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Drought Network News

Fall 2000

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From the Director

The NDMC hosted the first annual "Drought Monitor Forum" in November. Most of the readers of *Drought Network News* are probably aware of the Drought Monitor web site (http://enso.unl.edu/monitor/index.html) and the products that are provided to users. (Mark Svoboda of the NDMC provided an overview of the Drought Monitor product in the Winter/Spring 2000 issue of *Drought Network News*.) This weekly product, jointly produced by the NDMC, U.S. Department of Agriculture, and NOAA's Climate Prediction Center, has been widely accepted in the United States, and other countries are considering the adoption of a similar technique for mapping drought occurrence and classifying severity levels. The web site receives about 30,000 hits a week and is published widely in newspapers across the country. It has also been adopted by The Weather Channel.

A diverse set of users and technical specialists came together to review the product's successes and failures during its first year. We also discussed some of the more technical aspects of product development such as nomenclature and the use or modification of climate indices for incorporation in a blended index. Expect to see changes in the product, some subtle and some more dramatic, in the months ahead. We also expect NOAA's National Climatic Data Center to join us as a new partner in this activity in the spring of 2001. The Drought Monitor was highlighted in the report of the National Drought Policy Commission (NDPC) to Congress and the President in May 2000, and the NDPC recommended continued and expanded support for this partnership effort. (The NDPC report can be found at http://www.fsa.usda.gov/drought/finalreport/accesstoreports.htm.)

In the last issue of *Drought Network News*, I referred to the Expert Group Meeting on Early Warning Systems for Drought Preparedness and Drought Management, which I had organized with the World Meteorological Organization. This meeting was held in Lisbon, Portugal, in early September. The meeting was co-sponsored by the World Meteorological Organization, Secretariat of the U.N. Convention to Combat Desertification, and UNDP's Office to Combat Desertification and Drought. As promised, the summary (and recommendations) of that meeting is included in this issue (p. 13). The proceedings of the meeting were presented at the Fourth Session of the Conference of Parties to the

Convention to Combat Desertification in Bonn, Germany, in December 2000.

A growing number of drought network members have agreed to receive future issues of *Drought Network News* online. They have the advantage of receiving the newsletter several weeks before the printed version is available. If you'd like to join this group, contact Kim Klemsz (kklemsz2@unl.edu). We will notify you via e-mail when each new issue of *Drought Network News* is available. This will save us both printing and distribution costs—which are substantial. Back issues of *Drought Network News* are also available online.

This issue of the newsletter contains articles on the use of the SPI in northeastern Argentina, the application of NOAA/AVHRR data in Turkey, and a summary of a workshop on drought in Iran, in addition to the summary of the drought early warning systems meeting in Lisbon. Readers are encouraged to submit articles for the next issue by February 15, 2001. We also welcome announcements of workshops, conferences, and other information of interest to our network members.

Donald A. Wilhite

Contents

Using the SPI to Monitor the 1999–2000 Drought in Northeastern Argentina

Drought risk is a major concern across many regions of Argentina because precipitation is extremely variable. One of these regions, the Pampas, is the main agricultural and livestock production area, extending over 60 million hectares. This region was recently surveyed to detect, monitor, and assess the occurrence of drought using a network of 27 meteorological stations and the Standardized Precipitation Index (SPI), developed by McKee et al. (1993). The SPI has various categories that define drought intensities. A period is considered humid when the SPI value is greater than +1 and a period is considered dry when the value of the SPI is less than -1. The persistence of the extreme values was also analyzed temporally and spatially.

During the second half of 1999, the region most affected by drought was the agriculturally productive northeastern region of Argentina (Figure 1). The start of the normal rainy season was delayed for several months, further aggravating the problem and causing crop damage and production losses. This drought was due to the cumulative effect of inadequate rainfall during the 1999–2000 growing season. Several provinces in Argentina experienced the severe drought, with Entre Rios (Concordia and Gualeguychu), Buenos Aires (Junin, Nueve de Julio, and Bolivar), Sante Fe (Rosario and Ceres), and Córdoba (Villa María de Río Seco) being the most affected during January 2000 (Figure 1).

The drought was most severe and persistent in the area of Concordia and Gualeguaychu in the Entre Rios Province and extended to Junin in the Buenos Aires Province. Figure 2 shows the drought events observed in Concordia for the 3- and 6-month time scales. The SPIs are shown from January 1999 through August 2000, and both values are less than –1 for the period

