A global Cloud detection scheme for high spectral resolution instrument

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Purpose and methodology

➔ ECMWF 2004 workshop on 'Assimilation of high spectral resolution sounders in NWP :

Recommendations on cloud detection for IASI level 1c processing at NWP centres:

- need of a day-1 significant reduction of data
- intelligent NWP-independent cloud detection
- need of a robust and efficient clear detection scheme for short-term clear radiances assimilation

➔ Previous studies (see Dahoui and al, ITSC13) indicate that 'traditional cloud detection methods' are

- efficient on most clouds with large radiative effects on observation
- show poor sensitivity to clouds near surface and for fractional clouds

➔ Study of two methods :

1. Spectral signatures of clouds through PCAs
2. AVHRR cloud analysis in IASI fov

PCA-based cloud detection

Multiple thresholds cloud detection independent of NWP using cloud-signature eigenvectors

Training dataset:

- clear profiles: determine clear-air PCs
- cloudy profiles:
  - compute 'clear-air' component of observations using the clear-air PCs
  - remove 'clear-air' component from observations
  - determine cloud-signature PCs on residuals
- Determine thresholds on cloudy scores (20 thresholds for 10 cloudy PCs)

Test dataset:

- Compute the cloudy PCs scores for each observation
- Situation is cloudy if one score outside thresholds

PCA-based cloud detection: Data set

Method tested on AIRS:

- Area : North East Atlantic
- Period : 15 to 27 April 2004 -> 46 granules
  - 15 -> 21 April used as training period (granules:12 night, 9 day)
  - 22 ->27 April used as test period (granules:13 night, 12 day)
- Sea situations, day and night
- AIRS full spectrum
- MODIS MF/CMS cloud mask mapped on AIRS fov
  - number of cloud layers
  - For each layer: cloud type, coverage and top temperature

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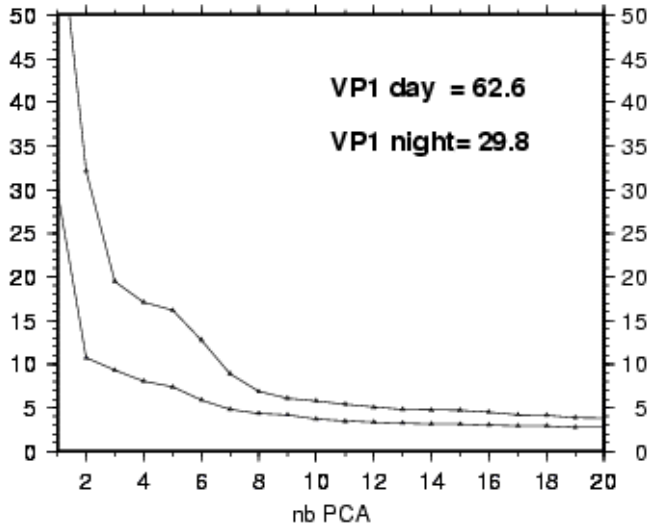
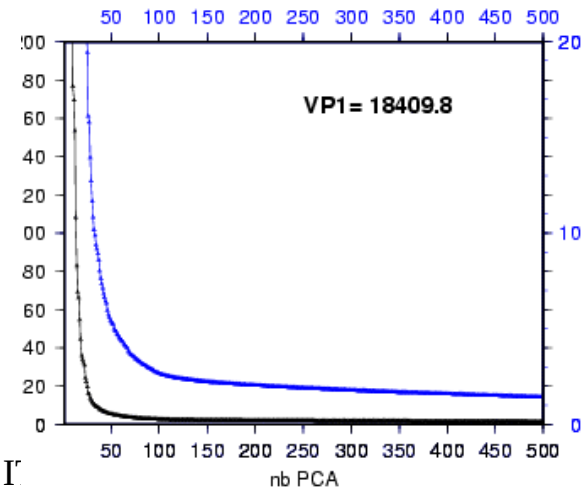
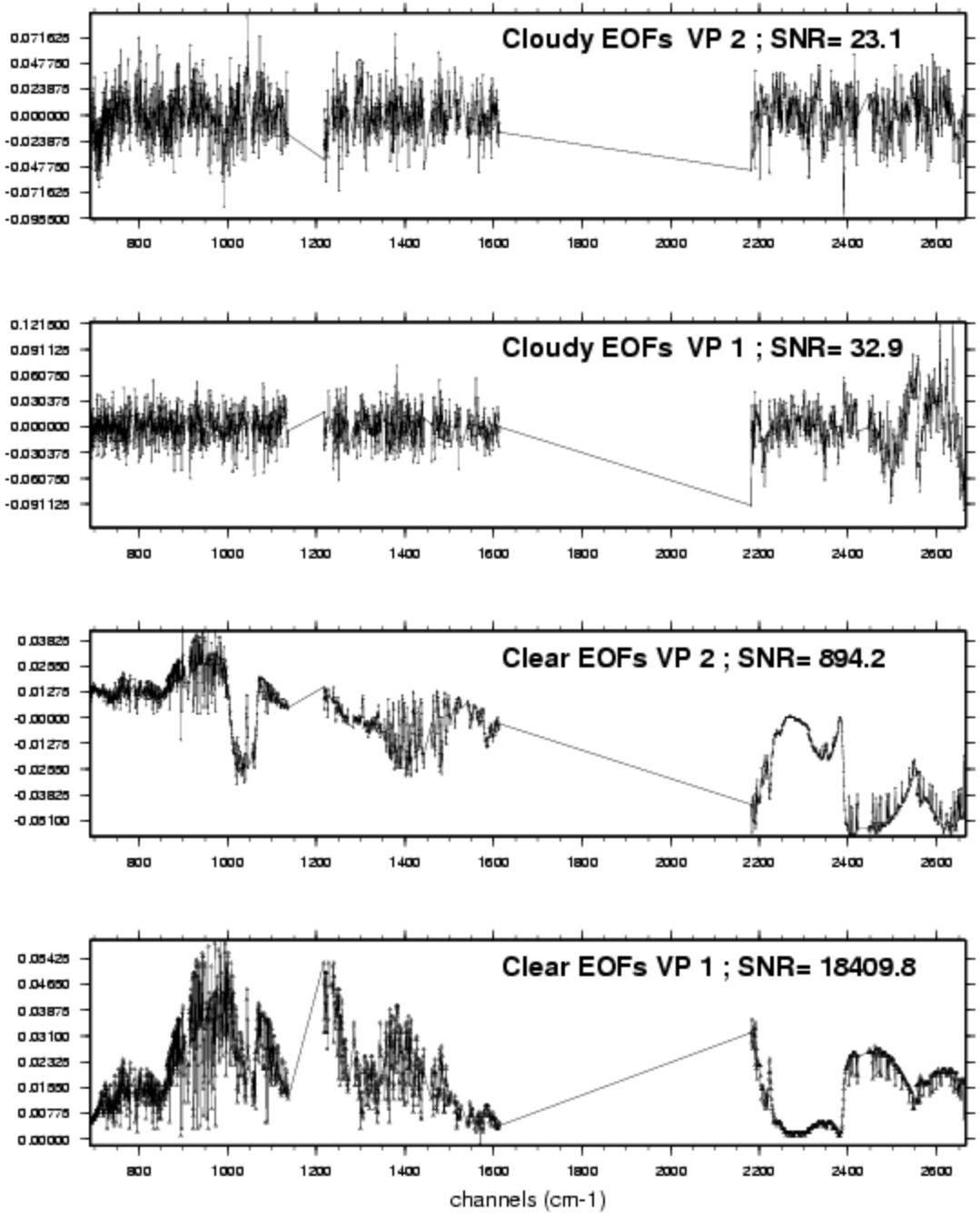
EOFs structures

