The use of satellite data and geospatial intelligence for flood risk assessment at UN-SPIDER RSO in Ukraine

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Sergii Skakun[1,3], Oleksii Kravchenko[1,2]

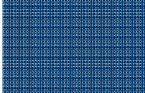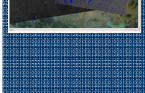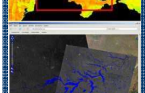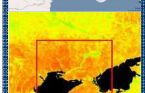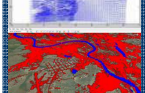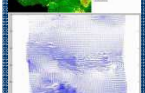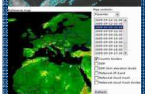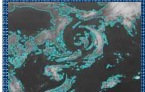[1]Space Research Institute NASU-NSAU
[2]National University of Life and Environmental Sciences of Ukraine
[3]National Technical University of Ukraine "KPI"

Content

- Flood hazard mapping using satellite data
- Deforestation mapping in Ukraine
- SICH-2 – new Ukrainian Earth remote sensing satellite

Importance

- Flood management has shifted from protection against floods to managing the risks of floods.

- In Europe, this shift is reflected in the Flood risk directive (FRD) of October 2007 (2007/60/EC; FRD).

- The FRD requires EU Member States to undertake a preliminary assessment of **flood risks** and, for areas with a significant flood risk, to prepare **flood hazard** and **flood risk maps** and **flood risk management plans**.
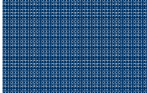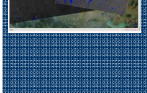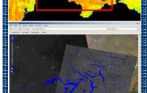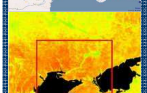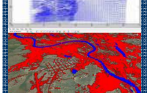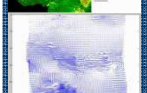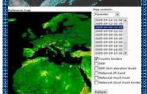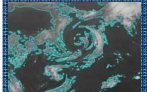
Measuring "flood risk"

Risk = F(Hazard, Vulnerability)

- A popular approach
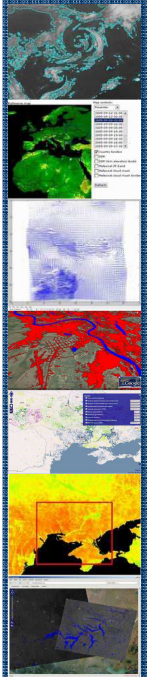 - Risk = *the probability of each possible flood event per year* x *the consequences of that event*
  - Simple risk measures:
    - average annual economic damage (AAD)
    - average annual number of casualties (AAC)
  - Problems
    - **regular flooding** with **limited consequences** and exceptional **flooding with huge consequences** may have **the same AAD**, but in practice they differ significantly: it is possible to cope with the first type but not with the second one
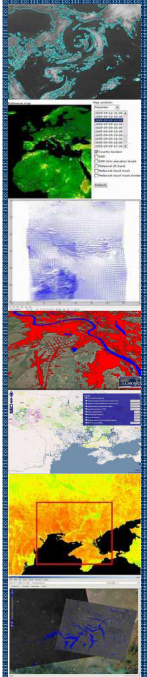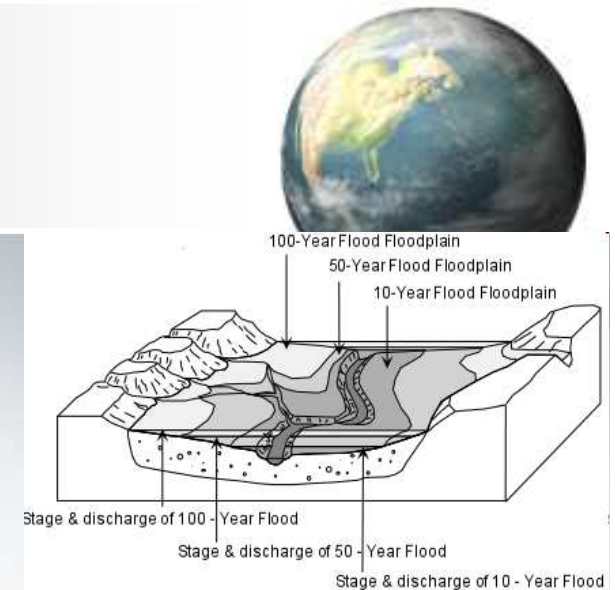
Flood Hazard Mapping

100-Year Flood Floodplain
50-Year Flood Floodplain
10-Year Flood Floodplain

Stage & discharge of 100 - Year Flood
Stage & discharge of 50 - Year Flood
Stage & discharge of 10 - Year Flood

- Flood modeling
  - Hydrological and other data are often far from complete,
  - Reliability is usually not perfect,
  - They can be analyzed in different ways, resulting in slightly or very different outcomes
  - An adequate *a priori* definition of flood inundation model parameters is very difficult

