Modelling wake effects using two CFD techniques

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BUSINESS, SCIENCE & TECHNOLOGY

OBJECTIVE: Validation of BEM-CFD coupling through a Moving Reference Frame (MRF) simulation

CFD approaches to simulate the rotor disks of wind turbines

### Moving Reference Frame (MRF)

• Blade geometry explicitly modelled

• Rotation effects taken into account through source terms (Coriolis force and centripetal) in the momentum equations
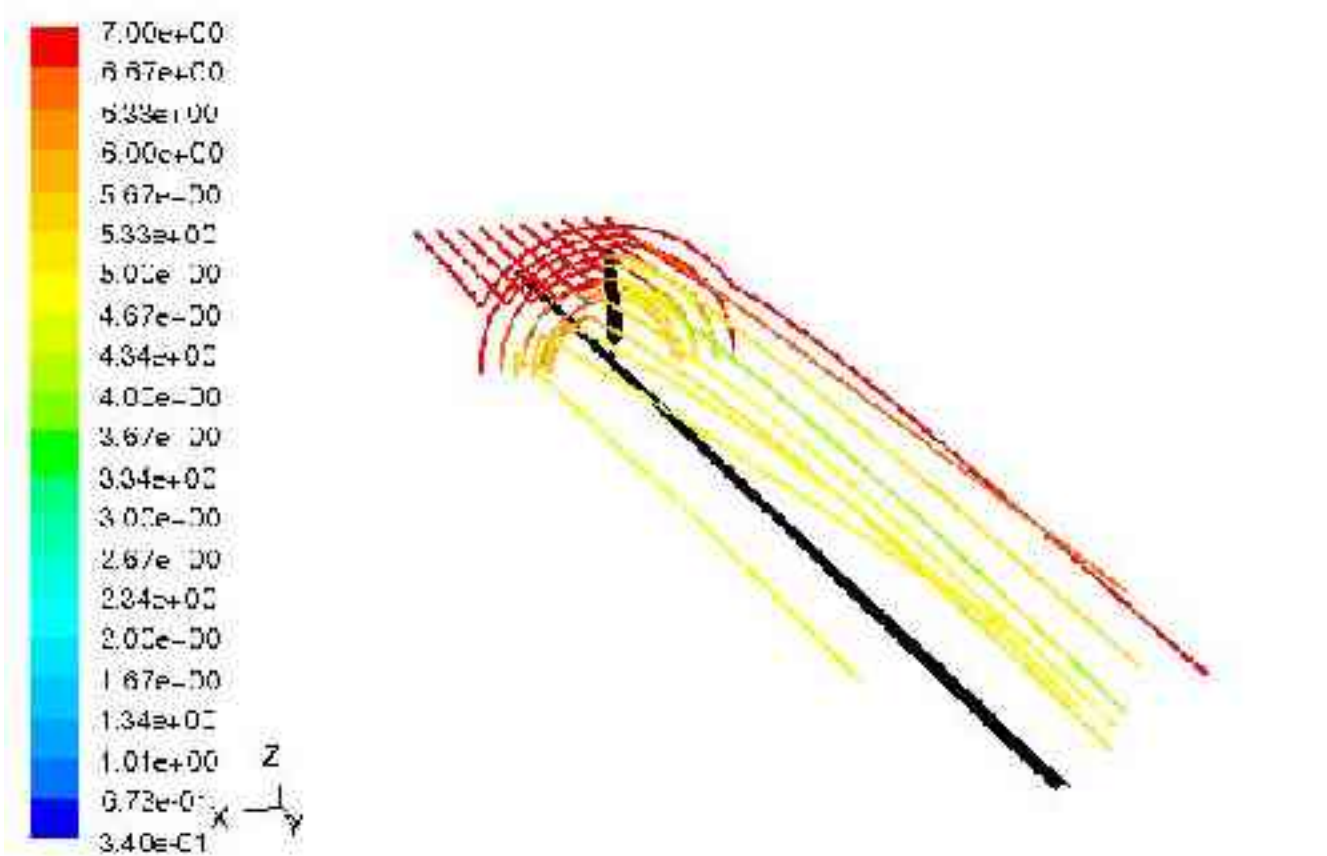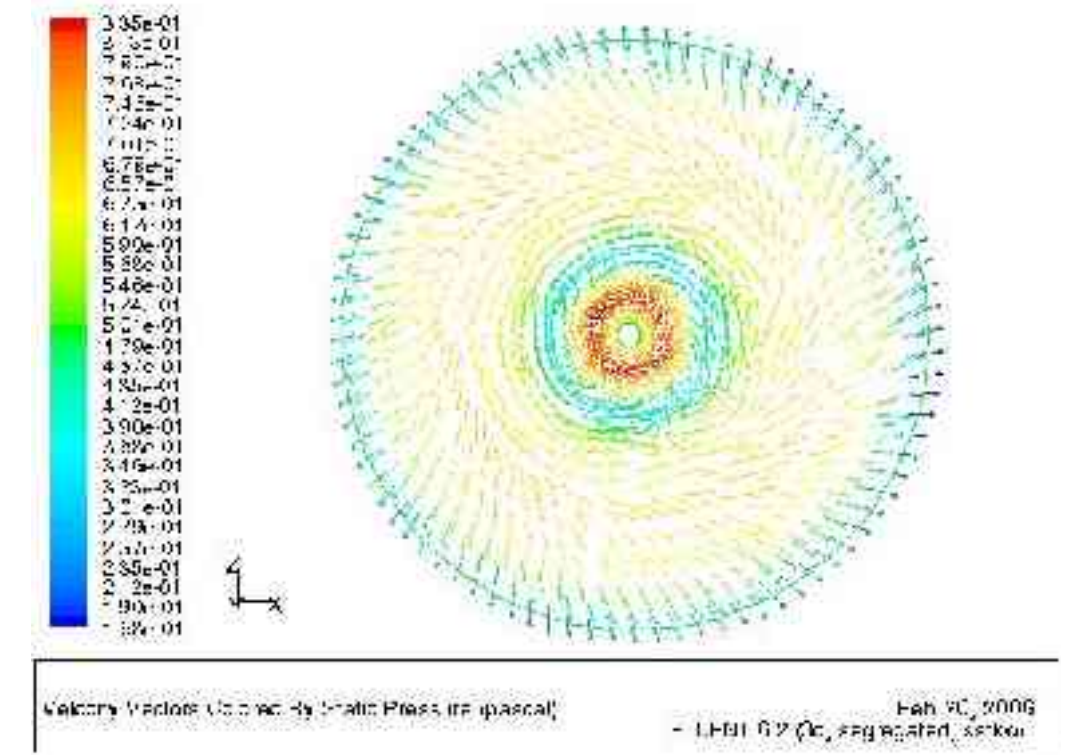

