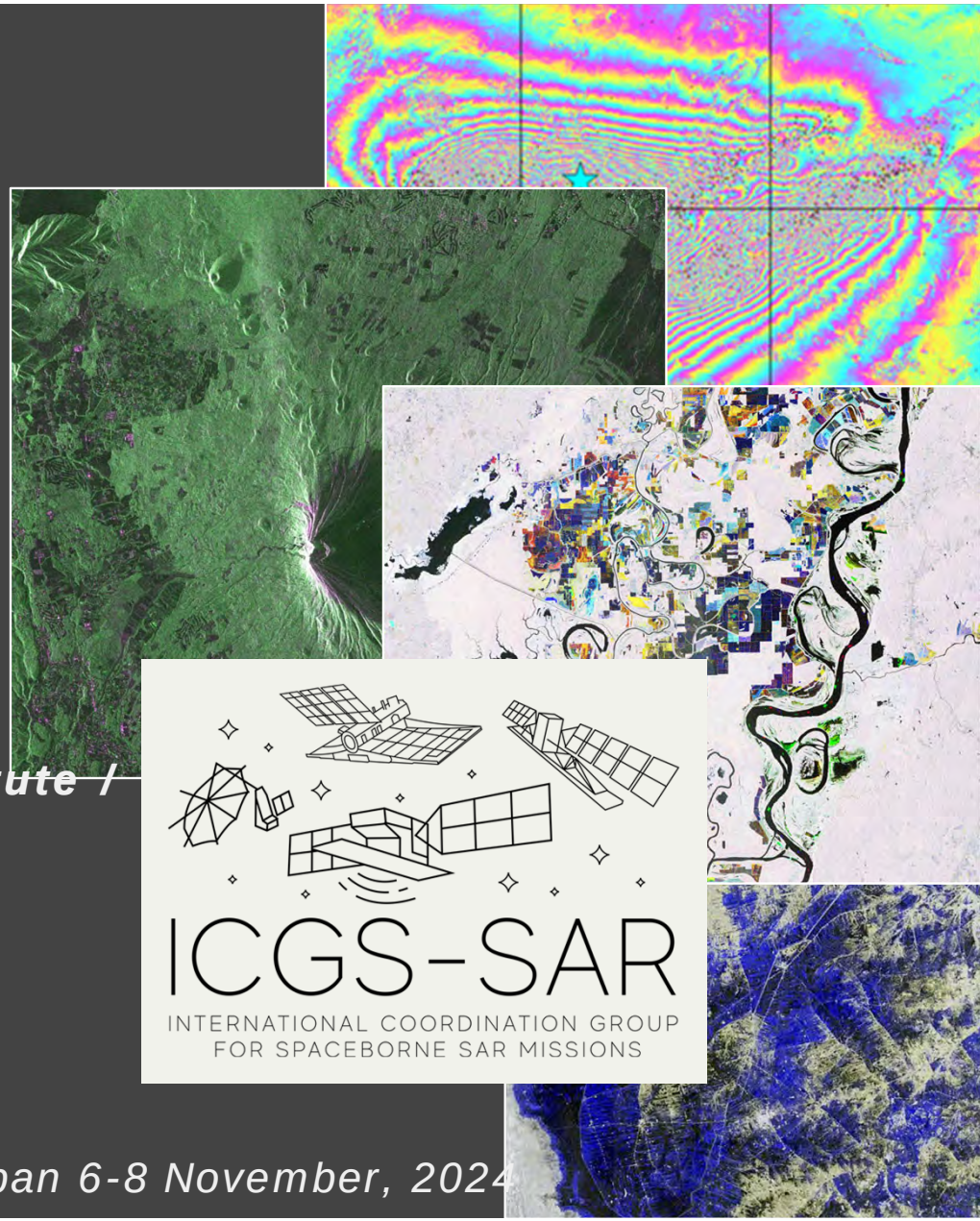
Ocean Surface Wind Retrieval from ALOS-2/PALSAR-2 under Tropical Cyclone Conditions



Udai Shimada, Meteorological Research Institute / Japan Meteorological Agency

Agenda item 7.1.5

Osamu Isoguchi (RESTEC), Takeo Tadono (JAXA),
Masato Ohki (JAXA), Shinichi Sobue (JAXA), Masahiro Hayashi (MRI),
Yasutaka Ikuta (MRI), Nadao Kohno (MRI), Wataru Yanase (MRI),
Satoki Tsujino (MRI), Munehiko Yamaguchi (MRI)

3rd International SAR Workshop Saga Prefecture, Japan 6-8 November, 2024

Spaceborne Ocean Surface Wind Observations



No high wind speed observations with high resolution from space.

