

# Recent Chinese SAR Missions for InSAR Applications

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# 2016...



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Space  
Agencies

**SAR  
satellites**

↑  
**Research**  
↓



(and many more!)

Applications



# 2026!



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Space  
Agencies

SAR  
satellites

Research

Applications



(and many more!)

Space  
Agencies

SAR  
satellites

Research

Applications



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中国航天 Shanghai Institute of Satellite Engineering



中国空间技术研究院  
中国航天 China Academy of Space Technology

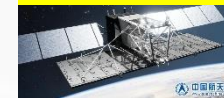


天仪研究院



中国科学院空天信息创新研究院  
Aerospace Information Research Institute, Chinese Academy of Sciences

LuTan-1



陆探一号, 2022年入轨

GF-3



高分三号, 2016/21/22 年入轨

Dual antenna



双天线, 预计2025年底

Tianyi



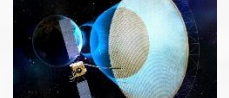
涪城一号, 23/24/25 年入轨

Hongtu



宏图一号, 23年入轨

LuTan-4



陆探四号, 23年入轨



自然资源部国土卫星遥感应用中心  
Land Satellite Remote Sensing Application Center, MNR

住房和城乡建设部信息中心

自然资源陕西省  
卫星应用技术中心



HUAWEI



煤 ARSC 航



# Progress of Chinese (In)SAR Missions

**2012 → 2026+**

from single civil SAR missions to InSAR constellations, GEO SAR and commercial small-SAR ecosystems



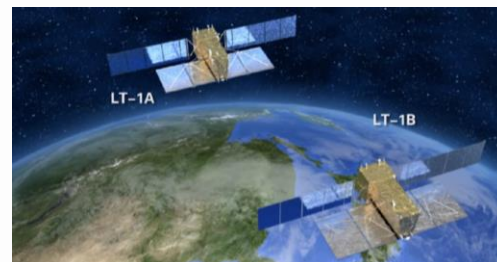
2012-2022

## National civil SAR

HJ-1C

**GaoFen-3 A/B/C**

C-band high-resolution SAR



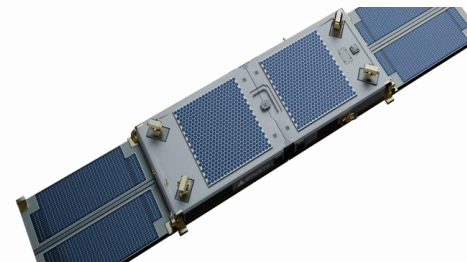
2019-2022

## InSAR-oriented systems

Tianhui-2 mapping pairs

**LuTan-1 A/B**

L-band bistatic InSAR



2020-2025

## Commercial small SAR

Spacety: Hisea-1

**Chaohu-1 / FuCheng-1**

Shenqi 01/02 constellation



2023-2025+

## New architectures

HongTu / PIESAT

**LuTan-4A GEO SAR**

HaiShao-1 • Taijing • AIRSAT

**Key trend** single sensor → operational constellation → formation / multi-static InSAR → GEO + VLEO + commercial dense revisit

# /01 GaoFen-3

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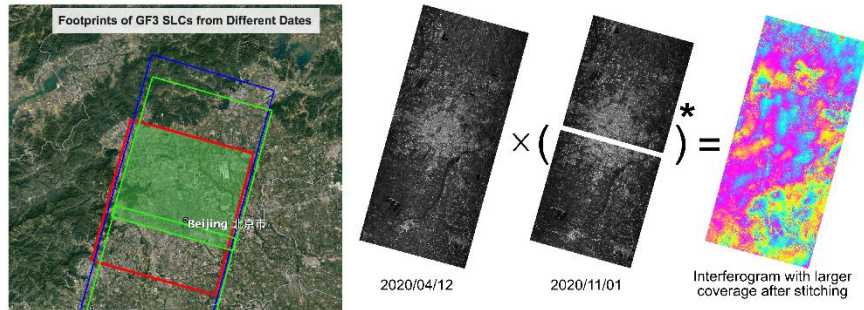
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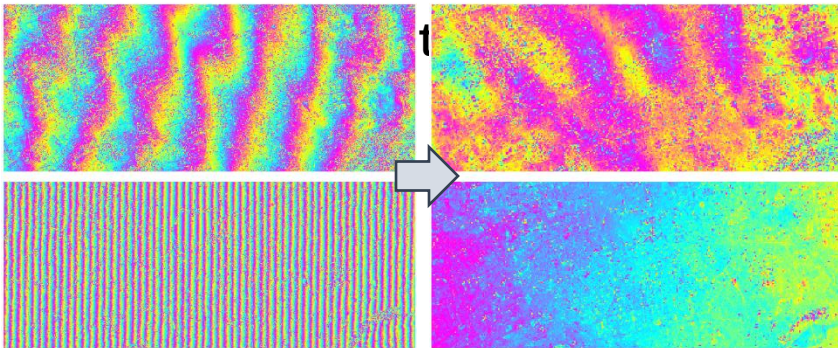
# InSAR for GaoFen-3

- The only SAR satellite in the “GaoFen Project” .
- In operation for nearly 9 years with a primary focus on ocean applications.
- Capabilities for interferometric measurements have not been effectively assessed.
- We conducted the first systematic analysis of GaoFen-3’ s interferometric performance...
- ... Giving promising results beyond our (everyone’ s) expectation!

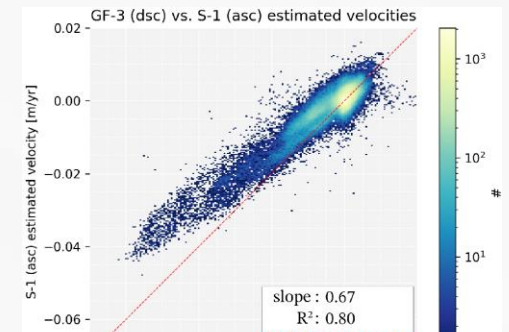
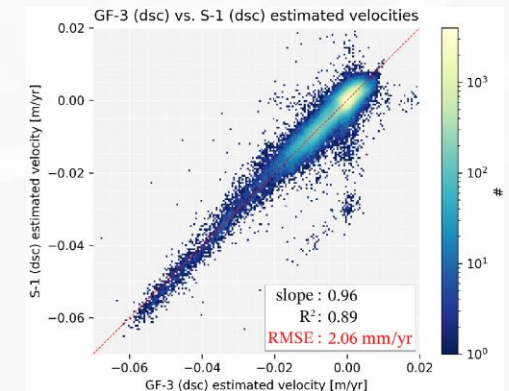
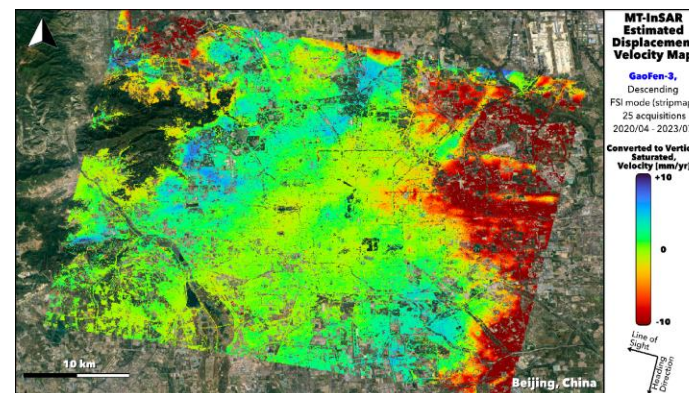
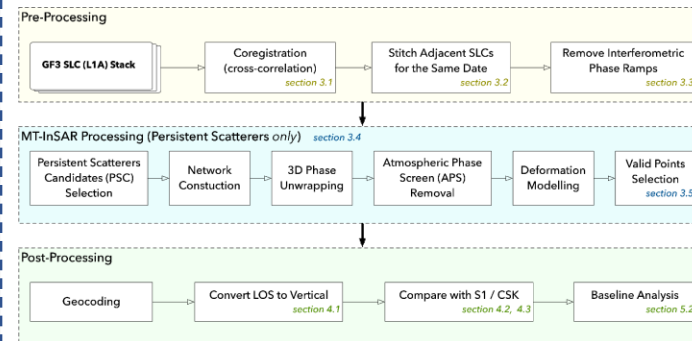
## Merging