Cell count: 2,745,000

Virtual Blade Model (VBM)

• BEM (Blade Element Theory) -CFD coupling

• Blade geometry implicitly modelled
(Cl-α, Cd-α required)

• No need to generate individual meshes over each of the rotor blades -> reduction of cell count
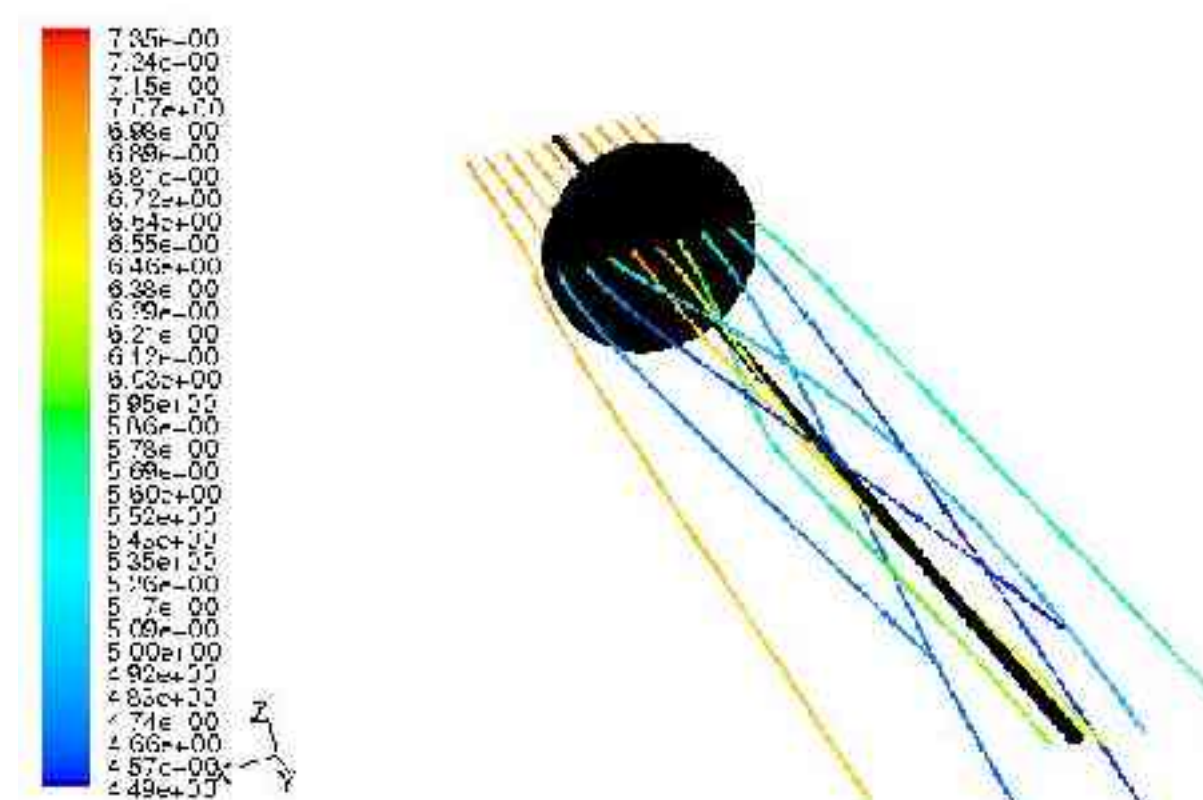

Cell count: 677,000

• Momentum sources obtained from BEM as a function of twist, chord and airfoil types along the radius [2] [3]

• VBM replaces rotor systems with the momentum sources on an actuator disk

Simulation features

• **Dimensions of domain:** 5Φ upstream - > 8Φ downstream
• **Mesh:** Non structured
• **Turbulence model:** kω SST

• **Discretization:**
- 2nd order upwind: momentum X, momentum Y, momentum Z, TKE and ε.
- PRESTO: pressure

