Learning from the MMP
Learning from the MMF
MMP is a three letter acronym that may refer to:

- **Mixed member proportional representation**, a voting system
- **Mass market paperback**, bookbinding format
- **Matrix metalloproteinase** enzymes
- Massively Multi-Player, a type of online game
- Massively multiprocessoring, large symmetric multiprocessing (SMP) computer systems
- **Metal Mind Productions**, Polish music label
- **Methuselah Mouse Prize**, for research into slowing cellular aging
- **Minuteman Project**, 2005 action to deter illegal immigration
- Manitoba Marijuana Party, now **Freedom Party of Manitoba**, a Canadian political party
- Moldova Metallurgical Plant, see **Moldova Steel Works**
- **Multi-Man Publishing**, a wargame company
- **Minute Maid Park**, a ballpark in Houston, Texas, United States
- **Millennium Mathematics Project**, of the University of Cambridge
- **Miss Moneypenny**, James Bond's secretary
- **International Organization of Masters, Mates & Pilots** (MM&P), maritime labor union
- **Tokyo Mew Mew**, also known as Mew Mew Power, a Japanese cartoon
Acknowledgments

Jim Benedict
Kate Thayer-Calder
Marat Khairoutdinov
Super-Parameterization
(a.k.a. the Multiscale Modeling Framework, or MMF)

Idea proposed by W. Grabowski
Compared to what?

<table>
<thead>
<tr>
<th>Super-Parameterizations</th>
<th>Conventional Parameterizations</th>
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<tbody>
<tr>
<td>2D or Quasi-3D</td>
<td>1D</td>
</tr>
<tr>
<td>Periodic boundary conditions</td>
<td>Boundary whats?</td>
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<tr>
<td>Shallow convection and turbulence must be parameterized.</td>
<td>Same</td>
</tr>
<tr>
<td>Microphysics is simplified but the required input is in pretty good shape.</td>
<td>Microphysics even simpler, and the required input (e.g., local vertical velocity) is not</td>
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<tr>
<td>Individual realizations</td>
<td>“Expected values”</td>
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“\text{It’s low-resolution, but at least it uses the right equations.}”  
-- Bjorn Stevens
The Madden-Julian Oscillation

- Lag Day: -25 to +20
- SST': Cool & dry
- p [hPa]: 850 to 200

Deepening cumulus heating & moistening, destabilization
Convective and stratiform rainfall, stabilization
Suppressed convection

~10-15 days
~10 days
~20 days
20-100 days

2-20 days
rather active development phase; nevertheless, we de-
cided to document our early experiences with the SP-
CAM, which we feel could be of interest to the atmo-
spheric science community, especially considering the
unique nature of such a GCM.

The results from the most recent 500-day long simu-
lation of the atmospheric general circulation using a 2D
SP based on a 2D CRM with 64 grid columns were
contrasted with those of a control run performed using
the conventional cloud parameterizations. In terms of
the mean state, the SP-CAM produces quite reasonable
geographical distributions of precipitation, precipitable
water, top-of-atmosphere radiative fluxes, cloud radia-
tive forcing, and high-cloud fraction for both seasons.
The most notable and persistent bias apparent in all the
SP simulations was associated with anomalously strong
precipitation in the Western Pacific for the summer
months.

It is apparent that the SP-CAM exhibits much im-
proved diurnal variability of nondrizzle precipitation
frequency in terms of the diurnal cycle. Over the sum-
mer time land masses, the control model tends to pre-
cipitate most frequently around local solar noon, which
is a few hours earlier than observations suggest. In con-
trast, the SP model tends to peak precipitation fre-
quency during late afternoon hours, in accord with ob-
servations. Over the ocean, both models precipitate
most frequently in the early morning hours as observed.

The SP model global distribution of the percentage of
days with nondrizzle precipitation compares to ob-
served distribution most favorably, while the standard
model tends to precipitate by about 20%–30% more
frequently. The global distribution of the wet-day prob-
ability as simulated by the SP-CAM agrees rather well
with observations in both the spatial patterns and am-
plitudes. The standard CAM, although generally agree-
ing with observations in spatial patterns, tends to over-
estimate the observed frequency of precipitation, espe-
cially in the Tropics. The SP model seems to improve
the convective intraseasonal variability over the stan-
dard model. Our preliminary results suggest that the SP
produces much more realistic variability of such fields
as 200-mb wind and OLR than the control, including
the MJO.

