Cloud detection from IASI radiance for climate analysis purposes

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The IASI sounder

- IASI = Infrared Atmospheric Sounding Interferometer
- On board the Metop (-A, -B and -C) satellites
- In the thermal infrared region (645-2760 cm^{-1})
- 8461 spectral channels
- Quasi global coverage 2x daily
- Almost 15 years of continuous measurements
- … + minimum 15 years to come with IASI-NG

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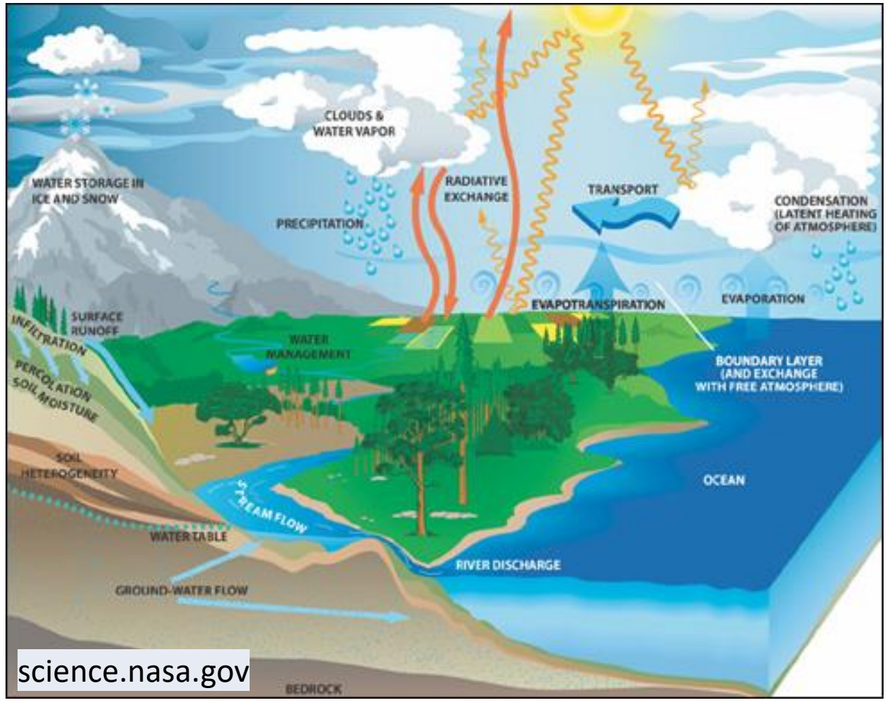
⟶ Excellent fundamental climate data record

- Clouds affect:
  - the weather;
  - the water cycle;
  - the Earth radiation budget

➔ Main source of uncertainties in climate projections

- Cloud filtering:
  - Essential preprocessing step for climate and atmospheric satellite applications
  - E.g. retrieval of trace gas concentrations, dust optical depth, Earth Outgoing Longwave Radiation



Different cloud products exist for IASI

- For example:
  - Operational IASI L2,
  - CIRS-LMD cloud product,
  - L1C-AVHRR, …
- … But
  - ➢ not strict enough
  - ➢ or not homogeneous on the whole IASI lifespan.

Product	Instrument(s)	Platform(s)	Algorithm
Operational IASI-L2	IASI	Metop	Until v6.4: (1) Cloud detection: - AVHRR collocated CMA, - NWP, - NN on IASI and AVHRR measurements (2) Characterization: CO_2-slicing and χ^2 method. Since v6.5: - Cloud fraction: Optimal Estimation - Cloud detection derived from the retrieved cloud fraction
LMD-CIRS	HIRS, AIRS, IASI	NOAA, Aqua, Metop	Weighted χ^2 method (channels around 15 μm)
IASI NN	IASI	Metop	Supervised NN (input: 45 IASI channels)
L1C-AVHRR	AVHRR	Metop	Sequence of threshold tests based on BT and inter-channel differences in the IR, vis and NIR + NWP forecast data
L3U AVHRR-AM (ESA Cloud_cci)	AVHRR	NOAA-12, 15, 17 Metop	CC4CL v3.0 retrieval system: (1) Cloud detection: ANN using the AVHRR channel radiance, illumination, scan angles and auxillary data (2) Cloud typing: Threshold decision tree (3) Characterization: Optimal Estimation
CLARA-A2.1 (CM-SAF)	AVHRR	NOAA, Metop	A. NWC SAF PPS cloud software: (1) CMA and CA: Multispectral thresholding technique, (2) CTO: - Comparison simulated and measured radiances, - inter-channel BT differences, B. CPP algorithm: CPH, COD, r_e, CWP: LUT approach
PATMOS-x	AVHRR	NOAA, Metop	(1) Cloud detection: Bayesian classifiers derived from CALIPSO, (2) Characterization: Optimal Estimation

