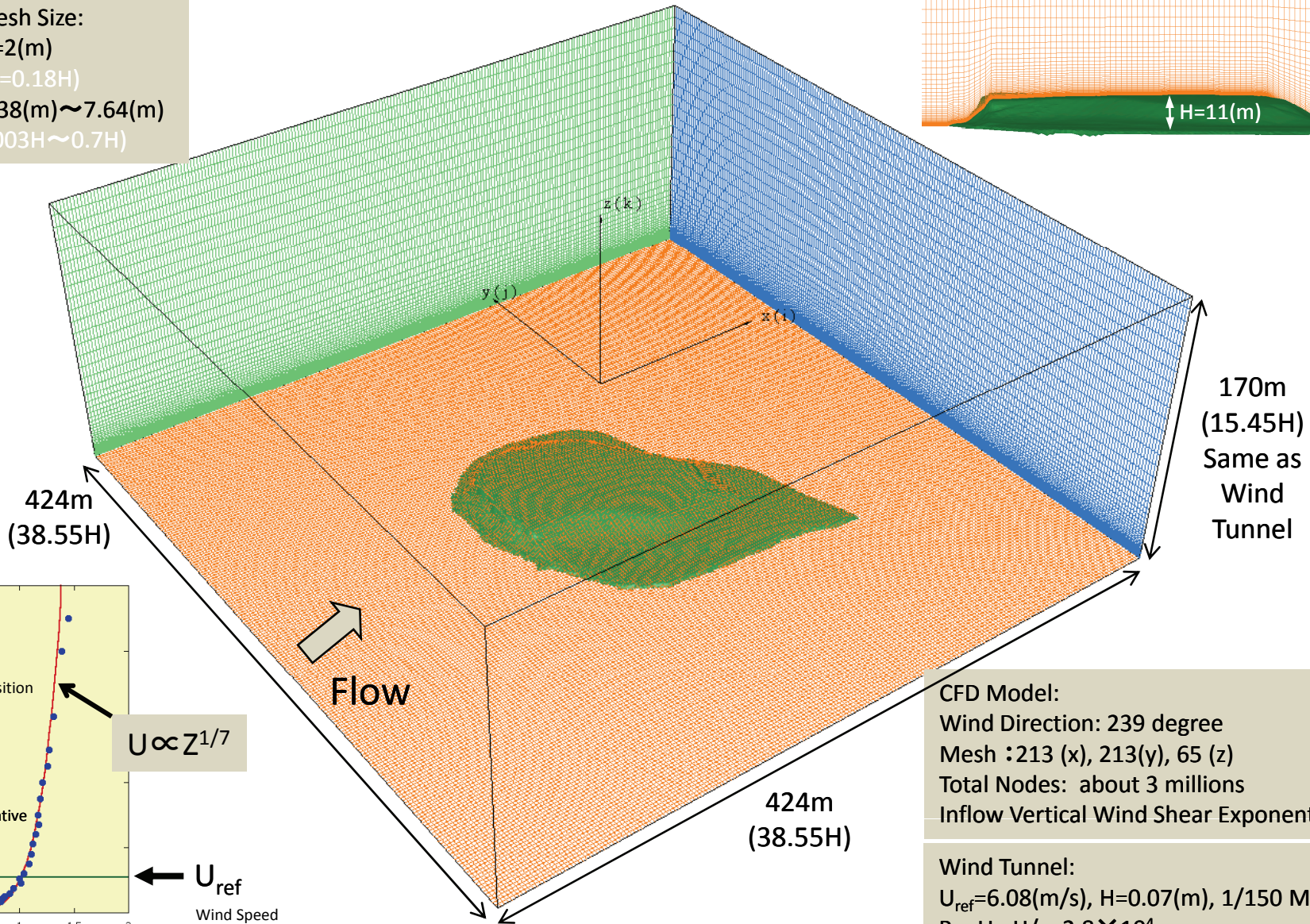
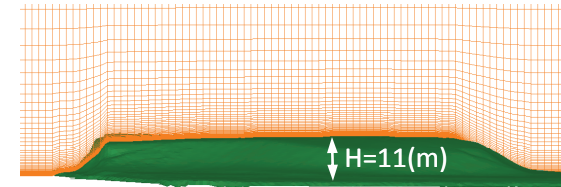
CFD Mesh Size:

$\Delta x = \Delta y = 2(m)$

($\Delta x = \Delta y = 0.18H$)

$\Delta z = 0.038(m) \sim 7.64(m)$

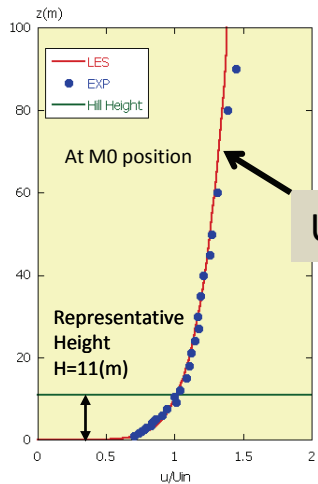
($\Delta z = 0.003H \sim 0.7H$)



170m
(15.45H)
Same as
Wind
Tunnel

424m
(38.55H)

424m
(38.55H)



$U \propto z^{1/7}$

U_{ref}

Wind Speed
Representative Scale

CFD Model:

Wind Direction: 239 degree

Mesh : 213 (x), 213(y), 65 (z)

