EVAPOTRANSPIRATION IN WATER RESOURCES MANAGEMENT

Ayse Kilic, University of Nebraska-Lincoln
Rick Allen, University of Idaho-Kimberly
Justin Huntington, Desert Research Institute

Landsat Science Team Meeting, October 29, 2013

Contributing Research Team members:
Dr. Babu Kamble, UNL
Ian Ratcliffe, UNL
Dr. Ricardo Trezza, UI
Charles Morton, DRI

Presentation Coverage

- Selected Current applications for ET:
  - Chile
  - Turkey
  - Nebraska
  - Landsat 8
  - Google Earth Engine
  - Nevada
  - Legal Uses

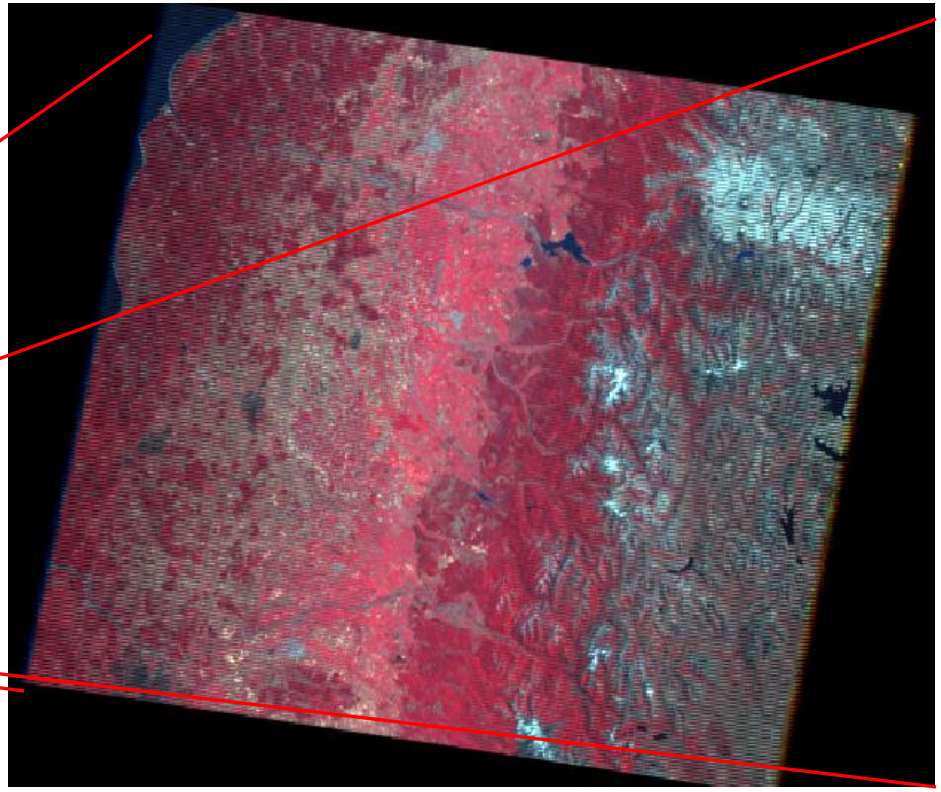
CHILE

Water Consumption by Olives and Vineyards

Motivation: New production of olives and vineyards is replacing natural vegetation:

a. Reduced ecosystem diversity and extent
b. Increased erosion from bare hilly slopes
c. Potential over-exploitation of water resources
d. Need to improve irrigation management

We have partnered with University of Talca (Dr. Samuel Ortega) to improve our ability to estimate ET for olives and vineyards



Study area is in the center of Chile

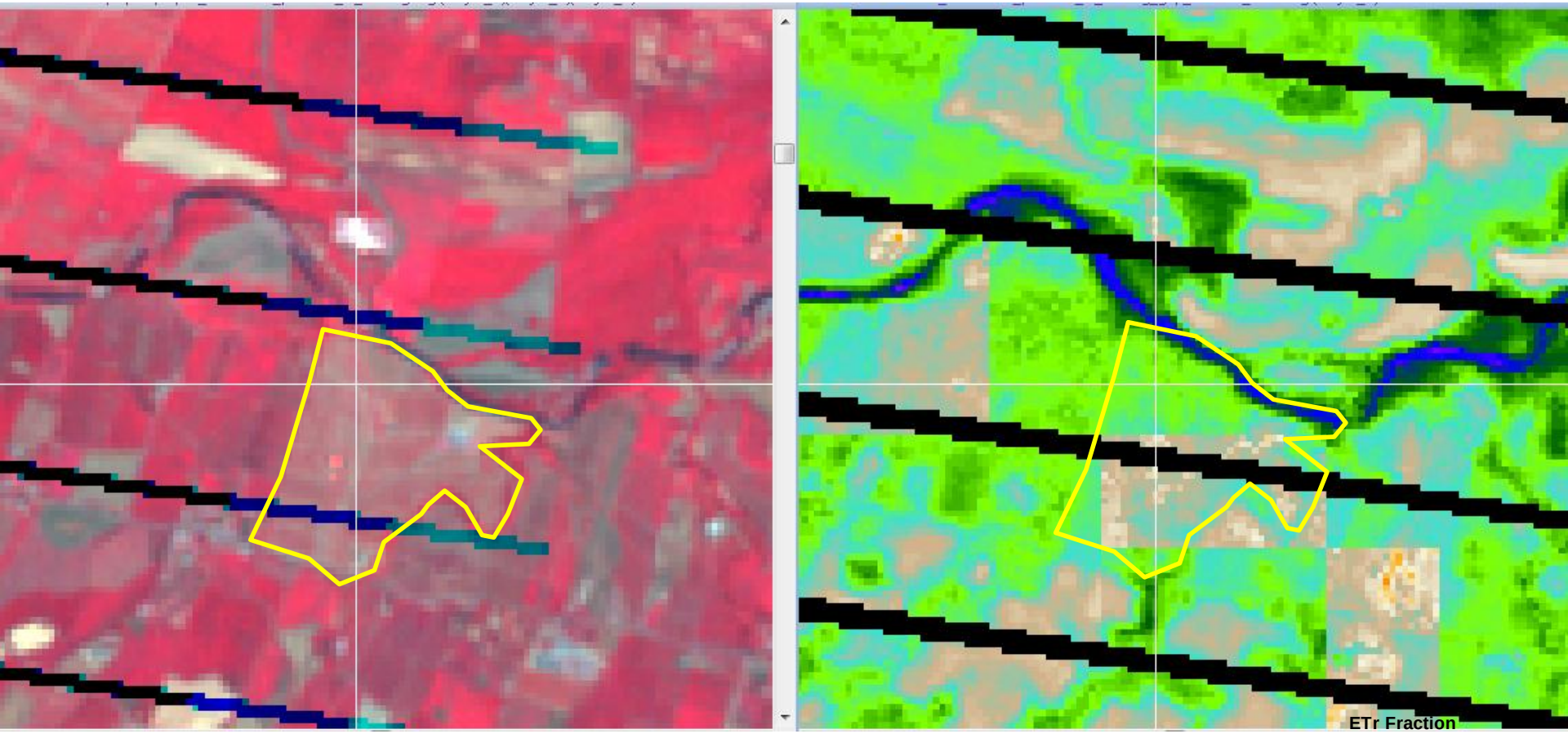
Path 233, Row 85, Landsat 7 processing (2011 & 2012)

Chile

New olive production in central Chile with relatively dense tree spacing.

ET fluxes were measured using an eddy covariance system mounted above the crop.

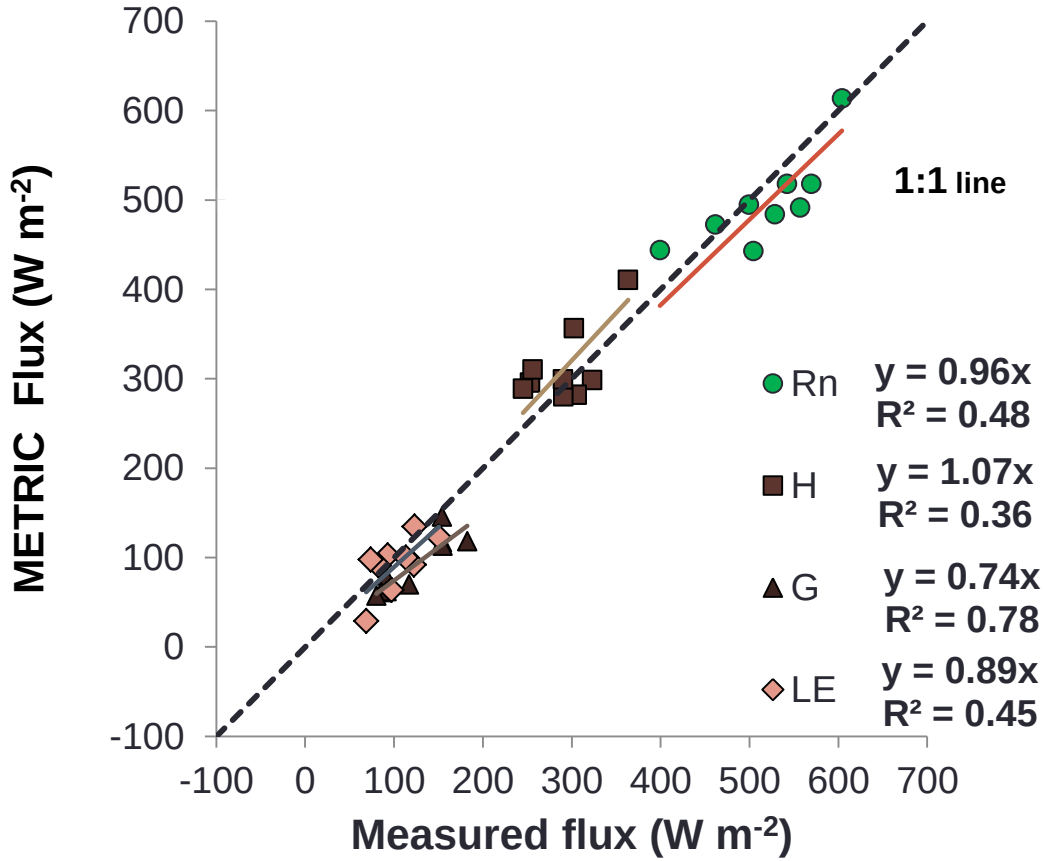
Photos by Dr. Samuel Ortega, Univ. Talca, Chile, collaborator with A. Kilic and R. Allen.



November 11, 2012 over the olive flux site.

Olives have low ground-cover and leaf area, making ET estimation challenging. 1000 m blockiness in ET (right) is caused by land use classification error in the Global Land Cover product.

METRIC vs. Ground Measurements – Olive Orchard near Talca, Chile



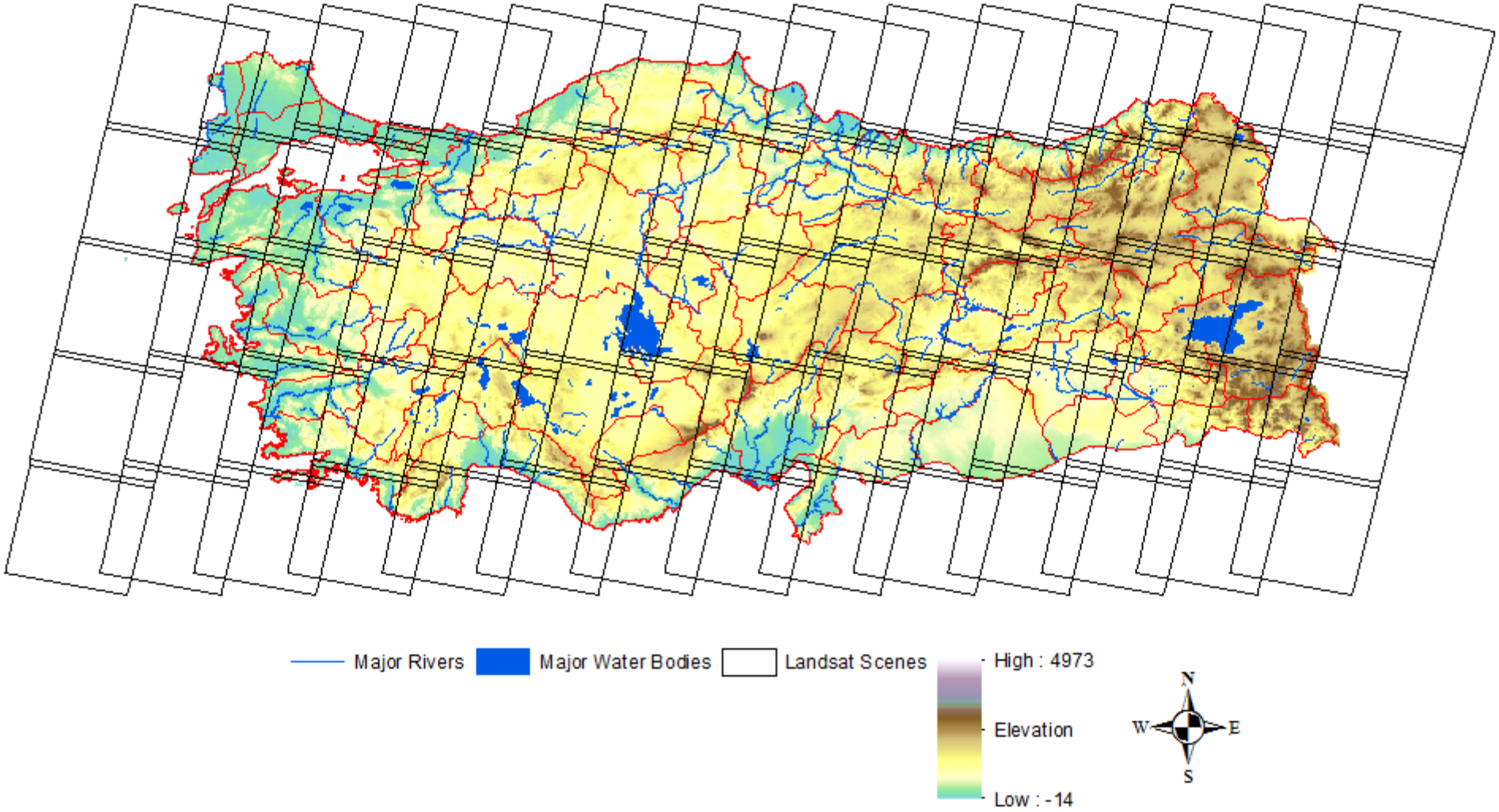
- We have made some enhancements to the model (Perrier function for surface roughness, Leaf Area Index)
- Correction to the global land cover map

