Unmanned Aerial Systems in Agriculture

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Seminar "Recent Developments of UAV Applications & Technology for Different Sectors & Problems and the Way Ahead"

Wednesday 20th of March 2013, kl. 9.00 – 16.00

Content

- UAS
- Agricultural applicability
- Precision farming
- Remote sensing in agriculture
- UAS benefits
- UAS applications in agriculture
- Some quantitative results
- UAV agri in Finland
- UAV as a working implement
- UAV regulations and agri
- UAS problems
- Future concepts
- Conclusions

Unmanned Aerial System (UAS)

- Unmanned aerial vehicles (UAV)
- Remotely piloted vehicles (RPV)
- Remotely operated aircraft (ROA)
- Remotely controlled helicopters (RC-Helicopter)
- Low altitude remote sensing (LARS)

- Ground station

Fig. 1 Examples of UAS currently used in environmental studies include **a** powered glider (Lelong et al. 2008), **b** powered parachute (Lelong et al. 2008), **c** helicopter (Eisenbeiss 2004), **d** fixed wing aircraft (Laliberte and Rango 2011), **e** Draganflyer X8 quadrocopter, and **f** Aeryon Scout quadrocopter

MTT

Agricultural applicability

- A remote sensing tool for precision farming
  - Identify variations in the field (crops, diseases etc.)
  - Support variable rate application (VRA) technologies
  - Support farm strategic planning
  - Gives continuous (relative) information

- Working implement
  - Pestiside supply
  - Nutrient supply?

- Combination of these two
  - Future concepts

Why precision farming?

- New tools for nitrogen management:
  - According to FAO, in the next 20 years, world food production must increase by 50%
  - Only about 50% of the N fertilizer added to cropping systems is taken up by the crop
  - The other 50% remains in soils or leaves cropping systems through air, surface water, or groundwater pathways
- Similar with other nutrients
- There is an increasing trend in the incidence of plant diseases. New tools are needed
- Pesticides are hazardous/unhealthy
- Farm economics/effectivity

- The basic underlying premise of remote sensing applications in precision farming is that differences in crop growth and soil condition can be detected through variations within the spectral responses

- Remote sensing and agriculture:
  - 1930’s, precise measurements of cropland, USA
  - 1956 determine the prevalence of certain cereal crop diseases, USA
  - …

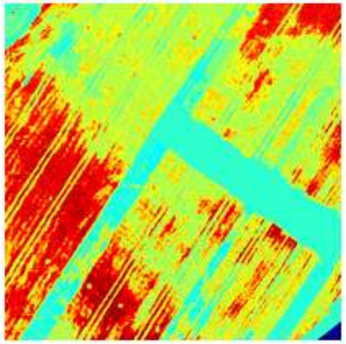
-soil properties monitoring and mapping
-crop species classification
-crop pest management
-plant water stress detection
-leaf chemical content analysis
-weed control monitoring
-yield mapping
-plant nitrogen content
-crop height
-weed extent
-leaf chrolophyll content
-timely changes

Current/other remote sensing tools

The adoption of satellite imagery and aerial photos in PA has changed from 16.1 to 30.3 % between 2004 and 2009 in USA.

Typically used for crop growth, crop stress, and to predict crop yield

- Aerial imaging
  - Clouds, high costs
  - Operational complexity
  - Lenghty delivery of products?

