Seminar: Schnee von gestern?
9.April 2024, Wien

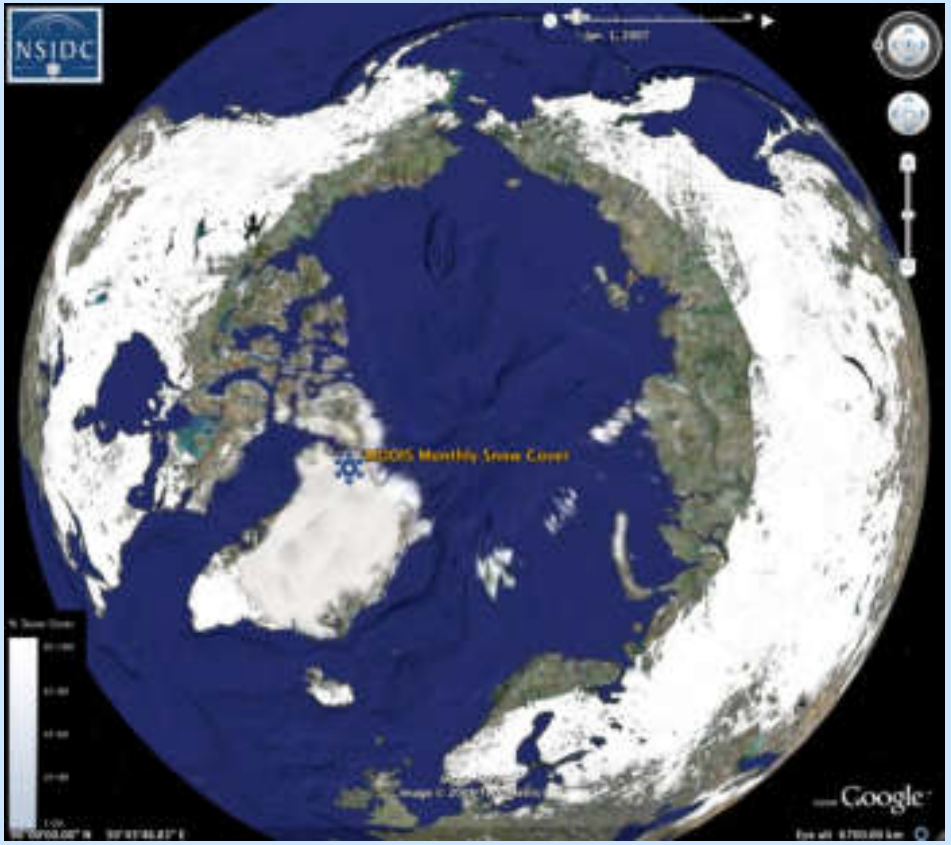
Änderungen der Schneedecke in Österreich

Remote sensing of snow cover and its variability in Austria

Juraj Parajka

Outline

1) Mapping snow cover using remote sensing
2) Snow cover changes in Danube/Austria



Mapping snow cover using remote sensing

(1) **Optical sensors**: good temporal resolution, medium spatial resolution, problem clouds

(2) **Microwave sensors:**
Active: very good spatial resolution, wet snow cover signal, dry snow-bare ground the same scatter, low temporal resolution

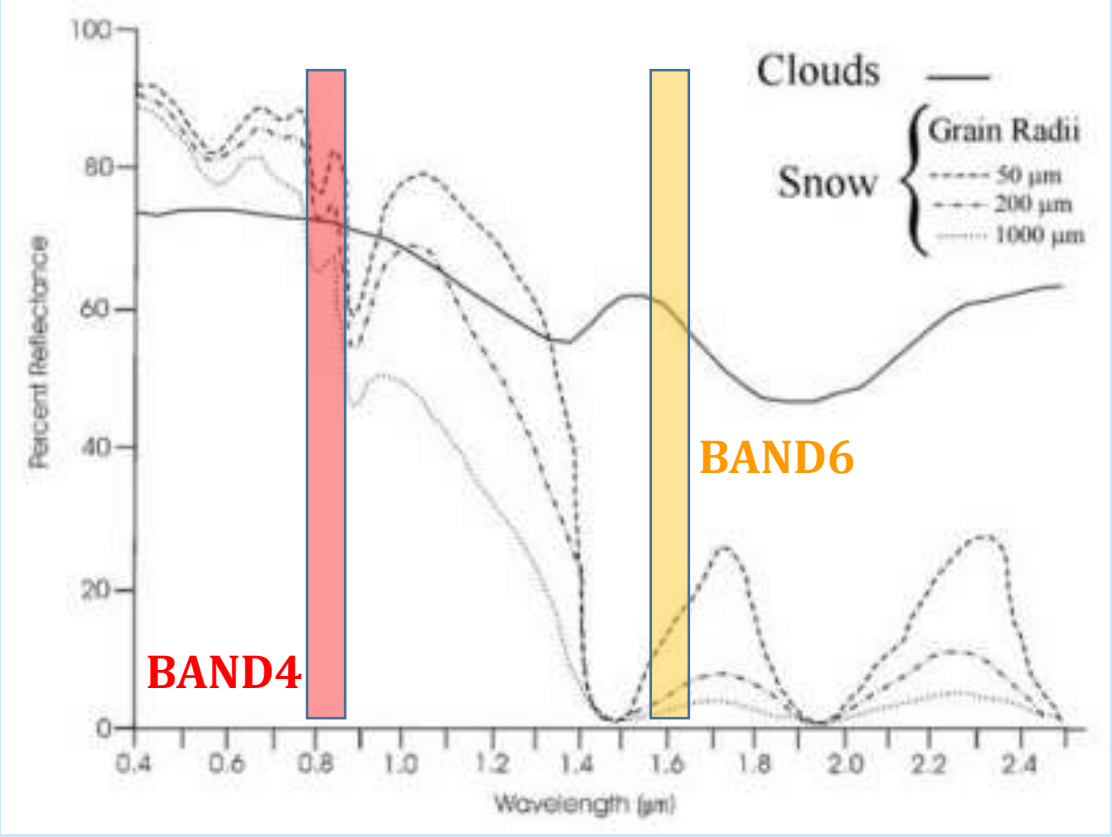
Passive: coarse spatial resolution, shallow and wet snow difficult to identify in complex terrain

Optical systems	No.bands	Pixel size [m]	Tem. res. [days]	Swath [km]	Mission date
MERIS	15	300-1200	<3	1150	2001
MODIS	36	250-1000	Daily	2330	2000
MOS	18	520	<5	200	1996
Landsat(TM, ETM, MSS)	4-7	30-120	<16	185	1972, 1982-1987, 1999
SPOT	4	10-20	<3	60	1986-90; 1993-1998; 2002
Aster	14	15-90	<16	60	1999
AVHRR	6	1100-4000	0.5	2800	1978
AATSR	7	1000	3	512	2000
ATSR	7	1000	3	512	1991
MSG	12	5000	15min.		2008

Microwave systems	Band	Pixel size [m]	Repeat [days]	Swath [km]	Mission date
ASAR	C	150-1000	35	60-100	2001
AMISAR	C	<30	35	100	1991
RADARSAT	C	8-100	24	45-500	1996
JERS-1	L	18	44	75	1992
SIR-C	C,L	25	NA	10-100	1999
X-SAR	X	10-25	NA	50-100	1999
SSM/I	Passive	25000	<1	1400	1987
SMMR	Passive	25000	<6	780	1978-87
AMSRE	Passive	25000	<2	2330	2002

Snow cover from optical sensors

Snow=high reflectance in the visible and the low reflectance in the short-wave infrared part of the spectrum
Clouds = high reflectance in both the visible and the short-wave infrared part of the spectrum



NSDI=(BAND4-BAND6)/(BAND4+BAND6)

MODIS: Band 4(841-876nm), Band6 (1628-1652nm)

MODIS snow cover mapping
(Moderate Resolution Imaging Spectroradiometer)

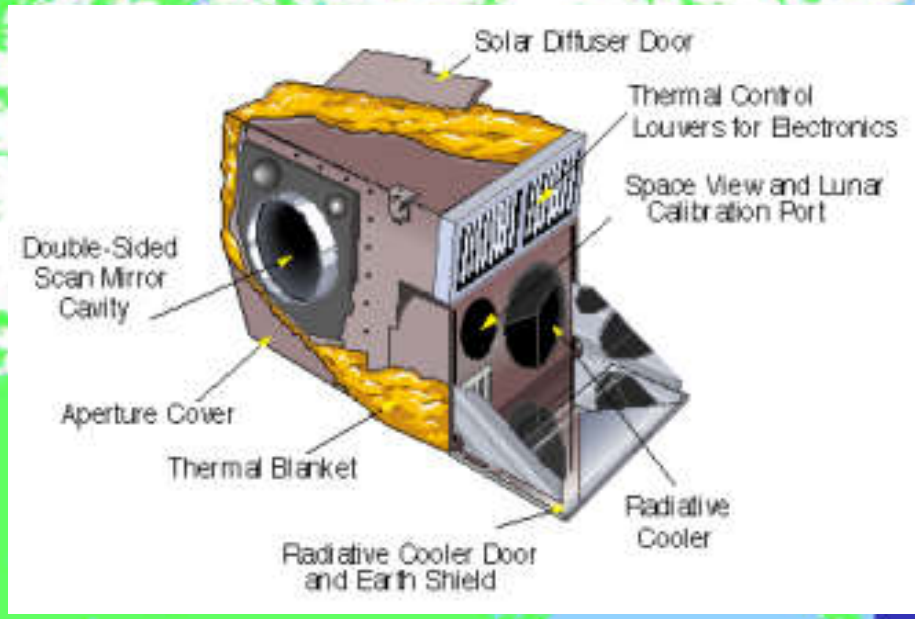
Webpage: www.nsidc.org

2 images per day (Terra from 02/2000 und Aqua from 06/2002)

