EMS 2016 - 386

Classifying 1 minute temporal variability in global and direct normal irradiances within each hour from ground based measurements

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DNICast

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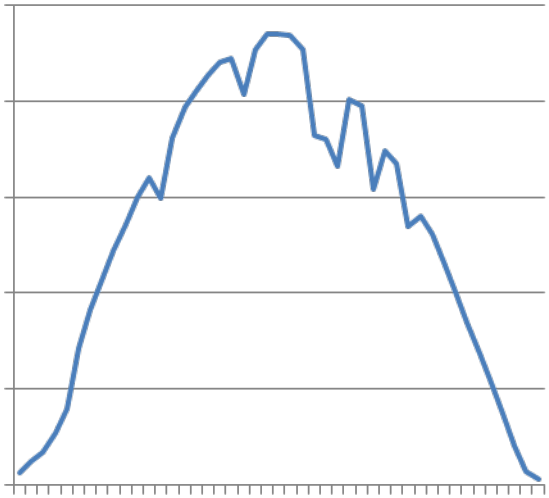
European Commission

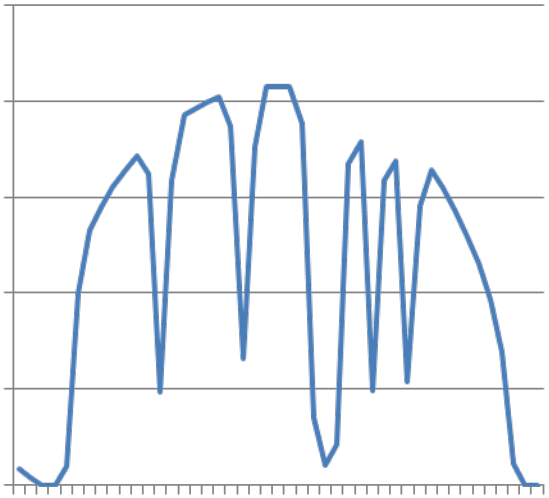
Today‘s satellite-based time series e.g. from the CAMS radiation service

