

River ice monitoring using remote sensing data. Case studies: Romania, winter season 2016-2017

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Introduction

The accurate and timely knowledge of the seasonal snow distribution and characteristics is essential for flood prediction due to rapid snow melt, for snow avalanche risk assessment, and for water resource management, including hydro-power production, agriculture and drinking water supply.

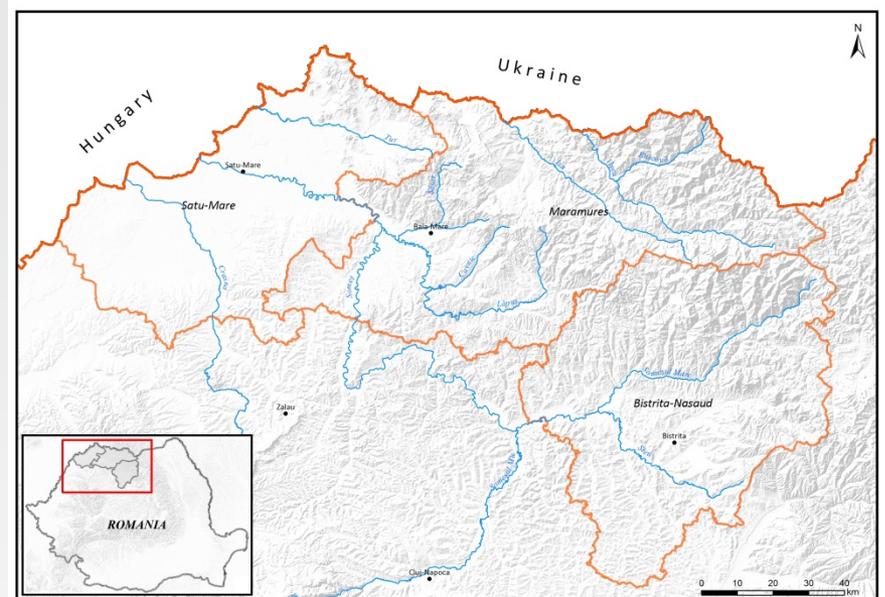
Optical sensors with moderate resolution, obtaining frequent (daily) coverage have often been the primary data source for monitoring of snow. The main reason is the compromise between accuracy, resolution and coverage. The shortcoming of optical data is the need for cloud free conditions. However, Synthetic Aperture Radar (SAR) sensors are able to map wet snow, and are able to see through clouds.

Case studie: Northwestern Romania

The negative air temperatures from the end of December 2016 and January 2017 have led to the emergence of ice formation on the most rivers of Romania.

The negative air temperatures from the end of December 2016 and January 2017 have led to the emergence of ice formation on the most rivers of Romania. Between 3 and 6 February the discharge increasing because of the combined action of rainfall, snow melting, evolution of the ice formation and propagation.

The level of awareness was increasing in North-Western Romania for the following rivers: Someșul Mare, Tisa, Iza, Tur, Lapus and Cavnic. The rainfalls overrun with 40-100 mm in Lapus basin (140 mm Cavnic, 99 mm Firiza and 44 mm for Lapus), 20-55 mm for Viseu, Iza and Tur and with 20-50 mm for Someșul Mare.



Radar Data

Sentinel-1 carries a SAR (Synthetic Aperture Radar) instrument in C band, to continue the legacy of ERS-1, ERS-2, Envisat and Radarsat. It is built to provide an all-weather, day and night data of Earth's surface. The Sentinel-1 mission consists in two identical radar satellites, Sentinel-1A, launched in April 2014 and Sentinel-1B, launched April 2016. The orbits are at 180° and the revisited time is 6 days.

Optical Data

Sentinel-2 is a multispectral mission with two satellites, Sentinel-2A launched on 23 June 2015 and Sentinel-2B launched on 7 March 2016.

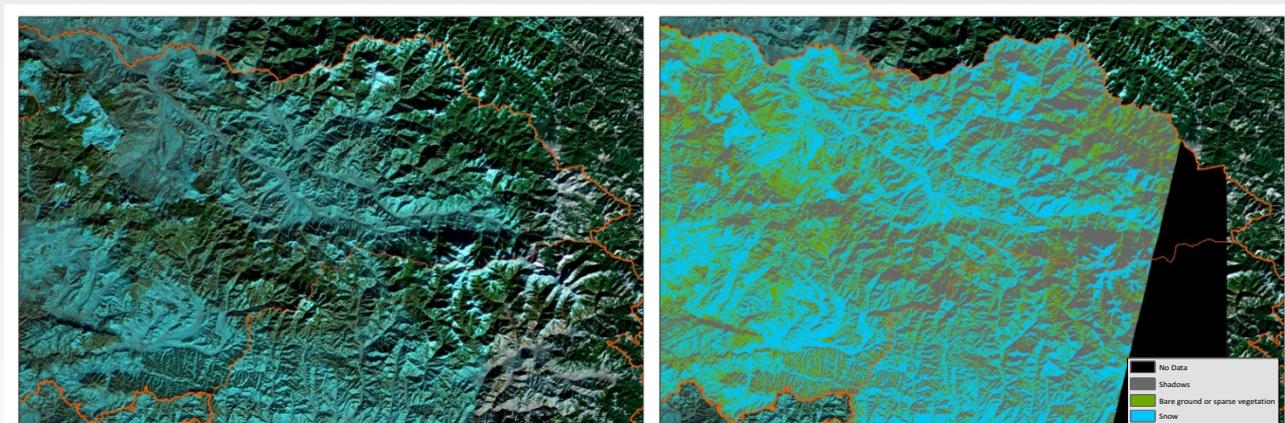
Landsat is a spatial project of U.S. Geological Survey and NASA (landsat.usgs.gov) started in 1972 and represents the longest and continuous mission of Earth Observation. **Landsat 8** is the latest satellite launched on 11 February 2013, having on board two instruments: OLI (Operational Land Imager) and TIRS (Thermal Infrared Sensor).

MODIS (Moderate Resolution Imaging Spectroradiometer) is the main instrument on board of Terra and Aqua satellites. The revisiting time of the two satellites is 1-2 days, acquiring data in 36 spectral bands or in a group of wavelengths.

Snow cover extracting process

The satellites images in optical domain can be process using different approaches for mapping snow extent considering their spectral and spatial resolution. The extraction methods can be based on using spectral bands and applying thresholds on them, unsupervised or supervised classification or by using spectral indices.

