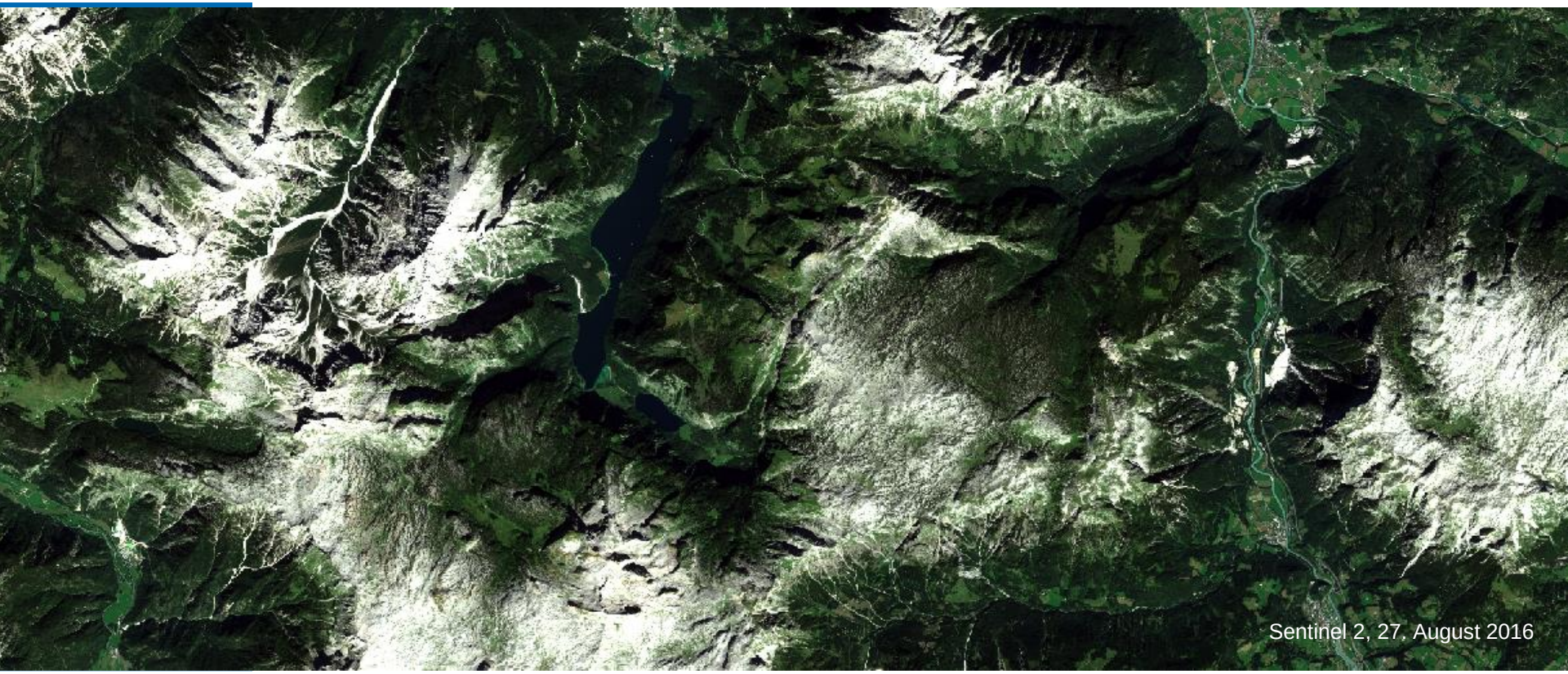
Deutscher Wetterdienst
Wetter und Klima aus einer Hand



Evaluation of satellite-based snow coverage information with surface observations

Jörg Trentmann, Vivien Priemer, Kai Werth, Uwe Pfeifroth, Richard Müller
Deutscher Wetterdienst Universität Frankfurt Universität Mainz

Satellite-based Snow Data Records

CyroClim

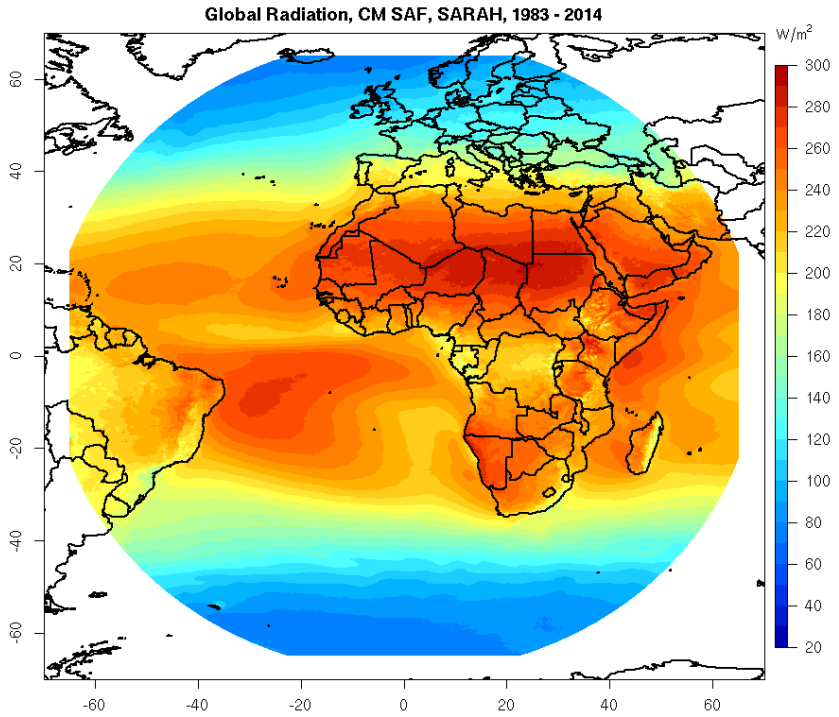
- Provided by MetNo
- High spatial (5 km) and temporal (daily) resolution
- Available 1993-2009
- Based on multiple satellite instruments

IMS

- Interactive Multisensor Snow and Ice Mapping System vom National Ice Center (US)
- Uses a number of satellite information, since Dec. 2014 also in situ data
- Provided daily from 1997 to today
- Spatial resolution 24 km, 4 km (since 2004), 1 km (since 2014)
- Northern hemisphere

Surface Solar Radiation Dataset – Heliosat (SARAH)

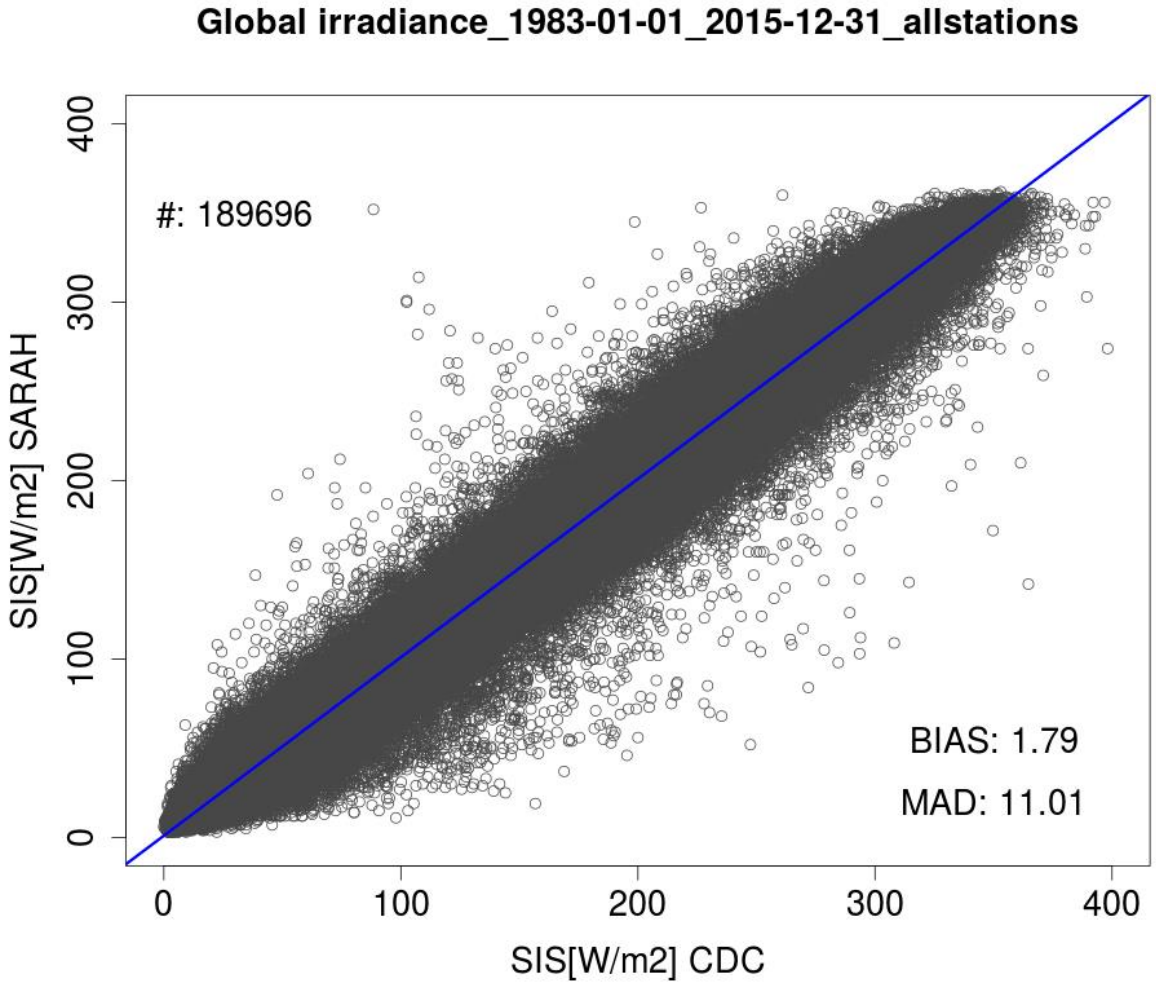
- **Variables**
  - Global irradiance (SIS)
  - Direct normalized irradiance (DNI)
  - Effective cloud albedo (CAL)
- **Resolution**
  - Spatial: 0.05° × 0.05°
  - Temporal: hourly, daily, monthly means
- **Coverage**
  - Spatial: Meteosat-Prime Full disk
  - Temporal: 1983 to 2016
- **Satellites / Instruments**
  - Meteosat 2 to 10 (MVIRI/SEVIRI)
- **'Heliosat'-retrieval method**



