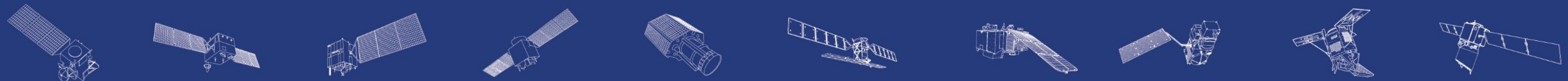

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2023 DRAGON 5 SYMPOSIUM

3rd YEAR RESULTS REPORTING

11-15 SEPTEMBER 2023

PROJECT ID. 59373

Investigation of internal waves in Asian Seas using European and Chinese satellite data

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14 SEPTEMBER, 9;45

ID. 59373

PROJECT TITLE: Investigation of internal Waves in Asian Seas Using European and Chinese Satellite Data

C-band of Radar Signatures of Convective Rain: a Case Study Using Sentinel-1 Multi-polarization SAR Images of the South China Sea

PRINCIPAL INVESTIGATORS: WERNER ALPERS, KAN ZENG

C-band of Radar Signatures of Convective Rain: a Case Study Using Sentinel-1 Multi-polarization SAR Images of the South China Sea

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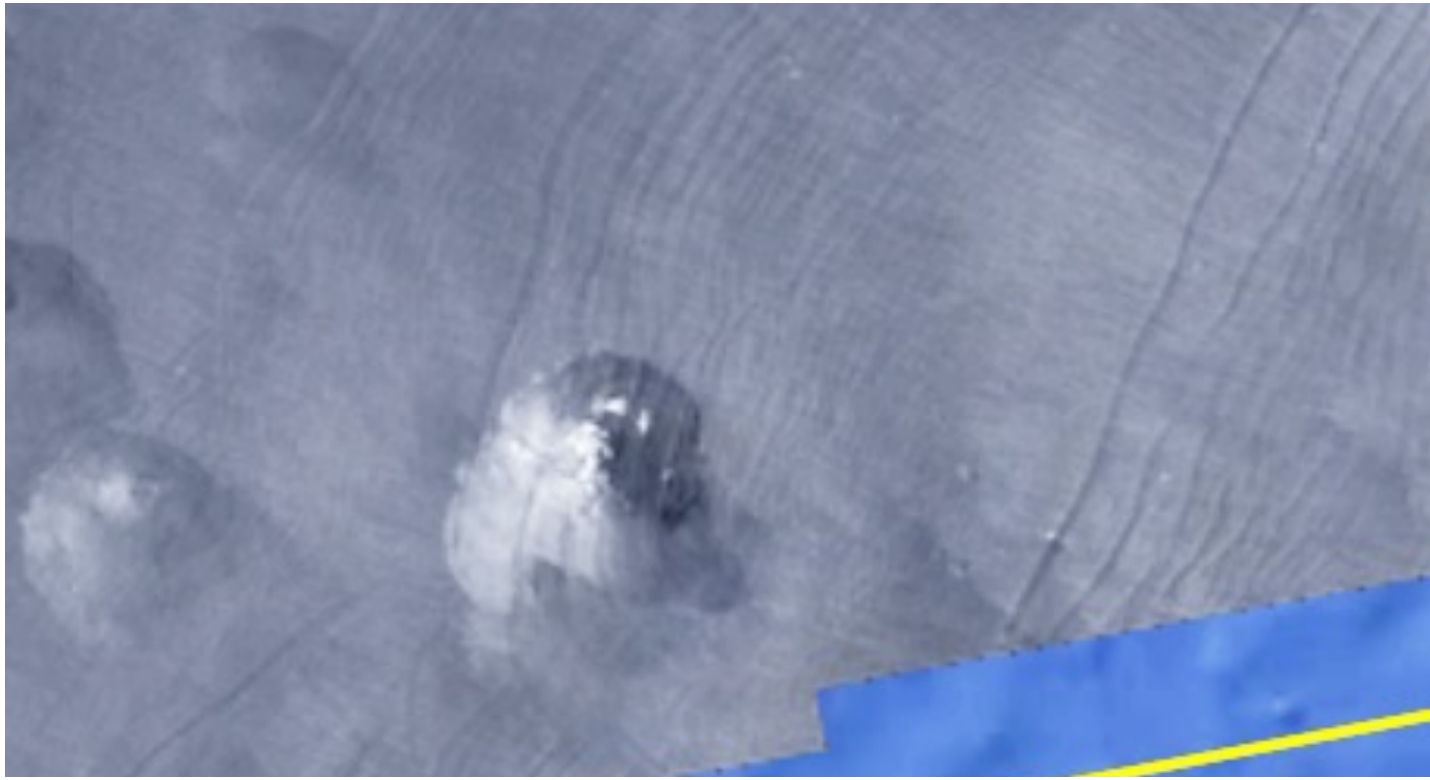
Wai Kong, Pak Wai Chan

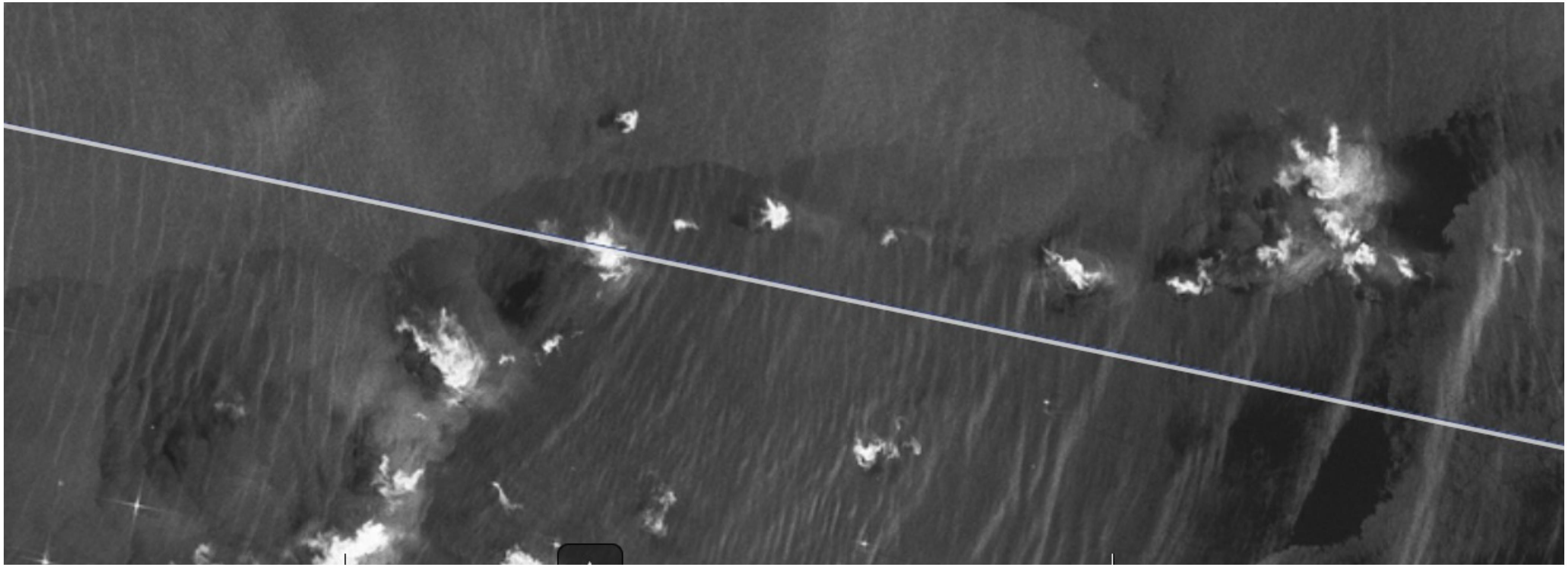
Hong Kong Observatory, Honh Kong

Radar signatures of convective rain over the ocean also affect radar signatures of internal waves