Cloudy Eigenvectors



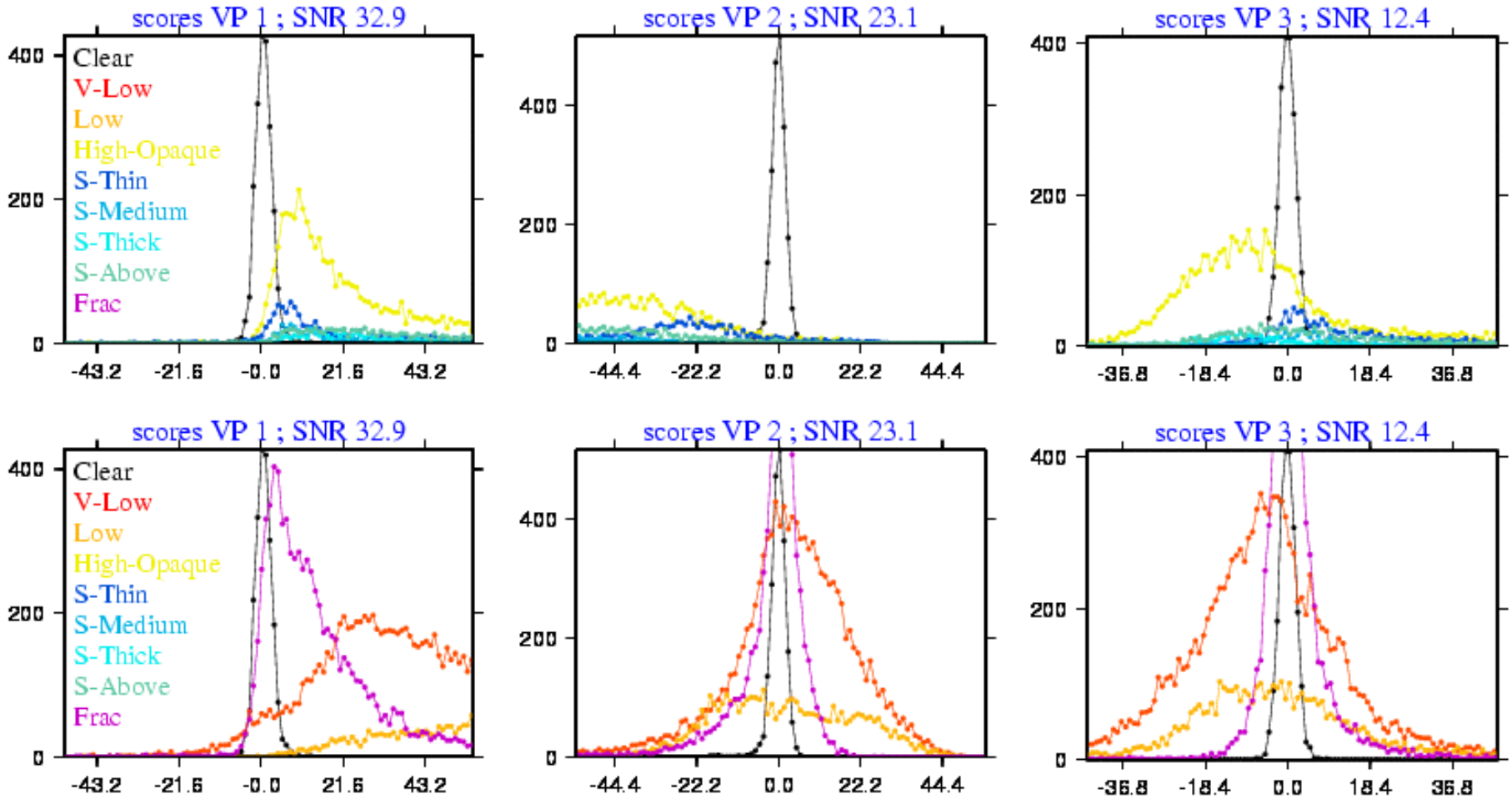
Clear Eigenvectors





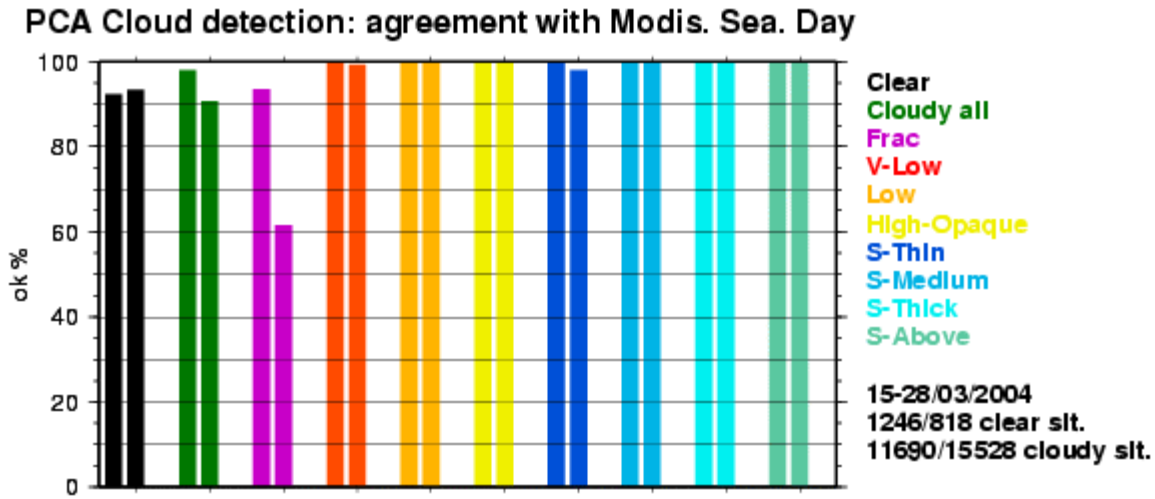
PCA-based Cloud detection: scores distribution

Thresholds: both feet of each clear histogram of training set values slightly relaxed for test set

