Using TRMM for drought monitoring

NIDIS Presentation

Chris Funk

There was a man, and it was raining

The water rose

And rose ...

And he died

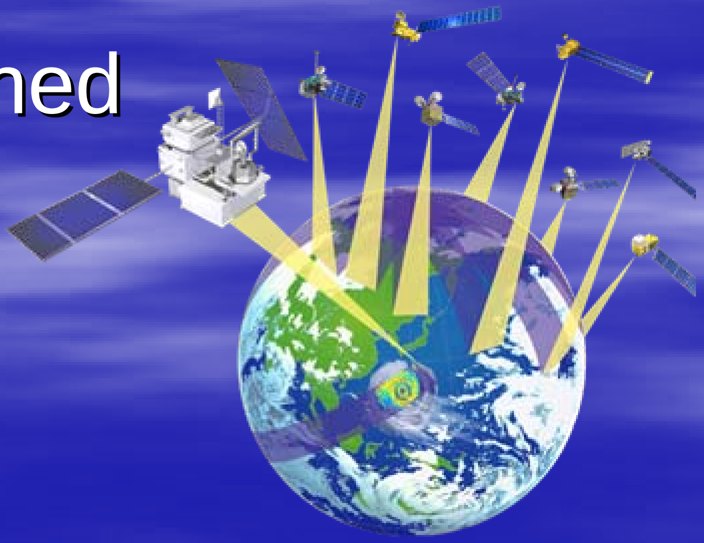
and went heaven

Moral

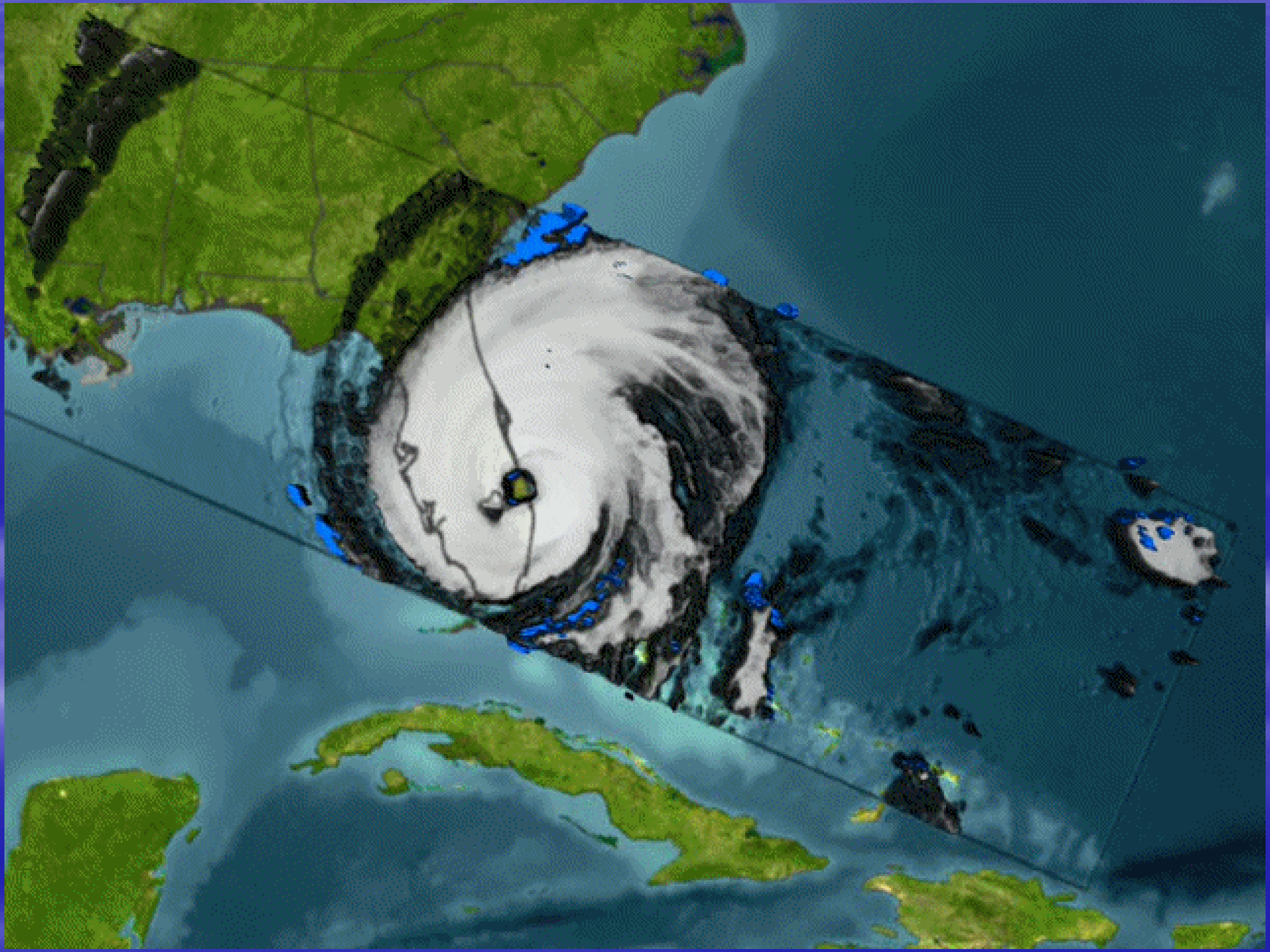
We have many opportunities to identify drought
… but it can be difficult to identify

Overview

- TRMM Process
- TRMM Products
- TRMM Applications
- Caveats & Lessons Learned



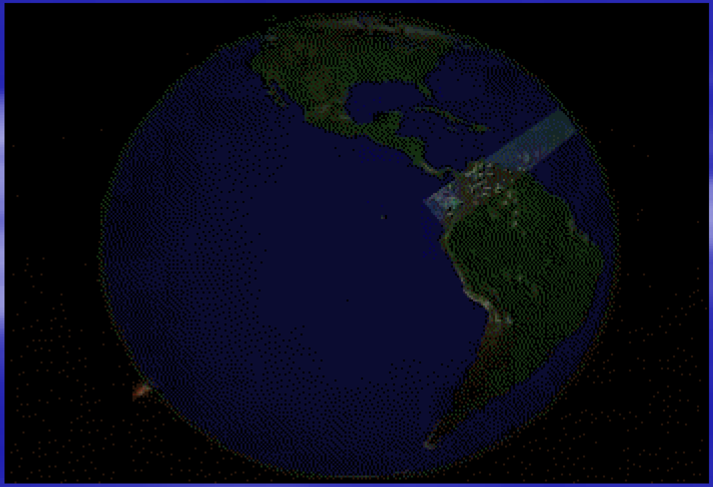
TRMM Radar and Microwave observations can give a 3 dimensional view of precipitation

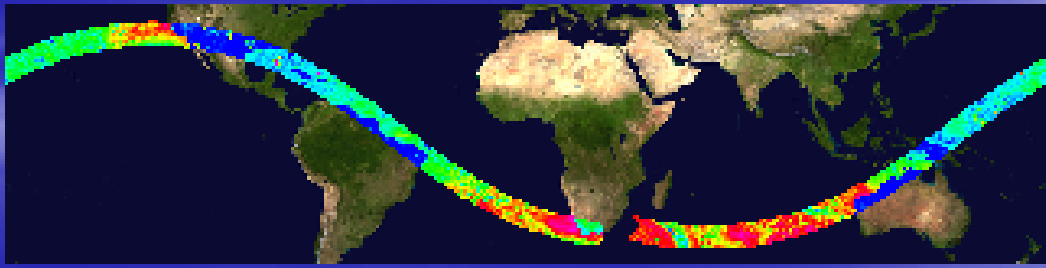


From Goddard Scientific Visualization Studio http://svs.gsfc.nasa.gov/

Microwave Processing Steps

- Multiple sources of microwave satellite rainfall estimates are probability-matched to TRMM Microwave Imager estimates (TMI)
- Estimates gridded to an 0.25° 3-hourly grid
- Rain rate estimates merged by pixel-weighted averaging