Analyses by Samuel Orlando Ortega Salazar, with UNL group

TURKEY

Assisting Irrigation and Water Resources Management

Landsat coverages for Turkey: ~ 12 paths x 4 rows = ~ 50 scenes



HOME NEWS BUSINESS INTERVIEWS COLUMNISTS ARTS & CULTURE OP-ED EXPAT ZONE SPORTS FEATURES

DIPLOMACY NATIONAL WORLD

Tigris, Euphrates have enough water for Turkey, Iraq, Syria

0 Recommend 0 Tweet 2 Google Share

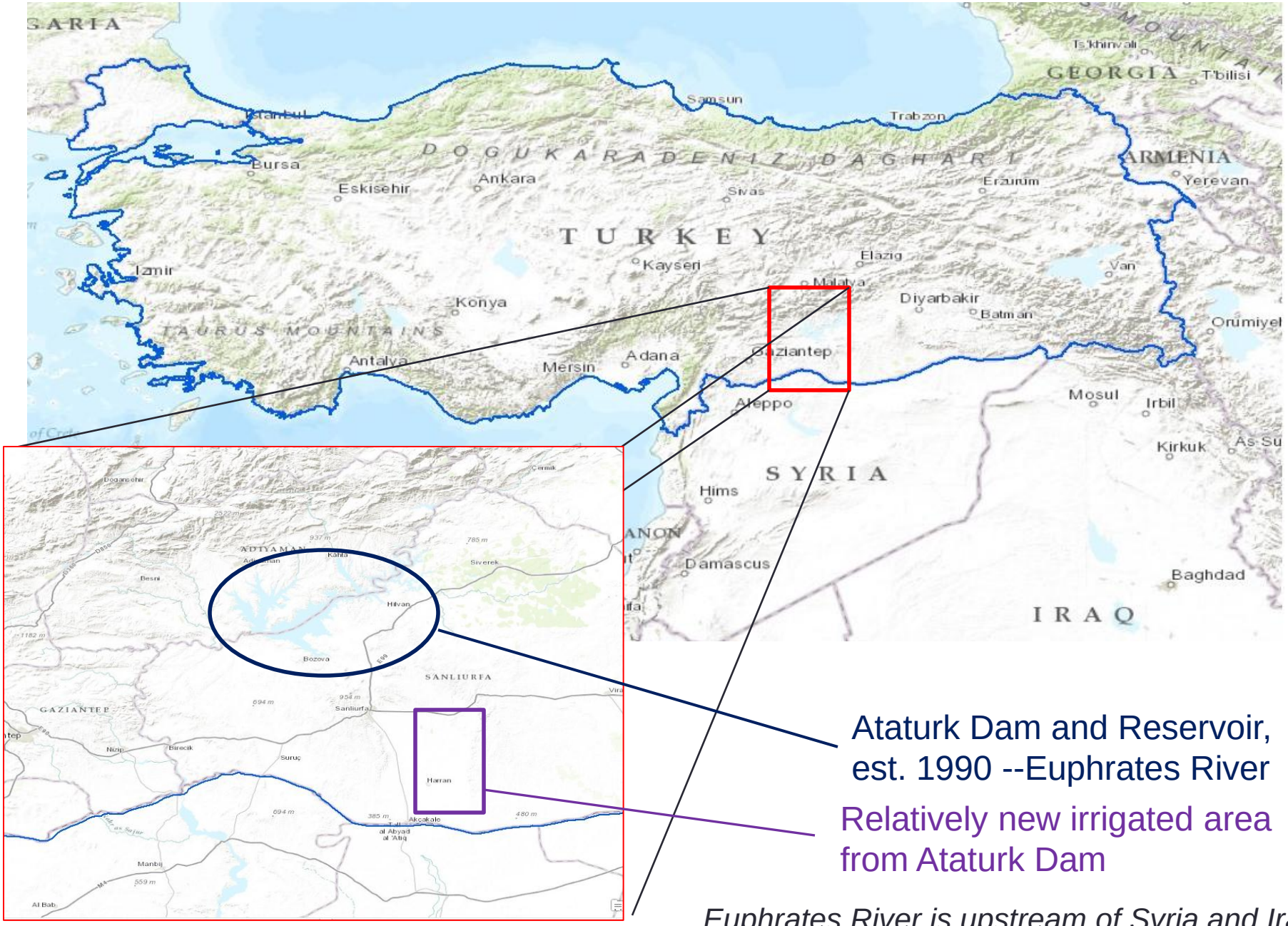
Atatürk Dam in Eastern Anatolia (Photo: Today's Zaman)

28 October 2013 /CUMALİ ÖNAL, İSTANBUL

Experts note that, when it comes to water, the Tigris and Euphrates are almost as often fought over as the Nile, but the fact is that these two rivers have more than an adequate

Impressions of adequate water availability vary with country

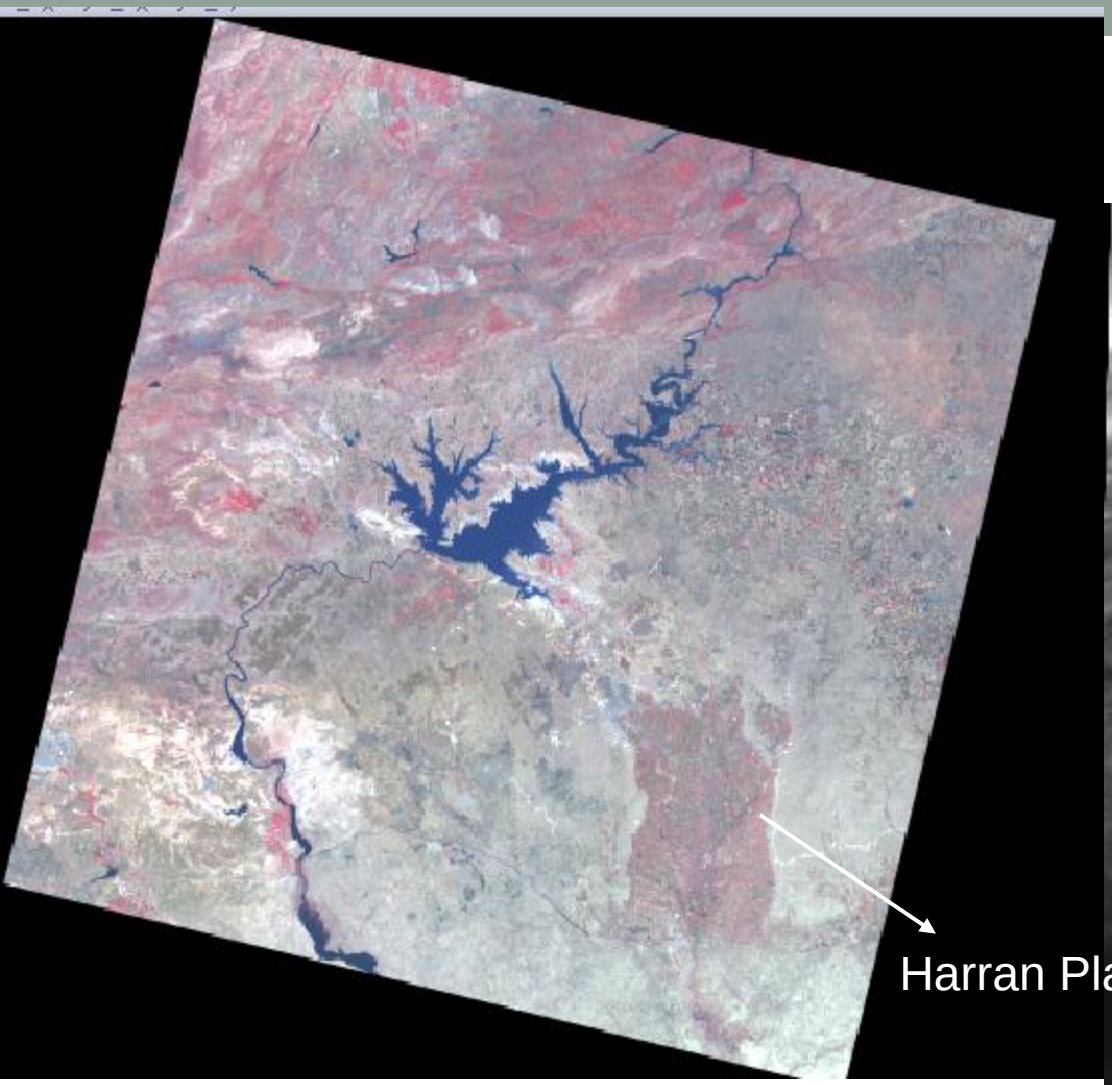
http://www.todayszaman.com/news-329986-tigris-euphrates-have-enough-water-for-turkey-iraq-syria.html



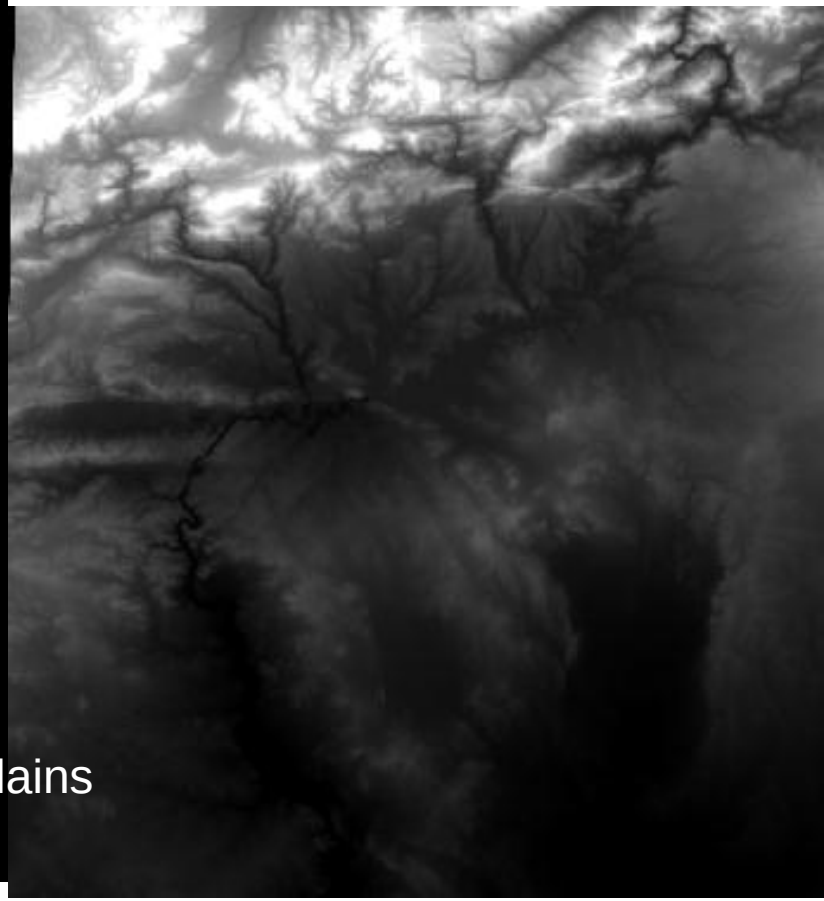
Ataturk Dam and Reservoir, est. 1990 --Euphrates River

Relatively new irrigated area from Ataturk Dam

Euphrates River is upstream of Syria and Iraq

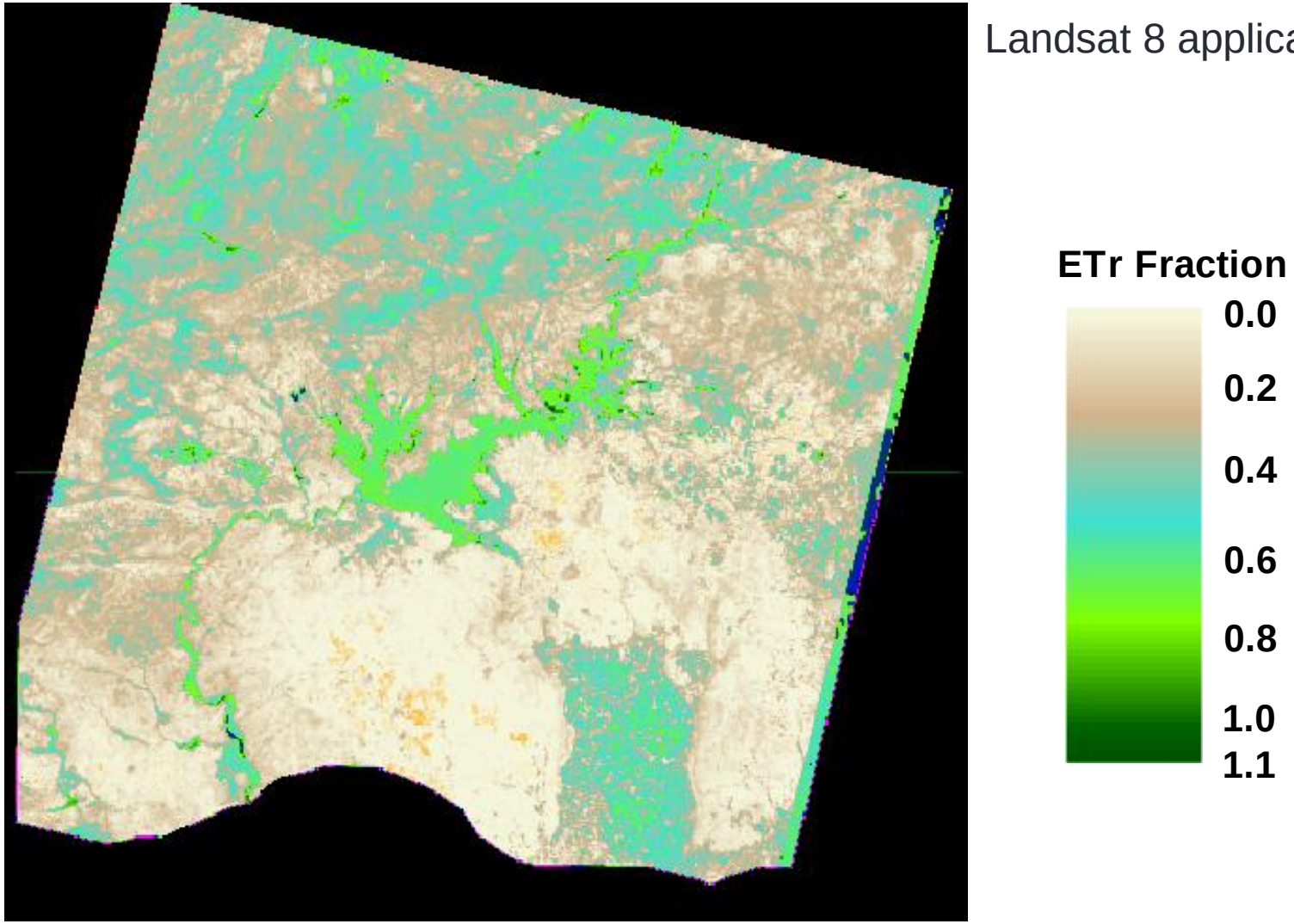


Landsat 8 image showing Ataturk Dam and Reservoir (center) and recent irrigation development (lower right) in Turkey, just north of Syria.
Water is taken from the Euphrates River upstream of Syria and Iraq.



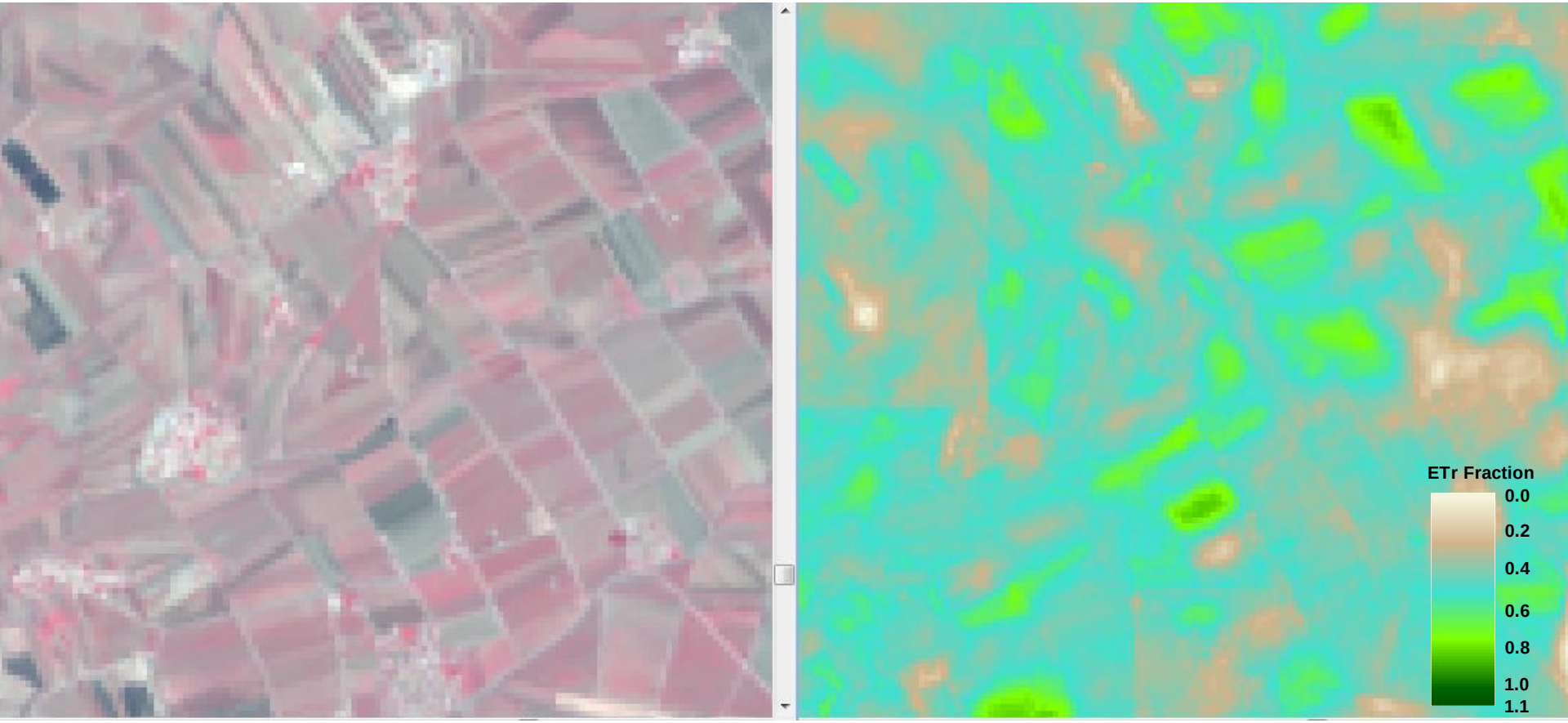
Digital Elevation Map showing relatively complex terrain

Landsat 8 application



ET map of the Turkish portion of Path 173, Row 34, for June 27, 2013, Expressed as fraction of reference ET (ETrF).

