SMAP Contributions
to
Drought Early Warning

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"SMAP Applications Workshop"

Silver Spring, Maryland – September 9-10, 2009

What is drought?

- A normal, recurrent feature of climate variability
- A deficiency of precipitation over an extended period of time, resulting in water shortage
- A temporary aberration relative to long term average balance between precipitation and evapotranspiration
- It occurs in virtually all climatic zones

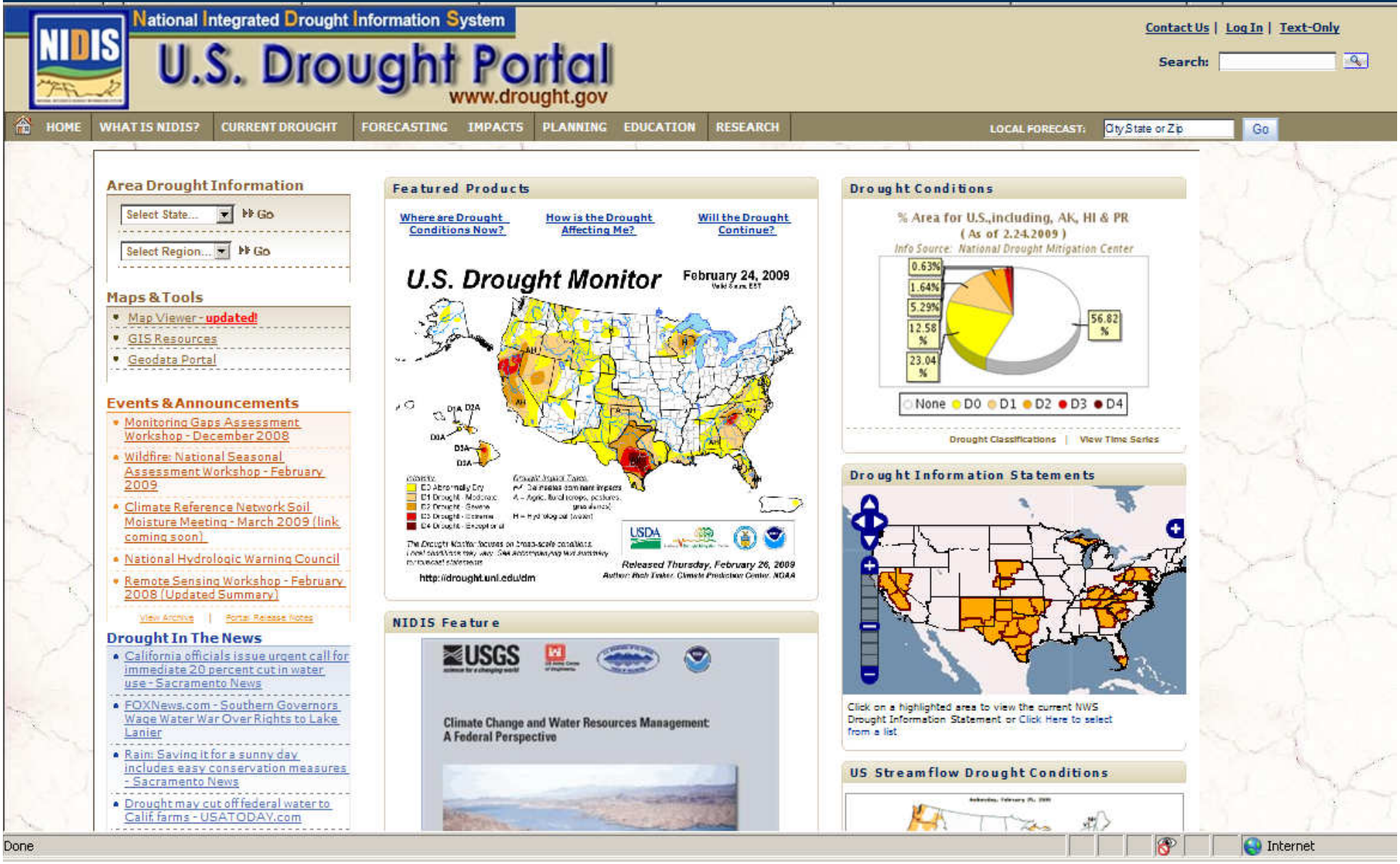
What is drought?

- ***Meteorological drought*** **based solely on departures of rainfall from expected amounts, e.g., days without rain above a certain threshold, and is region specific**
- ***Agricultural drought*** **is measured relative to crop water demand, and varies with crop type, stage of growth, and soil properties**
- ***Hydrological drought*** **occurs as shortage of surface or subsurface water supply, and lags the original deficiency of rainfall**

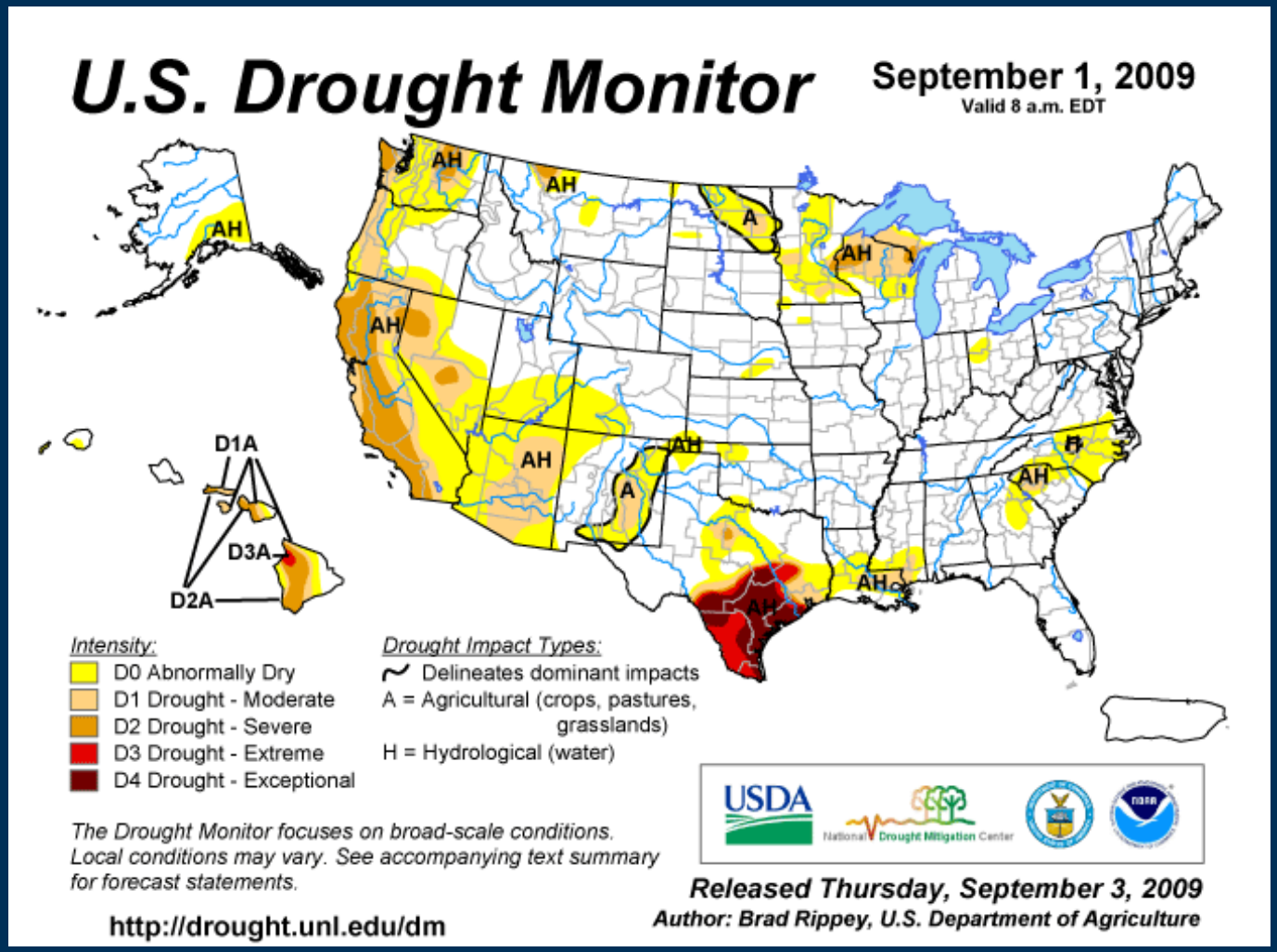
What is drought?

