Eidgenössische Technische Hochschule Zürich

中国地质环境监测院
China Geo Environmental Monitoring Institute

GENERATING LARGE SCALE SOIL SALINITY MAPS WITH GEOPHYSICS AND REMOTE SENSING

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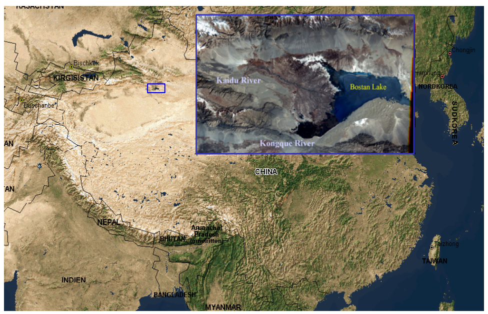
Introduction

Project area and rational

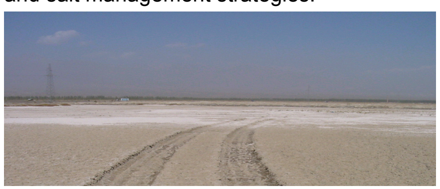
The project site is the semi-arid Yanqi Basin in Xinjiang Province, China. The Yanqi Basin is one of the most productive agricultural areas in this remote Chinese province. Intensive irrigation without drainage has caused a remarkable rise of the groundwater table. A large amount of water is evaporated directly from the groundwater leading to severe salinity problems in the Basin itself and in the downstream systems. Today, 46% of the crop land in Yanqi Basin is threatened by soil salination. As a consequence, crop yields are reduced and the downstream ecosystems and irrigation areas are endangered.



The Yanqi Basin is located in the TianShan mountain range between the Tarim Basin in the south and the Gobi Desert in the north.

Irrigation is based on the water of the Kaidu River.

Quantifying distribution and extent of salinity in any irrigation area is crucial for the evaluation and the development of water and salt management strategies.



A completely salinised field in the Yanqi Basin. Salination reduces crop yields and can even destroy the soil structure.

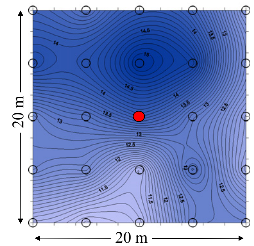
The method described in this paper allows to generate highly resolved salinity maps based on multispectral images and ground measurements. Large areas can be mapped in a short time with this method.

Ground Truth

Methods

Ground truth consists of a combination of different methods:

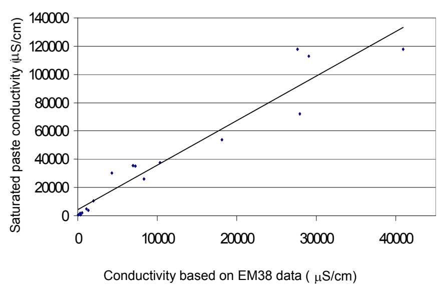
- Electromagnetic induction (using EM38): Quickly obtained measurements yield a three layered model of the soil conductivity (0-30 cm, 30-60 cm, 60-90 cm)
- Saturated paste conductivities of soil samples from different depths (Auger samples in the field)



EM38 measurements were performed every 5 meters (○) over a regular grid. Soil samples were taken in the centre of the layout (●). The figure shows interpolated point values of the horizontal EM38 reading. Together with measurements done in the vertical orientation of the instrument, the average conductivity for the three layers can be determined.

Relation between EM38 and soil samples

For each model layer, conductivities obtained from EM38 data were plotted against saturated paste conductivities of the soil samples. If the depth of the soil sample did not exactly match the depth of the EM38 model layer, a depth weighted average was calculated.

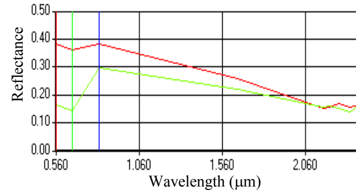


Correlation in the first layer (0- 30 cm) between EM38 measurement and the soil sample. Similar correlation coefficients are also found for the second and third layer.

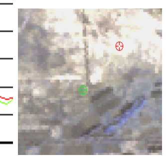
Conductivity data obtained with the EM38 were scaled according to the correlation.

Obtaining Salinity Maps and the Combination with Ground Truth

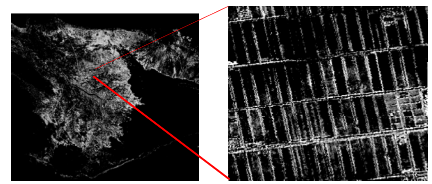
The calculation of uncalibrated salinity maps is based on atmospherically corrected reflectance images recorded by the ASTER sensor. Corrected ASTER images can be obtained for free and feature a high spatial and a satisfactory spectral resolution (nine channels). Using Spectral Correlation Mapper algorithms, a map consisting of the spectral similarity of every pixel to a completely salinised reference pixel (⊕) can be obtained. If the correlation between ground truth and the uncalibrated salinity map is significant, the map values can be scaled from spectral similarity to conductivity.



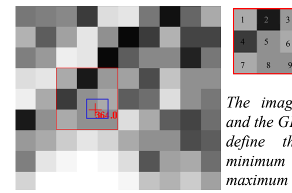
Reflectance in nine different channels over two different pixels



Due to the uncertainty of the GPS measurements, ground truth could potentially be situated on nine pixels around the estimated location. These pixels define the upper and the lower limits of spectral similarity.

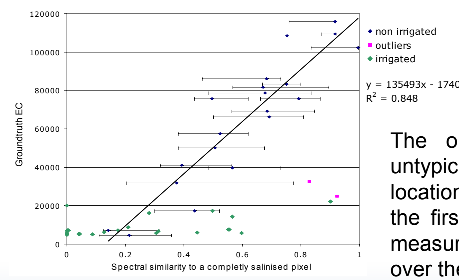


Uncalibrated salinity map: white areas feature a high spectral similarity to the salinised reference pixel. The salt leaching effect of surface irrigation is clearly visible. (Date: 11.10.2002)



The image resolution and the GPS- accuracy define the potential minimum and maximum of spectral similarity. Pixels over large roads are excluded (in this case pixel number 1,2,4,5)

As expected, the correlation holds only for non-irrigated areas. The error bars around the non-irrigated points in the plot show the maximum and the minimum similarity of the surrounding pixels.



The data points (y-axis) are the average of the scaled EM38 data (first layer). x- values are determined by the pixels that are touched of the area covered by the EM38 measurements (area weighted).

The outliers can be explained with the untypical salt profile found at these specific locations. The soil samples showed that only the first few cm are very saline. The EM38 measurements, however, yield an average over the first 30 cm.

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