

TROPICAL CYCLONES, TCS08, T-PARC and YOTC

Russell L. Elsberry
Graduate School of Engineering and Applied Sciences
Department of Meteorology
Naval Postgraduate School

TCS08: Tropical Cyclone Structure 2008
T-PARC: THORPEX Pacific Asian Regional Campaign

OUTLINE

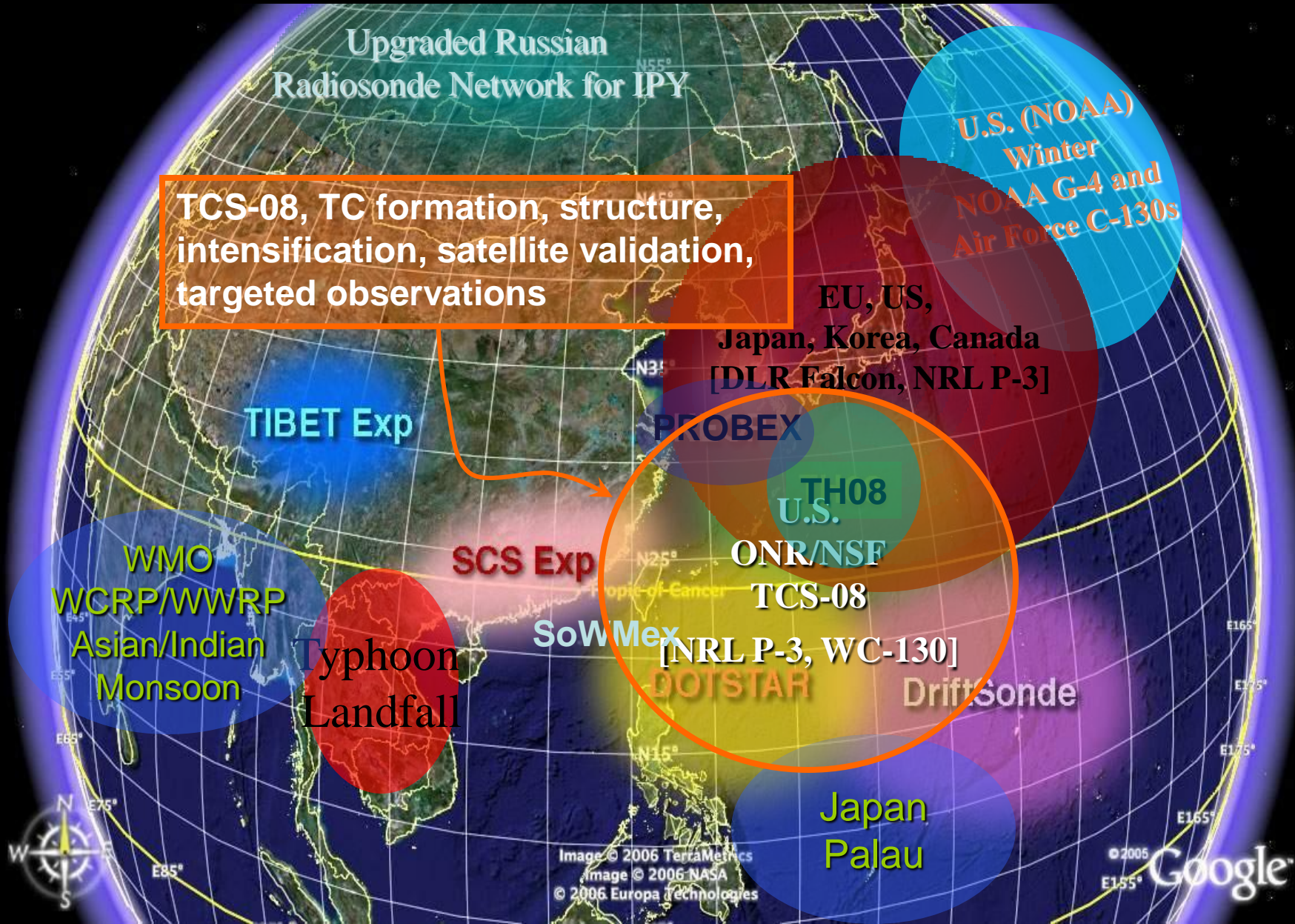
Background on TCS08 and T-PARC

Showcase Typhoon Sinlaku

Opportunities for YOTC studies

- Synoptic scale
- Convective scale
- Environment effects

THORPEX-Pacific Asian Regional Campaign/Tropical Cyclone Structure-08 Experiments and Collaborative Efforts



THORPEX-Pacific Asian Regional Campaign/Tropical Cyclone Structure-08 Experiments and Collaborative Efforts

Additional Extratropical Transition Components at DLR and FZK, Germany

Extratropical transition, downstream impacts, targeted observations

U.S. (NOAA) Winter
NOAA G-4 and Air Force C-130s

EU, US, Japan, Korea, Canada
[DLR Falcon, NRL P-3]

TIBET Exp

PROBEX

TH08
U.S.

WMO
WCRP/WWRP
Asian/Indian Monsoon

SCS Exp

ONR/NSF

TCS-08

Typhoon Landfall

SoWMex

DOTSTAR

DriftSonde

Japan
Palau

Key science questions to be addressed in a program aimed at increased understanding and predictability of tropical cyclone characteristics during formation, intensification, and recurvature over the western North Pacific

- **Highlights**
 - **Incorporates multiple space and time scales**
 - Large scale controls
 - Global and basin-wide spatial scales
 - Medium-range and synoptic temporal scales
 - Mesoscale organization pathways
 - During formation
 - During intensification
 - **Primary hypotheses with respect to:**
 - Large-scale role in pre-conditioning or inhibition due to ventilation
 - Mesoscale organizational pathways leading to construction of a potential vorticity monolith
 - Role of low-level convergence associated with deep convective cells
 - Stratiform regions of mesoscale convective systems
 - Relative roles of environmental and vortex structures in determining the evolution of the outer wind structure
 - **In tandem with the THORPEX Pacific Asian Regional Campaign (T-PARC)**

