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Regional cooperation in forecasting early warning and monitoring of typhoon

Chiashi Muroi
RSMC Tokyo Typhoon Center
Japan Meteorological Agency

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- Related activities
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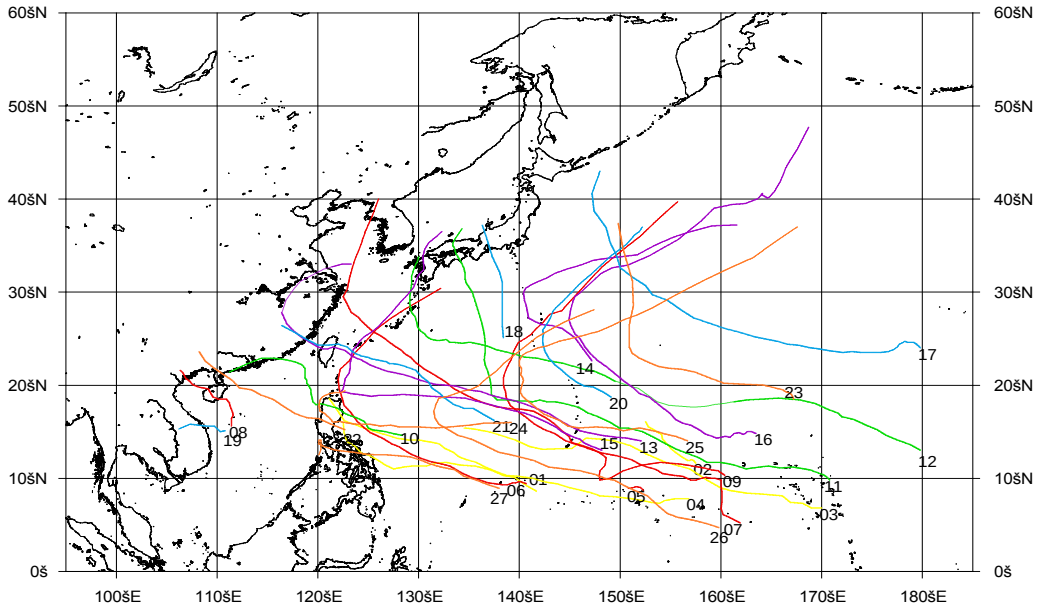
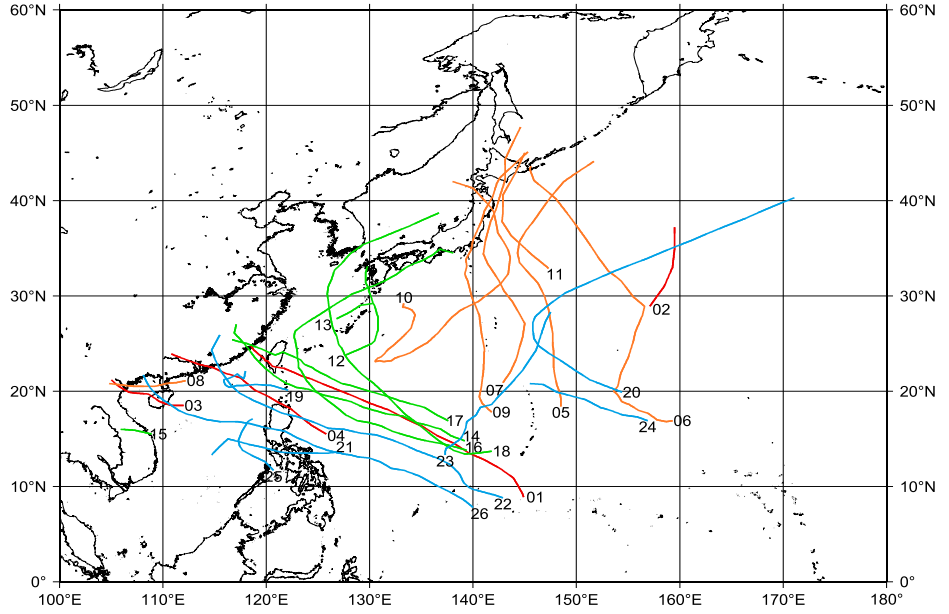
INTRODUCTION

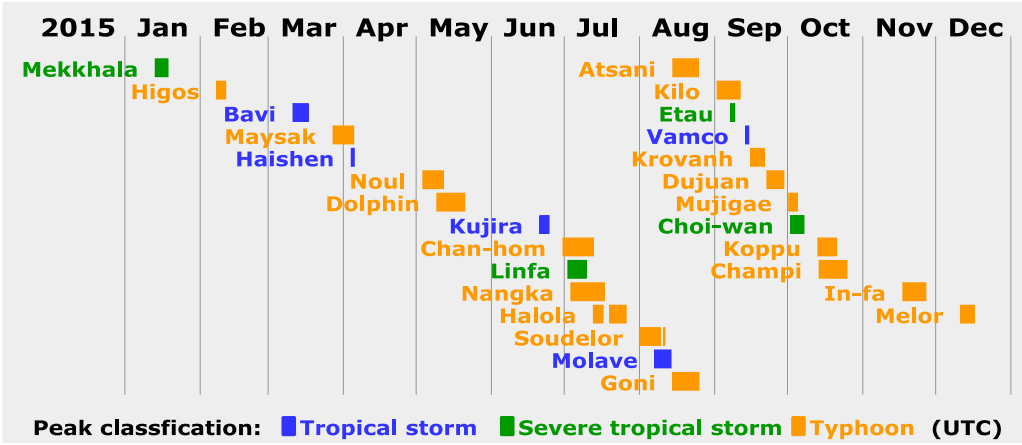
Tropical cyclones in 2015 and 2016

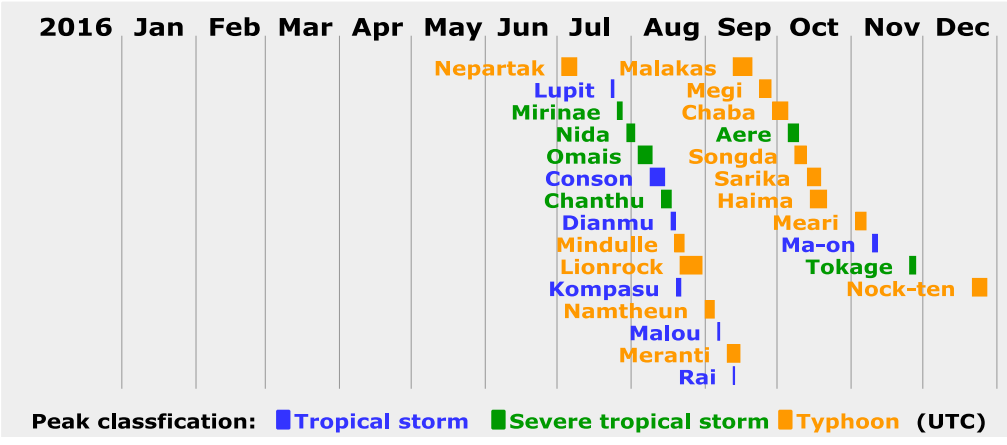
2015



2016

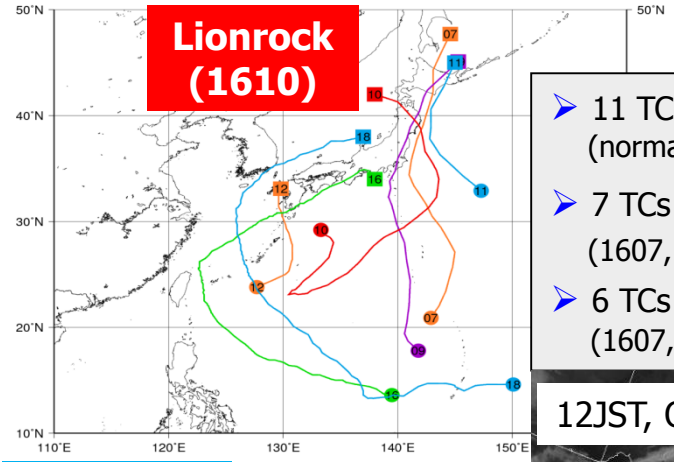






Tropical cyclones affected Japan in 2016 and 2017

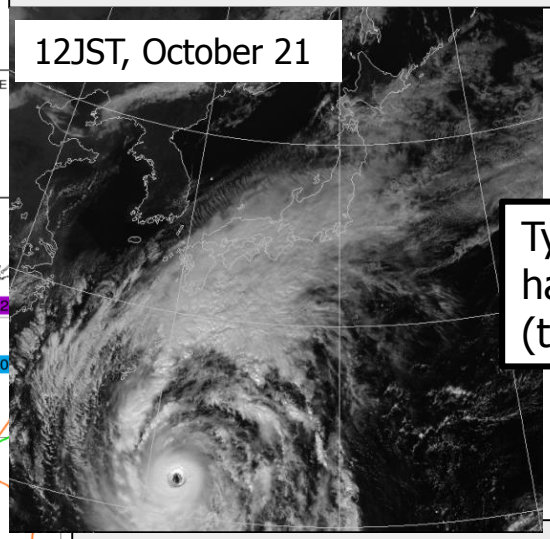
2016

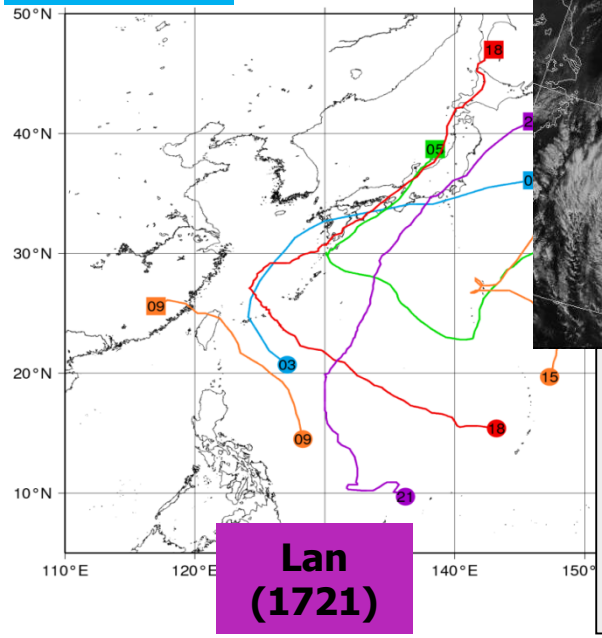


- 11 TCs approached
  (normal: 11.4 TCs / year)
- 7 TCs affected
  (1607, 1609, 1610, 1611, 1612, 1616, 1618)
- 6 TCs made landfall
  (1607, 1609, 1610, 1611, 1612, 1616)

Typhoon Lionrock left 20 people dead in Iwate Prefecture and 2 in Hokkaido with 5 missing.

2017





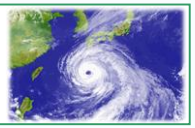
- 12 TCs approached
  (normal: 11.4 TCs / year)
- 7 TCs affected
  (1703, 1705, 1709, 1710, 1715, 1718, 1721)
- 4 TCs made landfall
  (1703, 1705, 1718, 1721)

Typhoon Lan brought huge amount of rainfall in Japan, having left 8 people dead with more than 200 injured (tentative statistics as of 26 Oct.)