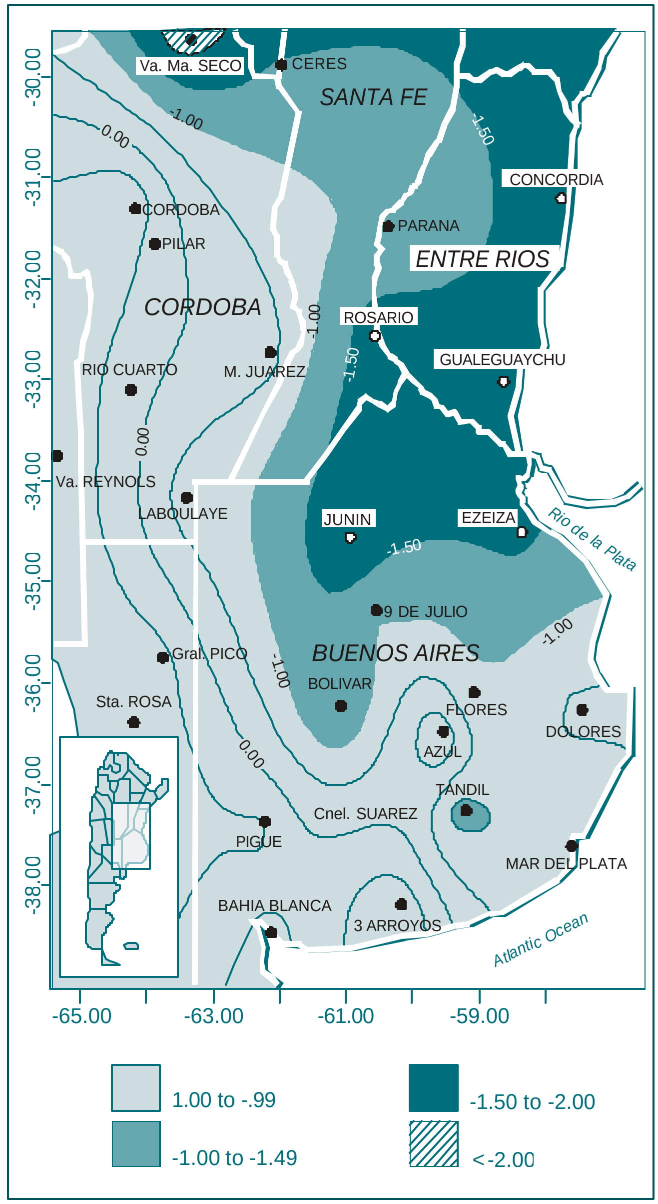

Figure 1. Areas of Argentina affected by severe drought are indicated by the Standardized Precipitation Index (SPI).

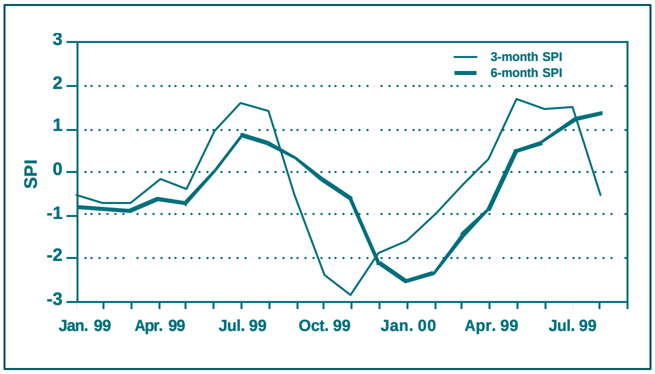

Figure 2. Time series of the Standardized Precipitation Index (SPI) for Concordia, Entre Ríos (Argentina), from January 1999 to August 2000.

from September 1999 to February 2000. Major crops were severely damaged because of this drought.

Examination of the precipitation patterns during this drought shows that precipitation over northeastern Argentina was below normal during both the critical spring (September–October–November) and summer (December–January–February) seasons. After sowing, there was a 35-day break in rainfall that caused the failure of most crops and damaged fruit trees. These conditions were thought to be the result of El Niño, which reached an acute phase during winter 1998. During September–October 1999 and February–March 2000, the change to La Niña also favored adverse environmental conditions. It was not until late March that rainfall returned to normal.

Long-term drought mitigation measures should be taken to help reduce drought impacts such as those seen during the1999–2000 drought in Argentina. Such measures should include developing an early warning and drought monitoring system as well as advising farmers and other decision makers about appropriate drought management and mitigation options.

The Center of Surveying and Analysis of Agriculture and Natural Resources (CREAN), located at the University of Córdoba in Córdoba Province, is currently keeping track of droughts through the use of several drought indices, including the SPI.

In this study, we presented a brief drought analysis using the SPI, and its potential use for drought analysis with minimal data requirements was demonstrated. It is our view that developing a drought monitoring system, based largely on meteorological and climatic information, could be a great help for the early assessment of drought impacts in the Pampas region of Argentina (Ravelo et al., 1999).

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Ravelo, A. C.; C. Rebella; C. Villanueva; R. Zanvettor; R. Rodriguez; W. Da Porta; and M. M. Skansi. 1999. Desarrollo de un Sistema para la Detección, Seguimiento y Evaluación de las Sequías Agrícolas en Argentina. *VIII Reunión Argentina de Agrometeorología*. Mendoza, Argentina.

Potential Use of NOAA/AVHRR Satellite Data for Monitoring Environmental Change in Turkey

Introduction

In Turkey, desertification has been taking place in areas of low rainfall and minimal vegetative cover. In particular, the central, eastern, and southeastern parts of the country are vulnerable to desertification because of erosion, deforestation, and degradation of vegetative cover. Rivers of those regions are characterized by very high sediment yields. Nearly 60% of the country's soils are subjected to severe erosion and approximately 450 million tons of sediment are carried to rivers each year. Meanwhile, wind erosion has been a very effective desertification process in central and southeastern parts of the country, where annual rainfall varies around 400–500 mm/year. Most central and southeastern parts of Turkey are considered semiarid, and some parts of the Central Anatolia region around Tuz Lake exhibit arid conditions, with 300 mm/year rainfall.

This study presents a potential use of remote sensing for monitoring desertification with AVHRR-derived NDVI (Normalized Difference Vegetation Index) data. NOAA series operational meteorological satellites provide data that can be used for various earth observation applications, such as vegetation indexes, sea surface temperatures, hydrologic applications, and natural disasters. The Advanced Very High Resolution Radiometer (AVHHR) is a multichannel scanning radiometer carried by the NOAA Polar Orbiter satellite series. It is a 5-channel radiometer, using a spinning mirror to scan across 111 degrees for a ground swath of 2,700 km, with an IFOV at a nadir of 1.1 km. Because of the temporal characteristics of AVHHR, it is possible to obtain valuable information for vegetation monitoring studies and other environment-linked applications (Gutman, 1991).

