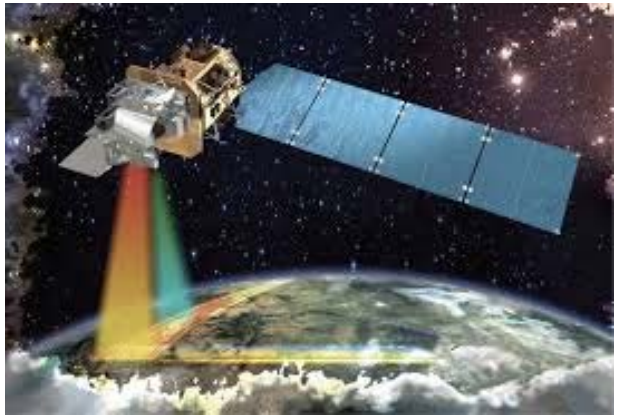
Google Earth Engine Evapotranspiration Flux --- EEFlux



Ayse Kilic, University of Nebraska-Lincoln

Rick Allen, University of Idaho

Members of the Landsat Science Team

Collaborators: **Justin Huntington,** Desert Research Institute **/ Wim Bastiaanssen,** UNESCO **/ Google**

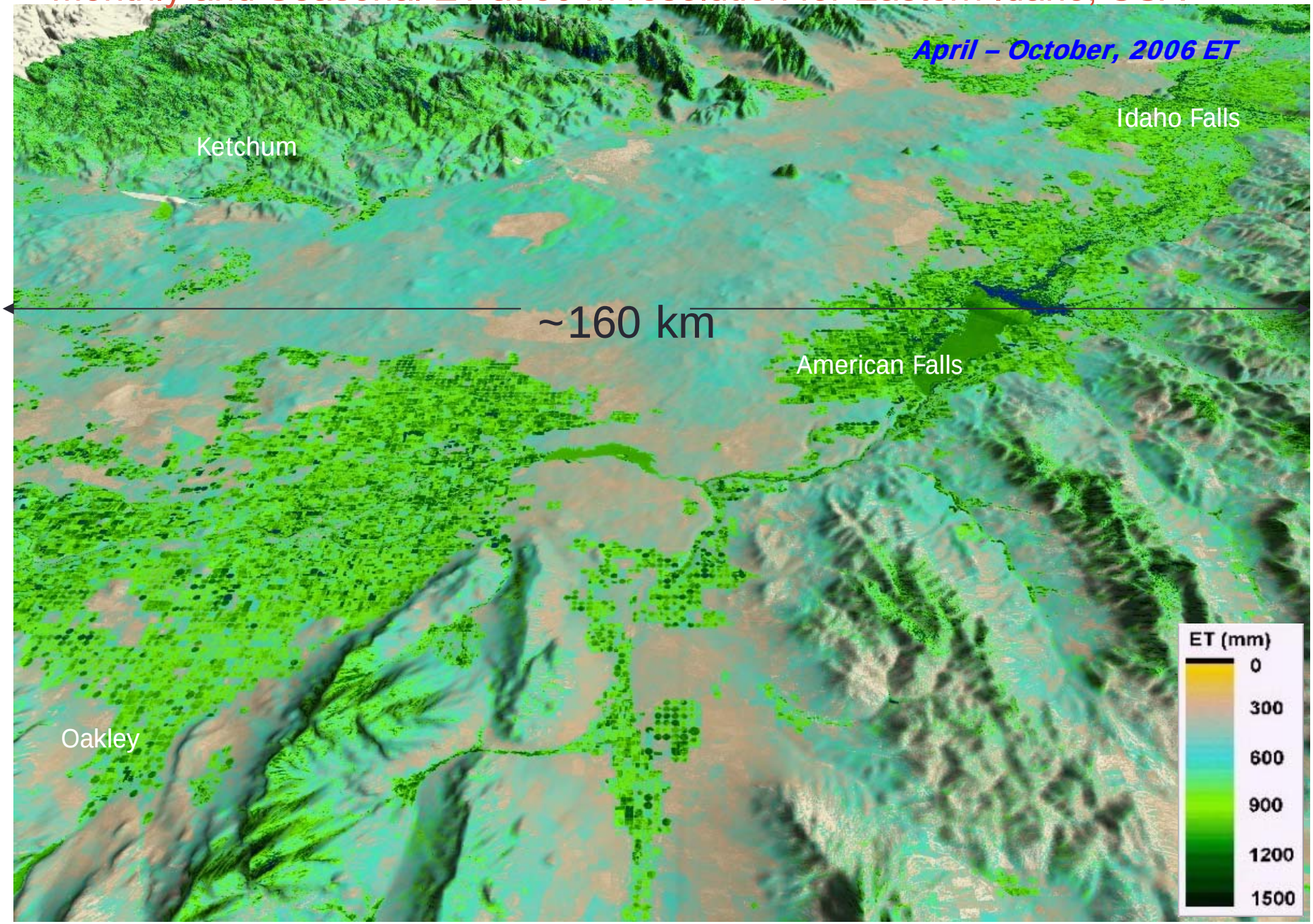
INOVAGRI, Fortaleza, Brasil, Sept. 1, 2015

Who Cares about Evapotranspiration?

- State Departments of Water Resources
- Federal Water Management
- Hydrologists
- Environment
- Irrigation Designers
- Irrigators
- Water Rights

