

Different Responses of MODIS-derived Drought indices in variety of agro-climatic conditions

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Introduction

Drought is a natural local or regional phenomenon, its basic cause being the lack of precipitation over a time period. This study focuses on meteorological drought. Meteorological droughts are temporary, recurring natural disasters, which originate from the lack of precipitation and can bring significant economic losses. It is not possible to avoid meteorological droughts, but they can be predicted and monitored, and their adverse impacts can be alleviated (Livada et al., 2007).

Study area

Iran is situated in Southwest Asia, bordering the Gulf of Oman, the Persian Gulf, and the Caspian Sea, between Iraq and Pakistan. Iran is frequently hit by recurring droughts. The most recent drought of 1998–2001 was the worst in the last 30 years with rainfall deficits consistently exceeding 60% of the mean annual rainfall in most of the country. The severity of this drought placed an extreme strain on water resources, livestock and agriculture. The Iranian Emergency Agency reported that 278 cities and 1050 villages had been affected.

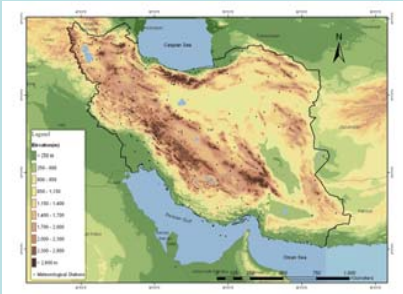


Figure 1. Geographical location and topographic map of Iran. Alijani et al. 2008 classified Iran to six separate climatic classes according to climatological parameters as Desert, Semi Desert, Mountains, Semi Mountains, Coastal Wet and Coastal Desert.

Methods

In this study four MODIS-derived drought indices are compared with three meteorological drought indices for their potential utility in detecting and measuring of drought intensity in ten different agro-climatic zones of Iran.

- MODIS-derived drought indices
 - Perpendicular Drought Index (PDI)
 - Modified Perpendicular Drought Index (MPDI)
 - Enhanced vegetation index (EVI)
 - Vegetation condition index (VCI)
- meteorological drought indices
 - China-Z index (CZI)
 - Modified CZI (MCZI)
 - Z-Score (Z)

At first, time series of MODIS satellite images (MOD13A3-V005) have been collected over the region spanning the time interval between February 2000 and December 2005 and the perpendicular drought index (PDI) and modified perpendicular drought index (MPDI) were calculated. Then, the indices were evaluated against meteorological drought indices including Zscore (Z), China-Z index (CZI) and modified China-Z index (MCZI) over 180 meteorological observing stations in Iran.

- ☑**Relationship between remote sensing indices and precipitation;**
 - All remote sensing indices and precipitation generally have statistically significant relationship for the time scales of 1- month but was modified by climatic region.
 - EVI and VCI have the weakest relationship especially in dry regions.
 - The strongest relationships belong to MPDI and PDI especially in wet regions.

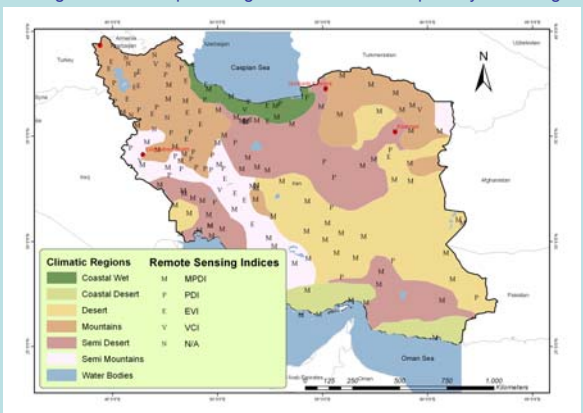


Figure 2. Spatial distribution of remote sensing indices with the best correlation with precipitation.

- ☑**Surface drought estimation and mapping**
 - According to the results of comparing of statistical and remote sensing drought indices, the following table can be used as a guide line to detect and classify drought phenomena in Iran. As shown in this table classification is related to climatic condition.

Table 1. Classification of the PDI and MPDI drought indices.