The use of satellite data for nonmeteorological applications in Turkey has been gaining momentum in recent years with the establishment of new HRPT stations. NOAA/AVHHR raw data used in this study were obtained from an HRPT receiving station located at the Turkish Scientific Research and Technical Council-Information Technologies and Electronics Research Institute (TUBITAK-Bilten), Middle East Technical University (METU), Ankara. The NOAA/HRPT receiving station in this institute was established in 1997 through the TU-REMOSEN Project under the NATO Science Stability Program. The station has received data from NOAA 11, 12, and 14 regularly since 1997

ORBIT					
NOAA 12–14 (since 1994 at Erdemli and 1997 at Tubitak-Bilten, Ankara) NOAA 15 (since it was launched)					
AVHRR Sensor					
Band	**1**	**2**	**3**	**4**	**5**
	0.58–0.68	0.725–1.0	3.55–3.93	10.30–11.30	11.50–12.50
FORMAT					
Rows	**Columns**	**Radiometric Res.**	**Data Volume**	**Spatial Res.**	**Temporal Res.**
1,700–1,900	2,048	10-bit	35–40 Mb	1.1 x 1.1 km.	12 hrs.

Table 1. Technical summary of satellite data used in the study.

and from NOAA 15 since it was launched. The data set used in this study is composed of 5-channel, 10-bit, raw AVHRR data, 2,048 pixels wide, at 1.1 km resolution (at nadir). It consists of only the afternoon (ascending) passes (Table 1). The data included in the study covers the period from July 1997 to May 1999.

Turkey has diverse vegetation cover, and that provides opportunities for using NOAA/AVHHR data for monitoring vegetation conditions across the country. In this study, the main emphasis is given to three regions that differ in vegetation and land-use characteristics. The selected regions are defined by grids that vary slightly in areal coverage. Region I represents the part of Central Anatolia that has the lowest annual precipitation in the country and lacks a major vegetative cover. The area underwent serious land degradation in the past and is still at great risk for drought and desertification. Region II covers part of the Aegean region where irrigated agriculture is practiced, and it is also relatively rich in forests. The third region is located in the Marmara region, which is the heavily urbanized and industrialized part of Turkey. This area is also covered by dense forests.

The Normalized Difference Vegetation Index

Many techniques have been developed to quantitatively and qualitatively study the status of the vegetation from satellite images (Kidwell, 1994). Based on the reflectance difference that green vegetation displays between the visible region and the near infrared region of the electromagnetic spectrum, in channels 1 and 2 of the AVHRR images of the NOAA satellites, the NDVI has been obtained (Goward et al., 1991). The NDVI formula takes the following form in the context of AVHRR derived data:

$$NDVI = \frac{r_2 - r_1}{r_2 + r_2}$$

where r_1 and r_2 are the reflectance values measured in AVHRR channel 1 (red) and channel 2 (near infrared), respectively. AVHRR channel 1 (0.58–0.68 µm) senses an area of the spectrum that shows an inversely proportional relationship to the amount of green vegetation present. On the other hand, AVHRR channel 2 (0.725–1.0 µm) senses a region of the spectrum with reflectance directly proportional to the density of photosynthetically active vegetation. The denser and more vigorous the vegetation is, the higher the reflectance of near-IR radiation. The range of values obtained by the NDVI is between -1 and +1. Increasing positive NDVI values are usually shown in increasing shades of green on images, indicating increasing amounts of green vegetation.

Data Processing

Cloud-free AVHRR observations of the land surface are necessary for monitoring vegetation conditions with NDVI. Images that provided clear observation of the selected regions at reasonable nadir viewing angles are included in the analysis. However, it was impossible to find completely cloud-free images for the selected regions at desired time intervals.

AVHRR data is processed to produce NDVI using the standard formula given in the previous section. The procedure for producing the final NDVI involves several steps (Figure 1). In this study, Map-X Ocean software was used to process the raw images. The process to elaborate a vegetation index (NDVI) begins with the acquisition of a NOAA satellite image. We then choose a subset of the image to create the NDVI. In the first step, a quick look at the raw data is obtained. Then the data is georeferenced to assign map coordinates to the image. After geo-encoding and calibrating each band and correcting for solar zenith angle and satellite zenith angle, AVHRR visible bands 1 and 2 are used to produce an NDVI image using the standard formula given earlier. After various coloring and enhancement techniques, the product takes its final form. The image products are 10-bit data files, and viewable 8-bit images are generated after the process.

