WGNE MJO Task Force/GASS Diabatic Heating and Vertical Structure Project

Vertical Structure and Diabatic Processes of the MJO: *Global Model Evaluation Project*

MJO TF **GASS**

MJO Phenomena/Modeling Expertise + Model Diagnostic/Development Expertise

- Characterize observed and modelled temperature, moisture, and cloud structures within the multi-scale convective systems during the MJO life cycle and determine the roles of various heating, moistening and momentum mixing processes.
- Evaluate the ability of current models to hindcast MJO events, and characterize the evolution of the "error" growth in the profiles of moistening, diabatic heating, etc.
- Elucidate key model deficiencies in depicting the MJO physical process evolution, and provide guidance to model development/improvement efforts.
- Based on above analyses, develop more targeted physics/detailed process model studies as well as formulate plans for needed observations (in-situ, airborne, satellite).

WCRP World Climate Research Programme | MJO TF | THORPEX A World Weather Research Programme | WWRP | GASS | GEWEX Atmospheric System Studies | YOTC

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MJO Task Force/YOTC and GASS

Time step / 2 –Day Physics Errors

Daily / Weekly Forecast Errors

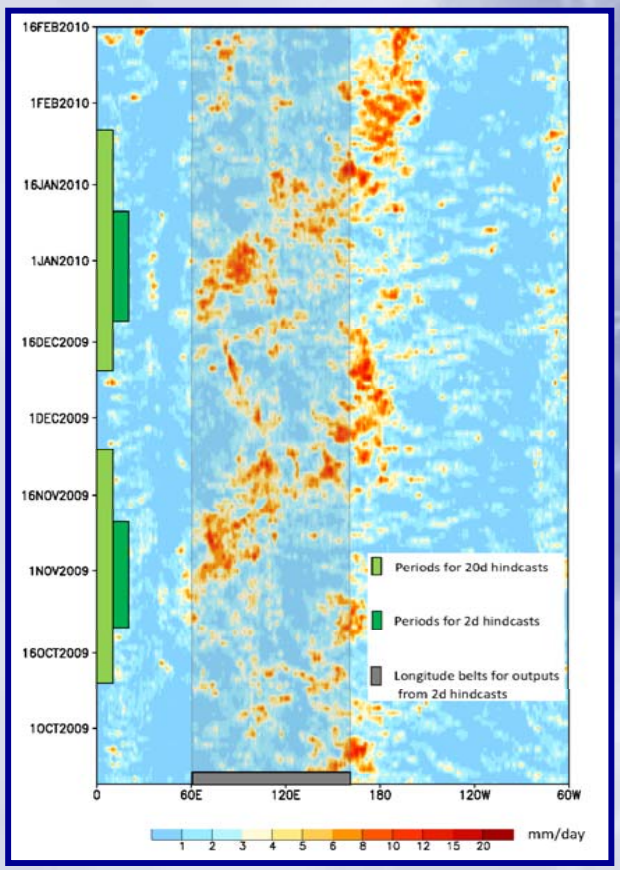
Long-Term Climate Simulation Errors

1. **climate simulation** – multi-year simulations coupled or atmosphere only

2. **short range hindcasts** – daily 48hr lead during ~20 days of the MJO

3. **medium range hindcasts** – daily 20-day lead time

www.ucar.edu/yotc/mjodiab.html



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	Model Experiment	Science Focus	Exp. POC
I.	**20 Yr Climatological Simulations** (1991-2010 if AGCM) 6-hr, Global Output Vertical Structure, Physical Tendencies	Model MJO Fidelity Vertical structure Multi-scale Interactions: (e.g., TCs, Monsoon, ENSO)	**UCLA/JPL** X. Jiang D. Waliser
II.	**2-Day MJO Hindcasts** YOTC MJO Cases E & F (winter 2009)* Time Step, Indo-Pacific Domain Output Very Detailed Physical/Model Processes	Heat and moisture budgets Model Physics Evaluation (e.g. Convection/Cloud/BL) *Short range Degradation*	**Met Office** P. Xavier J. Petch
III.	**20-Day MJO Hindcasts** YOTC MJO Cases E & F (winter 2009)* 3-hr, Global Output Elements of I & II	MJO Forecast Skill State Evolution/Degradation Elements of I & II	**NCAS/Walker in.** N. Klingaman S. Woolnough

