2012 HysplRI Symposium

May 16-17, NASA/GSFC Greenbelt (MD)

Identifying Priority Products to Support HysplRI's Science Questions

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Daily ET products at Landsat/HysplRI scale from MODIS & Landsat Data

May 16, 2012

RESEARCH GOAL

- Water demand has doubled in the last 50 years.
- A large fraction of water resource (about 60%) is used for agricultural irrigation but with efficiencies often less than 50% (ga.water.usgs.gov/edu/wuir.html).
- Climate forecasts of precipitation suggest a future reduction in water availability.
- Quantification of crop water loss (mainly through evapotranspiration) assumes a key role in agricultural water management.

Cost effective estimates of actual evapotranspiration (**ET**) on large areas (~ 10^2-10^4 km^2) can be obtained only through the use of thermal infrared (**TIR**) satellite data.

Practical applications require ET estimates at:

Daily and Season time-scales

Field or finer spatial-scales

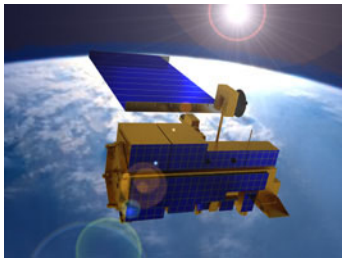
Currently, TIR satellite sensors are characterized by low spatial resolution (1-10 km) and high frequency (day to 15 min) or high spatial resolution (30-m) but low repeatability (2 weeks). **Multi-sensor technique have to be developed** to fuse the best qualities of the datasets.

CURRENT AND FUTURE MISSIONS

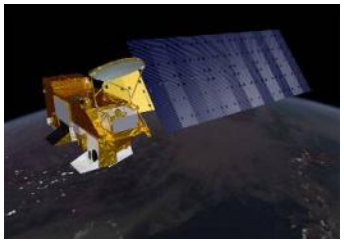
Landsat-5
120 m
16 days

Landsat-7
60 m
16 days

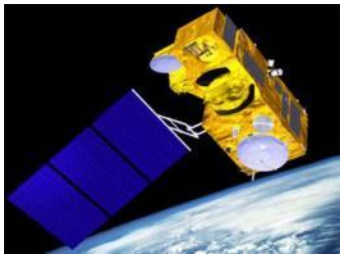
HyspIRI
60 m
5 days



MODIS/Terra
1 km
1 days



MODIS/Aqua
1 km
1 days



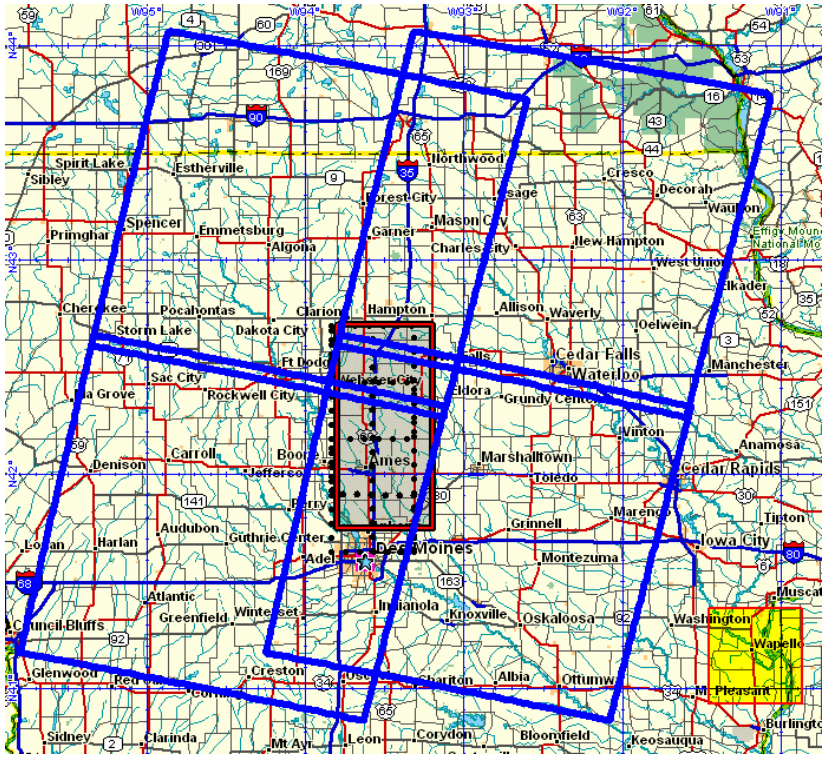
Sentinel-3
1 km
1 days

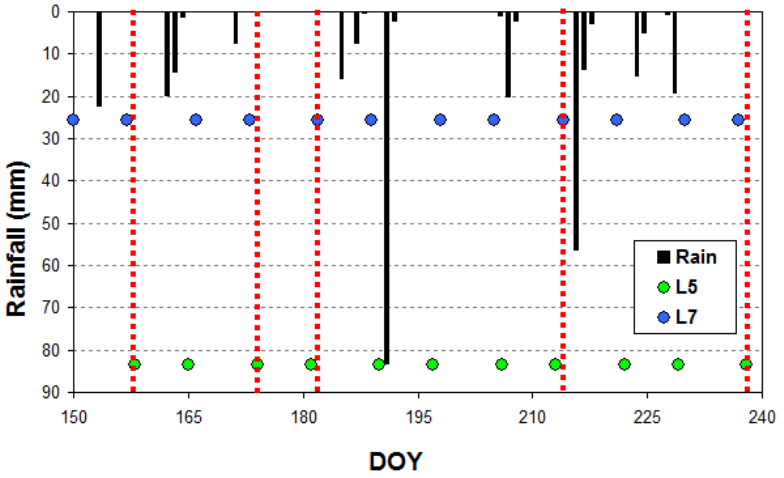
EFFECTS OF CLOUDS ON TIR DATA FREQUENCY

Cloud cover often reduces actual TIR data frequency from the nominal value, especially during winter period [Ju & Roy, RSE112: 2008].

During SMEX02:

- Summer period (June-August 2002)
- Both Landsat 5 and 7.



