المؤتمر العربي الخامس للمياه

22 - 23 نوفمبر 2023 | الرياض - المملكة العربية السعودية

Leveraging Remote Sensing and Numerical Models Data for Enhanced Water Resources Management in the Arabian Peninsula

وزارة البيئة والمياه والزراعة
Ministry of Environment Water & Agriculture

المؤتمر العربي الخامس للمياه

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Overview

Motivation

Methods

Results

Conclusions

Implementation: Water Ready Region

Motivation

- Addressing Water Scarcity and Climatic Challenges in the Arabian Peninsula
- Harnessing Technological Advancements for Enhanced Hydrological Understanding
- Leveraging Cloud-based solutions for Innovative Water Resources Management

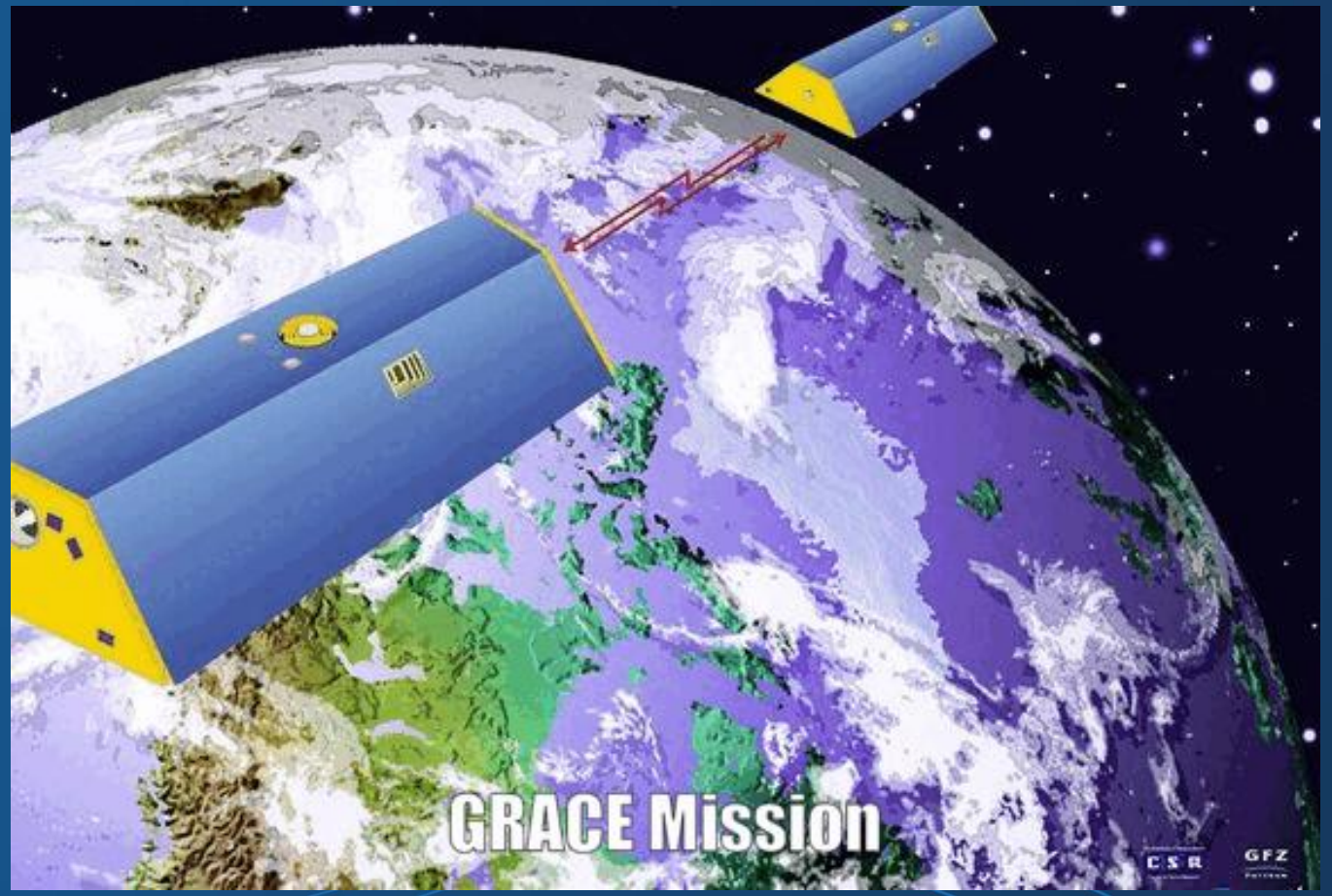
January 24, 2005- NASA's Terra observation

Remote Sensing-Based Data

GRACE Mission:
- Provides monthly "Equivalent Water Thickness" data reflecting TWS anomalies.

Normalized Difference Vegetation Index (NDVI):
- Sourced from MODIS surface reflectance data.

