

Space-borne inventory of existing sinkholes and detection of alike-occurring areas in the Siberian permafrost region

Climate change induces permafrost thawing, leading to many ecological impacts. It accelerates deforestation processes, causing increased soil warming, due to more intense sun variations and a thinner buffer layer of organic soil. As a consequence, it intensifies desertification as the ice layer blocking infiltration thaws and the evapotranspiration increases due to the disappearance of vegetation.

Over the last decades, several sinkholes in permafrost have suddenly appeared in Siberia. Their creation is believed to be a consequence of underground gas release, due to permafrost thawing.

Permafrost study is of utmost importance to gain knowledge of the water cycle and climate change phenomena.

Remote sensing of sinkholes using InSAR Coherent Change Detection, (CCD) allowing to know the location of the sinkhole and its date of appearance



Active layer thickness

InSAR: Sentinel-1
Repeat cycle: 6 days
Spatial resolution: 20m

Elevation change

InSAR: Sentinel-1
Repeat cycle: 6 days
Spatial resolution: 20m

Land surface temperature

MODIS
Repeat cycle: 1 day
Spatial resolution: 1km

NDVI

Sentinel-2
Repeat cycle: 5 days
Spatial resolution: 10 m

Freezing/thawing index

SMAP
Repeat cycle: 3 days
Spatial resolution: 3 km

Remote sensing permafrost variables

Elevation change
Meteosat SG
Geostationary
Spatial resolution: 5 km

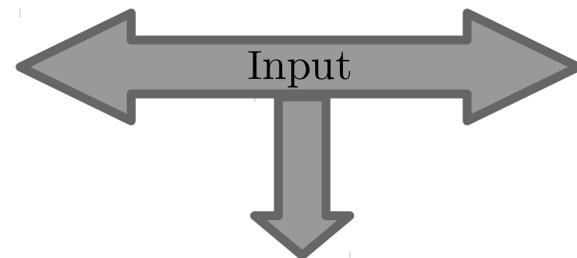
Comparison table: average of the permafrost variables on areas around the sinkholes detected by CCD, during a period P determined by the user

Name	Data type
Active Layer Thickness change	percentage
Land surface temperature change	percentage
NDVI change	percentage
Elevation change	percentage
Freezing/thawing index difference	scalar
Average of solar radiation index	scalar

Attribute hierarchy table, for a period P (with the processing date as end of period)

Name	Data type	Similarity metric	Priority	Tolerance threshold
Active Layer Thickness change	percentage	subtraction	User determined	User determined
Land surface temperature change	percentage	subtraction	User determined	User determined
NDVI change	percentage	subtraction	User determined	User determined
Elevation change	percentage	subtraction	User determined	User determined
Freezing/thawing index difference	scalar	subtraction	User determined	User determined
Average of solar radiation index	scalar	subtraction	User determined	User determined

Input



Adaptation of the method "Automation of similitudes measures" (AMR FUGA 2017)

Output

Classification of values within or outside the thresholds, enabling the detection of sinkholes alike-occurring areas

Conclusion: This process uses satellite data of permafrost characteristics to determine areas prone to sinkholes appearance, by considering that they are likely to appear in the same environmental, ecological and topographic conditions. By using coherent change detection and by adapting previous research work on data management and data mining, similarities to the average of permafrost variables around existing sinkholes can be detected and sinkholes alike-occurring areas mapped.

References:

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