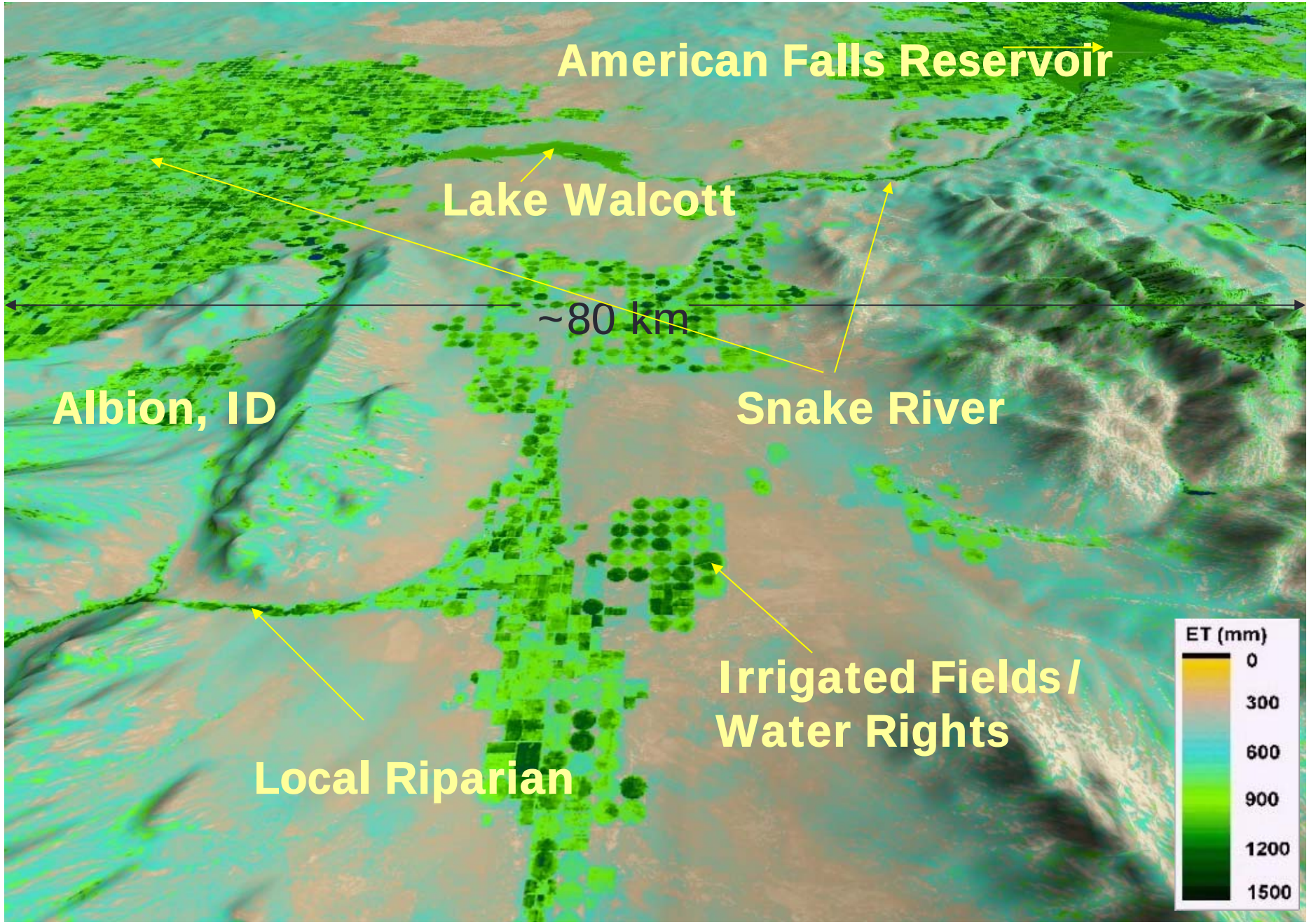
Does ET vary in Space? (Yes!)