- Satellite data
  - Complementary approach to flood modeling
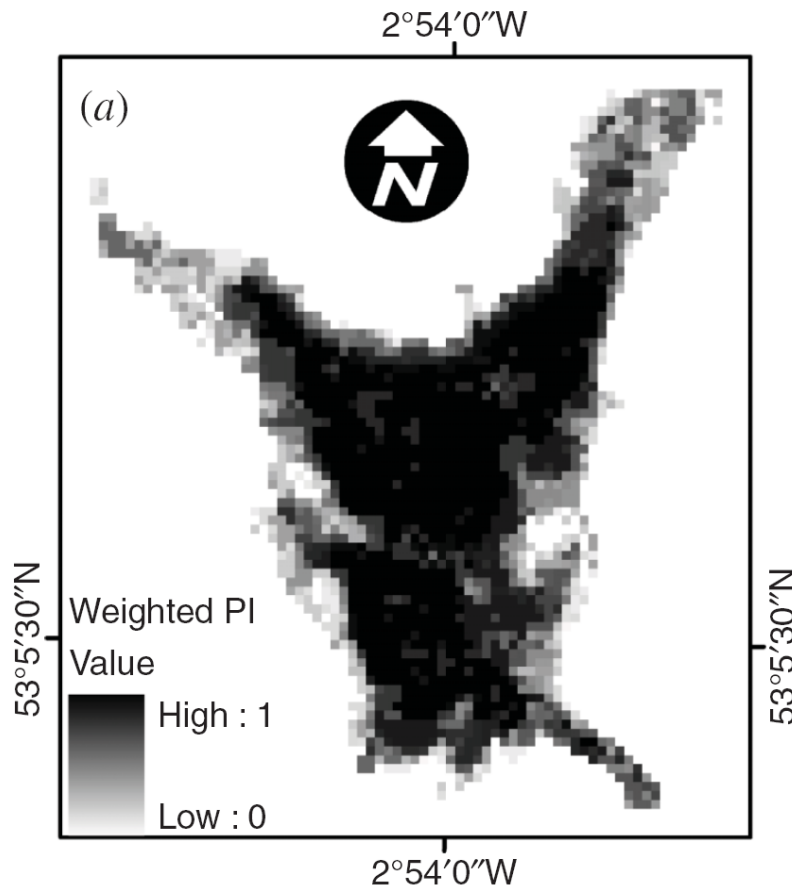 - Continuous, cost-effective, man-independent observations

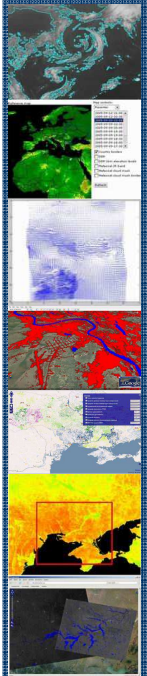# Existing Approaches: Flood Hazard Mapping

- Flood hazard map based on multi-algorithm ensembles [Schumann, G. and Di Baldassarre, G. (2010) 'The direct use of radar satellites for event-specific flood risk mapping', Remote Sensing Letters, 1: 2, 75 — 84]

$$F2 = \frac{\sum_{i=1}^{n} P_i^{D_1 M_1} - \sum_{i=1}^{n} P_i^{D_0 M_1}}{\sum_{i=1}^{n} P_i^{D_1 M_1} + \sum_{i=1}^{n} P_i^{D_0 M_1} + \sum_{i=1}^{n} P_i^{D_1 M_0}}$$

$$PI_i = \frac{\sum_{j=1}^{5} \omega_j (P_{j,\text{SAR}})_i + \sum_{k=1}^{5} \omega_k (P_{k,\text{ASAR}})_i}{\sum_{j=1}^{5} \omega_j + \sum_{k=1}^{5} \omega_k}$$
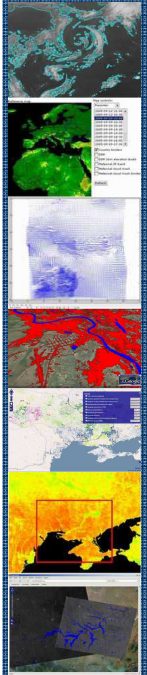
the weight ω_j takes the value of $F2^{D,M}$ with the ASAR image denoting the reference data set D and the SAR image being the data set assessed M.

Our approach

- Two methods proposed
  - The use of time-series of satellite data to flood hazard mapping
    - The use Landsat-5 and Landsat-7 data
    - Being used for Namibia
  - The use of neural network and SAR satellite data for event-specific flood hazard mapping
    - The use of ERS-2 and Envisat/ASAR data
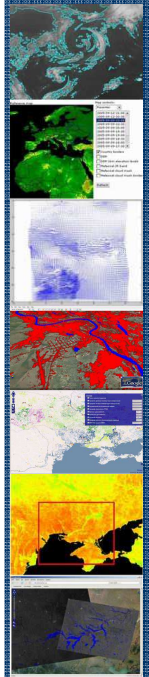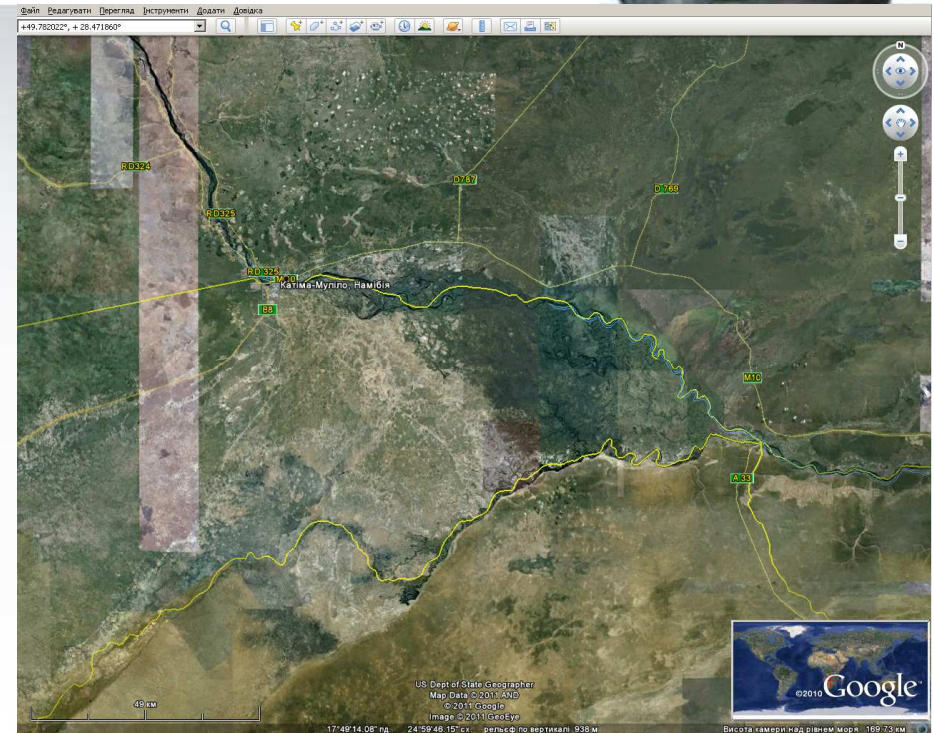   - Being used for Ukraine, preparing for Namibia

