

# **Welcome to NASA Applied Remote Sensing Training Program (ARSET) Webinar Series**

## **Introduction to Remote Sensing Data for Land Management**

**Course Dates: Every Tuesday, May 20-June 17  
Time: 12-1PM EDT**

**ARSET**  
**Applied Remote SEnsing Training**

A project of NASA Applied Sciences



# Important Information

- Presentations URL:
  - [Http://arset.gsfc.nasa.gov/webinars](http://arset.gsfc.nasa.gov/webinars)
- Contact for requesting recorded link for the webinars:
  - Marines Martins: [marines.martins@ssaihq.com](mailto:marines.martins@ssaihq.com)
- ARSET Land ListServ URL:
  - <https://lists.nasa.gov/mailman/listinfo/nasa-water-training>
- Homework update: Click on the Homework #1 link at <http://arset.gsfc.nasa.gov/ecoforecasting/webinars/nasa-remote-sensing-land-management>

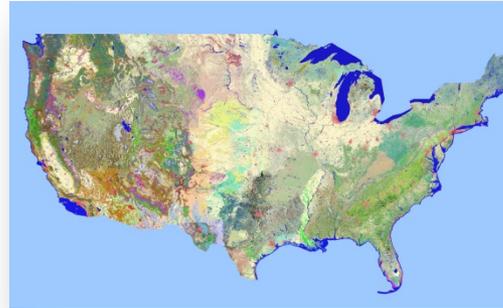
# Course Outline

## Week 1



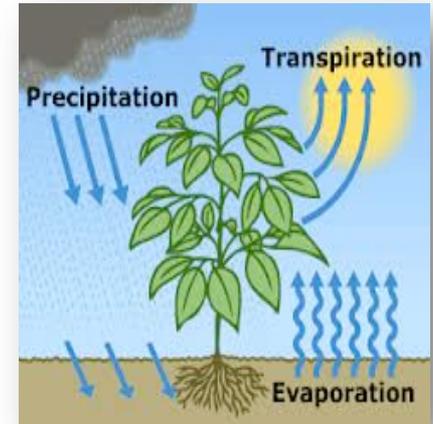
**Intro. & Background:  
Satellite Remote Sensing**

## Week 2



**Land Cover Mapping/  
Web tools for data  
access**

## Week 3



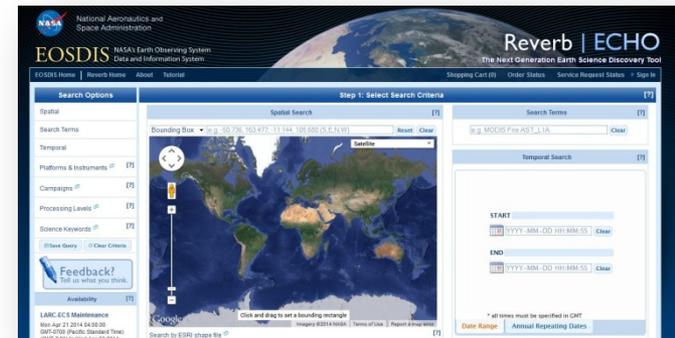
**Soil Moisture and  
Evapotranspiration**

## Week 4



**Change Detection**

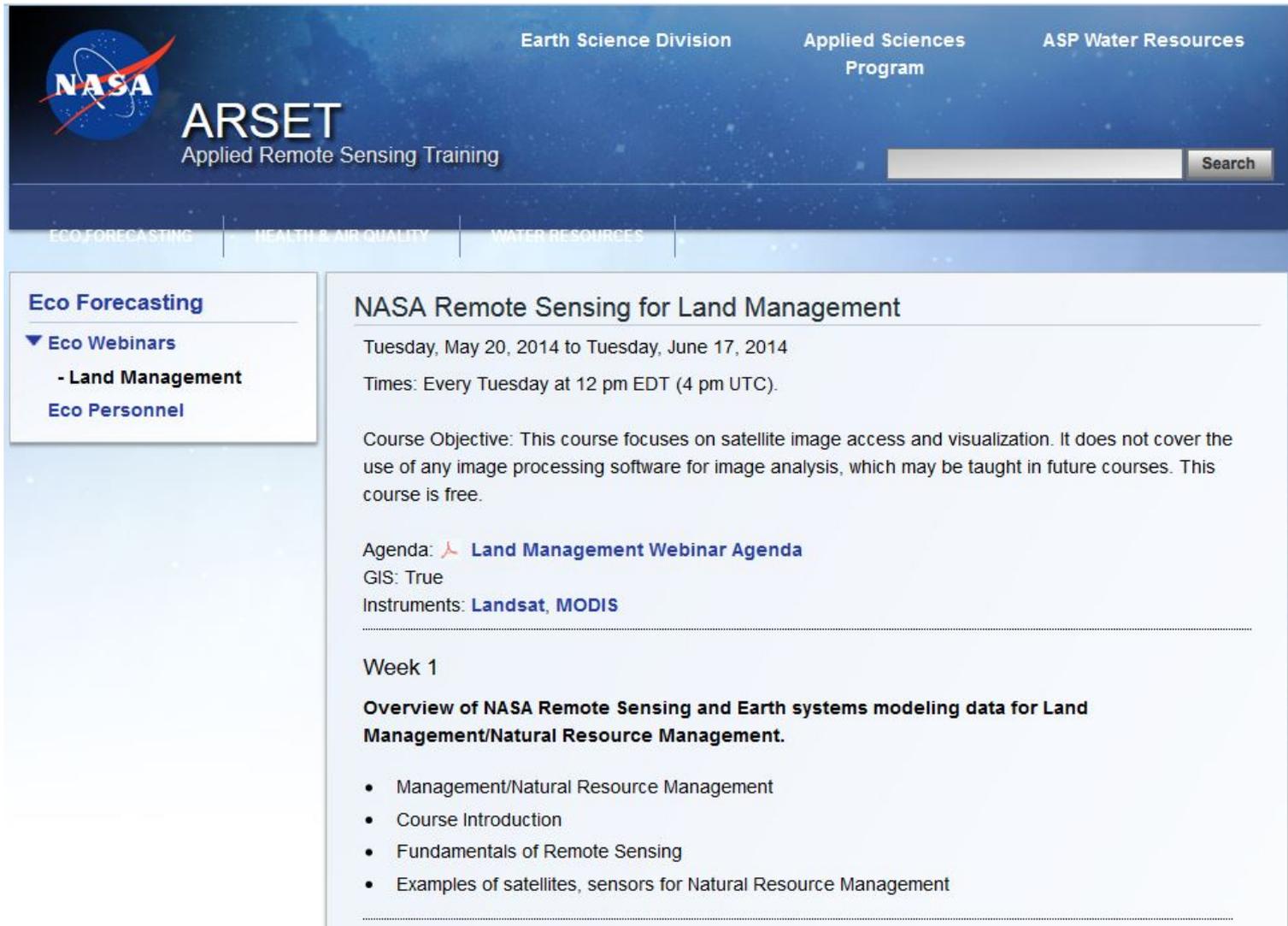
## Week 5



**Web tools for data access/  
Importing  
data into GIS**

# ARSET Land Resource Management

<http://arset.gsfc.nasa.gov/eco/webinars/land-management>



The screenshot shows the ARSET (Applied Remote Sensing Training) website. The header includes the NASA logo, the text 'ARSET Applied Remote Sensing Training', and navigation links for 'Earth Science Division', 'Applied Sciences Program', and 'ASP Water Resources'. A search bar is located on the right. Below the header, there are tabs for 'ECO FORECASTING', 'HEALTH & AIR QUALITY', and 'WATER RESOURCES'. The main content area is titled 'NASA Remote Sensing for Land Management' and provides details for a webinar held from May 20 to June 17, 2014, every Tuesday at 12 pm EDT. The course objective, agenda, GIS status, and instruments (Landsat, MODIS) are listed. A section for 'Week 1' includes an overview and a bulleted list of topics: Management/Natural Resource Management, Course Introduction, Fundamentals of Remote Sensing, and Examples of satellites, sensors for Natural Resource Management.

**ARSET**  
Applied Remote Sensing Training

Earth Science Division    Applied Sciences Program    ASP Water Resources

ECO FORECASTING    HEALTH & AIR QUALITY    WATER RESOURCES

**Eco Forecasting**

- ▼ Eco Webinars
  - Land Management
- Eco Personnel

## NASA Remote Sensing for Land Management

Tuesday, May 20, 2014 to Tuesday, June 17, 2014

Times: Every Tuesday at 12 pm EDT (4 pm UTC).

Course Objective: This course focuses on satellite image access and visualization. It does not cover the use of any image processing software for image analysis, which may be taught in future courses. This course is free.

Agenda: [Land Management Webinar Agenda](#)

GIS: True

Instruments: [Landsat](#), [MODIS](#)

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Week 1

**Overview of NASA Remote Sensing and Earth systems modeling data for Land Management/Natural Resource Management.**

- Management/Natural Resource Management
- Course Introduction
- Fundamentals of Remote Sensing
- Examples of satellites, sensors for Natural Resource Management

# Course Instructors for Today

- Cindy Schmidt (ARSET) –  
[Cynthia.L.Schmidt@nasa.gov](mailto:Cynthia.L.Schmidt@nasa.gov)
- Amita Mehta (ARSET) –  
[Amita.V.Mehta@nasa.gov](mailto:Amita.V.Mehta@nasa.gov)

# Outline

- **Soil Moisture**
  - Overview of satellites and sensors (including the upcoming SMAP sensor)
  - Models for soil moisture products
  - Web portals for data access
- **Evapotranspiration**
  - Definition
  - Challenges in measuring ET
  - Remote sensing methods

# **Soil Moisture**

# Soil moisture

- A critical component that depends primarily on water availability (precipitation) and demand (evapotranspiration)
- Depends on soil type and characteristics (terrain, vegetation, infiltration capacity)
- Indicator of hydrological drought conditions
- Influences surface run-off and flooding
- Influences ground water recharge
- Surface and root-zone level moisture very important for agriculture

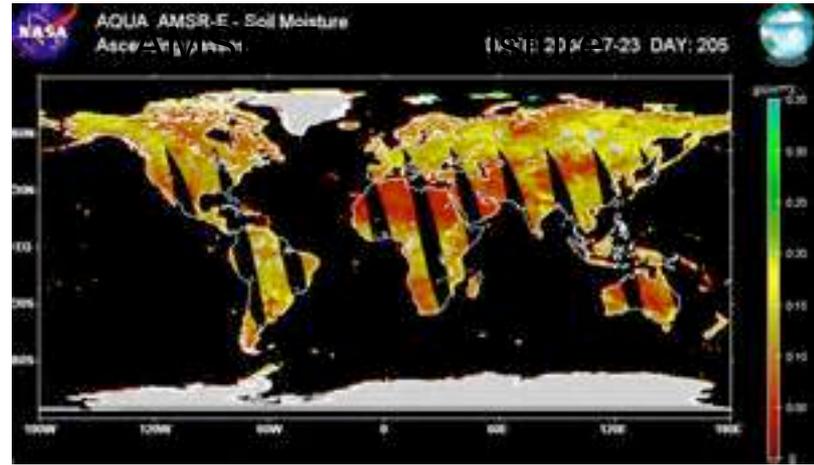
# NASA Remote Sensing Data for Rain and Snow

Satellite	Sensors	Quantities
<b>TRMM</b>	Precipitation Radar (PR) TRMM Microwave Imager (TMI) Visible Infrared Scanner (VIRS)	Rain Rate, Vertical Rain Rate Profile, Accumulated Rain
<b>Terra and Aqua</b>	MODERate Resolution Imaging Spectroradiometer (MODIS)	Snow Cover, Vegetation Index, Leaf Area Index, Land Cover
<b>Aqua</b>	Atmospheric Infrared Sounder (AIRS)  *Advanced Microwave Scanning Radiometer for EOS (AMSR-E)	3-dimensional Atmospheric Temperature and Humidity  Snow Water Equivalent, Sea Ice, Soil Moisture, Rain Rate
<b>Landsat</b>	(Enhanced) Thematic Mapper (ETM)	Vegetation Index, Leaf Area Index, Land Cover
<b>Grace</b>	K-Band Ranging Assembly	Terrestrial Water

