Advancing Global Drought Monitoring and Prediction: Introducing GIDMaPS

Amir AghaKouchak, Alireza Farahmand, Navid Nakhjiri

University of California, Irvine

GIDMaPS: Global Integrated Drought Monitoring and Prediction System

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

Global Integrated Drought Monitoring and Prediction System (GIDMaPS)

Map | Layers

- Drought Monitoring
- Seasonal Prediction

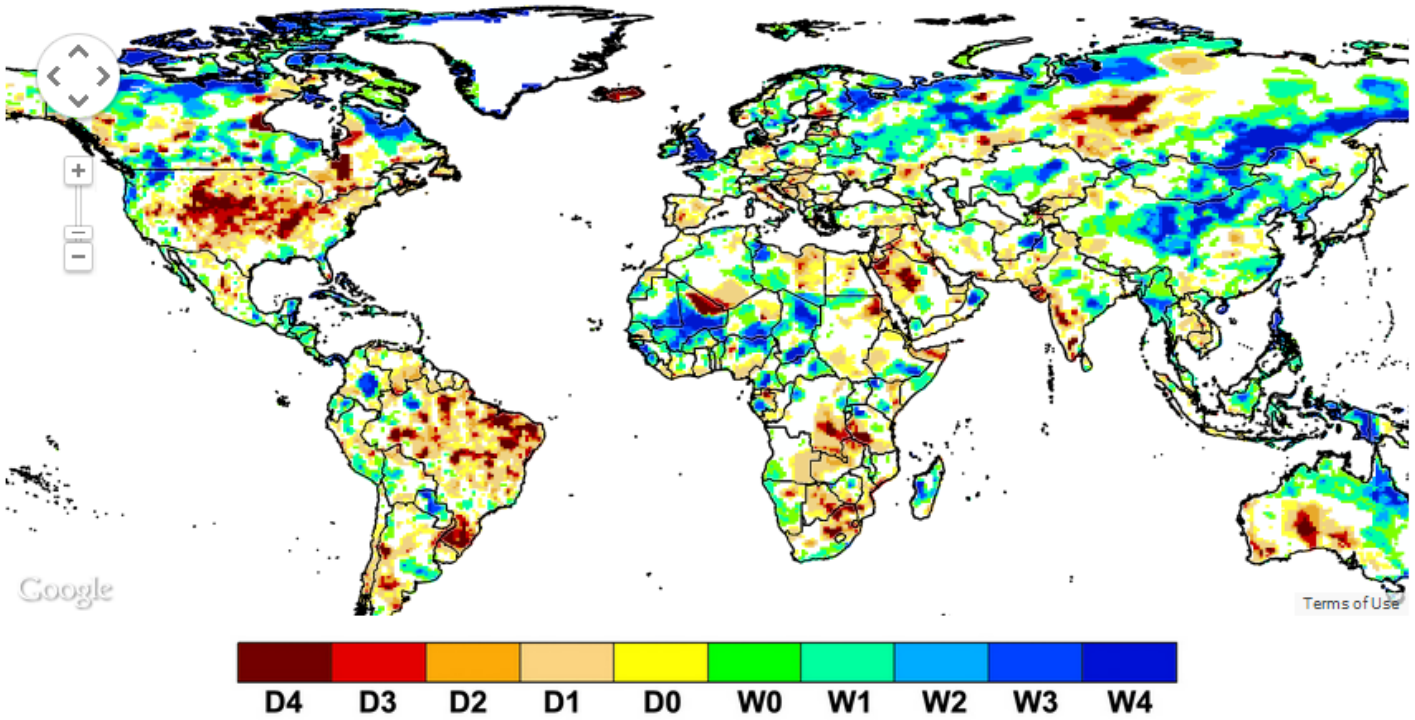
Data Set: MERRA

Year: 2012

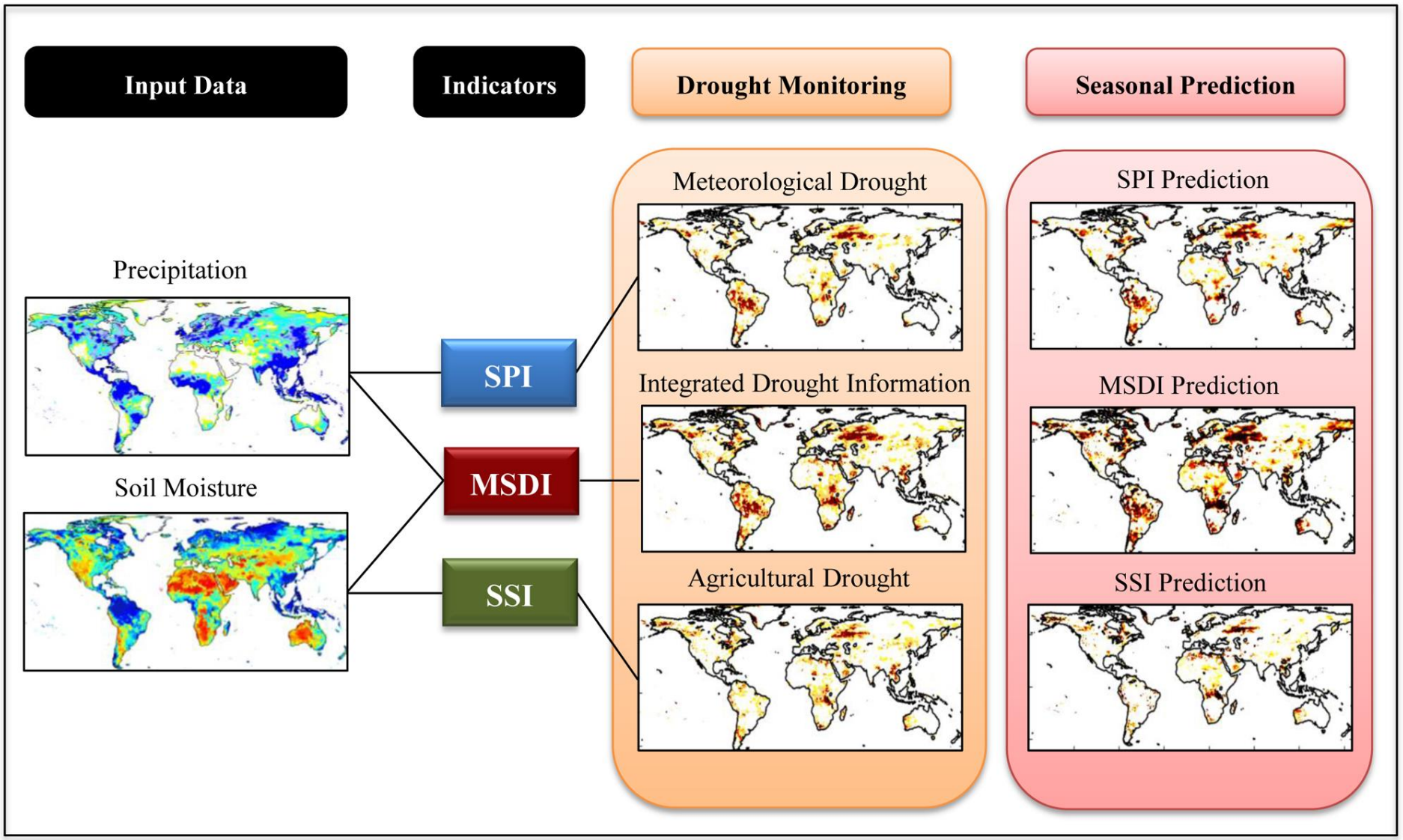
Month: August

Index: SPI

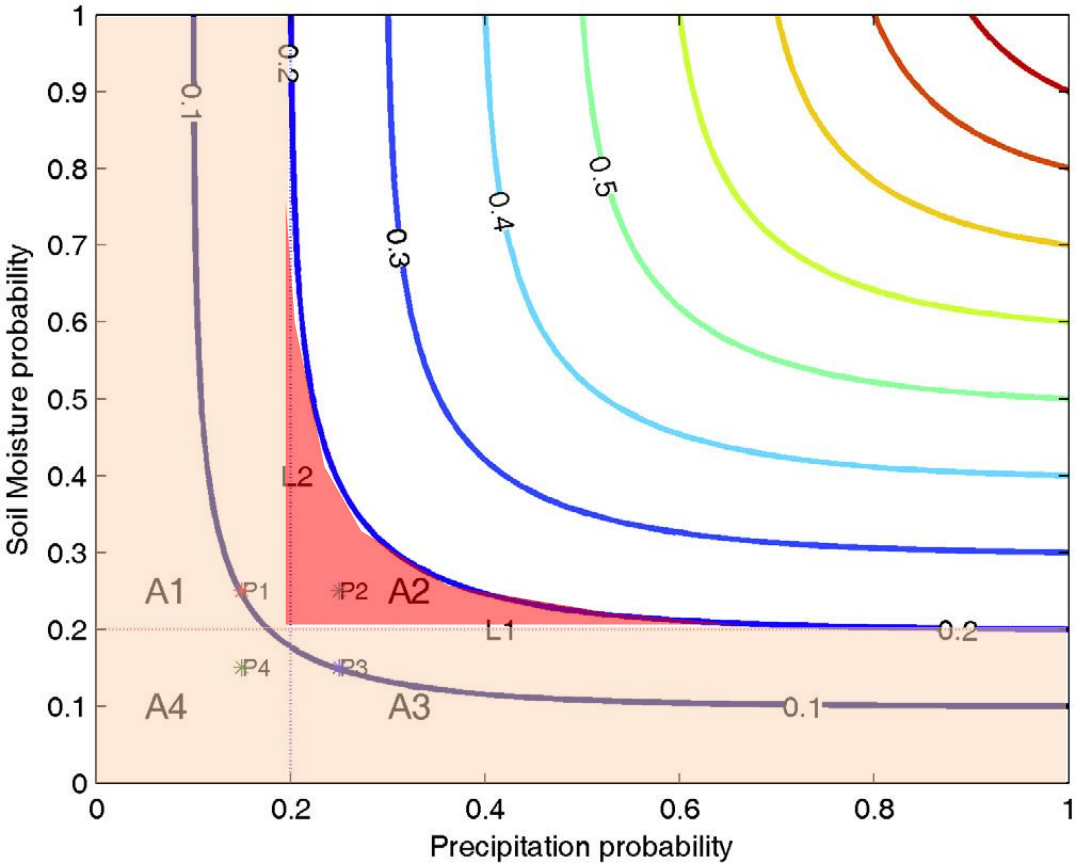
Load | Download Image



GIDMaPS: Global Integrated Drought Monitoring and Prediction System



Multi-Index Drought Monitoring



Standardized Precipitation Index (SPI)