- A slow-onset hazard
- Amorphous in extent, ambiguous in timing of onset and abatement
- Many early warning goals can be met through monitoring
- Remote sensing and modeling have important role to play in concert with surface observation networks
- Seasonal forecasting is increasingly important and effective

Drought Early Warning in the U.S.



Drought Monitoring in the U.S.



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The U.S. Drought Monitor

Integrates Key Drought Indicators:

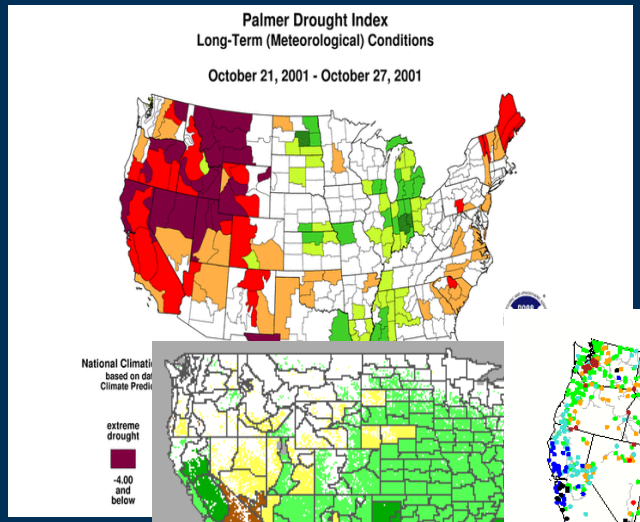
- Palmer Drought Index
- SPI
- KBDI
- Modeled Soil Moisture
- 7-Day Avg. Streamflow
- Precip. Anomalies

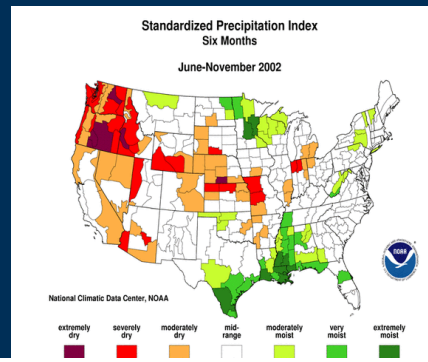
Growing Season:

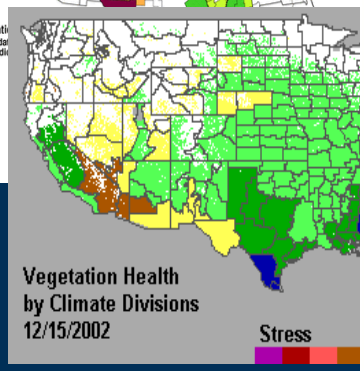
- Crop Moisture Index
- Sat. Veg. Health Index
- USDA Soil Ratings
- Mesonet data

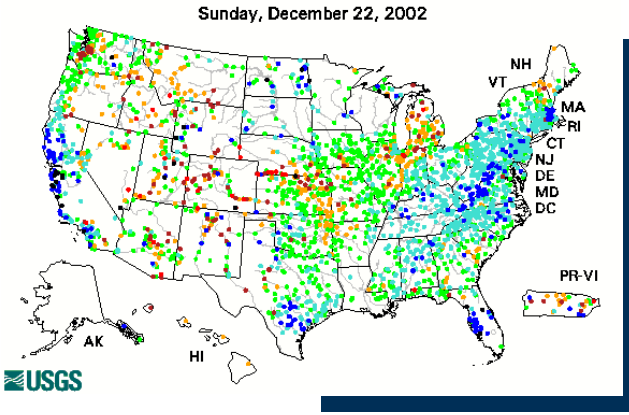
In The West:

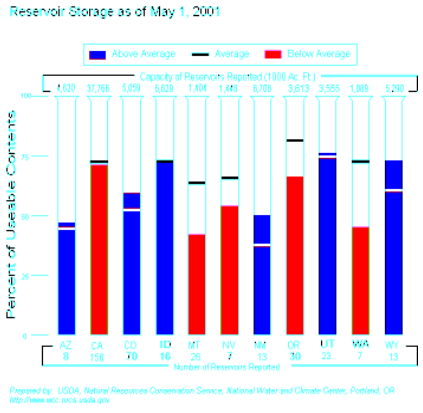
- SWSI
- Reservoir levels
- Snowpack

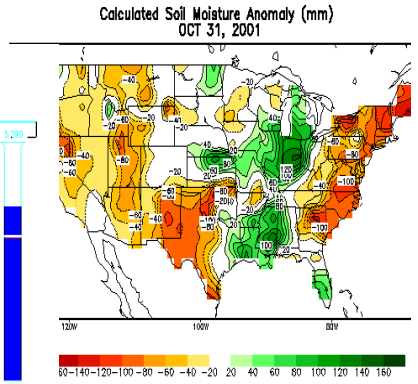


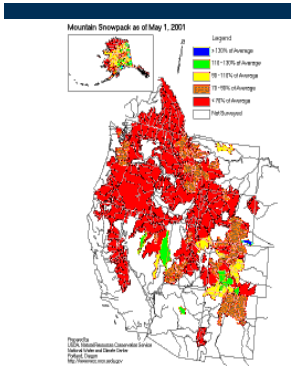






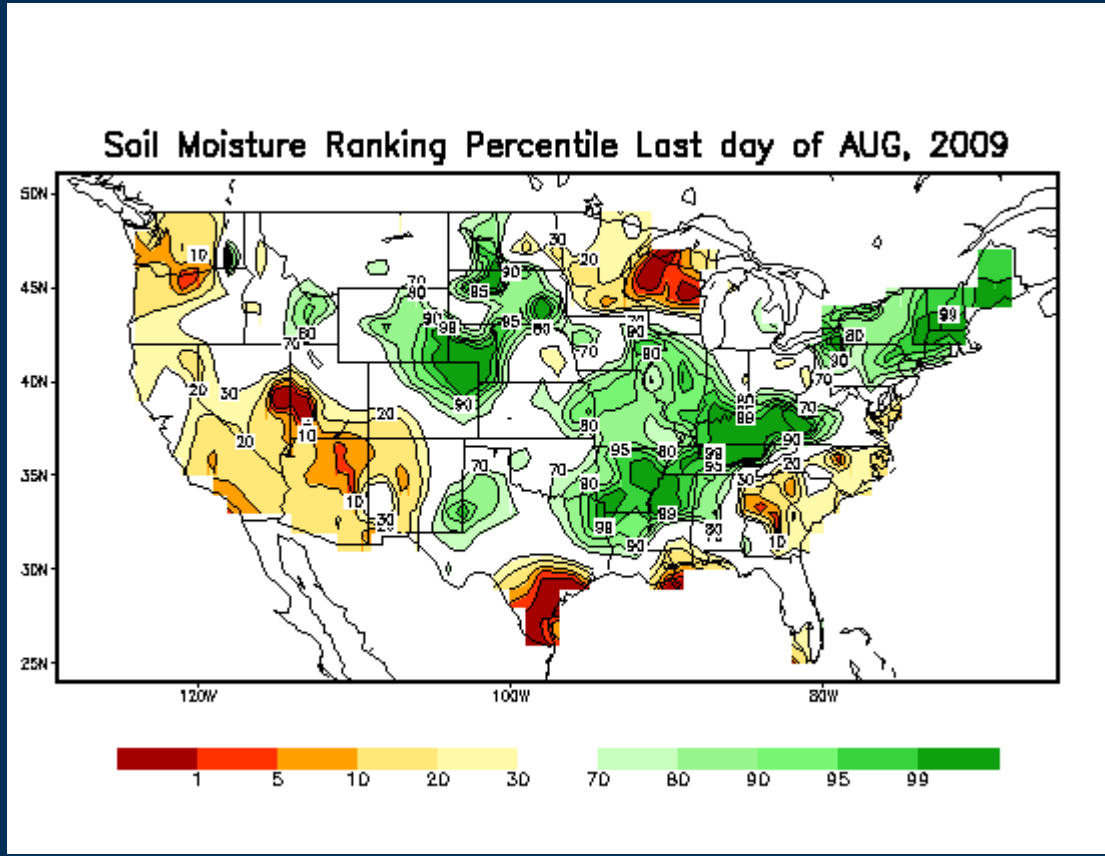






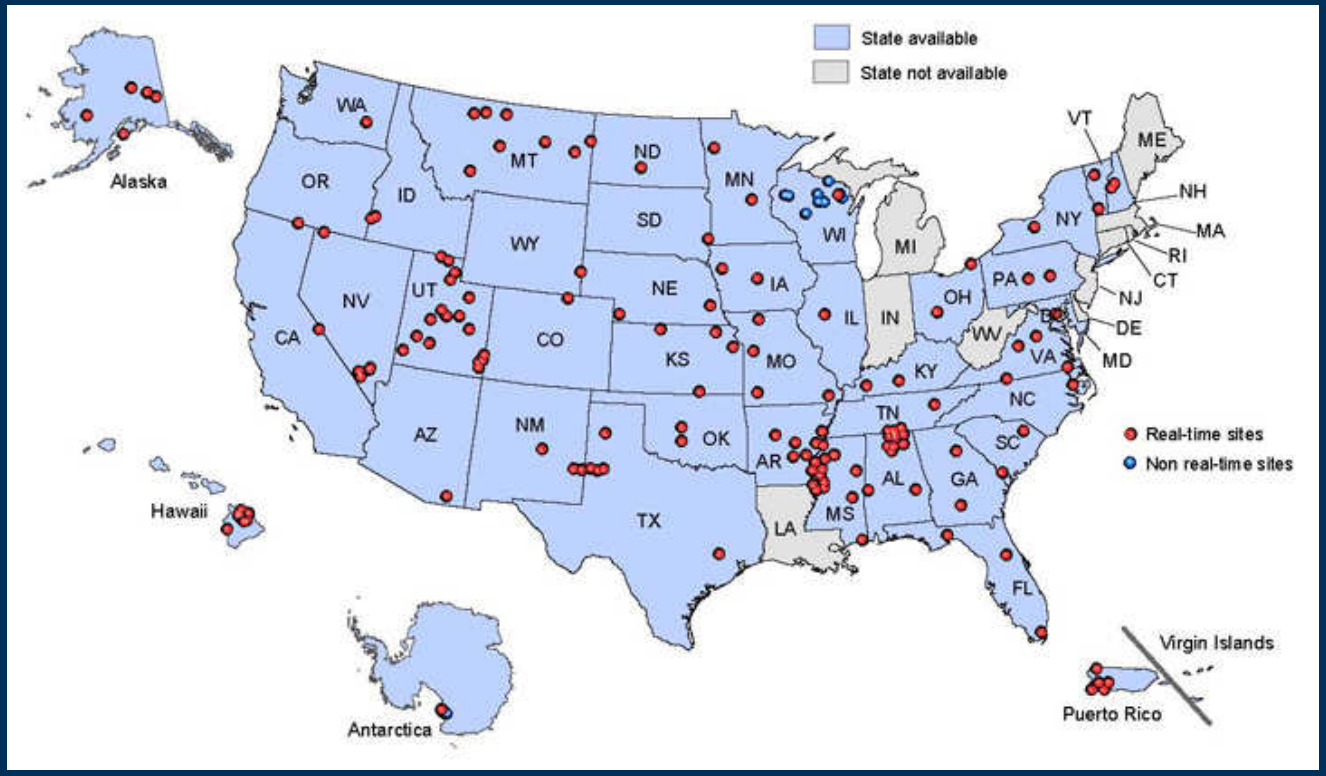
The U.S. Drought Monitor

- NOAA CPC 'Leaky Bucket' Soil Moisture Model



Drought Monitoring in the U.S.

- **NRCS Soil Climate Analysis Network (SCAN)**



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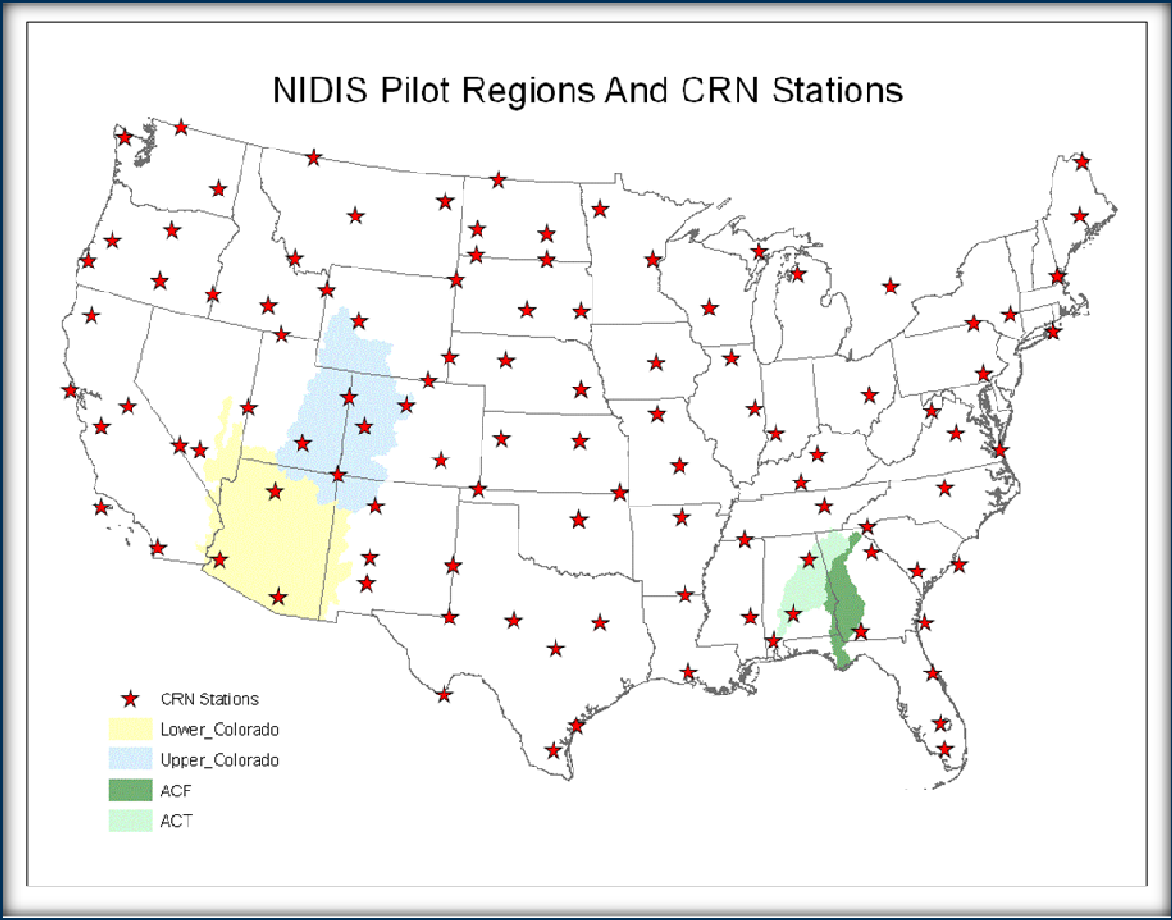
Drought Monitoring in the U.S.