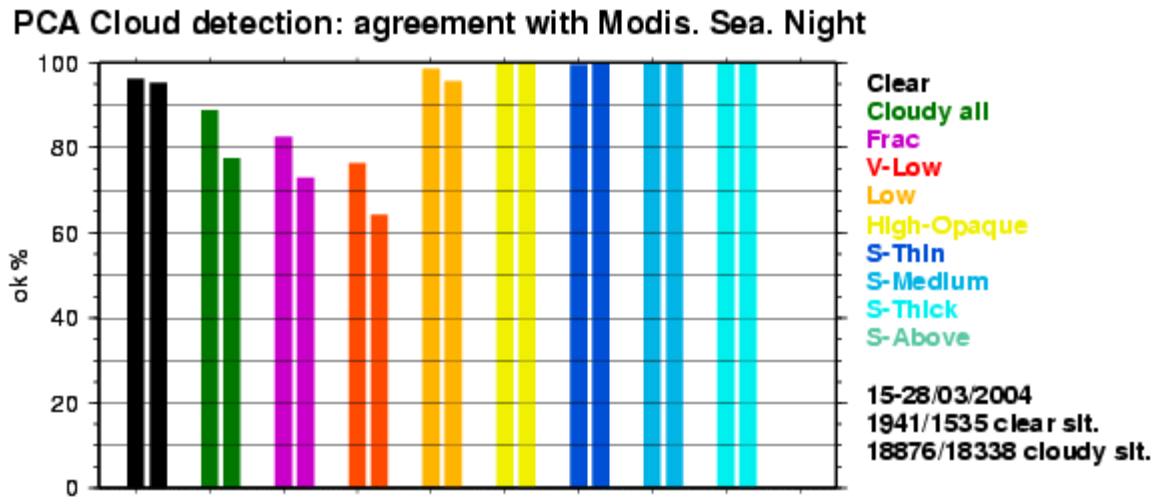


PCA-based Cloud detection: Validation

Day Sea



Night Sea



Left bar= training set

Right bar= test data set

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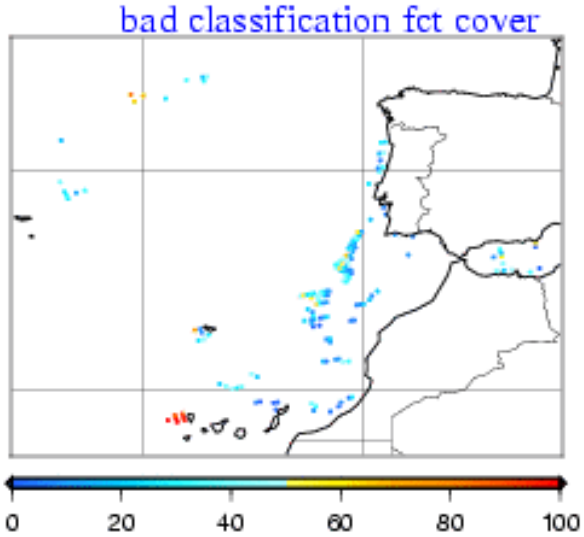