From Goddard Scientific Visualization Studio
http://svs.gsfc.nasa.gov/

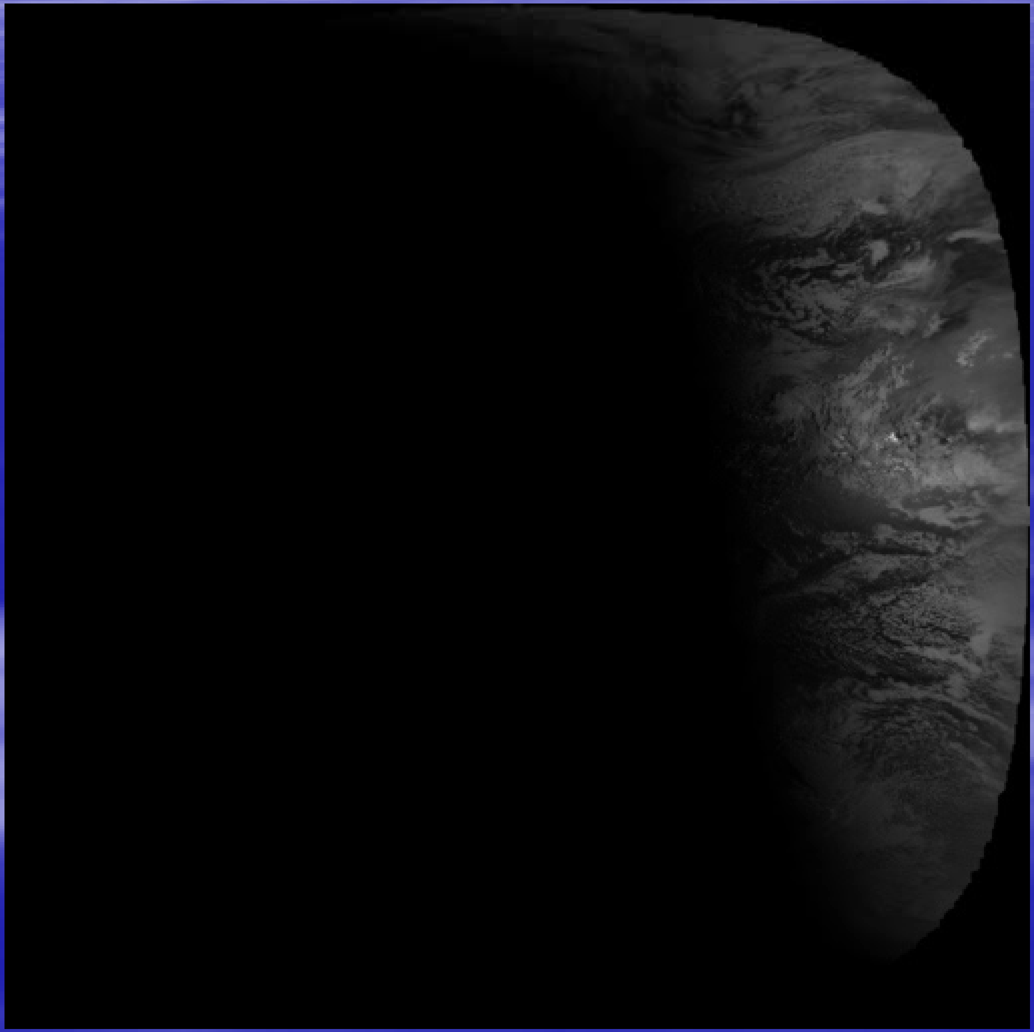
ftp://trmmopen.gsfc.nasa.gov/pub/merged/3B4XRT_README.pdf

Infrared Processing Steps

- For each month and location, historical infrared temperature / microwave observations are used to translate IR brightness temperatures into rain rate estimates
- The cloud top temperature-to-rainrate conversion is a simple look-up

