Strategies for Mitigating Rice GHG Emissions: Modeling and Geospatial Monitoring

April 23, 2010

William Salas
Applied Geosolutions, LLC
Durham, NH 03924 USA
wsalas@agsemail.com

APPLIED GEOSOLUTIONS, LLC

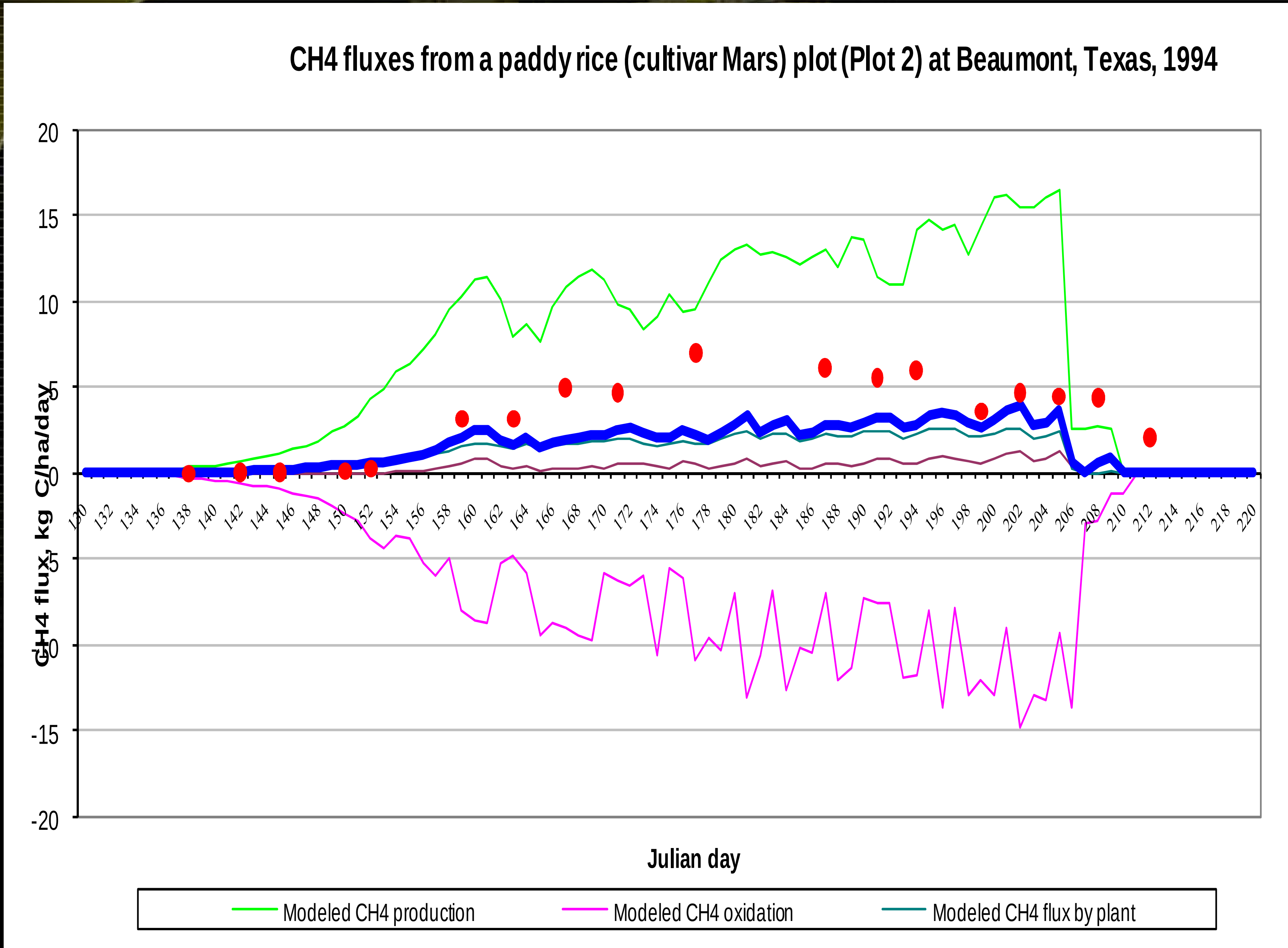
Presented at Technical Working Group on Agricultural Greenhouse Gases (T-AGG): Experts Meeting

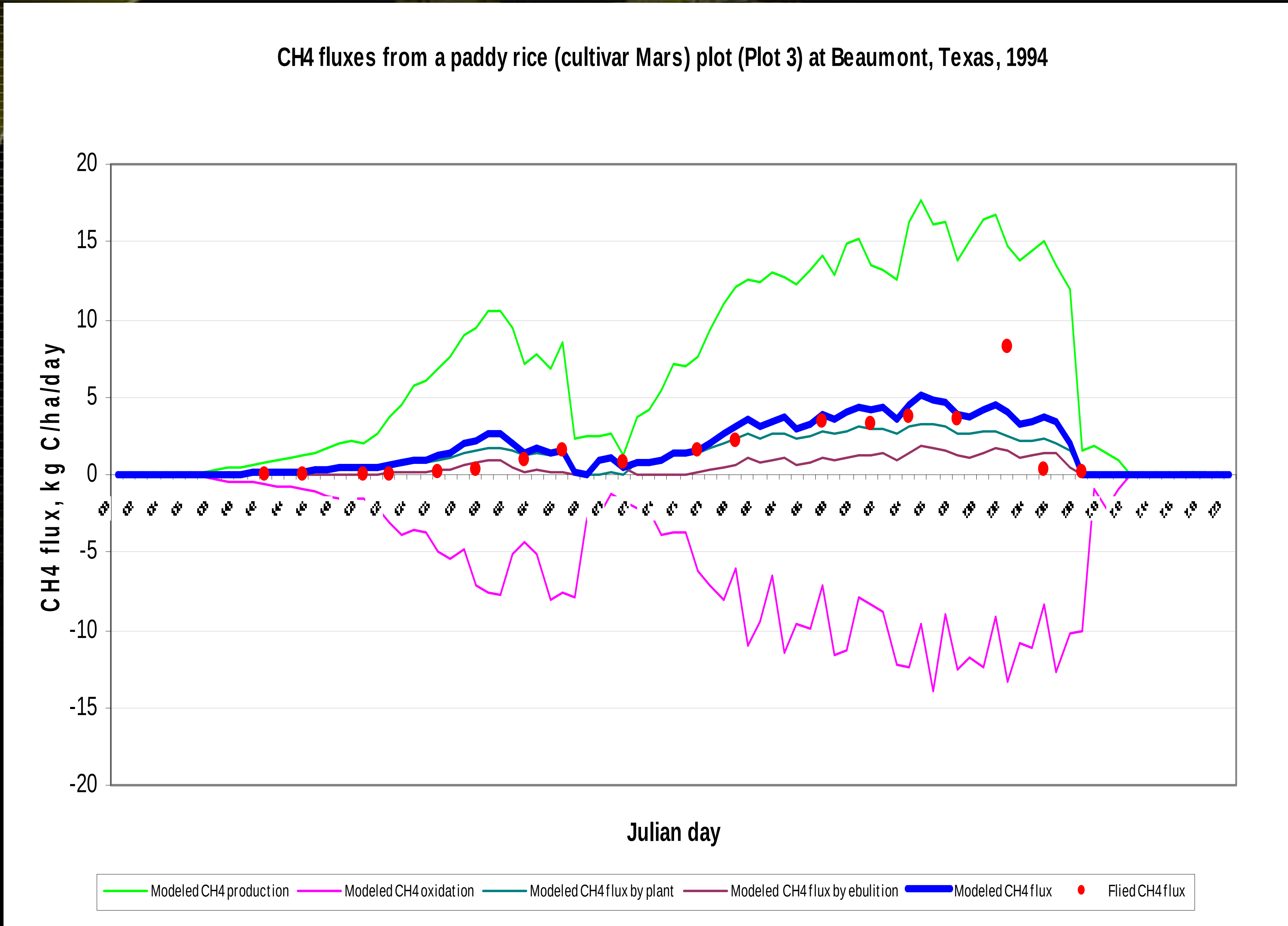
Overview

- Opportunities for mitigation of methane emissions from rice
- Mid-season drainage: need for full GHG accounting
- Role of remote sensing for monitoring and verification of management practices
- California rice case study: Using model for GHG inventory and assessing mitigating opportunities.

