



# WORLDWIDE MULTITEMPORAL CHANGE DETECTION USING SENTINEL-1 IMAGES

Elise Colin Koeniguer

ONERA / DTIS

Fabrice Janez

ONERA / DTIS

Jean-Marie Nicolas

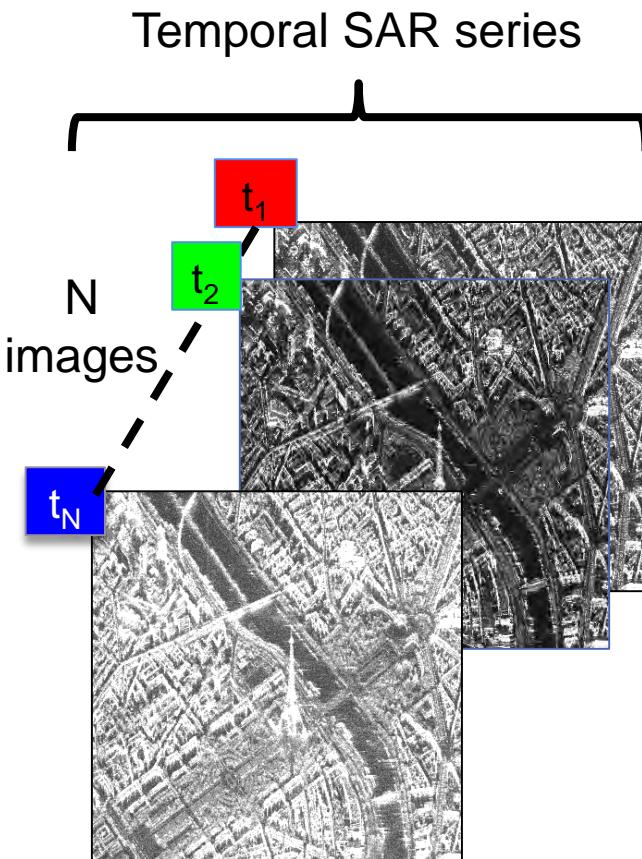
Telecom ParisTech



ONERA

THE FRENCH AEROSPACE LAB

# A new dimension: time

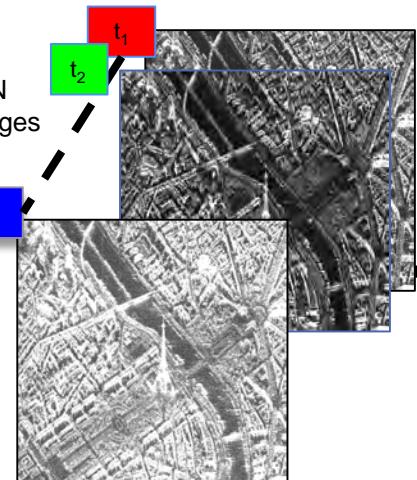


Change  
detection  
In  $N$  images  
 $N \gg 2$

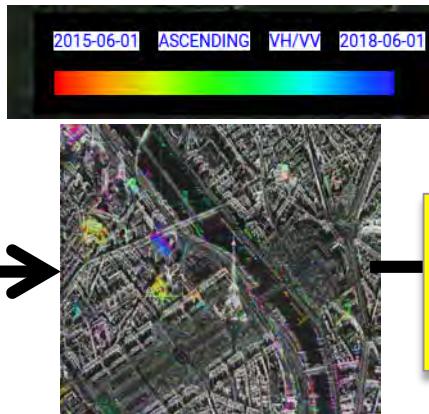
# Change detection: our framework

2 levels of product

Input: temporal SAR series



Product: visualization



Product: detection



Our change detection criterions

A « generic » criterion



$$CV = \frac{\sigma}{\mu}$$

High change detection performance  
for artificial or natural objects

$f_1(CV)$  Point-event detection



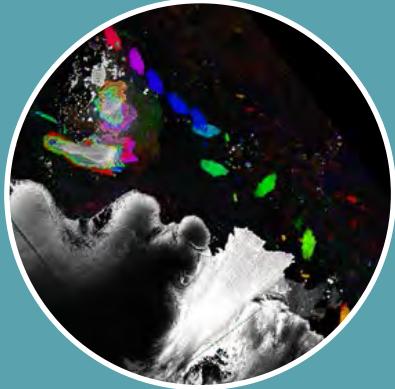
« Specific »  
criterions

$f_2(CV)$  Step signal transition



3

# Outline



Activity  
Visualization

Construction  
site  
detection

Point-event  
detection



# Visualization

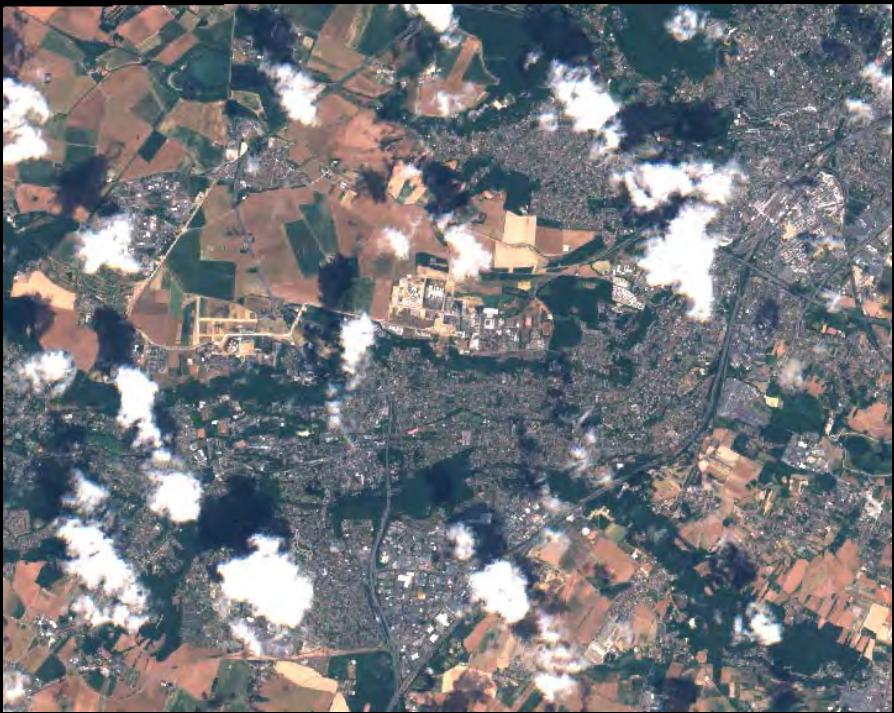
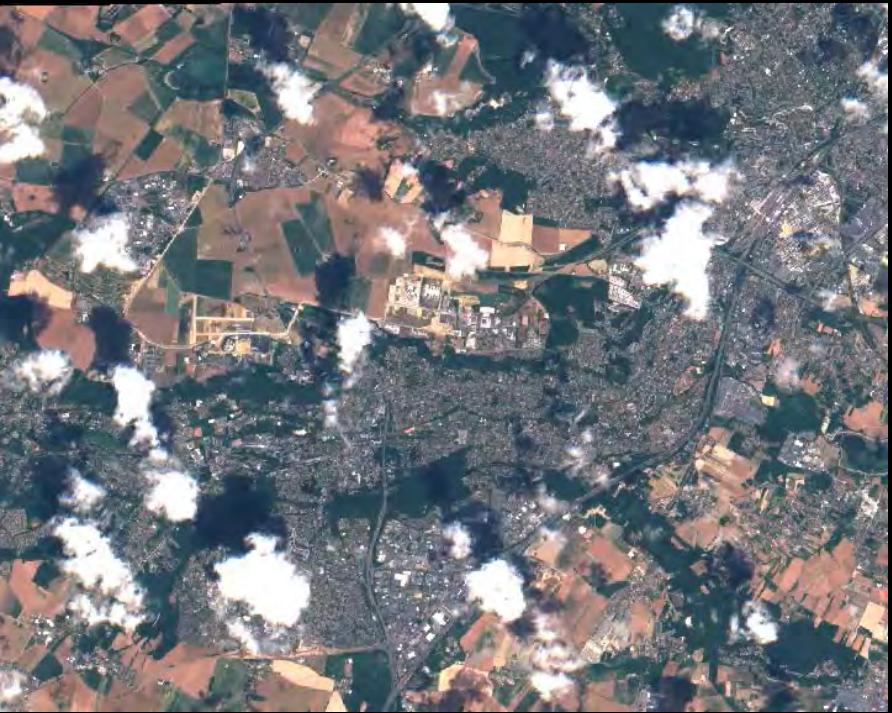


