# Estimating Nitrogen Uptake From Space: Prospects for Integration

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**Introduction | REACCH Seminar | Moscow, ID | December 11, 2014**

Motivation

- **Nitrogen use efficiencies (NUE) ranging from 10-80% on the field scale in the Palouse region** (*Huggins et al., 2010*)

- **Improving NUE can:**
  - **Reduce losses of excess N to the environment**
  - **Save farmers money by optimizing inputs**

80 kg/ha

120 kg/ha

60 kg/ha

WINGSCAPES   **1 DAY**   **AESCAM**   **JUN.15,13**   **09:00 AM**
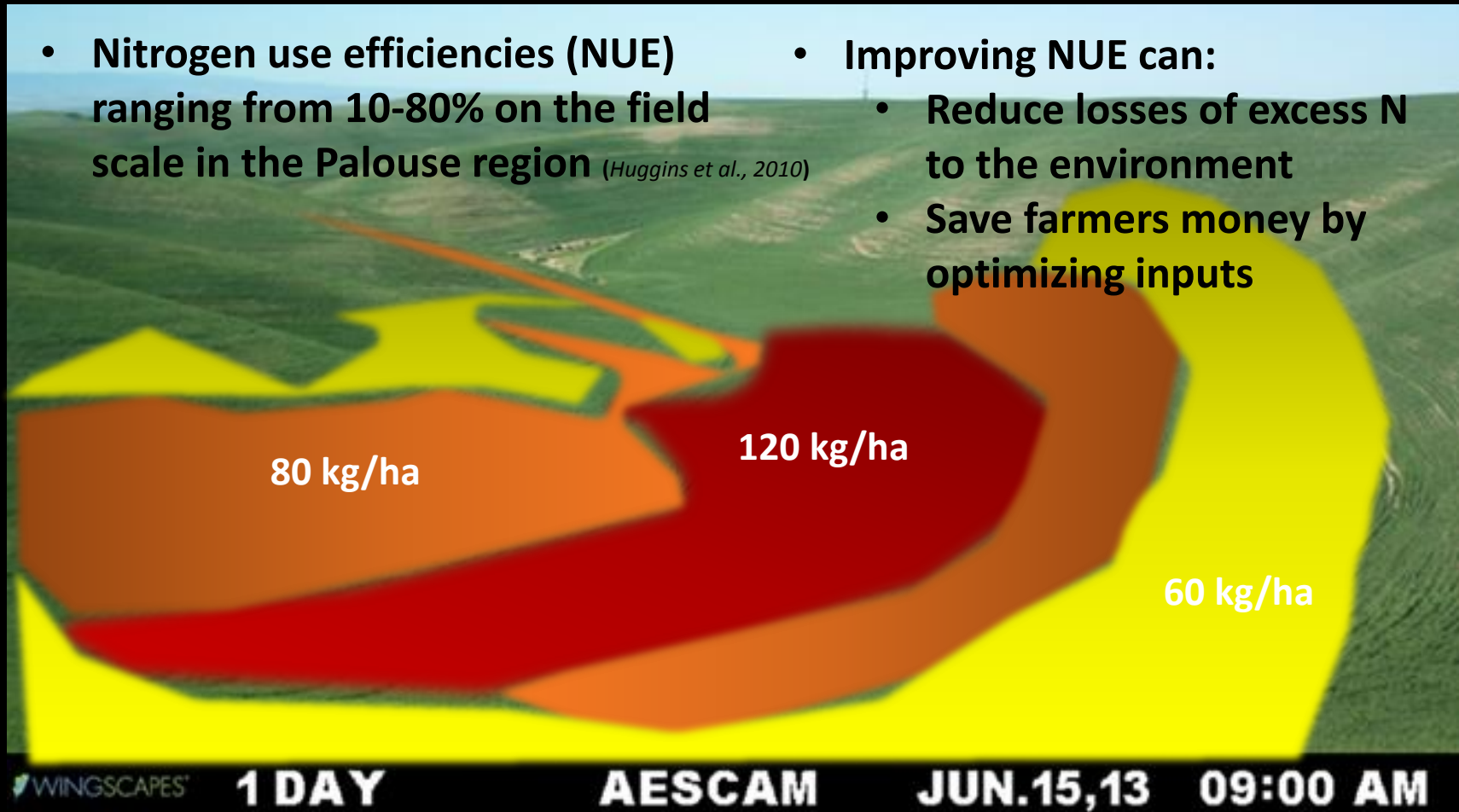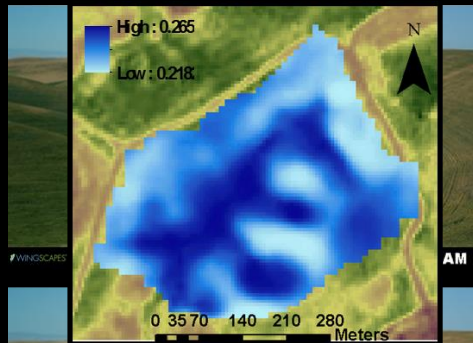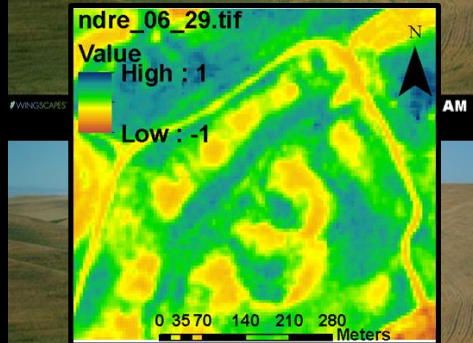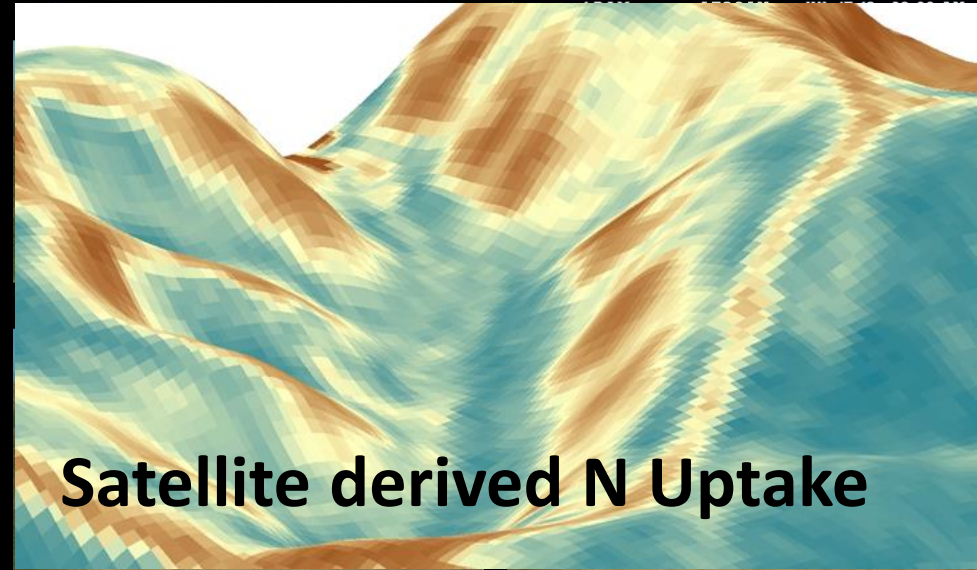
Motivation:
How do you manage what you can't measure?
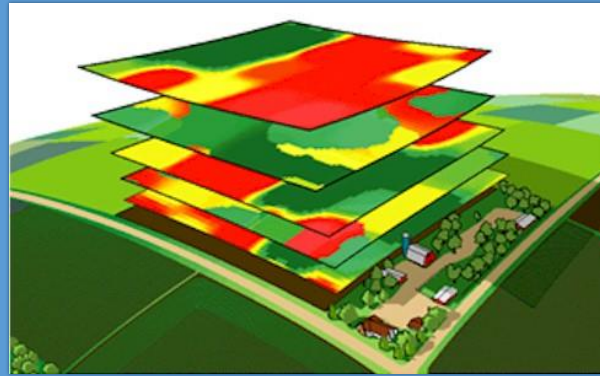
Patterns of crop N uptake vary across time and space. How well can we map this? What is driving these patterns?

