Enhancing Access to NASA Satellite Data by USDA WAOB and CUAHSI

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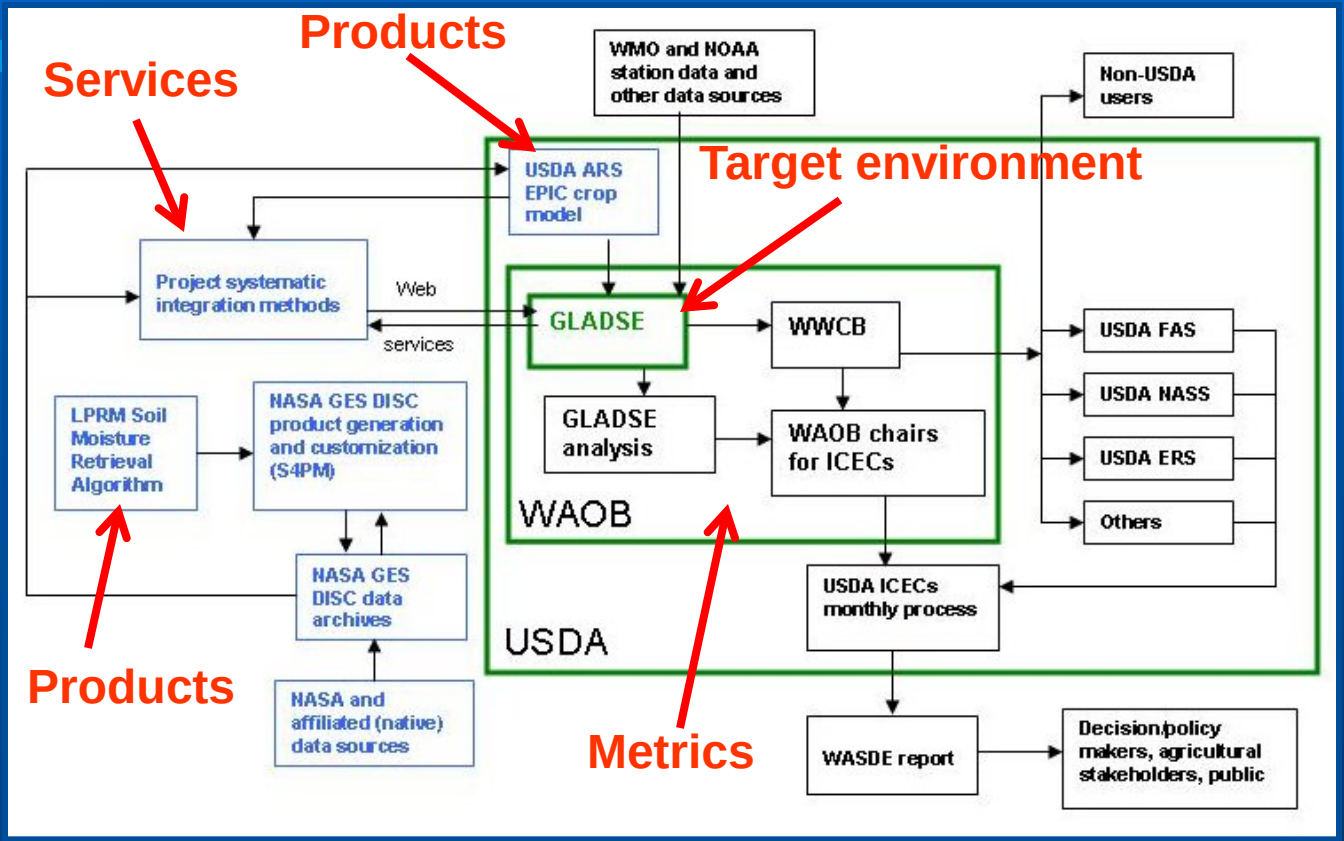
Work supported by NASA ROSES NNH08ZDA001N-DECISIONS, with contributions from VU Amsterdam, USDA ARS, and USDA WAOB; and by NASA ROSES NNH11ZDA001N-ACCESS

ROSES-DECISIONS USDA WAOB

Co-Is: H. Shannon, R. de Jeu, S. Kempler
USDA WAOB, VU Amsterdam, NASA GES DISC

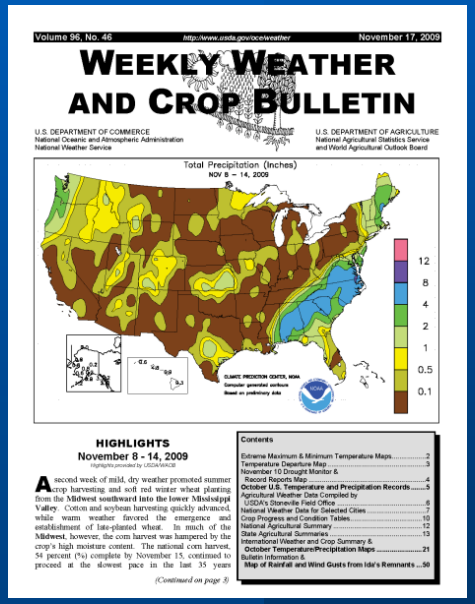
Overview



Operational flow of GLADSE and other USDA entities and of project components (in blue)

USDA WAOB GLADSE

Integrating agricultural and meteorological data for decision makers


Volume 96, No. 46 http://www.usda.gov/oce/weather November 17, 2009

WEEKLY WEATHER AND CROP BULLETIN

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Weather Service

U.S. DEPARTMENT OF AGRICULTURE
National Agricultural Statistics Service
and World Agricultural Outlook Board

Total Precipitation (Inches)
NOV 8 – 14, 2009

HIGHLIGHTS
November 8 - 14, 2009

A second week of mild, dry weather promoted summer crop harvesting and soft red winter wheat planting from the Midwest southward into the lower Mississippi Valley. Cotton and soybean harvesting quickly advanced, while warm weather favored the emergence and establishment of late-planted wheat. In much of the Midwest, however, the corn harvest was hampered by the crop's high moisture content. The national corn harvest, 54 percent (%) complete by November 15, continued to proceed at the slowest pace in the last 35 years

(Continued on page 5)

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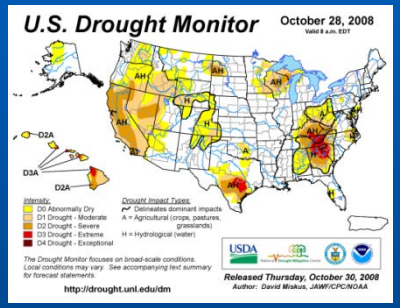
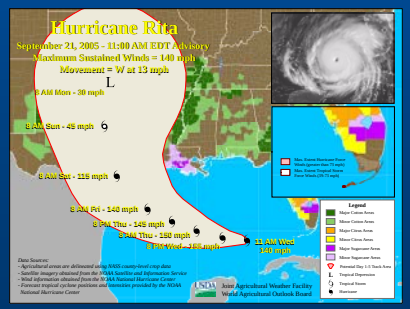
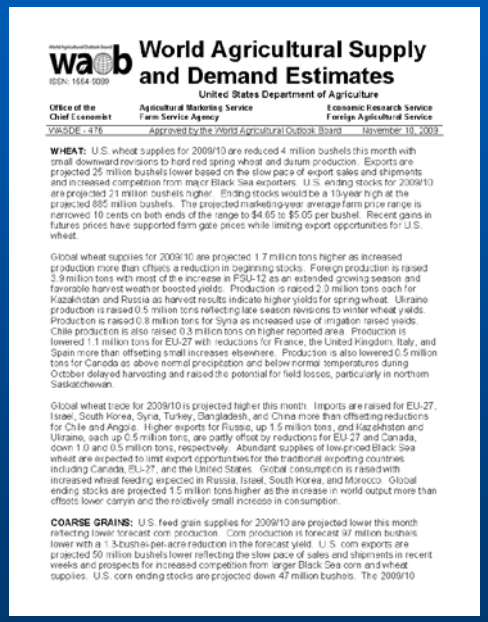
WWCB by Joint Agricultural Weather Facility (JAWF) between NOAA and USDA





