Calibration Aspects for Time Series of High Resolution TerraSAR-X Images

Gottfried Schwarz and Mihai Datcu

German Aerospace Center DLR
Remote Sensing Technology Institute

Image Time Series

- **http://en.wikipedia.org/wiki/Satellite_Image_Time_Series**

  "*Satellite observations offer new opportunities for understanding how Earth is changing, for determining what reasons cause these changes, and for predicting future changes*…"

- We aim at automated data analysis and mainly search for changes of visible and hidden phenomena.

- We look for events as well as for gradual changes.

- We study
  - o pixel brightness histories and
  - o the evolution of extracted features, classes, objects, image content.

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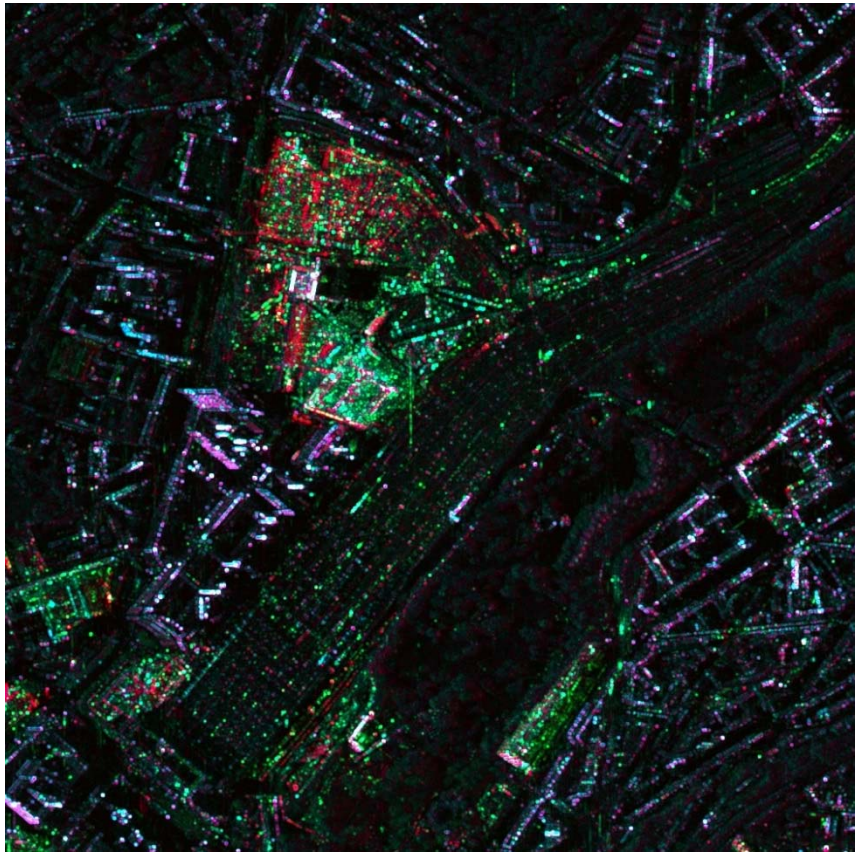
Europa District in Stuttgart, Germany seen by TerraSAR-X

Overview Image



Color Coded Temporal Changes

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Time Series: Requirements, Caveats and Extra Steps

- **Requirements**:

  Selection of appropriate and compatible candidate images
  Tested image analysis algorithms

- **Caveats**:

  Definite changes vs. transient changes
  What do the analysis algorithms see and extract?

- **Processing**:

  Identification, quantification and correction of offending effects?
  Application-dependent “extra calibration”?

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Validation Chances offered by TerraSAR-X
MGD High Resolution Spotlight Images

- **Excellent geometry**:

  Acquisitions from repeat orbits
  Identical viewing and processing parameters
  Co-alignment by horizontal and vertical shifting

- **Good radiometry of *radiometrically enhanced* products**:

  Low speckle
  Thermal offset corrected
  Co-addition still helpful

- **Stable targets**:

  Urban areas in Western Europe contain few short-term changes
  Availability of sufficient data

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Example 1: Inner City of Berlin, Germany

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Basic Imaging Parameters of the Time Series

- Acquisition period: Oct. 24, 2010 – Jun.12, 2011
- Repeat intervals: 11 days
- Polarization: VV
- Orbit branch: Descending
- Incidence Angle: 46.6°
- Acquisition time 05:17 UT
- Image resolution: 2.86 m
- Pixel spacing: 1.25 m

The Impact of Rain and Frost on These Images (1 of 3)

