Preliminary Results of the Goddard Multi-scale Modeling Framework

Jiun-Dar Chern, Wei-Kuo Tao,

and Robert Atlas

NASA Goddard Space Flight Center

Email: jchern@agnes.gsfc.nasa.gov

Goddard MMF Objectives

- Develop a MMF based on the Goddard Cloud Ensemble Model (GCE) and the finite-volume General Circulation Model (fvGCM)
- Better use of NASA high resolution satellite measurements (i.e. the EOS A-Train, TRMM/GPM)
- ➢ The MMF provides a link between high resolution observations and the coarse resolution of a GCM's grid box

- ➢ The NASA satellite measurements provide data for improve model initial/boundary conditions and physical parameterizations of the MMF.
- Inter-comparison of the MMF results among CSU, NCAR, NASA Goddard, NASA Langley and others to explore the capabilities and limitations of MMFs and study the effects of different GCMs and CRMs.
- The MMF provides global cloud data for improving the convectional parameterization schemes in GCMs.
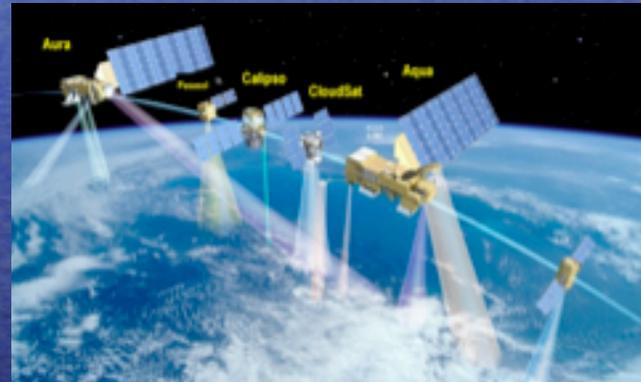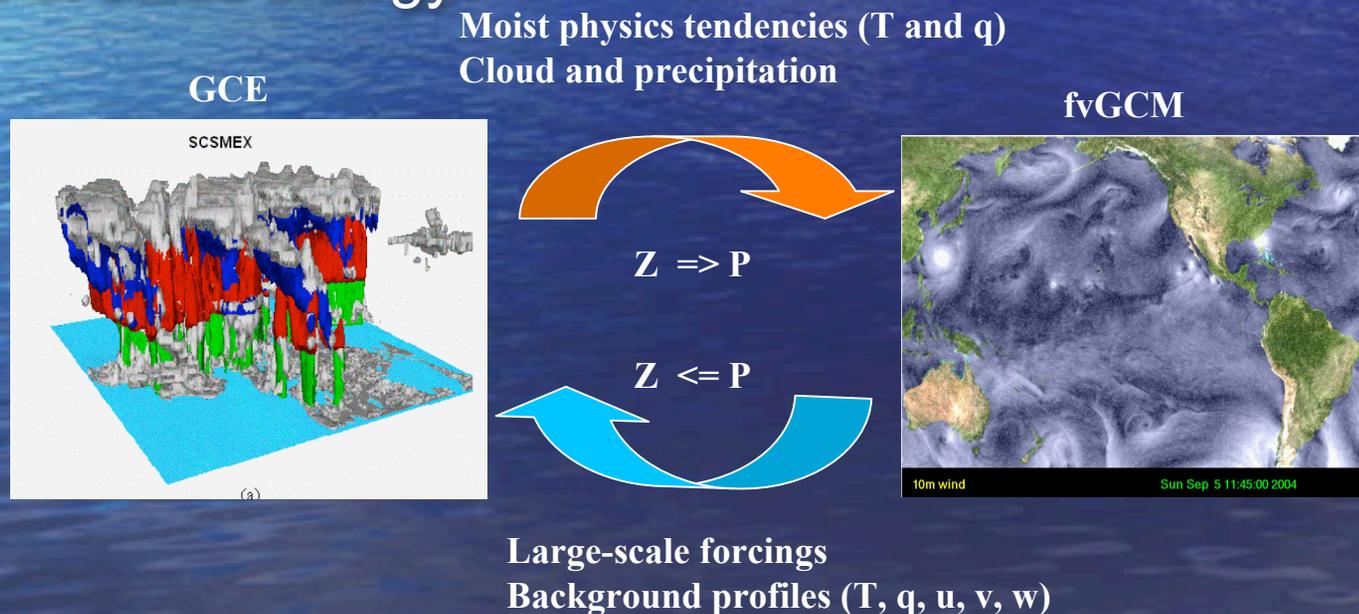
The Goddard MMF

- Based on the coupling system of fvGCM and 2D GCE model.

- fvGCM has been constructed with the finite-volume dynamic core (Lin, 2004), NCAR CCM3 physics package with an upgraded gravity wave scheme (NCAR WACCM), and the Community Land Model (CLM).

- 2D GCE is embedded in each grid point of the fvGCM based on the simple MMF framework.