## Orbits



## GF-3 PSInSAR



2mm/yr RMSE

# GaoFen-3B/C: Current Status & Features

Twin satellites extending GF-3 into China’s first operational civilian SAR constellation

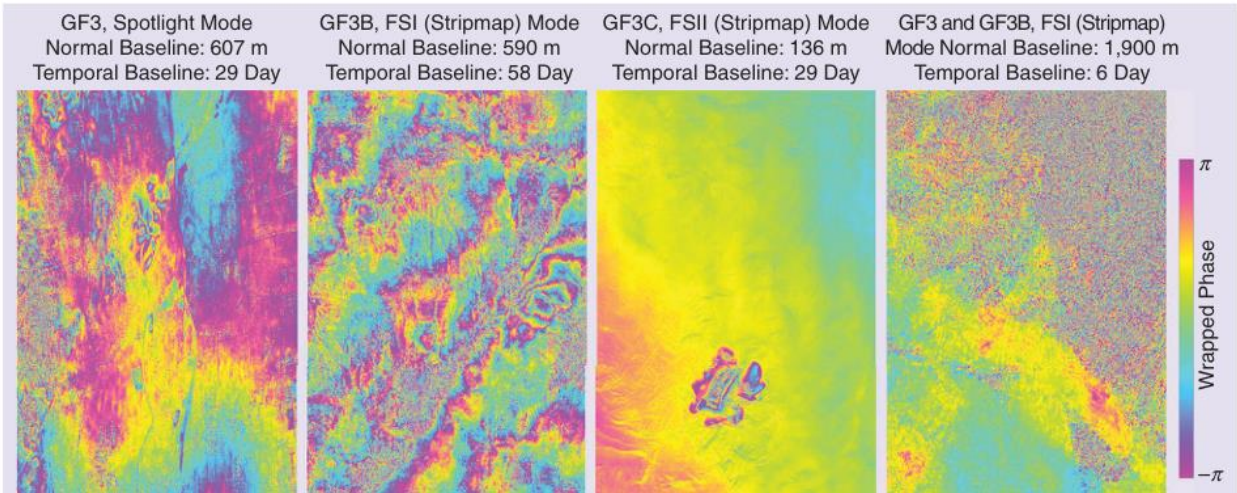
## Current status

|               |                                                                    |
|---------------|--------------------------------------------------------------------|
| 2021 / 2022   | GF-3B launched in Nov. 2021; GF-3C launched in Apr. 2022           |
| Feb. 2023     | Commissioning completed; both satellites entered routine operation |
| Till today... | All three satellites in good condition, next gen launching soon    |
| 1d / 6d / 22d | Constellation InSAR revisit time for 3-sat constellation           |

## Major upgrades in GF-3B/C

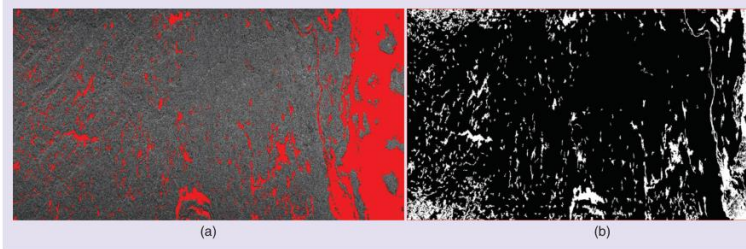
|                       |                                                                                                                     |
|-----------------------|---------------------------------------------------------------------------------------------------------------------|
| InSAR support         | Displacement and topography become standard products; coherent inter-satellite baselines of 1, 6, 22 and 29 days.   |
| Imaging modes         | TOPS replaces ScanSAR; wave mode improves to 8 m and 20 × 20 km; HRWS expands UFS / FS1 / QPS1 swaths.              |
| AIS + SAR             | Integrated AIS receiver supports vessel tracking; each satellite receives >200k AIS records for >20k vessels daily. |
| Onboard processing    | Real-time focusing: <1 min for FS1/QPS1 and <5 min for TOPS; onboard ship, flood and oil-spill detection.           |
| Duty cycle & products | Maximum imaging time per orbit extended to 100 min; new L1C, maritime SLC, wave, wind and AIS/SAR products.         |

## Interferometry examples from the constellation



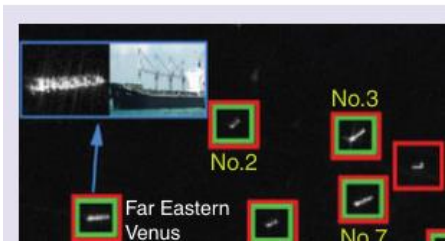
GF-3B/C were designed with explicit InSAR considerations, enabling cross- and repeat-pass interferograms.

## Onboard application-oriented processing



Example: real-time onboard flood detection product from GF-3B/C.

## AIS Support



AIS/SAR vessel tracking



# /02 LuTan-1



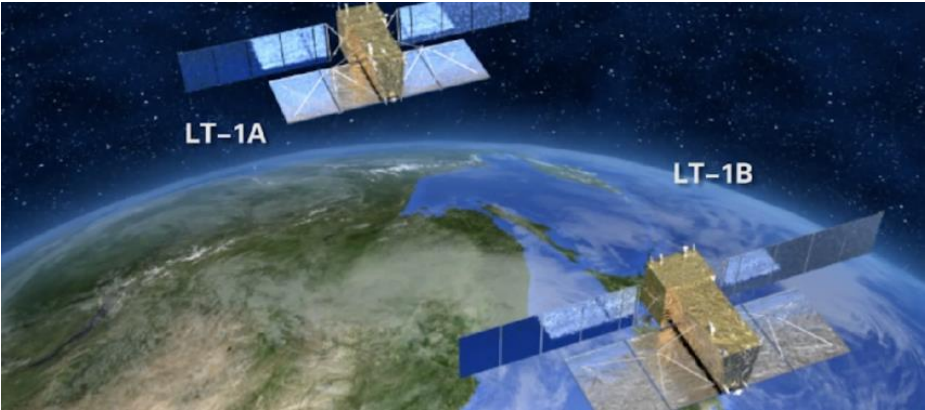
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# LuTan-1 Status & Key Statistics

China's L-band bistatic InSAR constellation for operational deformation and 3D products

## Mission configuration: LT-1A / LT-1B



Operational L-band distributed SAR twin constellation

IN SERVICE

official in-orbit delivery on 2023-12-29

## Status timeline

2022.01.26

2022.02.27

2023.12.29

Now



LT-1A launch



LT-1B launch



In-orbit delivery



Operational services

## Key mission statistics

2

satellites: LT-1A / LT-1B

L-band

full-polarimetric SAR

3 m

best spatial resolution

400 km

maximum swath width

~600 km

quasi-sun-synchronous orbit

4 / 8 d

dual / single-satellite repeat

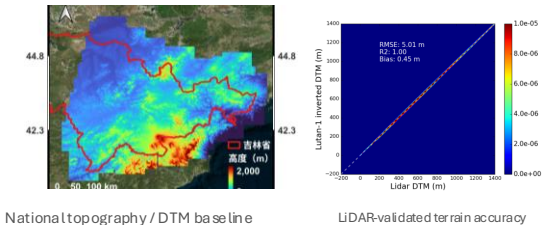
28 d

national deformation map update

cm-mm

deformation measurement capability

## Operational product status



## Primary operating modes

Bistatic mode

DEM / topography mapping

Monostatic mode

repeat-pass deformation mapping

L-band penetration

vegetated terrain & forestry use

LuTan-1 has moved from launch and commissioning into operational production: 3 m-class L-band InSAR data, country-wide deformation updates, and bistatic 3D products.