Flood Risk Mapping for Namibia

- **Region: Katima Mulilo, Namibia**

- **Data**
  - Satellite
    - Landsat-5/TM and Landsat-7/ETM+
      - 44 images
      - Time period
        » 2000-2010
    - TRMM
      - Time period
        » 1999-2010
  - Ground
    - Water level and water flow
    - Time period
      - 1943-1954
        1965-2010

Flood Risk Mapping for Namibia

- **10 year flood**
  - Flow: 5746 m3/sec
- **50 year flood**
  - Flow: 7093 m3/sec
- **100 year flood**
  - Flow: 8993 m3/sec

43 year flood ←

30 year flood ←
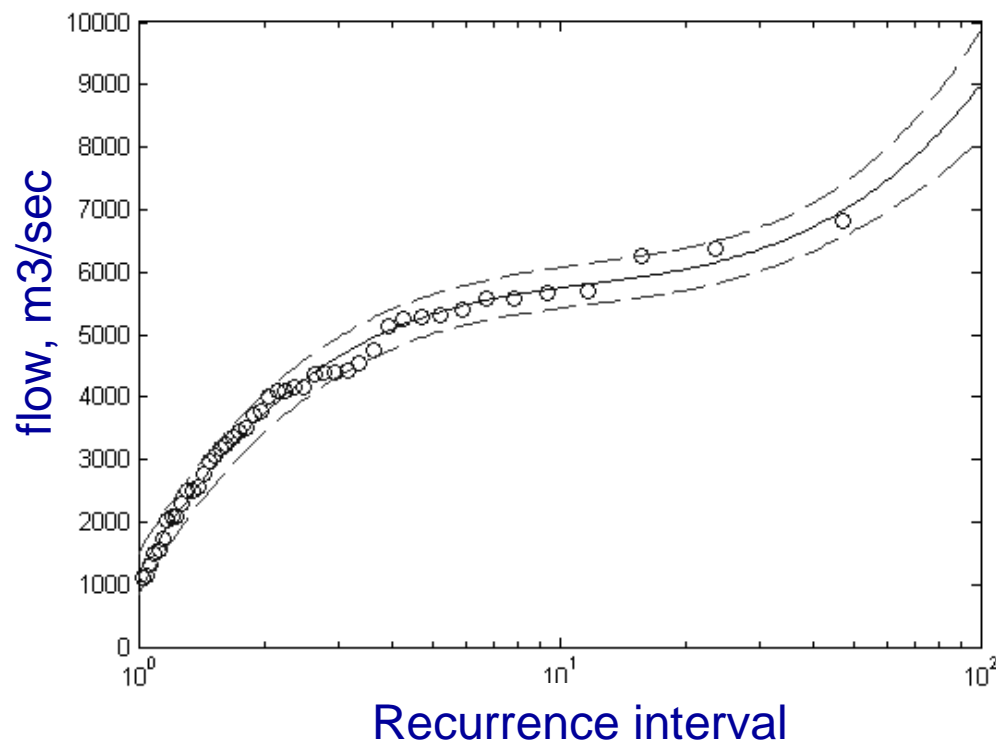
	year	flow, m3/sec
1	1969	6817
2	**2009**	**6365**
3	1978	6251
4	**2010**	**5704**
5	1979	5675
6	1976	5568
7	**2007**	**5564**
8	1975	5409
9	1968	5312
10	1966	5276

