# การประยุกต์ใช้เทคโนโลยีอนุกรมเวลาอินซาร์เพื่อติดตามการเคลื่อนตัวของเขื่อนศรีนครินทร์

# Application of Time-series InSAR Technology for Displacement Monitoring of the Srinakarin Dam

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## บทคัดย่อ

SAR)

Time – series InSAR)

Sentinel-

Time-series InSAR

Cesium The Platform for D Geospatial

Monitoring the dam's displacement is modern and accurate, but several factors can cause the dam's movement. Therefore, it should be inspected in a wide area and can be inspected at any time without restrictions on human resources in the field. This research applies time-series InSAR technology to monitor the displacement of dam structures and to study a 3D rendering model suitable for engineering structural analysis through the Cesium The Platform for 3D Geospatial. We process the time-series InSAR using 24 Sentinel-1 images from October 18, 2017, to August 22, 2021. The study area is the Srinakarin Dam, located in the Ban Chao Noen area, Tha Kradan Subdistrict, Si Sawat District, Kanchanaburi. Thailand's largest earth core dam is 140 meters high, 610 meters long, and 15 meters wide. Usually, it can store 17,745 million cubic meters of water. From research, the results were aligned with the satellite line of sight (LOS) with a displacement of approximately -05.22 mm/yr. to +07.04 mm/yr. The application of the InSAR time series to detect dam motion is to identify the area where the displacement occurred. It is just a safety warning showing which areas need more accurate inspections and on-site inspections to check dam safety. This research demonstrates the ability to apply Time-series InSAR technology. It presents the results obtained by tracking the dam's movement in three dimensions via the Cesium The Platform for 3D Geospatial.

Keywords: InSAR, Time-series InSAR, Srinakarin Dam, Displacement monitoring

## 1. บทนำ

[1]

-

[2]

## Abstract

Satellite data from Synthetic Aperture Radar (SAR) has successfully been applied to monitor dam displacement.

[11]

[3]

[4]

[5]

*1.1 ขอบเขตการวิจัย*

*1.1.1 พื้นที่ศึกษา*

Visual Inspection)

Dam Instrumentation) [6]

GPP)

2545 2552 2552

GPP 72,954 92,923

12]

[7]

(InSAR)

(Phase Differential)

[8]

,

2516 2520

[7] 5

0.70 (

Plover Cove 1.50 [13]

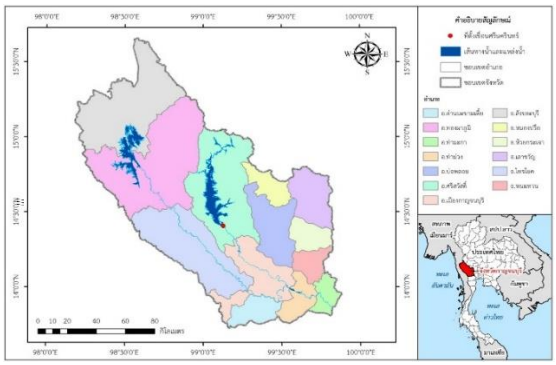
[9] Three Gorges

[7]

[10]

Sentinel-1

*Cesium The Platform for 3D Geospatial*



**รูปที่ 1**

*1.1.2 เขื่อนหินถม (Rock-Fill Dams)*

[6] Rock-Fill Dams)

International

Commission on Large Dams (ICOLD)

[14]

2

Rock-Fill with Clay Core)

Concrete Faced Rock-Fill)

*1.1.3 ระยะเวลาดำเนินการ*

Sentinel-

Synthetic Aperture Radar, SAR)

Sentinel-1

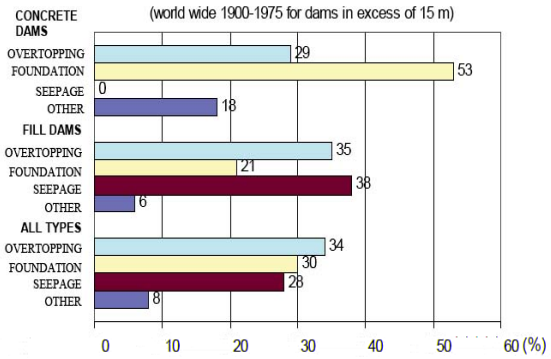
SAR

[7]

