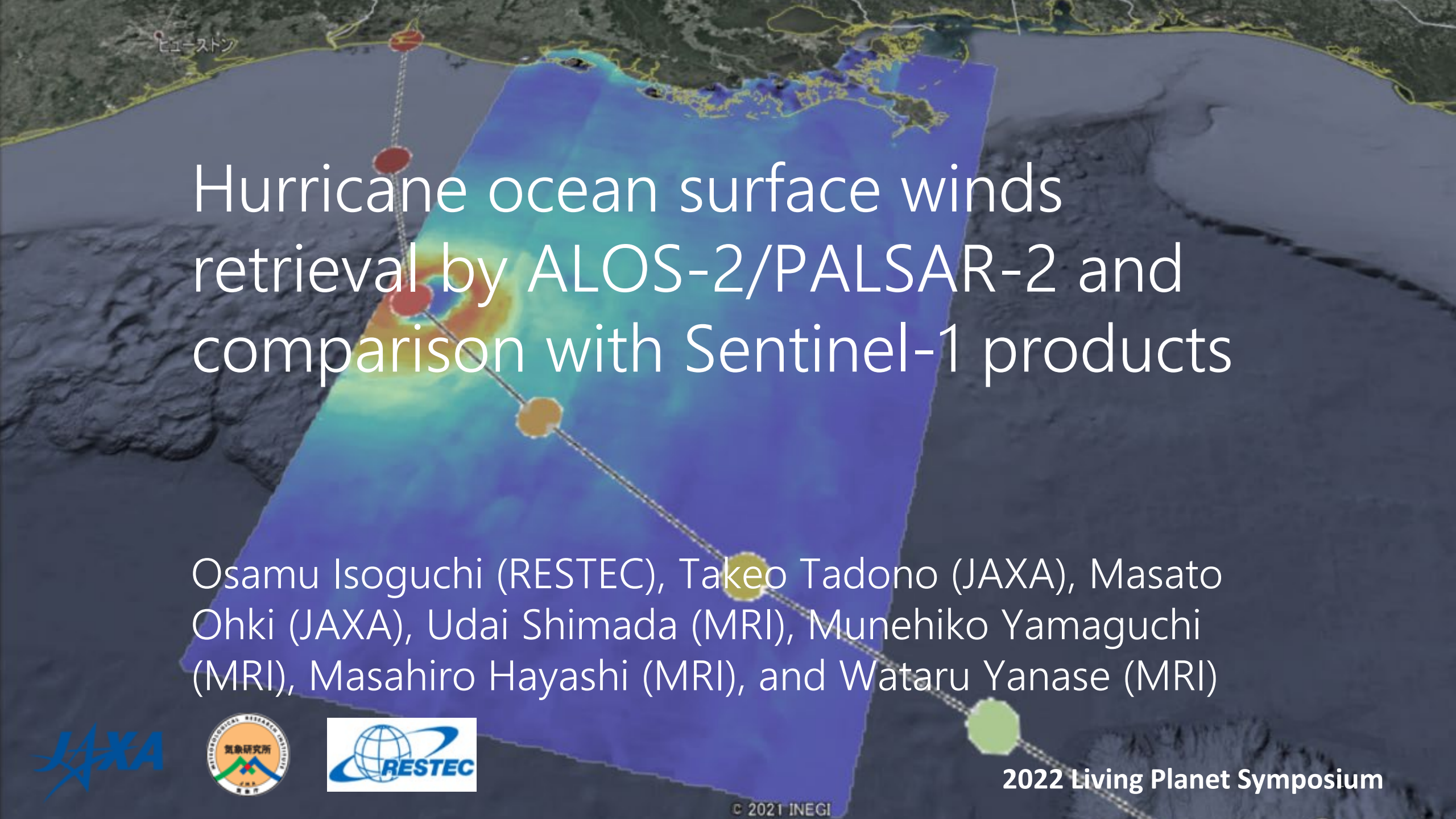


Hurricane ocean surface winds retrieval by ALOS-2/PALSAR-2 and comparison with Sentinel-1 products

Osamu Isoguchi (RESTEC), Takeo Tadono (JAXA), Masato Ohki (JAXA), Udai Shimada (MRI), Munehiko Yamaguchi (MRI), Masahiro Hayashi (MRI), and Wataru Yanase (MRI)

2022 Living Planet Symposium

Introduction

JAXA-MRI(Meteorological Research Institute) joint research

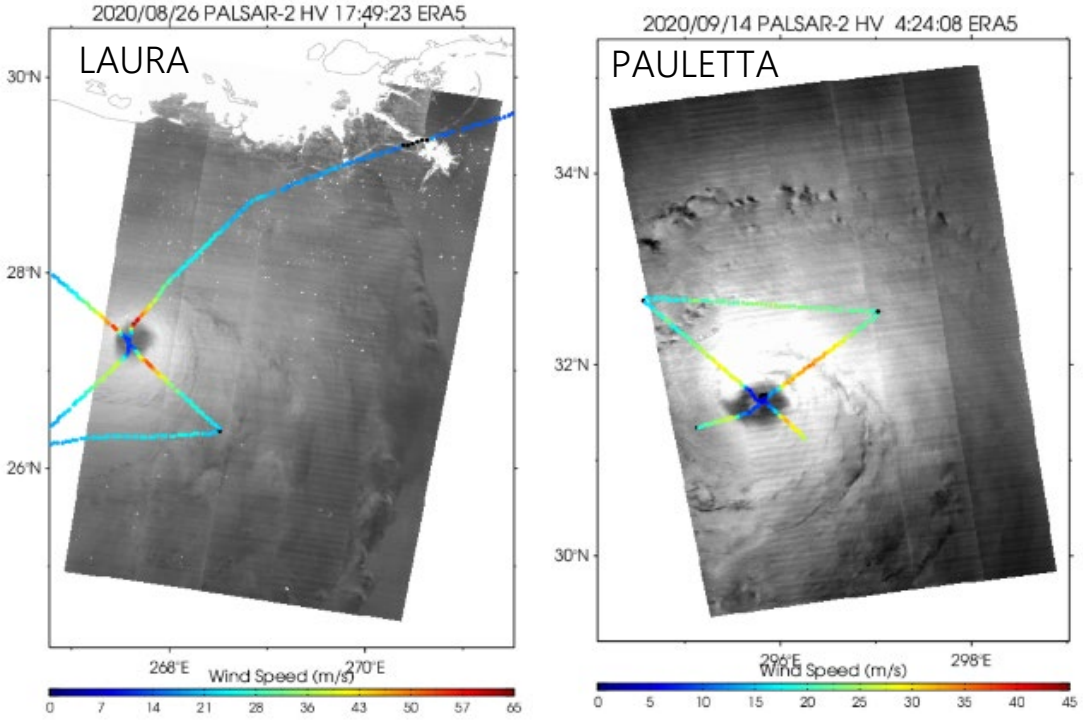
Objective:

✓ to enable wind speed detection by L-band SAR (PALSAR-2) and to use it for it in operational weather forecasting under typhoon conditions

Previous study

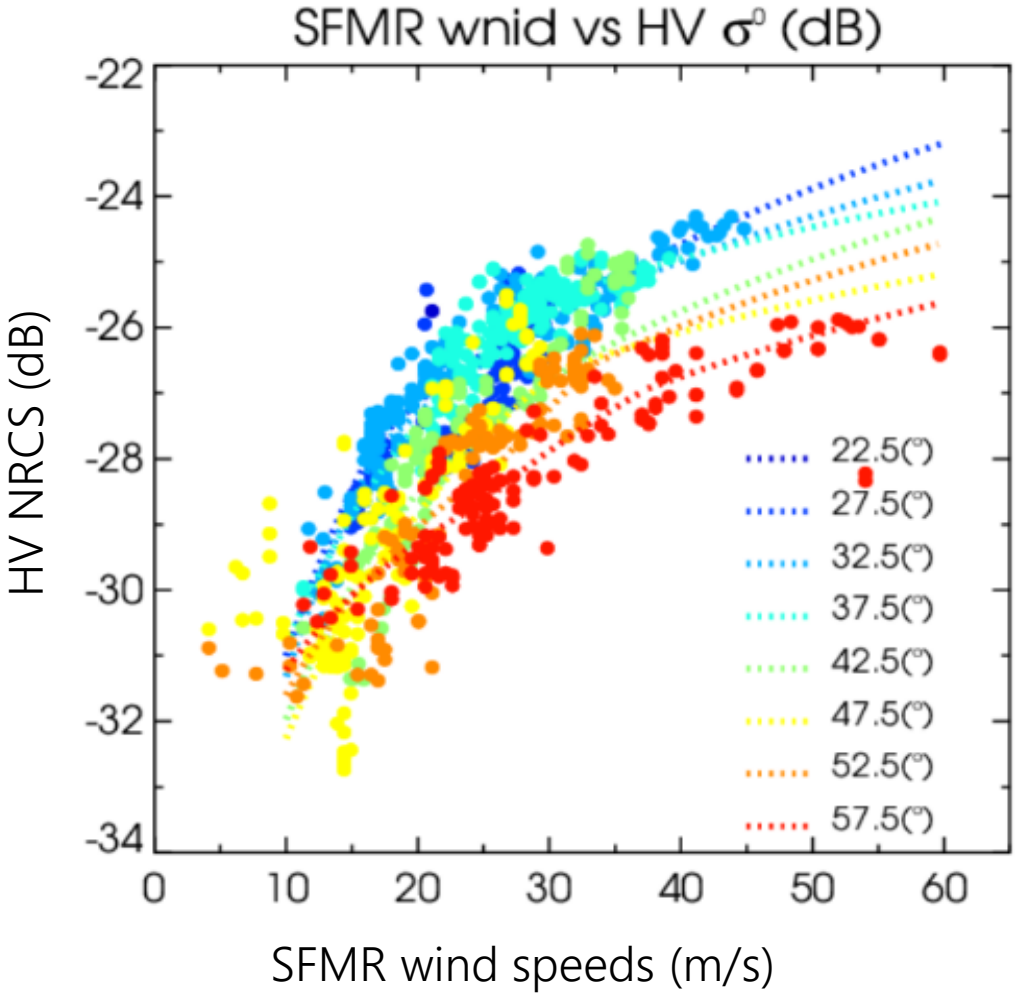
✓ developed an L-band cross-pol (HV) geophysical model function (GMF) under the extreme condition using the PALSAR-2 and simultaneously observed Stepped-Frequency Microwave Radiometer (SFMR) wind data,

Examples of match-ups between PALSAR-2 HV σ^0 and SFMR surface winds.



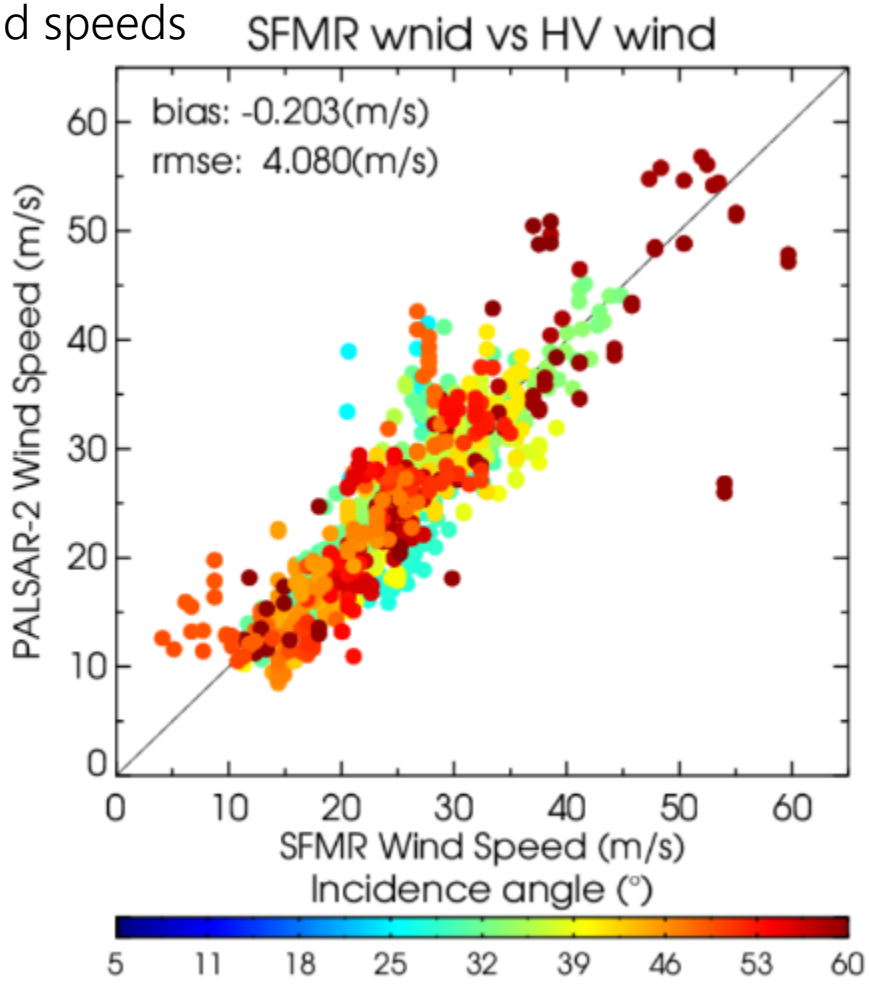
Model Derivation

Based on the method proposed by C-band (Hwang et al., 2015), a model function was constructed as a function of wind speed (U10) and incident angle (θ).



