GEISA -08 Spectroscopic Database New Edition: Evaluation for IASI Hyperspectral Remote Sensing Applications

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- Presentation
- Vertical sounding
- Research themes
- Tools
- Geisa
- HFTP
- Publications
- Oral Publications
- Acronyms
- Contacts
- Links
- Jobs
- Intranet

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The ARA Group

The Atmospheric Radiation Analysis group is specialized in the study of the variability and evolution of the climate of the Earth from space borne observations made principally by vertical sounders, in the infrared and the microwave domains.

Its main research themes relate to the collection of a long term, global, climatology of the earth-atmosphere state: temperature and moisture; cloud characteristics, including their microphysical properties; greenhouse gases, mainly CO_2, in relation with the carbon cycle; aerosols (volcanic, dust, smoke, etc.) infrared characteristics in relation with the earth radiative budget; continental surface infrared emissivities, in relation with the interaction between the surface and the atmosphere. The group is also deeply involved in statistical analysis of large spatio-temporal data bases (inverse problems, linear and non linear inference, neural networks, classification, pattern recognition, etc.).
The group has developed numerous tools in spectroscopy of the atmospheric gases, forward and inverse radiative transfer modelling, etc. In particular, the group develops and maintains the spectroscopic data base GEISA « Gestion et Etude des Informations Spectroscopiques Atmosphériques » *(Study and management of atmospheric spectroscopic information)*.

The Laboratoire de Météorologie Dynamique (LMD) is a Laboratory of the French Centre National de la Recherche Scientifique (CNRS), of the Ecole Polytechnique, of the Ecole Normale Supérieure, of the Université Pierre et Marie Curie (Paris 6), and belongs to the Institut Pierre-Simon Laplace (IPSL). It is also one of the French space laboratories working in cooperation with the Centre National d'Etudes Spatiales (CNES).

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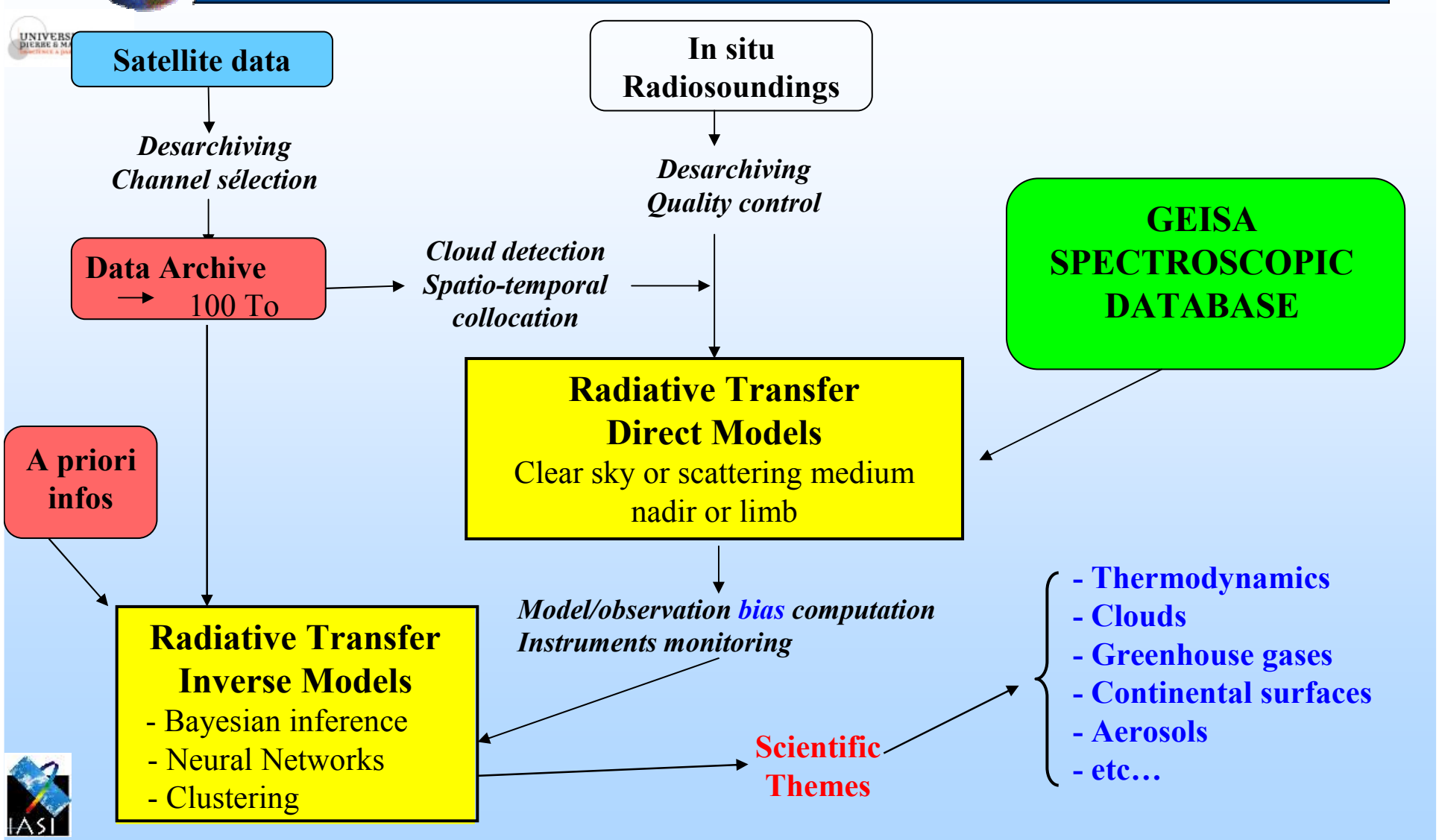
FROM SATELLITE OBSERVATIONS TO CLIMATE VARIABLES: a long process based on RadiativeTransfer



Courtesy A. Chédin, Trattoria/CNES
2-3 April 2008

GEISA-2008 NEW EDITION FINALIZED

GEISA-2008 PAPER IN PREPARATION

OUTLINE

- [1] GEISA System Overview
- [2] GEISA-08 line transition parameters sub-database update summary
- [3] From GEISA-08 to GEISA/IASI-08
- [4] GEISA interactive free distribution
- [5] Concluding comments

❖ [1] THE GEISA-2008 SYSTEM

Gestion et **E**tude des **I**nformations **S**pectroscopiques **A**tmosphériques
Management and Study of Atmospheric Spectroscopic Information

