Drought Monitoring and Impact Evaluation
from Scientific Methods to Disaster Response

Jianjun Wu
Academy of Disaster Reduction and Emergency Management, Beijing Normal University
BNU Drought Mitigation Center
jjwu@bnu.edu.cn
Global Distribution of Drought Risk

Total Economic Loss

Drought Total Economic Loss
Risk Deciles

1st - 4th
5th - 7th
8th - 10th

Center for Hazards and Risk Research
The Earth Institute at Columbia University
www.ldeo.columbia.edu/chrn/research/hotspots
Drought events in China is increasing

- 2006, drought in Chongqing
- 2008, drought in Jiangxi and Hunan
- 2009, North China drought
- 2010, Southwest China drought
- 2011, drought in SW China, Yangtze river basin
Drought is different and difficult

Drought differs from other natural hazards and is difficult to deal with

- the absence of a precise and universally accepted definition-----difficult to be defined
- it is accumulate slowly----difficult to be monitored
- impacts are less obvious and spread over a larger geographical area------difficult to quantify the loss and to relief the disasters
How We Should Handle Drought

risk management

Preparedness
Prediction and Early Warning
Mitigation
Disaster
Protection
Recovery
Impact Assessment
Reconstruction
Response
Recovery
crisis management

NDMC and others
What is the most important for drought

• Monitoring
to find out where is drought

• Evaluating its impacts (or ,loss)
to investigate what is the drought result in, eg. agriculture, water resource

• Assessing the risk
to identify where is potentially dangerous area, and where is most dangerous (risk)
Risk Mapping

Hazard, Vulnerability and Risk

• Hazard, WDCC defined the hazard as a threatening event that would make supply inadequate to meet demand.

• Vulnerability, characteristics of populations, activities, or the environment that make them susceptible to the effects of drought.

• Risk, the potential adverse effects of drought as a product of both the frequency and severity of the hazard and corresponding vulnerability.
Agricultural Drought Risk

Hazard describes the physical characteristics of drought, and can’t be prevented. Reducing the vulnerability is the way to decrease drought risk.

Conceptual Model:

Risk = Hazards × Vulnerability

Based on the basic concept of natural hazard risk, the spatio-temporal pattern of agricultural drought risk in China was conducted on 10km*10km grid.
MODELING-Assessment for Hazard

- Droughts hazard analysis revolves around an understanding of the:
  - Frequency
  - Intensity
  - Duration, and
  - spatial extent

of drought occurrences.

- The Standardized Precipitation Index (SPI) at the three-month time scale is used to define the drought characteristics.
### MODELING-Assessment for Hazard

\[ DHI = (MD_r \times MD_w) + (SD_r \times SD_w) + (VD_r \times VD_w) \]

<table>
<thead>
<tr>
<th>SPI</th>
<th>Drought severity</th>
<th>weight</th>
<th>Percentage of occurrence of</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>0~0.99</td>
<td>Mild drought</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>-1.0~1.49</td>
<td>Moderate drought</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-1.5~1.99</td>
<td>Severe drought</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤-2</td>
<td>Extreme drought</td>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

|            | High      | 1        |
|            | Less high | 2        |
|            | Moderate  | 3        |
|            | Low       | 4        |

|            | High      | 1        |
|            | Less high | 2        |
|            | Moderate  | 3        |
|            | Low       | 4        |

|            | High      | 1        |
|            | Less high | 2        |
|            | Moderate  | 3        |
|            | Low       | 4        |
Spatial extent of moderate, severe and extreme drought occurrences at 3 months time step in China
Drought Hazard

MODELING-Assessment for vulnerability

Drought vulnerability indicators

A holistic drought vulnerability index should take into account the ecological, socio-economic and planting conditions. Indicators could represent the vulnerability to agricultural drought are

✓ climate, represented by seasonal crop water deficiency
✓ soil, represented by soil water holding capacity, and
✓ irrigation, represented by irrigation availability

