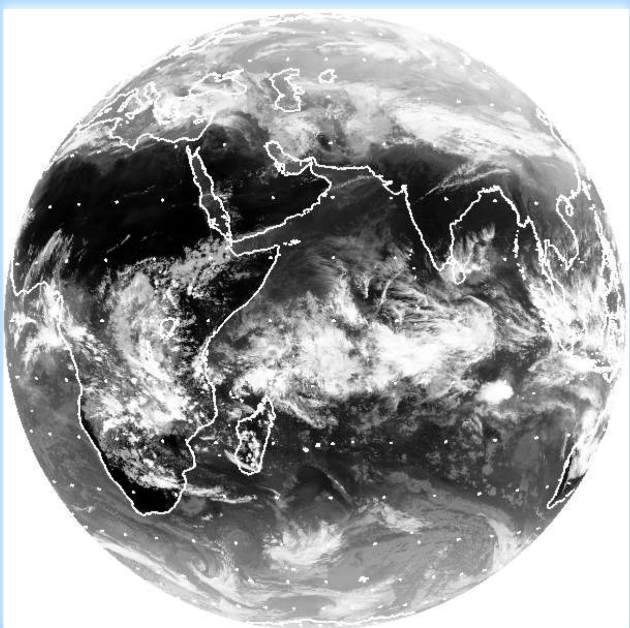
Vertical Structure and Diabatic Processes of the MJO: A Global Model Inter-comparison Project

A joint research activity of the WCRP-WWRP/THORPEX Year of Tropical Convection (YOTC)/MJO Task Force and the GEWEX Cloud System Study (GCSS)

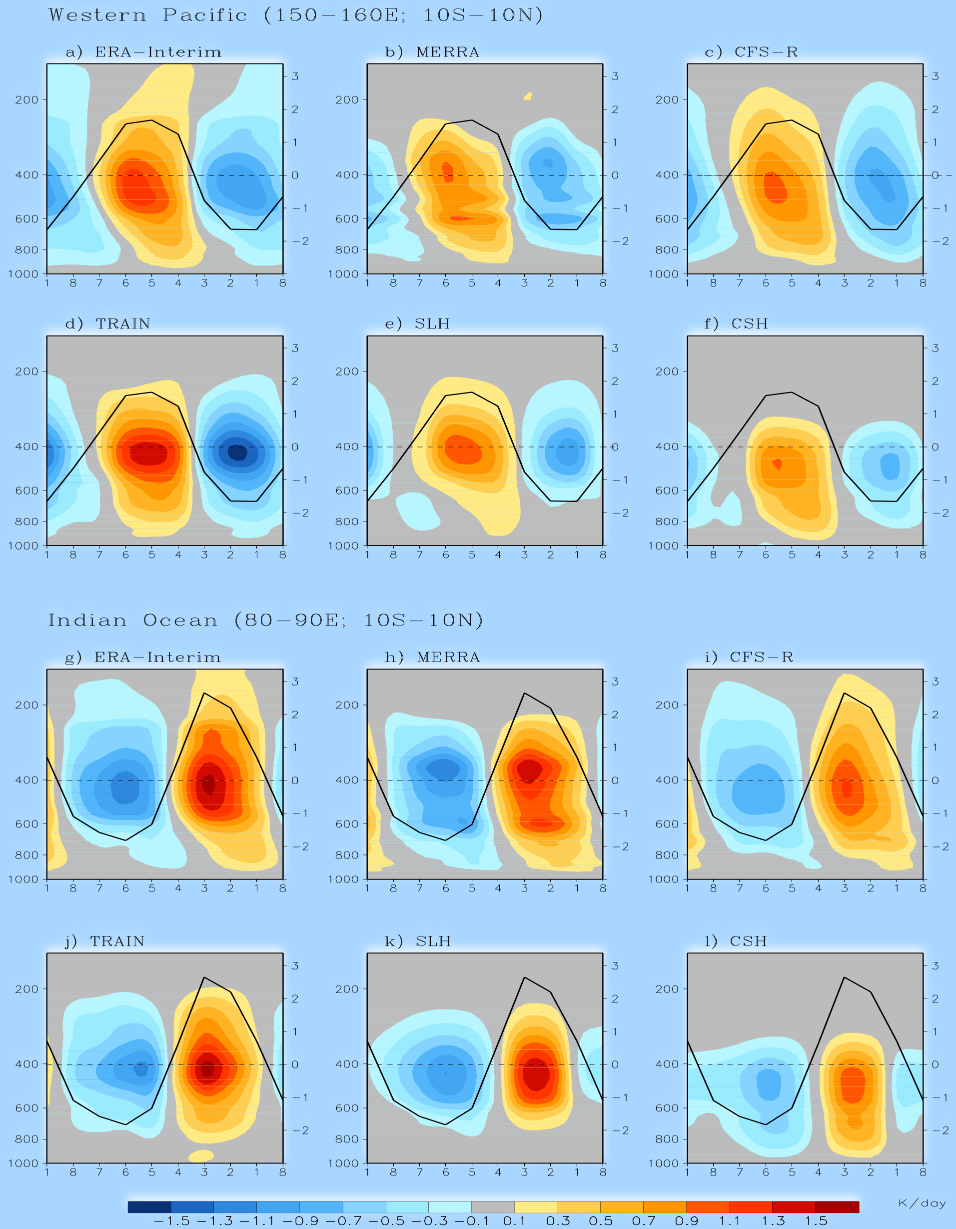
Leads: Jon Petch (Met Office/GCSS), Duane Waliser (JPL/YOTC)
Xianan Jiang (JPL), Prince Xavier (Met Office), Steve Woolnough (Univ. Reading)