RSMC TOKYO TYPHOON CENTER

Tropical Cyclone Information Chain

Observation

- Meteorological Satellites 
- Weather Radars 

Upper-air Observation

- Wind Profilers 
- Radiosondes 

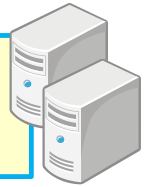
- Surface Observation "AMeDAS" 

- Observation of Central Governmental and Local Authorities

Quality Control / Monitoring

Statistics 
- Normal value
- Extreme values

Analysis 
- Short-range forecasts
- Precipitation analysis

Numerical Models 
- Numerical prediction

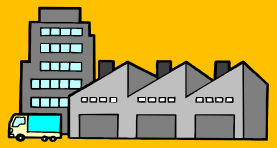
Forecast

Warning

Real-time Monitoring Data

Disaster prevention

Socioeconomic activities



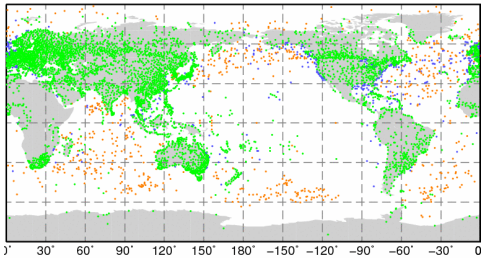
Transportation

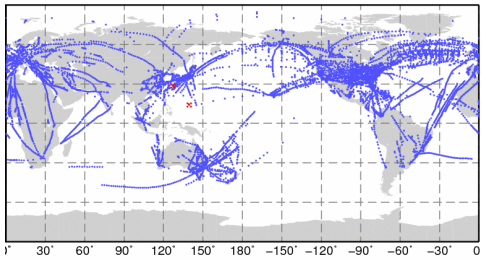
etc.

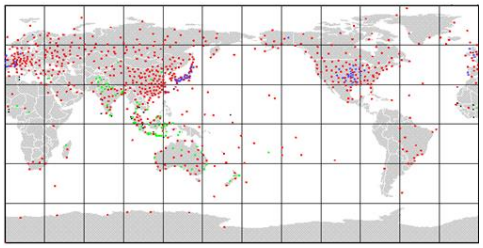
Numerical Weather Prediction (NWP)

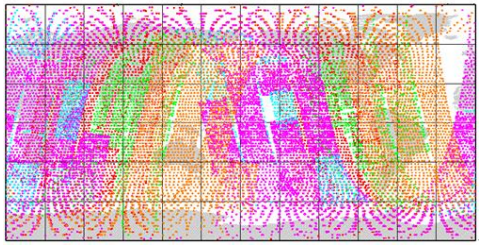
Forecast

Observation data



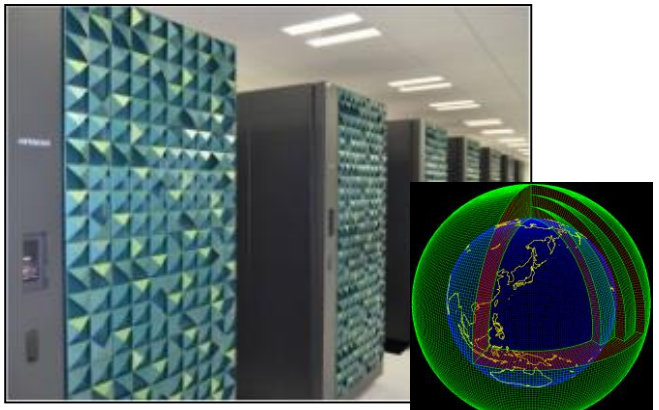






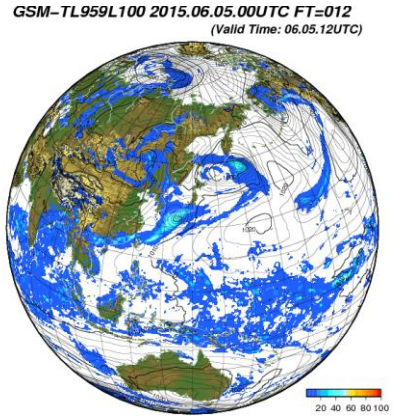
assimilation

Numerical Prediction



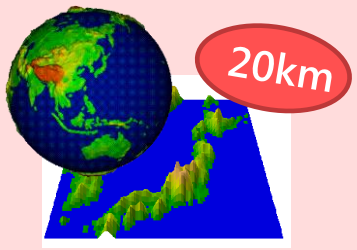
Super Computer
(9th-generation since 1959)

NWP products

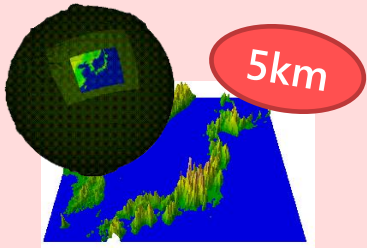


JMA's NWP models

Global Scale Model (GSM)

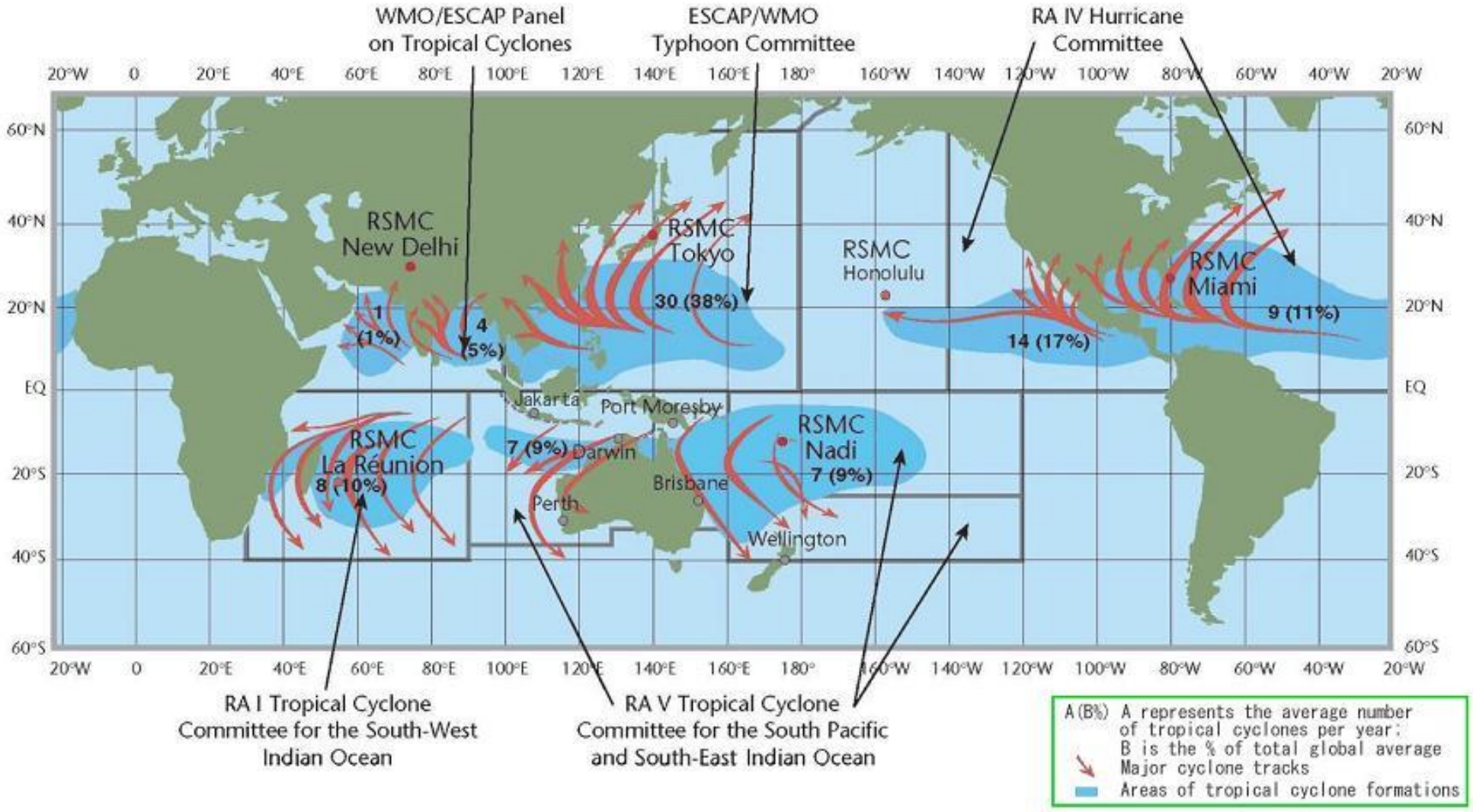


Meso-Scale Model (MSM)



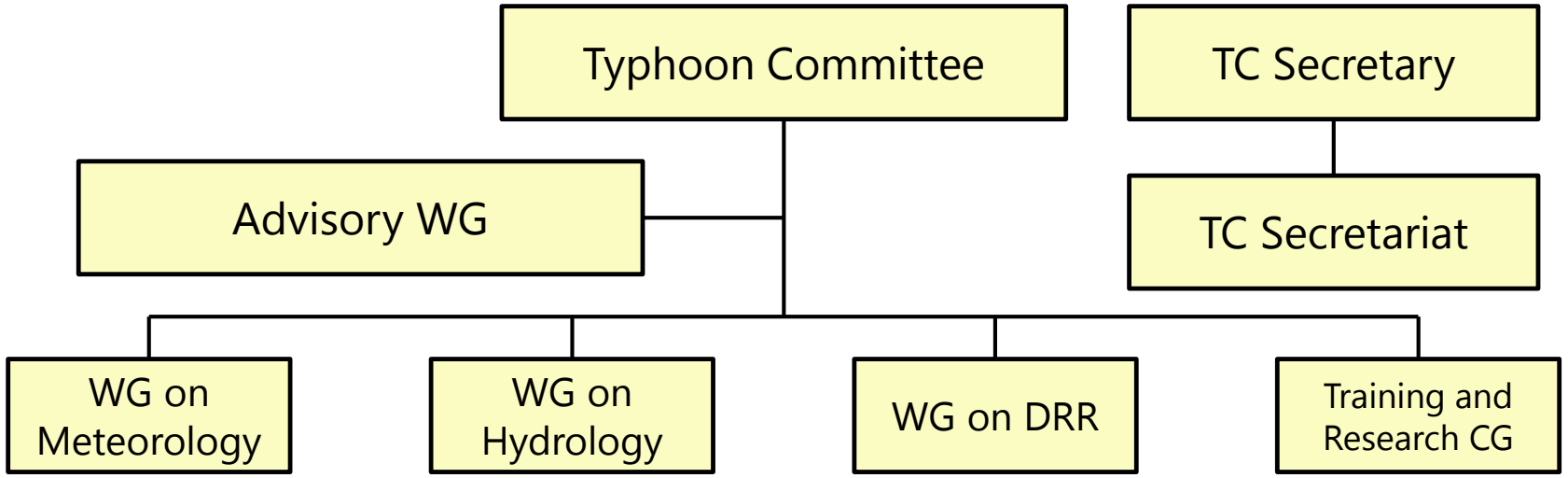
Local Forecast Model (LFM)

RSMC Tokyo – Typhoon Center



ESCAP/WMO Typhoon Committee

14 Members: Cambodia, China, DPR Korea, Hong Kong(China), Japan, Lao PDR, Macao (China), Malaysia, Philippines, Republic of Korea, Thailand, Viet Nam, Singapore, U.S.A.