Average field size is 2-10 ha.



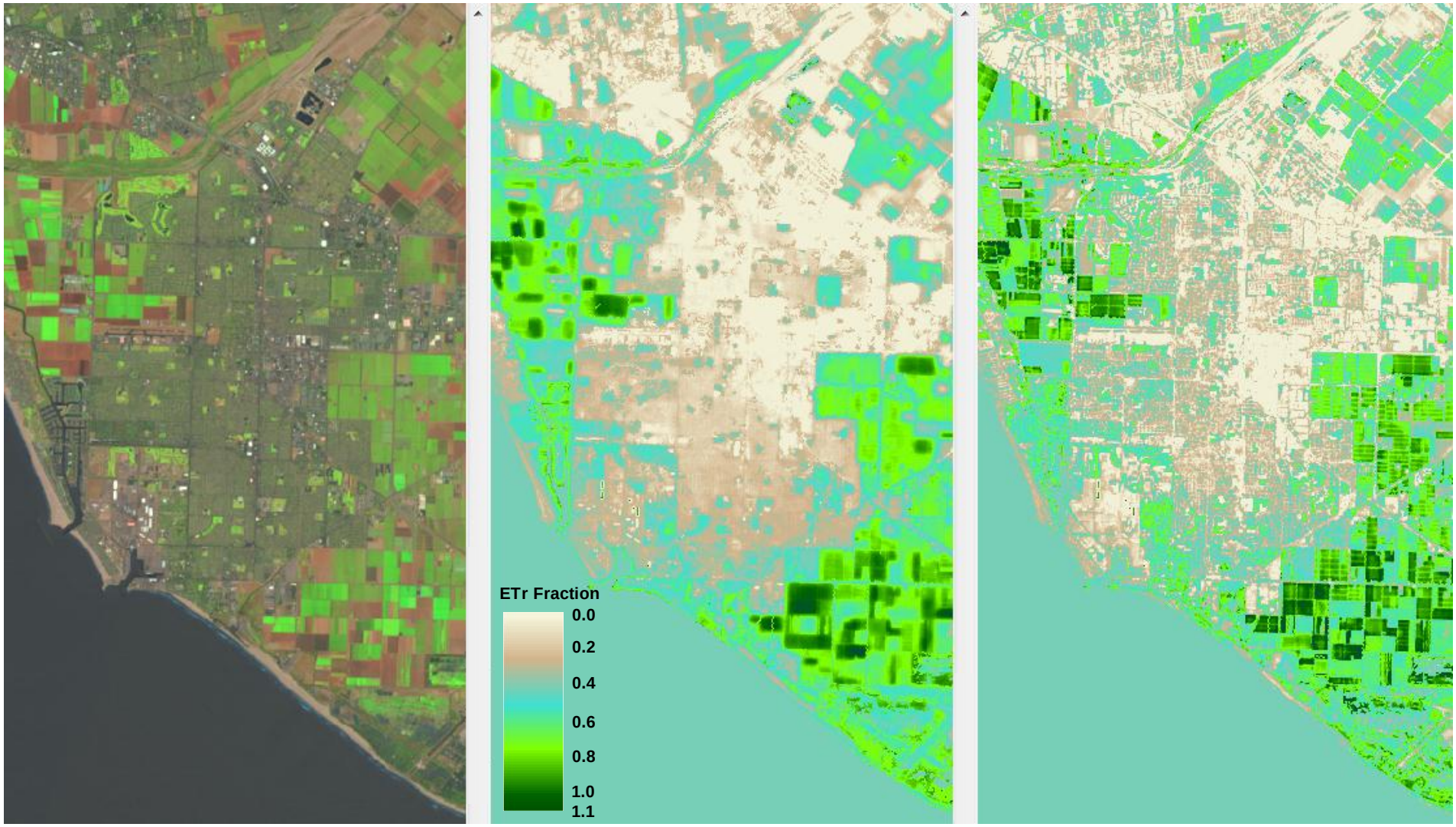
The small fields in Turkey are somewhat challenging to differentiate at 100 m (thermal-based ET-Landsat 8) (right). Fields are more clear at 30 m (left). 1000 m blockiness in ET (right) is caused by land use classification error in the Global Land Cover product.

FIRST APPLICATIONS OF LANDSAT 8 FOR EVAPOTRANSPIRATION IN THE US

Ricardo Trezza, Rick Allen – Univ. Idaho
Ayse Kilic, Ian Ratliffe, Babu Kamble, Univ. Nebraska

---- Using METRIC

Impact of sharpening thermal from 100 m to 30 m using NDVI



Landsat 8 image, Ventura, CA, May 2013. False color (left), ETrF (center), ETrF from sharpened thermal (right)

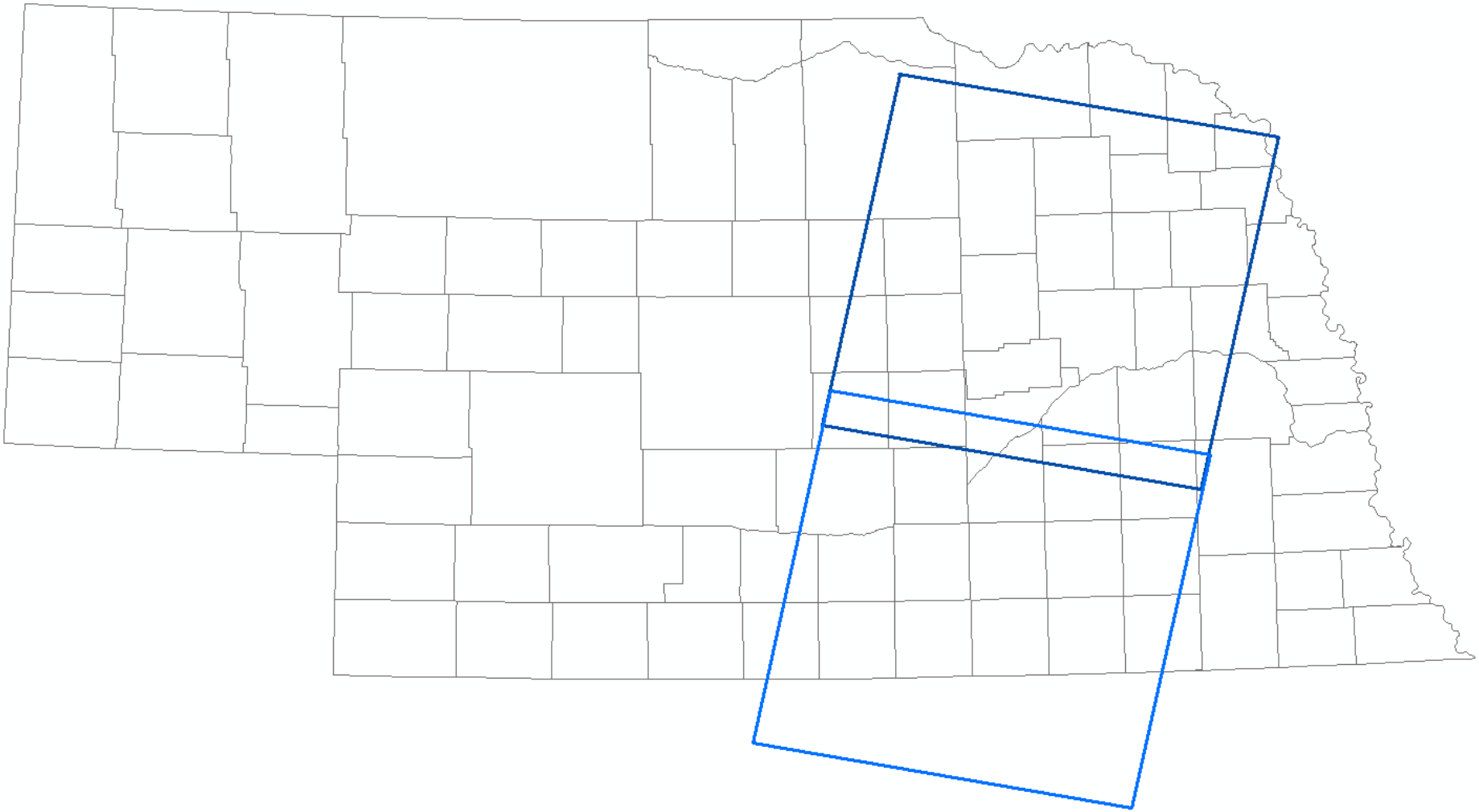
NEBRASKA

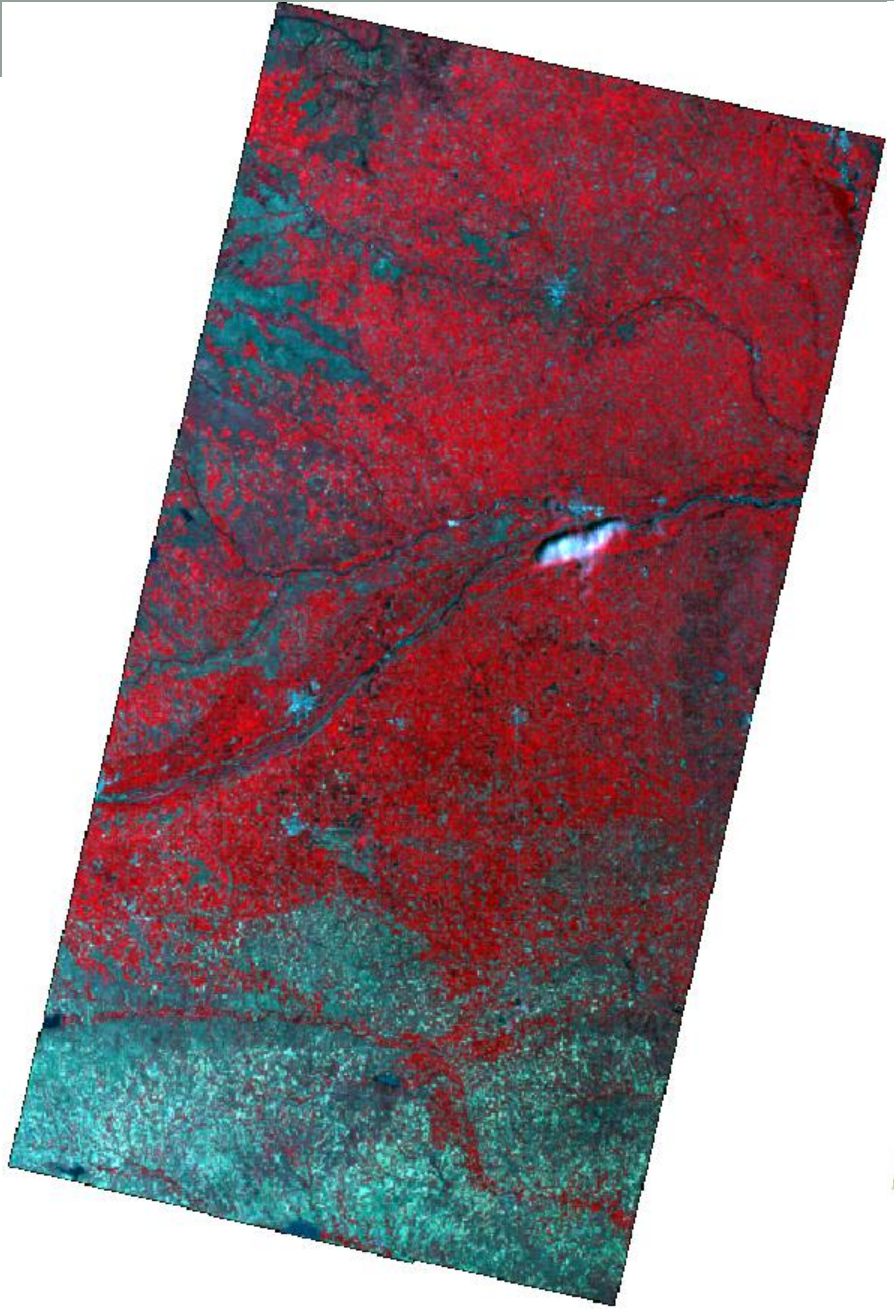
Landsat 8 Applications to the Central Platte Natural Resources District (NRD)

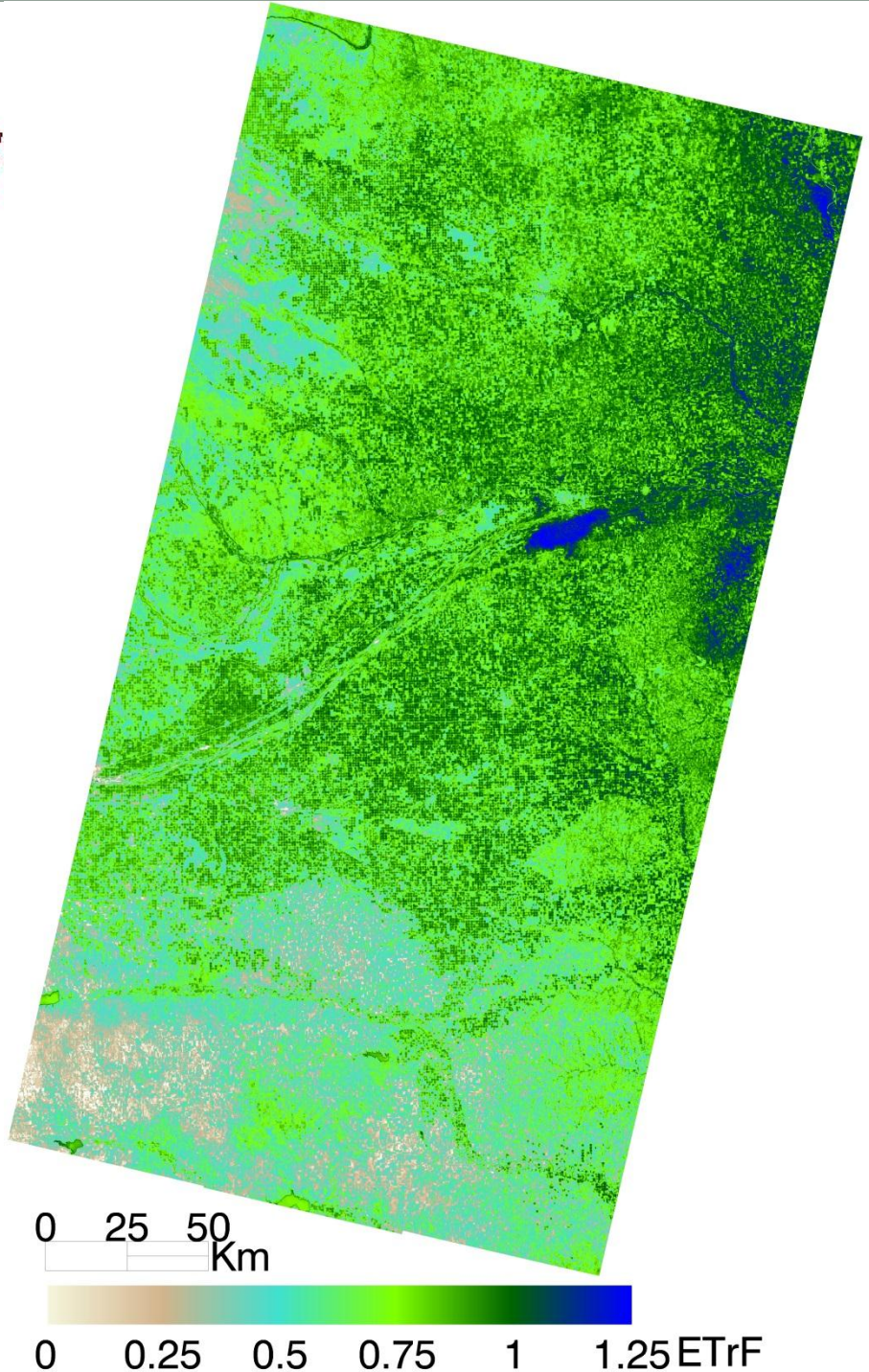
Objective: Manage depletions to the Ogalla Aquifer

