title

author

institute

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Outline for section 1

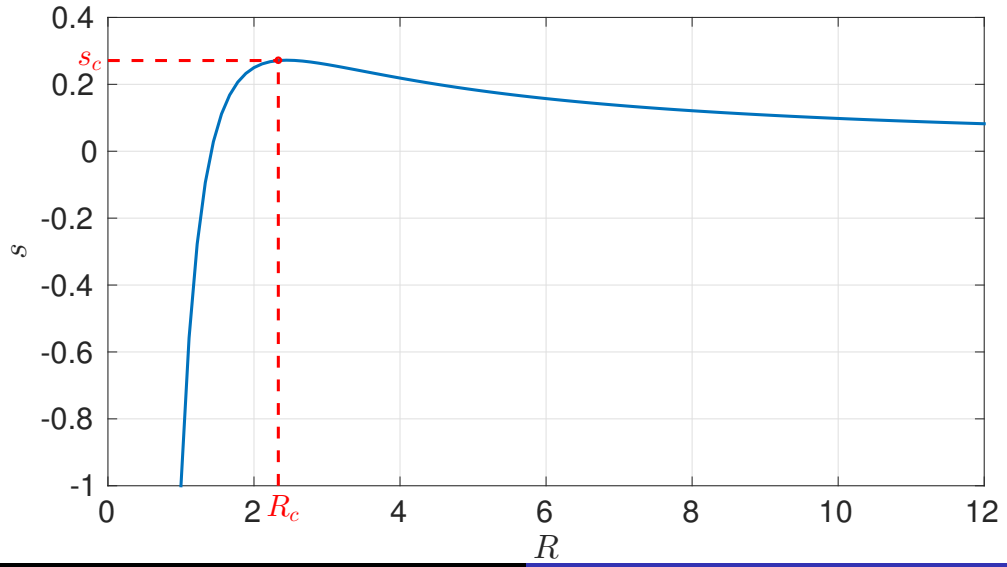
1. Models
   - Droplet growth
   - LES
   - Stochastic model
2. Simulations
   - Parameters
   - LES simulations
   - Stochastic model
   - Steady simulations

Droplet growth

Equation of evolution

- Curvature effect: Kelvin equation
- Salinity effect: Raoult's law

$$\frac{\mathrm{d}R_i^2}{\mathrm{d}t} = 2A_3\left(s(X_i,t) - \frac{c}{R_i} + \frac{h}{R_i^3}\right)$$



LES

Velocity

Turbulent flow field $\boldsymbol{u} = (u, v, w)$

Supersaturation

$$\frac{\partial s}{\partial t} + (\boldsymbol{u} \cdot \boldsymbol{\nabla})s = \kappa \nabla^2 s + A_1(w + w_0) - A_2 \frac{\mathrm{d}q_w}{\mathrm{d}t}$$

- $A_1(w + w_0)$: Adiabatic cooling due to the updraft
- $A_2 \frac{\mathrm{d}q_w}{\mathrm{d}t}$: *Local* change of water content due to droplets evolution

Droplets

Movement dictated by Stokes drag and gravity

Supersaturation evolution

$$\frac{\partial s}{\partial t} + (\boldsymbol{u} \cdot \boldsymbol{\nabla})s = \kappa \nabla^2 s + A_1(w + w_0) - A_2 \frac{\mathrm{d}q_w}{\mathrm{d}t}$$

Feedback term

$$A_2 \frac{\mathrm{d}q_w}{\mathrm{d}t} \propto \sum_{\text{cell}} \frac{\mathrm{d}R_i^3}{\mathrm{d}t} \propto \sum_{\text{cell}} R_i \left(s_i - \frac{c}{R_i} + \frac{h}{R_i^3} \right)$$
$$\neq -\frac{s}{\tau_s}$$

Stochastic model

Velocity

1D turbulence modeled by a Langevin equation

$$w_i(t+dt) = w_i(t) - \frac{w_i}{T_0}dt + v_{\mathrm{rms}}\sqrt{2\frac{dt}{T_0}}\xi_i(t)$$

Supersaturation

Supersaturation modeled by a Langevin equation, coupled with the velocity

$$s_i(t+dt) = s_i(t) - \frac{s_i - \langle s \rangle}{T_0}dt + A_1(w_i + w_0) - A_2\frac{\mathrm{d}q_{w,i}}{\mathrm{d}t} + \mathrm{forcing}$$

Outline for section 2

1. Models
   - Droplet growth
   - LES
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   - Parameters
   - LES simulations
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   - Steady simulations

Parameters

Droplets

Droplets have the same initial size and share the same properties

$$R_0 = 0.24\mu\mathrm{m}$$

$$c = 1.2\mathrm{nm} \quad h = 9.8\times10^{-3}\mu\mathrm{m}^3 \quad R_c = 4.9\mu\mathrm{m}$$

$$A_3 = 50\mu\mathrm{m}^2/s$$

Cloud parcel

- Periodic box, 100m^3, simulated for 20 mn
- 130 droplets per cm^3
- Kinetic energy dissipation: $\epsilon = 10^{-3}\mathrm{m}^2/\mathrm{s}$
- $A_1 = 5 \times 10^{-4}\mathrm{m}^{-1}$ $\quad A_2 = 350\mathrm{m}^3/\mathrm{kg}$

