ESA - MOST Dragon 2 Programme

2011 DRAGON 2 SYMPOSIUM

中国科技部-欧洲空间局合作 "龙计划"二期

"龙计划"二期2011年学术研讨会

Application of coastal monitoring using high resolution SAR

Proj. ID 5338

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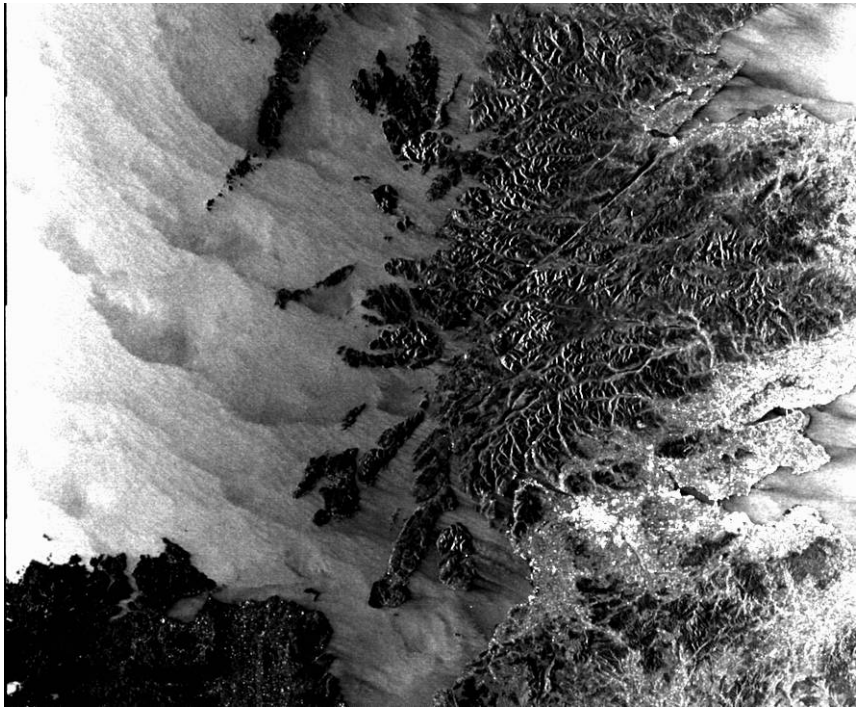
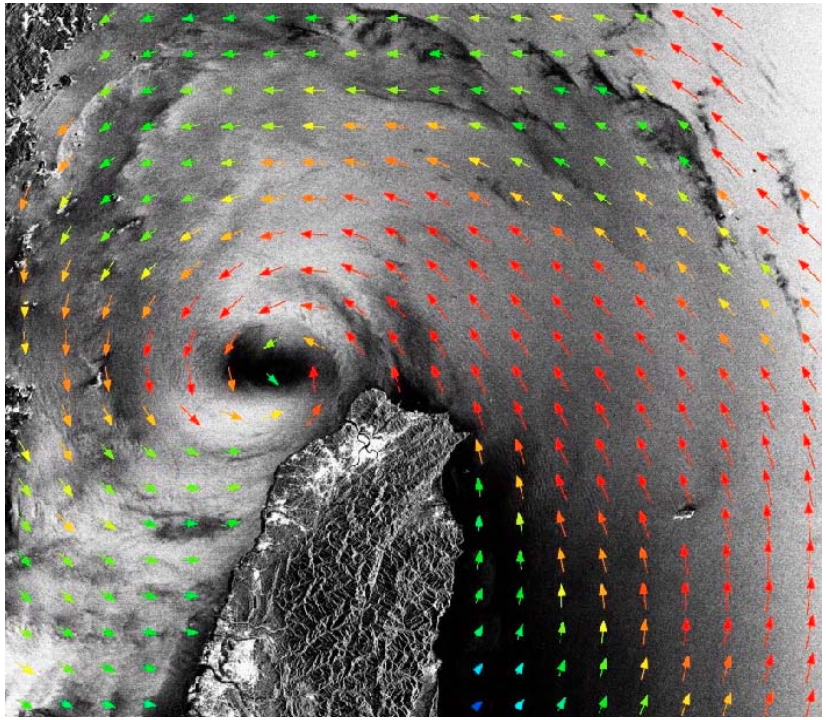
Main Topics of Proj.5338 in DRAGON 2

- Severe Storms Tropical Cyclones – ASAR/TS-X
- Global Sea State – DWD, shipping security, ASAR Wave Mode
- Investigations of highly variable coastal wind and wave fields, TS-X, wind and wave farming, coastal protection
- Environmental Monitoring – Oil Spill

❖ Investigation of Severe Storms by wide swath SAR



Storm over Scotland 13-Jan-2007



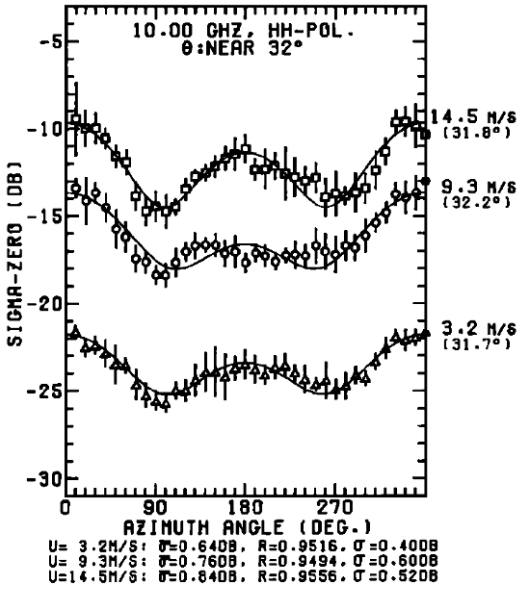
Typhoon Marcel over Taiwan

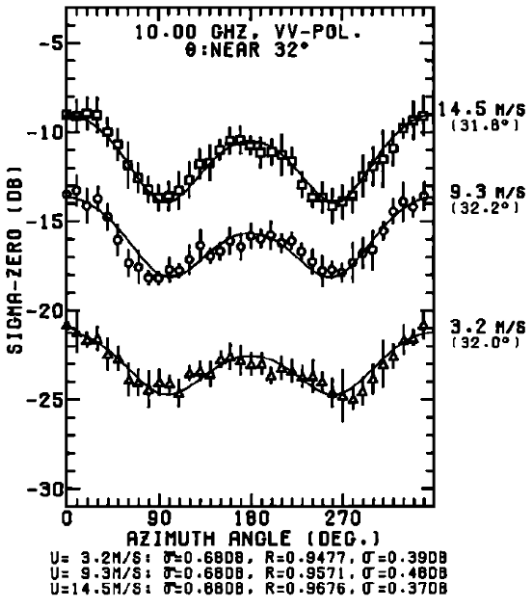
SAR/Scatterometer GMF for retrieving sea surface wind field

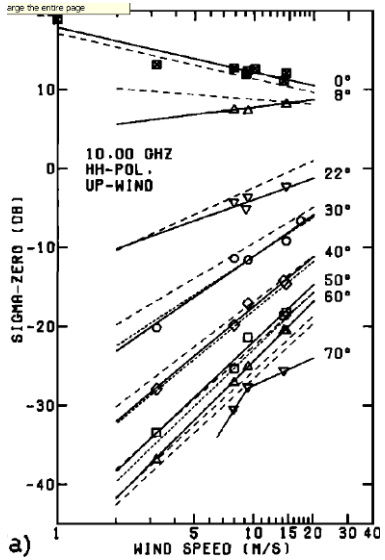
$$\sigma(\lambda, p, \theta, U, \varphi) = \sum_{n=0} A_n(\lambda, p, \theta, U)\cos\{n(\varphi - \alpha)\}$$

XMOD:

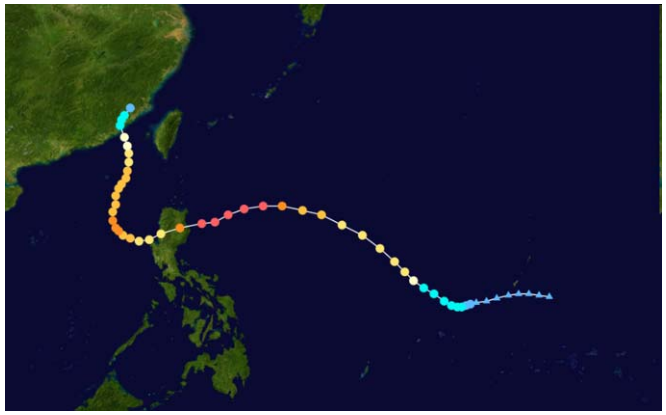
$$\sigma_0(U, \theta, \varphi) = x_0 + x_1 U + x_2 \sin(\theta) + x_3 \cos(2\varphi) + x_4 U \cos(2\varphi)$$



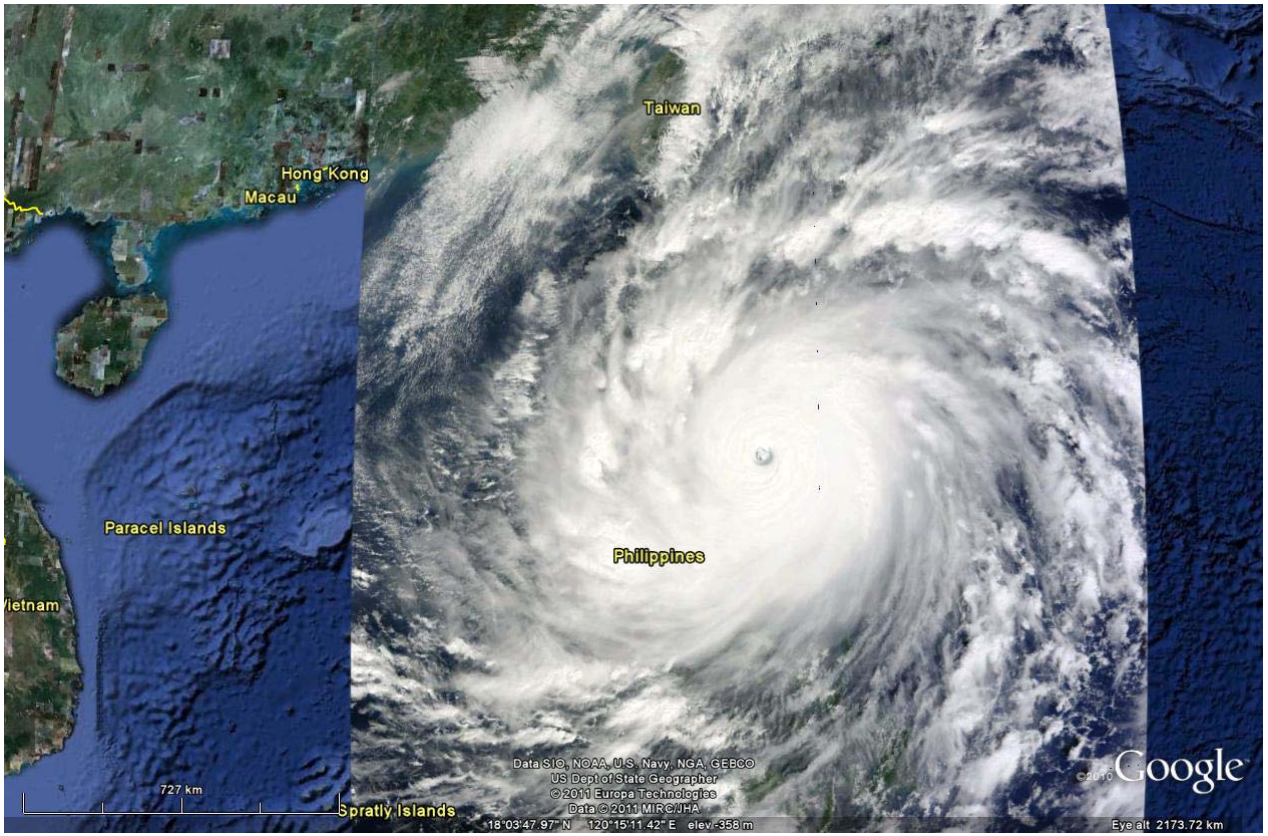




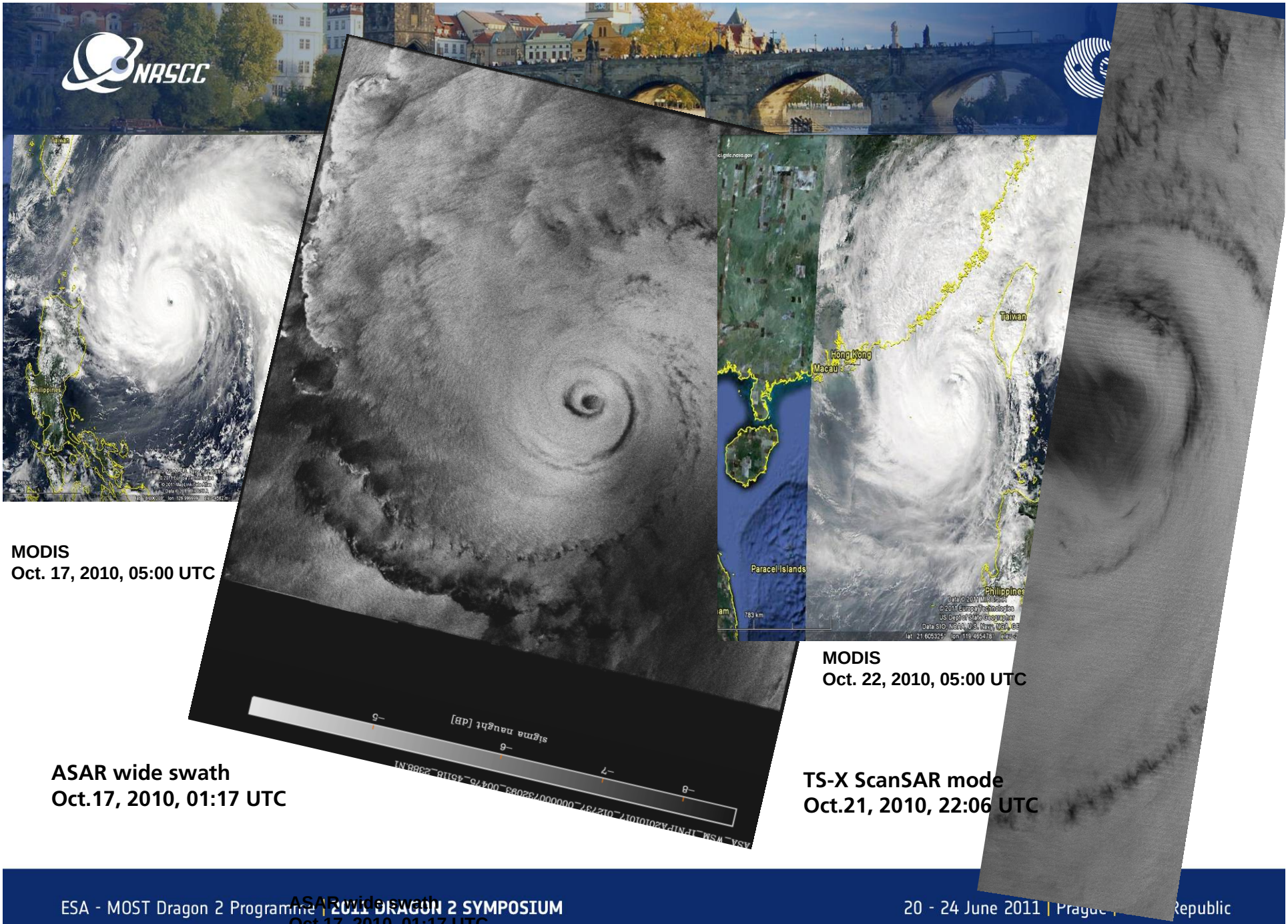
Case study - Observation of typhoon Megi



