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Using AVHRR radiances analysis for retrieving atmospheric profiles with IASI in cloudy conditions

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Experimental production at CMS of near-real time atmospheric profile retrievals from local HRPT METOP IASI/AMSU/MHS acquisitions

Purpose:

- to evaluate their potential benefit for the monitoring and short-range forecast of inverse profiles available before the NWP analysis
  mainly in the context of meaningful meteorological phenomena (ex precursors of strong storms or convective systems)
- To get some elements in the choices of the future sounder IRS over MTG, from NowCasters learning on real cases

HRPT broken: use of global data over Europe until further notice

Retrieval software

Input data:

- IASI + coregistered AMSU/MHS over Europe
- PFS (HRPT) or BUFR (EUMETCast) formats
- All IASI ifovs

Cloud detection/channels selection:

- AVHRR thresholds cloud classification applied on L1c-IASI AVHRR clusters
- ECMWF channels selection using cloudy radiances (opaque clouds) or clear radiances (other situations)

1DVar Levenberg-Marquardt minimization:

- Guess: ECMWF 12 hour forecast

L1c-IASI AVHRR clusters

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

- Number of classes actually present in IASI fov (up to 7)
- For each class:
  - -Fraction of IASI fov covered
  - -Mean value of the 5 AVHRR channels
  - -Standard deviation of the data -> information about compactness of the cluster

Clusters can benefit to global processing:

- -one file only to read
- -no need of full AVHRR coregistration inside IASI fov
- -cloud mask : hyper-fast process

'Geophysical' clusters allow to :

- -determine the heterogeneous degree of the IASI ifov
- -select clear situations
- -simulate cloudy radiances for multi opaque cloud layers
- -apply cloud-clearing for partly-cloudy situations using cluster cover
- -apply co2-slicing on IASI channels for homogeneous semi-transparent situations

Cloud Mask

- Adaptation of the operational METOP/AVHRR full resolution CMS MAIA cloud mask
  - -thresholding technique applied on each AVHRR cluster to single channels and various combination of channels differences,
  - -dynamic thresholds depending on background and viewing geometry
  - -no local texture available: additional test using RTTOV

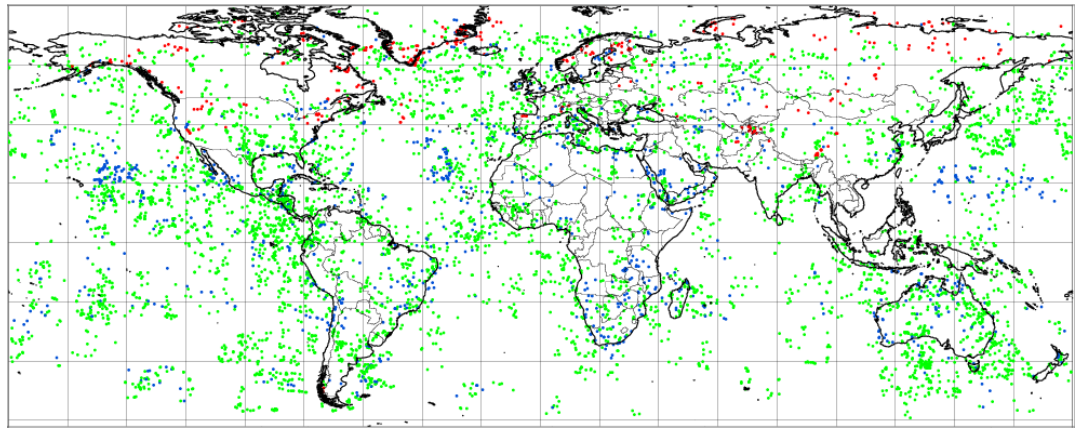
- Outputs : % clear in IASI fov

- for each cluster:
  - -Surface type + solar conditions (day/night/glint/twilight)
  - -Cluster coverage
  - -Clear/cloudy/snow/sea-ice flag
  - -Cloud Type: 5 opaque cloud, 3 semi-transparent, 1 class of semi-transparent clouds above lower clouds, 1 fractional clouds class
  - -Cloud top pressure/temperature for classes identified as opaque clouds
  - -Surface temperature from split-window for classes identified as clear

METOP/AVHRR full resolution cloud mask validation

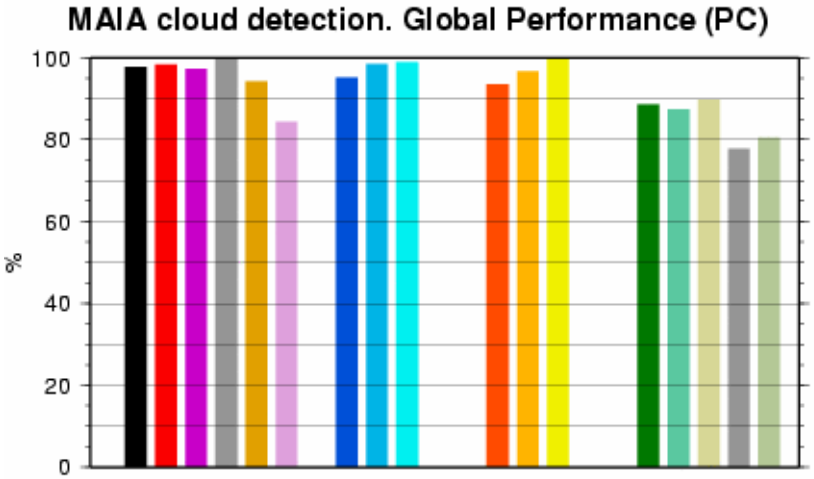
More than 7200 sea+ land world-wide METOP/AVHRR targets collected with manual identification of cloud type by nephanalyst.

Statistical scores:PC=$(n_a+n_d)/(n_a+n_b+n_c+n_d)$



Cloudy
Clear
Sea-ice

	Cloud detected	Clear detected
Cloud observed	n_a	n_b
Clear observed	n_c	n_d

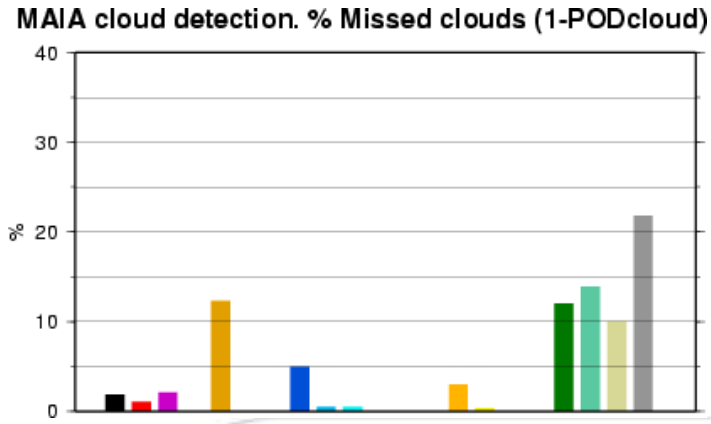


Sea all : 4354
Sea day : 2661
Sea night : 1297
Sea twilight : 51
Glint : 359
Sea Ice : 72