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

Standardized Soil moisture Index (SSI)

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

Multivariate Standardized Drought Index (MSDI)

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

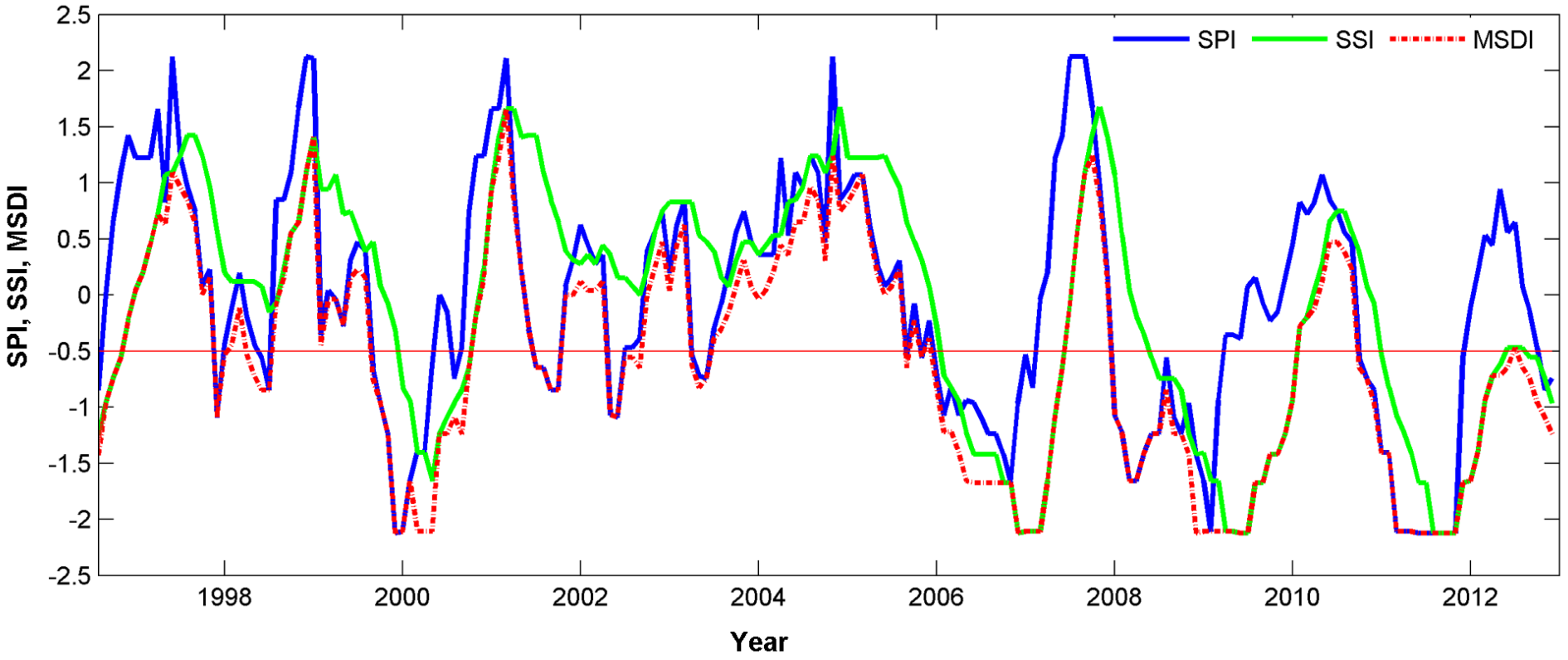
$$MSDI = \phi^{-1}(p_{MSDI})$$

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

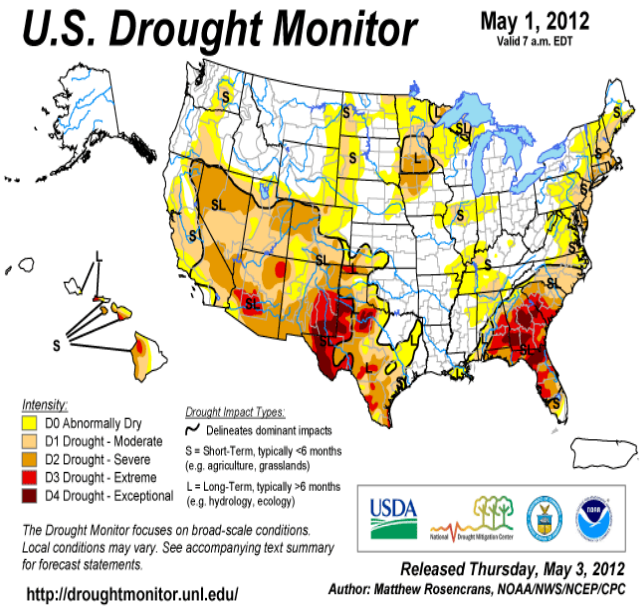
Multi-Index Drought Monitoring



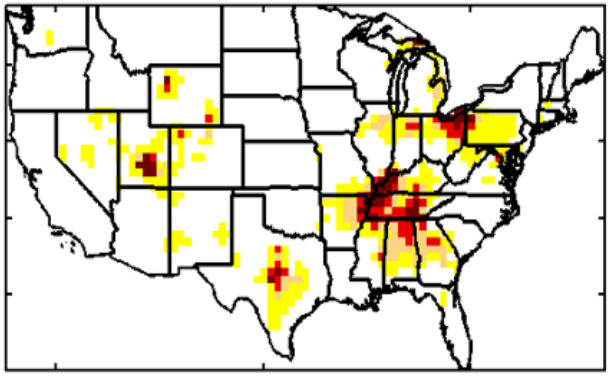
Sample time series of the 6-month SPI, SSI and MSDI for a grid cell in Texas (Location: longitude 100 W and latitude 30 N).

Multi-Index Drought Monitoring

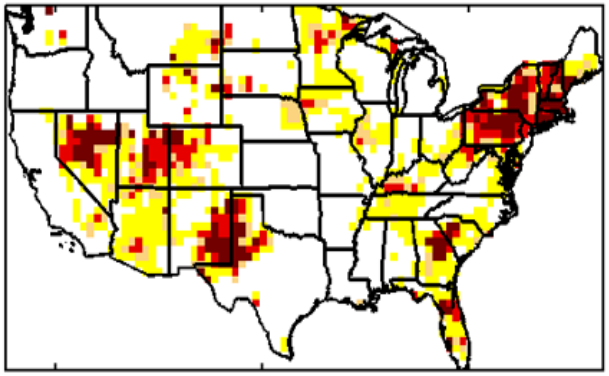
SPI and SSI Derived Using NASA MERRA-LAND Precipitation and soil moisture Data.