Spatial resolution 500m

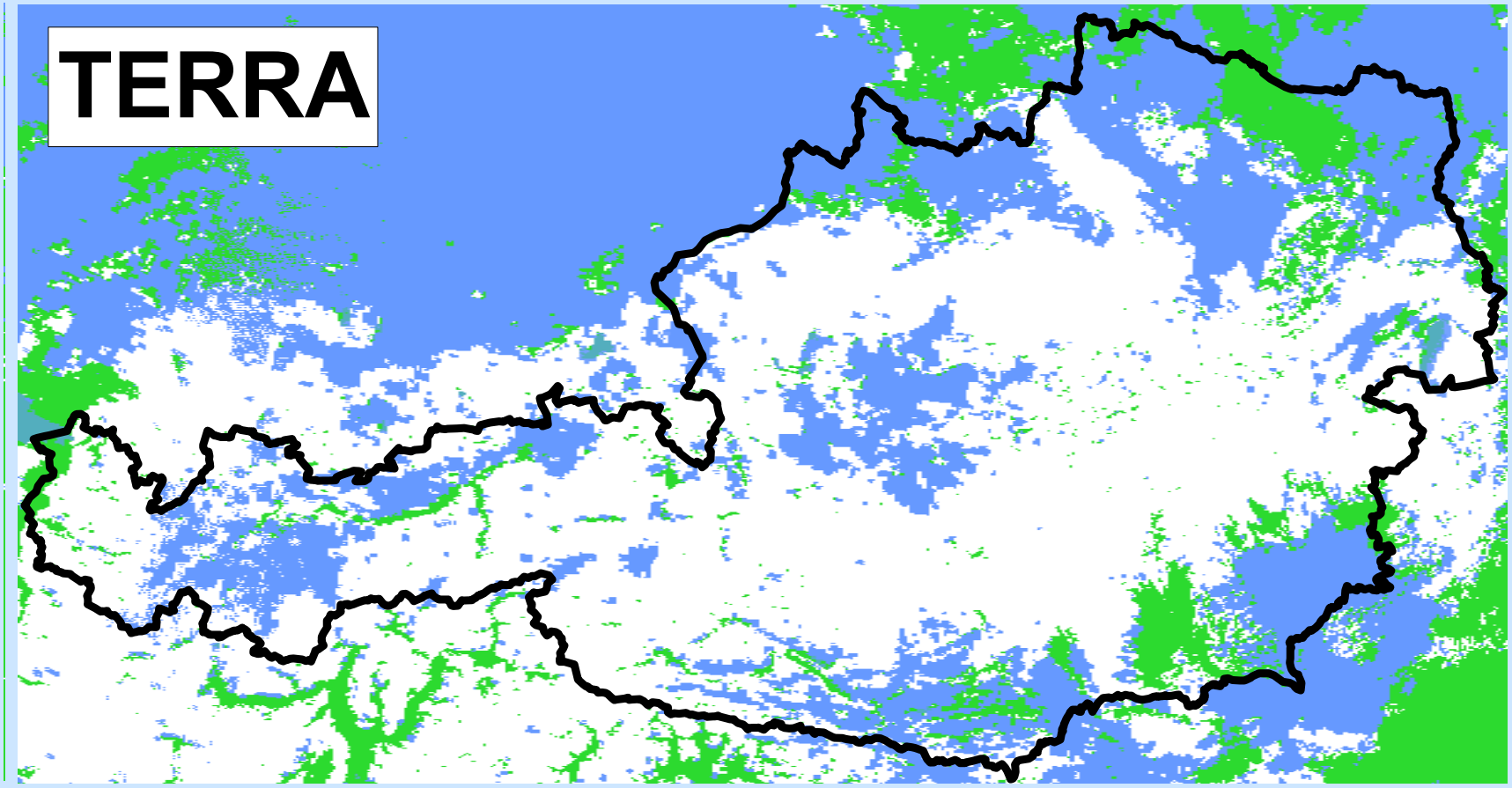
Optical sensor

Clouds are problem



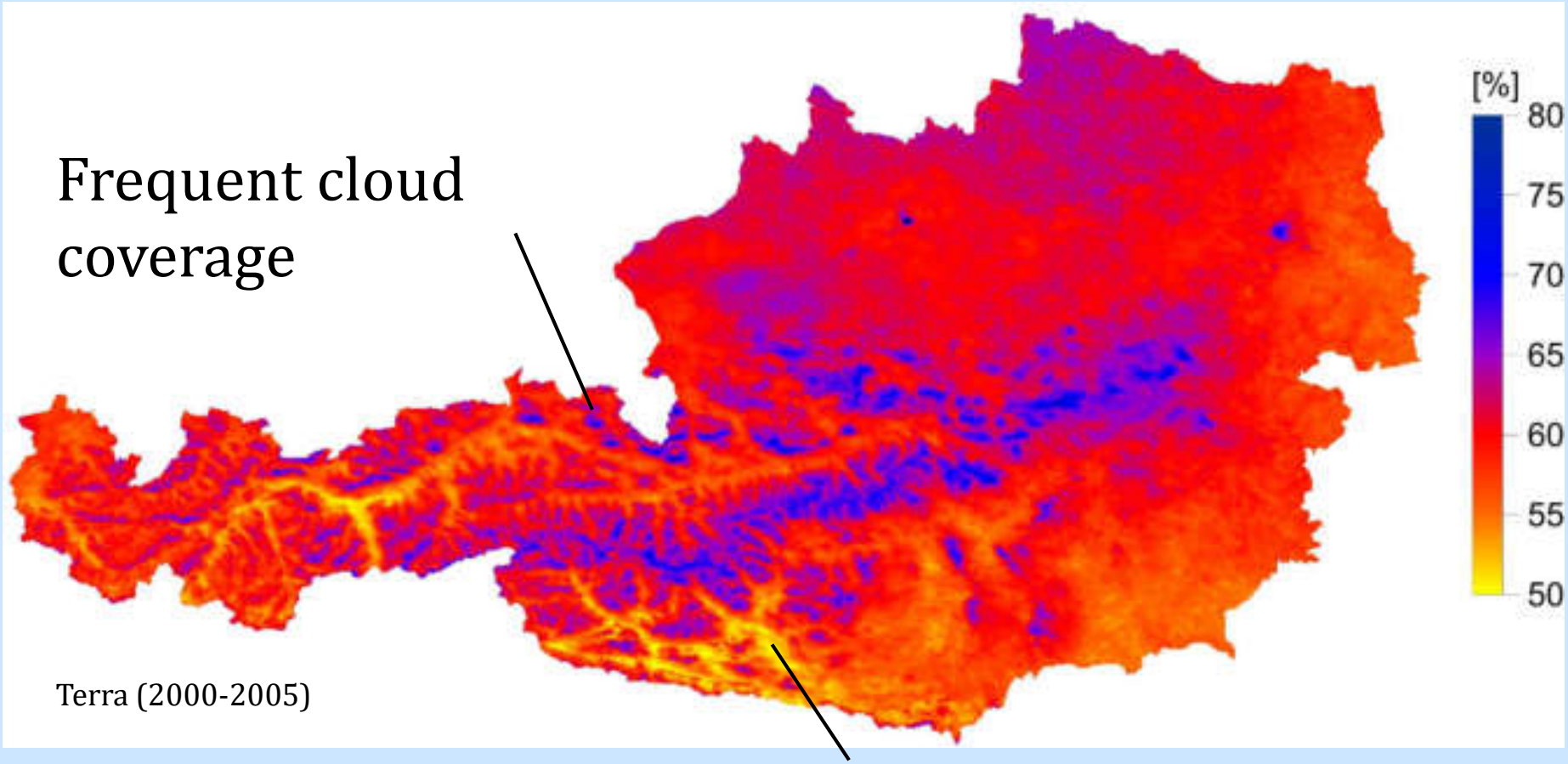
MODIS, 19.3.2003

Example of MODIS (Terra) image for Austria



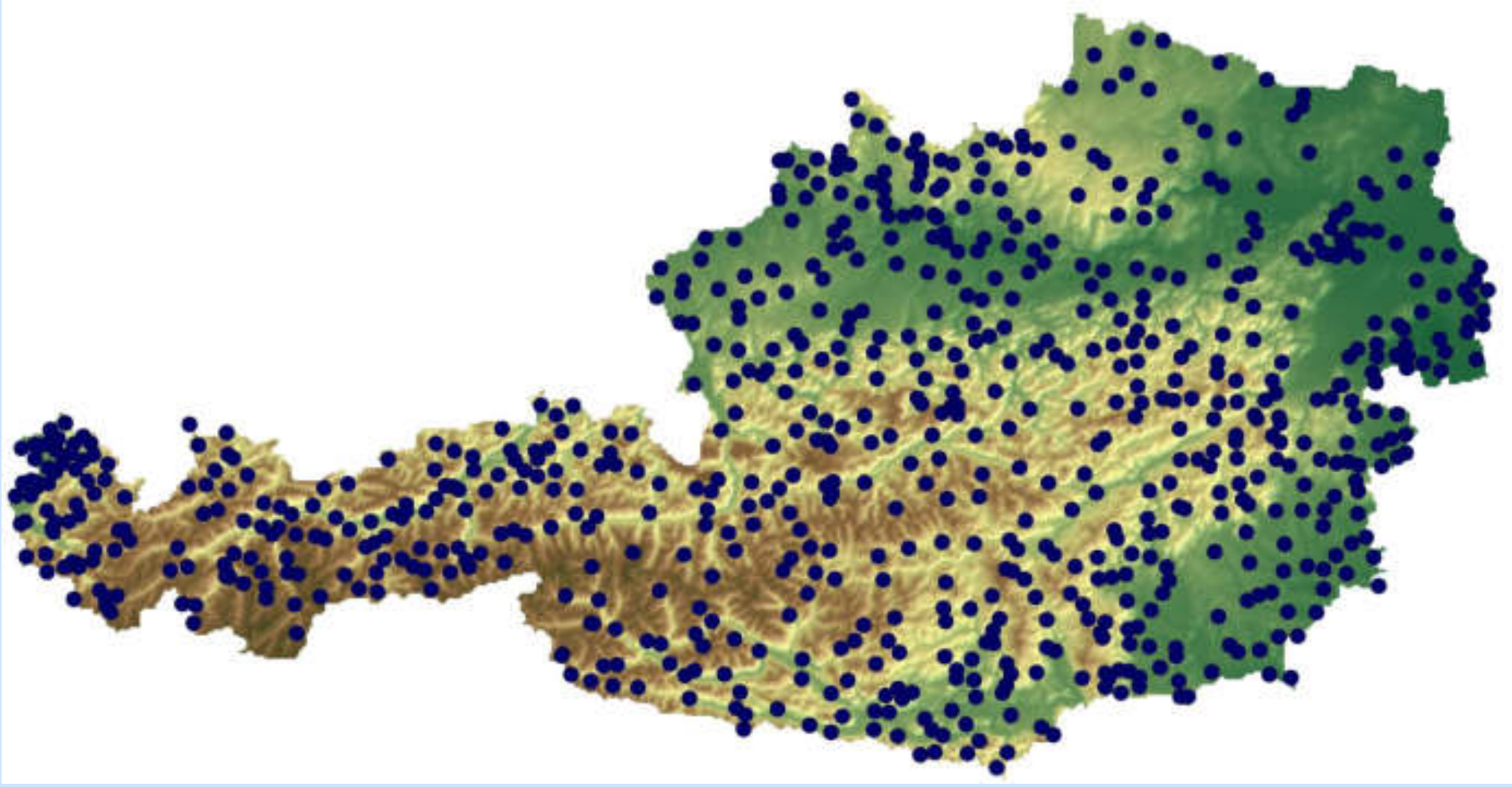
How much clouds? How accurate? How to reduce clouds?

How much clouds?



How accurate?

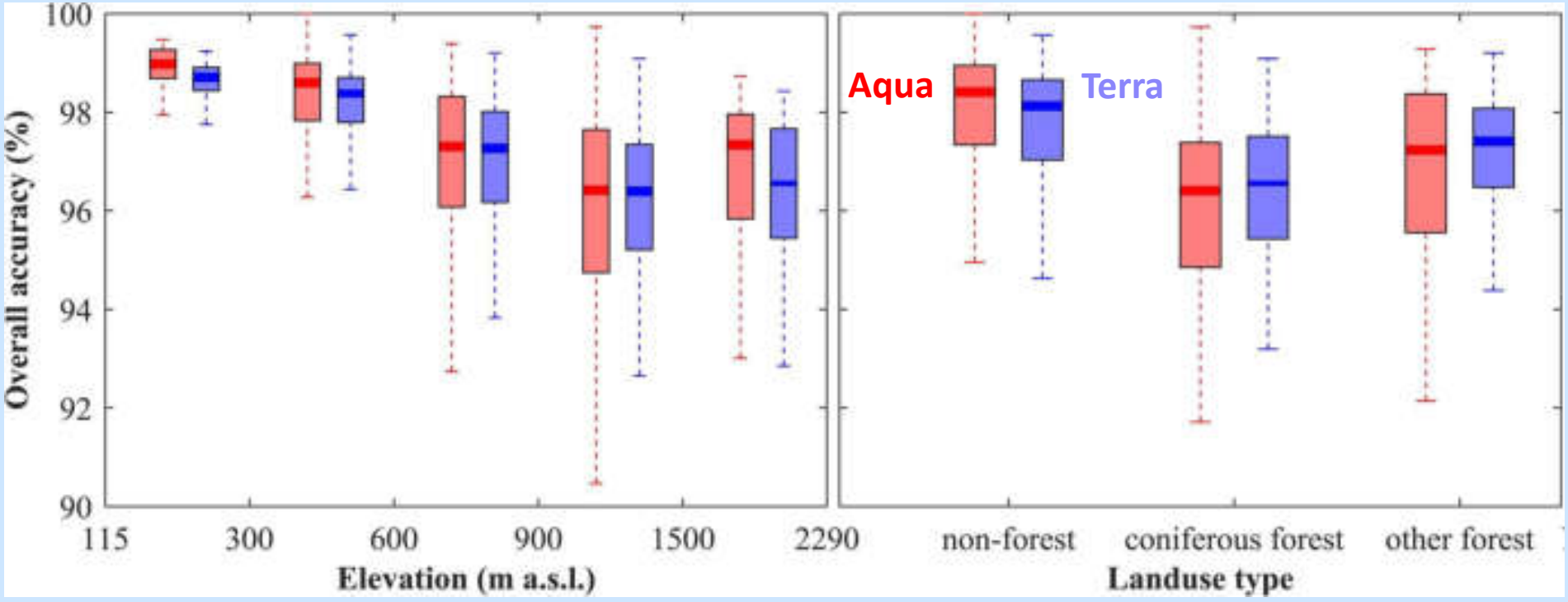
(Parajka and Bloschl, 2006, Parajka et al., 2012, Tong et al., 2020)



Mapping accuracy

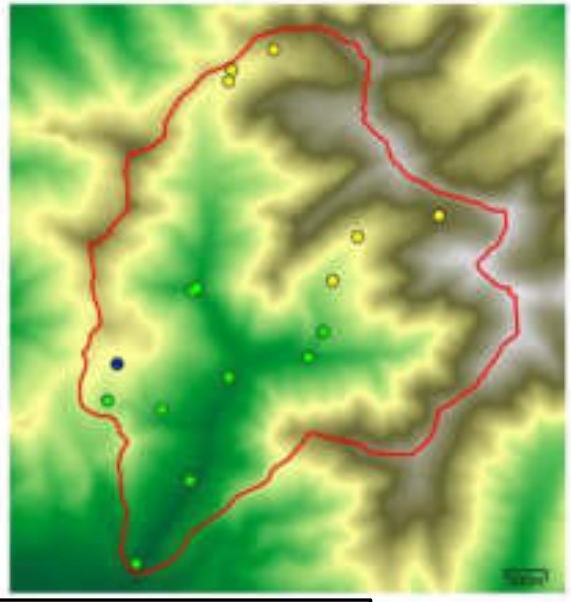
