Towards improved 1-D settler modelling: impact on control strategies using the Benchmark Simulation Model

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Problem statement

- **Intense rain events cause extreme hydraulic peaks in inflow of WWTPs**
- **Traditional 1-D SST models do not sufficiently capture settling dynamics under these conditions**
- **Performance of SST affects biomass inventory (through recycle flow) and thus performance of entire WWTP**

Objectives

- **Investigate effect of new 1-D SST model by Bürger et al. (2013) on operation and control using BSM1**
- **Elucidate specific added value of the model's features on the predictions of biomass concentrations throughout the system**

Bürger-Diehl model

A new 1-D SST model was developed by Bürger et al. (2011, 2013).

Features

- Settling flux calculated by mathematically sound Godunov flux to ensure convergence (**nr of layers can be set by user**)
- Additional layers in effluent and underflow region to ensure **conservation of mass across outlet boundaries**
- Allows accounting for several phenomena (hindered settling, compression settling, inlet dispersion) in a **modular** way

Model PDE

$$\frac{\partial C}{\partial t} = -\frac{\partial}{\partial z}F(C,z,t) + \frac{Q_f(t)C_f(t)}{A}\delta(t) + \frac{\partial}{\partial z}\left(\left\{d_{comp}(C) + d_{disp}(z,Q_f(t))\right\}\frac{\partial C}{\partial z}\right)$$

Convective flow + hindered settling ($F(C,z,t)$)

Feed inlet ($\frac{Q_f(t)C_f(t)}{A}\delta(t)$)

Compression function ($d_{comp}(C)$)

Dispersion function ($d_{disp}(z,Q_f(t))$)

$$d_{comp} = \begin{cases} 0 & \text{if } 0 \le C < C_{crit} \\ \dfrac{\rho_s\,.\,\alpha\,.\,v_s(C)}{g(\rho_s - \rho_f)} & \text{if } C \ge C_{crit} \end{cases}$$

Effect of compression settling

- Accounting for compression settling **dampens the underflow concentration** and **causes an increased effect on SBH** for variations in loading rate (Figure 1)
- Predicted trends show better correspondence to reality than traditional SST models (Figure 2, left)
- More pronounced effect of storm peak on MLSS concentration (Figure 2, right)

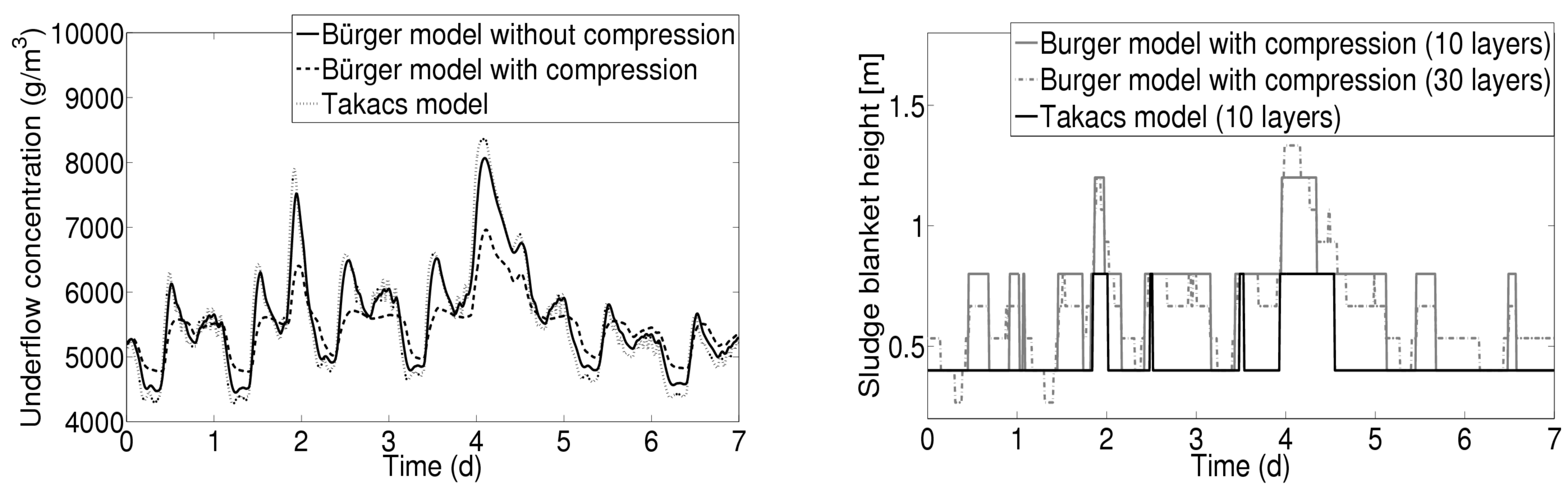

Figure 1: Dynamic simulation of the underflow concentration (left) and the sludge blanket height (right) under storm weather conditions.