T-PARC/TCS-08 Components

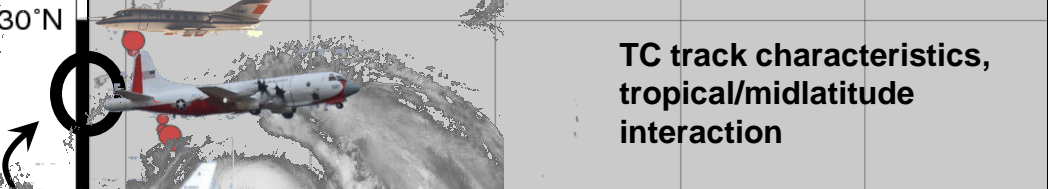
TY Nabi, 29 Aug – 8 Sep, 2005

Midlatitude operating
NRL P-3, FALCON

Japan, Atsugi, NAF

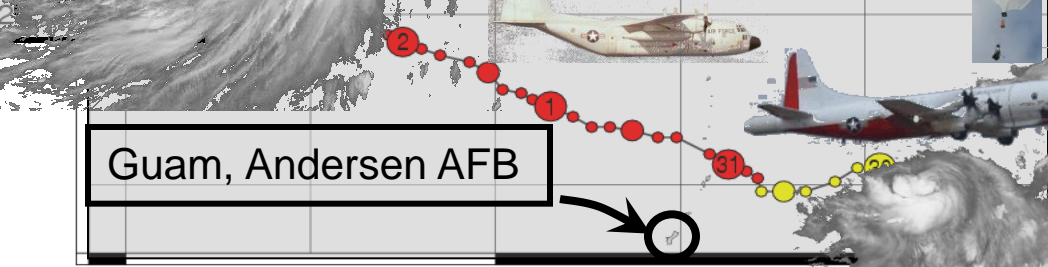


Subtropical operating region
Driftsonde, NRL P-3,
DOTSTAR, WC-130



TC track characteristics,
tropical/midlatitude
interaction

Tropical operating region
Driftsonde, NRL P-3,
DOTSTAR, WC-130



Guam, Andersen AFB

Extratropical Transition
(ET – recurvature),
Downstream Impacts

ET characteristics, forcing
of downstream impacts,
tropical/midlatitude
interactions, extratropical
cyclogenesis

TC Intensification
and structure
change
Recurvature, initiation of
ET

Tropical Measurements

Large-scale circulation,
deep convection,
monsoon depressions,
tropical waves,
TC formation

Operations by the numbers...

- **9 participating nations**

- Canada, China, England, France, Germany, Japan, South Korea, Taiwan, United States

- **Over 500 aircraft mission flight hours**

- 216 C-130, 179 P-3, 83 Falcon, 37 DOTSTAR

- **76 missions**

- 25 Falcon, 23 C-130, 21 P-3, 7 DOTSTAR

- **7 airfields**

- Andersen AB, Guam; NAF Atsugi, Japan; Kadena AB, Japan; Taiwan, Yokota AB, Japan; MCAS Iwakuni, Japan; Misawa AB, Japan

- **11 tropical circulation systems**

- 4 typhoons, 1 TD, 1 ex-TS, 5 others

Tropical Circulation Systems by the numbers...

- During August – September, there were 12 total systems \geq TD intensity over the western North Pacific
 - 4 typhoons, 4 tropical storms, 4 TDs
- 51 TCS systems
 - With a few recycled a time or two
- 11 systems in which aircraft missions were flown
 - 4 typhoons, 1 TD, 1 ex-TS, 5 others
- 72% of all missions were flown on the 4 typhoon cases
 - 6 Nuri, 28 Sinlaku, 5 Haguput, 15 Jangmi (54/75 = 72%)

Operations: Aircraft

- Mission objectives

- NRL P-3



- TC formation, structure, intensification, TUTT structure, targeting for formation, extratropical transition

- WC-130J



- TC formation, structure, intensification, satellite validation, targeting for formation and track, extratropical transition

- FALCON



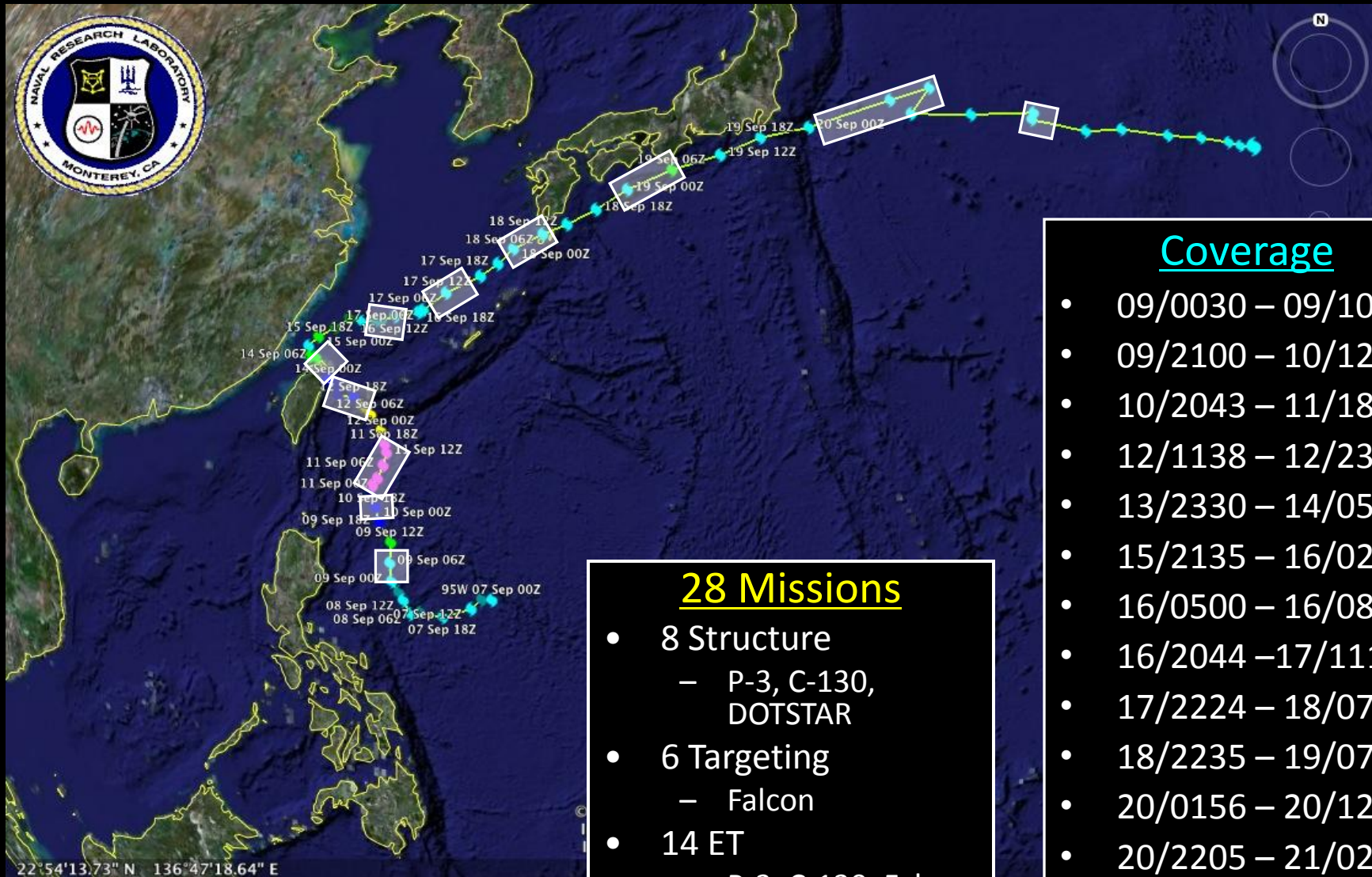
- Typhoon targeting, extratropical transition, targeting, ridge-building, tropical water vapor transport