Oct. 12 ~ 24, 2010



Oct. 18, 2010, Category 5



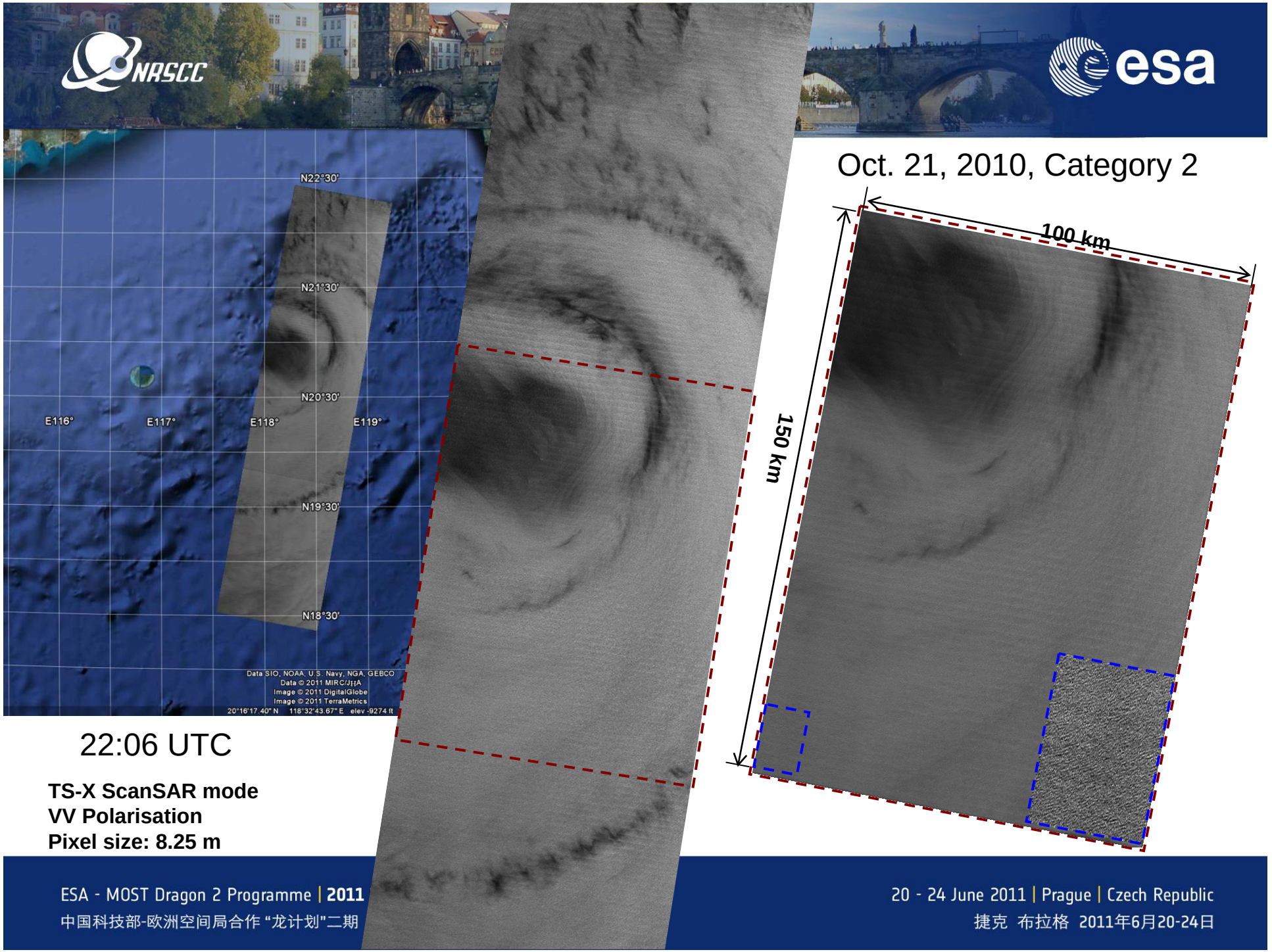
MODIS
Oct. 17, 2010, 05:00 UTC

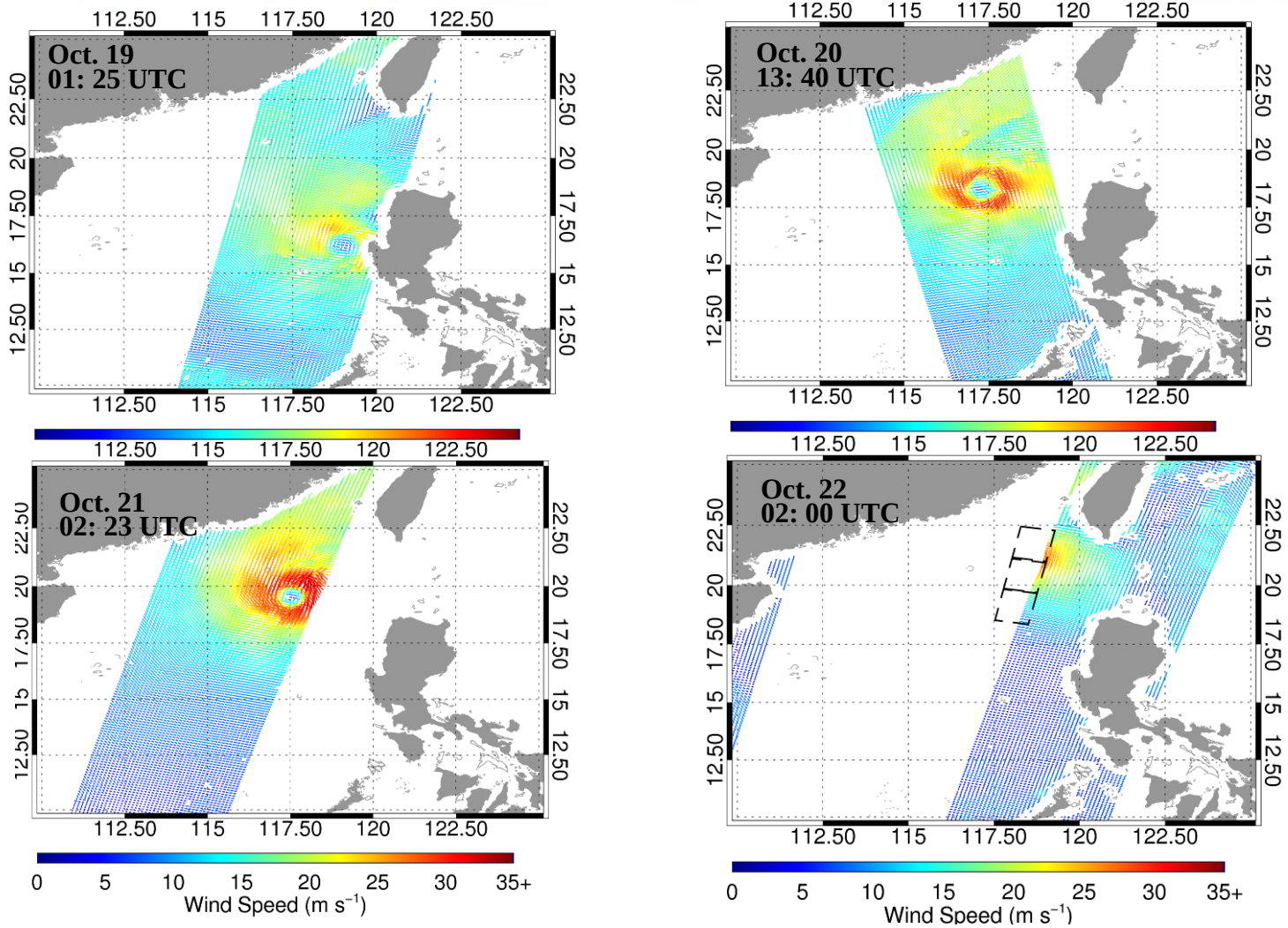
MODIS
Oct. 22, 2010, 05:00 UTC

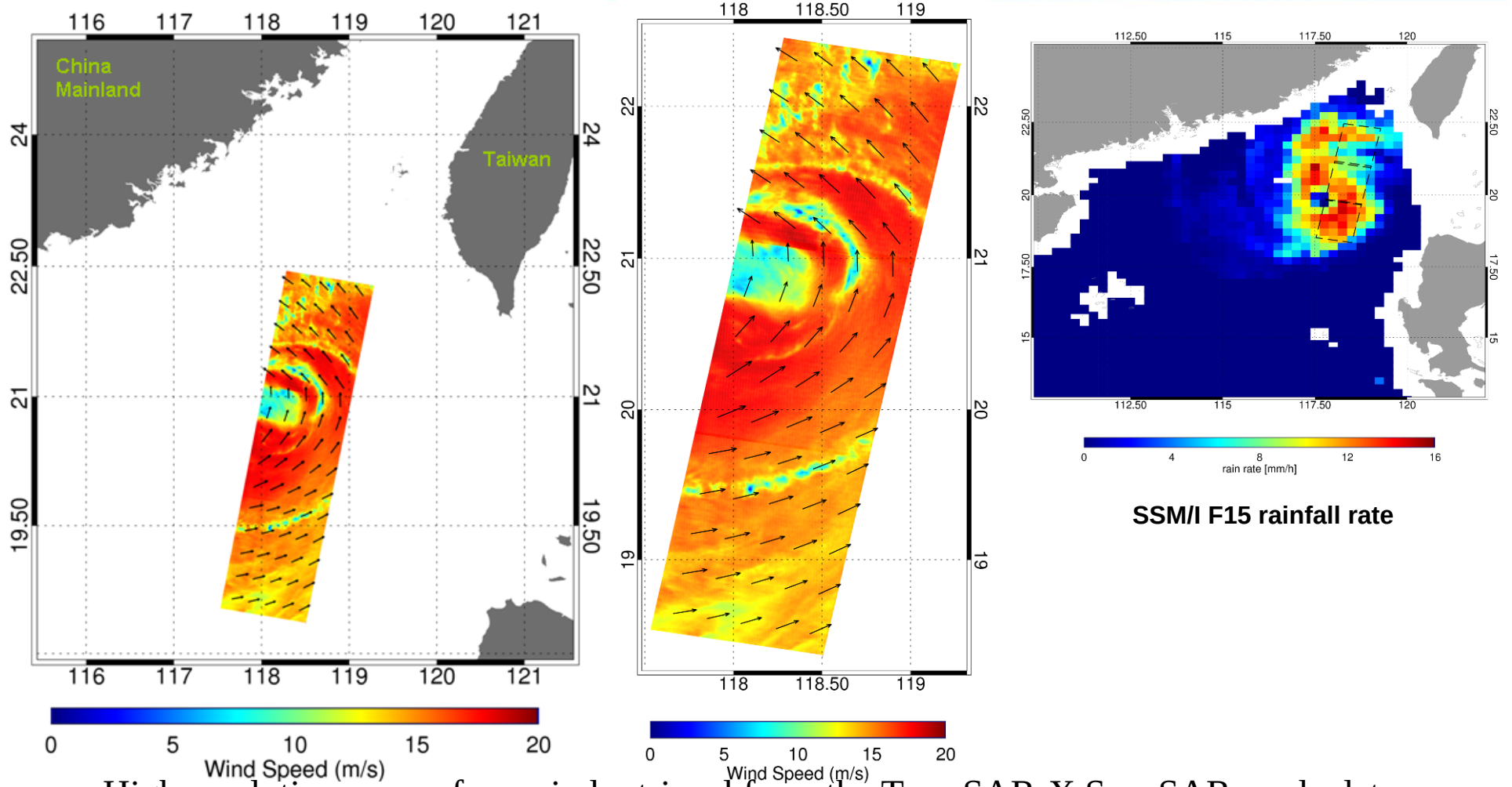
ASAR wide swath
Oct.17, 2010, 01:17 UTC

TS-X ScanSAR mode
Oct.21, 2010, 22:06 UTC

ASAR wide swath
Oct.17, 2010, 01:17 UTC

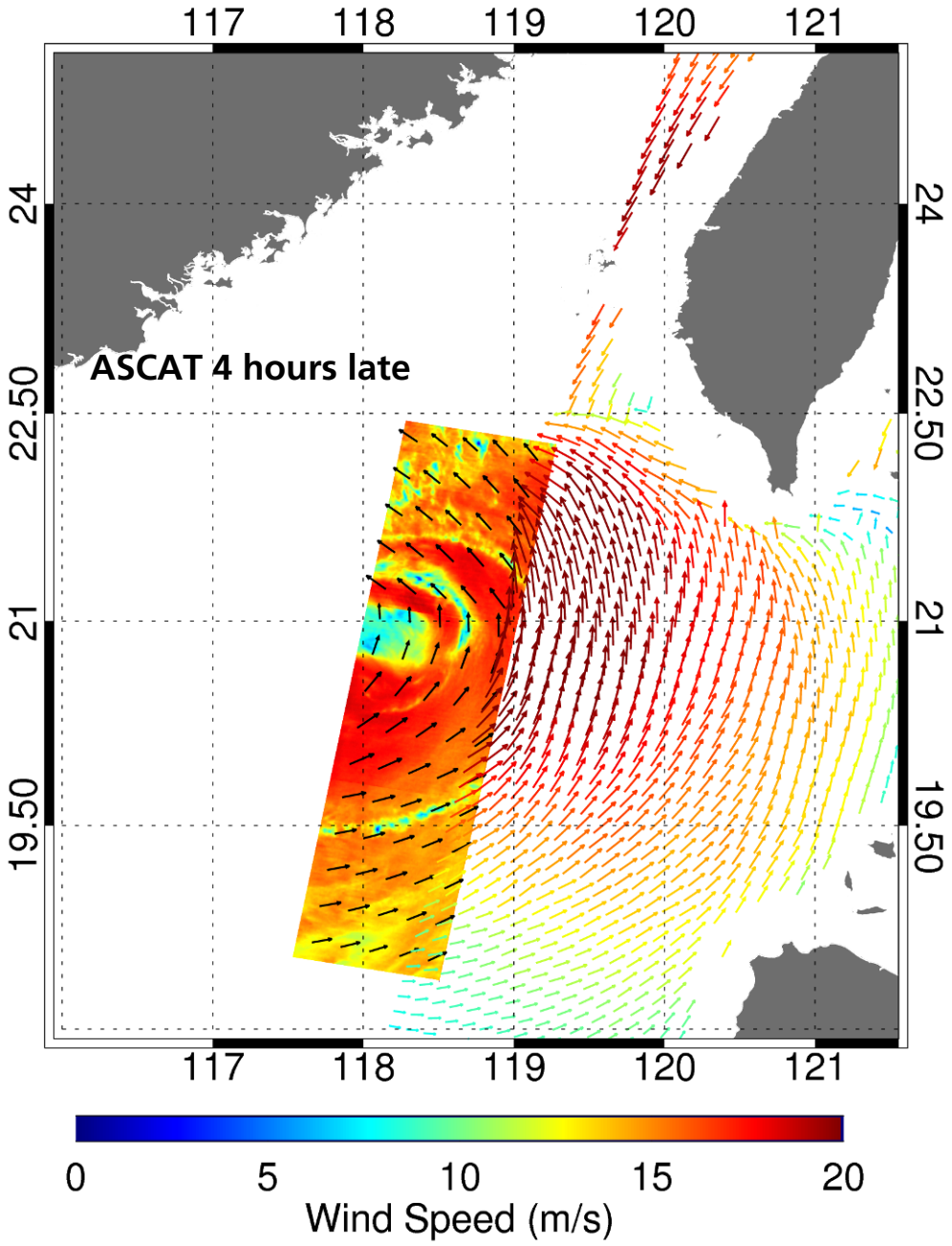

NASCC
esa
Oct. 21, 2010, Category 2
N22°30'
N21°30'
N20°30'
N19°30'
N18°30'
E116°
E117°
E118°
E119°
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Data © 2011 MIRC/JAXA
Image © 2011 DigitalGlobe
Image © 2011 TerraMetrics
20°16'17.40" N 118°32'43.67" E elev -9274 ft
100 km
150 km
22:06 UTC
TS-X ScanSAR mode
VV Polarisation
Pixel size: 8.25 m
ESA - MOST Dragon 2 Programme | 2011
中国科技部-欧洲空间局合作 "龙计划"二期
20 - 24 June 2011 | Prague | Czech Republic
捷克 布拉格 2011年6月20-24日


Oct. 19
01: 25 UTC
Oct. 20
13: 40 UTC
Oct. 21
02: 23 UTC
Oct. 22
02: 00 UTC
112.50 115 117.50 120 122.50
22.50 20 17.50 15 12.50
0 5 10 15 20 25 30 35+
Wind Speed (m s^{-1})



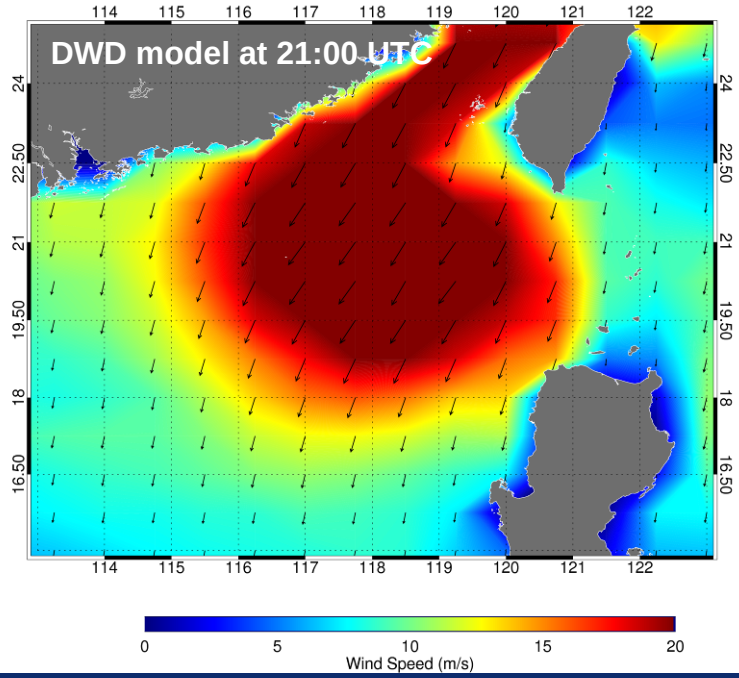
SSM/I F15 rainfall rate

High resolution sea surface wind retrieval from the TerraSAR-X ScanSAR mode data using the developed XMOD. The enlarge wind field map is shown in right panel.