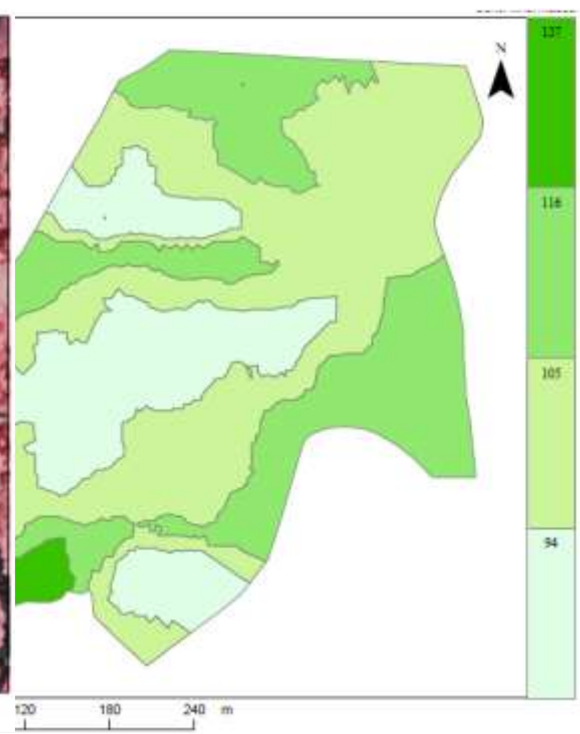


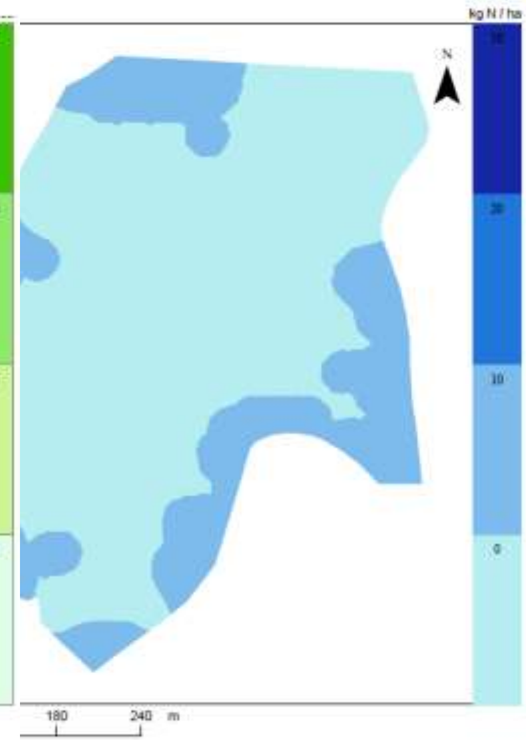
- Satellite images
  - Clouds
  - Low resolution
  - poor revisiting times

Cameras on tractor

Has gained some market acceptance
High invest
Low resolution
Limited adaptability

Aerial images





Kemira Loris in Finland
~1999-2004
-3,5€-7,5€/ha
-Max 250 users in Finland

Similar attempts e.g. in Netherlands

Satellite images

- Medium resolution satellite imagery
  - e.g. LandsatTM, ASTER, SPOT5
  - Only for large scale studies

- Higher resolution satellite imagery
  - e.g. WorldView-2 and GeoEye-1
  - Frequency, clouds

GeoEye-2 Attributes & Capabilities

Imagery		
	Panchromatic	*Multispectral*
Spatial Resolution	.34 meter	1.36 meters
Positional Accuracy	5 meter CE90 (specification) 3-4 meter CE90 (expected)	
Collection Capacity	600,000 sq km/day (Pan + MSI)	

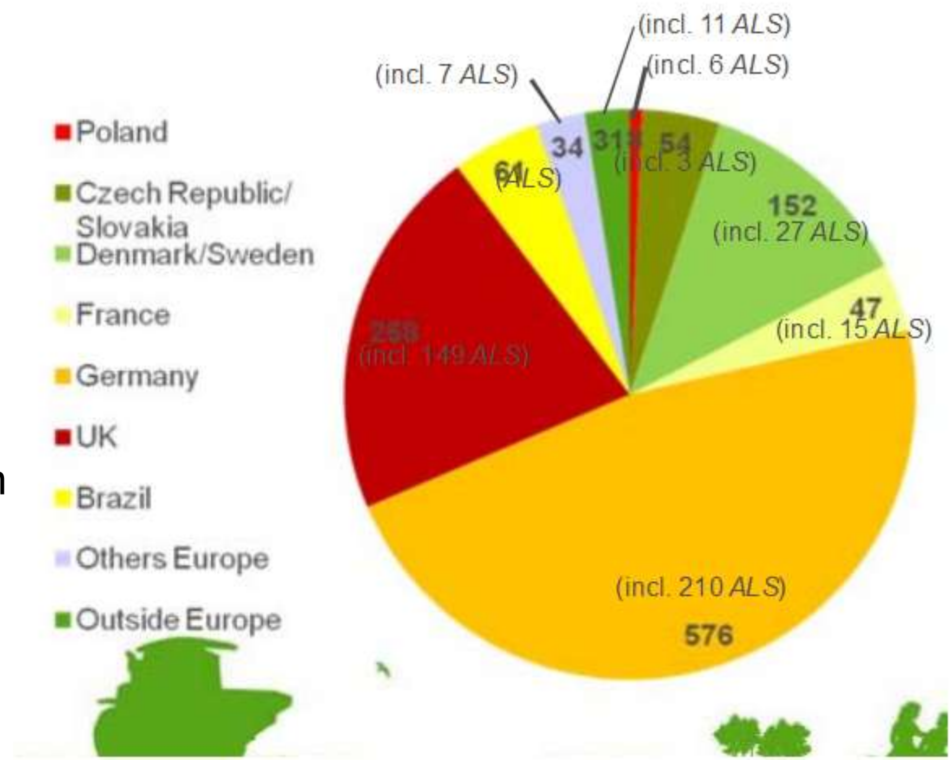
Satellite	
Swath Width	14.5 km
Off-Nadir Imaging	Up to 60 degrees
Dynamic Range	11 bits per pixel
Mission Life	Expected > 10 years
Revisit Time	Approximately 3 days
Orbital Altitude	681 km
Nodal Crossing	10:30 am