- DOTSTAR



- Typhoon targeting

TY Sinlaku (TCS-033 / TD15W)



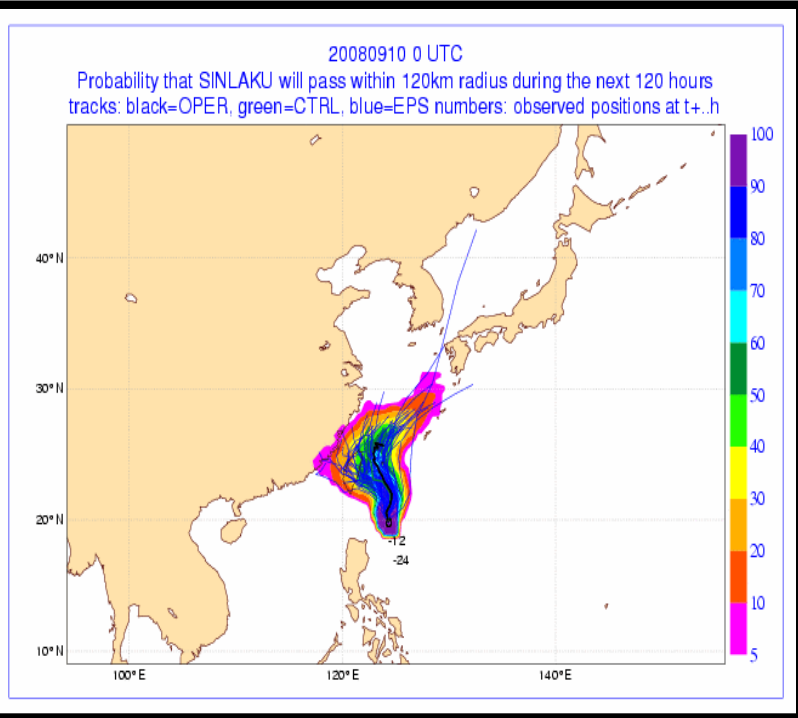
28 Missions

- 8 Structure
 - P-3, C-130, DOTSTAR
- 6 Targeting
 - Falcon
- 14 ET
 - P-3, C-130, Falcon

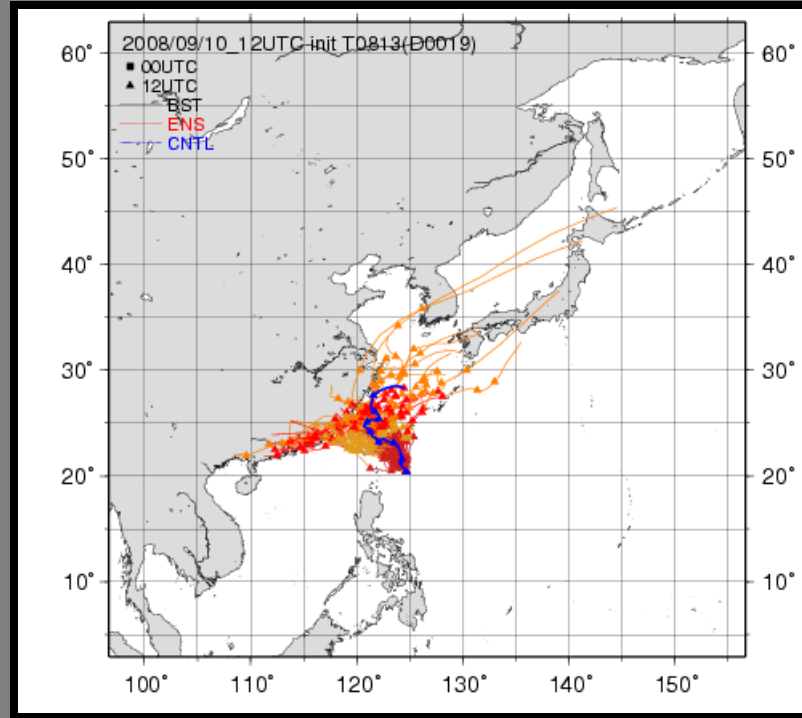
Coverage

- 09/0030 – 09/1045
- 09/2100 – 10/1225
- 10/2043 – 11/1828
- 12/1138 – 12/2318
- 13/2330 – 14/0555
- 15/2135 – 16/0205
- 16/0500 – 16/0800
- 16/2044 – 17/1115
- 17/2224 – 18/0720
- 18/2235 – 19/0725
- 20/0156 – 20/1206
- 20/2205 – 21/0205

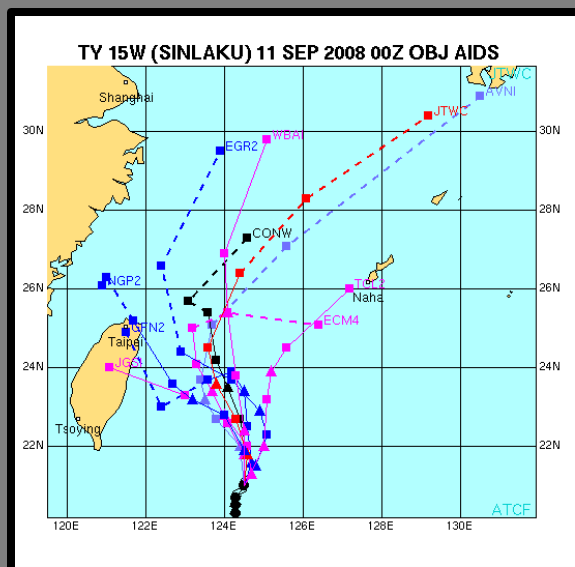
Targeting Motivation: Track Uncertainty 10 September



ECMWF Strike Probability



JMA Ensemble Members



Numerical model aids

Summary

- **Anomalous weather conditions to start**
 - Non-existent monsoon trough
 - Anomalous low-level easterlies
 - Weak wave activity and strong upper-level cold lows (TUTT) dominated throughout August
 - 1 typhoon
 - However, many aircraft missions conducted for TC formation, wave structure, TUTT structure, subtropical cyclone development
- **Active September**
 - 3 typhoons (1 super typhoon, i.e. cat 5)
 - 2 recurvature tracks
- **Successfully addressed all science objectives in field phase**