A serious issue of TC-related disaster prevention

Satellite observations:

- Microwave Scatterometer (ASCAT etc.)
  ✓Saturation above ~20m/s
- Microwave Radiometer (AMSR2, etc.)
  ✓Low resolution (50km)
- Microwave Sounder (AMSU, Estimate from a warm core)
  ✓Low resolution (~20km)
- SMAP, SMOS (L-band Radiometer)
  ✓Low resolution (40~45km)
- IR Atmospheric Motion Vector (AMV)
  ✓Poor coverage in the inner core of TCs

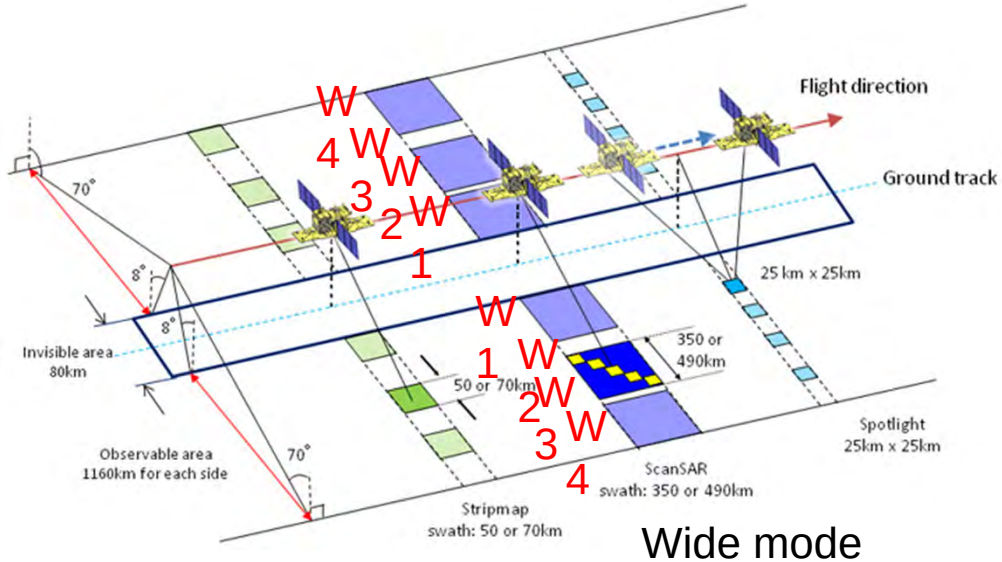
ALOS-2/PALSAR-2

SAR can observe ocean surface backscatter even under tropical cyclone conditions, allowing the retrieval of ocean wind speeds with high spatial resolution and accuracy.

JAXA and MRI/JMA started joint research to develop tropical cyclone ocean wind products using ALOS-2/PALSAR-2 in 2019.