On a tractor

- GreenSeeker
- Yara N-sensor
  - For nitrogen fertilization
  - ~15 000 €

Yara-N-Sensor

- The yield increases **3.1% higher yield** (186 field trials)
- **Lodging** problems are reduced
- gives easier and safer **harvesting** and better grain **quality**
- Fertilizer costs can be lower
- **4.4 kg N/ha in higher nitrogen uptake** in the crop(82 field trials)
- Variable rate nitrogen fertilization reduces nutrient leaching
- **0.5 to 4 kg N/ha in reduced nitrogen leaching** depending on soil type



Source/more info:
http://www.njf.nu/filebank/files/20130201$090249$fil$QEBhVkgEHIAv7LxK7r58.pdf

- Applications of remote sensing in general have been shown to be beneficial and profitable, but current applications in precision farming are still limited.
  - unavailability of reliable economic estimates of return from the application of remotely sensed images.

- the costs, availability, flexibility, and the processing of remotely sensed imagery from satellites have made their applications prohibiting and thus non-practical?

UAS benefits

- Low cost of operation(?)
- High spatial resolution(?)
- High temporal accuracy(?)
- Flexibility in image acquisition programming(?)

UAS applications in agriculture worldwide:

- small weed patches in rangelands 2005->
- monitoring crop biomass 2005->
- water stress in crops 2009
- mapping vineyard vigour 2012->
- examining the results of various nitrogen treatments on crops 2005->
- assess irrigation systems at the field scale
- sample pollen and spore (siitepöly, itiöt) 2005->
- agricultural disease agents 2008->
- Crop elevation 2011->