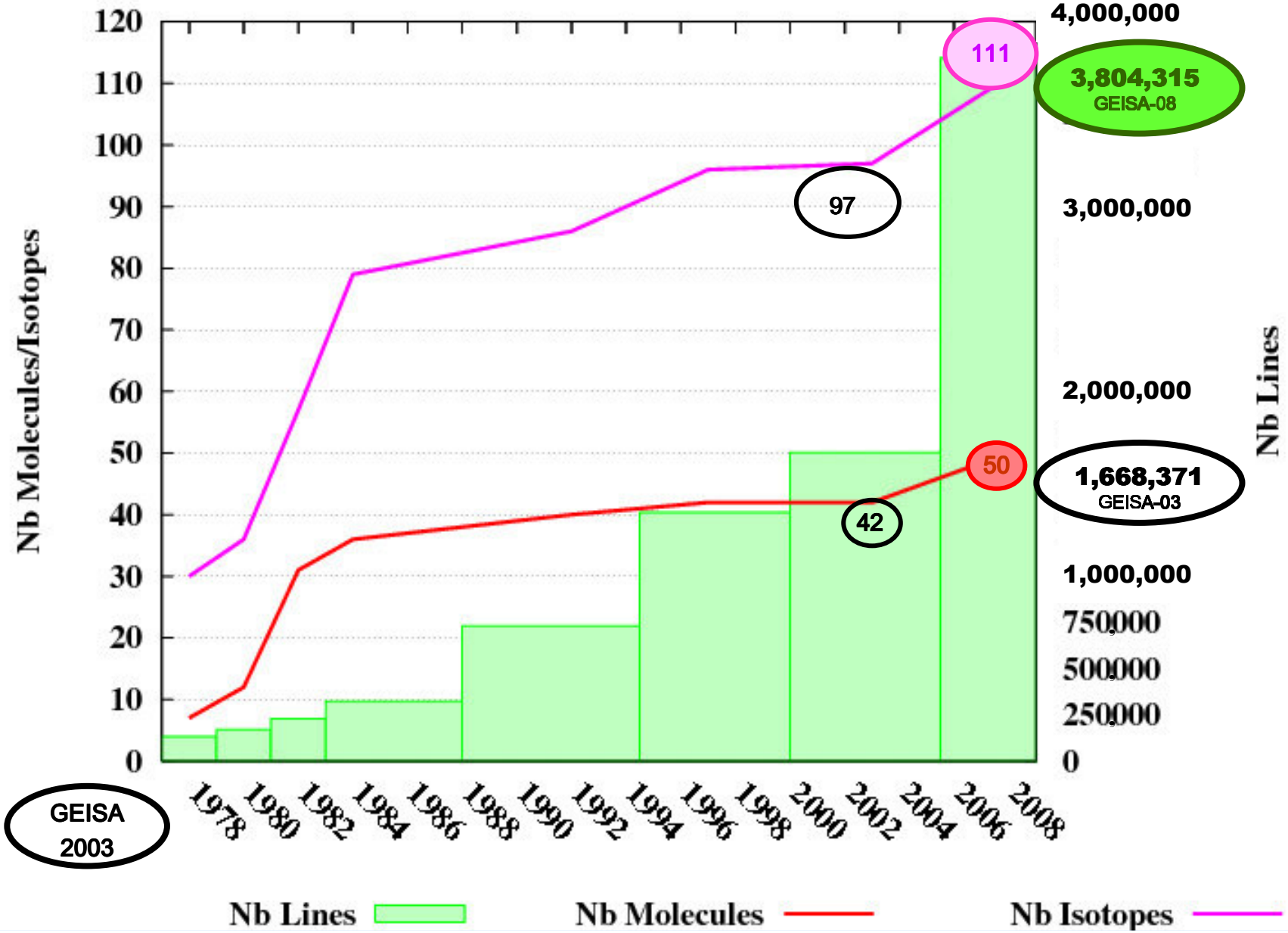
Three SUB-DATABASES

- Line transition parameters database
  - 50 molecules (111 isotopic species)
  - over 3, 804,315 entries between 0 and 35,877 cm^{-1}
- Absorption cross-sections database
  - IR: 39 molecular species (mainly CFC's)
  - UV/Visible : 11 molecular species
- Aerosol data archive and softwares

ASSOCIATED MANAGEMENT SOFTWARES

(For each sub-database)

GEISA-08 line transition parameters sub-database evolution since 1978



GEISA and GEISA/IASI-08 Line Transitions Record Format Modifications

252 characters Record **30 Parameters**

(A) Wavenumber (cm^{-1}) of the line associated with the vibro-rotational transition.
(B) Intensity of the line (cm $molecule^{-1}$ at 296K).
(C) Lorentzian collision halfwidth (cm^{-1} atm^{-1} at 296K).
(D) Energy of the lower transition level (cm^{-1}).
(E) Transition quantum identifications for the lower and upper levels of the transition
(F) Temperature dependence coefficient *n* of the halfwidth
(G) Identification code for isotope.
(I) Identification code for molecule.
(J) Internal GEISA code for data identification.

Extended format length

Parameter	A	B	C	D	E1	E2	E3	E4	F	G	I	J	K	L
Field length	12	11	6	10	25	25	15	15	4	3	3	3	2	1
Fortran descriptor	F12.6	1PD11.4	0PF6.4	F10.4	A25	A25	A15	A15	F4.2	I	I3	A3	I2	I1

M	N	O
10	5	8
1PE10.3	0PF7.4	F9.6

(M) Einstein A-coefficient
(N) Self broadening pressure halfwidth (HWHM) ($cm^{-1}atm^{-1}$) at 296K
(O) Air pressure shift of the line transition ($cm^{-1}atm^{-1}$) at 296K

Extended format length

Field P and Q suppressed
(External references)

GEISA and GEISA/IASI-08 Line Transitions Records (following) No Modification

(R) Temperature dependence coefficient n of the air pressure shift
(A') Estimated accuracy (cm-1) on the line position
(B') Estimated accuracy on the intensity of the line in (cm^{-1}/(molecule.cm^{-2}))
(C') Estimated accuracy on the air collision halfwidth (HWHM) ($cm^{-1}atm^{-1}$)
(F') Estimated accuracy on the temperature dependence coefficient n of the air broadening HW
(O') Estimated accuracy on the air pressure shift of the line transition ($cm^{-1}atm^{-1}$) @296K
(R') Estimated accuracy on the temperature dependence coefficient n of the air pressure shift

More Water specific

(N') Estimated accuracy on the self broadened (HWHM) ($cm^{-1}atm^{-1}$) @296K
(S) Temperature dependence coefficient n of the self broadening halfwidth
(S') Estimated accuracy on the temperature dependence coefficient n of the self broadening HW
(T) Self pressure shift of the line transition ($cm^{-1}atm^{-1}$) @296K
(T') Estimated accuracy on the self pressure shift of the line transition ($cm^{-1}atm^{-1}$) @296K
(U) Temperature dependence coefficient n of the self pressure shift
(U') Estimated accuracy on the temperature dependence coefficient n of the self pressure shift

