The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5-9 June 2022, Oslo, Norway

FAST, DATA-ASSISTED SIMULATIONS OF MULTI-SCALE FLOWS BASED ON EXTRAPOLATED TIME SERIES

Thomas Lichtenegger[1,*], **Sanaz Abbasi**[1,2], **Stefan Pirker**[3]

[1] Department of Particulate Flow Modelling, Johannes Kepler University, Altenberger Str. 69, 4040 Linz, Austria, thomas.lichtenegger@jku.at
[2] School of Computing and Engineering, University of Missouri – Kansas City, 5110 Rockhill Road, Kansas City, MO 64110, United States, sa8x5@umkc.edu
[3] Department of Particulate Flow Modelling, Johannes Kepler University, Altenberger Str. 69, 4040 Linz, Austria, stefan.pirker@jku.at

Keywords: *Temporal multi-scale problems, Data-assisted simulations, Recurrence Statistics, Recurrence CFD*

The simulation of slow, long-term processes on dynamic backgrounds is a common but extremely challenging problem. The fast degrees of freedom require small time steps which limit the scope to short observation durations. Recurrence CFD addresses this problem for recurrent flows where characteristic patterns keep reappearing: A short time series of flow fields is recorded, its recurrence statistics calculated and then time-extrapolated with an iterated method of analogues. Any passive or weakly coupled process like species or heat transport may be simulated at little numerical costs using the time-extrapolated velocity field.

The power of the approach is illustrated with the example of heat transfer in a fluidized bed under transio-recurrent conditions. With short time series corresponding to two gas inlet velocities, we were able to picture the thermal evolution of the system for any fluid velocity between the recorded values [1]. Surprisingly, the method even works in the absence of pronounced recurrences as is the case for highly turbulent flows. Fluctuations hide any characteristic, coherent structures so that a reasonable nearest-neighbor identification becomes impossible. Nevertheless, time-extrapolated series of flow fields may be used to picture transport, which we demonstrate for bubble dynamics in a double jet [2].

Finally, we discuss current limitations and envisioned future developments to improve our methodology and make it suitable for a larger range of application cases.

REFERENCES

[1] T. Lichtenegger, P. Kieckhefen, S. Heinrich and S. Pirker, Dynamics and long-time behavior of gas-solid flows on recurrent-transient backgrounds, *Chem. Eng. J.*, Vol. **364**, pp. 562–577, 2019.

[2] T. Lichtenegger, S. Abbasi and S. Pirker, On the time-extrapolation, statistical symmetrization and interpolation of transport in turbulent flows, *in preparation*, 2022.