High: 0.265
Low: 0.218
N

0 35 70   140   210   280
Meters

Soil Moisture Routing Model

Daily resolution from time lapse camera

ndre_06_29.tif
Value
High : 1
Low : -1
N

0 35 70   140   210   280
Meters

Satellite Image of Vegetation

Satellite derived N Uptake

1 DAY   AESCAM   JUL.21,13   09:00 AM
1 DAY   AESCAM   JUL.22,13   09:00 AM
1 DAY   AESCAM   JUL.23,13   09:00 AM

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Site-Specific Climate Friendly Farming Team

Grad students and post-docs
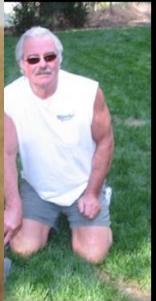
Methods: Research sites

Colfax Farm
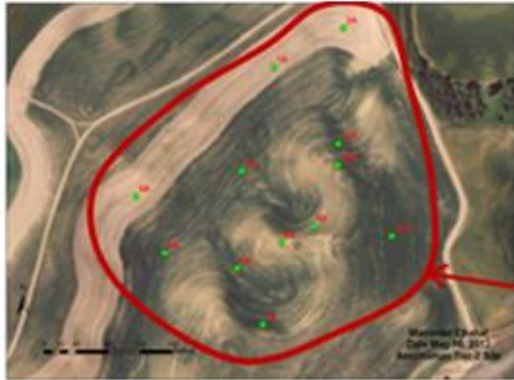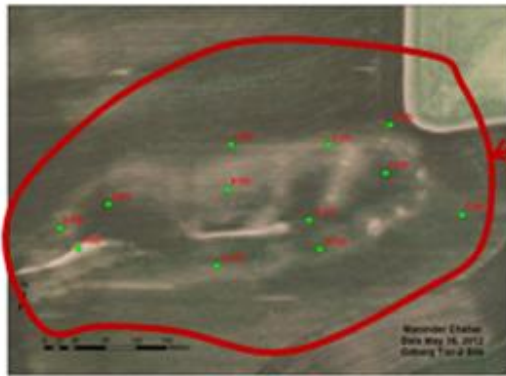
Genesee Farm

Troy Farm

Leland Farm

400 m

400 m

E. Brooks
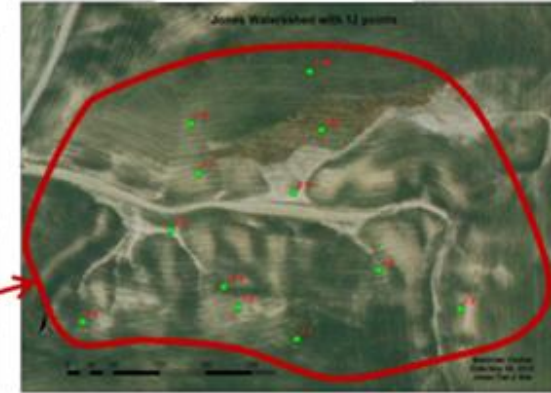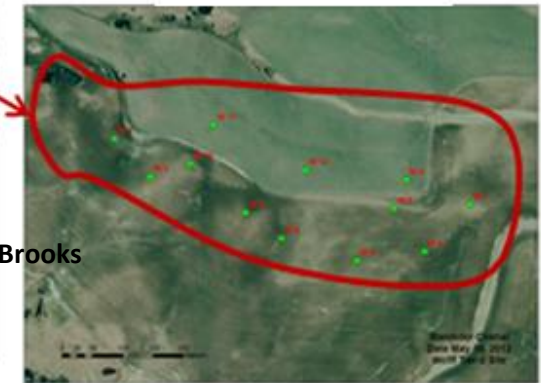
Methods: Research sites
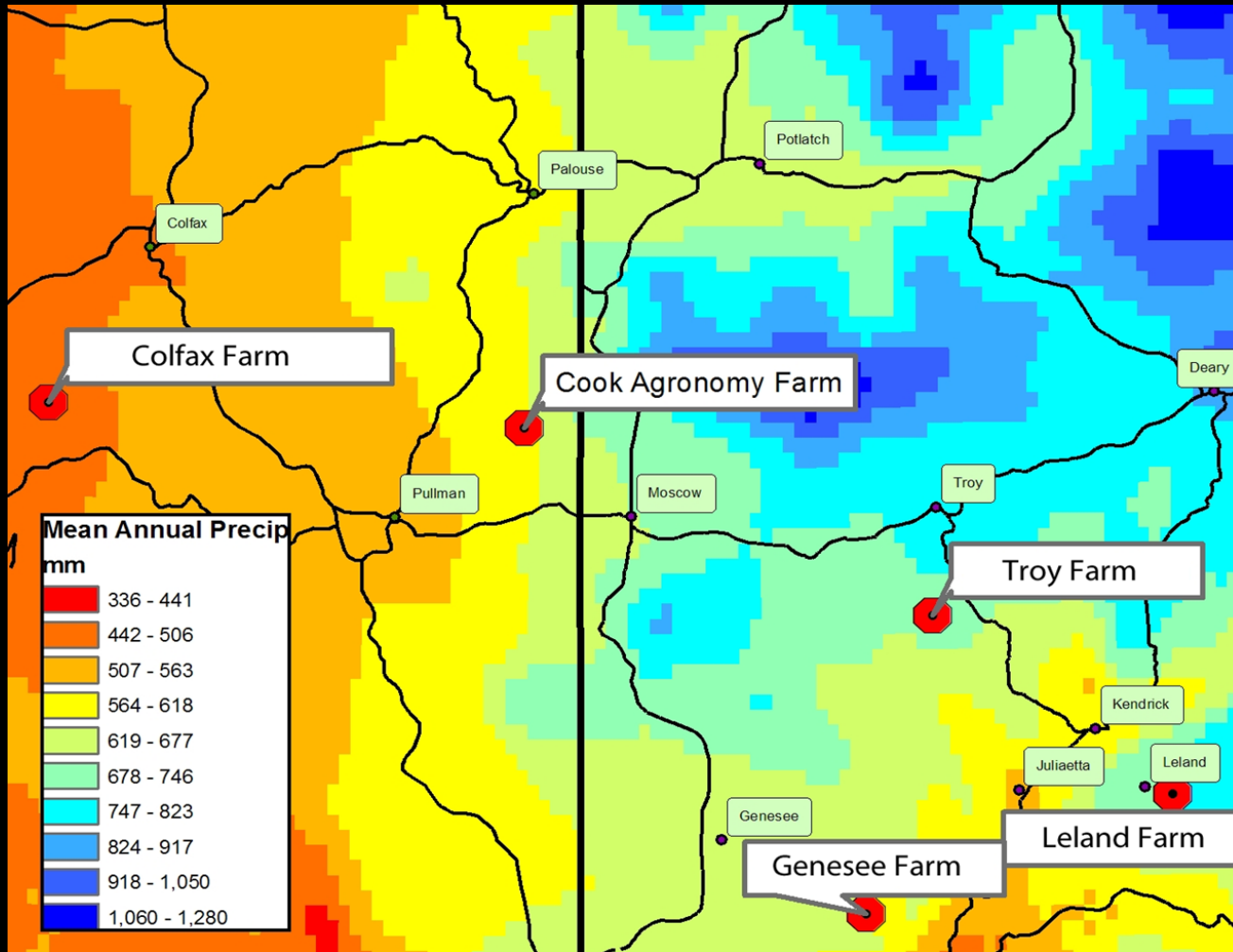
Methods

