Open questions and issues

I. Cloud Physics and Simulation Open Questions

II. Computer Science / Engineering Open issues

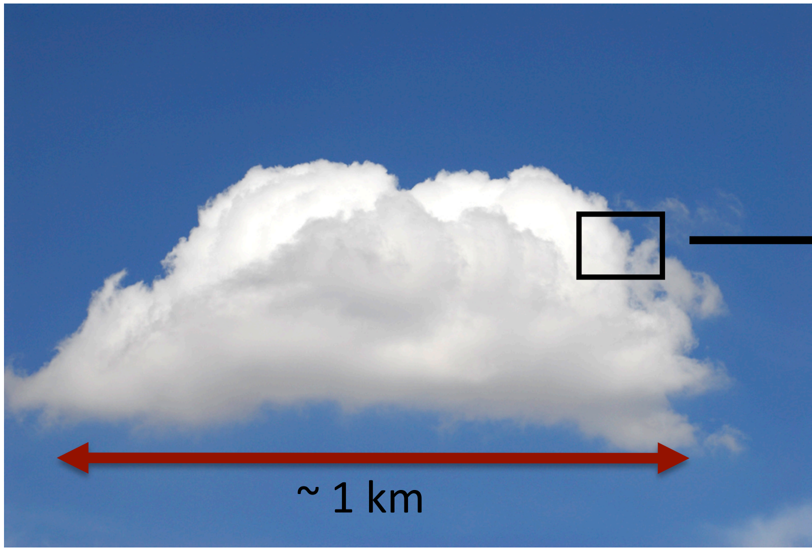
Part I.

