Local stability analysis of swirling shear flows

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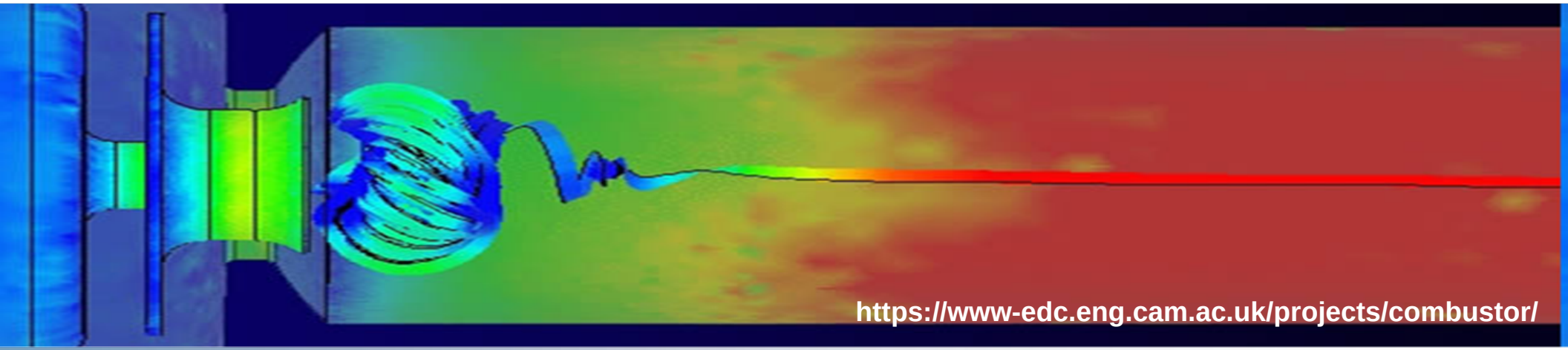
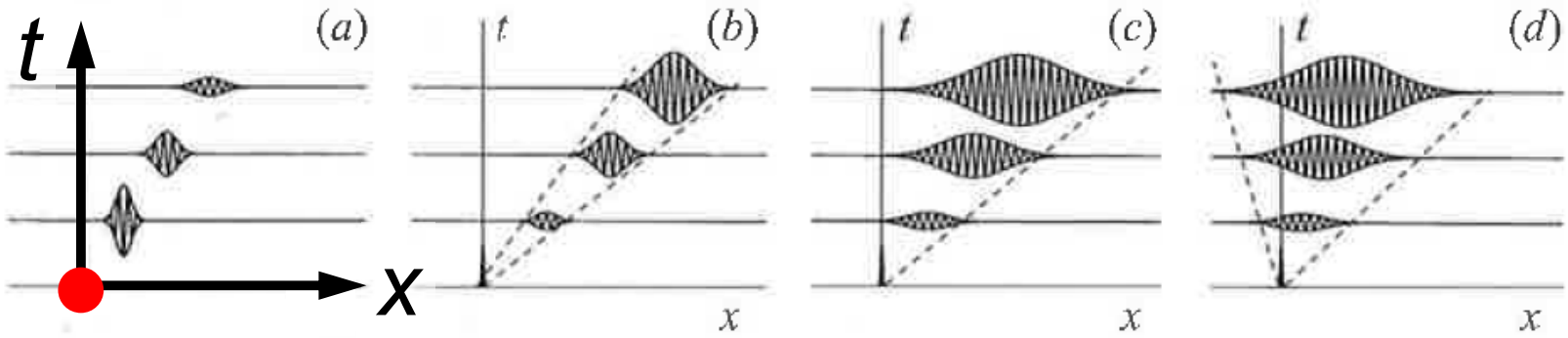
Background

