

# 観測のツボの効用

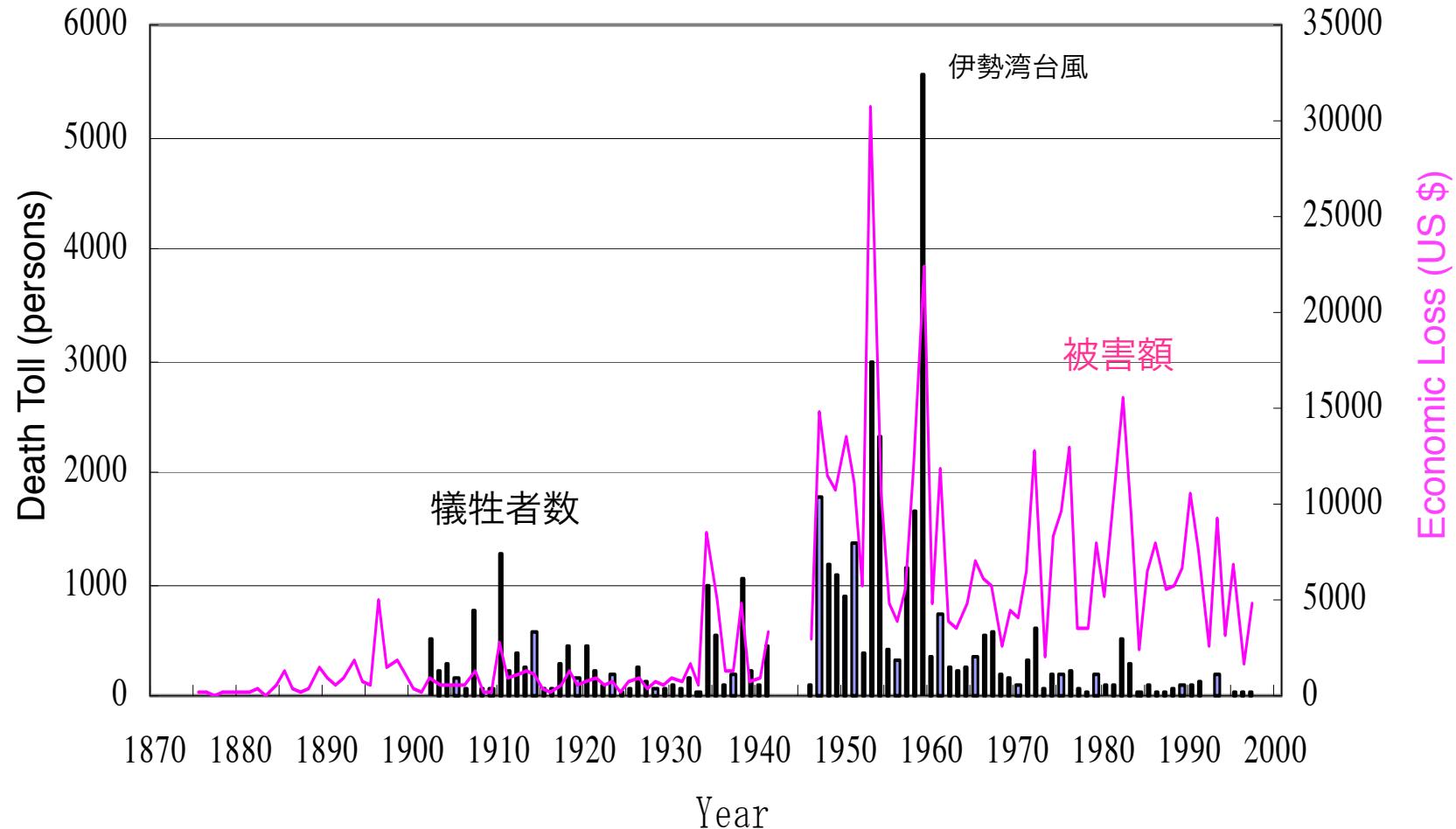
## Impact of Special Observations for TC Track Forecasts in T-PARC 2008 Toward Better Understanding of Typhoon Life Cycle

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K. Bessho<sup>1</sup>, T. Komori<sup>7</sup>, Y. Ohta<sup>7</sup>, K. Yamashita<sup>7</sup>, S. C. Jones<sup>8</sup>, H.-S. Lee<sup>9</sup>,  
D. Richardson<sup>10</sup>, M. Yamaguchi<sup>4</sup>, F. Harnisch<sup>3</sup>, and D. Parsons<sup>11</sup>

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JMA/NPD<sup>7</sup>, Univ. of Karlsruhe<sup>8</sup>, KMA/NIMR<sup>9</sup>, ECMWF<sup>10</sup>, WMO<sup>11</sup>

# 日本における洪水による犠牲者ならびに 経済的損失(1990年の値に換算)



Urbanization may increase vulnerability

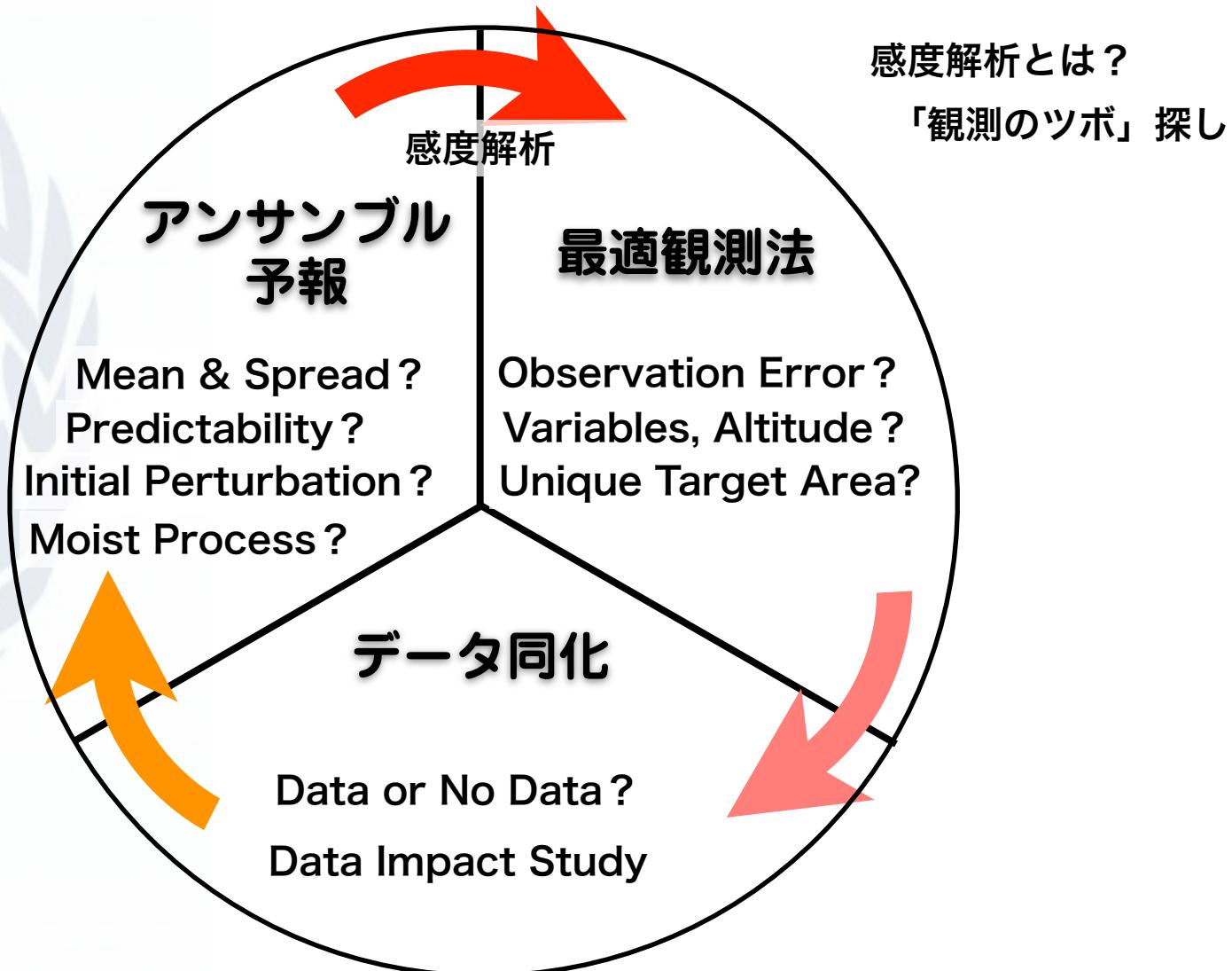
Courtesy T. Oki

## 日本での自然災害に対する保険会社支払額トップ10

(billion yen)

	Name of Disaster	Place	Date	Claims Paid (incl. estimates)			
				Fire and Miscellaneous	Automobile	Marine	Total
1	Typhoon No. 19	Nationwide	Sep. 26-28, 1991	522.5	26.9	18.5	567.9
2	Typhoon No. 18	Nationwide	Sep. 4-8, 2004	356.4	25.9	5.1	387.4
3	Typhoon No. 18	Kumamoto, Yamaguchi, Fukuoka, etc.	Sep. 21-25, 1999	284.7	21.2	8.8	314.7
4	Typhoon No. 7	Kinki*1	Sep. 22, 1998	151.4	6.1	2.4	160
5	Typhoon No.23	Western Part of the Nation	Oct. 20, 2004	111.3	17.9	8.8	138
6	Typhoon No.13	Fukuoka, Saga, Nagasaki, Miyazaki, etc.	Sep. 15-20, 2006	131.7	11	N/A	121.9
7	Typhoon No.16	Nationwide	Aug.30-31, 2004	103.7	13.8	3.5	121
8	Downpour,	Aichi etc.	Sep. 10-12, 2000	44.7	54.5	3.9	103
9	Typhoon No.13	Kyusyu*2, Shikoku*3, and Chugoku*4	Sep. 3, 1993	93.3	3.5	1	97.7
10	Hailstorm	Chiba and Ibaraki	24-May-00	37.2	30.3	2.5	70

# 双方向予報システム



# 双方向予報システム

## ■ 最適観測法

- 数値モデルの結果を用いて、誤差成長率が大きいと考えられる場所（高感度領域）で観測を行い、予報の改善をめざす観測手法のこと。感度領域を推定することを感度解析と呼ぶ。
- 高感度領域＝”観測のツボ”

## ■ データ同化

- 数値モデルに観測データを取り入れること。近年では予報変数でなく衛星からのデータそのものを同化できるようになってきている。

## ■ アンサンブル予報

- 一つの予報を走らせるのではなく、少しずつ違う初期値から多くの予報を行うこと。予報の確からしさを推定できる。

# アンサンブル予報とは？

## THORPEX Interactive Global Grand Ensemble (TIGGE)

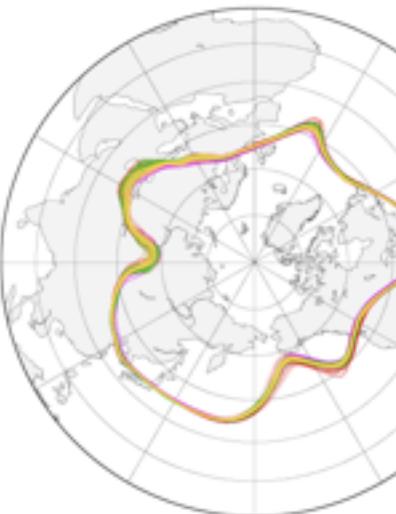
### Initial

Medium-Range Ensemble Forecast

Spaghetti Diagram: 5500m

Initial Time: 20070109

Valid Time: 20070109 12UTC



Legend: ECMWF (blue), JMA (red), UKMET (magenta), NCEP (green)

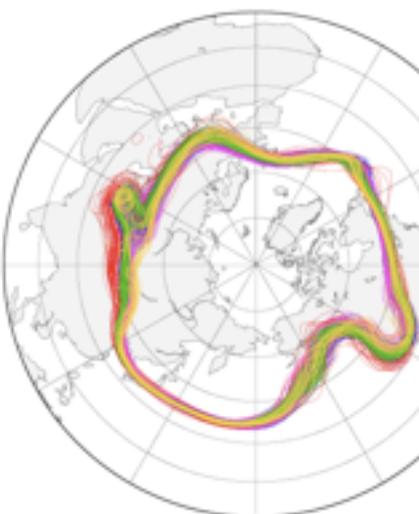
### Day3

Medium-Range Ensemble Forecasts

Spaghetti Diagram: 5500m

Initial Time: 20070109

Valid Time: 20070112 12UTC



Legend: ECMWF (blue), JMA (red), UKMET (magenta), NCEP (green)

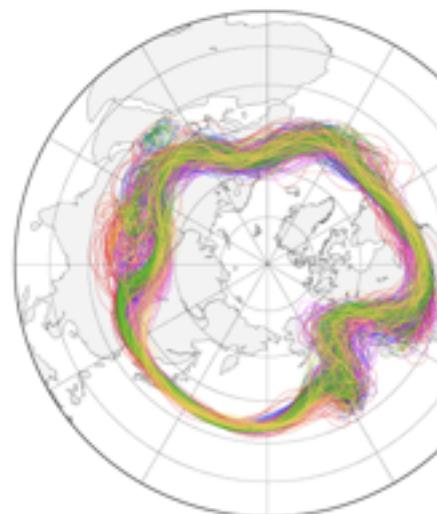
### Day6

Medium-Range Ensemble Forecasts

Spaghetti Diagram: 5500m

Initial Time: 20070109

Valid Time: 20070115 12UTC



Legend: ECMWF (blue), JMA (red), UKMET (magenta), NCEP (green)

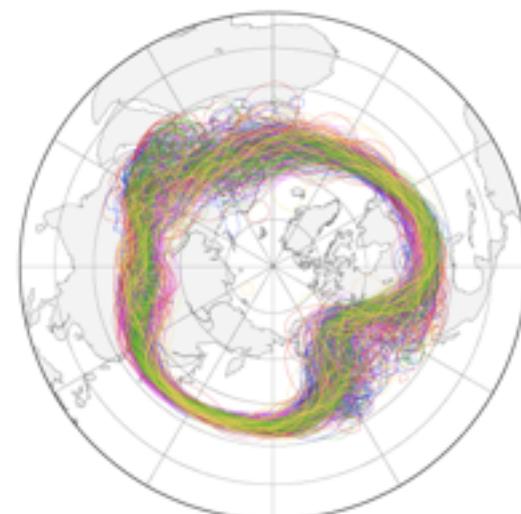
### Day9

Medium-Range Ensemble Forecasts

Spaghetti Diagram: 5500m

Initial Time: 20070109

Valid Time: 20070118 12UTC



Legend: ECMWF (blue), JMA (red), UKMET (magenta), NCEP (green), CMC (yellow)

◎ Total Ensemble Size: 295

CMC (17\*2)

ECMWF (51\*2)

JMA (51)

NCEP (15\*2)

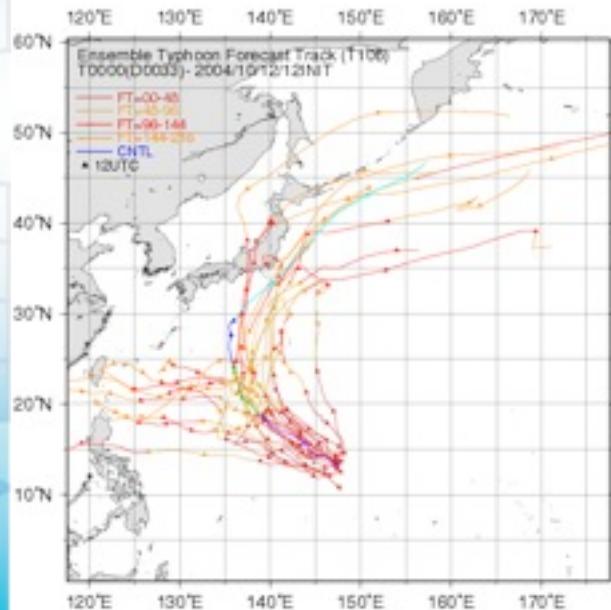
UKMET (24\*2)

Data is available at <http://tigge.ucar.edu/home/home.htm>  
<http://air.geo.tsukuba.ac.jp/~mio/tigge2.html>

