Development of New Types of Glacier Dynamics Maps

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- Background
  - The Project OMEGA
  - Measurement of Glacier Movements using SAR
- Map Generation
  - Glacier Marginal Changes
  - Glacier Strain Rate
  - Glacier Velocity
- Conception and Generation of a True-3D Map

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The Project OMEGA

- Development of an **O**perational **M**onitoring System for **E**uropean **G**lacial **A**reas – Synthesis of Earth Observation Data of the Present, the Past and the Future

- Research project of the European Commission with participation of several institutes und companies

- Period: April 2001 – April 2004
- Funding: 3,24 M€

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The Project OMEGA, ctd.

- Changes of the European glaciers induced by climatic changes
- Development of a European Monitoring System for the European glaciated areas
- Using of preferably versatile basic data sets
- Development of new evaluation methods
- Publishing of the results
- Sensitisation of the public

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OMEGA Test Sites - Requirements

- Existing long-time glaciological and meteorological observations
- Reference points available
- Reachability
- Rating of the influence of climatic changes

Svartisen Ice Caps

Hintereisferner

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SAR - Basics

SAR: Sending & receiving of microwaves

- Tilted receiving geometry
- Azimuth along track (synthetic aperture), range across track

InSAR: Elimination of sensor geometry effects and ambiguousness

- One range of phase differences between π and –π: “Fringe”

D-InSAR: 3 or 4 SAR Images → 2 Interferograms:

- One consists only topographic fringes
- One consists fringes with topographic changes

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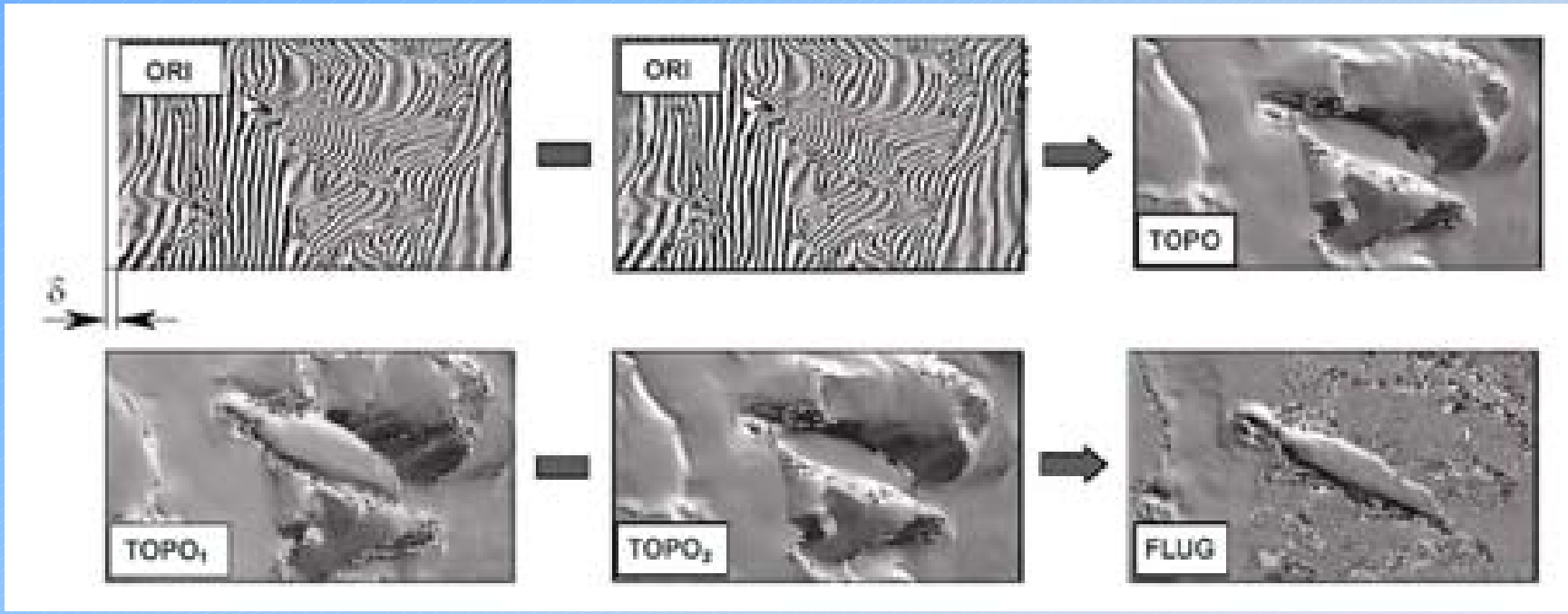
Gradient Approach InSAR – GINSAR

- Partial derivation of wrapped phase = partial derivation of unwrapped phase
- Subtraction of an interferogram from the transformed interferogram
- A. Sharov: “Topogram” – 3 channels: gradients in azimuth, range and total



- Subtraction of 2 topograms
- “Fluxogram” – 4 channels: differences in azimuth, range, total and direction of differential movement

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Map Generation – Initial Situation

Requirements	Original Data	Software
• Copies • Size • Topic • Purpose	• Topography • Topographic map • Elevation contours • DEM/DTM • Topic-related data • Interferograms • Satellite images	• ESRI ArcInfo 8.1 • Erdas Imagine 8.4 • Macromedia Freehand 10 • Adobe Illustrator 9.0

Further sources:

- Colour tables
- World Wide Web

Map Design – Title and Content

"Svartisen Ice Caps (Norway) – Glacier Rheology"
"Hintereisferner (Austria) – Glacier Rheology"

Title	Topic	Topography
Glacier Marginal Changes	• 2nd glacier stadium • Areas of in- and decrease	• Coast line • Glacier area • Hydrography • Elevation contours • Spot heights • Lettering
Glacier Strain Rate	• Rates of deformation	
Glacier Velocity	• Flow velocity	
Original Interferogram	• Interferogram	
EROS Orthoimage Map	• EROS satellite image	