Pre-storm forecast maps


waob ISSN: 1554-5099

World Agricultural Supply and Demand Estimates

United States Department of Agriculture

Office of the Chief Economist | Agricultural Marketing Service, Farm Service Agency | Economic Research Service, Foreign Agricultural Service

WASDE - 476 Approved by the World Agricultural Outlook Board November 10, 2009

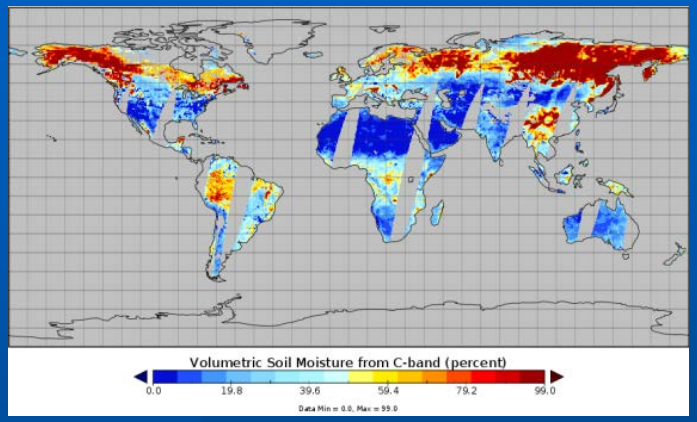
WHEAT: U.S. wheat supplies for 2009/10 are reduced 4 million bushels this month with small downward revisions to hard red spring wheat and durum production. Exports are projected 25 million bushels lower based on the slow pace of export sales and shipments and increased competition from major Black Sea exporters. U.S. ending stocks for 2009/10 are projected 21 million bushels higher. Ending stocks would be a 10-year high at the projected 885 million bushels. The projected marketing-year average farm price range is narrowed 10 cents on both ends of the range to $4.65 to $5.05 per bushel. Recent gains in futures prices have supported farm gate prices while limiting export opportunities for U.S. wheat.

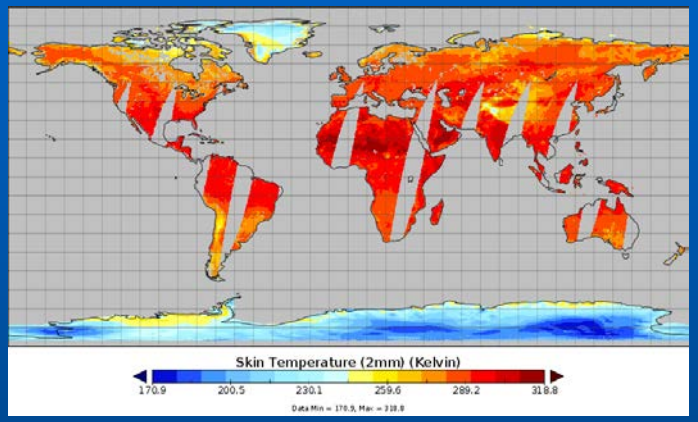
Global wheat supplies for 2009/10 are projected 1.7 million tons higher as increased production more than offsets a reduction in beginning stocks. Foreign production is raised 3.9 million tons with most of the increase in FSU-12 as an extended growing season and favorable harvest weather boosted yields. Production is raised 2.3 million tons each for Kazakhstan and Russia as harvest results indicate higher yields for spring wheat. Ukraine production is raised 0.5 million tons reflecting late season revisions to winter wheat yields. Production is raised 0.8 million tons for Syria as increased use of irrigation raised yields. Chile production is also raised 0.3 million tons on higher reported area. Production is lowered 1.1 million tons for EU-27 with reductions for France, the United Kingdom, Italy, and Spain more than offsetting small increases elsewhere. Production is also lowered 0.5 million tons for Canada as above normal precipitation and below normal temperatures during October delayed harvesting and raised the potential for field losses, particularly in northern Saskatchewan.

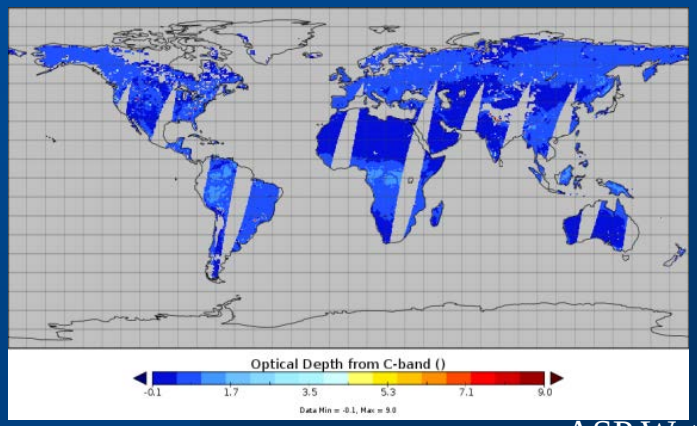
Global wheat trade for 2009/10 is projected higher this month. Imports are raised for EU-27, Israel, South Korea, Syria, Turkey, Bangladesh, and China more than offsetting reductions for Chile and Angola. Higher exports for Russia, up 1.5 million tons, and Kazakhstan and Ukraine, each up 0.5 million tons, are partly offset by reductions for EU-27 and Canada, down 1.0 and 0.5 million tons, respectively. Abundant supplies of low-priced Black Sea wheat are expected to limit export opportunities for the traditional exporting countries including Canada, EU-27, and the United States. Global consumption is raised with increased wheat feeding expected in Russia, Israel, South Korea, and Morocco. Global ending stocks are projected 1.5 million tons higher as the increase in world output more than offsets lower carryin and the relatively small increase in consumption.

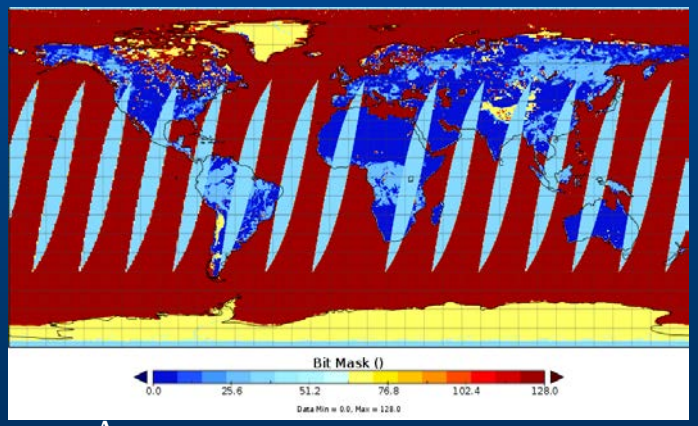
COARSE GRAINS: U.S. feed grain supplies for 2009/10 are projected lower this month reflecting lower forecast corn production. Corn production is forecast 97 million bushels lower with a 13-bushel-per-acre reduction in the forecast yield. U.S. corn exports are projected 50 million bushels lower reflecting the slow pace of sales and shipments in recent weeks and prospects for increased competition from larger Black Sea corn and wheat supplies. U.S. corn ending stocks are projected down 47 million bushels. The 2009/10