-- Monthly and Seasonal ET at 30 m resolution for Eastern Idaho, USA



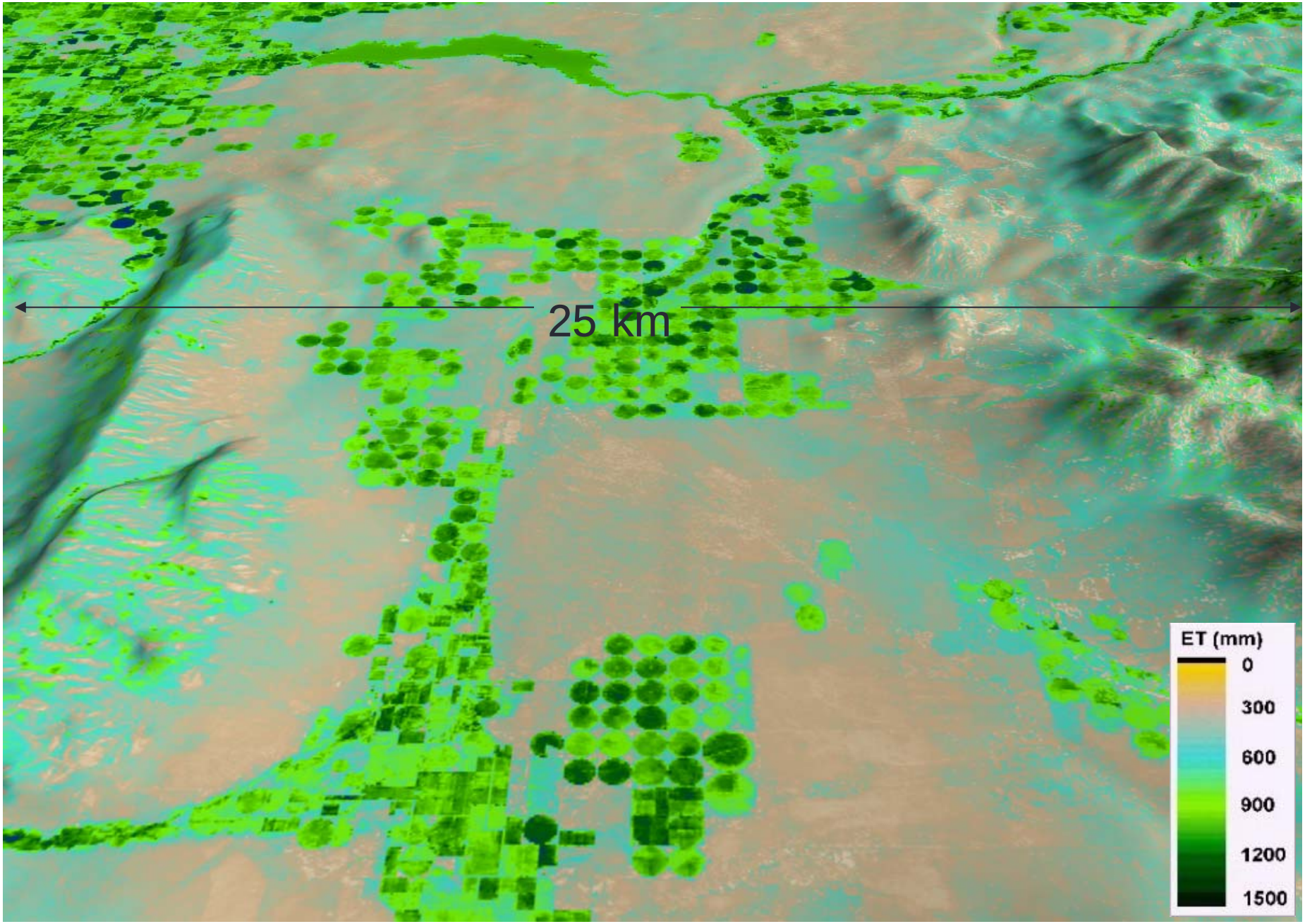
ET features at 30 m resolution

April – October, 2006 ET from METRIC-Landsat



ET features at 30 m resolution

April – October, 2006 ET from METRIC-Landsat



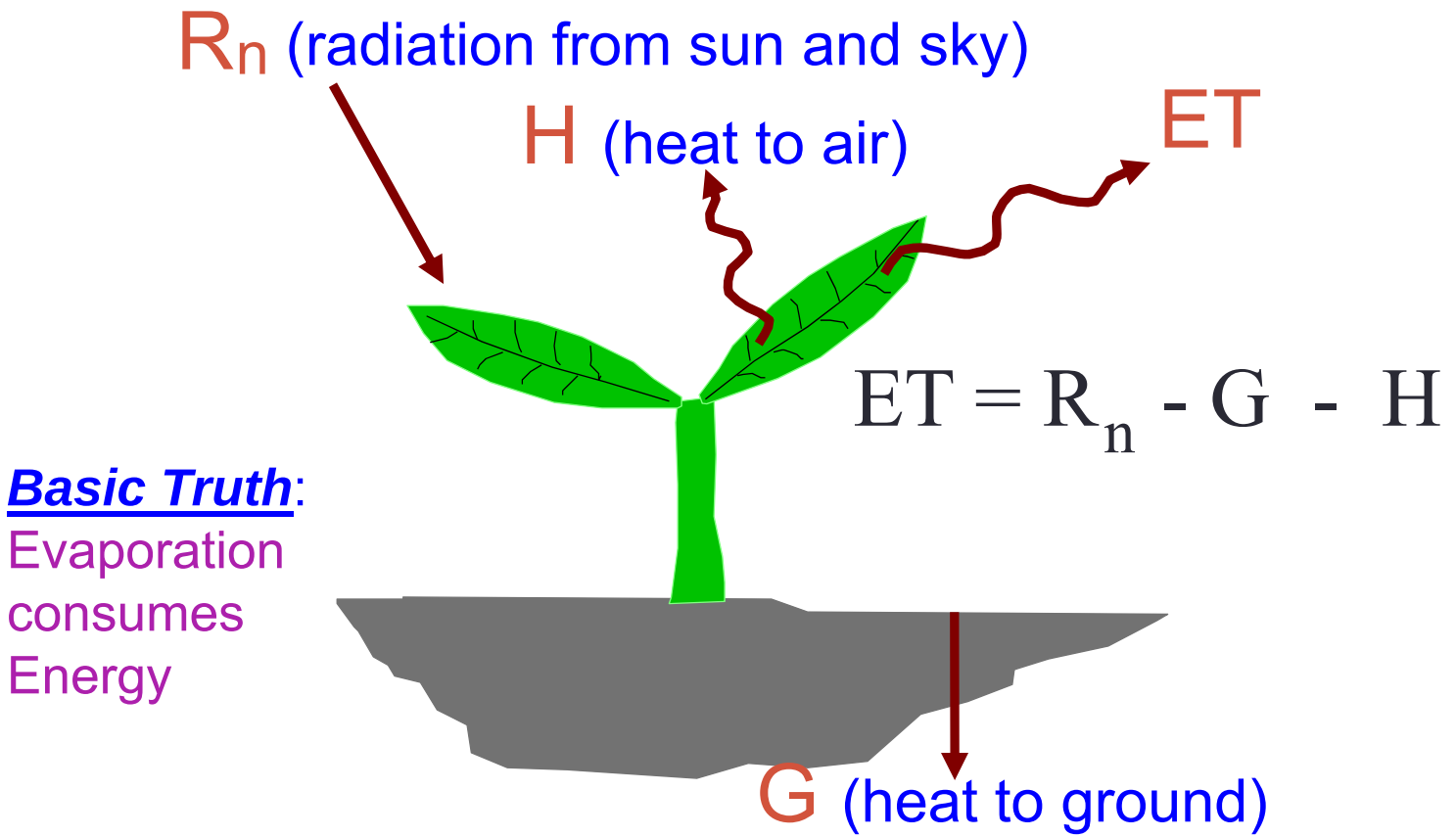
Acronyms

- METRIC – Mapping Evapotranspiration at high Resolution using Internalized Calibration

- EEFlux -- Earth Engine Evapotranspiration Flux

METRIC and EEFlux use an "Energy balance"

- ET is calculated as a "residual" of the energy balance



Energy balance gives us "actual" ET

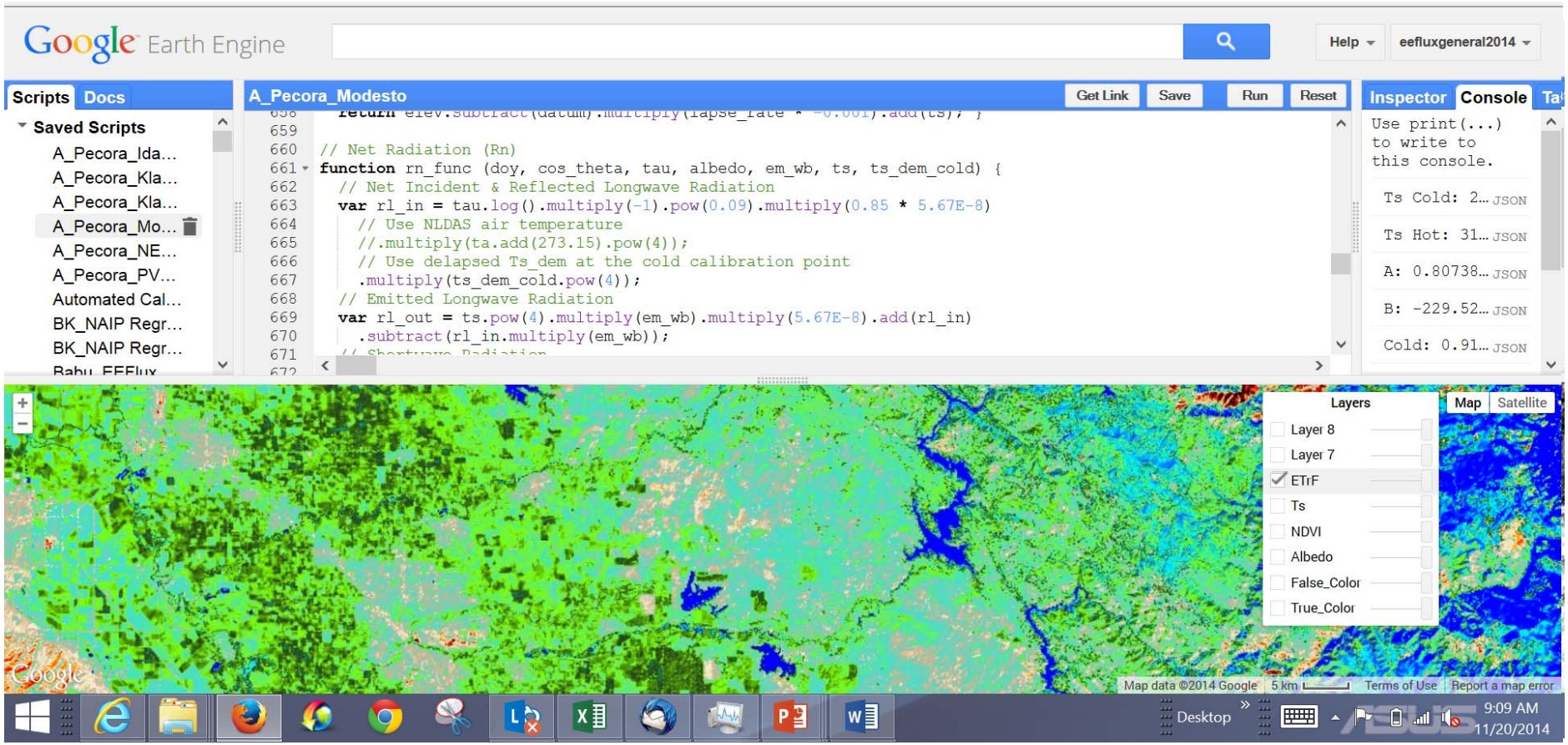
Energy Balance can 'see' impacts on ET caused by:

- **water shortage**
- disease
- crop variety
- planting density
- cropping dates
- salinity
- management

- *(these effects can cause the ratio ET / amount of vegetation to vary widely, thus the need to compute ET as a residual of the energy balance)*

EEFlux runs on the Google Earth Engine “Cloud”

Earth Engine JavaScript Language and Development “Playground”

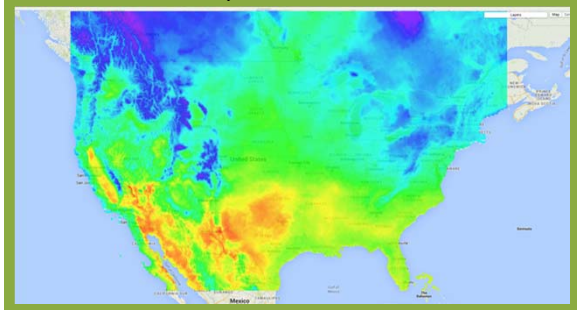


Modesto, California (Central Valley) area

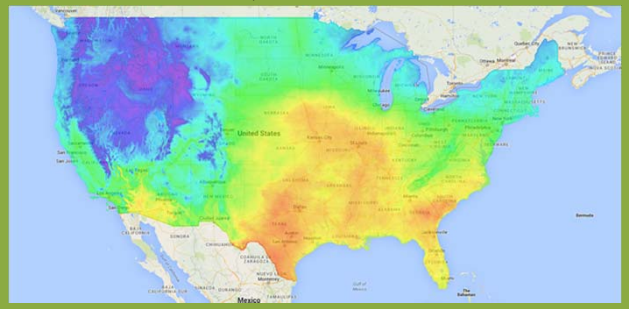
--- *monitoring impacts of drought*

Data Resources Used by EEFlux

NLDAS-Jan 1, 1979 - Current



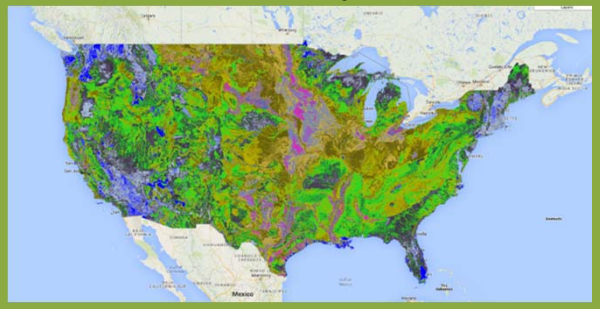
GRIDMET-Jan 1, 1979 - Current



NLCD Landuse

DEM

Soil Data Layers



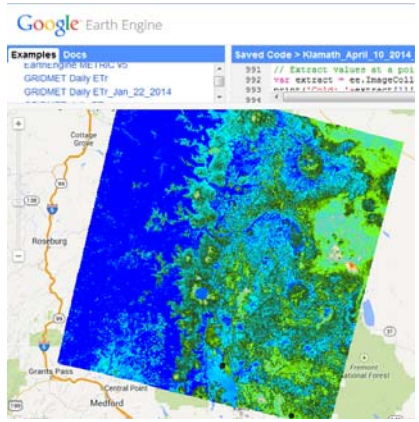
- Landsat 5/7/8 and MODIS
- Weather Data
  - Hourly Weather Data (NLDAS)--CONUS
  - Daily Weather Data (GRIDMET)--CONUS
  - Climate Forecast System Version 2, 6-hourly Products (CSFV2)--nonCONUS
- Landuse and Digital Elevation Maps
- Soil Data Layers (STATSGO--CONUS and FAO)

EEFlux (ET) on Google Earth Engine

Data:

- Gridded Weather data – used to calibrate EEFlux energy balance and to calculate Reference ET used for Time Interation of ET:
  - NLDAS – North American Land Data Assimilation System
    -- hourly weather data at 12 km available for > 30 year period for CONUS
  - GridMET - daily, bias corrected weather data at 4 km available for > 30 year period for CONUS
  - Climate Forecast System Version 2, 6-hourly Product (CSFV2)—nonCONUS
  - Real Time Mesoscale Analysis (RTMA) – downloaded daily to Earth Engine – used to fill in time gaps between NLDAS and today for processing recent Landsat imagery

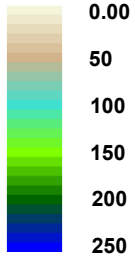
- Soils -- Used to produce a daily time series of evaporation from bare soil.
  - Statsgo soils data is available for CONUS for top 0.15 m of soil
  - FAO soils data base used for rest of globe



