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Towards operational land cover change monitoring from space

Heiko Balzter
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Section for Earth Observation
Monks Wood

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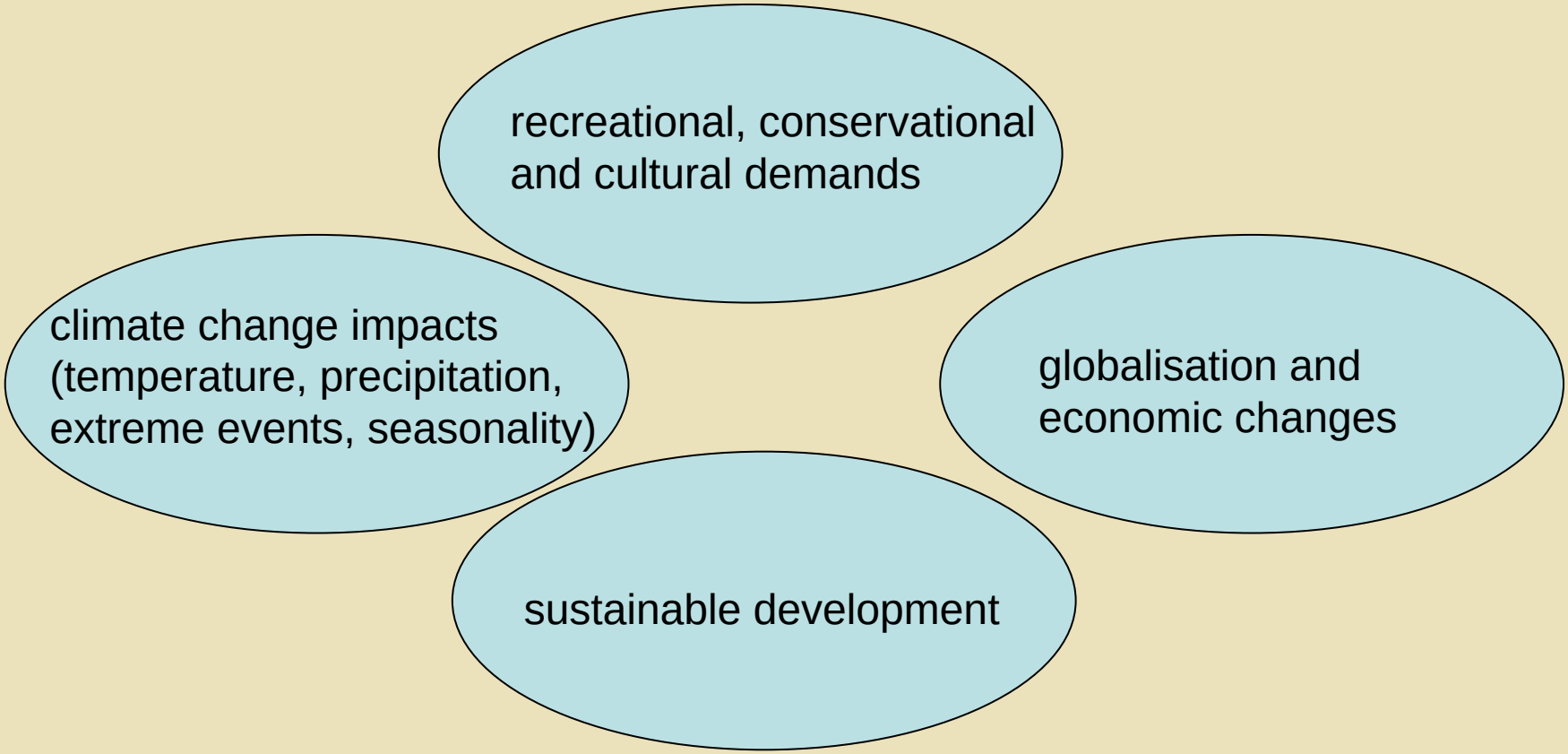
Why ?



manageable (to a degree)

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Land cover change detection

Change detection methods (Coppin et al. 2004) :

- post-classification comparison
- composite analysis
- univariate image differencing
- image ratioing
- bi-temporal linear data transformation using principal components
- multivariate change vector analysis
- image regression
- multi-temporal spectral mixture analysis
- multidimensional temporal feature space analysis
- hybrid schemes.

