NEW SPACE FOR SAR

SMALL SAR SATELLITES ARE PROBABLY NOT WHAT YOU IMAGINE…

28 SEP 2022

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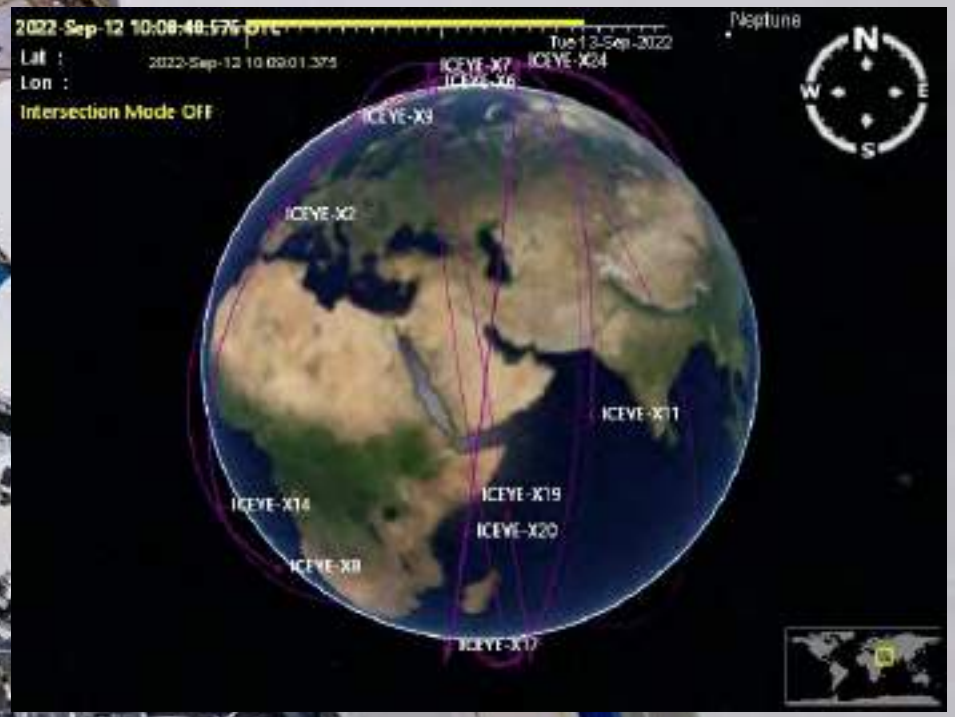
THINGS I HAD TO LEARN….

- Size matters …
- The World is not quite ready yet …
- Resolution is for everyone …
- Everybody lies. So fail fast and find out the truth …

Size matters…

21 SATELLITES

LAUNCHED TO DATE



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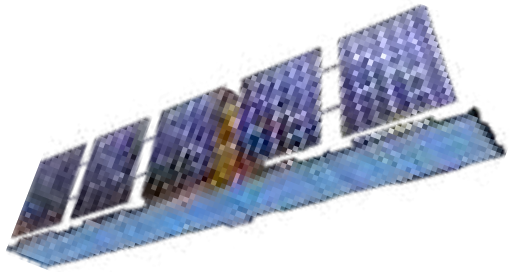
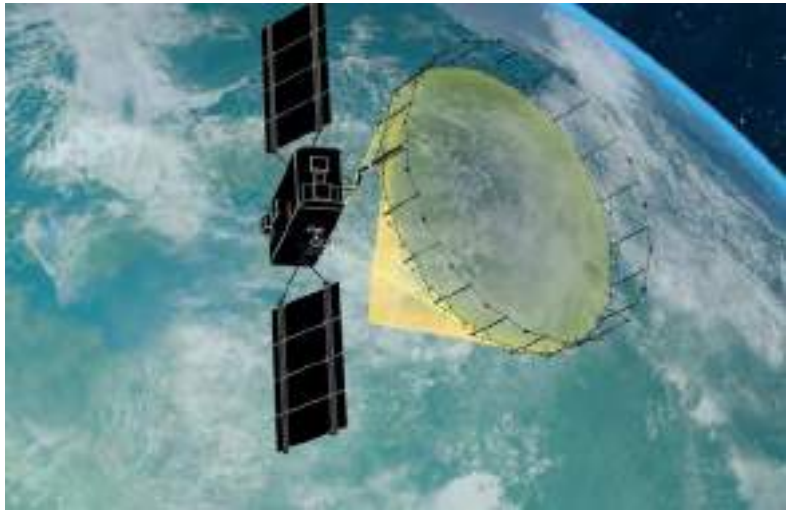
TWO COMPETING PHILOSOPHIES



