

Advancing Global Drought Monitoring and Prediction: Introducing GIDMaPS

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<http://drought.eng.uci.edu/>

Global Integrated Drought Monitoring and Prediction System (GIDMaPS)

Map **Layers**

☒ Drought Monitoring
☐ Seasonal Prediction

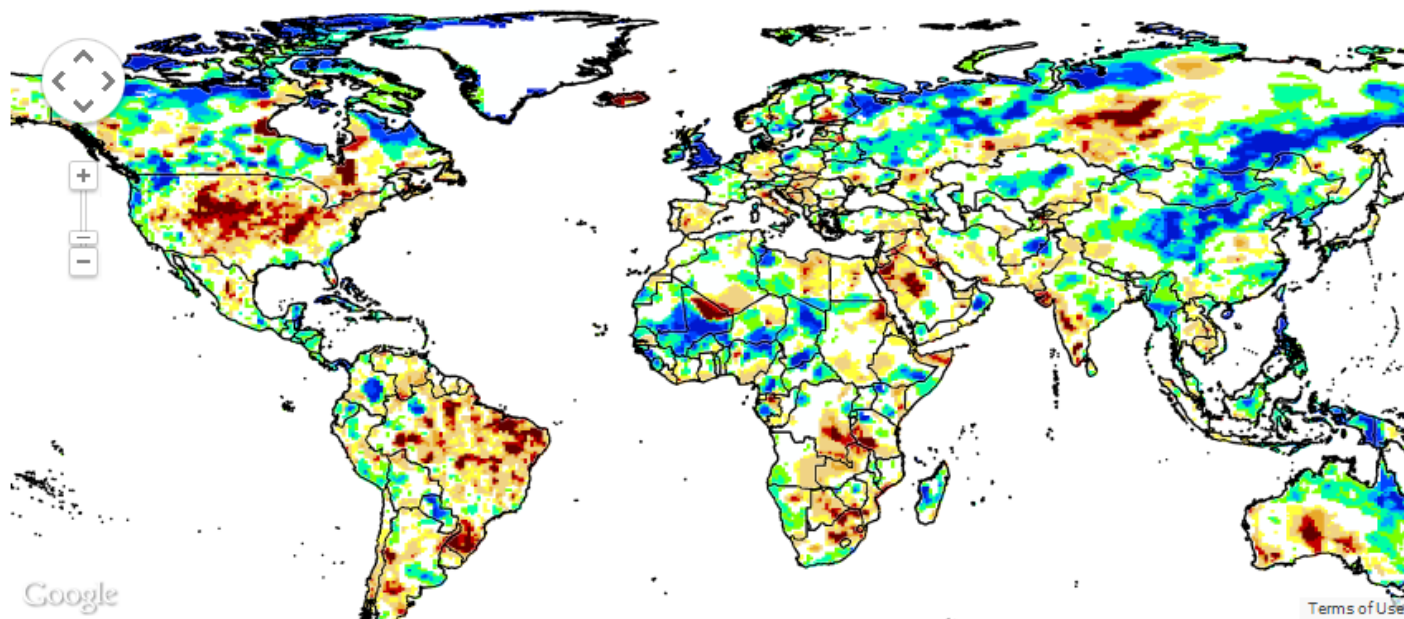
Data Set:
MERRA ▼

Year:
2012 ▼

Month:
August ▼

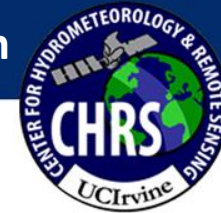
Index:
SPI ▼

Load **Download Image**



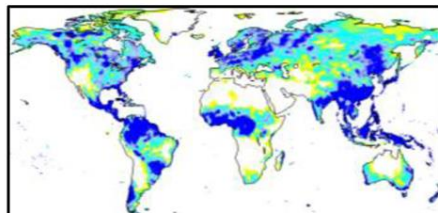


GIDMaPS: Global Integrated Drought Monitoring and Prediction System

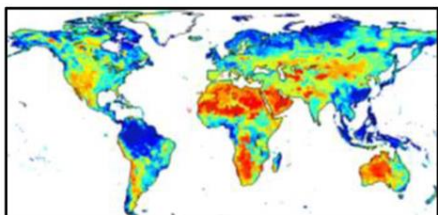


Input Data

Precipitation



Soil Moisture



Indicators

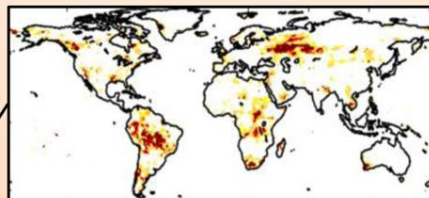
SPI

MSDI

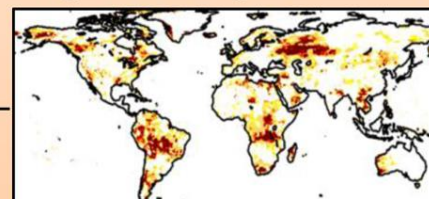
SSI

Drought Monitoring

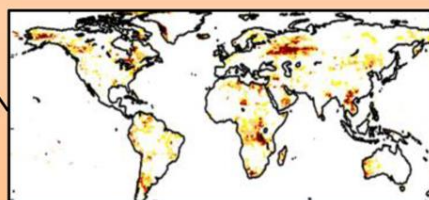
Meteorological Drought



Integrated Drought Information

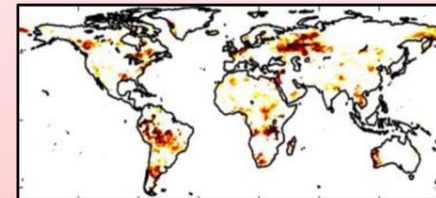


Agricultural Drought

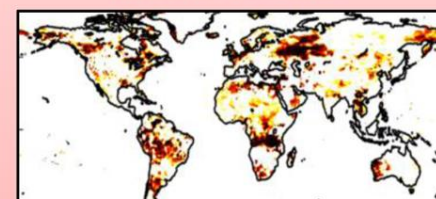


Seasonal Prediction

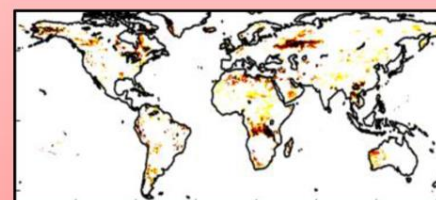
SPI Prediction



MSDI Prediction

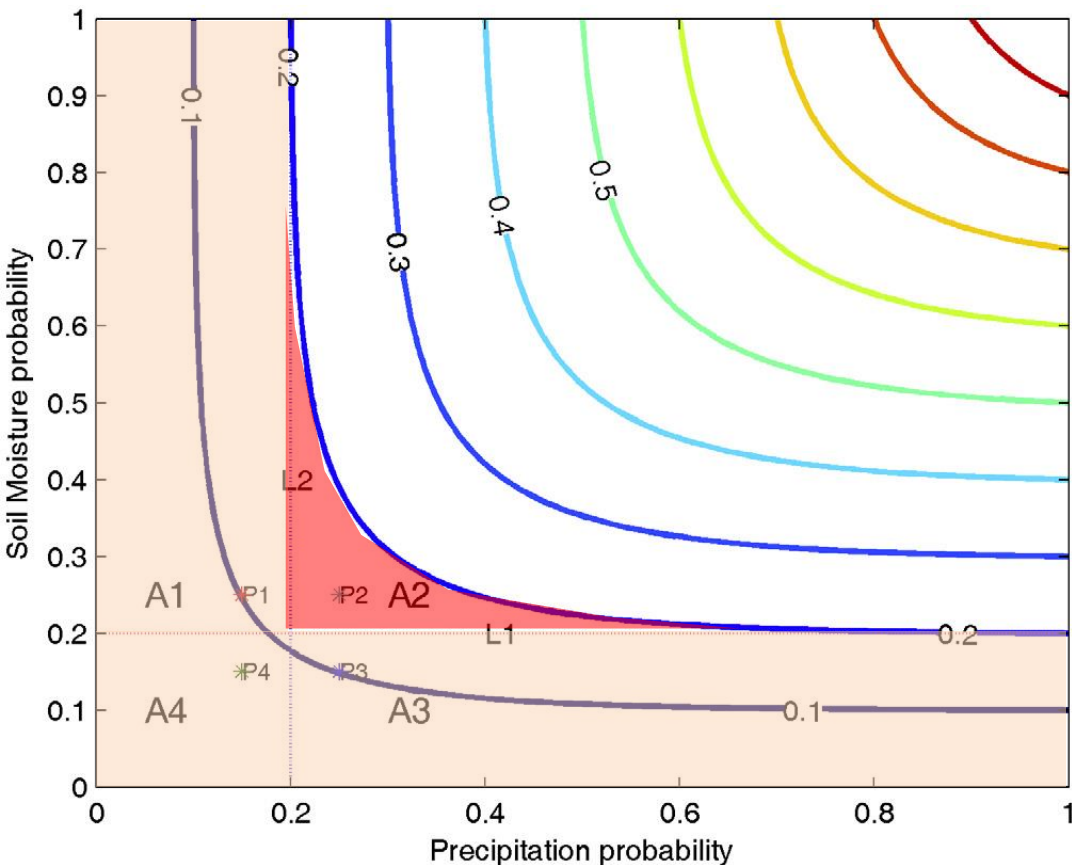


SSI Prediction





Multi-Index Drought Monitoring



Standardized Precipitation Index (SPI)

$$p_{SPI} = P(X \leq x) \quad SPI = \phi^{-1}(p_{SPI})$$

Standardized Soil moisture Index (SSI)

$$p_{SSI} = P(Y \leq y) \quad SSI = \phi^{-1}(p_{SSI})$$

Multivariate Standardized Drought Index (MSDI)

