# Year of Tropical Convection (YOTC)

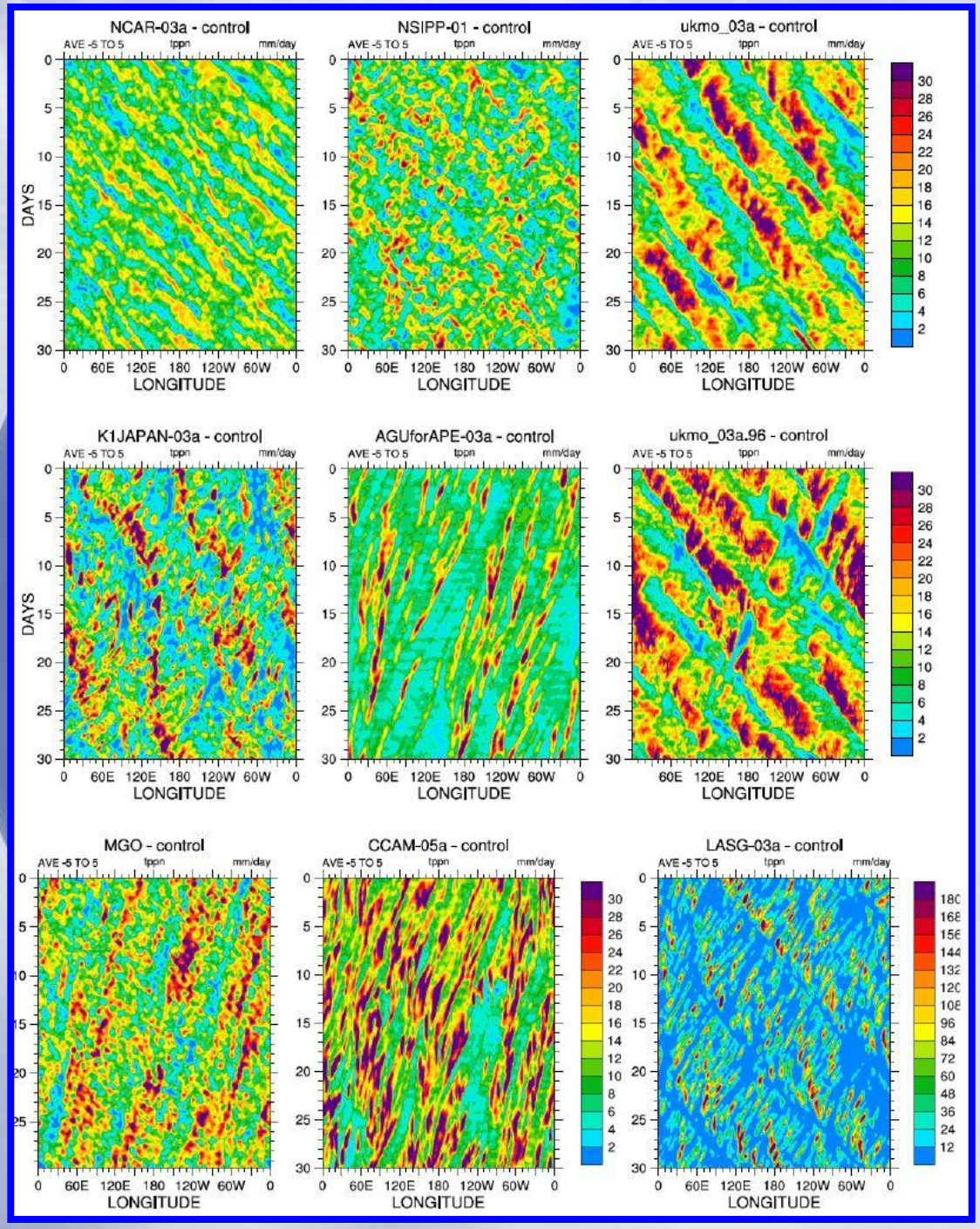
*Tropical convection, its organization and its large-to-global scale interaction*

**Duane Waliser, JPL/Caltech**
**Mitch Moncrieff, NCAR**
**Co-chairs, YOTC Science Planning Group**

WWRP World Weather Research Programme
THORPEX A World Weather Research Programme
WMO
WCRP

A Contribution to Seamless Weather-Climate Prediction

CLIVAR IAG, June 2010




# A Stark Demonstration of the "Tropical Convection Problem"

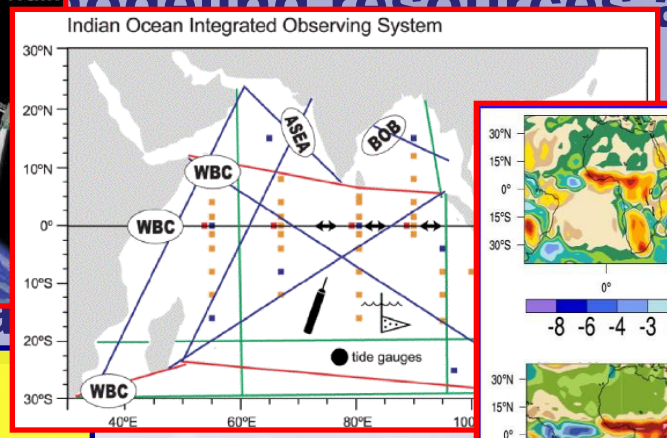
**Aqua-Planet Experiment**

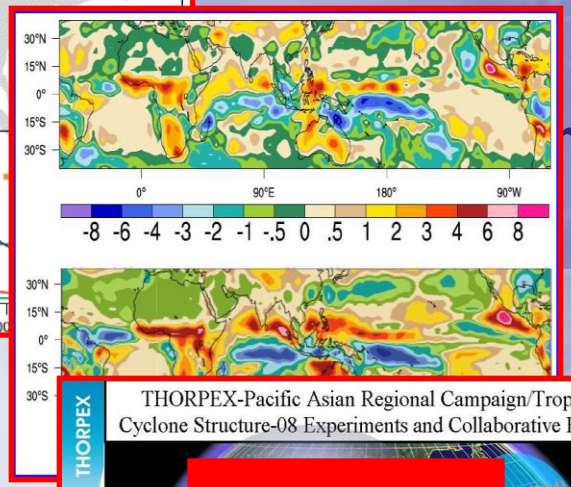
**N Models => N Answers**

Courtesy,
Dave Williamson, NCAR

# How to address this problem?

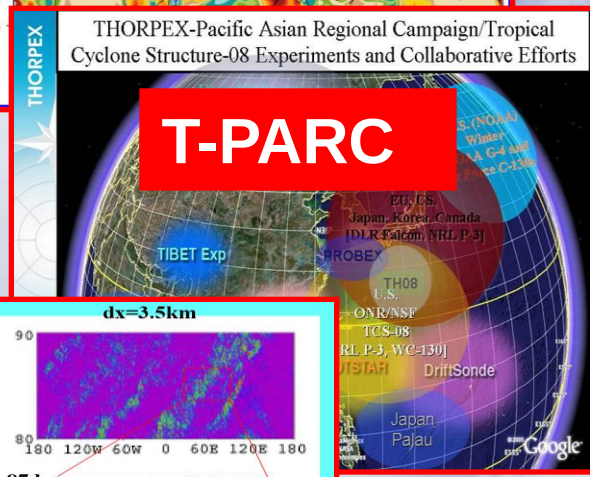
**i.e. to simultaneously address the large-to-global scale and the scales of convective organization?**

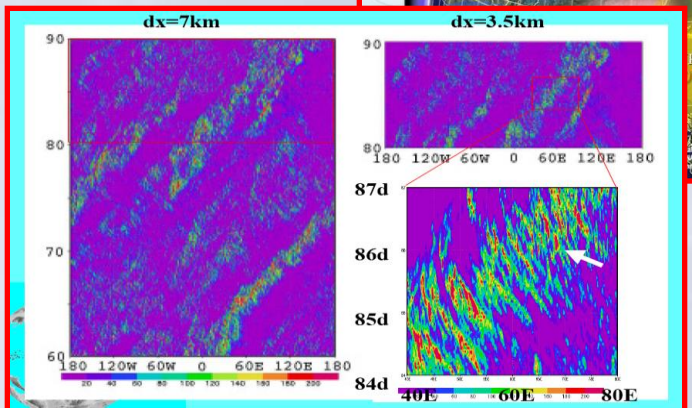




## New/Improved Resources

- **Satellite Observations (e.g., EOS)**
- **In-Situ Networks (ARM, CEOP)**
- **GOOS (e.g., TAO, PRADA, drifters)**
- **IOPs (e.g., VOCALS, T-PARC, AMY)**
- **High-Resolution Deterministic Forecast Models & Global Analyses**
- **Research Models [e.g., Regional and Global Cloud(-System) Resolving Models)**



# Develop a virtual "field Program" with existing resources with model, parameterization & forecast improvement as a chief objective.

**New/Improved Resources**

- **Satellite Observations (e.g., EOS)**
- **In-Situ Networks (ARM, CEOP)**
- **GOOS (e.g., TAO, PRADA, drifters)**
- **IOPs (e.g., VOCALS, T-PARC, AMY)**
- **High-Resolution Deterministic Forecast Models & Global Analyses**
- **Research Models [e.g., Regional and Global Cloud(-System) Resolving Models)**

