Water Leak Detection using SAR Data -- One example for the leak happened in Feb 2015

<table>
<thead>
<tr>
<th>Date of detection</th>
<th>Data of repair</th>
<th>Estimated leakage flow (L/s)</th>
<th>Days</th>
<th>Coordinates</th>
</tr>
</thead>
<tbody>
<tr>
<td>2/19/2015</td>
<td>2/27/2015</td>
<td>6</td>
<td>8</td>
<td>Lat 41,18698411, Lon 1,501312152</td>
</tr>
</tbody>
</table>

The data used for study the leak is Sentinel 1 images. After data processing (calibration, multilook, speckle-filtering, terrain-correction), the backscatter at the leak position was analyzed both for VV and VH polarizations. The result shows that after the leak happened, the backscatter increased for both polarizations and decreased after the leak has been repaired. In figure 1 (left), only VV polarization is shown. Although the backscatter is corrected for incidence angle (incidence angle is shown in blue line) some influence remains in the backscatter. For that reason, the satellite data is seperated by satellite tracks (track 30 and track 110 in this case) since the incidence angle is constant within a track. For both tracks, the backscatter (in red line) increases after the leak happened and decreases after the repair date. The blue bar figure is the precipitation in corresponding days.

Using this property of backscatter change, calculating the backscatter difference between two dates, the result will show the soil moisture change which relates to water leakage. In the right figure, the result shows the backscatter difference of VV polarization along the transportation network between date Feb. 28 and Feb. 16. The red points on the channel are of high differences. Where the leak happens, the VV difference is 2.82 dB, while the VH difference is 2.20 dB. However, there are some noisy red points appear along the channel, to eliminate them, several methods has been tried. First try is to combine different bands and conditions, set threshold to detect the leak. Second try is to compare the backscatter coefficient of the leak pixel, the average value of the 9 pixel with the leak in the center, and the 1 km area average, the difference between them removes rain effects and changes in a relatively wide range. In another try, we also compared the backscatter coefficient of the leak pixel with the average of time series backscatters. In the end, combination of different bands and conditions including the estimated threshold for wet soil eliminates most of the noisy red points (shows in the last figure).

The condition for the example leak is

- VH_Feb28 - VH_Feb16 > 2 dB
- VV_Feb28 - VV_Feb16 > 2 dB
- VH_Feb16 < -15 dB & VV_Feb16 < -10 dB

However, a more general condition needs to be figured out for the monitor service to detect any water leaks.