## 2. หลักการและทฤษฎี

*2.1 การพิบัติของเขื่อน*

USCOLD) 6




**รูปที่ 2** [34]

*2.1.1 การพิบัติของเขื่อนจากการน้ำล้นสันเขื่อน*

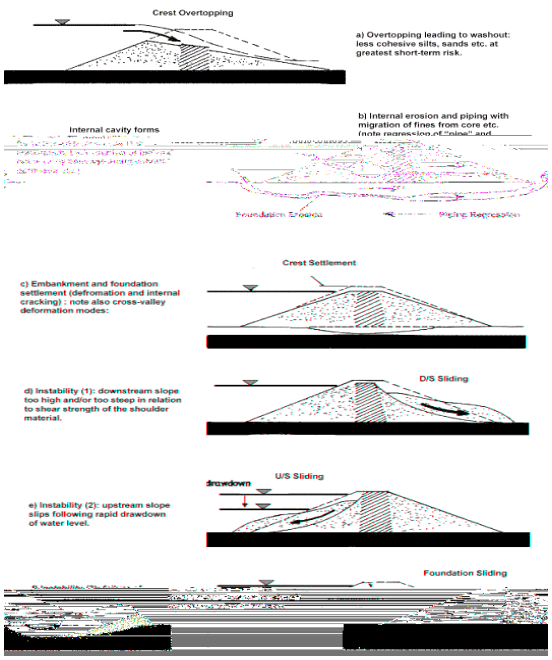
[33]

*2.1.2 การรั่วซึมของฐานรากและตัวเขื่อน*

[33]

2.1.3

[14]




**รูปที่ 3** 6 USCOLD [33]

*2.2 ดาวเทียม Sentinel-1*

Sentinel-1

**รูปที่ 4**

21]

[15]

[17,18,19]

Sentinel-

Sentinel- A

Sentinel- B

Sentinel-1

[32]

**ตารางที่ 1** Sentinel- A Sentinel- B [32]

| Altitude | Inclination | Cycle | Local Time at Ascending Node |
|---|---|---|---|
| 693 kilometers | 98.18° | 12 days | 18:00 hours |

*2.3 Interferometric Synthetic Aperture Radar (InSAR)*

SAR SAR)

(SAR)

[21]

[19]

(SAR)

[8]

Deformation Pattern [22]

[20]

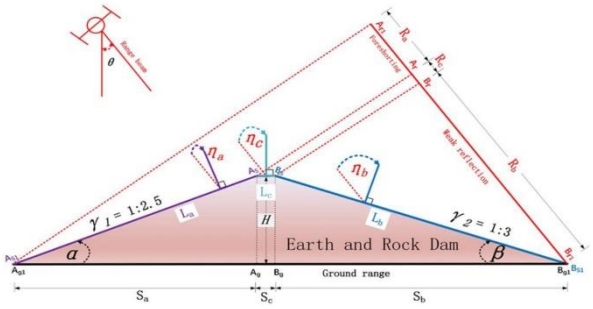
*2.5 การบิดเบือนทางเรขาคณิตแบบความชัน*

α

β θ H $\gamma_1$

$\eta_a$, $\eta_b$ $\eta_c$ $L_a$, $L_b$

$L_c$ SAR $\eta_c$




**รูปที่ 5**

[31]

$L_a$

$\gamma_1$ [31]

$$\gamma_1 = \tan(\alpha) = \frac{1}{2.5} = \frac{H}{S_a}$$

H α $S_a$

Ag1 Ag $\eta_a$

$\eta_b$ [31]

$$\eta_a = \eta_c - \alpha$$
$$\eta_b = \eta_c - \beta$$

$\eta_c$

θ

$L_a$, $L_b$ $L_c$

[31]

$$R_a = L_a \times \sin(\eta_a)$$
$$R_b = L_b \times \sin(\eta_b) \quad (3)$$
$$R_c = L_c \times \sin(\eta_c)$$

$R_a$ $R_b$ $R_c$ $R_a$

$L_a$ $R_b$

$L_b$ $R_c$

[31]