**Rapid and EAsy Change detection  
in radar TIme-series by Variation  
coefficient**

# Remote sensing becomes **temporal**

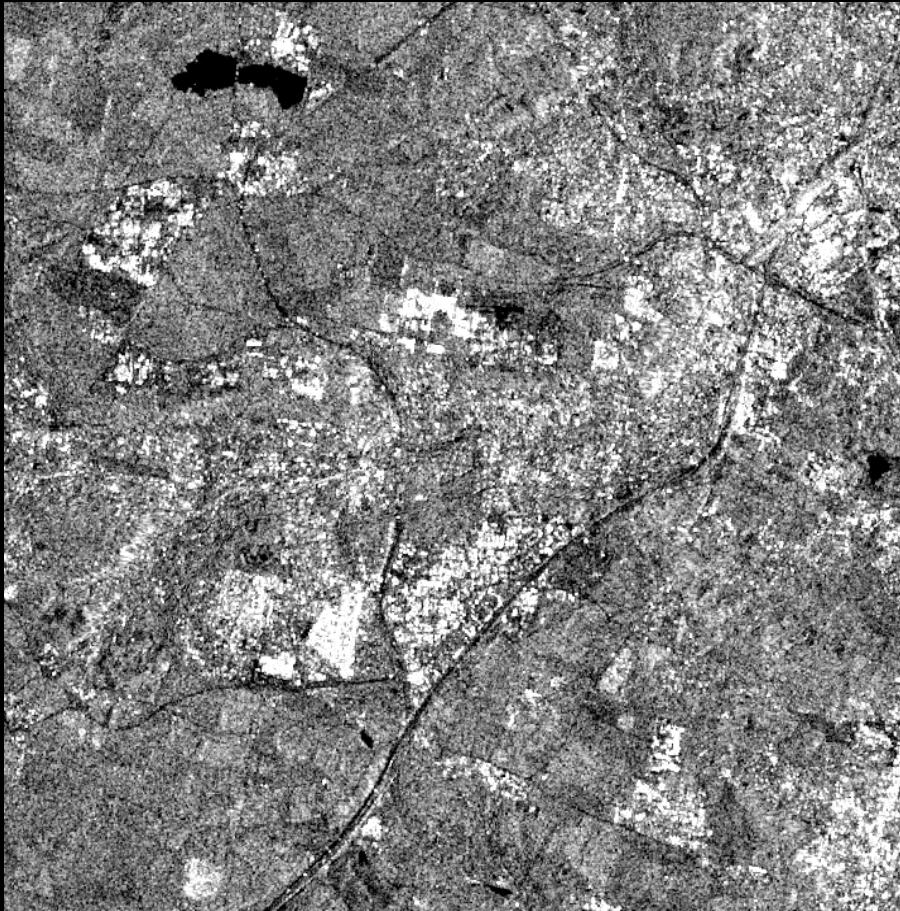


In Sentinel 2 time-series:

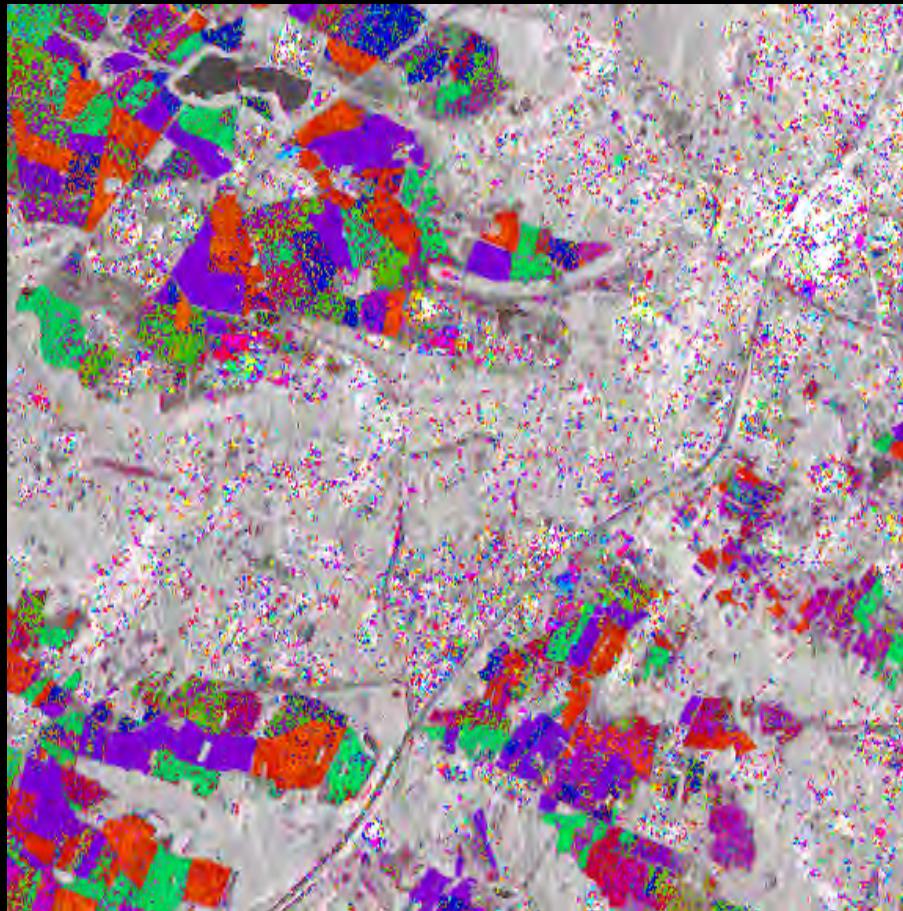


*Sentinel 2 images, Palaiseau (France), 2015 -2018*

# Sentinel 1 time-series, from 2015 to 2018



# Synthetic information

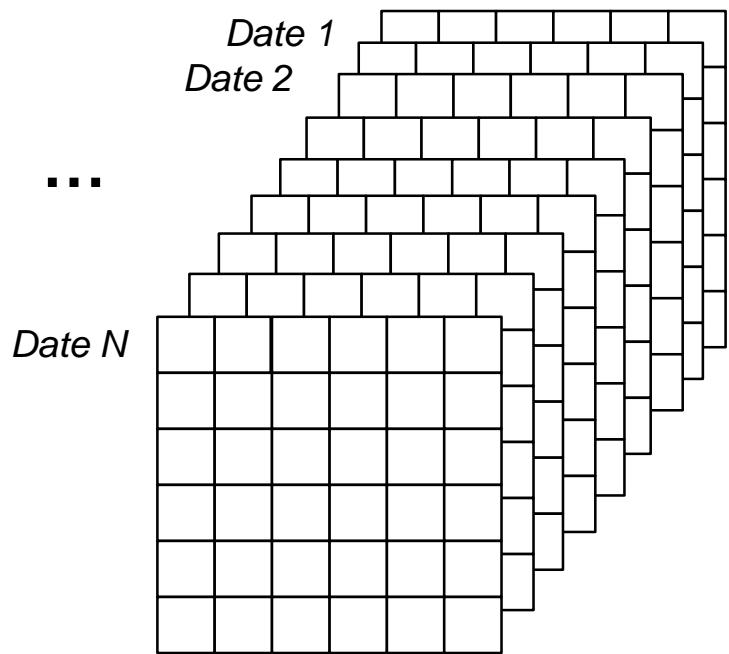


2015

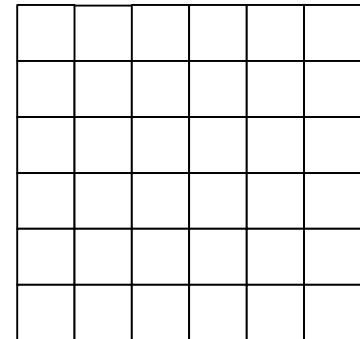


2018

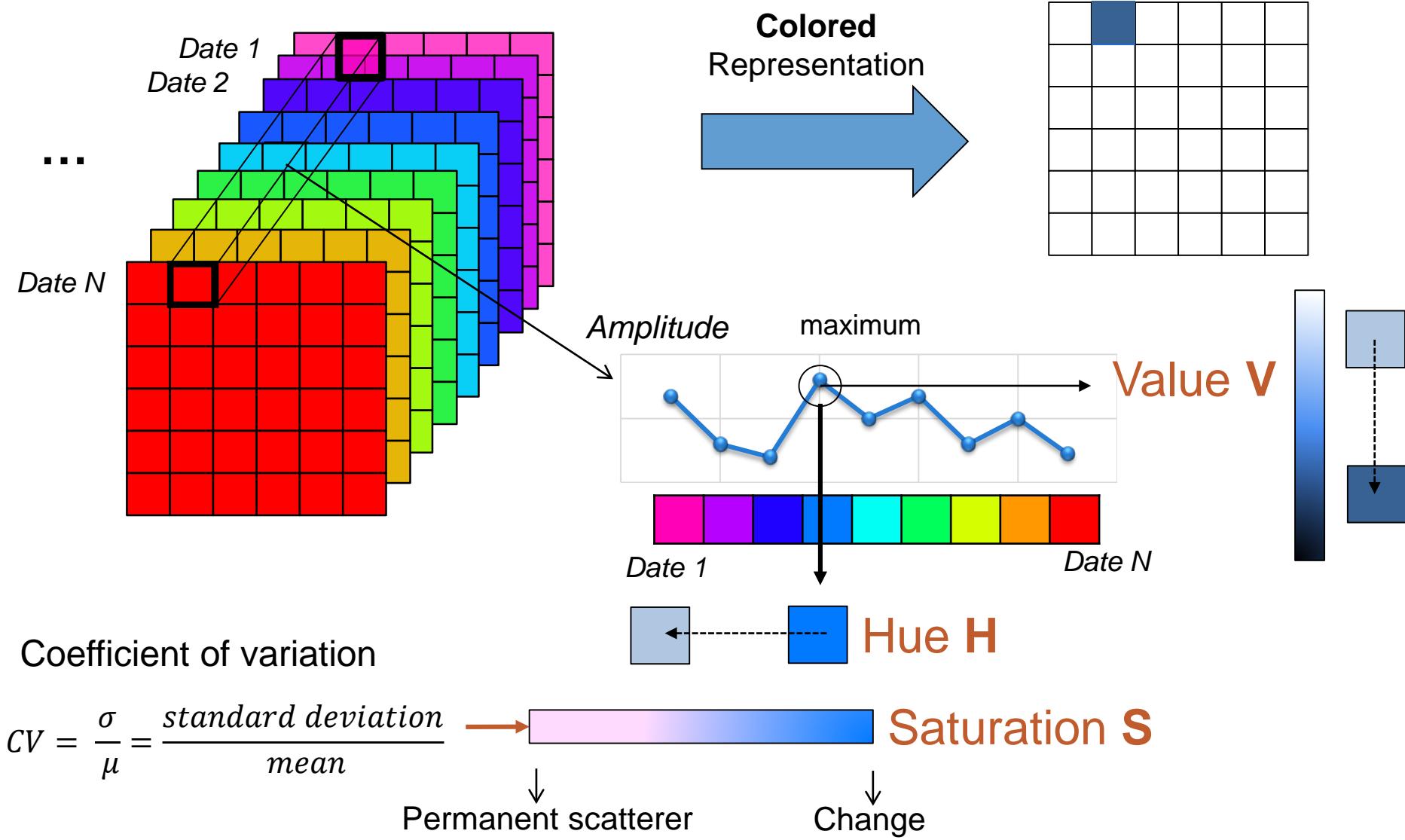
# Synoptic



**Colored**  
Representation



# Synoptic



# Use of the Google Earth Engine platform

The screenshot shows the Google Earth Engine interface. On the left, there's a sidebar with 'Scripts' (containing visuSentinelVH\_min, visuSentinelVH\_max, visuSentinelVH\_mean, main\_IW), 'Assets' (users/ekoenguer/reactiv/main\_IW), and sections for 'Writer' and 'Reader'. The main area has tabs for 'Get Link', 'Save', 'Run', 'Reset', and a gear icon. The 'Console' tab is active, with a message: 'Use print(...) to write to this console.' Below the tabs is a code editor with the following snippet:

```
41 var linear = function(image) {
42   var imlin = image.expression(
43     '10*(amplitude/20)', {
44       'amplitude': image.select(polar)
45     });
46   return imlin; // conversion in linear, then compute
47 };
48
49 var stdLinear = sentinel1.select(polar).map(linear);
50 var meanLinear = sentinel1.select(polar).map(linear);
51 var magic=stdLinear.divide(meanLinear);
```

Below the code editor is a map viewer showing a polarimetric image with a color bar at the top labeled '2015-05-10 ASCENDING VH 2018-05-10'. The map includes a legend, zoom controls, and a scale bar.