*DYNAMO Case TBD

Commitments: Over 40 Modeling Groups with AGCM and/or CGCM

Status and Plans

- **Over 40 modelling groups signed up; 13 groups started/completed upload.**
- ***Initial results to be presented and discussed at Pan-GASS Meeting Sep 10-14, 2012.***
- ***November DYNAMO case identified as priority for extension***
- ***Identify critical / poorly-constrained processes for subsequent detailed GASS process modelling studies.***
- ***Dovetails with MJO TF Diagnostics/Metrics Work.***

WCRP MJO TF THORPEX GASS YOTC

Model	POC	Institution	Experiment		
			Climatological simulation	Short-term Hindcast	Long-term Hindcast
GEOS-5 AGCM	Siegfried Schubert	NASA	X	X	X
	Hailan Wang	NASA/GMAO			
IPRC GCM	Xiouhua Fu	University of Hawaii	X	X	X
	Baoqiang Xiang	University of Hawaii			
SPCAM	David Randall	Colorado State University	X	X	X
	Charlotte Demott	Colorado State University			
	Mike Pritchard (UW)	UCSD			
NASA GISS	Daehyun Kim	LDEO	X	X	X
	Anthony Del Genio	LDEO			
GEM model	Hai Lin	Environment Canada	X	X	X
NICAM	Masaki Satoh	AORI, Univ. of Tokyo	-	X	X
	Tomoe Nasuno	JAMSTEC			
SINTEX	Jingjia Luo	JAMSTEC			
LMDZ	Jean-Philippe Duvel	LMD, Paris	X	-	-
	Sandrine Bony	LMD, Paris			
MRI-GCM	Eiki SHINDO	MRI	X	X	X
	Akio Kitoh	MRI			
CWB AGCM	Mong-Ming LU	CWB, Taiwan	X	X	X
	Hsin-Hsing CHIA	CWB, Taiwan			
	Hsiao-Chung TSAI	CWB, Taiwan			
WRF	Samson M Hagos	PNNL	X	X	X
CCSM4	David Straus	COLA and GMU			
	Ben Kirtman	University of Miami			
	Joe Tribbia	NCAR			
CFS T62L60	Kyong-Hwan Seo	PNU, Korea	X	X	X
	Sooraj K P	PNU, Korea			
IFS	Frederic Vitart	ECMWF	-	X	X
ECHAM	Traute Crueger	ZMAW			-
MetUM GA3.0	Prince Xavier	Met Office UK			X
INGV	Silvio Gualdi	CMCC			
HiRAM	Ming Zhao	GFDL			X
CCSM4, CESM1	Rich Neale	NCAR			X
NAVGEM	Jim Ridout	NRL			
	Young-Joon Kim	NRL			X
	Maria Flatau	NRL			
AM3/CM3	Bill Stern	GFDL			
CAM3/CAM5	Guang Zhang	UCSD			
Global WRF	Zhiming Kuang	University of Harvard	-	-	X
SPCAM	Zhiming Kuang	University of Harvard	-	-	X
CFSv2	Wanqiu Wang	NCEP/CPC	X	-	-

