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Using remote sensing data to estimate near real-time crop water consumption

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The estimation of crop water consumption (ET) has traditionally been difficult when based on field measurements of flows and deliveries over large regions.

This presentation describes a satellite-based near real-time ET estimation system and the applications of the ET product from the system.

Outline

I. Background

II. Near Real-time ET Estimation System

III. ET Product and Validation

- Flux towers
- METRIC (*Mapping Evapotranspiration at high Resolution and with Internalized Calibration*) Landsat estimates

IV. Potential Applications

- Agriculture Water Management
- Terrestrial Water Storage Change

V. Conclusions

Background

In general, remote sensing (RS) techniques can NOT measure ET directly.

However, RS measurements may be used to estimate variables in surface energy balance. ET is hence calculated as a residual of the energy balance.

A number of methods have been developed to use satellite data for ET estimation (*i.e. Bastiaanssen et al., 1998; Allen et al, 2007; Mu et al., 2007*).

One of the challenges here is to get an operational, high resolution, free of charge, and also reliable near real-time ET product.

Background

Moderate Resolution Imaging Spectroradiometer (MODIS)

- Land cover, Surface reflectance, Vegetation indices, Land surface temperature (LST) /emissivity and Albedo

Available in near real-time ***(LST, 3 days to 1 week)***
Off the shelf *(acknowledgement to MODIS products teams)*
Free of charge
High frequency ***(2 passes per day)*** ***and resolution*** ***(250 m to 1 km)***
Reliable ***(e.g. Error of LST < 1K for clear-sky cases)***

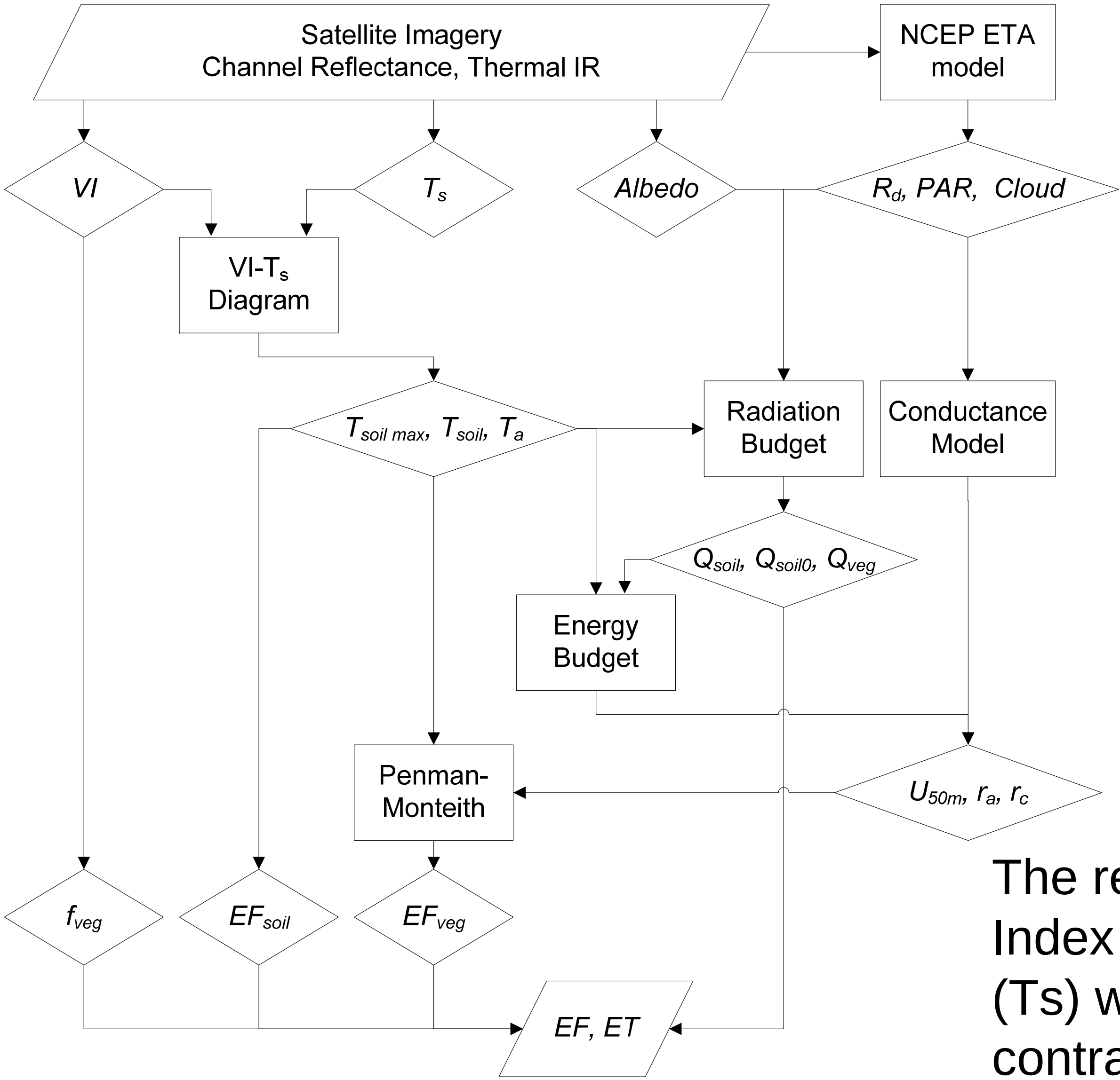
GEWEX Continental Scale International Project (GCIP) Surface Radiation Budget (SRB) Data derived from the Geostationary Operational Environmental Satellites (GOES)