➔ Need for a new cloud detection algorithm for IASI measurements

- Accurate
- Consistent over the 15 years of IASI
- Strict enough to be used in retrieval frameworks

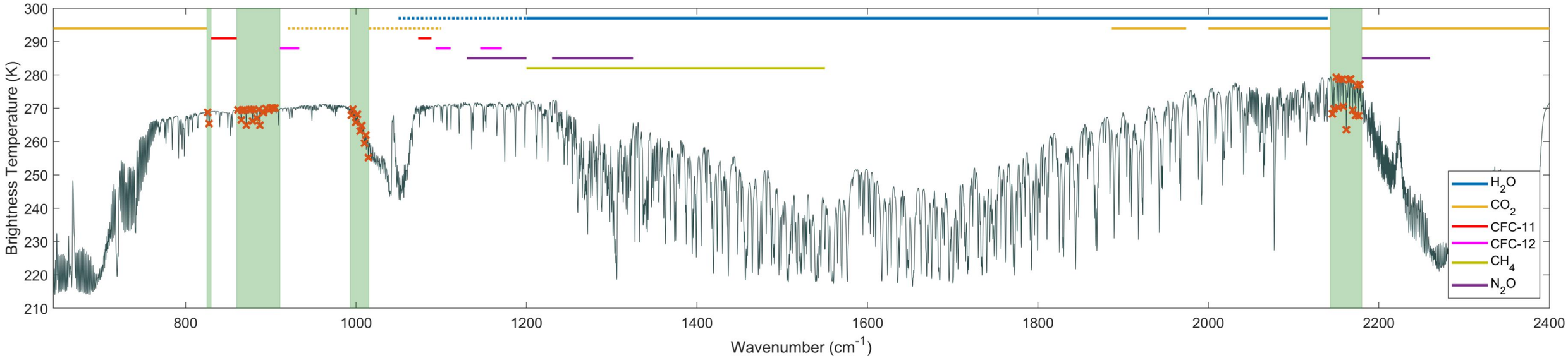
Supervised neural network :

