Fachtagung Energiemeteorologie 2016

1-Minuten-Variabilität der Strahlung innerhalb einer Stunde – aus Bodendaten und Satellitendaten

Deutsches Zentrum für Luft- und Raumfahrt (DLR)

Earth Observation Center (EOC)

German Remote Sensing Data Center (DFD)

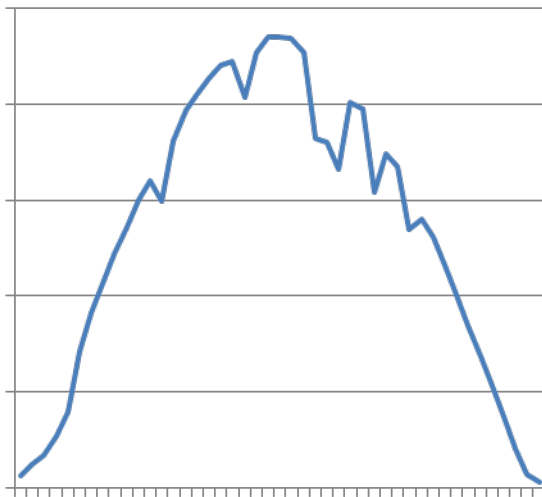Marion Schroedter-Homscheidt, Sandra Jung, Miriam Kosmale
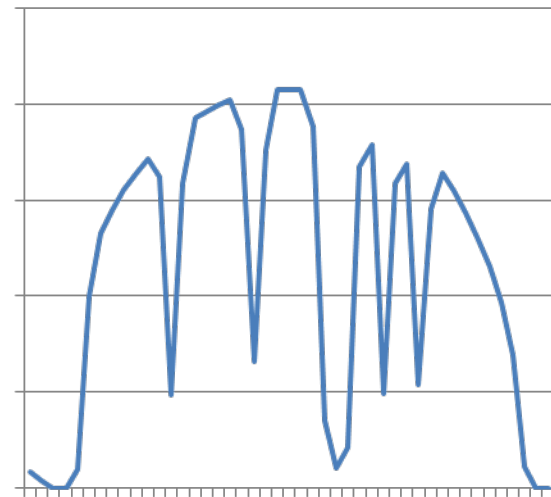
Today's satellite-based time series

global
horizontal
irradiance

15 min resolved

direct
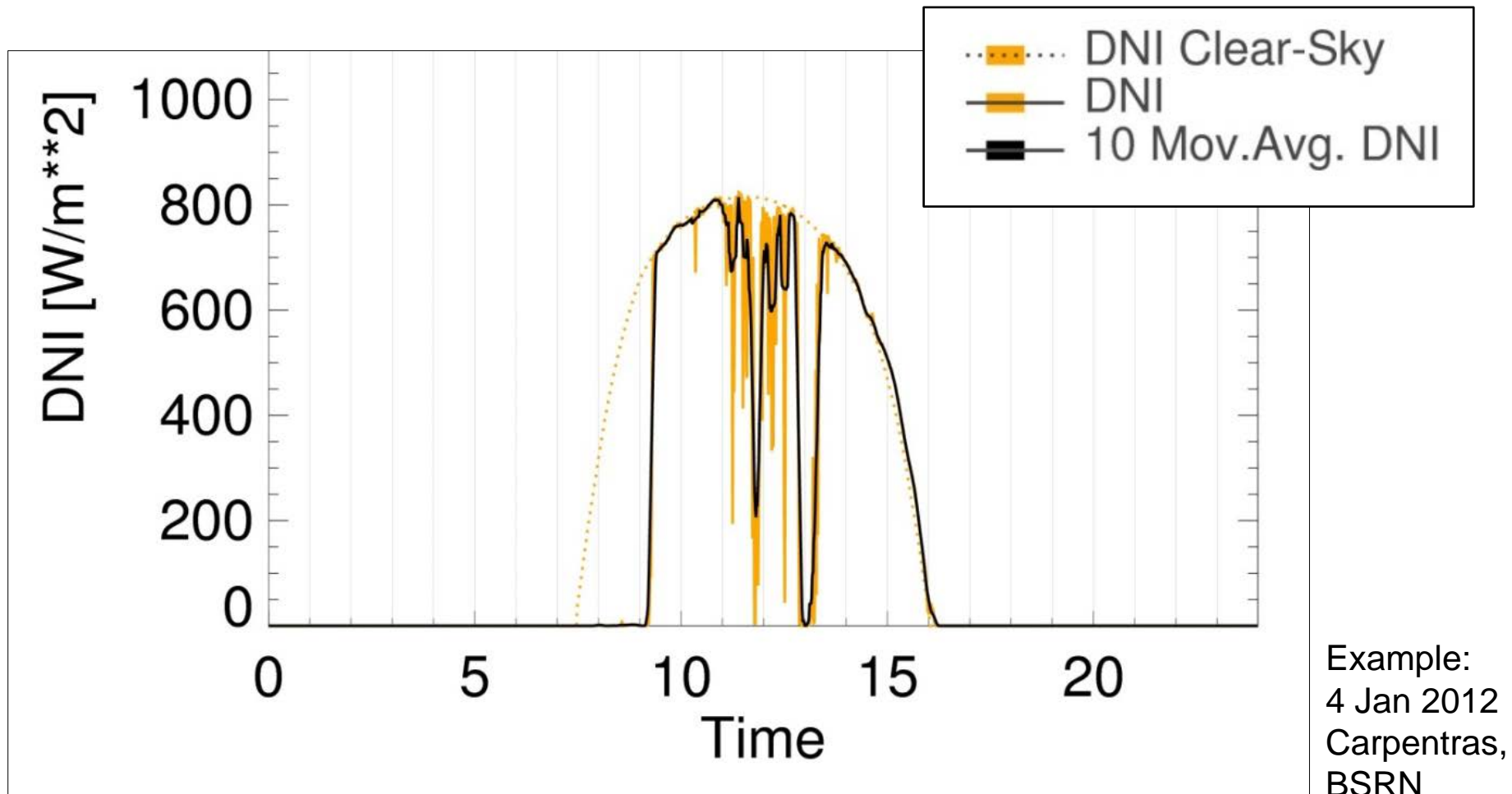normal
irradiance

15 min resolved

Typical variability in 1 min ground observations



Example:
4 Jan 2012
Carpentras,
BSRN

Idea

- 1 min observations from satellites not feasible
- Can we create a 1 min time series
with a good artificial variability inside an hour?

- What kind of variability do we have?
- We need a reference dataset of hours.

- How can we quantify/detect this from ground observations?

- We know the cloud situation from satellites (cumulus, cirrus, scattered clouds, overcast,...) every 15 minutes
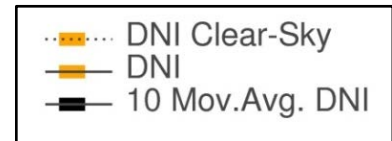- Can we quantify/detect variability in irradiances from satellites?

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What kind of variability in 1 min is important?