Central Platte NRD has embraced the use of Landsat based ET and they support the full cost of production

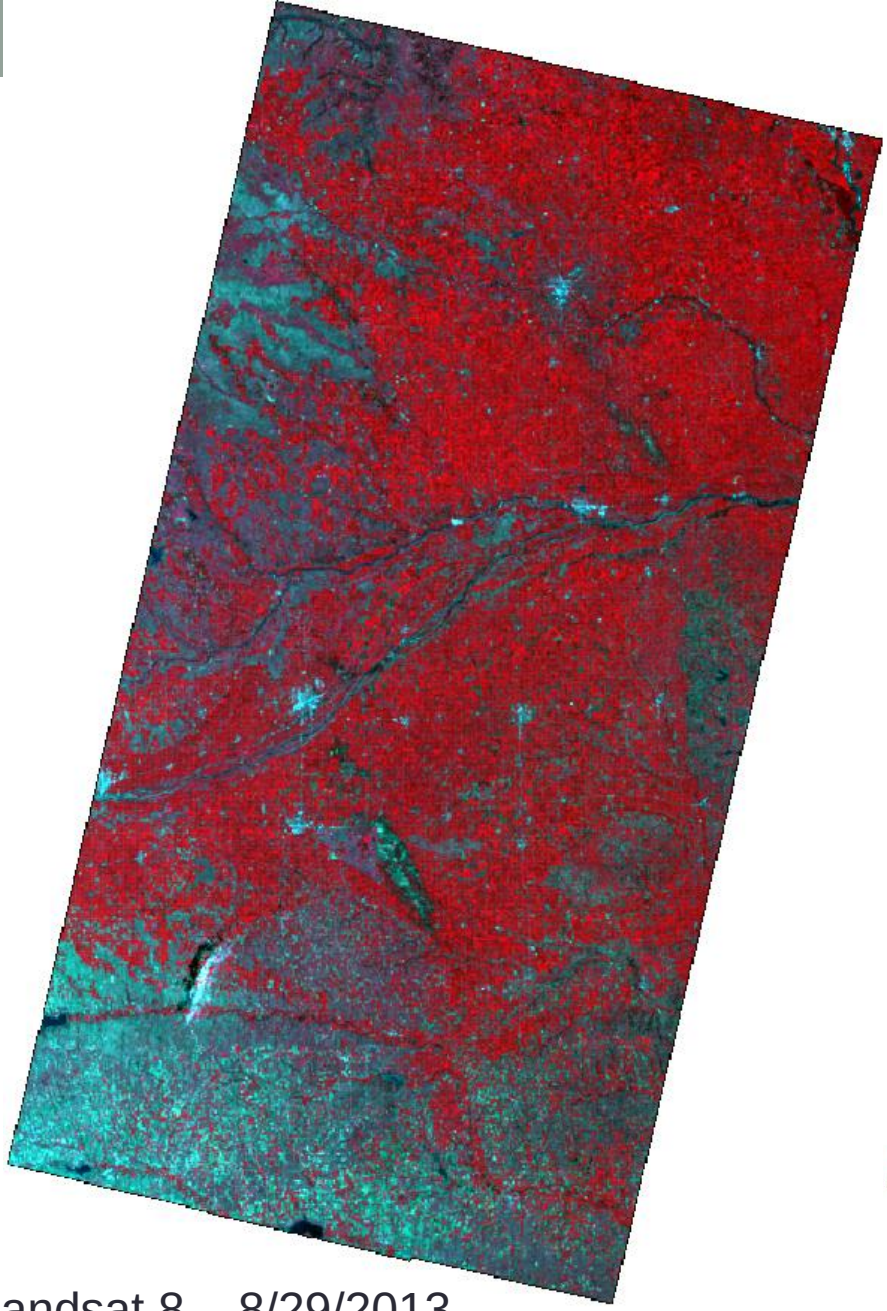
Landsat 8 applications to date in East-Central Nebraska