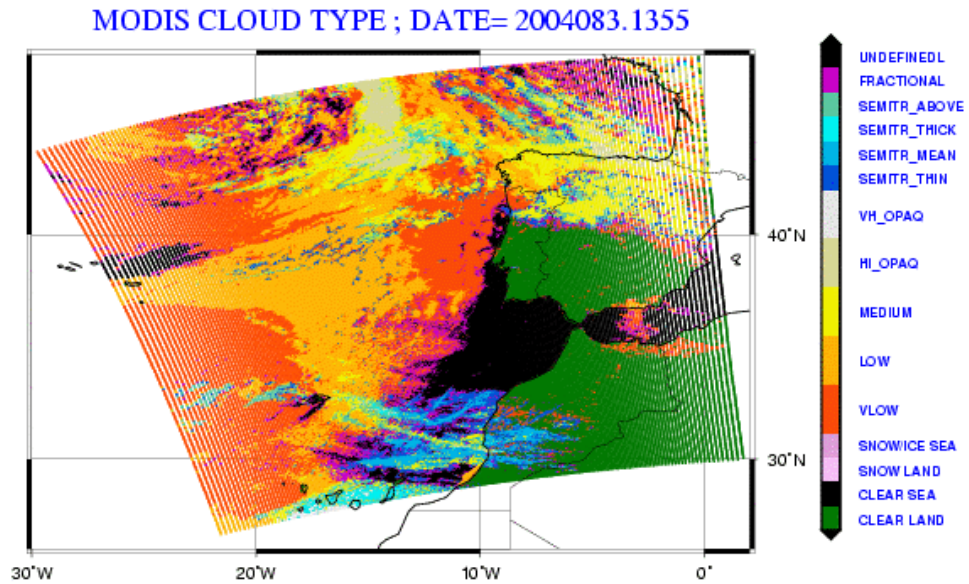
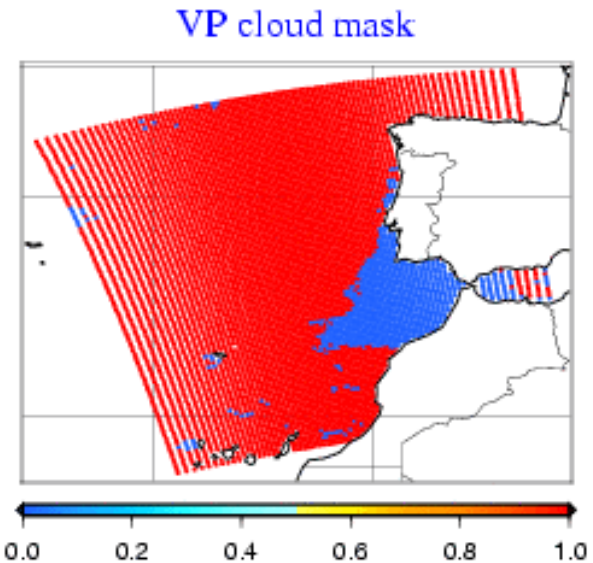
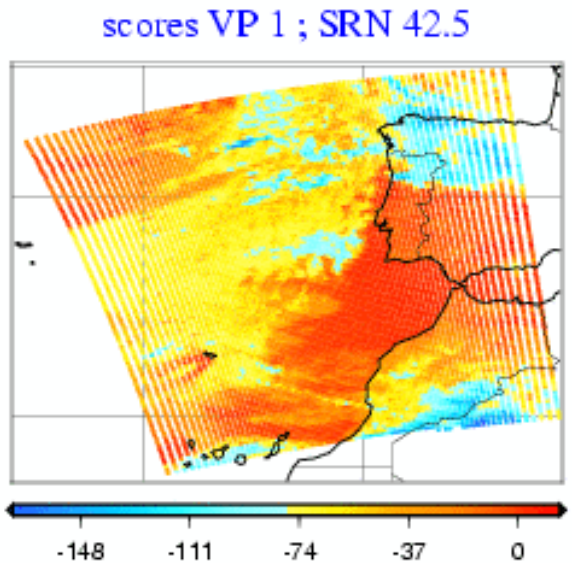
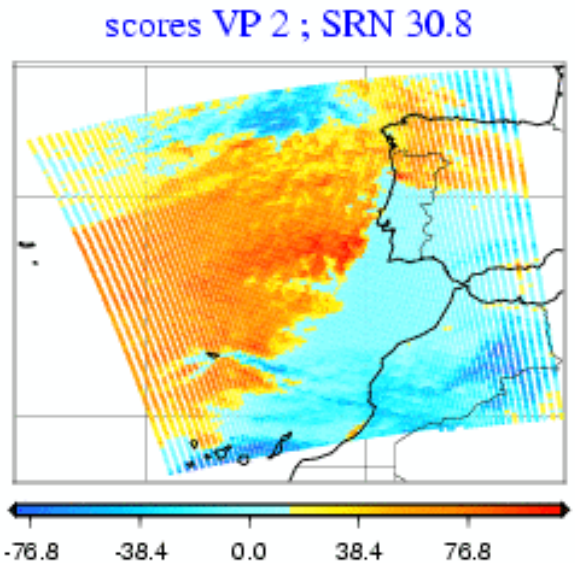
PCA cloud detection: Example 23/04/2003-13h55