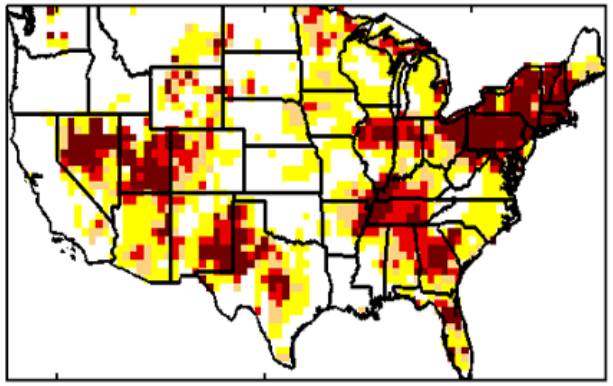
SPI, Apr 2012



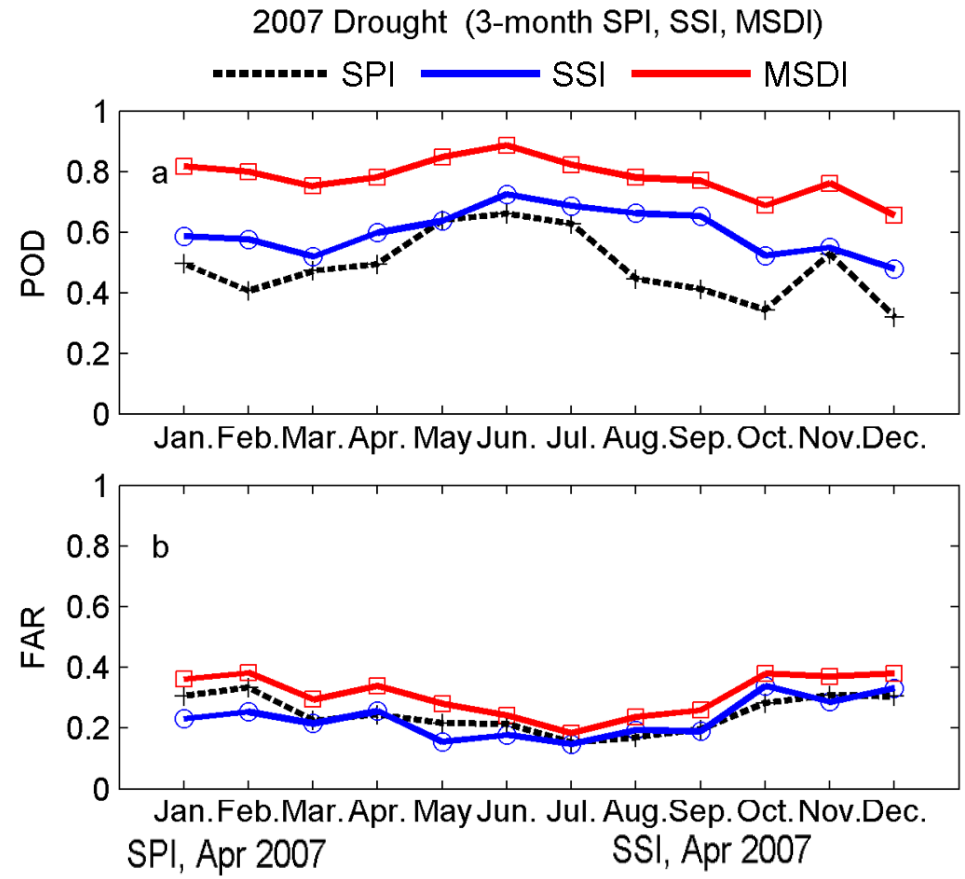
SSI, Apr 2012

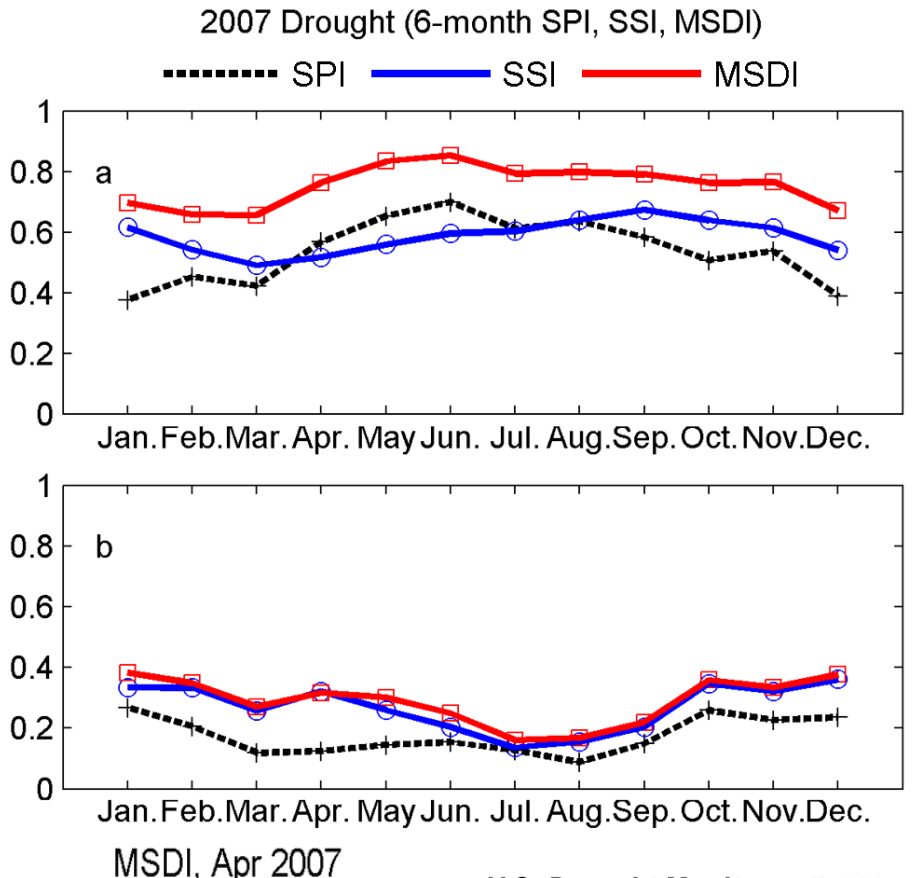


MSDI, Apr 2012

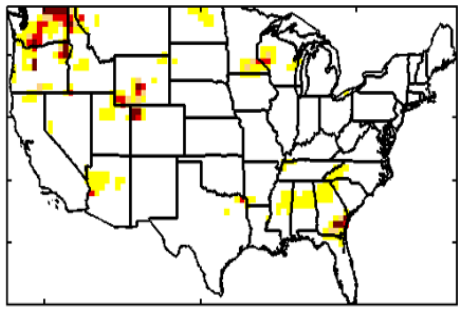


Multi-Index Drought Monitoring

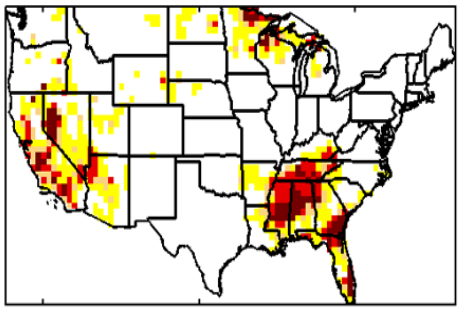




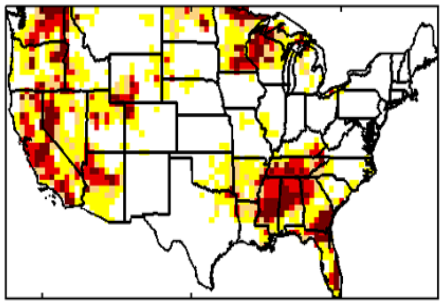
SPI, Apr 2007

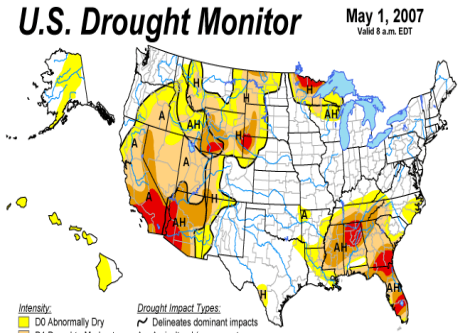


SSI, Apr 2007



MSDI, Apr 2007

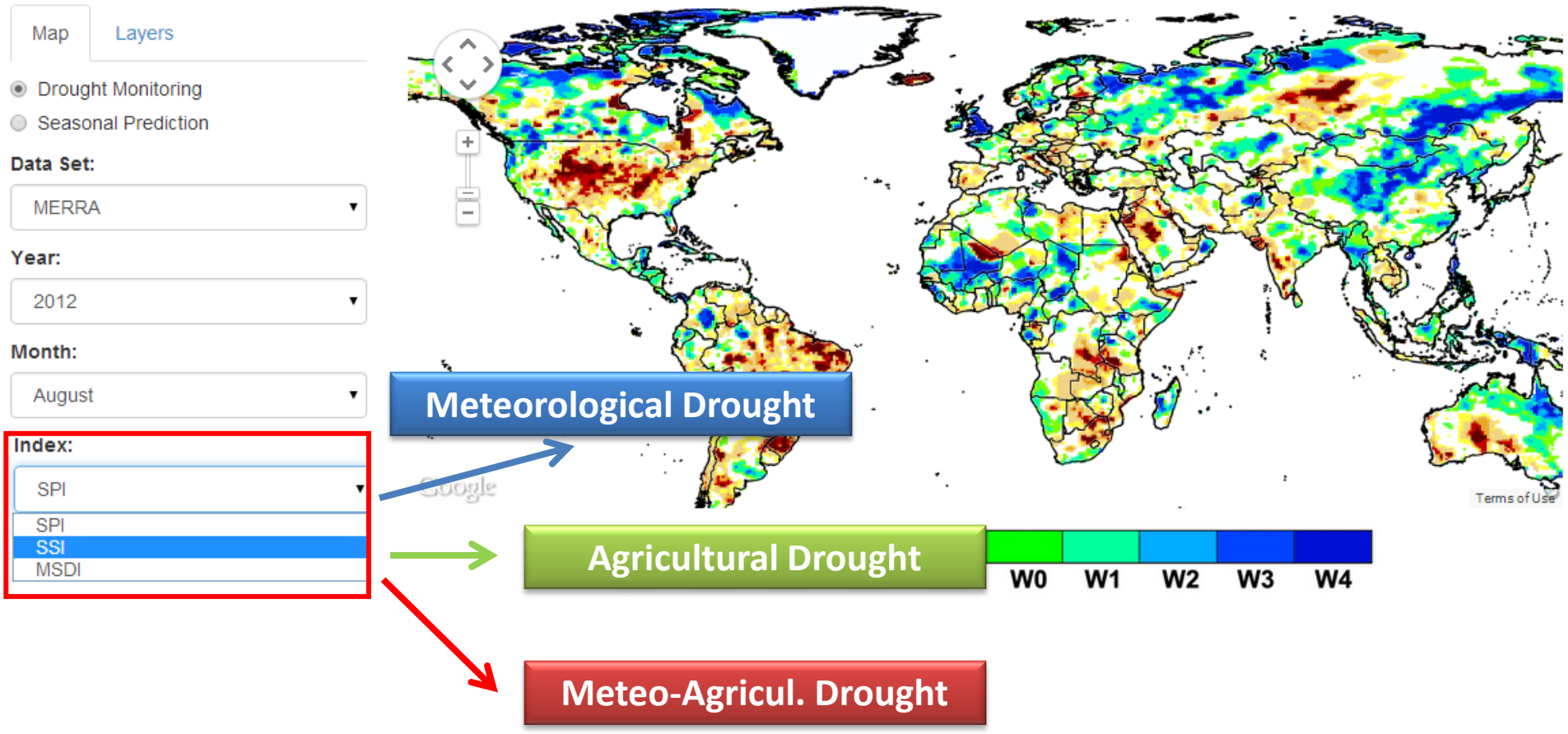




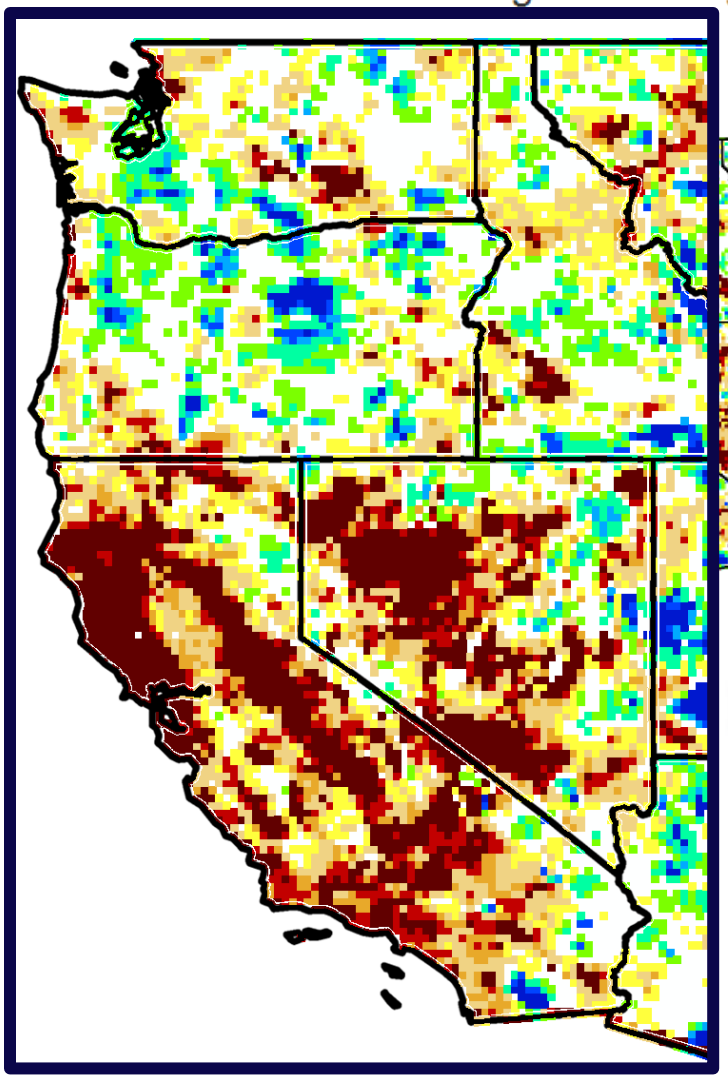
GIDMaPS: Global Integrated Drought Monitoring and Prediction System