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Examples

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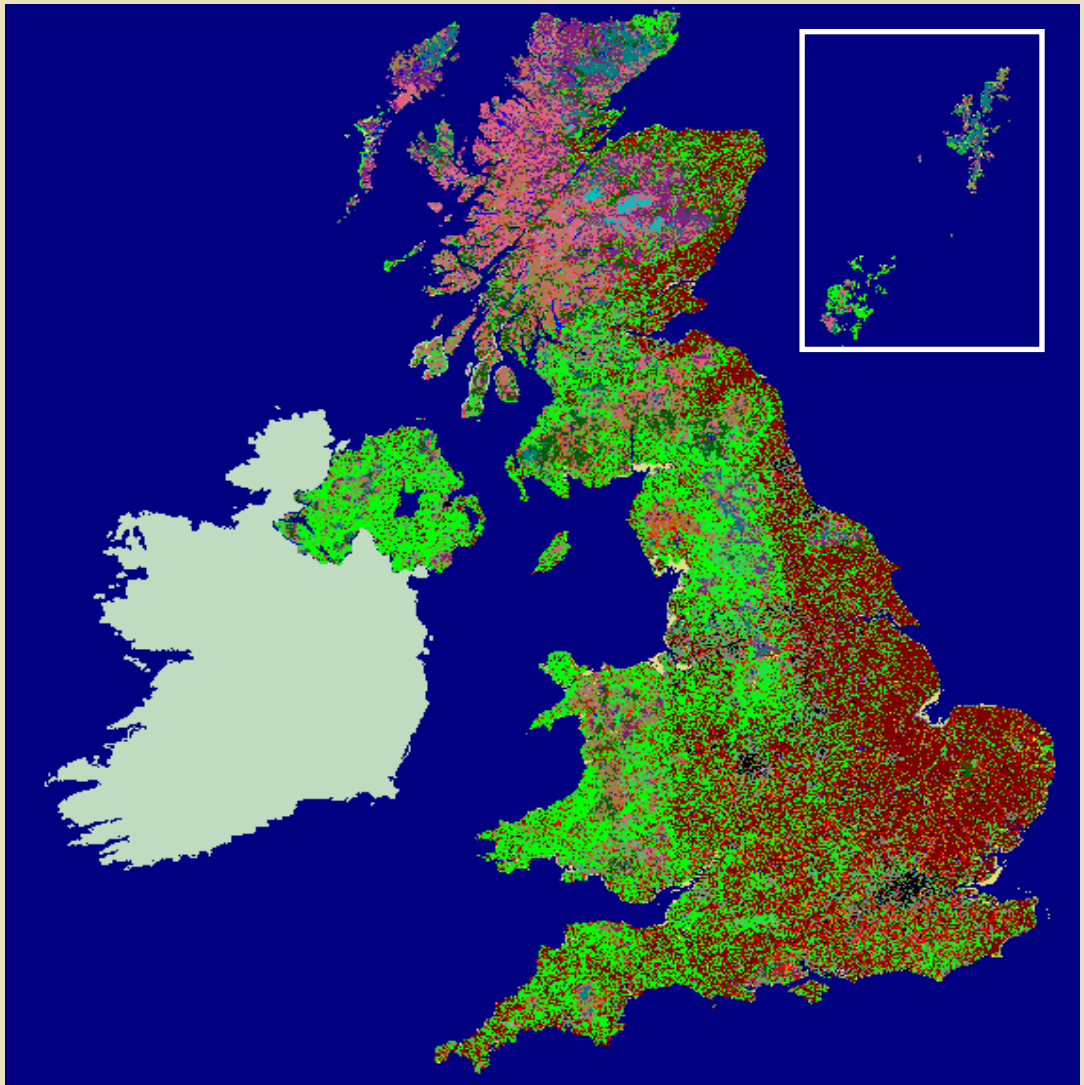
The UK Land Cover Map 2000



