The 10th GEOSS Asia-Pacific Symposium
"Accelerating the realization of the SDGs with Earth Observations: Lessons from the Asia-Oceania Region"
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Using remote sensing and modeling techniques to manage multi-purpose reservoirs in the Red River basin

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1. G2G Program

- G2G project: Government to Government

- The sub project: Water and Climate Services for Transboundary Water Management and Disaster Risk Management
- Viet Nam side: Department of National Remote Sensing (NRSD)
- Netherlands side: Netherlands Space Office (NSO)
- Principle concept of G2G:
  - to build a partnership of Vietnamese and Dutch organizations to support transboundary water management and disaster risk management.
  - closely related to the use of satellite earth observation and geographic information systems in combination with hydrologic models and other relevant models/databases.
- **This project focused on reservoirs in the Red River basin.**

2. Water conflict

The large reservoirs in the Red River basin

Conflict between:

- **Countries**
- **States**
- **Groups**

2. Water conflict

- **What we should do with the reservoirs in case:**

drought ?

flood ?

or just:

less rainfall ?

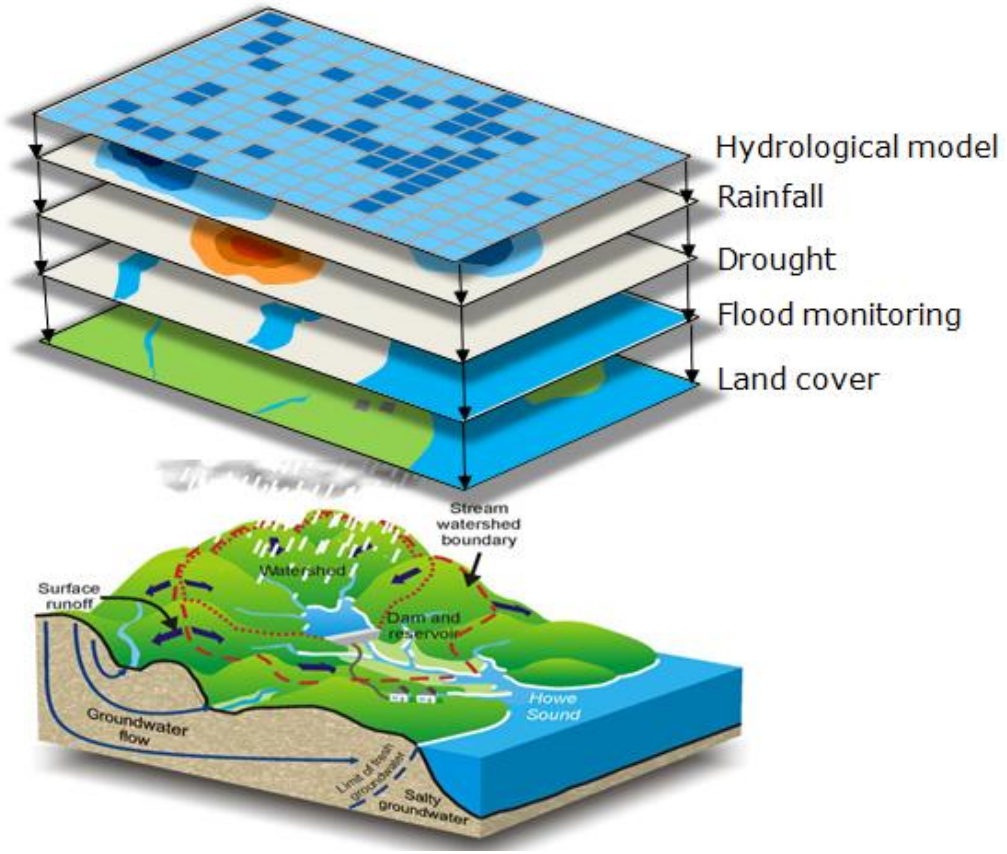
Heavy rainfall ?

=> Study possible disaster scenarios

3. Approach method

- Integrated Water Management

  •Local datasets & infrastructure (collection and delivery of data)
  •Hydrological modelling
  •Rainfall and drought monitoring



3. Approach method

- To make information data from satellite data

SPATIAL DATA
(topographical, meteo, radar)

↓

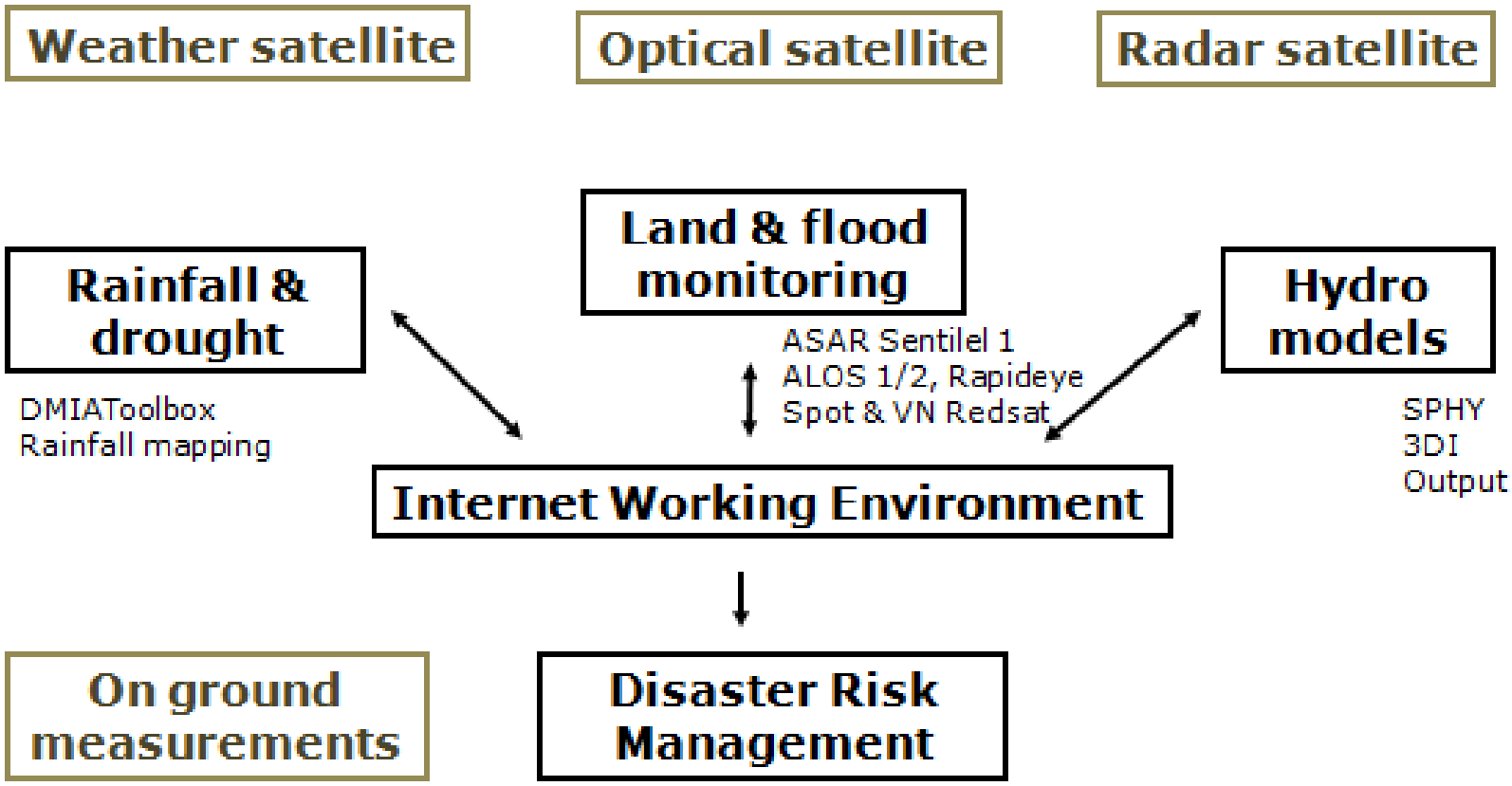
TOOLS
(rainfall mapping, DMI toolbox, lizard, sphy, 3di,..)

↓

Information products

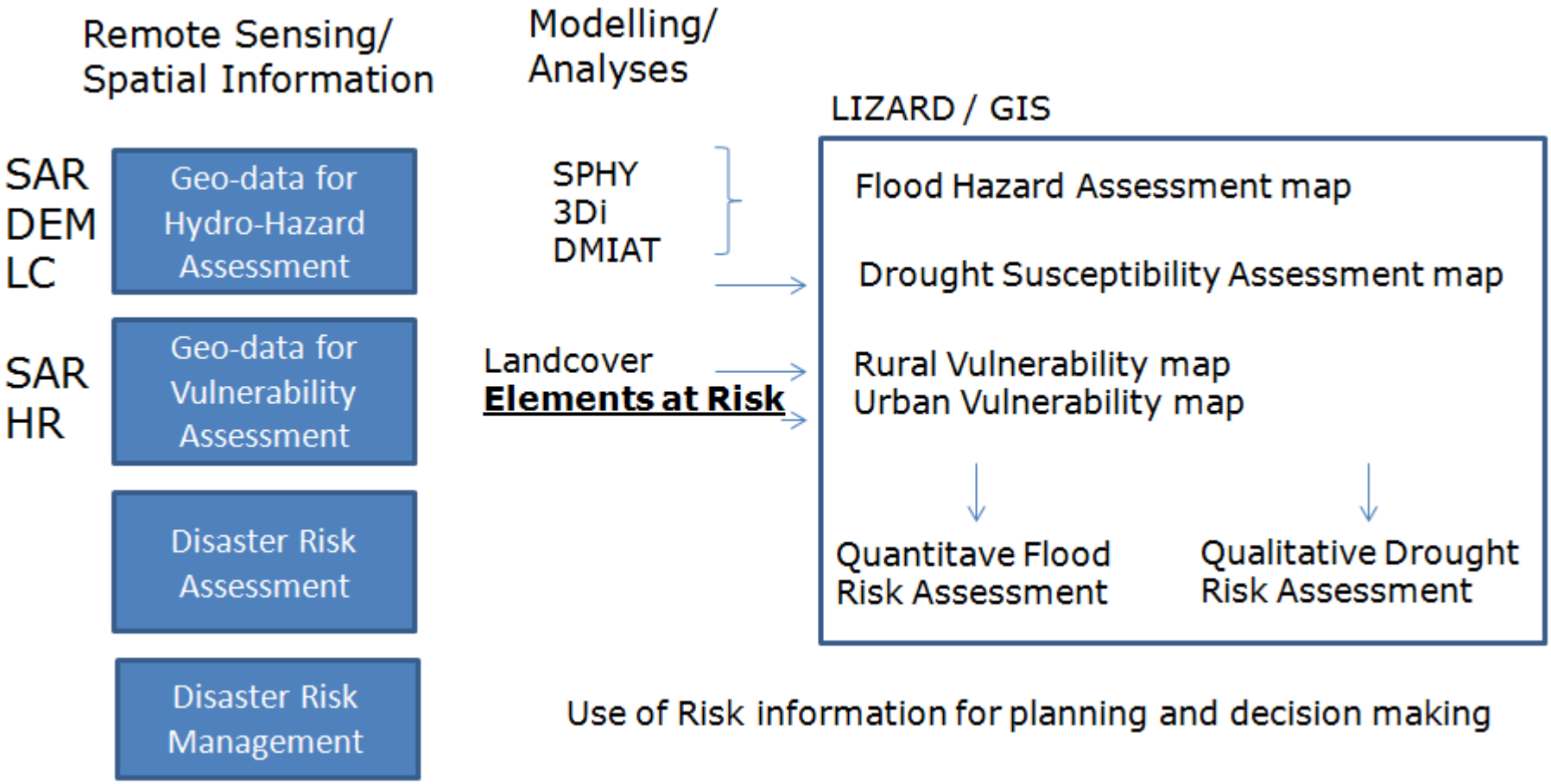
3. Approach method

- NSO proposal:



3. Approach method

- NSO proposal:

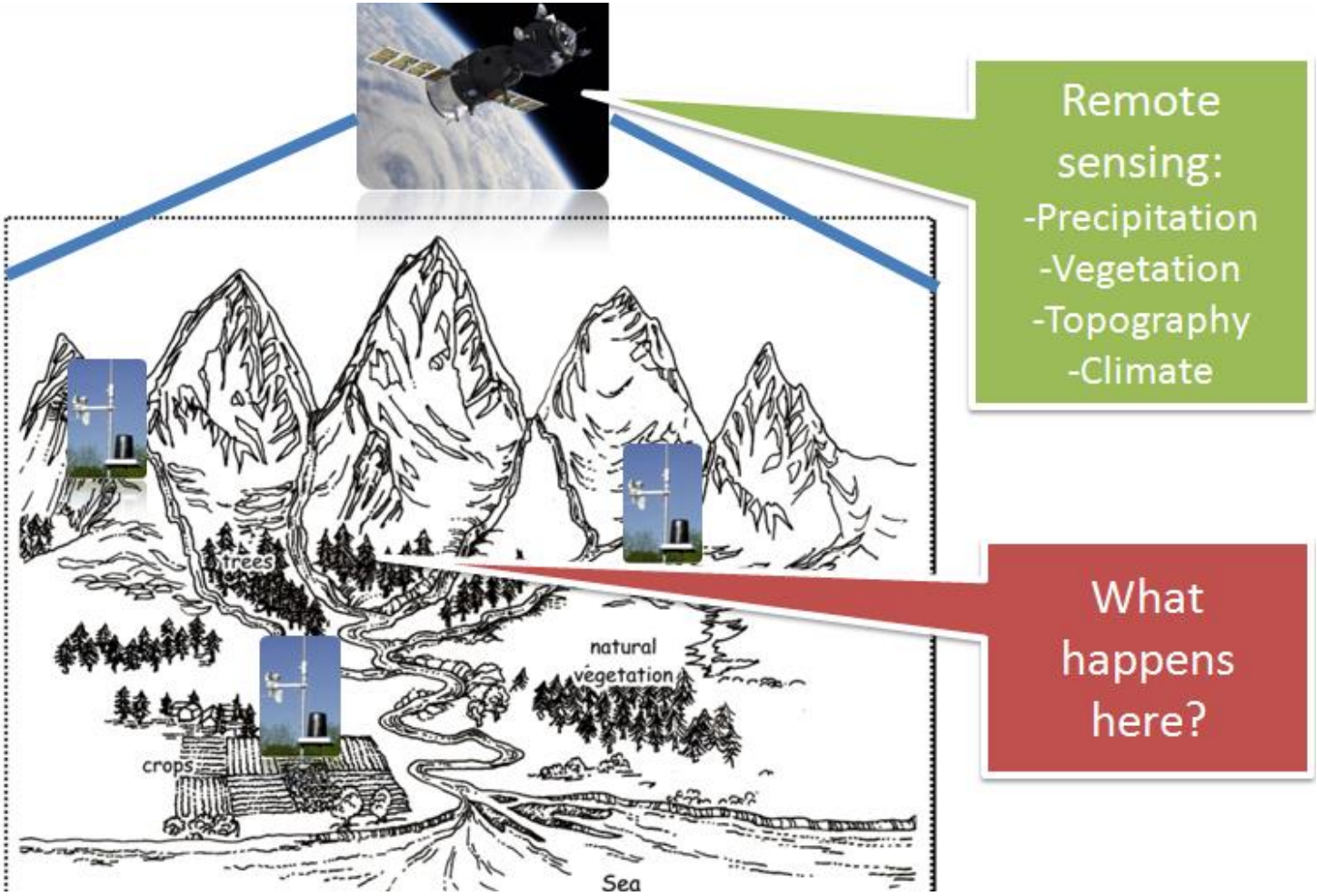


4. Rainfall mapping

- Rainfall is an important input for G2G products, and analyses in general: flood monitoring, drought mapping, irrigation advice, etc.)
- Spatially detailed information is needed, especially in mountainous areas
- Options
  - Rainfall stations (statistical interpolation?)
  - Remote sensing products (eg. TRMM, PERSIANN)

4. Rainfall mapping

- High resolution rainfall monitoring



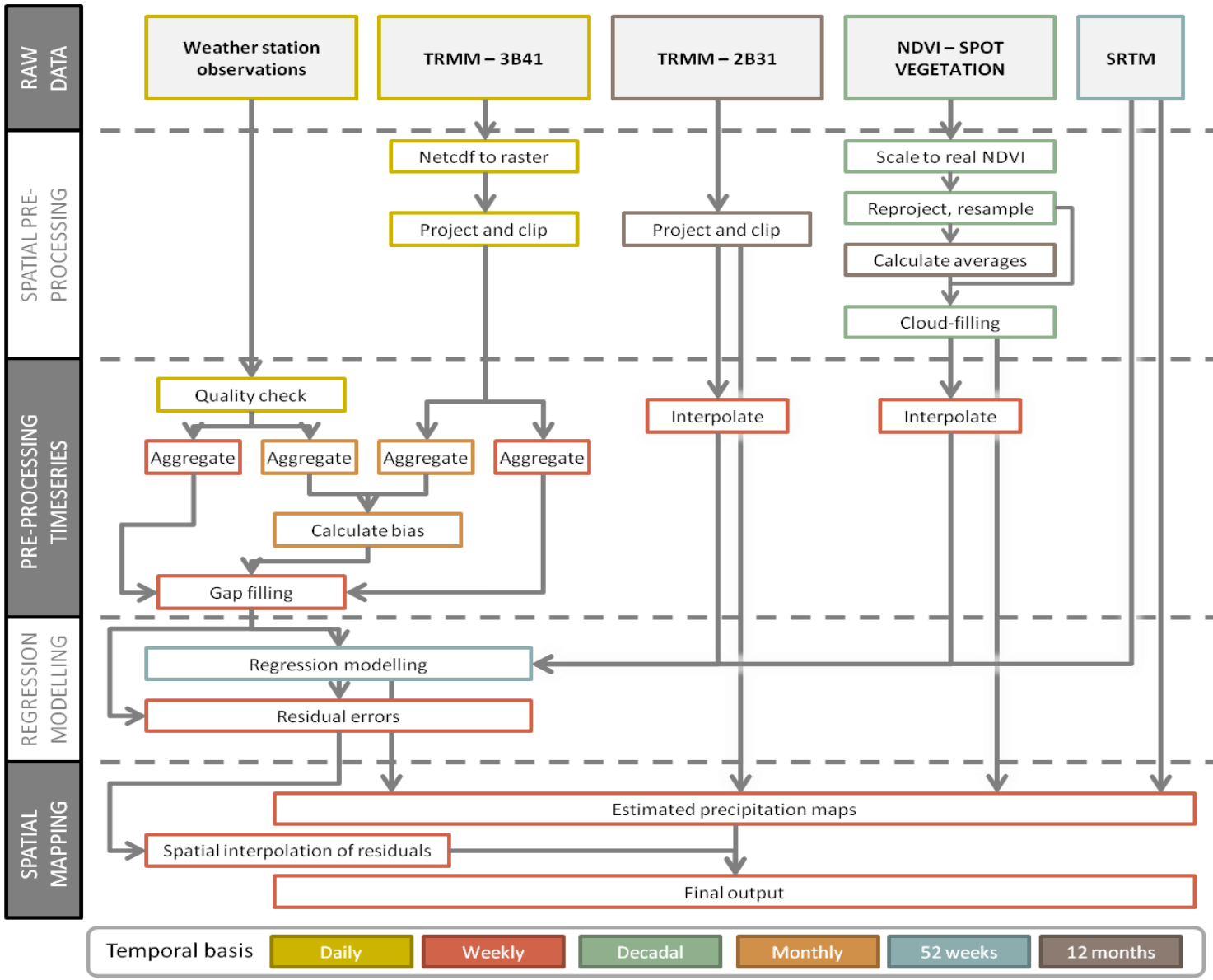
4. Rainfall mapping

- Using the data per station location for 2000-2013 (measured and remotely sensed, regression models are built):

$$PCP_j = a + b * DEM + c * CLIM_j + d * NDVI_{j+1}$$

- Accurate estimation of spatial distribution of rainfall to support decision making and hydrological planning:
  - Fill data gaps in recorded rainfall series – bias correction of TRMM
  - Predict spatial distribution of rainfall based on regression models
  - Deriving residuals per station location, and interpolate (not all explanatory variables are included in the model)

4. Rainfall mapping



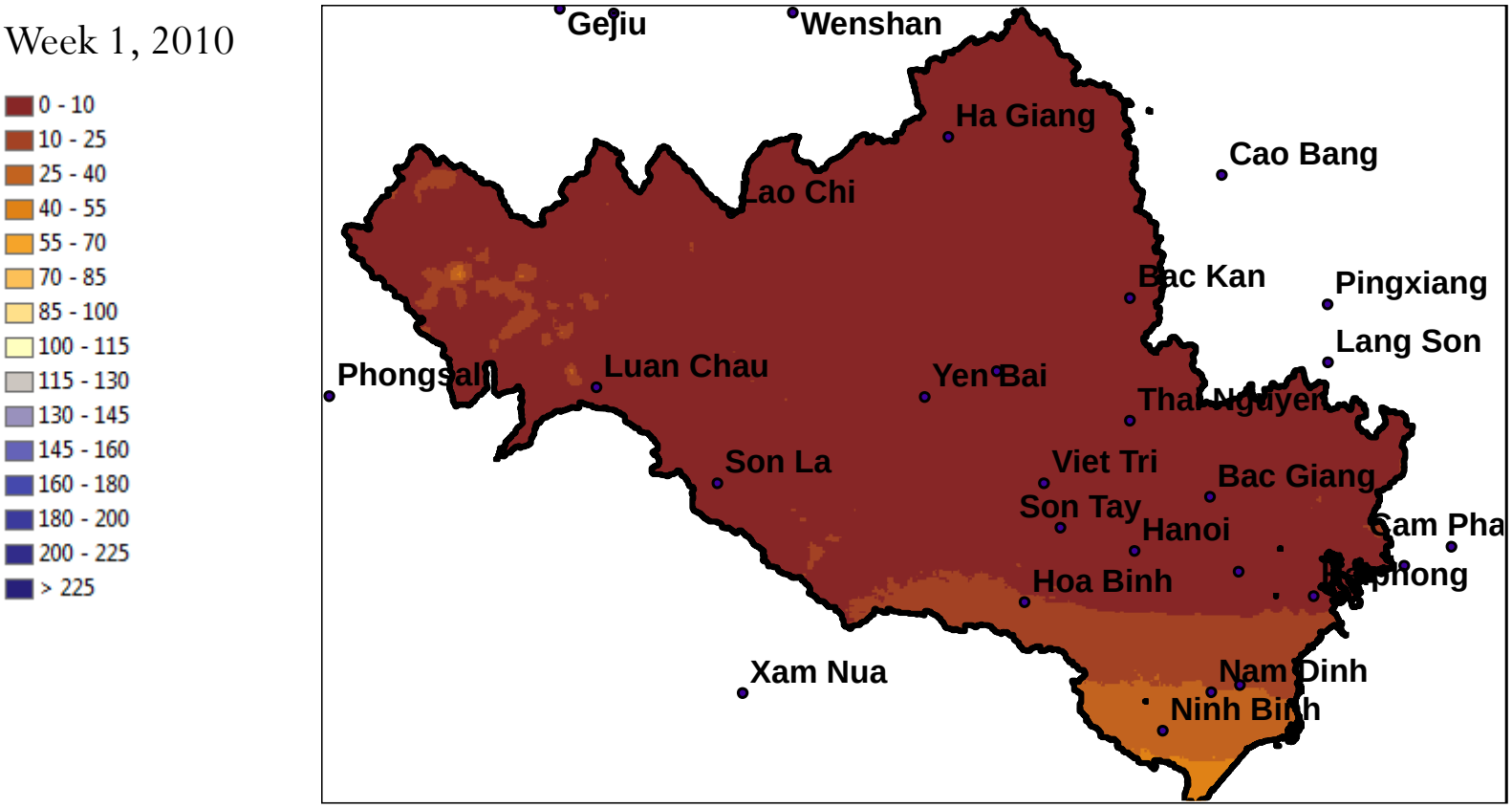
4. Rainfall mapping

- Created for the entire Vietnamese Red River Basin
- Weekly intervals, spatially discrete data with a 1 km spatial resolution
- Based on an integration of station observation and products remote sensing