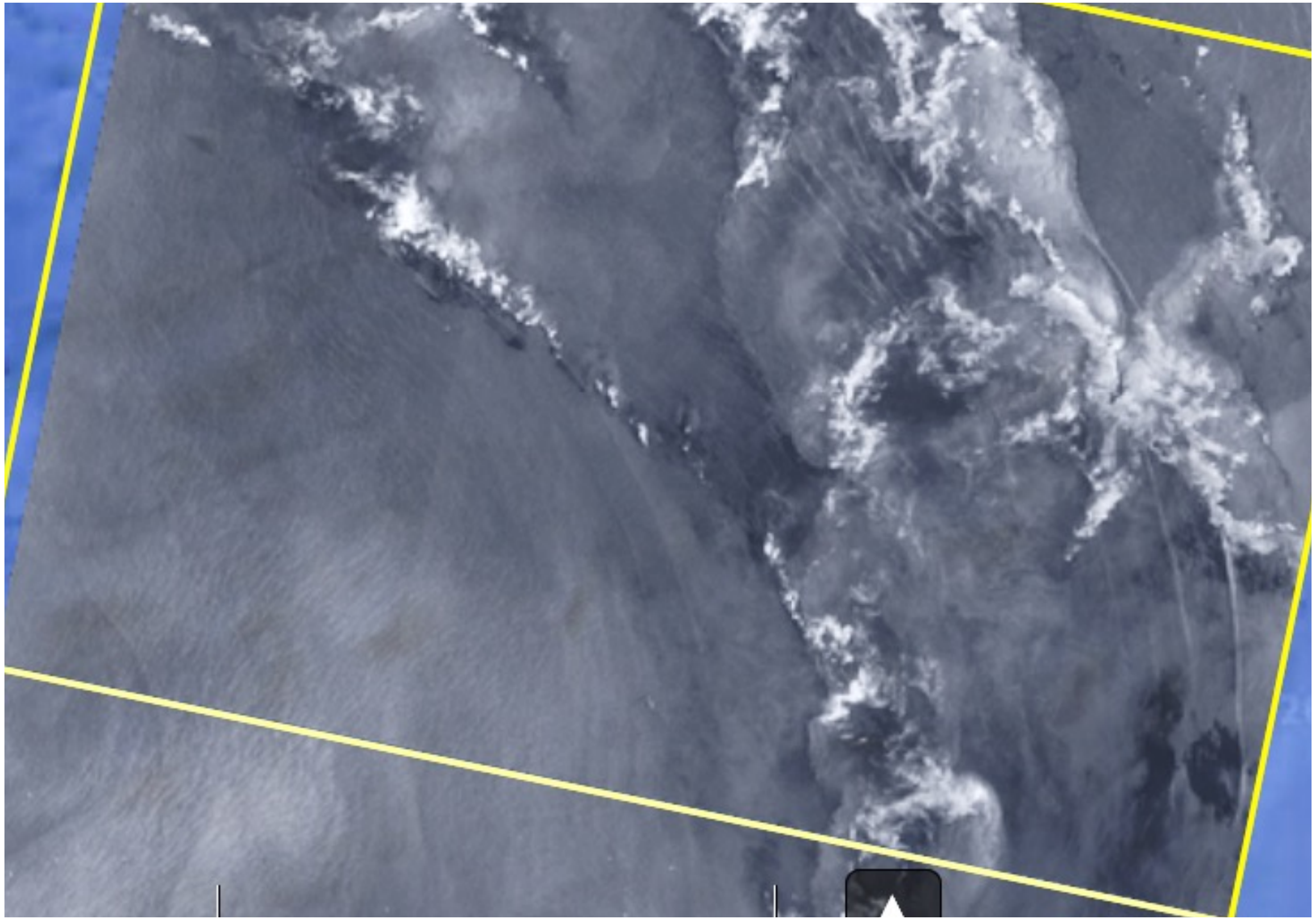
Sentinel-1A image, 6 Aug 2020, 1025 UTC
South China Sea, SE of Hong Kong



Zoom on the rectangular area showing an internal wave pattern disturbed by a rain cell



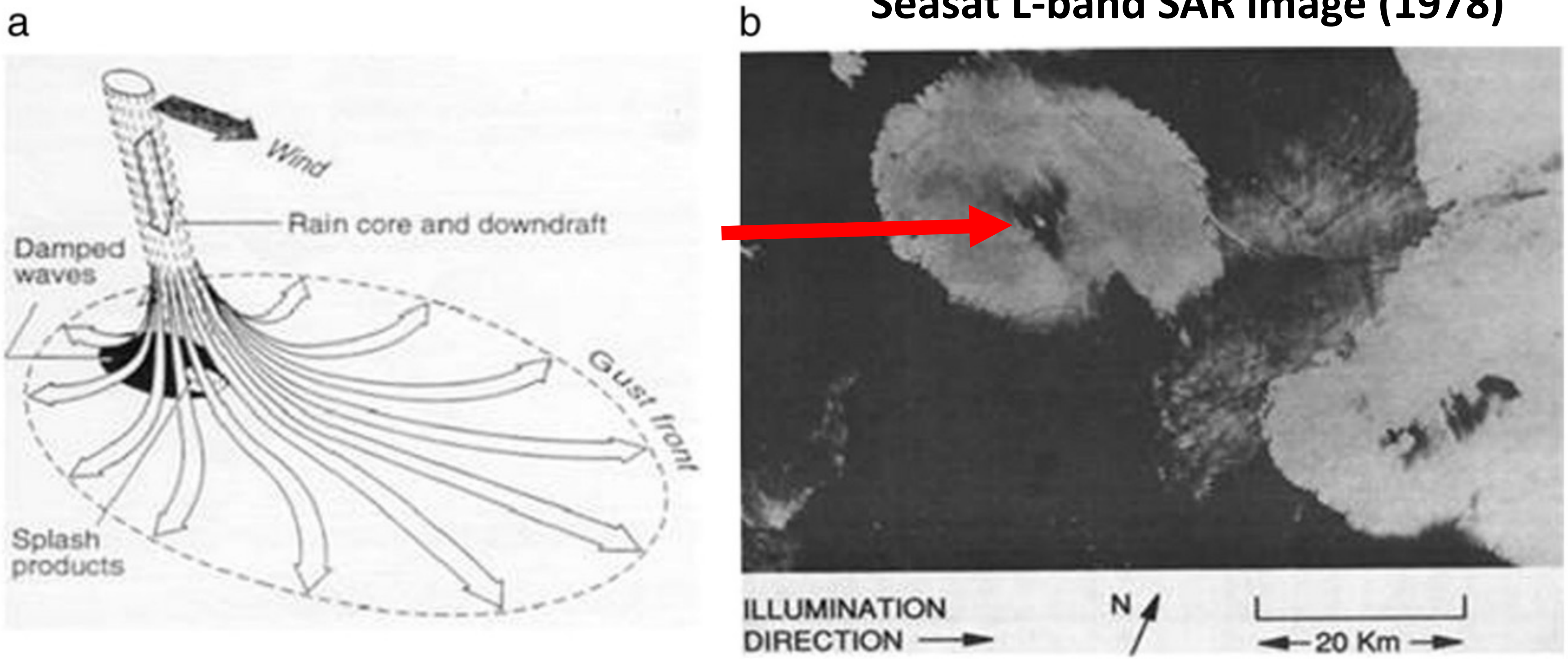
Sentinel-1a, Andaman Sea, 14 Sept 2022, 2320 UTC,



Sentinel-1A, Andaman Sea, 5 May 2022, 2331 UTC

For a long time, the physical mechanism causing "bright blobs" in radar signatures of rain cells over the ocean was discussed controversially

Seasat L-band SAR image (1978)



. (a) Schematic sketch of the downdraft of a rain cell spreading over the sea surface where it causes roughening of the sea surface (adapted from Atlas, 1994); (b) Seasat SAR image red over the Gulf of Mexico on 11 September 1978 at 17:14 UTC showing at the upper left an elliptically-shaped bright downdraft pattern with a black area in the center, which ins a small bright patch.
ted from Fu and Holt (1982).

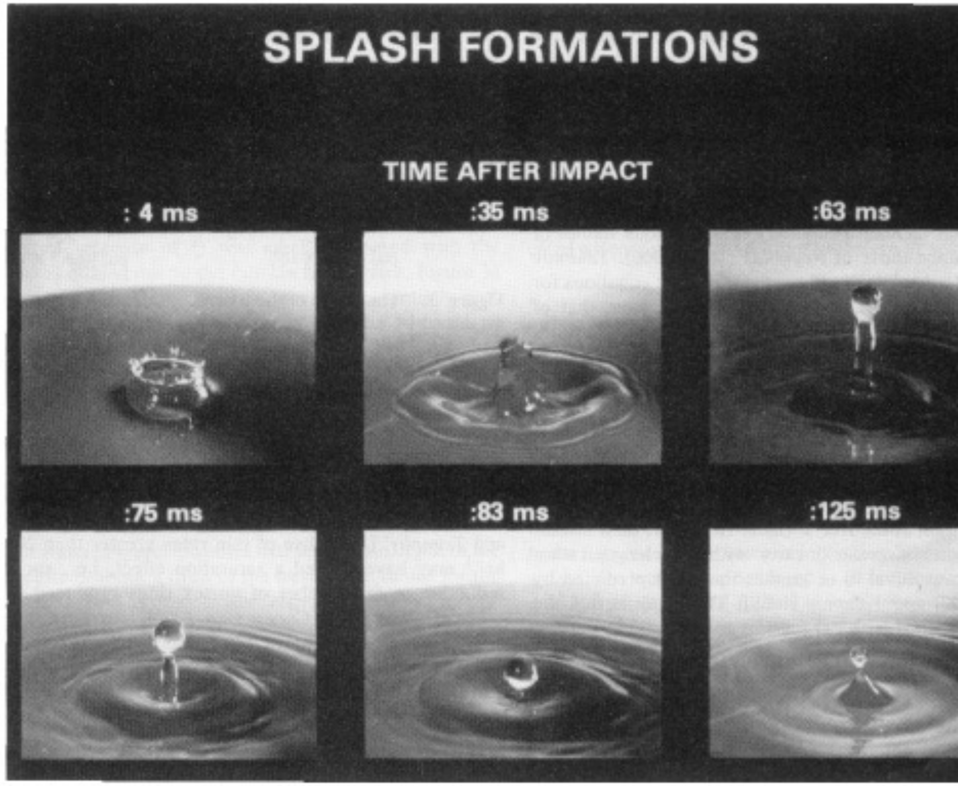
Several scattering mechanisms have been proposed to explain this phenomenon:

1) scattering at splash products generated by raindrops impinging onto the sea surface (Atlas, 1994a, 1994b)

2) radar pulse reflection from the sea surface followed by scattering at raindrops above the sea surface (Jameson et al., 1997)

3) scattering at low-salinity "puddles" in the upper water layer generated by intense rainfall (Wijesekera and Gregg, 1996)

4) scattering at steep slopes at the rim of the craters produced by impinging raindrops (Braun, 2003).

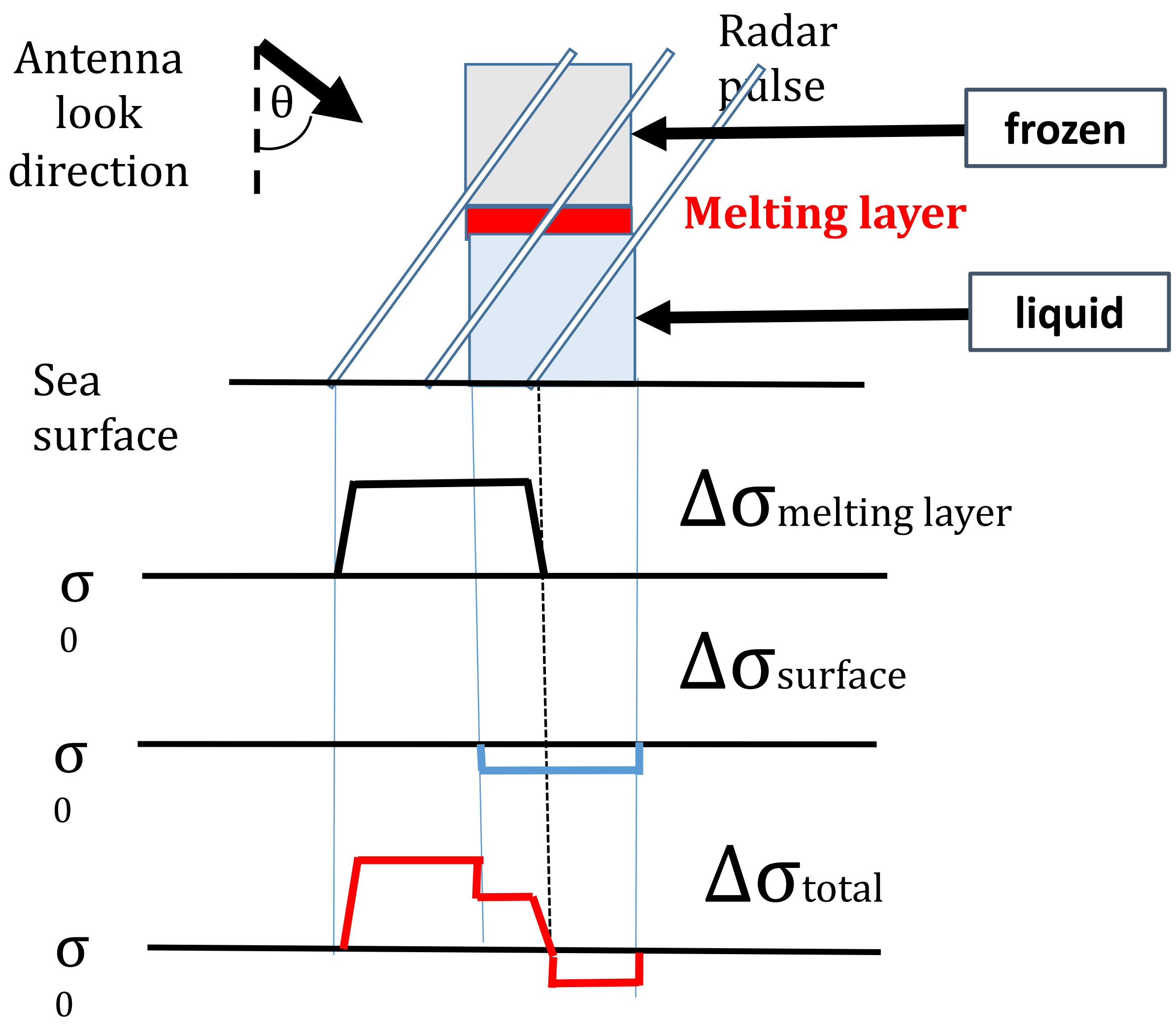


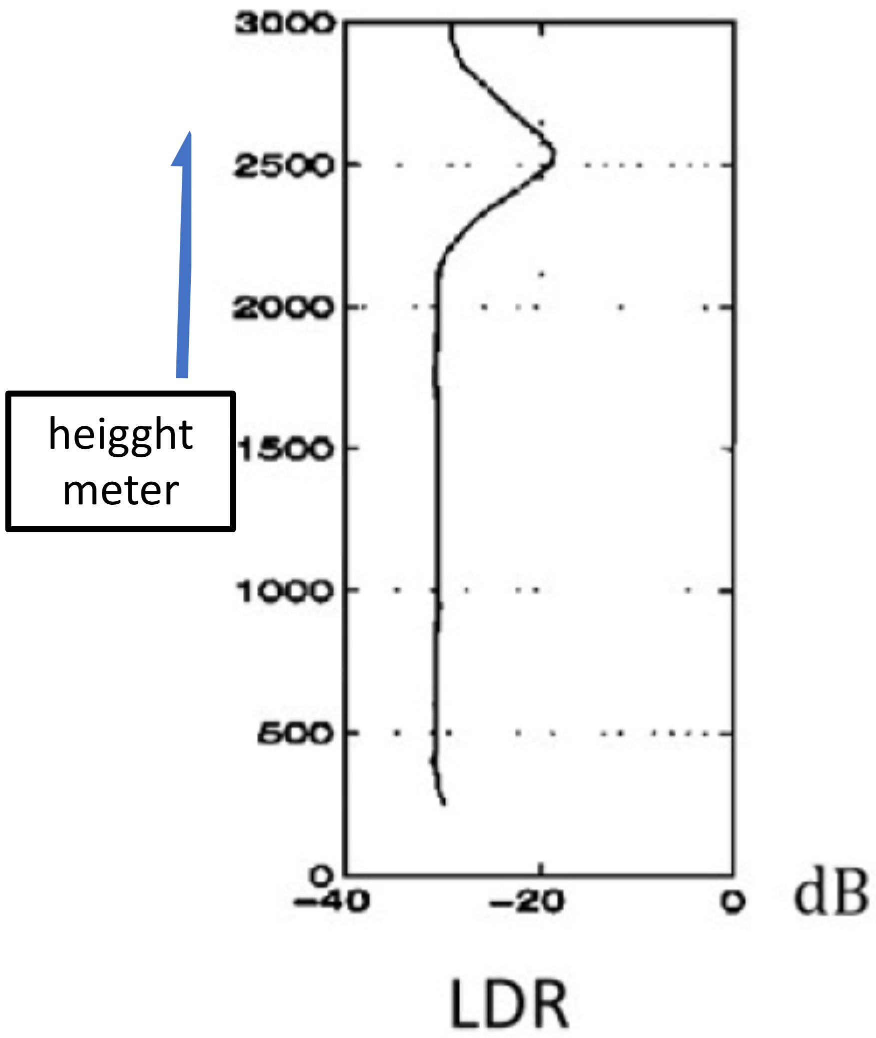
In 2021, we published a paper showing that the bright blobs are due to radar backscattering at the **melting layer.**

Alpers, W., Y, Zhao, A. Mouche, and P.W. Chan, 2021. “A note on radar signatures of hydrometeors in the melting layer as inferred from Sentinel-1 SAR data acquired over the ocean”. Remote Sens. Environ. 253:112177