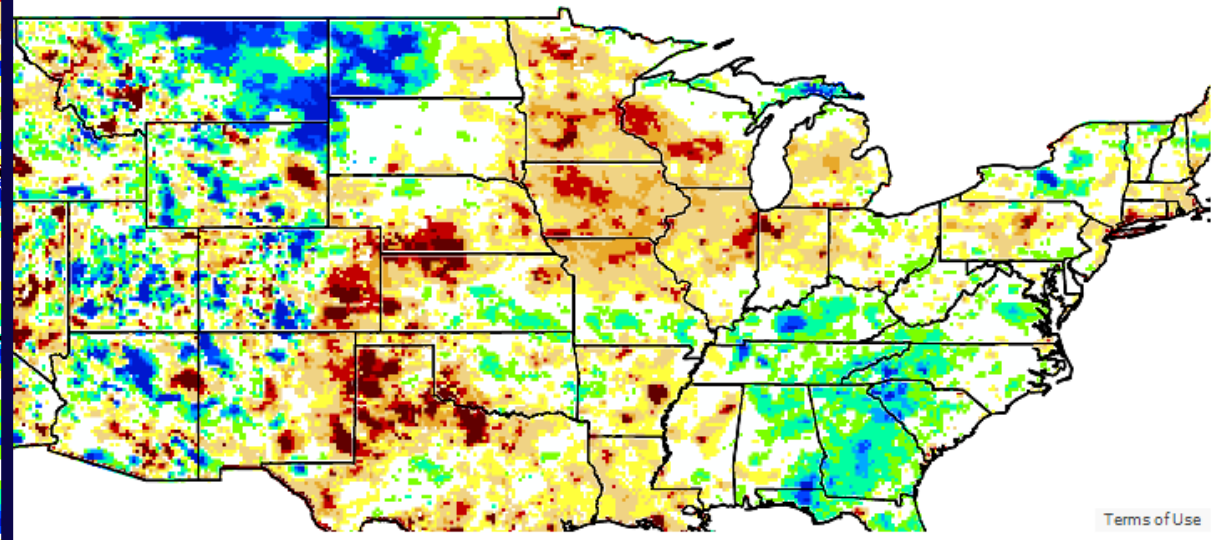
http://drought.eng.uci.edu/

Global Integrated Drought Monitoring and Prediction System (GIDMaPS)



Global Integrated Drought Monitoring and Prediction System (GIDMaPS)





GIDMaPS: Global Integrated Drought Monitoring and Prediction System

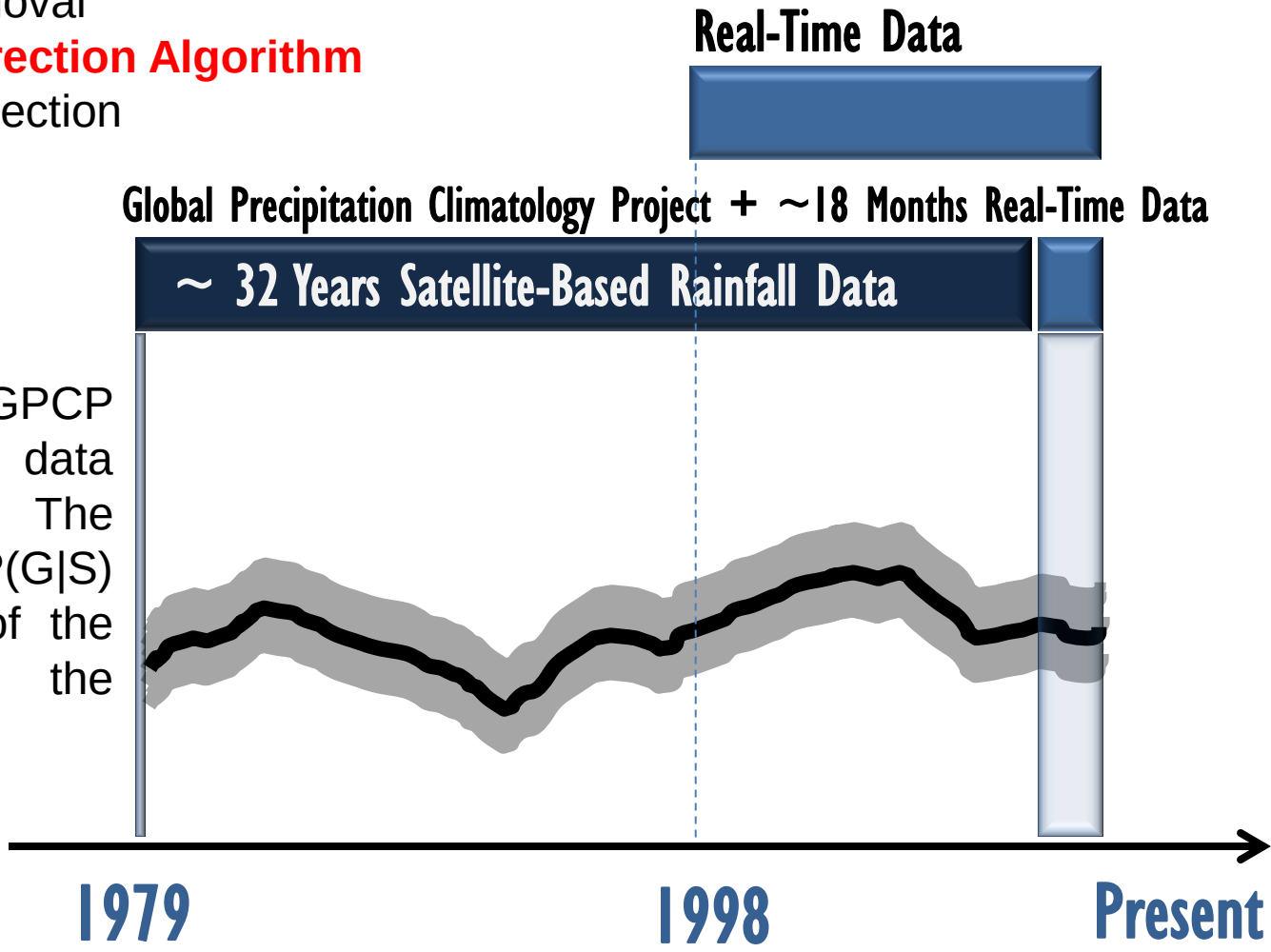
Input Data Set	ID	Source	Resolution
NASA Modern-Era Retrospective analysis for Research and Applications – Reichle et al., 2011 - Precipitation and Soil Moisture	MERRA	NASA	2/3°x 1/2°
North American Land Data Assimilation System - Kumar et al., 2006 - Precipitation and Soil Moisture	NLDAS	NASA	0.125 ^{o}
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^{o}
Global Land Data Assimilation System (GLDAS) - Peters-Lidard et al., 2007 - Precipitation and Soil Moisture	GLDAS	NASA	1^{o}

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.

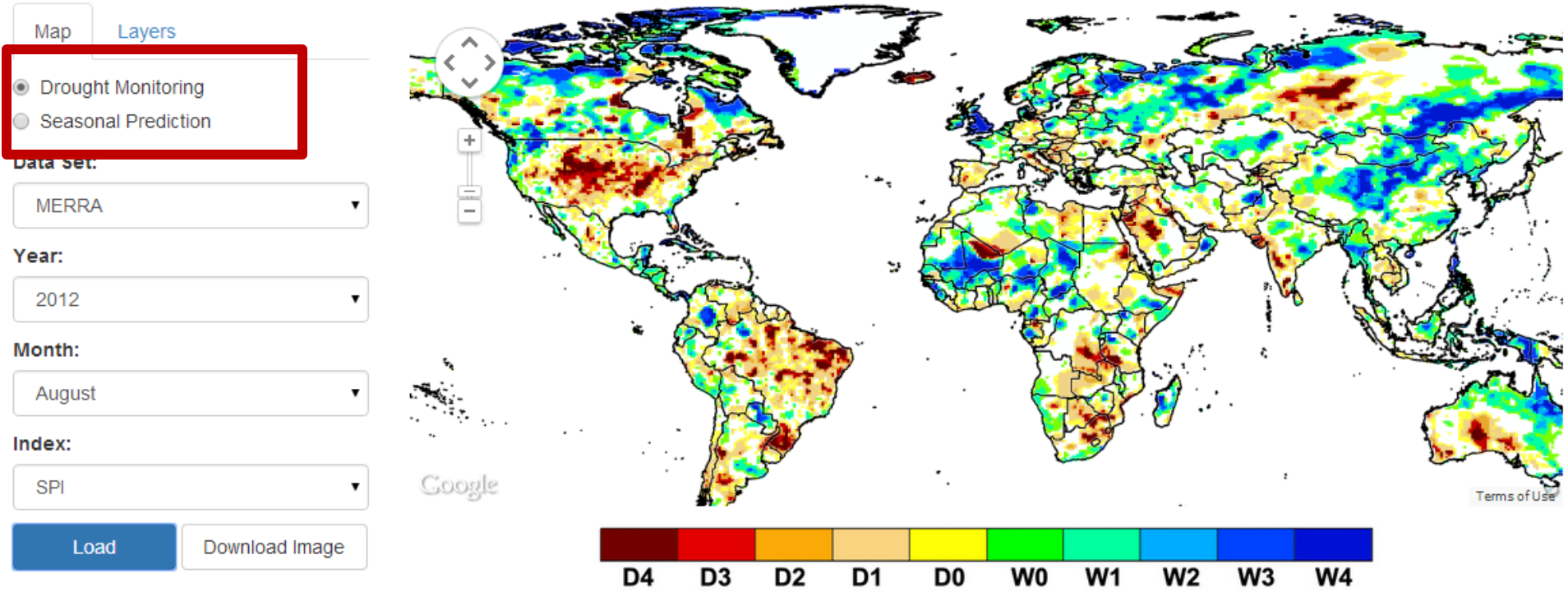


AghaKouchak A., and Nakhjiri N., 2012, A Near Real-Time Satellite-Based Global Drought Climate Data Record, Environmental Research Letters, 7(4), 044037, doi:10.1088/1748-9326/7/4/044037.