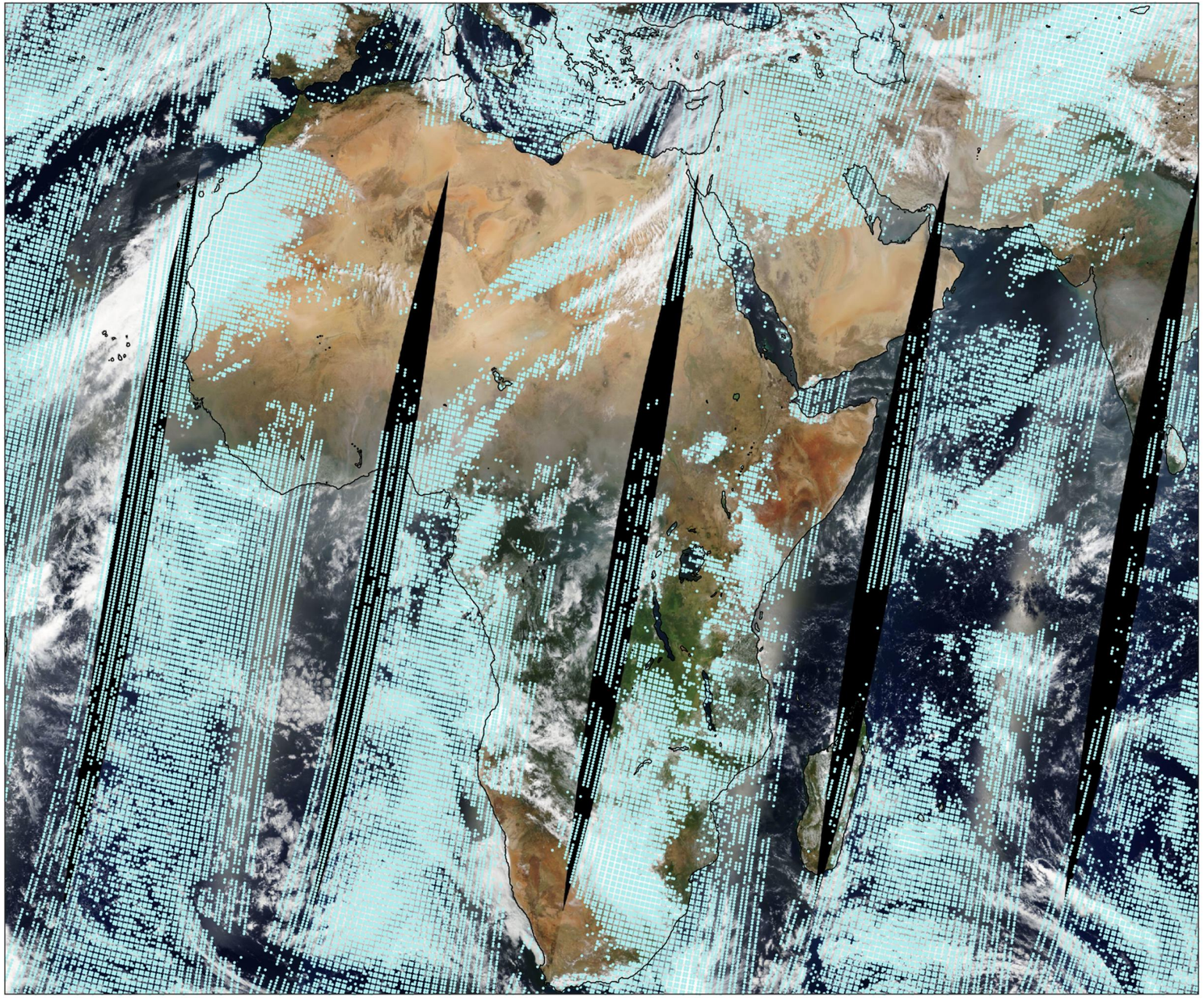
- Pattern recognition network
- Reference dataset: latest version of the IASI L2 cloud product (cloud flag)

- Inputs: IASI information only
  - ➔ 45 IASI channels
  - ➔ Exclusion: CO_2, CH_4, N_2O, CFC-11 and CFC-12 absorption lines + ν_2 H_2O

Training:

- ➔ 54,000 cloud free and 54,000 cloud scenes
- ➔ performance: 87.3%

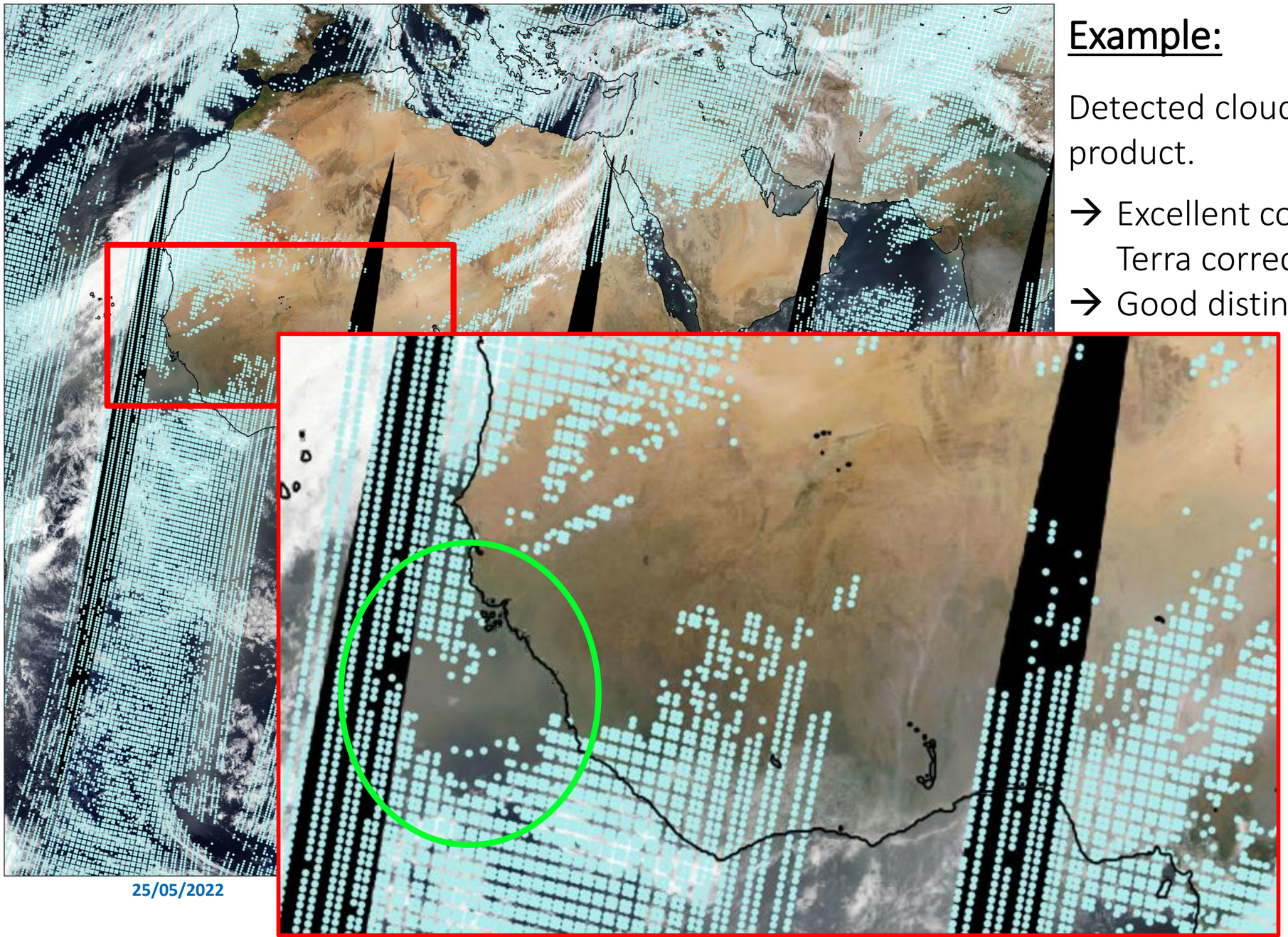




Example:

Detected clouds (2018/02/15) with the IASI NN product.

→ Excellent correspondence with the MODIS Terra corrected reflectance imagery.



