VegDRI Evaluation: Focus on Owyhee and Upper Colorado Basins

Jesslyn Brown and Brad Stricherz
U.S. Geological Survey (USGS)/Earth Resources Observation and Science (EROS) Center
BLM Project

- Validation of VegDRI over BLM lands
  - Owyhee and Upper Colorado Basins
- Ecosystem Performance Anomalies
  - Work by B. Wylie and S. Boyte
Goals for Owyhee and UCR Basins

• Use RAWS data for VegDRI evaluation
  ■ Independent from VegDRI training data (Co-op and AWDN stations)
• Evaluate version 4 models (released in 2010)
• Evaluate eMODIS and AVHRR histories
  ■ Requires rerunning entire historical record
    • 1989 – 2009 for AVHRR
    • 2000 – 2009 for MODIS
  ■ Use staged approach
Background

• Early VegDRI development—SD and NE
• Prospects for monitoring western rangelands
• Self-calibrated PDSI
• eMODIS >> improved radiometric sensitivity and improvements in product delivery and automation allowing for weekly VegDRI production (rather than biweekly)
VegDRI Evaluation – Multiple Approaches

1. Statistical cross-validation of model results
   Correlation coefficient values ranging from 0.81 to 0.88

2. Comparison with other drought indicators (i.e., USDM)

3. Feedback from a network of evaluators
   a) 2010: 150+ evaluators across 30-states
   b) state climatologists, USDM authors, and agricultural experts and producers
   c) provide qualitative and quantitative information regarding VegDRI’s accuracy for their respective area

4. Comparison with various ground truth data sets
   USDA crop yields, clip plot biomass, and soil moisture
VegDRI Evaluation

• Funding and resources demand an opportunistic and “convergence of evidence” approach to evaluation
• Must be based on a variety of data
• Crop yield data comparison in the “Corn Belt”
  ■ Evaluate VegDRI as an agricultural drought indicator.
  ■ Crops exhibit sensitivity to drought during different phenological stages.
  ■ Corn has known drought-sensitivity, soybeans are less sensitive.
  ■ County crop yields available yearly from USDA-NASS.
Yield and Drought—Background

- Past studies show the PDSI has moderate to strong relationships with crop yields
- The self-calibrated PDSI is relatively new (2004) and fewer studies have been published using this index (Mavromatis, 2007).
Corn and soybean yield comparison--methods

• Study Area: Nebraska
• Largely agricultural state
  ■ Nearly 46 m acres of land in farms
  ■ Corn for grain (acres) – 7.3 m\(^1\)
  ■ Soybeans (acres) – 4.5 m\(^1\)

• Good crop and irrigation masks\(^2\)
  ■ Nebraska 2006 and 2007 Cropland Data Layers
    http://www.nass.usda.gov/research/Cropland/SARS1a.htm
  ■ 2005 Nebraska Land Use—Irrigation Data Layer
    http://www.calmit.unl.edu/2005landuse/statewide.shtml

\(^1\) Statistics from the 2002 USDA Census of Agriculture
\(^2\) Provided by USDA/NASS and UNL-CALMIT
Nebraska—Corn and Soybeans and Drought in 2006 and 2007

VegDRI
8/22/2006

VegDRI
8/27/2007

U.S. Drought Monitor
8/23/2006

U.S. Drought Monitor
8/28/2007
Non-irrigated corn (2nd half of August)

$R^2 = 0.4827$
Non-irrigated soybeans
(1st half of September)

$R^2 = 0.2766$

Detrended Yield

Median (scaled) VegDRI

USGS

National Drought Mitigation Center
Owyhee Basin
Great Basin: Climate and weather variability
Oregon farmers & ranchers challenged by lack of water

Friday, June 11, 2010 10:29 AM CDT

One Department of Agriculture - Winter and spring storms along the Pacific Coast have seemed to split off as they approach southern Oregon, specifically veering north and south while missing the parched Klamath Basin altogether. For an area dependent on water for irrigation but historically steeped in water-related challenges, the summer of 2010 is just the latest obstacle for a valuable agricultural production area. But local farmers and ranchers are being commanded for trying to make the most of a difficult situation.

“The people of the Klamath Basin, in particular the producers, deserve our attention, our respect, and all the help we can give them under the current circumstances,” says Katy Coba, director of the Oregon Department of Agriculture. “I’m impressed with the way local farmers and ranchers are trying to move forward even when there isn’t enough water to go around. The word ‘challenging’ doesn’t adequately describe what they are going through. But I am grateful for their hard work and willingness to continue producing under trying circumstances.”

Coba and the State Board of Agriculture toured parts of the Klamath Basin last week and heard from a panel of local residents connected to farming and ranching. The tour and panel were organized by the board’s newest member, Tracey Liskey - himself a diversified farmer in Klamath County.

“We’ve been working hard for the past five years in finding solutions to our water crisis,” says Liskey. “We’ve developed some things that, if they work like they are supposed to, will hopefully be an answer. But it will take five to ten years to implement. So we have to make sure we stay whole in the meantime. Everybody has to work for a common goal to get all of us through this.”