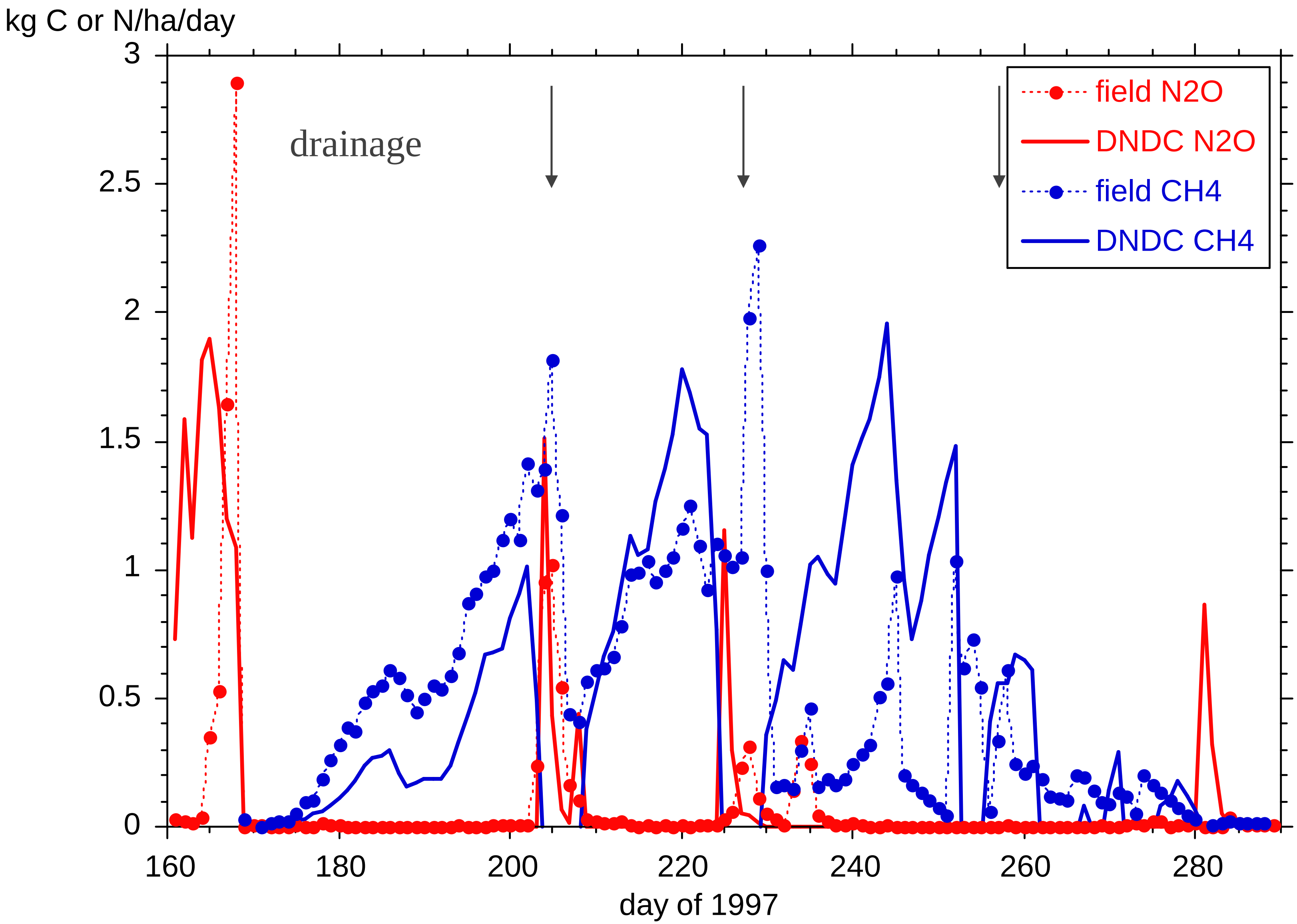
Rice Methane Mitigation Strategies

- Increase soil Eh to stop methanogenisis
  - ✓ Upland rice
  - ✓ Mid-season drainage/shallow flooding
  - ✓ Addition of oxidants (e.g. use of sulfate and nitrate fertilizers)
- Decrease availability of C (DOC, CO2) during low Eh conditions (below -150 mV)
  - ✓ Crop residue management
  - ✓ Use of cultivars with lower root biomass (root exudates)
- Slow transport of CH4 from root/soil to atmosphere to enhance methanotrophy