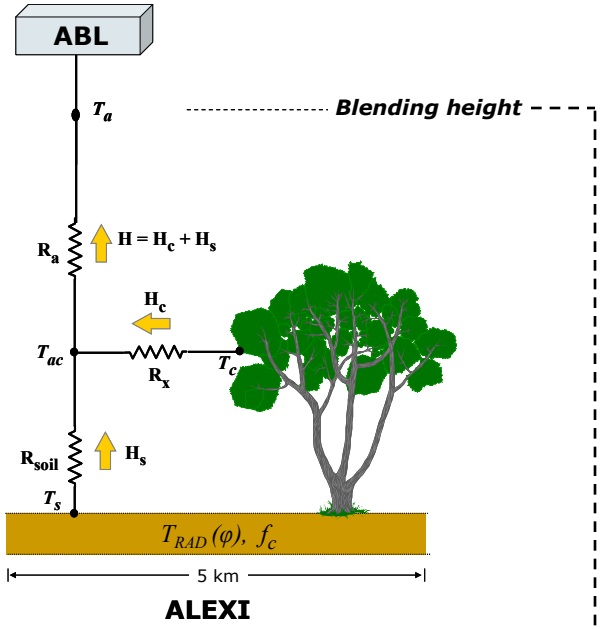


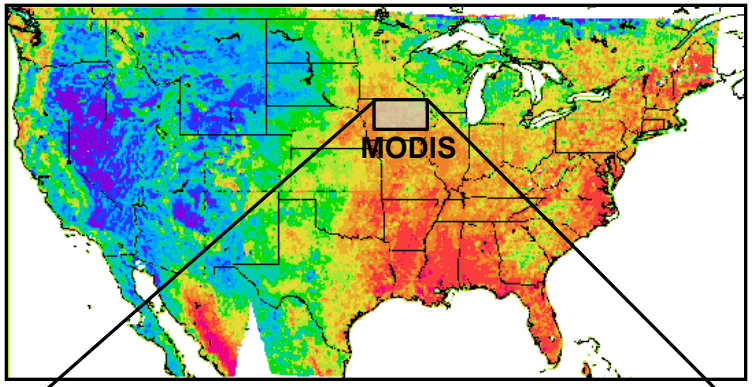
- Only **5 scenes** were clear.
- Average frequency of 21 days.
- Maximum gap of 32 days.

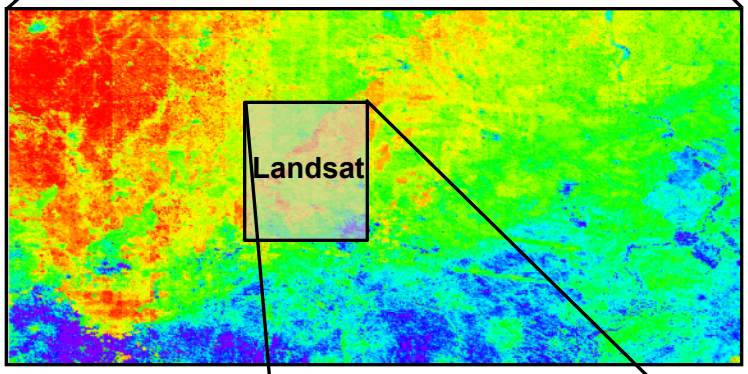
METHODOLOGY (1/2)