SMAP Mission:
- Global coverage of soil moisture observations



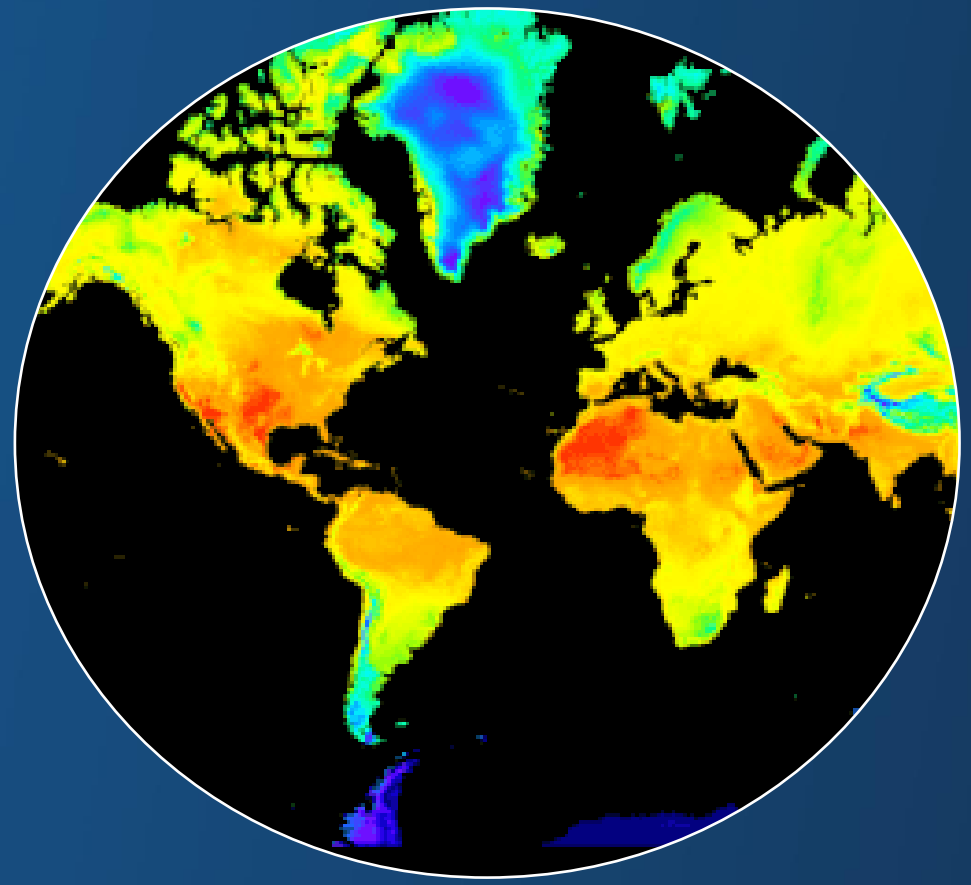
Model-Based Data

ERA5-Land Reanalysis:

- High-resolution land variable data set over several decades.
- Integrates global observations with model data for coherent analysis.

Data Coverage and Resolution:

- Daily aggregated data from 1950 to present
- Facilitates diverse climatological applications due to extensive temporal coverage.



Methods - Climatological and Trend Analysis

Objective of Analysis:
Investigate temporal and spatial fluctuations of key water components from 2002 to 2017.
Need for Real-Time Monitoring:
Identified the necessity for near real-time systems to monitor climate components.
Utilized Climate Engine platform for advanced statistical analyses.
Analytical Techniques Used:
Time series analysis at point-based and regional levels.
Mann-Kendall test for trend detection.
Sen's slope estimator for quantifying rate of change.
Outcome:
Revealed significant patterns in water resource dynamics.
Stressed the critical need for real-time management strategies.

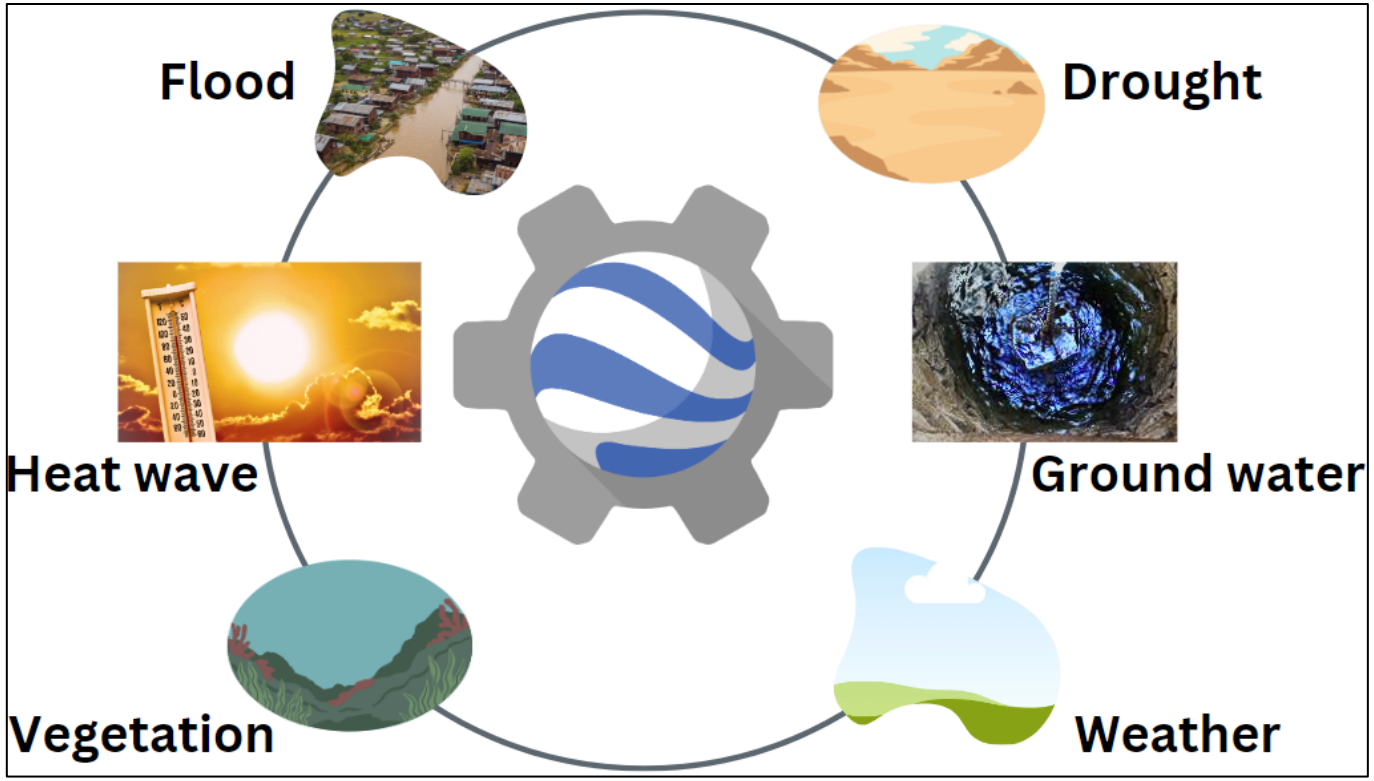


Illustration of integrated near real-time monitoring system for informed water resources management

Methods - Utilizing Google Earth Engine (GEE)

Integration with GEE:
Applied the study's methods within the Google Earth Engine platform.
Leveraged GEE's extensive Earth Observation (EO) data catalog.
Capabilities of GEE:
Enabled swift algorithm development and analysis.
Provided powerful computational resources for large-scale data processing.
Advantages of Cloud-Based Analysis:
Facilitated remote sensing data access and visualization.
Enhanced efficiency in handling and analyzing vast datasets.
Synergy with Other Platforms:
Compatible with GIS software and Python for expanded applications.
Supported comprehensive water resources monitoring and management.