Mitch Moncrieff
NCAR Earth System Laboratory
YOTC Co-Chair

Knowledge Transfer Breakout Session
CMMAP 11th Team Meeting
Fort Collins, CO, Aug 9-11, 2011

Q1 for MJO from 3 reanalyses (ERA-I, MERRA, CFS); and 3 TRMM algorithms (TRAIN, SLH, and CSH)



Courtesy: Xianan Jiang (2011) [MWR, in press]

Components of the WCRP/WWRP-THORPEX Year of Tropical Convection (YOTC) Project

Collaborative research at the intersection of weather and climate with an emphasis on moist convective organization and its interaction with the large-scale circulation

The YOTC Framework: "Virtual Field Campaign"

Utilizing existing new/improved resources with model, parameterization and forecast improvement as a chief objective

New/Improved Resources

- **Satellite Observations, e.g., EOS**
- **In-Situ Networks e.g., ARM, CEOP**
- **GOOS, e.g., TAO, PRADA, drifters**
- **Field campaigns, e.g., VOCALS, T-PARC, AMY, DYNAMO**
- **High-Resolution Deterministic Weather Prediction and Global Analyses, e.g., ECMWF T799 (25 km)**
- **High-resolution models e.g., Regional to Global Cloud-System Resolving Models**
- **Dynamical analogs**

+

Framework

FGGE,
GATE,
TOGA
COARE

"Virtual Field Campaign"

=

YOTC

YOTC Focus Period

"Year" (May '08 – Apr '10)

ECMWF T799 (25 km)