Automated measurements	Manual measurements

Soil moisture/temp/ec

Weather station

Satellite

Leaf Area Index (LAI, m^2/m^2)
Leaf Nitrogen Concentration (%)
SPAD (Relative Leaf Chlorophyll)
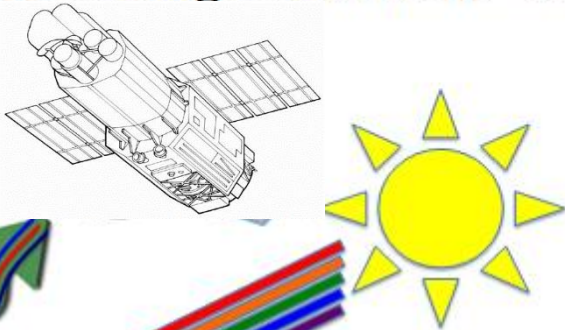Soil Inorganic N
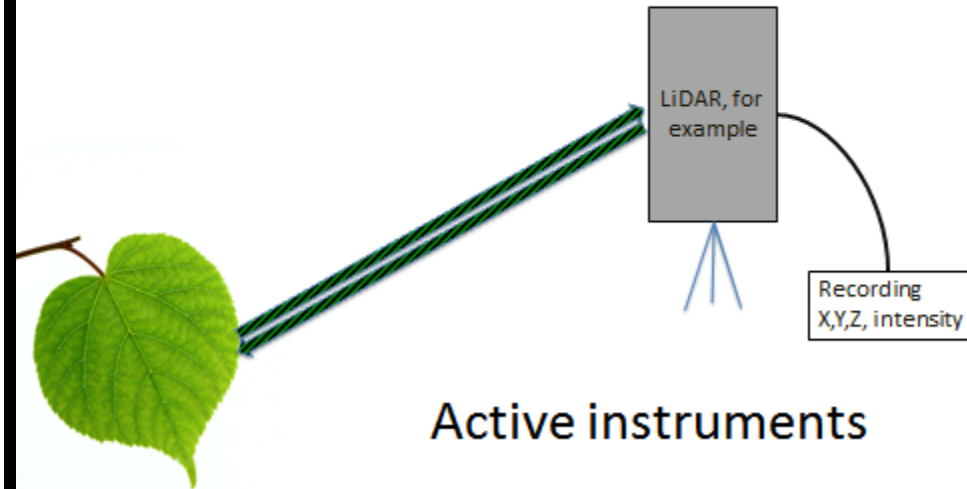Soil Carbon
Bulk Density etc.