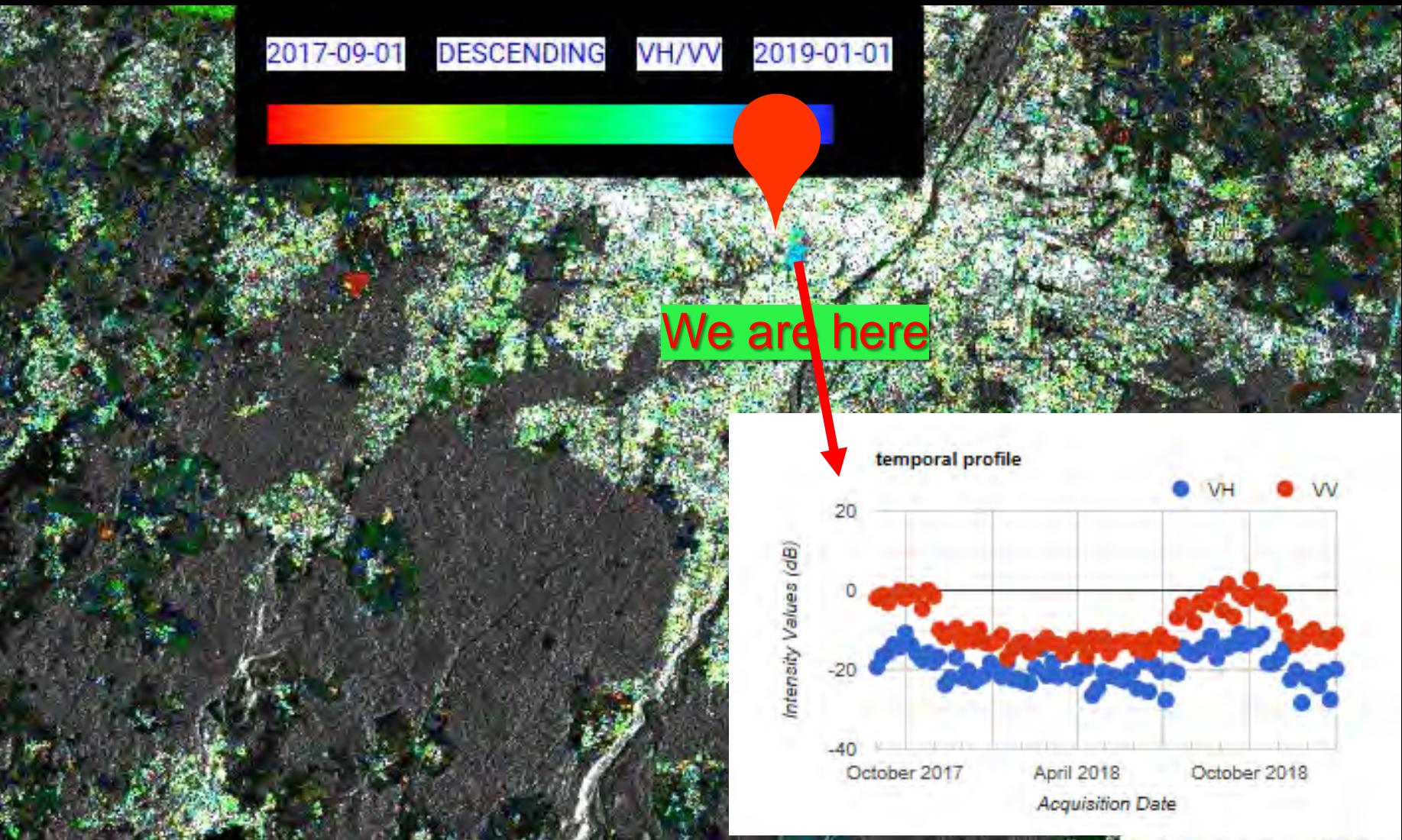
Why ?

- Enables worldwide demonstration!