Wind speed inversion

Scatter plot of PALSAR-2-derived and SFMR-derived wind speeds

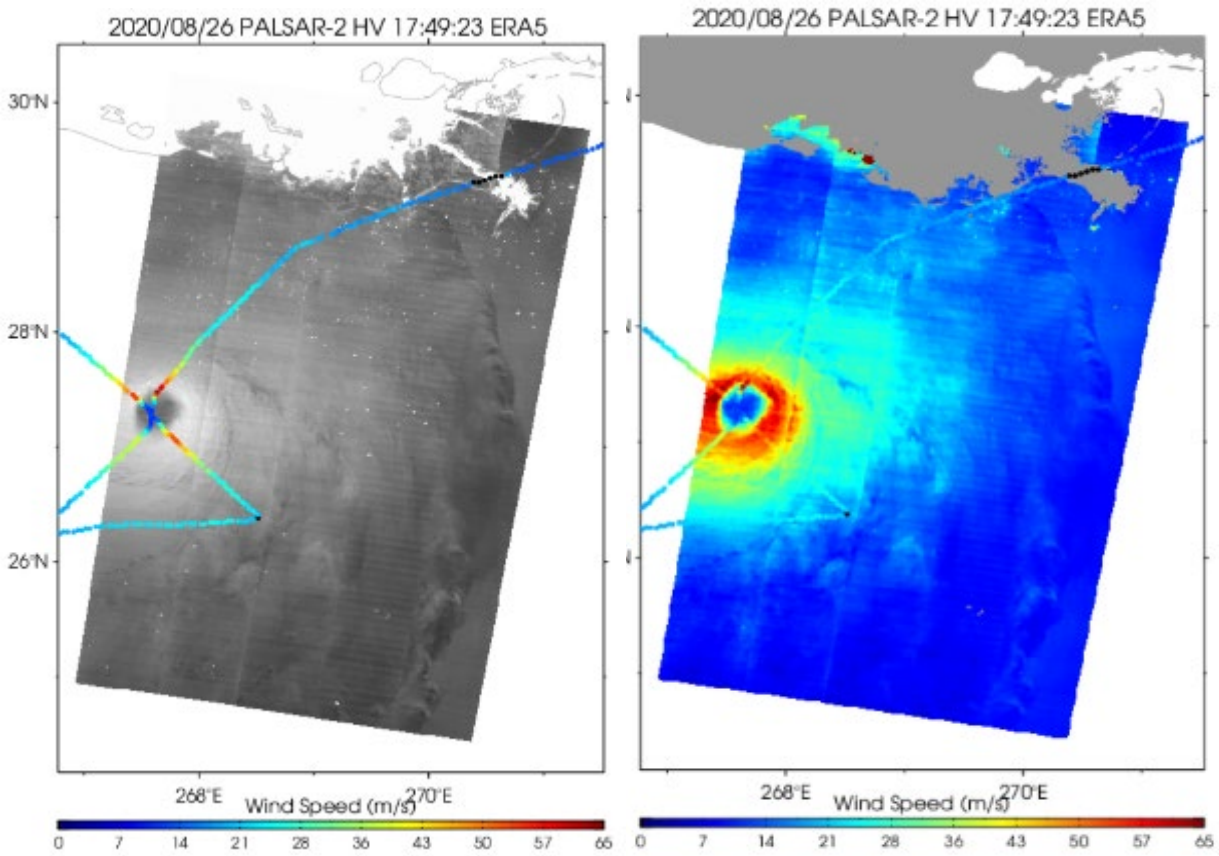


Wind speed can be detected up to about 50 m/s or more

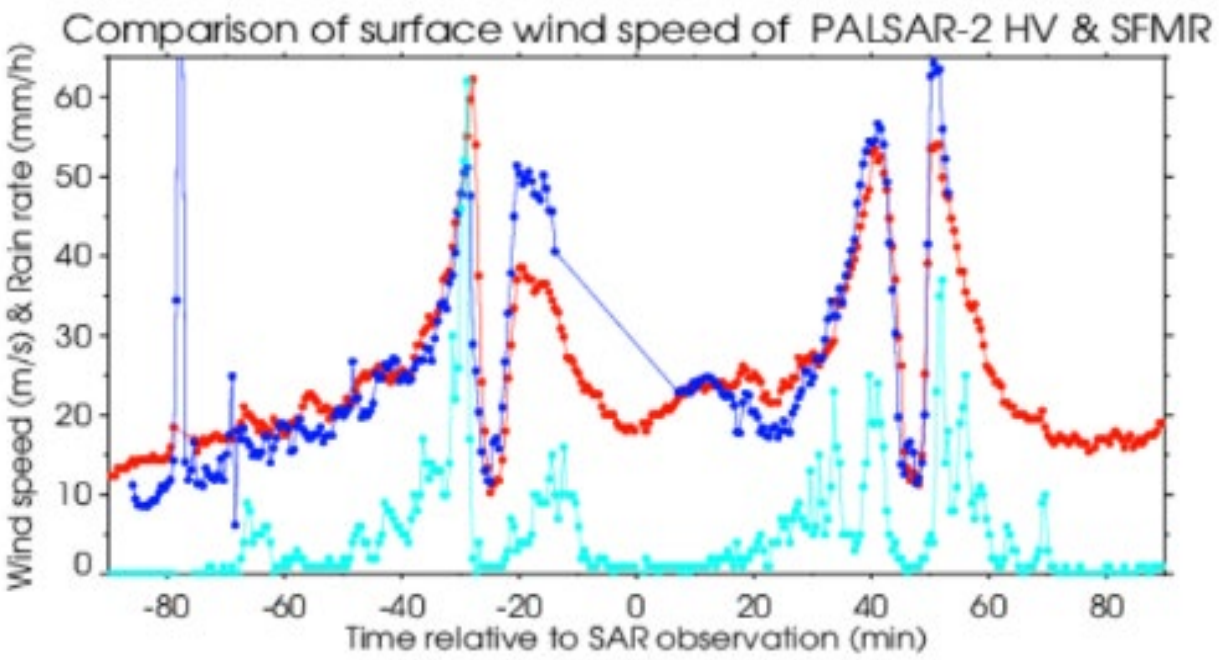
Hurricane wind speed detection

PALSAR-2-derived surface wind speed of LAURA.

LAURA



Comparison of (‘red lines) SFMR-derived and (blue lines) PALSAR-2-derived surface wind speeds. Cyan lines show SFMR-measured rain rate.



- Variations including maximum wind speed of about 60m/s and sudden changes in wind speed near the eye wall are captured, although some biased differences exist.
- Currently, the effect of rain rate seems to be insignificant.

Introduction

The present study

✓demonstrate the retrieval of hurricane/typhoon wind structure and its temporal change using a suite of satellite-derived wind products, PALSAR-2, AMSR-2 and Sentinel-1 SAR.

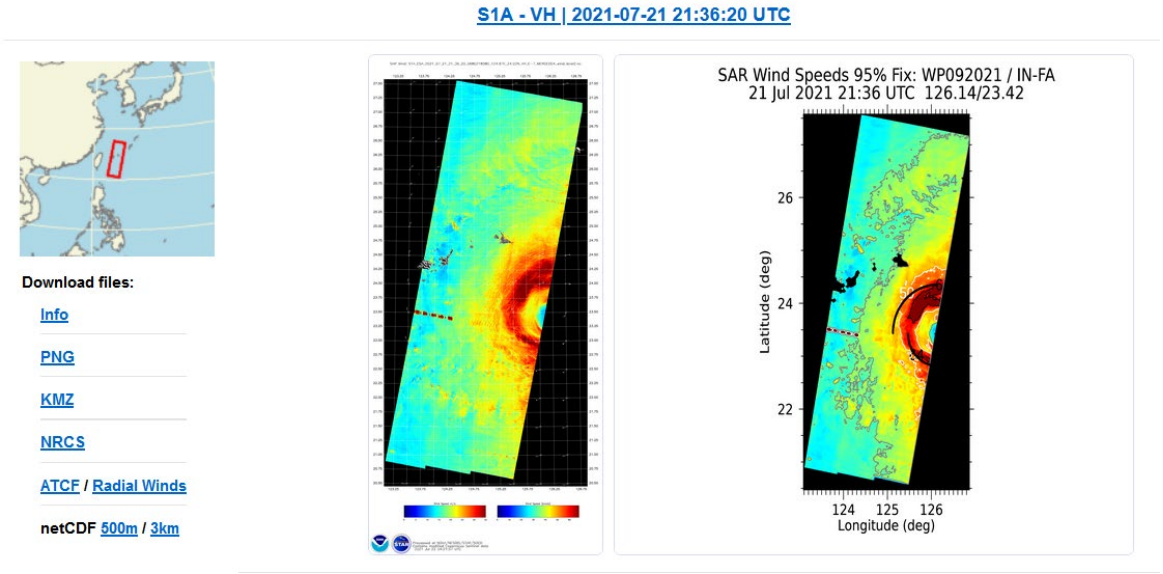
Outline

✓Satellite products we used
✓Comparison of wind speed structure with best track data
✓Retrieval of Temporal change of TC wind structure
✓Summary

Satellite products

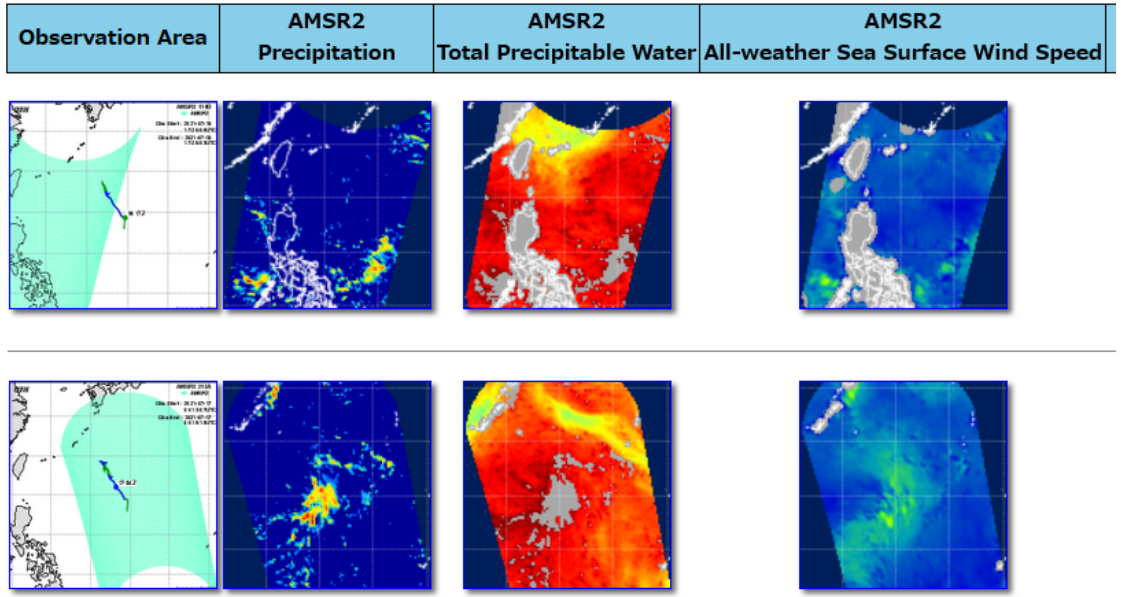
Sentinel-1

NOAA SAROPS Tropical Cyclone Winds (https://www.star.nesdis.noaa.gov/socd/mecb/sar/AKDEMO_products/APL_winds/tropical/index.html)



AMSR-2

All Weather Sea Surface Wind Speed obtained from JAXA/EORC Tropical Cyclone Database (https://sharaku.eorc.jaxa.jp/TYP_DB/index.html)

