SPACE TECHNOLOGIES AND GROUNDWATER

SATELLITE BASED SPATIO-TEMPORAL VARIATION OF GROUNDWATER STORAGE WITH SPATIAL REGRESSION MODEL (GTWR)

BY

DR. KHALID MAHMOOD

(CO-PI, REMOTE SENSING, GIS AND CLIMATIC RESEARCH LAB, NCGSA, PAKISTAN)
(ASSISTANT PROFESSOR, SPACE SCIENCE, UNIVERSITY OF THE PUNJAB, PAKISTAN)

INTRODUCTION

- A lot of development has been made by scientists worldwide in developing technology for better understanding the environment, and providing scientific support to decision makers for better planning and effective utilization of resources.

INTRODUCTION:THE PROBLEM

- Most of the models are well-suited to developed world as there are no constraints of budget and technology, whereas, the same is very different in context of developing/under-developed world. In developing world, due to lack of expertise and limited budget, policy makers usually remain unable to make use of proper scientific studies before making decision.
- The improper utilization of the limited budget usually results into finical and environmental disasters.

INTRODUCTION: THE SOLUTION

- In this perspective, geospatial technologies can be utilized to develop simplified and inexpensive alternates of existing methods to be easily adopted by the developing world.
- These developments of second tier of science, keeping in view economic and technical conditions of developing world, can utilize freely available satellite data.
- This class of satellite data has greatly been improved in recent times.

THE PURPOSE

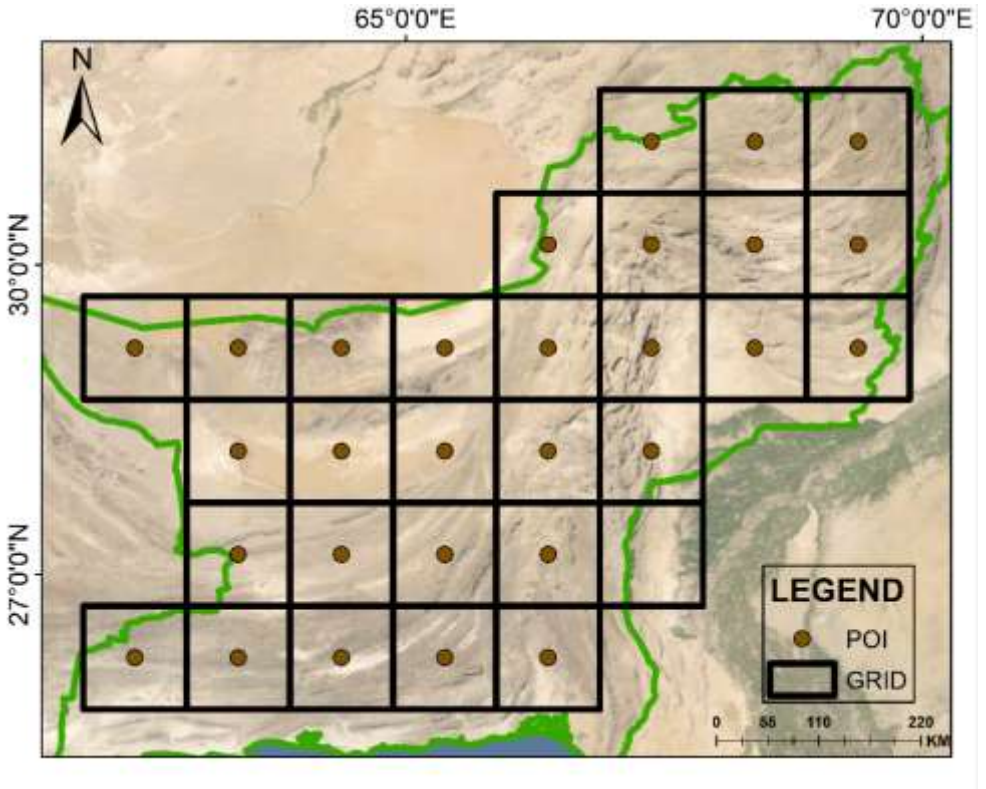
- The main purpose of this talk is to emphasize the development and purification of satellite based observations, along with proper spatial analysis, as an easy and cost effective substitute of expensive and time intensive ground measurements for groundwater fluctuations and its possible causes.
- For demonstration, geographic assessment of groundwater anomaly in Baluchistan, Pakistan has been considered.

