Opportunities of hyperspectral vegetation indices to assess nitrogen and chlorophyll content in crops

Ilina B. Kamenova

Supervisors:

Petra van Vliet
Lammert Kooistra

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For quality of life

BLGG AGROXPERTUS

Introduction:

- Of all the major plant nutrients, nitrogen is often the most important determinant of plant growth and crop production *(Henry, Sullivan et al1999)*

- The mismanagement of N and its excessive application, causes many negative effects which has dramatically altered the global nitrogen cycle *(Keeney and Hatfield 2008)*

- Precision agriculture aims to maximize the productivity applying specific inputs, such as fertilizers, for specific conditions at a specific location and a specific time *(Moran, Inoue et al. 1997)*

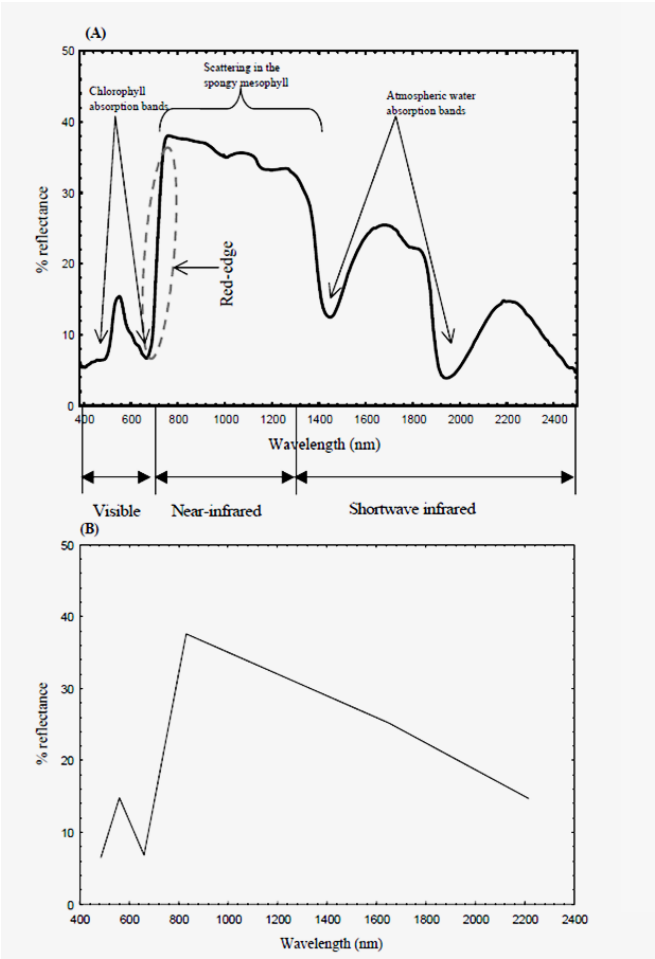
  - How to measure N on regular basis?
  - How to cover large areas over agricultural croplands and pastures?
  - Which technology is feasible?

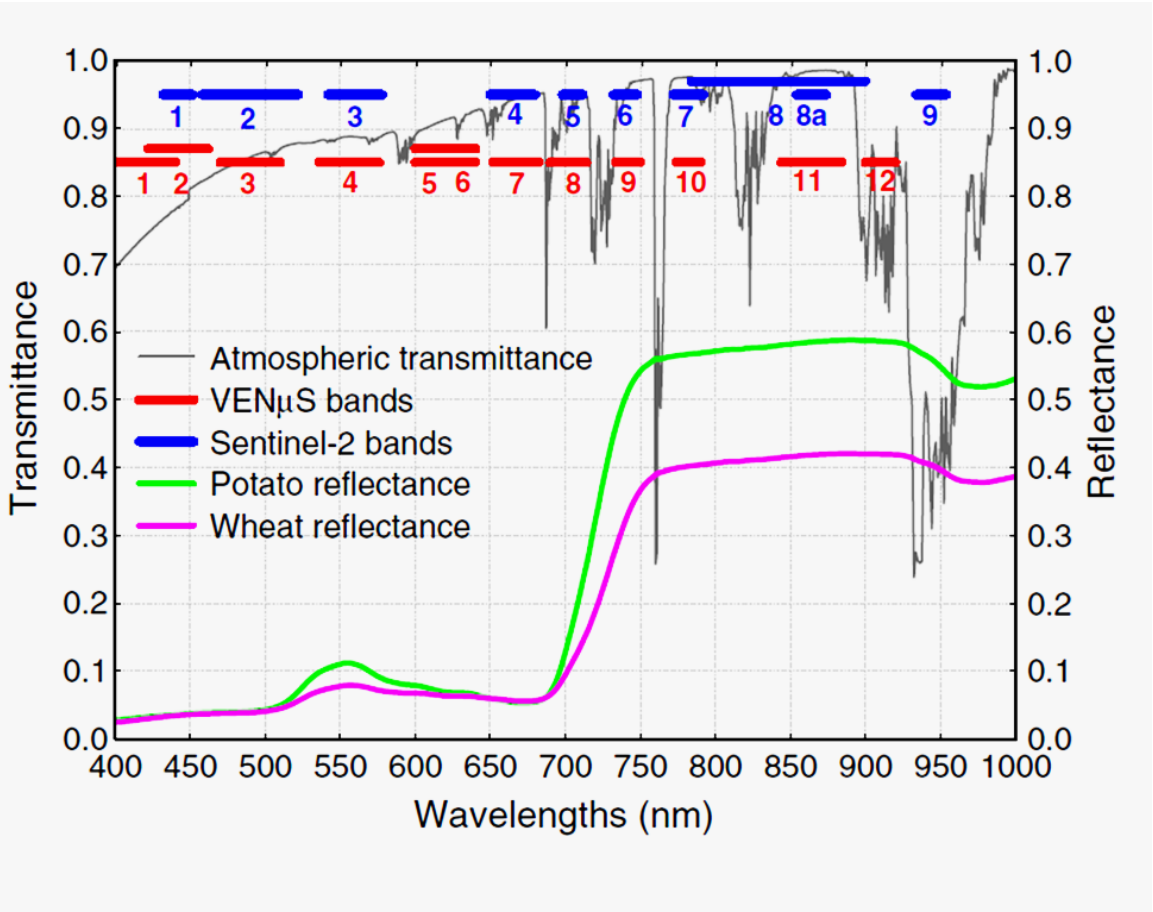
Problem definition:

- Destructive plant sampling
- SPAD measurements
- Strong relationship between chlorophyll and nitrogen
- Crop specific relations
- Variation over the growing season
- Sensitivity of different vegetation indices
- The ‘saturation’ effect of indices using red band

Problem definition:

- Broadband vs. hyperspectral remote sensing.





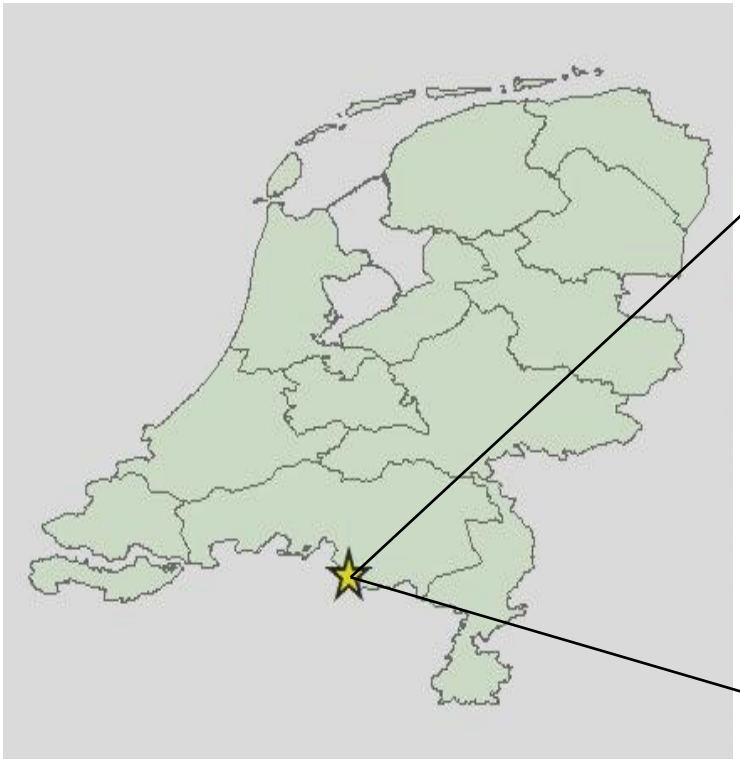
Research objectives :

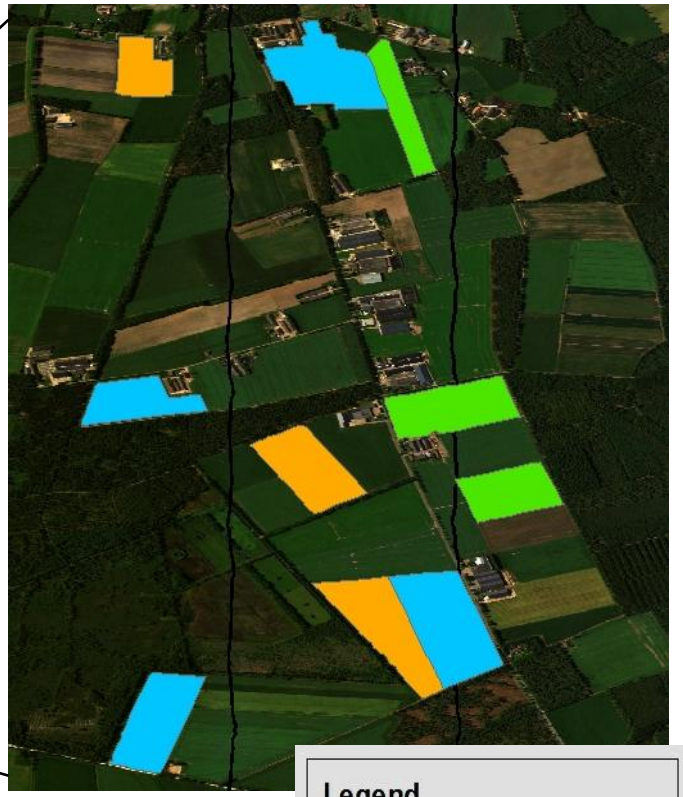
A. To test the ability of hyperspectral vegetation indices (VIs) vs. broadband VIs to predict nitrogen and chlorophyll content of crops like potato, maize and grassland