ftp://trmmopen.gsfc.nasa.gov/pub/merged/3B4XRT_README.pdf

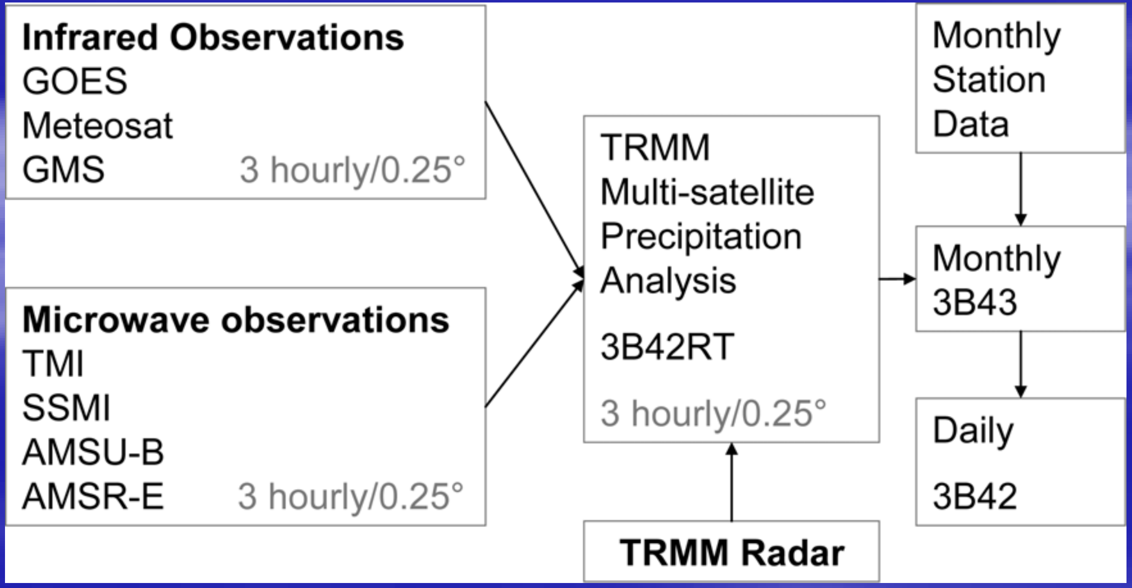
GOES Animation of Katrina

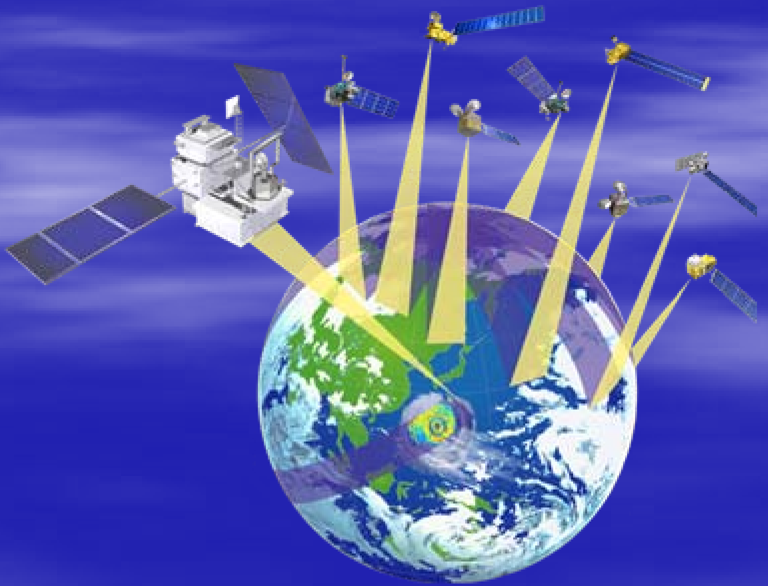


From Goddard Scientific Visualization Studio
http://svs.gsfc.nasa.gov/

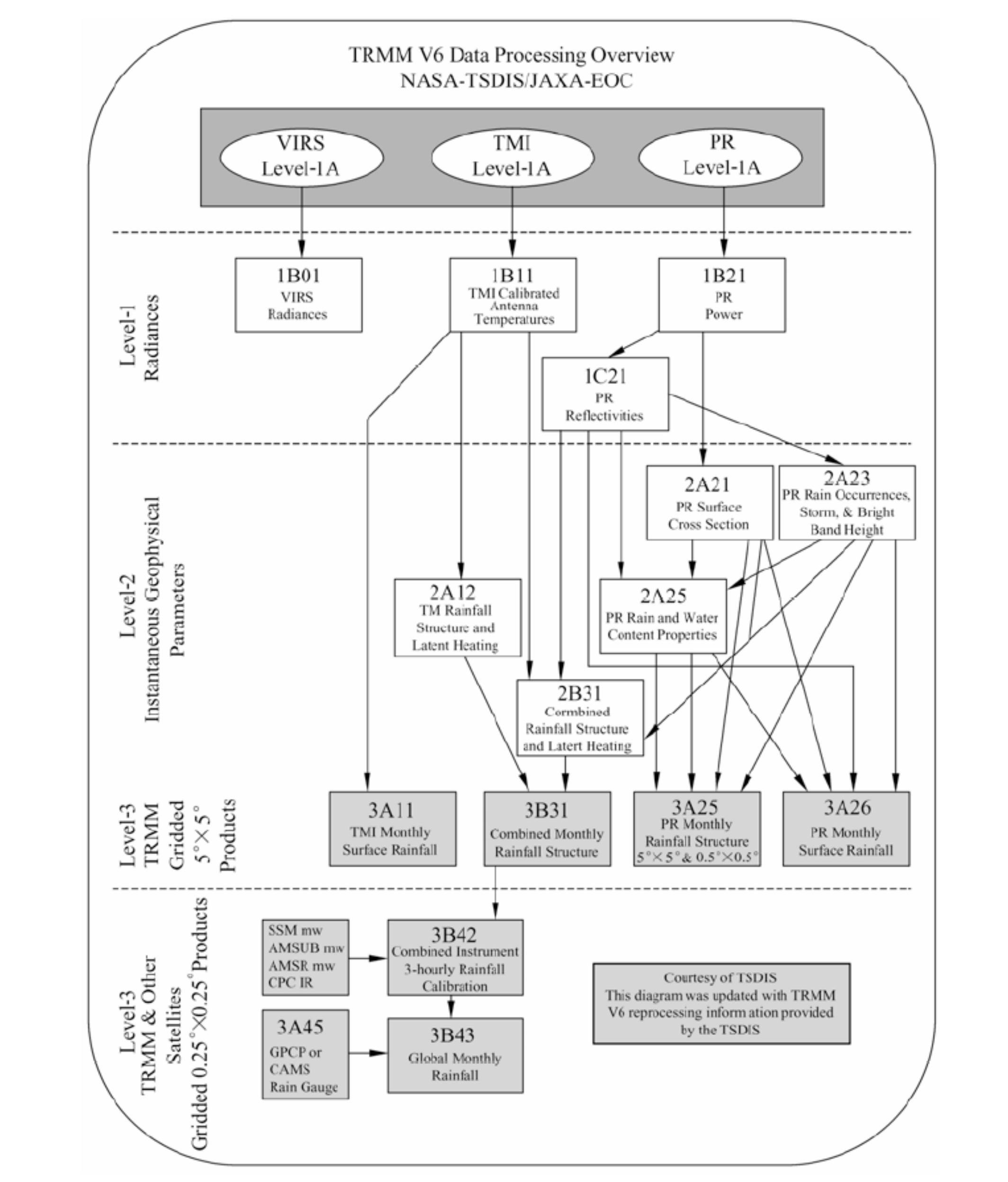
Merging Procedure

- If a 3-hourly, 0.25° microwave estimate is available, use it.
- If no microwave is available, use an infrared estimate in it’s place