RESEARCH OBJECTIVE

- The basic aim of the case study is to quantify the impact of controlling factors on Groundwater Storage Anomaly (GWSA) by using statistical regression model with following sub-objectives:
  - Suitability comparison of regression models
  - Dependency of GWSA on meteorological and geographical factors
  - Assessment of spatial and temporal heterogeneity to find neighborhood dependency of GWSA.

STUDY AREA : BALUCHISTAN

- Baluchistan is the largest province of Pakistan in terms of land.
- The area consists of ancient Karez water supply system.
- The region receives low rainfall, and life mainly depends on groundwater. An increase in tubewells from 5000 to more than 40000 from 1970 to date



DATASETS

- Gravity Recovery and Climate Experiment(GRACE) and Global Land Data Assimilation System(GLDAS) for the computation of Groundwater Storage Anomaly (GWSA)
- Precipitation from GPM-IMERG (Integrated Multi-Satellite Retrievals for Global Precipitation Measurement)
- Temperature and Evapotranspiration from FLDAS (Famine Early Warning Systems Network)
- Soil Moisture and runoff from TerraClimate
- Normalized Difference Vegetation Index (NDVI) from MODIS (Moderate Resolution Imaging Spectroradiometer)
- Population Density from SEDAC (Socioeconomic Data and Applications Center)

METHODOLOGY

- GWSA has been computed using GRACE and GLDAS with the relation:

$$GWSA = TWSA - (SWE + SMA + CANA)$$

TWSA: Terrestrial Water Storage Anomaly; SWE: Snow Water Equivalent; SMA: Soil Moisture Storage Anomaly; CANA: Canopy Storage Anomaly

- Fishnet extraction has been applied to GWSA as well as controlling parameters to simplify the processing.
- Suitability assessment of global regression model (OLS: Ordinary Least Square) and local regression models (GWR: Geographically Weighted Regression and GTWR: Geographically Temporal Weighted Regression) to select best fit model.
- Taking the mean values of coefficient to understand the spatio-temporal heterogeneity on the basis of best fit statistical model.

RESULTS AND DISCUSSION : OLS MODEL

- OLS ignores the spatial nature of data and has used a unit value to explore the relationship as:

$$GWSA = P^{***} + NDVI^{***} - E^{***} - T^{*} + S^{***}$$

- Runoff and population density is not significant ($p < 0.05$) because they have a very limited spread over space, generating very small coefficient of determination (13%). It is because of averaging over large area.

COMPARISON OF MODEL

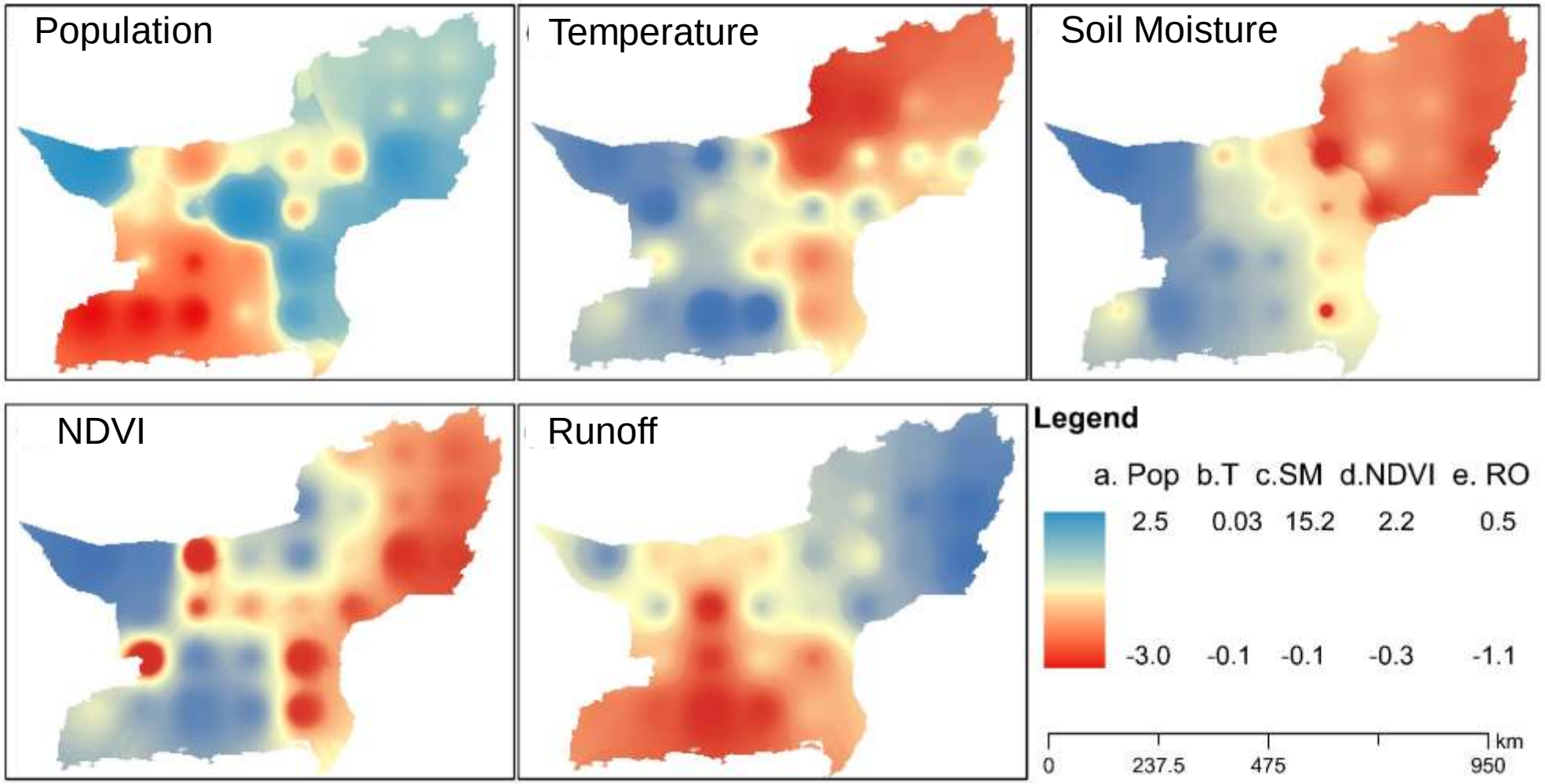
Models	R_2 (%)	AICc
OLS	13	-2567
GWR	45	-2982
GTWR	**84**	**-4496**