Motivation

Global Radiation

- CM SAF SARAH Climate data record
- Excellent agreement with surface measurements



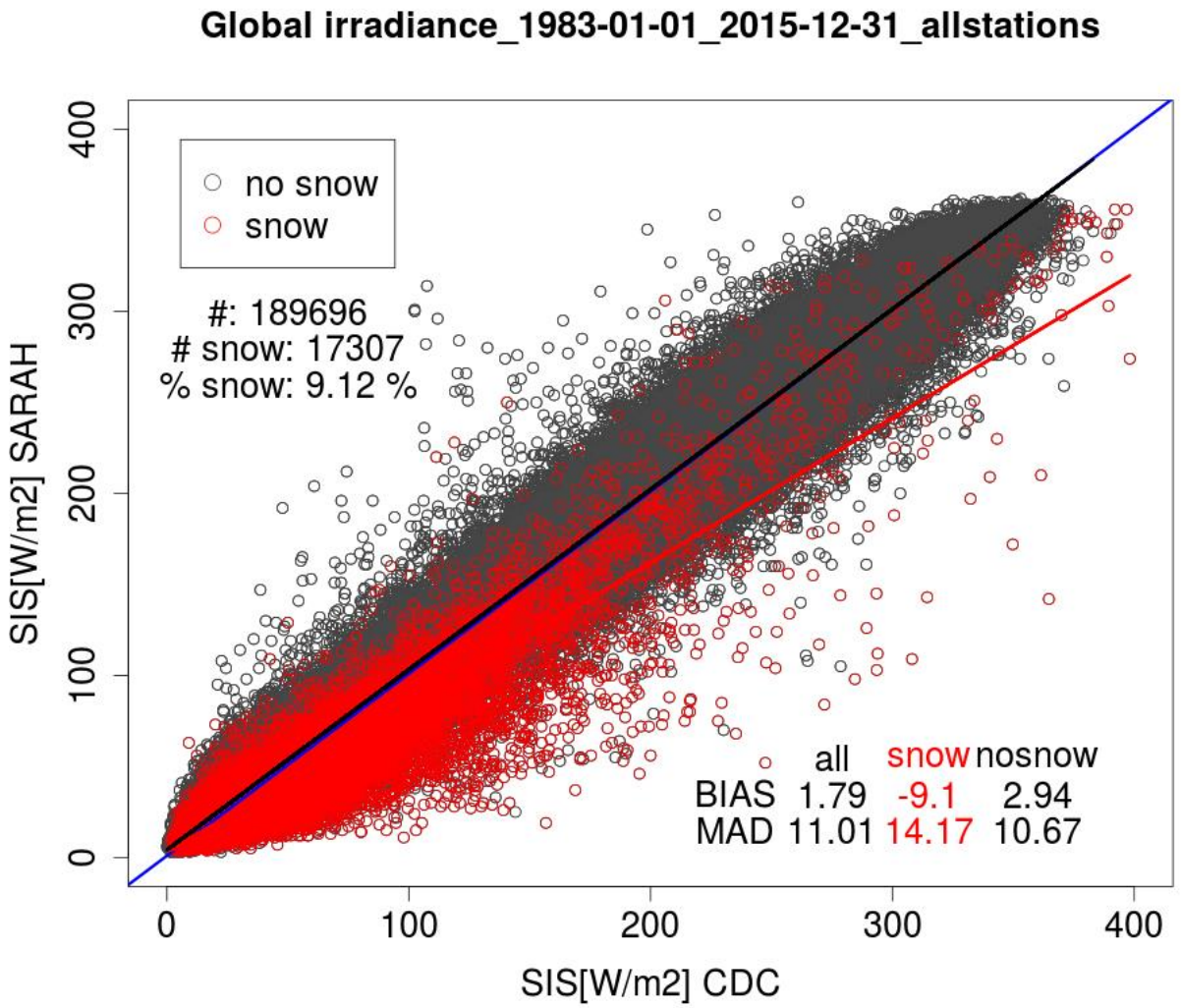
- Systematic under-estimation of surface radiation in snow-covered situations

March

BIAS_snow: -21.47 $\frac{W}{m^2}$

MAD_snow: 25.73 $\frac{W}{m^2}$

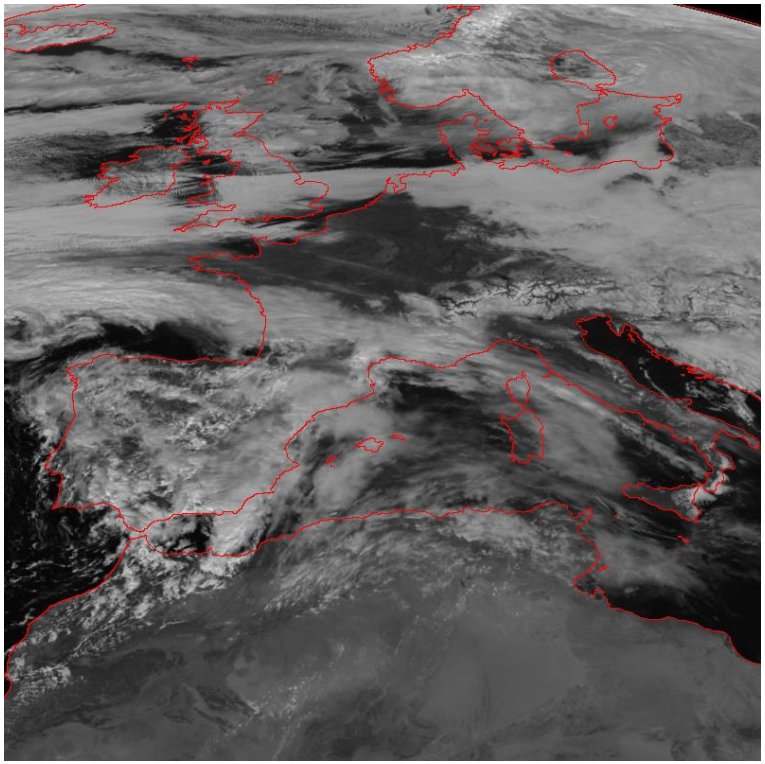
- Problem:
  Snow is classified as cloud