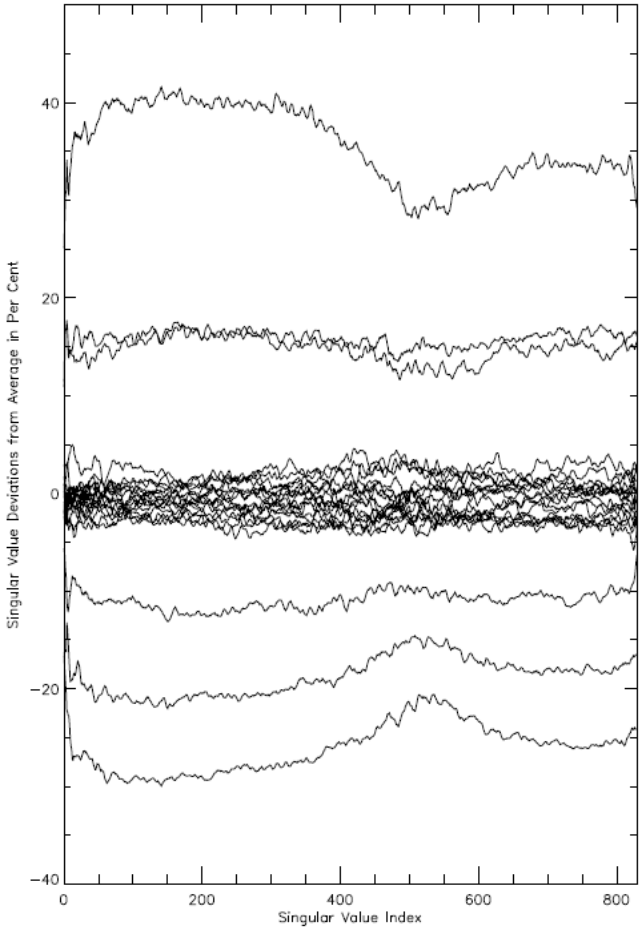
- **SAR images are affected by**:

  Falling rain
  Soil moisture
  Wet snow
  Ice on water
  Frost (trees)
  Wind

- **Simple analysis tools**

  Mean values, histograms, image statistics
  Singular Value Decomposition (SVD) $image = U \Sigma V^*$
  Σ: singular values (square roots of eigenvalues)

The Impact of Rain and Frost on These Images (2 of 3)



De-trended singular value deviations of a business district sub-scene

moist soil

moist soil

"normal" images (typ.±5% deviations)

frozen soil

frozen soil

frozen soil

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The Impact of Rain and Frost on These Images (3 of 3)

Shall we care for soil moisture and frost effects?

- Yes, if our interpretation algorithms are brightness level dependent.

How can we identify and quantify the effects?

- Comparison with meteorological data

Can we correct the effects?

- Leave out the problem cases
- Try a correction factor
- Use scaled image differences *(A-B) / (A+B)*

The Impact of Wind on Public Park Scenes (1 of 3)

- **SAR images are affected by**:

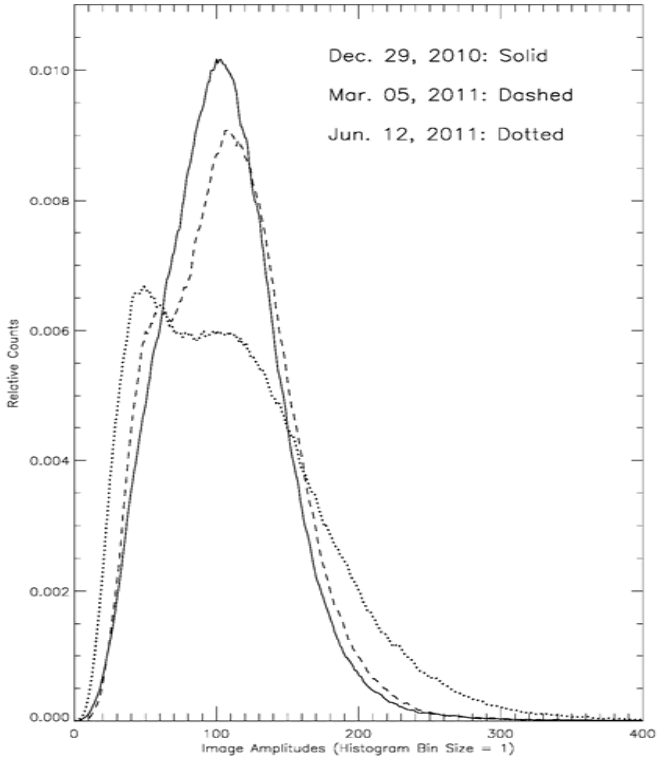
  Wind over vegetation (trees and bushes): loss of contrast

- **Simple analysis tools**

  Compare canopy shadows in summer (histograms of neighbor images)

The Impact of Wind on Public Park Scenes (2 of 3)

http://www.panoramio.com/photo/73648037



Wind destroys the “dark edge”

The Impact of Wind on Public Park Scenes (3 of 3)

Shall we care for these wind effects in public parks?