More, Full List Available on Project Website

www.ucar.edu/yotc/mjodiab.html

WGNE MJO Task Force Process-Oriented Diagnostics

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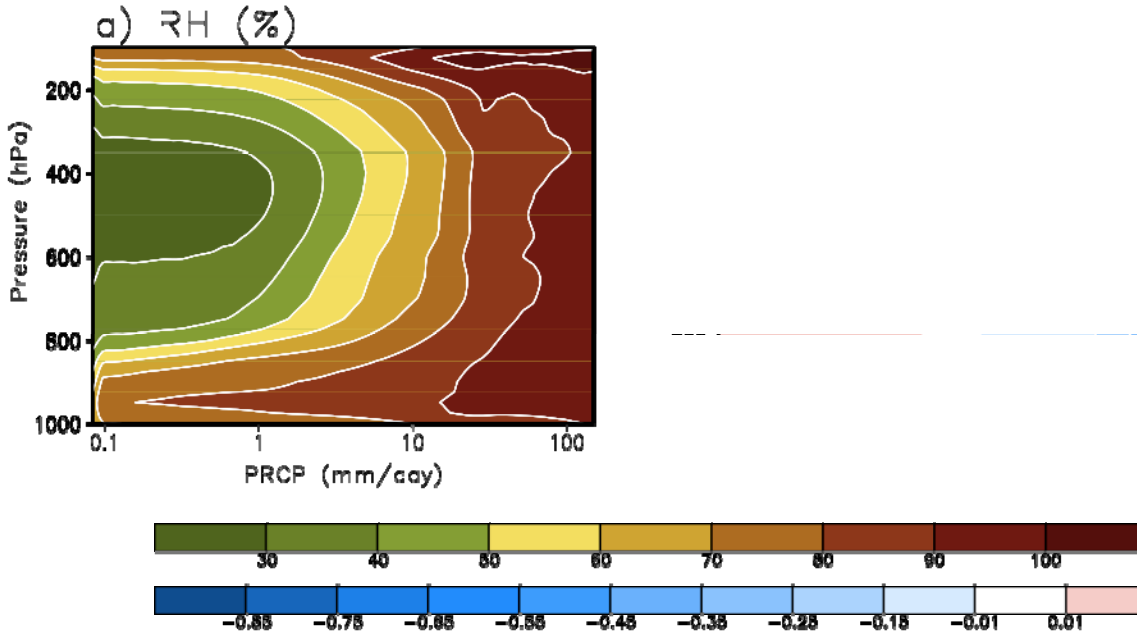
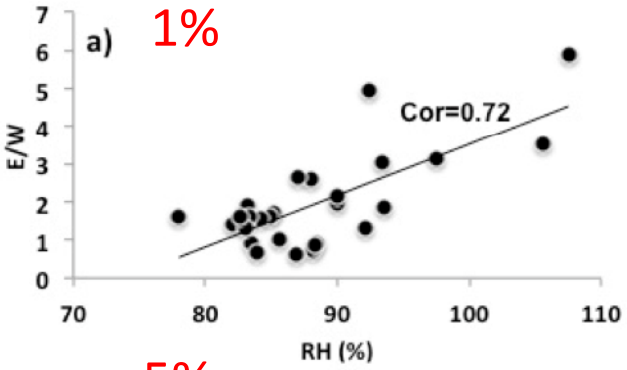
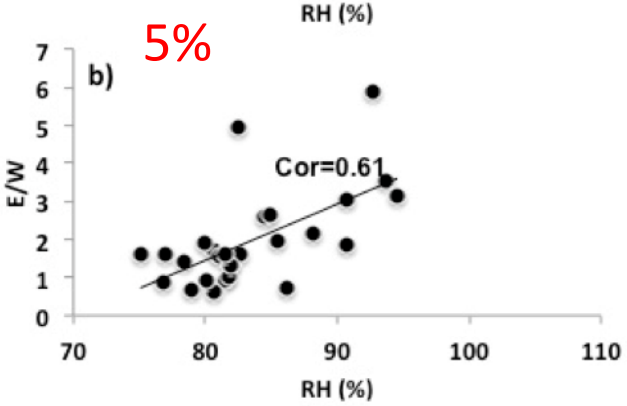
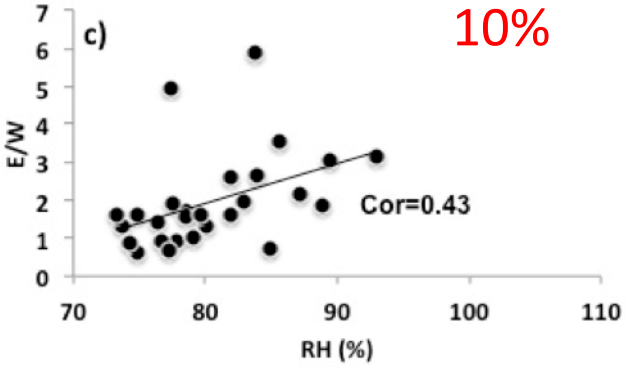
E/W Power Versus 500-850 RH for Highest Precip Percentiles