**+**

**Conceptual Framing**

**FGGE, GATE, TOGA COARE**

**=**

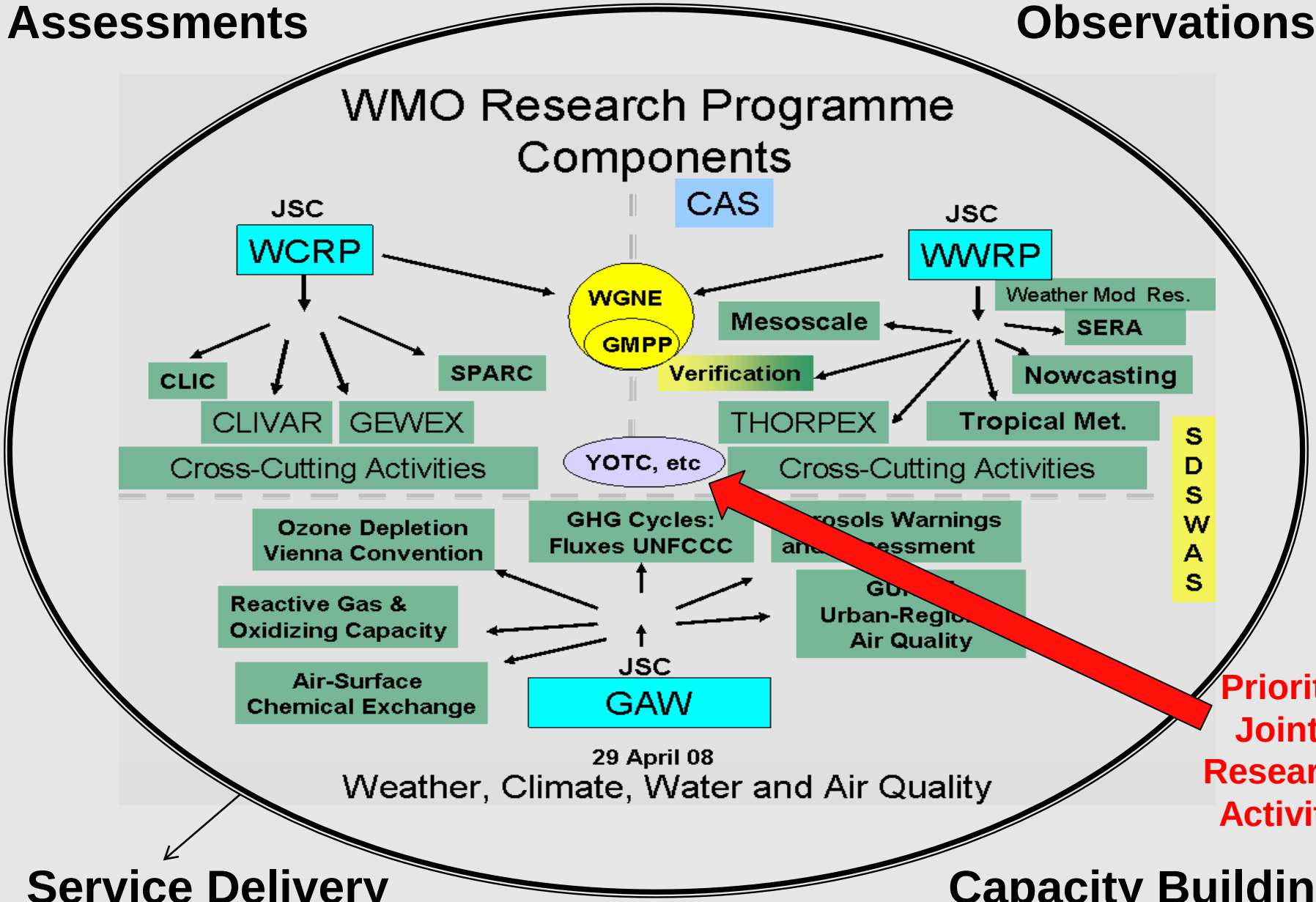
**YOTC**

**Focus "Year" Virtual IOP**

Prediction

Assessments

Observations

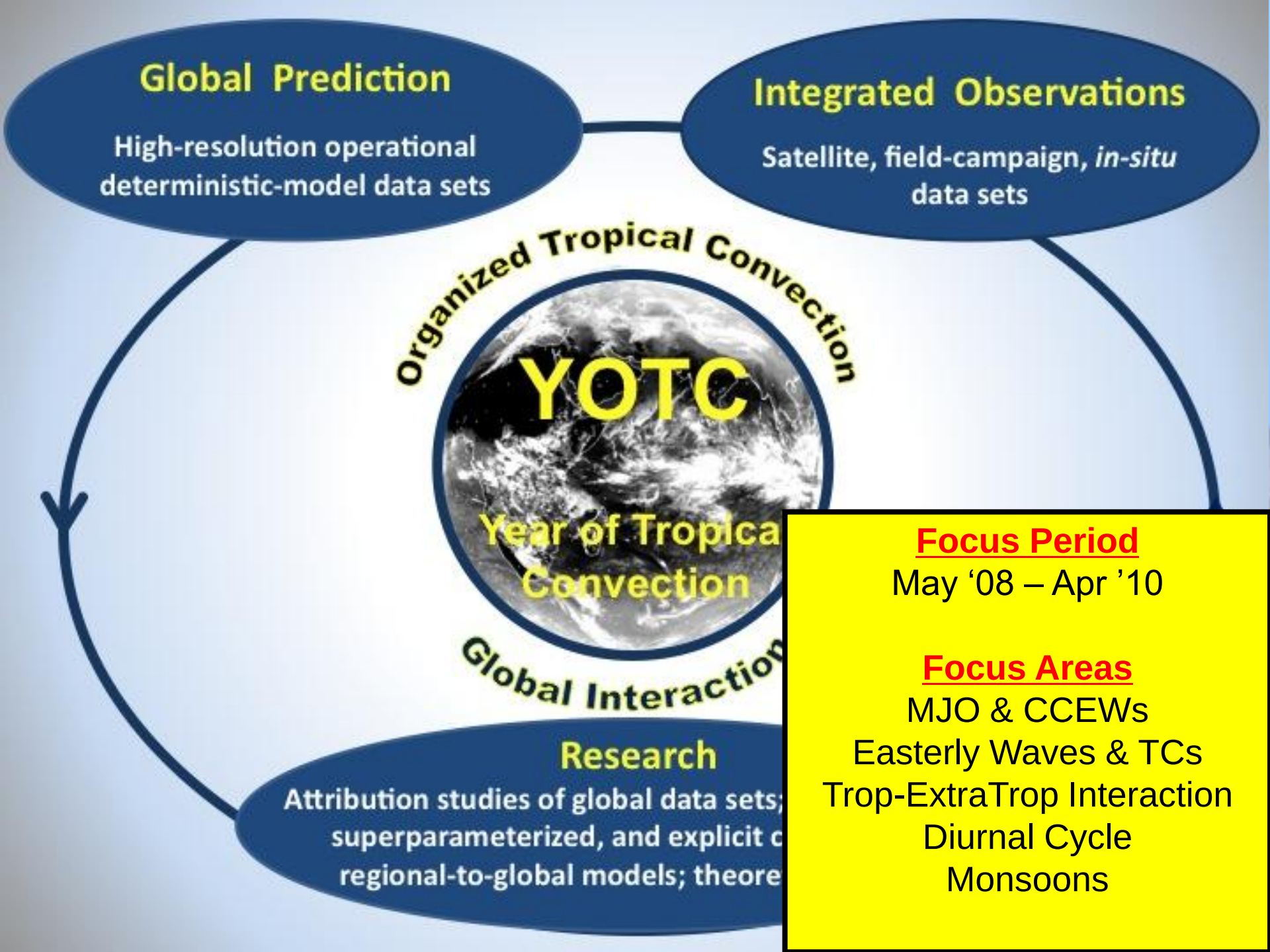



Priority Joint Research Activity

Service Delivery

Capacity Building

WWRP JSC 2008


Global Prediction
High-resolution operational deterministic-model data sets
Integrated Observations
Satellite, field-campaign, in-situ data sets
Organized Tropical Convection
YOTC
Year of Tropica
Convection
Global Interaction
Research
Attribution studies of global data sets;
superparameterized, and explicit c
regional-to-global models; theore
Focus Period
May '08 – Apr '10
Focus Areas
MJO & CCEWs
Easterly Waves & TCs
Trop-ExtraTrop Interaction
Diurnal Cycle
Monsoons

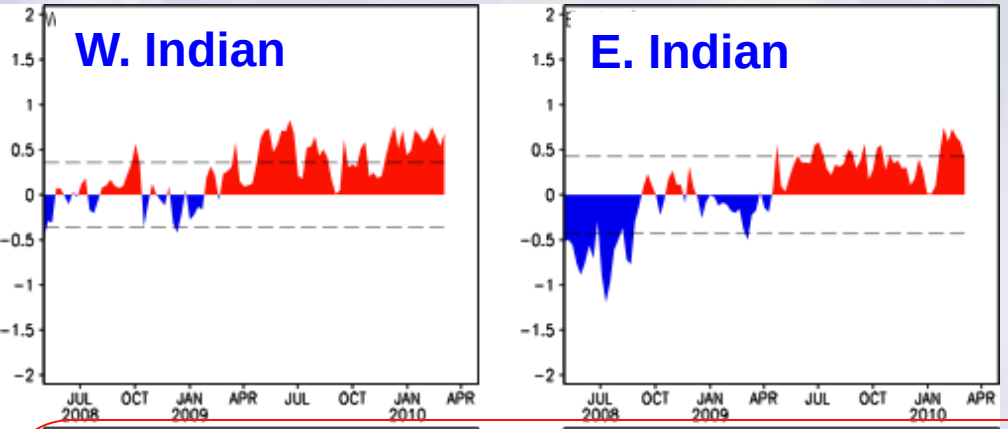
# The "Year" of Tropical Convection (May 2008 to April 2010): Climate Variability and Weather Highlights