- Cloud cover, Incoming shortwave (SW) radiation, and PAR

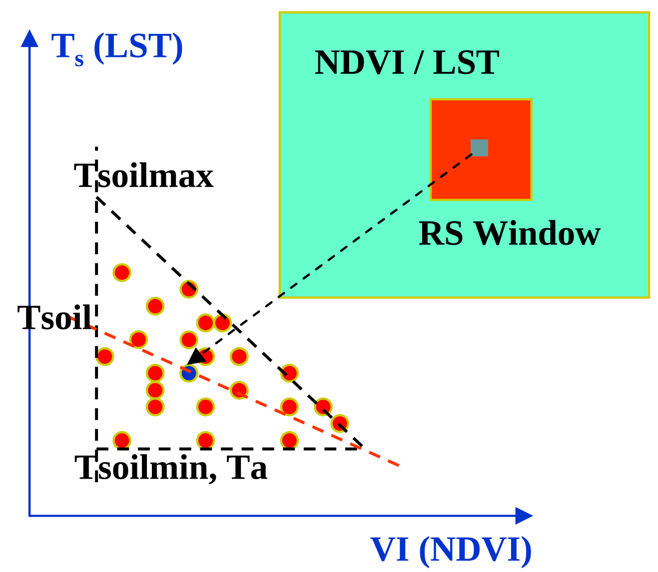
Available in near real-time ***(~2 days)***
Off the shelf *(acknowledgement to GEWEX teams, University of Maryland)*
Free of charge
High temporal frequency ***(hourly)***
Reliable ***(SW Wm^{-2}; RMS ~ hourly: 20-100 daily: 20-30 monthly: 12-18)***

Near Real-time ET Estimation System

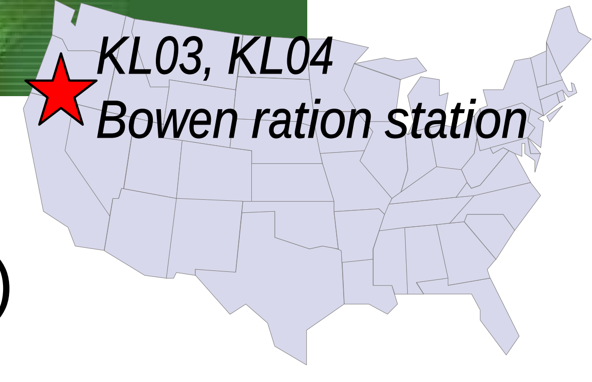
Nishida et al (2003) Method



VI-T_s Diagram



The relationship between Vegetation Index (VI) and Surface Temperature (Ts) with a sufficiently large hydrological contrast is the basis for Nishida method.



Near real-time implementation

- Constant-EF hypothesis (*EF=ET/Q(available energy)*)