- Broadleaved / mixed wood
- Coniferous woodland
- Arable & horticultural land
- Improved grassland
- Setaside & rough grass
- Neutral & calcareous grass
- Acid grassland
- Bracken
- Dense dwarf shrub heath
- Open dwarf shrub heath
- Fen, marsh and swamp
- Bogs
- Inland water
- Montane habitats
- Inland rock and bare ground
- Suburban / rural development
- Urban and industrial areas
- Supra-littoral rock / sediment
- Littoral rock and sediment
- Saltmarsh
- Sea

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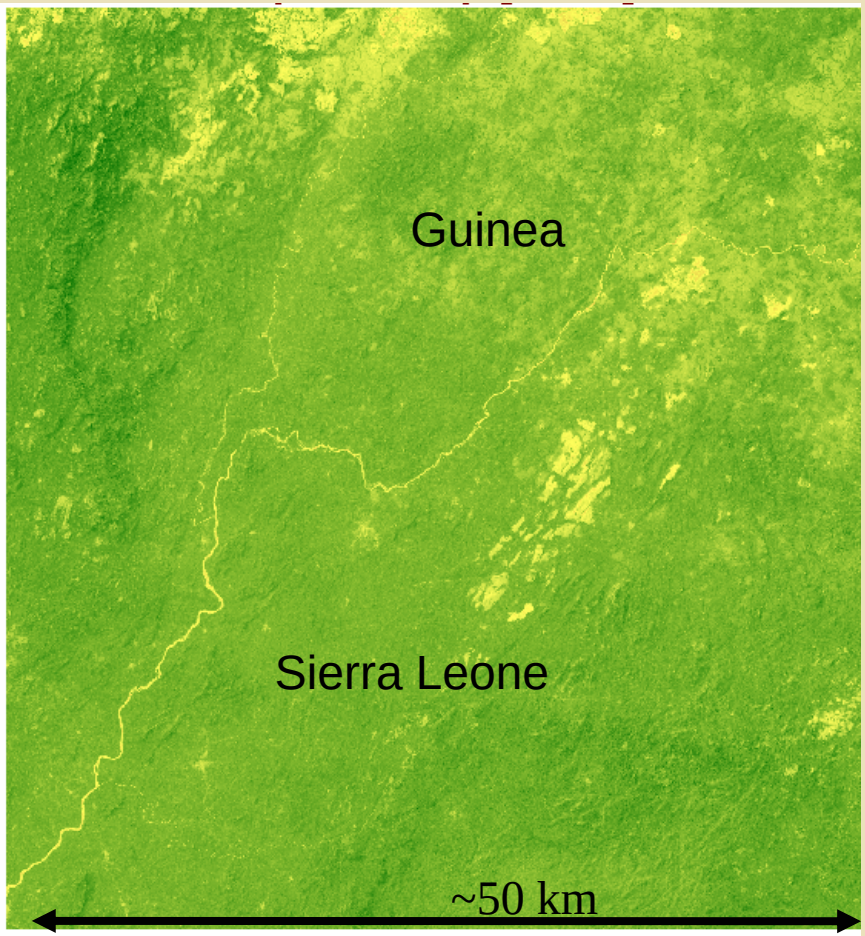
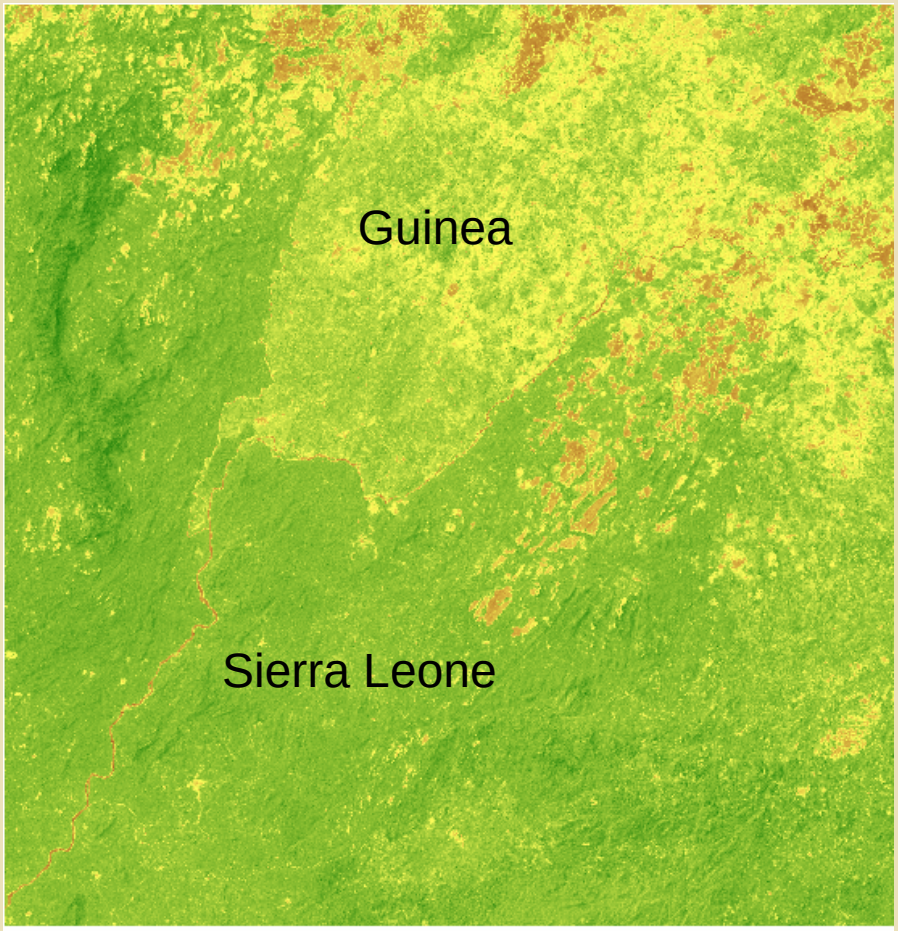
Monitoring forest cover change



