AUTOMATIC DETECTION OF VOLCANIC THERMAL FEATURES USING SATELLITE OBSERVATIONS (V35E-0176)

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MOTIVATIONS

Satellite observations are widely used to investigate, monitor, and forecast volcanic activity. Spaceborne thermal infrared (TIR) measurements of thermal volcanic features improve our understanding of the underlying processes leading to eruptions[1-3]. Unfortunately, although different approaches have been proposed to detect and estimate the temperature above background of volcanic thermal anomalies, detecting subtle changes is still a challenging task. Here, we develop an artificial intelligence (AI) approach to automatically detect volcanic thermal features by using both low-spatial, high-temporal resolution MODerate-resolution Imaging Spectroradiometer (MODIS) data to detect hotter thermal features at short time scales; as well as high-spatial, low-temporal resolution Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) to detect more subtle thermal changes otherwise missed by MODIS.

SPACEBORNE THERMAL INFRARED SENSORS

HIGH SPATIAL RESOLUTION: ASTER

ASTER is on board of Terra satellite. It has a revisit time of 16 days at the equator, but with to the URP program started in 2009, it acquires data much more rapidly.

- TIR bands [8.125-11.65] at 90m spatial resolution are available
- Topographically corrected images AST_L1T are used

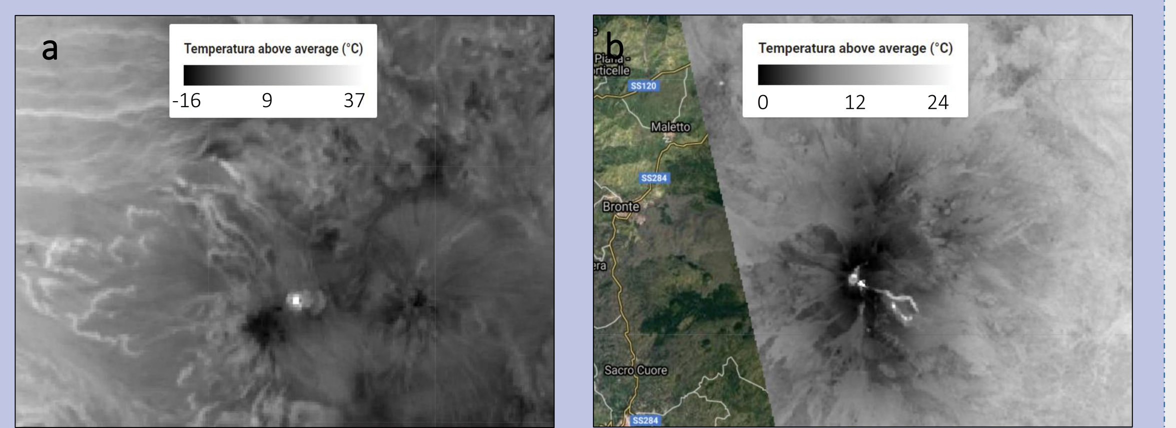


Fig.1. ASTER acquisition over Lascar, 21/10/05 03:16 (a) and Etna - 06/09/04 21:02 (b)

HIGH TEMPORAL RESOLUTION: MODIS

MODIS is on board of Terra and Aqua satellites. The MODIS sensors are viewing the entire Earth's surface up to 4 times per day.

- Images acquired at 36 spectral bands at 1km are available
- Level 2 LST (Land Surface Temperature) is used

