Numerical Modeling of Brash Ice

Author:

Ivan Montenegro Cabrera

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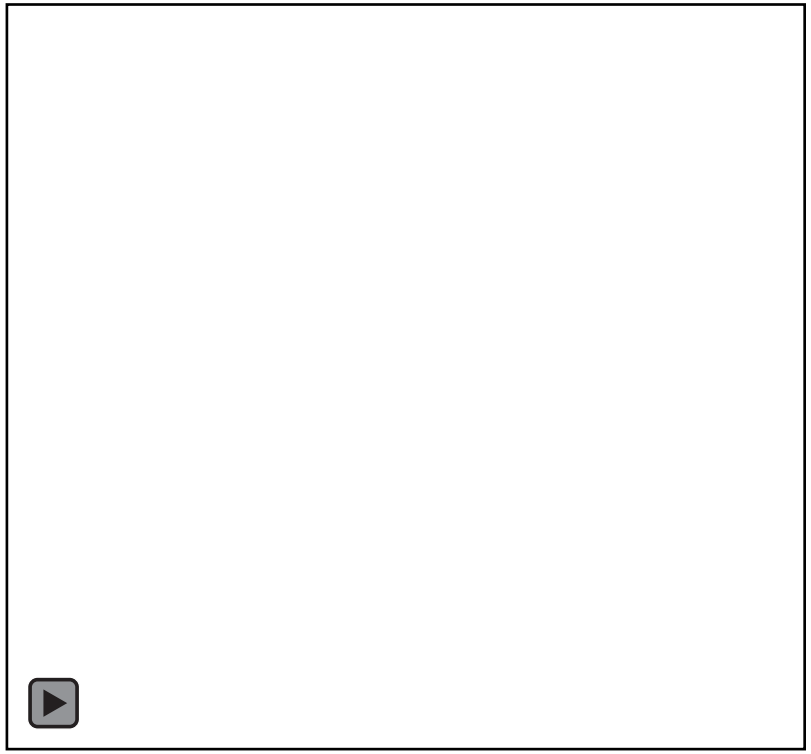
CONTENTS

1.1 BRASH ICE DESCRIPTION AND PROBLEMATIC

- Mixture of rigid ice pieces and water
- Common in arctic channels of navigation
- Affects resistance and behavior
- No complete numerical model available