WGM projects initiated by RSMC Tokyo

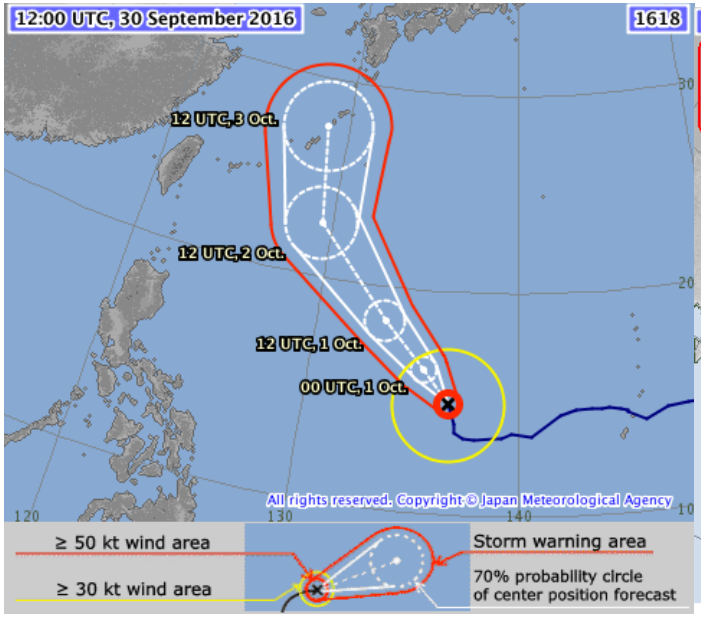
- Enhanced use of ensemble forecast
- Development of regional radar network
- Storm surge watch scheme
- Development of tropical cyclone forecasting competency
- Enhancing utilization of Himawari 8/9 products (in plan)

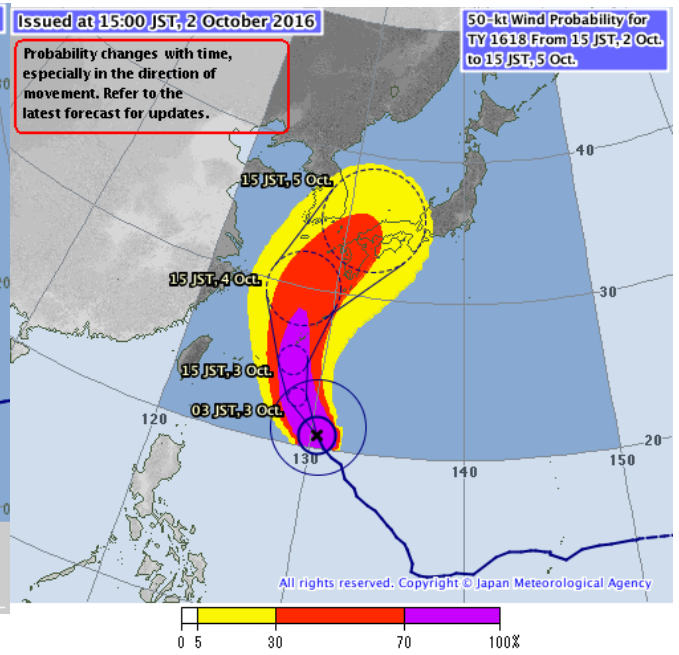
RSMC Tokyo Products via GTS

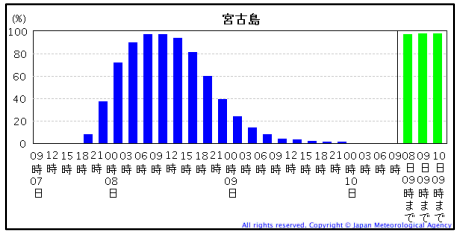
RSMC TC advisory for 3-day forecast (WTPQ20-25)	issued within 50 minutes after observation times at 00, 06, 12, 18 UTC
RSMC TC advisory for 5-day track forecast (WTPQ50-55)	issued within 90 minutes after observation times at 00, 06, 12, 18 UTC
SAREP (IUCC10) in BUFR Format	issued a half to 1 hour after observations at 00, 03, 06, 09, 12, 15, 18, 21 UTC
Guidance for Forecast (FXPQ20-25)	GSM predictions: issued 3.5 hours after initial analyses at 00, 06, 12, 18 UTC (up to 84 hours ahead) GEPS ensemble mean track predictions: issued 4.2 hours after initial analyses at 00, 06, 12, 18 UTC (up to 132 hours ahead)
Tropical Cyclone Advisory for SIGMET (FKPQ30-35)	issued 6 hourly for aviation via the AFTN
Tropical Cyclone Best Track (AXPQ20)	issued one and a half month after a TC dissipated
Prognostic Reasoning (WTPQ30-35)	issued at 00 and 06 UTC following the TC advisory

RSMC TC Advisory

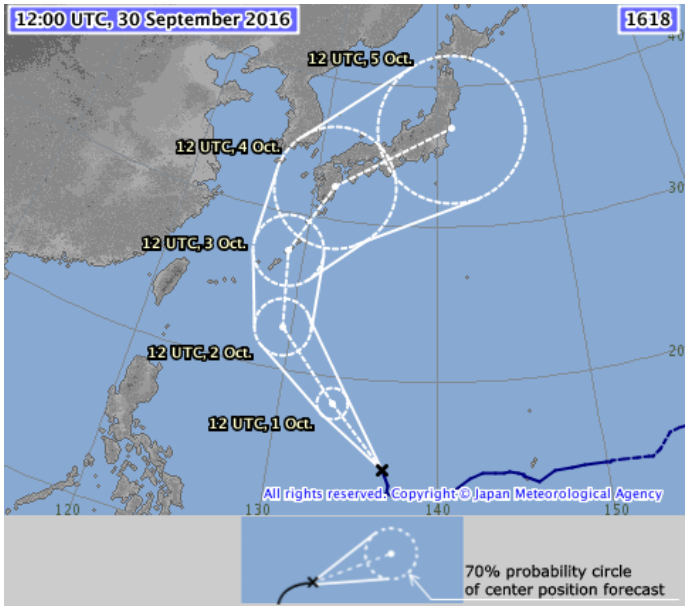
3-day track and intensity forecast







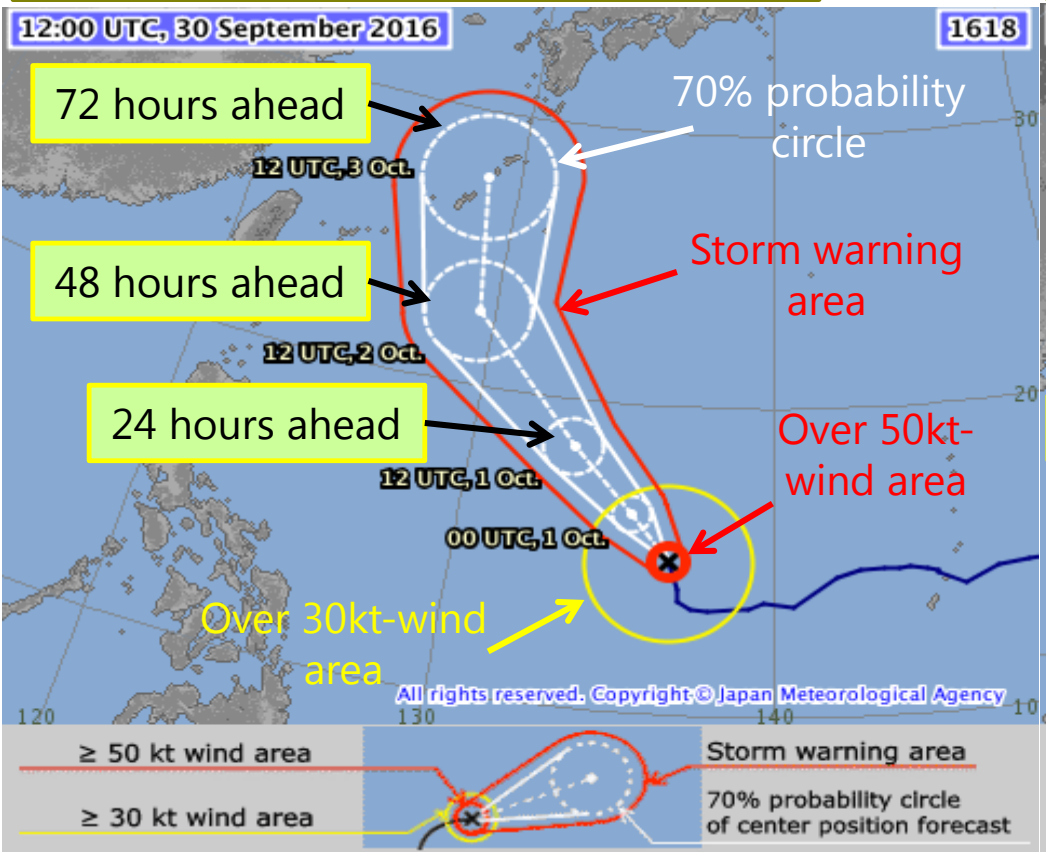
5-day track forecast



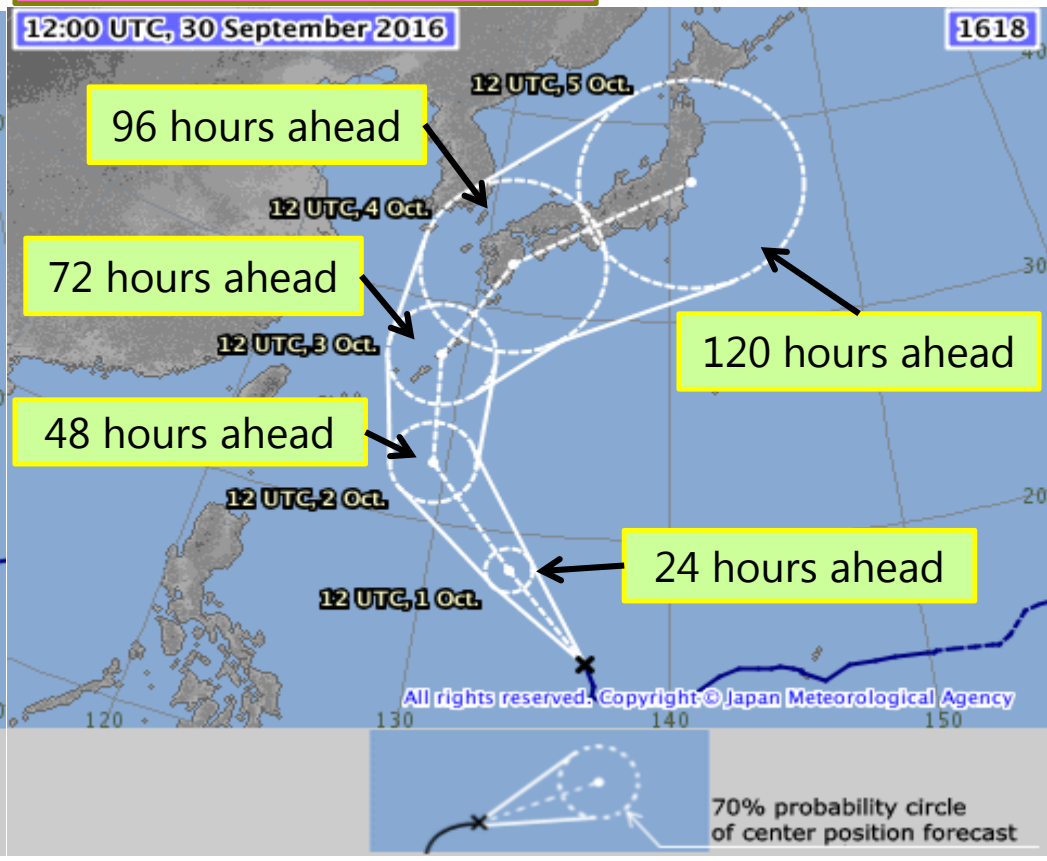
- Determined by operational forecasters with reference to global NWP models, environmental fields (Sea Surface Temperature, low/mid- level humidity, interaction with land etc), knowledges and experiences.