- Smaller area electronically steered phased array
  - Lower directivity
    - Less power efficient
  - Wider beam
  - Easier beam agility
  - Resilience through many T/R elements



Courtesy Oxford Space Systems https://oxford.space/offsetreflector/ [other vendors are available ;]

- Larger area lightweight reflector antenna
  - Higher directivity
    - More power efficient
  - Smaller beam
  - Lower beam agility
  - Lower resilience

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NOISE EQUIVALENT SIGMA ZERO ?

A measure of the sensitivity of a SAR system by comparing thermal noise to mean radar cross section

Not so useful for small SAR satellites with fine resolution

Prefer RADAR Generalised Image Quality Equation[1]

Channel Capacity (Shannon-Hartley)

$$C\ (bits) = B\ log2\ (1 + SNR)$$

B ➔ range and azimuth resolution (transmit and Doppler bandwidth)

SNR➔ 'terrain to noise ratio' for SAR

$$C = B_{Az}B_{Rg}log_2\left(1 + \frac{\sigma}{NESZ + \sigma_0(N_{islr} + N_{amb} + N_Q)}\right)$$

Radar Cross Section of signal

Bandwidth for ground IPR

Mean radar crosss section of background clutter

Integrated sidelobe ratio

Range and azimuth ambiguity noise in image

Quantisation noise from sampling

1. W. Schwartzkopf, J. Brown, G. Farquharson, C. Stringham, M. Duersch and J. Heemskerk, "Radar Generalized Image Quality Equation Applied to Capella Open Dataset," *2022 IEEE Radar Conference (RadarConf22)*, 2022, pp. 1-5, doi: 10.1109/RadarConf2248738.2022.9764201.

Also check out SARPY: https://sarpy.readthedocs.io/en/latest/

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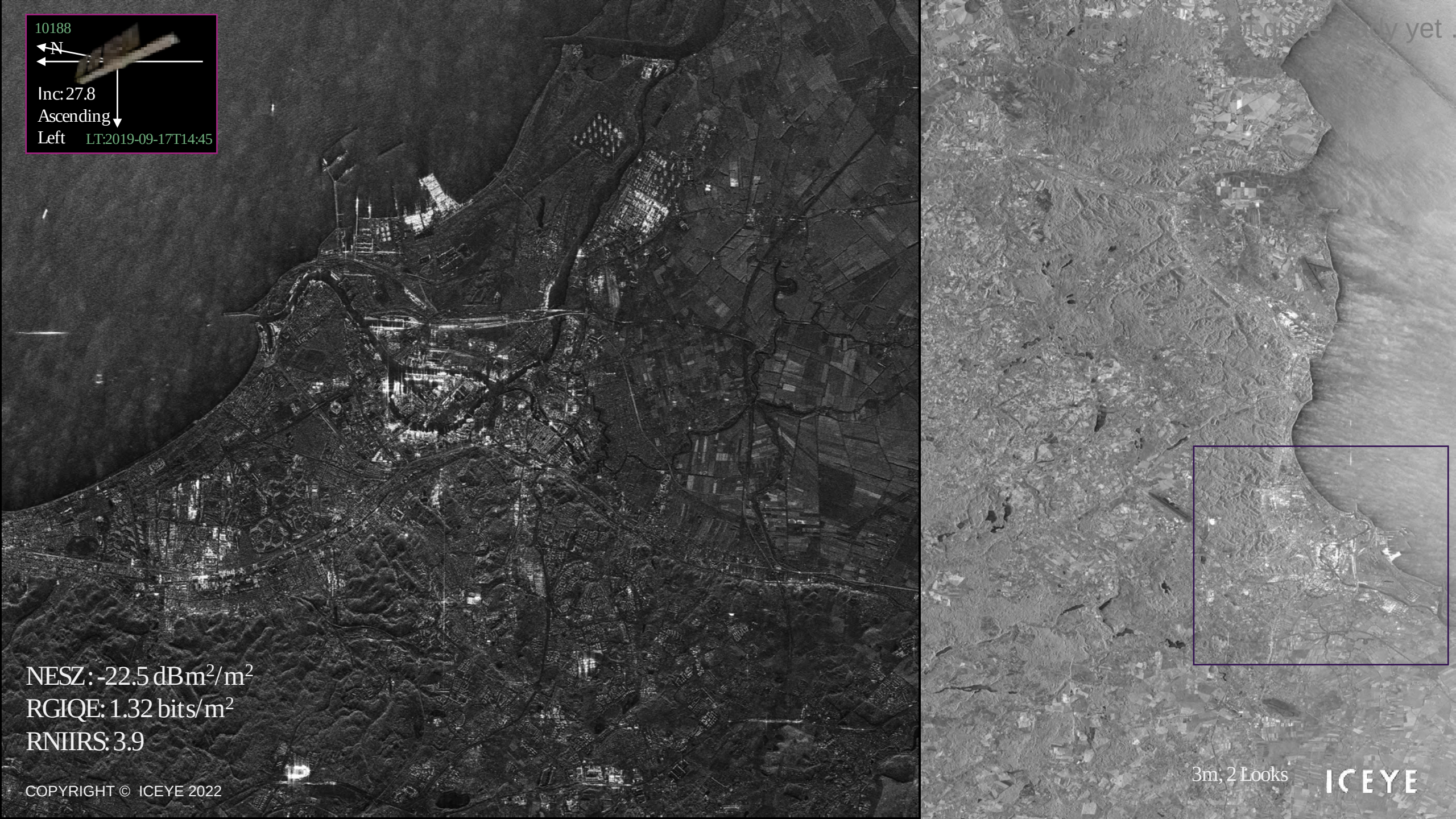
10188
N
Inc: 27.8
Ascending
Left
LT:2019-09-17T14:45
NESZ: -22.5 dBm²/m²
RGIQE: 1.32 bits/m²
RNIIRS: 3.9
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3m, 2 Looks
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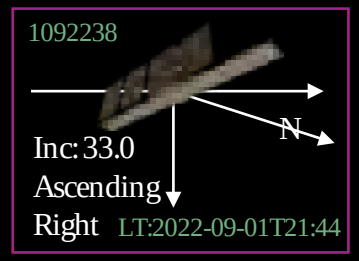


