# Application of satellite remote sensing in natural hazard management: the Mount Mangart landslide case study

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# Introduction

- Mount Mangart landslide
- First landslide on 15 November 2000
- Liquefaction
- Second landslide in the night from 16 to 17 November 2000
- Travelling velocity 8 to 15 m/s
- Approximately 3.000.000 $m^3$ of material moved
- Seven people died
- Immense damage
  - bridges, roads
  - changed countryside


Murska Sobota
Maribor
Log pod
Mangartom
Kranj
Ljubljana
Nova Gorica
Novo mesto
Koper
N
0
20 km

# Introduction (3)

Photo by Igor Modic

# Space and Major Disasters

- UNISPACE III conference in July 1999
- Charter started in October 2000 by
  - European Space Agency (ESA)
  - Canadian Space Agency (CSA)
  - Centre National d'Etudes Spatiales (CNES)
- Joined later
  - National Oceanic and Atmospheric Administration (NOAA)
  - Indian Space Research Organization (ISRO)
  - Argentine Space Agency (CONAE)
  - Japan Aerospace Exploration Agency (JAXA)
- The Mount Mangart landslide is the first time it was activated
- 80 actions in five years

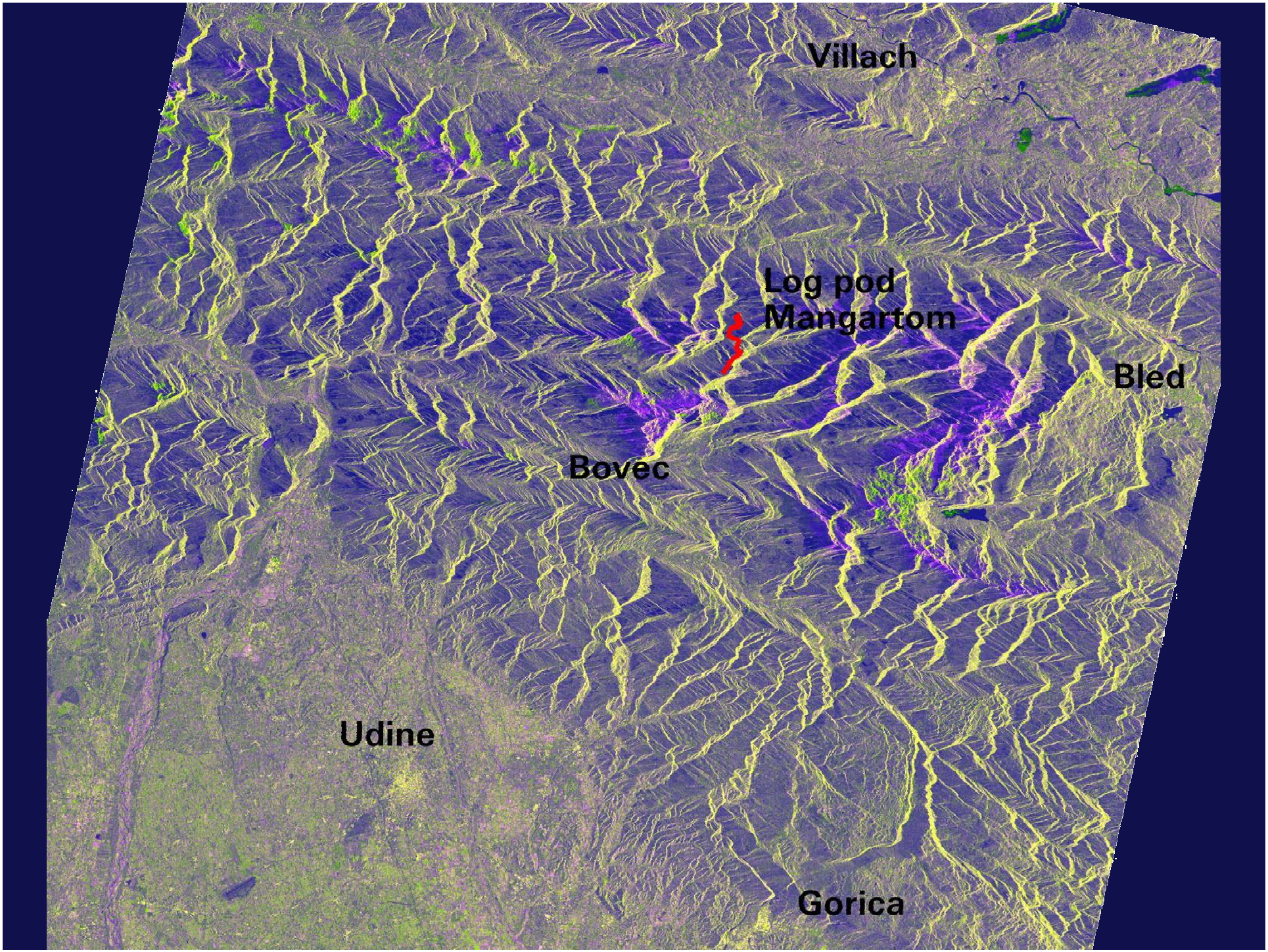
# Space and Major Disasters (2)