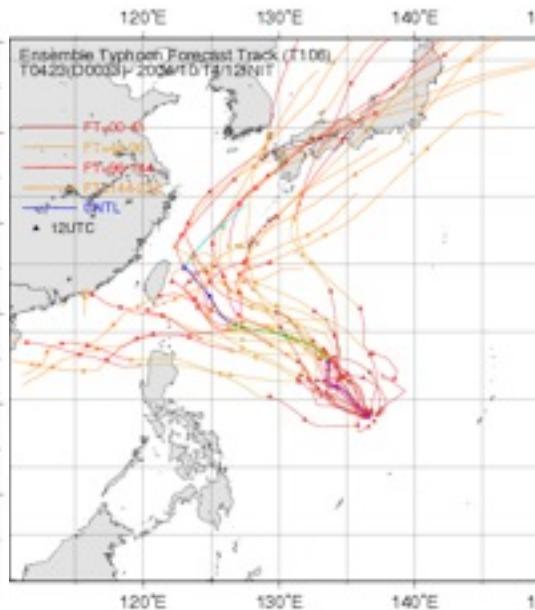
Courtesy of Dr. Matsueda

# 2004年台風第23号のアンサンブル予報

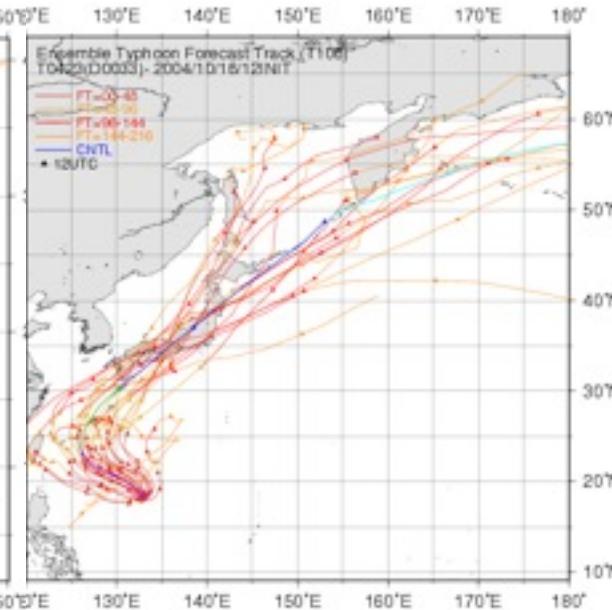
10/12 12Z Initial  
(上陸8日前)



10/14 12Z Initial  
(上陸6日前)



10/16 12Z Initial  
(上陸4日前)



西進と転向に別れる

転向がやや大勢？

転向して上陸！

# THORPEX

A World Weather Research Programme

Accelerating improvements in the accuracy  
of one-day to two weeks high-impact weather forecasts  
for the benefit of society, economy and environment

2005



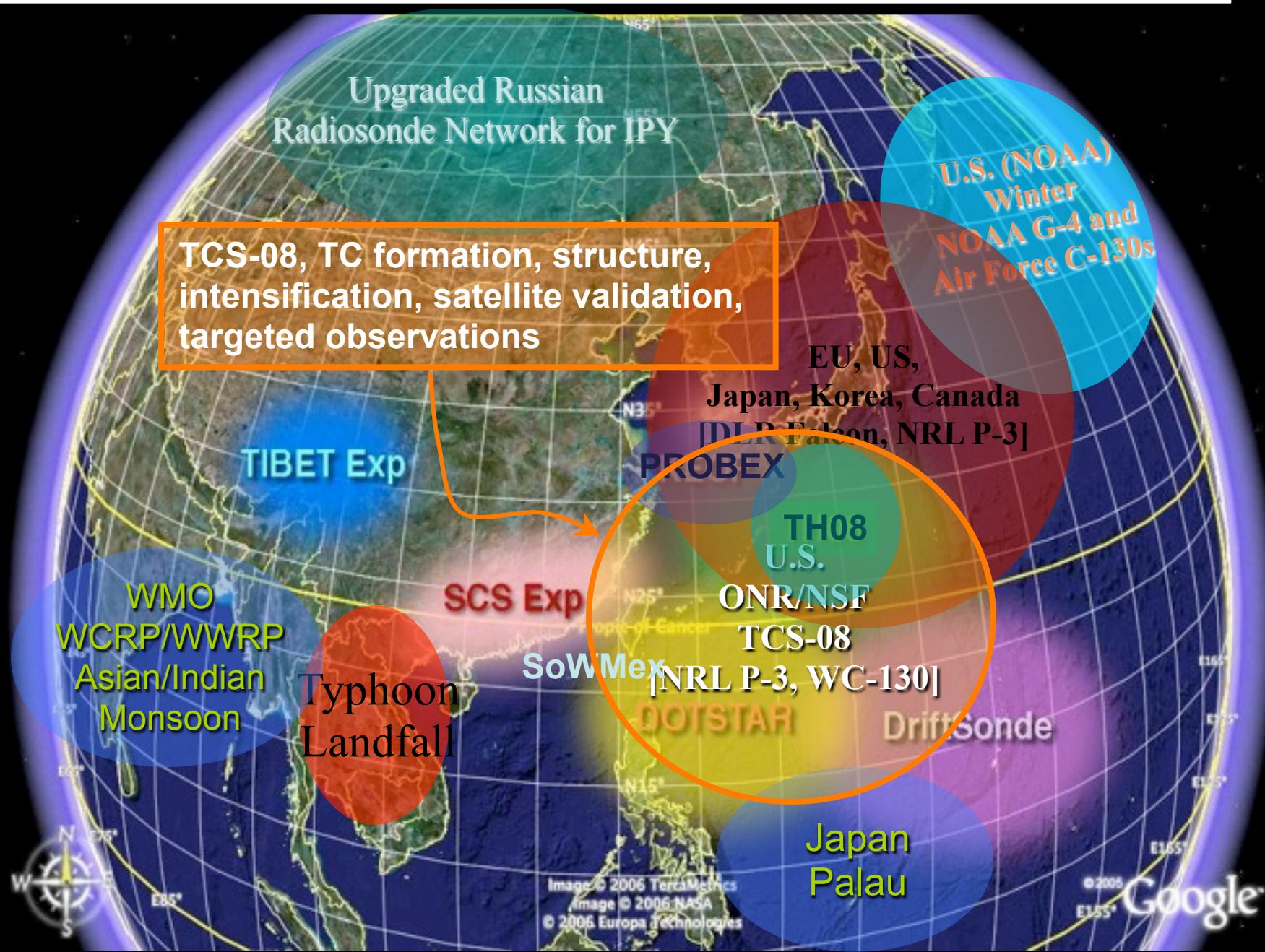
2014...

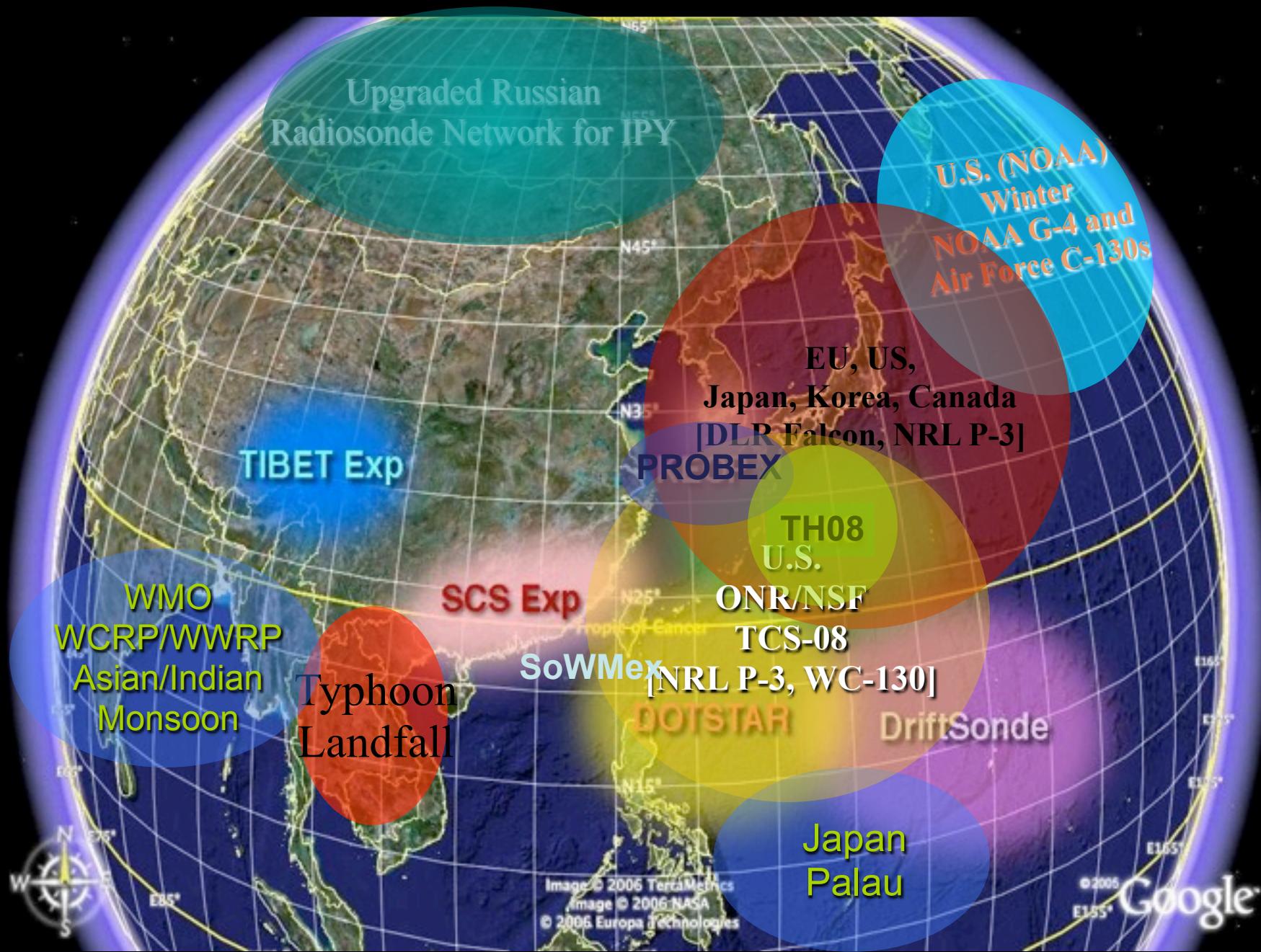
A photographic collage depicting the societal, economic and ecological impacts of severe weather associated with four Rossby wave-trains that encircled the globe during November 2002.

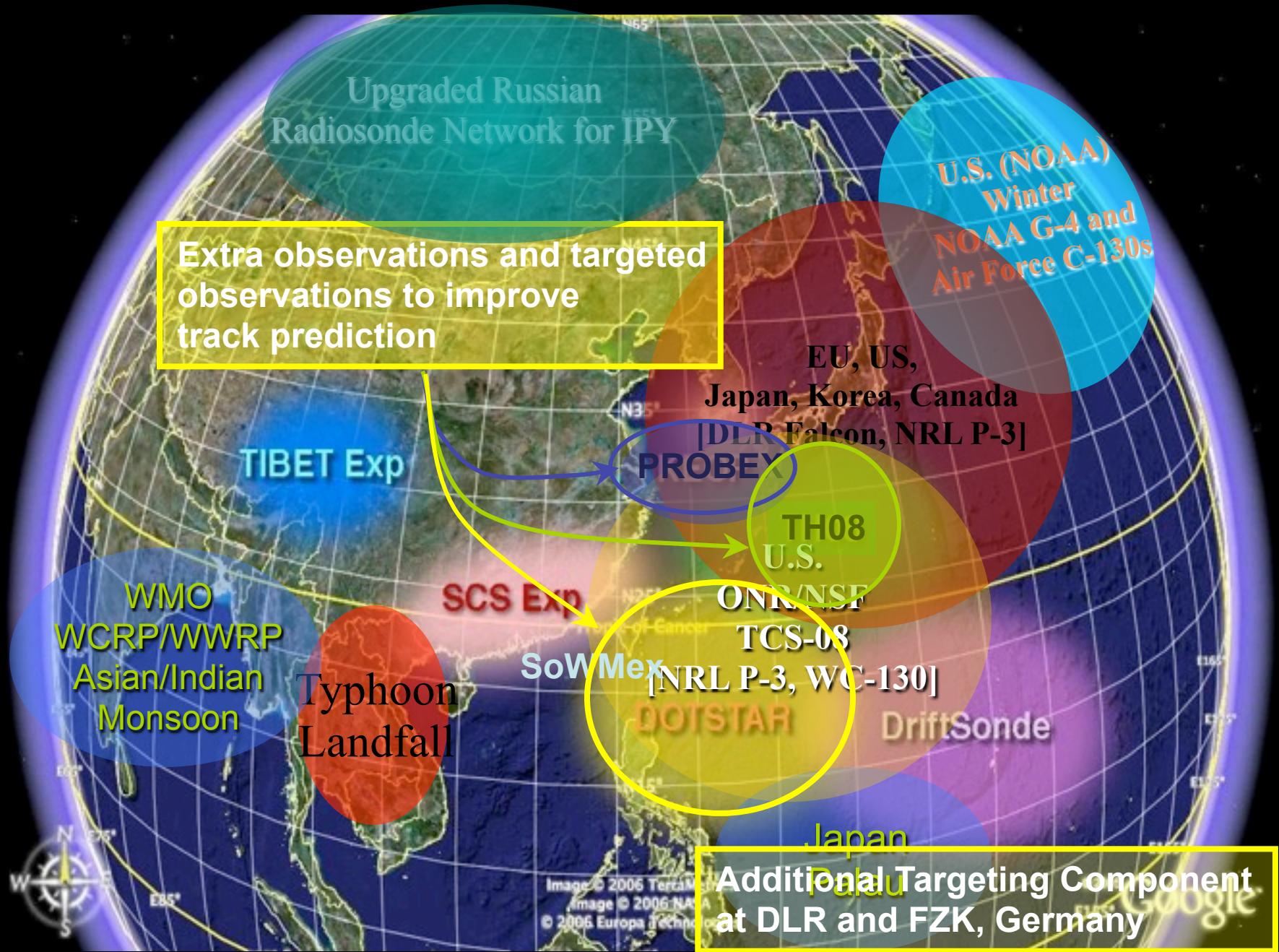
1日から2週間までのhigh-impact weatherの予報精度を向上させ、社会、経済、環境に恩恵をもたらすこと

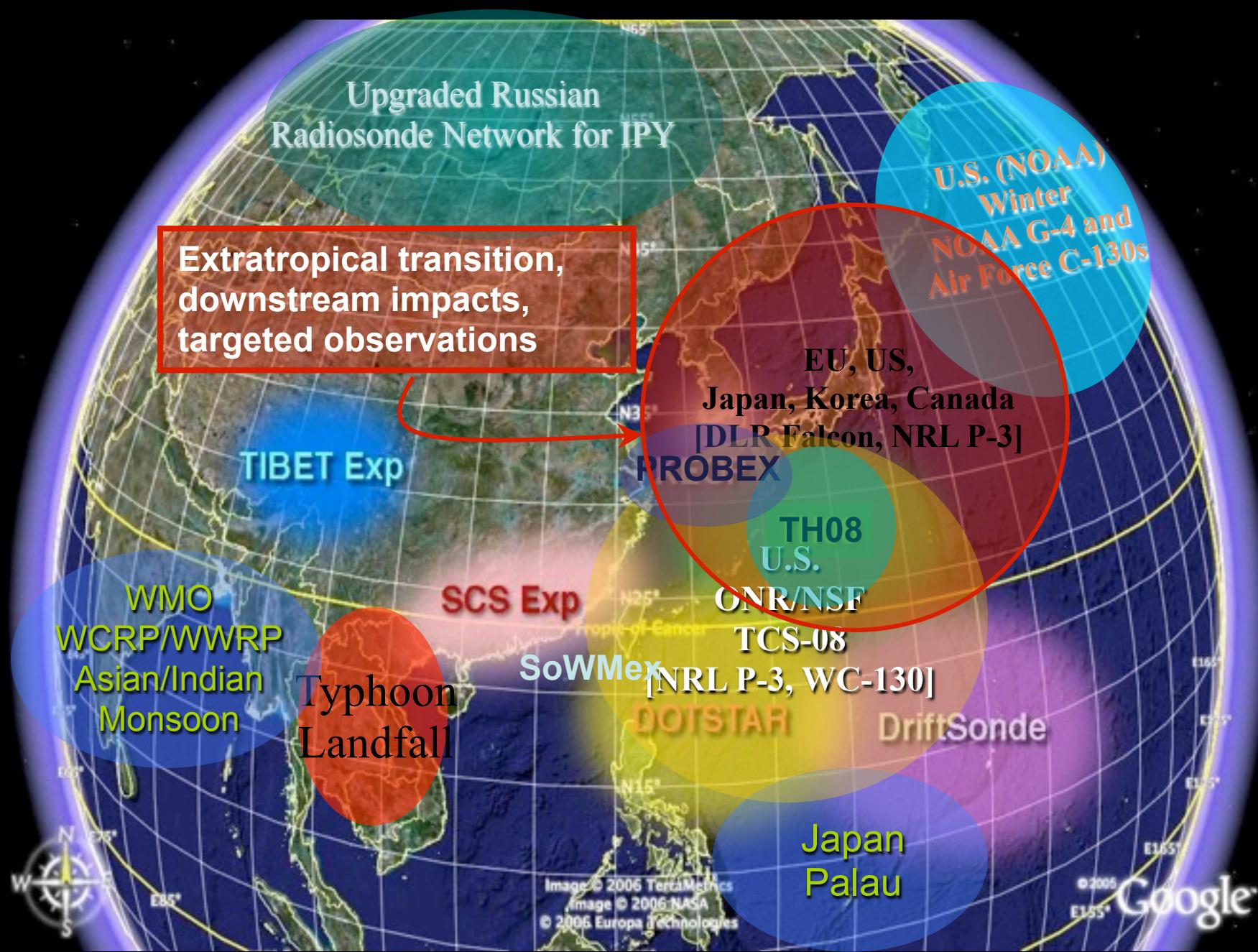
# How does THORPEX contribute to the Society? Health Forecasting