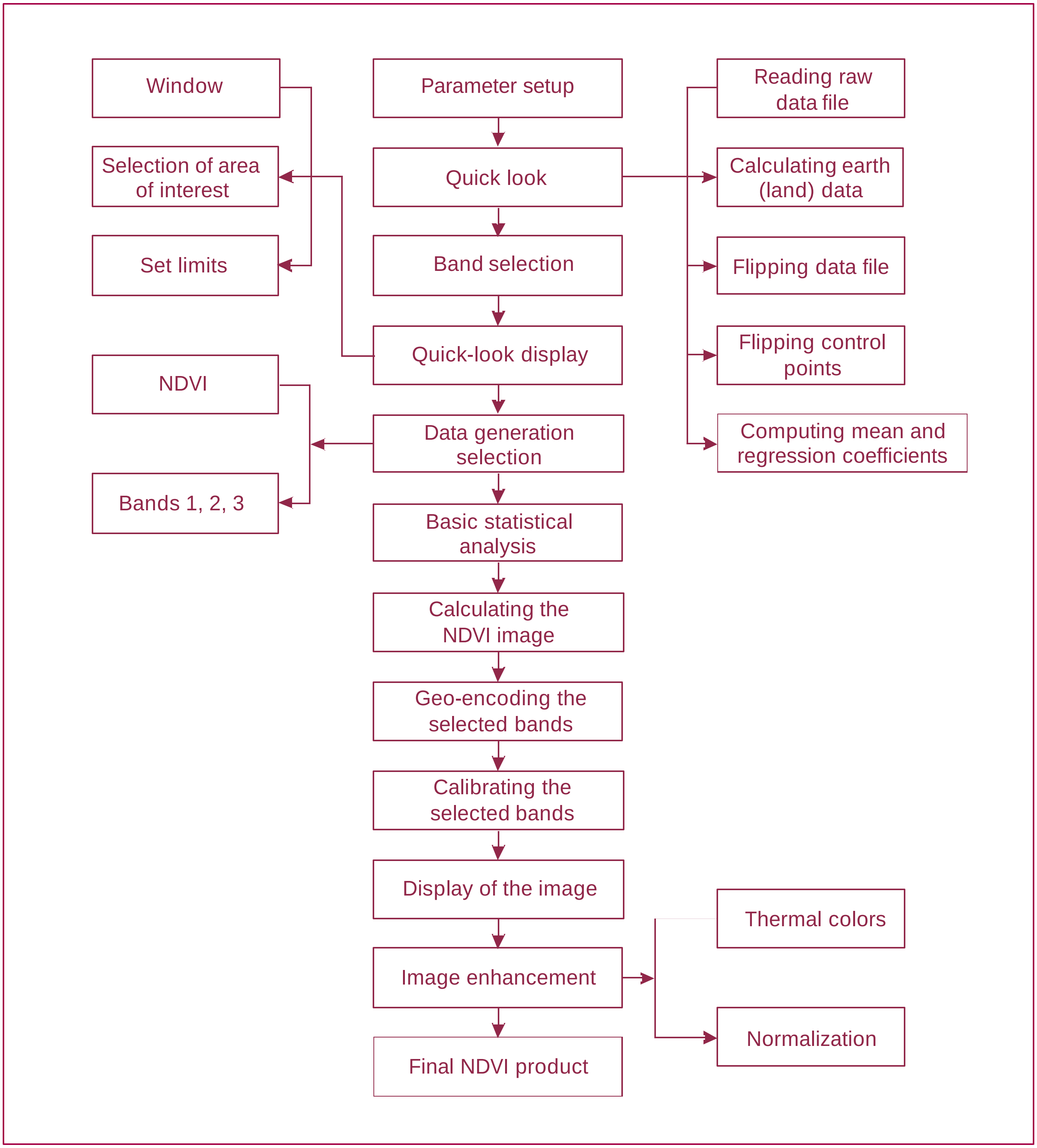

Figure 1. NDVI generation scheme by Map-X Ocean program.