Methods: Remote Sensing theory

Passive   vs.   Active Sensors

Methods: Remote Sensing theory
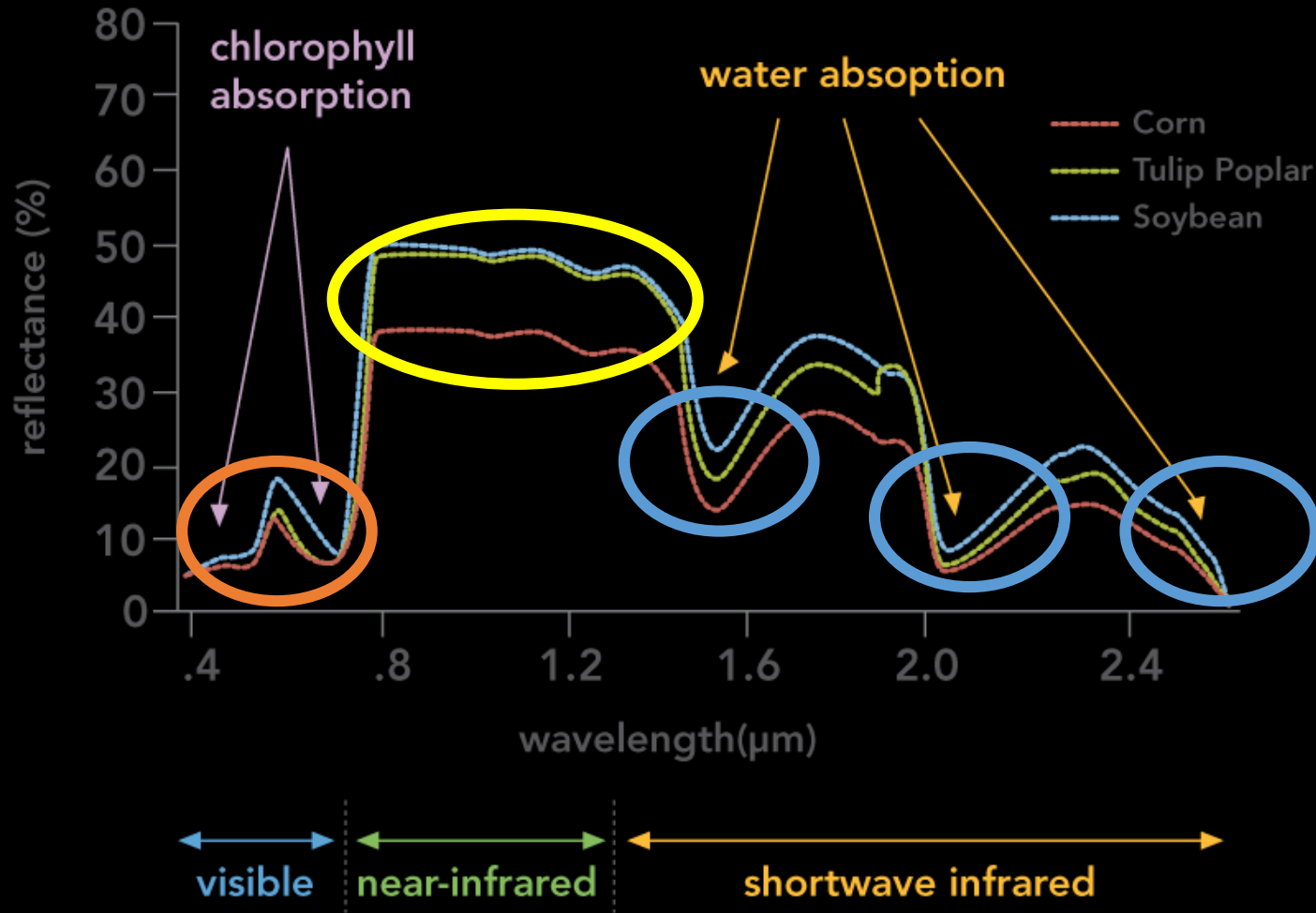
Plant pigments/nutrient concentration, water content, and leaf area all impact how light is being reflected

The Satellite: RapidEye
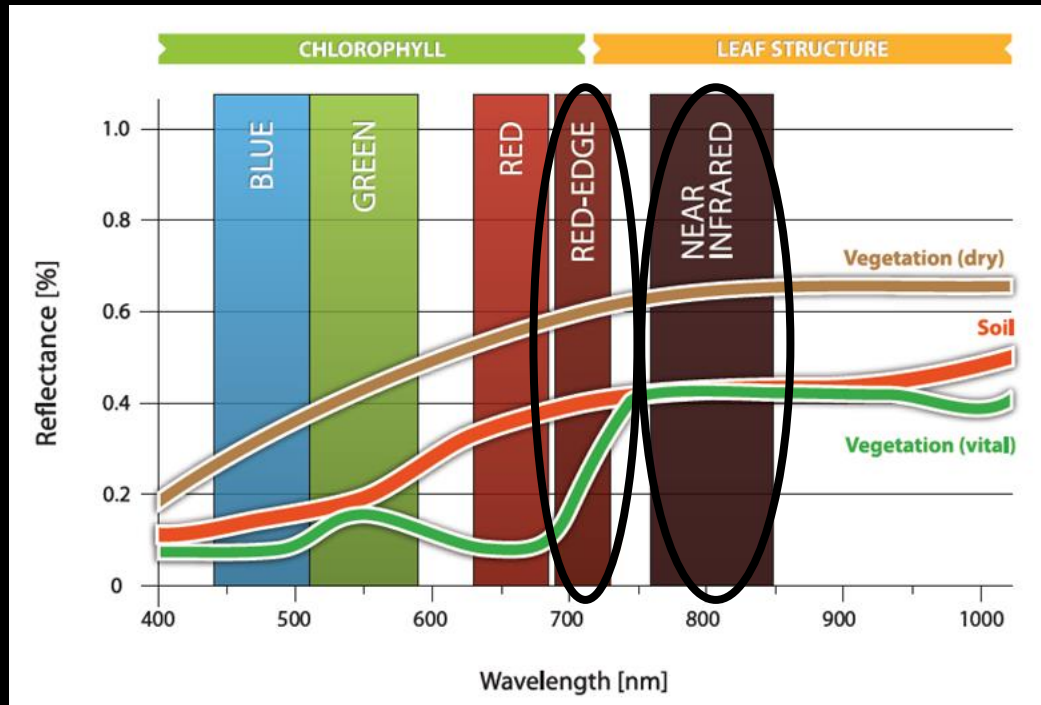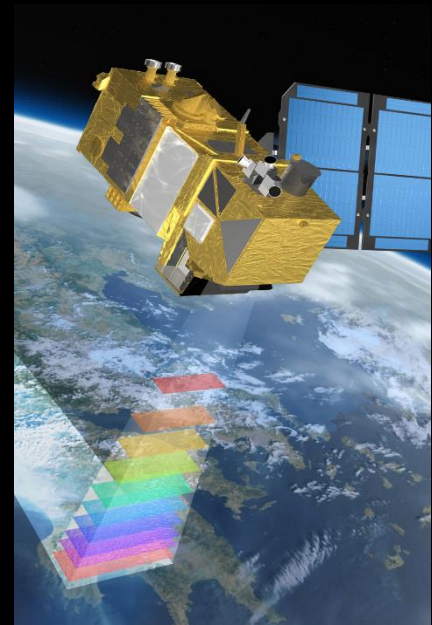
BlackBridge AG

- **5 x 5 m pixel resolution**
- **~5-10 day revisit time**
- **Extensive ground validation (Eitel et al., 2008)**

Normalized Difference Red Edge Index (NDRE)= $\frac{\rho NIR - \rho Red\text{-}Edge}{\rho NIR + \rho Red\text{-}Edge}$

Methods: Variable Rate N Application

Cook Farm 2013 & 2014

Colfax Farm 2013

Control (0)
40 kg/ha
80 kg/ha
120 kg/ha

● SRS sensors

★ NIR ATLS + time lapse camera

★ Red ATLS

X = fortnightly dry mass and %N
 1.5 x 1.5 m area at perimeter of large plot
*All plots get weekly LAI, SPAD, and height data
*All plots get flown by UAV (Rob Blair) 3 times seasonally

Field A   Field B   Field C

40m   40m

● 5TE (Drain Gauge)
● 5TE (Drain Gauge) Spring
● 5TM

0   50   100   200 Meters

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Creating Maps of aboveground N

It's tough.

