INSTITUTO DE INGENIERÍA UNAM

THE GEOLOGICAL SOCIETY OF AMERICA®

29.2 *Petroleum And Interactions In Mexico's South-Central Region*

A Framework to Quantify Water Availability in Shale Gas Regions of Mexico: Baseline and Development Scenarios

Presented by:

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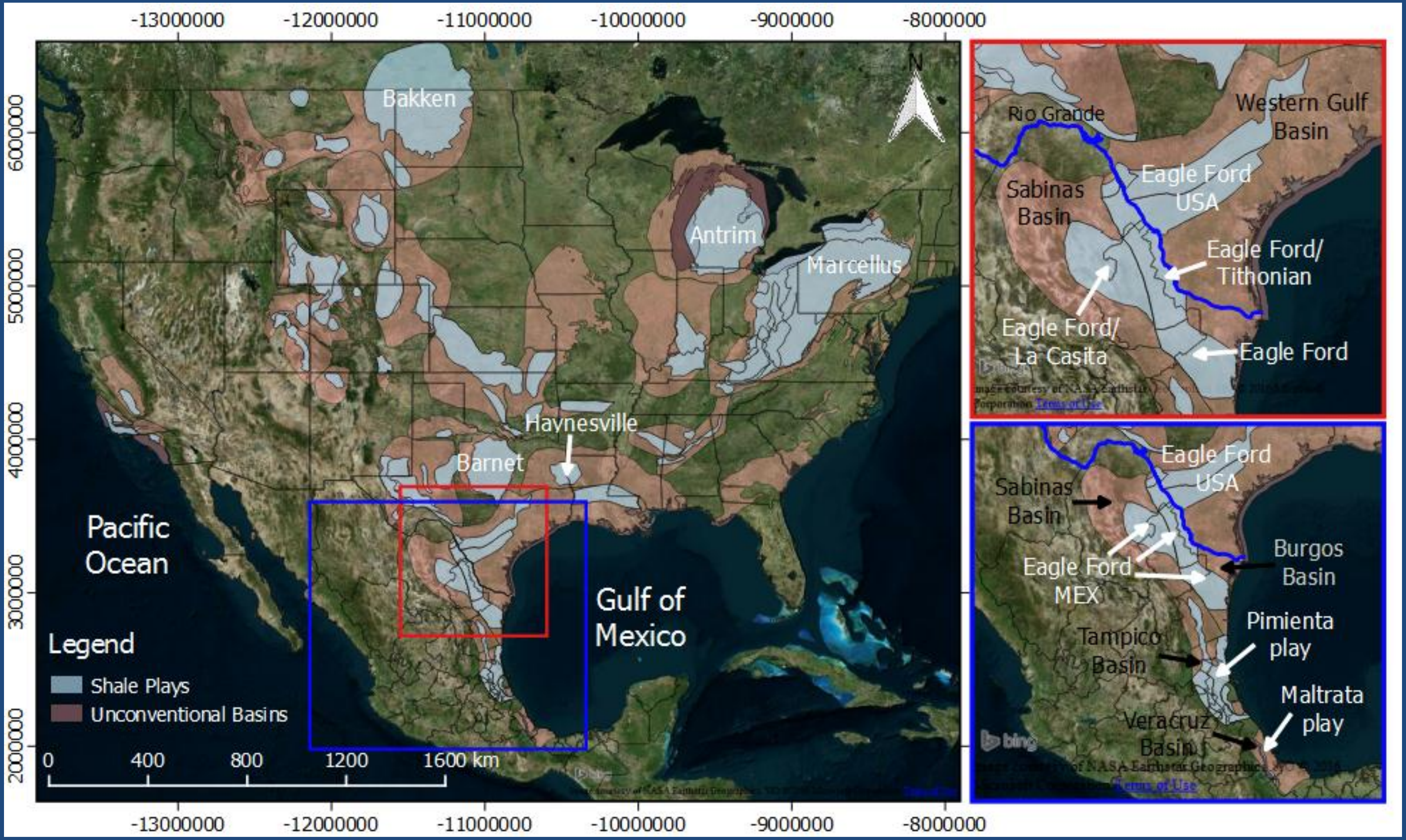
1. Introduction: Mexico's water-energy (shale oil and gas) nexus

Mexico is the sixth country with highest shale oil/gas resources and it is one of the three countries with the highest water stress (EIA, 2013)