Sea day North Lat : 273
Sea day Mid Lat : 1364
Sea day low Lat : 1035

Sea Night North Lat : 93
Sea Night Mid lat : 863
Sea Night Low Lat : 336

Land all : 2277
Land day : 1343
Land Night : 745
Land Twilight : 70
Snow : 185



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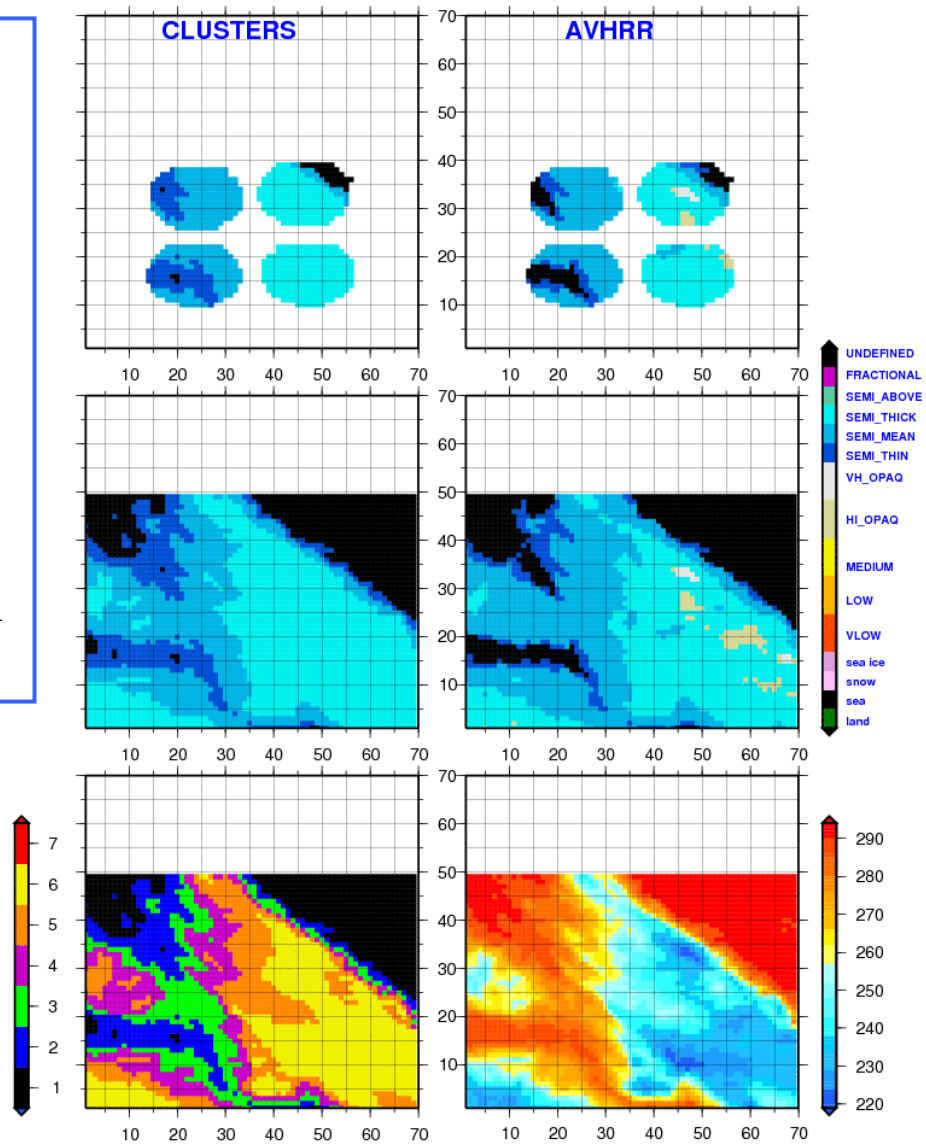
Clusters validation (1)

comparaison of cloud masks using full-resolution AVHRR data and using OPS clusters

study part of the IASI calval level1.
done on one global orbit. CNES test case

Full–resolution AVHRR mask:

- no local texture used
- coregistered in IASI fov
- all pixels with same cloud type agregated to the same layer



Lower left: IASI l1c AVHRR radiance classification projected on AVHRR image
Lower right: mapped full AVHRR Tb4
Middle left: cloud mask from clusters
Middle right: mapped full AVHRR cloud mask
Upper left: 'clusters' cloud mask in IASI IPFS
Upper right: full AVHRR cloud mask in IASI

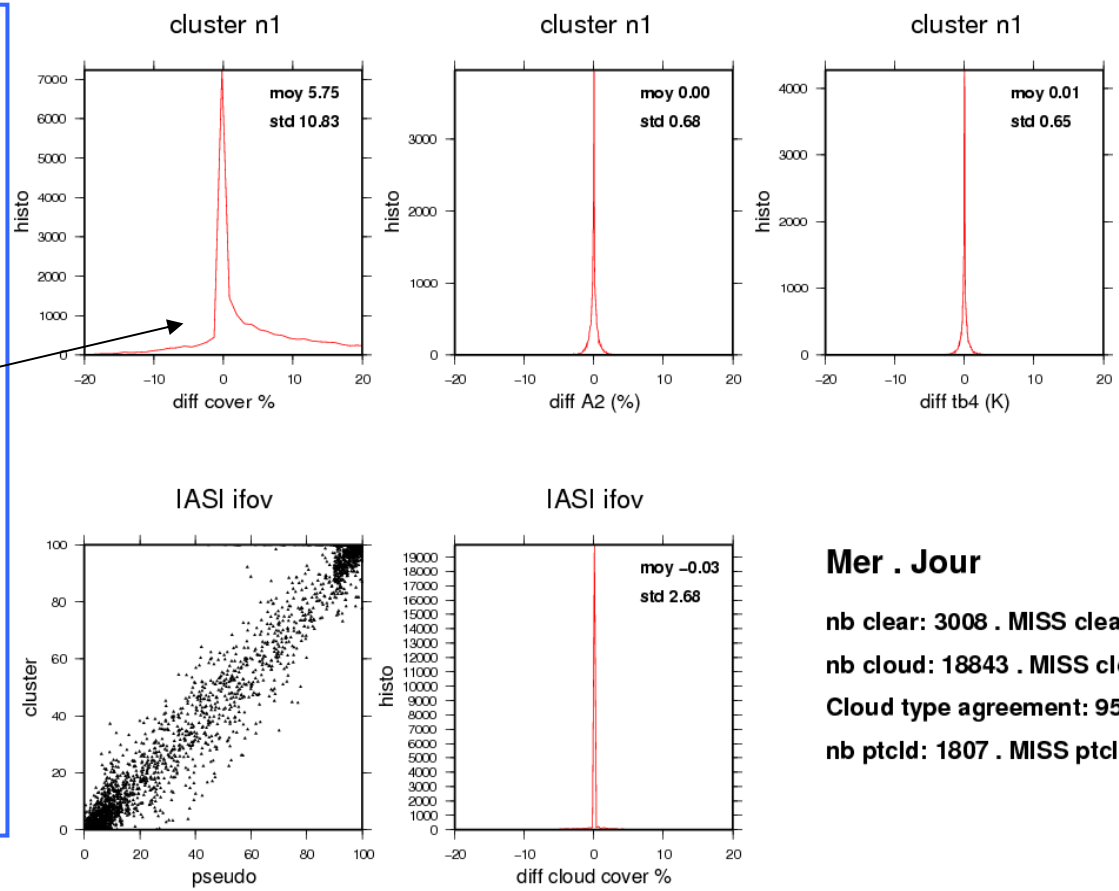
Clusters validation (2)

Upper figures: main layer in terms of coverage in IASI fov
Lower figures: all layers together

Cluster cloud mask less cloudy than full AVHRR mask (positive wing)

Dispersion of the cover for each cluster individually

Missed few completely clear/ overcast situations.