Landsat TM (NDVI) 1986



Landsat TM (NDVI) 2000

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Policy drivers

- EC/ESA GMES initiative (Global Monitoring for Environment and Security)
- ESA Earthwatch Programme
- ESA Earth Explorer Programme
- NASA Earth Observing System
- Group on Earth Observations, “System of Systems” (GEOSS)
- UNEP-FAO, GCOS, GTOS, GOOS, GOFC-GOLD

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GMES

- Aim: European capacity for the provision and use of operational information for Global Monitoring of Environment and Security by 2008.
- Three modules constitute the GMES system:
  1. production and dissemination of information in support of EU policies for Environment and Security;
  2. communication mechanisms between stakeholders, providers and users
  3. legal, financial, organisational and institutional frame

  (www.gmes.info)

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Global Monitoring for Environment and Security (GMES)

- **Strand 1 *Delivering Information and Services***
  - **EC projects**
  - **ESA GMES Services Element (GSE)**
- **Strand 2 *Assessments and Recommendations***
  - **cross-cutting assessment studies**

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GMES Priority Themes

A. Land cover change in Europe (BIOPRESS, GEOLAND)

B. Environmental stress in Europe (LADAMER, OCEANIDES, EUROSION)

C. Global vegetation monitoring (SIBERIA-2, GEOLAND)

D. Global ocean monitoring (MERSEA, MAMA, ESONET)

E. Global atmosphere monitoring (DAEDALUS-CREATE, APMoSPHERE, Meth-MOniTEUR, GATO)

F. Support to Regional Development Aid (AMESD)

G. Systems for risk management (DISMAR)

H. Systems for crisis management and humanitarian aid (RISK_FORCE, ISIS)

I. Information management tools and Contribution to the development of a European spatial data infrastructure (EOLES, EUFOREO)

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Global Earth Observation System of Systems (GEOSS)

Societal Benefits

1. Improve Weather Forecasting
2. Reduce Loss of Life and Property from Disasters
3. Protect and Monitor Our Ocean Resource
4. Understand, Assess, Predict, Mitigate and Adapt to Climate Variability and Change
5. Support Sustainable Agriculture and Forestry and Combat Land Degradation
6. Understand the Effect of Environmental Factors on Human Health and Well-Being
7. Develop the Capacity to Make Ecological Forecasts
8. Protect and Monitor Water Resources
9. Monitor and Manage Energy Resources