- Focus on meningitis & malaria to enable national health services to scale up interventions in time to cope with disasters as they unfold (Malaria causes between 1.5 & 2.7 million deaths each year, 80% are children under 5)
- Build on the experience of DEMETER (Development of a European Multi-model Ensemble System for Seasonal to Inter-Annual Prediction), which has predicted malaria risk and demonstrated how to deliver this information to the health sector (see *Nature* Jan 2006)
  - 隆膜炎やマラリアに焦点
  - 国際健康関連機関が感染拡大時に機敏な活動を展開できるようにする
  - 西アフリカでマラリアで毎年 5 歳以下の 80%、全体で 200 万人の死者
  - 季節～年々変動予測マルチモデルアンサブルシステム DEMETER の経験あり  
そのモデルでマラリアの危険を予測し、健康関連機関に注意を促した  
(*Nature* 2006 年 1 月号)









Additional Extratropical Transition  
Components at DLR and FZK, Germany

Extratropical transition,  
downstream impacts,  
targeted observations

TIBET Exp

WMO  
WCRP/WWRP  
Asian/Indian  
Monsoon

Typhoon  
Landfall

Upgraded Russian  
Radiosonde Network for IVY

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

PROBEX

TH08  
U.S.

ONR/NSF  
TCS-08  
[NRL P-3, WC-130]

SoWMex

DOTSTAR

Japan  
Palau

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

DriftSonde



# 觀測實施体制



**THORPEX-Pacific Asian Regional Campaign (T-PARC)**  
THORPEX (The Observing-System Research and Predictability Experiment)  
**And**  
**Tropical Cyclone Structure-08 Experiments (TCS-08)**  
**Collaborative Efforts**

# 観測に参加した航空機

- 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

# 熱帯の対流システム：数字からみると

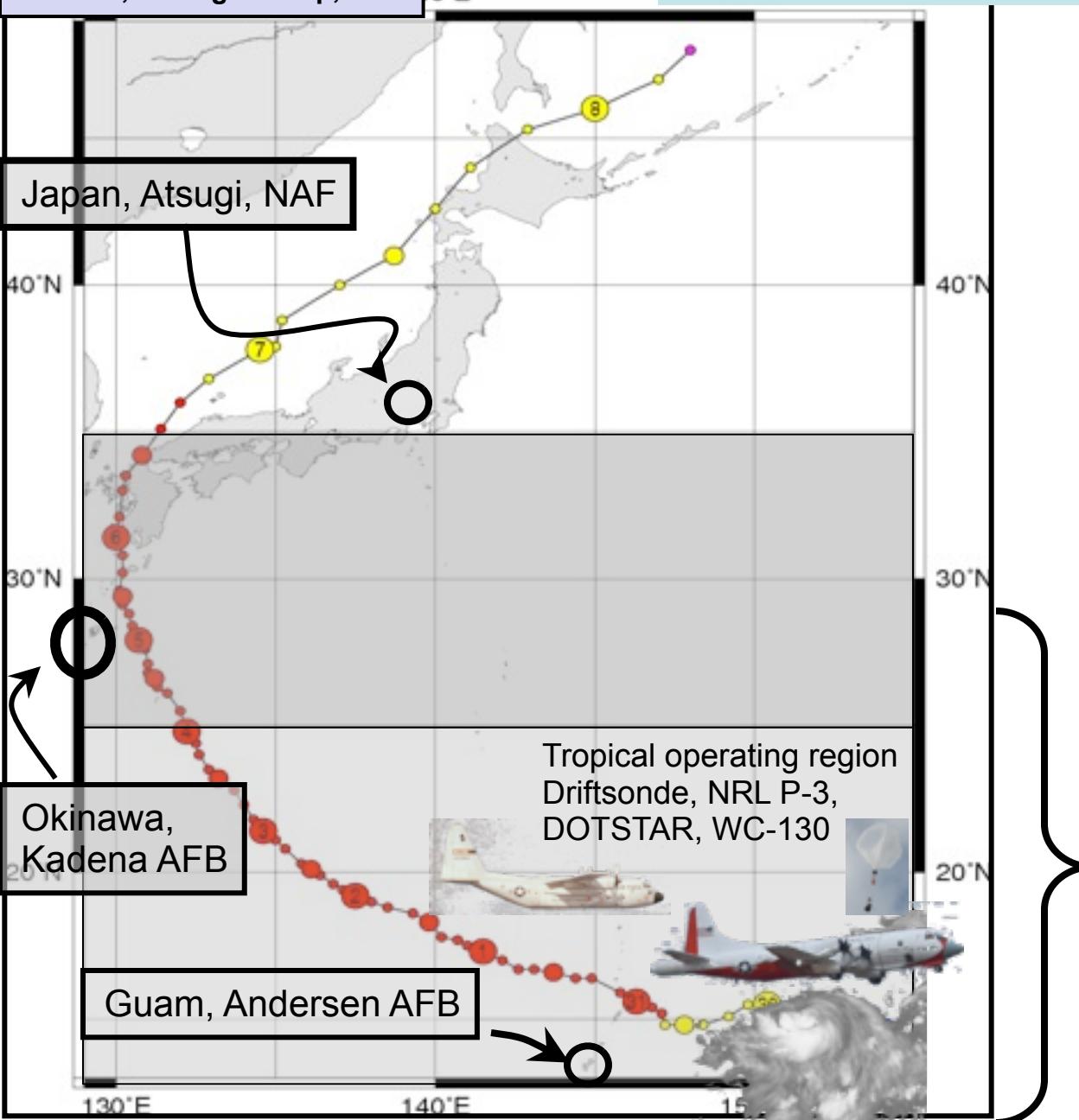
- During August – September, there were 12 total systems  $\geq$  TD intensity over the western North Pacific
  - 4 typhoons, 4 tropical storms, 4 TDs
- 51 TCS systems
  - With a few recycled a time or two
- 11 systems in which aircraft missions were flown
  - 4 typhoons, 1 TD, 1 ex-TS, 5 others
- 72%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

# 実施した観測：数字からみると

- 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

# 理想的な台風観測例

TY Nabi, 29 Aug – 8 Sep, 2005

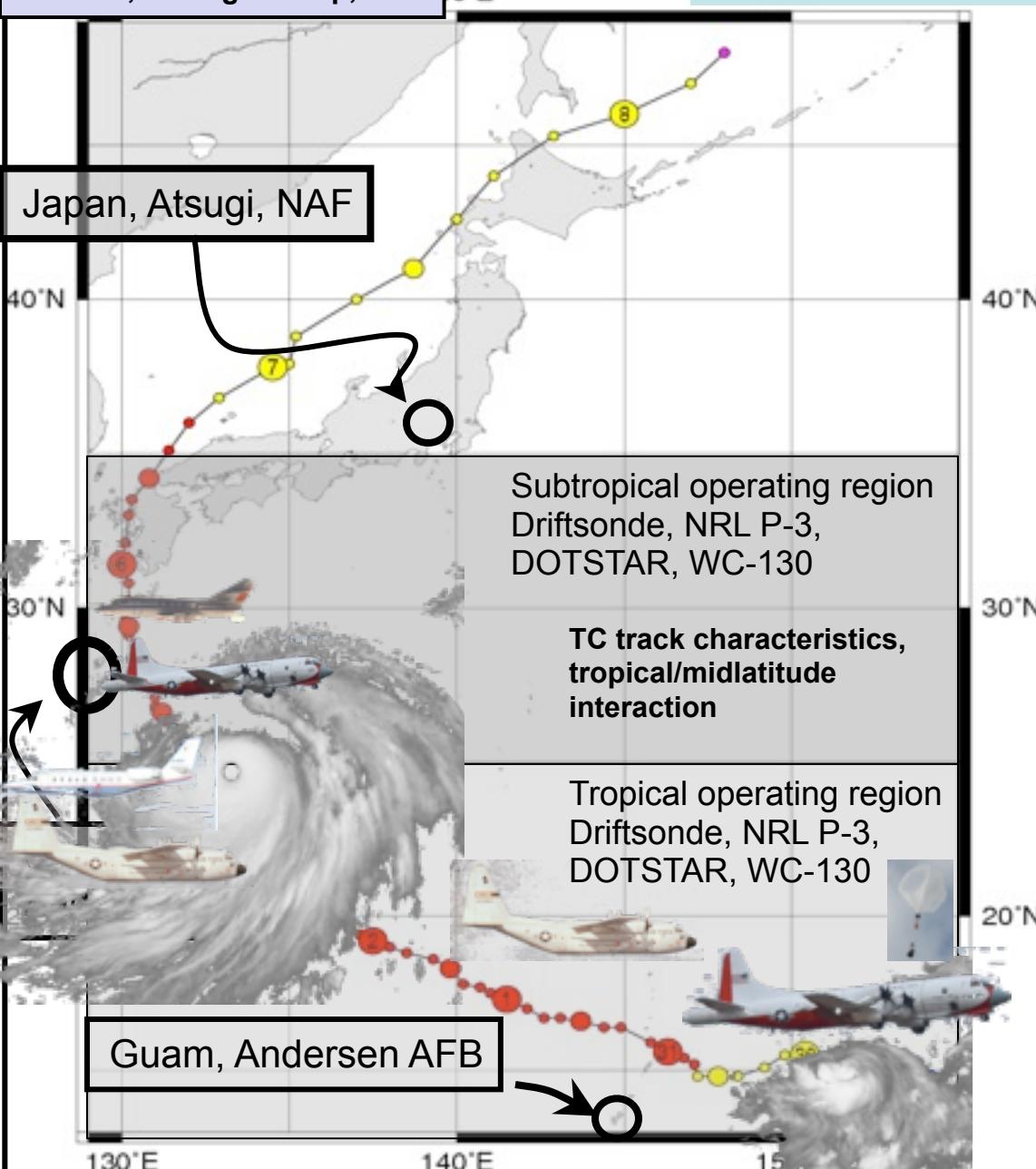


## Tropical Measurements

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

# 理想的な台風観測例

TY Nabi, 29 Aug – 8 Sep, 2005



TC Intensification  
and structure  
change  
Recurvature, initiation of  
ET

Tropical Measurements

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

# 理想的な台風観測例

TY Nabi, 29 Aug – 8 Sep, 2005

Midlatitude operating region  
NRL P-3, FALCON

Japan, Atsugi, NAF

40°N

40°N

30°N

30°N

130°E

140°E

150°E

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

TC track characteristics,  
tropical/midlatitude  
interaction

Guam, Andersen AFB

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

Extratropical Transition  
(ET – recurvature),  
Downstream Impacts

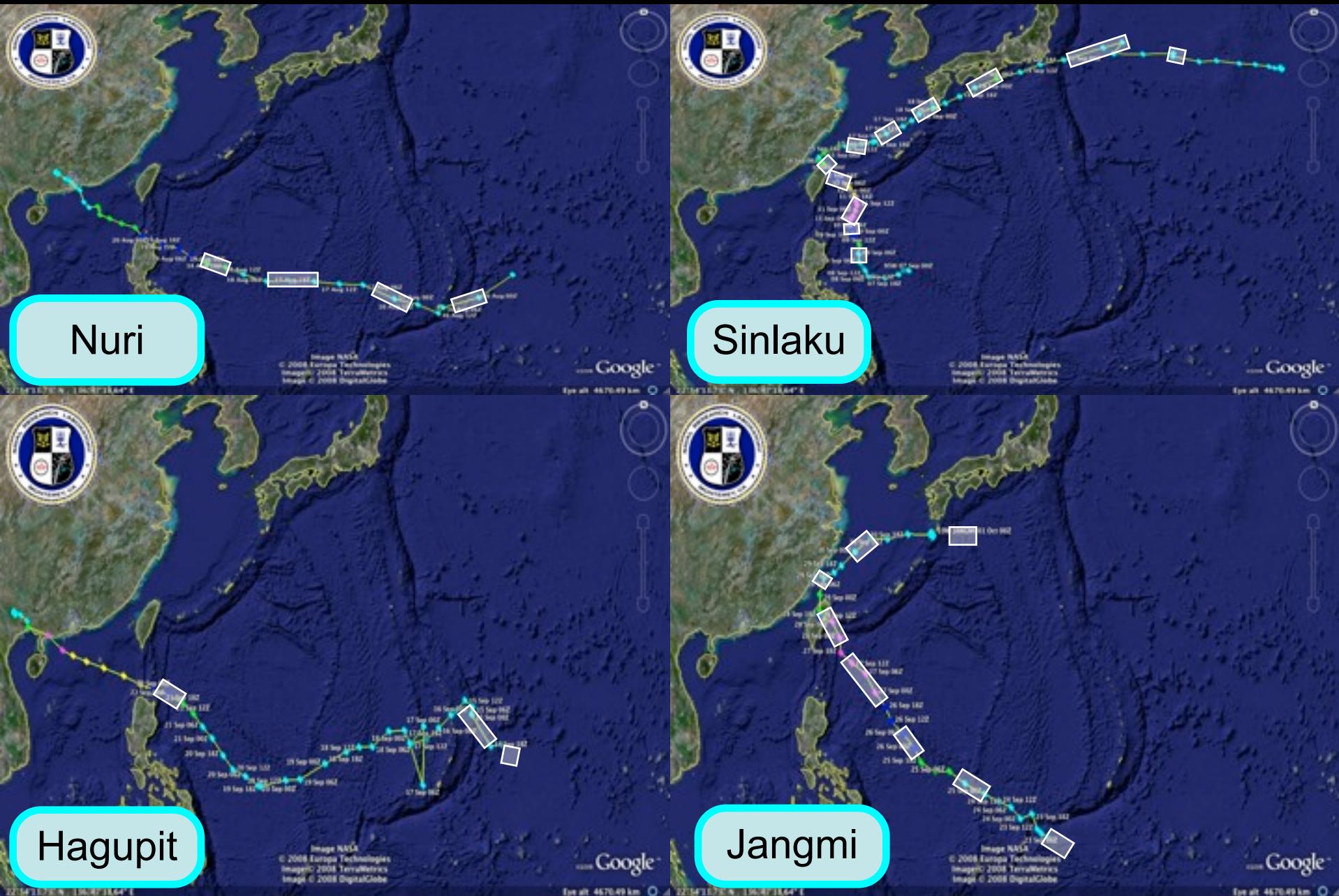
ET characteristics, forcing  
of downstream impacts,  
tropical/midlatitude  
interactions, extratropical  
cyclogenesis