Used sensors for image capture

Optical & passive

-cameras

-cameras with a near infrared band

-multi-spectral camera

-hyper-spectral camera

-thermal image sensors

Vineyard vigour

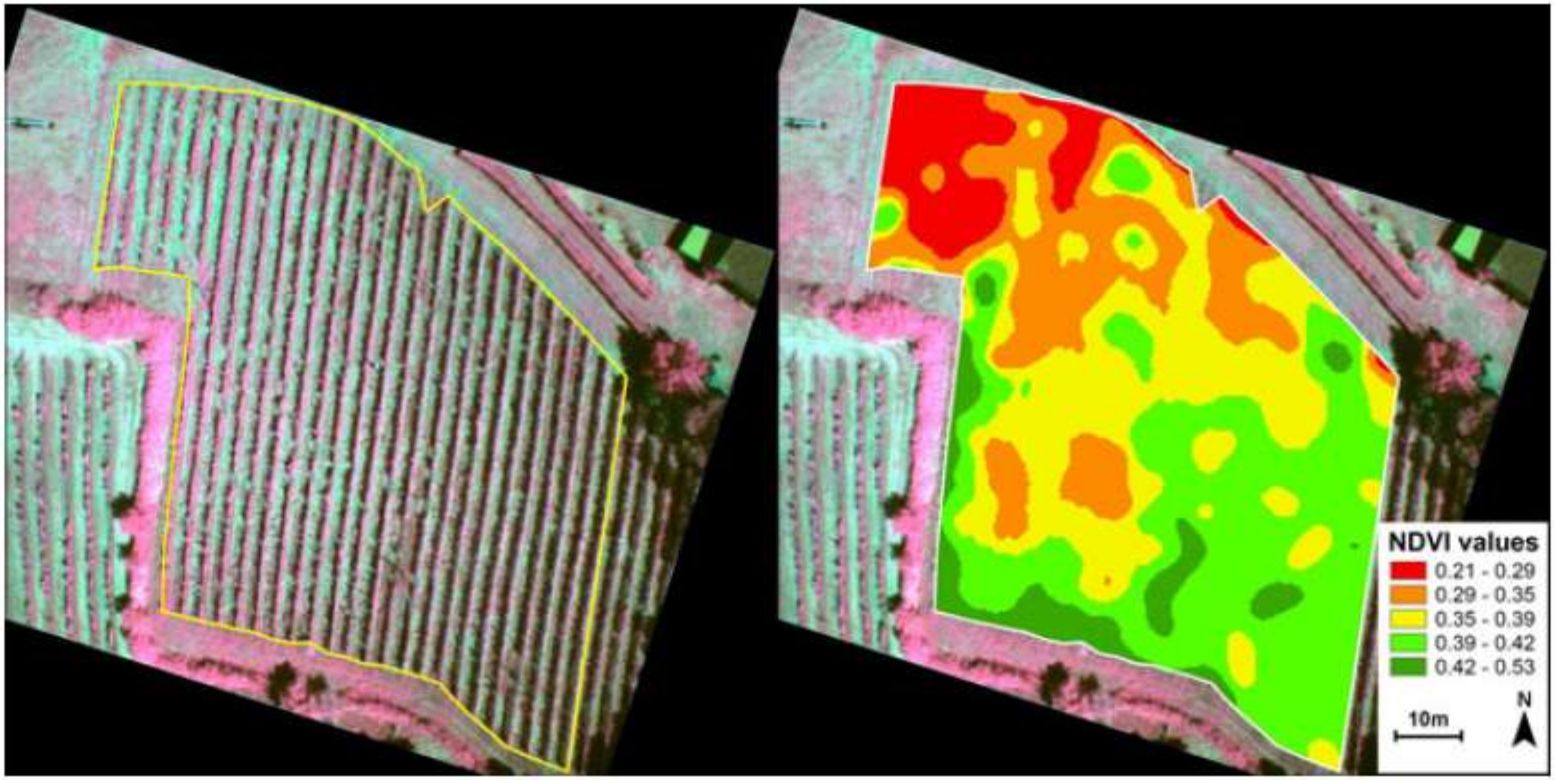
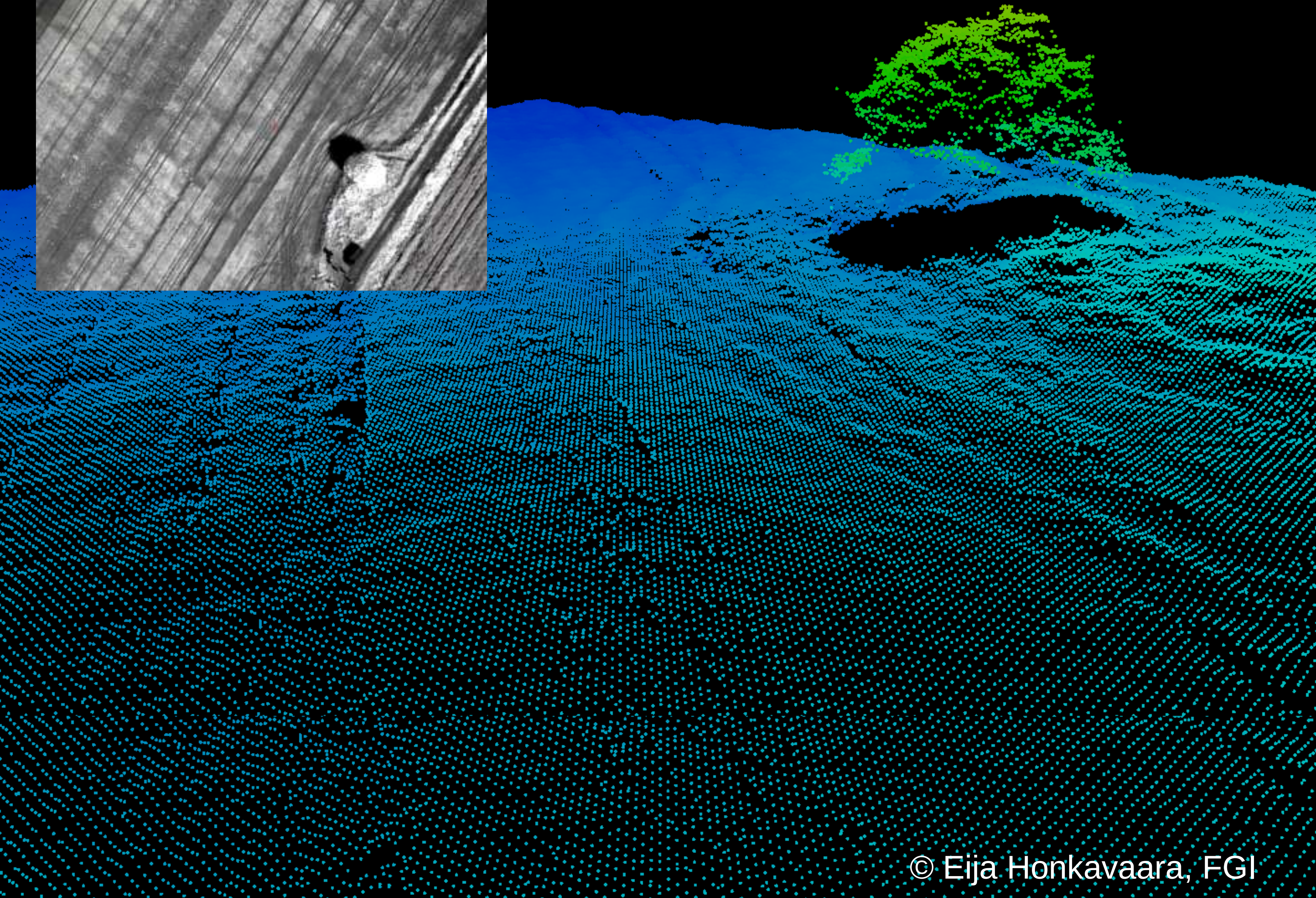