analysis, forecasts, special diagnostics

Primary Research Areas

MJO & Convectively Coupled Waves

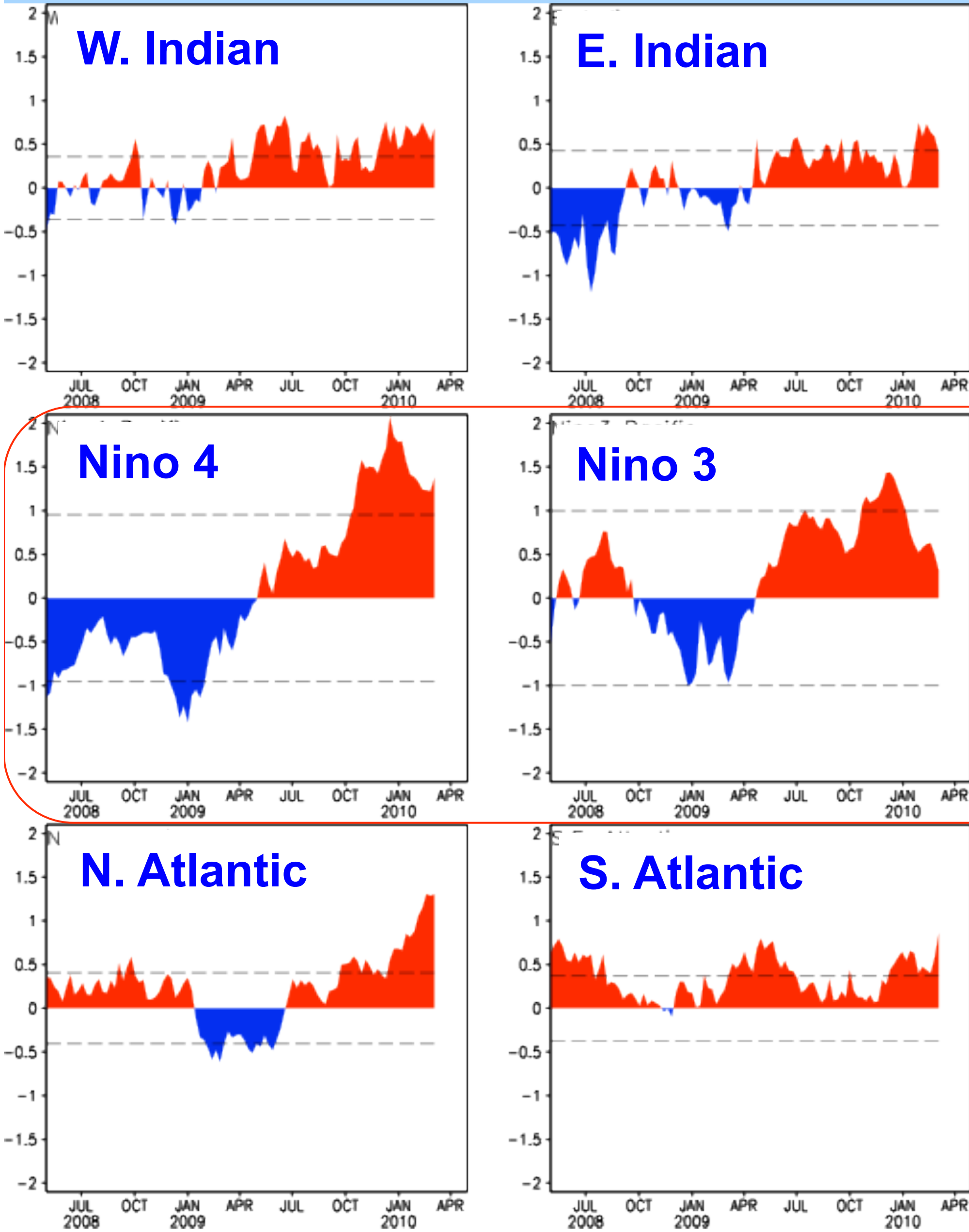
Monsoon Intraseasonal Variability

Tropical-Extratropical Interaction

Easterly Waves & Tropical Cyclones

Diurnal Cycle

Tropical SSTs during "Year"