LPRM-AMSR-E Soil Moisture

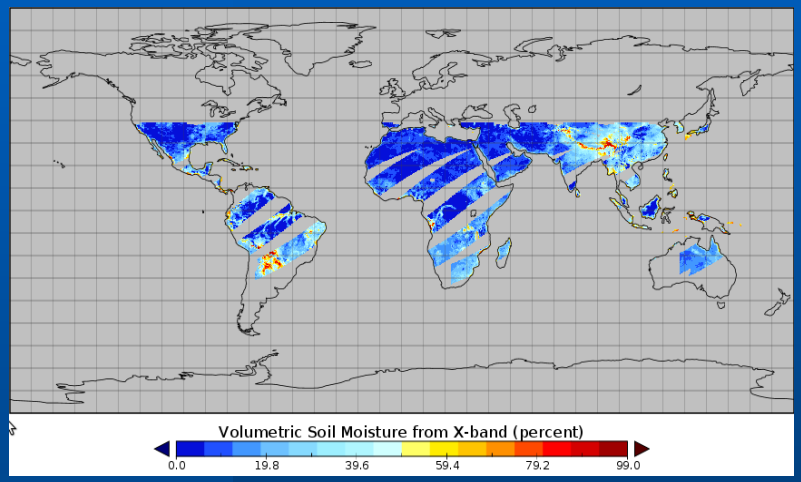


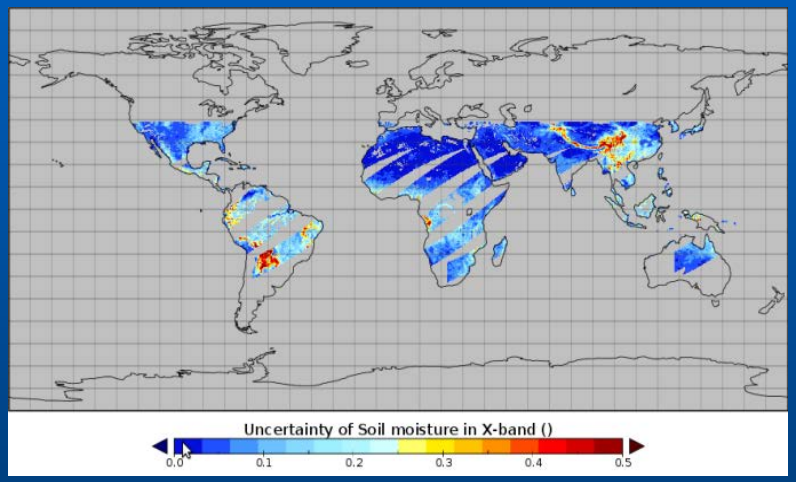




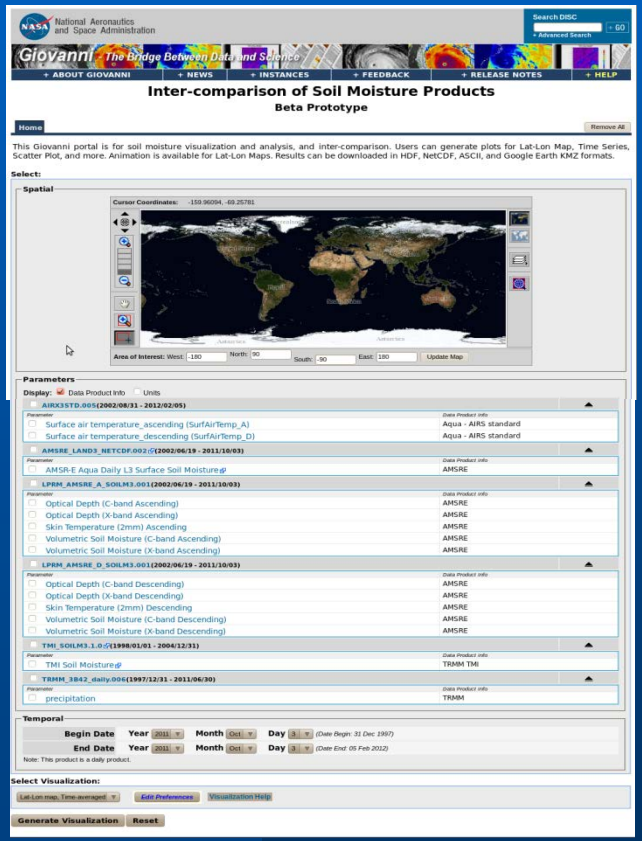


EOS/Aqua AMSR-E Loss and Mitigation



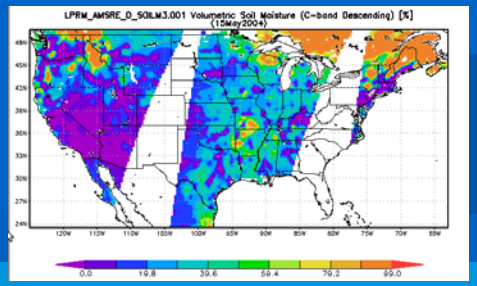


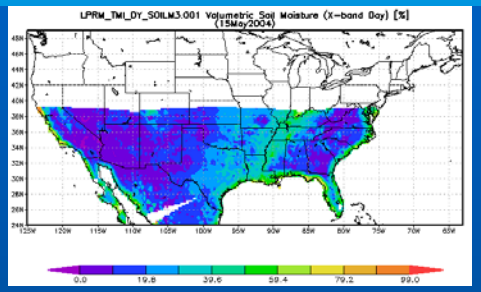
Integration into WAOB - Giovanni

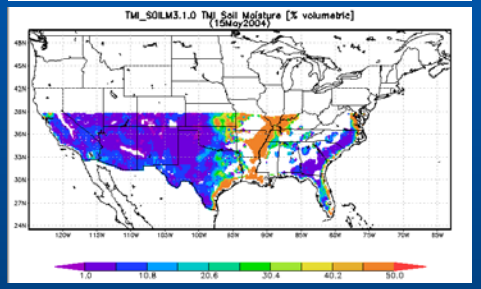


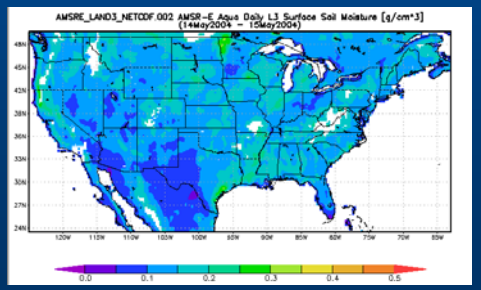
Giovanni, a Web-based application, for simple and intuitive way to visualize, analyze, and access vast amounts of Earth science remote sensing data without having to download the data

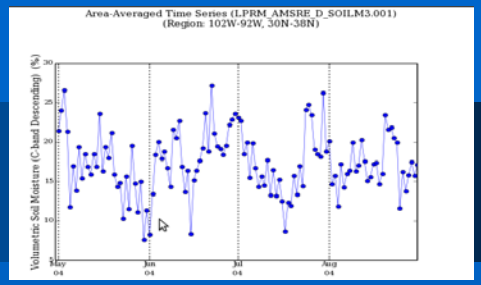
http://gdata1.sci.gsfc.nasa.gov/daac-bin/G3/gui.cgi?instance_id=soilmoisture_daily

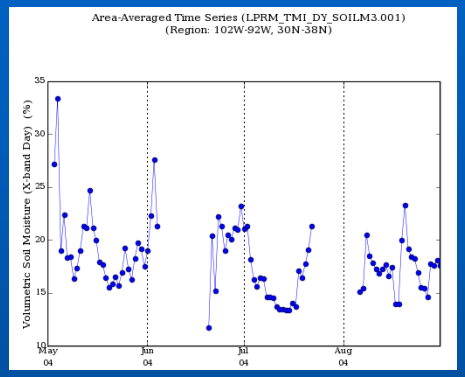

LPRM_AMSRE_D_SOILM3.001 Volumetric Soil Moisture (C-band Descending) [%]
(15May2004)
0.0
19.8
39.6
59.4
79.2
99.0

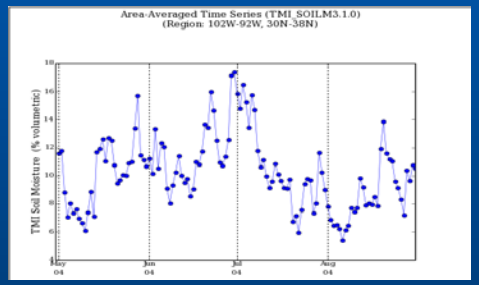

LPRM_TMI_DY_SOILM3.001 Volumetric Soil Moisture (X-band Day) [%]
(15May2004)
0.0
19.8
39.6
59.4
79.2
99.0

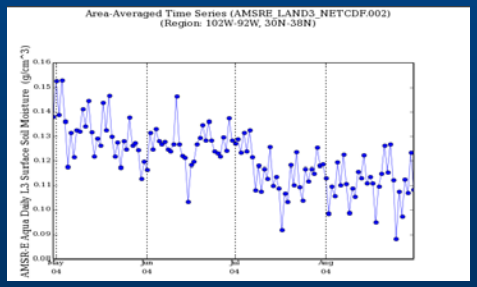

TMI_SOILM3.1.0 TMI Soil Moisture [% volumetric]
(15May2004)
1.0
10.8
20.6
30.4
40.2
50.0