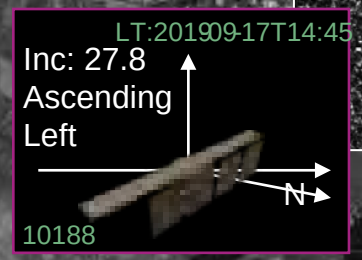
15km

The World is not quite ready yet .

15km

NESZ: -22.5 dB m²/m²
RGIQE: 1.32 bits/m²
RNIIRS: 3.9

1m, 2 Looks



NESZ: -17.9 dB m²/m²
RGIQE: 13.1 bits/m²
RNIIRS: 5.2

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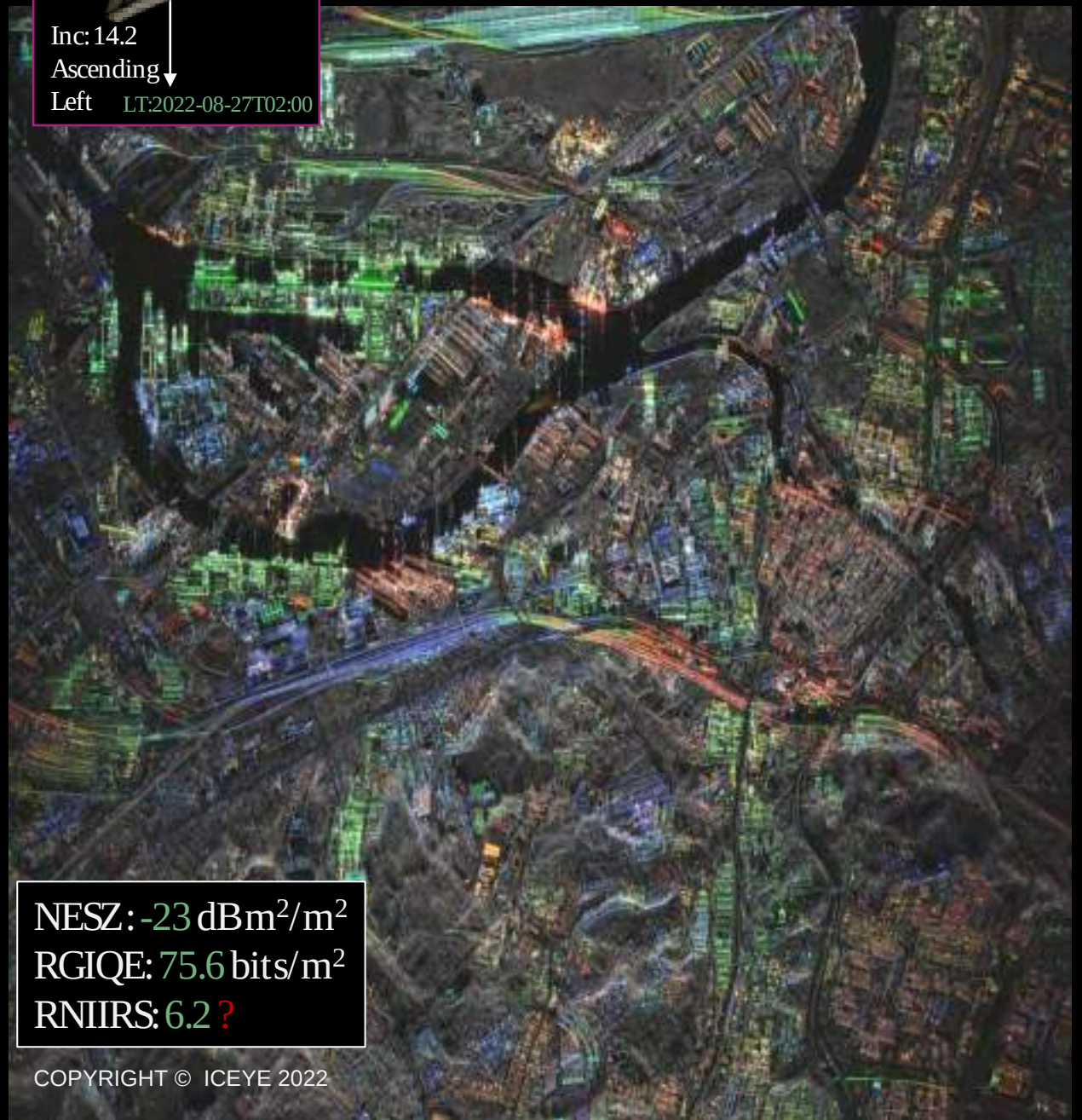
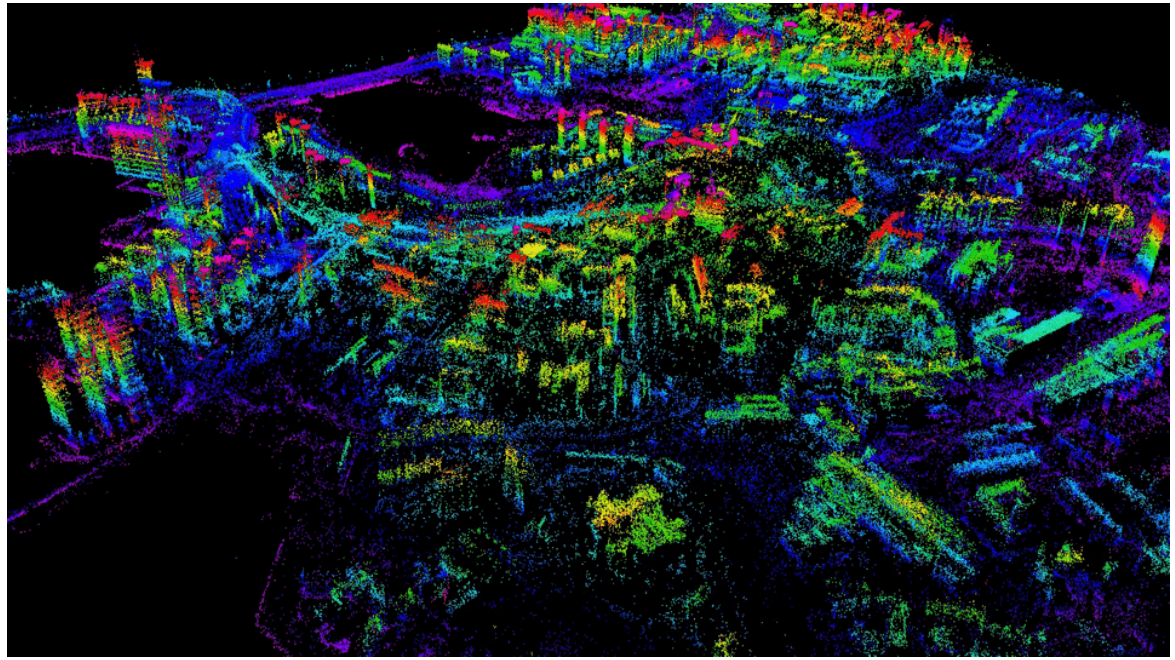
The World is not quite ready yet .



