An Objective Method to derive the variable Height-Dependence of Precipitation

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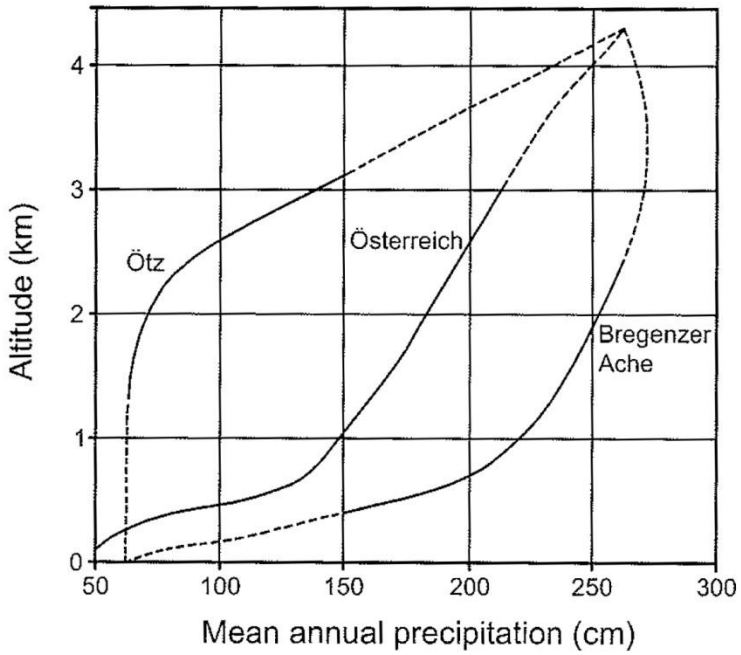
Overview:

- Motivation
- Fingerprint Technique
- Examples of Height Dependence
- Open Problems
- Conclusion and Outlook

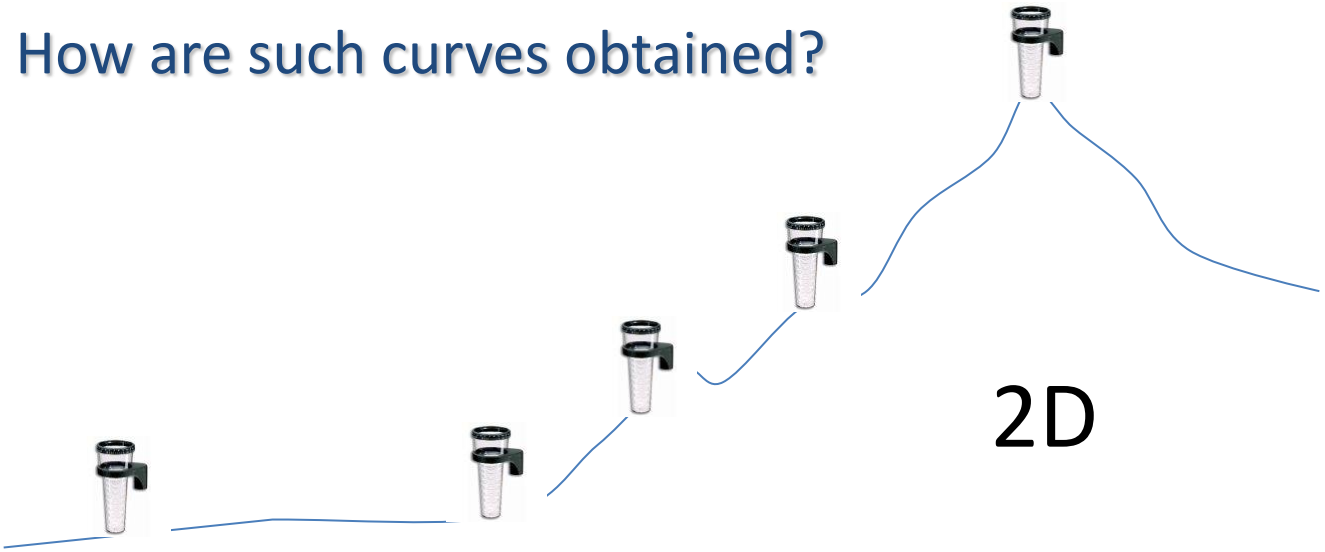
Motivation:

It is well known and documented, that most mountain regions of the world exhibit a significant height dependence of precipitation

The altitudinal profile of mean annual precipitation (cm) for Austria as a whole, for the Otzal in a lee situation and the Bregenz area in a windward situation (from Lauscher, 1976a).