Total Nodes: about 3 millions

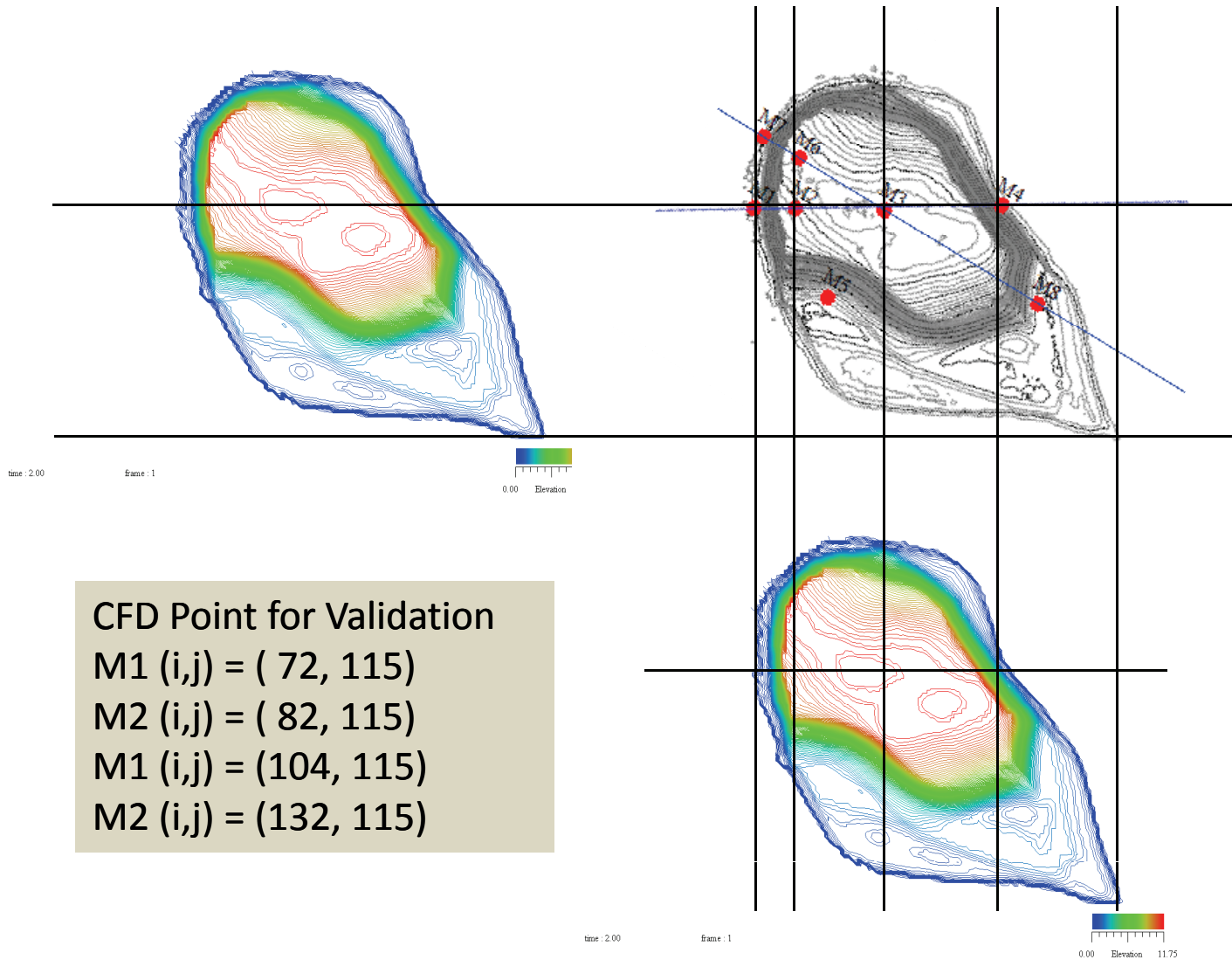
Inflow Vertical Wind Shear Exponent: 0.14

Wind Tunnel:

$U_{ref} = 6.08(m/s)$, $H = 0.07(m)$, 1/150 Model

$Re = U_{ref}H/\nu = 2.8 \times 10^4$

Calculation Domain



CFD Point for Validation

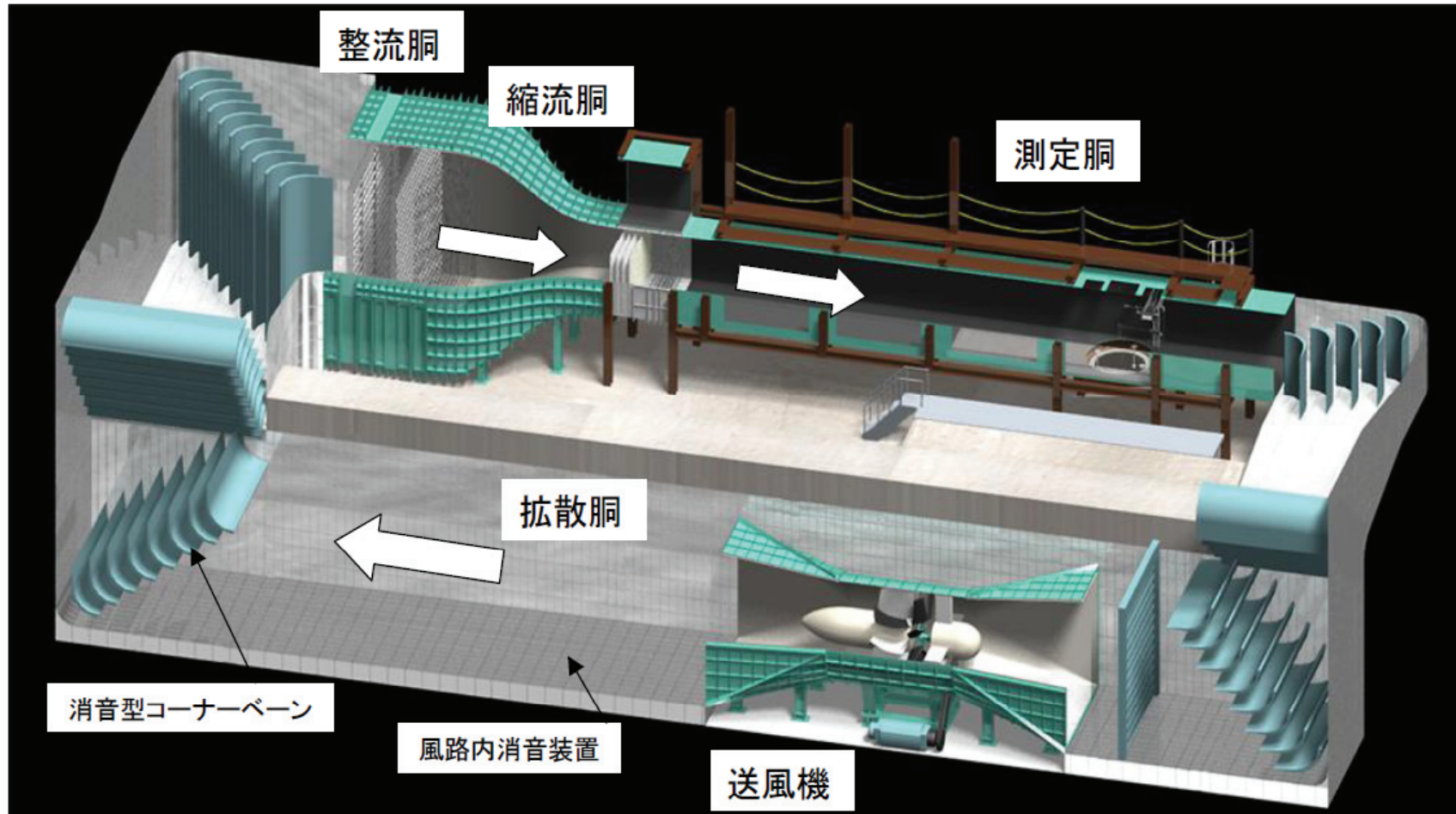
M1 (i,j) = (72, 115)

M2 (i,j) = (82, 115)

M1 (i,j) = (104, 115)

M2 (i,j) = (132, 115)

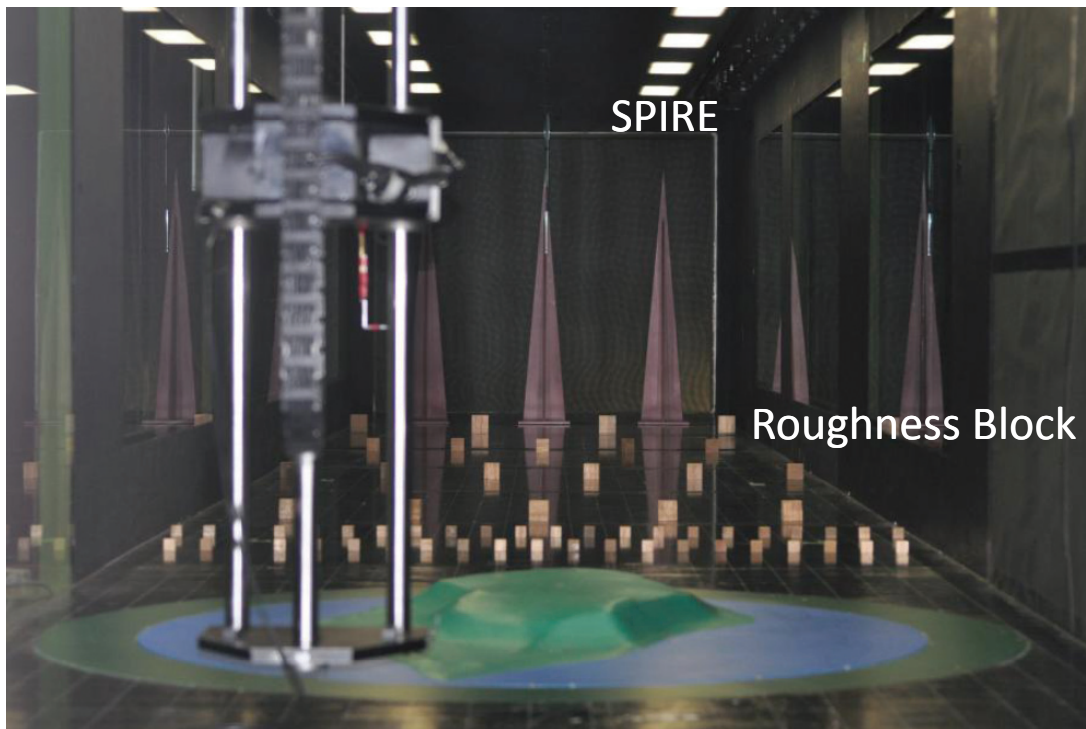
Wind Tunnel



Wind Tunnel at Institute of Industrial Science, University of Tokyo
(Length 16.5, Width 2.2m, Height 1.8m)