Confusion matrix	Station snow	Station land
MODIS snow	A	B
MODIS land	C	D

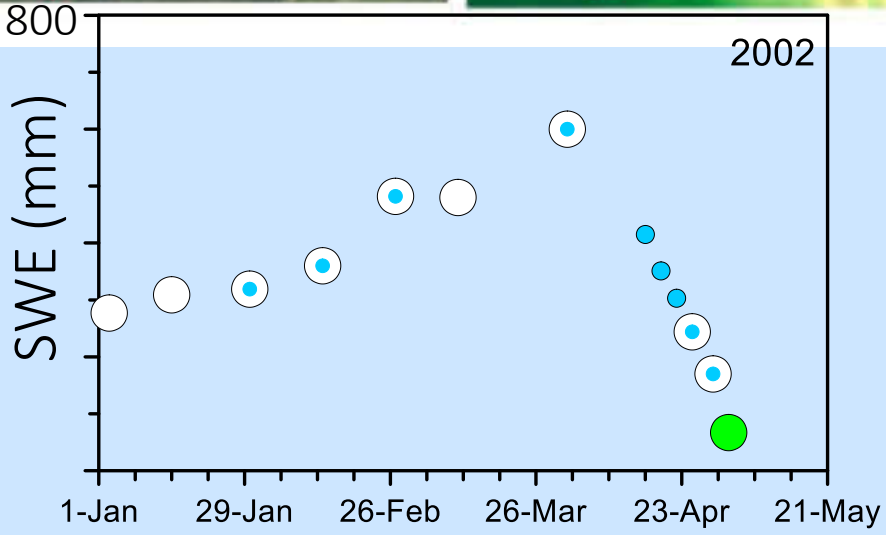
$$OA_T = \frac{A+D}{A+B+C+D} \bullet 100\%$$



MODIS accuracy in the forest

(Parajka et al., 2012, HESS)





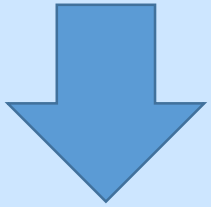
92.7 % (Aqua+Terra)
94.6% (2-day Filter)

Disagreement: patchy snow cover, geolocation error

MODIS accuracy

Overall accuracy for cloud-free conditions is very high (97%, Tong et al, 2020), problem is cloud coverage