- fvGCM at 2.0^o X 2.5^o latitude-longitude grids with 32 vertical levels from surface to 0.4 Pa (there are 8 layers below 850 hPa)

- Globally there are more than 13,104 copies of 2D GCE running at the same time.
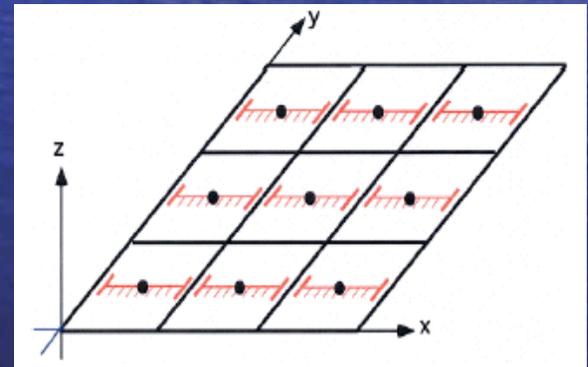
The Goddard MMF (continue)

- 2D GCE has 64 x 28 (x-z) grid points with 4 km horizontal resolution
- The time step for GCE is 10 second.
- fvGCM and 2D GCE coupling time is one hour
- Interpolation between hybrid P (fvGCM) and Z (GCE) coordinate: using finite-volume Piecewise Parabolic Mapping (PPM) to conserve mass, momentum and moist static energy.

Moist physics tendencies (T and q)
Cloud and precipitation

GCE

fvGCM

$Z \Rightarrow P$

$Z \Leftarrow P$

Large-scale forcings
Background profiles (T, q, u, v, w)

The Control Experiments

- Two yearly (1998 and 1999) control runs were carried out on NASA Columbia supercomputer.
- fvGCM called radiation, turbulence, surface processes, and gravity wave drag schemes.
- Feedback from GCE: tendencies of T and qv.
- Model started at Nov. 1, 1997 and Nov. 1, 1998, respectively.
- Initial conditions were interpolated from GEOS 4 CERES analysis (1° x 1.25^o with 55 vertical levels)
- Observed SST (NOAA weekly OI SST) was used.

Seasonal mean precipitations
(control experiment)

Seasonal mean precipitation
(control experiment)

GPCP fvGCM MMF

1999 DJF
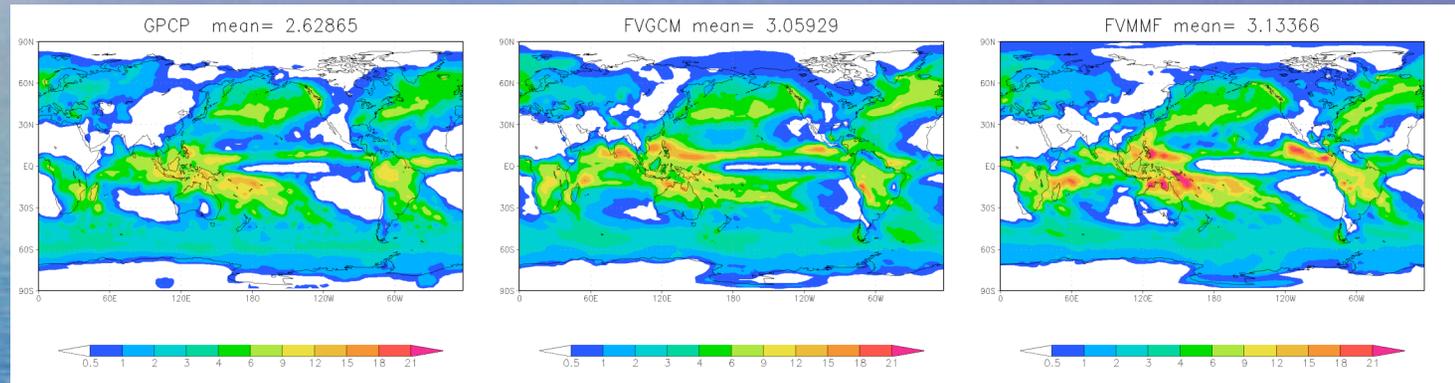
1999 JJA
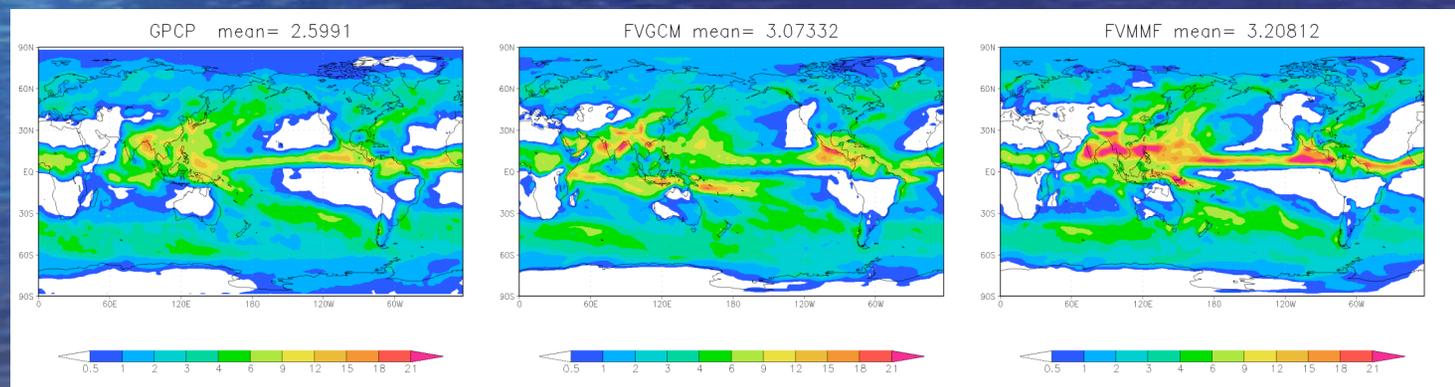
MJO Signal (Control Experiment)