All the simulations based on the 2D SP have fea-
tured an unrealistically rainy region in the tropical
western Pacific, during the Northern Hemisphere sum-
mer. The problem seems to be mitigated when the 2D
SP is replaced with a 3D SP that uses the same number
of grid columns and horizontal resolution as the 2D SP,
but arranges them in an 8×H11003 pattern. In one of two
runs with the 3D SP, the large-scale momentum trans-
port due to the SP convection was allowed in contrast
to the 2D SP-CAM. Interestingly, the double ITCZ

Fig. 15. Geographic distribution of symmetric MJO variance of (a)–(c) 200-hPa zonal winds and (d)–(f) OLR. The MJO signal is computed via an inverse Fourier transform of the coefficients corresponding to eastward-moving waves with zonal wavenumbers 1–4 and periodicities in the 20–70-day range. To simplify the display, the transform is applied to the equatorially symmetric time series, which accounts for nearly 80% of the total variance near the equator.
Seasonal Change, 1986-2003

El Nino
La Nina
Normal

MMF

NOAA
The MMF is able to maintain the observed structure of the MJO for a week or more.

The CAM loses the signal immediately.
Figure 5. The zonal-mean distribution of a) SST, b) precipitable water, and c) precipitation rate for the control and two SST perturbation experiments.

Figure 6. The zonal-mean distribution of the OLR variance filtered for the a) MJO, b) equatorial Rossby waves, and c) Kelvin waves for the control and two SST perturbation experiments.
Is the SP-CAM’s MJO realistic?
Precipitable water & OLR

Composite of 46 events in GPCP/ERA40 and 46 in SP-CAM

- Overestimated PW'
- Excessively negative OLR'
- Exaggerated peak rainfall
OLR & Rainfall Comparison

OLR′ (Wm\(^{-2}\))

Total rain (mm)

Time (days relative to precip max)
State variables

- Not bad, but easterlies excessive
- Moisture anomaly too strong, less tilt than observed
- Leading and trailing cool upper trop. too weak in SP-CAM, warm anoms similar
- Upward motion too strong, less tilt than in reanalysis
Moisture Advection

\[
\begin{align*}
( -u \frac{\partial q}{\partial x} )' + ( -v \frac{\partial q}{\partial y} )' \\
( -\omega \frac{\partial q}{\partial p} )'
\end{align*}
\text{(g/kg/d)}
\]

Total rain (mm)
Zonal vs meridional moisture advection

Post-event drying:
- 0 to +15 days: both zonal and meridional

Pre-event moistening:
- -30 to -15 days: weakly meridional, zonal in boundary layer
- -10 to 0 days: primarily zonal
Geographical differences

Westerlies shift eastward relative to precip max
Easterlies weaken
Low-level zonal wind anomalies

Westerly Onset Comparison, 925 hPa

$u' \, (m/s)$

Total rain (mm)

Time (days relative to precip max)

SPCAM  GPCP
Why is the SP-CAM’s MJO realistic?
Rainfall-humidity composites

SP-CAM

CAM Relative Humidity Profile per Value of Rainrate (98-99)

Base of moist layer at 600 mb

ERA-40 and TRMM
Why very wet matters

Downdrafts stabilize BL

Downdrafts ineffective
Static stability vs. rain rate

**SP-CAM**

**CAM**

**ERA-40**

Cool layer at 600 mb
Discharge-Recharge Oscillator

Bladé and Hartmann

The diagram illustrates the relationship between sea surface temperature (SST') and pressure (p) over time. The oscillation period is categorized into different phases:

- **Cool & Dry:** At low pressure levels, indicating cool and dry conditions.
- **Deepening cumulus heating & moistening, destabilization:** This phase occurs at lag days from -25 to -10, characterized by increased heating and moistening, leading to destabilization.
- **Convective and stratiform rainfall, stabilization:** The period from lag day 0 to +5 is marked by convective and stratiform rainfall, followed by stabilization.
- **Suppressed convection:** From lag day +10 to +20, convection is suppressed, maintaining cooler and drier conditions.
Discharge and Recharge

Models

ERA-40 & TRMM
What I think is going on

- During the “recharge” phase, convective stabilization occurs mainly through the effects of downdrafts on the PBL moist static energy (Raymond’s BL QE).

- When the troposphere becomes very moist, this mechanism does not work well. The brakes fail.

- Convection then intensifies, exciting a large-scale disturbance.

- The disturbance produces warming aloft and strong dry advection west of the heating, which shut off the deep convection.

- Recharge resumes.

- This is generally consistent with the model of Bony and Emanuel (JAS, 2005), who discussed a “moisture-convection feedback.”

- For this mechanism to work, a model needs:
  - A tendency to moisten a deep layer as the rainfall rate increases
  - Downdrafts that modify the PBL
Summary

- Despite their identical dynamical cores, the SP-CAM makes a robust MJO while the CAM does not.
- The seasonal variations of the MJO simulated by the SP-CAM are realistic.
- Preliminary MJO forecasting experiments look promising.
- The structure of the simulated MJO is realistic, but its amplitude is excessive.
- The standard CAM dries out the middle troposphere when the rain rate is high.
- The ability to moisten the entire troposphere appears to be a key to the successes of the MMF.