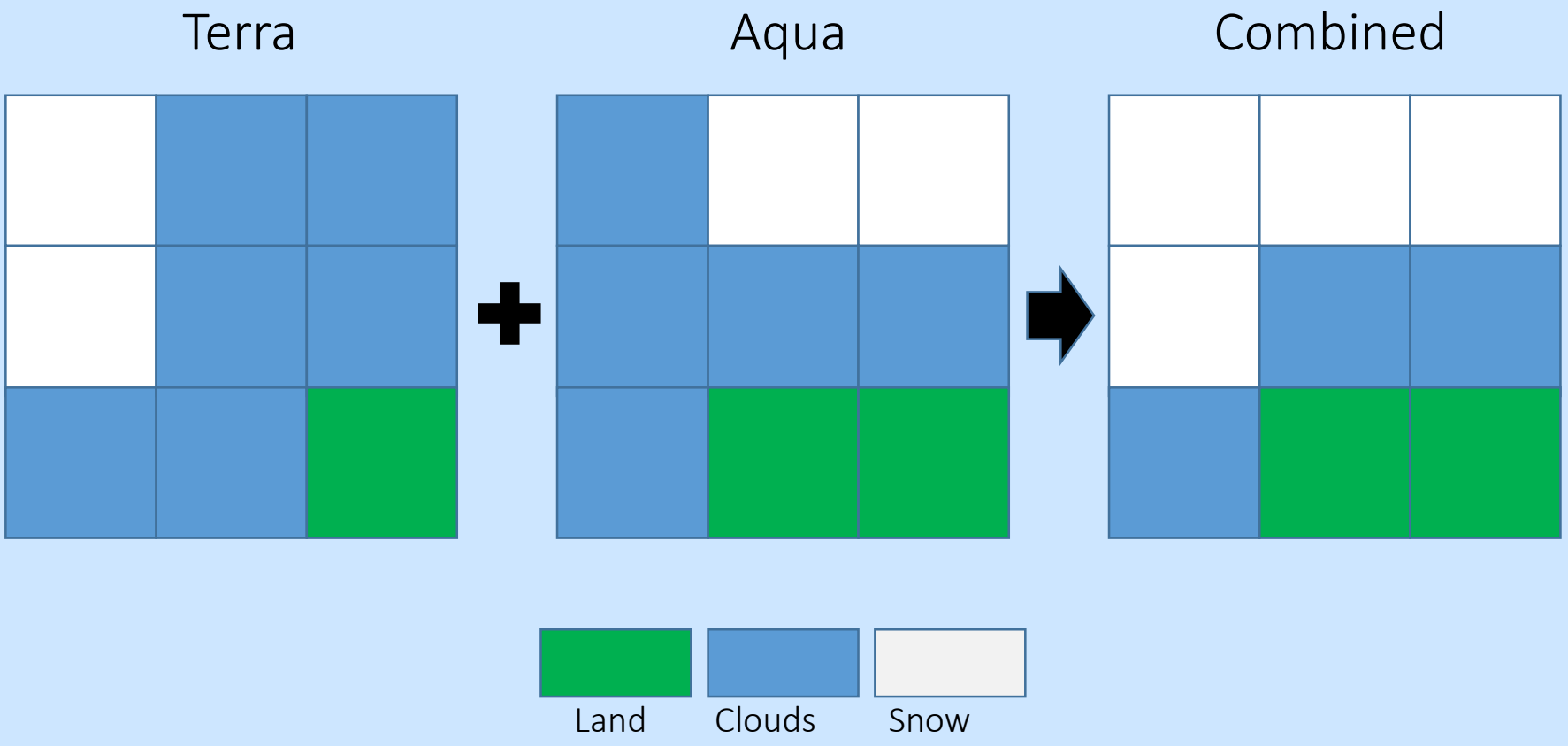
Average cloud coverage >60% (in winter months>80%)

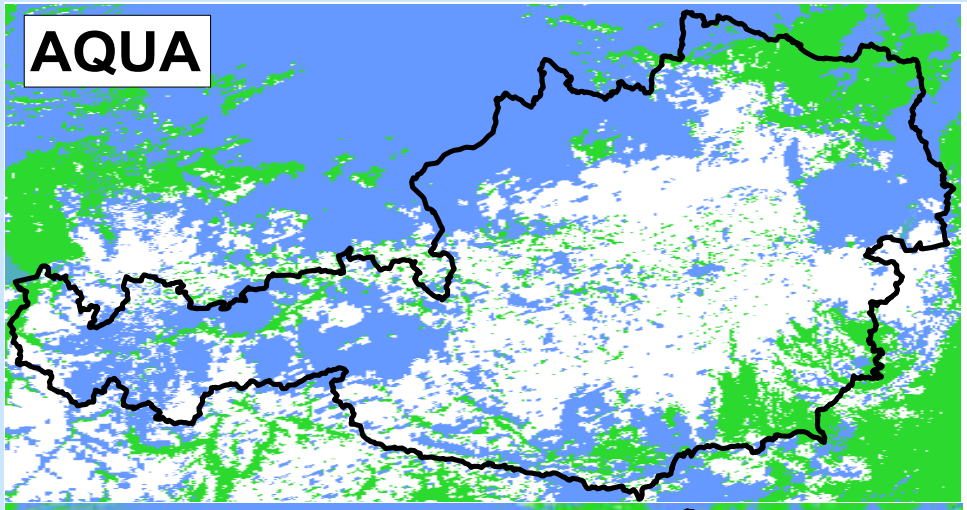


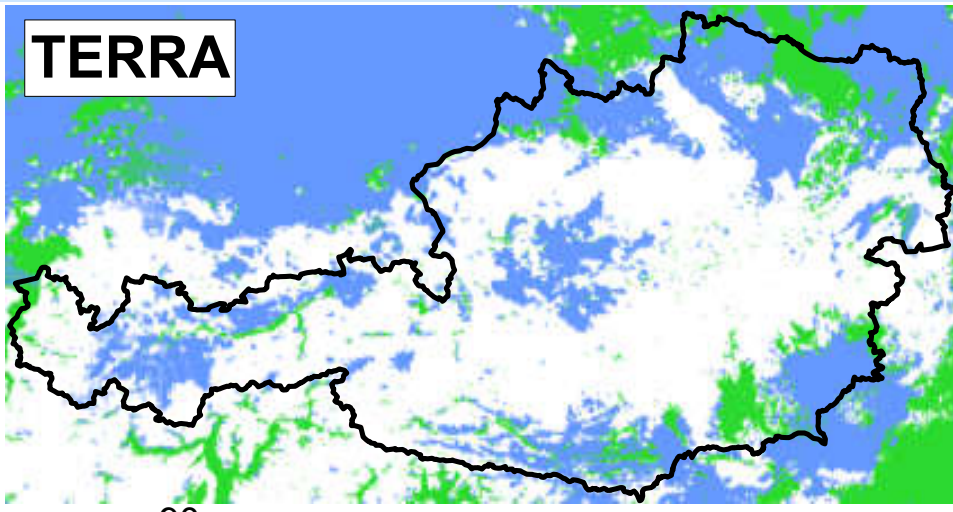
Development of methods for cloud reduction:

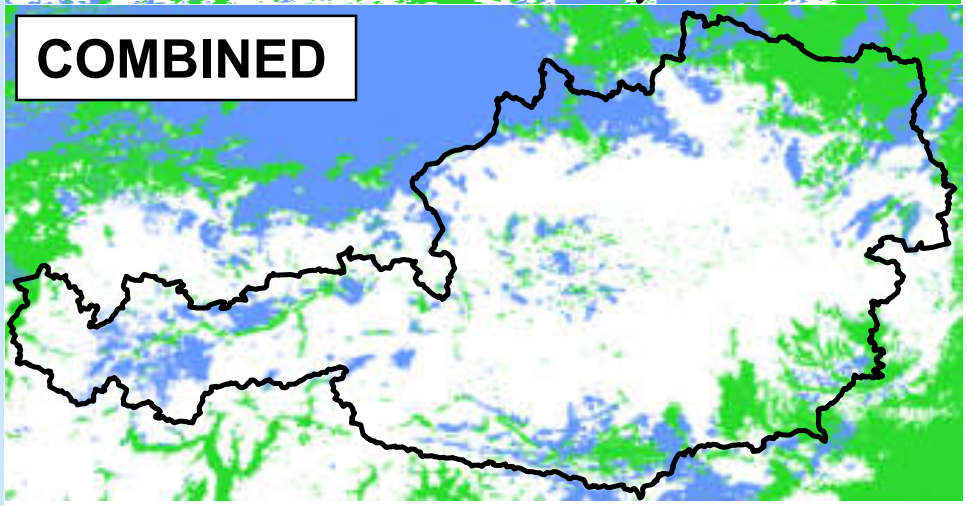
- Combination of Terra and Aqua snow cover data
- Spatial filter
- Temporal filter (1-, 3-, 5-, 7-days)
- Snow line method