Cloud Physics and Simulation Open Questions

Multiscale cloud-environment mixing and its impact on cloud microphysics

Wojtek Grabowski

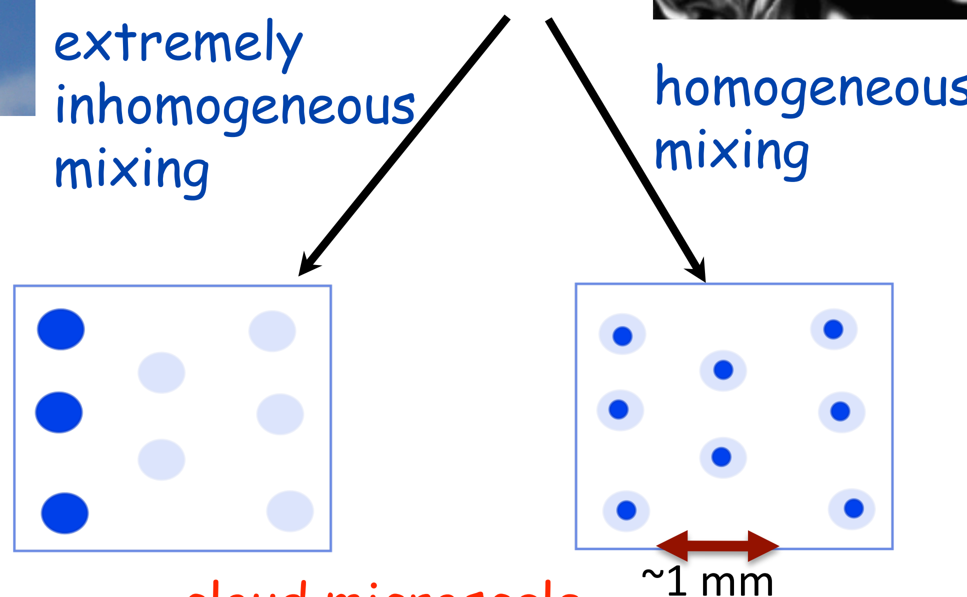
cloud macroscale



turbulence

Cloud chamber

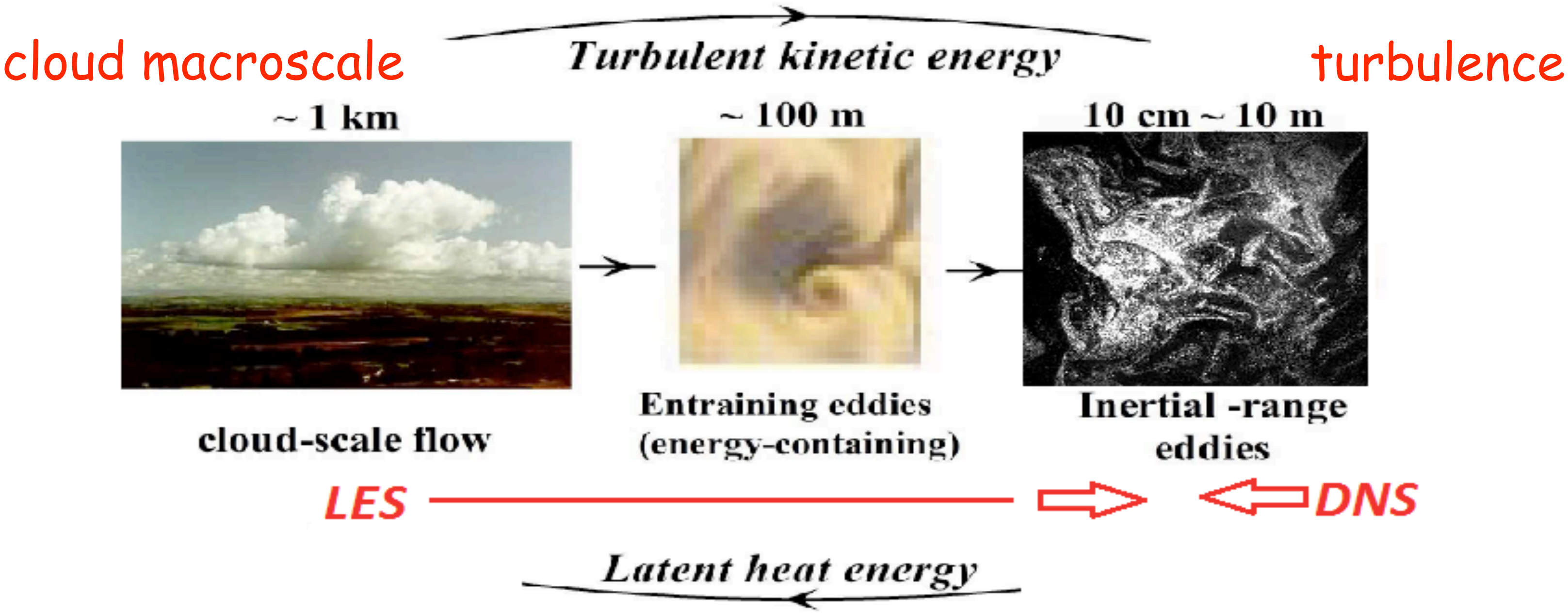
DNS simulation



cloud microscale

Cloud microphysics is affected by cloud-scale processes as well as by small scale turbulence. Understanding overall effect has challenged cloud physics community for decades…

Andrzej Wyszogrodzki: **LES of multiscale cloud processes**



What should be included into the LES system to most accurately represent multiscale processes especially the energy transfer at different scales?

Which microphysical and turbulence models: how much should be resolved vs parametrized?

Tradeoffs between efficiency and accuracy in physics and numerics.

Bridging the LES-DNS gap

Steve Krueger

- – Difficulty depends on process of interest.
- – Higher resolution or improved conventional parameterization may work for some processes.
- – For investigating how turbulence affects cloud droplet growth, **multi-scale modeling** (super-parameterization) is a promising solution.

LES Limitations

- The premise of LES is that only the large eddies need to be resolved.
- Why resolve any finer scales? Why resolve the finest scales?
- LES is appropriate if the important small-scale processes can be parameterized.
- Many cloud processes are subgrid-scale, yet can’t (yet) be adequately parameterized.

