Drought risk assessment in Ukraine using satellite data

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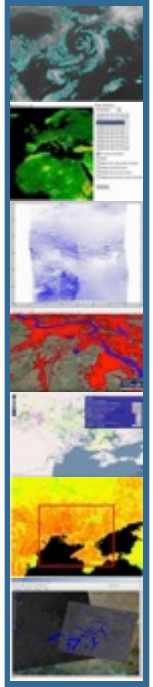
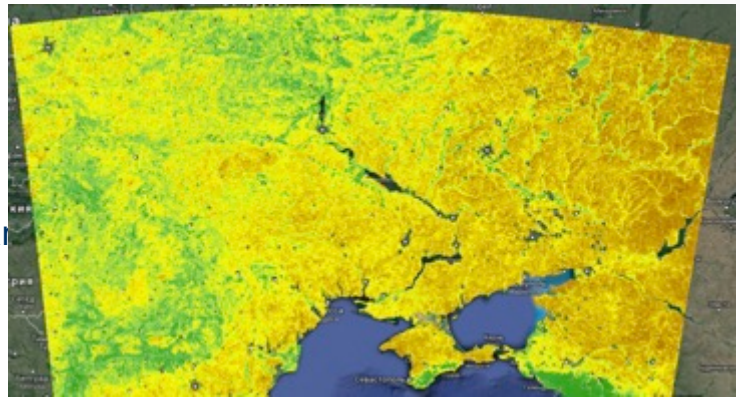
Introduction



- Agriculture in Ukraine
  - **1st world** largest **sunflower** producer and exporter (in 2013)
  - **9th world** largest **wheat** producer (in 2013)

    [source: *FAS USDA*]
- **Drought** influence on **agriculture** in Ukraine
  - Five droughts in past decade: **2003**, **2007**, **2008**, **2009** and **2010**
  - Affected up to **80%** of the major grain crop area
- Existing approaches:
  - use of **rainfall**, **temperature** and **soil moisture** measurements from **ground** meteorological stations:
    - E.g. **extreme value theory** (**EVT**) [Beguería & Vicente-Serrano 2006]
  - ground-based indicators:
    - **PDSI (Palmer drought severity index)** [Palmer 1965]
    - **SPI (Standardized Precipitation Index)** [Guttman 1998],
    - **CMI (Crop Moisture Index)** [Palmer 1968]
    - **SWSI (Surface Water Supply Index)** [Shafer & Dezman 1982]

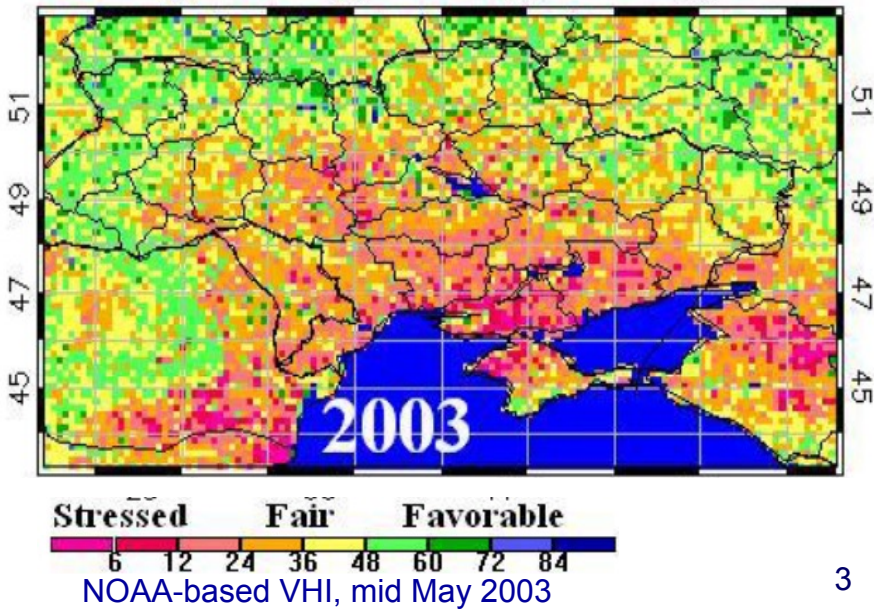


FAPAR, 29.08.2014

Objective

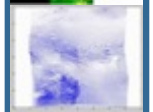
- Accuracy of ground-based indicators
  - dependant on the **density** and **uniformity** of station location [Tonini et al. 2012]
- Earth observation (EO)
  - **better coverage**, **consistent** & **human-independent** observations
  - Indices: **NDVI**, **VCI**, **TCI**, **VHI**, …
- The goal:
  - to provide **quantitative** estimation of **drought risk** in Ukraine based on satellite data