Combination of Terra and Aqua snow cover data

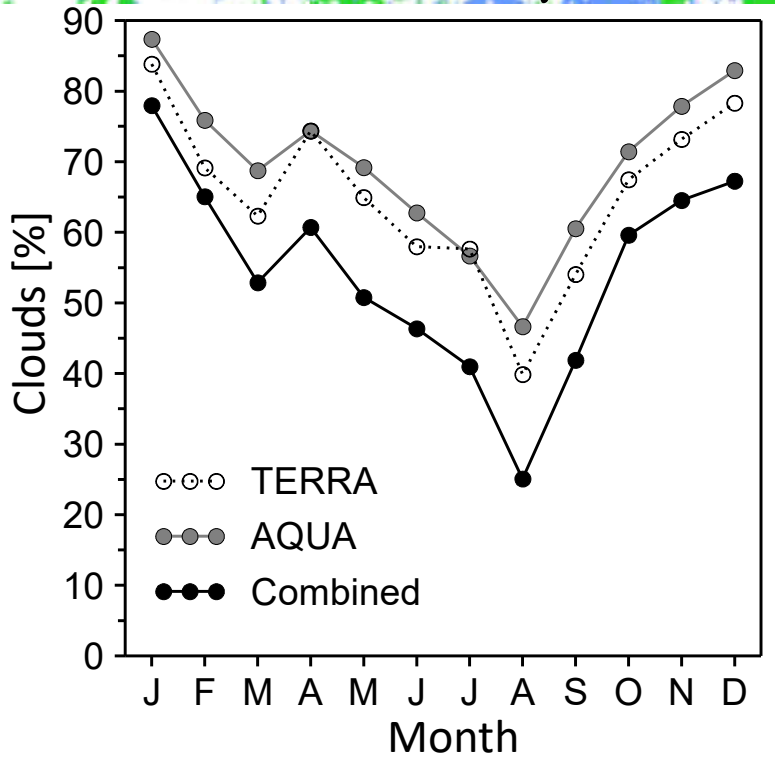




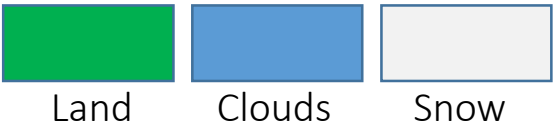


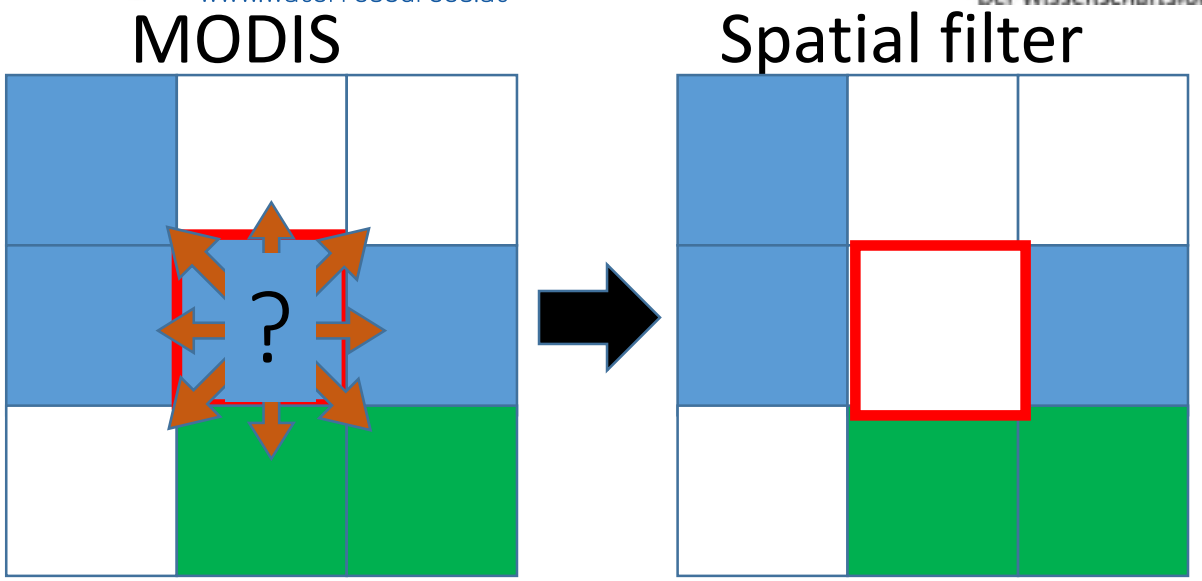


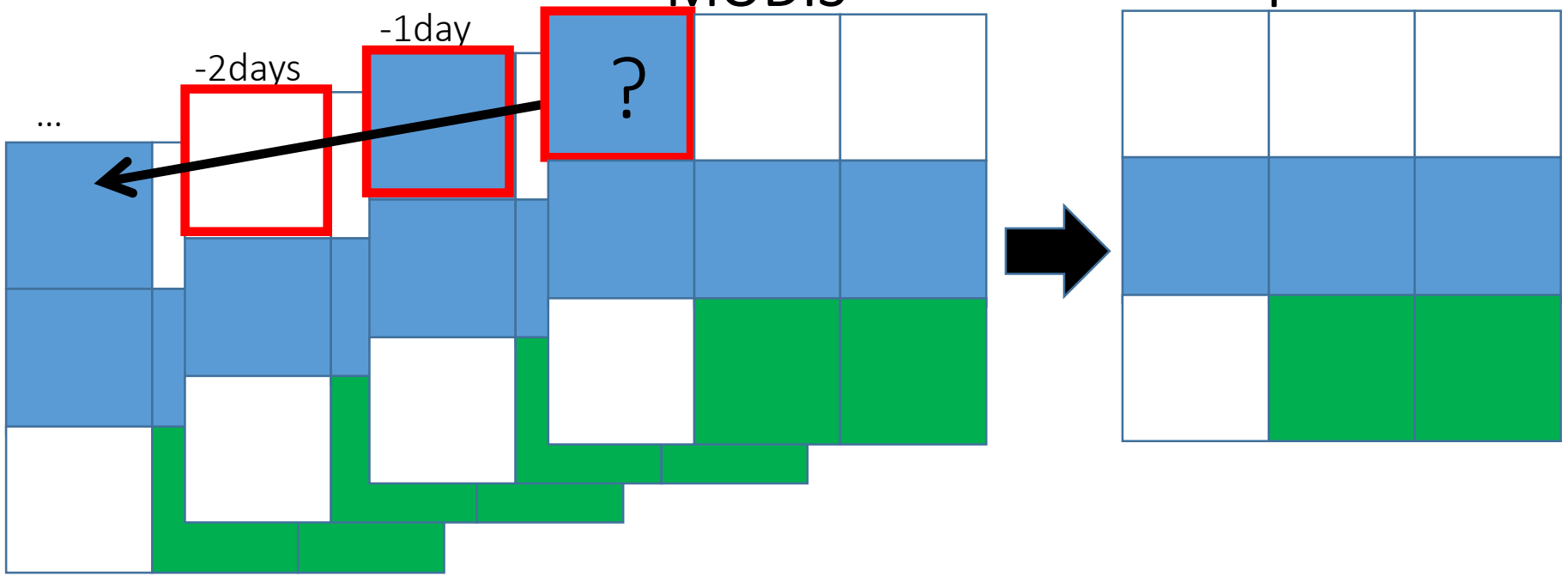