1998 Hovmoller diagrams daily precip. rate (10° S - 10° N)

GPCP   fvGCM   MMF

MJO Signal (Control Experiment)

1999 Hovmoller diagrams daily precip. rate (10° S - 10° N)
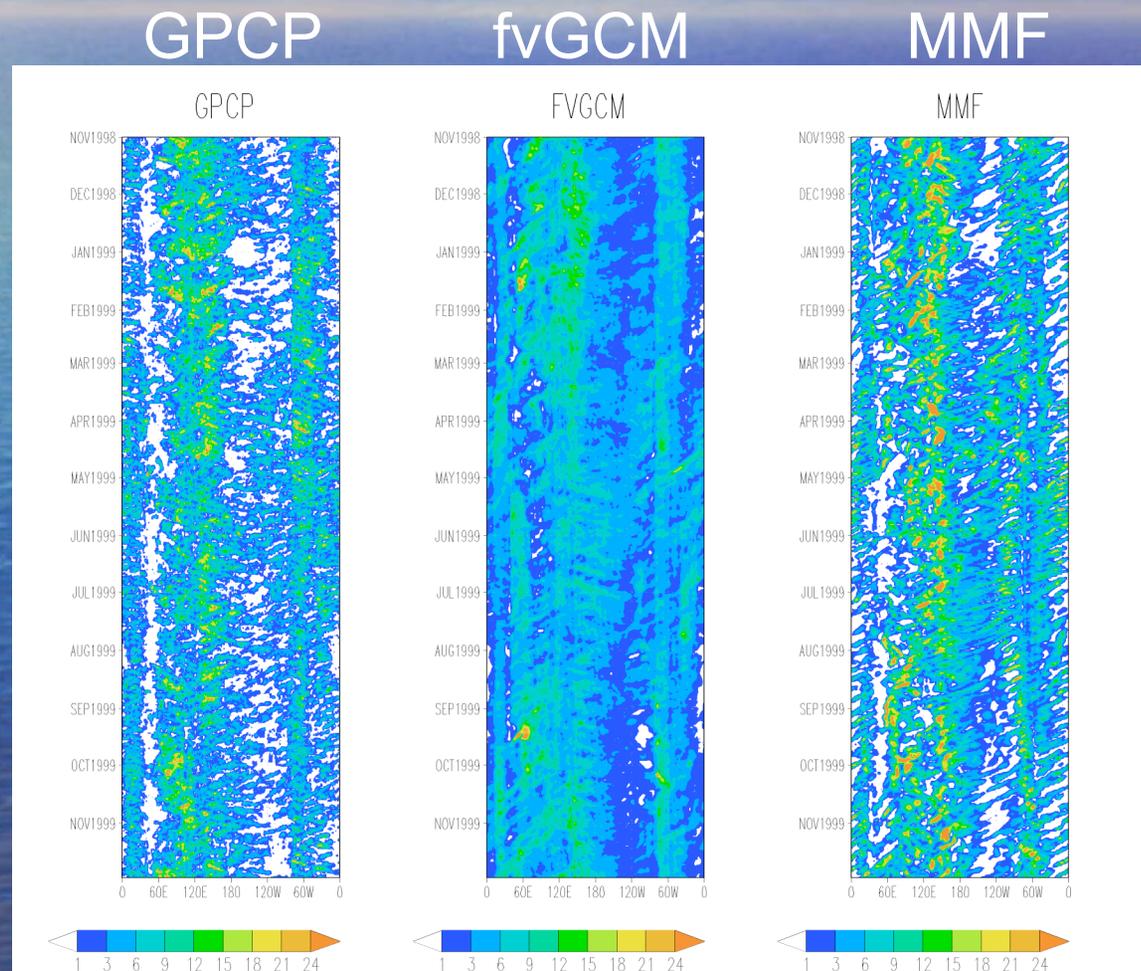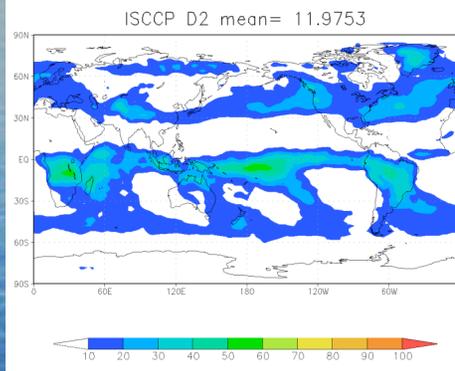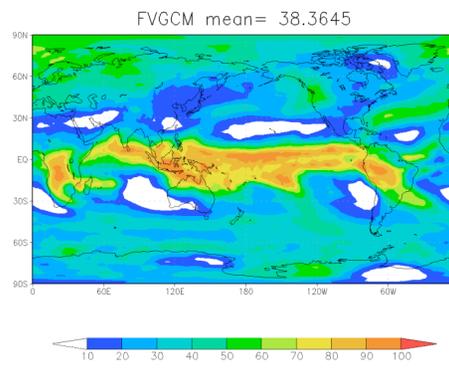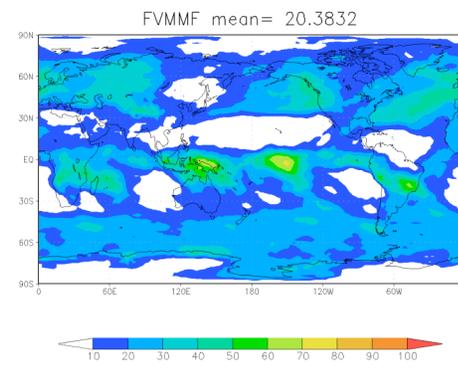
GPCP   fvGCM   MMF