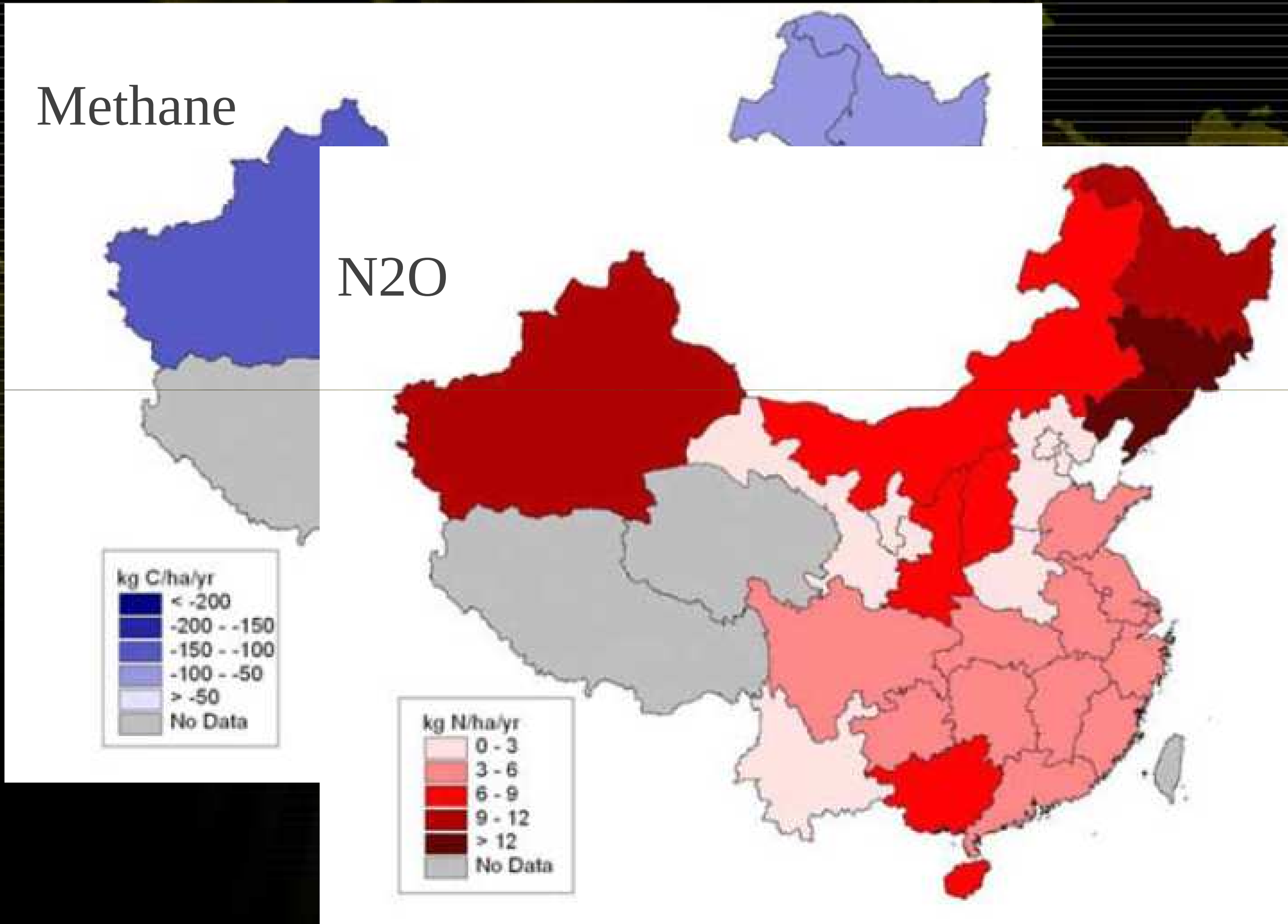

CH4 fluxes from a paddy rice (cultivar Mars) plot (Plot 2) at Beaumont, Texas, 1994
CH4 flux, kg C/ha/day
Julian day
Modeled CH4 production
Modeled CH4 oxidation
Modeled CH4 flux by plant


CH4 fluxes from a paddy rice (cultivar Mars) plot (Plot 3) at Beaumont, Texas, 1994
20
15
10
5
0
-5
-10
-15
-20
C H4 flux, k g C/h a/d ay
Julian day
Modeled CH4 production
Modeled CH4 oxidation
Modeled CH4 flux by plant
Modeled CH4 flux by ebulition
Modeled CH4 flux
Flied CH4 flux

Observed and modeled CH_4 and N_2O fluxes from paddy with mid-season drainage, Jiangsu Province, China, 1997

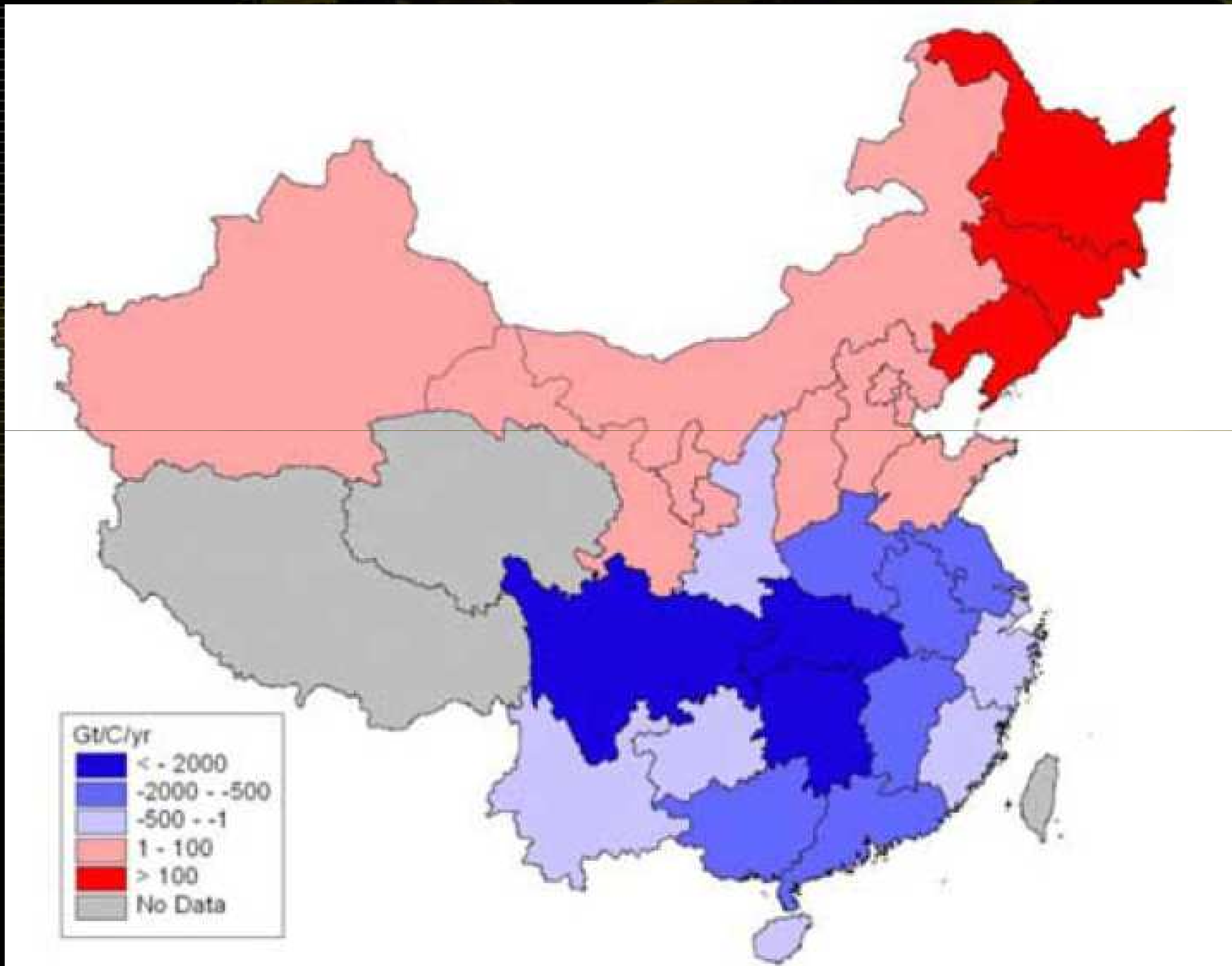


China Mid-season Drainage: Change on CH4 and N2)



Source: Li et al. 2005, GBC

Midseason Drainage: Net Impacts



Source: Li et al. 2005, GBC

Comparing GHG, Yield and Water Requirement Effects of Different Mitigation Options from DNDC

Numbers Represent Annual Averages over 2000-2020 Relative to Baseline

Management option	CH_4	N_20	CO_2	GWP	Yield	Water
	(kg CO_2eq/ha)	(kg CO_2eq/ha)	(kg CO_2/ha)	(kg CO_2eq/ha)	(kg C/ha)	(mm/yr)
Midseason drainage	-2411	1283	-1	-1129	81	-9
Shallow flooding	-7402	-2440	591	-9251	134	-248
Upland rice	-11794	-3018	239	-14573	-381	-566
Off-season straw	-663	-40	21	-682	43	0
Ammonium sulfate	-367	-3668	-85	-4120	28	0
Slow-release fert.	287	727	-191	823	131	0