TC Intensification  
and structure  
change  
Recurvature, initiation of  
ET

Tropical Measurements

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

# T-PARC/TCS-08で観測された4台風



# 台風の最適観測法:

## 観測のツボを押さえる

Sensitive Area  
Tsubo in Japanese  
經絡 in Chinese  
Pressure Point

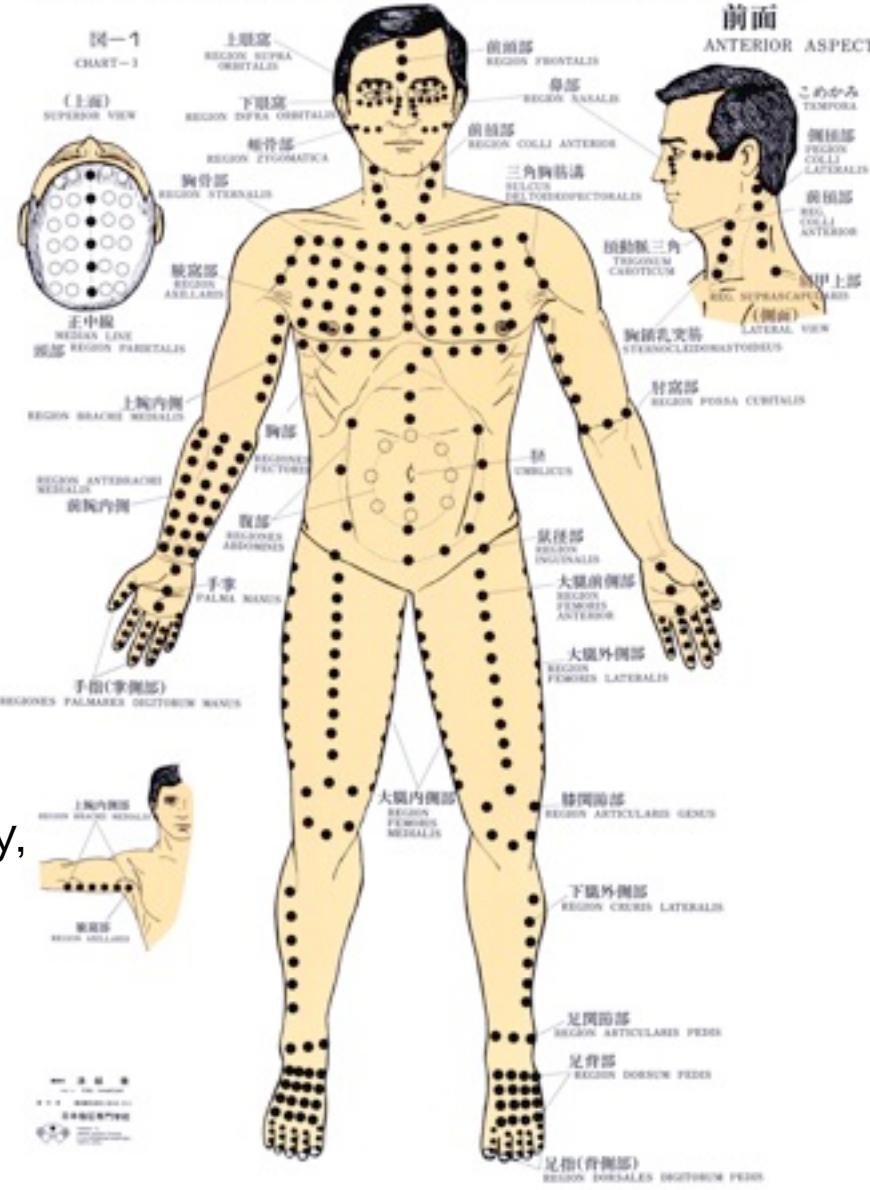
analogy to therapeutic point for body

“sensitive area”, where errors grow quickly,  
estimated by **sensitivity analysis**

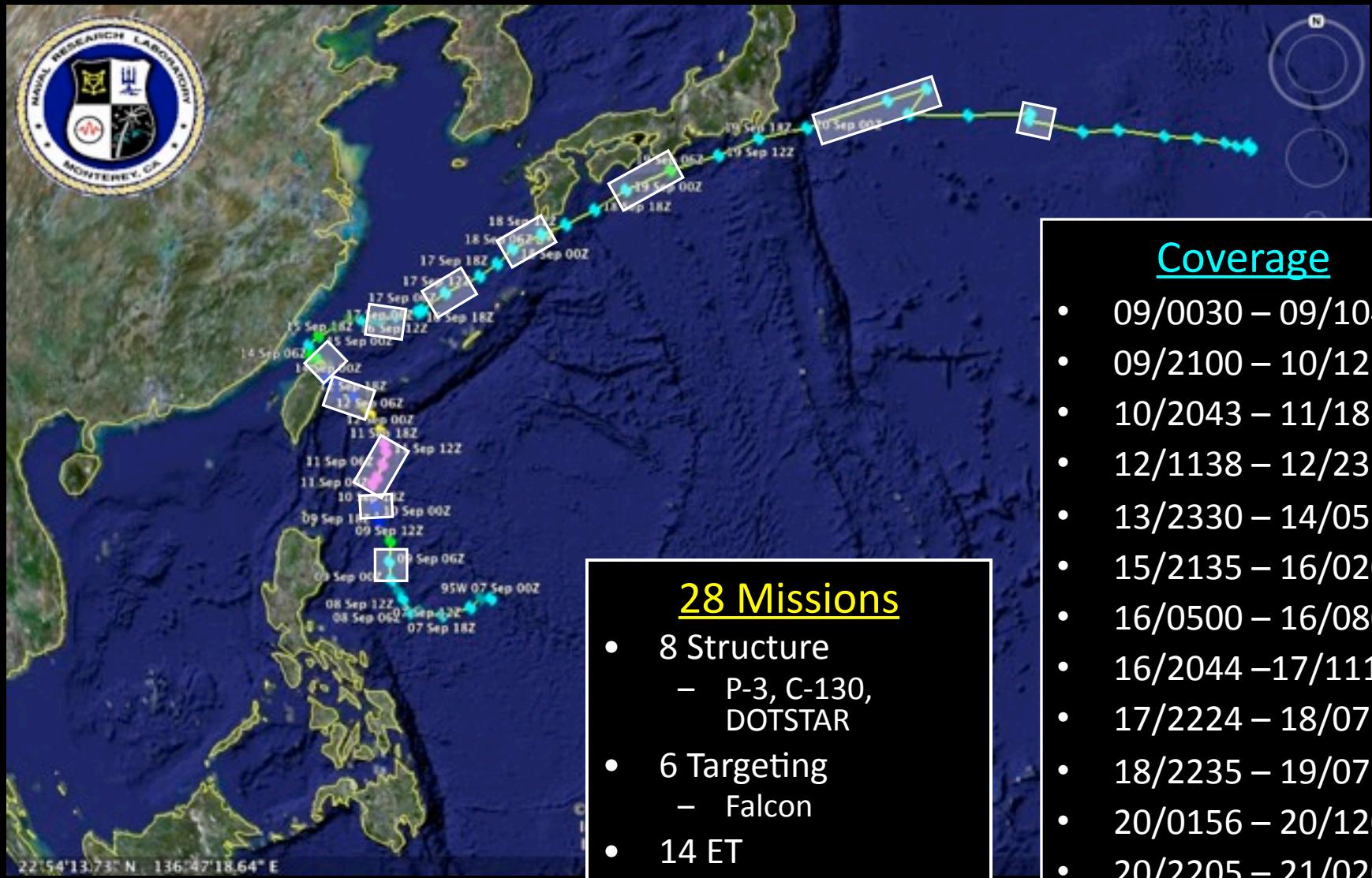
We will improve the forecast if we make  
observations at right positions.

(We will improve the body condition if we  
massage at the right positions!)

指圧療法全身基本圧点分布図  
DISTRIBUTION OF SHIATSU THERAPY TOTAL BASIC PRESSURE POINTS

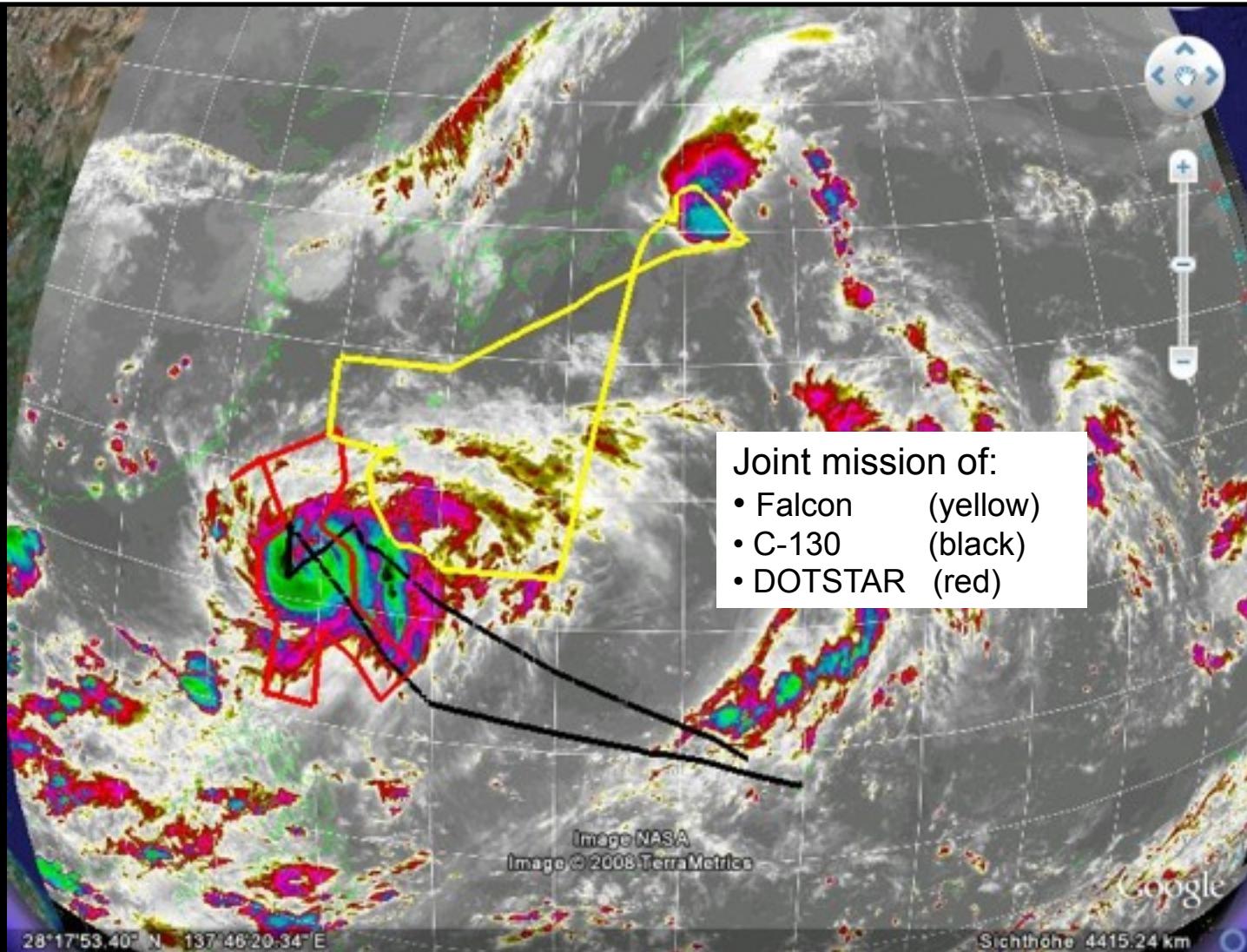


# TY Sinlaku (TCS-033 / TD15W)



# 航空機3機による初めての台風同時観測

TY-core, TY-environment and distant sensitive region (“Sinlaku”)

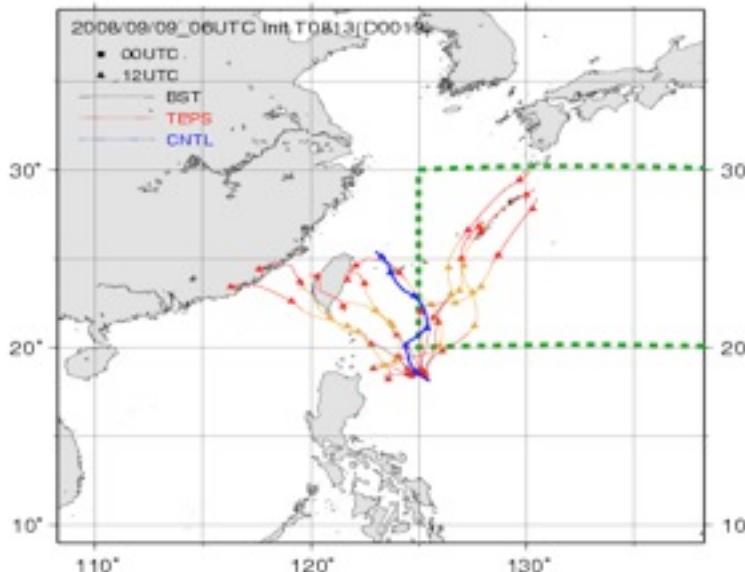


# 台風進路のアンサンブル予測

THOR

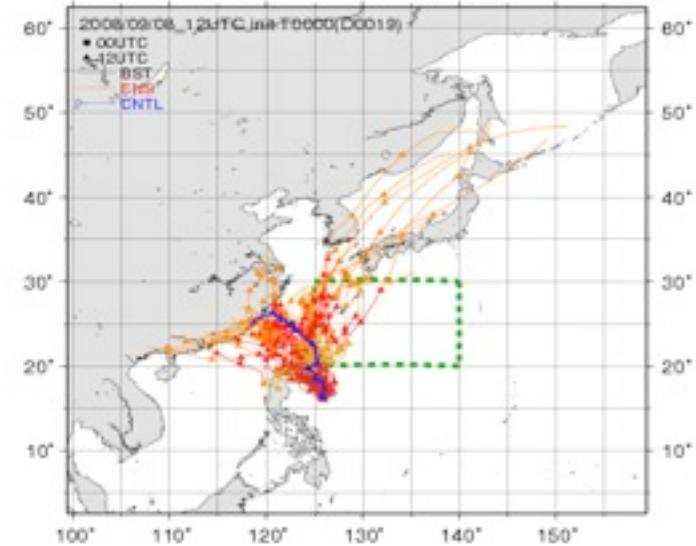
JMA Typhoon EPS

2008.09.09 06UTC ini +132h

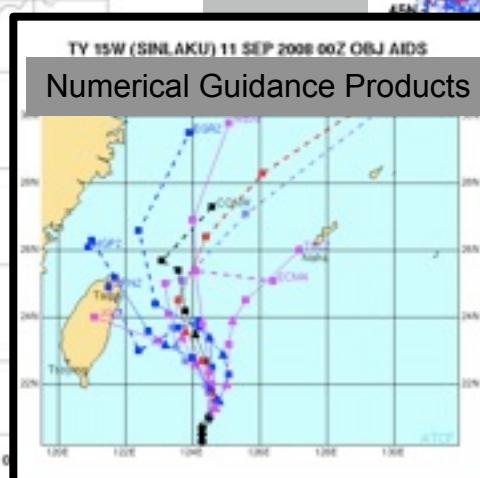
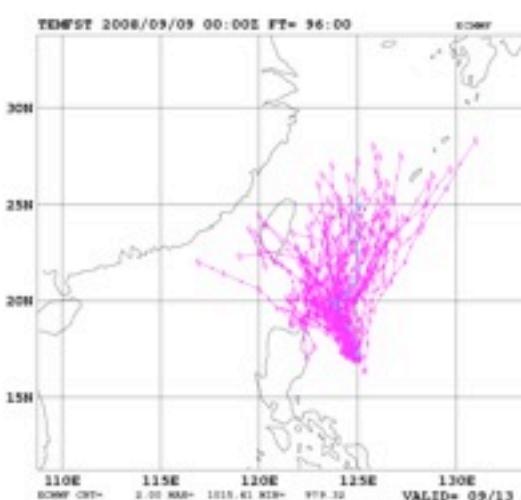