Zhao et al., 2021
Subrahmanyam et al., 2023

Radar backscattering from a rain column





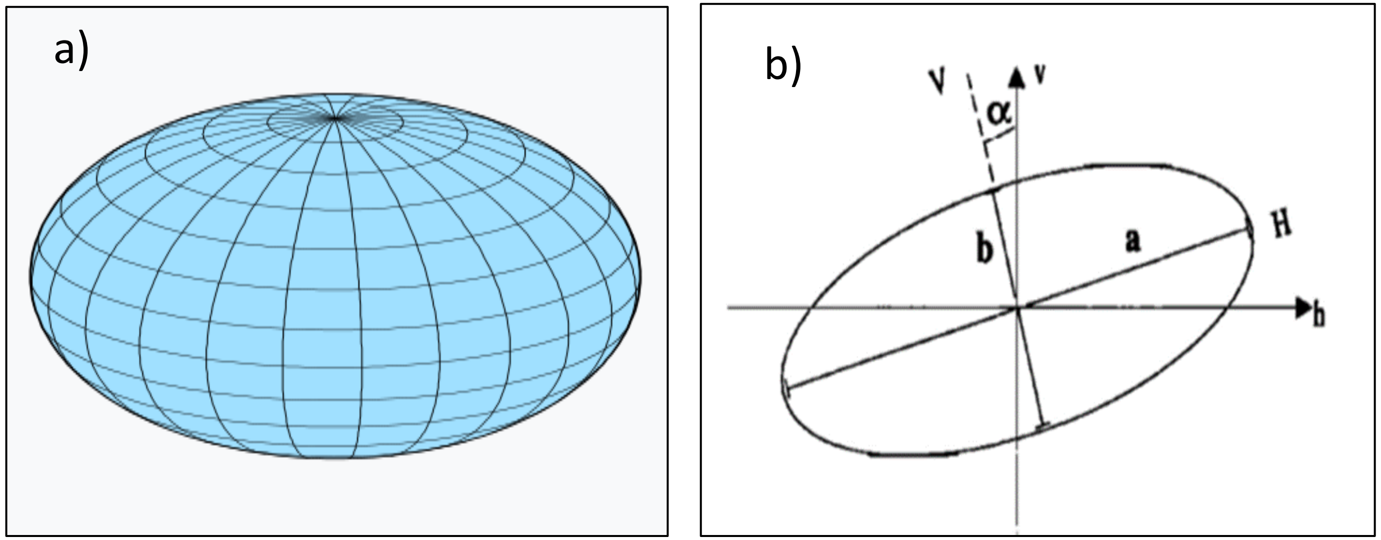
The melting layer is well known to radar meteorologists, who call it bright layer

Z = reflectivity

$$LDR = 10 \log_{10} (Z_{HV}/Z_{HH})$$

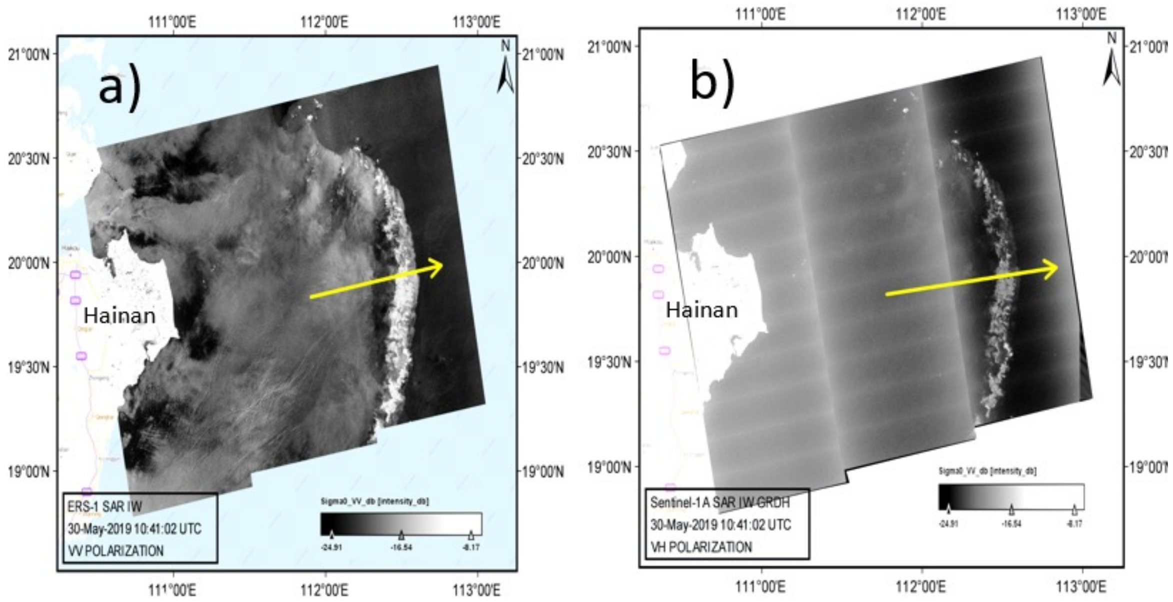
LDR = Linear depolarization ratio

Since the hydrmeteors have spheroidal shape and wobble (tumble) in the melting layer, there is also a c ross-polarization component in the backscattered radar signal

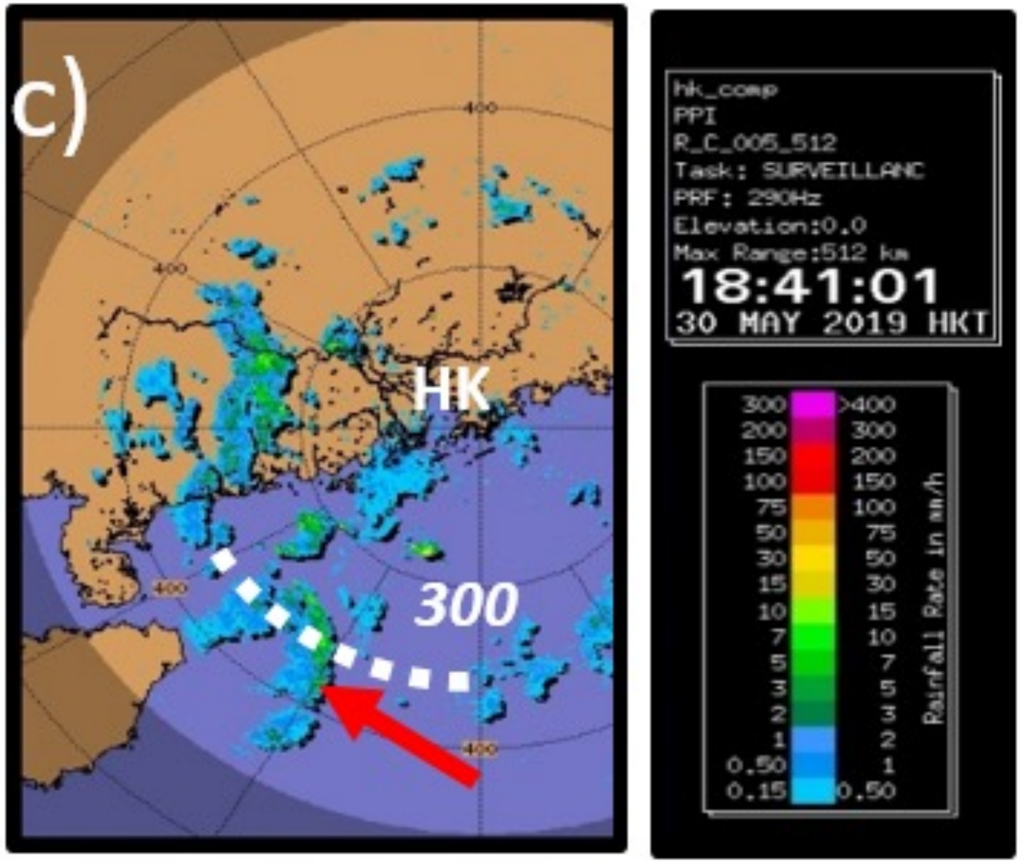


. a) Oblate spheroid used in the scattering model for the shape of hydrometeors; b) spheroidal hydrometeor tilted by an angle α away from the vertical. Here H denotes the horizontal axis and V the vertical axis. The major axis has a length of 2a, and the minor axis a length of 2b). A typical value for the ratio a/b is 1.6. (Figure 2b reproduced from D'Amico et al.,1998).