RSMC TC Advisory

3-day track & intensity forecast



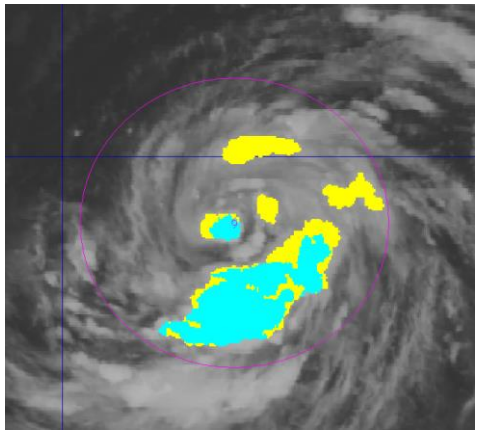
5-day track forecast



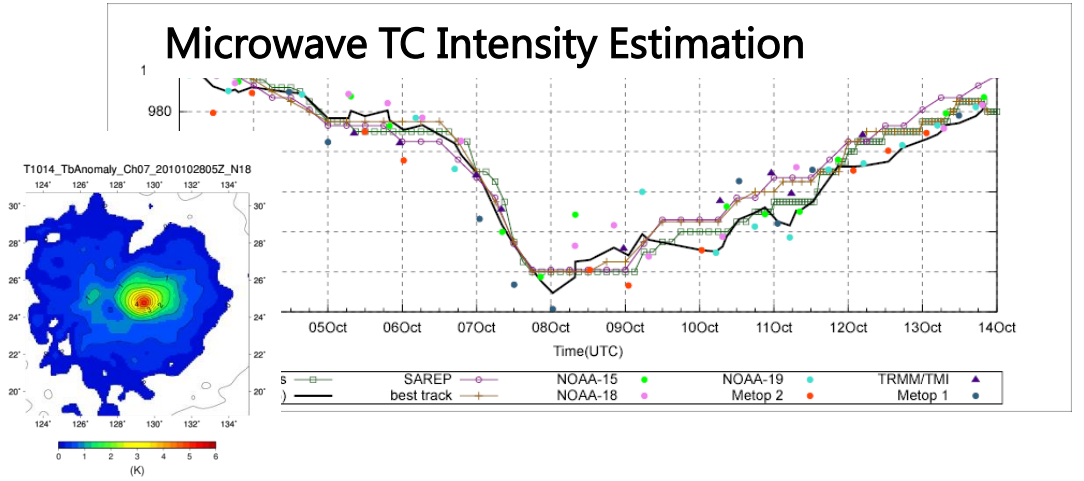
issued every 6 hours

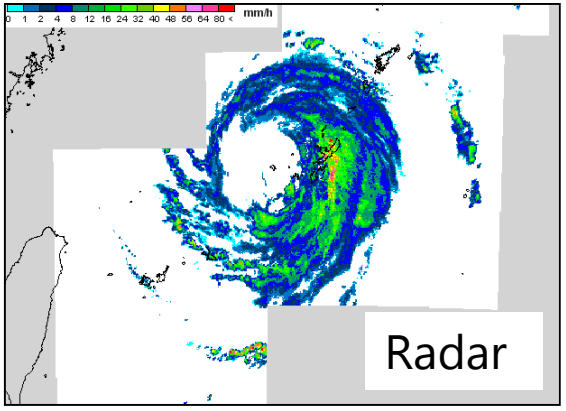
TC Analysis (00, 03, 06, 09, 12, 15, 18, 21 UTC)

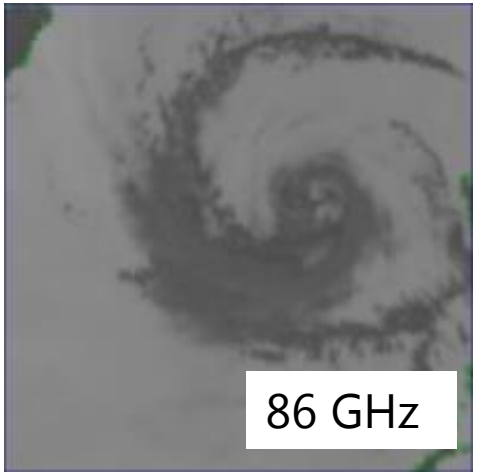
- Determine TC position every 3 hours and intensity every 6 hours using satellite observations, and surface observations if any (e.g., Himawari-8, satellite microwave and radar).

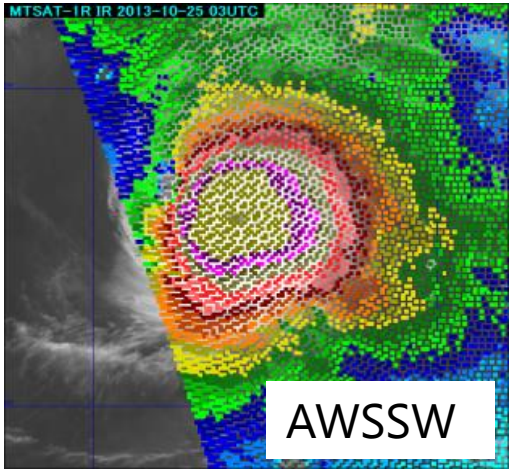


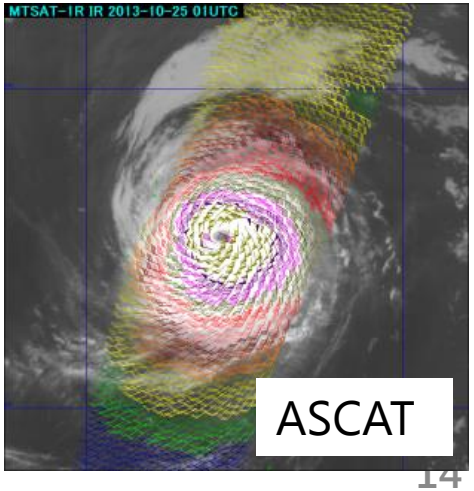
Dvorak (semi-objective, CLOUD)





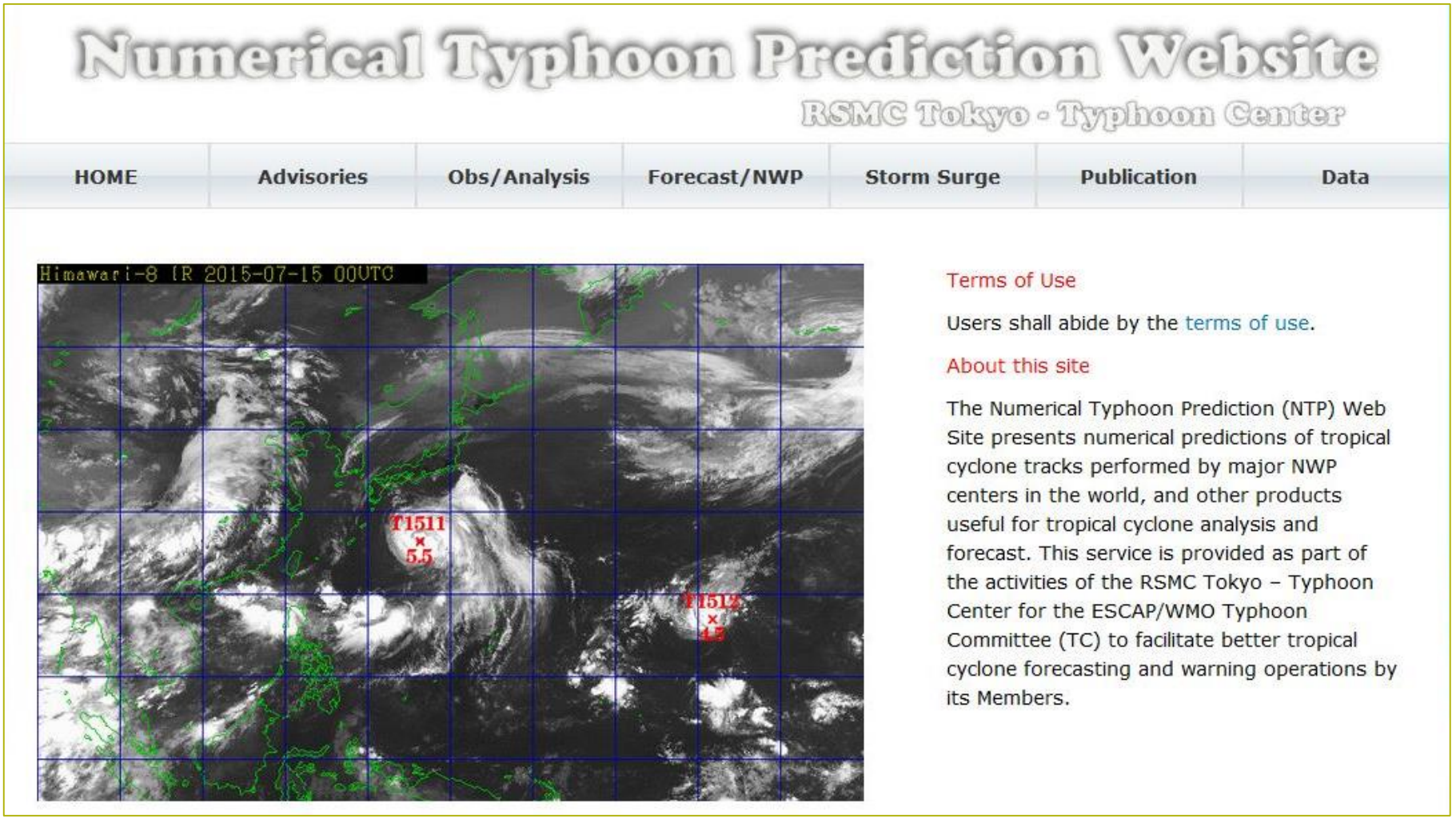






RSMC Tokyo Products via Internet for TC members

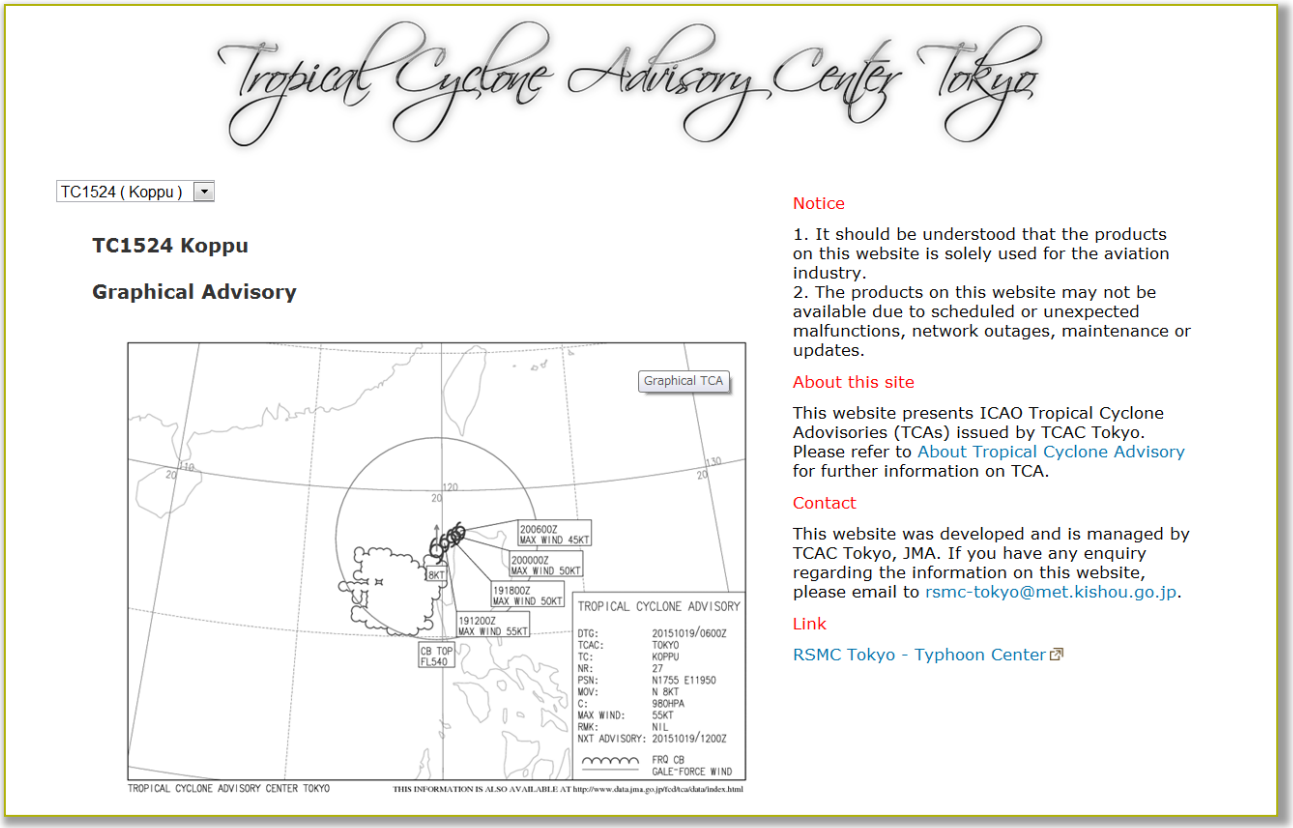
- available for registered TC Members.
- TC related products supporting user's operational TC Service are provided.