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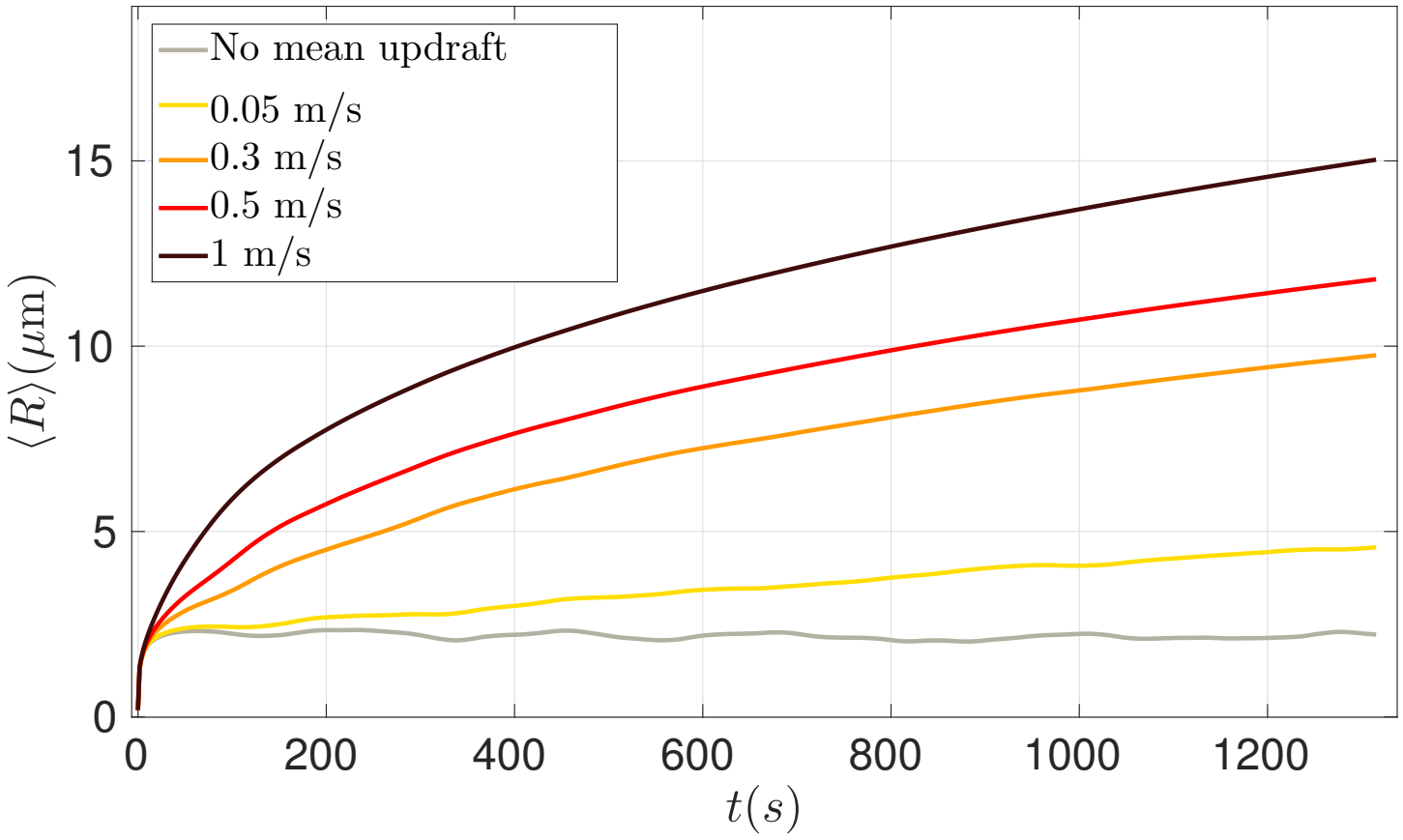
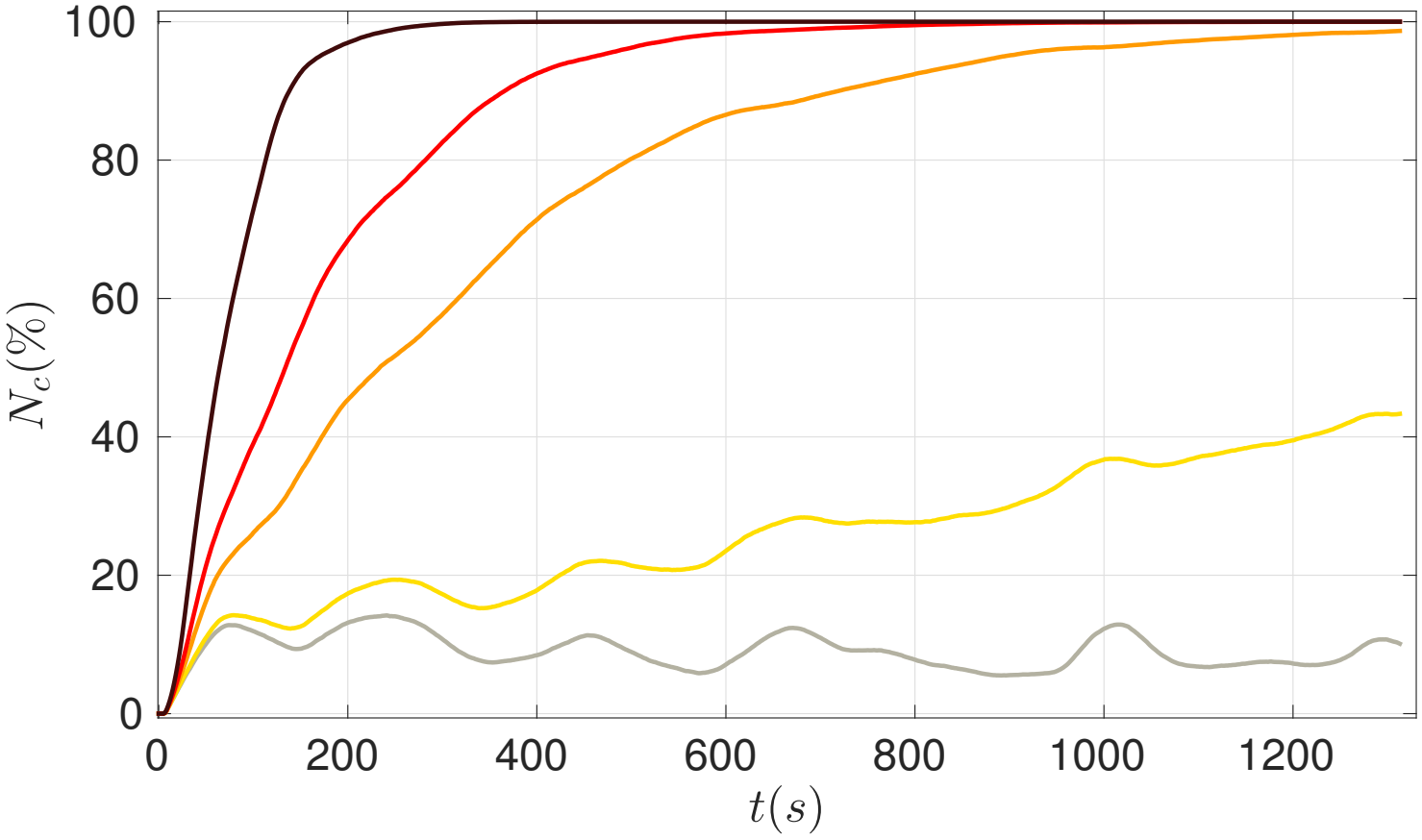
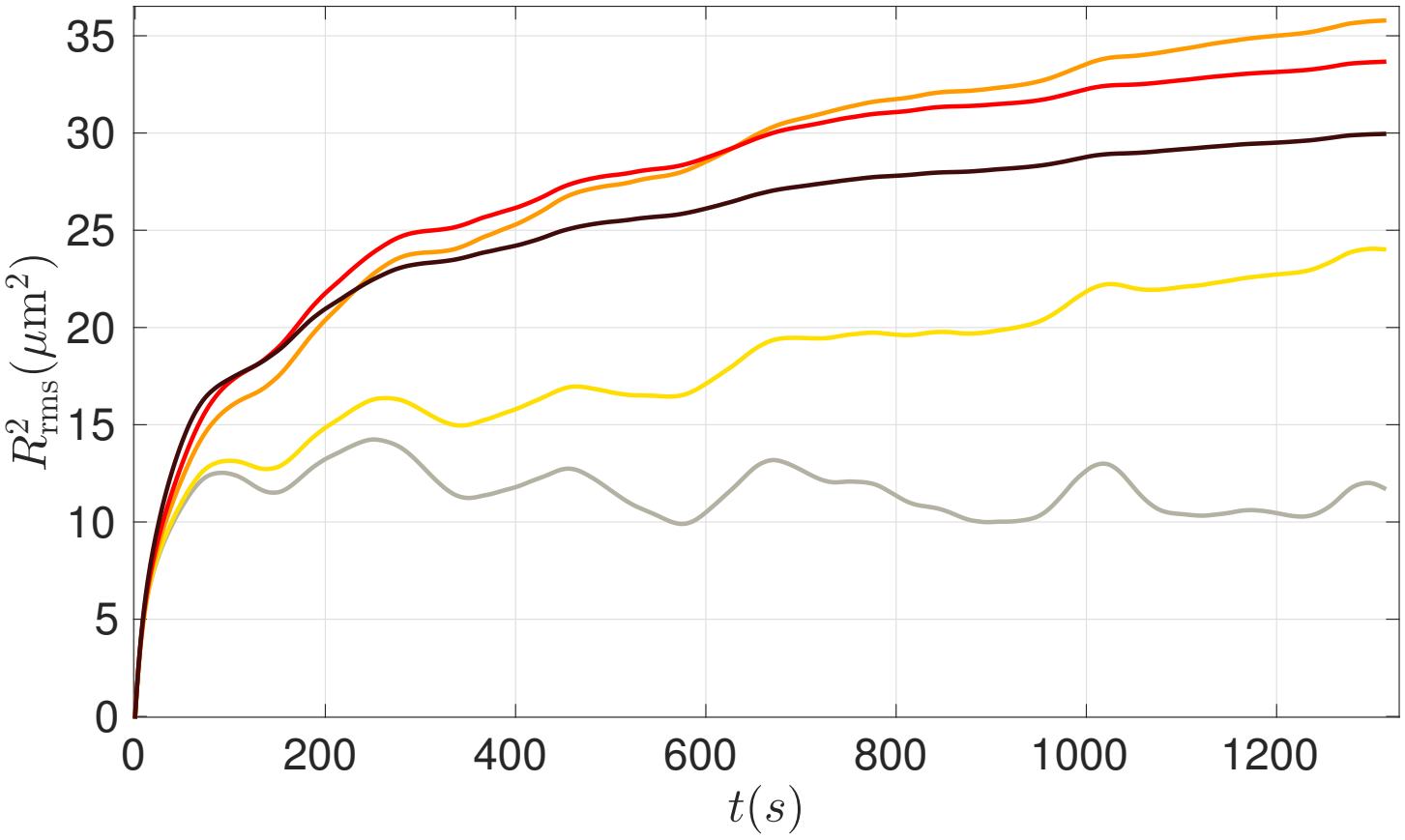
LES, resolution: 64^3
Mean radius