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Project example: SIBERIA-2

- Multi-sensor concepts for greenhouse gas accounting of Northern Eurasia
- EU FP5 project

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SIBERIA-2 Data Products

- land cover and change
- fPAR and LAI
- snow depth
- burned forest area
- vegetation damage caused by industrial pollution
- Af- Re- and Deforestation
- freeze / thaw transitions
- open water bodies

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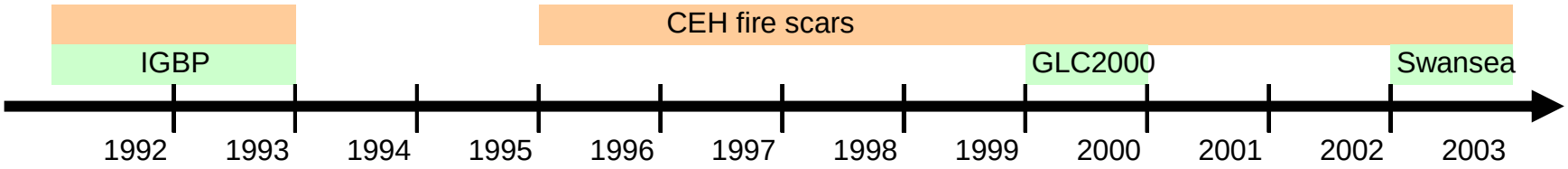
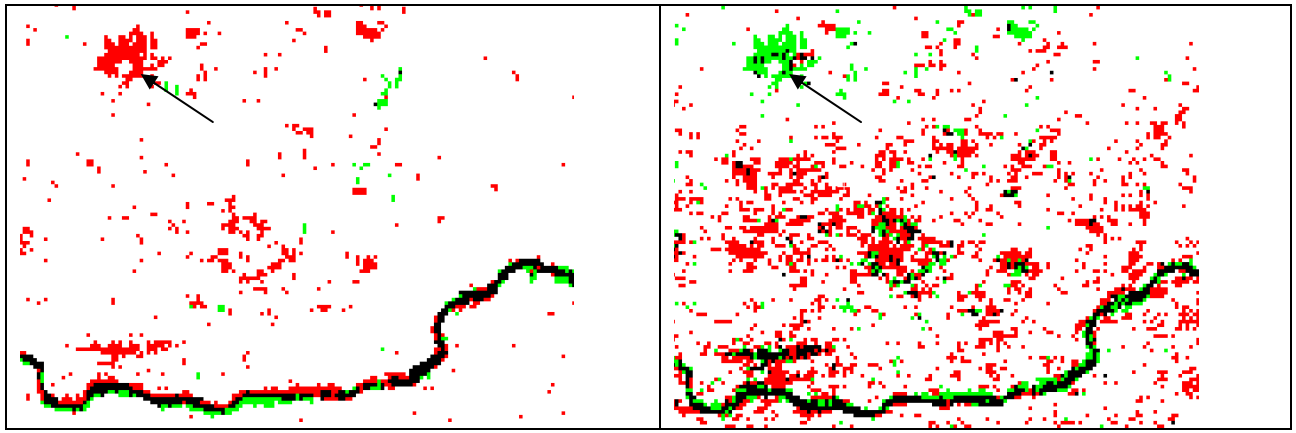
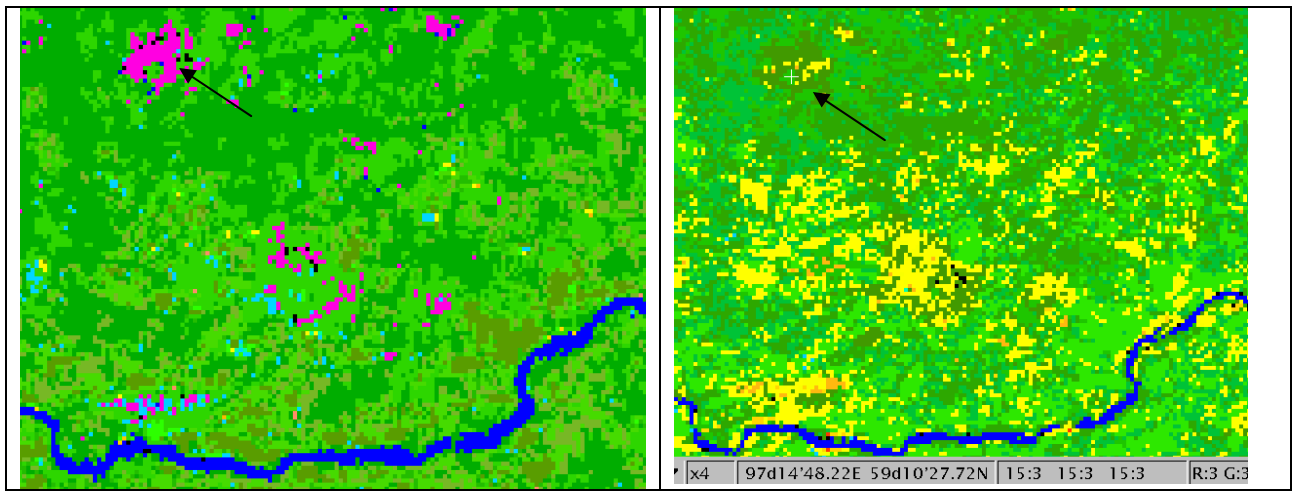
Land cover change in Siberia