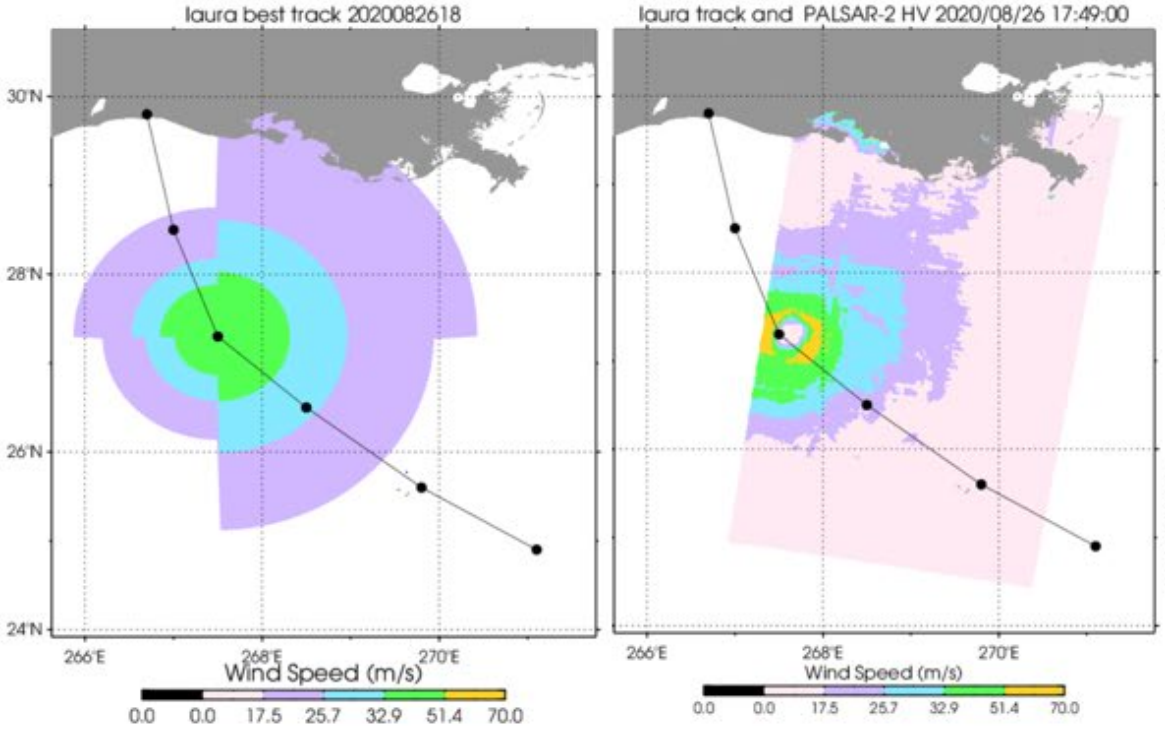


Comparison of wind speed structure with best track data

LAURA

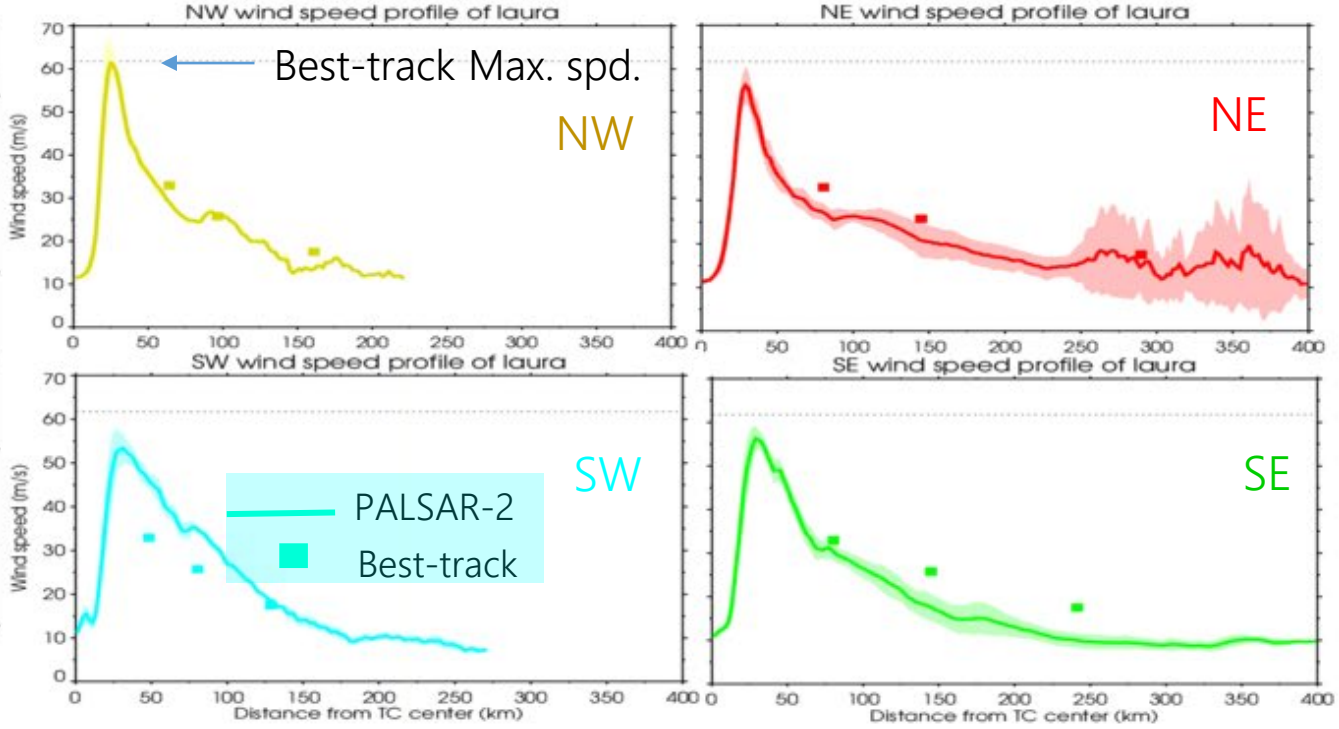
Two-dimensional wind structure

Best-track



PALSAR-2

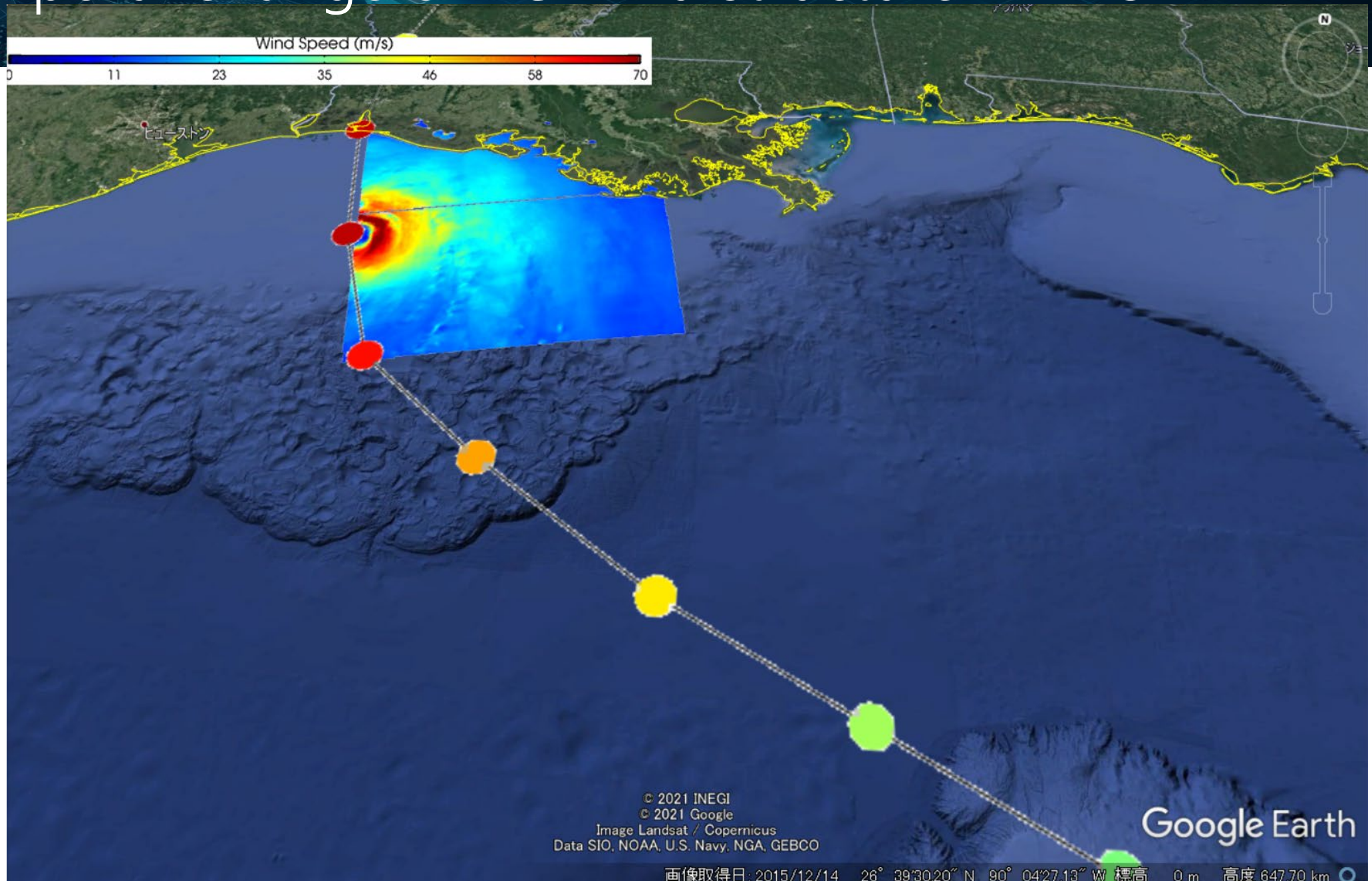
Omnidirectional surface wind profile as a function of distance from the hurricane center



Wind speed radii of 3 levels(34Knot, 50Knot, 64Knot)

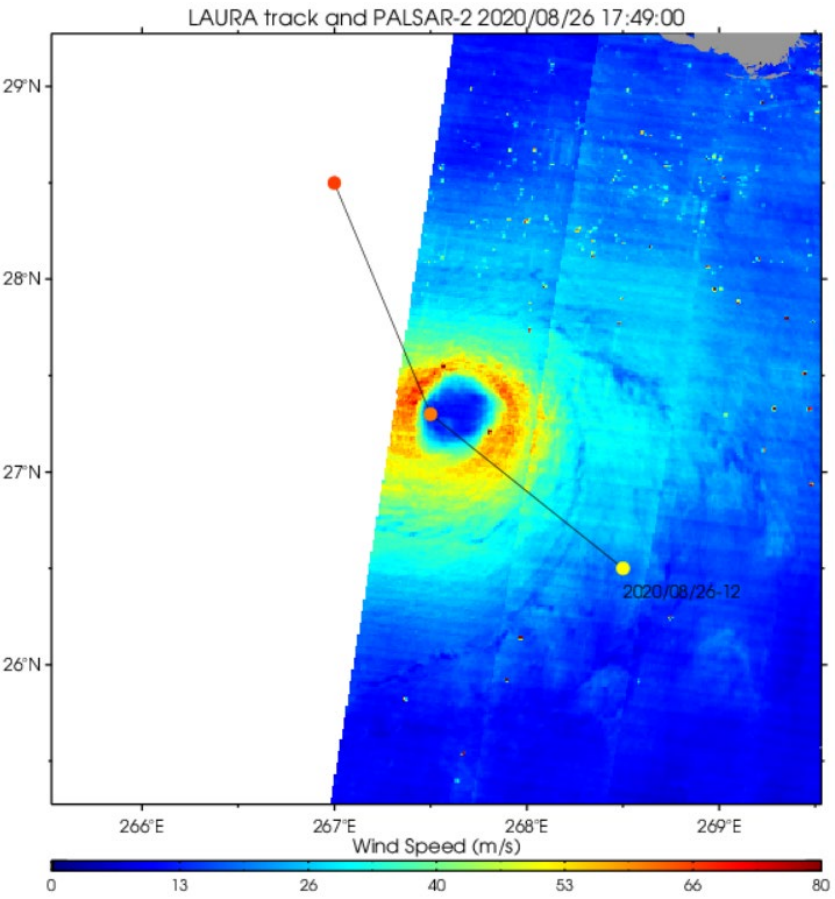
- ✓ The asymmetry of the wind speed pattern is roughly the same: smaller in NW and SW than in NE and SE .
- ✓ The absolute value of the wind speed radius and the decreasing tendency with respect to the distance are the same.