Standardized parameter
missing values
in GEISA-08

❖ [2] FROM GEISA-03 TO GEISA-08

31 updated molecular species

H_2O CO_2 O_3 N_2O CH_4 O_2 NO SO_2

NO_2 PH_3 HNO_3 OCS H_2CO C_2H_6 CH_3D

C_2H_2 C_2H_4 HCN C_3H_8 C_2N_2 C_4H_2 HC_3N

N_2 CH_3Cl H_2O_2 H_2S HCOOH SF_6 C_3H_4

$ClONO_2$ NH_3

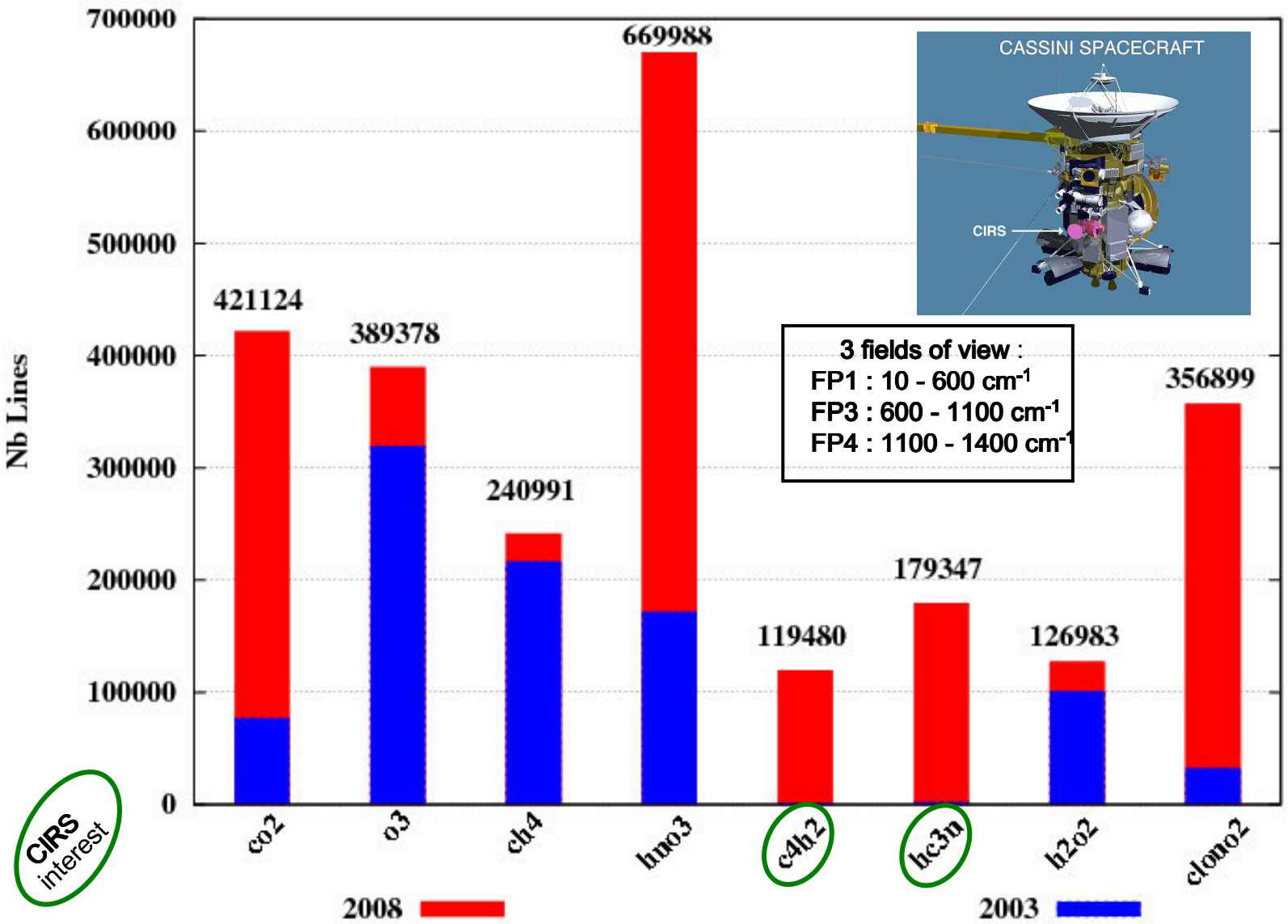
11 non updated molecular species

CO, OH, HF, HCl, HBr, HI, ClO,GeH4, HOCl, COF2, HO2