\*Ended in October 2011

# Advanced Microwave Scanning Radiometer for EOS (AMSR-E)

- On-board Aqua – polar orbiting satellite
- Twelve-channel, six-frequency, passive-microwave 6.925, **10.65**, **18.7**, 23.8, 36.5, and 89.0 GHz
- **Surface Soil moisture** (top about 1 cm) and snow equivalent water
- Provides historical reference data



**Temporal Coverage: June 2000-September 2011**

**Temporal resolution: Daily, Monthly**

**Spatial Resolution: 0.25°x0.25°**

<http://nsidc.org/data/amsre/inex.html>

# Upcoming Mission : Soil Moisture Active Passive (SMAP)

<http://smap.jpl.nasa.gov/mission/>

**Expected Launch in October 2014**

**Orbit : Near-polar, sun-synchronous**

**Altitude: 685 km**

**Advanced instruments for measuring soil moisture will include:**

**Radar (1.26 Ghz) with high-resolution data over land**

Spatial resolution: 3 km grids

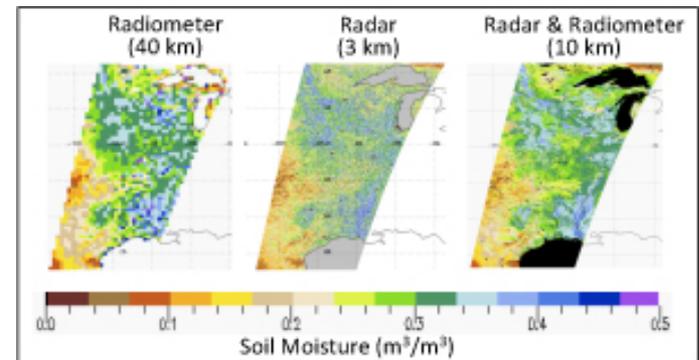
**Radiometer (1.41 Ghz)**

Swath size: 1000 km

Spatial Resolution : 39x47 km IFOV

**Spatial Coverage: Global**

**Temporal Coverage: Daily, 6 am/pm local time**



# SMAP Data Products

Data Product Short Name	Short Description	Gridding (Resolution)	Latency*
L1A_Radar	Radar raw data in time order	-	12 hours
L1A_Radiometer	Radiometer raw data in time order	-	12 hours
L1B_S0_LoRes	Low resolution radar $\sigma_o$ in time order	(5x30 km)	12 hours
L1B_TB	Radiometer $T_B$ in time order	(36x47 km)	12 hours
L1C_S0_HiRes	High resolution radar $\sigma_o$ (half orbit, gridded)	1 km (1-3 km)**	12 hours
L1C_TB	Radiometer $T_B$ (half orbit, gridded)	36 km	12 hours
L2_SM_A	Soil moisture (radar, half orbit)	3 km	24 hours
L2_SM_P	Soil moisture (radiometer, half orbit)	36 km	24 hours
L2_SM_A/P	Soil moisture (radar/radiometer, half orbit)	9 km	24 hours
L3_F/T_A	Freeze/thaw state (radar, daily composite)	3 km	50hours
L3_SM_A	Soil moisture (radar, daily composite)	3 km	50 hours
L3_SM_P	Soil moisture (radiometer, daily composite)	36 km	50 hours
L3_SM_A/P	Soil moisture (radar/radiometer, daily composite)	9 km	50 hours
L4_SM	Soil moisture (surface & root zone)	9 km	7 days
L4_C	Carbon net ecosystem exchange (NEE)	9 km	14 days

\* Mean latency under normal operating conditions (defined as time from data acquisition by the observatory to availability to the public data archive). The SMAP project will make a best effort to reduce these latencies.

\*\* Over outer 70% of the swath.

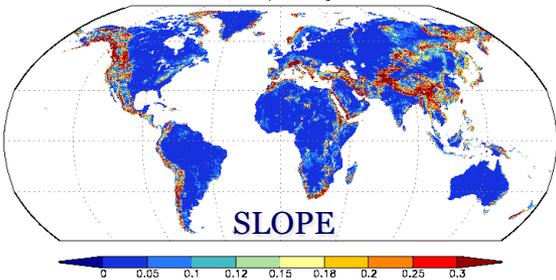
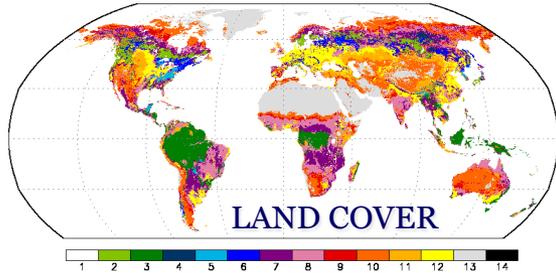
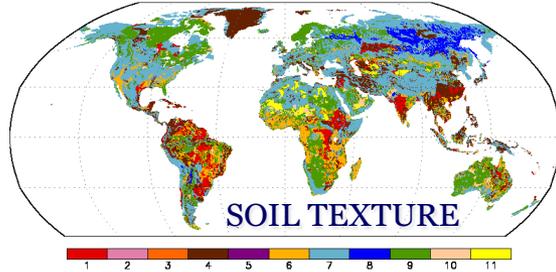
# NASA Models for Soil Moisture and Evapotranspiration

Models	Quantities
<b>GLDAS/NLDAS</b>	<b>Evapotranspiration, Multi-layer Soil Moisture</b> , Rainfall, Snowfall Rate, Snow Melt, Snow-Water Equivalent, Surface and Sub-surface Runoff

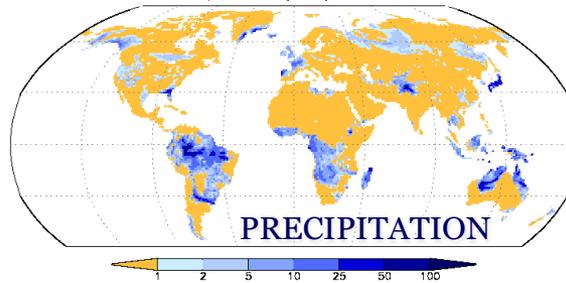
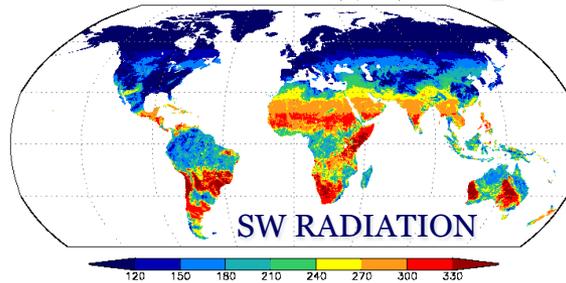
# Global Land Data Assimilation System (GLDAS)

**GOAL:** Integrate ground and satellite observations within sophisticated numerical models to produce physically consistent, high resolution fields of land surface states (e.g., snow) and fluxes (e.g., evaporation)

## Parameter Inputs

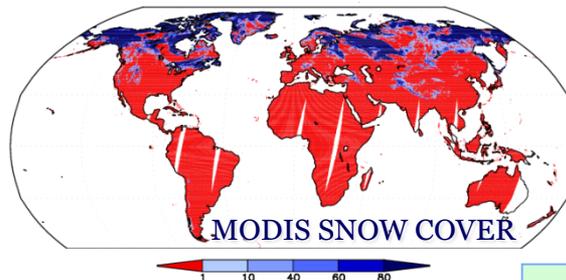


## Satellite Based Forcing



**AVAILABILITY:** Output from 1979-present simulations of Noah ( $1/4^\circ$ ;  $1^\circ$ ), CLM ( $1^\circ$ ), and Mosaic ( $1^\circ$ ), and VIC ( $1^\circ$ ), at <http://disc.gsfc.nasa.gov/hydrology/index.shtml>

## Assimilated Observations



**USES:** Weather and climate forecast initialization studies, water resources applications, hydrometeorological investigations

## Integrated Output

Soil Moisture  
Evapotranspiration  
Snow Water Equivalent  
Run Off

# North-American Land Data Assimilation System (NLDAS)

- A collaboration project among : NOAA/NCEP's Environmental Modeling Center ([EMC](#)), NASA's Goddard Space Flight Center ([GSFC](#)), [Princeton University](#), the [University of Washington](#), the NOAA/NWS Office of Hydrological Development ([OHD](#)), and the NOAA/NCEP Climate Prediction Center ([CPC](#))
- Spatially and temporally consistent, land-surface model (LSM) datasets from the **best available observations and model output.**
- Currently running in near real-time on a [1/8th-degree](#) grid over central North America; retrospective NLDAS datasets and simulations also extend back to [January 1979](#).

# NASA Multi-layer Soil Moisture Data

## Land-Atmosphere Models:

- Global Land Data Assimilation System (**GLDAS**)
- North American Data Assimilation System (**NLDAS**)

Temporal Coverage: 1979-present

Spatial Resolution: (1/8°, 1/4°, 1° )

# GLDAS/NLDAS: Giovanni Hydrology Portal

<http://giovanni.gsfc.nasa.gov/>

The screenshot shows the NASA GIOVANNI website interface. At the top, there is a NASA logo and the text "GES DISC Goddard Earth Sciences Data and Information Services Center". A search bar is located in the top right corner. Below the header, there are navigation tabs for "GES DISC Home", "Data Services", "Science Portals", and "Mission Portals". A secondary navigation bar contains links for "Analyze Data with Giovanni", "Search for Data with Mirador", "Simple Subset Wizard", and "More...". A banner image features the text "Giovanni - The Bridge Between Data and Science" over a collage of satellite and weather data images.

The main content area is titled "Giovanni" and includes a breadcrumb trail: "You are here: GES DISC Home » Giovanni » Overview » Giovanni". Below this, there are two tabs: "Giovanni Portals" (selected) and "Giovanni Parameter List". The "Giovanni Portals" section is expanded to show a list of categories:

- ▶ Atmospheric Portals (scroll down to view complete list)
- ▶ Application and Education Portals
- ▶ Meteorological Portals
- ▶ Ocean Portals
- ▶ Hydrology Portals
  - [Global Land Data Assimilation System Monthly Data](#)
  - [Global Land Data Assimilation System 3-Hourly Data](#)
  - [North American Land Data Assimilation System Hourly Data](#)
  - [TRMM Online Visualization and Analysis System \(TOVAS\)](#)

A red rectangular box highlights the three links under the "Hydrology Portals" category. On the left side, there is a sidebar with an "OVERVIEW" section containing links like "What is Giovanni?", "Who Uses Giovanni?", and "Giovanni Parameters". Below that is an "Additional Features" section with links for "News", "Users Manual", "Publications", "Newsletters", "Feedback", and "FAQ". A blue arrow points to the "FAQ" link. On the right side, there is a vertical "Hide News" button.

# GLDAS/NLDAS: Giovanni Hydrology Portal

<http://giovanni.gsfc.nasa.gov/>

The screenshot displays the Giovanni Hydrology Portal interface. A red oval highlights a list of data products under the heading "NLDAS-2 Noah Model (0.125x0.125 degree) monthly climatology (1980/01/01 - 2009/12/31)". The list includes various soil moisture and availability parameters. Below the list is a "Temporal" section with "Begin Date" and "End Date" fields, each with a "Month" dropdown menu set to "Dec". At the bottom, there is a "Select Visualization:" section with a dropdown menu set to "Lat-Lon map, Time-averaged", and buttons for "Edit Preferences" and "Visualization Help". At the very bottom, there are "Generate Visualization" and "Reset" buttons.