$$p_{MSDI} = P(X \leq x, Y \leq y)$$

$$MSDI = \phi^{-1}(p_{MSDI})$$

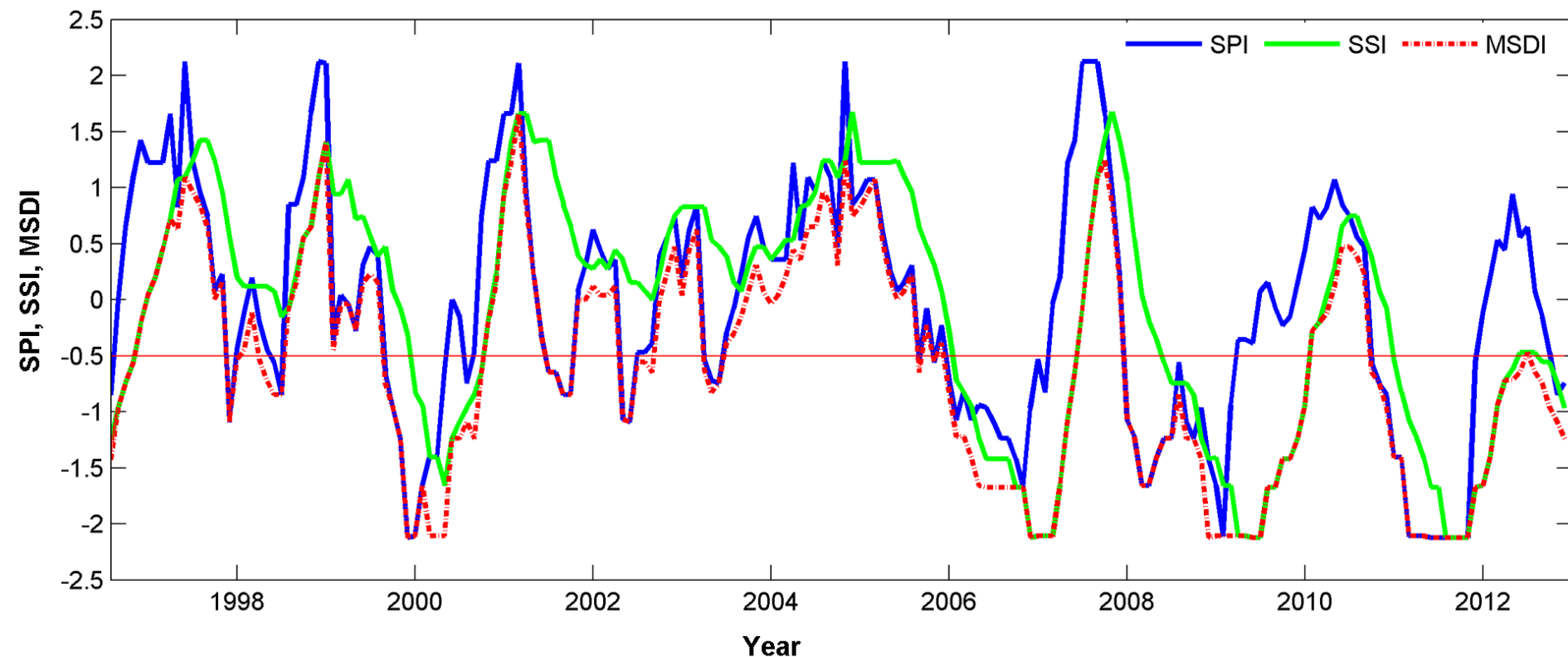
Where: X: accumulated precipitation;
Y: accumulated soil moisture;
 ϕ : standard normal distribution

MSDI (Hao and AghaKouchak, 2013):

- Standardized index similar to SPI
- Improves drought onset detection
- A multi-Index for composite meteorological -agricultural drought monitoring



Multi-Index Drought Monitoring



Sample time series of the 6-month SPI, SSI and MSDI for a grid cell in Texas (Location: longitude 100 W and latitude 30 N).



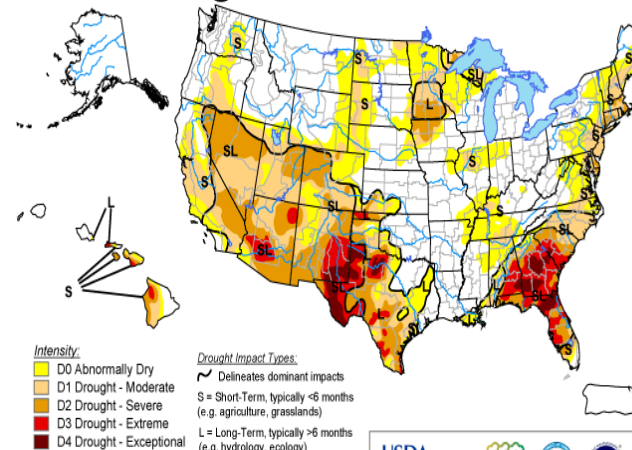
Multi-Index Drought Monitoring



SPI and SSI Derived Using NASA MERRA-LAND Precipitation and soil moisture Data.

U.S. Drought Monitor

May 1, 2012
Valid 7 a.m. EDT



The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

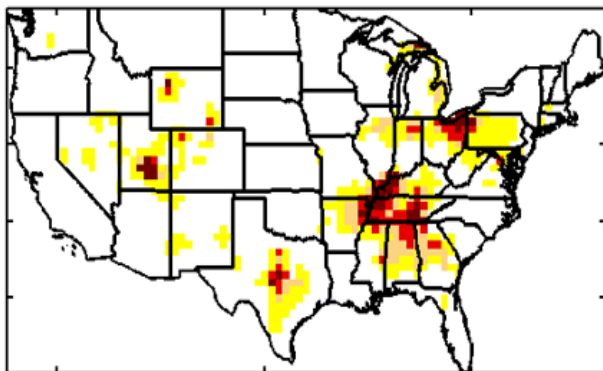
<http://droughtmonitor.unl.edu/>



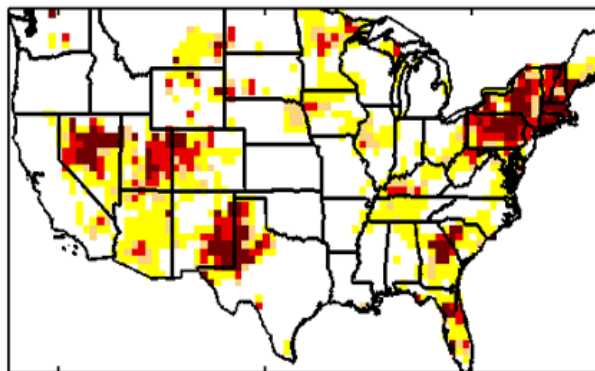
Released Thursday, May 3, 2012

Author: Matthew Rosenkrans, NOAA/NWS/NCEP/CPC

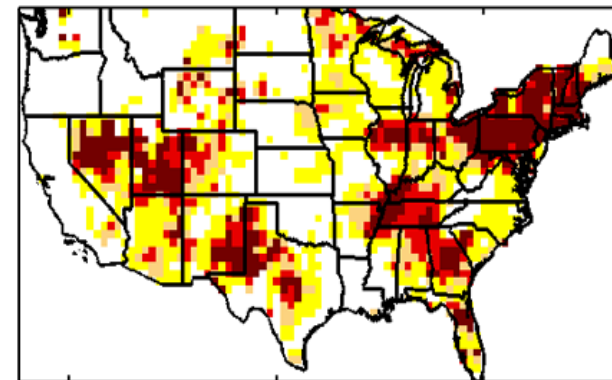
SPI, Apr 2012



SSI, Apr 2012



MSDI, Apr 2012



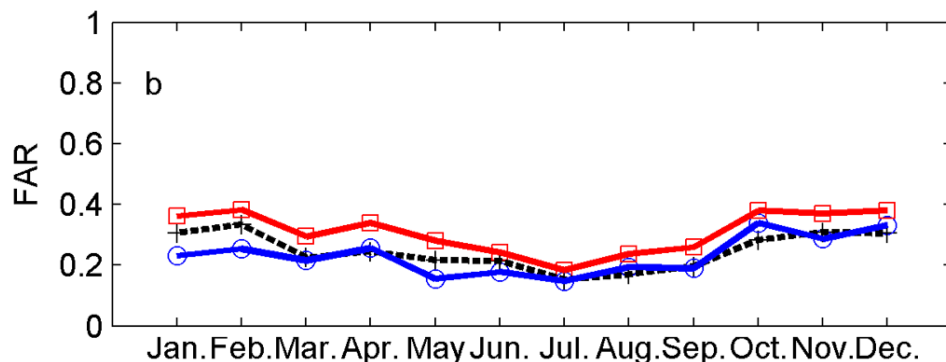
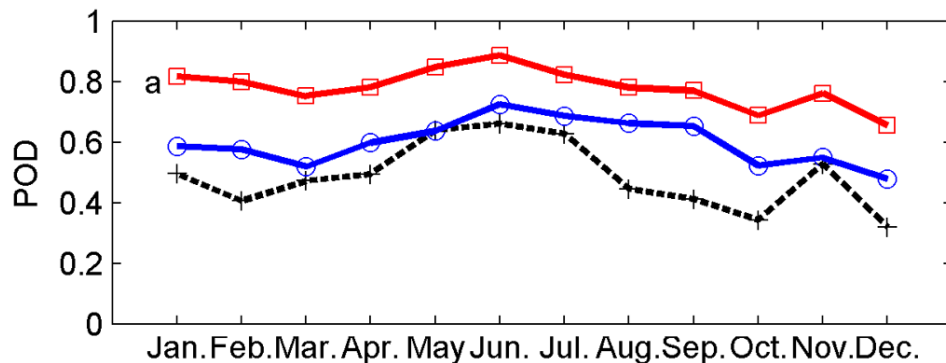


Multi-Index Drought Monitoring



2007 Drought (3-month SPI, SSI, MSDI)

----- SPI — SSI — MSDI

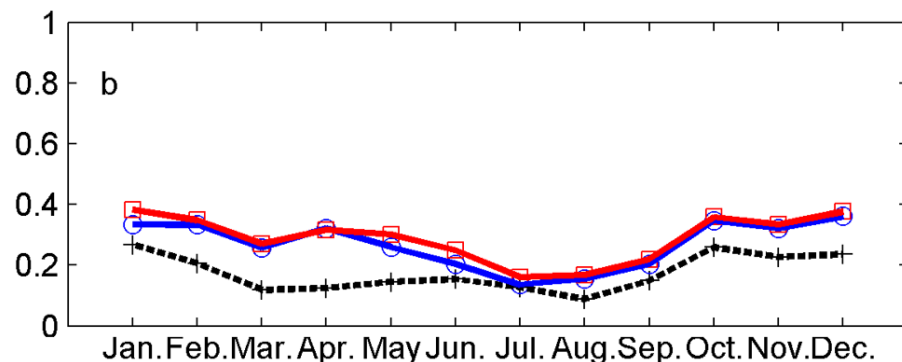
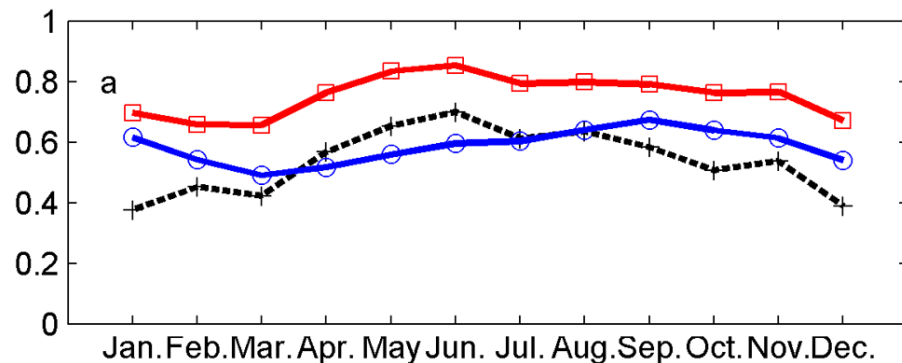