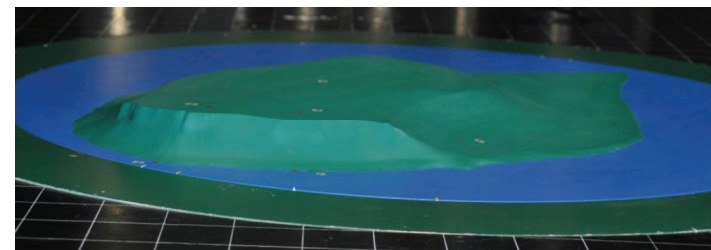
Wind Tunnel

Rear View

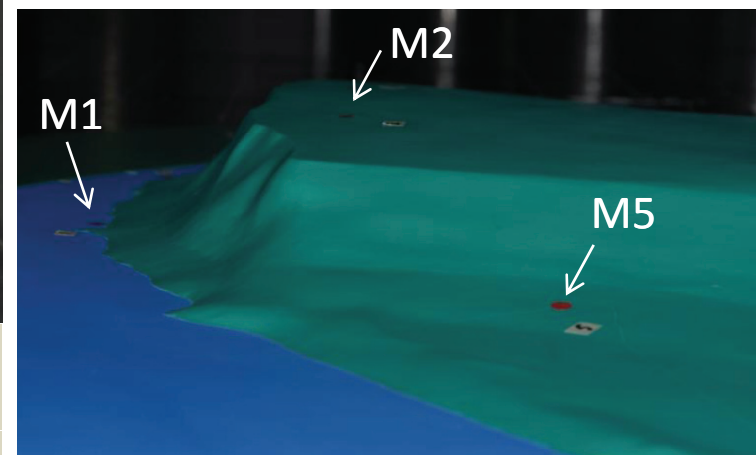


Actual Hill Height 11m - Wind Tunnel Height 7cm
Model Scale : 1/150

Wind Tunnel Model

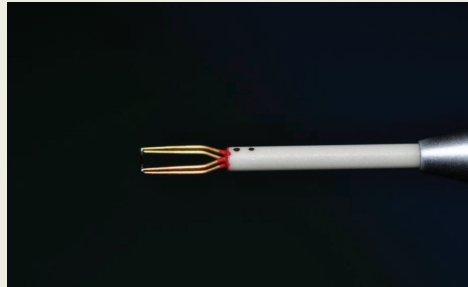


Measurement Points



Measurement Device

- Split-Fiber Probes



- 60 seconds measurement at 1kHz sampling frequency

- Measurement heights (actual scale) :

M1 to M8

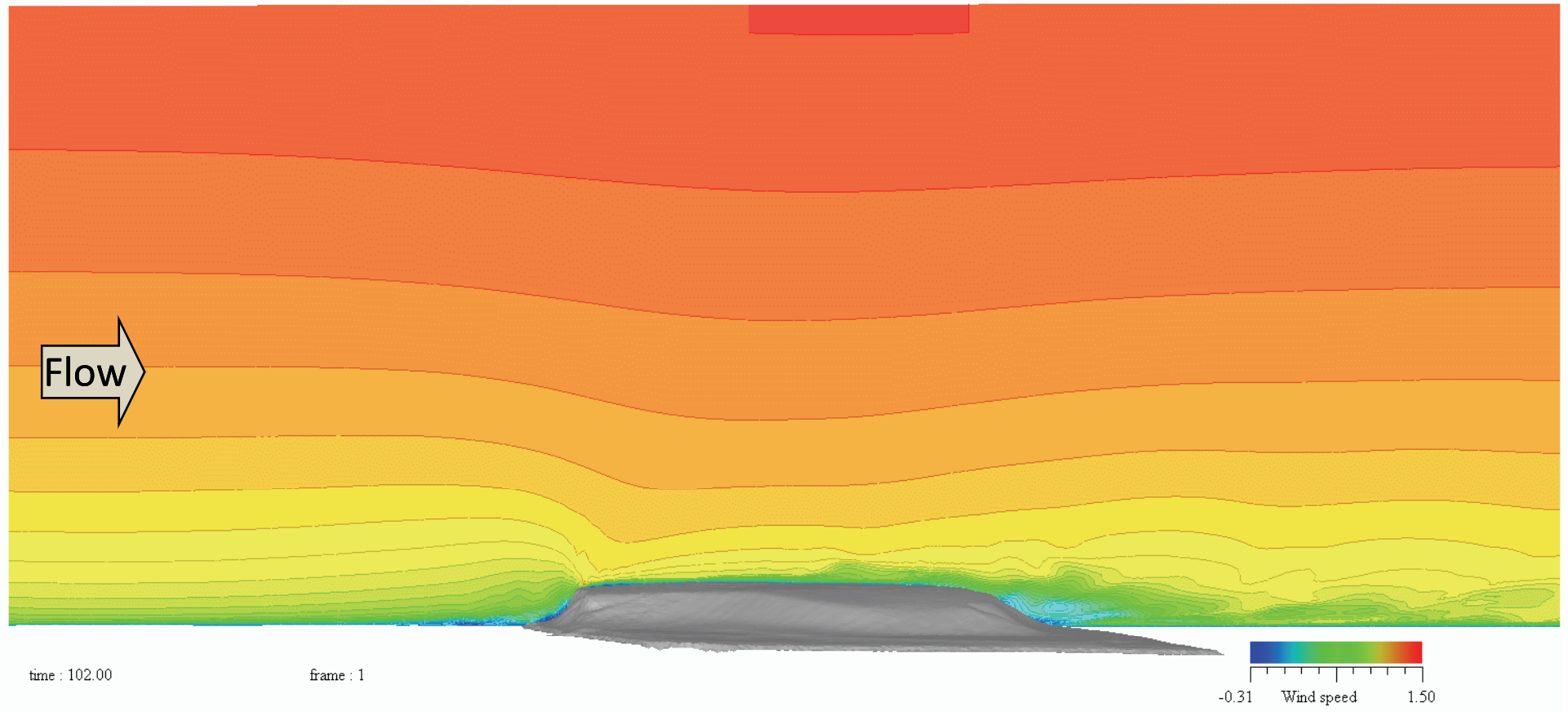
1m, 1.5m, 2m, 2.5m, 3m, 3.5m, 4m, 4.5m, 5m, 6m, 7.5m, 9m, 10.5m, 12m,
15m, 18m, 21m, 24m, 27m, 30m, 35m, 40m, 45m, 50m, 60m, 80m