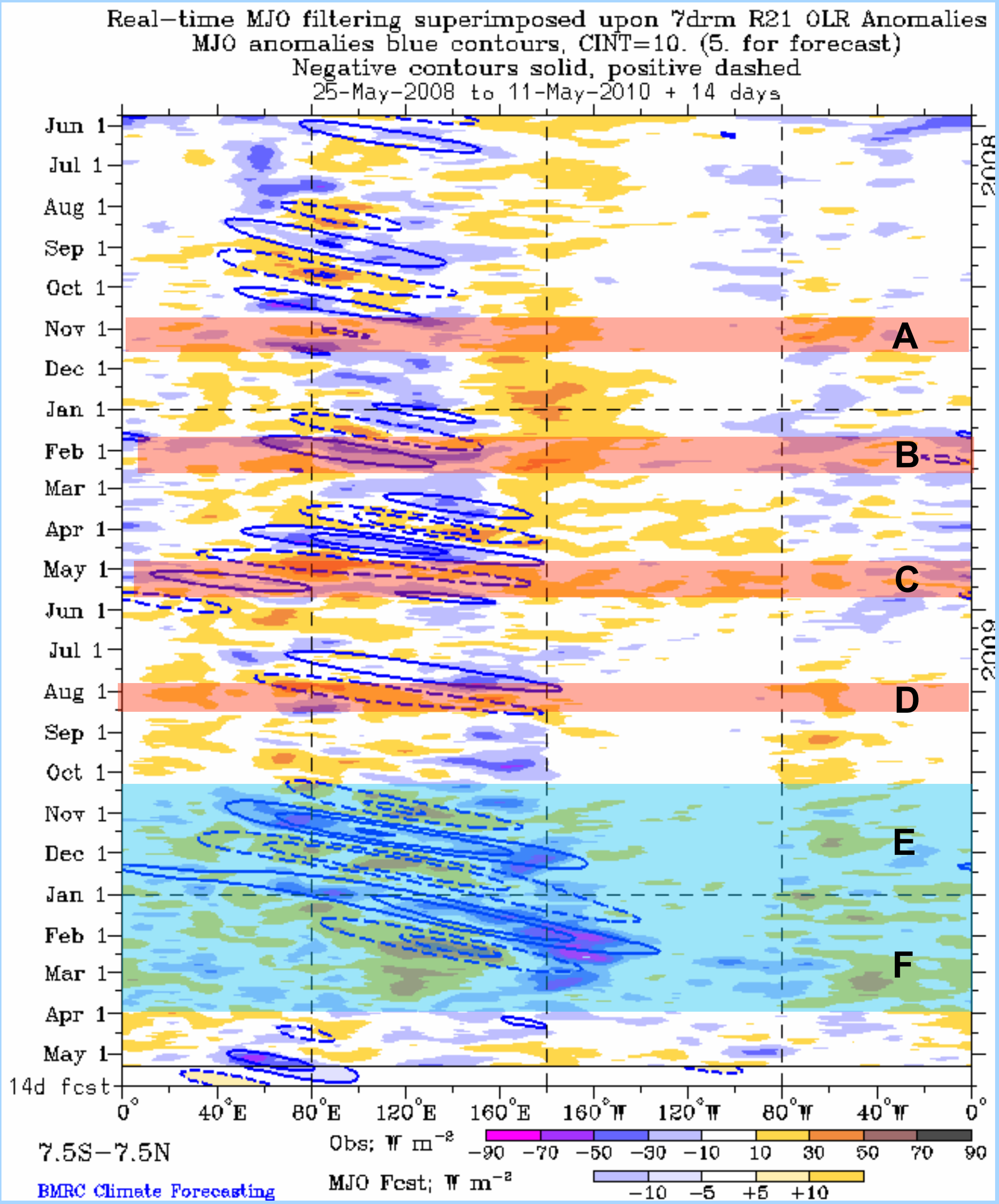


Warm in Year 2
(Indian Ocean Dipole in a Positive State)

Year 1 – Modest La Nina
Year 2 – Modest El Nino

Warm Atlantic

MJOs for the "Year" (May 2008-April 2010)



Examined in WGNE/WGCM Transpose-AMIP project

<u>La Nina conditions</u>: Four weak and short-lived MJO's, nevertheless producing devastation, e.g. Australian floods & fires associated with event B.

<u>El Nino conditions</u>: Two stronger MJOs, successive events (E & F) associated with tropical-extratropical interaction or regeneration of event E.

Examined in YOTC/ MJOTF project

Vertical Structure and Diabatic Processes of the MJO: A framework for improving physics parameterizations in global weather & climate models

- Objective: Characterize, compare and evaluate the heating, moistening and momentum transport associated with the produced by global weather & climate models.

