Focus on deep and shallow convection, and turbulence
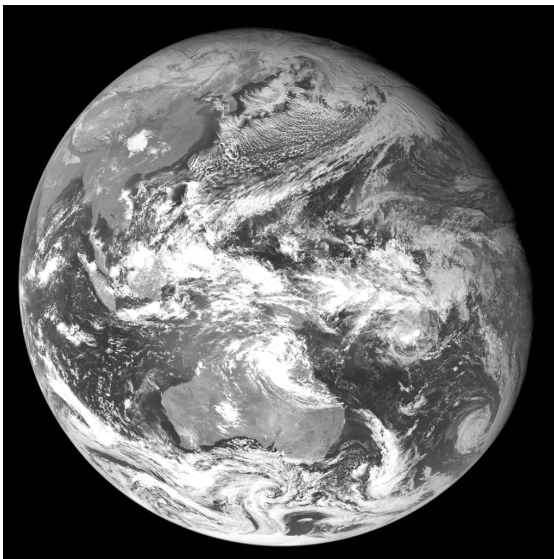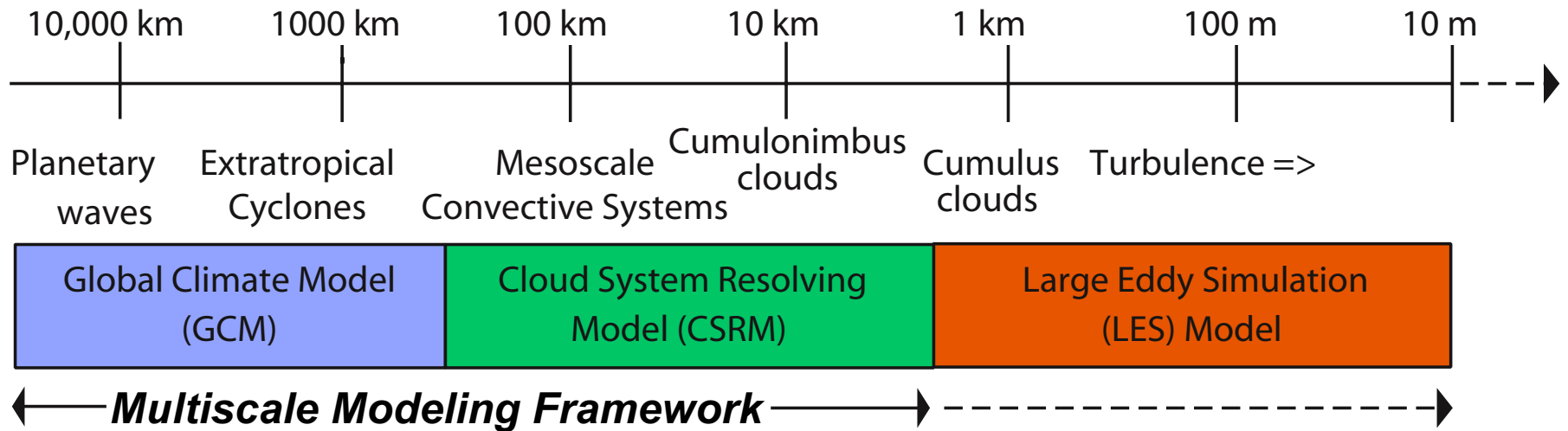
Steve Krueger and Chin-Hoh Moeng

Fort Collins, CO
August 2007

Scales of Atmospheric Motion

10,000 km	1000 km	100 km	10 km	1 km	100 m	10 m

Planetary waves

Extratropical Cyclones

Mesoscale Convective Systems

Cumulonimbus clouds

Cumulus clouds

Turbulence =>

Global Climate Model (GCM)	Cloud System Resolving Model (CSRM)	Large Eddy Simulation (LES) Model

← *Multiscale Modeling Framework* →

Boundary layer clouds in cloud-system-resolving models (CSRMs)

- CSRMs may have horizontal grid sizes of 4 km or more.

- Such CSRMs are used in MMF, GCRMs (global CSRMs), and tropical cyclone models.

- In MMF and GCRMs, CSRMs are expected to represent all types of cloud systems.

- However, many cloud-scale circulations are not resolved by CSRMs.

- Representations of SGS circulations currently used in CSRMs can be improved.

Strategy

- **Objectives:**
  Improve the representation of SGS convection, turbulence, and microphysics in CSRMs used in MMFs, GCRMs, and NWP.

- **Proposed parameterizations**

  - *PDF/HOC:* Cheng & Xu, Lappen & Randall

  - *Two-scale MMF:* CSRM plus boundary-layer-eddy-resolving model (ERM)

- **Additional physics to be included**

  - SGS microphysics

  - Effects of *surface inhomogeniety* (elevation, land surface properties): both resolved by the CSRM and SGS

Strategy

- Better understand interactions of deep and shallow clouds, and turbulence.

- Better understand representation of interactions of deep and shallow clouds, and turbulence in prototype MMF.

- Test improved physics in MMF.

Short-term Plans

- **Better understand interactions of deep and shallow clouds, and turbulence.**

  - Analyze existing and new *benchmark simulations.*

    ACTION ITEM: Perform large-domain LES of deep convection.

    (Computer time is required.)

  - Analyze *observational datasets.*

    ACTION ITEM: Identify and/or develop appropriate datasets.

Short-term Plans

- **Better understand representation of interactions of deep and shallow clouds, and turbulence in prototype MMF**

  - Identify physical processes responsible for MMF deficiencies (e.g., great red spot).

    ACTION ITEM: Analyze existing MMF simulations.

    ACTION ITEM: Perform new MMF simulations that involve changes to MMF physics. *(Computer time is required.)*

    (1) Use CAM physics except for convection tendencies (Q_1, Q_2).

    (2) Replace boundary layer turbulence scheme used in CRM.

Long-term Plans

- **Test improved physics in MMF.**

Issues

- **Computer time will be required for the proposed simulations.**

- **Large size of large-domain LES output dataset will make it a challenge to access and analyze. We need help to design.**

- **Access to SP-CAM code and results: We need a clone of Marat!**