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Use of upper-tropospheric Atmospheric Motion Vectors (AMV) for diagnosing tropical cyclone intensity

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1. Background and purpose

Though many types of satellite observations such as infrared and microwave channel observations are recently available for tropical cyclone (TC) analysis, to estimate TC intensity, i.e., maximum sustained wind (MSW) is still an important issue to work on. This research aims to seek for the use of upper-tropospheric Atmospheric Motion Vectors (AMV) for diagnosing MSW by using the intensity of TC vortex near cloud top.

2. Data and Methodology

For 27 TCs in 2011-2014 (right table), below investigations are performed using upper-tropospheric MTSAT-2 AMVs (above 400 hPa level).

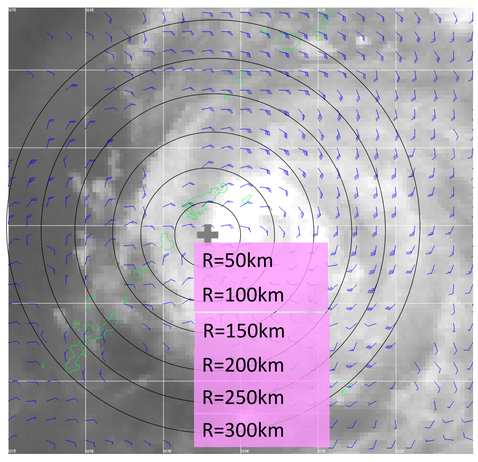
- Correlation between the max tangential wind of AMVs (*UMaxWind*) and *MSW*, and a suggestion for the Quality Control (QC) of *UMaxWind*.
- Relationship between *UMaxWind* and the max radial wind of AMVs (*UMaxOutflow*) reflecting "convective burst" known as a precursor of TC rapid intensification.

In addition, for several TCs in 2015, an estimation of MSW from *UMaxWind* is performed using MTSAT-2 AMVs and Himawari-8 AMVs.

JMA typhoon number	
1106	1320
1112	1323
1115	1324
1215	1326
1216	1327
1217	1408
1303	1409
1304	1411
1307	1412
1312	1414
1315	1415
1317	1418
1318	1419
1319	

Data	Explanation
MTSAT-2 AMV (2011～)	6 hourly high-level (above 400 hPa level) IR-AMV(10.8μm)and WV-AMV(6.8μm) derived using MTSAT-2 15-min interval images at 0.25-degrees grids. AMVs with QI above 0.3 are used. : *Oyama (2010)*
Himawari-8 AMV (2015～)	10-min interval high-level (above 400 hPa level) IR-AMV (10.4μm) and WV-AMV (6.2μm) derived using Himawari-8 target area observation (1000x1000km)at intervals of 5 minutes at 0.1-degrees grids. AMVs with QI above 0.3 are used. : *Shimoji (2014)*
JMA best-track data	Max sustaind wind (MSW) (6 hourly)

Derivations of UMaxWind and UMaxOutflow



Max of azimuthally averaged values in annuli (±50km) from the rotation center

AMV Quality Control (QC) tested

A simple QC method was made to reject a spatially uniform vector field which appears when the environment wind is very strong or image navigation is no good. Conditions to accept winds are:

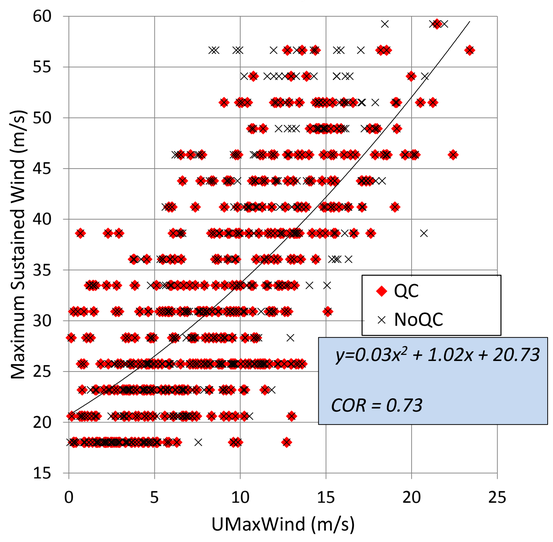
1. Procedure using entropy of vector spatial arrangement (Matsumoto and Imai 2008)
   8.2 < Entropy(r<600km)
2. Procedure using mean speed
   Mean speed(r<600km) < 9m/s

