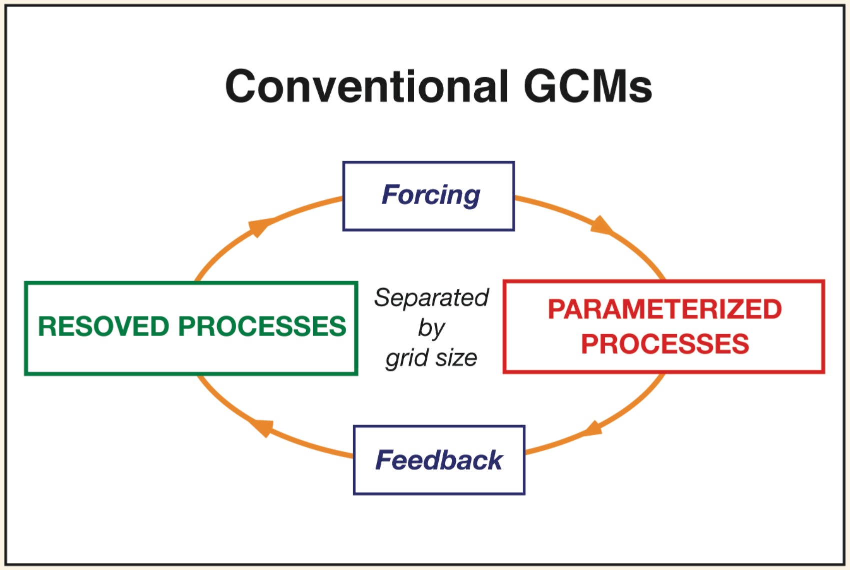
Presentations

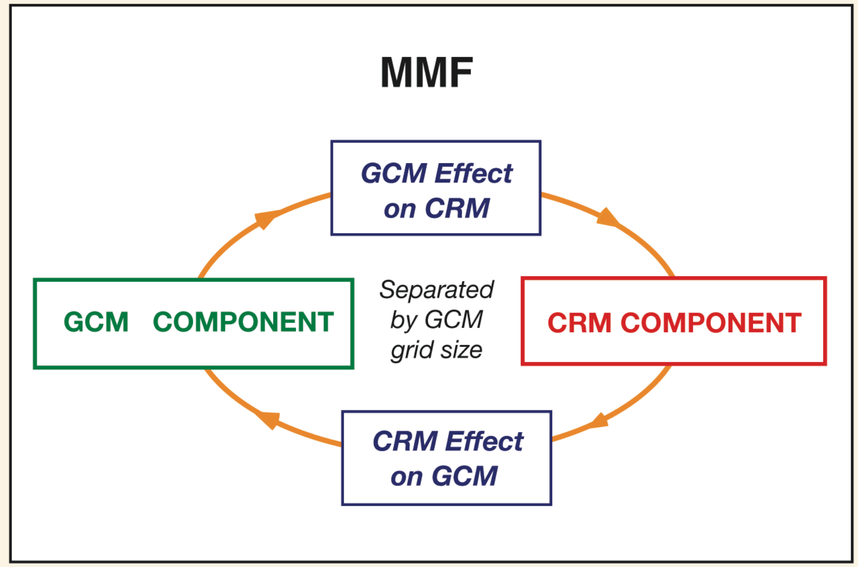
- AA & JHJ on coupling issues with the MMF
- CK & RH on VVM and GCRM
- AC on tests of turbulence parameterization in VVM