- Scope:
  - Only granular flow approach explored



2.1 BRASH ICE AS A GRANULAR FLOW

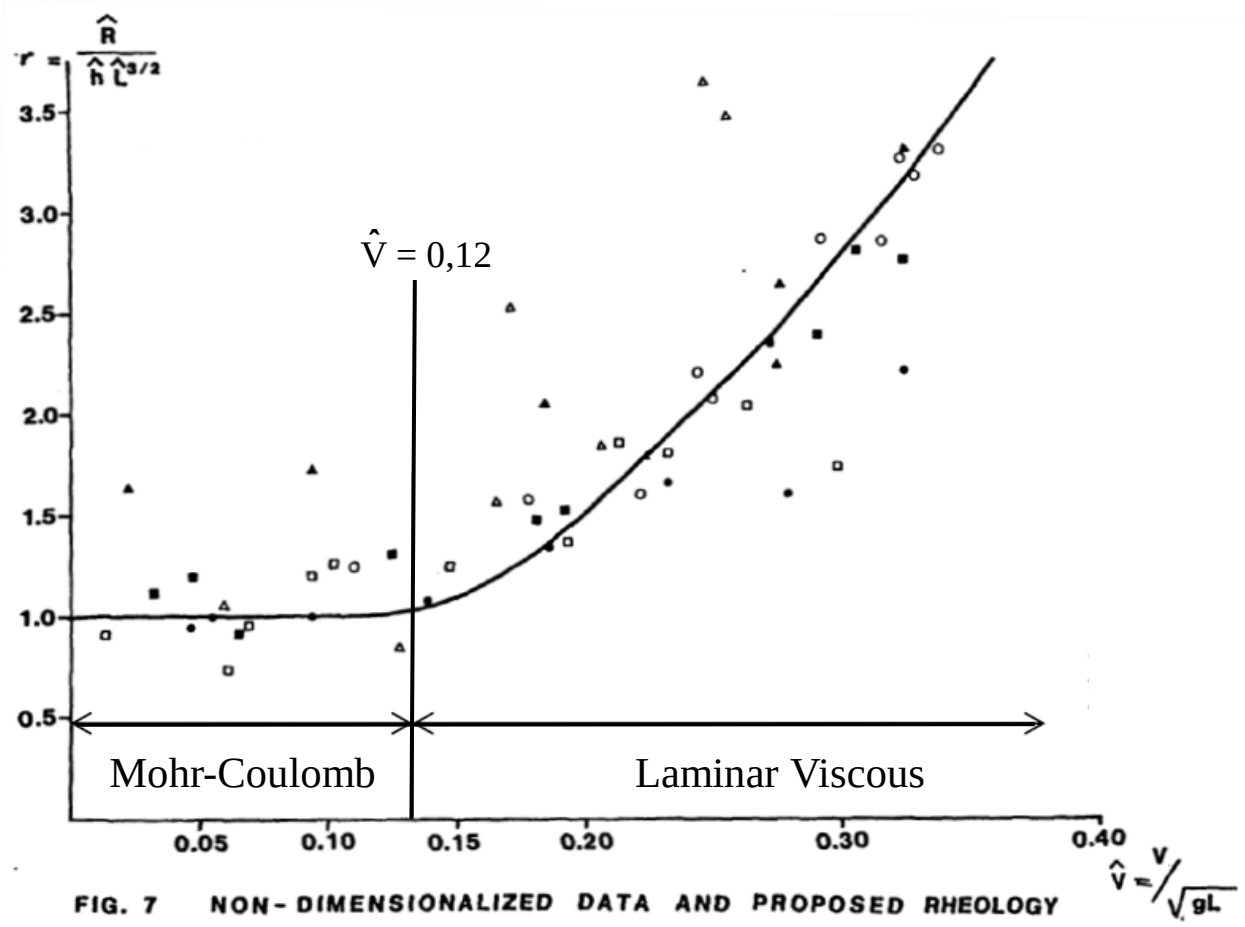


FIG. 7 NON-DIMENSIONALIZED DATA AND PROPOSED RHEOLOGY

Data taken from US Navy "Brash ice behavior", 1981

- Mohr-Coulomb region:
  - Constant resistance
  - Strain-rate independent
- Laminar viscous region:
  - Power law resistance
  - Strain-rate dependent

