Readme LATMOS-ULB FORLI-CO data retrieved from IASI

Please note:

- These data have been processed at **LATMOS** using a retrieval code, **FORLI** (Fast Optimal Retrievals on Layers for IASI), developed at **ULB** (Université Libre de Bruxelles). Any use of the data for presentations should mention "**CO data provided by LATMOS/CNRS and ULB**".
- In case of a publication, if the paper makes an important use of IASI data, **co-authorship** should be offered. For any use in publication please contact Cathy Clerbaux (cathy.clerbaux@latmos.ipsl.fr) and add in acknowledgements "**The authors thank the AERIS infrastructure (http://www.aeris-data.fr) for providing access to the IASI CO data**".
- **We would be glad to have your feedback** about the quality of the data, on the usefulness of the quality flags, and/or if you find anything that seems wrong or strange in the data files.
- Since December 2, 2010, a new flag has been added in column 7 to indicate when Eumetsat IASI L2 temperature profiles used in our retrieval were retrieved by linear regression (http://www.eumetsat.int/Home/Main/News/ProductServiceNews/802463?l=en). This new flag is given for information. It is not taken into account for the definition of the "super" quality flag. It is equal to 0 when temperature profile is retrieved by optimal estimation and it is equal to 1 when temperature profile is retrieved by linear regression.

FORLI versions :

Before September 30, 2014, all the IASI data were processed with the **v20100815** version of the retrieval code. **From September 30, 2014**, data have been processed with the **v20140922** version.

How to read the data since December 2, 2010 :

Each file contains data for one day of observation. In each file, each line corresponds to one observation.

File names include date of observation. Their structure is:
iasi_CO_LATMOS_ULB_YYYYMMDD_vXXXXXXXX.txt
where : YYYY = year, MM = month, DD = day, XXXXXXXX = version number of the retrieval code.

The data are organized in 60 columns:

columns 1 and 2	latitude and longitude
columns 3 and 4	date (yyyymmdd) and time (hhmmss)
column 5	solar zenith angle
column 6	IASI field of view (0, 1, 2 or 3)
column 7	information flag about Eumetsat IASI L2 temperature profiles retrieval method (see above)
columns 8 to 15	quality flags (see hereafter)
column 16	"super" quality flag (see hereafter)
column 17	Eumetsat cloud coverage in the pixel (in %, between 0 and 25 %)
column 18	Degrees Of Freedom of the Signal (DOFS, ~number of independant information pieces concerning CO vertical distribution in the signal)
column 19	fit residual root mean square (in $W/m^2/cm^{-1}$)
column 20	fit residual bias (in $W/m^2/cm^{-1}$)
column 21	CO total column (in $molec.cm^{-2}$)
column 22	CO total column relative error (observation_error/observation ratio)
columns 23 to 41	Xa, a priori CO profile in partial columns (in $molec.cm^{-2}$) and on the same vertical layers as the A matrix, with -999 for missing levels
columns 42 to 60	A, averaging kernel vector for the total column in 19 vertical layers (in partial column), with -999 for missing levels (see hereafter for the description of the layers)

How to read the data before December 2, 2010 :

Each file contains data for one day of observation. In each file, each line corresponds to one observation.

File names include date of observation. Their structure is:
iasi_CO_LATMOS_ULB_YYYYMMDD_vXXXXXXXX.txt
where : YYYY = year, MM = month, DD = day, XXXXXXXX = version number of the retrieval code.

The data are organized in 59 columns:

columns 1 and 2	latitude and longitude
columns 3 and 4	date (yyyymmdd) and time (hhmmss)
column 5	solar zenith angle
column 6	IASI field of view (0, 1, 2 or 3)
columns 7 to 14	quality flags (see hereafter)
column 15	« super » quality flag (see hereafter)
column 16	Eumetsat cloud coverage in the pixel (in %, between 0 and 25 %)
column 17	Degrees Of Freedom of the Signal (DOFS, ~number of independant information pieces concerning CO vertical distribution in the signal)
column 18	fit residual root mean square (in $W/m^2/cm^{-1}$)
column 19	fit residual bias (in $W/m^2/cm^{-1}$)
column 20	CO total column (in $molec.cm^{-2}$)
column 21	CO total column relative error (observation_error/observation ratio)
columns 22 to 40	Xa, a priori CO profile in partial columns (in $molec.cm^{-2}$) and on the same vertical layers as the A matrix, with -999 for missing levels
columns 41 to 59	A, averaging kernel vector for the total column in 19 vertical layers (in partial column), with -999 for missing levels (see hereafter for the description of the layers)