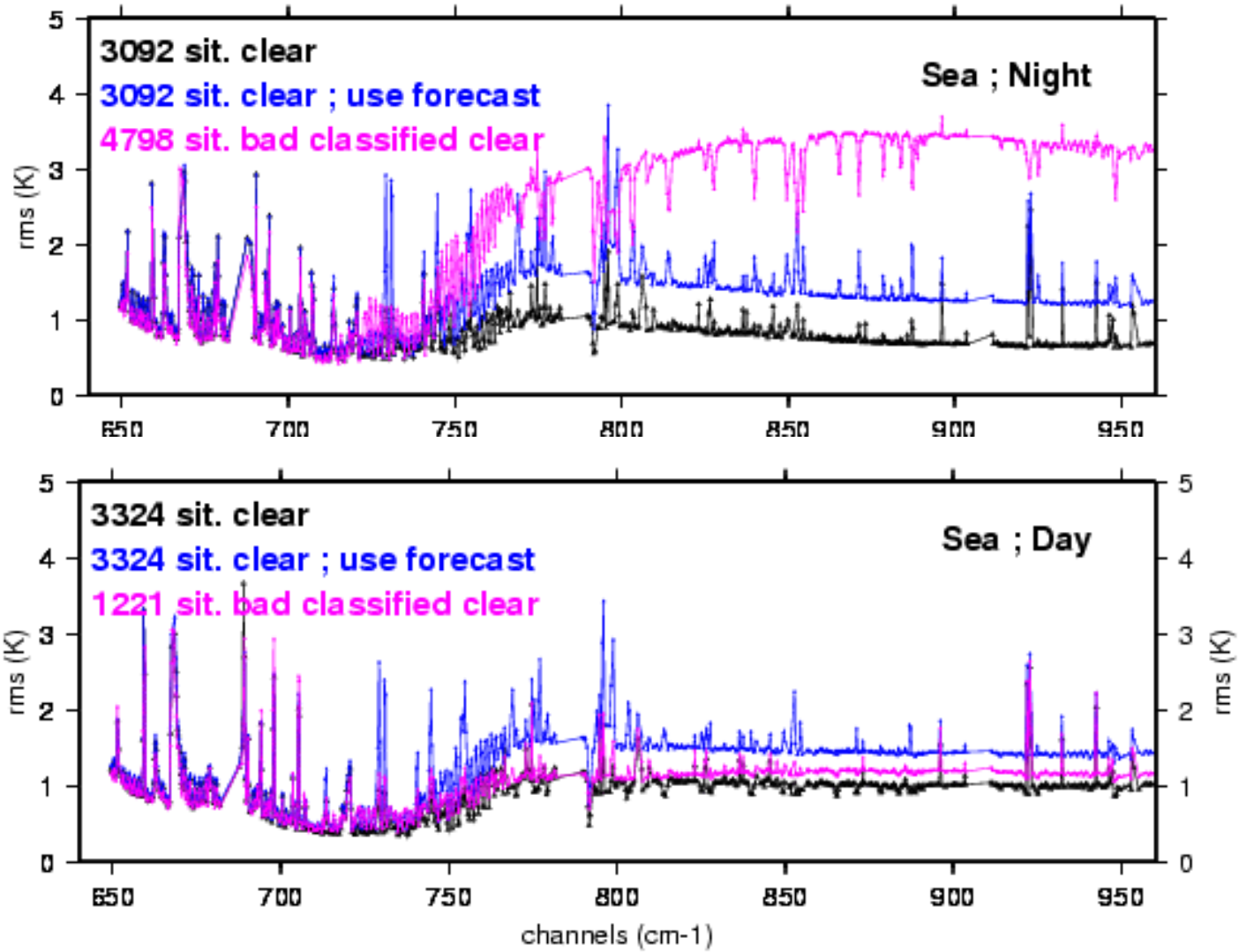






PCA-based cloud detection: Radiances residuals

training set



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PCA-based cloud detection: preliminary conclusions

1. Preliminary conclusions:
   - General good agreement with MODIS cloud mask
   - Low sensitivity to noise through use of PCs > 1
   - Better results for day than for night situations (near-infrared sunlight information)
   - Very efficient for semi-transparent clouds
   - Some indication that the thresholds are dependent on environmental conditions

2. Short-term perspectives:
   - Thresholds determination through a multiple dimension optimiser (ex: Simplex) or penality function
   - Determine cloudy PCs specific to low level clouds
   - Test the method over land

IASI L1c radiance analysis

Description of AVHRR radiance spatial distribution into the IASI fov in terms of clusters.