Mer . Jour

nb clear: 3008 . MISS clear: 1.03%

nb cloud: 18843 . MISS cloud: 0.21%

Cloud type agreement: 95.16%

nb ptcld: 1807 . MISS ptcld: 8.85%

Clusters validation (3)

Conclusion:

Correct positionning of the clusters

Radiometry of clusters statically in good agreement with classes from full AVHRR

Enough clusters to describe the complexity of the situations -> clusters often with the same cloud type after applying the cloud mask.

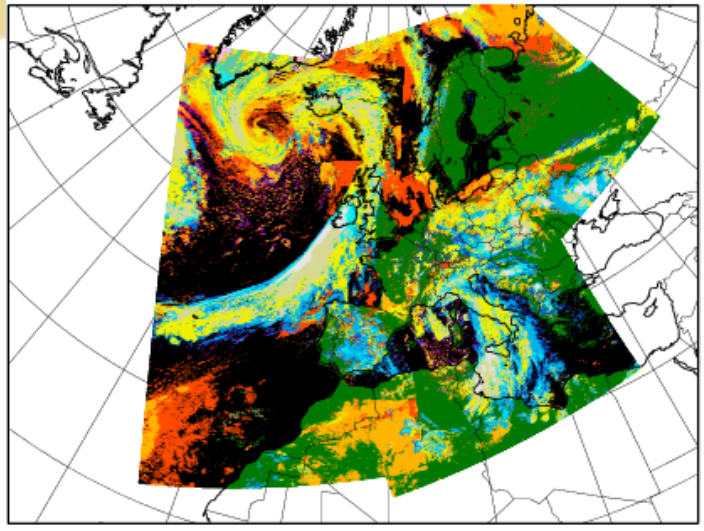
Clusters cloud mask slightly reduced the complexity of the situation

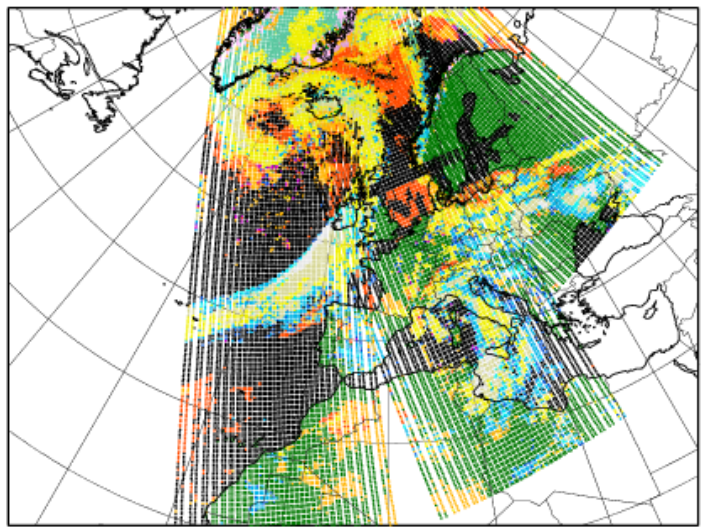
Slightly less cloudy compared to the full AVHRR mask but seems precise enough for the selection of clear situations

Cover variability quite large for partly-cloudy situations

20070602_21 ; 183951-215607 ; METOP02

AVHRR cloud mask





Clusters cloud classification

IASI monitoring at CMS (1)

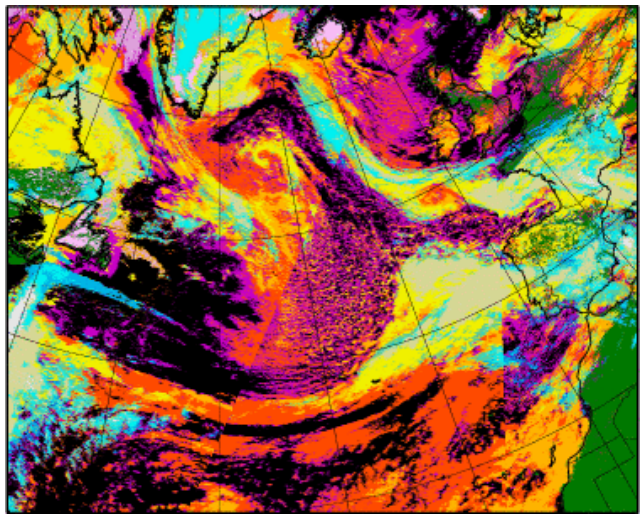
- Mean/SD of O-B spectra:
  - EUMETCast granules over Europe:
    - MAIA cloud classification on L1c-IASI AVHRR clusters
    - Add RTTOV + Bg Ts in MAIA to improve the cloud detection near the surface
    - 314 channels
  - ECMWF analysis fields get on 91 ‘model levels’ -> improve water vapor channels monitoring compared to 25 ‘standard levels’
    - 1ºx1º ; 6hour step
  - Sea/land
  - clear/opaque clouds

- SST/LST from AVHRR split-window for clear clusters
- Opaque clusters: Pcld/ Nεcld from AVHRR.
- RTTOV8.7 with Kcarta spectroscopy + 43 working levels