RESOLUTION IS IMPORTANT….
But it also isn't

- It takes us beyond 'the picture'
  - ML needs ~100 samples per target to classify. (so classify objects of dimensions 2.5 m x 2.5 m)*
  - Resolution == bandwidth == information ! How do we unlock this ?
- Fine resolution is no longer (that) difficult (unlike optical systems)
  - All SAR engineers will soon have 1.2GHz bandwidth (~0.25 m ground resolution)
  - The fact that anyone CAN do it will mean that everyone WILL do it !
- So what next:
  - Phase exploitation and complex data analysis
  - Time Series analysis
  - Fast-time, spectral analysis
  - Community driven tools
- Useful data links:
  https://www.iceye.com/lp/iceye-18000-public-archive
  https://www.capellaspace.com/gallery/
  https://scihub.copernicus.eu
  https://earth.esa.int/eogateway/catalog/radarsat-2-esa-archive
  https://earth.esa.int/eogateway/catalog/terrasar-x-esa-archive
  https://earth.esa.int/eogateway/catalog/cosmo-skymed-esa-archive



*In theory, big pinch of salt point is that resolution is approaching typical target size

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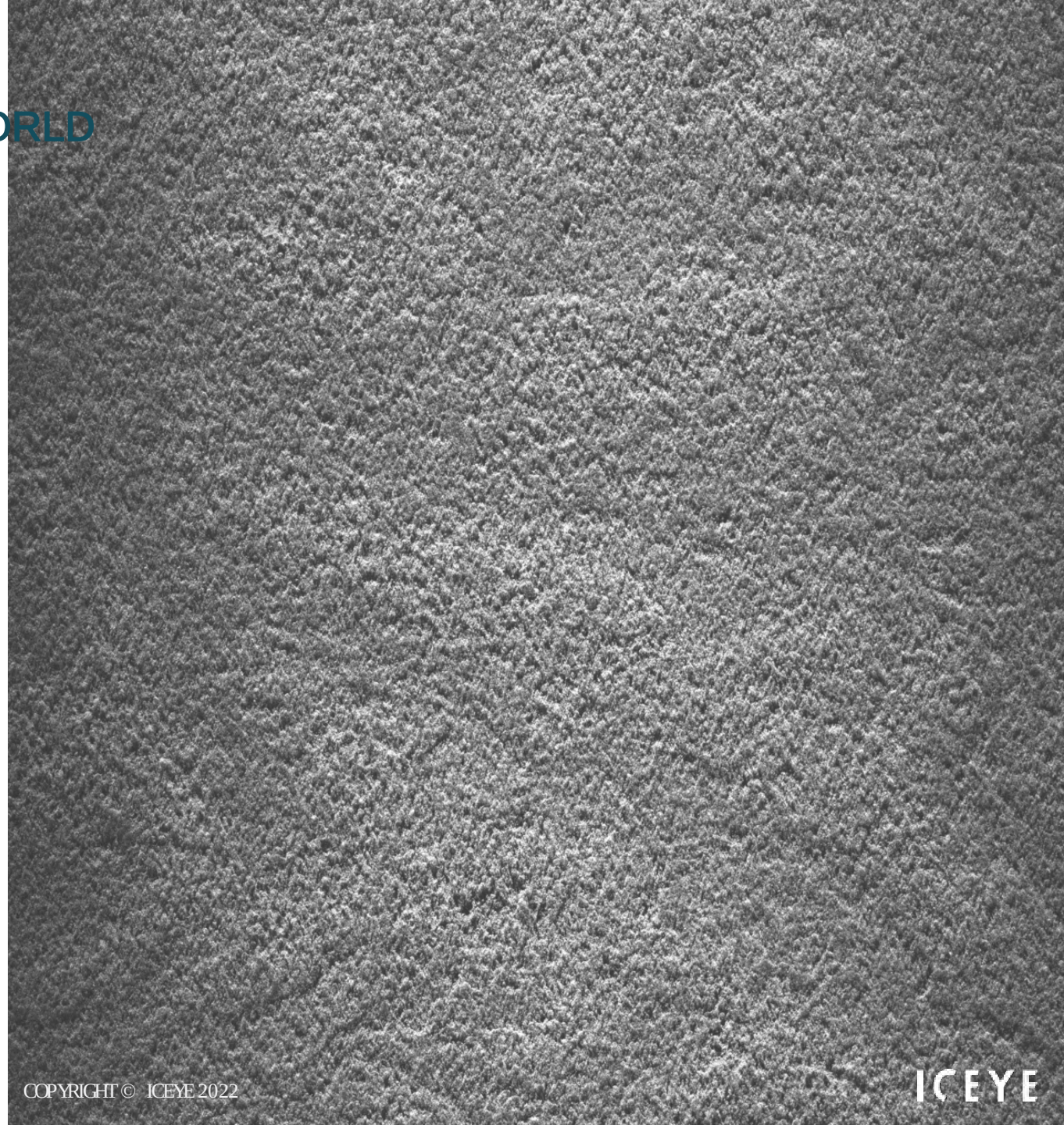
THE MOST BORING SAR VIDEO IN THE WORLD