NON-STATIONARITY TEST FOR LOCAL MODELS

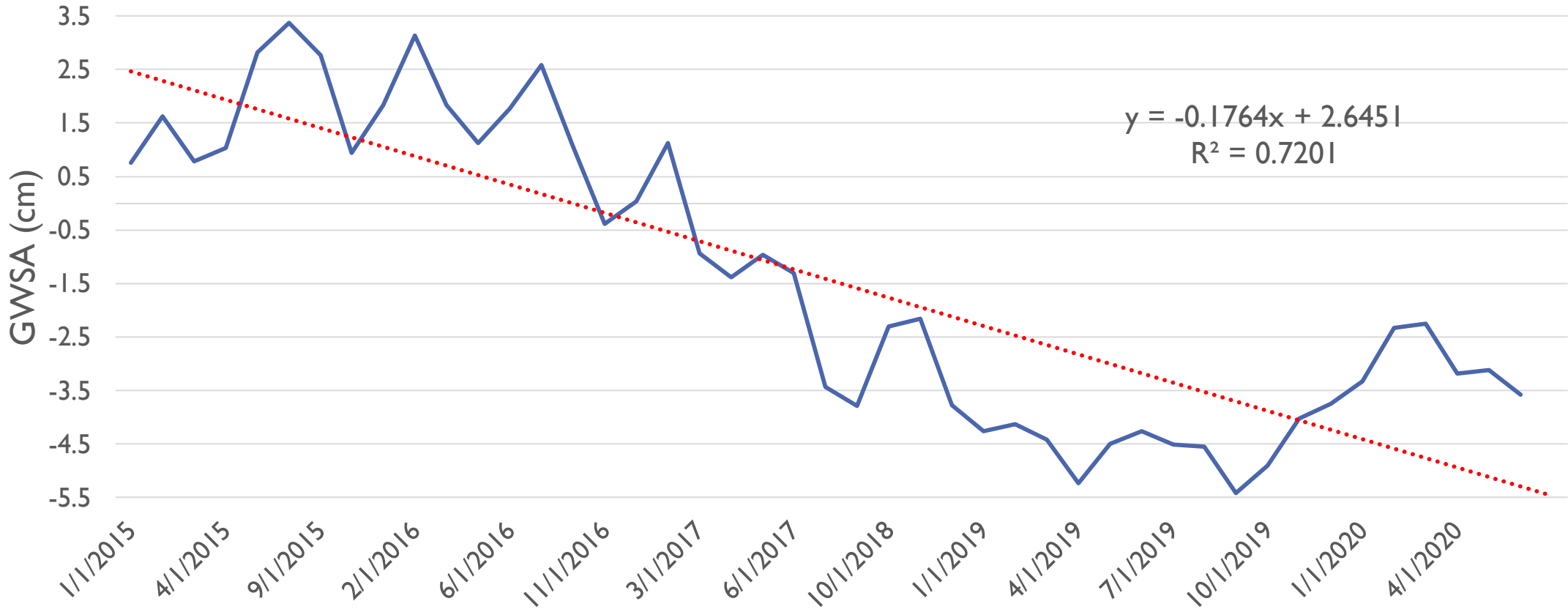
Non-stationarity of the parameters has been checked by comparing the interquartile range of the local model coefficients with Twice Standard Error (2xSE) from global model.