ϕ

α β ω

ψ

[31]

$$\omega = \tan^{-1}\left(\frac{H}{S_{a1}}\right) = \tan^{-1}\left(\frac{H}{S_a} \times \cos\phi\right)$$
$$\psi = \tan^{-1}\left(\frac{H}{S_{b1}}\right) = \tan^{-1}\left(\frac{H}{S_b} \times \cos\phi\right) \quad (4)$$

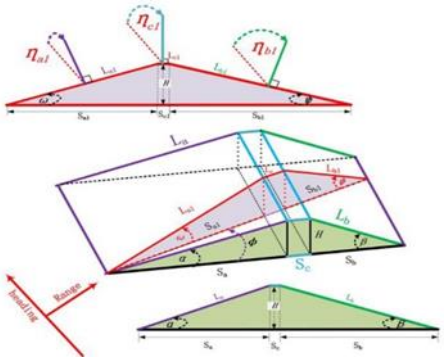
$S_{a1}$ $L_{a1}$

$S_{b1}$ $L_{b1}$

$L_a$, $L_b$ $L_c$

$L_{a1}$ $L_{b1}$ $L_{c1}$ [31]

$$L_{a1} = L_a / \cos\phi$$
$$L_{b1} = L_b / \cos\phi \quad (5)$$
$$L_{c1} = L_c / \cos\phi$$



6 32]

ϕ

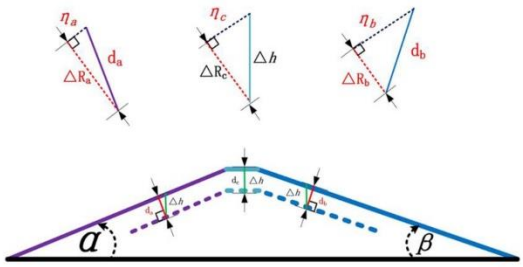
$\eta_{a1}$ $\eta_{b1}$

[31]

$$\eta_{a1} = \eta_{c1} - \omega$$
$$\eta_{b1} = \eta_{c1} + \psi$$

ϕ ω ψ

a1 = b1 = c1



**รูปที่ 7**

$\Delta h$ $\Delta R_a$, $\Delta R_b$ $\Delta R_c$

$$\Delta R_a = d_a \times \cos\eta_a = \Delta h \times \cos\alpha \times \cos\eta_a$$
$$\Delta R_b = d_b \times \cos\eta_b = \Delta h \times \cos\beta \times \cos\eta_b \quad (7)$$

$d_a$ $d_b$

*2.6 Cesium the Platform for 3D Geospatial*

Cesium The Platform for 3D Geospatial

[23] Cesium

open source

software) commercially available

software)

Cesium

[24]

Cesium

cesium platform [25] Cesium

## 3. วิธีการดำเนินการวิจัย

*3.1 การเตรียมการและอินเตอร์เฟอโรเมตรีแบบกระจายถาวร (PSI)*

PSI

Sentinel-1A

PSI

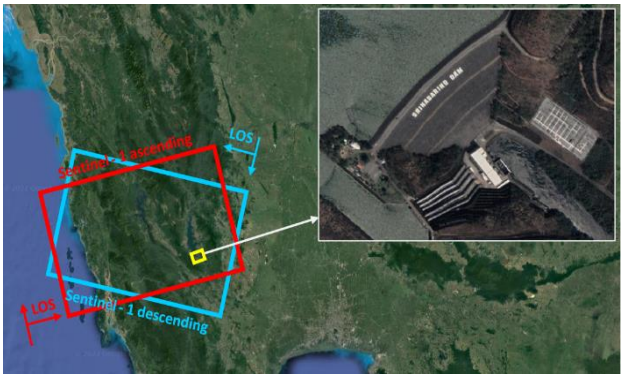
SAR

26] SAR

]

