# Precipitation response by Qom Playa, Iran


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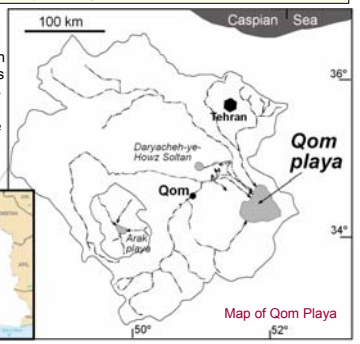
**Summary**

Playas, or dry lakes, are common landforms in the arid and semi-arid parts of the world that integrate surface runoff and preserve it as lakes or elevated groundwater. The wet/dry cycles of playas control their dust production. High-resolution multispectral satellite remote sensing has been conducted for most of the Earth since 1973 and the archives are publicly available. These images offer a means of examining current and historical regional variations in precipitation, independent of point measurements, that may be especially valuable where weather monitoring programs are not available. Landsat and Terra images show variations in hydrology as patterns of wetting and drying of Qom Playa, south of Tehran, that we tested against precipitation data. The results suggest that imaging between storms yields robust semi-quantitative data on precipitation events and amounts. Vegetation monitoring can augment this information by showing where precipitation occurred.

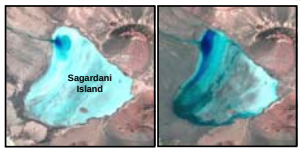

## Qom Playa

Qom Playa is a large salt playa in a tectonically active area of northern Iran whose drainage basin includes Tehran (index map to right). In wet years in contains standing water, especially in its northern end. Most of its surface is covered by halite, which even when "dry" (below) appears light blue in Landsat TM Band 7,5,2 (RGB) (lower right) due to absorption in the short-wave infrared (1.0-2.5 μm) by water of hydration. Krinsley (1968) reports that the sediments from the lake show alternating layers of halite and gypsum and silt/clay. Neighboring playas Daryacheh-ye-Howz Soltan and Arak are similar but record hydrological conditions elsewhere in the drainage basin.




Roads cross Qom Playa, even in areas that are intermittently wet, although Shoreline erosion suggests that they must be rebuilt locally. Dust production from the dry playa is occasionally severe. Upper parts of the basin are vegetated; greening occurs seasonally and after major storms at these higher elevations.

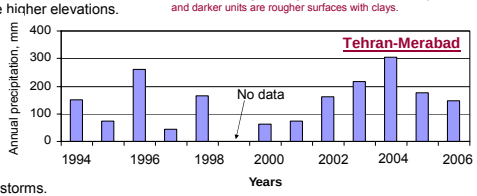
Gravel beach, east side of Sagardani Island, 1.2 m above the salt crust, 8/28/67 (Krinsley, 1968).




Landsat TM 1/13/99 (L) and 1/29/99 (R) images showing fluvial influx to Qom Playa. Dark blue in these false-color images indicates standing water; light blue indicates water of hydration; and darker units are rougher surfaces with clays.

## Precipitation history

Precipitation in Tehran is <300 mm/yr.
It occurs mainly during winter (Dec. – Mar.) low-pressure systems from the northern Mediterranean. Higher elevations may receive snow. Heavy monthly rainfall results from one or two storms.




Influx of water to Qom Playa is from two rivers, groundwater springs on the northern shore, and direct rainfall. Flood hydrographs depend on storm duration/intensity and rain/snow and lead to ponding on the NW shore. Spring discharge and groundwater changes vary more slowly, slowly seasonally and annually. Direct precipitation briefly wets the playa as a whole.

## Approach

We examined Landsat browse images from 1973 to 2006 and compared Thematic Mapper images from 1994 to 2006 to monthly precipitation data for Tehran. TM images were evaluated using a photointerpretive index (below) that assessed increasing wetness on a scale of 1-6. Vegetated area was assessed approximately using band ratio TM5/2 and thresholding, guided by photointerpretation, as a proxy for NDVI.