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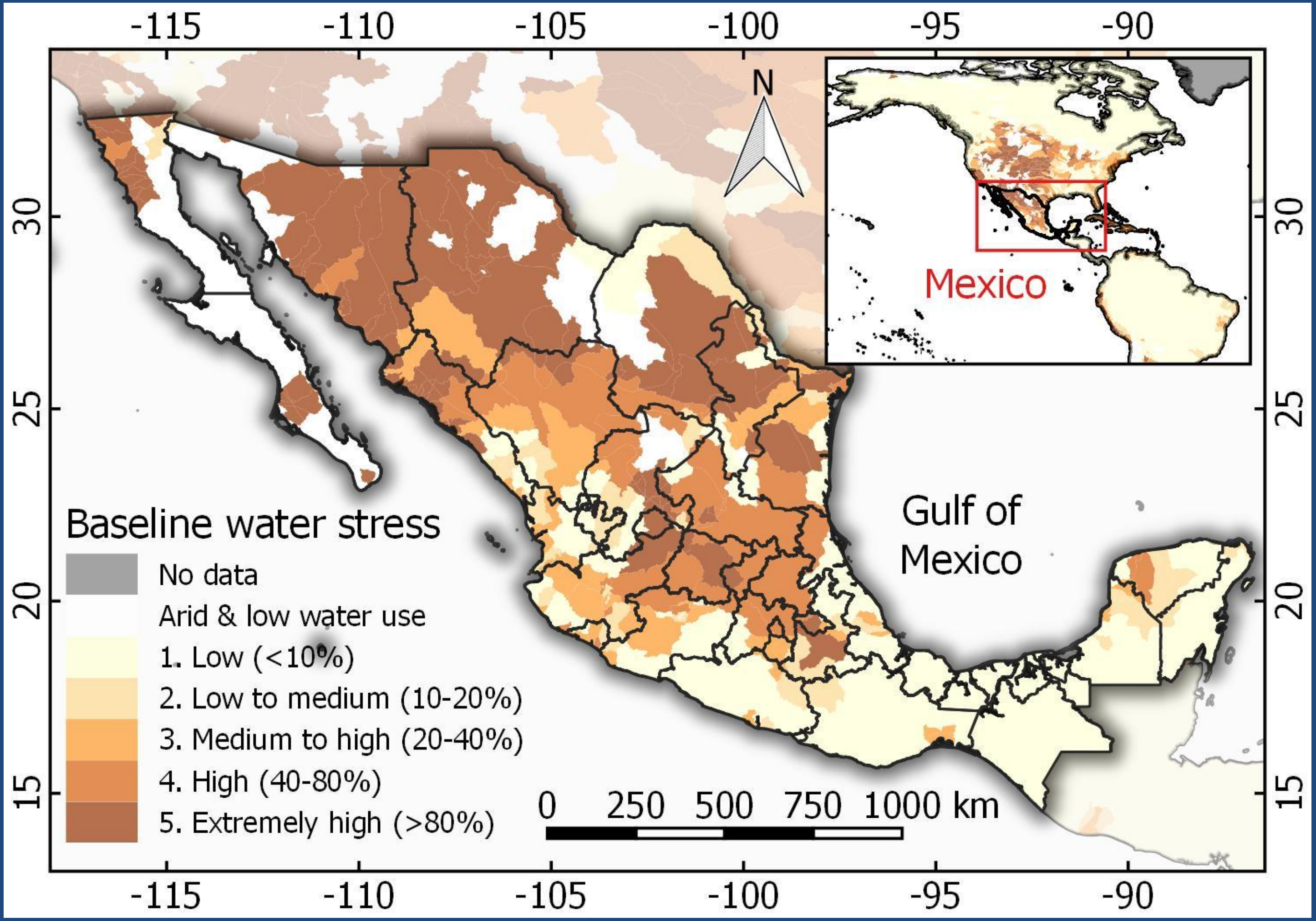
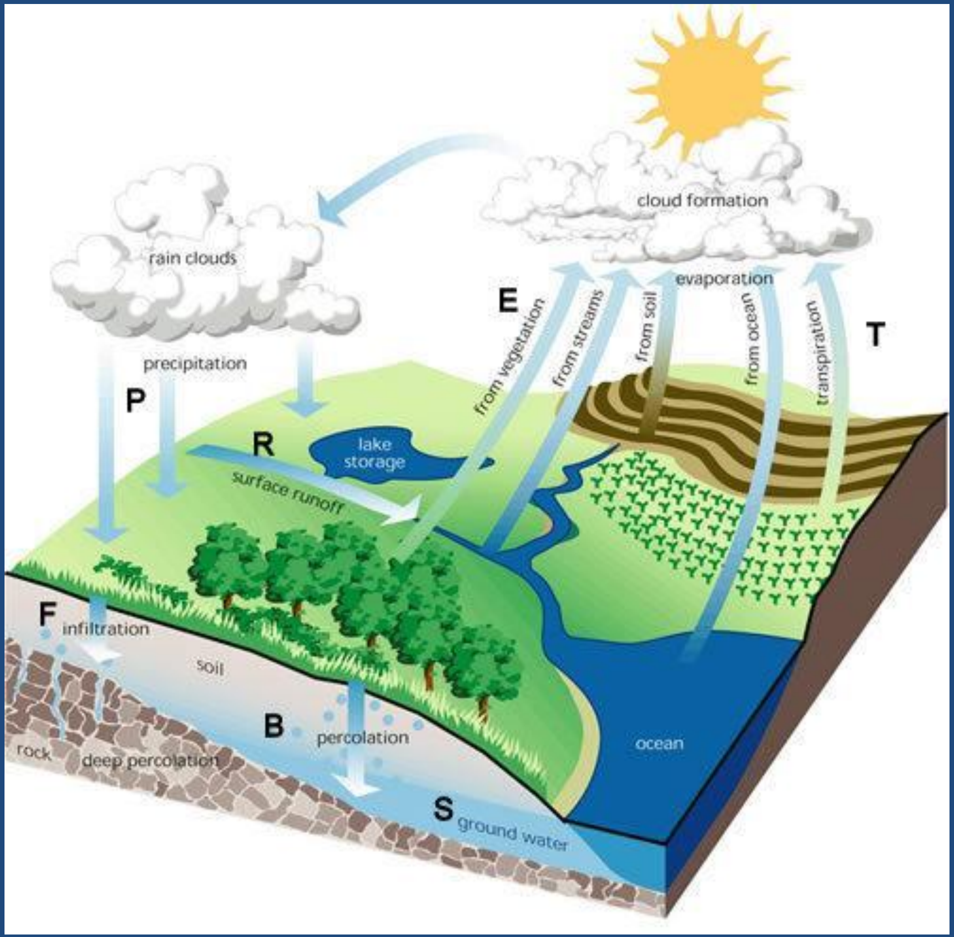
1. Introduction: Mexico's water availability

Fifty percent of Mexico is considered as an arid/semiarid region with scarce physical water availability (IWMI, 2007).



1. Introduction: Water balance in ungauged basins

Water budget of a region is an easy task to compute, except when information is sparse or null, as it is common in several regions of Mexico



$$\Delta TWS = \Delta SW + \Delta SM + \Delta GW$$

$$\Delta \mathrm{SW} = P + Q_{GW} - ET - R - F$$

$$\Delta \mathrm{SM} = F - B$$

$$\Delta \mathrm{GW} = B + R_A + Qb_i - Qb_o - Q_{GW}$$

In-situ and model based source	Variable
Directly measured	P, R
Empirical equations	ET, F, Qbi, Qbo, R
Numerical models	B, ΔSM, ΔGW, F, R, Qbi, Qbo
Water commissions	R_A, Q_{GW}

Remote sensing and data assimilation	Variable
Space borne	ΔTWS, SM, P, ET
Land models	R, ET, F, B, SM
Derived from Remote Sensing	Q_{GW}