PSI

Sentinel-




**รูปที่ 8** Sentinel-1

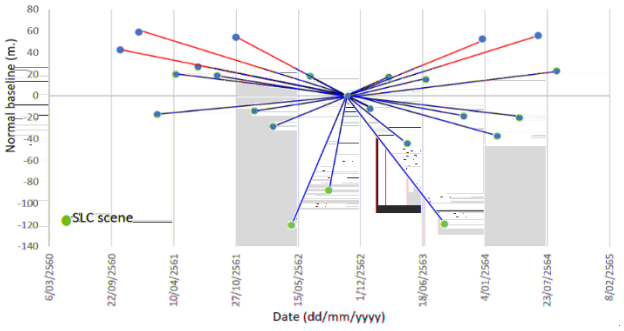
SLC VV

20 2562 Master)

SAR)

Sentinel-1A 24

PSI Master) slave)




**รูปที่ 9** PS Y Base line X

*3.2 การแสดงข้อมูลบนแผนที่และการจัดกลุ่ม*

QGIS

QGIS

QGIS layer

**ตารางที่ 2**

| longitude | latitude | Deformation (mm. y.) |
|---|---|---|
| 99.16238 | 14.45198 | -5.22082 |
| 99.08904 | 14.34657 | .04236 |




**รูปที่ 10** QGIS

*3.3 การแสดงผลลัพธ์แบบสามมิติ*

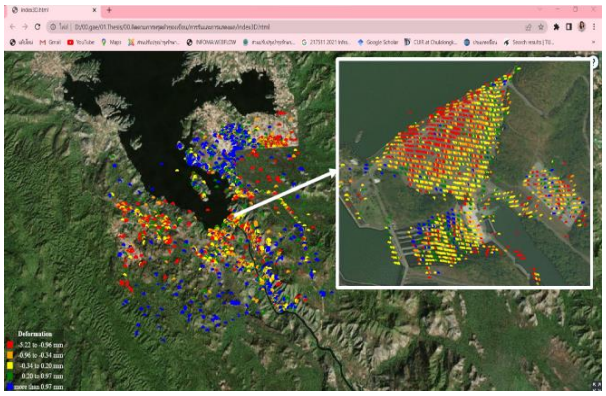
Cesium The Platform for D Geospatial

Cesium The Platform visual studio code

Cesium The Platform for D Geospatial

Cesium The Platform visual studio code

Cesium The Platform



**รูปที่ 11** Cesium The Platform for D Geospatial

## 4. ผลลัพธ์

*4.1 การกำหนดลักษณะ PSI*

Sentinel-

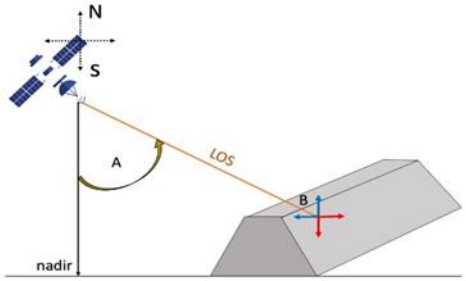
Sentinel-

AOI

,

SAR (

SAR (




**รูปที่ 12**

A B

A A

[36]

SAR (

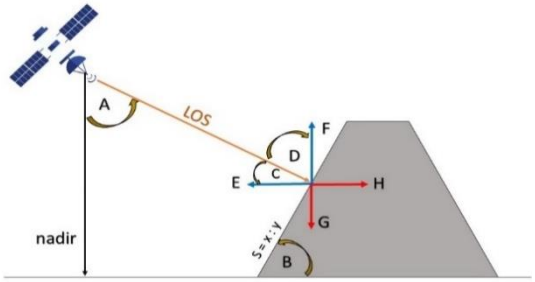
A nadir A

38° B D

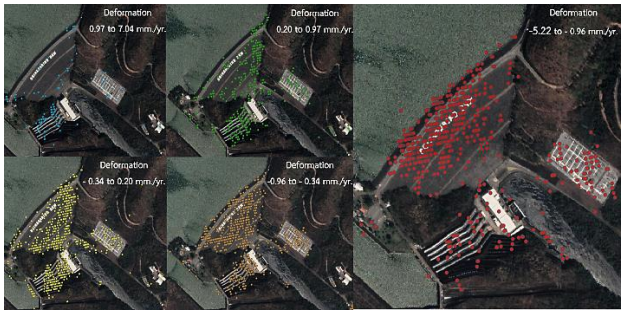
C

B

D A C .94




**รูปที่ 13**




**รูปที่ 14**

SAR

( [33]