CNES software implemented in the OPS package

Day-1 IASI L1c product:

- Number of classes actually present in IASI fov (up to 7)
- For each class:
  - Fraction of IASI fov covered
  - Mean value of AVHRR channels
  - Standard deviation of the data -> provides information about compactness of the cluster

Information should be available on GTS, EUMETCast in BUFR

IASI L1c radiance analysis based cloud mask

MF/CMS AVHRR full resolution cloud mask:

Thresholds tests series of channels combinations to each pixel

Uses local variances to determine fractional /thin semi-transparent

IASI L1c radiance analysis cloud mask

Uses an adaptation of the AVHRR cloud mask

No local variances available: adds additional tests on radiances differences between clusters

NWP dependency:

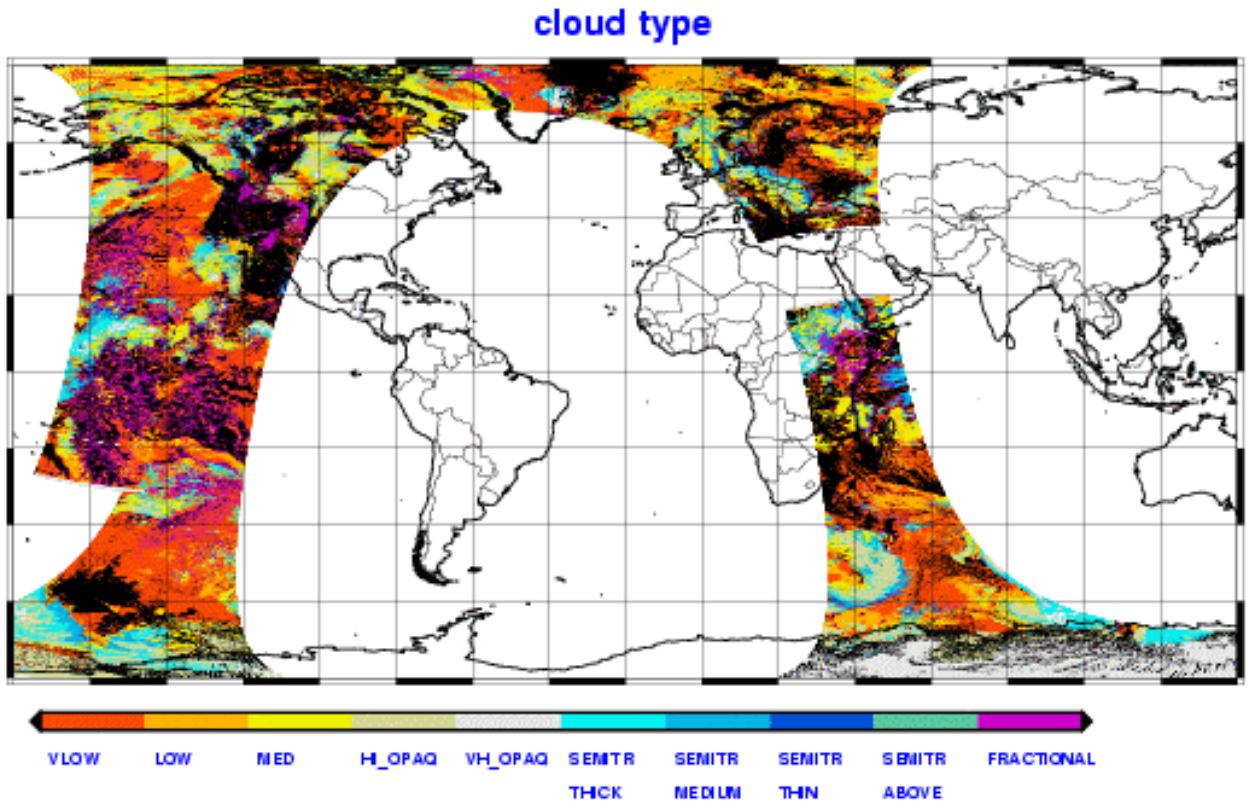
Sea: TWVC from NWP or collocated AMSU

Land: T2m and TWVC from NWP

IASI L1c radiance analysis cloud mask: dataset

EUMETSAT pre-launch test global orbit

Generated from Noaa17 full AVHRR acquisition



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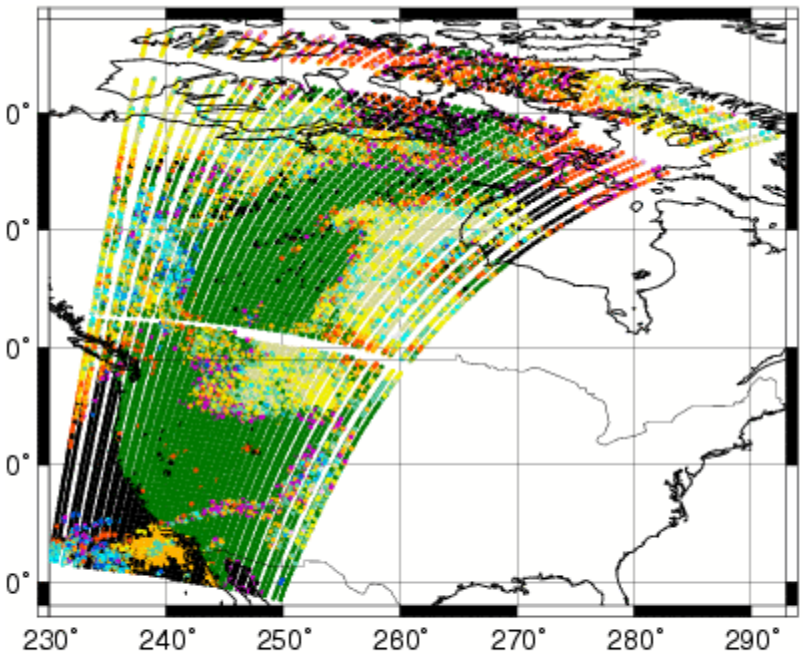
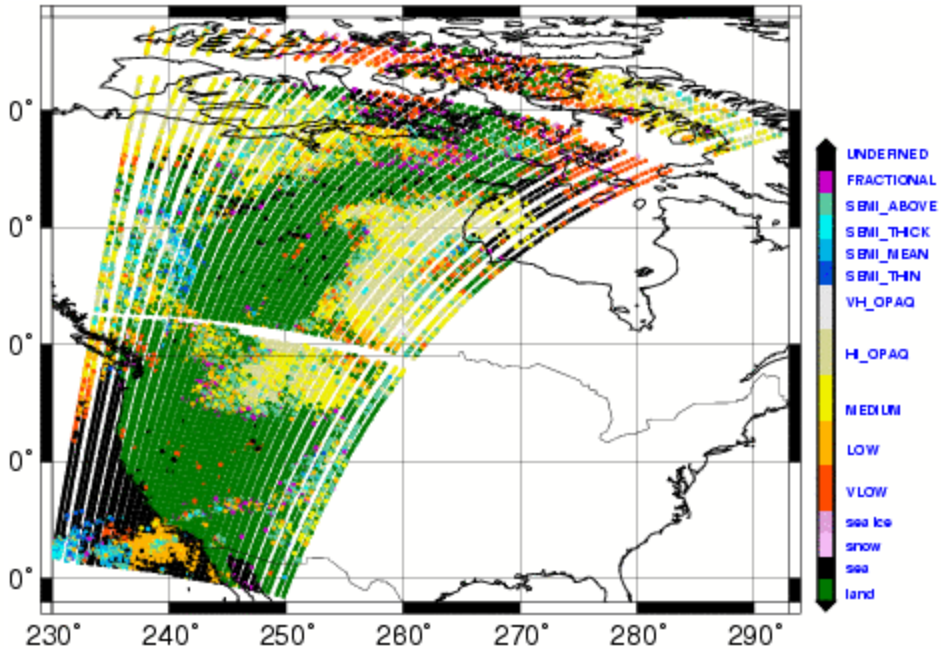
IASI L1c radiance analysis cloud mask

Day-land part of orbit

AVHRR full resolution cloud mask



Cloud mask from IASI l1c radiance analysis



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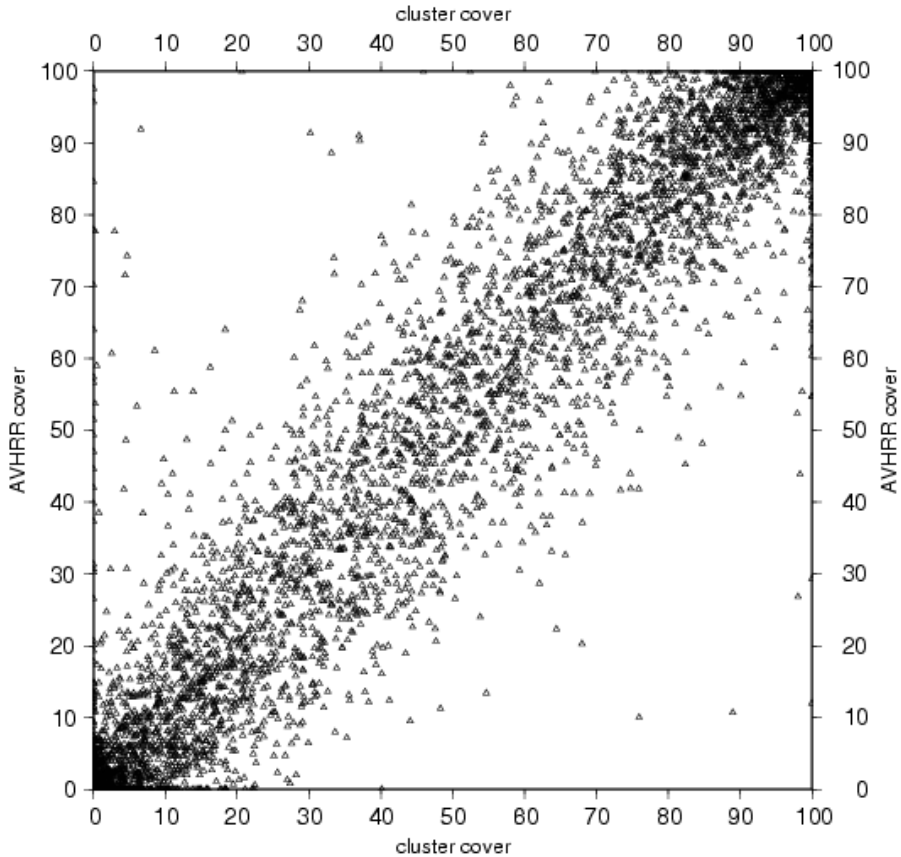
IASI L1c radiance analysis: Clustering impact