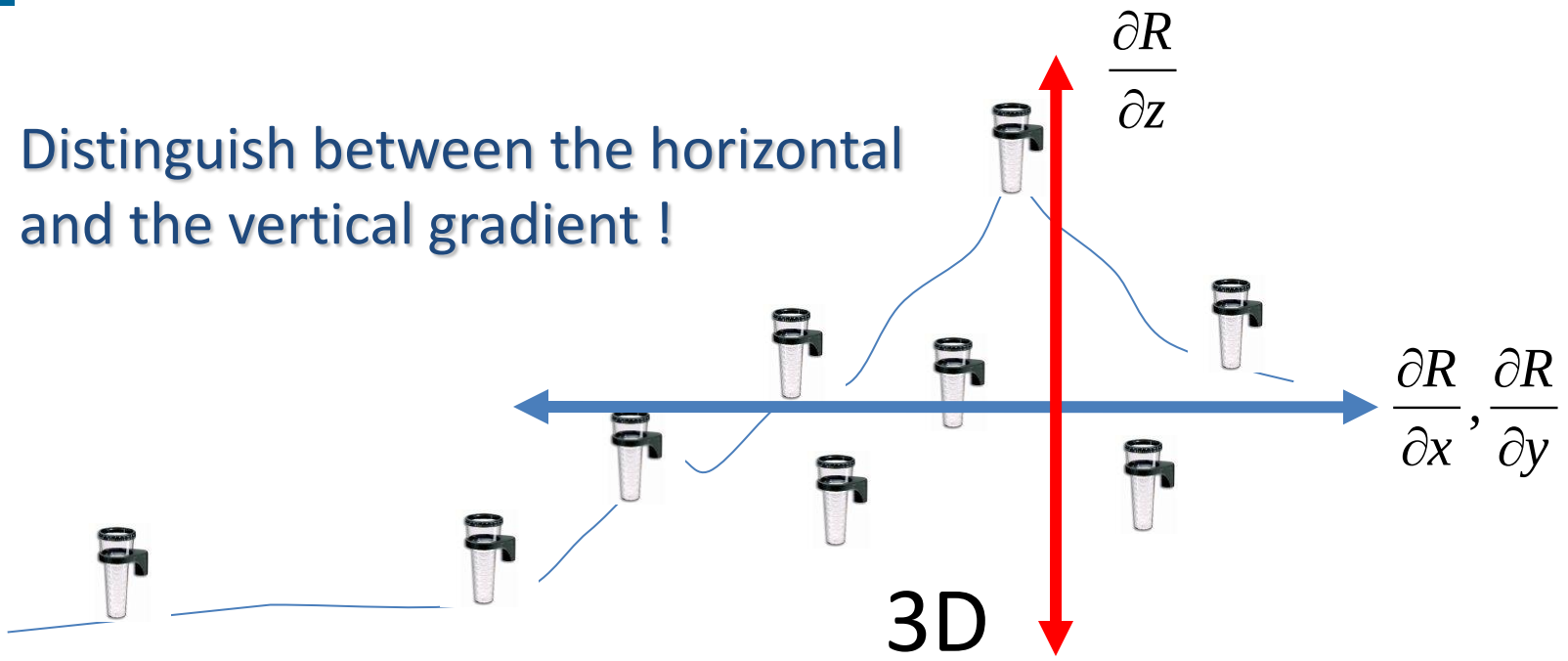
How are such curves obtained?



But this is not the vertical gradient !

This is the gradient along the slope !

Distinguish between the horizontal and the vertical gradient !



A dense precipitation network is required at different horizontal and vertical locations !

Mathematical solution to determine the horizontal and vertical precipitation gradient:

Fingerprint technique

given

$$R(x,y,z,t) = R_0(x,y,z,t) + c_h(x,y,t) \cdot R_h(x,y) + c_v(x,y,t) \cdot R_v(z) + \ldots$$

Total precipitation

Residual precipitation

weight

Horizontal gradient (Fingerprint 1)

weight

Vertical gradient (Fingerprint 2)

smooth

Solution for R_0 , c_h , c_v through application of variational principle, using smoothness constraint !