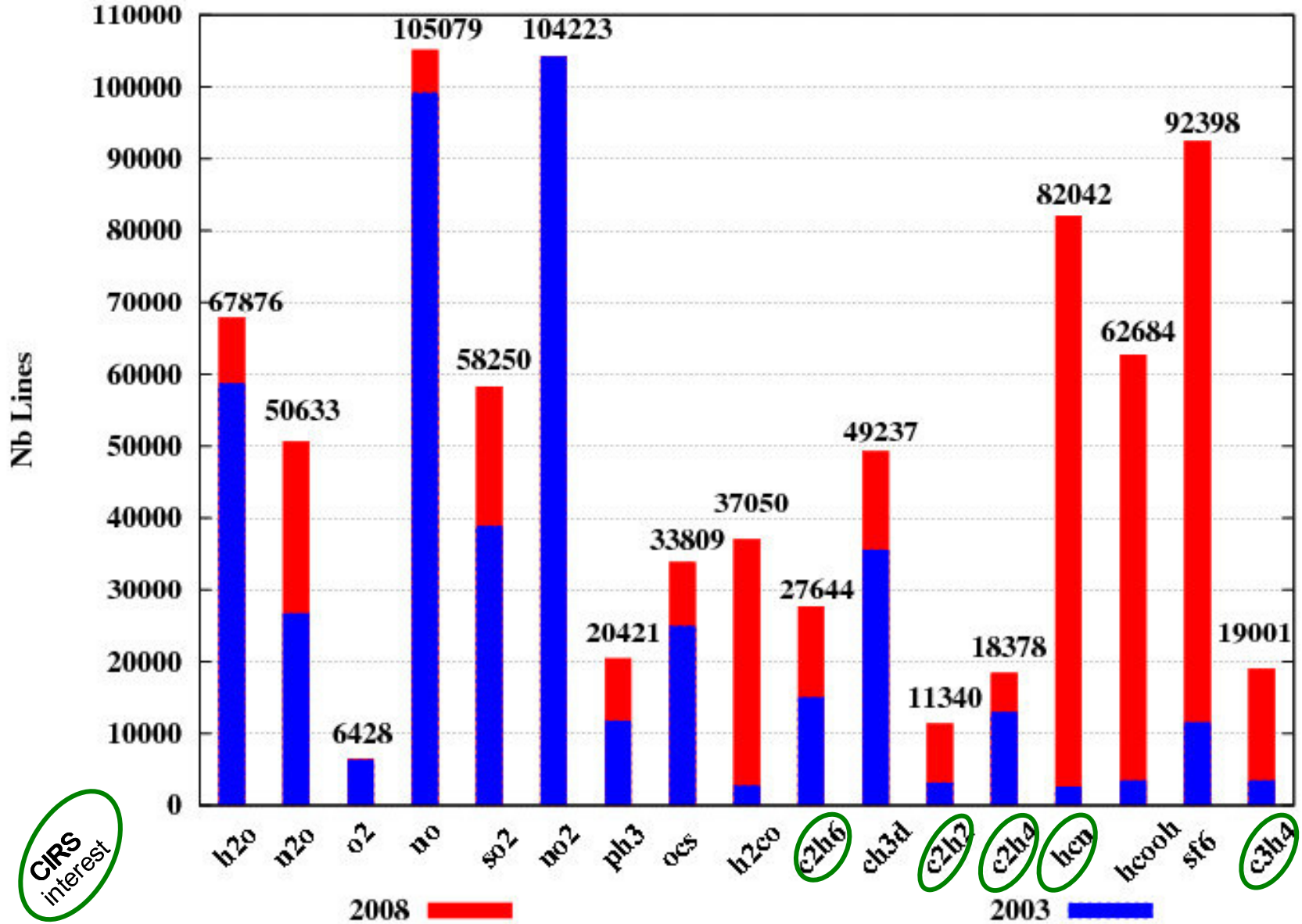
8 new molecular species

CH_3Br	794 – 1706 cm^{-1}
CH_3OH	0.02 - 33 cm^{-1} 10 µm region
NO+	1635- 2530 cm^{-1}
HNC	0.22 - 12594 cm^{-1}
C_6H_6	642 –705 cm^{-1}
C_2HD	451 - 580 cm^{-1} 600 - 760 cm^{-1}
CF_4	594 – 1313 cm^{-1}
CH3CN	870 – 1650 cm-1

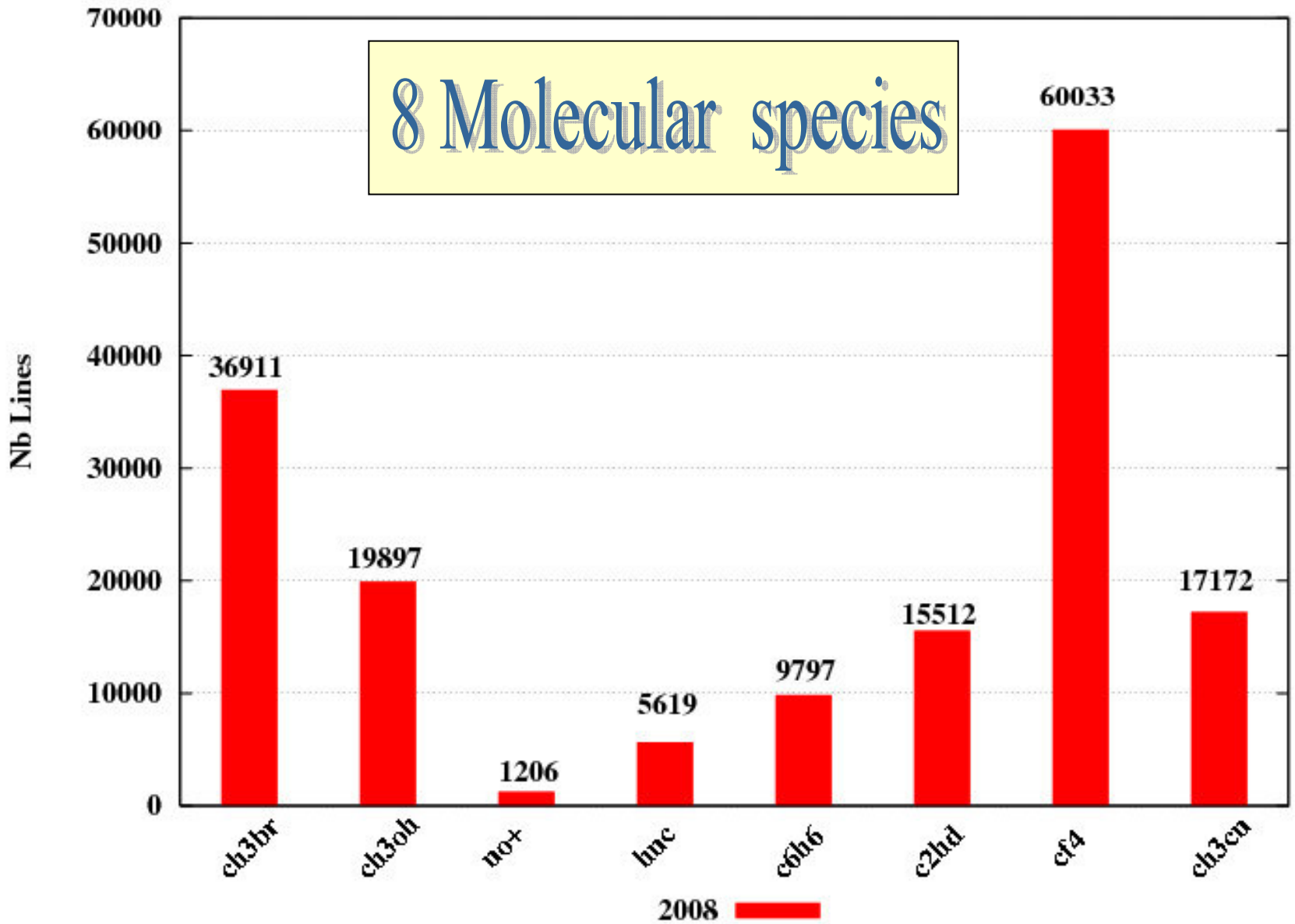
LINES EVOLUTION SINCE 2003 for UPDATED MOLECULES



LINES EVOLUTION SINCE 2003 for UPDATED MOLECULES (following)