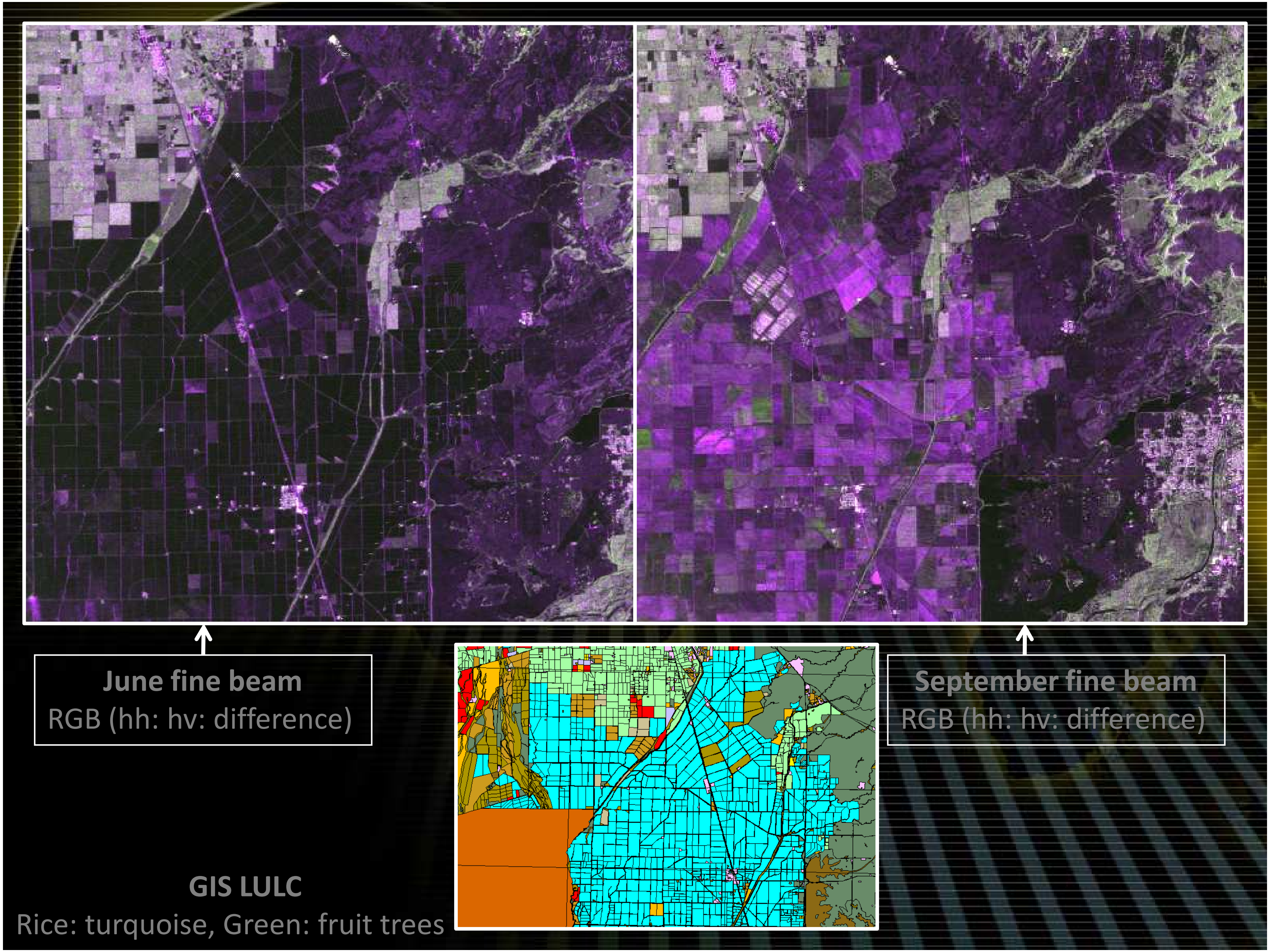
California rice case study:

Coupling Remote Sensing and Models for GHG inventory and assessing opportunities for reducing GHG emissions.

NRCS, EDF and CRC Funding
PIs: Eric Holst (EDF) and Paul Buttner (CRC)
Collaboration with UC Davis

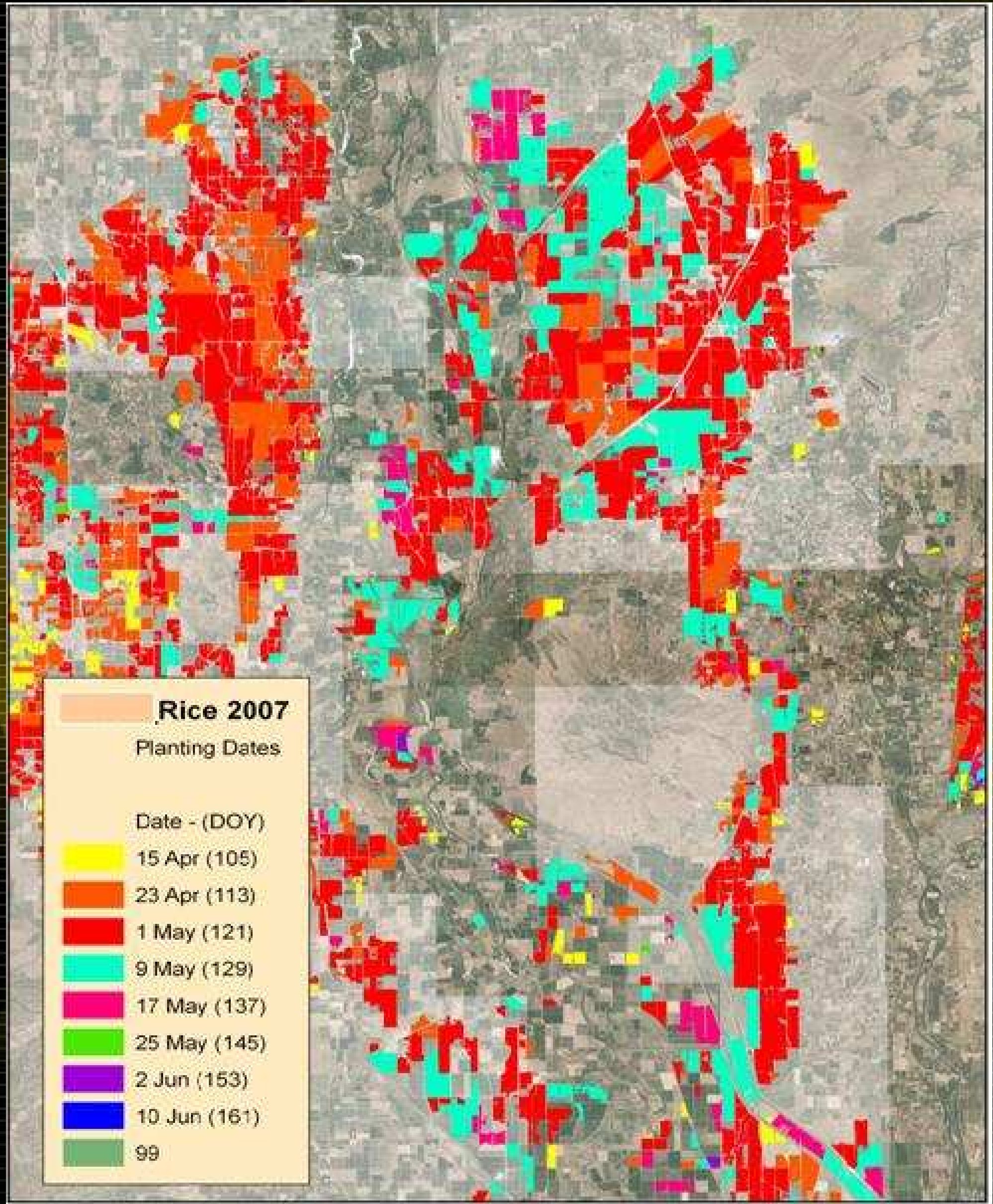
Remote Sensing Mapping Goals:

- Location of rice fields
- Water management: when fields are flooded and drained:
- Planting and harvest dates
- Plant development and biomass
- Tillage and residue management