Klamath, 2014

ET between Landsat dates is scaled using Reference ET App of Google EE

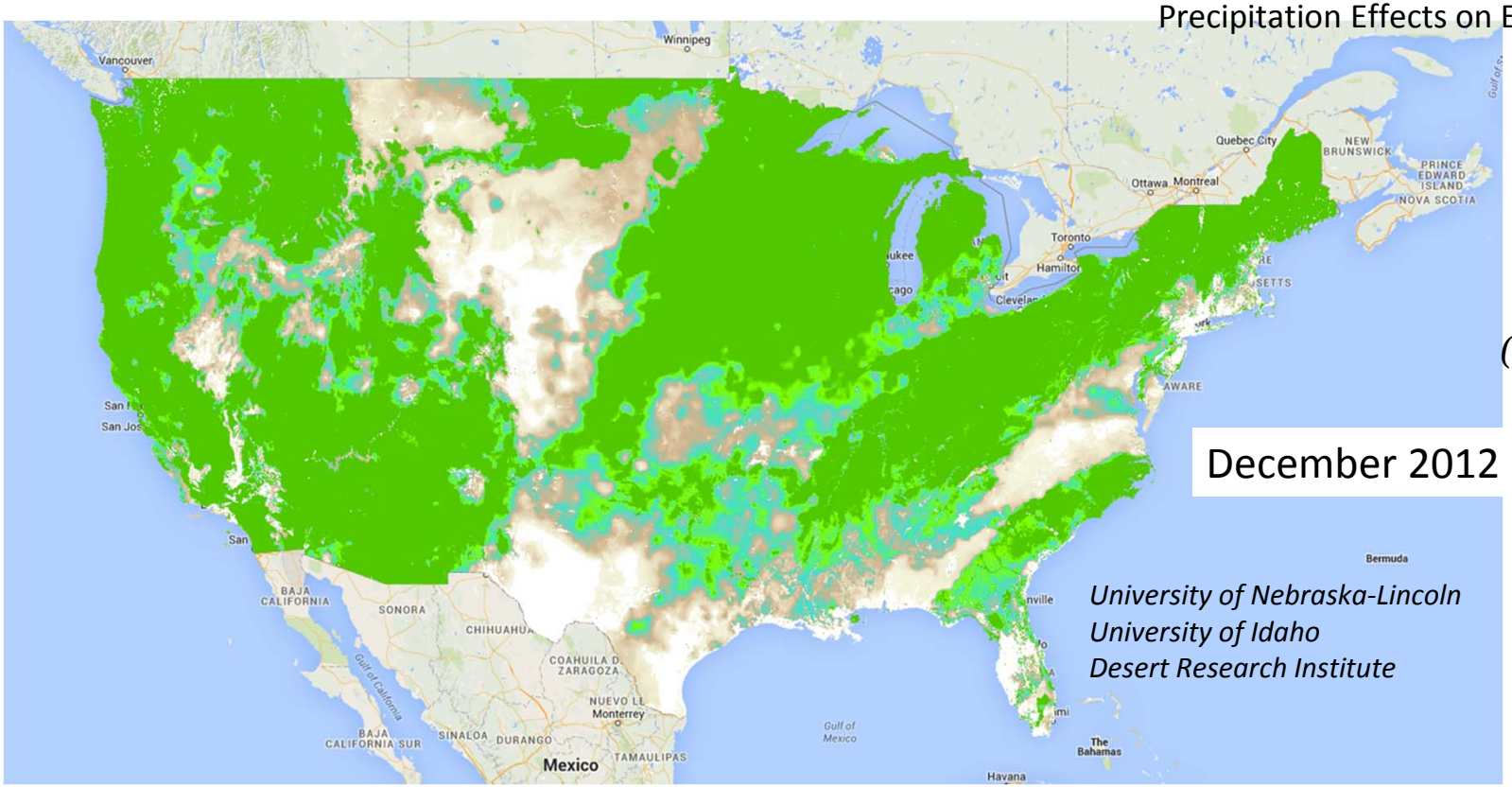
Reference ET (mm/mo)

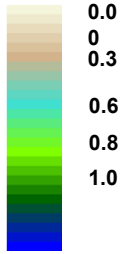


Reference ET is calculated using the ASCE Standardized Penman-Monteith Equation for the Tall Reference (Alfalfa) --computed from the daily GridMET data set of Abatzoglou (2012)

The Soil Surface Evaporation Component of the Google Earth Engine EEFlux App.

--- **Evaporation from Bare Soil** --- used to calibrate the EEFlux Evapotranspiration Surface Energy Balance to account for background Precipitation Effects on ET Evap. Coef. (K_e)



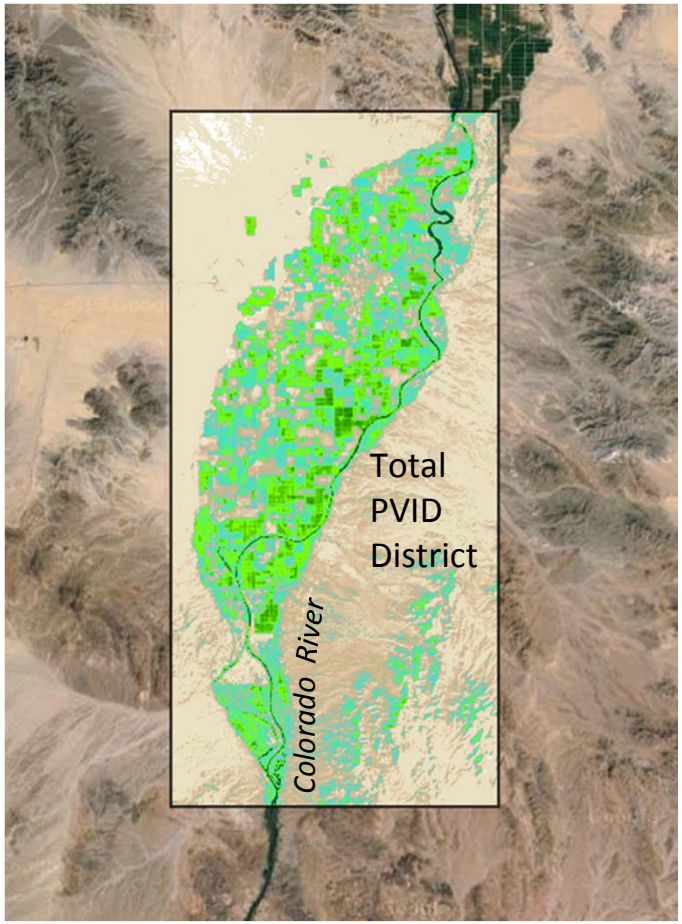


$(K_e = E_{act} / ET_{ref})$

--computed from the GridMET weather data set of Abatzoglou (2012)