4. Rainfall mapping

Weekly high-resolution rainfall maps (mm/week) of the Red River Basin in Vietnam

Week 1, 2010

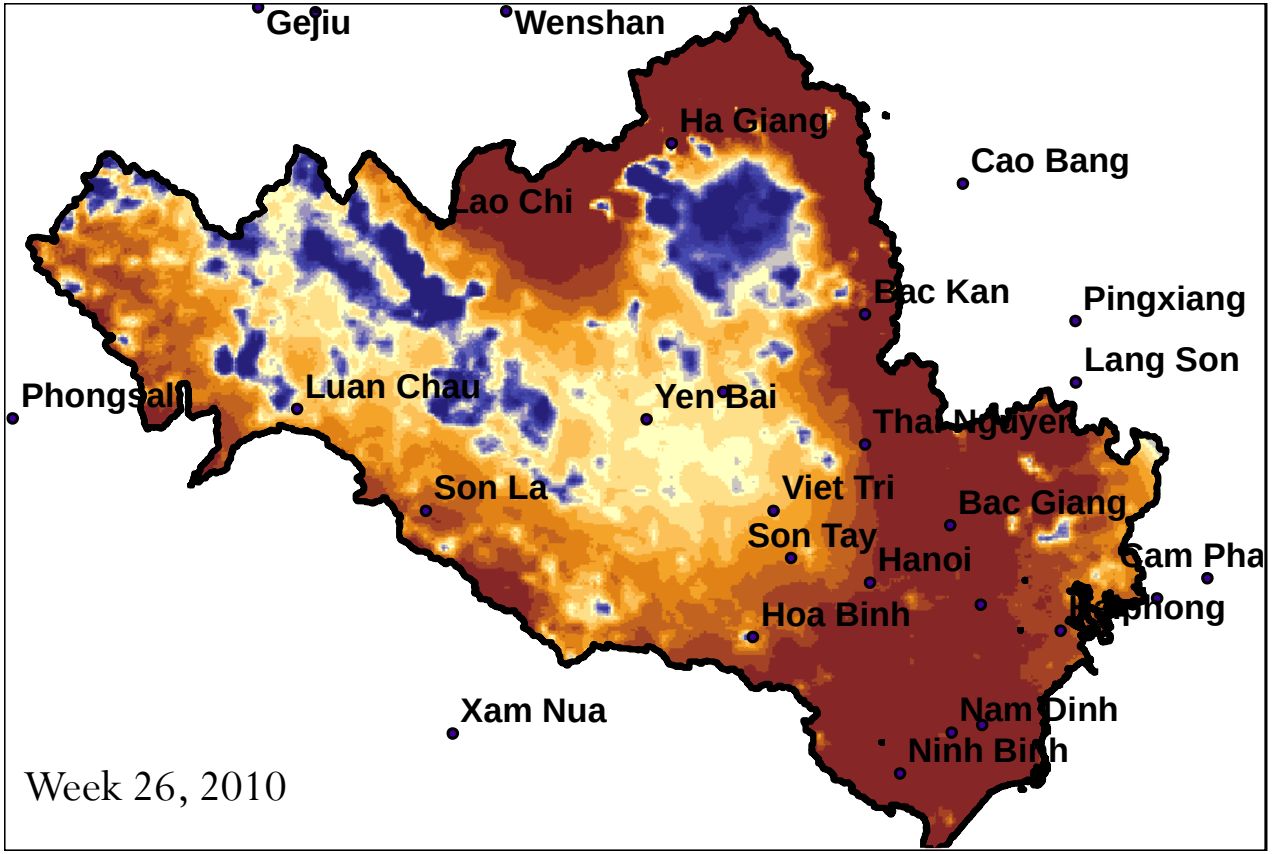


4. Rainfall mapping

Weekly high-resolution rainfall maps (mm/week) of the Red River Basin in Vietnam

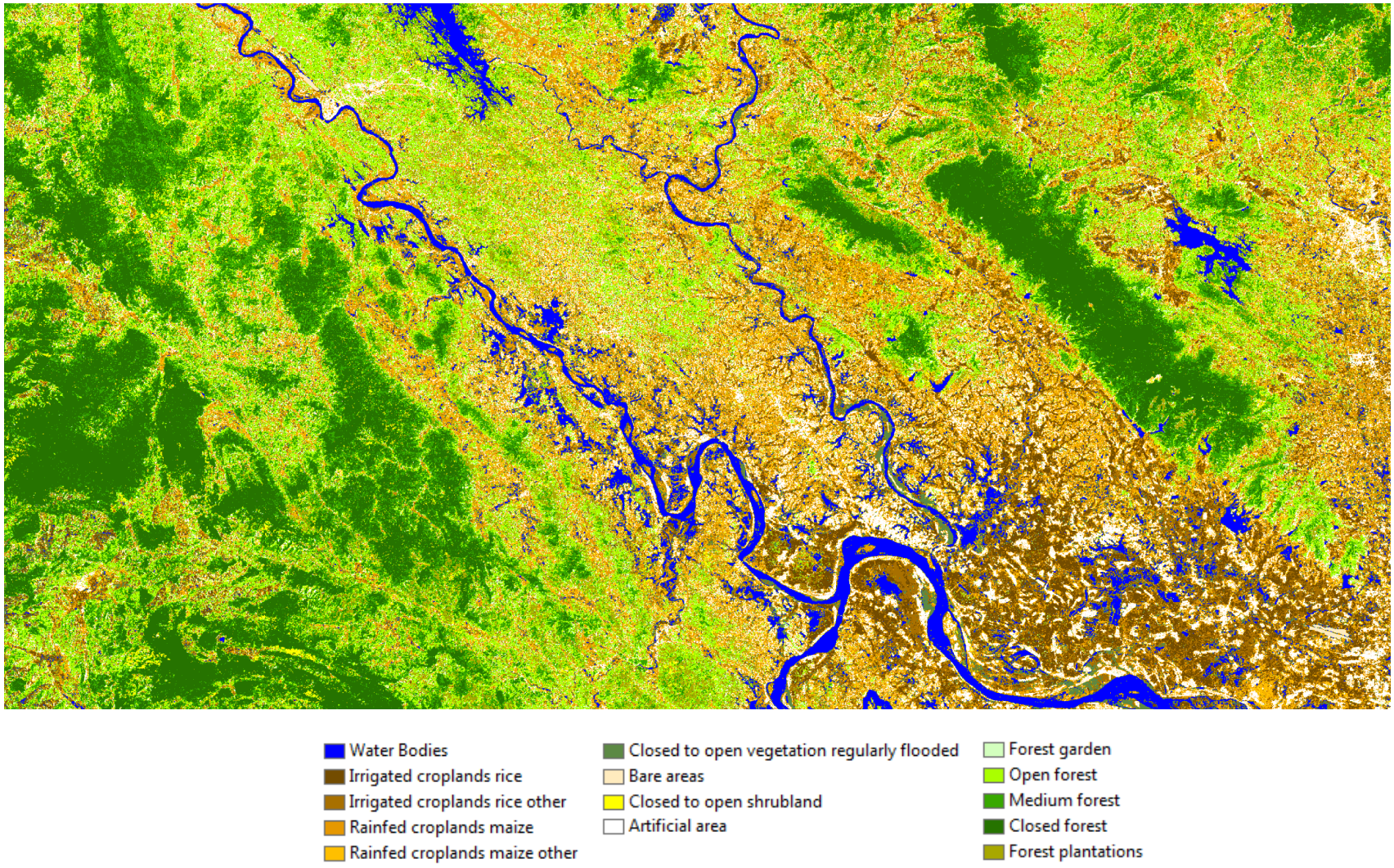
Week 26, 2010

- 0 - 10
- 10 - 25
- 25 - 40
- 40 - 55
- 55 - 70
- 70 - 85
- 85 - 100
- 100 - 115
- 115 - 130
- 130 - 145
- 145 - 160
- 160 - 180
- 180 - 200
- 200 - 225
- > 225



5. Landcover mapping

- Integrate Optical and Radar satellite data to make detail landcover map.