JMA Medium-Range EPS

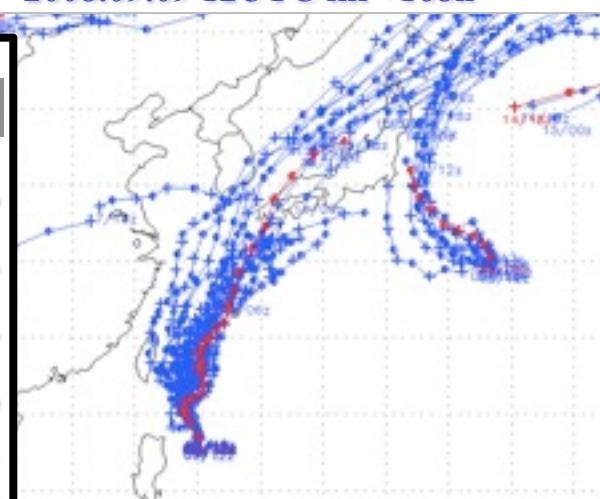
2008.09.08 012UTC ini +216h



ECMWF EPS 2008.09.08 12UTC +120h



GFS EPS  
2008.09.09 12UTC ini +168h

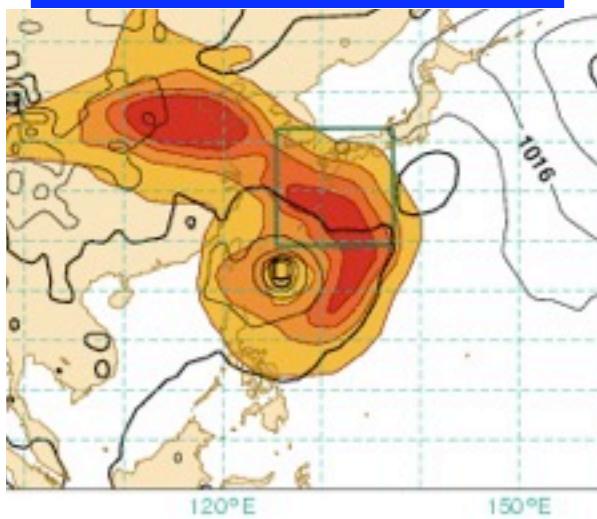


WWRP

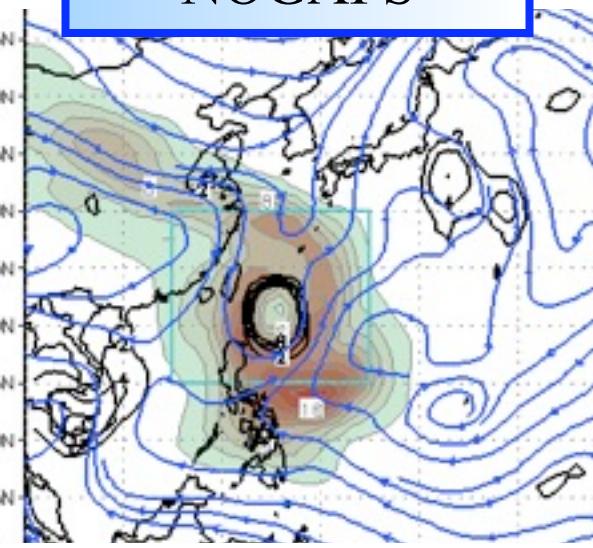
WMO  
OMM

# 観測のツボ情報 観測時刻： 09/11 00Z

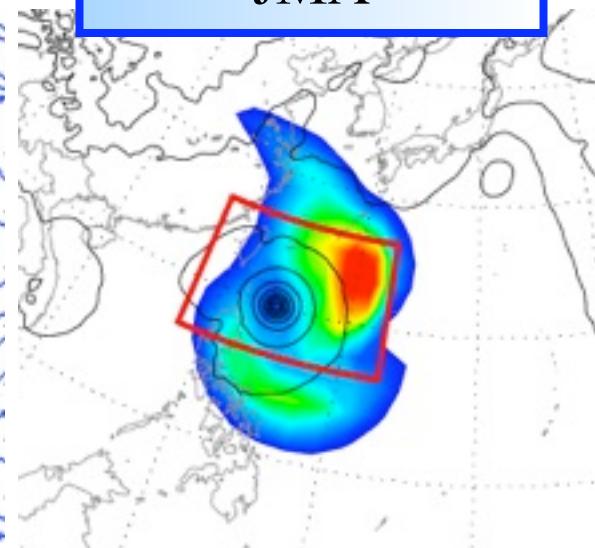
ECMWF



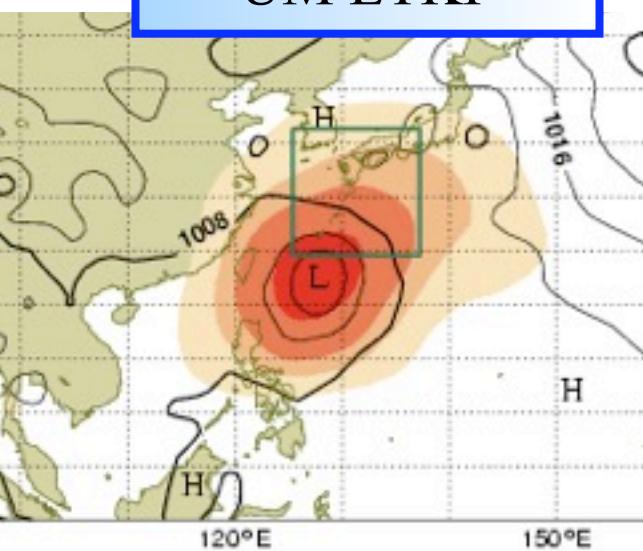
NOGAPS



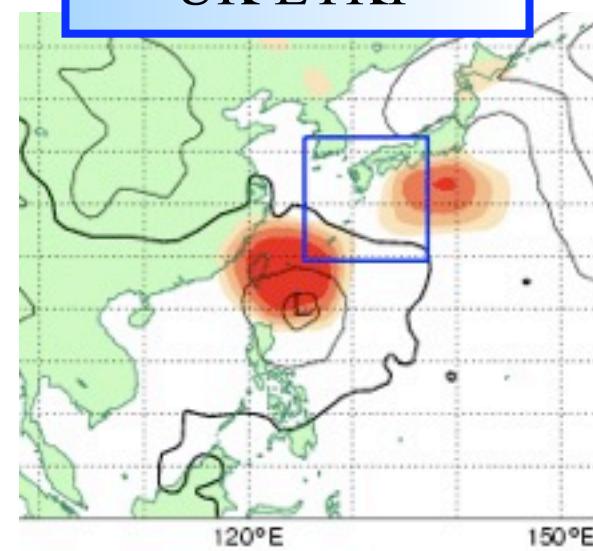
JMA



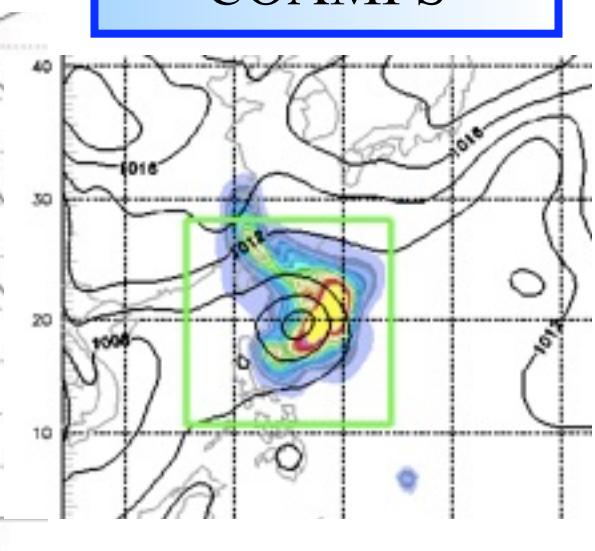
UM ETKF



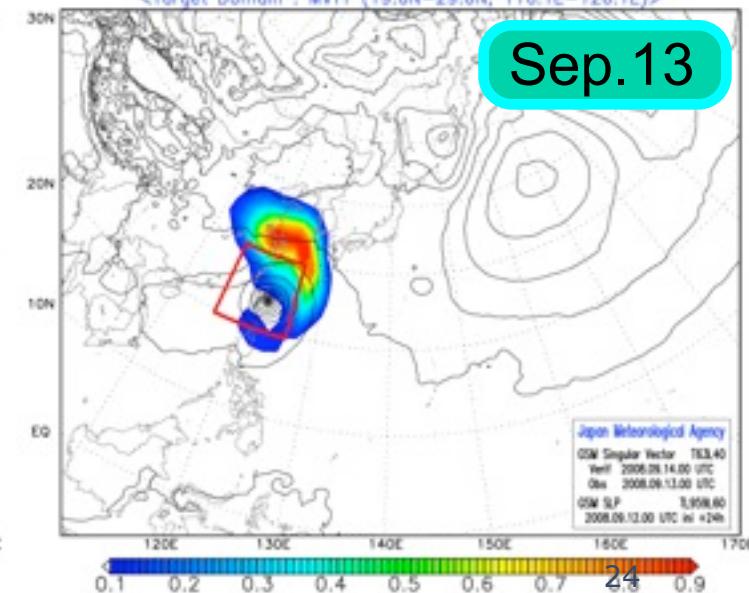
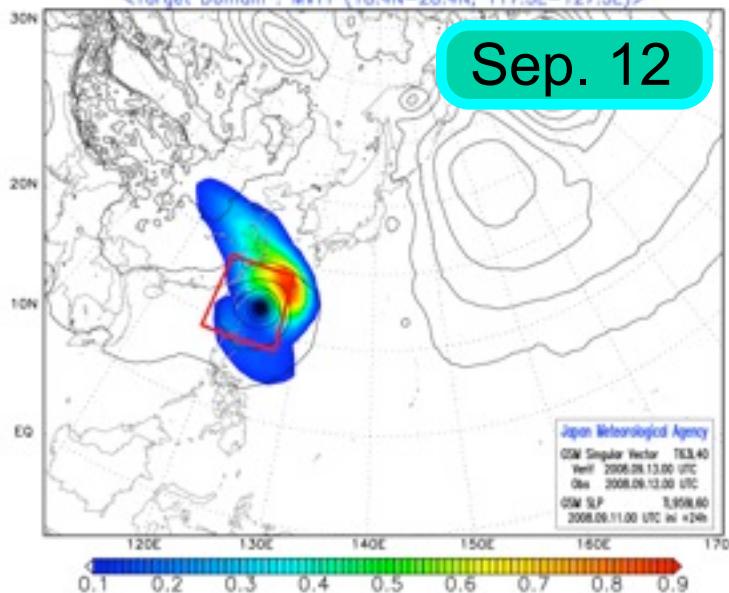
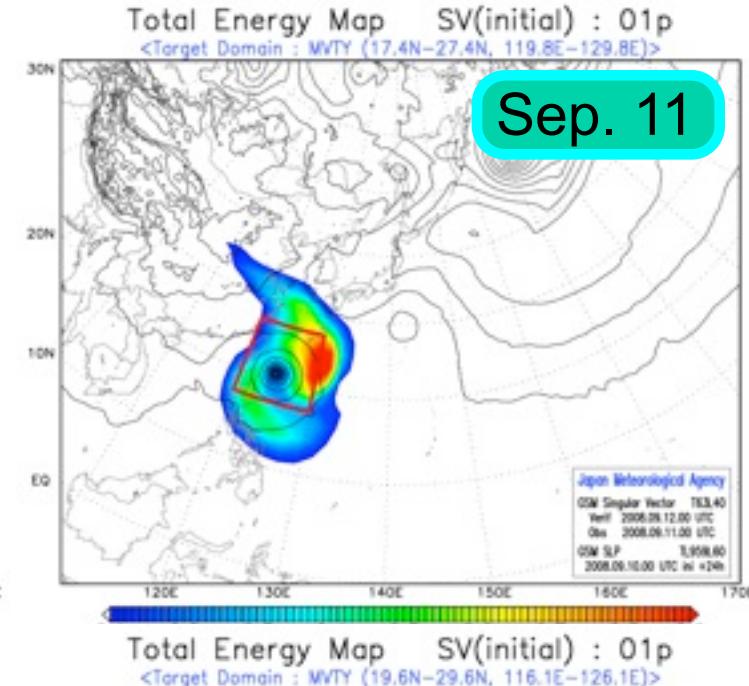
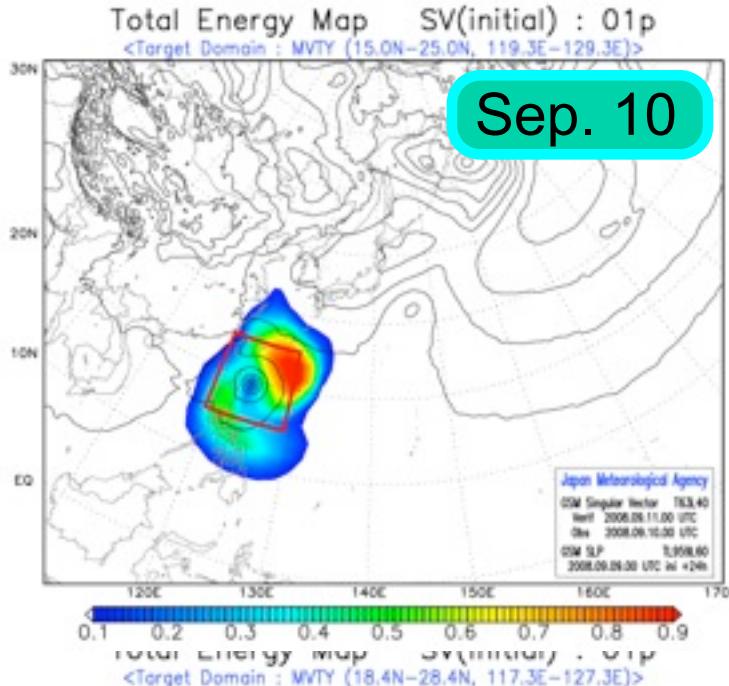
UK ETKF



COAMPS



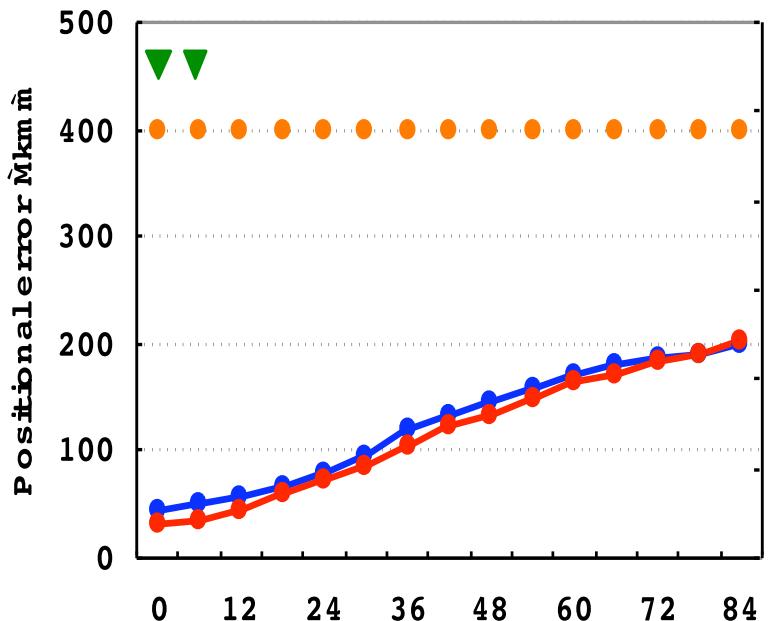
# 気象庁が求めた、SINLAKUの「観測のツボ」



# 台風SINLAKUの進路予報は改善したか？

*before-recurvature stage*

(Period : from 00 UTC 09/09/2008 to 18 UTC 14/09/2008)

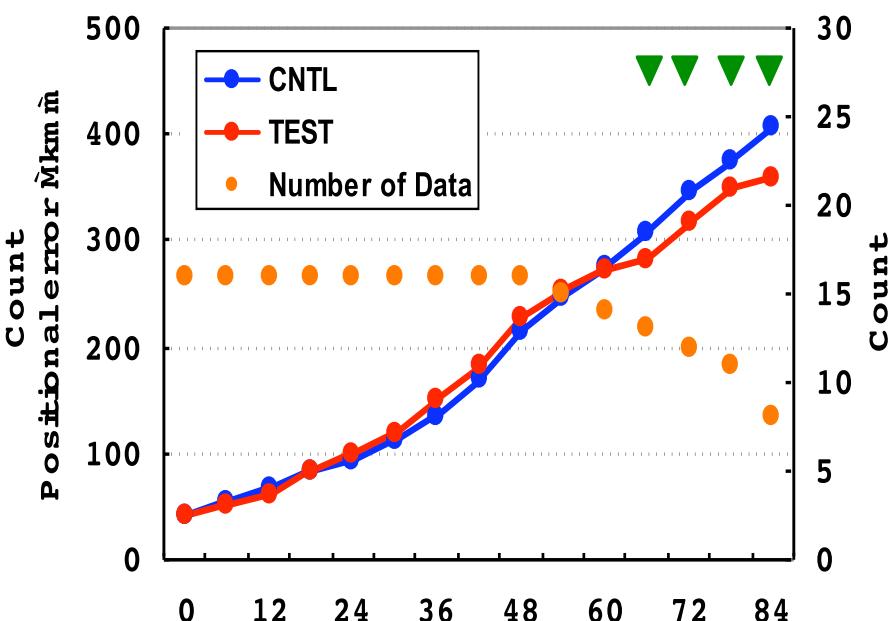


Forecast time (hours)