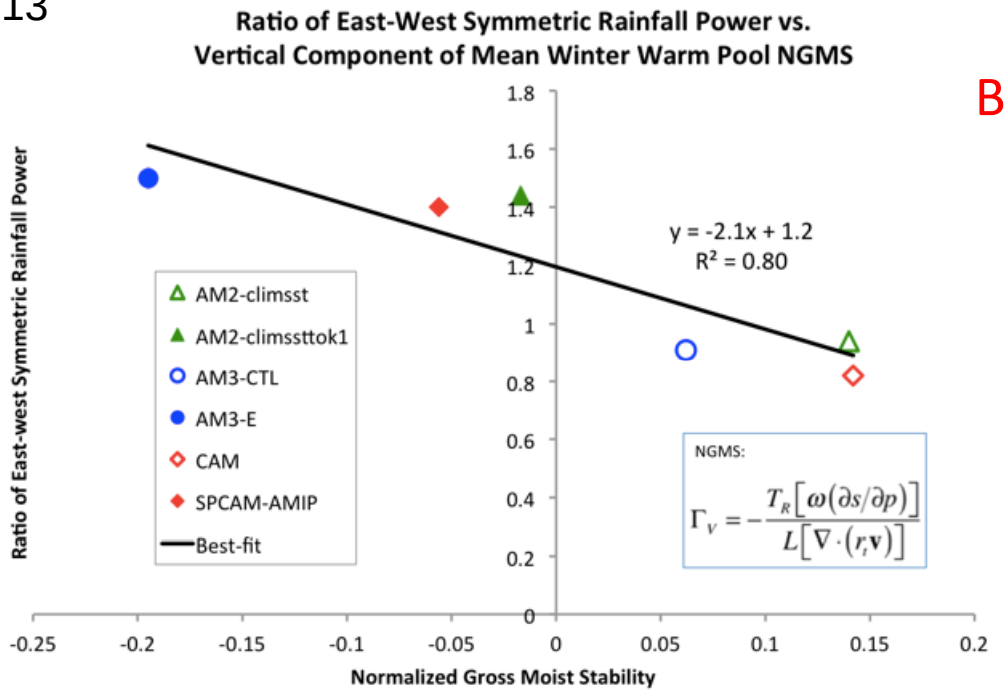




Kim et al. 2013

MSE Budget Diagnostics

Hannah and Maloney 2011; Benedict et al. 2013



Benedict et al. 2013

- Models in which convection and associated circulations are less efficient as discharging moist static energy (~latent heat) from the column produce more realistic MJOs
- Diabatic heating profiles and vertical profiles of MSE both regulate this diagnostic

Application to DYNAMO Hindcasts

MSE Budget Diagnostics: Application to DYNAMO CAM5 hindcasts

Simulation	Entrainment [km^{-1}]
ZM_0.2	0.2
ZM_1.0	1.0
ZM_2.0	2.0

Courtesy of Walter Hannah

- CAM5 with enhanced entrainment produces much-improved DYNAMO hindcast skill versus simple undiluted CAPE convective closure