https://tynwp-web.kishou.go.jp/

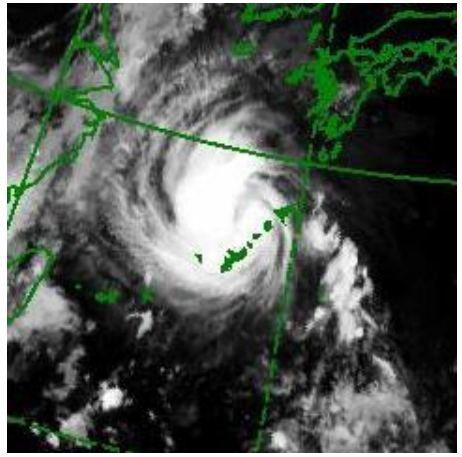
Tropical Cyclone Advisory for SIGMET in graphical format

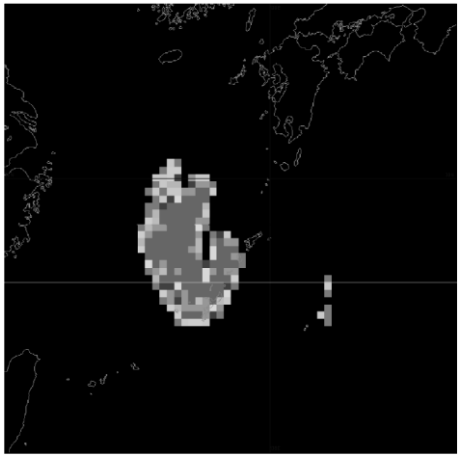
- RSMC Tokyo, as ICAO TCAC, has provided TC advisories (TCAs) for aviation users in graphical format according to MODEL TCG in ICAO Annex 3 since August 2015.
- Cloud grid information is used for the analysis of CB areas.



http://www.data.jma.go.jp/fcd/tca/data/index.html

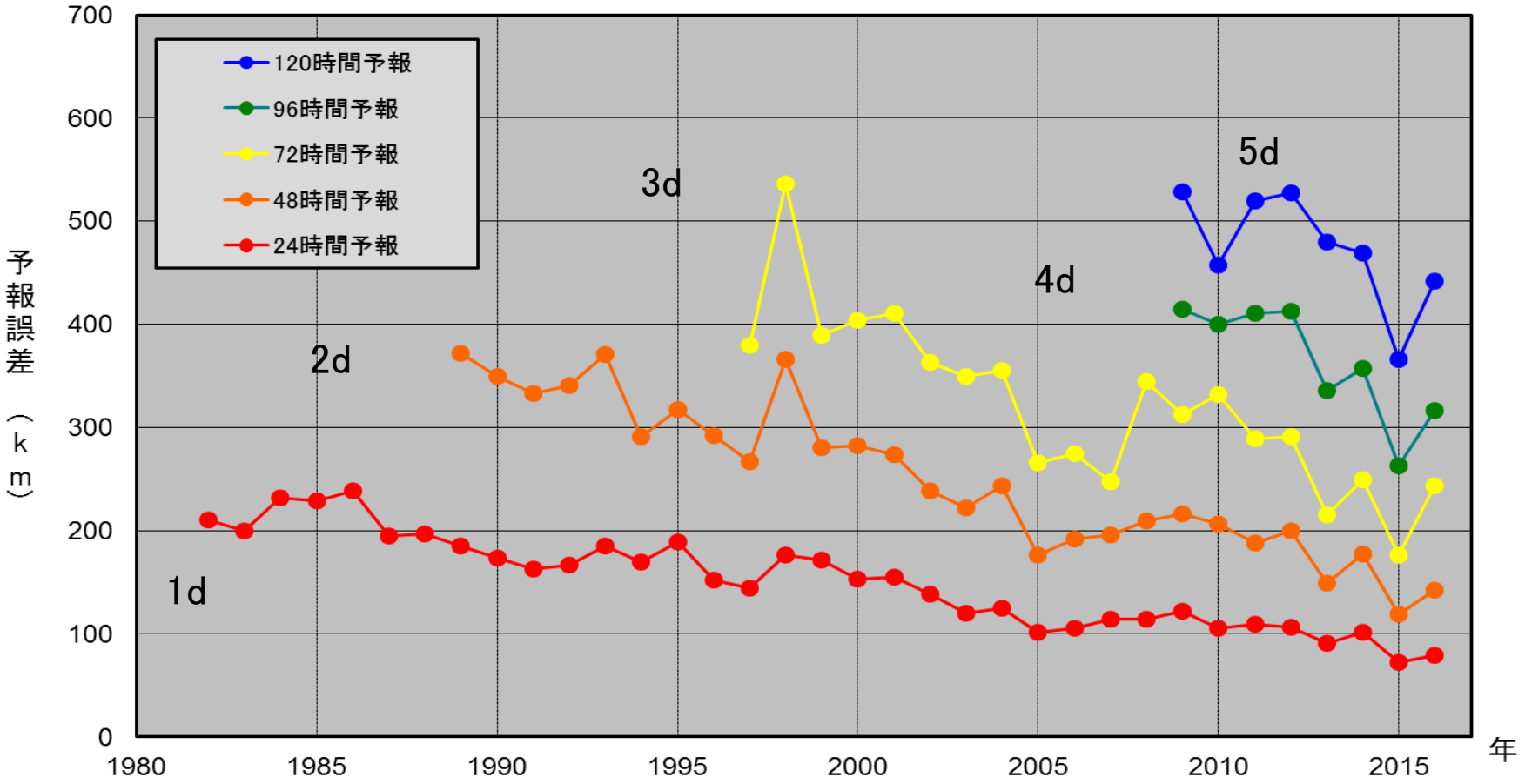
satellite imagery (IR)





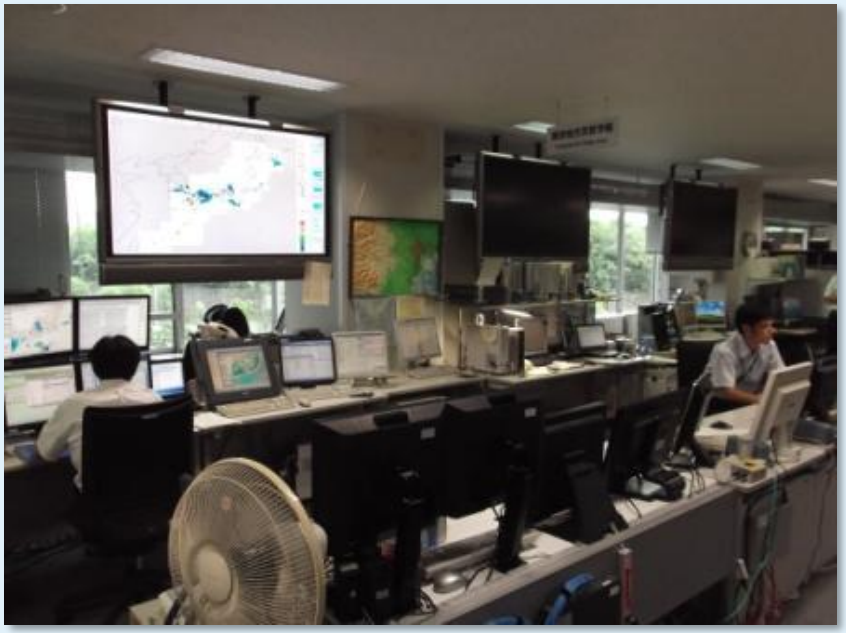
cloud grid information
(Amount of Convection Cloud)

Accuracy of Typhoon Track Forecast

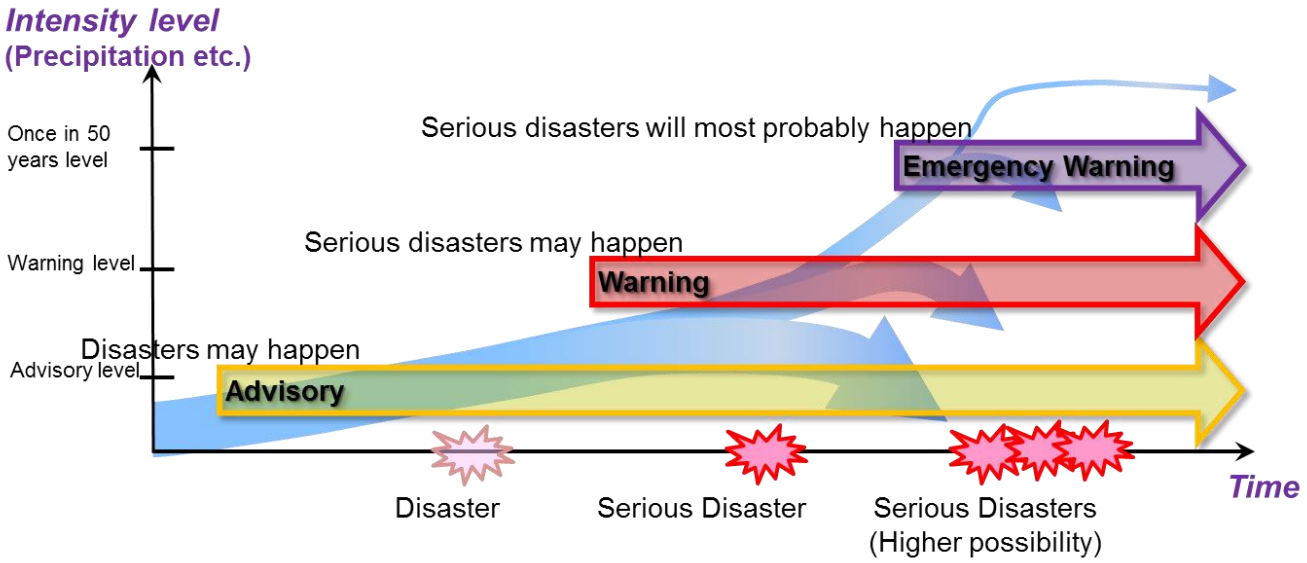


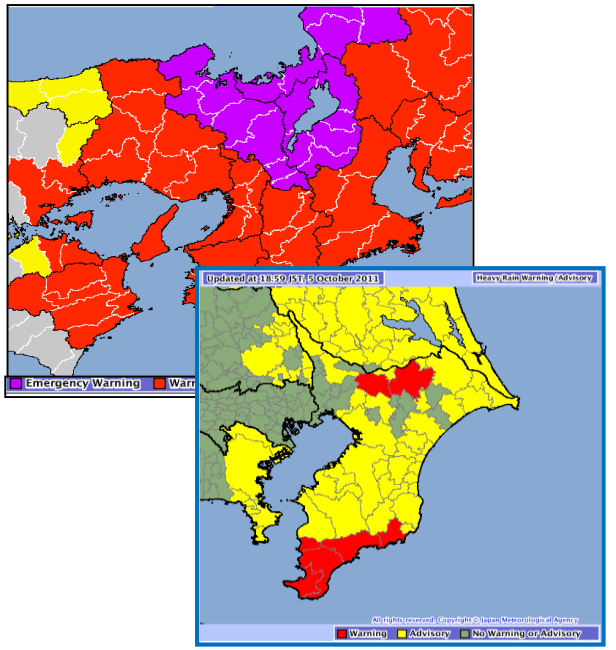
Although the precision of typhoon course forecast is yearly fluctuation due to the characteristics of the typhoon of that year,
Steadily improving by improving forecasting technology such as improvement of numerical forecast model.