THE PROBLEM OF COUPLING THE TWO COMPONENTS OF MMF

The basic structure of conventional GCMs



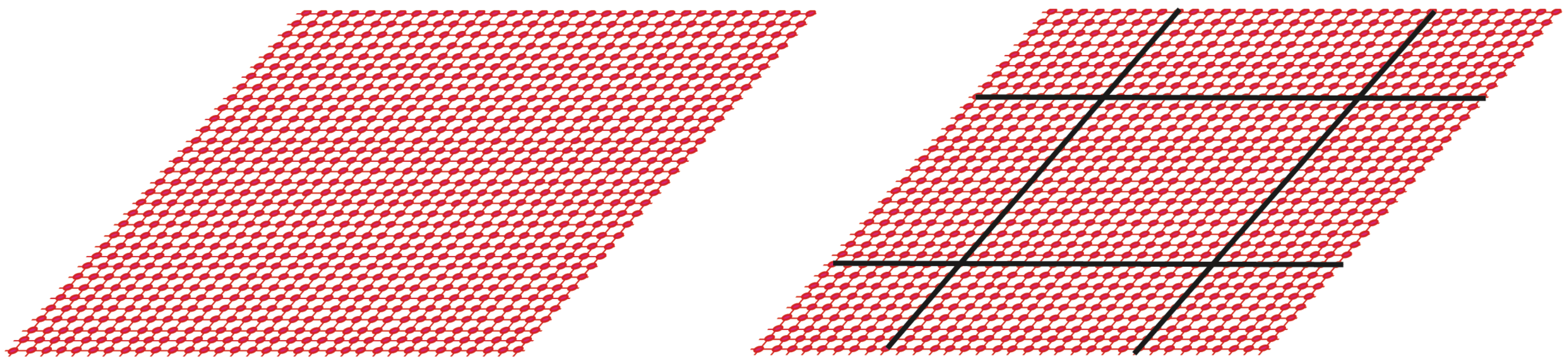
MMF inherits this basic structure



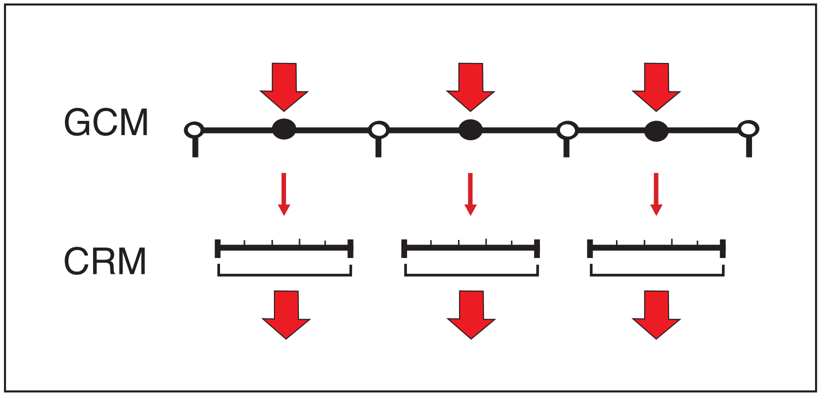
The classical closure problem of cumulus parameterization is now replaced by the problem of formulating the coupling of the two components.

To study the coupling problem in a way independent of the dimensionality, we use

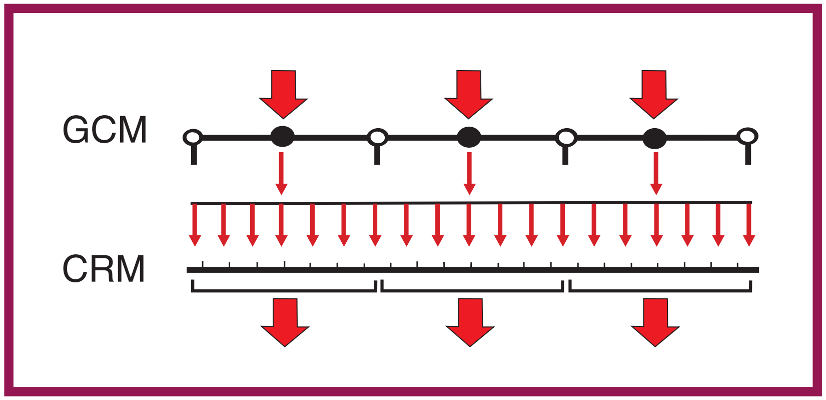
3D CRM (for benchmark simulation) **3D MMF** (for testing of coupling)



PROTOTYPE COUPLING
(as originally suggested)