- Yes, if our interpretation algorithms are susceptible to histogram changes

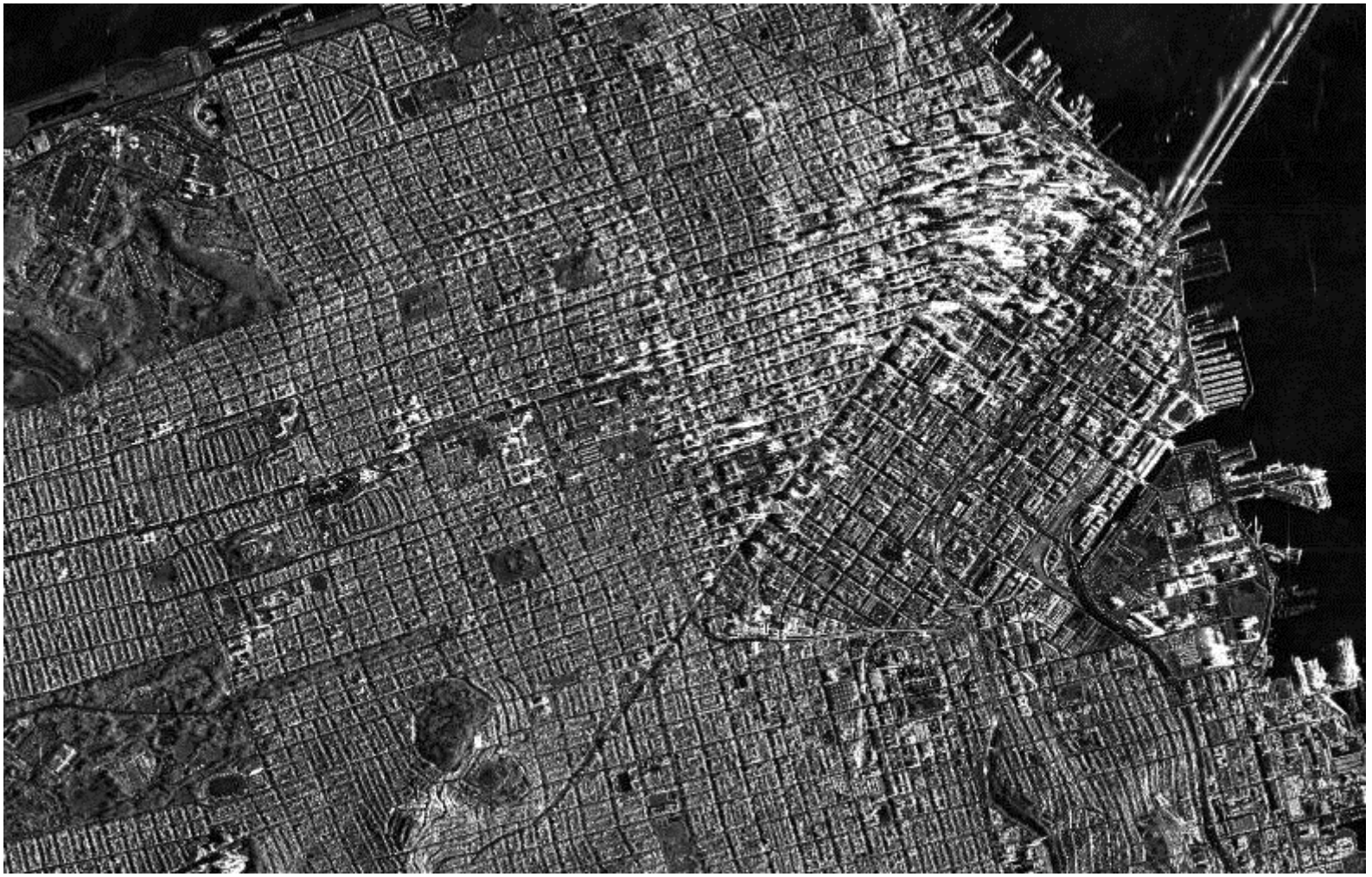
How can we identify and quantify the effects?