Snow Land Clouds



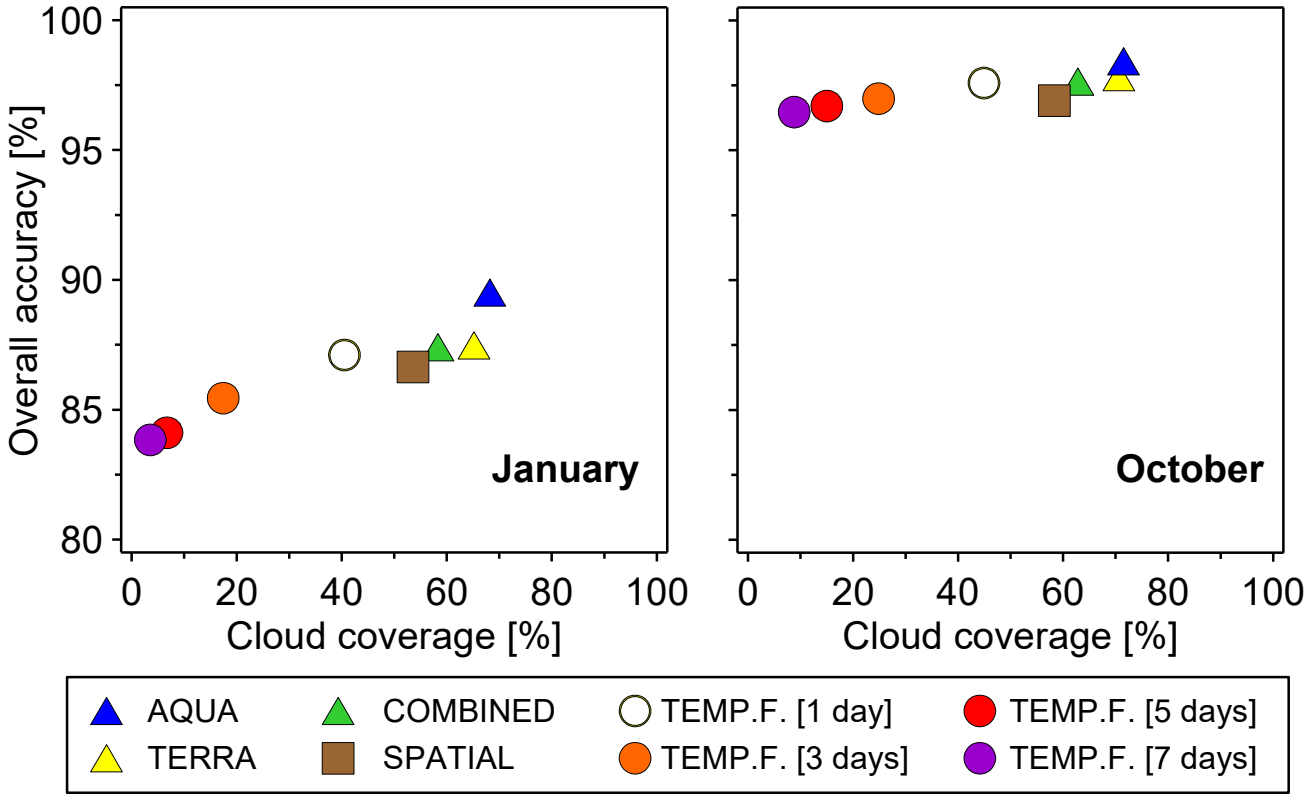
Spatial and temporal filters



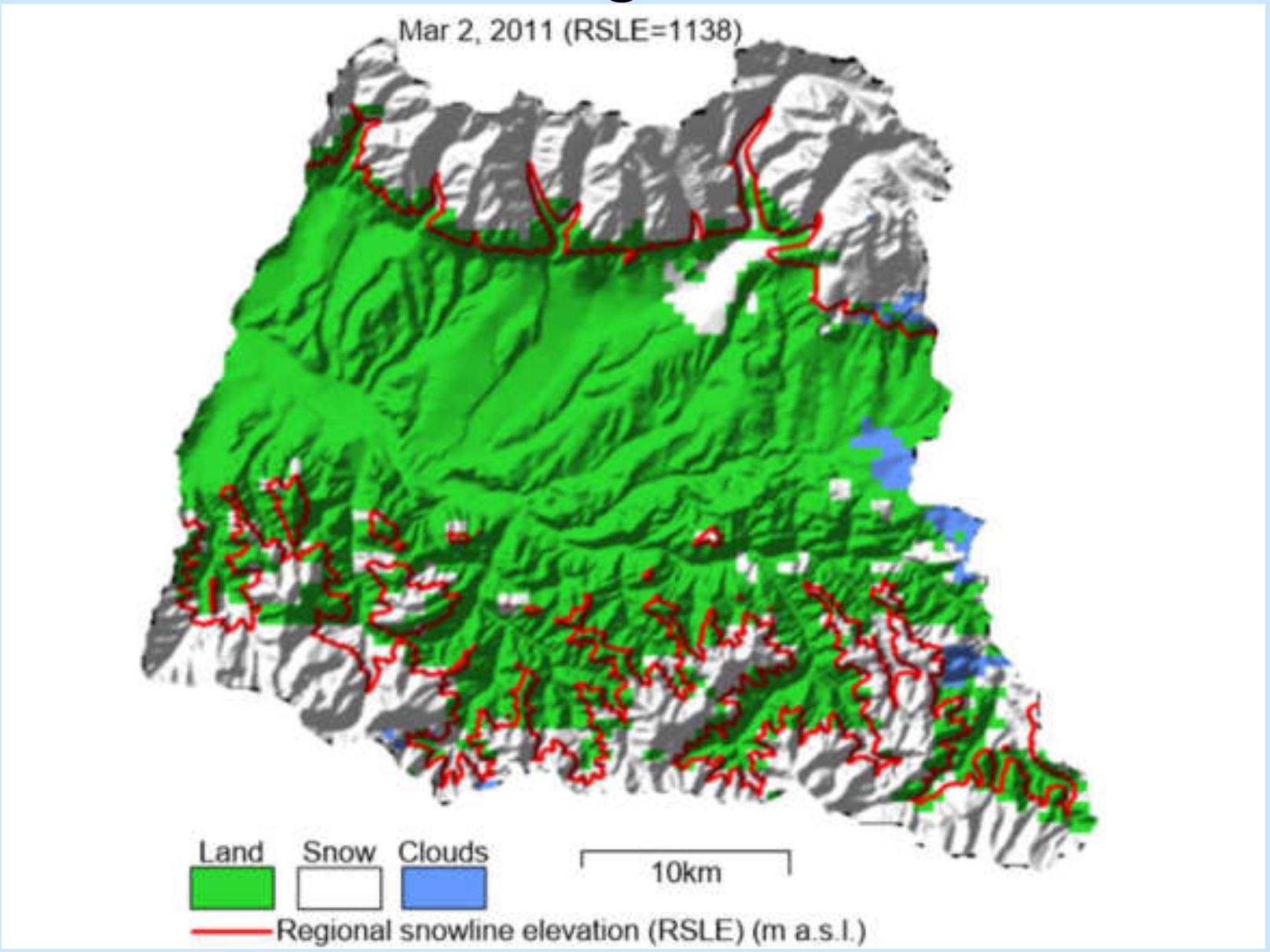




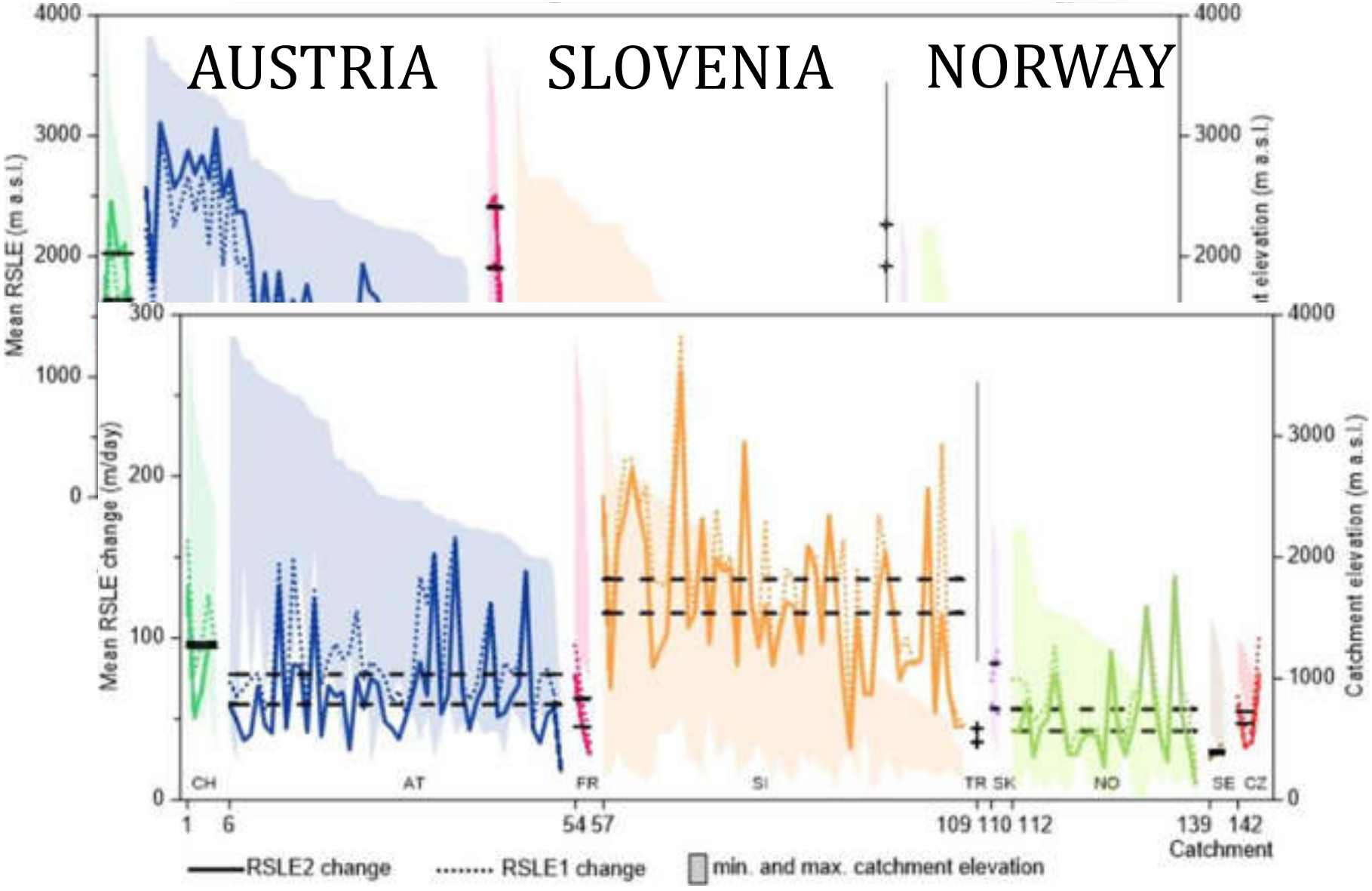
Spatio-temporal filtering to reduce clouds