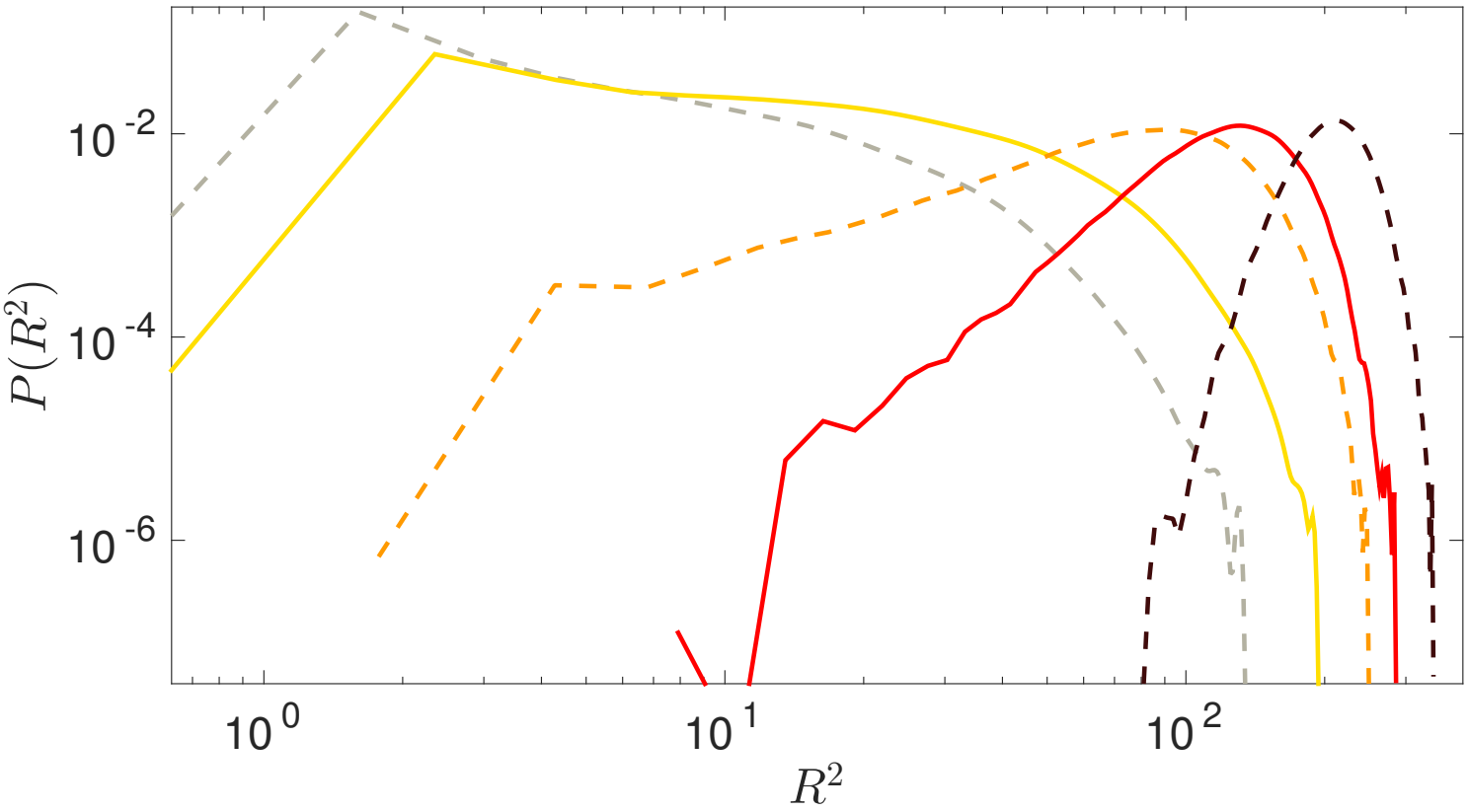
LES, resolution: 64^3
Fraction of activated droplets ($R > R_c$)