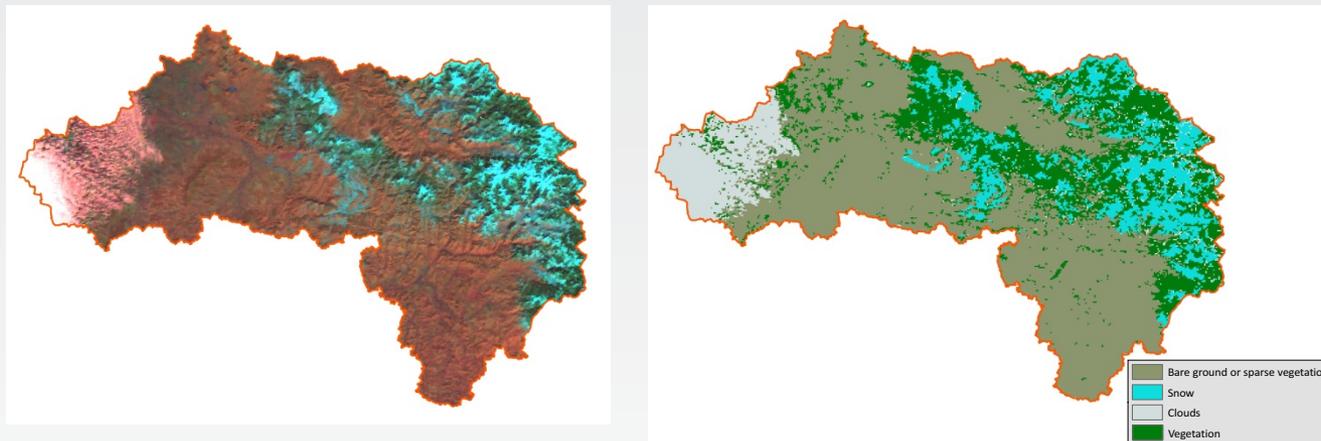
In this particular case, NDVI is used to separate bare ground or sparse vegetation by snow. . The positive values up to 0,3 corresponding with shadows, bare ground and sparse vegetation. Between 0,3 and 0,35 snow values are occurring, but if clouds appear on image, their values can be in the same interval as snow.



Snow classification using NDVI from Landsat 8, resolution 30 m

Snow cover extracting process

Snow cover extent extracted from MODIS is based on unsupervised classification using Iso Cluster method. This method combines the functionalities of Iso Cluster and Maximum Likelihood Classification and the resulting signature data can be used as input in other types of classification, for a better control over the classification parameters. Because of the close data ranges, the results are good, but in some cases snow and clouds could be incorrectly classified.



Iso Cluster Unsupervised Classification on MODIS

The wet snow mapping algorithm

Wet snow may be detected in SAR image by comparing backscatter coefficient values with corresponding backscatter coefficients from a reference image obtained at snow free or dry snow conditions (Nagler and Roth, 2000; Nagler et al., 2016).

The algorithms proposed by Nagler et al. (2016) for Sentinel-1 relies on a reference image acquired in the same repeat cycle. We consider a slightly different approach and only construct two reference images for our area of interest, one for ascending satellite pass and one for descending. In order to suppress terrain effects, we apply the flattening gamma terrain flattening approach by Small (2011).

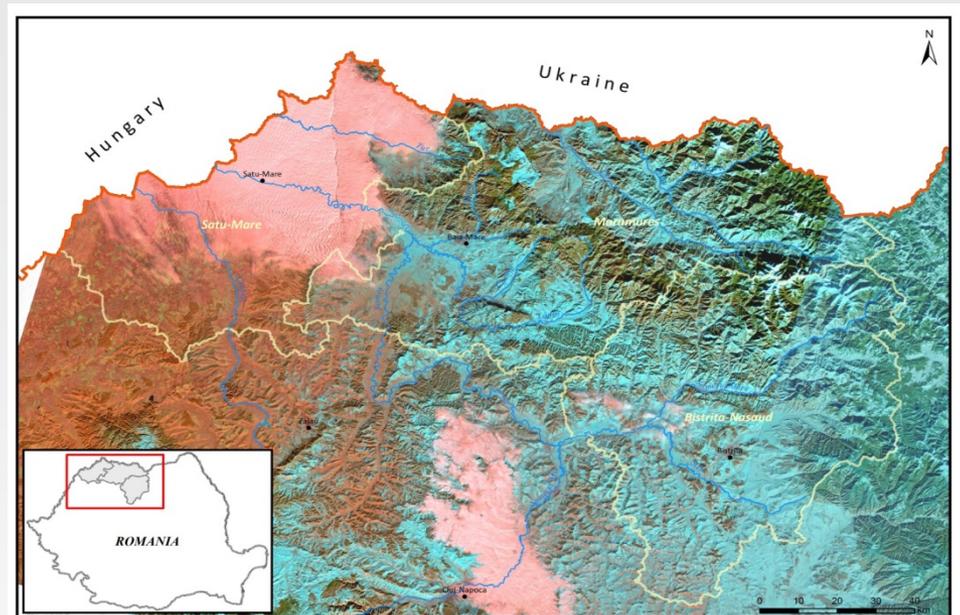
The flattening gamma SAR methodology suppresses a large part of the brightness variation in the SAR images caused by terrain variation, and may therefore provide a proper treatment to the hill-slope modulations (Small, 2011). The Flattening Gamma products have showed great potential for improving SAR-based mapping of wet snow in mountainous areas, e.g. at time of spring snow melt (Small, 2011). However, the quality of the flattening gamma products depends strongly on the quality of the DEM and precision of the geocoding.

Results

At the **beginning of January**, snow covered about 4440 km² from a total of 16085 km², the surface of Satu Mare, Maramures and Bistrita-Nasaud counties. The total amount of snow cover was estimated from Landsat 8 images acquired from 01 to 10 January 2017.

Snow depth at met station: 7 to 26 cm
 Targu Lapus – 26 cm
 Iezer, Sighetu Marmatiei – 21 cm

Temperature at met station: dropping fast in a short period of time
 Bistrita, from -6 to -15
 Targu Lapus, from -8 to -19.7
 Sighetu Marmatiei, from -1.3 to -14.7



Snow cover extent over Satu Mare, Maramures and Bistrita-Nasaud from Landsat 8 – mosaic 01-10.01.2017