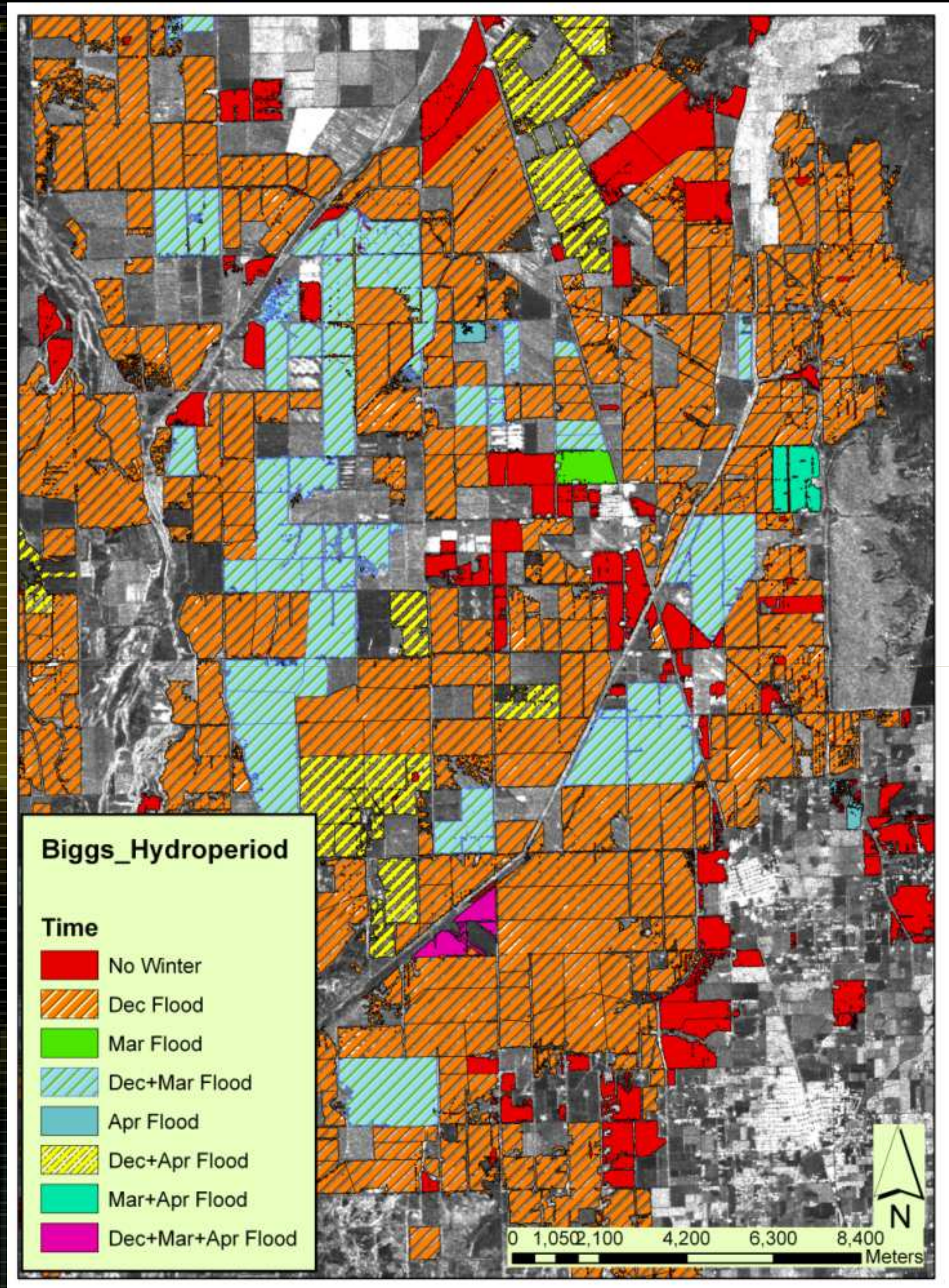

June fine beam
RGB (hh: hv: difference)
September fine beam
RGB (hh: hv: difference)
GIS LULC
Rice: turquoise, Green: fruit trees

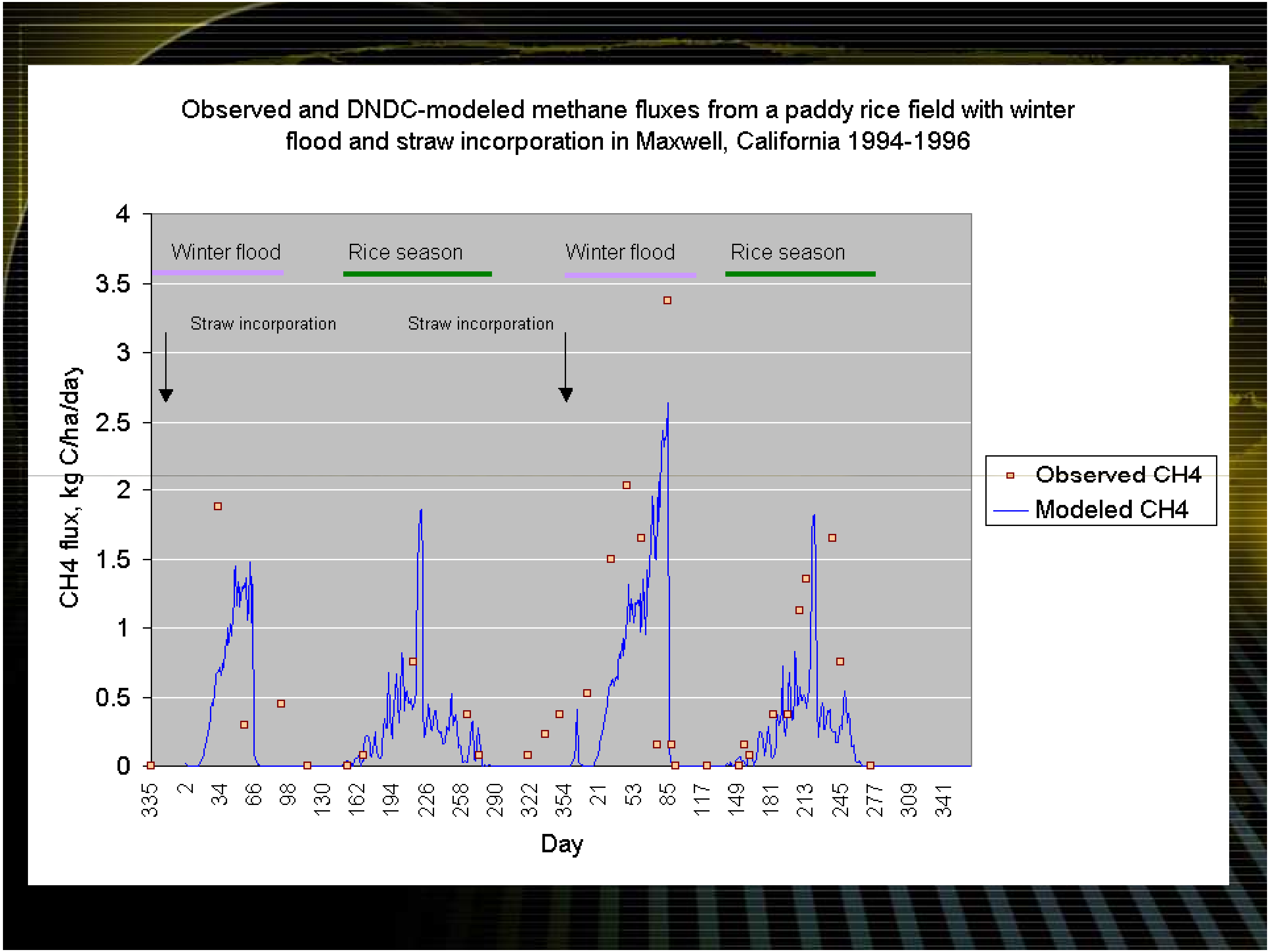
Operational rice products
- Hydroperiod
- Crop calendar (DOY)
- Planting dates
- Parameterize models