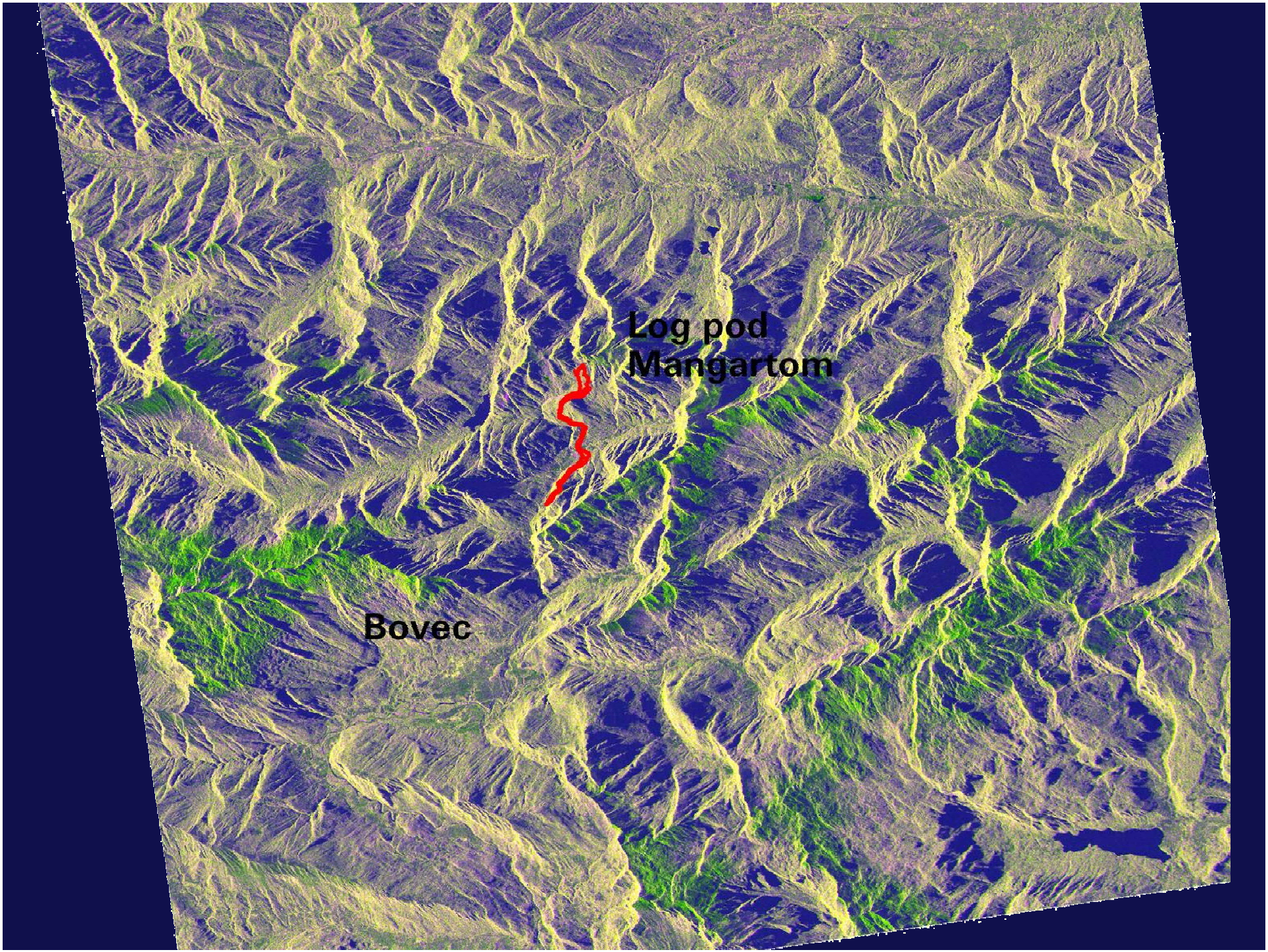
# Remote sensing

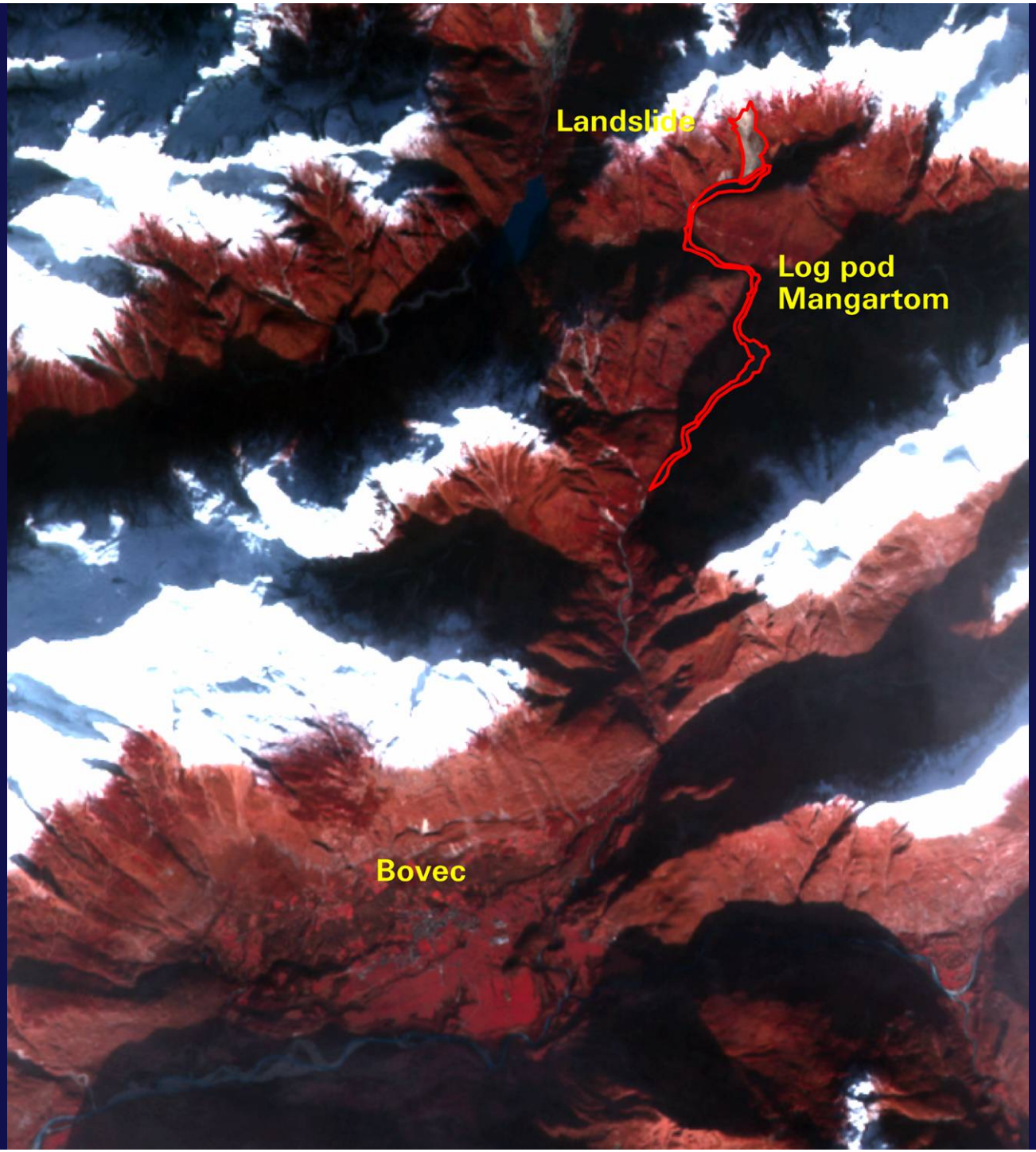
- Acquisition plan
  - SPOT and RADARSAT observed western Slovenia for several weeks
- 13 satellite images were used in total (8 obtained in the frame of the Charter)
  - 5 ERS (1 and 2),
  - 2 RADARSAT,
  - 4 SPOT, and
  - 2 Landsat
- As an additional layer a digital elevation model InSAR DEM 25 was used

