
Overview of
Research Objectives

Clouds Are Central to the Earth Sciences

- Climate change
- Weather prediction
- The water cycle
- Global chemical cycles
- The biosphere

We are being held back in all of these areas by an inability to simulate the global distribution of clouds and their effects on the Earth system.

The Cloud Parameterization Deadlock

"...The modeling of clouds is one of the weakest links in the general circulation modeling efforts."

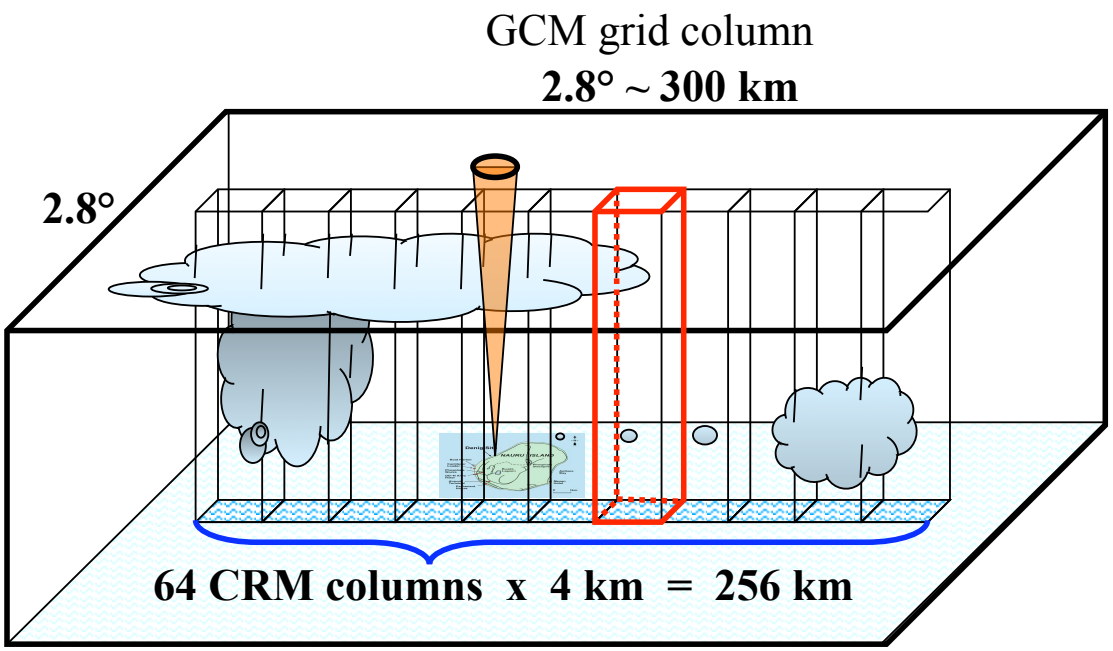
--Charney et al., National Academy Report, 1979

Deficiencies in the representation of cloud processes in climate models drive much of the uncertainty surrounding predictions of climate change.

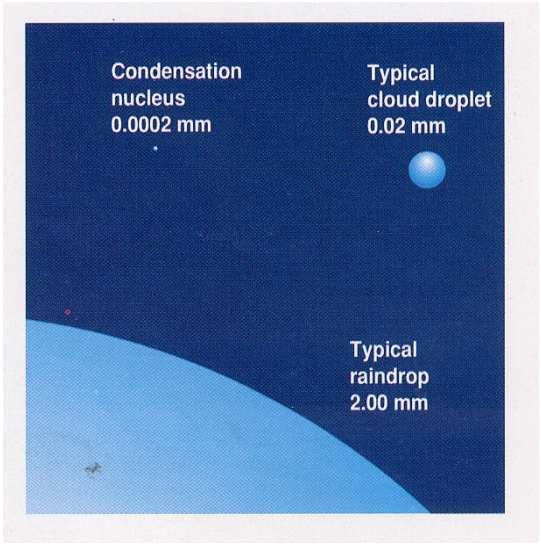
This was true 30 years ago, it's true now, and at the rate we are going it will still be true 30 years from now.