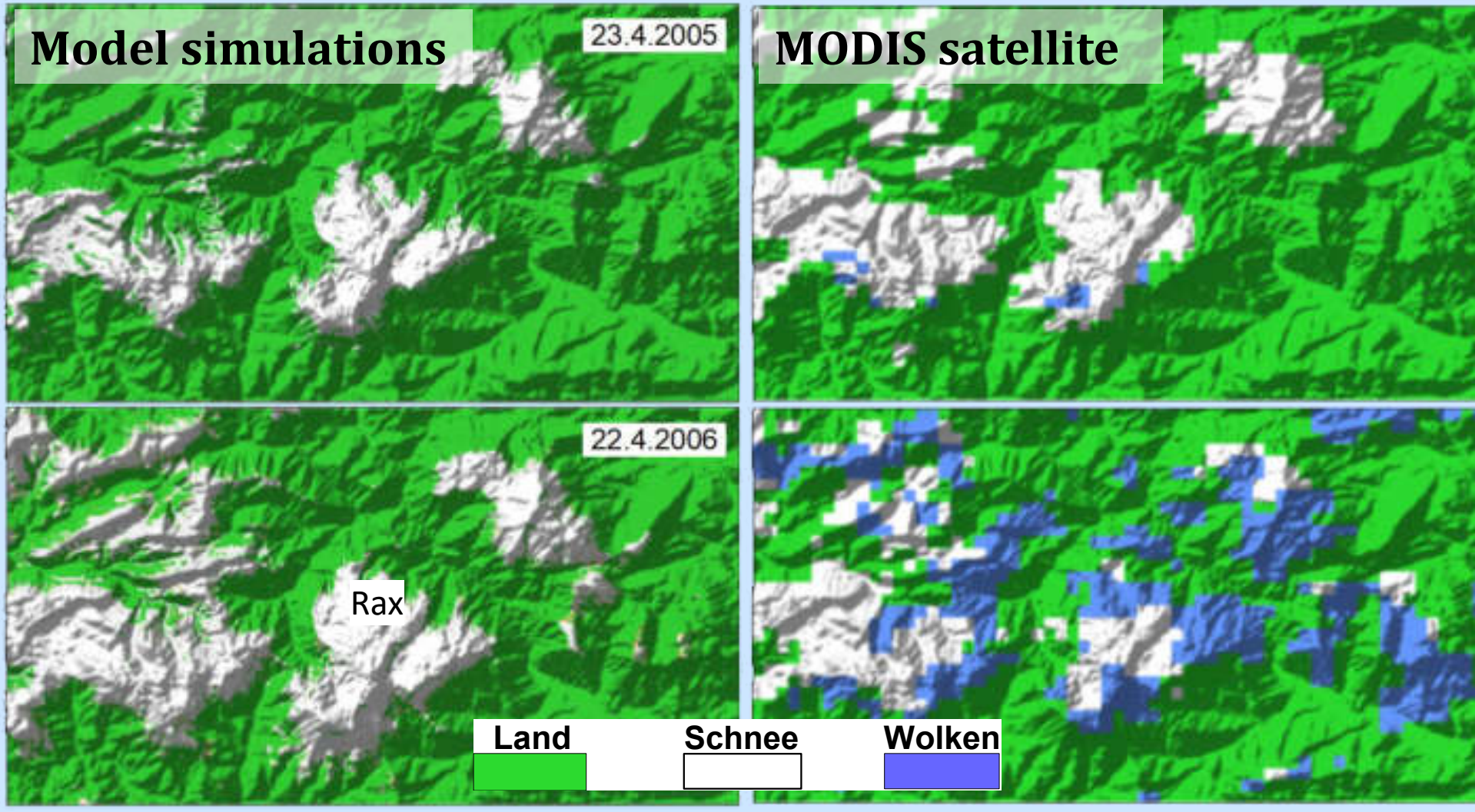
Snowline elevation changes

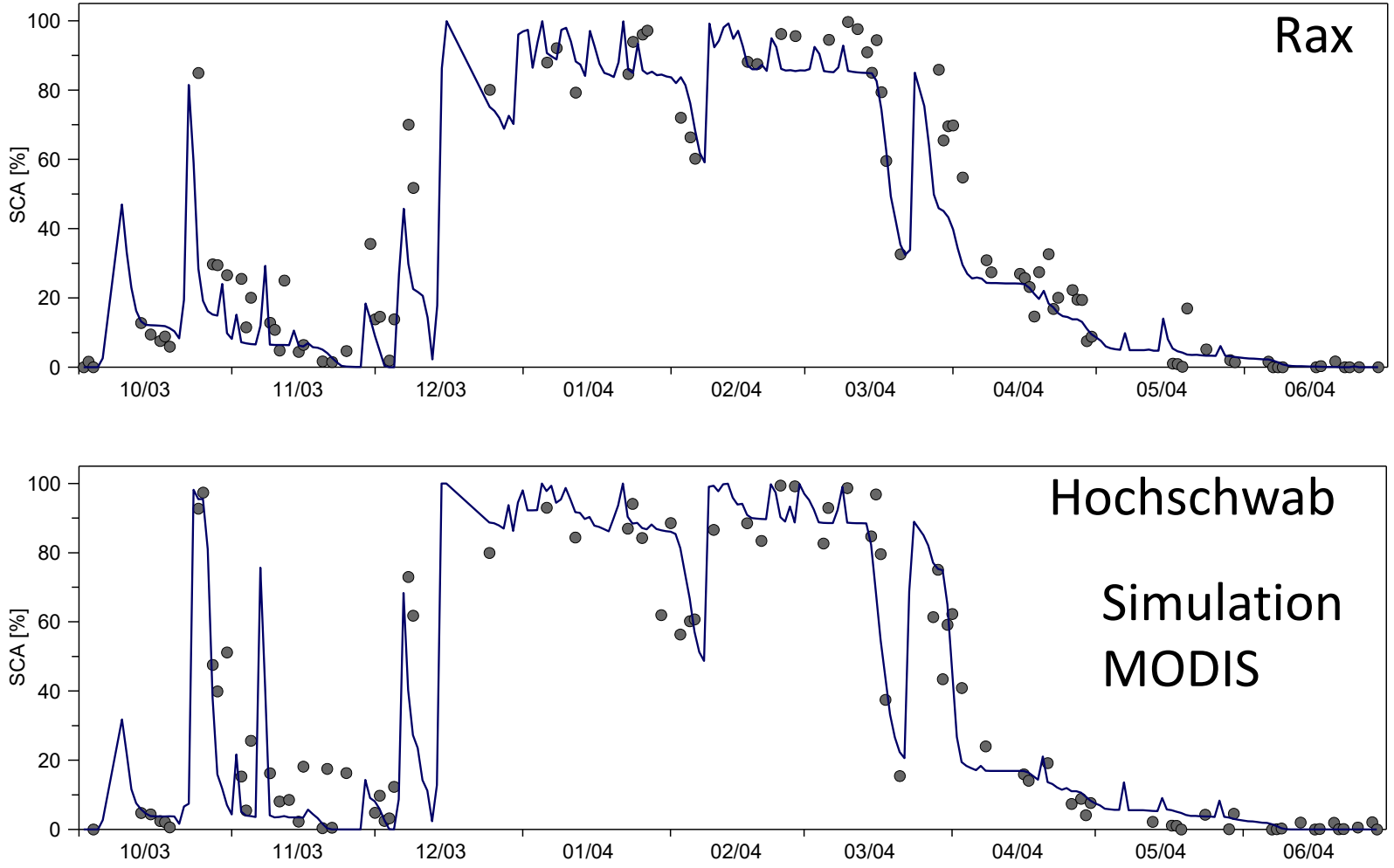


Snowline changes during events (2000-2015)



Calibration and validation of hydrological/snow models with snow cover data




Rax
SCA [%]
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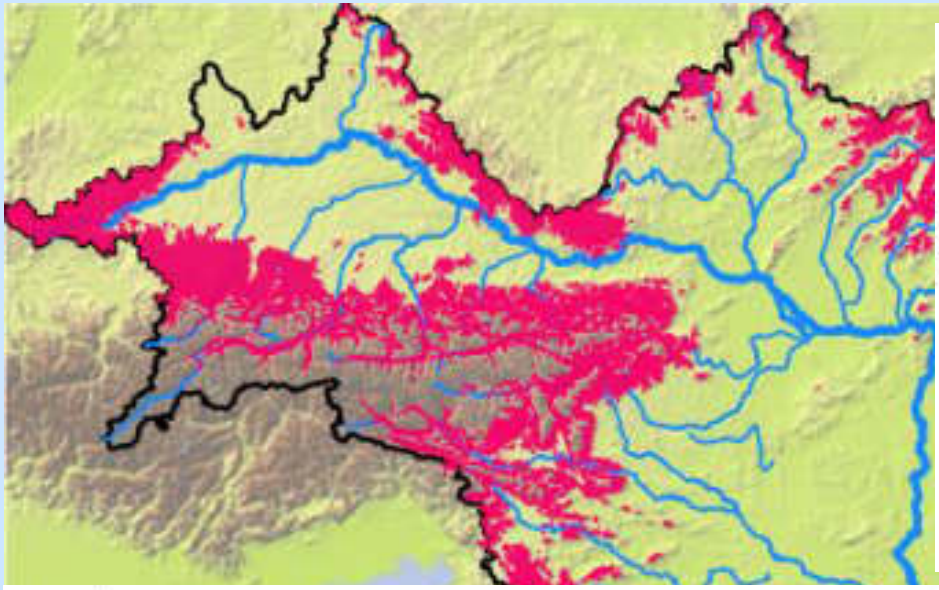
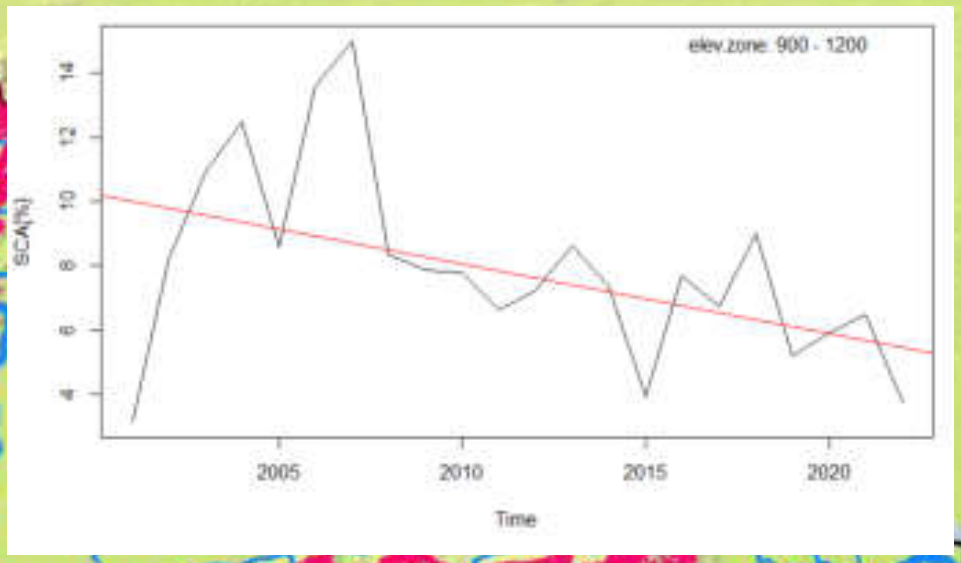
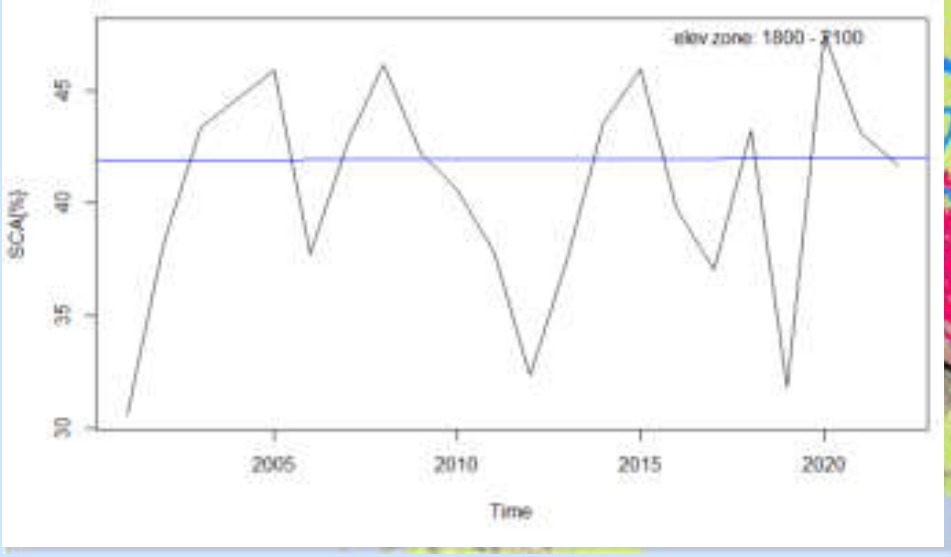
2003/2004