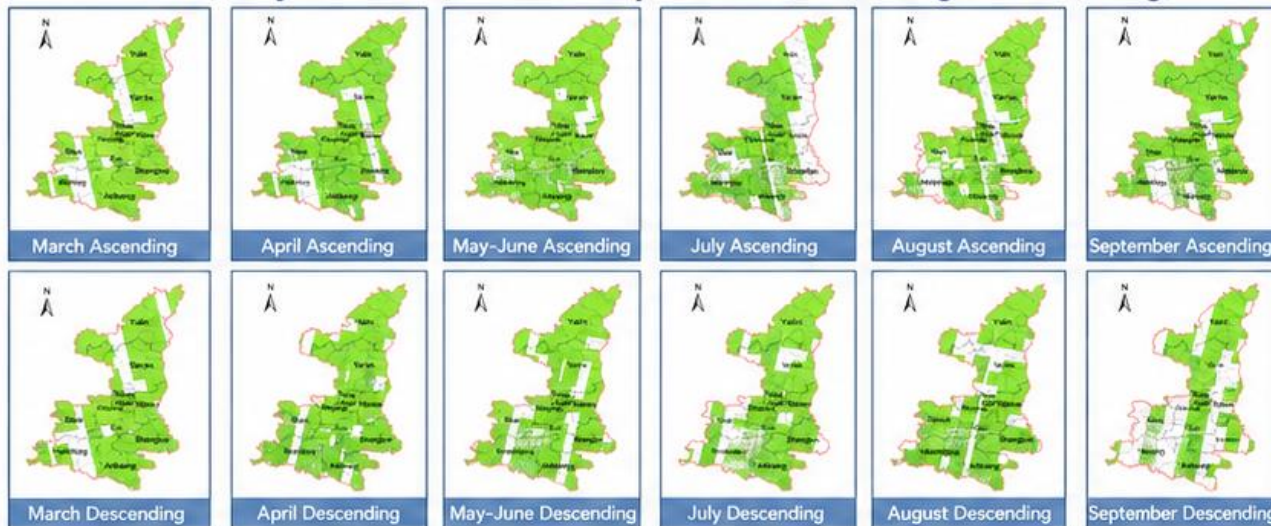
# LuTan-1 for Shaanxi in Daily Operation

Monthly Operational InSAR Mapping and Hazard Monitoring



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## Monthly DInSAR deformation products (ascending / descending)



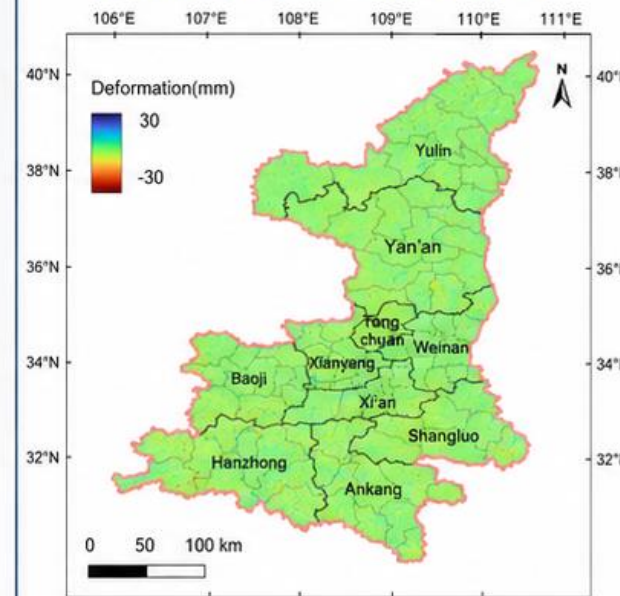
### Legend

- Provincial Boundary
- City Boundary
- County Boundary

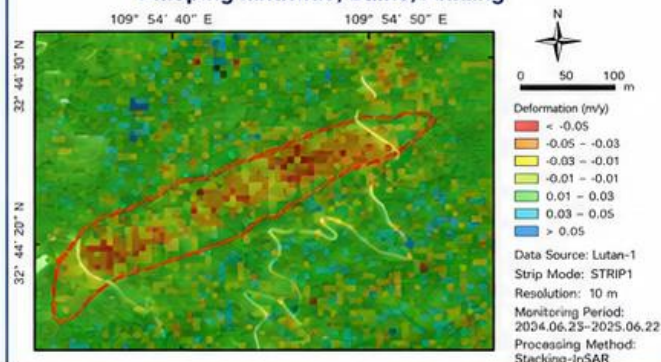
- Satellite: Lutan-1
- Processing method: DInSAR
- Period: March-September 2025



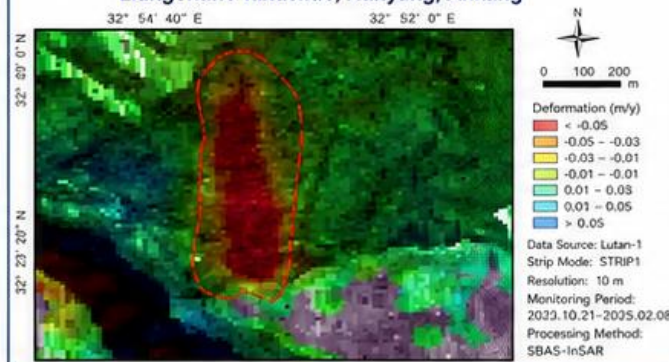
## Province-scale deformation overview



## Maoping landslide, Baihe, Ankang



## Liangchahe landslide, Xunyang, Ankang



Monthly ascending and descending DInSAR maps



Province-wide deformation screening



Operational support for geological hazard monitoring



Follow-up monitoring of typical landslides



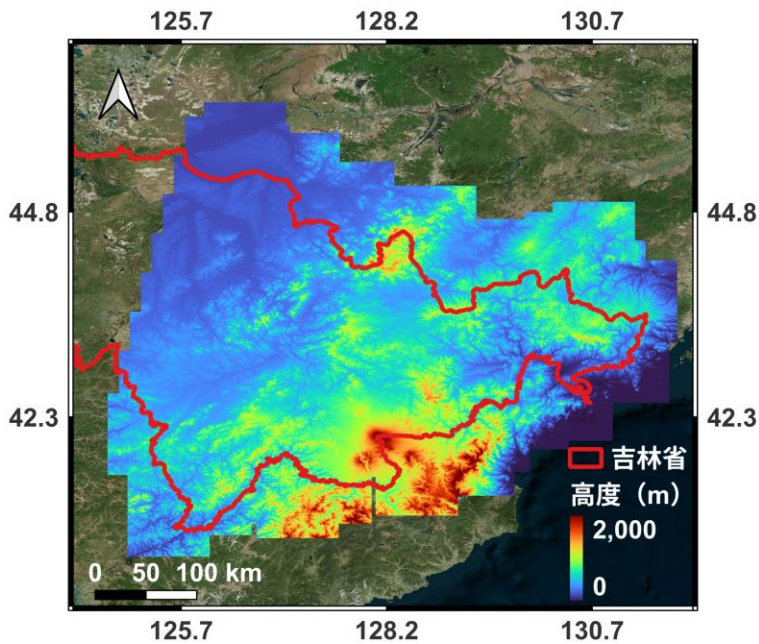
Operational LuTan-1 InSAR service in Shaanxi: province-wide screening plus localized hazard monitoring.



# LuTan-1 Bistatic InSAR for Country-wide 3D Products

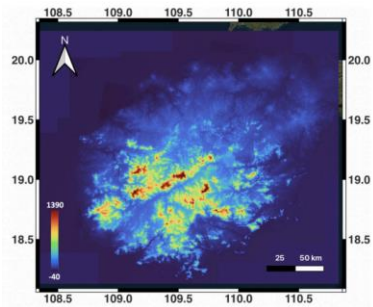
National topography (DTM) and tree-height mapping with LuTan-1

Country-wide topography baseline: LuTan-1 InSAR DTM



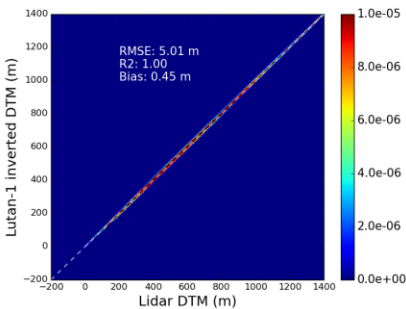
National DTM one-map production from LuTan-1 bistatic InSAR

Regional terrain product



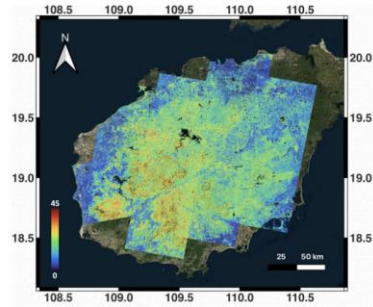
DTM / terrain-detail extraction

Vertical accuracy validated with LiDAR DTM



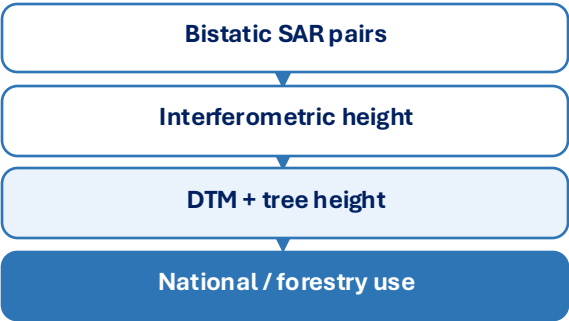
RMSE 5.01 m | R<sup>2</sup> 1.00 | Bias 0.45 m

Tree-height product



Canopy height retrieval for forestry applications

Operational production chain



- National DTM one map
- Bistatic InSAR 3D products
- LiDAR-validated accuracy
- Tree height for forestry

LuTan-1 bistatic InSAR is being used to build a national topography baseline and tree-height products for operational 3D remote sensing.