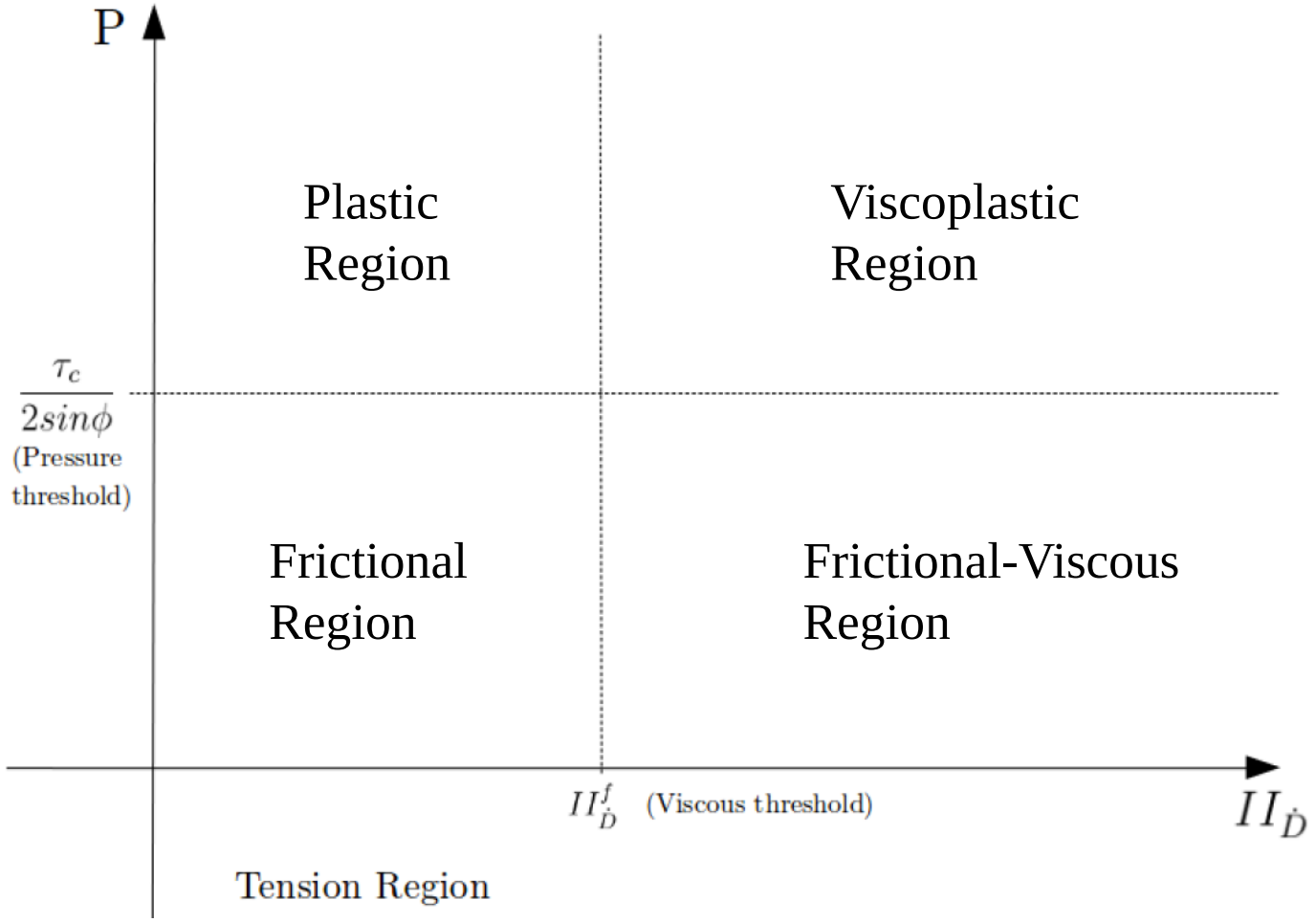
2.2 GRANULAR FLOWS DESCRIPTION

- Flow of grain:
  - Carrier phase, dispersed phase
  - Between solid and fluid behavior

- Rheology:
  - Relation between strain-rates and shear stresses

- Represented by continuum mechanics equations