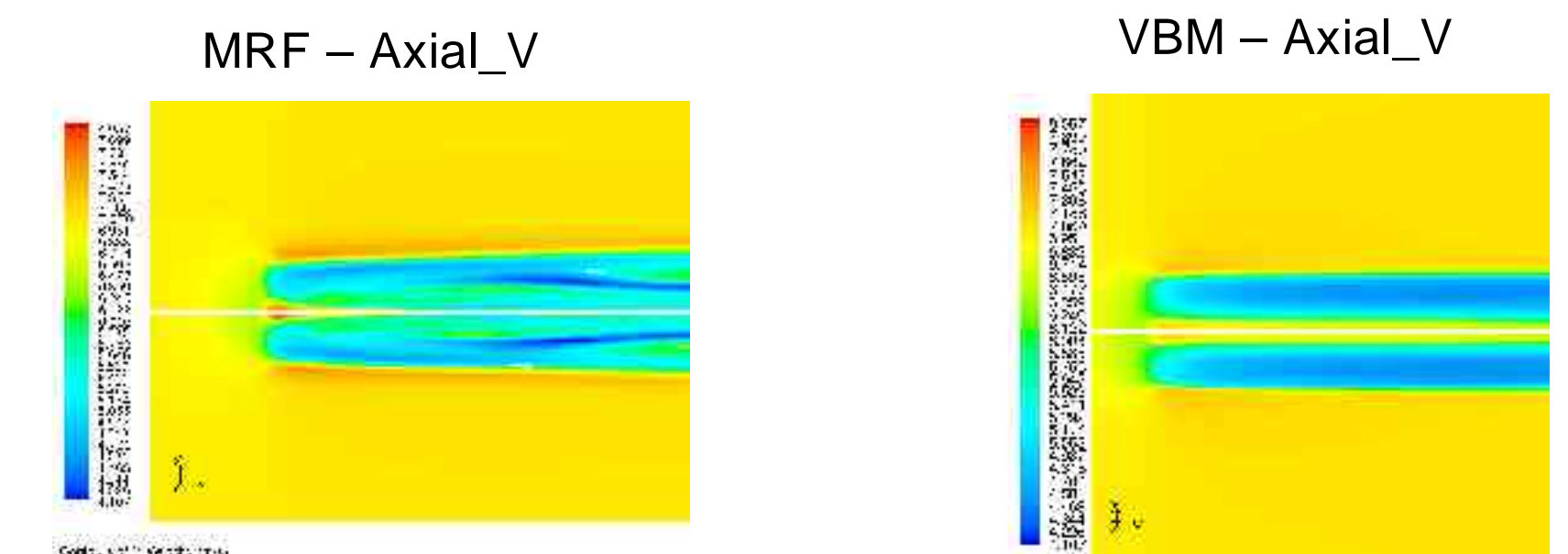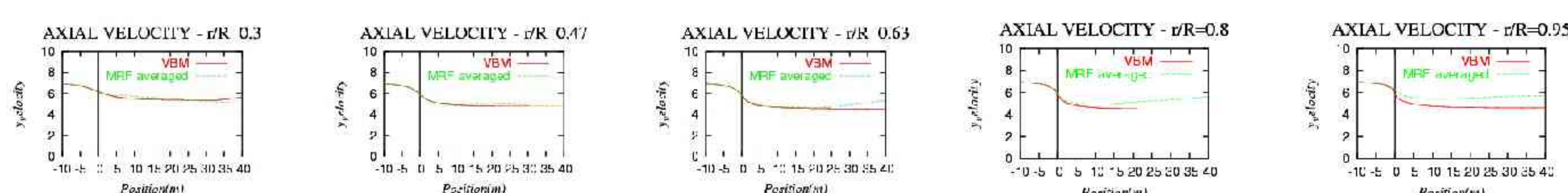## Validation data on forces and pressures over the blades for MRF from NREL Phase VI wind tunnel data
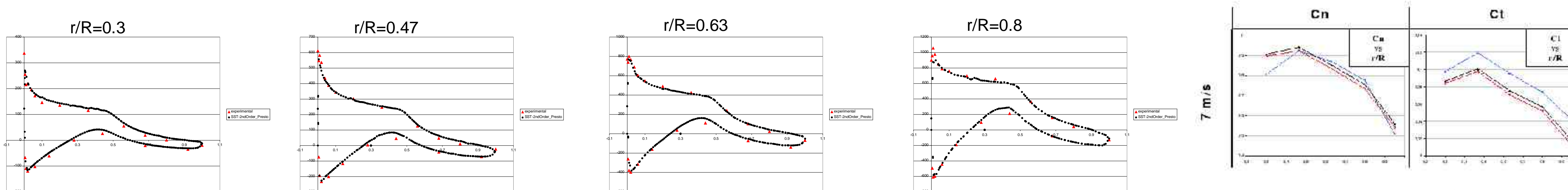
- S809 airfoil
- Sequence S, averaged values for azimuths from -90º to 90º
- Inlet velocity = 7 m/s