AMSRE_LAND3_NETCDF.002 AMSR-E Aqua Daily L3 Surface Soil Moisture [g/cm^3]
(14May2004 - 15May2004)
0.0
0.1
0.2
0.3
0.4
0.5

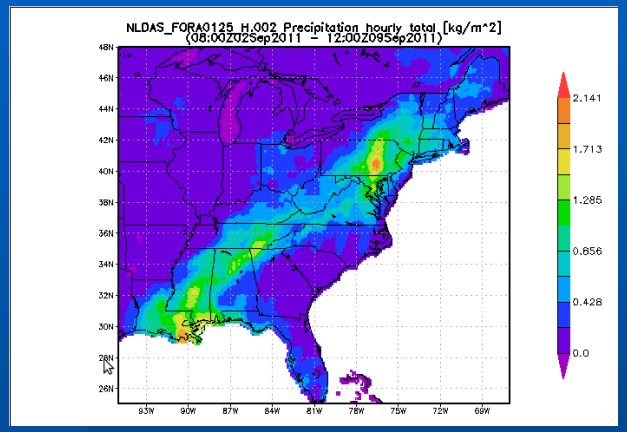

Area-Averaged Time Series (LPRM_AMSRE_D_SOILM3.001)
(Region: 102W-92W, 30N-38N)
Volumetric Soil Moisture (C-band Descending) (%)
May 04
Jun 04
Jul 04
Aug 04

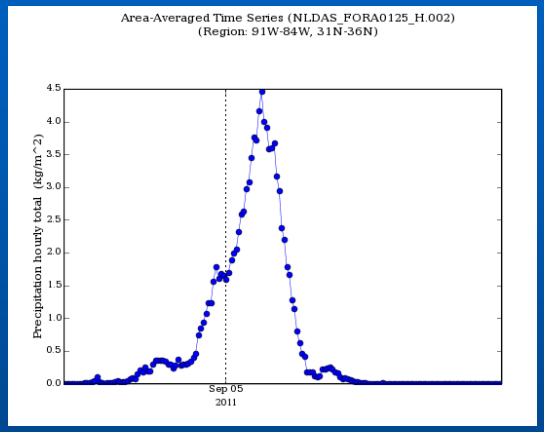

Area-Averaged Time Series (LPRM_TMI_DY_SOILM3.001)
(Region: 102W-92W, 30N-38N)
Volumetric Soil Moisture (X-band Day) (%)
May 04
Jun 04
Jul 04
Aug 04

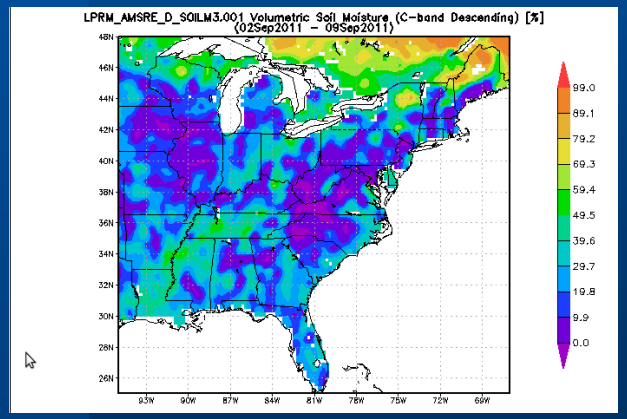

Area-Averaged Time Series (TMI_SOILM3.1.0)
(Region: 102W-92W, 30N-38N)
TMI Soil Moisture (% volumetric)
May 04
Jun 04
Jul 04
Aug 04

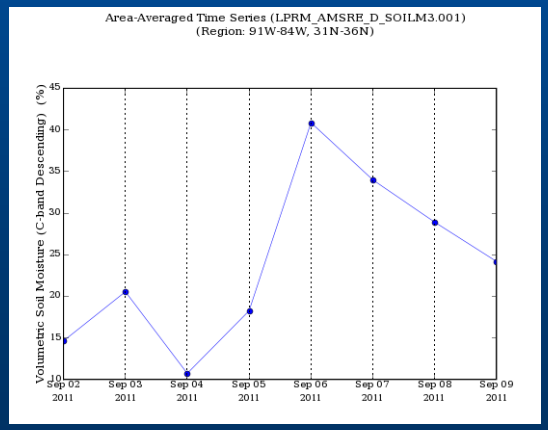

Area-Averaged Time Series (AMSRE_LAND3_NETCDF.002)
(Region: 102W-92W, 30N-38N)
AMSR-E Aqua Daily L3 Surface Soil Moisture (g/cm^3)
May 04
Jun 04
Jul 04
Aug 04

Integration into WAOB - Giovanni

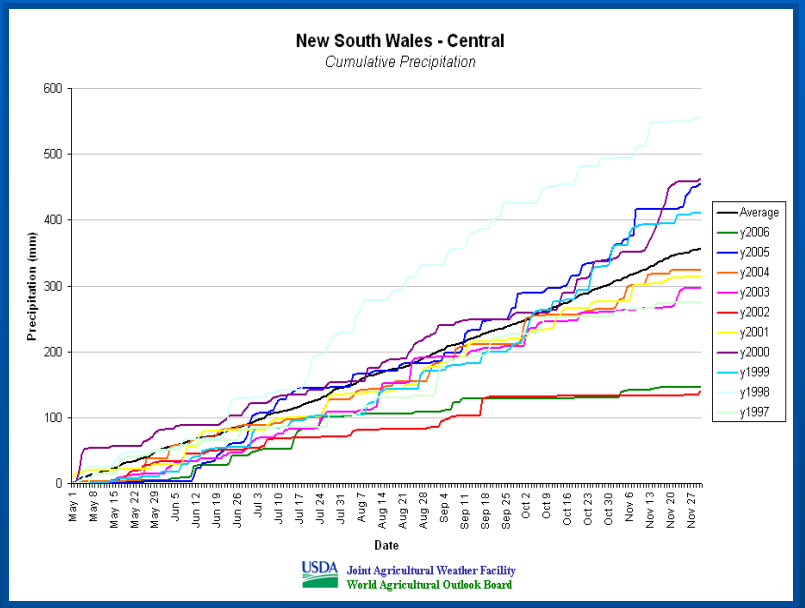




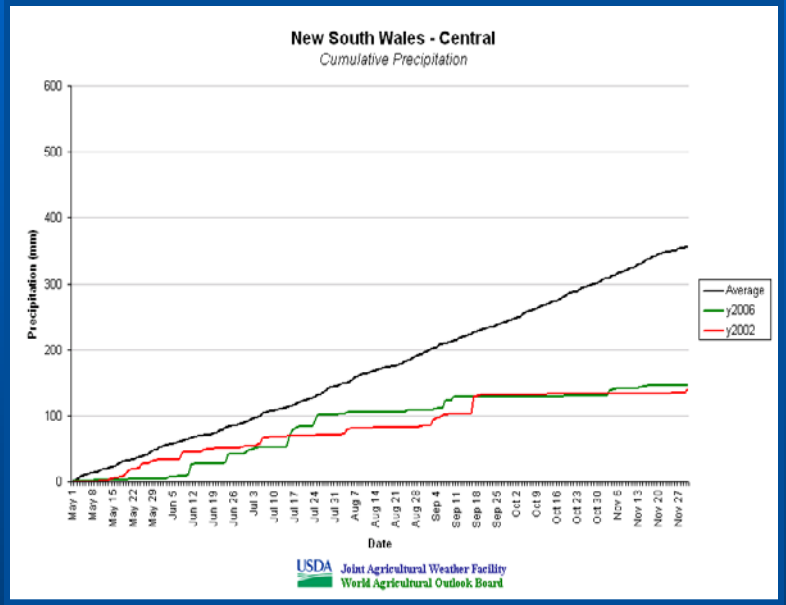




Benchmark and Metrics



2006 is the target year…
…what year(s) are similar?