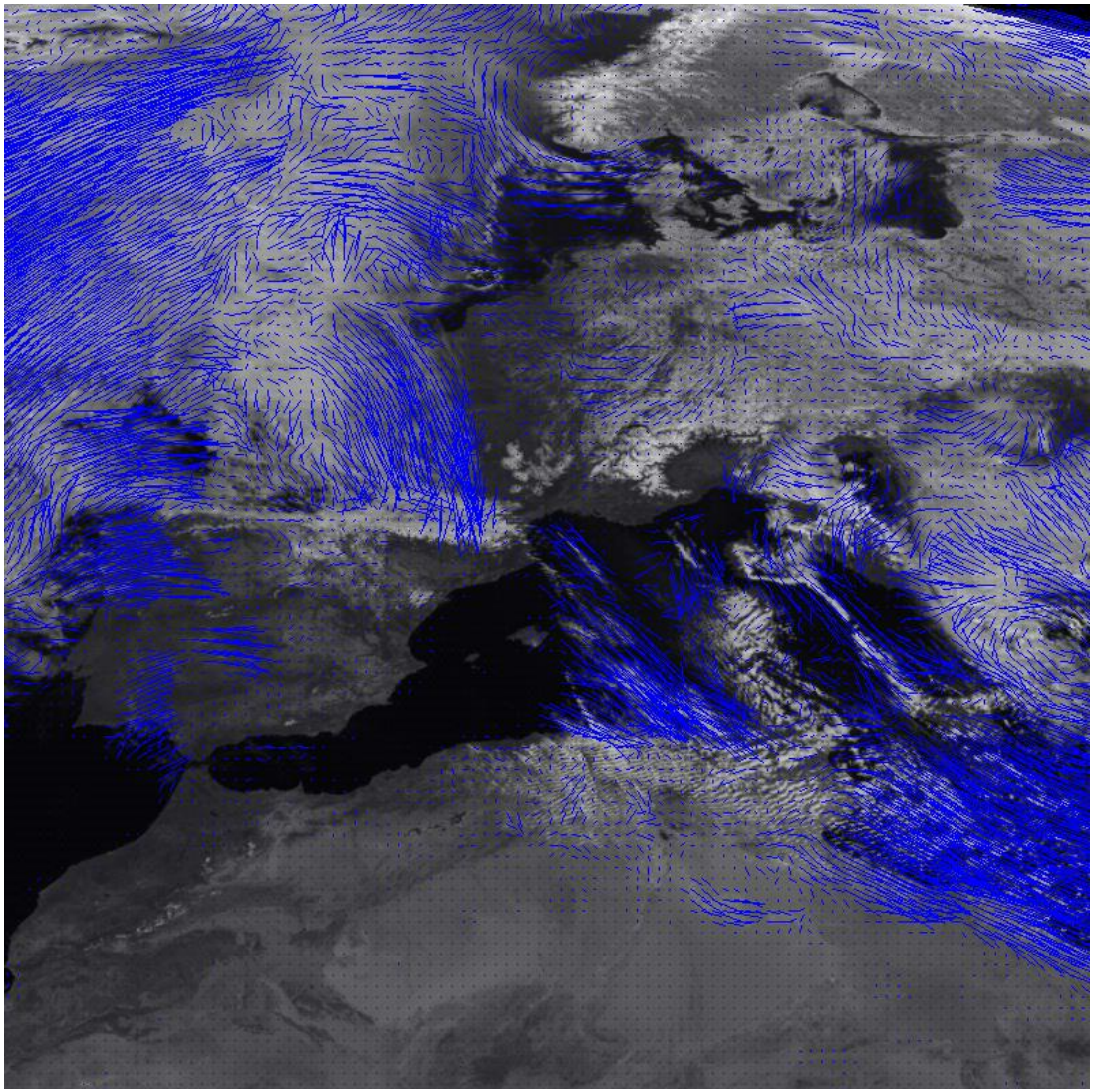
Schneeerkennung

HelSnow

- *Starting Point:*
  Separation between cloud and snow based on early satellite data problematic (only 3 spectral channels available)
- Solution:
  Separation between Cloud and Snow based on ‚motion‘
- Intelligent / modern / efficient programming (OpenCV: ‚optical flow‘) allows the processing of long time series

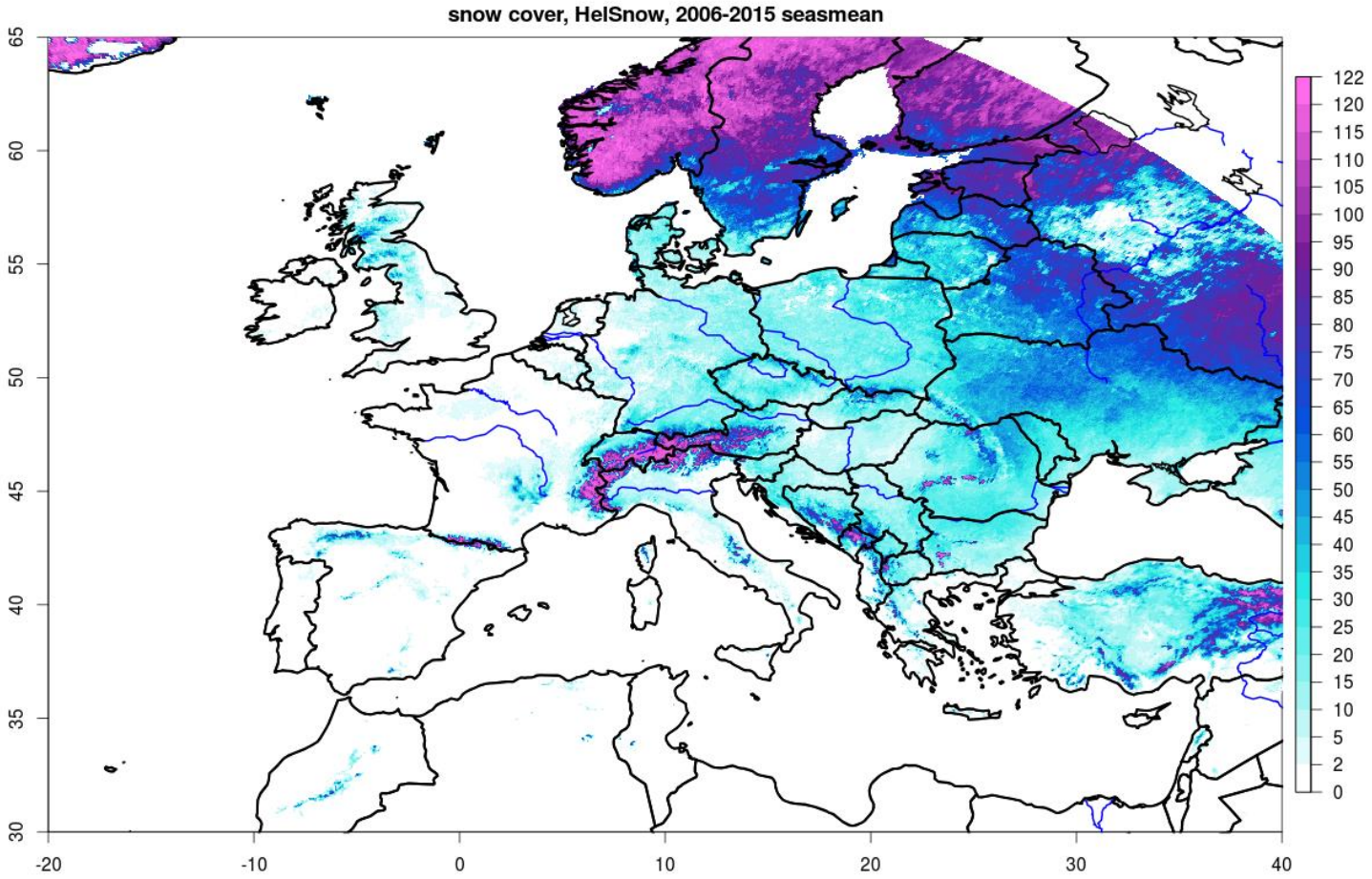


18 March 2006, 1200 + 1230 UTC



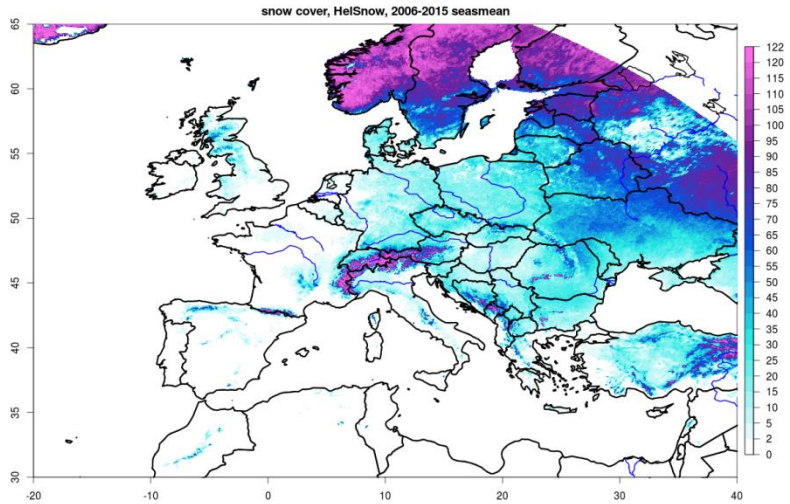
Optical flow between the satellite images for March 12, 2006 12:00 and 12:30