*Many authors/contributions*

*BAMS Submission Expected in June*

# Background Conditions & Low Frequency SST

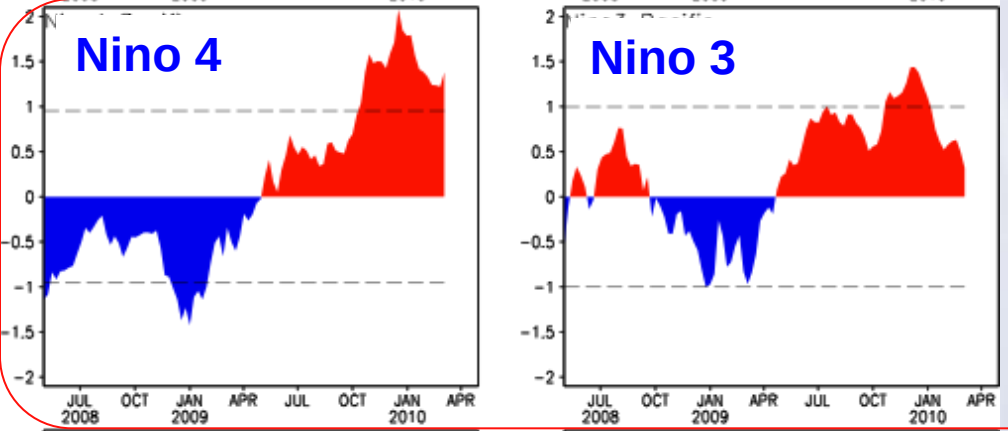
## Tropical SSTs







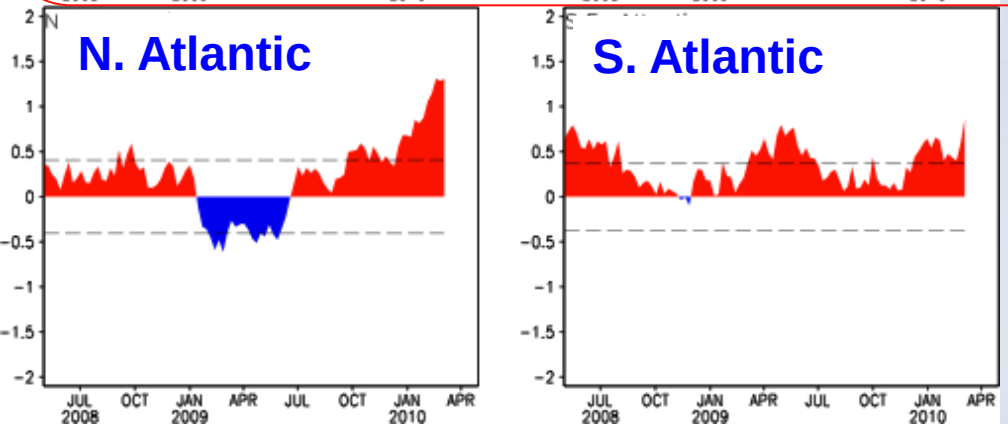
Warm in Year 2
Mostly +DMI







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





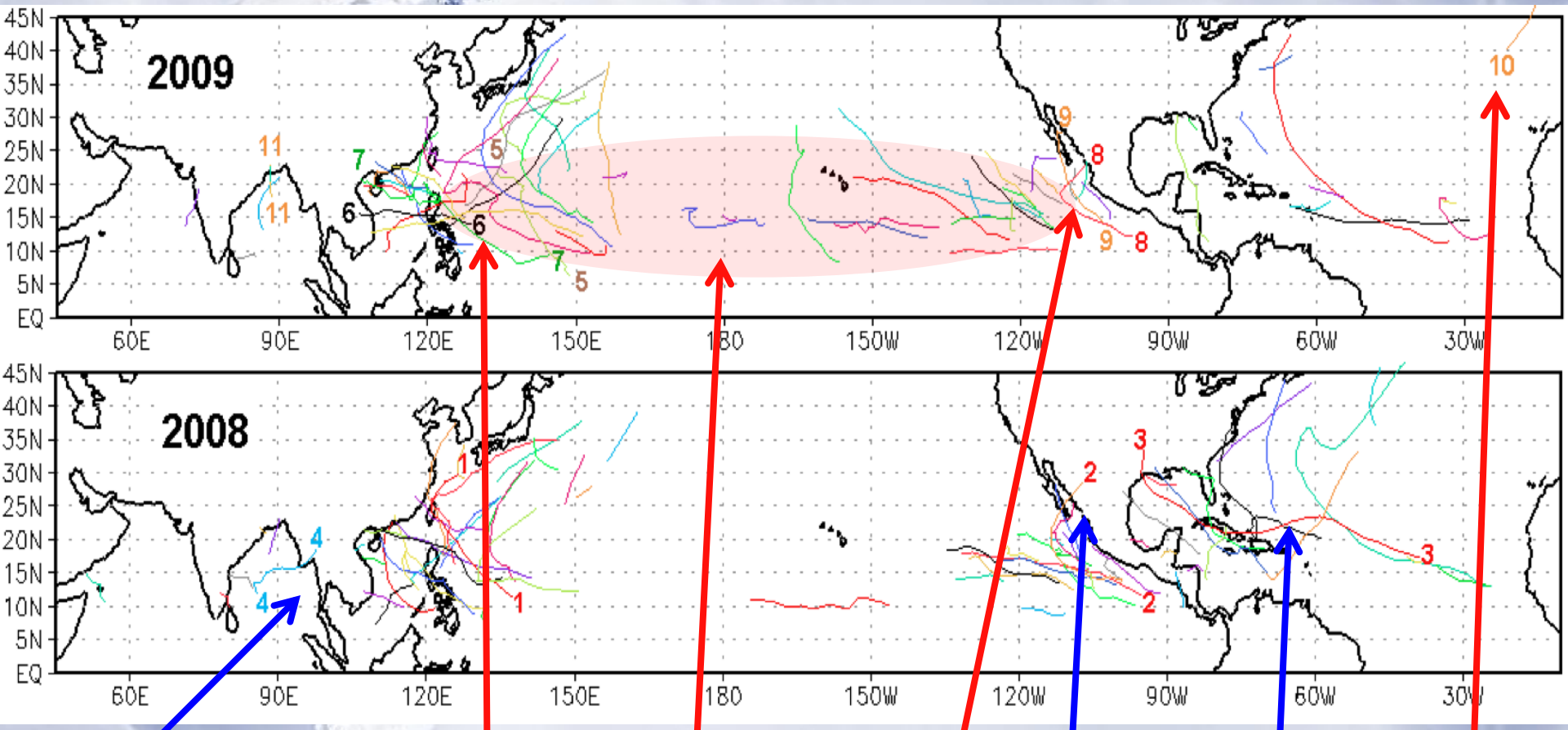


Mostly Warm Atlantic

# Tropical Cyclone Occurrence During YOTC

## *Boreal Summer*

Julian Hemming




Nargis, landfall over Myanmar, huge storm surge, 100,000 lives

Parma-1.8 m Rainfall

El Nino Modulation

Rick, 2nd Strongest

3 landfalls in Mexico

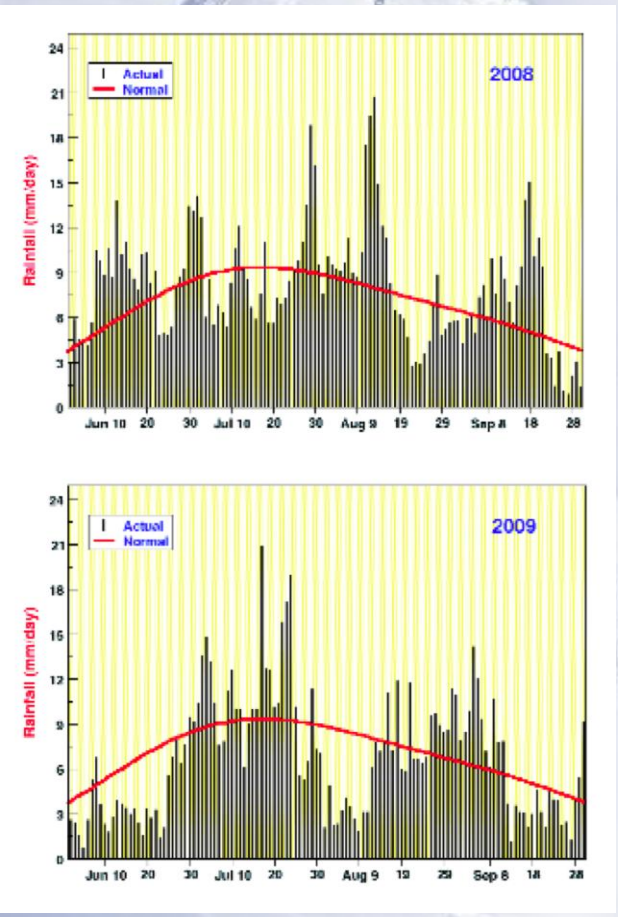
Ike - Largest size & Marko - smallest TC ever in this basin.