In-season harvest for satellite validation

WINGSCAPES 10 SECONDS TL CAM APR.16,13 03:26 PM
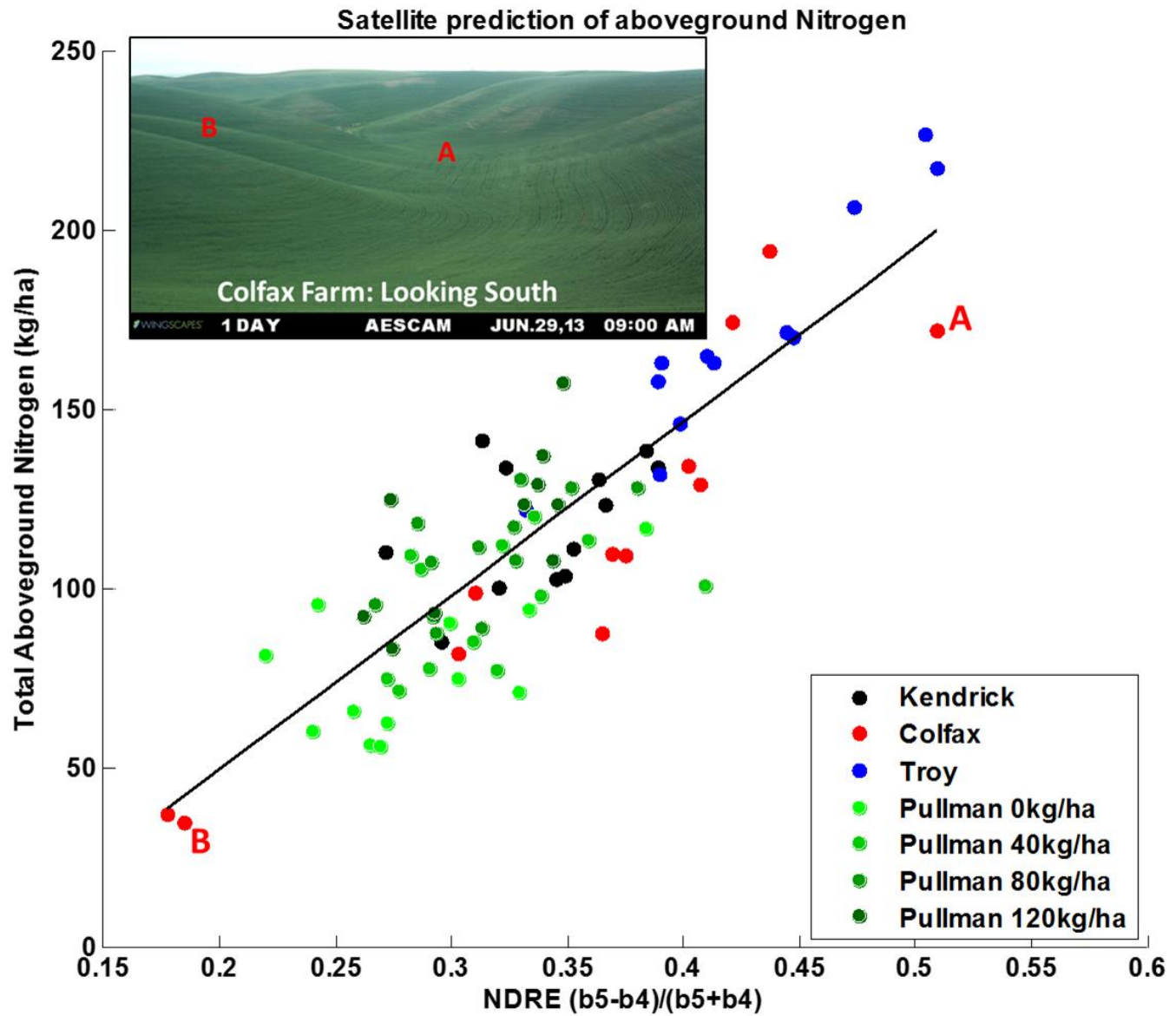
Results | REACCH Seminar| Moscow, ID| December 11, 2014

Satellite Validation

Satellite prediction of aboveground Nitrogen

Colfax Farm: Looking South

Results | REACCH Seminar | Moscow, ID | December 11, 2014
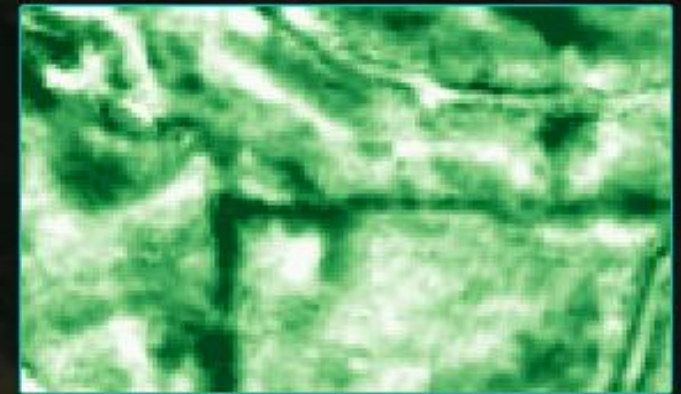
Creating Maps of aboveground N

Leland Farm. June 15. 2013
Spring Wheat

RGB Satellite Image

Aboveground N (kg/ha)

180

160

120

80

40

0

@ Peak Biomass

Aboveground N ~ NDRE*slope + intercept

Evaluating field-scale performance

N balance index = $\dfrac{\text{NDRE computed aboveground N}}{\text{N applied}}$

Potential explanations:
- Improved internal drainage
- Warmer soil temperatures
- Early nutrient mineralization
- Spurs growth rate and development
- More extensive root system
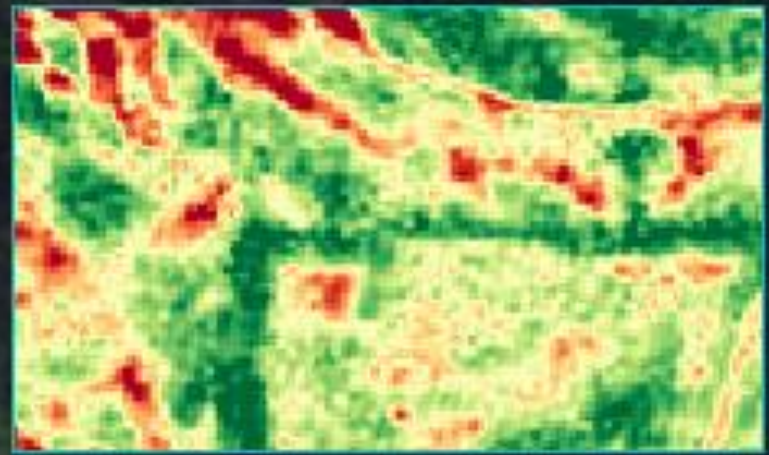- Greater water and N-use efficiency
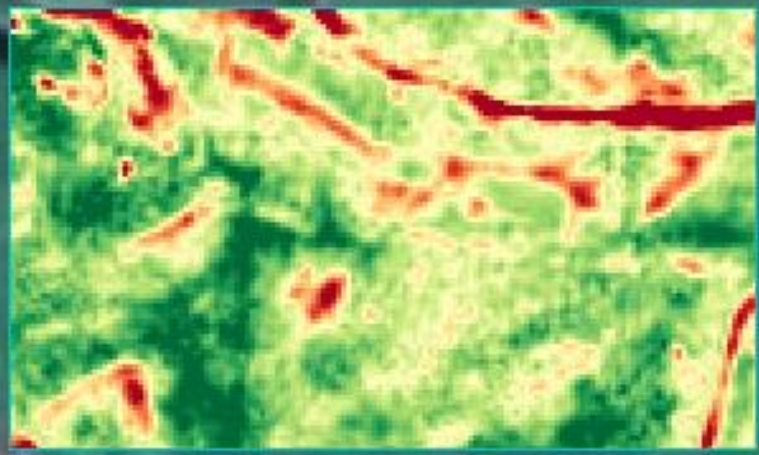
Fence line, farmed < 10 years