3. Result - Results for TCs in 2011-2014 using MTSAT-2 AMVs -

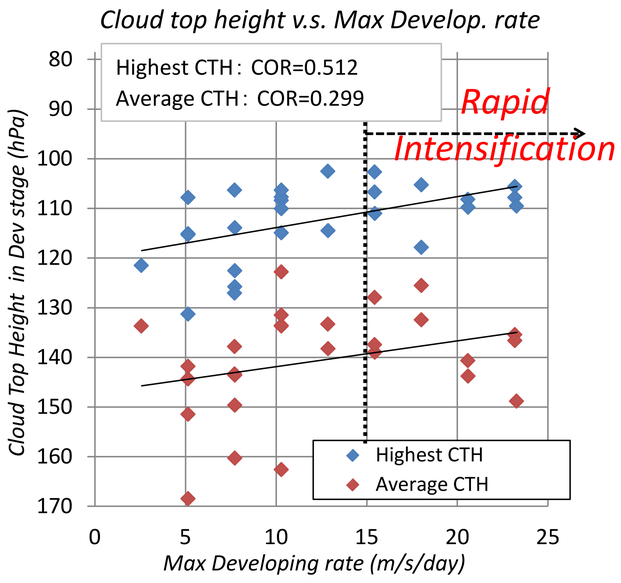
UMaxWind (0<) v.s. MSW (17.2m/s<)

QC : N=517, COR=0.73

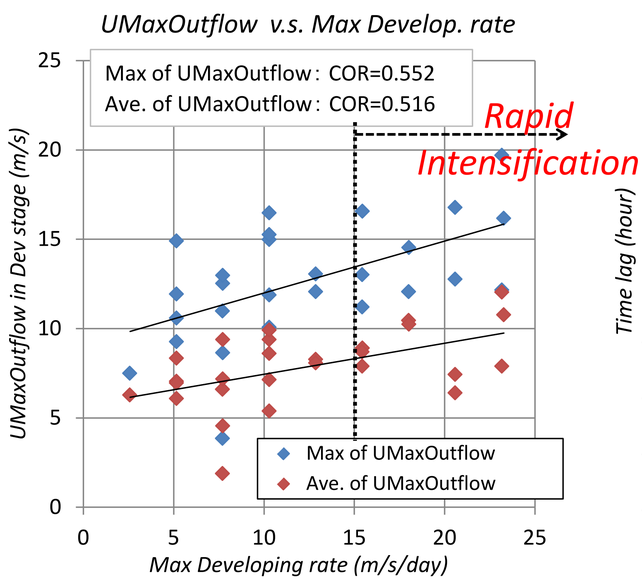
(No QC: N=681, COR=0.72)



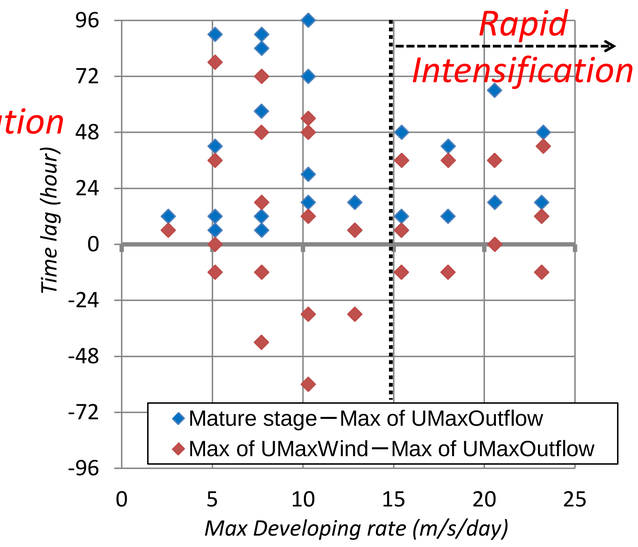
Cloud top height in TC developing stage v.s. Max TC developing rate (each plot denotes TC)