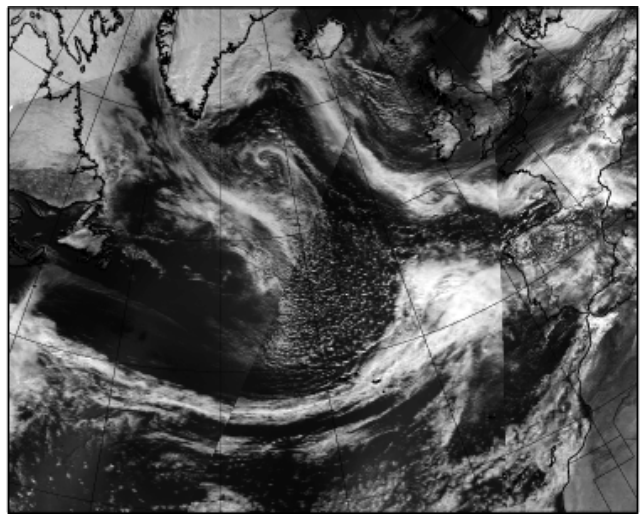
IASI ifov cloud classification

AVHRR VIS1 20080417
06h46 – 16h55

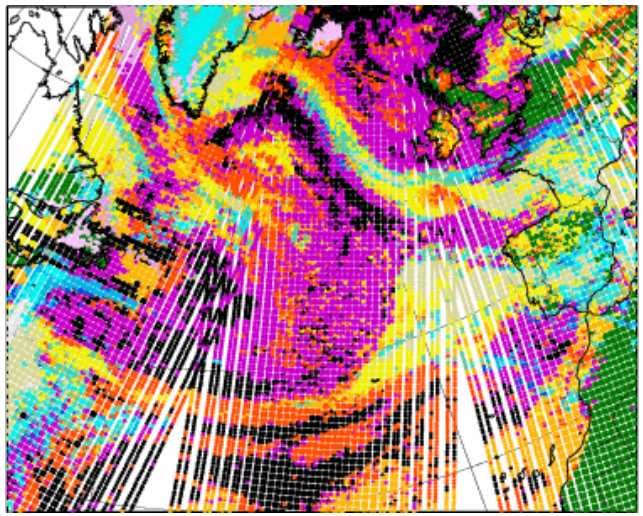
AVHRR cloud type

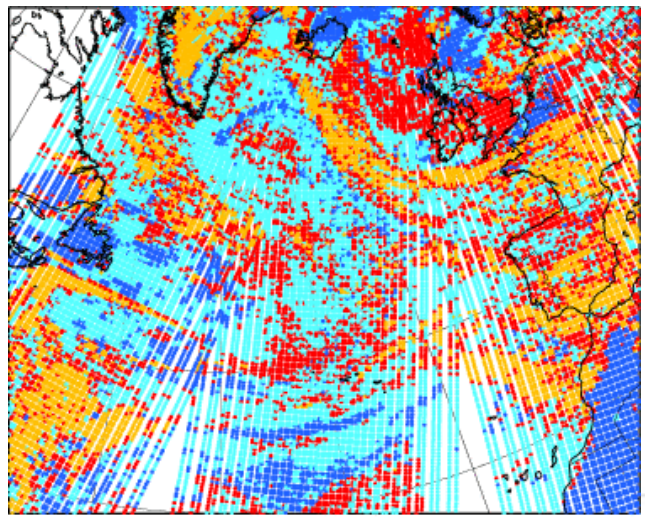


- Un processed
- Cloudfree land
- Cloudfree sea
- Snow covered
- Sea ice
- Very low clouds
- Low clouds
- Medium level clouds
- High clouds
- Very high clouds
- Very thin cirrus
- Thin cirrus
- Thick cirrus
- Cirrus above low/medium
- Fractional clouds
- Unclassified



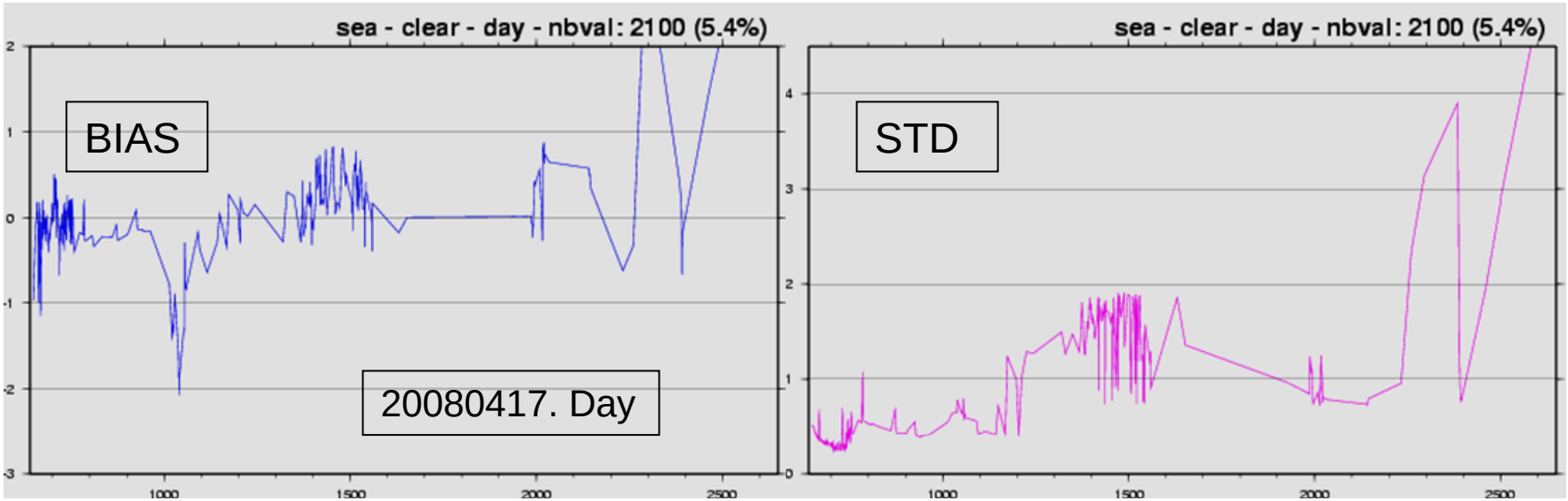
IASI 'main' clusters cloud type

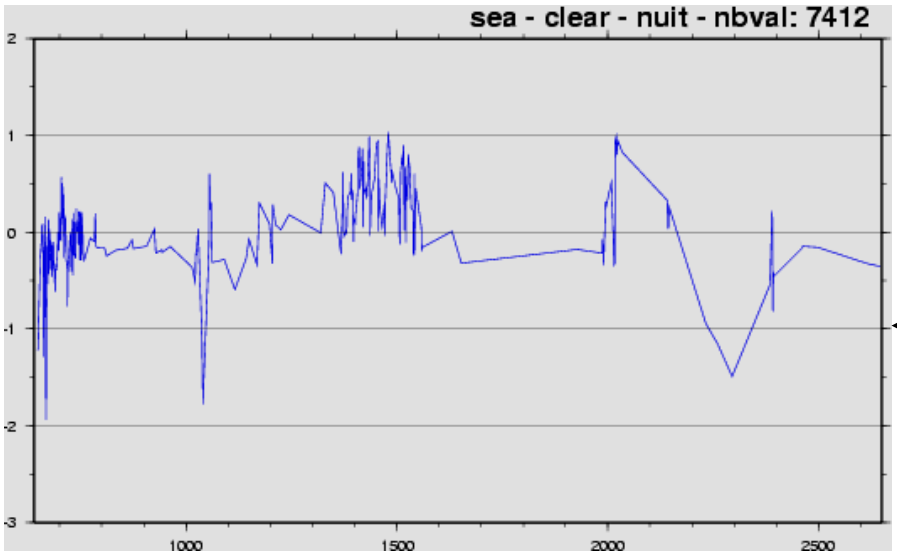




IASI ifov classif:
Clear
Opaque clouds
Non-opaque homogeneous
Semi-tr + others

Monitoring (2). Clear/sea. ECMWF Bg: 0.5ºx0.5º





SST from AVHRR split-window

Global. 20080401.
Night data.
About 3%
NWP resolution: 1°x1°

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Monitoring (3). Opaque or partly-opaque clouds/sea

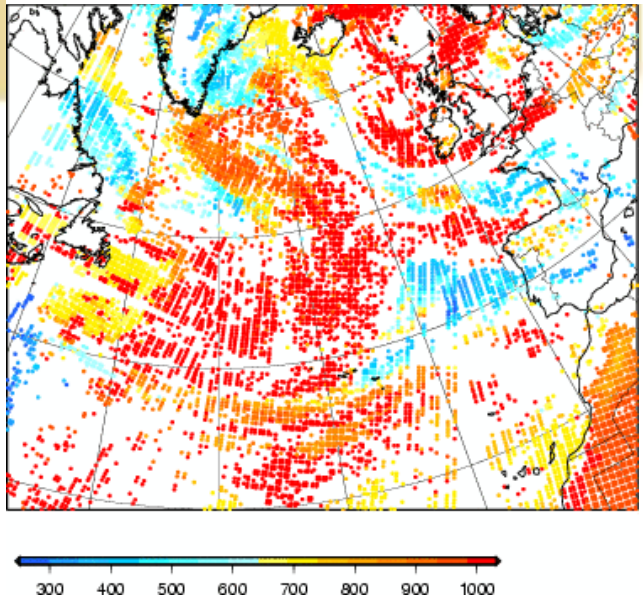
Opaque clouds: cloudy clusters with A4-A5<1k.