Mean Number of Snowdays, DJFM, 2006 - 2015

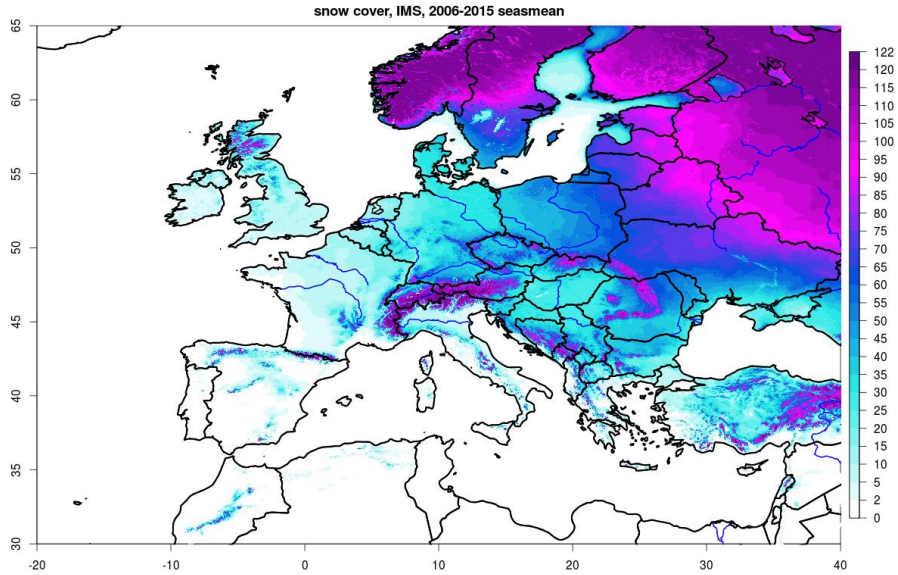


Mean Number of Snowdays, DJFM, 2006 - 2015

HelSnow



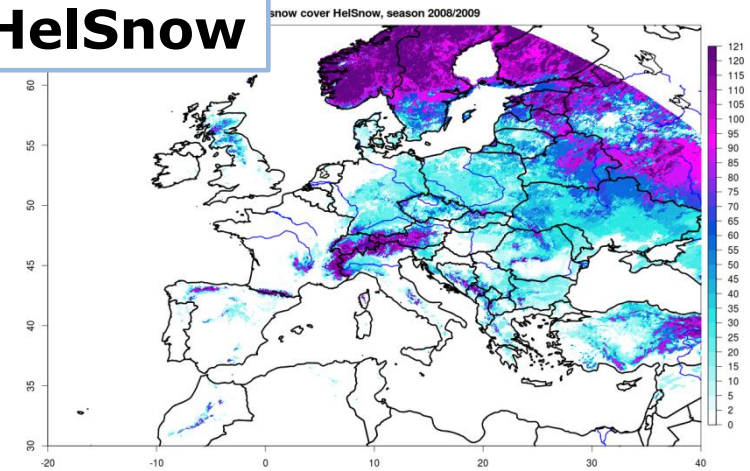
IMS



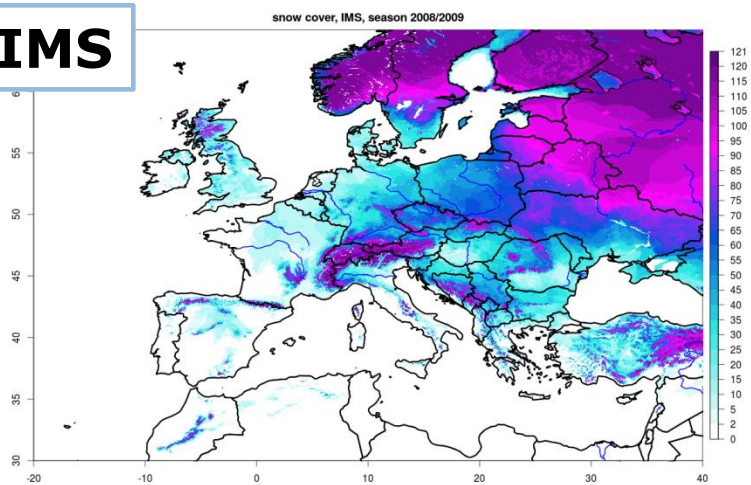
- ➔ General structure well reproduced by HelSnow
- ➔ HelSnow tends to identify fewer snow days than IMS

Mean Number of Snow days, DJFM, 2008 / 2009

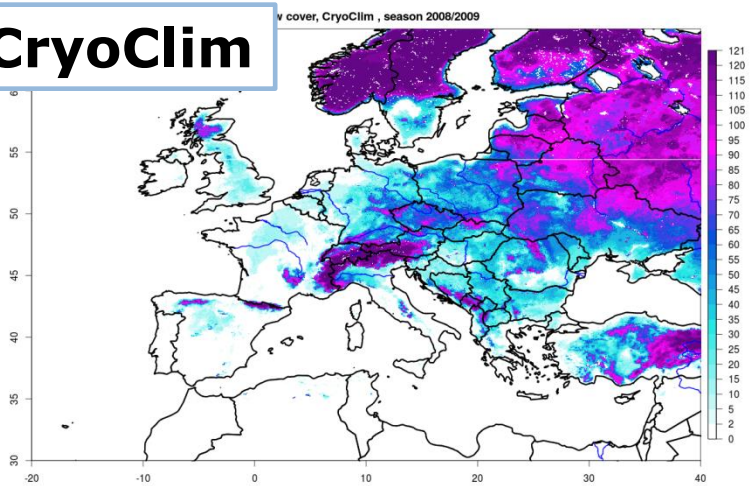
HelSnow



IMS

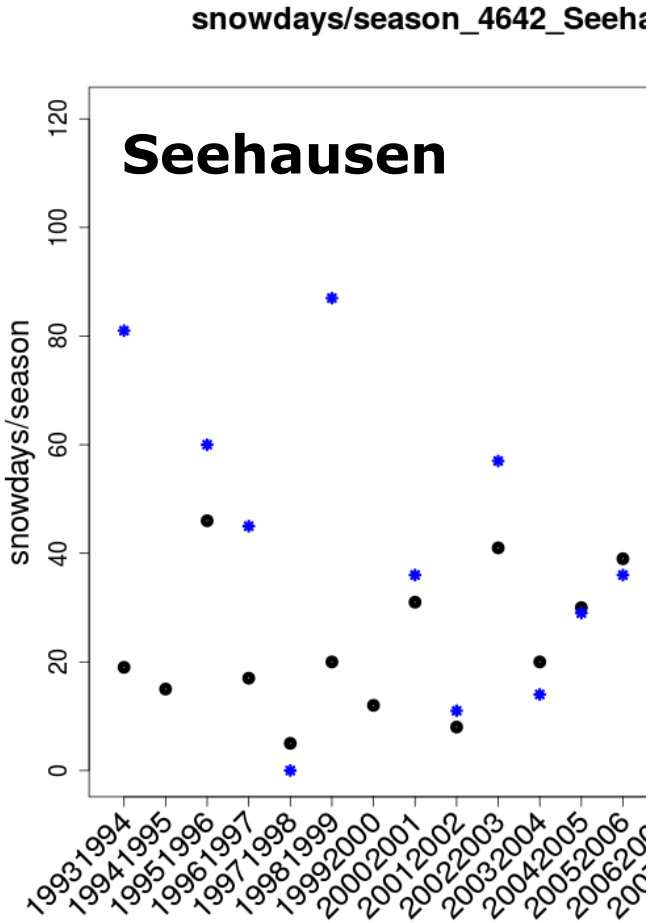


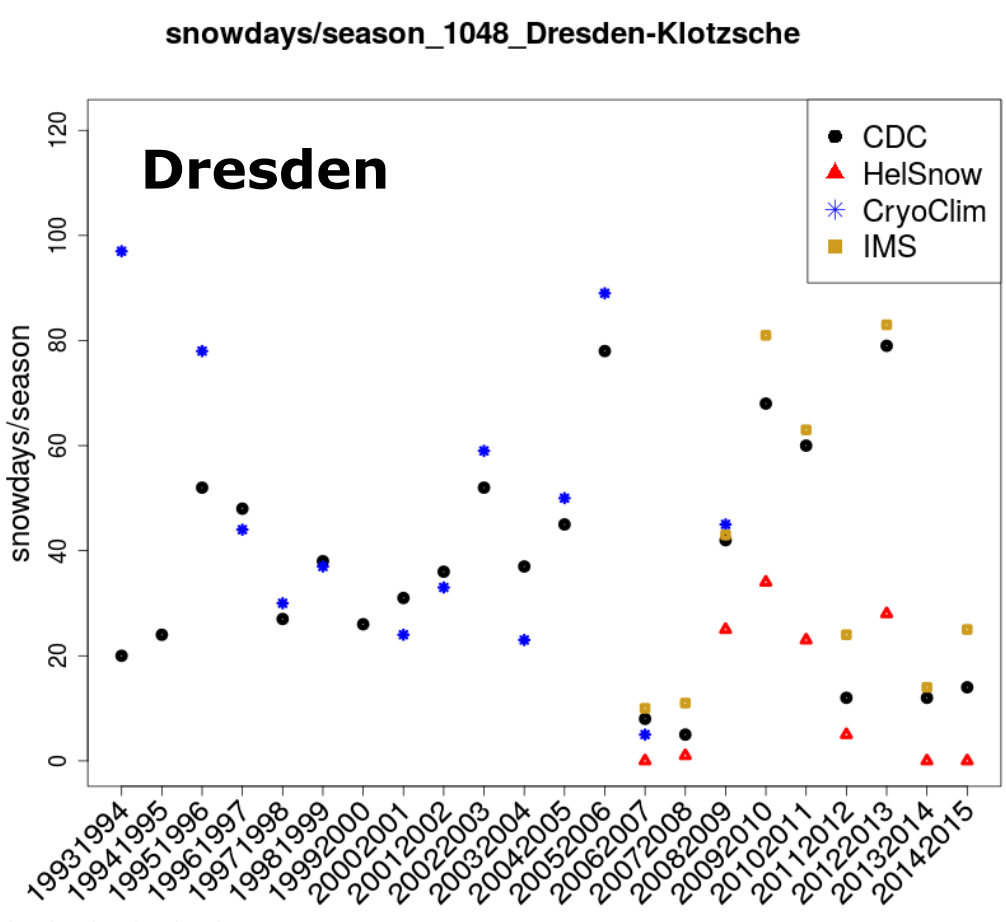
CryoClim



- General structure well reproduced by HelSnow
- HelSnow tends to identify fewer snow days than IMS and CyroClim