NEW MOLECULAR SPECIES in GEISA 2008



❖[3] From GEISA-08 to GEISA/IASI-08

- **Extraction of GEISA-08 between 599 & 3001 cm^{-1}**
  - **Individual spectral lines spectroscopic parameters sub-database**
    14 molecules (53 isotopic species): **H_2O, CO_2, O_3, N_2O, CO, CH_4, O_2, NO, SO_2, NO_2, HNO_3, OCS, C_2H_2, N_2**
  - **IR absorption cross-sections sub-database (mainly CFC's)**
    6 molecular species**: CFC-11, CFC-12, CFC-14, CCl_4, N_2O_5, HCFC-22**
  - **Microphysical and optical properties of Basic Atmospheric aerosol components sub-database** (similar wi
- **Continuous update**
- **Related with:**
  - **CNES/EUMETSAT EPS mission**
  - **IASI measurement capabilities assessr**
  - **ISSWG**

Molecular species related with IASI Trace Gas Retrievals considered for addition

HCN
NH3
HCOOH
C2H4
CH3OH

Associated interest for AIRS

GEISA/IASI-08 Update

10 participating Laboratories

GSMA	Groupe de Spectrométrie Moléculaire et Atmosphérique
ICB	Institut Carnot de Bourgogne
JPL	Jet Propulsion Laboratory-USA
LADIR	Laboratoire de Dynamique, Interaction et réactivité
LISA	Laboratoire Inter-Universitaire des Systèmes Atmosphériques
LPMAA	Laboratoire de Physique Moléculaire pour l'Atmosphère et l'Astrophysique
LTS	Laboratory of Theoretical Spectroscopy)-Russie
ULB	Université Libre de Bruxelles

University of Denver
College of Williams and Mary

11 Molecules updated

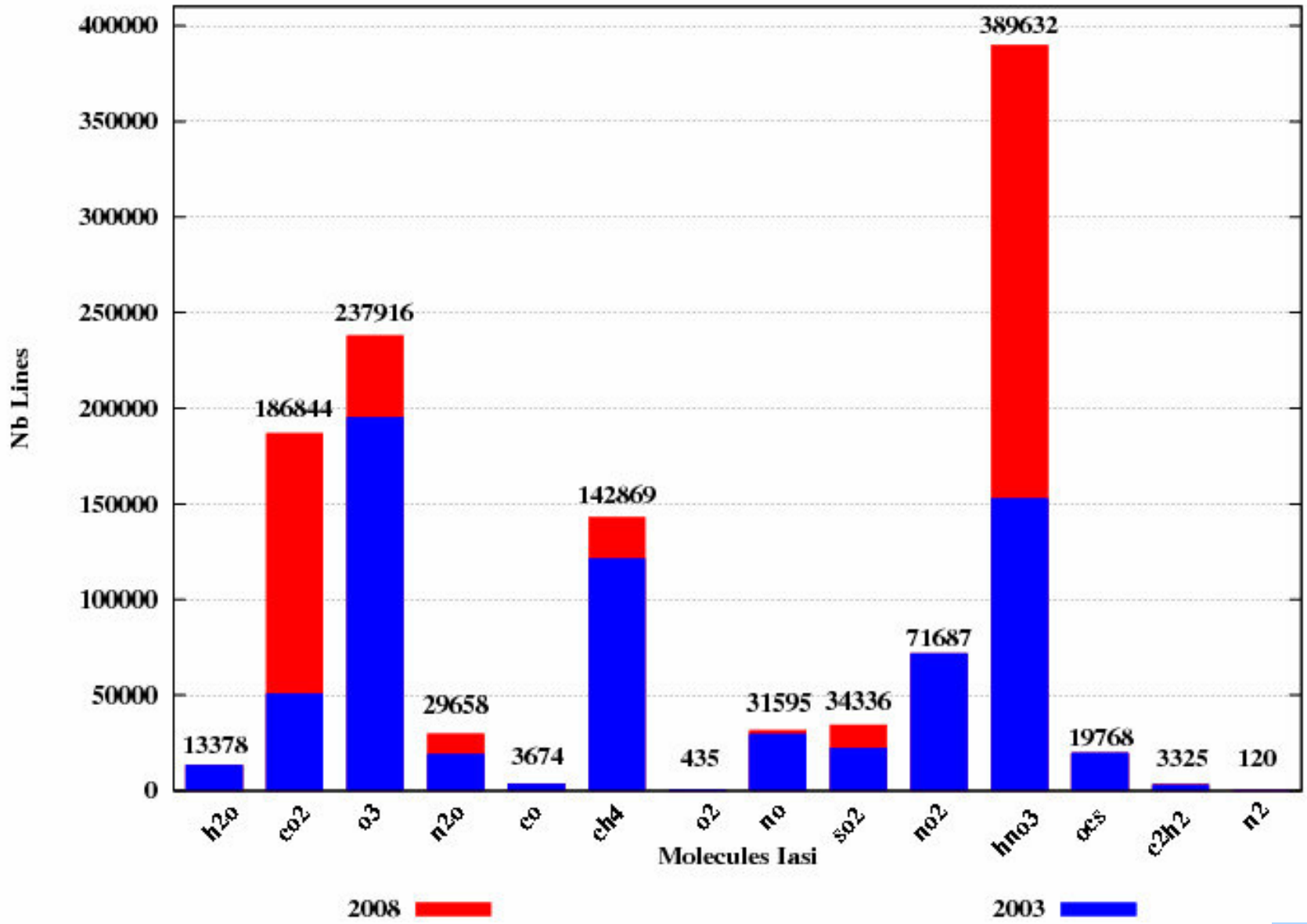
3 Molecules non updated: CO, O_2, OCS

Details of GEISA/IASI-08 Update

MOL. ID	# LINES 2003	# LINES 2008	SPECTRAL RANGE (cm^{-1})	REF.
H_2O	13,278	13,378	599.680794 - 3000.881410	JPL LISA R.A. Toth L. Coudert
CO_2	50,840	186,844	599.003000 - 3000.995510	LTS (CDSD Database) V.I. Perevalov
O_3	195,102	237,916	599.000793 - 3000.983640	GSMA LTS A. Barbe S. Mikhailenko M.R. De Backer
N_2O	18,966	29,658	599.022089 - 2926.296675	JPL R.A. Toth
CH_4 CH_3D	121,281	142,869	599.952535 - 3000.998767	ICB JPL LISA L.R. Brown V. Boudon I. Kleiner
NO	29,608	3,1595	599.088570 - 3000.717430	Denver University A. Goldman
SO_2	22,301	34,336	599.029370 - 2787.860880	LISA J.M. Flaud