Name of class	Mountains , Coastal wet	Semi mountains, Semi desert , Coastal desert, Desert,
Moderately Wet		≥ 0.5
Normal	≥ 0.5	0.3 – 0.5
Moderately Dry	0.3 – 0.5	≤ 0.5
Severely Dry	≤ 0.5	

Conclusion

- PDI was effective for bare soil applications or early stages of vegetation growth but may not be used for vegetated surfaces.
- MPDI had acceptable performance in vegetated area.
- The relative frequency histograms of the derived remote sensing indices and the meteorological drought indices allowed a simple categorization of these indices. It indicated that they were sensitive to climatic conditions.
- For developing countries like Iran, there is a big shortage of meteorological data in both of temporal and spatial points of view and several missing data periods, which suggests using these two remote sensing drought indices as a powerful agricultural drought monitoring tools for both vegetated and bare surface.

Results

- ☑**Temporal distribution of remote sensing indices;**
 - Results indicate that Both, PDI and MPDI have in general the same reverse behavior to fluctuations of precipitation in several climatic conditions.
 - Indices were varying in the different climatic zones, which mean that the amount of PDI and MPDI are related to climatic conditions.

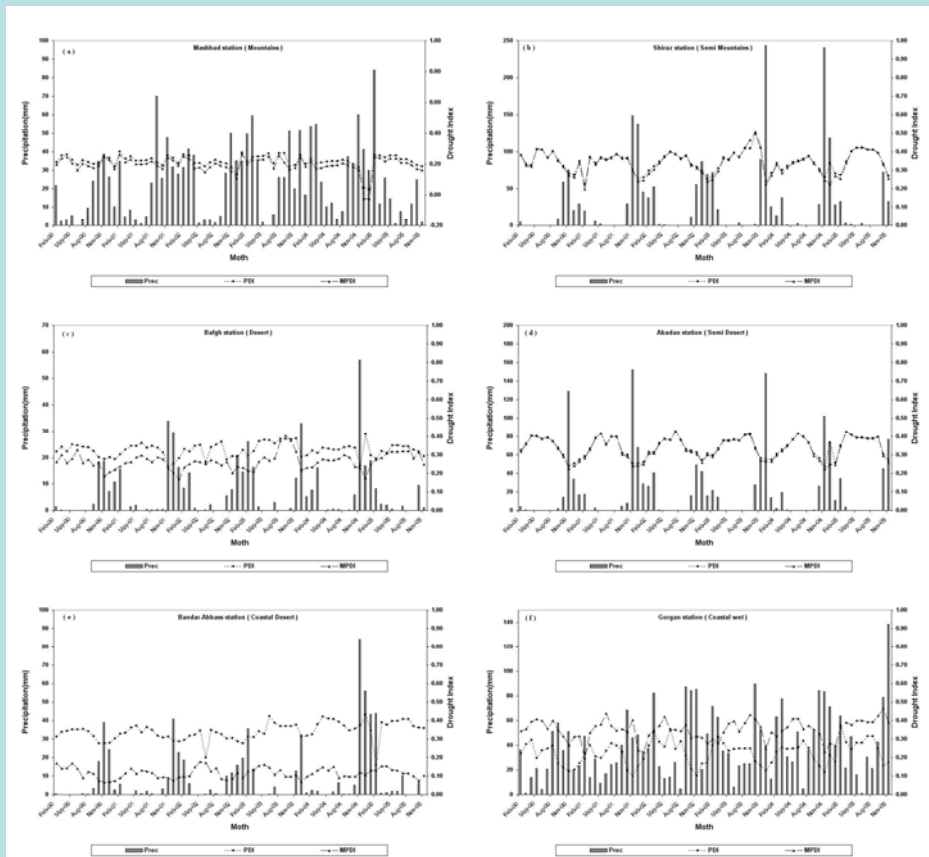


Figure 3. Temporal distribution of remote sensing indices (PDI and MPDI) vs. precipitation during Feb. 2000 to Dec. 2005 of six climatic regions in Iran; (a) Mashhad station located in mountain climatic region, (b) Shiraz station located in semi mountain climatic region, (c) Baqgh station located in desert climatic region, (d) Abadan station located in semi desert climatic region, (e) Bandar-abbass station located in coastal desert climatic region, (f) Gorgan station located in coastal wet climatic region.

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