N Balance patterns over time:
Leland Farm
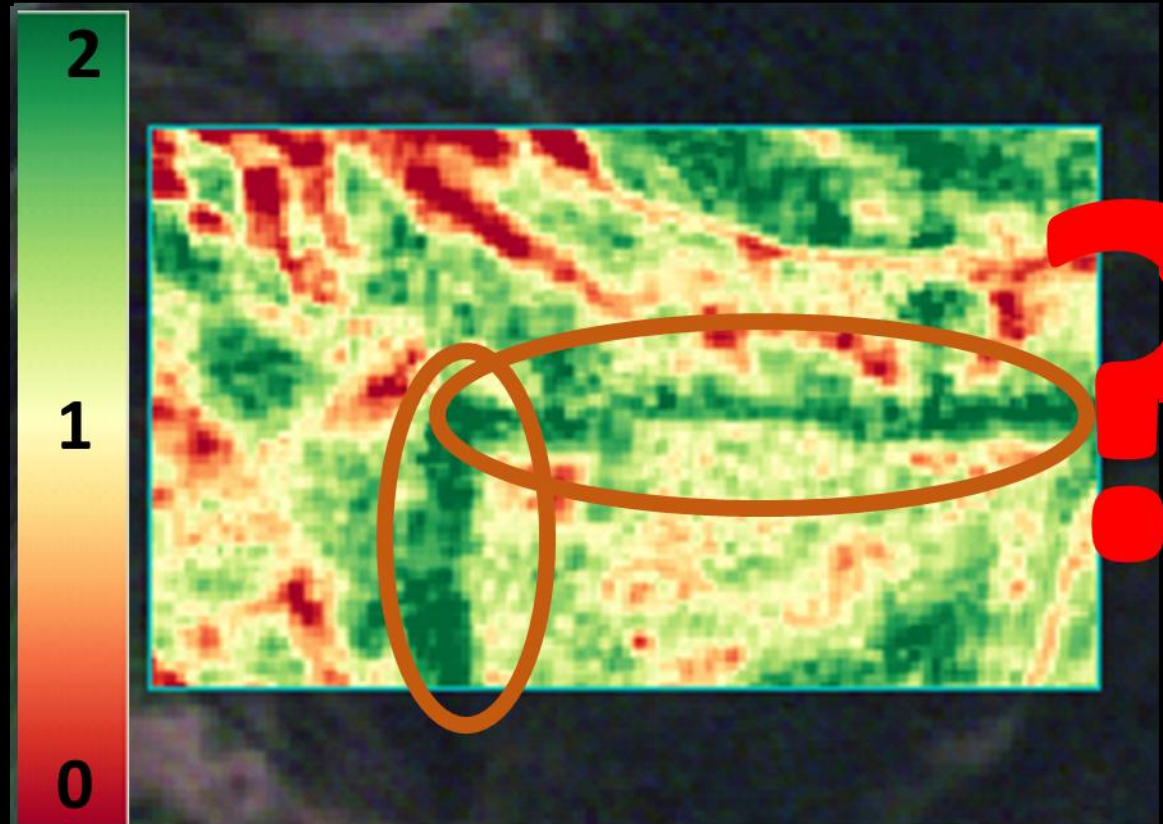
July 15, 2013. Spring Wheat