23-30% Improvement  
for 12-h forecasts

*after-recurvature stage*

(Period : from 00 UTC 15/09/2008 to 18 UTC 18/09/2008)

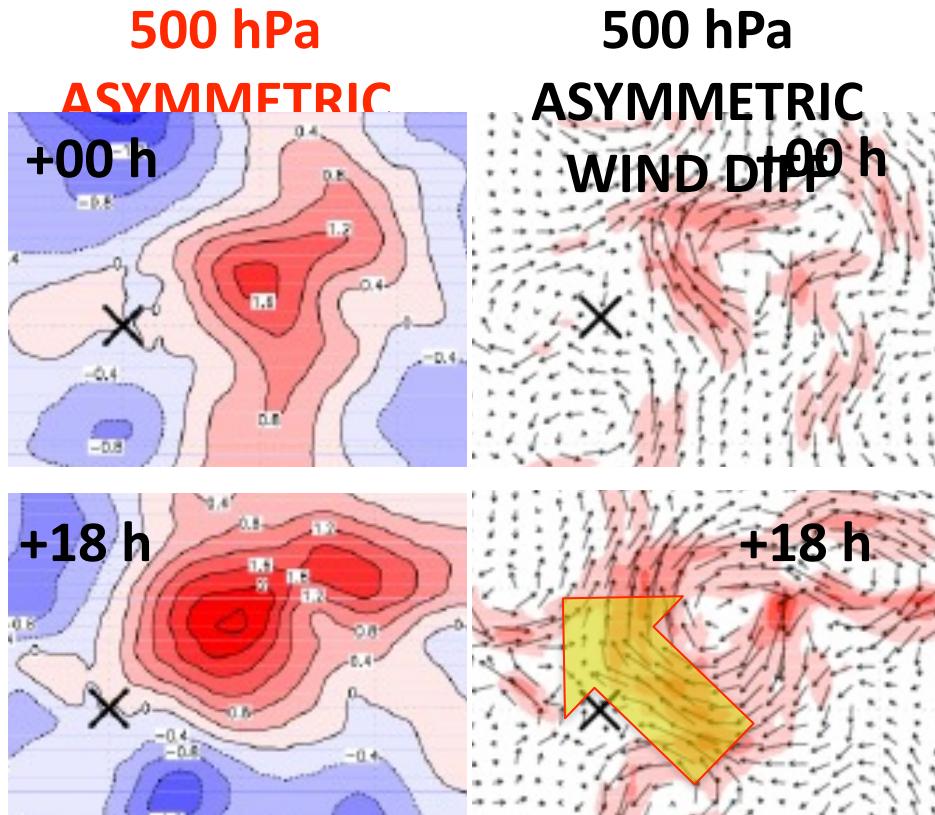
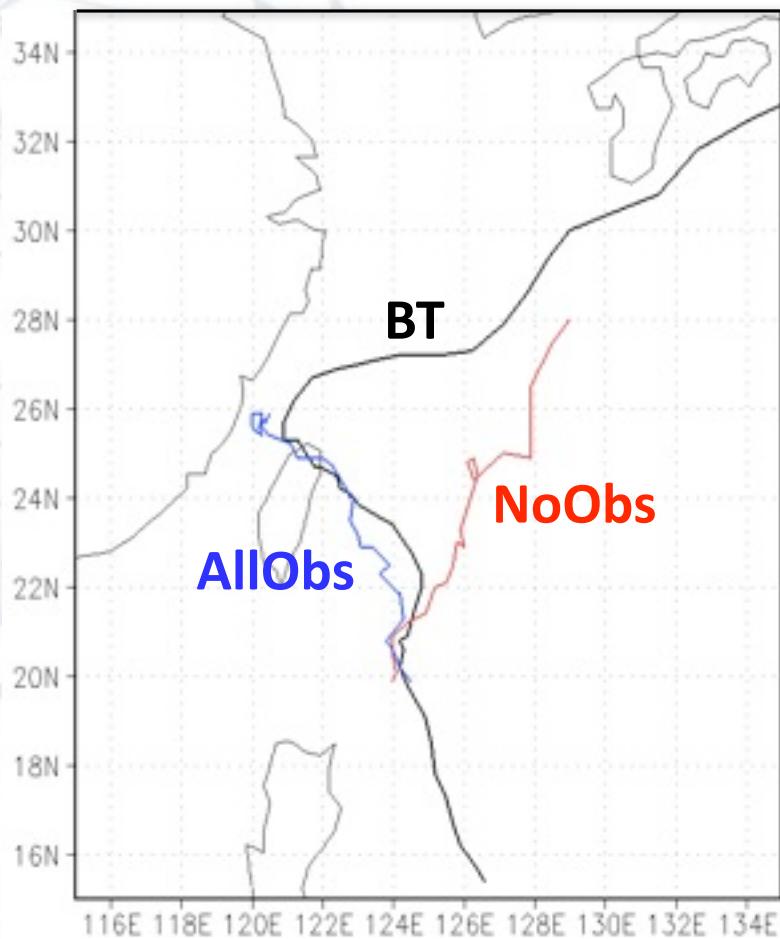


Forecast time (hours)

10% Improvement  
for 66- to 84-hour forecasts

# 台風SINLAKUの進路予報は改善したか？

Sinlaku by NCEP GFS 9/10 00UTC



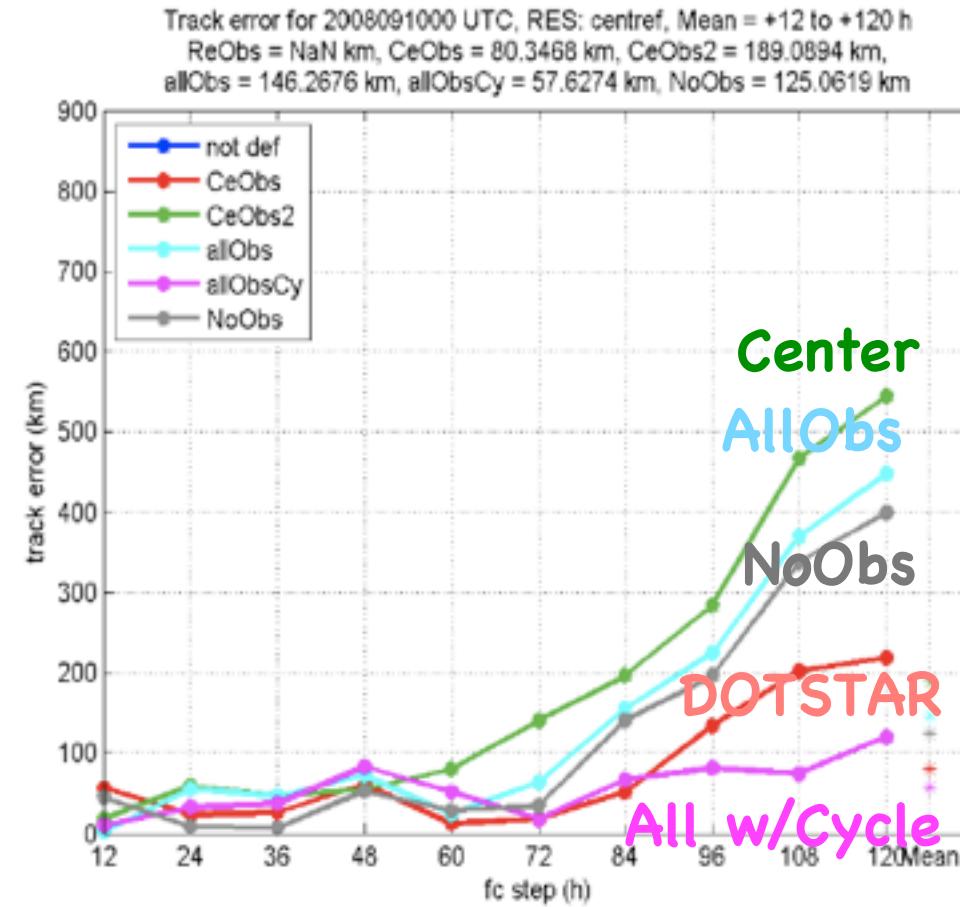
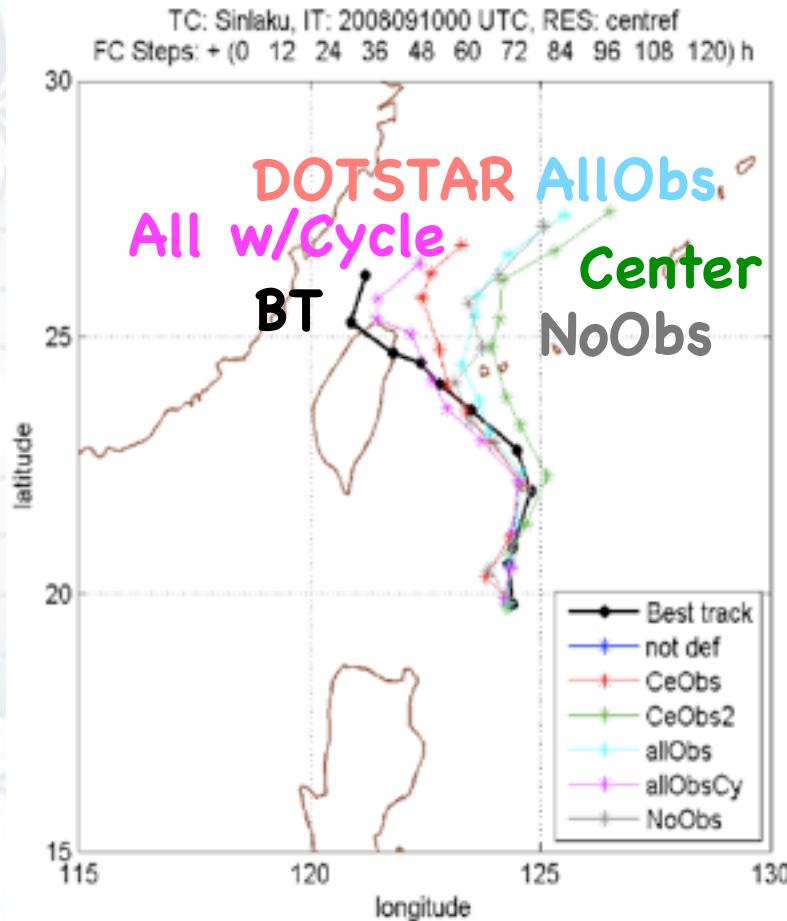
## Effect of drops:

Strengthened vortex, decreased RMW  
Strengthened subtropical ridge,  
inducing northwestward flow

# の進路予報は改善したか？

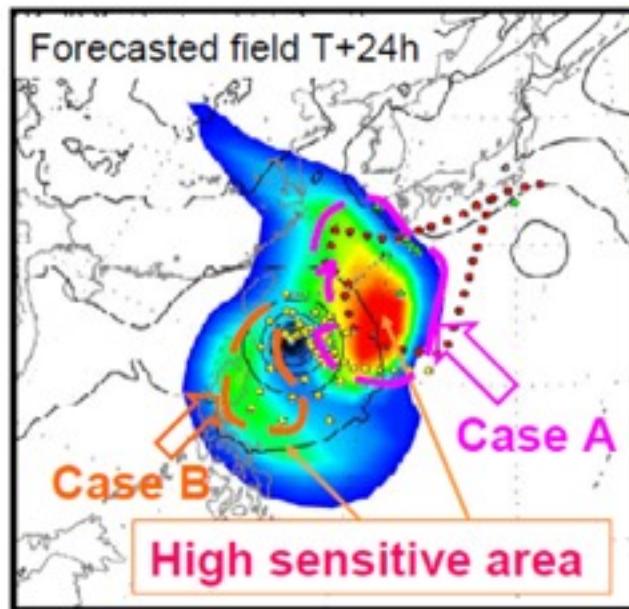
## Sinlaku by ECMWF

## 9/10 00UTC



(Courtesy of Dr. Martin Weissmann)

# 観測のツボの効用は？



OBS. 00-18 UTC 11/09/2008

Init. 00 UTC 10/09/2008

**Green points:** Upper-soundings by JMA research vessels and ground observatories

**Red points:** Dropsondes released by Falcon aircraft

**Yellow points :** Other planes

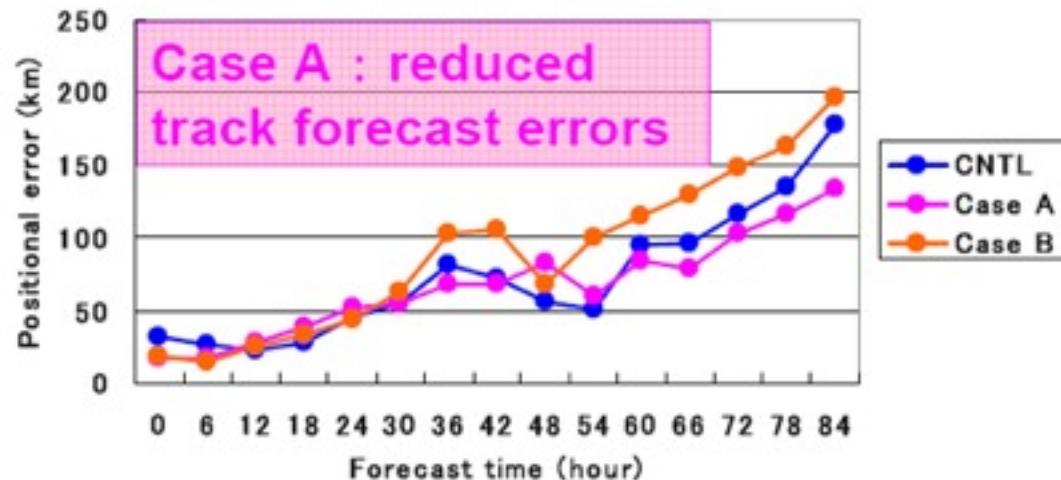
Case study using targeted observations in the sensitivity area on 6-hourly continuous data assimilation from 00 to 12 UTC 11 September 2008

**Case A :** Using targeted observations in the north-east area of typhoon center

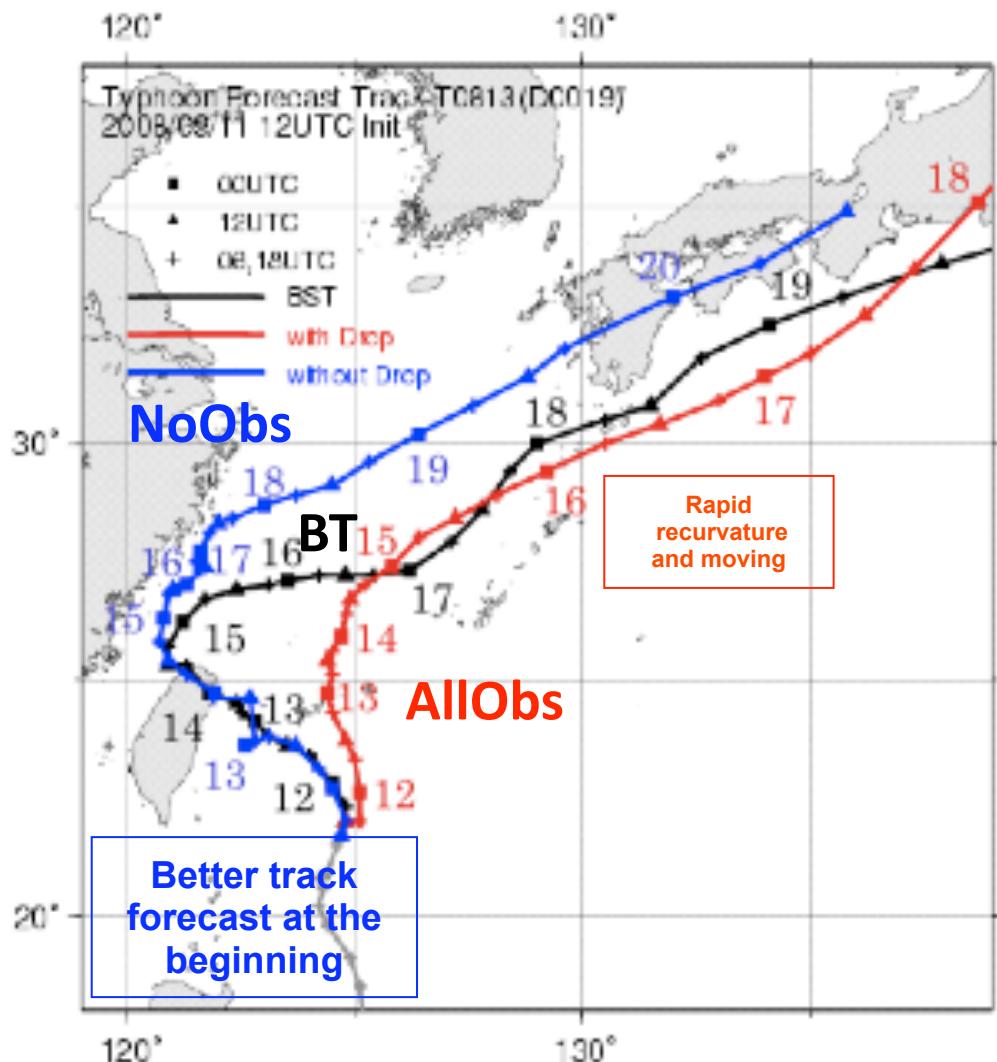
**Case B :** Using targeted observations in the south-west area of typhoon center