Significations of quality flags:

1. *descriptive flags :*

flag 1	is 1 if surface altitude in our model is negative
flag 2	is 1 if Tskin is missing in IASI level 2 data and is replaced by the brightness temperature at 2143.25 cm^{-1} in our model
flag 3	is 1 if the difference in absolute value between Tskin of IASI level 2 data and the brightness temperature at 2143.25 cm^{-1} is higher than 5K
flag 4	is 1 if a desert is detected at the Earth's surface

2. *fit flags :*

flag 5	is 1 if the maximum number of iterations is reached without convergence
flag 6	is 1 if the fit residual bias is sloped
flag 7	is 1 if the contrast of CO lines is weak
flag 8	is 1 if the averaging kernel vector includes strange values (generally too high)

3. ***"Super" quality flag:***

The "super" quality flag is a summary of the detailed quality flags. To describe it, we use two additional fit flags: one to indicate that the fit residual root mean square is too high and one to indicate that the fit residual bias is too high (see above).

The super quality flag can have 3 values:

- **0** when (i) all the previous flags are null or
  (ii) the cloud cover is less than 12 % (but higher than 0) and only flag 2 is equal to 1 ;
- **1** when (i) all the fit flags are null with at least one descriptive flag equal to 1 or
  (ii) all the fit flags are null with only flag 2 equal to 1 and the cloud cover equal to 0 or
  (iii) all the fit flags are null with only flag 2 equal to 1 and the cloud cover higher or equal to 12 % ;
- **2** when at least one fit flag is equal to 1.

For data validation purpose, we recommend to use the data for which the "super" quality flag is equal to 0.

The **averaging kernel matrix** is dimensionless but calculated from profiles in partial columns units, on **19 layers** (level 1 corresponds to the first layer of the atmosphere [0-1km], level 2 [1-2km],.. level 19 [18-60km, top of the atmosphere]).

Because only CO total columns are provided here, we provide the corresponding averaging kernel vector.

When the first levels are not available (because of the orography), **data=-999**.

To smooth a carbon monoxide profile, one should use:

X_smoothed= A*Xr + (I-A)*Xa with

Xr the profile (in partial columns) to be smoothed
A the IASI averaging kernel vector
Xa the IASI a priori profile (in partial columns).
(Cf Rodgers, 2000)

To properly use the averaging kernel vectors two conditions must be fulfilled:

- Profiles must be in partial columns;
- The profile to be smoothed (Xr) must go at least as low as the IASI profile in altitude (it can go lower than IASI).

If these conditions are not met, smoothing with the vector does not give the same result as smoothing with the complete averaging kernel matrix.

FORLI a priori CO profile in VMR between 0 and 60 km is the following:

0	1.0161773E-07	16	4.1054126E-08	31	4.6196803E-08	46	1.8742890E-07
1	9.4855840E-08	17	3.6674835E-08	32	4.9959250E-08	47	2.1709527E-07
2	9.1867937E-08	18	3.2485751E-08	33	5.4181389E-08	48	2.4970039E-07
3	8.9939589E-08	19	2.9398235E-08	34	5.8425609E-08	49	2.8425973E-07
4	8.8739003E-08	20	2.6610051E-08	35	6.3029508E-08	50	3.2205485E-07
5	8.8418514E-08	21	2.4046862E-08	36	6.7743093E-08	51	3.6187539E-07
6	8.7545818E-08	22	2.3019179E-08	37	7.2737994E-08	52	4.0372110E-07
7	8.6420669E-08	23	2.2254821E-08	38	7.7949241E-08	53	4.4595348E-07
8	8.3986495E-08	24	2.1616224E-08	39	8.3286388E-08	54	4.9068308E-07
9	8.0001663E-08	25	2.1599277E-08	40	8.9656617E-08	55	5.3657991E-07
10	7.5277656E-08	26	2.5668884E-08	41	9.7574193E-08	56	5.8427115E-07
11	6.9161481E-08	27	3.0270625E-08	42	1.0816715E-07	57	6.3513023E-07
12	6.3326457E-08	28	3.4893978E-08	43	1.2211041E-07	58	6.9045460E-07
13	5.7343264E-08	29	3.9139751E-08	44	1.4033574E-07	59	7.4988295E-07
14	5.1686031E-08	30	4.2789457E-08	45	1.6217000E-07	60	8.1519043E-07
15	4.6027417E-08						