OPPORTUNITIES FOR YOTC SYNOPTIC STUDIES

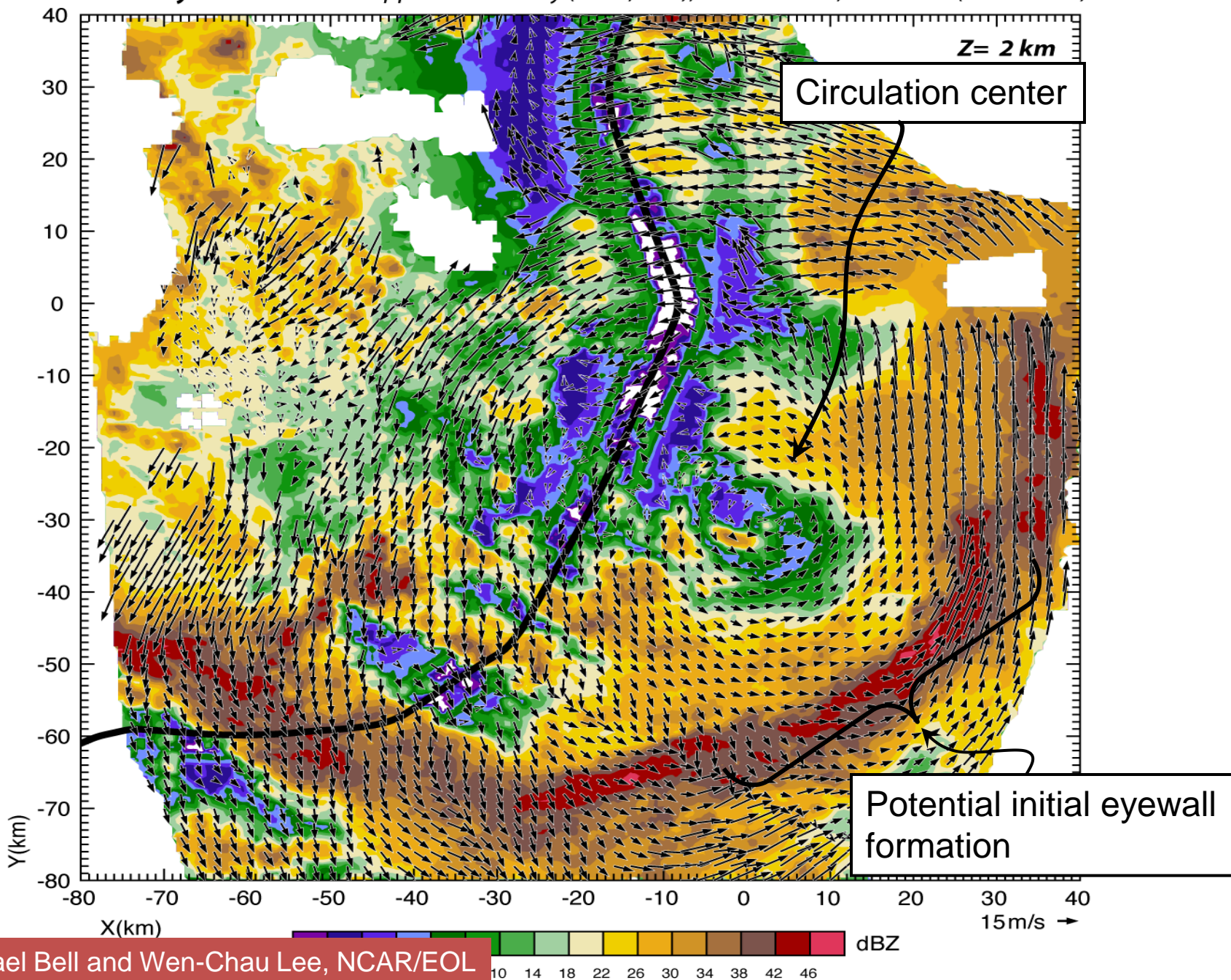
- **First operation of WC-130Js at 31,000 ft altitude except when penetrating a mature tropical cyclone**
 - Dropped sondes and AXBTs from high altitude
 - Data sets for synoptic systems including non-developers through typhoon
- **First systematic targeting operation in the WPAC**
 - Comparison of several methods from a variety of operational and research organizations
 - Multiple aircraft with both inner-core and environmental observations
- **First four plane operation in a WPAC TC**
 - Planned mesoscale model intercomparison study of Sinlaku landfall
- **First buoy drop in front of a WPAC TC**
 - Two TCs
 - First time a category 5 TC passed over buoys dropped in its path
- **First systematic observations of full extratropical transition process**
 - Multiple aircraft and land-based radar
 - Timed with satellite overpass

OPPORTUNITIES FOR YOTC CONVECTIVE-SCALE

- First use of the ELDORA radar in tropical convection over the western North Pacific within:
 - Cloud clusters
 - Developing tropical cyclones
 - Mature tropical cyclones
 - Tropical cyclones undergoing extratropical transition

Typhoon Nuri 18 August 2008 (0142 - 0205 UTC)

Preliminary ELDORA Dual-Doppler Reflectivity (color, dBZ), wind vectors, and track (thick black)