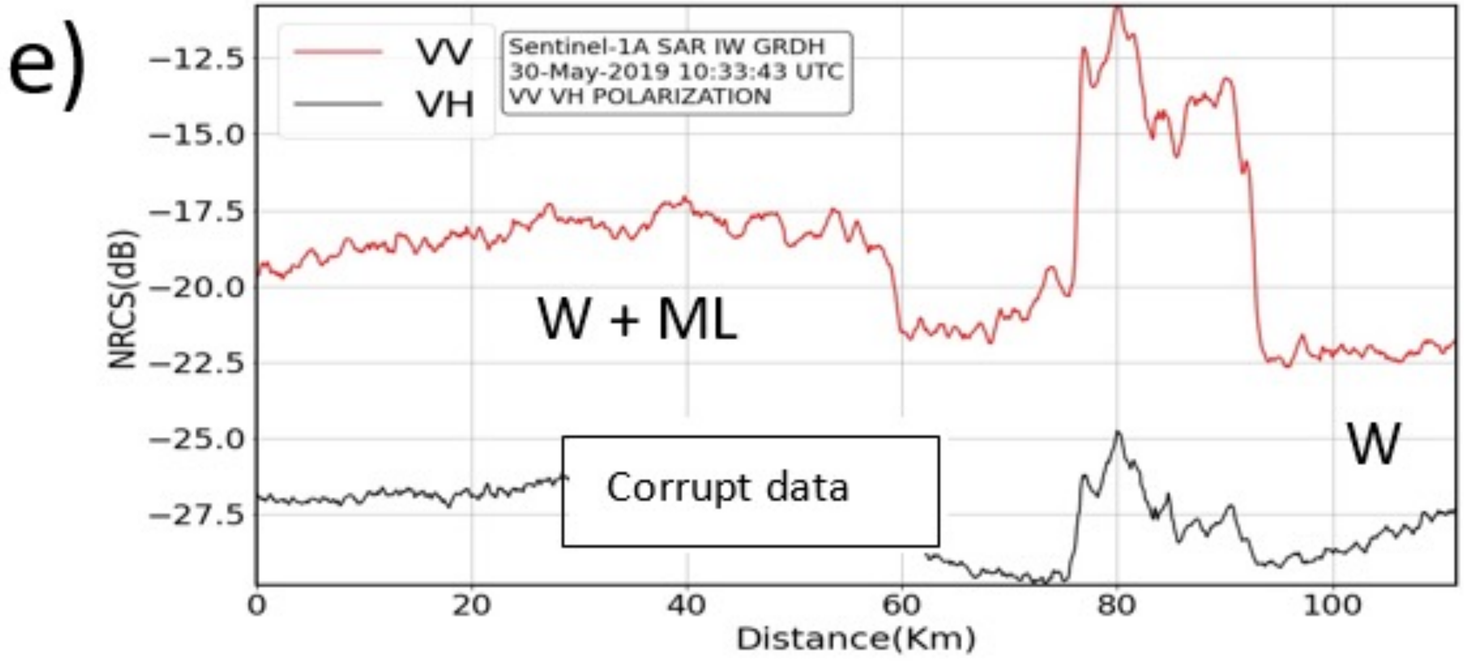
Case study of a strong rain band over the South China Sea east of Hainan



. Section of the Sentinel-1A SAR image acquired **at 10:41 UT on 30 May 2019** over the East China Sea east of Hainan at VV polarization (a) and VH polarization (b), The bright band visible in the right-hand section of both images is the radar signature of a rain band. This rain band is also visible on the quasi-simultaneously acquired weather radar image of the Hong Kong (HK) weather radar (c) (marked by a ed arrow)

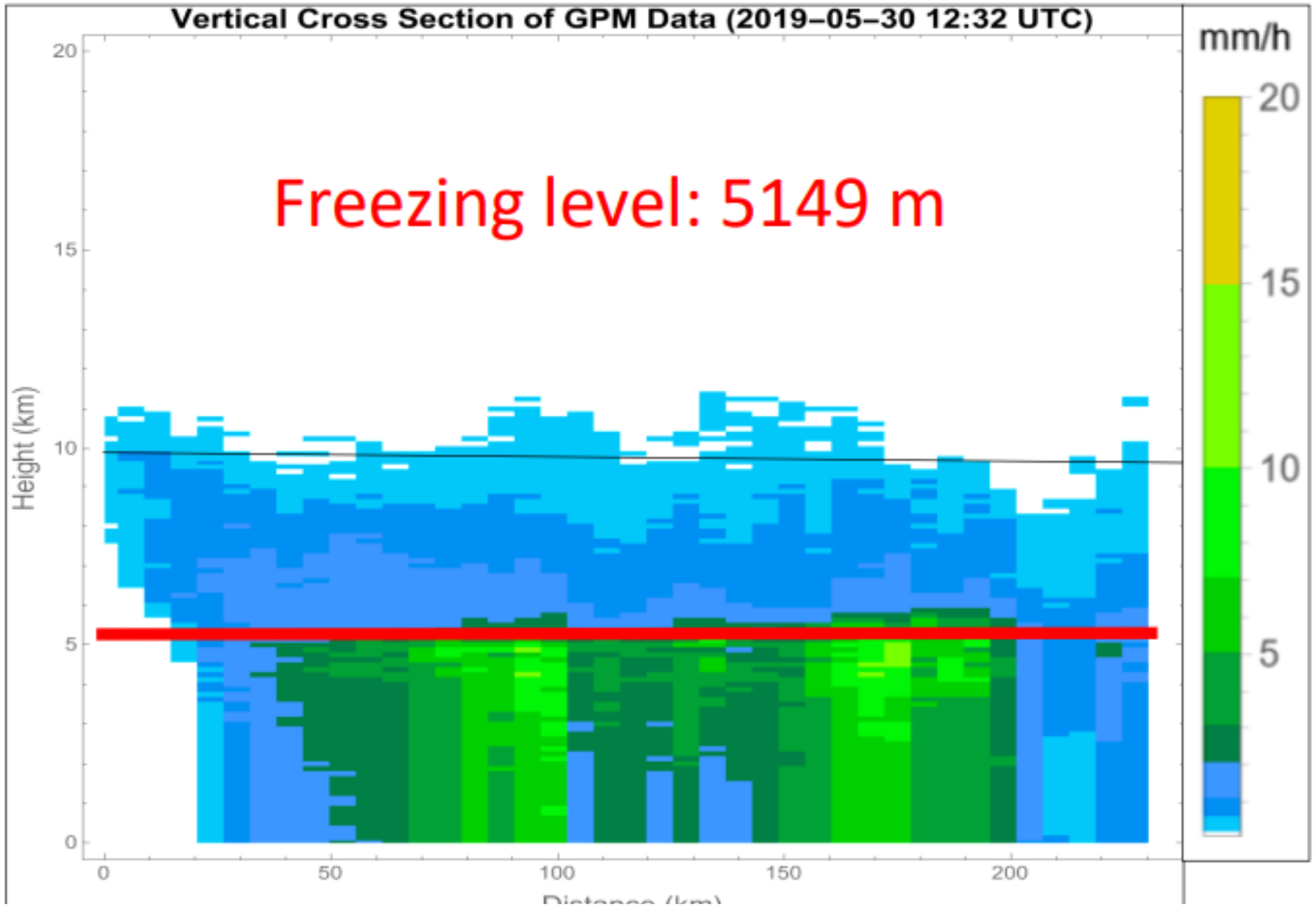


At 300 km from HK the lowest beam has a height of 6.4 km



Vvariation of the NRCS along the transects inserted as yellow arrows into the VV and HH SAR images (Panels a and b).