B. To calibrate and validate an empirical model, relating VIs and in situ measurements

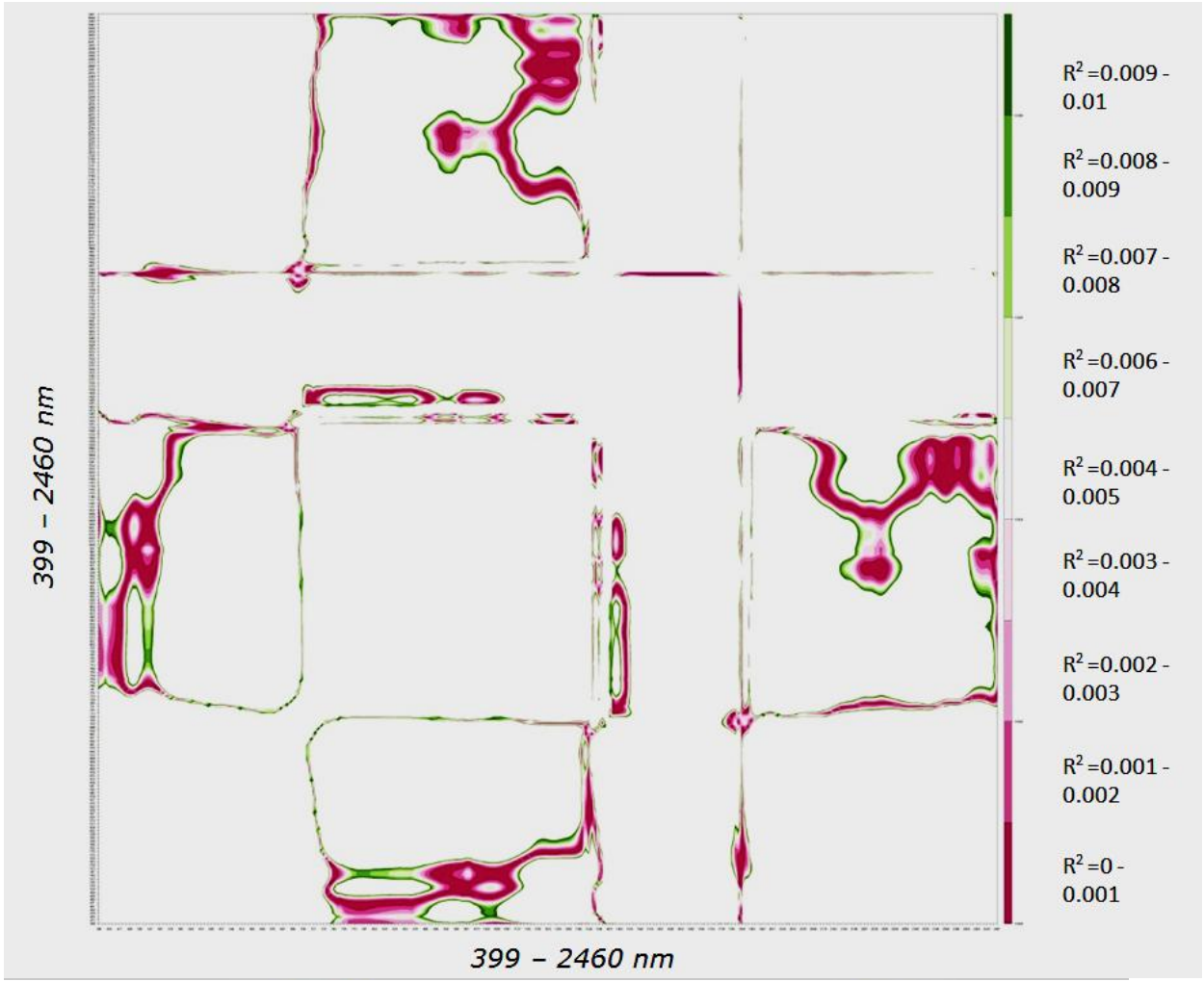
Materials and methods:
Study area

Study area





APEX dataset



apex
Airborne PRISM Experiment

vito

Vegetation indices:

Index	Formulation	Reference
REP	$(((R_{670} + R_{780})/2 - R_{700})/(R_{740} - R_{700}))*40 + R_{700}$	Guyot and Baret (1988)
MTCI	$(R_{754} - R_{709})/(R_{709} - R_{681})$	Dash and Curran (2004)
MCARI/OSAVI	$(((R_{700} - R_{670}) - 0.2*(R_{700} - R_{550}))*(R_{700}/R_{670}))/(1.16*(R_{800} - R_{670})/(R_{800} + R_{670} + 0.16))$	Daughtry (2000)
MCARI/OSAVI RE	$(((R_{750} - R_{705}) - 0.2*(R_{750} - R_{550}))*(R_{750}/R_{705}))/(1.16*(R_{750} - R_{705})/(R_{750} + R_{705} + 0.16))$	Wu et al. (2008)
TCARI/OSAVI	$((R_{700} - R_{670}) - 0.2*(R_{700} - R_{550})*(R_{700}/R_{670}))*3/(1.16*(R_{800} - R_{670})/(R_{800} + R_{670} + 1.16))$	Haboudane et al.(2002)
TCARI/OSAVI RE	$((R_{750} - R_{705}) - 0.2*(R_{750} - R_{550})*(R_{750}/R_{705}))*3/(1.16*(R_{750} - R_{705})/(R_{750} + R_{705} + 1.16))$	Wu et al. (2008)
CI red edge	$(R_{783}/R_{703}) - 1$	Gitelson et al.(2003, 2006)
CI green	$(R_{783}/R_{550}) - 1$	Gitelson et al.(2003, 2006)
NDNI	$(\log(1/R_{1510}) - \log(1/R_{1680}))/(\log(1/R_{1510}) + \log(1/R_{1680}))$	Serrano (2002)
SIPI	$(R_{800} - R_{445})/(R_{800} - R_{680})$	Penuelas et al. (1995)
DCNI	$(R_{720} - R_{700})/(R_{700} - R_{670})/(R_{720} - R_{670} + 0.03)$	Chen et al. (2010)
NDRE	$(R_{750} - R_{720})/(R_{750} + R_{720})$	Tilling (2007)
NDRE1	$(R_{740} - R_{705})/(R_{740} + R_{705})$	Gitelson and Merzlyak (1994)
NDRE2	$(R_{783} - R_{705})/(R_{783} + R_{705})$	Barnes et al. (2000)
NDVI	$(R_{800} - R_{670})/(R_{800} + R_{670})$	Rouse (1974)
CCCI	$((R_{750} - R_{720})/(R_{750} + R_{720}))/((R_{800} - R_{670})/(R_{800} + R_{670}))$	Barnes et al. (2000)
WDRVI	$(0.2*R_{800} - R_{670})/(0.2*R_{800} + R_{670})$	Gitelson et al. (2004)