Model for agricultural drought vulnerability assessment

\[ V = G(f(C), f(S), f(I)) \]
Seasonal crop water deficiency

\[ SCWD = \frac{ET - P}{ET} \]

\[ ET = ET_0 \cdot Kc \]
# Vulnerability to Agricultural Drought

<table>
<thead>
<tr>
<th>Agricultural drought vulnerability factor</th>
<th>Vulnerability class</th>
<th>weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil AWC</td>
<td>&lt; 100mm</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>100–175mm</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>175–250mm</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>&gt;250mm</td>
<td>1</td>
</tr>
<tr>
<td>Seasonal crop water deficiency</td>
<td>&lt;0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>0–30%</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>30–60%</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>&gt;60%</td>
<td>5</td>
</tr>
<tr>
<td>Irrigation support</td>
<td>Available irrigation</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>No irrigation</td>
<td>4</td>
</tr>
</tbody>
</table>
Vulnerability to Agricultural Drought

J. Wu, B. He., 2011, Quantitative assessment and spatial characteristics analysis of agricultural drought vulnerability in China, Nat. Hazards. 56: 785–801
Mapping for agricultural risk in China

Risk = Hazard × Vulnerability

B. He, J. Wu., 2011, Drought hazard assessment and spatial characters analysis in china, J. Geographical Sciences, 21(2):235-249

Quantitative assessment and spatial characteristics analysis of agricultural drought risk in China, Nat. Hazards (accepted)

J. Wu, B. He., 2011, Quantitative assessment and spatial characteristics analysis of agricultural drought vulnerability in China, Nat. Hazards. 56: 785–801
Summery-Risk Mapping

• The research outcome generated map of drought risk to agricultural in China

• The risk assessment could provide essential information to help address the issue of drought risk and could also direct drought management strategies for mitigation purposes.

• Identifying regional vulnerabilities can lead to changing practices in water-dependent sectors and can help decision makers to incorporate droughts into resource planning for disaster mitigation.

• The outcome could be very helpful for the commercial insurance company, which is interested in the agricultural natural disasters insurance.

• The risk is relative in regional scale duo the weights measurements, which could be improved in the further analysis
Monitoring Drought by Remote Sensing

- NDVI or NDVI anomalies
- VCI Vegetation Condition Index
- TCI Temperature Condition Index
- VSWI Vegetation Supply Water Index
- TVDI Temperature-Vegetation Dryness Index
- NDDI, NDWI, … …
A New Method-Integrated Surface Drought Index (ISDI)

Drought

- Temperature
- Soil
- Eco-region
- Irrigation
- Landcover
- Elevation
- Vegetation
Motivity of improving the method

• Drought is a complex natural disaster but all traditional meteorological and remote sensed drought indices used to describe drought have their own weaknesses and shortcomings.

• The drought intensity differences caused by vegetation type, temperature, elevation, manmade irrigation, and other factors under the same water condition must be considered.

• Integrated drought index based on data mining provides a promising approach to better characterize the spatial extent and intensity of drought.

• ISDI can be established based on large numbers of variables because data mining can handle a variety of data types.
Drought in 2006

- 2006 was selected as a typical partially dry year to compare the six MODIS images-derived and meteorological-measured drought indices.

- **Two comparative methods**
  - spatial drought detecting characteristics
  - Indices curve of 2006 was extracted using 9*9km window at the location of 11 agro-meteorological stations for the purpose of temporal trend comparison

- the precipitation of 2006 was also selected as the evaluation criteria.
Drought investigated by field observation

- The south of Shanxi province and North China plain region were affected by varying degrees of drought during April-June 2006.

- Two typical periods (April 23th-May 8th and 9th May-24th May, 2006) of drought monitoring results were selected to compare the spatial monitoring characteristic of drought indices.