SAR (

*4.2 การติดตามตรวจสอบการเคลื่อนตัว*

Plover Cove [9]

[35]

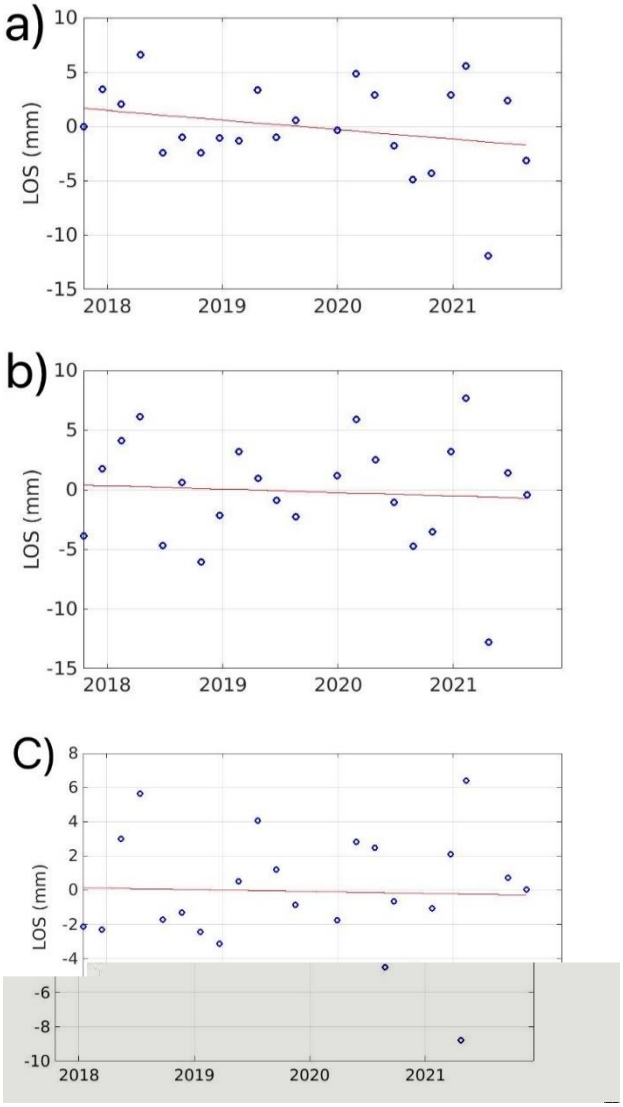
*4.3 การตรวจสอบอนุกรมเวลา PSI*

SAR , PSI

X

Y

PSI

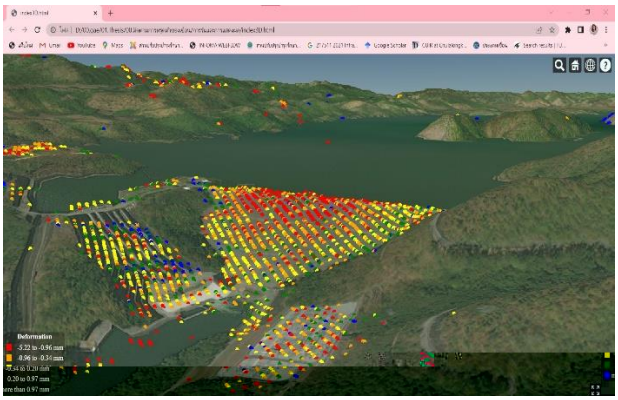



**รูปที่ 15**

50 a) 14.4
99.129 b)
c) 14.4048 99.1282

*4.4 ผลการแสดงผลลัพธ์แบบสามมิติ*

Cesium The Platform for D Geospatial



**รูปที่ 16** Cesium The Platform for D Geospatial

## 5. สรุปผลและข้อเสนอแนะ

Single Look Complex (SLC) Sentinel- A

SAR (
SAR
(

Cesium The Platform

open source

*5.1 ข้อจำกัดของงานวิจัย*

*5.2 ปัญหาและอุปสรรค*

## กิตติกรรมประกาศ

European Space Agency (ESA)
Copernicus Sentinel ASF DAAC

ESA
Cesium The Platform for D Geospatial

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20-21

2550

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