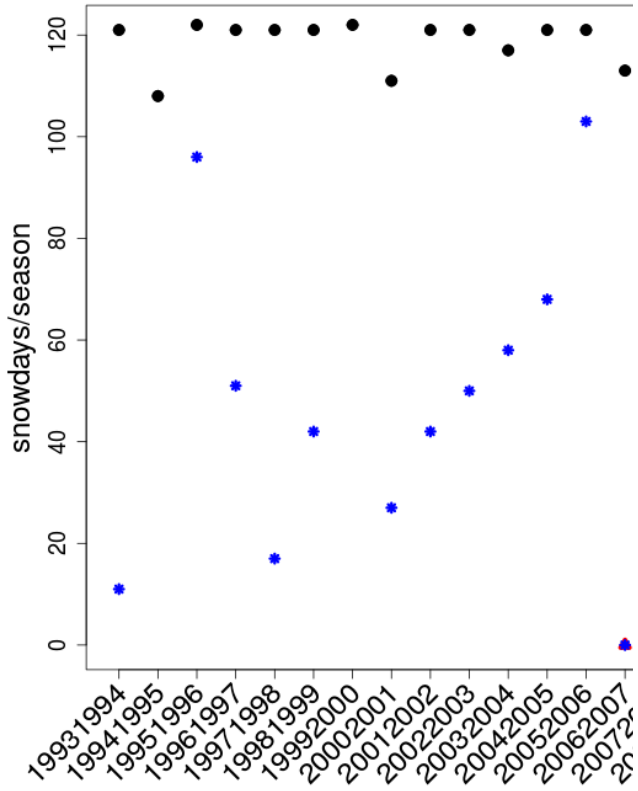
Evaluation: Number of Snow days, DJFM, 1993 - 2015



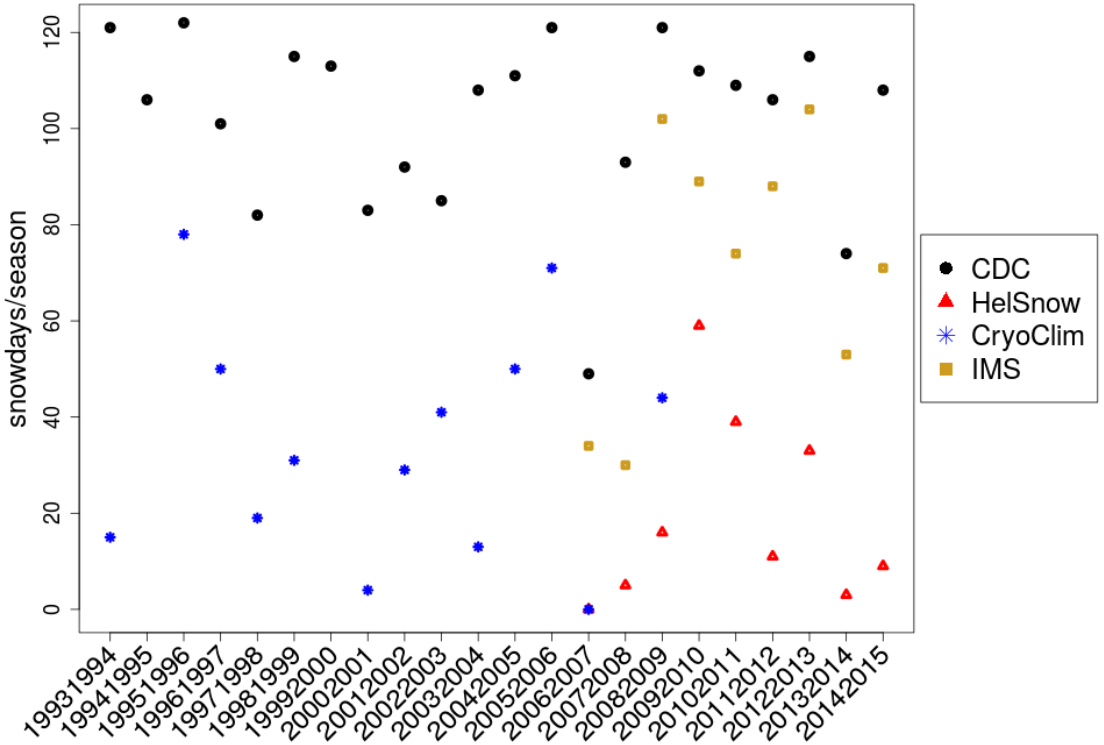


Evaluation: Number of Snow days, DJFM, 1993 - 2015

snowdays/season_1832_ Großer Arber

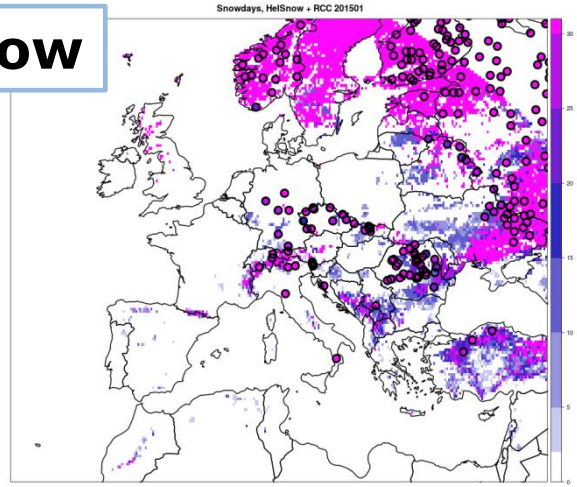


snowdays/season_3513_ Neuhaus / Rennsteig

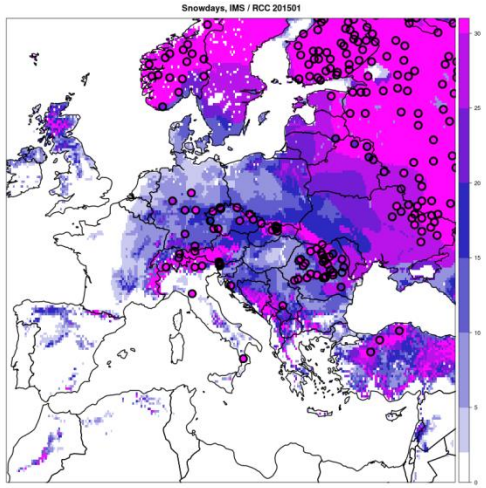


Mean Number of Snow days, January 2015

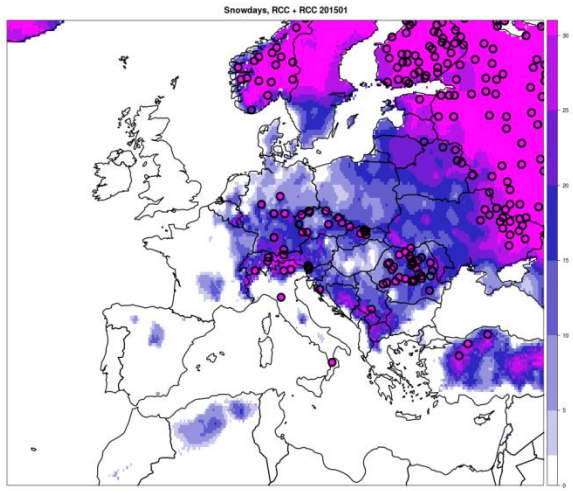
HelSnow



IMS



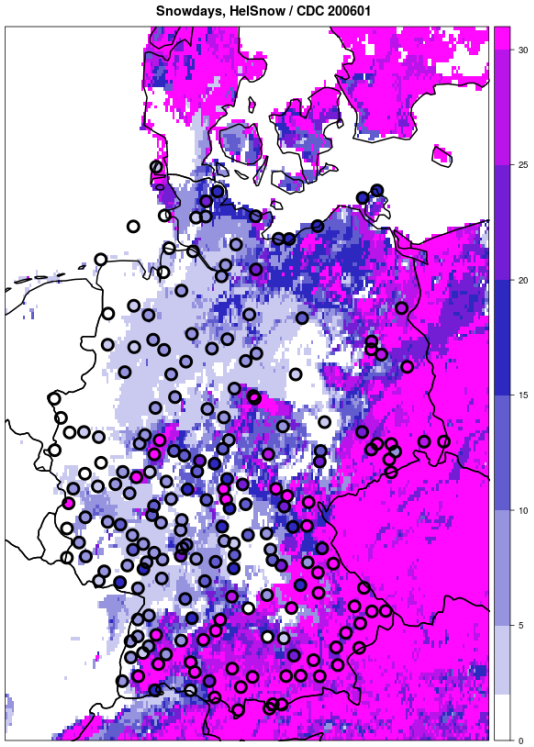
RCC



- ➔ IMS and RCC (station-based gridded) compare well
- ➔ HelSnow tends to underestimate number of snow days