Temporal change of TC wind structure - LAURA



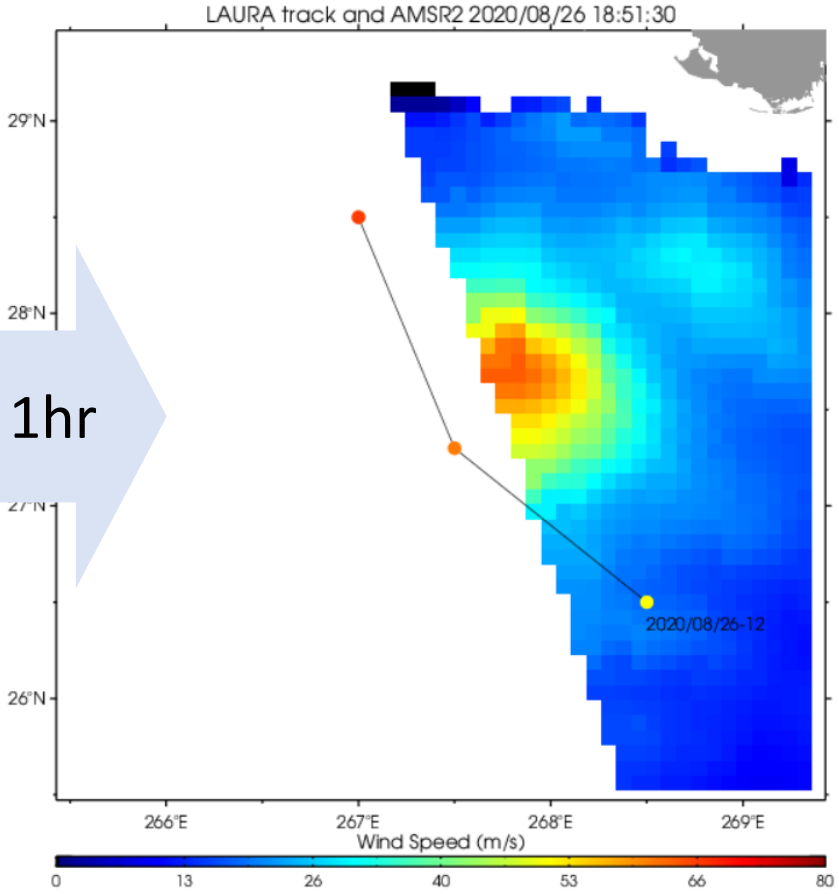
Temporal change of TC wind structure - LAURA

PALSAR-2
2020/8/26 17:49 (UT)



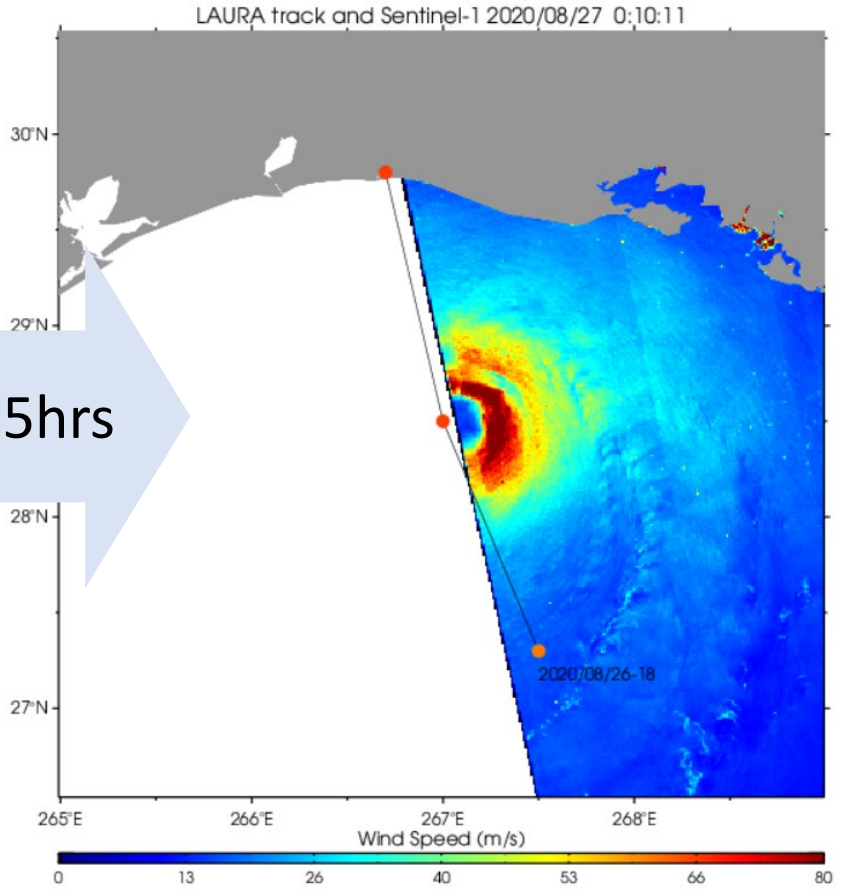
1hr

AMSR-2
2020/8/26 18:51 (UT)

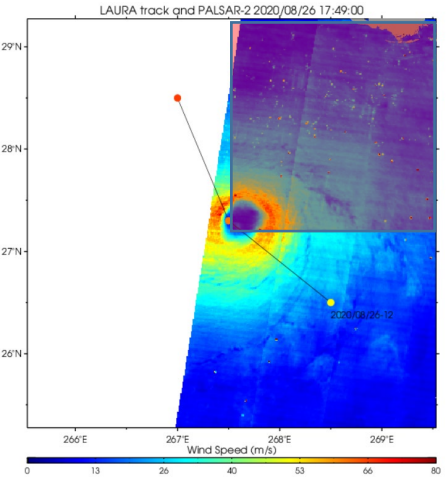


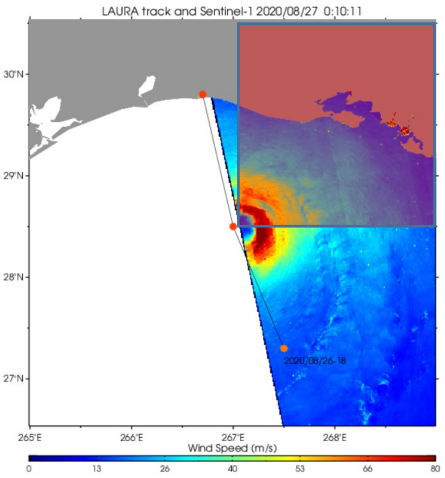
5hrs

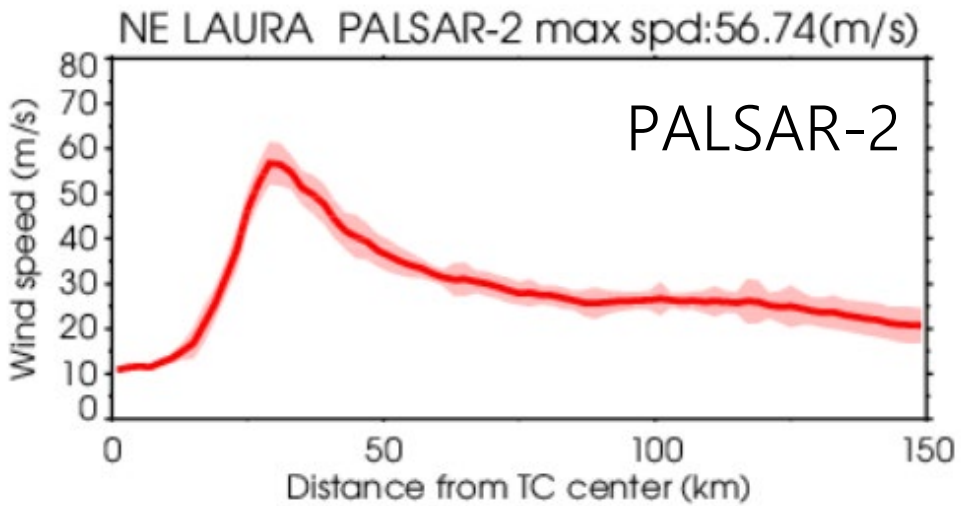
Sentinel-1
2020/8/27 0:10 (UT)

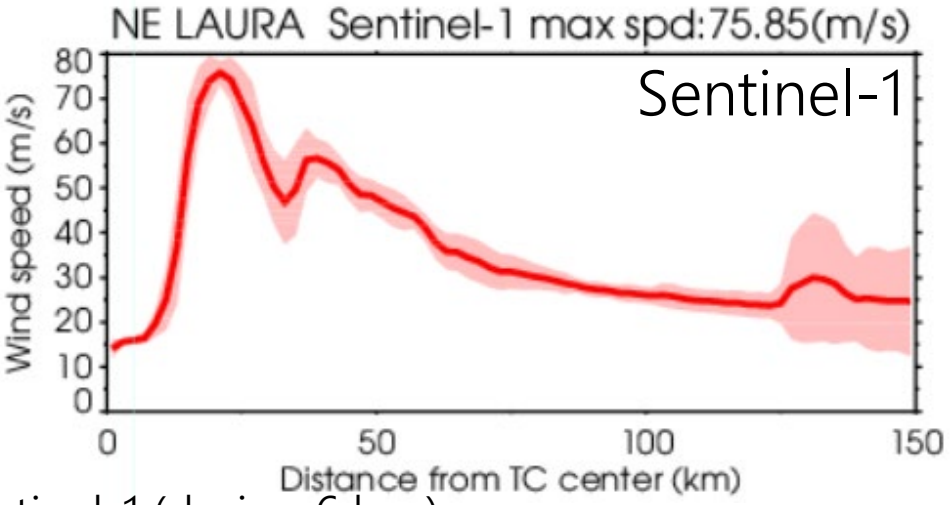


Temporal change of TC wind structure - LAURA





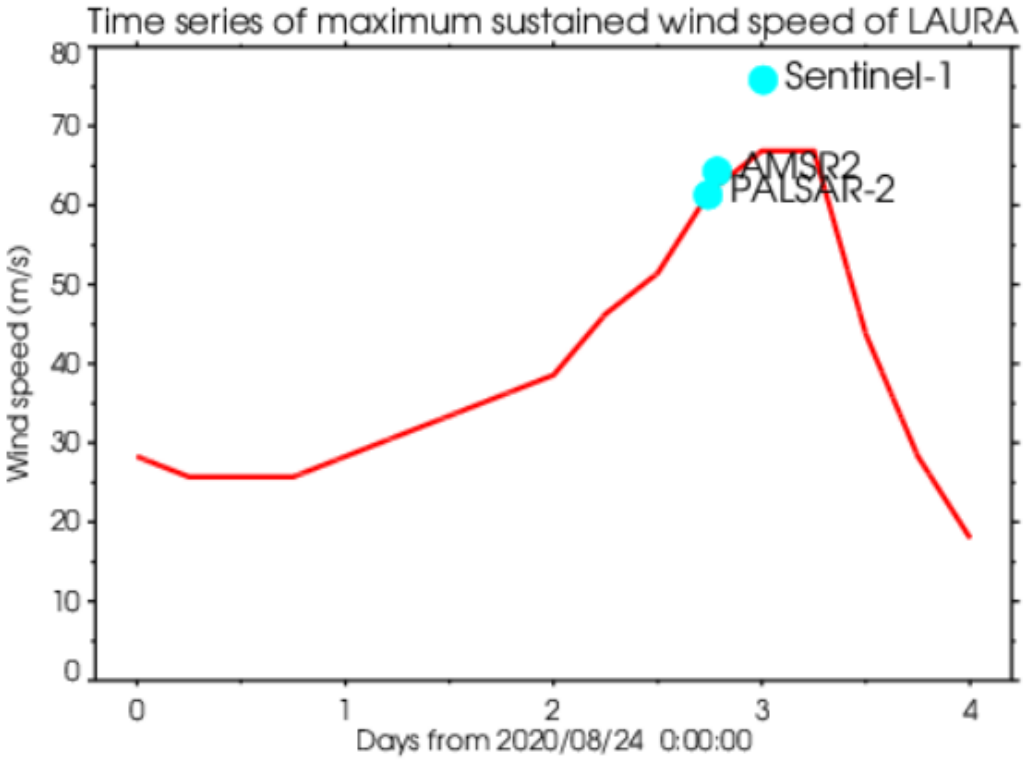




From PALSAR-2 to Sentinel-1 (during 6 hrs.)