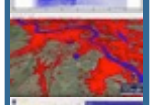
Meteo stations in Ukraine. Density 1 st. per 3,225 sq. km

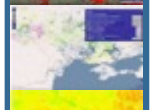


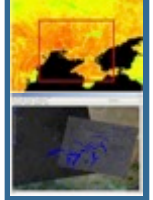
NOAA-based VHI, mid May 2003

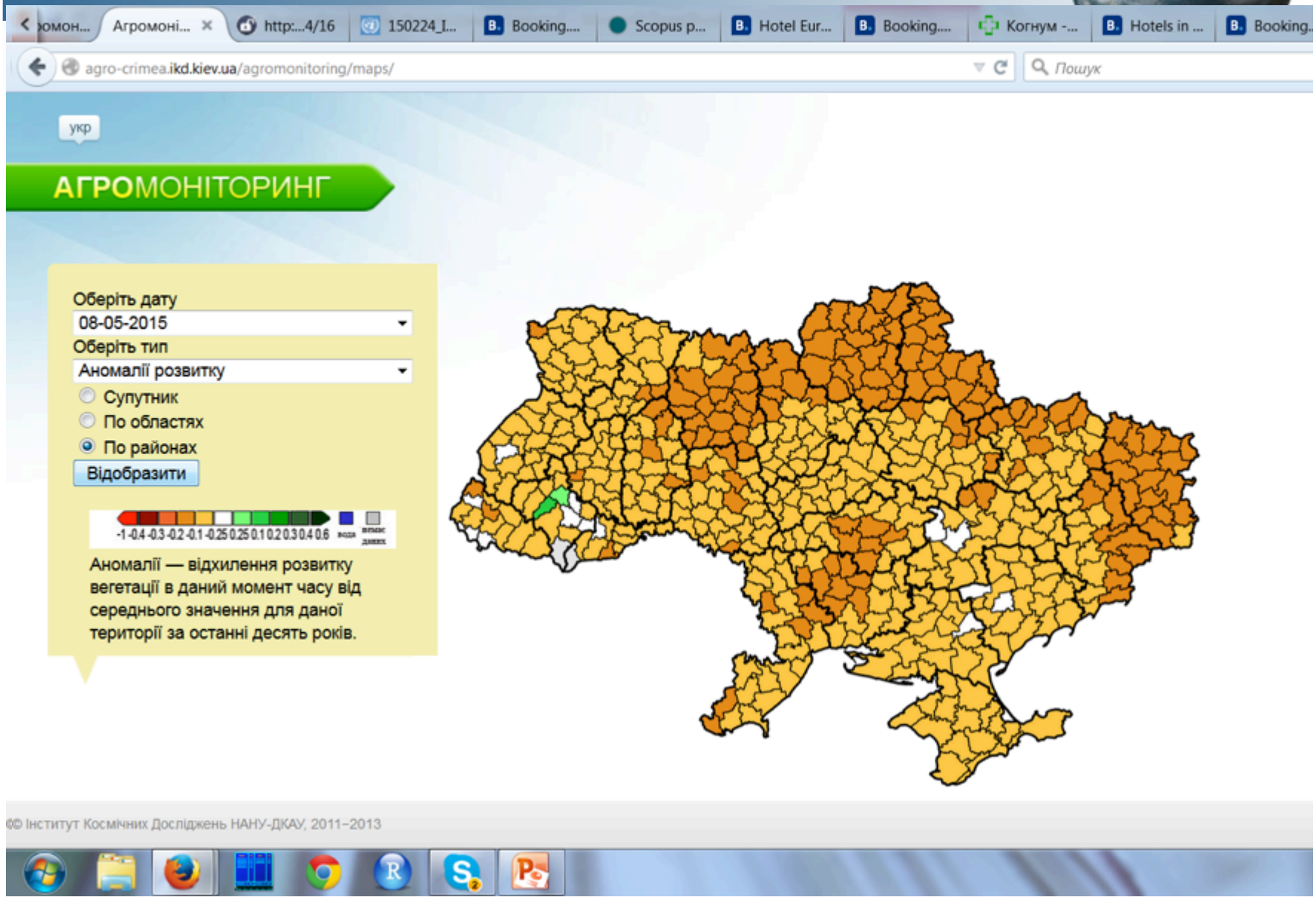
Anomalies monitoring





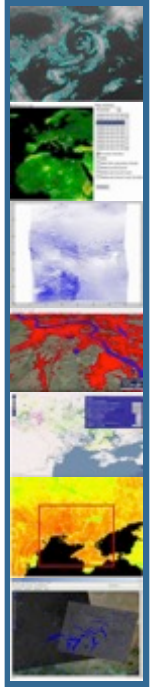






Bonn
2015

Methodology



Risk = **Hazard** (Probability) x **Losses** (Vulnerability)

