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Meancalc for statistical quality assurance in the Automotive CFD Prediction Workshop – *update including best practices*

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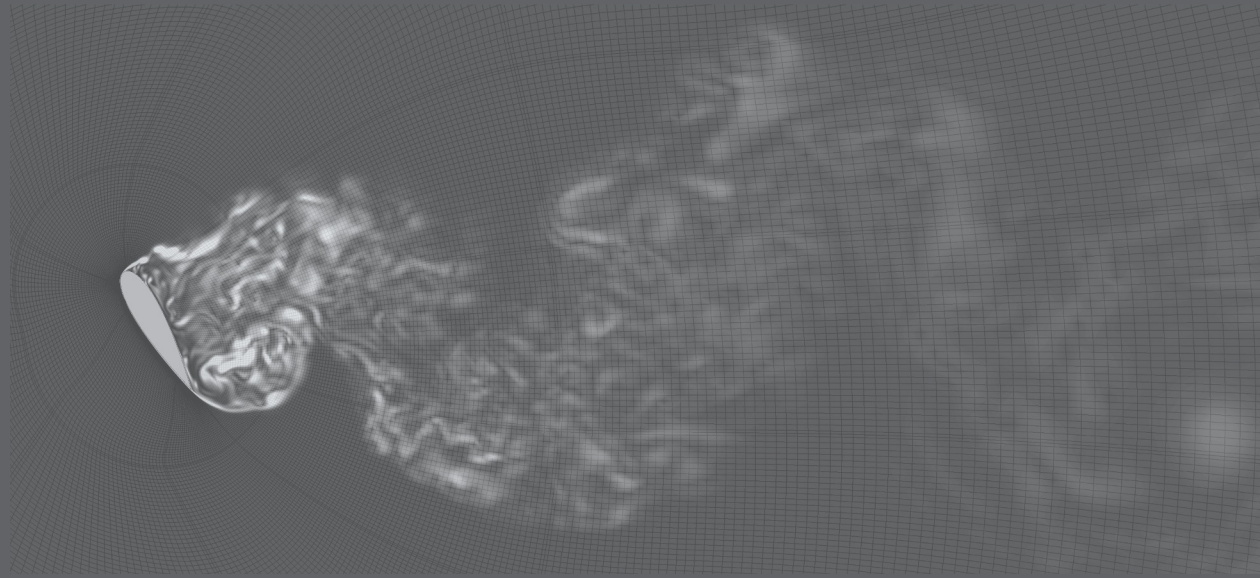
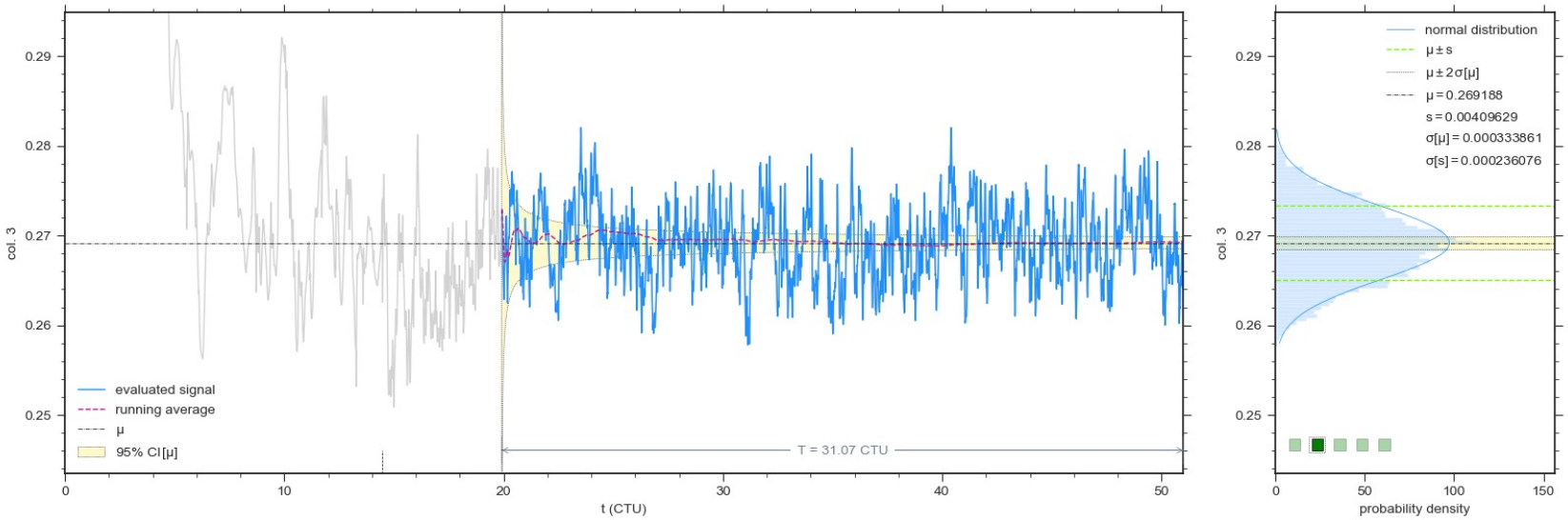


