

Jahrestreffen der ProcessNet Fachgruppen Extraktion, Phytoextrakte und Membrantechnik
Frankfurt, May 23 to 24, 2022

Drop-Based Modeling of Batch Settlers: The Final Model

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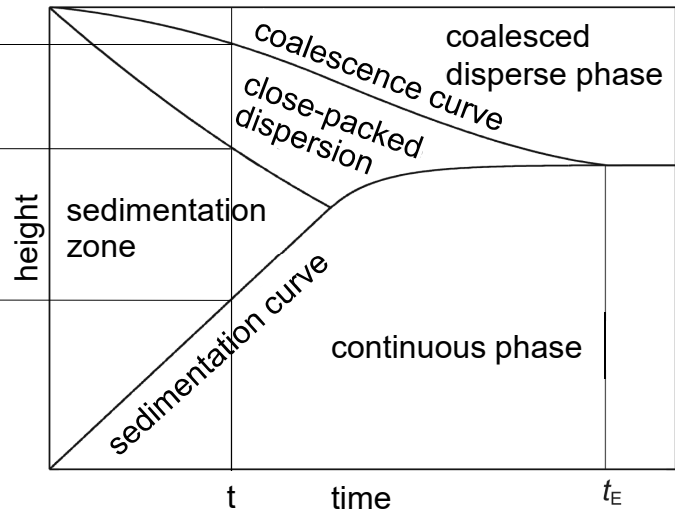
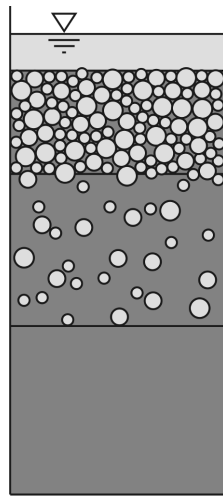


agenda

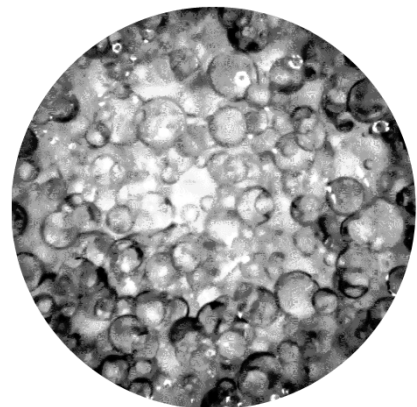
- general settler concepts
- experimental approach
- sedimentation
- coalescence
- conclusions



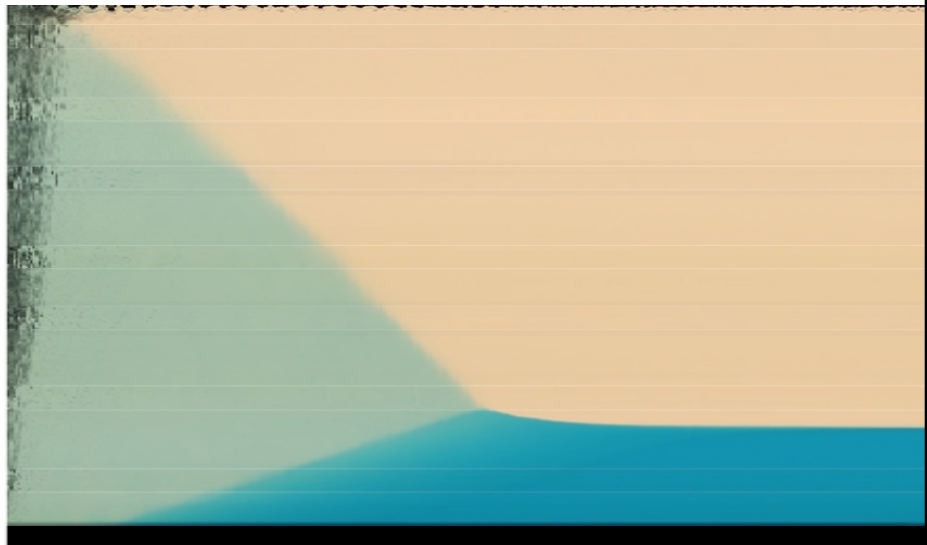
general settler concept



settling cell with SOPAT probe



iso-optical system

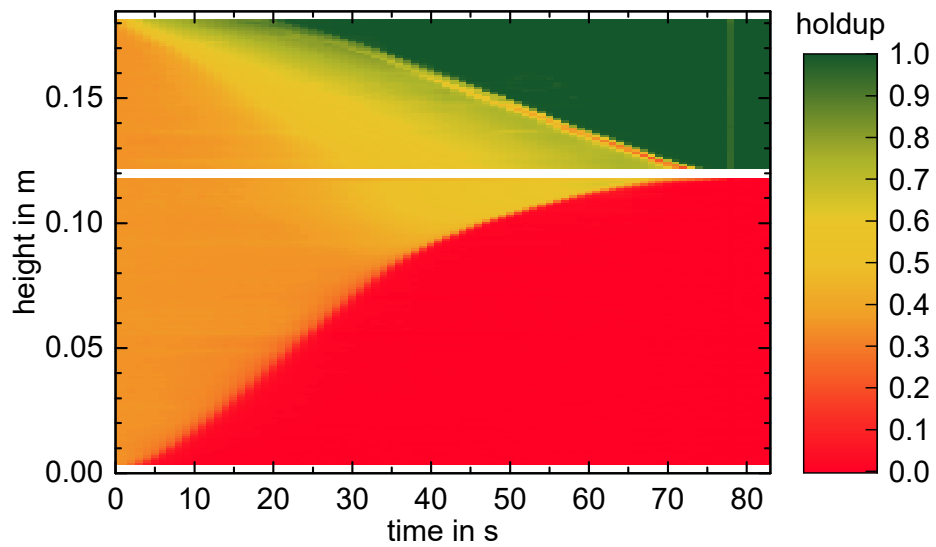


PEPs water + ethylene glycol + hexane
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experimental holdup, initial holdup: 35 % organic