- **NIDIS is adding soil moisture sensors to the U.S. Climate Reference Network**



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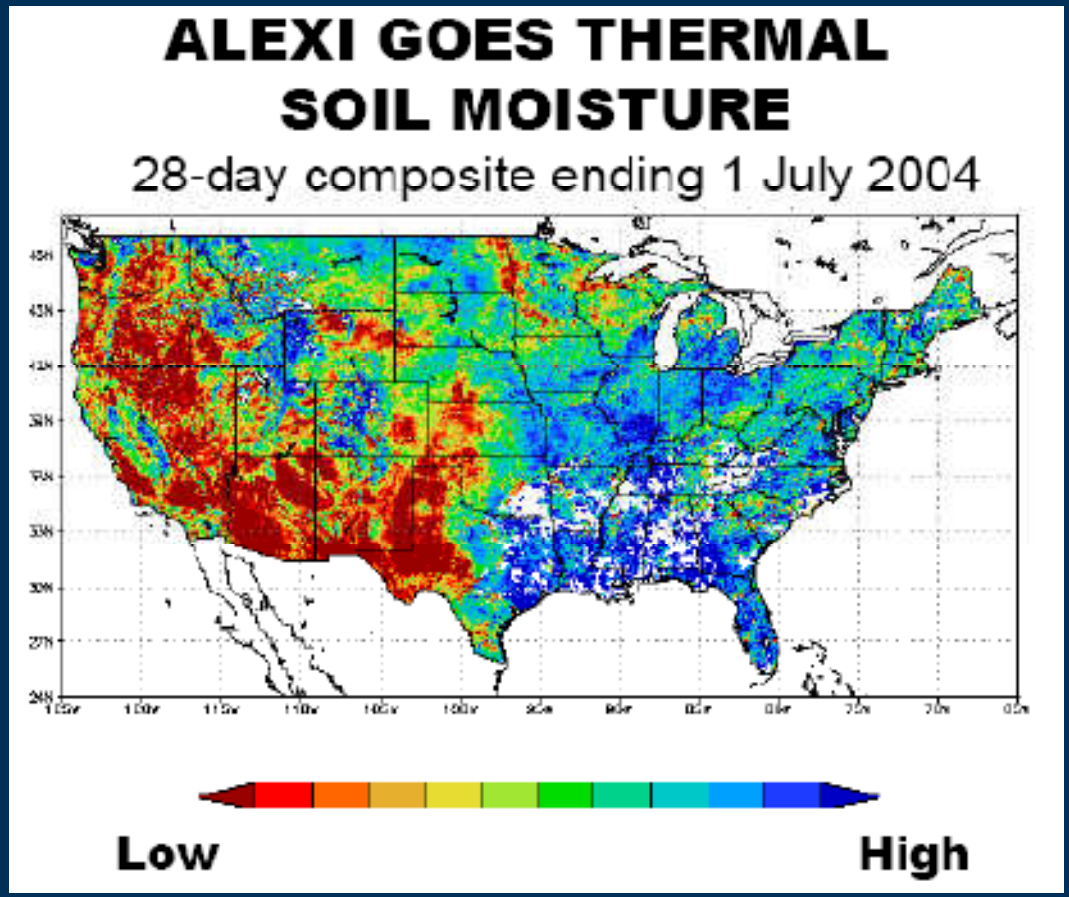
Drought Monitoring in the U.S.

- Remote sensing, modeling required due to coverage, scale problems
- ALEXI TIR ET model, M. Anderson, USDA/ARS



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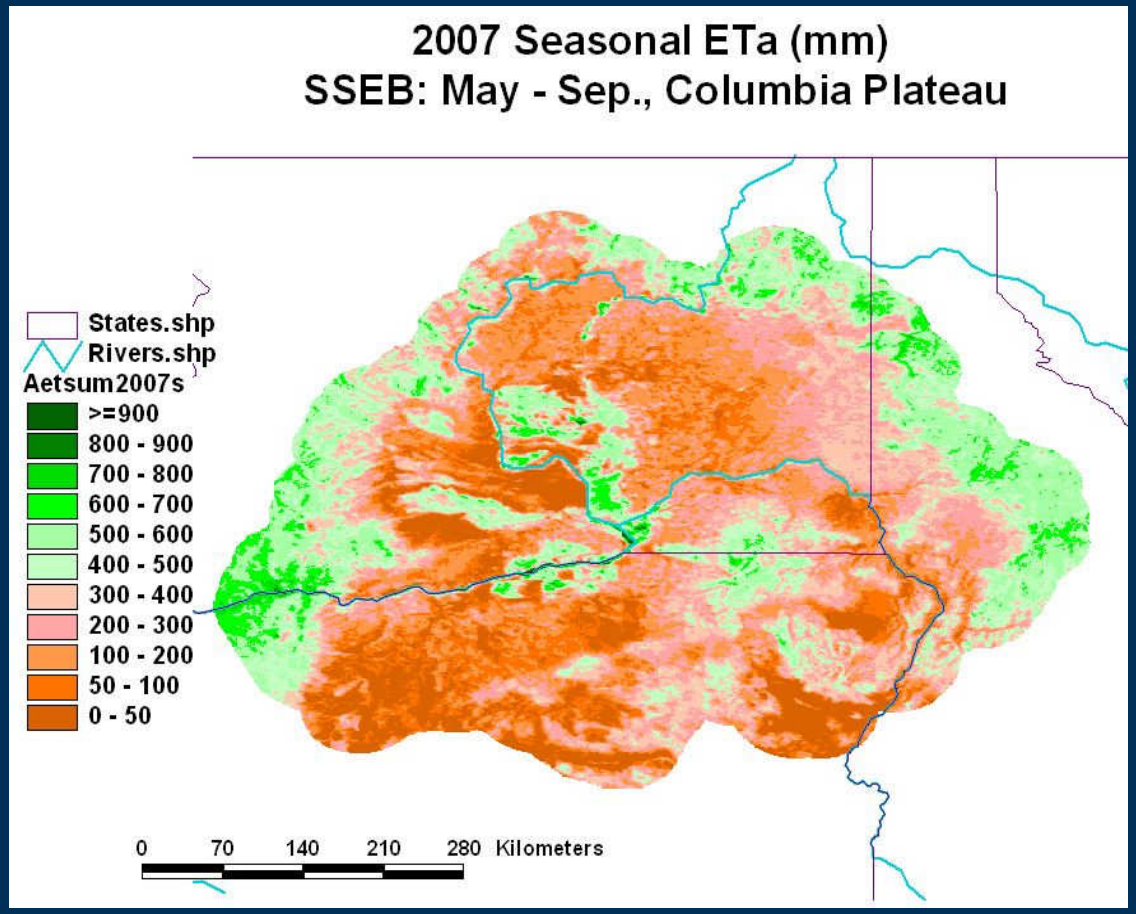
Drought Monitoring in the U.S.

- Remote sensing, modeling required due to coverage, scale problems
- MODIS LST estimates of ET, G. Senay, USGS/EROS



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Drought Forecasting in the U.S.

- NIDIS is supporting seasonal forecast modeling activities in the context of regional pilots
- In the Upper Colorado River Basin, linking CFS (NOAA/CPC), ESP (CBRFC), and reservoir operations model (USBR)
- In the Southeast U.S., linking CFS (NOAA/CPC) with Princeton multi-model hydrologic forecasting system

Drought Early Warning Outside the U.S.