UMaxOutflow in TC developing stage v.s. Max TC developing rate (each plot denotes TC)



Time lag of events to max UmaxOutflow v.s. Max TC developing rate (each plot denotes TC)



- Comparison with simulation using JMA-NHM : Roke (1115) -

MTSAT-2 AMV & Best Track MSW

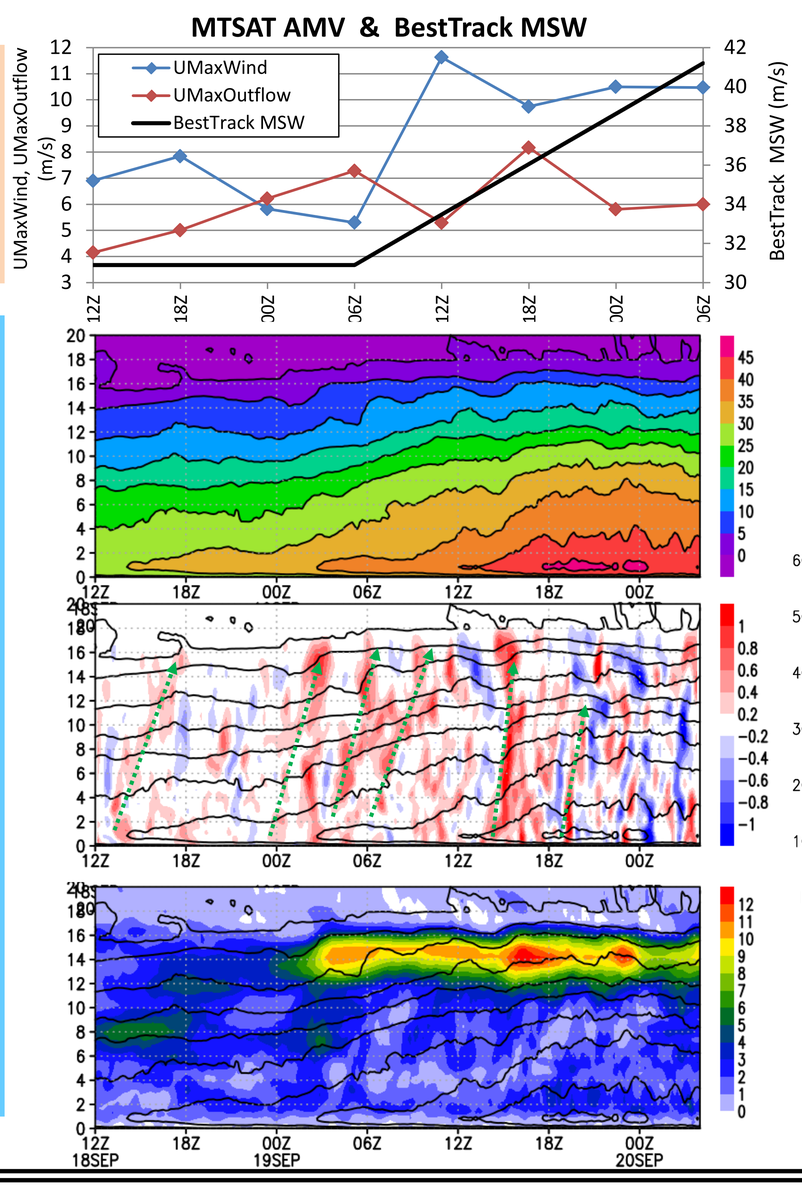
JMA-NHM

(2.5km, 10min output, initial and boundary conditions: JMA Meso Analysis)