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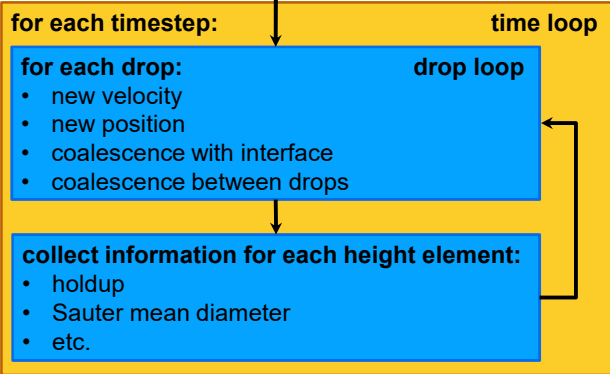
6



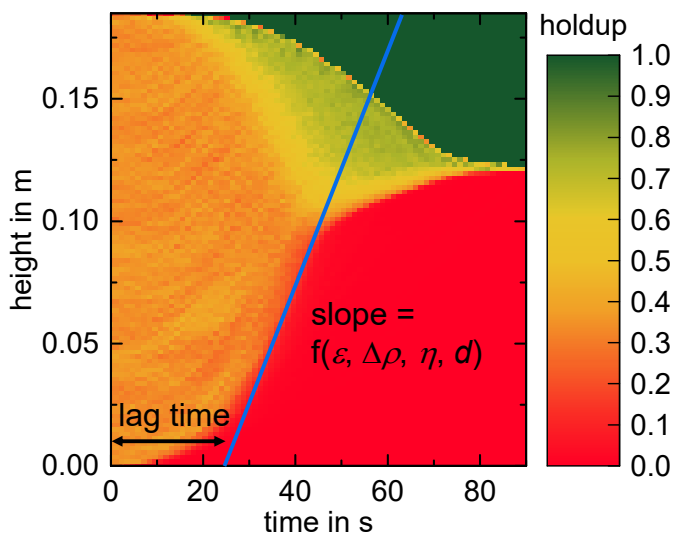
ReDrop: drop-based modeling

definition of system:

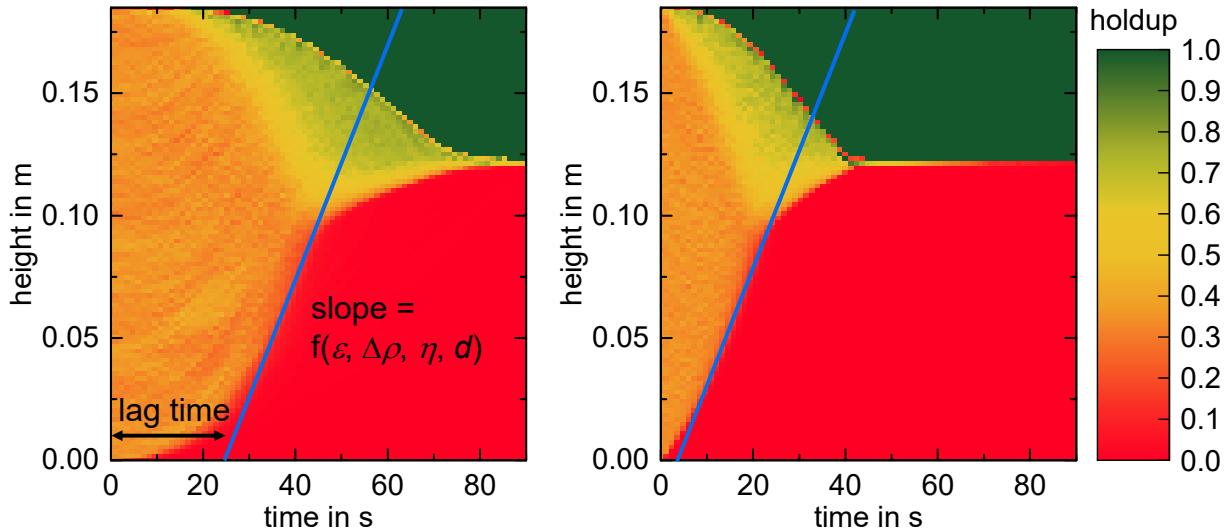
- material properties
- process variables
- simulation parameters
- set up arrays and system