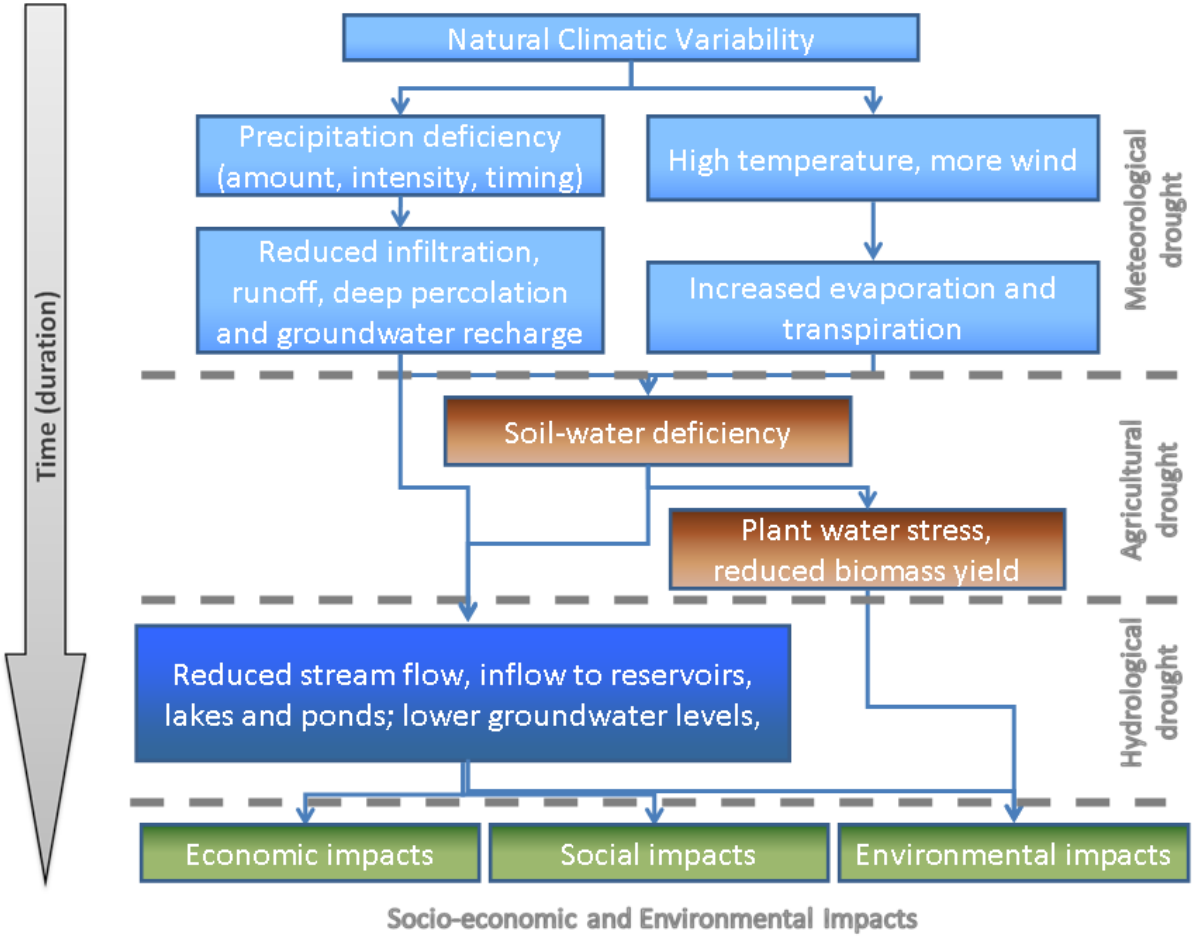


6. Drought Risk Assessment

- Drought is a serious threat to the people and the environment in Vietnam:
  - Drought can have high negative impacts on agricultural production, fishing, loss of income, navigation, hydroelectricity, and higher spreading of diseases
  - On average, 1.2 million people in Vietnam are affected per drought event – 130 mio USD of economic damage (International Disaster Database, 1980 - 2010)
  - Drought assessment and alleviation is very complex (drought impacts vary significantly across space and occur over large areas, management should include surface water, soil water and groundwater)
  - Climate change could increase drought substantially

6. Drought Risk Assessment

- **Drought processes:**



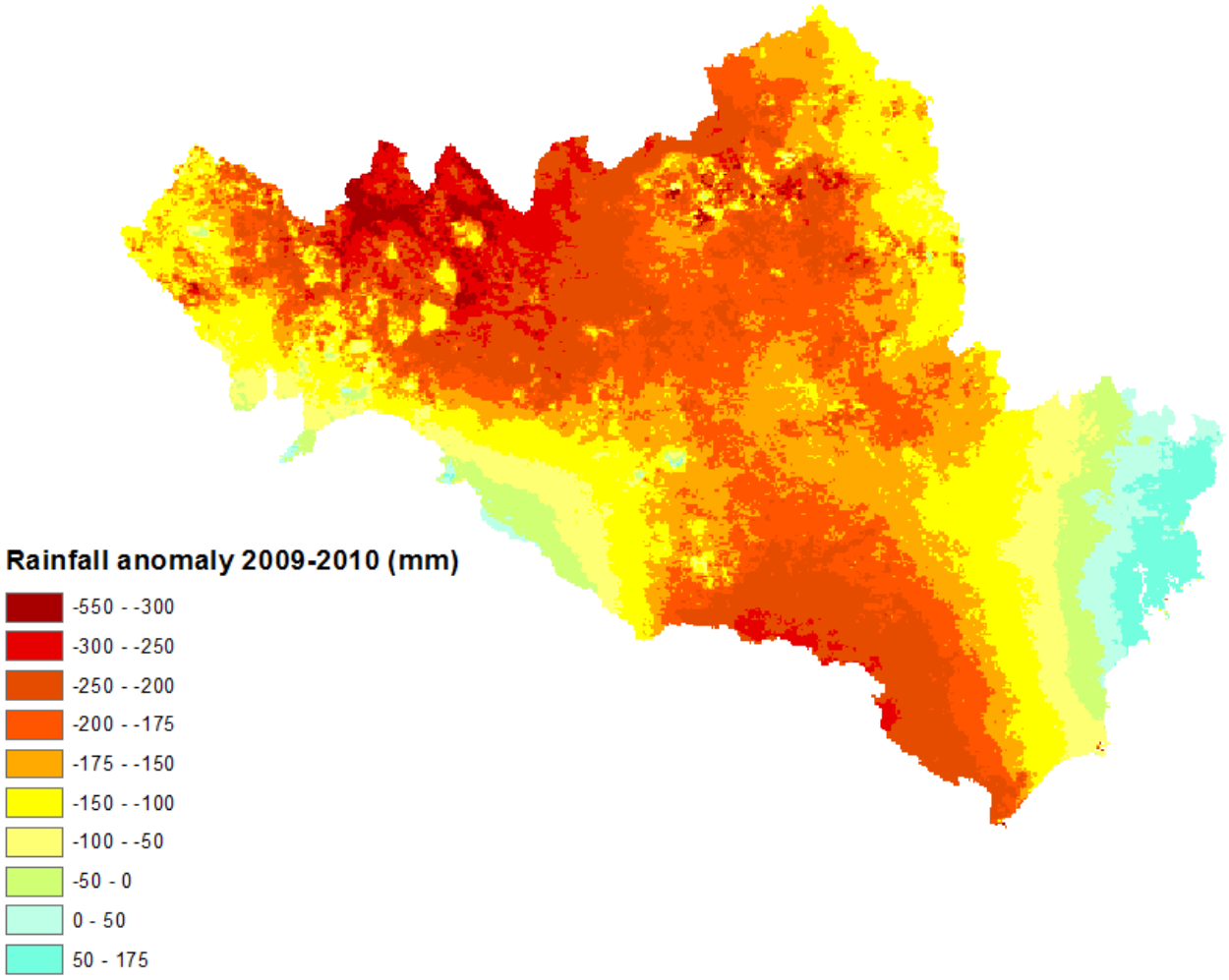
6. Drought Risk Assessment

- 2009/2010 was a very dry period: selected as a G2G focus drought period
- The water level is the lowest in more than 100 years (from 1902).

The dried-up bed of the Red River, near Long Bien Bridge in Hanoi on Dec. 1, 2009
Nguyen Huy Kham / Reuters