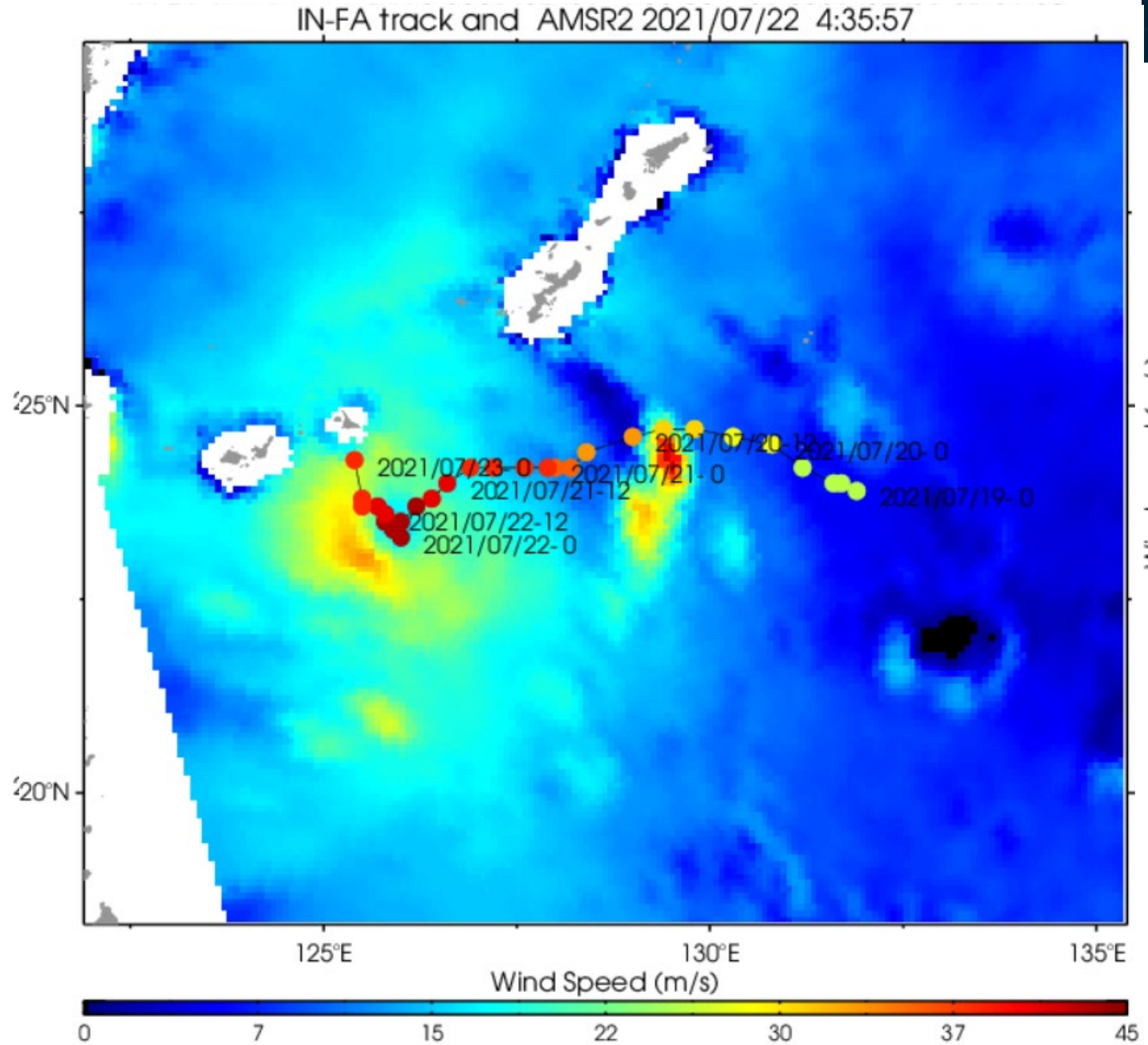
- Wind speed strengthens as the radius of peak wind speed decreases
- Wind distribution becomes double-structured

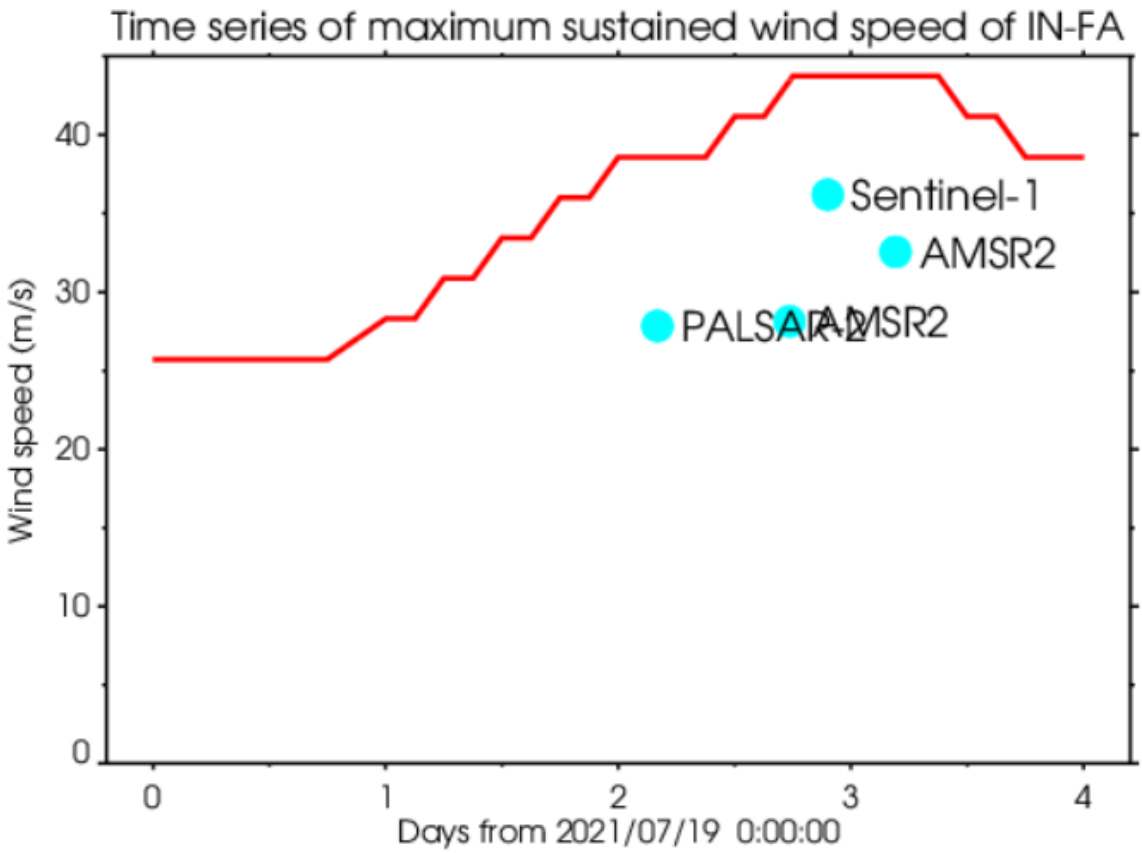
Time series of Max wind speed from Best-track



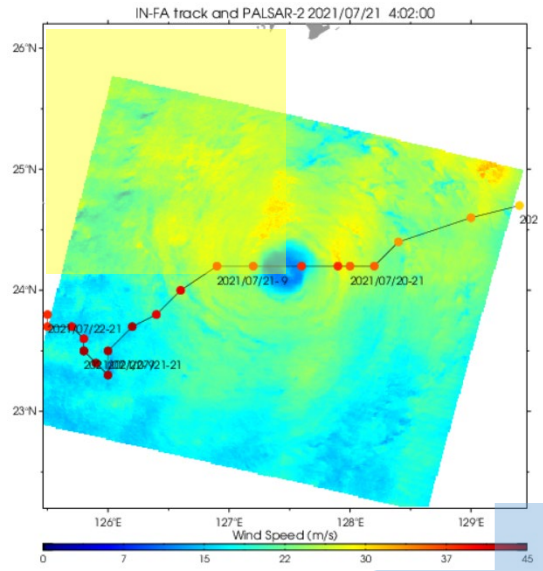
- The enhanced wind speeds are reproduced in the satellite winds.
- S1 wind speeds are stronger than the best track

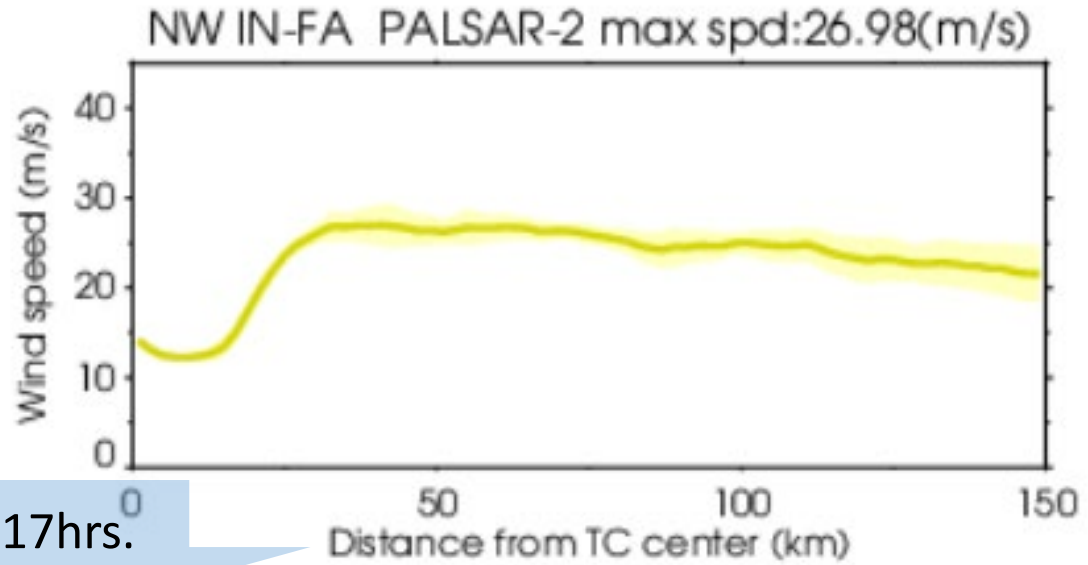
Temporal change of TC wind structure - INFA



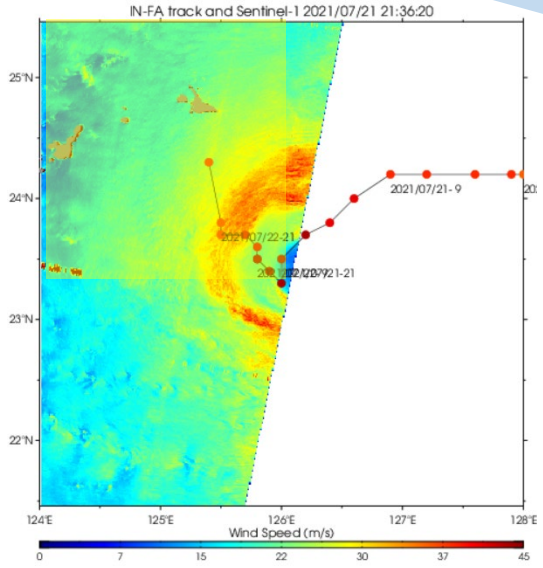


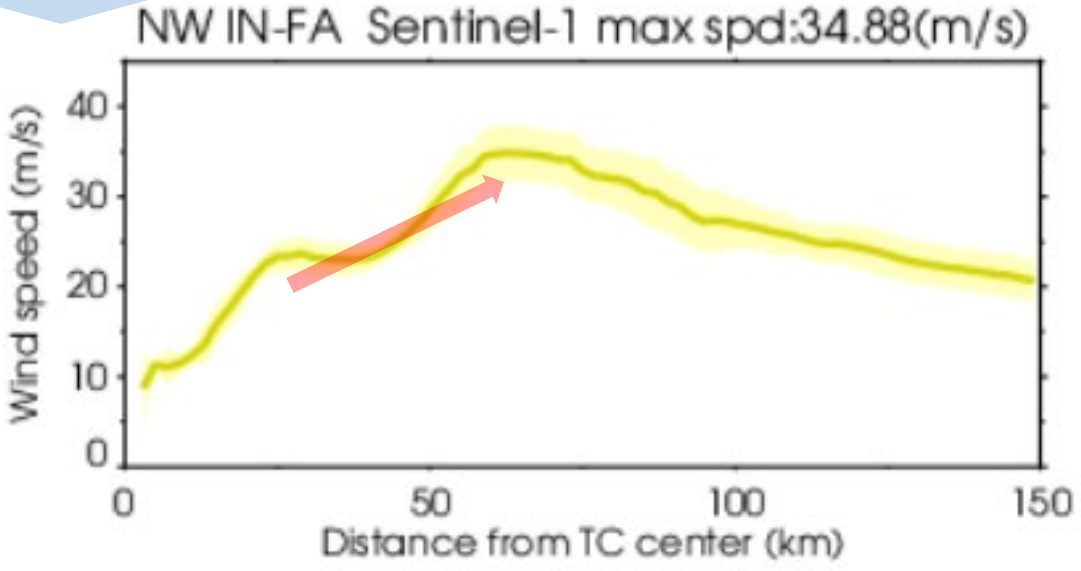
Temporal change of TC wind structure - INFA





17hrs.