Height profile of reflectivity along the rain band from GPM data



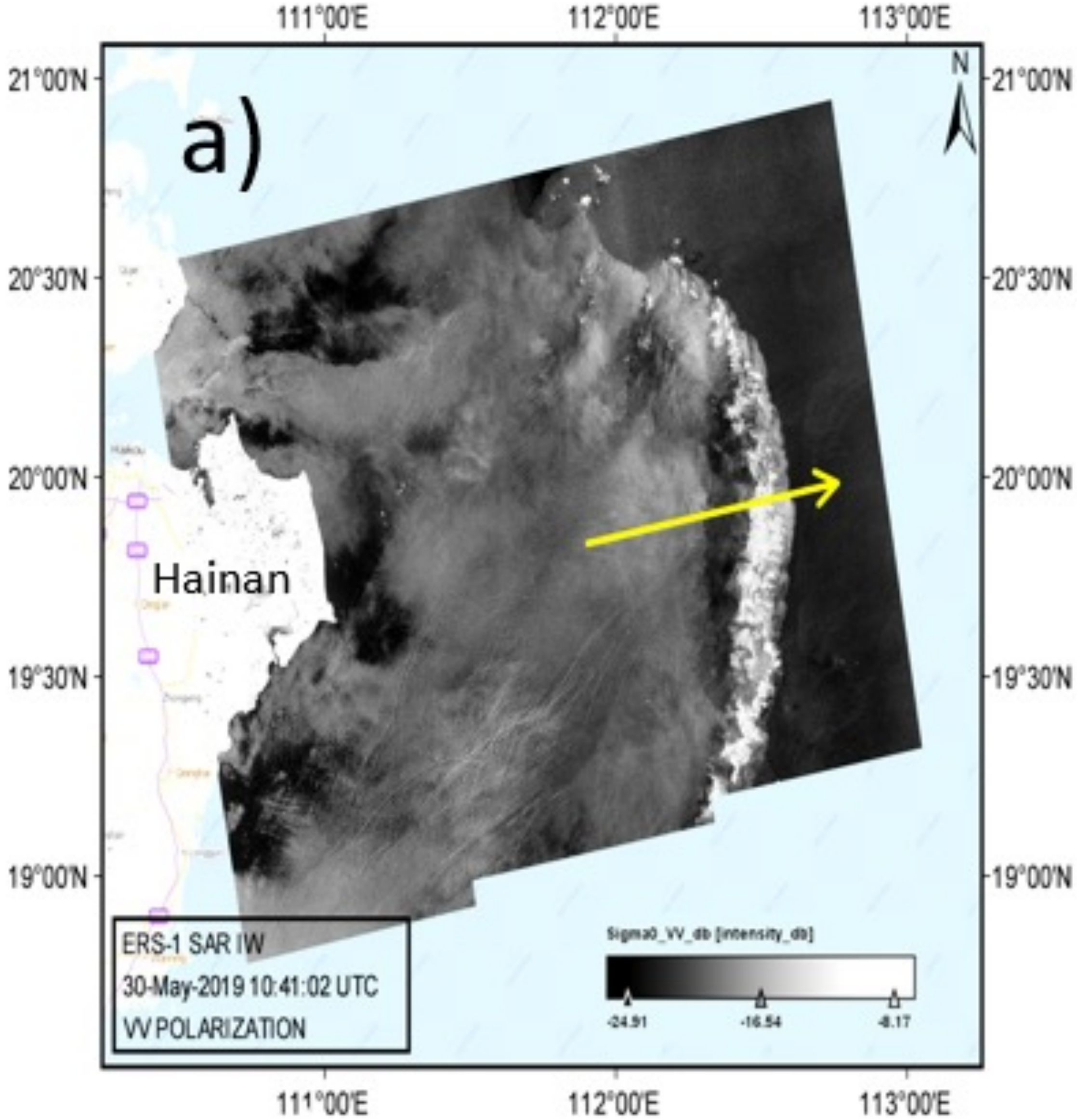
Same day,12:32 ITC

30 May, 212>32 UC

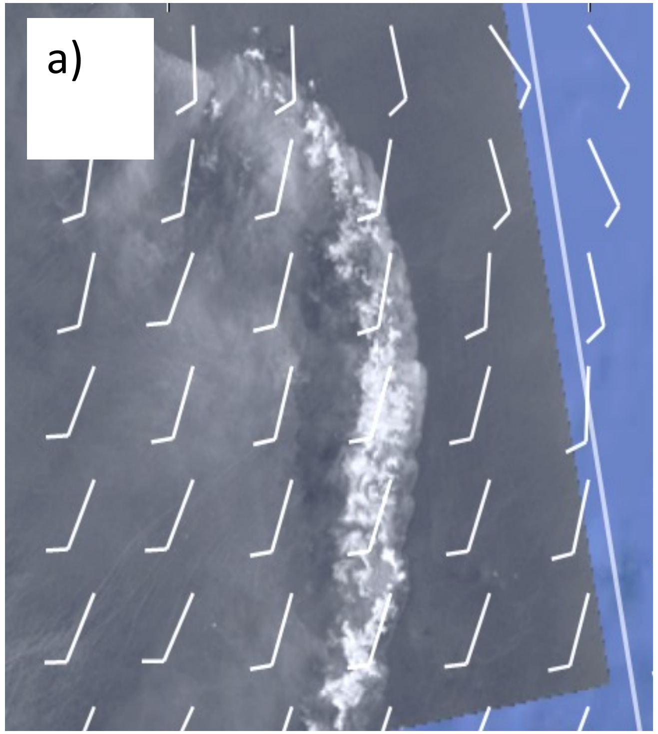
.Height profiles of the reflectivity converted into rain rate measured by the nadir-looking Ku band radar

The GPM data as well as the HK weather radar data show hydrometeors above the freezing level also outside the rain band

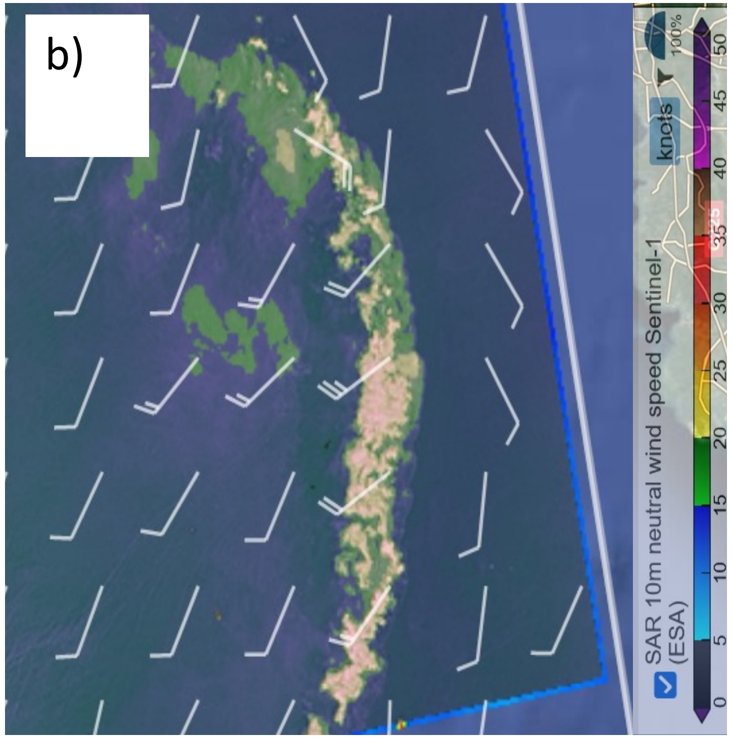
These hydrometeors must fall through the melting layer and generate a signal on the SAR image, **which can be confounded with a wind signal**.



ECMWF wind speed

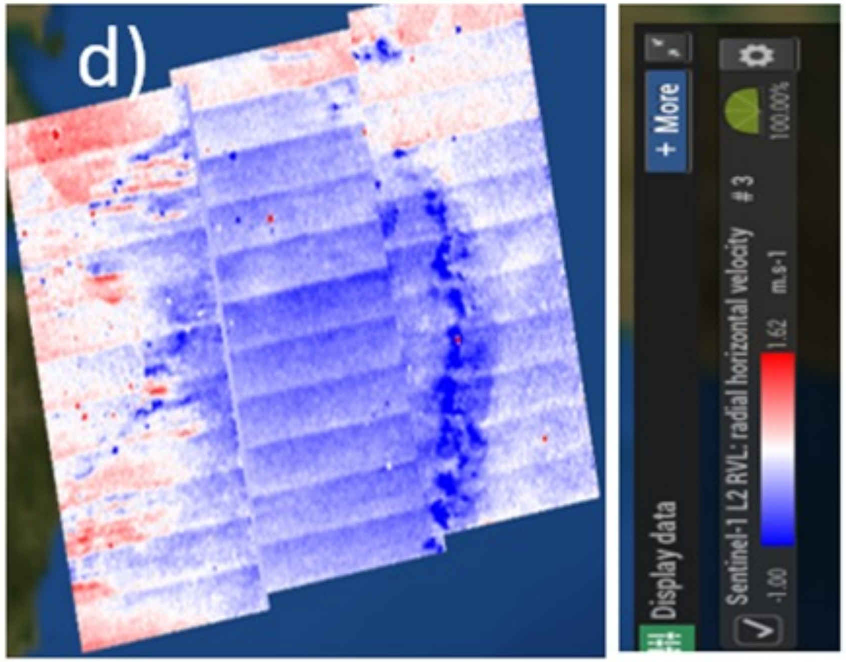


SAR derived wind speed



Radar scattering at hydrometeors in the melting layer give rise to **wrong sea surface wind speeds**