Fig. 2 Multi-spectral images of the Monteboro vineyard (*left*) false color image at 5 cm of spatial resolution and (*right*) classified NDVI based vineyard vigour map

Irrigation systems

Crop elevation



Some quantitative results

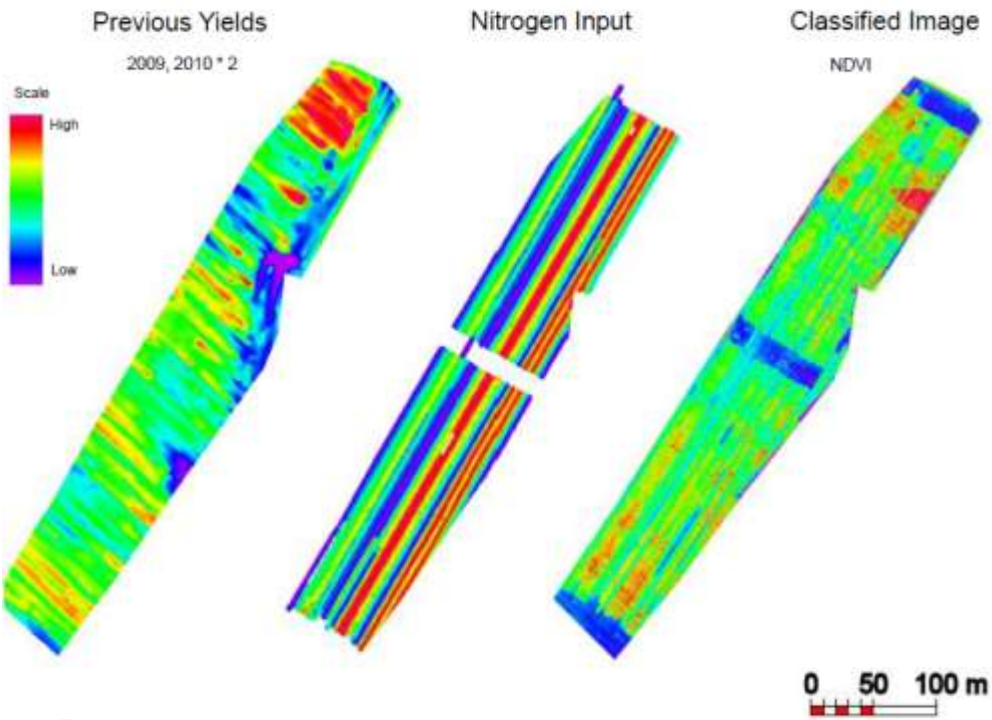
- **Acquisition of NIR-green-blue digital photographs from unmanned aircraft for crop monitoring, 2010 USA**
  - Winter wheat,
  - LAI-2000 Plant Canopy Analyzer & GNDVI, R^2 = 0,79