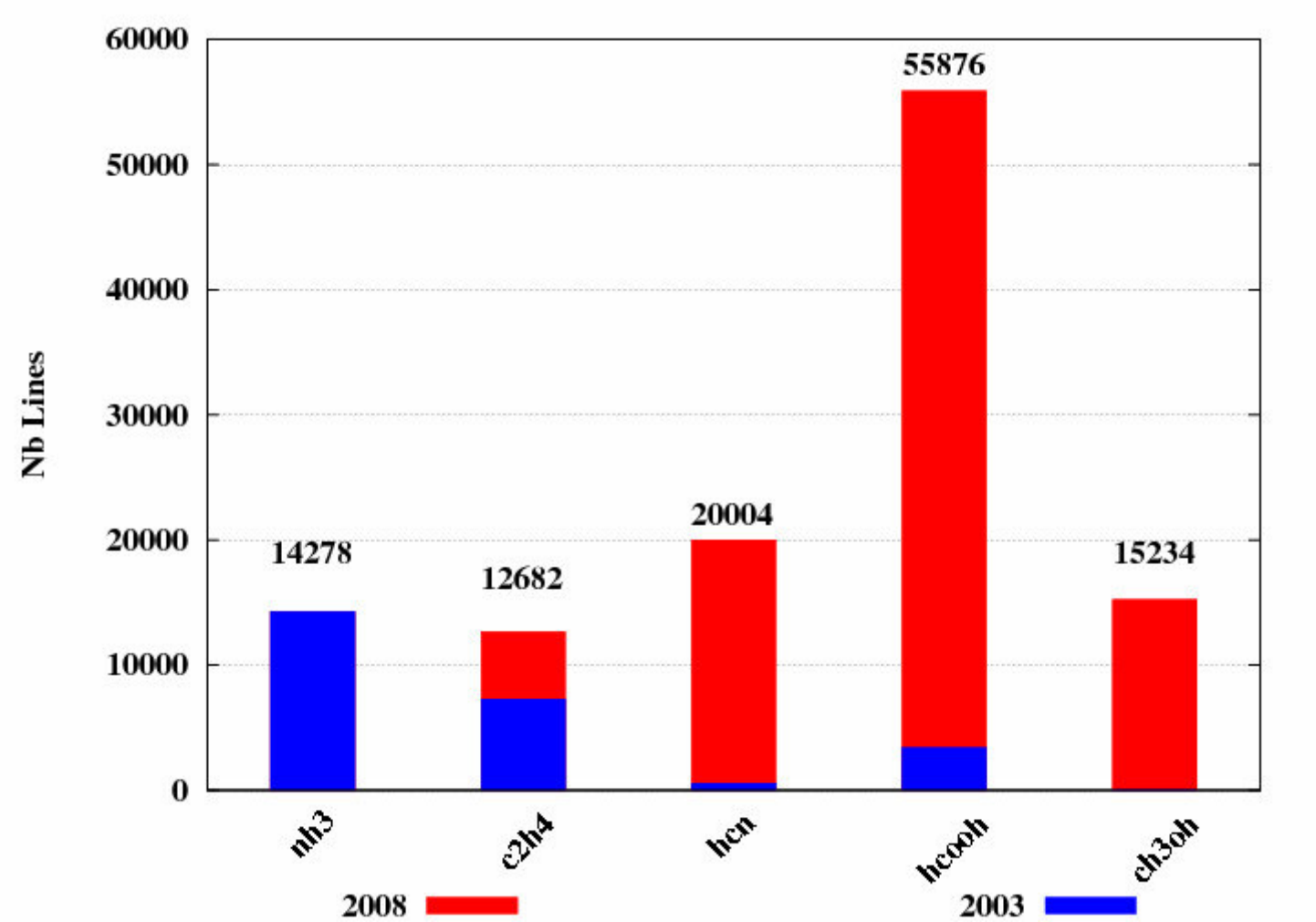
(2009)

Details of GEISA/IASI-08 Update (following)



GEISA/IASI-08 Update (following)

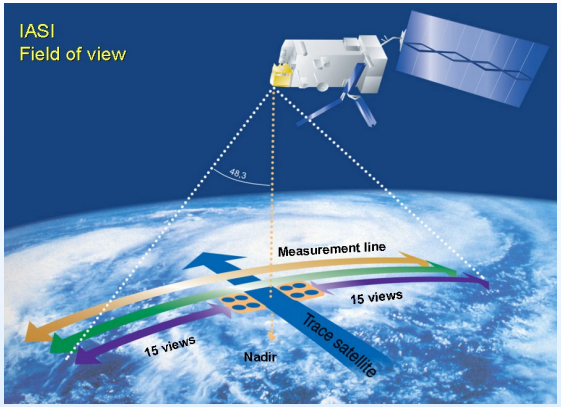
Additionnal Molecular Species in GEISA/IASI-08



GEISA/IASI EFFECTIVE USE

IASI (Infrared Atmospheric Sounding Interferometer) on METOP
(October 19th 2006 launch)

3 Bands
[1] 645-1210 cm^{-1}
[2] 1210-2000 cm^{-1}
[3] 2000-2760 cm^{-1}



Related to

IASI Level 1 Cal/Val activities@ CNES

- **GEISA/IASI (599-3001 cm^{-1}) used as the reference spectroscopic database**
- **Validation achieved using 4A/OP line by line Radiative Transfer Model** [Scott & Chédin, J.Appl.Met (1981); 4A/LMD http://ara.lmd.polytechnique.fr; 4A/OP co-developed by LMD and Noveltis with the support of CNES (2006)]

❖[4] GEISA interactive free distribution

Ether: Welcome - Mozilla

Ether — Centre for Atmospheric Chemistry Products and Services

Atmos. chemistry | Activities | Data/Services | Community | Images

Welcome

Welcome to the Ether website

This website offers various products of French activities in nationals and international projects . The access rights vary according to the products (see "Login Request"). More information ...

Latest news

Site

- SOLSPEC : new data
- ADOMOCA : version 3
- REPROBUS : 2008

Community

- Ether workshop : first call

Your proposal for new Ether activitie

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Original products

- IASI : french activities
- MIMOSA : Potential vorticity and temperature analysis and forecasts in Northern, Southern Hemisphere and Tropics
- NDACC-FRANCE: Network for Detection of Atmospheric Composition Change
- GEISA : spectroscopic data
- REPROBUS : Chemistry Transport Model in Polar winters
- ECCAD : data for emissions calculation
- ARLETTY : temperature and pressure profiles calculation
- Chemical Kinetics Database
- ODIN-SMR : official data and specific production (O3, CO, ...)
- GIRAFE : biomass burning plumes
- SOLSPEC : solar radiation spectrum data

Other products

- Select by Experiment
- Models and Assimilations
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Conclusions from ISSWG-2.1

IASI Sounding Science Working Group Meeting
30 June 2008 - 2 July 2008, CNES, Paris, France