SPI, Apr 2007

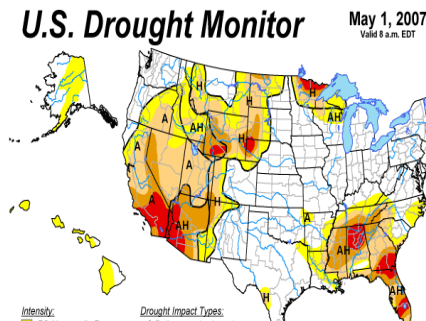
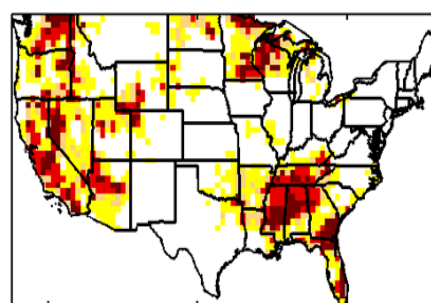
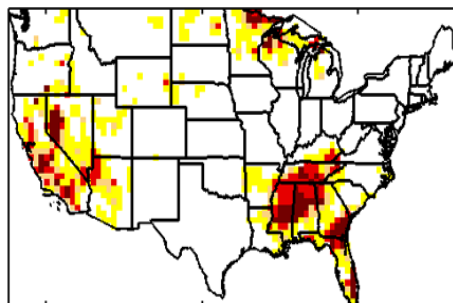
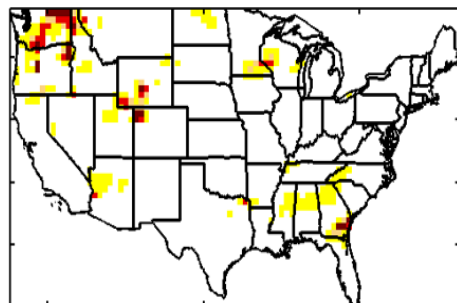
SSI, Apr 2007

2007 Drought (6-month SPI, SSI, MSDI)

----- SPI — SSI — MSDI



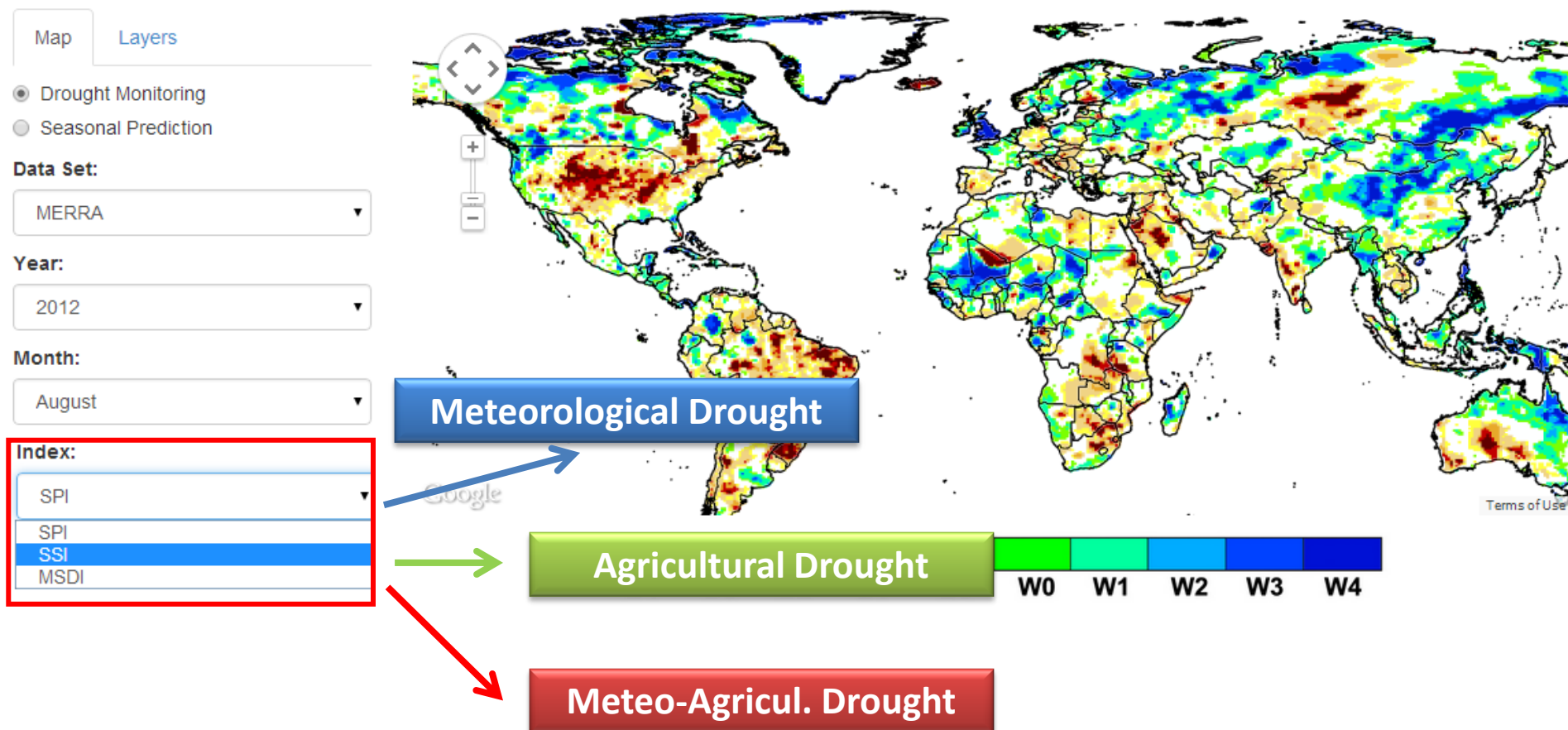
MSDI, Apr 2007





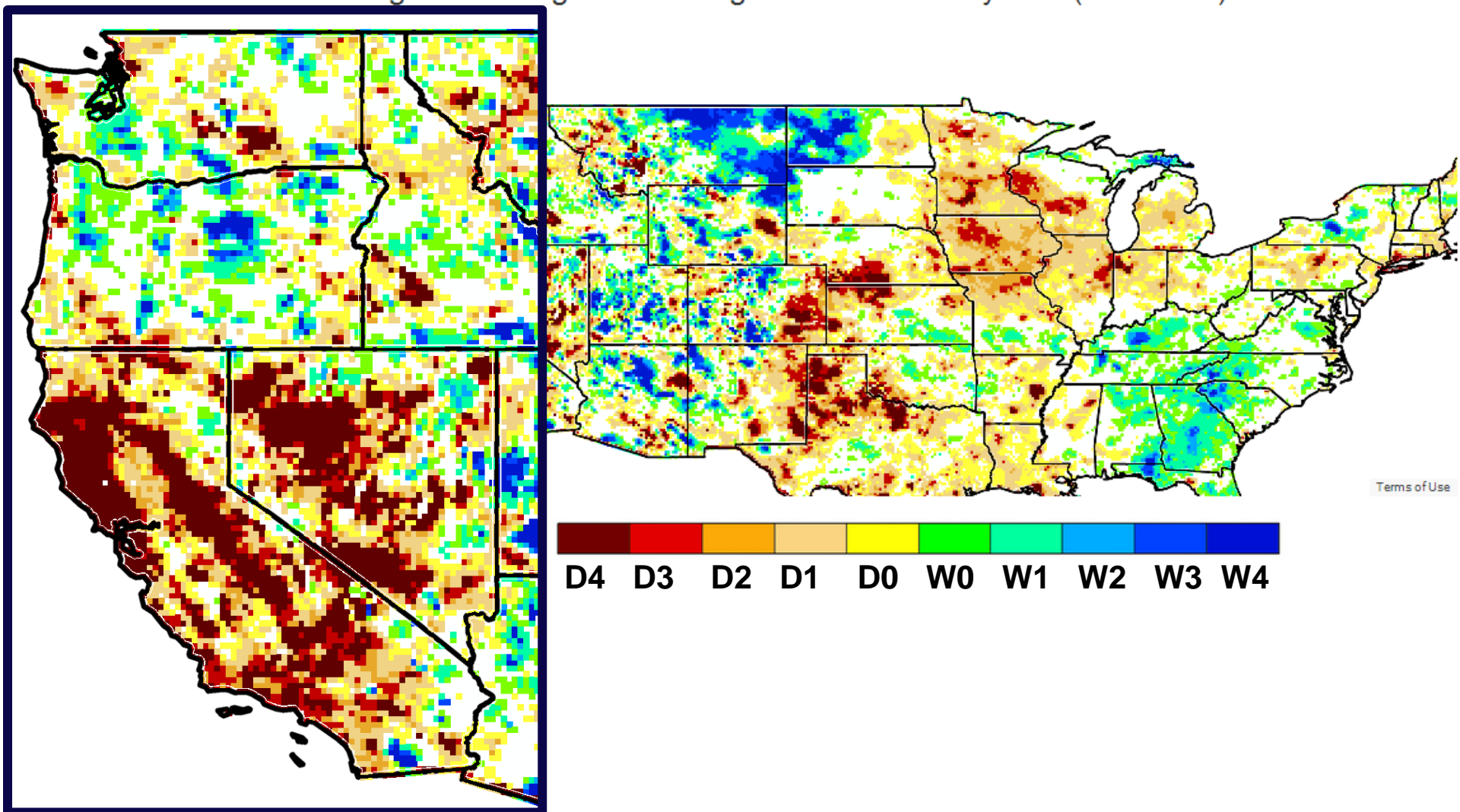
<http://drought.eng.uci.edu/>

Global Integrated Drought Monitoring and Prediction System (GIDMaPS)





Global Integrated Drought Monitoring and Prediction System (GIDMaPS)





Input Data Set	ID	Source	Resolution
NASA Modern-Era Retrospective analysis for Research and Applications – Reichle et al., 2011 - Precipitation and Soil Moisture	MERRA	NASA	2/3°x 1/2°
North American Land Data Assimilation System - Kumar et al., 2006 - Precipitation and Soil Moisture	NLDAS	NASA	0.125 °
Global Drought Climate Data Record - AghaKouchak and Nakhjiri, 2012 – Precipitation – combines real-time PERSIANN satellite data (Sorooshian et al., 2000; Hsu et al., 1997) with long-term GPCP (Adler et al., 2001) observations.	GDCDR	UCI	0.5°
Global Land Data Assimilation System (GLDAS) - Peters-Lidard et al., 2007 - Precipitation and Soil Moisture	GLDAS	NASA	1°