High Cloud Amount (Control Experiment)
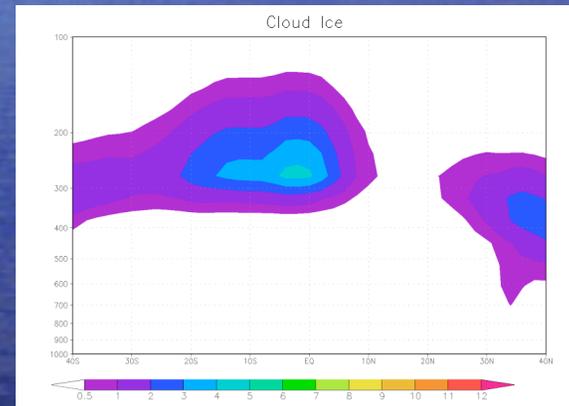
ISCCP D2 fvGCM MMF

1998 DJF
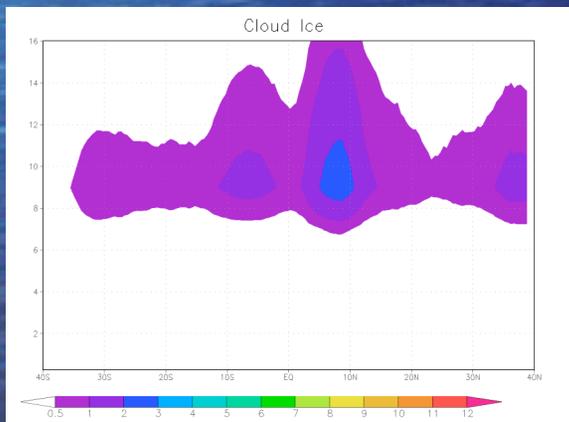
1998 JJA

High Cloud Amount (Control Experiment)
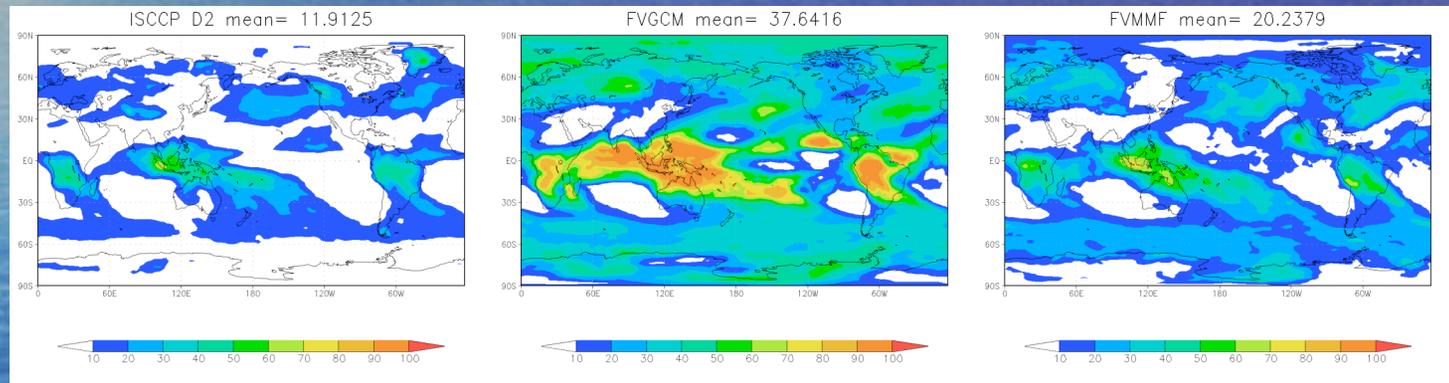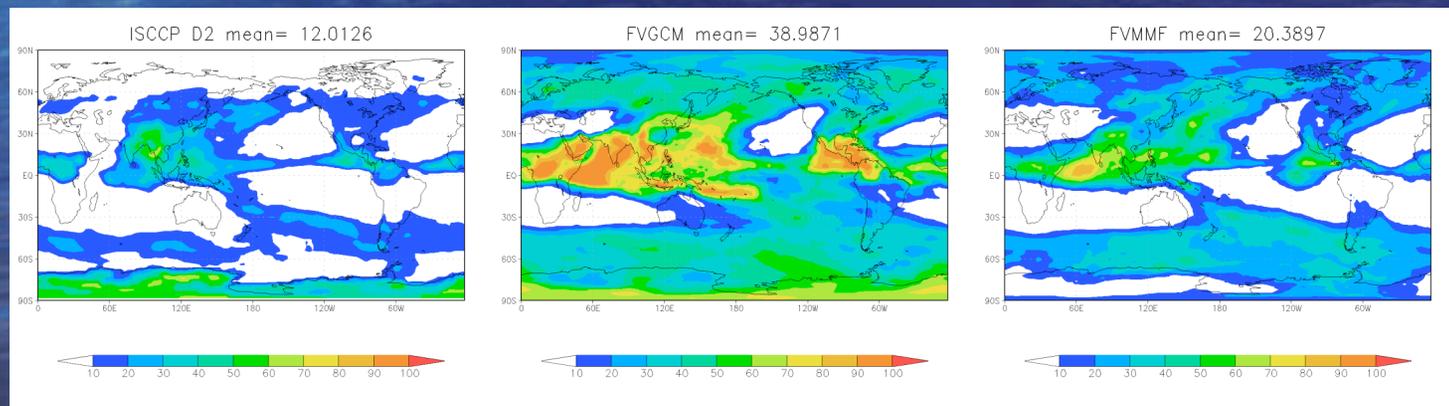
Zonal Mean Cloud Ice (Control experiment)