GIDMaPS: Global Integrated Drought Monitoring and Prediction System

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

Global Integrated Drought Monitoring and Prediction System (GIDMaPS)



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

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

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

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

$$SSI^{(i)} = P(AS \le AS^{(i)}_{n+1,\,m}) \qquad SPI^{(i)} = P(AP \le AP^{(i)}_{n+1,\,m})$$

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

GIDMaPS: Global Integrated Drought Monitoring and Prediction System

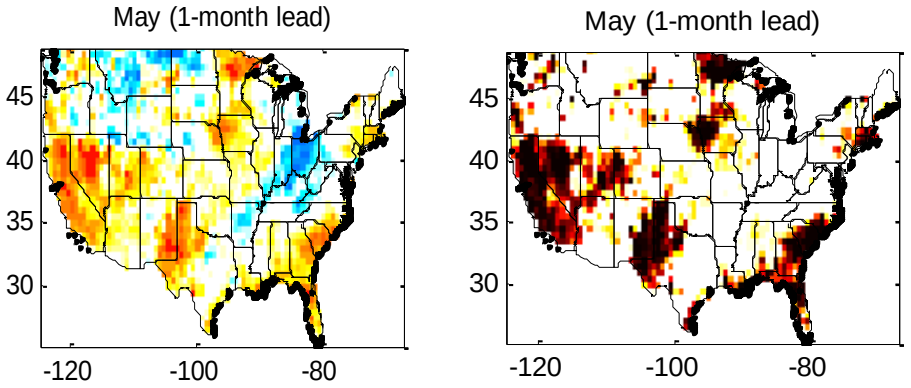
Prediction component is based on a drought persistence model which requires historical observations. The seasonal drought prediction component is based on two input data sets (MERRA and NLDAS) and three drought indicators (SPI, SSI and MSDI).

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

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

.....

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



Standardized Relative Humidity Index (SRHI) based on AIRS Data

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

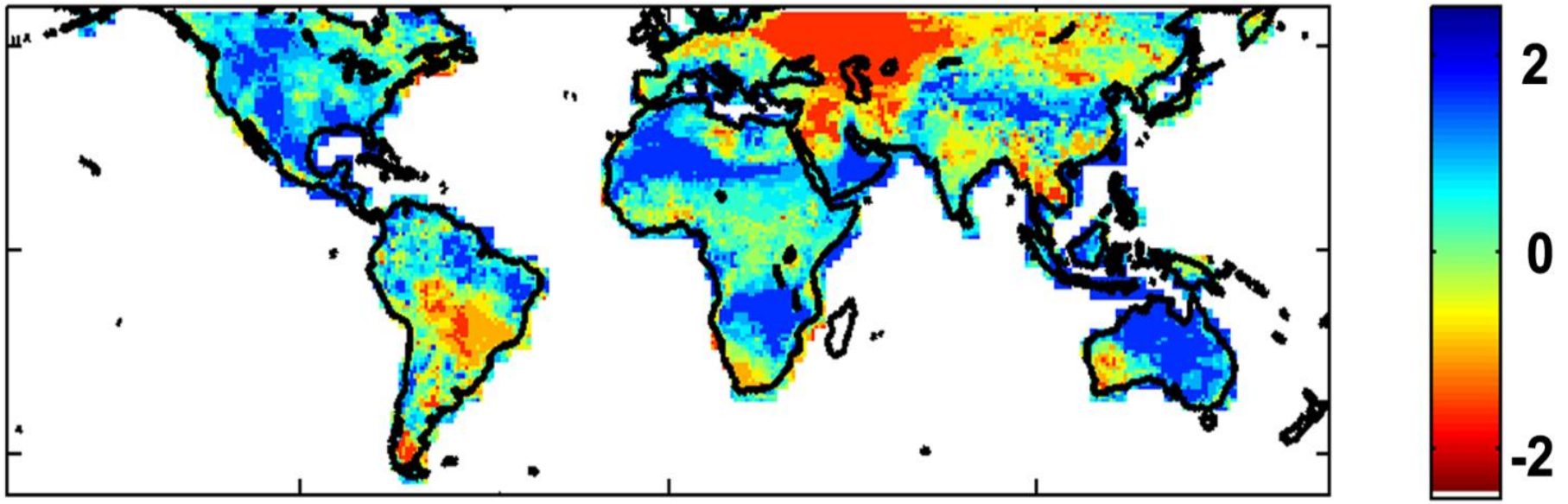
$$SRHI = \Phi^{-1}(p(RH_i))$$

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

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

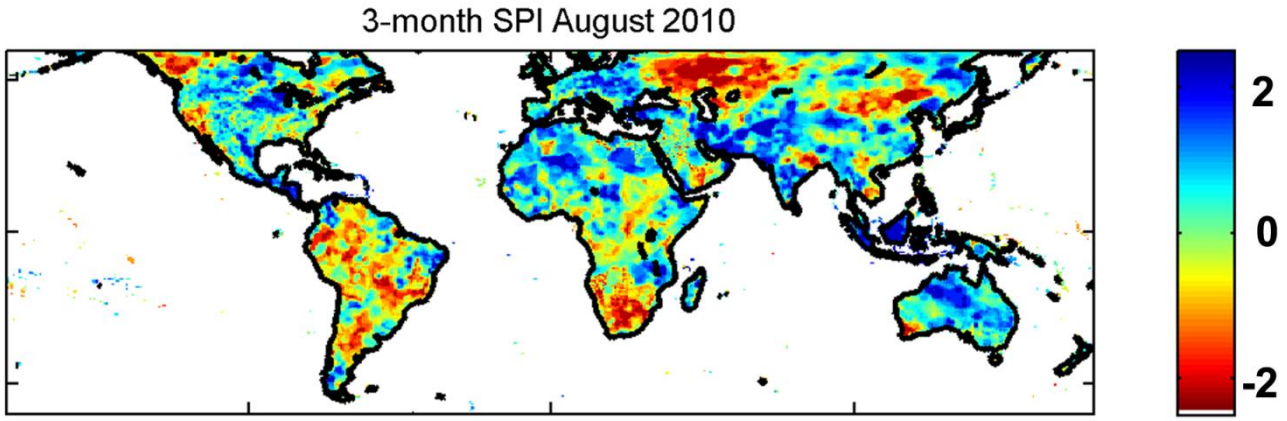
$$t = \begin{cases} \sqrt{\ln \frac{1}{p(RH_i)^2}} & \text{if } 0 < p(RH_i) \leq 0.5 \\ \sqrt{\ln \frac{1}{(1 - p(RH_i))^2}} & \text{if } 0.5 < p(RH_i) \leq 1 \end{cases}$$

3-month SRHI August 2010

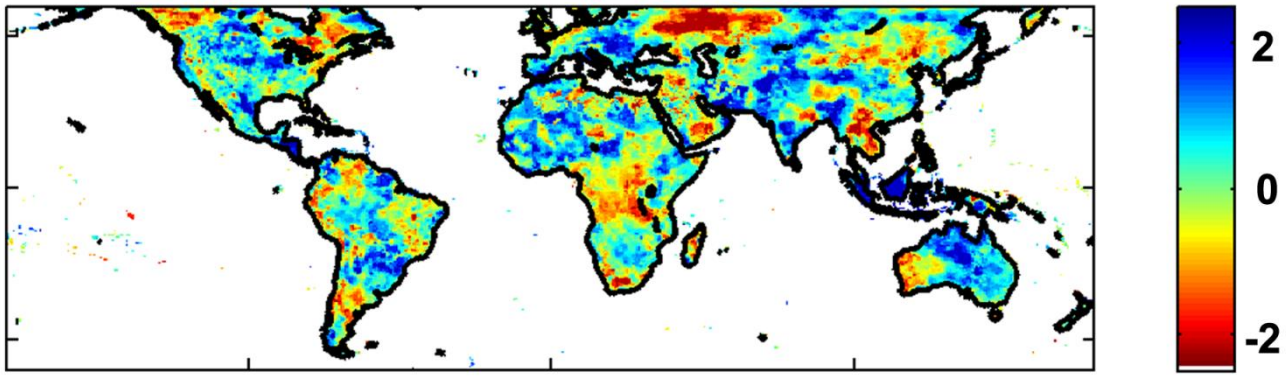


Integration of AIRS Data into GIDMaPS

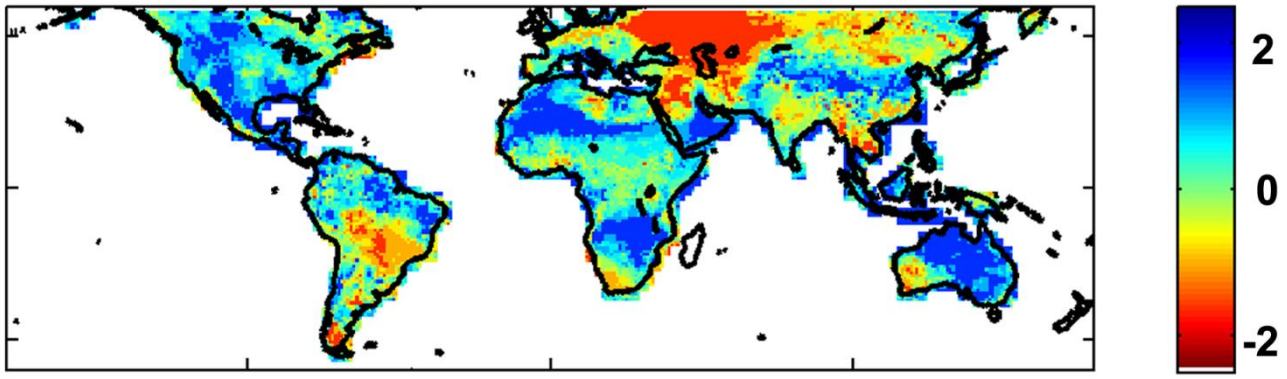
Precipitation (MERRA)



Soil Moisture (MERRA)

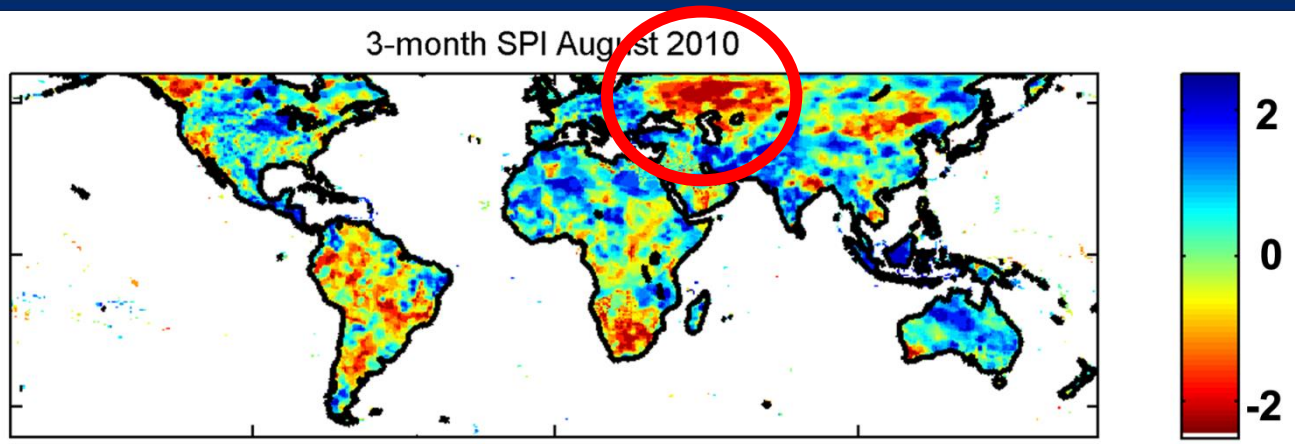


Relative Humidity (AIRS Data)