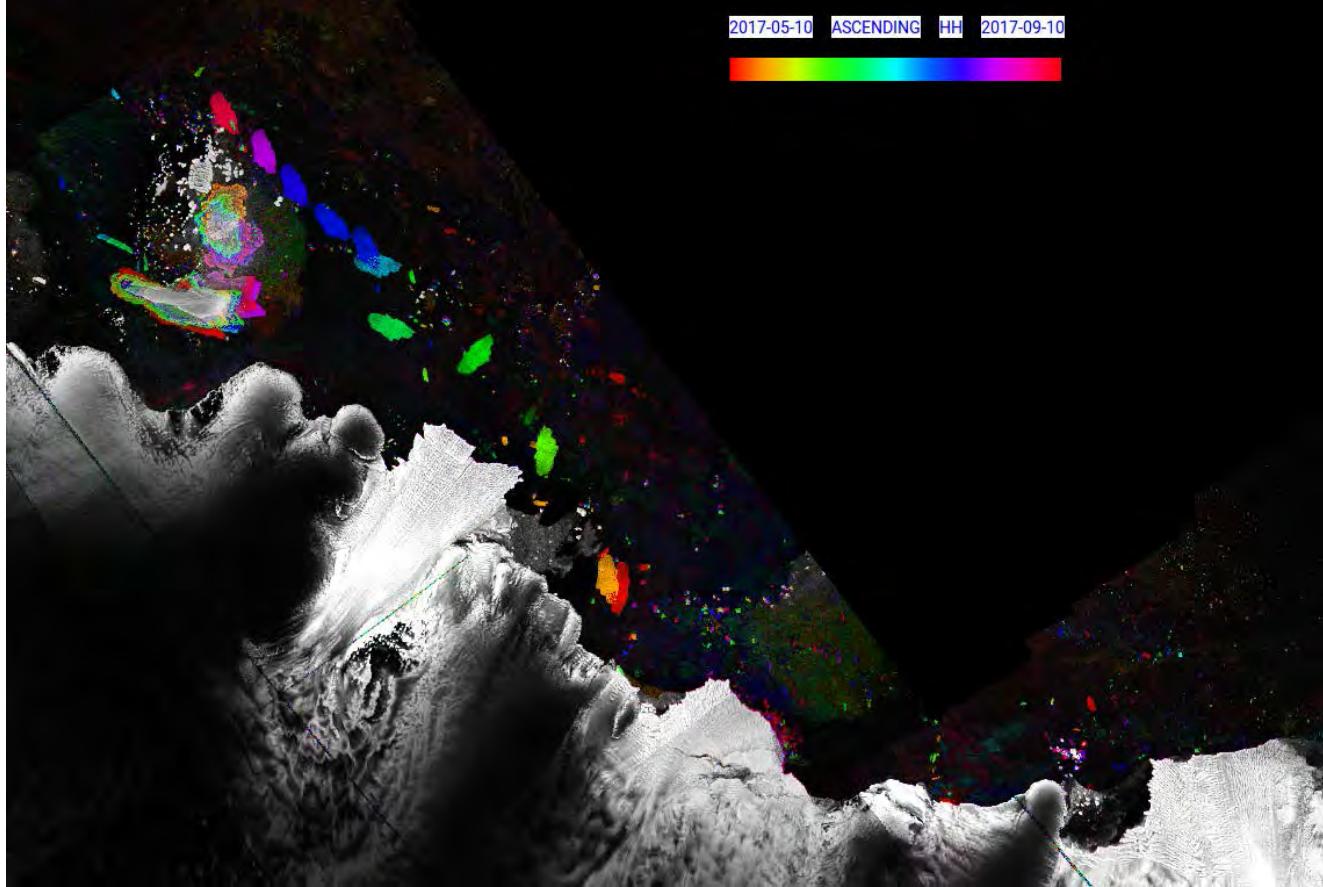
Regrettable choice

- dynamics, coregistration
- no SLC : polarimetric/coherent information is lost



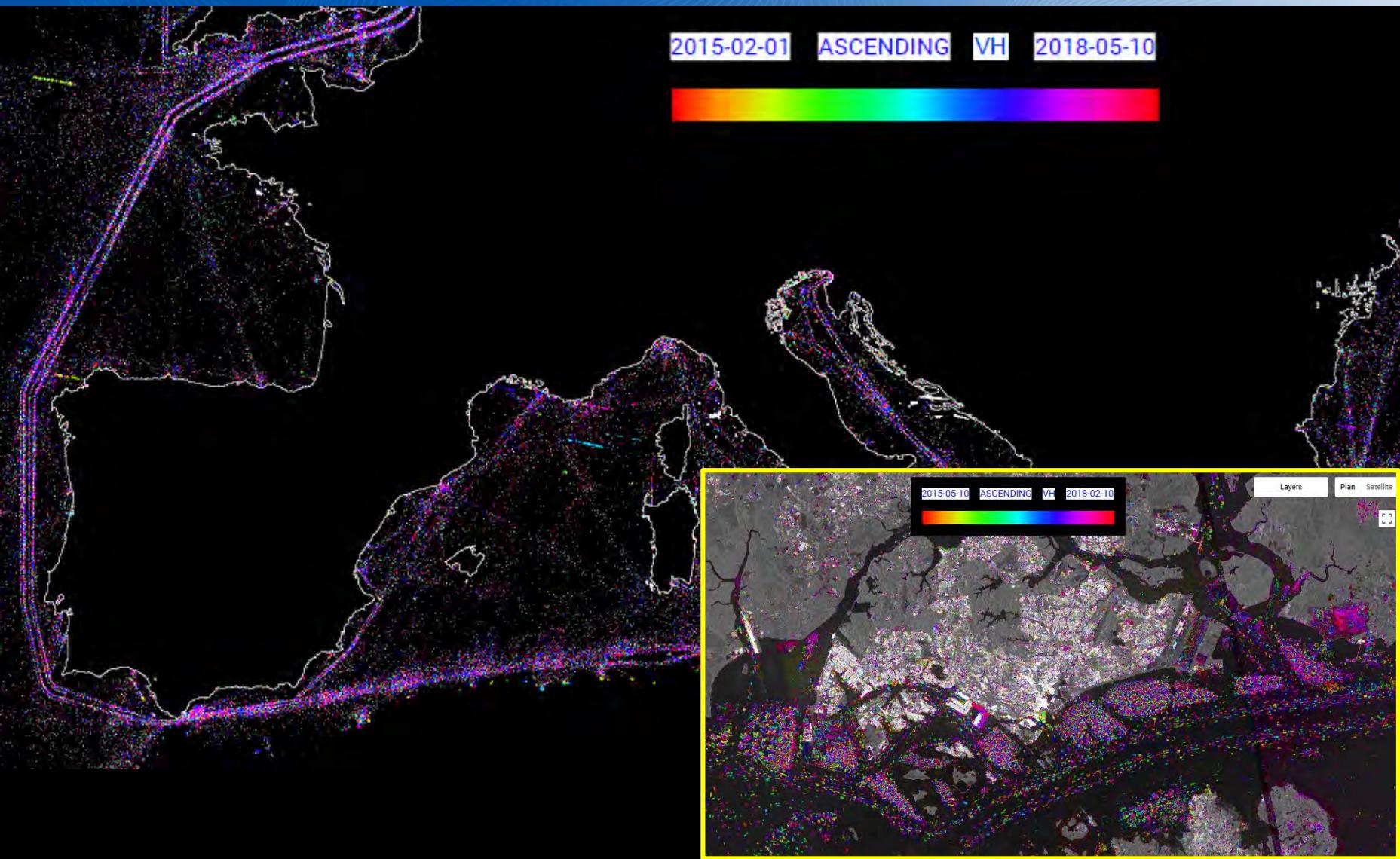
# Icebergs tracking

Sentinel 1, Google Earth Engine



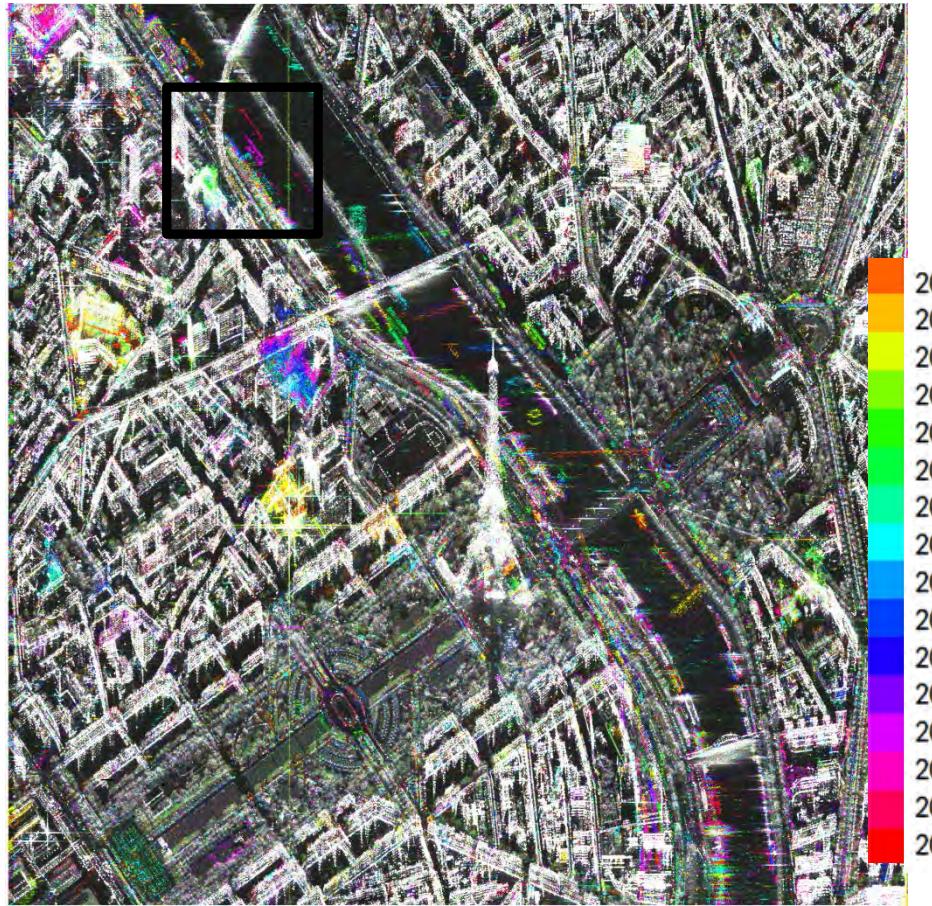