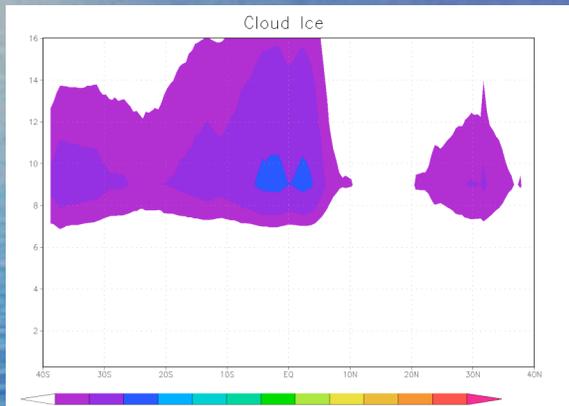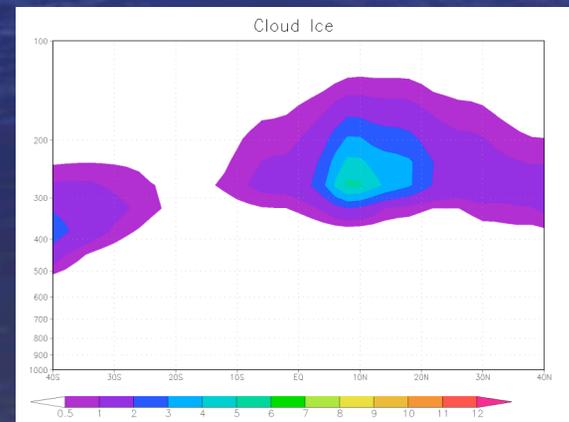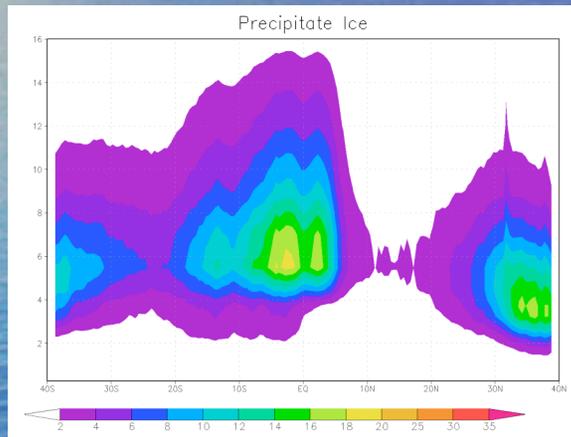
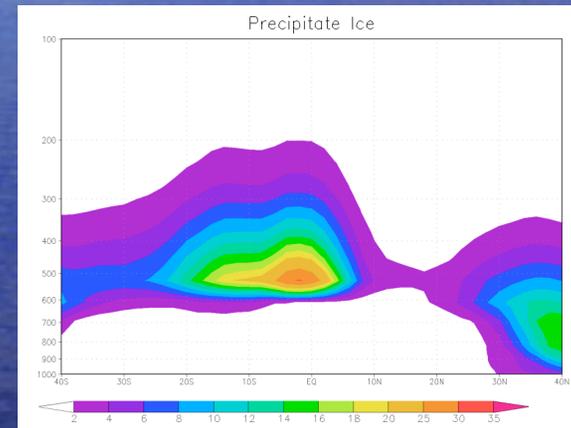# Zonal Mean Precipitate Ice (Control experiment)
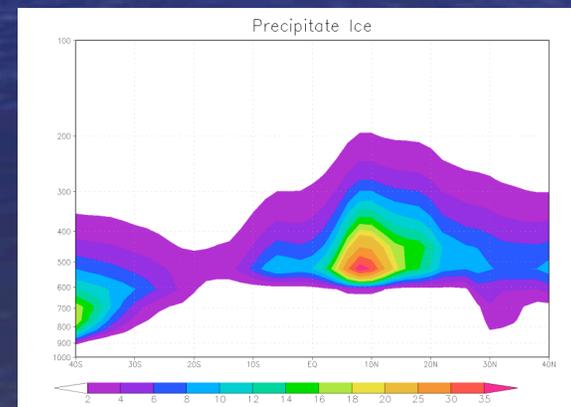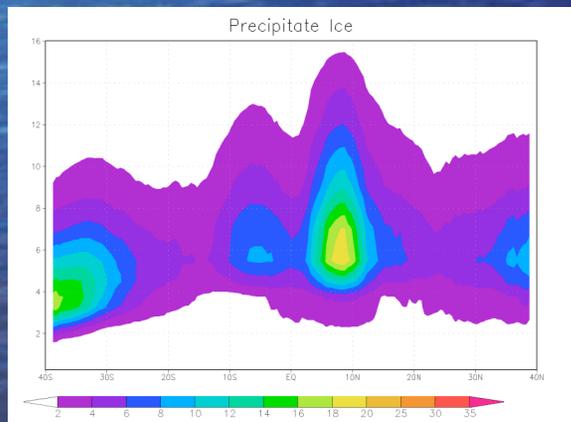
Aura Microwave Limb Sounder (MLS) Measurements of Upper-Tropospheric Cloud Ice