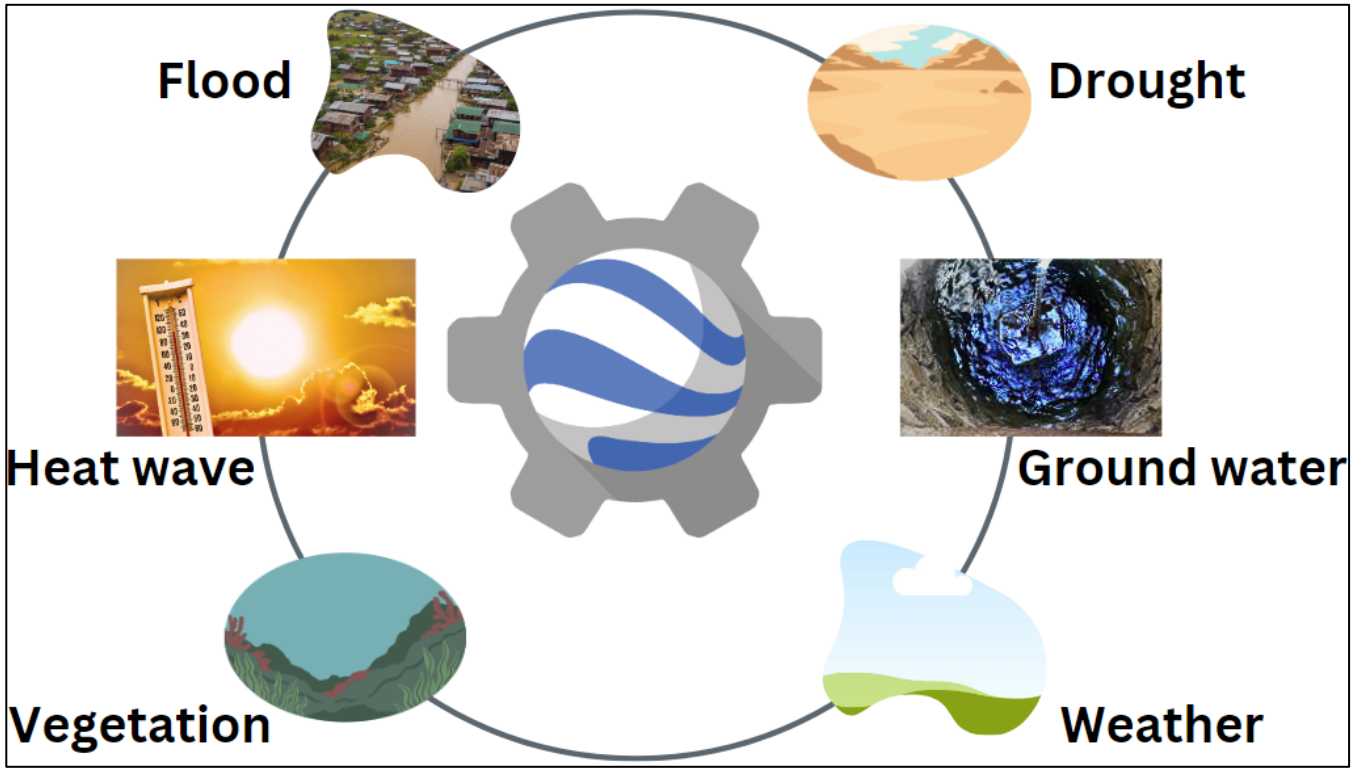


Illustration of integrated near real-time monitoring system for informed water resources management

Results - Data Extraction and Analysis

Precipitation Trends

- Consistent declining trend across AP, posing challenges for water resource management.

GRACE Water Storage Trends:

- Detected significant negative trend coefficients in TWS, indicating depletion.
- Range of anomalies: −9.2 × 10^−2 to −0.6 × 10^−2 cm/month.

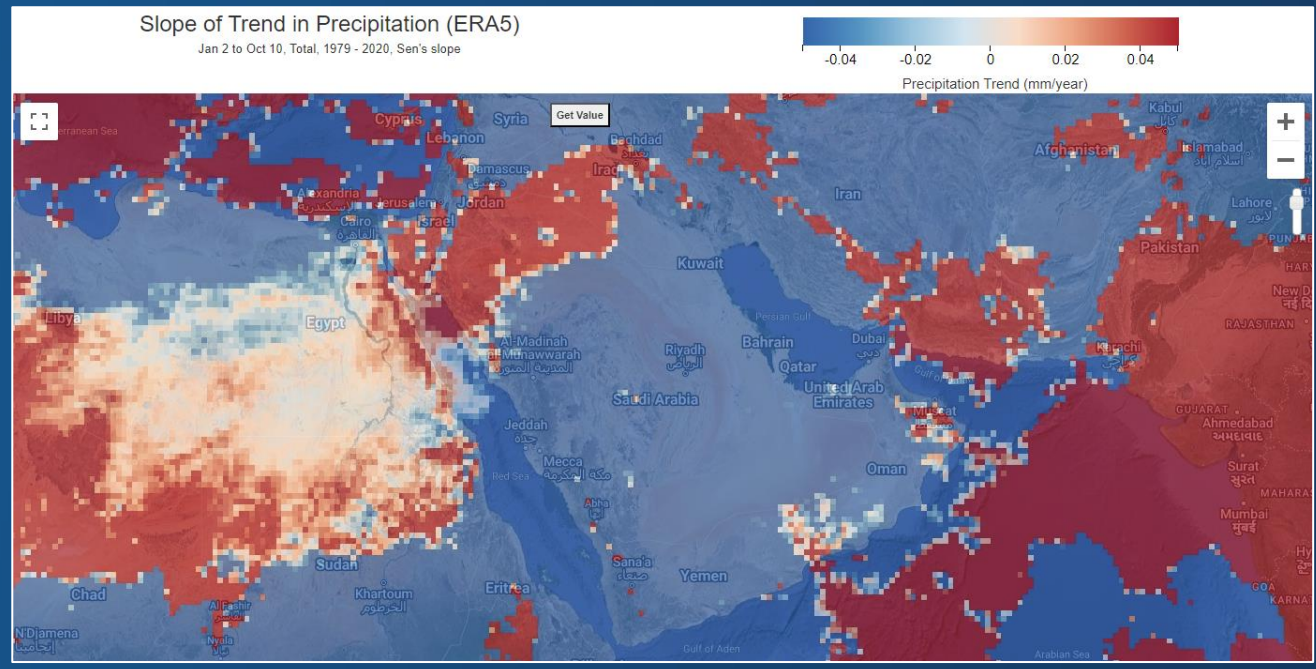
Rainfall and Soil Moisture Trends:

- Observed diverse patterns of rainfall and soil moisture across different AP regions.
- Southwest Yemen and northern AP showed atypical climatic patterns with no significant decline.

- trends.

- Key Finding:

- Significant decrease in key water-related parameters almost across the entire AP.



Results - Innovative Monitoring System on GEE

- Tools and Insights:

Actionable insights for stakeholders via visualization of climatic conditions and water availability.

- Archival Data Utilization:

Vital for retrospective analysis of water storage patterns and trends.

Enhances understanding of water resources for sustainable management in the Arabian Peninsula.

- Holistic System Capabilities:

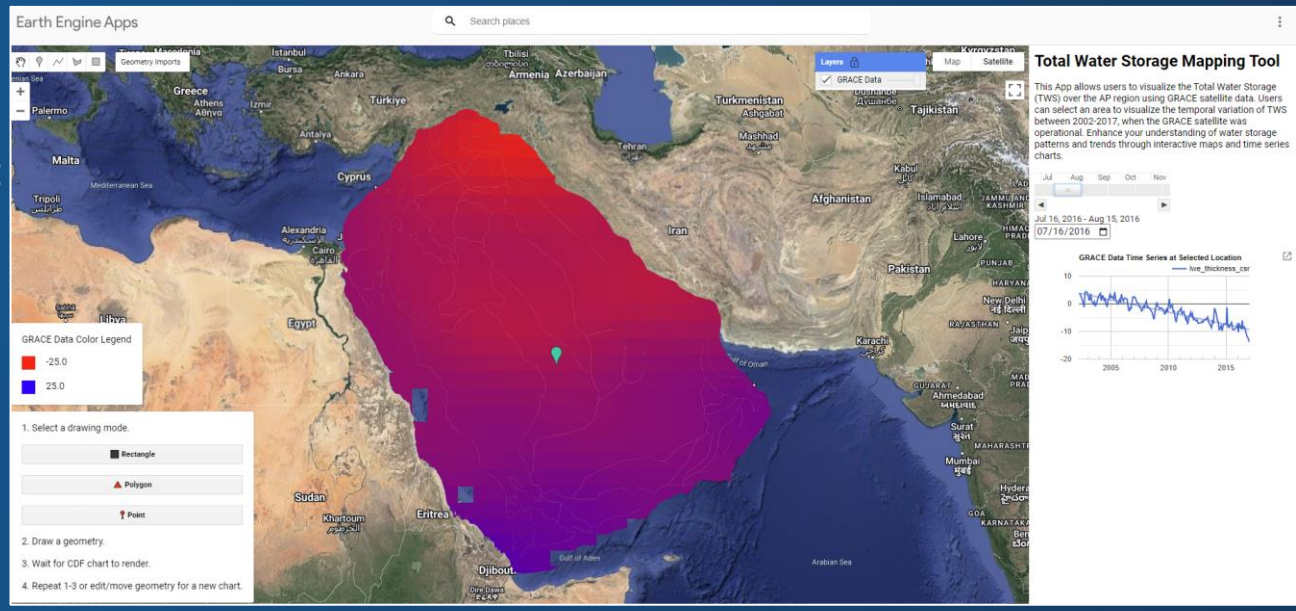
Amalgamates various temporal scales for nuanced analyses.

Highlights seasonality and fluctuations in TWS crucial for groundwater reserve management.