$y = 2969{,}8x^3 - 9567{,}7x^2 + 11162x + 1181{,}8$

$R2 = 0{,}9907$

$x = \log_{10}(R)$

flow, m3/sec

Recurrence interval

Flood Risk Mapping for Namibia

- Distribution of satellite data (Landsat 5, 7) path 174, row 072, during flood season
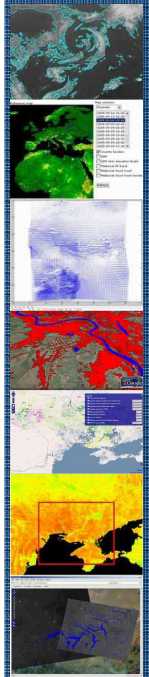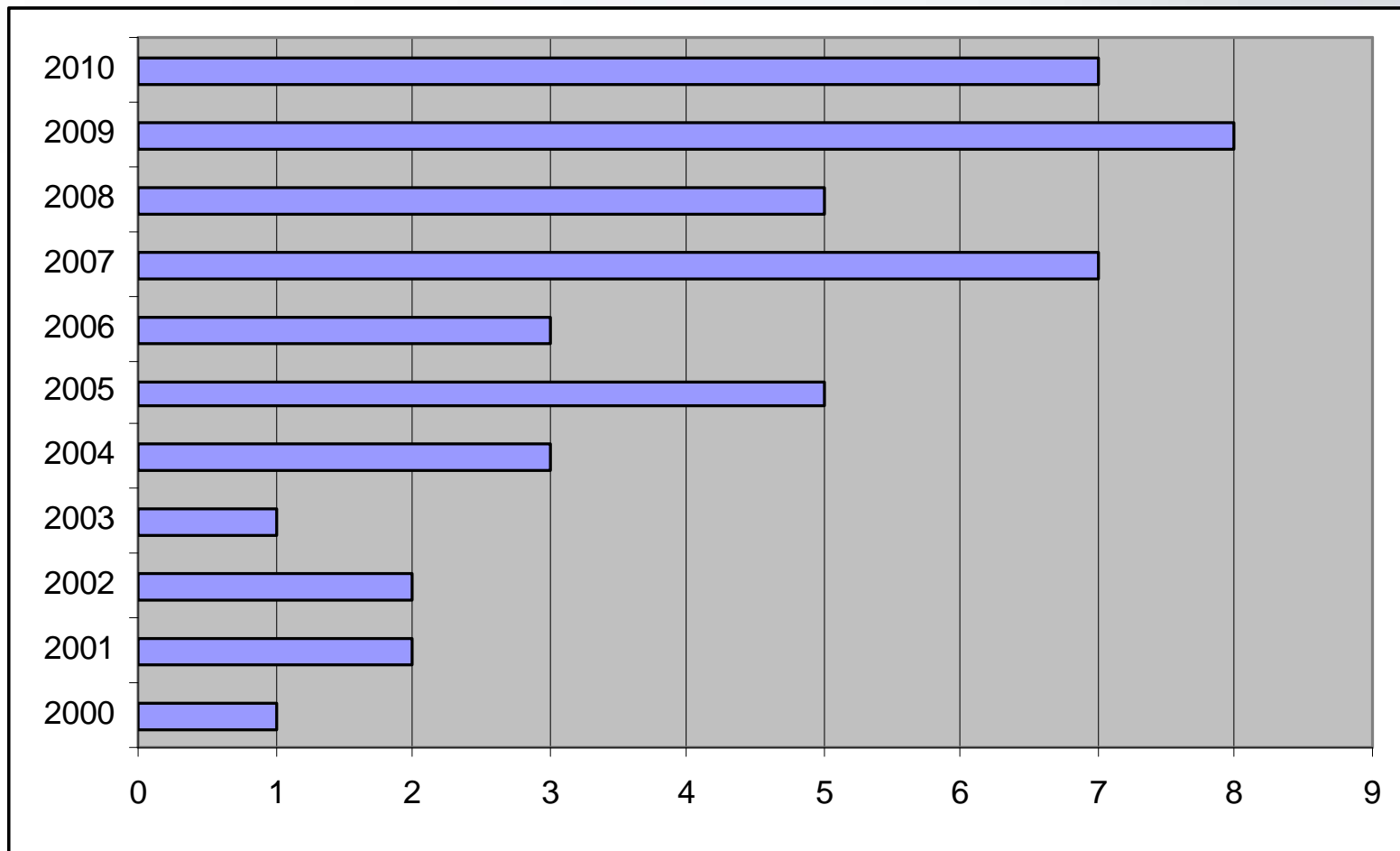
Year	Value
2010	7
2009	8
2008	5
2007	7
2006	3
2005	5
2004	3
2003	1
2002	2
2001	2
2000	1

