Routine Mapping of Land-surface Carbon, Water and Energy Fluxes at Field to Regional Scales by Fusing Multi-scale and Multi-sensor Imagery

Rasmus Houborg

Earth System Science Interdisciplinary Center, University of Maryland, College Park

European Commision, JRC, Institute for Environment and Sustainability, Ispra, Italy

Martha C. Anderson & W.P. Kustas

USDA-ARS Hydrology and Remote Sensing Laboratory, Beltsville, MD

Feng Gao & Matthew Rodell

NASA Goddard Space Flight Center, Greenbelt, MD

Motivation

- Routine carbon and water cycle predictions at fine spatial resolution (< 100 m) are of critical importance in applications such as drought monitoring, yield forecasting, agricultural management and crop growth monitoring
- These applications require both high spatial resolution and frequent coverage in order to effectively resolve processes in heterogeneous landscapes at the scale of individual fields or patches
- Multi-scale and multi-sensor fusing approaches have the ability to blend aspects of spatially coarse (e.g. MODIS) and spatially fine (e.g. Landsat) resolution sensors to extend the applicability of land surface modeling schemes to provide meaningful decision support at micrometeorological scales (< 100m)
- One of the major challenges to applying a LSM over spatial and temporal domains lies in specifying reasonable inputs of key controls on vegetation dynamics and ecosystem functioning

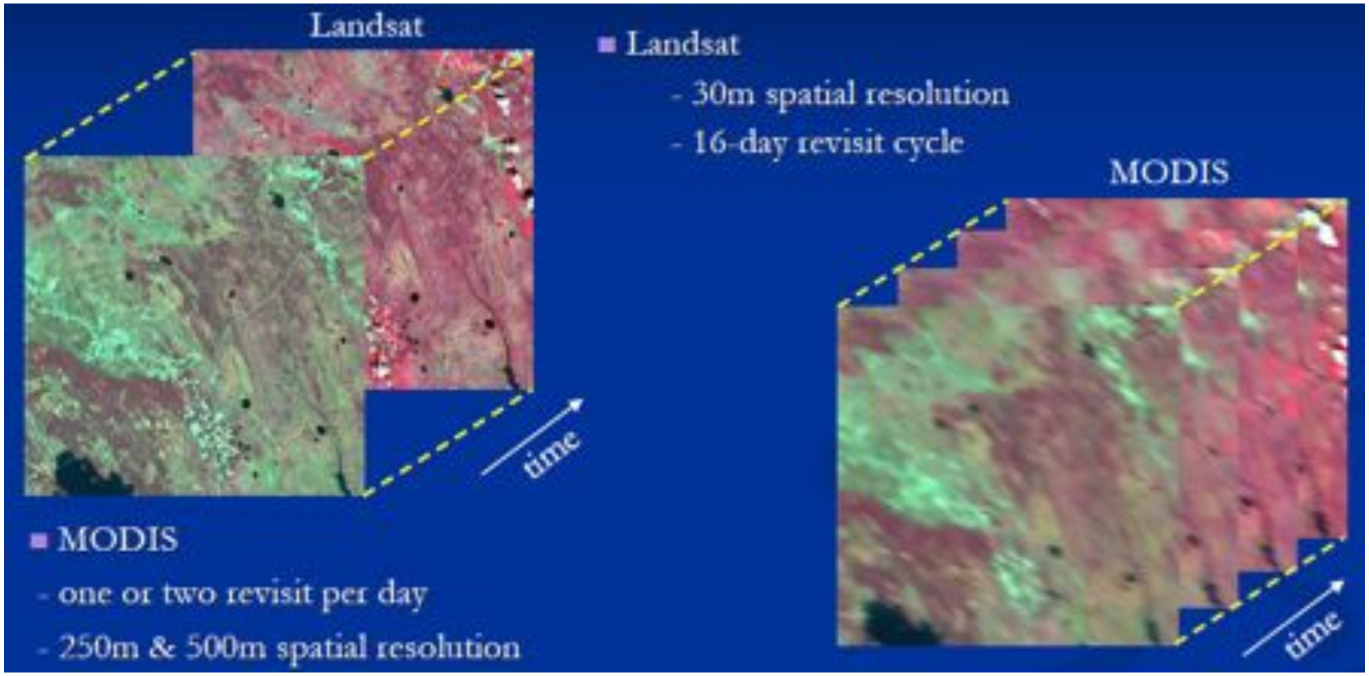
Goals and Objectives

- Fuse Landsat and MODIS data streams to facilitate high spatial resolution monitoring of carbon, water and heat fluxes at a temporal frequency not otherwise possible
- Refine and implement a novel technique for using satellite estimates of leaf chlorophyll to delineate variability in photosynthetic efficiency in space and time
- Develop and apply a scalable thermal-based flux modeling system and multi-scale data fusion approach to targeted regions that encompass a range of land cover types and environmental conditions
- Validate blended vegetation biophysical products and flux simulations using a combination of in-situ datasets, multi-year flux tower observations and independent satellite datasets and LSM output
- Work toward an automated approach to enable routine thermal-based flux mapping at fine spatial scales (<100 m) critically important to local water resource and agricultural management