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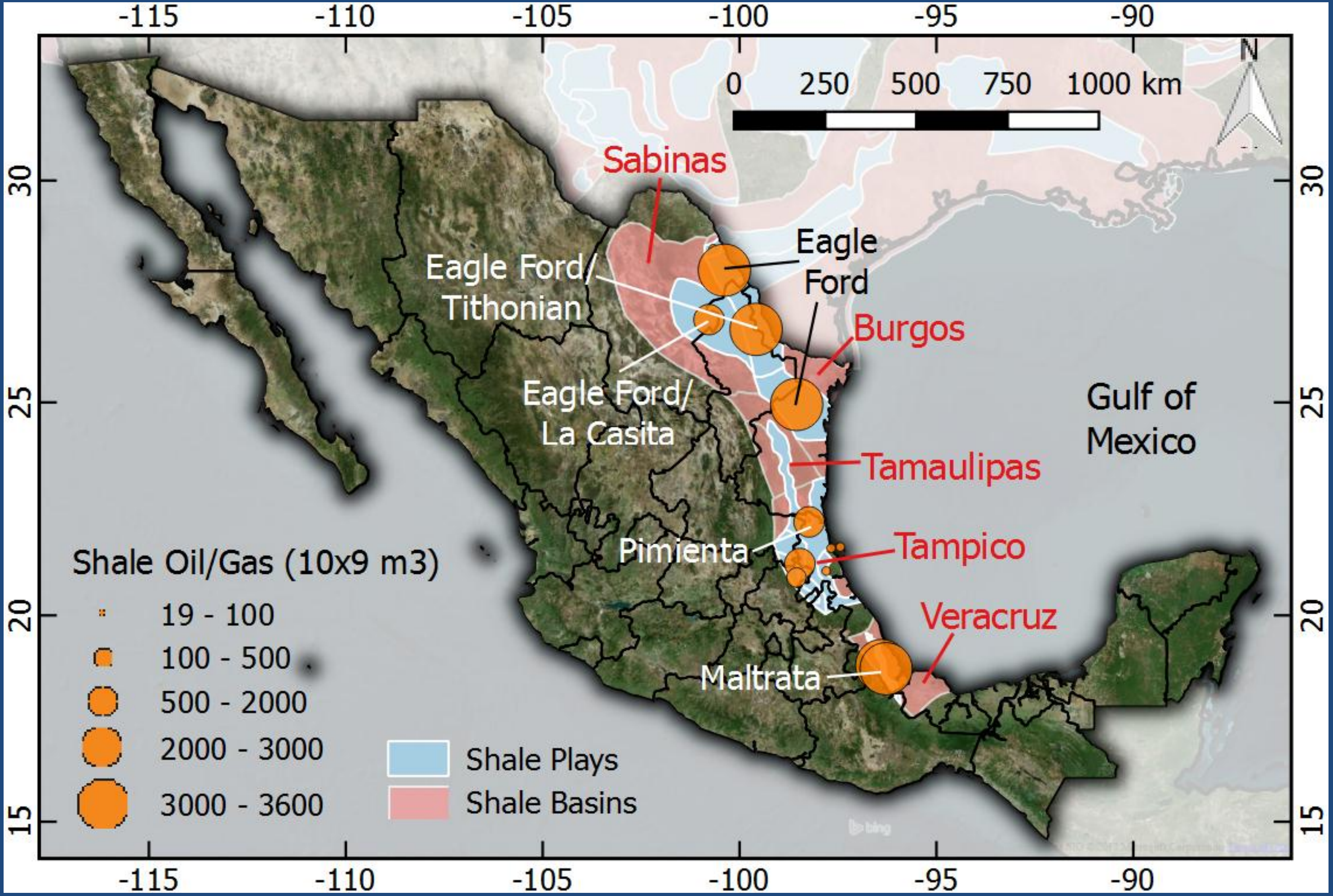
2. Development of shale oil/gas in Mexico

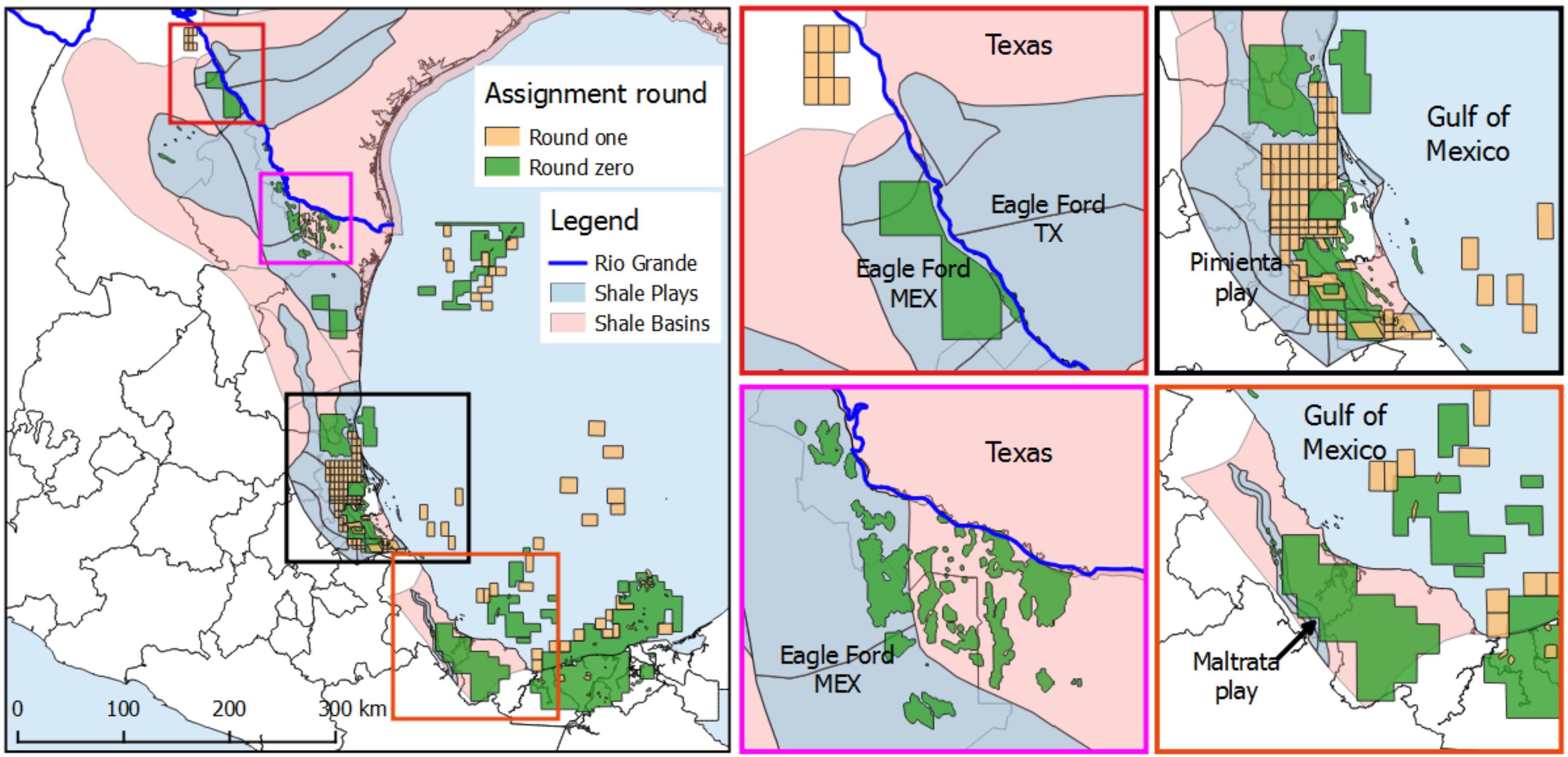
Mexico has important unconventional resources contained in 4 basins: 1)Burgos 2) Tampico-Misantla 3) Sabinas 4) Veracruz



2. Development of shale oil/gas in Mexico

Some challenges are expected in the shale oil/gas development in Mexico: lack of infrastructure, security and water scarcity.