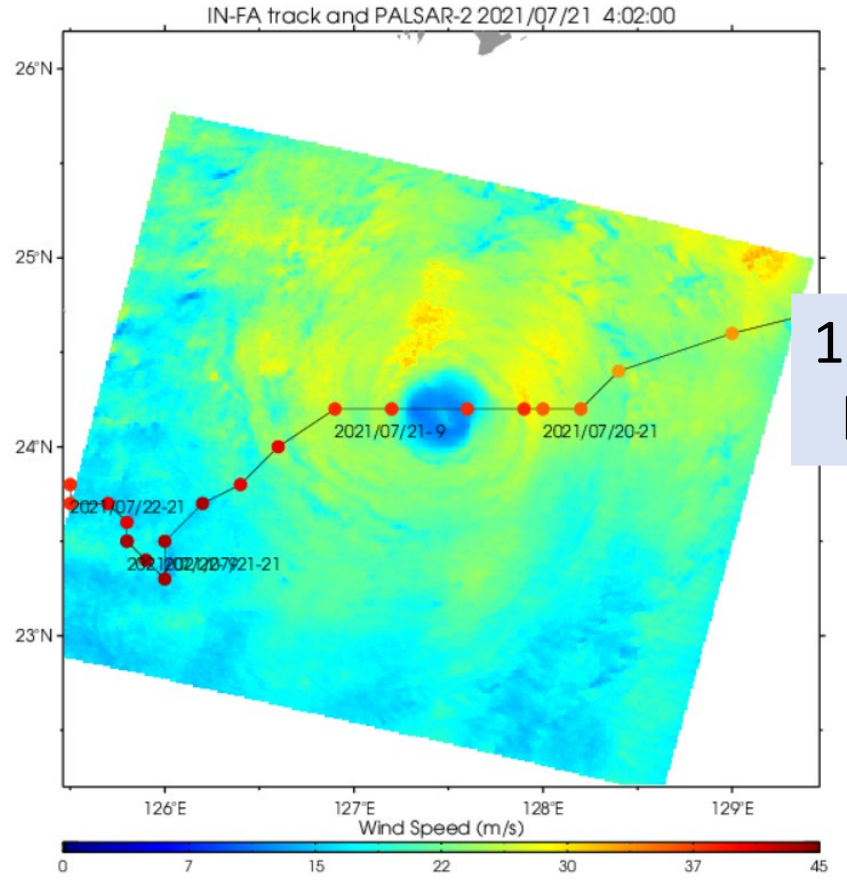


From PALSAR-2 to Sentinel-1 (during 17 hrs.)

- Wind speed is enhanced in S1 acquisition, forming the peak at 60km outside the wind speed peak at 30km in PAL2 acquisition.

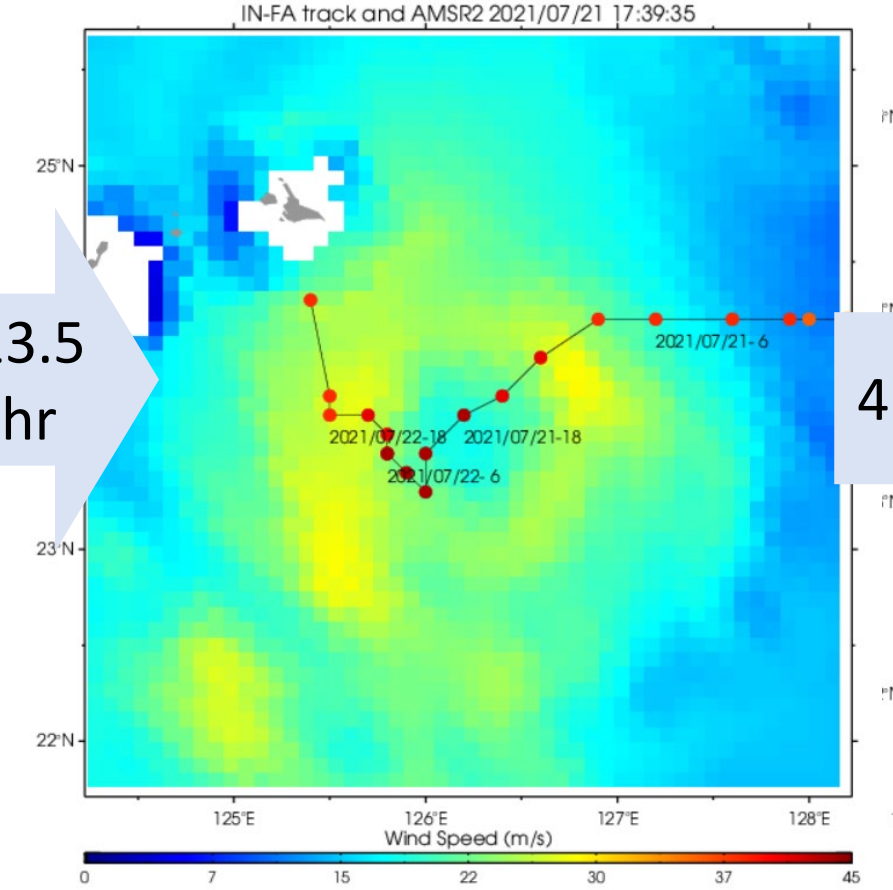
Temporal change of TC wind structure - INFA

PALSAR-2
2021/7/21 04:02 (UT)



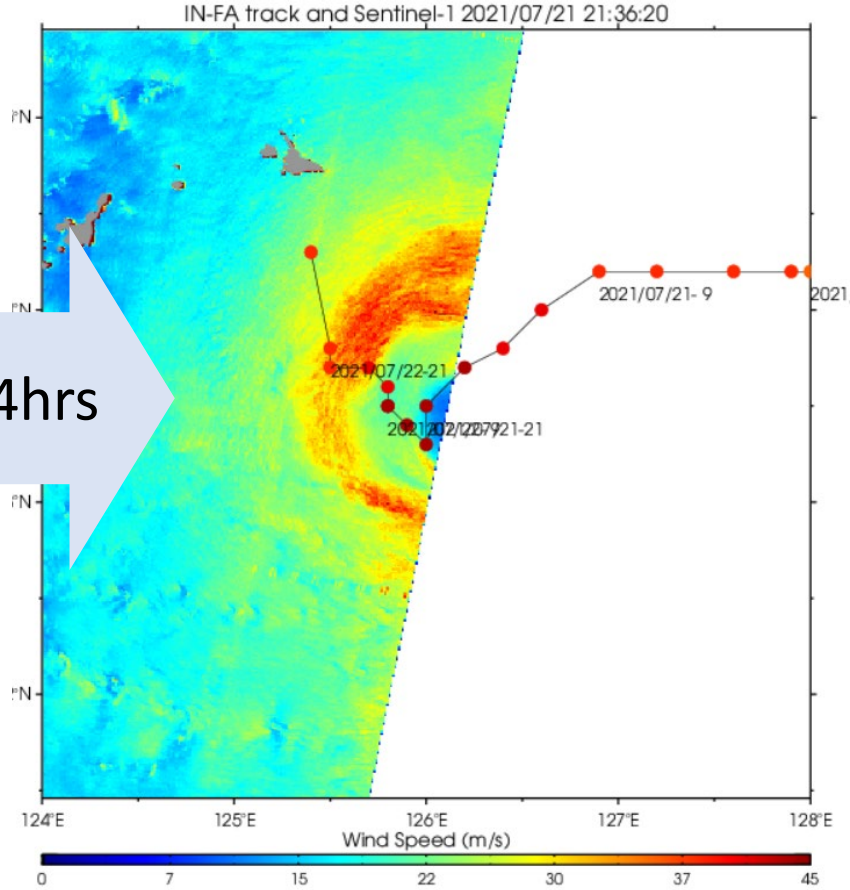
13.5 hr

AMSR-2
2021/7/21 17:39 (UT)



4hrs

Sentinel-1
2021/7/21 21:36 (UT)



Summary and Next step

Summary

- Wind speed structure detection by PALSAR-2 was demonstrated under hurricane/typhoons.
- The integrated use with S1 and AMSR winds showed the possibility of detecting temporal change of hurricane/typhoon wind speed structure in detail.

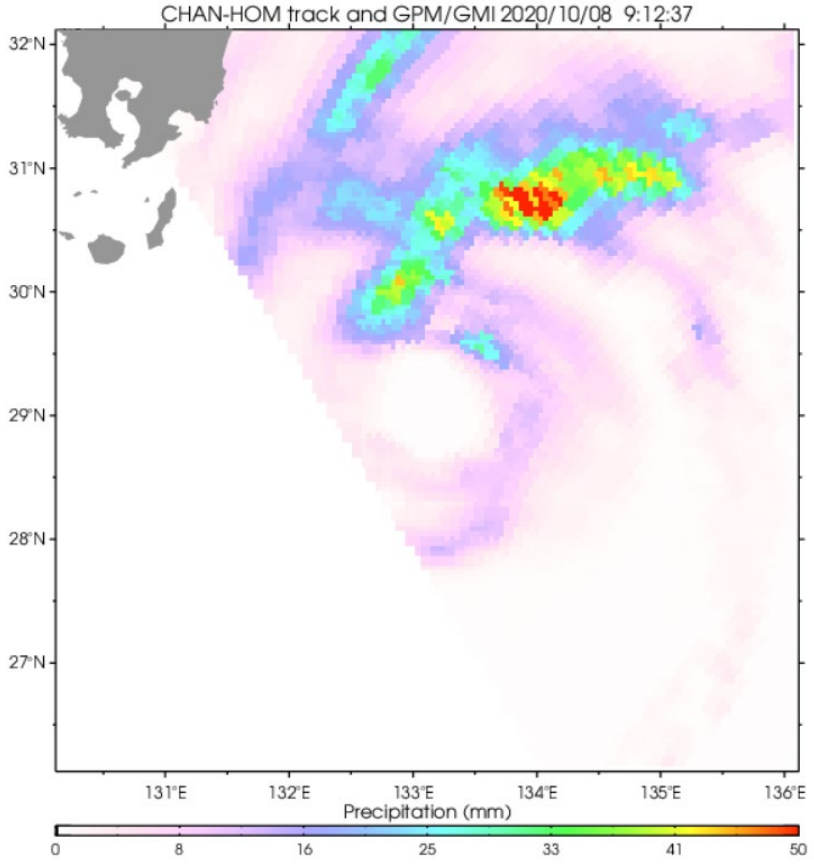
Next step

- Improvement of GMF and validation of retrieved wind speed.
  - Needs more in-situ match-up data
- Wind vector retrieval using dual-pol (HH and HV) data.
- Investigation of characteristics of SAR TC data and effective use of data through integrated use of various satellite products.

Summary and Next step

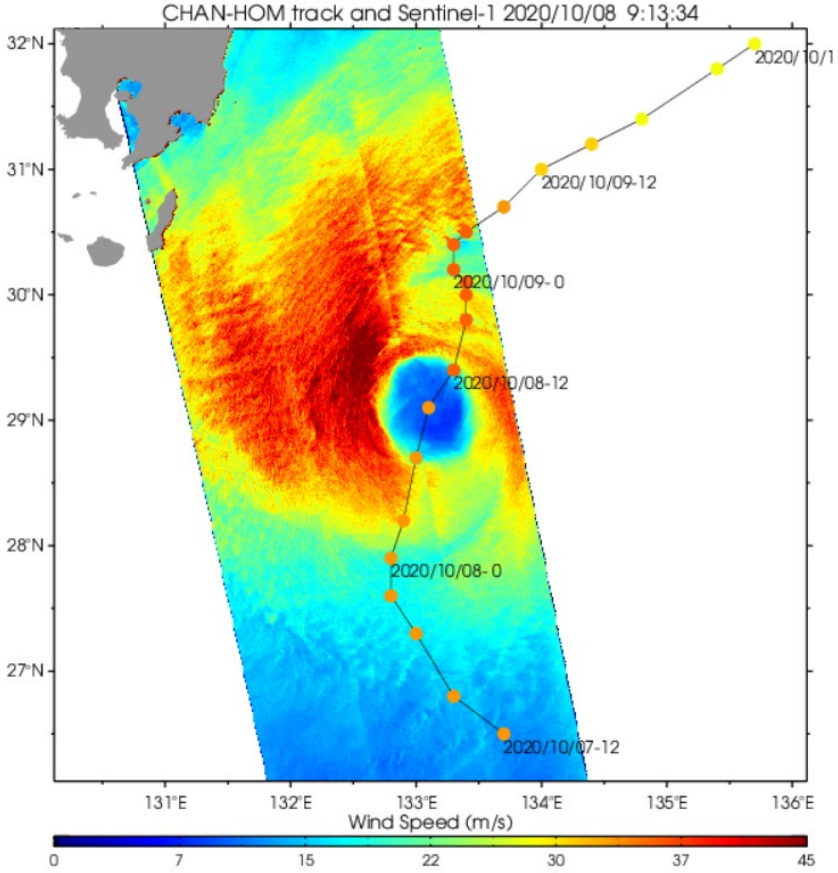
Precipitation 2020/10/08 9:12

The Global Precipitation Measurement (GPM) Microwave Imager (GMI)