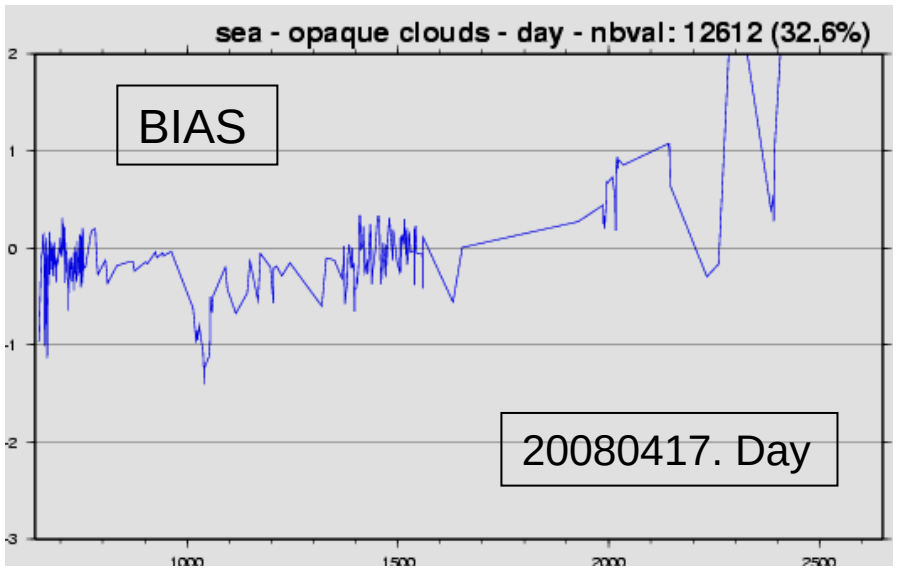
Pcld from Bg profile and A4 εcld=1 and A5 εcld>0.99. N=cluster fraction

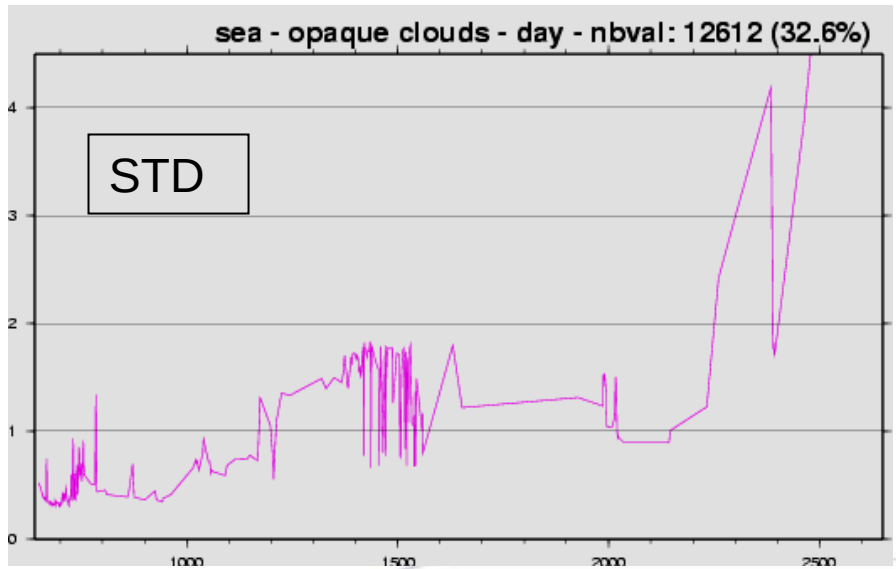
More than 2 clusters:

RTE done outside RTTOV -> radiances computed on each cluster and averaged

AVHRR Pcld (opaque) + Ps (clear)

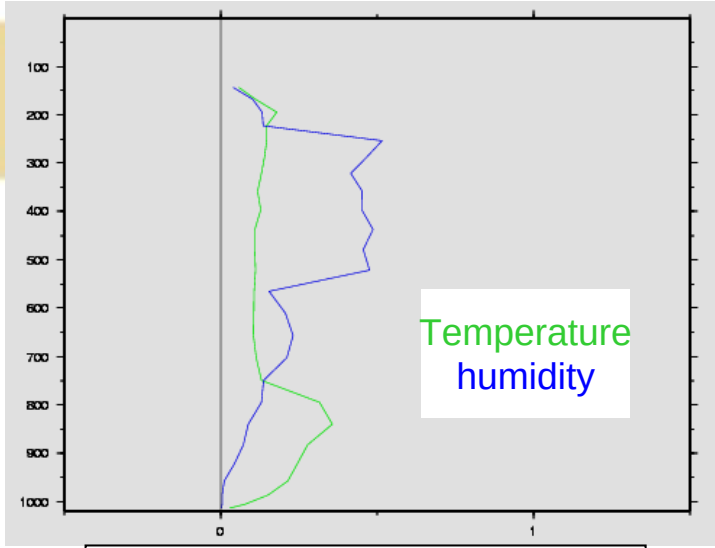




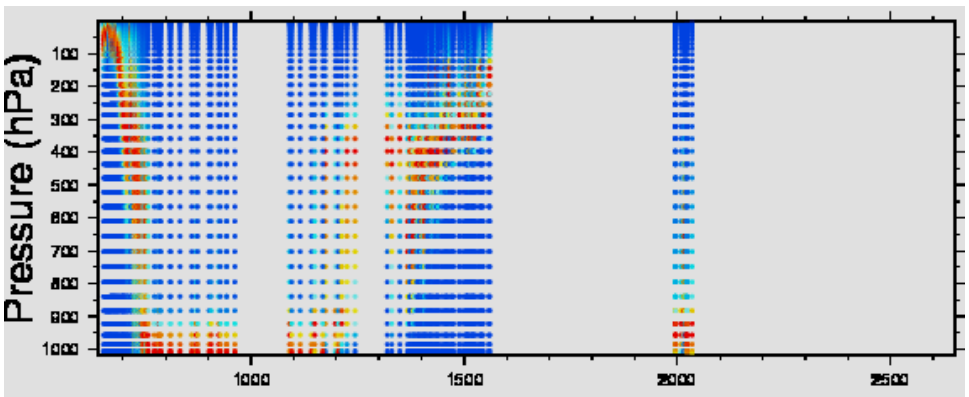


1DVar Levenberg-Marquardt minimization

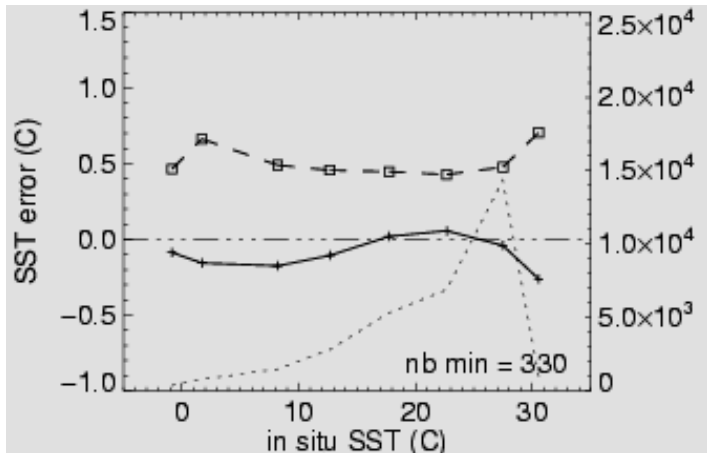
- Guess: ECMWF 12-18 hour forecast
- Ts / Tcld from AVHRR
- Bg covariance matrix computed over Europe
- Channels: subset of the ECMWF 300 selected channels (no ozone and no NIR channels) -> maximum of 263 channels in clear conditions
- RTTOV8.7 – 43 levels
- Retrieved parameters: T, q. (Ts, Tcld, εcld fixed)