global horizontal irradiance



15 min resolved

direct normal irradiance



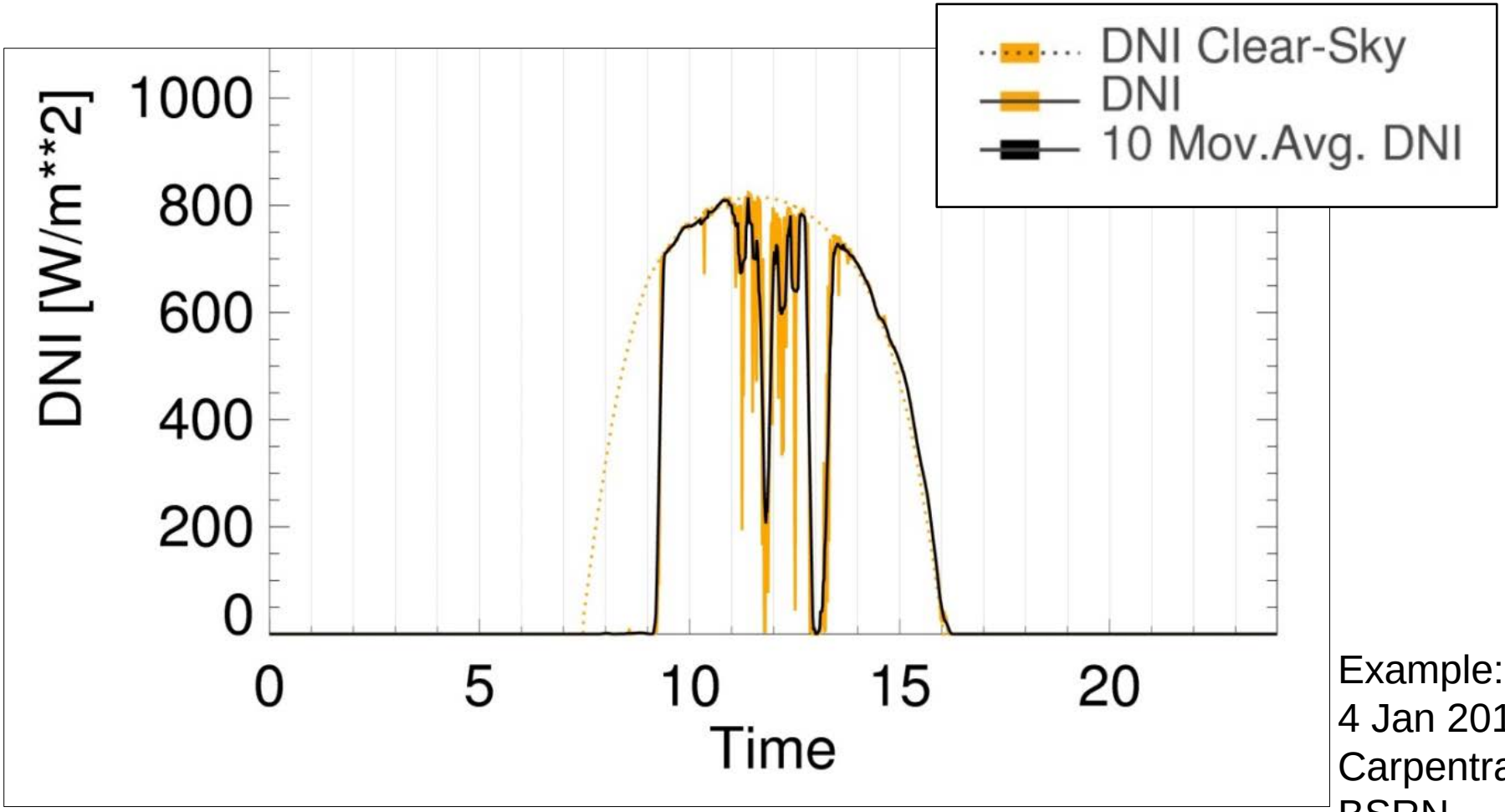
15 min resolved

Copernicus
Europe’s eyes on Earth

Atmosphere Monitoring Service

DLR

Typical variability in 1 min ground observations



Example:
4 Jan 2012
Carpentras,
BSRN

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Idea

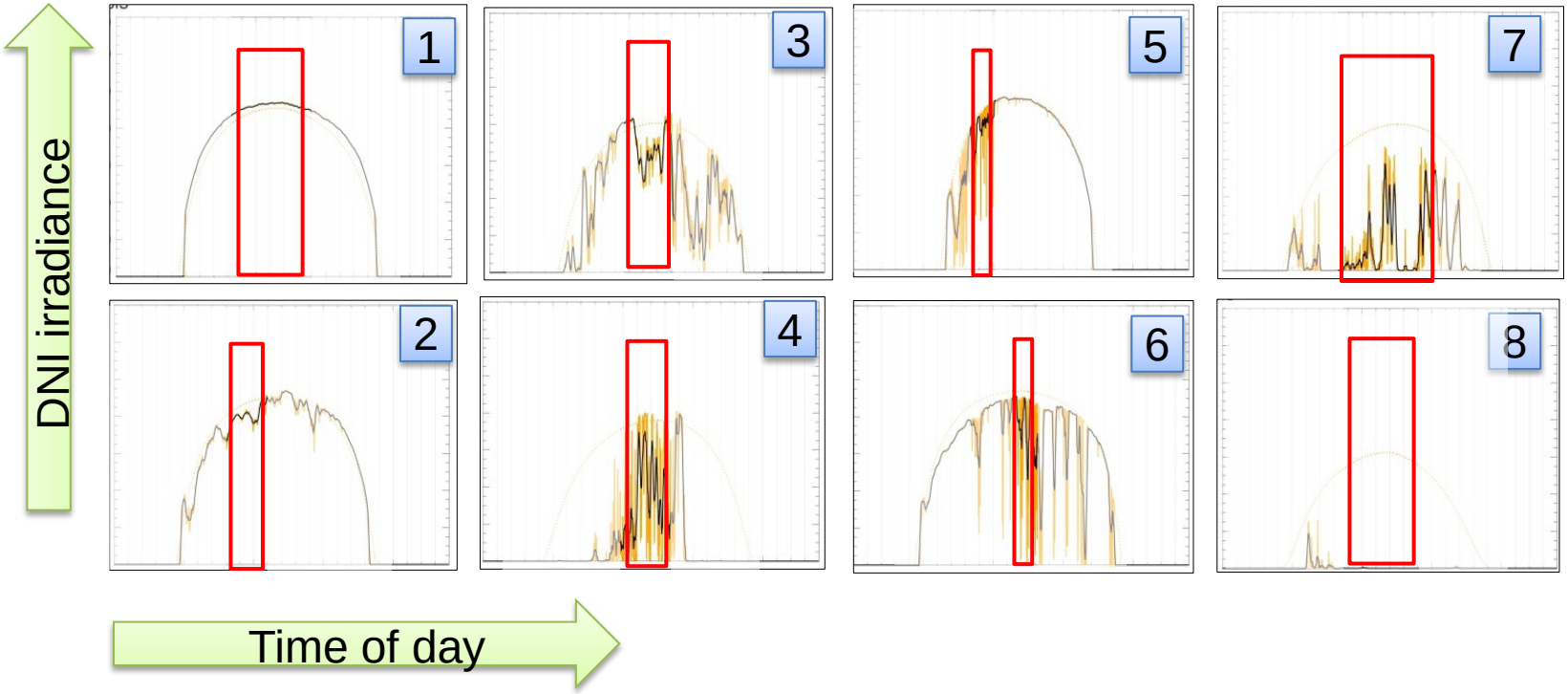
- 1 min observations from satellites not feasible
- Can we create a classification of each hour?