-- GridMET is traceable to NLDAS and PRISM data sets

Google Earth Engine Flux --- EEFlux



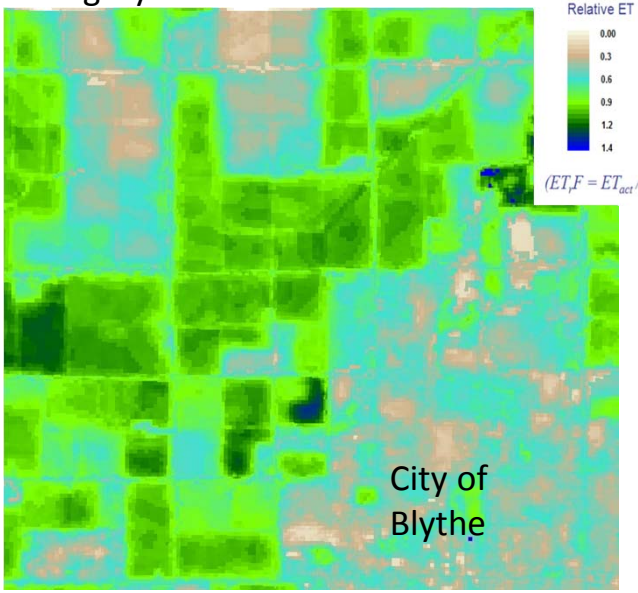
Earth Engine Evapotranspiration Flux

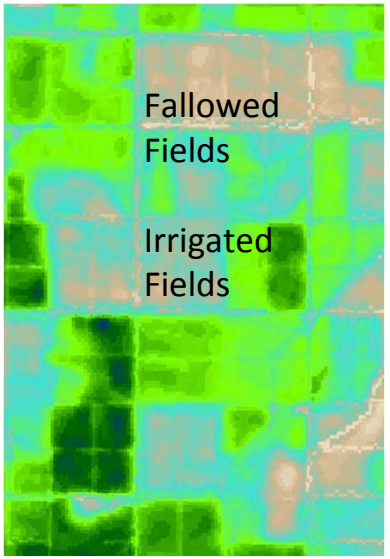
Palo Verde Irrigation District

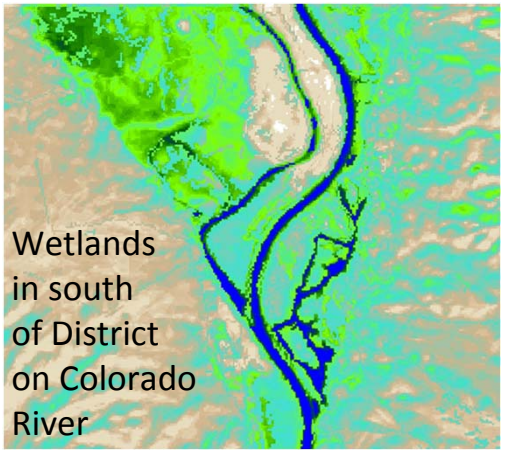
Blythe, California – Jan. – Dec. 2008

-- Landsat 5 imagery

Dec.







Univ. Nebraska-Lincoln, Univ. Idaho, Desert Research Institute

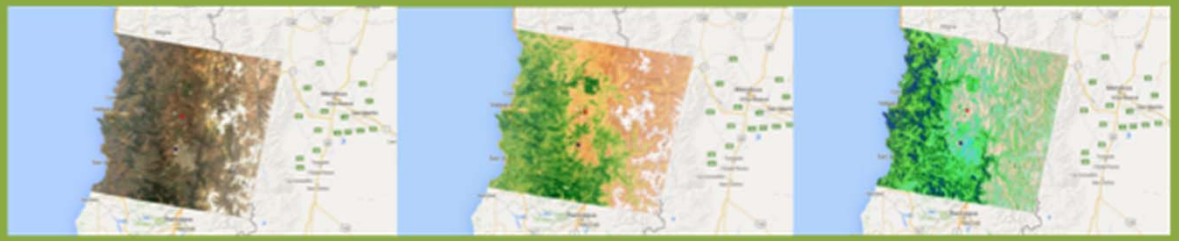
Computations are based on a complete surface energy balance *(METRIC)*