Satellite products

Satellite sensor	Products	Spatial resolution	Temporal resolution
Terra MODIS	Surface reflectance (MOD0909A1)	500 m	Daily
Terra MODIS	Surface reflectance (MOD09A1)	500 m	8 Day
Terra MODIS	Land Surface Temperature (MOD11A1)	1000 m	Daily
Terra MODIS	Land Surface Emissivity (MOD11A2)	1000 m	8 Day
Terra/Aqua MODIS	Leaf area index (MCD15A2)	1000 m	8 Day
Terra MODIS	Vegetation Indices (MOD13Q1)	250 m	16 Day
Terra MODIS	Aerosol optical depth (MOD04_L2)	10 km	Daily
Aqua AIRS	Total Precipitable Water and Column Ozone	45 km	Daily
Landsat 7 ETM+	At-sensor radiance and brightness temperature	30 m, 60 m	16 Day
Landsat 5 TM	At-sensor radiance and brightness temperature	30 m, 120 m	16 Day
GOES-10 & 12	Brightness temperature	10 km	15 min

STARFM = Spatial and Temporal Adaptive Reflectance Fusion Model

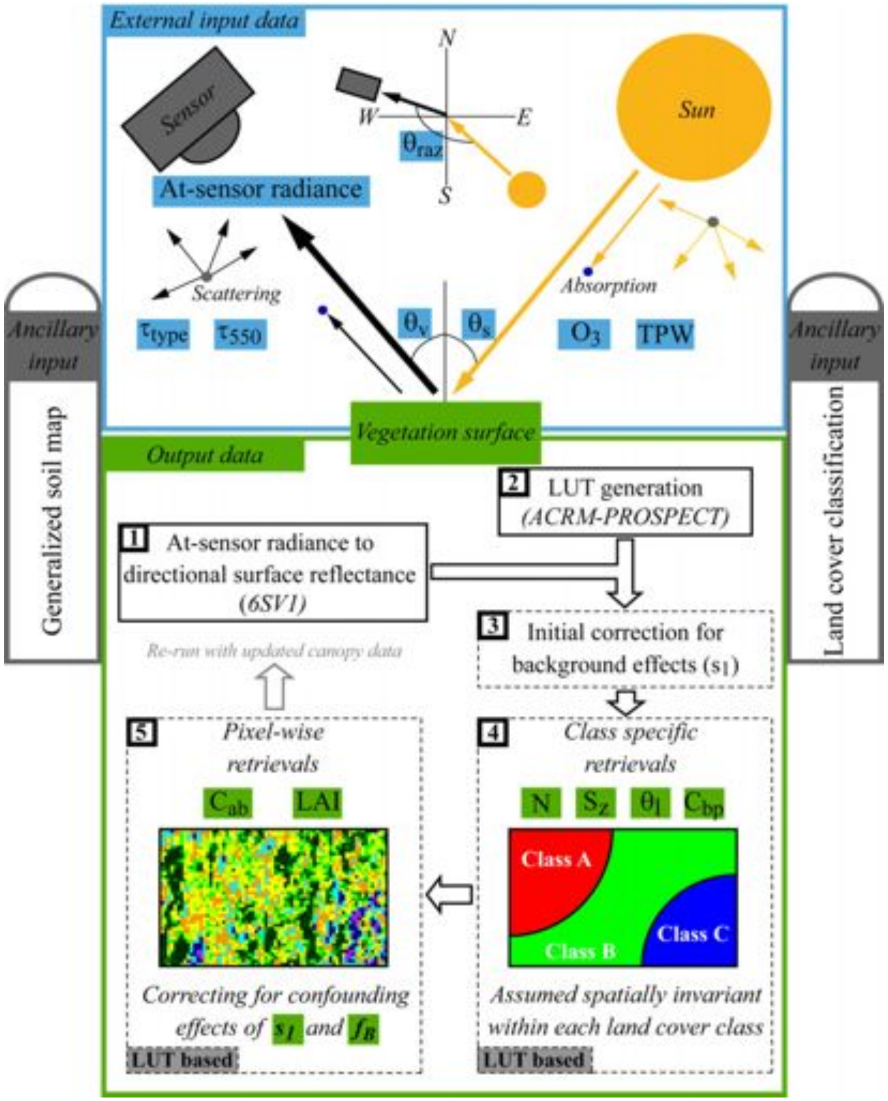


	Landsat 5	Landsat 7	MODIS
Equatorial Crossing	9.45 ± 15 min	10.00 ± 15 min	10:30 a.m.
Field of view	± 7.5˚	± 7.5˚	± 55˚
		Spectral bandwidths	
Green	0.520 - 0.600	0.520 - 0.600	0.545 - 0.565
Red	0.630 - 0.690	0.630 - 0.690	0.620 - 0.670
Near-infrared	0.760 - 0.900	0.770 - 0.900	0.841 - 0.876