# /03 TianYi

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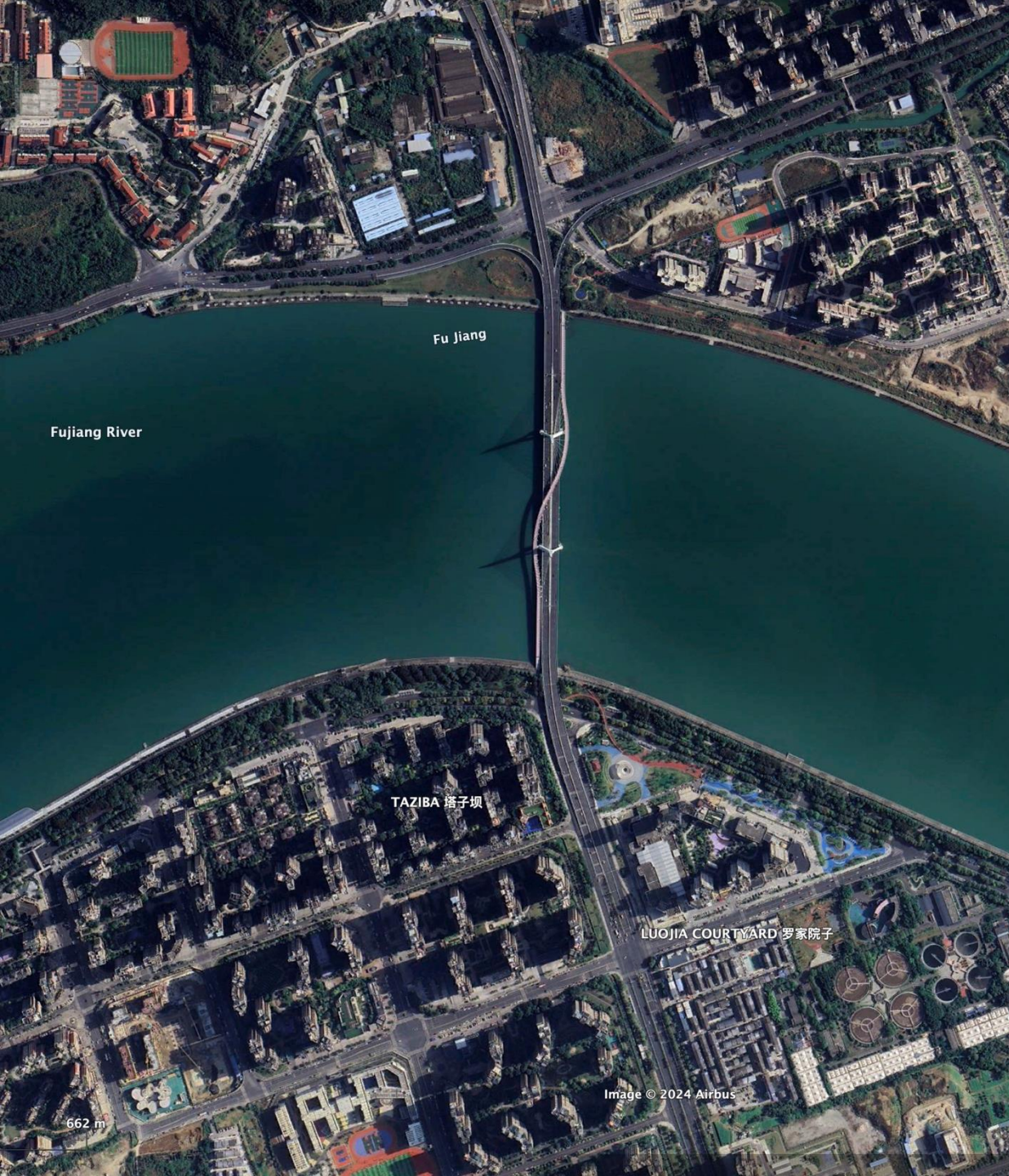


# Evolution of TY Commercial SAR and Future Mission Roadmap



Roadmap logic: from first commercial small SAR demonstration to operational repeat-pass InSAR, then toward higher revisit and industry-specific mission services.







## Fucheng-1 image-quality assessment

| Parameter                            | Verified value                                                          |
|--------------------------------------|-------------------------------------------------------------------------|
| Resolution                           | Slant range: 0.78 m<br>Azimuth: 2.26 m                                  |
| Side-lobe ratio (PSLR)               | Range PSLR: -22.07 dB<br>Azimuth PSLR: -23.65 dB                        |
| System sensitivity (NESZ)            | Spotlight: better than -20 dB<br>Stripmap / ScanSAR: better than -22 dB |
| Precise orbit determination accuracy | Position accuracy: better than 10 cm                                    |
| Doppler centroid frequency           | Better than 200 Hz                                                      |

### Key interpretation

- Same order of range/azimuth resolution as TerraSAR-X
- PSLR / ISLR support point-target stability for time-series analysis
- Baseline control is the dominant system-side indicator for InSAR suitability