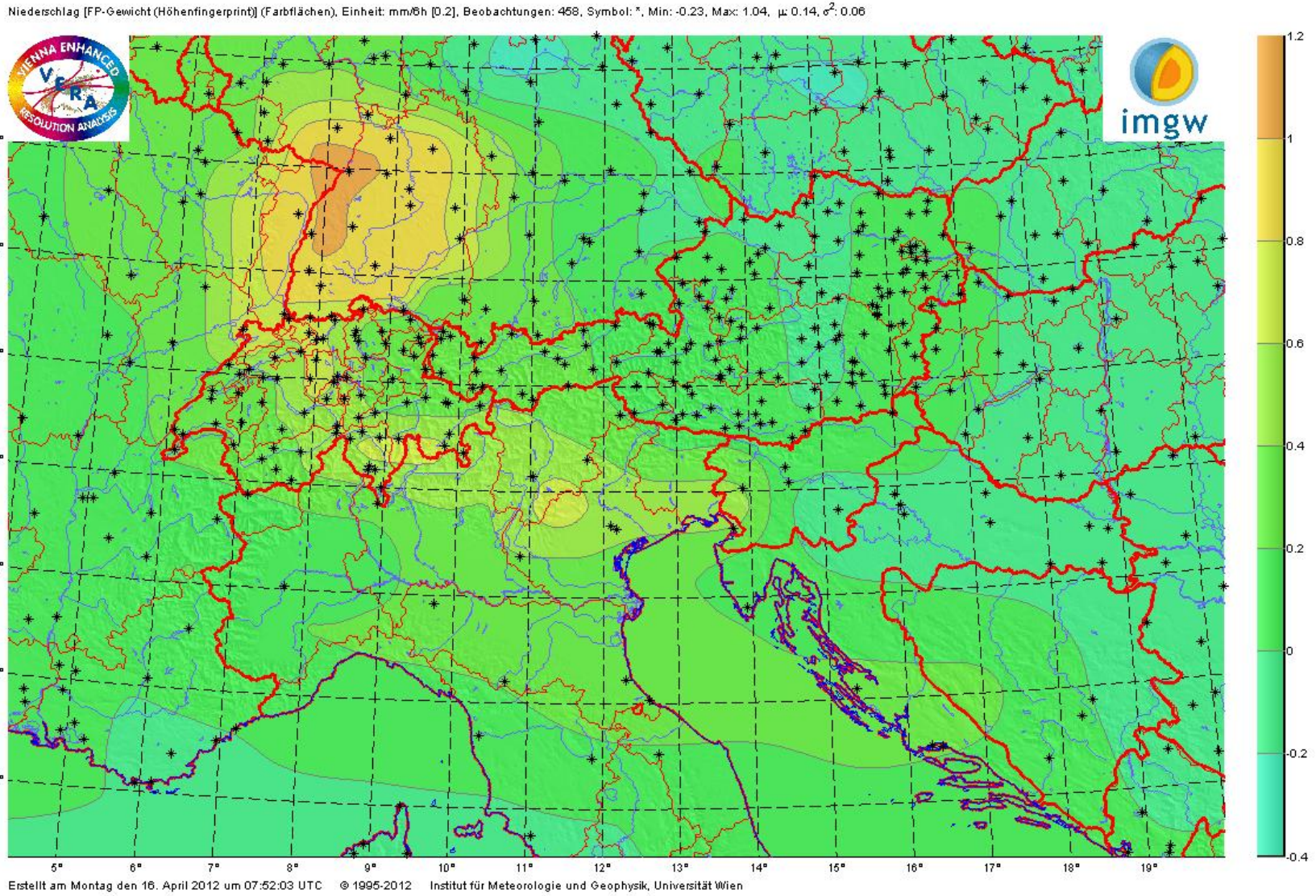
The application of the fingerprint technique is operationally carried out by the VERA (Vienna Enhanced Resolution Analysis) System