Example:
4 Jan 2012
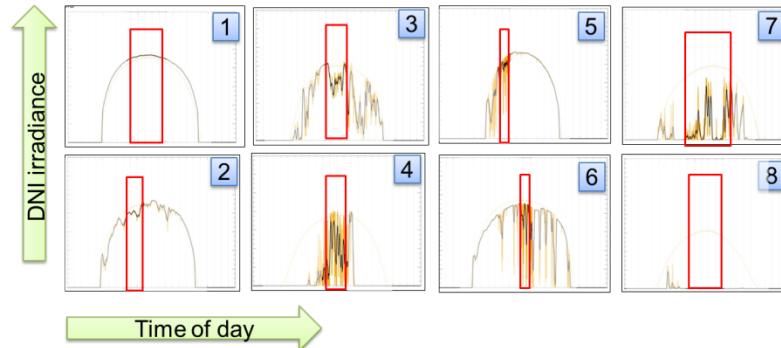Carpentras,
BSRN
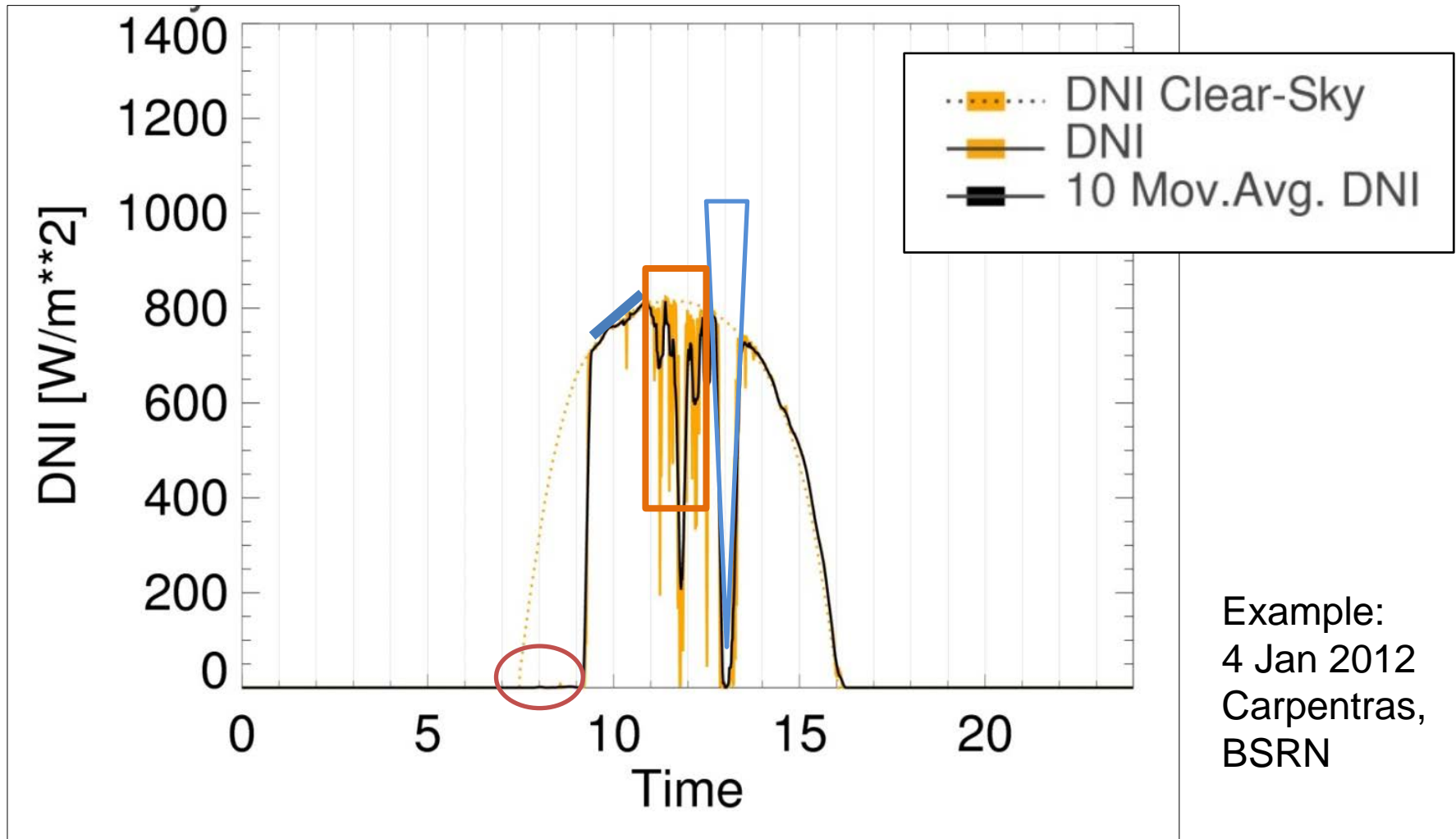
Definition of 8 variability classes
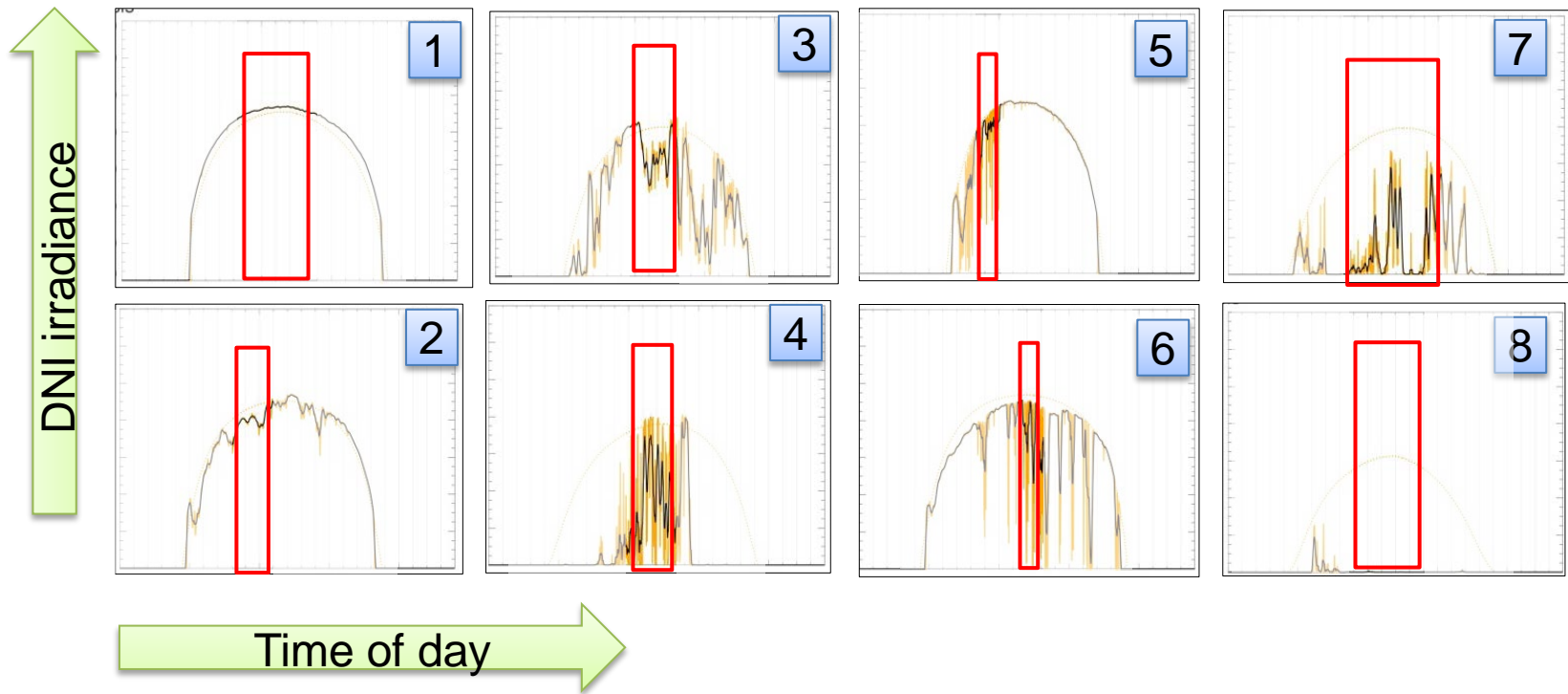
red boxes = hours classified as variability class i, i = 1..8
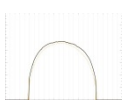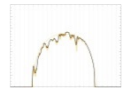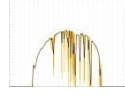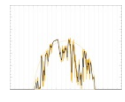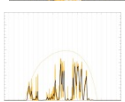
Generation of a reference data set