LES, resolution: 64^3
Standard deviation of R^2



LES, resolution: 64^3
Spectra of R^2 after 20 minutes



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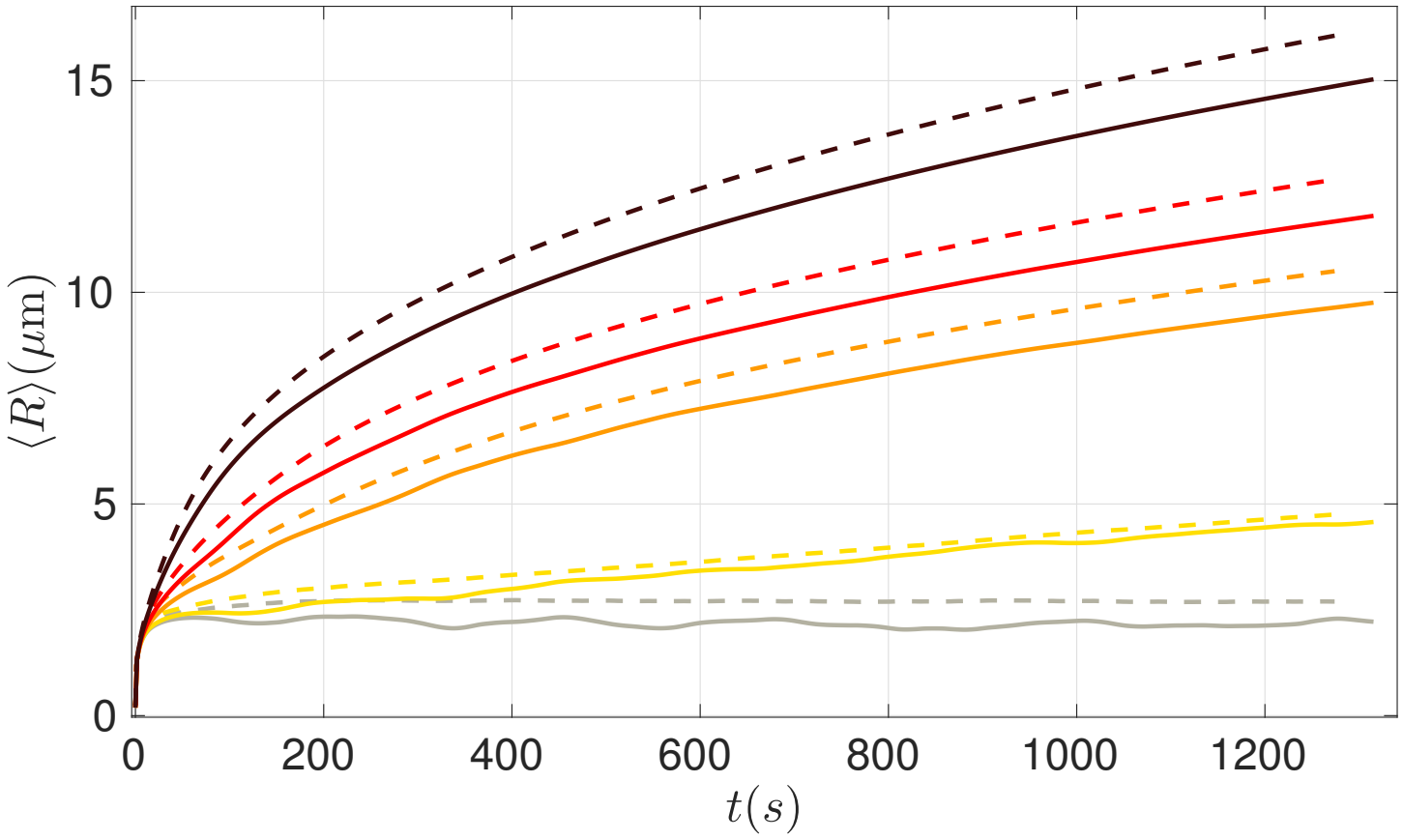
Comparison between LES and Stochastic model
Mean radius