Processing Workflow

Calibration
Transformation to TOA reflectance

Cloud & shadow detection

Water detection

Inundation map

Flood Risk Mapping for Namibia

- 2010, DOY=81, Flow = 5704 (max in 2010)
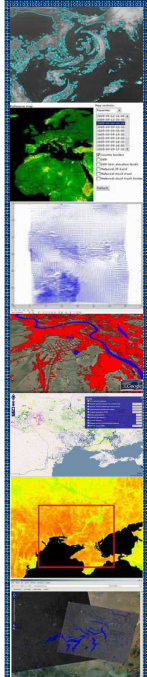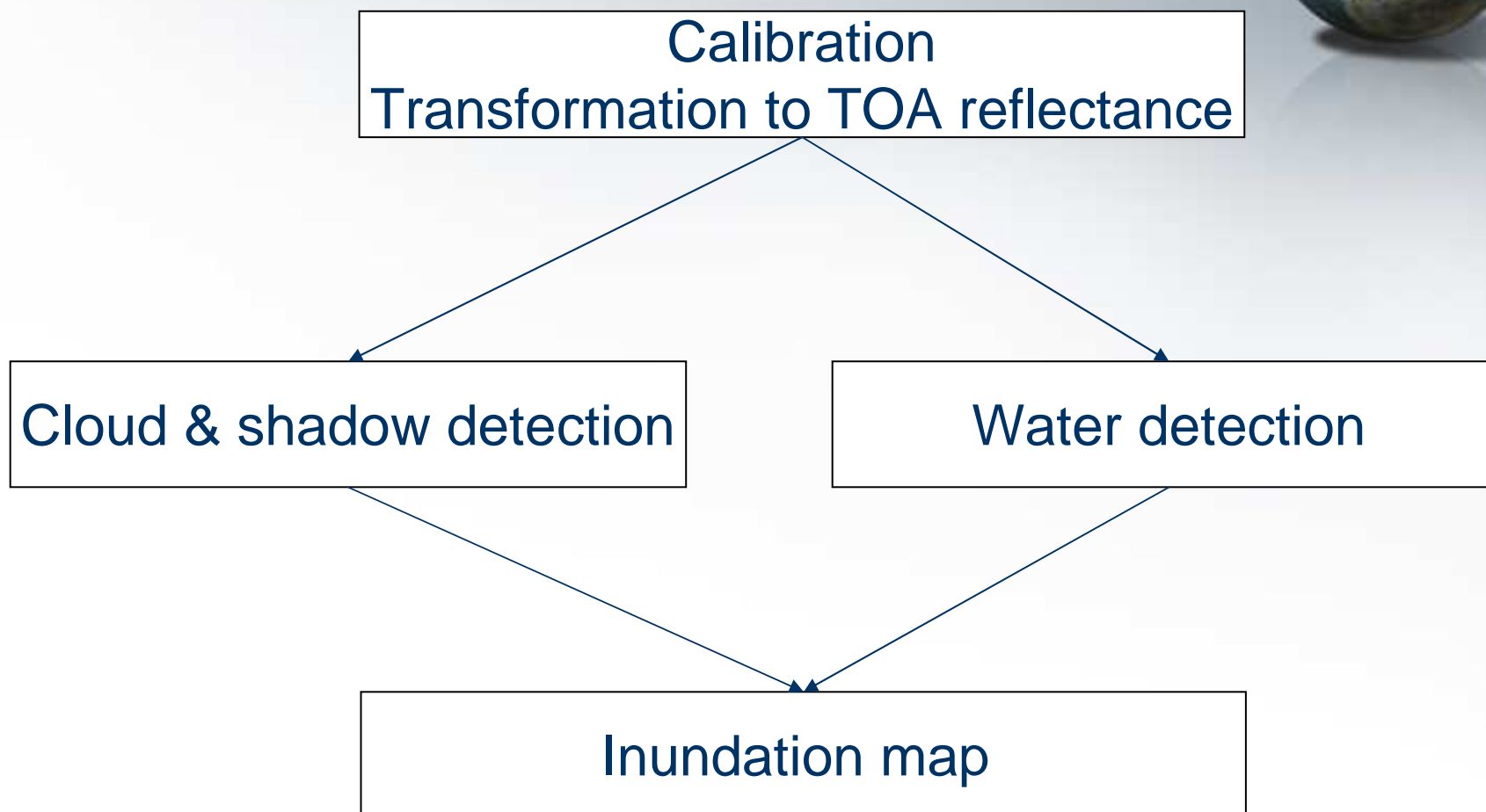
Flood Risk Mapping for Namibia

- 2010, DOY=81, Flow = 5704 (max in 2010)
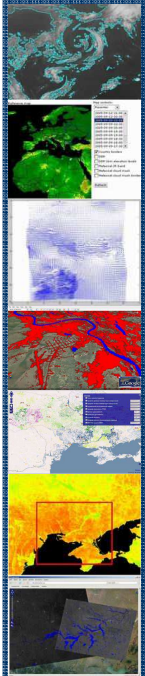
UN-SPIDER

2011

Flood Risk Mapping for Namibia

- Probability density function estimation using a time-series of satellite data

Flooded

Non-Flooded

$$PI_{pixel} = \frac{1}{N} \sum_{i=1}^{N} \mathbf{I}_{pixel=flooded}$$

No data (clouds, shadows, SLC-off)