Features
- “now-cast” ability; fully automated
- 95%+ accuracy
- multiscale (spatial & temporal)
  - 6.25 m seasonal (PALSAR)
  - Moderate (Landsat/AWiFS)
  - 250m daily (MODIS)
  - 250m 8-day (MODIS)



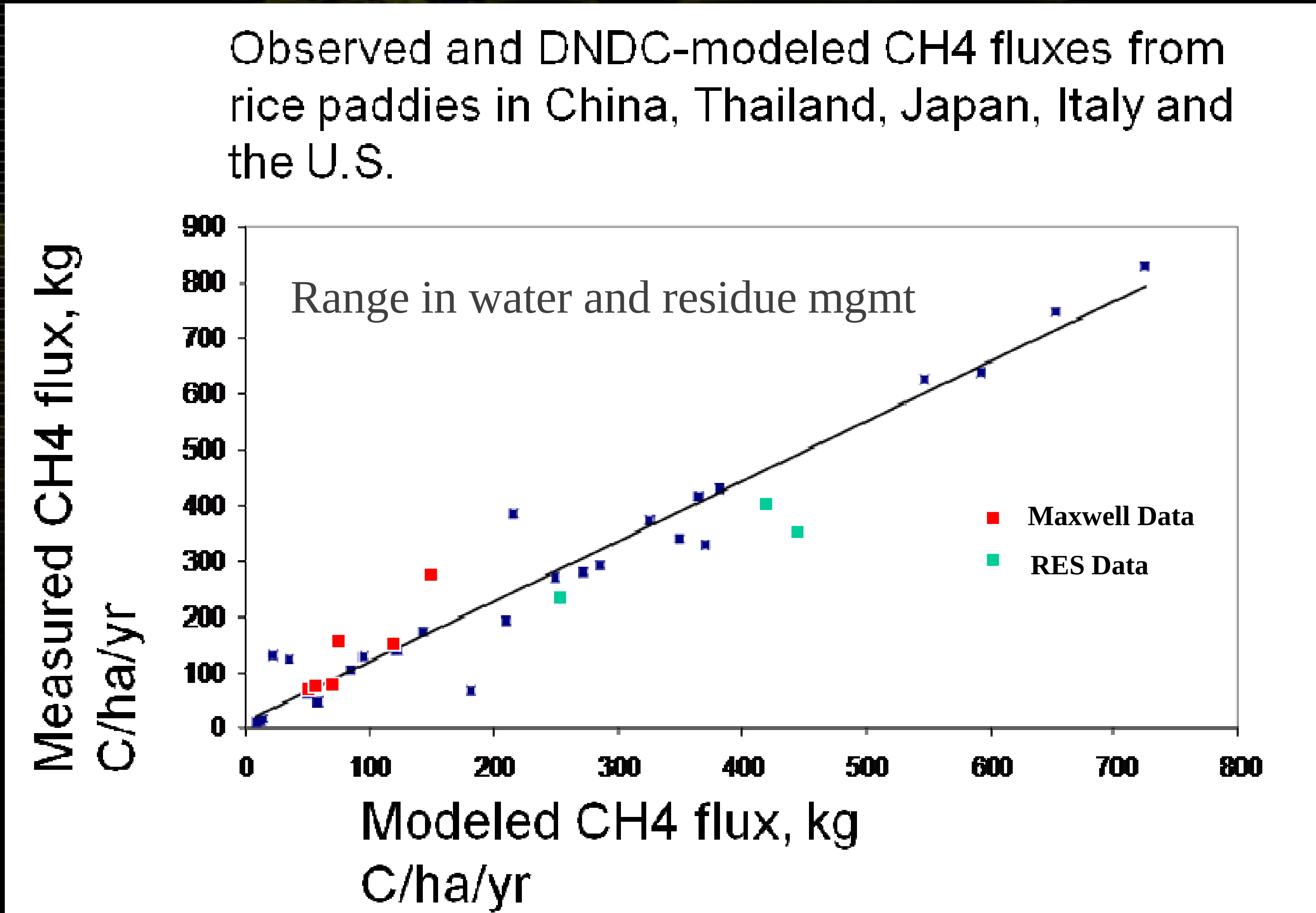
- Used Remote Sensing (PALSAR and MODIS) to map rice extent and water management – indentify baseline management.
- ~230,000 ha of rice (~500,000 acres)
- Mapped duration of winter flooded
  - -few fields had standing water in April (likely due to precipitation)





Observed and DNDC-modeled methane fluxes from a paddy rice field with winter flood and straw incorporation in Maxwell, California 1994-1996
Winter flood
Rice season
Winter flood
Rice season
Straw incorporation
Straw incorporation
CH4 flux, kg C/ha/day
Day
Observed CH4
Modeled CH4

CH4 Model Validation: With CA Sites



Methane Emissions from Rice: Comparison of Methods/Models

- US EPA Emission Factor: 210 kg CH4/ha/yr
- ARB Emission Factor: 122 kg CH4/ha/yr
- DNDC Model: ~500 Kg CH4/ha/yr

Source of discrepancies?

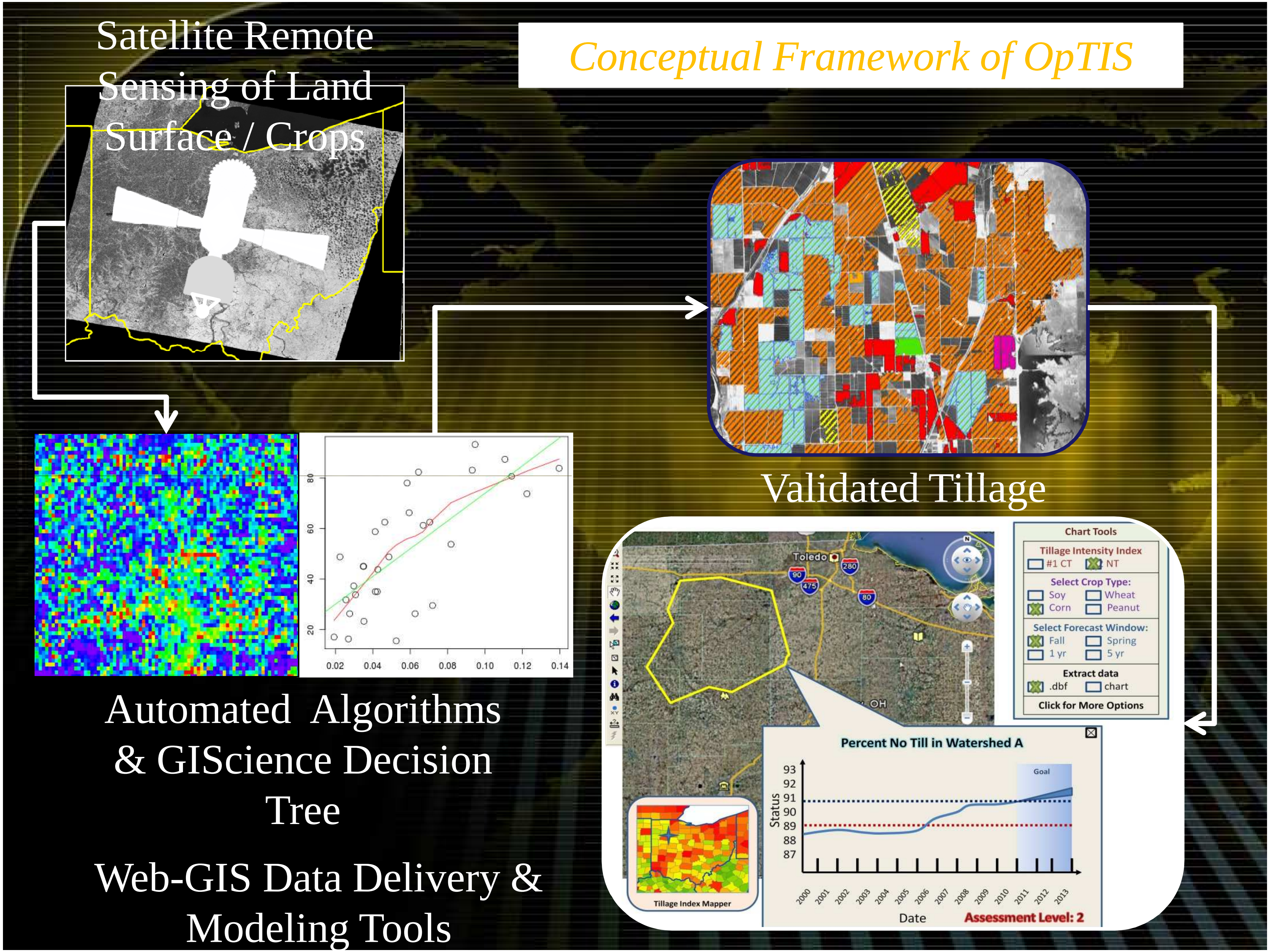
CA Maxwell site has heavy soils (50% clay) and thus low emissions ~170 kg CH4/ha)