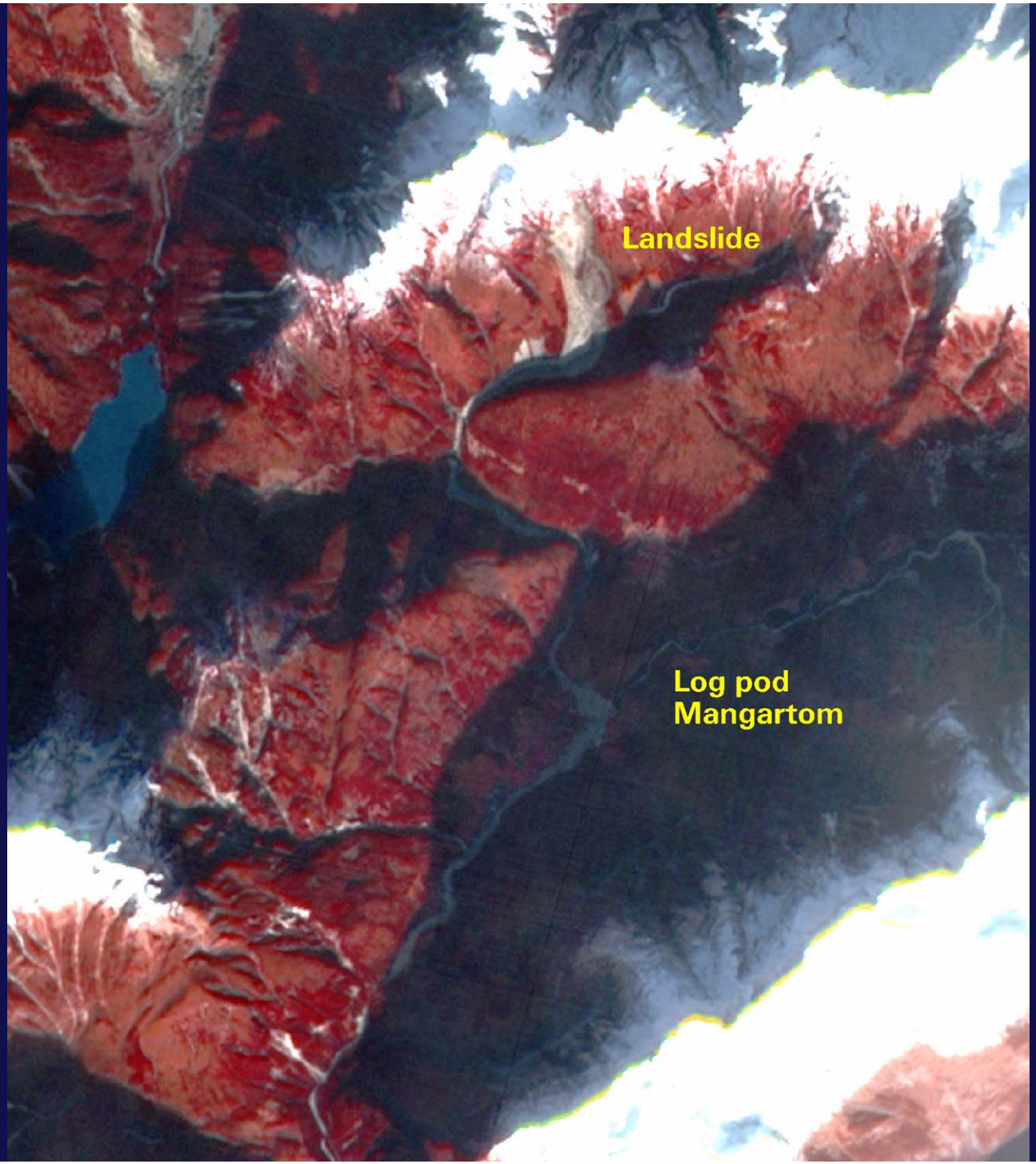
# Satellite images used

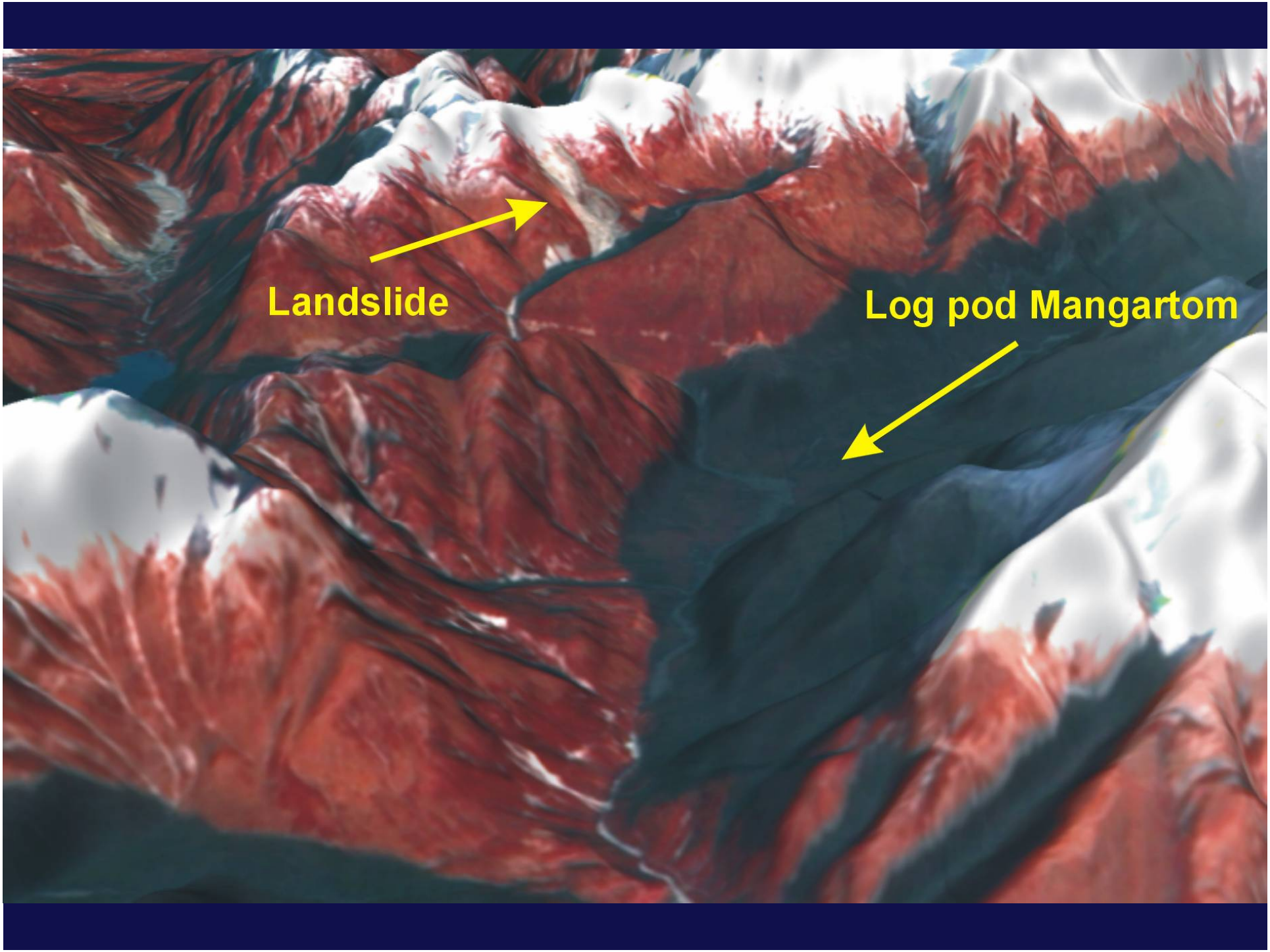
| Agency | Satellite | Type | Acq. date | Acq. time | Received |
|---|---|---|---|---|---|
| ESA | ERS | radar | 1999-11-05 | 9:56 | 2000-11-30 |
| ESA | ERS | radar | 2000-11-24 | 9:56 | 2000-11-30 |
| CSA | RADARSAT | radar | 1998-10-25 | 17:02 | 2000-12-13 |
| CSA | RADARSAT | radar | 2000-12-01 | 17:02 | 2000-12-13 |
| CNES | SPOT | optical | 2000-08-19 | 10:08 | 2000-12-14 |
| CNES | SPOT | optical | 2000-08-21 | 10:08 | 2000-12-14 |
| CNES | SPOT | optical | 2000-11-29 | 9:58 | 2000-12-14 |
| CNES | SPOT | optical | 2000-11-29 | 10:11 | 2000-12-14 |
| ESA | ERS | radar | 1998-03-20 | 9:56 | before |
| ESA | ERS | radar | 1998-04-24 | 9:56 | before |
| ESA | ERS | radar | 1998-05-29 | 9:56 | before |
| ESA | Landsat | optical | 1992-08-18 | 9:14 | before |
| ESA | Landsat | optical | 1999-09-15 | 9:14 | before |


Villach
Log pod
Mangartom
Bled
Bovec
Udine
Gorica


Log pod
Mangartom
Bovec


Landslide
Log pod
Mangartom
Bovec


Landslide
Log pod
Mangartom


Landslide
Log pod Mangartom

# Landslide analysis

- Visual interpretation is important in landslide monitoring and rescue operations
- Landslide was observed, directly or indirectly, on images acquired after the event
- Satellite images are an important source of information for GIS analyses