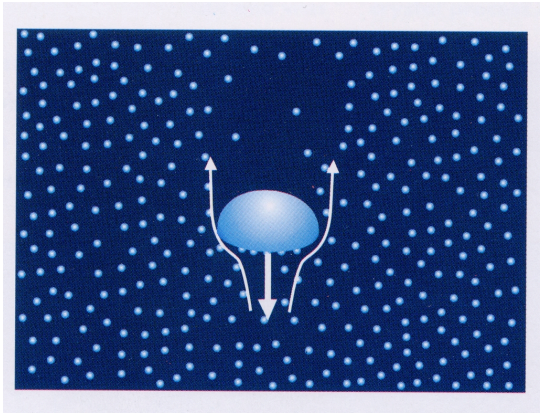
What can we do about it?

Super-Parameterization

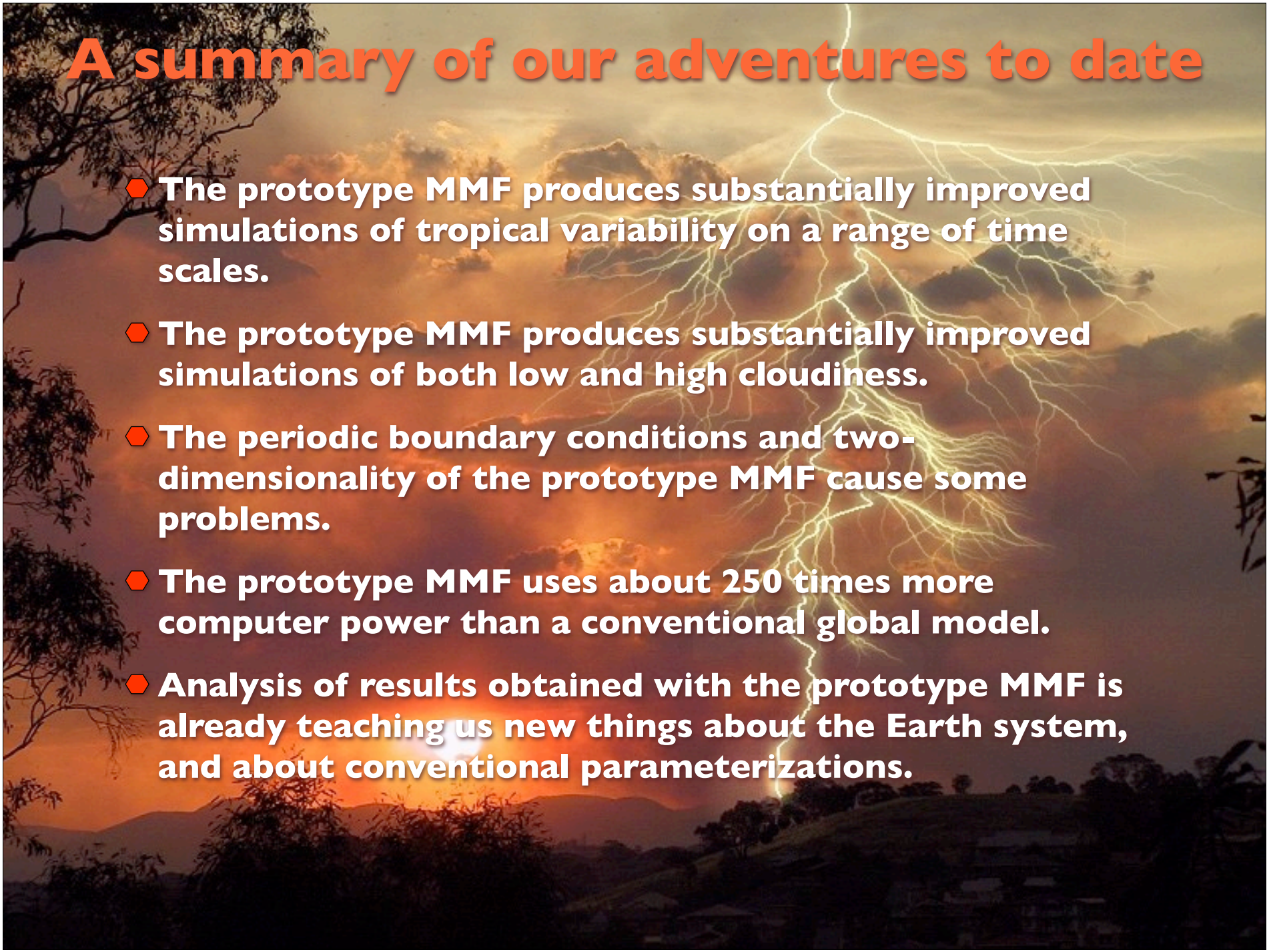


Limitations (and Strengths) of CRMs





- **Microphysics must still be parameterized.**
- **Radiative transfer must still be parameterized.**
- **Turbulence and shallow convection must still be parameterized.**