Map Design – Scale & Geodetic Parameters

	Svartisen Ice Caps		Hintereisferner	
Base maps/ scale	Topografisk Hovedkartserie M711 1 : 50.000		Österreichische Karte 1 : 50.000 ÖK 50	
Geodetic parameters	Ellipsoid WGS 84 Projection: UTM Grid: UTM		Ellipsoid: Bessel Projection: Gauss-Krueger Grid: Austrian Bundesmeldenetz (BMN)	
Glacier actuality	1997/2000		1998	
Digital elevation data	Raster data, resolution 25 m		Elevation contours	
	Main maps	Detailed maps	Main map	Secondary maps
Topics	• Differential Interferogram • Glacier Strain Rate	• Glacier Velocity • Glacier Marginal Changes	• Glacier Marginal Changes	• Eros Orthoimage Map • Original Interferogram • Glacier Velocity • Glacier Strain Rate
Scale	1 : 100.000	1 : 50.000	1 : 25.000	1 : 50.000
Grid width	5 km	2.5 km	2 km	2 km

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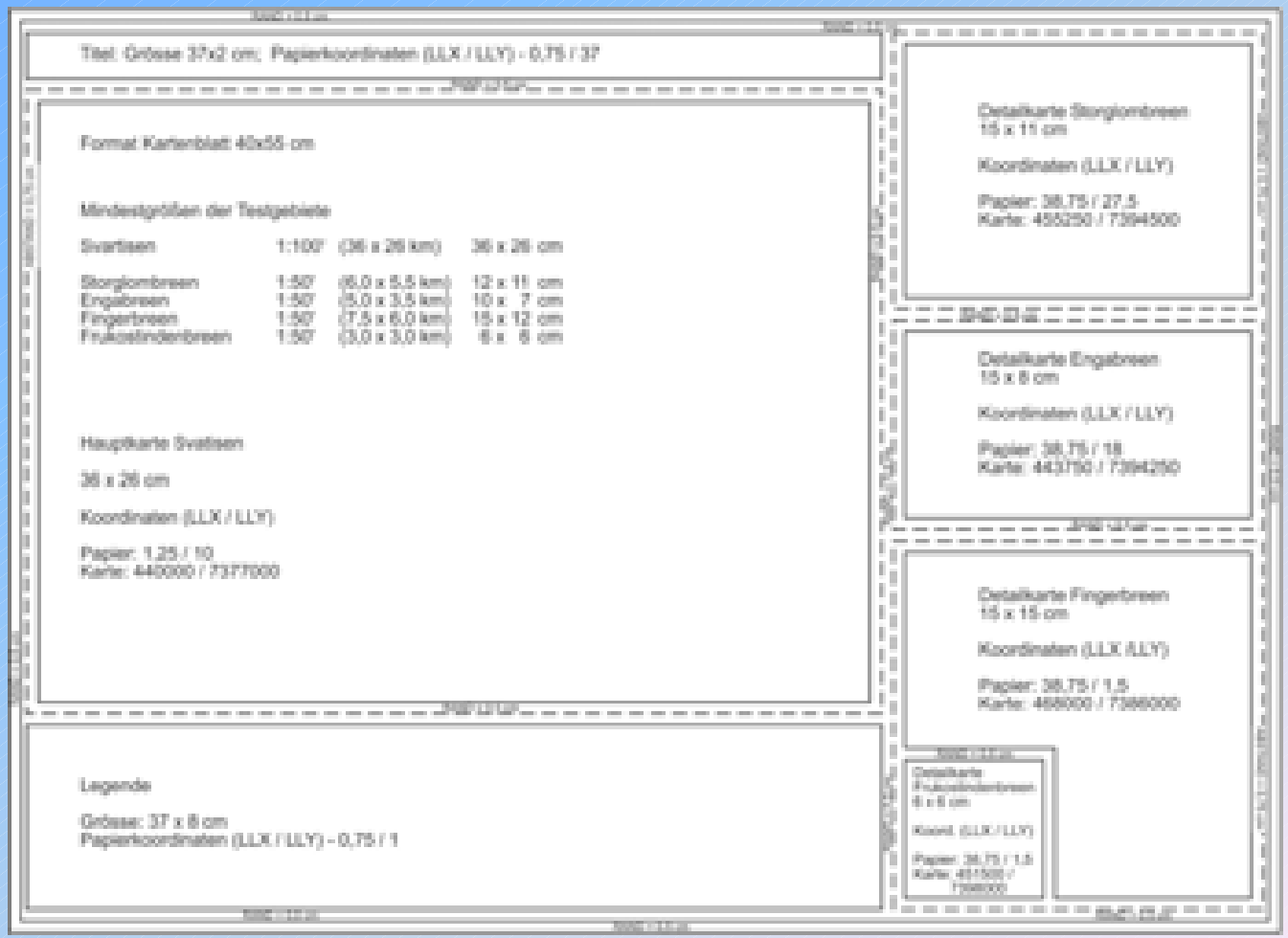
Map Design – Layout Svartisen Ice Caps

- Format
  - 55 cm * 40 cm
  - landscape
- Area 370 km²
- 30 km N-S
  40 km W-E
- 0.5 cm margins
- 0.5 cm frame for coordinates
- Foldable to smaller than A4



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Map Design – Layout Hintereisferner

- Format
  - 55 cm * 40 cm
  - portait
- Area 8 km²
- 8 km N-S
  8 km W-E
- 0.5 cm margins
- 0.5 cm frame for coordinates
- Foldable to smaller than A4