Product Name	ID	Model	Time Range
<input type="checkbox"/> NLDAS-2 Noah Model (0.125x0.125 degree) monthly climatology (1980/01/01 - 2009/12/31)			
<input type="checkbox"/> Soil moisture availability (root zone, 0-100 cm)	NLDAS_NOAH0125_MC.002	Noah Model	1980/01 - 2009/12
<input type="checkbox"/> Soil moisture availability (total column, 0-200 cm)	NLDAS_NOAH0125_MC.002	Noah Model	1980/01 - 2009/12
<input type="checkbox"/> Soil moisture content (layer 1, 0-10 cm)	NLDAS_NOAH0125_MC.002	Noah Model	1980/01 - 2009/12
<input type="checkbox"/> Soil moisture content (layer 2, 10-40 cm)	NLDAS_NOAH0125_MC.002	Noah Model	1980/01 - 2009/12
<input type="checkbox"/> Soil moisture content (layer 3, 40-100 cm)	NLDAS_NOAH0125_MC.002	Noah Model	1980/01 - 2009/12
<input type="checkbox"/> Soil moisture content (layer 4, 100-200 cm)	NLDAS_NOAH0125_MC.002	Noah Model	1980/01 - 2009/12

**Temporal**

Begin Date: [ ] Month: Dec

End Date: [ ] Month: Dec

**Select Visualization:**

Lat-Lon map, Time-averaged [v] [Edit Preferences](#) [Visualization Help](#)

[Generate Visualization](#) [Reset](#)

# NLDAS Soil Moisture – A Major Component of Drought Monitoring

US and Global Drought, Drought Monitoring, Drought Forecast, Current Forecast - Mozilla Firefox

File Edit View History Bookmarks Tools Help

US and Global Drought, Drought Monitoring... +

hydrology.princeton.edu/forecast/current.php

drought monitor and soil moisture

## Drought Monitoring and Hydrologic Forecasting with VIC

Nowcast/Forecast | Historical Droughts/Hindcast | Documentation | About the Project

As of 2012/05/01, CFS forecasts are switched to CFSv2. Hover mouse on items to see more info.

Product/Date/Variable (click to change)

Monitoring validated < 2013/10/10 > for  Soil Moisture  Snow  Streamflow  Precipitation

Forecast initialized < 2013/10/01 > for  Soil Moisture  Drought Probability

PRINCETON UNIVERSITY

Total Column Soil Moisture Percentiles for 2013/10/10  
based on VIC Simulations forced with NLDAS-2  
(w.r.t. samples within a 49-day window in 1951-2004)

Contours show the changes in quantiles in the past 7 days.

1 5 10 20 30 70 80 90 95 99

Link to Image

Timeline (click & hover to change)

2013/08/08  
2013/08/15  
2013/08/22  
Preceding 2013/09/29  
Monitoring 2013/09/05  
2013/09/12  
2013/09/19  
2013/09/26

Forecast	CFS	CPC	ESP
2013/10	0.5mo	0.5mo	0.5mo
2013/11	1.5mo	1.5mo	1.5mo
2013/12	2.5mo	2.5mo	2.5mo
2014/01	3.5mo	3.5mo	3.5mo
2014/02	4.5mo	4.5mo	4.5mo
2014/03	5.5mo	5.5mo	5.5mo

Monitoring from other centers:

- US Drought Monitor
- USGS Streamflow/Drought
- CPC Drought Severity
- CPC Soil Moisture
- UW Surface Water Monitor
- NLDAS Drought Monitor

Website created by Lifeng Luo and maintained by Ming Pan  
EEWR/CEE, Princeton University  
Last update: Wed Feb 6 12:52:11 2013 EST

# Soil Moisture Applications

- Agriculture:** Prediction of agricultural productivity, famine early warning, crop monitoring
- Natural Disaster:** Drought early warning and decision support, Improved flood forecasting and mapping, soil infiltration condition
- Weather:** More accurate rainfall prediction
- Water resources:** Regional water balance and effective governance

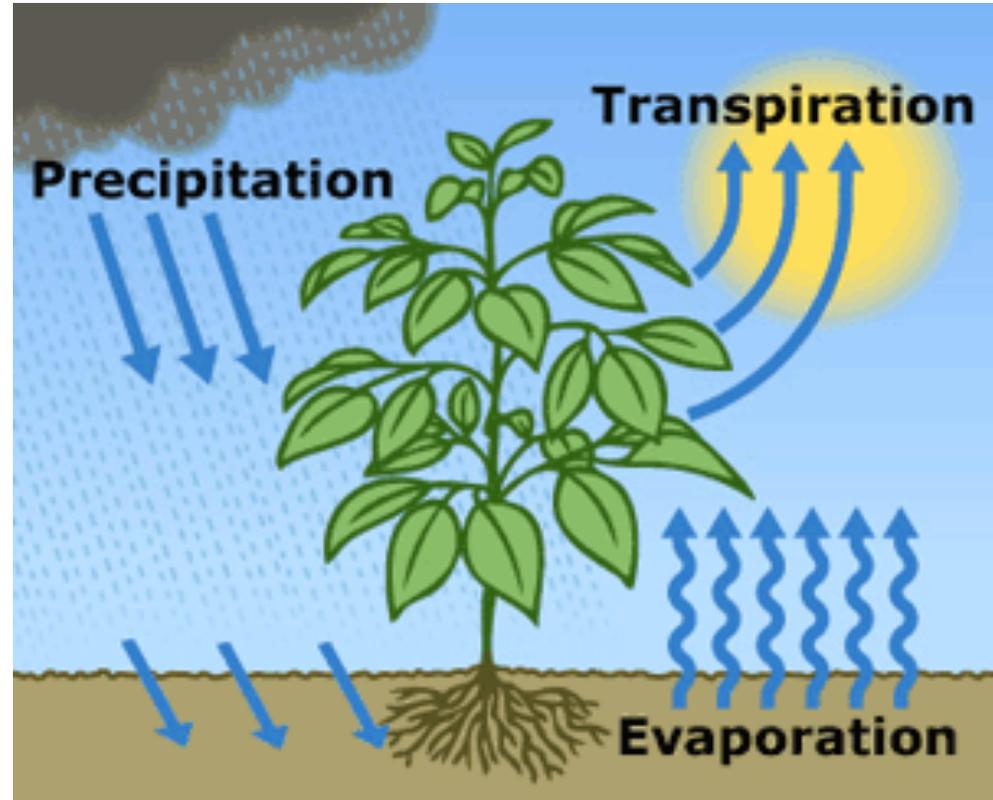
# Evapotranspiration

# Overview

- Importance of ET
- Challenges of Measuring ET
- Benefits and opportunities of using remote sensing for ET
- Methods of deriving ET using remote sensing:
  - Pros and Cons
  - Applications of ET
- Summary

# What is Evapotranspiration?

The sum of evaporation from the land surface plus transpiration from plants



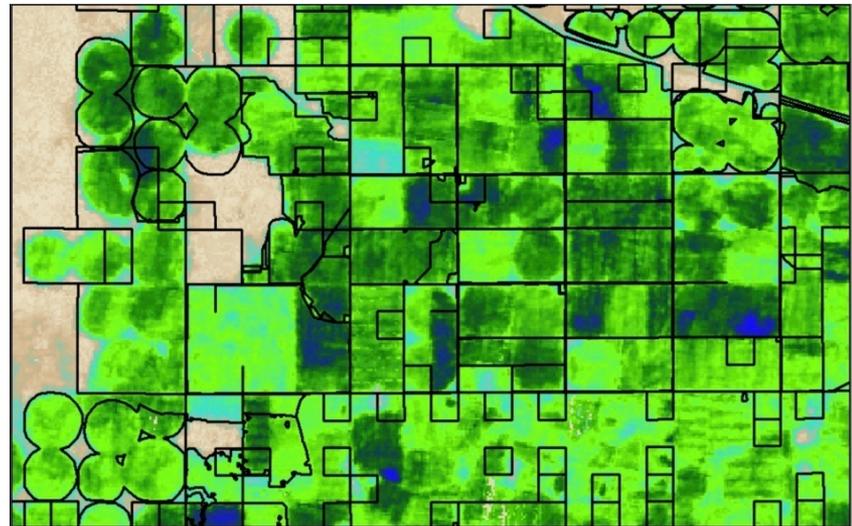
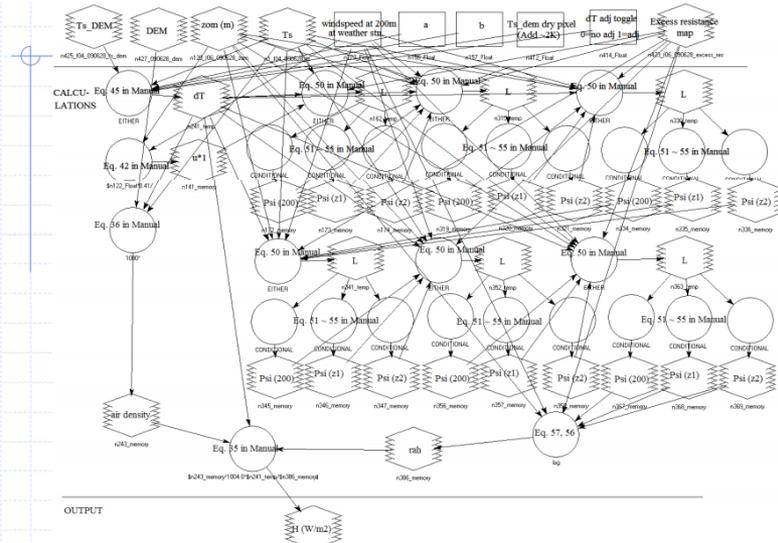
Source: USGS

# Importance of ET

- Critical component of water and energy balance of climate-soil-vegetation interactions.
- Used for
  - Determining agricultural water consumption
  - Assessing drought conditions on vegetation
  - Understanding ecosystem productivity (especially in water-limited areas)

# Challenges of Measuring ET

- ET is complex (many variables)
- ET varies across time and space (A LOT!)



# Main Limitation of ET Ground Measurements

They are point measurements and cannot capture spatial variability



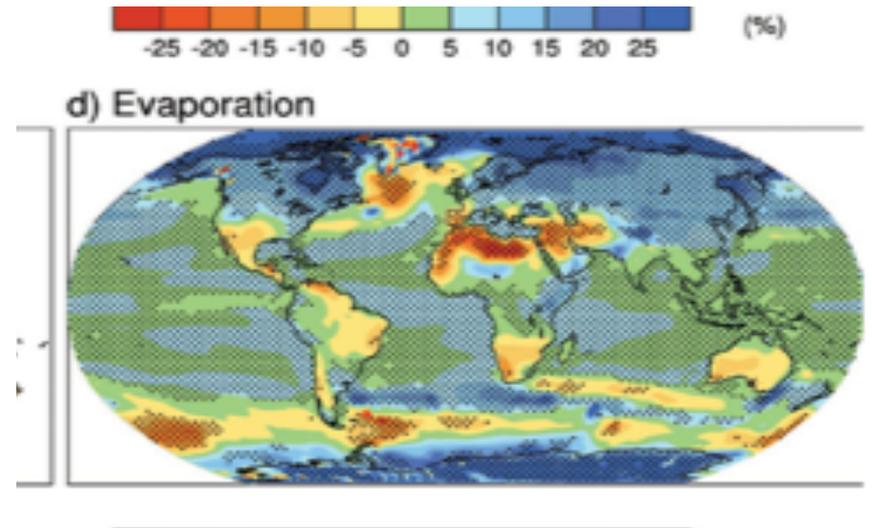
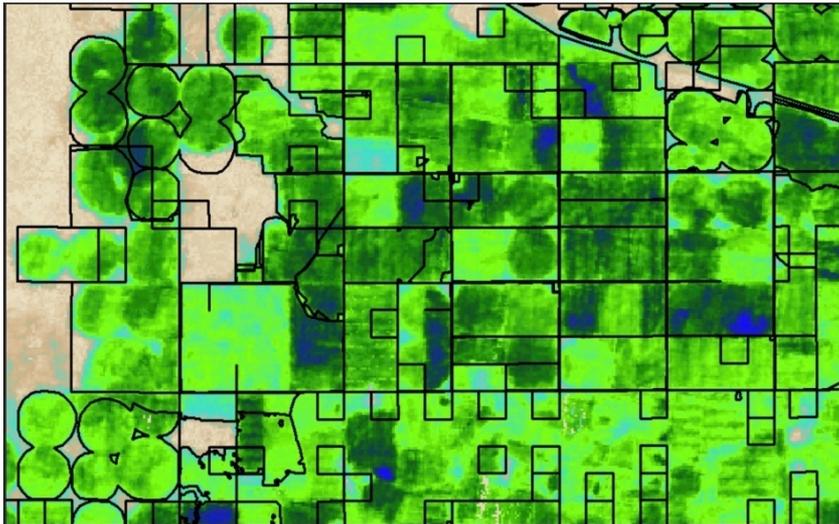
Eddy Flux Towers



