A GOES-based Drought Product using Thermal Remote Sensing of Evapotranspiration

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Given known radiative energy inputs, how much water loss is required to keep the soil and vegetation at the observed temperatures?

**WATER BALANCE APPROACH**
("prognostic modeling")

**ENERGY BALANCE APPROACH**
("diagnostic modeling")
Sensitivity to irrigation

Landsat 7 – 60m

MODIS – 1km

ET

PET

0.0  0.2  0.4  0.6  0.8  1.0
Sensitivity to shallow water tables

Simulated climatological water table*  Temporal variability in ET/PET

* Miquez-Macho et al, BAMS, 90, 663-672
APPLICATIONS

... evapotranspiration

ALEXI – Atmosphere-Land Exchange Inverse Model

(Anderson et al, JGR, 2007)
Atmosphere-Land Exchange Inverse (ALEXI)

**Regional scale**
- **Surface temp:** $\Delta T_{RAD}$ - GOES
- **Air temp:** $T_a$ - ABL model

**Landscape scale**
- **$T_{RAD}$** - TM, MODIS, HyspIRI
- **$T_a$** - ALEXI

Available energy

\[
ET = (R_{NET} - G) - H
\]
APPLICATIONS
... monitoring drought

Anomalies in \( \frac{AET}{PET} \)
Evaporative Stress Index
SEASONAL ANOMALIES

Standardized anomalies
(April-Sept. wrt 2000-2009 normals)

Drier
-2σ
-1
0
1
2σ

Wetter

2000
2001
2002
2003
2004
2005
2006
2007
2008
2009

ΔUSDM
ESI
ΔSPI-3
ΔSMnoah
ΔETnoah
MONTHLY ANOMALIES

USDM  ΔUSDM  ESI-2  ΔSMnoah  ΔETnoah  ΔSPI-3

APR  MAY  JUN  JUL  AUG  SEP  OCT

Drier  Wetter  2007
2007 SEASONAL ANOMALIES

USDA AMSR-E MICROWAVE
- samples 5cm layer
- 50km pixels (AMSR)
- ~2-day coverage
- light vegetation cover

LIS – NOAH SM
- samples ~1-2m layer
- 60m - 5km pixels (L7, GOES)
- ~15-day coverage (90%)
- low to high vegetation cover

USDM

ALEXI GOES THERMAL
DUAL ASSIMILATION INTO NOAH

Noah run with degraded precip
Noah assimilating microwave SM
Noah assimilating TIR SM
Dual assimilation
METEOSAT APPLICATIONS

... Africa
Northeast Africa

METEOSAT COVERAGE

LAI

LST

L7-ETM+ 1/12/02 USGS Image Gallery
2009 APRIL-SEPTEMBER

Average ALEXI ET (MJ m⁻² d⁻¹)

Average ALEXI ET/PET
THERMAL REMOTE SENSING DATA HAVE GREAT UTILITY:

- multi-scale ET mapping
- drought monitoring
- soil moisture mapping

COMPLEMENTS INFORMATION FROM PRECIPITATION DATASETS
Geostationary Satellite Coverage

GOES W 135°W
NOAA (US)

GOES E 75°W
NOAA (US)

Meteosat 0°
Eumetsat (EU)

Meteosat 63°E
Eumetsat (EU)

GMS 140°E
JAXA (Japan)
August 2004
Midday latent heat flux (clear-sky composite)
Western Africa

ALMIP AMMA Land Surface Model Intercomparison Project

African Monsoon Multidisciplinary Analysis (CNRM, CESBIO)
ALEXI validation sites

- SMEX02/05
  - Bondville
  - Goodwin Creek
  - Gainesville
  - Walker Branch

- SMEX04
  - Audubon
  - Bushland
  - Everglades
  - CLASIC

- Other Sites
  - Fort Peck
  - Black Hills
  - BARC

- Scene Counts
  - 3 scenes
  - 1 scene
  - 10 scenes
  - 18 scenes
  - 2007

Effect of TIR resolution on validation

GOES (10 km) | MODIS (1 km) | Landsat (~100 m)

MAD: 75 Wm\(^{-2}\) (25%) | MAD: 63 Wm\(^{-2}\) (20%) | MAD: 47 Wm\(^{-2}\) (15%)