Comparison of TerraSAR-X retrieved surface wind field to the measurements of scatterometer ASCAT (with spatial resolution of 12.5 km). The acquisition of TerraSAR-X data is around 3 hours earlier than the Scatterometer. The colorful arrows present wind speed and wind direction of ASCAT measurement. The black arrows present the wind direction derived from the TerraSAR-X data.

Most of wind field structure of Megi is out of swath of the ASCAT, while the TS-X provides very good measurements for that.



❖ Holland Model for tropical cyclone wind field

Holland [1980] proposed a simple parametric model to represent the **symmetric** tropical cyclone wind field

$$U_r = \left[\frac{AB(p_n - p_c)\exp(-A/r^B)}{\rho r^B} + \frac{r^2 f^2}{4} \right]^{0.5} - \frac{rf}{2}$$

$$B = \rho e \frac{v_M^2}{p_n - p_c}$$

Defines the shape of the profile

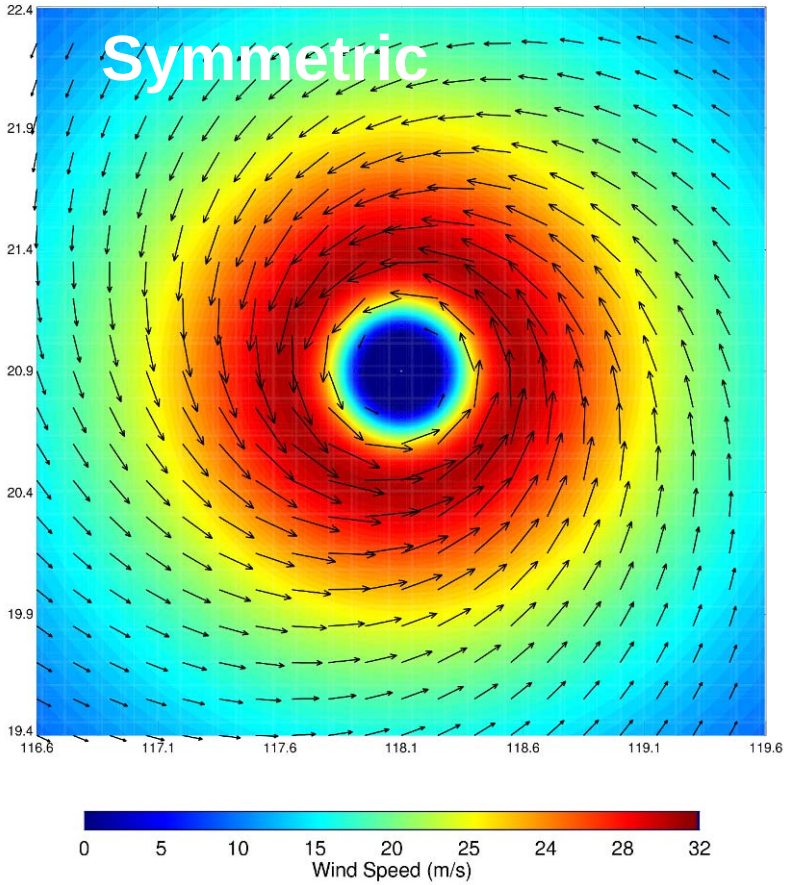
$$A = R_{MW}^B$$

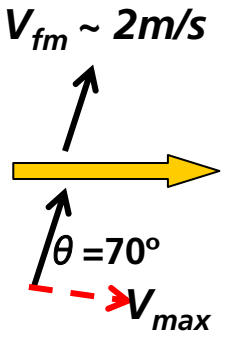
Determines its location relative to origin

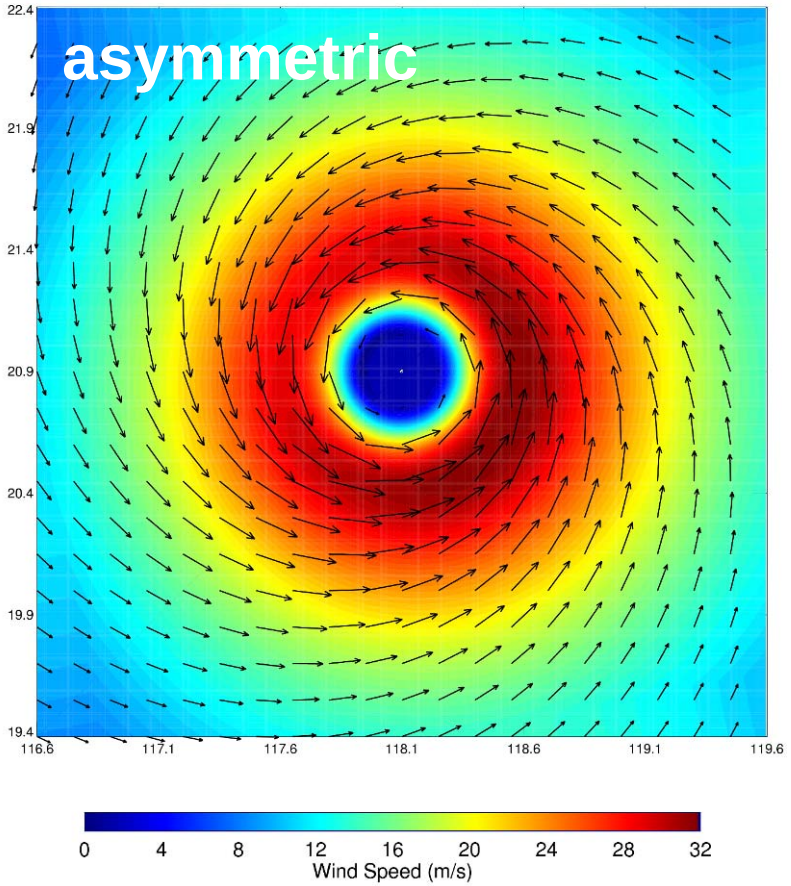
$$B = 1.5 + (980 - p_c)/120$$

Empirical expression of parameter *B*

Simulation results of Holland Model







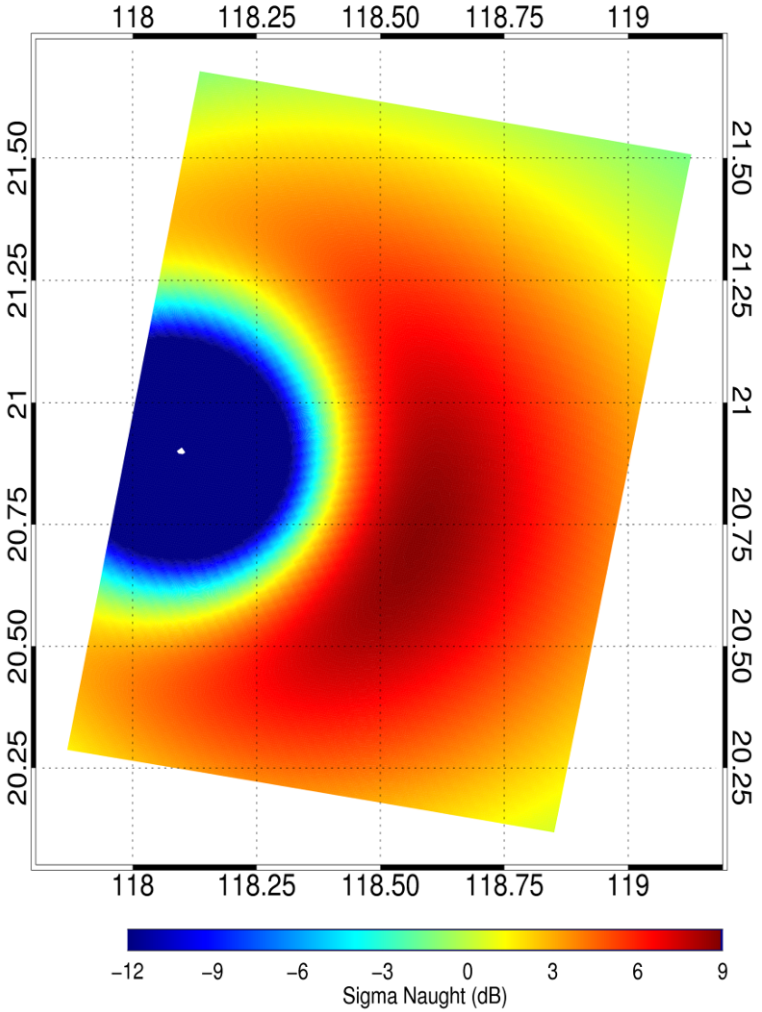
Simulated SAR backscatter using Holland Model

Wind speed & Direction (Holland model)

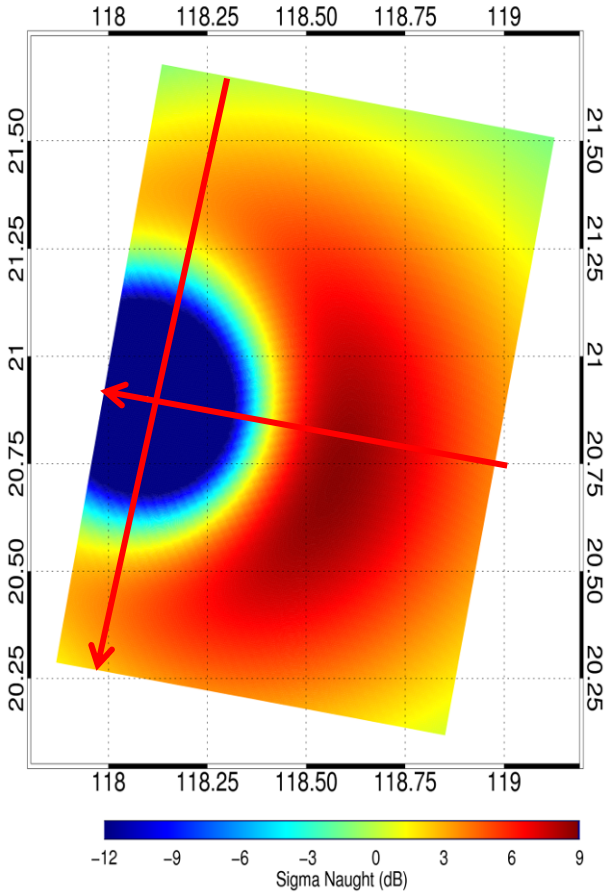
Local incidence angle (TS-X Geo.xml)