References:

Algorithm description

FORLI radiative transfer and retrieval code for IASI
D. Hurtmans, P.-F. Coheur, C. Wespes, L. Clarisse, O. Scharf, C. Clerbaux, J. Hadji-Lazaro, M. George, S. Turquety
J. Quant. Spectrosc. Radiat. Transf., 113, 11, 1391.1408, **2012**

Validation

Carbon monoxide distributions from the IASI/METOP mission: evaluation with other space-borne remote sensors
M. George, C. Clerbaux, D. Hurtmans, S. Turquety, P.-F. Coheur, M. Pommier, J. Hadji-Lazaro, D.P. Edwards, H. Worden, M. Luo, C. Rinsland, and W. McMillan
Atmos. Chem. Phys., 9, 8317-8330, **2009**

IASI carbon monoxide validation over the Arctic during POLARCAT spring and summer campaigns
M. Pommier, K.S. Law, C. Clerbaux, S. Turquety, D. Hurtmans, J. Hadji-Lazaro, P.-F. Coheur, H. Schlager, G. Ancellet, J.-D. Paris, P. Nédélec, G.S. Diskin, J.R. Podolske, J.S. Holloway, and P. Bernath
Atmos. Chem. Phys., 10, 10655-10678, doi:10.5194/acp-10-10655-2010, **2010**

Retrieval of MetOp-A/IASI CO profiles and validation with MOZAIC data
E. De Wachter, B. Barret, E. Le Flochmoën, E. Pavelin, M. Matricardi, C. Clerbaux, J. Hadji-Lazaro, M. George, D. Hurtmans, P.-F. Coheur, P. Nedelec, and J. P. Cammas
Atmos. Meas. Tech., 5, 2843-2857, doi:10.5194/amt-5-2843-2012, **2012**

Validation of IASI FORLI carbon monoxide retrievals using FTIR data from NDACC
T. Kerzenmacher, B. Dils, N. Kumps, T. Blumenstock, C. Clerbaux, P.-F. Coheur, P. Demoulin, O. García, M. George, D.W.T. Griffith, F. Hase, J. Hadji-Lazaro, D. Hurtmans, N. Jones, E. Mahieu, J. Notholt, C. Paton-Walsh, U. Raffalski, T. Ridder, M. Schneider, C. Servais, and M. De Mazière
Atmos. Meas. Tech., 5, 2751-2761, doi:10.5194/amt-5-2751-2012, **2012**

Assimilation of IASI satellite CO fields into a global chemistry transport model for validation against aircraft measurements
A. Klonecki, M. Pommier, C. Clerbaux, G. Ancellet, J.-P. Cammas, P.-F. Coheur, A. Cozic, G.S. Diskin, J. Hadji-Lazaro, D.A. Hauglustaine, D. Hurtmans, B. Khattatov, J.-F. Lamarque, K.S. Law, P. Nedelec, J.-D. Paris, J.R. Podolske, P. Prunet, H. Schlager, S. Szopa, and S. Turquety
Atmos. Chem. Phys., 12, 4493-4512, doi:10.5194/acp-12-4493-2012, **2012**

Carbon monoxide urban emission monitoring: A ground-based FTIR case study
Y. Té, E. Dieudonné, P. Jeseck, F. Hase, J. Hadji-Lazaro, C. Clerbaux, F. Ravetta, S. Payan, I. Pépin, D. Hurtmans, J. Pelon, and C. Camy-Peyret
J. Atmos. Oceanic Technol., 29, 7, 911-921, doi: 10.1175/JTECH-D-11-00040.1, **2012**

Decadal record of satellite carbon monoxide observations
H.M. Worden, M.N. Deeter, C. Frankenberg, M. George, F. Nichitiu, J. Worden, I. Aben, K.W. Bowman, C. Clerbaux, P.-F. Coheur, A.T.J. de Laat, R. Detweiler, J.R. Drummond, D.P. Edwards, J.C. Gille, D. Hurtmans, M. Luo, S. Martínez-Alonso, S. Massie, G. Pfister, and J.X. Warner
Atmos. Chem. Phys., 13, 837-850, doi:10.5194/acp-13-837-2013, **2013**

References related to FORLI-CO and IASI are updated here: http://iasi-chem.aero.jussieu.fr/documentation.htm

For more IASI publications, you can refer to: http://smsc.cnes.fr/IASI/A_publications.htm