

# IASI cloud detection on the Antarctic plateau and comparison with ground-based interferometric measurements

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## Introduction

A comparison between the Infrared Atmospheric Sounding Interferometer (IASI) L2 cloud products and ground-based cloud products is performed. The IASI acquisitions are colocated (meaning that the ground site is included in the IASI FOV) with downwelling radiances measured by the Radiation Explorer in the Far Infrared-Prototype for Applications and Development (REFIR-PAD) interferometer, which is operating at the Concordia station (−75.10, 123.33), Dome-C, Antarctic Plateau. The ground-based products are obtained by processing the REFIR-PAD spectra with a **machine learning algorithm** named Cloud Identification and Classification (**CIC**), which is used to identify and classify scattering layers (including thin ice clouds and aerosols).

Cloud occurrence at Dome-C is studied based on both IASI L2 cloud products and CIC classifications of REFIR-PAD downwelling spectra. **Annual and monthly cloud statistics** (from 2012 to 2020), derived from the two sensors on the Dome-C area, are presented and discussed. Additionally, temporally colocated ground-based and satellite-based observations are used to produce one-to-one statistics and assess the agreement between the different classification techniques.

## Measurement Site

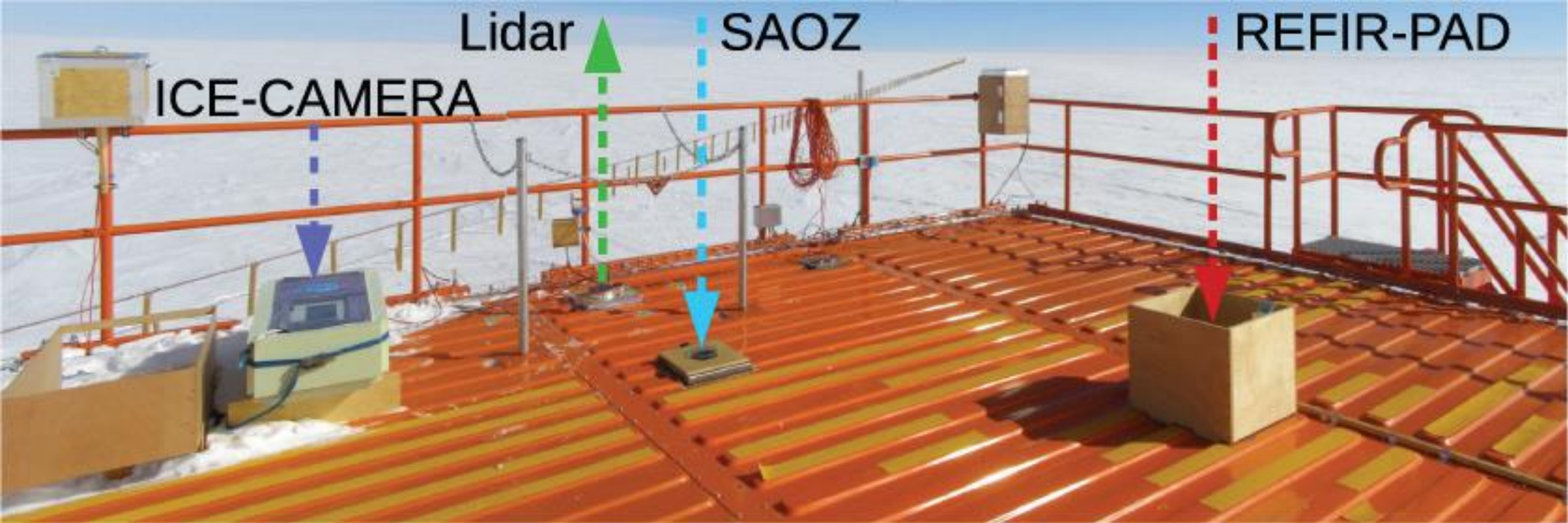


Figure 1. Physical shelter in Concordia station, Antarctica.