PEMEX rounds of assignment areas for exploration and exploitation of unconventional and conventional resources (2014)



3. Datasets and methods

Main water budget components are derived from satellites and global hydrological models.

Dataset	Description	Extension	Spatial resolution	Temporal resolution	Time period	Reference
TRMM	Tropical Rainfall Measuring Mission (TRMM) product 3B42	Global	1/4 degree	Monthly	1998-2016	Huffman et al. (2010)
GRACE	Gravity Recovery and Climate Experiment (GRACE) product RL05	Global	1 degree	Monthly	2003-2016	Seo et al. (2006)
NOAA	Rainfall and temperature derived from the interpolation of weather stations	USA and Mexico	1/16 degree	Daily	1950-2013	Livneh et al. (2013)
VIC	Output from Variable Infiltration Capacity model	USA and Mexico	1/16 degree	Daily	1950-2013	Livneh et al. (2015)
GLDAS	Global Land Data Assimilation System (GLDAS) version 2	Global	1/4 degree	Monthly	1948-2009	Hualan y Hiroko (2013)
NLDAS	North American Land Data Assimilation System (NLDAS) version 2	USA and northern of Mexico	1/8 degree	Monthly	1979-2016	Robles-Morua et al. (2012)
MODIS VI	Moderate-resolution Imaging Spectroradiometer (MODIS) Vegetation Index (VI)	Global	250 m	16 days	2001-2016	Bastiaanssen y Ali (2003)

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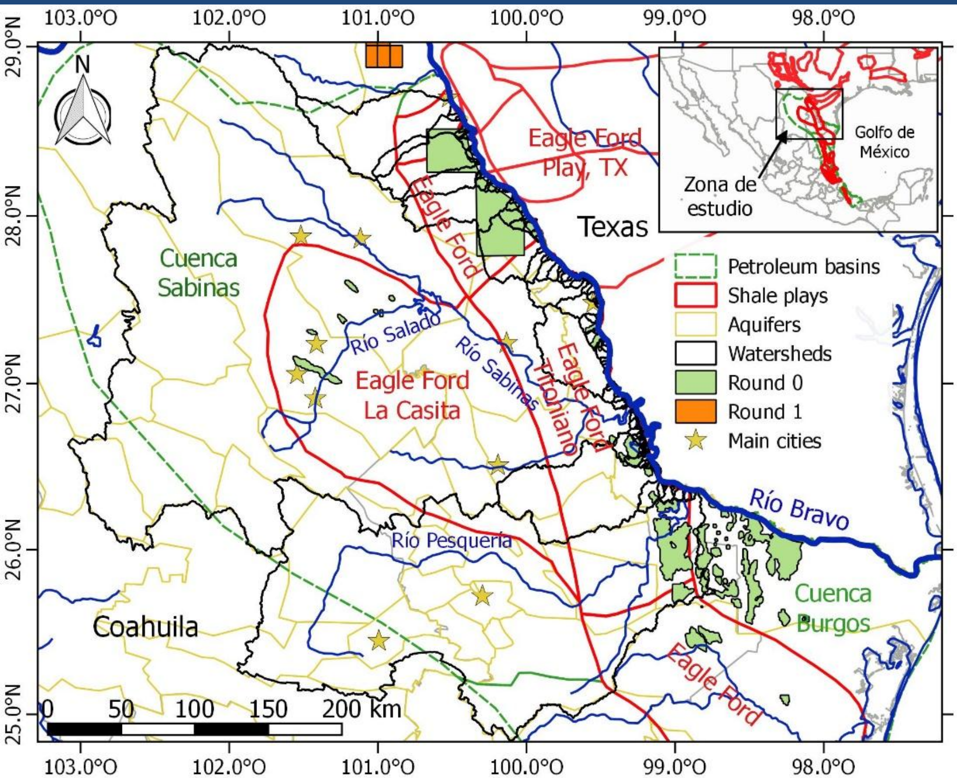
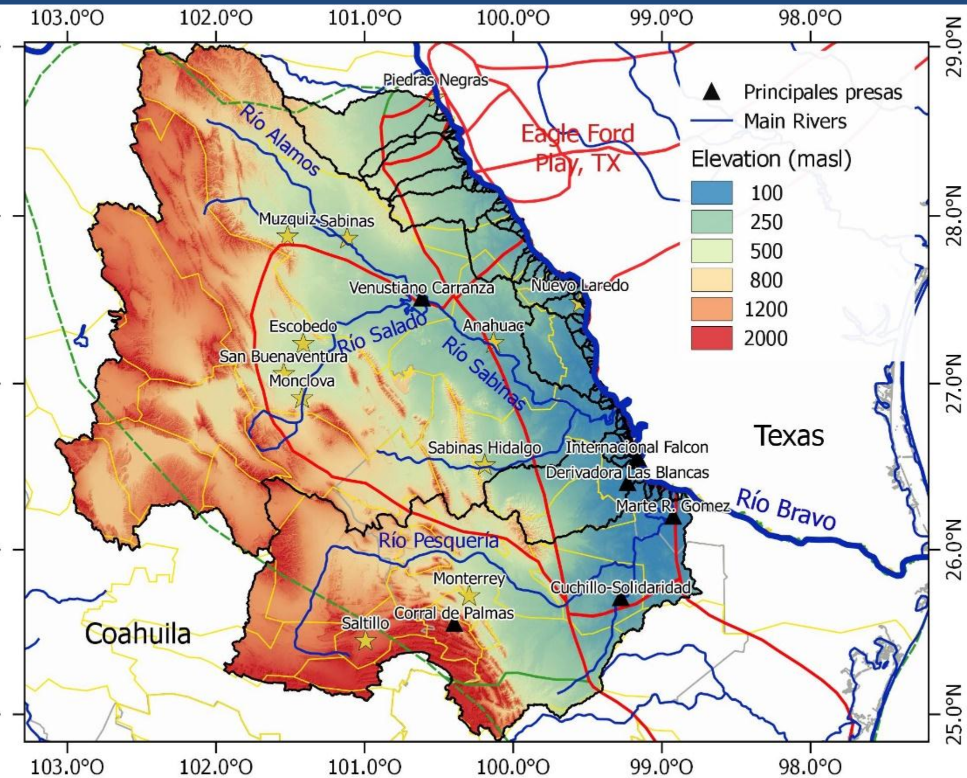
4. Water use in Mexico's northeast