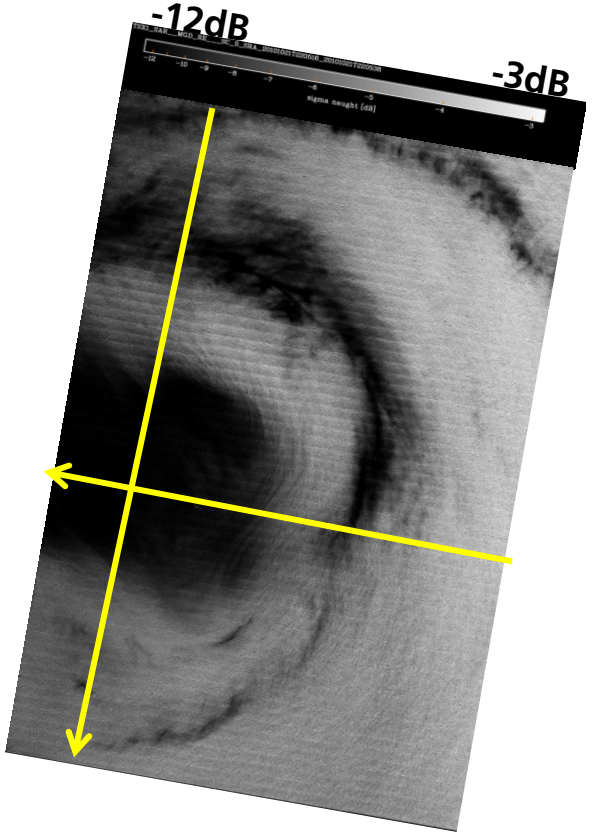
TS-X

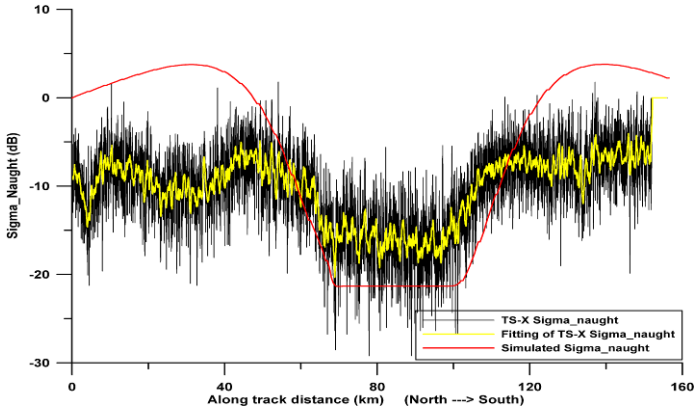
XMOD

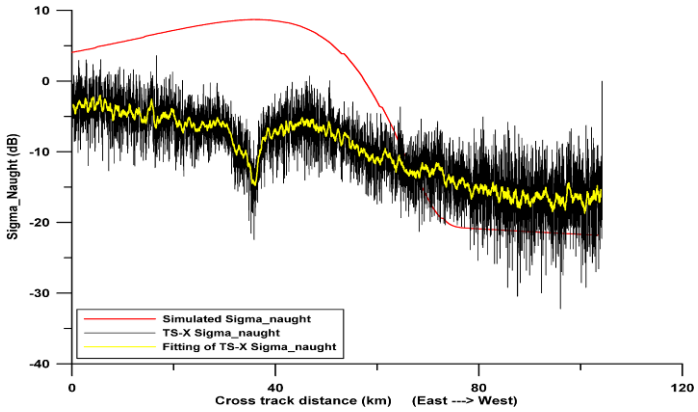


Profile comparision of simulated and TS-X measured backscatter

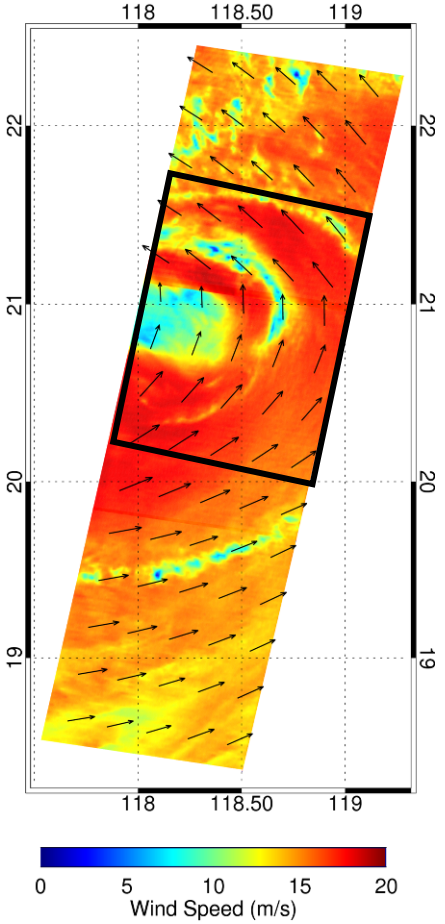




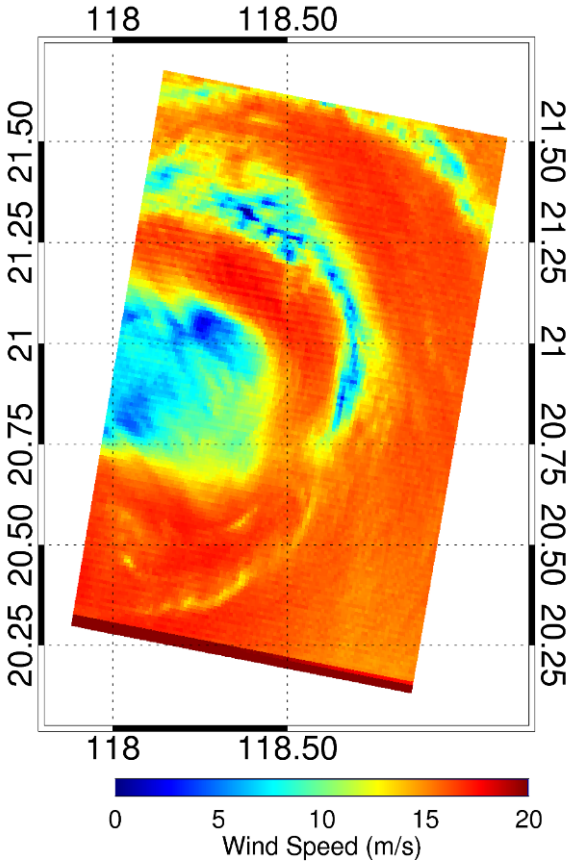




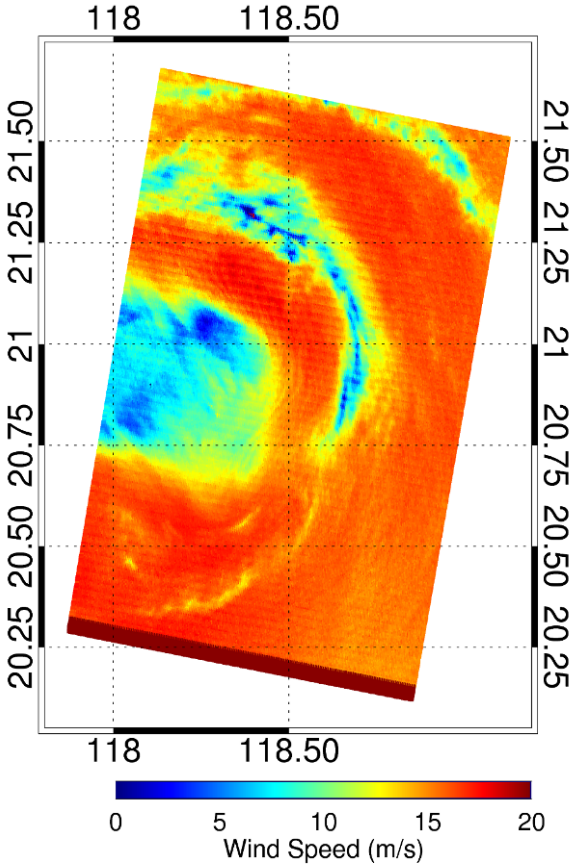
Comparision of TS-X retrieved wind speed using different wind direction input



Wind streaks observed in TS-X image



Holland model, inflow angle of 20˚ Spatial res. 1 km

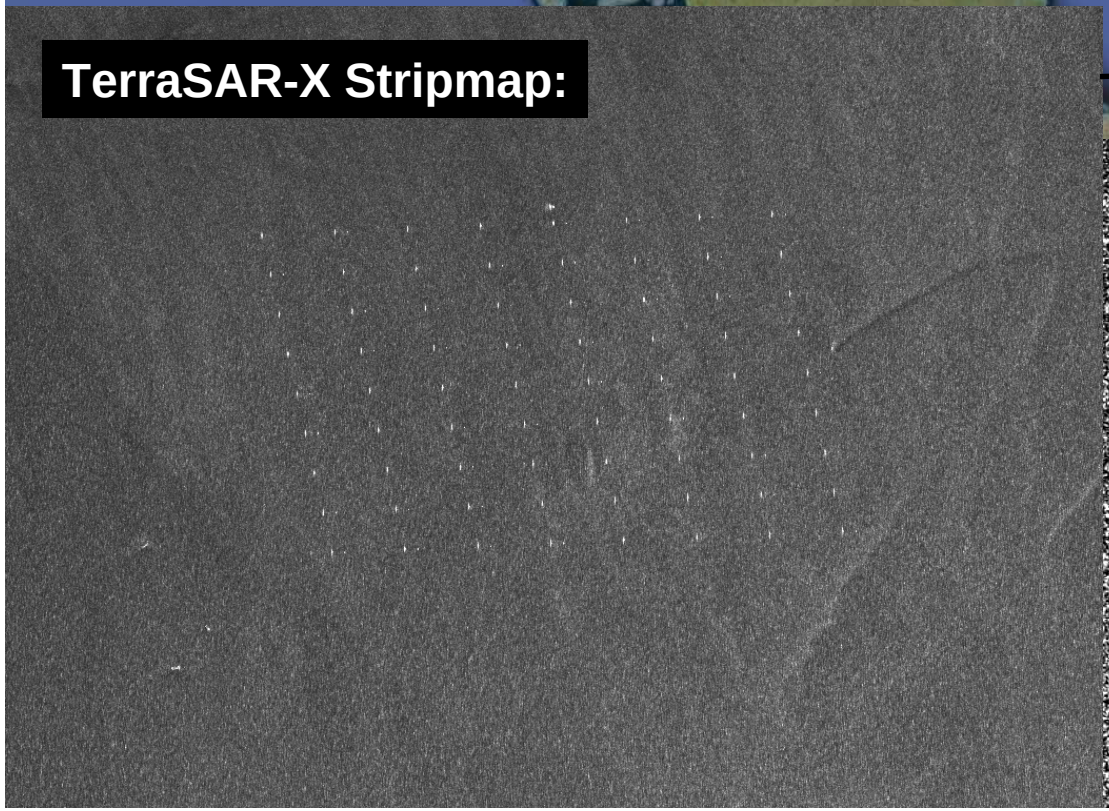


Holland model, inflow angle of 20˚ Spatial res. 500m

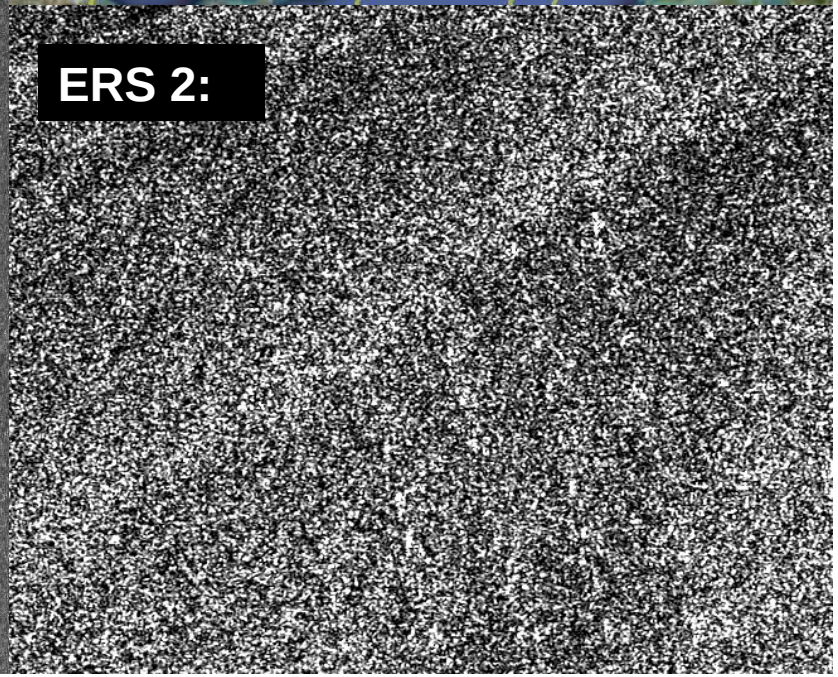
High resolution sea surfa wind mapping
Using TS-X for wind farming

Stripmap: 28.05.2009 Windfarm Nysted

TerraSAR-X Stripmap:



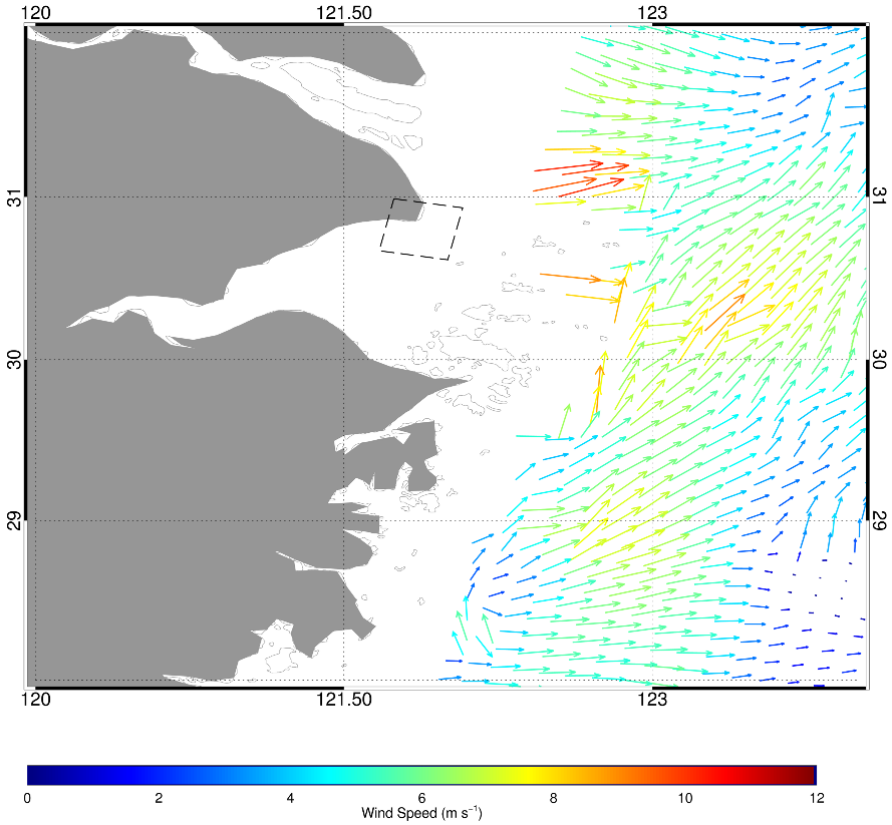
ERS 2:

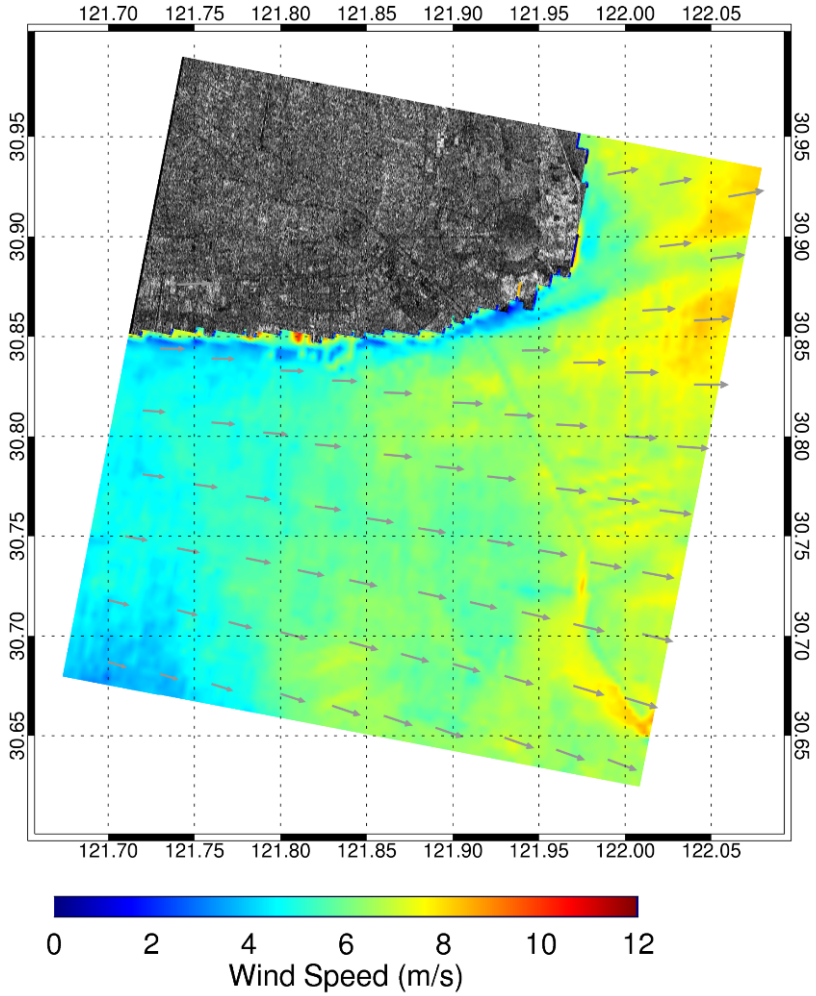


TS-X Stripmap data acquired on Feb.08, 2011 at 22:02 UTC; HH polarisation; pixel size of 1.25 m; Resolution is of 3 m.

China's first large-scale offshore wind farm

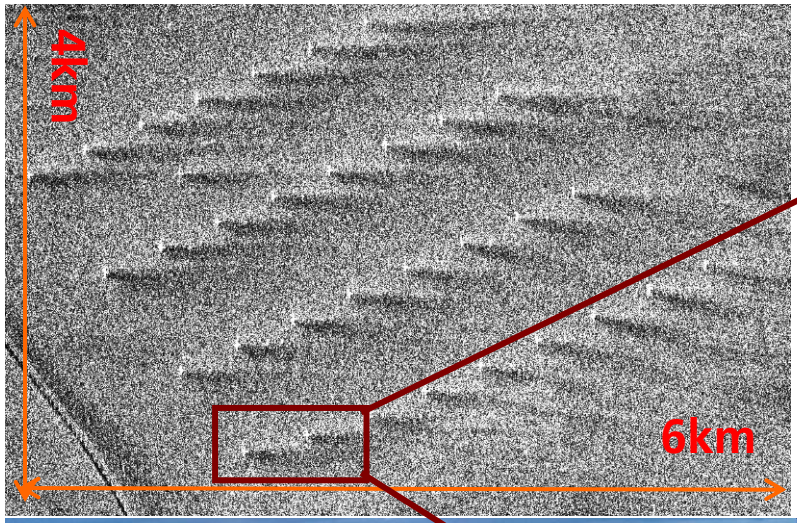
Sea surface wind speed retrieval over China East Sea wind park

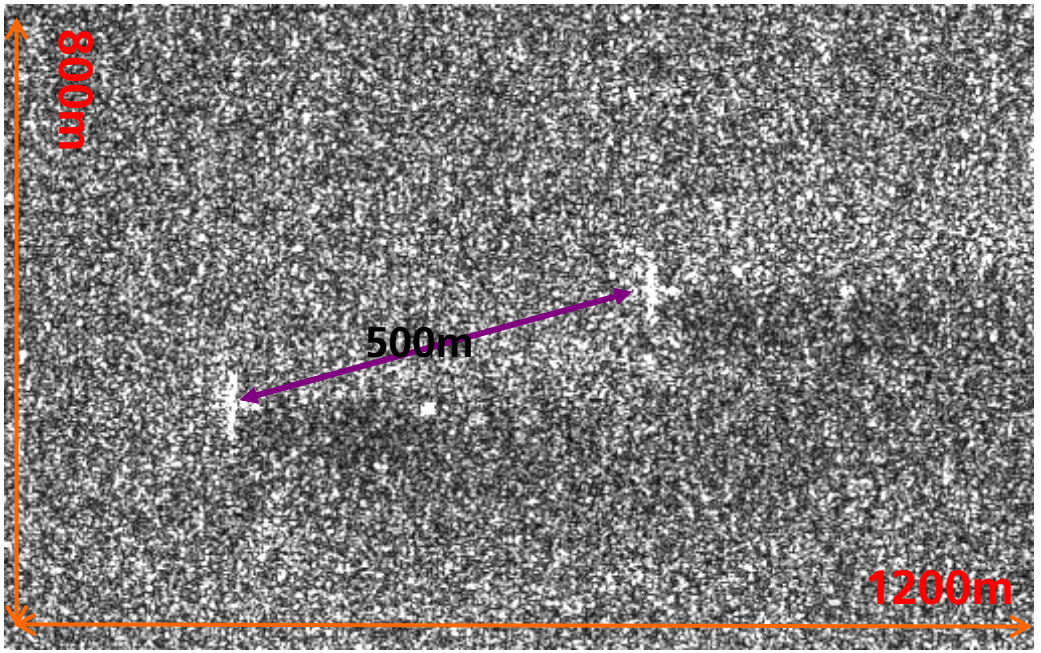




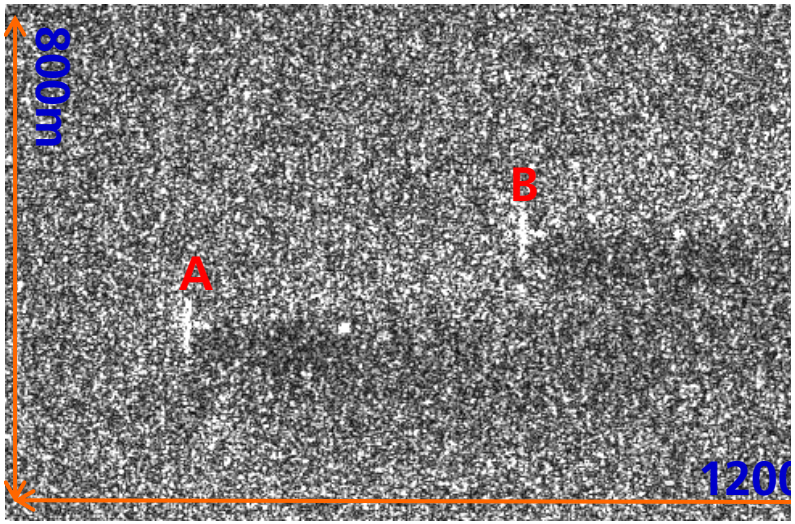
ASACT wind field @01:40 UTC in Feb.8

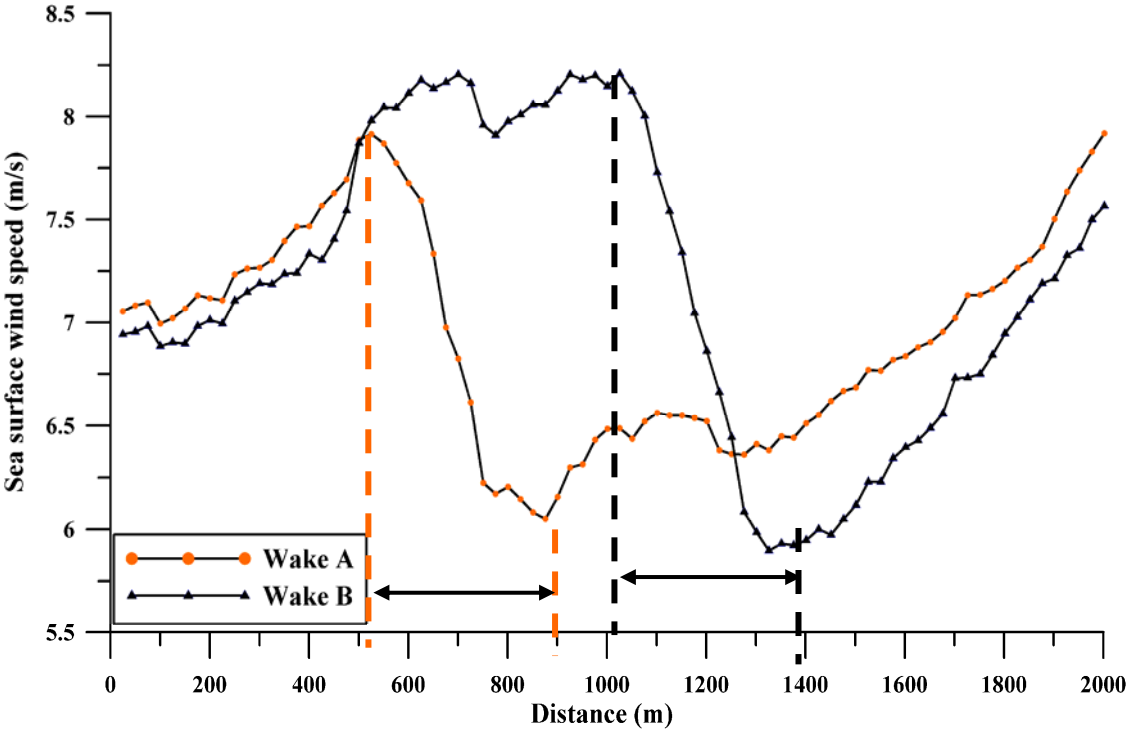
Wake effects over turbines





Spatial varibility of wind speed in wind wake

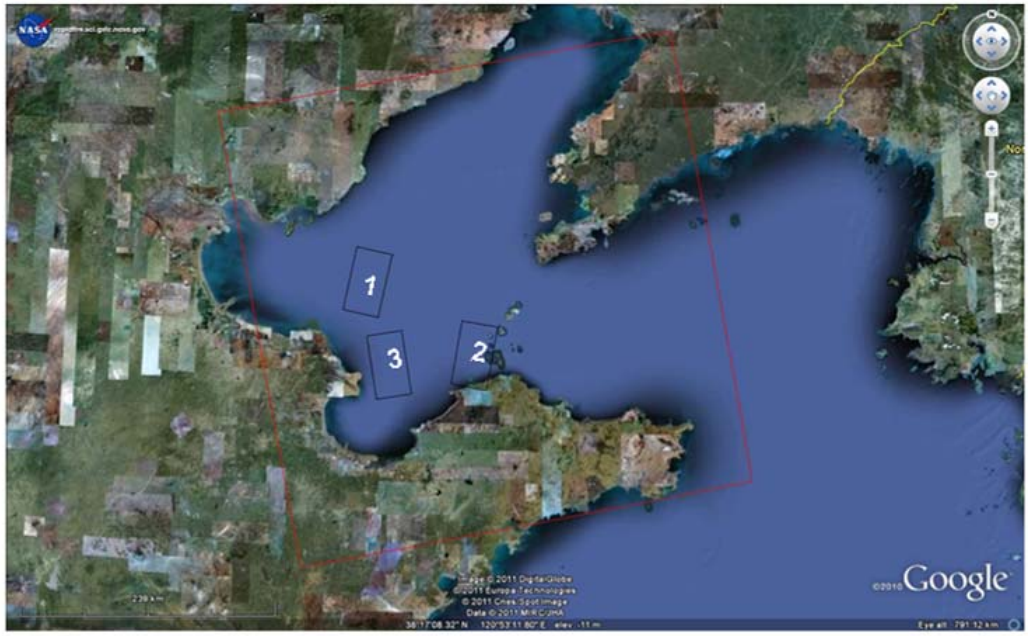




- ✓ Wake length ~ 400 m
- ✓ Effect of turbulence can reduce wind speed 1 m/s, i.e, Velocity deficit 14%
- ✓ Neighbour effect generated by turbulence
- ✓ „Slit effect“?