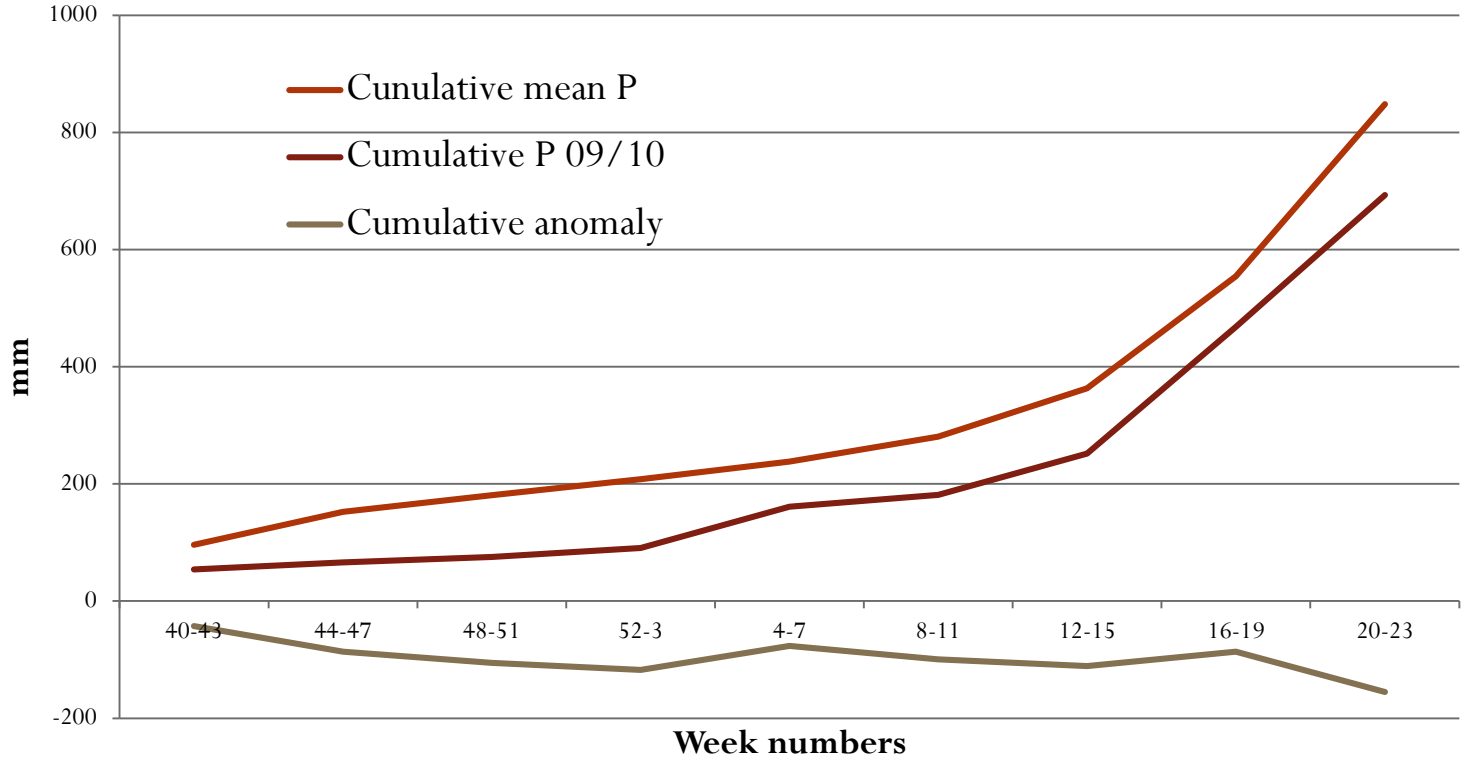
6. Drought Risk Assessment

- **Characterizing the 2009/2010 drought**



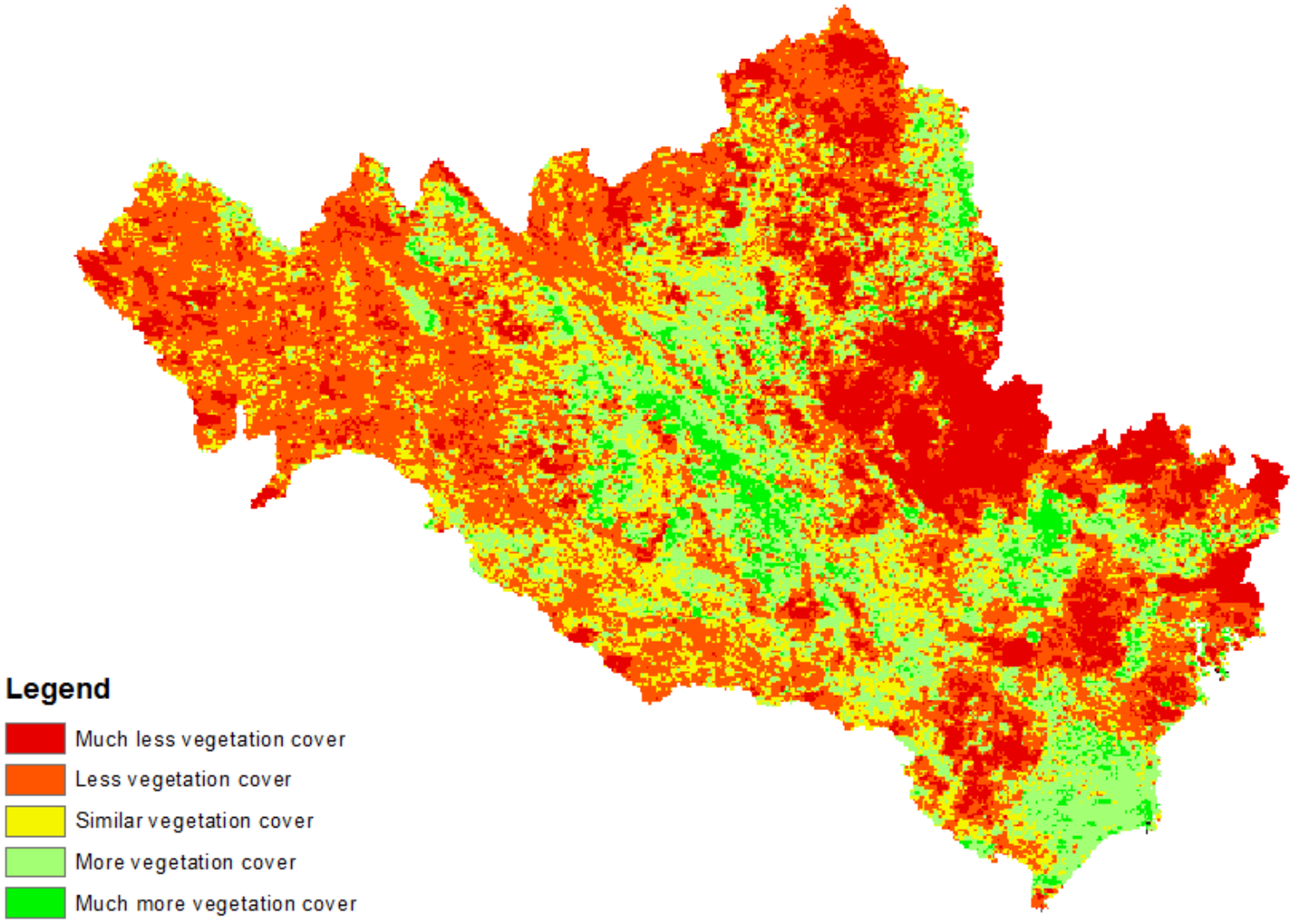
6. Drought Risk Assessment

- Rainfall time series: consistent period of negative rainfall anomaly



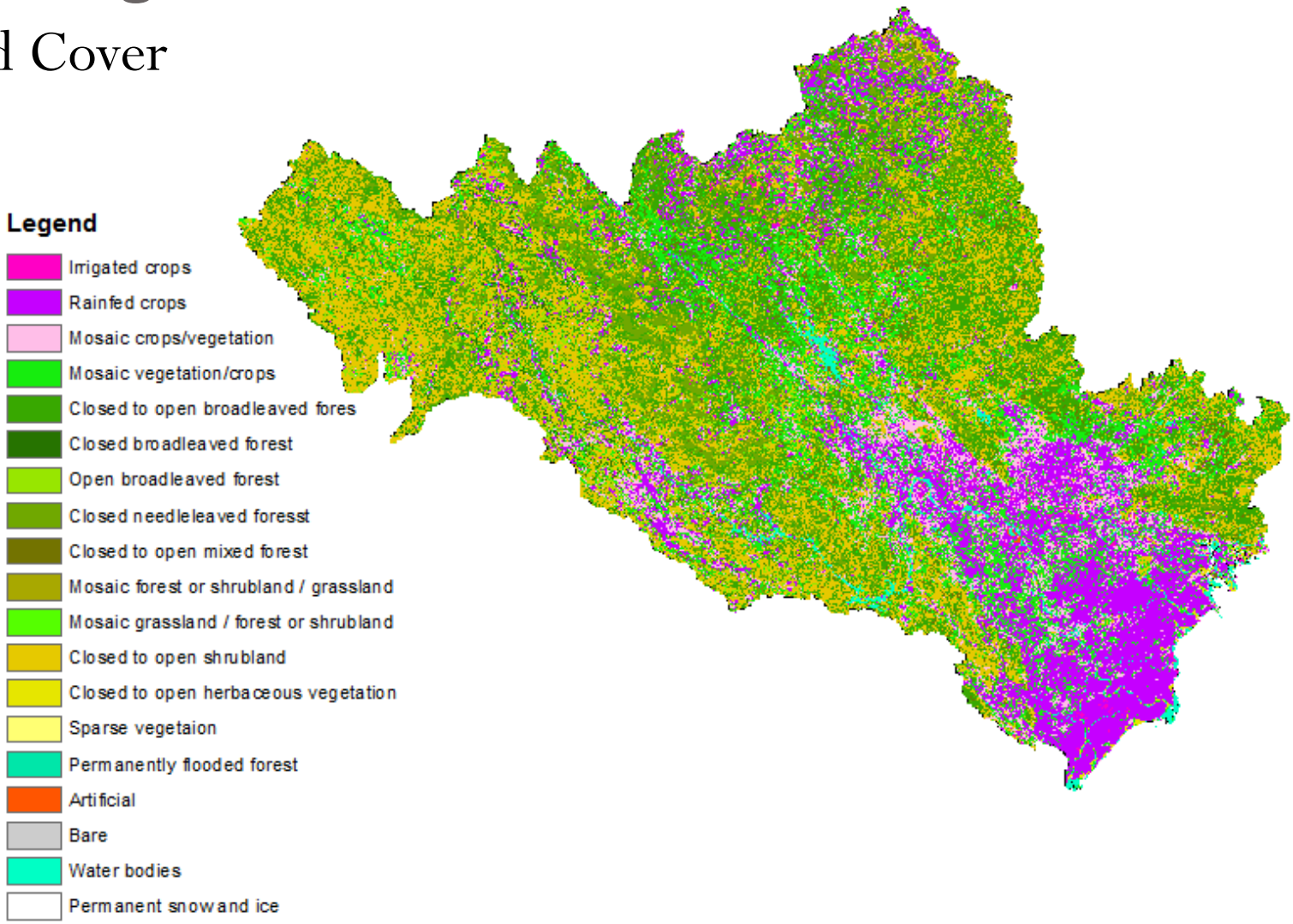
6. Drought Risk Assessment

- NDVI anomaly April 2010



6. Drought Risk Assessment

Land Cover



6. Drought Risk Assessment

Drought Risk Map Model

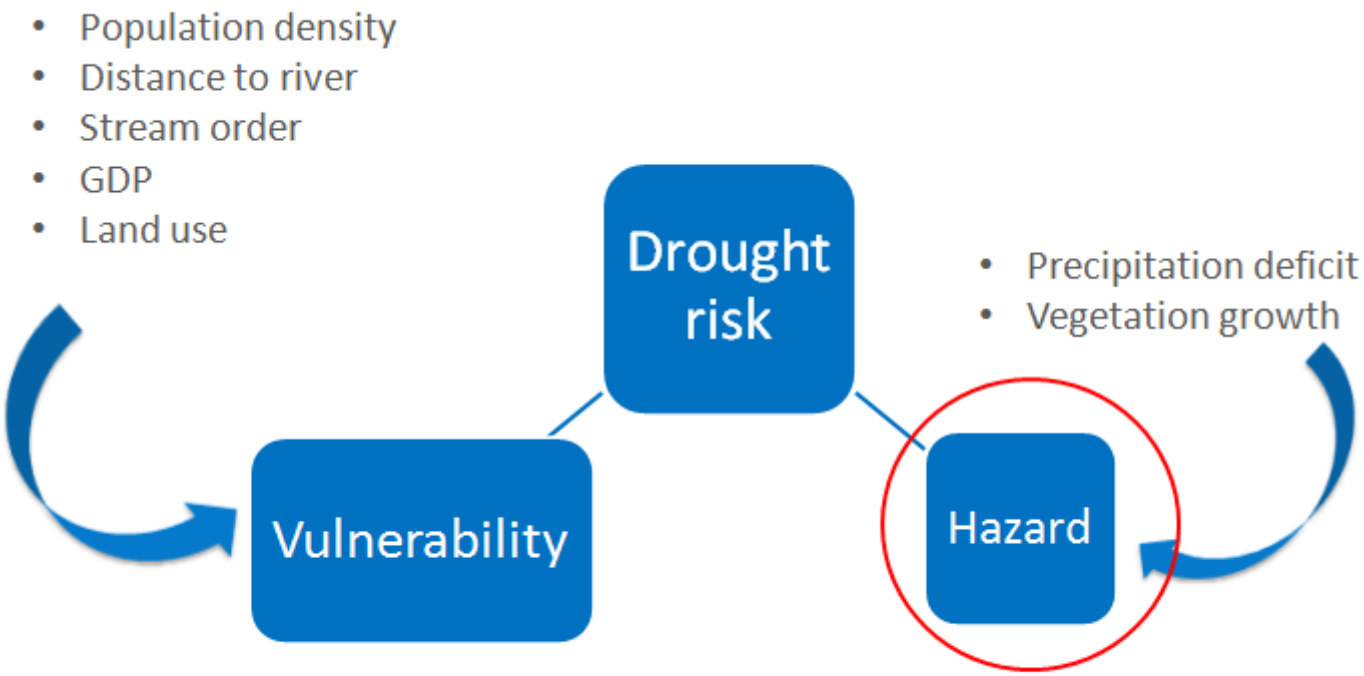
- Model was based on the relationship between Hazard and Vulnerability:

$$RISK = HAZARD \times VULNERABILITY$$

- *hazard*: the probability of occurrence of a potentially damaging phenomenon
- *vulnerability*: the degree of loss resulting from the occurrence of the phenomenon

6. Drought Risk Assessment

Drought Risk Map Model



Outputs: Hazard Index maps, Vulnerability Index maps, Drought Risk maps

6. Drought Risk Assessment

HAZARD INDEX MAP

- $DRI = DHI * DVI$
- $DHI = (HI_1 + HI_2 + HI_3 + HI_4) / 4$

in which:

HI_1 = Mean total dry season rainfall (2000-2013)

HI_2 = CV of total dry season rainfall (2000-2013)