HV σ^o 2020/10/08 9:13

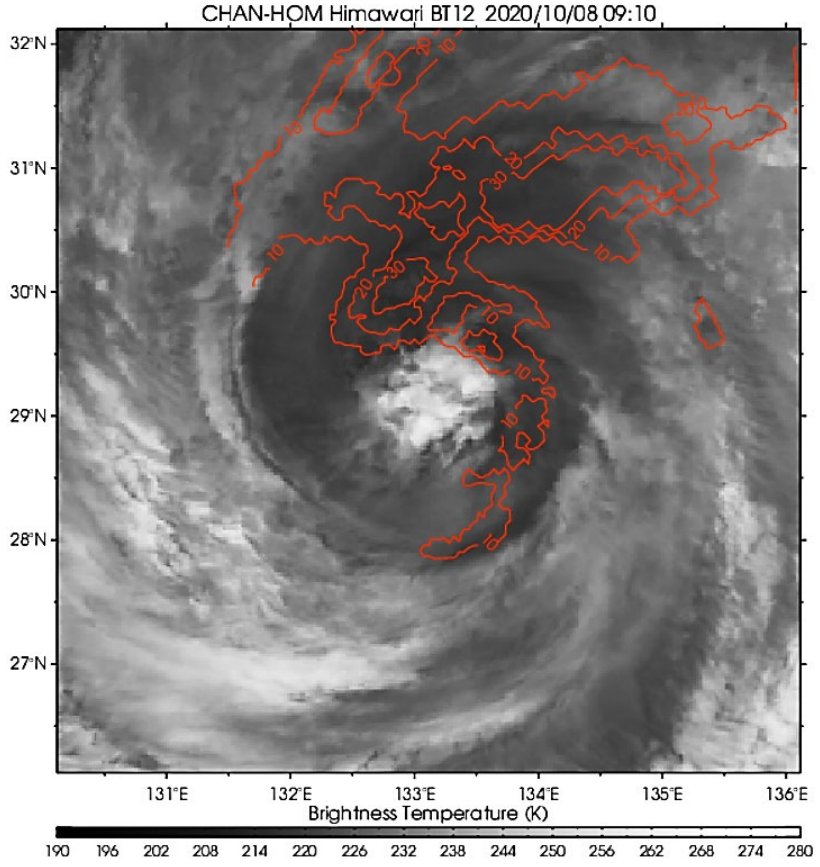
Sentinel-1 SAR



Brightness Temperature

2020/10/08 9:10

Himawari-8 geostationary meteorological satellite IR12

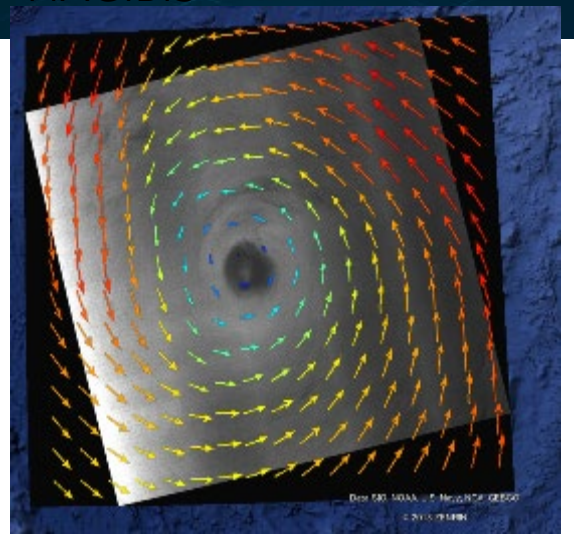


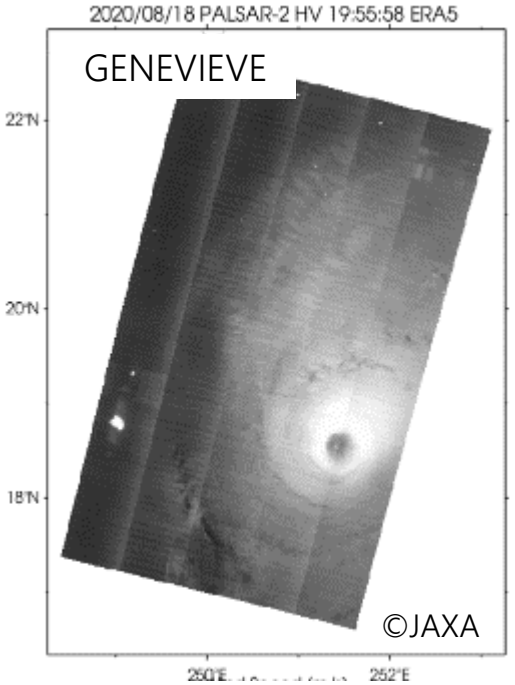
Match-up data collection

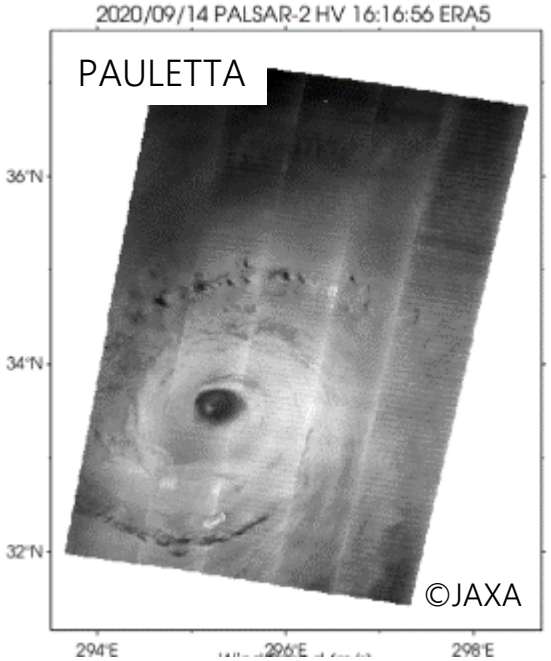
Major typhoon / hurricane observation results

Hurricane/Typhoon	Obs. Time (UT)	Beam/ Obs. dir	Airplane Obs.
DORIAN	2019/9/5 17:19:45	W2/R	○
HAGIBIS	2019/10/9 13:59:42	W3/L	
	2019/10/11 14:42:48	W1/R	
DOUGLAS	2020/7/26 9:40:58	W2/L	○
GENEVIEVE	2020/8/18 19:55:30	W3/L	
	2020/8/19 6:39:26	W3/L	
	2020/8/20 7:00:59	W1/L	
LAURA	2020/8/26 5:52:46	W1/R	
	2020/8/26 17:48:56	W3/R	○
MYSAK	2020/9/2 3:59:05	W2/R	
PAULETTA	2020/9/14 4:23:41	W3/R	○
	2020/9/14 16:16:29	W2/R	
TEDDY	2020/9/18 16:05:16	W1/L	○
	2020/9/19 2:51:53	W4/L	
ELSA	2021/7/3 17:16	W3/L	○

HAGIBIS







Match-up data collection

Radiometric correction

- ✓ Radiometric adjustment (correction) between beams and scans was conducted using the Amazon forest observation data.

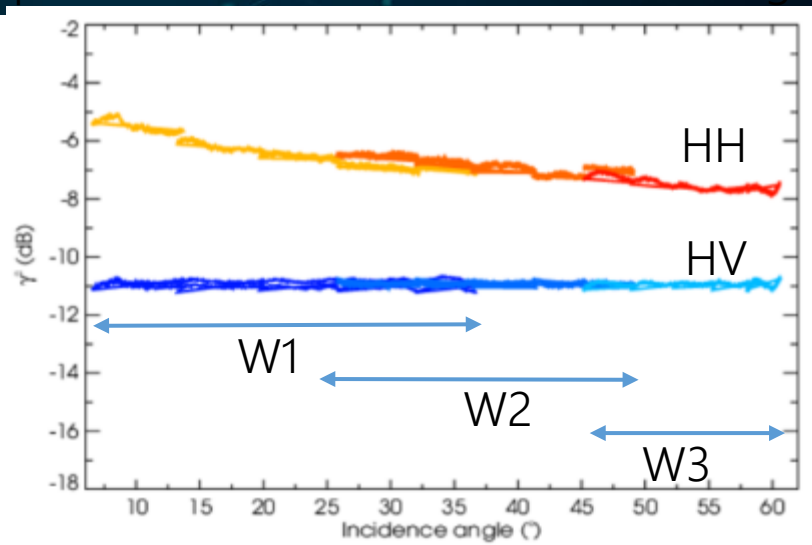
- ✓ The Faraday rotation angle (Ω) is estimated from the total electron contents (TEC), and the correction is performed using the following formula assuming the VV / HH polarization ratio (PR).

$$\sigma^{o}_{hh} = \frac{\sigma^{o'}_{hh}}{cos^4\Omega + sin^4\Omega PR},$$

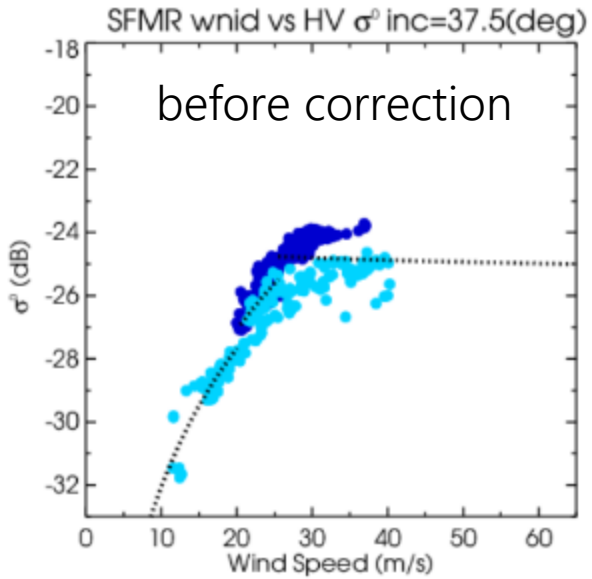
$$\sigma^{o}_{hv} = \sigma^{o'}_{hv} - \sigma^{o}_{hh} sin^2\Omega cos^2\Omega (1 + \mathrm{PR})$$

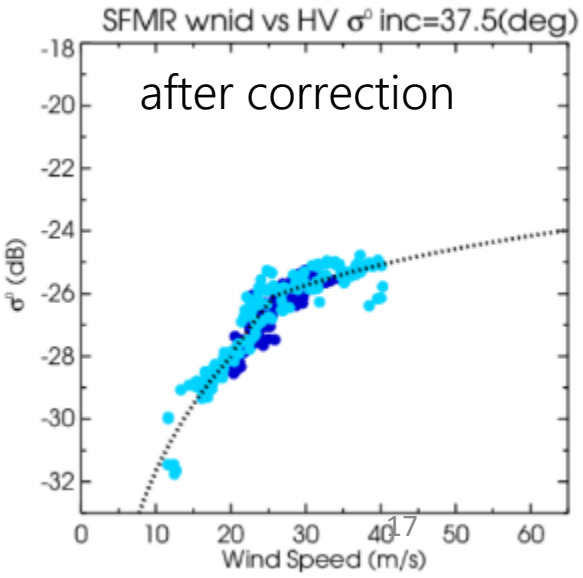
- ✓ TEC maps: Global ionosphere maps (GIM) (http://www.aiub.unibe.ch/download/)
- ✓ The Earth's magnetic field : International Geomagnetic Reference Field (IGRF) model (https://www.ngdc.noaa.gov/IAGA/vmod/igrf.html)

γ^0 profiles as a function of incidence angle



HV σ^0 as a function of wind speed (θ=37.5deg)