107.1 m

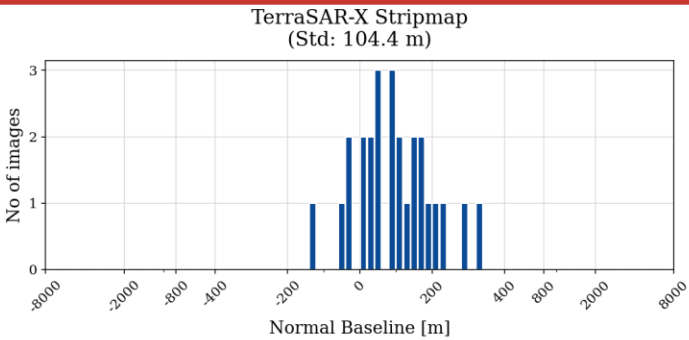
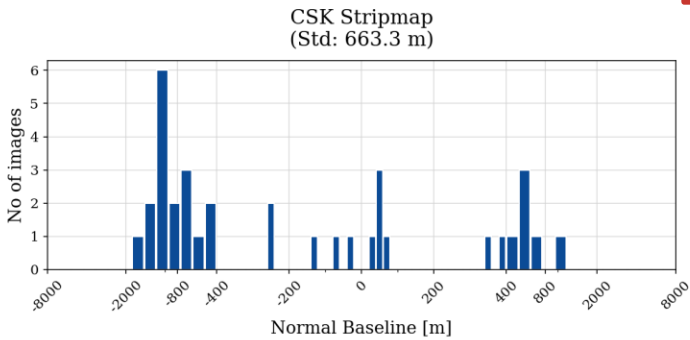
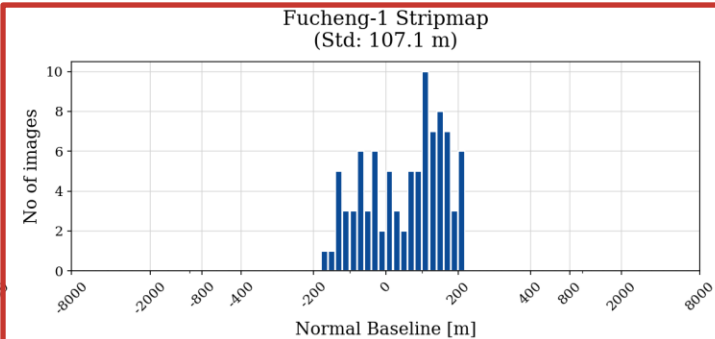
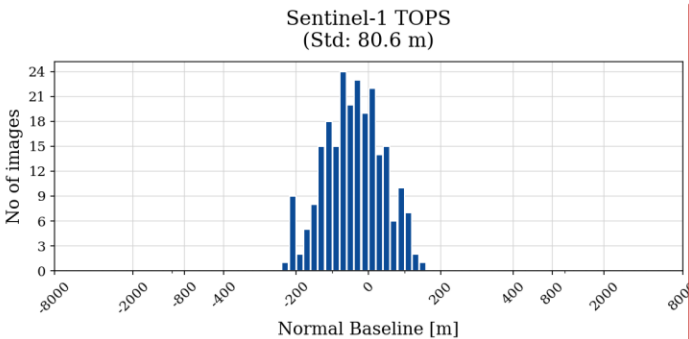
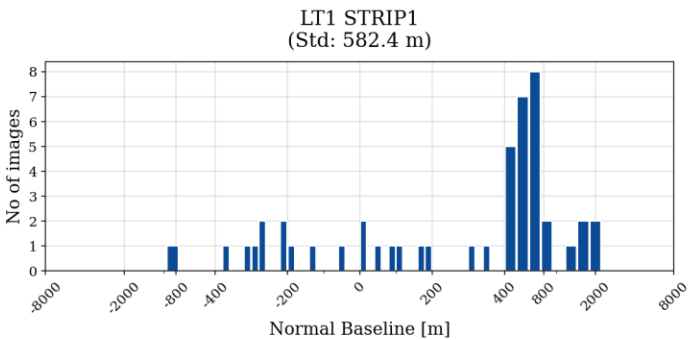
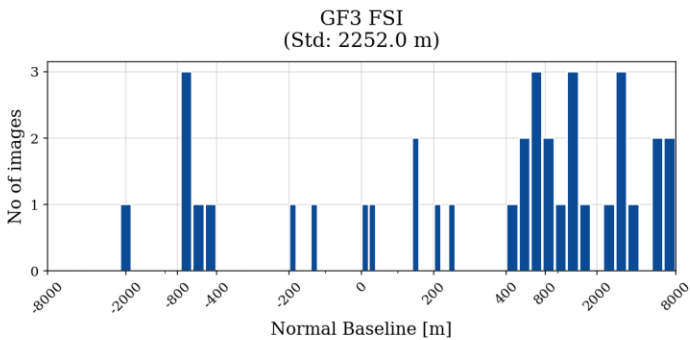
Fucheng-1 normal-baseline std.

104.4 m

TerraSAR-X reference level

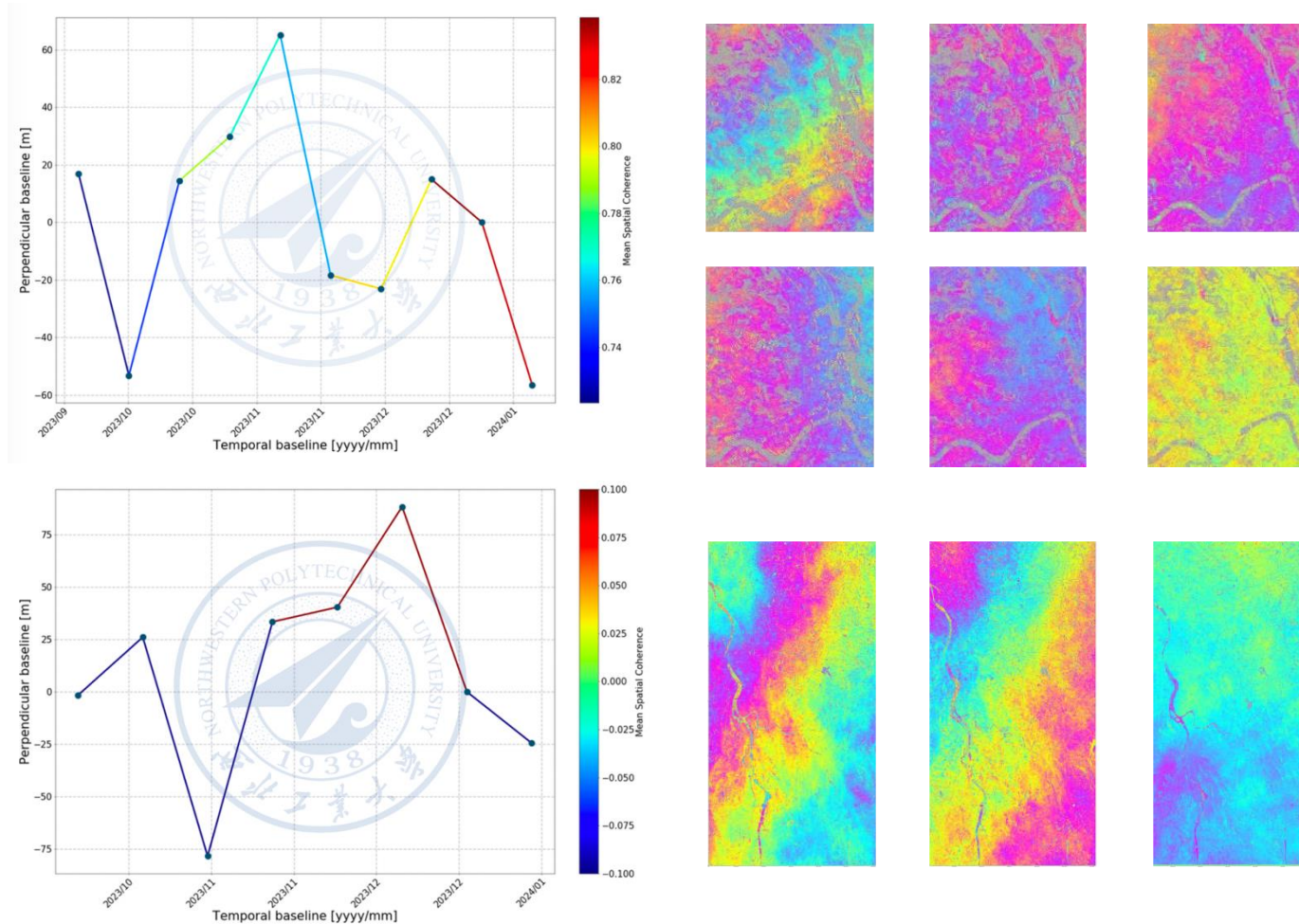
80.6 m

Sentinel-1 TOPS reference

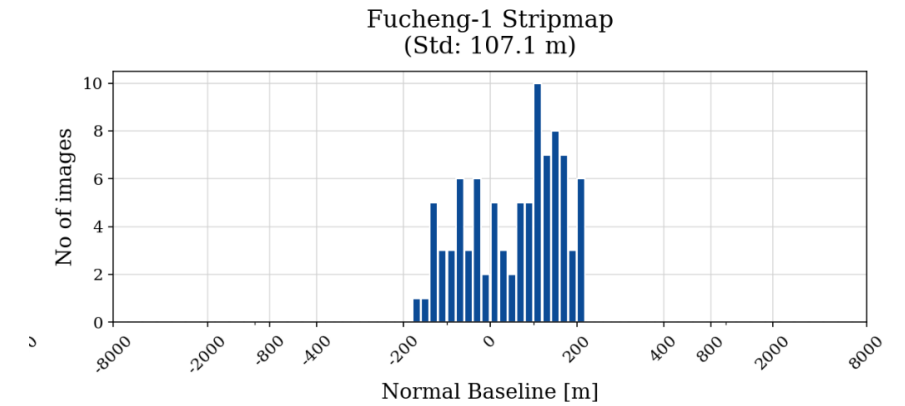


Fucheng-1: controlled baseline distribution

# TY InSAR Capability: from controlled baselines to interferograms



Representative repeat-pass interferograms



## Normal-baseline stability

- Short, repeatable baselines enable coherent interferograms.
- Multiple pairs are suitable for SBAS / PSInSAR network construction.
- Controlled geometry reduces sensitivity to DEM residuals and unwrapping failures.

## Operational implication

TY data can deliver interferograms for daily production workflows, not only experimental demonstrations.