- Drought risk in area *A*

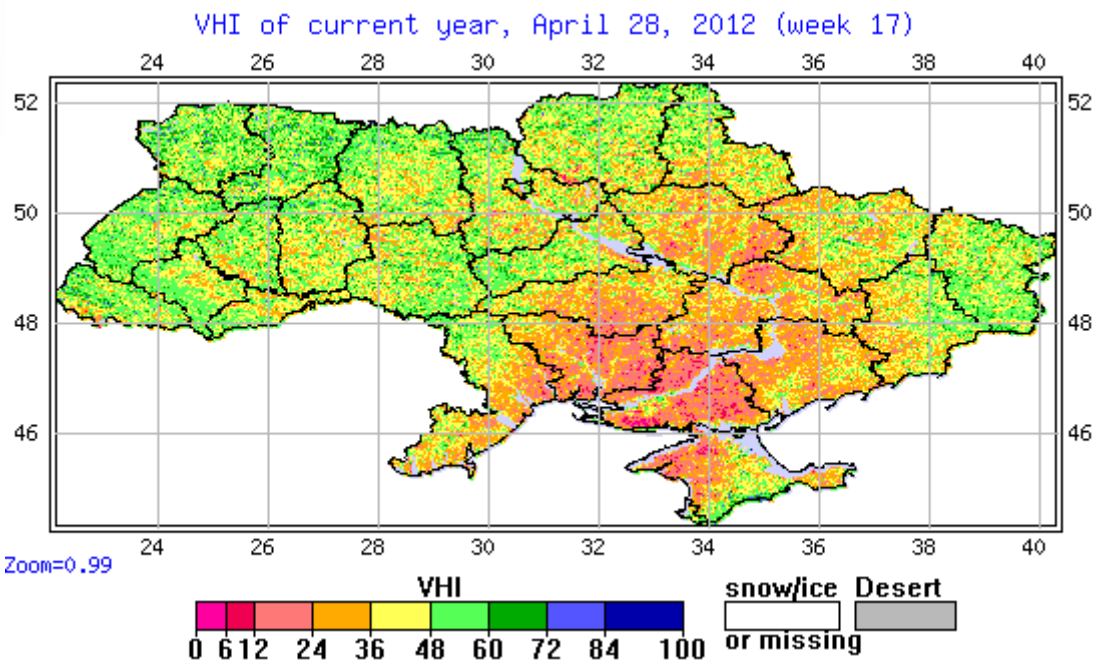
$$R_A = \int_A r(x,y)dxdy = \sum_k \int_A \int_{z_1}^{z_2} p_{xy}(z) d_k(x,y,z) y_k(x,y) s_k(x,y) v_k dzdxdy$$

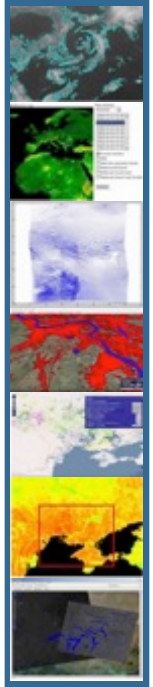
- Drought probability density function (pdf) estimation
  - Main indicator: NOAA-based **Vegetation Health Index** (**VHI**) [Kogan 1997]