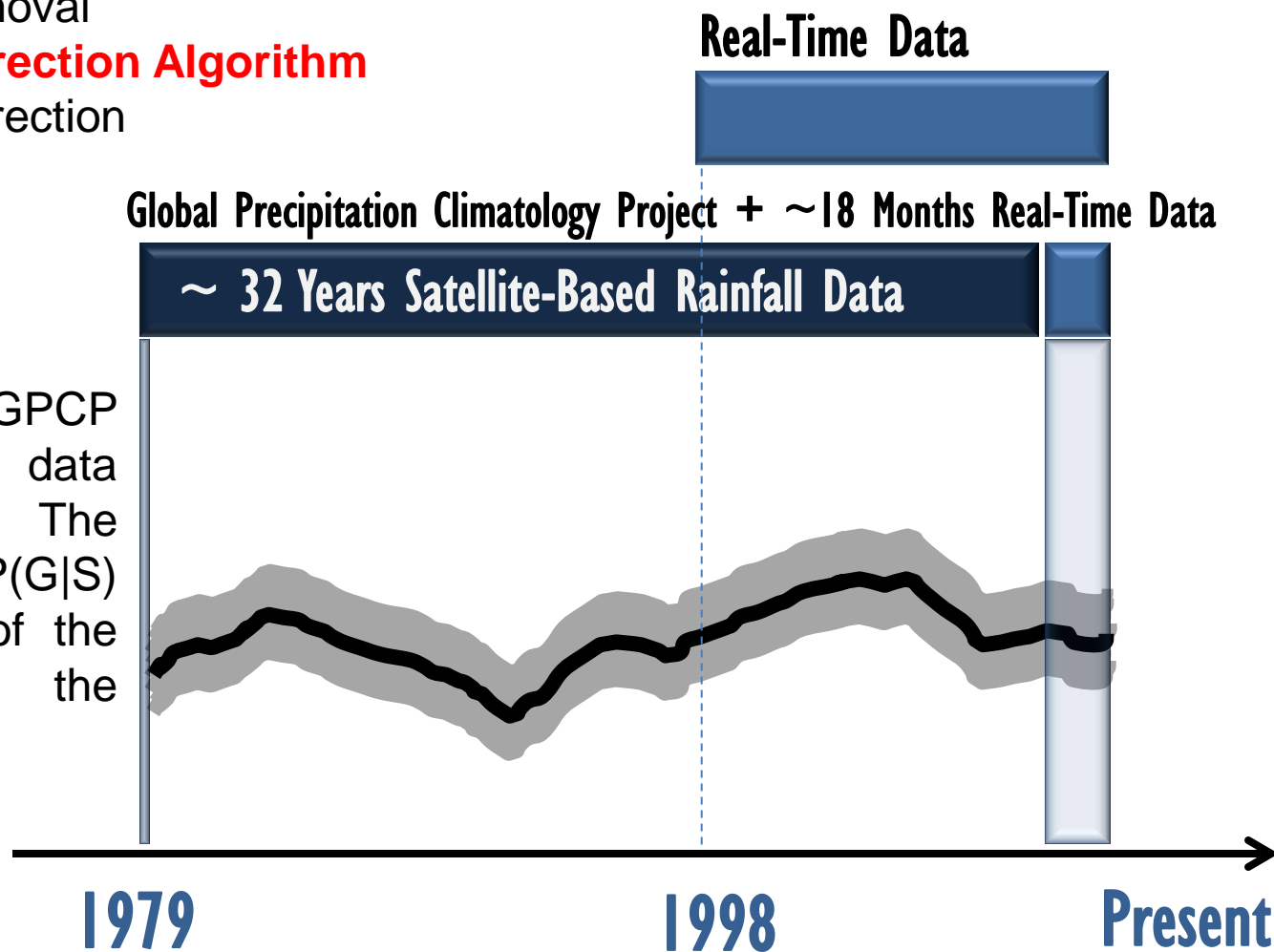
Drought Indicator	ID	Reference
Standardized Precipitation Index	SPI	McKee et al., 1993
Standardized Soil Moisture Index	SSI	Hao and AghaKouchak, 2013a
Multivariate Standardized Drought Index	MSDI	Hao and AghaKouchak, 2013a,b



- Empirical PDF Matching
- Mean-Fields Bias Removal
- **Bayesian-Based Correction Algorithm**
- Parametric Fitting Correction

$$P(G|S) = \frac{P(G, S)}{P(S)}$$

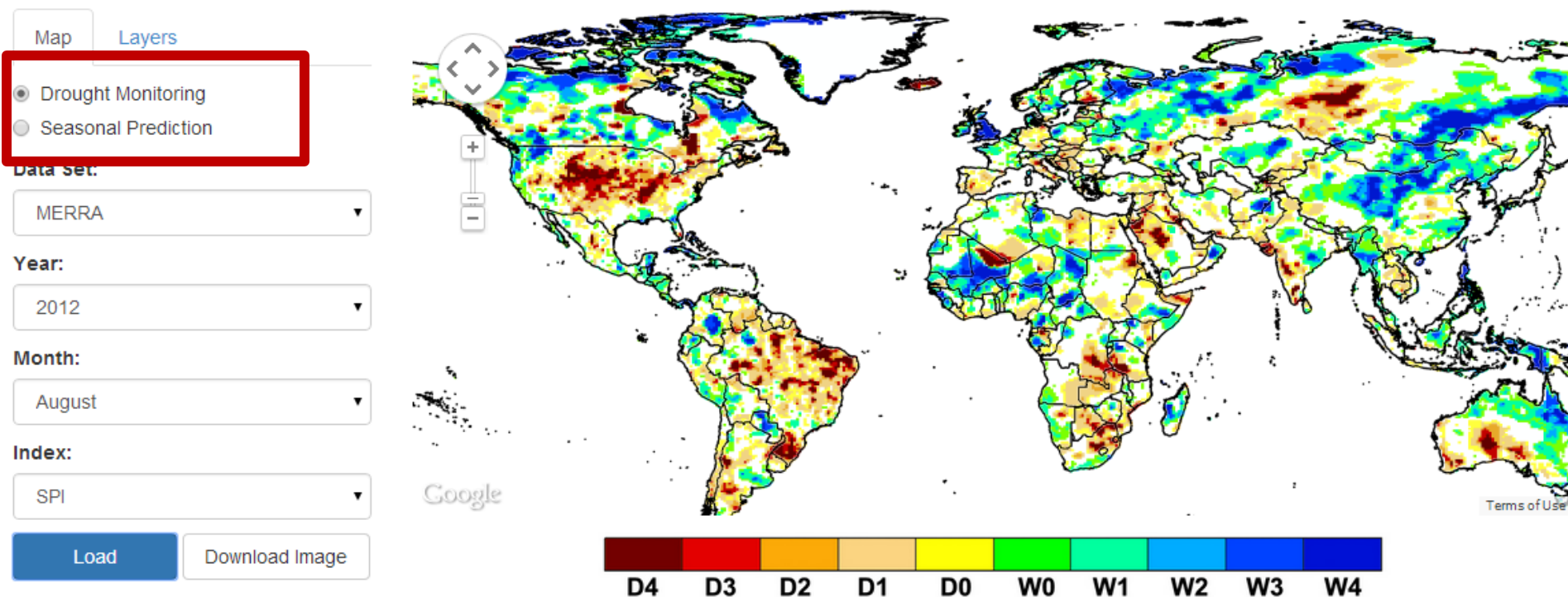
where G and S denote GPCP and real-time satellite data (potentially, **GPM**). The conditional probability $P(G|S)$ indicates the likelihood of the measurement G given the satellite observation S.





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Global Integrated Drought Monitoring and Prediction System (GIDMaPS)





$$AP_{n+1, m} = P_{n+1, m-5} + P_{n+1, m-4} + P_{n+1, m-3} + P_{n+1, m-2} + P_{n+1, m-1} + \underline{P}_{n+1, m}$$

$$AS_{n+1, m} = S_{n+1, m-5} + S_{n+1, m-4} + S_{n+1, m-3} + S_{n+1, m-2} + S_{n+1, m-1} + \underline{S}_{n+1, m}$$

$$AP^{(i)}_{n+1, m} = P_{n+1, m-5} + P_{n+1, m-4} + P_{n+1, m-3} + P_{n+1, m-2} + P_{n+1, m-1} + \underline{P}_{i, m}$$

$$AS^{(i)}_{n+1, m} = S_{n+1, m-5} + S_{n+1, m-4} + S_{n+1, m-3} + S_{n+1, m-2} + S_{n+1, m-1} + \underline{S}_{i, m}$$

$$SSI^{(i)} = P(AS \leq AS^{(i)}_{n+1, m})$$

$$SPI^{(i)} = P(AP \leq AP^{(i)}_{n+1, m})$$

$$MSDI^{(i)} = P(AP \leq AP^{(i)}_{n+1, m}, AS \leq AS^{(i)}_{n+1, m})$$



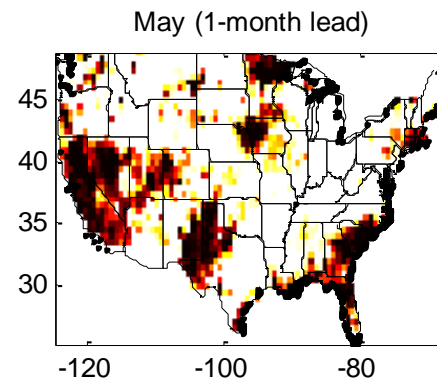
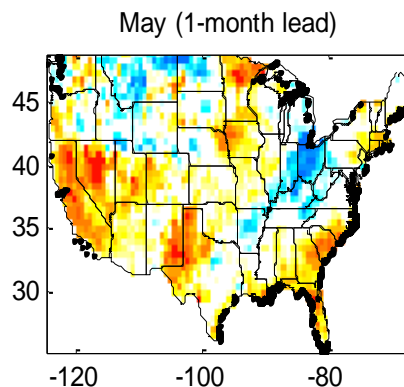
Prediction component is based on a drought persistence model which requires historical observations. The seasonal drought prediction component is based on two input data sets (MERRA and NLDAS) and three drought indicators (SPI, SSI and MSDI).

$$A_{i+1}(1) = S_{i-4} + S_{i-3} + S_{i-2} + S_{i-1} + S_i + S(1)_{i+1}$$

$$A_{i+1}(2) = S_{i-4} + S_{i-3} + S_{i-2} + S_{i-1} + S_i + S(2)_{i+1}$$

.....