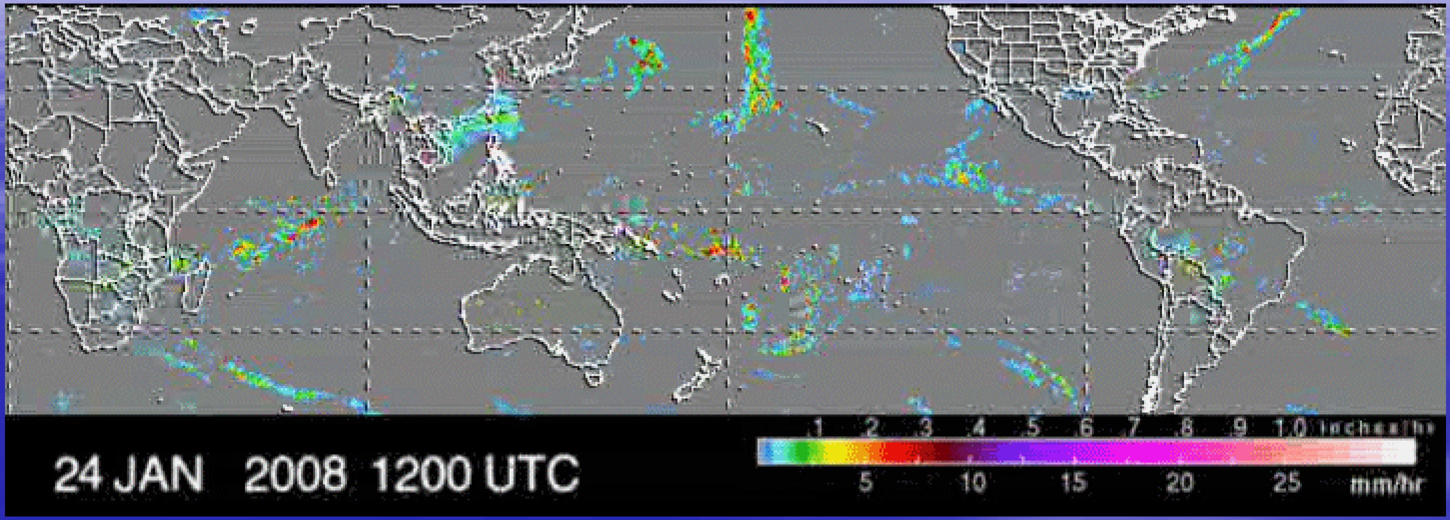


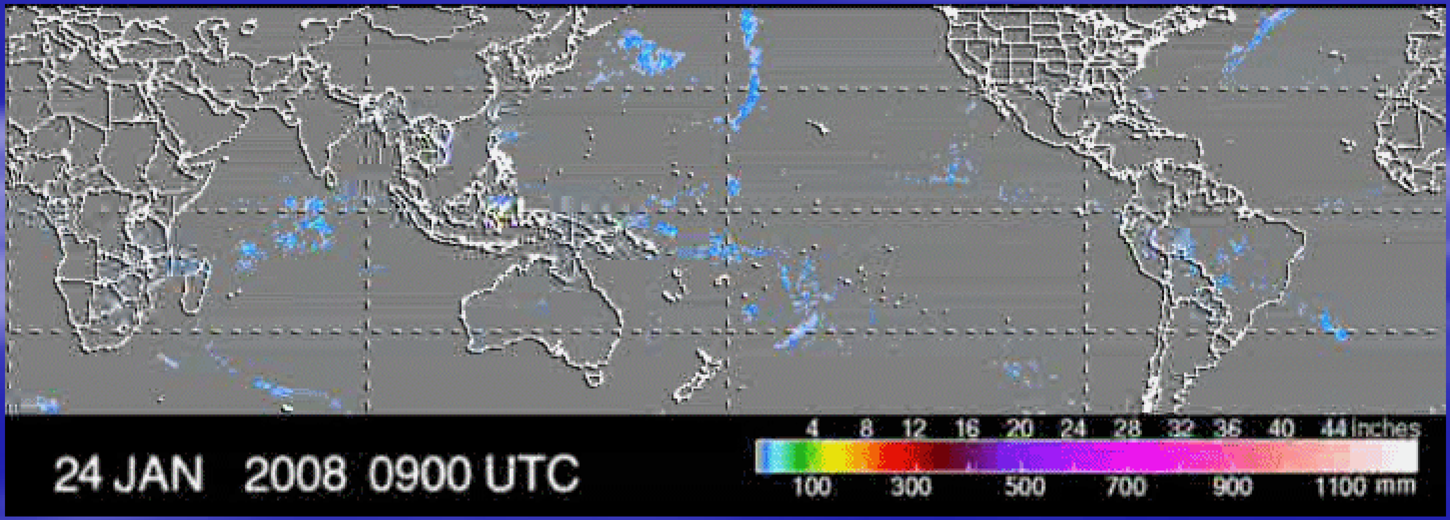
TRMM 3B43/2 v6 Processing



From: Qu, J.J., Gao W., Kafatos, M., Murphy, R.E., Salomonson, V.V., 2006,Tropical Rainfall Measuring Mission Data and Access Tools, Chapter 12, Earth Science Satellite Remote Sensing, Vol. 2: Data, Computational Processing, and Tools, Springer Berlin Heidelberg, 10.1007/978-3-540-37294-3. 202-219.

TRMM Global Animations



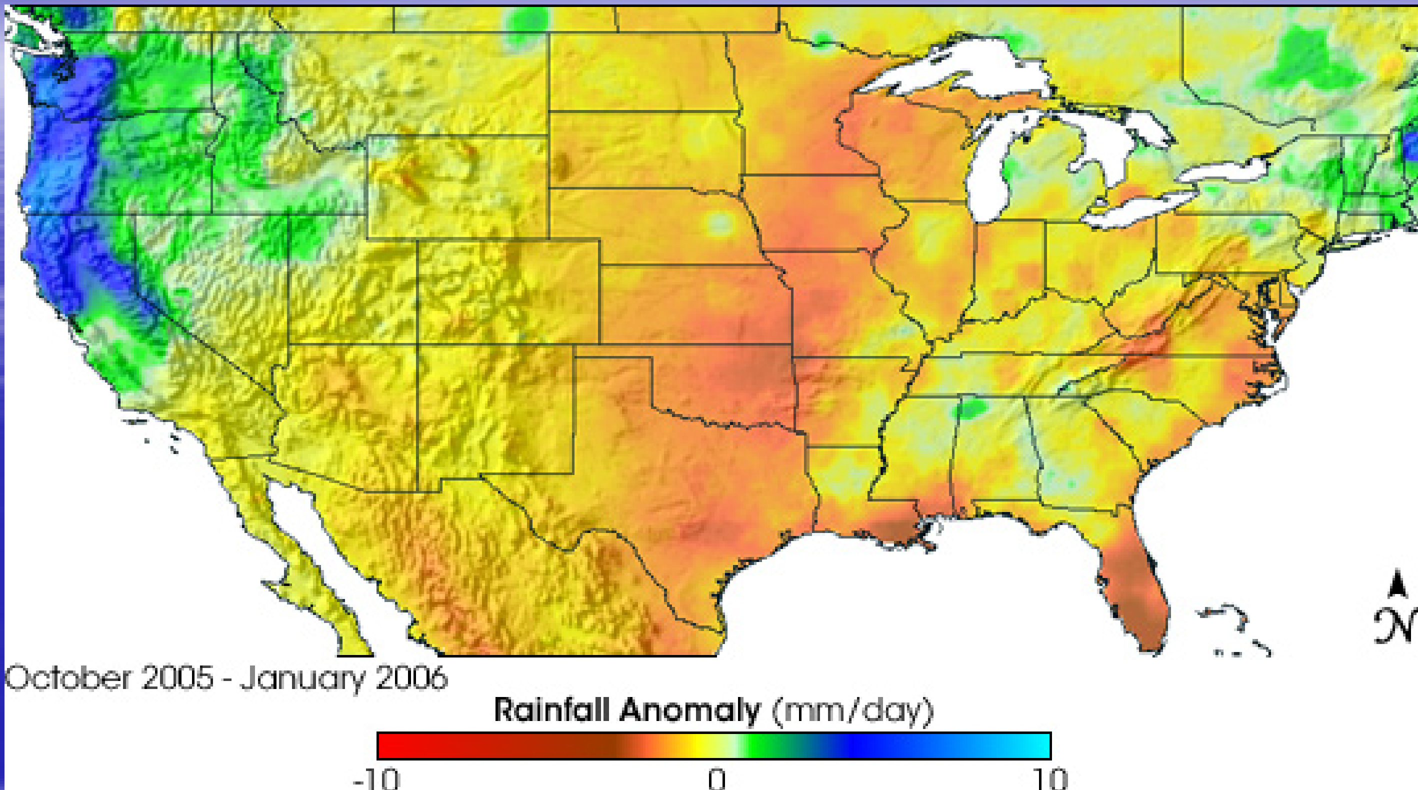


From trmm.gsfc.nasa.gov

Recommended Applications

- Near-real time
  - Agricultural monitoring
  - Rangeland monitoring
  - Hydrologic applications
  - Advantage – timely
  - Disadvantage – no stations, changing process
- Climatological
  - Fire modeling?
  - Low frequency hydrologic modeling?
- Can real-time and climatological sources be blended?