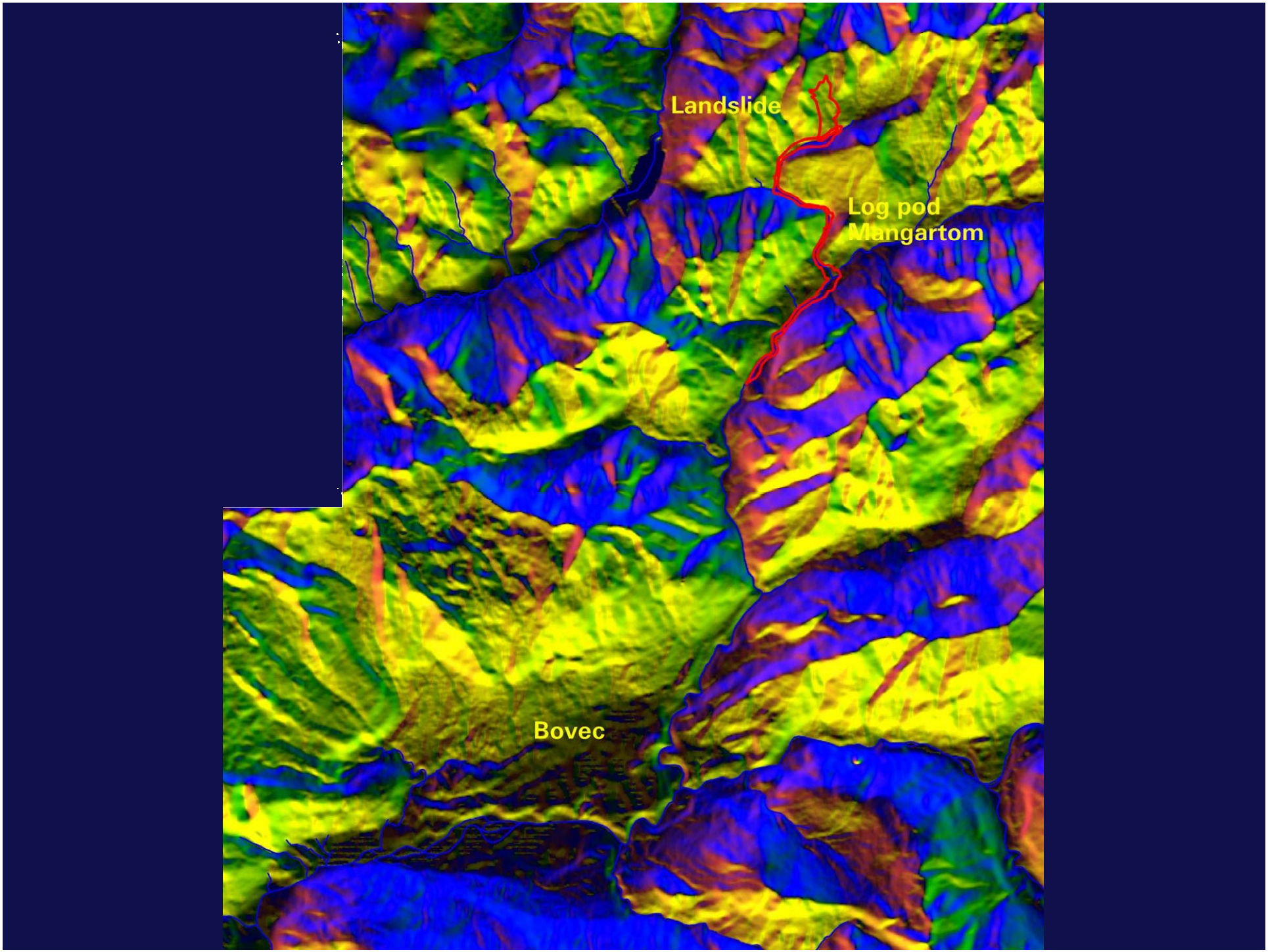
# Landslide analysis (2)

- Landslide and impact areas were delineated on images acquired by SPOT after the event (29 November 2000)
- Estimated area of the landslide is 25.7 ha
- The landslide travelled several kilometres
- The area of additional destruction in the valley is 50.1 ha
- The total area is 75.8 ha

# Digital elevation model

- InSAR DEM 25 – produced with radar interferometry
  - ERS-1 and 2 images were used
    - tandem mode
  - advanced interferogram combination
    - external DEM modelling
    - ascending and descending orbit
  - vertical accuracy of 8 m was achieved
    - in plains better than 2 m
    - in mountains 10 m or more