2.3 BRASH ICE PROPOSED RHEOLOGY

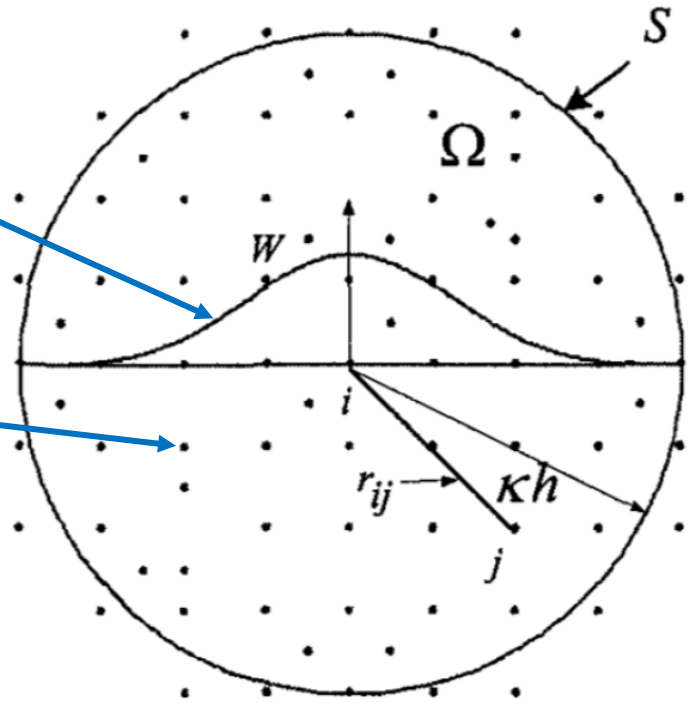


Parameters involved:

- P: Pressure
- II_D : Second invariant
- τ_c: shear strength
- ϕ: friction angle
- μ: viscosity

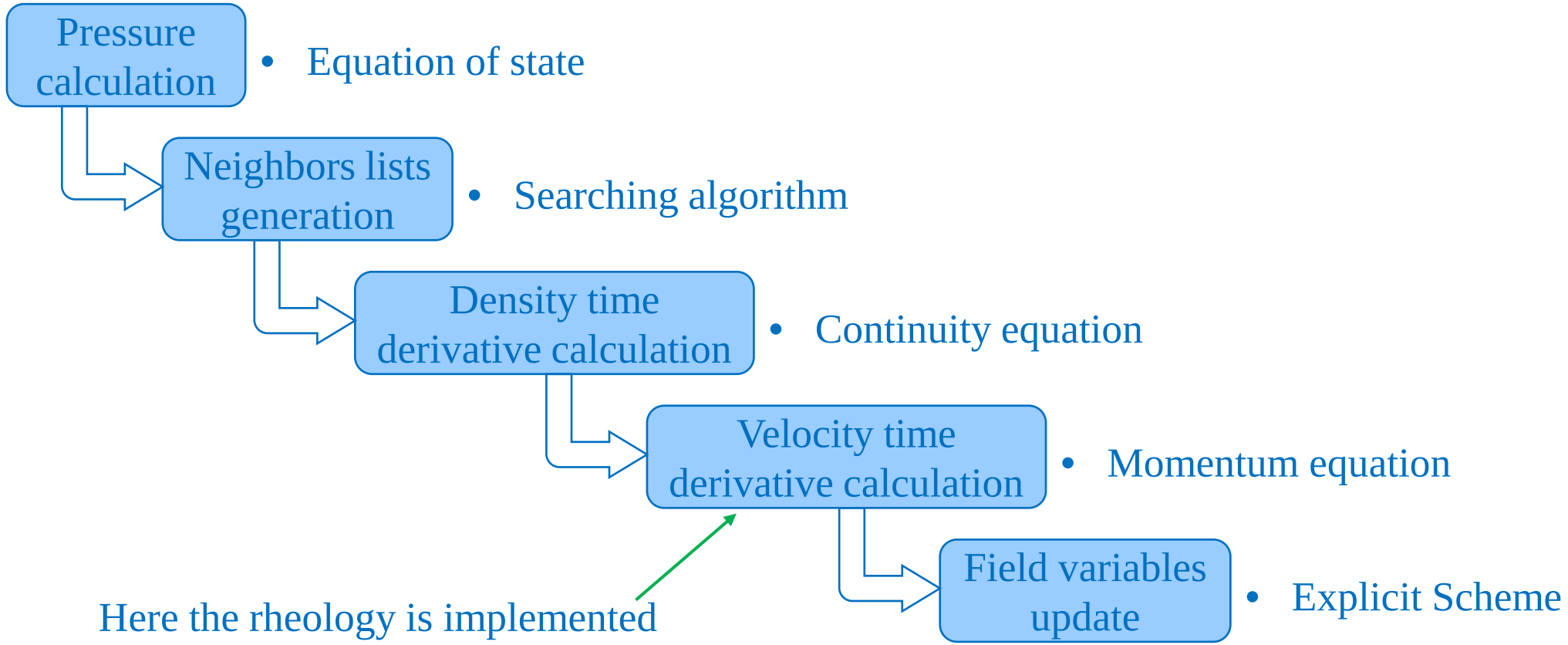
3.1 SMOOTHED PARTICLE HYDRODYNAMICS (SPH)