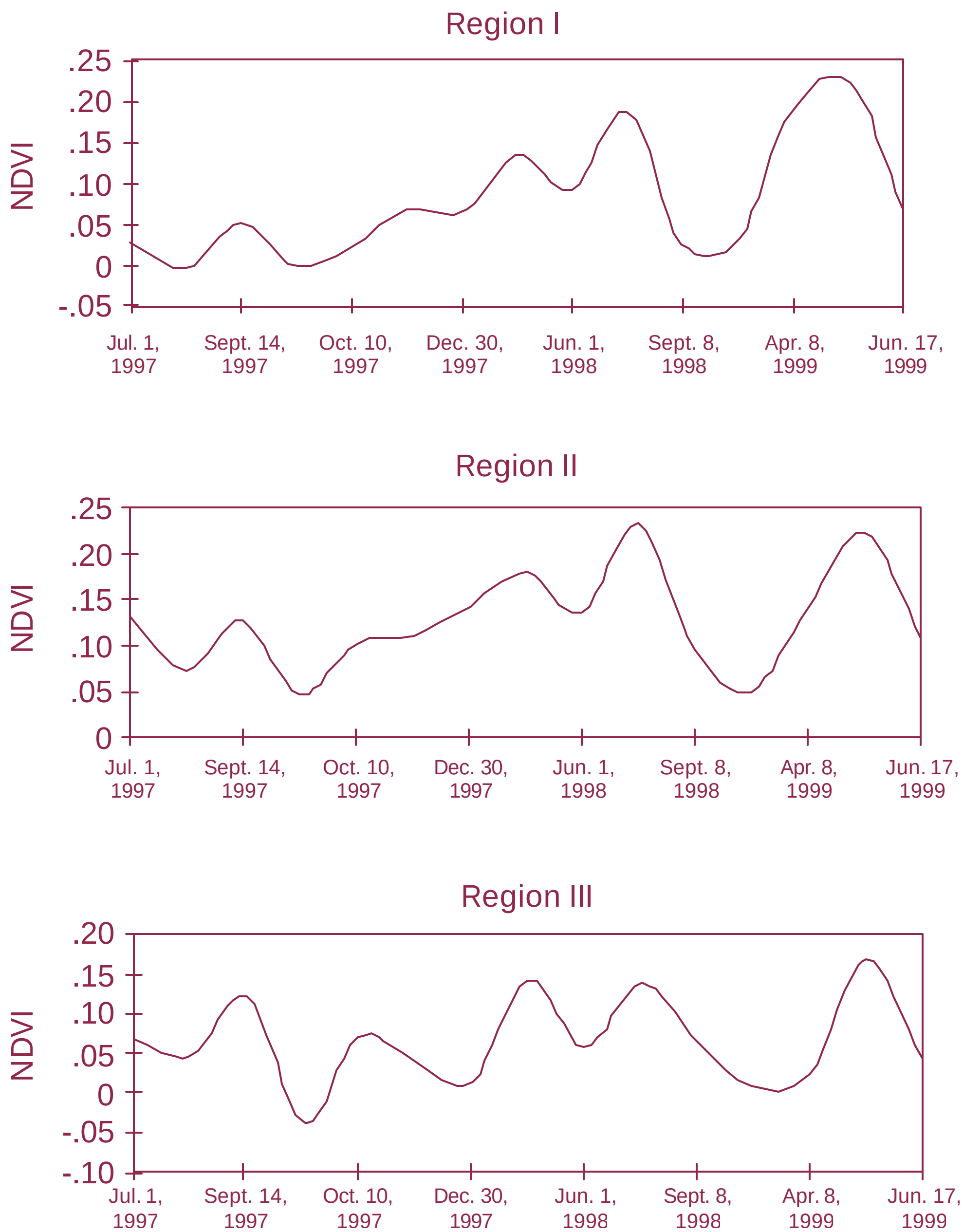

Figure 2. Temporal variations in NDVI for the selected regions.

NDVI Analysis and Results

In this study, mean NDVI and certain threshold values were evaluated with respect to their temporal changes for the selected areas, which represented different vegetation and land-use characteristics. Figure 2 illustrates time variations in NDVI for the selected regions. Interestingly, Regions I and II exhibit similar patterns, except that negative values are dominant in certain periods in Region I. That is typical, considering the lack of vegetation in the region. The values usually peak in summer months, when green biomass is greatest in all the regions. Peaks in biomass activity in the summer periods of both 1998 and 1999 are common in all three regions. Region III exhibits a more variable temporal pattern of NDVI data and is characterized by negative values in certain periods, which is likely the result of inclusion of a large water surface in the analysis. It should be kept in mind that Region III has a very diverse surface cover, including industrial areas, dense settlements, and forest cover in the north. It is our belief that cloudiness in the images also affected variation of the NDVI values to a certain extent.

The study proves that the NDVI is a useful tool for monitoring vegetative conditions and other land-use characteristics in desertification-prone areas. By examining the NDVI values over a period of time, it would be possible to monitor long-term trends in desertification processes in Turkey and include such information in drought and desertification mitigation programs. Further investigation of NDVI data will be done as the data becomes available.

Acknowledgments

Data used in this study were provided by the Turkish Scientific Research and Technical Council–Information Technologies and Electronics Research Institute (TUBITAK-Bilten), Middle East Technical University (METU). The authors wish to thank the staff of the TUBITAK-Bilten for providing the data and their assistance during the course of this study.

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Workshop on Drought-Related Issues in Fars Province, Iran: Critical Points and Resolutions

As a result of the occurrence of overwhelming severe drought over most parts of the Islamic Republic of Iran, an educational/professional workshop on drought issues was held at the College of Agriculture, Shiraz University in Iran, October 18–19, 2000. The workshop was sponsored by the College of Agriculture, the office of Fars Provincial Government, the Agricultural Bank, and Shiraz Abfa Company. The workshop was mainly focused on the assessment of drought impacts and severity in Fars province, in the southern part of Iran.

The inauguration ceremony was attended by some of the parliament members (from Fars province), the Chancellor of Shiraz University and his deputies, the construction deputy of Fars Government, the director of the National Disaster Office (NDO), the NDO staff in Fars Province, general managers from various departments of the province, postgraduate students, and about 400 professional staff from various disciplines. All sessions, including the closing session, were well attended by the participants.

In addition to the presentation of 22 papers, the workshop provided a good opportunity for executive managers to discuss some of the ongoing drought policies and the related problems influencing their individual organizations. Some specific outcomes of the meeting were:

1 Drought is a natural, frequently occurring event in our ecosystem that should be managed properly.
2. A number of important indices (e.g., Palmer Drought Severity Index, Standard Precipitation Index) were introduced as suitable indicators for evaluating drought intensities in Iran. As a follow-up, it would be essential to combine such indices and apply them in modeling procedures for a more realistic analysis of drought conditions.
3. Considering the importance of ground water as the major water resource for urban and agricultural applications, opportunities should be provided for professionals to study and develop realistic methods for utilization of ground water without sociopolitical concerns. In such a case, it would be possible to counter drought crises by using static and dynamic storage capacities of ground water resources.
4. It was shown that occurrences of drought and excess rainfall in Fars and Khoozeston provinces are influenced by the El Niño/Southern Oscillation (ENSO) phenomenon. Further research on the relationships between rainfall and large-scale climatological indices was recommended.
5. A computer model for determining optimal water allocation from the storage dams was introduced. It was emphasized that without detailed studies and computer modeling, it would not be possible to optimally allocate water demands from large storage dams such as Doroodzan in Fars Province.
6. Because of the limited water supply and the diversity in crop types over the regions irrigated by Doroodzan Dam, a computer model was introduced to determine the optimal irrigation depth for achieving maximum benefit. Such a model is useful for determining the land area that could be irrigated by the dam during drought events. The application and development of this model is recommended.
7. The rules and regulations set by the Farmers Insurance Plan (affiliated with the Bank of Farming) for insuring drought-affected crops were praised by the audience as practical and lawful procedures to assist needy farmers. This is the first time that drought-affected farms have been officially insured by the Bank. Shiraz University announced her willingness to assist with the plan as required.
8. The criteria considered for the allocation of drought funds (in Fars province) were discussed by the representatives from the Fars NDO. Shiraz University, while grateful for the previous efforts,

indicated her willingness to evaluate the present proposal as well as provide suggestions for modification of drought and flood budget resources in the form of research proposals.