$$EF_{instantaneous} = EF_{day}$$

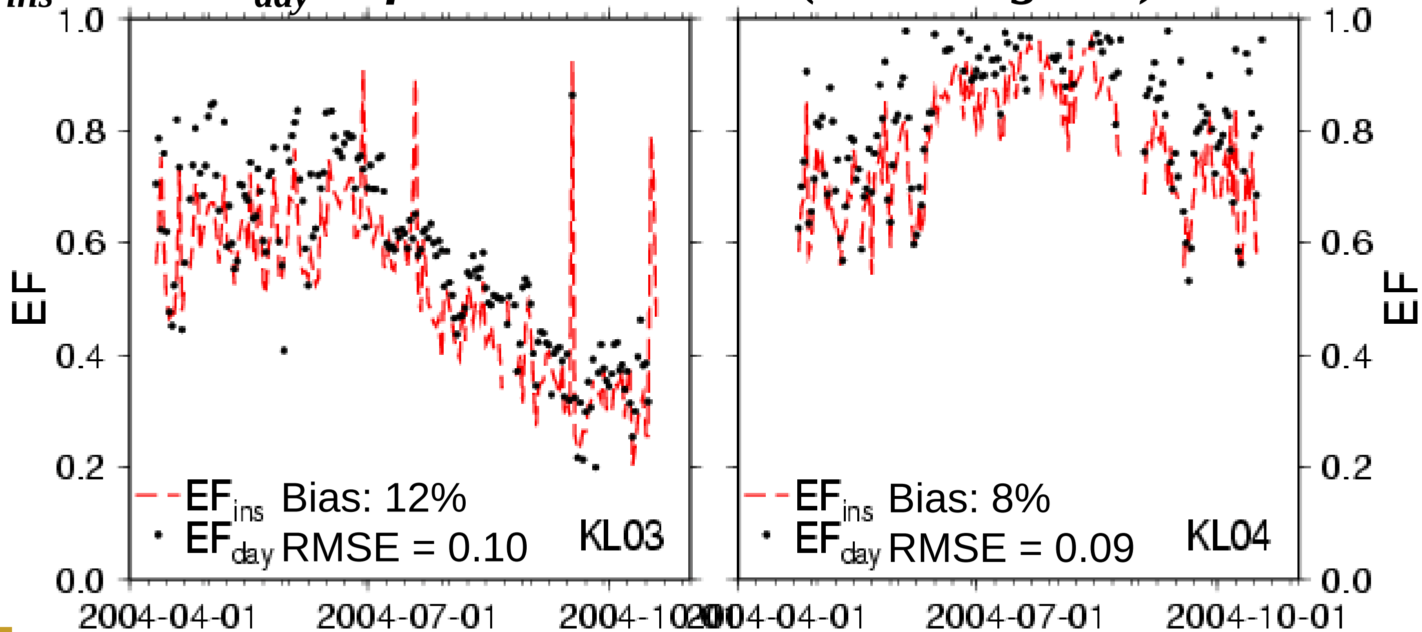
- Closest available data rule

  For days when the retrieval data (Ts) is unavailable (mostly due to cloudy conditions), the data (Ts) for the closest available day is used instead.

- Time lag: 3 days to 1 week

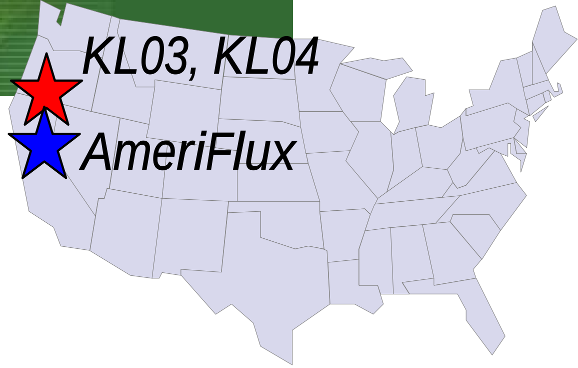
  The latency is controlled by release of the MODIS products. It could be reduced to about 2 days through use of MODIS Rapid Response products.

EF_{ins} and EF_{day} at flux tower KL03 (non-irrigated) and KL04 (irrigated)



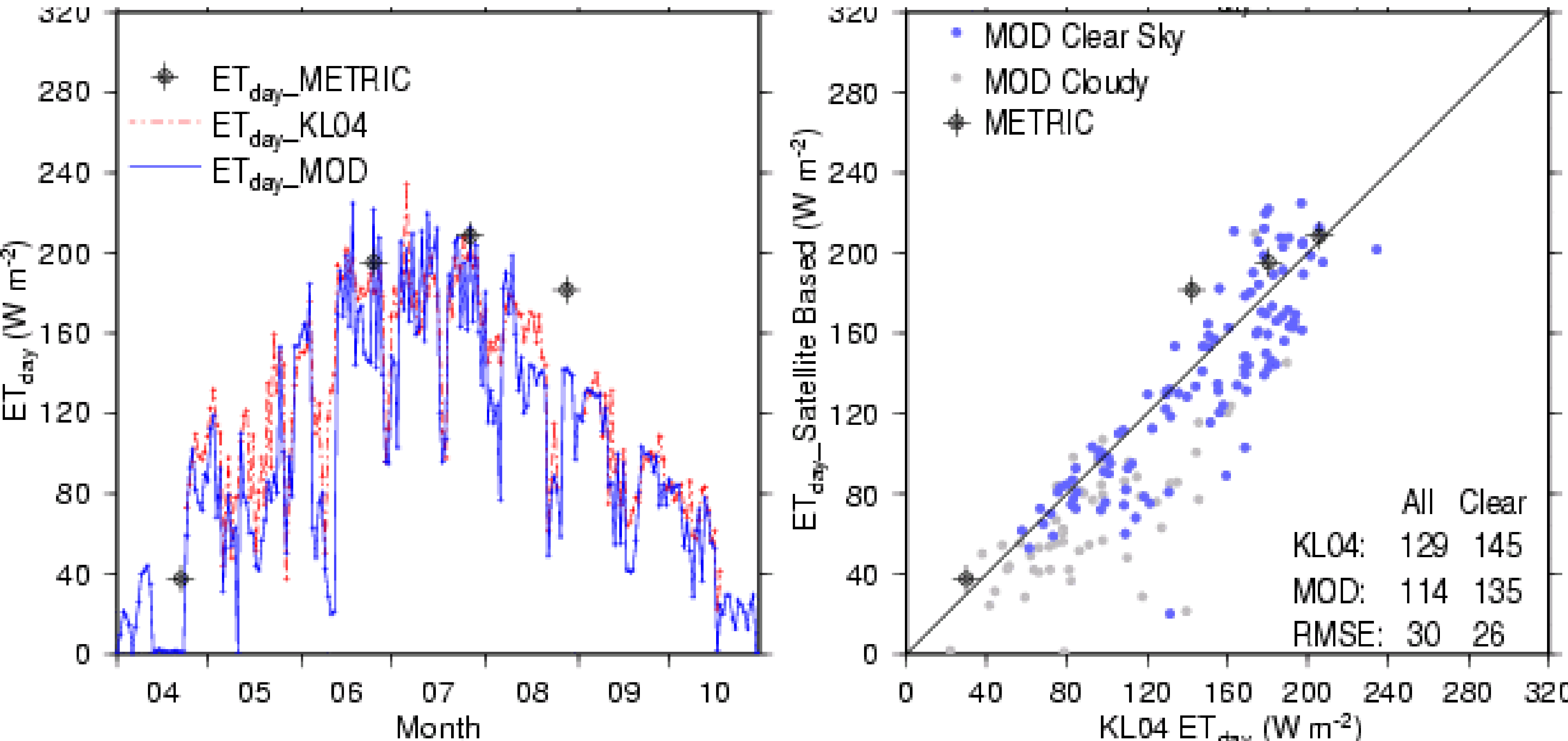
Tang et al (2008; submitted to J. Geophys. Res.)