Grace

# Summer Monsoons During YOTC

India
BN Goswami

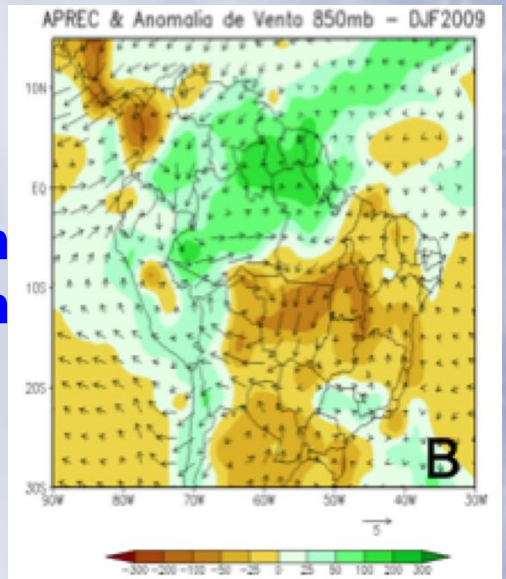
S. America
Jose Marengo




**2008**

**"Normal"**
**98% AIR**

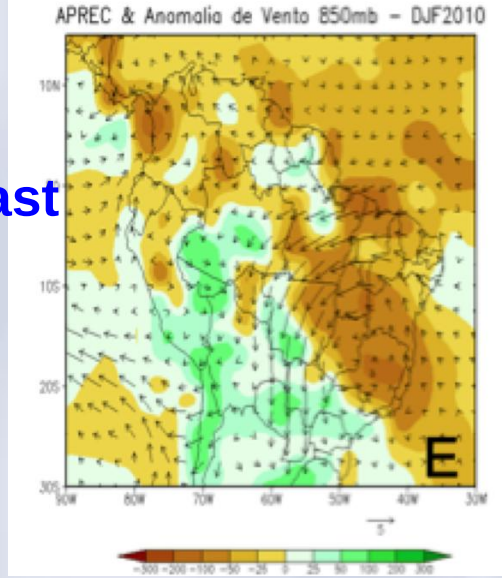
**Wet-north**
**Dry-south**




**2009**

**Very Large**
**Drought**
**78% AIR**

**Dry-north/east**
**Wet-south**

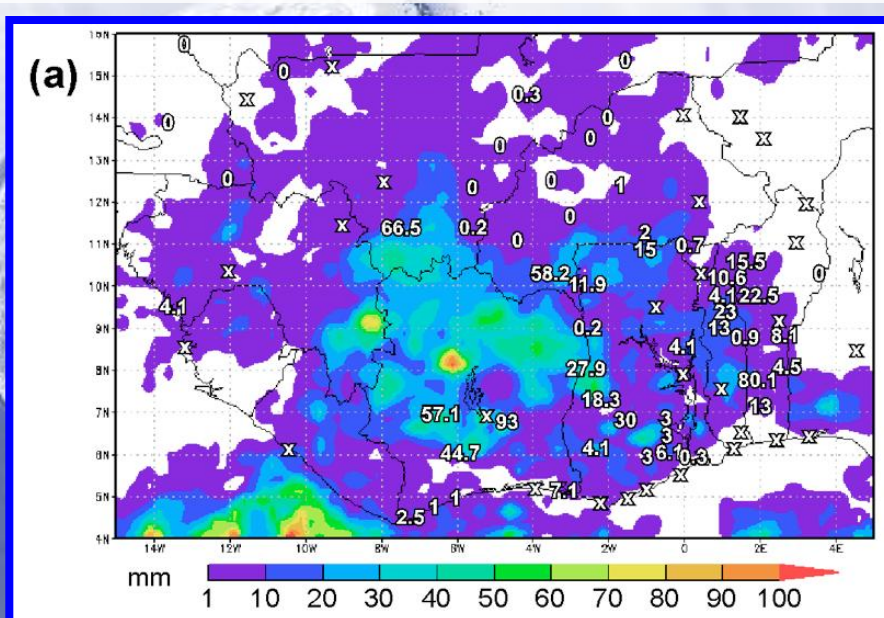


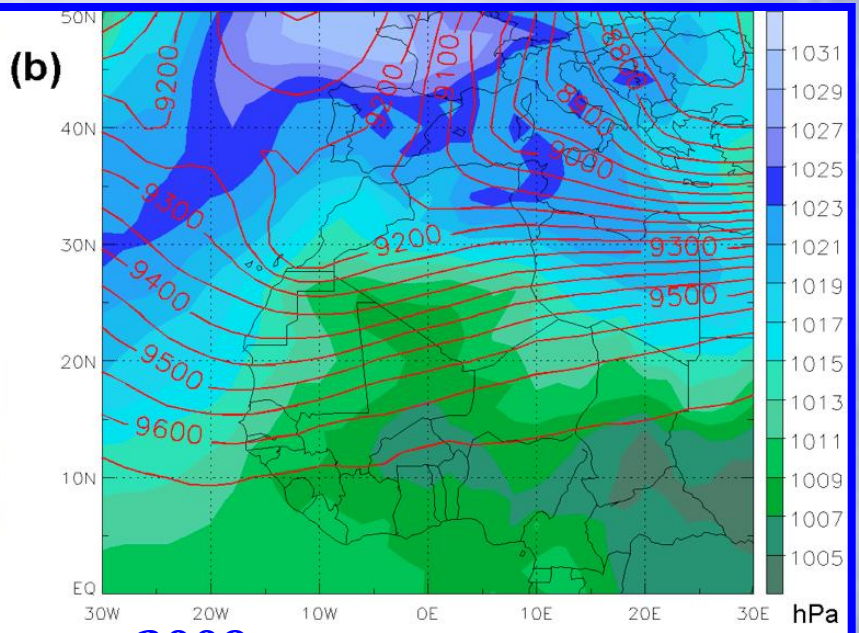

***Breaks influenced by ISV***

# Extra-Tropical Impact on Tropical Convection

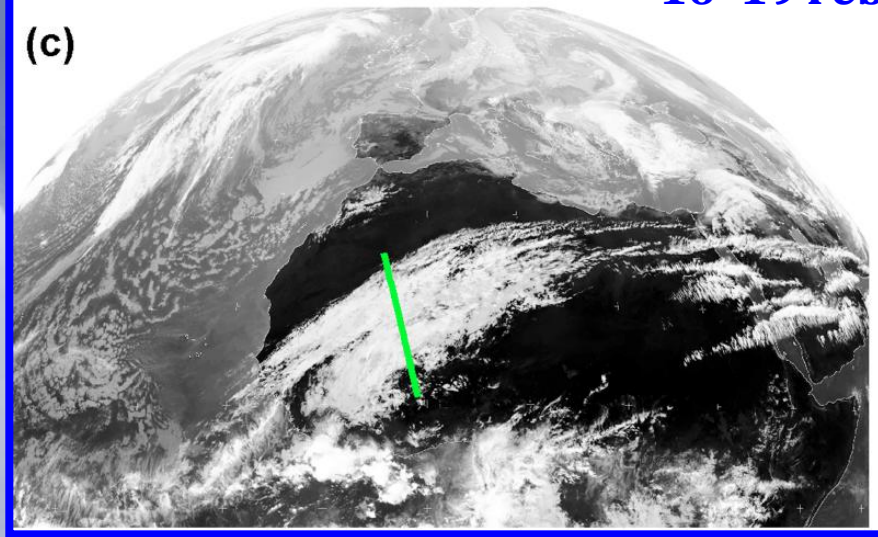
## 5 Significant DRY-Season Wet Episodes in W. Africa

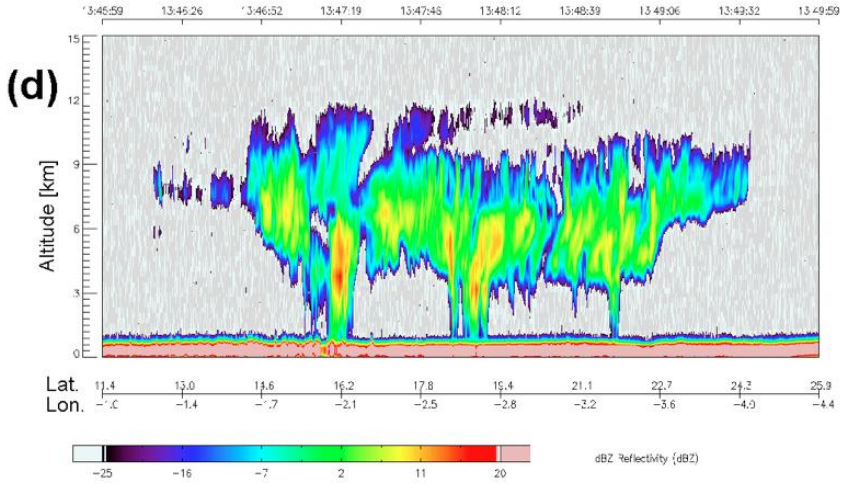
Peter Knippertz
Andrea Fink




**16–19 February 2009**

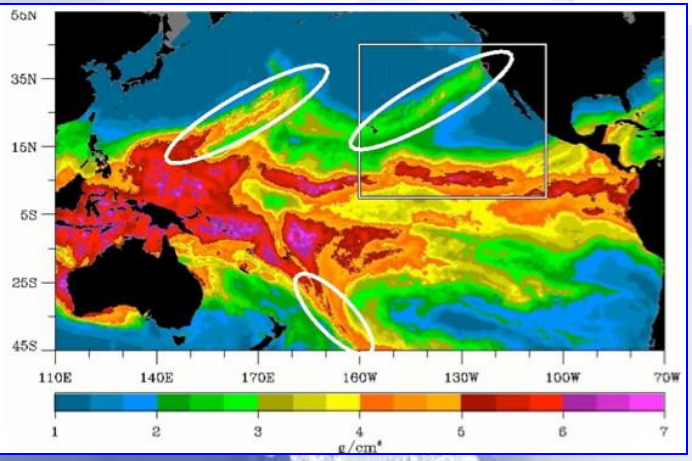


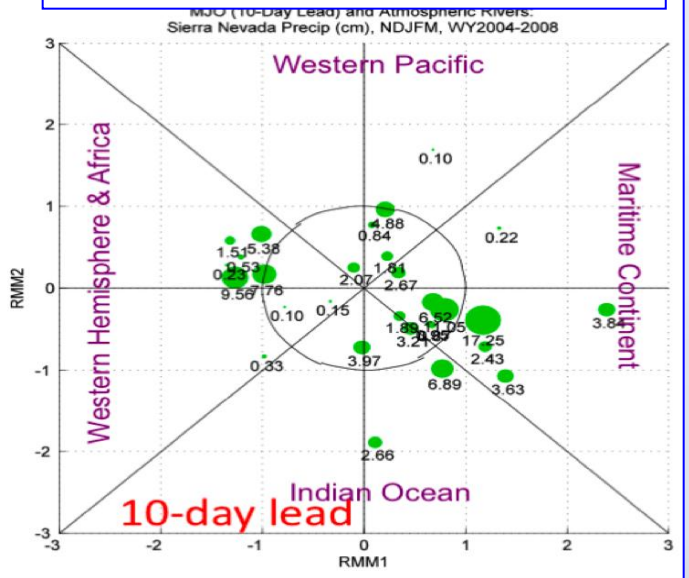
# Atmospheric Rivers During YOTC

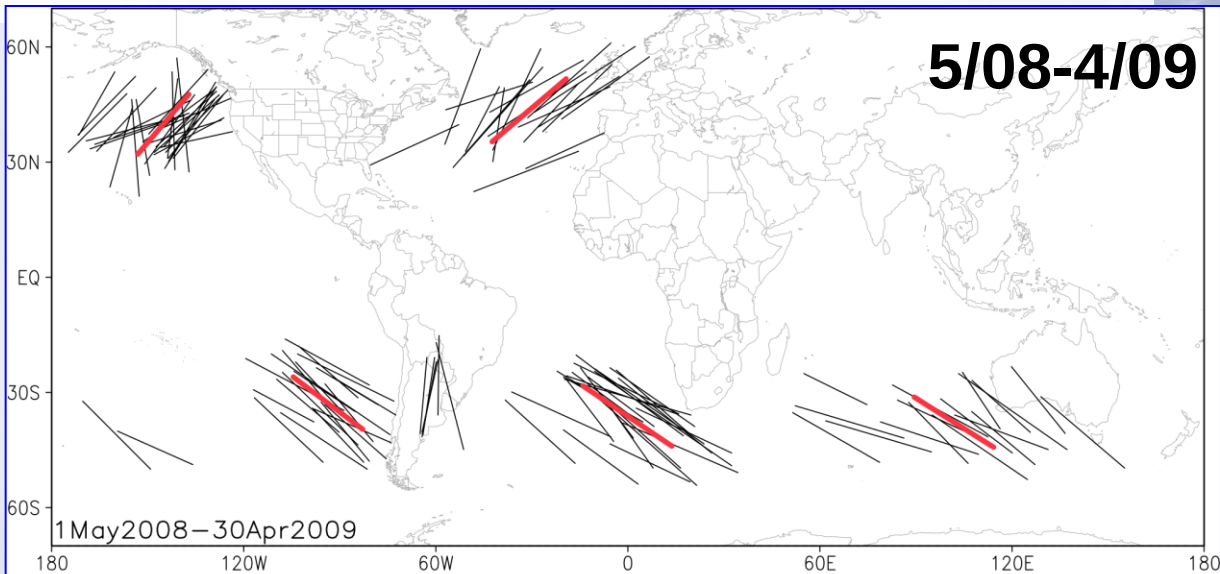
## *Tropical-Extratropical Interactions*