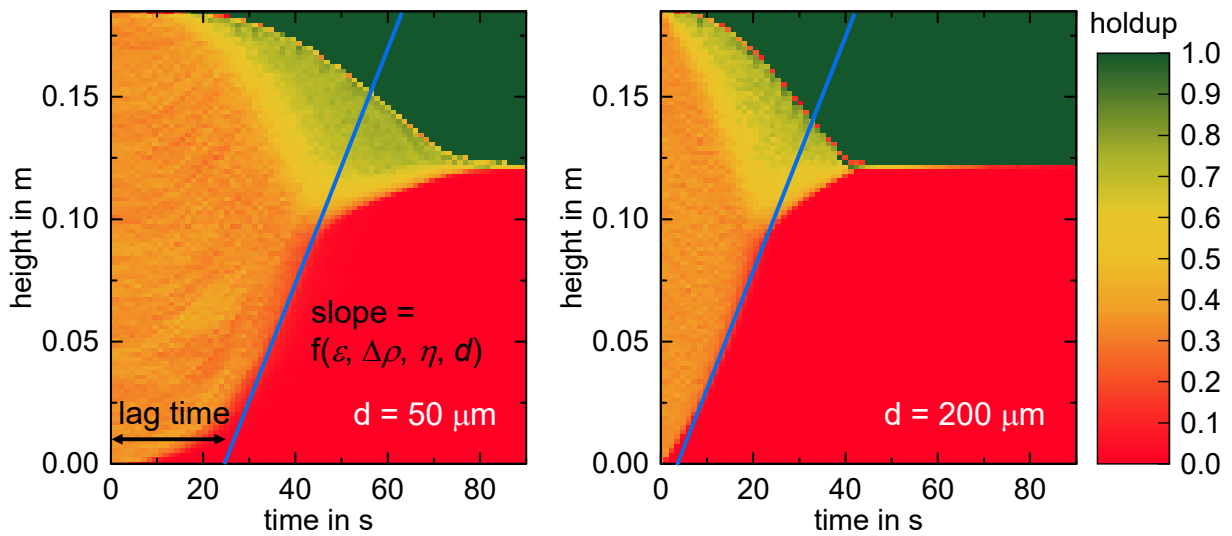
lag time & characteristic drop diameter



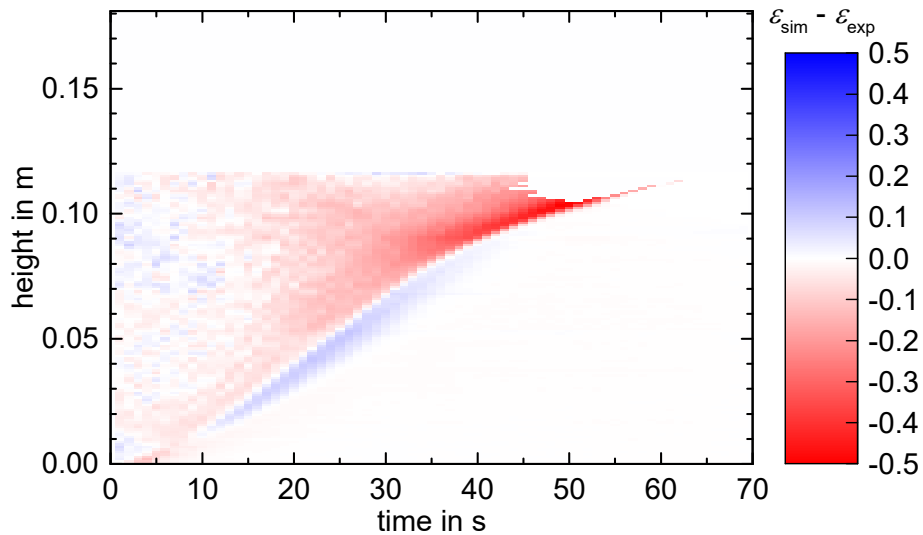
lag time & characteristic drop diameter



lag time & characteristic drop diameter



infinite-dilution drop velocity & swarm model

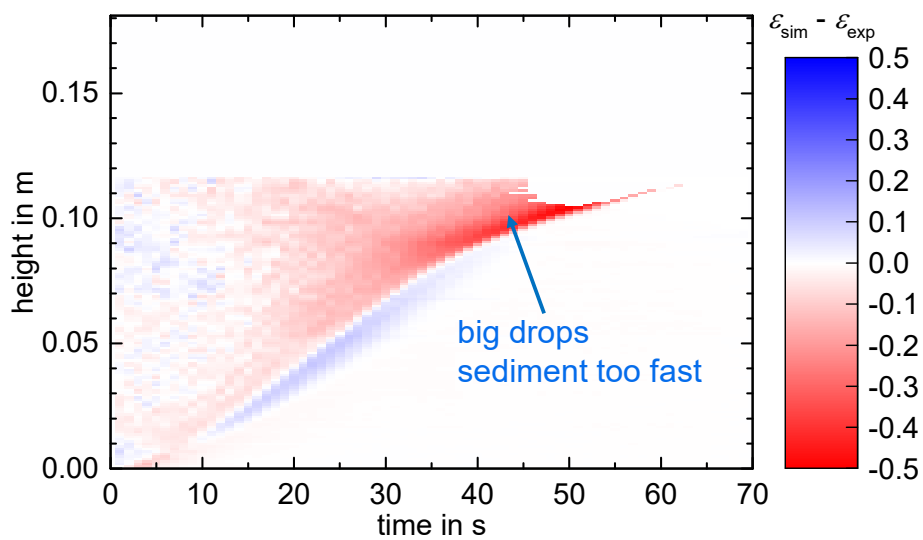


PEPs only sedimentation zone shown
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infinite-dilution drop velocity & swarm model

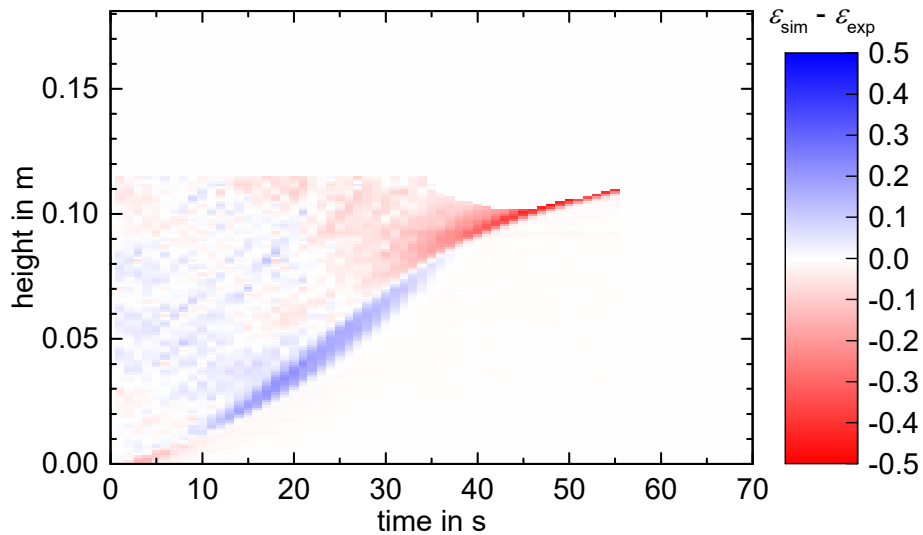


PEPs only sedimentation zone shown
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only around 25% drop-size dependent velocity