GOES

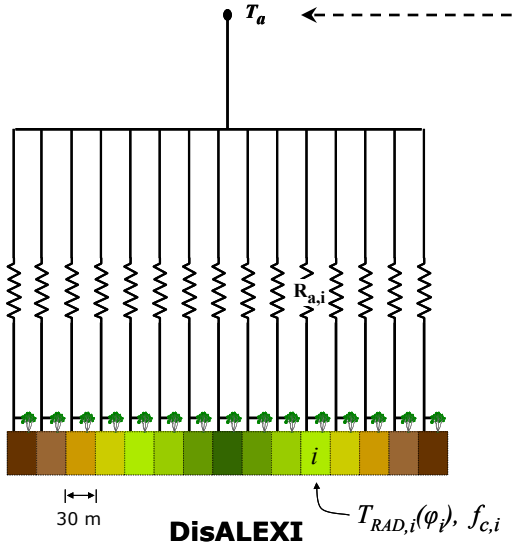
Two-Source Model

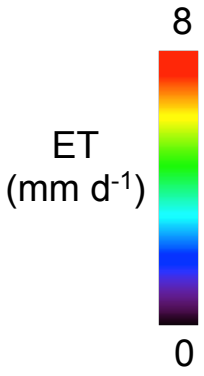


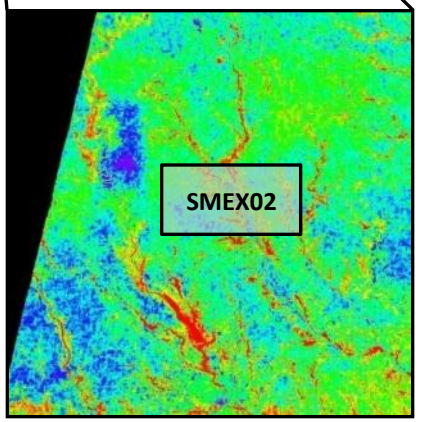




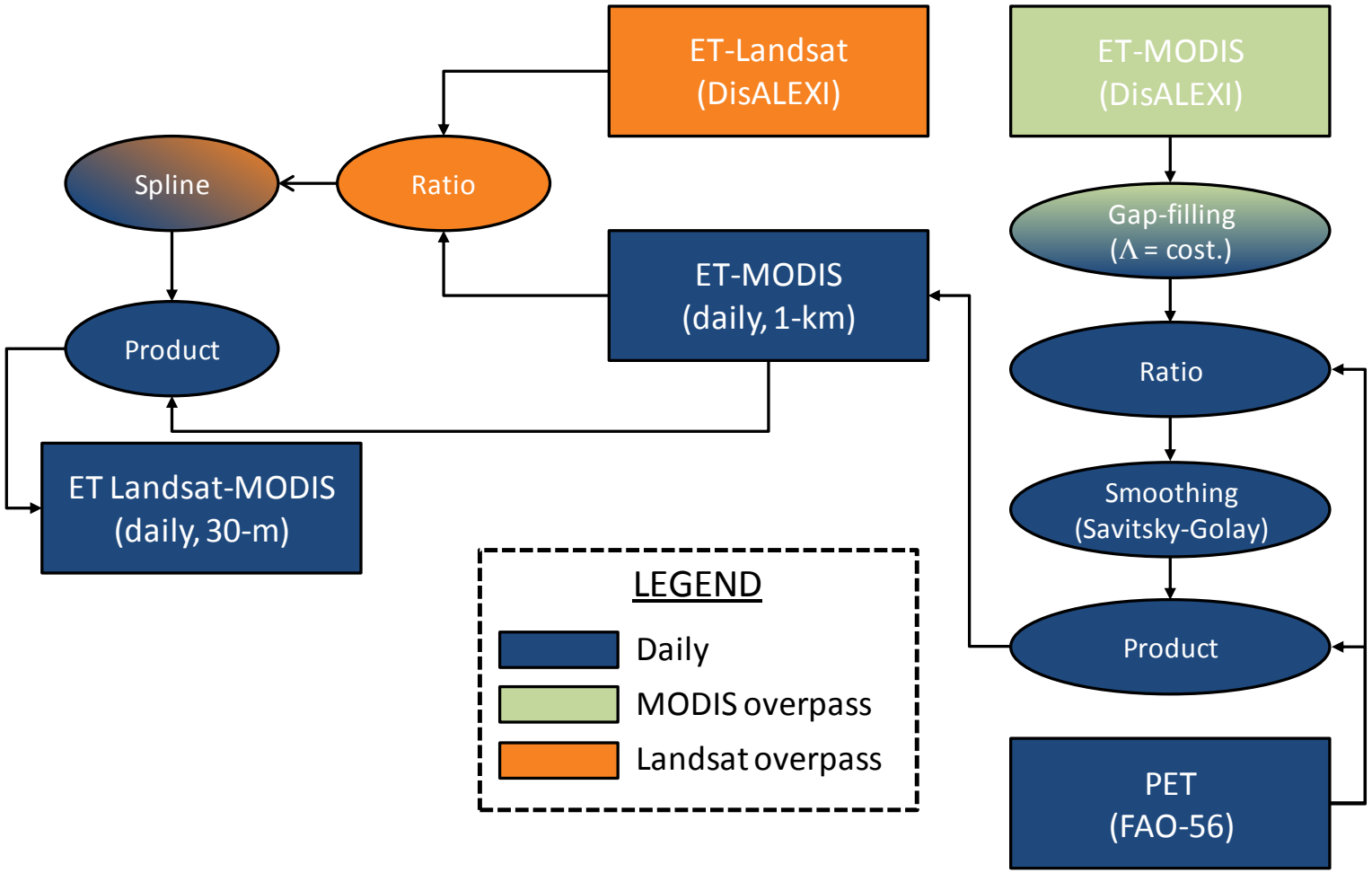
MODIS
Landsat





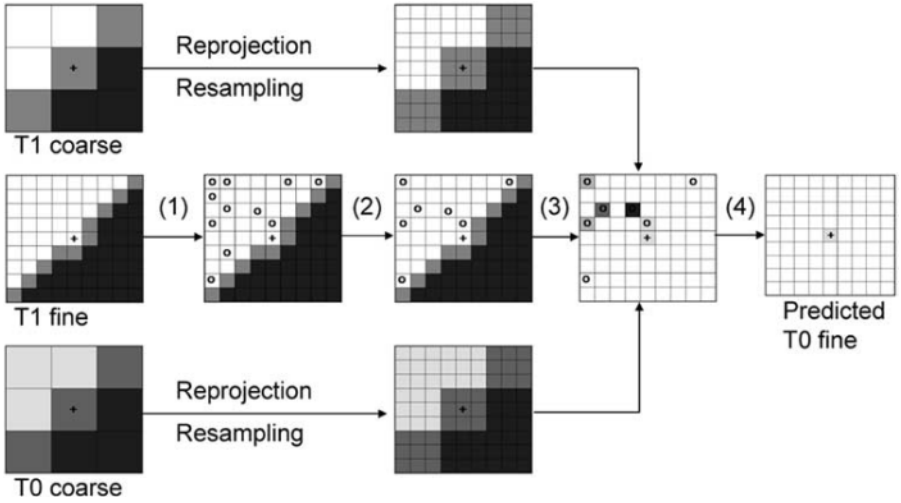


METHODOLOGY (2/2)