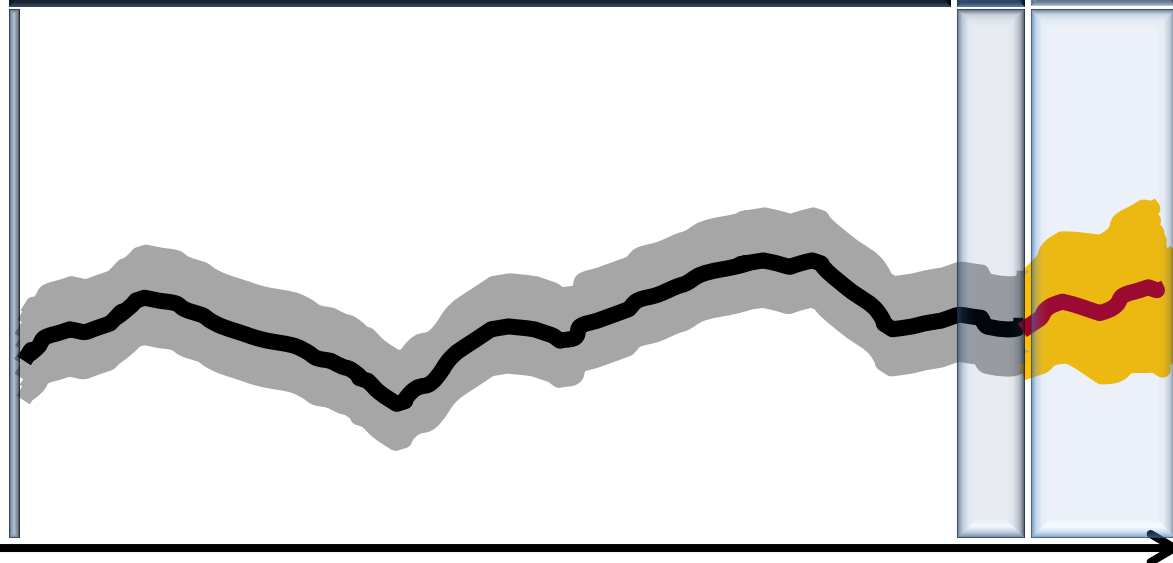
$$A_{i+1}(m) = S_{i-4} + S_{i-3} + S_{i-2} + S_{i-1} + S_i + S(m)_{i+1}$$



Real-Time (e.g., **GPM**)

1-, 6-Month Forecast

~ 30 Years Satellite-Based Rainfall Data



1979

NOW



Standardized Relative Humidity Index (SRHI) based on AIRS Data

$$p(RH_i) = \frac{i - 0.44}{n + 0.12}$$

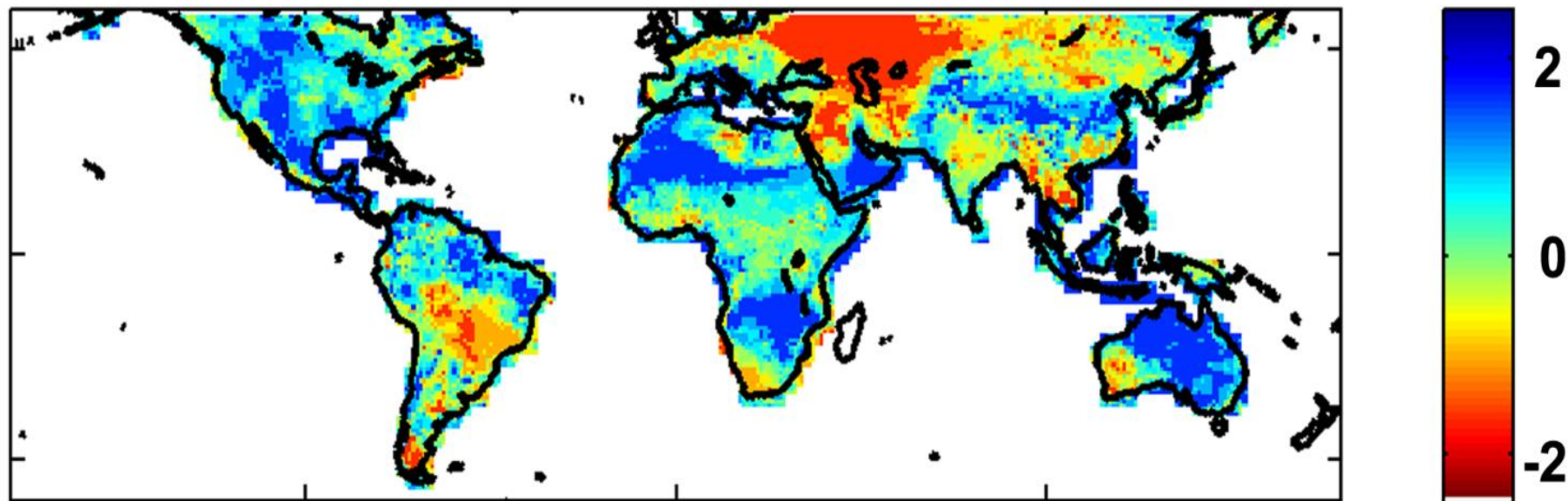
$$SRHI = \Phi^{-1}(p(RH_i))$$

$$SRHI = \begin{cases} -\left(t - \frac{C_0 + C_1 t + C_2 t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3}\right) & \text{if } 0 < p(RH_i) \leq 0.5 \\ +\left(t - \frac{C_0 + C_1 t + C_2 t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3}\right) & \text{if } 0.5 < p(RH_i) \leq 1 \end{cases}$$

where $c_0 = 2.515517$; $c_1 = 0.802583$; $c_2 = 0.010328$; $d_1 = 1.432788$; $d_2 = 0.189269$; $d_3 = 0.001308$; and

$$t = \begin{cases} \sqrt{\ln \frac{1}{p(RH_i)^2}} & \text{if } 0 < p(RH_i) \leq 0.5 \\ \sqrt{\ln \frac{1}{(1-p(RH_i))^2}} & \text{if } 0.5 < p(RH_i) \leq 1 \end{cases}$$

3-month SRHI August 2010

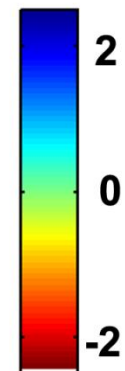
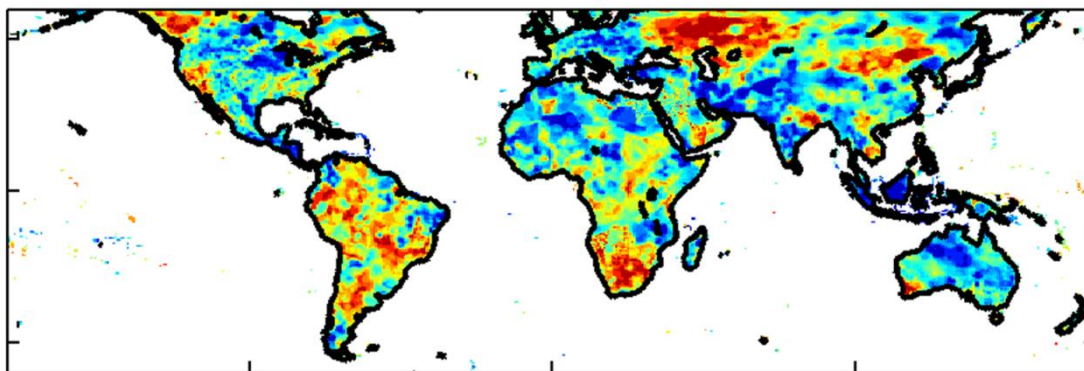




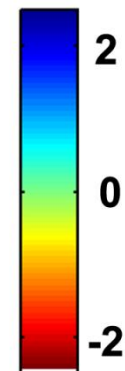
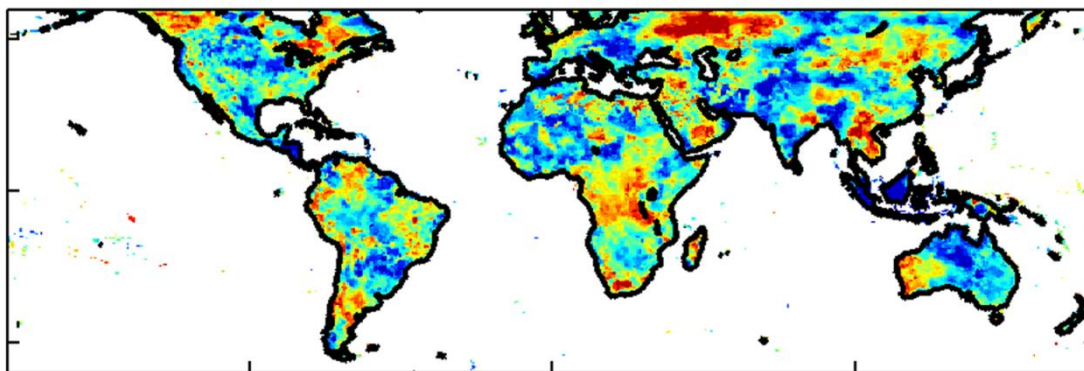
Integration of AIRS Data into GIDMaPS



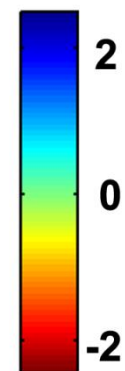
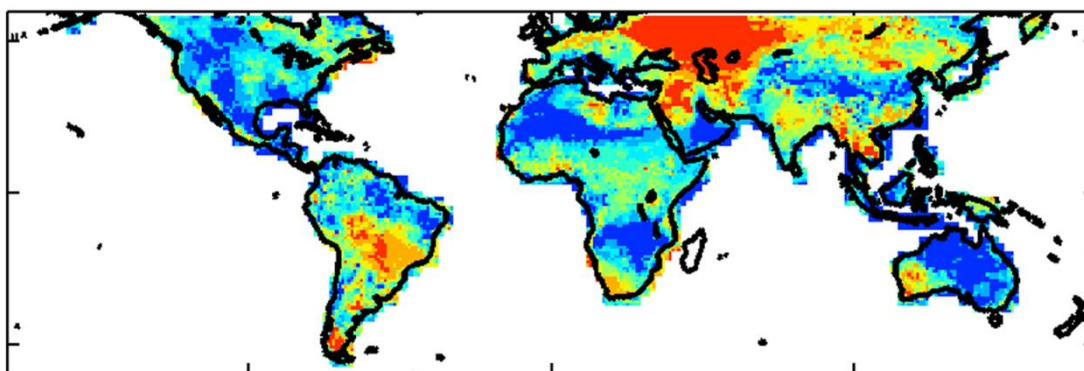
3-month SPI August 2010



3-month SSI August 2010



3-month SRHI August 2010



Precipitation
(MERRA)

Soil Moisture
(MERRA)

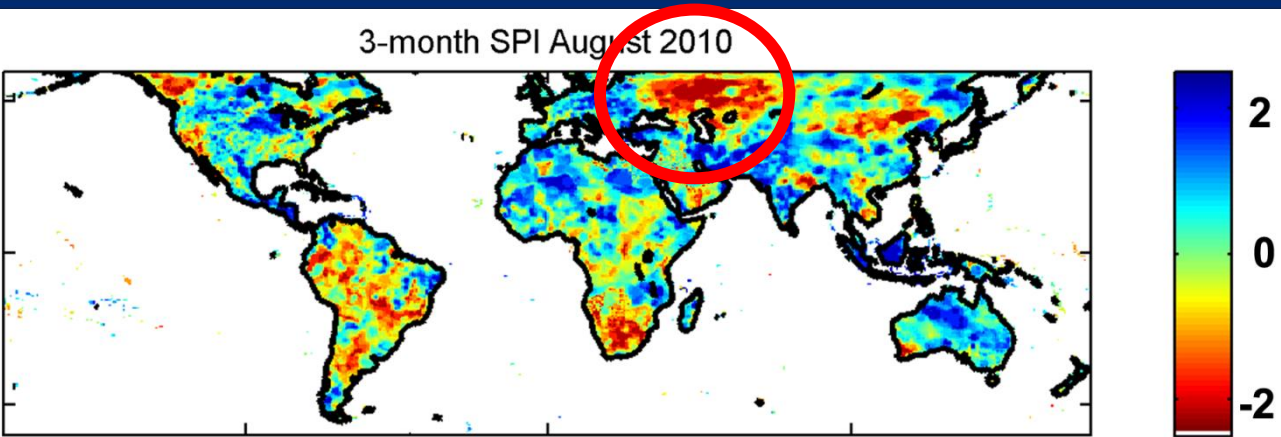
Relative
Humidity
(AIRS Data)