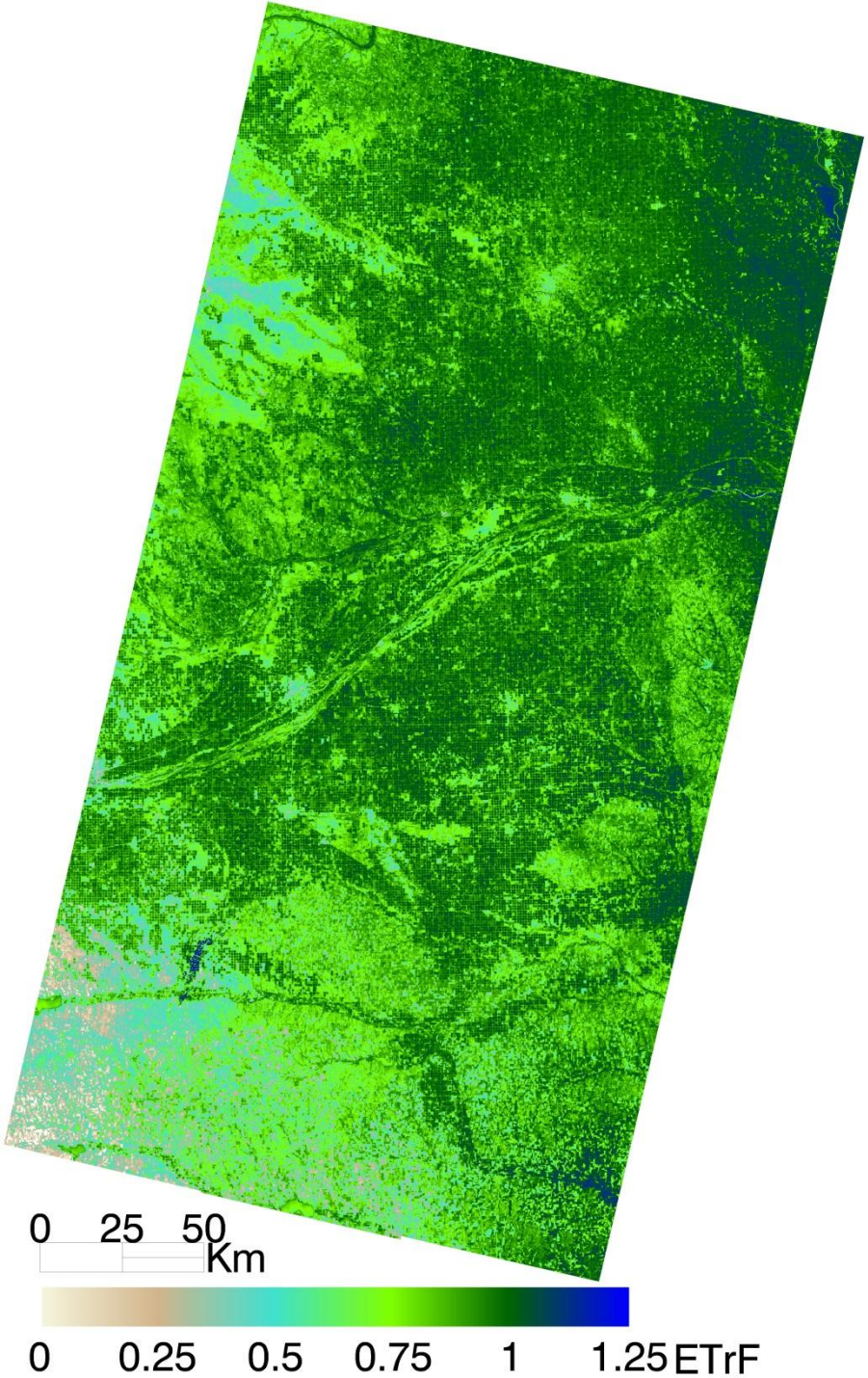






Landsat 8 – 7/12/2013
Path 29, Rows 30-31





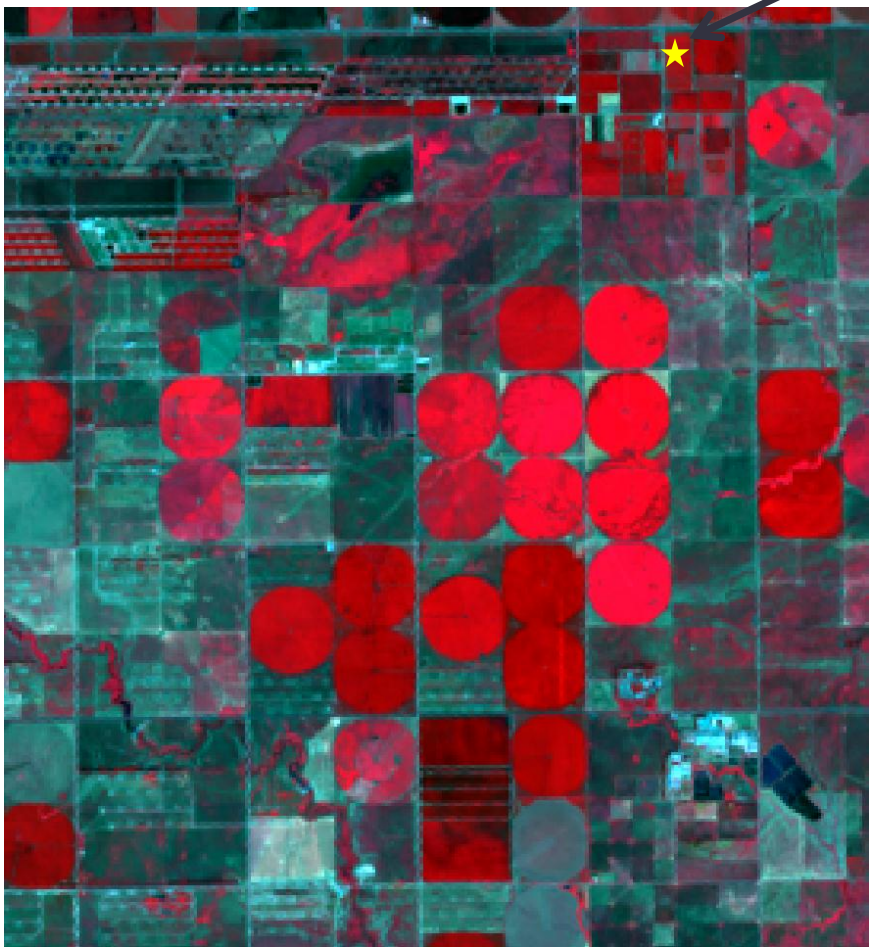
Landsat 8 – 8/29/2013

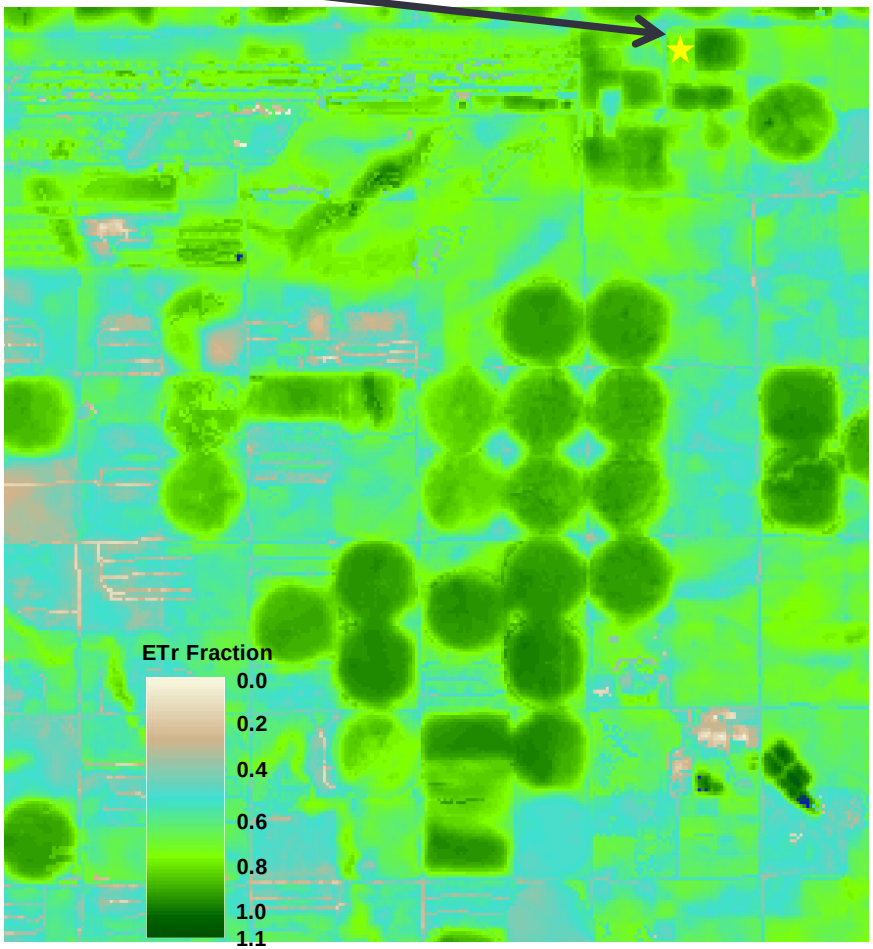
Path 29, Rows 30-31

Landsat 8 – 7/12/2013
False Color Composite Bands 5/4/3

ET Flux Site

METRIC ETrF – 7/12/2013

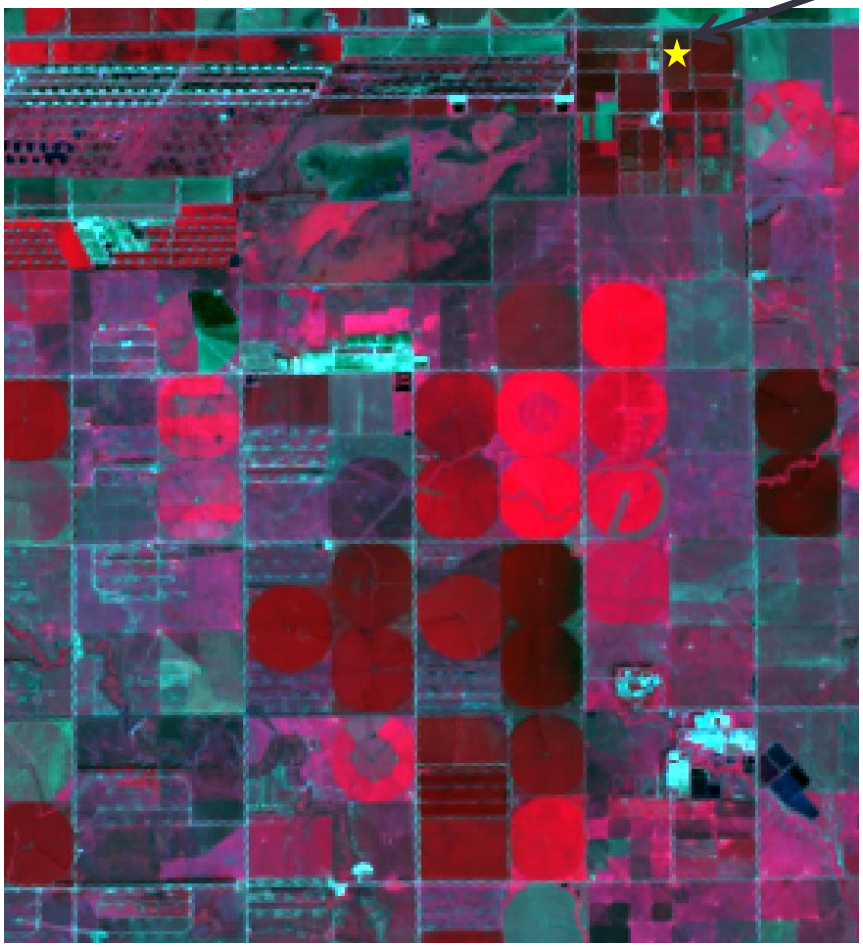


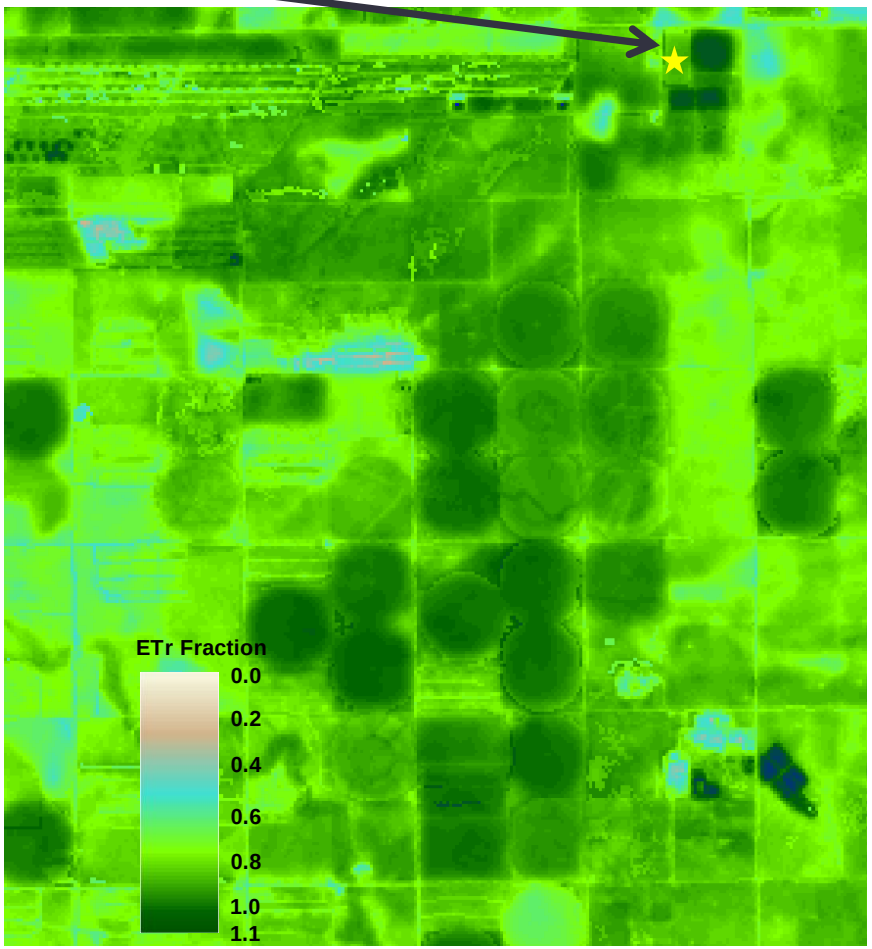


Landsat 8 – 8/29/2013
False Color Composite Bands 5/4/3

ET Flux Site

METRIC ETrF – 8/29/2013





GOOGLE EARTH ENGINE

METRIC → EEFlux (Earth Engine Evapotranspiration Flux)
Cloud Base Processing

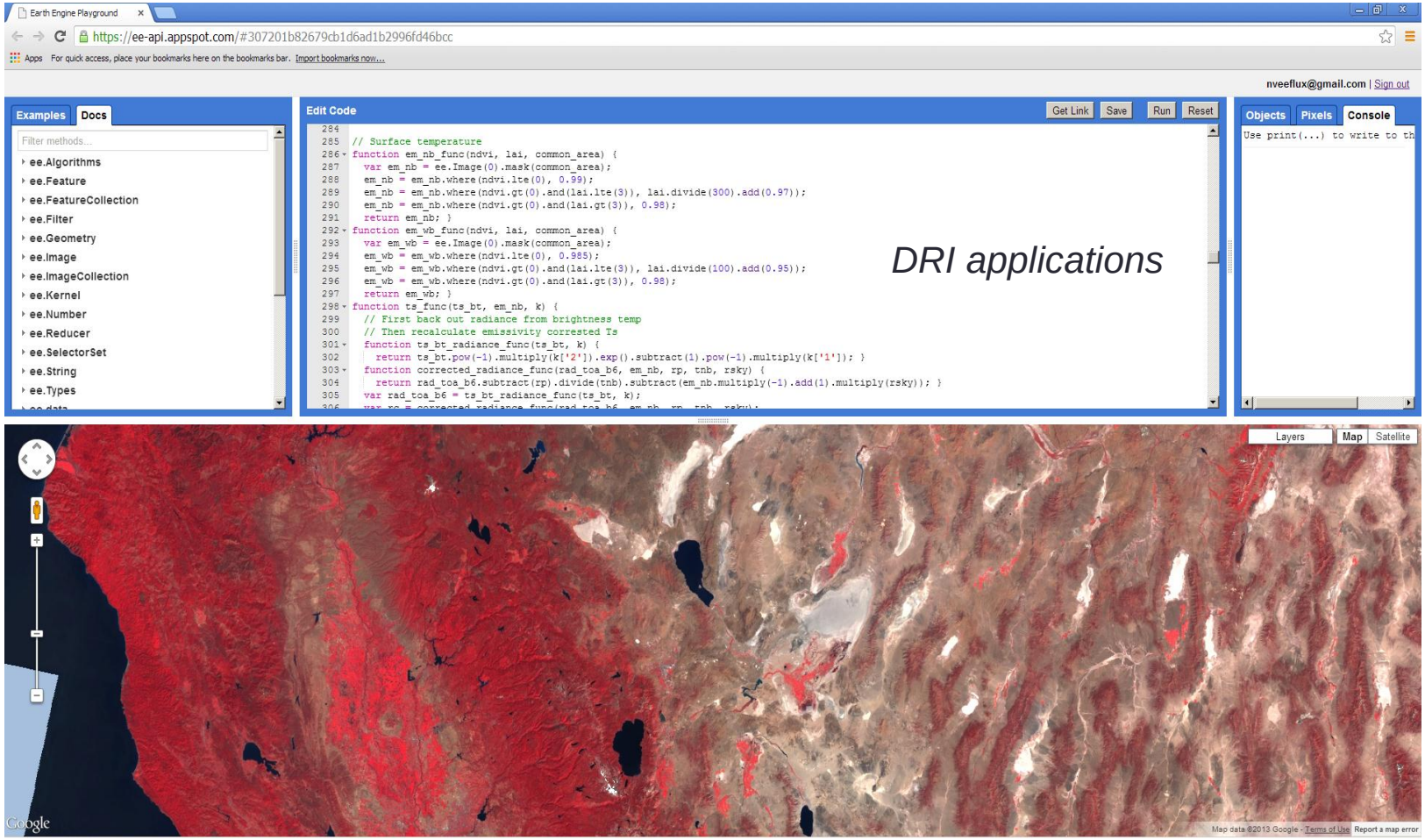
Univ. Nebraska; Univ. Idaho; Desert Res. Inst.

Code developers: Baburao Kamble and Charles Morton

Support by Google, Inc.

Complementary Work

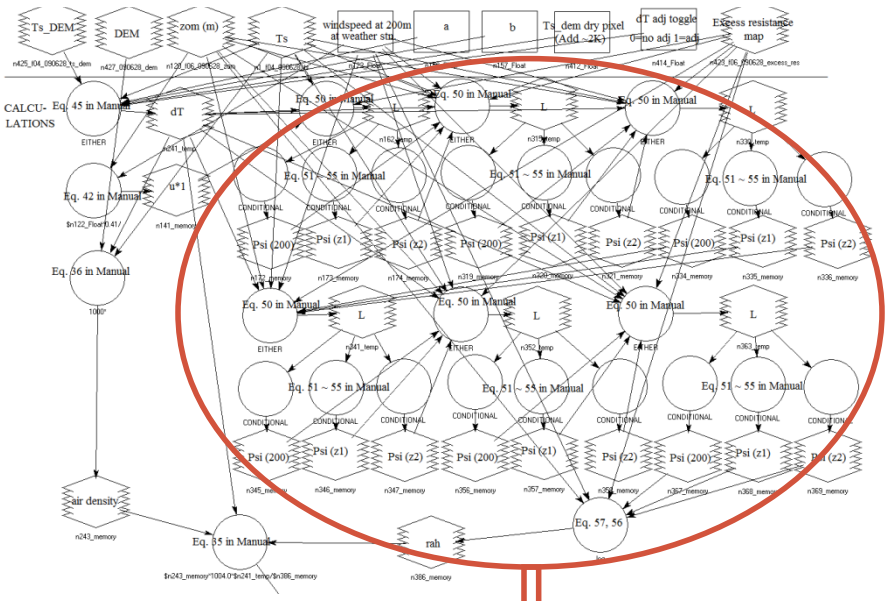
- Google Earth Engine
  - Implementing METRIC on Google Earth Engine with LEDAPS and NLDAS Gridded Weather Data
  - Currently Testing in Google Earth Engine Java Script Playground



METRIC on Earth Engine using Python & GDAL

- Automated operation
  - Entire modeling process is run from command line
- Python
  - Open source / open platform programming language
- GDAL
  - Open source / open platform GIS libraries to support Python
  - Language used in Google Earth Engine

Traditional sensible heat flux METRIC model in Erdas

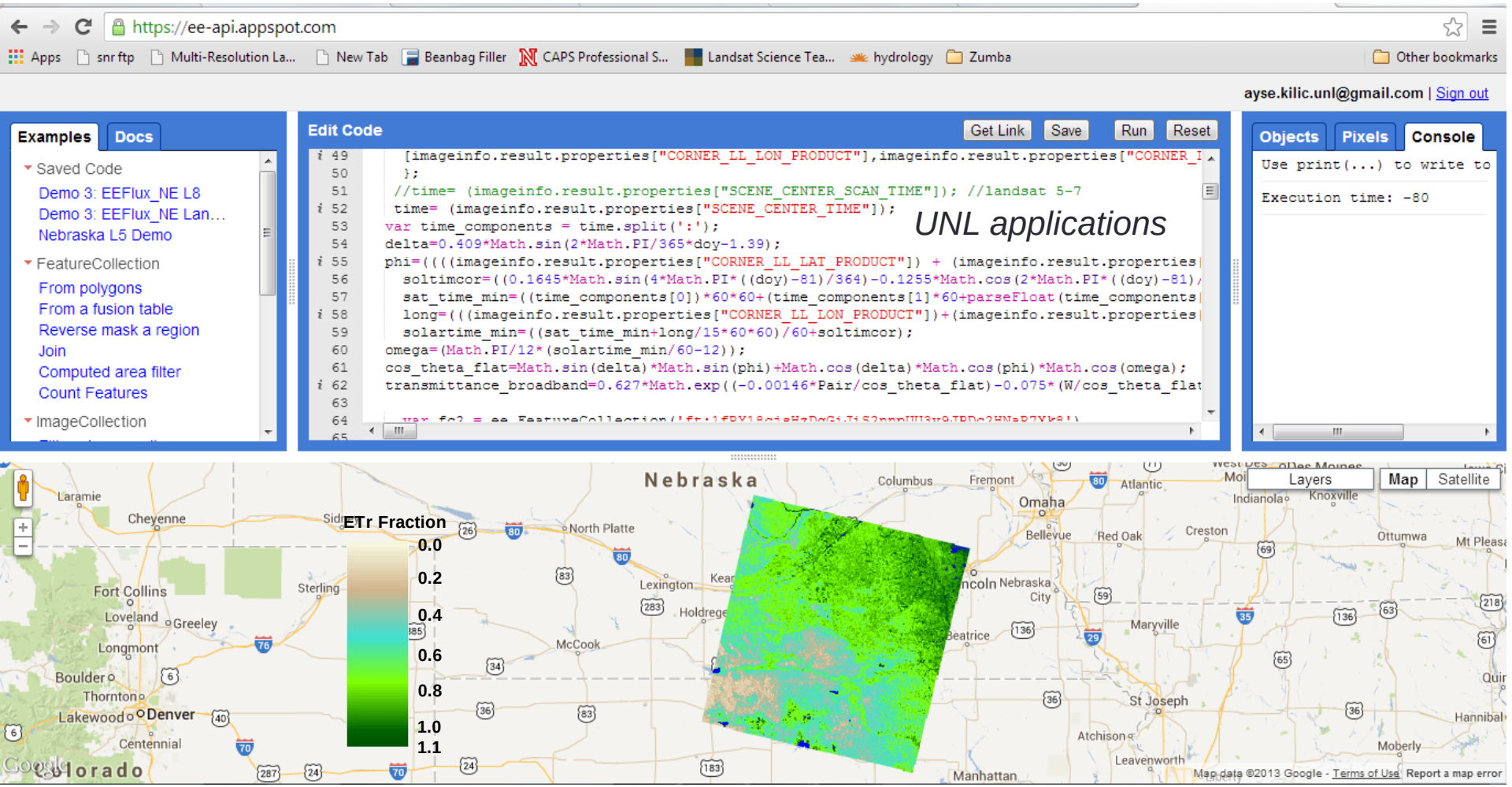


Clipped Python version of METRIC sensible heat flux model

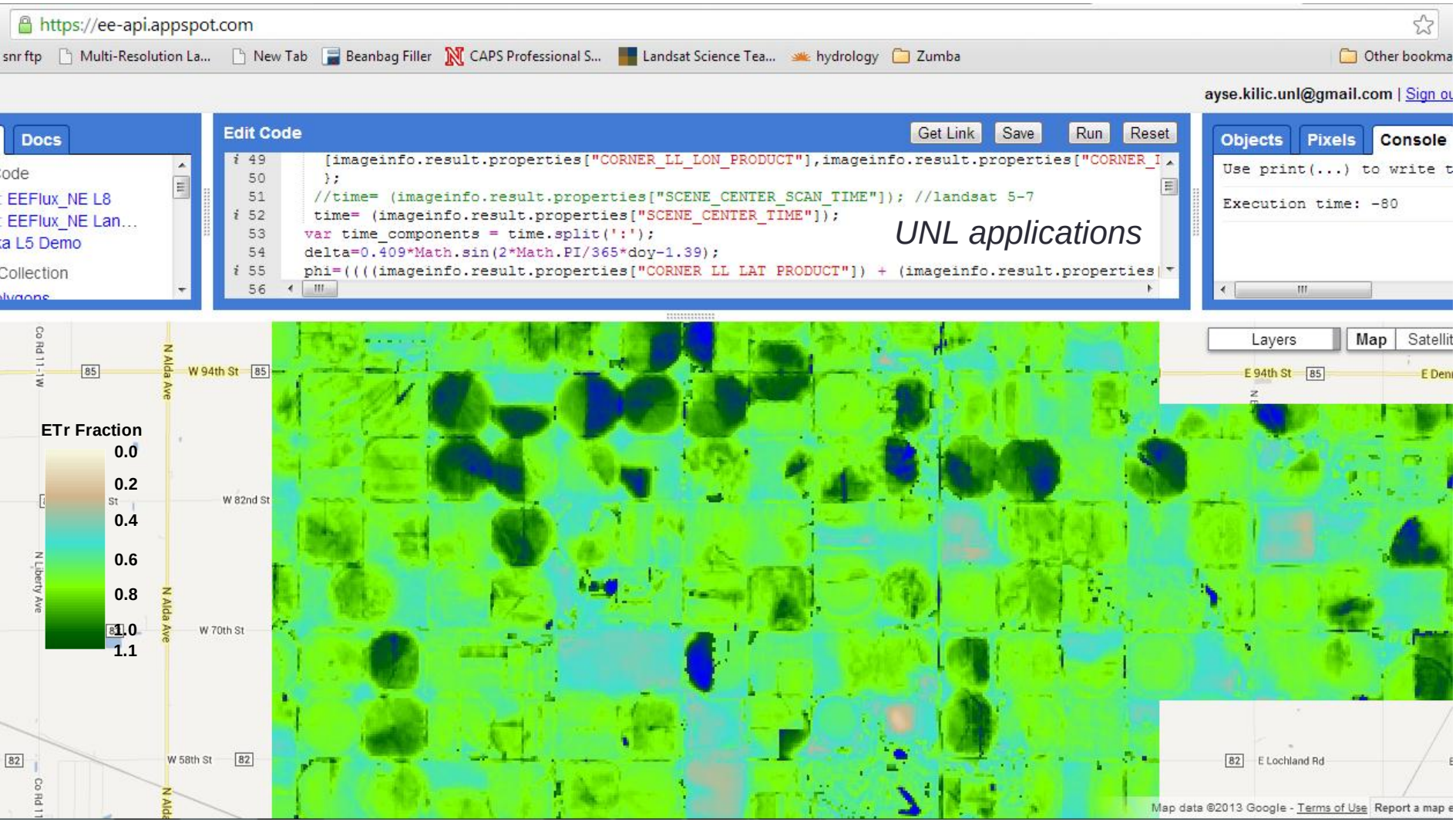
```
for i in range(6):
    u*(u, z, zom, psi_z3)
    rah(z, psi, u*, ex_res)
    l(dt, u*, Ts, rah)
    psi_z3(l, z3)
    psi_z2(l, z2)
    psi_z1(l, z1)
    if stable(): break
```

Google Earth Engine Demo of EEFlux with Landsat 8 in Nebraska.