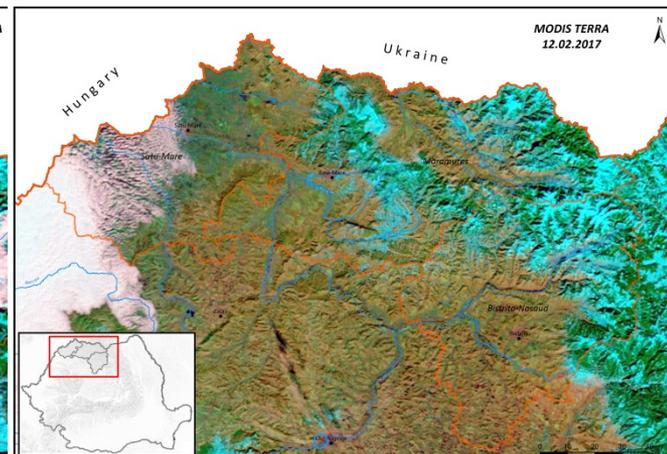
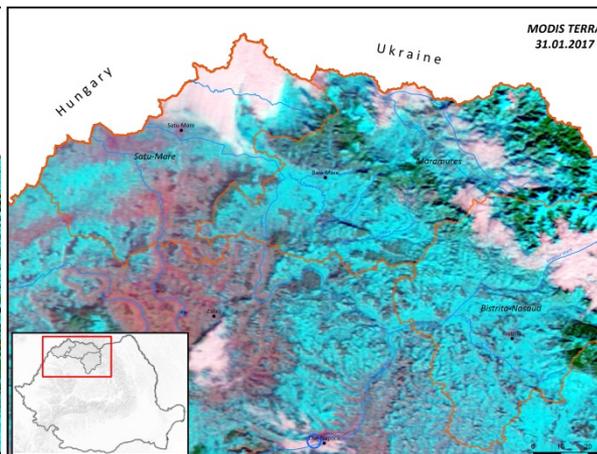
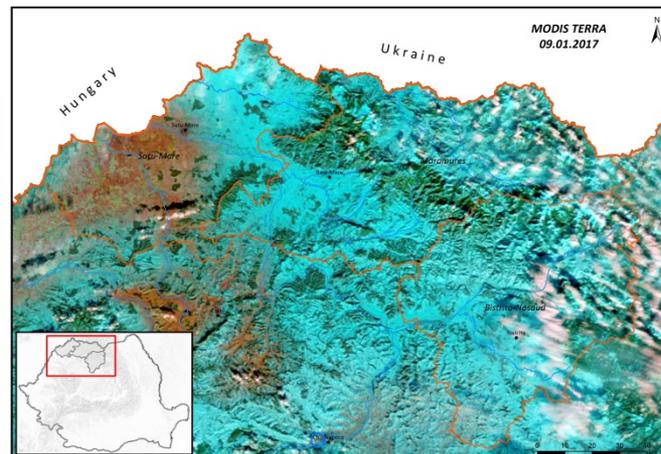
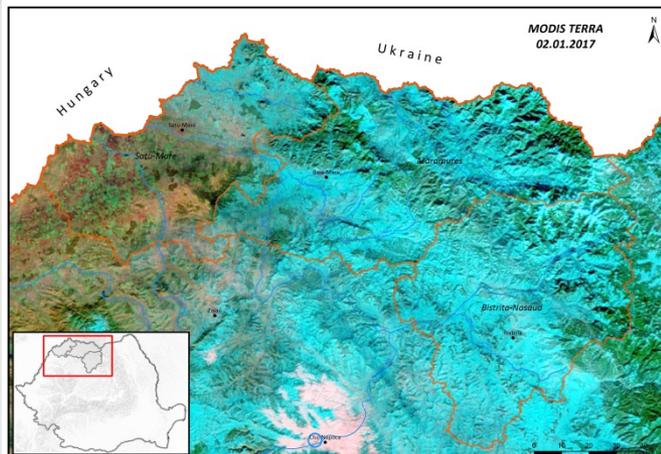
Results

By **mid-January**, a light snow covers more ground but the snow depth has a descending trend overall.

Until 31.01.2017 the total surface covered by snow reaches 9224 km² (estimated from MODIS), doubled since the first days of month.

On February 12th, the only surfaces with snow were at high altitude, for example, lezer meteorological station (2100 m) record 36 cm of snow.

In the **MODIS** images it is shown the evolution of snow cover from 02.01.2017 to 12.02.2017, when just 1998 km² of ground was covered with snow



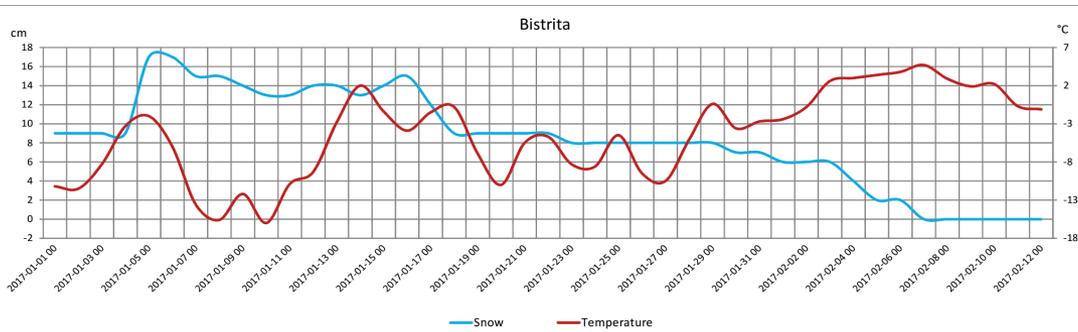
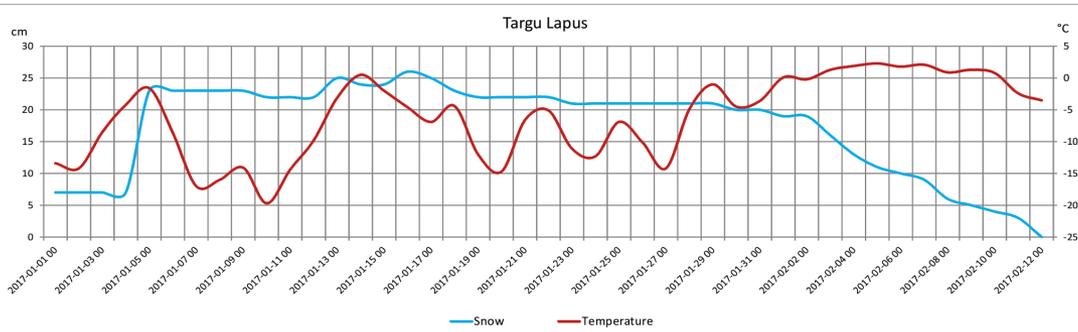
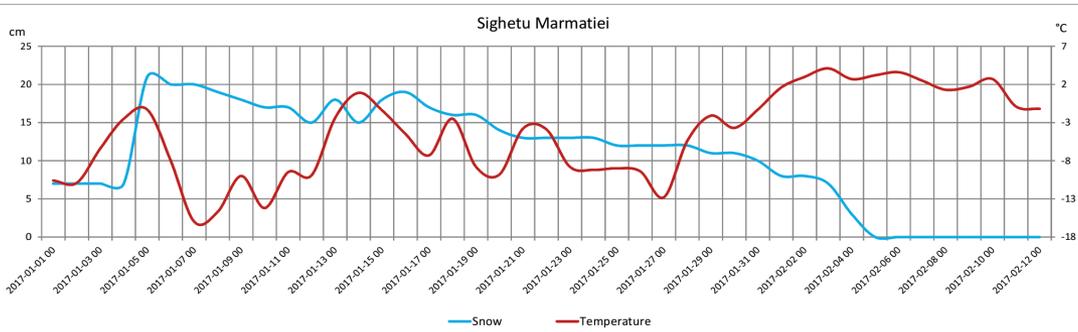
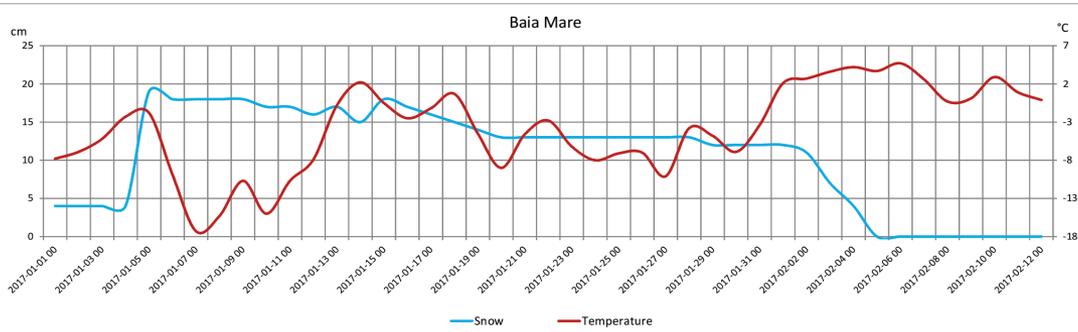
Evolution of snow cover from 02.01.2017 to 12.02.2017