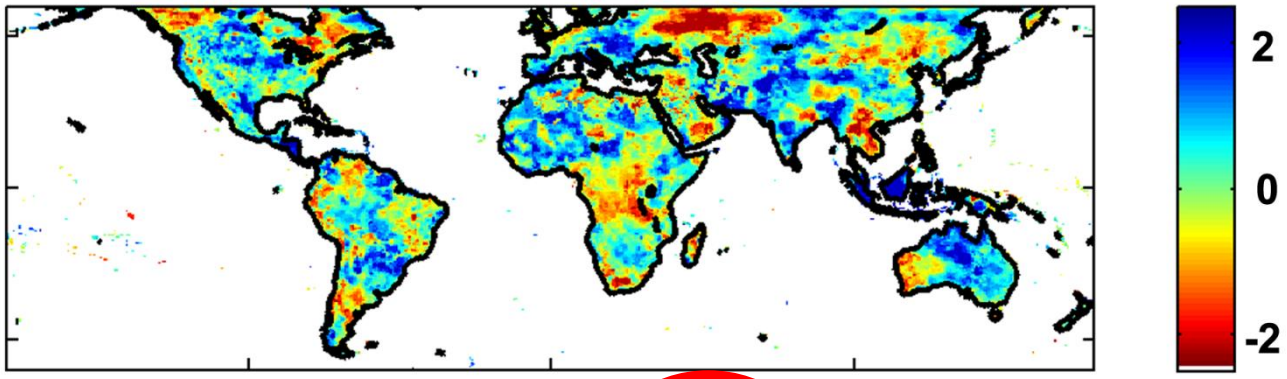


Integration of AIRS Data into GIDMaPS

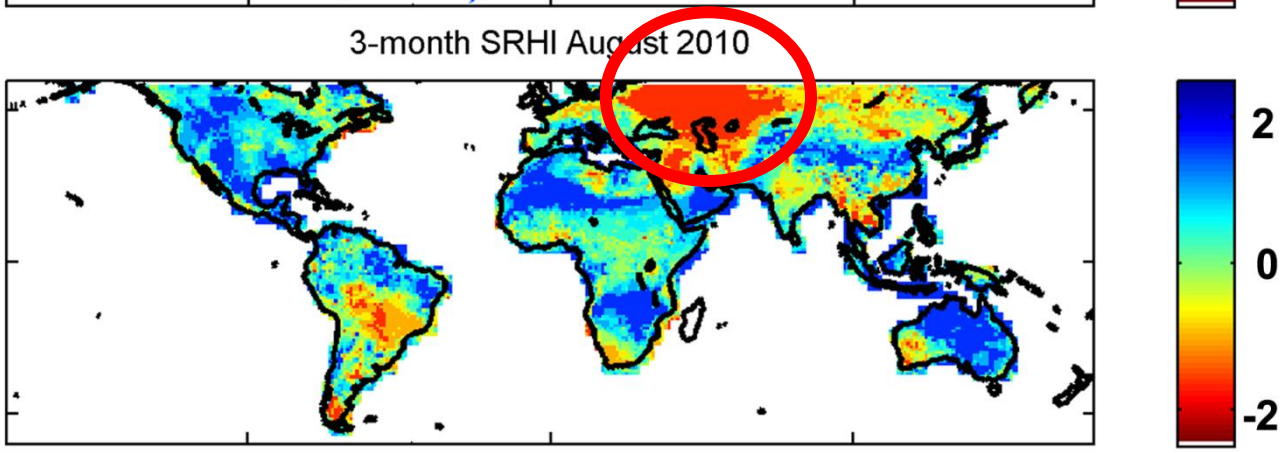
Precipitation (MERRA)



Soil Moisture (MERRA)

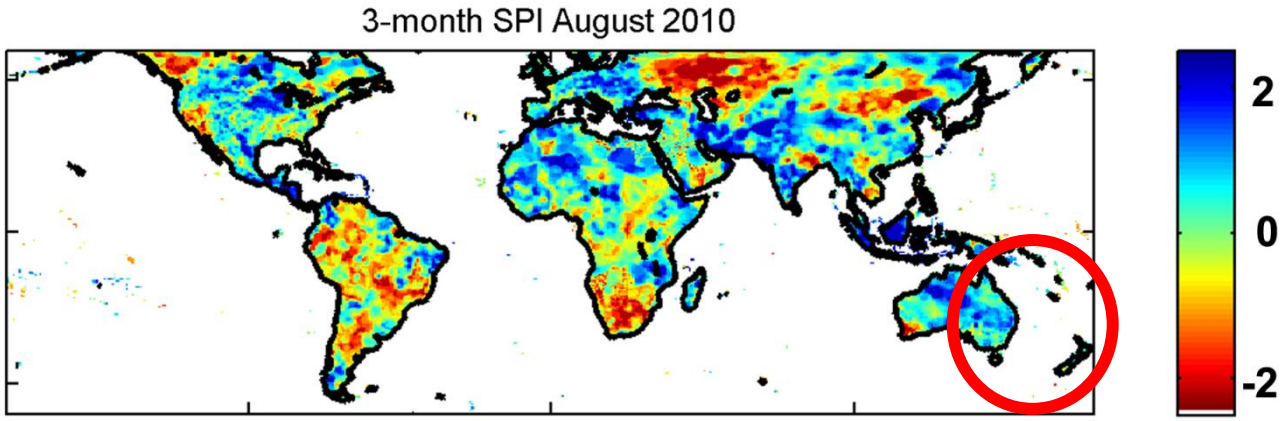


Relative Humidity (AIRS Data)

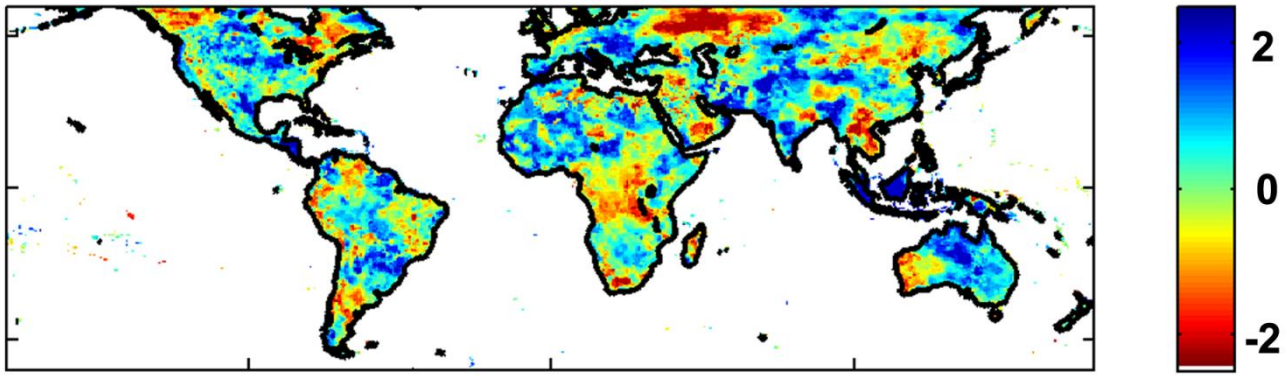


Integration of AIRS Data into GIDMaPS

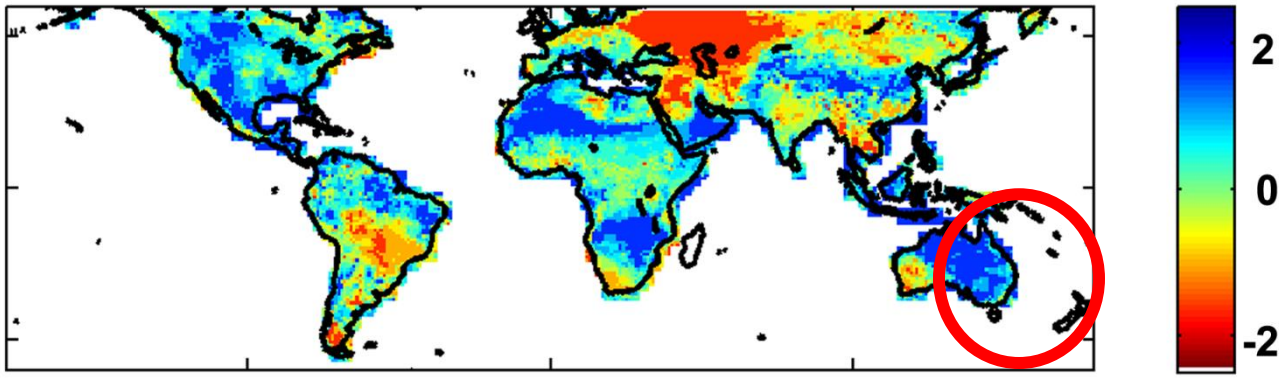
Precipitation (MERRA)



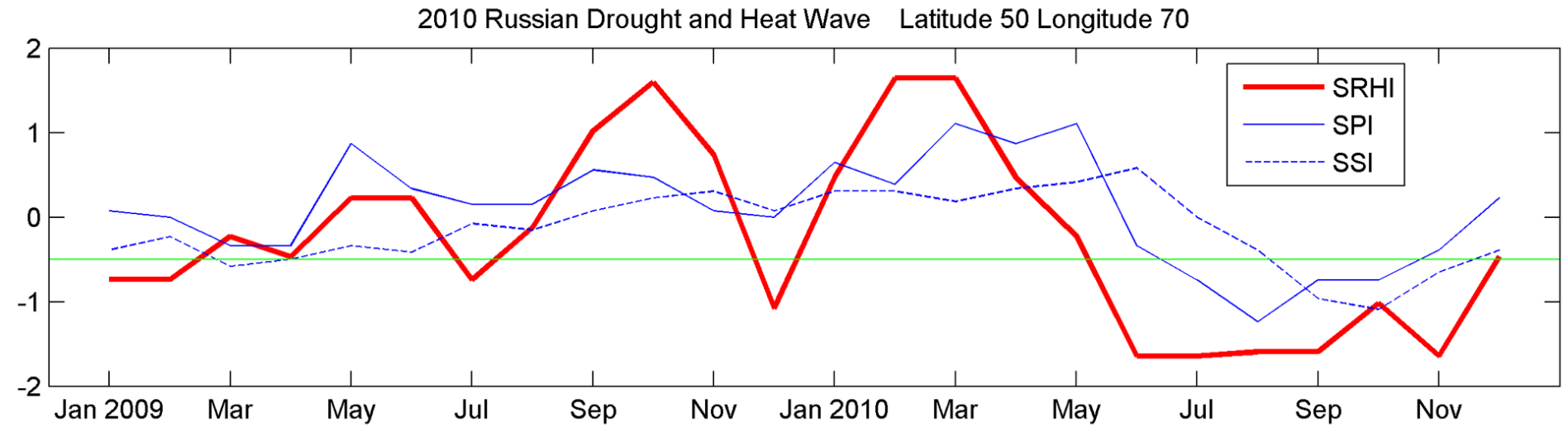
Soil Moisture (MERRA)