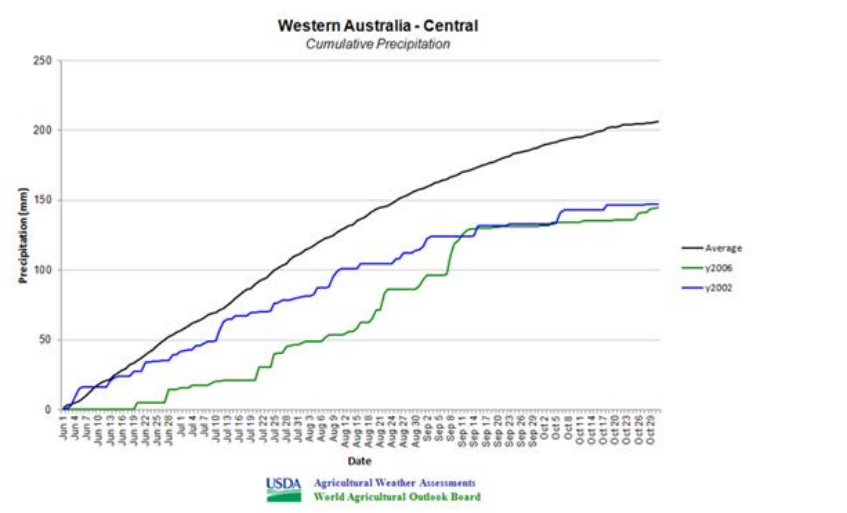


2006 is the target year…
… 2002 is an analog year.

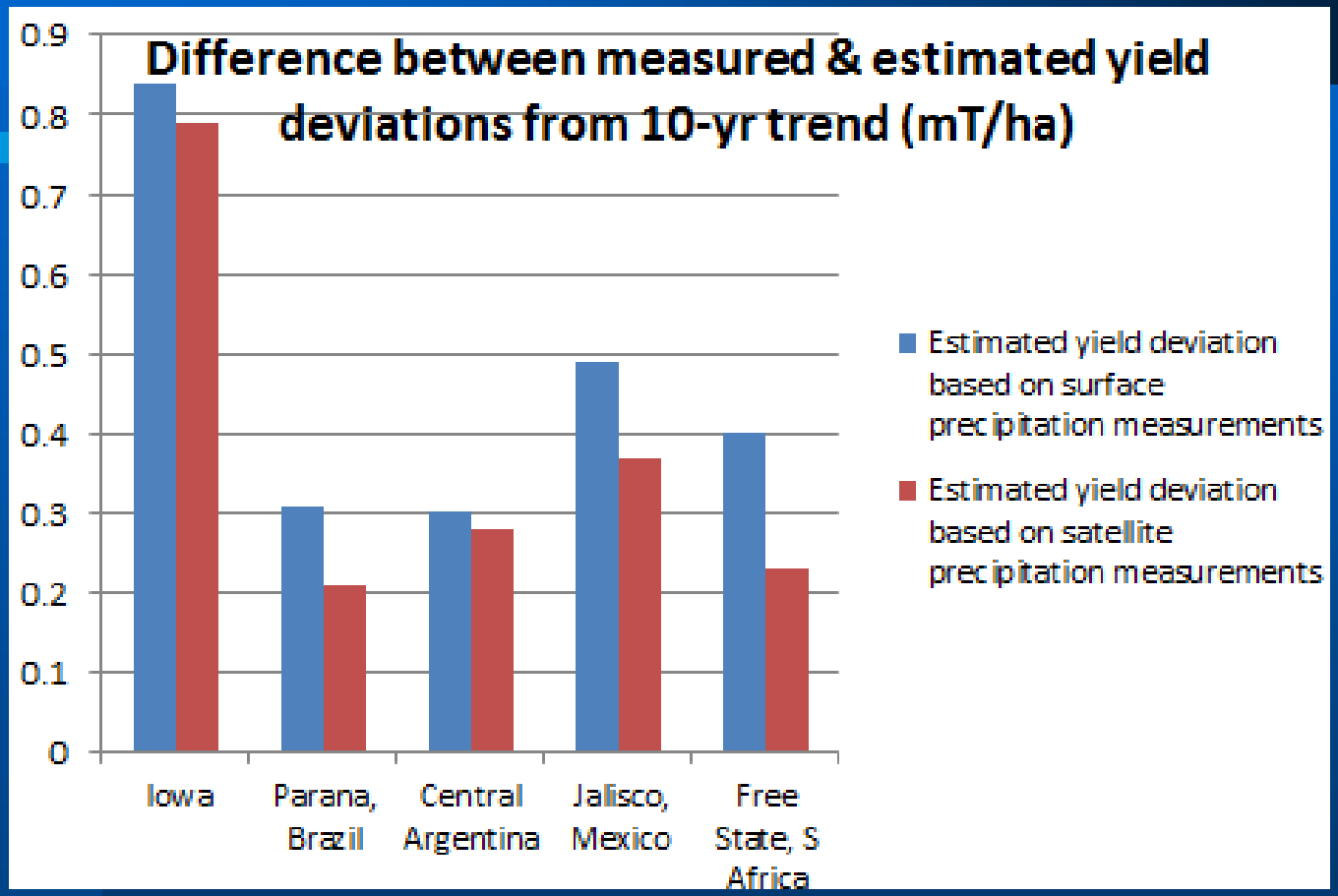
Actual Δ winter wheat yields from trend (T/ha):

2006 -1.63; 2002 -1.38

Benchmark and Metrics



- (Western Australia) Importance of timing of precipitation relative to stages of crop development.
- Similar amounts of rain fell during the 2002 and 2006 winter wheat growing seasons.
- 2002: Noticeable drying trend throughout season.
- 2006: Overall dry but w/ period of near-normal rainfall approaching moisture-sensitive reproductive stages of development (early Sep).
- Winter wheat yields: 2006 (1.27 t/ha) > 2002 (0.91 t/ha).


Difference between measured & estimated yield deviations from 10-yr trend (mT/ha)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Iowa
Parana, Brazil
Central Argentina
Jalisco, Mexico
Free State, S Africa
Estimated yield deviation based on surface precipitation measurements
Estimated yield deviation based on satellite precipitation measurements

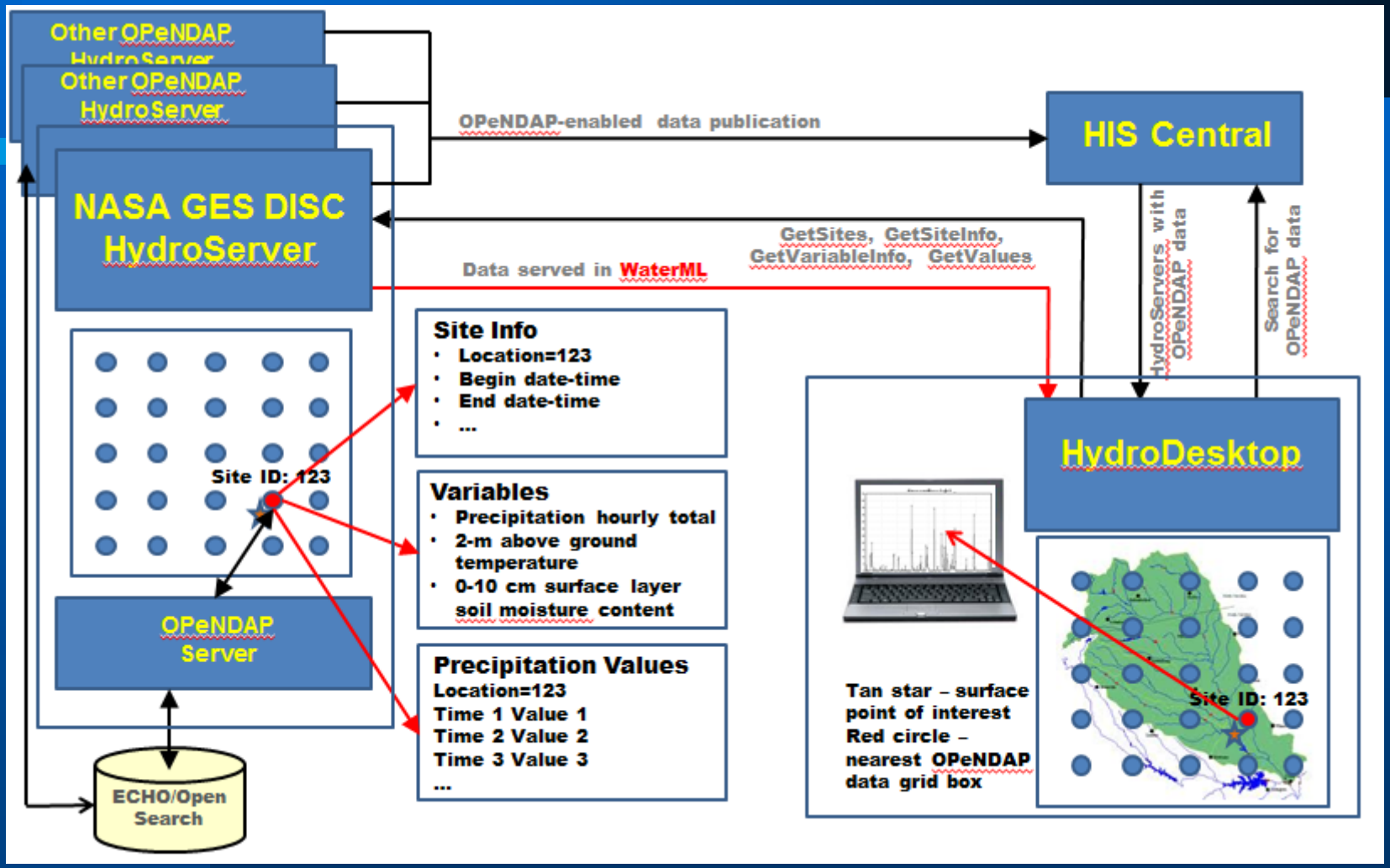
Toward Handing Off to WAOB and Making a Difference