- 1992/93 IGBP Land Cover Map by USGS
- 2000 Global Land Cover Map GLC2000
- 2003 Land Cover Map by SIBERIA-2 team (University of Swansea)
- 1992-2003 Forest fire scar map by



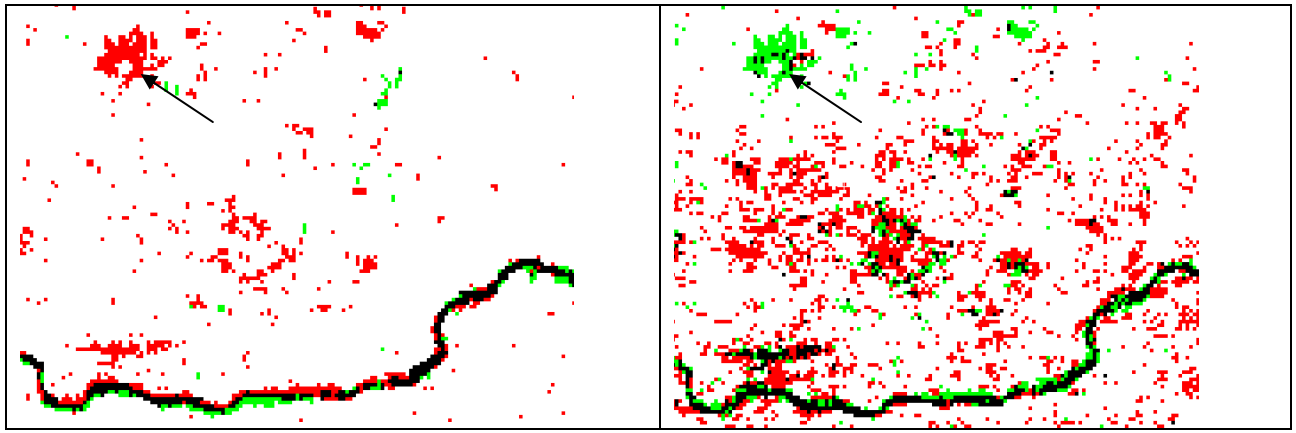


- (a) **deforestation** / **reforestation** between IGBP 1992 and GLC 2000
- (b) between GLC 2000 and Swansea map 2003



- (c) GLC2000 map, **fire scars**, **forest**, and **water**.
- (d) Swansea land cover map 2003, **croplands**, **forest**, and **water**.