Regression analysis:

- Calibration

→ Simple regression, using linear and exponential models

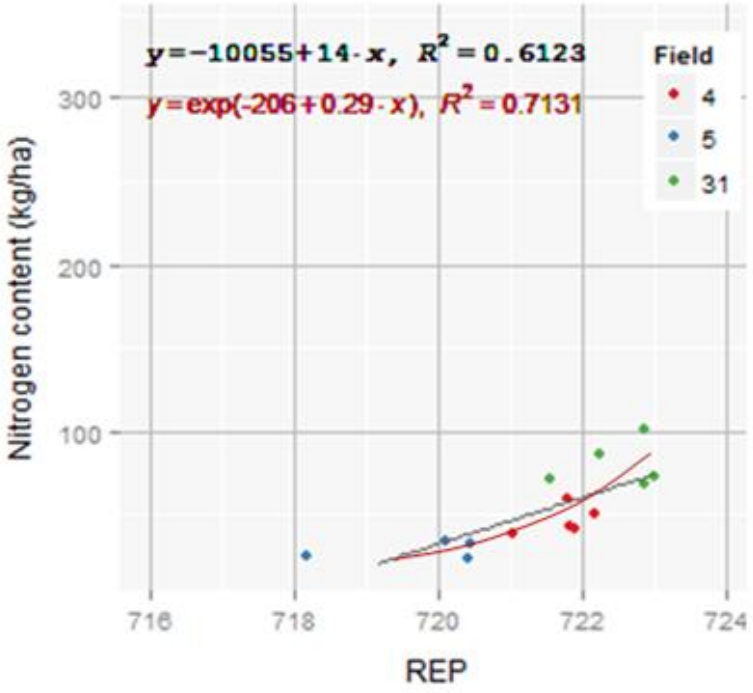
→ Model diagnostics : R- squred, RMSE, F statistics