http://www.univie.ac.at/amk/veraflex/test/public/
http://www.univie.ac.at/amk/veraflex/test/fingerprint/

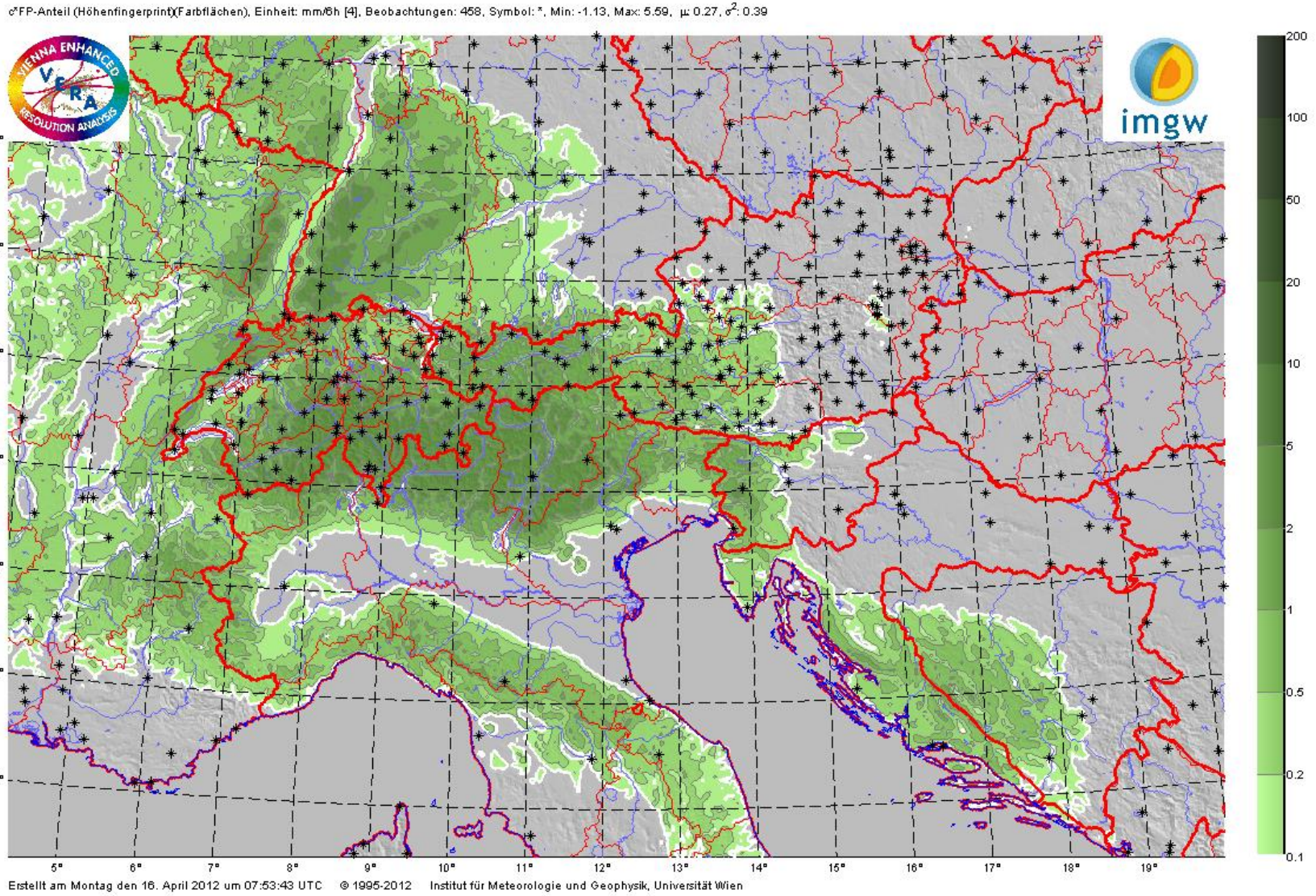
Examples: weight of the vertical fingerprint