The Klamath Basin Restoration Agreement (KBRA), years in the making but agreed to this year, attempts to address all uses and issues surrounding water in the basin. The complex agreement moves towards a settlement that essentially gives agriculture certainty and reliability of water supply.
Selected RAWS Stations have >= 18 years of data and <= 6 months of missing data
Owyhee = 32
Upper Colorado = 48
# Very Preliminary Results

<table>
<thead>
<tr>
<th>Data</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>All stations, all months</td>
<td>0.266</td>
</tr>
<tr>
<td>All stations, all months, Owyhee</td>
<td>-0.039</td>
</tr>
<tr>
<td>All stations all months, UCRB</td>
<td>0.336</td>
</tr>
<tr>
<td>All stations, May</td>
<td>0.337</td>
</tr>
<tr>
<td>All stations, June</td>
<td>0.318</td>
</tr>
<tr>
<td>All stations, July</td>
<td>0.238</td>
</tr>
<tr>
<td>All stations, August</td>
<td>0.091</td>
</tr>
<tr>
<td>All stations, September</td>
<td>0.207</td>
</tr>
<tr>
<td>All stations, October</td>
<td>0.396</td>
</tr>
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\[ p \leq 0.01 \]

R*: Spearman’s rank order correlation, 2009 only, version 3 model
# Very Preliminary Results

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<td>0.067</td>
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<tr>
<td>All stations, June, Owyhee</td>
<td>-0.094</td>
</tr>
<tr>
<td>All stations, July, Owyhee</td>
<td>-0.076</td>
</tr>
<tr>
<td>All stations, August, Owyhee</td>
<td>-0.311</td>
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<tr>
<td>All stations, September, Owyhee</td>
<td>-0.213</td>
</tr>
<tr>
<td>All stations, October, Owyhee</td>
<td>-0.038</td>
</tr>
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$p \leq 0.01$

$R^*$: Spearman’s rank order correlation, 2009 only, version 3 model
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<tr>
<td>All stations, June, UCRB</td>
<td>0.393</td>
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<tr>
<td>All stations, July, UCRB</td>
<td>0.284</td>
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<td>All stations, August, UCRB</td>
<td>0.176</td>
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<tr>
<td>All stations, September, UCRB</td>
<td>0.326</td>
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<tr>
<td>All stations, October, UCRB</td>
<td>0.489</td>
</tr>
</tbody>
</table>

p<= 0.01

R*: Spearman’s rank order correlation, 2009 only, version 3 model
VegDRI Evaluation: Next Steps

• Evaluate model inputs within the Basins
  ■ Determine ranges of climate and satellite-based seasonal greenness
  ■ Investigate climate data quality
    • Treatment of winter moisture input into PDSI calculations

• Rerun version 4 VegDRI histories
Big Sagebrush productivity: A time-series cluster analysis based on weather variations

Cluster temporal signatures
Georegistration
Compositing
Surface Reflectance

Stacking
Smoothing
Anomaly Detection
Metrics Calculation
(SOS, SG, PASG)

EMODIS System

Vegetation Dynamics
and VegDRI Models

Partners get
“Regular data over
the Nation
served quickly”
# eMODIS System Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Expedited</th>
<th>Forward/Historical</th>
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</thead>
<tbody>
<tr>
<td>Geographic Area</td>
<td>CONUS</td>
<td>CONUS</td>
</tr>
<tr>
<td>Latency</td>
<td>6 hours from last acquisition</td>
<td>Avg. 8 days from last acquisition (dependent on delivery of precision input)</td>
</tr>
<tr>
<td>Data Source</td>
<td>LANCE (surface refl., geolocation, cloud mask)</td>
<td>LAADS (surface refl., geolocation, cloud mask)</td>
</tr>
<tr>
<td>Product</td>
<td>NDVI</td>
<td>NDVI</td>
</tr>
<tr>
<td>Spatial Resolution</td>
<td>250-m, 500-m, 1000-m</td>
<td>250-m, 500-m, 1000-m</td>
</tr>
<tr>
<td>Compositing Interval</td>
<td>Daily rolling 7-day based on AVHRR calendar</td>
<td>7-day based on AVHRR calendar</td>
</tr>
<tr>
<td>Mapping Grid</td>
<td>Lambert Azimuthal</td>
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</tr>
</tbody>
</table>

27 Jul 2010
Data Continuity

• Significant differences between AVHRR/3 and MODIS NDVI: 2 ~ 2.5 % on average
• Polynomial regression
  ■ Bias error correction resulting in 25% reduction of variations
  ■ Second-order term statistically significant
  ■ Little impact of measurement errors
• Phenology and temporal dependencies
?Questions?

jfbrown@usgs.gov
(605)594-6003
Goodness-of-fit measures

• Coefficient of determination ($R^2$)

$$R^2 = \frac{SSTotal - SSRes}{SSTotal} = 1 - \left( \frac{SSRes}{SSTotal} \right)$$

Where $SSTotal$ is the total sum of squares of the data and $SSRes$ is the residuals of the sum of squares.

• Index of agreement ($d$)

$$d = \frac{\sum_{i=1}^{n} (O_i - P_i)^2}{\sum_{i=1}^{n} (|P_i - \overline{O}| + |O_i - \overline{O}|)^2}$$

Where $O_i$ is the observed variable and $P_i$ is the predicted variable.

• Nash-Sutcliffe coefficient of efficiency (NCSE)

$$NSCE = 1 - \frac{\sum_{i=1}^{n} (P_i - O_i)^2}{\sum_{i=1}^{n} (O_i - \overline{O})^2}$$

Where $P_i$ is the predicted variable, $O_i$ is the observed variable, $O$ is the observed mean, and $n$ is the number of variables.