**CNTL :** No special observations are assimilated

Average of typhoon positional error  
(SINLAKU: 00,06 and 12 UTC 11 September 2008)



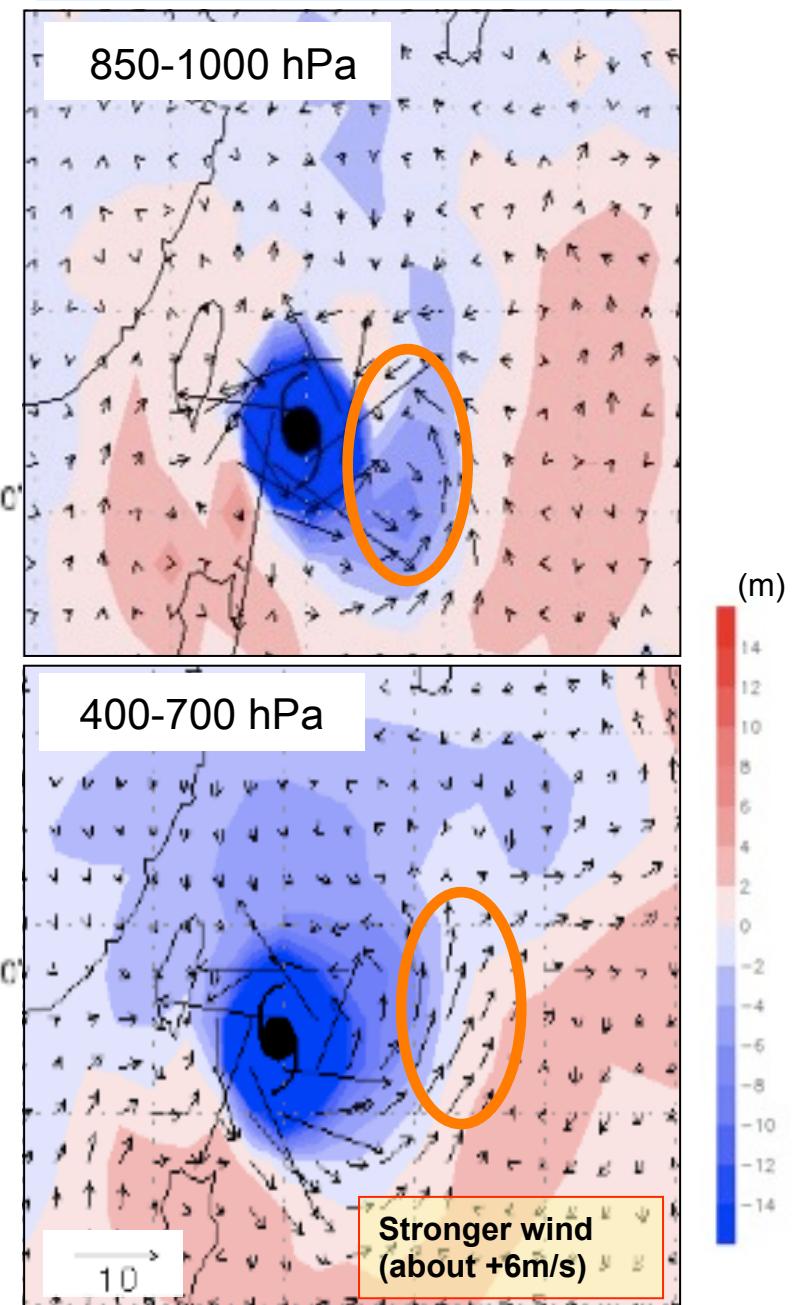
# SINLAKU by JMA 9/11 12UTC



Red : With Drop ( Test ) Blue : Without Drop ( Cntl )

Black : JMA Besttrack

## Difference of Test-Cntl in Z and Wind



# なぜ台風進路予報が悪くなる時があるのか？

## Impacts of Sondes differ in models

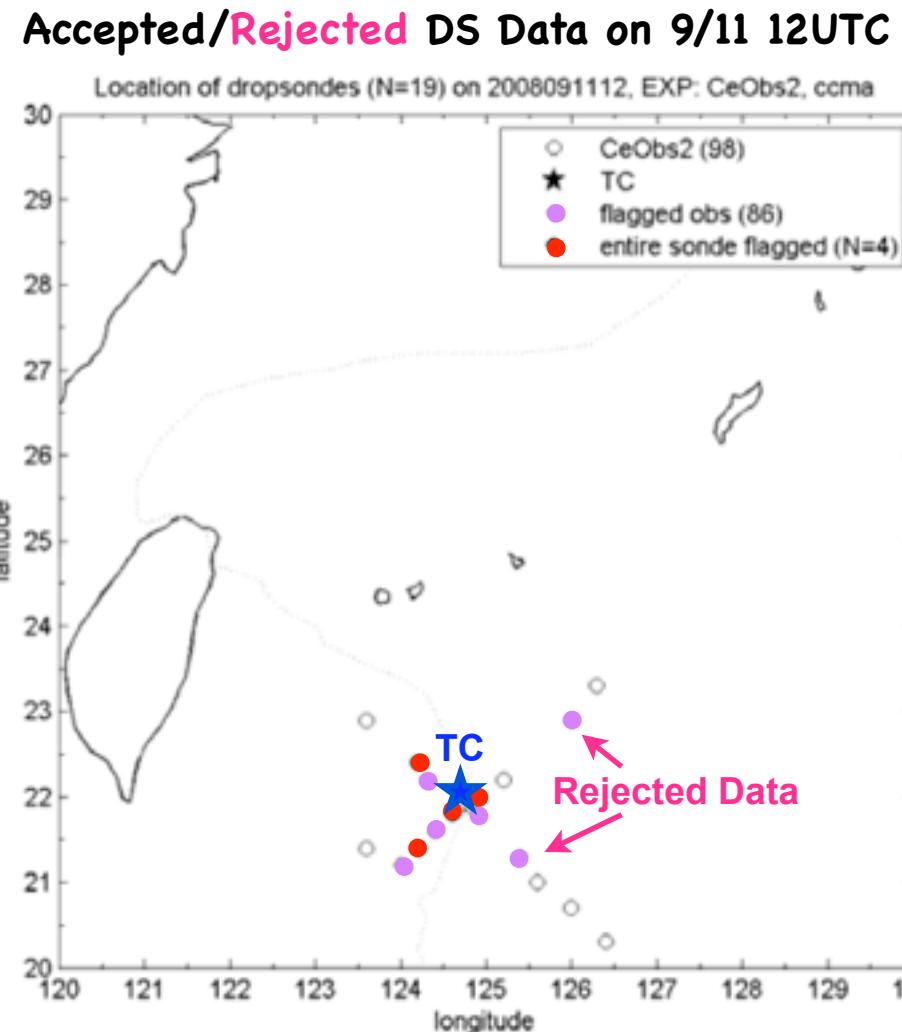
### Why?

Not in Targeted Observation

But maybe in the Systems

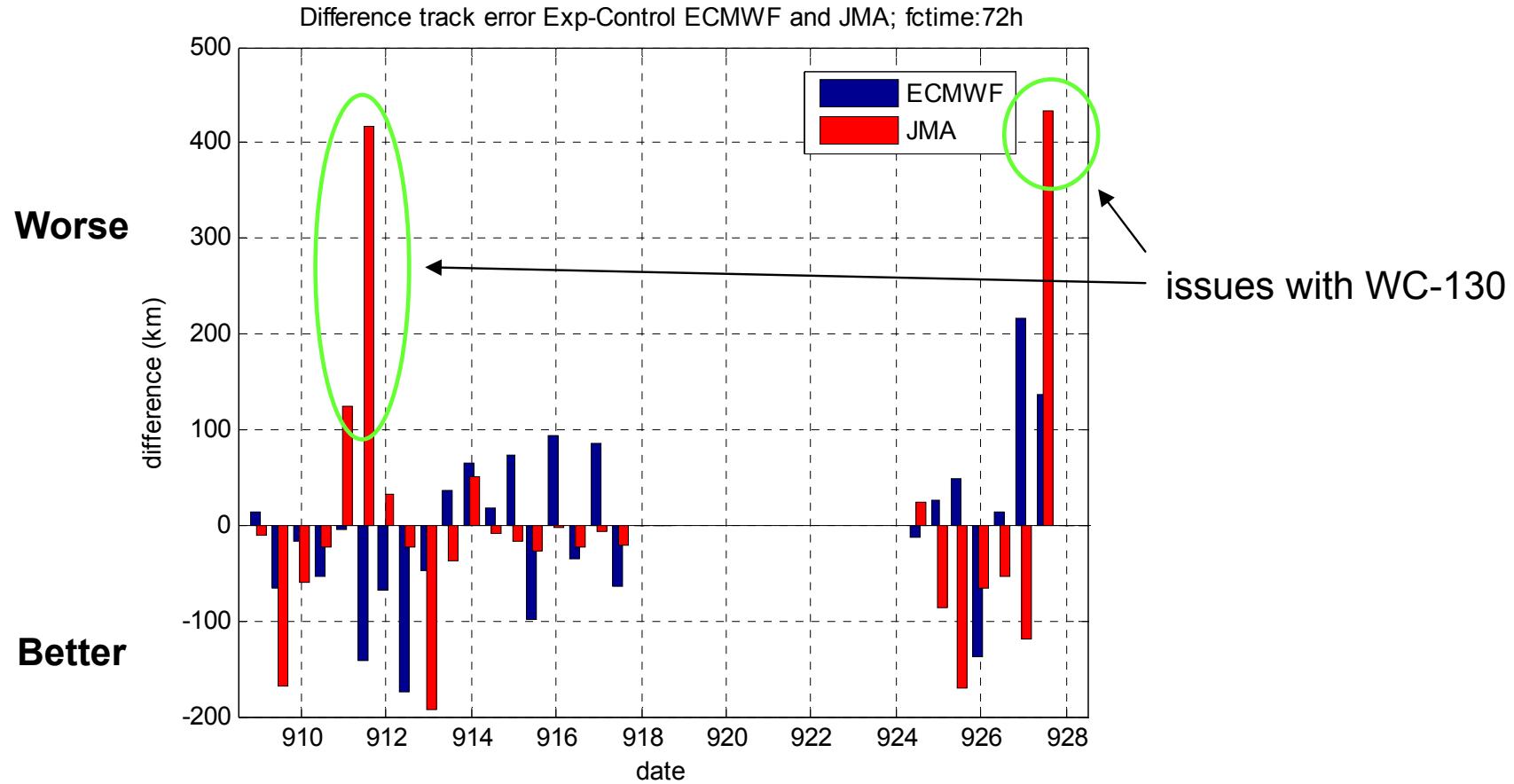
(Analysis, Model)

- First Guess
- Assimilation of Data (accept/reject) **near the TC center**
  - **Data Quality** near the center
- DOTSTAR gives large impacts
  - Better Quality around the TC



(Courtesy of Dr. Martin Weissmann)

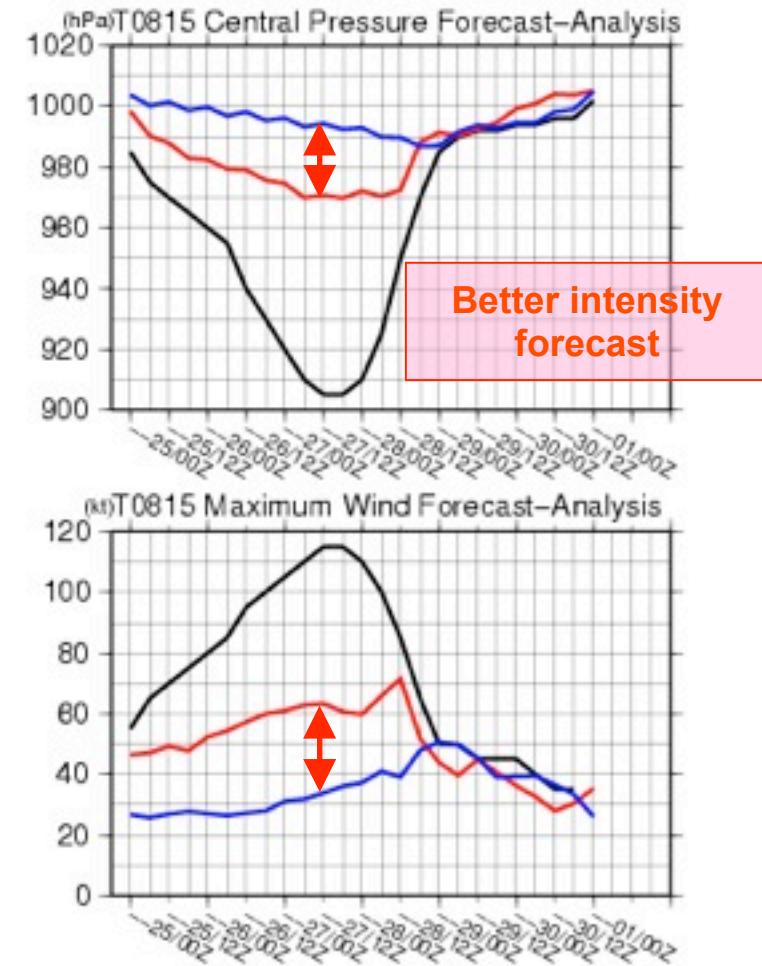
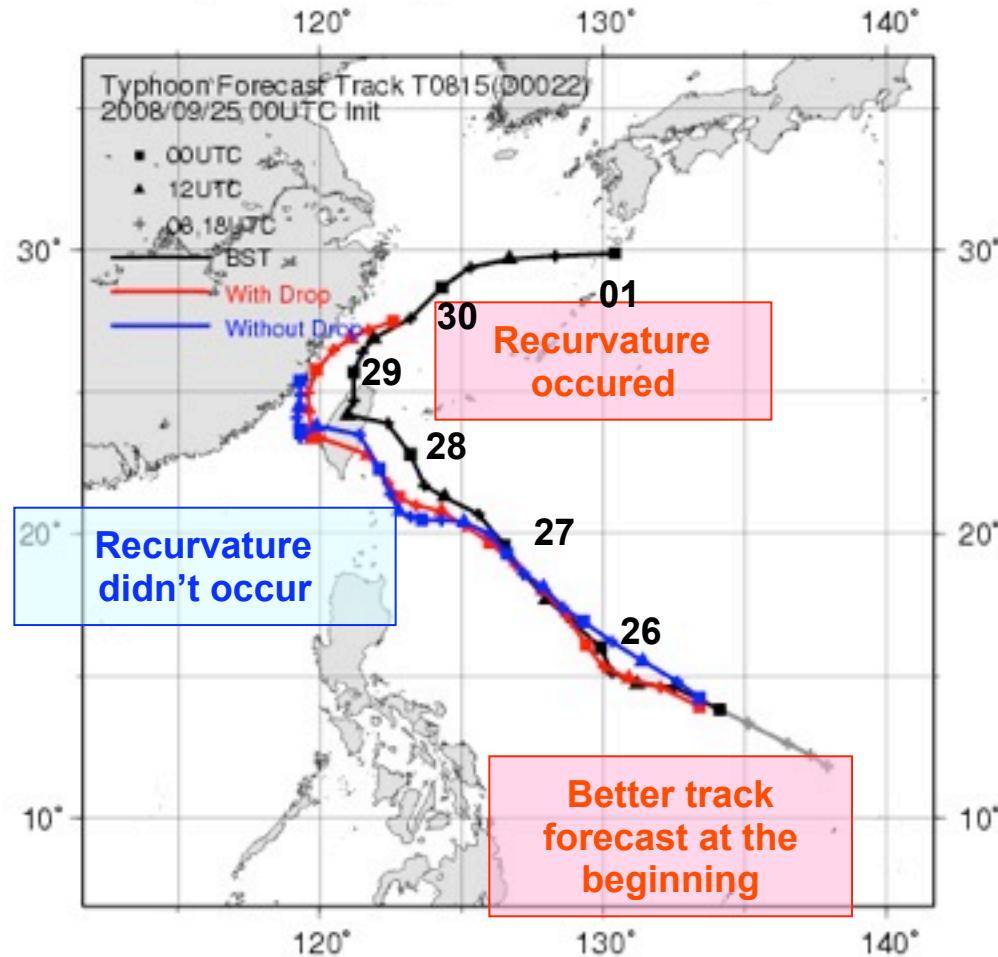
## ECMWF and JMA: 72h