VHI = a*VCI+(1-a)*TCI

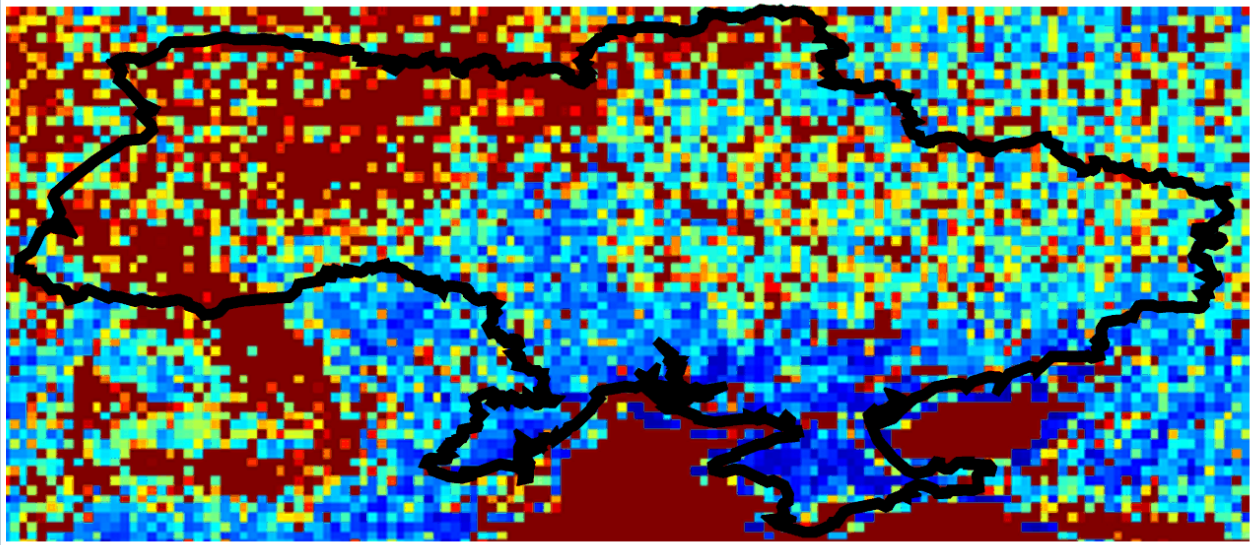
Data

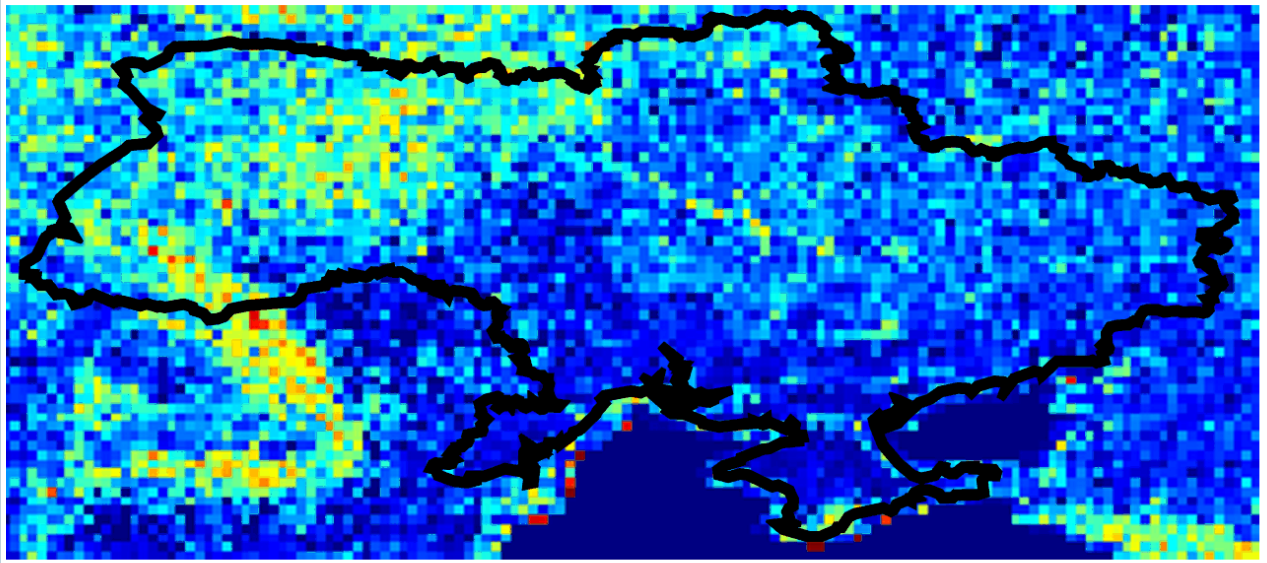
- Vegetation Health Index (VHI) from NOAA satellites
  - Sensor: Advanced Very High Resolution Radiometer (AVHRR)
  - Satellites: **NOAA-7, 9, 11, 14, 16, 17 (morn.),18, 19**
  - Data Resolution:
    - Spatial: **16 km**
    - Temporal: **7-day** composite
  - Period: **30+ years (since 1981)**