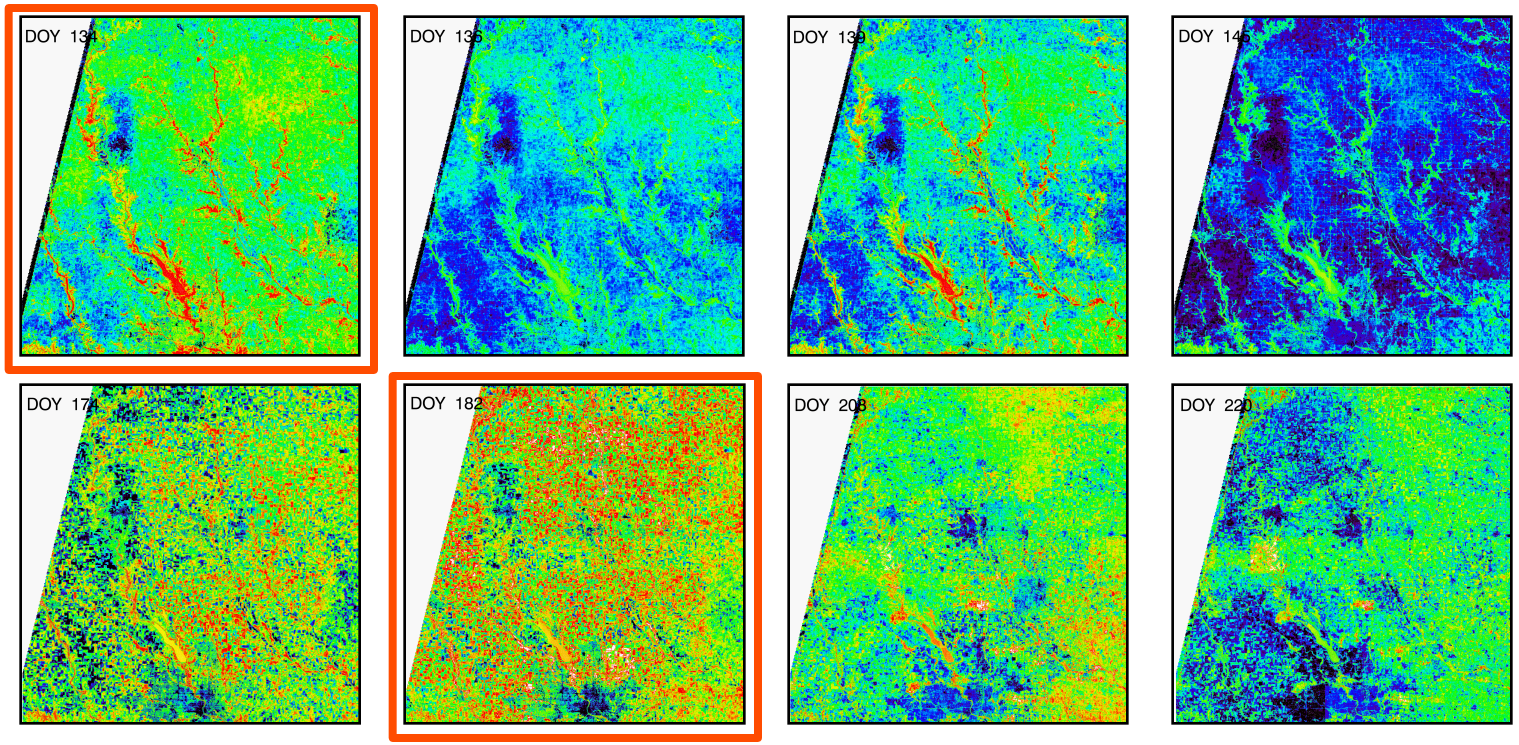


- A change at MODIS scale have equal effects on all the Landsat pixels.
- Landsat and MODIS estimates are consistent at MODIS resolution.

METHODOLOGY (2/2)