https://www.eorc.jaxa.jp/ALOS/jp/alos-2/a2_about_j.htm



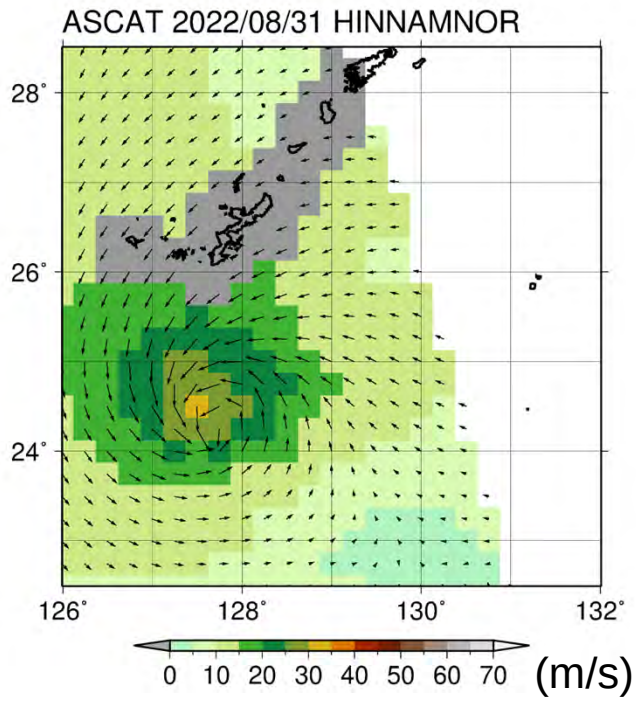
Wide mode

Comparison b/w ASCAT and ALOS winds

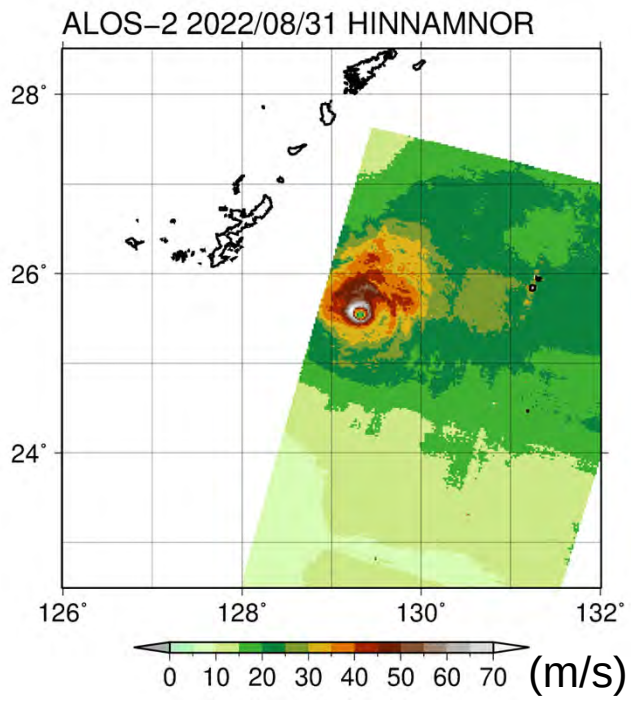
- Scatterometer (ASCAT) cannot observe high wind speeds (>30m/s) and detailed inner core structure
- ALOS-2 observes a small eye and high wind speeds > 50m/s

Typhoon Hinnamnor (2022)