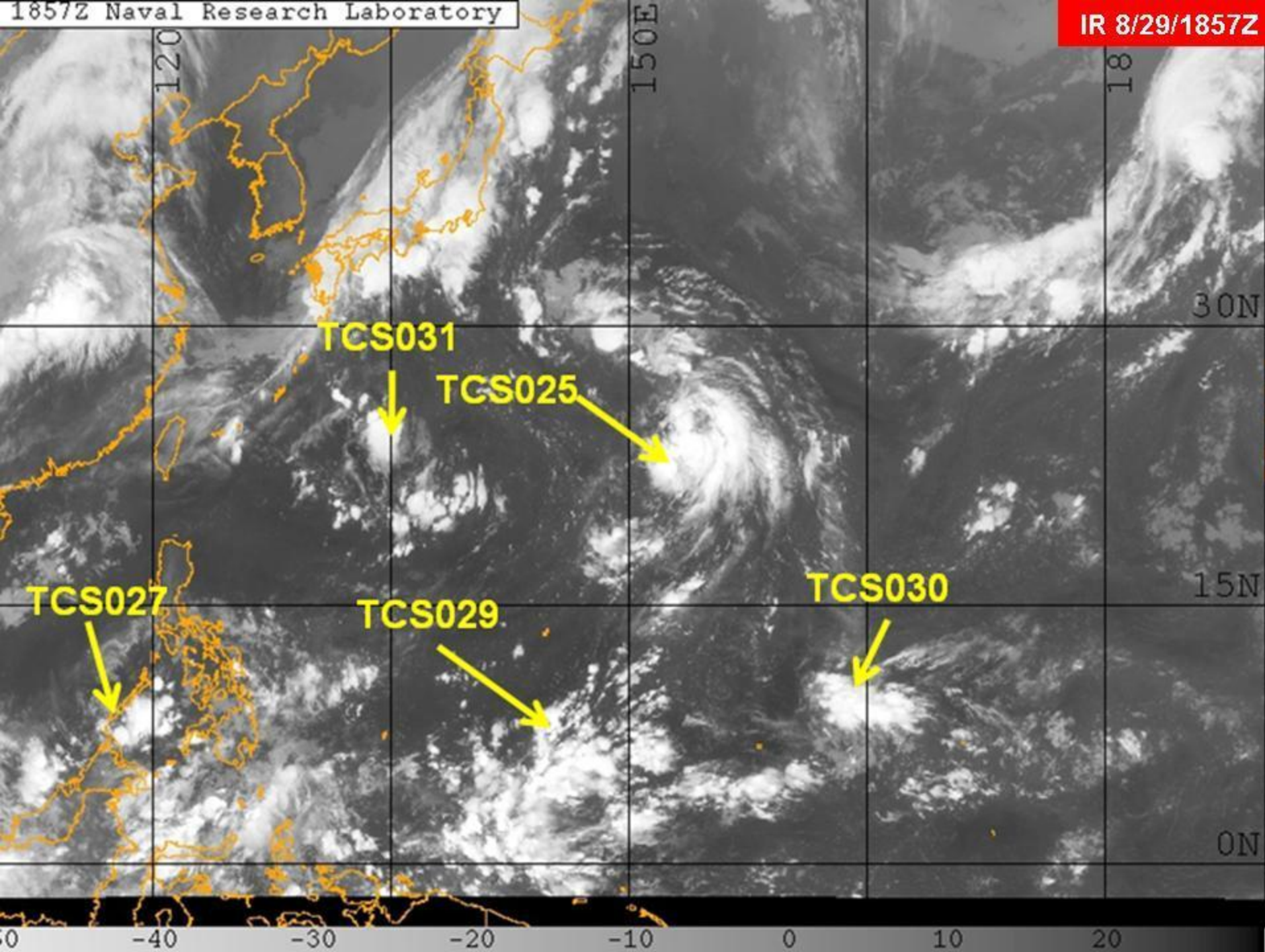
OPPORTUNITIES FOR YOTC ENVIRONMENTAL EFFECT STUDIES

Large-scale environment effects on tropical convection

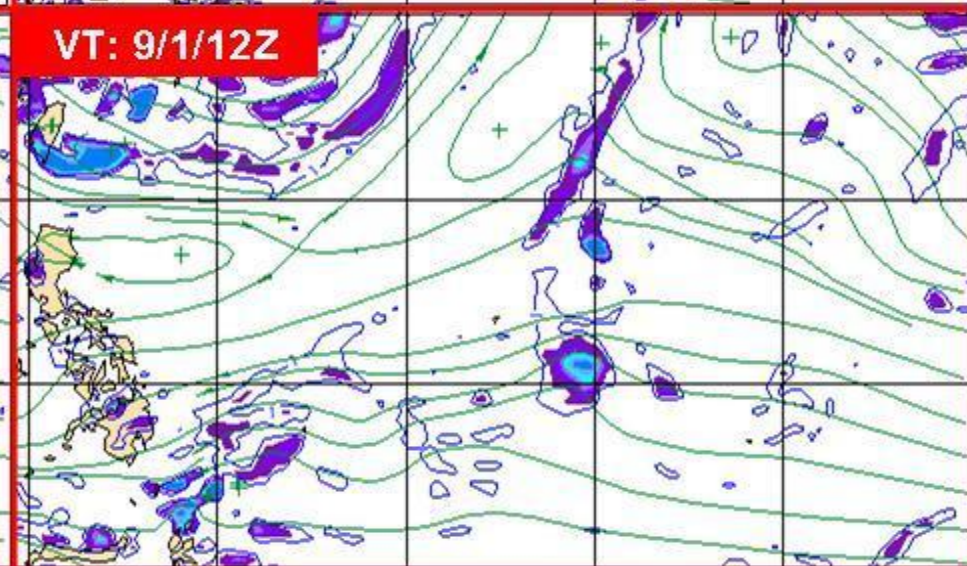
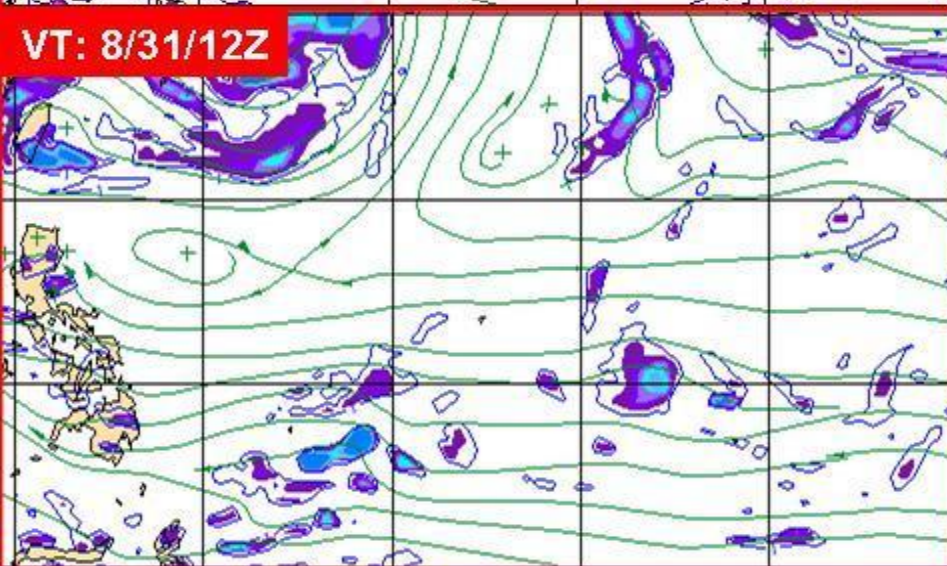
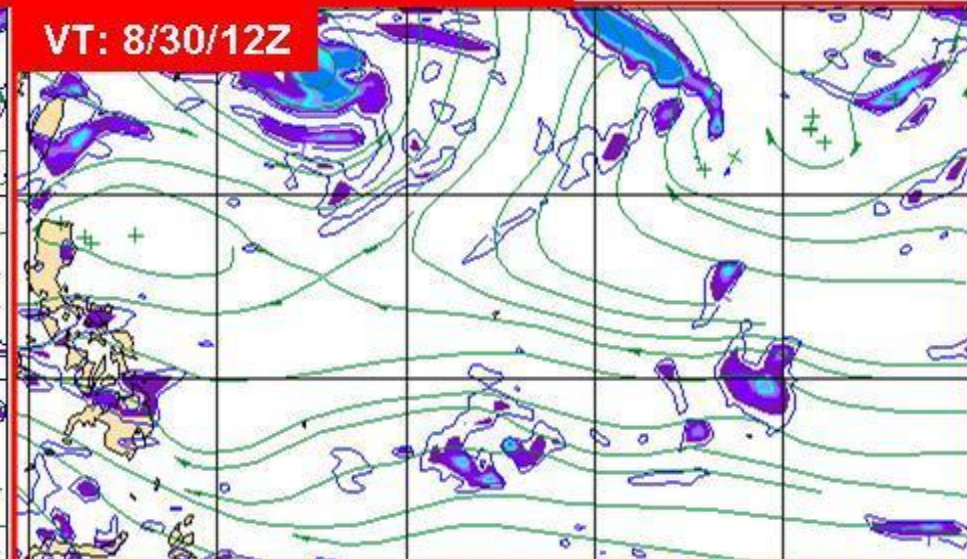
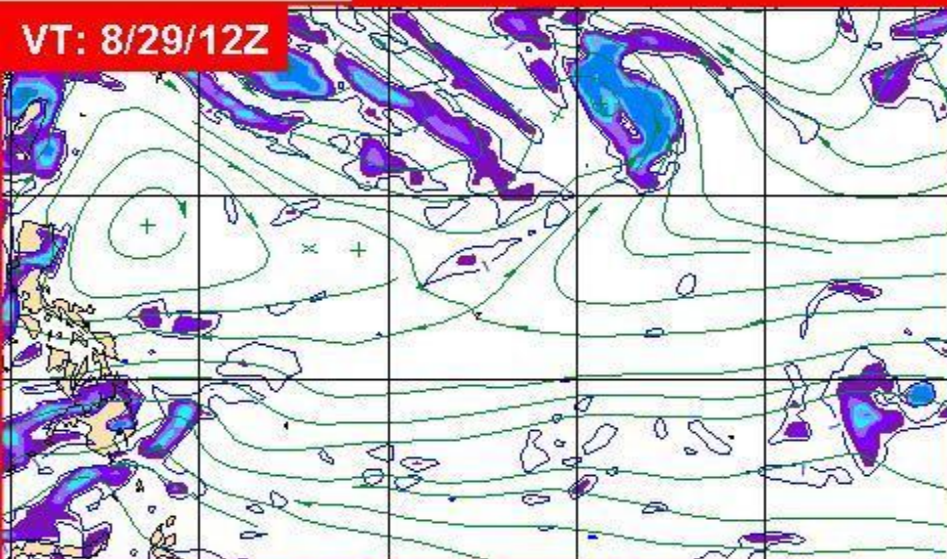
TCS08 was during third consecutive typhoon season that was influenced by La Niña