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Gla

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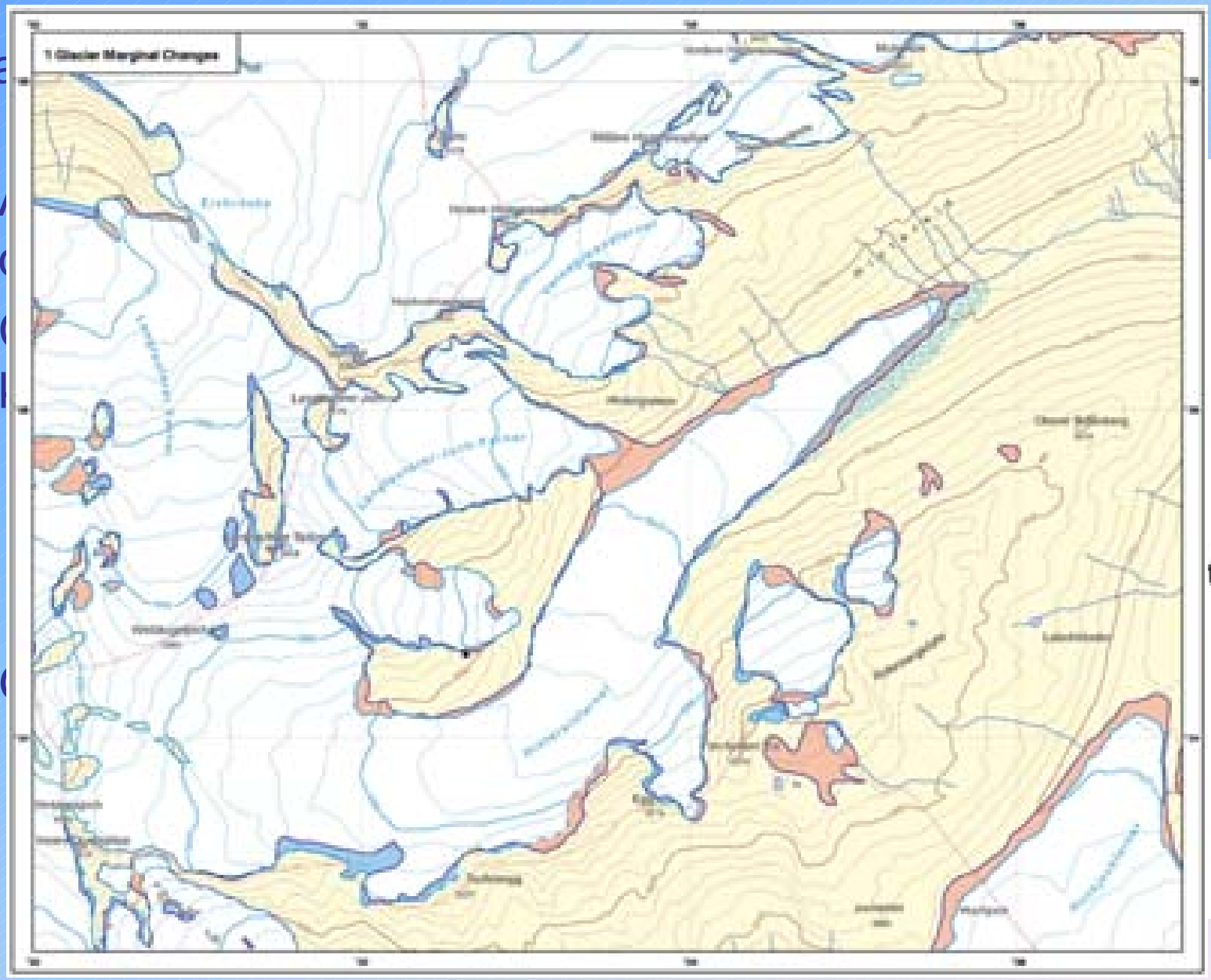
- C



1998)

Development of Three New Types of Glacier Dynamics Maps

Manfred F. Buchroithner, Sebastian Walther, Klaus Habermann, TU Dresden, Institute for Cartography

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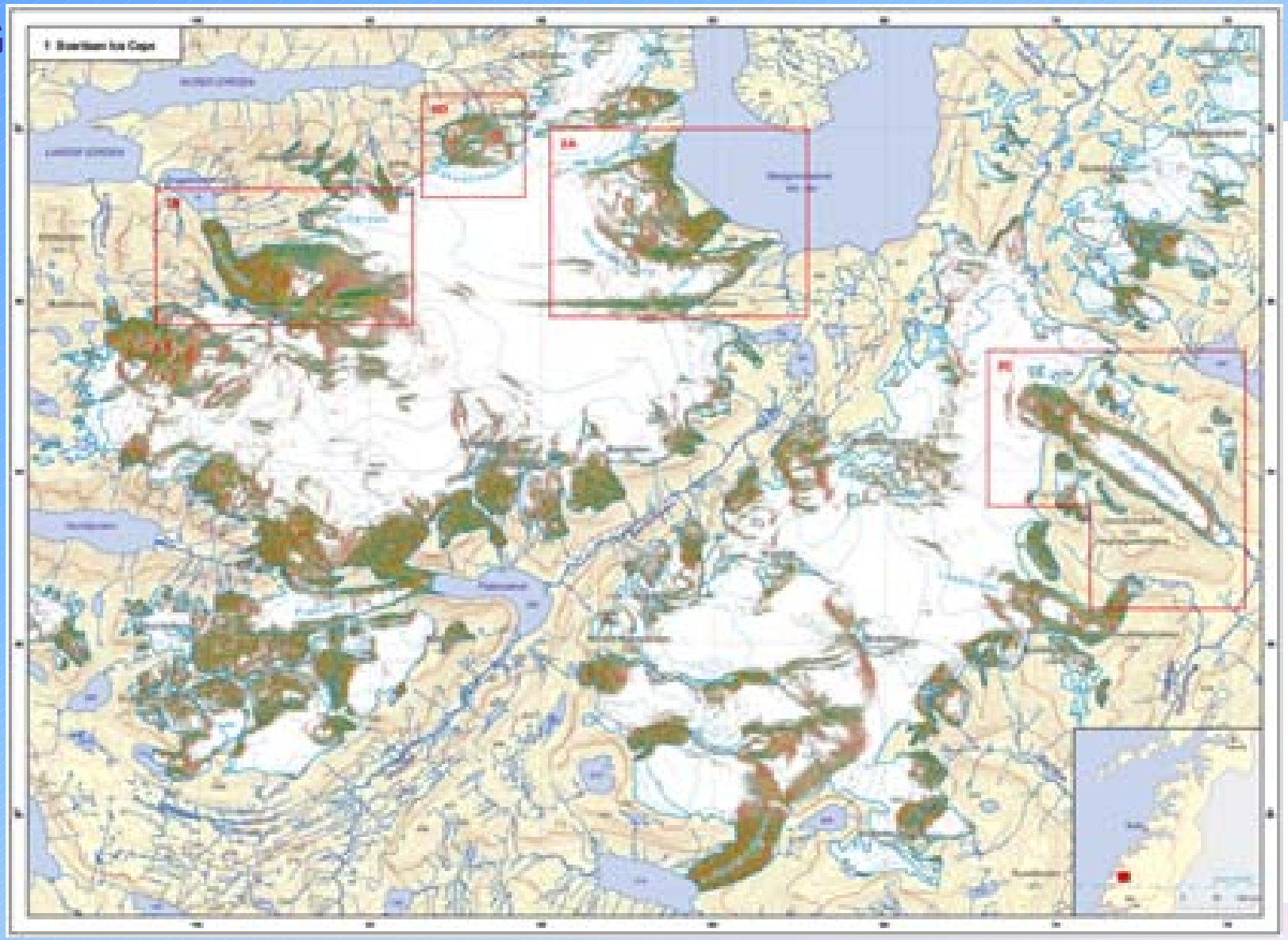