Validation - Flux towers

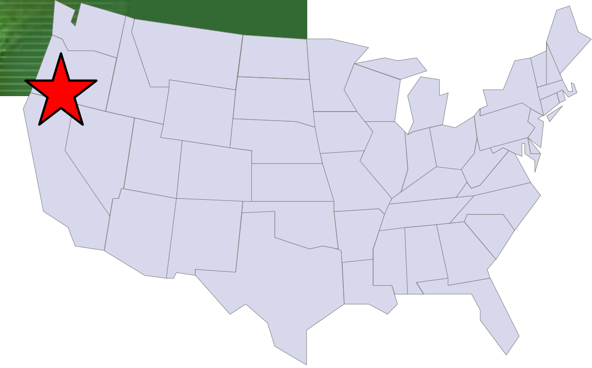


Bias: -7% for clear sky; -12% for all days

from April 1 to October 31, 2004

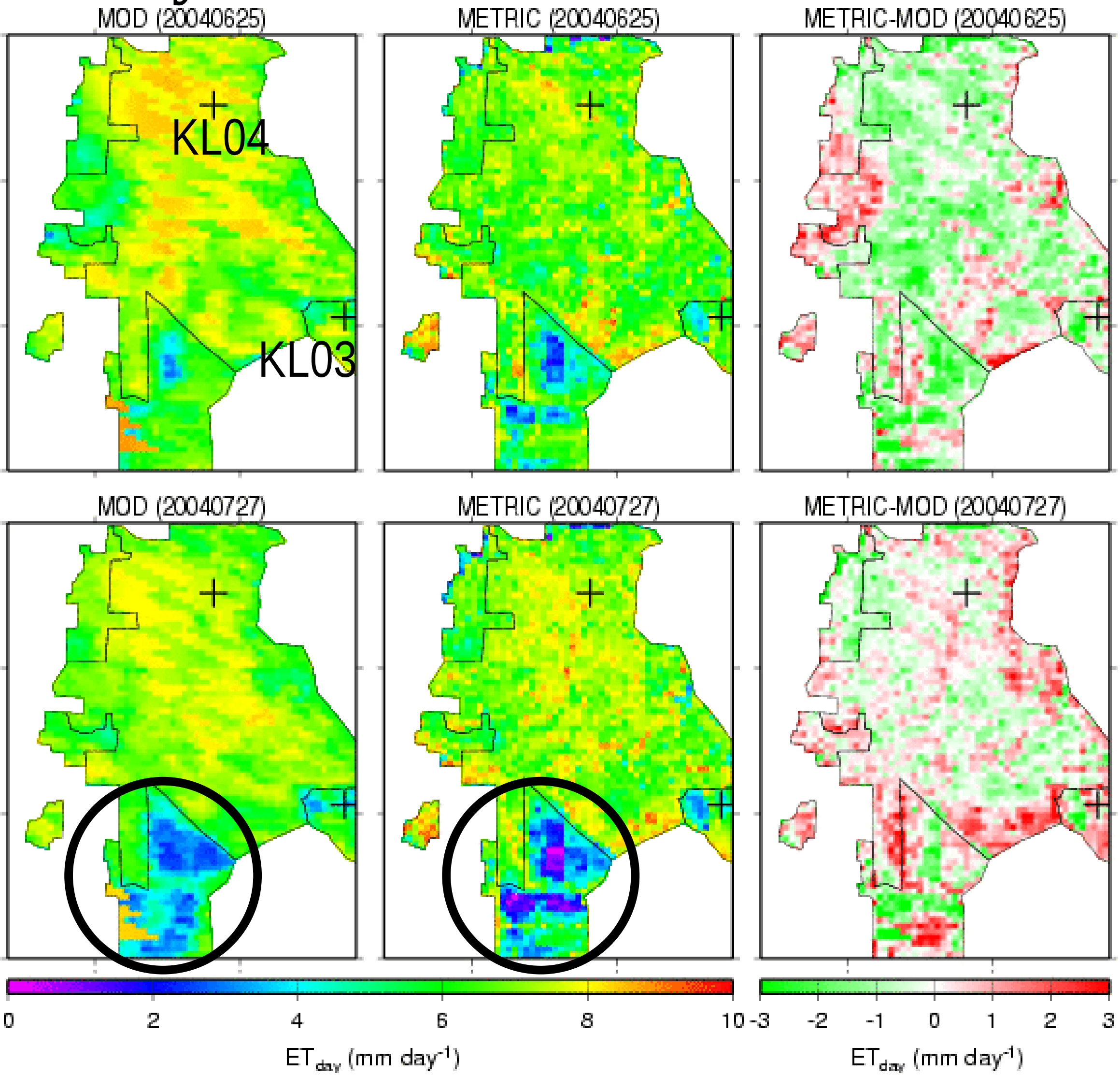


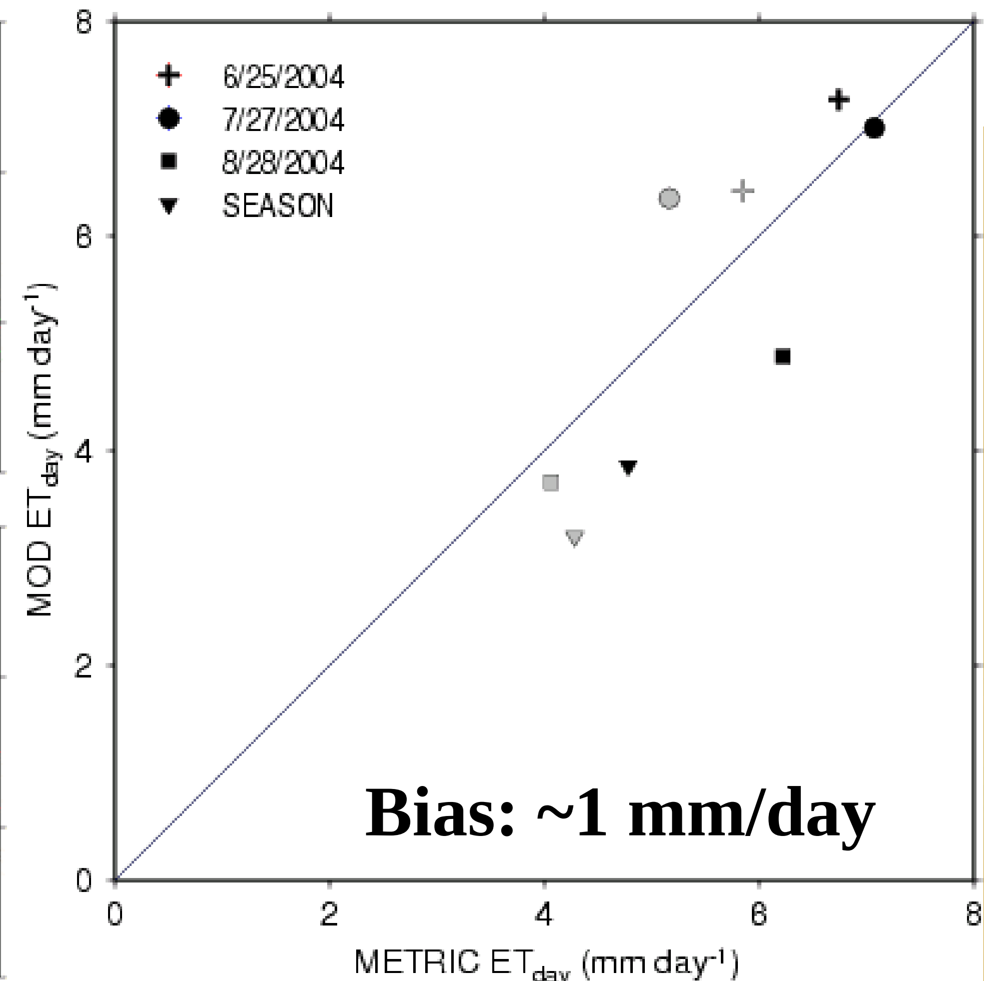
Observed and estimated ET_{day} at flux tower KL04 (irrigated site)



