VegDRI Evaluation: Focus on Owyhee and Upper Colorado Basins

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U.S. Geological Survey (USGS)/Earth Resources Observation and Science (EROS) Center

VegDRI and VegOUT Workshop
27 Jul 2010

U.S. Department of the Interior
U.S. Geological Survey

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
- Easterling et al., 1988, Meyer et al., 1991, Quiring and Papakryiakou, 2003, Scian and Bouza, 2005 Wu et al., 2004, and Mavromatis, 2007.
- 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]**

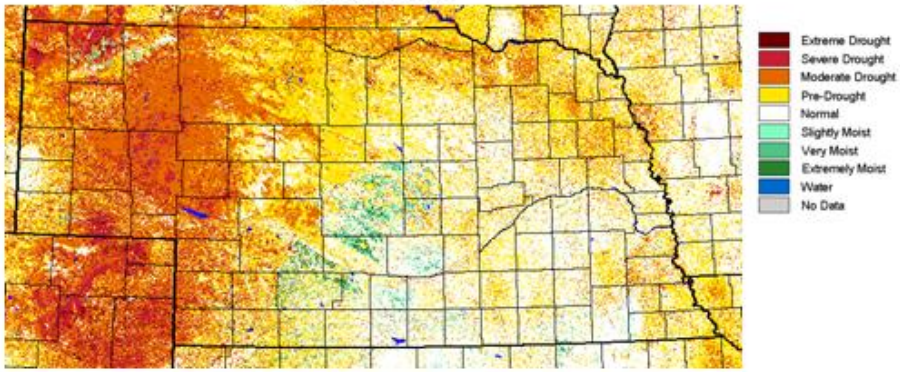
- **Good crop and irrigation masks[2]**
  - **Nebraska 2006 and 2007 Cropland Data Layers**
    http://www.nass.usda.gov/research/Cropland/SARS1a.htm

  - **2005 Nebraska Land Use—Irrigation Data Layer**
    http://www.calmit.unl.edu/2005landuse/statewide.shtml

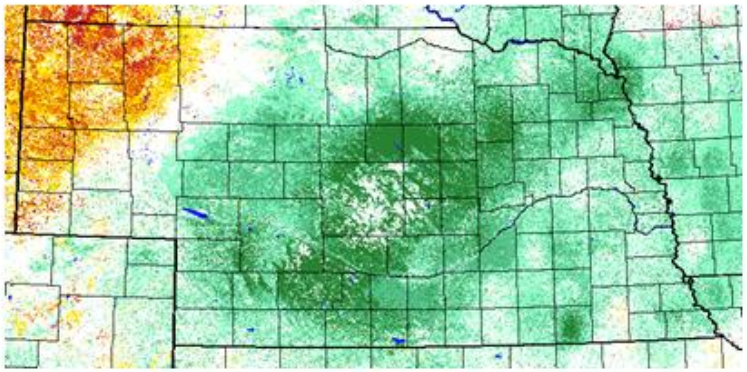
[1] Statistics from the 2002 USDA Census of Agriculture
[2] Provided by USDA/NASS and UNL-CALMIT

Nebraska—Corn and Soybeans and Drought in 2006 and 2007

VegDRI
8/22/2006



VegDRI
8/27/2007



U.S. Drought Monitor
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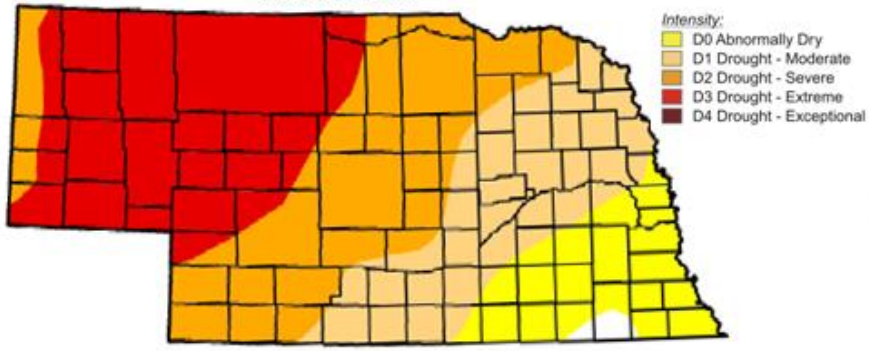