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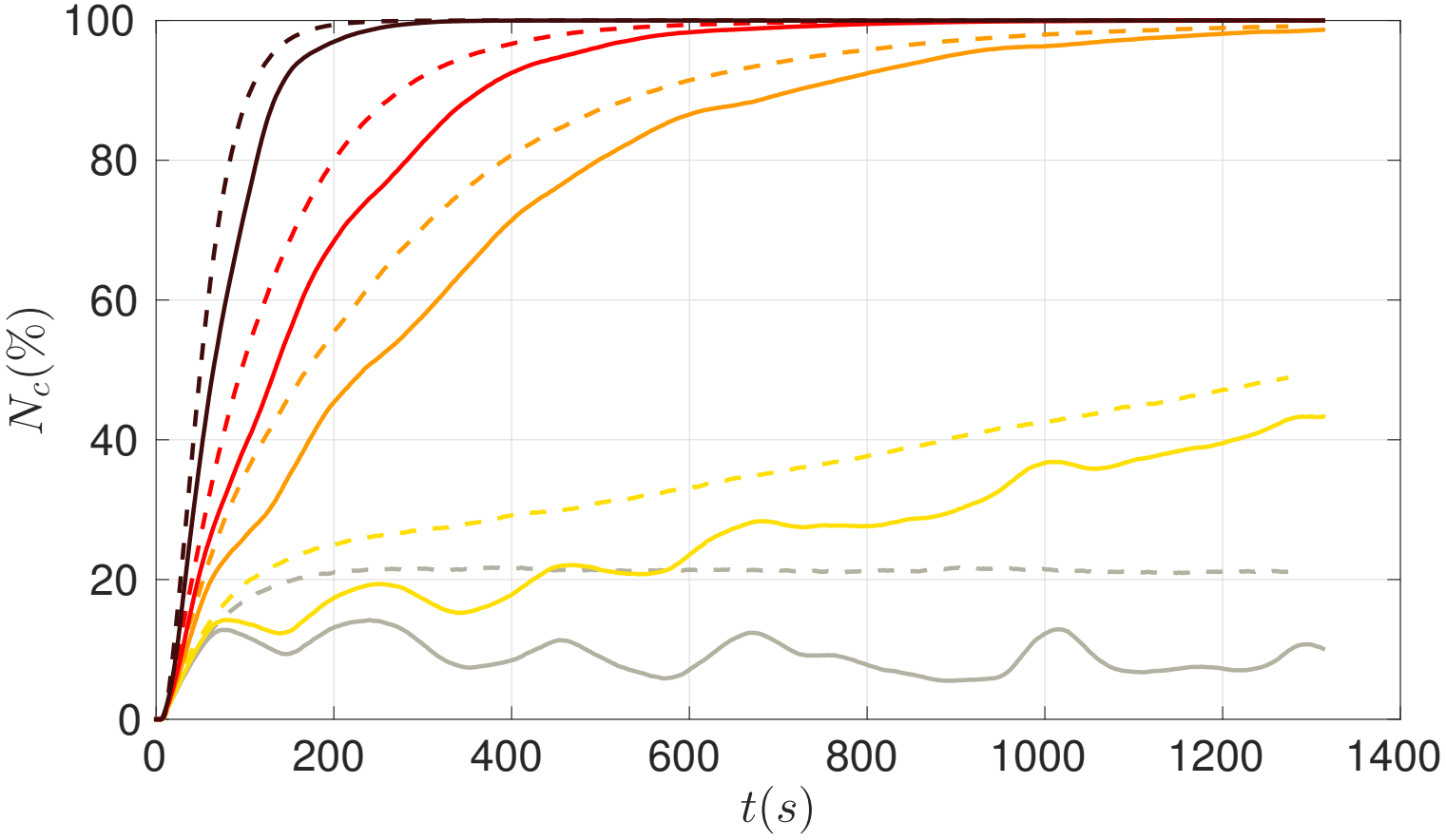