Drought Monitoring – Seasonal Rainfall Anomalies



http://earthobservatory.nasa.gov/NaturalHazards/shownh.php3?img_id=13410

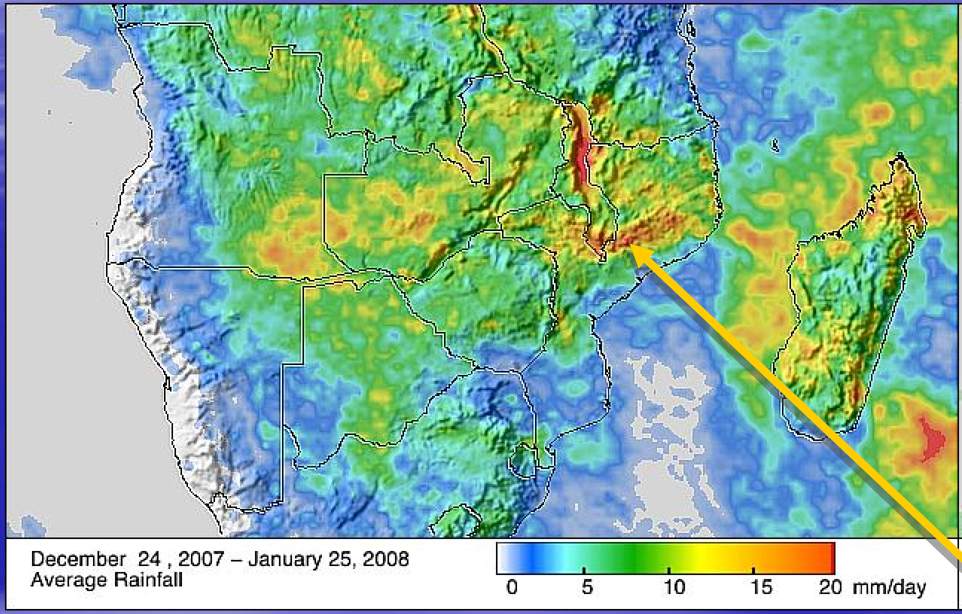
Unit choices: mm per season
standardized precipitation index,
percent precipitation
application specific measures