LiDAR		REFIR-PAD	
Parameter	Values	Parameter	Values
Channels	Backscatter and depolarization channels	Spectral bandwidth	100–1500 cm <sup>−1</sup> (100–6.7 μm)
Wavelength	532 nm (linear polarization)	Spectral resolution	0.4 cm <sup>−1</sup> (double-sided interferograms)
Measurement range	30–7000 m	Optical throughput	0.01 cm <sup>2</sup> sr
Vertical resolution	7.5 m	Line of sight	Zenith looking with a field of view of about 100 mrad
Line of sight	Zenith looking through a window all weather	Single-spectrum integration time	80 s
Telescope	10 cm diameter, f = 30 cm refractive optics	Measurement	~ 5.5 min (average of four observations), Repetition rate ~ 14 min (sequence duration)
Filter	0.15-nm interference filter	Measurement cycle	5-6 hours of measurements 1-3 hours of analysis
Laser	Quantel (Brio)	NESR	About 10 <sup>−3</sup> W/(m <sup>2</sup> sr cm <sup>−1</sup> ) at 400 cm <sup>−1</sup>

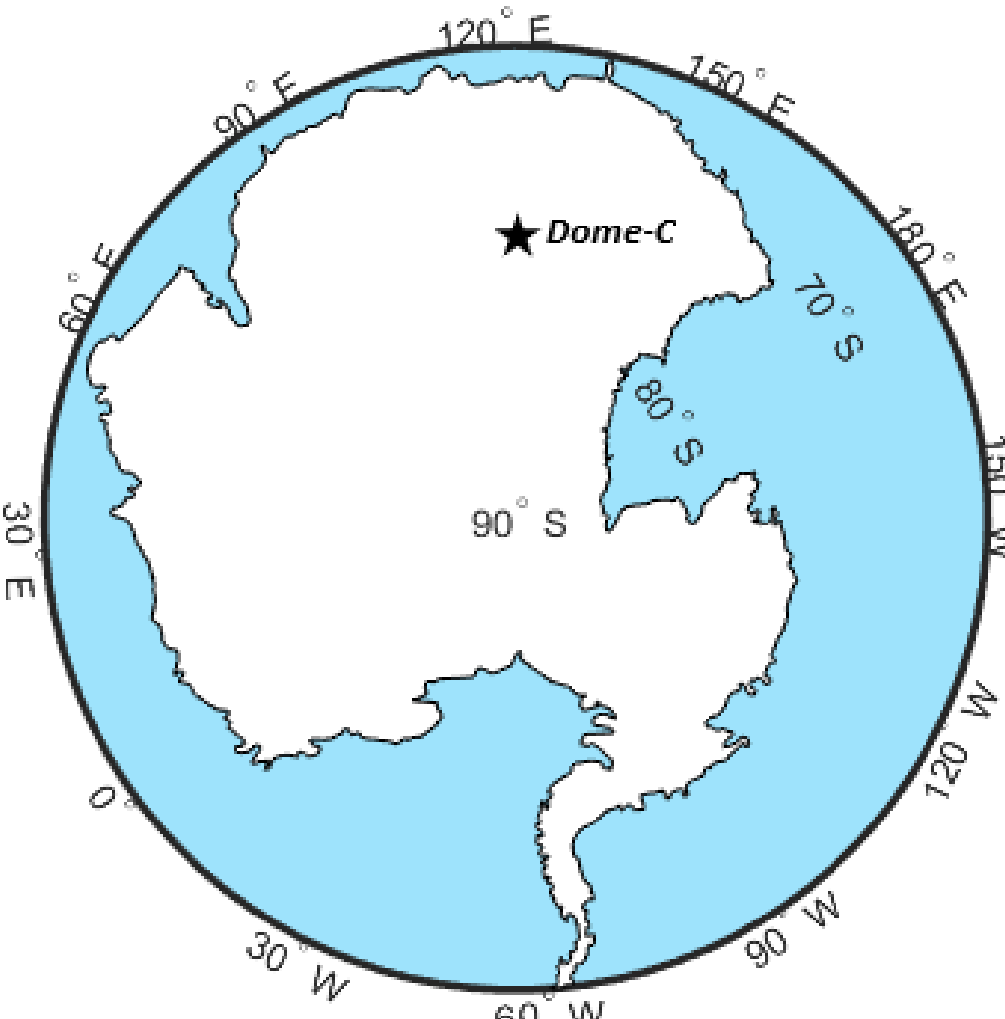


Figure 2. Geographical position of Concordia station.