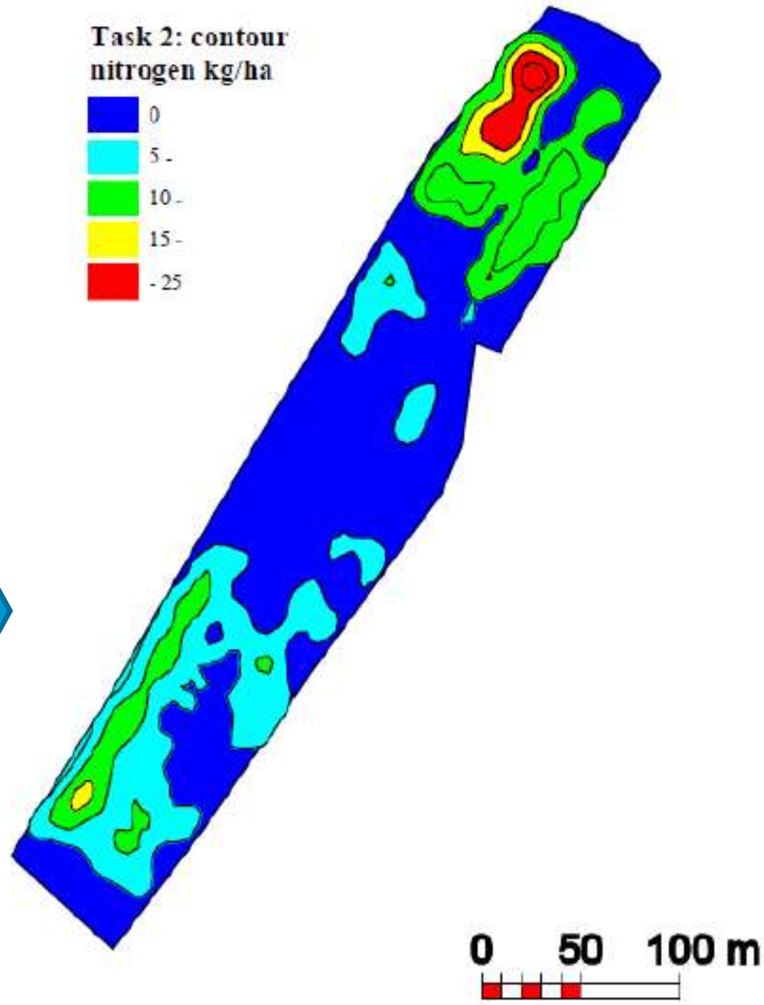
- **Remote sensing of vegetation from UAV platforms using lightweight multispectral and thermal imaging sensors, 2010 Germany**
  - Canopy temperature, water potential R^2=0,82

Typical publicized R^2 results around 0,6-0,9

UAV and agriculture in Finland

- UASI project 2011-2013
  - Nitrogen fertilization
  - Potato infestations





Some UASI platforms

UAV as a working implement

- Mainly for spraying applications, since ~2007
- AG210, AG120
  - http://www.youtube.com/watch?v=PtwshJkdeTQ
  - http://www.youtube.com/watch?v=Pa0xTDgcMV4
  - http://www.youtube.com/watch?v=rwE2lubaPOU

UAV regulations and agriculture

Spraying:

- Aerial spraying directives quite heavy
- Handheld spraying directives?

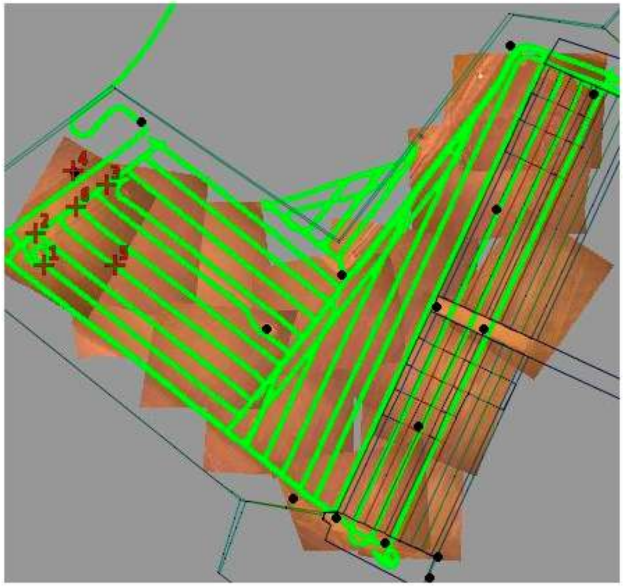
Aviation regualtions:

- The operator should always see the flying UAV
  - Remote farm and large area
- Cargo dumbing in faulty situations
  - High concentration
- Residential area limitations
- Local regulations:
  - operator lisences, insurances, UAV team

UAS problems

- Platform reliability
- Platform stability
- Sensor capability
- Short flying time
- Payload limitations
- Platform prize

- Image quality
- Prosessing time
- Flying costs
- Relevance of the final product
- Disappearing accuracy

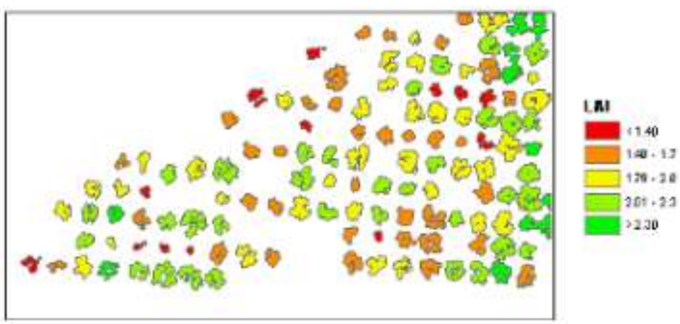


However…

- Those problems are technological and could be solved with new technology development

Current successful applications

- monitoring rangeland conditions
- monitoring vineyard conditions



Future concepts

Better platforms

New sensors onboard

- Active

Better applications

- High value crops
- From relative zonal mapping to more accurate applications
- Farm machinery improvements

Real time data analysis

- Disease spots etc. (no intact map needed)

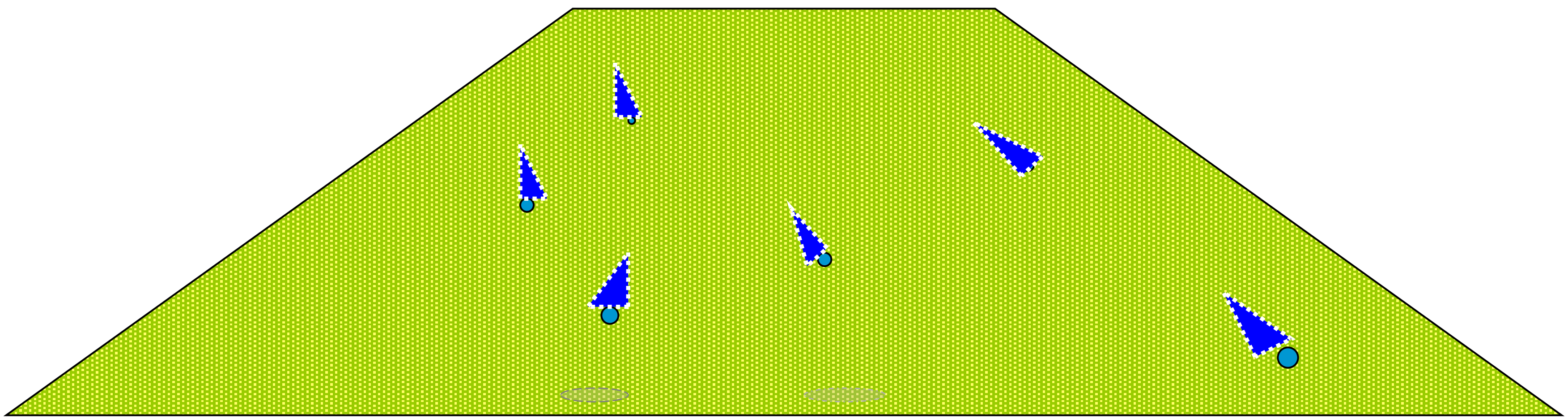
Future concepts

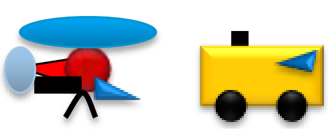
As an agricultural machine, e.g.:

- Seeks the areas that needs to be threaten
- Threaths the area
- Automatically changes battery and fills the tank
- Continues working