- visual interpretation
- Sandra Jung, Marion Schroedter-Homscheidt, Jan Kleissl
- definition of classes

- search for hours having such characteristics
- 1 year 1 min resolved observations, BSRN, Carpentras, only between 9-14 UTC, whole hour one class
- visual classification

Class characteristics (DNI)

class	Average kc DNI	Direction changes DNI	Description for DNI
1	0.99	0 – 2	**V**ery **H**igh **H**eight, **L**ow **I**rradiance **C**hanges
2	0.95	0 – 7 (mean 1)	**H**igh **H**eight, **L**ow **I**rradiance **C**hanges
3	0.93	0 – 18 (mean 8)	**H**igh **H**eight, **M**edium **I**rradiance **C**hanges
4	0.71	6 – 33 (mean 16)	**H**igh **H**eight, **H**igh **I**rradiance **C**hanges
5	0.67	0 – 13 (mean 6)	**M**edium **H**eight, **M**edium **I**rradiance **C**hanges
6	0.41	6 – 23 (mean 15)	**M**edium **H**eight, **H**igh **I**rradiance **C**hanges
7	0.18	0 – 20 (mean 8)	**L**ow **H**eight, **M**edium **I**rradiance **C**hanges
8	0.00	0 – 1	**V**ery **L**ow **H**eight, **L**ow **I**rradiance **C**hanges

Classes characteristics (GHI)

class	Average kc	Direction changes GHI	# overshootings > 5% clearsky	# overshootings > 10% clearsky value
1	0.97	0 – 2	0	0
2	0.96	0 – 6 (mean 1)	0-41 (mean 2)	0-14 (mean 1)
3	0.96	0 – 15 (mean 8)	0-18 (mean 4)	0-9 (mean 1)
4	0.86	6 – 33 (mean 16)	0-34 (mean 11)	0-24 (mean 5)
5	0.88	0 – 12 (mean 6)	0-30 (mean 4)	0-26 (mean 2)
6	0.77	4 – 22 (mean 15)	0-34 (mean 11)	0-27 (mean 8)
7	0.64	0 – 18 (mean 8)	0-13 (mean 3)	0-10 (mean 1)
8	0.20	0 – 7 (mean 1)	0	0

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Now we have a reference data base

How can we find the classes in ground data?

Manual/visual search is not the future !!!!

Automatic?

Quantitative variability indices under review

- Variability after Perez et al. (2011): $|\Delta kc_{\Delta t}|$, $\sigma|\Delta kc_{\Delta t}|$, $\max|\Delta kc_{\Delta t}|$
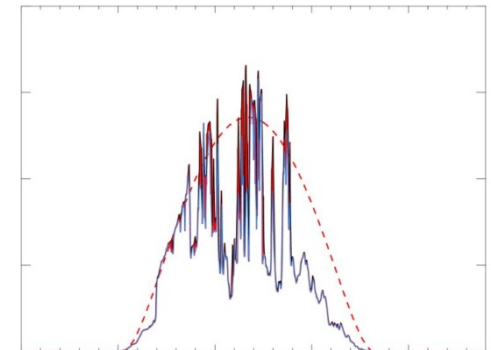- Variability Index after Skartveit et al. (1998):

$$\rho = \sqrt{\frac{\left(kc(t)-kc(t-1)\right)^2+\left(kc(t)-kc(t+1)\right)^2}{2}}$$

- Variability Index (VI) after Stein et al. (2012):

$$VI = \frac{\sum_{k=2}^{n}\sqrt{(GHI(k)-GHI(k-1))^2+\Delta t^2}}{\sum_{k=2}^{n}\sqrt{(CSI(k)-CSI(k-1))^2+\Delta t^2}}$$
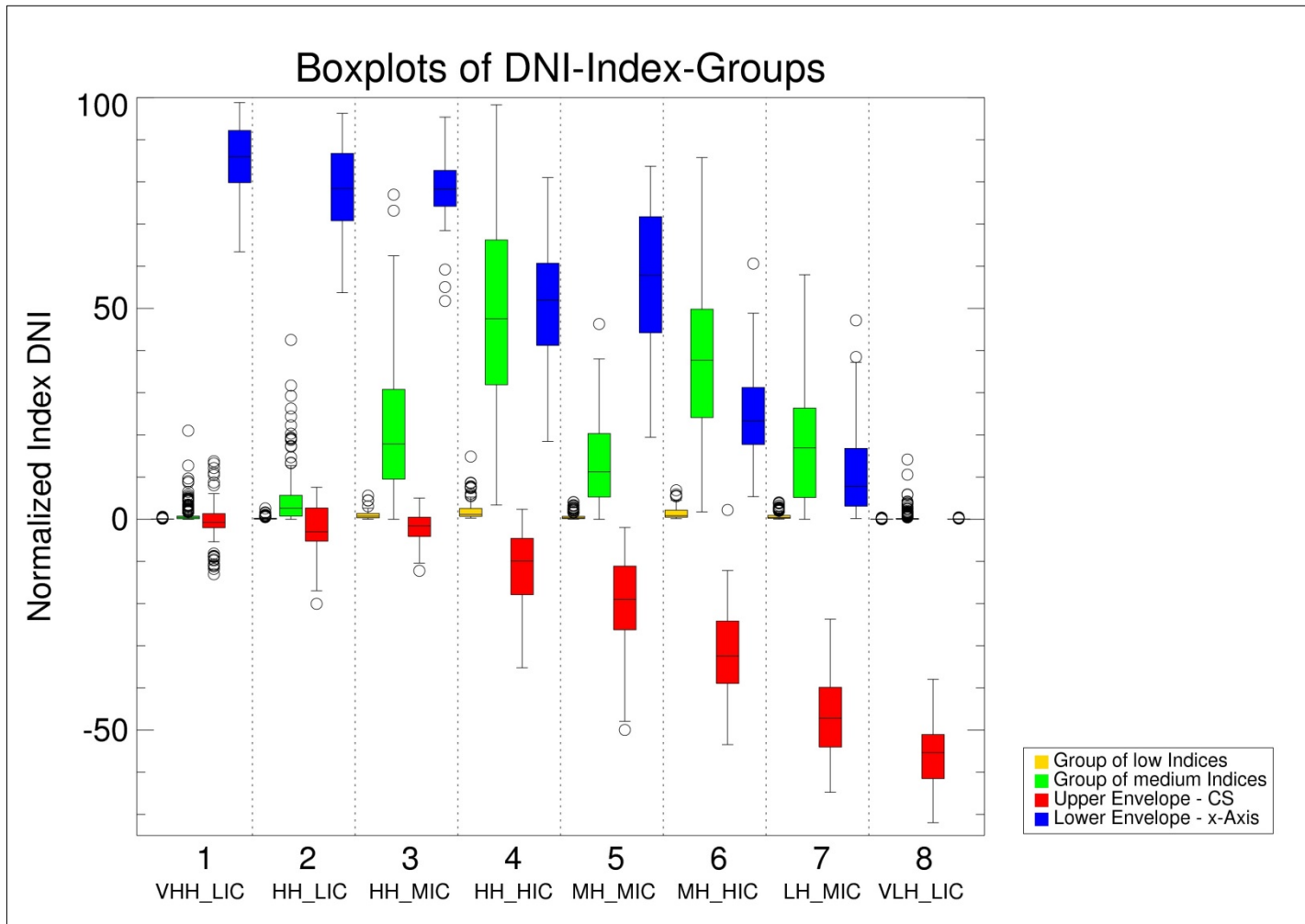
- Variability Index after Coimbra & Kleissl (2013): $V = \sqrt{\frac{1}{N}\sum_{t=1}^{N}(\Delta kc)^2}$