# Maritime traffic

Sentinel 1, Google Earth Engine



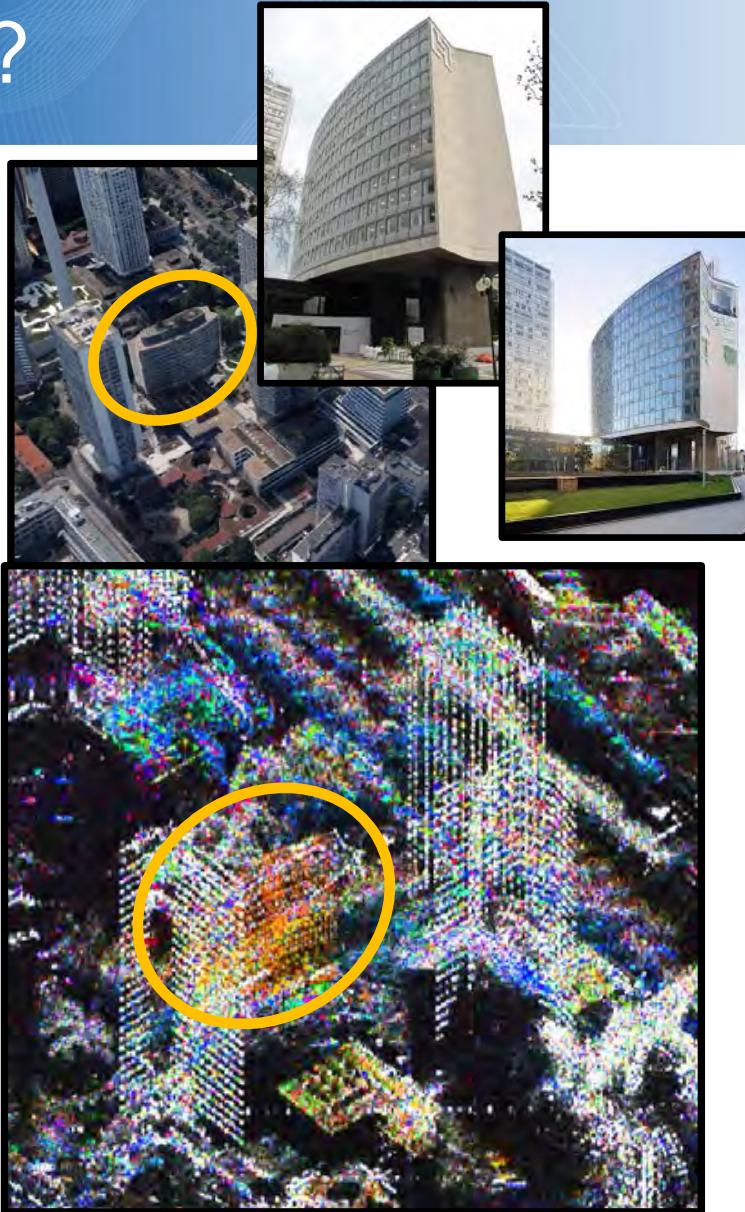
# What about High resolution?

TerraSAR-X (DLR)



• (1m)

• (25 cm)

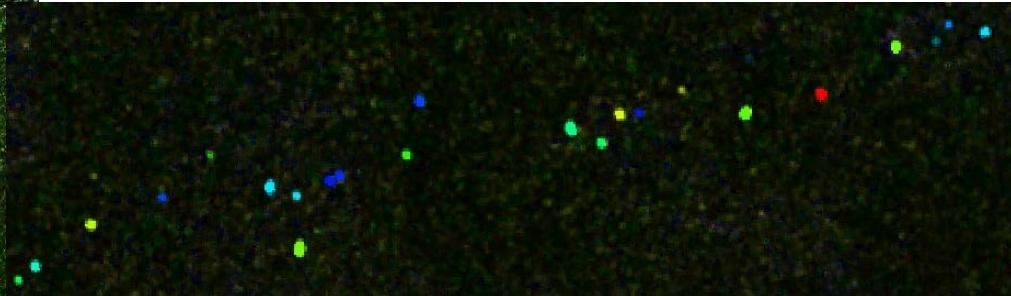
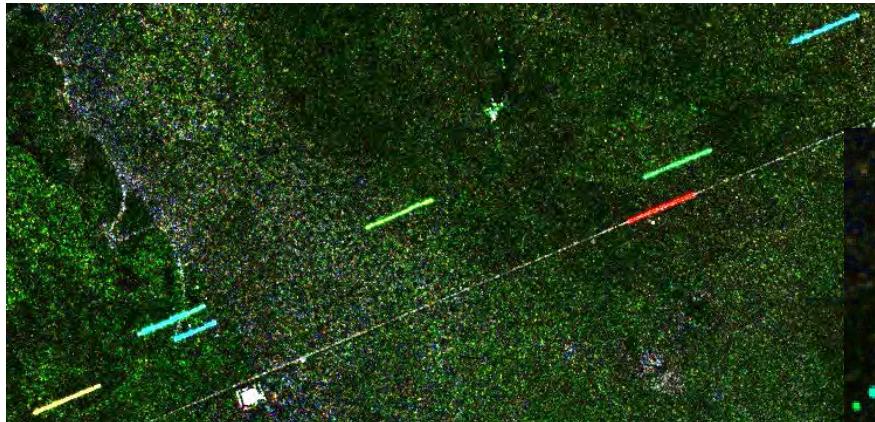