Accurate prediction of pressure and forces distribution -> Supposed good description of velocities and pressure downstream [1]
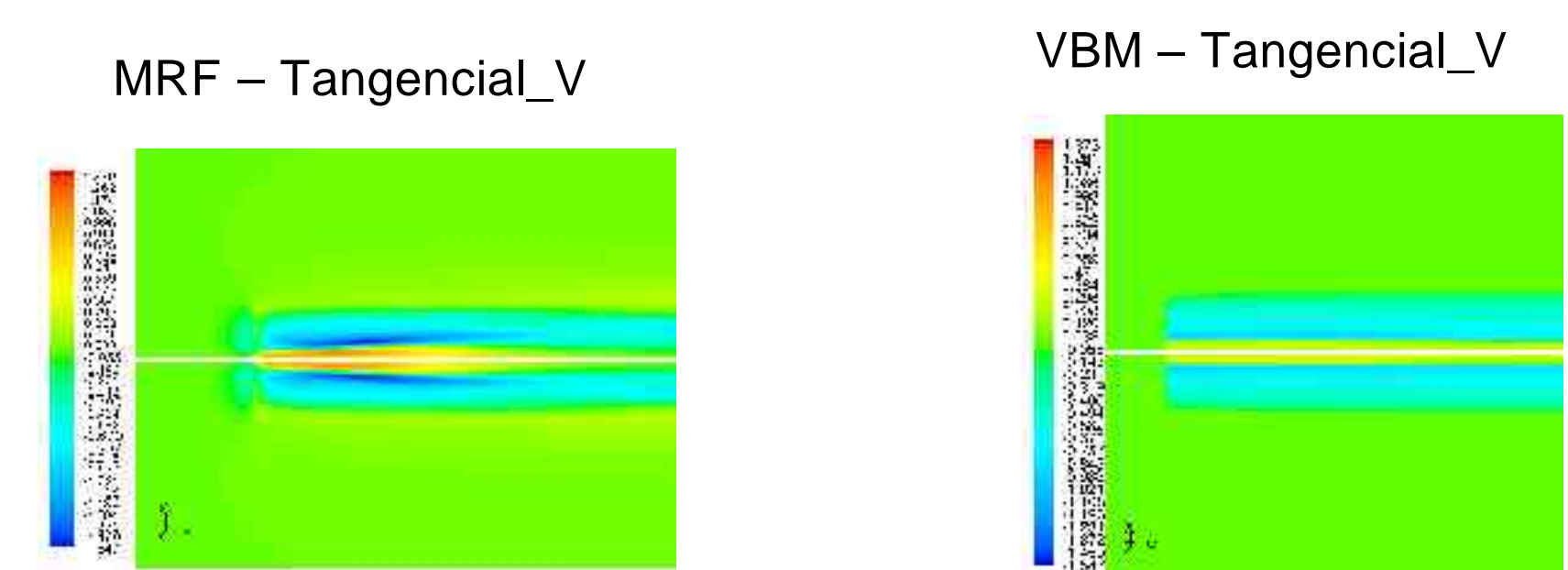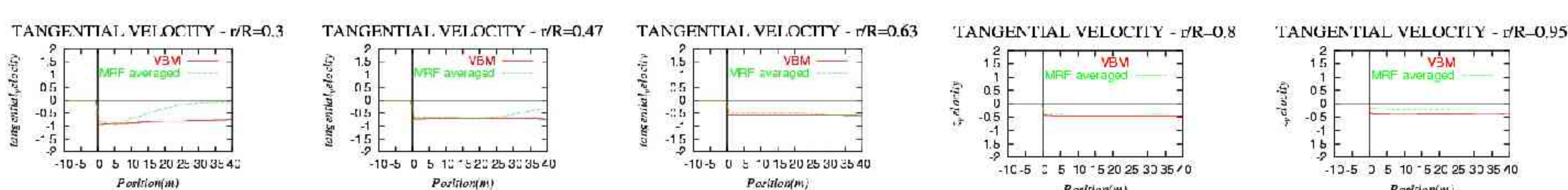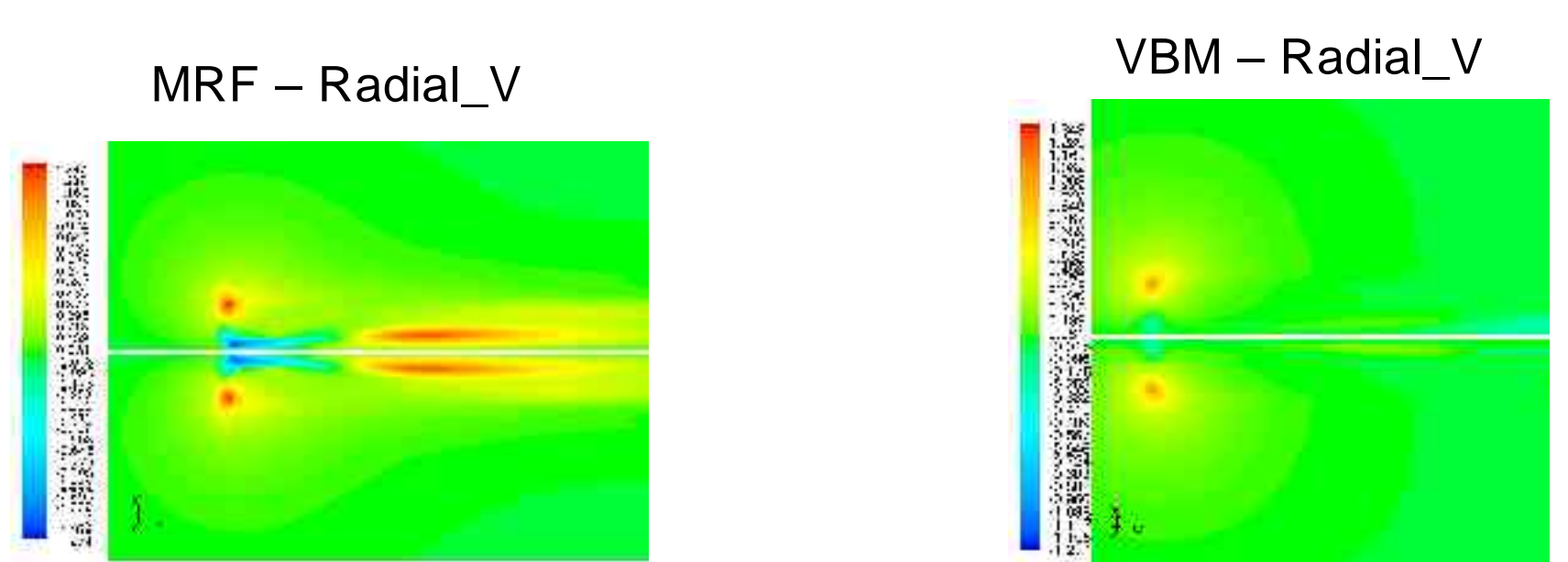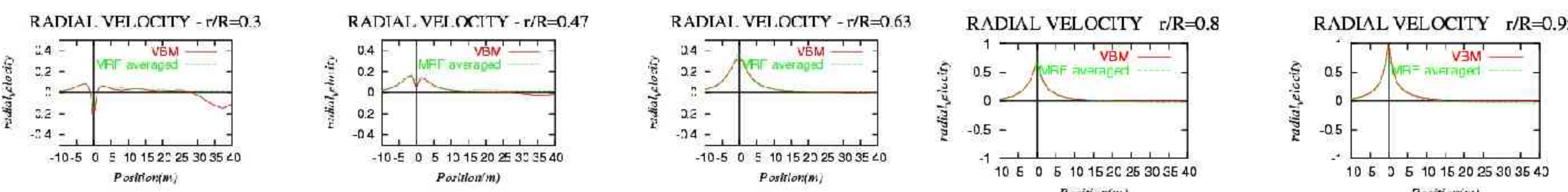
Results