EFs do not include Winter flooding

RES data (~450 kg CH4/ha, source: Assa and Horwath, unpublished)

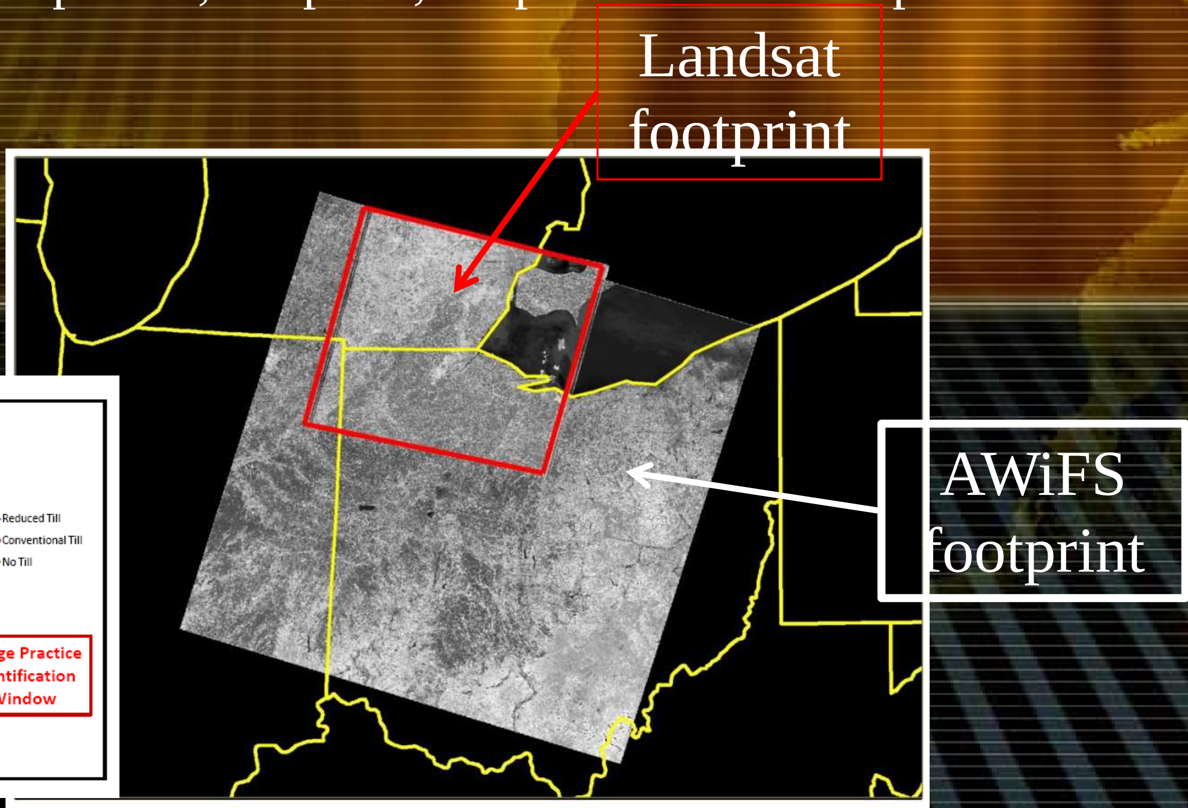
Remote Sensing of tillage practices

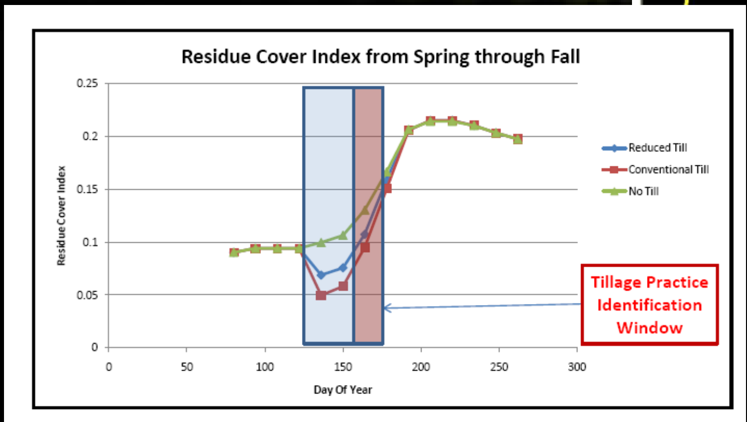
Operational Tillage Information System (OpTIS)


Conceptual Framework of OpTIS
Satellite Remote Sensing of Land Surface / Crops
Validated Tillage
Automated Algorithms & GIScience Decision Tree
Web-GIS Data Delivery & Modeling Tools
0.02
0.04
0.06
0.08
0.10
0.12
0.14
20
40
60
80
Toledo
OH
Chart Tools
Tillage Intensity Index
#1 CT
NT
Select Crop Type:
Soy
Wheat
Corn
Peanut
Select Forecast Window:
Fall
Spring
1 yr
5 yr
Extract data
.dbf
chart
Click for More Options
Percent No Till in Watershed A
Status
93
92
91
90
89
88
87
Goal
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Date
Assessment Level: 2
Tillage Index Mapper

Integrating multiple satellite platforms

- AWiFS current acquisition strategy ongoing with USDA/USGS/NASA
  - 5-day repeat, 56m spatial, 740km wide swath
- Landsat 5 and continued LDCM scale imagery
  - 16-day repeat, 30m spatial, 180km wide swath
- MODIS high temporal frequency accurate phenology / farm activity info
  - Daily, 8-day composites, 250/500m spatial, 1200km tiles
- Integration of different spectral, temporal, & spatial resolutions provide optimal information