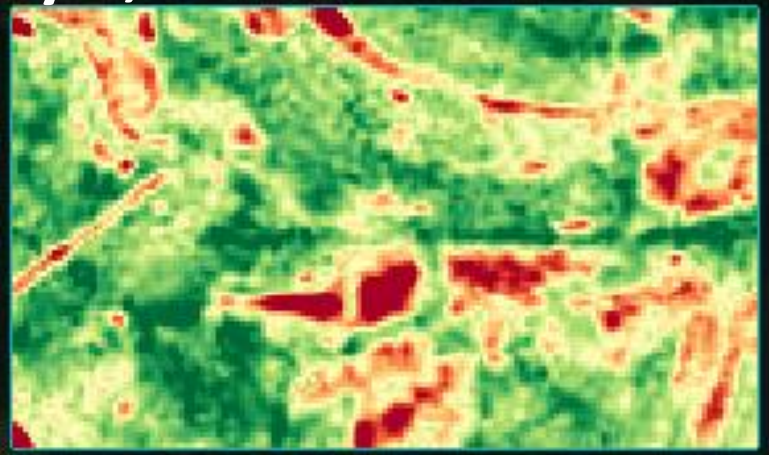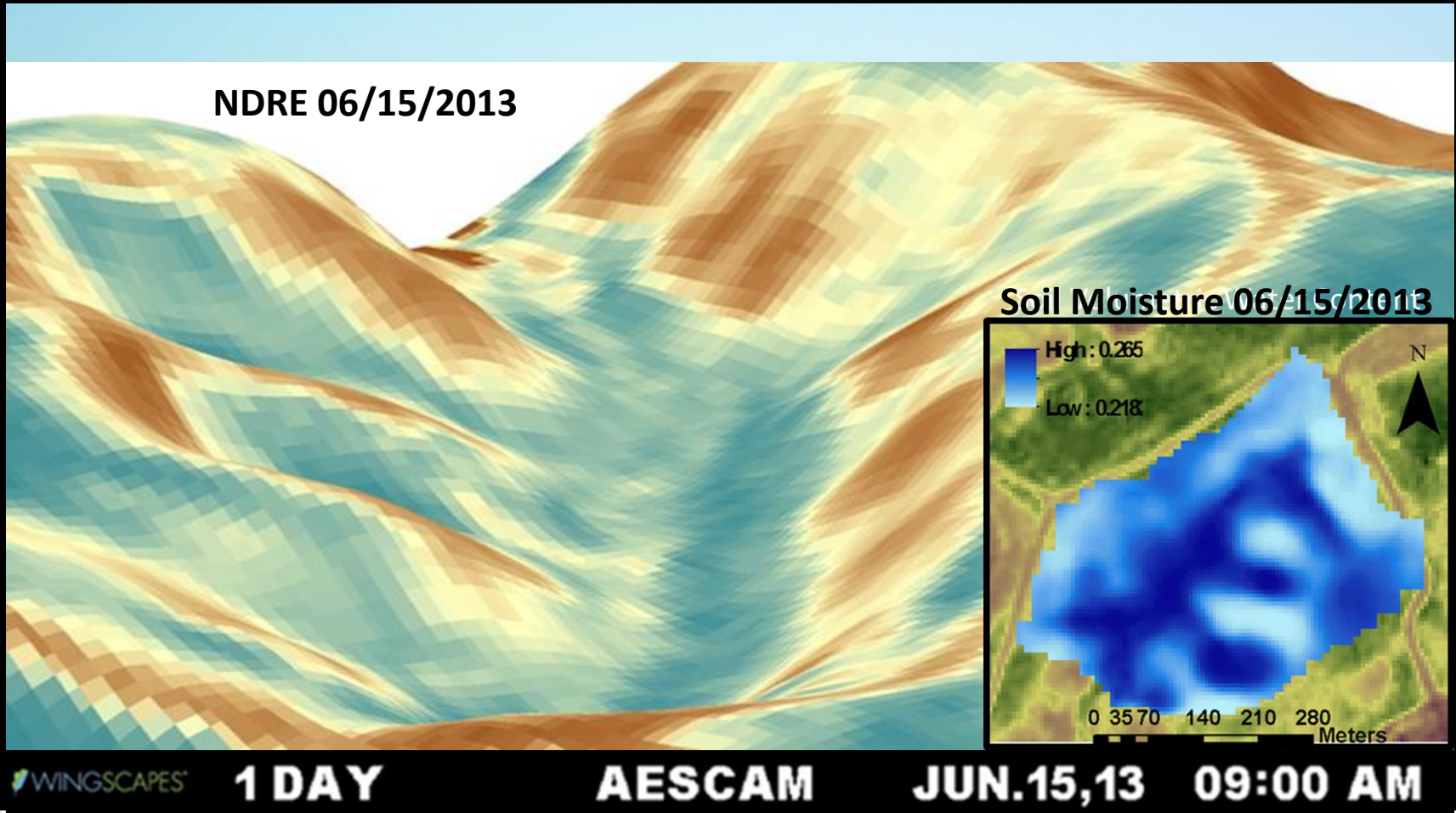**August 8, 2012. Garbs.**

July 6, 2014. Winter Wheat

2

1

0

What we can do with this?

A Prospect for Integration using the Soil Moisture Routing Model
At the Colfax farm.
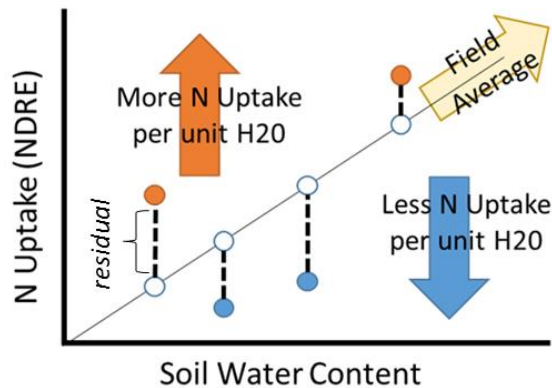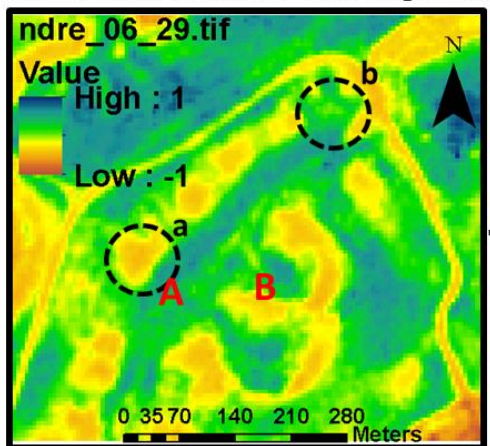

NDRE 06/15/2013

Soil Moisture 06/15/2013

High : 0.265

Low : 0.218

0 35 70   140   210   280
Meters

WINGSCAPES   1 DAY   AESCAM   JUN.15,13   09:00 AM

Results | REACCH Seminar| Moscow, ID| December 11, 2014

This leads to many more questions...

Soil Volumetric Water Content (m³/m³)

High: 0.265
Low: 0.218

0 35 70   140   210   280
Meters

Normalized Difference Red-Edge Index

ndre_06_29.tif
Value
High : 1
Low : -1

A   B

0 35 70   140   210   280
Meters

N Uptake (NDRE)

More N Uptake per unit H20

Less N Uptake per unit H20

Field Average

residual

Soil Water Content
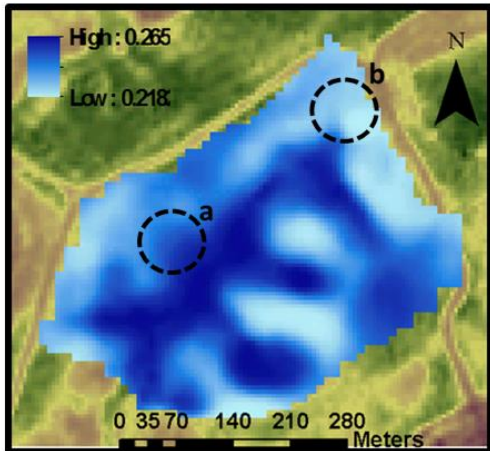
Map of Residuals

High N uptake
Average N uptake
Limited N uptake
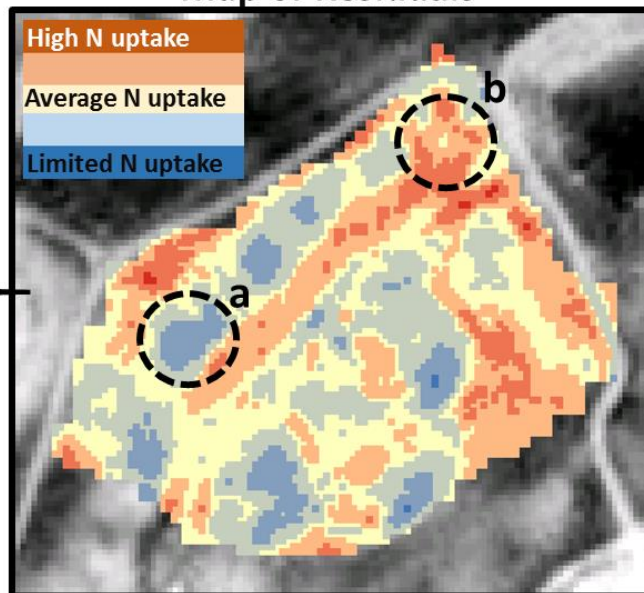
a) What is driving the low N uptake rates in this relative high water zone?
b) What is driving the high N uptake rates in this relative low water zone?