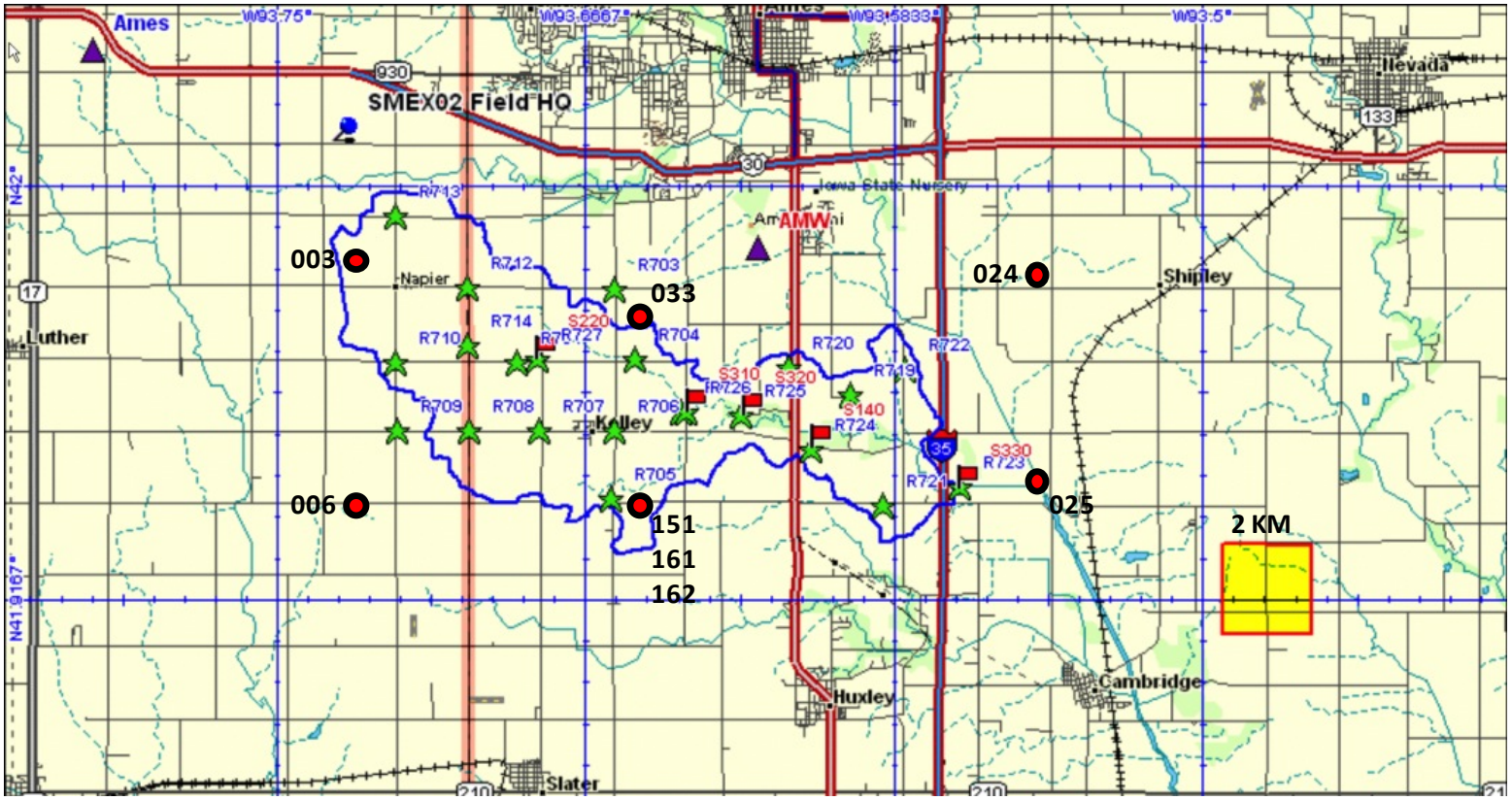


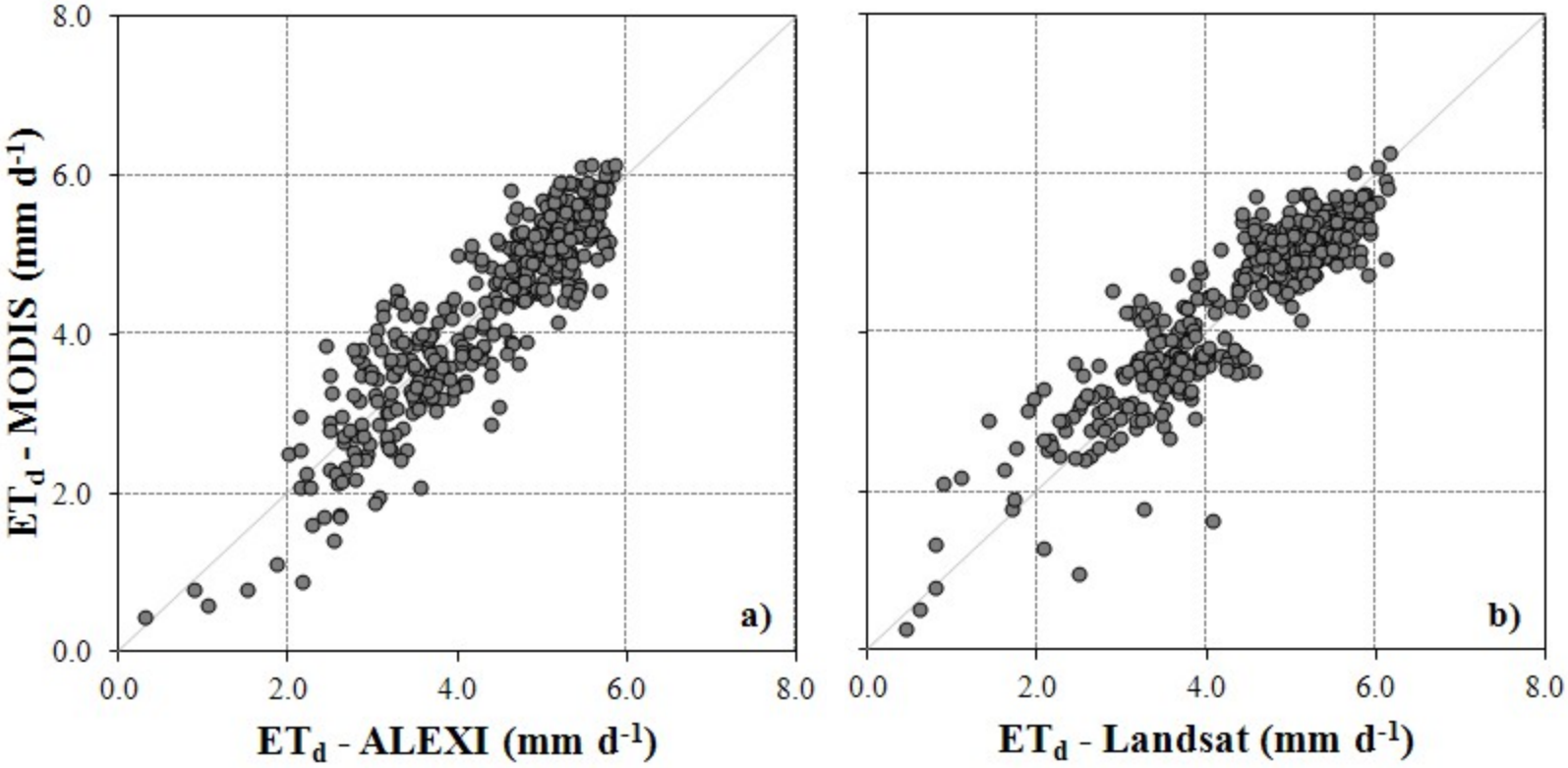
- A pair coarse/fine resolution is required.
- Similarities are detected at high resolution.
- Prediction determined using a weighting function.



STUDY CASE

- Soil Moisture EXperiment (**SMEX02**), **June-August** 2002.
- Walnut Creek watershed (5,100-ha), **central Iowa**.
- ET monitoring by means of **8** micrometeorological **flux towers** (red dots in figure) on **corn** and **soybean** fields during a period of rapid crop development.