<table>
<thead>
<tr>
<th>Station ID</th>
<th>Station Name</th>
<th>Year, Month</th>
<th>Disaster Type</th>
<th>Object</th>
<th>Intensity</th>
<th>Affected Area (Mn.)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>53868</td>
<td>Linfen</td>
<td>2006, 4</td>
<td>Drought</td>
<td>Winter-Wheat</td>
<td>Mild</td>
<td>150000</td>
<td>30-39%</td>
</tr>
<tr>
<td>53868</td>
<td>Linfen</td>
<td>2006, 5</td>
<td>Drought</td>
<td>Winter-Wheat</td>
<td>Mild</td>
<td>200000</td>
<td>40-49%</td>
</tr>
<tr>
<td>53868</td>
<td>Linfen</td>
<td>2006, 6</td>
<td>Drought</td>
<td>Winter-Wheat</td>
<td>Mild</td>
<td>200000</td>
<td>40-49%</td>
</tr>
<tr>
<td>54827</td>
<td>Taian</td>
<td>2006, 4</td>
<td>Drought</td>
<td>All-Crops</td>
<td>Mild</td>
<td>150000</td>
<td>10-19%</td>
</tr>
<tr>
<td>54827</td>
<td>Taian</td>
<td>2006, 5</td>
<td>Drought</td>
<td>All-Crops</td>
<td>Mild</td>
<td>150000</td>
<td>10-19%</td>
</tr>
<tr>
<td>57089</td>
<td>Xuchang</td>
<td>2006, 4</td>
<td>Drought</td>
<td>Winter-Wheat</td>
<td>Mid</td>
<td>Unknown</td>
<td>Unknown</td>
</tr>
<tr>
<td>57089</td>
<td>Xuchang</td>
<td>2006, 5</td>
<td>Drought</td>
<td>Winter-Wheat</td>
<td>Mid</td>
<td>Unknown</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

Field observation data are derived from China agro-meteorological disasters ten-day dataset of China Meteorological Data Sharing Service System...
Vegetation Index  LST  Land cover

Eco-region  AWC  Irrigation  DEM

Beijing Normal University
Data related in Drought

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Acronym</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palmer Drought Severity Index</td>
<td>Climate</td>
<td>PDSI</td>
<td>China Meteorological Data Sharing Service System (MDA)</td>
</tr>
<tr>
<td>Standardized Precipitation Index</td>
<td>Climate</td>
<td>SPI</td>
<td>China Meteorological Data Sharing Service System (MDA)</td>
</tr>
<tr>
<td>Normalized Difference Vegetation Index</td>
<td>Satellite</td>
<td>NDVI</td>
<td>Land Processes Distributed Active Archive Center (LP DAAC)</td>
</tr>
<tr>
<td>Land Surface Temperature</td>
<td>Satellite</td>
<td>LST</td>
<td>LP DAAC</td>
</tr>
<tr>
<td>Vegetation Condition Index</td>
<td>Satellite</td>
<td>VCI</td>
<td>LP DAAC</td>
</tr>
<tr>
<td>Temperature Condition Index</td>
<td>Satellite</td>
<td>TCI</td>
<td>LP DAAC</td>
</tr>
<tr>
<td>Vegetation-Supply Water Index</td>
<td>Satellite</td>
<td>VSWI</td>
<td>LP DAAC</td>
</tr>
<tr>
<td>Start of Season Anomaly</td>
<td>Satellite</td>
<td>SOSA</td>
<td>LP DAAC</td>
</tr>
<tr>
<td>Percent of Average Seasonal Greenness</td>
<td>Satellite</td>
<td>PASG</td>
<td>LP DAAC</td>
</tr>
<tr>
<td>Elevation</td>
<td>Biophysical</td>
<td>Ele</td>
<td>Environmental &amp; Ecological Science Data Center for West China, National Natural Science Foundation of China</td>
</tr>
<tr>
<td>Ecological Regions</td>
<td>Biophysical</td>
<td>EcoRe</td>
<td>China’s Eco Geographical Region Map</td>
</tr>
<tr>
<td>Land Cover</td>
<td>Biophysical</td>
<td>NLCD</td>
<td>NASA Goddard Space Flight Center (MODIS Land Products)</td>
</tr>
<tr>
<td>Soil Available Water Capacity</td>
<td>Biophysical</td>
<td>AWC</td>
<td>International Geosphere-Biosphere Programme, IGBP</td>
</tr>
<tr>
<td>Irrigated Agriculture Region</td>
<td>Biophysical</td>
<td>IrrAg</td>
<td>Global Map of Irrigated Area (GIAM)</td>
</tr>
</tbody>
</table>

