Drought monitoring and early warning indicators as tools for climate change adaptation

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Integrated Drought Management Programme in Central and Eastern Europe
A GWP and WMO initiative
Bratislava
October 5, 2012
3 classes of water problems in CEE

• too little water
• too much water
• water pollution

Can (and will) be exacerbated by climate change
Observed changes in annual precipitation between 1961–2006

Red: decrease
Blue: increase

mm per decade

- 300
- 270
- 240
- 210
- 180
- 150
- 120
- 90
- 60
- 30
- 0
- 30
- 60
- 90
- 120
- 150
- 180
- 210
Main drought events in Europe, 2000–2009
Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (IPCC, 2012)
Decrease in return period implies more frequent extreme temperature events.

The time between “20-year” (unusually) warm days will decrease.
There is medium confidence that droughts will intensify in the 21st century in some seasons and areas, due to reduced precipitation and/or increased evapotranspiration.

This applies to regions including southern Europe and the Mediterranean region, central Europe, central North America, Central America and Mexico, NE Brazil, and S Africa.
Multiple competing objectives

- Hydropower
- Ecosystems health
- Consumptive use
- Agriculture
- Flood control
- Recreation
- Pulwarty, NIDIS
Just what is drought?

- Precipitation deficits?
- Soil moisture?
- Streamflow?
- Plants wilting?
- Wildfire?
- Famine?
- Other?

Drought is a multi-faceted issue and requires a multi-faceted assessment.
Key Variables for Monitoring Drought

• climate data
• soil moisture
• stream flow
• ground water
• reservoir and lake levels
• snow pack
• short, medium, and long range forecasts
• vegetation health/stress and fire danger
A multidisciplinary set of indicators to constantly monitor the various environmental components potentially affected by droughts (soil, vegetation, etc.) in order to obtain a comprehensive and updated picture of the situation.
Multi-Indicator Approach

Source: National Drought Mitigation Center, University of Nebraska-Lincoln, USA
Proceeding of precipitation deficit throughout the hydrological cycle

(Rasmusson, 1993)
Agricultural Drought Indices

– Agricultural drought indices should be based on soil moisture and evapotranspiration deficits and should help effectively monitor agricultural drought.

– A drought index should integrate various parameters like RR, T, ET, runoff and other water supply indicators into a single number and give a comprehensive picture for decision-making.

WMO, 2008
A consensus agricultural drought index?

- A consensus agricultural drought index should help explain not only the degree of severity of droughts, but also assist policy makers in taking early actions.
- Depending upon available data and resources a composite agricultural index is the best means of achieving a standard consensus index.
- Until the resources are available for the composite index, a simple index incorporating rainfall and soil moisture should first be adopted, then water balance index should be tiered into the agricultural drought indexing methodology. Finally, as the data and resource become available, a composite agricultural drought index should be adopted as a standard for monitoring the onset, severity, and end of agricultural drought.
SIMPLE APPROACH
Precipitation Departures

- Precipitation the key indicator for vegetation growth, water resources
- Temperature effects also important, but precipitation dominates
- Measured virtually everywhere
- Easy to calculate
- Can be done for points or over areas (such as a state or climate division)
Palmer Drought Severity Index (PDSI), 1965

• First widely used soil moisture model
• Uses temperature and precipitation departures to determine dryness
• Ranges from -4 (extreme drought) to +4 (extreme wet)
• Standardized to local climate
   Based on departures from local climate normals
• Good for measuring long-term drought in relatively uniform regions
   Not good for short-term drought / rapid changes
   Not good for variable terrain (i.e., mountains)
• May lag emerging drought conditions by several months
Palmer Drought Severity Index (PDSI)

Drought Severity Index by Division

Weekly Value for Period Ending 12 APR 2008

Long Term Palmer

-4.0 or less (Extreme Drought)
-3.0 to -3.9 (Severe Drought)
-2.0 to -2.9 (Moderate Drought)
-1.9 to +1.9 (Near Normal)
+2.0 to +2.9 (Unusual Moist Spell)
+3.0 to +3.9 (Very Moist Spell)
+4.0 and above (Extremely Moist)

CLIMATE PREDICTION CENTER, NOAA
Crop Moisture Index (CMI), 1968

- Geared for agricultural drought
- Uses same categories as PDSI
- Responds more rapidly than PDSI
  Short-term dryness or wetness
- Starts and ends growing season at near zero
  Not good for long-term assessments
- May overestimate recovery resulting from short-term rainfall
Crop Moisture Index (CMI)

Crop Moisture Index by Division
Weekly Value for Period Ending 12 APR 2008
Short Term Need vs. Available Water in 5 Ft Profile

-3.0 or less (Severely Dry)
-2.0 to -2.9 (Excessively Dry)
-1.0 to -1.9 (Abnormally Dry)
-0.9 to +0.9 (Slightly Dry/Favorably Moist)
+1.0 to +1.9 (Abnormally Moist)
+2.0 to +2.9 (Wet)
+3.0 and above (Excessively Wet)
Standardized Precipitation Index (SPI), 1990s

• Can be produced for a variety of time periods, depicting both short-term and long-term conditions
• Based on precipitation over an accumulation period compared to the station’s historical distribution
• Statistical “unusualness” of a period
• PDSI uses a water-balance model to estimate evaporation based on temperature
• Values of -2 or less are extremely dry; +2 and greater are extremely wet
Standardized Precipitation Index (SPI)