- Kernel approximation
  - Smoothing length, Kernel function
- Particle approximation
- Main advantages:
  - Differential operators only affect the Kernel function
  - Mesh-free

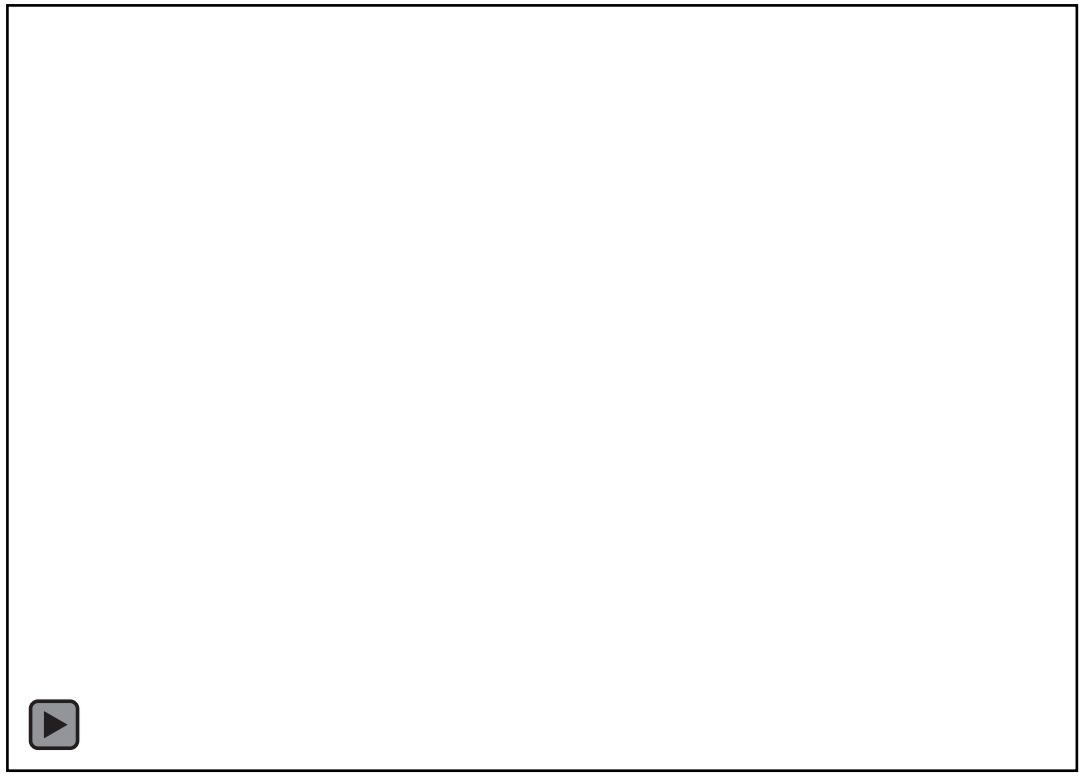


G.R. LIU & M.B LIU, “Smoothed Particle Hydrodynamics a Meshfree Particle Method”