- MODIS data indices
  - NDVI
  - LST
  - VCI
  - TCI
  - PASG
  - SOSA
  - VSWI

- Meteorological indices
  - PPA
  - SPI
  - PDSI

Biophysical Data

- 16 day PPA, SPI data in a tabular form were spatially interpolated into a raster image format by using spline method of ArcMap.
Spatial monitoring characteristic of drought indices

Fig. 5 Comparison of MODIS- and meteorological-derived drought indices in the study area for the 113th day in 2006 (April 23-May 8)
Spatial monitoring characteristic of drought indices

Fig. 5 Comparison of MODIS- and meteorological-derived drought indices in the study area for the 129th day in 2006 (May 9th-24th)
correlation and regression analysis among the drought indices

Correlation matrix among the integrals under the curves of MODIS- and meteorological-derived drought indices as well as integral of relative air humidity curve and cumulative rainfall at the location of 11 agro-meteorological stations for 2006

<table>
<thead>
<tr>
<th>Drought indices</th>
<th>Precipitation</th>
<th>Relative air humidity</th>
<th>VSWI</th>
<th>VCI</th>
<th>TCI</th>
<th>PASG</th>
<th>PPA</th>
<th>SPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006 (a dry year)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Precipitation</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relative air humidity</td>
<td><strong>0.545</strong></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VSWI</td>
<td><strong>0.620</strong></td>
<td><strong>0.916</strong>*</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VCI</td>
<td>-0.289</td>
<td>0.486</td>
<td>0.295</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TCI</td>
<td>0.474</td>
<td><strong>0.866</strong>*</td>
<td><strong>0.684</strong></td>
<td>0.520</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PASG</td>
<td>0.132</td>
<td><strong>0.829</strong>*</td>
<td><strong>0.672</strong></td>
<td><strong>0.825</strong>*</td>
<td><strong>0.800</strong>*</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PPA</td>
<td><strong>0.507</strong></td>
<td>0.081</td>
<td>0.024</td>
<td>-0.540*</td>
<td>0.007</td>
<td>-0.187</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>SPI</td>
<td>0.255</td>
<td>-0.229</td>
<td>-0.372</td>
<td>-0.347</td>
<td>-0.133</td>
<td>-0.308</td>
<td><strong>0.781</strong>*</td>
<td>1</td>
</tr>
</tbody>
</table>

Higher correlations are marked in bold. *** represent the significant values at the p<0.01. ** represent the significant values at the p<0.05. * represent the significant values at the p<0.1.
Cross plots of the integral under the indices for typical sites during 2006

- VSWI curve has remarkable correlations with the cumulative precipitation. Land surface temperature (LST) contributes more to the result of hybrid index (VSWI) than reflective information such as NDVI.

Integrated Surface Drought Index for drought monitoring
## Model construction results and intersect validation

<table>
<thead>
<tr>
<th>Variables Phase</th>
<th>Average error</th>
<th>Relative error</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>PASG, SOSA, SPI, elevation, Landcover, AWC, GIAM, Eco_region, PDSI</td>
<td>Spring</td>
<td>0.3569</td>
<td>0.23</td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td>0.7064</td>
<td>0.42</td>
</tr>
<tr>
<td></td>
<td>Autumn</td>
<td>0.4105</td>
<td>0.22</td>
</tr>
<tr>
<td>VSWI, SOSA, SPI, elevation, Landcover, AWC, GIAM, Eco_region, PDSI</td>
<td>Spring</td>
<td>0.3619</td>
<td>0.24</td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td>0.6376</td>
<td>0.37</td>
</tr>
<tr>
<td></td>
<td>Autumn</td>
<td>0.4291</td>
<td>0.22</td>
</tr>
<tr>
<td>LST, SOSA, SPI, elevation, Landcover, AWC, GIAM, Eco_region, PDSI</td>
<td>Spring</td>
<td>0.3569</td>
<td>0.23</td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td>0.7064</td>
<td>0.42</td>
</tr>
<tr>
<td></td>
<td>Autumn</td>
<td>0.4105</td>
<td>0.22</td>
</tr>
<tr>
<td>NDVI, SOSA, SPI, elevation, Landcover, AWC, GIAM, Eco_region, PDSI</td>
<td>Spring</td>
<td>0.3569</td>
<td>0.23</td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td>0.7064</td>
<td>0.42</td>
</tr>
<tr>
<td></td>
<td>Autumn</td>
<td>0.4105</td>
<td>0.22</td>
</tr>
<tr>
<td>PASG, TCI, SOSA, SPI, elevation, Landcover, AWC, GIAM, Eco_region, PDSI</td>
<td>Spring</td>
<td>0.3569</td>
<td>0.23</td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td>0.7064</td>
<td>0.42</td>
</tr>
<tr>
<td></td>
<td>Autumn</td>
<td>0.4105</td>
<td>0.22</td>
</tr>
<tr>
<td>VCI, TCI, SOSA, SPI, elevation, Landcover, AWC, GIAM, Eco_region, PDSI</td>
<td>Spring</td>
<td>0.3569</td>
<td>0.23</td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td>0.7064</td>
<td>0.42</td>
</tr>
<tr>
<td></td>
<td>Autumn</td>
<td>0.4105</td>
<td>0.22</td>
</tr>
</tbody>
</table>
The construction results of plan 7 which was used to build the ISDI

