Satellites for Agri-Food

Challenges in agriculture (Crops, livestock and aquaculture)

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Leading the way in Agriculture and Rural Research, Education and Consulting
Just some thoughts and ideas...

• Not based on an exhaustive review
• Nor complete..
• Just to get you thinking!!
The problem...??

Figure 2.3  World population: 1950-2010 and projections (three variants)

Source :FAO WORLD AGRICULTURE TOWARDS 2030/2050
The 2012 Revision
The problem..??

Source: FAO WORLD AGRICULTURE TOWARDS 2030/2050
The 2012 Revision
• Improvements in the yield and sustainability of crop and livestock food products.

How can monitoring both crops and livestock contribute?

REAL VARIATION IN PRODUCTION IS THE KEY

- Sensing systems to accurately monitor aspects of the production system
- Acquisition of data
- Conversion of this data into information
- Effective crop and livestock production management (production efficiency, health, sustainability etc)
- Supply chain and compliance/traceability/provenance
Sources of growth in crop production (2005/07 to 2050)

Source: Bruinsma (FAO 2006)
Crops - yield limiters..

- Nutrient deficiencies and imbalances (nitrogen, phosphorus, potassium, zinc, and other essential nutrients)
- Water stress, Flooding
- Suboptimal planting (timing or density)
- Soil problems (salinity, alkalinity, acidity, iron, aluminum, boron toxicities, compaction, and others)
- Weed pressures
- Insect damage
- Diseases (head, stem, foliar, root)
- Lodging (from wind, rain, snow, or hail)
- Inferior seed quality

Source: Lobell et al. 2009
Diseases/pests/weeds with spatial variability.

Yellow rust – 2% UK yield loss (*Puccinia striiformis*)

PCN (*Globodera rostochiensis* and *Globodera pallida*) damage – most important potato pest in UK.

Blackgrass (*Alopecurus myosuroides*) – up to 0.5% UK yield loss

*Ursula multispectral image*
Nutrient disorder with spatial variability..

- E.g. Nitrogen
- Related to chlorophyll content
- Crop “height”? 

Cilia et al 2014
• Are individual plant counts possible?
• Can growth of individuals be monitored?
Satellite applications – Current Arable Market

- 5m UK arable hectares
- 2 distinct commercial services across c. 5-600k ha
- 3 Satellite constellations in use
- All services focused on optical imagery, at resolutions ranging from $22m^2$ to $5m^2$
- Key uses of the service include:
  - Variable Nitrogen
  - Agronomic Monitoring (via smartphone)
Satellite application example – AgSpace

- Wholesale service through multiple resellers
  - Includes 2 of the 3 largest UK agronomy companies
  - Operating in 7 African countries
  - Collaborative project underway with key partners in China
- Currently utilising 2 constellations, infrastructure in place to use Sentinel 2 data when it is available
- Crowd-sourced observations added to satellite imagery (via Mobile App)
- 18 months into research projects on SARS for crop monitoring
  - Opportunities for data fusion with optical imagery
Agspace view - Future Opportunities

- Falling Costs
  - Sentinel 1 & 2 – good resolution levels for Agriculture Market
  - Micro/Nano Satellites
- Rapid Revisit
  - ‘Flocks’ of Micro Satellites mean more frequent revisits than previous constellations allowed
  - Cloud Piercing imagery with SARS
- International Markets
  - Technology is applicable everywhere
  - Modernisation of farming in emerging markets
Also – Can satellite data be combined?

- Combined with other remote sense data (e.g. UAV’s)
- Combined with site-specific gathered data?
- Imagery “on-demand??
- Daily then!!
Livestock...