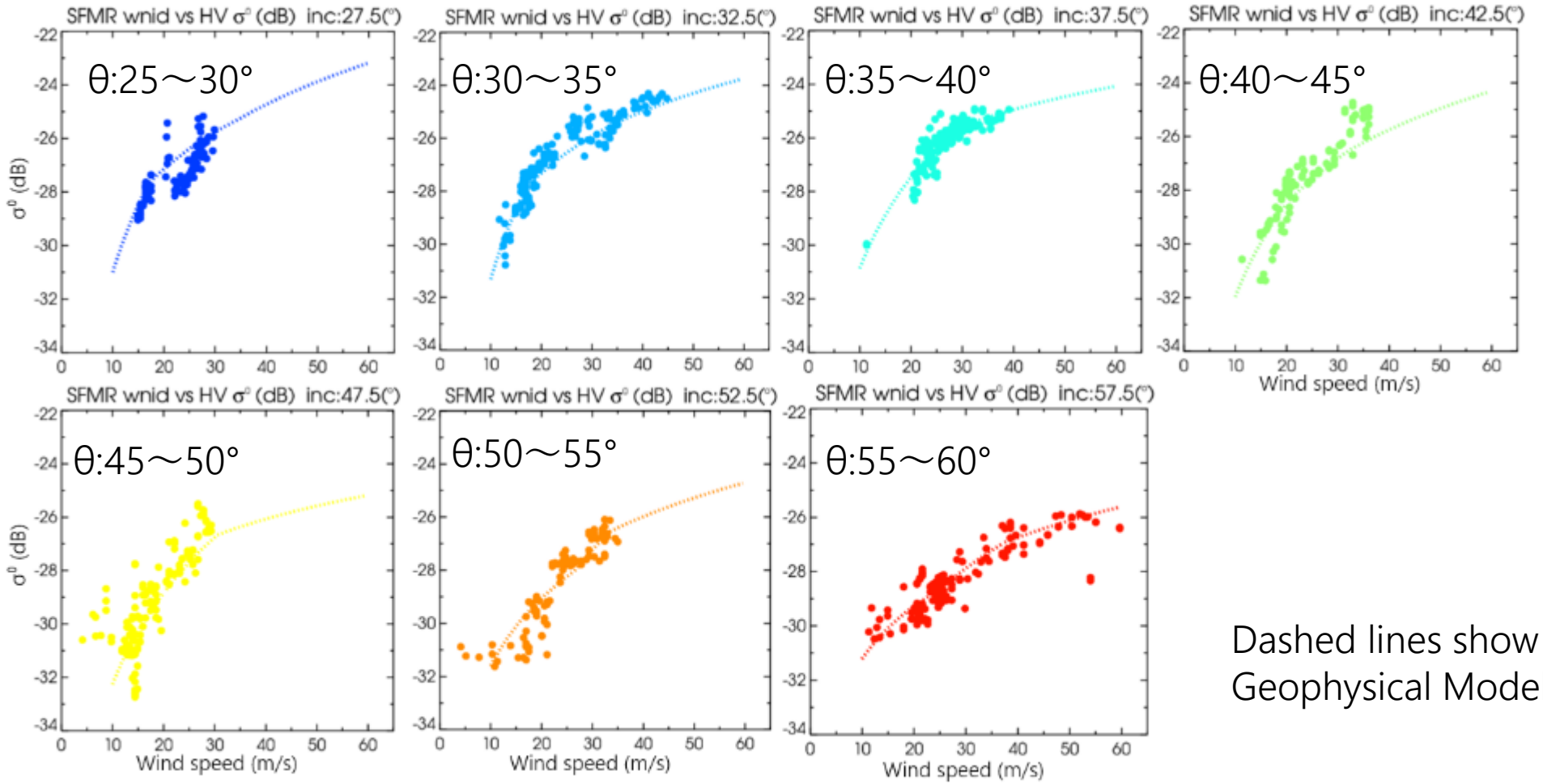




Model Derivation

Match-up data are divided into bins with an incident angle of 5°and a wind speed of 2 m/s, and quality check is performed at ± 2σ.

Relationship between PALSAR-2 HV σ^0 and ocean surface wind speed measured by SFMR.



Dashed lines show derived Geophysical Model Function (GFM).

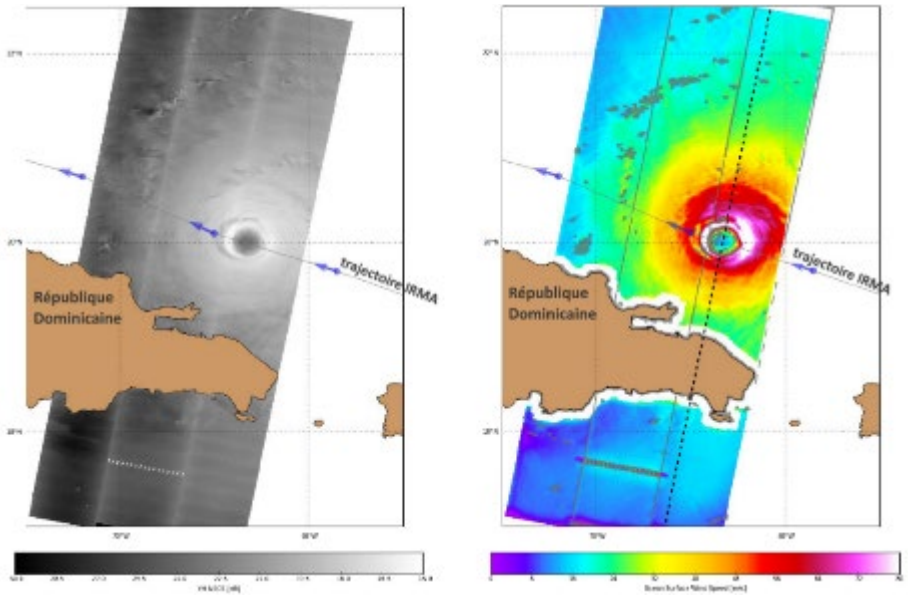
PALSAR-2 HV σ^0 increases with the increase of wind speed up to 50m/s without saturation.

Introduction

Hurricane wind speed detection by C-band SAR

- ✓ Geophysical model functions (GMFs) for C-band cross-polarization was developed to detect high ocean surface winds i.e under the Typhoon (Hurricane).

Sentinel-1 VH image and detected surface wind speed of Hurricane Irma



after "https://www.aviso.altimetry.fr/en/applications/atmosphere-wind-and-waves/hurricanes/irma-2017.html"

JAXA-MRI(Meteorological Research Institute) joint research

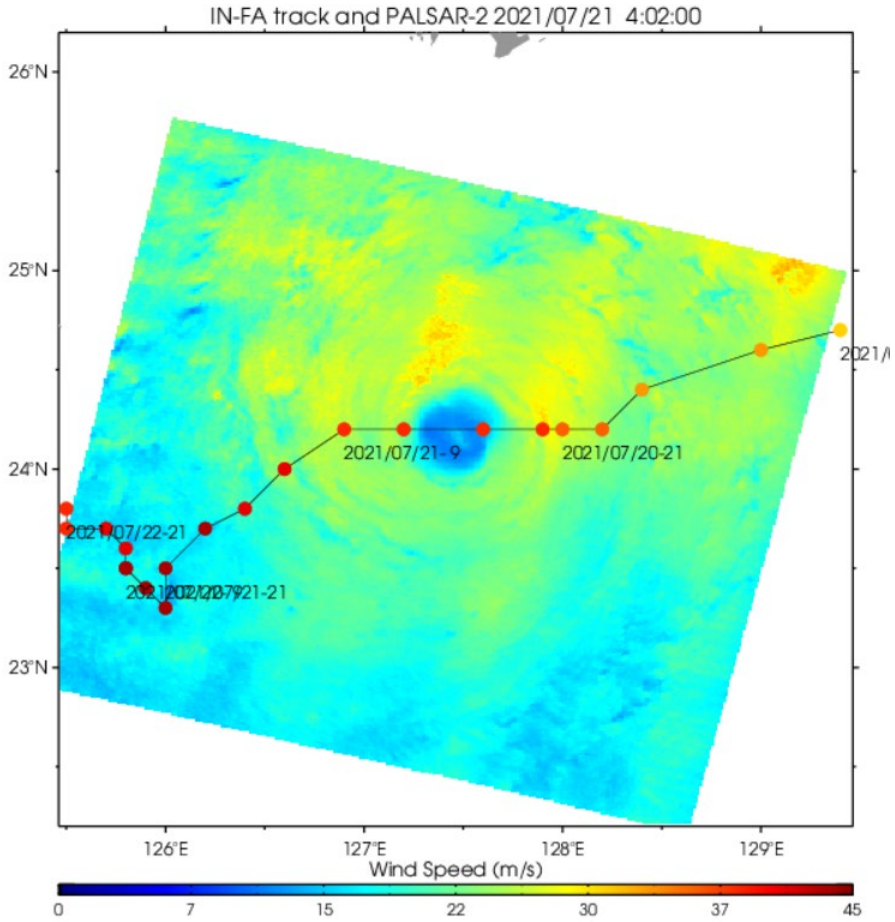
Objective:

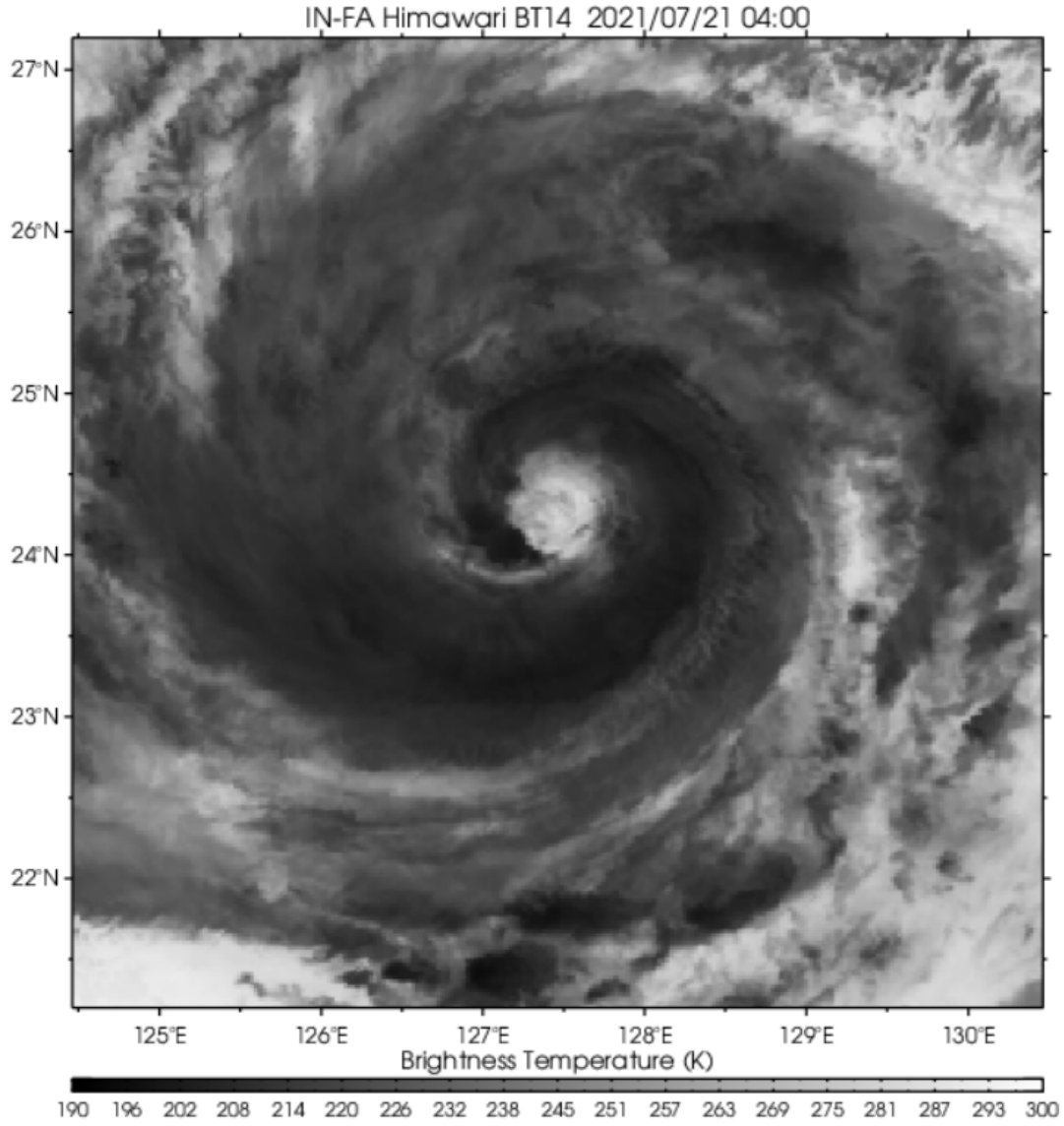
- ✓ to enable wind speed detection by L-band SAR (PALSAR-2) and to use it for operational weather forecasting under typhoon conditions

Research interest

- ✓ Detectable wind speed range and the effect of rain on the L-band σ^0 and wind speed estimation.

Temporal change of TC wind structure - INFA





Temporal change of TC wind structure - INFA