Models

Vegetation parameter retrieval tool

REGFLEC = REGularized canopy reFLECtance tool



Houborg & Anderson (2009)

- **Physically-based approach for estimating key descriptors (LAI and leaf chl) of vegetation dynamics**
- **Combines leaf optics (PROSPECT), canopy reflectance (ACRM), and atmospheric radiative transfer (6SV1) modules**
- **Requires at-sensor radiance observations in green, red and nir wavebands, standard atmospheric state data, land cover and soil map**
- **The retrieval system is entirely image-based and does not rely on local ground-based data for model calibration**
- **REGFLEC accommodates variations in sensor and atmospheric absorption and scattering conditions, soil background conditions, surface BRDF and species composition**

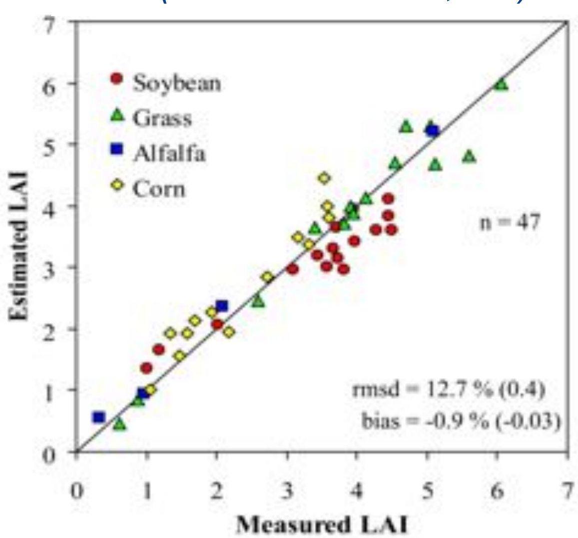
Models

Vegetation parameter retrieval tool

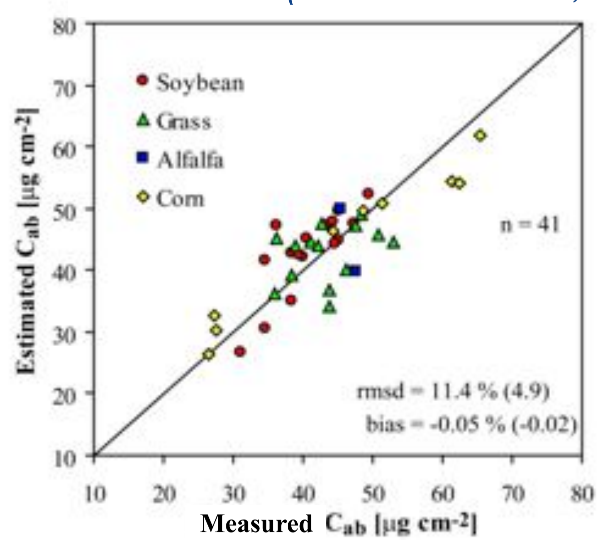
REGFLEC LAI and leaf chl retrieval accuracies

Sensor	Vegetation	N		LAI		Cab	
		LAI	Cab	RMSD	Bias	RMSD	Bias
SPOT 20m *(OK, U.S.)*	Cotton/peanuts/corn/ grass/wheat	26	23	14% (0.39)	-3.2% (-0.09)	19% (9.1)	-4.1% (-2.0)
SPOT 10m *(MD, US)*	Soybean/grass/ corn/alfalfa	47	41	13% (0.40)	-0.9% (-0.03)	11% (4.9)	-0.1% (-0.02)
Aircraft 1m *(MD, US)*	Corn	31	31	10% (0.25)	0.5% (0.01)	10% (4.4)	-2.2% (-0.9)
SPOT 20m *(Denmark)*	Maize/barley/wheat	19	26	19% (0.74)	-9.0% (-0.40)	10% (5.3)	-0.2% (-0.08)
MODIS 250m *(DK)*	Barley/wheat	48	-	20% (0.54)	9.0% (0.24)	-	-
	Forest	19	-	18% (0.63)	-15% (-0.52)	-	-