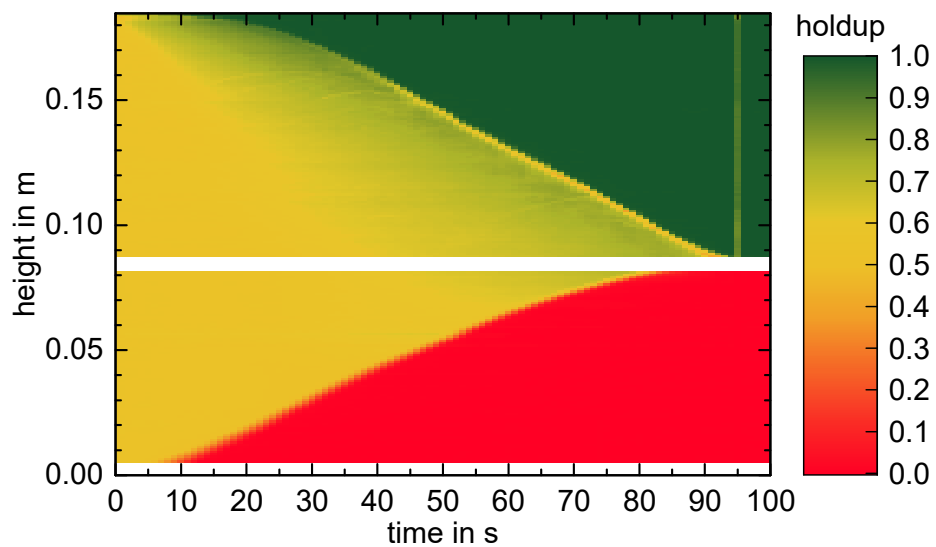


PEPs only sedimentation zone shown
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experimental holdup, initial holdup: 53 % organic

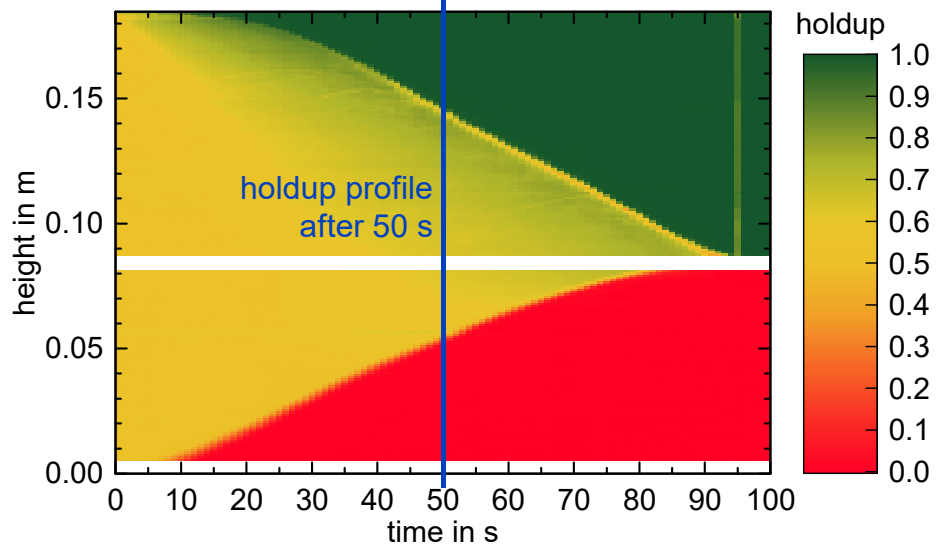


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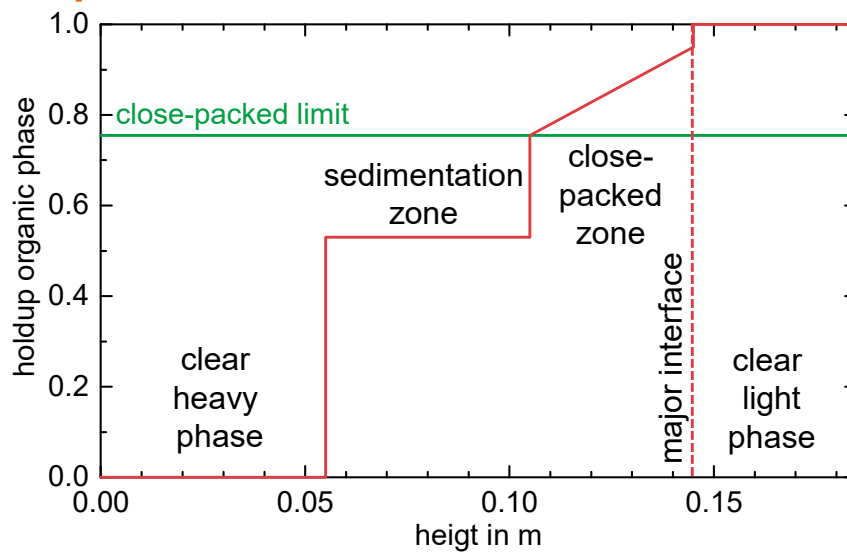
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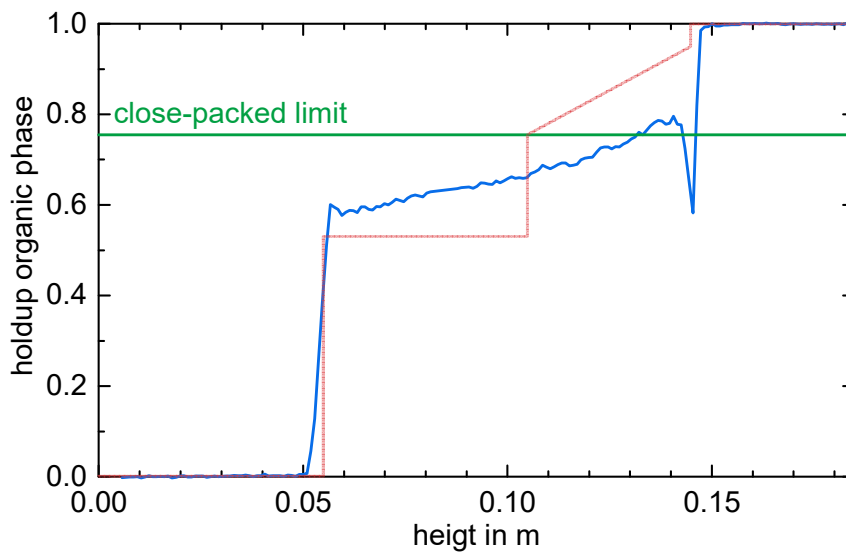
experimental holdup, initial holdup: 53 % organic