Scatterometer Wind

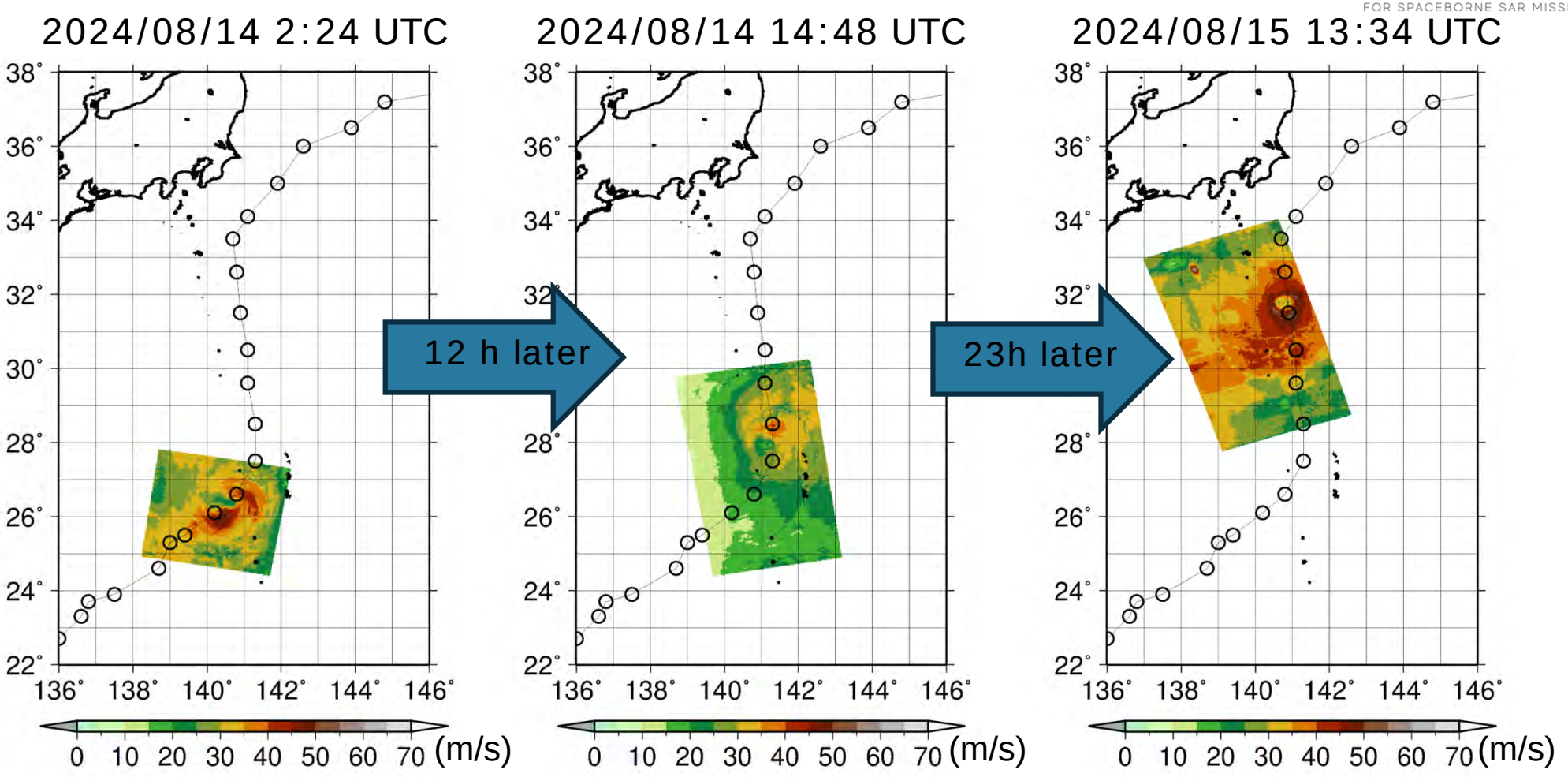


ALOS-2 Wind



Typhoon Ampil (2024)

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Application studies

- Use C-band SAR wind products in addition to ALOS-2 wind
  - Sentinel-1, Radarsat, etc.
  - Horizontal resolution: 3km
  - Period: 2015-2024

1, Tropical cyclone wind field estimation using SAR wind data as ground truth

2, Data assimilation of SAR wind data

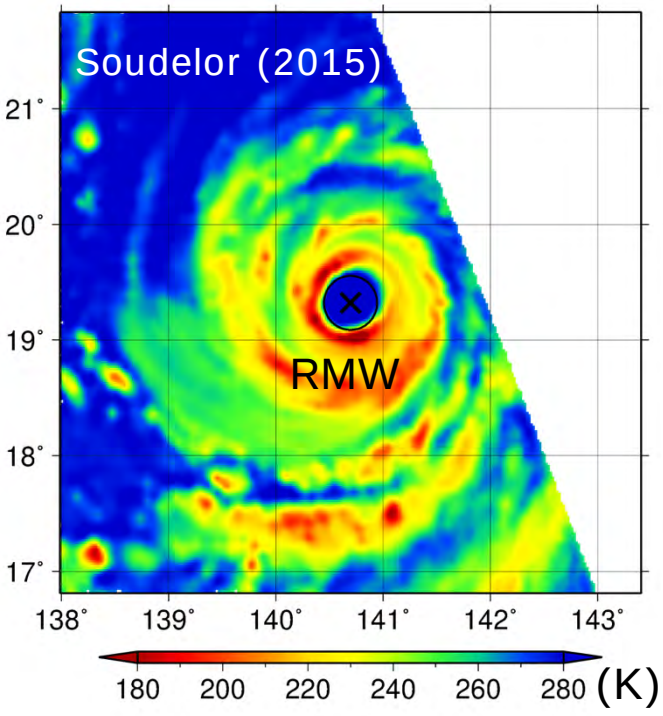
1, Tropical Cyclone Wind Field Estimation
-RMW Estimation Using Microwave Satellite Data-