Animation

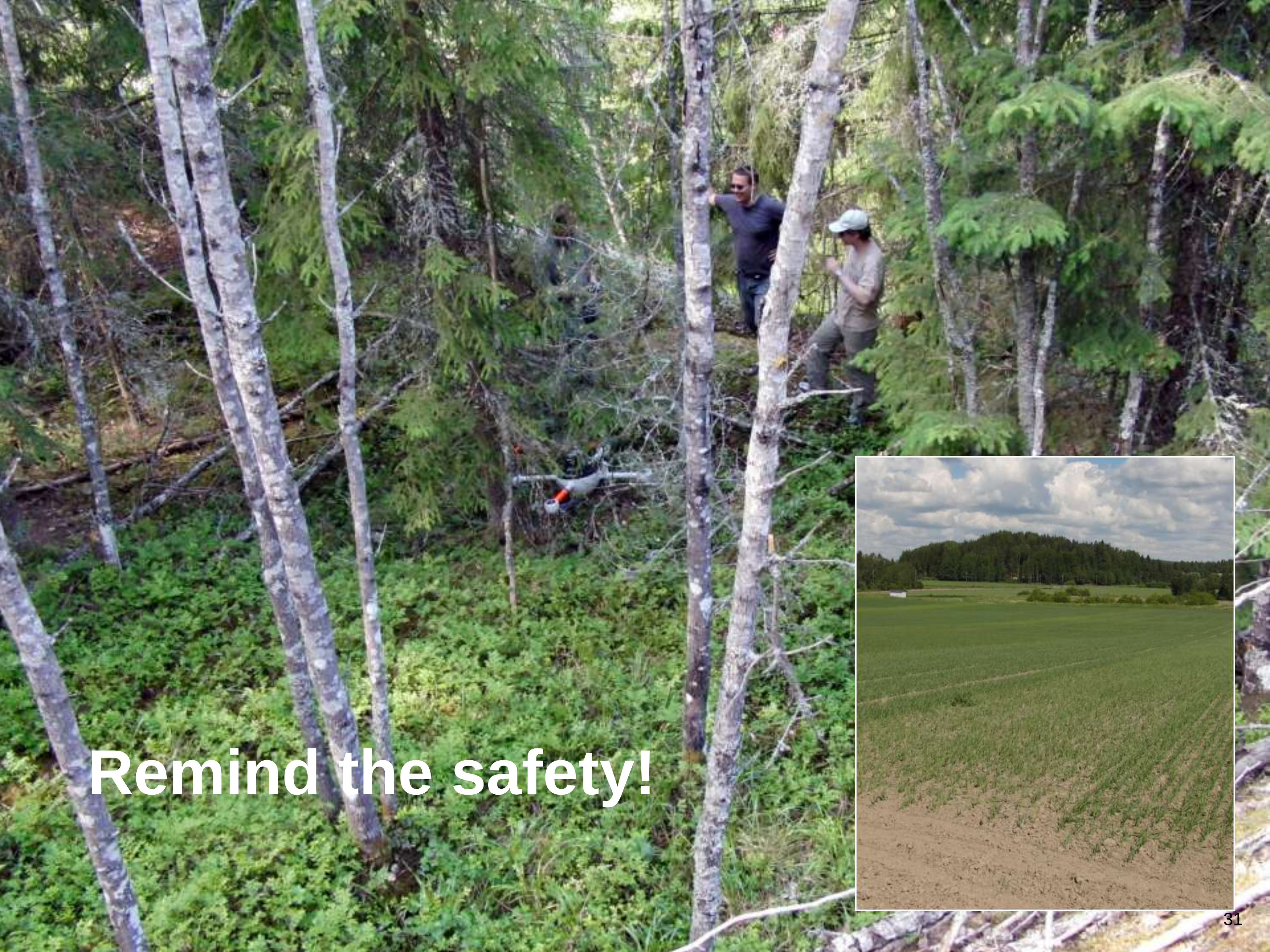
http://www.youtube.com/watch?v=4z3HNt5-ygQ





Conclusions

- Applications for localizing weeds and deceases, detecting vegetation differences and the production of an accurate elevation models are currently possible
  - Verifying benefits is difficult
- Many sensitive and separate parts, fragile chain
- Cumulative errors, important quality management
- Components for next generation models are available



Remind the safety!

Thank you!

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The application of small unmanned aerial systems for precision agriculture: a review

Chunhua Zhang · John M. Kovacs

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