3D MMF COUPLING



Approach A:* *Explicit formulation of GCM/CRM effects

Approach B:* *Mutual adjustments of prognostic variables

Approach C:* *Hybrid of A and B

- Approach A includes an ad hoc way of eliminating the double counting.
- Horizontal resolution of GCM: 96 km

Paper to be presented at EGU

Planar Hexagonal Anelastic Model

(Completed Tasks)

- ☑ A paper presenting a unification of the anelastic and quasi-hydrostatic systems of equations is submitted.
- ☑ Coding: Horizontal advections of variables for cell centers, corners and walls are completed (parallelized and optimized).
- ☑ Several solution methods for the 3D elliptic w-equation are tested.
- ☑ Coding: The 3D elliptic solver is coded (parallelized and optimized).

3D Elliptic w-Equation

$$\left\{\nabla_H^2 w + \frac{\partial}{\partial z}\left[\frac{1}{\rho_0}\frac{\partial}{\partial z}(\rho_0 w)\right]\right\} = RHS$$

III) Relaxed Method with Multigrid Solver

$$\mu\frac{\partial w}{\partial t} = \left\{\nabla_H^2 w + \frac{\partial}{\partial z}\left[\frac{1}{\rho_0}\frac{\partial}{\partial z}(\rho_0 w)\right]\right\} - RHS$$

Forward in time

Centered in space

Backward in time

Centered in space

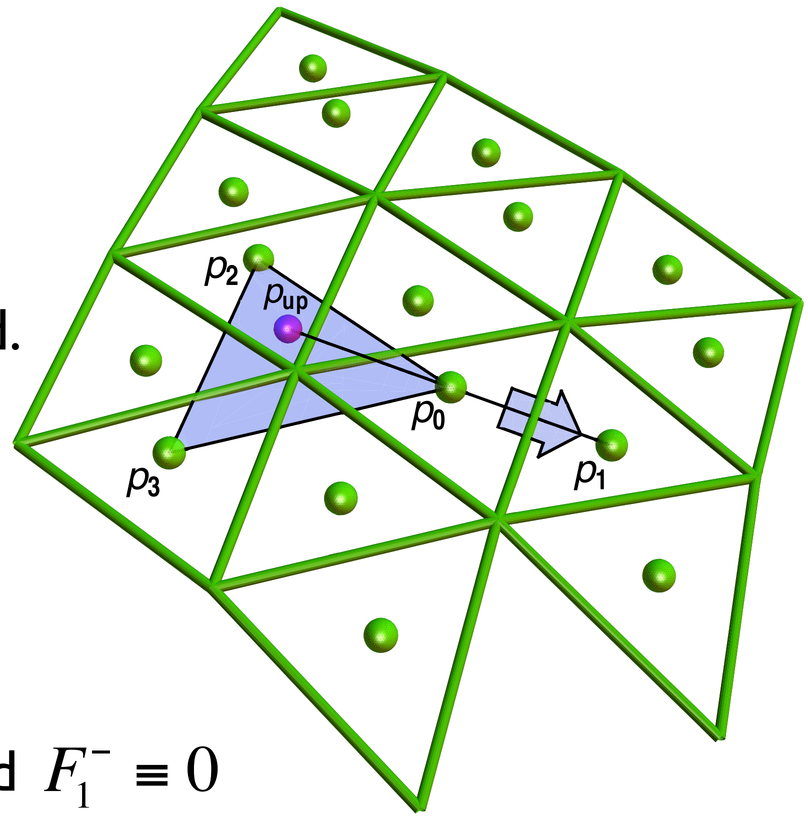
Backward in time for the center point

Forward in time for the surrounding points

The 3rd-order (upstream-biased) advection

❖ Based on Hsu and Arakawa (1990)

$$\frac{\partial m}{\partial t} + \frac{1}{A}\sum_{i=1} F_i = 0$$



❖ The incoming and outgoing fluxes depend on the direction of the wind.