9. The weather situation of the 1999–2000 agricultural year was compared with corresponding long-term values. It was shown that, in this year, Fars province experienced a reduction of normal rainfall anywhere from 35% to 90%. The figures indicate the occurrence of an exceptional drought event for this year.
10. The devastating effects of drought on wetlands and ecological zones of Fars province, including Lake Bakhtegon, Lake Kaftar, and Lake Parishon, were evaluated, and the present critical and sad situation was described for the audience. It was suggested that in cooperation with the executive organizations, alternative solutions should be studied to avoid any future problems as a result of drought events on wetlands and in ecological zones of the province.
11. An analysis of the long-term rainfall data of Shiraz was presented. The general viewpoint was that the recent drought was preceded by several droughts. However, the population increase was the main reason this recent event turned into a national crisis. It was pointed out that drought is a natural phenomenon that should be separated completely from improper management of water resources in arid zones.
12. It was noted that forage production last year was reduced anywhere from 10% to 70%, causing the elimination of about half of the animals from the rangelands within the province. Most losses were concentrated around the cities of Firoozabad, Lar Shiraz, Darab, and Noorabad.

The Resolutions of the Workshop

In the closing session of the workshop, the presented papers and viewpoints were discussed and approved by the participants. The following is a summary of the conclusions of the workshop, as approved:

1. For the sake of continuity in drought-related research, organizing an international conference (in 2002) at Shiraz University was emphasized. The topic and themes of the conference would be fixed later.
2. Realizing the socioeconomic side effects of drought, the need to support affected farmers was emphasized. The implementation of lawful supportive approaches such as agricultural crop insurance on a cooperative basis, in addition to the government support, was noted.
3. The establishment of a Drought and Flood Research Center at Shiraz University was emphasized and approved.
4. Study and evaluation of the influence of large-scale oceanic-atmospheric events (such as ENSO) on Iranian climatological conditions were emphasized.
5. Since the wetlands and lakes are strongly affected by drought events, water resources should be used in a way that will minimize drought damage.
6. The formation of a committee (with members from the university, executive branches, agriculture, industry, water resources, and social services) to help with the minimization of drought-related damages was emphasized.
7. With reference to the research results by Shiraz University, Jihad Sazandegi Research Center, and Fars Province Meteorological Department, it was recommended that funds be allocated for the development of a Fars drought atlas. The information gained from this project could facilitate the evaluation of drought issues.
8. The organization of educational/professional short courses on drought management for professional staff and managers and public educational programs to deal with drought problems were emphasized.
9. Since a majority of the streams are affected by agricultural and industrial pollutants, it was suggested that the Ecological Organization should have more power to control water pollution, especially during drought periods.
10. Because of the natural limitation of available water

resources, and the fact that a country's population is the main consumer of water resources, population control projects are of prime importance.

Coordinator's Message

Readers with suggestions or comments about the workshop are kindly requested to contact Dr. M. J. Nazemosadat, the workshop coordinator, at the addresses below.

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Improving Drought Early Warning Systems in the Context of Drought Preparedness and Mitigation

***Editor's Note:** The following article is the executive summary of the Expert Group Meeting on Early Warning Systems for Drought Preparedness and Drought Management, held September 5–7, 2000, in Lisbon, Portugal. It originally appeared in the Proceedings of the meeting, published in December 2000 by the World Meteorological Organization and edited by Donald Wilhite, M. V. K. Sivakumar, and Deborah Wood.*

Introduction

Effective drought early warning systems are an integral part of efforts worldwide to improve drought preparedness. Timely and reliable data and information must be the cornerstone of effective drought policies and plans. In pursuit of the goal of improving the effectiveness of drought early warning systems, participants of the experts meeting were asked to address three fundamental questions:

1. What is your assessment of the current status of drought early warning systems?
2. What are the shortcomings, limitations, and needs for drought early warning systems?
3. How can drought early warning systems be improved to better support drought preparedness and mitigation efforts at the local, national, and international level?

Participants identified the primary users of data and information derived from drought early warning systems as a first step in evaluating the status of early warning systems. Users were diverse, including government agencies, farmers, extension services, insurance companies, media, donors, NGOs, and the general public. Leadership for drought early warning systems is provided principally by meteorological or agricultural services. In general, where meteorological services were the lead agency, the information tended to be more meteorologically based. In contrast, leadership for drought early warning systems that were more agriculturally based tended to take a more multidisciplinary or integrated approach to monitoring. An integrated approach is considered preferable because information from all elements of the hydrologic system must be considered to obtain a comprehensive assessment of climate and water supply conditions. Although forecasting and monitoring are considered critical components of all early warning systems, there appeared to be little evidence of the beneficial use of that information by farmers.

It was noted that few countries currently have a national drought policy in place. Australia is an exception and progress in South Africa and the United States was noted. It was apparent that other countries were moving in the direction of a national drought policy. In some instances, subnational policies were in existence. Comprehensive early warning systems should be the foundation on which national drought policies and plans are constructed. Although many countries have some type of drought early warning system in place, these systems are not comprehensive and have very limited financial and human resource inputs.

Shortcomings and Needs of Drought Early Warning Systems

Participants noted the following shortcomings and needs of existing drought early warning systems:

Data Networks. In many countries, the density of meteorological and hydrological stations is insufficient to provide adequate coverage for drought monitoring. A wide range of data is necessary to adequately monitor climate and water supply status (i.e., precipitation, temperature, streamflow, ground water and reservoir levels, soil moisture, snow pack). These data are often not available at the density required for accurate assessments. Data quality (i.e., missing data) and length of record also represent critical deficiencies in data networks for many locations. Existing data networks need to be maintained and expanded in coverage and data reporting needs to be automated wherever possible to ensure timely receipt of data.