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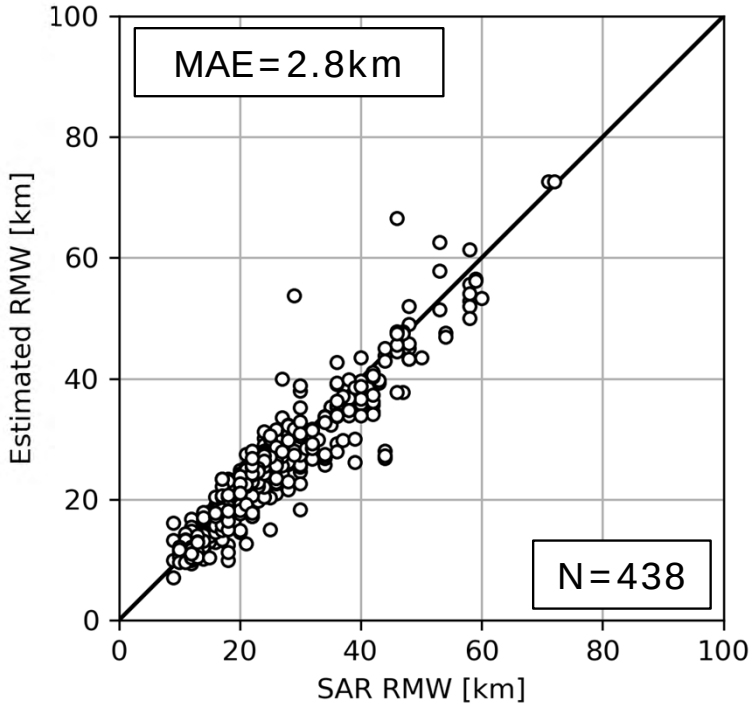
RMW: Radius of maximum wind
Regression between RMW and Reye.
Reye = −40℃ radius of azimuthal mean 89GHz Tb.