1-month SPI through the end of February 2008

3-month SPI through the end of February 2008

6-month SPI through the end of February 2008

12-month SPI through the end of February 2008
SPI on several time scales for Ljubljana

(Ceglar et al., 2007)
Keetch-Byram Drought Index (KBDI)

- Estimates dryness of soil and dead vegetation
- Ranges from 0 (saturated soil) to 800 (dry soil)
- Based on combination of recent precipitation and estimated evaporation
  - Soil may dry because of extended periods without precipitation or by high temperatures / strong winds
- Developed for fire management purposes, but also a good short-term drought indicator
Keetch-Byram Drought Index (KBDI)

<table>
<thead>
<tr>
<th>KBDI Value</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-200</td>
<td>No Drought-Slight Drought. Fuels and ground are quite moist.</td>
</tr>
<tr>
<td>200-400</td>
<td>Moderate Drought. Dry vegetation begins to contribute to fire.</td>
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<tr>
<td>400-600</td>
<td>Severe Drought. Escaped fire is difficult to control.</td>
</tr>
<tr>
<td>600-800</td>
<td>Extreme Drought. Fire suppression is a major problem.</td>
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</tbody>
</table>
Other Drought Tools

• Evaporation models
  – Often the missing link in drought understanding
  – Direct measurement difficult and disappearing (pan evap)
  – ET models are getting more sophisticated

• Soil Moisture
  – Integrates precipitation deficits over time
  – Lagging indicator but strongly related to impacts
  – Valuable for assessing recovery
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

http://drought.unl.edu/dm

Released Thursday, August 4, 2011

Author: Brad Rippey, U.S. Department of Agriculture
European Drought Observatory – EDO

General philosophy &
Technical solutions

http://edo.jrc.ec.europa.eu
Web-based Platform for detection, monitoring, forecasting and information exchange

- commonly agreed products (e.g. drought indices)
- joint comparison and analysis of information
- mutual exchange of knowledge & methodologies
- direct up- and downscaling
- real-time monitoring and forecasting (early warning, preparedness)

Multi-scale approach, integrating

- EU / continental level
- MS level
- Regional / river basin level

Subsidiarity principle

- European level information + platform (JRC)
- National datasets managed at MS level
- regional information processed by river basin / regional environmental authorities
- De-central data holding
Precipitation (SPI)
- for aggregation periods of 1, 3, 6, 9, 12, 24 months

Soil Moisture
- Daily soil moisture
- Daily soil moisture anomaly
- Forecasted soil moisture anomaly (7 days)
- Forecasted soil moisture trend

Vegetation status
- NDWI 10-day composites
- NDWI anomalies
- fAPAR 10-day composites
- fAPAR anomalies

Composite Drought Indicator (Drought Alert)
10-days fAPAR anomaly: 1. 8. 2012
Anomaly of fAPAR (fraction of Absorbed Photosynthetically Active Radiation): 10-day time composite, 1 Km spatial resolution, derived from MERIS fAPAR.
3-month SPI for 10-12/2008 aggregated to regional level

http://edo.jrc.ec.europa.eu/

Products:
- Precipitation Indicators
- Modelled Soil Moisture
- Remote Sensing Indicators

SPI: Standardized Precipitation Index
Soil moisture anomaly

Soil Moisture over 10 days: LISFLOOD modelled top soil moisture suction (pF value) for Europe in the original 5 km resolution. Information is presented where reliable data on the soil properties are available.
## Factsheets of EDO Indicators

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<tr>
<th>INDICATOR</th>
<th>FACTSHEET</th>
<th>RELATED INFO</th>
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<tbody>
<tr>
<td>Combined Drought Indicator</td>
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<tr>
<td>Daily Soil Moisture</td>
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<td>Average per Region</td>
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<tr>
<td>Daily Soil Moisture Anomaly</td>
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<td>Average per Region</td>
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<td>SPI at SYNOP stations from the MARS database</td>
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<tr>
<td>SPI at SYNOP stations interpolated to 0.25dd grid</td>
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<td>Spatial average of SPI at SYNOP stations / interpolated SPI for Eurostat NUTS3 regions</td>
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<td>Vegetation Productivity (fAPAR)</td>
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Characteristics of Crisis Management

- Reactive, post-impact
- Poorly coordinated
- Untimely
- Poorly targeted
- Ineffective
- Decreases self-reliance → greater vulnerability
Need for Drought Mitigation Actions in CEE

- Improved monitoring
- Drought planning
- Communication and coordination
  - Information Services
- Education/public awareness
- Water supply augmentation
- Demand reduction/water conservation
- Water use conflict resolution
- Legislation/policy changes
Extra slides
Adaptive capacity
“the ability or potential of a system to respond successfully to climate variability and changes“ (IPCC 2007)

- Awareness
- Technology and infrastructure
- Economic resources
- Institutions
Vulnerability to climate change “is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity” (IPCC 2007).

- Countries which expect a high increase in impact seem to be less able to adapt.
- Climate change would trigger a deepening of the existing socio-economic imbalances between the core of Europe and its periphery.

Future runs counter to territorial cohesion?