IMPACT-BASED FORECAST AND EARLY WARNING



Warnings / Advisories Lineup





Warning zone is divided into municipalities

Issued by Local Met. Offices

Emergency Warnings (6)

Storm	Snow-storm	
Heavy rain	Heavy snow	
Storm surge	High waves	

Warnings (7)

Storm	Snow-storm	Flood
Heavy rain	Heavy snow	
Storm surge	High waves	

Advisories (16)

Heavy rain	Gale	Gale and snow
Heavy snow	Dense fog	Thunderstorm
Dry air	Avalanche	Ice (snow) accretion
Frost	Flood	Low temperature
Storm surge	High waves	Snow-melting

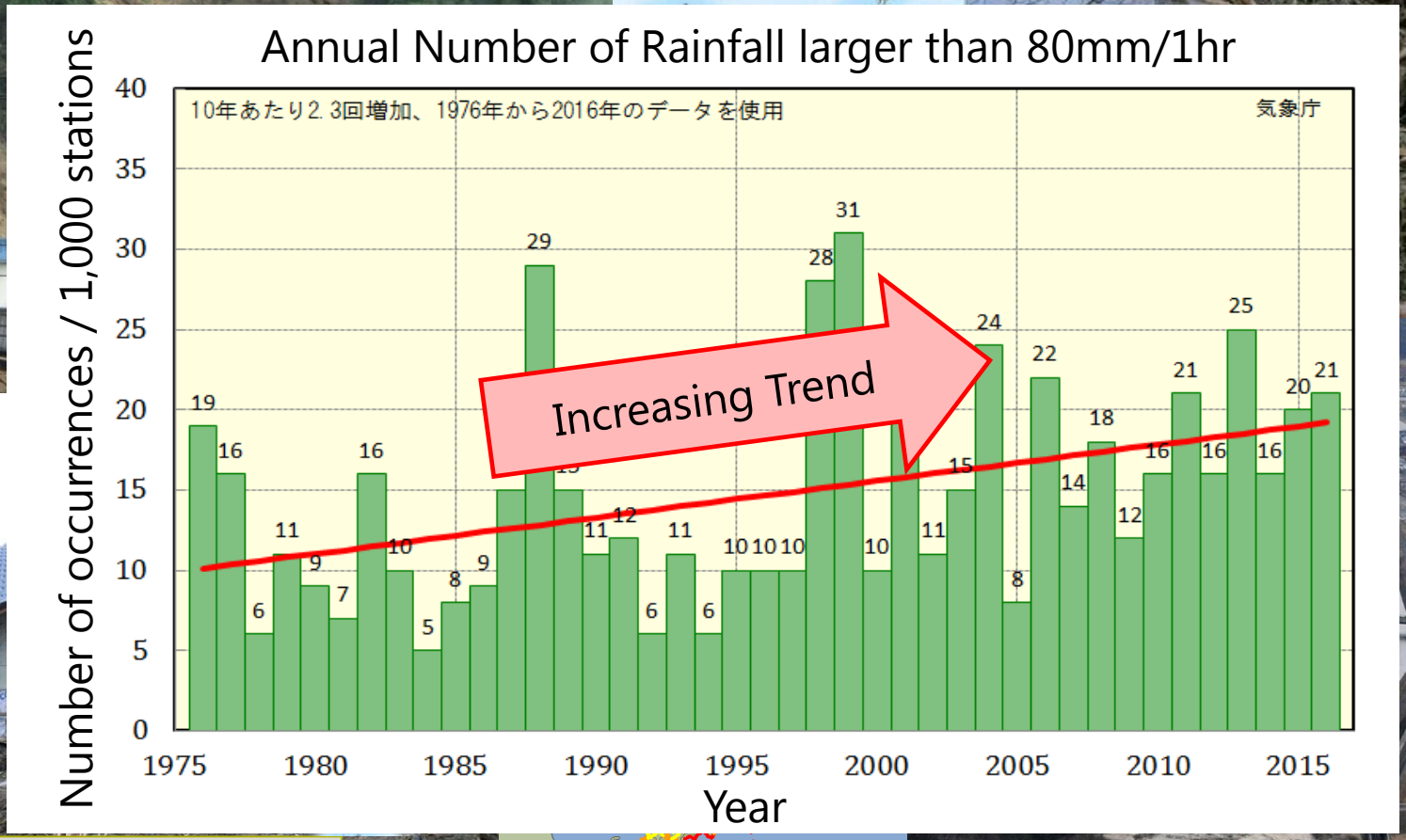
Disasters in Japan since 2011

Landslide Disaster in Hiroshima in 2014

20 Aug. 2014
217.5 mm/3hr in Hiroshima City
74 People Killed

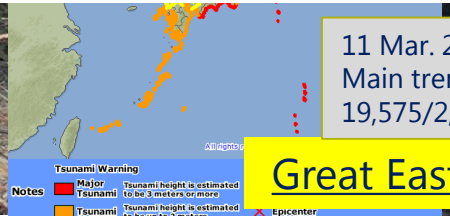
Flood Disaster by Lionrock (T1610)

30 Aug. 2016
231 mm/24hr in Kuji City, Iwate
22 People Killed, 5 People Missing



16 Oct. 2013
122.5mm/1hr, 824.0mm/24hr in Izu-Oshima
35 People Killed, 4 People Missing

Landslide Disaster by Wipha (T1326)

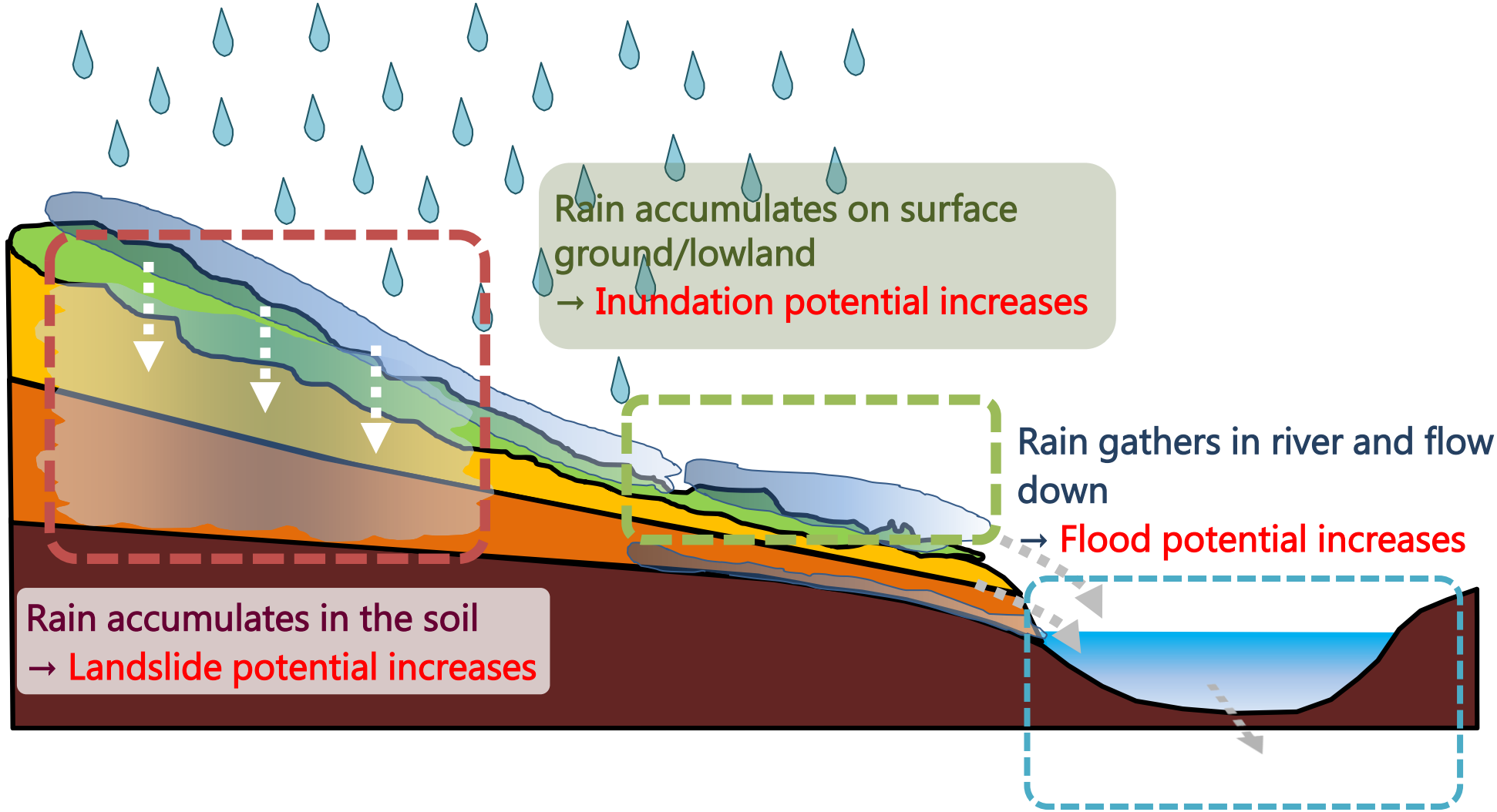


11 Mar. 2011
Main tremor magnitude 9.0, recorded tsunami height: 9.3 m in Souma
19,575/2,577 dead and missing

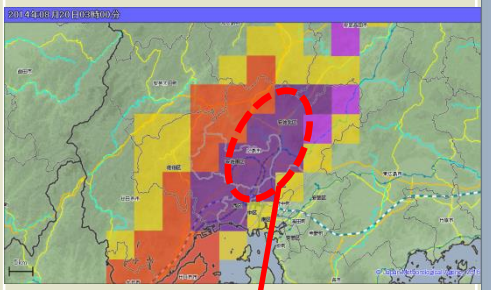
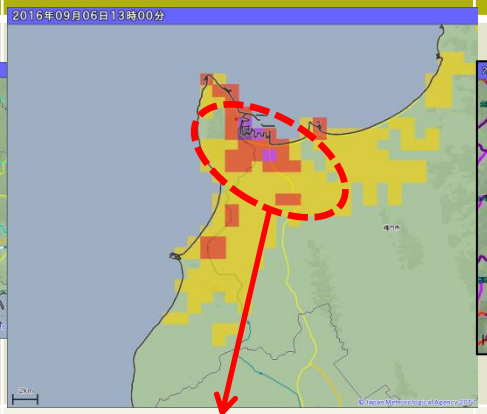
Great East Japan Earthquake and Tsunami in 2011

Risks of Rainfall-induced Hazards

Rainfall increase the risks of **three disasters**



Real-time Risk Map

	Landslide (2015-)	Inundation (2017-) NEW!	Flood (2017-) NEW!
Risk Map			
Related Disaster			
Resolution	5 km	1 km	1 km
Update Interval/Lead-time	10 min / 2hours	10 min / 1hour	10 min / 3hours

- Supplement information to shows levels of risk on Map with an of five risk levels ranking from of white to purple

Utilization of Real-time Risk Map

Warning Message

- Heavy rain Advisory
- Heavy rain Warning
- Landslide Disaster Alert Information
- etc.