Cruise experiment in Bohai Sea

Campaign over China Bohai Sea in July, 2010
-Validation of sea surfac wind field retrieval from C/X band SAR

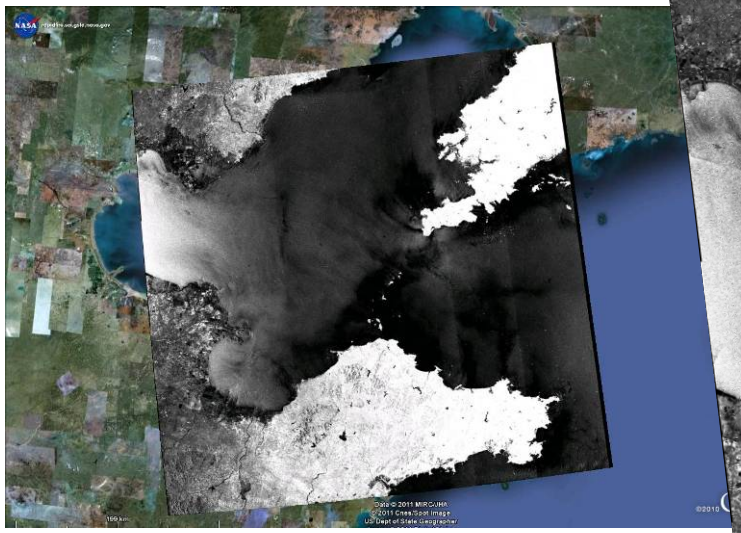


Cruise route: white triangle
Flight route: white rectangle

ASAR Wide swath, July 24, 2010, at 13:50 UTC (400 x 400 km)

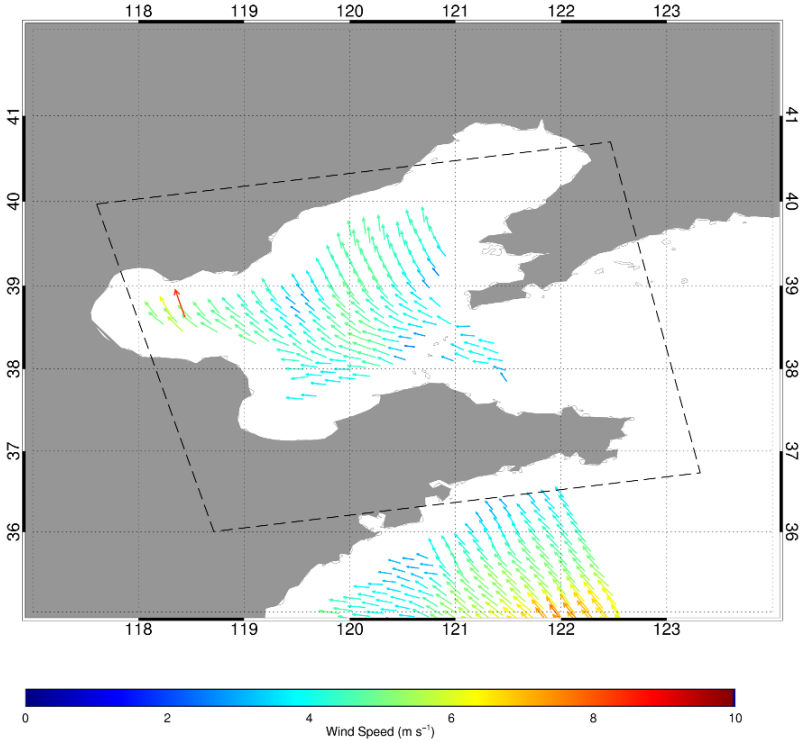
1: TS-X Stripmap, July 24, 2010, at 22:17 UTC (30 km x 70 km)
2: TS-X Stripmap, July 25, 2010, at 22:00 UTC (30 km x 70 km)
3: TS-X Stripmap, July 27, 2010, at 09:54 UTC (30 km x 70 km)

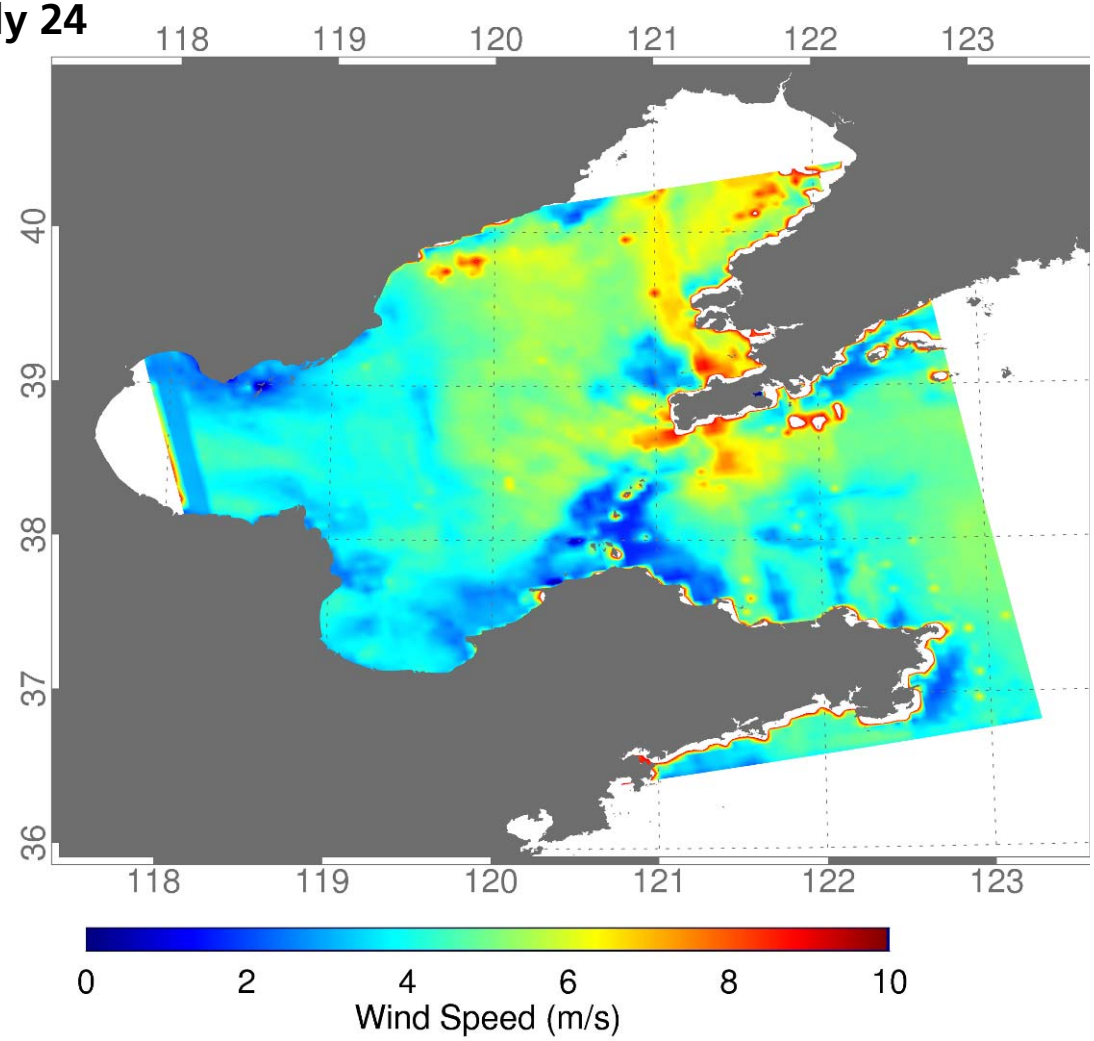
Sea surface wind retrieval – ASAR Wide swath data



13:50 UTC, July 24, 2010
Pol. VV
Pixel size: 75 m

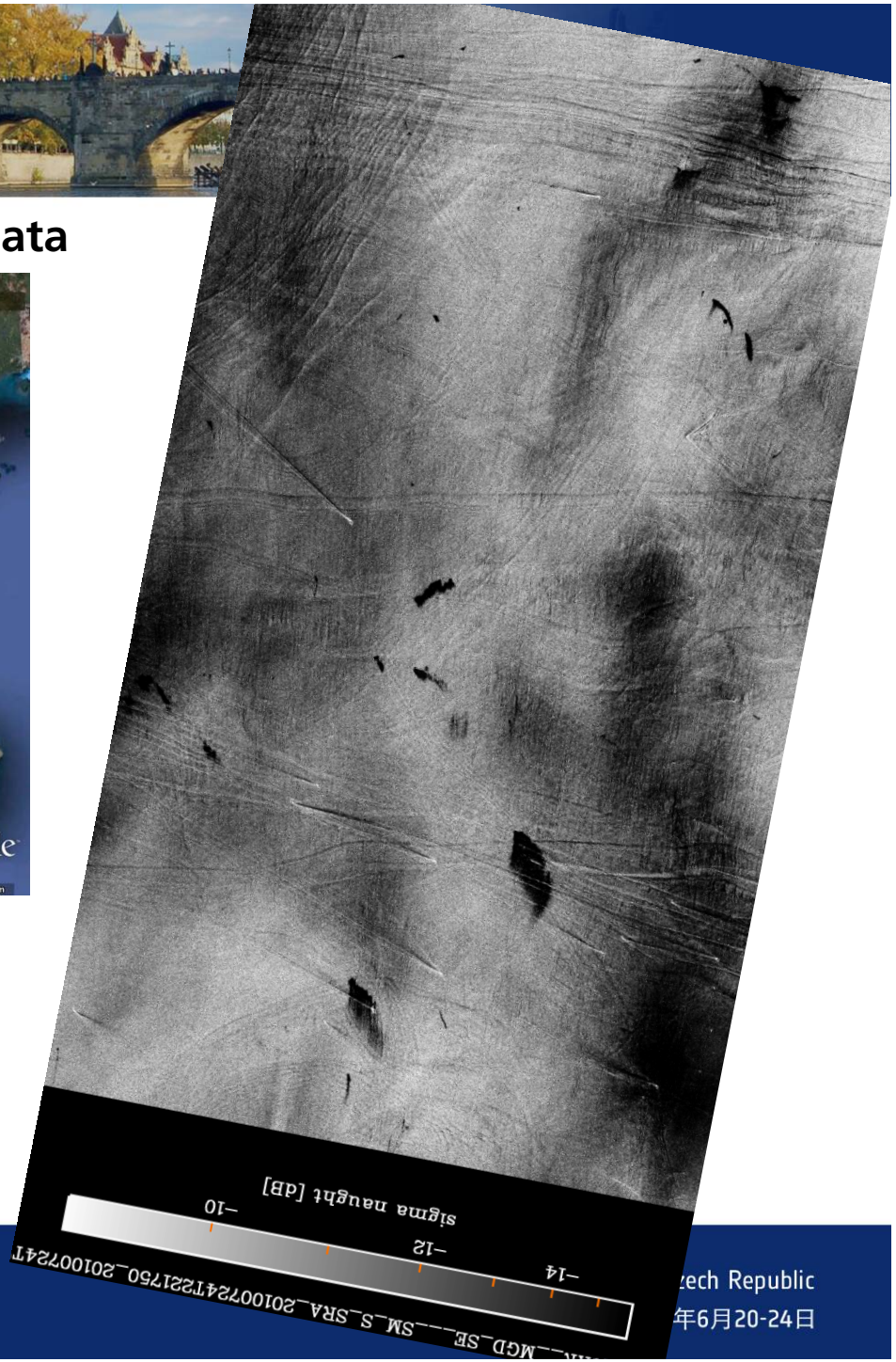
ASCAT measurement at 12:30 UTC on July 24



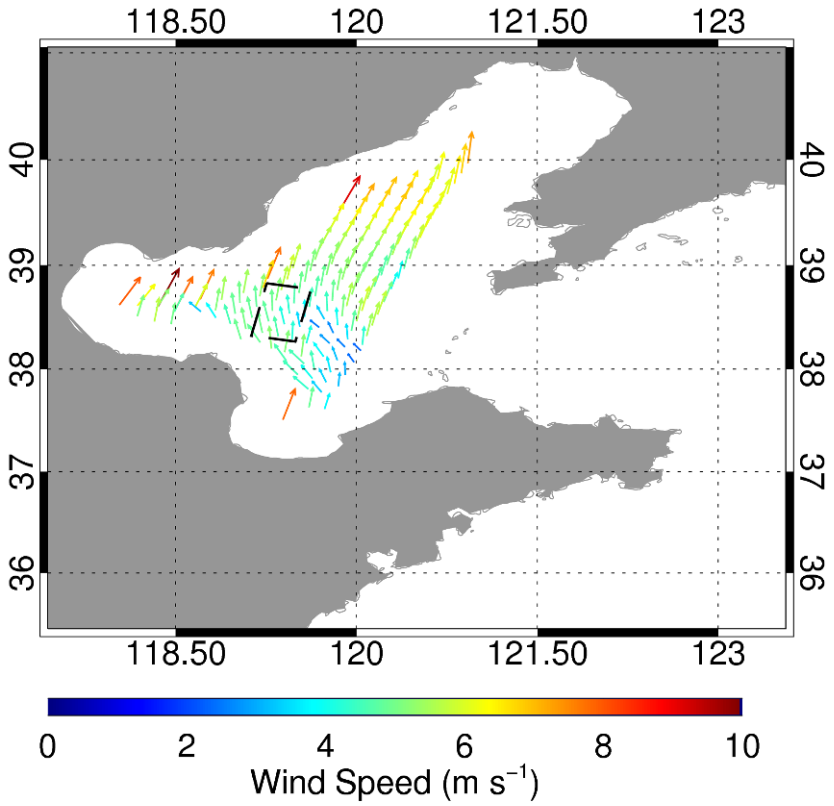


In situ obesrvation on July 24 at 7:12 UTC, 6 hours before ASAR wind speed is 5.3 m/s, wind direction 83 deg.
At: 37.75°N/121.12°E

Sea surface wind retrieval – TSX Stripma data

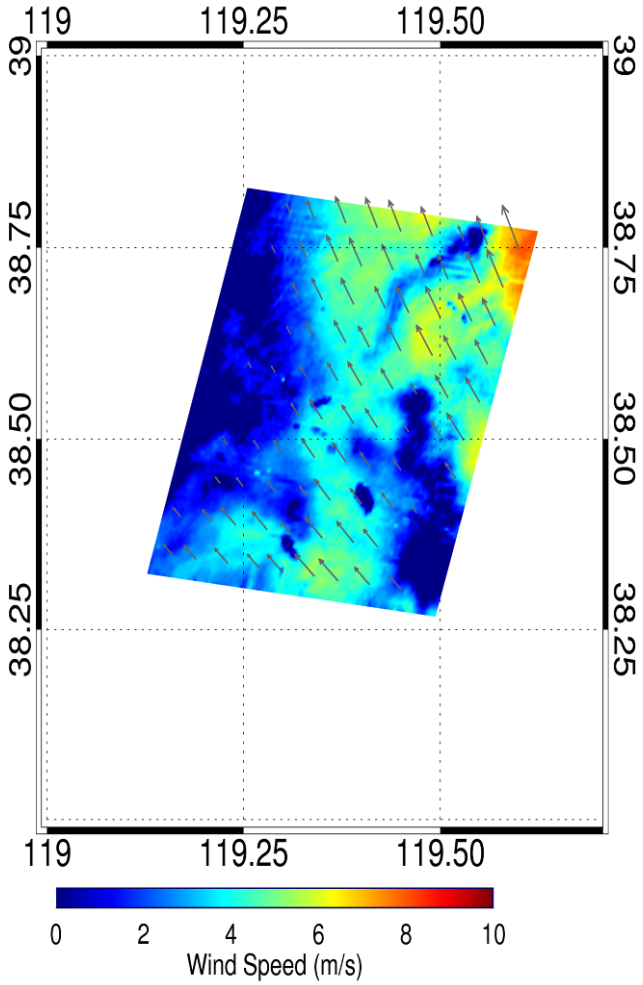


TS-X image acquired on July 24 at 22:17 UTC
Pol: HH, pixel size: 1.25 m



ASCAT measurement at 01:37 UTC on July 25

In situ obesrvation on July 25 at 0:03 UTC
Wind speed 1.7 m/s, wind direction 100 deg.
Altitude: 6.7 m