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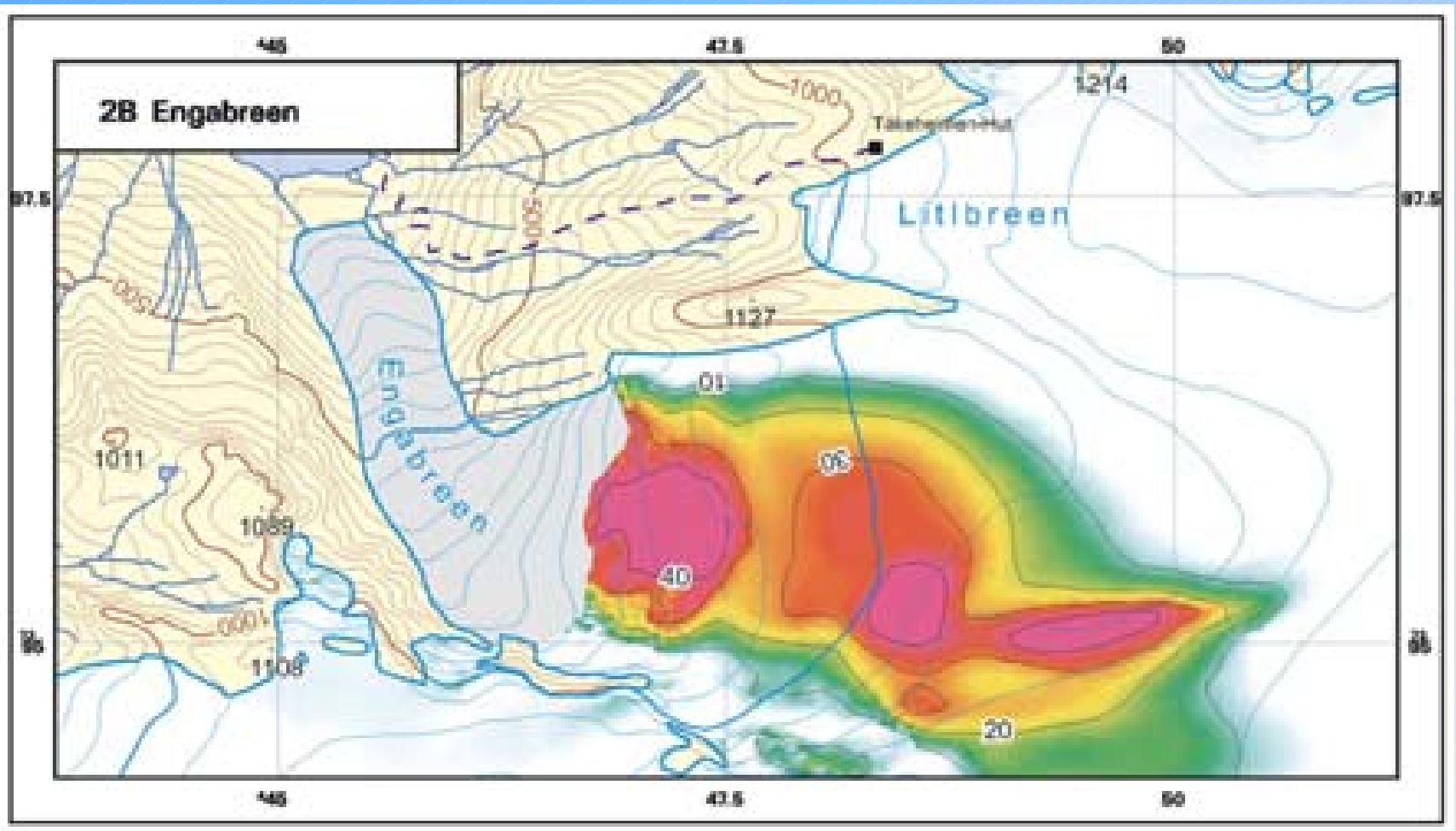
Glacier Velocity