## Image Data

Most of the Qom basin (~185x185 km) is captured in a single Landsat TM frame. Options for imaging recur every 16 days, but cloudiness and scheduling precludes acquisition at every opportunity. Some images are available free, but most of the digital time series must be purchased. Landsat MSS images extend the time series back to 1973, but because MSS did not take SWIR data the images are sensitive only to roughness (shadowing) and standing water (dark blue), not hydrated salts.

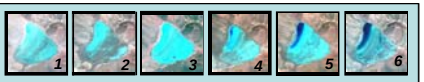
Landsat TM and Terra/ASTER images include thermal IR images that allow estimation of thermal inertia and soil moisture levels in the playa. RADAR imaging (SAR) also would be sensitive to soil moisture and standing water.

MODIS and AVHRR images have the potential for more densely populated time series because of their short repeat times (e.g., daily) and this could prove useful for for large playas such as QOM Playa, but smaller ones such as Daryacheh-ye-Howz Soltan or Arak would not be well represented because of low pixel resolution.

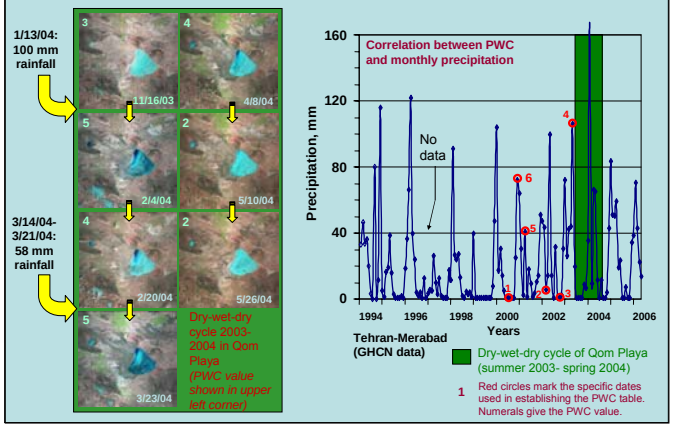
Because of the cost factor in this preliminary study, we used browse images of TM data available from GLOVIS, a browse port for the USGS at EROS Data Center.

## Playa Wetness Class (PWC)

*Empirical scale of water in playas assessed photointerpretively*

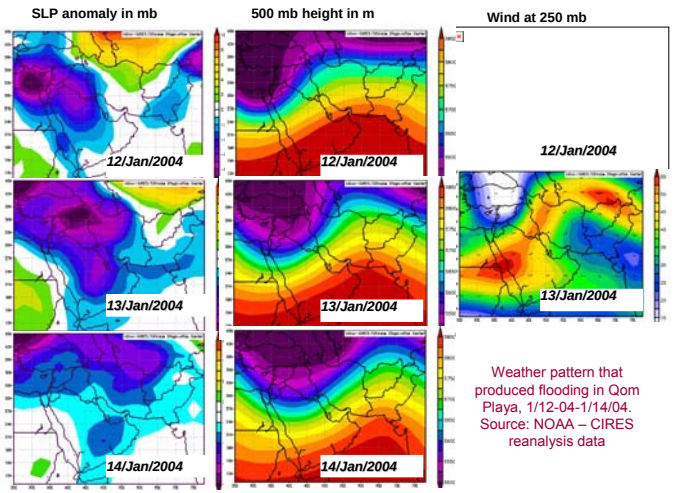



**1**- Northwestern basin is whitish – salt crystals are dehydrated. (8/19/00)
**2**- Center is dark, indicating heaving of clayey strata and micro-shadowing. NW basin hydrated. (3/2/02)
**3**- Playa is dry, including northwestern basin. Salts are hydrated; entire playa is light blue. (9/10/02)
**4**- Small pond of standing water (dark blue) occupies ≤1/3 of NW basin; rest is mostly light blue. (3/5/03)
**5**- Standing water in ≤2/3 of north basin. (3/31/01)
**6**- Standing water fills NW basin; rest shows increasing dark, moist clay. (1/10/01)