LAI *(SPOT 10m - MD, US)*

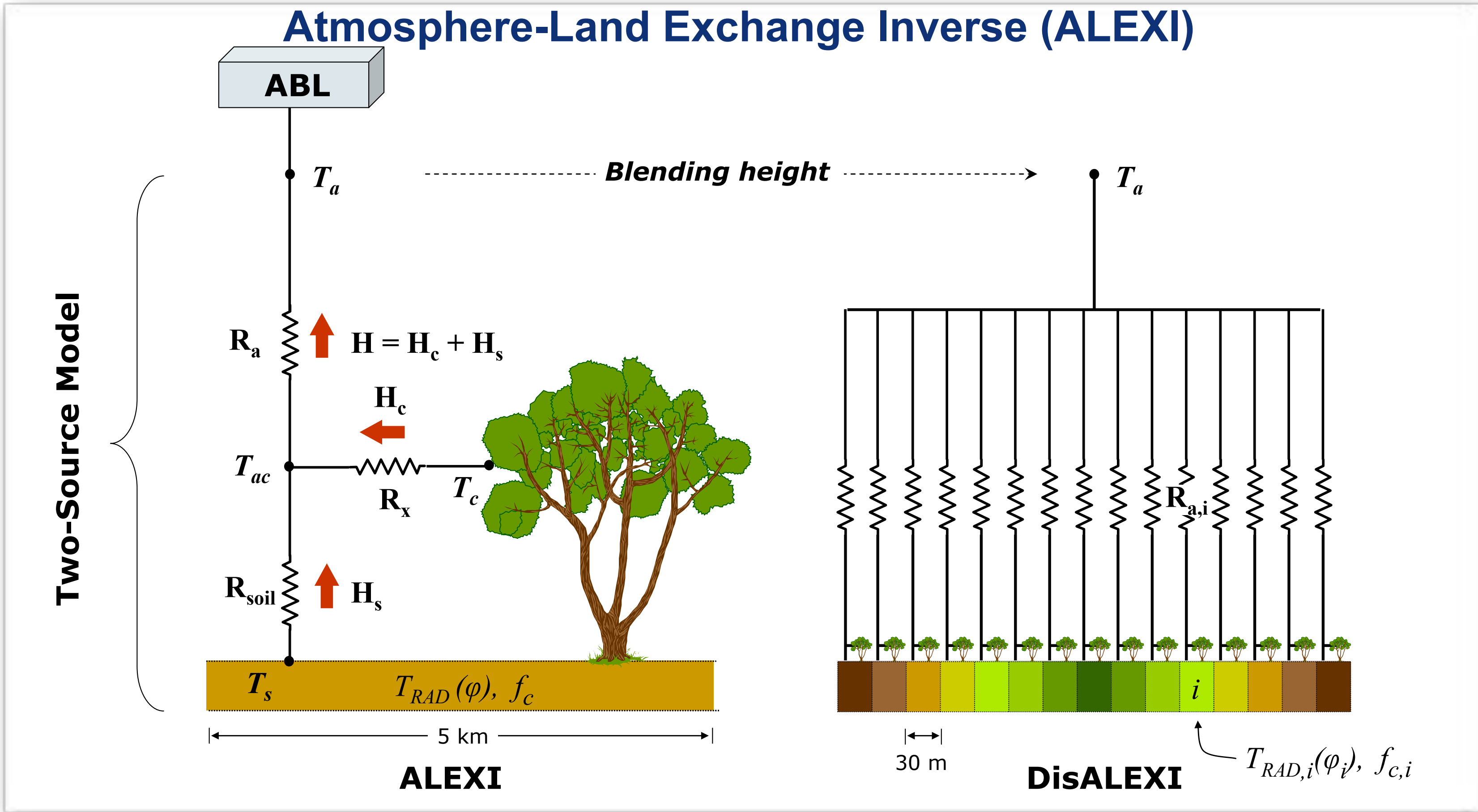


Leaf chl *(SPOT 10m - MD, US)*



Models

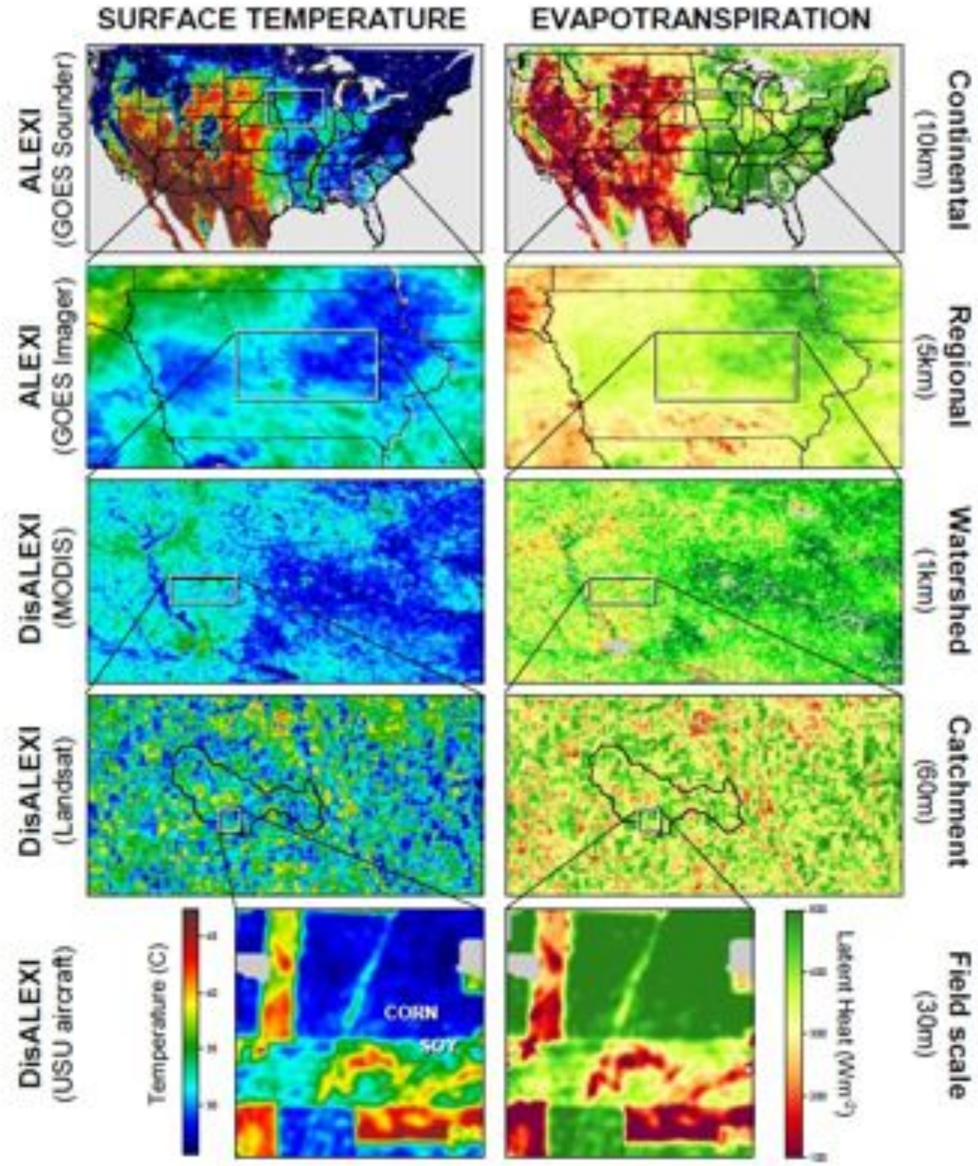
Land-surface model