Data Sharing. Meteorological and hydrological data often are not widely shared between agencies of government. This restricts early assessment of drought and other climate conditions and retards its use in drought preparedness, mitigation, and response. In some countries, the high cost of data acquisition from meteorological services restricts the flow of information for timely assessments and for use in research. Memoranda of Understanding (MOUs) between government agencies would facilitate data sharing and use and could bring tremendous societal benefits.

Early Warning System Products. Data and information products produced by early warning systems often are not user friendly. Many products are too complicated and do not provide the type of information needed by users for making decisions. Users are seldom trained on how to apply this information in the decision-making process or consulted before product development. Many products are not evaluated for their utility in decision making. User needs should be assessed and products evaluated through permanent feedback mechanisms.

Drought Forecasts. Long-term drought forecasts (a season or more in advance) are not reliable in most instances. Drought forecasts often do not provide the specificity of information needed by farmers and others (e.g., the beginning and end of the rainy season, distribution of rainfall within the growing season) to be useful for operational decisions. Greater investments in research to improve the reliability of seasonal forecasts would provide significant economic benefits to society if these forecasts were expressed in user-friendly terms and users were trained in how these forecasts can be applied to reduce climate risks.

Drought Monitoring Tools. Tools for detecting the early onset (and end) of drought are inadequate. The Standardized Precipitation Index (SPI) was noted as an important new tool that is receiving widespread acceptance in many countries. The SPI needs to be tested and applied in more drought-prone areas, and the results should be shared. Triggers for specific mitigation and response actions are often unreliable because of the inadequacy of detection tools and inadequate linkages between indices and impacts. Integrated assessment products are preferred, but few attempts have been made to integrate meteorological and hydrological information into a single product for purposes of detecting and tracking drought conditions and development. The Drought Monitor product recently developed in the United States could serve as a model. More research is needed on climate indices such as the SPI as an early warning tool and the relationship between SPI values and impacts in specific sectors to form the basis for triggers for mitigation and response actions. Also, drought should be monitored on weekly rather than monthly time intervals in order to more accurately evaluate changes in severity and spatial characteristics. Satellite-derived remote sensing data (AVHRR) offers considerable advantages and should be an integral part of drought early warning systems.

Integrated Drought/Climate Monitoring. It is critical that an integrated approach to climate monitoring be employed to obtain a comprehensive assessment of the status of climate and water supply. Too often, drought severity is expressed only in terms of precipitation departures from normal, neglecting information about soil moisture, reservoir and ground water levels, streamflow, snow pack, and vegetation health. Seasonal climate forecasts may also provide valuable information regarding whether conditions are likely to improve or deteriorate in the coming months. Use of multiple climate indices and parameters provides monitoring specialists with an assortment of tools, each with its own strengths and weaknesses. Understanding these strengths and weaknesses will provide a scientific basis for accepting or rejecting indicators. By comparing multiple drought indicators, the relationships between these indices/tools will be better understood. The experience in the United States with the integrated drought assessment tool, the Drought Monitor, during 1999–2000 is potentially a good model to follow in future assessment efforts for some countries. This product integrates six different indicators/parameters, including vegetation health, in its assessment of drought severity in the United States.

Impact Assessment Methodology. One of the missing links in early warning systems is the connection between climate/drought indices and impacts. The lack of effective impact assessment methodologies has hindered the activation of mitigation and response programs and reliable assessments of drought-related impacts. Impact assessment methodologies need to be improved in order to help document the magnitude of drought impacts and the benefits of mitigation over response. Significant investment in interdisciplinary research on impact assessment methodologies could result in considerable progress in addressing this problem. Social scientists should be an integral part of the research team necessary to address this issue.

Delivery systems. Data and information on emerging drought conditions, seasonal forecasts, and other products often are not delivered to users in a timely manner. This characteristic significantly limits the usefulness of these products for most users. It is critical that delivery systems be improved and that they be location appropriate. For example, the Internet provides the most timely and cost-effective method of information delivery in many settings but is inappropriate in most developing countries. Electronic and print media, as well as local extension networks, need to be used more fully as part of a comprehensive delivery system to diverse user groups.

Global Early Warning System. Because of the many definitions and characteristics of drought, no historical drought data base exists. Similarly, no global drought assessment product illustrating current and emerging drought conditions is available to governments, international organizations, donors, and NGOs. A global drought assessment product that relies on one or two key variables (e.g., precipitation, vegetation health) would be a valuable tool to provide early warning of areas of potential concern.

Recommendations

Considerations:

- Recognizing that drought is a natural hazard that is quite distinct from other natural hazards in terms of its slow onset, spatial extent, and nonstructural impacts, the participants of the meeting recommend that countries develop national drought policies and preparedness plans that address the unique features of drought.
- Acknowledging that significant diversity exists within each country, the participants of the meeting emphasized the need to conduct risk assessments to identify and address the most vulnerable people and sectors at the national and subnational level. It is also essential to identify the information needs of all users at the local level.
- Recognizing that drought is a complex phenomenon, a comprehensive drought early warning system must be at the foundation of a national drought policy and preparedness plan.

In the light of the above considerations, the participants of the meeting propose the following:

Recommendation 1:
A drought preparedness and mitigation plan should be integrative and proactive, and should incorporate the following elements:

- Drought monitoring and early warning system;
- Drought risk and impact assessment; and
- Institutional arrangements, including mitigation and response actions and programs.

All of the above elements must be underpinned by research.

Recommendation 2:
As a first step, a vulnerability profile should be completed to capture the socioeconomic conditions of diverse population groups.