Pacific Decadal Oscillation also switched sign in May 2008 and may have amplified La Niña signal (R. A. Trevino M.S. thesis)

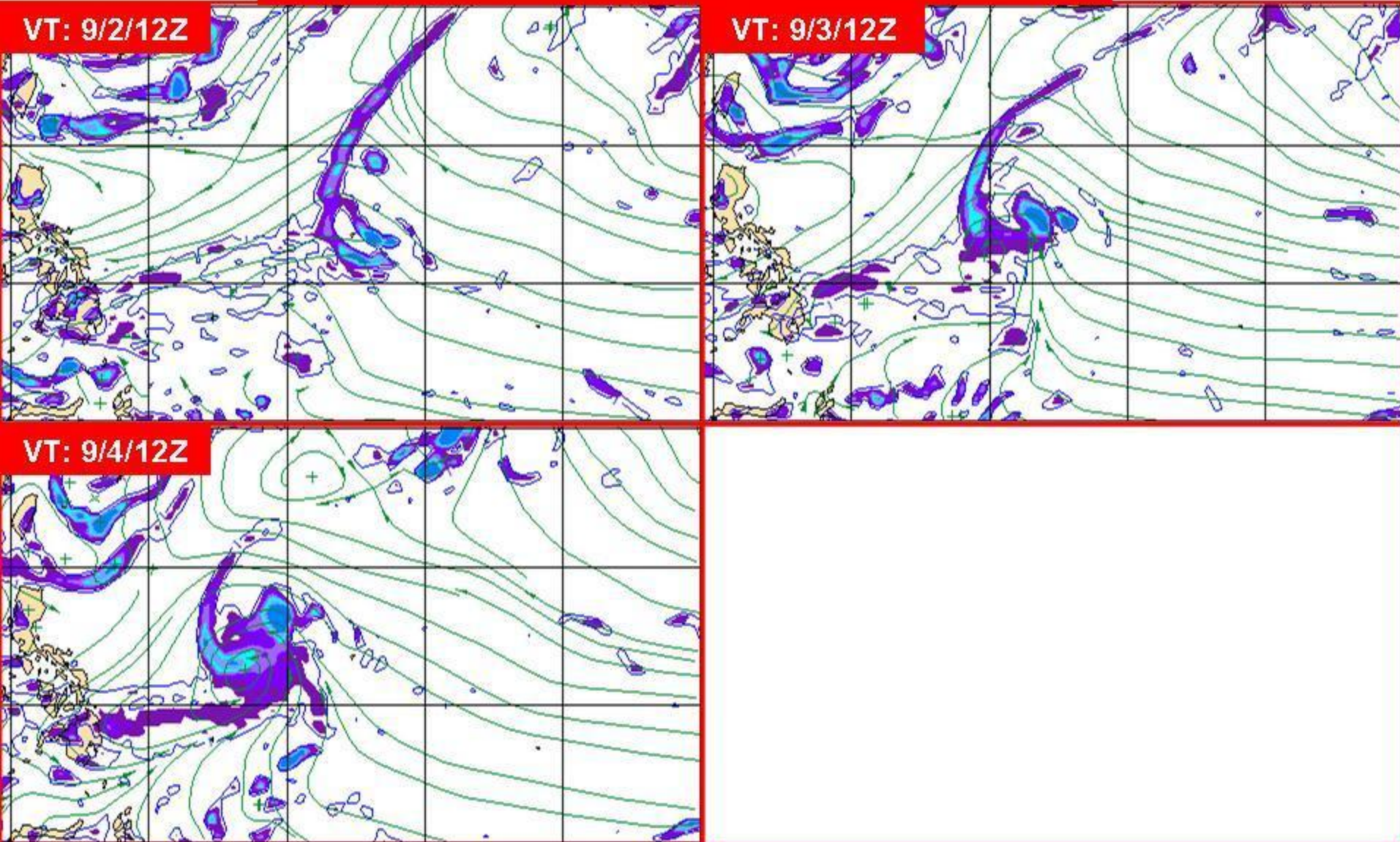
- Reverse-oriented monsoon trough
- Amplified mid-Pacific trough
- Contribution to erroneous ECMWF forecast