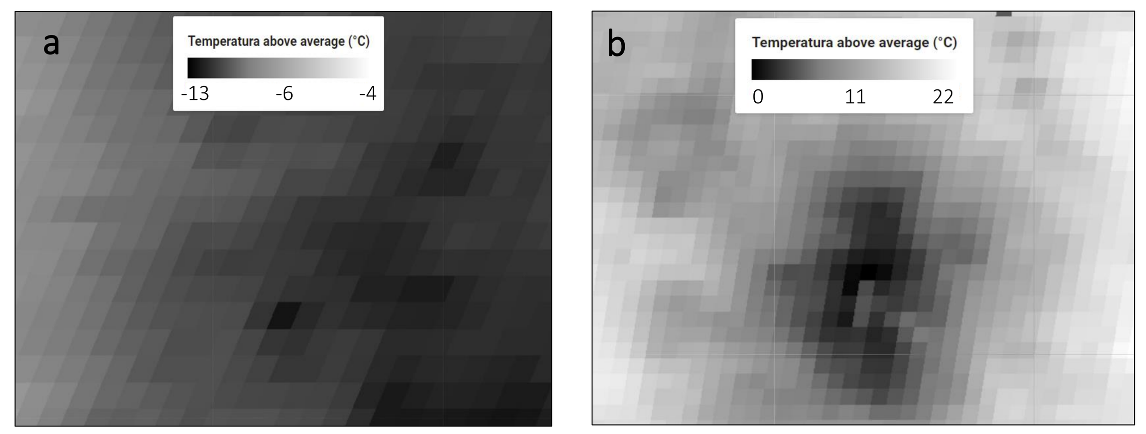


Fig. 2. MODIS acquisition over Lascar - 21/10/05 03:16 (a) and Etna - 06/09/04 21:02 (b)

ARTIFICIAL INTELLIGENCE TECHNIQUES FOR VOLCANIC THERMAL FEATURE DETECTION

SPATIAL VOLCANIC THERMAL FEATURE EXTRACTION USING DEEP LEARNING (DL)

Supervised techniques require a large volume of training labeled data. Here we use a statistical approach (more details in V35E-0178) to label data followed by an expert supervision step required to check correctly labeled images, which serve as a target. Input and target data are then processed and fed into a UNET that will learn volcanic thermal features against background, clouds and missing data (i.e. border pixels with missing values).