$$RMW = 0.71 * Reye + 4.37$$

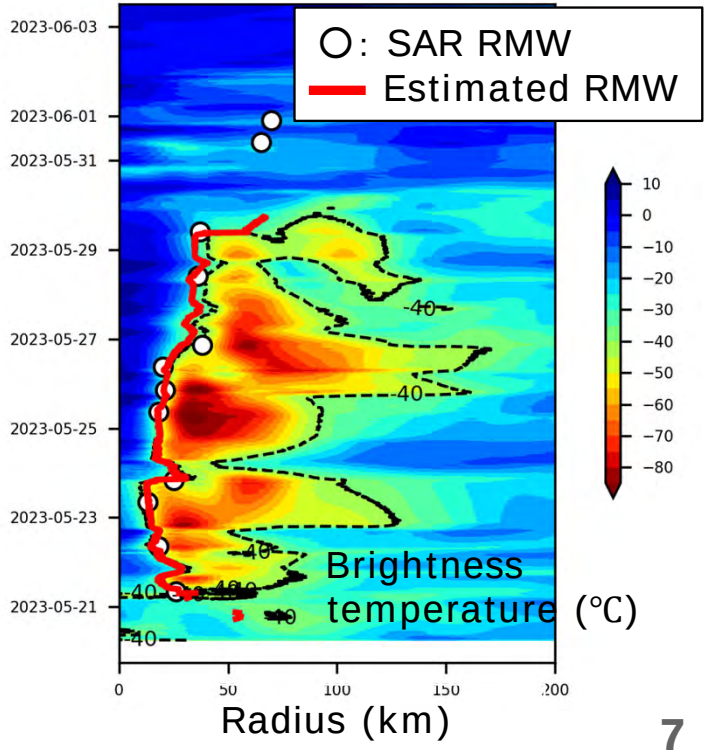
Microwave Satellite



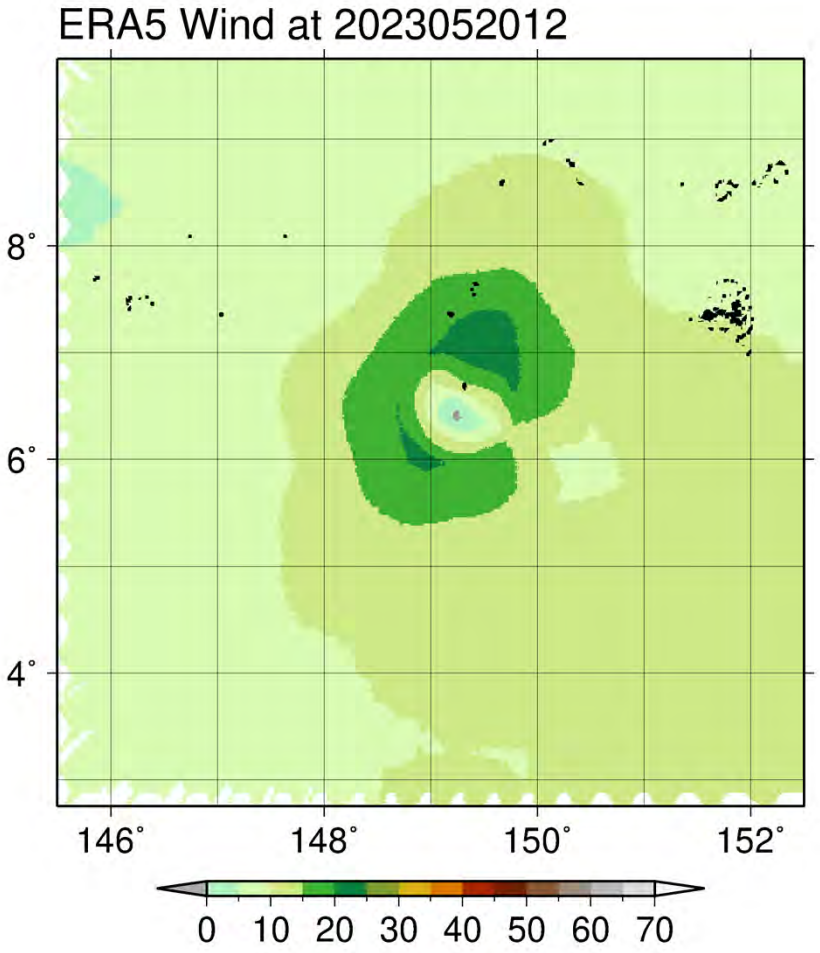
Estimated RMW



Typhoon Mawar (2023)



1, Surface Wind Field Estimation



【Method】
Azimuthal-mean Vmax: JMA best track Vmax
RMW: RMWs estimated by microwave satellite data

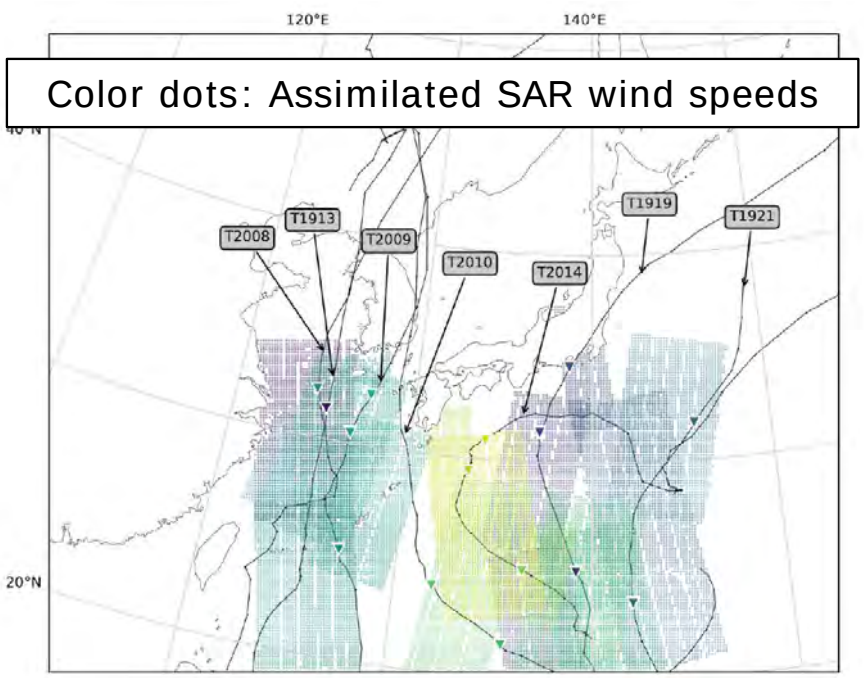
Radial Profile
・Outer Region: Simple correction of ERA5 wind speed
・Outside of RMW ～ Outer region:
Modified Rankine vortex for a single eyewall or an exponential profile for concentric eyewalls
・Inside of RMW: Rankine vortex