Results

Meteorological
the values were
Bistrita -3.6°),
of time (Baia M

After February
temperature in
cover at meteor



way
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January 30 when
Targu Lapus -4.5°,
of this period
(7°).

due to high
records of snow



SnowBall
27 April 2



Results

The predominantly negative air temperatures recorded in **late December**, and throughout the month of **January**, have led to the emergence and intensification of river ice formations, so that in early February, on most rivers in the country, there were recorded important ice formations, and mostly ice bridges.

The values of the rivers discharges in **early February 2017** were generally situated between 40-90% from the monthly multiannual averages, and lower (under 40% from monthly normal) on the rivers: Iza, Crasna, some tributaries of the Someş (Sălăuța, Ilișua, Lonea, Fizeș, Lăpuș).

Between **February 3rd to 6th**, the river discharges were generally increasing due to the combined effect of liquid precipitations, snowmelt contribution, ice formations evolution, and flood routing.

Results

The penetration of a warm air mass and heavy rain recorded in the period 03-05.02.2017 in the following river basins: Vișeu, Iza, Tur, Someș, Crasna, led to a significant snowmelt, the triggering of runoff on hills slopes, and the activation of torrents, generating significant increases of discharges and water levels.

The liquid precipitations recorded in this 96 hours interval (from February 3rd in the morning, until February 6th in the morning) exceeded 40 – 100 mm in Lăpuș river basin (140 mm at Cavnice hydrometric station, on Cavnice River; 99 mm at Firiza hydrometric station, on Firiza River, and 44 mm at Răzoare hydrometric station on Lăpuș River).

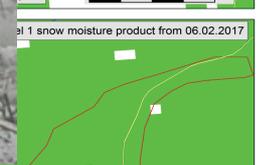
Also, significant liquid precipitations quantities were recorded in the river basins: Vișeu, Iza, Tur (with total amount between 20-55 mm) and Someșul Mare (20-50 mm).

Results

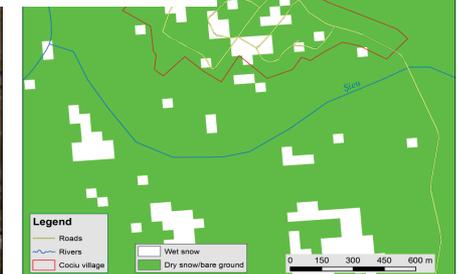
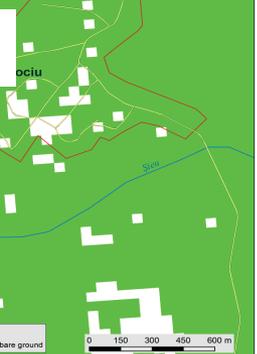
Cociu village
Junction of S

The ice on
blocks. Bec
River, the ic
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One of the c
car was c
damaged.

No casualties were recorded.



Damaged made by ice formation on Somes River near Cociu Village
Source: www.bistriteanul.ro



Left: Snow cover extent from Sentinel-2 (29.01.2017 and 11.02.2017); Right: Snow wetness from Sentinel-1 (03.02.2017 and 06.02.2017)

Results

In Viseu de Sus (Maramures County), 70 people remained isolated after the access road was covered with ice formation. Six kilometers from Vaser River were covered by ice. Also, six buildings were damaged.



Ice formation on Vaser River and damaged buildings by ice

Source: digi24.ro

Results



Flooded pastures by the Vaser River after snow and ice formation melted. Source: digi24.ro