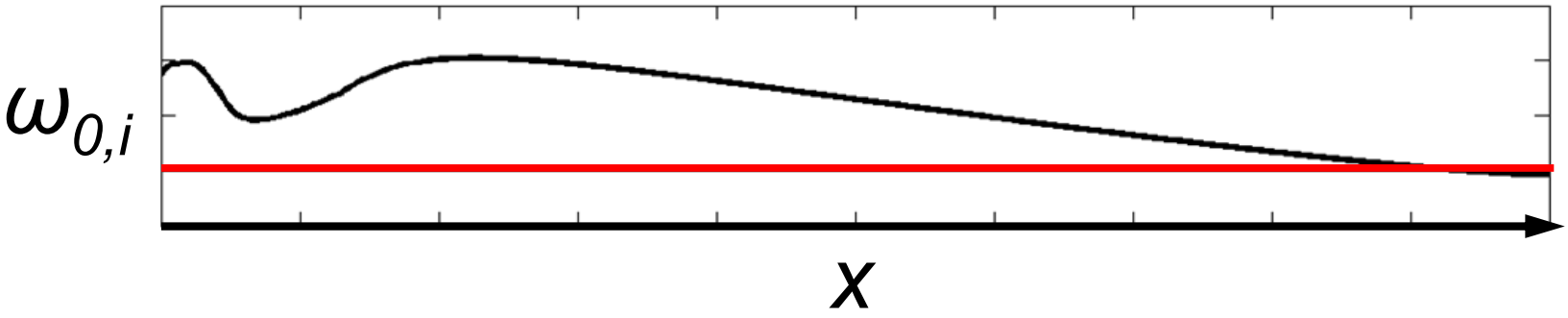
- Gas turbines: compromise between thermal efficiency and NO_x emissions
- Global analysis important for fuel injector design
  - Expensive (time and cost)
- **Local analysis** can provide insight *quickly* and with *less demanding computer requirements*



Local stability analysis

- Perform spatio-temporal analysis (**convectively** unstable or **absolutely** unstable)

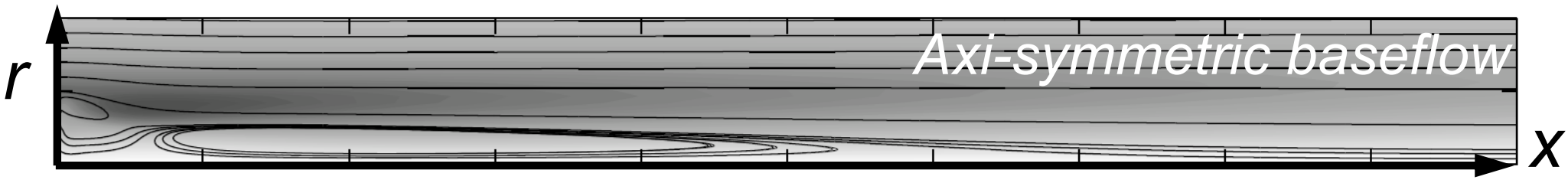




- Estimate global linear **frequency** and **growth rate**
- Force flow to calculate **global mode**

Swirling wake

- Local analysis *performs well* for **slowly evolving** flows



Swirling wake

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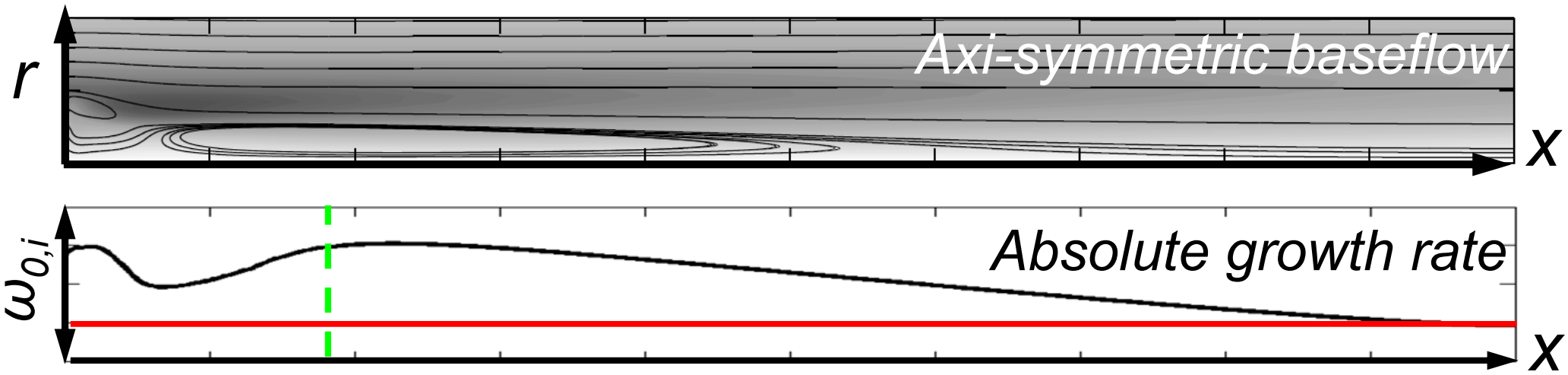