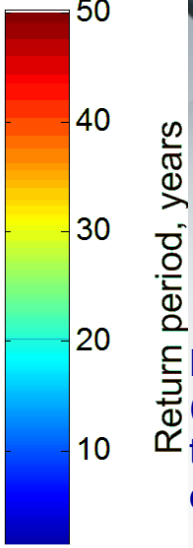




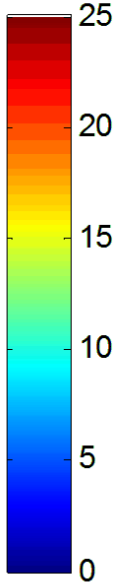
Results: drought pdf







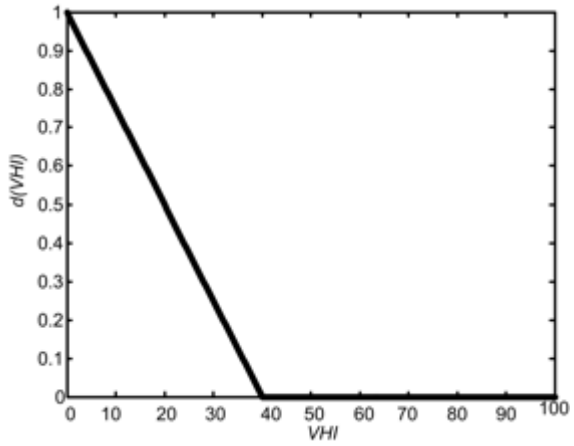
Return period (in years) for the exceptional droughts