Recommendation 3:
Priority should be given to improving existing observation networks and establishing new meteorological, agricultural, and hydrological networks, as well as associated analytical and predictive tools and models. This effort would include:

- identifying weaknesses in the current observation system, including the critical needs of marginal areas and the most drought-prone areas;
- drought monitoring products that are prepared in collaboration with decision makers and presented in an easy-to-understand format; and
- periodic user evaluation of drought monitoring products.

Recommendation 4:
Social, economic, and environmental assessments of drought impacts must be addressed by:

- identifying appropriate and relevant physical and social indicators;
- developing triggers that link indicators of drought severity to impacts during the onset and termination of drought conditions; and
- appropriate interpretation of information and clearly expressing that assessment to decision makers in a timely manner.

Recommendation 5:
Develop institutional capacity for national drought policy and planning that includes the creation of a drought task force or commission composed of government agencies with principal responsibility for drought preparedness, monitoring and assessment, mitigation, and response. This task force could also include key stakeholder/citizen groups, NGOs, and donors.

The objectives of a national drought policy should be broadly stated and

- establish a clear set of principles or operating guidelines to govern drought management;
- be consistent and equitable for all regions, population groups, and economic/social sectors;
- be consistent with the goals of sustainable development;
- reflect regional differences in drought characteristics, vulnerability, and impacts;
- promote principles of risk management by encouraging development of
  - reliable forecasts
  - comprehensive early warning systems
  - preparedness plans at all government levels
  - mitigation policies and programs that reduce drought impacts
  - a coordinated emergency response program that ensures timely and targeted relief during drought emergencies.

Drought plan objectives are more specific and will vary between countries, reflecting the unique physical, environmental, socioeconomic, and political characteristics of the country. A national drought preparedness plan should include the following:

1. Collection and analysis of drought-related information in a timely and systematic manner.
2. Criteria for declaring drought emergencies and triggering various mitigation and response activities.
3. An organizational structure and a delivery system that assures information flow between and within levels of government.
4. Definition of the duties and responsibilities of all agencies with respect to drought.
5. Maintenance of a current inventory of mitigation and response programs used in assessing and responding to drought conditions.
6. Identification of drought-prone areas and vulnerable economic sectors, individuals, or environments.
7. Identification of mitigation actions that can be taken to address vulnerabilities and reduce drought impacts.

8. A mechanism to ensure timely and accurate assessment of drought's impacts on agriculture, industry, municipalities, wildlife, tourism and recreation, health, and other areas.
9. Provision of accurate, timely information to media in print and electronic form (e.g., via TV, radio, and the World Wide Web) to keep the public informed of current conditions and response actions.
10. A strategy to remove obstacles to the equitable allocation of water during shortages and requirements or incentives to encourage water conservation.
11. A set of procedures to continually evaluate and exercise the plan and provisions to periodically revise the plan so it will stay responsive to the needs of the country.

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Announcements

2000 National Disaster Medical System Conference

The National Disaster Medical System (NDMS) will hold its annual conference at the Adam's Mark Hotel in Dallas, Texas, April 21–25, 2001. The 2001 NDMS Conference is designed to promote interaction between local, state, and federal public health practitioners and policy makers. The conference targets practitioners from the fields of clinical medicine; public health; emergency medical services; mental health; veterinary medicine; law enforcement; fire service; mortuary service; disaster response; emergency management; and federal, state, and local specialized response teams. More than 75 accredited educational sessions will be held, focusing on areas such as planning, health, medicine, counter-terrorism, tactical, tools, mentoring, and communications. Additionally, pre-conference workshops will be held. For additional information, contact NDMS by calling 1–800–USA–NDMS and pressing the "star" key, or by e-mail at ndms@usa.net; or check their website at www.oep-ndms.dhhs.gov.

Management Strategies to Mitigate Drought in the Mediterranean: Monitoring, Risk Analysis and Contingency Planning

A short course, "Management Strategies to Mitigate Drought in the Mediterranean: Monitoring, Risk Analysis and Contingency Planning," will be held in Rabat, Morocco, May 21–26, 2001. The course is jointly organized by the CIHEAM, through the Mediterranean Agronomic Institute of Zaragoza, and the Institut Agronomique et Vétérinaire Hassan II of Morocco, with the cooperation of the European Commission (DG I). It will be given by international experts in drought policy and management issues in drought-prone regions. These lecturers come from national and international research centers, universities, government departments, and private companies.

The course is aimed at agronomists, livestock specialists, water managers, and policy makers responsible for drought management. The goal of the course is to provide participants with methodologies and technical tools to develop and implement a comprehensive drought preparedness plan. The specific objectives of the one-week course will be to provide participants with the training necessary to: define appropriate drought policy and planning objectives; collect, analyze, and deliver timely drought-related information; define reliable indicators of emerging drought conditions; determine those most at risk to drought; ensure timely and reliable assessments of drought severity and impacts; and establish criteria for declaring drought and triggering mitigation and response programs.

Application forms should be sent before February 28, 2001, to Dr. Tayeb Ameziane; Institut Agronomique et Vétérinaire Hassan II; Direction de la Formation Agronomique, P.O. Box 6202, Rabat-Instituts, Morocco (telephone: +212 37 778645; fax: +212 37 779314; e-mail: t.ameziane@iav.ac.ma). The registration fee is 300 Euros.

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Drought Network News encourages readers to submit information on current episodes of drought and its impacts; timely reports of response, mitigation, and planning actions of governments and international organizations (successes *and* failures); recent research results and new technologies that may advance the science of drought planning and management; recent publications; conference reports and news of forthcoming meetings; and editorials. If references accompany articles, please provide *full bibliographic citations*. All artwork *must* be *camera-ready*—please provide clear, sharp copies (in black/gray and white only—we are unable to reproduce color artwork) that can be photocopied/reduced without losing any detail. Correspondence should be addressed to

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