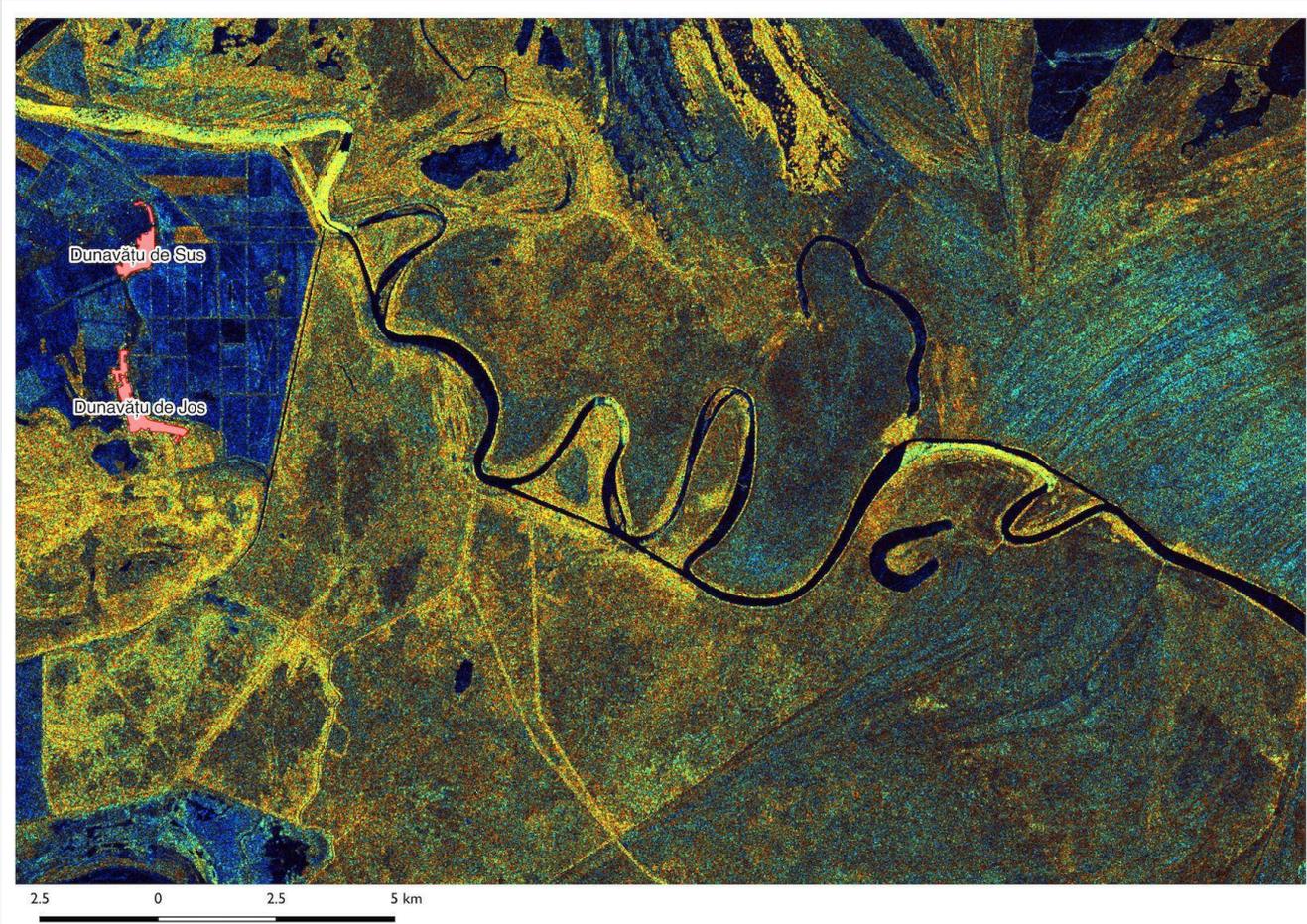
Results

On the Salauta River the ice formation measured about 500 m in length resulting in flooding of 15 houses from Telcisor village. The main road also was flooded by the Salauta River, leading to road closure. South from Telciu village, the ice formation measured 4 km, as a result, authorities decided to detonate it to prevent potential flooding.



Ice formation on Salauta River. Source: digi24.ro

Ice on Danube River



The problem

Over the big chill of the past few weeks, about 170 km of Danube were entirely frozen. Ice breakers had to be called from Hungary to help Serbia clear the area of the middle Danube around Belgrade after large chunks of ice formed and sometimes left the entire surface frozen. In some areas, the river froze to a depth that sometimes reached four meters. Other rivers and lakes throughout the region were also covered with ice.

- ICPDR

Affected parties: cargo transports

Ice on Danube River 4 meters thick at Dalj Bend

Ice on the Danube at the so-called Dalj Bend is four meters thick, says MUP Emergency Situations Sector chief Predrag Matic.

SOURCE: TANJUG | THURSDAY, JANUARY 19, 2017 | 09:57

Recommend Share 340 Tweet G+1 0



According to Maric, two more icebreakers will arrive in Serbia, to reopen the river to navigation all the way to Belgrade.

The Telegraph News

UK | World | Politics | Science | Education | Health | Brexit | Royals | Investigations

News

'Ice jams' form on the Danube River in Hungary

share tweet email



Shipping has been suspended due to huge chunks of floating ice

By **George Fuller**, VIDEO SOURCE STORYFUL

12 JANUARY 2017 · 7:07AM

Video shows huge chunks of ice or 'ice jams' forming on the Danube River in Budapest, Hungary.

Authorities have suspended shipping on the river due to dangerous floating ice.

It's been reported that parts of the Danube has frozen over along some stretches.

STIRILE PRO TV
14.02.2017, 21:43

STIRI #special Romania, te iubesc! Show-Buzz Programe Ardeal Video

Actualitate International Social Politic Travel Entertainment Vremea Sport iLikeIT CSID Partii de milioane

ultimele stiri

Ministerul Mediului: Valorile de radiatii in zona Muzeului National de Geologie din Capitala nu afecteaza sanatatea oamenilor