Area of averaging kernels with ECMWF Bg cov. matrix and IASI Obs cov. matric



Weighing function of selected channels



Split-window SST validation against buoys

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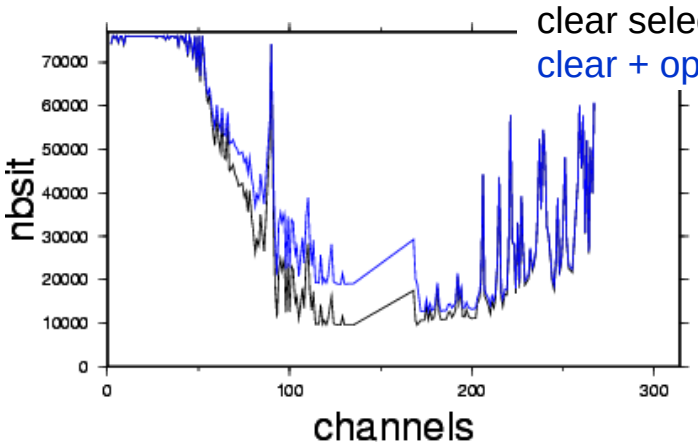
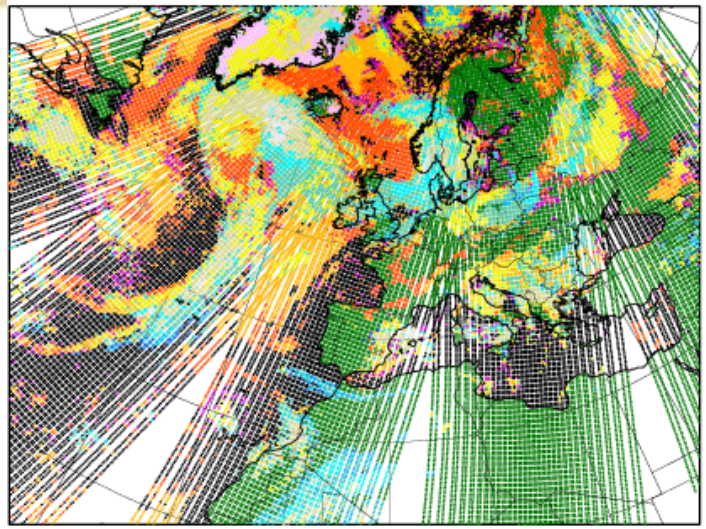
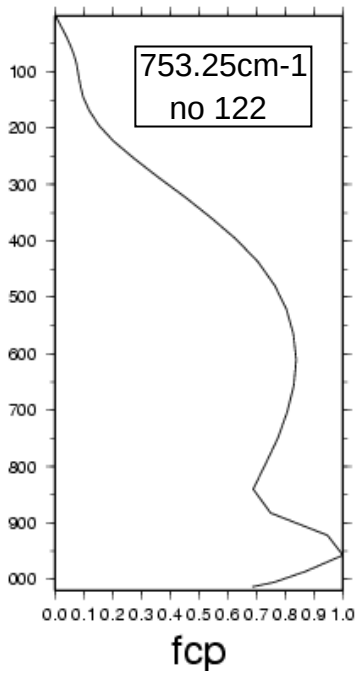
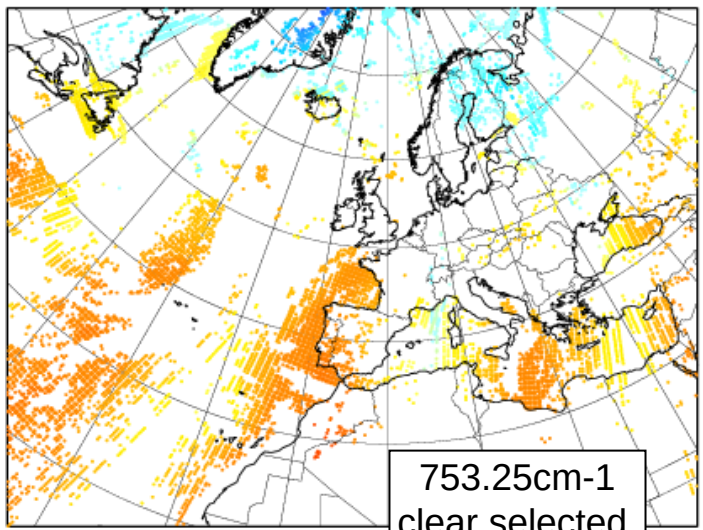
Channels selection for opaque cloudy situations

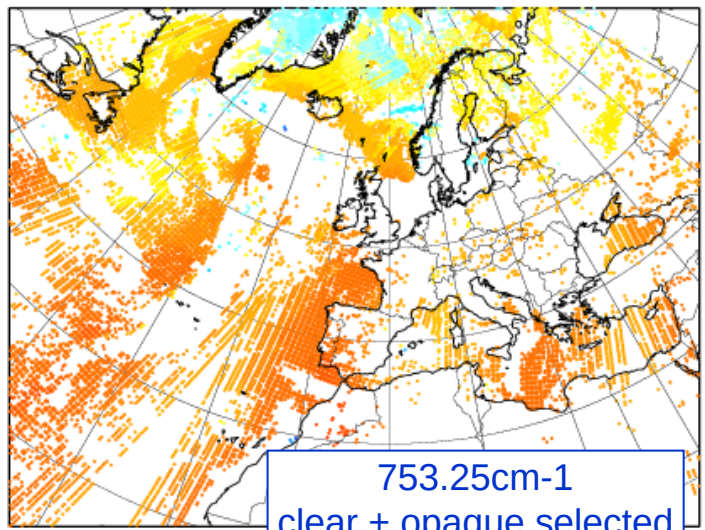


Use of ECMWF channels selection









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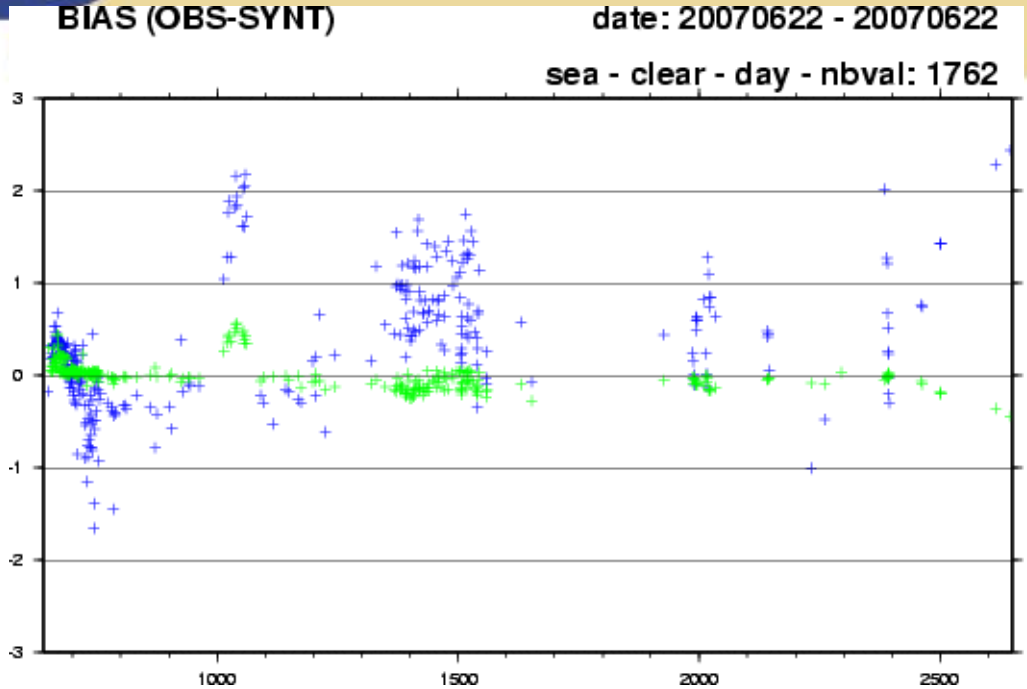
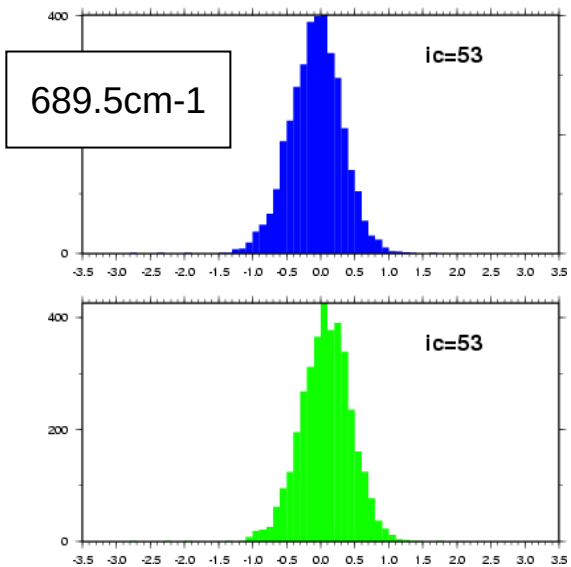
BIAS correction