- Outside the U.S., agricultural drought is our biggest concern
- Drought can reduce crop production for export, impacting global markets
  - Role of USDA/FAS IPAD
- Drought can undermine food security in developing countries
  - Role of USAID FEWS NET
- Due to sparse ground networks, both rely on many of the same remote sensing systems

Monitoring Agricultural Drought for Famine Early Warning

- **Primary motivation is early identification of potential *production anomalies* in regions of subsistence agriculture**
- **Subsistence agricultural systems are typically *water-limited***
- **Consequently, early estimates of prospective food availability depend in large measure on *drought monitoring and forecasting***

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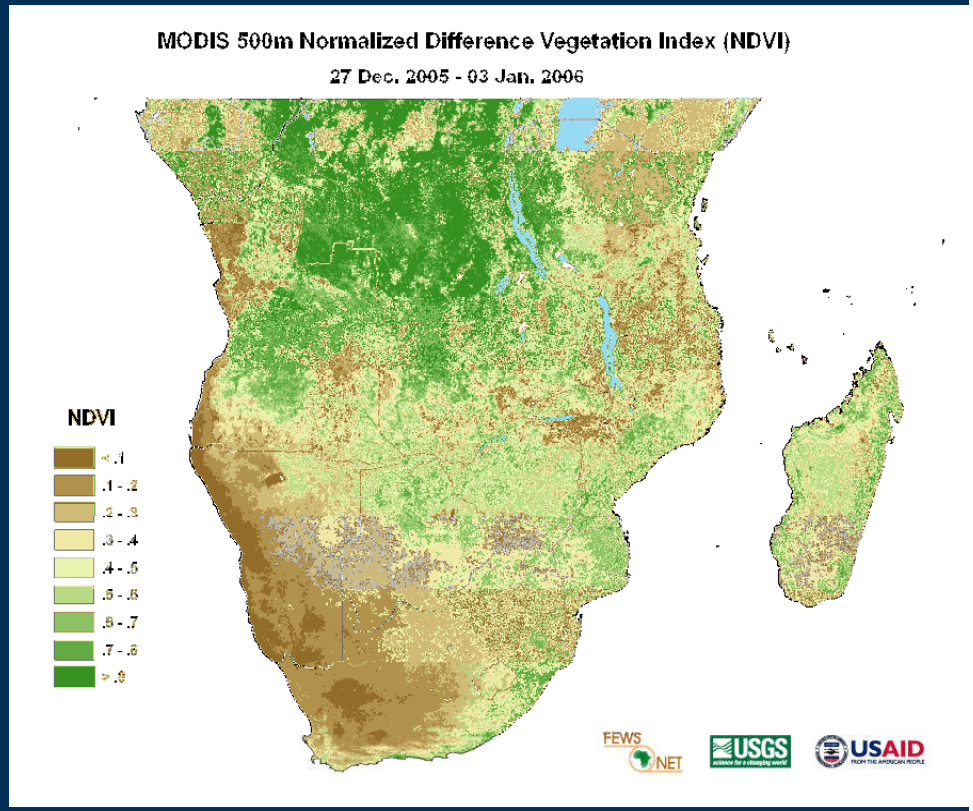
Monitoring Agricultural Drought for Famine Early Warning

- Tradition of NDVI use back to 1985
- MODIS NDVI data show strong correlation with USDA crop estimates
- Soil moisture status is implicit in the vigor of the plant canopy



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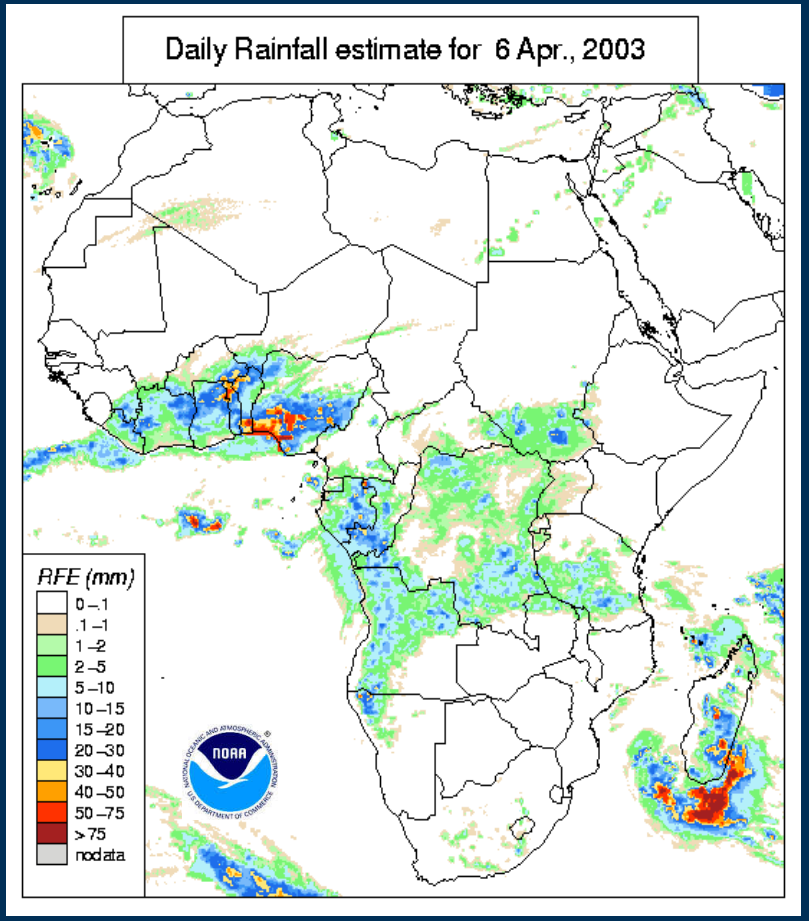
Monitoring Agricultural Drought for Famine Early Warning

- Use of satellite RFE since mid-1990s
- Blend TIR, MW, and station observations
- Soil moisture status calculated in crop water balance model



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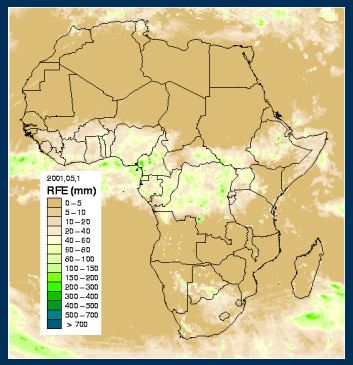
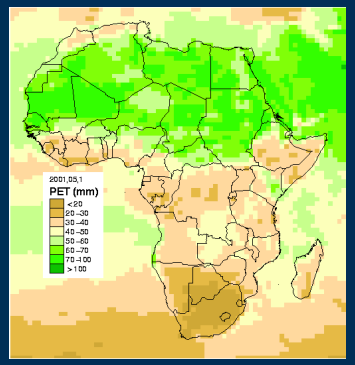
Water Requirement Satisfaction Index (WRSI)

WRSI = f (ppt, pet, WHC, Crop Type, SOS, EOS, LGP)

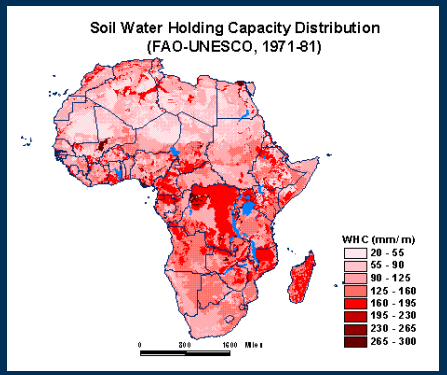
RFE (NOAA)



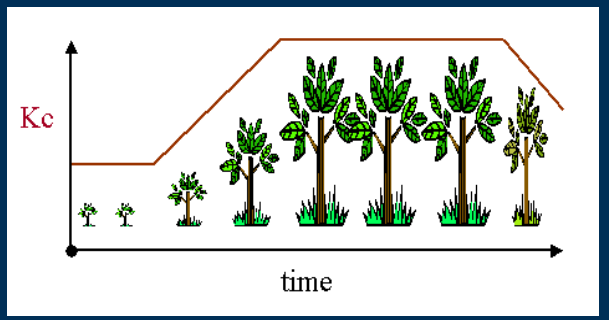
calculated from NOAA GDAS at EROS



FAO soils map of the world



Kc (FAO)