Land cover change in the Angara region, Siberia



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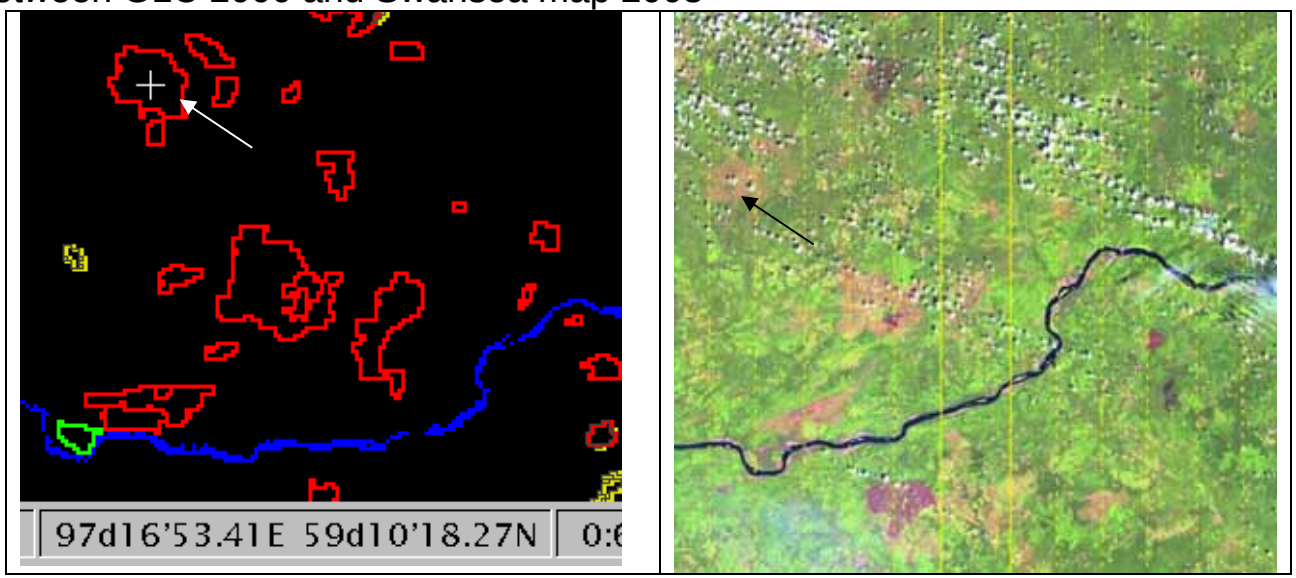

- (e) CEH fire scar map, **areas burned before 2000**, **other colours after 2000**.
- (f) Landsat ETM+ SLC 7140019000320051, acquired 19/07/2003.

Land cover change in the Angara region, Siberia

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Problems with post-classification analysis

- different class definitions
- classification methodology
- class confusion
- co-registration accuracy

- But: Reasonably robust when aggregating classes.

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Project example: GEOLAND

- aims to establish geo-information products and services
- pre-operational end-user applications
- monitoring of land cover and vegetation

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GEOLAND

Regional services:

- Nature Protection Observatory: Habitats and Bird Directive, Ramsar Convention, Convention on Biological Diversity;
- Water and Soil Observatory: Thematic Strategy for Soil Protection, Water Framework Directive;
- Spatial Planning Observatory: European Spatial Development Perspective, European Spatial Observatory Network;
- Core Service Land Cover: cross-cutting land cover and land cover change products