(total of 26 points)

M0

90m, 120m, 150m, 165m (in additional to above heights, total of 30 points)

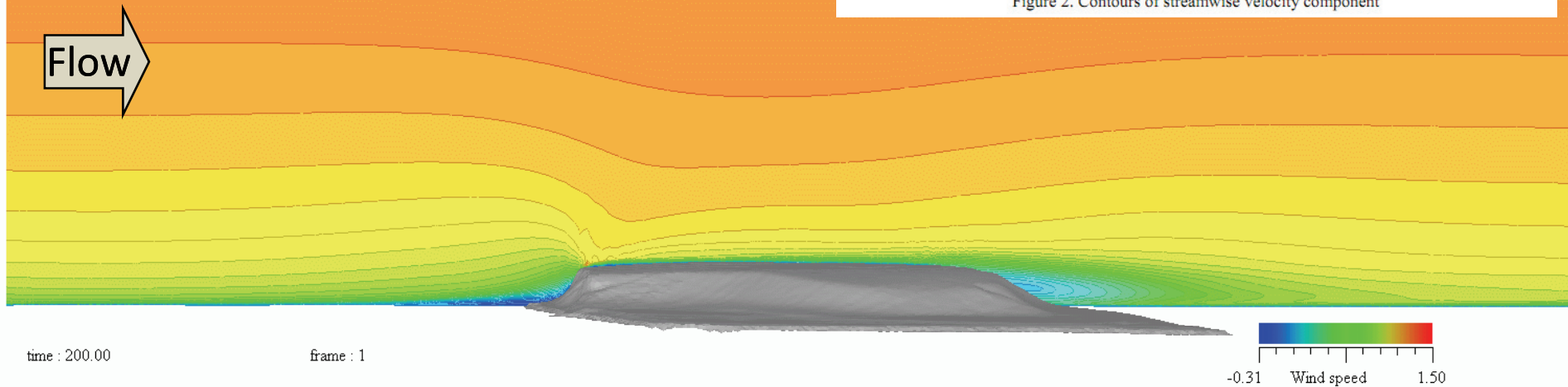
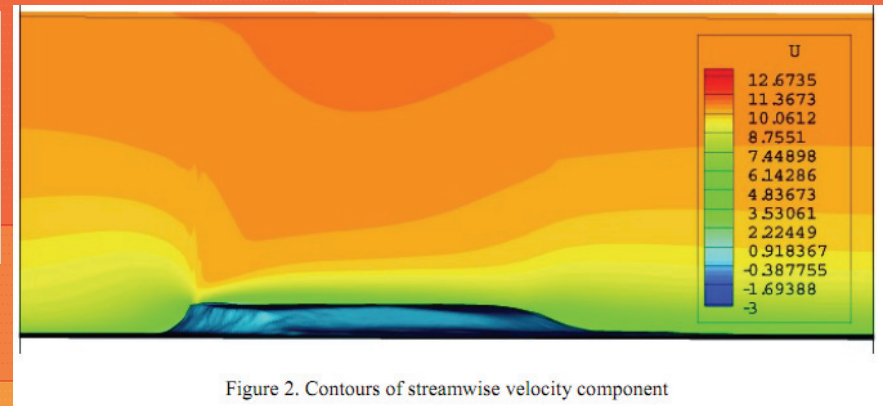
CFD Results



Wind Speed Distribution (U_x) of Vertical Plane along Line A
Instantaneous Result