The study area comprises the Eagle Ford play in the Sabinas and the Burgos basins in the arid/semiarid region of Mexico

Study area location



Hydrography

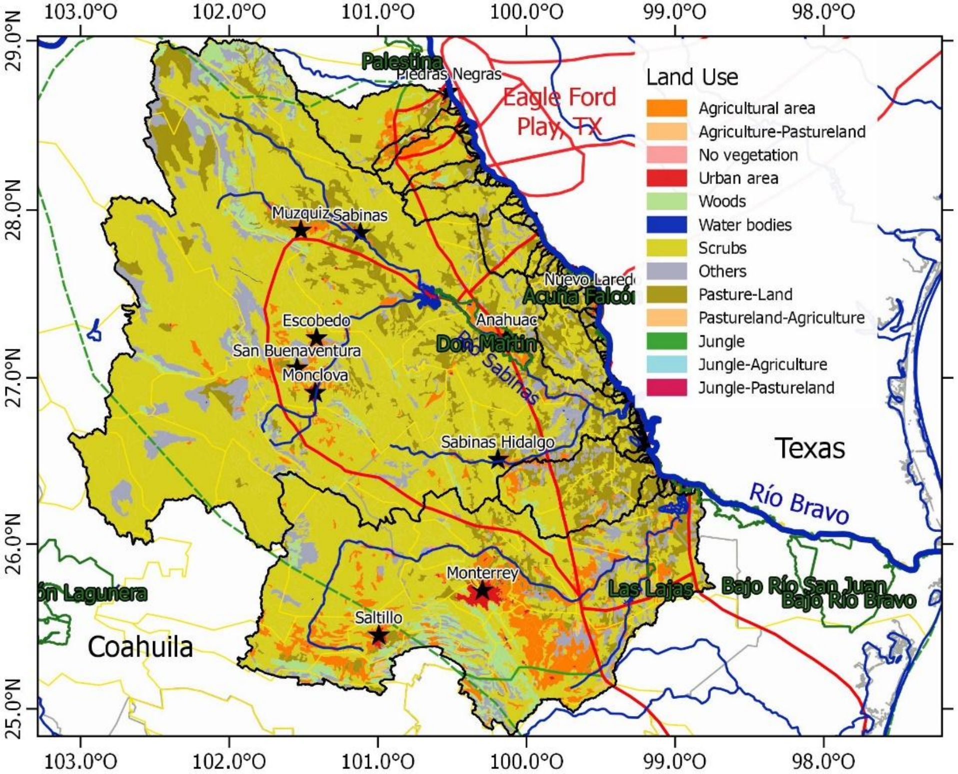


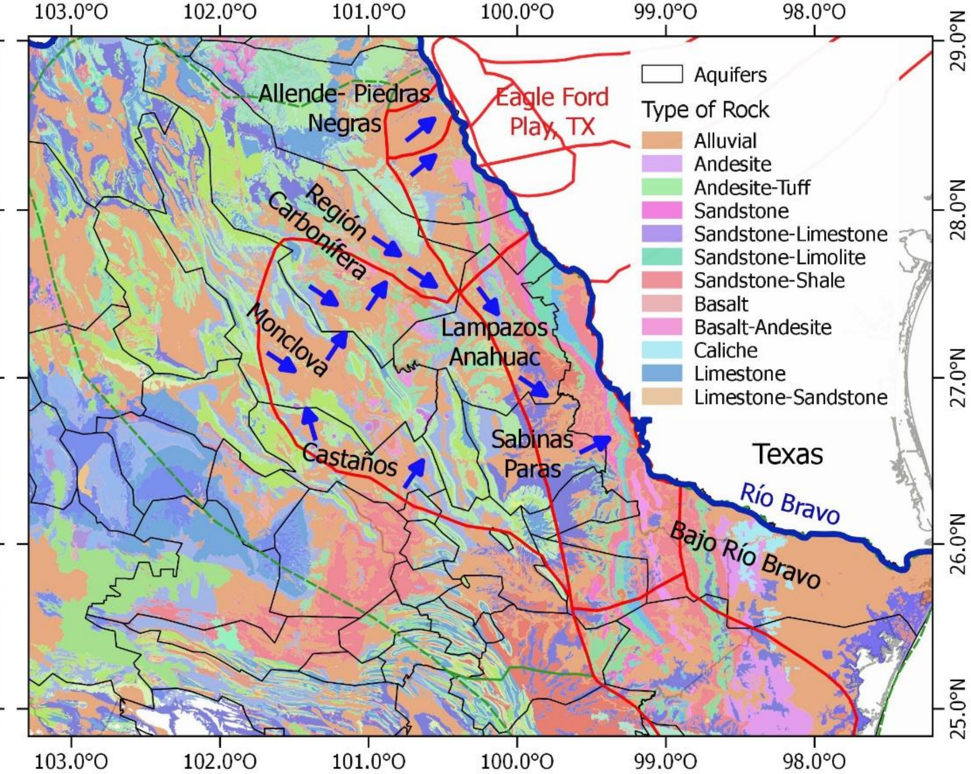
4. Water use in Mexico's northeast

The study area is composed mainly by alluvial unconfined aquifers with groundwater availability estimates from CONAGUA