Meancalc

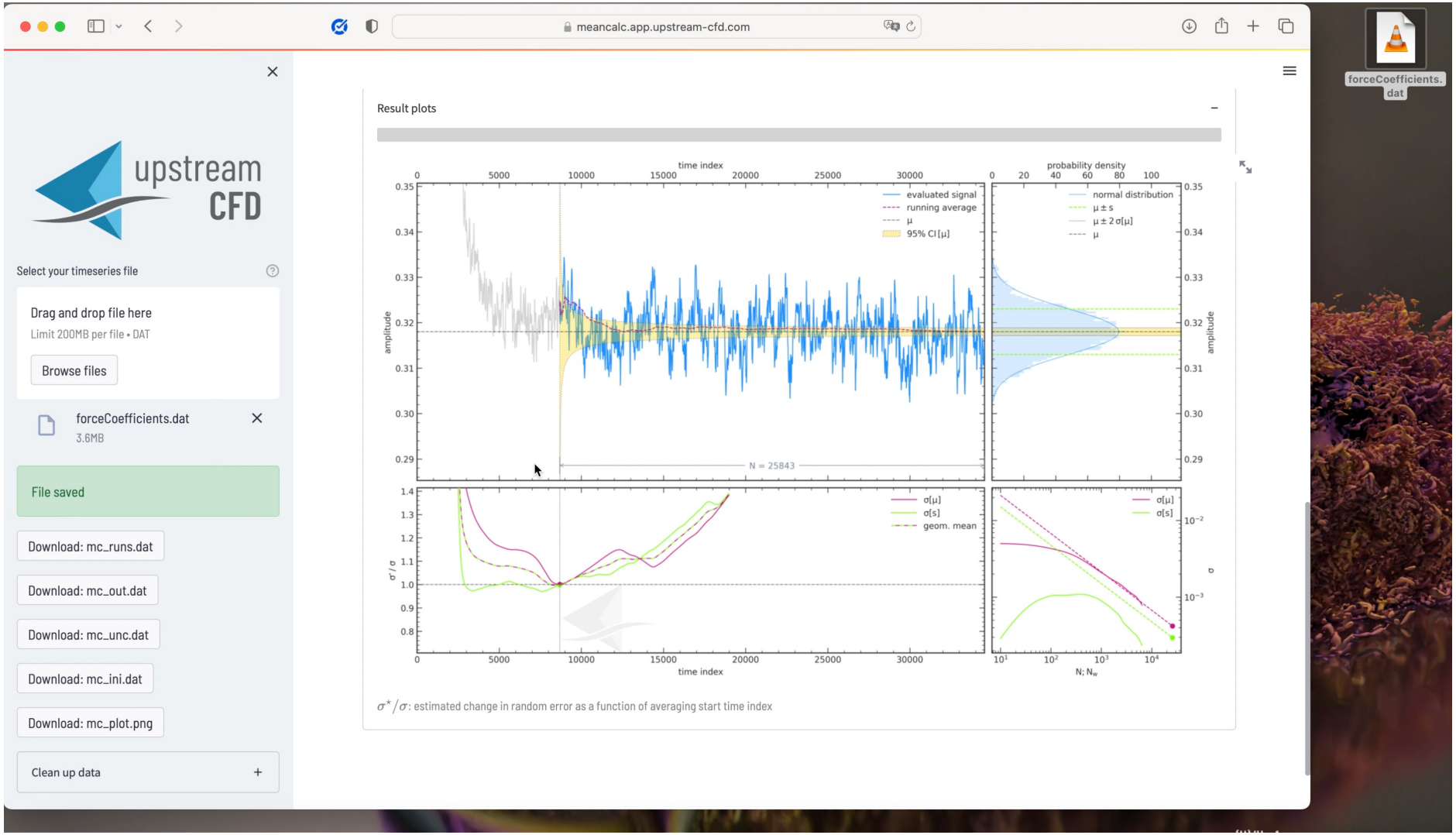
- Upstream CFD's time series analysis tool:
  1. Automatic detection and removal of initial transient
  2. Quantification of the statistical error (e.g. 95% confidence interval) on mean and standard deviation

Example for automotive CFD force coefficient:



- Underlying mathematical assumption: Statistical error scales as bandwidth-limited white noise ($\sigma \propto 1/\sqrt{T}$)
  - Algorithms detailed in C. Mockett, T. Knacke, F. Thiele (2010): "Detection of Initial Transient and Estimation of Statistical Error in Time-Resolved Turbulent Flow Data", ETMM8 (full text available on ResearchGate)
- Available as command-line tool or with browser-based GUI

Demonstration of Meancalc web GUI (current beta version)



Meancalc in AutoCFD-4

- Proposed usage: Participants run time histories (e.g. force and moment coefficients) through Meancalc and report the output upon data submission:
  - Quality check that submitted mean values are transient-free
  - Addition of statistical confidence intervals (error bars) on cross-plots
  - Specification of statistical accuracy targets to ensure validity of conclusions
- Upstream CFD provide access to the current (beta) web GUI for AutoCFD-4 participants free of charge for the duration of the workshop
  - Also support and advice to participants and TFGs on Meancalc-related topics