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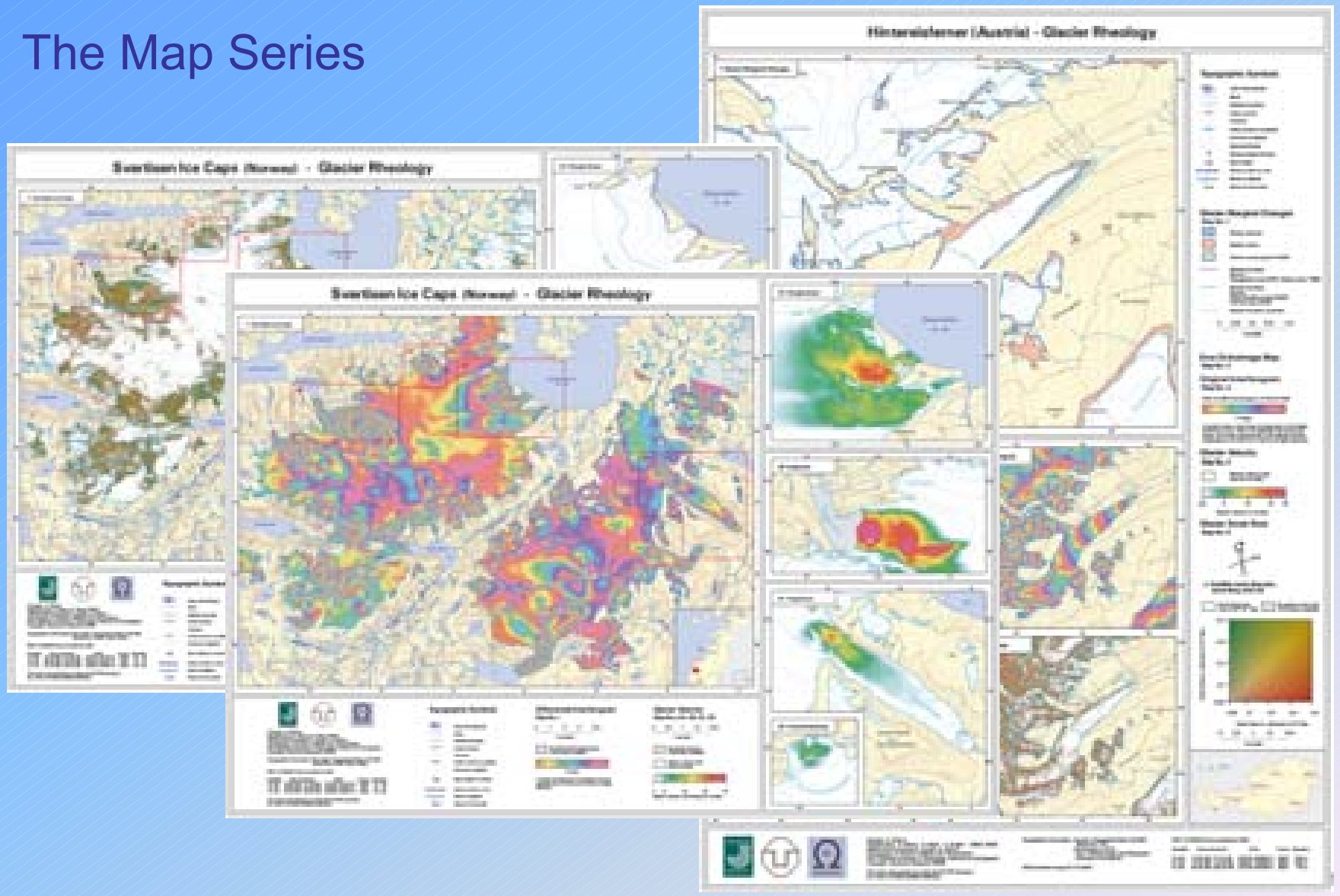
The Map Series



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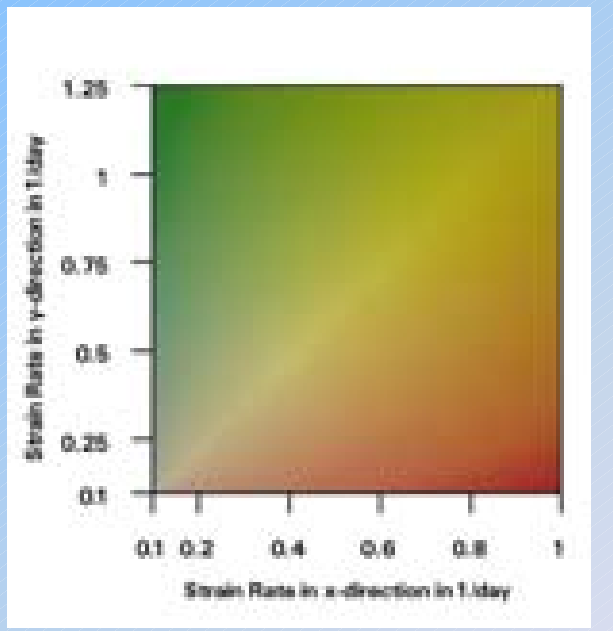
Proposal I: Useful Glacier Strain Rate Maps



Realised presentation: Without classification

- Continuous colour gradient
- Direction-dependent
- Indicative for crevasses

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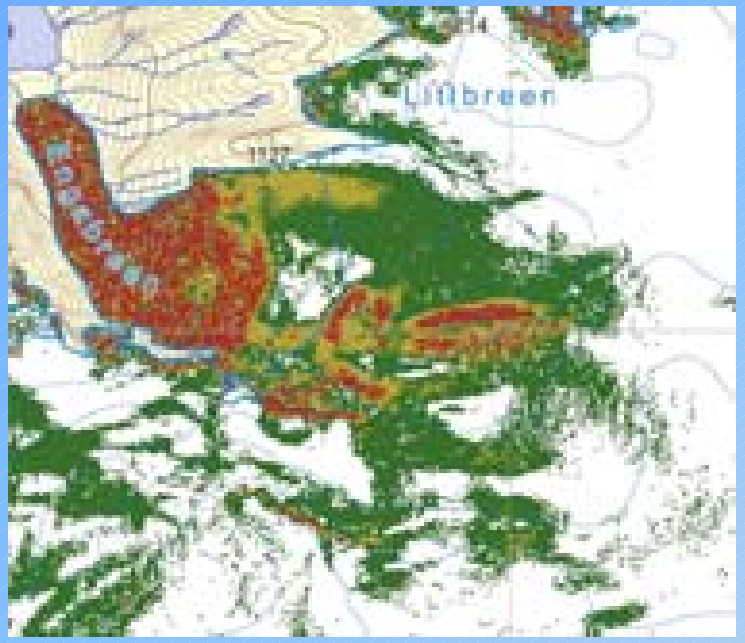
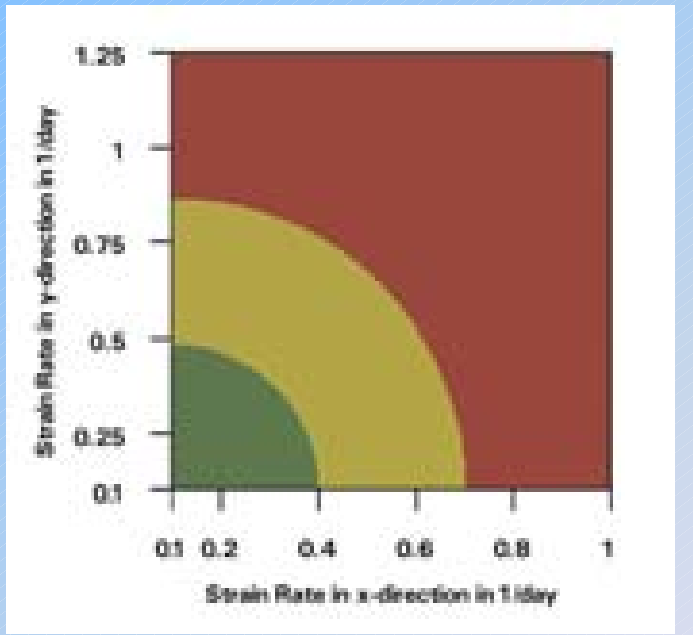
Proposal I: Useful Glacier Strain Rate Maps - I