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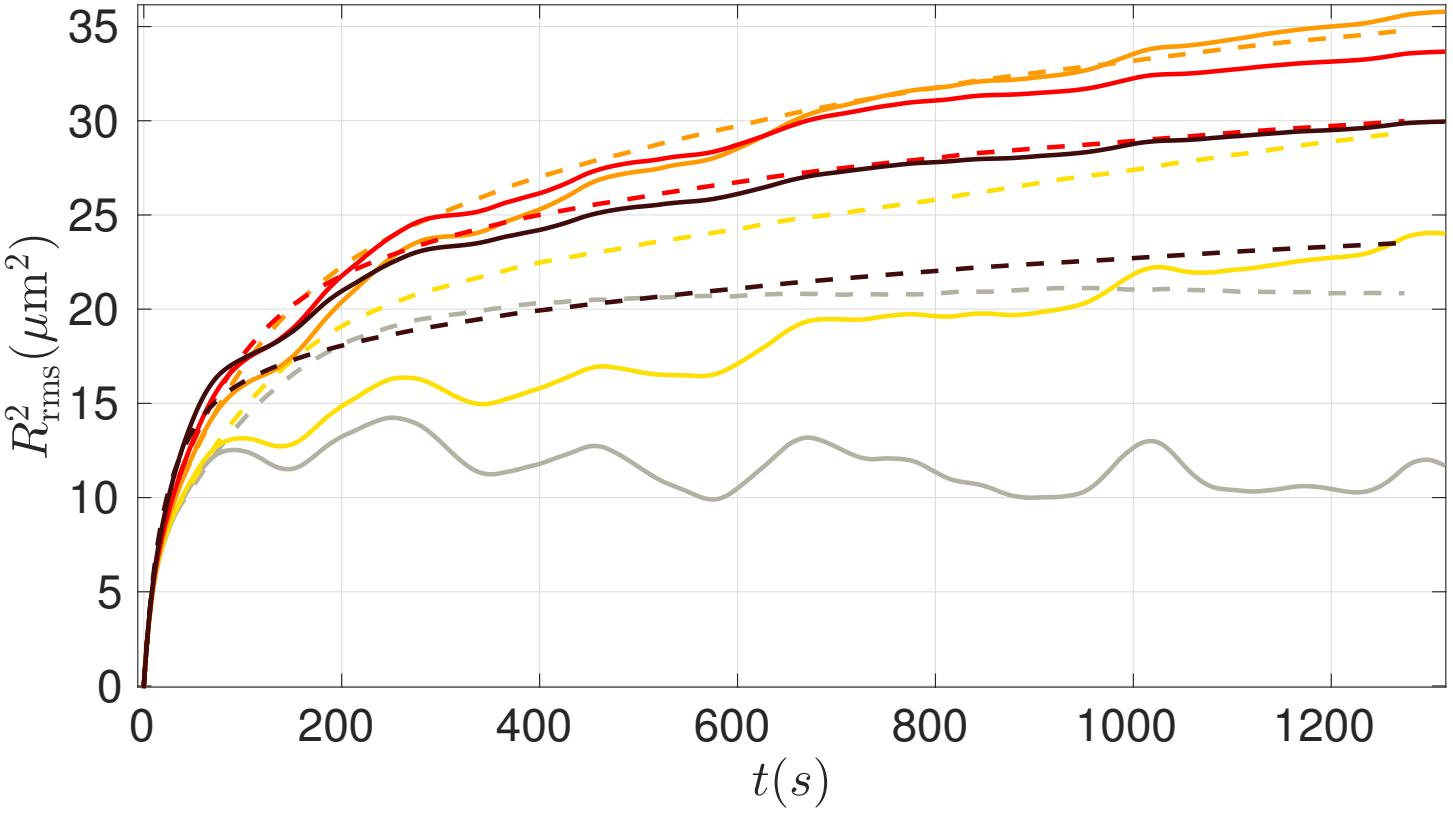