4.1 OPEN SOURCE – “DualSPHysics”

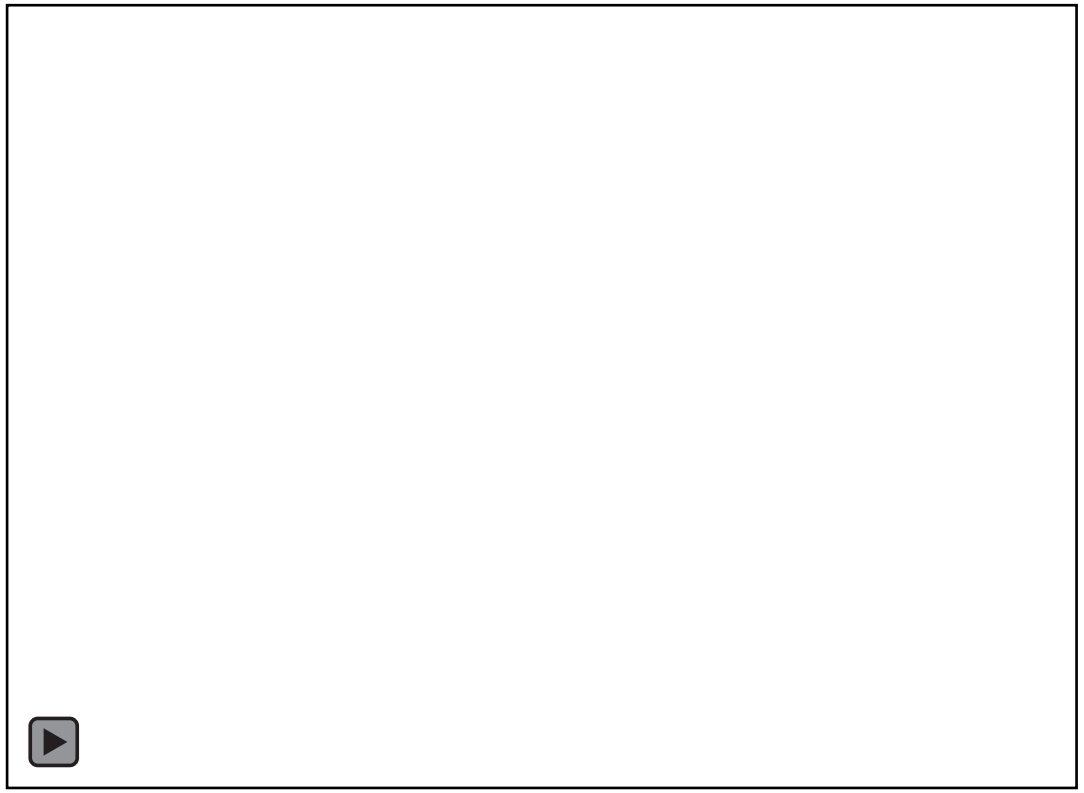


4.2 MODIFICATION RESULTS



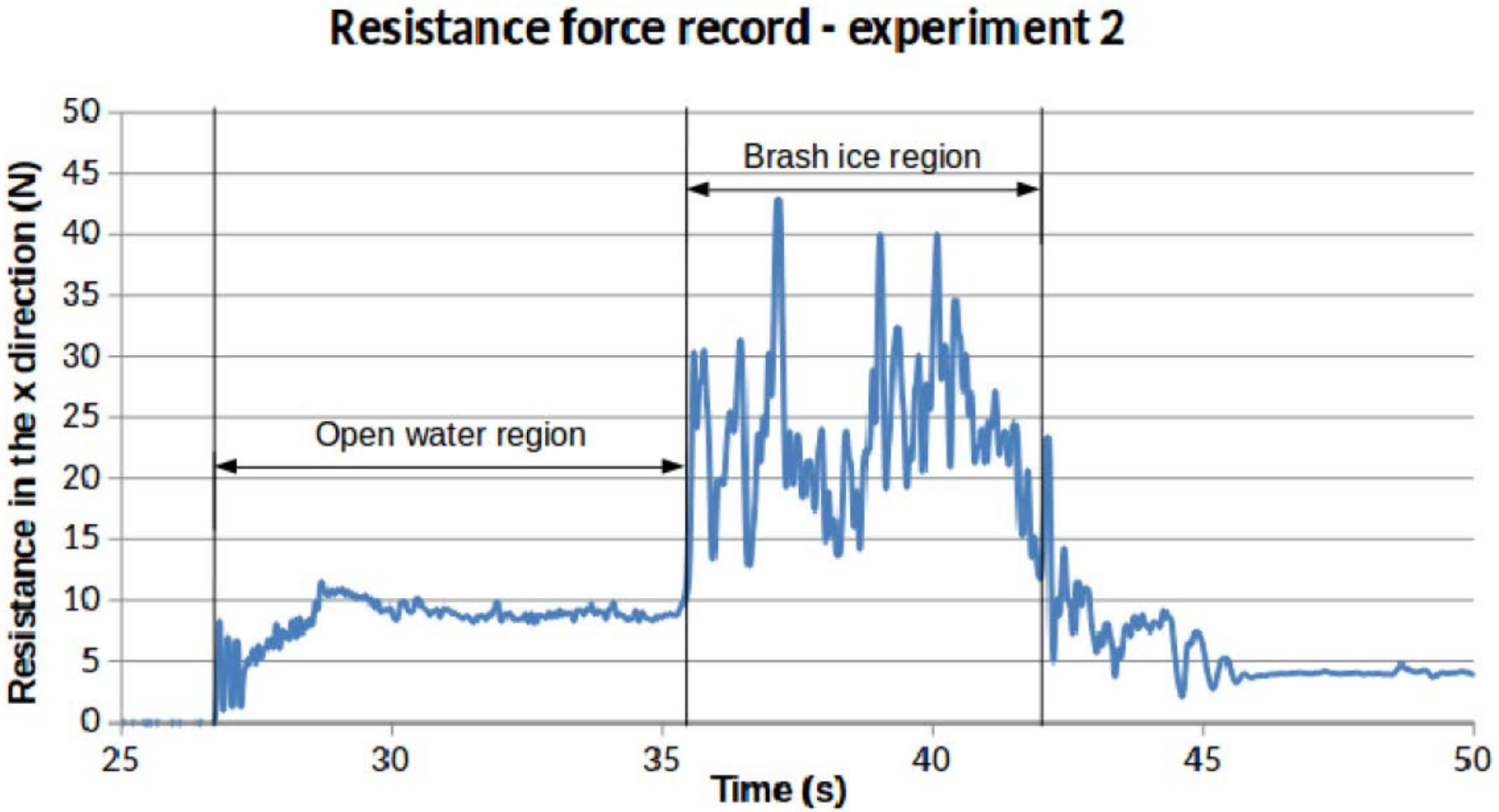
- Granular flow behavior
- Time convergence
- Influence of parameters