A summary of our adventures to date

- The prototype MMF produces substantially improved simulations of tropical variability on a range of time scales.
- The prototype MMF produces substantially improved simulations of both low and high cloudiness.
- The periodic boundary conditions and two-dimensionality of the prototype MMF cause some problems.
- The prototype MMF uses about 250 times more computer power than a conventional global model.
- Analysis of results obtained with the prototype MMF is already teaching us new things about the Earth system, and about conventional parameterizations.

A door has swung open.

We have demonstrated the potential of the prototype MMF. ***This is a revolutionary, transformative new approach to understanding cloud processes.***

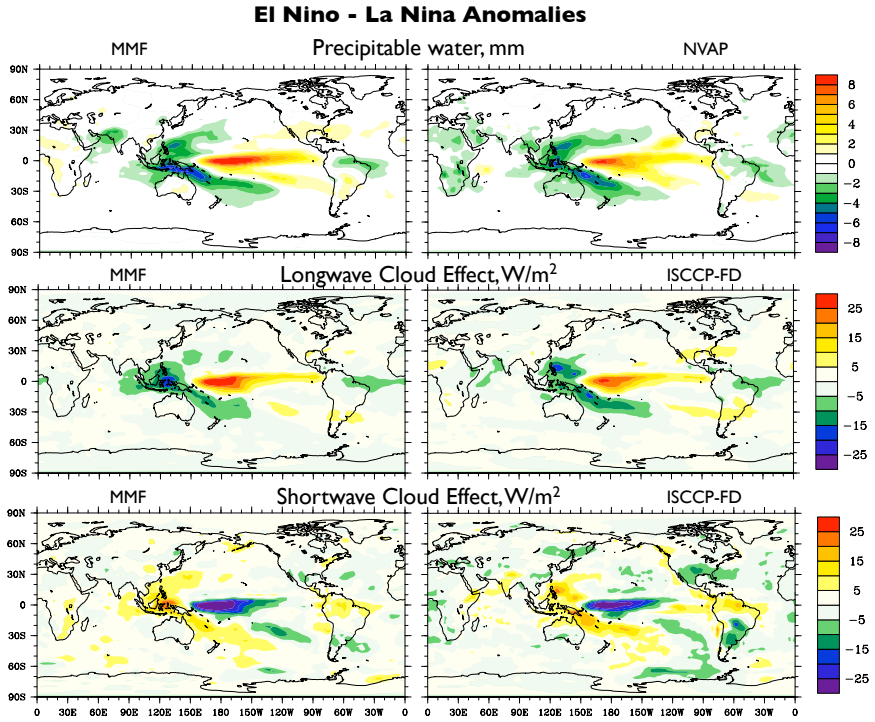
Now we need to use this new approach to better-understand the Earth System.

We need to establish MMF development and applications as a major new research activity, complementing but not replacing the older activities.

In order to do this, we need to engage the cloud parameterization enterprise, world-wide, through a ***multi-institutional collaborative effort with a centrally defined focus and an extended lifetime*****.**

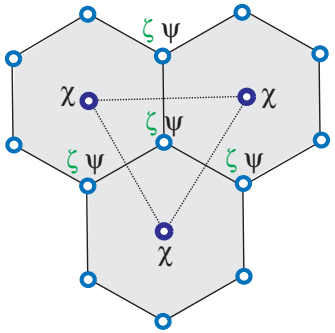
This is CMMAP.