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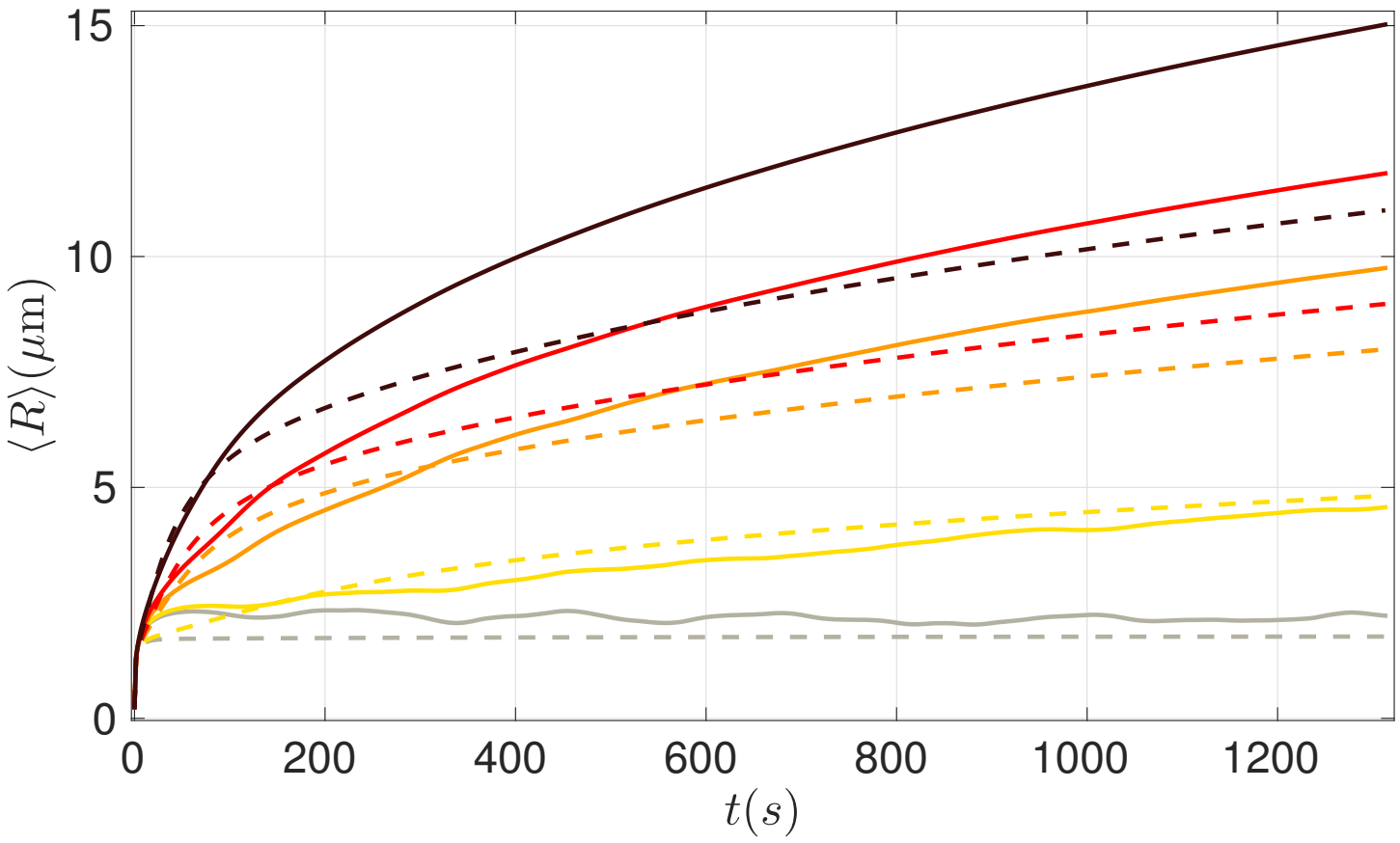
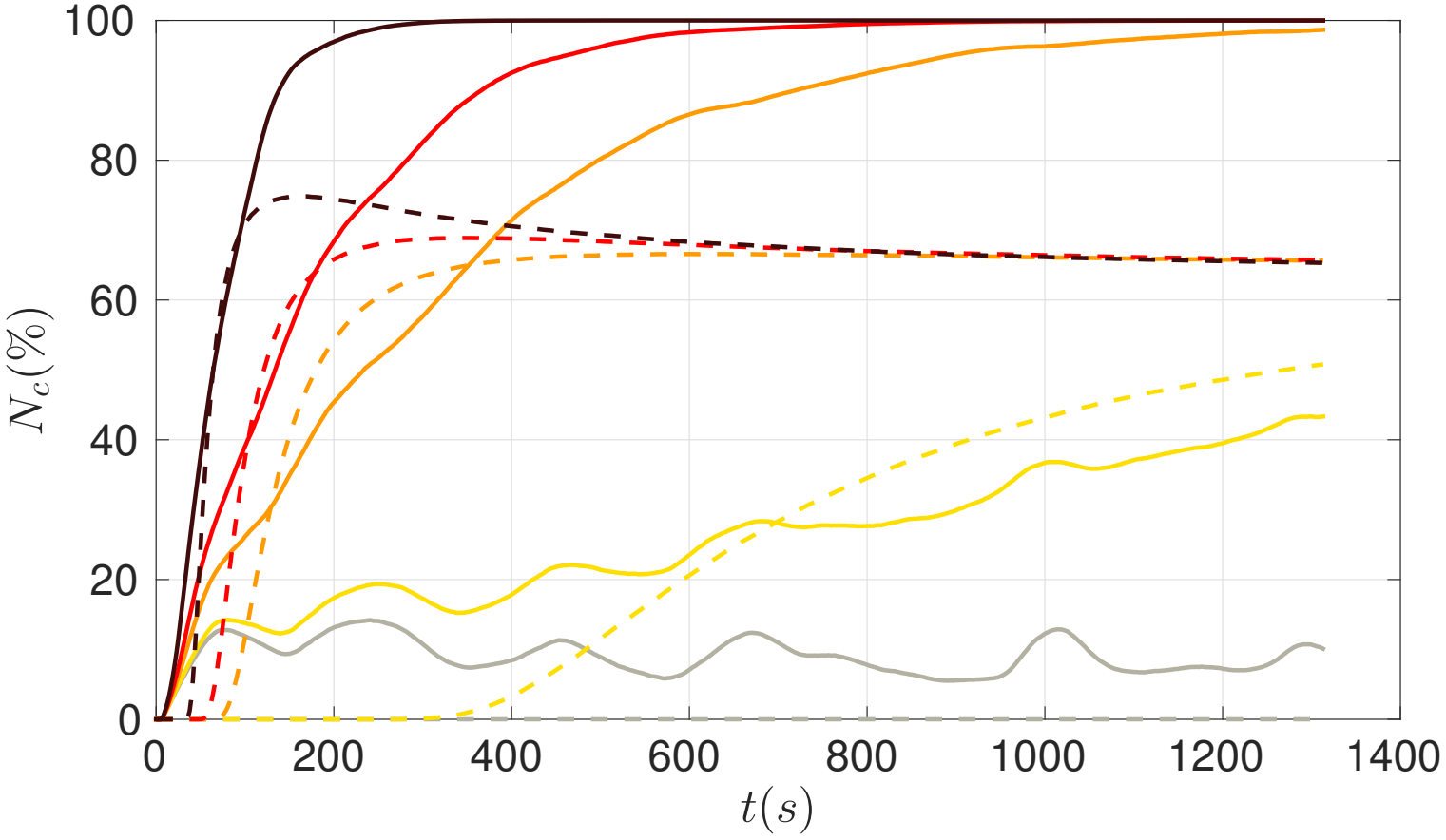
Comparison between LES and Steady case
Mean radius



Comparison between LES and Steady case
Fraction of activated droplets ($R > R_c$)