- Does this lead to effective radiation parameterizations?
- 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?

Definition of 8 variability classes



red boxes = hours classified as variability class i, i = 1..8

DNI Clear-Sky
DNI
10 Mov.Avg. DNI

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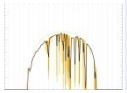
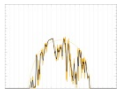
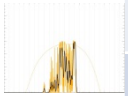
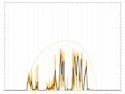
Generation of a reference data set

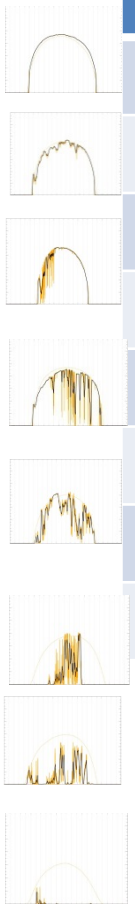
- visual interpretation
- search for hours having such characteristics
- 1 year 1 min resolved observations, BSRN, Carpentras, only between 9-14 UTC, whole hour one class

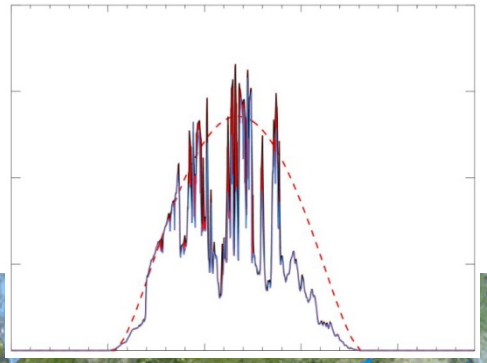
Class characteristics (DNI)

	class	Average kc DNI	Direction changes DNI	Description for DNI
	1	1.0	0	Very High DNI, Low Irradiance Changes
	2	0.95	0 – 7 (mean 1)	High DNI, Low Irradiance Changes
	3	0.92	3 – 18 (mean 8)	High DNI, Medium Irradiance Changes
	4	0.71	6 – 33 (mean 15)	High DNI, High Irradiance Changes
	5	0.66	0 – 13 (mean 6)	Medium DNI, Medium Irradiance Changes
	6	0.41	6 – 22 (mean 15)	Medium DNI, High Irradiance Changes
	7	0.20	0 – 20 (mean 8)	Low DNI, Medium Irradiance Changes
	8	0.00	0 – 2	Very Low DNI, Low Irradiance Changes
				

Classes characteristics (GHI)

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





Now we have a reference data base

How can we find the classes in ground data?

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

Automatic?

More physical understanding than only machine learning?

Indicators may help to generate artifical time series afterwards.