# PSInSAR comparison: Fucheng-1 with respect to TerraSAR-X



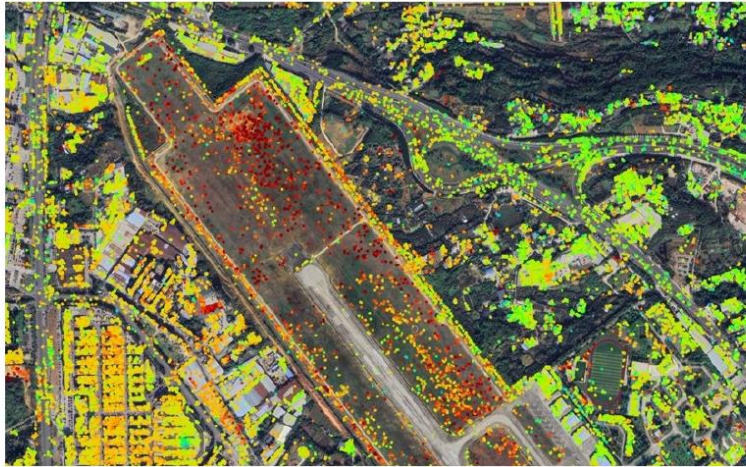
**Sentinel-1 Time Series**

**Fucheng-1 Time Series**





# PSInSAR comparison: Fucheng-1 with respect to TerraSAR-X



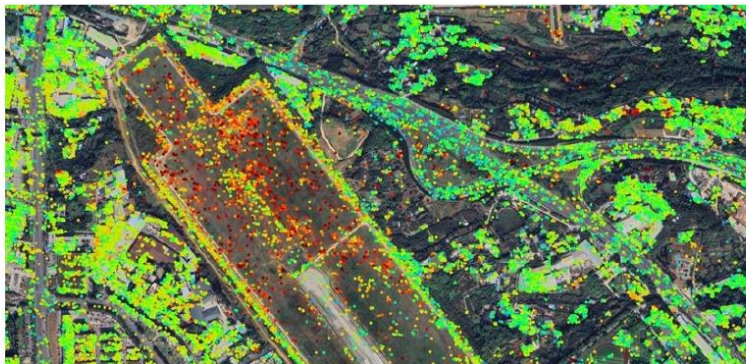
(a1) TerraSAR-X



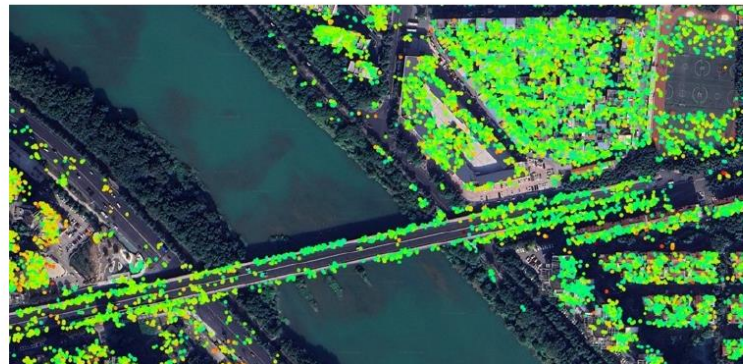
(b1) TerraSAR-X



(c1) TerraSAR-X



TerraSAR-X



Fucheng-1

Qualitative result: Fucheng-1 PSInSAR retrieves building-scale deformation patterns that are spatially consistent with TerraSAR-X over the same test sites.

Calibration and longer time series remain the next step for quantitative accuracy assessment.

# /04 LuTan-4



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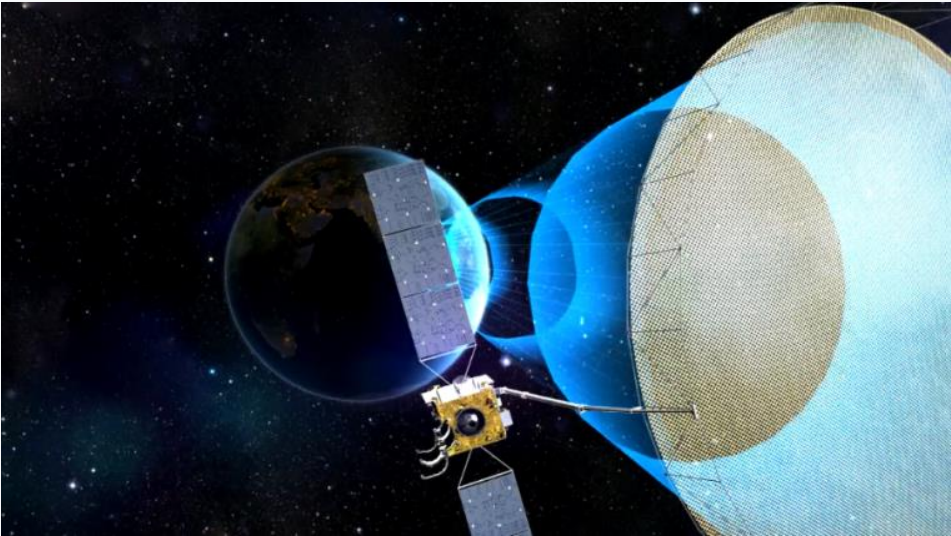


World’s first geosynchronous-orbit SAR satellite

Mission position

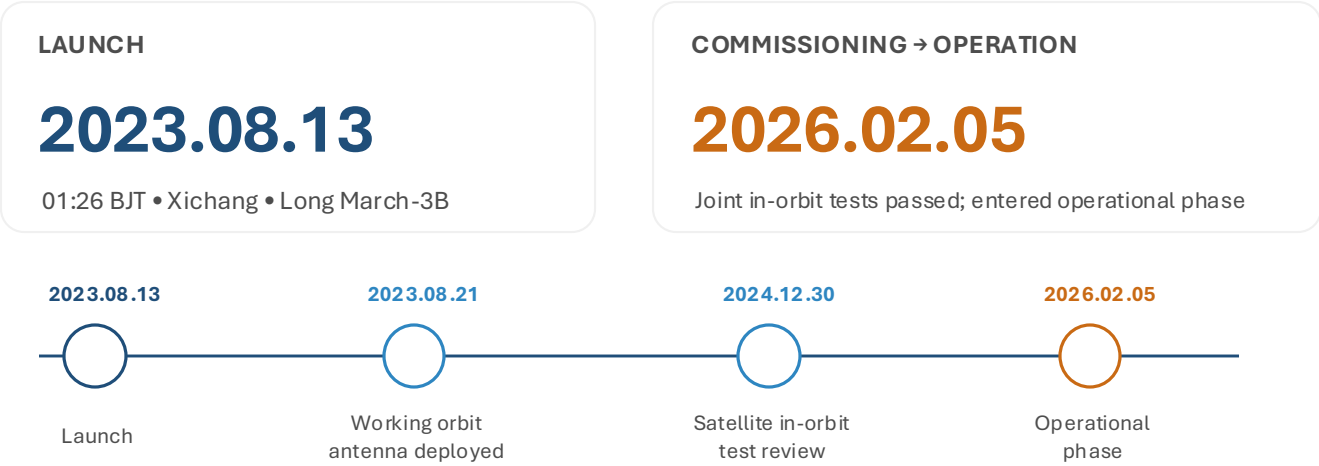
A high-orbit L-band SAR platform designed for rapid, large-scale microwave observation of China and surrounding regions.

It complements low-orbit SAR missions by providing frequent regional access for disaster monitoring, land resources, ocean, water, meteorology, agriculture, environment, and forestry applications.



GEO SAR: long dwell time, wide-area coverage, hourly revisit

L-band SAR • inclined geosynchronous orbit • all-weather / all-time observation



Launch confirmed at Xichang, Aug 13, 2023

Status update from CAST: engineering in-orbit test review completed on 2024.12.30; joint in-orbit tests passed and operational phase began in 2026.

# GEO SAR Baseline Evaluation from TLE Data

TLE → phase alignment → baseline series

Reference points on inclined GEO ground track



High-/low-latitude points capture spatially varying orbit-repeatability.