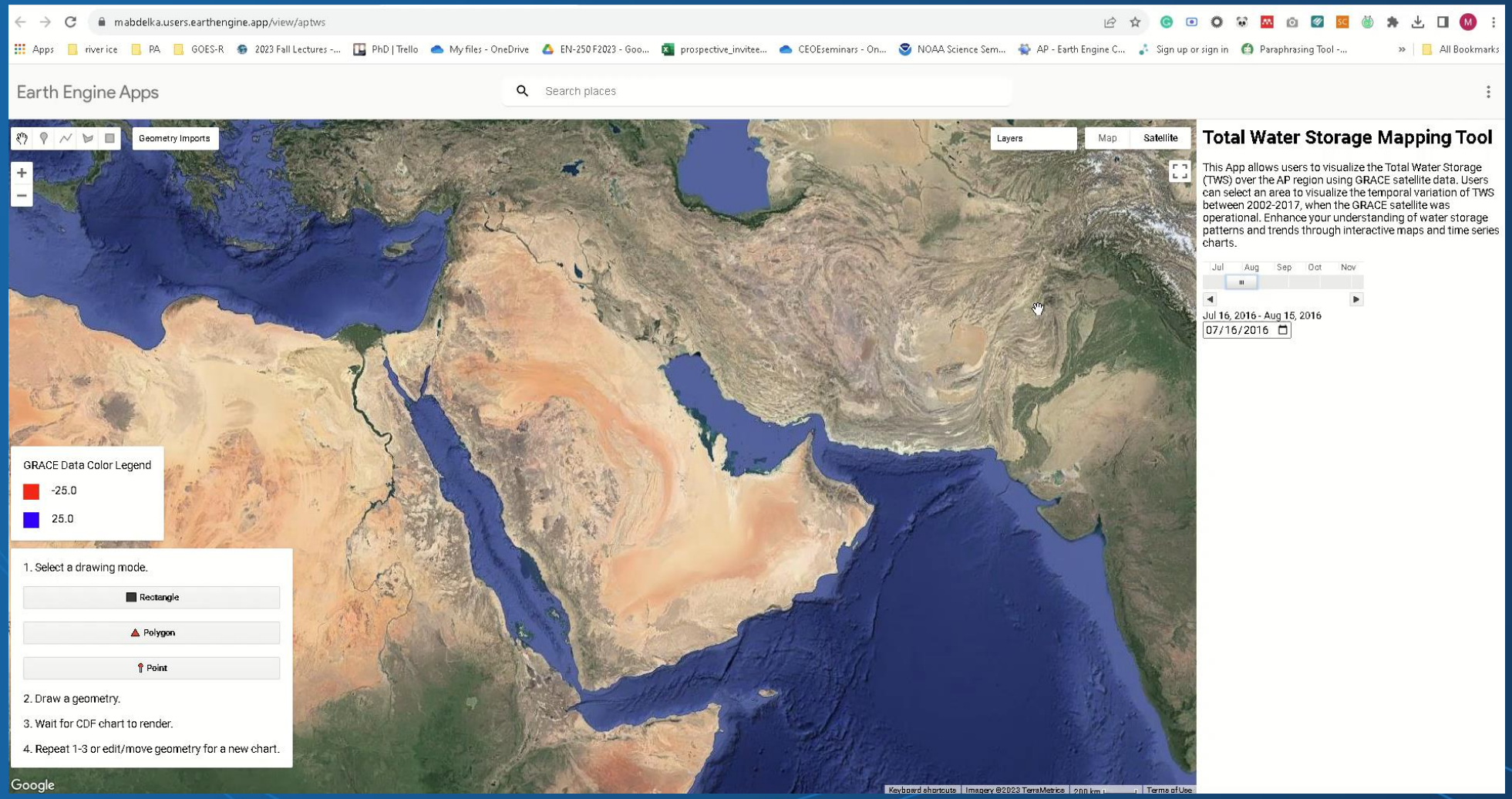
- Future-Ready Framework:

Adaptable to future satellite missions and datasets.

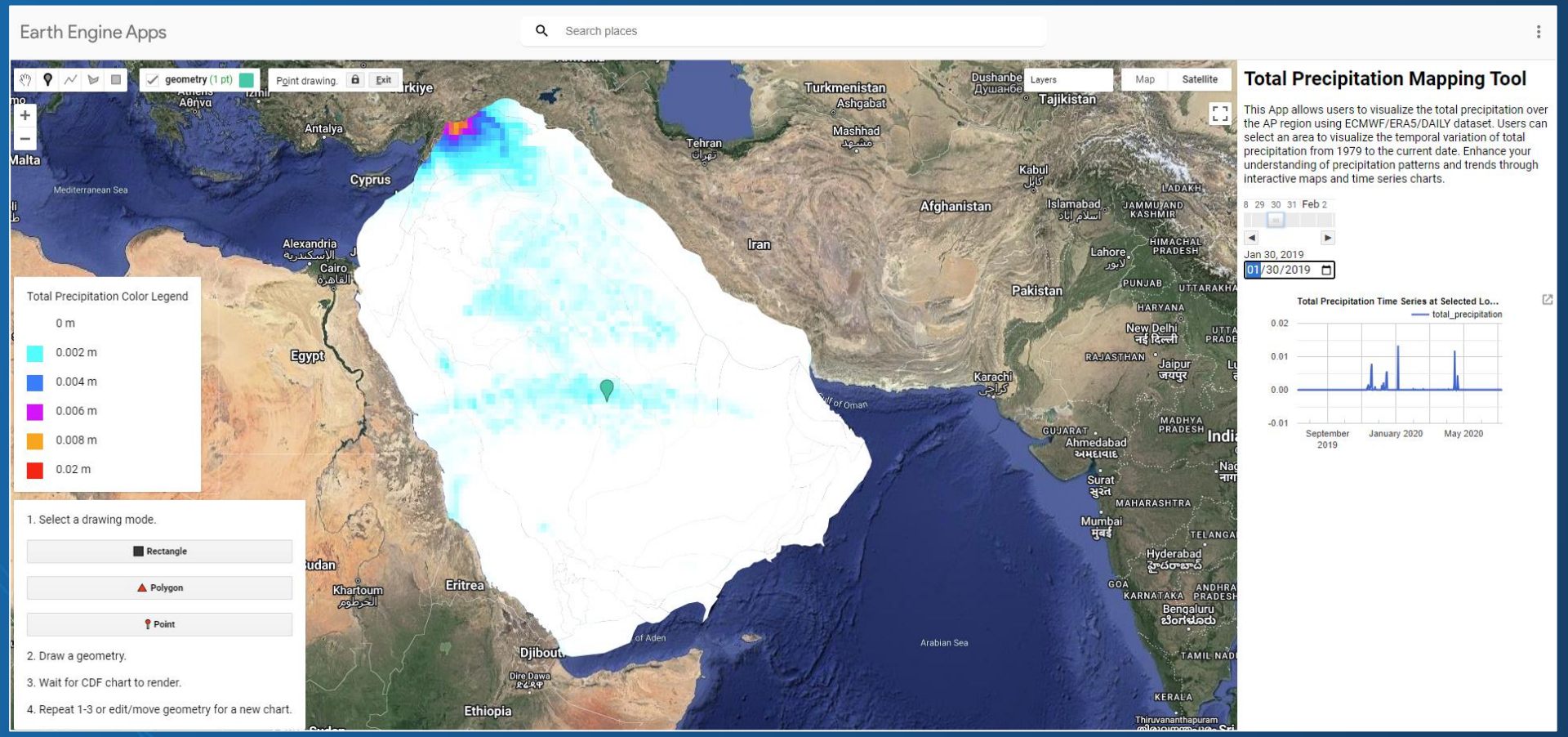
Proves versatility in incorporating historical data for future advancements.