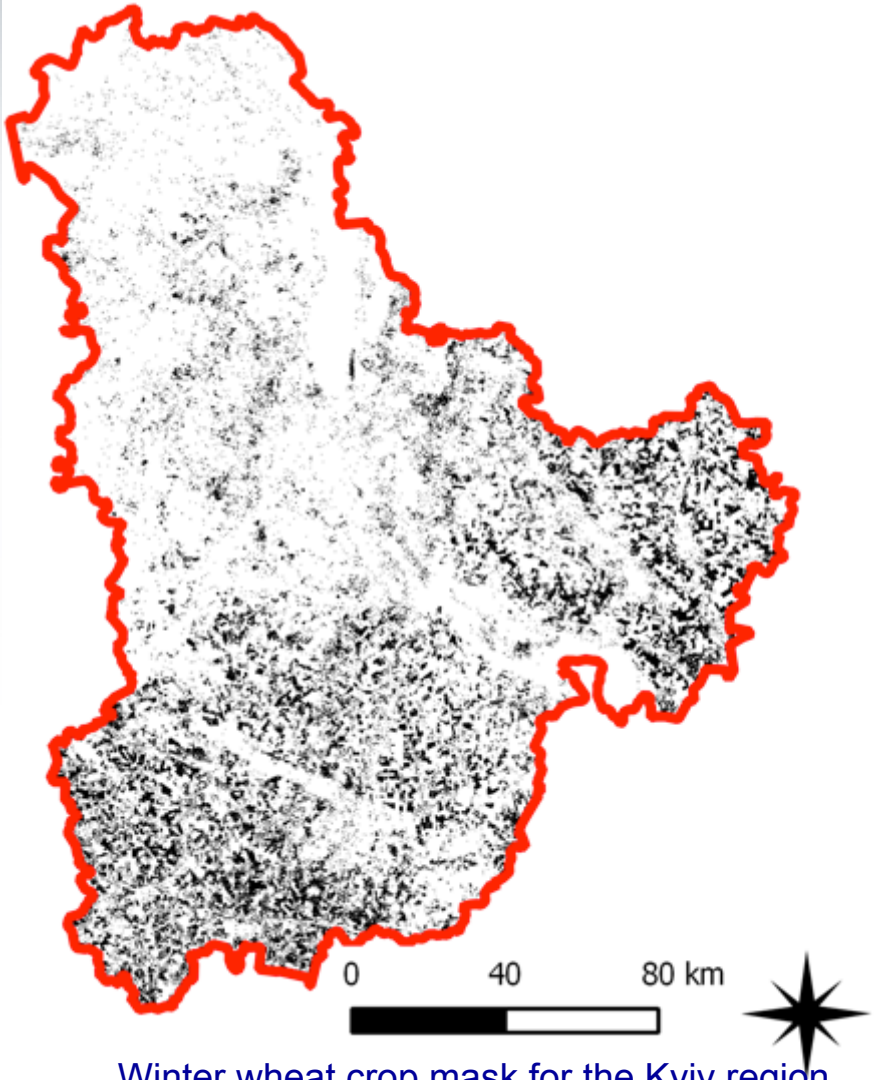


VHI values for the return period of 20 years (probability 0.05)

Results: drought risk estimation

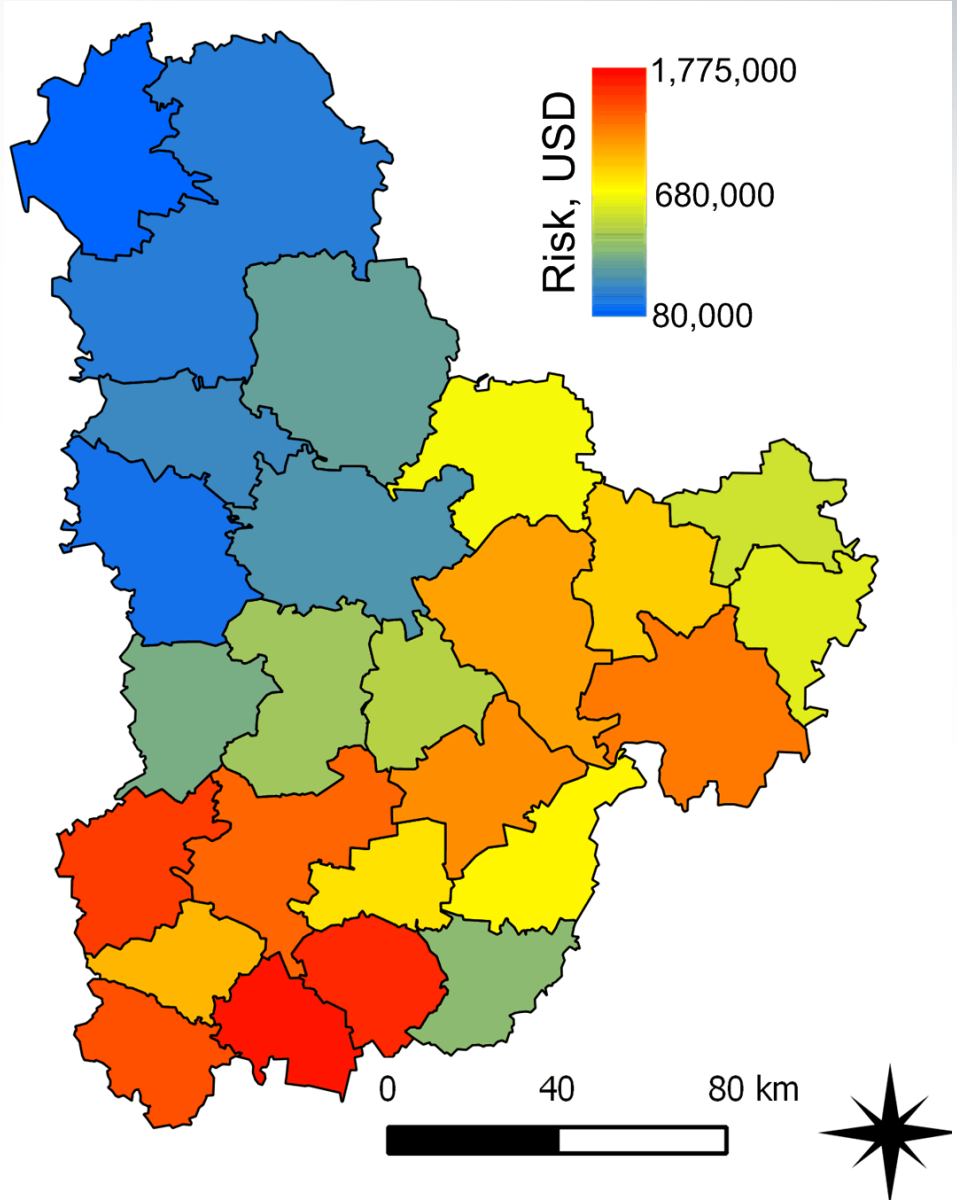
- Case study: Kyiv region
  - Drought risk estimation for **winter wheat** (>40% of production of all crops)
  - Input parameters:
    - **Crop yield, y = 4 t ha^{-1}**
    - **Crop cost, v = 213 USD/t** (average price for winter wheat in Ukraine)
    - **Damage rate**