Indicators	GTWR	GWR	2(S.E.) OLS	Local Variation
Precipitation	0.08	0.13	0.211668	**No**
NDVI	0.43	0.38	1.19E-05	Yes
Temperature	0.06	0.03	0.000669	Yes
Population	0.76	0.95	3.24E-05	Yes
Runoff	0.85	0.96	0.001254	Yes
Soil Moisture	0.48	0.44	0.000248	Yes
Evaporation	0.08	0.10	0.117151	**No**

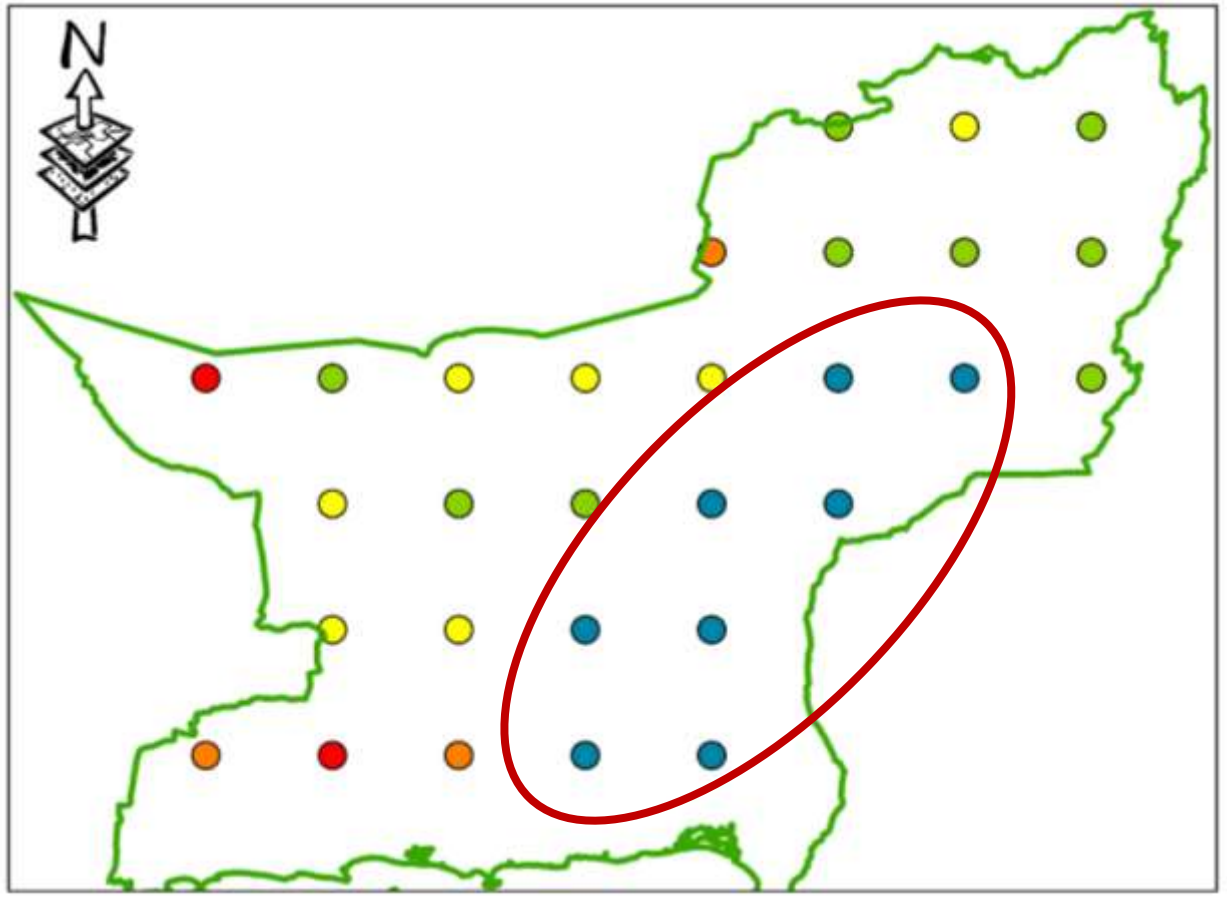
SPATIAL IMPACT OF CONTROLLING FACTORS ON GWSA