Doppler map of the rain band

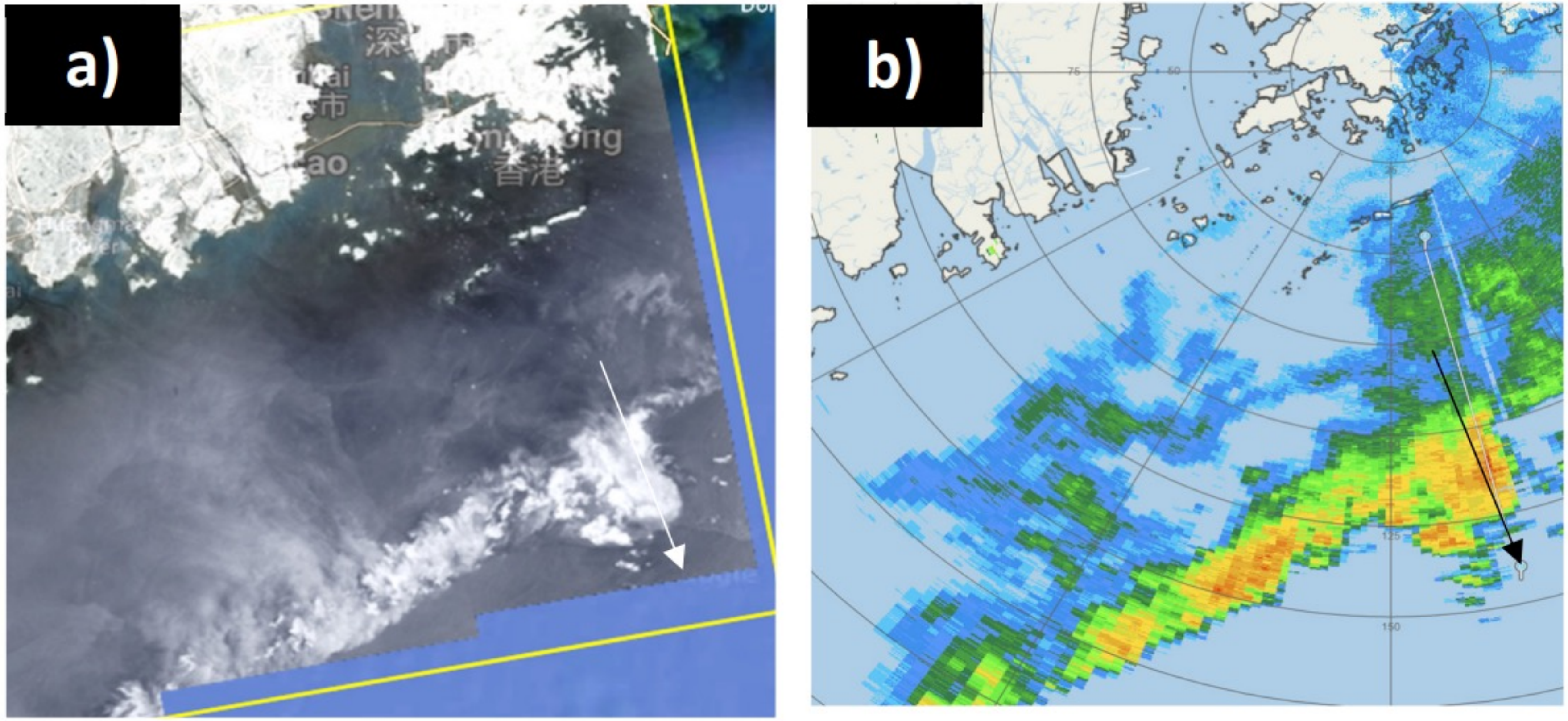


Deep blue: 1m/s radial velocity
White: zero radial velocity

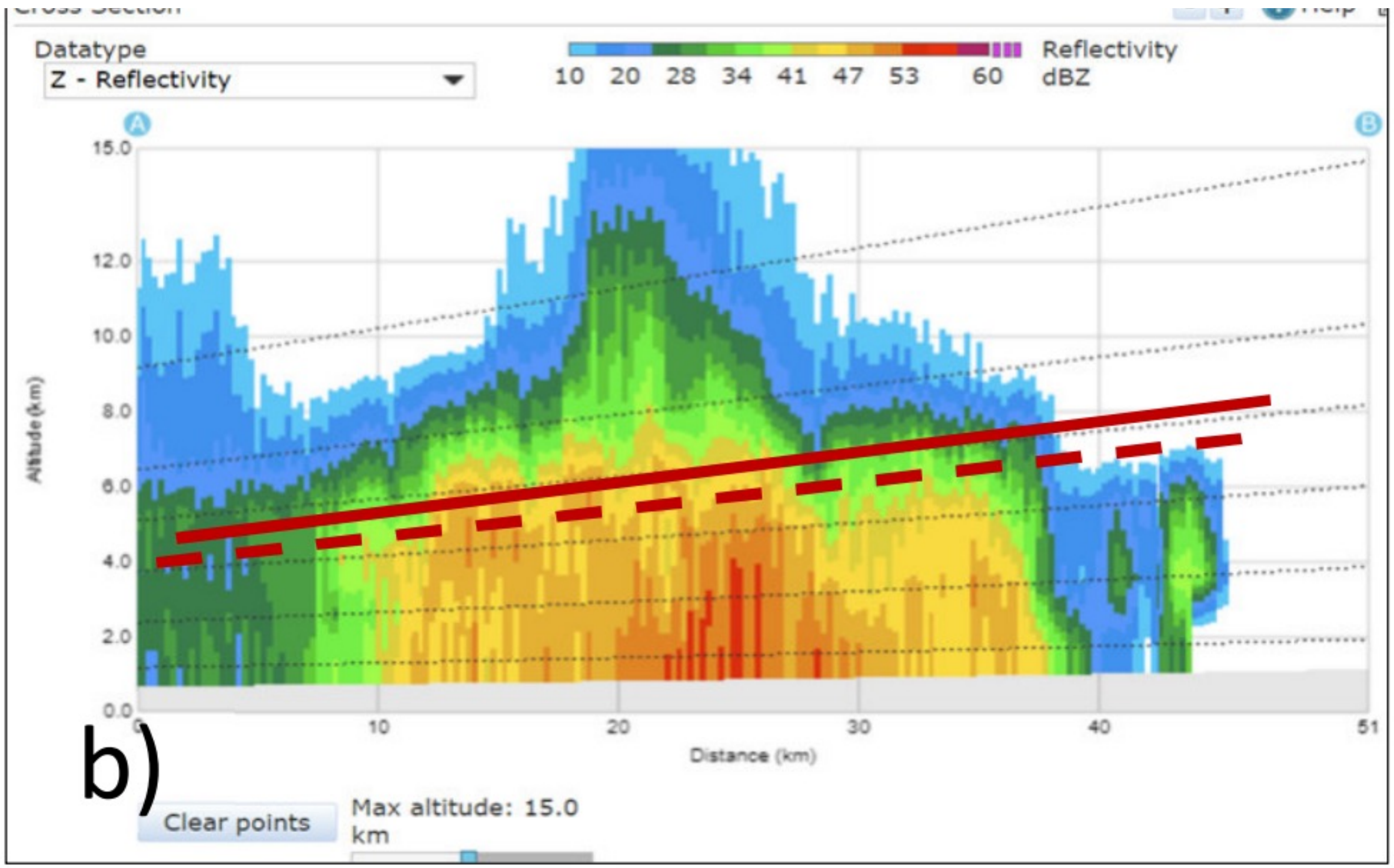
The rain band --and also of the area west of the rain band - moves at a different velocity than the scatter elements on the sea surface.

The radar signature of the rain band - and also of the area west of the rain band- results from volume scattering at hydrometeors in the melting layer.