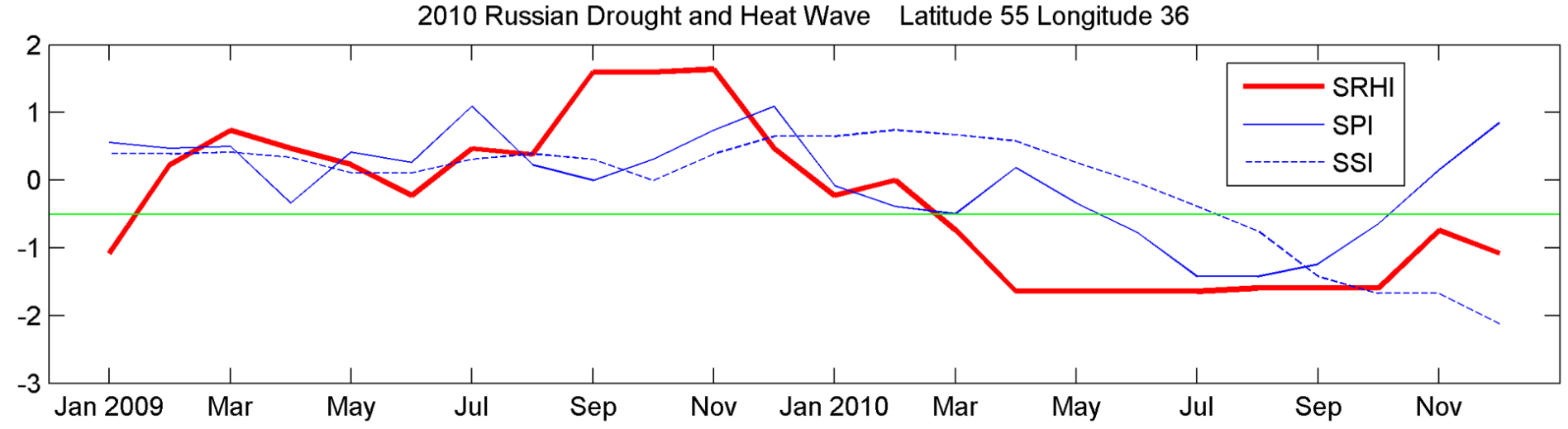


Relative Humidity (AIRS Data)

