Data Fusion Techniques for Mapping Daily Water Use at Field Scales

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DATA FUSION: daily ET at field scale

1 July 2002 – 10:30AM LST
GOES/MODIS/Landsat FUSION

Daily Evapotranspiration – Orlando, FL, 2002

Spatial Temporal Adaptive Reflectance Fusion Model (STARFM) (Gao et al, 2006)
GOES/MODIS/Landsat FUSION

Daily Evapotranspiration – Orlando, FL, 2002

Spatial Temporal Adaptive Reflectance Fusion Model (STARFM) (Gao et al, 2006)

R²: 0.83 (9% error)
GOES/MODIS/HysPIRI Fusion

Daily Evapotranspiration – Orlando, FL, 2002

Spatial Temporal Adaptive Reflectance Fusion Model (STARFM) (Gao et al, 2006)
SMEX02
Soil Moisture Experiment 2002
Ames, Iowa
Rainfed corn and soybean

BEAREX08
Bushland ET and Remote sensing Experiment 2008
Bushland, Texas
Rainfed and irrigated cotton

MEAD
Ameriflux site (S. Verma)
Mead, NE
Rainfed and irrigation corn and soybean
Model performance on Landsat dates

**SMEX02**

- **MAE:** 1.08 MJ m\(^{-2}\) d\(^{-1}\)
- **RE:** 8%

**BEAREX08**

- **MAE:** 1.3 MJ m\(^{-2}\) d\(^{-1}\)
- **RE:** 10%

**MEAD**

- **MAE:** 1.3 MJ m\(^{-2}\) d\(^{-1}\)
- **RE:** 11%
Validation using flux tower data

Rainfed soybean – SMEX02 (Iowa)
Validation using flux tower data

Rainfed soybean – SMEX02 (Iowa)

Daily ET (mm per day)

Day of Year

Reference ET
Observed ET
Landsat retrievals
Landsat-only
Validation using flux tower data

Rainfed soybean – SMEX02 (Iowa)

Daily ET (mm per day)

Reference ET
Observed ET
Landsat retrievals
Landsat-only
Landsat-MODIS fusion

Day of Year
Validation using flux tower data

Rainfed soybean – SMEX02 (Iowa)

Daily ET (mm per day)

Cumulative ET (mm)

Day of Year

Reference ET

Observed ET

Landsat retrievals

Landsat-only

Landsat-MODIS fusion

RAIN

HyspIRI Workshop, 29 May 2013
SMEX02: soybean and stunted corn

HyspIRI Workshop, 29 May 2013
SMEX02 cumulative fluxes

Modeled cumulative flux (mm)

Observed cumulative flux (mm)

Landsat-only
Landsat-MODIS
(7% RE)
(4% RE)

$y = 1.0089x - 7.2676$
$R^2 = 0.8784$

$y = 1.2552x - 76.752$
$R^2 = 0.8699$

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Daily ET at field scale (Landsat+MODIS)
BEAREX08 and MEAD

Unirrigated cotton

Irrigated cotton

Irrigated corn

Unirrigated corn

ET (mm d\(^{-1}\))

DOY

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Applications for Remotely Sensed ET

WATER MANAGEMENT

DROUGHT MONITORING

FOOD AND WATER SECURITY
APPLICATIONS FOR SATELLITE ET

... Monitoring Drought
Evaporative Stress Index

1 month composite ending August 27, 2012

The Evaporative Stress Index (ESI) describes temporal anomalies in evapotranspiration (ET), highlighting areas with anomalously high or low rates of water use across the land surface. Here, ET is retrieved via energy balance using remotely sensed land-surface temperature (LST) time-change signals. LST is a fast-response variable, providing proxy information regarding rapidly evolving surface soil moisture and crop stress conditions at relatively high spatial resolution. The ESI also demonstrates capability for capturing early signals of “flash drought”, brought on by extended periods of hot, dry and windy conditions leading to rapid soil moisture depletion.

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Version 2.1.2
hrsl.arsusda.gov/drought/index.php
2012 FLASH DROUGHT

Figure 1. 2012 State Corn Yields as a Percent of Trend Yield.
Multiscale Drought/Stress Monitoring

GOES Evaporative Stress Index

JUNE 2002

MODIS (1 km)  Landsat (60 m)  MODIS (1 km)  Landsat (60 m)

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APPLICATIONS FOR SATELLITE ET

... Food and Water Security
Daily Evapotranspiration
9 February 2008

ALEXI ET over MENA Region
GEZIRA IRRIGATION SCHEME

ALEXI

NOAH

MOD16

LAI

JAN-FEB  MAR-APR  MAY-JUN  JUL-AUG  SEP-OCT  NOV-DEC

LAI (-)

ET (mm d⁻¹)

0 1 2 3

0 1 2 3 4
SUDD WETLAND

JAN-FEB  MAR-APR  MAY-JUN  JUL-AUG  SEP-OCT  NOV-DEC

ALEXI  NOAH  MOD16  LAI

LAI (-)  ET (mm d⁻¹)
**Satellite Evapotranspiration**

- Monitoring water use at field to continental scales
- Land-surface temperature conveys early warning of vegetation stress
- Independent check on precipitation-based drought indices
- Applications in global water and food security

*We can’t manage what we can’t measure* ...
African Monsoon Project

AMMA Land Surface Model Intercomparison Project

African Monsoon Multidisciplinary Analysis (CNRM, CESBIO)

Flux towers

BENIN

Mali

Niger

(MJ m\(^{-2}\) d\(^{-1}\))
MONTHLY AVERAGE LATENT HEAT

2007 JANUARY

(MJ m² d⁻¹)
Inland Niger Delta, MODIS
Lake Chad and Logone floodplain, MODIS
Given known radiative energy inputs, how much water loss is required to keep the soil and vegetation at the observed temperatures?
Correlations of ESI with corn yield

Corn yield dependence on ESI, 2000-2012

(Dave Johnson, NASS)
EXPANSION of IRRIGATION

Landsats 4,5,7 – visible, near infrared bands: vegetation amount
CONSUMPTIVE WATER USE

Landsat 8 – thermal infrared bands: vegetation status and water use

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