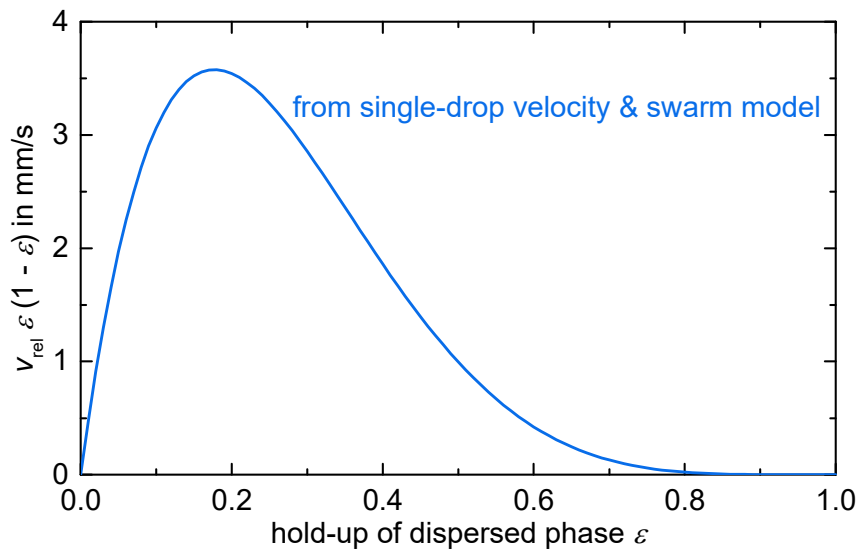
what we expect



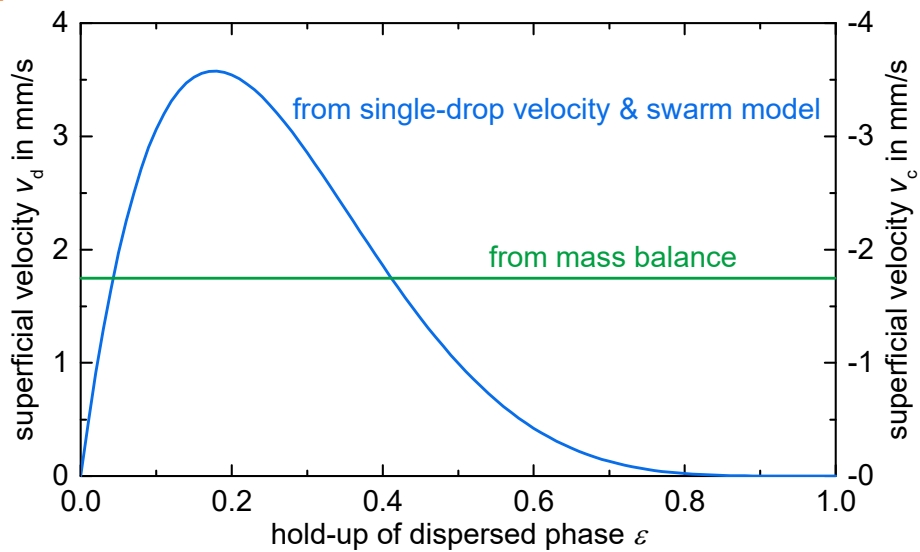
what we find



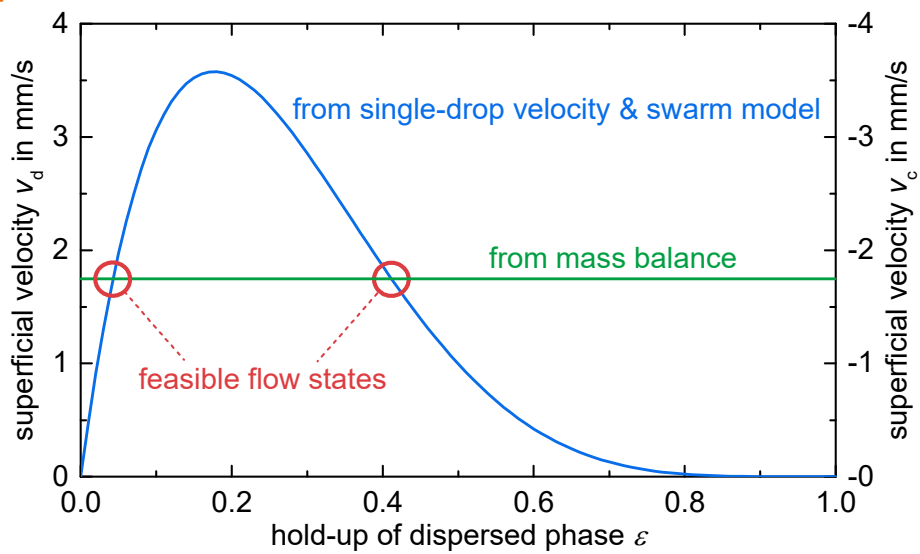
Wallis plot



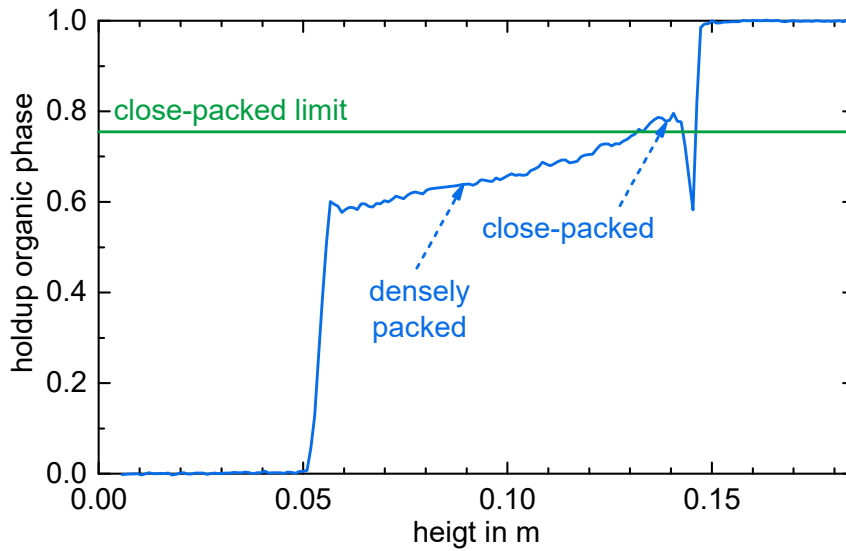
Wallis plot