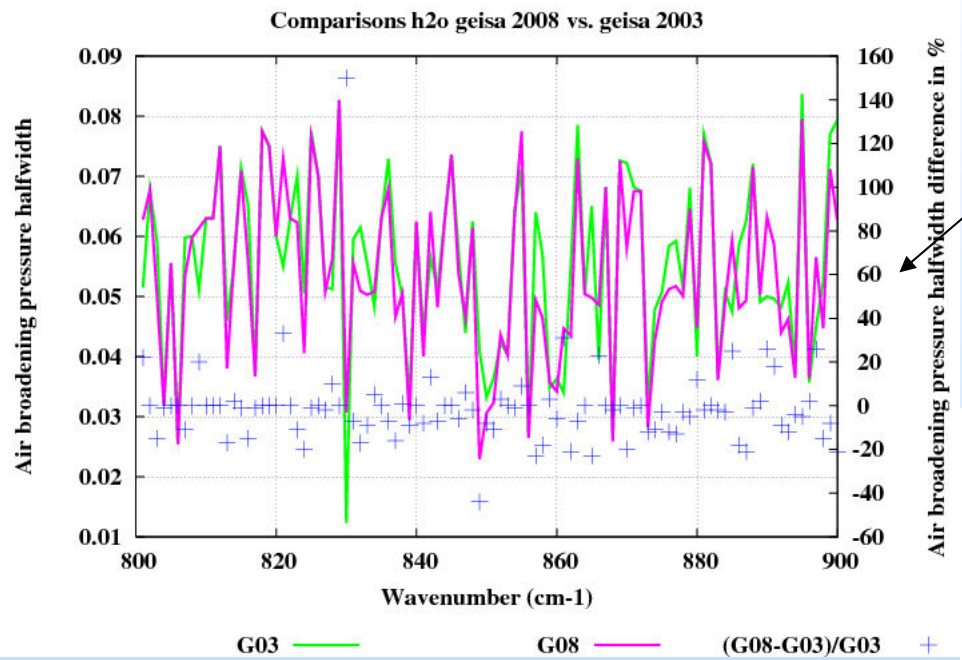
Assessment of spectroscopy for IASI

- **Comparison with HITRAN and GEISA, in particular for water vapour, and real IASI spectra, compared to simulations with ECMWF provided radiosondes, lead to the conclusion that in particular water vapour needs to be validated, and the continuum reinvestigated.**

- **In the discussion urgent areas to investigate were considered to be line coupling, (which should be independent of the data bases) and non LTE.**

- **IASI related spectroscopy problems with H_2O and CO_2 as first priority**

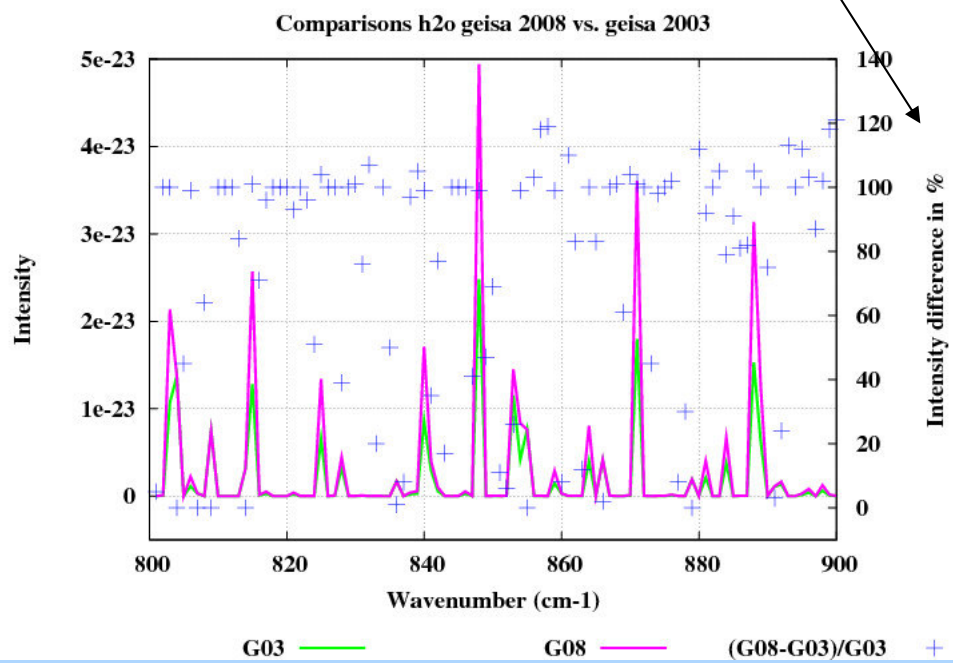
H2O archive Differences in 2003 and 2008



Air broadening pressureHW

and Intensities

differences (%)



- R.A. Toth [JPL) http://mark4sun.jpl.nasa.gov
  Spectral region : 500-8000 cm^{-1}

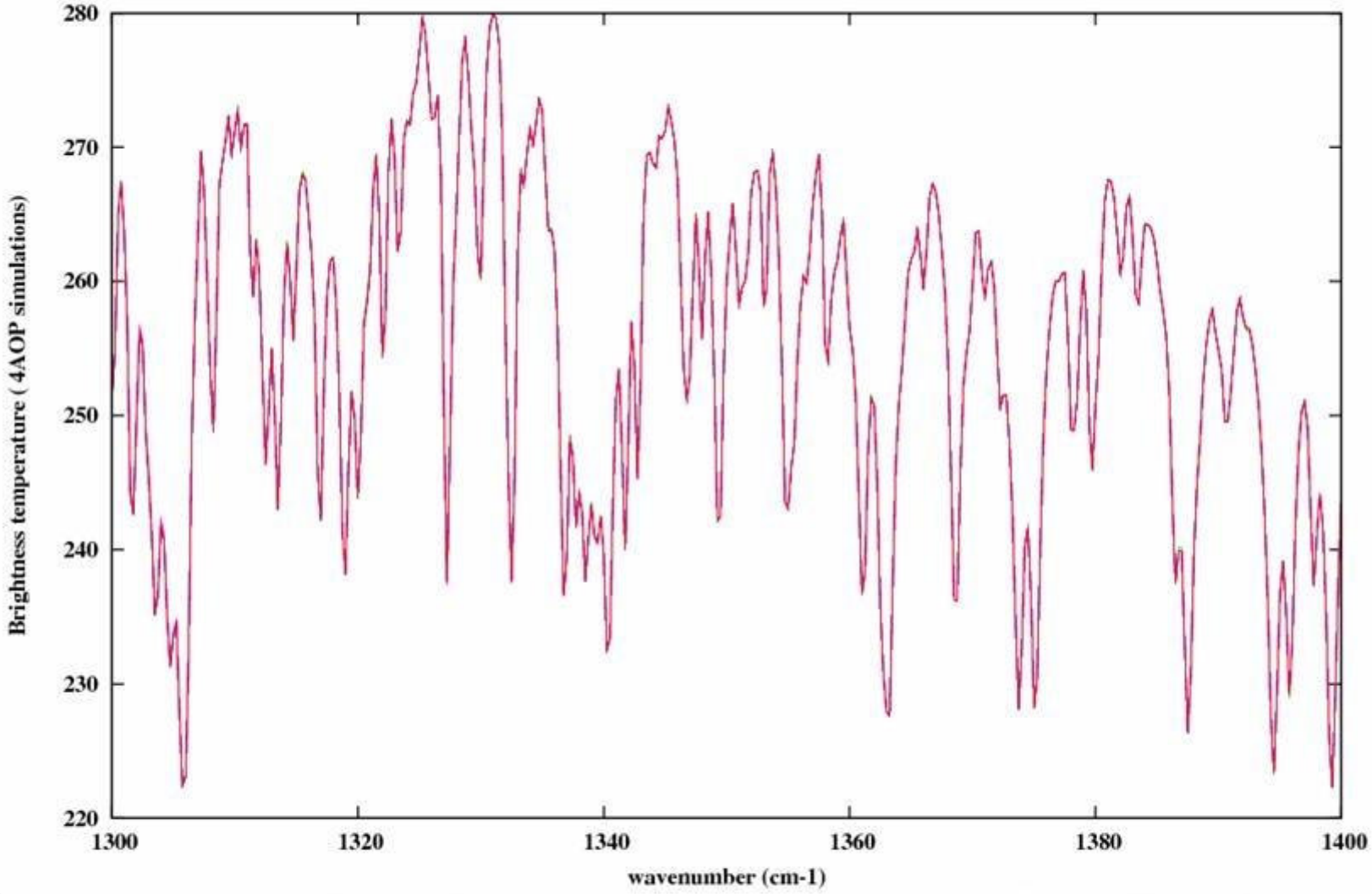
- L. Coudert LISA
  10-2000 cm^{-1} ; principal isotope (161)