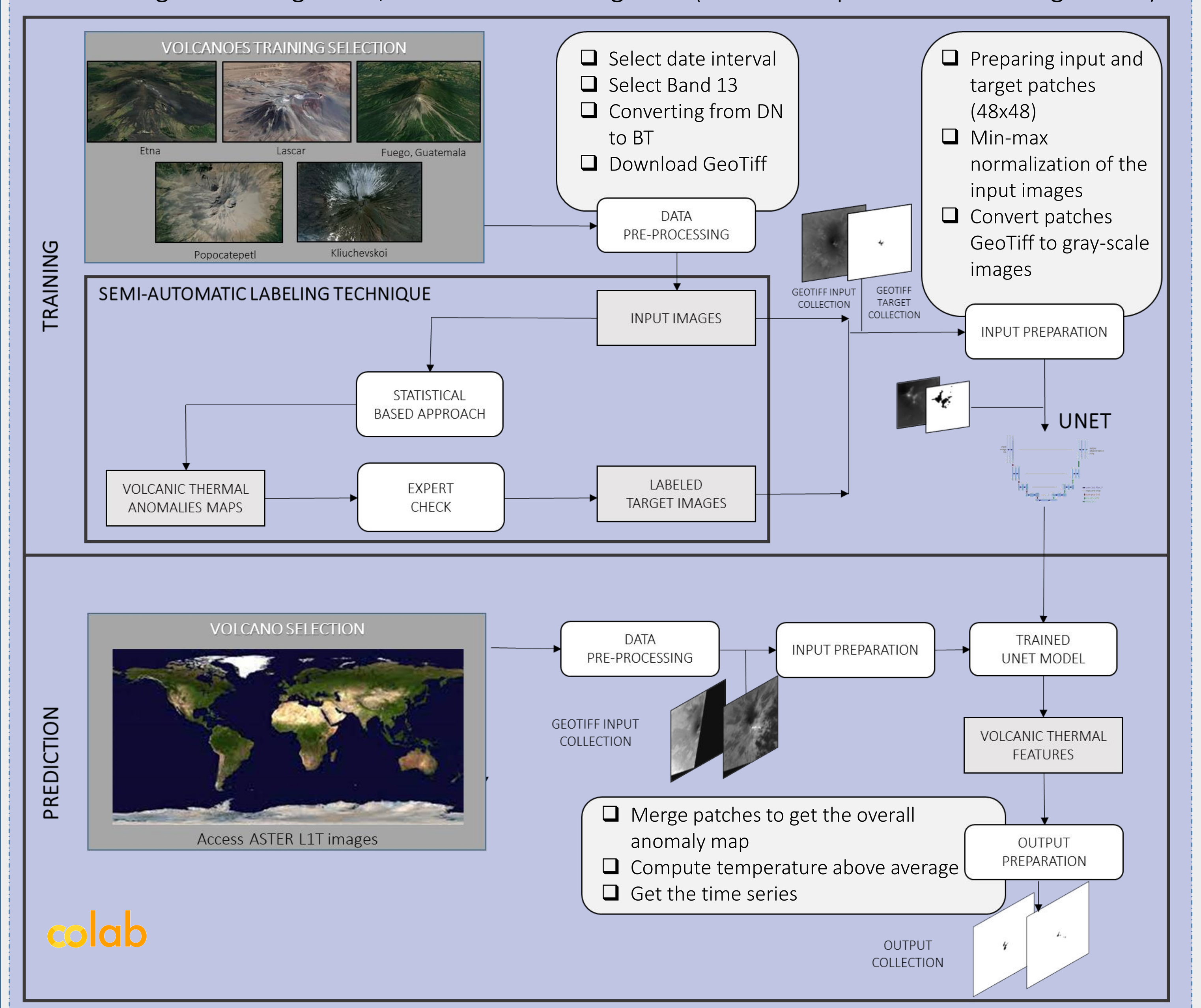


Fig. 3. Workflow of the proposed deep learning (DL) approach to retrieve volcanic spatial thermal features.

TEMPORAL VOLCANIC THERMAL FEATURE EXTRACTION USING ARTIFICIAL INTELLIGENCE (AI)