EEFlux Applications

Imperial Valley and Palo Verde, CA

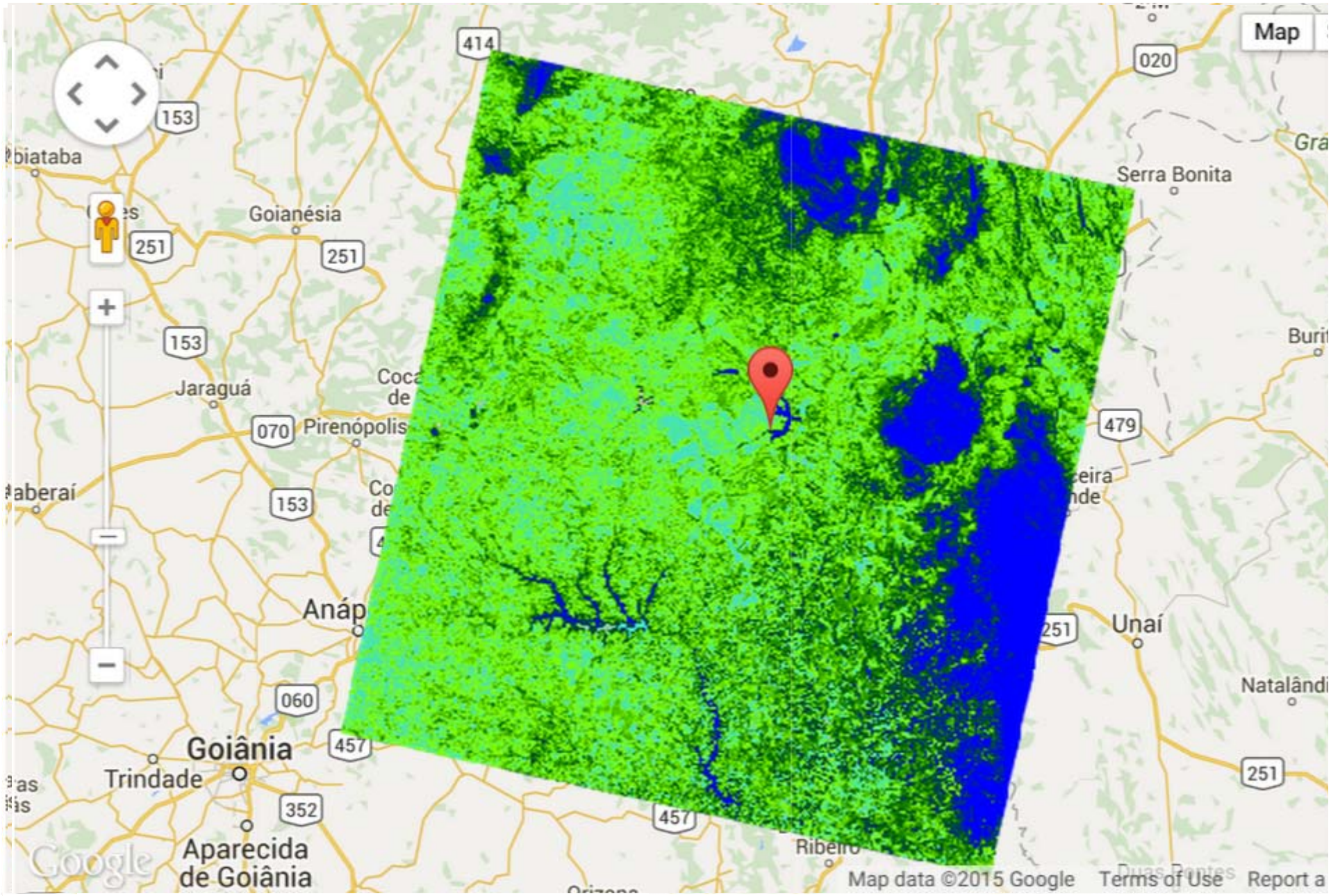
Jordan

Chile



We are testing EEFlux over the globe in a number of Countries and Conditions

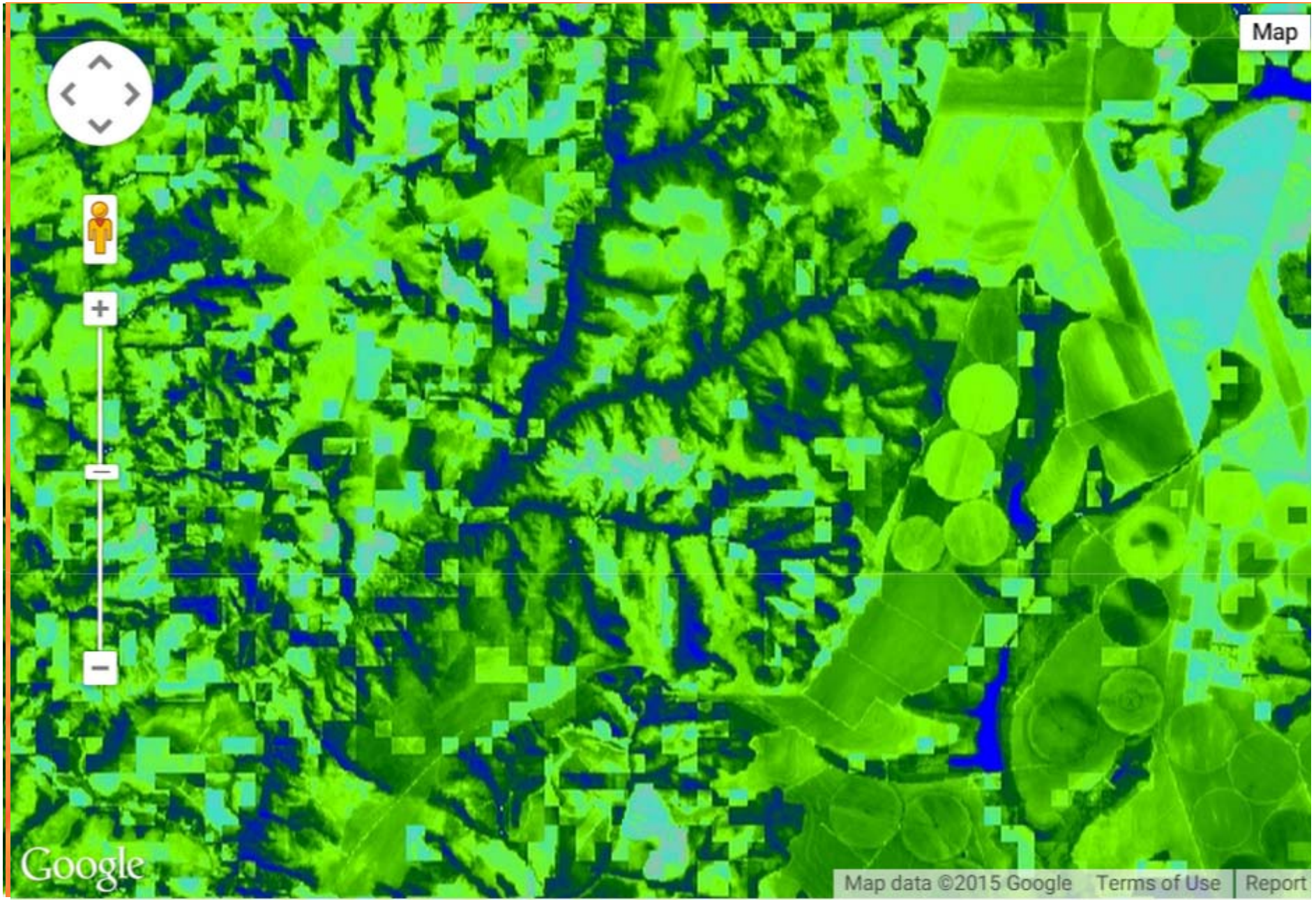
July 3, 2015 – Landsat 8 Path 221 Row 71 (Brasilia)



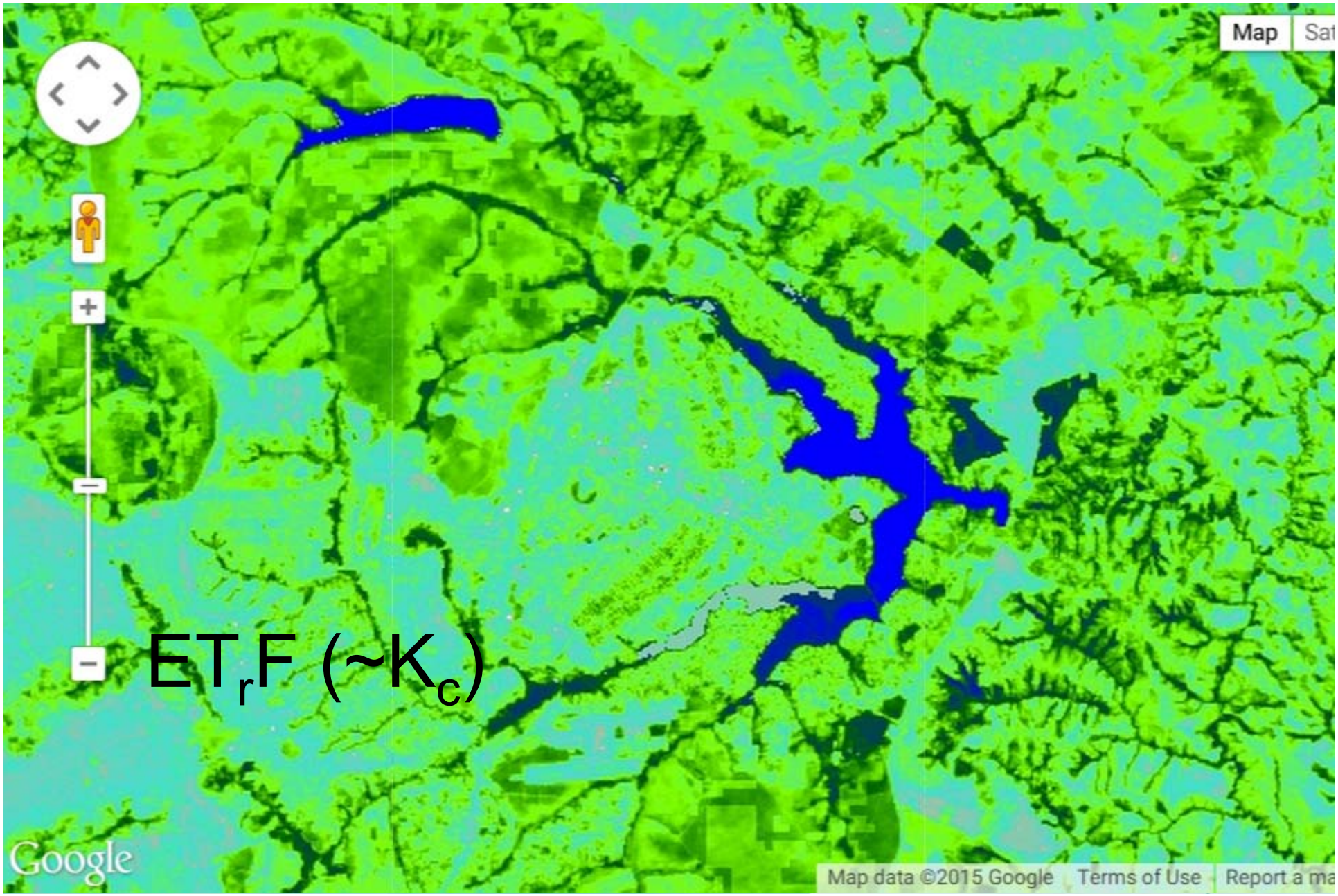
ET_rF $(= K_c)$

July 3, 2015 – Landsat 8 Path 221 Row 71

ET_rF (= K_c)