$$F_i = F_i^+ + F_i^-$$

❖ Suppose the wind directed from p_0 toward p_1, then, for example

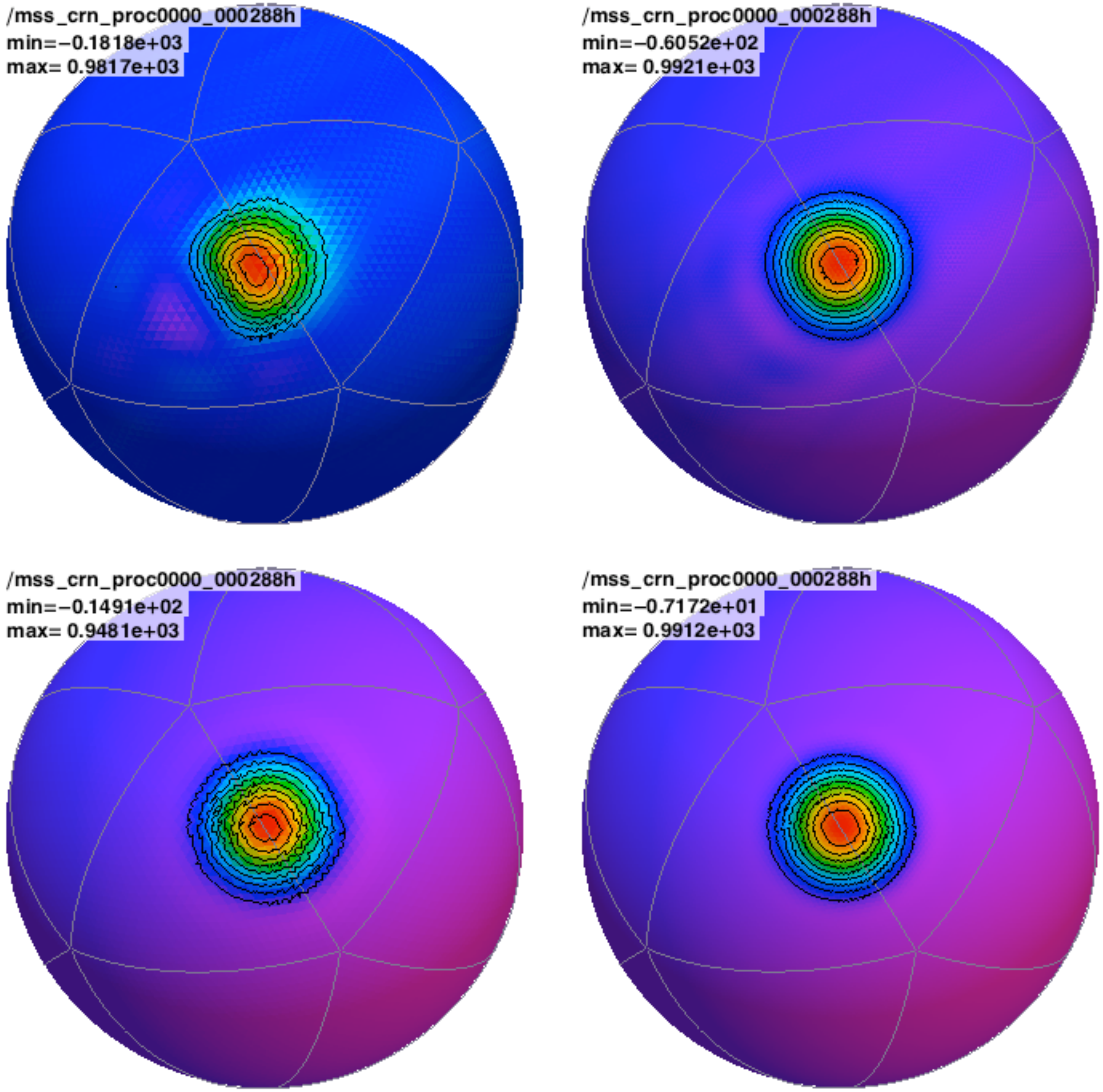
$$F_1^+ \equiv F_1^+\left(m_{up}, m_0, m_1, \mathbf{v}_{up}, \mathbf{v}_1\right) \text{ and } F_1^- \equiv 0$$

where F_1^+ depends on the curvature of the upstream field.