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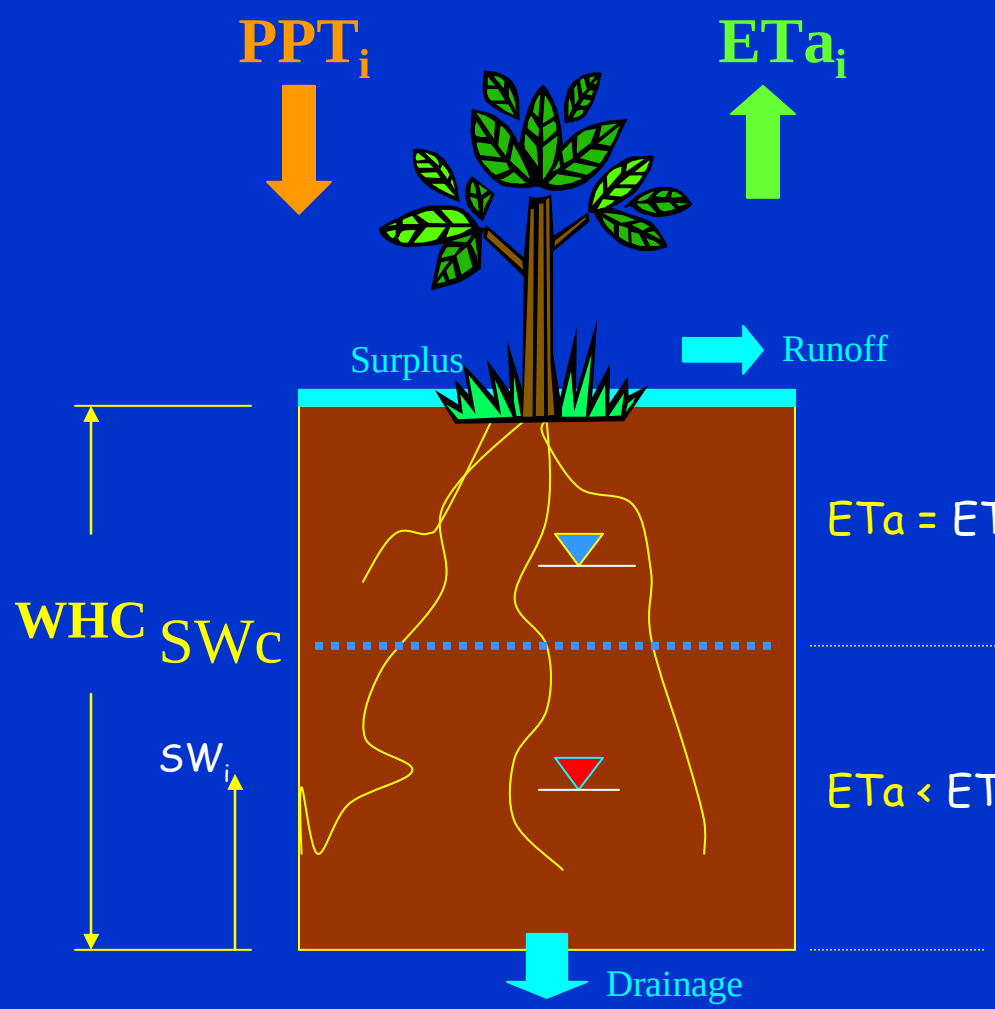
Crop Water Balance



$ETp = kc * ETo$

$ETa = ETp$ $\quad ETa = Kc * ETo$

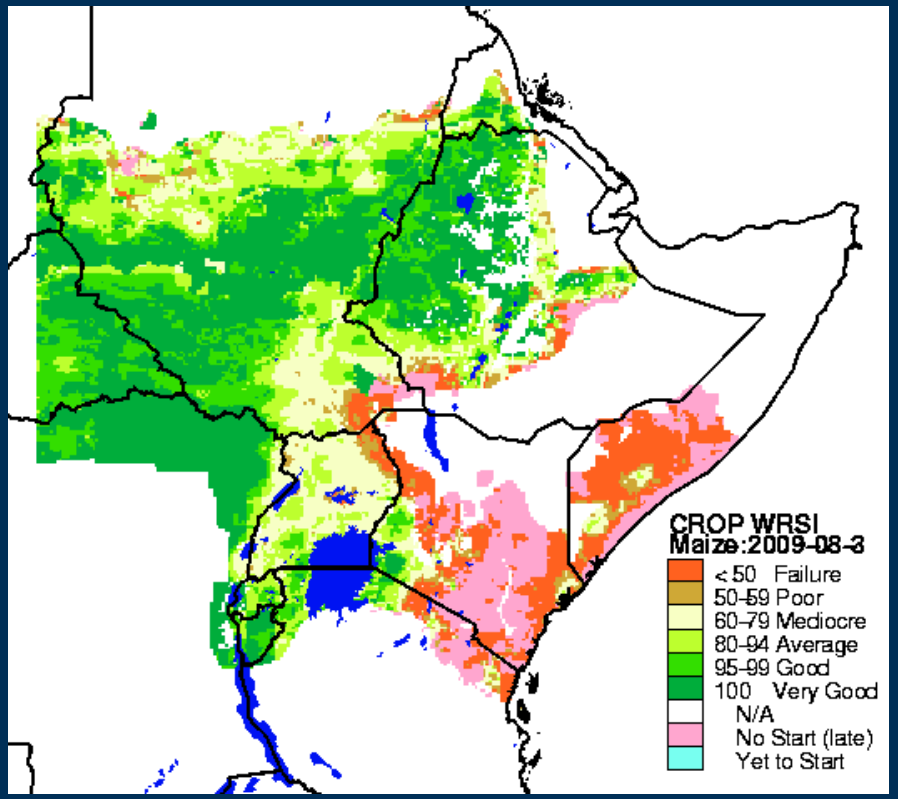
$ETa < ETp$ $\quad ETa = Ks * Kc * ETo$

$$Ks = \frac{SWi}{SWc}$$

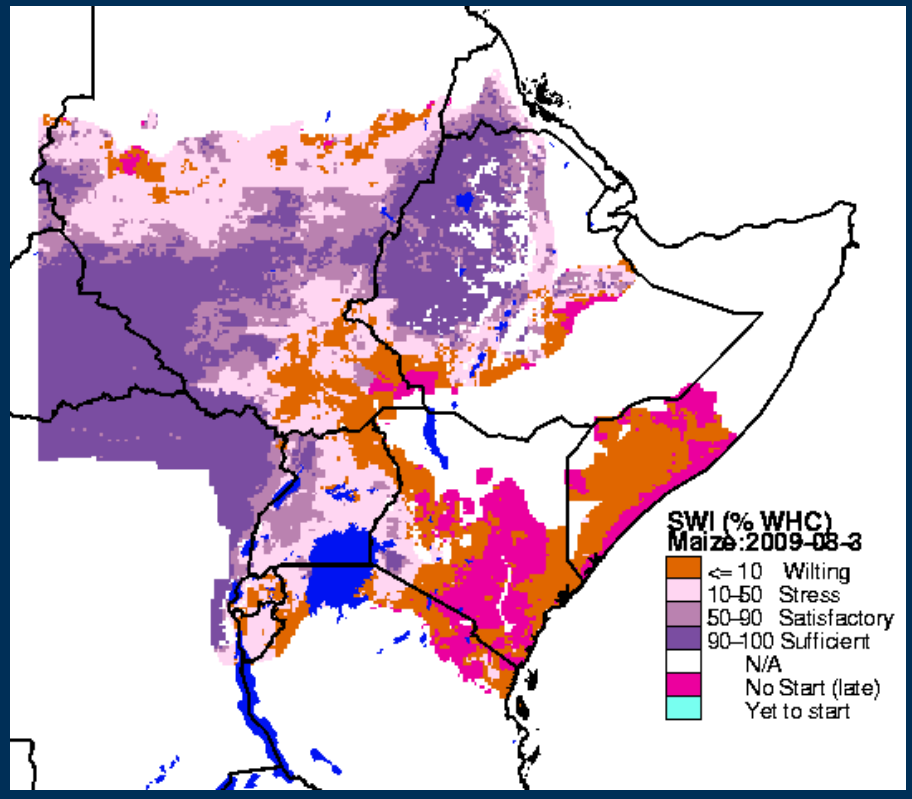
$$SW_i = SW_{i-1} + PPT_i - ETa_i - RF_i - DD_i$$