Landslide
Log pod
Mangartom
Bovec


Landslide
Log pod
Mangartom
Bovec

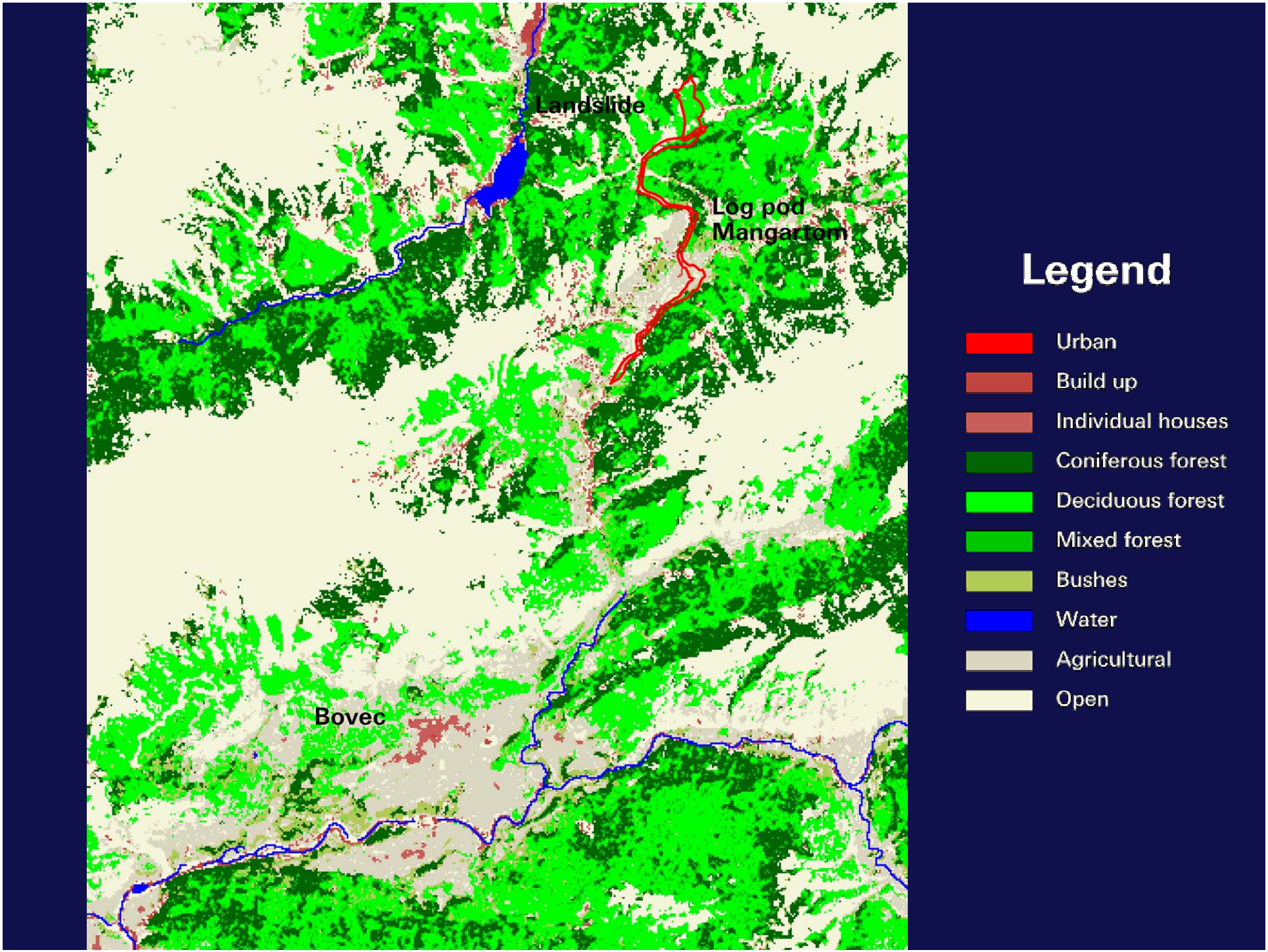
# Digital elevation model (4)