Axial Velocity

MRF – Axial_V   VBM – Axial_V

-Accurate estimation for sections near the root and medium sections
-Slight deviation at 80% and 95% due to tip effect (tip effect correction disabled in VBM)
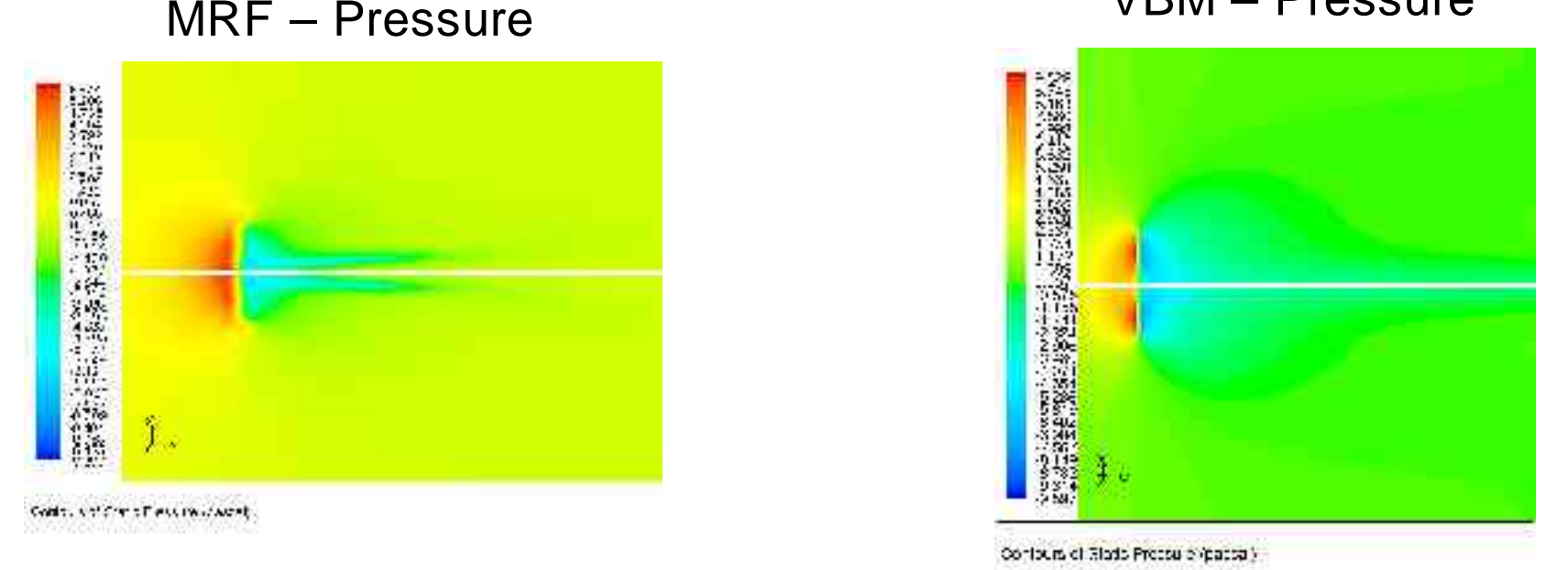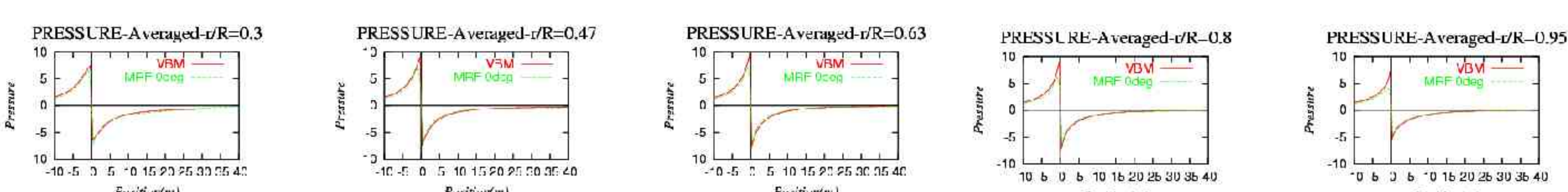
Tangential Velocity

MRF – Tangencial_V   VBM – Tangencial_V

- Deviation of 1 m/s downstream at 30% due to 3D rotational effects

Radial Velocity

MRF – Radial_V   VBM – Radial_V

- Good representation of radial velocity at sections near the tip

Static Pressure

MRF – Pressure   VBM – Pressure

- Similar pressure jump
- Fair description with no important deviations

REFERENCES
[1] Ferrer E., Munduate X., *Preliminary CFD simulations of the NREL Phase VI Rotating Blade*,. European Wind Energy Conference (2006)
[2] Burton, T., Sharpe D., *Wind Energy Handbook*, John Wiley & Sons (2001)
[3] VBM Tutorial Guide, Fluent Inc.
[4] Alinot C., Masson C., *Aerodynamic Simulations of wind turbines operating in atmospheric boundary layer with various thermal stratifications*, AIAA-2002-0042
[5] Fluent Users Guide, Fluent Inc.

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