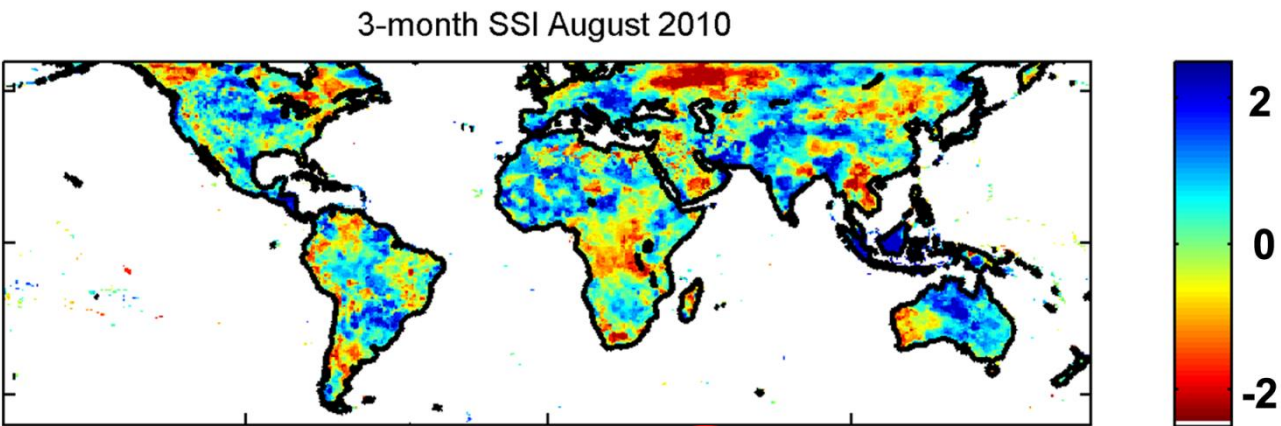
Integration of AIRS Data into GIDMaPS



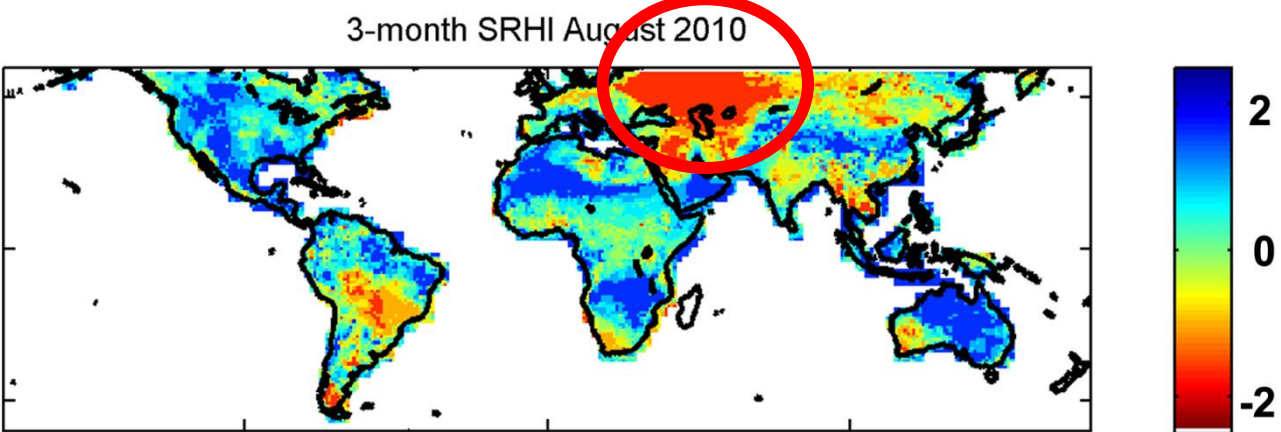
Precipitation
(MERRA)



Soil Moisture
(MERRA)



Relative
Humidity
(AIRS Data)



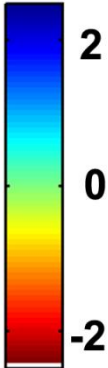
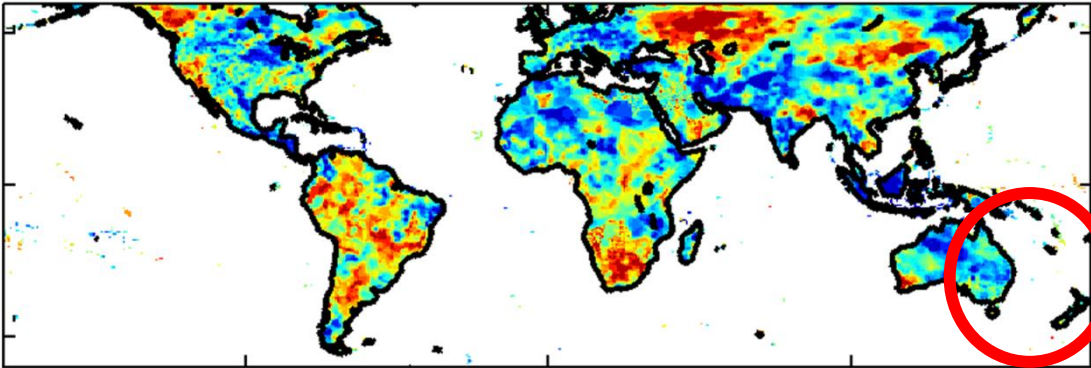


Integration of AIRS Data into GIDMaPS



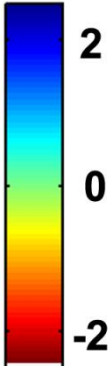
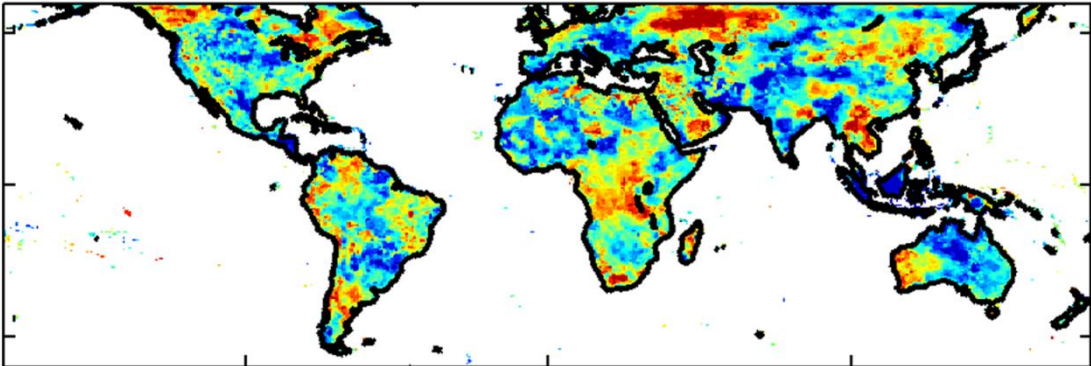
Precipitation
(MERRA)

3-month SPI August 2010



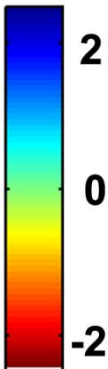
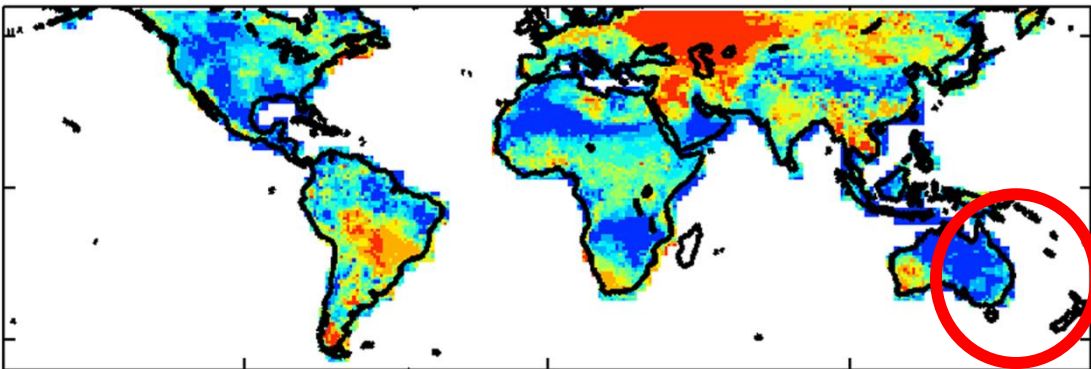
Soil Moisture
(MERRA)

3-month SSI August 2010



Relative
Humidity
(AIRS Data)