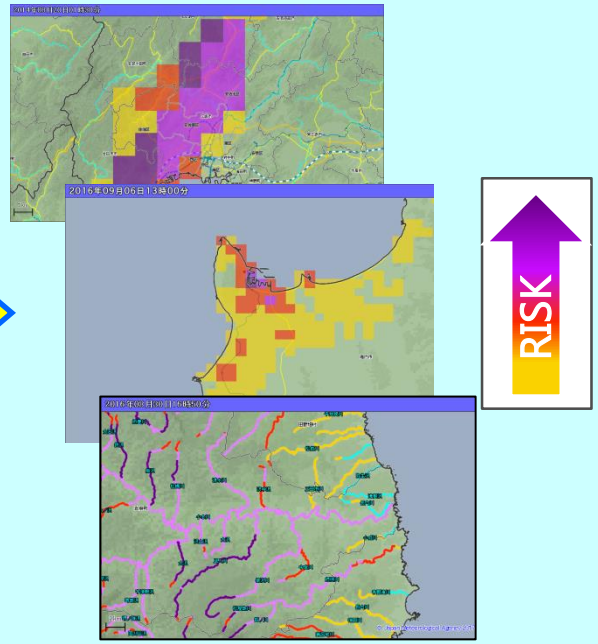
Inform Increase of Risk

DRR stakeholders

Residents

Check the risk area in detail

Real-time Risk Map



Understand the detail of disaster risks

- prompt evacuation orders by Mayors
- rapid evacuation of residents

Enhancement of top-level communication

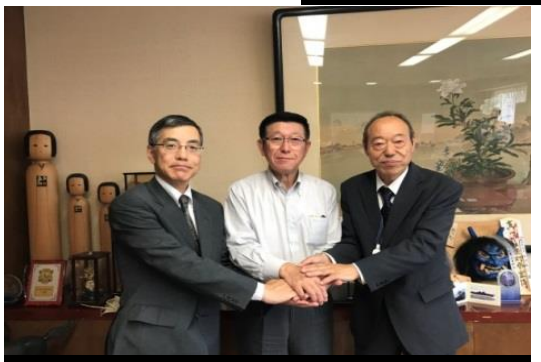
Top-level communications

【Construction of face-to-face relationship with municipalities】

Regular visits, communications on SNSs, joint training/drill activities

Meeting with Mayor of Ikutsu

Mayor of North Akita on Facebook



Meeting with Governor of Akita Prefecture

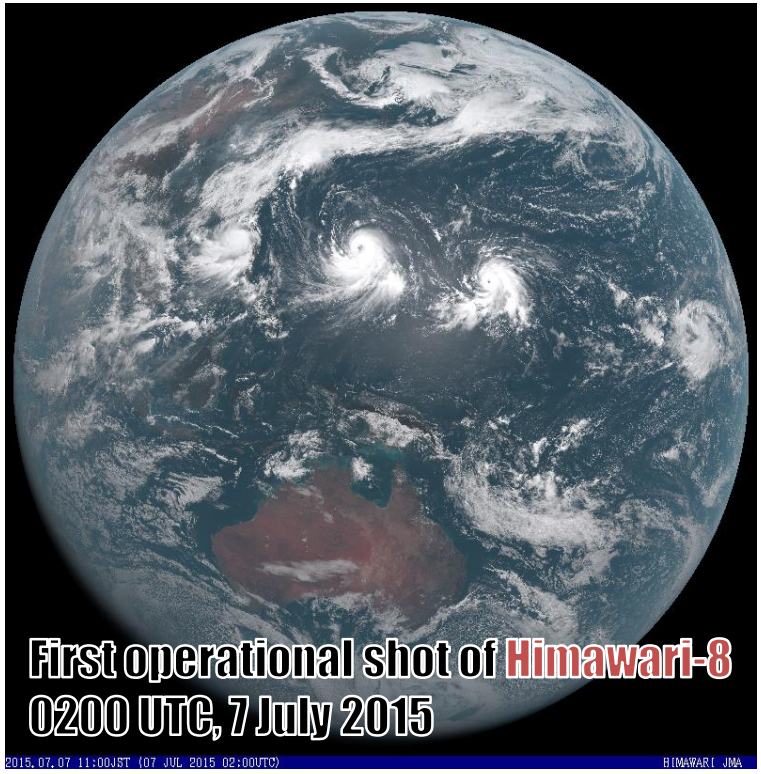
Advice in disaster situation

【Weather commentary from Director-General of Meteorological Office 】

Sharing the risk of approaching disaster, issuing instructions for prompt evacuation orders by Mayors and rapid evacuation of residents.

RELATED ACTIVITIES

Himawari-8 Utilization Support



- **Himawari-8** began operation on 7 July 2015 replacing **MTSAT-2**.
- **Himawari-9** was also launched and started backup operation for Himawari-8 at 00 UTC on 10 March 2017.

- Significant improvements of observation
  - Number of bands: **5** → **16**
  - Interval: **30/60 min.** → **10 min.**
  - Resolution: **1 km (VIS), 4 km (IR)** → **0.5 km (VIS), 2 km (IR)**

- JMA established three services for data distribution/dissemination.
  - **HimawariCast**: Primary data sets via a communication satellite
  - **HimawariCloud**: All imagery via an Internet cloud
  - **WIS server**: Limited data sets via WIS server
- **JMA has conducted experts dispatch missions to 23 countries in western North Pacific to enhance their weather monitoring and forecasting capacity using Himawari-8 imagery.**

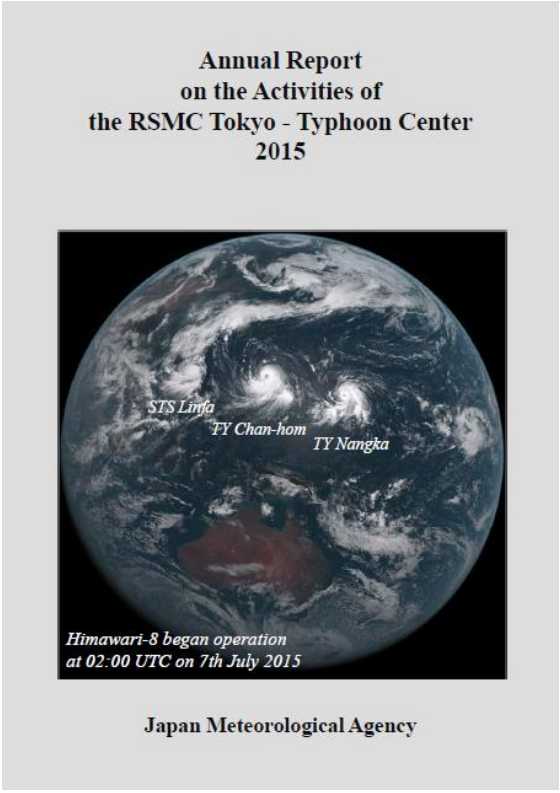
RSMC Tokyo Forecaster Training Attachment

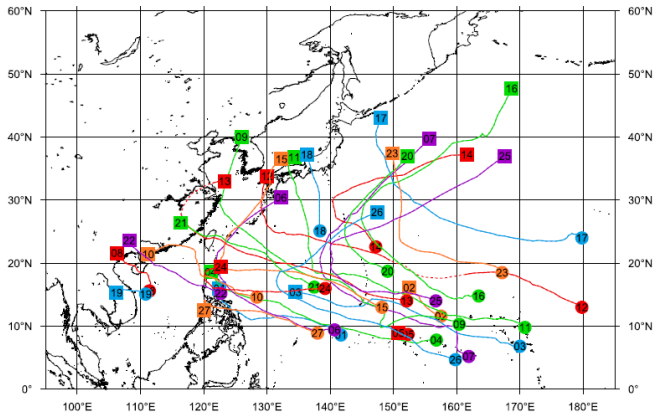
- The RSMC Tokyo Forecaster Training Attachment first came in 2007.
- The training focused on improvement of skills on tropical cyclone analysis/forecasts through practical training using Satellite Analysis and Viewer Program (SATAID), and covered a range of lectures such as storm surge forecasts.

This training provides opportunities for forecasters of TC (and PTC) members to improve their abilities, exchange various experiences and understand RSMC's activities.

Publications

Annual Report





Tropical Cyclone			24-hour Forecast			48-hour Forecast			72-hour Forecast			96-hour Forecast			120-hour Forecast		
			Ratio (%)	Num.	Radius (km)	Ratio (%)	Num.	Radius (km)	Ratio (%)	Num.	Radius (km)	Ratio (%)	Num.	Radius (km)	Ratio (%)	Num.	Radius (km)
STS	Mekkhala	(1501)	100	17	148	92	12	231	100	6	296	100	2	407	-	0	-
TY	Higos	(1502)	100	11	130	100	7	204	100	3	296	-	0	-	-	0	-
TS	Bavi	(1503)	62	21	147	100	16	266	100	11	389	100	7	519	100	3	695
TY	Maysak	(1504)	100	30	135	100	26	236	100	22	347	100	18	444	100	14	556
TS	Haishen	(1505)	100	1	130	-	0	-	-	0	-	-	0	-	-	0	-
TY	Noul	(1506)	97	30	138	96	26	223	100	22	347	94	18	399	93	14	513
TY	Dolphin	(1507)	81	42	145	79	38	256	88	34	380	87	30	457	85	26	577
TS	Kujira	(1508)	55	11	132	57	7	204	0	3	296	-	0	-	-	0	-
TY	Chan-hom	(1509)	78	46	137	81	42	231	82	38	344	85	34	455	77	30	574
STS	Linfa	(1510)	73	26	138	73	22	231	72	18	354	64	14	444	70	10	556
TY	Nangka	(1511)	100	51	138	98	47	227	98	43	336	82	39	454	80	35	578
TY	Halola	(1512)	91	35	138	96	26	238	100	19	321	73	15	484	67	15	648
TY	Soudelor	(1513)	100	29	137	100	25	228	100	21	340	100	17	444	100	13	556
TS	Molave	(1514)	96	23	153	100	18	295	100	14	431	100	10	519	83	6	695
TY	Goni	(1515)	97	39	142	97	35	257	97	31	373	96	27	447	100	23	555
TY	Atsani	(1516)	100	38	138	100	34	232	100	30	327	92	26	427	73	22	535
TY	Kilo	(1517)	100	34	140	100	30	252	100	26	378	95	22	444	89	18	556
STS	Etau	(1518)	67	3	145	-	0	-	-	0	-	-	0	-	-	0	-
TS	Vamco	(1519)	100	1	130	-	0	-	-	0	-	-	0	-	-	0	-
TY	Krovanh	(1520)	94	17	144	100	13	279	100	9	401	100	5	519	100	1	695
TY	Dujuan	(1521)	83	24	135	100	20	218	100	15	309	82	11	444	43	7	595
TY	Mujigae	(1522)	100	10	141	100	6	232	100	1	296	-	0	-	-	0	-
STS	Choi-wan	(1523)	83	18	135	100	14	254	100	10	359	100	6	494	100	2	695
TY	Koppu	(1524)	85	27	139	100	23	237	100	19	326	100	15	415	100	11	535
TY	Champi	(1525)	83	42	147	95	38	278	100	34	398	77	30	462	73	26	614
TY	In-fa	(1526)	84	31	141	63	27	248	70	23	375	79	19	448	80	15	556
TY	Melor	(1527)	84	19	134	100	15	210	82	11	306	100	7	370	100	3	482
Annual Mean (Total)			89	676	140	93	567	242	94	463	355	88	372	450	83	294	573