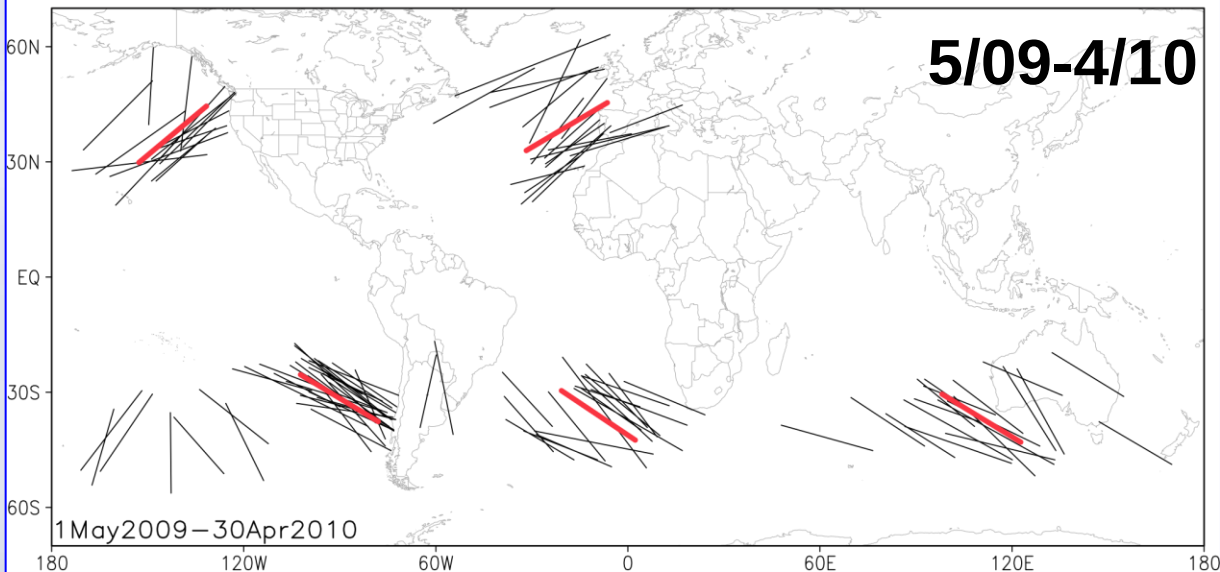
Bin Guan



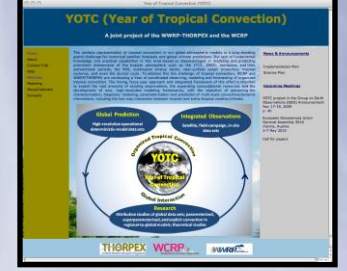

**MJO -> AR -> CA Precip**



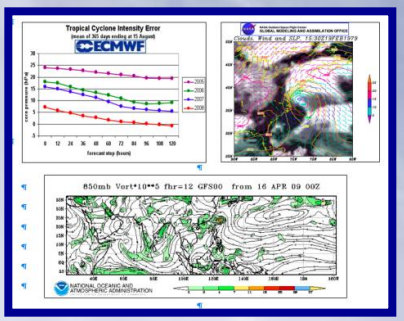



# YOTC: Progress & Pla

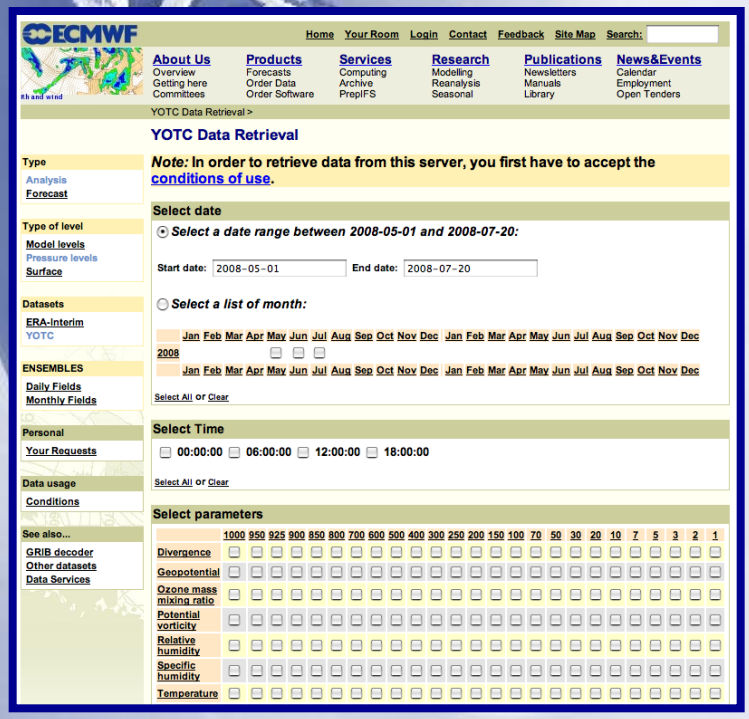


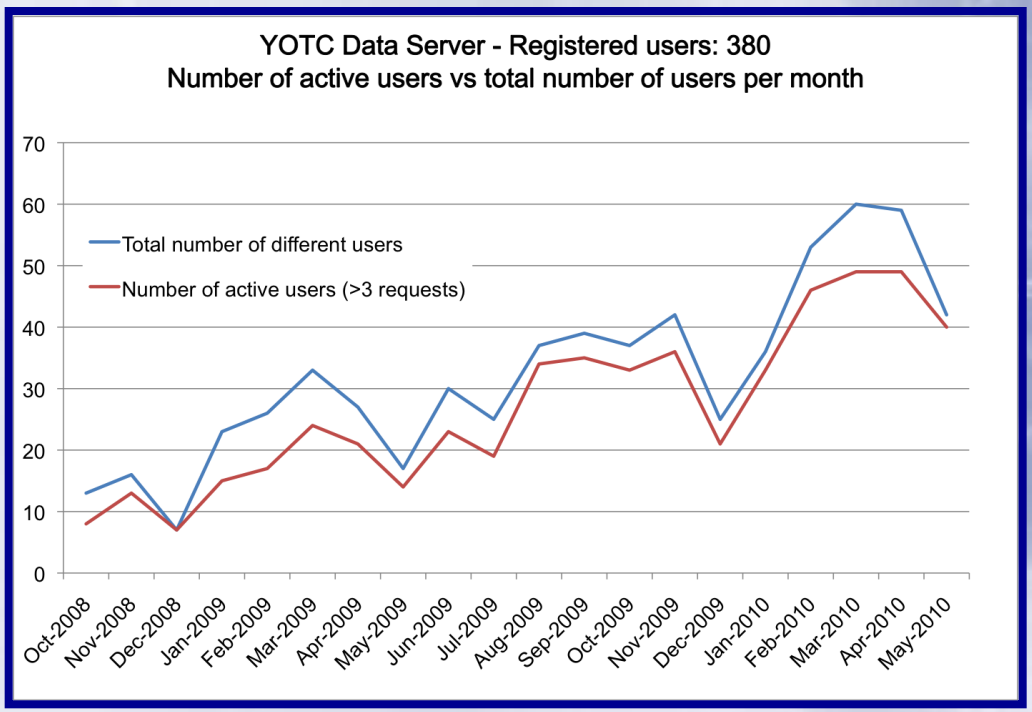

- **Science Plan –** Completed, WMO Technical Document.
- **Program Support/Information Specialist** – (Part-time): US THORPEX Exec Committee funding via U.S. NSF, NOAA, NASA.
- **Web site:** http://www.ucar.edu/yotc
- **Implementation Plan Drafted and Discussed/Approved at IP Meeting in Honolulu July 13-15, 2009.**
- **WCRP-WWRP/THORPEX YOTC MJO Task Force – 12/2009**
- **YOTC Science Sessions**– Fall AGU'08, AMS'09, Spring AGU'09, Fall AGU'09, WP-AGU'10, AGU of Americas 2010, Fall AGU'10,
- MJO TF Meeting and MJO Workshop, Busan, June 2010.
- YOTC Science Workshop + WGNE Meeting, China, Spring 2011.

# YOTC: Analyses, Forecasts & Special Diagnostics




- High-resolution, global analysis and forecast data sets are being made available to the community from ECMWF, NCEP and GMAO/NASA. e.g. T799 = 25km ECMWF + diagnostic fields *(as of Jan'10, T1279 = 16kms)*

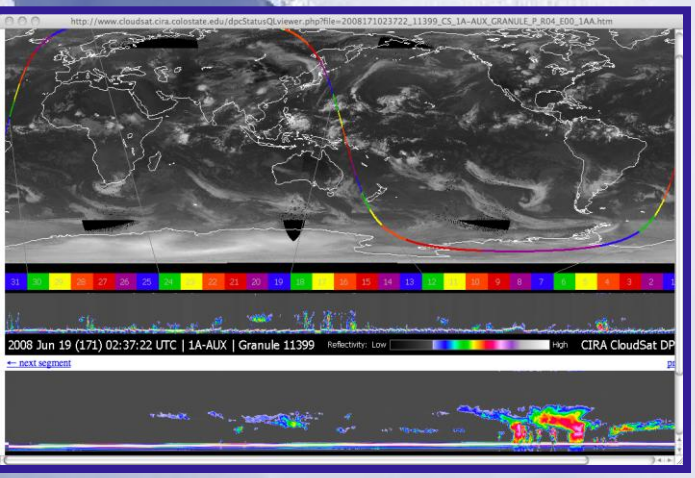


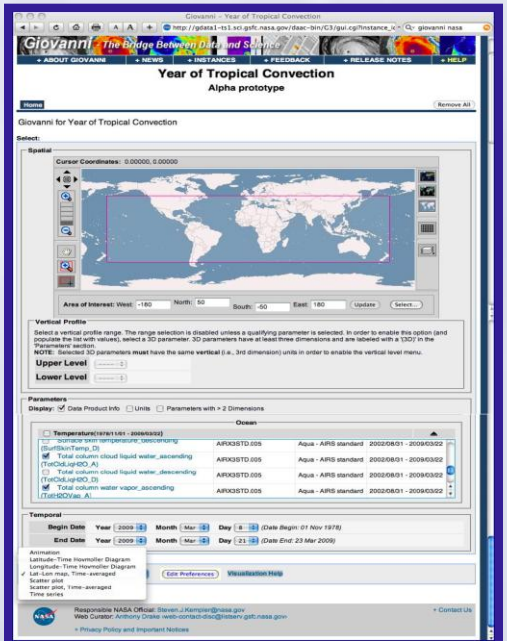



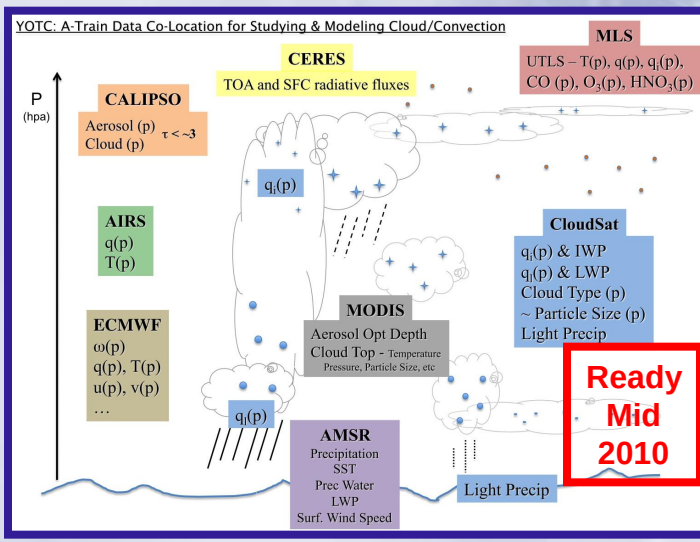

**ECMWF-YOTC Replicated at NCAR in coming months.**

# YOTC: Satellite Data


- Key satellite data (e.g., NASA A-Train, TRMM, geostationary) have been identified and funding secured from NASA for the:
  - Giovanni-based dissemination framework – Now Available
  - Multi-sensor CloudSat-Centric A-Train Data Set.