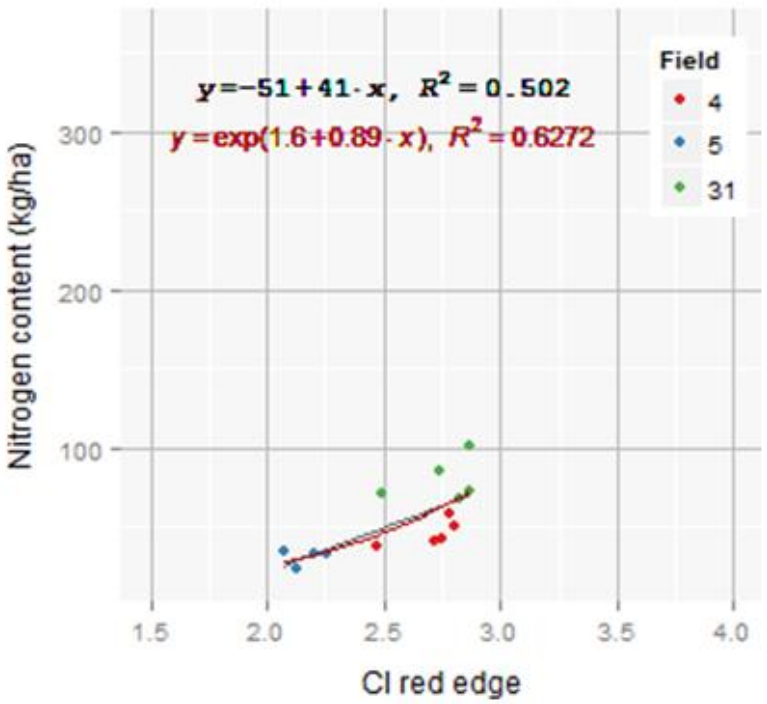
- Validation

→ Leave one out cross validation, RMSECV

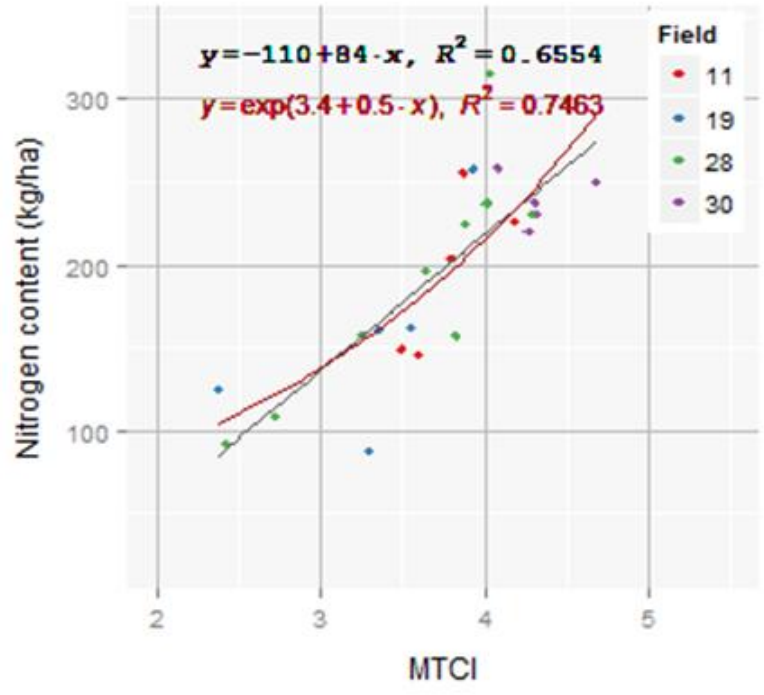
→ Independent validation, RMSEP

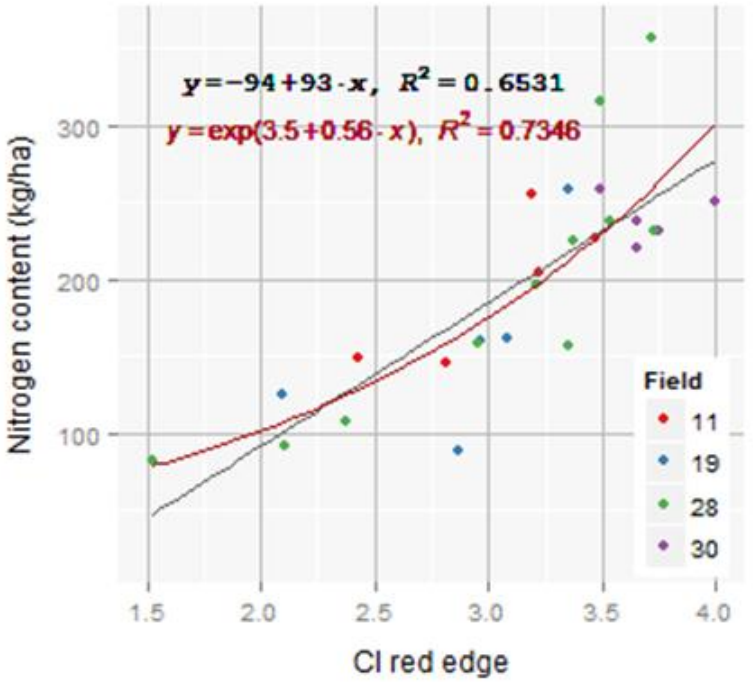
Results grassland:



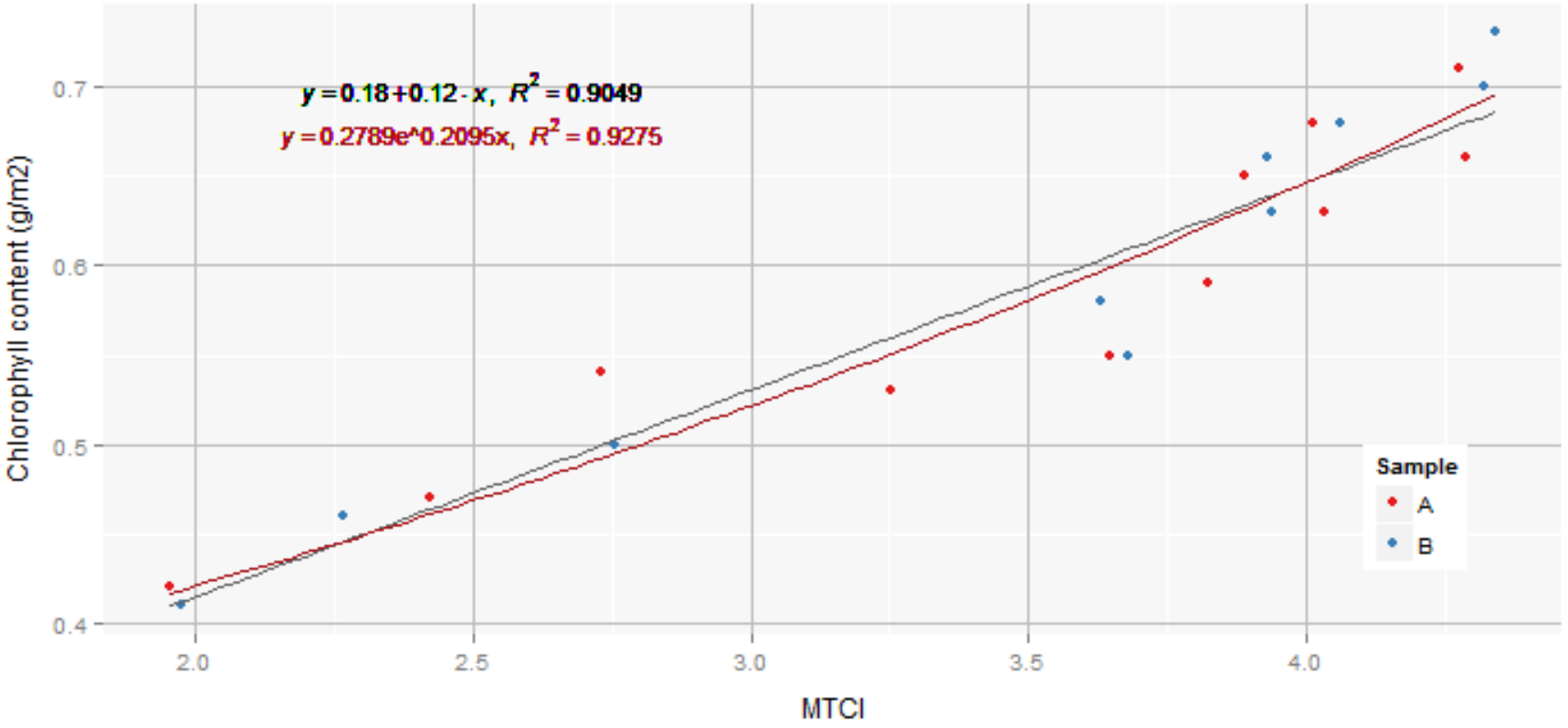


Results potato:

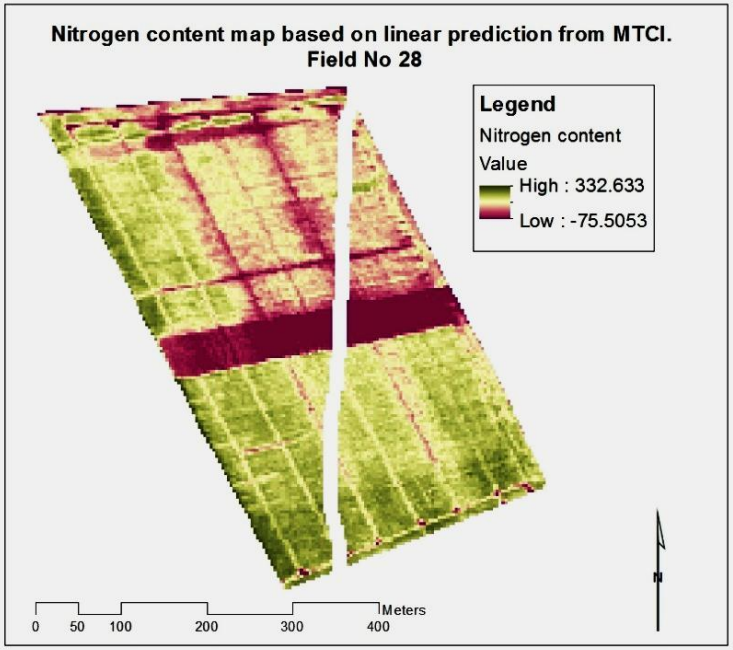


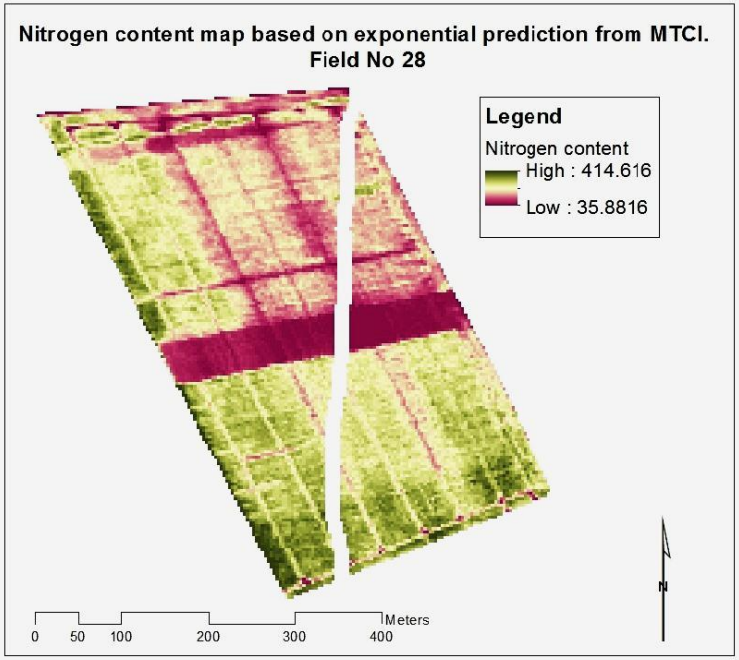


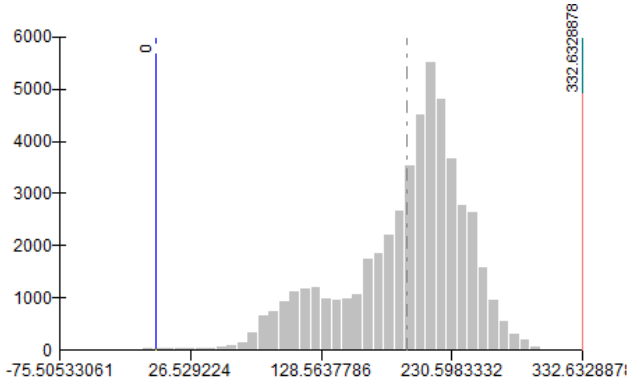
Results potato chlorophyll:

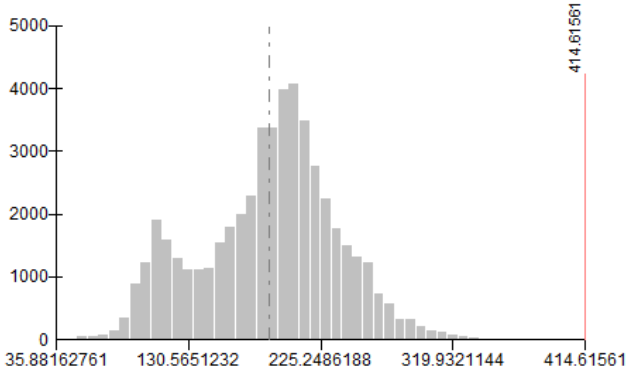


Nitrogen maps MTCI:

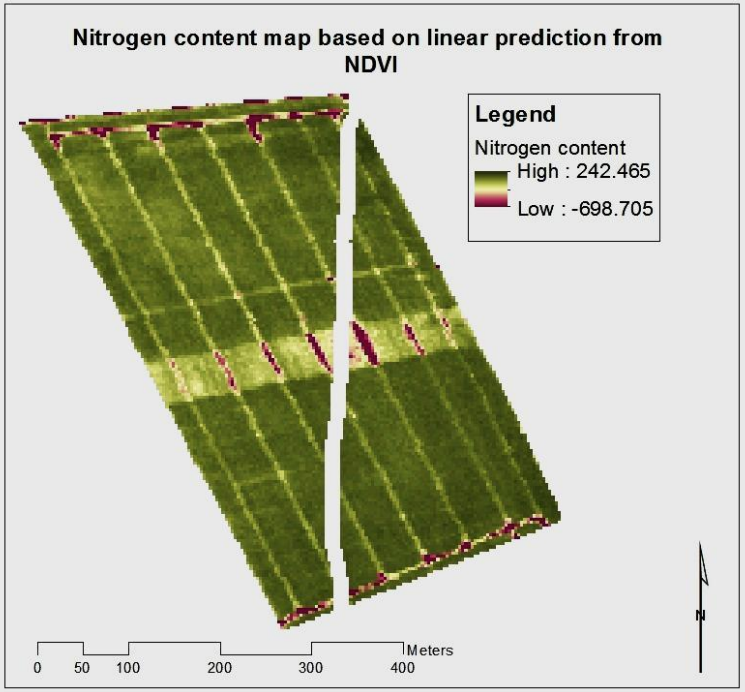


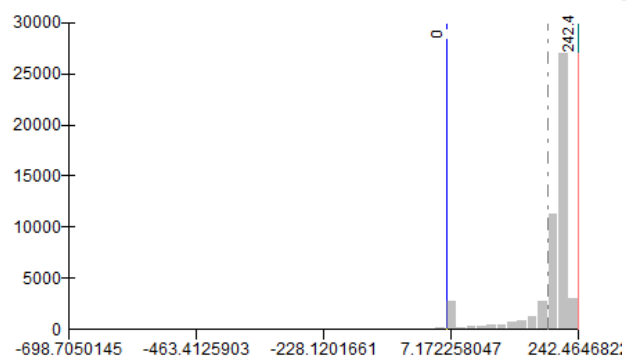


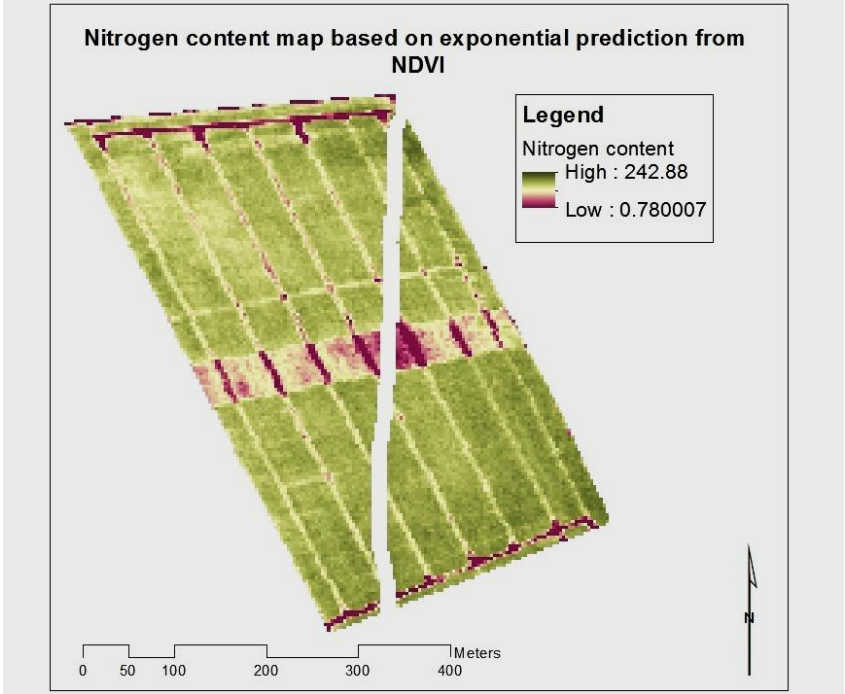


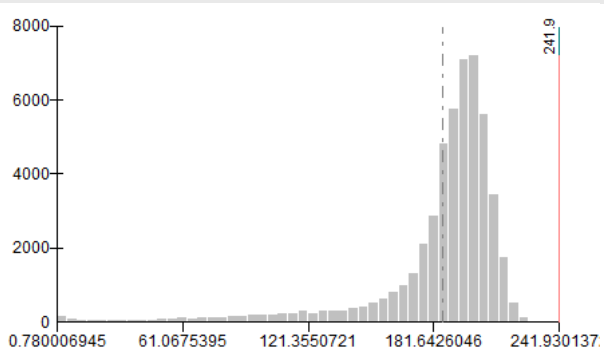


Nitrogen maps NDVI:









Conclusions:

- Hyperspectral VIs are promising tool for N and chlorophyll estimation
- Best performing indices for grass are REP and MCARI/OSAVI RE
- Best performing indices for potato are MTCI, CI red edge
- Red-edge bands are very important for estimation od chlorophyll and N
- Sentinel-2 sensor can achieve comparable results as hyperspectral sensors