3-month SRHI August 2010

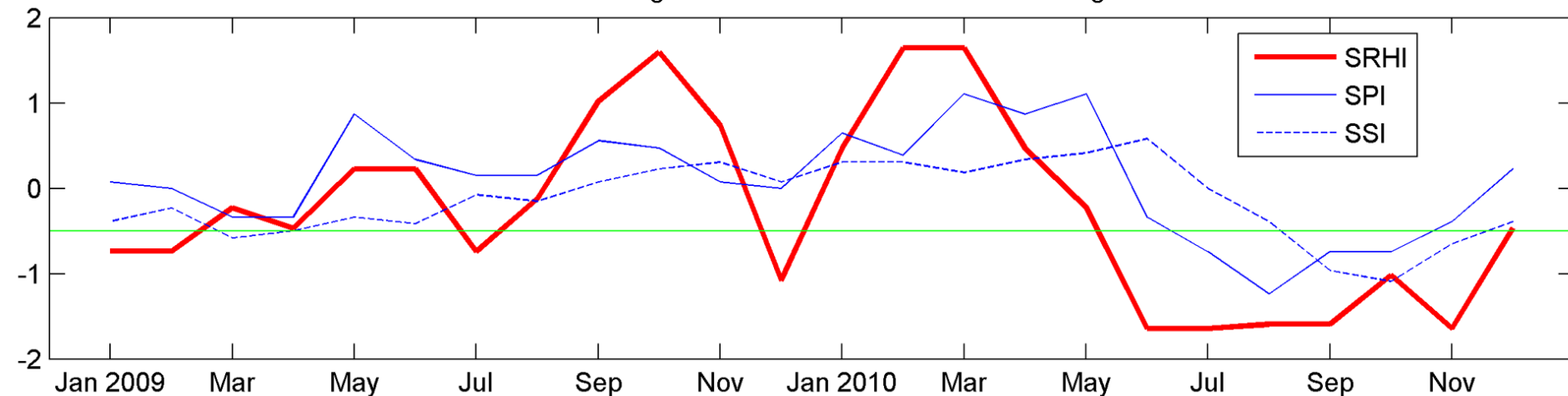




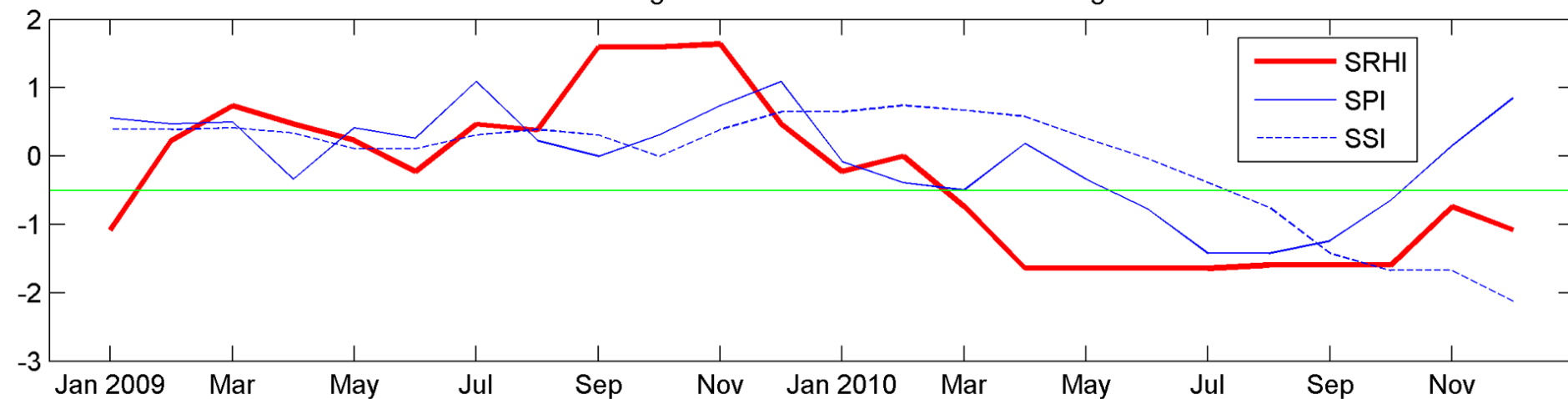
Integration of AIRS Data into GIDMaPS



2010 Russian Drought and Heat Wave Latitude 50 Longitude 70



2010 Russian Drought and Heat Wave Latitude 55 Longitude 36

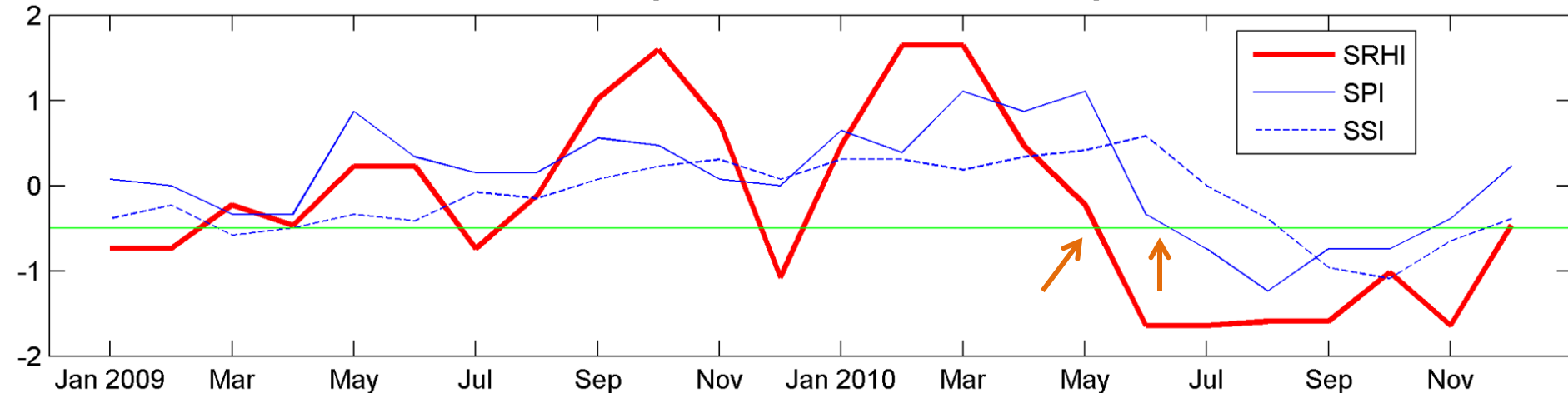




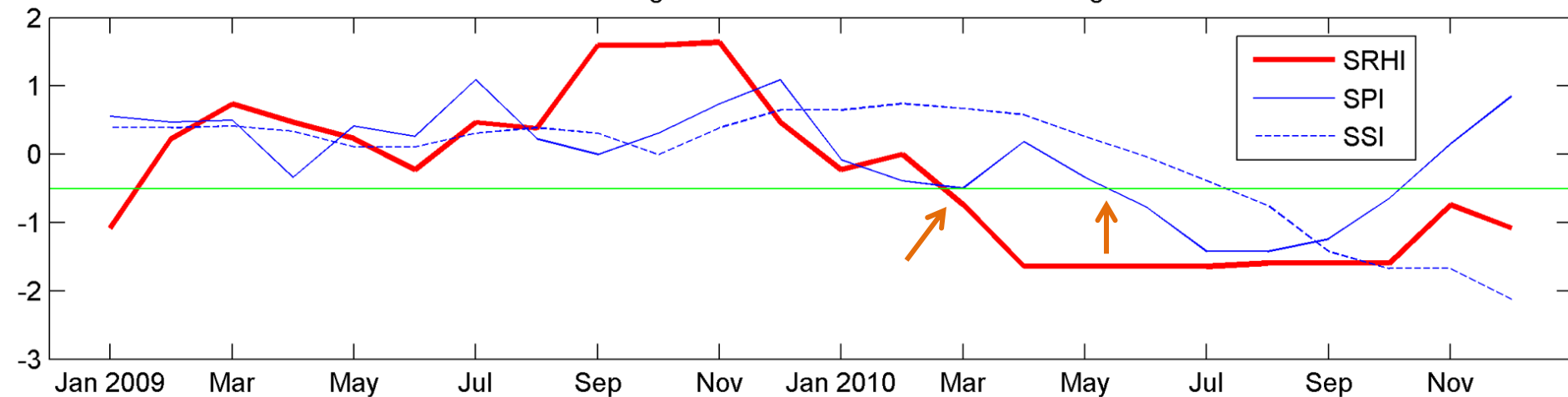
Integration of AIRS Data into GIDMaPS



2010 Russian Drought and Heat Wave Latitude 50 Longitude 70



2010 Russian Drought and Heat Wave Latitude 55 Longitude 36

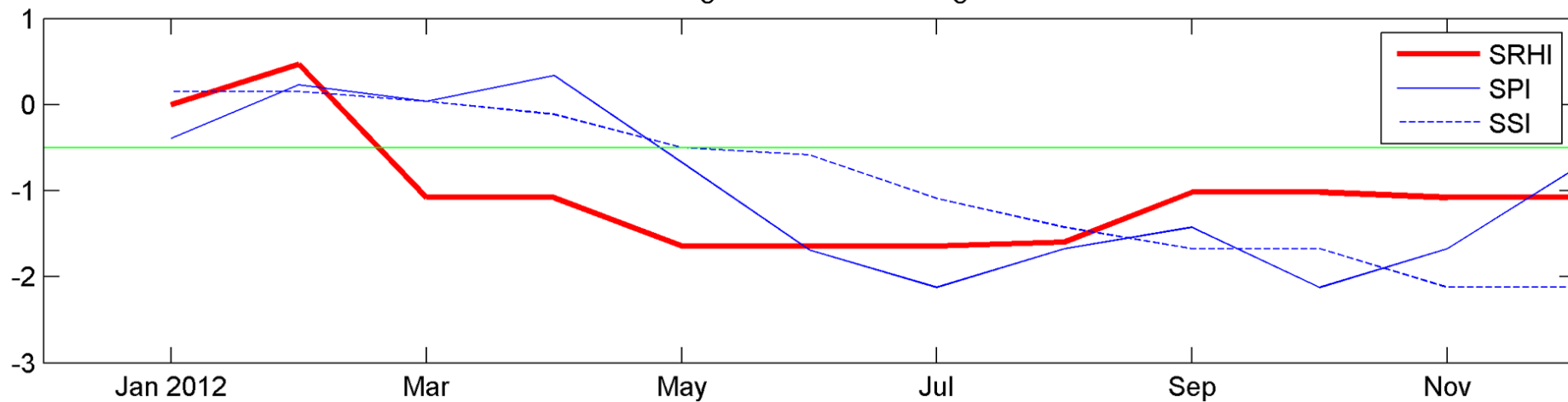




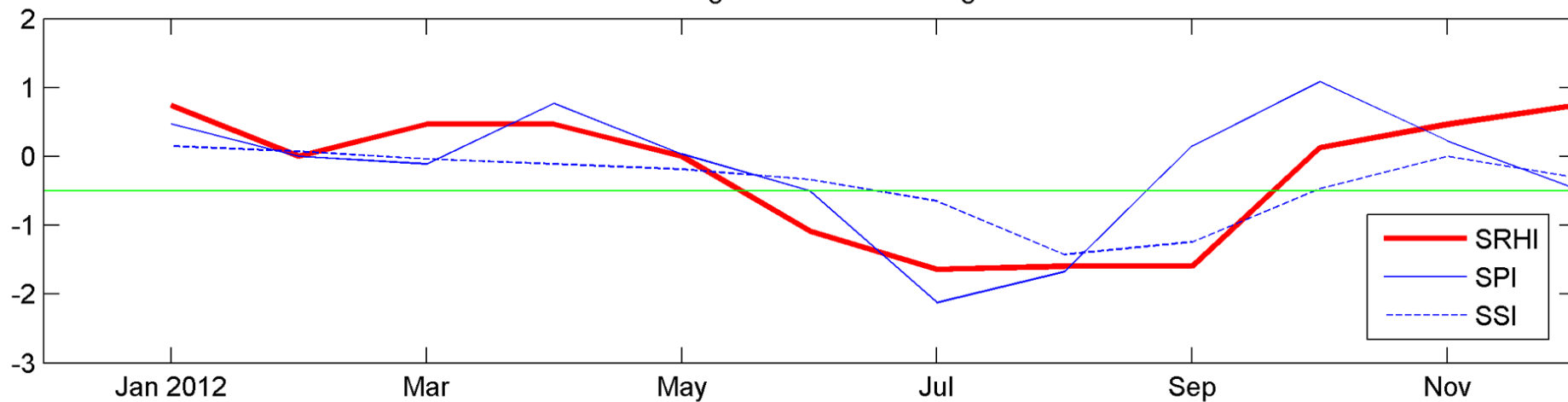
Integration of AIRS Data into GIDMaPS



2012 US Drought Latitude 40 Longitude -100