Quantitative variability indices under review

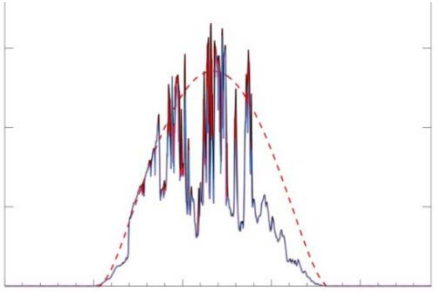
- Variability after Perez et al. (2011): $|\Delta kc_{\Delta t}|$, $\sigma|\Delta kc_{\Delta t}|$, $\max|\Delta kc_{\Delta t}|$
  - kc =GHI/GHI_clear
- Variability Index after Skartveit et al. (1998):

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

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

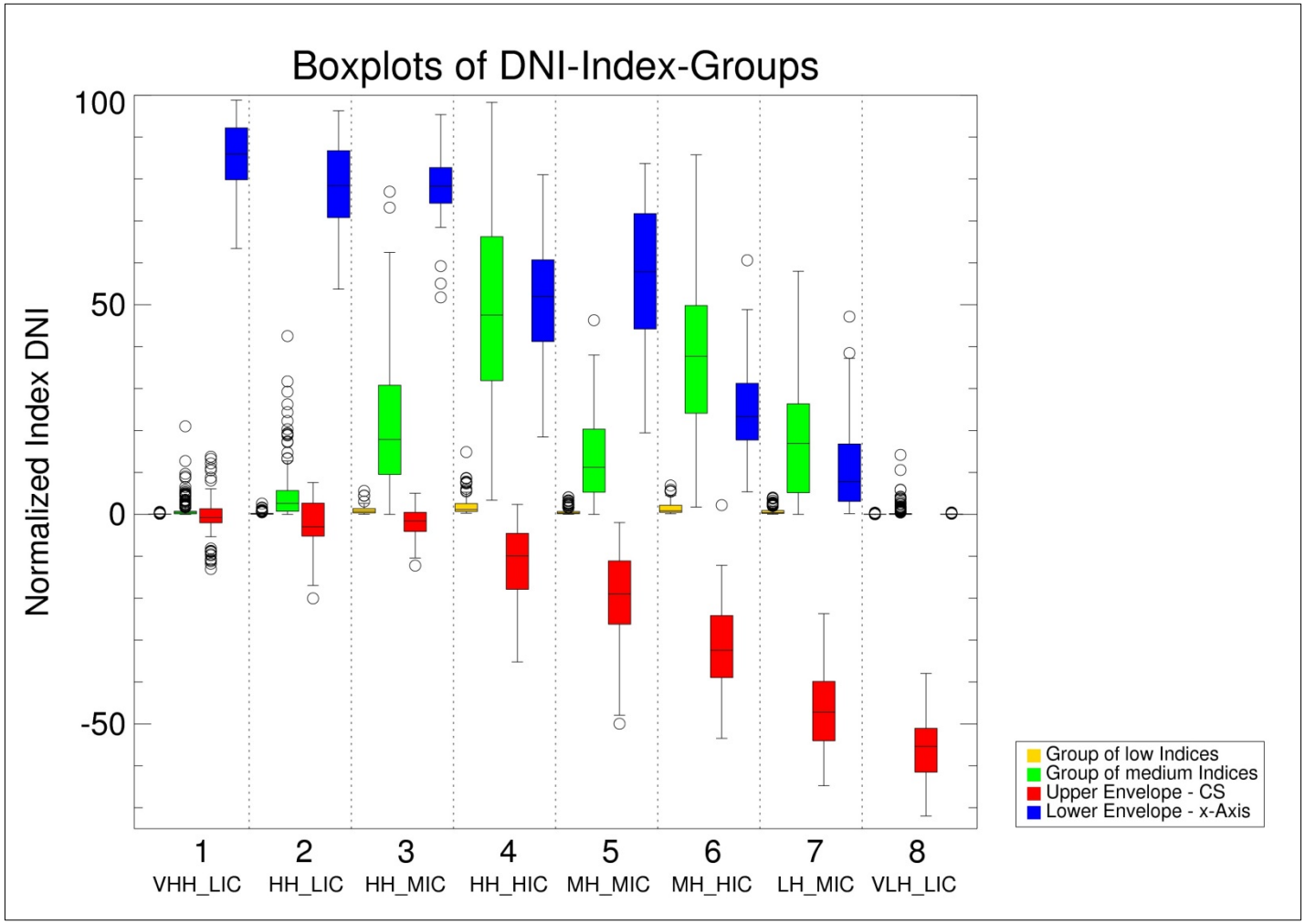
$$VI = \frac{\sum_{k=2}^{n}\sqrt{(GHI(k)-GHI(k-1))^2+\Delta t^2}}{\sum_{k=2}^{n}\sqrt{(CSI(k)-CSI(k-1))^2+\Delta t^2}}$$