- Focus on vertical structure: Improve understanding of the role of convection, cloud, radiative and dynamic processes in the MJO in order to improve its fidelity in global models.

- Approach: Take advantage of links between biases in short-range forecasts and long-term climate modeling.

- Primary focus: Use the YOTC-ECMWF global analysis and profiling products from contemporary satellites (e.g. TRMM, CloudSat, Calipso, AIRS), along with model experiments, to characterize, compare and evaluate the vertical structure of MJOs produced by global models.

- Secondary focus: Provide (less detailed) output to characterize and analyze week 2-4 hindcast skill of MJO events, and a framework to examine possible cases in the DYNAMO/CINDY2011 field-campaign in 2011-12 boreal winter.

- Anticipated follow-on: Detailed analysis of physical tendencies of heat, moisture and momentum from the numerical experiments will lead to process-model experiments (e.g., GCSS) and inform the needs for future field-campaigns and observing systems.

- **References:**

1) Petch et al. 2011: A Global Model Intercomparision of the Physical Processes Associated with the Madden-Julian Oscillation. *GEWEX* News, August edition.

2) YOTC website (www.ucar.edu/yotc)

Specific objectives of the model inter-comparison

- **Characterize the diabatic heating profiles associated with the MJO in current state-of-the -art climate models, including those relative to observations (e.g., reanalysis and TRMM estimates).**

- **Quantify various heating components for the MJO by examining relationships between the MJO simulation/hindcasts and the diabatic heating and its components.**

- **Evaluate the ability of current models to hindcast MJO events; characterize the evolution of the “error” growth in the diabatic heating profiles as a function of lead time; seek commonalities between good and bad performance.**

- **Characterize diabatic heating, moisture, and structures of organized convective systems within the MJO as a function of the MJO lifecycle.**

- **Examine the critical processes responsible for the transition in diabatic heating profiles and cloud structures during MJO evolution, and examine how these processes are represented in different GCMs.**

- **Elucidate model deficiencies in depicting the MJO heating and associated cloud structures and provide critical guidance for the parameterization of physical processes, including convective organization.**

- **Compare modeled diabatic heating profiles associated with the MJO with those from global satellite observations to determine the utility of the satellite and reanalysis products in evaluating model simulations of the MJO; and provide feedback to the satellite formulation and algorithm communities regarding strengths, shortcomings and gaps in present-day products.**

Experiment design: Two main components

A) <u>20-year climate simulations</u> to characterize the models' intrinsic capabilities in representing MJO variability. Simulations from both ocean-coupled global models as well as those that use specified SSTs are solicited. Output will include information on vertical structure/processes at 3-hourly resolution so that adequate information is available for investigating multi-scale interaction.