Lysimeters

# Benefits of Using Remotely Sensed Satellite Data

- Provides relatively frequent and spatially continuous measurement of biophysical variables at different spatial scales:
  - Radiation
  - Vegetation coverage and density



# Methods for Deriving ET

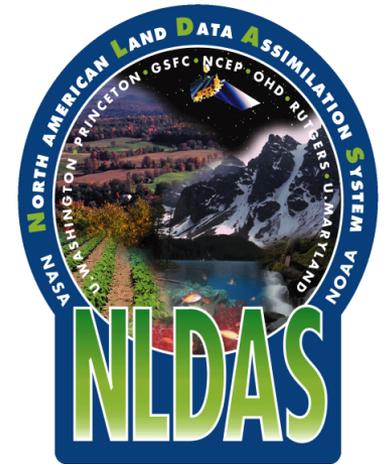
Method	Spatial Resolution	Source	Availability
Land Surface Models: NLDAS/GLDAS	1 - 1/8 degree (Global)	NASA/NOAA	Free/download
Other Physical Models: MODIS	1km (Global)	University of Montana	Free/download
Energy Balance: METRIC/SEBAL	30 m (Local, Regional)	Various	Not Free/contract
Vegetation/ET Relationships	30 m (Local, Regional)	Various	Free/Not Free
ALEXI/ DisALEXI	10 km – 30 m	USDA	Not yet available

**METHODS FOR DERIVING ET:**

**NASA'S LAND DATA  
ASSIMILATION SYSTEM**

# NASA's Land Data Assimilation System (LDAS)

- Use uncoupled land surface models forced with real time output from:
  - Numerical prediction models
  - Satellite data
  - Precipitation measurements
- Provides hourly information in 1/8<sup>th</sup> degree in near real-time
- Extends back to 1979
- GLDAS (global) and NLDAS (North America)
- Can access data through NLDAS Drought Monitor (NOAA), Giovanni



# NLDAS Drought Monitor

## Evapotranspiration

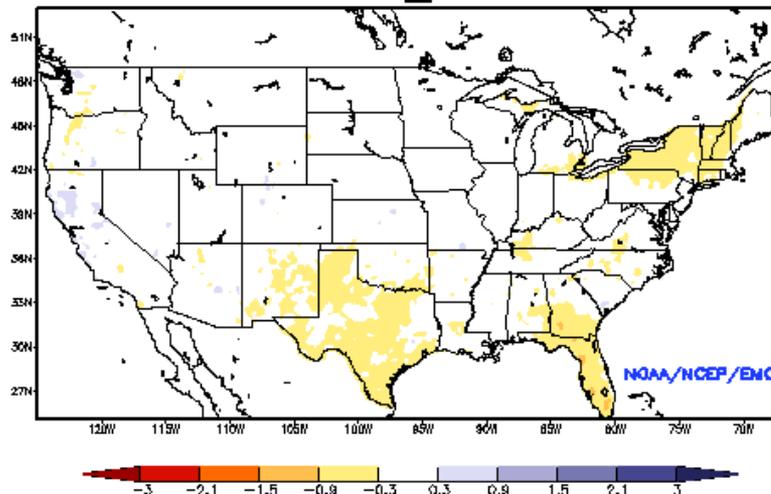
**NOTE: This page is best viewed with a screen resolution of at least 1024x768**

**DISCLAIMER: Any data provided on this server should be used for research or educational purposes only. This data should NOT be relied on for any operational use as data gaps can occur due to hardware failure and/or model upgrading procedures.**

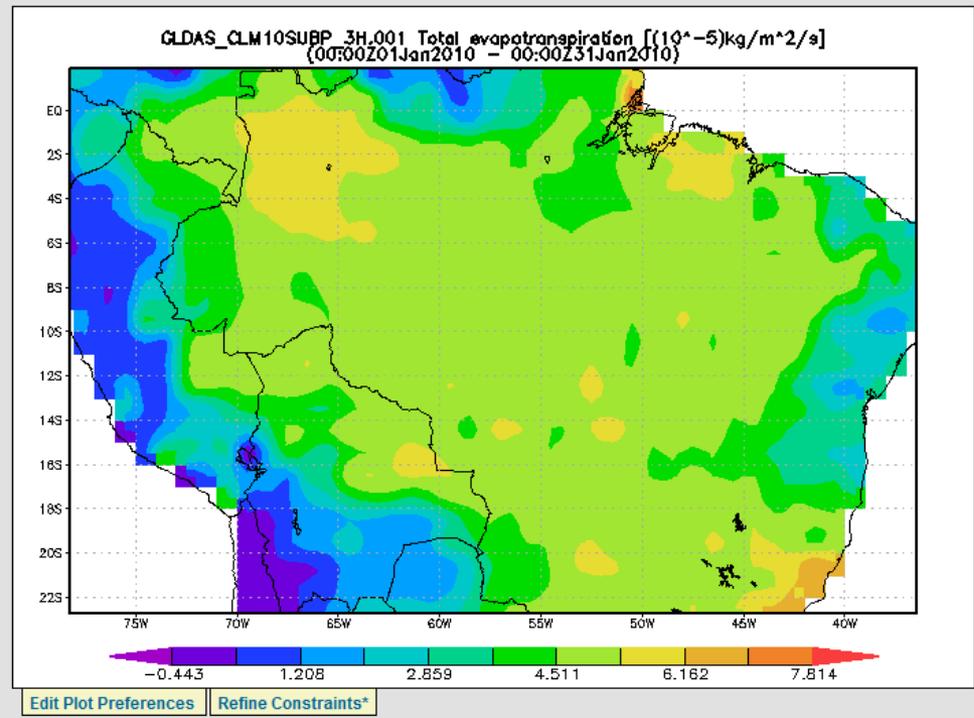
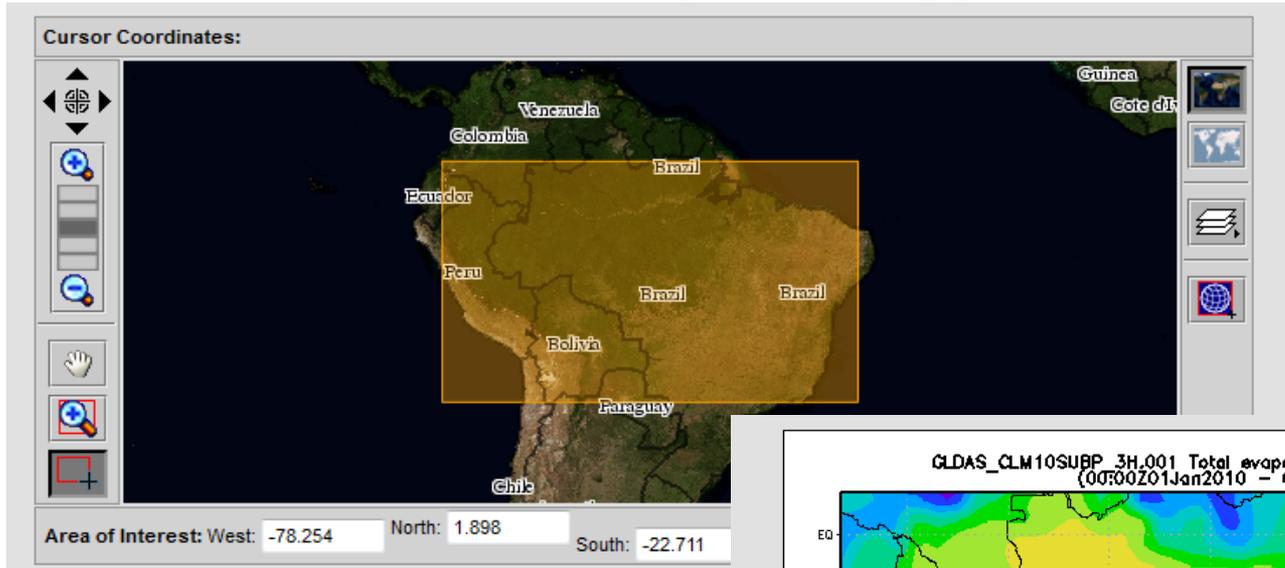
### Ensemble Mean LSM OUTPUT:

Current Evapotranspiration Anomaly

Ensemble-Mean: Current Evaporation Anomaly (mm/day)  
NCEP NLDAS Products Valid: NOV 17, 2012



# Total ET From GLDAS Using Giovanni Hydrology Portal



Brazil

**METHODS FOR DERIVING ET:**

**MODIS**

# **MODIS-based Global Evapotranspiration and Drought Severity Index products**

**Qiaozhen Mu, Maosheng Zhao, Steven W. Running**

Numerical Terradynamic Simulation Group (NTSG), College  
of Forestry & Conservation, The University of Montana,  
Missoula

What is MODIS????

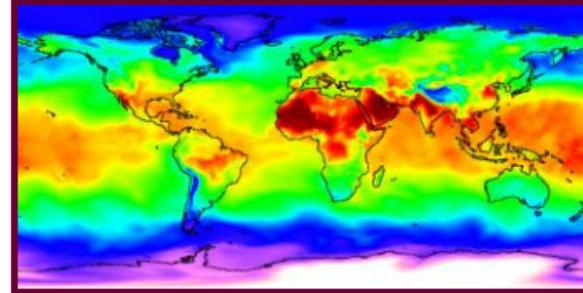
# What Is MODIS?

- Moderate Resolution Imaging Spectrometer
- Launched on Terra: December 1999
- Launched on Aqua: May 2002
- Spatial Resolution: 250m, 500m, 1km
- Temporal Resolution: Daily, 8-day, 16-day, monthly, quarterly, yearly
- 36 bands:
  - Radiation Budget (Surface Reflectance, Temperature, Albedo)
  - Ecosystem Variables (Vegetation Indices, Leaf Area Index, etc.)
  - Land Cover Characteristics (Fire, Land Cover)

# MODIS and ET



Input MODIS data (RS)  
(Albedo, FPAR/LAI, Land cover)



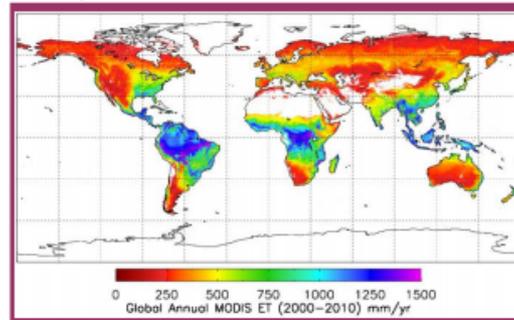
Daily Meteorological data (MET)  
( $S_{\downarrow}$ , VPD, Temperature. No Precp!)