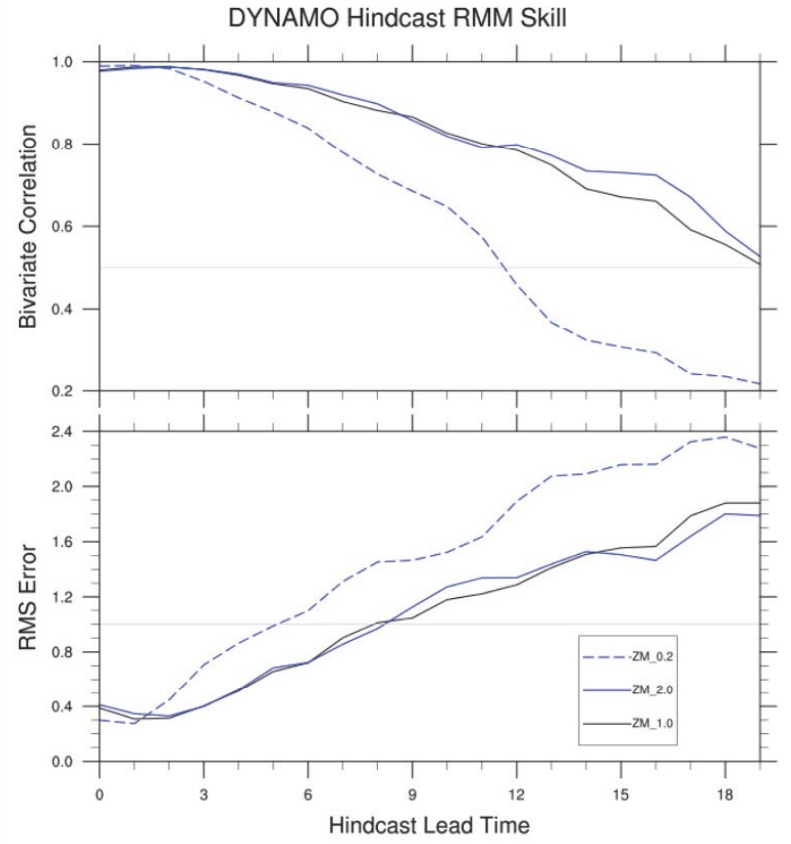


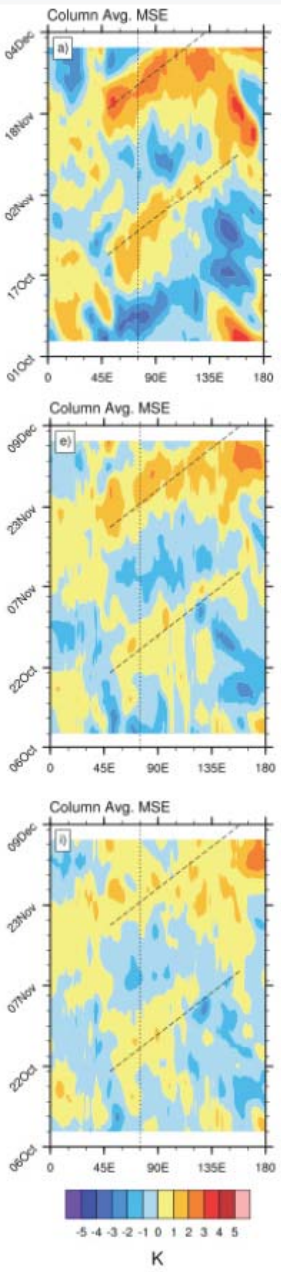
Fig 1. RMM skill score for each hindcast run over the DYNAMO period. Interannual variability was retained when calculating RMM values.

MSE Budget Diagnostics: Application to DYNAMO hindcasts

ERAi

ZM_1.0

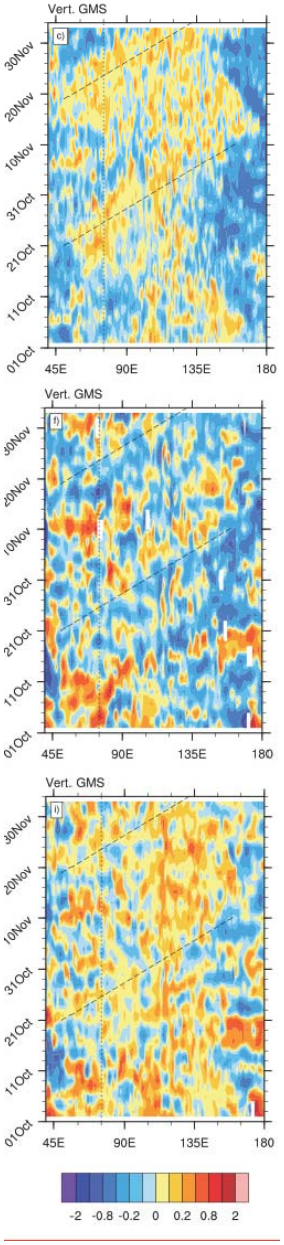
ZM_0.2



MSE anomalies

Gross moist stability

$$\Gamma_\psi = \frac{\langle \omega \vartheta_p h \rangle}{\langle \omega \vartheta_p s \rangle}$$



- CAM5 with enhanced entrainment produces much-improved DYNAMO hindcast skill versus simple undiluted CAPE convective closure