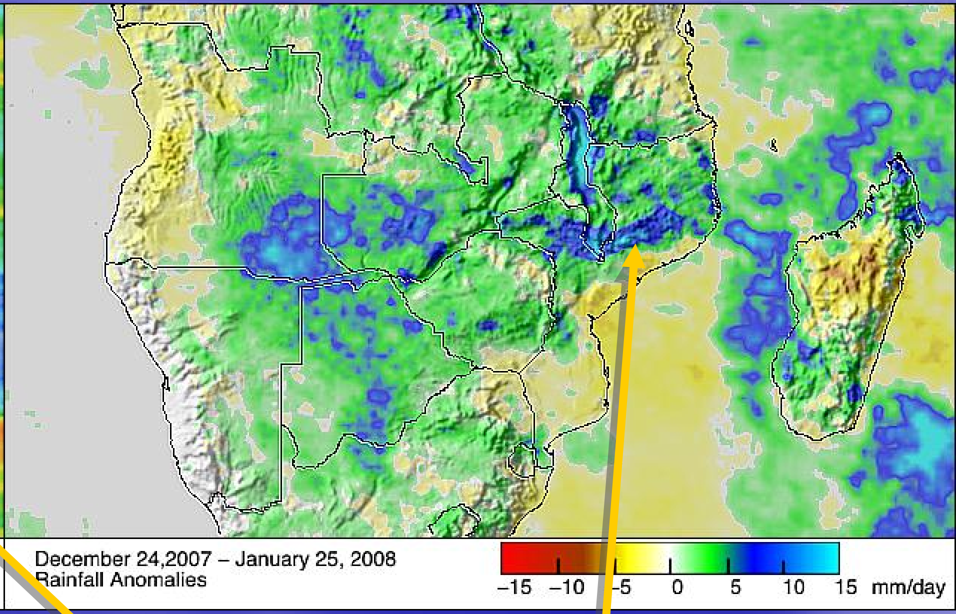
Absolute Value

Absolute Value

Past knowledge enhances current observations

TRMM shows Southern African Flooding

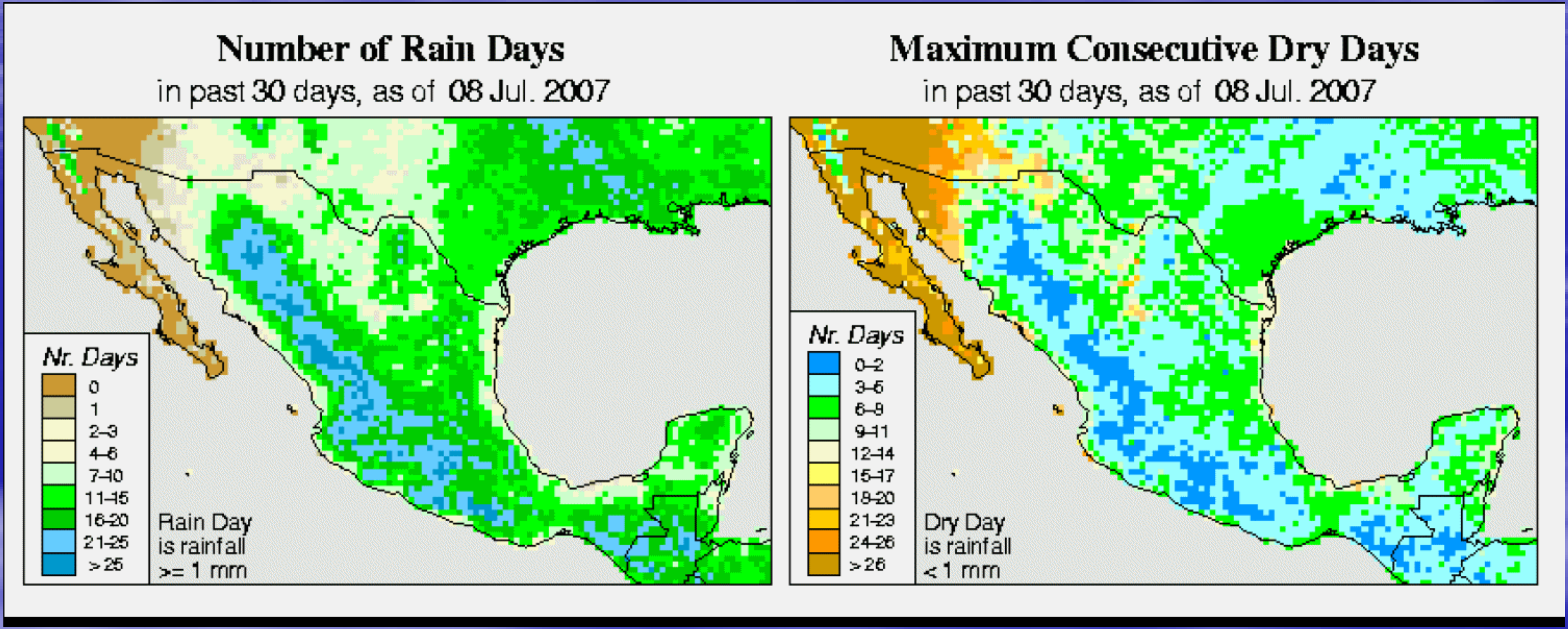




Recent flooding due to extreme precipitation extreme in absolute

and relative value

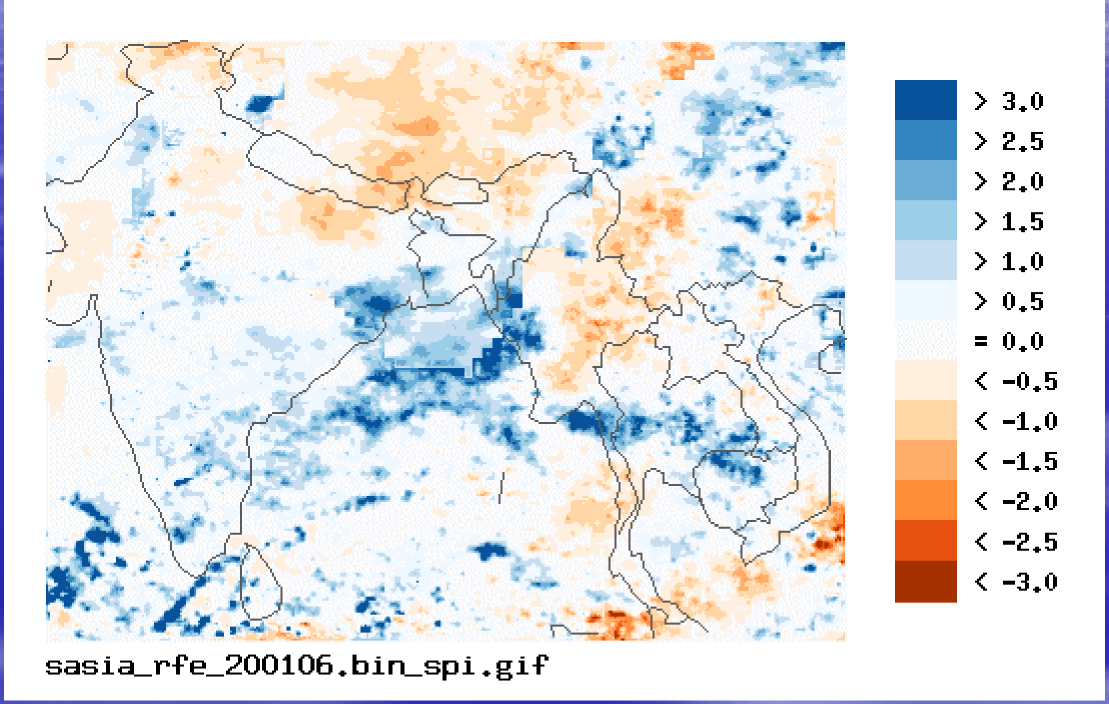
Dry days & wet days



Quite useful indicator of extremes, and tolerant of errors in satellite estimation.
'rain vs. no rain' observed well, so 30 days of no rain in the middle of a wet season sends a clear signal.

Images obtained from EROS, Animation prepared by Lindsey Everett

Standardized Precipitation Index

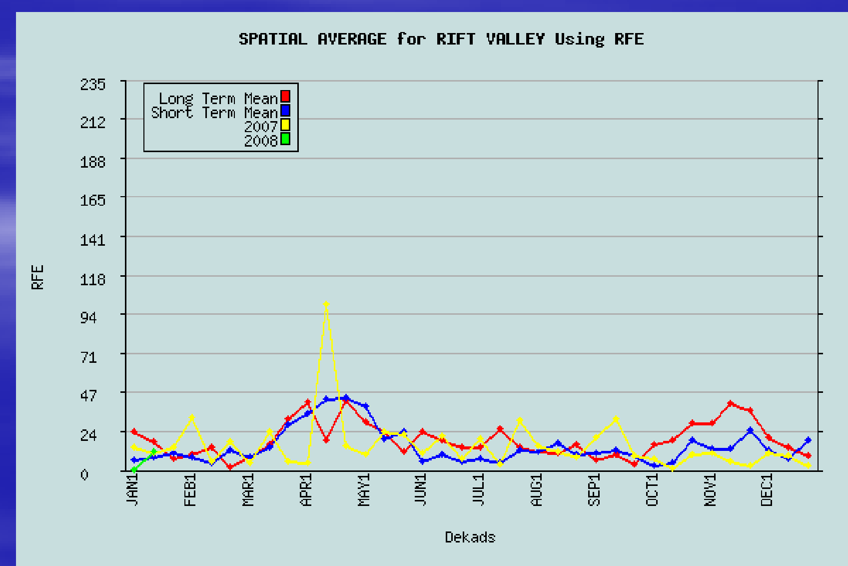


- Expresses rainfall as standardized deviations from zero (z-scores)
  - -2 or less very low *and* uncommon
  - 0 ~ normal
  - 2 or greater very high *and* uncommon
- A relative metric!

Other Precipitation Monitoring Approaches

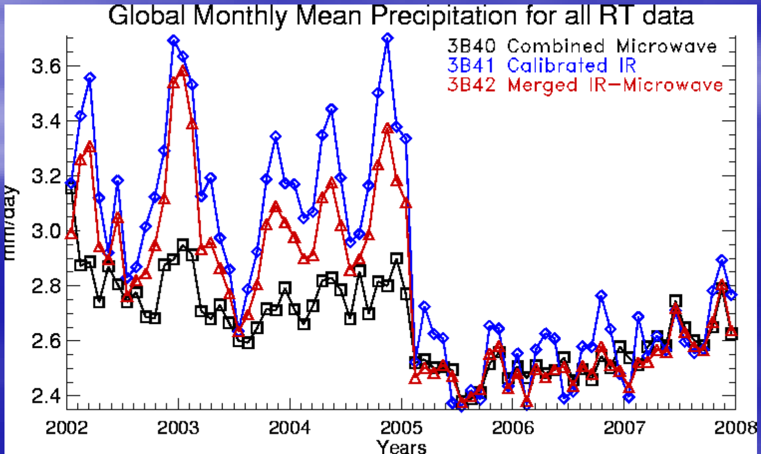
- Simple and sophisticated crop models
  - Water Requirement Satisfaction Index
  - CERES
- Simple and sophisticated hydrologic models
  - Bucket models, soil moisture indices
  - GeoSFM, etc.
- Looking at time-series of precipitation

Time-series from the EROS map server show terrible short rains in the Rift Valley