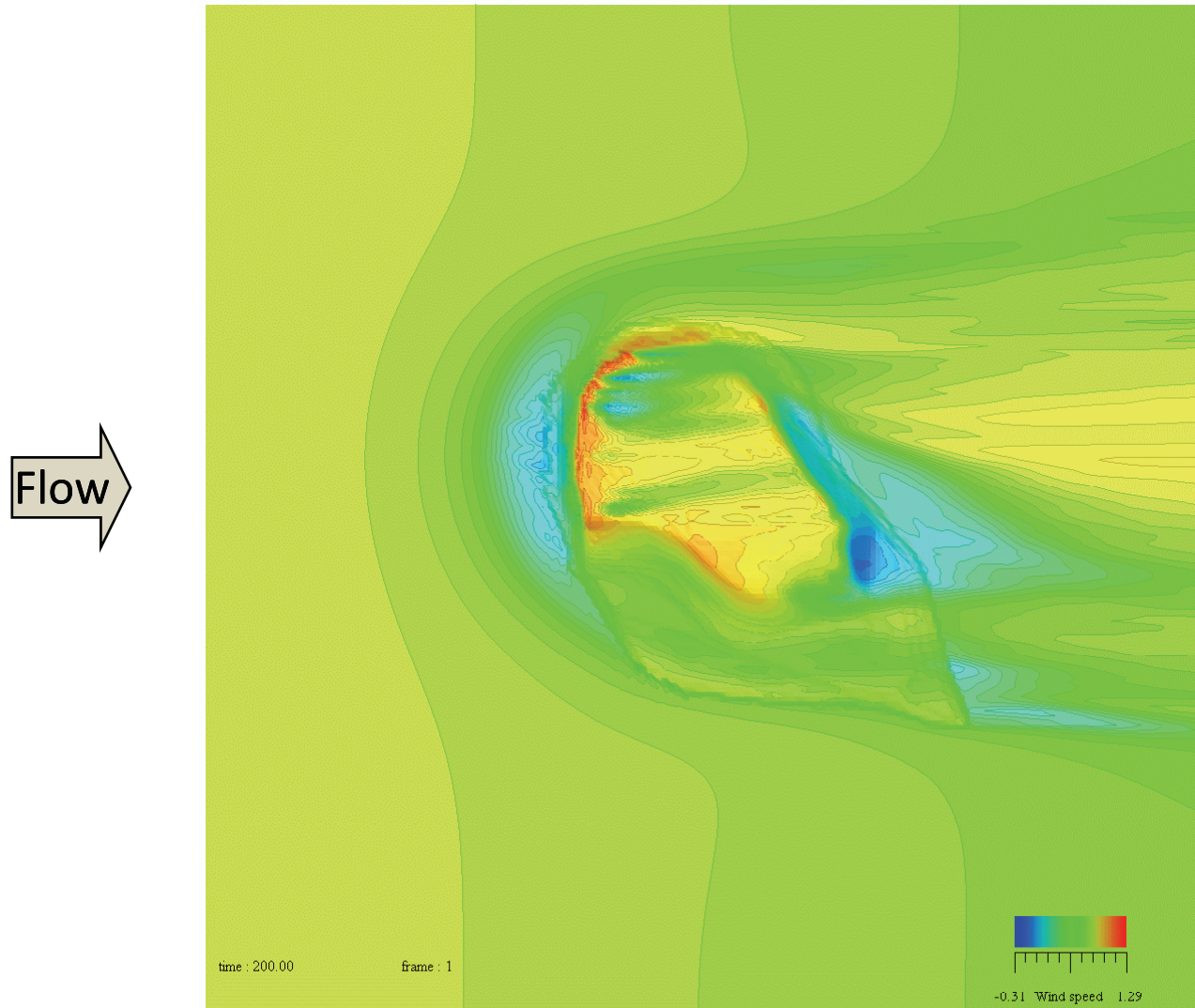
CFD Results

Comparison with Results take from
Numerical simulation of atmospheric boundary layer flow over
complex terrain The Bolund hill case
Nikola Mirkov * and Saša Kenjereš **, * Laboratory for Thermal
Engineering and Energy, Institute of Nuclear Sciences „Vinča“, Serbia,
**Department of Multi-Scale Physics, TU Delft, The Netherlands



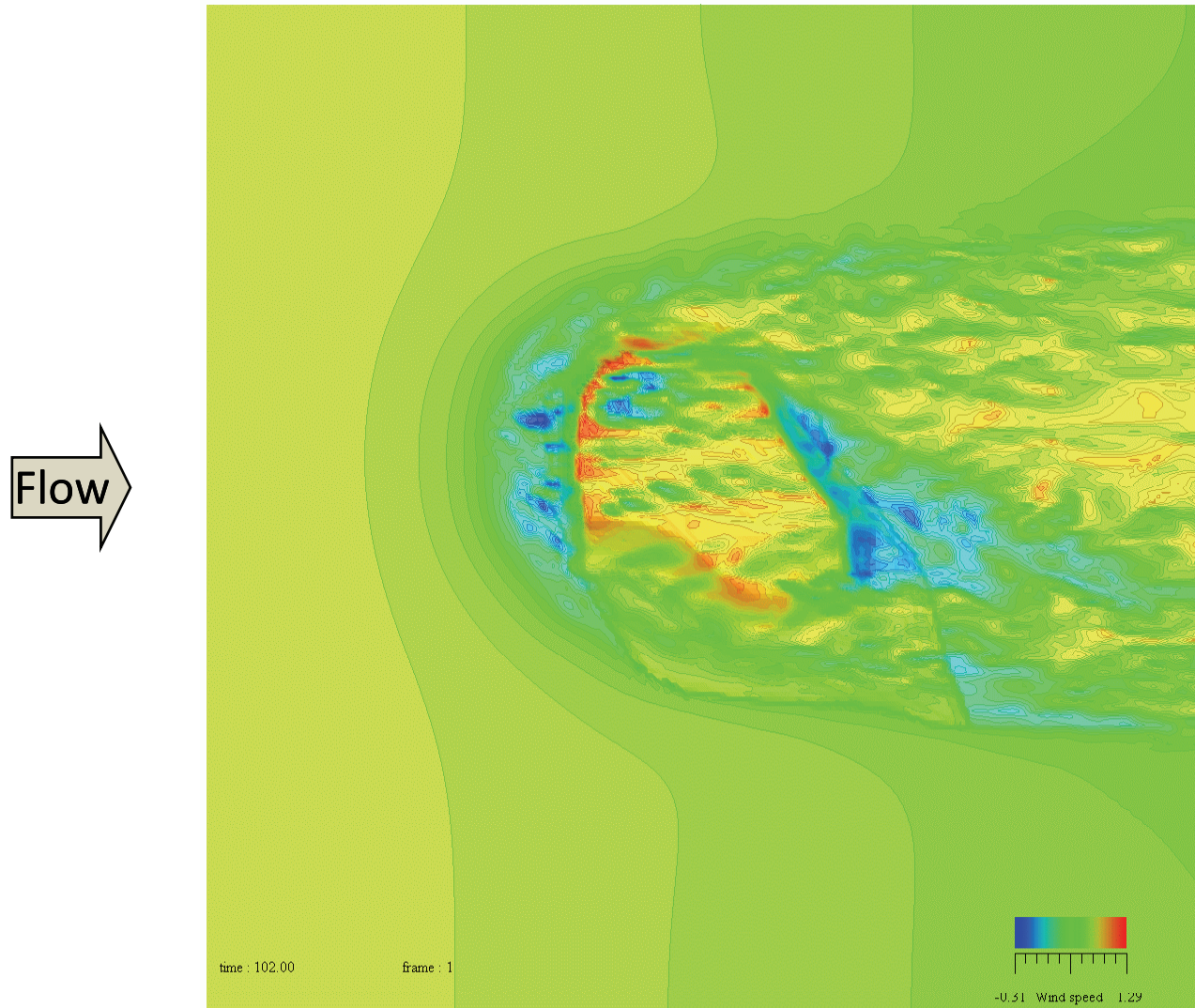
Wind Speed Distribution (U_x) of Vertical Plane along Line A
Time Average Result ($t = 100 \sim 200$)

