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Multi-temporal thermal analyses for submarine groundwater discharge (SGD) detection over large spatial scales in the Mediterranean

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Submarine groundwater discharge (SGD) sites act as important pathways for nutrients and contaminants that deteriorate marine ecosystems. In the Mediterranean it is estimated that 75% of freshwater input is contributed from karst aquifers. Thermal remote sensing can be used for a pre-screening of potential SGD sites in order to optimize field surveys. Although different platforms (ground-, air- and spaceborne) may serve for thermal remote sensing, the most cost-effective are spaceborne platforms (satellites) that likewise cover the largest spatial scale (>100 km per image). Therefore an automatized and objective approach that uses thermal satellite images from Landsat 7 and Landsat 8 was used to localize potential SGD sites on a large spatial scale. The method using descriptive statistic parameter specially range and standard deviation by (Mallast et al., 2014) was adapted to the Mediterranean Sea. Since the method was developed for the Dead Sea were satellite images with cloud cover are rare and no sea level change occurs through tidal cycles it was essential to adapt the method to a region where tidal cycles occur and cloud cover is more frequent . These adaptations include: (1) an automatic and adaptive coastline detection (2) include and process cloud covered scenes to enlarge the data basis, (3) implement tidal data in order to analyze low tide images as SGD is enhanced during these phases and (4) test the applicability for Landsat 8 images that will provide data in the future once Landsat 7 stops working.
As previously shown, the range method shows more accurate results compared to the standard deviation. However, the result exclusively depends on two scenes (minimum and maximum) and is largely influenced by outliers. Counteracting on this drawback we developed a new approach. Since it is assumed that sea surface temperature (SST) is stabilized by groundwater at SGD sites, the slope of a bootstrapped linear model fitted to sorted SST per pixel would be less steep than the slope of the surrounding area, resulting in less influence through outliers and an equal weighting of all integrated scenes.
Both methods could be used to detect SGD sites in the Mediterranean regardless to the discharge characteristics (diffuse and focused) exceptions are sites with deep emergences. Better results could be shown in bays compared to more exposed sites. Since the range of the SST is mostly influenced by maximum and minimum of the scenes, the slope approach can be seen as a more representative method using all scenes.
References:
Mallast, U., Gloaguen, R., Friesen, J., Rödiger, T., Geyer, S., Merz, R., Siebert, C., 2014. How to identify groundwater-caused thermal anomalies in lakes based on multi-temporal satellite data in semi-arid regions. Hydrol. Earth Syst. Sci. 18 (7), 2773-2787.