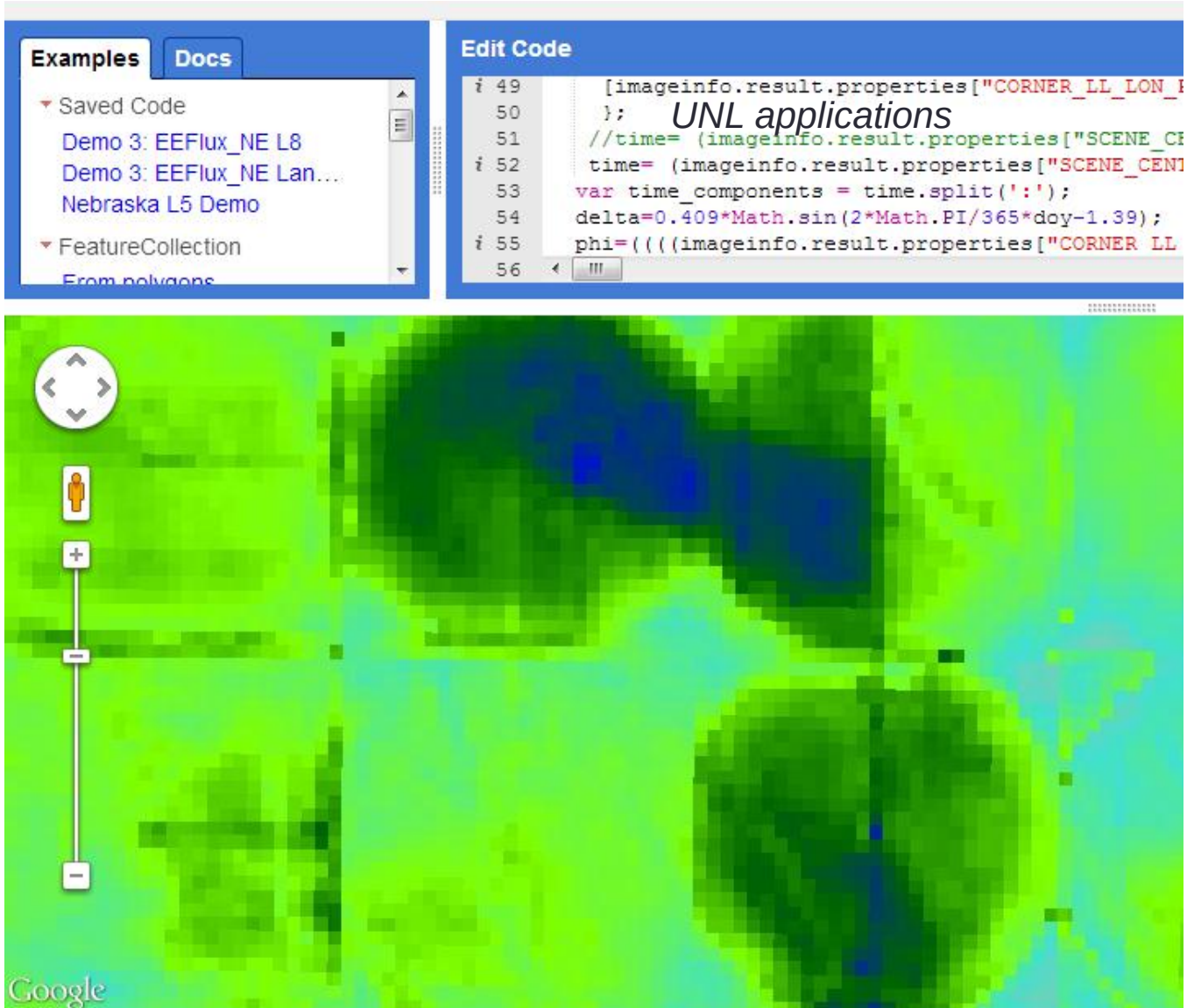
Computation time for full production of ET for one scene was less than 2 seconds.

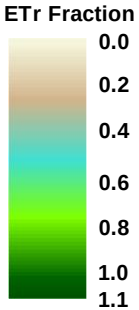


Google Earth Engine Demo of EEFlux with Landsat 8 in Nebraska.
Computation time for full production of ET for one scene was less than 2 seconds



Google Earth Engine Demo of EEFlux with Landsat 8 in Nebraska.
Computation time for full production of ET for one scene was less than 2 seconds

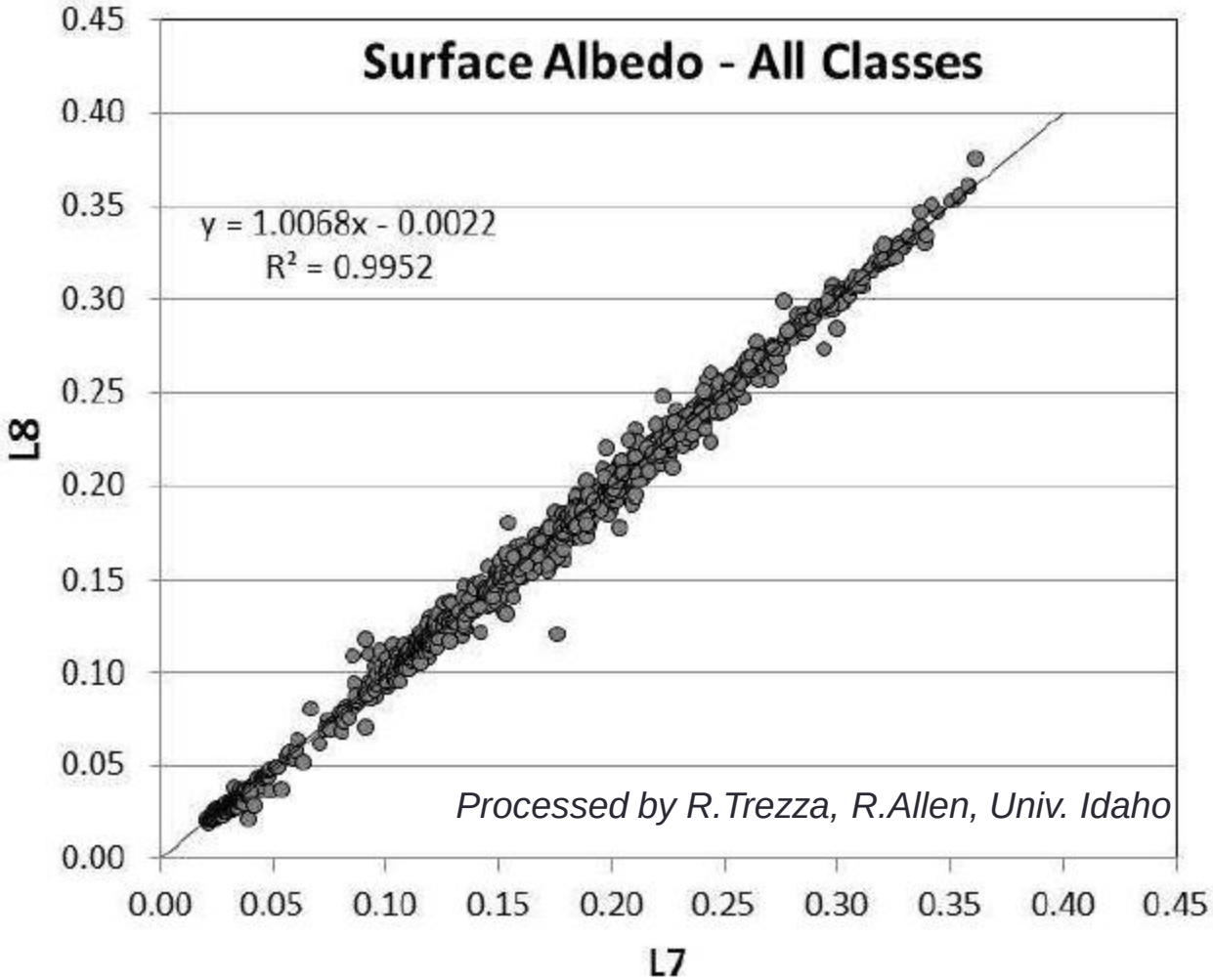




LANDSAT 8 – 7 UNDERFLY MARCH 29-30, 2013

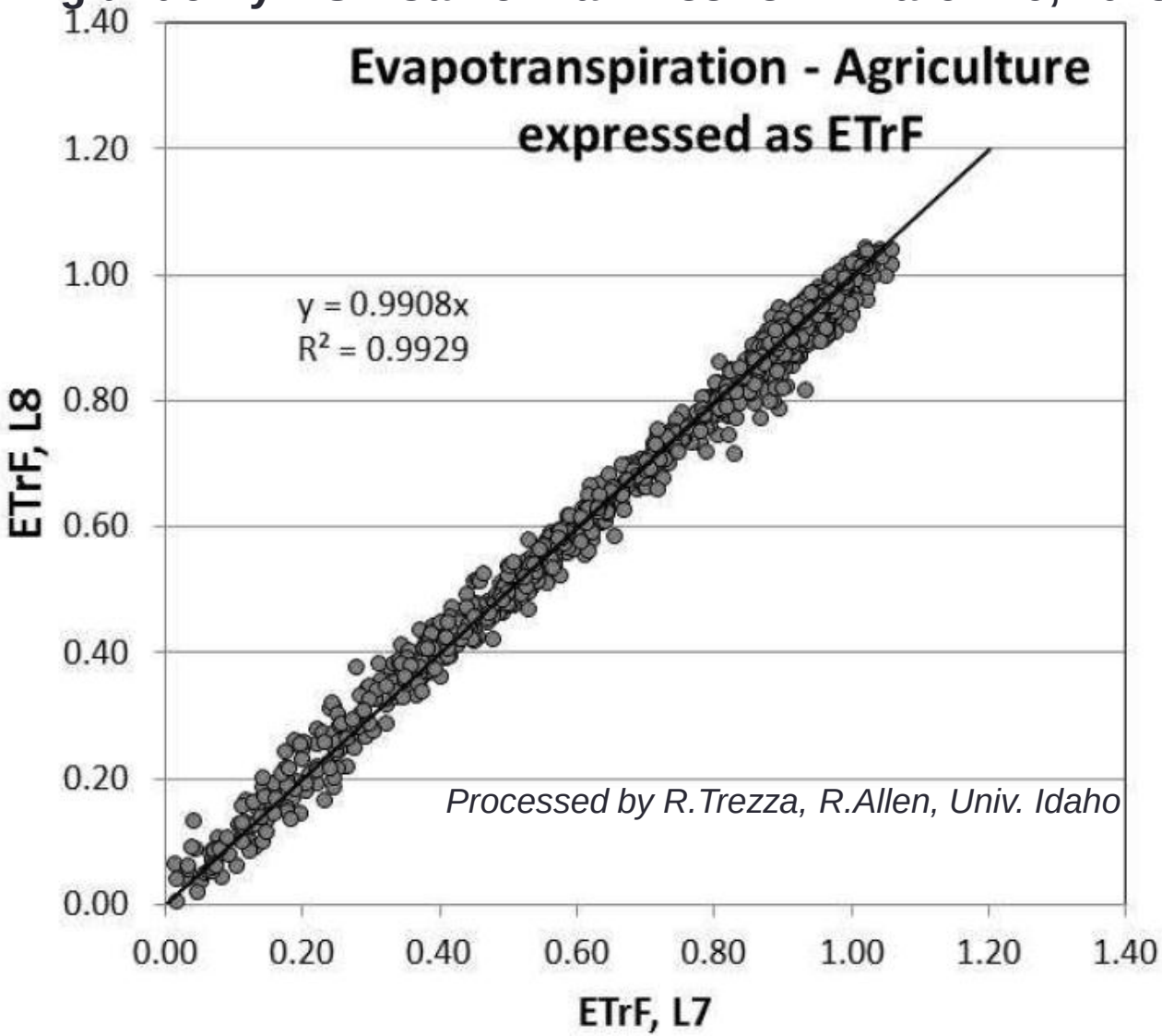
Comparison of surface albedo and Evapotranspiration

Comparison of at-surface albedo from METRIC using Landsat 8 vs. using Landsat 7 during underfly – SE California – P38R37 – Mar. 29, 2013 for ag. and desert land use



Conclusion: Good correspondence between the two systems

Comparison of ET from METRIC using Landsat 8 vs. using Landsat 7 During underfly – SE California – P38R37 – March 29, 2013



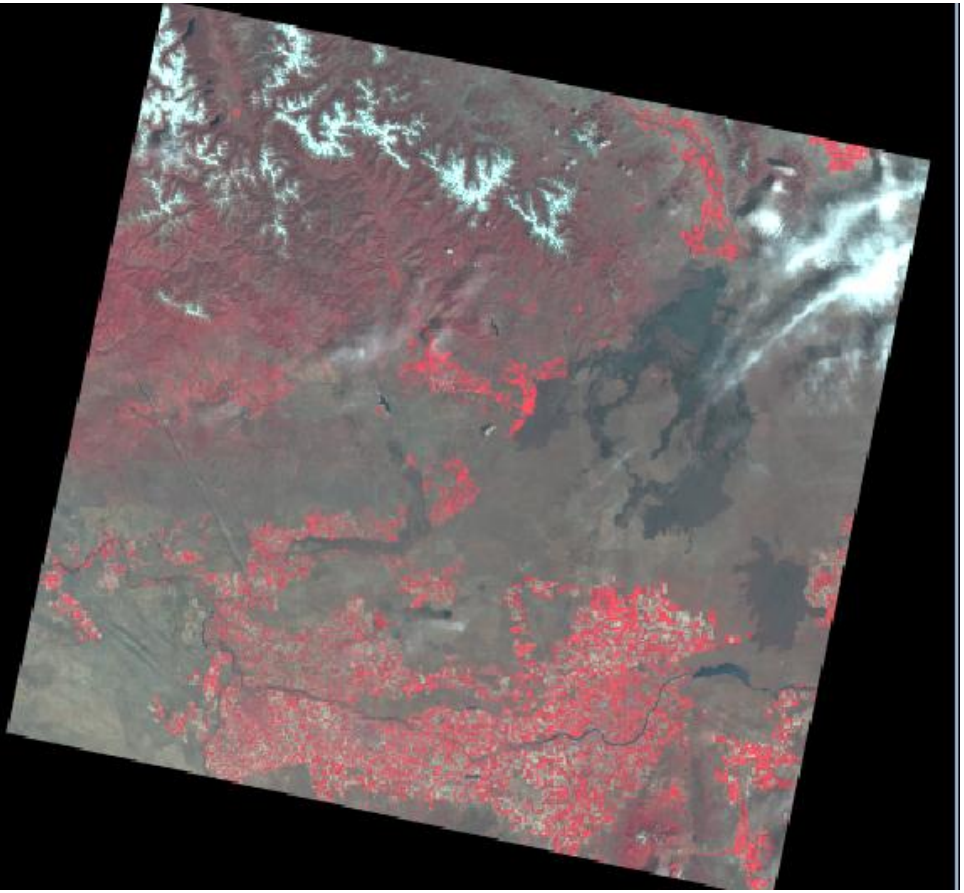
Conclusion: Excellent correspondence between the two systems, even with bias in L8-TIRS due to the internal anti-bias calibration mechanism in METRIC