Resolutions:
  ~ 3.5 km vertical
~ 200 km horizontal
Range of Sensitivity:
~ 2 to 50 mg/m^3

Retrieval Scheme
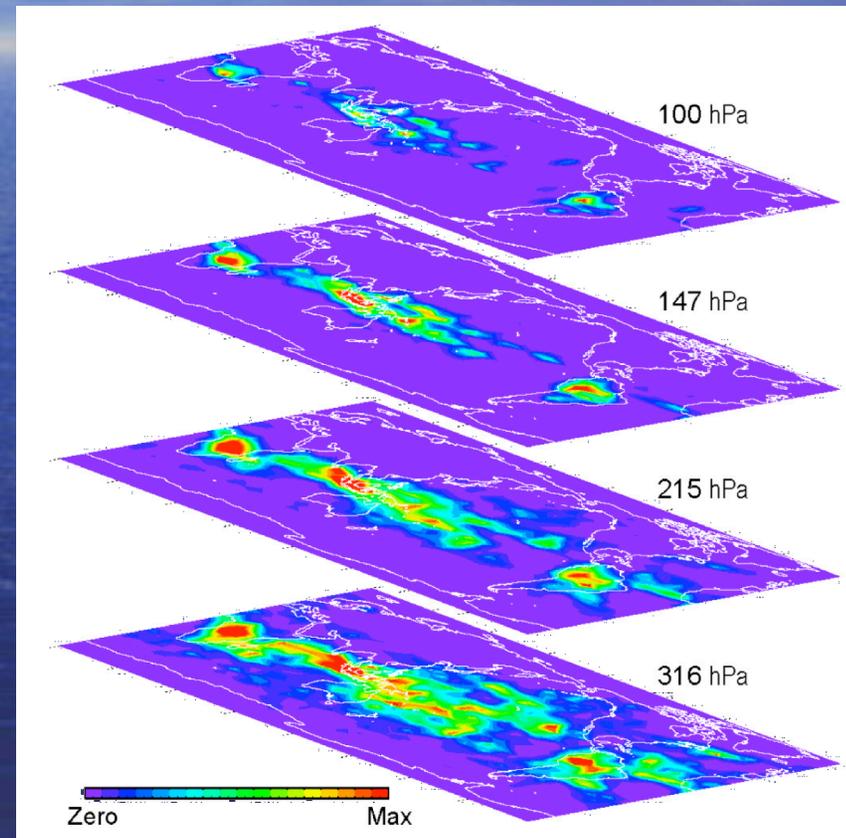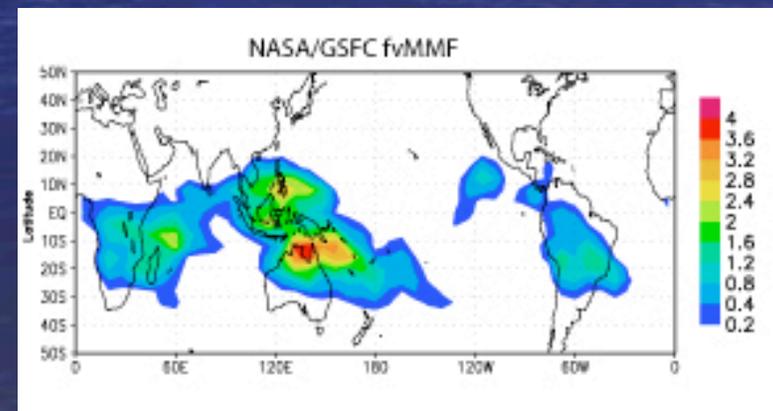1. Retrieve T, q, Chem
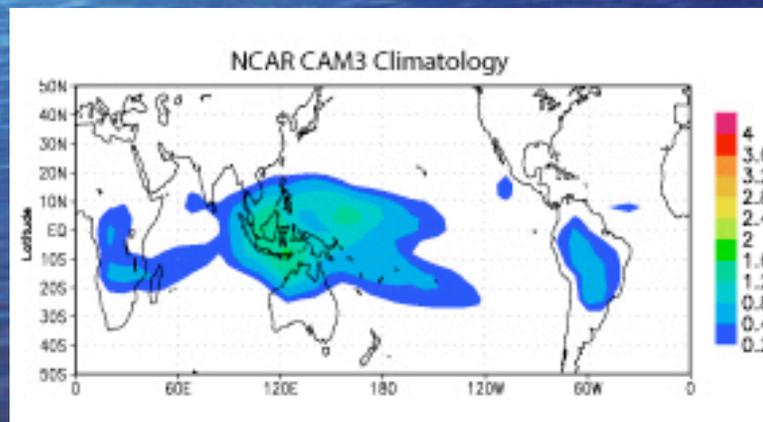