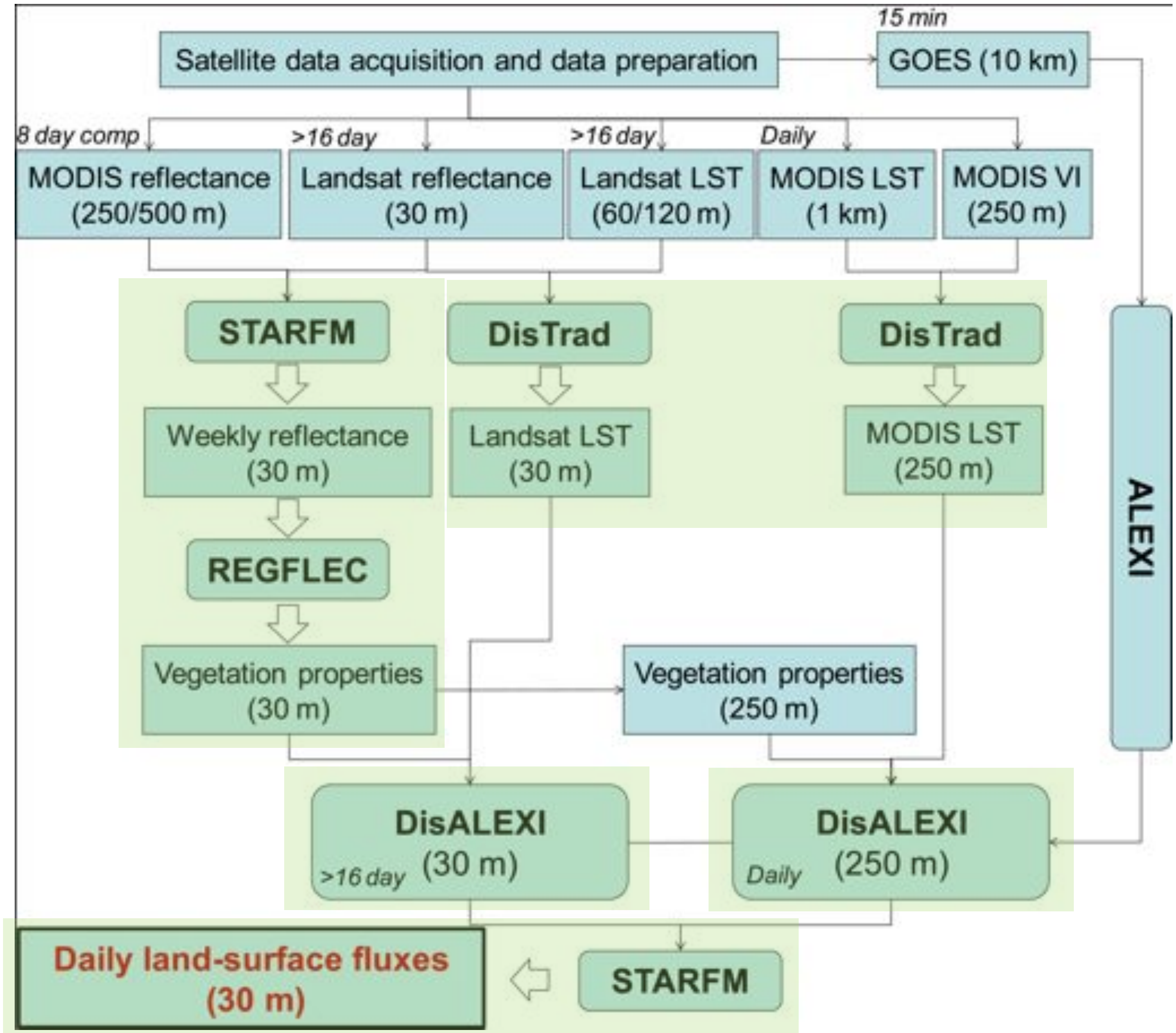
	Regional scale	**Landscape scale**
Surface temp:	ΔT_{RAD} - GOES	T_{RAD} - Landsat, MODIS
Air temp:	T_a - ABL model	T_a - ALEXI