USE OF THE LANDSAT 8 CIRRUS BAND

Path 40 Row 30 in Southern Idaho – Landsat 8 – June 7, 201

Use of the Cirrus band to detect cirrus clouds and jet contrails

False color



Path 40 Row 30 in Southern Idaho – Landsat 8 – June 7, 201

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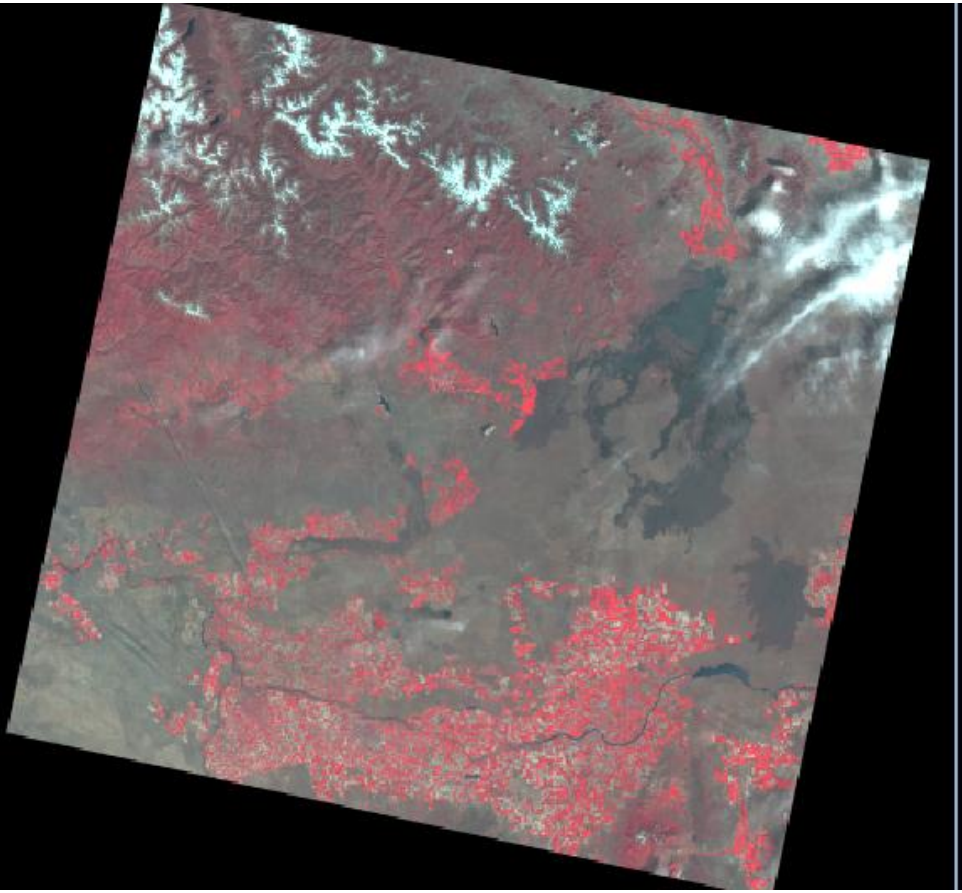
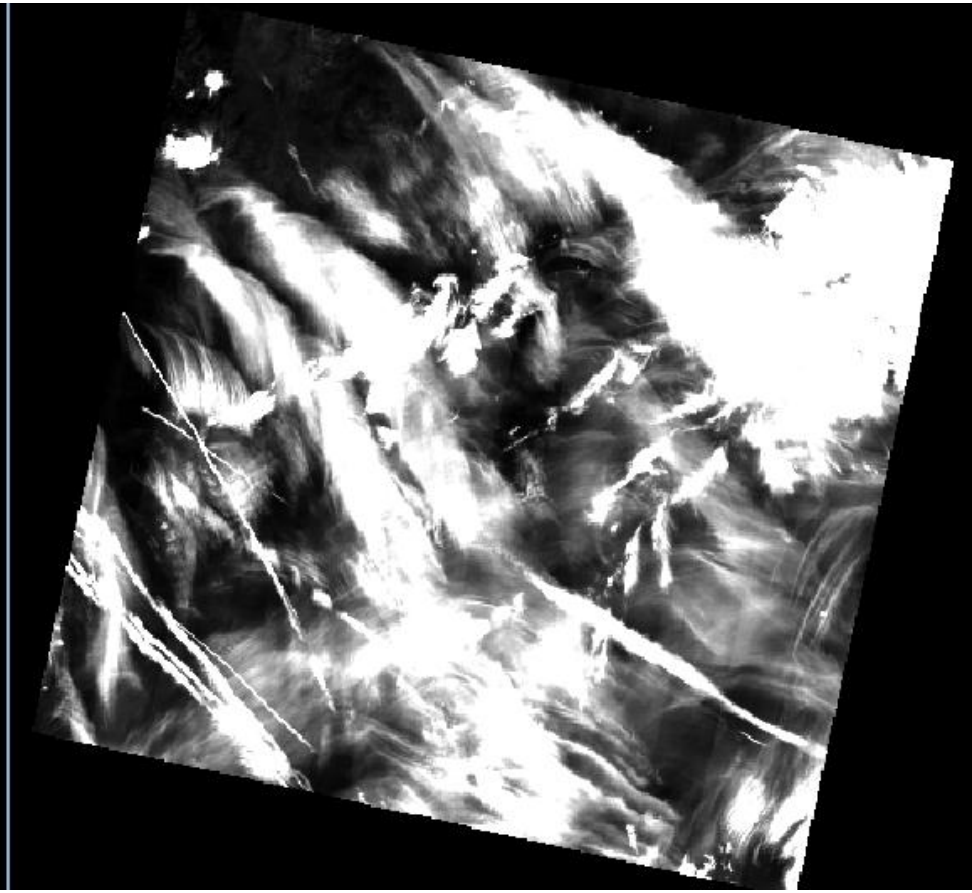


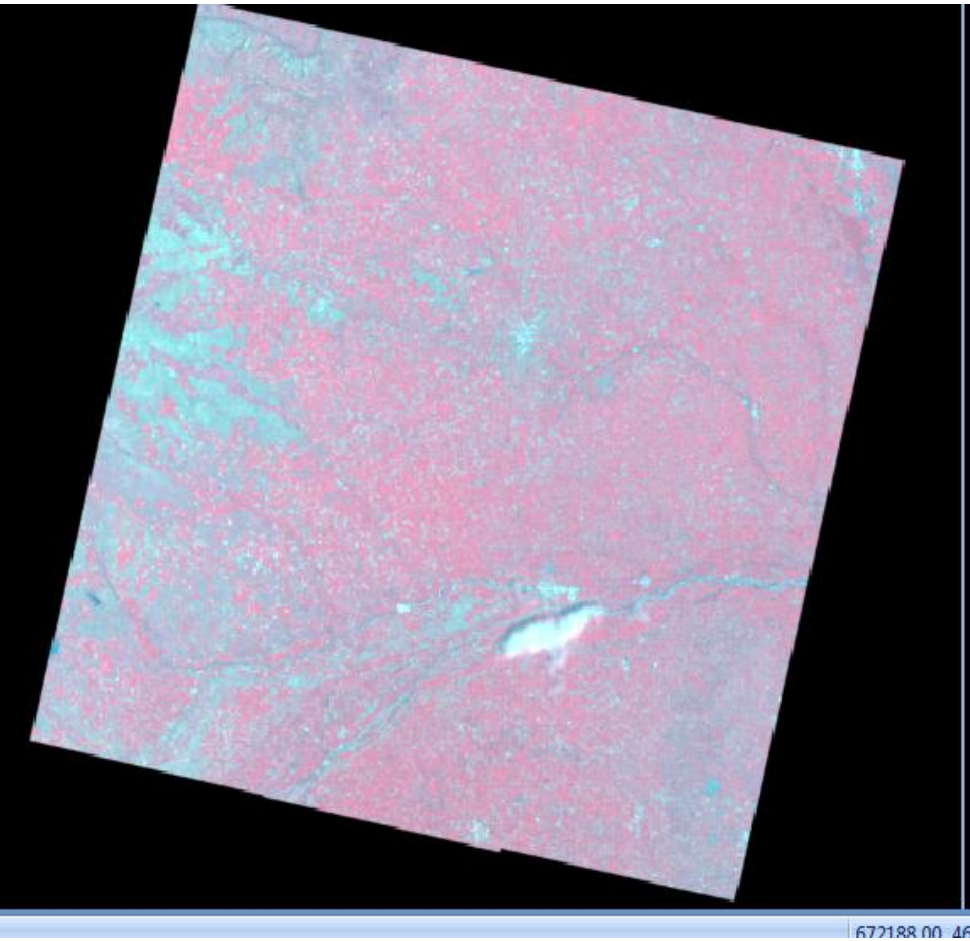
Cirrus band (9)



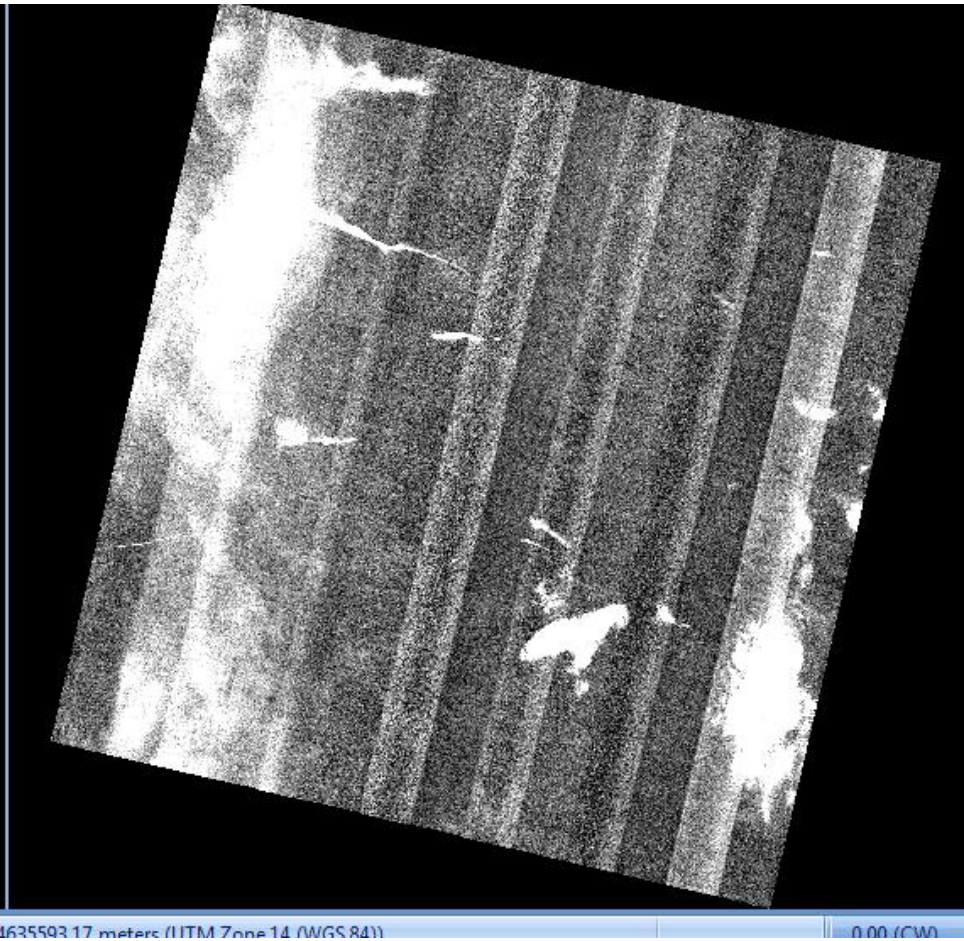
*Comment: The cirrus band can show **all kinds** of cloud and contrail artifacts that might impact the thermal image*

Path 29 Row 31 in Eastern Nebraska – Landsat 8 – July 12, 2013

False color



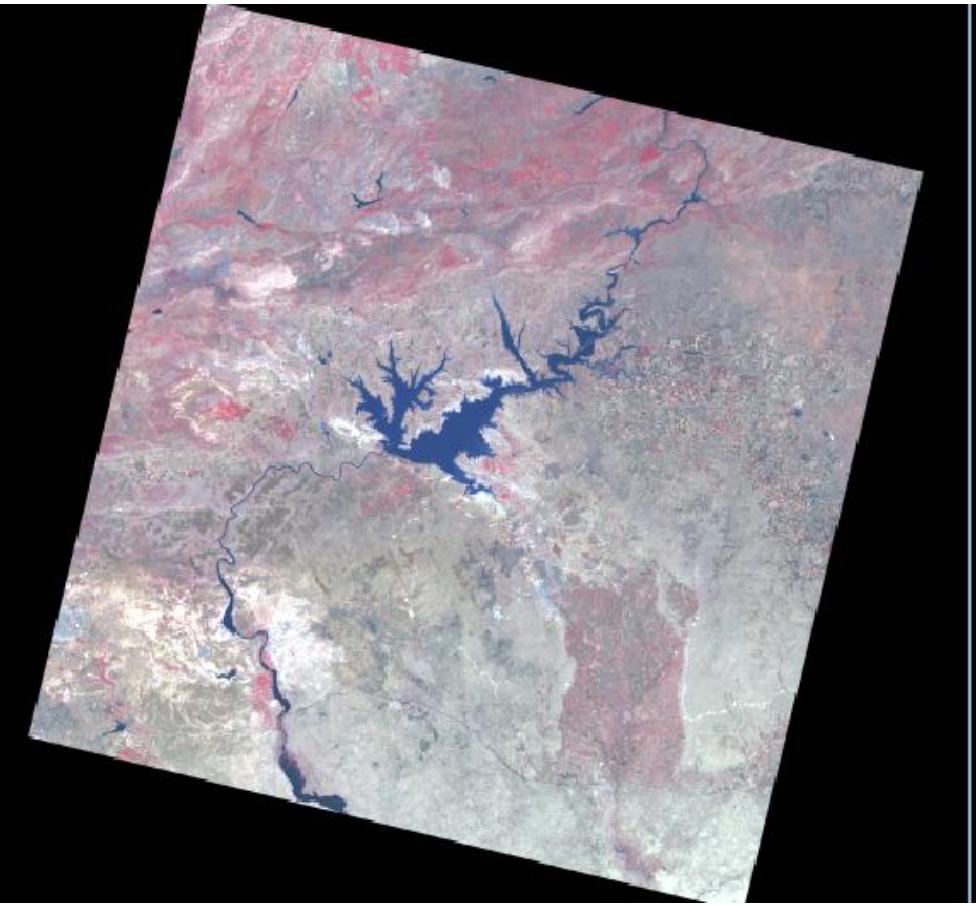
Cirrus band (9)