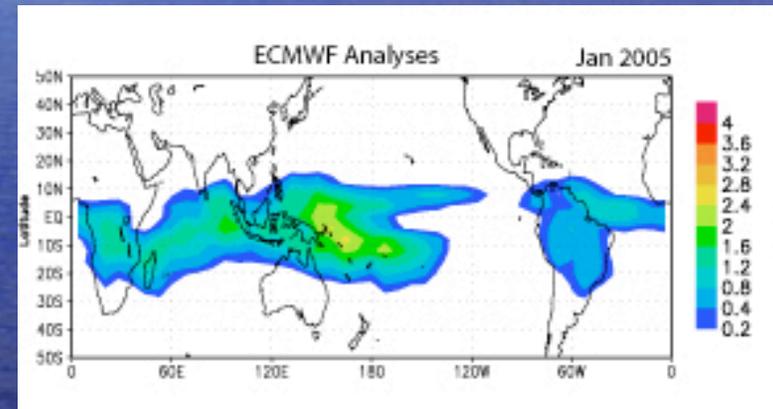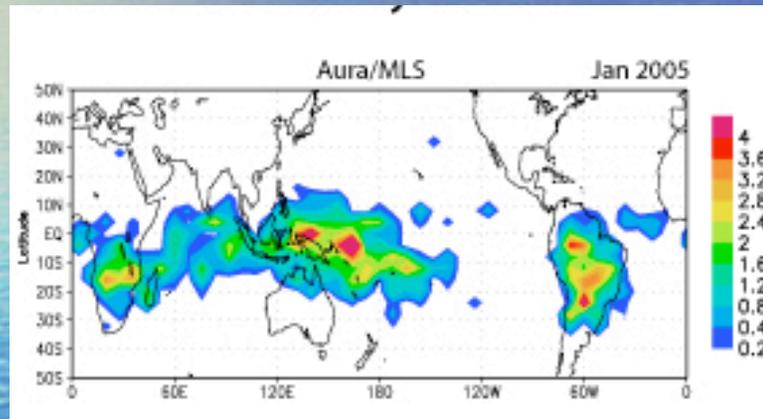2. Compute Clr-Sky Rad
3. Obs-Clr -> Clouds

FIG 1. EOS MLS measurements of cloud ice. Maps shown here give average values for Aug 25 to Sep 6 at four pressure levels.