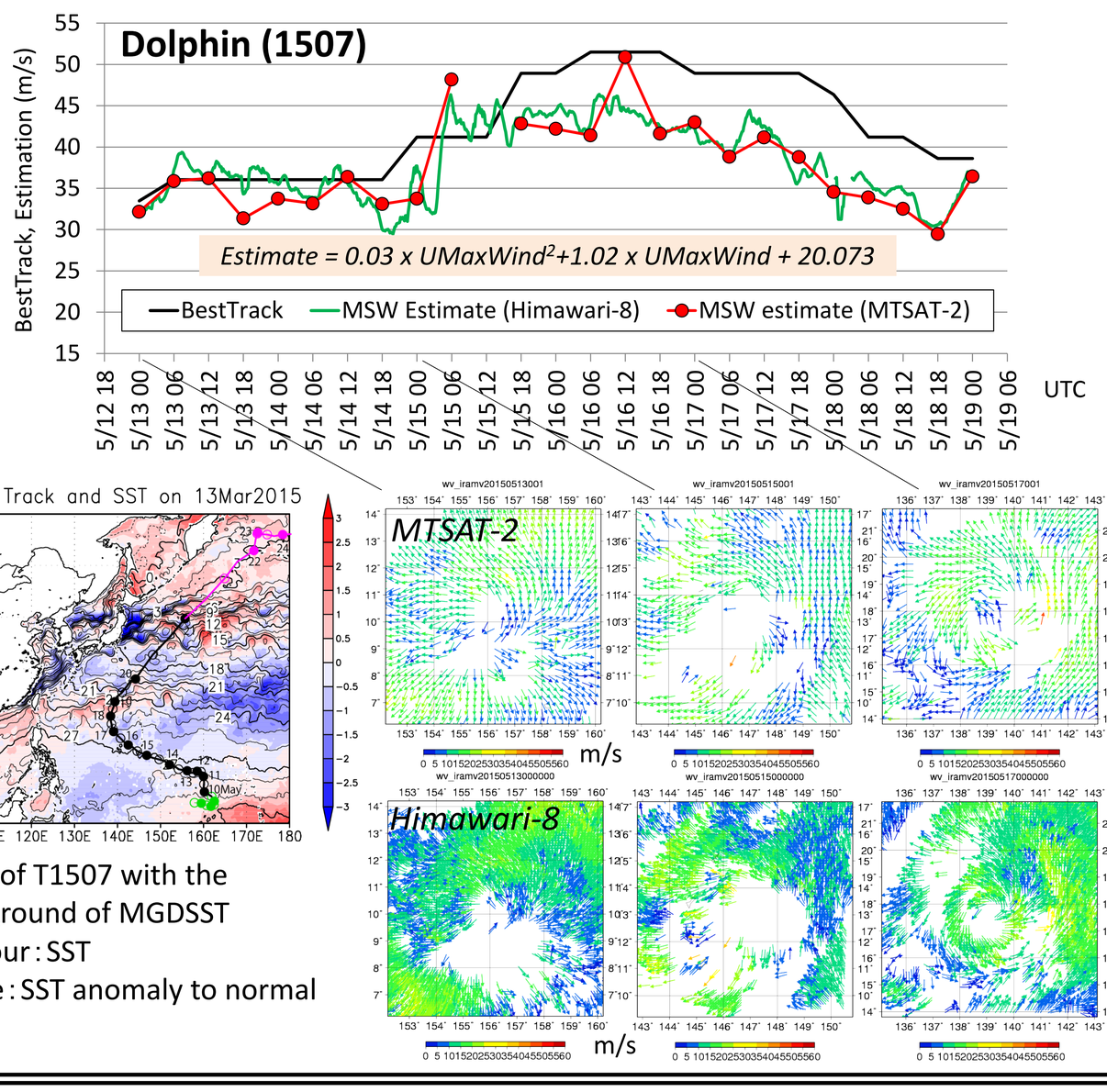
Max tangential wind VMax (m/s)

dVMax/dt

Max Outflow (m/s)



- Estimation of MSW from UMaxWind: Dolphin (1507) -



Track of T1507 with the background of MGDSST
Contour : SST
Shade : SST anomaly to normal

4. Summary

- This study showed correlation between *UMaxWind* and *MSW* is 0.72～0.73, and QC tested here is effective to rejecting uniform vector field due to strong jet and image navigation error.
- A positive correlation (～0.55) between maximum TC developing rate and the magnitude of *UMaxOutflow* is found.
- For TCs with rapid intensification, the time when *UMaxOutflow* experiences maximum is 12-70 hours before the mature stage.
- The results suggest the possibility of diagnosing TC intensity using *UMaxWind* and *UmaxOutflow* from MTSAT and Himawari-8 AMVs.
- It is expected that Himawari-8 AMVs will have an advantage for the TC analysis regarding temporal and spatial resolution.