Proposed classification with three classes of strain rate

- Value-dependent
- No perceptibility of direction of crevasses
- Highly generalised

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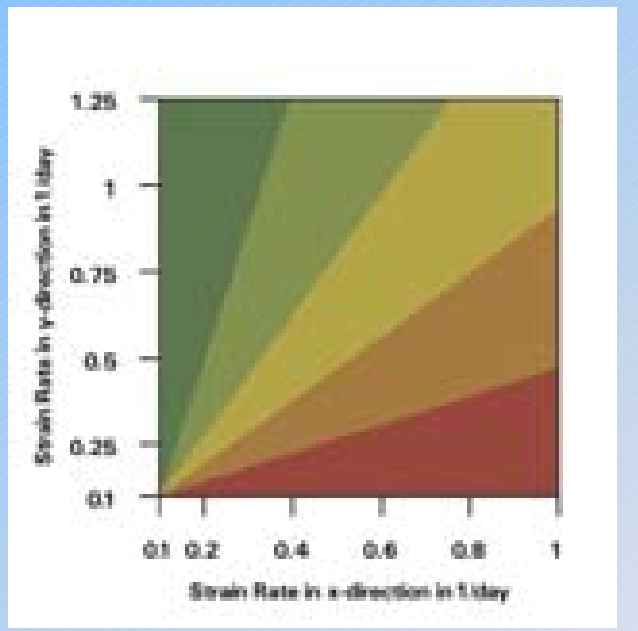
Proposal I: Useful Glacier Strain Rate Maps - II



Proposed classification with five classes of strain rate

- Direction-dependent
- 5 classes
- Perceptibility of direction of crevasses

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Proposal II: 3D-Visualisation – Intention & Realisation

- Objective: Visualisation of highly-complex phenomena in a user-friendly way suitable for fieldwork.

- OMEGA: Not only the changes in glacier coverage are of interest, also the alterations in thickness, and, hence, in the mass-household are important!

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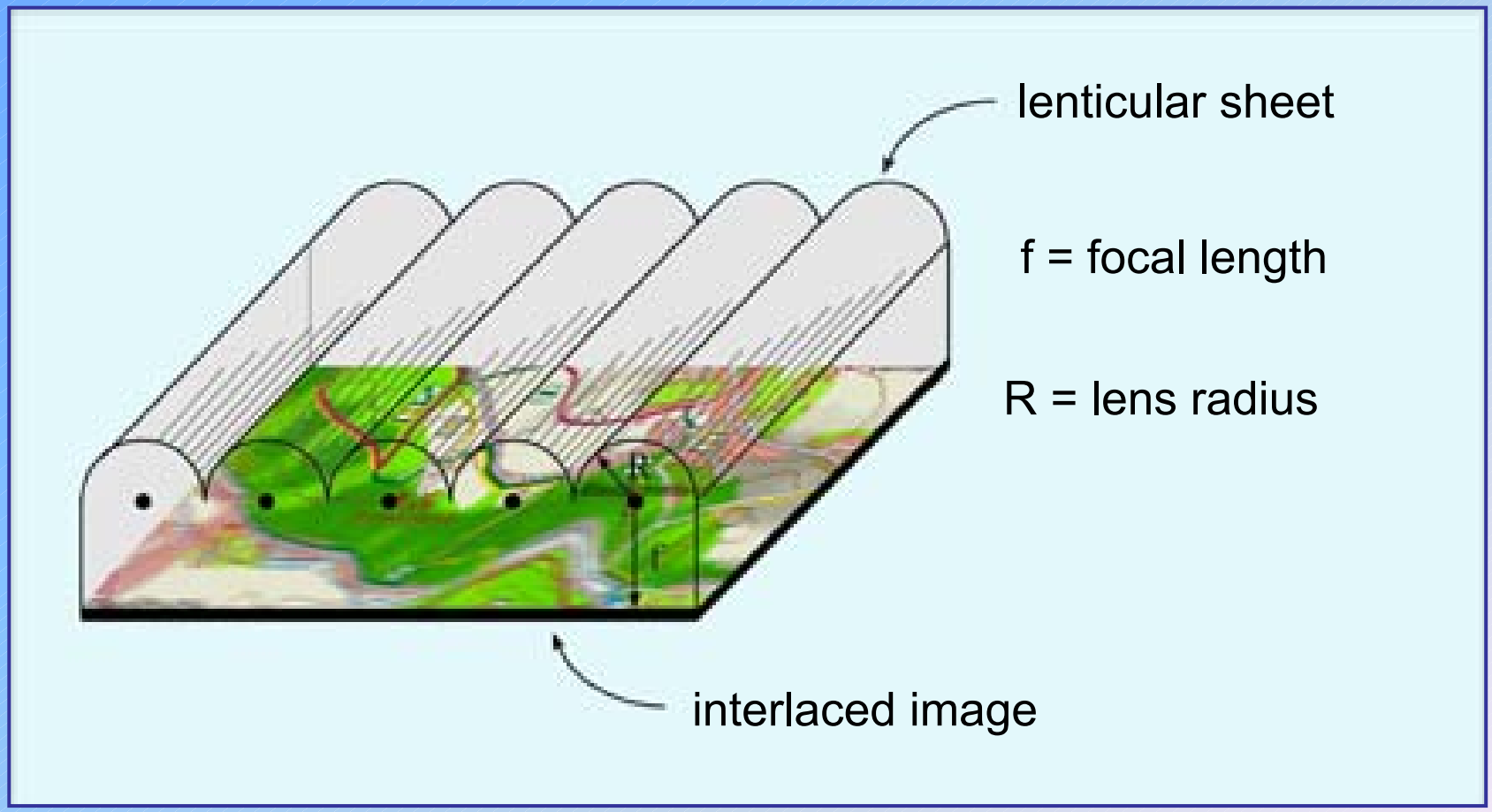
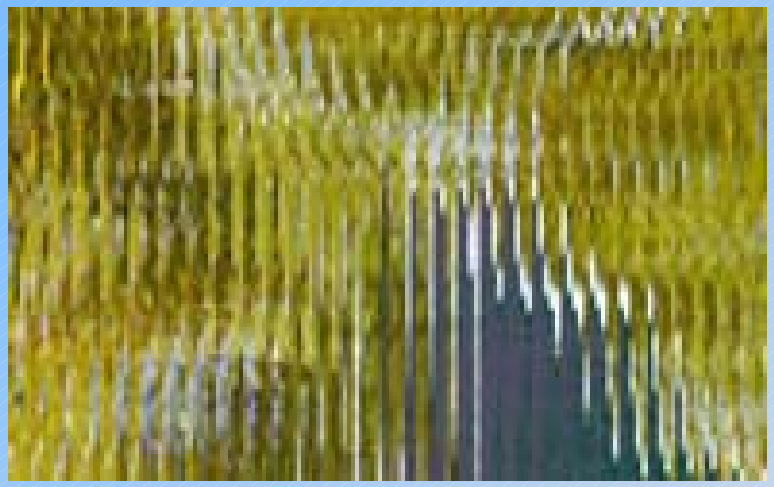
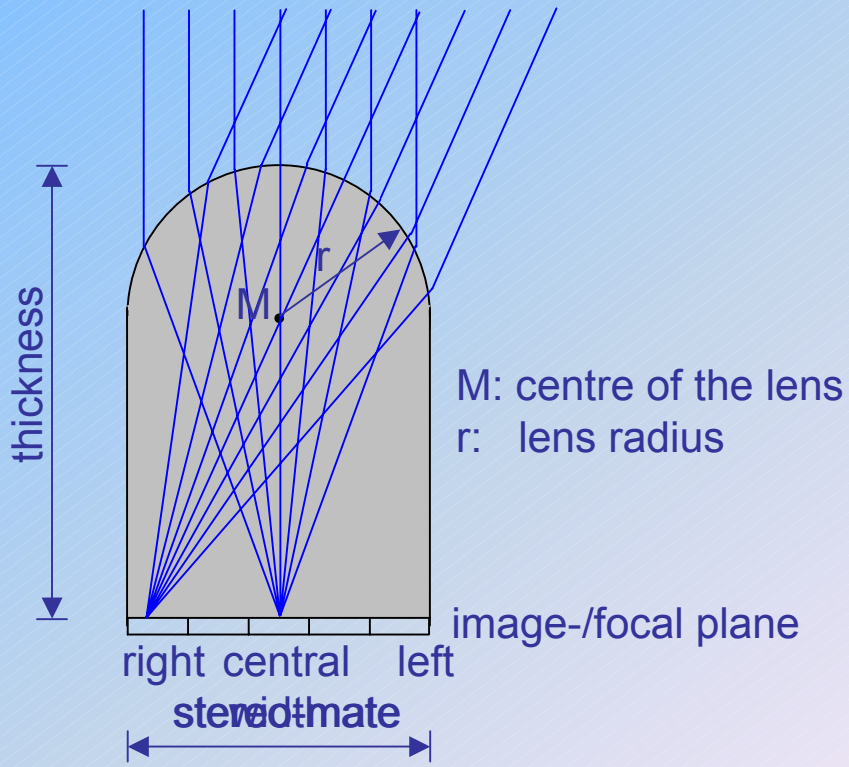
Principle of Lenticular Foil Technology