Land use

Hydrogeology





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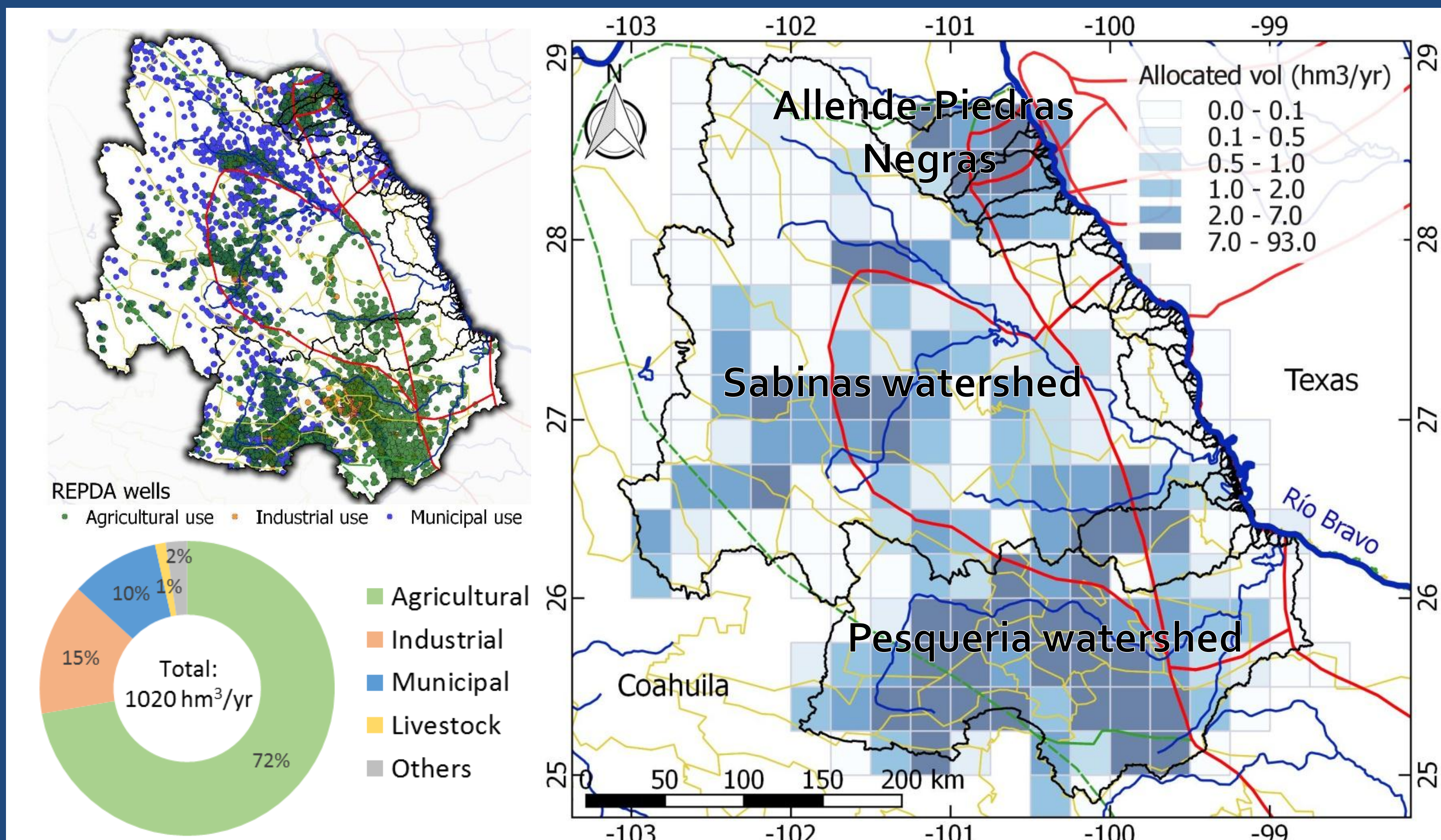
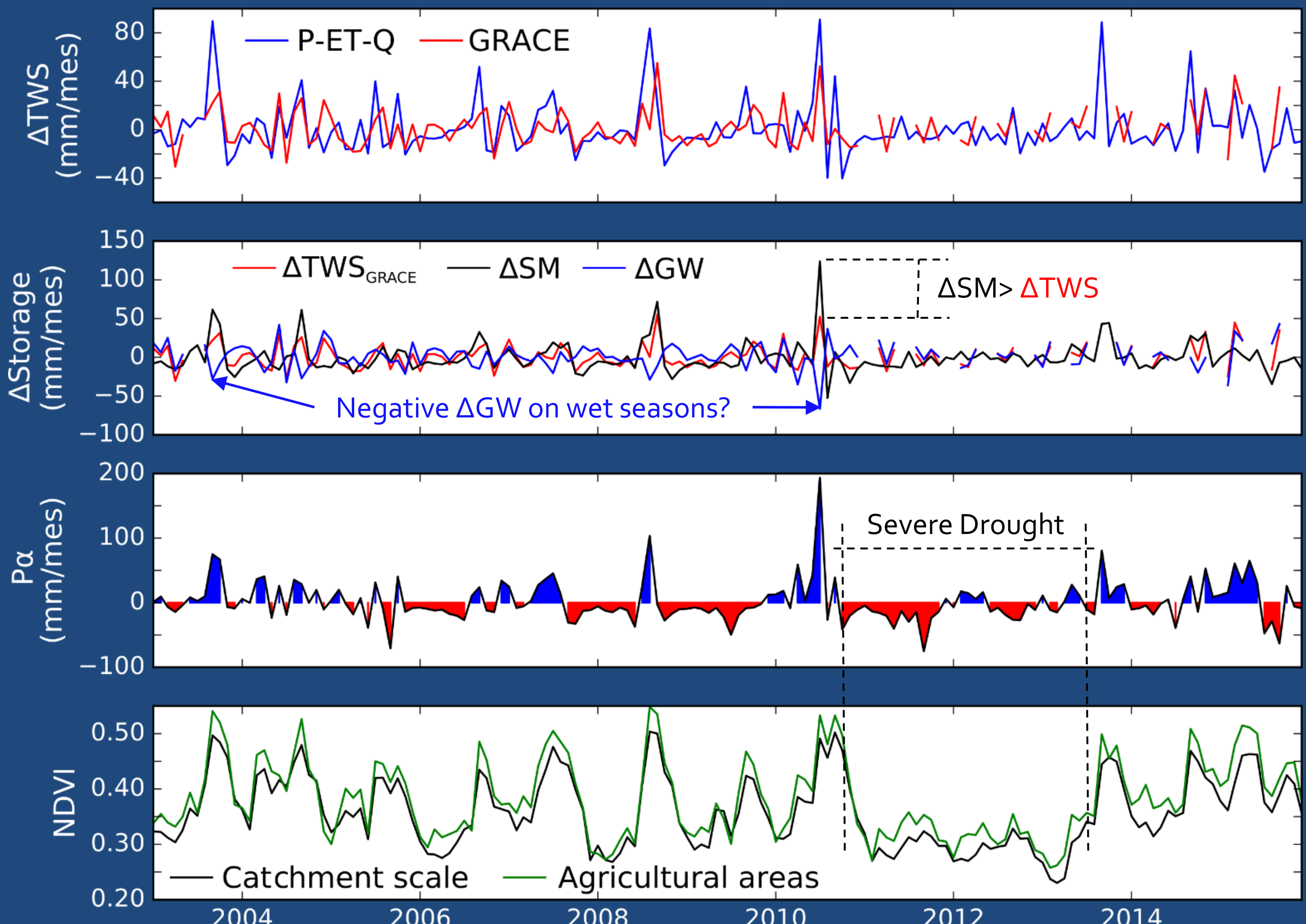
4. Water use in Mexico's northeast

Agricultural groundwater demand is the most important use in the study area (72 %) followed by Industrial and Municipal.