Coudert's lines have replaced Toth's if common

Database update Evaluation

Impact evaluation of spectroscopy changes between GEISA/IASI-03 and GEISA/IASI-08

Example with H_2O, N_2O, CH_4 Stransac/4A-OP Brightness Temperatures Modelization (K)



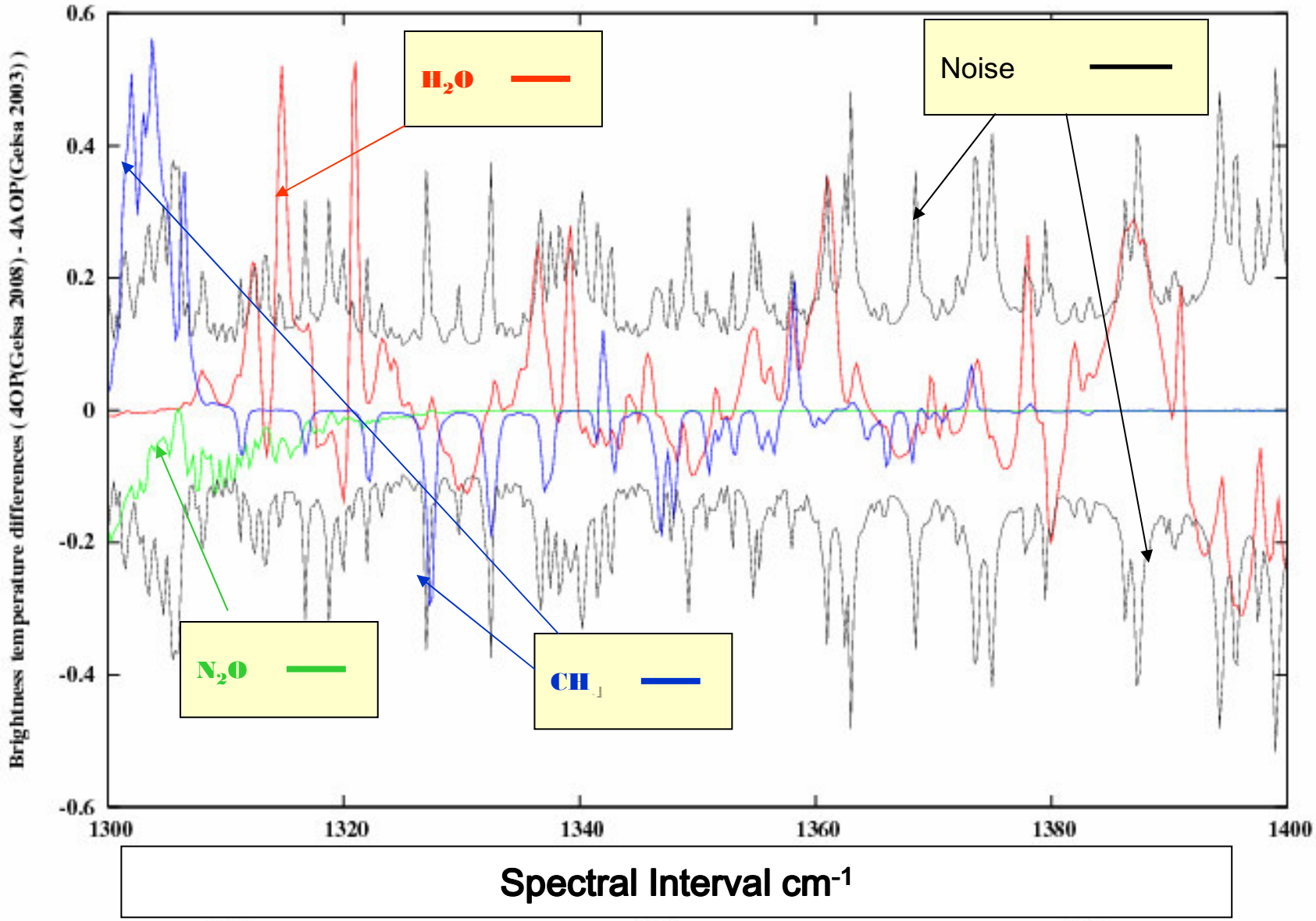
H2O from GEISA-08

N2O from GEISA-08

CH4 from GEISA-08

GEISA-03

Brightness Temperature Differences (K) [4AOP/GEISA-03 -4A-OP/GEISA-08]



❖ [5] Concluding Comments

NECESSARY VALIDATION

And

Assessment of Molecular species related with IASI Trace Gas Retrievals to be considered for addition

HCN
NH3
HCOOH
C2H4
CH3OH

ACKNOWLEDGMENTS

to

CNES, CNRS/INSU and EUMETSAT

for their Encouragements and Supports

THANK YOU FOR YOUR ATTENTION