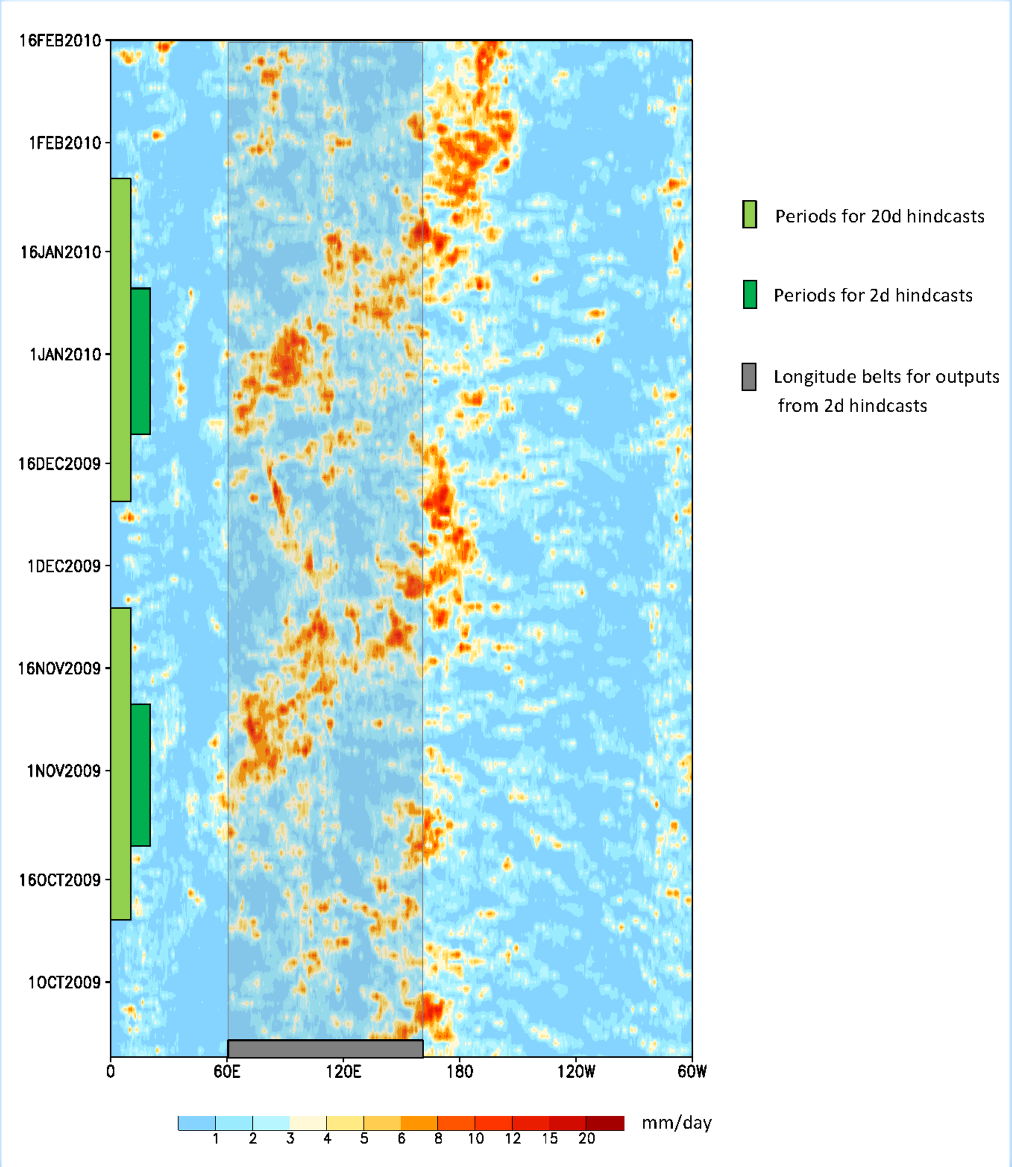
B) <u>2-day initialized hindcasts</u> of the successive YOTC events (E & F).

a) Provide detailed and comprehensive model output over a selected near-equatorial Indian Ocean / western Pacific Ocean domain for the initial two days of hindcasts to provide information on the evolution of the simulated MJOs as they progress from the observed state to a state of intrinsic variability within the models.

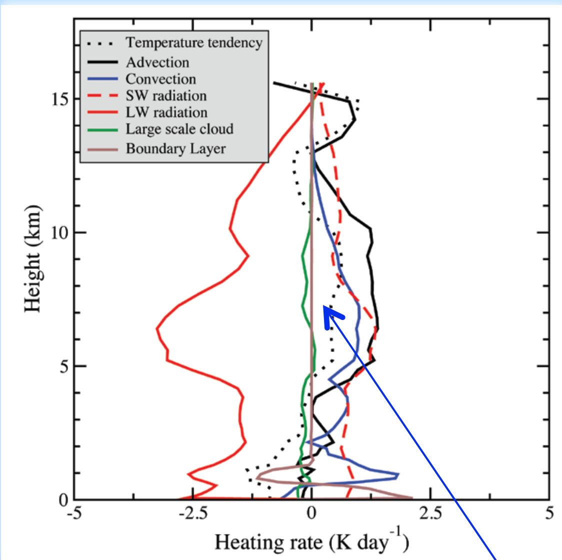
b) Provide (less detailed) output helpful for the characterization of possible cases from the DYNAMO/CINDY2011 field-campaign in 2011-12 boreal winter.

c) Differing from b) only in the level of diagnosis, the performance of the models' MJO as a function of forecast lead time from 1 to 20 days will be analyzed.

