

A tool for IASI hyperspectral remote sensing applications: The GEISA/IASI database in its latest edition

The screenshot shows the website interface with a search bar at the top. The main content area includes a 'Home' section with a paragraph about the research group's focus on atmospheric variability and modeling. Below this are 'Research themes' with icons for Clouds, Carbon cycle, Aerosols, and Surface properties. The 'Tools' section features icons for Forward RT, Inverse RT, Cal./Val., and Statistical. The 'Databases' section includes icons for Spectroscopy (GEISA), TIGR, ARSA, and Archives. A footer contains logos for CNRS, LMD, and UPMC.

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C. Boutammine,
R. Armante, L. Crépeau,
A. Chédin, N.A. Scott,
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**Laboratoire de Météorologie Dynamique
Atmospheric Radiation Analysis Group/ABC(t)
Ecole Polytechnique
91128 Palaiseau, France**

**GEISA: Gestion et Etude des Informations Spectroscopiques Atmosphériques ;
Management and Study of Atmospheric Spectroscopic Information**

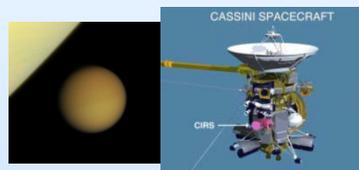
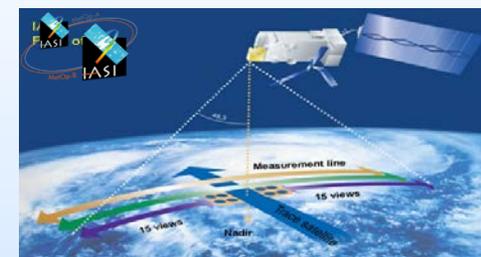
<http://ara.abct.lmd.polytechnique.fr>

OUTLINE

- [1] GEISA SYSTEM GENERAL CONTEXT AND IASI SOUNDING IMPLICATION
- [2] CRITICAL EVALUATION OF SPECTROSCOPIC DATA QUALITY (Examples)
- [3] TOWARDS IASI/NG
- [4] GEISA/IASI INTERACTIVE DISTRIBUTION
- [5] CONCLUDING COMMENTS

[1] GEISA-11 SYSTEM GENERAL CONTEXT

Spectroscopy is at the root of modern planetology, enabling to determine the physical properties of planets remotely



(CASSINI-HUYGENS
29/01/06 TITAN)

Computer-accessible Spectroscopic Database

GEISA

Gestion et Etude des Informations
Spectroscopiques Atmosphériques ;
Management and Study of Atmospheric Spectroscopic Information

spectral range 10^{-6} - $35,877 \text{ cm}^{-1}$
 1010 - $0.28 \text{ }\mu\text{m}$

Line parameters sub-database
3,794,426 entries
50 molecules (111 isotopic species)

Absorption cross-sections sub-database
IR: 39 molecular species
UV/Visible : 17 molecular species

Microphysical and optical properties
of atmospheric Aerosols sub-database

GEISA 2013 UPDATE UNDERWAY

[1] GEISA and IASI Atmospheric Sounding

GEISA/IASI -11 spectral range [599 - 3001] cm^{-1} of GEISA-11

2013 UPDATE UNDERWAY

Reference database for
IASI Level 1 Cal/Val activities and operational
processing @ CNES and @ LMD



❖ Individual spectral lines spectroscopic parameters sub-database

20 molecules (66 isotopic species):

- 14 molecules (53 isotopic species) selected for operational meteorology
 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
- 6 molecules (13 isotopic species) selected for IASI trace gas retrievals
 HCN , NH_3 , HCOOH , C_2H_4 , CH_3OH , H_2CO

❖ 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;
- PAN (peroxyacetyl nitrate)

❖ Microphysical and optical properties of Basic Atmospheric aerosol components sub-database

Validation achieved using 4A/OP line by line Radiative Transfer Model

[Scott & Chédin, J.Appl.Met (1981); 4A/LMD <http://ara.abct.lmd.polytechnique.fr>]

4A/OP co-developed by LMD and Noveltis with the support of CNES (2006)]



42 co-auteurs
16 laboratoires

Journal of Quantitative Spectroscopy &
Radiative Transfer 95 (2005) 429–467



53 co-auteurs
27 Laboratoires

Journal of Quantitative Spectroscopy &
Radiative Transfer 109 (2008) 1043–1059

Journal of
Quantitative
Spectroscopy &
Radiative
Transfer

www.elsevier.com/locate/jqsrt

The GEISA spectroscopic database: Current and future archive for Earth and planetary atmosphere studies

The 2003 edition of the GEISA/IASI spectra

N. Jacquinet-Husson^{a,*}, N.A. Scott^a, A. Chédin^a, K. Gar

N. Jacquinet-Husson^{a,*}, N.A. Scott^a, A. Chédin^a, L. Crépeau^a, R. Armante^a, V. Capelle^a, J. Orphal^b, A. Coustenis^c, C. Boone^d, N. Poulet-Crovisier^d, A. Barbe^c, M. Birk^f, L.R. Brown^g, C. Camy-Peyret^h, C. Claveau^h, K. Chanceⁱ, N. Christidis^j, C. Clackrad^{k,l}, B.F. Colwell^l, V. Dana^j, J. Demoussy^e, M.B. De Bevoise^o