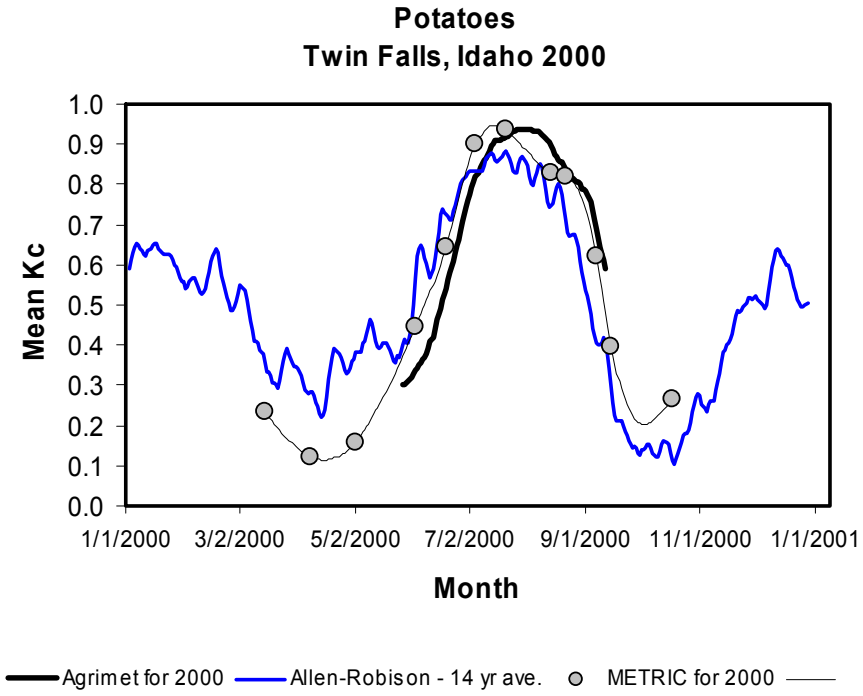


July 16, 2014 – Brasilia – results from EEFlux - Landsat



The impact of Number of Images on estimating Water Consumption

- *For estimating ET over extended time periods, we would 'like' information for any one 'point' each 32 days (at a minimum) to follow evolution of vegetation and water availability*
- *For parcel scale ET mapping, this requires multiple Landsat-type satellites*

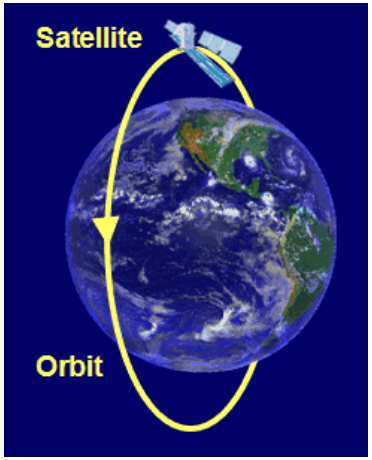


A formula for calculating revisit time for a satellite (and the number of satellites needed for a daily “Selfie”)

Earth’s Circumference = 40,000,000 m

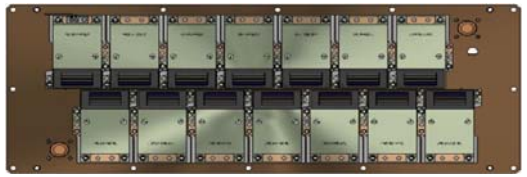
x

Satellite Orbit time = 98.9 minutes for L8



= 16 days for 1 sat.

or 16 satellites for daily



x

constrained by telescope size and signal to noise ratio req.

Effective Number of Detectors (no. pixels) = ~5,700 for L8

Pixel size = 30 m for L8

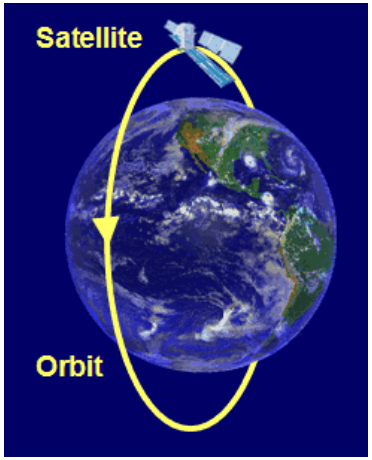
Swath Width of Satellite

A formula for calculating revisit time for a satellite (and the number of satellites needed for a daily “Selfie”)

Earth’s Circumference = 40,000,000 m

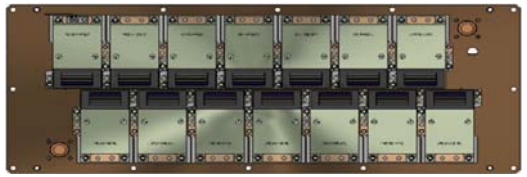
x

Satellite Orbit time = 98.9 minutes for L8



= 48 days for 1 sat.

or 48 satellites for daily



x

constrained by telescope size and signal to noise ratio req.

Effective Number of Detectors (no. pixels) = ~5,700 for L8

Pixel size = 10 m

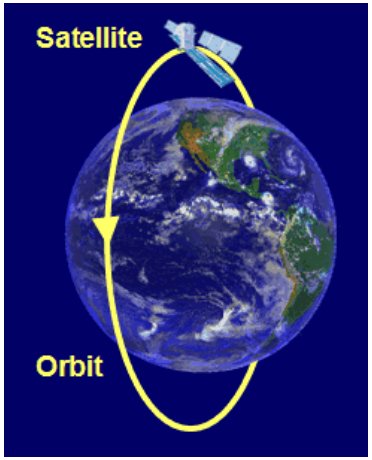
Swath Width of Satellite

A formula for calculating revisit time for a satellite (and the number of satellites needed for a daily “Selfie”)

Earth’s Circumference = 40,000,000 m

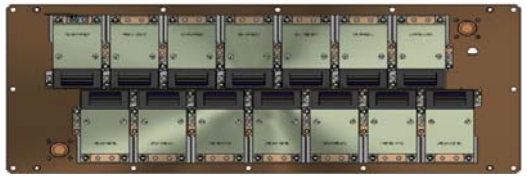
x

Satellite Orbit time = 98.9 minutes for L8



= 480 days for 1 sat.

or 480 satellites for daily



x

constrained by telescope size and signal to noise ratio req.

Effective Number of Detectors (no. pixels) = ~5,700 for L8

Pixel size = 1 m

Swath Width of Satellite

How much would a Daily Landsat Cost? i.e., 16 Landsat satellites in orbit

= $15 billion over 10 years

= 16 Landsats per 10 years

Cost Equivalency - three coffee-lattes per American per year