Subgrid-scale Cloud Processes

- Small-scale finite-rate **mixing** of clear and cloudy air determines evaporative cooling rate and affects buoyancy and cloud dynamics.
- Small-scale variability of water vapor due to entrainment and **mixing** broadens droplet size distribution (DSD) and increases droplet collision rates.
- Small-scale **turbulence** increases droplet collision rates.

Open problems relevant to cloud physics

Martin Maxey

- How to include effects of finite droplet Reynolds numbers?

- How to better treat the detailed process of droplet coalescence? e.g., local deformation due to the lubrication force and other short-range interaction forces.

- The role of ice in clouds. We tend to focus on droplet coalescence but one could explore riming processes in the same way.

- How can LES incorporate all we have learnt into a parameterized sub-grid model or a probabilistic Langevin model.

- We tend to think of one parameter for a problem - deterministic problems. In the end we may have a range of parameter values and an uncertain outcome that is statistical in nature.

Turbulent collision-coalescence and parameterization

Lian-Ping Wang

How to incorporate accurate short-range interaction model in HDNS?

Turbulent background flow, Oseen disturbance flow, etc.

How to obtain the most information / best benefits from the hybrid DNS?

Local collision statistics conditioned on dissipation rate?

Multiscale analysis of the data?

How to address the limitations of hybrid DNS?

Domain size or Re number effects?

Flow intermittency?

Better theoretical models of relative velocity and radial distribution functions?

How to integrate HDNS and LES? The size gap problem.

Simulation of turbulent droplet-droplet interactions

Lou Rossi

Can we improve the existing cloud turbulence/droplet algorithm to be

Consistent: The algorithm converges to Navier-Stokes as we increase the resolution in time and space.

Scalable: Amenable to peta-scale computing on existing hardware.

???

Commentary:

I suspect the first goal is not achieve in the next year or perhaps even the next decade outside of full multphase DNS. Our approach has and will be to include more physics in the algorithm in a consistent way, and I believe this is our only hope for reaching the desired Reynolds numbers. I believe the roadmap will involve more investigation into the application of uniformly valid expansions via matched asymptotics or renormalization group methods.

Part II.
Computer Science / Engineering Open issues

Open Questions in Parallel Computing

Daniel Orozco

- What is a good Parallel Program Execution Model?
  - MPI? OpenMP? Dataflow? Other?
  - Data movement or computation movement?
- How to build power efficient programs?
  - HPC: Charge per Hour or per Joule?
- What is an efficient architecture?
- What is the role of the scientist?
  - Writing the program/Algorithm?
  - Optimizing the program?
  - Knowledge of the machine?
- **Will past techniques work in the future?**

Challenges in HPC/Program Optimization

Xiaoming Li

- Map programs to heterogeneous computers
  - CPU, GPU and other accelerators
  - Simple core vs. complex core
- Handling of extreme level of parallelism
  - A handful of thread is easy. How about millions of threads?
  - Ad-hoc solutions won't work well.
- Data transfer and resource sharing
  - Deep but segregated memory hierarchy.
  - Latency vs. bandwidth
  - Extensive resource sharing: communication channel, data storage, and computation unit.

Multivariate Visualization

Chandra Kambhamettu

Multivariate visualization is an important subfield of data visualization that focuses on data items composed of more than two variables.

Problem: The clutter problem, where data gets overlapped onto itself.

Solution1: Saliency based multi-resolution and hierarchical data analysis.

Solution2: Utilize Flythrough visualization, i.e, the bird's eye view navigation of visualization data.

Petascale computing

Lian-Ping Wang

Why is it challenging to develop a code that can run efficiently on O(100,000) processors?

Communication and latency bottleneck

Will simple algorithms (i.e., lattice Boltzmann) be better than the more traditional methods (NS-based finite difference, pseudo-spectral)?

How to train students?

Questions from the participants

Are you using Fortran for Sci. Computation?