- Number of overshootings
- Number of direction changes Kraas et al. (2011)
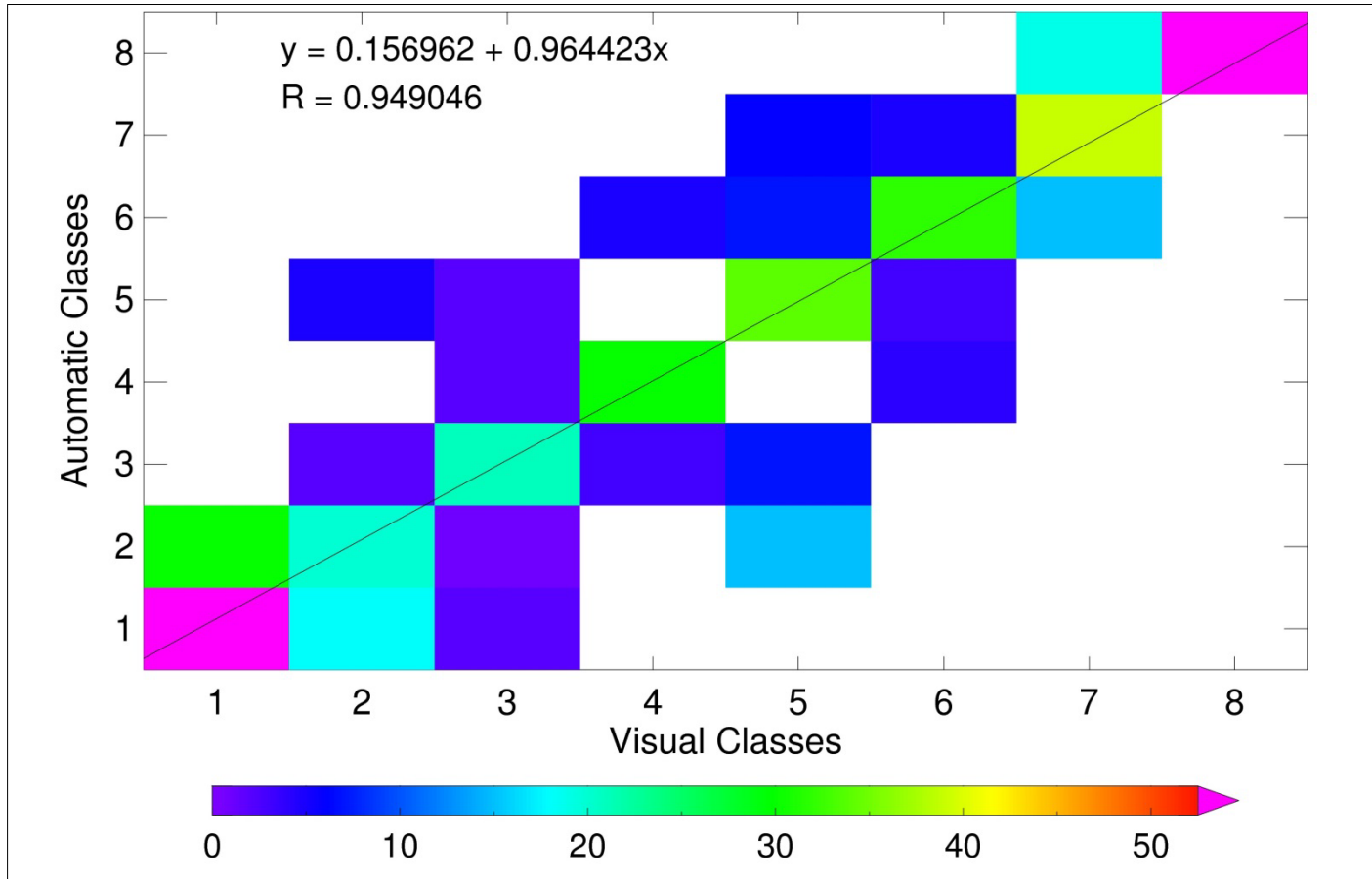- Envelope for minima and maxima

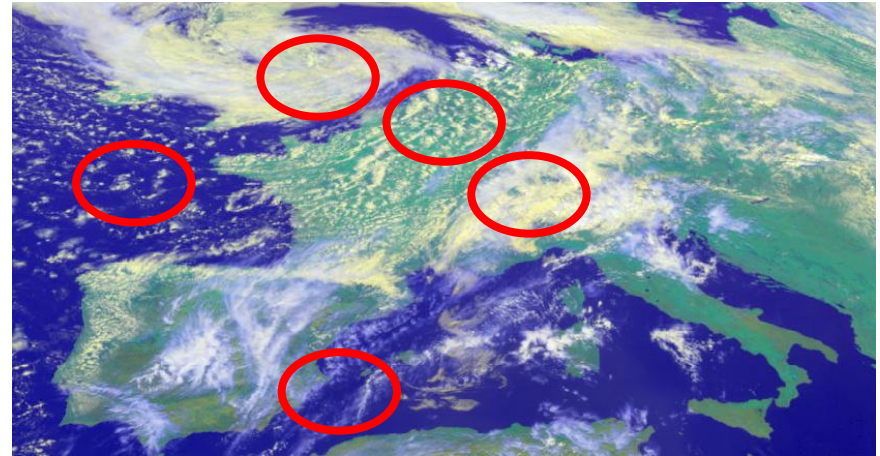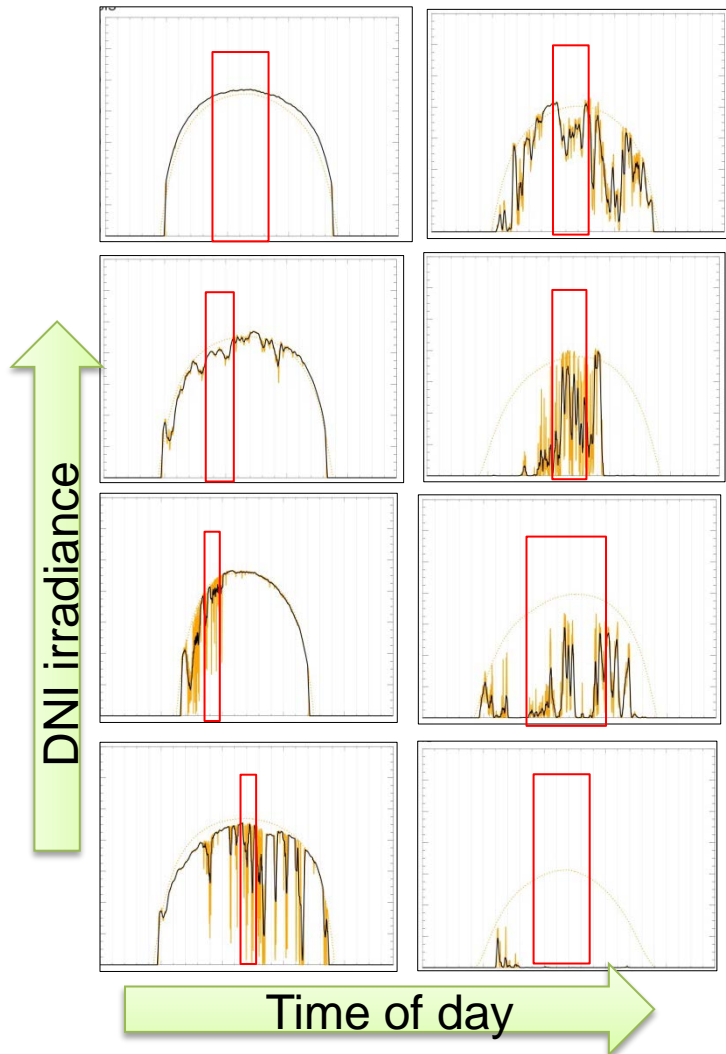# Automated classification from ground data
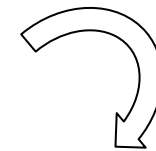
Reference
database:

Automatic classification vs. manual classification

Can we get the classes from satellite information?
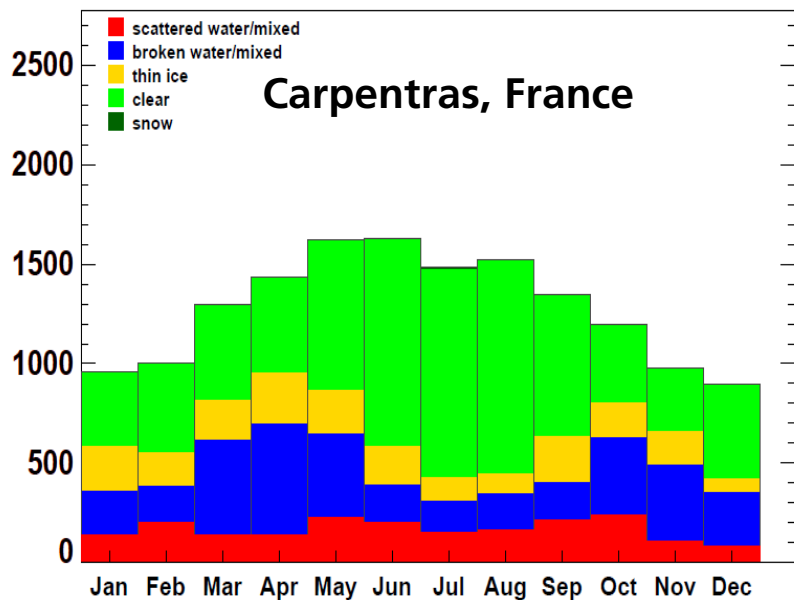
DNI irradiance

Time of day

Spatial structures satellites
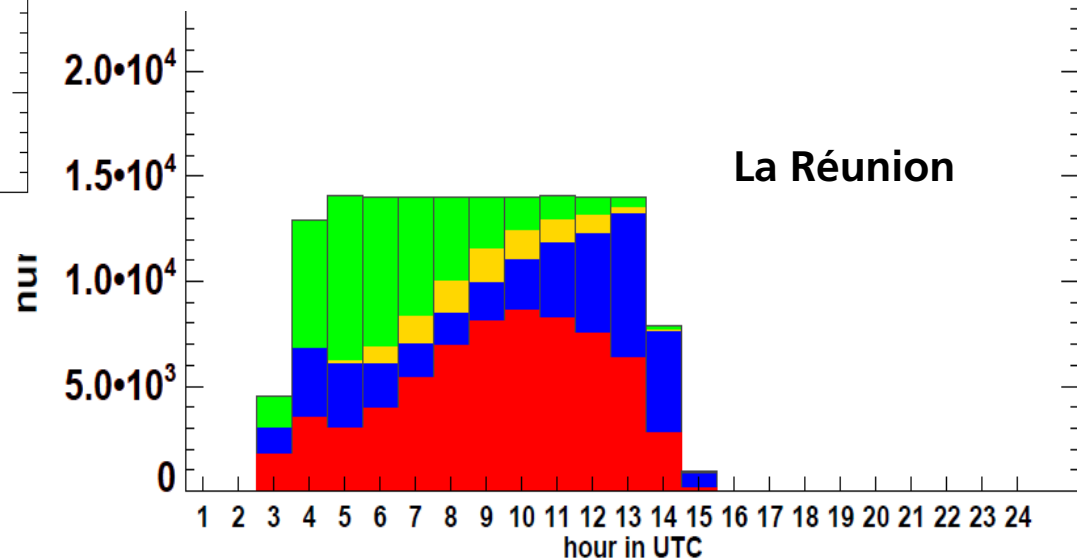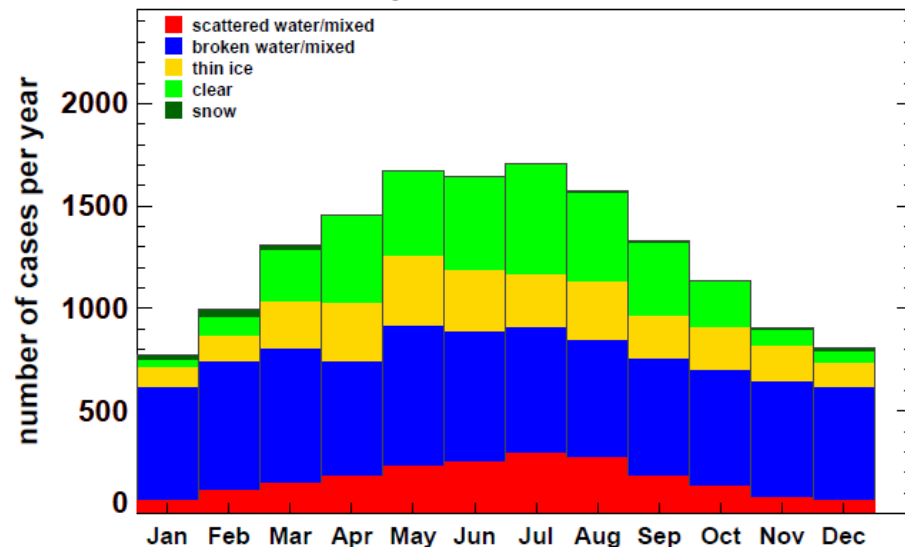
Automatic variability class detection for the hour
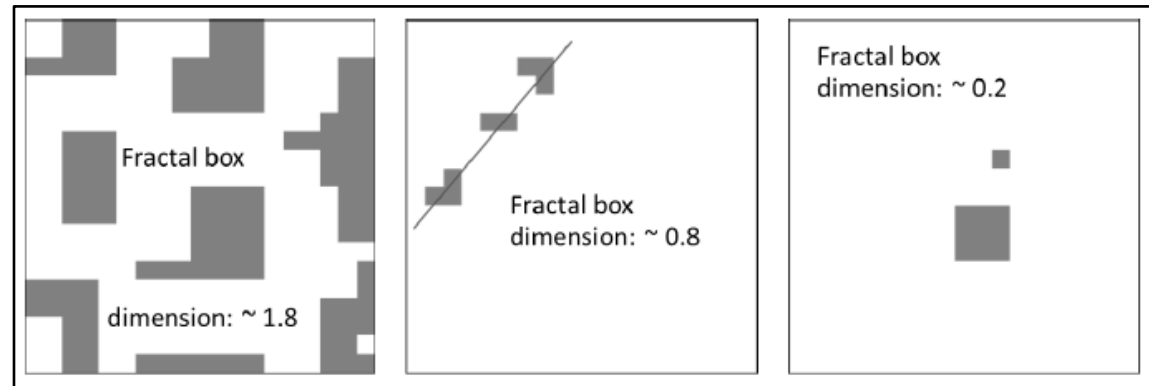
Long term cloud/snow statistics

green = clear
blue = overcast/broken clouds
yellow = cirrus, thin ice
red = scattered clouds