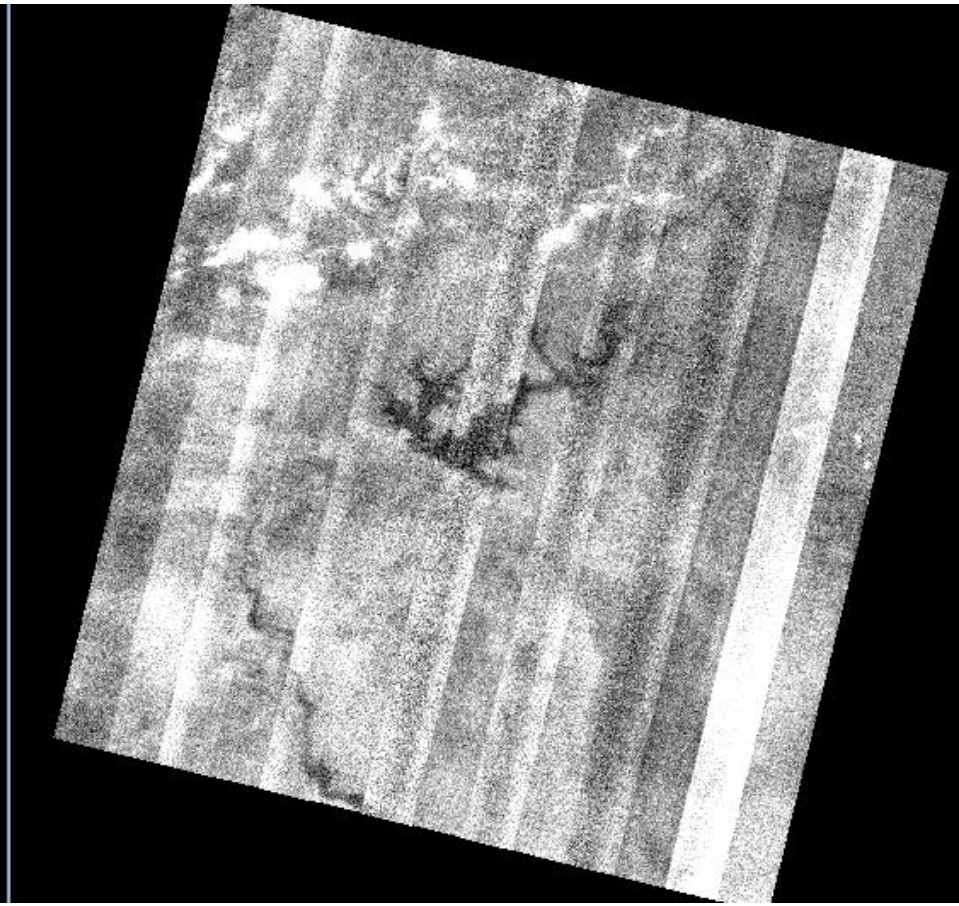
Comment: The cirrus band shows cirrus clouding in the NW of the image that helps us translate cool thermal signals. The image has substantial striping , partly due to the grey-scale image stretch of the ERDAS display system. Image downloaded from EROS on Oct. 29, 2013

Landsat 8 Path 173, Row 34, for June 27, 2013 in Turkey

False color



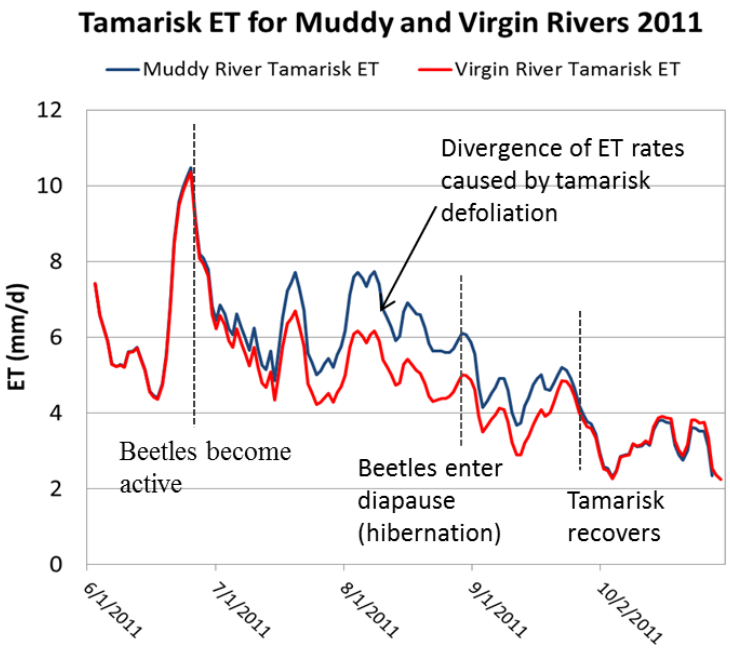
Cirrus band (9)



Comment: The cirrus band shows substantial striping that masks out much cirrus. Image downloaded from EROS on Oct. 29, 2013

NEVADA APPLICATIONS

Reduced ET from Tamarisk (Salt Cedar) Defoliation along the Lower Virgin and Muddy Rivers" – Took a DRI Grad Student 2 weeks to complete



- Classified defoliated areas using a multi-temporal spectral angle mapper approach
- Tamarisk ET estimated using METRIC for 2011 in defoliated and non-defoliated Tamarisk areas
- Estimated total water savings from defoliation along Lower Virgin River in 2011 = 1,200 ac-ft = $10,000,000. (@$ 8,000 /ac-ft)

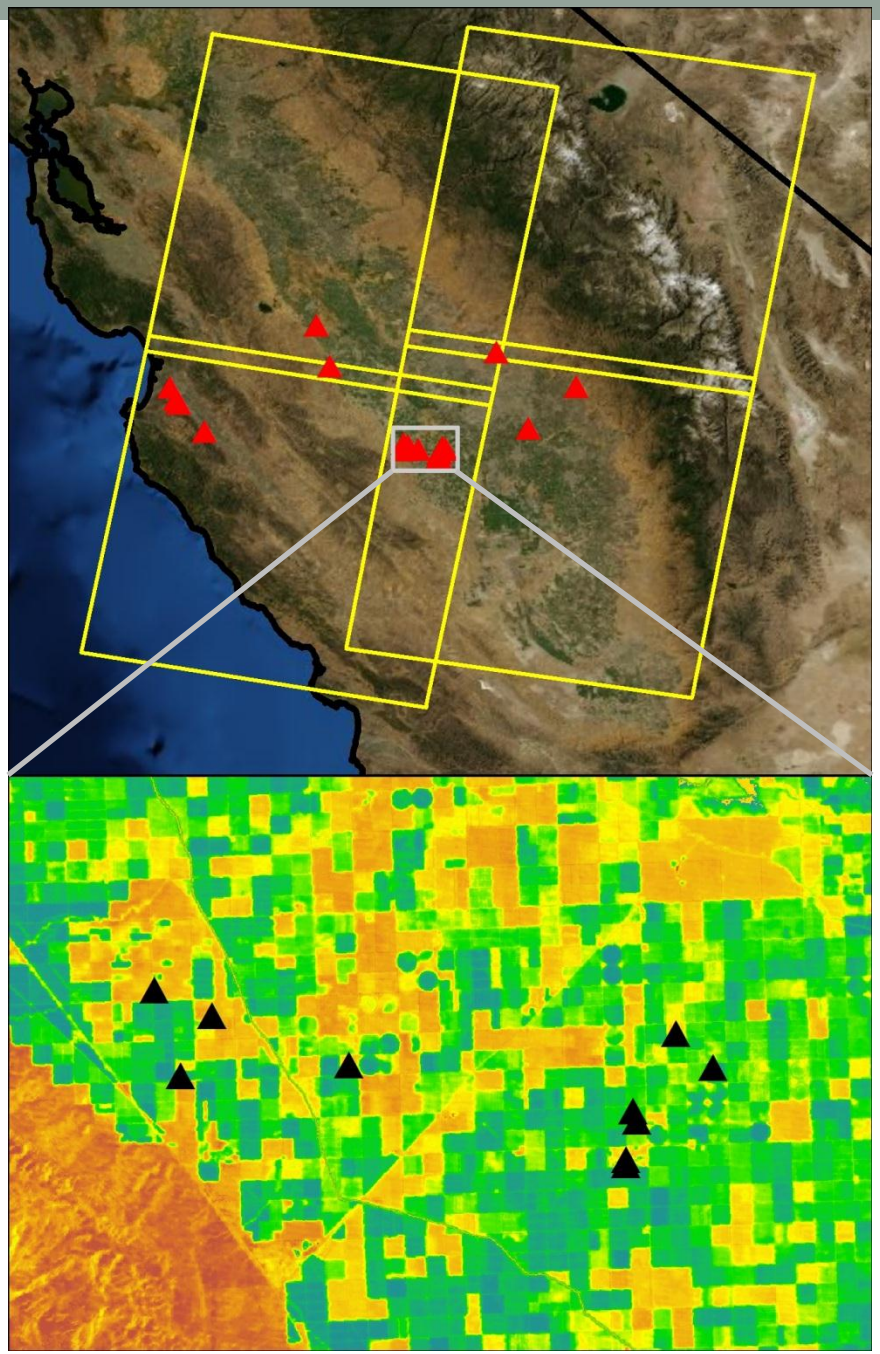
METRIC Collaborations with NASA

- DRI is collaborating with NASA Ames/Cal State Monterey Bay (Forrest Melton)
- METRIC Python is running on the NASA Earth Exchange (NEX) high performance computer
- Run METRIC for entire states / years

Central Valley, California

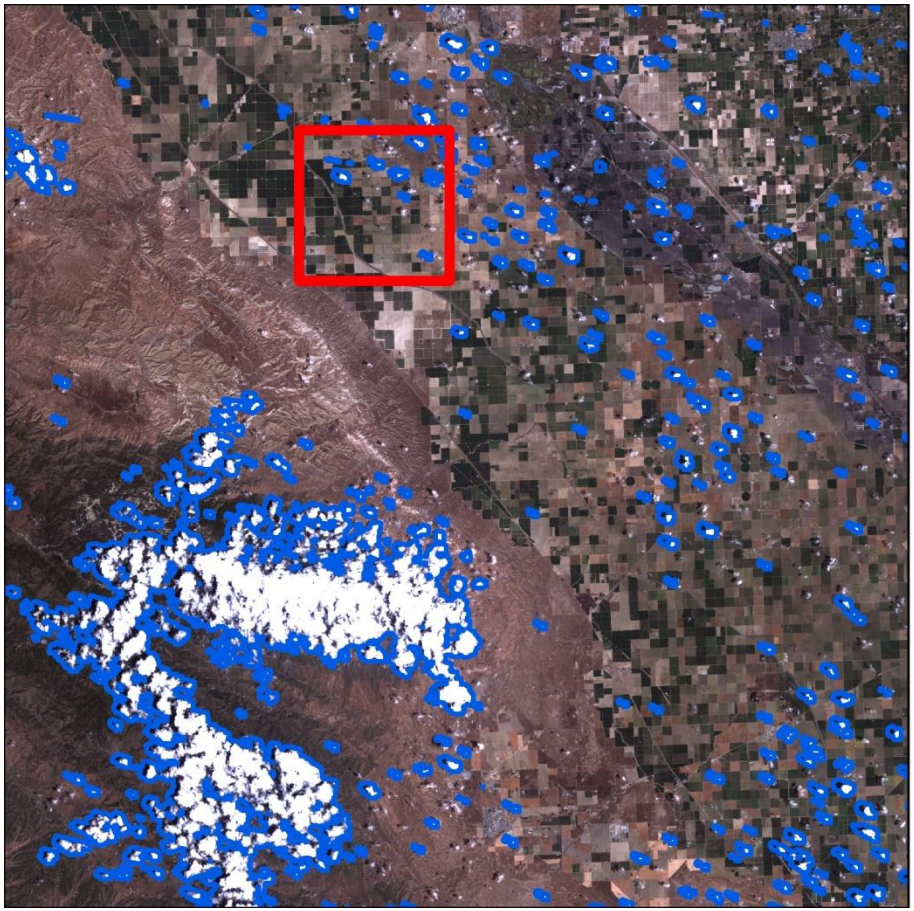
- Currently testing and validating METRIC Automated Calibration Algorithm (w/LEDAPS) on the NASA Earth Exchange (NEX)

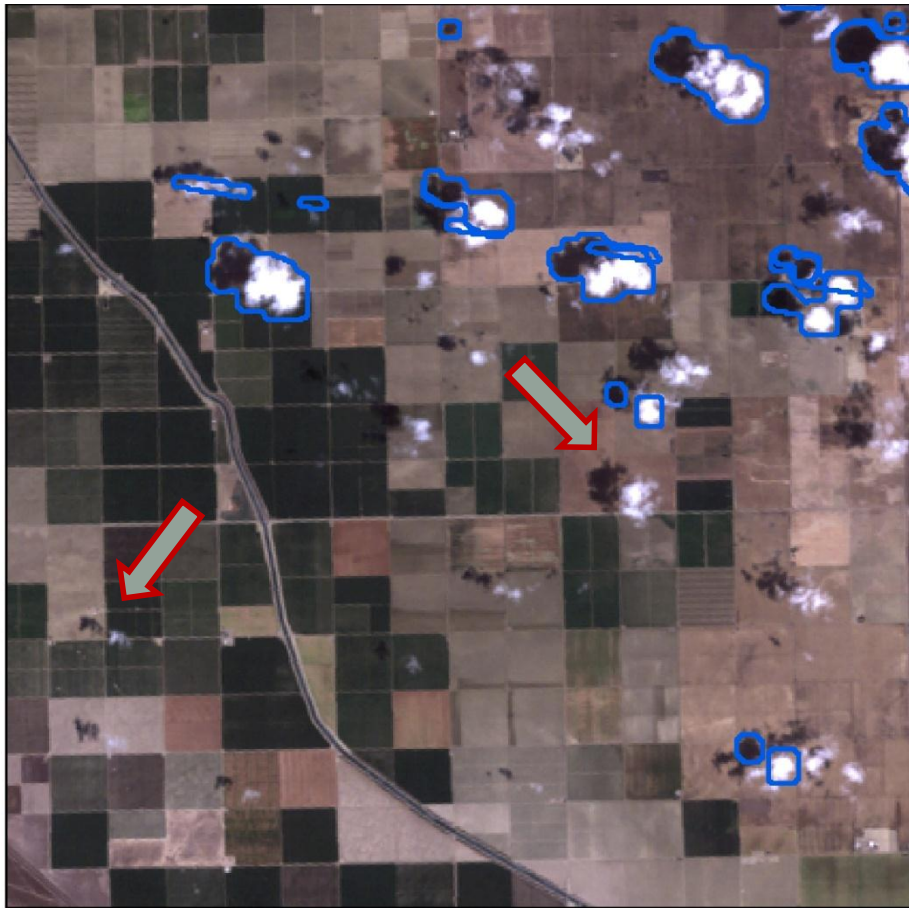
- Validating automated METRIC ET estimates at multiple NASA / CSMB field sites



Testing Automated Cloud Masks

- Testing FMASK & LEDAPS masks within METRIC framework in Central Valley of CA
- Still have shadows and small clouds to deal with, but good start to build on
- Combining different masks and buffering masks to extend areas, and manually QA/QCing and modifying masks for every image used





Court Introductions of ET from Landsat

- Superior Court of California -- *Los Angeles County Waterworks District No. 40 v. Diamond Farming Co.* (ET from METRIC introduced by Dr. Jan Hendrickx, NMT to show connection between ground-water pumpage by Cty of Los Angeles in Antelope Valley and water use by local vegetation)

- Idaho Supreme Court – *A&B Irrigation District v. State of Idaho.* (ET from METRIC introduced by Idaho Dept. Water Resources to show lack of evidence for injury of senior water user by junior water users)

- US Supreme Court – *Montana v. Wyoming, No. 137, Original* (METRIC ET maps introduced to document some expansion of irrigated acreage by Wyoming beyond Yellowstone Compact allowances)

Other International Collaborations with our Research Group:

- Univ. Lisbon, Portugal – olives and forest
- Univ. Cordoba, IFAPA, Spain – olives, almonds, vineyards
- Chinese National Academy of Science – ET estimation in mountains
- Univ. Bahia, Brazil – fruit trees, mango