(a) Spring Phase

Average |err| 0.3569
Relative |err| 0.23
Correl Coeff 0.94

(b) Summer Phase

Average |err| 0.7064
Relative |err| 0.42
Correl Coeff 0.87

(c) Autumn Phase

Average |err| 0.4105
Relative |err| 0.22
Correl Coeff 0.95
Relationship between the years of ISDI monitoring of the drought intensity and the result of the site observations
Regional scale validation on ISDI model for drought monitoring

Table 4 Field observations of selected 6 agro-meteorological stations in study area for 2006

<table>
<thead>
<tr>
<th>Site name</th>
<th>Longitude (° E)</th>
<th>Latitude (° N)</th>
<th>Drought occurrence time (2006)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linfen</td>
<td>111.5</td>
<td>36.06</td>
<td>April</td>
</tr>
<tr>
<td>Linfen</td>
<td>111.5</td>
<td>36.06</td>
<td>May to early June</td>
</tr>
<tr>
<td>Xilinhot</td>
<td>116.12</td>
<td>43.95</td>
<td>Early May to early September</td>
</tr>
<tr>
<td>Taian</td>
<td>117.15</td>
<td>36.16</td>
<td>Late April to early May</td>
</tr>
<tr>
<td>Taian</td>
<td>117.15</td>
<td>36.16</td>
<td>Late October to early November</td>
</tr>
<tr>
<td>Taian</td>
<td>117.15</td>
<td>36.16</td>
<td>Mid-November to late November</td>
</tr>
<tr>
<td>Taian</td>
<td>117.15</td>
<td>36.16</td>
<td>December</td>
</tr>
<tr>
<td>Xuchang</td>
<td>113.85</td>
<td>34.01</td>
<td>Mid-April to early May</td>
</tr>
<tr>
<td>Shangzhou</td>
<td>109.96</td>
<td>33.86</td>
<td>In mid-June</td>
</tr>
<tr>
<td>Haixian</td>
<td>115.77</td>
<td>33.87</td>
<td>Late April to mid-June</td>
</tr>
</tbody>
</table>

- J. Wu, L. Zhou., Generating an Integrated Surface Drought Index (ISDI) for drought monitoring in Mid-Eastern China, Agricultural and Forest Meteorology(under review)
Evaluating the impact on agriculture from drought

Huanghuaihai Plain is of more importance for Chinese agriculture
(1) Experiments

- Location: Gucheng, Hebei
- Crop: winter wheat
- Objective of the experiment:
  - To obtain crop growth parameters under different water conditions