2012 US Drought Latitude 39 Longitude -90

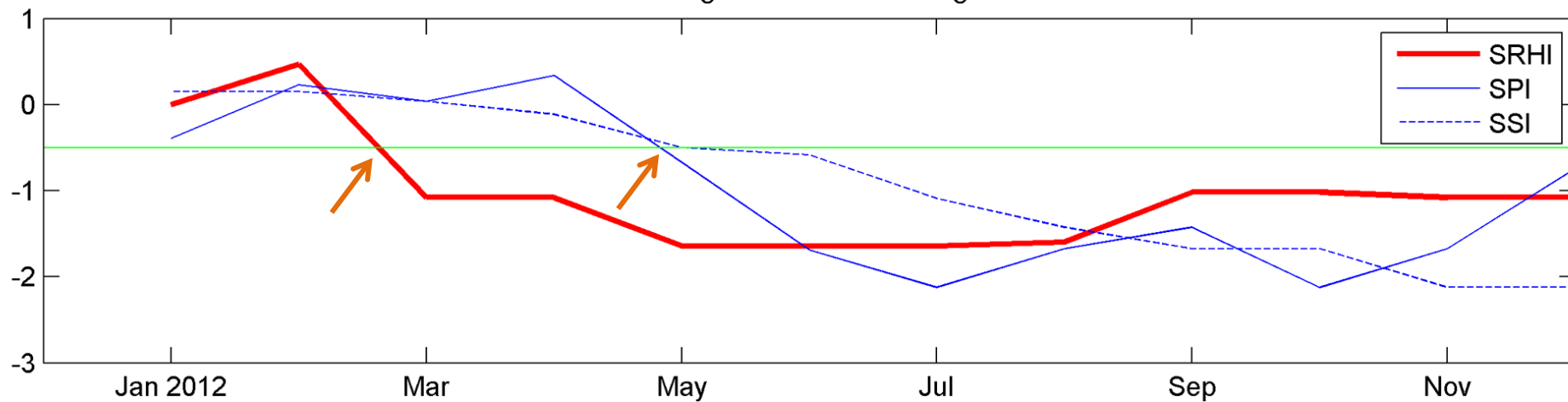




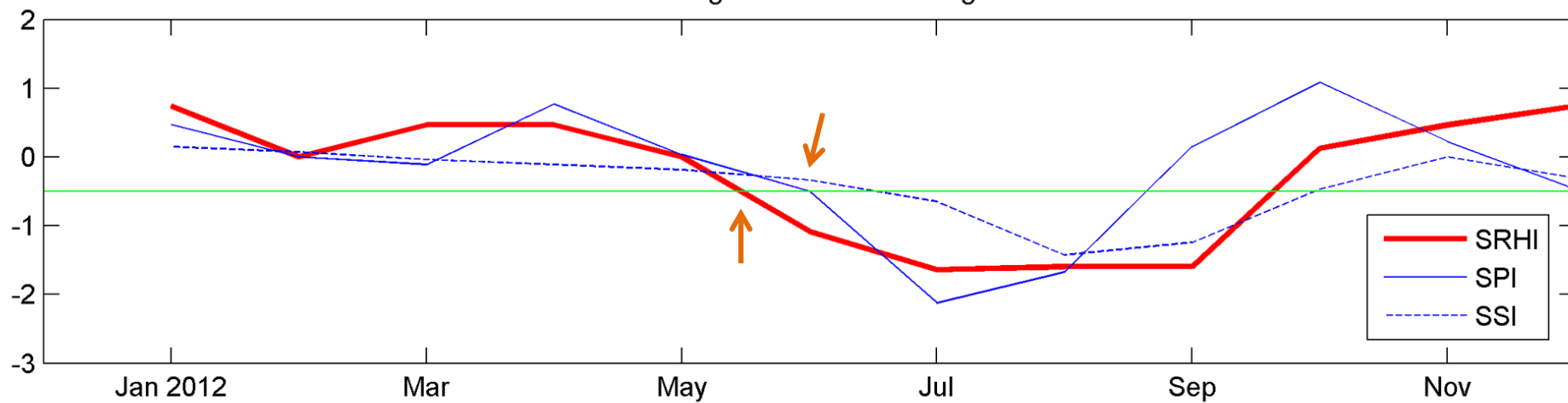
Integration of AIRS Data into GIDMaPS



2012 US Drought Latitude 40 Longitude -100



2012 US Drought Latitude 39 Longitude -90

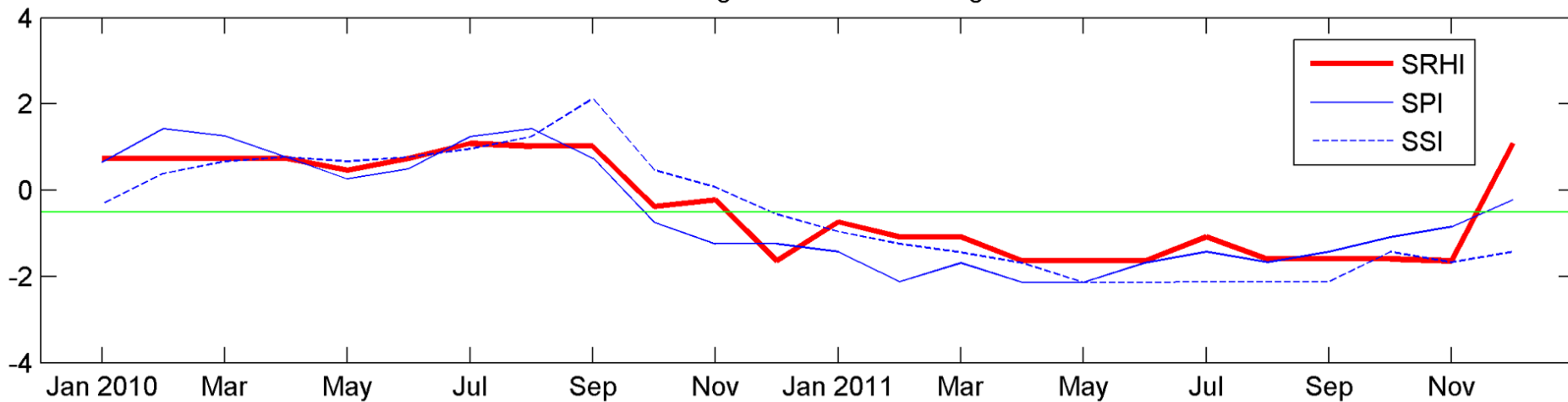




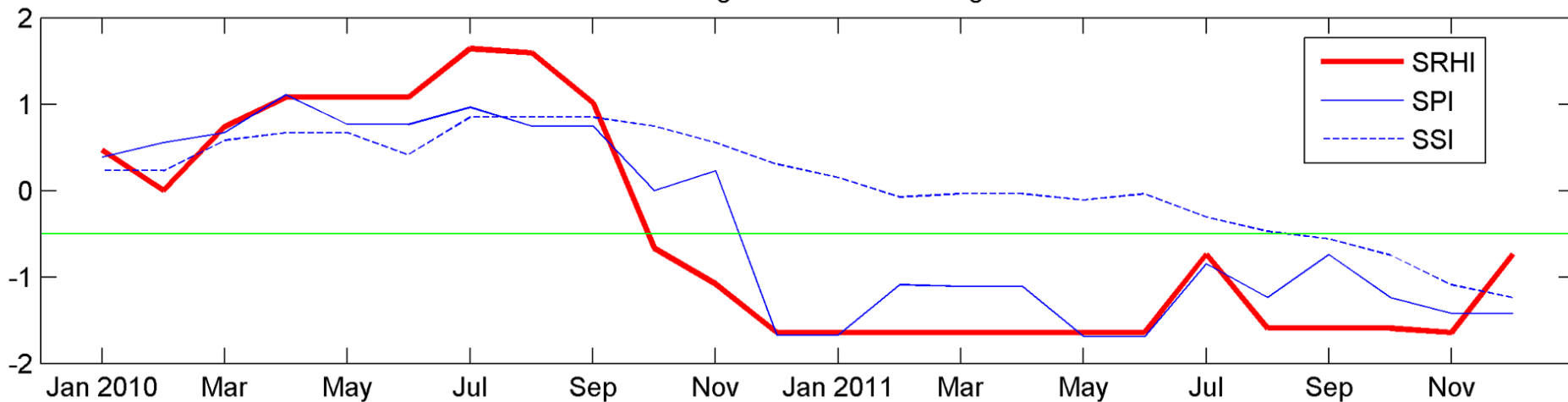
Integration of AIRS Data into GIDMaPS



2011 Texas Drought Latitude 31 Longitude -102



2011 Texas Drought Latitude 26 Longitude -104

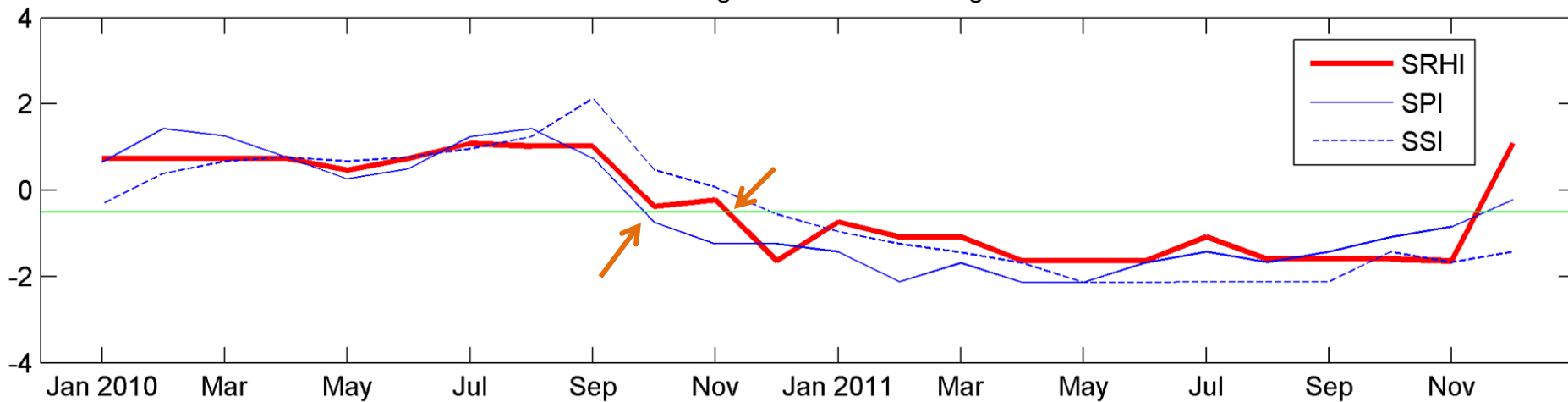




Integration of AIRS Data into GIDMaPS



2011 Texas Drought Latitude 31 Longitude -102



2011 Texas Drought Latitude 26 Longitude -104