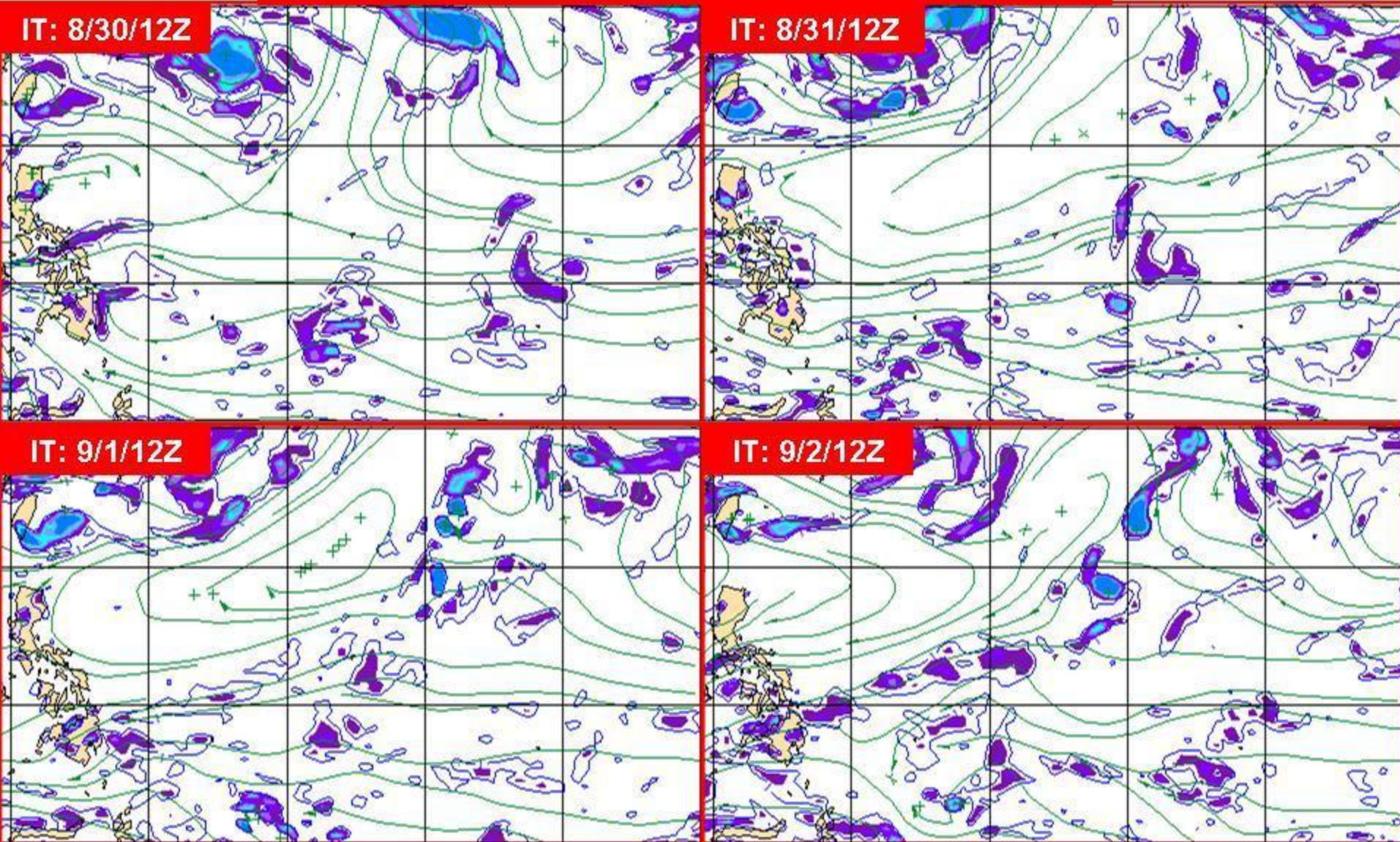
8/29/12Z ECMWF Forecast



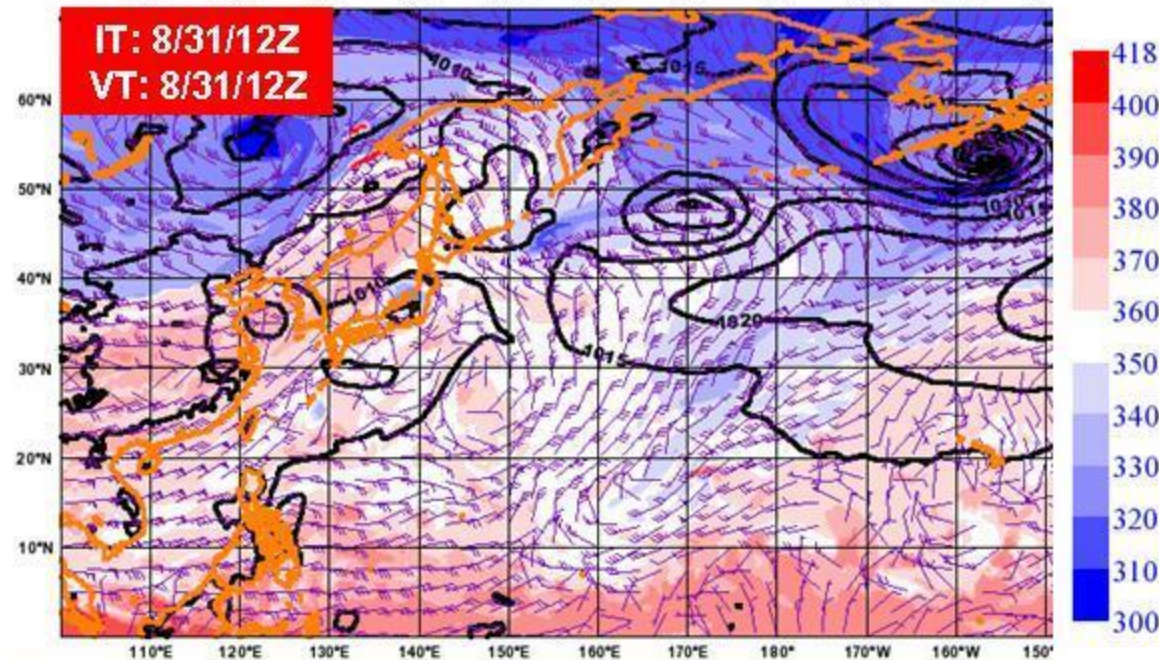
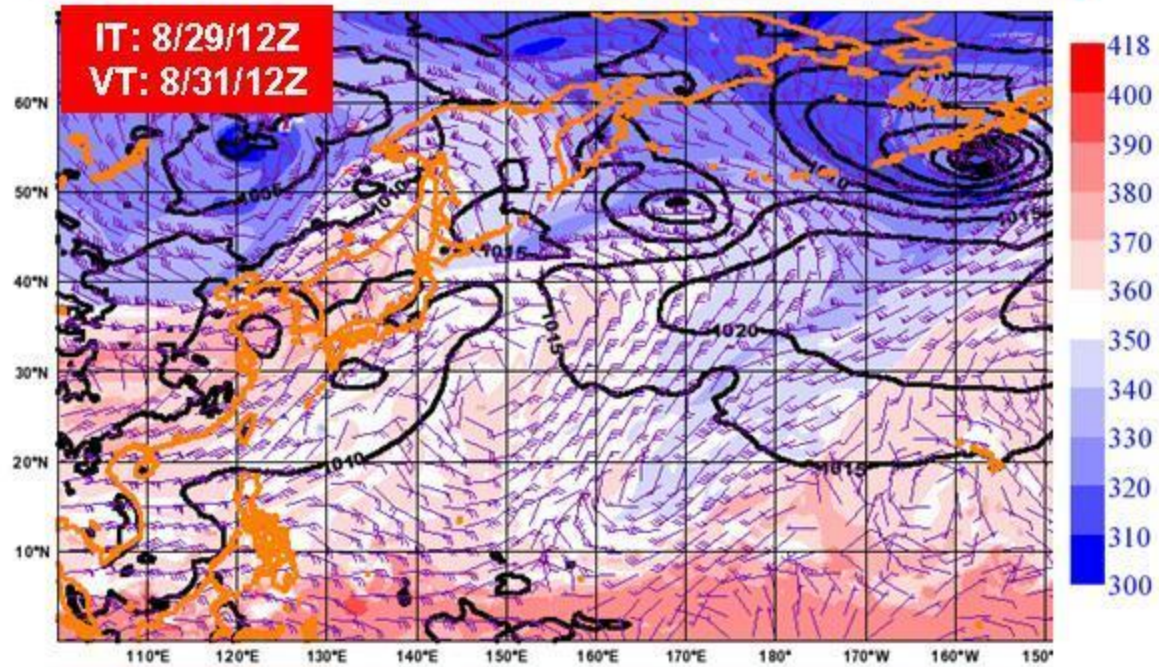
8/29/12Z ECMWF Forecast