100%

0
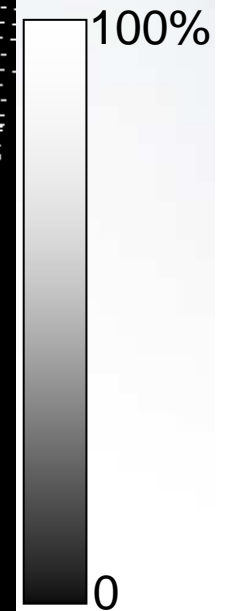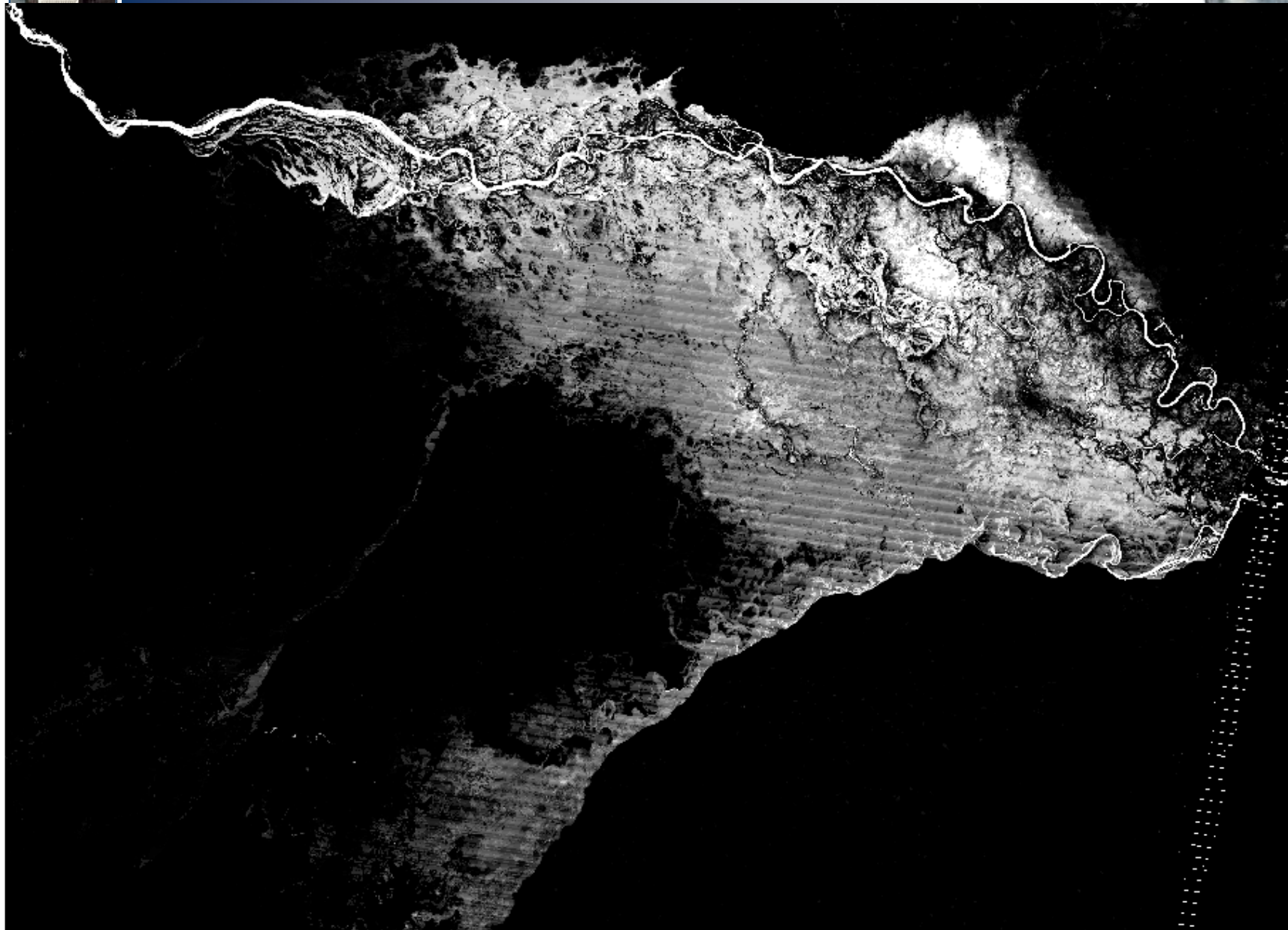
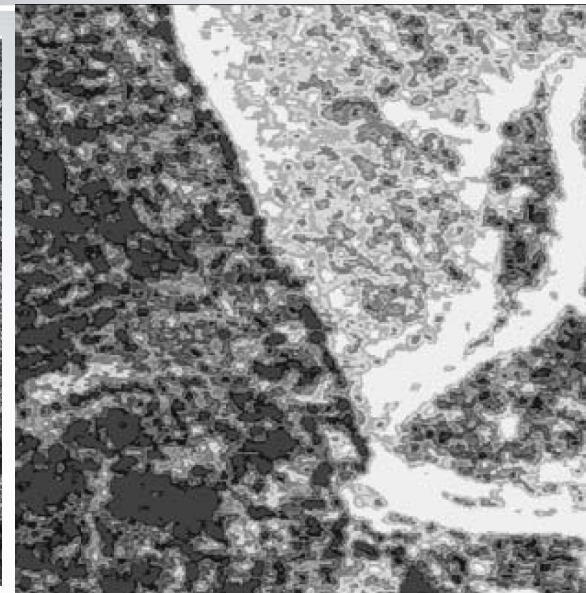# Flood Risk Mapping for Namibia