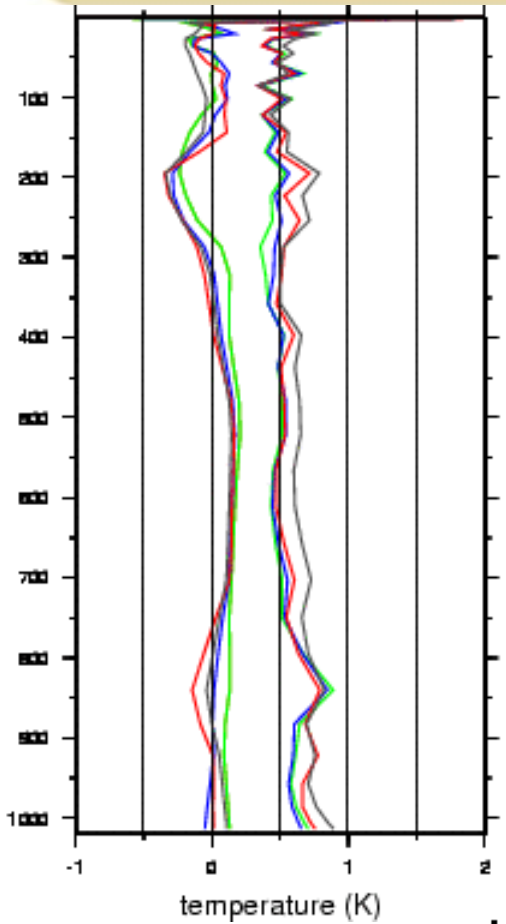


Thickness 1000-300hpa
Thickness 200-50hpa
Thickness 50-5hpa
Twv
Twv**2
Zenith angle
(Zenith angle)**2
(Zenith angle)**3
(Zenith angle)**4

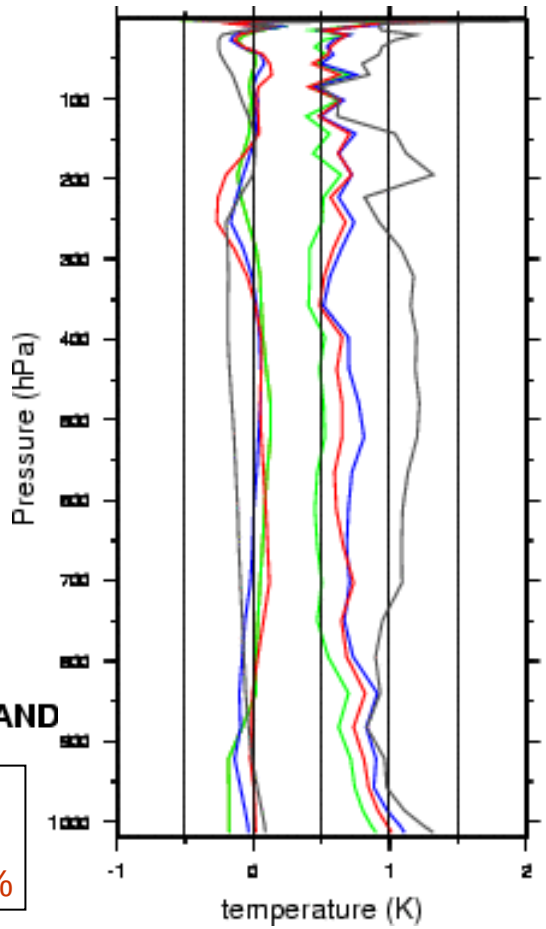
- Coefficients computed on the 10 previous days
- Same for clear and cloudy data



IASI retrievals. First results



SEA : 20071011



LAND

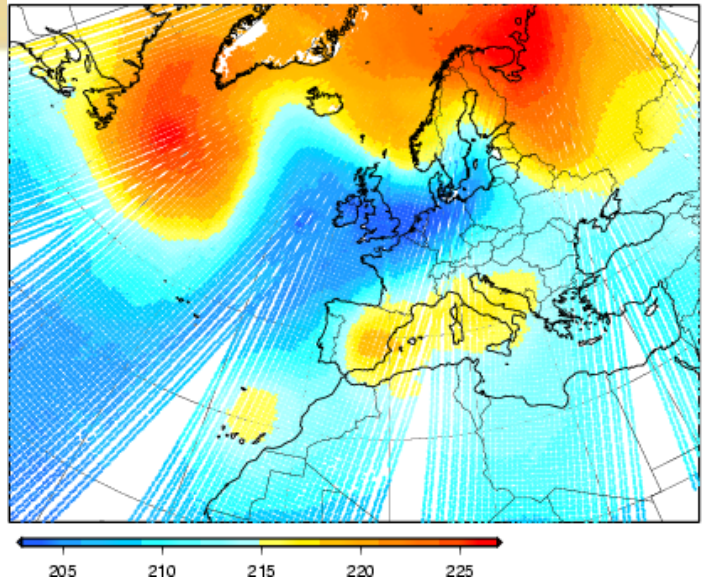
guess
cl : 12158
ptcld: 12255
cld : 36045