- PDF version available on website
- DVD version contains:
  MTSAT and Himawari-8 imagery of all TCs with a viewer program

Available at http://www.jma.go.jp/jma/jma-eng/jma-center/rsmc-hp-pub-eg/annualreport.html

Technical Review

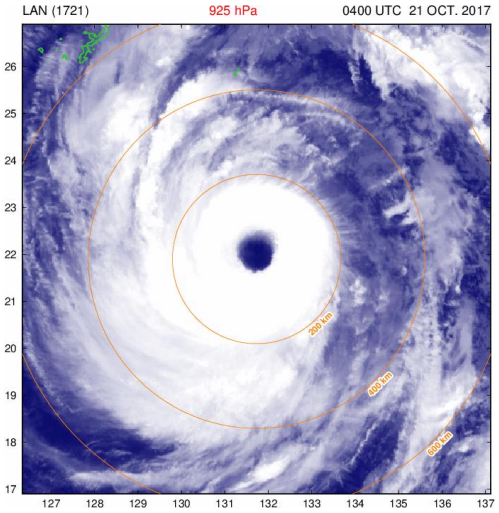
Technical Review No. 19 (published in March 2017)

- Comparative Study of Dvorak Analysis in the western North Pacific
- Upgrade of JMA's Storm Surge Prediction for the WMO Storm Surge Watch Scheme (SSWS)

http://www.jma.go.jp/jma/jma-eng/jma-center/rsmc-hp-pub-eg/techrev.htm

Collaborations among operation and research

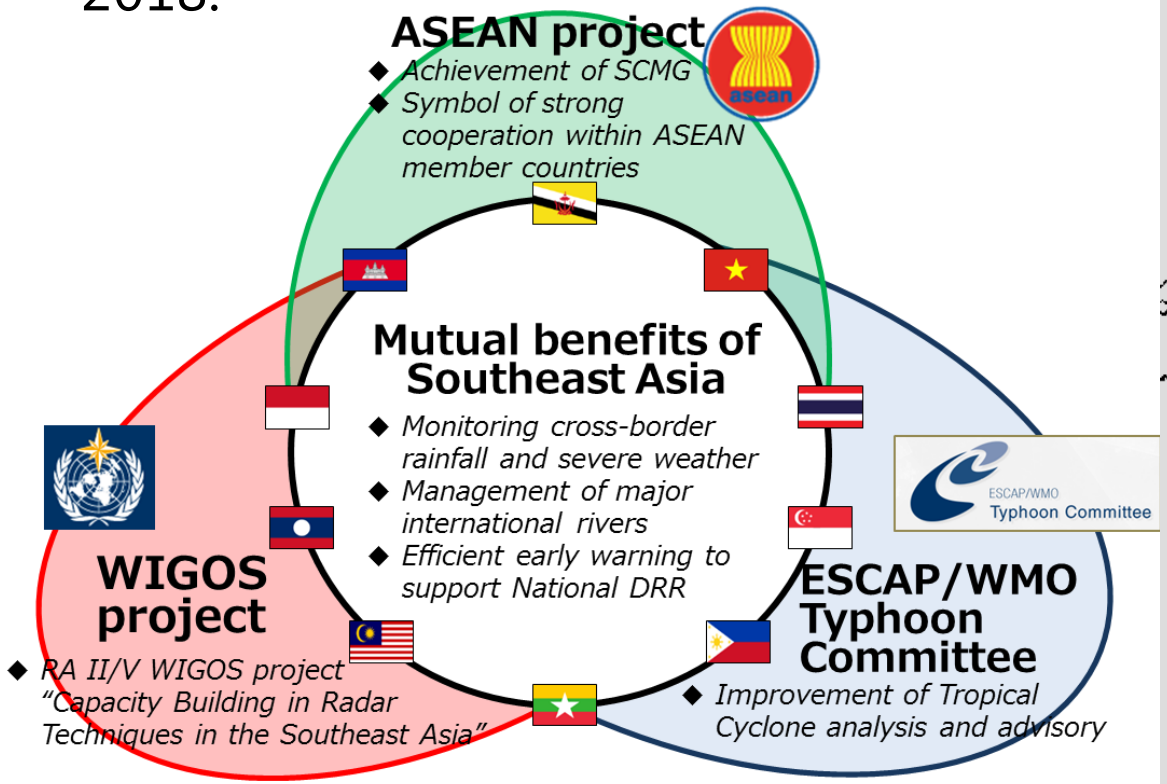
- Nagoya University team to use aircraft to gauge potency of super typhoons
  - T-PARCII (Tropical cyclones-Pacific Asian Research Campaign for Improvement of Intensity estimations/forecasts)

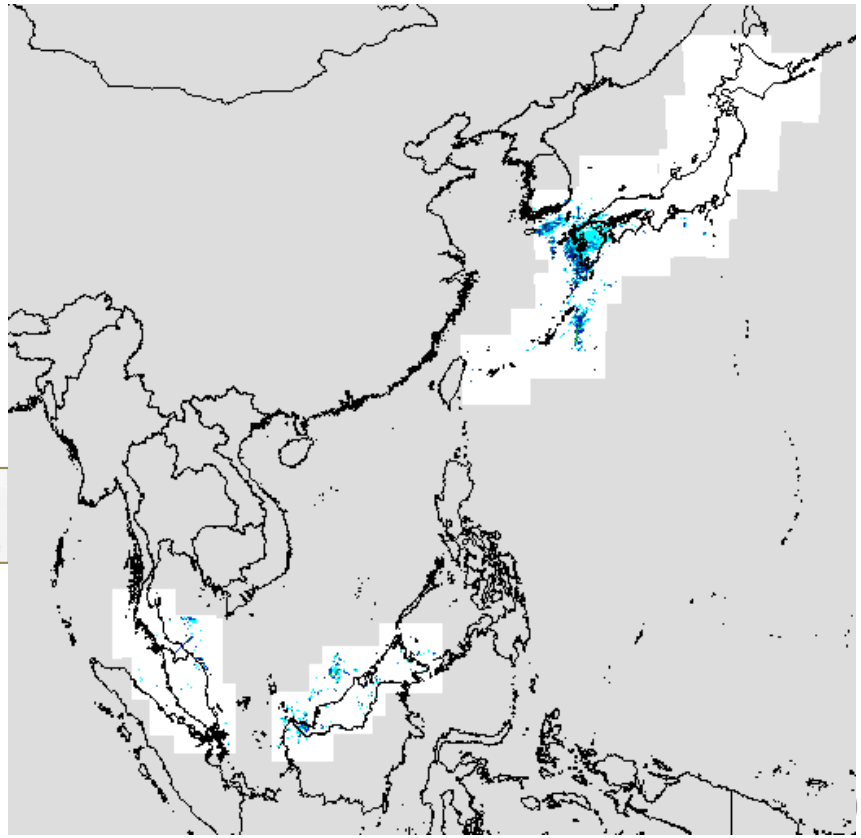


International Collaboration

Development of regional radar network

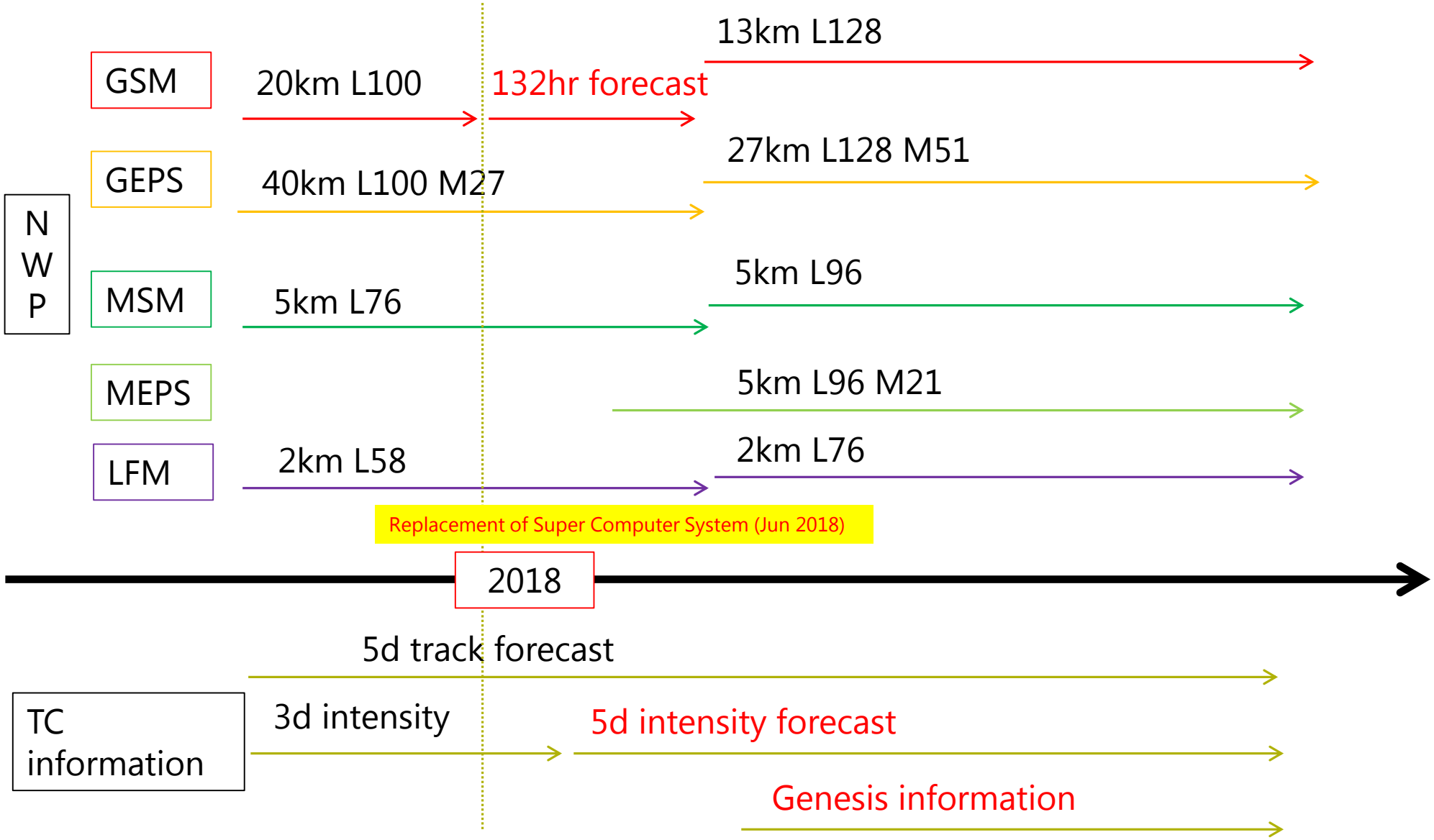
- Approved at RA II-16 (Abu Dhabi, UAE, Feb. 2017)
- It aims to enhance radar QC capacity in ASEAN region and to promote regional radar data exchange through experiments.
- Coordination Group was established.
- WIGOS/ASEAN Radar workshop (Bangkok, Thailand) is to be held in Feb. 2018.





FUTURE PLAN

Future plan of JMA NWP and TC information



Future Direction

- Much efforts for high accuracy of track and intensity forecast will be required.

- Development of EWS toward risk-based warnings are also required.
  - Collaboration with national and local disaster management authorities in developing and operating EWS

SUMMARY

Summary

- The Japan Meteorological Agency provides weather and typhoon information both domestically and abroad as RSMC on tropical cyclones.
- Typhoon analysis and forecasting techniques is a fundamental technology, focusing on more accurate estimation of center position / intensity, development of numerical prediction model. Accuracy has been steadily improved.
- We will continue leading various activities in cooperation with domestic and foreign regions to reduce typhoon disasters.

Thank you