Dwelling Density

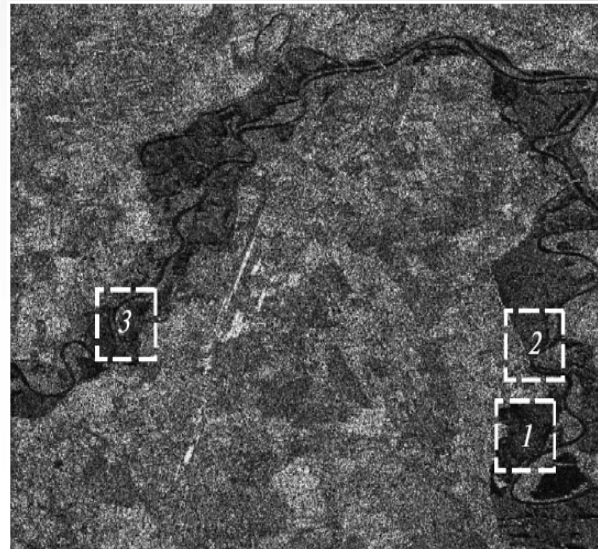# Event-specific flood hazard mapping

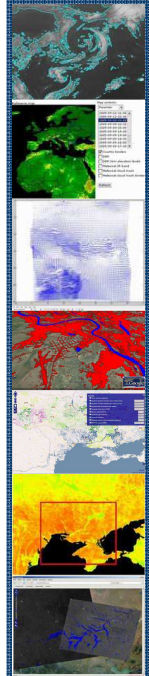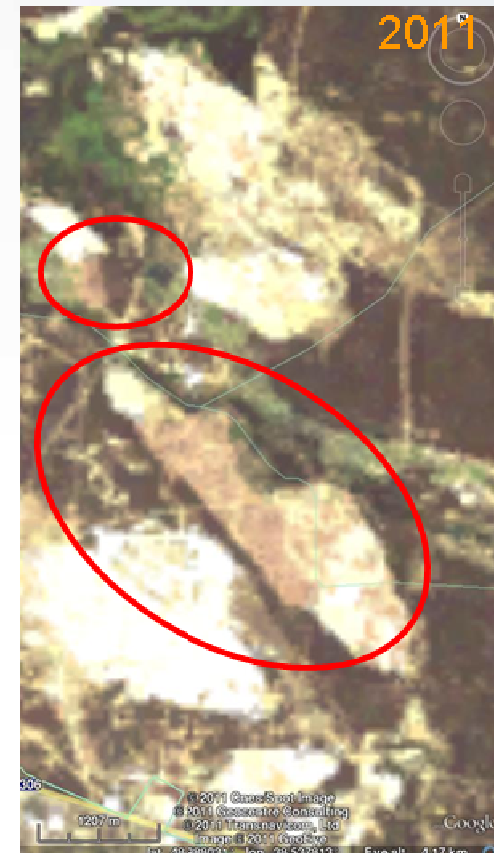SAR/ERS-2, 2001, Ukraine
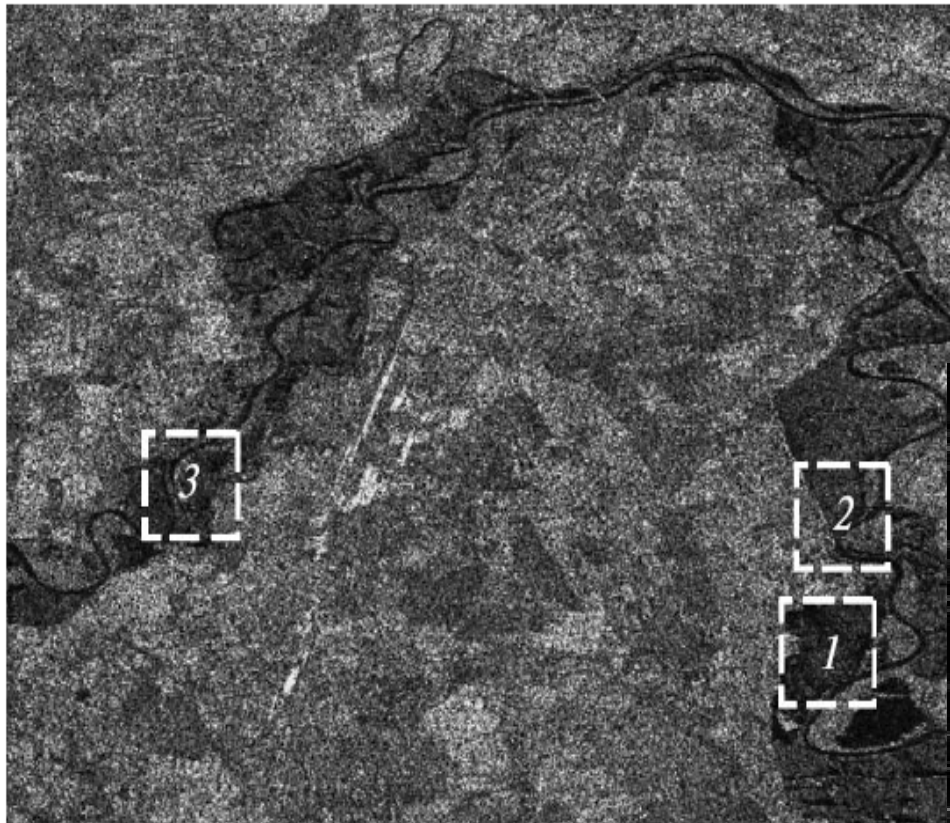
Event-specific flood hazard mapping
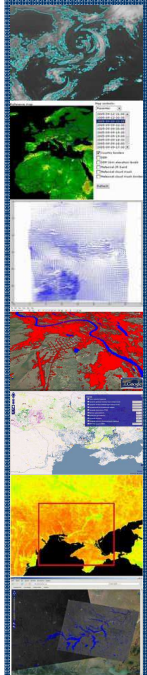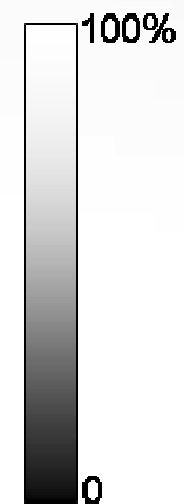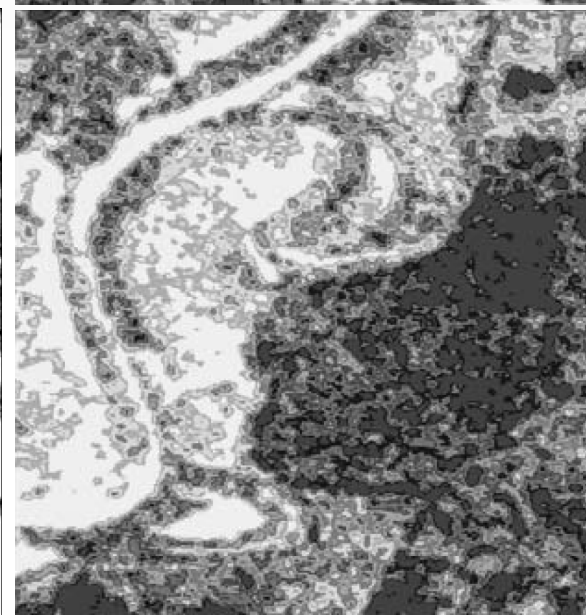
Deforestation monitoring in Ukraine