## Cloud Identification and Classification Algorithm

CIC is a machine learning algorithm based on the **principal component analysis** (PCA) capable of classifying the scene as clear or cloudy, and to identify the cloud phase (Maestri et al., *Cloud identification and classification from high spectral resolution data in the far infrared and mid-infrared*, 2019). The version of the algorithm used in this study is described in Donat et al., *The Cloud Identification and Classification (CIC) algorithm for high spectral resolution observations in the far and mid-infrared part of the spectrum*, 2024. The algorithm generates extended datasets (ETS) by merging the “Training Set” (TS) with the observation. The PCA is used to evaluate the information content changes in the TS due to the addition of the analyzed spectra. A Similarity Index (SI) is defined for each ETS. These indices are then used in a decision tree to produce the scene classification.

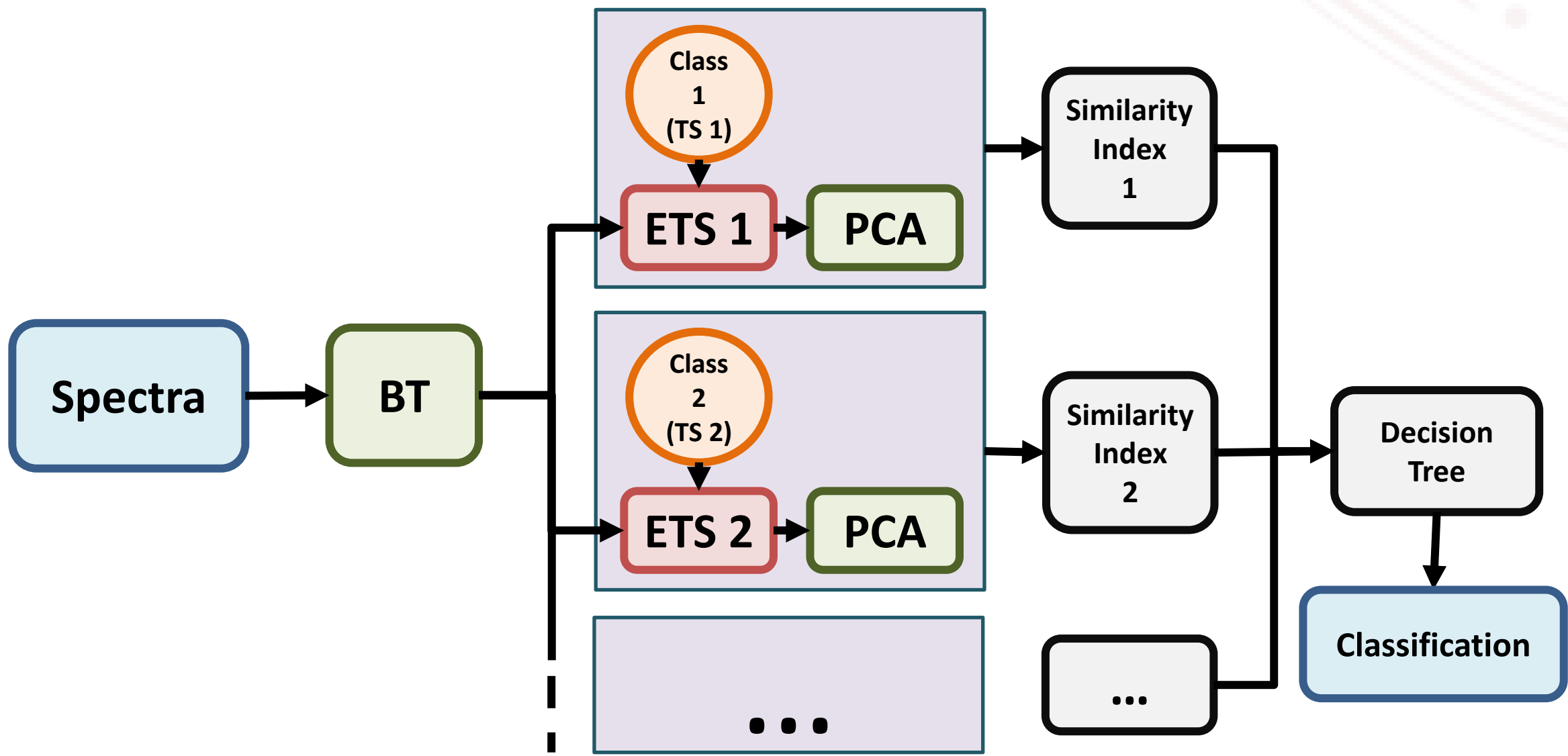


Figure 3. Schematic representation of the CIC algorithm.

For this study, a total number of 5 training and test sets are used. The scene truth is established by using the lidar information (Cossich et al., *Ice and mixed-phase cloud statistics on Antarctic Plateau, 2021*).

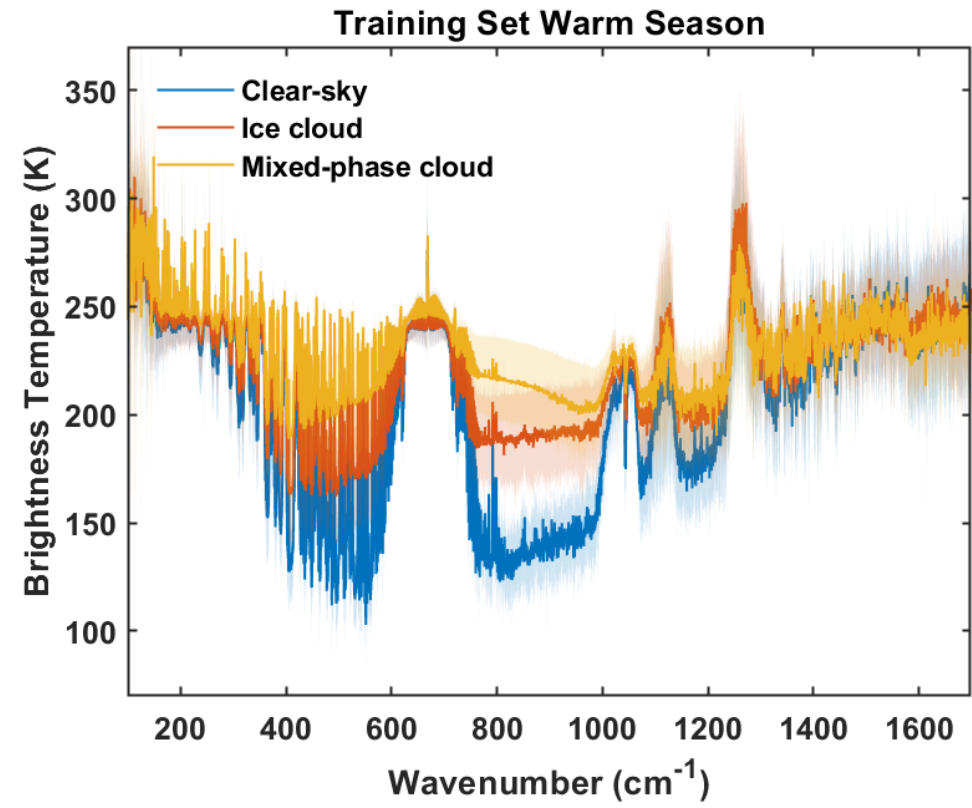


Figure 4. Mean radiance values for warm season training sets.