Cloud Ice Content at 150 hpa
## (Duane Waliser and Frank Li at NASA/JPL)

The Sensitivity Experiments

- One month runs (July 1998) with initial conditions from the control run.

- Experiment 1: With 2-ICE (cloud ice and snow) microphysics scheme in GCE.

- Experiment 2: Feedback convective momentum transport to the fvGCM.

- Experiment 3: Feedback cloud ice, cloud water, snow, rain, and graupel to the fvGCM.
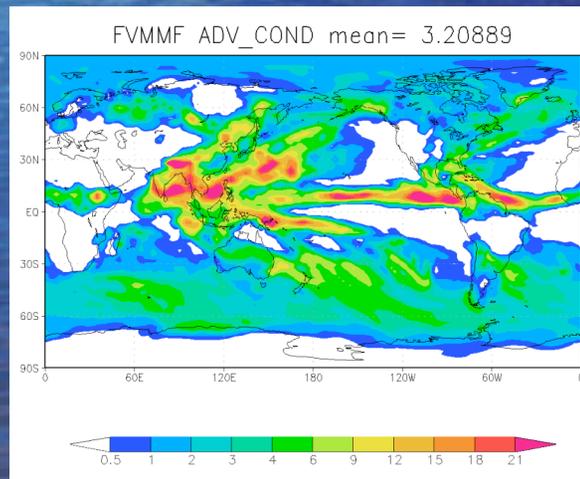
Monthly Mean Precipitation July 1998
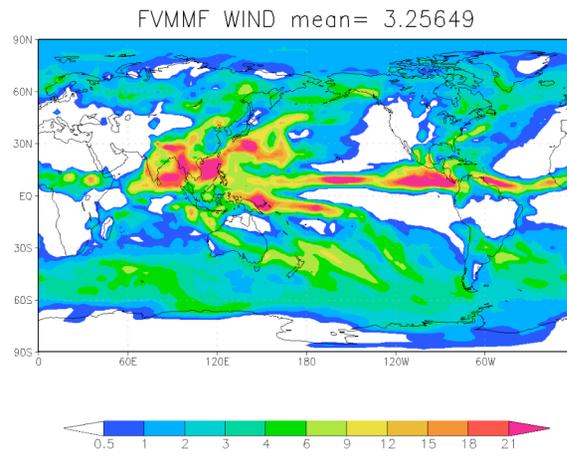

Control
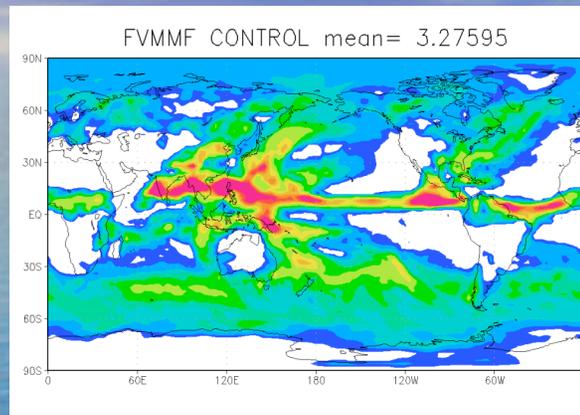
2ICE microphysics
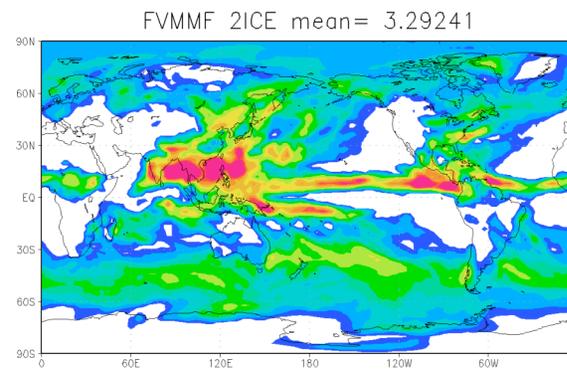
Cloud and Condensates Feed back

Momentum Feed back

Future works

- Implement NASA Goddard radiation into the MMF.
- Couple NASA Goddard Land Information System (LIS) into the MMF. Hence, GCE will call radiation, turbulence moist physics, and surface processes at cloud scale. The fvGCM only handles large-scale advection.
- Carry out MMF simulation of year 2005 and work with Dr. Waliser's group at JPL to validate the MLS cloud ice products.
- Carry out MMF simulations of year 2006-2007 and use CloudSat and the A-train dataset to validate the MMF results.