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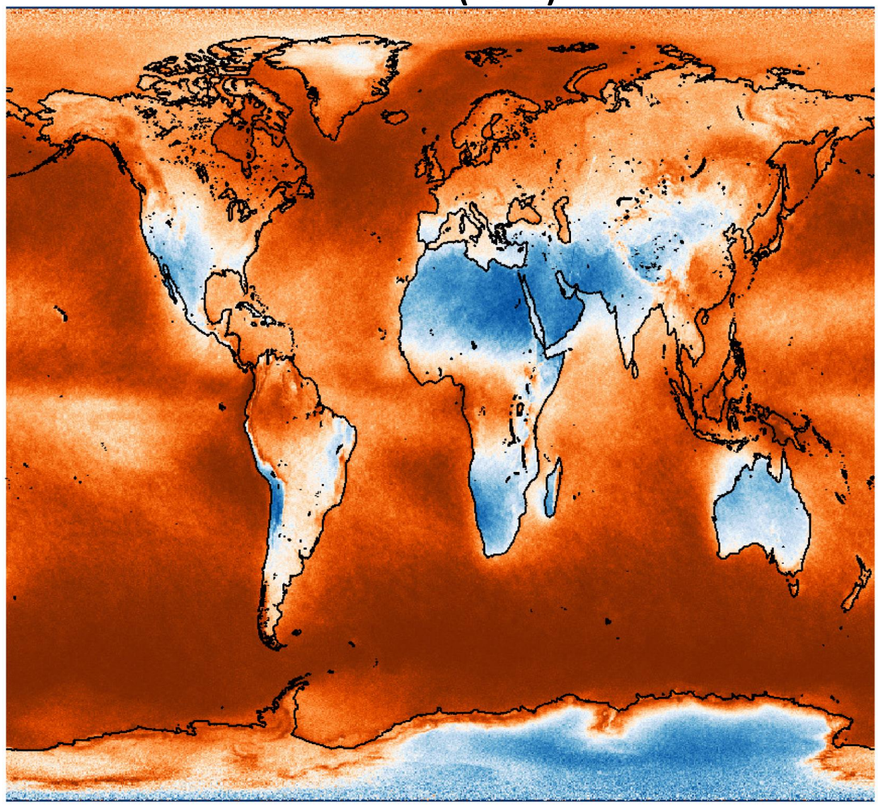
Detected clouds (2018/02/15) with the IASI NN product.

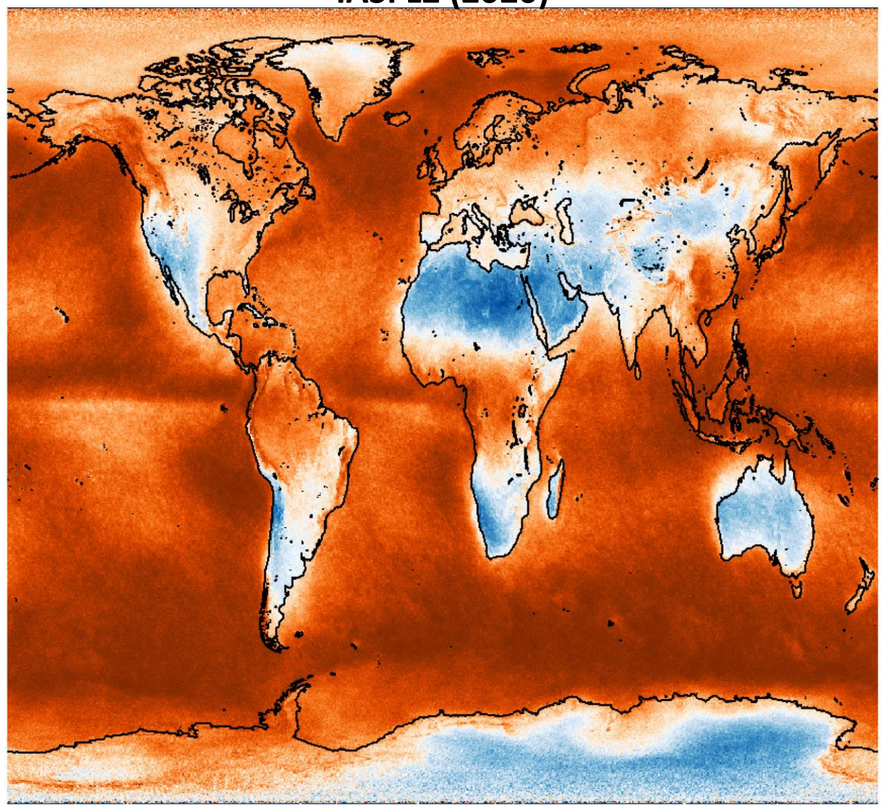
→ Excellent correspondence with the MODIS Terra corrected reflectance imagery.

→ Good distinction between clouds and dust plumes.

