Presentation Rough Layout

Introduction

- Introduce ourselves and the phenomena we are trying to analyse.
- Explain what phenomena we expect to see and what our hypothesis is as to what causes it.
    - Ground effect
    - Porpoising
- Link to relevant literature
    - Yves Pomeau paper on turbulence in parallel flows.
    - Kolmogorov paper (1941) on turbulence/microscales.
    - Kraichan 2D turbulence cascade.
- There should be a clear link complexity phenomena on turbulence.

Methods

- Explain model used: LBM
    - How it is derived from LGA (clear link to automata)
    - Smagorinsky LES model to resolve turbulence and avoid computationally expensive DNS.
    - D2Q9
    - Conditions (slip vs. no slip)
- Parameters varied
- How we identified complexity phenomena e.g. lyapunov exponent
- Energy spectrum analysis
- Theoretical limitations of the model.
- Shouldn’t explain the code that much actually

Results

- Complexity phenomena found and potential reasons.
- Clear link back to literature for what caused it.
- Lack of chaos is fine to explain
- Explain errors we experienced
    - Breakdown of rideheight sweep at 25.6 is really interesting.

Conclusion

- Answer original hypothesis, correct or incorrect?
- Suggest areas for further improvement i.e direct solving, higher and more realistic reynolds number

More Detailed layout

Introduction

1. “Good morning, we are group 12 and the aim of our project was to examine the emergence of complex phenomena in turbulent flows, specifically within the context of the ground effect phenomena in F1 cars”
2. Sources:
    a. Brief explanation on Yves Pomeau paper on turbulence in parallel flows.
    b. Brief explanation on Kolmogorov paper (1941) on turbulence/microscales.
    c. Brief explanation on Kraichan 2D turbulence cascade.
3. Ground Effect (Research)
    a. Link back to research questions and hypothesis:
    b. At what point and under what conditions does a phase transition to chaotic flow? What order of phase transition is it?
        i. As the Reynolds number increases via reduced viscosity or increased velocity, the flow field will undergo a subcritical bifurcation from laminar to turbulent flow.
    c. How does the inclusion of “ground/track” in the virtual wind tunnel affect the transition to chaotic flow?
        i. The inclusion of ground/track will still result in a transition to turbulent flow but with a different transition type and characteristics.
    d. Discuss how turbulence chaos and complexity relate in this scope (quick discussion 20 to 30 seconds)
4. GE (Implementation)
    a. How sensitive is turbulent flow to initial conditions such as viscosity, ride height etc.
        i. There exists a “tipping point” (dependent on ride height and viscosity) that results in a sudden transition to chaotic flow.
    b. How do microscopic particle interactions relate to macroscopic, turbulent behaviour?
        i. Macroscopic turbulent structures are emergent properties of the microscopic particle collisions, attractions and repulsions.
    c. Might need to explain further links to complexity if not explained already.

Methods

5. Explanation of Lattice Boltzmann Model and how it is derived from the Lattice Gas Automata model.
    a. D2Q9
6. Use of Smagorinsky Large Eddy Simulation (LES) model to resolve turbulence and avoid computationally expensive direct numerical simulation.
    a. Boundary conditions (slip vs. no slip)

b. Reflections
c. Height variations (suspension, balance, wheels, etc.)

7. How we identify complexity phenomena
   a. Plotting Minima and Maxima
   b. Lyapunov Exponent (Ruelle-Tokens-Newhouse route to chaos)
   c. Regimes
8. Energy spectrum analysis (power laws -)
   a. Kolmogorov
   b. Kraichann

Results

9. Varying Reynolds number
   a. Bifurcation diagram
   b. Energy spectra analysis at Re = 1000 and Re = 25 000
      i. Could be nice to show the model breakdown at Re = 25 000 due to numerical instability.
      ii. Kolmogorov's formulated his theory explicitly for 3D turbulence.
10. Varying Ride Height
    a. Show Bifurcation Diagram at Re = 5000, 10 000 and 500
    b. Transition point at a ride height of 25.3 and how the model actually broke down there without further refinement.
11. Ricardo's Simulation.

Conclusion

12. Transition occurred at …
    a. Actually appeared to be a supercritical transition
    b. Qualitatively describe transition type
13. Second order continuous transition
    a. Lyapunov exponent grows continuously from, not jumping from 0 to a finite value.
    b. In the bifurcation diagram amplitude, the spread of extrema increases gradually.
    c. No coexistence region (?Hysteresis) First-order transitions have a region where both phases (e.g., periodic and chaotic) are stable. Regime diagram shows clean sequential transitions.
14. Areas for further improvement
15.