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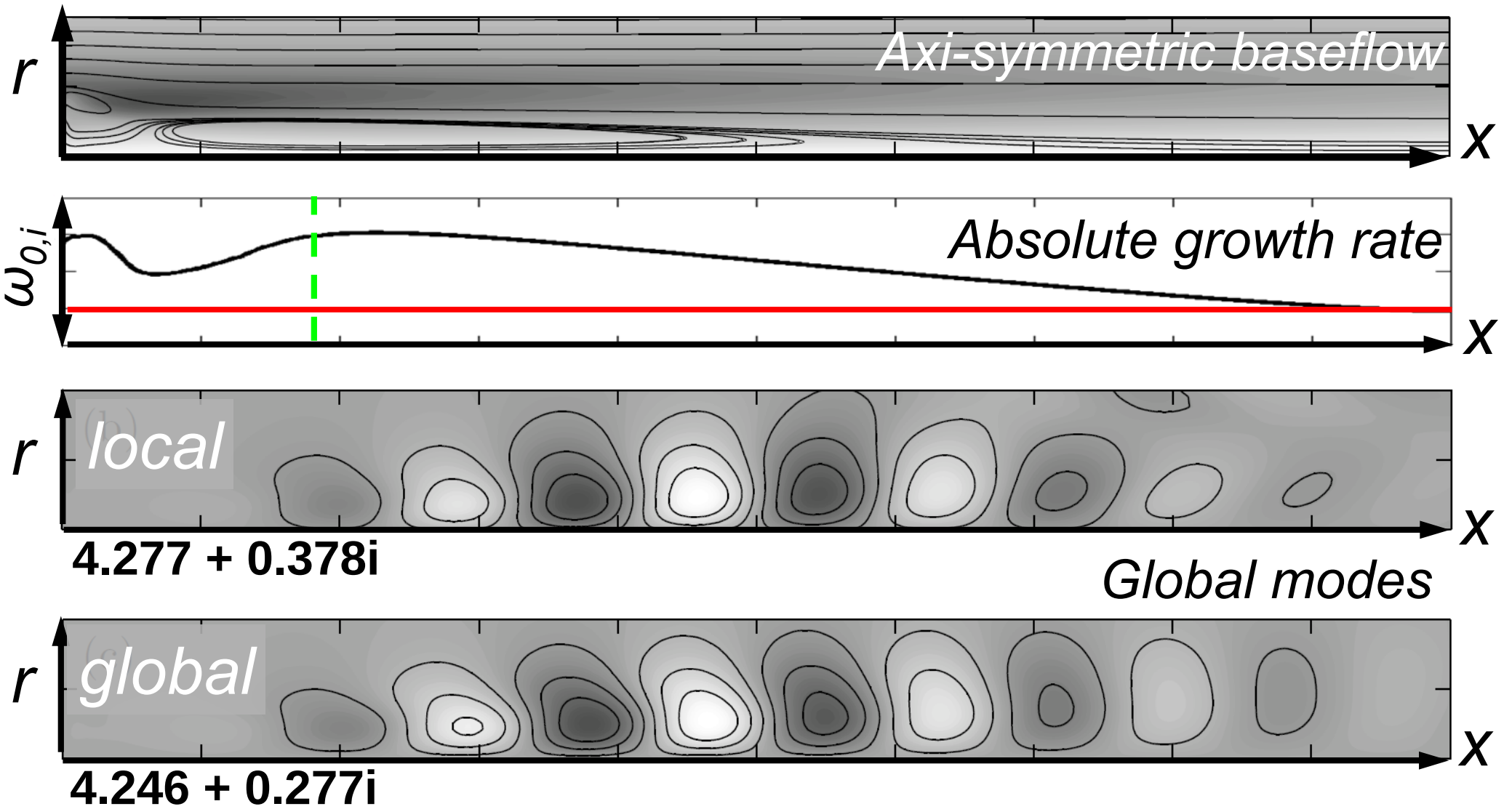
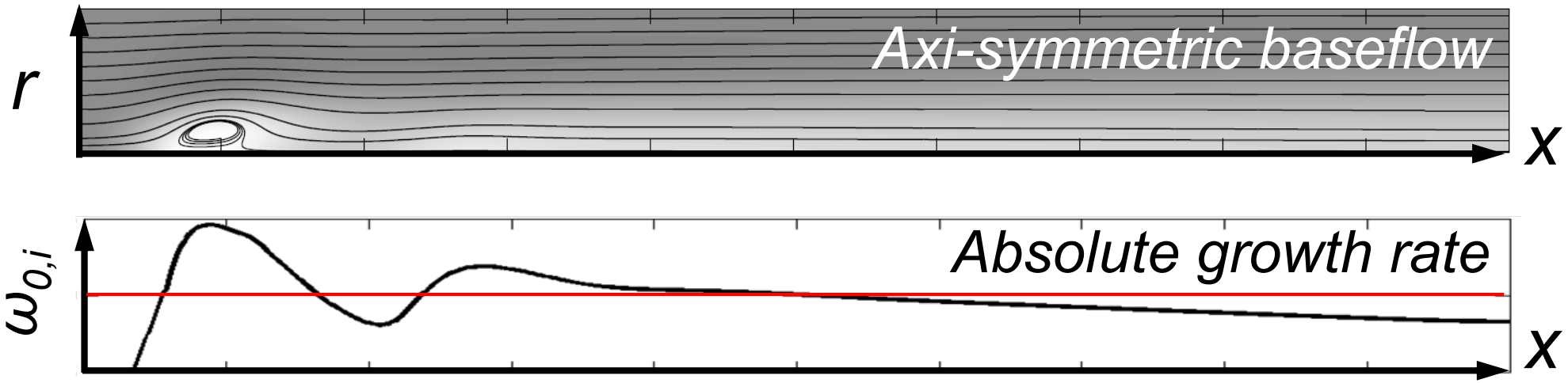