- Live, operational, forward-processing satellite precipitation and soil moisture data products.
- Service options for accessing and integrating data products into GLADSE.
- Operational Giovanni portal.
- Results thus far: Crop yield estimates derived from satellite-based precipitation data are closer to measured yields than are estimates derived from surface-based precipitation measurements.
- “Calibrating” analog analysis methodology in station-rich areas; apply in station-poor areas of the world; significantly extend global coverage.
- WAOB is focal point for economic intelligence within USDA. Improving WAOB's agricultural estimates (WASDE) will be significant for USDA and visibly demonstrate value of NASA resources for societal benefits.

ROSES-ACCESS CUAHSI HIS

Co-Is: B. Vollmer, H. Rui, R. Strub, D. Maidment, T. Whiteaker, C. Peters-Lidard, D. Mocko, D. Kirchbaum

NASA GES DISC, Univ. of Texas, NASA GSFC HSL


Other OPeNDAP HydroServer
Other OPeNDAP HydroServer
NASA GES DISC HydroServer
OPeNDAP-enabled data publication
HIS Central
GetSites, GetSiteInfo, GetVariableInfo, GetValues
Data served in WaterML
HydroServers with OPeNDAP data
Search for OPeNDAP data
Site ID: 123
OPeNDAP Server
ECHO/Open Search
Site Info
Location=123
Begin date-time
End date-time
...
Variables
Precipitation hourly total
2-m above ground temperature
0-10 cm surface layer soil moisture content
Precipitation Values
Location=123
Time 1 Value 1
Time 2 Value 2
Time 3 Value 3
...
HydroDesktop
Tan star – surface point of interest
Red circle – nearest OPeNDAP data grid box
Site ID: 123

Questions?

William.L.Teng@nasa.gov

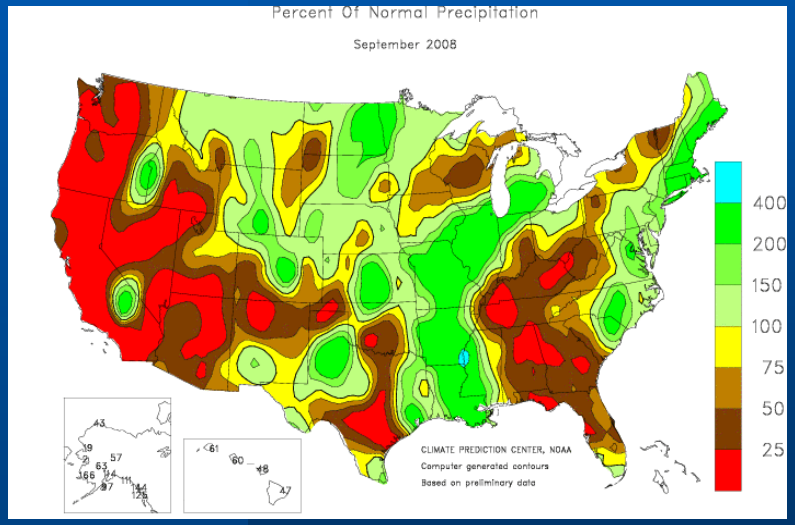
http://gdata1.sci.gsfc.nasa.gov/daac-bin/G3/gui.cgi?instance_id=soilmoisture_daily

http://1.usa.gov/TYDTnO

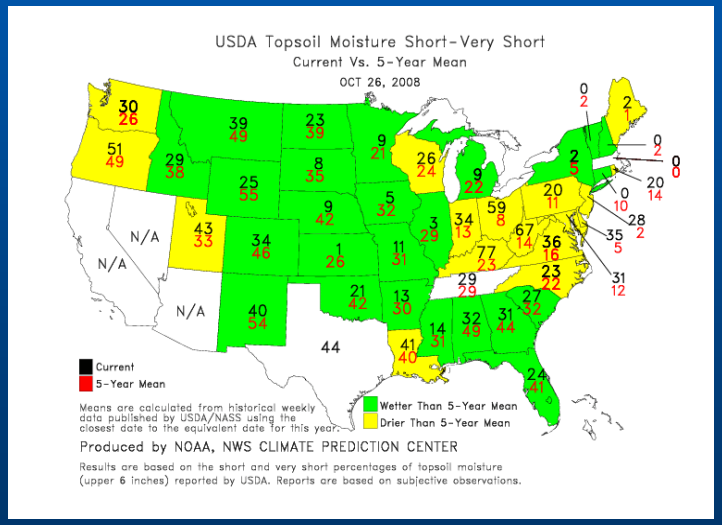
Extras

USDA WAOB GLADSE

Soil moisture is currently a primary data gap at WAOB.



Percent of Normal Precipitation



USDA Topsoil Moisture

Satellite Soil Moisture Products

Microwave sensors (primary measurements; launch date):

- Windsat (ocean surface wind; 1/2003)
- SMOS (Soil Moisture and Ocean Salinity; 11/2009)
- Aquarius (sea surface salinity; 6/2011)
- AMSR2 (water cycle; 5/2012)
- GPM (Global Precipitation Measurement; est. 2014)
- SMAP (Soil Moisture Active & Passive; est. 11/2014)

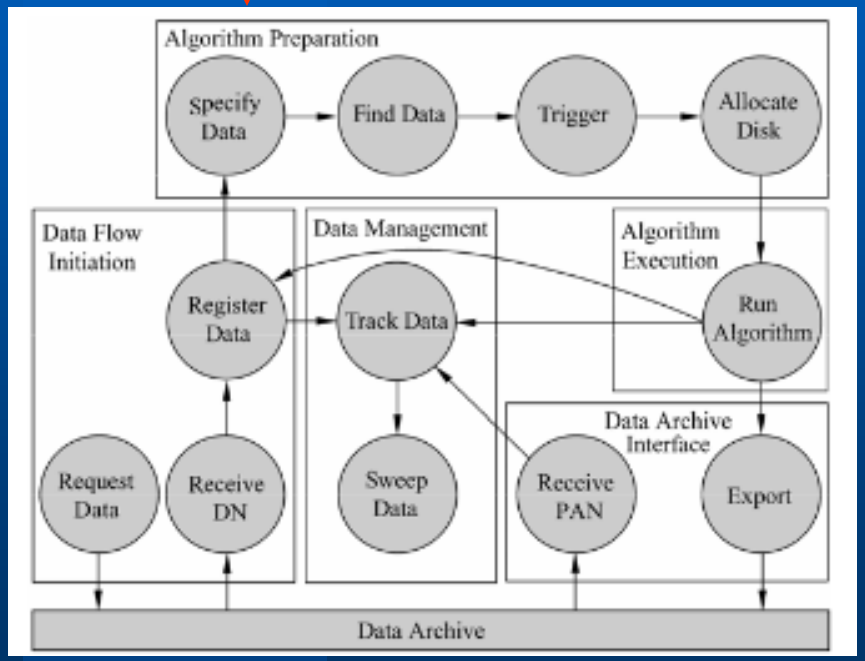
Other existing products include TMI (LSMEM), AMSR-E (EOS Aqua), AMSR-E (SCA).