January 2006; Number of Snow days

HelSnow



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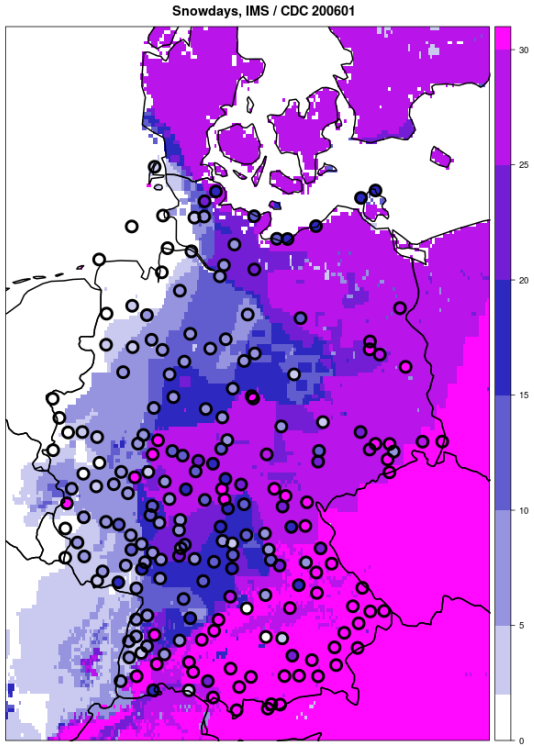
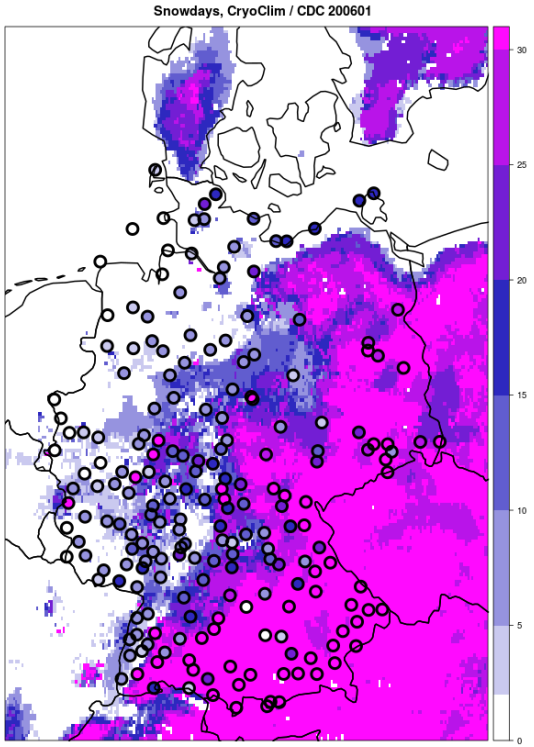


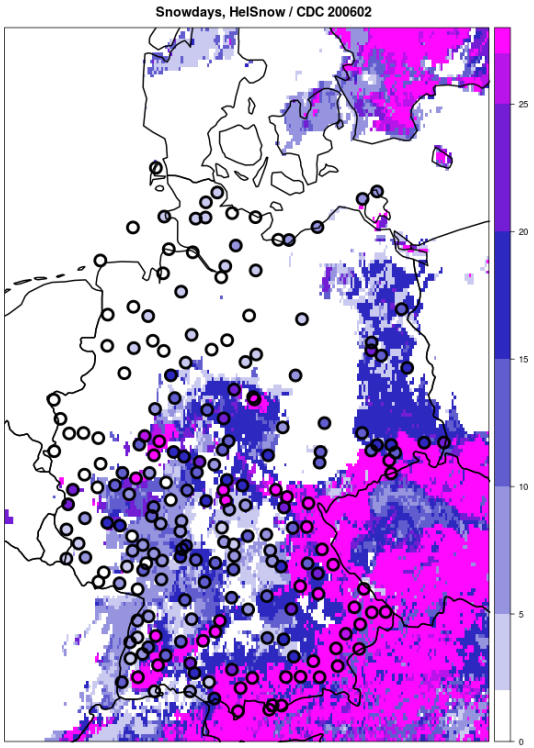
CyroClim



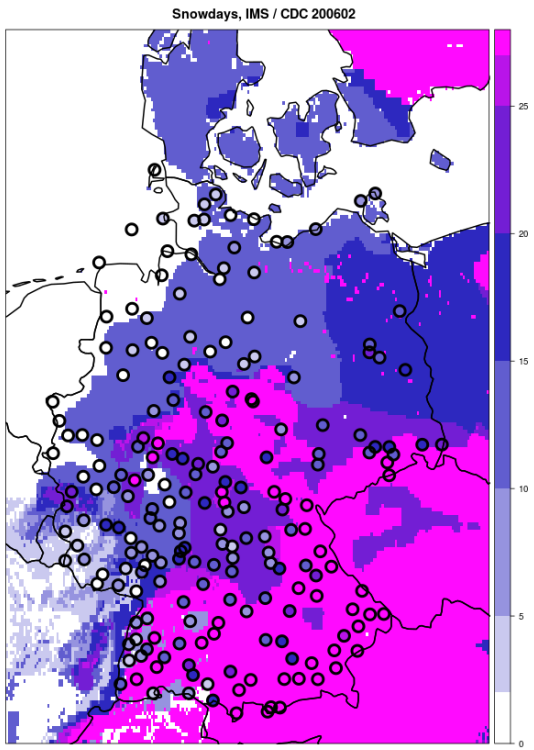
➔ Larger-scale snow coverage in IMS; more realistic?