Objective	Actions Required	Time-frame	Team Leader
1. Extensions, evaluations and applications of the prototype MMF	Perform and analyze AMIP (Atmospheric Model Intercomparison Project) simulations with the prototype MMF	Year 1	Khairoutdinov
	Perform and analyze coupled ocean-atmosphere simulations with the prototype MMF	Year 2	
	Create and test a geodesic version of the prototype MMF	Year 2	

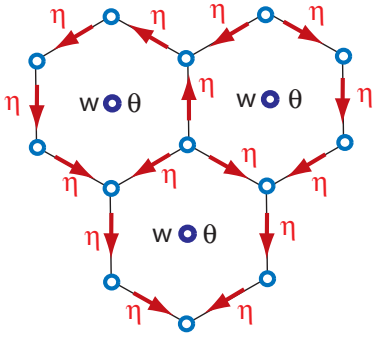


Objective	Actions Required	Time-frame	Team Leader
2. Development of a second-generation MMF	**Develop and test improved numerical representation of cloud-scale dynamics**	**Year 2**	**Arakawa/ Randall**
	Develop and test a global cloud-resolving model	**Year 2**	
	Develop and test Quasi-3D MMF	**Year 3**	

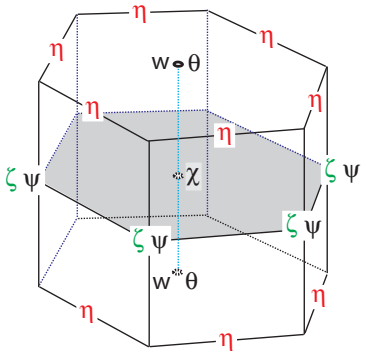
Layers



Levels



3-D view of the grid

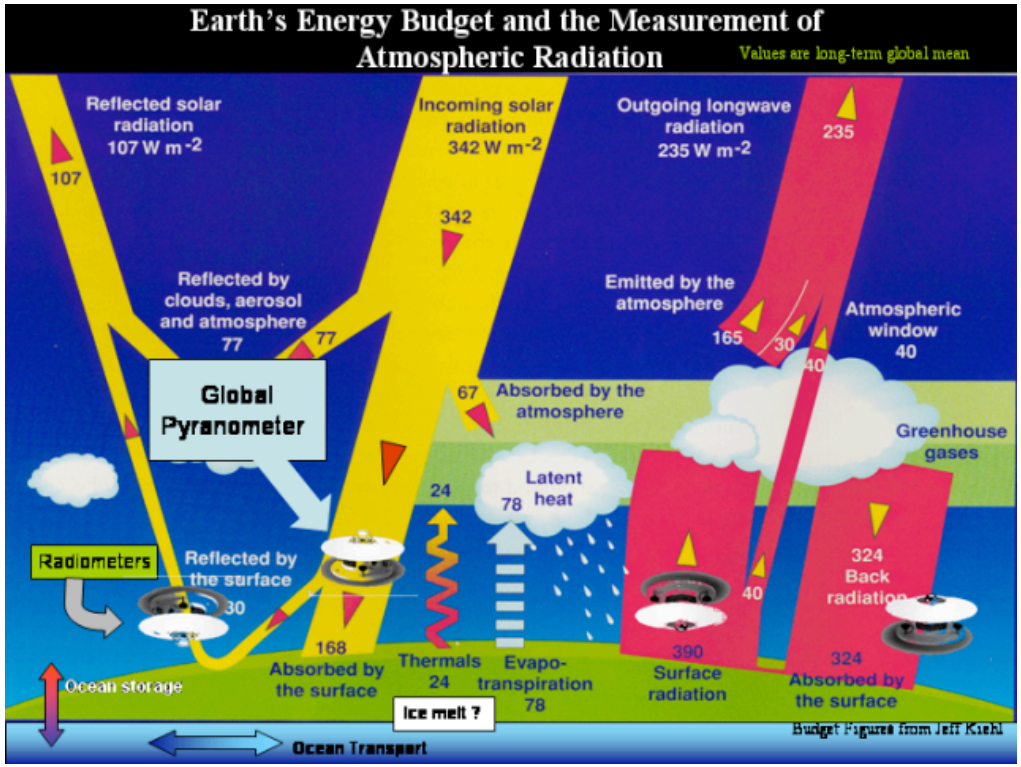



The design, testing, and application of an improved MMF will be the central, organizing component of CMMAP's research.