Cloud cover:
clear: <2%
cloudy: >70%

20071011_06 ; 065653-135053 ; iasiOAc_METOP02

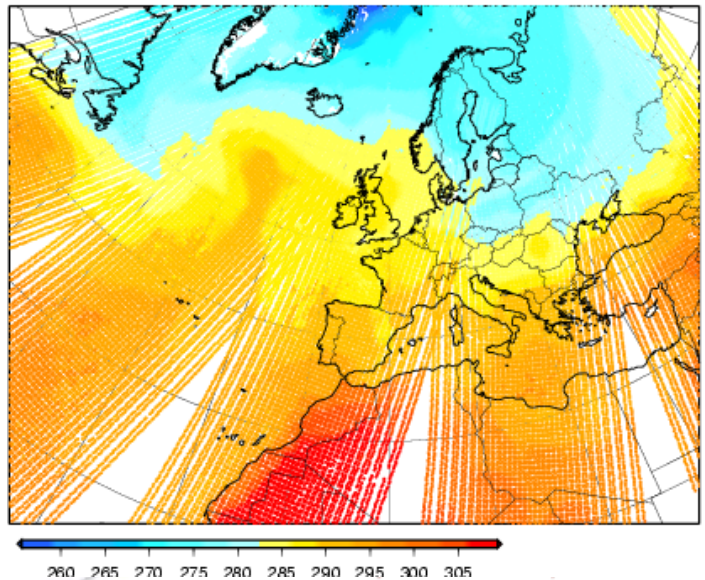
CHANNEL 150 hPa

Min/Max: 202.9 - 227.2

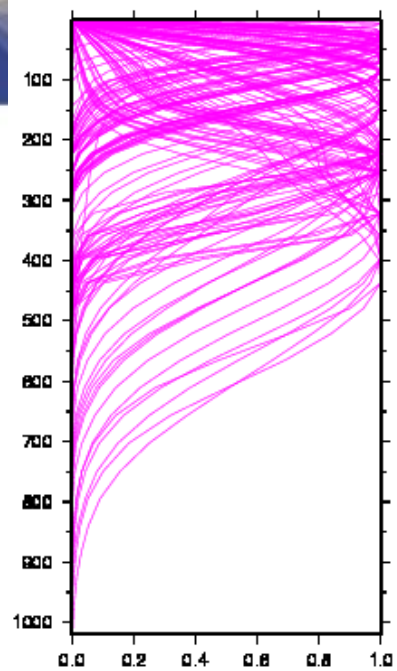


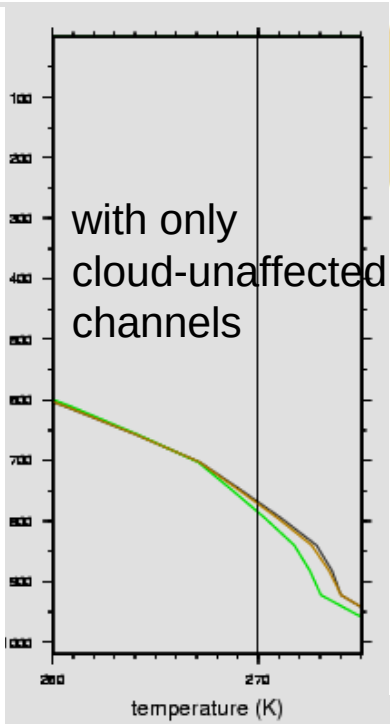
CHANNEL 1000 hPa

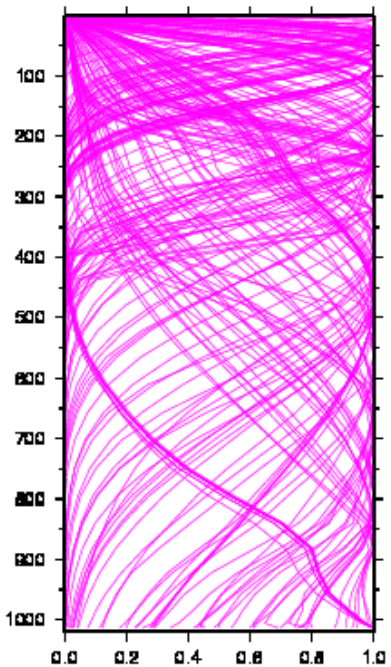
Min/Max: 255.5 - 310

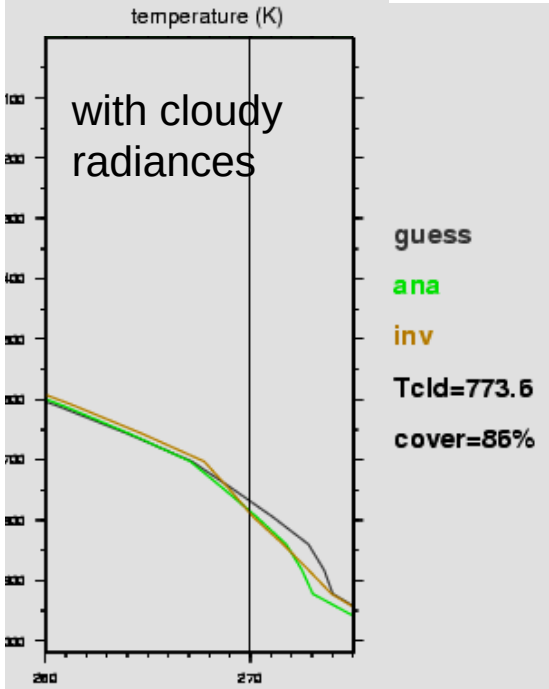


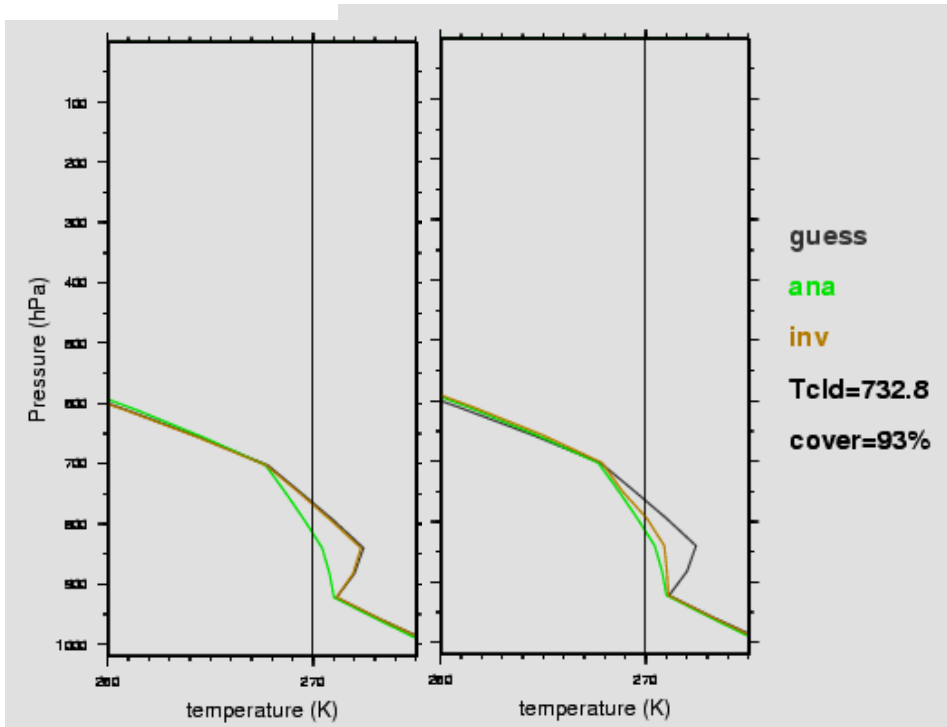
Examples using cloudy radiances opaque clouds











Preliminary conclusions

- problems to retrieve the humidity profile not well understood:
  - Correct convergence of 1DVar
  - But with 'correct ' Bg and Obs cov matrixes: 1DVar degrades the forecast compared to analysis even in temperature for clear conditions
  - Not observed when using simulated noisy IASI radiances
  - Needs to artificially increase the Obs covariance matrix for humidity channels to improve the T profile but the Q profile remains the Bg
  - Could be due to :
    - the 43 RTTOV levels ? ->test of 100 levels (water vapor fluctuations)
    - Diagonal Obs cov matrix ?
    - Problems in spectroscopy for water vapor ?
    - …

- implementation is still not finished (CO_2-slicing, AMSU/MHS,...)
- Test of cloudy 1DVar (cloud parameters as control variables)
- Nowcasting aspects have not started (ex: water vapor convergence in low troposphere, vertical instability index, ….)