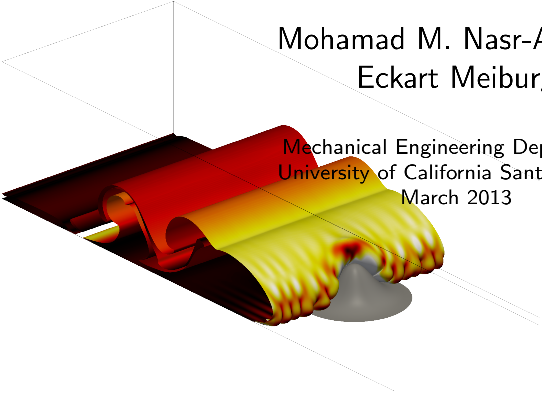
Introduction to TURBINS



Mohamad M. Nasr-Azadani
Eckart Meiburg

Mechanical Engineering Department,
University of California Santa Barbara
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UC SANTA BARBARA engineering

What is TURBINS?

- **TURB**idity currents via **I**mmersed-boundary **N**avier-**S**tokes
- Three-dimensional DNS parallel solver
- C-code using MPI-based parallelism
- Solves density-driven currents: particles, salinity, temperature gradients
- Can handle any complex topography
- TURBINS-2D: only serial

Nasr-Azadani, M. M. and Meiburg, E. (2011), *Computers & Fluids* 45 (1), 14-28.

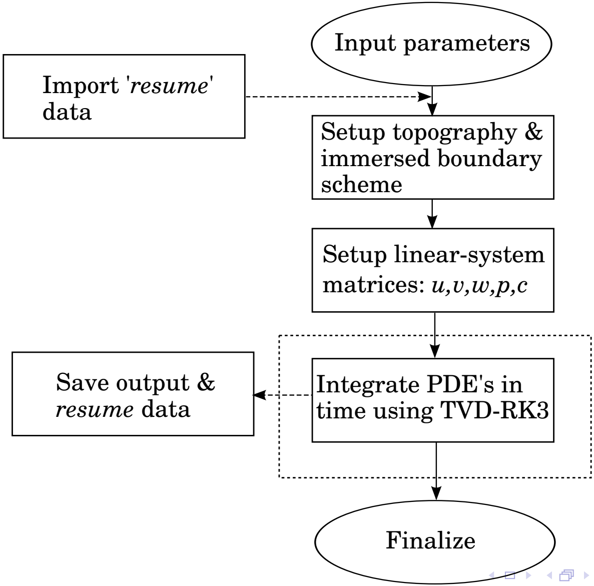
Numerical method

- Viscous terms: Implicit second-order finite difference scheme
- Convective terms: Third-order ENO
- Time integration: Third-order TVD Runge-Kutta method
- To impose a divergence-free velocity field: A fractional projection method
- Complex topography: Immersed boundary method with direct forcing

TURBINS: requirements

- PETSc (http://www.mcs.anl.gov/petsc/)
- Hypre (http://acts.nersc.gov/hypre/)
- MPICH (or any compatible MPI-package)
- ParaView (or Visit) for visualization (post-processing stage)

Code components



Time integration flowchart

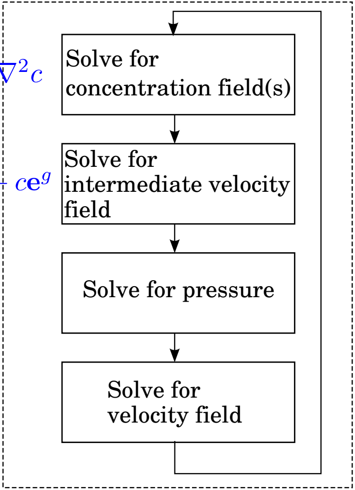
$$\frac{\partial c}{\partial t} + \left(\mathbf{u} + u_s^i \mathbf{e}^g\right) \cdot \nabla c = \frac{1}{Pe} \nabla^2 c$$

$$\frac{\partial \mathbf{u}^*}{\partial t} + \mathbf{u}^* \cdot \nabla \mathbf{u}^* = \frac{1}{Re} \nabla^2 \mathbf{u}^* + c\mathbf{e}^g$$

$$\nabla^2 \phi = \frac{1}{\Delta t} \nabla \cdot \mathbf{u}^*$$

$$\frac{\mathbf{u} - \mathbf{u}^*}{\Delta t} = -\nabla \phi$$

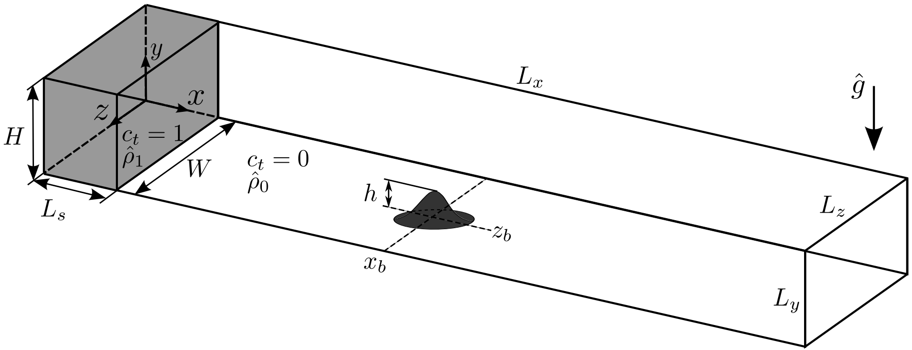
TVD-RK sub-step



Post-processing

- Raw-binary data is saved during simulation runtime
- A data-converter is run separately to convert data into VTK format
- VTK format can be visualized in: **ParaView** and **Visit**
- Other data analysis: simply use MATLAB, Python, etc

General setup: lock-exchange configuration



Input parameters

- Basic information should be passed to TURBINS via **input.inp**
- Several fine-tuning parameters should be set in **Input.c**
- Bottom topography should be described in **Grid.c**, function **Grid_describe_interface(...)**

Input parameters: example 'input.inp'

```
************************************************
*************1-Geometrical Parameters:**********
Number of Cells in x-direction:
50
Number of Cells in y-direction:
30
Number of Cells in z-direction:
5
Minimum x:
0.0
Maximum x:
5.0
Minimum y:
0.0
Maximum y:
1.5
Minimum z:
0.0
Maximum z:
0.1
************************************************
*************2-Grid:****************************
Is X-Grid Uniform (YES/NO)?:
YES
Is Y-Grid Uniform (YES/NO)?:
YES
Is Z-Grid Uniform (YES/NO)?:
YES
Import Grid From File (YES/NO)?:
NO
************************************************
*************3-Flow Parameters:*****************
Reynolds Number:
2200.0
Number of Concentration Fields:
1
Peclet Number(s):
2200.0
Initial Maximum Volume Fraction of Each Concentration Fiel
1.0
Particle Settling Velocity(ies)(in y-direction):
0.02
Physical Particle Volume Fraction(s):
0.0
************************************************
*************4-Runtime Parameters:**************
Maximum Simulation Time:
35.0
Saving Output Results Time-Step:
0.2
************************************************
*************5-Lock Parameters:*****************
Initial x Position of Lock:
1.0
```

Acknowledgment

- Dr. Brendon Hall
- PETSc team
- CSDMS: Beach, Janus supercomputing facility

Contact

- TURBINS is a research code: still evolving
- Contact me for installation, job submission and more

  mmnasr@engineering.ucsb.edu
- Check CFD-lab website for more updates

  https://sites.google.com/site/ucsbcfdlab/