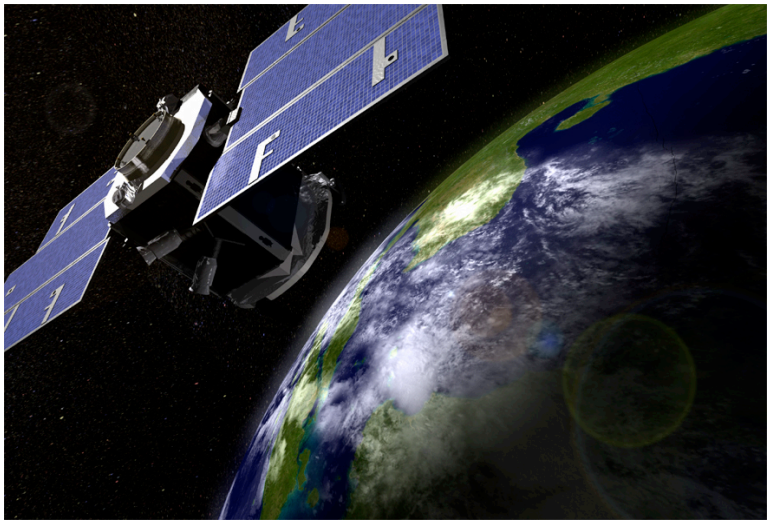
Objective	Actions Required	Time-frame	Team Leader
3. Develop and test improved microphysics parameterizations for MMFs and GCRMs	**Develop new microphysics parameterization and test in CSRM**	**Year 3**	**Krueger/ Kreidenweis**
	Test new parameterization in MMF and GCRM	**Year 4**	

Objective	Actions Required	Time-frame	Team Leader
4. Develop improved parameterizations of boundary-layer clouds and turbulence for use in MMFs and GCRMs	**Develop new boundary-layer cloud and turbulence parameterization and test in CSRM**	**Year 3**	**Bretherton/ Moeng**
	Test new parameterization in MMF and GCRM	**Year 4**	

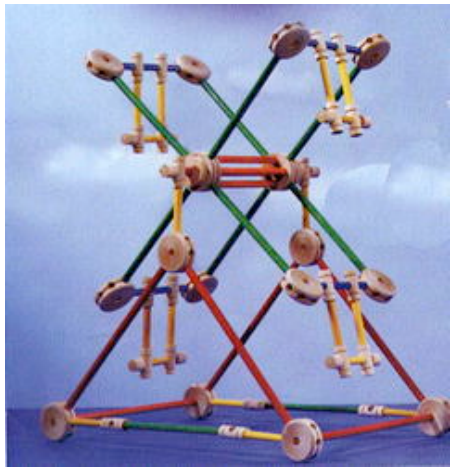
Objective	Actions Required	Time-frame	Team Leader
5. Test sensitivity of CSRMs to more detailed radiation calculations	**Develop new radiation parameterization and test in CSRM**	**Year 3**	**Barker**
	Test new parameterization in MMF and GCRM	**Year 4**	



Objective	Actions Required	Time-frame	Team Leader
6. Innovative analysis, evaluation and interpretation of MMF results using emerging datasets	**Acquire and adapt in situ and ground-based remotely sensed datasets for use in evaluating the MMF**	**Ongoing**	**Rossow**
	Acquire and adapt satellite datasets for use in evaluating the MMF		
	Develop and apply advanced, non-linear, multi-variate diagnostic analysis methods to elucidate multi-scale atmospheric processes.		



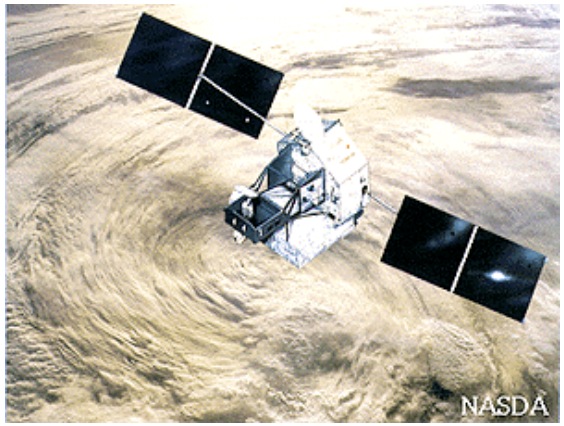
Objective	Actions Required	Time-frame	Team Leader
7. Accelerating improvement of conventional parameterizations	**Develop and test improved parameterizations of cumulus convection**	**Ongoing**	**Stevens**
	Develop and test improved parameterizations of stratiform clouds		
	Develop and test improved parameterizations of the boundary layer		



Objective	Actions Required	Time-frame	Team Leader
8. Optimal use of computational and data storage resources	Port the MMF and GCRM to a variety of computing platforms including those associated with NSF's petascale initiative	Ongoing	Helly
	Efficiently distribute model output and observational datasets to users		