LPRM Soil Moisture

- Provide global soil moisture with high temporal resolution and 0.25 degree spatial resolution, for the top few cm of the soil column (Owe et al., 2008).
- Three-parameter retrieval model based on microwave radiative transfer model that links surface geophysical variables to observed Tbs.
- Extensively validated; has an accuracy of ~0.06 m^3 m^{-3} for sparse to moderate vegetated regions (De Jeu et al., 2008).

Integration into WAOB

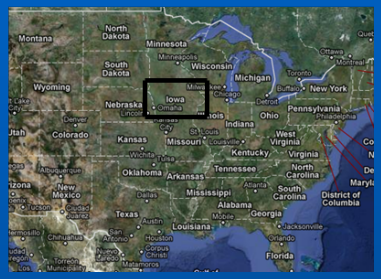
LPRM algorithm



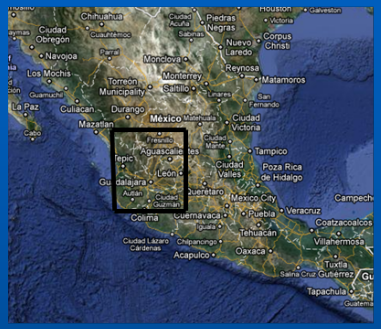
- Simple, Scalable, Script-Based, Science Product Archive (S4PA) for operational online data access.
- Simple, Scalable, Script-Based Science Processor for Missions (S4PM) for automated processing of science data (Lynnes, 2006).
- Customization for WAOB (e.g., subsetting, re-formatting, re-gridding) ensures direct and easy integration into GLADSE, in a form that is usable and effective.
- Machine-to-machine:
  - Leverage existing operational Web services (e.g, GDS, WMS, WCS).
  - LPRM → GLADSE
  - LPRM → EPIC → GLADSE

Study areas

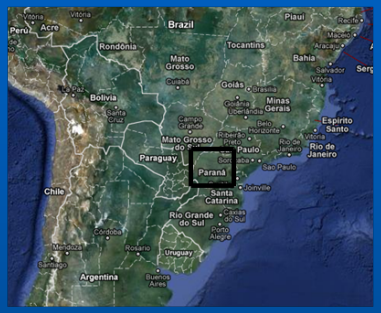
Five major agricultural regions worldwide were analyzed. The size of individual study areas selected depends on the variability of weather within each area and the availability of crop yield data.



Iowa is the largest corn producing state in the U.S., accounting for about 19% of domestic production annually. U.S. is the largest corn producer and exporter in the world.



Approximately 70 percent of total corn production in Mexico come from eight states. Including Jalisco. Mexico is the fourth largest corn producing country in the world.



Argentina is the world's second largest exporter, and fifth largest producer, of corn.

Free State is the largest corn-producing state in South Africa.

•Benchmark and Metrics

REGION (crop)	Measured yield deviations from the 10-yr trend (OBS)	Estimated yield deviations from trend based on surface data (SFC)	Absolute value of OBS-SFC	Estimated yield deviations from trend based on satellite data (SAT)	Absolute value of OBS-SAT
Iowa, U.S.A. (corn)	-0.53 (mT/ha)	0.31	***0.84***	0.26	***0.79***
Parana, Brazil (soybeans)	0.33 (mT/ha)	0.02	***0.31***	0.12	***0.21***
central Argentina (corn)	-0.79 (mT/ha)	-0.49	***0.30***	-0.51	***0.28***
Jalisco, Mexico (corn)	-0.44 (mT/ha)	0.05	***0.49***	-0.07	***0.37***
Free State, South Africa (corn)	0.53 (mT/ha)	0.13	***0.40***	0.30	***0.23***

- For all areas, diff (meas. deviation from 10-yr trend (OBS), est. deviation based on surface data (SFC)) > diff (OBS, est. deviation based on satellite data (SAT)).
- Tested traditional, visual method by USDA WAOB agricultural meteorologist.
- For all areas, analyst selected analog year(s) with better yield estimates, using satellite data.

- ***Station-based precipitation:*** Regional time series are derived by averaging daily cumulative precipitation from multiple surface observing stations distributed evenly throughout each study area. Iowa, U.S. – 8 stations from NOAA/NWS Cooperative Observer Program (COOP) network; Jalisco, Mexico – 4 stations from World Meteorological Organization (WMO) network; Parana, Brazil – 6 WMO stations; central Argentina – 5 WMO stations; Free State, South Africa – 5 WMO stations.

- ***Crop yield:*** U.S. – annual state-level corn statistics from USDA National Agricultural Statistics Service (NASS); Mexico - Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación (SAGARPA); Brazil – annual soybean statistics from Instituto Brasileiro de Geografia e Estatística; Argentina - Ministerio de Agricultura, Ganadería y Pesca (MAGyP); South Africa – National Estimates Committee (NEC).

- ***TRMM Multi-satellite Precipitation Analysis*** (TMPA; 3B42-V6) (Huffman et al., 2007): 0.25-deg; daily (averaged from 3-hourly); source data sets merged (TRMM, AMSR-E, SSM/I, others); temporal coverage 1998-present.

The coefficient of determination is often used to measure how well modeled estimates represent observed values. A generic form of the coefficient of determination (R^2) can be expressed as

$$R^2 = 1 - \frac{\sum_i (OBS_i - MOD_i)^2}{\sum_i (OBS_i - \overline{OBS})^2}$$

where OBS are observed values, MOD are modeled estimates, and $\overline{OBS}$ is the mean of the observed data. An R^2 of 1.0 indicates that the observed data and modeled estimates are perfectly correlated but does not guarantee that they are identical. Because the generic form of the coefficient of determination is unable to simultaneously resolve similarities in the timing and magnitude of precipitation, a modified form of this equation was used in this study to identify analog years. The modified equation, termed the analog index (AI), is expressed as

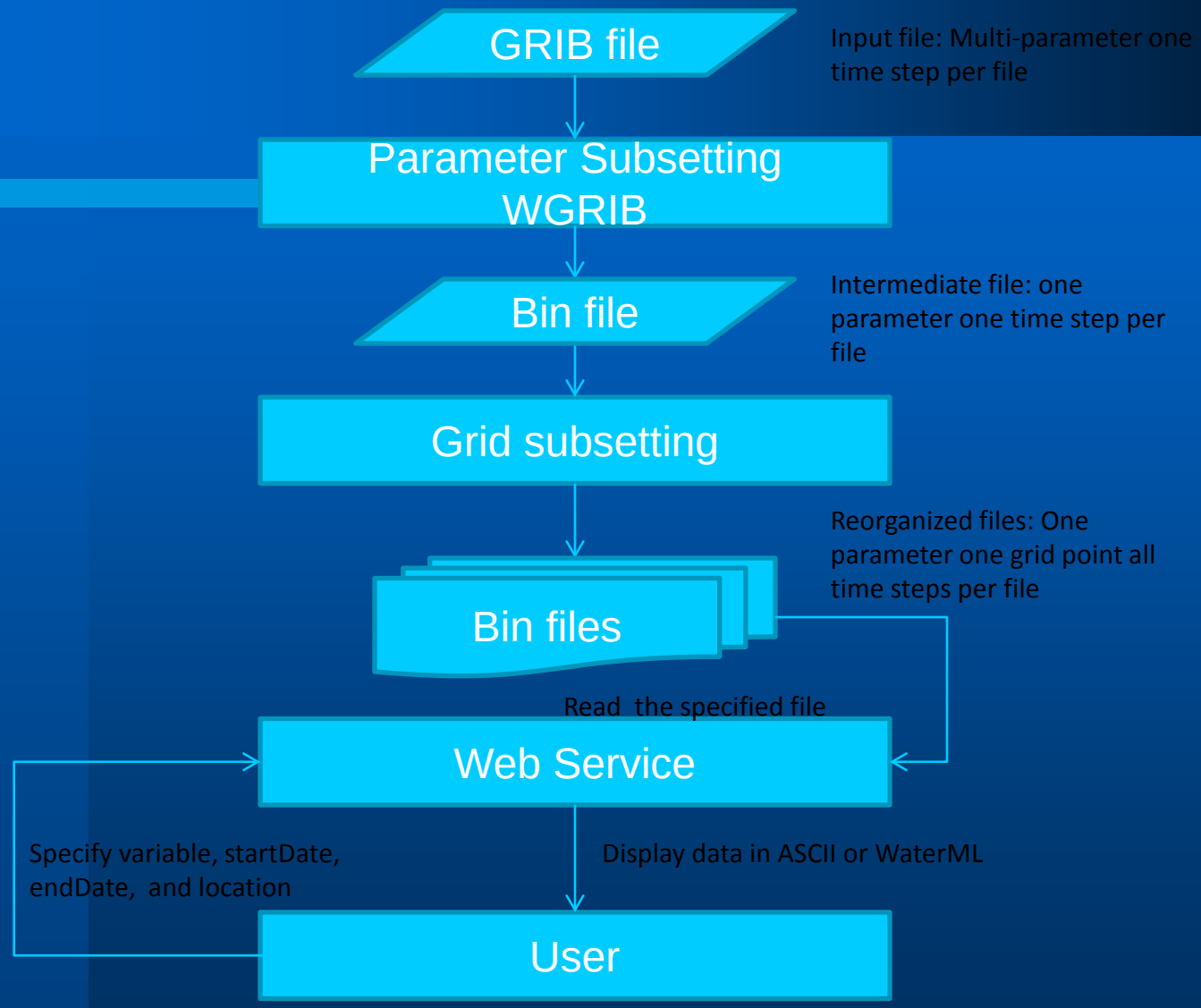
$$AI = 1 - \frac{\sum_i (P_i - PA_i)^2}{\sum_i (P_i - coeff * P_i)^2}$$