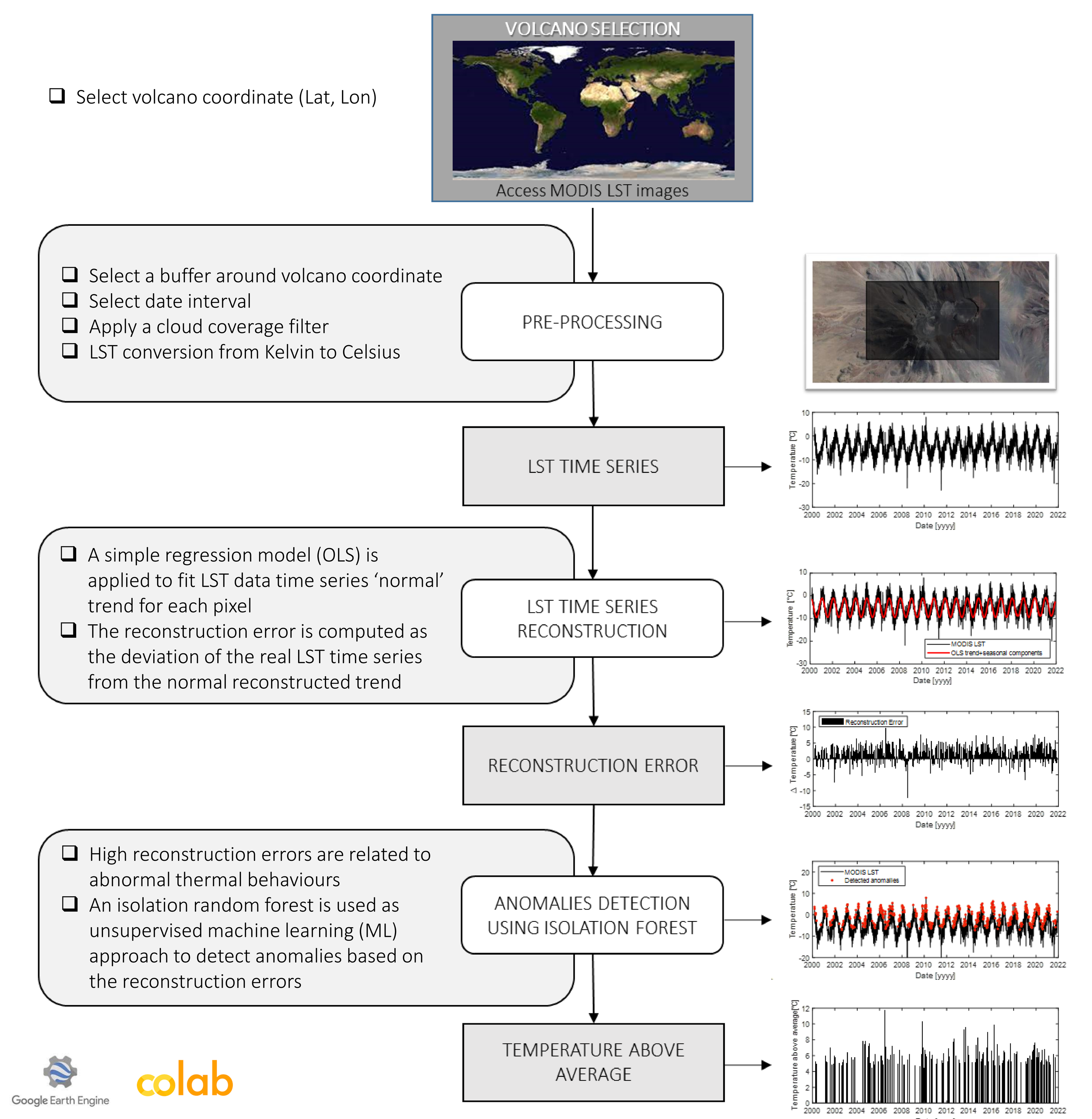