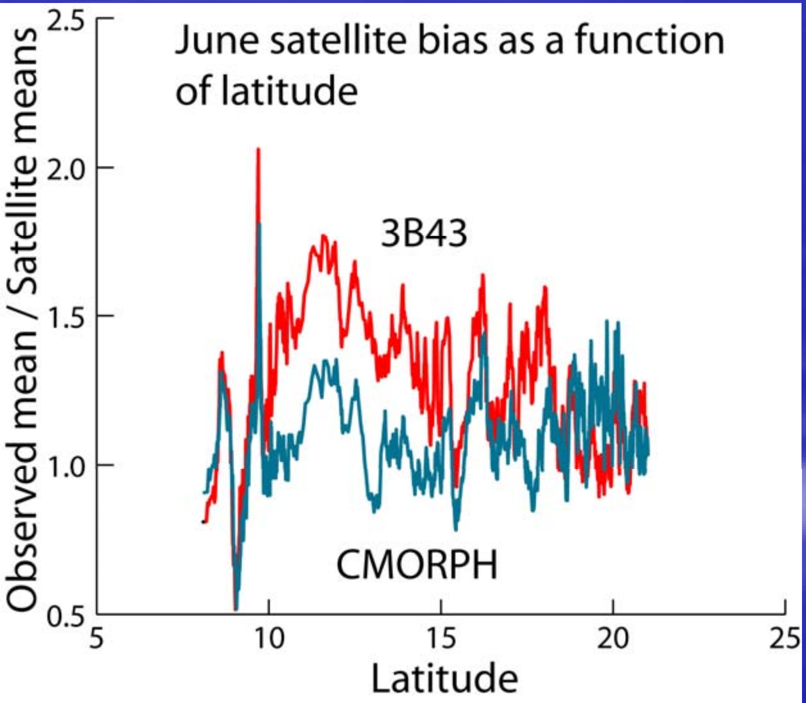
Caveats and Lessons Learned

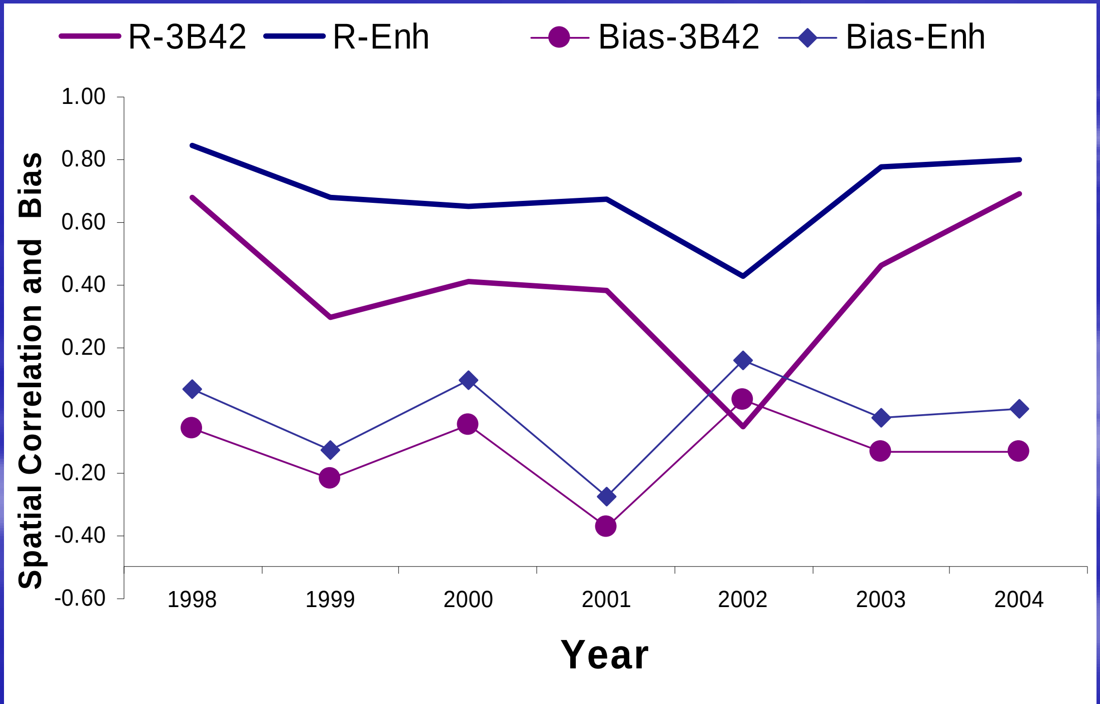
- Satellite estimates provide extensive, rapidly updated estimates of precipitation. They can be extremely useful for drought monitoring.
- Satellite estimates of precipitation are indirect. They must use statistical inference to produce millimeters.
- Precipitation estimates this have significant random and systematic errors.
- Drought monitoring focuses on temporal (and sometimes spatial) aggregations of precipitation
  - This can dampen the impact of random errors
  - This can amplify the impact of systematic errors



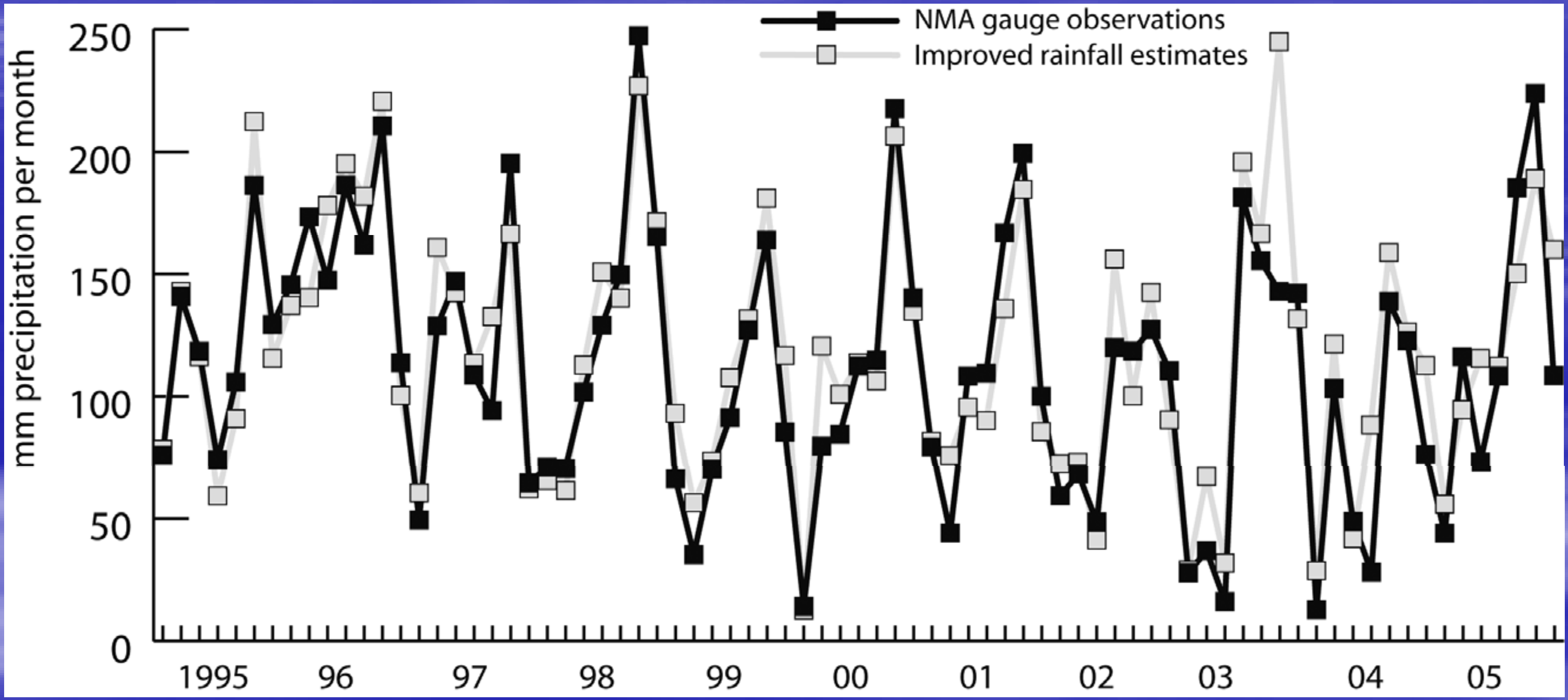
Global means of the combined microwave (3B40), infrared (3B41) and combined (3B42). Note the shift in 2005 associated with the transition to version 1.3. Graphic prepared by Pete Peterson.