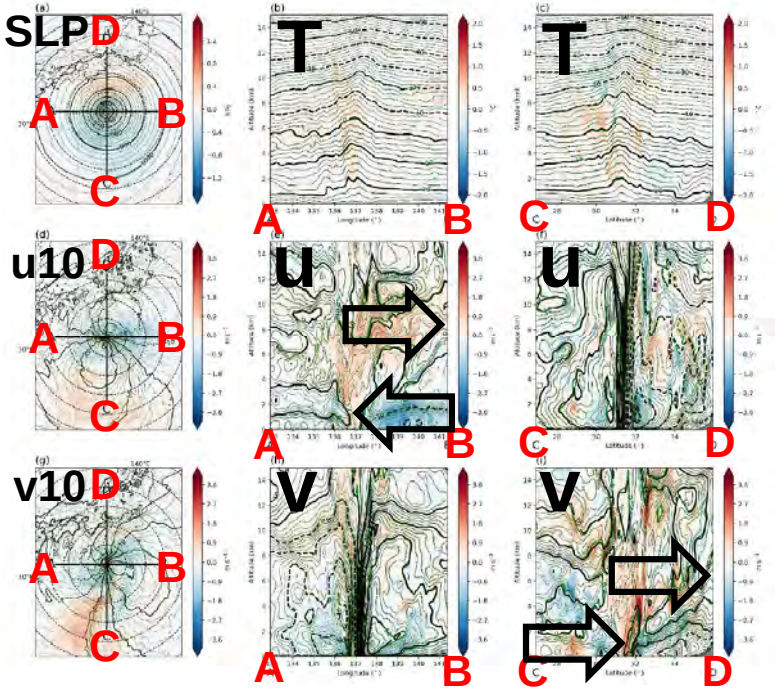
Asymmetry
・Use asymmetric component of ERA5 wind speed

2, C-band SAR Assimilation (by Dr. Ikuta)

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- ✓C-band SAR assimilation by the JMA's regional 4D-Var system.
- ✓Confirm positive effects on analyses and forecasts.





Colors:
Analysis increments

- ✓ The assimilation modified not only the low-level inflow, but also the upper outflow.
- ✓ The SAR assimilation effect propagated from the surface to the upper troposphere.

Ikuta, Y., and U. Shimada, 2024: Impact of Assimilation of the Tropical Cyclone Strong Winds Observed by Synthetic Aperture Radar on Analyses and Forecasts. *Mon. Wea. Rev.*, **152**, 1007-1025, doi:10.1175/MWR-D-23-0103.1..

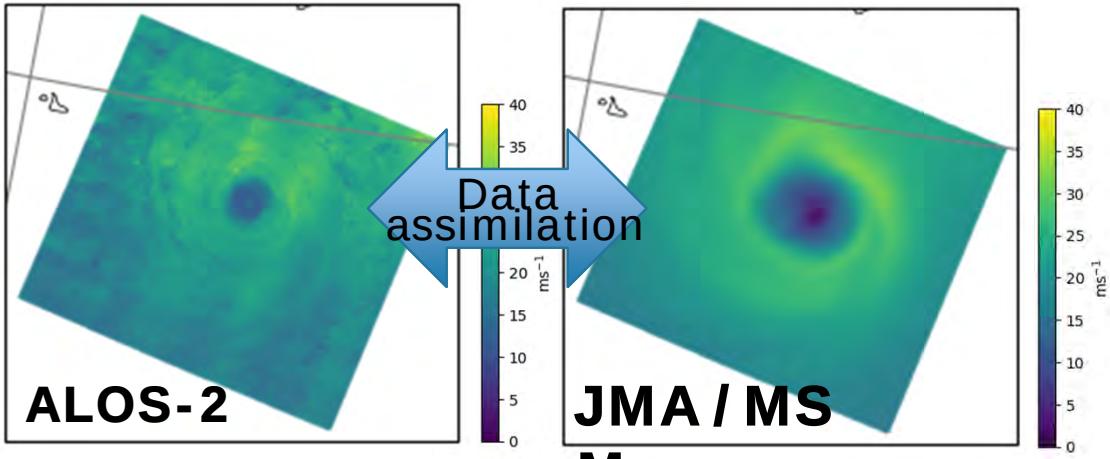
2, ALOS-2 Wind Assimilation (by Dr. Ikuta)