Spatial satellite based cloud parameters used

- VIS and IR channels of MSG satellites
- APOLLO parameter
  like cloud optical depth
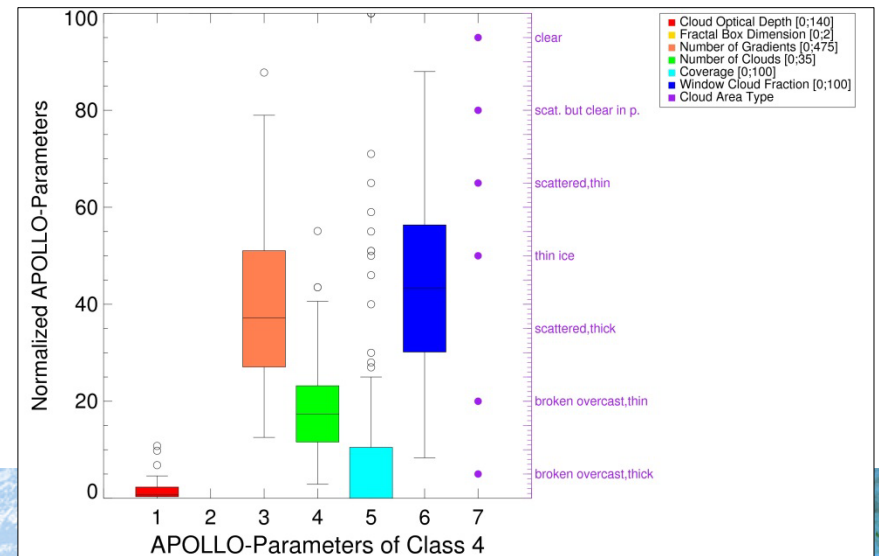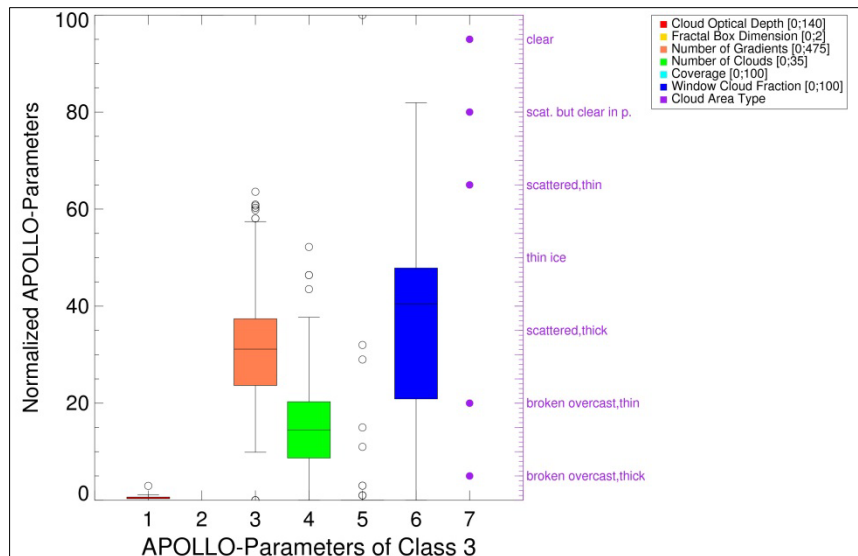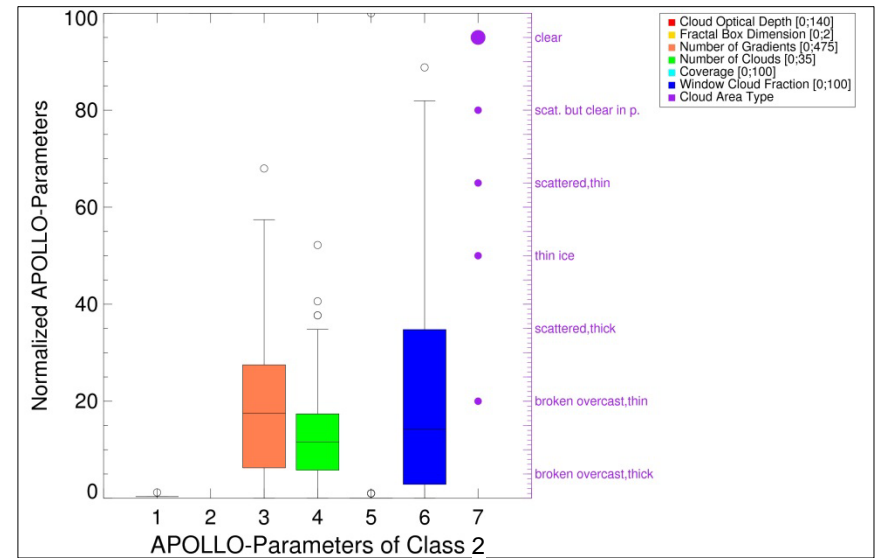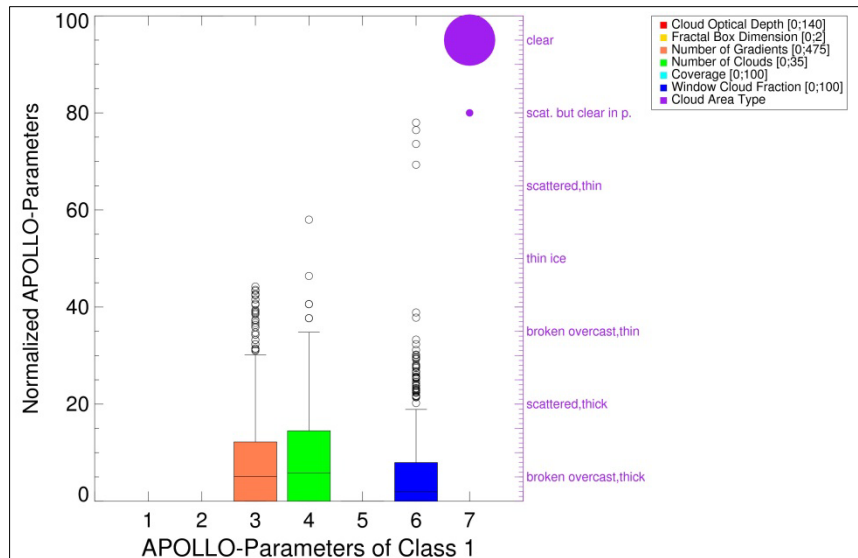 (talk N. Killius)
- cloud coverage
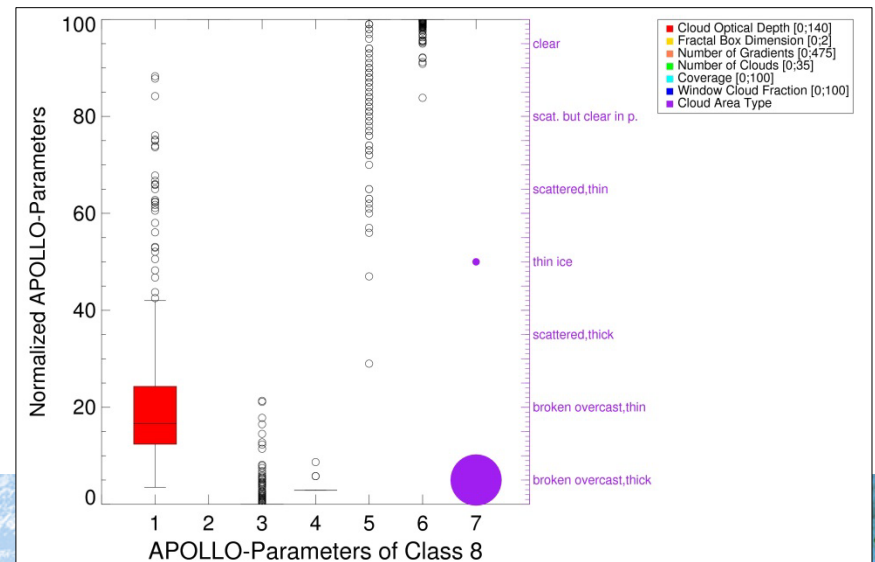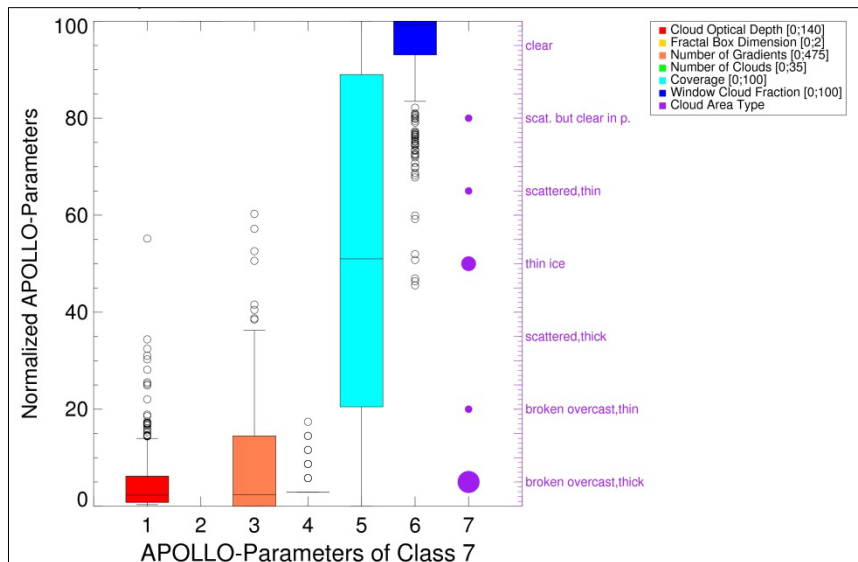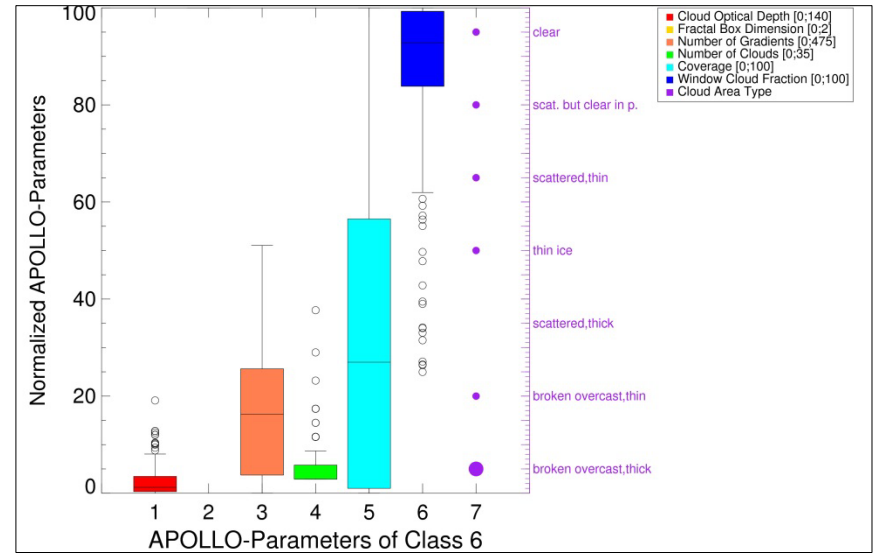- fractal box dimension
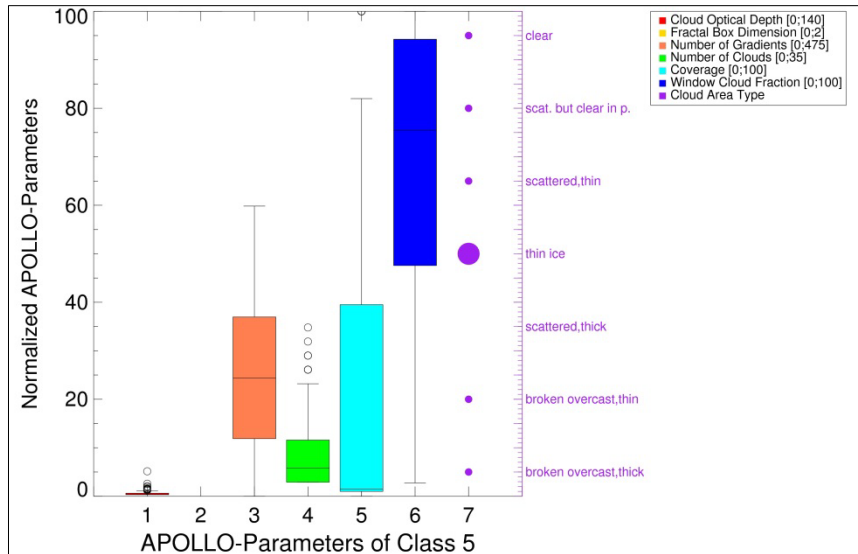