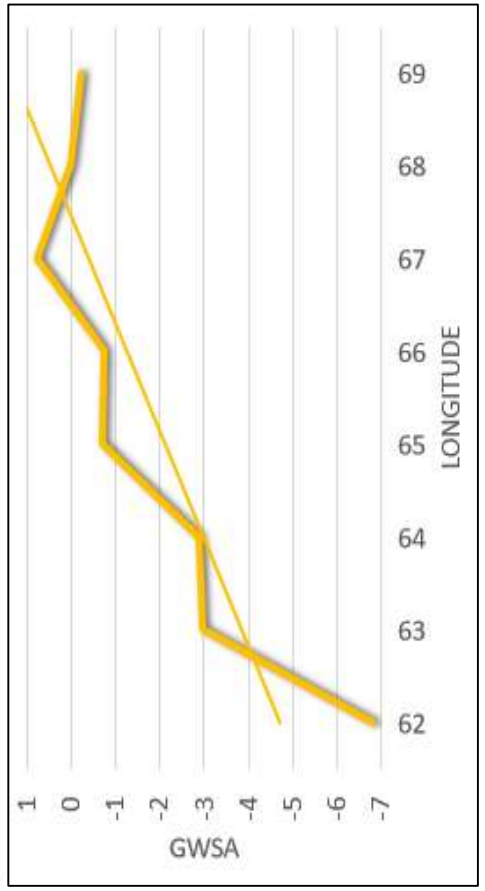


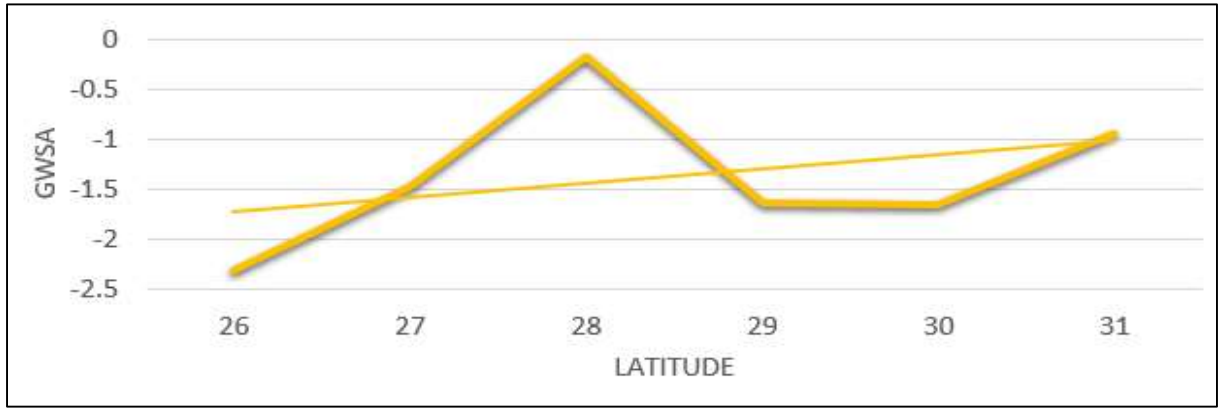
TEMPORAL HETEROGENEITY

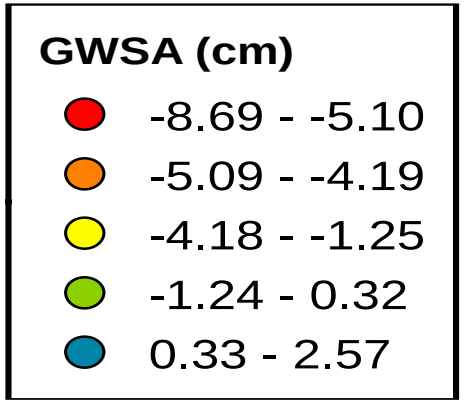


SPATIAL HETEROGENEITY

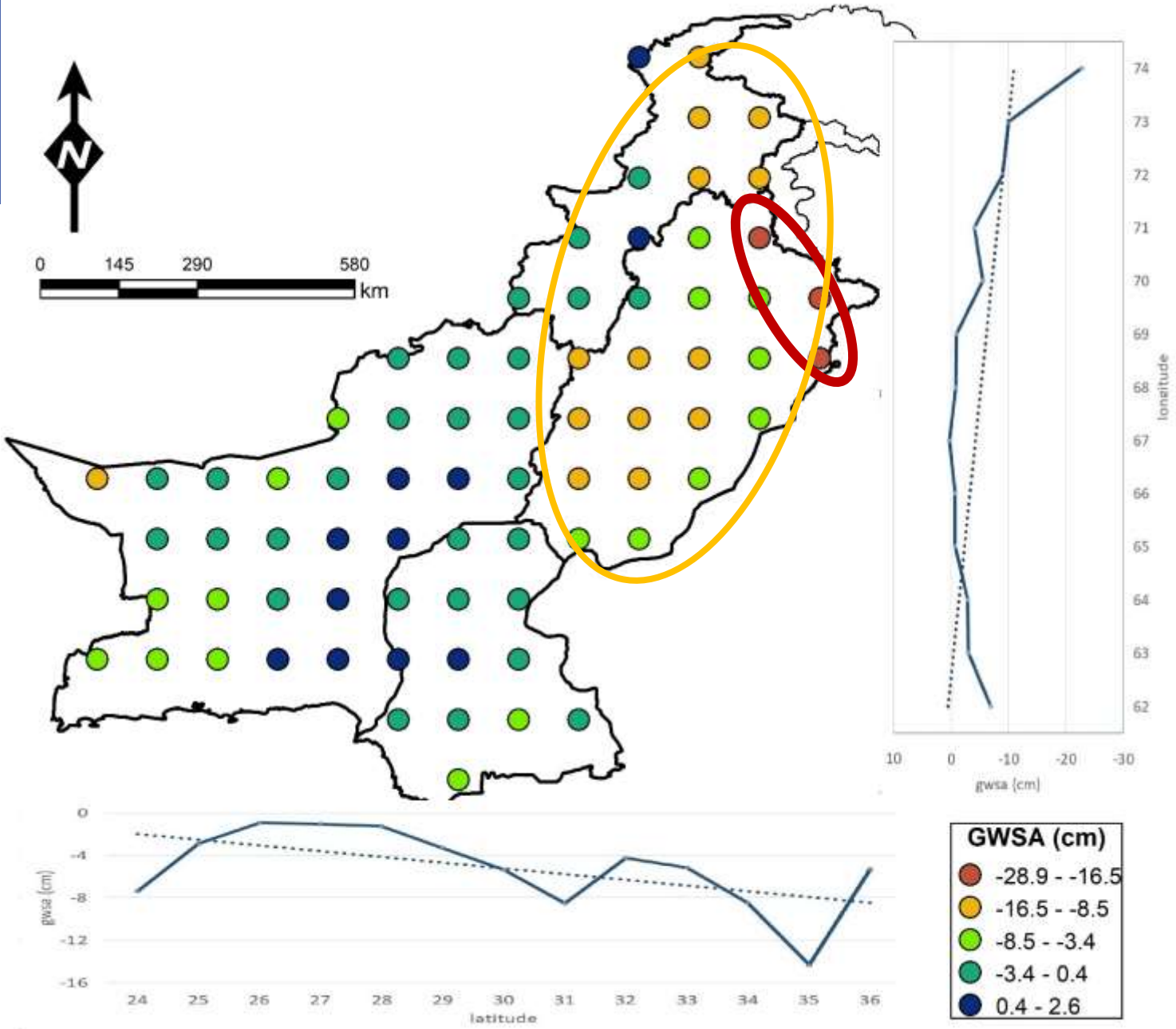








THE BIG PICTURE



CONCLUSIONS AND RECOMMENDATIONS

1. Use of Space technologies with proper spatial analysis needs to be encouraged at a bigger scale as Economic Alternative, and to understand the big picture of scenario for decision making.

- Availability of free satellite data sets
- Training of geospatial techniques for developing countries

2. Water Resources needs global plans above regional politics, otherwise, we all get dry one day.

- Preparation of global datasets
- Balancing of resources through international laws

THANK YOU