![Field Experiment Diagram]
## Data of Experiments

<table>
<thead>
<tr>
<th>NO.</th>
<th>Parameters</th>
<th>method</th>
<th>Observation times</th>
<th>Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Canopy water content</td>
<td>Dry Weight</td>
<td>4</td>
<td>300</td>
</tr>
<tr>
<td>2</td>
<td>Leaf water content</td>
<td>Dry Weight</td>
<td>4</td>
<td>300</td>
</tr>
<tr>
<td>3</td>
<td>Soil moisture</td>
<td>Dry Weight</td>
<td>4</td>
<td>60</td>
</tr>
<tr>
<td>4</td>
<td>Canopy spectrum</td>
<td>ASD</td>
<td>4</td>
<td>600</td>
</tr>
<tr>
<td>5</td>
<td>Leaf spectrum</td>
<td>ASD</td>
<td>4</td>
<td>300</td>
</tr>
<tr>
<td>6</td>
<td>Biomass</td>
<td></td>
<td>4</td>
<td>60</td>
</tr>
<tr>
<td>7</td>
<td>LAI</td>
<td>LI-2000</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>8</td>
<td>Chlorophyll content</td>
<td>SPAD-502</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>9</td>
<td>Crop Yield</td>
<td></td>
<td>1</td>
<td>15</td>
</tr>
</tbody>
</table>
Evaluation of Crop yield decrease based on Crop Growth Model

• Crop growth model integrates the major processes that occur in the soil-crop-atmosphere-management system
• Simulate weather, hydrology, soil erosion by wind and water, nutrient cycling, tillage, crop management and growth, and field-scale costs and return
• Well suitable for modeling agricultural drought
Crop Growth Model

- Flow Chart of Modeling

- Temperature
- Wind
- Water
- Nutrient
- Management

Crop Grow Model

- Yield
- Biomass
Sensitivity analysis for model

Through calibrating the parameters which are sensitive to the model output can reduce the workload in estimating parameters.
model calibration

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>DESCRIPTION</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>WA</td>
<td>Potential radiation use efficiency</td>
<td>34.8</td>
</tr>
<tr>
<td>HI</td>
<td>Normal harvest index</td>
<td>0.45</td>
</tr>
<tr>
<td>DLAI</td>
<td>Point in the growing season when leaf area begins to decline due to leaf senescence</td>
<td>0.45</td>
</tr>
<tr>
<td>DLP1</td>
<td>Crop parameter control leaf area growth of the crop under non-stress control</td>
<td>15.1</td>
</tr>
<tr>
<td>DLP2</td>
<td>Crop parameter control leaf area growth of the crop under non-stress control</td>
<td>48.0</td>
</tr>
<tr>
<td>DMLA</td>
<td>Maximum potential LAI</td>
<td>6.5</td>
</tr>
<tr>
<td>RLAD</td>
<td>Point in the growing season when leaf area begins to decline due to leaf senescence</td>
<td>1.0</td>
</tr>
</tbody>
</table>
Crop Growth Model—Real-time Risk Model

- Well suit for modeling agricultural drought
Yield Reduction due to drought

- assess the reduction of crop yield caused by drought
- \( Y_{\text{Reduction}} = \Delta \text{Yield} = Y_n - Y_d \)
  - \( Y_n \) is the yield under normal condition in growth season
  - \( Y_d \) is the yield suffered from drought events
Real-time (Yield Decrease) Risk Model

- Well suit for modeling agricultural drought
GIS-Real time Loss Assessment Model for Drought

(WU et al. 2007)
Drought monitoring and evaluation system
Drought monitoring and evaluation system
Drought monitoring and evaluation system
Drought monitoring and evaluation system
-Data Management
Drought monitoring and evaluation system

Monitoring by RS
Drought monitoring and evaluation system
Monitoring by PDSI
Drought monitoring and evaluation system
Monitoring by ISDI
Drought monitoring and evaluation system

Mapping subsystem
Response to Drought Event
Response to Drought Event
Response to Drought Event
Proposed Action Plan For Drought Research Collaboration
Between
The Academy of Disaster Reduction and Emergency Management (ADREM)
at Beijing Normal University (BNU), China
And
The U.S. National Drought Mitigation Center (NDMC)
at University of Nebraska-Lincoln (UNL), U.S.A.

July 6, 2011, in Beijing, China

6. Joint education cooperation: The two parties conduct joint education cooperation to train Master and Ph.D. students in drought research fields. The ADREM at BNU recommends young scholars to conduct research at the NDMC at UNL. The ADREM at BNU invites scholars from UNL to conduct joint research in drought fields in China.