U.S. Drought Monitor
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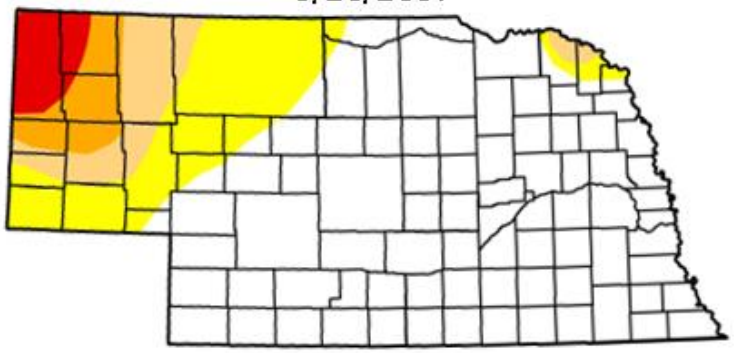

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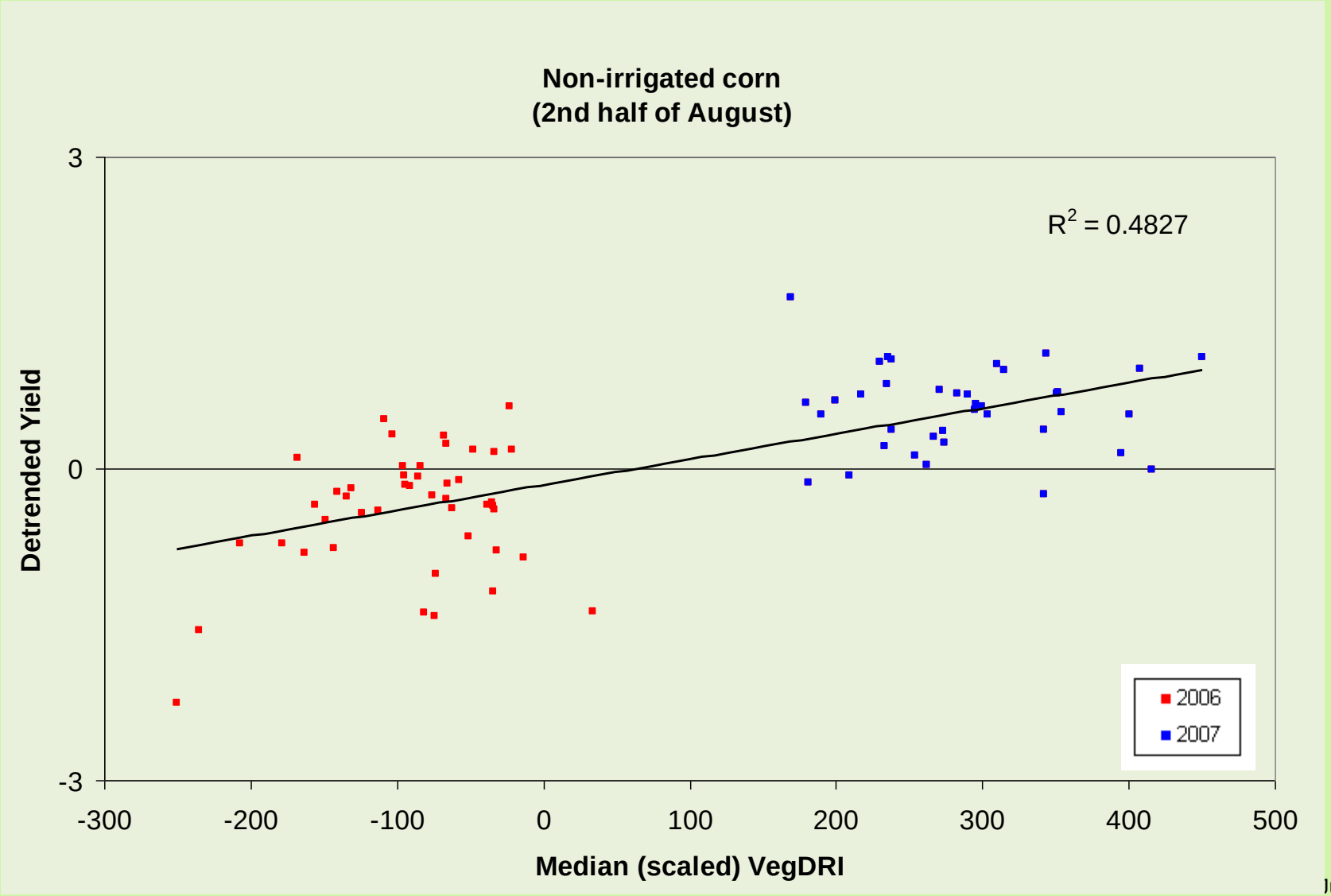