Montag, 16. April 2012, 06:00 UTC, Alpenraum (16 km Gitter)

$$R_h = 10mm * \sin(\pi(h - h_{valleyfloor})/6km)$$



Examples: vertical fingerprint

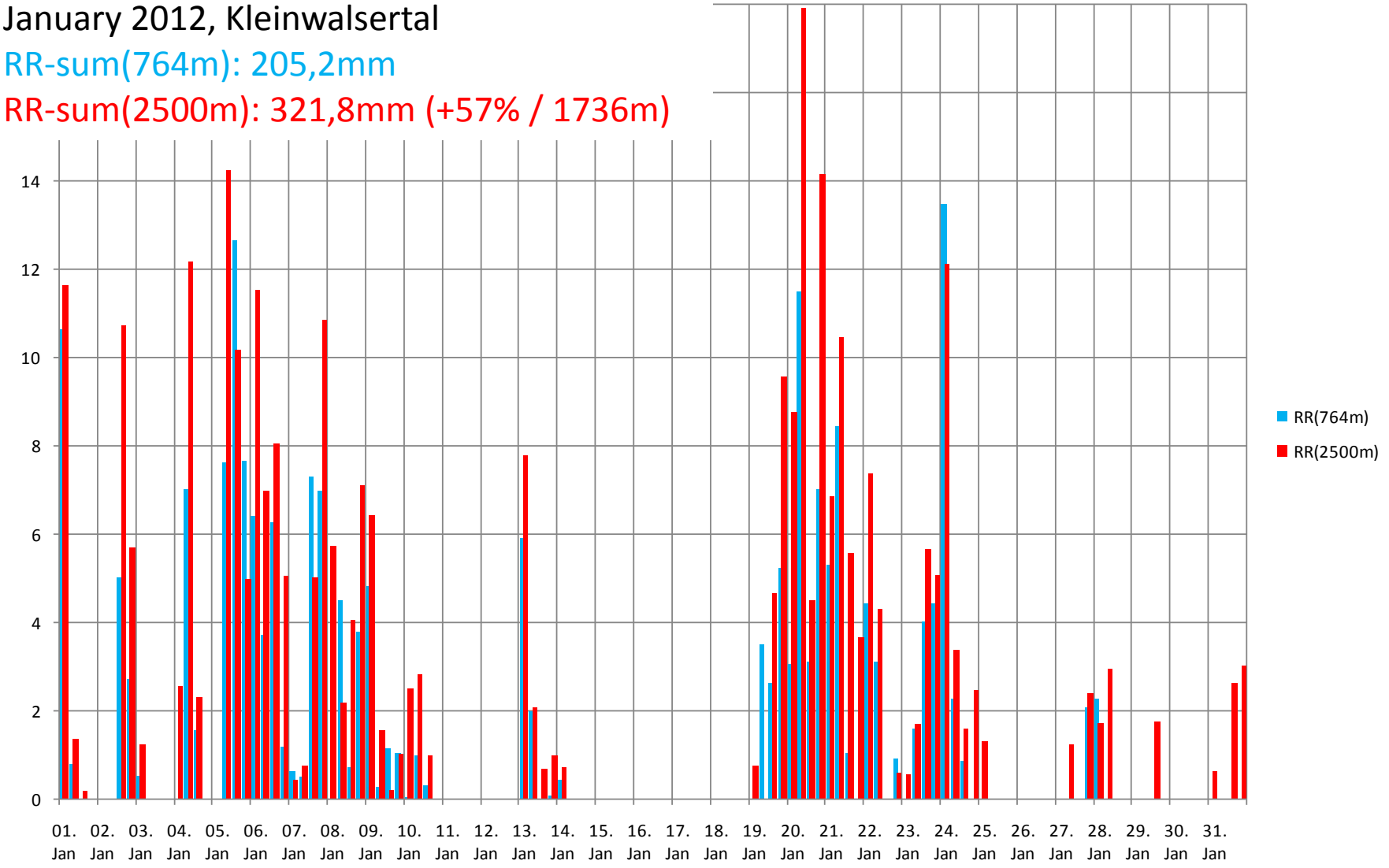


Examples: 6hr-time series of vertical precipitation difference

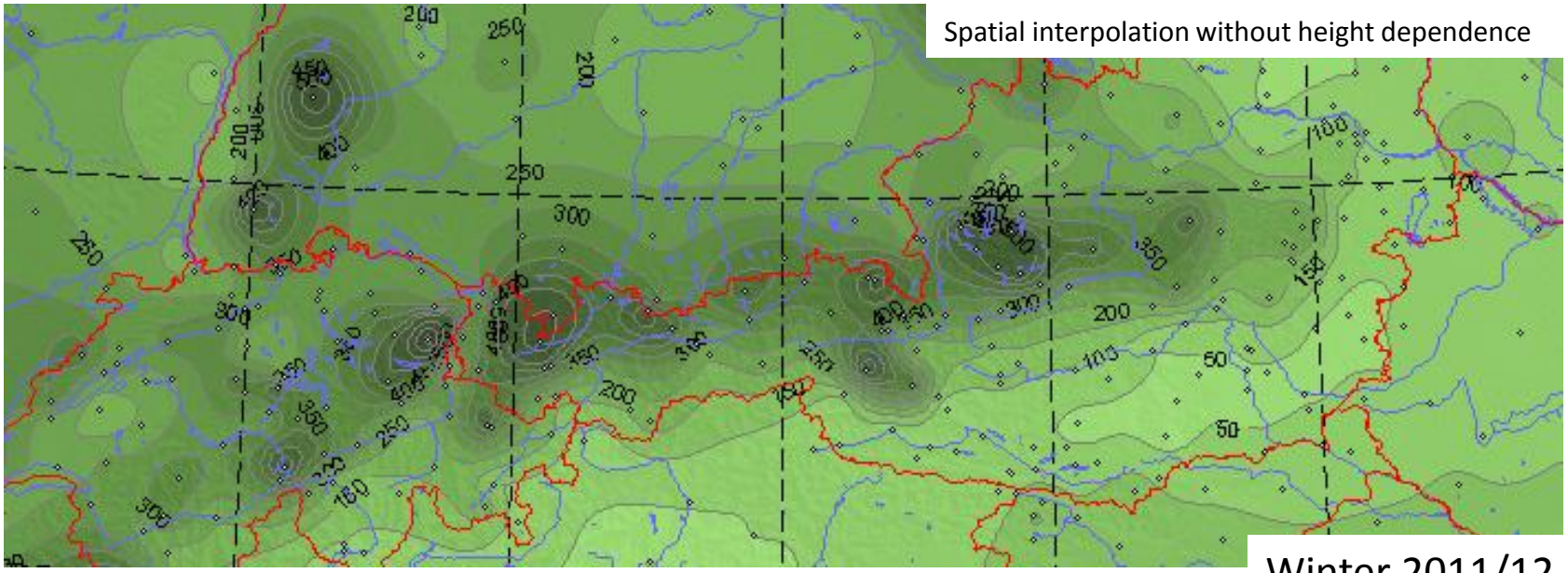
January 2012, Kleinwalsertal

RR-sum(764m): 205,2mm

RR-sum(2500m): 321,8mm (+57% / 1736m)