Swirling vortex

- Local analysis cannot identify wavemaker region



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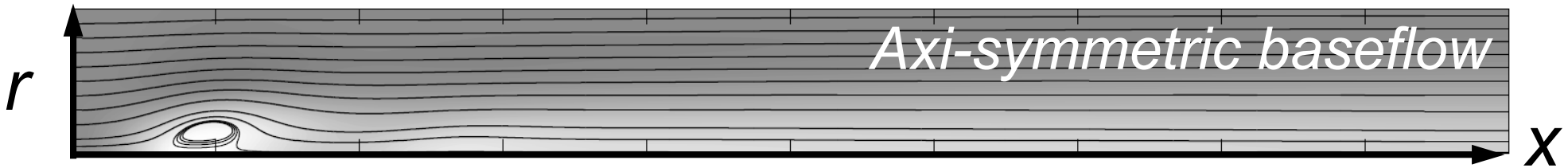
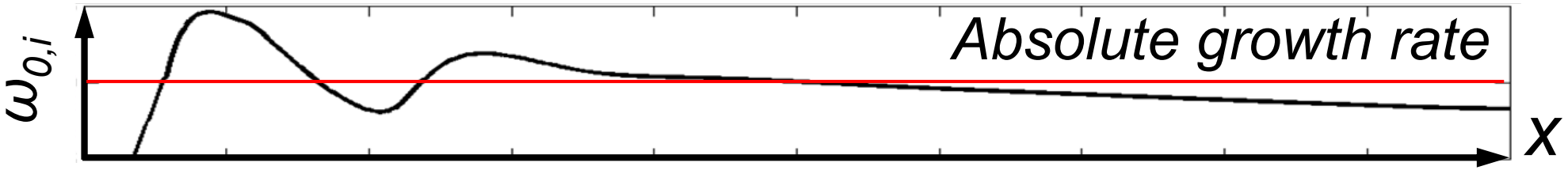
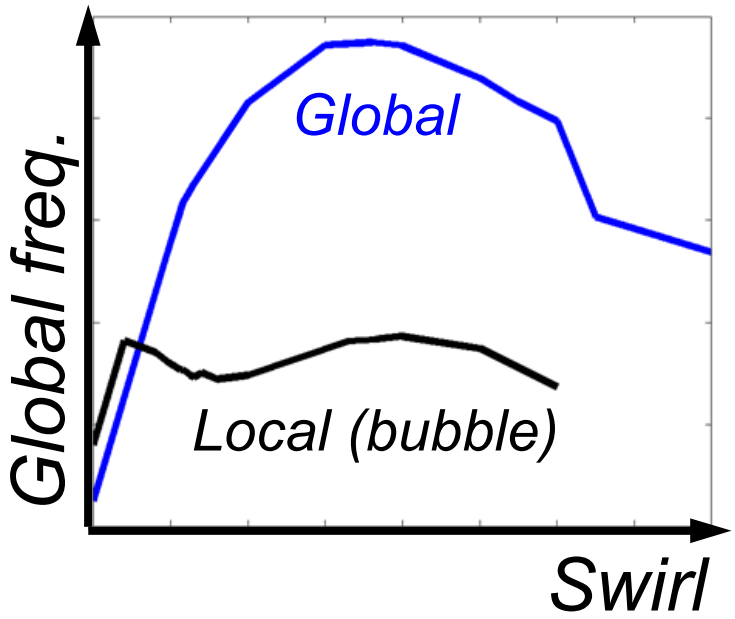