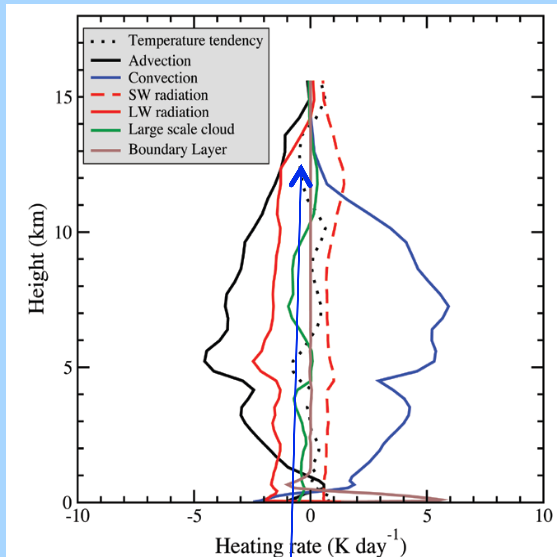
Rainfall evolution of the successive YOTC MJO events E & F



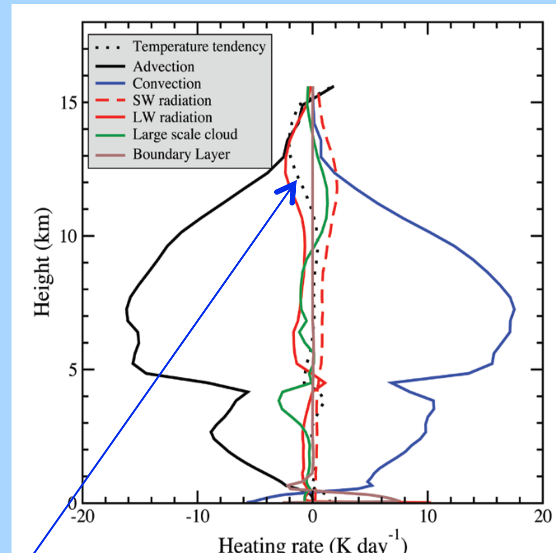
An Example: Temperature tendencies for the physical/dynamical processes in MetUM 24-hr forecast (40-km grid) initialized on 20 October 2009 during the successive MJO event



a) Suppressed
(Indian Ocean)



b) Transition
(Sumatera)



c) Active
(between Sumatera & Borneo)

Dotted line: total tendency for the 24-hour period
(each 3 x 3 degree boxes)

Courtesy: Petch et al. (2011)
[GEWEX News, Aug. 2011]

Joint YOTC/MJO Task Force - GCSS Model Intercomparison Project on Diabatic Processes