Dragnea: 'Mini premier coaliite discutat cu Por

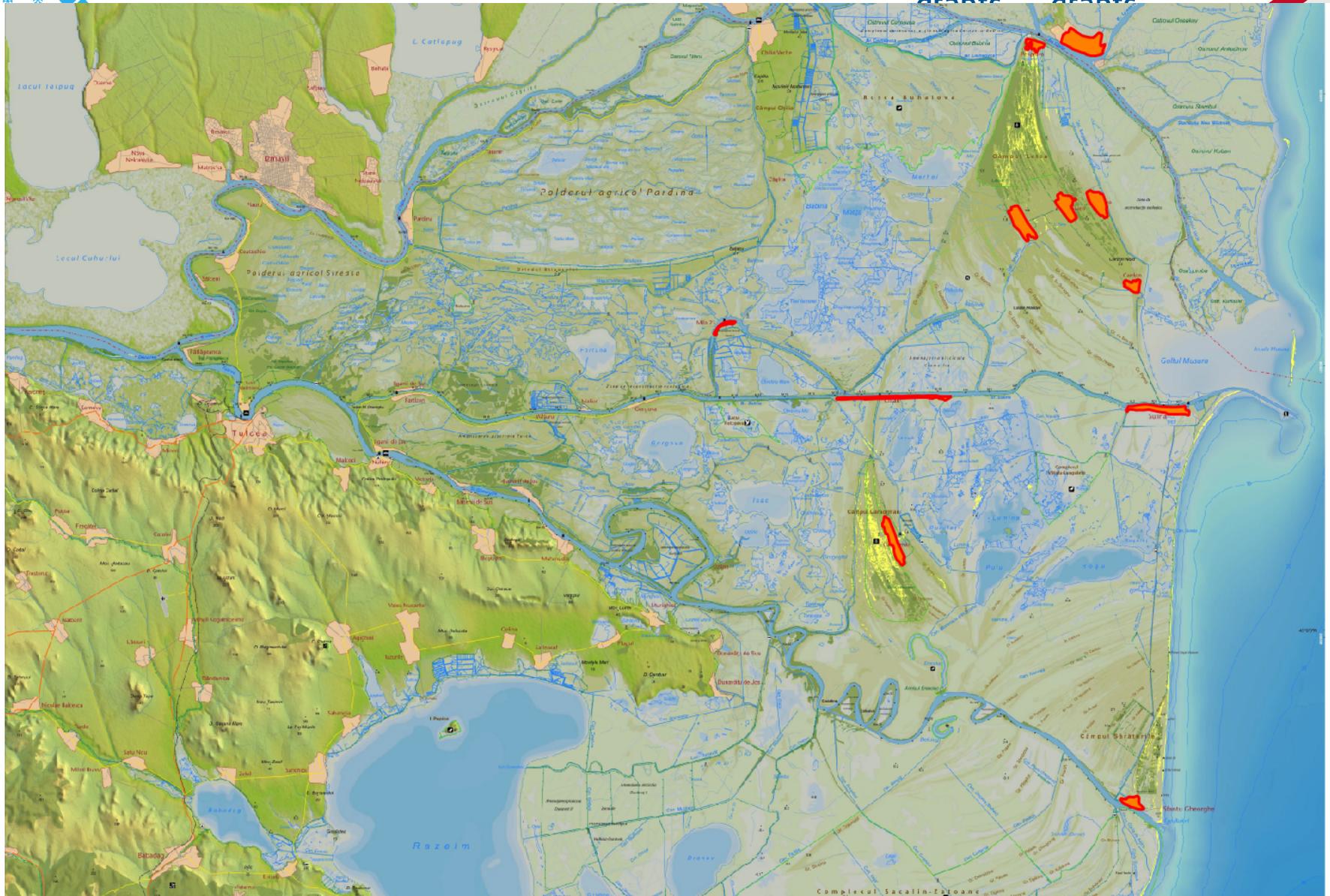
STIRI > Actualitate

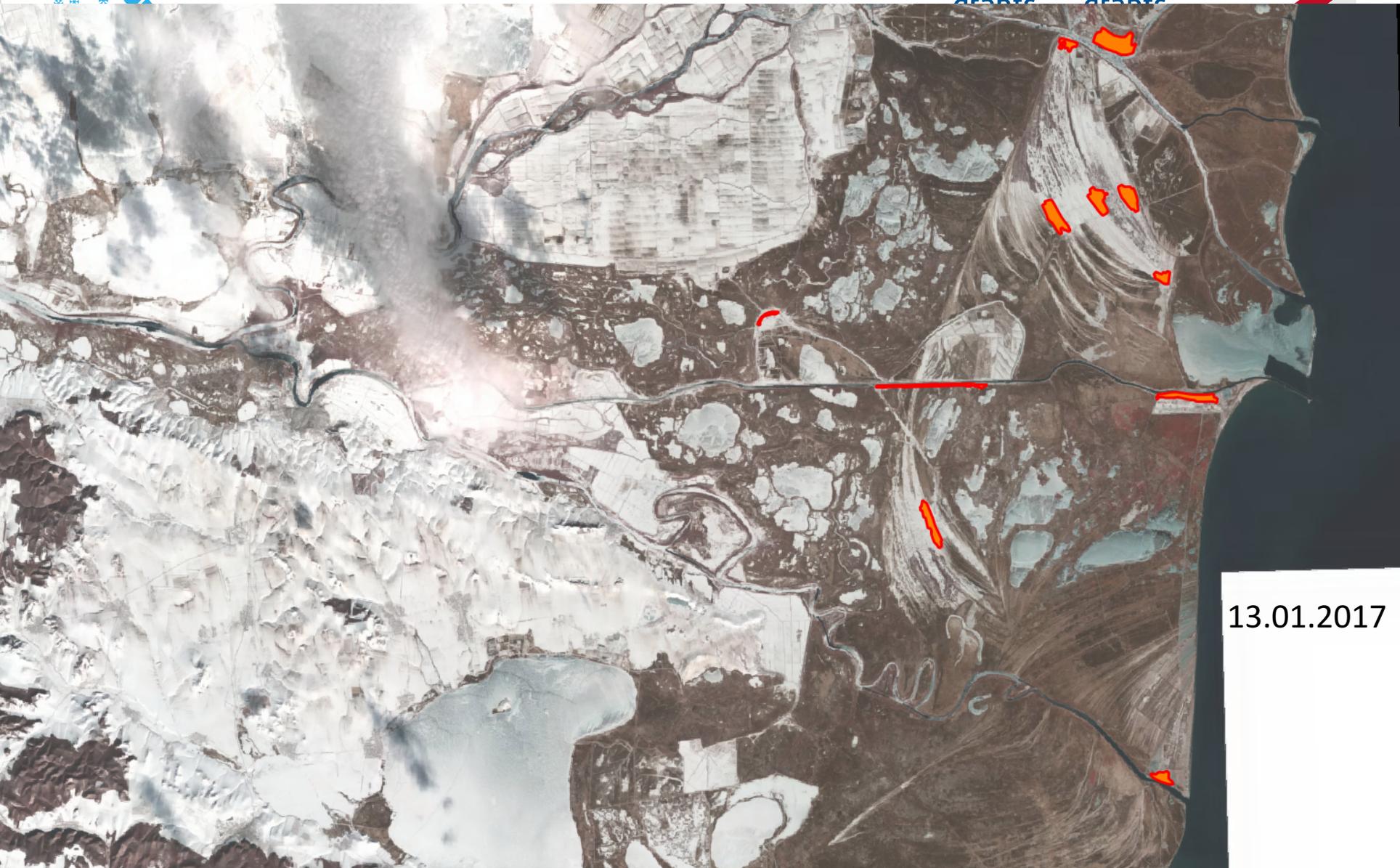
Gheata de pe Dunare a blocat 26 de barje, pagubele fiind de 40 de milioane de euro. Operatorii portuari ameninta cu proteste

Embed: <iframe src="http://www.stirileprotv.ro/bin/video_embed.php?media_id=61865149§ion=26">