Models

Land-surface model

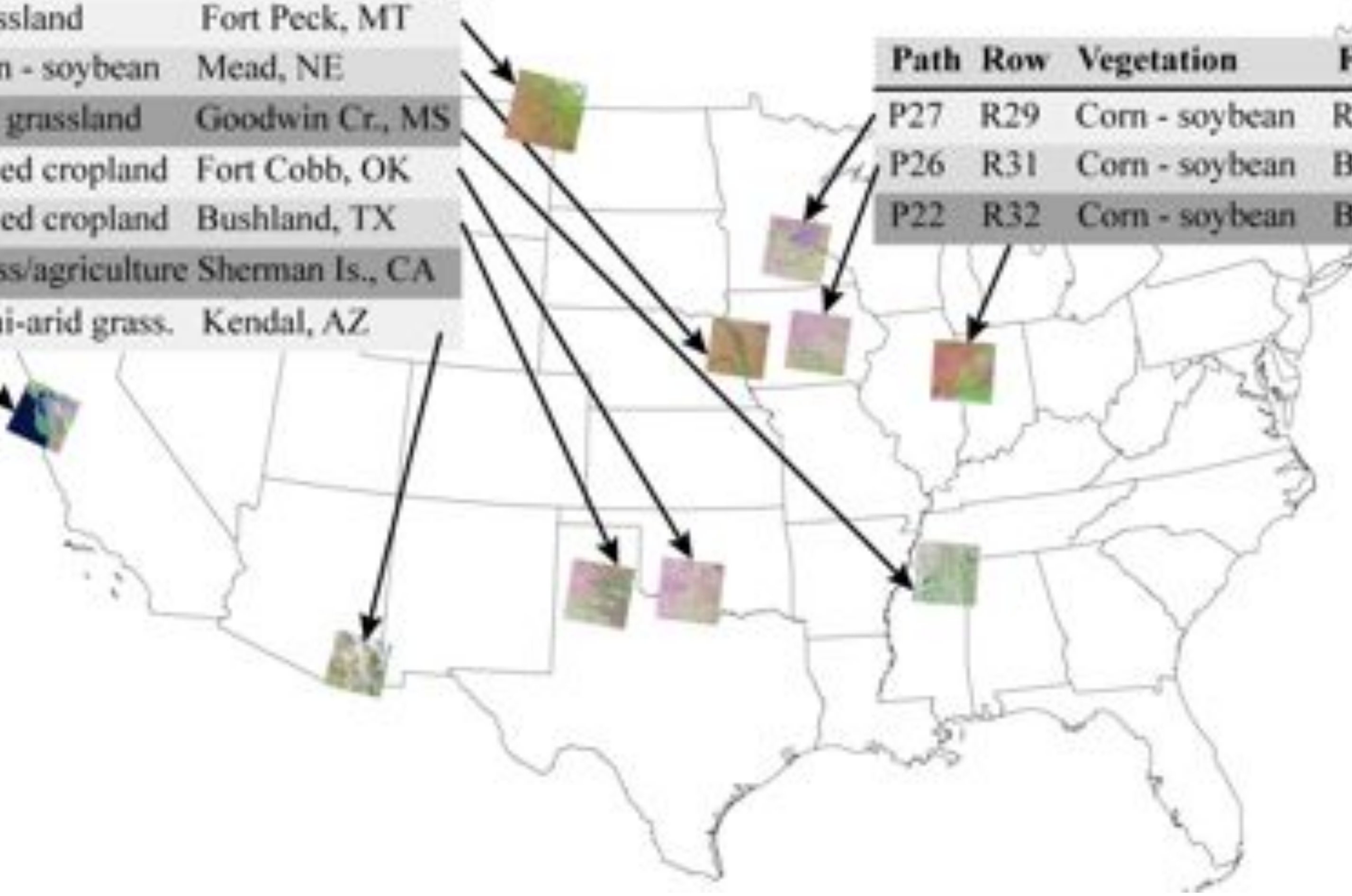


Processing steps



Study regions

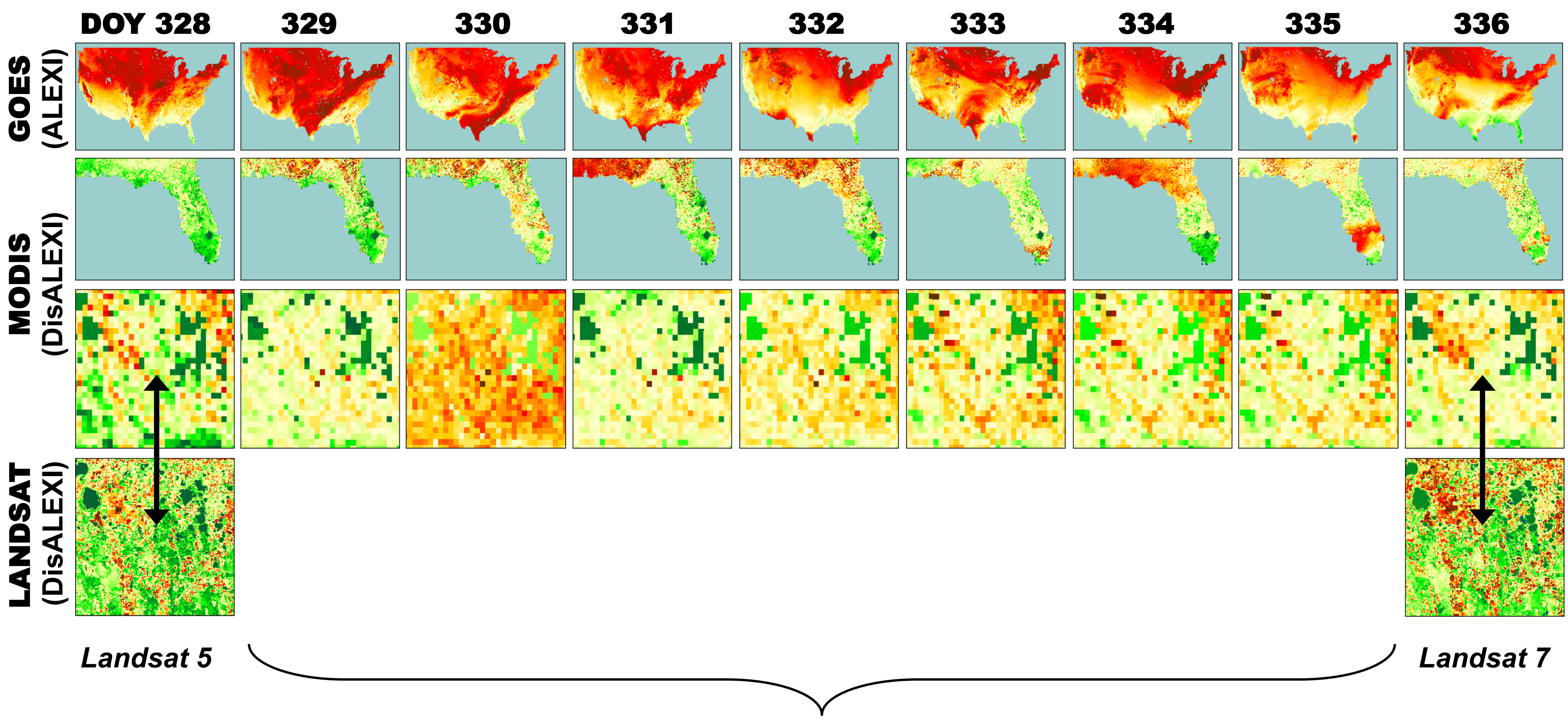
Path	Row	Vegetation	Flux tower
P35	R26	Grassland	Fort Peck, MT
P28	R31	Corn - soybean	Mead, NE
P22	R36	Wet grassland	Goodwin Cr., MS
P28	R36	Mixed cropland	Fort Cobb, OK
P30	R36	Mixed cropland	Bushland, TX
P44	R34	Grass/agriculture	Sherman Is., CA
P35	R38	Semi-arid grass.	Kendal, AZ