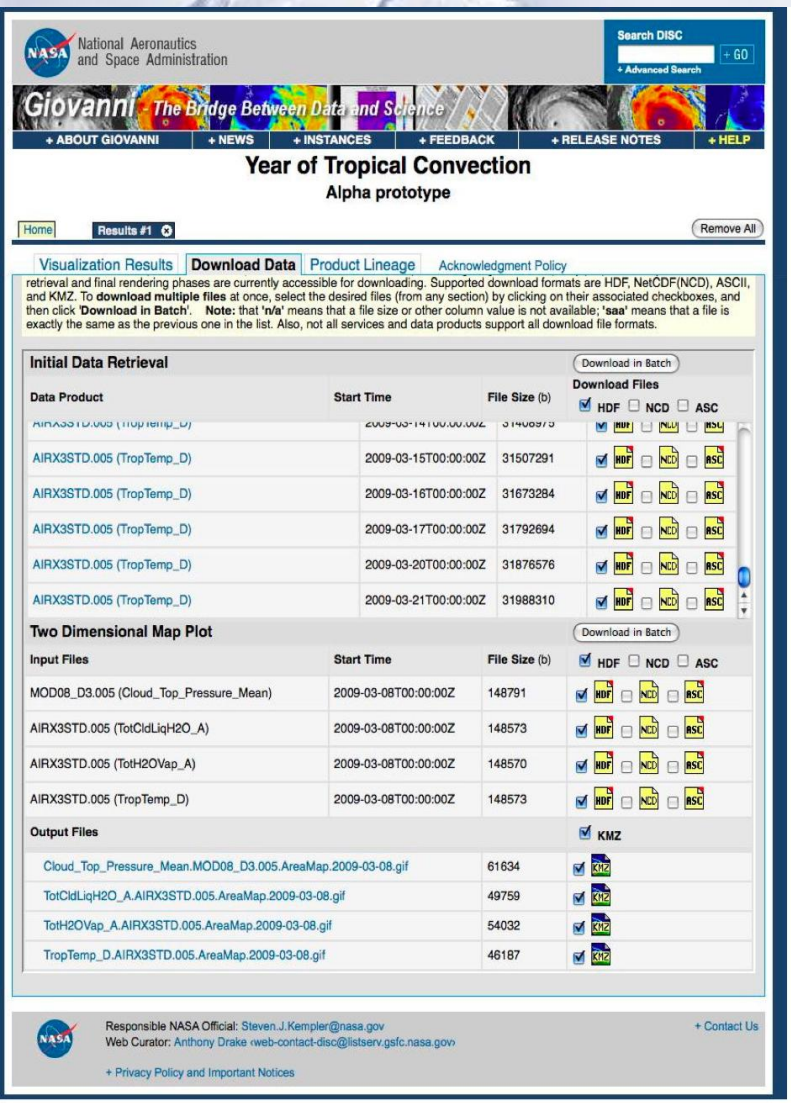


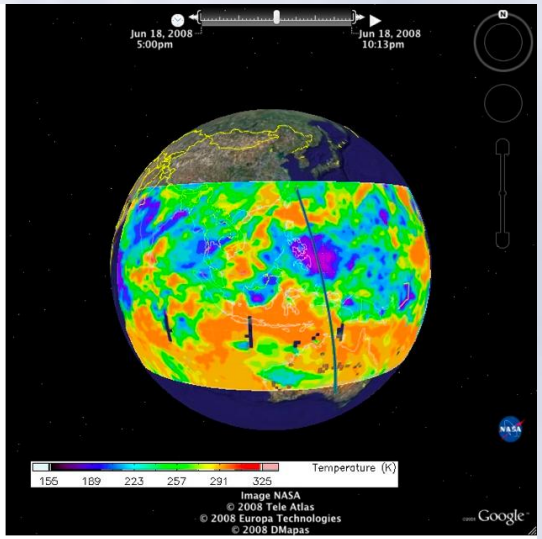



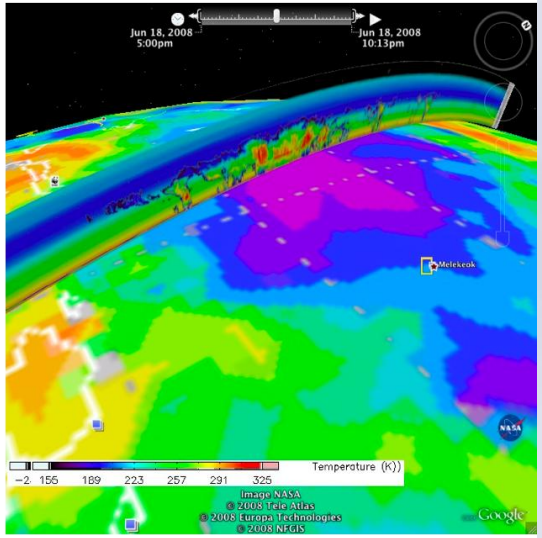



# Satellite Data Analysis & Dissemination

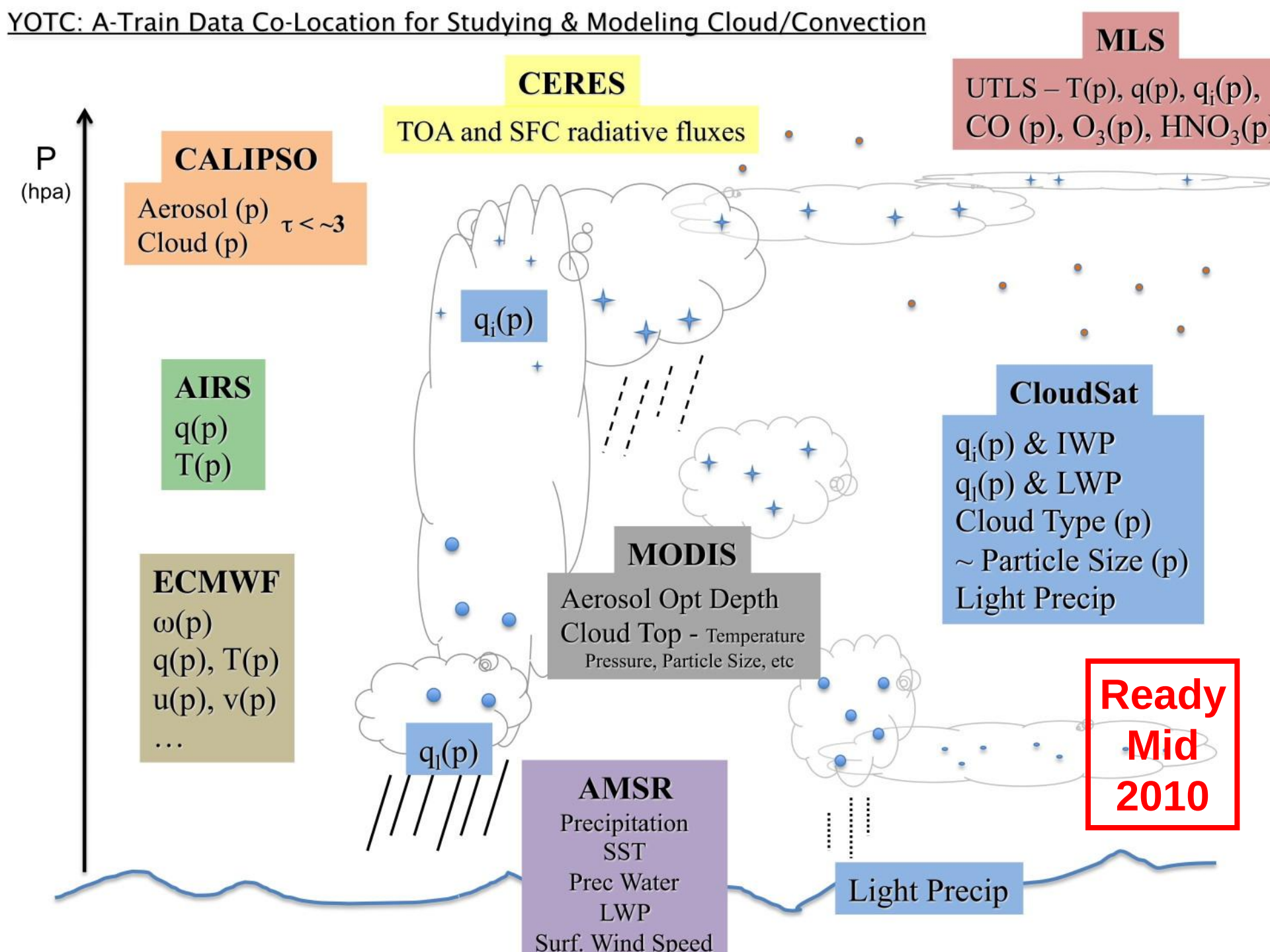
## NASA Giovanni & A-Train Data Interfaces




**AIRS**
**AMSR-E**
**CALIPSO**
**CERES**
**CloudSat**
**GPS**
**ISCCP**
**MLS**
**MODIS**
**PEHRRP**
**QuikSCAT**
**TRMM/TMI**