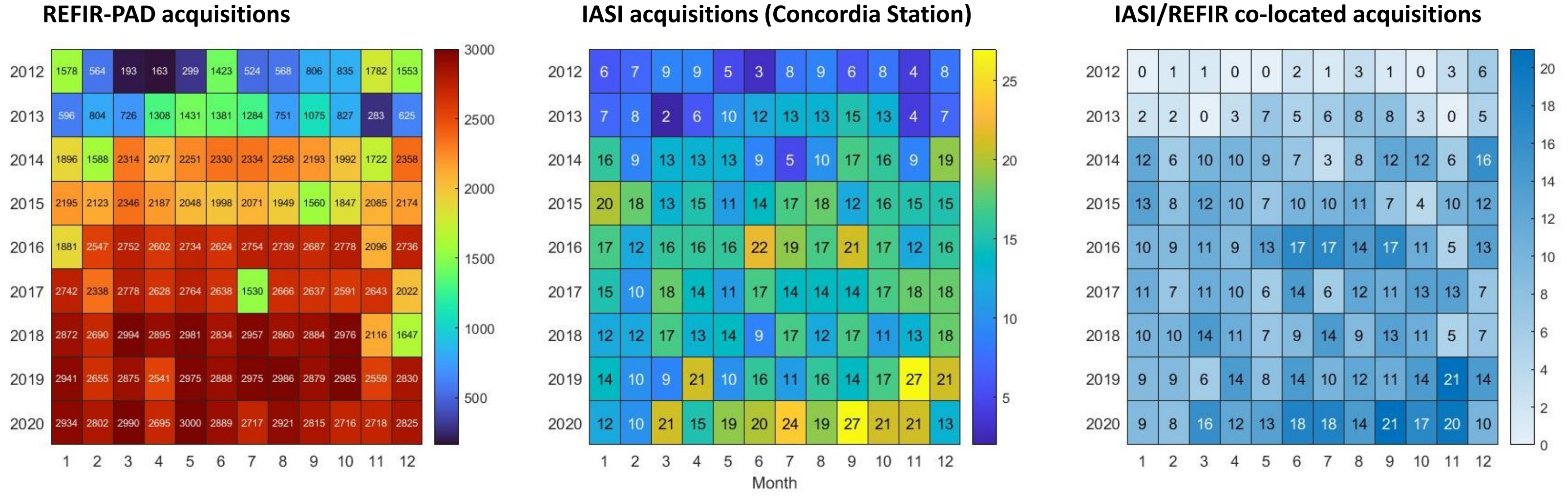
Class	N° Training Set	N° Test Set	Hit Rate
Warm Season Ice Cloud	70	130	0.977
Warm Season Mixed-phase Cloud	70	130	0.954
Warm Season Clear	70	130	0.977
Cold Season Ice Cloud	70	130	0.962
Cold Season Clear	70	130	0.992