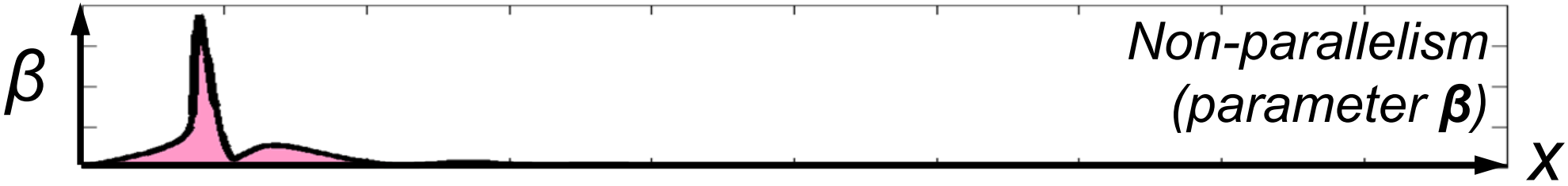




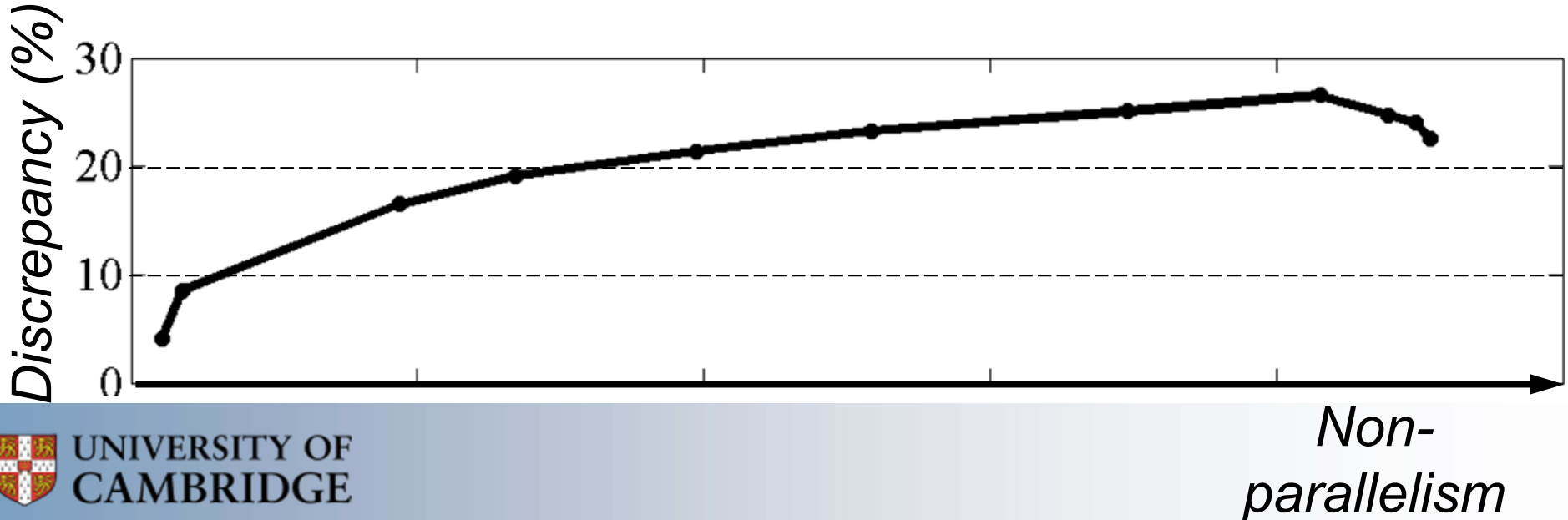
- Discrepancy between local and global analysis
- Attributed to non-parallelism

Non-parallelism effects

- Local analysis makes **locally parallel** approx.
- Not valid for strongly non-parallel flows

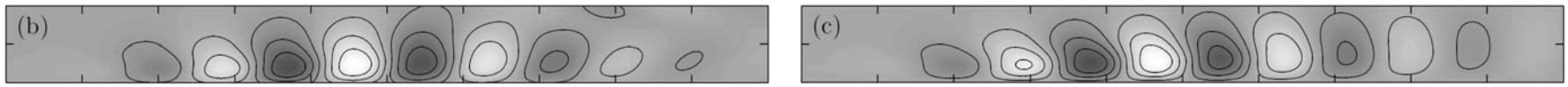


- Strongly *non-parallel* in **recirculation bubble**
- Local analysis accurate in *locally parallel* **wake region**