Glas 2014, S. 19.

- number of cloud/cloud free changes among pixels in window
- cloud fraction in window in %
- number of clouds in window

- cloud area type in window (broken/overcast, scattered, thin ice, clear)

Classification based on cloud structural indicators

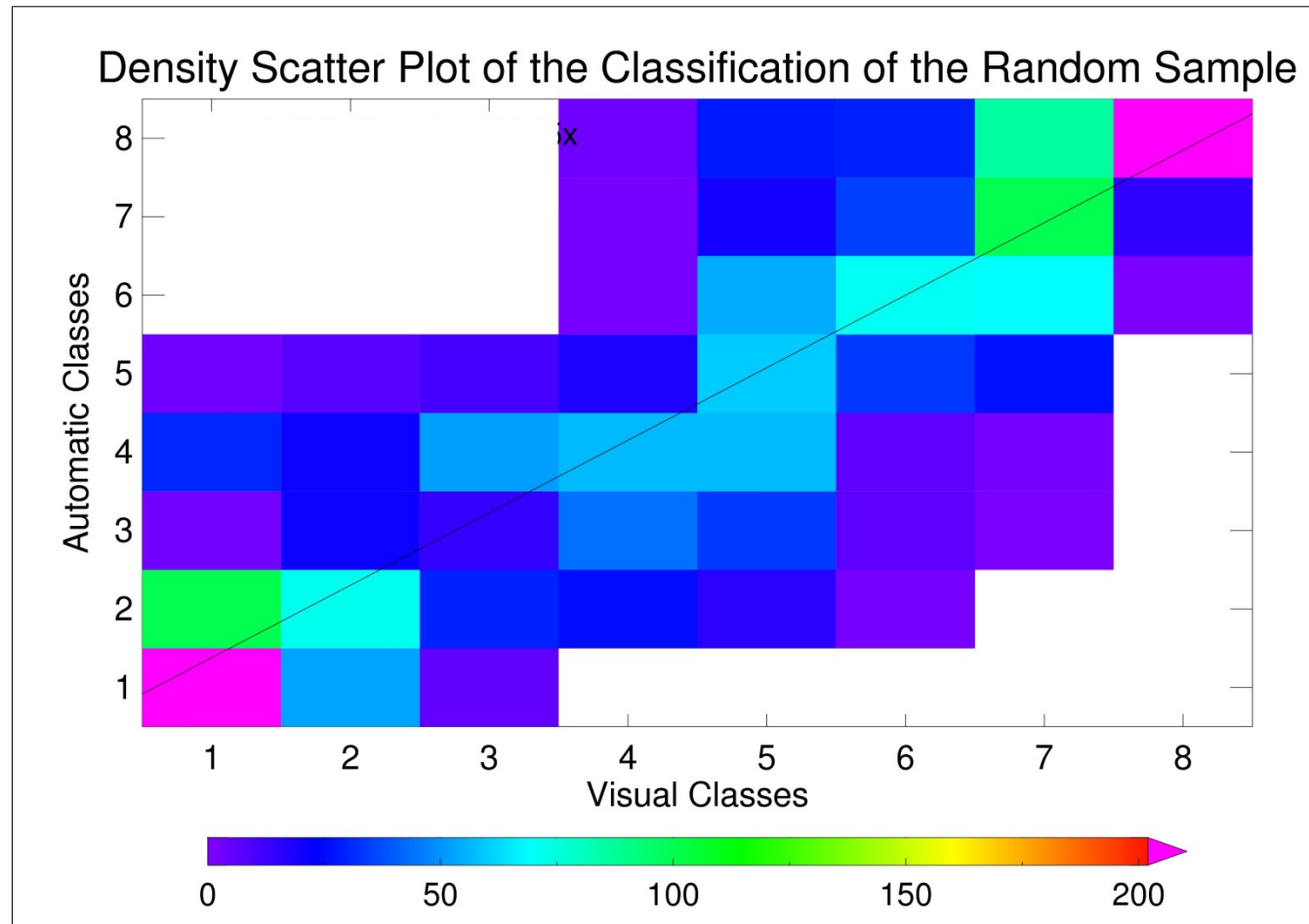# Classification based on cloud structural indicators

Preliminary result:
How good is the satellite-based variability class detection?

15 min data

52 % correctly identified

88% if we accept
1 class deviation

1 year
BSRN Carpentras
and
MSG SEVIRI/
APOLLO

Density Scatter Plot of the Classification of the Random Sample

How to validate with respect to irradiances ?

- We know typical patterns in each variability class.

- We can super-impose them on the time series.

- But we can't get exact 1 min values, of course.
  We hope to get good representation of variability.

- How to validate? Give any 1 sigma of DNI within the hour around
  the point in time of the nowcast value?

- Can you evaluate KSI to assess distributions in 1 hour?

Conclusions

- Variability class reference data base

- Review on variability as in literature performed

- automatic classification of ground observations per hour

- automatic classification from the satellite

    - every 15 minutes

    - variability inside an hour

Additional slides
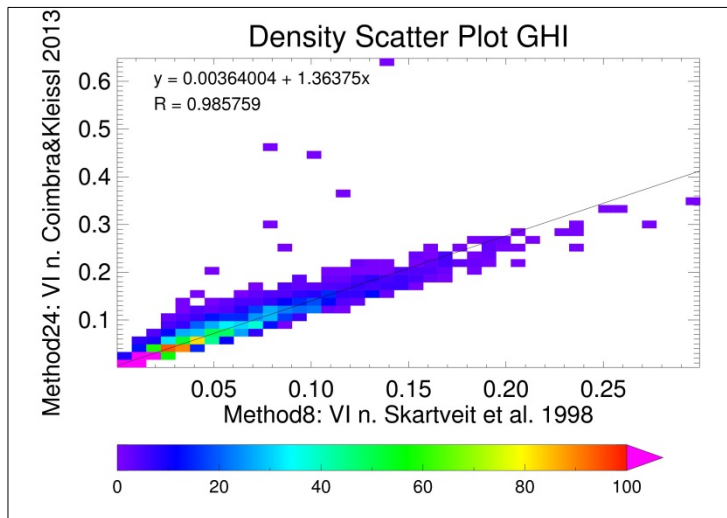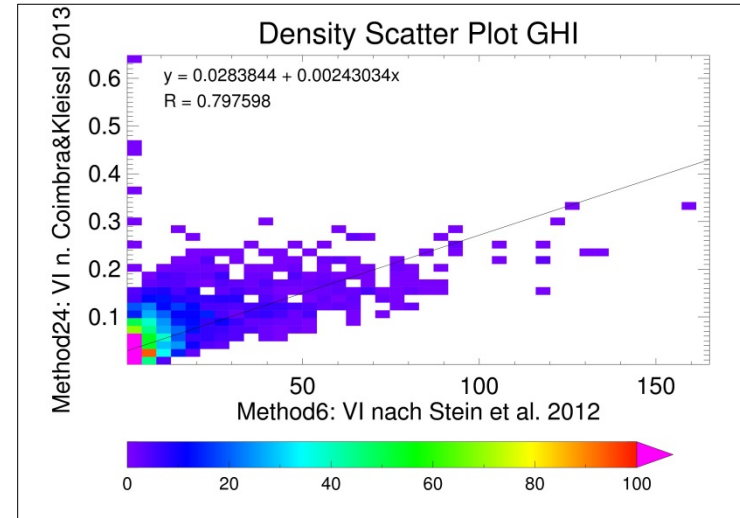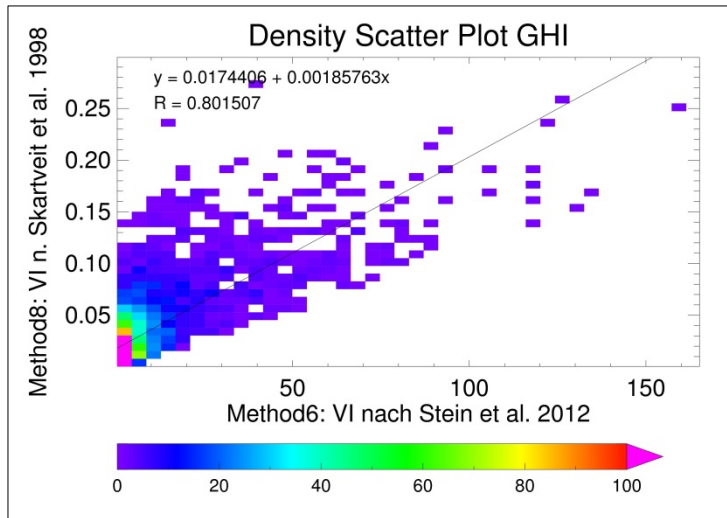
Compare indices

BSRN Carpentras, 2012