7. Publication cooperation: The two parties cooperate in research publications and scientific dissemination of newly derived knowledge. The two parties support co-authorship in journal publications and academic books in drought field. Regarding the journal publications, the two parties could joint-invite international drought experts to publish a special drought session in the International Journal of Disaster Risk Science in 2012. The two parties could also joint-invite international drought scholars to co-publish a drought book in 2012.

On July 6, 2011, a special session was held at the National Drought Mitigation Center in Lincoln, U.S.A. and the Academy of Disaster Reduction and Emergency Management at Beijing Normal University, China. The two parties discussed the agreement and expressed a strong desire to continue the discussion in July 2011.

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1. General statement of cooperation: The two parties express mutual interest in scientific disaster risk management cooperation.

2. Overall goals and strategies: The two parties agree to conduct regular meetings to discuss drought issues.

3. Project cooperation: The two parties agree to cooperate on specific projects to address drought-related issues.

4. International cooperation: The two parties agree to work with similar organizations worldwide to address common challenges.

5. Expert knowledge exchange: The two parties agree to facilitate mutual exchange of knowledge and expertise, including visiting scholars and joint publications.

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International Workshop
“Drought Monitoring, Assessing and Planning under Global Climate Change”
Beijing Normal University, Beijing, China: June 4-5, 2012

Overview
Drought is one of the most important natural hazards and a major threat to people’s livelihoods and communities, especially in developing countries. Each year, drought results in significant economic losses, affecting millions of people, and has serious social, economic, environmental, and political problems. The DMAPGCC workshop on "Drought Monitoring, Assessing and Planning under Global Climate Change" will provide an opportunity to present the findings and to share the experiences on the drought related research for the scientists from different countries and organizations. The language of this workshop will be English.

Topics
- Drought Monitoring and Forecasting
- Drought Mitigation and Planning
- Drought Risk and Impact Assessment
- Space Technology on Drought Reduction
- Latest Initiative for Drought Research

Important Dates
- Abstract submission: April 30, 2012
- Full paper submission: May 20, 2012
- Registration: June 3, 2012
- Workshop: June 4 & 5, 2012

Venue and Accommodation
The workshop will be held at the Beijing Normal University (BNU), Beijing, China. The organizing staff of this workshop can book your accommodation in the JINSHA hotel, which is located in BNU campus. Please visit the hotel website (http://www.cae.bnu.edu.cn/english_welcome.htm) and get information you need.

Organizing Committee
- Jianjun Wu, Ph.D. Beijing Normal University
- Michael J. Hayes, Ph.D. U.S. National Drought Mitigation Center
- Guangju Yang, Ph.D. International Center for Drought Risk Reduction
- Suji Li, Ph.D. UN-SPIDER
- Zhenghong Tong, Ph.D. University of Nebraska-Lincoln

Sponsors
- Beijing Normal University, China (BNU)
- U.S. National Drought Mitigation Center (NDMC) and University of Nebraska-Lincoln, USA.
- UN Platform for Space-Based Information for Disaster Management and Emergency Response (UN-SPIDER)
- International Center for Drought Risk Reduction (ICDRR)

Contact
The contact for this event is Wenjuan Zhang (DMAPGCC@yahoo.cn). Tel: +86 10 58805461.

Website of workshop:
http://www.adrem.org.cn/dmapgcc/
Contact: Wenjuan Zhang
DMAPGCC@yahoo.cn
Tel: +86 10 58805461
United Nations International Conference on Space-based Technologies for Disaster Management "Risk Assessment in the Context of Global Climate Change

7-9 November 2012, Beijing, China

Thank you for your attention!

Academy of Disaster Reduction and Emergency Management
Beijing Normal University, Beijing 100875, China
http://adrem.org.cn/
http://adrem.org.cn/Faculty/WuJJ/Index.html
Seasonal crop water deficiency

\[ SCWD = \frac{ET - P}{ET} \]

**SCWD**: Seasonal crop water deficiency;
**ET**: Seasonal crop water use;
**P**: Precipitation during crop growing season.

\[ ET = ET_0 \cdot Kc \]

**ET**₀: potential evapotranspiration;
**Kc**: crop coefficient.