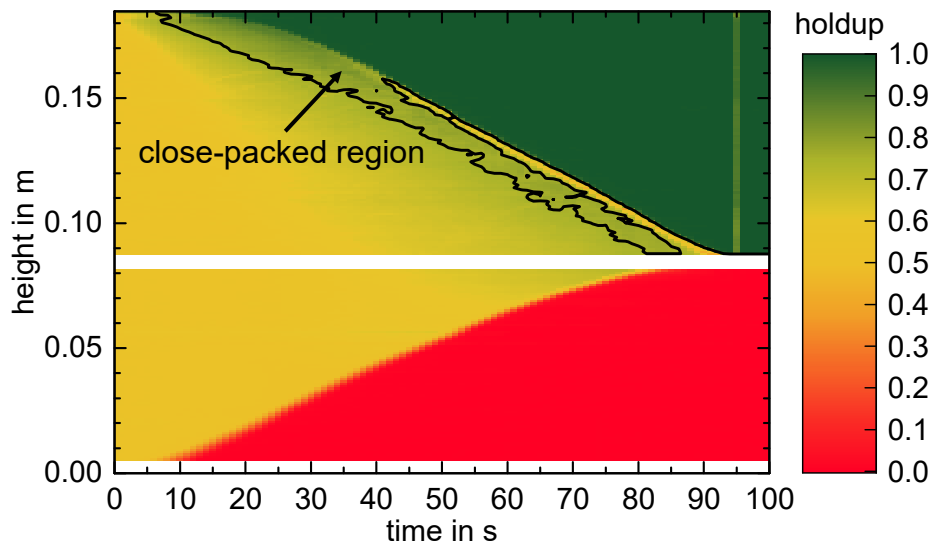
Wallis plot



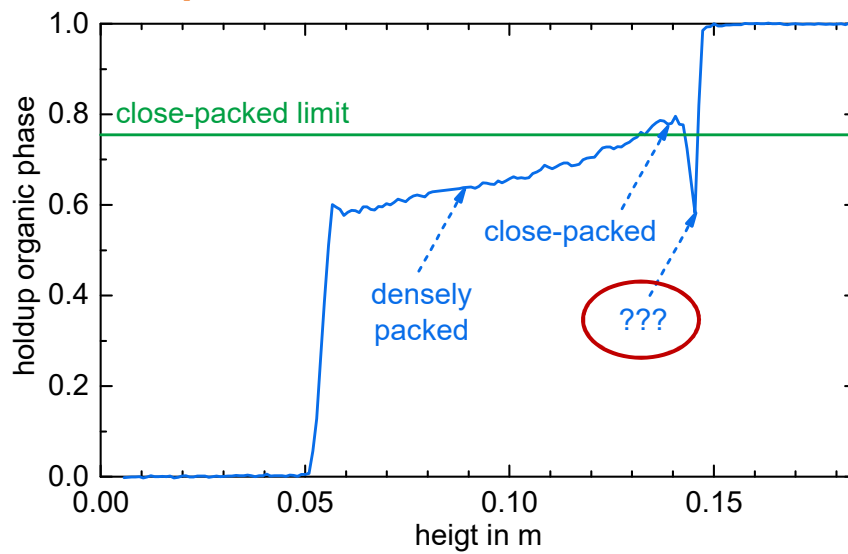
we find a wide densely packed zone



experimental holdup, initial holdup: 53 % organic

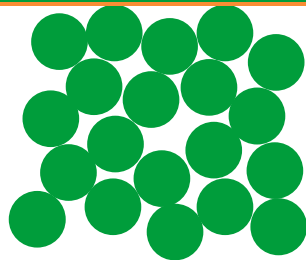


what is this bump?