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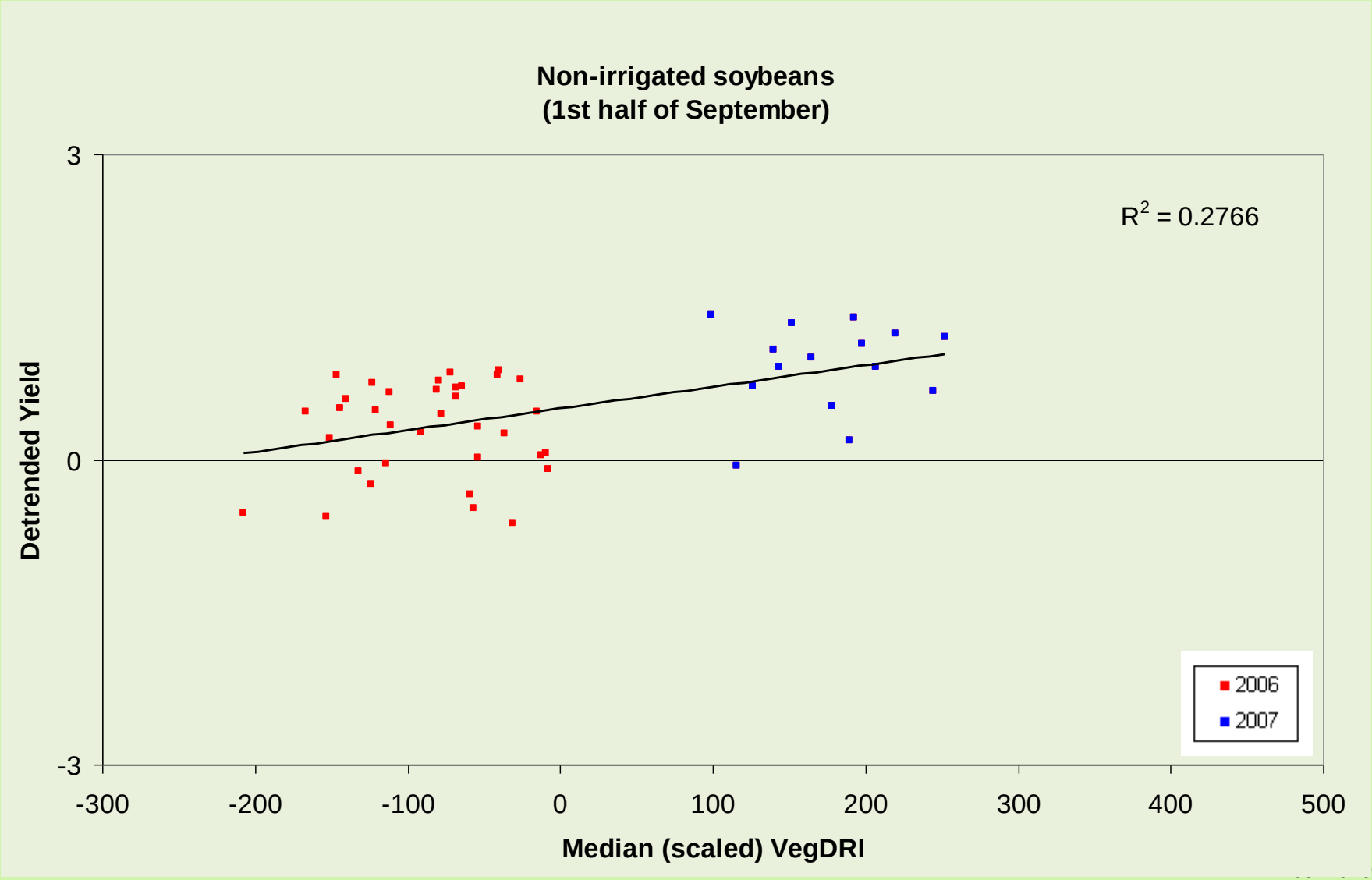
Non-irrigated soybeans
(1st half of September)
3
0
-3
Detrended Yield
R2 = 0.2766
2006
2007
-300
-200
-100
0
100
200
300
400
500
Median (scaled) VegDRI