Results - Innovative Monitoring System on GEE



GEE Framework Tools and Applications - Precipitation Data Mapping Tool

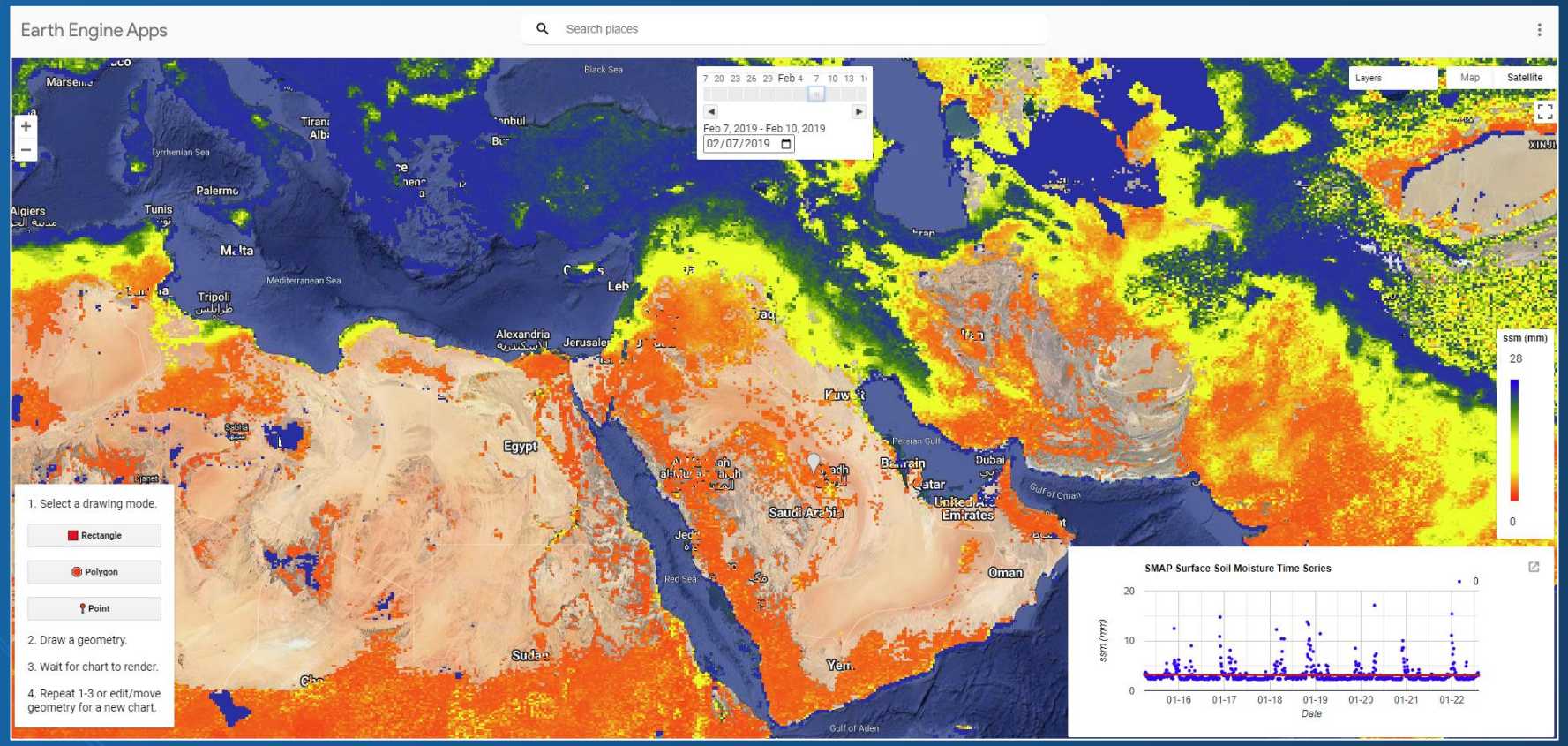


Real-time and historical precipitation data visualization

Essential for water resource allocation, flood anticipation, and agricultural planning