CFD Results



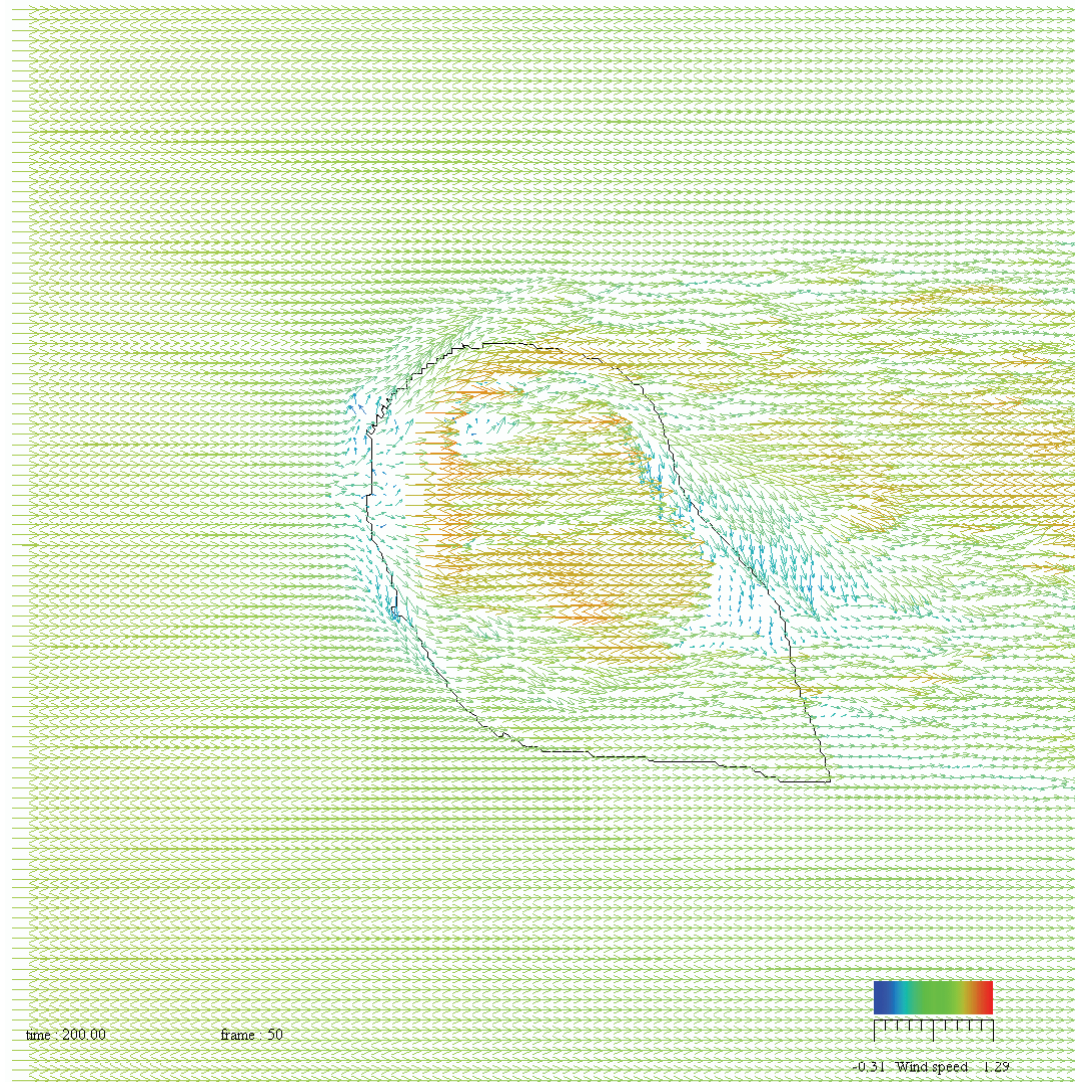
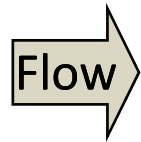
Wind Speed Distribution (Ux) at 2m height
Time Average Result (t=100~200)