a) Participants interested in performing model forecasts/simulations

	Model	POC	Institution	Email	Experiment[1]		
					Climatological simulation	Short-term Hindcast	Long-term Hindcast
1	GEOS-5 AGCM	Siegfried Schubert	NASA	Siegfried.D.Schubert@nasa.gov	X	X	X
2	GEOS-5 AGCM	Hailan Wang	NASA/GMAO	Hailan.Wang-1@nasa.gov			
3	IPRC GCM	Xiouhua Fu	University of Hawaii	xfu@hawaii.edu	X	X	X
4	IPRC GCM	Baoqiang Xiang	University of Hawaii	baoqiang@hawaii.edu			
5	SPCAM	David Randall	Colorado State University	randall@atmos.colostate.edu	X	X	X
6	SPCAM	Charlotte Demott	Colorado State University	demott@atmos.colostate.edu			
7	SPCAM	Mike Pritchard (UW)	UCSD	mikepritchard@ucsd.edu			
8	NASA GISS	Daehyun Kim	LDEO	daehyunk@gmail.com	X	X	X
9	NASA GISS	Anthony Del Genio	LDEO	anthony.d.delgenio@nasa.gov			
10	GEM model	Hai Lin	Environment Canada	Hai.Lin@ec.gc.ca	X	X	X
11	NICAM	Masaki Satoh	AORI, Univ. of Tokyo	satoh@aori.u-tokyo.ac.jp	-	X	X
12	NICAM	Tomoe Nasuno	JAMSTEC	nasuno@jamstec.go.jp			
13	SINTEX	Jingjia Luo	JAMSTEC	luo@jamstec.go.jp			
14	LMDZ	Jean-Philippe Duvel	LMD, Paris	jpduvel@lmd.ens.fr			
15	LMDZ	Sandrine Bony	LMD, Paris	sandrine.bony@lmd.jussieu.fr			
16	MRI-GCM	Eiki SHINDO	MRI	eishindo@mri-jma.go.jp	X	X	X
17	MRI-GCM	Akio Kitoh	MRI	kitoh@mri-jma.go.jp			
18	CWB AGCM	Mong-Ming LU	CWB, Taiwan	lu@rdc.cwb.gov.tw	X	X	X
19	CWB AGCM	Hsin-Hsing CHIA	CWB, Taiwan	ccjrl@cwb.gov.tw			
20	CWB AGCM	Hsiao-Chung TSAI	CWB, Taiwan	hctsai.cwb@gmail.com			
21	WRF	Samson M Hagos	PNNL	samson.hagos@pnnl.gov	X	X	X
22	CCSM4	David Straus	COLA and GMU	straus@cola.iges.org			
23	CCSM4	Ben Kirtman	University of Miami	bkirtman@rsmas.miami.edu			
24	CCSM4	Joe Tribbia	NCAR	tribbia@ucar.edu			
25	CFS T62L60	Kyong-Hwan Seo	PNU, Korea	khseo@pusan.ac.kr	X	X	X
26	CFS T62L60	Sooraj K P	PNU, Korea	soorajmet@gmail.com			
27	IFS	Frederic Vitart	ECMWF	Frederic.Vitart@ecmwf.int			
28	ECHAM	Traute Crueger	ZMAW	traute.crueger@zmaw.de			
29	MetUM GA3.0	Prince Xavier	Met Office UK	prince.xavier@metoffice.gov.uk	X	X	X
30	INGV	Silvio Gualdi	CMCC	silvio.gualdi@bo.ingv.it			
31	HiRAM	Ming Zhao	GFDL	ming.zhao@noaa.gov	X	X	X
32	CCSM4, CESM1	Rich Neale	NCAR	rneale@ucar.edu	X	X	X
33	NAVGEM	Jim Ridout	NRL	james.ridout@nrlmry.navy.mil			

b) Participants who are interested (e.g., in analysis) but will not conduct model forecasts/ simulations

	Contact	*Institution*	*Email*	*Interests*
1	Scott L. Harper	Office of Naval Research	scott.l.harper@navy.mil	Possible funding
2	Hongyan Zhu	Bureau of Meteorology, Australia	H.Zhu@bom.gov.au	Diagnosis,. Share results
3	Jian Ling	Uni. Miami	jling@rsmas.miami.edu	Diagnosis
4	Rajib Chattopadhyay	Uni. Miami	rajib@rsmas.miami.edu	Diagnosis
5	Chidong Zhang	Uni. Miami	czhang@rsmas.miami.edu	Diagnosis
6	Kyle Mozley	NOAA	Kyle.Mozley@noaa.gov	General interest
7	Vincent Larson	UWM	vlarson@uwm.edu	General interest
8	Yuhei Takaya	Climate Prediction Division of JMA	ytakaya@met.kishou.go.jp	General interest
9	Jun-ichi Yano	ZMAW	jun-ichi.yano@zmaw.de	General interest
10	Qin Zhang	NOAA	Qin.Zhang@noaa.gov	General interest
11	Franklin R. Robertson	NASA/MSFC Earth Sci. Office	pete.robertson@nasa.gov	General interest
12	Pallav Ray	Uni. Hawaii	pallavkrray@gmail.com	General interest