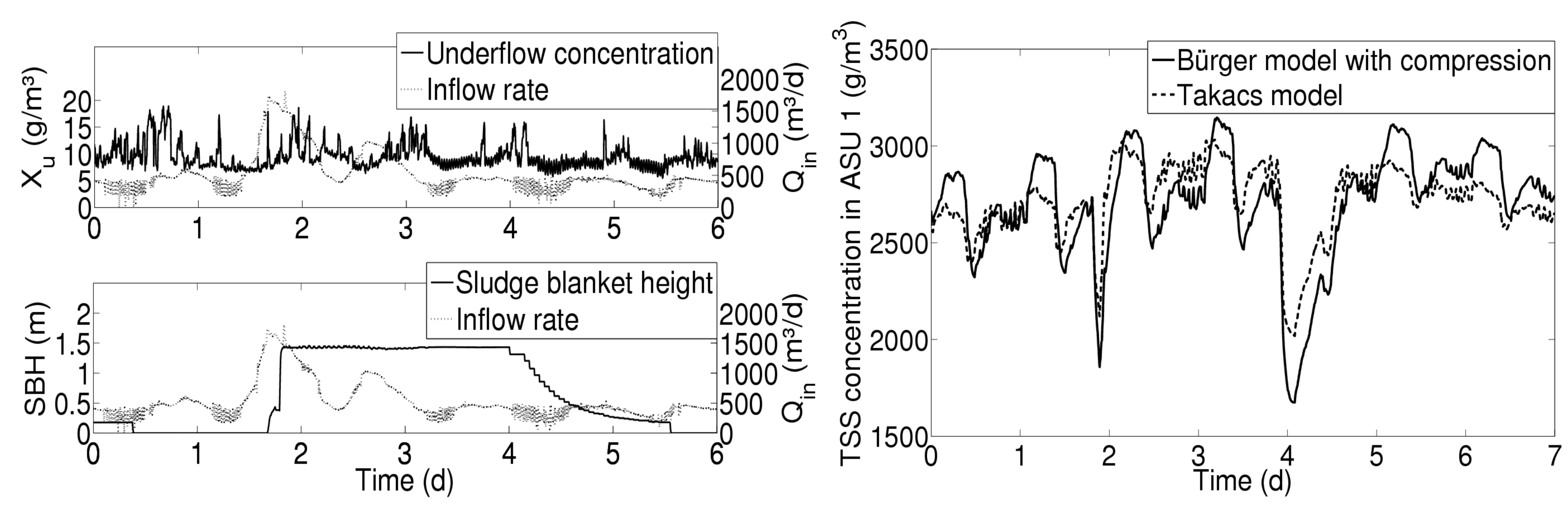

Figure 2: On-line data of sludge blanket height (SBH), underflow concentration (Xu) and inflow rate (Qin) from the WWTP of Eindhoven, The Netherlands (left) and dynamic simulation results of the BSM1 MLSS concentration in ASU1 (right).

Effect on MLSS controller

- PI controller (Kc=100 and τI=1) for MLSS at setpoint (2.8 g/l)
- Choice of settler model significantly influences control actions
- Dampening effect of compression function results in smoother control actions and ASU TSS concentrations (Figure 3)

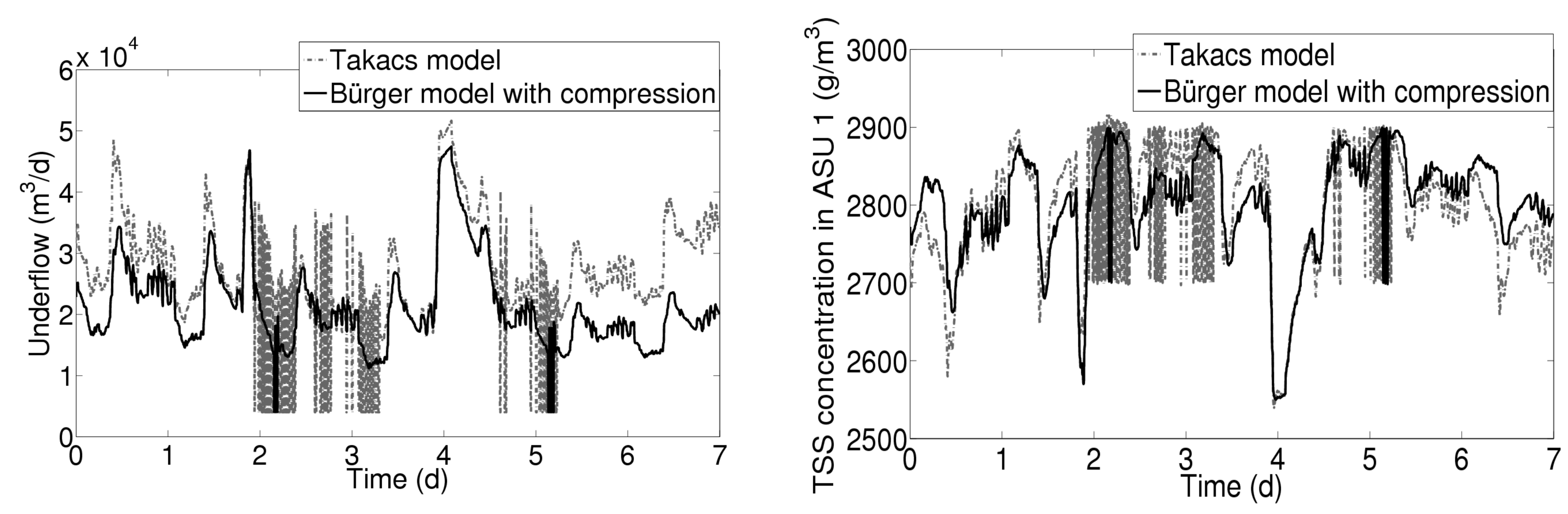

Figure 3: Dynamic simulation with the implementation of an MLSS control strategy. Manipulation in underflow rate (left) and MLSS concentration in the first activated sludge tank (right) under storm weather conditions.

Conclusions

- **Dampening of underflow concentration and more pronounced variations in sludge blanket height by accounting for compression settling**
- **Description of settling behaviour significantly influences sludge inventory and related control actions**
- **Improved settler model recommended for controller design and evaluation of control strategies**

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