Interlacing of Stereo-Mates





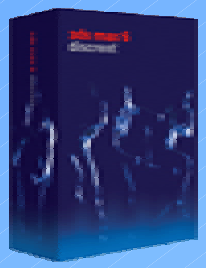
Effects of lenticular displays

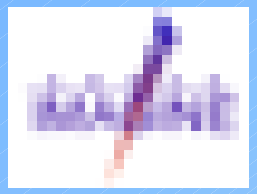
2D Effects	3D Effects	Combined Effects
Flip	True-3D	All combinations of 2D- and 3D Effects
Morphing		
Zoom		
Animation		

Changed after MICRO LENS TECHNOLOGY 2005

Workflow and Software

Modelling





MatLab/C++

Publishing

Magic Interlacer

Flashband Generator

Display

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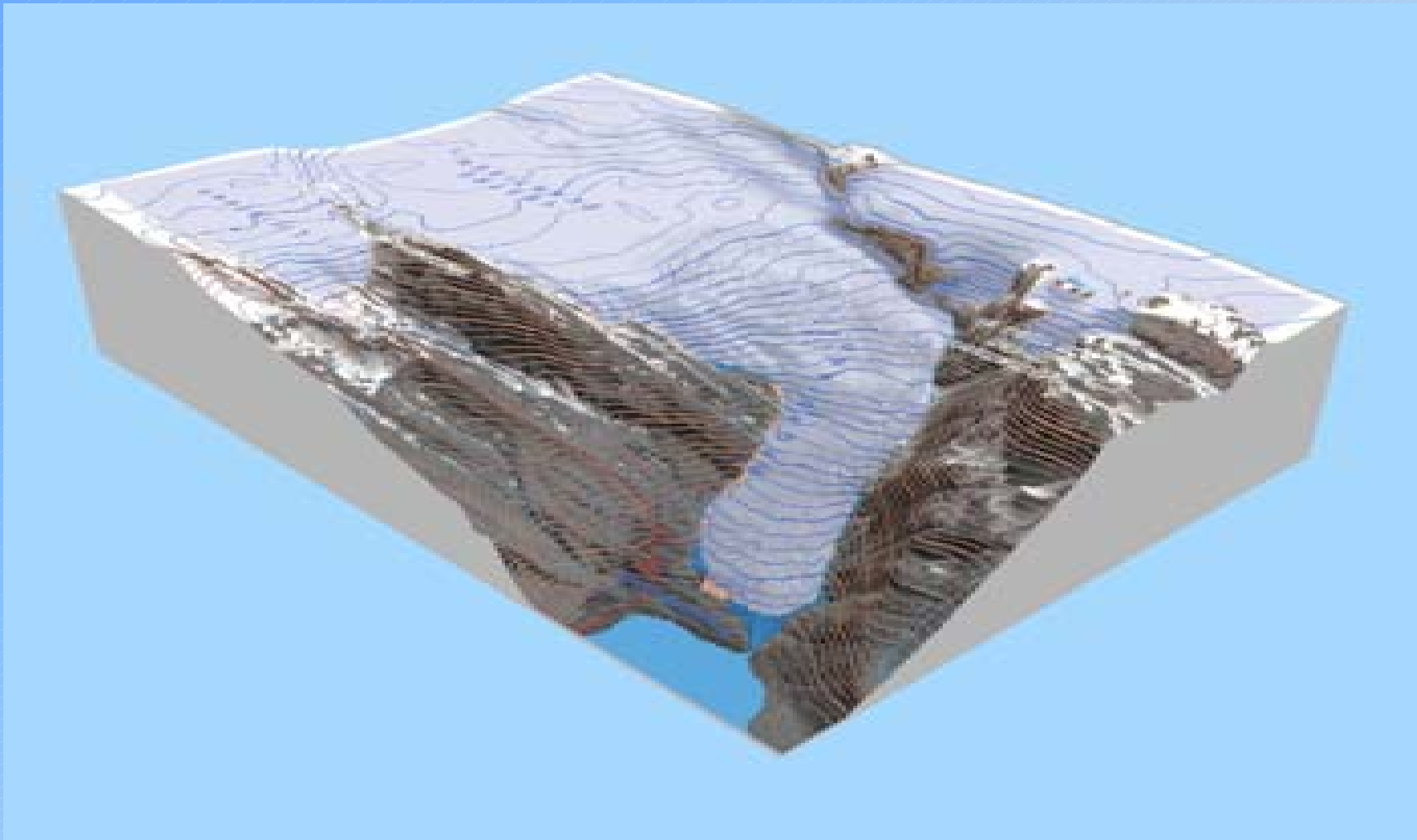
3D-Modelling