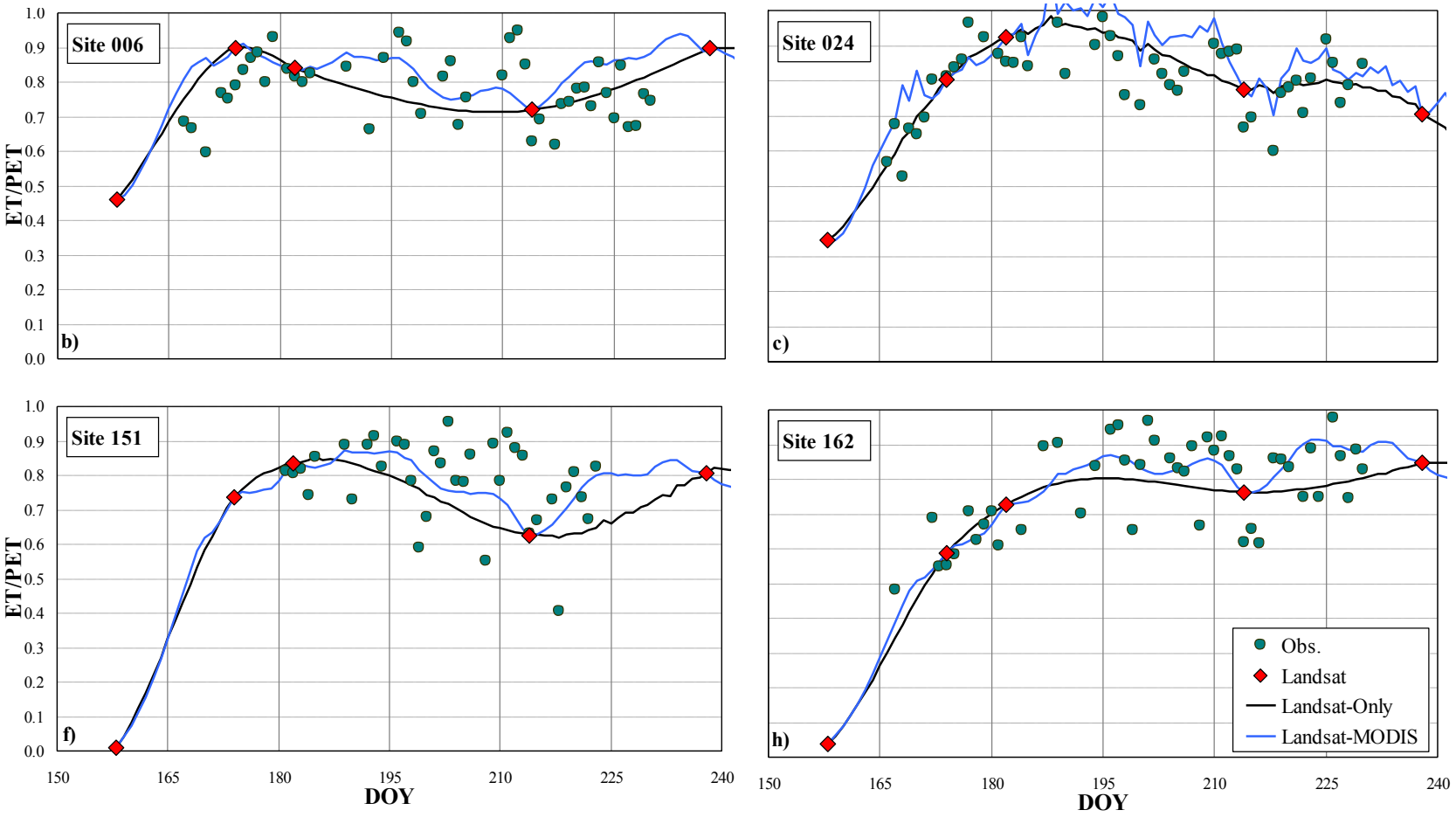




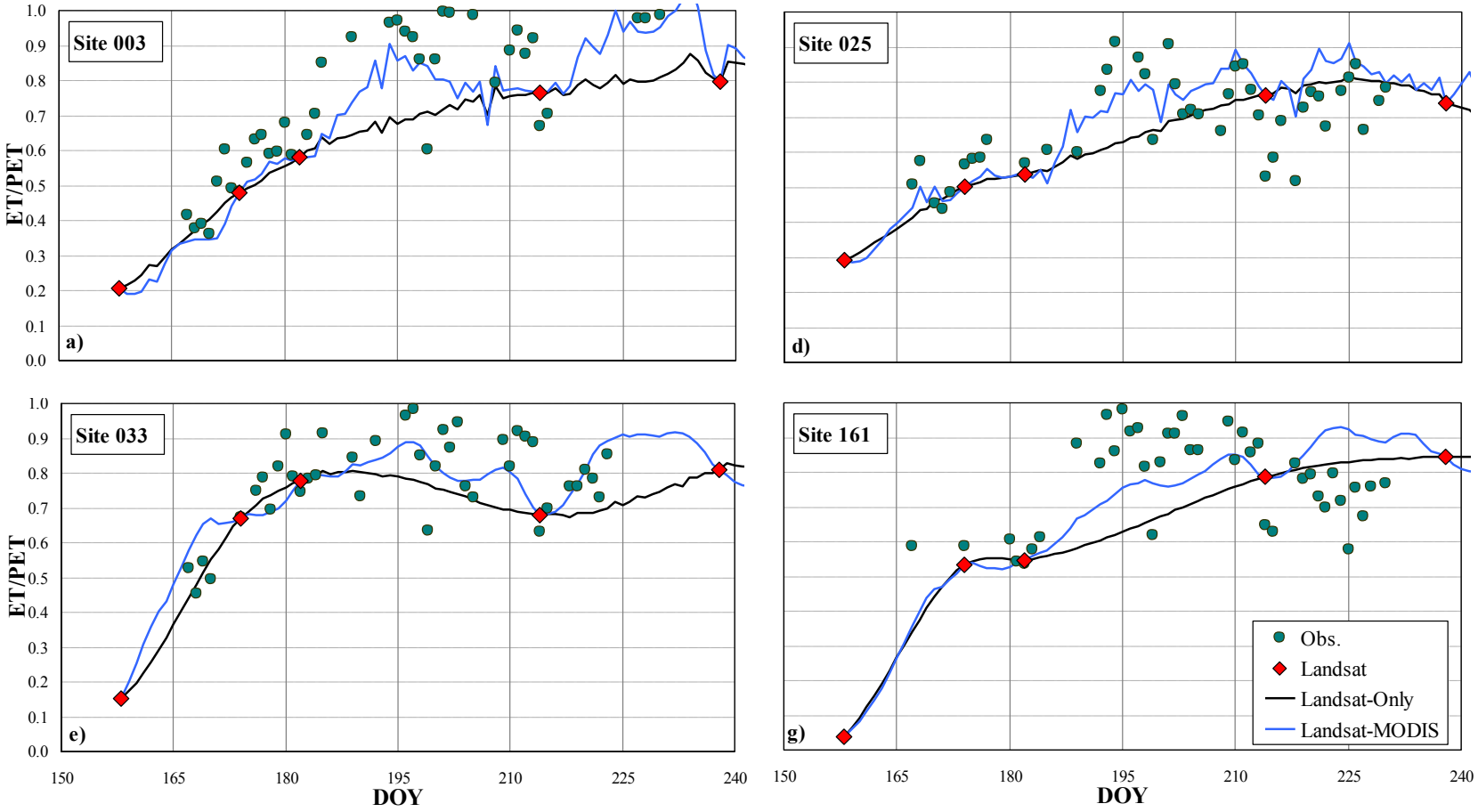
RESULTS (1/4)

- Absence of biases among the three maps at ALEXI resolution.
- Some dispersion is present in both data due to the smoothing procedure.
- Slopes practically equal to 1, R^2 of 0.82 (Landsat) and 0.80 (MODIS).
- Agreement in the order of 0.3 mm d^{-1}.

RESULTS (2/4)



- Good performance of Landsat-Only model.
- Increasing trend until DOY 185 and a successive stable stage around 0.8.
- Rainfall events seem to do not cause significant changes in water stress.