Owyhee Basin

27 Jul 2010

Great Basin: Climate and weather variability

Ag Weekly Online: Twin Falls, Idaho - Windows Internet Explorer

http://www.agweekly.com/articles/2010/06/30/news/irrigation/irrigation37.txt

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Water supply outlooks continues to swell

by Cindy Snyder Ag Weekly correspondent
Wednesday, June 30, 2010 10:04 AM CDT

An irrigator near Murtaugh checks corrugates. A nearly ideal spring has improved the water supply outlook since April 1. Photo by Cindy Snyder.

TWIN FALLS - Southern Idaho irrigators couldn't have asked for a better spring from Mother Nature. Yet it was certainly a different weather pattern than forecasters were predicting in late winter.

American Falls Reservoir refilled during the last half of June. It's been a long time since the lowest reservoir in the Upper Snake system has filled a second time, especially that late in June.

Twin Falls Canal Company has the oldest natural flow priority area in south central Idaho and doesn't begin to draft storage water until natural flows in the Snake River can't meet its irrigation demand. As of June 28, TFCC hadn't

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Ag Weekly Online: Twin Falls, Idaho - Windows Internet Explorer

http://www.agweekly.com/articles/2010/06/30/news/irrigation/irrigation38.txt

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Oregon farmers & ranchers challenged by lack of water

Friday, June 11, 2010 10:29 AM CDT

Ore. 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 commended 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 when there simply isn't enough water to go around this year. 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 on 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 signed earlier 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

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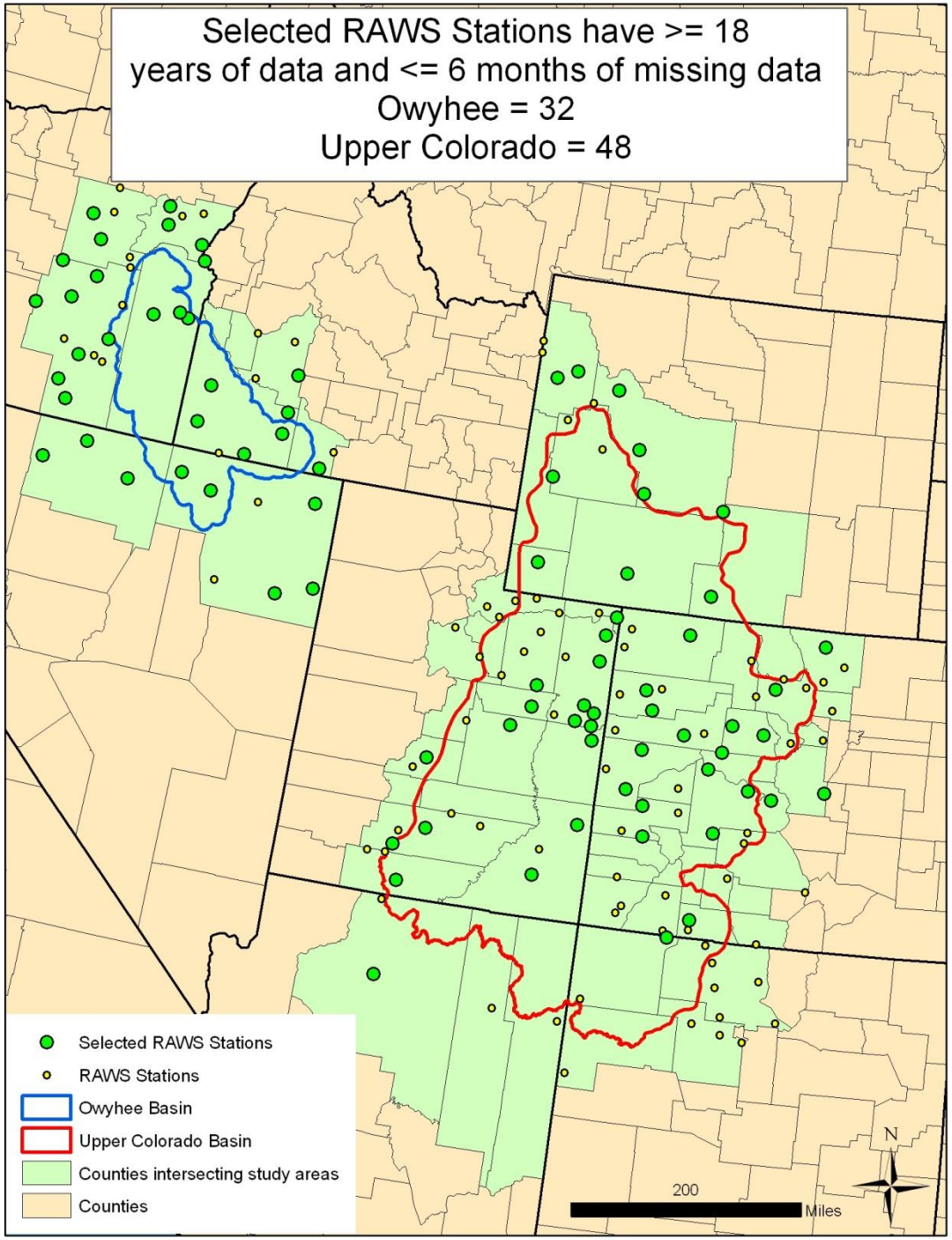
RAWS Data