Case study of a convective rain system southeast of Hong Kong



a) Section of a Sentinel-1 A SAR image acquired at 10:33 UTC on 17 August 2019 over the East China Sea east of Hong Kong; b) corresponding section of the radar reflectivity image from the HK weather radar acquired quasi-simultaneously on 17 August 2019 at 10:33:19 UTC

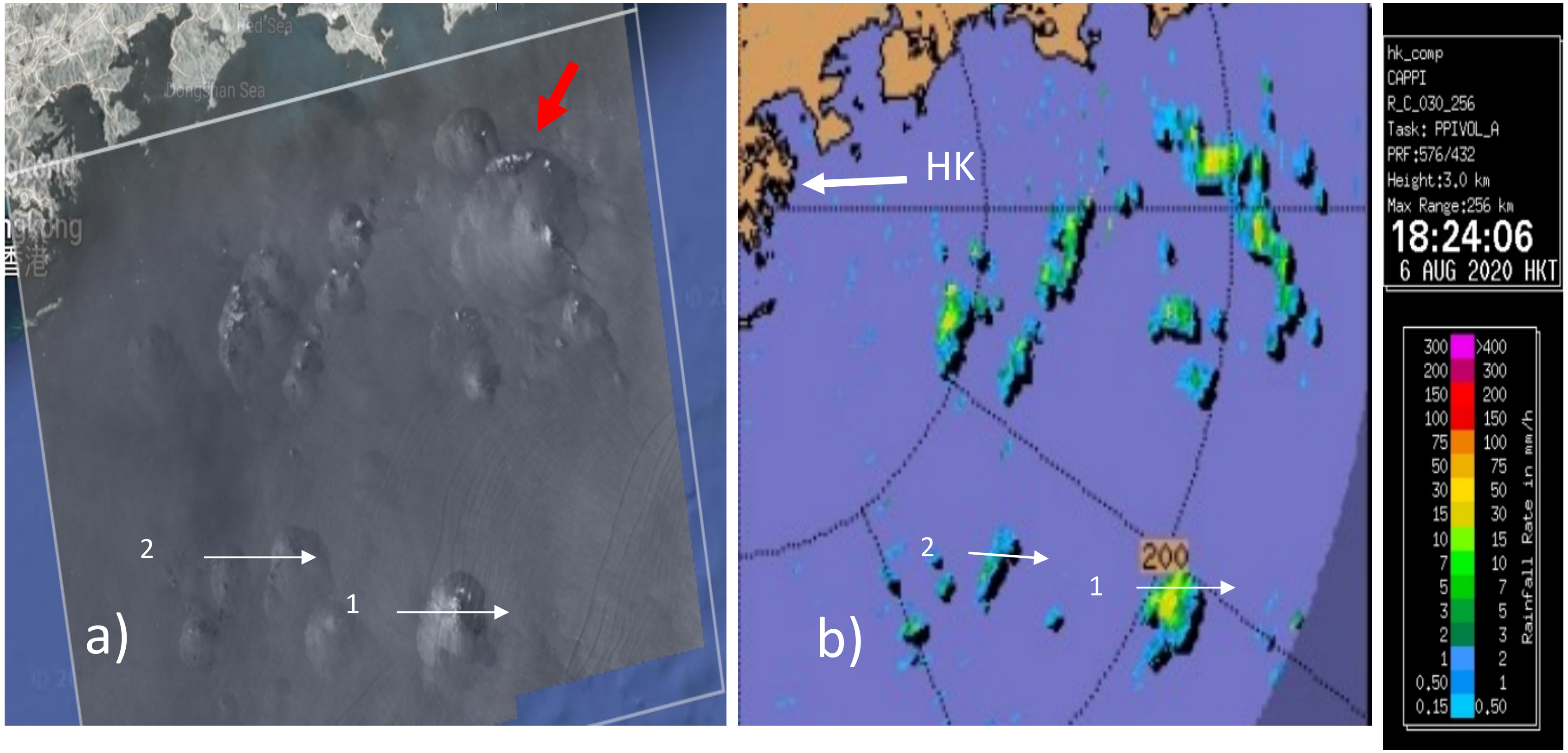


Datatype
Z - Reflectivity
10 20 28 34 41 47 53 60
Reflectivity dBZ
15.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Altitude (km)
0
10
20
30
40
51
Distance (km)
b)
Clear points
Max altitude: 15.0 km

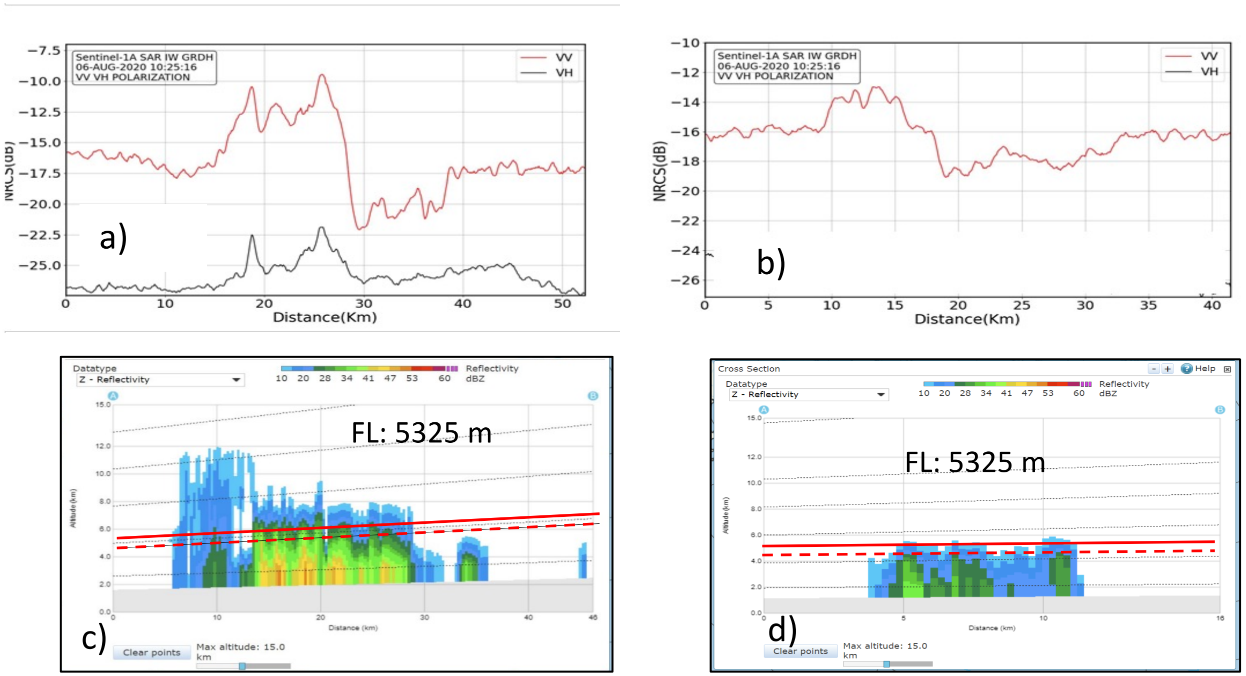
Case study of a rain cells over the South China Sea south east of Hainan

Some show “bright blobs” and some not.

Dragon 5 3rd Year Results Project



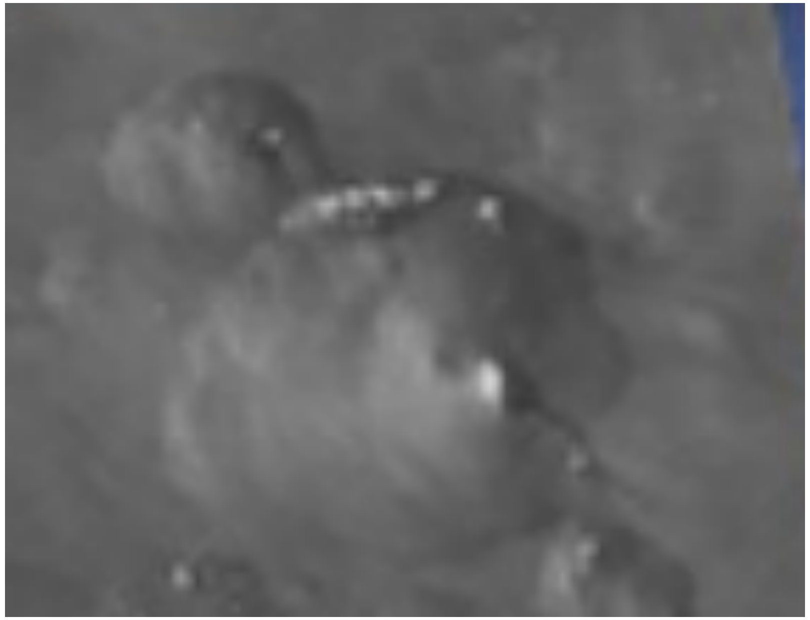
Sentinel-1A SAR image acquired on 6 August 2020 at 10:25 UTC; b) Radar reflectivity image of the weather radar of the HHKO acquired on the same day at110:06 UTC17, i.e., quasi-simultaneously with the Sentinel-1A image. The thin white arrows inserted in both images denote the transects along which we have measured the variation of the NRCS and the reflectivity. The thick red arrow on the SAR image points to small white blobs located at the rim of the downdraft pattern of a large rain cell.



NRCS and reflectivity profile scans through the signature of a rain cell associated with bright blob and another not associated with a bright blob.

The reason is that ,in the case of no bright blobs, hydrometeors have not reached the freezing layer and cannot fall through the melting layer to generate strong co-polarized radar backscatter signals.

Often bright blobs are encountered also at the rim of downdraft patterns. Here, the uplift is so strong that it carries moist air up to the freezing layer



Thus, bright blobs provide information on the dynamics within a rain cell

Conclusion

Radar scattering at the melting layer as a wider impact on SAR images of he sea than previously anticipated.

In particular, it can falsify the wind field retrieved fom SAR images.

Thank you for your attention!