USGS science for a changing world

Monitoring Agricultural Drought for Famine Early Warning



WRSI



Soil Water Index

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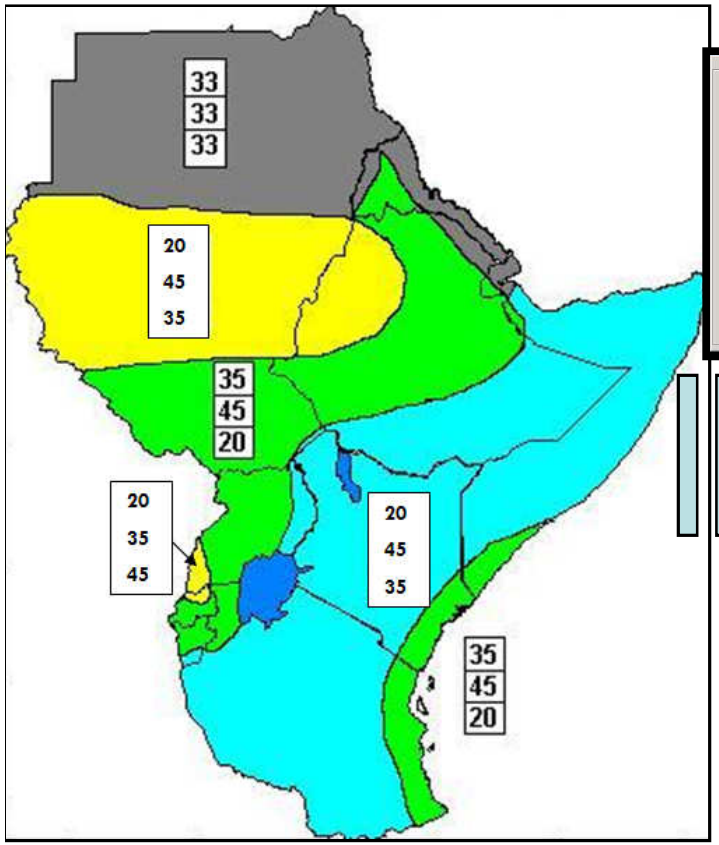
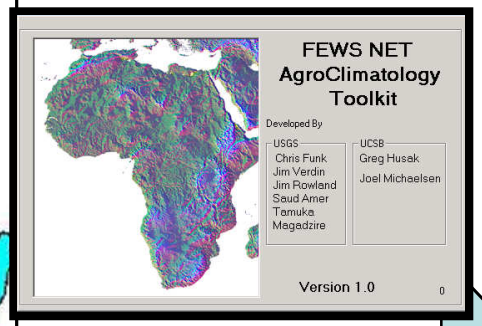
Monitoring Agricultural Drought for Famine Early Warning

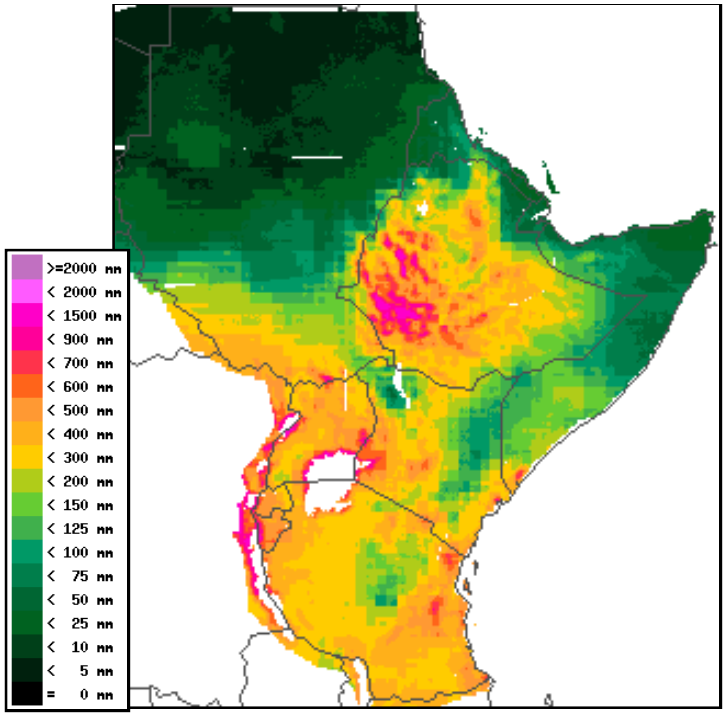
- **Many sources of uncertainty in Soil Water Index calculation:**
  - ***FAO Digital Soil Map of the World 1:5 M***
  - ***Satellite RFE***
  - ***Reference crop ET from atmospheric model analyses***
- **No source of soil moisture data with which to verify/validate**
- **An early opportunity for SMAP**

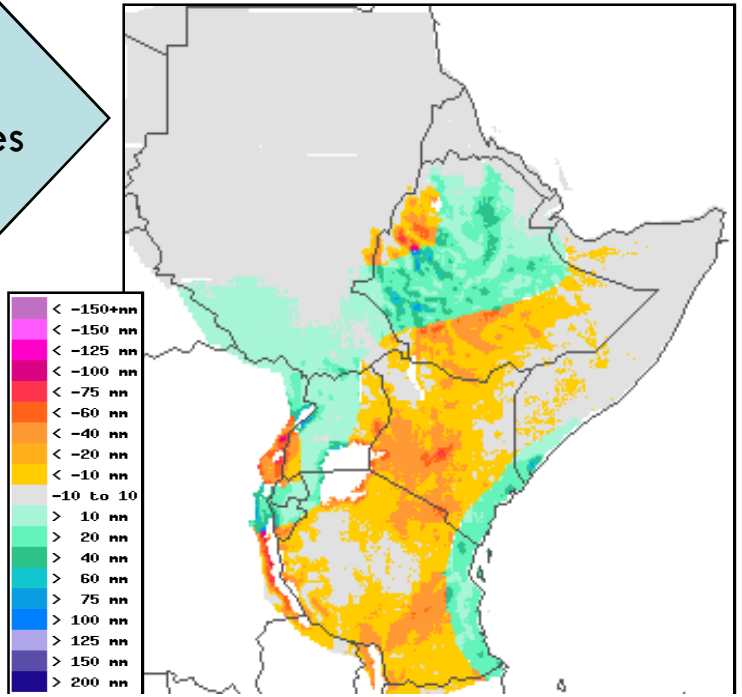
Seasonal Rainfall Forecasting and Interpretation with the Forecast Interpretation Tool (FIT)

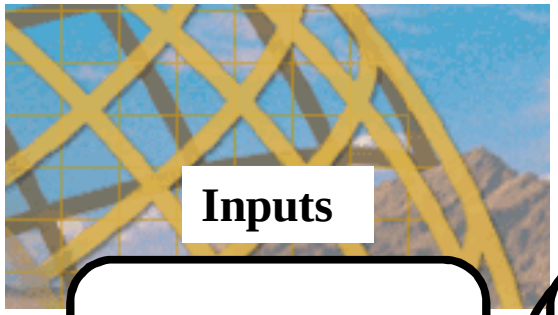




Translating prob.
Into rainfall anomalies







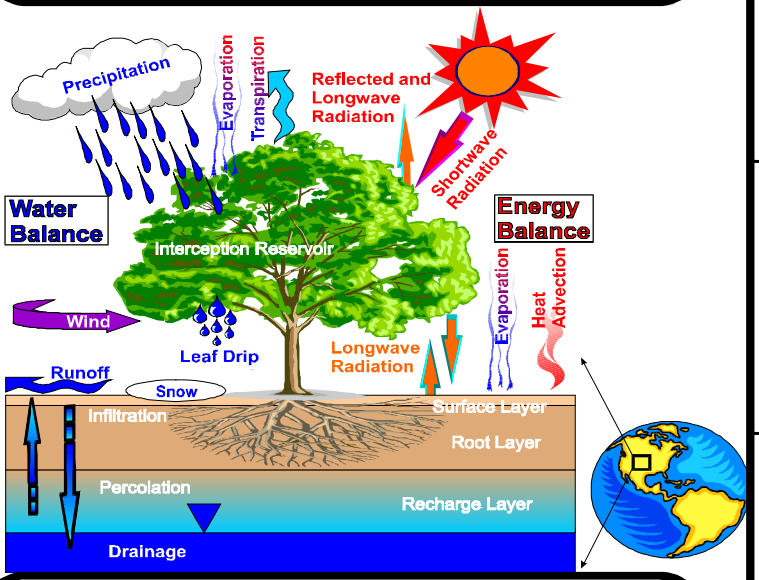
A LIS Instance for FEWS NET

Inputs

- Topography, Soils
- Land Cover, Vegetation Properties
- Meteorological Forecasts, Analyses, and/or Observations
- *Snow*
- *Soil Moisture*
- *Temperature*