Selected RAWS Stations have >= 18 years of data and <= 6 months of missing data
Owyhee = 32
Upper Colorado = 48
Selected RAWS Stations
RAWS Stations
Owyhee Basin
Upper Colorado Basin
Counties intersecting study areas
Counties
200
Miles
N

Very Preliminary Results

Data	R
All stations, all months	0.266
All stations, all months, Owyhee	-0.039
All stations all months, UCRB	0.336
All stations, May	**0.337**
All stations, June	**0.318**
All stations, July	0.238
All stations, August	0.091
All stations, September	**0.207**
All stations, October	**0.396**

p<= 0.01

R*: Spearman's rank order correlation, 2009 only, version 3 model

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Very Preliminary Results

Data	R
All stations, all months, Owyhee	-0.039
All stations, May, Owyhee	0.067
All stations, June, Owyhee	-0.094
All stations, July, Owyhee	-0.076
All stations, August, Owyhee	-0.311
All stations, September, Owyhee	-0.213
All stations, October, Owyhee	-0.038

p<= 0.01

R*: Spearman's rank order correlation, 2009 only, version 3 model

Very Preliminary Results

Data	R*
All stations all months, UCRB	0.336
All stations, May, UCRB	**0.338**
All stations, June, UCRB	**0.393**
All stations, July, UCRB	0.284
All stations, August, UCRB	0.176
All stations, September, UCRB	0.326
All stations, October, UCRB	**0.489**

p<= 0.01

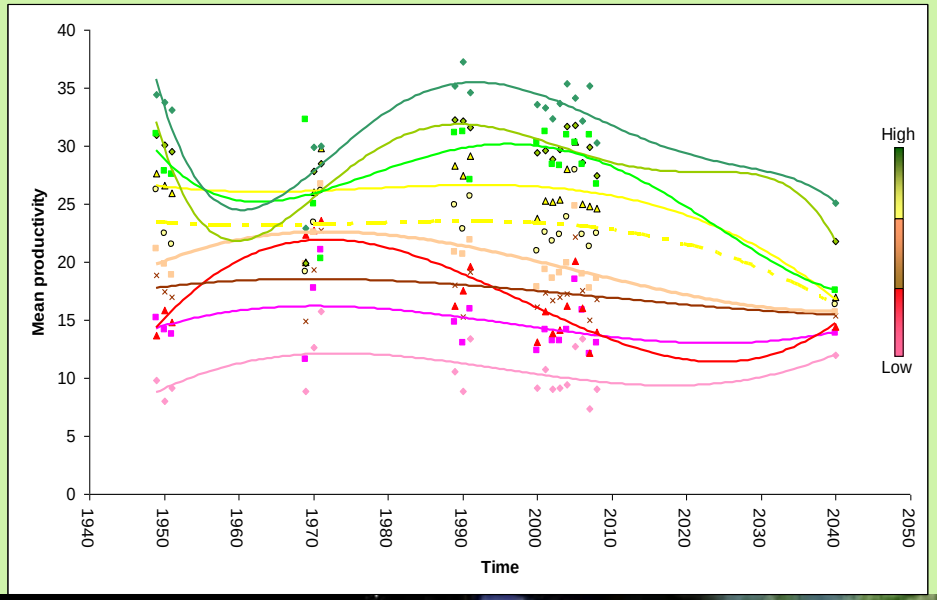
R*: Spearman's rank order correlation, 2009 only, version 3 model