- URL for web app: https://meancalc.app.upstream-cfd.com
- For access: Send an email to meancalc@app.upstream-cfd.com and mention the AutoCFD-4 workshop

- Getting started guide (one-pager): https://meancalc.app.upstream-cfd.com/docs/MeancalcGettingStartedGuide.pdf
  - Also available from menu in web app
- Best practice settings on next slides

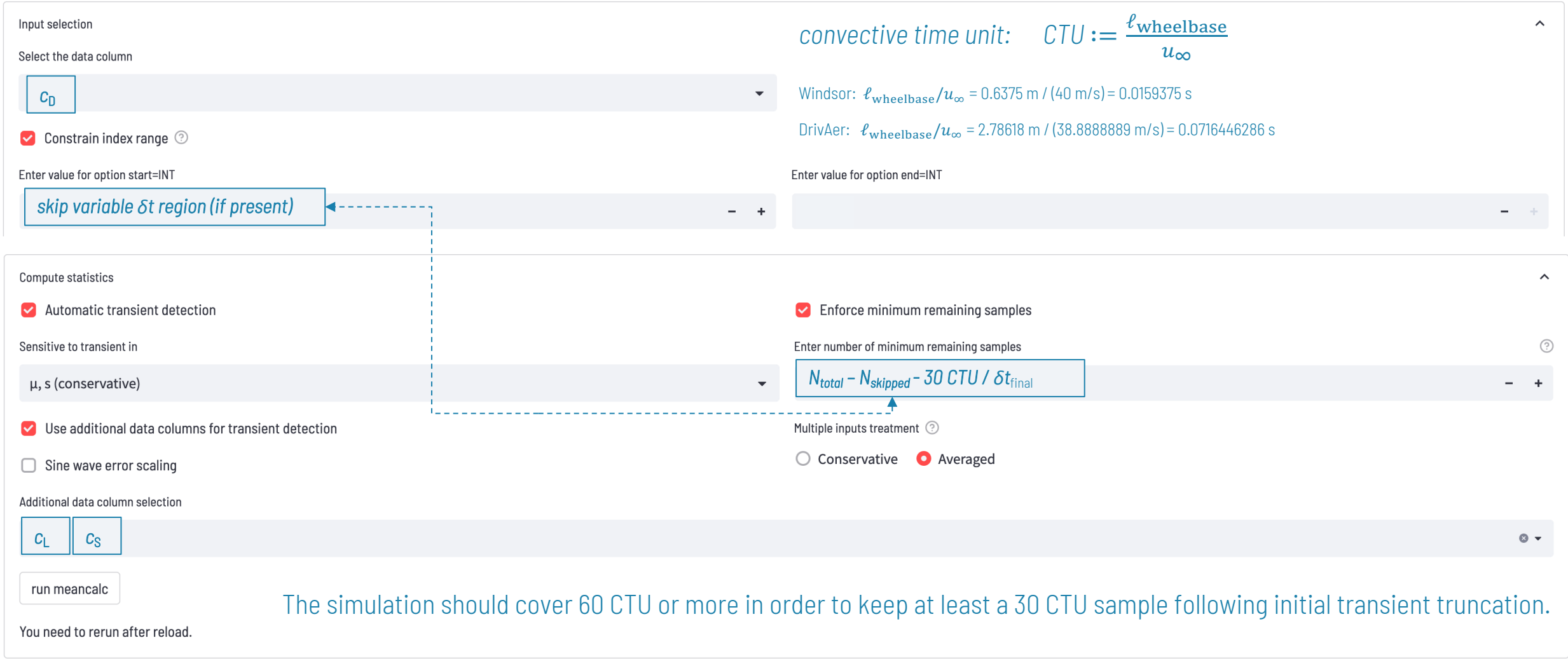
Proposed Meancalc best practices for AutoCFD-4 workshop

1. Consideration of multiple signals for initial transient detection
   - Reduces sensitivity to single extreme events in individual signals (averaging effect)
   - Includes potentially useful data from other signals
   - Using lift, drag and side force vector components showed good results when tested for DrivAer signals provided by Ford

2. Use knowledge of flow time scales to optimise transient detection limiter
   - Upper bound for transient detection "Enforce minimum remaining samples" (minSampleCTU)
   - Set to percentage (45%) of total signal length by default
   - Helpful to formulate best practice in terms of non-dimensional Convective Time Units (CTU)
   - Proposed approach: Subtract 30 CTUs from total signal length
     - This has the effect of limiting the maximum initial transient to 30 CTUs (approx. 2s for DrivAer case)

- We recommend that all simulations are carried out for at least 60 CTU
  - 30 CTU "worst case" initial transient + 30 CTU statistics

Recommended Meancalc GUI settings for AutoCFD-4



The simulation should cover 60 CTU or more in order to keep at least a 30 CTU sample following initial transient truncation.

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Thank you for your attention, any questions?