- Histogram analysis: Verify the annual vegetation cycle (no perfect gamma distribution)
- Histogram analysis: Check the actual canopy shadow
- Comparison with meteorological data

Can we correct the effects?

- Leave out the problem cases

Example 2: San Francisco, USA seen by TerraSAR-X



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Example 2: Oakland Bridge in San Francisco, USA

(Source: https://maps.google.de/maps)

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The Impact of Wind, Currents and Rain on Bridge Reflections (1 of 5)

- **SAR images are affected by**:

  Wind over water (generation of waves)

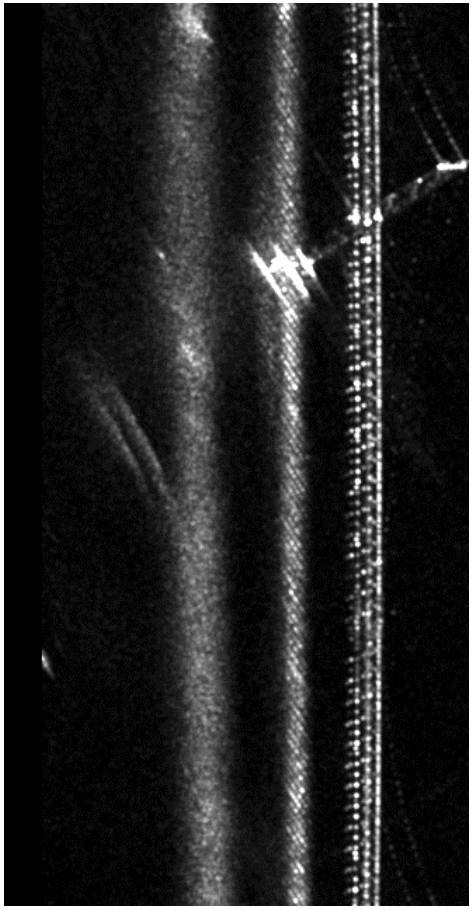
  Water currents (motion effects)

  Falling rain smoothing the water surface

- **Simple analysis tools**

  Check known target reflections

The Impact of Wind, Currents and Rain on Bridge Reflections (2 of 5)



Top side reflections:

right column

satellite – bridge deck – *satellite*

Lateral face reflections:

center column

satellite – bridge lateral side – water – satellite

Bottom side reflections:

left column

satellite – water – bridge bottom side – water – satellite

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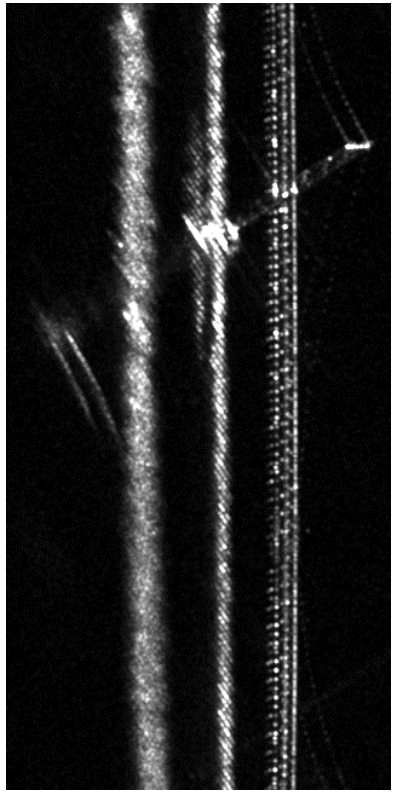
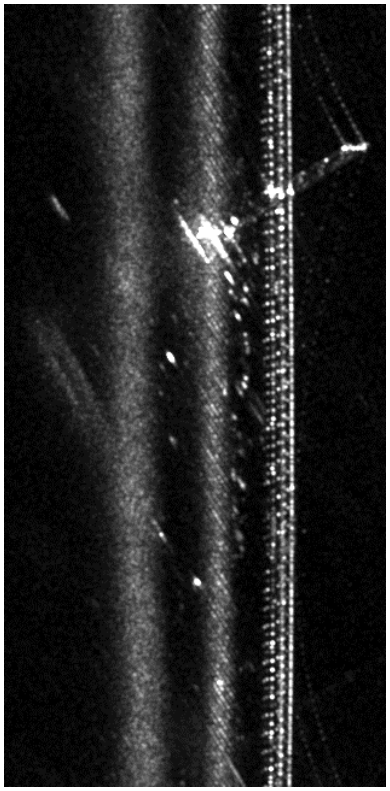
The Impact of Wind, Currents and Rain on Bridge Reflections (3 of 5)

High contrast



Low contrast



How wide is the bridge?