Supports informed reservoir management to prevent overflow situations

GEE Framework Tools and Applications - Soil Moisture Insights via SMAP Interface

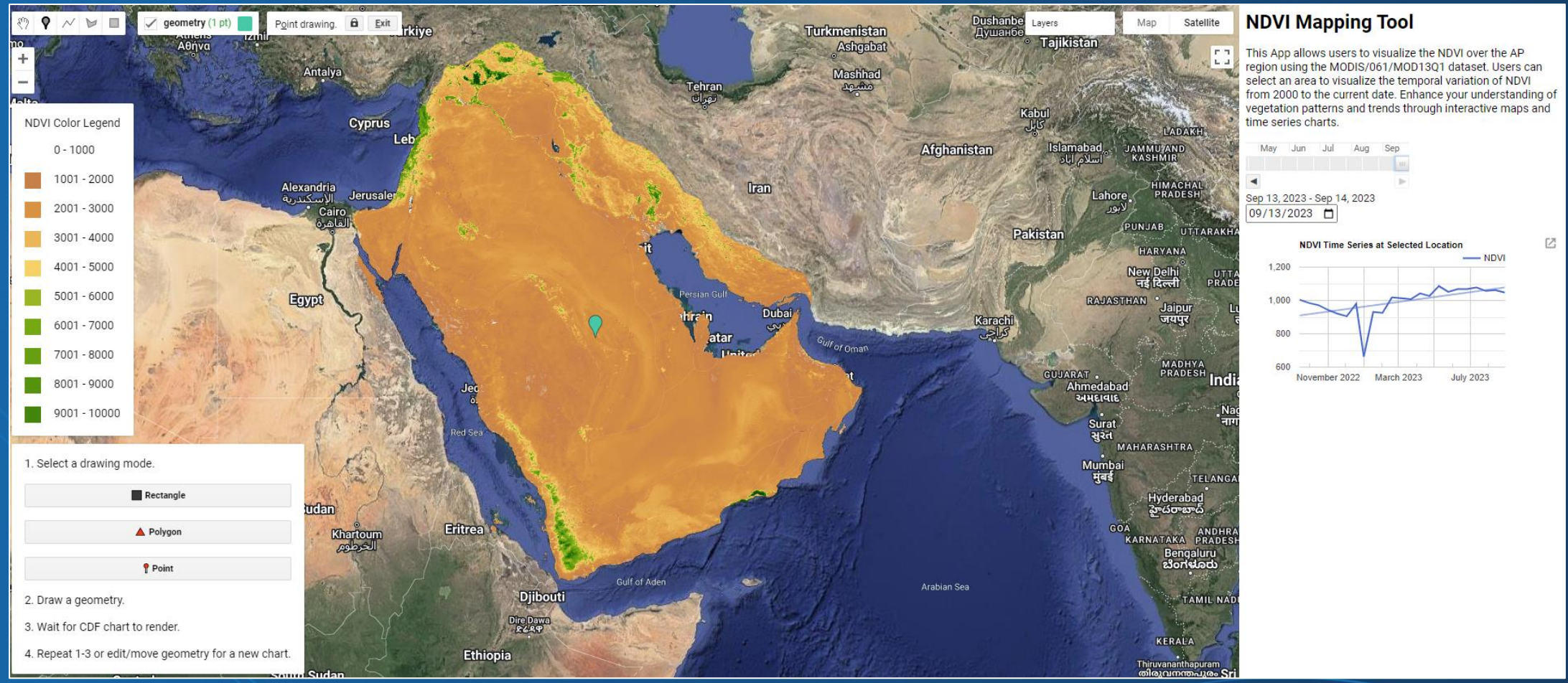


SMAP data integration aids in precise irrigation and drought anticipation.

Enhances flood risk assessments and ecosystem vitality monitoring.

Enables informed irrigation scheduling and crop yield predictions.

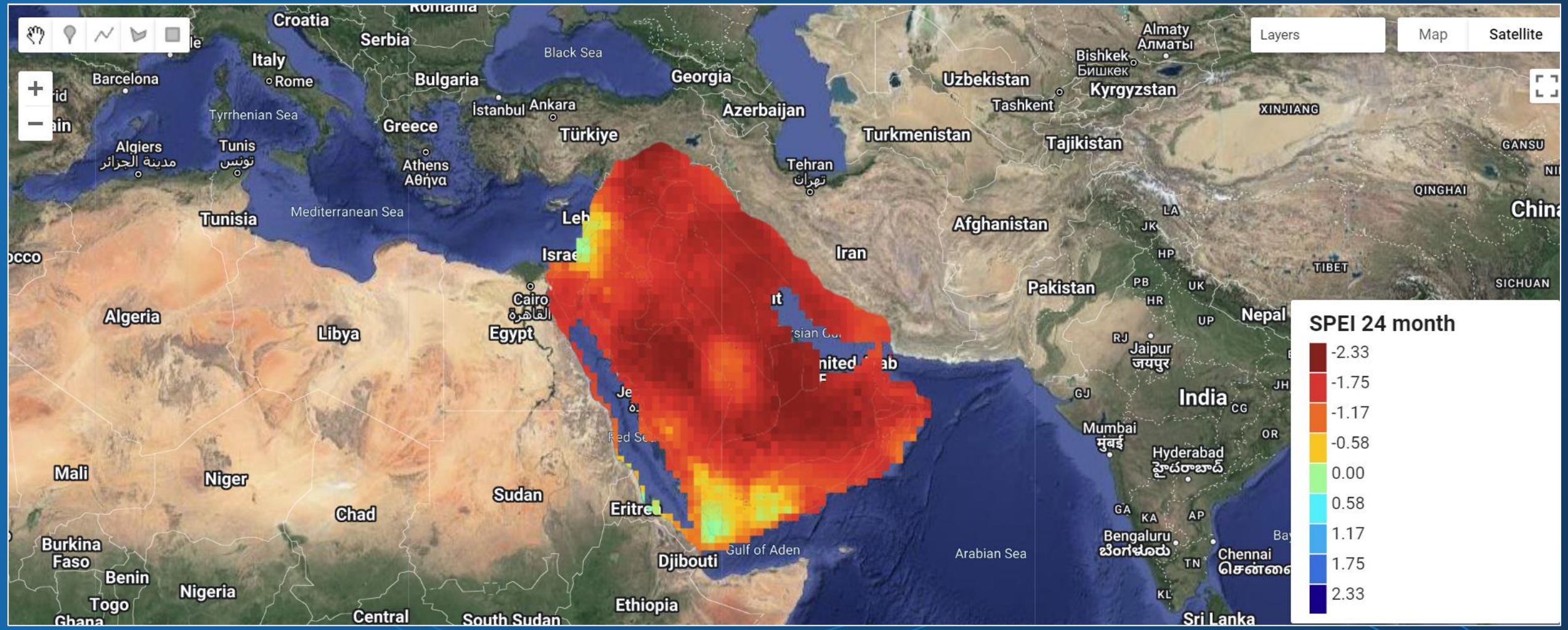
GEE Framework Tools and Applications - NDVI



Assists in ecological health monitoring and conservation efforts.

NDVI data integration aids in agricultural drought anticipation.

GEE Framework Tools and Applications – SPEI Index



Conclusions:

1. Integrated Monitoring Imperative:
- Our advanced monitoring system on GEE is pivotal for addressing water scarcity in the Arabian Peninsula.
- Provides near real-time analysis and is essential for understanding climatic variations and water demand.

2. Climatic Complexity and Data Integration:
- Detailed assessment of climatological dynamics in the AP through multiple data sources.
- Identifies declining trends in precipitation, groundwater, and soil moisture, with regional complexities such as southwest Yemen.

3. Transformative Impact on Policy and Management:
- The system informs policymakers with real-time data for strategic decisions in water management.
- Offers enhanced policy formulation integrating economic data for sustainable water stewardship.

4. Proactive and Predictive Resource Management:
- Emphasizes the shift towards a system that is not only reactive but also predictive, aiding in sustainable management.