## Conclusions

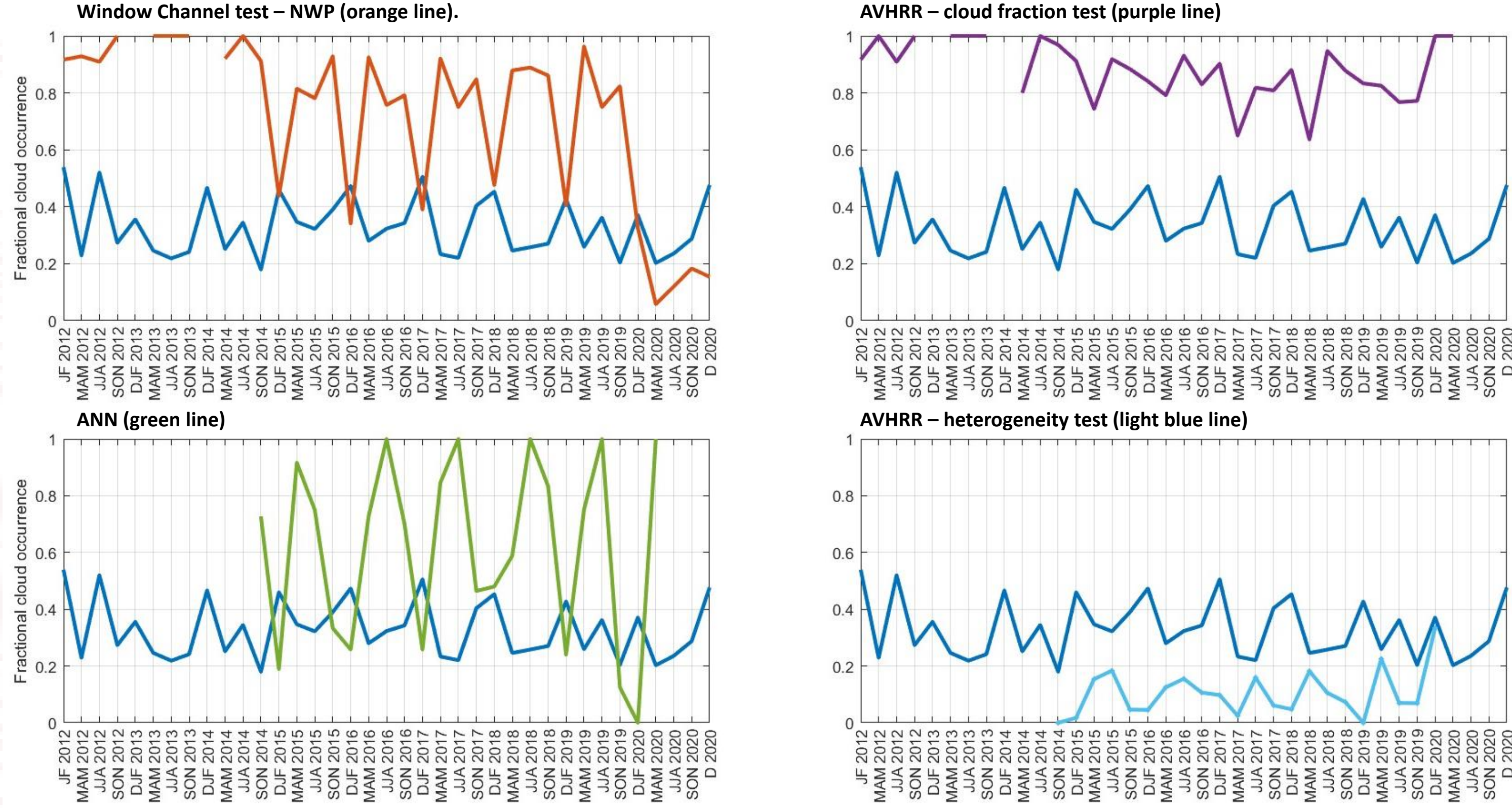
The study accounts for a long record of ground-based interferometric measurements to test IASI L2 cloud products in challenging observational conditions such as those encountered on the Antarctic Plateau. Results show that:

- the cloud occurrence time series derived from IASI-L2 tests (ANN and NWP) are in counterphase with respect to the REFIR-CIC ground-based statistics;
- a frequent anticorrelation behavior is present between spatio-temporally colocated satellite and ground-based products;
- among the IASI-L2 cloud tests and cloud products, the best agreement with ground-based cloud products is reached for the product *cloud phase*.

