Direct Numeric Simulations: Turbulent Flows

Challenges in Turbulence

Small scale structures require high resolution

Nonlinear term is relevant

Reynolds = Inertial / Viscous Forces = Captures Nonlinearity

$$\frac{\partial \vec{u}}{\partial t} + \vec{u} \cdot \nabla \vec{u} = \cdots + \frac{1}{Re} \nabla^2 \vec{u}$$

Approach

Extremely simplified physics: 2D, Incompressible, periodic BC, homogeneous

Solve in Fourier space

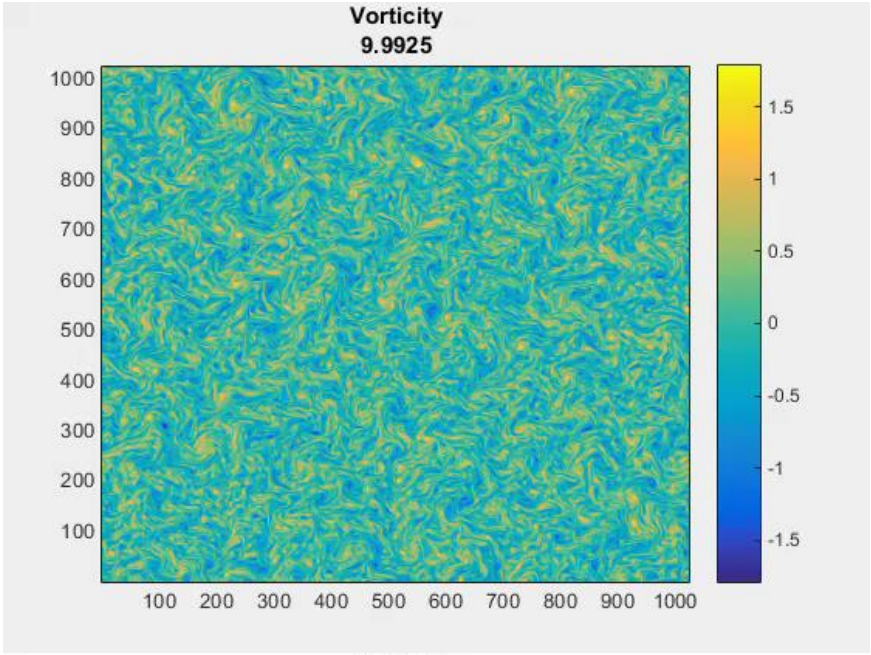
Use integration scheme to maximize Δt

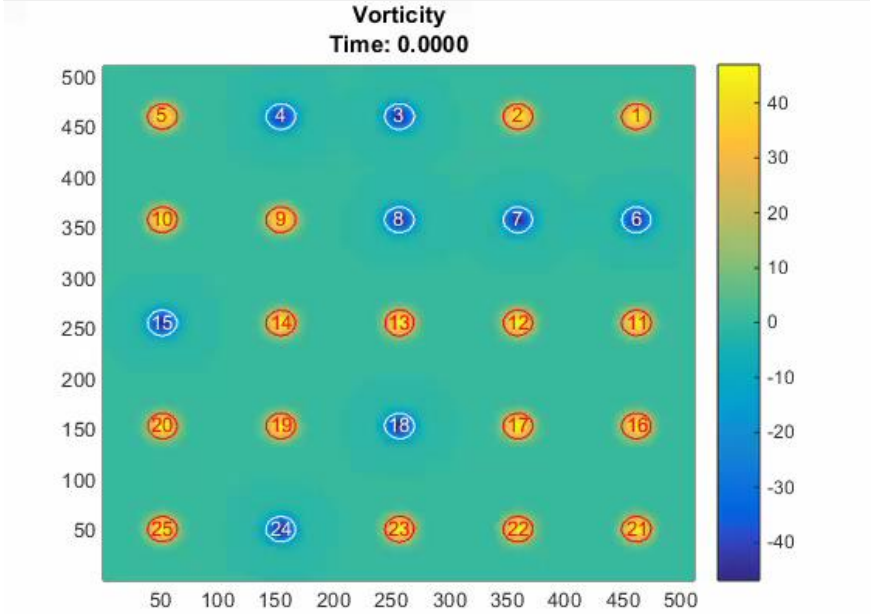
Computational Problem

Higher Re → refined mesh → smaller Δt → Increased cost

Turbulence is chaotic – many sims needed for reliable stats

Even with simplified physics simulations take a week





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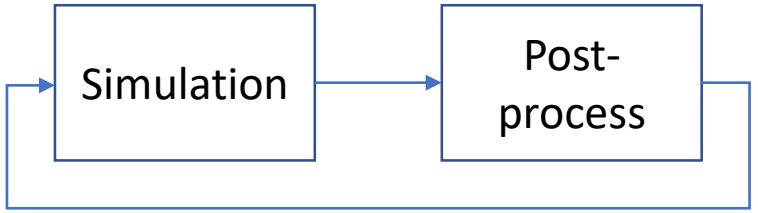
Short term work
Code Optimization
Parallel Programming
Post-process feedback to simulation
GPU Computing
Build cluster

Long term work
Model additional physics
3D turbulence
Heat transfer
Complex geometry

```
for k = 1:Num_Vortices
    Update_Perimeter()
    Update_Properties()
    Verify_Structure()
end
```



Update Δt
Update N
End loop