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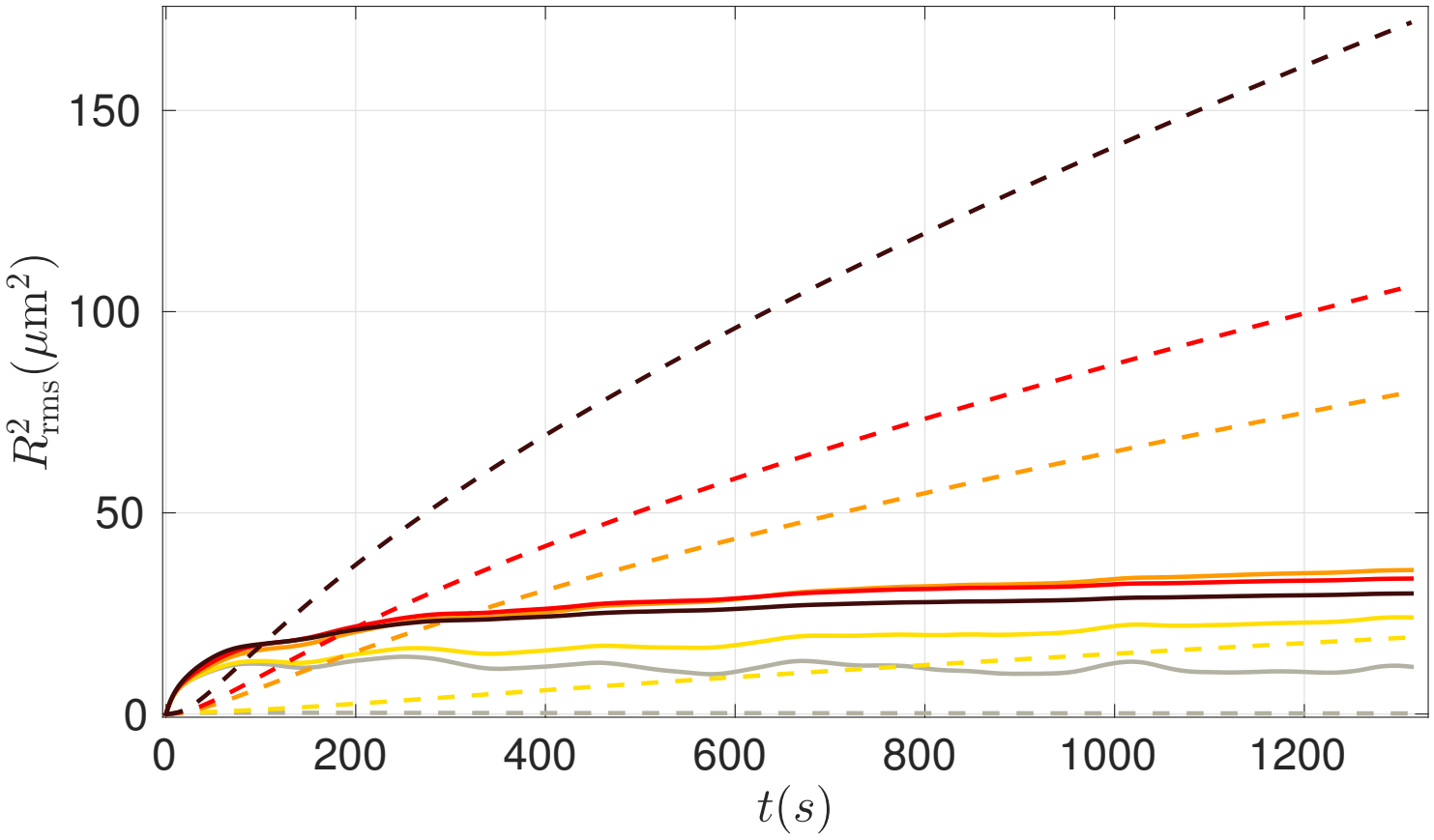
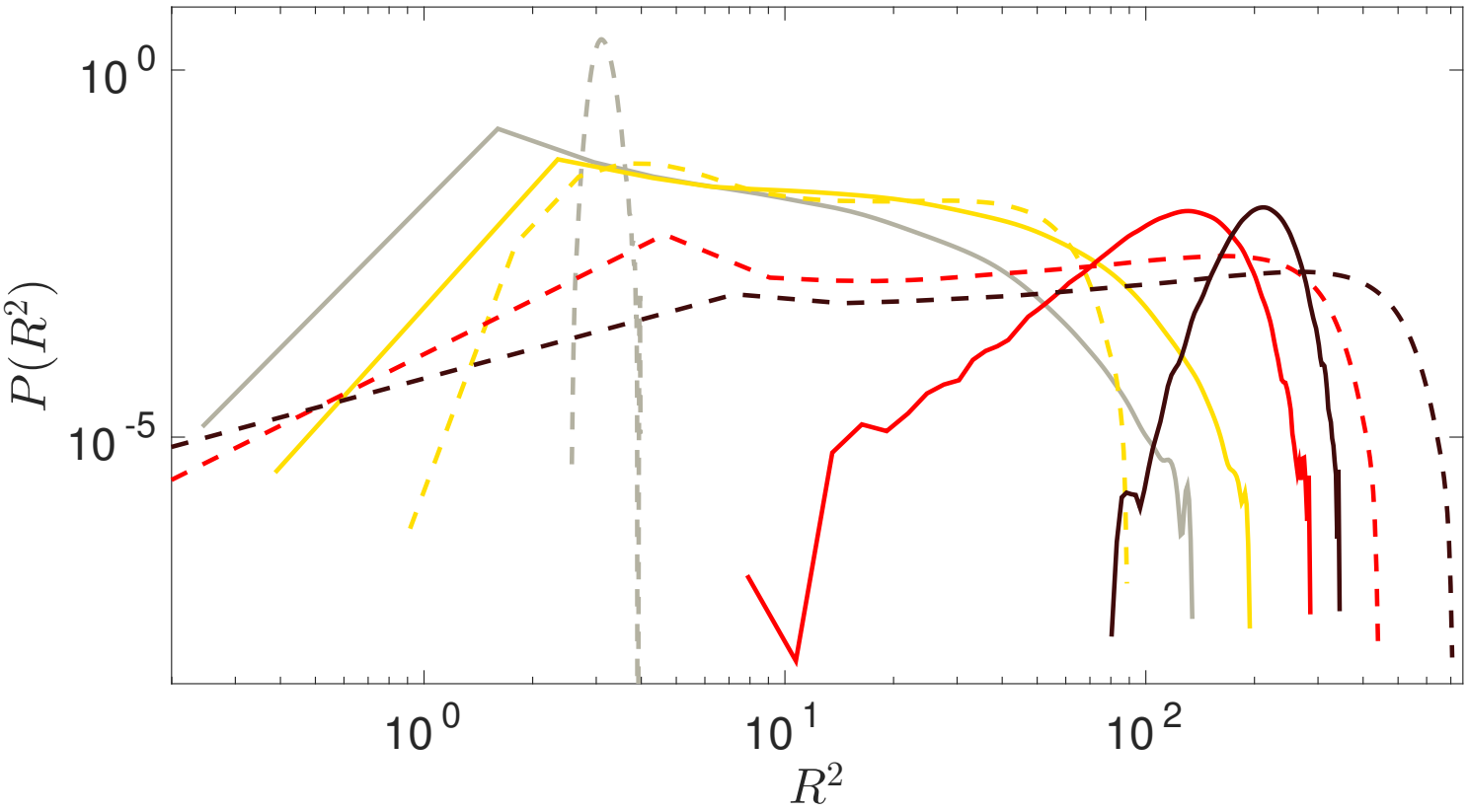
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