- Landslide analysis regarding elevations, slope and orientation

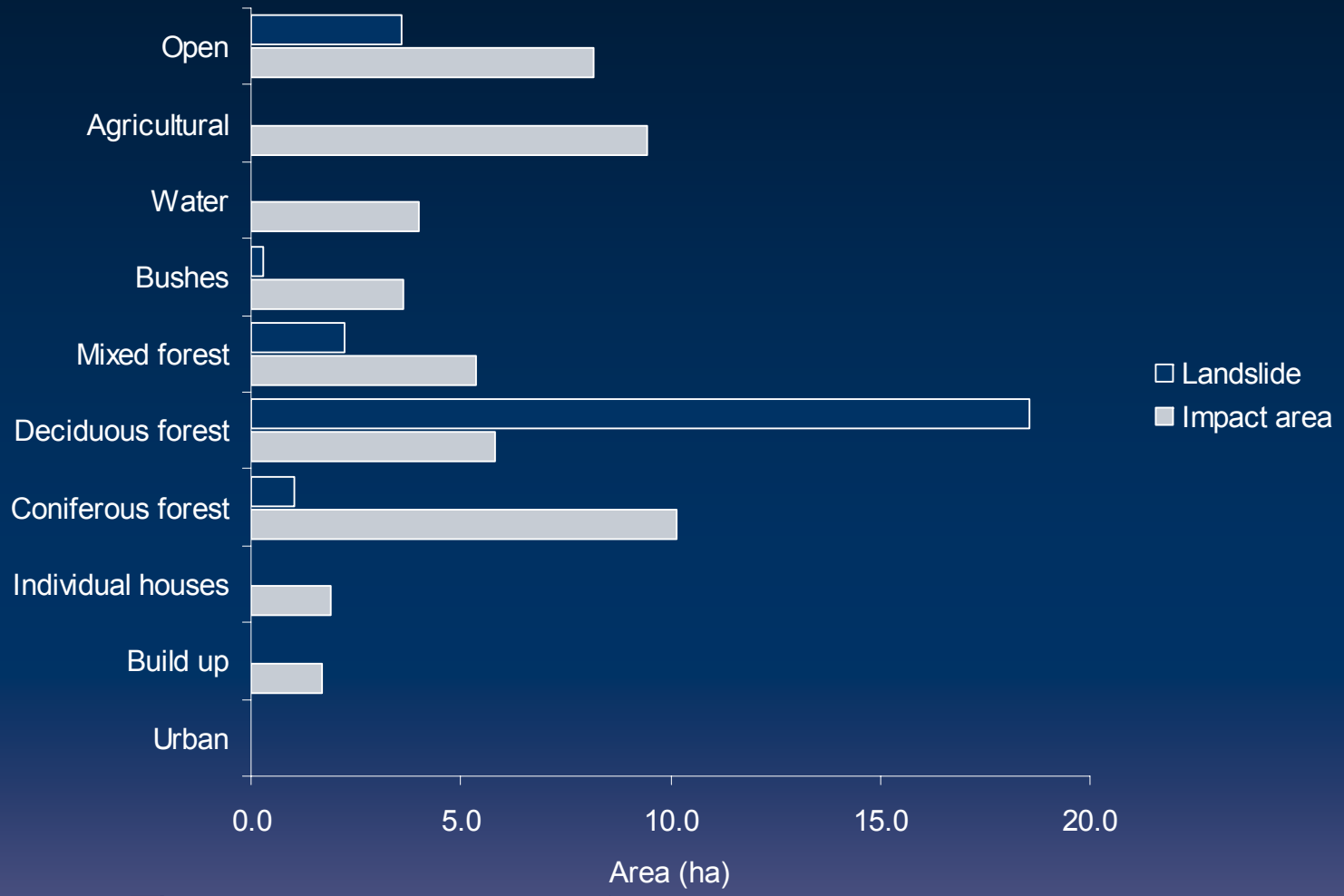
| | | Landslide | Impact area |
|---|---|---|---|
| Elevation (m) | Average | 1386 | 824 |
| | Std. dev. | 109 | 243 |
| Slope (%) | Average | 24 | 19 |
| | Std. dev. | 6 | 12 |
| Orientation (deg.) | Average | 161 | 224 |
| | Std. dev. | 25 | 83 |

# Land cover

- SPOT and Landsat
- Advanced supervised classification
  - DEM modelling
  - forest mixing
- 10 classes
  - urban, build up, individual houses,
  - coniferous, deciduous, mixed forest, bushes,
  - water,
  - agriculture, and
  - open
- Estimated attribute accuracy is 90%


Landslide
Log pod
Mangartom
Bovec
Legend
Urban
Build up
Individual houses
Coniferous forest
Deciduous forest
Mixed forest
Bushes
Water
Agricultural
Open

# Land cover (3)


Open
Agricultural
Water
Bushes
Mixed forest
Deciduous forest
Coniferous forest
Individual houses
Build up
Urban
0.0
5.0
10.0
15.0
20.0
Area (ha)
Landslide
Impact area

# Conclusions

- The possibilities of remote sensing and geographical information systems in natural hazard observation are shown
- Combination of images
  - optical (land cover, area delineation)
  - radar (humidity, digital elevation model)
- SPOT imagery was most useful

# Conclusions (2)

- The total destroyed area is 76 ha
  - 26 ha landslide
  - 50 ha impact area
- Steep and rather homogenous landslide area
- Much lower and heterogeneous impact area
- Mostly covered with forests, but also a considerable amount of agricultural and urban areas

# Conclusions (3)

Charter Space and Major Disasters

- proved to be very useful
- images used in rescue operations and (mostly) damage estimation
- faster image delivery is urgent, direct transfer is preferred
- more user influence in image acquisition plan is desired

The results of the research are available on
www.zrc-sazu.si/pic/
www.disasterscharter.org

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