## Penman-Monteith equation

$$\lambda E = \frac{\Delta \cdot R_a \cdot (R_n - G) + \rho \cdot C_p \cdot VPD}{R_a \cdot (\gamma + \Delta) + \gamma \cdot R_s}$$

MODIS ET: soil evaporation, evaporation from intercepted water by canopy and plant transpiration.

$$ET = f(RS, MET)$$

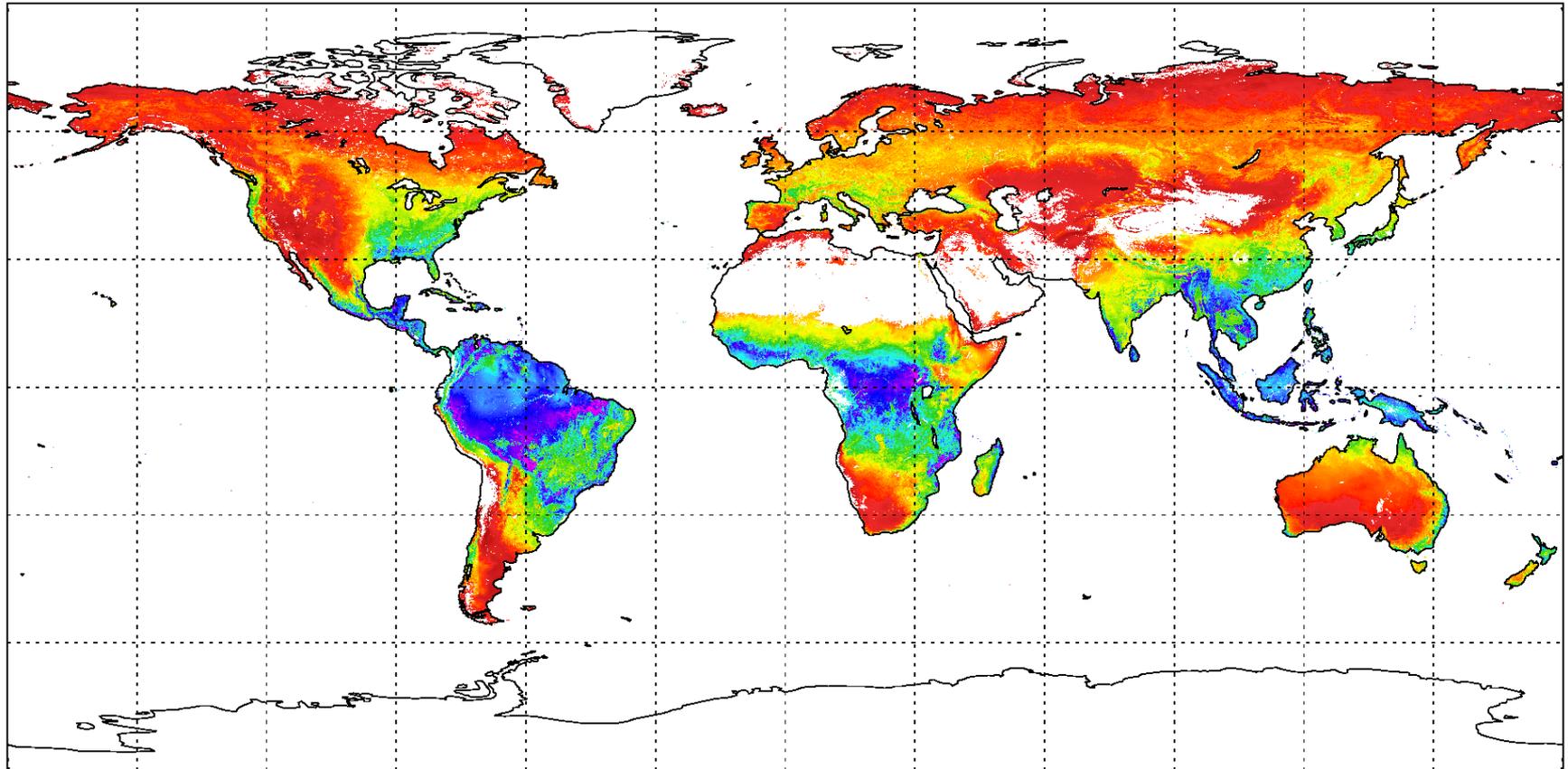


# Characteristics of MODIS ET Products

- Spatial Resolution 1 km
- Spatial Coverage: Global
- Time frame: 8-day, monthly, annual
- Time period: 2000-2013

# Global Annual 1-km ET over 2000-2010

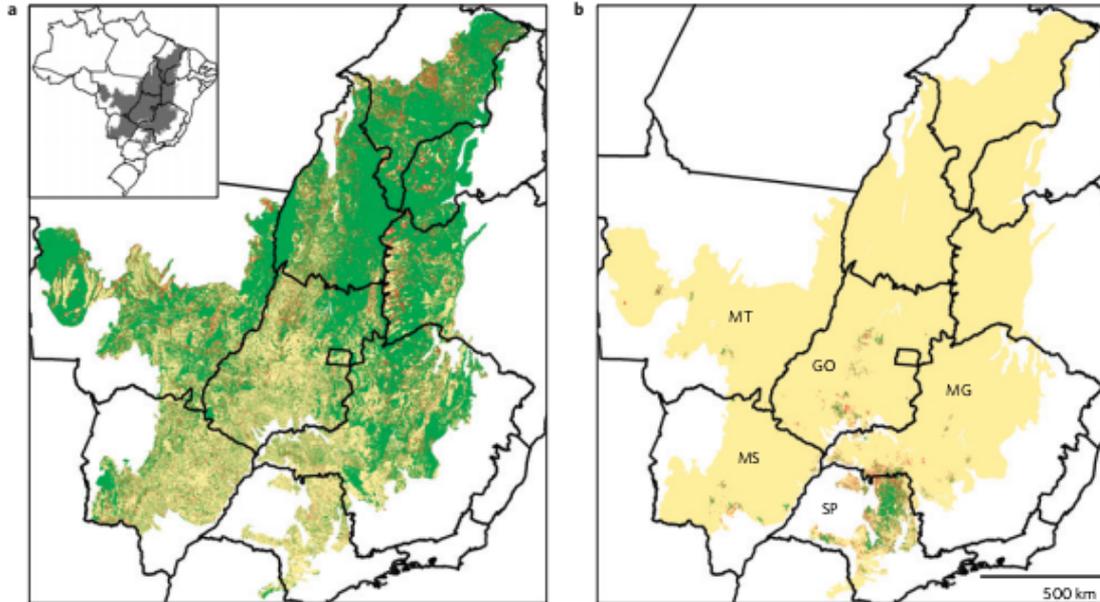
The Global average MODIS ET over vegetated land surface is  $575.9 \pm 381.6$  mm yr<sup>-1</sup>.



0      250      500      750      1000      1250      1500  
Global Annual MODIS ET (2000–2010) mm/yr

# Application of MODIS ET

Direct impacts on local climate of sugarcane expansion in Brazil  
Loarie, S. R, et al. (2011)



Natural vegetation in green Areas of planted sugar cane for biofuel  
Cleared areas in red

Conversion of natural vegetation to a crop/pasture mosaic  
warms the area an average of  $1.55^{\circ}\text{C}$

Conversion of the crop pasture mosaic cools the region by an  
average of  $.93^{\circ}\text{C}$ . (changes the surface albedo and ET)

# *Where Can You Get MODIS ET Products?*

- MODIS Global Evapotranspiration Project



The University of Montana

 **Numerical Terradynamic Simulation Group**  
Modeling and Monitoring Ecosystem Function at Multiple Scales

Projects Data Publications People Teaching Media Event Contact

**MODIS Global Evapotranspiration Project (MOD16)**

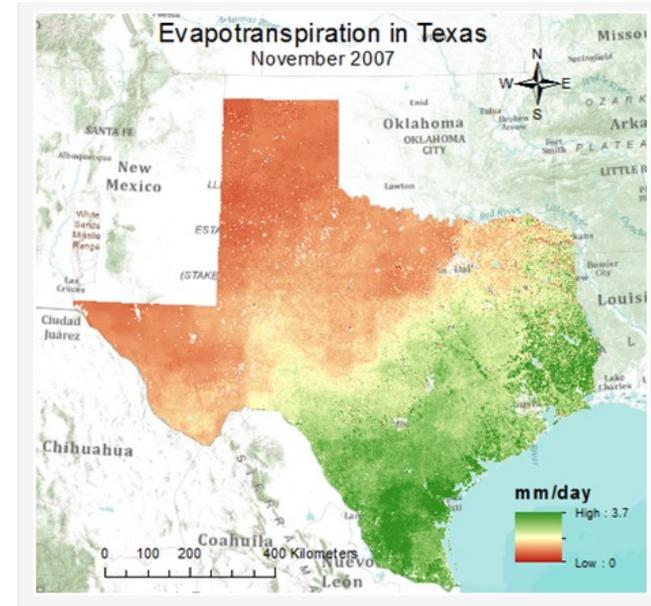
MODIS

Project Description Documentation Scientists Publications Data Product

<http://www.ntsg.umt.edu/project/mod16>

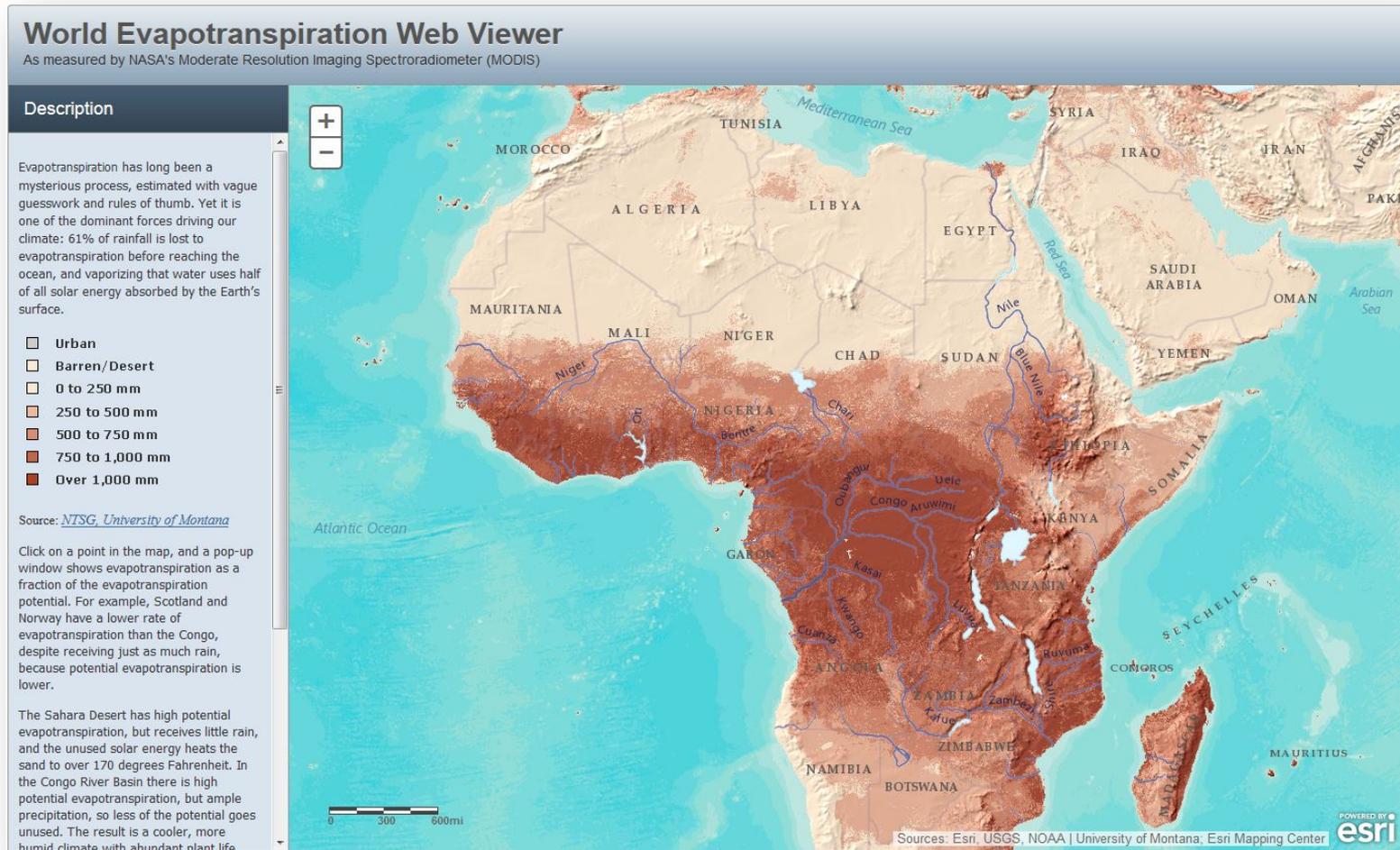
# MODIS Toolbox (ArcGIS)