Affected parties: people





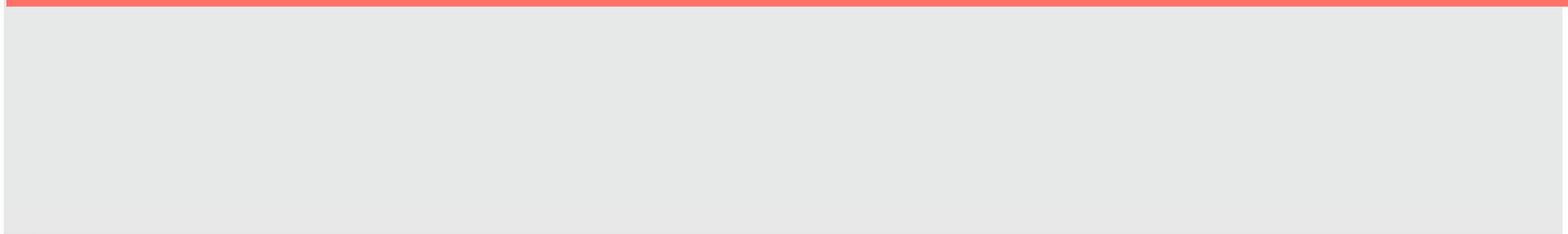


13.01.2017



02.02.2017

• Interactive map



Overview

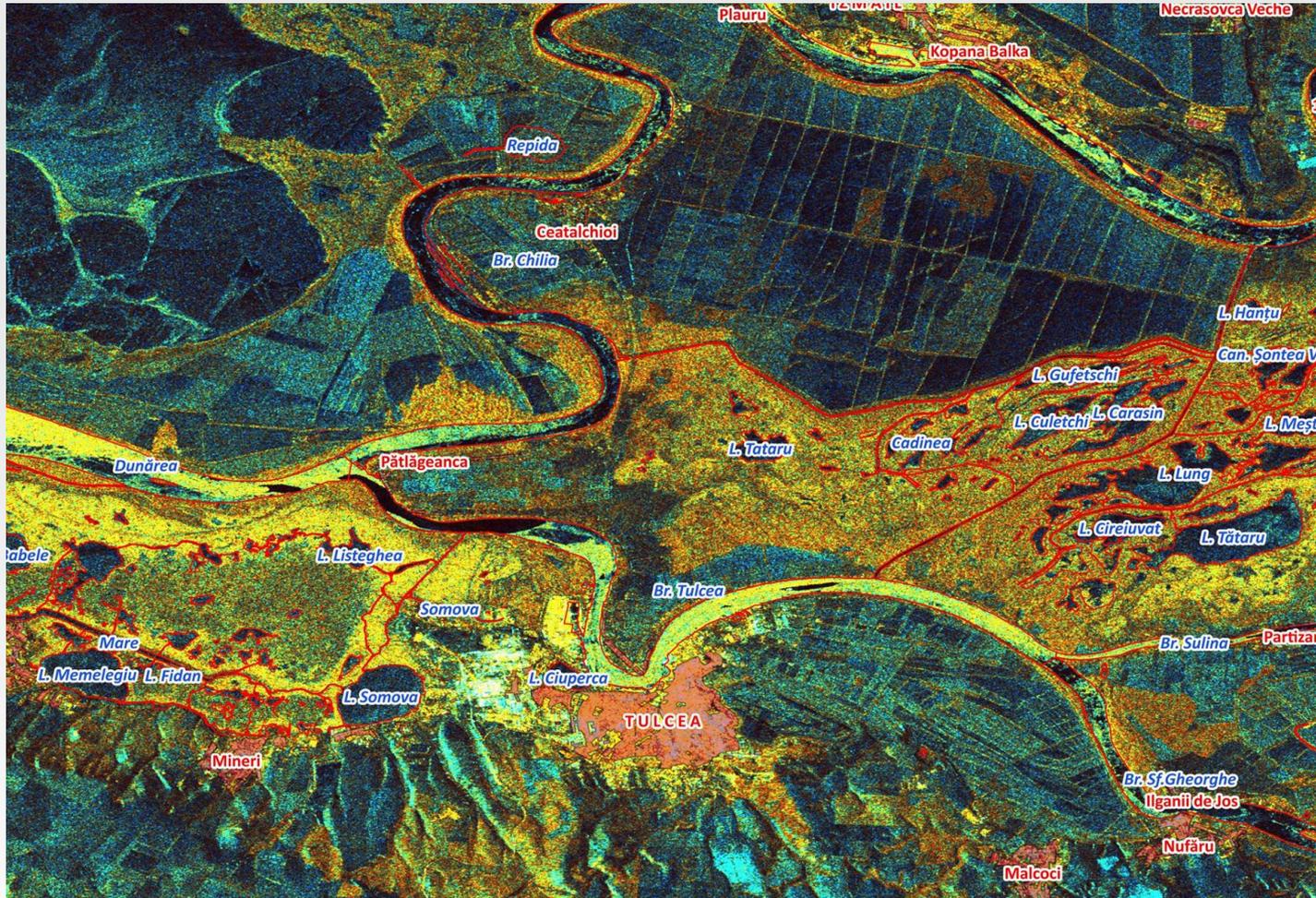
Sessions ▾ vs. [Select a metric](#)