Path	Row	Vegetation	Flux tower
P27	R29	Corn - soybean	Rosemount, MN
P26	R31	Corn - soybean	Brooks Field, IA
P22	R32	Corn - soybean	Bondville, IL

Flux-based data fusion

Daily Evapotranspiration – Orlando, FL, 2002



Spatial Temporal Adaptive Reflectance Fusion Model (STARFM) *(Gao et al, 2006)*

Flux-based data fusion

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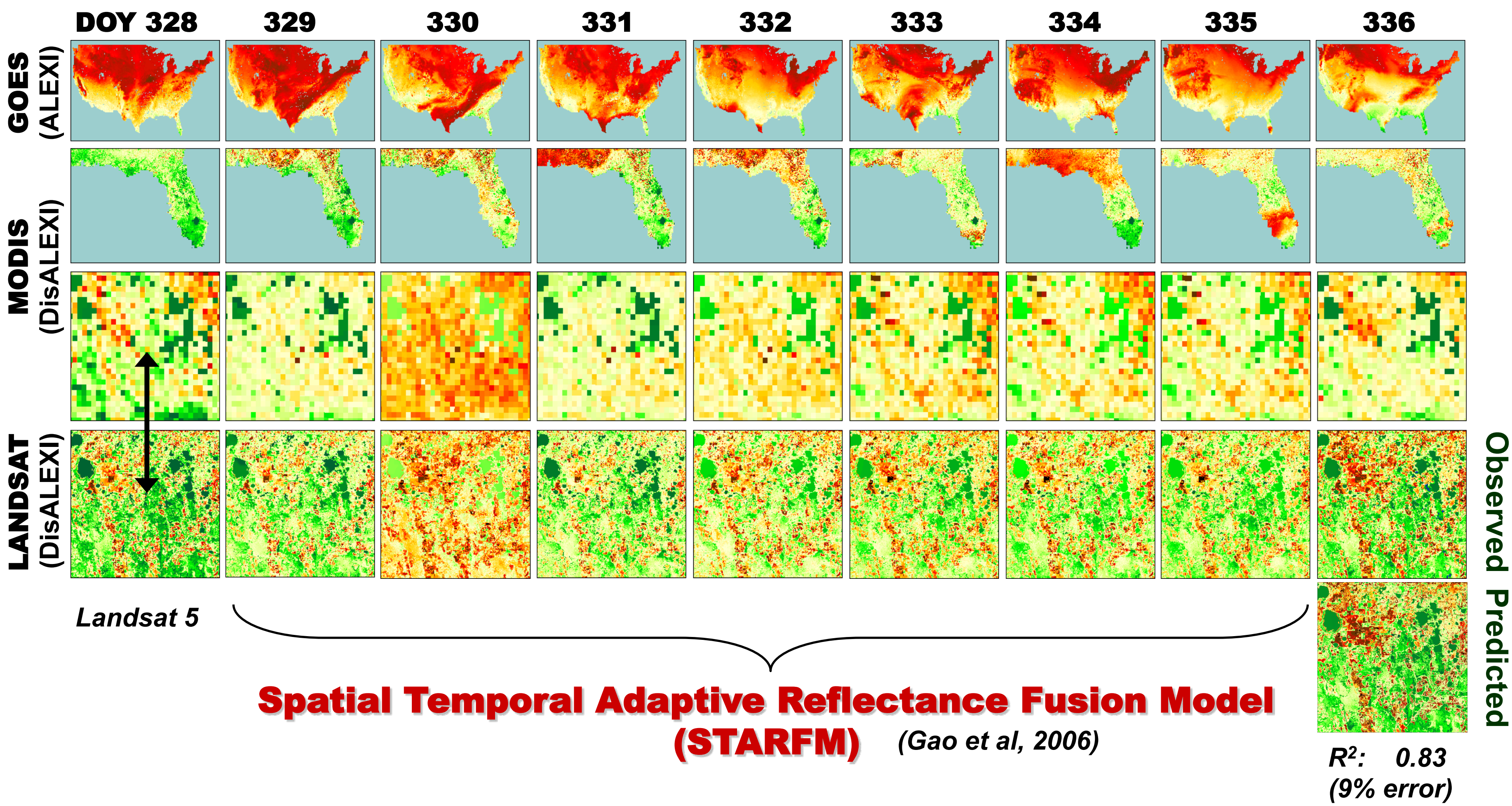

Validation efforts

Retrieved vegetation biophysical products will be validated using a combination of in-situ datasets and independent satellite datasets

The quality of observed and blended flux maps will be evaluated at localized points using available flux tower observations

Generated flux maps will be compared to independent flux output from the suite of LSMs embedded within the Land Information System (LIS) Land Data Assimilation System (LDAS)