- Developed by Center for Research in Water Resources at University of Texas, Austin
- Download from ArcGIS Resource Center, Geoprocessing Model and Script Tool Gallery: <http://resources.arcgis.com/gallery/file/geoprocessing>



# World Evapotranspiration Web Viewer

(available through ArcGIS online: [www.arcgis.com](http://www.arcgis.com))



**METHODS FOR DERIVING ET:**

**ENERGY BALANCE AND  
VEGETATION INDICES**

# What Satellite Do These Two Methods Use?

- *Energy Balance Method*
- *Vegetation Indices/ET Relationship*

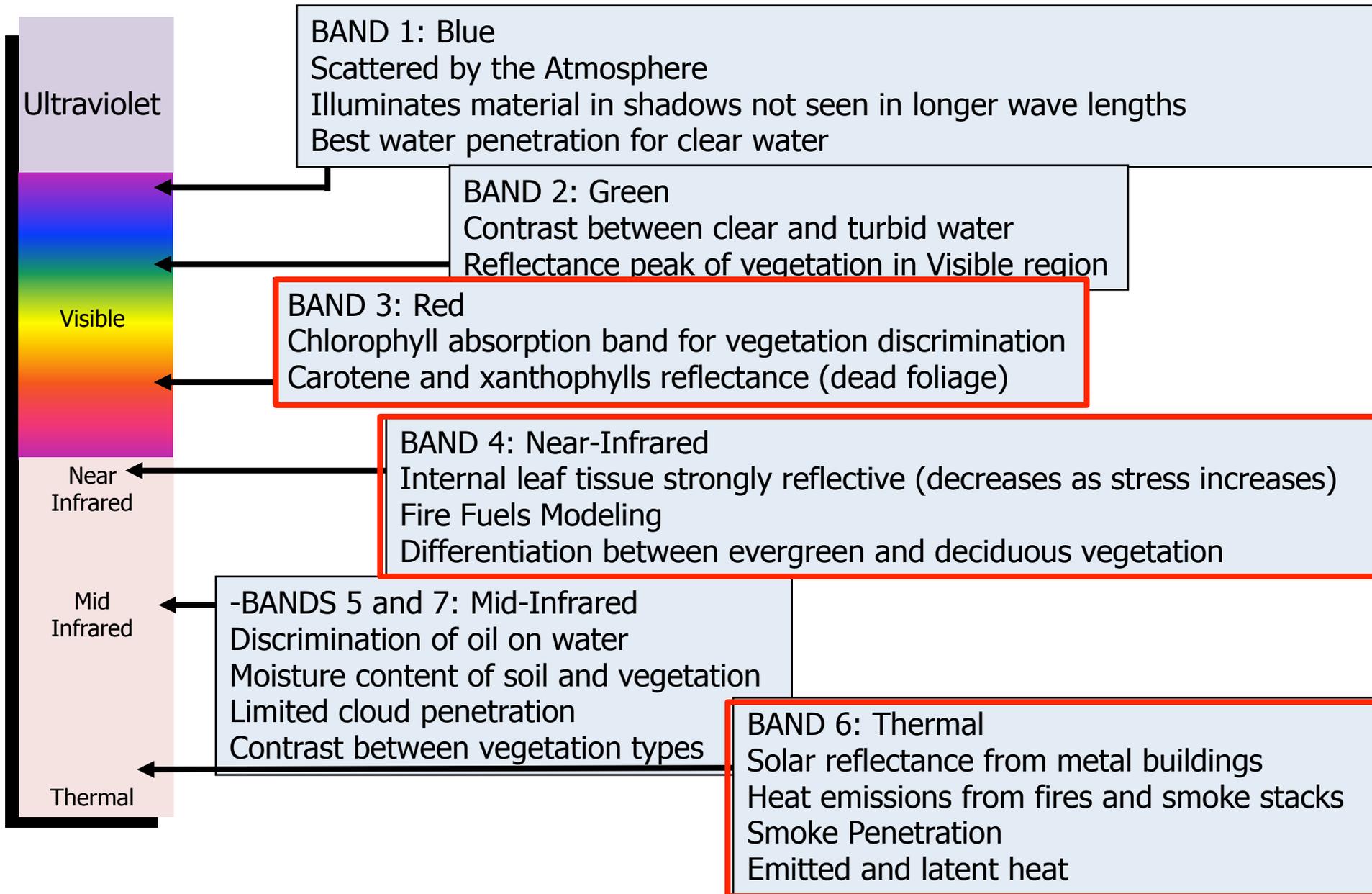
*Answer: The LANDSAT satellite*

*A Quick LANDSAT Review....*

# Landsat

- 7 (L 5,7); 11 (L8) Spectral Bands (Visible, Near-Infrared, Mid-Infrared, Thermal)
- Spatial Resolution:
  - Landsat 5
    - All bands EXCEPT thermal: 30 meters
    - Thermal: 120 meters
  - Landsat 7
    - All bands EXCEPT thermal: 30 meters
    - Thermal: 60 meters
  - Landsat 8
    - All bands EXCEPT thermal: 30 meters
    - Thermal: 100 meters
- Revisit Time: 16 days

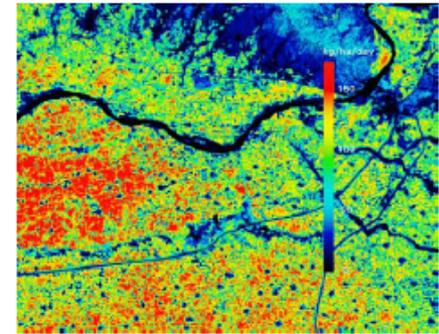
# Landsat Bands: What Are Important for ET?



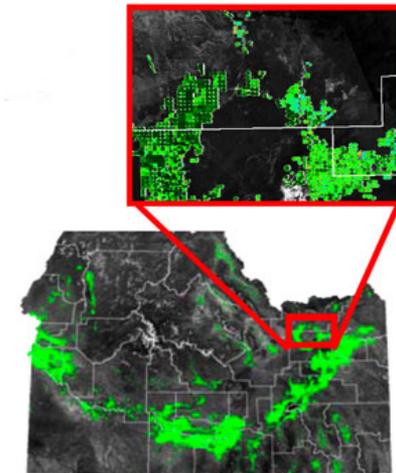
**METHODS FOR DERIVING ET:  
ENERGY BALANCE**

# ET, Landsat and Energy Balance: SEBAL and *METRIC*<sup>tm</sup>

- SEBAL –
  - Surface-Energy Balance Algorithm for Land
  - Developed by Dr. Wim Bastiaanssen (Netherlands)
  - Applications: ET and crop productivity
- METRIC
  - Mapping Evapotranspiration with High Resolution and Internalized Calibration
  - Developed by Dr. Rick Allen, University of Idaho

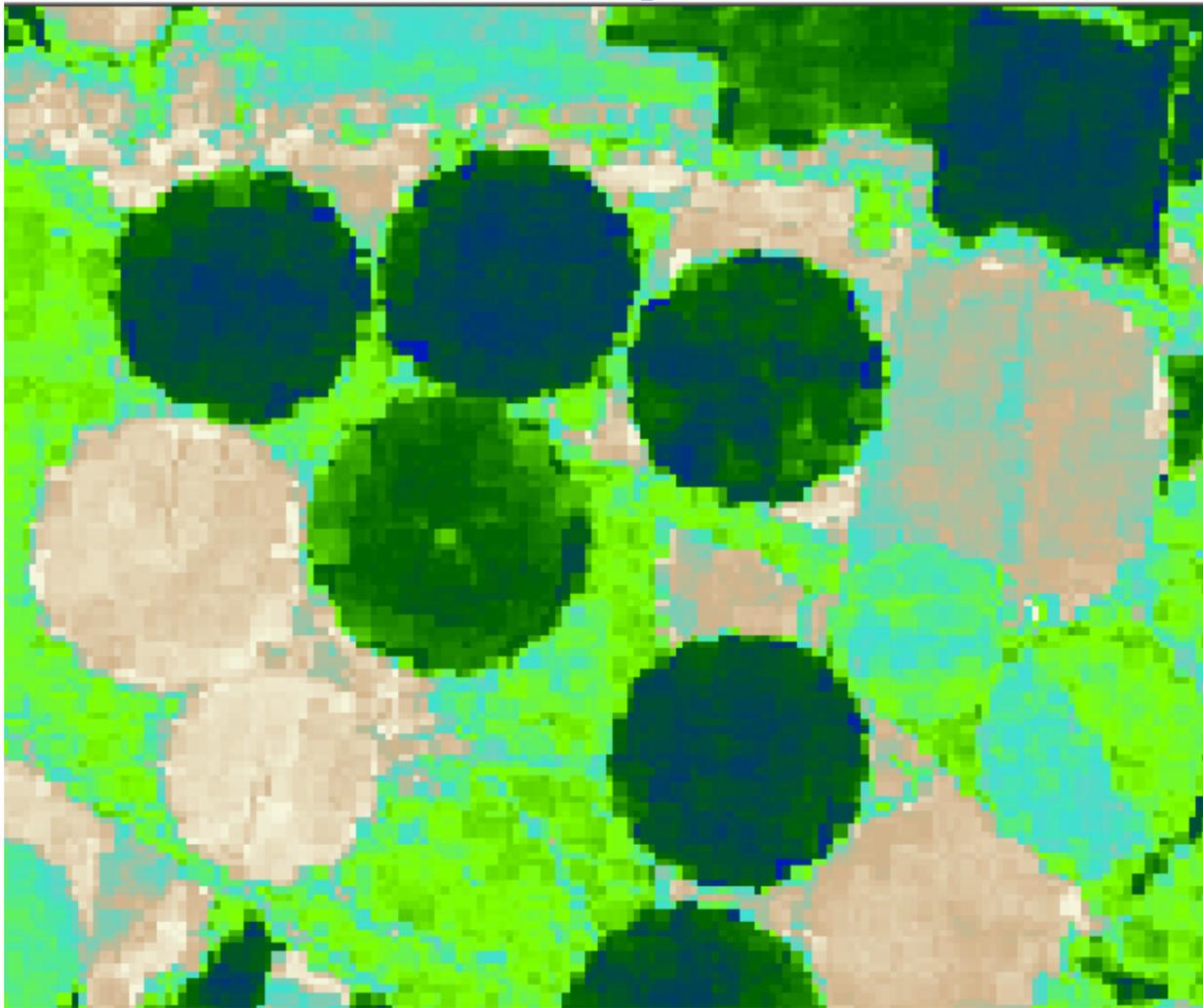


India: Crop growth on 4 February 2001



Agricultural evapotranspiration for southern Idaho. Image courtesy of IDWR.