CFD Results



Wind Speed Distribution (Ux) at 2m height
Instantaneous Result

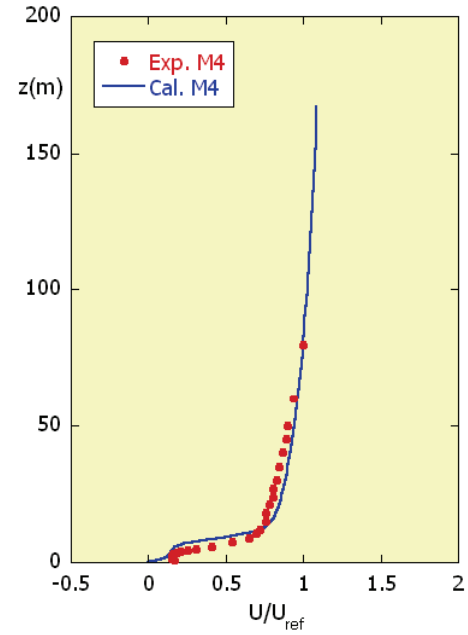
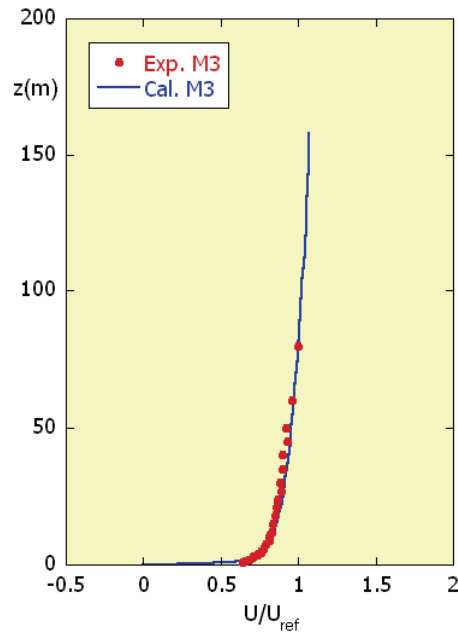
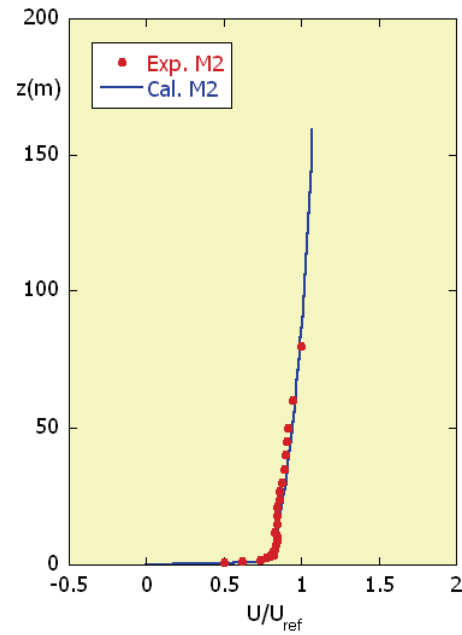
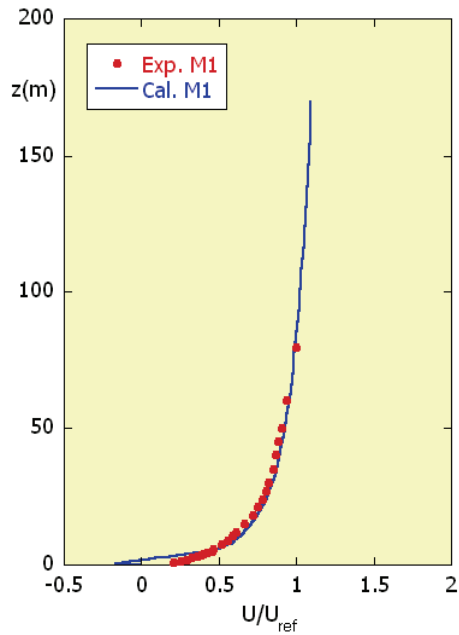
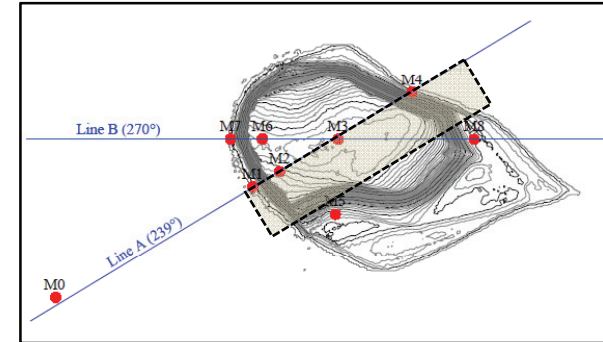
CFD Results



Wind Speed Vector at 2m height
Instantaneous Result

CFD Results

Average Wind Speed Vertical Profile
Comparison of CFD Prediction with Wind Tunnel Data



Summary

- CFD was carried out using LES based RIAM-COMPACT for Bolund Hill (Elevation data from Riso National Laboratory, Denmark).
- Wind tunnel model was constructed and flow measurement was conducted at the wind tunnel facilities at Kato Laboratory, Institute of Industrial Science, University of Tokyo.
- CFD results were compared with experimental data from wind tunnel.
- CFD results are in good agreement with experimental data which demonstrated the effectiveness of LES based CFD.