Main areas of research

Agriculture

- **Testing PROBA-V and VEGETATION Data for Agricultural Applications in Bulgaria and Romania (The PROAGROBURO Project)**
- **Assessment of Agricultural Crop Development Using Satellite Vegetation Products (AVHRR, MODIS, MERIS)**
- **Crop Identification Using SPOT-Vegetation NDVI S10 Time Series**

Land cover, Land Use and Planning

- **Land Cover Mapping and Change Detection**
- **Landscape-Ecological Planning Using Geoinformation Technologies**
- **Monitoring Green Areas Dynamics in the City of Plovdiv Using Aerospace Data**

Vegetation assessment

- **Assessment of Abiotic Stress in Coniferous Forests using Narrow-band Spectral VIs**
- **Mapping Coniferous Forest Structure and Biomass with Optical RS Data**
- **Mapping Wildfire's Effect on Vegetation**

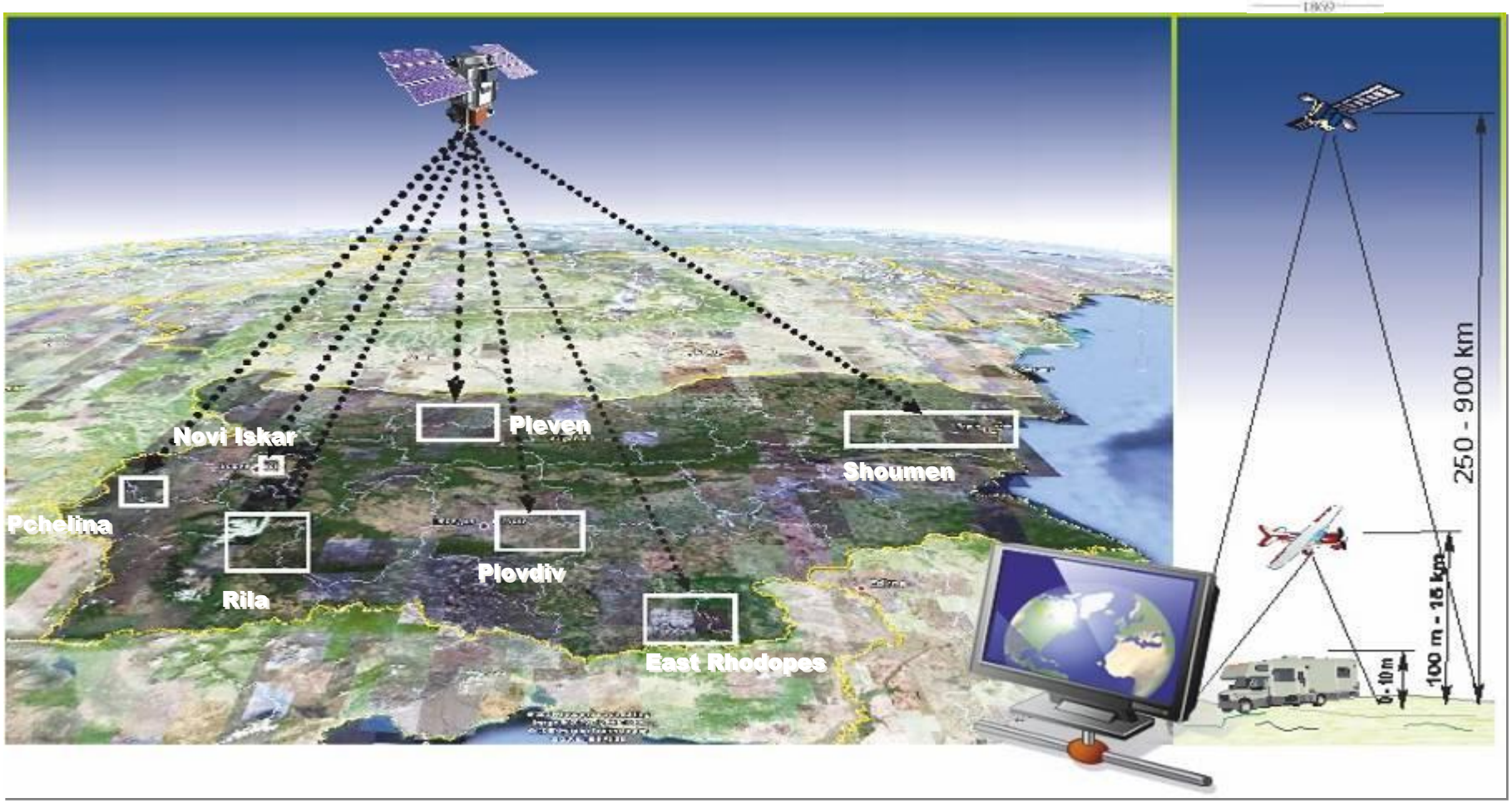
Archaeology

- **Development of Archeological Geodatabase for the Medieval Bulgarian Capital *Pliska* Using Satellite and Ground-based Data**

Natural Hazards

- **Modeling High Waves Risk on the Bulgarian Black See Coast (The SCHEMA Project)**
- **Studies of Geological Hazardous Processes Using RS and Ground-based Methods**

AEROSPACE TEST SITES ON THE TERRITORY OF BULGARIA



Project: "Information Complex for Aerospace Monitoring of the Environment" (ICASME)

Thank you for your attention

BULGARIAN ACADEMY OF SCIENCES
SPACE RESEARCH AND TECHNOLOGY INSTITUTE
Department of *REMOTE SENSING AND GIS*

Address: *Acad. G. Bonchev Str., bl. 1 1113 Sofia, BULGARIA*

E-mail: roumenina@space.bas.bg