Physics

- Land Surface Models (CLM, Noah, VIC, etc)



- *Data Assimilation Modules*

Outputs

- Soil Moisture & Temperature
- Evaporation Sensible Heat Flux
- Runoff
- Snowpack Properties

Applications

- Weather
- Climate
- Water Resources
- Agriculture
- Drought
- Natural Hazards

SMAP Applications – Initial Thoughts

Products with appeal for drought:

- L3_SM_A/P Radar-Radiometer Soil Moisture on Earth Grid at 10 km with 24 hr latency
- L4_SM Surface and Root Zone Soil Moisture on Earth Grid at 10 km with 7 day latency

SMAP Applications – Initial Thoughts

- Before launch, use findings of simulation field campaigns to provide a basis for mapping places and times of favorable/unfavorable vegetative cover
- Use within-season SMAP soil moisture spatial patterns, temporal evolution to check existing drought monitoring products

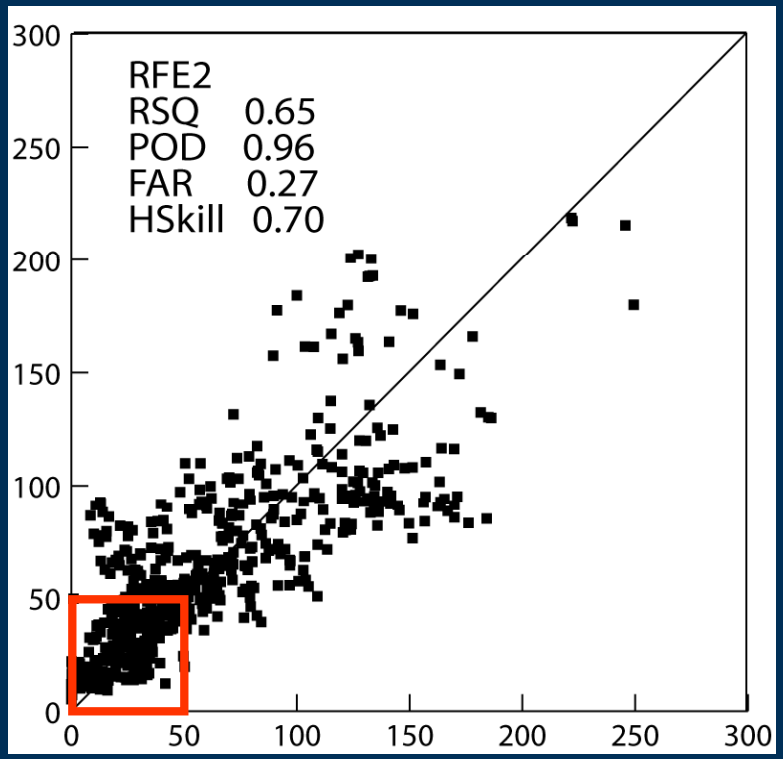
SMAP Applications – Initial Thoughts

- Explore use of SMAP products in conjunction with LST, NDVI products
- Assimilation of SMAP products by LSMs used to create hydrological re-analyses and seasonal forecasts of soil moisture and stream flow

Thank you

Importance of Precipitation Data

Satellite estimates are good at identifying low values (drought) because they are based on observed cloud properties



A GEO System of Systems for Agricultural Monitoring for Famine Early Warning

- Global trends: yield improvements not keeping pace with declining per capita cultivated area -> reduced availability
- Climate change: increased drought risk
- Global food crisis: unexpectedly rapid spikes in the price of food, fuel

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A GEO System of Systems for Agricultural Monitoring for Famine Early Warning - Near Term Needs

- Application of Land Surface Modeling
- Specifically for EW domains, data streams, and monitoring/forecast needs
- Ready integration of satellite EO, atmospheric model forcings (reanalyses, NWP, seasonal forecasts, GCM scenarios)
- Multi-model ensembles, est. uncertainty
- Take greater advantage of the work of the climate science community

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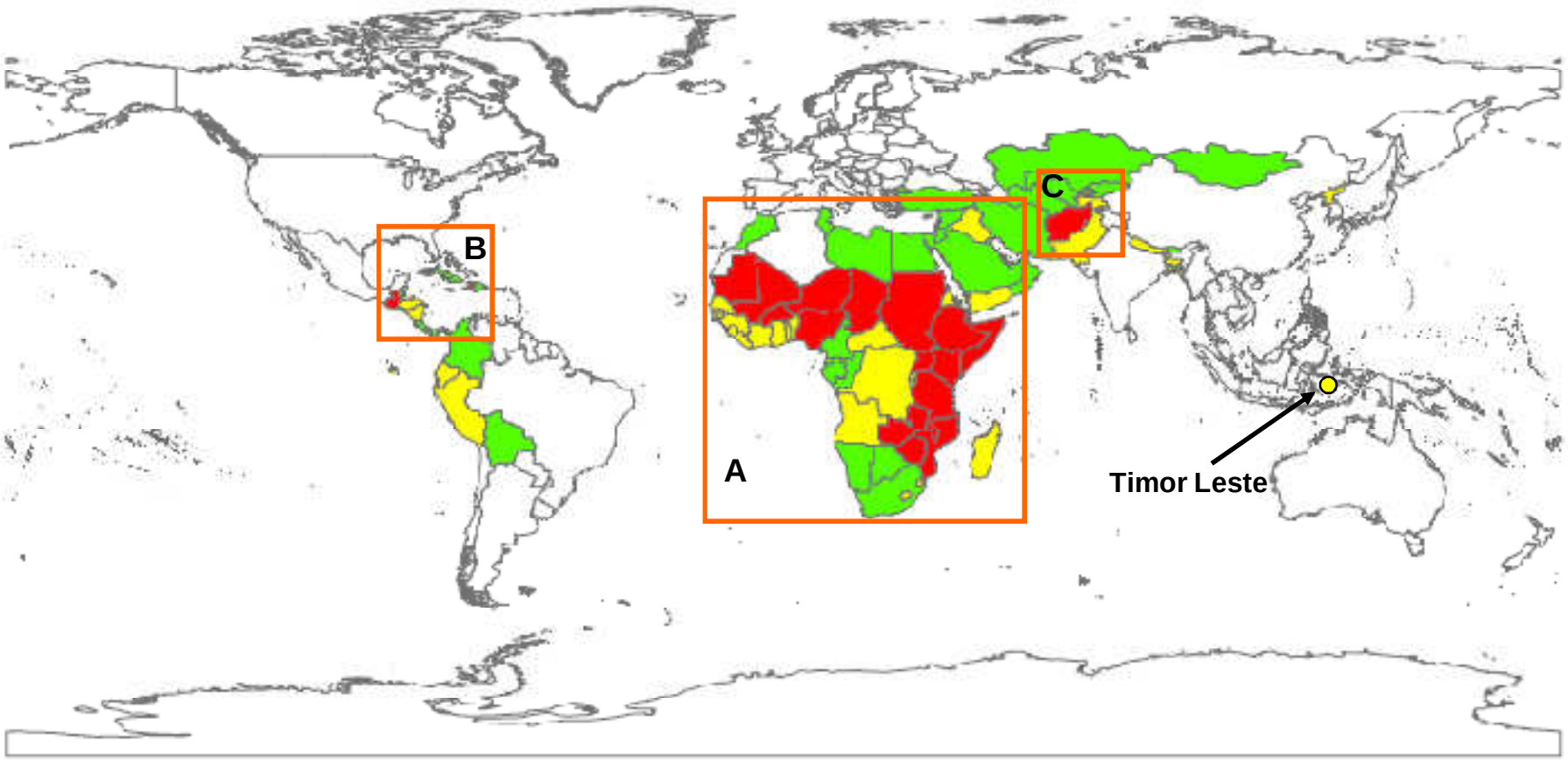
Proposed FEWS Operational Priority Countries



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Red – Current countries

Yellow – Weather/ag outcomes AND availability/access monitoring

Green – Weather/agricultural outcomes