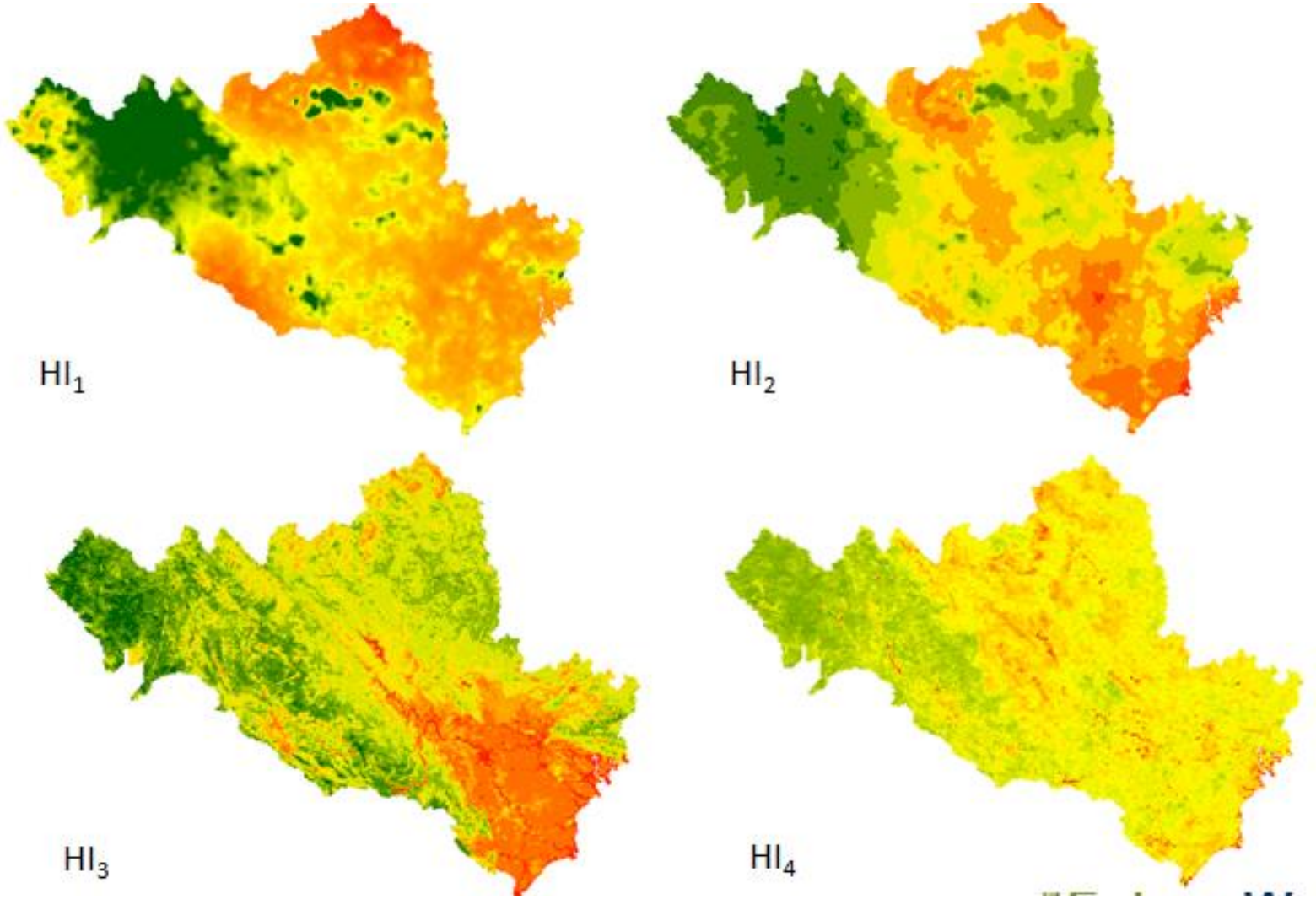
HI_3 = Mean dry season NDVI (2000-2013)

HI_4 = CV of dry season NDVI (2000-2013)

- $HI_1 = 1 - (value - min_{values}) / (max_{values} - min_{values})$
- $HI_2 = (value - min_{values}) / (max_{values} - min_{values})$