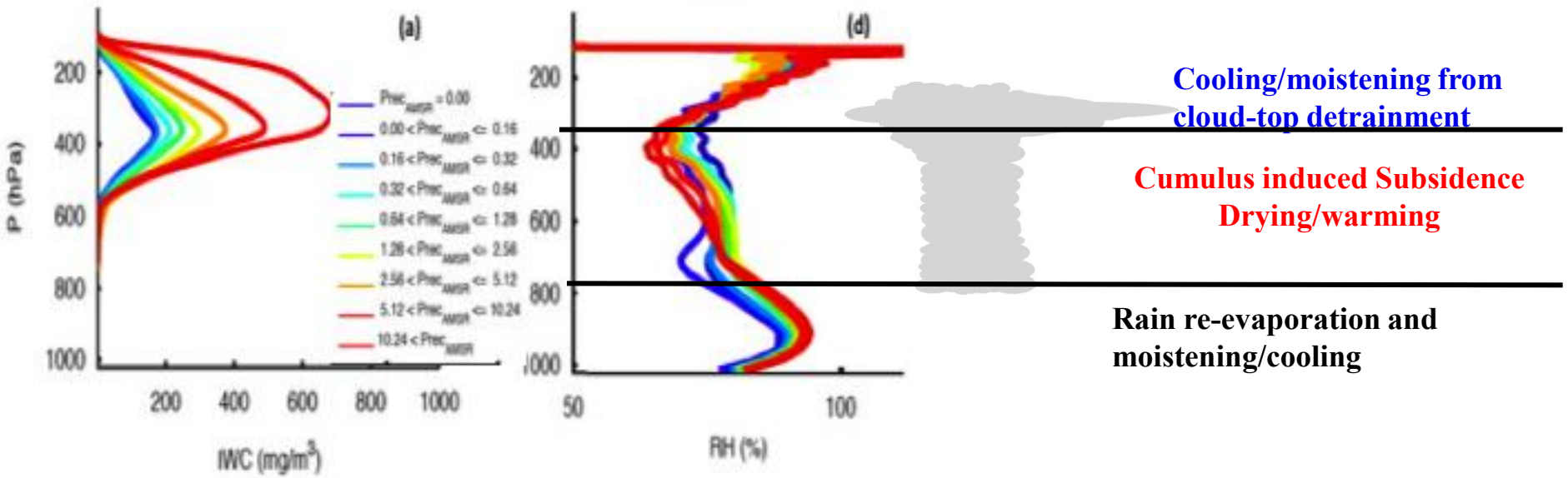

YOTC: A-Train Data Co-Location for Studying & Modeling Cloud/Convection
MLS
UTLS – T(p), q(p), $q_i$(p),
CO (p), $O_3$(p), $HNO_3$(p)
CERES
TOA and SFC radiative fluxes
P
(hpa)
CALIPSO
Aerosol (p)
Cloud (p)
τ < ~3
$q_i$(p)
AIRS
q(p)
T(p)
CloudSat
$q_i$(p) & IWP
$q_l$(p) & LWP
Cloud Type (p)
~ Particle Size (p)
Light Precip
MODIS
Aerosol Opt Depth
Cloud Top - Temperature
Pressure, Particle Size, etc
ECMWF
ω(p)
q(p), T(p)
u(p), v(p)
…
$q_l$(p)
Ready
Mid
2010
AMSR
Precipitation
SST
Prec Water
LWP
Surf. Wind Speed
Light Precip

# YOTC Satellite Data Application – Convective / Microphysics Moistening/Drying

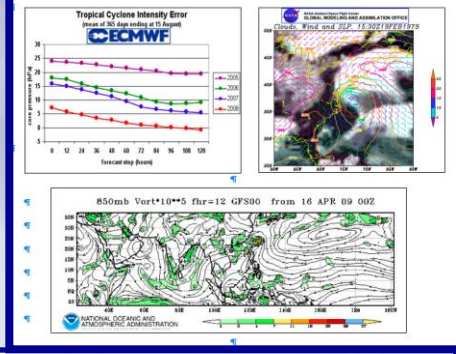
**1 – month of A-Train & ECMWF Data**

- *AMSR – Rain Rate*
- *CloudSat – IWC and Cloud Class*
- *ECMWF – Rel Hum*

  *-> Need to replace with AIRS*



# YOTC: Field Programs & Synoptic Periods




- Overlapping field programs (e.g., T-PARC, VOCALS, AMY) that benefit from and contribute to YOTC were discussed.
- A number of synoptic periods of interest have been identified and agreed upon (e.g. late May 2008 – early July 2009). *These pave the way for extended analysis on the observation data sets and frame many of the modeling experiments. A premise of YOTC is community focus along the lines that field programs provide.*

# YOTC Implementation: Collaborative research

**Weather: initial-value problem (IVP) for climate (seamless prediction)**

- Transpose-AMIP: 5-day hindcasts of YOTC period(s) by:

1. DOE/PCMDI CAPT Program with NCAR CAM (and maybe GFDL).
2. A number of CMIP5 Models as Proposed by WGNE/WGCM.
3. Multiple GCMs via GEWEX/EUCLIPSE project -> CFMIP2/GCSS.
4. NCAR CAM utilizing super-parameterization (SP-CAM).

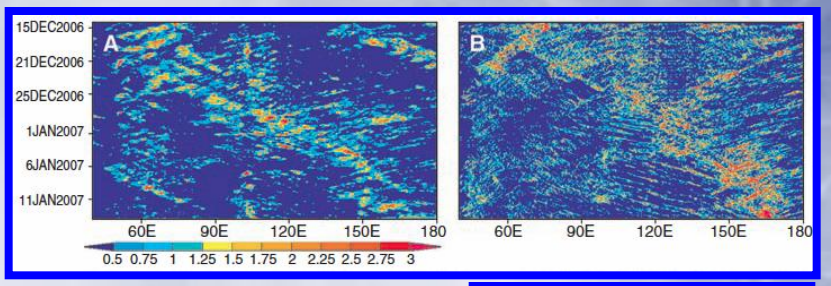
ABOVE GREATLY FACILITED VIA ECMWF YOTC CONTRIBUTION

**MJO & Convectively-Coupled Equatorial Waves**

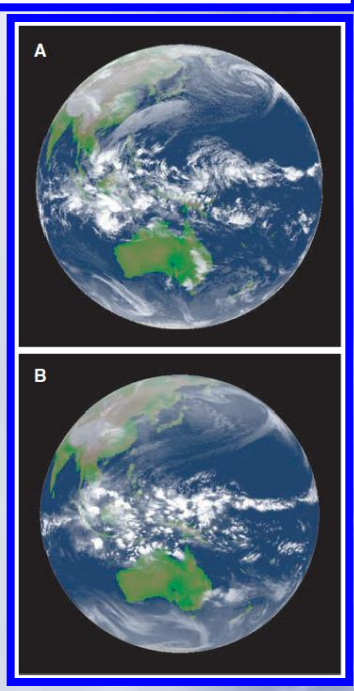
- High Resolution (~5-20km) MJO/CCEW hindcasts: UK *Cascade*, NICAM, GMAO GEOS, GMAO HiRes, CMMAP and GSFC MMFs, Rave/WRF.
- MJO multi-model 20-year hindcast experiment in (CLIVAR AAMP and AMY) to address prediction skill & predictability – extra output for YOTC.
- **WWRP-WCRP YOTC MJO Task Force Activities – more process-oriented simulation diagnostics, boreal summer forecast metrics, etc.**

# MJO Case Study Experiments

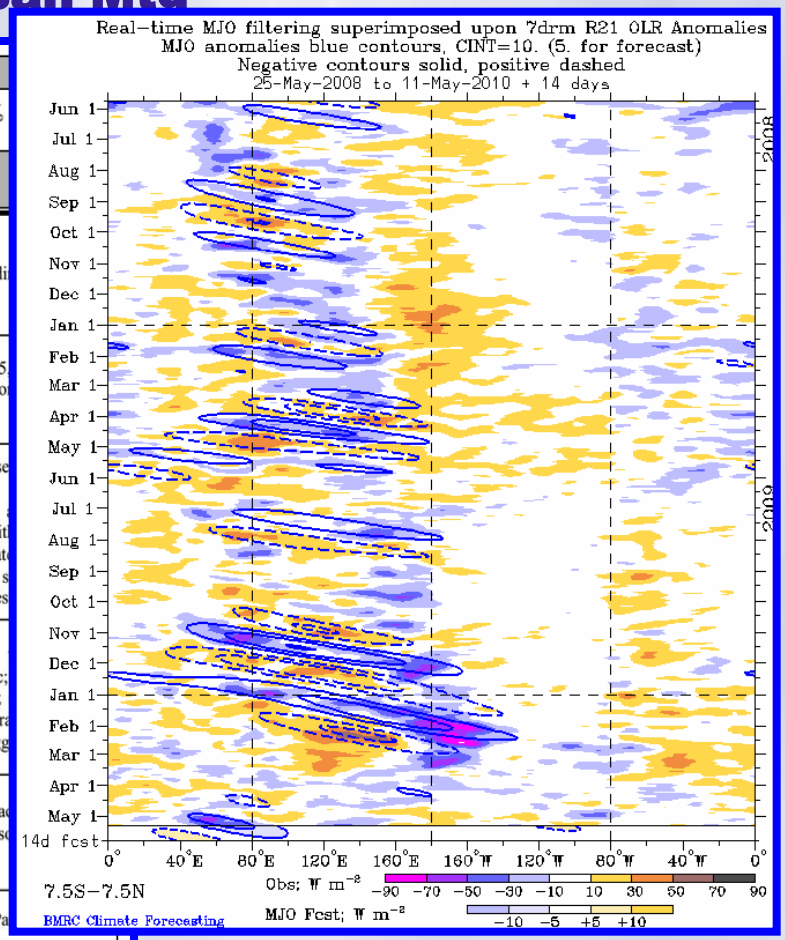
- 6 periods identified w/ help M. Wheeler
- ~5 modeling groups committed
- Details TBD Busan Mtg

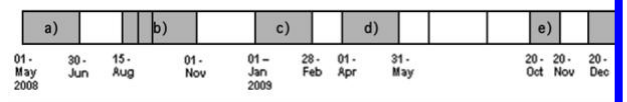



Miura et al. 2007




Dec 2006 MJO




| Target Periods (priority) | Features |
|---|---|
| a) 01MAY2008 - 30JUN2008 (4) | - fast propagation of MJO into Bay of Bengal.<br>- caused strong modulation of eastern Pacific ITCZ, includi<br>embedded TCs. |
| b) 15AUG2008 - 01NOV2008 (5) | - MJO convective onset (in central IO) about Aug 15<br>suppressed period in mid-Sept, the second convective o<br>Ocean occurred around Oct 12. |
| c) 01JAN2009 - 28FEB2009 (3) | - Weak sequence of the MJO that started with a suppresse<br>IO from about 10-20 Jan.<br>- MJO convection onset then followed in the IO on<br>propagating into N Australia in early Feb; coincident wit<br>Australia; strong compensating descent to south exacerbat<br>temperature in NSW/Victoria that affected the wild fires;<br>cyclones, i.e., association with severe weather (floods, fires |
| d) 01APR2009 - 31MAY2009 (2) | - strongest MJO in the YOTC period up to Hawaii<br>confined to Indian Ocean and Tropical Western Pacific;<br>propagation; convectively coupled Kelvin wave activity;<br>westerly anomalies in Pacific; basin-wide SST increase; tra<br>for MJO between La Nina and El Nino; MJO possibly trigg |
| e) 20OCT2009 - 20DEC2009 (1) | - strong MJO onset in Indian ocean; propagation into E. Pa<br>El Nino conditions; effects on N-hemispheric weather seas<br>climate. |
| f) 20DEC200 - 20FEB2009 (1) | - strong MJO onset in Indian Ocean; propagation into E. Pa<br>southward in mid-Pacific region. |

# YOTC Implementation: Collaborative research

**GEWEX Cloud System Study (GCSS):**

- Extension of GEWEX Pacific Cross-section Intercomparison (GPCI) for June-August 2008 of YOTC: transition of stratocumulus, trade-cumulus, deep convection.