# Why use Landsat Imagery?: Good Spatial Resolution

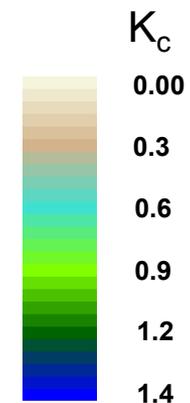


*METRIC application in La Mancha, Spain, 2003*

Source: Rick Allen, University of Idaho

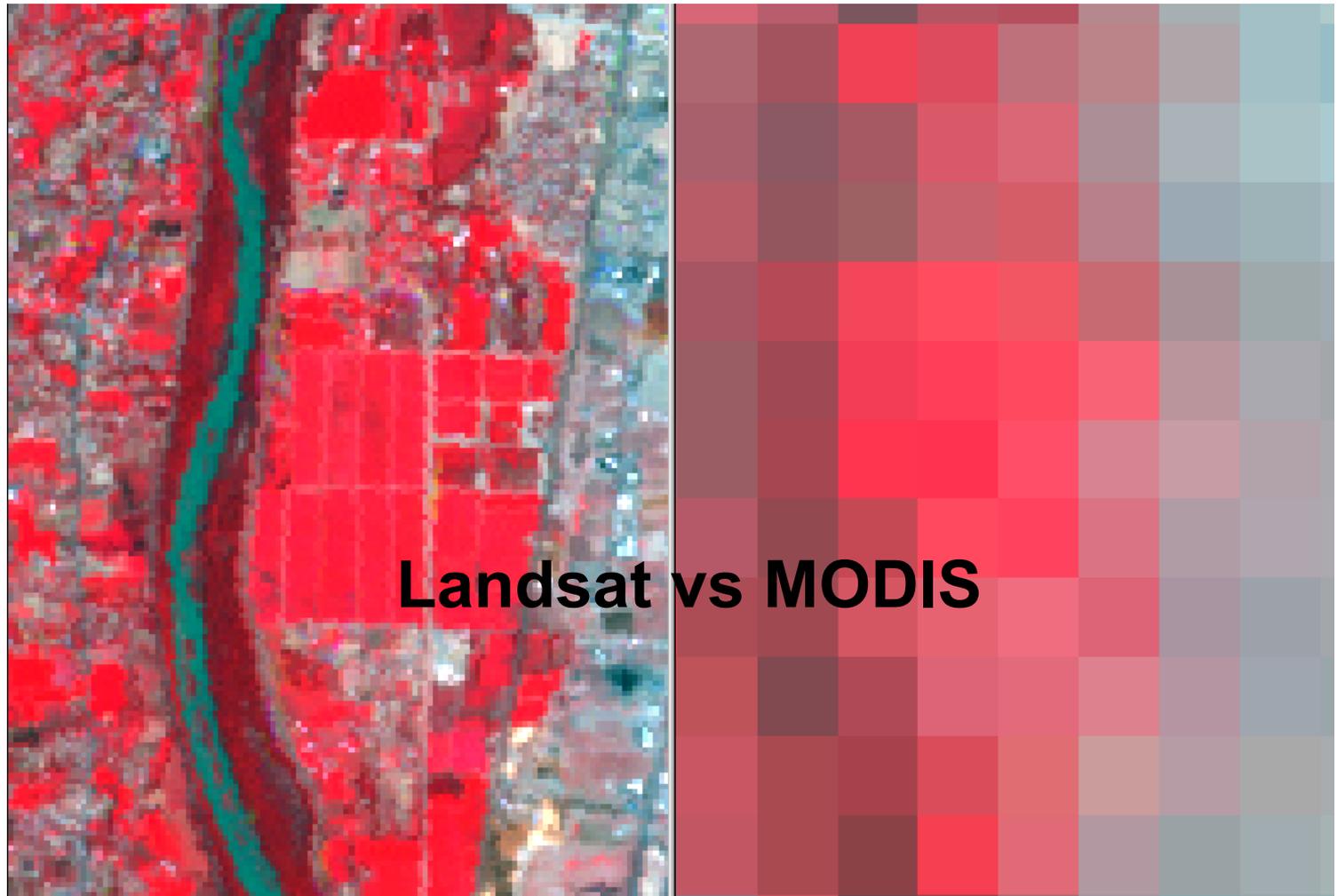
ET from  
individual  
Fields is  
Critical for:

- ◆ Water Rights,
- ◆ Water Transfers,
- ◆ Farm Water Management



*( $K_c$  based on  $ET_0$ )*

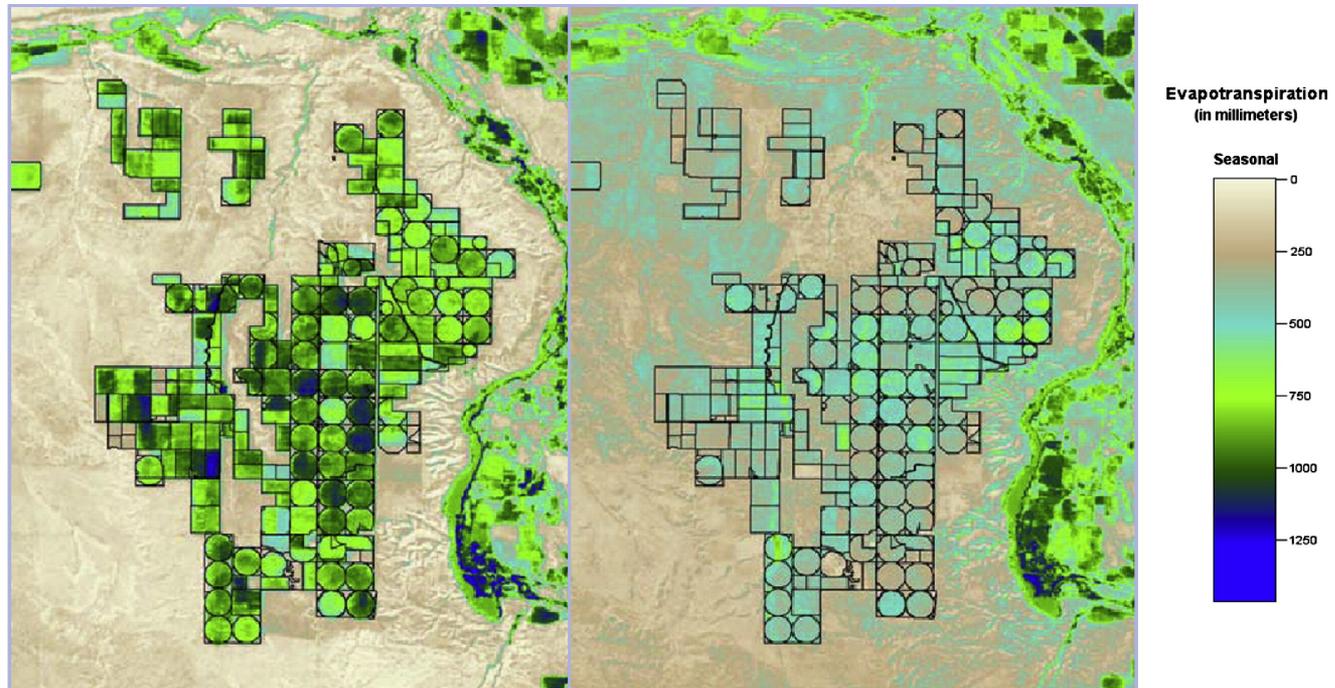
# More on Spatial Resolution



**Landsat False Color (MRG)**  
8/26/2002 10:33am

**MODIS False Color (MRG)**  
8/26/2002 11:02am

# Application of ET from Landsat

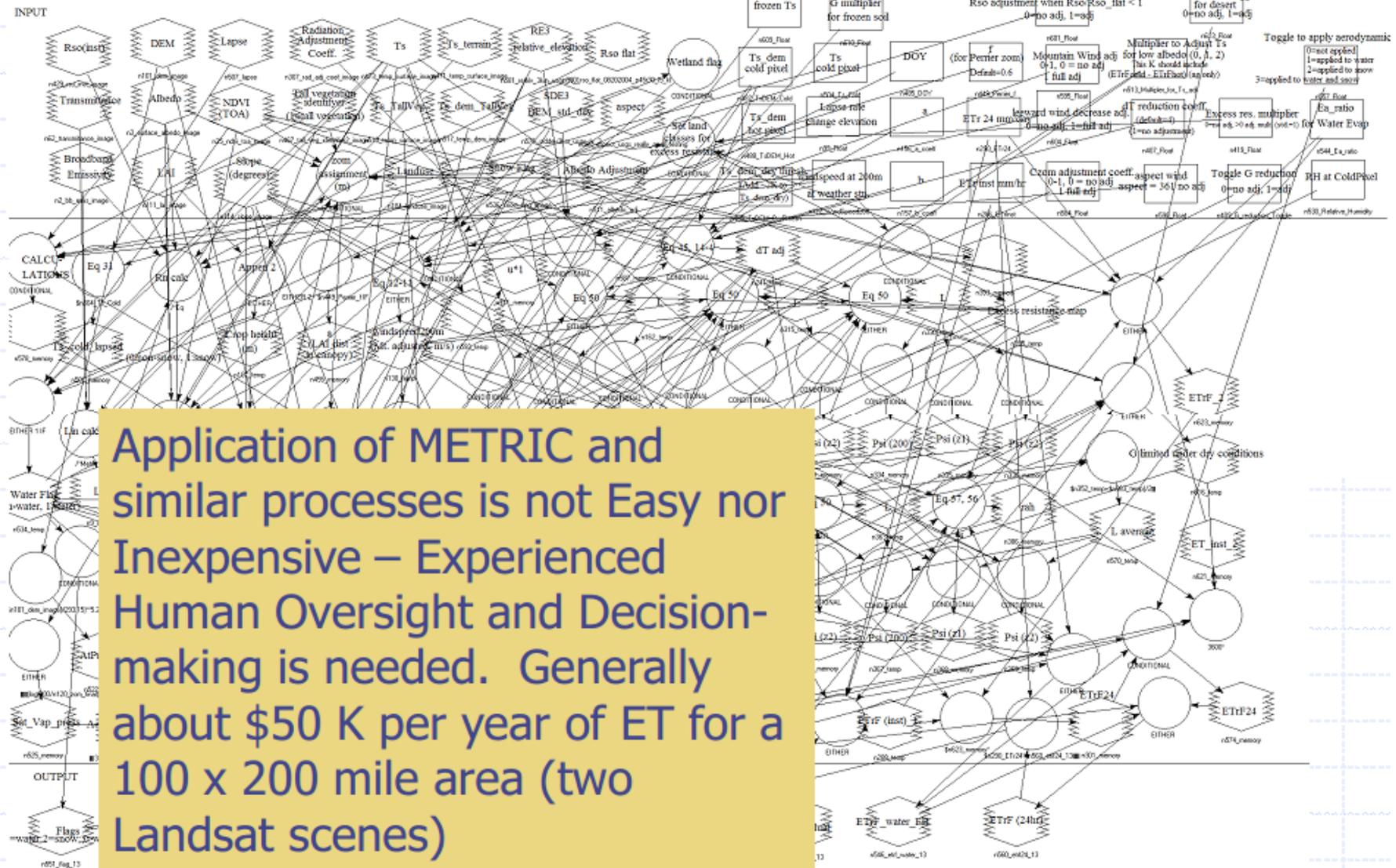


ET from irrigation project in Idaho contrasting ET before and after a permanent buyout of irrigation rights by the State of Idaho in 2005. The 2006 image shows ET supplied by residual soil water stored during 2005.

Source: Anderson, M.C., et al. 2012, *Remote Sensing of Environment*

# 'full' METRIC<sup>tm</sup>-ERDAS submodel for sensible heat and ETrF

v02, Main energy balance model for METRIC: Sensible heat flux, Net radiation, Ground heat flux, Reference ET fraction and ET. Last change: Sept 2011, R.Trezza for frozen soil and G-red, in desert  
 Copyright (C) 2003-2011, R.G.Allen, M.Tasumi, R.Trezza, J. Kjaersgaard, and University of Idaho. All rights reserved. --Populated by VBscript 9/13/2011 at 10:07:34 AM



Application of METRIC and similar processes is not Easy nor Inexpensive – Experienced Human Oversight and Decision-making is needed. Generally about \$50 K per year of ET for a 100 x 200 mile area (two Landsat scenes)

## **TAKE HOME MESSAGE**

Although Landsat data are free, using the energy balance method to derive ET costs time and money!