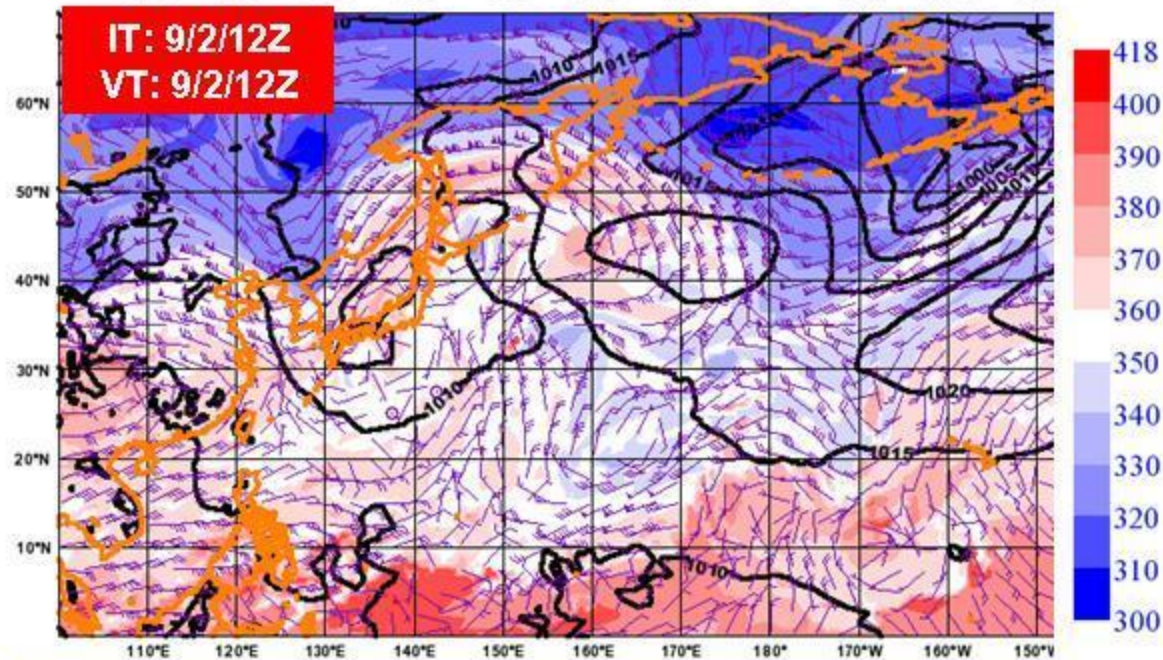
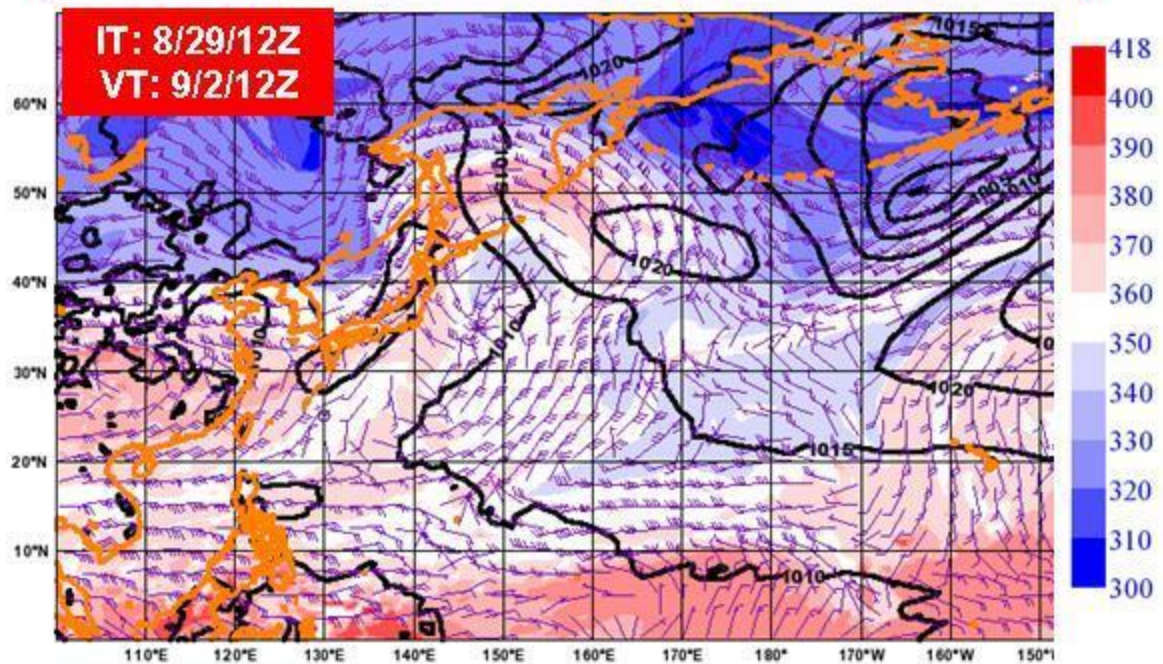
ECMWF Forecast Initializations



ECMWF Dynamic Tropopause & PMSL



ECMWF Dynamic Tropopause & PMSL



CONCLUSIONS REGARDING FALSE PREDICTION OF FORMATION

ECMWF model predicted a continuing favorable superposition of 850-mb vorticity maximum under a region of weak, diffluent flow at the base of a sharp, upper-tropospheric trough

ECMWF model predicted well the 850-mb vorticity maximum translation

Improper prediction of the westward translation of the upper-tropospheric trough in synch with the 850-mb vorticity maximum led to the false prediction of tropical cyclone formation and intensification

SUMMARY

- TCS08/T-PARC PERIOD OF AUGUST-SEPTEMBER 2008 PROVIDES OPPORTUNITIES FOR YOTC SYNOPTIC STUDIES OF TROPICAL CONVECTION IN WESTERN NORTH PACIFIC WITH UNPRECEDENTED OBSERVATIONS AND MODEL FIELDS
- CONTINUATION OF YOTC THROUGH OCTOBER 2009 WILL POTENTIALLY ALLOW STUDIES (ALBEIT WITHOUT COMPARABLE IN SITU OBSERVATIONS) IN A DIFFERENT (AND MORE TYPICAL) MONSOON ENVIRONMENT IF RECENT PREDICTIONS OF AN EL NIÑO ARE CORRECT