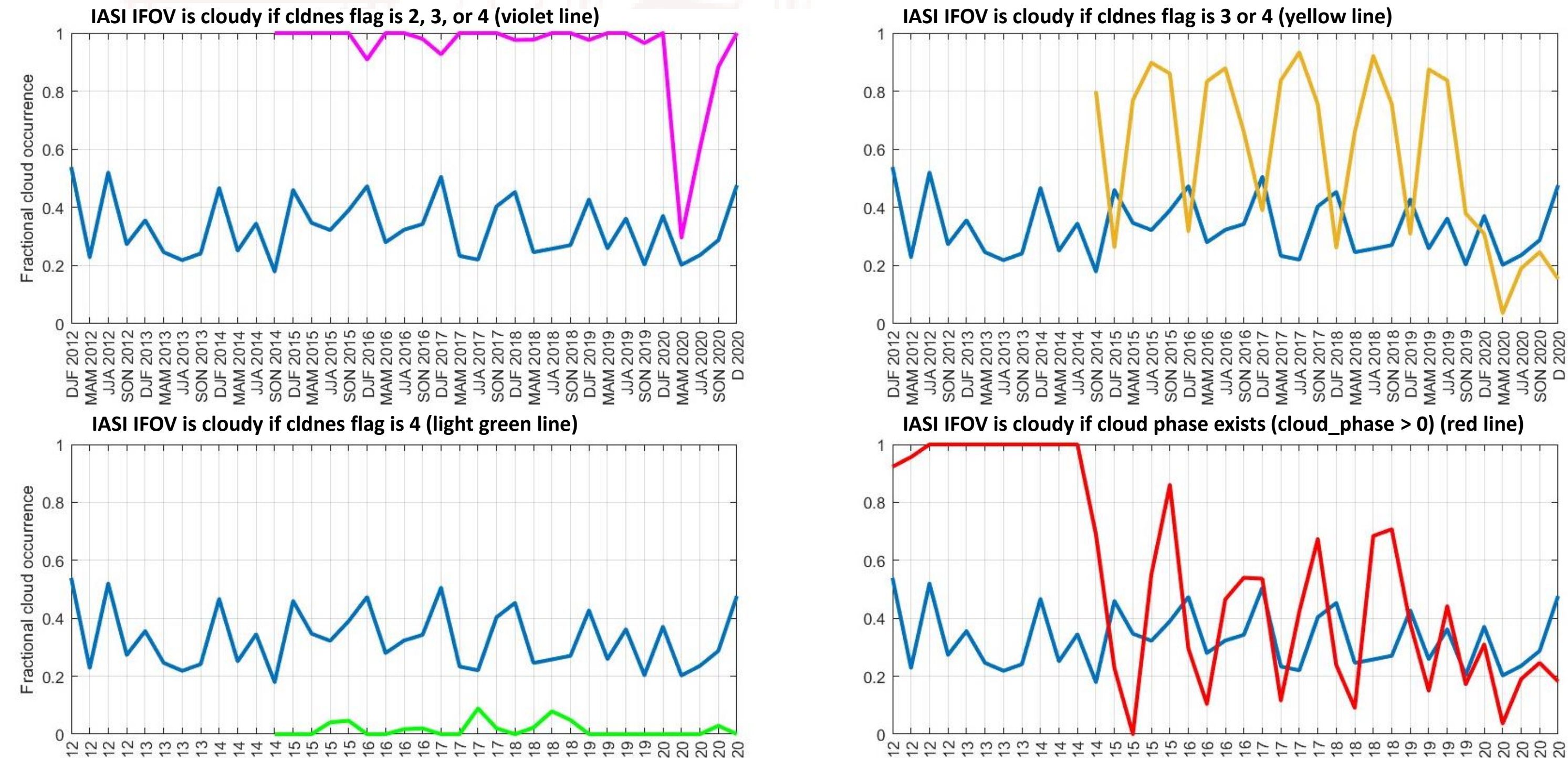
## Analysis and results



REFIR/CIC cloud occurrence statistics (blue) compared with IASI tests



REFIR/CIC cloud occurrence statistics (blue) compared with IASI products cldnes and cloud phase



The *cldnes* flag product is derived as a combination of the ANN, NWP and AVHRR tests with the retrieval products of cloud fraction and cloud top height. This flag indicates, depending on its value, a confident clear scenario (*cldnes* = 1), possible cloud contamination (*cldnes* = 2), partially cloudy (*cldnes* = 3), or high cloud coverage (*cldnes* = 4). The product *cloud phase* is derived from the cloud phase retrieval.