Cloud cover comparison

Sea, night situations



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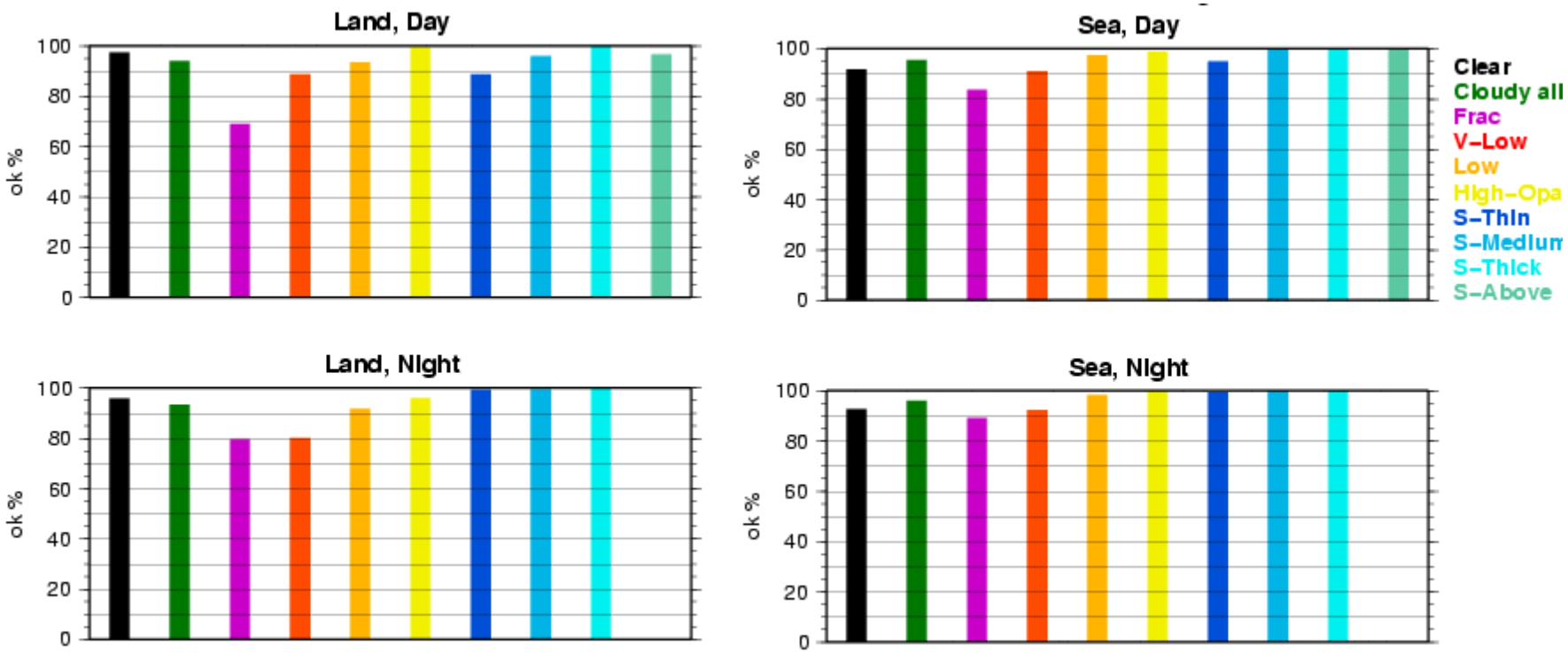
IASI L1c radiance analysis cloud mask: Validation

Agreement with AVHRR full resolution mask



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IASI L1c radiance analysis cloud mask

1. Conclusions:
   - Good agreement with AVHRR cloud mask at full resolution
   - Allows to discriminate between completly and partially covered situations
   - Allows to provide a cloud type
   - Some weakness for detecting fractional clouds
2. Short-term perspectives:
   - Improvement of the fractional clouds detection through the use of the clusters standard deviation

IASI global cloud detection scheme: recommendations

PCA-based cloud detection:

- Good solution for a rapid pre-selection of data
- NWP-independent method
- Could be implemented in a IASI day-2 EUMETSAT CGS pre-processing
- Day-2 level1c product could include:

  cloud-signature scores or PCA-based clear/cloudy flag

Radiance analysis based cloud mask:

- Good solution to take advantage of imager information for a global very fast processing
- Access to cloud cover information.
- Uses some NWP data (mainly over land)
- Could be implemented in the NWP assimilation process in connection with other methods (ex: ECMWF clear channels selection, CO_2-slicing)