February 2006

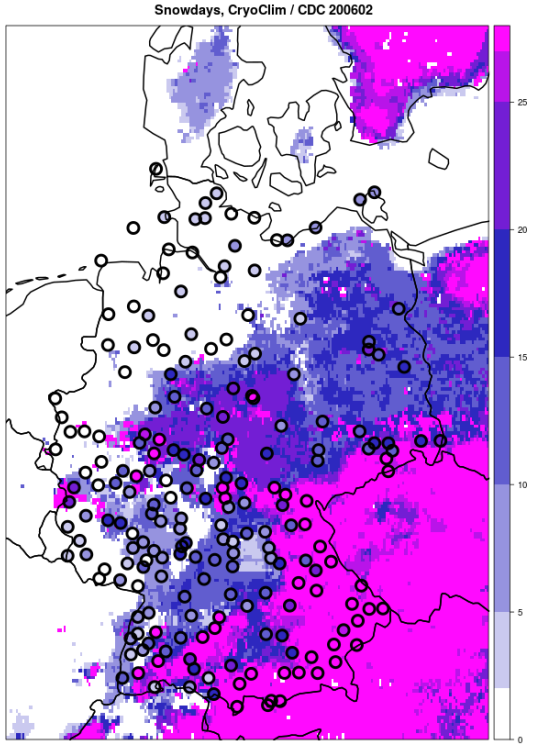
HelSnow



IMS



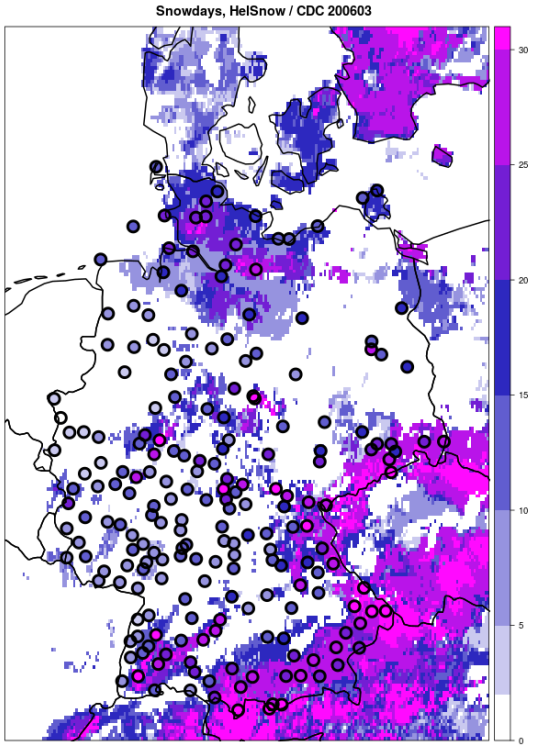
CyroClim



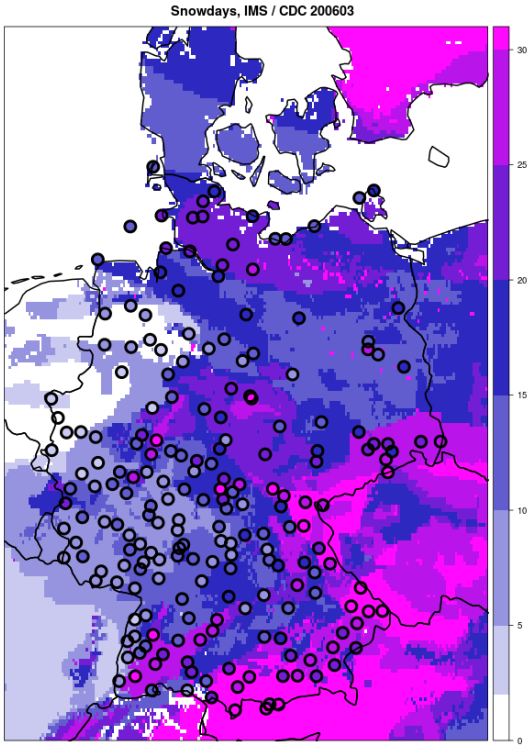
➔ IMS seems to overestimate snow coverage; strong gradients in HelSnow

March 2006

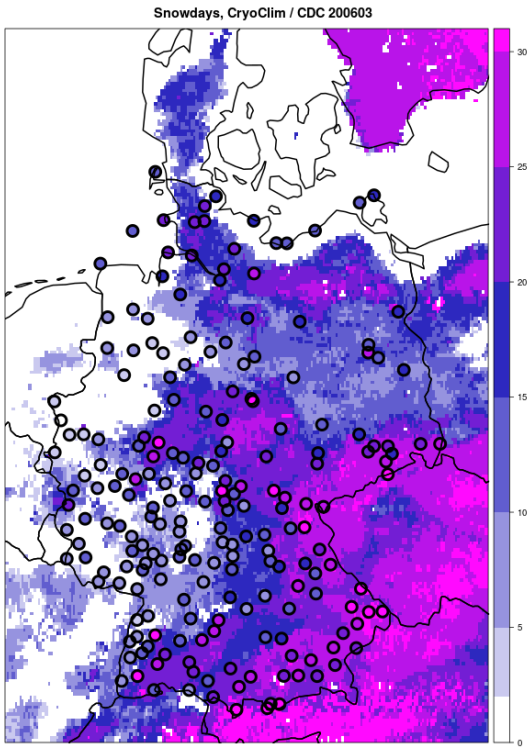
HelSnow



IMS

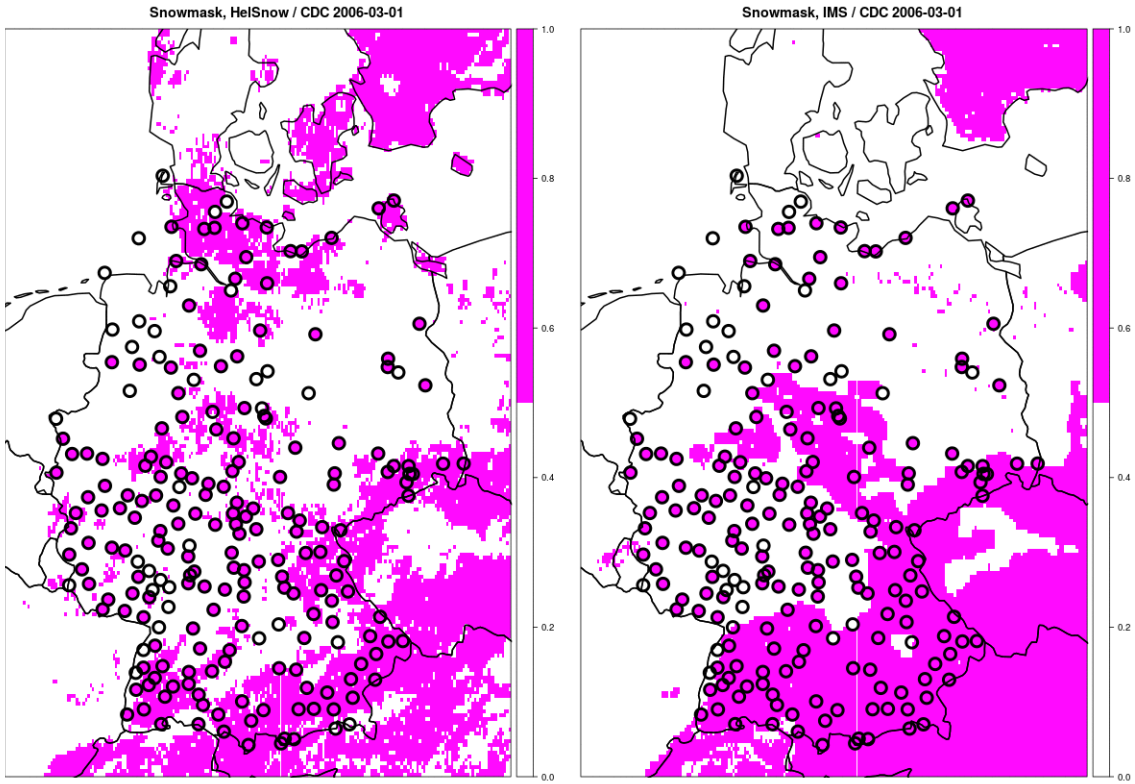


CyroClim



➔ HelSnow underestimates snow coverage in some areas

Snow Mask March 2006



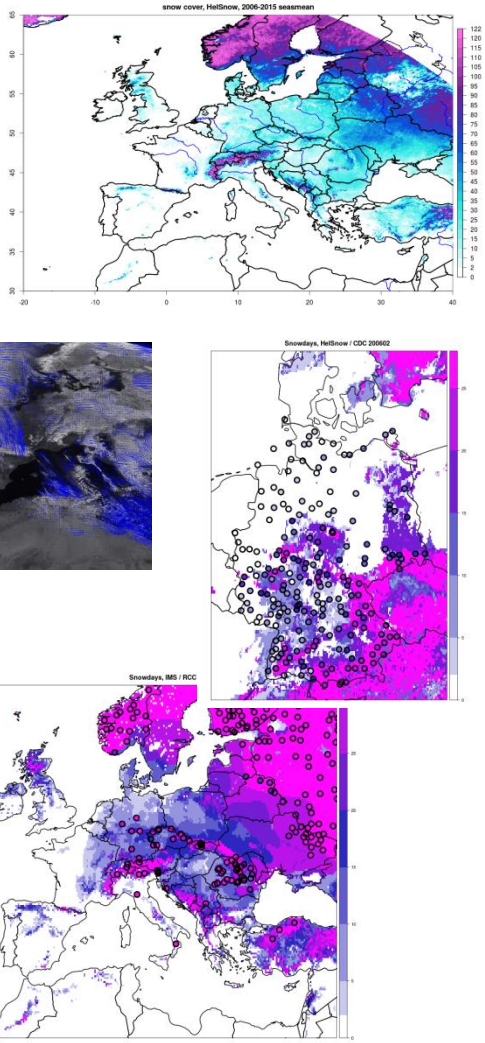
Scores (DJFM, Germany)

scores	HelSnow (2006-01-01 – 2015-12-31)	IMS (2006-01-01 – 2015-12-31)	CryoClim (1993-01-01 – 2009-03-31)	best value	always snow (2006-01-01 – 2015-12-31)	never snow (2006-01-01 – 2015-12-31)
ACC	0.78	0.85	0.74	1	0.28	0.7
CSI	0.32	0.61	0.40	1	0.28	0
FAR	0.23	0.27	0.39	0	0.72	NA
POD	0.36	0.79	0.54	1	1	0
POFD	0.04	0.12	0.16	0	1	0
BIAS	0.46	1.09	0.88	1	5.02	0
Skill scores						
ETS	0.23	0.48	0.24	1		
PSS	0.31	0.66	0.38	1		
HSS	0.37	0.65	0.39	1		
ORSS	0.84	0.93	0.72	1		

- ➔ IMS performs best (according to these scores)
- ➔ HelSnow underestimates the frequency of snow; lowest FAR, POFD
- ➔ CyroClim and HelSnow have comparable performance

Summary

- No consistent, large-scale climate data record of snow coverage available; satellite data have to potential to provide this information
- Modern algorithms allow the retrieval of snow coverage from historical Meteosat data despite the limited spectral information
- Results from the HelSnow-algorithm are satisfactory
- HelSnow allows the snow detection in historical satellite data; high potential for further developments
- Consistent and homogeneous 33-year time series of snow coverage soon available
- Improvement of the CM SAF SARAH data record of surface solar radiation over snow