Validation - METRIC Landsat estimates

ET System **METRIC** **Difference**

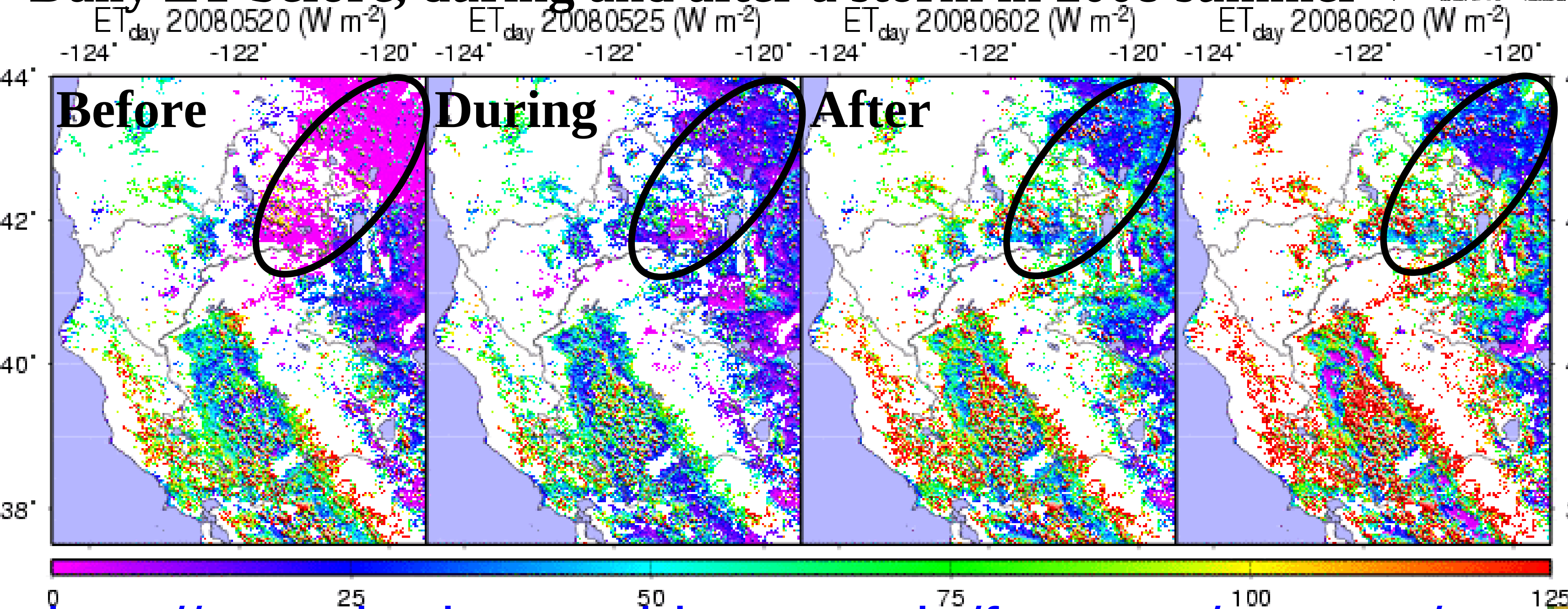




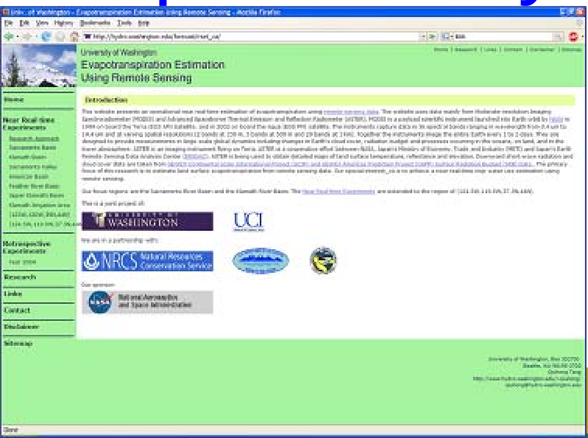
METRIC: Mapping Evapotranspiration at high Resolution and with Internalized Calibration