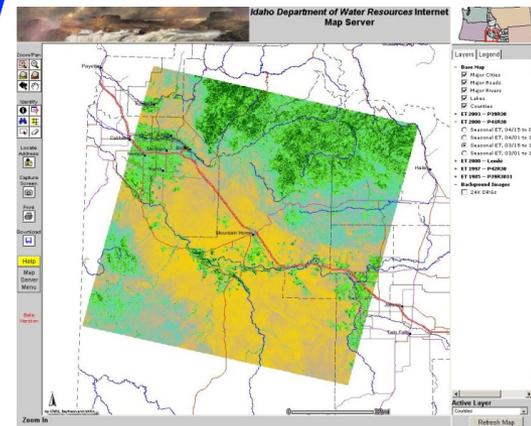
# SEBAL and METRIC : Additional Information

◆ <http://www.sebal.us/>



◆ [www.kimberly.uidaho.edu/water/](http://www.kimberly.uidaho.edu/water/) (METRIC<sup>tm</sup>)

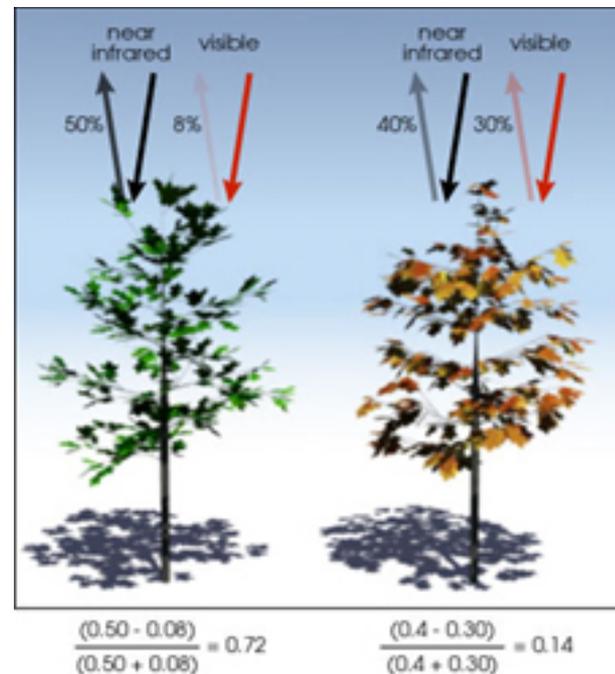
◆ <http://maps.idwr.idaho.gov/et/>



**METHODS FOR DERIVING ET:  
VEGETATION INDICES**

# Vegetation Index and ET Relationships

- *What is a vegetation index?*
  - *Based on the relationship between red and near-infrared wavelengths.*
  - *Chlorophyll strongly absorbs visible (red)*
  - *Plant structure strongly reflects near-infrared*



# Normalized Difference Vegetation Index (NDVI)

Near Infrared – Red  
Near Infrared + Red

Values represent varying levels of vegetation density



North America, July 2000



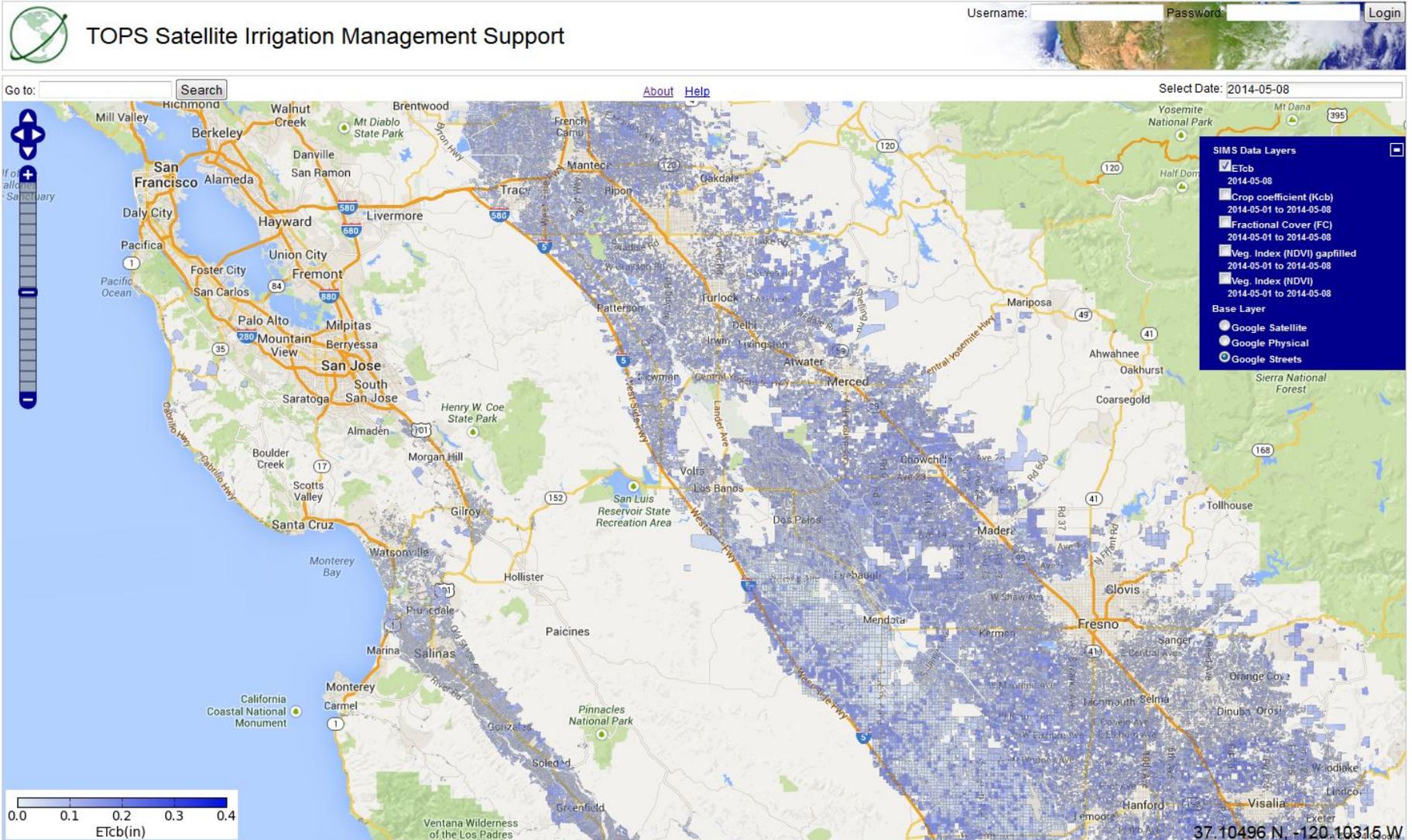
Africa, March 2000

# Application of ET Derived from NDVI



- Landsat imagery was used to map crop development and crop water demand throughout California's Central Valley, Central Coast, and North Coast at  $\frac{1}{4}$  acre resolution from 2010-2012.
- A web-interface was developed for agricultural producers and water managers to understand crop canopy conditions and irrigation demand.
- This project was conducted by the Ecological Forecasting Lab at NASA Ames Research Center.

# Beta website: <http://ecocast.arc.nasa.gov/dgw/sims>

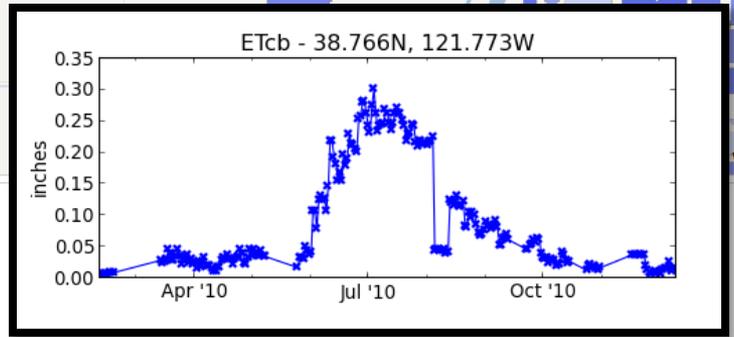
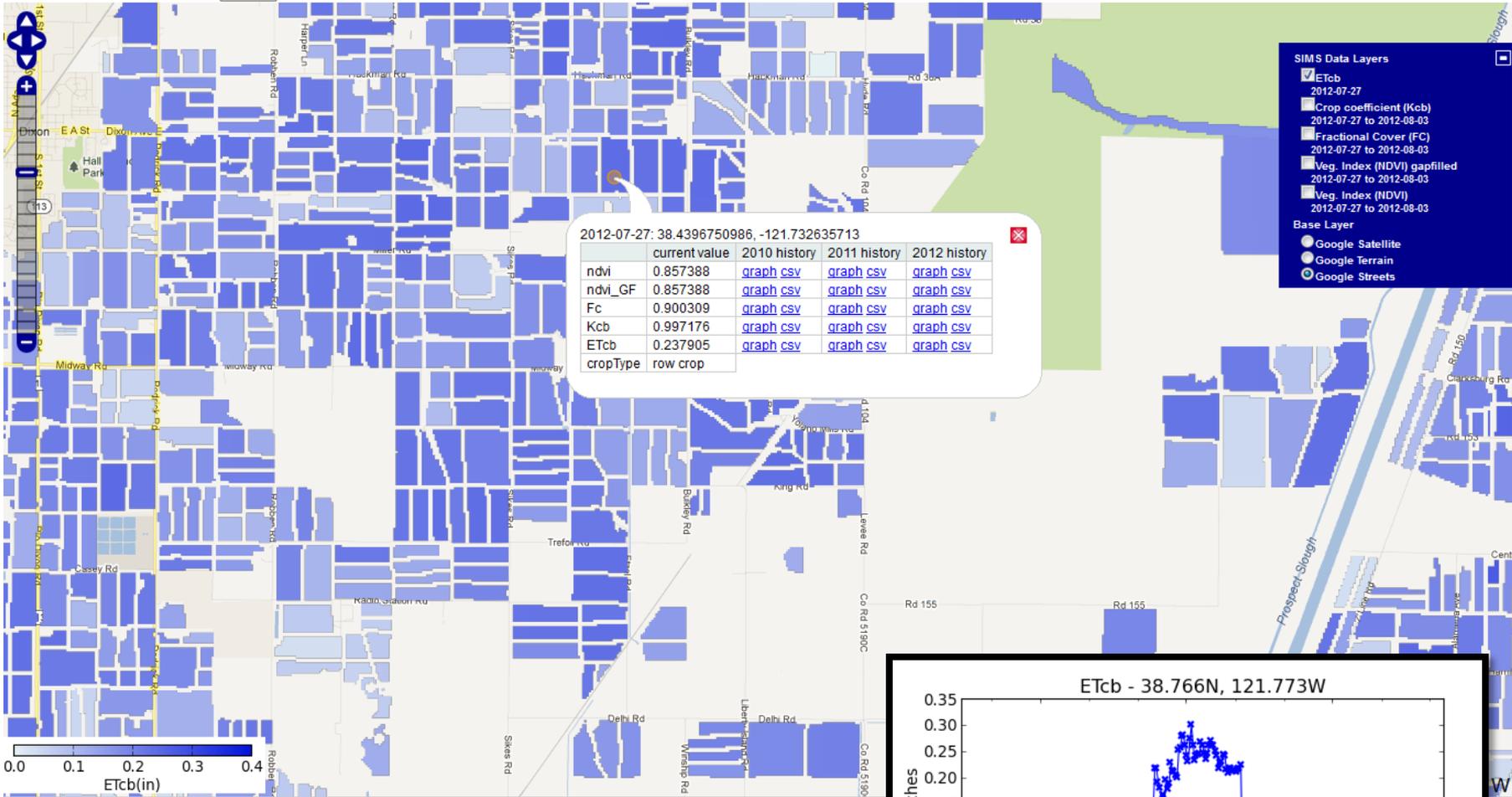




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# Advantages/Disadvantages for ET Derived from Vegetation Indices

- Primarily useful for estimating ET of a well-watered crop on a dry soil surface
- This method is simple and quick, and inexpensive.
- Can be used on other types of imagery – not just Landsat

# Summary

- ET is not directly measured from satellites.
- Deriving ET is a complex process (some methods are more complex than others).
- There are multiple ET products available that utilize different approaches and remote sensing instruments at different temporal and spatial resolutions.
- You can download ET data from NLDAS, GLDAS, and the University of Montana (from MODIS)
- Any of the ET data derived from Landsat require special processing capabilities BUT you can view/download for California from SIMS website.

# **Coming up next week!**

**Week 4 (10 June 2014)**

## **Change Detection**

**In the next few weeks, please feel free to suggest specific demonstrations of portals or use of data that you might be interested in for WEEK 5.**

Thank You!

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