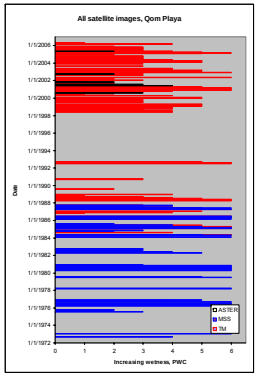


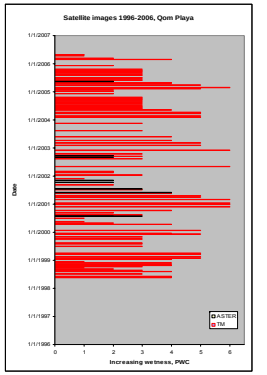

**Seasonal cycle**. A series of images (above) shows a seasonal cycle of wetting/drying and PWC for Qom playa from summer 2003 through the spring 2004. The dates are marked on the Tehran-Merabad monthly rainfall graph. Winter 2003-2004 was the wettest on the available record, with >100 mm Jan 13. Dec. 2003 and Feb. 2004 were relatively dry and March was wet, with ~60 mm in the week before the 3/23/04 image. Large yellow arrows indicate rainfall episodes, above. Small arrows show increasing date.

**Weather pattern**. The synoptic pattern (below) that produced this unusual January rain in NW Iran involved a sea-level pressure pattern for Jan 12-14, 2004 that indicated that a low-pressure system from the Eastern Mediterranean (Jan 12) moved to the ENE, arriving over NW Iran on Jan 13. This surface system was assisted by a deep upper trough ( 500 mb height). The jet stream extended from a southern position over the Eastern Mediterranean to northern Iran.




Weather pattern that produced flooding in Qom Playa, 1/12-04-1/14/04. Source: NOAA – CIRES reanalysis data




## Satellite data record

A total of 261 Landsat and ASTER images have been taken of Qom Playa since 1972; 219 were cloud-free over the playa (above, left). The wettest years preceded ~1980, as shown above but especially by the number of times the playa filling overflowed the northern basin. Does this represent an actual increase in drought? Gaps in the record make that interpretation difficult. The detailed record since 1997 (above, right) shows periodic cycle of wet and dry years and correspond to the period 1994-present (within the putative drought) for which monthly precipitation for Tehran is available.

## Quantitative information from images

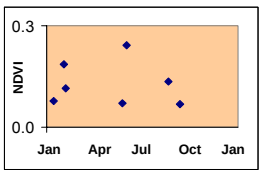
Photointerpretation yields information on location and state of wet areas, but images may be mined quantitatively for ratio information as well. Examples (and key properties) pertinent to Qom Playa include:
-- moisture (absorption, temperature, thermal inertia)
-- mineralogy (reflectivity, emissivity)
-- vegetation cover (chlorophyll absorption)
-- roughness (stereo)

## Calculating wetness

- Standing water: lightness $\alpha\ \rho e^{-2\kappa z}$ ($\rho$ is substrate reflectivity; k is absorption coefficient for $H_2O$; z is depth)
- Soil moisture: depth of $H_2O$ bands indicates how wet soils are; temperature anomalies indicate evaporative cooling
- Water of hydration: depth of $H_2O$ bands
- Subsurface moisture: increases thermal inertia

## Example: Vegetation cover & intensity

Vegetation cover (chlorophyll) is measured by the ratio of NIR reflectance and red absorption, given by the vegetation index NDVI. The graph at right shows NDVI for unirrigated vegetation from 7 images from 1999-2003. In Iran, vegetation is variable from year to year but flourishes after rainy spells.





Qom Playa from the south, perspective view (Google earth). Relief is exaggerated 3x.


**Sponsors**

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