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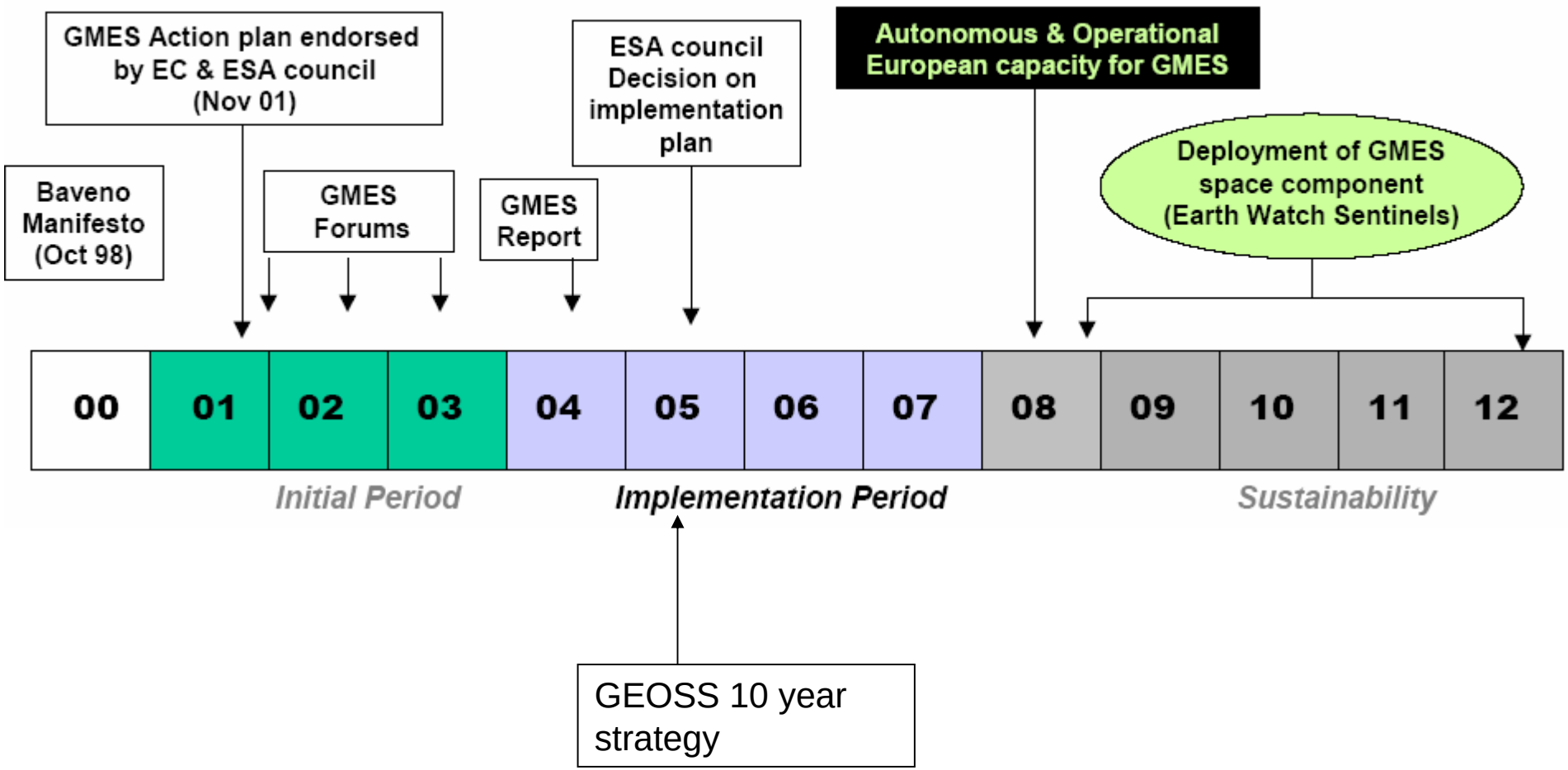
GEOLAND

Global services:

- Natural Carbon Fluxes Observatory: UN Framework Convention on Climate Change;
- Global Land Cover and Forest Change Observatory: UN Forum on Forest, EC Forest and Development Communication;
- Food Security and Crop Monitoring Observatory: Council regulations on Food Aid Policy, Environmental Measures in Developing Countries,
- Core Service Bio-geophysical Parameters: cross-cutting parameter products

Outlook


GMES Action plan endorsed by EC & ESA council (Nov 01)
Baveno Manifesto (Oct 98)
GMES Forums
GMES Report
ESA council Decision on implementation plan
Autonomous & Operational European capacity for GMES
Deployment of GMES space component (Earth Watch Sentinels)
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Initial Period
Implementation Period
Sustainability
GEOSS 10 year strategy

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ESA Earthwatch Sentinels

Need for EO Data continuity

- Sentinel 1: C-band SAR
- Sentinel 2: MR WS superspectral optical
- Sentinel 3: Ocean Altimeter & Colour
- Sentinel 4: Atmospheric GEO
- Sentinel 5: Atmospheric LEO

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Unresolved issues

1. Operational delivery of information services is more than imaging. → Synergy between applied environmental science and remote sensing.
2. Economic and organisational scenarios for provision of operational services → Synergy between information providers, users, academia, space agencies and industry.
3. Understanding causes and effects of land cover / land use change.