5. Results: Water storage change

Water storage changes at total study area



Total Water Storage Changes

Storage Changes

Precipitation anomalies

NDVI temporal changes

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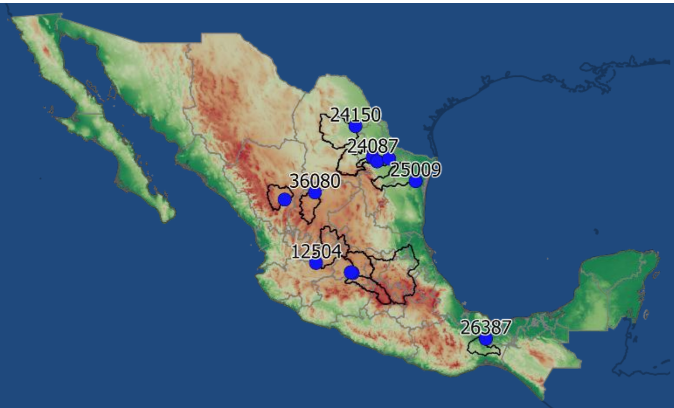
5. Results: Water storage changes

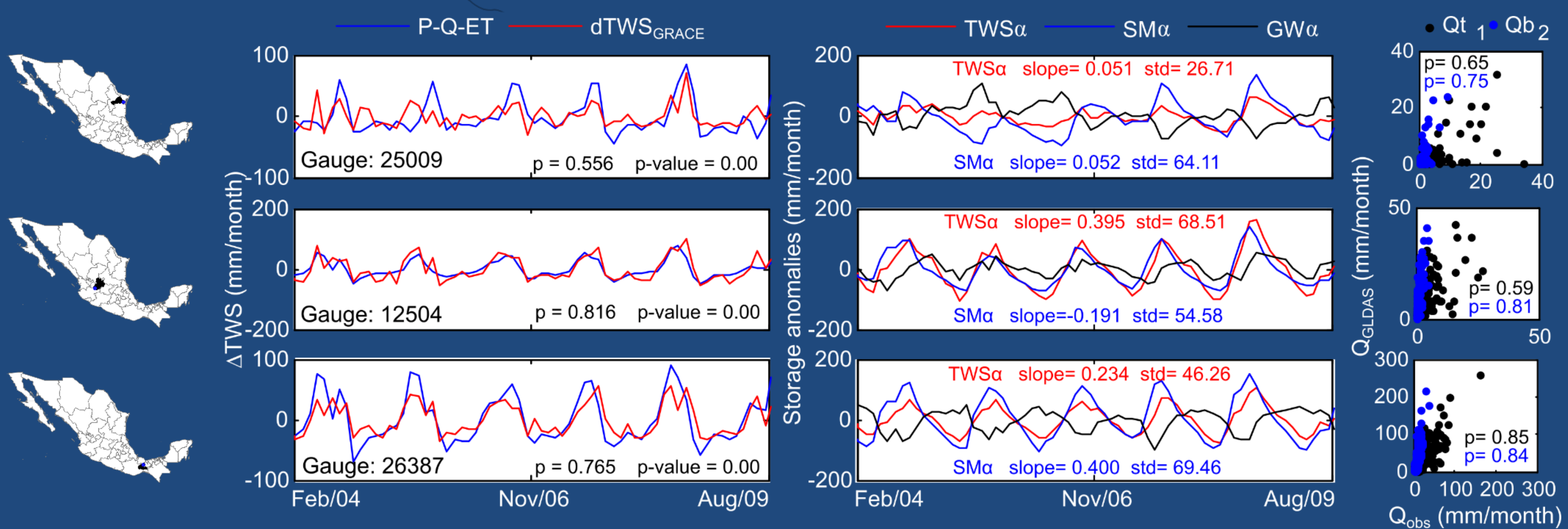
Water budget validation across Mexico



12 Watersheds with area>8000 km²

Streamflow gauges with data from 2000-2010

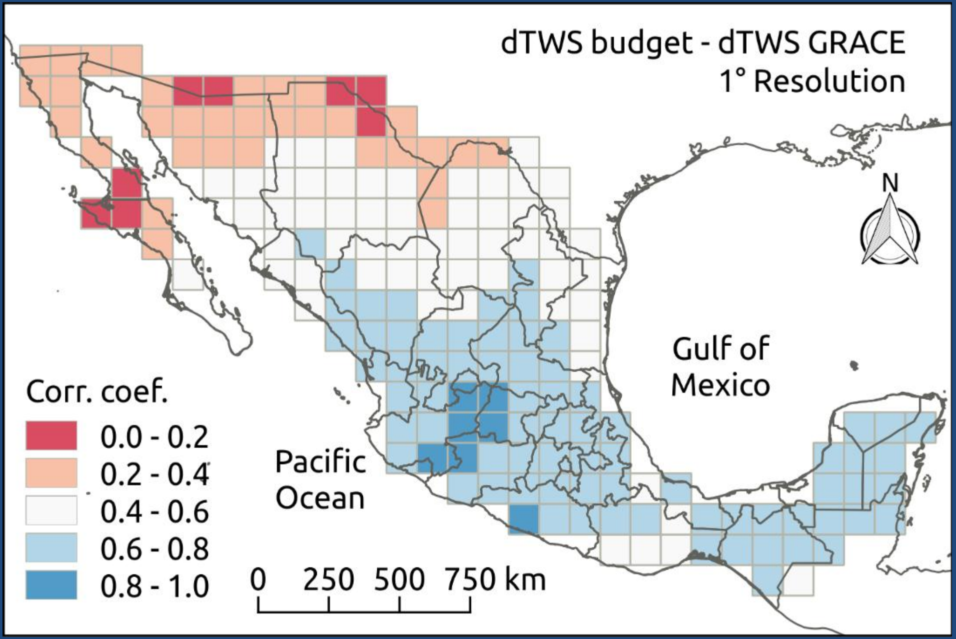
Natural discharge or poor controlled flow