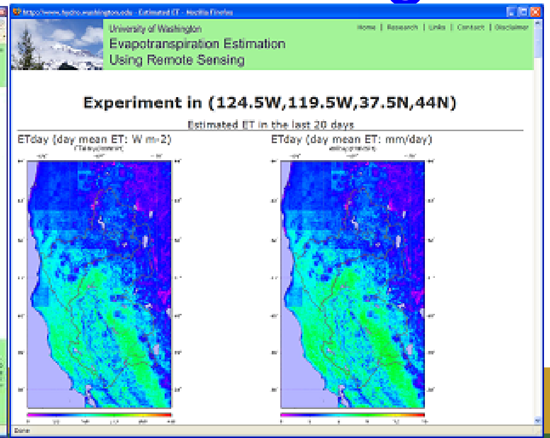
ET Product

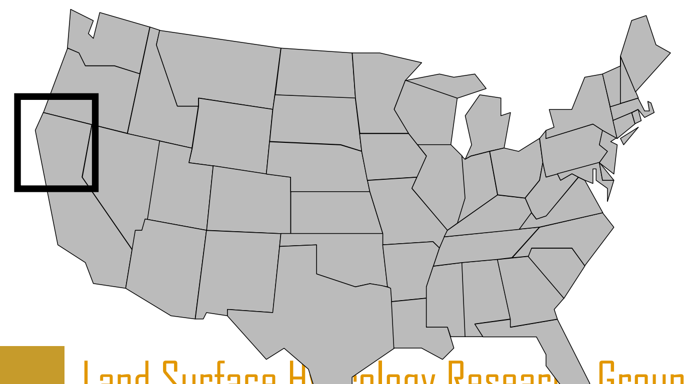
Daily ET before, during and after a storm in 2008 summer