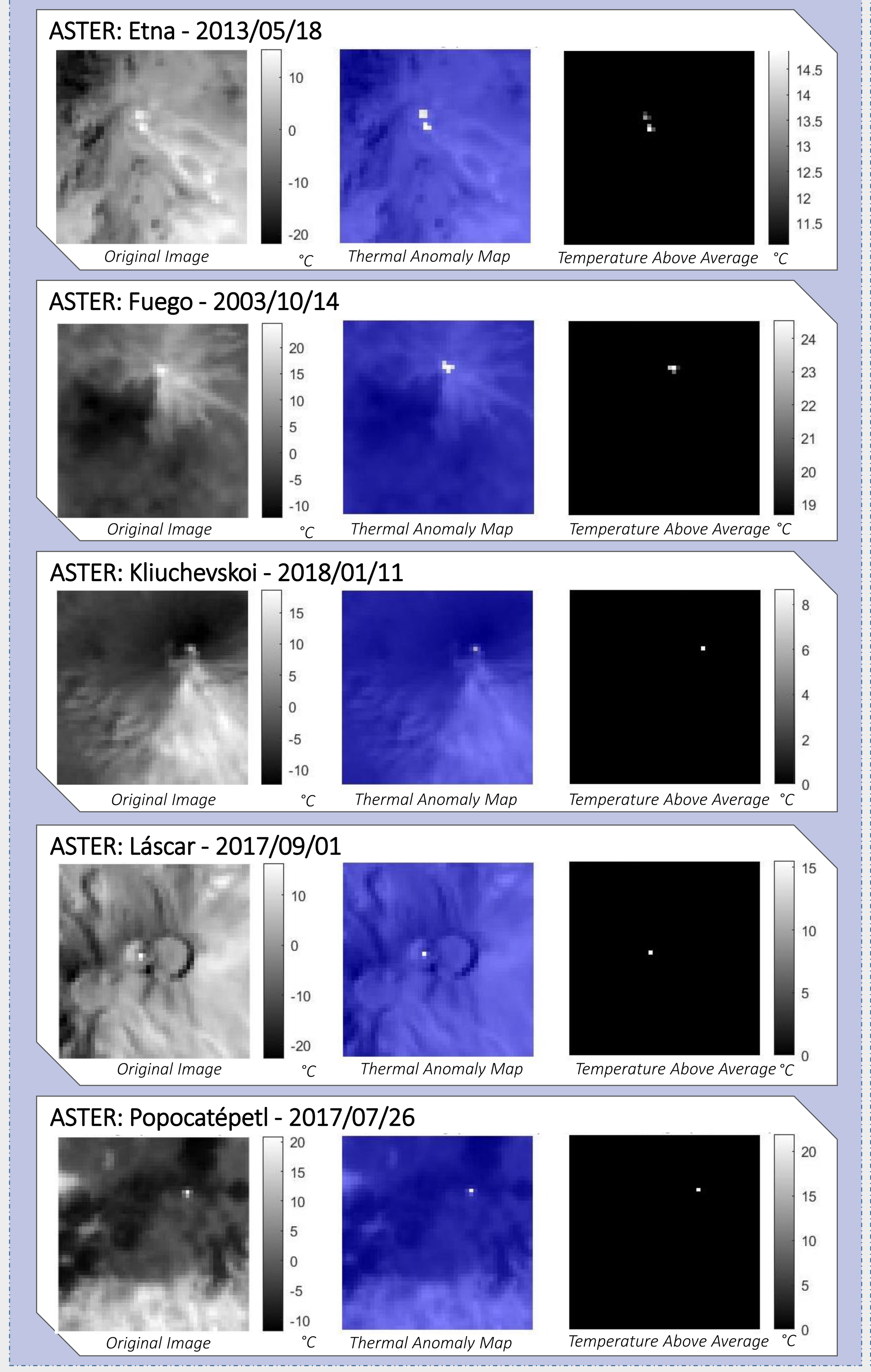