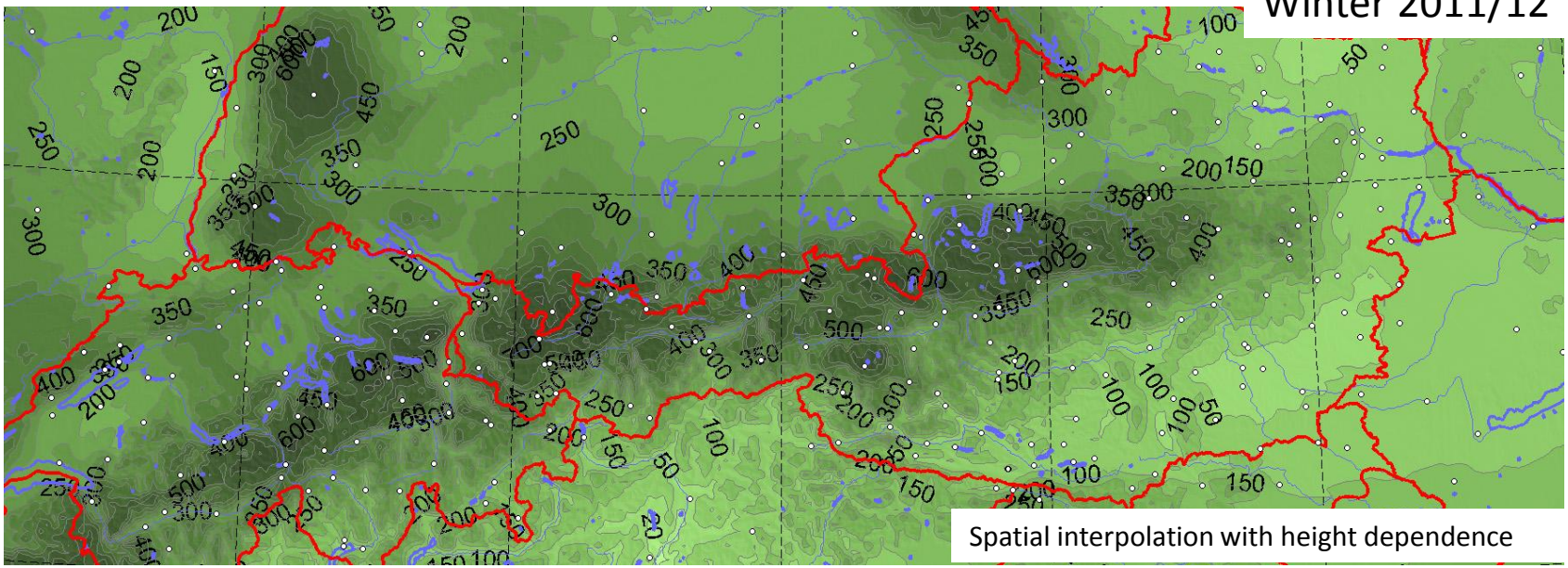


Examples: downscaling with vertical fingerprint



Spatial interpolation without height dependence

Winter 2011/12



Spatial interpolation with height dependence

Open problems/ work to be done:

- precipitation correction (wind, solid precipitation,…)
- selection of optimal fingerprints (functions)
- defining minimum requirements for station density/distribution
- systematic evaluation of height dependence with respect to weather patterns/flow regimes
- comparison with other platforms, e. g. vertical pointing radar

Conclusion and Outlook:

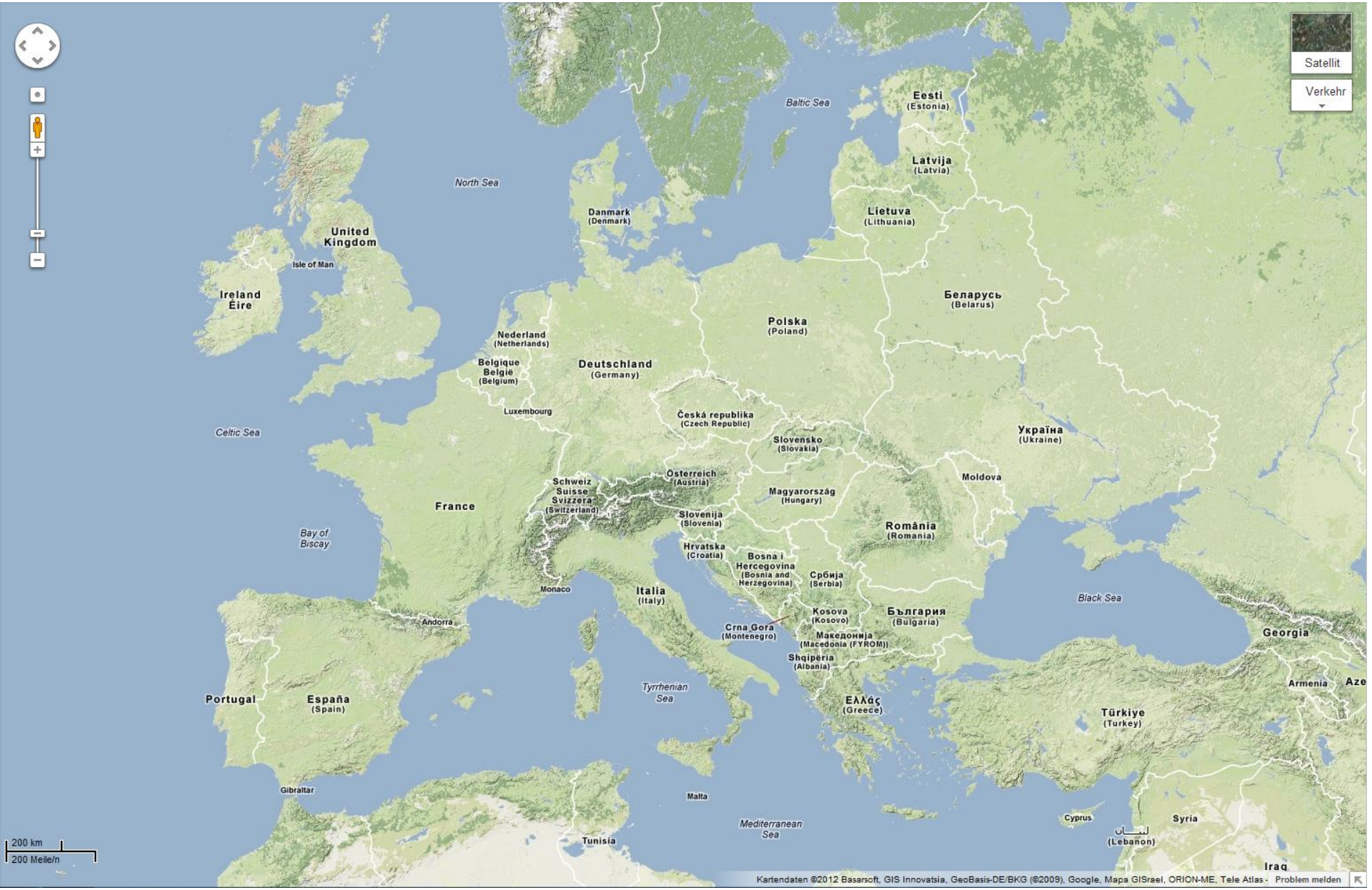
- the (pure) vertical gradient of precipitation can be obtained from a sufficiently dense observational network
- this can be used for downscaling purposes, on short term as well as climatological time scales
- investigation of vertical gradients with respect to weather pattern/ flow regimes promises a better insight into precipitation processes over complex terrain
- knowing such relations promises an improved nowcasting/forecasting of the small scale precipitation distribution over complex terrain