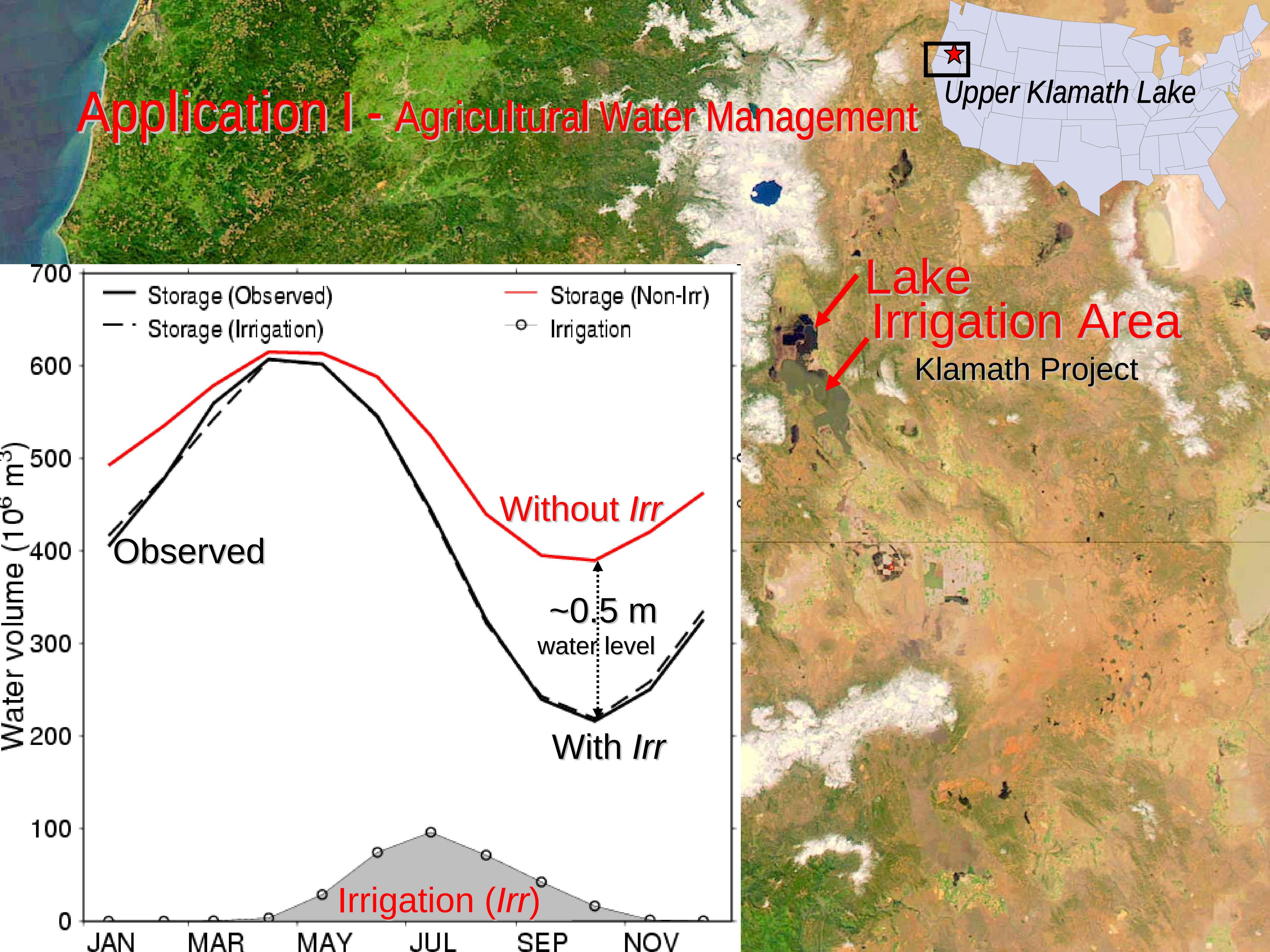


http://www.hydro.washington.edu/forecast/rset_ca/







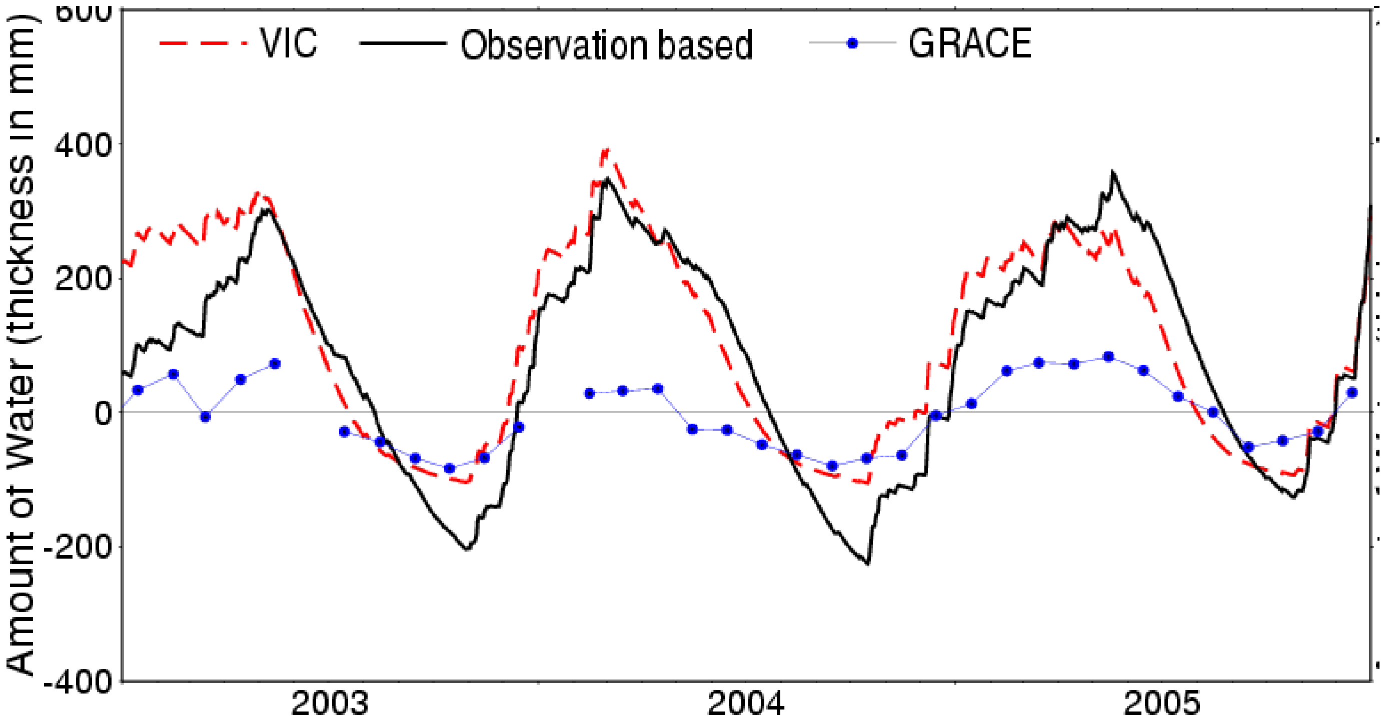

Application I - Agricultural Water Management
Upper Klamath Lake
Lake
Irrigation Area
Klamath Project
Storage (Observed)
Storage (Irrigation)
Storage (Non-Irr)
Irrigation
Water volume (10^6 m^3)
700
600
500
400
300
200
100
0
JAN
MAR
MAY
JUL
SEP
NOV
Without *Irr*
Observed
~0.5 m
water level
With *Irr*
Irrigation (*Irr*)

Application II - Terrestrial Water Storage Change (TWSC)

- Observation-based TWSC

TWSC = Precipitation (PRISM) – ET - Runoff

- Variable Infiltration Capacity (VIC) modeled TWSC
- Gravity Recovery and Climate Experiment (GRACE) TWSC



Klamath and Sacramento River Basin (1.1×10^5 km^2)

(acknowledgements to PRISM group for precipitation and Dr Don P. Chambers for GRACE data)

Tang et al (2008; submitted to J. Clim.)

Conclusions

We have illustrated a satellite-based method for near real-time ET estimation at regional scales.

It can provide operational, high resolution, free of charge, and also reliable near real-time ET product.

Applications show that the ET estimation system is useful in regional scale agricultural water management and land surface water budget.

END

Thank you for your time and attention!

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