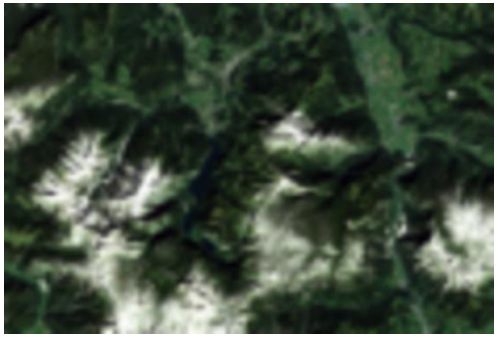
Meteosat Satelliten (EUMETSAT)

1. Generation (MVIRI) (1982- 2006)

- 3 spektrale Kanäle
- Zeit: 30 min
- Raum: 5 km

2. Generation (SEVIRI) (1984 - ~ 2020)

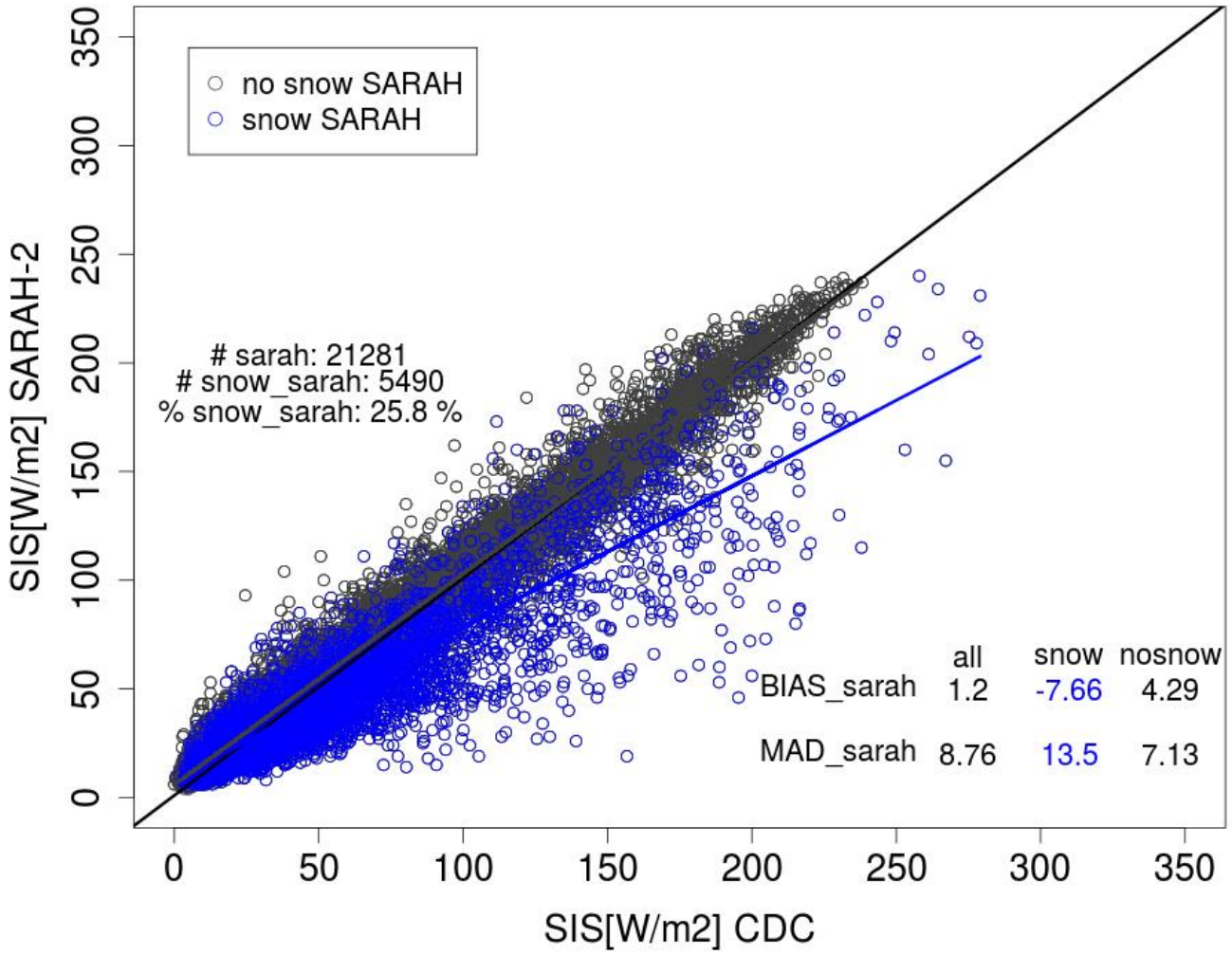
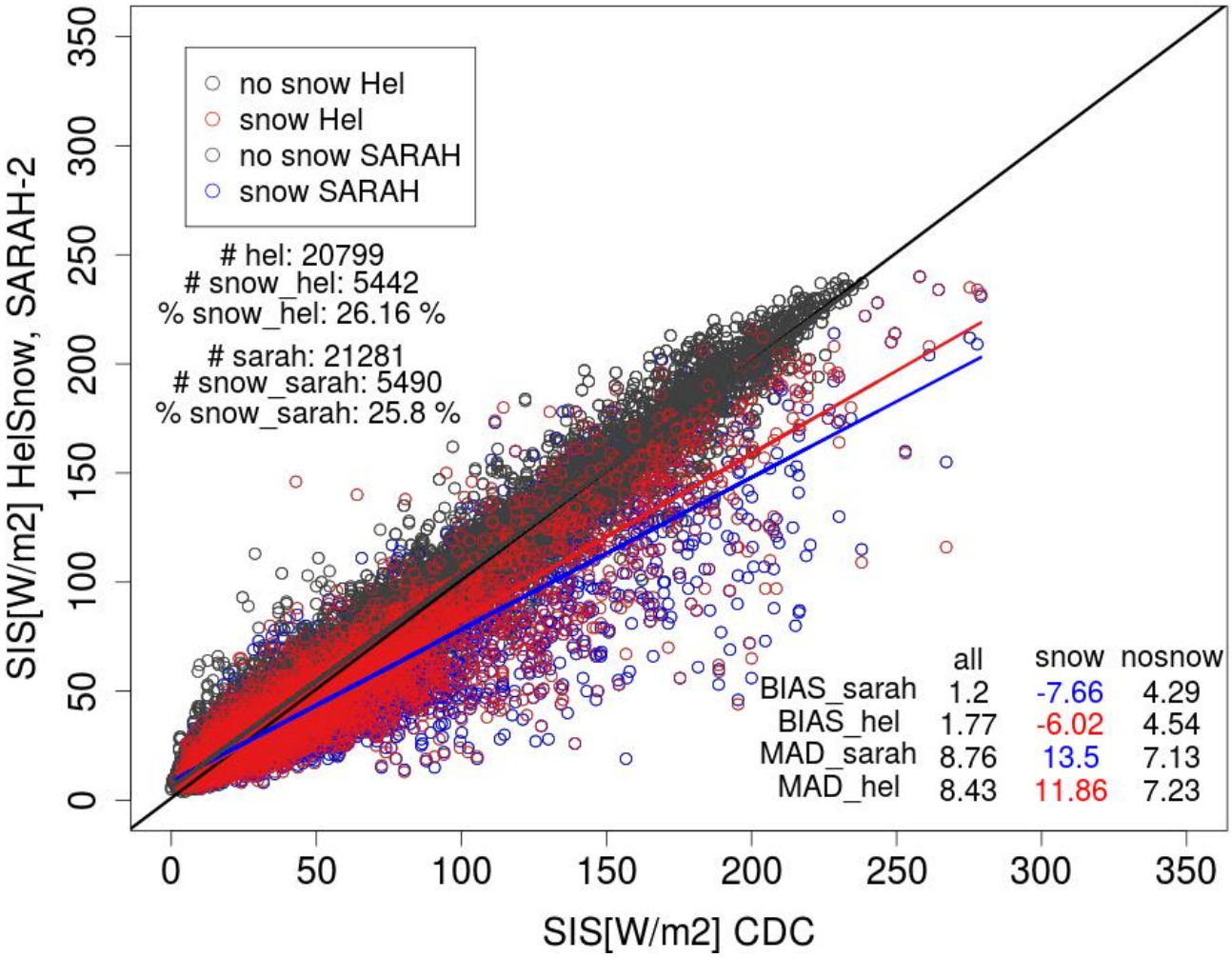
- 11 spektrale Kanäle
- 5 min bis 15 min
- 5 km / 1 km



3. Generation (FCI) (ab ~ 2020)

- 16 spektrale Kanäle
- 2.5 min bis 10 min
- 500 m / 1 km / 2 km

Global irradiance, 2006-01-01_2015-12-31 winter_allstations



Global irradiance, 2006-01-01_2015-12-31 winter_allstations