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Case study of Typhoon IN-FA (2021)
- ✓Assume an observation error of 1.8 m/s and no bias correction
- ✓Use the JMA's regional data assimilation system (4D-Var)

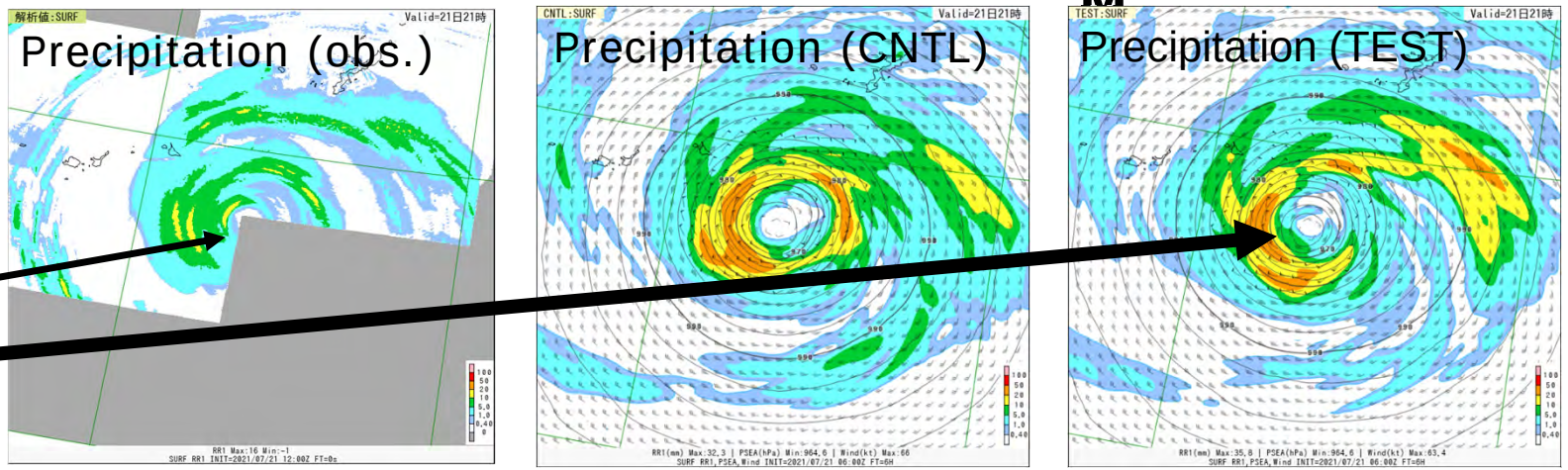
CNTL : no SAR assimilation
TEST : SAR assimilation

Wind speed: 07/21/2021 0400UTC



Initial time:
07/21/2021 0600UTC
Forecast time: 6 hour

A remnant of an inner eyewall is reproduced.



Summary

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- Satellite observations of high wind speeds for tropical cyclones (TCs) with high accuracy and high horizontal resolution have not been possible.
- In response to recent TC violent wind disasters, development of ALOS-2 ocean wind products for TCs and application studies using SAR wind products began in 2019.
- The development of the ALOS ocean wind products can be groundbreaking in terms of TC disaster prevention and scientific understanding of TCs.
- Advantages of L-band SAR (ALOS-2, ALOS-4) for tropical cyclone wind observations:
  - Wide scan mode: Allowing to observe an entire tropical cyclone area
  - Quality: Less rain attenuation than C-band SAR
  - High wind speed observation: No saturation for high wind speeds

- Application studies: Useful as ground truth for TC wind field estimation and for improving numerical weather model TC prediction through data assimilation.