- Field monitoring of herd behaviours
- Livestock counting?
- Traceability of livestock
- Individual monitoring?
- Grazed area biomass?
Global Meat Livestock production

Animals slaughtered worldwide:

Official and estimated data, 2011, heads

- Chickens: 1,383,000,000
- Cattle: 296,000,000
- Goats: 430,000,000
- Sheep: 654,000,000
- Pigs: 5,811,000,000
- Ducks: 24,000,000
- Turkeys: 517,000,000
- Guinea fowl: 2,817,000,000

Slaughter by countries, four most important, 2011, heads:

- China: 8,954,959,000
- USA: 6,174,000
- Brazil: 5,973,680
- India: 5,370,102,000

- USA: 110,956,304
- Germany: 59,920,000
- Vietnam: 661,702,976
- China: 44,270,000
- India: 38,600,000
- Bangladesh: 28,980,000

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Livestock example – herd behaviours...

• Identification of individuals in a pattern?
• Related to health? Isolation behaviour..
• Identify parturition?
• Sub-herd identification (social heirarchies)
• Grazing behaviour
• More optimised pasture use?
Livestock example – “black loss”...

• A two-year study, led by the Highlands & Islands Sheep Health Association, found that black loss on the four participating hill farms averages 18.5%.
• Therefore a many ££M’s UK problem
• The lambs just “disappear”!
• Various potential causes, predation, illness etc.
• Could numbers be monitored remotely??
Livestock...

Kenyan Insurer Uses Satellite Data for Livestock Insurance

by Matt Ball on January 24, 2010

Insurance hasn’t been an option for herders in Northern Kenya, because the insurance companies didn’t want to go to the expense to justify claims by traveling great distances to count dead animals in the cases of drought related deaths. Satellite imagery is now being deployed to assess pasture health and to pay out claims if the imagery confirms severe drought conditions.

This is an inspiring application of remote sensing technology to aid in economic development, and to deliver a practical solution that makes sound business sense.
Disease spread & contact networks: Disease is slower in the TRUE network
Duncan et al. 2012, 2014
LymeApp: commercial fusion of science (vector-borne disease) and satellite data

- ESA funded
- Using NHS data on Lyme
- Satellite data on climate, weather, vegetation, user location
- To provide an information system delivered by web and phone to assist users of outdoors
Grass biomass – China example.

- MODIS data and model created (Zhao et al 2014)
- Ground truthed observations and measures

**Figure 1.** Grassland types and the distribution of sampling sites in the study area. The total number of sampling sites was 1205.

**Figure 3.** Relationship between the estimated aboveground biomass and actual aboveground biomass.
Virtual Fencing – could be mapped to biomass?

Day 0

Day 1
Aquaculture applications

- Algal blooms – impacts including oxygen depletion, taints, gill damage, etc.
- Jellyfish blooms – causing gill damage.
- Chlorophyll production – indication of ecosystem productivity for shellfish farming, etc.
- Thermal and current imaging – aiding in farm site selection.
- Communications, remote sensing and data networks in remote environments.
- Exploring aquaculture interactions with the environment – animal tracking, etc.

Simpson & Sharples, 2012
Aquaculture industry suggestions...

- Establish industry needs, and highlight current satellite based technology capabilities.
- Development of systems to aid in new aquaculture site selection.
- Implementation of real time environmental monitoring tools to aid in proactive management (early warning systems, etc).
- Integration of satellite imaging tools into future regulatory and planning systems.
- Aspirational strategies for satellite based technology to deliver step changes to existing infrastructure.

Source: Copernicus.eu – Pancreas disease virus spread model
Satellites and GHGs...

- Monitoring of agricultural GHG's, CO₂, CH₄ and N₂O?
- CH₄ is nearly 25 times as potent as CO₂
- N₂O is nearly 300 times
- Including fluxes?

Source: Copernicus.eu
Ground truthing!!!!!

Essential to validate any approach
Possible partner? - Agri-EPI Centre

UK Centres of Agricultural Innovation

possible Agricultural Engineering & Precision Innovation Centre

Open for business as a partner Dec 2015
Monitoring key sectors throughout the entire production and processing chain.

Precision monitored to identify performance and variance.

Unified technology for full data utility - all linked to AgriMetrics Centre.

A unique resource of exemplar farms for development, evaluation and demonstration of technology.
THANK YOU

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