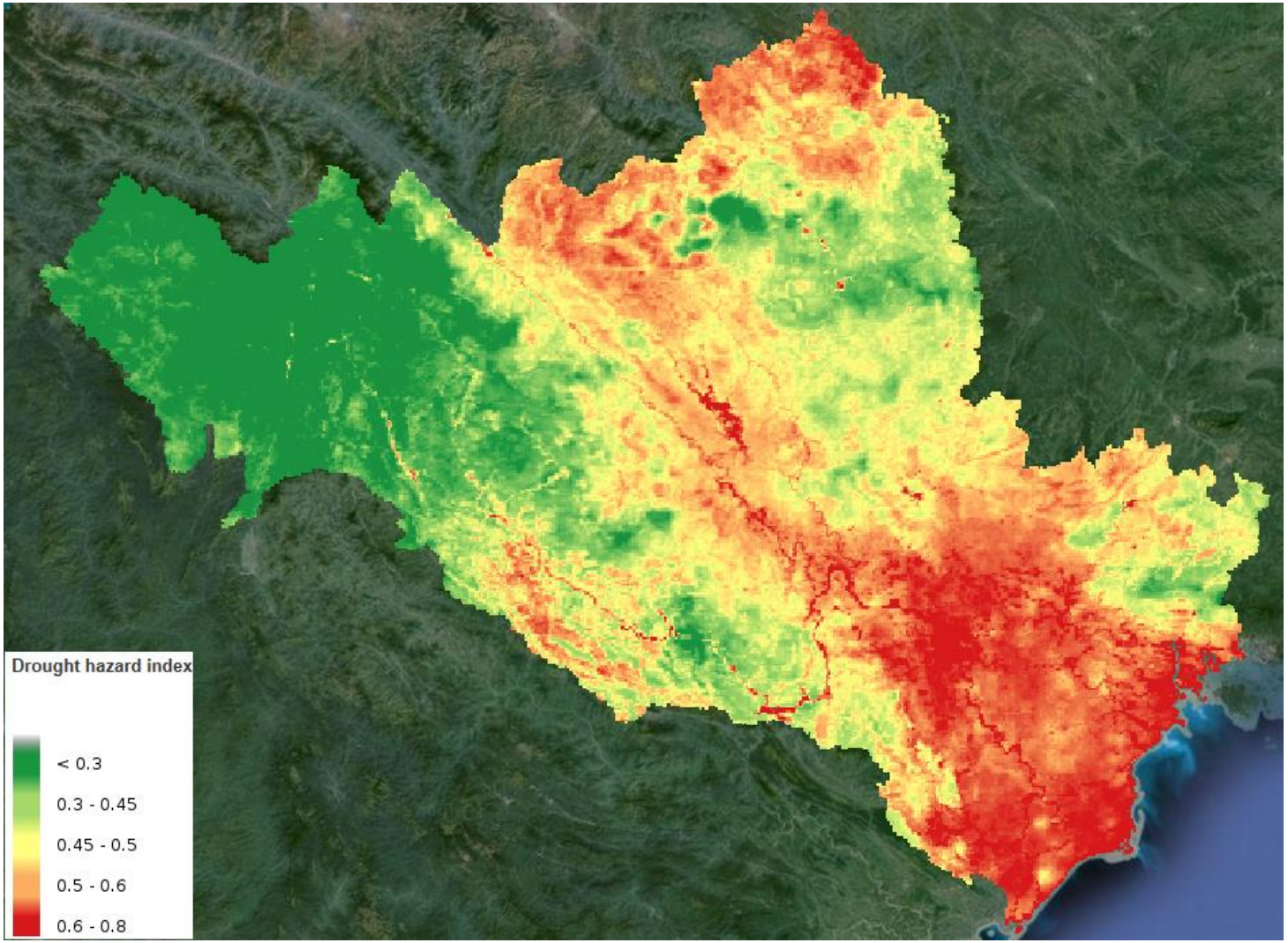
6. Drought Risk Assessment

HAZARD INDEX MAP



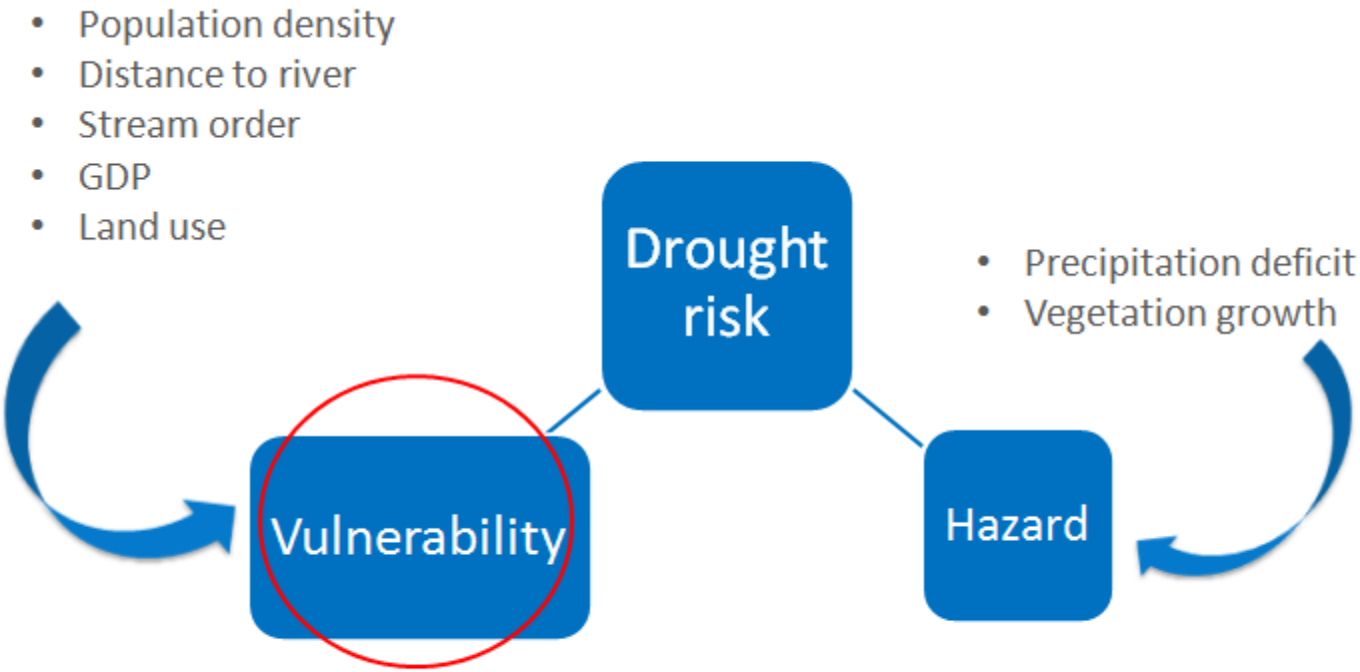
6. Drought Risk Assessment

DROUGHT HAZARD INDEX MAP



6. Drought Risk Assessment

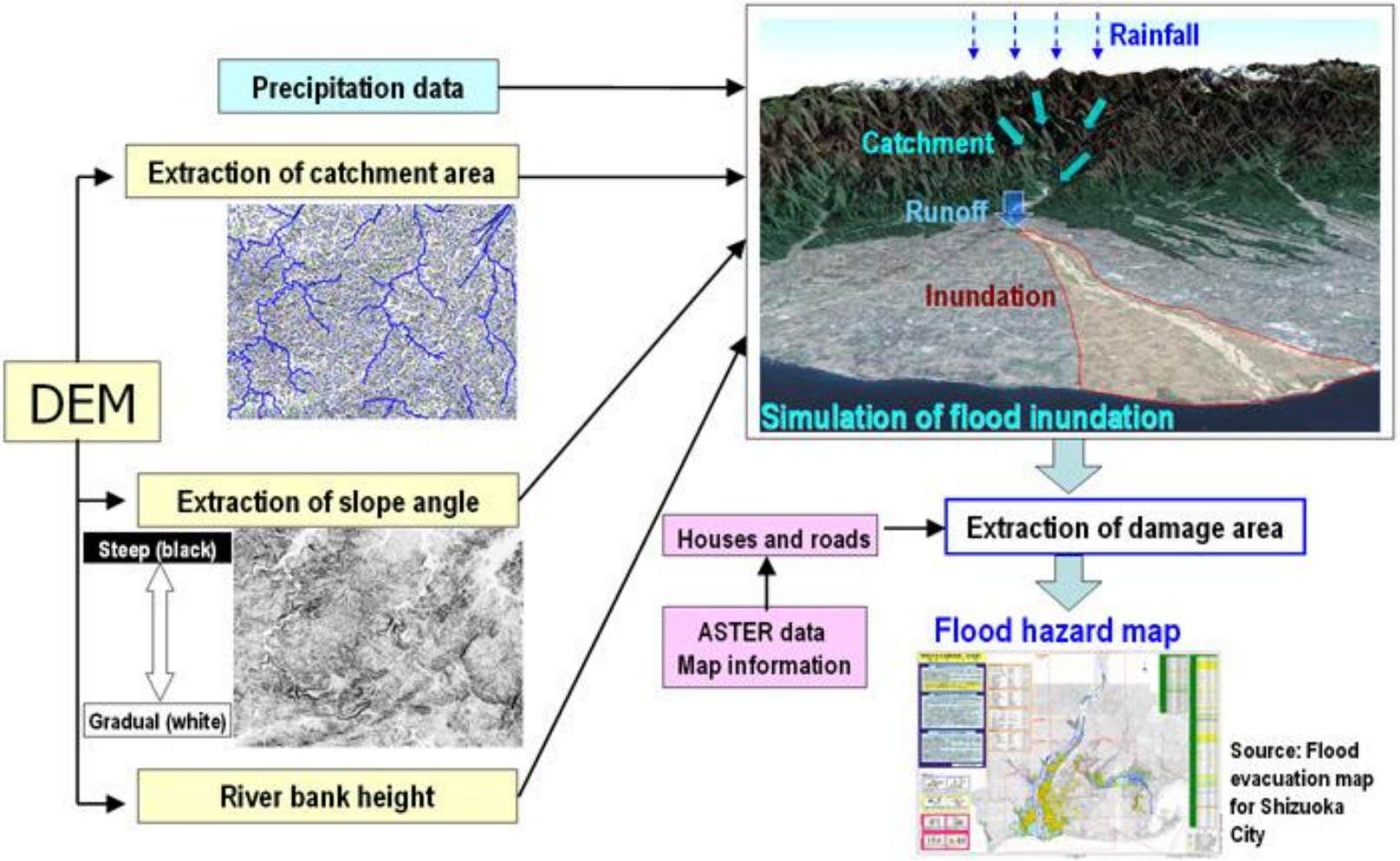
Drought Risk Map Model



Outputs: Hazard Index maps, Vulnerability Index maps, Drought Risk maps

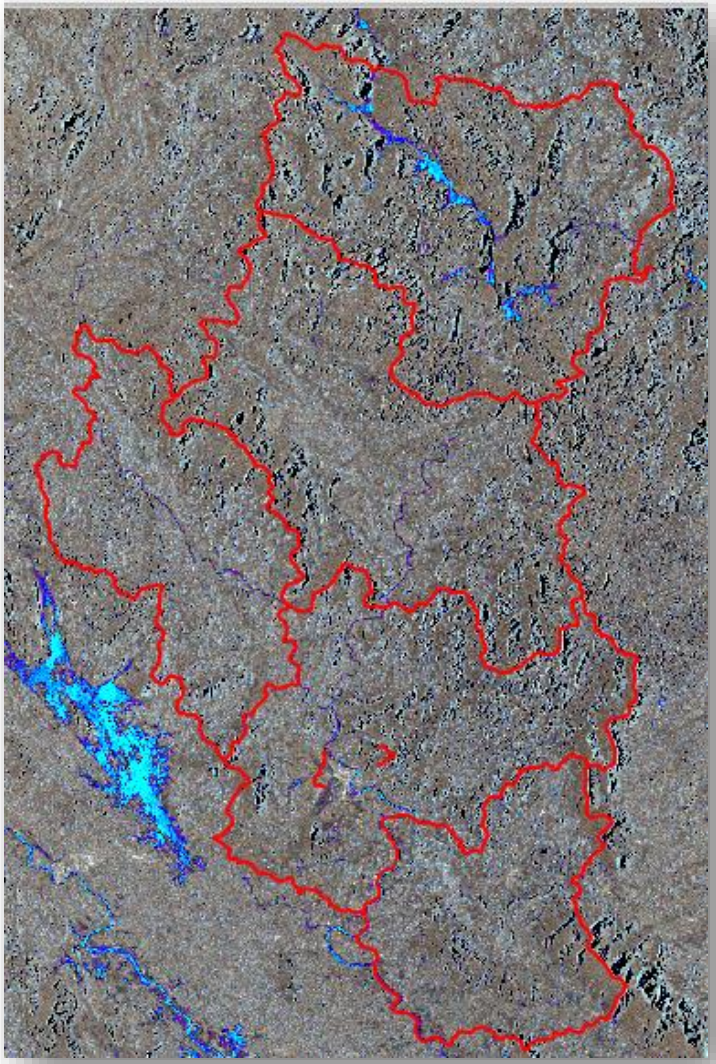
6. Flood Risk Assessment

Flood Risk Model



6. Flood Risk Assessment

Flood mapping



ALOS PALSAR Wide Beam
resolution ca. 100m

Extract flood / non-flood events
from radar time series;
count flooding events

Dates of PALSAR WB time series:

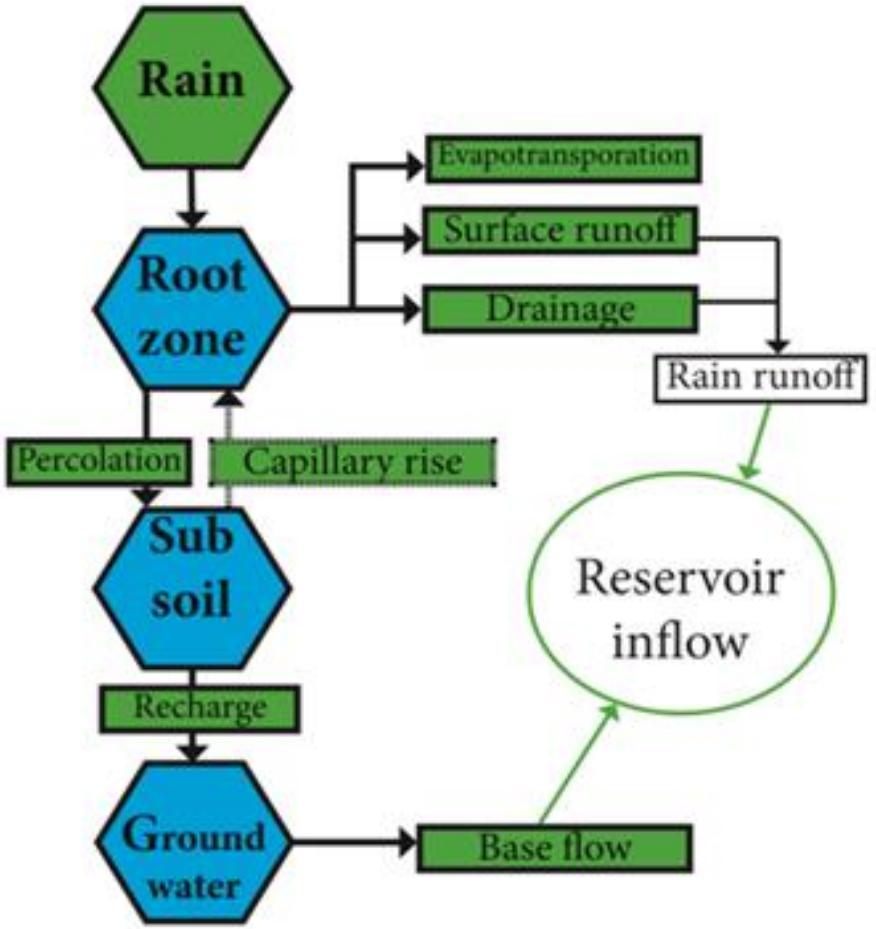
20070813
20070928
20090628
20090703
20090818
20090928
20100706
20101001
20101006

6. Flood Risk Assessment

Reservoir inflow (and outflow)

SPHY

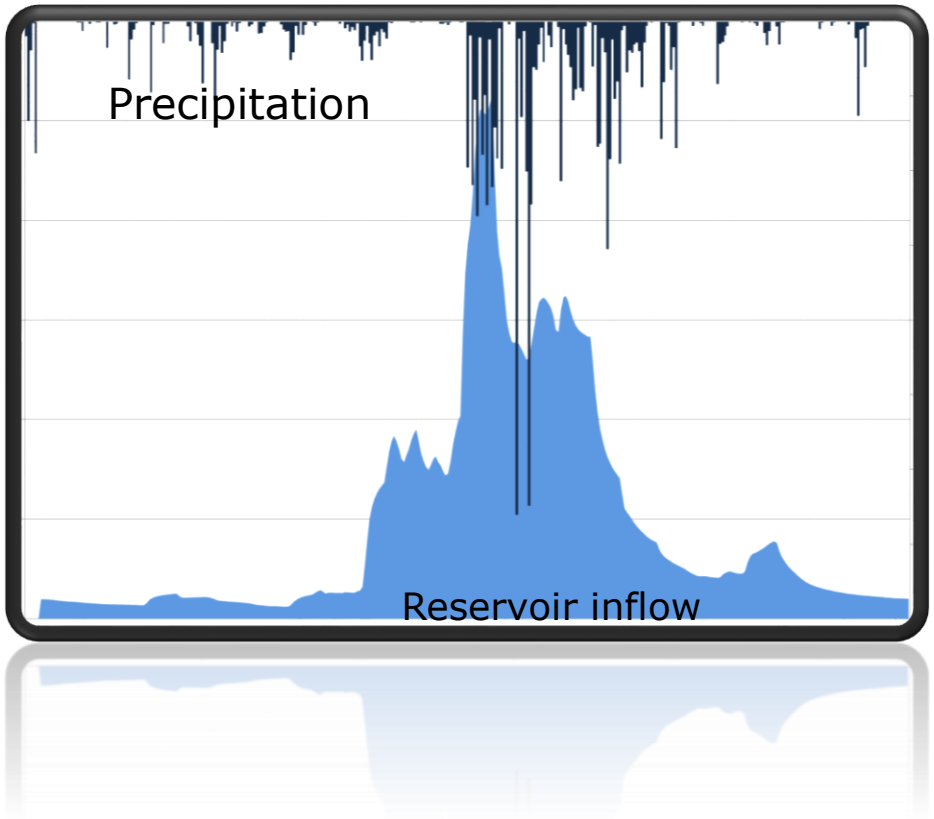
- SPHY (**S**patial **P**rocesses in HYdrology)
- Developed by FutureWater
- Raster based model
- Easy to use with remote sensing data
- Advanced routing scheme
- Open source