(Courtesy of Dr. Martin Weissmann)

# 台風 JANGMI の場合は？

9/25 00UTC Initial (JANGMI)



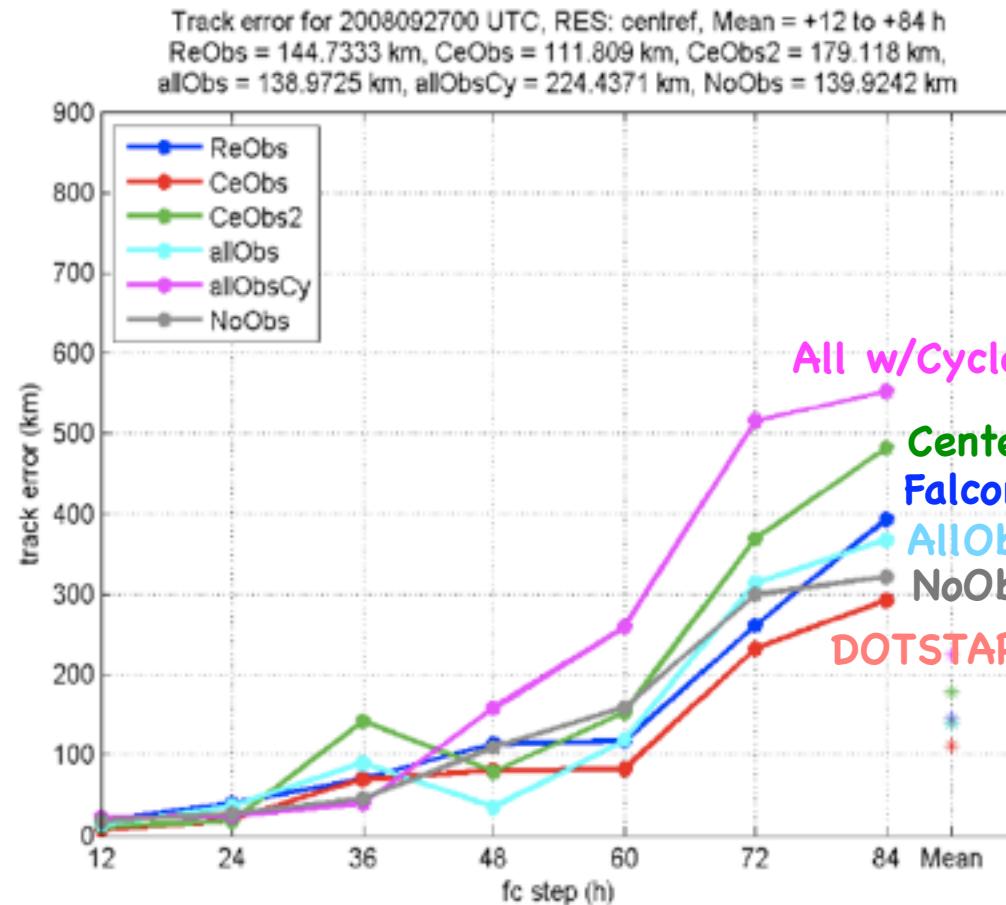
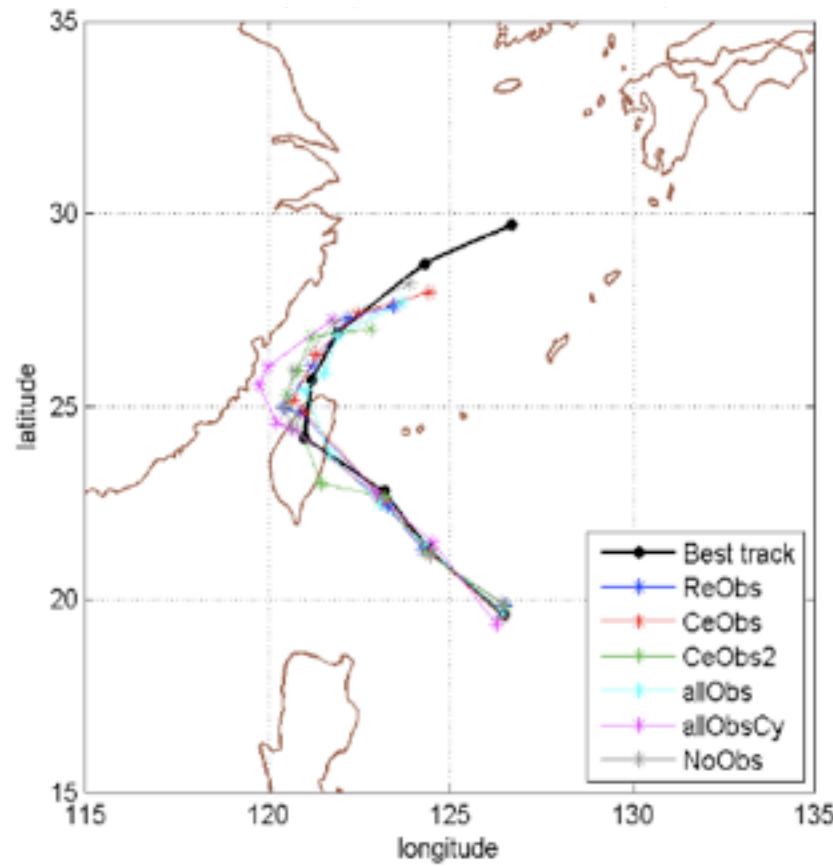
Red : With Drop ( Test ) Blue : Without Drop ( Cntl )

Black : JMA Besttrack

# 台風 JANGMI の場合は？

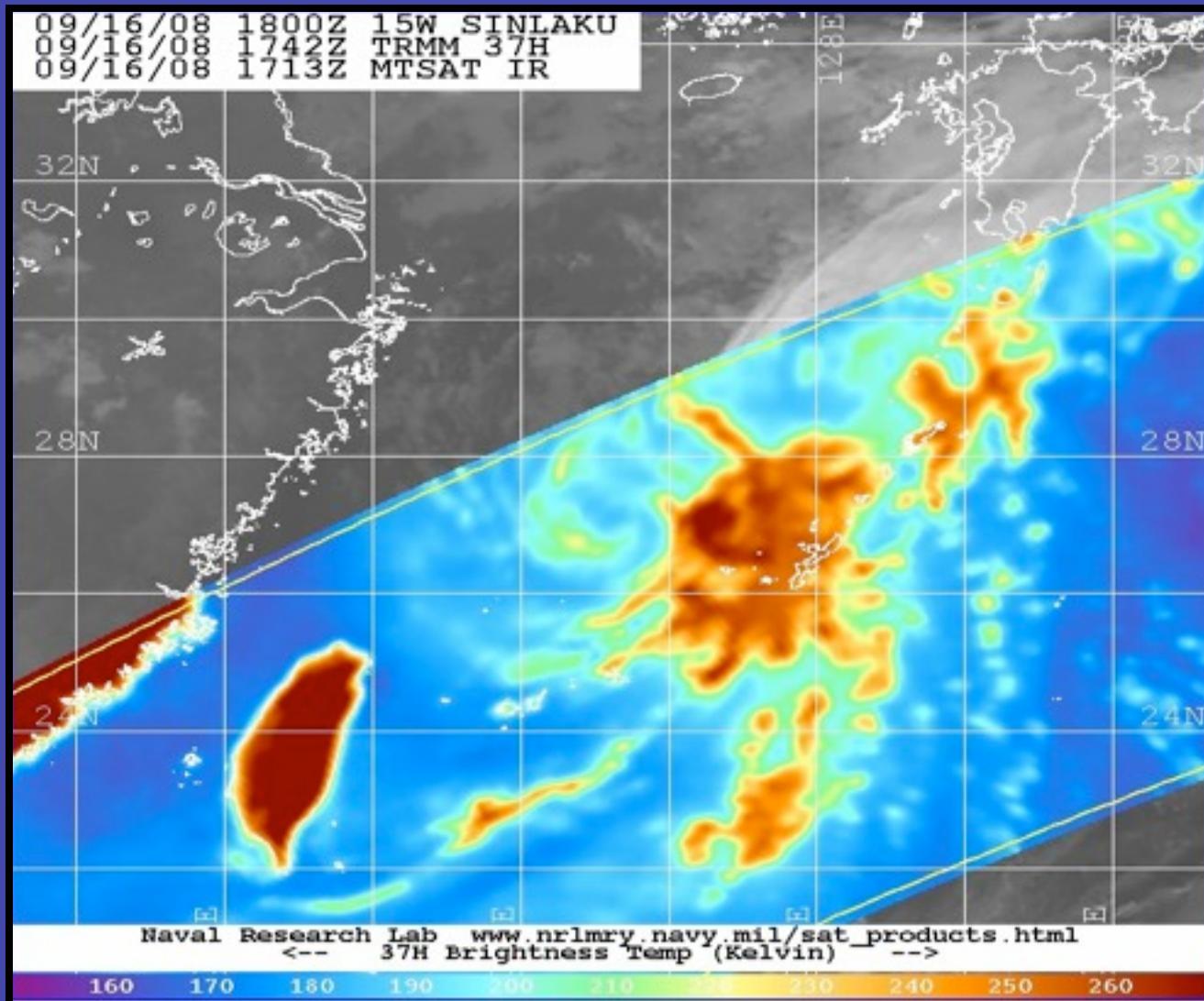
## Impact Studies for Jangmi by ECMWF

9/27 00UTC

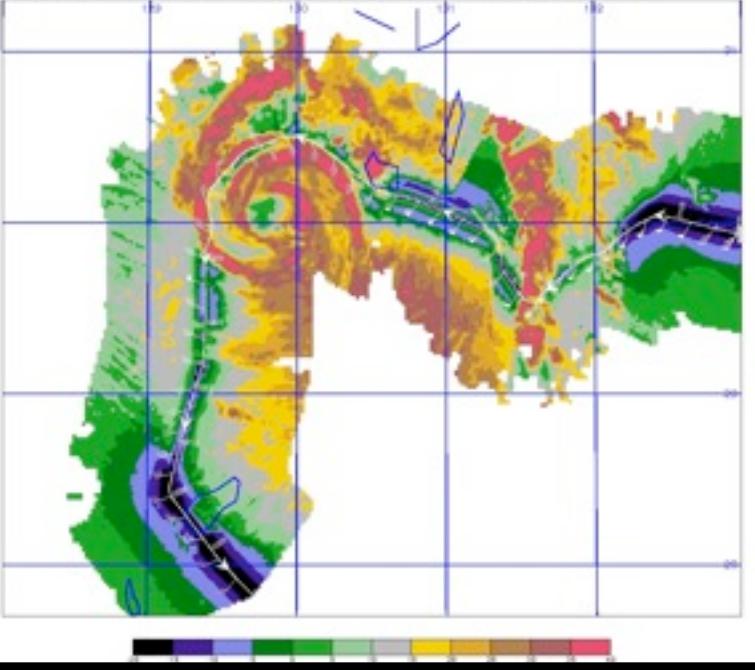


# Tropical Cyclone Intensity/Structure Changes, Extratropical Transition, and Downstream Impacts

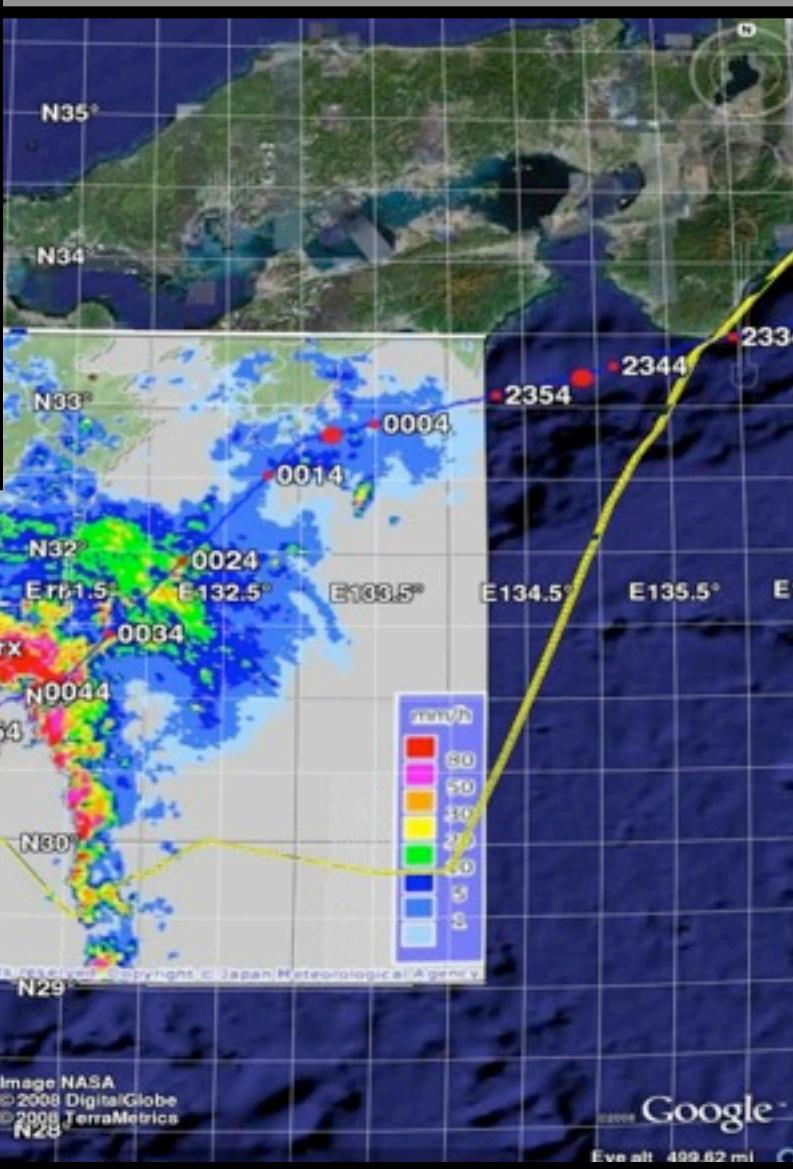
TY Sinlaku recycles to move east-northeast under strong westerly shear



NRL P-3 RF14 ELDORA-TA 1.5KM DBZ(2008/09/18 01:00-02:30)



Despite the strong shear, Sinlaku re-intensified to typhoon strength as the ET process initiated.



# Firsts

- First four plane operation in a WPAC TC
- First systematic targeting operation in the WPAC
  - Comparison of several methods from a variety of operational and research organizations
  - Multiple aircraft
  - ECMWF/UKMO Data Targeting System
- First systematic observations of full extratropical transition process
  - Multiple aircraft, land-based radar, MTSAT rapid-scan winds
  - Timed with satellite overpass
- First operation of WC-130Js at 31,000 ft altitude except when penetrating a mature TC
  - Dropped sondes and AXBTs from high altitude
  - Timed with passage of polar-orbiting satellites for satellite intensity validation
- First buoy drop in front of a WPAC TC
  - Two TCs
  - First time a category 5 TC passed over buoys dropped in its path

# 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**

# 昨年の台風特別観測T-PARCがめざしたもの

- 最適観測法=「観測のツボ」を探ること
  - ここで観測すれば予報を改善できる、という場所を推定できるようになってきた
  - まだ研究段階、確立された方法ではない
- 観測データのインパクト実験
  - すでにいくつかの台風で予報改善効果を確認
  - それぞれのインパクトをさらに調べる必要あり
    - 航空機からのドロップゾンデ
    - 地上、海上からの高層観測
    - 「ひまわり」からの高頻度観測