Hourly **Day** Week Month

● Sessions

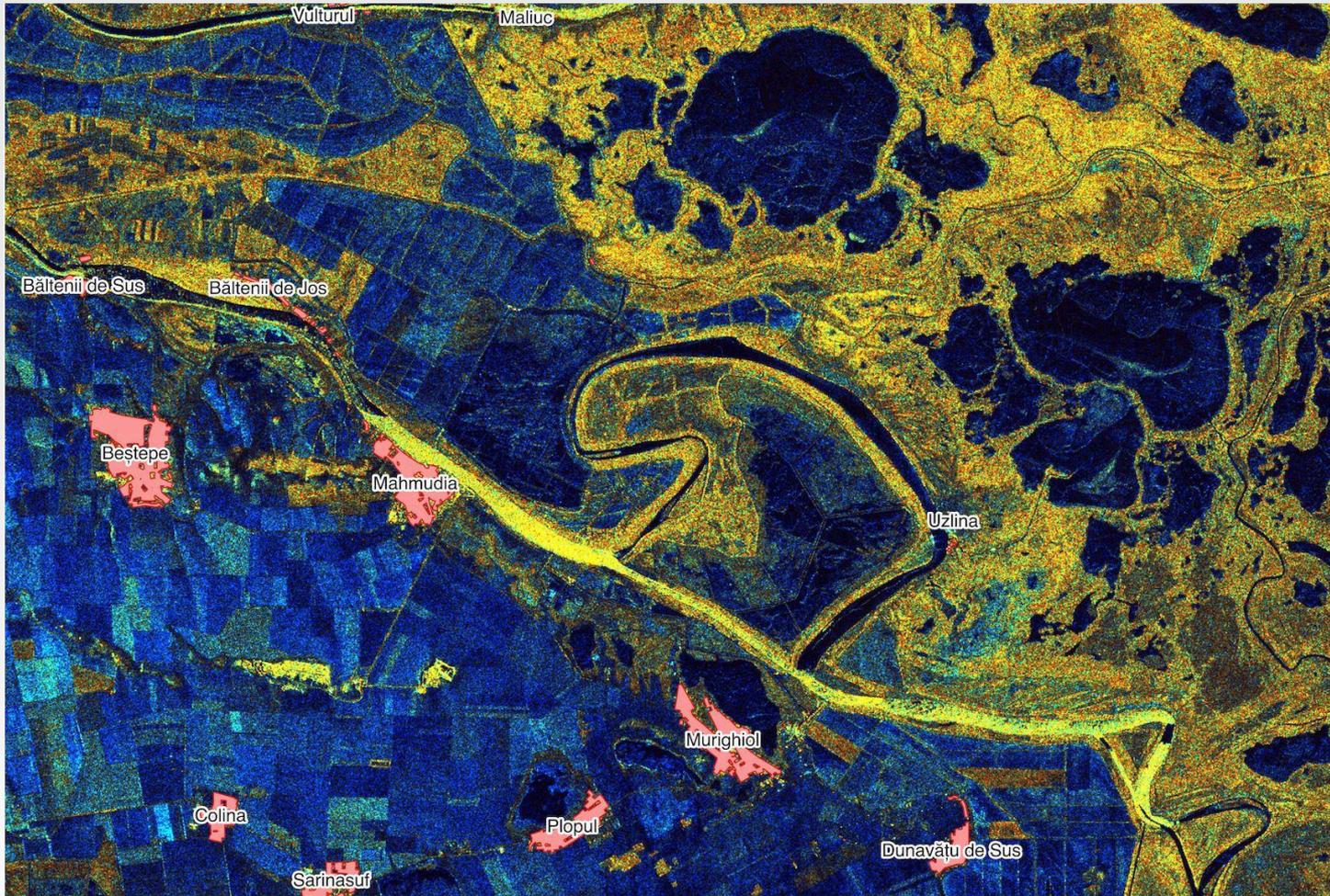


Affected parties: people



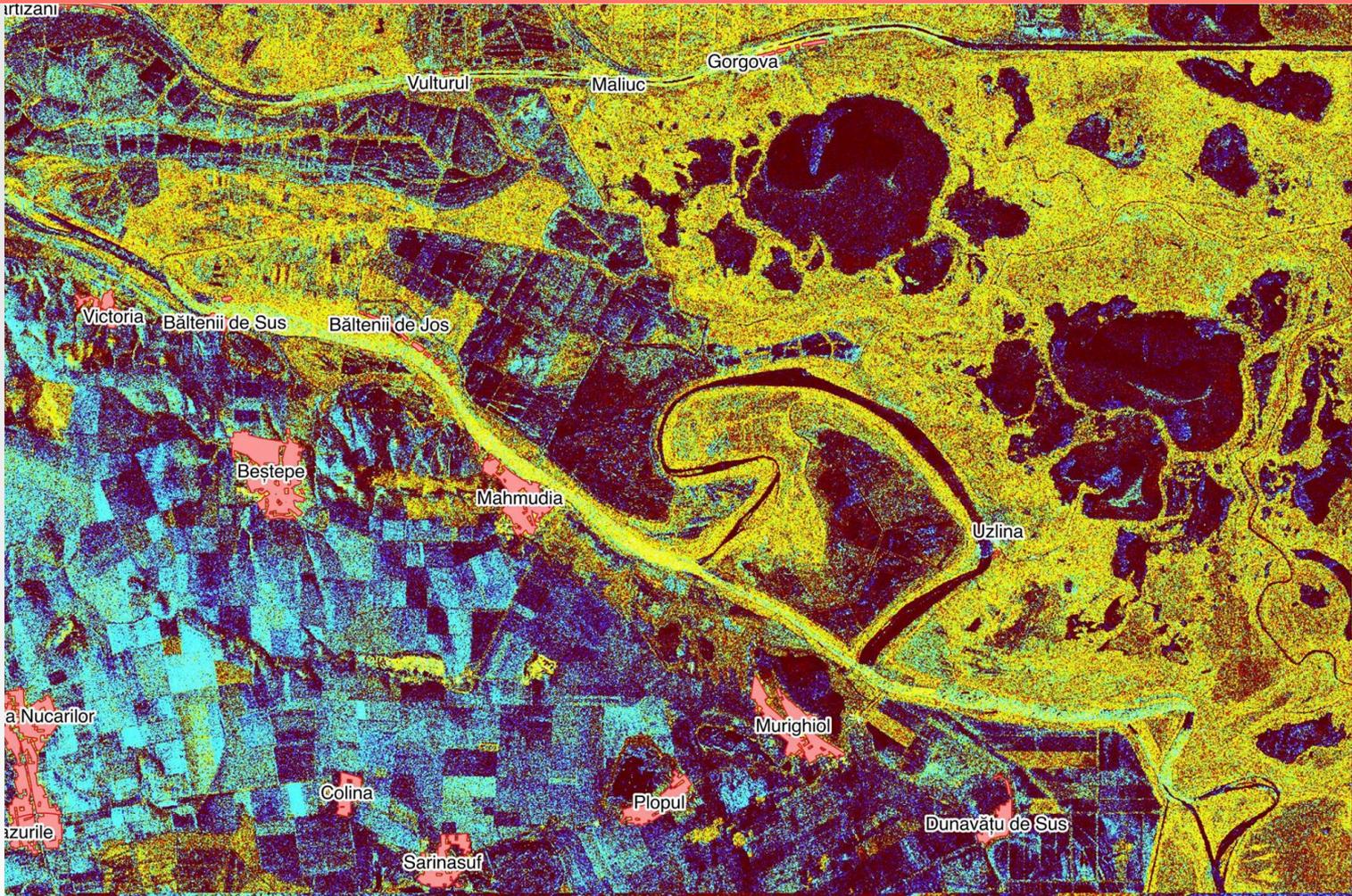
21.01.2017

Affected parties: people



13.02.2017

Affected parties: people



15.02.2017

Affected parties: people



Affected parties: people

**LIBER
TATEA**

ȘTIRI MONDEN VIDEO SPORT RELAȚII & SEX FEMININ UTILE ȘI SERVICII FATA DE LA PAGINA 5

Ajută copiii Horoscop Horoscop Urania Vremea Povesti de viata Ponturi Pariuri Premille Oscar 2017 Eurovision 2017 BUCUREȘTI

ULTIMA ORĂ 22 de ani susține nu a mai dormit de 84 de ani. Cum a rezistat fără somn atâția ani **22:25** **Contestația lui Liviu I**

Acasa > Știri > Știri interne > Apel disperat din Delta Dunării: Locuitorii din Sfântu Gheorghe, complet izolați, din cauza sloiurilor de gheață

Apel disperat din Delta Dunării: Locuitorii din Sfântu Gheorghe, complet izolați, din cauza sloiurilor de gheață

15 februarie 2017 15:59 De: **ALEXANDRU BOARIU**,



   **Îmi place** **Distribue**

Locuitorii din Sfântu Gheorghe, comună situată la vărsarea în Marea Neagră a

CELE MAI NOI ARTICOLE



Un tânăr a rămas cu mașina în mijlocul râului



Cum arăta Carmen Șerban cu ani în urmă. Nu are nimic de-a face cu cea care este astăzi



Un bărbat și-a stropit soția cu benzină și i-a dat foc

Horoscop Zilnic



Not so affected people

21.02.2017

Actualitate Vacanțe



🏠 > ȘTIRI > ACTUALITATE > PETRECERE CU GRĂTAR PE UN SLOI ÎN MIJLOCUL DUNĂRII

Petrecere cu grătar pe un sloi în mijlocul Dunării

Șapte bărbați dintr-o comună brăileană situată pe malul Dunării au organizat o petrecere cu mici și pește la grătar pe un sloi de gheață care plutea pe fluviu.



Singura lor asigurare a constat în două bidoane de plastic legate cu o funie, potrivit publicației [Obiectiv Vocea Brăilei](#) care a relatat cazul. “Dacă se rupe gheața ne ținem de frânghie, că bidoanele nu se duc la fund!”, au explicat petrecăreții. Din fericire totul a decurs fără incidente, iar la final, spre seară, cei șapte au băut o șampanie, au lansat un lampion luminos și s-au întors la mal, cu o barcă.

Motivul oficial a fost marcarea într-un mod inedit a sfârșitului iernii și a topirii ghețurilor de pe Dunăre, după cum a spus Vasile Puia, cel ce a avut inițiativa acestei acțiuni ieșite din comun. Grupul petrecăreților a fost format din șapte bărbați și doar unul dintre ei a avut o ezitare când a fost invitat la un grătar în mijlocul Dunării. Și acesta și-a recăpătat curajul, însă, imediat ce a coborât pe



The end. Questions?