- Rapid mapping of potential deforestation areas
- Area: Lugansk oblast, Ukraine
- State Agricultural Inspection
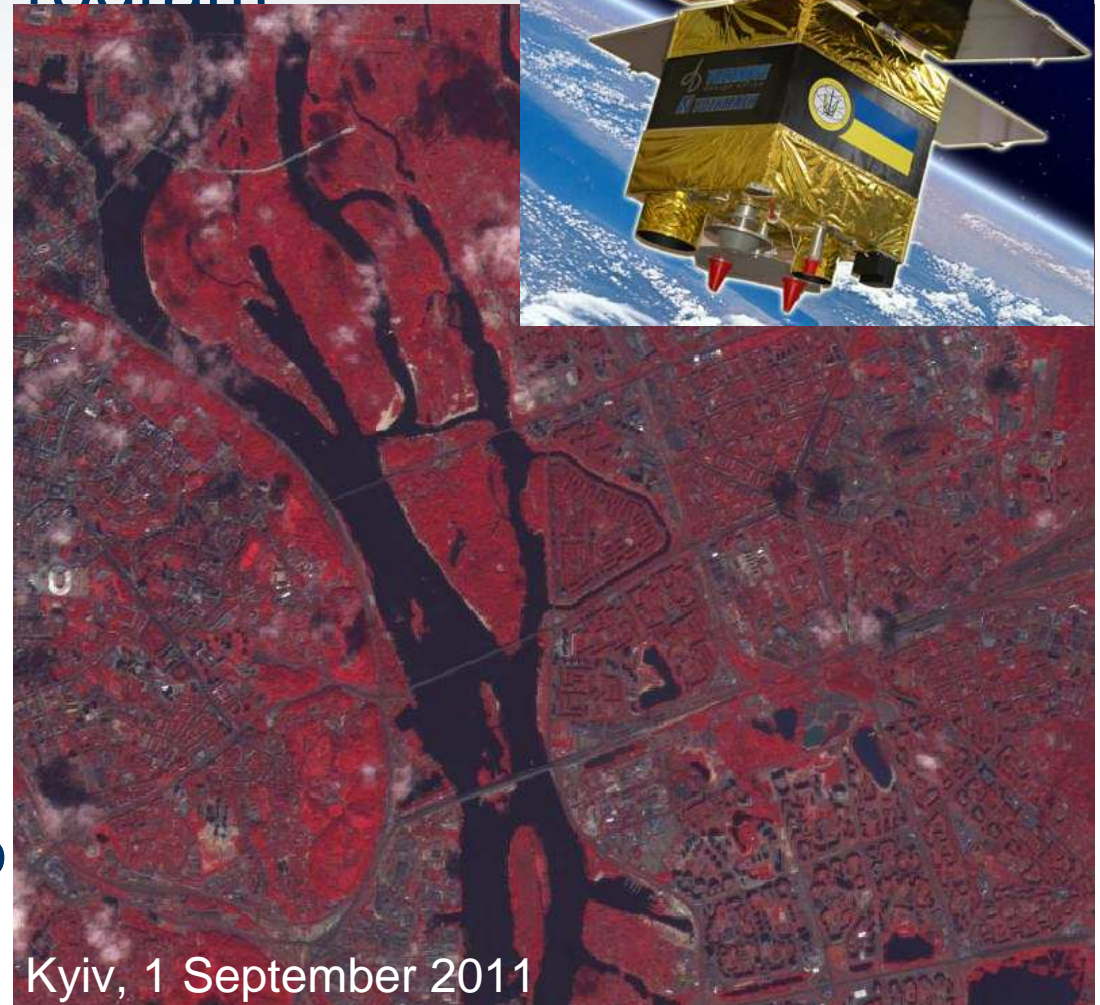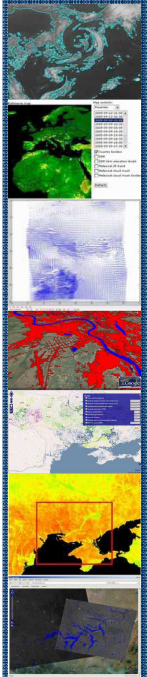- Estimated deforestation area: 2300 ha

Sich-2 Earth Remote Sensing Satellite

- First Ukrainian ERS within new National Space Program

- Optical
  - VNIR (8 m), SWIR (40 m)
  - 48.8 km swath
  - Inclination angle: ± 30°
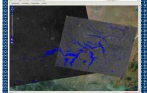
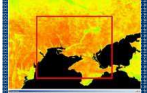- Launched 17 August 2011
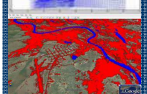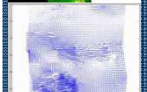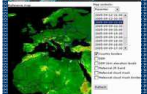 - Ukrainian Dnipro launcher

Kyiv, 1 September 2011

Conclusions

- Satellite data provide cost-effective approach to flood hazard mapping

- Integrated use of optical & radar data

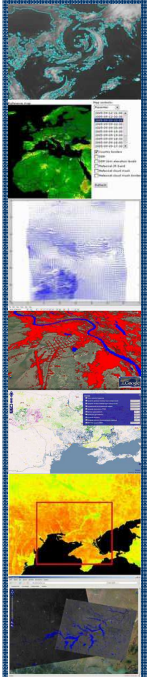- Should be exploited in conjunction with flood models to decrease errors and uncertainties

Future actions

- Integration of optical and SAR data for flood risk mapping

- Event-specific flood hazard mapping from SAR data

- To provide flood risks maps with vulnerability parameters such as:

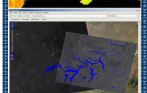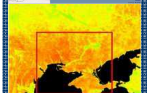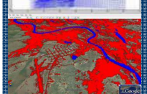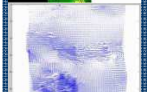 – Dwelling density (estimate number of people effected by floods)

Thank You!