at the interface

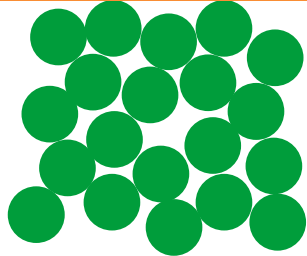
interface



before coalescence

at the interface

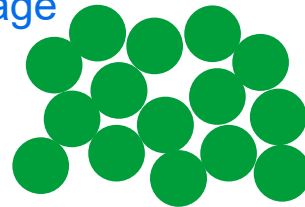
interface



before coalescence

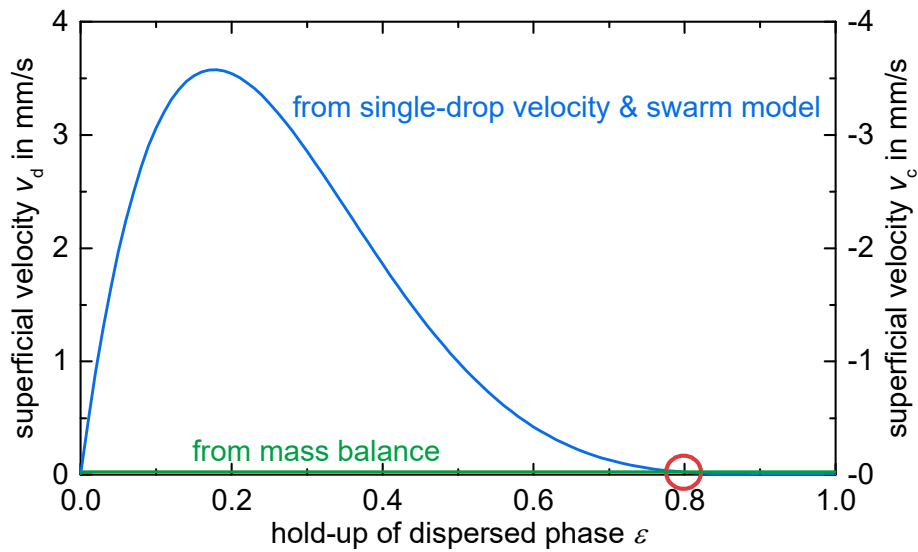
interface

voidage

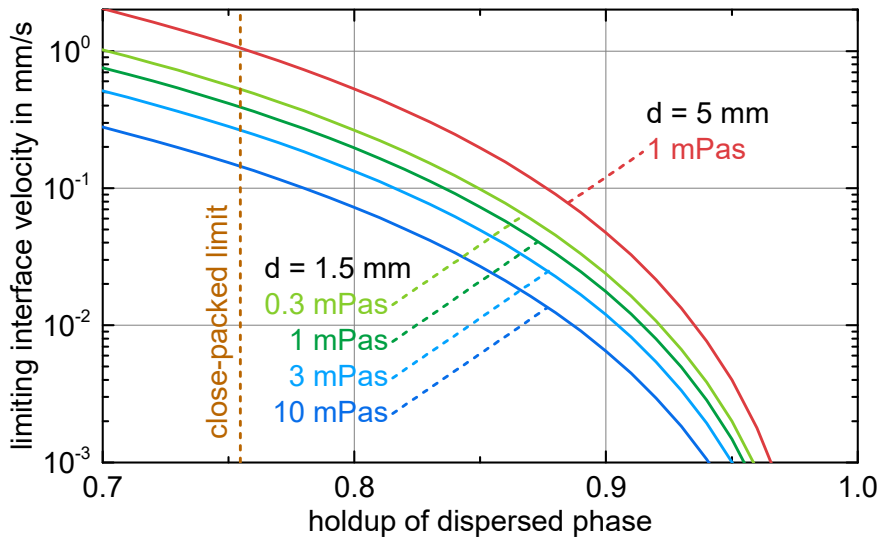


after coalescence

flowrate close to interface



is this a general effect?



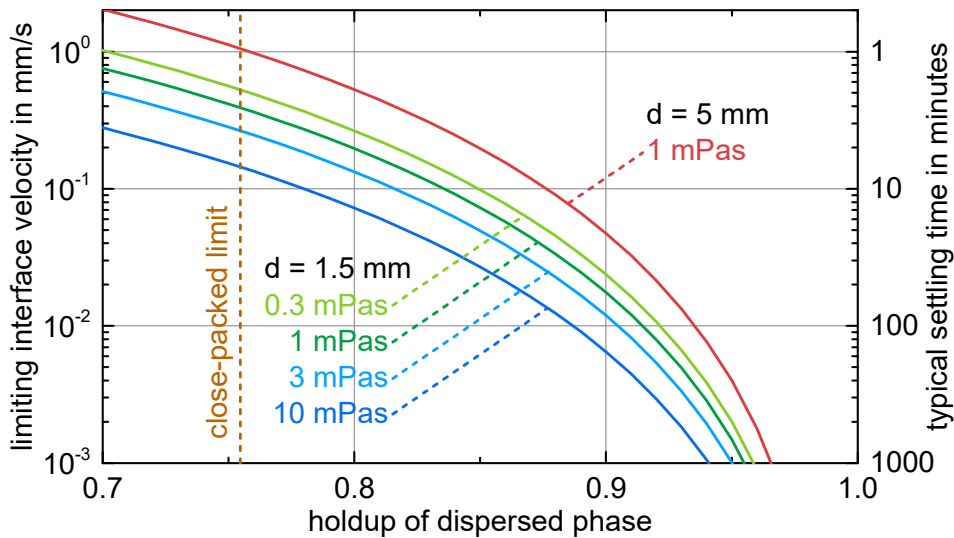
$\Delta\rho = 400 \text{ kg/m}^3$

model: Henschke, Waheed, Pfennig, 2000 & Richardson, Zaki, 1954

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is this a general effect?



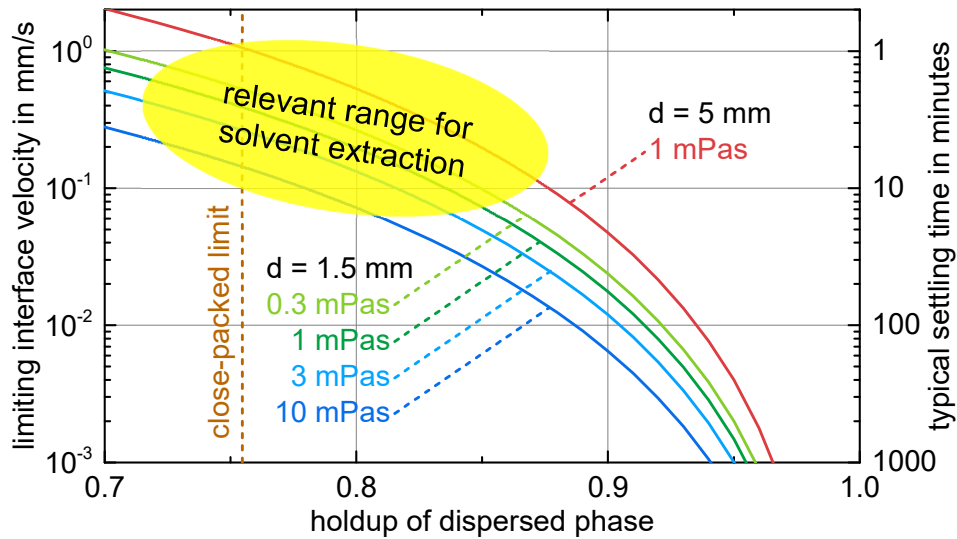
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is this a general effect?



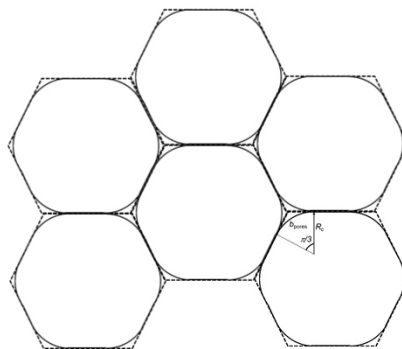
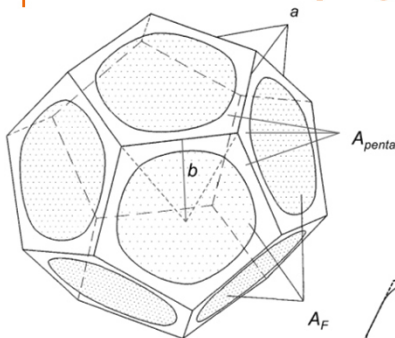
$\Delta\rho = 400 \text{ kg/m}^3$

model: Henschke, Waheed, Pfennig, 2000 & Richardson, Zaki, 1954

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coalescence: polyhedron model of Henschke



