REMOTE SENSING OF IRRIGATION WATER USING DIFFERENT RESOLUTION SENSORS IN THE ARAL SEA BASIN

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INTRODUCTION

Central Asia is a region plagued by both excessive irrigation and soil salinity problems. It is said to be the most saline-rich area in the world in irrigated farms. In 1994 about 40 percent of irrigated land was considered saline and this figure is higher today. Fig.1 shows a typical irrigated land in the Aral Sea Basin while Fig.2 shows observation results on the increase of salinity levels with time and from upstream towards downstream. Salinity level generally increases towards the downstream due to salt load in the return flows from irrigated areas discharged via the collector drains, which are usually poorly maintained.

Fig. 1 Typical furrow irrigation in Uzbekistan (Forkutsa 2002)

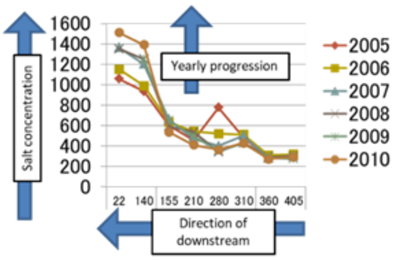

Fig.2 Salinity increase in Zeravshan river (Khujanazarov et. al 2012)

SATELLITE ANALYSIS

Satellite sensors with different resolutions were used for this study. These include; MODIS (Moderate Resolution Imaging Spectro-radiometer) sensor land surface temperature data. This data is at a time resolution of 12 hours and a spatial resolution of 1km. MODIS collects daily global observations at approximately 11:30 a.m. and 11:30 p.m. and 1:30 a.m. and 1:30 p.m. equatorial crossing time for Terra and Aqua satellites respectively.

Secondly, analysis of MODIS NDVI (Normalized Difference Vegetation Index) data was carried out. The NDVI data used in this study is 16-day composite data at a spatial resolution of 250m. NDVI provides a consistent spatial and temporal comparisons of vegetation canopy greenness, a composite property of leaf area, chlorophyll and canopy structure.

Thirdly, analysis of METEOSAT 8 IODC (Indian Ocean Data Coverage) data was carried out. METEOSAT 8 is a Geostationary satellite from the intergovernmental organization (EUMETSAT).

This satellite has a temporal resolution, of 15 minutes. Its Spatial resolution for visible channels is 1km for High Resolution Visible (HRV) channel, while that of infrared channels is 3km. The satellite was recently moved to its new position 41.5E and has been providing coverage data since 1st February 2017. METEOSAT 8 data presents an opportunity to observe and understand the irrigation regime applied by farmers at a wide scale. The satellite's high temporal resolution enables the evaluation of the rate of temperature changes with time.

METHODOLOGY

Water has a higher heat capacity than land. This means that a layer of water added to the soil does not respond immediately to changes in temperature. Therefore, this property could be used to detect irrigation water.

For MODIS sensor land surface temperature, Eq. (1) and Eq. (2) below were used to analyze the data. These represent the indices used for irrigation water detection.

⊿LST = LST day – LST Night (1)

⊿LST – Average ⊿LST of surrounding area (2)

Where:

LST day is satellite based day time recorded temperature

LST Night is satellite based night time recorded temperature

⊿LST is the difference between day time and night time satellite recorded temperature.

Eq. (1) represents an index which can be used to detect; (i) Change in Temperature difference over time. (ii) Trend in Land surface temperature distribution.

Both Eq. (1) and (2) can be used to Estimate total area of land under irrigation. However, Eq. (2) represents a more suited index as it can remove climatic influence of the surrounding.

METEOSAT 8 High Rate SEVIRI Level 1.5 Image data was used in this research. Cloud effect was corrected based on cloud mask data from EUMETSAT. Moreover, for heat capacity analysis to assess the irrigation regime, it is vital to isolate temperature changes resulting from rainfall from that of irrigation effect. Global Satellite Mapping of Precipitation (GSMaP) data was used to mask out the clouds and identify precipitation incidences to remove rainfall effect on surface temperature.