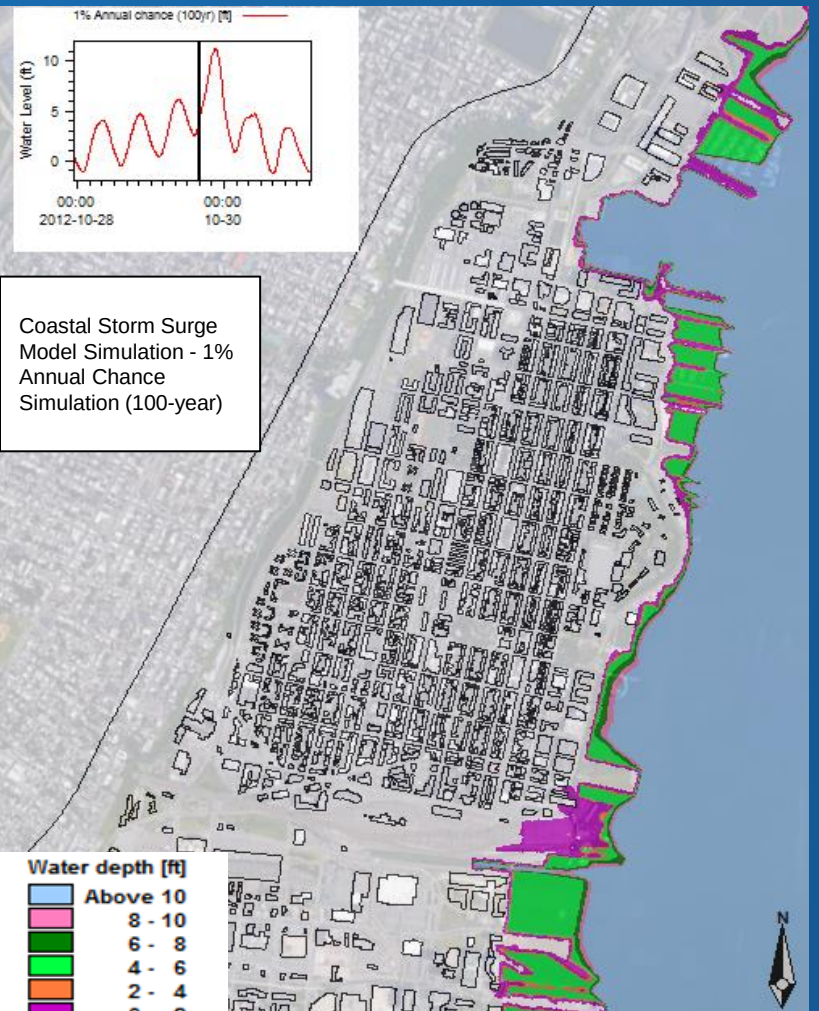
5. Groundwater Monitoring and Sustainable Utilization:
- Utilizes GRACE data to monitor groundwater changes, emphasizing the need for monitoring non-renewable water resources.

6. Regional Groundwater Depletion Concerns:
- Evidence of considerable groundwater loss, highlighting the impact of drought and anthropogenic activities.

7. Large-Scale Hydrological Variable Monitoring:
- Remote sensing datasets reveal an overall depletion of TWS, with trend analyses indicating significant spatial dependencies and climate change impacts.

Implementation: Water Ready Region

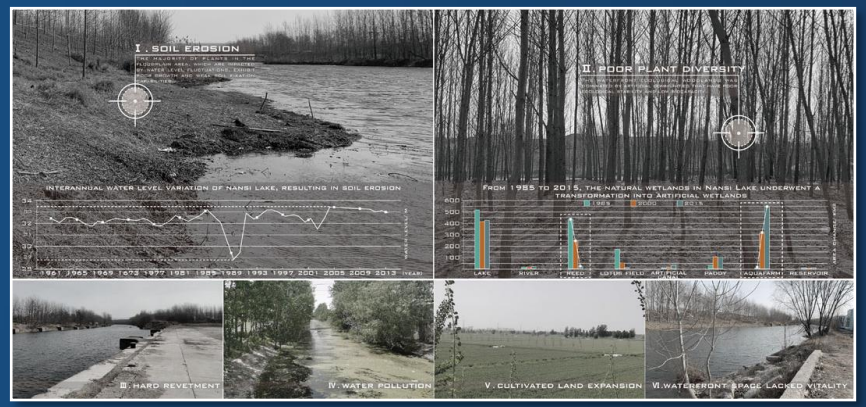
Integrated Resilience, Sustainable and WRM Strategy

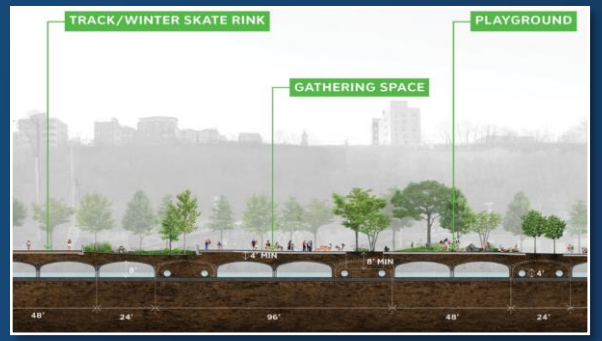


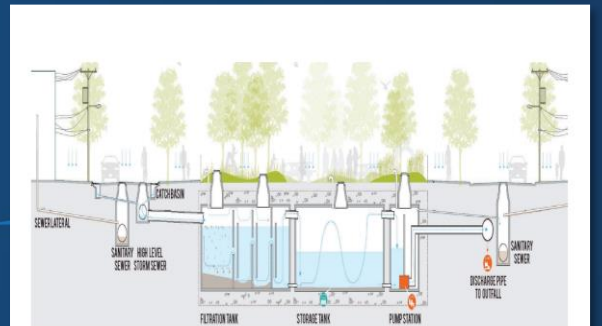
Coastal Storm Surge Model Simulation - 1% Annual Chance Simulation (100-year)

Coastal Barrier Alignment in **RED**
Inland Measures are shown in **GREEN**

100-year Rainfall Intensity shown **RED**
100-year Coastal Storm Surge shown in **BLUE**







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