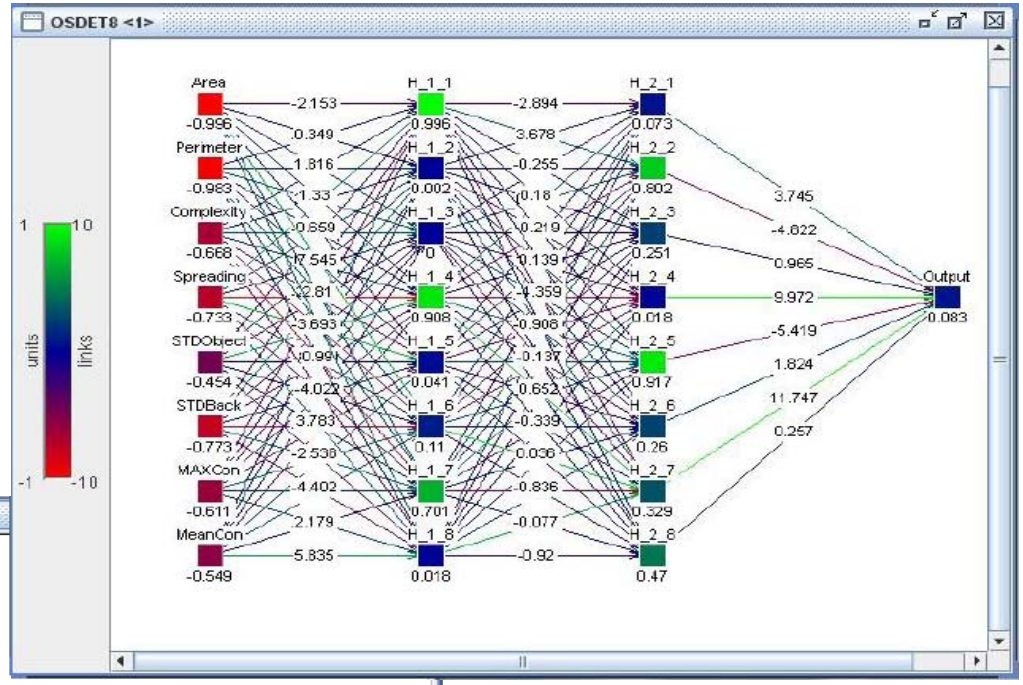
TS-X at 22:17 UTC on July 24

Oil Spill monitoring using SAR imagery

Neural Network – Topology and Training method

Input Features:

Area, Perimeter, Complexity, Spreading, StdDev Obj, StdDev Bck, Max Contr, Mean Contr

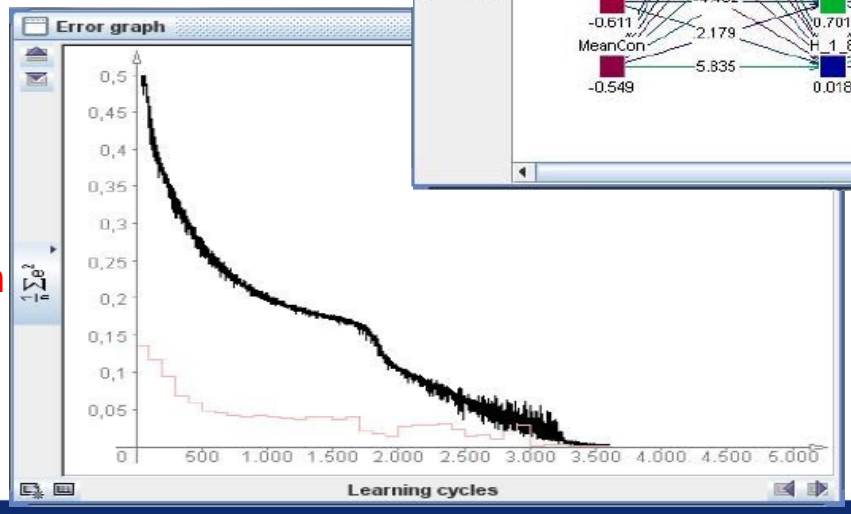


Training method:

MLP Backpropagation

Training Cycles:

4000



Neural Network – Data Collection

TerraSAR-X including different modes (ScanSAR, StripMap and SpotLight) and Polarizations

60 Oil spills (mainly spill accident)

58 Look-Alikes (mainly low-wind areas, biogenic slicks)

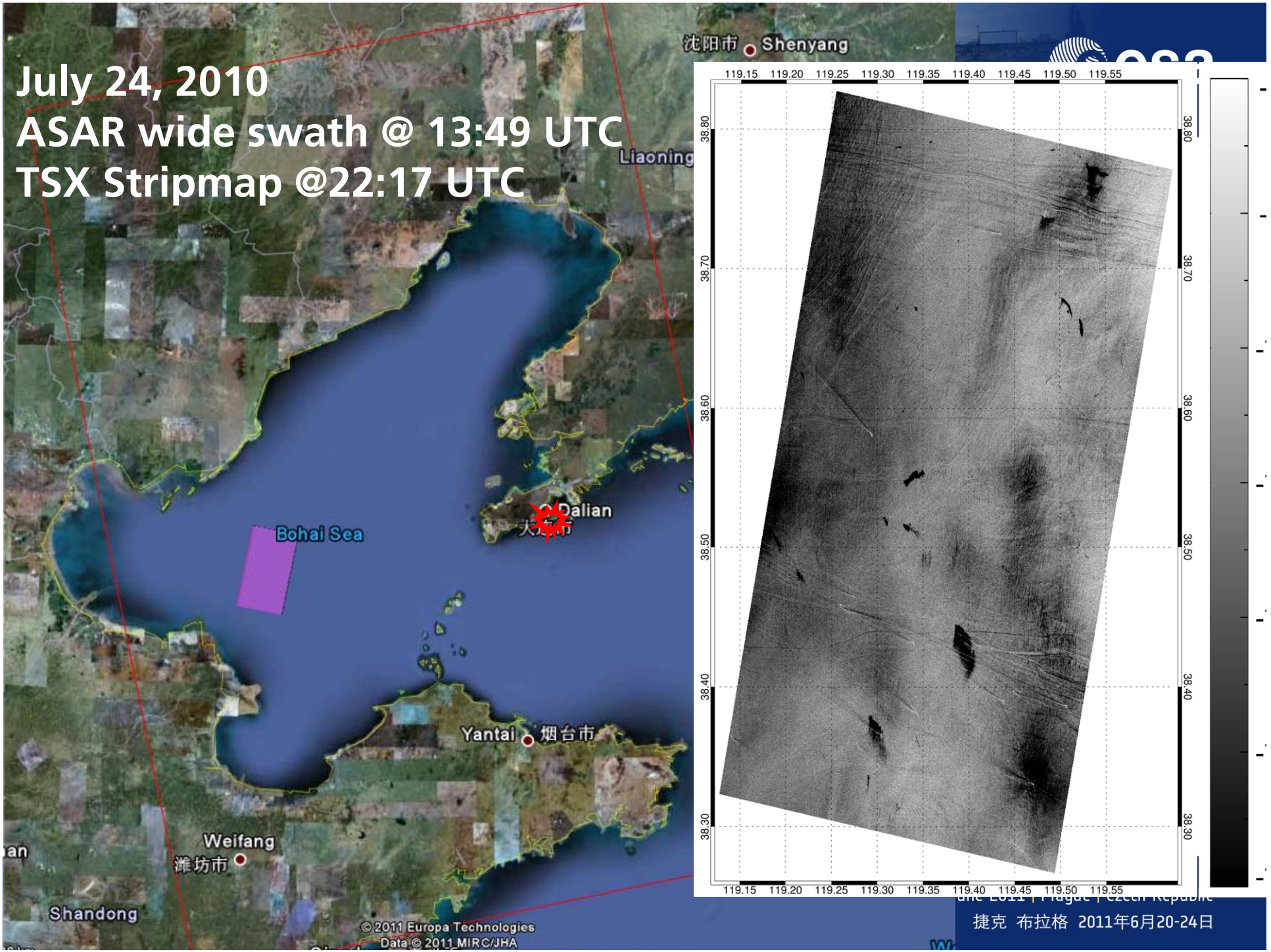
Training Dataset: 94 Oil spills and Look-alikes

Test Dataset: 24 Oil spills and Look-Alikes

Validation Dataset: 25 Oil spills, 25 Look-Alikes

Oil Spill in Dalian - China (July 16, 2010)

Protect our environment !



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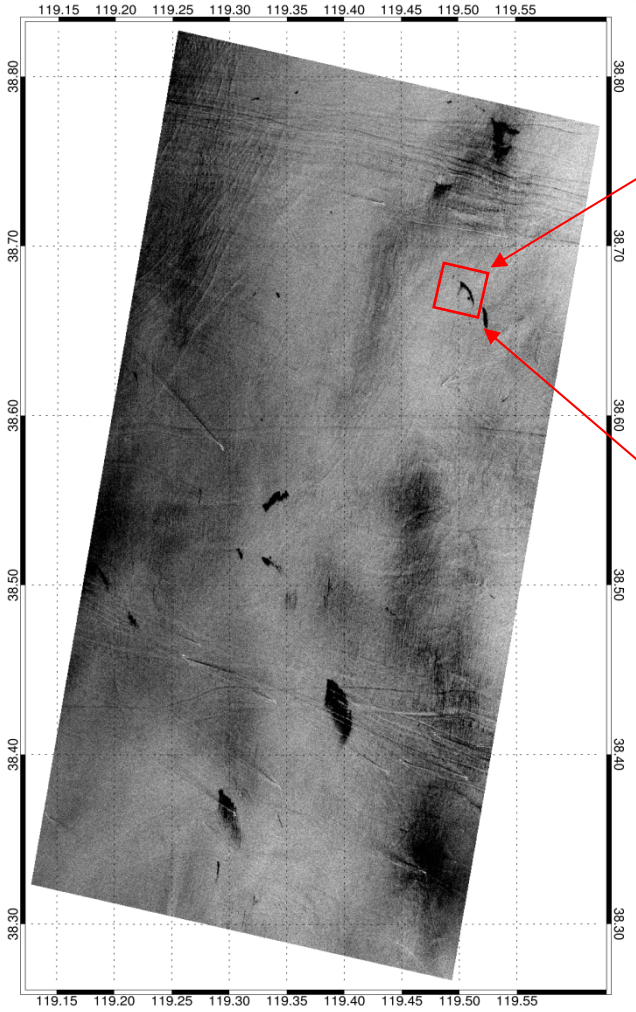
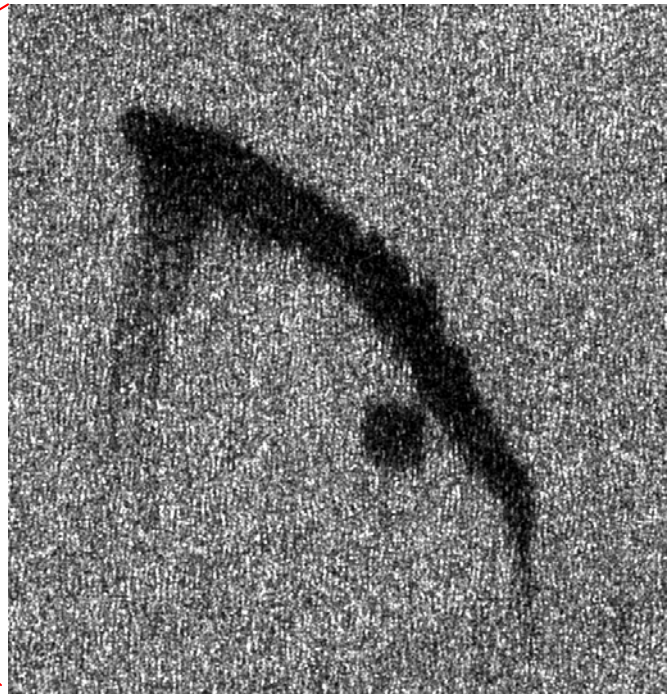


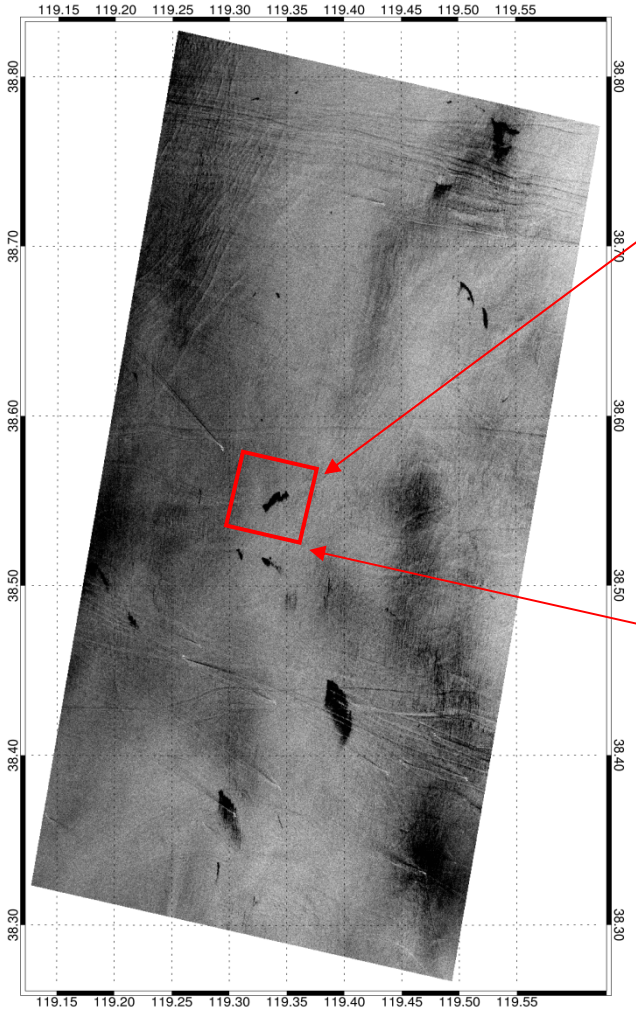


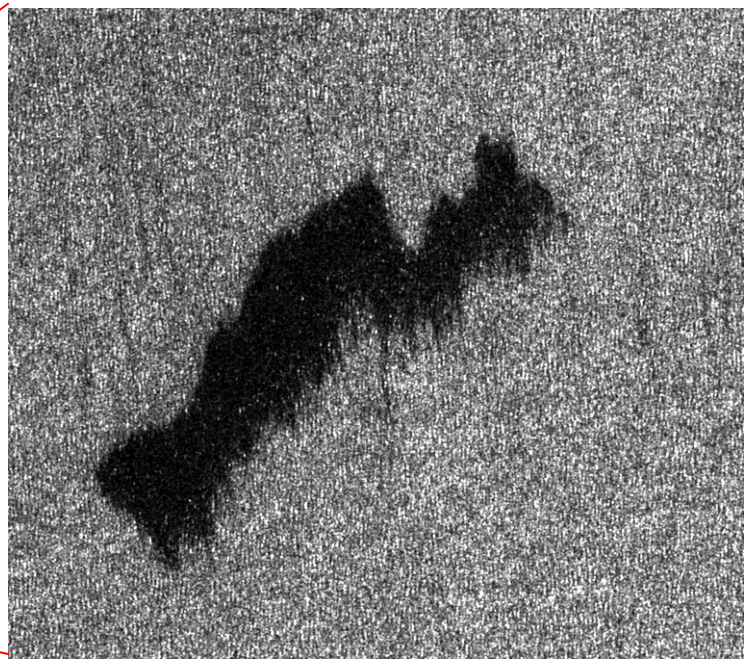
FEATURES EXTRACTED

Area (km^2):	0.39312
Perimeter (km):	4.75000
Complexity (scalar):	2.13709
Spreading (percentage):	6.00000
StdDev Obj (dB):	1.98400
StdDev Bck (dB):	1.12579
Max Contr (dB):	11.5419
Mean Contr (dB):	7.40558