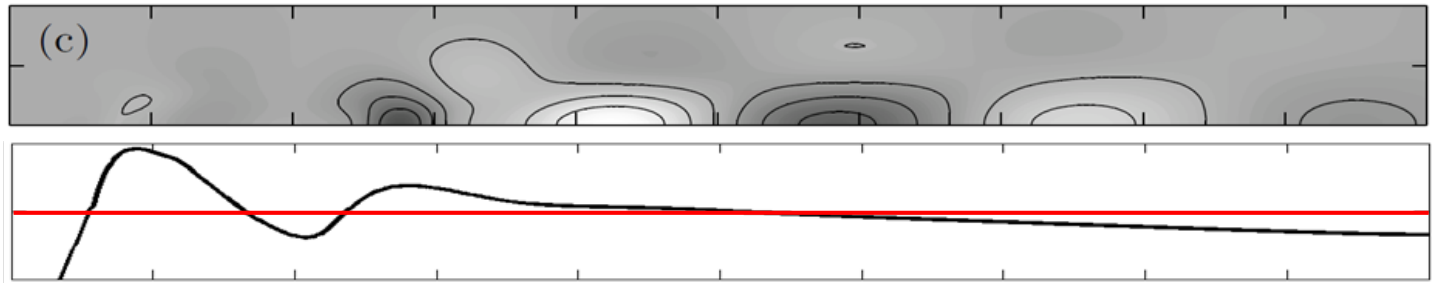


Summary

- Local analysis can examine flows **much faster** than global analyses
- Gives very **good results** for *slowly evolving* flows



- Still provides useful information (**absolute instability & frequency**)



- Useful as a diagnostic tool to better understand global flow behaviour from global analysis

Acknowledgements:
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Questions?