$$p_{\text{coalescence}} = 1 - \exp\left(-\frac{t_{\text{contact}}}{t_{\text{coalescence}}}\right)$$

$$t_{\text{coalescence}} \sim \frac{6\pi^2 \mu R_F R_a^{3/2}}{F_{\text{driving}} r_s^* \sqrt{h_{\text{critical}}}}$$

$$F_{\text{driving}} = F_{\text{Young-Laplace}} = \frac{2\pi R_F^2 \sigma}{R}$$

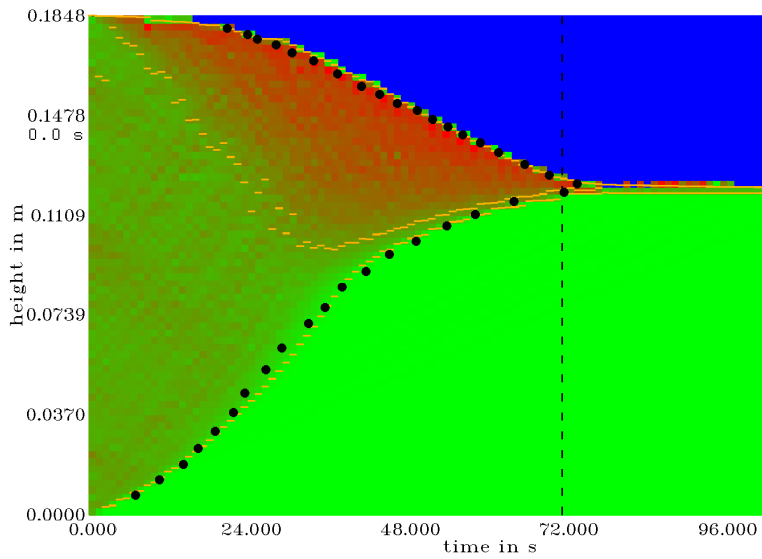


Henschke, 1995: Dimensionierung liegender Flüssig-flüssig-Abscheider anhand diskontinuierlicher Absetzversuche

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drop-based simulation results

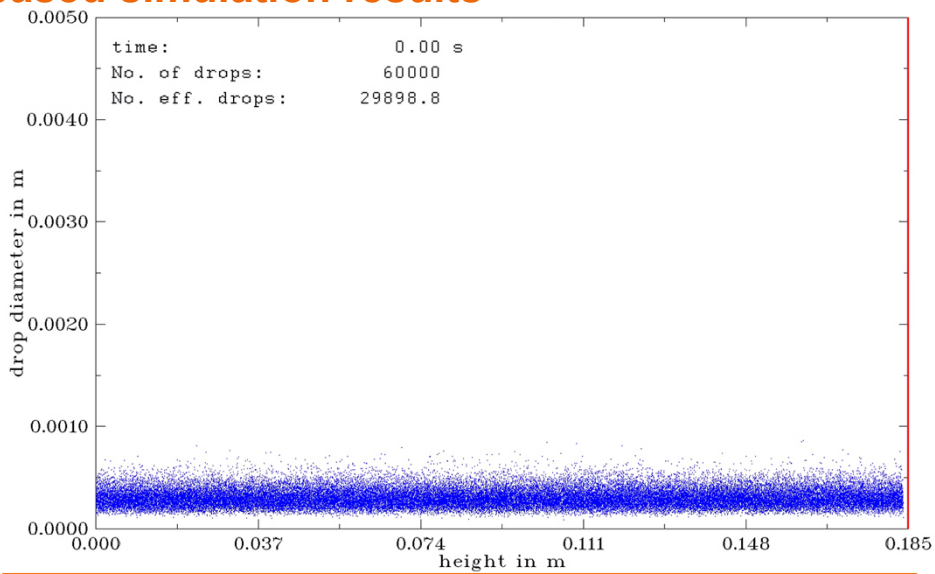


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drop-based simulation results

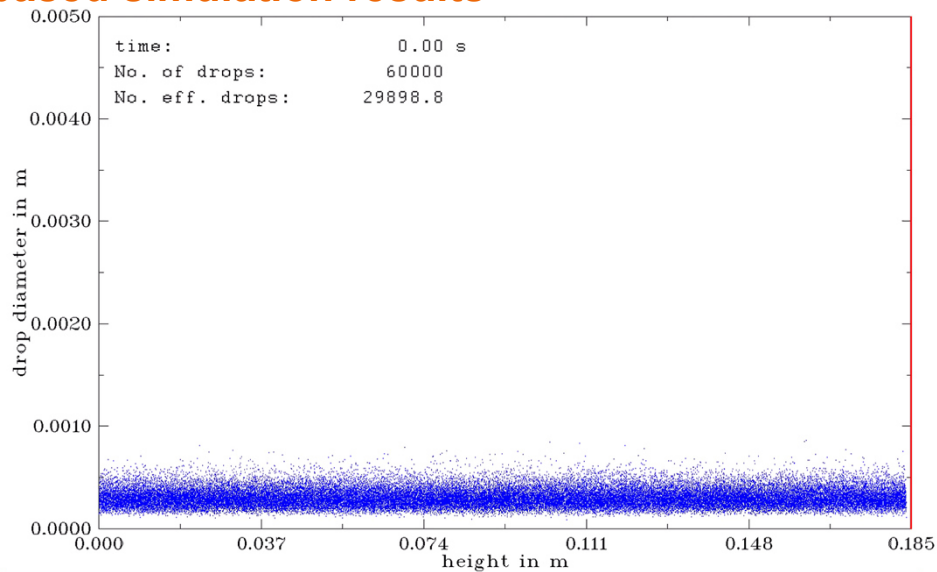


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drop-based simulation results



conclusions

- lag time: small drops, hardly sediment but coalesce
- densely packed zone
- close-packed zone: drops don't press on interface
- low holdup close to interface
- modeling, simulation: ReDrop (representative drops)
 - drop sedimentation: polydisperse swarm up to high holdup
 - coalescence: Henschke polyhedron model

conclusions

- lag time: small drops, hardly sediment but coalesce
- polydisperse swarm: drops sediment only $\approx 25\%$ individually
- densely packed zone
- close-packed zone: drops don't press on interface
- low holdup close to interface
- modeling, simulation: ReDrop (representative drops)
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