Key words: Remote sensing, Irrigation water requirement, Aral Sea Basin
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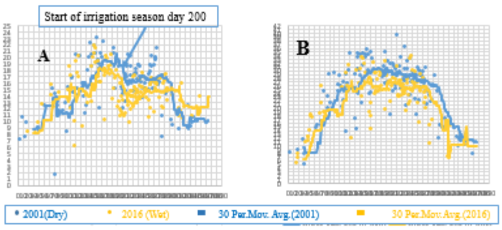
In-situ field measurement

Fig.3 below shows the extent of the study area for this research. There are three testing farms in Uzbekistan. Bayavut, Kyzylkesec and Nukus collaborating with ICARDA (International Center for Agricultural Research in the Dry Areas). These sites are shown by the red dots in Fig.3 below. Soil Moisture is kept at a specific level. Nukus was instated as a testing farm in 2015. Located in a severely arid region and is the most sensitive to climate change. (Touge et al., 2015)

Fig.3 Irrigation observation sites in Aral Sea Basin (P. Micklin, 2006).

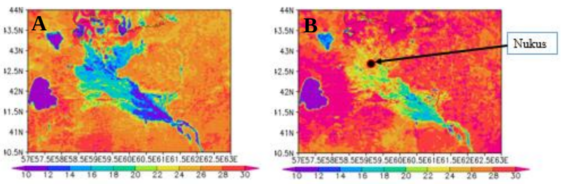
RESULTS AND DISCUSSION

MODIS ⊿LST time series data shows a clear difference between an irrigated point and one which is not. Since water has a higher heat capacity than soil. A layer of water added to the soil does not immediately respond to temperature changes. Fig.4 (A) and (B) below show a 16-year time series analysis of ⊿LST[K] from MODIS data. (A) shows a drop in temperature during summer where irrigation water is added to the soil. Fig.5(A) and (B) shows ⊿LST [K] distribution during the irrigation season day 220 both in wet year 2016 and Dry year 2001 in the Karakalpakstan region. Nukus site is located in this region.



(A) Irrigated point (60.5E, 41.5N). (B) Non-irrigated point (63E, 44N).

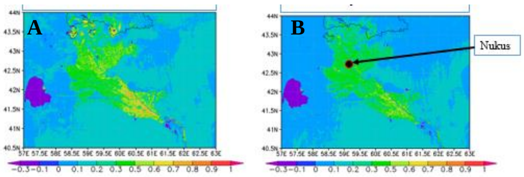
Fig.4 ⊿LST[K] time series by MODIS.



(A) Wet year 2016. (B) Dry year 2001.

Fig.5 ⊿LST[K] distribution from MODIS.

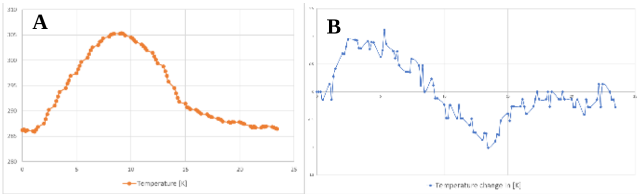
Fig.6 (A) and (B) show MODIS NDVI distribution of the in Karakalpakstan region. During the wet year 2016, NDVI is shown to increase but it decreases during the dry year 2001. It can be deduced that ⊿LST shows a much clearer picture of the impact of a dry year on irrigation water as compared to NDVI. 2000 and 2001 were famously dry years, about 90% of the rice crop and 75% of the cotton crop were lost due to drought (FAO, 2013).



(A) Wet year 2016. (B) Dry year 2001.

Fig.6 NDVI distribution from MODIS.

Figure 7 (A) and (B) below show the time series of METEOSAT 8 derived brightness temperature on Bayavut site (69.0059E, 40.2847N) on 24th August 2017. Due to the high time resolution, it presents an opportunity to estimate the heat capacity from the rate of temperature change with time.



(A) Time series data. (B) Trend of Temperature change

Fig.7 Brightness temperature[K] time series data

CONCLUSION

Knowledge of the irrigation regime is important to mitigate soil salinity and understand climate variability. Heat capacity difference between water and soil thus presents an effective opportunity for this function as it can be used for the detection of irrigated land, drought and the identification of the irrigation regime.

ACKNOWLEDGEMENT

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