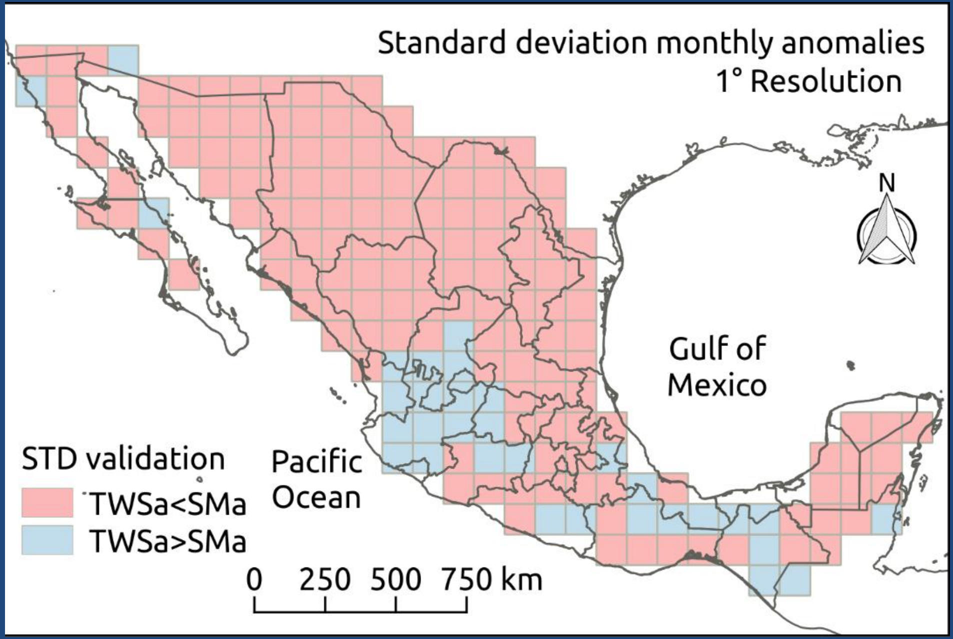
5. Results: Products validation

Validation of results using GLDAS and GRACE datasets

Total Water Storage correlation between GLDAS and GRACE



Total Water Storage with GRACE and Soil Moisture standard deviation



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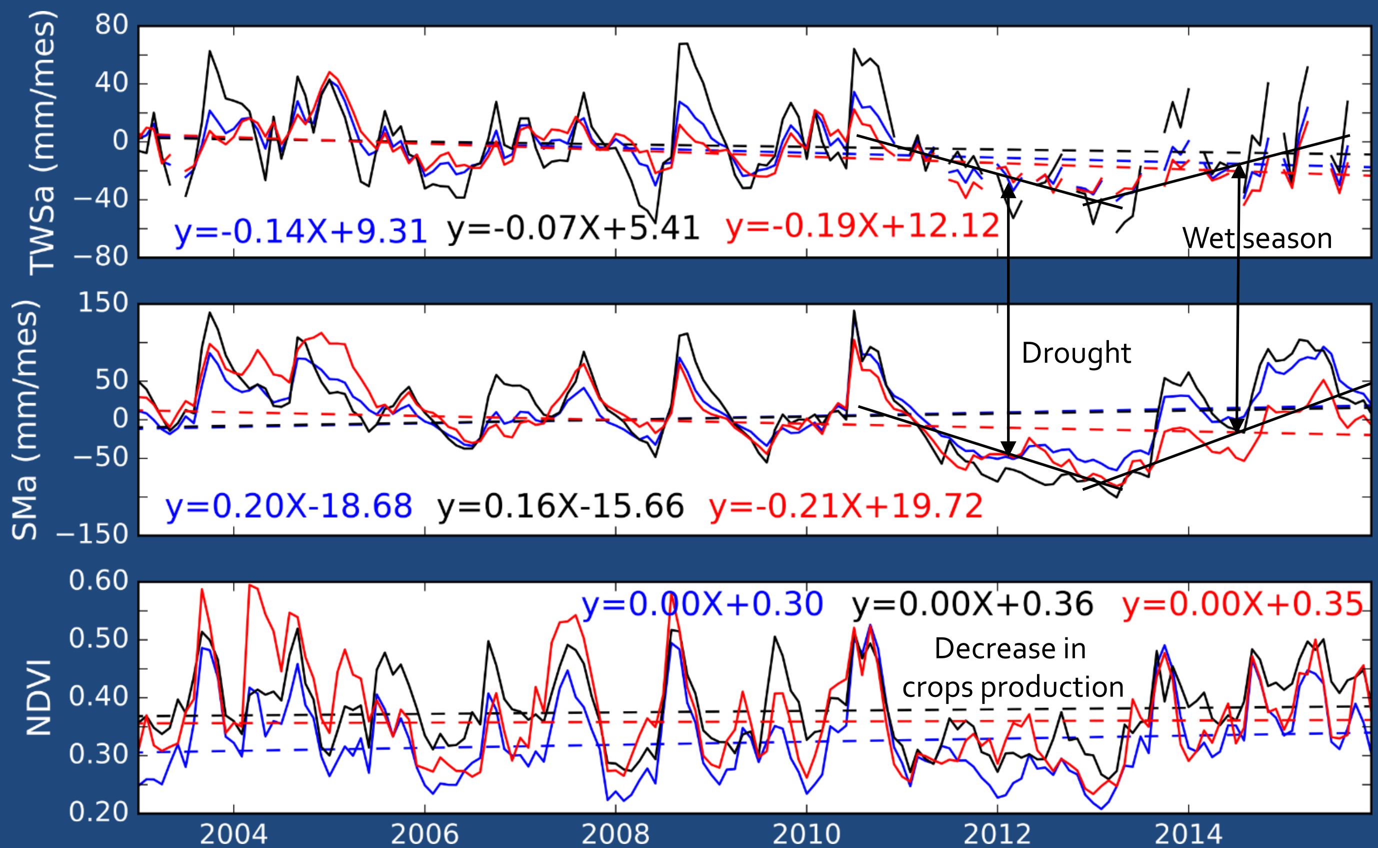
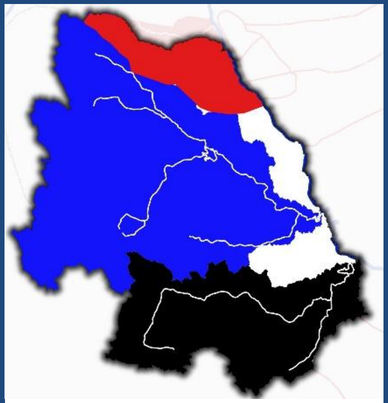
5. Results: Storage anomalies

Trends in water storage and NDVI across the study area



Subregions analysis



Allende-Piedras Negras

Sabinas watershed

Pesqueria watershed

5. Conclusions

- Water balance estimates (GW) using remote sensing shows significant uncertainty in Mexico's drylands due to inconsistencies between datasets (GLDAS, NLDAS, GRACE).
- The study area is sensitive to Drought periods: during rainless years storages shown strong depletions and in humid years it shows a faster recovery.
- The Allende-Piedras Negras aquifer shows a lower recovery capacity (TWS and SM) after a long drought period.
- Historical droughts and future water demands should be considered for water management in semiarid/arid regions with potential of shale oil/gas regions to avoid conflicts between users.

Thanks

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