NEURAL NETWORK RESPONSE

99.92%



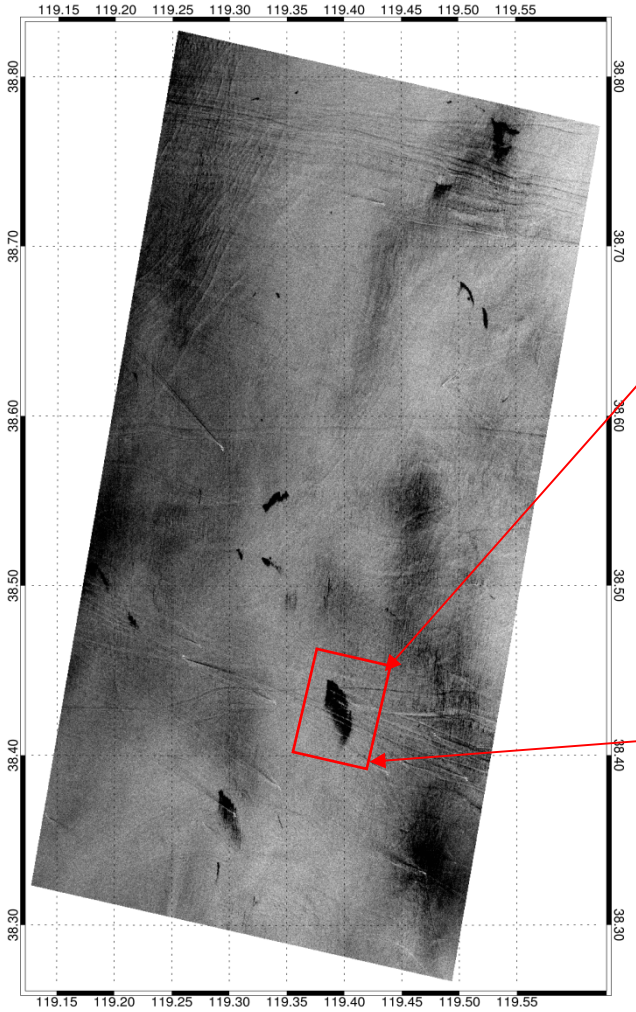


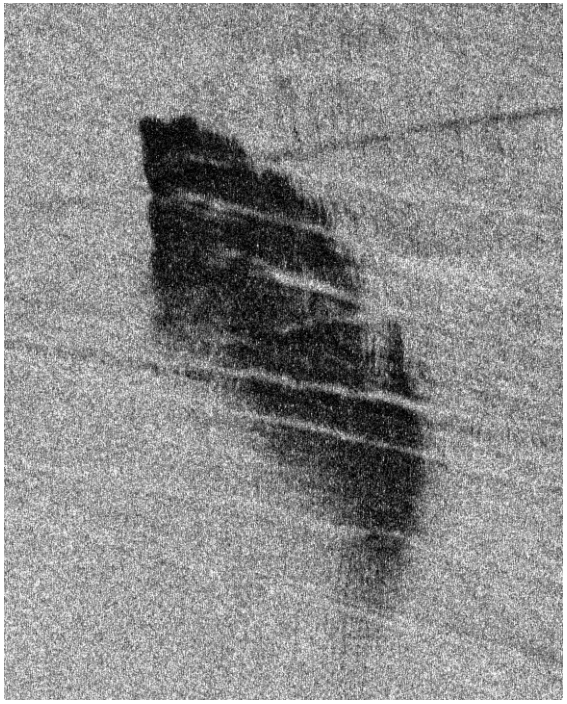
FEATURES EXTRACTED

Area (km^2):	0.87187
Perimeter (km):	6.22500
Complexity (scalar):	1.88065
Spreading (percentage):	7.00000
StdDev Obj (dB):	1.89828
StdDev Bck (dB):	1.17765
Max Contr (dB):	12.9874
Mean Contr (dB):	9.14287

NEURAL NETWORK RESPONSE

99.94%



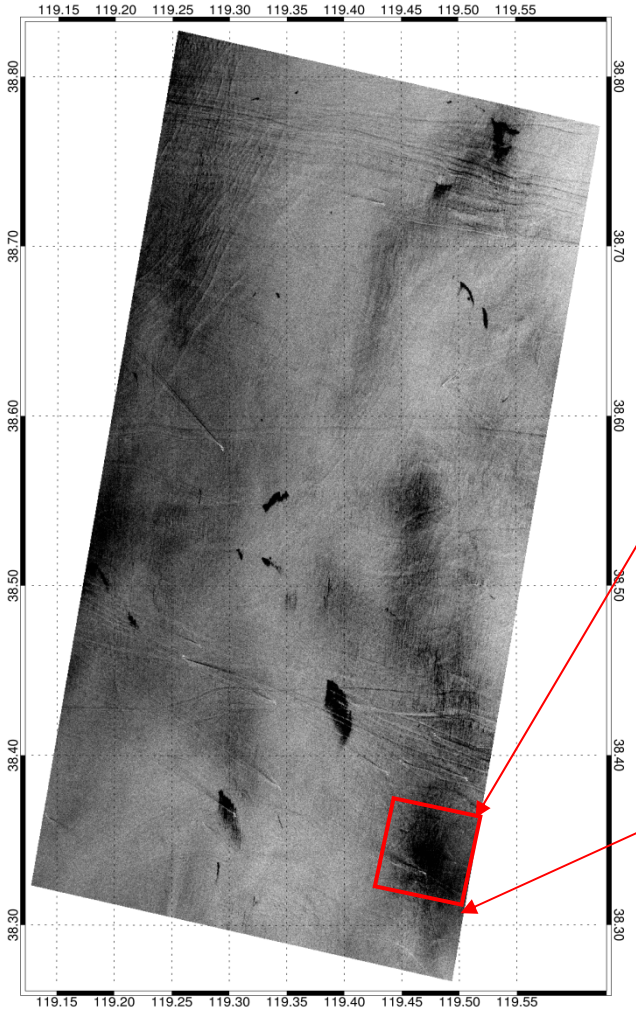


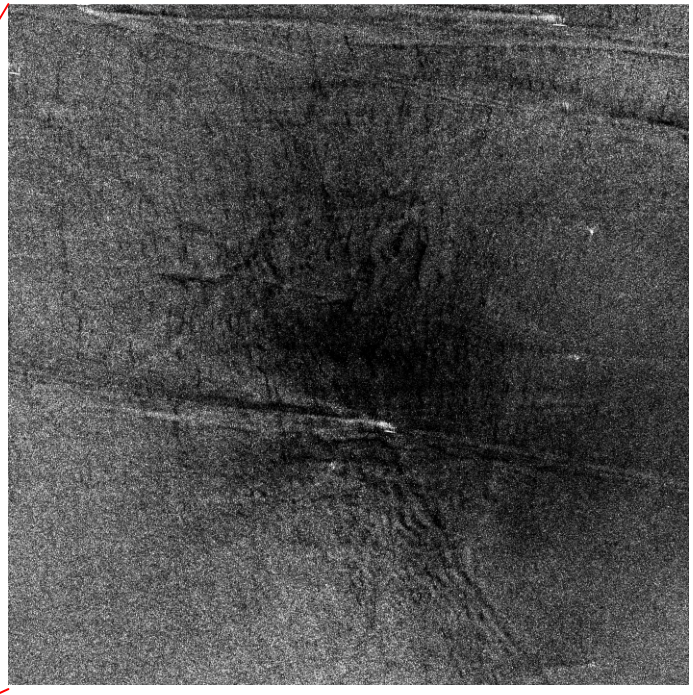
FEATURES EXTRACTED

Area (km^2):	4.46125
Perimeter (km):	29.5250
Complexity (scalar):	3.94327
Spreading (percentage):	12.0000
StdDev Obj (dB):	2.44880
StdDev Bck (dB):	1.24891
Max Contr (dB):	13.3168
Mean Contr (dB):	7.31043

NEURAL NETWORK RESPONSE

99.97%



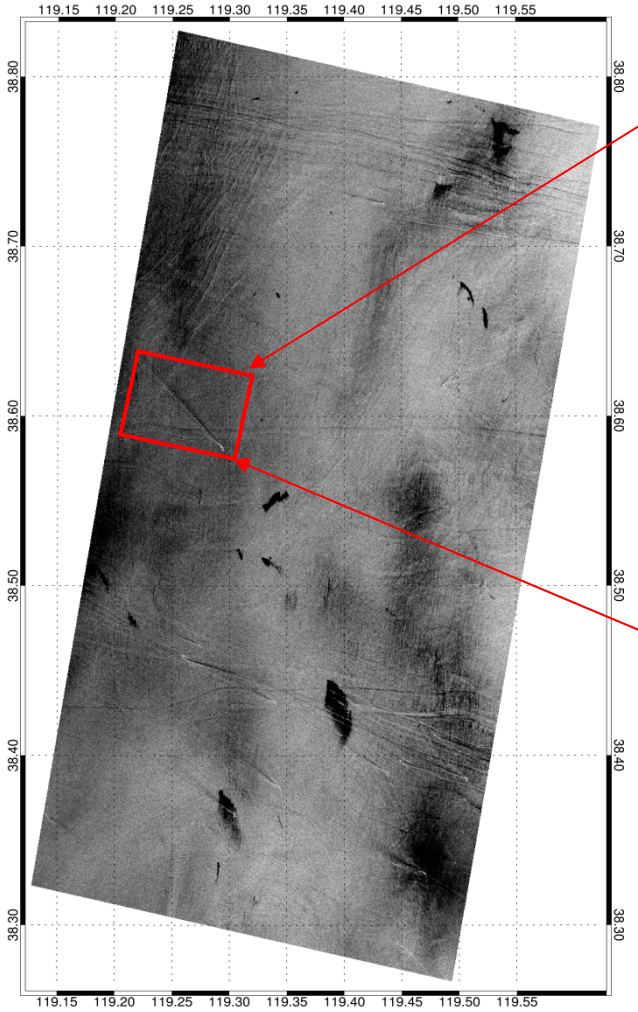


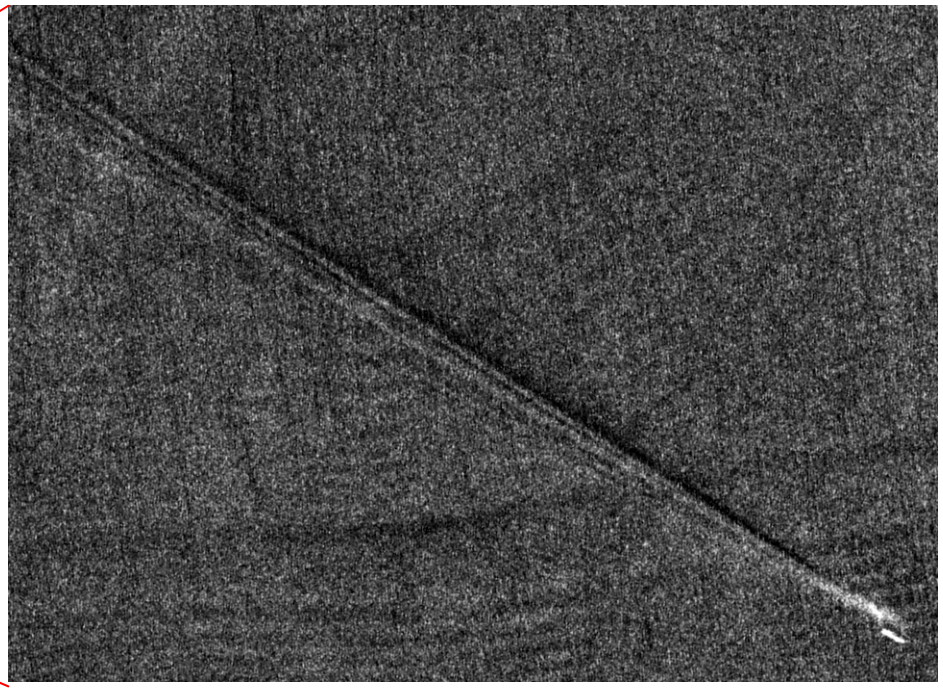
FEATURES EXTRACTED

Area (km^2):	5.30188
Perimeter (km):	95.4250
Complexity (scalar):	11.6908
Spreading (percentage):	20.0000
StdDev Obj (dB):	1.29251
StdDev Bck (dB):	1.82964
Max Contr (dB):	9.60661
Mean Contr (dB):	4.18214

NEURAL NETWORK RESPONSE

1.23%





FEATURES EXTRACTED

Area (km^2):	0.74812
Perimeter (km):	19.9250
Complexity (scalar):	6.49840
Spreading (percentage):	1.00000
StdDev Obj (dB):	0.97392
StdDev Bck (dB):	1.09845
Max Contr (dB):	5.77728
Mean Contr (dB):	2.24080

NEURAL NETWORK RESPONSE

87.57%

Summary

- ✓ Development of new X-band sea surface wind retrieval algorithm
- ✓ Application of multiple SAR sensor on typhoon observation
- ✓ Application of high resolution TS-X SAR on sea surface wind mapping over the China wind farming park in East sea
- ✓ Preliminary development of NN method for oil spill monitoring
- ✓ Joint validation experiment for sea surface wind field retrieval from the C- and X-band SAR sensors in Bohai Sea.