- 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

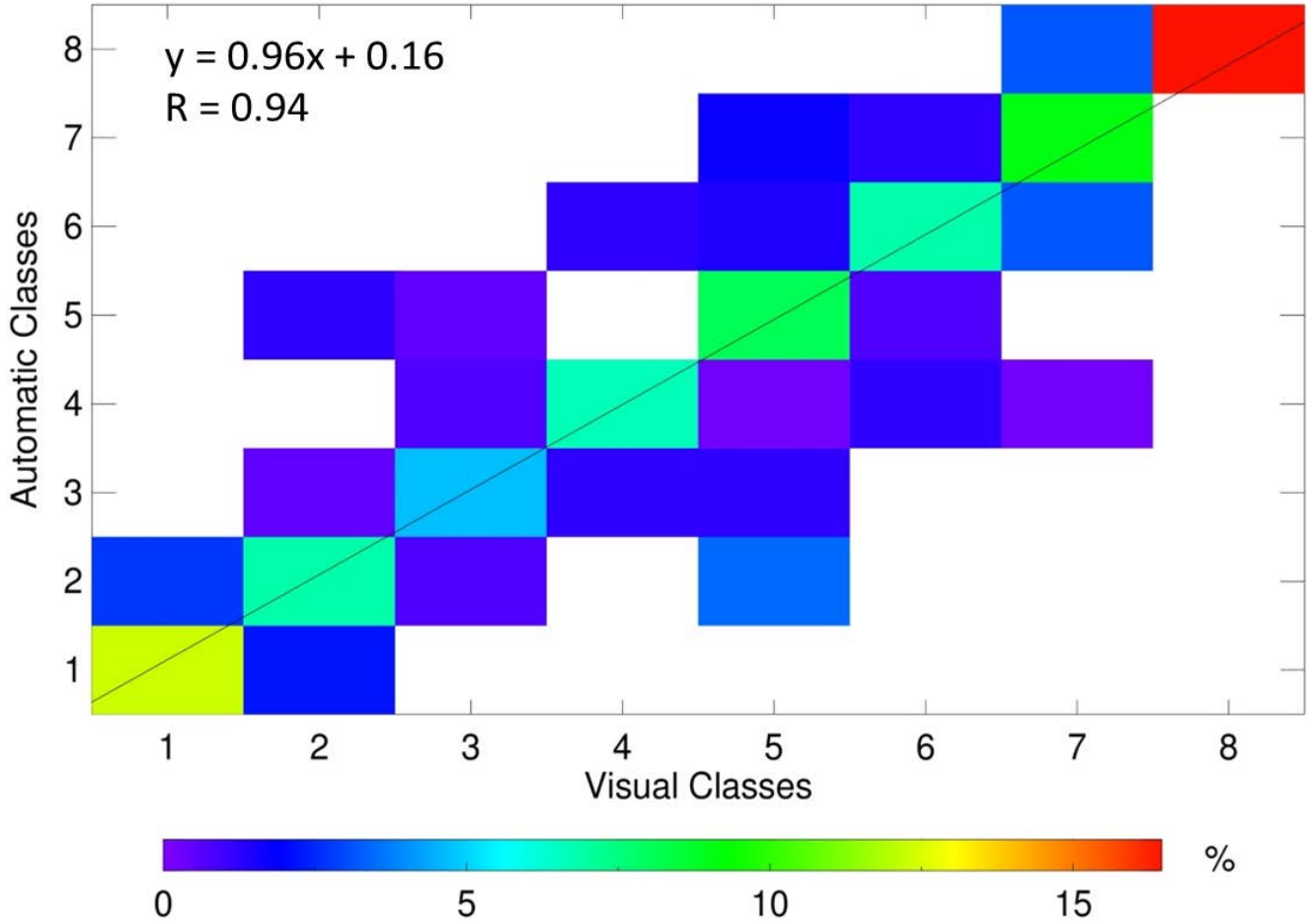


Automated classification from ground data

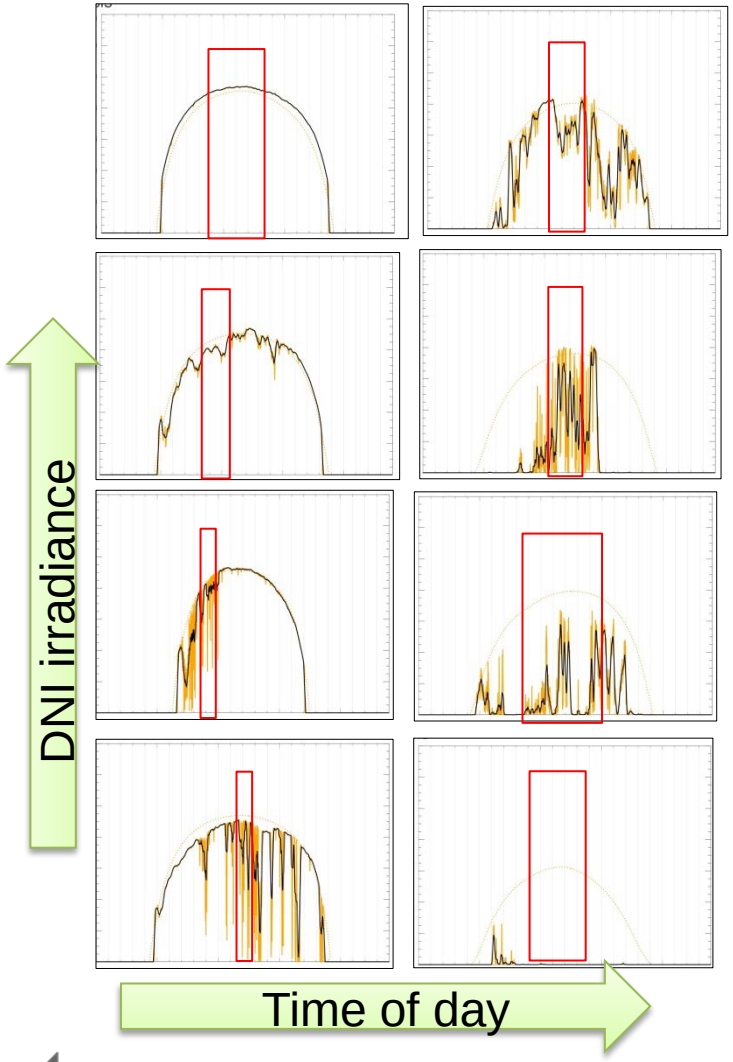
Reference database:

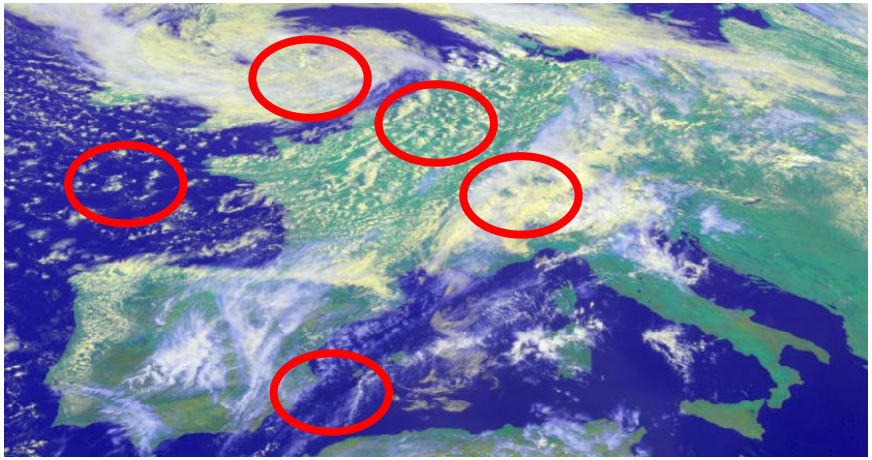


Automatic classification vs. manual classification



Can we get the classes from satellite information?





Spatial structures satellites

Automatic variability class detection for the hour

Conclusions

- variability class reference data base
- review on variability as in literature performed
- automatic classification of ground observations per hour

- Next steps currently investigated:
  - we know the cloud situation from satellites (cumulus, cirrus, scattered clouds, overcast,...) every 15 minutes
  - we know the spatial neighbourhood
  - we apply an automatic classification of the same classes from the satellite

- Thanks to EC for funding of DNICast, grant agreement 608623