IASI NN (2020)



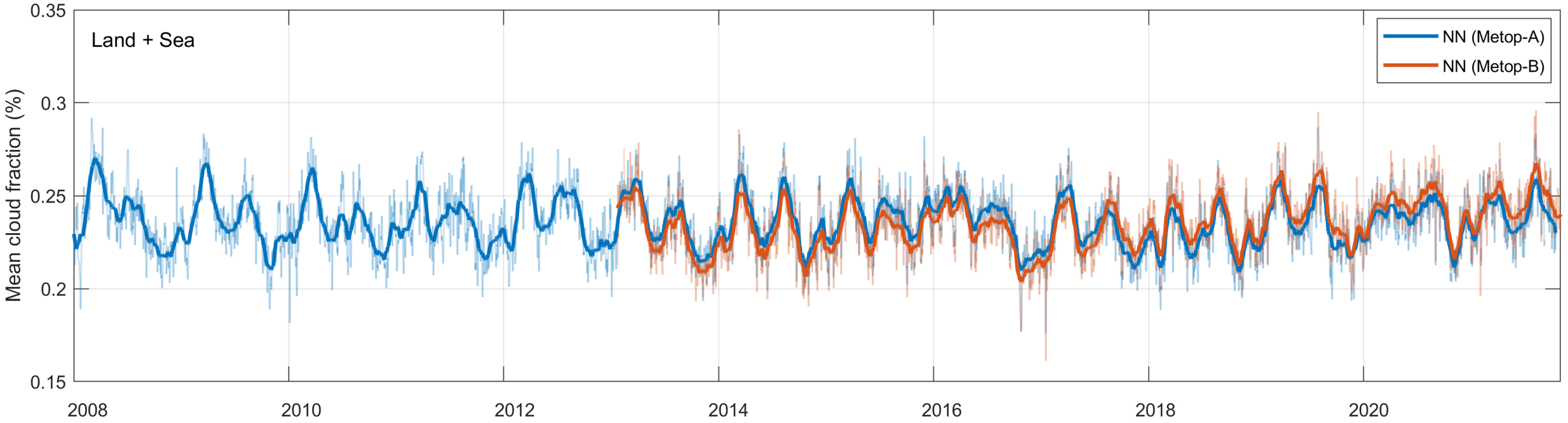
IASI L2 (2020)



Good correspondence between the IASI neural network and the IASI L2 cloud product:

- Identical mean cloud amount (76%)
- Correlation coefficient: 0.91
- Mean of the absolute difference: 5%

Fraction of IASI cloud free pixels



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Atmospheric Measurement Techniques Discussions

A CO_2-free cloud mask from IASI radiances for climate applications

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Abstract. With more than 15 years of continuous and consistent measurements, the Infrared Atmospheric Sounding Interferometer (IASI) radiance dataset is becoming a reference climate data record. To be exploited to its full potential, it requires a cloud filter that is both accurate, unbiased over the full IASI lifespan, and strict enough to be used in satellite data retrieval schemes. Here, we present a new cloud detection algorithm which combines (1) a high sensitivity, (2) a good consistency over the whole IASI time series and between the different copies of the instrument flying on board the suite of Metop satellites and (3) simplicity in its parametrization. The method is based on a supervised neural network (NN) and relies, as input parameters, on the IASI radiance measurements only. The robustness of the cloud mask over time is ensured in particular by avoiding the IASI channels that are influenced by CO_2, N_2O, CH_4, CFC-11 and CFC-12 absorption lines and those corresponding to the ν_2 H_2O absorption band. As a reference dataset for the training, the latest version of the operational IASI Level 2 (L2) cloud product is used. We provide different illustrations of the NN cloud product, including comparisons with other existing products. We find a very good agreement overall with the last version of the operational IASI L2 with an identical mean annual cloud amount and a pixel-by-pixel correspondence of about 87%. The comparison with the other cloud products shows a good correspondence in the main cloud regimes but with sometimes large differences in the mean cloud amount (up to 10%) due to the specificities of each of the different products. We also show the good capability of the NN product to differentiate clouds from dust plumes.

Integration in:

- the ANNI (Franco et al., 2018),
- the dust (Clarisse et al., 2019) and
- the spectrally resolved OLR (Whitburn et al., 2020)

IASI retrieval frameworks.

Cloud mask data available (soon) on https://iasi-ft.eu/