# Vehicle detection

Sentinel 1  
VV/VH



*Finsch Petra Diamond Mine,  
South Africa*



Trains



Trucks

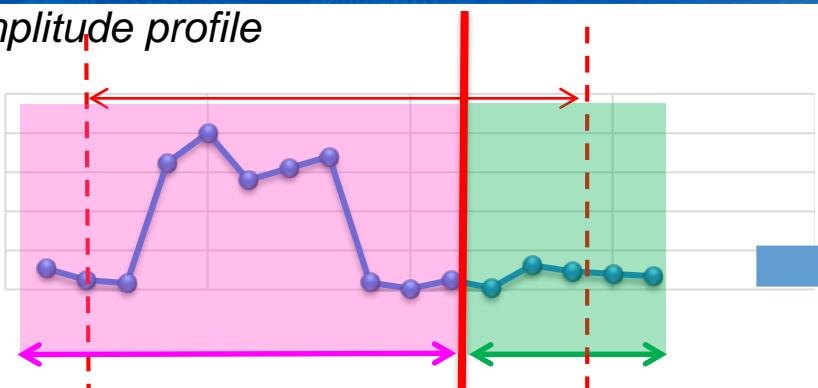


# OVER BUILDINGS



# Parameters to analyze a specific event

Amplitude profile



$$CV_1 = \frac{\sigma_1}{\mu_1}$$

$$CV_2 = \frac{\sigma_2}{\mu_2}$$

$$CV = \frac{\sigma}{\mu}$$

highlights any kind of changes from « stable » speckle

$$\min\left(\frac{CV_1}{CV_2}, \frac{CV_2}{CV_1}\right)$$

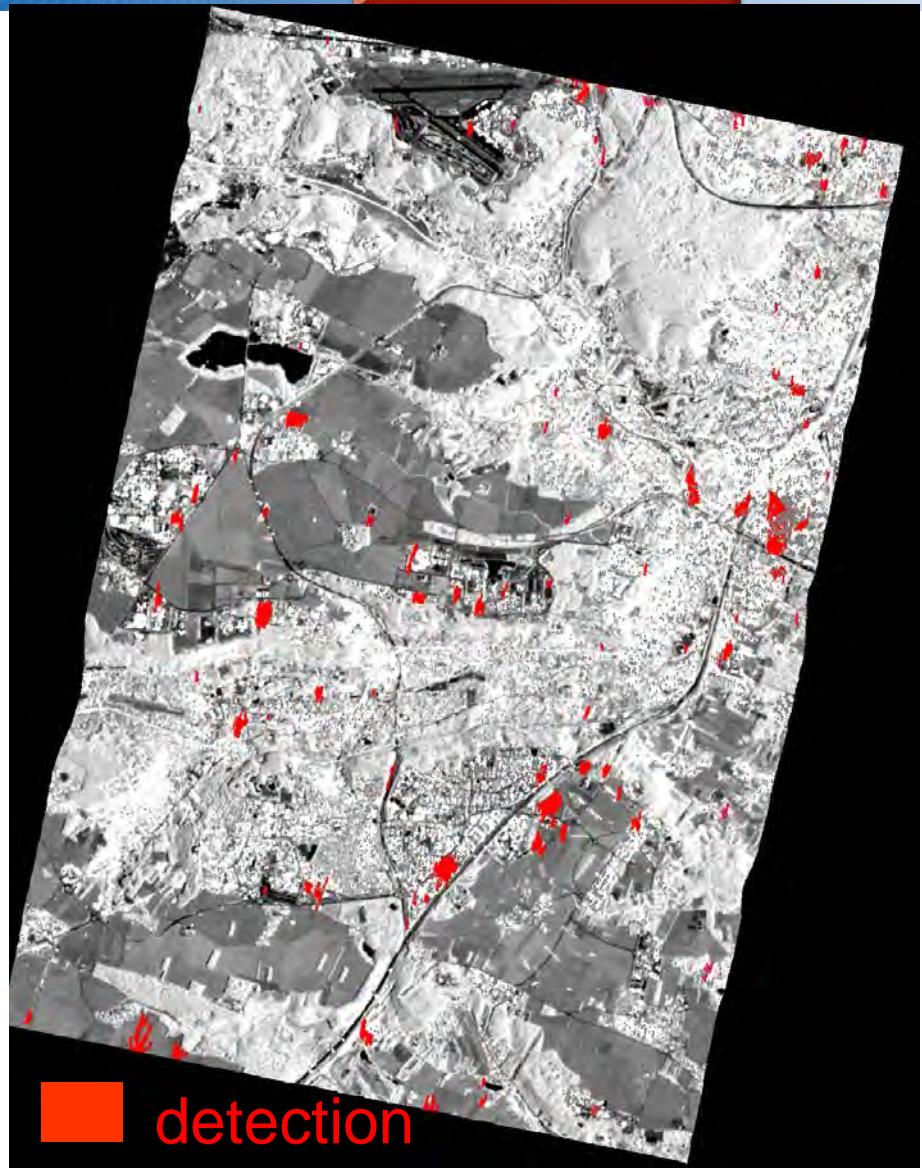
$$\longrightarrow$$

$$R = 1 - \sum_s \min\left(\frac{CV_1}{CV_2}, \frac{CV_2}{CV_1}\right)$$

highlights constant piecewise signals

# Results

Sentinel 1  
VV/VH

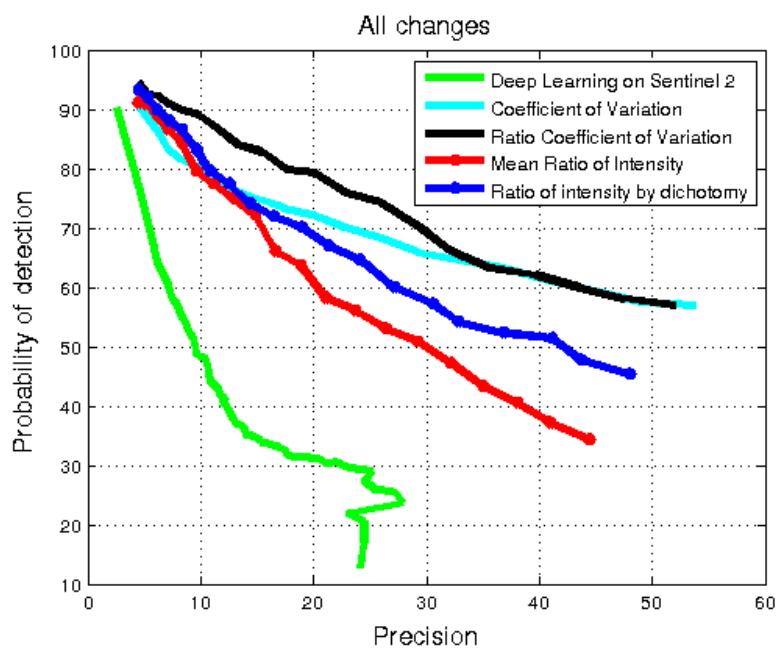
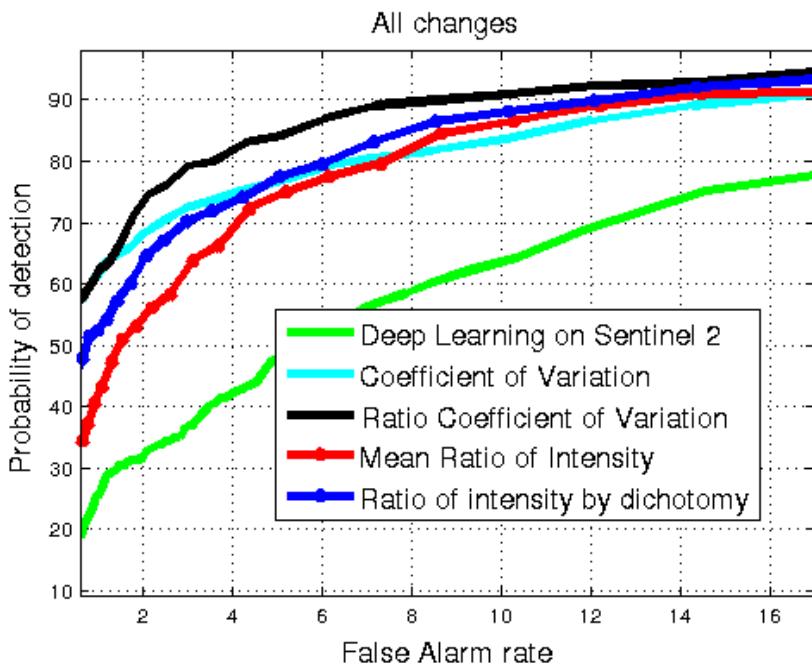


# Results

Sentinel 1  
VV/VH

Coefficient of Variation and specific CV ratio compared to:

- Radar intensity based criterions
- Deep learning on Sentinel 2 images



PhD Onera  
Rodrigo Caye Daudt

# TIME-SERIES FOR POINT-EVENTS



# Detection of one-point event

$$R = 1 - \min\left(\frac{CV_1}{CV_2}, \frac{CV_2}{CV_1}\right)$$

$CV_1$  computed without max value  
 $CV_2$  computed without min value

Amplitude profile EXAMPLE 1



***without maximal value***



$CV_1$  low

***without minimal value***



$CV_2$  high

$R \approx 1$

Amplitude profile EXAMPLE 2



***without maximal value***



$CV_1$  high

***without minimal value***

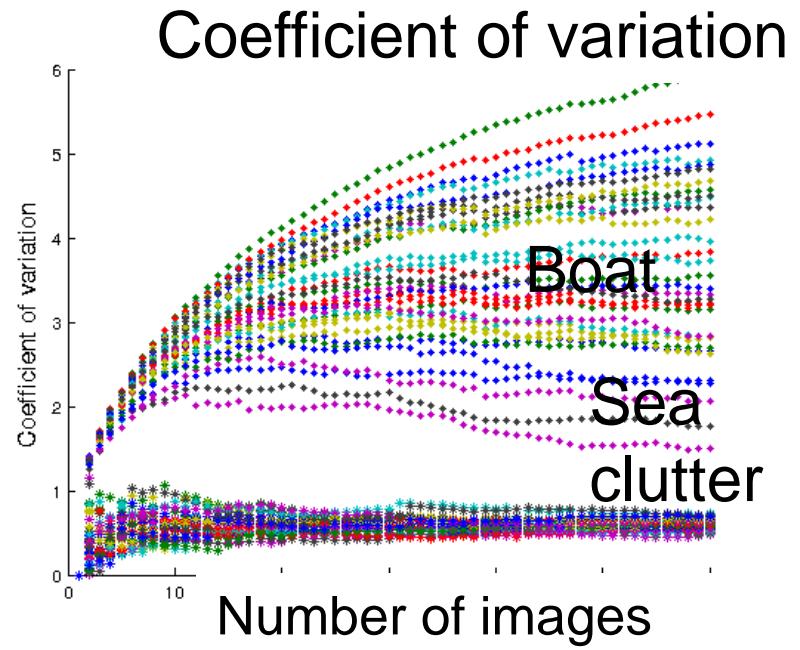
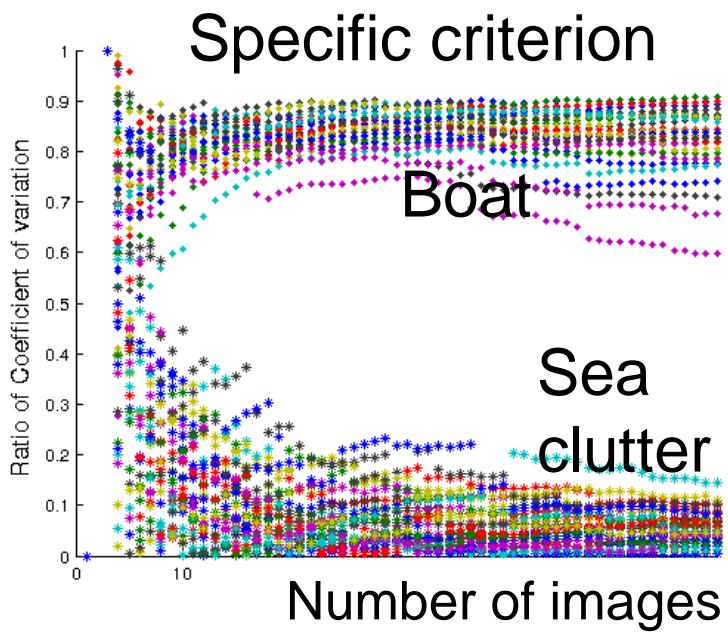
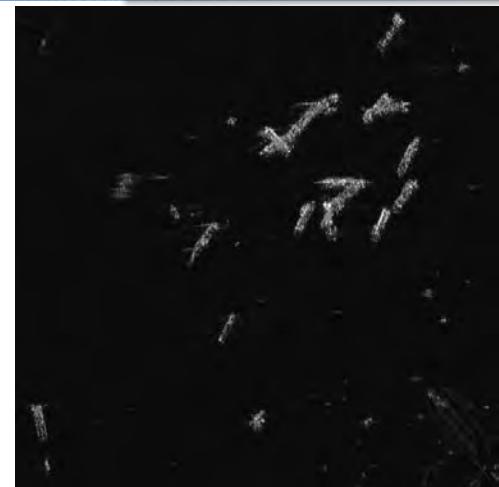
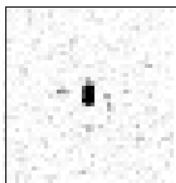
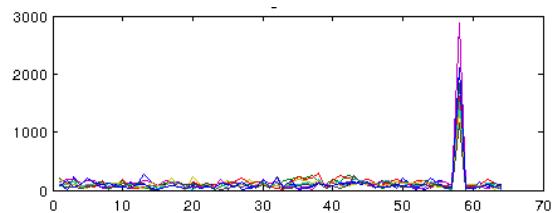
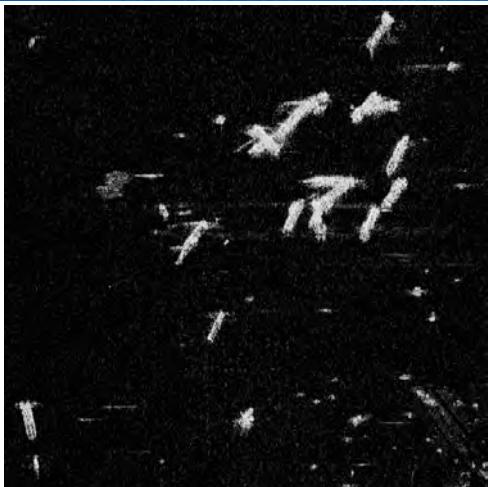


$R \approx 0$

$CV_2$  high

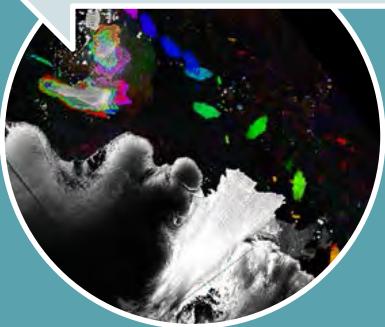
# Comparison between CV and ratio of CV

UAVSAR  
VV/VH



# Summary

## Worldwide demonstration



### Visualization

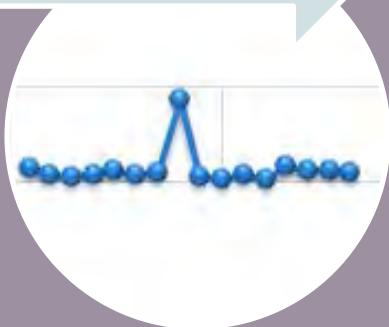
Powerful tool to see all kinds of change

Based on theoretical study on coefficient variation statistics

### Construction site detection

**Very good performance compared to:**

- state of the art in SAR time-series
- optical best known results based on deep learning



### A new dedicated detector

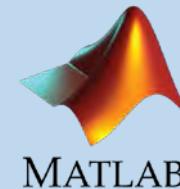
More specific than CV

Requires more than 20 images

# Thanks for your attention

## Available code sources

<https://github.com/elisekoeniguer/REACTIV>



*TERRASAR-X images have been provided by DLR  
UAVSAR images – NASA-JPL*

Next:

- implementation on European GEP platform
- *Post doc position about fusion with optical images!*  
*CNAM – Onera*