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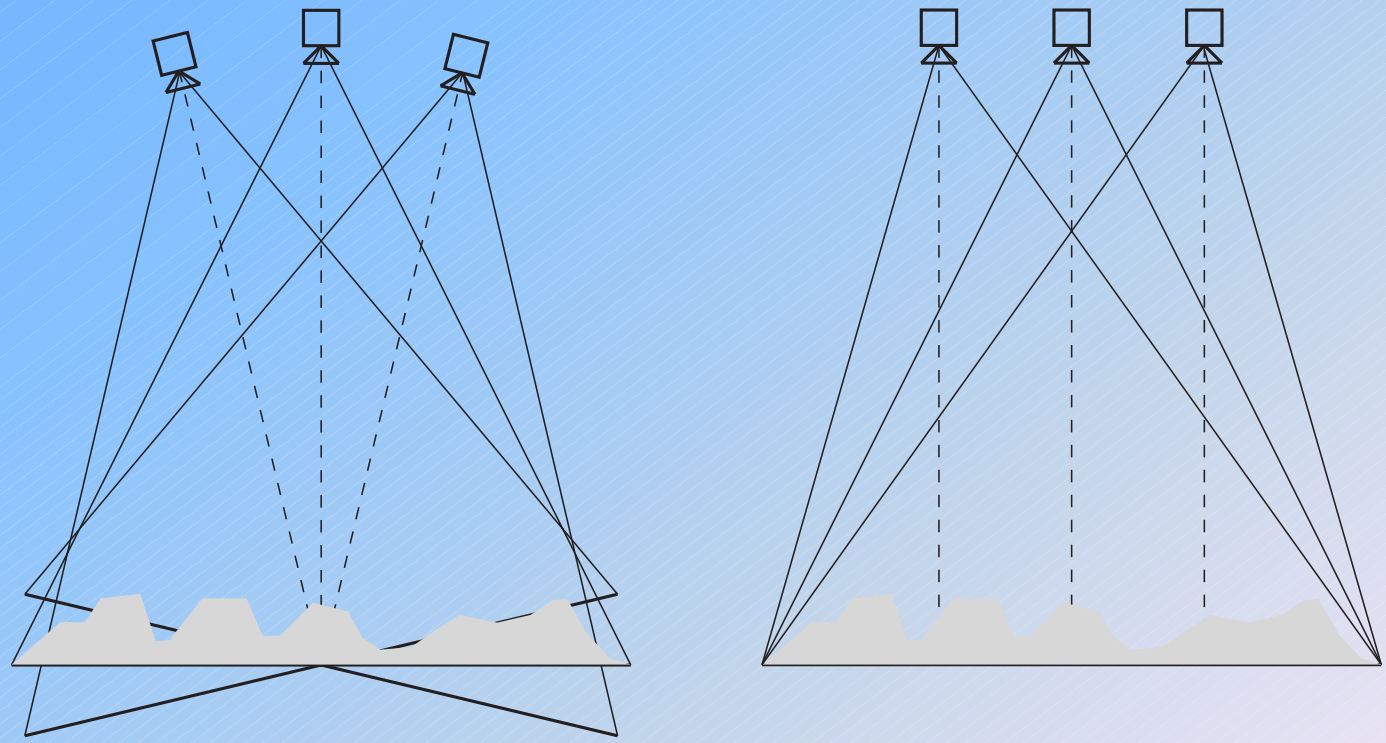
Virtual Camera Disposition

convergent vs. parallel



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... to sum it up:

True-3D hardcopies: a new subject in scientific cartography with a high potential for tourism and outdoor activities.

To be investigated in more detail: cognitive, syntactic and semantic aspects of cartographic models perceived in true-3D as well as geometric and material aspects of lens foils.

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Acknowledgements

The initiative of the work presented, the input-data provision and the eager interest in our map design of Dr. Alexej Sharov, Institute of Digital Image Processing of Joanneum Research, Graz, Austria, is thankfully acknowledged. So are the valuable contributions, both in terms of brainwork and hands-on work, carried out by Sebastian Walther, Sven-Heico Etzold and Thomas Gruendemann, IfC, TU Dresden.

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The presented types of new glacier dynamics maps allow to cartographically visualise areas which are potentially dangerous due to the occurrence of crevasses, even under a hiding cover of snow. In connection with the increasing winter outdoor-tourism in glaciated areas these types of maps may help to increase safety in alpine and polar regions.

For further questions please contact:
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KlausHabermann@tu-dresden.de
http://web.tu-dresden.de/kartographie/

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USPs – Unique Selling Propositions

In contrast to anaglyphs, chromo-stereoscopy, active and passive polarisation:

- No glasses required
- No active or special illumination required
- Spontaneous stereoscopic perception
- Multi-user capability
- Multi-scene-displays
- Short animations possible
- Easily portable
- No energy (electric power) required
- Bendable (even foldable) displays