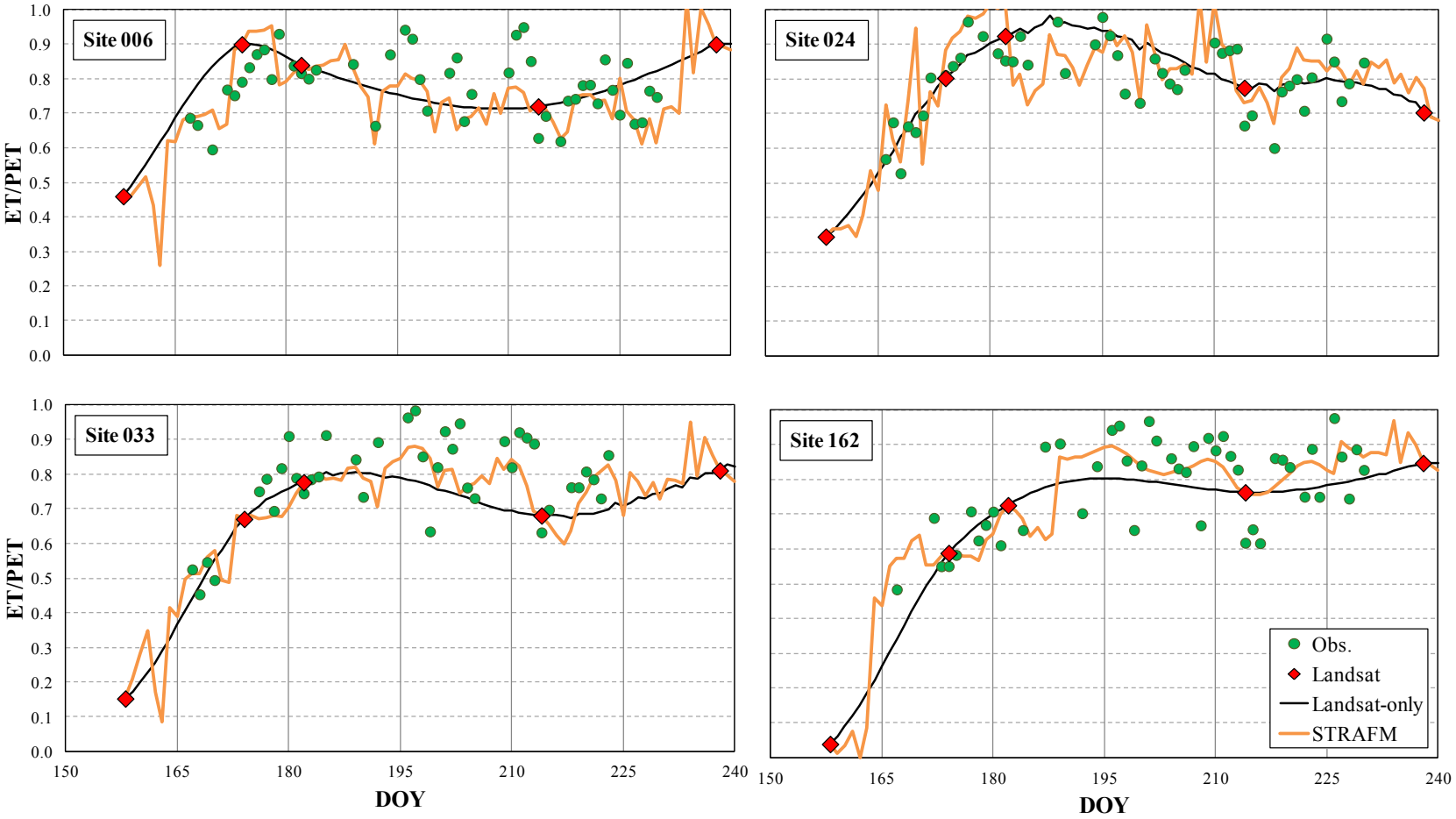
RESULTS (3/4)

- Significant leap in the ratio ET/PET after the first rainfall event (DOY 185).
- Landsat-Only seems to underestimate the observations in DOY 185-210.
- Fused Landsat-MODIS partially overcomes the underestimates.

Site	Crop Type	Obs. Cum. (mm)	Landsat-only MAD (mm d^{-1})	Landsat-only RE (%)	Landsat-only Slope	Landsat-only ΔCum. (mm)	Landsat-MODIS MAD (mm d^{-1})	Landsat-MODIS RE (%)	Landsat-MODIS Slope	Landsat-MODIS ΔCum. (mm)
003	Soybean	237	1.02	19.4	0.81	-41.0	0.78	14.9	0.87	-28.5
006	Corn	292	0.82	14.6	0.90	-17.4	0.79	14.1	0.95	-1.9
024	Corn	270	0.45	8.2	1.02	6.8	0.55	9.9	1.06	17.6
025	Corn	210	0.67	14.4	0.93	-10.9	0.61	13.1	1.01	5.0
033	Corn	230	0.66	12.1	0.89	-21.8	0.54	9.9	0.96	-4.6
151	Corn	212	0.81	15.0	0.89	-21.0	0.65	11.9	0.94	-8.2
161	Soybean	210	0.92	17.8	0.88	-21.0	0.78	15.2	0.98	0.5
162	Soybean	258	0.65	12.3	0.92	-15.8	0.52	9.9	0.99	-2.6
Average		240	0.75	14.2	0.90	-17.8	0.65	12.3	0.98	-2.8

RESULTS (4/4)

- Both **MAD** and **RE** (errors) are in average **reduced** of about **10%**.
- The systematic **bias** (underestimation) of Landsat-only model (slope = 0.90) is **significantly reduced** (slope = 0.97) by introducing MODIS data.
- The **total difference** on seasonal cumulative ET is **reduced of ≈ 50%**.
- Almost all the sites show improvements by introducing MODIS data.