**Tropical-Extratropical interaction**

- Tropical – extratropical interaction studies (TPARC and TCS08) focusing on the life cycle and impacts of tropical convection on the prediction and predictability of mid-latitude weather (e.g., ET, storm tracks).

**Easterly Waves and Tropical Cyclones**

- Synergistic forecast and analysis study in the Atlantic sector of easterly waves, tropical cyclones and their modulation by intraseasonal variability. Cases during YOTC identified.

**NCAR Tropical Channel Model (TCM) simulations:**

- 4-km mesh, ECMWF T799 dataset for initial & meridional BCs.
- Maritime Continent 'prediction barrier': orographic, diurnal cycle, coastal effects on MJO

# YOTC Implementation: Next Steps

- Move forward with collaborative research identified at the July 2008 YOTC Implementation Planning Workshop – a multi-year effort.
- YOTC synoptic description article(s) e.g., BAMS and/or special issue – drafts expected May 2010.
- Expand involvement of tropical interests in YOTC (e.g., Africa, China, India, Korea, S. America) -> WP AGU, S.A. AGU, WGNE + YOTC Science Workshop in China Sp'2011
- Planning first YOTC MJO Task Force meeting along with Monsoon ISV Workshop June 2010, APCC, Busan.
- Address multi-agency research funding for multi-year collaborative projects. Order of $2$^{+}$M/yr for 3+ years.
  (MJO, TCs/EWs, monsoon, trop-extratrop, diurnal cycle)
- Help frame DYNAMO field campaign in 2011 focused on MJO onset in Indian Ocean.

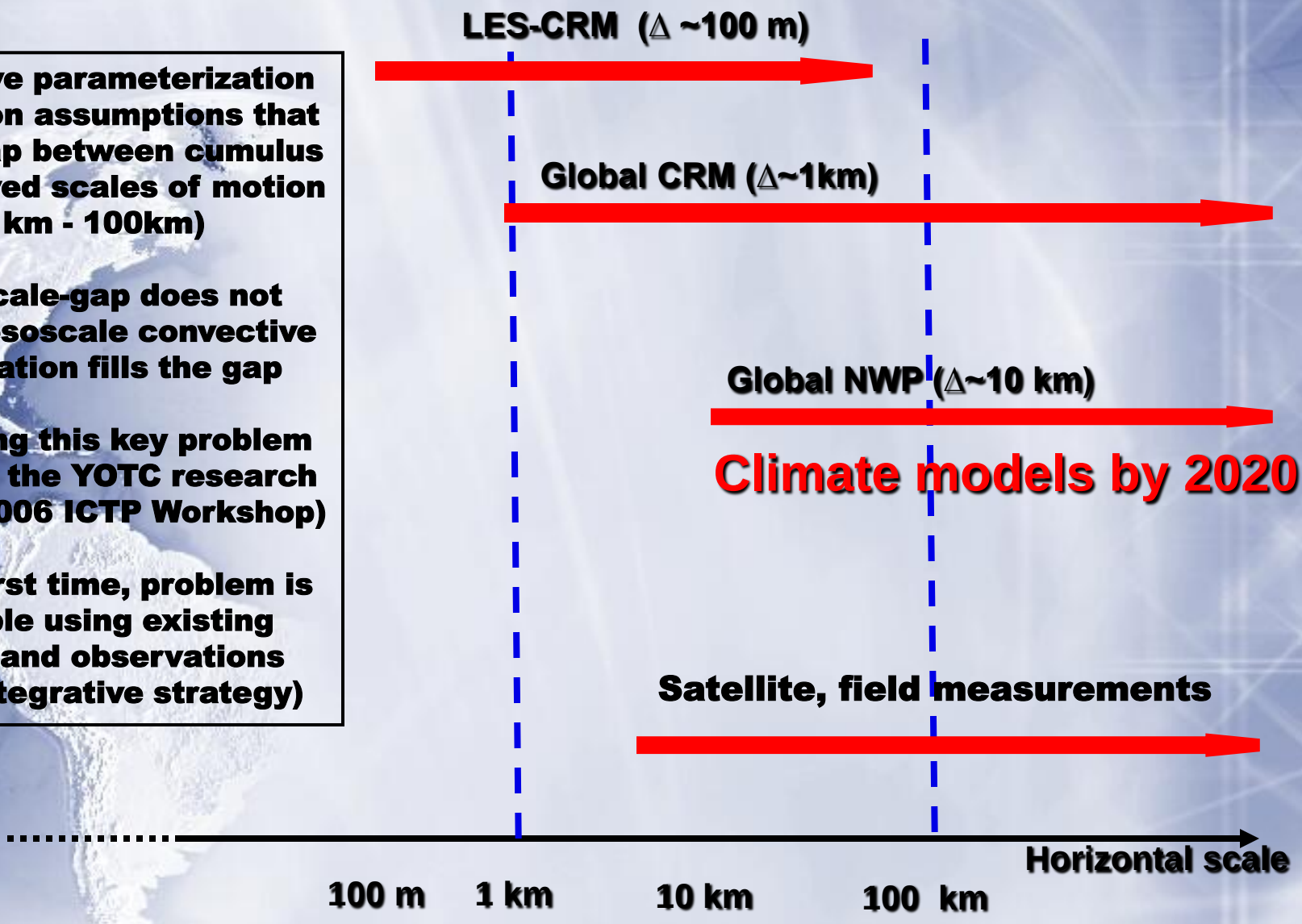
# Bridging the Scale Gap

Convective parameterization is based on assumptions that imply a gap between cumulus and resolved scales of motion (~1km - 100km)

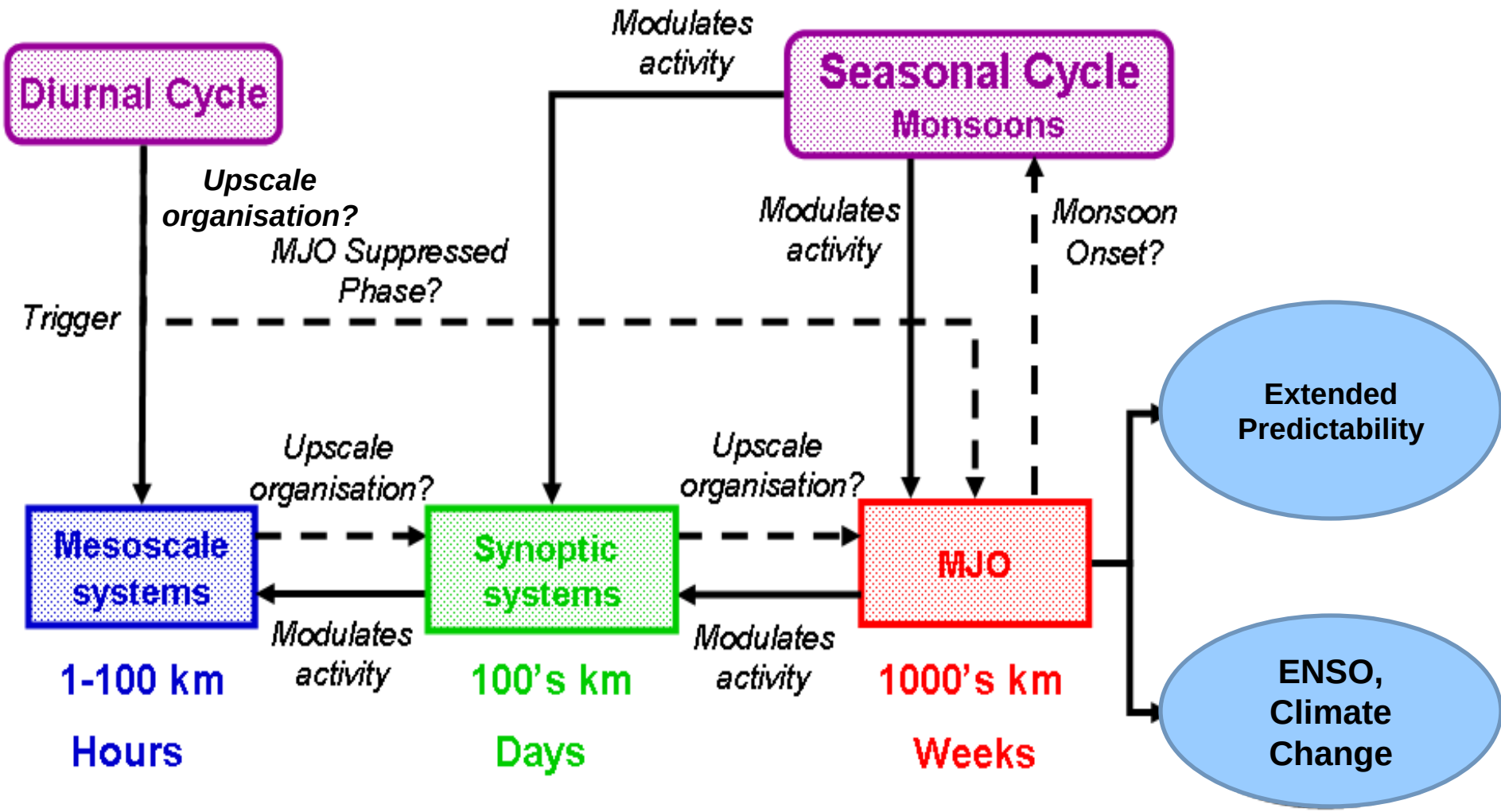
**But** a scale-gap does not exist : mesoscale convective organization fills the gap

Addressing this key problem is high on the YOTC research agenda (2006 ICTP Workshop)

For the first time, problem is tractable using existing models and observations (YOTC integrative strategy)



# Tropical Convection-Wave Continuum




2006 ICTP Workshop (Moncrieff et al. 2007)