Fig. 4. Workflow of the proposed artificial intelligence (AI) approach to retrieve temporal volcanic thermal features. Graphs show the time series of the maximum values inside the region of interest

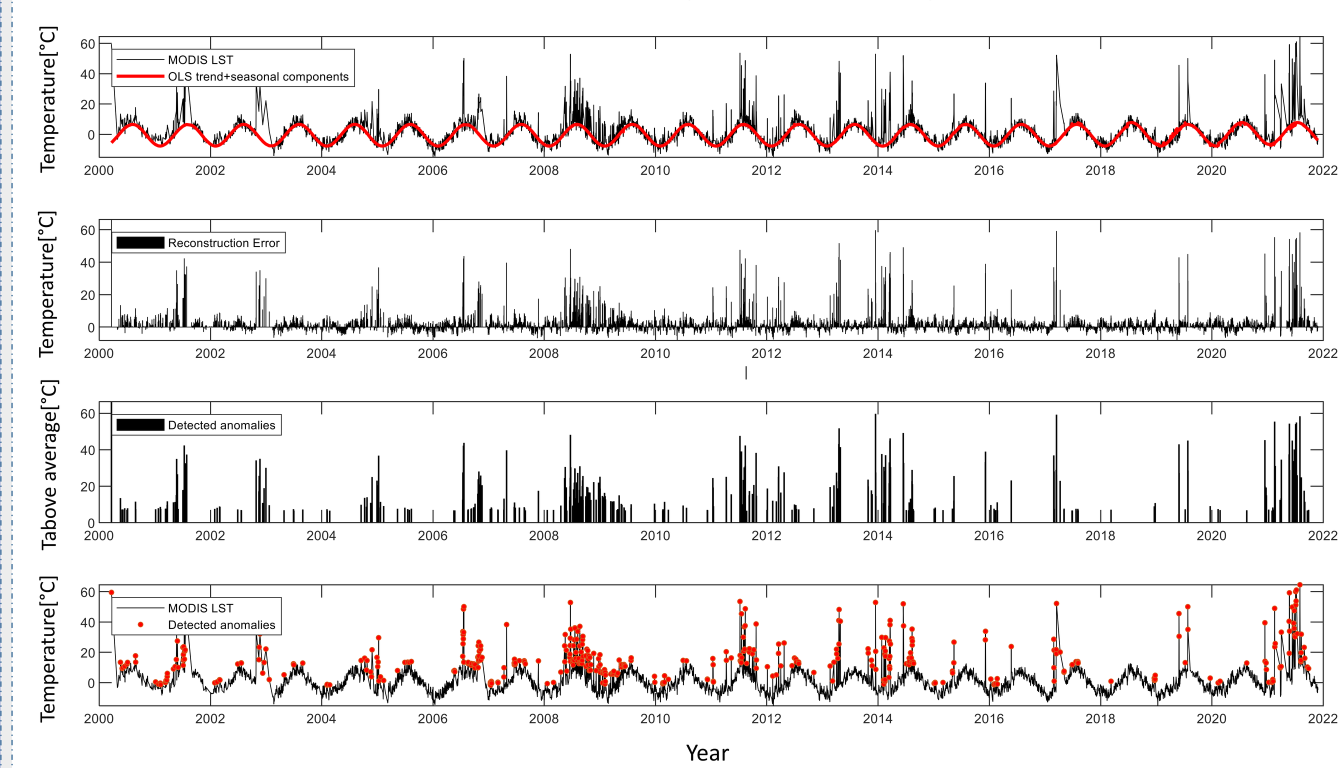
RESULTS

SPATIAL VOLCANIC THERMAL FEATURES EXTRACTION USING DL

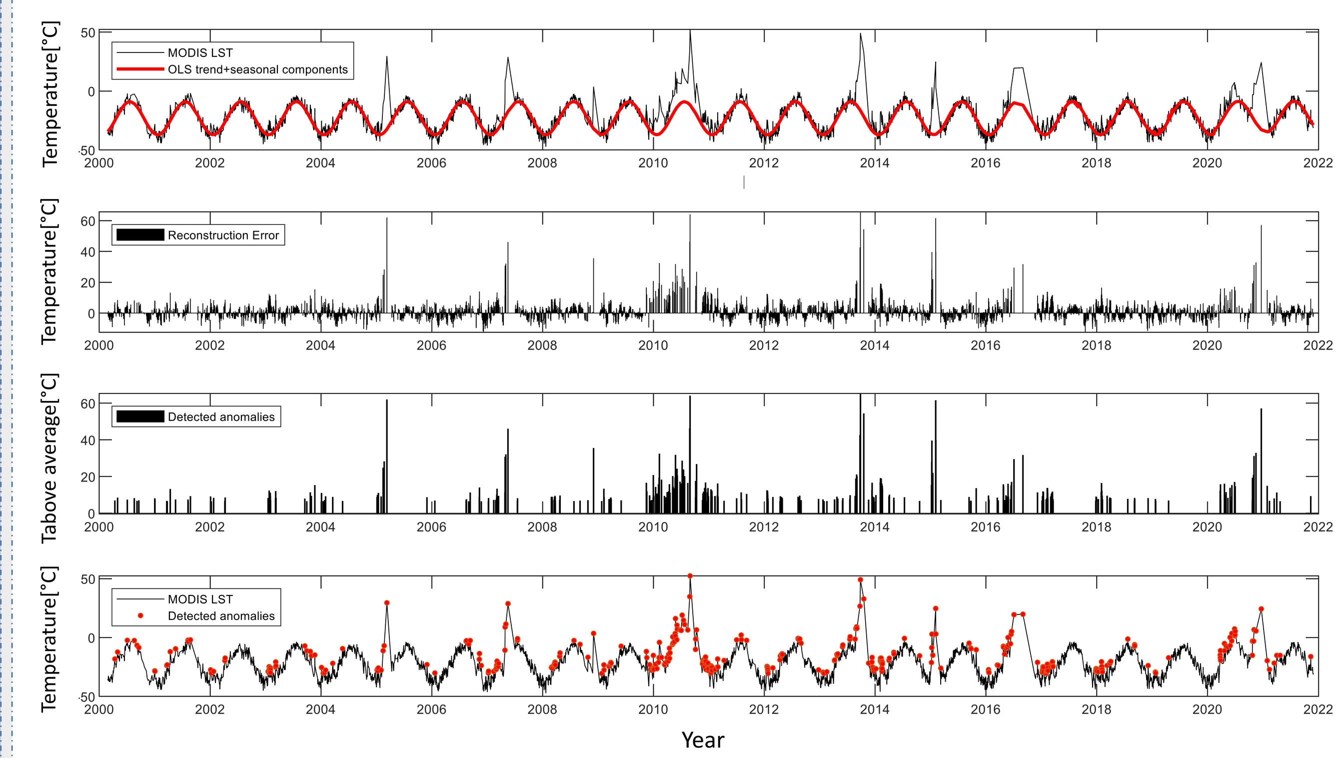


TEMPORAL VOLCANIC THERMAL FEATURES EXTRACTION USING AI

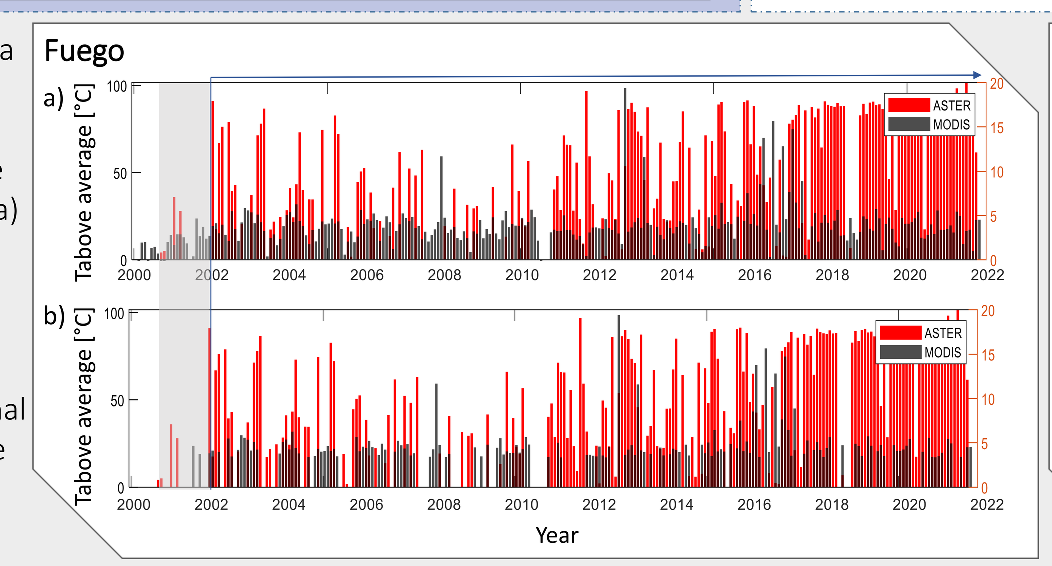
MODIS: Etna (2000 to 2021)

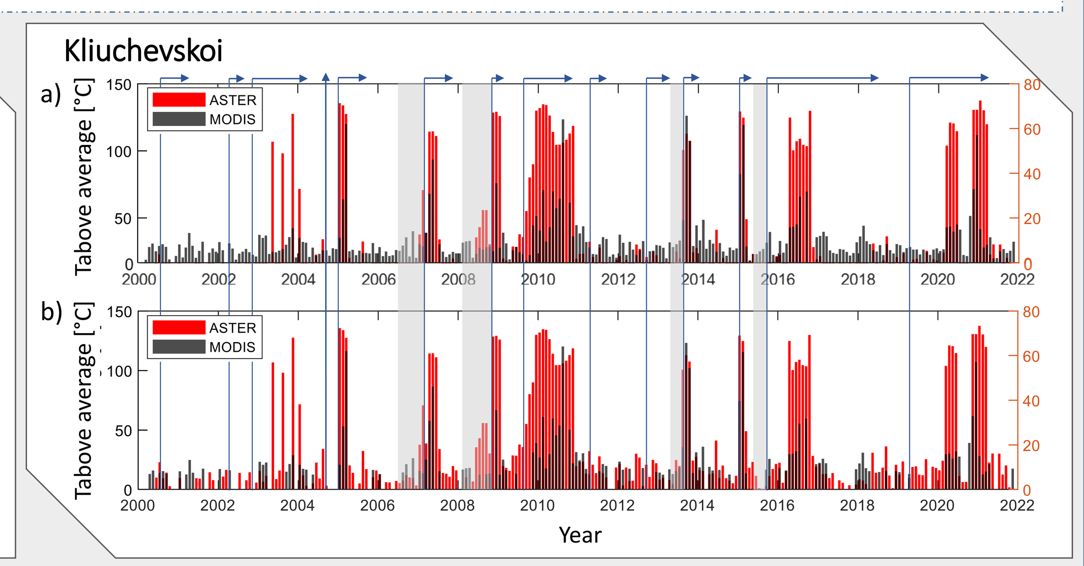


MODIS: Kliuchevskoi (2000 to 2021)



- ASTER and MODIS data are shown together
- For each month, the maximum value of the reconstruction error (a) and the detected anomalies (b) are shown
- For some eruptions (blue arrows), a thermal increase occurs before an eruption (gray shaded area)





CONCLUSIONS

An AI approach has been designed to automatically extract volcanic features both spatially (exploiting high spatial resolution satellite thermal data using convolutional neural networks) and temporally (exploiting high temporal resolution satellite data using the isolation random forest as anomaly detection algorithm). With these techniques, very large datasets can be easily processed and high temporal and high spatial resolution satellite data combined to improve thermal volcanic precursory monitoring by detecting very low-level anomalies linked to pre-eruptive activity.

REFERENCES

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