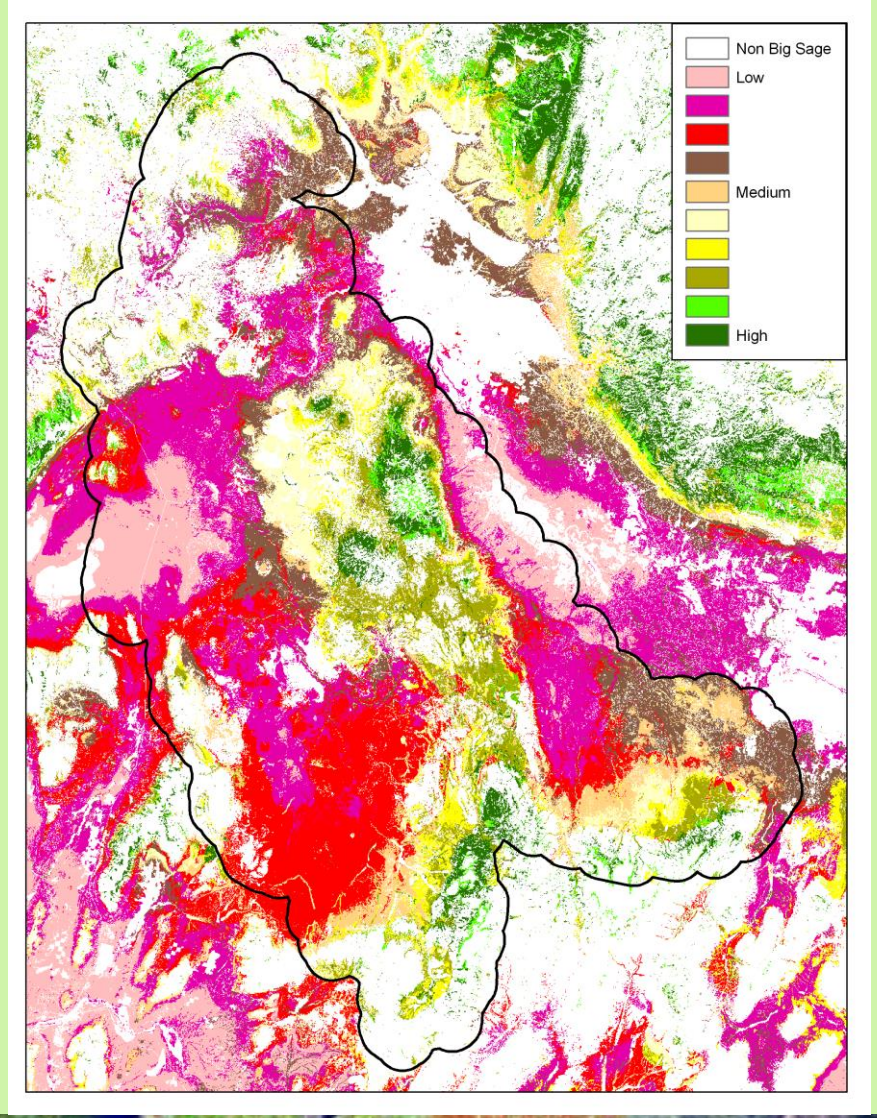
VegDRI Evaluation: Next Steps

- **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





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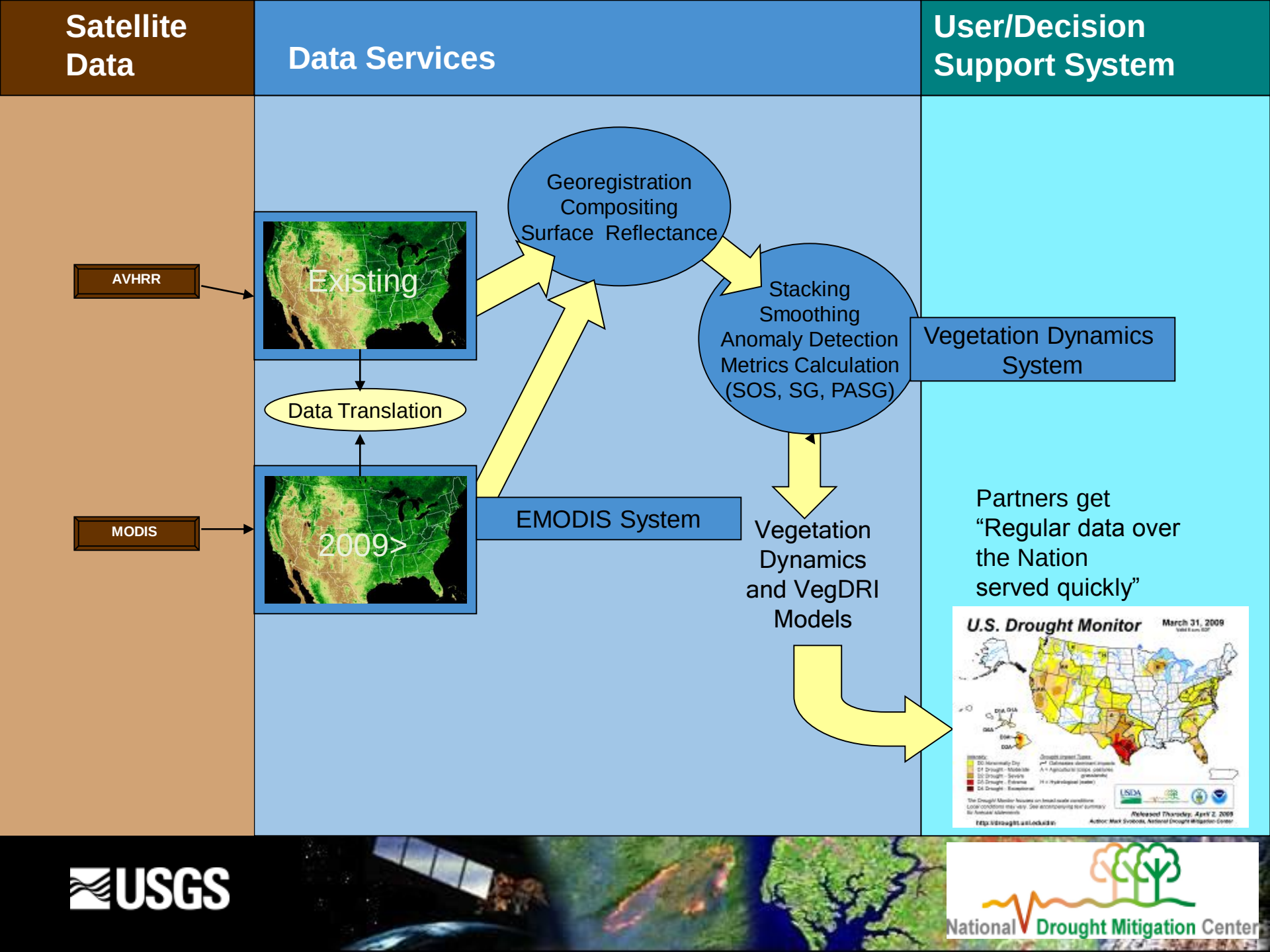
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User/Decision Support System
AVHRR
MODIS
Existing
2009>
Data Translation
Georegistration
Compositing
Surface Reflectance
Stacking
Smoothing
Anomaly Detection
Metrics Calculation
(SOS, SG, PASG)
Vegetation Dynamics System
EMODIS System
Vegetation Dynamics and VegDRI Models
Partners get "Regular data over the Nation served quickly"
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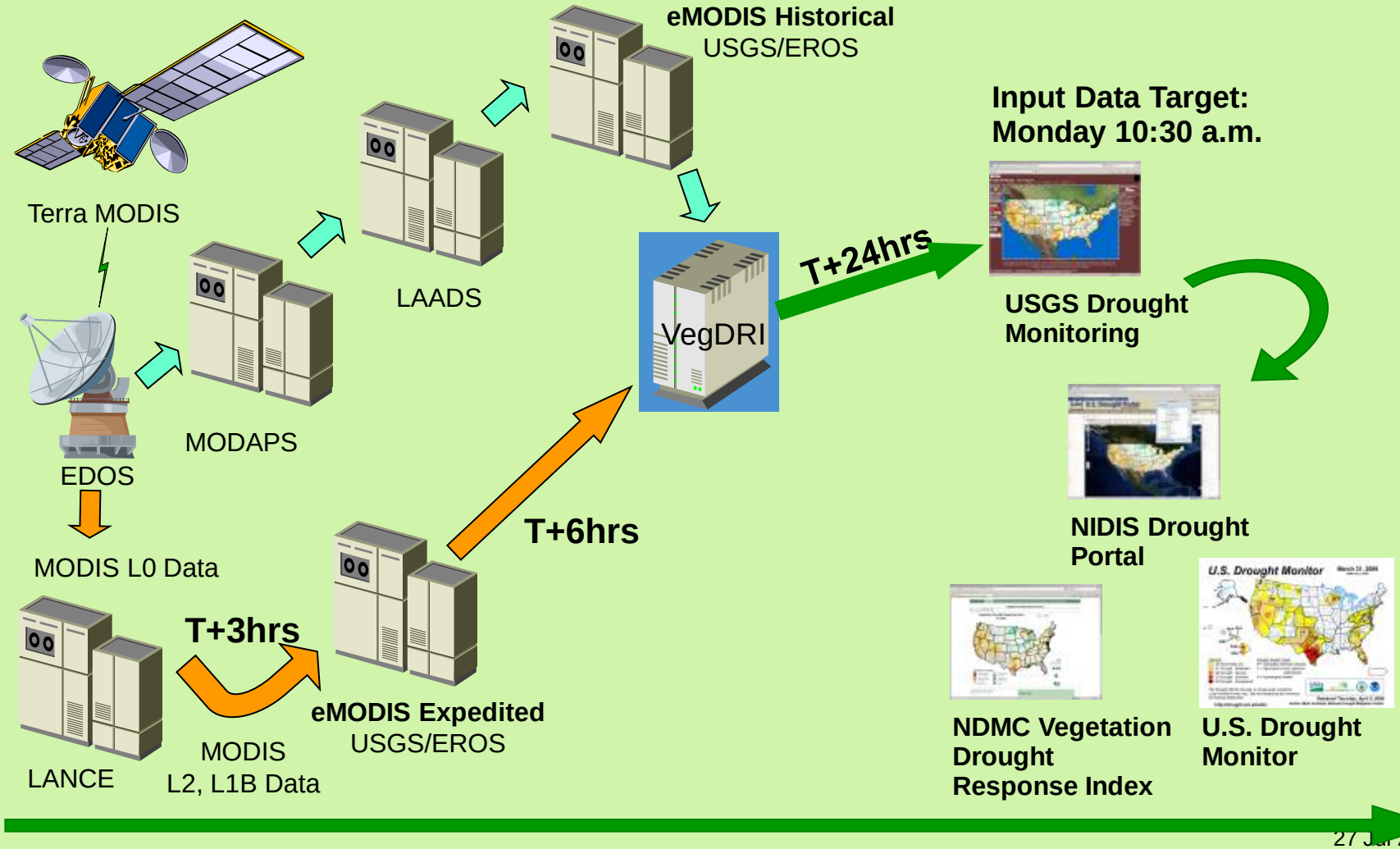
eMODIS Production Flow



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eMODIS System Characteristics

	Expedited	Forward/Historical
Geographic Area	**CONUS**	**CONUS**
Latency	**6 hours from last acquisition**	**Avg. 8 days from last acquisition (dependent on delivery of precision input)**
Data Source	**LANCE (surface refl., geolocation, cloud mask)**	**LAADS (surface refl., geolocation, cloud mask)**
Product	**NDVI**	**NDVI**
Spatial Resolution	**250-m, 500-m, 1000-m**	**250-m, 500-m, 1000-m**
Compositing Interval	**Daily rolling 7-day based on AVHRR calendar**	**7-day based on AVHRR calendar**
Mapping Grid	**Lambert Azimuthal**	**Lambert Azimuthal**
Distribution Site	**ftp://emodis.cr.usgs.gov/eMODIS/CONUS/expedited**	**ftp://emodis.cr.usgs.gov/eMODIS/CONUS/historical**

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
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Goodness-of-fit measures

- **Coefficient of determination (R^2)**

$$R^2 = \frac{SSTotal - SS\,\mathrm{Res}}{SSTotal} = 1 - \left(\frac{SS\,\mathrm{Res}}{SSTotal}\right)$$

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*)**

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

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.

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