❖ The scheme can be positive-definite or not.

(appx. mass) at 12 days

- Columns: 10242 and 40962
- Rows: Centered in space and upstream biased



Projections

Planar Hexagonal Anelastic Model

Feb 2008: Test of full dynamics, without physics

Mar 2008: Test of model with physics

July 2008: Tests with the *unified system of equations*

Global Geodesic Anelastic Model

Mar 2008: Test of full dynamics, without physics

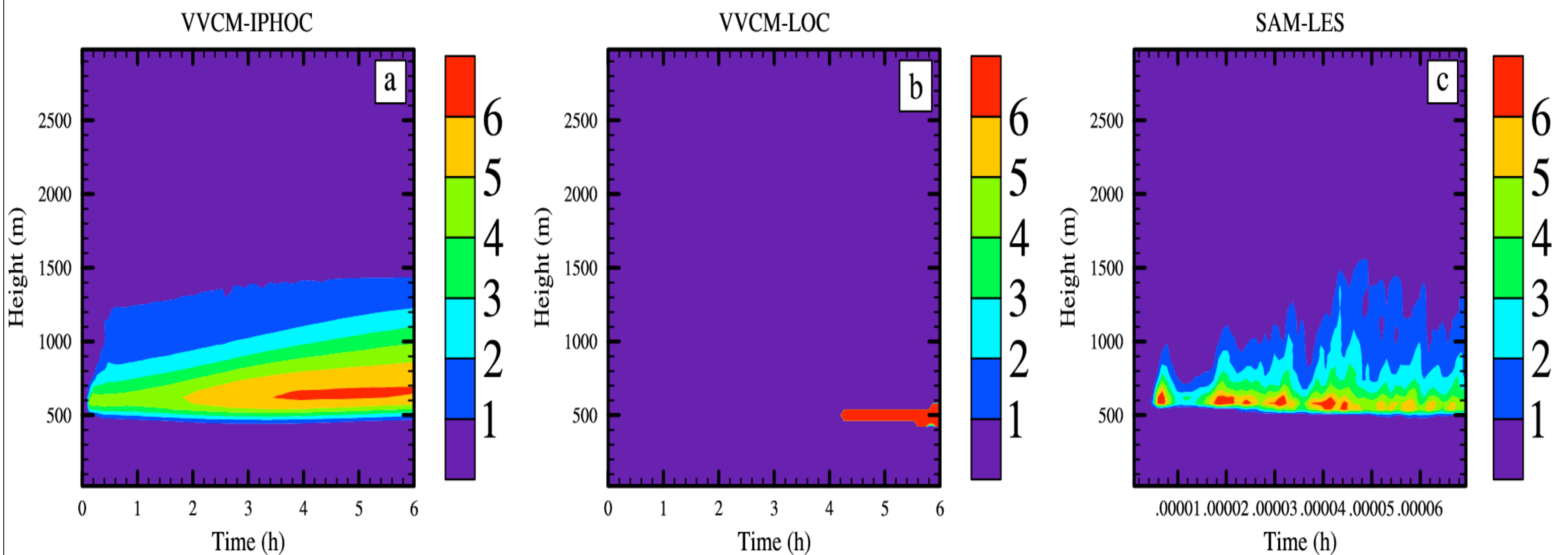
May 2008: Test of model with physics

Paper to be presented at EGU

Intermediately Prognostic Higher-Order Closure Model

- Double-Gaussian distribution of liquid-water potential temperature, total water mixing ratio and vertical velocity
- Skewnesses of these three third-order moments predicted
- All first-, second-, third- and fourth-order moments, subgrid-scale condensation and buoyancy based on the same probability distribution function
- Subgrid-scale bulk microphysics in development: Rain In Cumulus over the Ocean (RICO) case

Time evolution of cloud field for BOMEX (%)



Summary and Discussion

- An IP-HOC has been implemented in VVCM
- Mechanism to produce shallow cumulus clouds in CRM resolution begins to work
- System bias on mean profiles of wind is still under invetigation
- Higher resolution runs for GCSS clouds need more work
- Extensive testing is underway