Central American Unbiasing





Ethiopia Unbiasing



Results

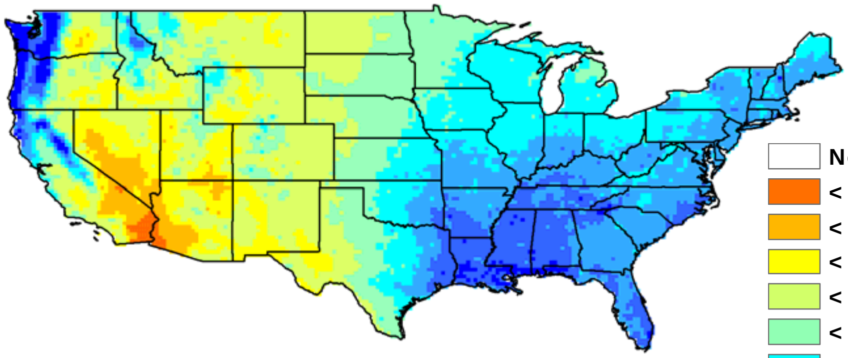
Cross-validated time series for Ethiopia

Ethiopian test site evaluation statistics. The March-September and Monthly rows report statistics for the seasonal March-September and individual monthly March-September accumulations, respectively. The first and second columns report mean bias and mean absolute errors based on the average of all stations. The MAE STD^{-1} column provides a relative metric of uncertainty, with typical errors being about ~33% of the temporal standard deviation. The time R2 is calculated using 11 years of data (1995-2005). The last three columns are similar to the regional metrics, but based on calculations using the individual station values. Seasonal at-station values were not available do to the random sampling associated with the cross-validation.

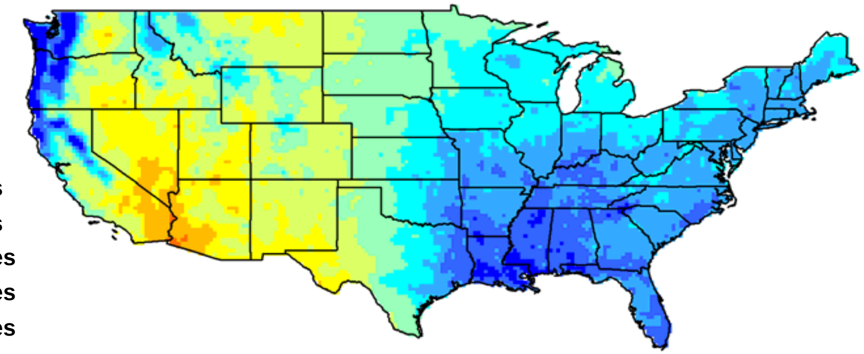
US SPI Example

(work by Greg Husak, AGU 2006)

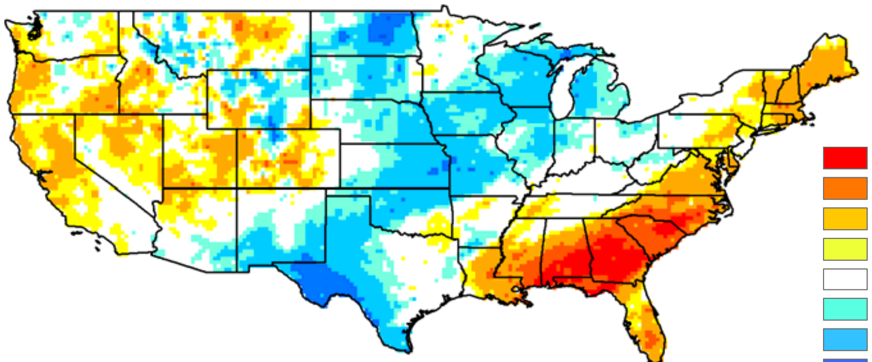
URD Historical Mean

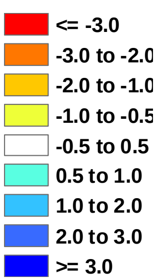


CPC Real-time historical mean

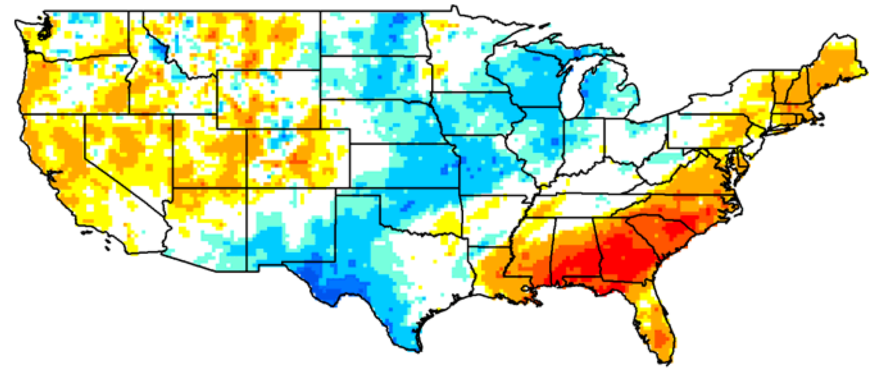


Unadjusted SPI March 2004





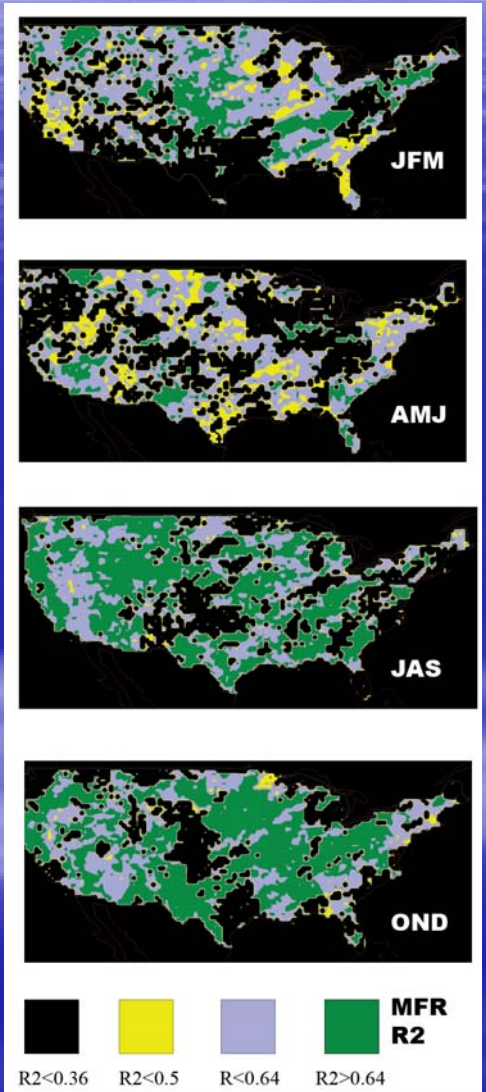
Adjusted SPI March 2004



In our first attempt to produce a US SPI, a less-dense real time gauge network produced systematic errors that obscured drought in parts of the western US.

Combining observation and forecast systems can improve the utility of both: US SPI Forecast study

(work by Greg Husak & Chris Funk, AAG 2007)



- Generally lower correlations during winter, especially in the west
  - Poor predictor of snowfall
- Summer and fall show good correlations throughout the US
  - Good news for agricultural applications
  - Conditions are the most sub-tropical, lending to this technique

Summary

- TRMM blends Infrared and microwave estimates through a process of successive matches
  - Other microwave estimates matched to the TRMM Microwave Imager
  - Infrared temperatures values are matched to the microwave values
  - Latency ~ 6 hours
- The real time TRMM values are blended with monthly gauge data to produce a high quality product … the version 6
  - Latency ~ 1 month
- Both absolute and relative measures of rainfall can be important
  - As can the temporal distribution
- Using relative measures can mitigate the impact of systematic errors – if estimation procedure is stable.
- Consider blending v6 and real time data?
- Consider unbiasing, blending gauges
- Consider using the GIS friendly daily accumulations provided by EROS