NCAR
SDSC
NERSC
ORNL
NAS

Comparison with Observations

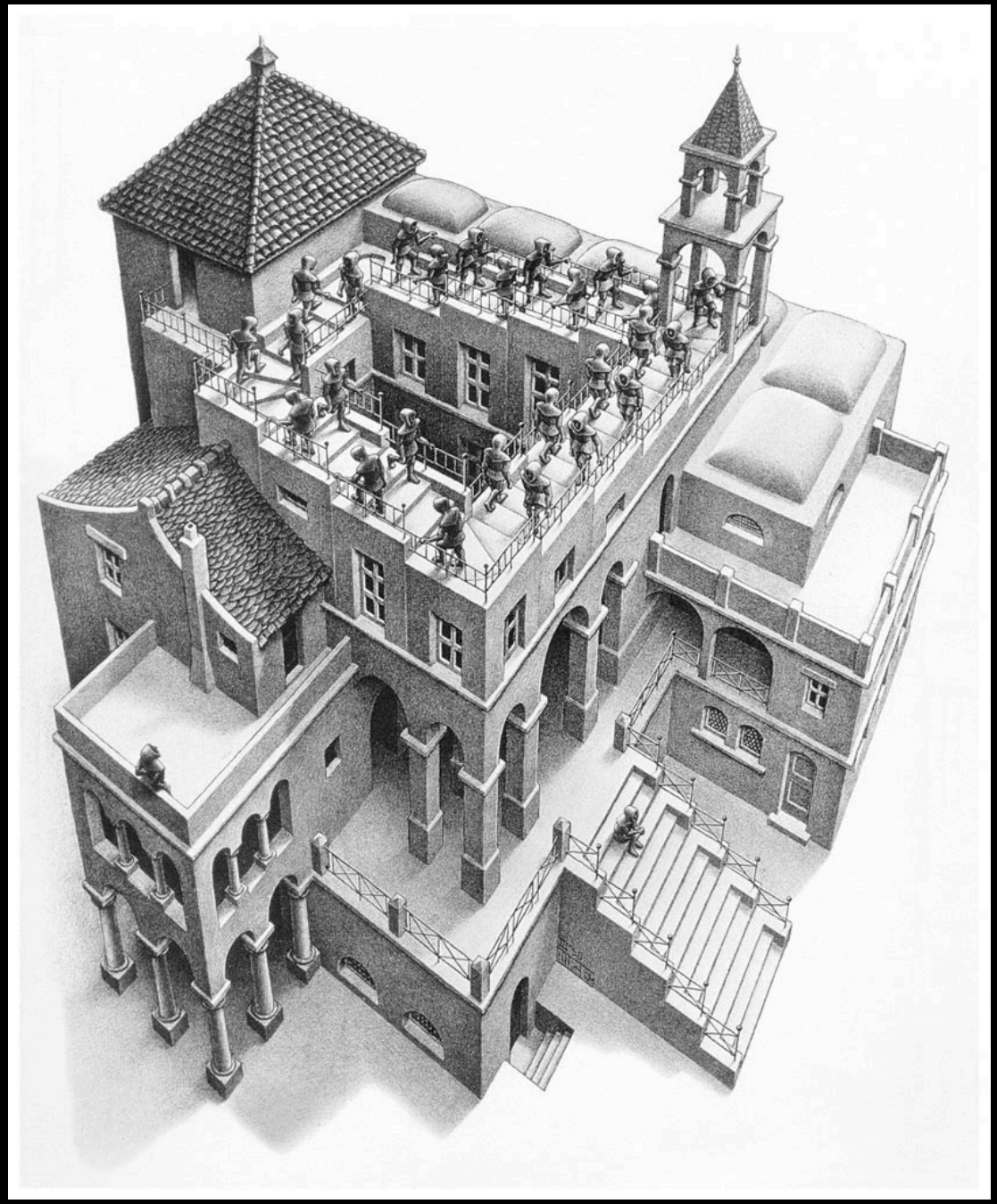


TRMM/GPM

ARM

CloudSat

Chill



How to make progress

Scientists

Funding

Big Idea

Extended Duration

Minimal Public Service Obligations

Centralized Direction


CMMAP
Reach for the sky.