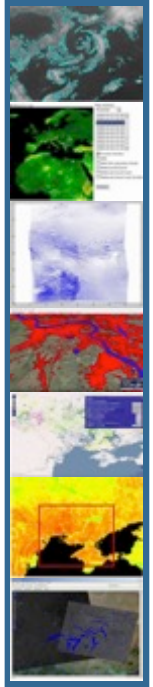
Winter wheat crop mask for the Kyiv region derived from Landsat-8 images in 2015

Results: drought risk estimation



Risk of economical losses due to exceptional droughts (VHI<6) influencing winter wheat in the Kyiv region accumulated by counties. Total risk is ~19 million USD

Conclusions

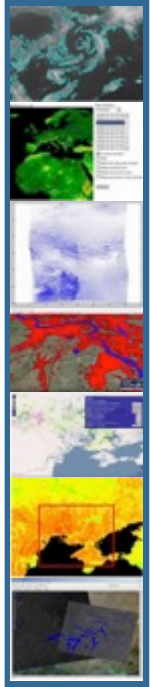


- Main advantage of using remote sensing images comparing to in situ (ground) measurements is **coverage** and **repeatability**

- **Time-series of satellite data** and **extreme value theory** (EVT) techniques, in particular **GP model**, → **estimation** and **mapping** of **drought risk probability density** function

- **Integration** of **coarse** resolution (16 km, NOAA/VHI, **drought probability**) and **finer** resolution (20-30 m, Landsat-8, Spot-5, Sentinel-1 **drought vulnerability**) → **quantification** and **mapping** of **drought risk**

Publications



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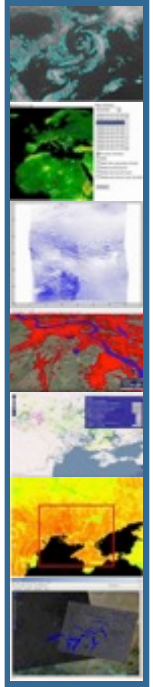
Publications



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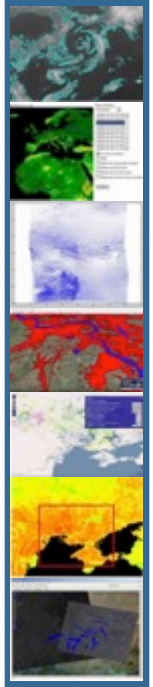
Conferences



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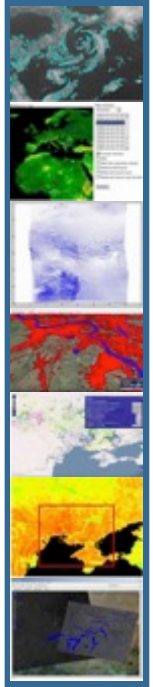

Thank you!