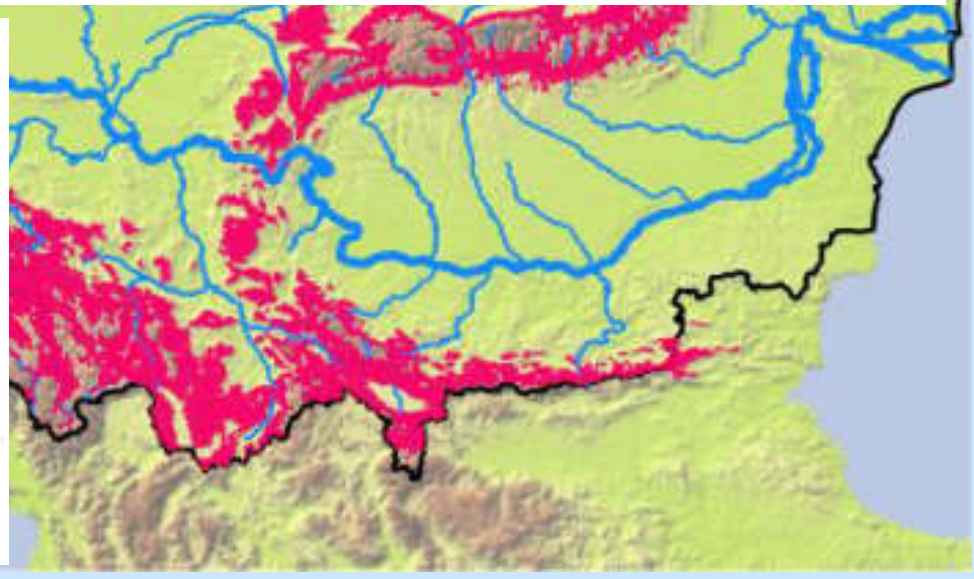
Snow cover changes in Danube

Snow cover area change in 2001-2022

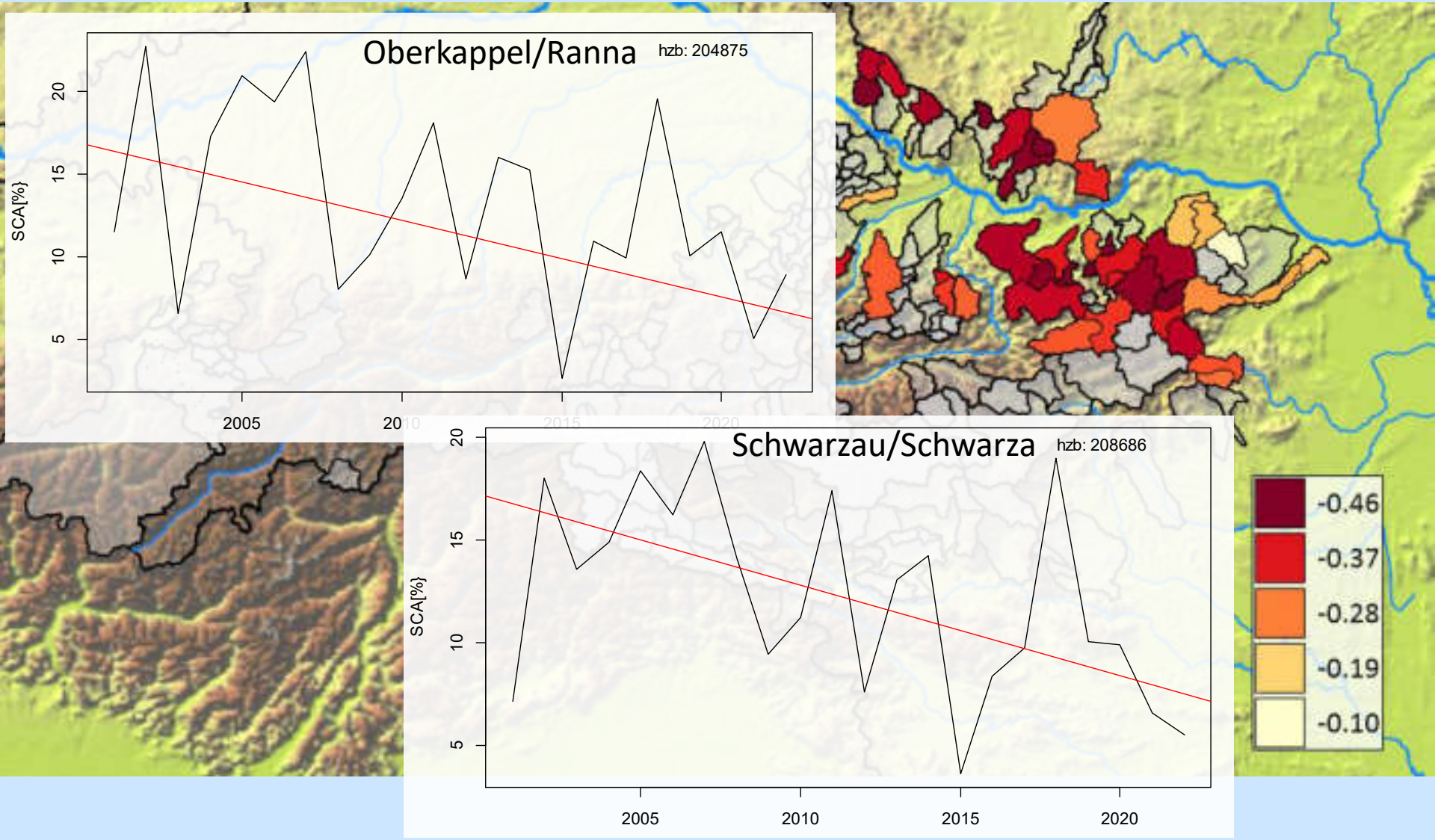








Snow cover area changes in Austria



Conclusions

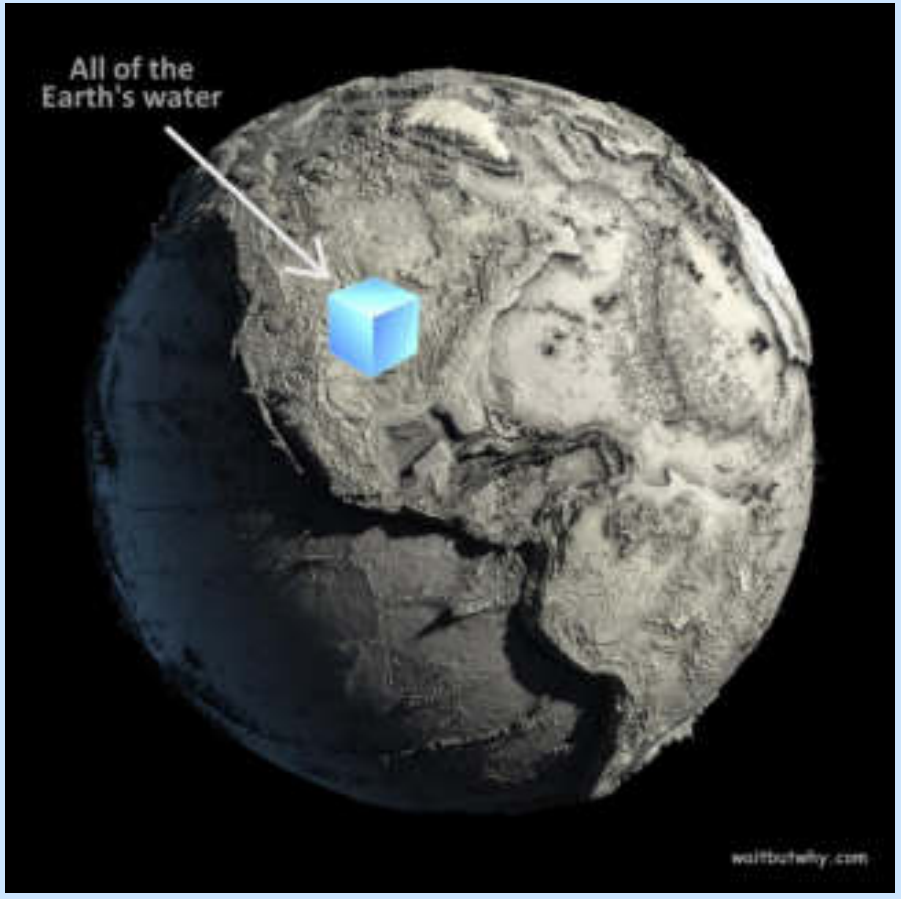
Remote sensing data sets are an important basis for performing comparative hydrology, to generate a-priori expectations of dominant processes, to test hydrological models and improve process understanding.

MODIS provides accurate observations of snow cover at regional scale

MODIS design life=6 years, now close to end (Dec. 2025?), but alternatives exist (e.g. VIIRS – 375m, daily, from 2012)

Recent advances in remote sensing bring new, large and very detailed datasets of terrestrial water cycle, but the further advance should not go at expenses of reducing conventional local measurements

Thank you ...



All the water underground, on the surface, and in the atmosphere amounts to about 332 million cubic miles. That makes a cube with a side of 693 miles