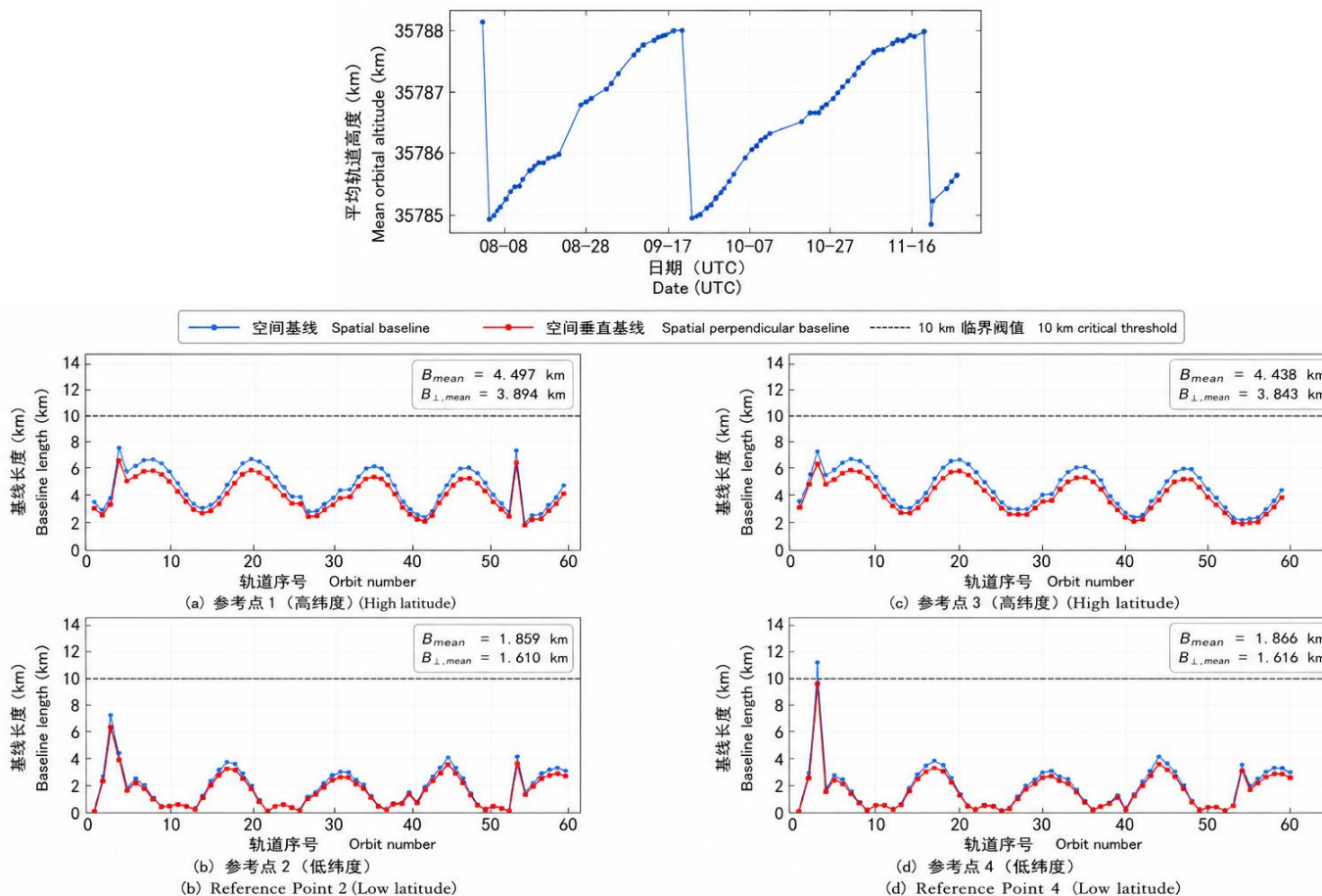
**0–8 km**

adjacent-cycle spatial baseline

**4.17 km**

mean spatial baseline

- Orbit-control events introduce short baseline pulses, but repeat-pass geometry remains bounded.
- Low-latitude observation points are more stable than high-latitude points in the 60-day test.



**3.6 km**

mean effective  $B_{\perp}$

**< 10 km**

engineering coherence threshold

**120 d**

continuous TLE analysis span

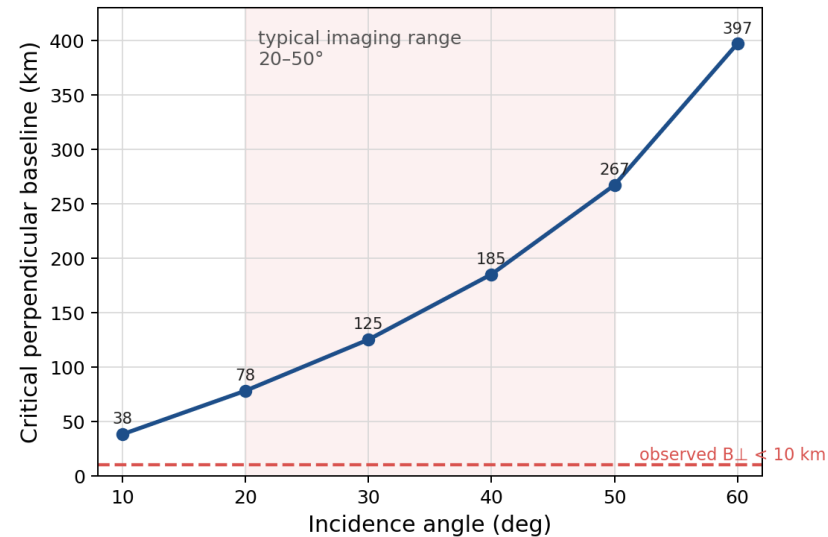
**2–7 km**

high-latitude 60-d range

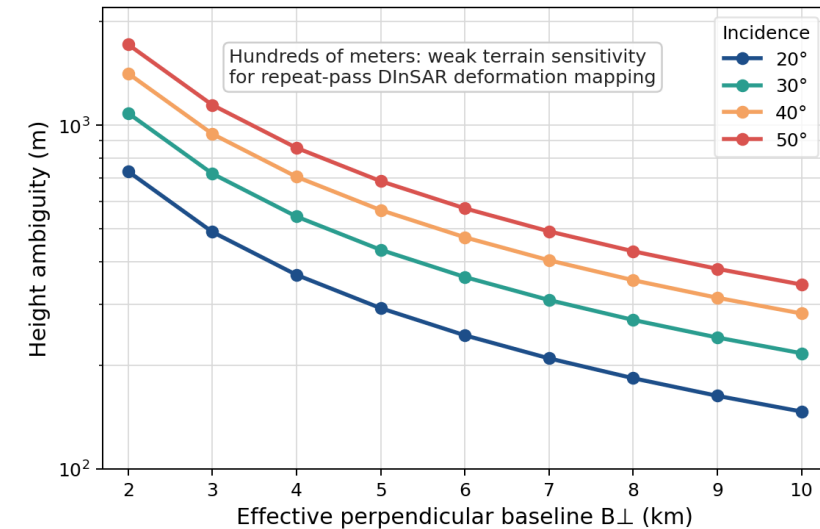


# GEO SAR InSAR Capability Assessment

## Critical perpendicular baseline is very large in GEO geometry



## Height ambiguity remains in the hundreds of meters



### Assessment conclusion

- **Effective  $B_{\perp}$  is controlled within ~10 km, below the 10% critical-baseline criterion.**
- High spatial coherence is expected for short repeat-pass DInSAR pairs.

- Large height ambiguity suppresses DEM-error sensitivity; it is advantageous for deformation retrieval.
- The same property makes high-precision DEM generation less favorable under short-baseline repeat passes.

**Recommended: short-term wide-area deformation monitoring & disaster response.**

/05 and ...