Thank you

Steinacker, R, M. Ratheiser, B. Bica, B. Chimani, M. Dorninger, W. Gepp, C. Lotteraner, S. Schneider and S. Tschannett, 2006: Mesoscale Data Analysis and Downscaling Method over Complex Terrain. MonWeaRev, **134**, 2758-2771.

Steinacker, R., D. Mayer, and A. Steiner, 2011: Data Quality Control Based on Self-Consistency. MonWeaRev, **139**, 3974-3991.

See also Poster # XY36, XY38, Session AS1.2, this Conference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Danmark
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Ireland
Éire
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Polska
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Nederland
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Belgique
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Luxembourg
Česká republika
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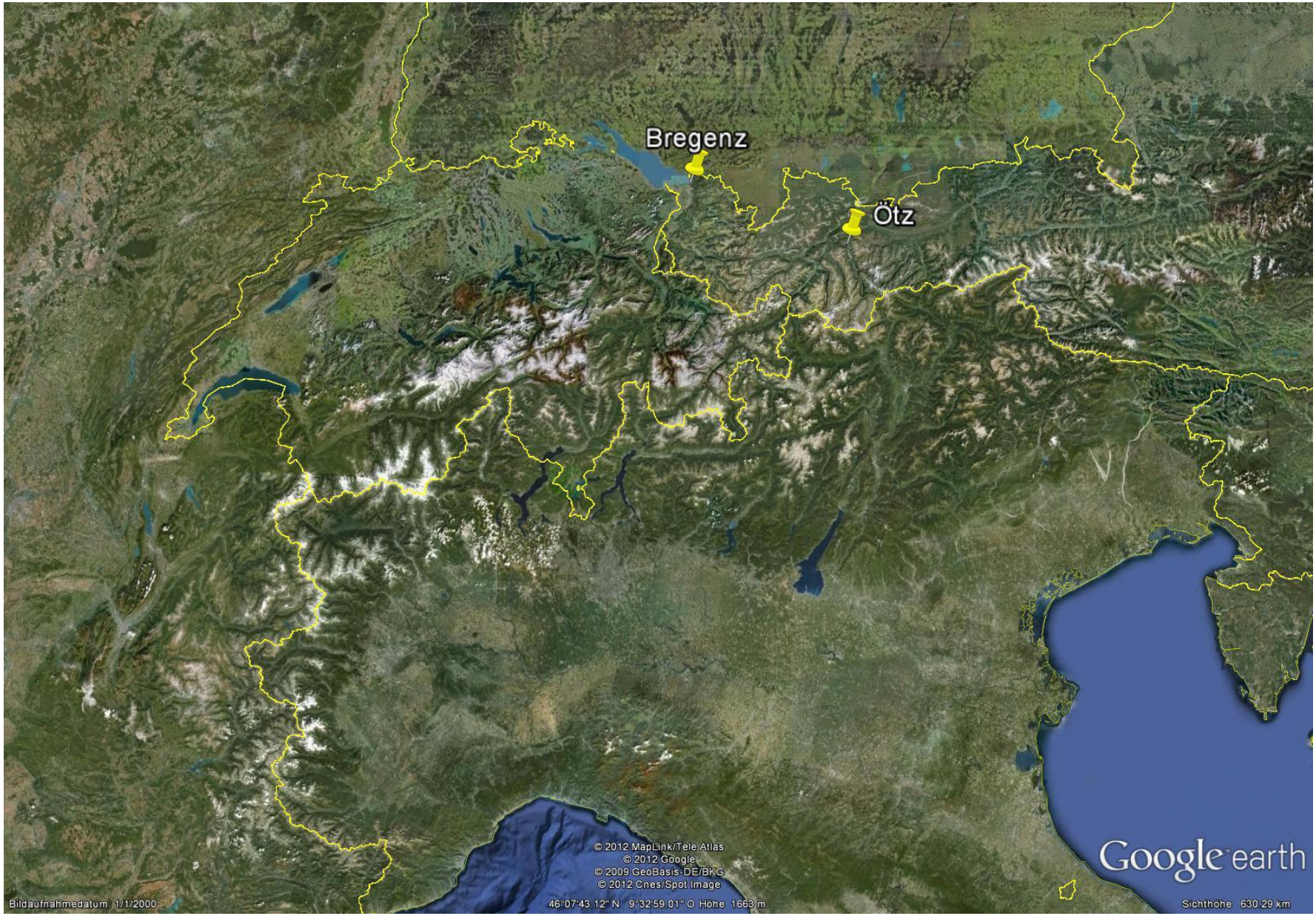
Bregenz
Ötz
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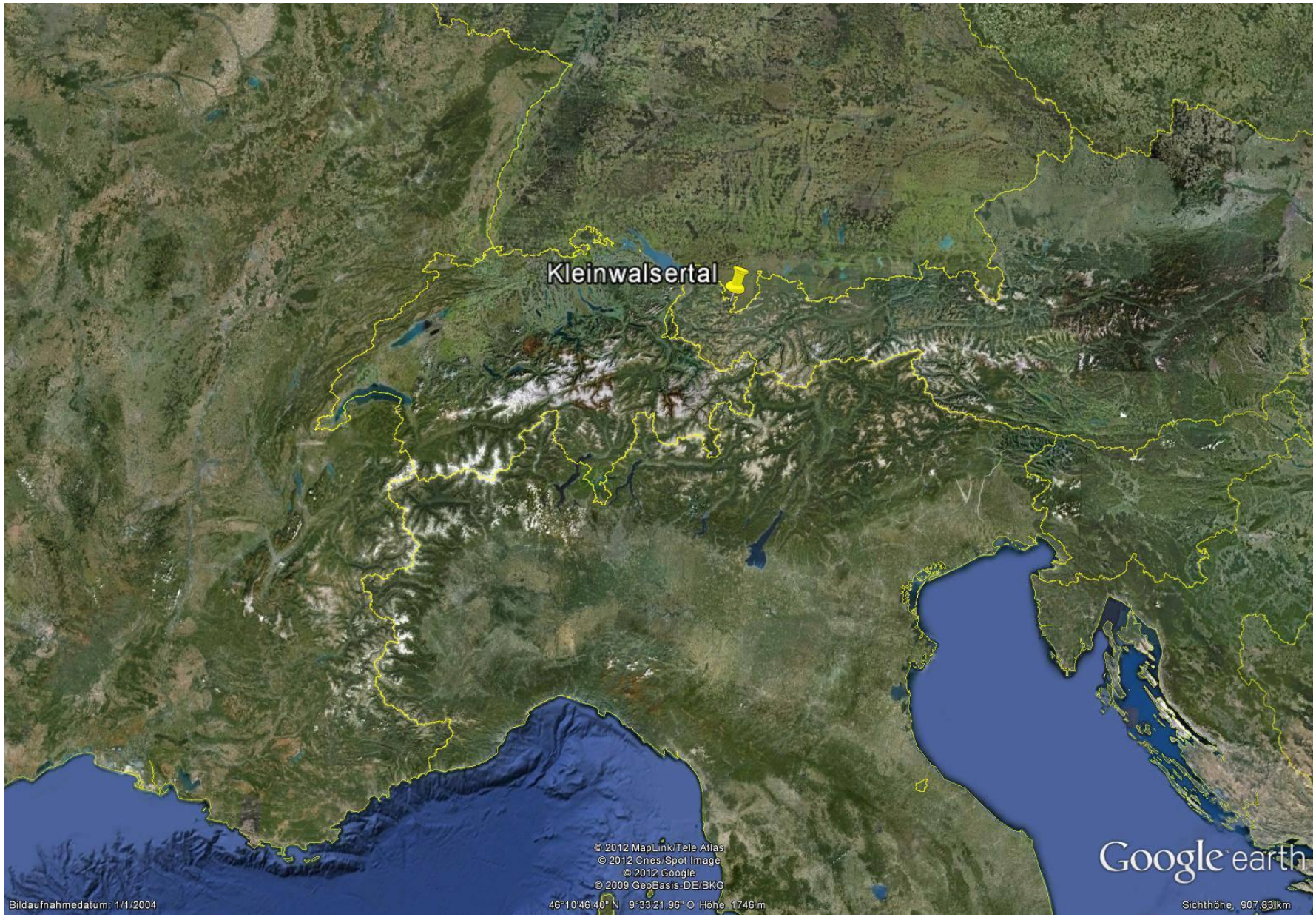
Bildaufnahmedatum: 1/1/2000
46°07'43.12" N 9°32'59.01" O Höhe 1663 m
Google earth
Sichthöhe 630.29 km


Kleinwalsertal
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Bildaufnahmedatum: 1/1/2004
46°10'46.40" N 9°33'21.96" O Höhe 1746 m
Google earth
Sichthöhe 907.83 km