5.1 CYLINDER TEST DESCRIPTION

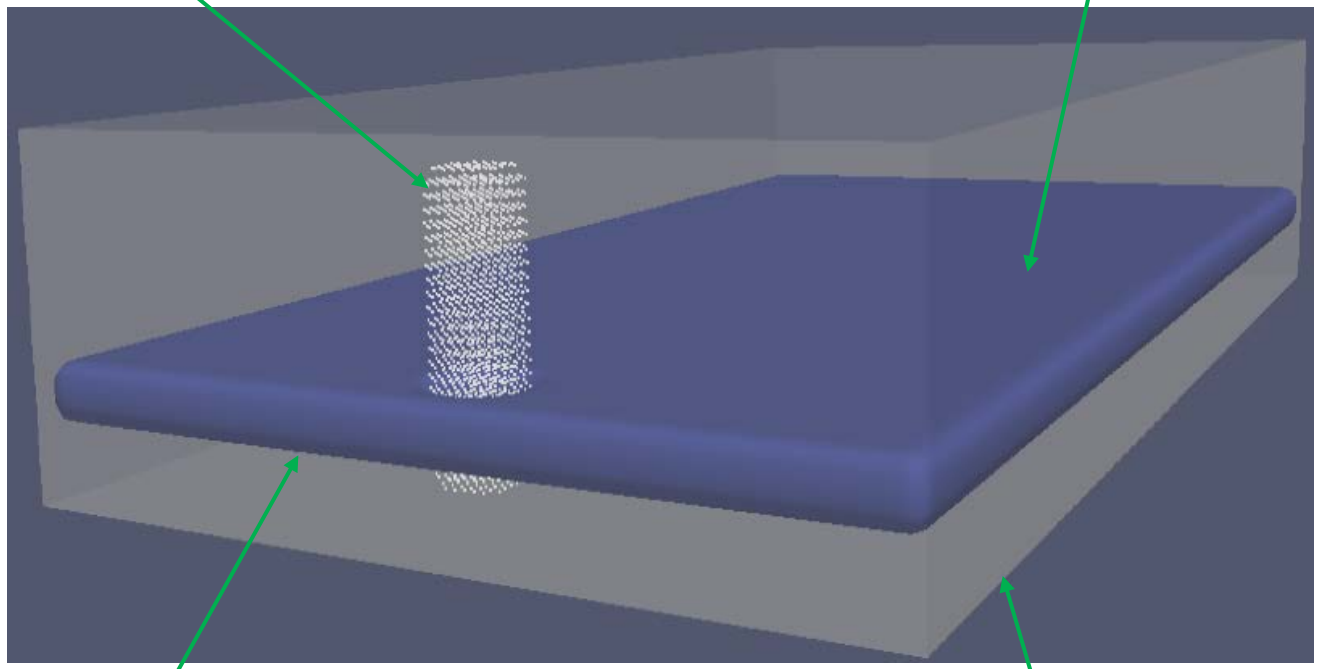


- Constant speed
- Fixed draft
- Two regions
- Resistance measurement

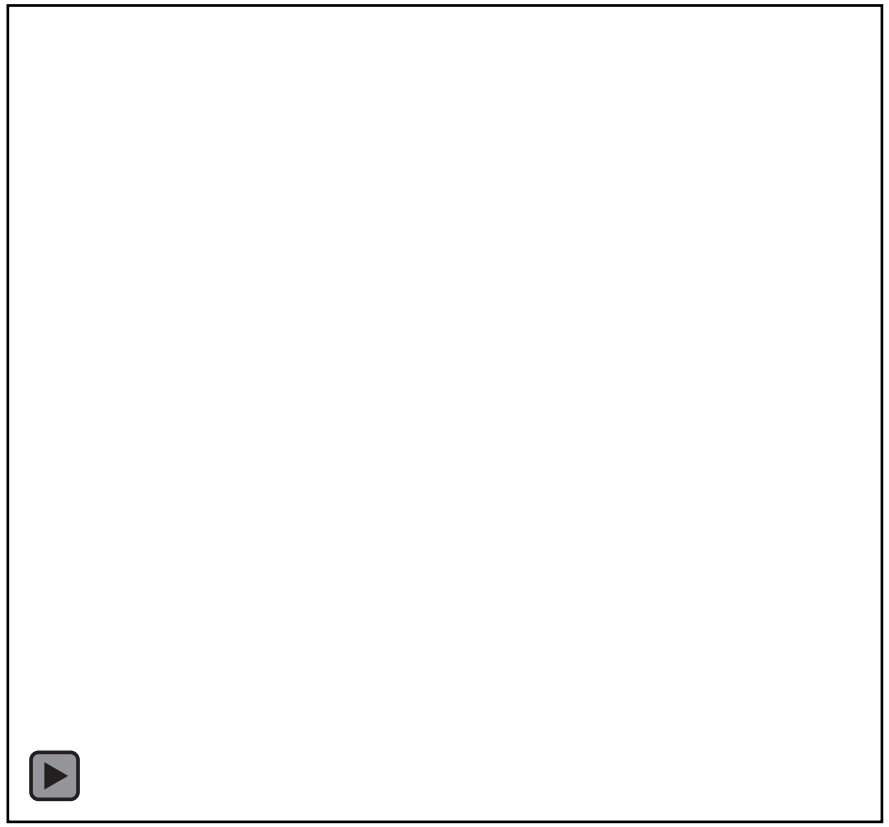
5.2 CYLINDER TEST - RESISTANCE RESULTS



5.3 BRASH ICE MODEL DESCRIPTION

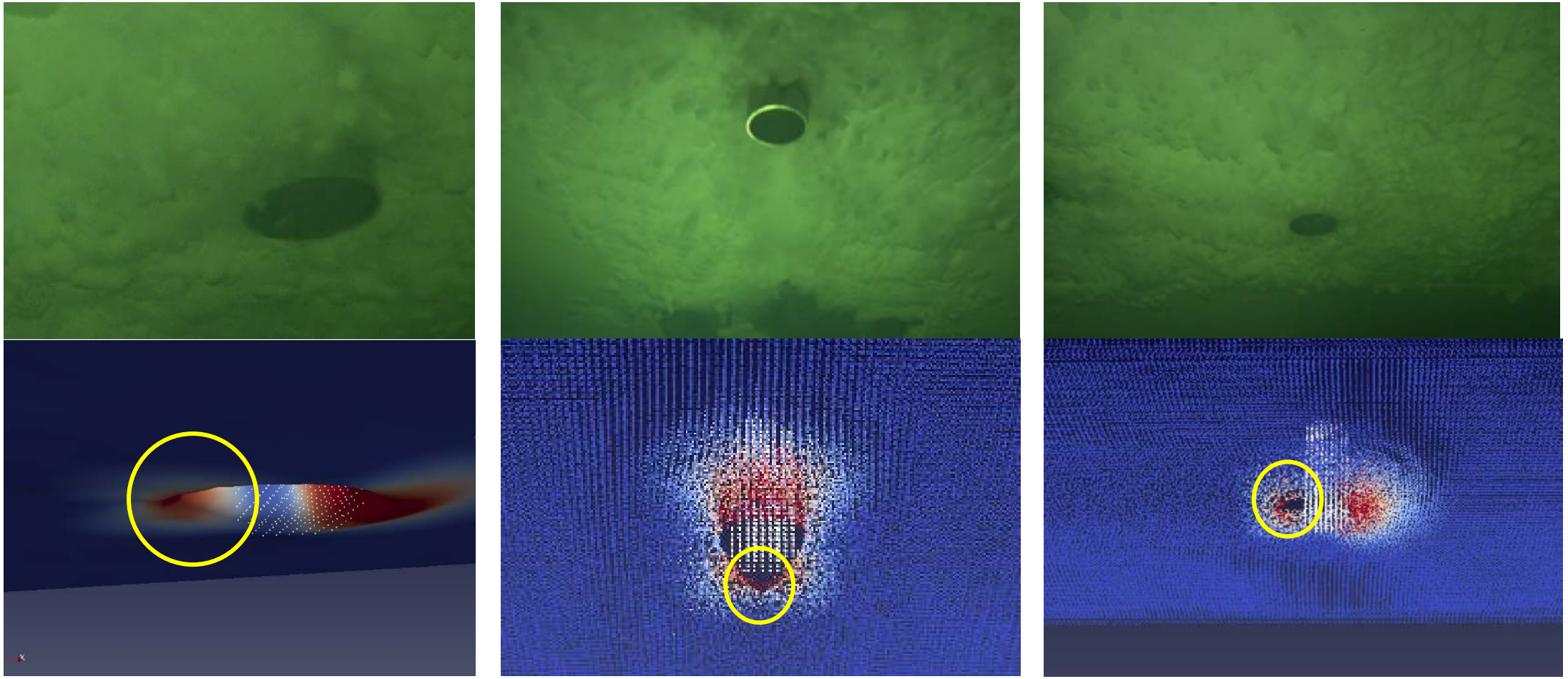


5.4 BRASH ICE REGION - SIMULATION

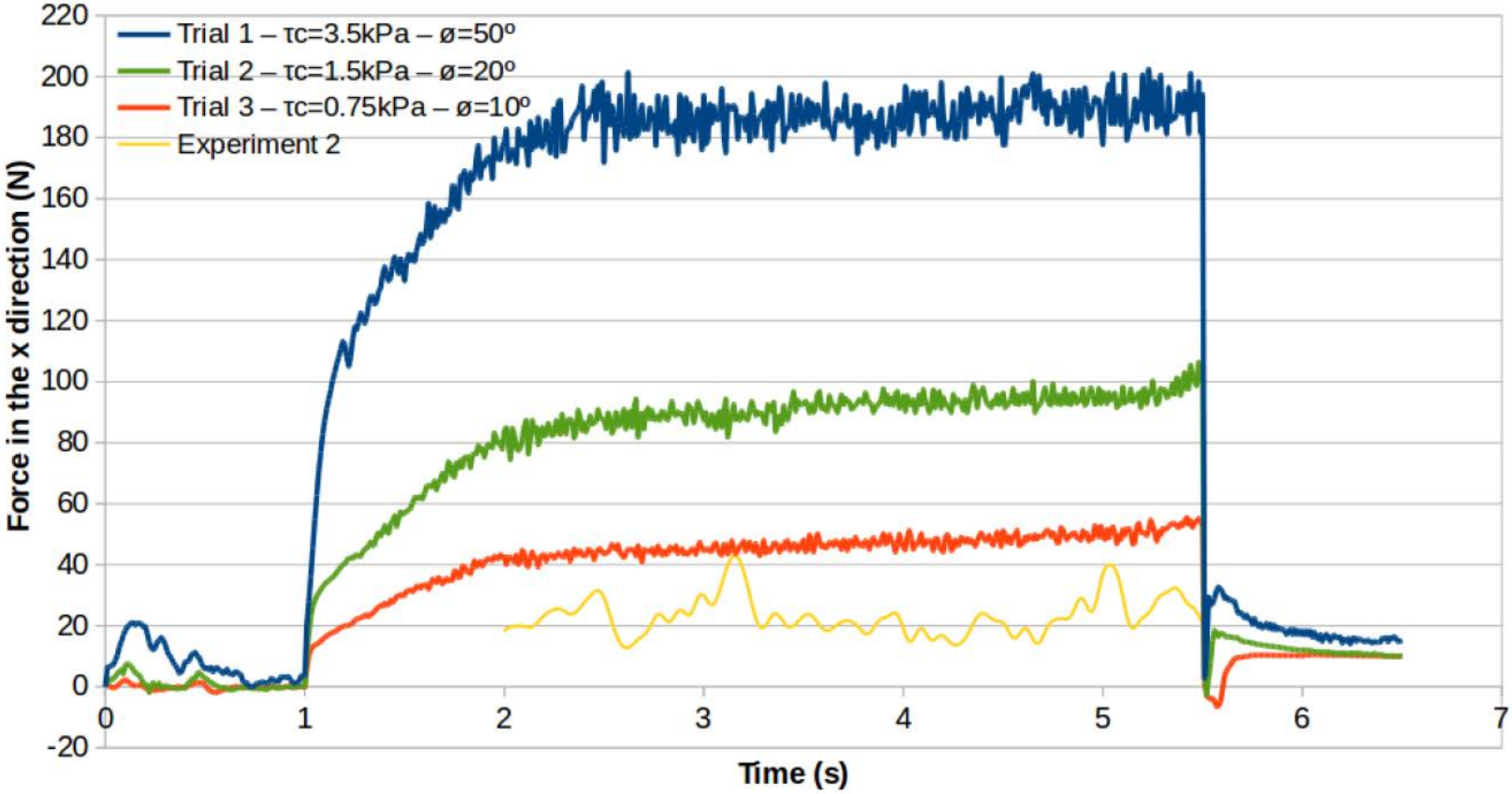


- Different parameters tested
- Visual comparison
- Resistance comparison

5.5 BRASH ICE REGION - VISUAL COMPARISON



5.6 BRASH ICE REGION - RESISTANCE COMPARISON



CONCLUSIONS

- Granular flow equations can describe brash ice as a medium
- More complex rheological behaviors can be tested
- A reasonable set of parameters can be selected to provide sounder results