The **SAR Video** enables us to easily validate volume scattering of target for calibration purposes



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Temporal– COLOUR MULTI-LOOK

Applications

Human object detection | Target categorization

Gradual change in imaging angles enables human structure detection from forest canopy

Advanced Spot imaging over the Chichen Itza archaeological site in the Mexican state of Yucatán

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SLED – WHAT CAN YOU DO WITH THIS ?

The **SAR Video** enables us to derive surface wind speed and direction over water bodies

COHERENT CHANGE STACK YEAR IN CALIFORNIA

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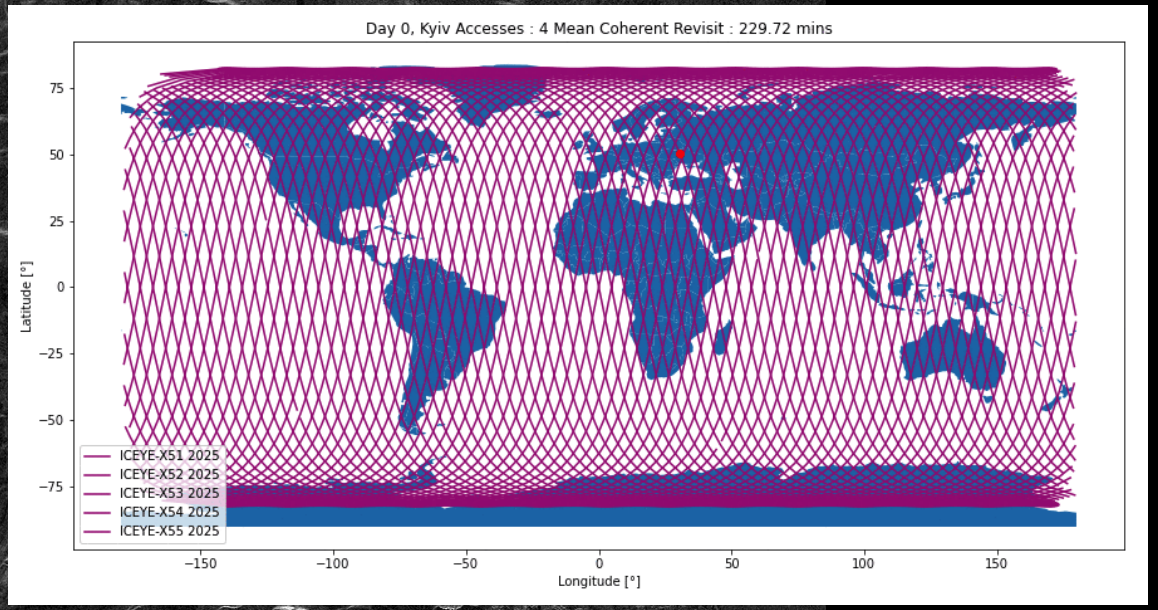

Muldrow Glacier - 30 April 2021

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SUMMARY

- A (perhaps a little biased) perspective on the emerging Small SAR Satellite community
- A different breed to larger satellites – better and worse
  - But **NOT** a low cost replacement for large Satellite capabilities
- Good for:
  - Fine resolution, rapid revisit
  - Experimentation and evolution

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QUESTIONS / COMMENTS ?

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