6. Flood Risk Assessment

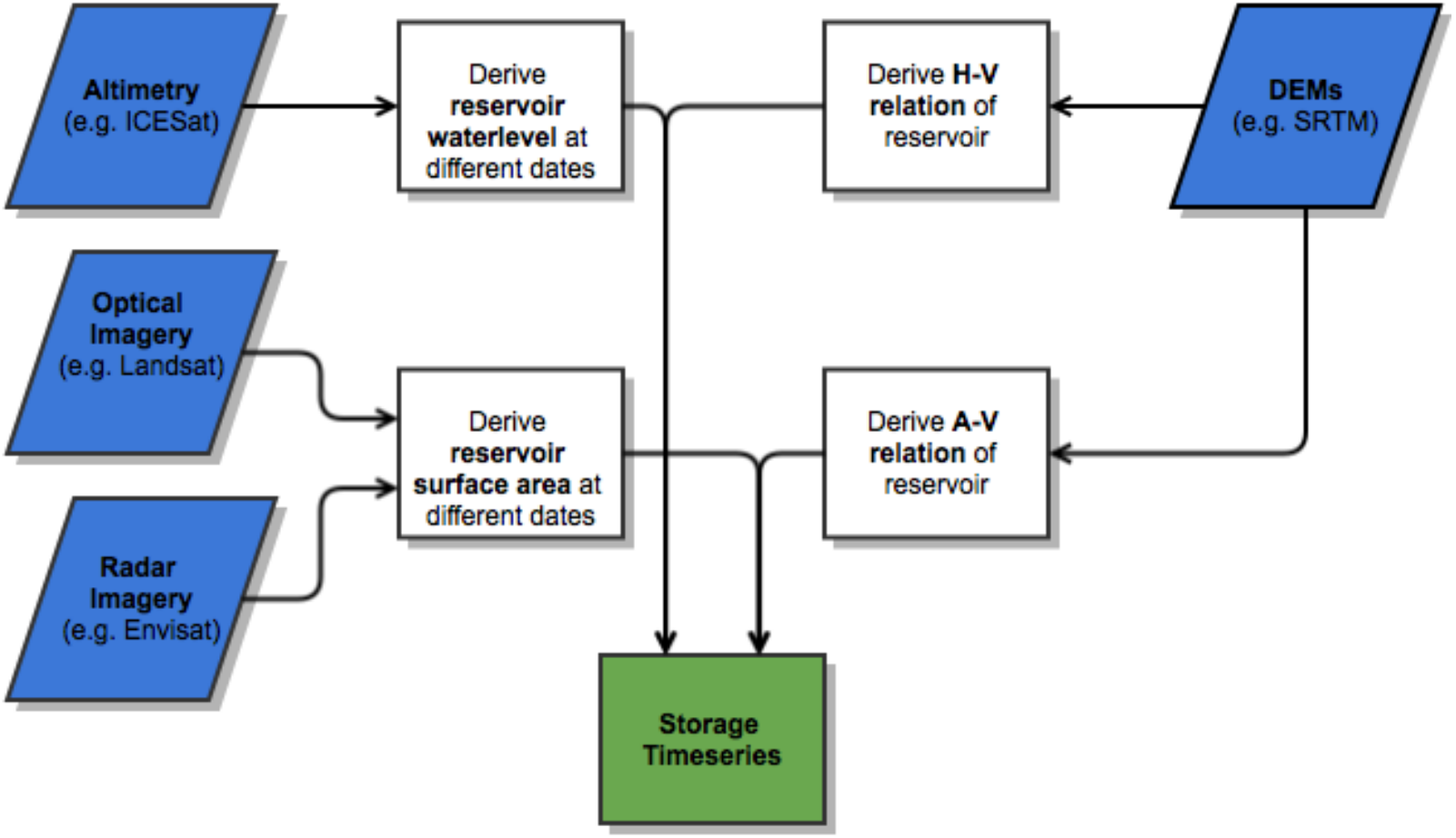
Reservoir inflow

- There are more possibilities for use of precipitation and land cover maps.
- With the hydrological mode SPHY we predict the inflow of reservoirs and evaporation
- The timescale is daily and the spatial resolution 100 by 100 meter



6. Flood Risk Assessment

Storage Timeseries Up-to-date model



6. Flood Risk Assessment

Flood Risk

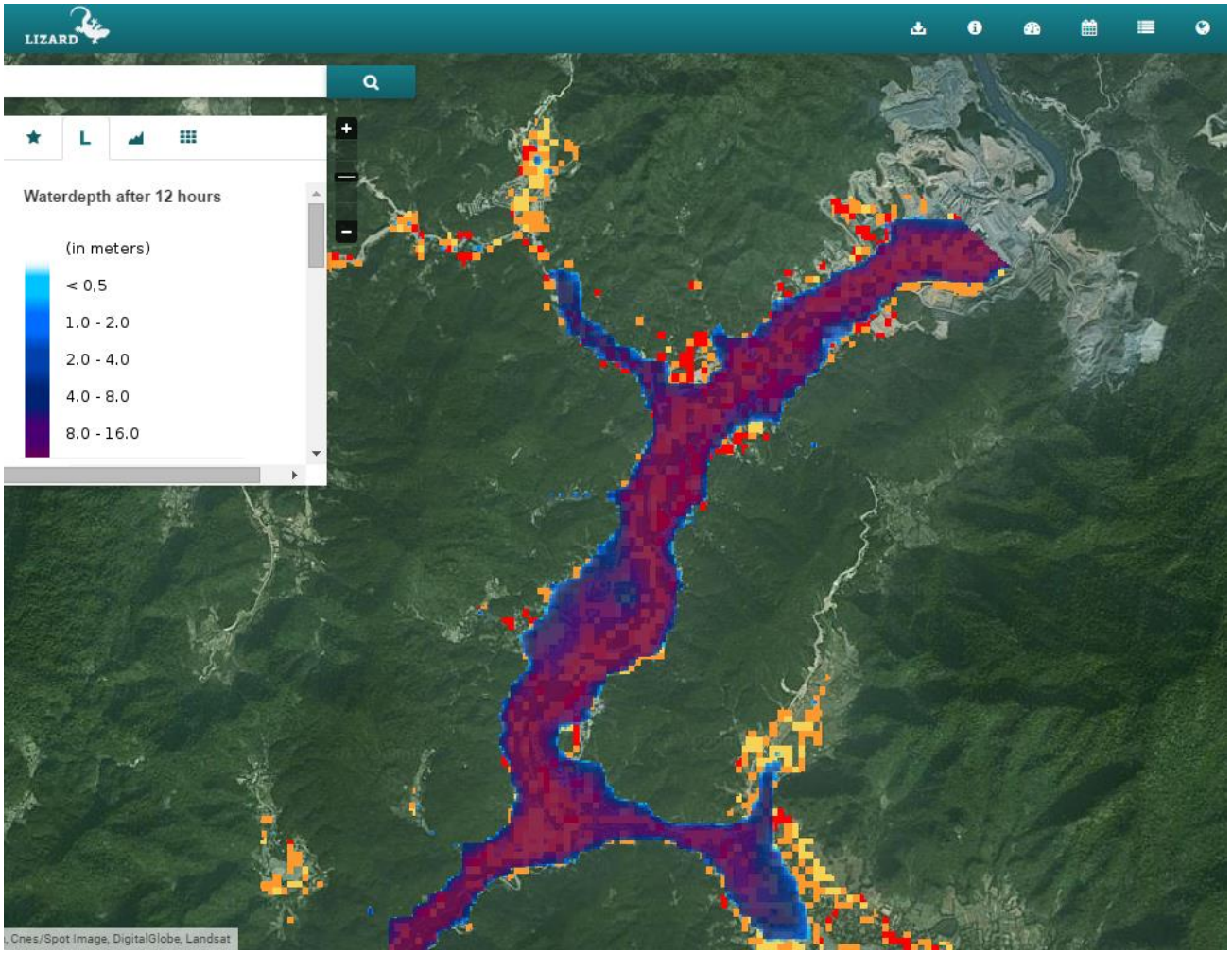
- State-of-the-art flood model
  - ✓High level of detail 15x15 m^2
  - ✓Online, fast and interactive

- Damages and losses:
  - ✓Flood scenario & land cover
  - ✓Estimate damages ($ / m^2)

- Useful for:
  - ✓Evacuation plans
  - ✓Urgent measures
  - ✓Urban spatial planning

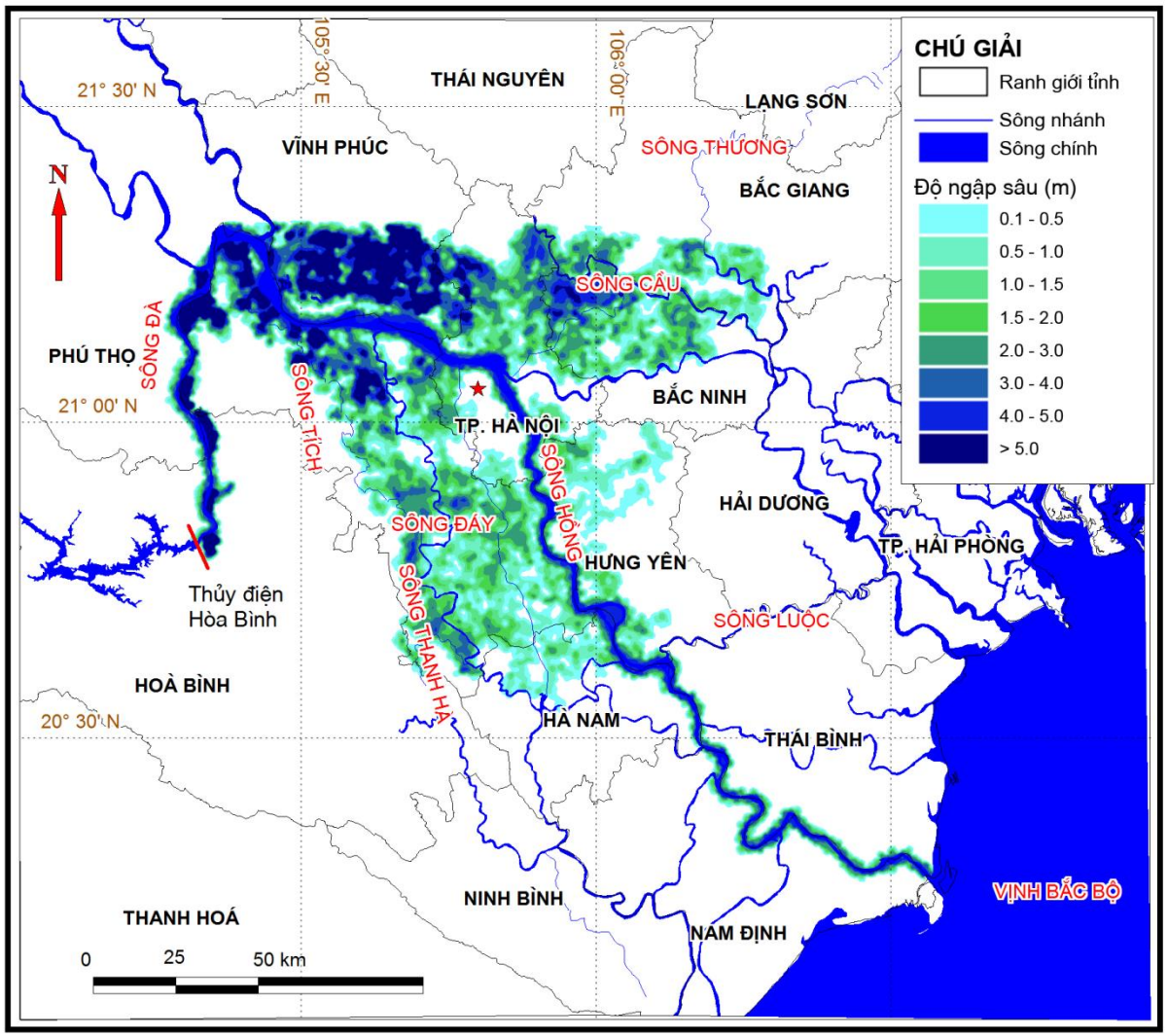
6. Flood Risk Assessment

Flooding map in case: Na hang dam break scenario



6. Flood Risk Assessment

Flooding map in case: Hoa Binh dam break scenario



- Run 2 videos

6. Conclusion

- Remote sensing and modeling techniques is very useful for the monitoring and management of Water and Disaster risk of the reservoirs in the Red River basin.

-This project shows that remote sensing not only to extract information of landcover , water bodies, rainfall to provide input data of models but also to validate models.

- To develop two main disaster scenario: flood and drought, many models were built and developed in this project as:

- ✓Improving the density of rainfall data for the Red River basin
- ✓Combined radar and optical data to extract highly detail of landcover , water bodies information.
- ✓Drought Risk Map Model
- ✓Reservoir inflow (outflow) model
- ✓Storage Timeseries Up-to-date model
- ✓Dam break model
- ✓Flood inundation model

There is no sociology or economics model in this project so this need to research in the future.

Netherlands Space Office

Thank you for attention

ITC UNIVERSITY OF TWENTE.

FutureWater

TU Delft

Nelen & Schuurmans

SarVision