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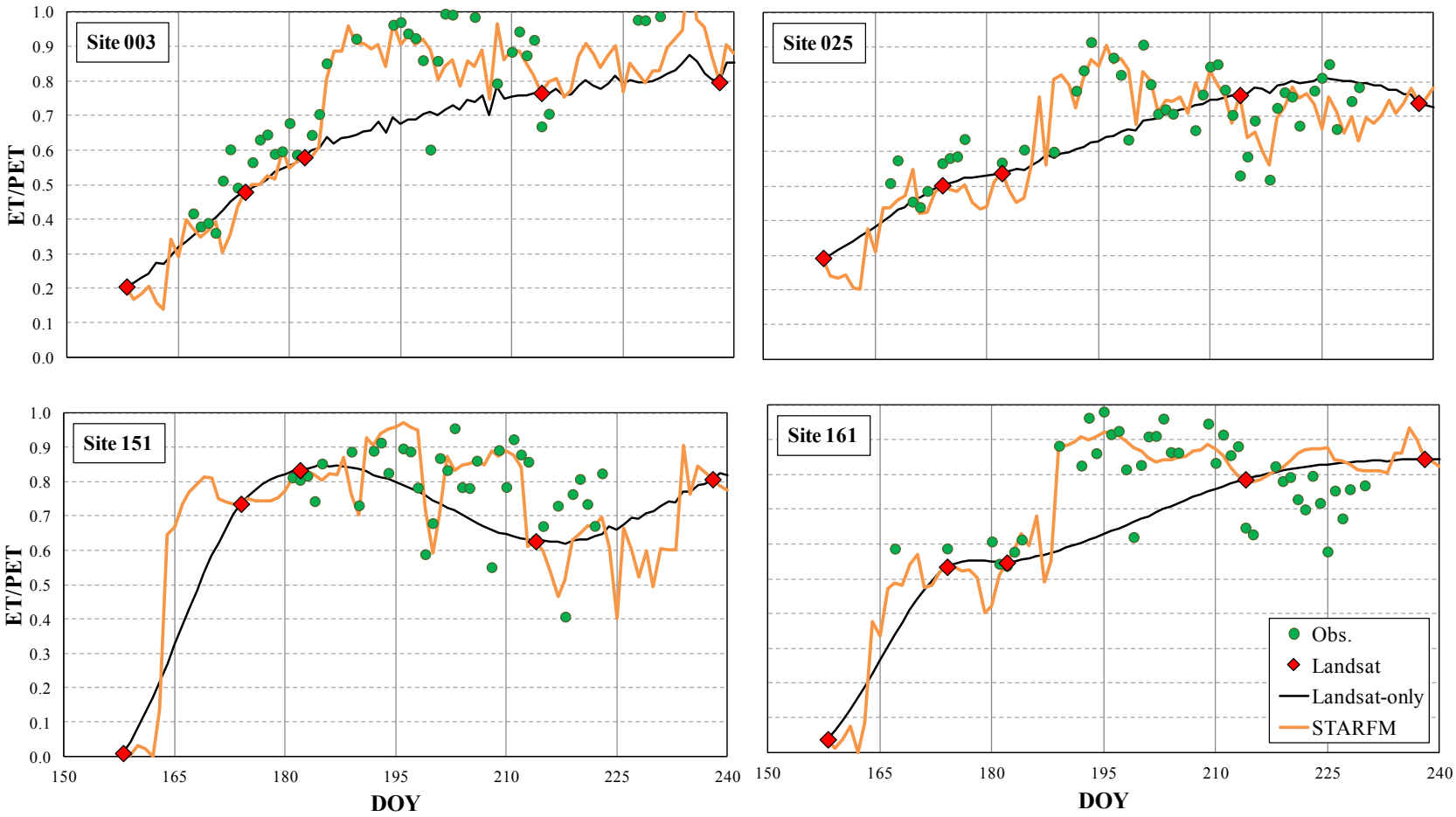
RESULTS (3/4)



- Significant leap in the ratio ET/PET after the first rainfall event (DOY 185).
- Landsat-Only seems to underestimate the observations in DOY 185-210.
- Fused Landsat-MODIS partially overcomes the underestimates.

Site	Crop Type	Obs. Cum. (mm)	Landsat-only MAD (mm d^{-1})	Landsat-only RE (%)	Landsat-only Slope	Landsat-only ΔCum. (mm)	STARM MAD (mm d^{-1})	STARM RE (%)	STARM Slope	STARM ΔCum. (mm)
003	Soybean	237	1.02	19.4	0.81	-41.0	0.64	12.3	0.92	-17.9
006	Corn	292	0.82	14.6	0.90	-17.4	0.78	14.0	0.90	-24.3
024	Corn	270	0.45	8.2	1.02	6.8	0.49	8.9	1.03	9.7
025	Corn	210	0.67	14.4	0.93	-10.9	0.54	11.5	0.97	-5.6
033	Corn	230	0.66	12.1	0.89	-21.8	0.52	9.6	0.94	-12.1
151	Corn	212	0.81	15.0	0.89	-21.0	0.65	12.0	0.97	-5.2
161	Soybean	210	0.92	17.8	0.88	-21.0	0.50	9.7	1.02	5.9
162	Soybean	258	0.65	12.3	0.92	-15.8	0.53	10.1	0.97	-4.3
Average		240	0.75	14.2	0.90	-17.8	0.58	11.1	0.98	-6.7

RESULTS (4/4)

- Both **MAD** and **RE** (errors) are in average **reduced** of about **20%**.
- The systematic **bias** (underestimation) of Landsat-only model (slope = 0.90) is **significantly reduced** (slope = 0.98) by introducing MODIS data.
- The **total difference** on seasonal cumulative ET is **reduced of ≈ 60%**.
- Almost all the sites show improvements by introducing MODIS data.

SUMMARY AND CONCLUSIONS

- A **multi-scale** (from continental to field) and **multi-sensor** (geostationary and polar-orbit satellites) **modeling framework** was tested to derive **ET** maps at **high resolution** (≈ 10-100 m) and **daily** frequency.

- The proposed **methodology** is developed to be consistent at different scales and it is **suitable** (and transferable) for next generation sensors (as **HyspIRI**).

- A **general improvement** in the agreement with in-situ measurements was observed by **fusing MODIS** (daily, 1-km) data **with Landsat** (16 days, 30-m) maps if compared to Landsat-only case.

- The **gain** related to MODIS data is **higher** when **leaps** in water availability were observed **between** two **successive Landsat** acquisitions.

- The obtained **average errors** (10% on daily evapotranspiration and 5% on seasonal cumulative ET) are **appropriate** to provide a support tool in **practical management** of agricultural water resource.

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Animal and Natural Resources Institute (ANRI)
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