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# Low cost Huawei MIMO radar for ground monitoring

- Low cost domestic MIMO radar (3,000 euro)
- 50% capacity for car speed; 50% capacity for slope monitoring
- Remarkable performance: 500 meters in range, mm level accuracy in displacement

## HuaWei MIMO Millimeter-Wave Radar

### 华为发布新一代超远距高精度毫米波交通雷达

2022-08-01 17:22 发布于：北京市

[中国，长沙，2022年7月27日] 在第二十四届中国高速公路信息化大会举办的智慧高速技术发展论坛上，华为正式发布新一代超远距高精度毫米波交通雷达ASN850和融合感知引擎SNE800产品，将智慧高速侧感知杆距部署能力提升到1000米，感知精度提升到95%，并分享了华为业界首个超远杆距和多种复杂场景部署的成功实践。



Indoor



Outdoor



Road

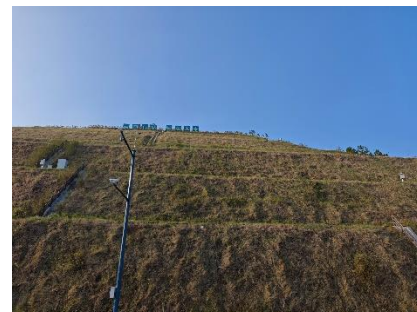


Pit

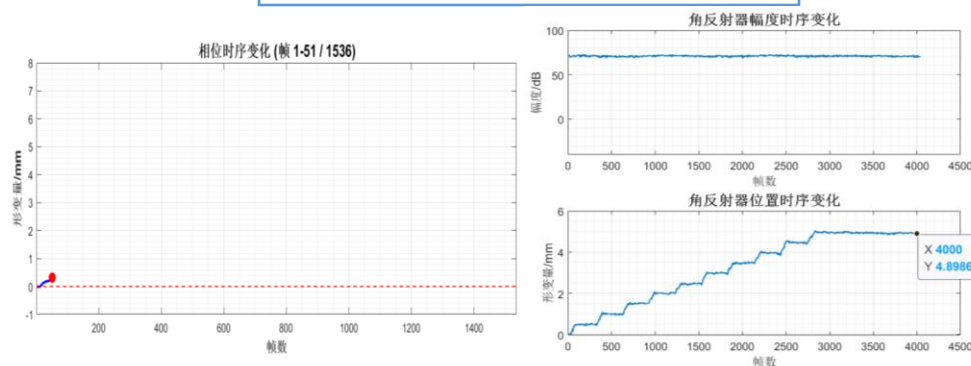


Slope

## Deformation Verification



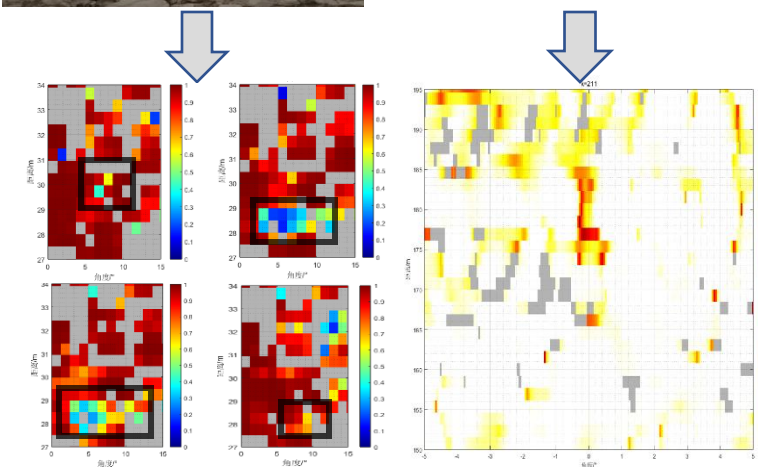
Slope accuracy test with precision stage



Corner-reflector phase & amplitude

Sub-mm accuracy validates high-precision monitoring capability

## Slope Monitoring w/ Coherence Change



Coherence Monitoring

Differential Monitoring

# Other Emerging Chinese SAR Missions...

Formation, VLEO and dual-antenna architectures are expanding the InSAR design space

## 01 Hongtu-1 / PIESAT-1

### Cartwheel multi-static X-band InSAR

#### 4-sat hub-spoke formation

- One active SAR satellite plus three passive receivers in a cartwheel formation.
- Simultaneous acquisition provides six single-pass interferometric pairs.
- Strong for DSM / height-change updating; multi-static coherence is promising for forest and land-cover information.



## 02 Haishao-1 / HS-1

### Low-inclination VLEO SAR

#### 350 km VLEO · 43° inclination

- Launched on 2024-12-04 to target tropical and equatorial observation gaps.
- Public reports indicate up to 5.7 daily observations over the South China Sea.
- Public specifications list X-band SAR with 1 m stripmap imaging and an integrated night-light sensor.

## 03 Dual Antenna

### Dual-antenna X-band InSAR concept

#### single-pass / dual-antenna potential

- Planned / emerging mission direction; detailed public specifications remain limited.
- A single-platform interferometric baseline could reduce temporal decorrelation.
- Interesting bridge from LT-1 / TanDEM-X-style topography toward city-scale X-band 3D and change products.

### Design message for InSAR

- China is moving beyond repeat-pass SAR toward single-pass, multi-static and formation-flying systems.
- The application envelope expands from deformation mapping to 3D topography, height change, forest structure, low-latitude ocean monitoring and rapid disaster response.
- Other missions to watch: Hongtu expansion / PIESAT-2, Haishao HS-2/3/4, and future P-/L-/X-band specialization.

/06 teresa



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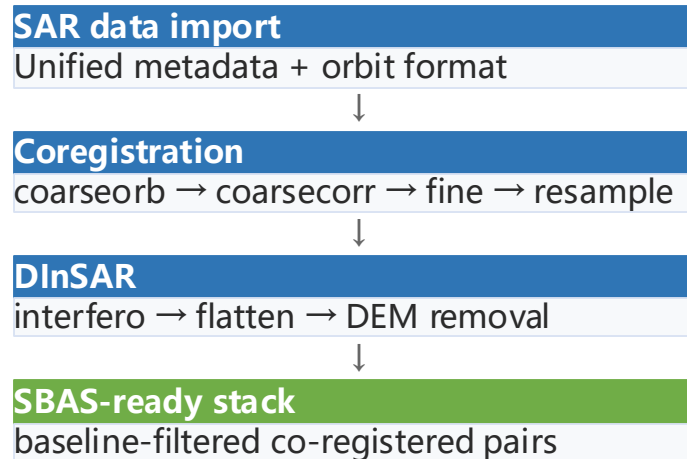
# teresa: an Open-source Tool for Chinese SAR

Terrain Registration and Sampling Software · open-source pre-processing from coregistration to DInSAR

## Why TERESA?

- **Chinese SAR-optimized:** GaoFen-3, LuTan-1, Spacety/TY and more
- **Free and open-source:** fills a key gap in domestic InSAR preprocessing
- **One-click batch processing:** multi-temporal SLC stacks
- **Operational-ready:** cross-platform; already used by research institutes
- **Currently a DORIS wrapper**

## Batch InSAR pre-processing pipeline



## Operational use case



TERESA coregistration outputs used in a Tianjin Jinnan InSAR monitoring project.

## Supported domestic sensors

Current: GaoFen-3 · LuTan-1A/B · FuCheng-1 / Shenqi-1/2  
Coming: Gamma SLC · Hongtu · additional sensors via shared data samples

## Run and contribute

GitHub:  
[github.com/aprilab-dev/teresa.git](https://github.com/aprilab-dev/teresa.git)

## Roadmap

- SNAP backend support
- Advanced parallel computing
- Fully independent co-registration

## Key message

TERESA provides the missing open processing bridge between rapidly growing Chinese SAR missions and operational InSAR applications.

# Where to Get the Data?

Data access channels and coordination routes for research and applications



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## CRESDA Data Portal

[data.cresda.cn](http://data.cresda.cn)

### National civil SAR / EO data

GaoFen-series and related national Earth-observation products through the official data service portal.

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## Spacety / TY Portal

[data.spacety.cn](http://data.spacety.cn)

### Commercial small-SAR data

Archive search, tasking and application-oriented data services for TY / Spacety SAR missions.

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## Research Coordination

Talk to me at  
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### For test data and applications

Use cases, validation sites, collaboration needs and data access constraints can be matched through discussion.

WORK IN PROGRESS

**We are working on promoting data access, processing tools, and application demonstrations.**

Goal: bridge satellite data with research needs and operational applications — and make Chinese SAR missions easier to use.



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## Next Steps

- Promising results are shown for a variety of Chinese domestic SAR satellites for InSAR purpose;
- We need to...
  - Promote our data as well as our processing tools;
  - Bridge the satellite data with the application needs;
- **And, looking forward to more and more domestic SAR missions in the next five years!**

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# Stay Tuned!



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