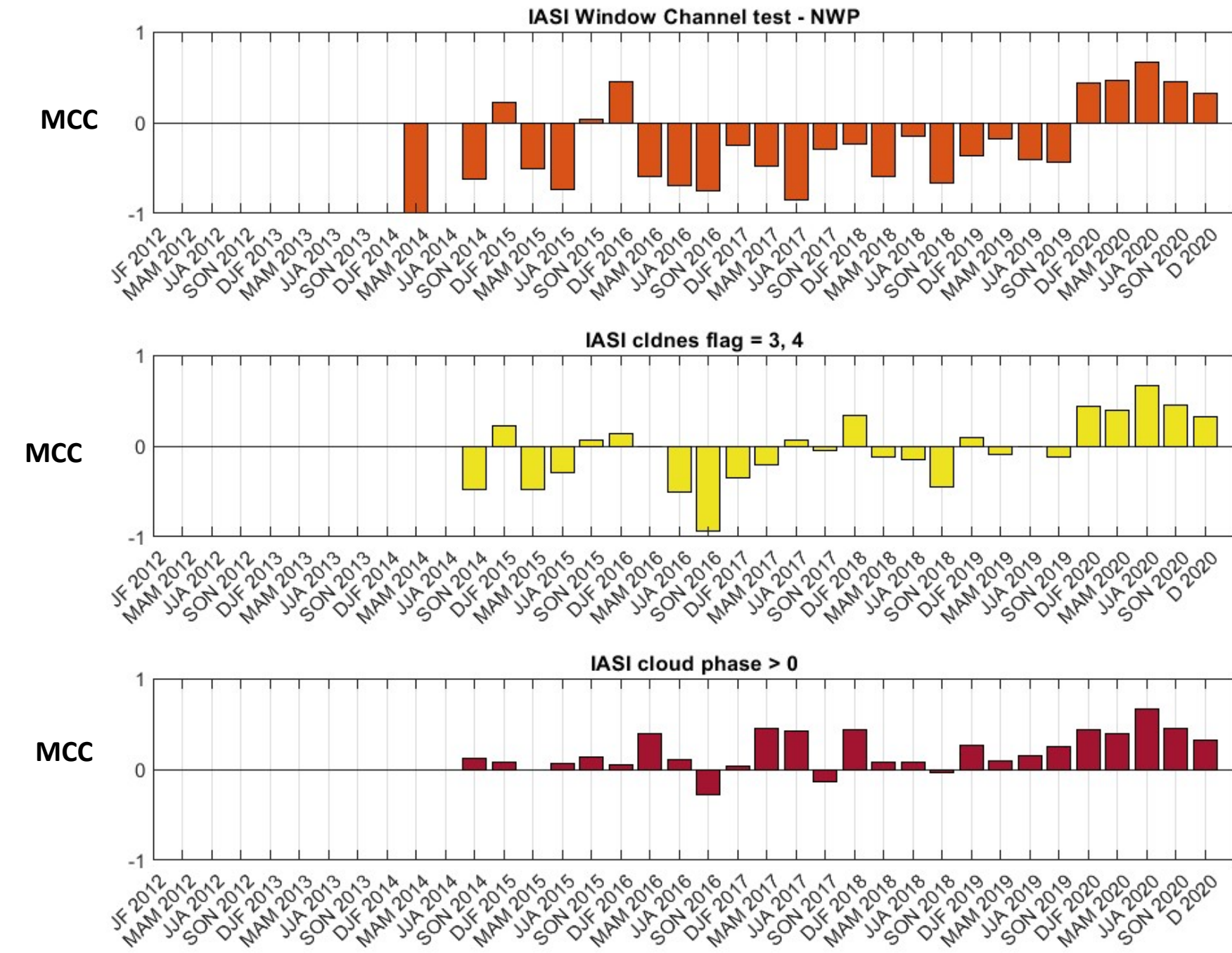
This information is retrieved from: “IASI Level 2: Product Guide, DocNo: EUM/OPS-EPS/MAN/04/0033, 11 July 2017”

“IASI Level 2: Product Generation Specification, DocNo: EPS.SYS.SPE.990013, 10 July 2017”

“IASI Level 2: Product Guide, DocNo: EUM/OPS-EPS/MAN/04/0033, 19 July 2012”

The IASI data were downloaded from the Eumetsat collection EO:EUM:DAT:METOP:IASI:ND02 in netCDF4\_satellite format using the application *eumdac*.

Matthew Correlation Coefficient (MCC) between spatio-temporally colocated IASI L2 and REFIR/CIC products



- If MCC > 0 positive correlation between ground-based and satellite products is found
- If MCC < 0 negative correlation between ground-based and satellite products is found
- MCC = 1 implies perfect agreement
- Although the FOVs of the two classifiers is different, they should show a positive correlation