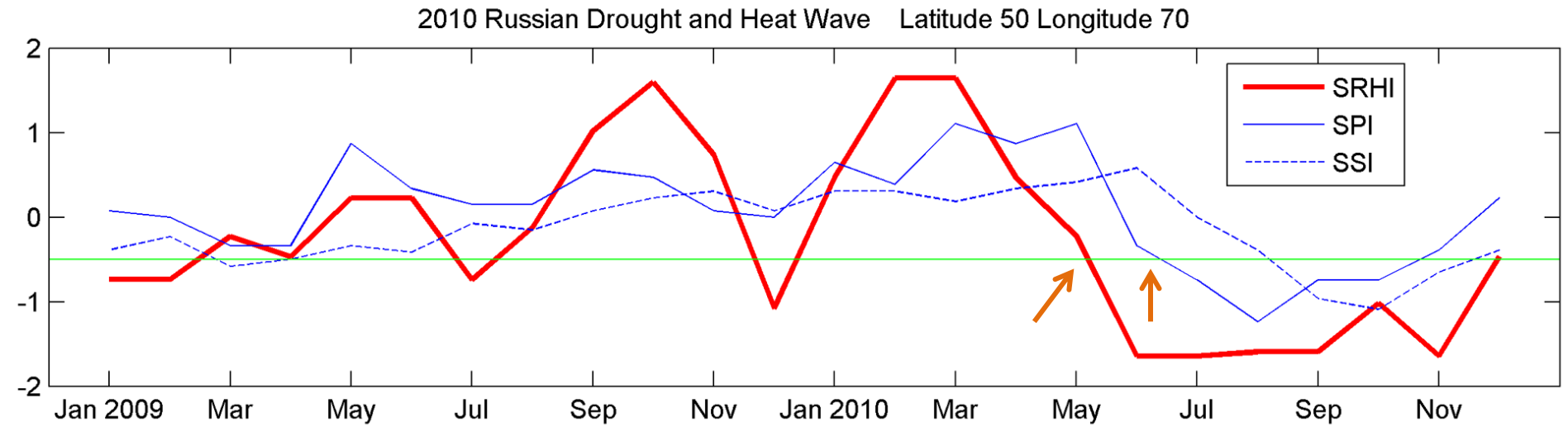


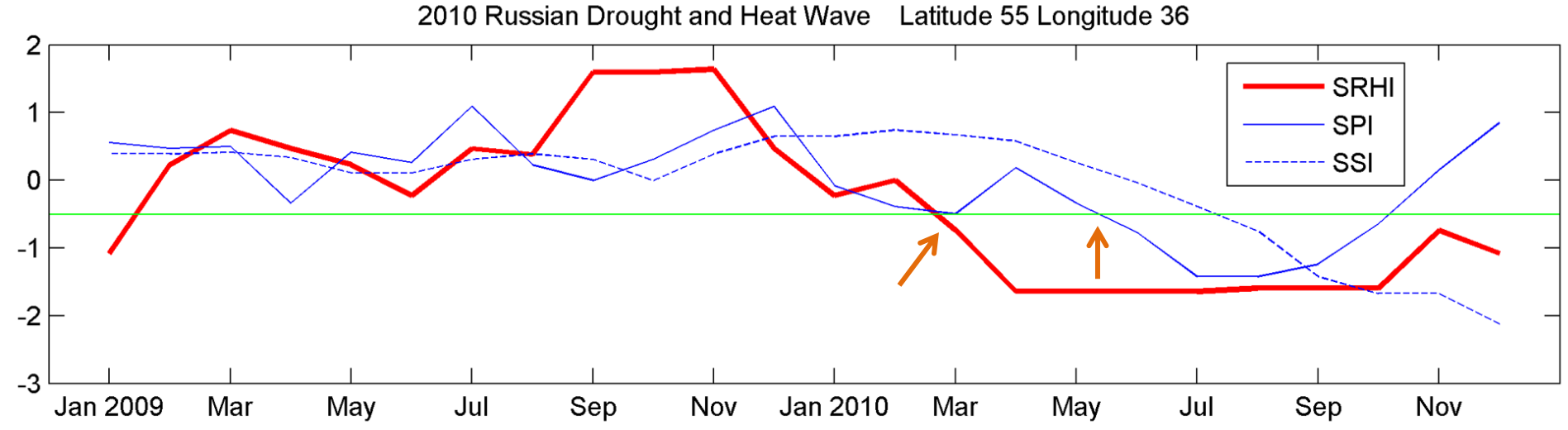
Integration of AIRS Data into GIDMaPS



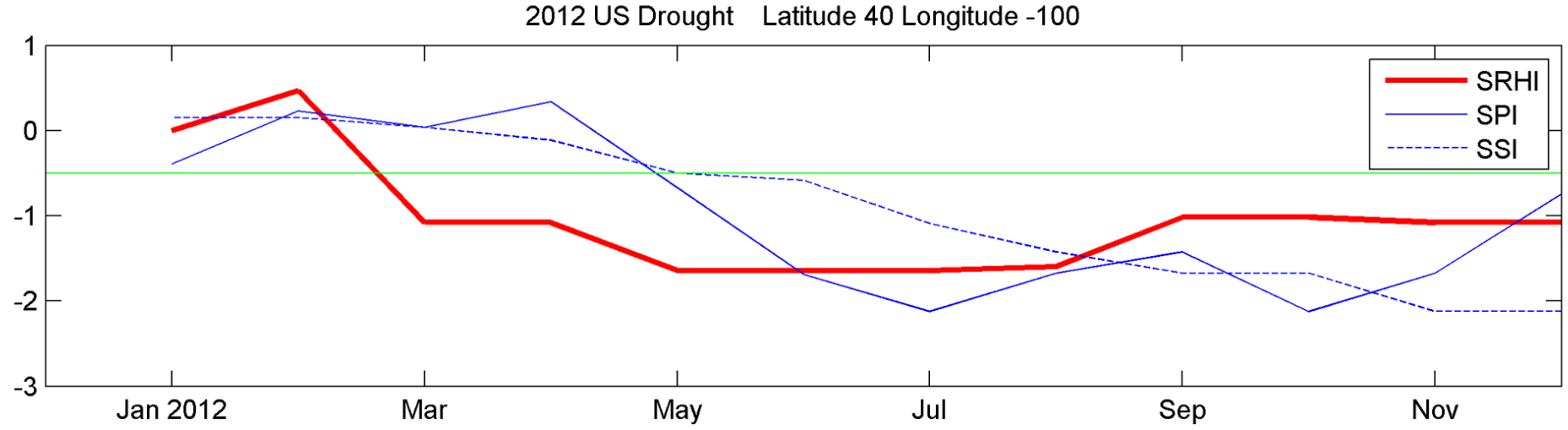


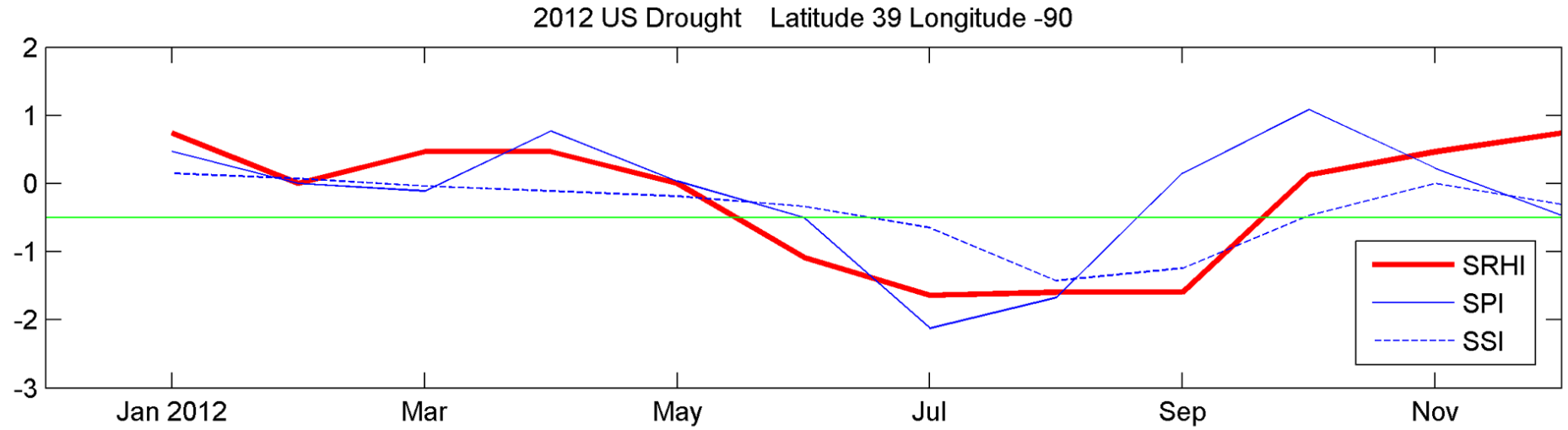
Integration of AIRS Data into GIDMaPS



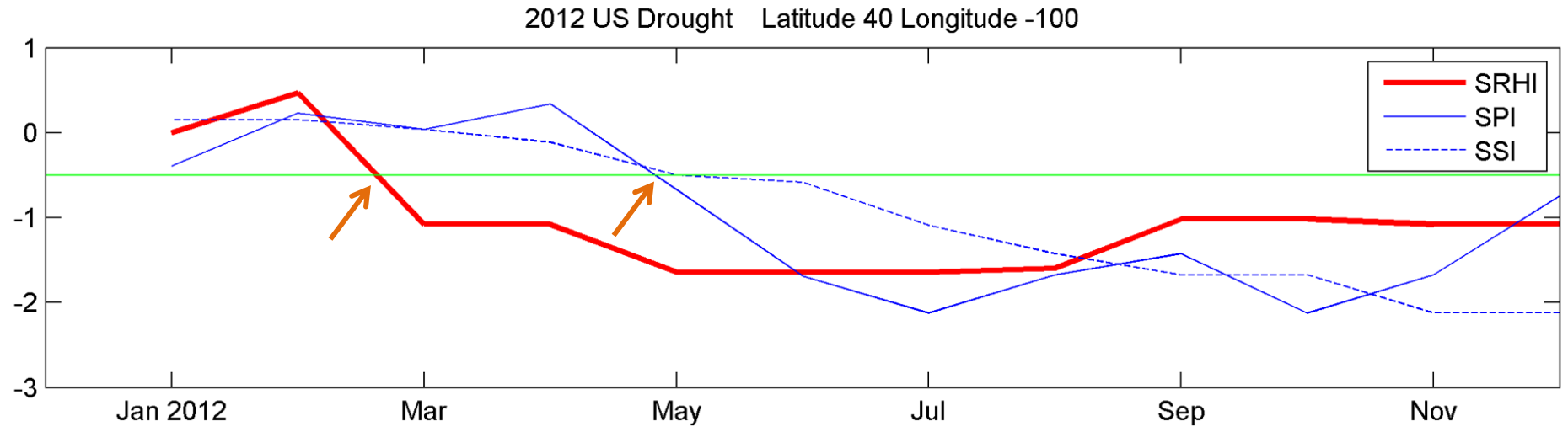


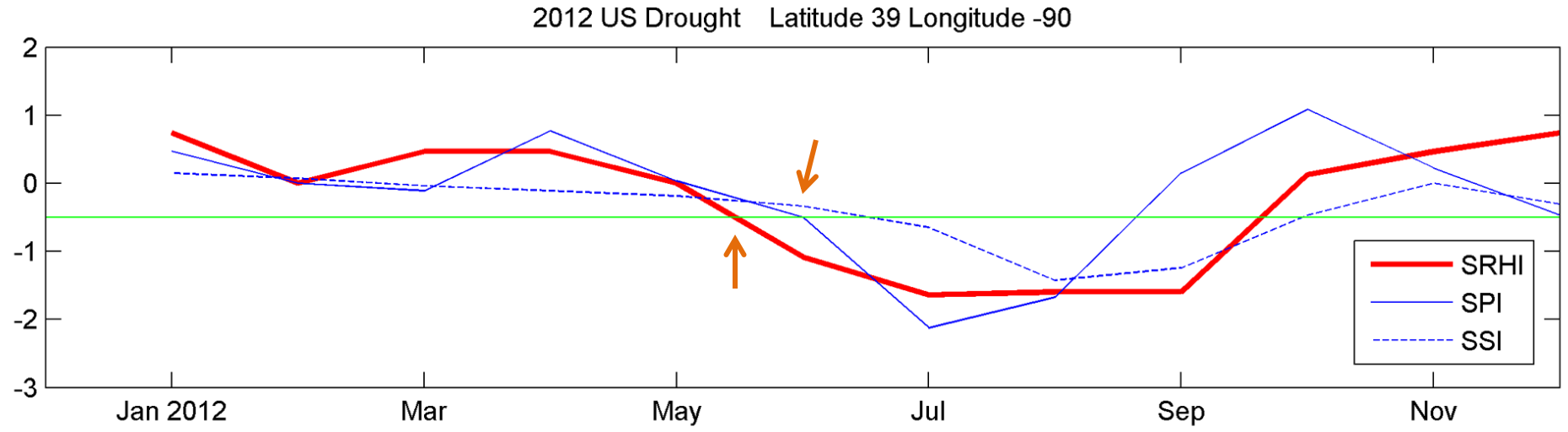
Integration of AIRS Data into GIDMaPS



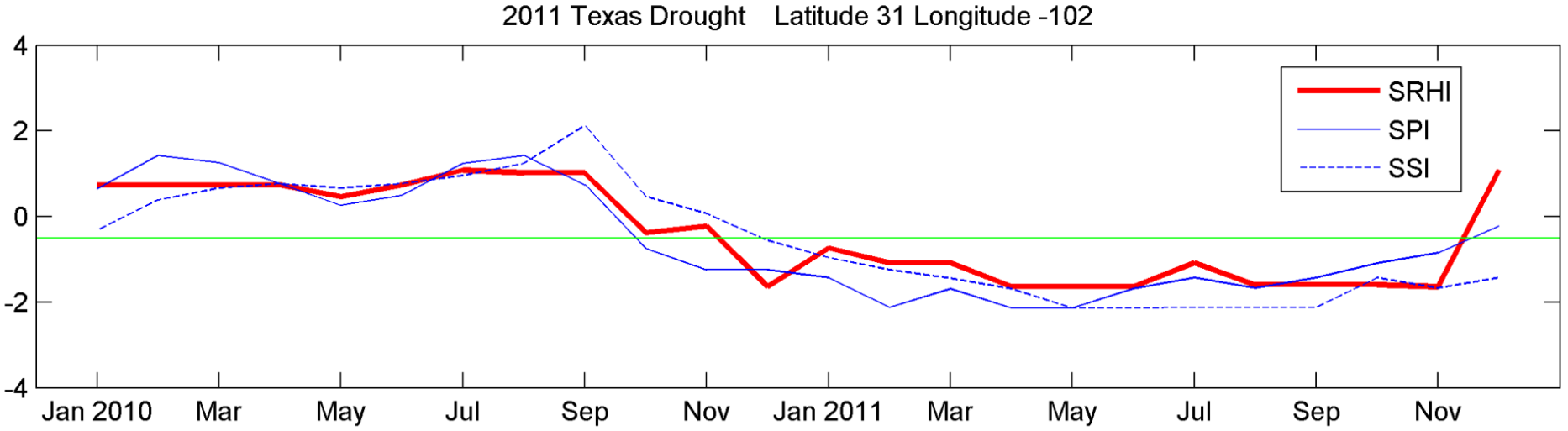


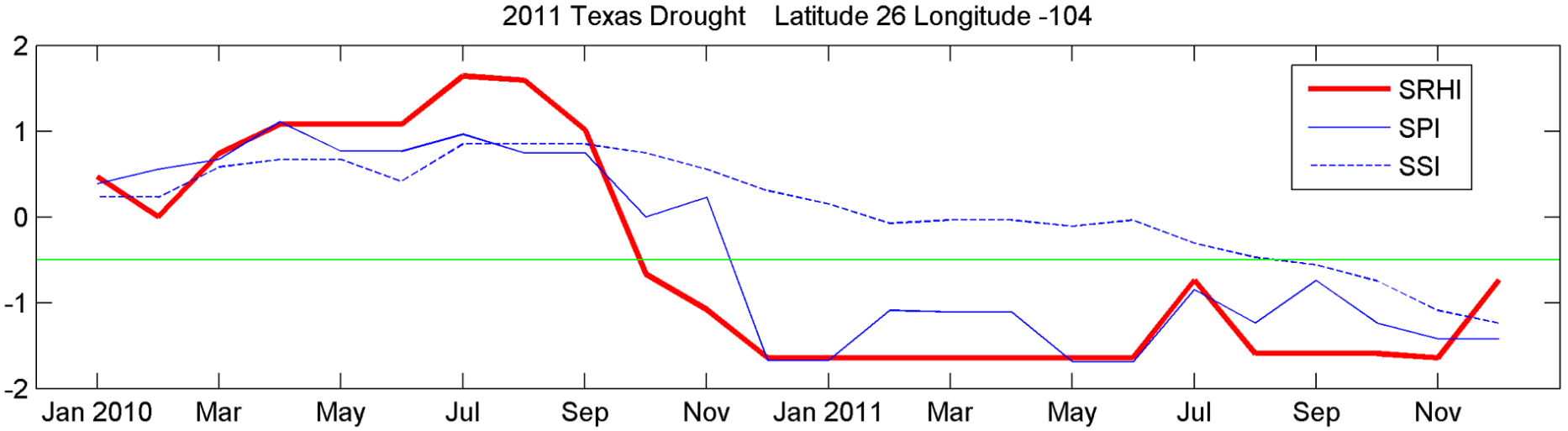
Integration of AIRS Data into GIDMaPS





Integration of AIRS Data into GIDMaPS





Integration of AIRS Data into GIDMaPS