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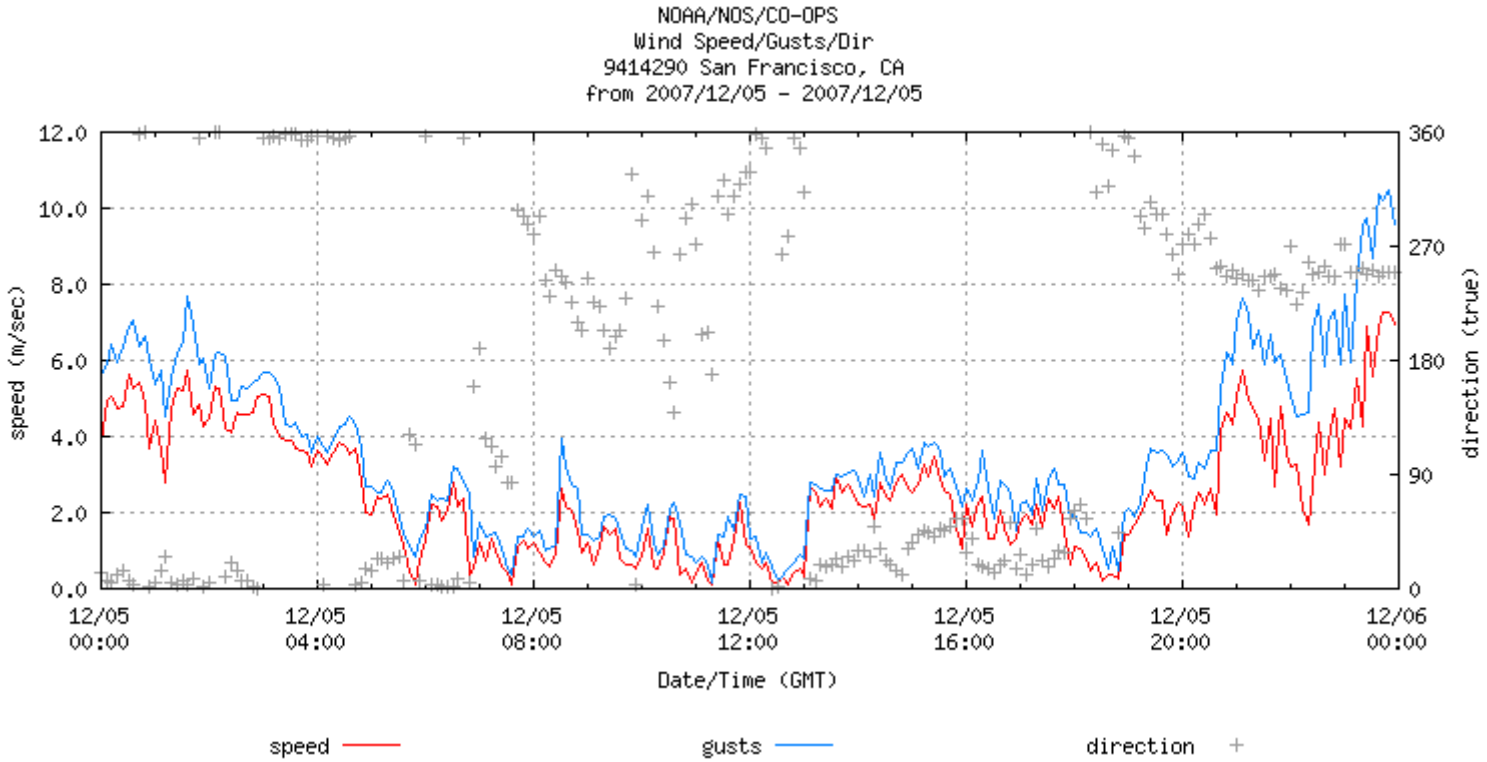
The Impact of Wind, Currents and Rain on Bridge Reflections (4 of 5)



The Impact of Wind, Currents and Rain on Bridge Reflections (5 of 5)

Shall we care for these bridge reflection effects?

- Yes, if our interpretation algorithms determine the width of a bridge.

How can we identify and quantify the effects?

- Comparison with (hopefully existing) optimal measurements

Can we correct the effects?

- ?

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Example 3: Outlook

Agriculture near Ludwigshafen, Germany:

- Soil roughness changes, e.g., by plowing
- Soil moisture changes by rain and possibly irrigation
- Annual vegetation cycle
- Transient targets (tractors, etc.)

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