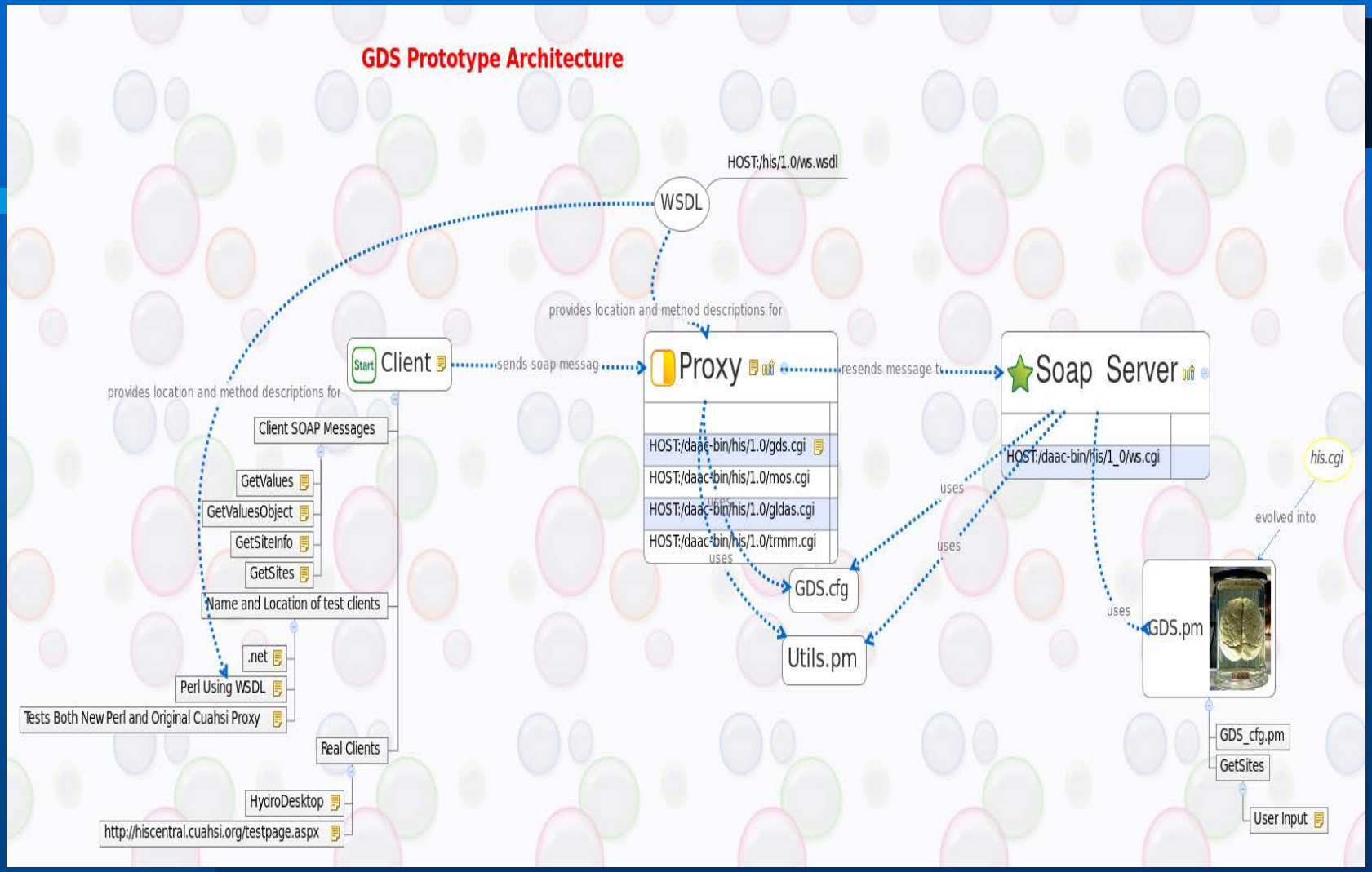
where P is the precipitation during the target year, PA is the precipitation during the potential analog year, and $coeff$ serves as a threshold that helps evaluate the goodness of fit between P and PA. AI values range from $-\infty$ to 1.0, with values approaching 1.0 indicative of the strongest analog relationships between P and PA. In this study, time series with positive AI values are considered analog years.

Values of $coeff$ could range from 0.0 to 1.0 and, theoretically, be arbitrarily set close to 1.0, to limit the number of time series that qualify as analog years. However, when the same $coeff$ was applied across different areas or different target years, the results were poor, suggesting that a unique $coeff$ is needed for each study area and time period of interest, to identify the best set of analog years. Because the $coeff$ is an unknown for each study area and time period, an iterative approach was adopted for calculating the AI.

In this study, the 2008 growing season was selected as the target year. The 2003, 2004, 2005, 2006, and 2007 growing seasons were treated as potential analog years. Initially, the AI was calculated for each potential analog year using a $coeff$ of 0.95. The AI values were then summed to determine the strength of the analog relationships. If the sum was less than 1.0, no strong analogs were identified, so the $coeff$ was decreased a small amount and the AI values and the sum of these values were recalculated. This iterative process was repeated until the sum of the AI values equaled 1.0 or the $coeff$ equaled 0.0. This approach ensured that only the strongest analog years were identified AND that no analog years were identified if the time series were not reasonably similar to the target year.

Data Reorganization and Retrieving




GDS Prototype Architecture
HOST:/his/1.0/ws.wsdl
WSDL
provides location and method descriptions for
Start
Client
sends soap messag
Proxy
resends message t
Soap Server
provides location and method descriptions for
Client SOAP Messages
GetValues
GetValuesObject
GetSiteInfo
GetSites
Name and Location of test clients
.net
Perl Using WSDL
Tests Both New Perl and Original Cuahsi Proxy
Real Clients
HydroDesktop
http://hiscentral.cuahsi.org/testpage.aspx
HOST:/daac-bin/his/1.0/gds.cgi
HOST:/daac-bin/his/1.0/mos.cgi
HOST:/daac-bin/his/1.0/gldas.cgi
HOST:/daac-bin/his/1.0/trmm.cgi
uses
GDS.cfg
Utils.pm
HOST:/daac-bin/his/1_0/ws.cgi
uses
uses
uses
his.cgi
evolved into
GDS.pm
GDS_cfg.pm
GetSites
User Input