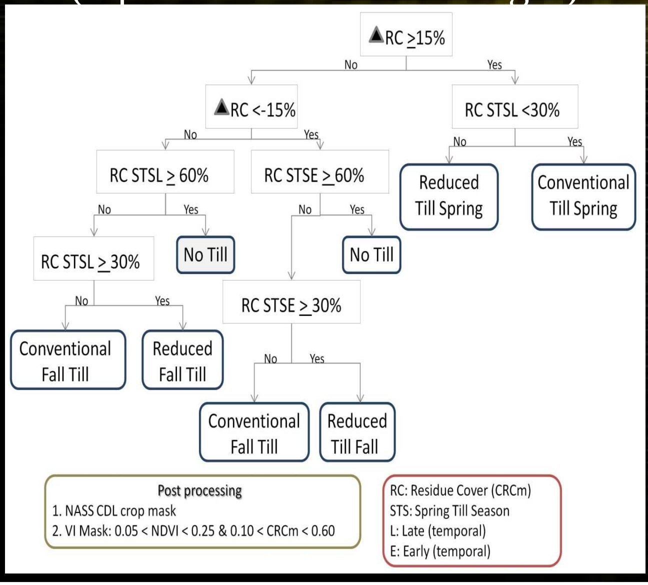




Decision Tree Approach

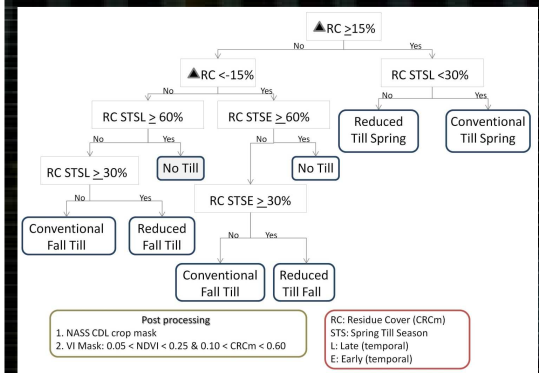
- ➢ Automated and operational; easily scalable & transferable
- ➢ Key off indices sensitive to residue cover
- ➢ Selects appropriate decision tree based on information available
  - o Requires at least one appropriately-timed Moderate Resolution image
  - o Can use one or multiple sensors providing various info
  - o Outputs: maps of crop residue cover, tillage practice, and pixel accuracy

Operational Decision Tree Framework L2
(input includes 2 MR images)

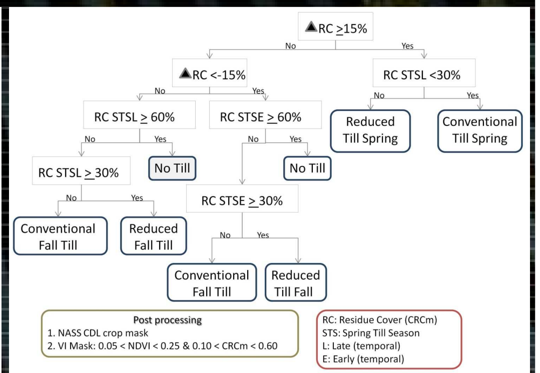


Operational Decision Tree Framework L6
(input includes previous year crop type and 2 MR images)

Corn

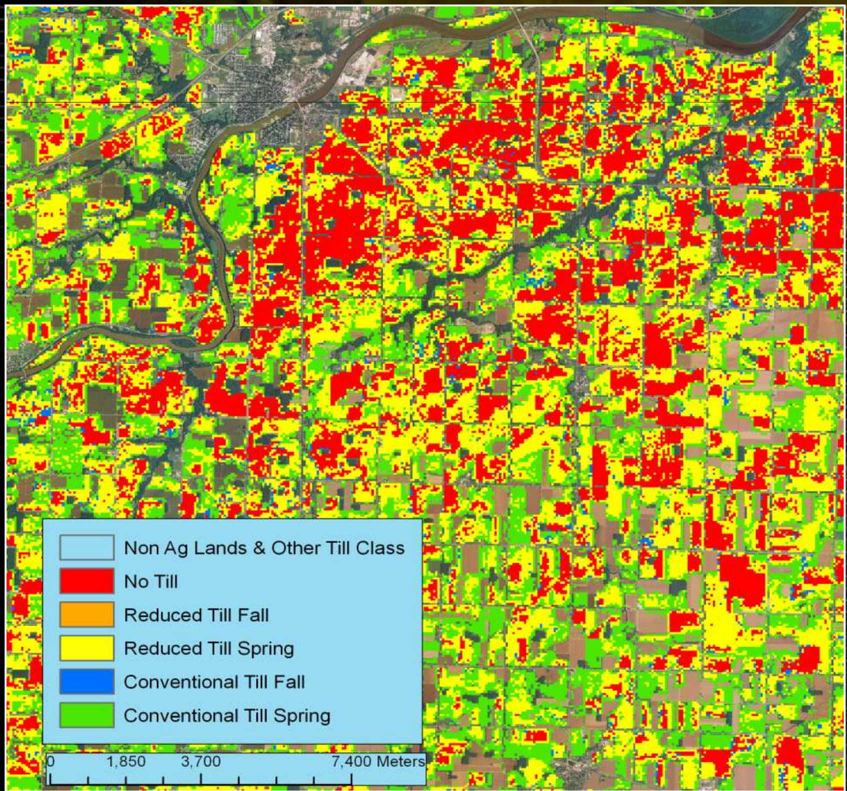


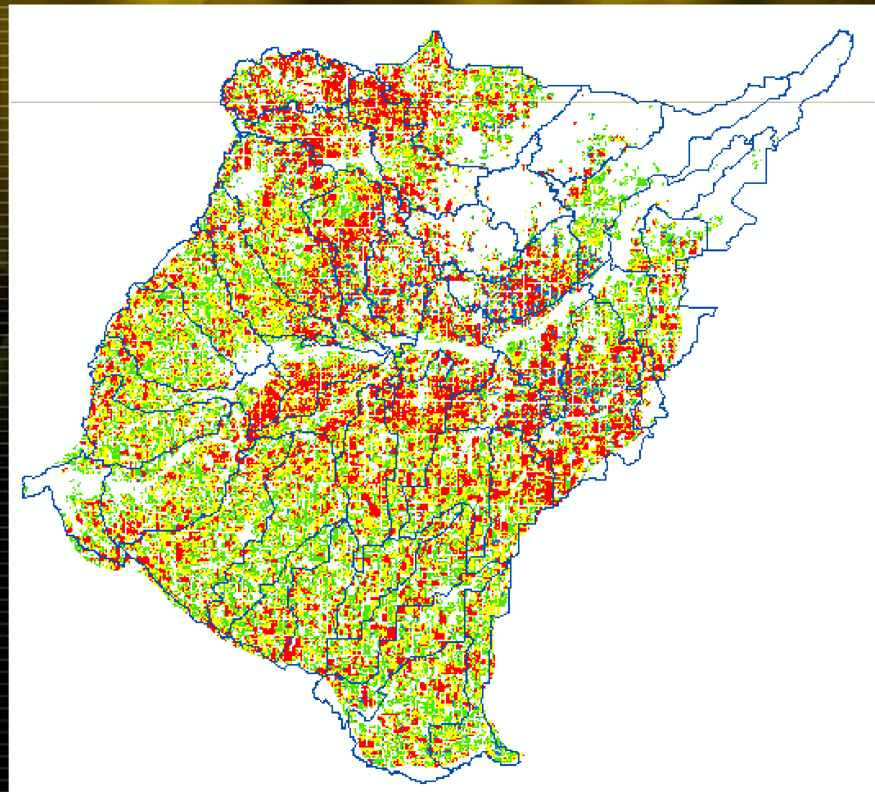
Soybean



Classification Highlights

- Consistently achieves 80% accuracy in an operational context
- Accuracy is a function of class definition schemes (# of classes and residue bins)
- Maps tillage intensity throughout the year (Fall, Spring, Annual)
- Approach can map tillage, trends, & rotations





Role of Operational Remote Sensing…

Important for developing regional databases and for mapping and potentially monitoring management practices: for compliance, verification , or tracking sustainability…

Summary: Rice Mitigation Opportunities

- Significant methane reductions possible on a per hectare basis
  - ✓US Area ~1,300 ha
  - ✓Must account of changes in SOC and N2O
  - ✓Water use co-benefits?
- Way forward: coupled measurement and model development (Ray's Sinusoidal curve)
- RS can play an important role.