Towards an integrated understanding of field scale patterns over space and time:

1) **Digital Soil Mapping**

2) **Digital Terrain Modelling**

3) **Soil Moisture Routing**

4) **Crop System Modelling**

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Future Directions

Map of Residuals

High N uptake

Average N uptake

Limited N uptake

b

a

1 DAY   AESCAM   JUN.15,13   09:00 AM

Hypothetical management zones
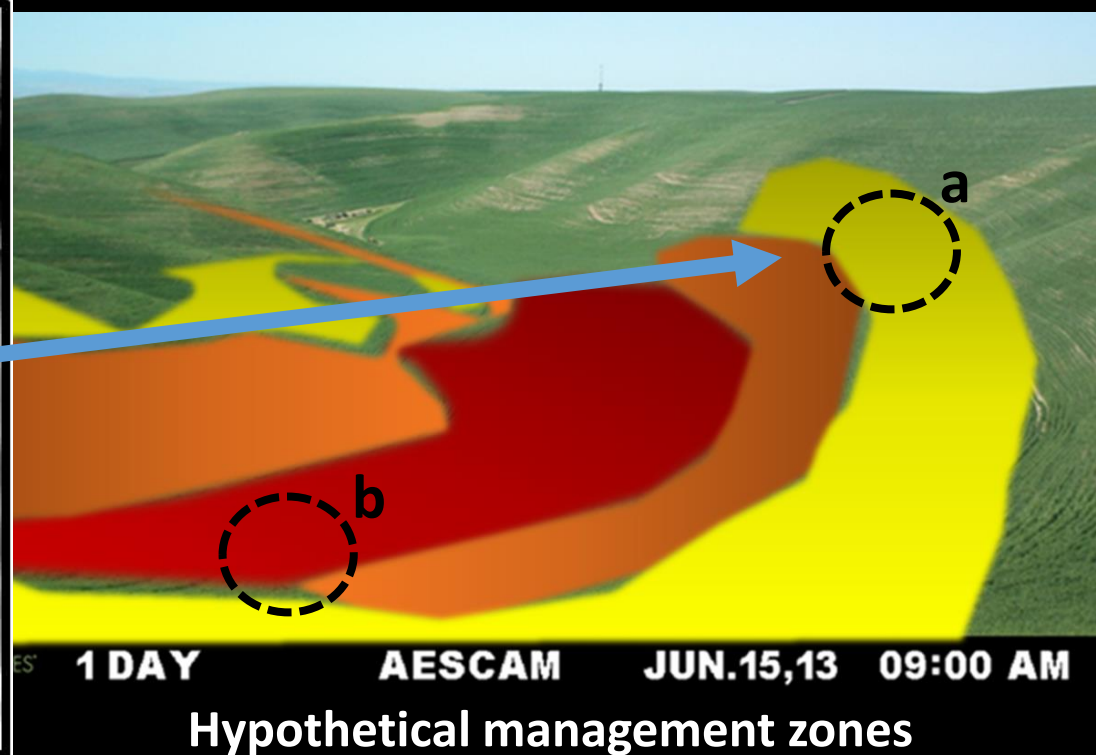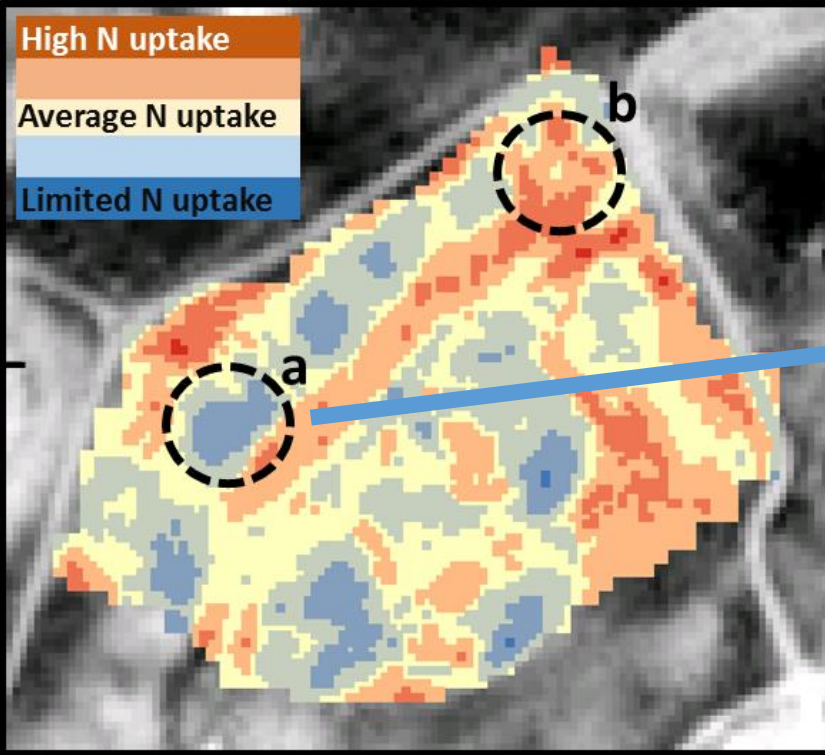
RS in agriculture: Potential and limitations

According to a recent REACCH poll of PNW growers:

- 43% of respondents reported that they don't use available precision agriculture technologies because the <u>equipment is too expensive</u>
- 30% said the <u>software is too expensive</u> or requires <u>too much technical support</u> or training
- 27% responded that it is <u>too time consuming</u> to learn

RS in agriculture: Potential and limitations

- Make sure these technologies are giving us the information we think they are
- Simple tech transfer to growers
- Field scale evaluation
- Provide growers with field scale data, and allow their innovation to aid in their own management
- RS: Far from being a one-off solution
- Bottom up not top down
- <u>Others?</u>

RS in agriculture: Potential and limitations
We need to be more upfront about our limitations.

Because our fields look more like this...

Than this.

Conclusions| REACCH Seminar| Moscow, ID| December 11, 2014

Conclusions:

- Satellite Imagery can be used to estimate spatially and temporally explicit crop N uptake.
- An interdisciplinary approach could lead to a more process-based understanding of the drivers of N uptake from space.
- We need to be aware of our limitations.
    - What about all of the things we can't model?
- There is a lot of work to be done.
- Thanks for listening!