59 co-auteurs
26 laboratoires

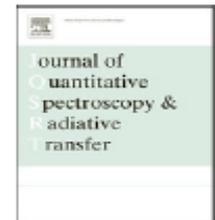
Journal of Quantitative Spectroscopy & Radiative Transfer 112 (2011) 2395–2445



Contents lists available at ScienceDirect

Journal of Quantitative Spectroscopy & Radiative Transfer

journal homepage: www.elsevier.com/locate/jqsrt



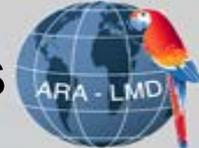
UPDATED IN 2011

2013 UPDATE UNDERWAY

The 2009 edition of the GEISA spectroscopic database

N. Jacquinet-Husson^{a,*}, L. Crepeau^a, R. Armante^a, C. Boutammime^a, A. Chédin^a, N.A. Scott^a, C. Crevoisier^a, V. Capelle^a, C. Boone^d, N. Poulet-Crovisier^d, A. Barbe^c, A. Campargue^d, D. Chris Benner^e, Y. Benilan^f, B. Bézard^g, V. Boudonⁿ, L.R. Brownⁱ, L.H. Coudert^f, A. Coustenis^g, V. Dana^j, V.M. Devi^e, S. Fally^k, A. Fayt^l, J.-M. Flaud^f, A. Goldman^m, M. Hermanⁿ, G.J. Harris^o, D. Jacquemart^p, A. Jolly^f, I. Kleiner^f, A. Kleinböhlⁱ, F. Kwabia-Tchana^p, N. Lavrentieva^q, N. Lacombe^p, Li-Hong Xu^r, O.M. Lyulin^q, J.-Y. Mandin^j, A. Maki^s, S. Mikhailenko^q, C.E. Millerⁱ, T. Mishina^q, N. Moazzen-Ahmadi^t, H.S.P. Müller^u, A. Nikitin^q, J. Orphal^v, V. Perevalov^q, A. Perrin^f, D.T. Petkie^w, A. Predoi-Cross^x, C.P. Rinsland^y, J.J. Remedios^z, M. Rotger^c, M.A.H. Smith^y, K. Sungⁱ, S. Tashkun^q, J. Tennyson^o, R.A. Tothⁱ, A.-C. Vandaele^k, J. Vander Auweraⁿ

[1] Archived Spectroscopic Line Parameters



- A Wavenumber (cm^{-1}) of the line
- B Intensity of the line in ($\text{cm}^{-1}/(\text{molecule}\cdot\text{cm}^{-2})$)
- C Air broadening pressure halfwidth (HWHM)(*) ($\text{cm}^{-1}\text{atm}^{-1}$)
- D Energy of the lower transition level (cm^{-1})
- E Transition quantum identifications for the lower and upper state of the transition
- F Temperature dependence coefficient n of the air broadening HWHM
- G Identification code for isotope as in GEISA
- I Identification code for molecule as in GEISA
- J Internal GEISA code for the data identification
- K Molecule number in HITRAN
- L Isotope number (1=most abundant. 2= second...etc) in HITRAN
- M Einstein A-coefficient (s^{-1}).
- N Self broadening pressure HWHM ($\text{cm}^{-1}\text{atm}^{-1}$) (for water)
- O Air pressure shift of the line transition ($\text{cm}^{-1}\text{atm}^{-1}$)
- 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 ($\text{cm}^{-1}/(\text{molecule}\cdot\text{cm}^{-2})$)
- C' Estimated accuracy on the air collision HWHM ($\text{cm}^{-1}\text{atm}^{-1}$)
- F' Estimated accuracy on the temperature dependence coefficient n of the air broadening HWHM
- O' Estimated accuracy on the air pressure shift of the line transition ($\text{cm}^{-1}\text{atm}^{-1}$)
- R' Estimated accuracy on the temperature dependence coefficient n of the air pressure shift
- N' Estimated accuracy on the self HWHM
- T Self pressure shift of the line transition ($\text{cm}^{-1}\text{atm}^{-1}$)
- T' Estimated accuracy on the self pressure shift of the line transition ($\text{cm}^{-1}\text{atm}^{-1}$)
- U Temperature dependence coefficient n of the self pressure shift
- U' Estimated accuracy on the temperature dependence coefficient n of the self pressure shift broadened HWHM ($\text{cm}^{-1}\text{atm}^{-1}$)
- S Temperature dependence coefficient n of the self broadening HWHM
- S' Estimated accuracy on the temperature dependence coefficient n of the self- broadening

(*) HWHM: line half-width at half-maximum



[2] CRITICAL EVALUATION OF SPECTROSCOPIC DATA QUALITY (Examples)

Selected molecules:

[2-a] H_2O *GEISA-11 and HITRAN-08 comparison*

[2-b] CH_4 (including CH_3D) *GEISA-11 and GEISA-03*

[2] Critical Evaluation of Spectroscopic Data Quality

Evaluation of the impact of H₂O spectroscopic archive on IASI radiative transfer modelling

❖ Radiative transfer simulations with ARA/ABC(t)/LMD radiative transfer models in their latest versions

➤ **STRANSAC**; line-by-line and layer-by-layer model
[N.A. Scott, 1974, JQSRT, 14, 691-707]

➤ **4A** (Automatized Atmospheric Absorption Atlas); fast and accurate line-by-line radiative transfer model
[N.A. Scott and A. Chédin, 1981, J. Appl. Meteor., 20, n° 7, 802-812; Tournier et al. 1995; Chéruey et al. 1995]

❖ Selected Spectroscopic Databases

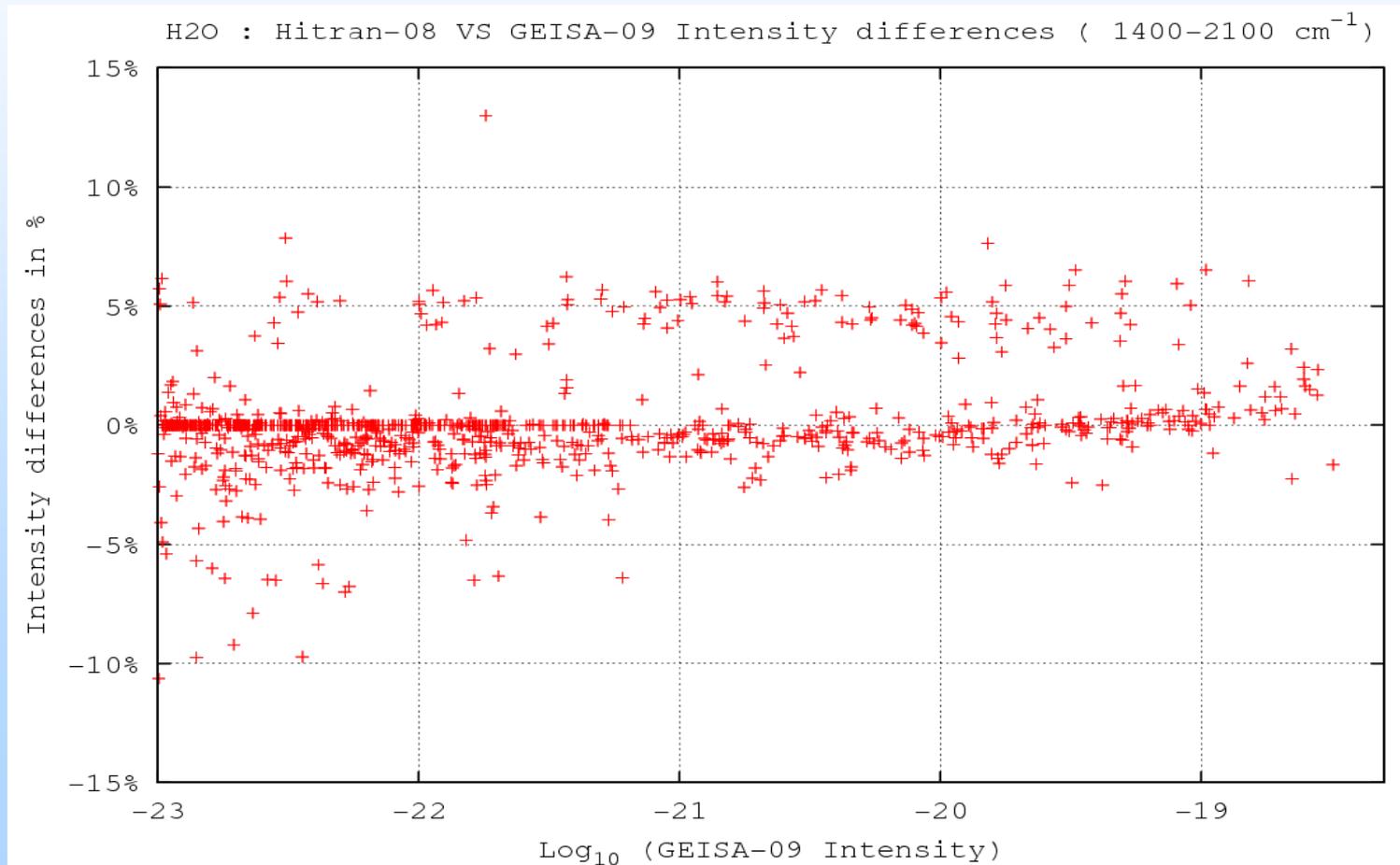
GEISA [Jacquinet-Husson N. et al. JQSRT 112 (2011) 2395-2445] Revision 2011 of this reference

HITRAN [Rothman L.S. et al. JQSRT 110 (2009) 533-572] its latest revision

Differences in spectroscopic parameters archives and subsequent IASI radiative transfer modelling, in terms of Brightness Temperature (K) differences ΔBT (K)

[2] Quantitative comparison between H₂O intensity values in GEISA-11 and HITRAN-08

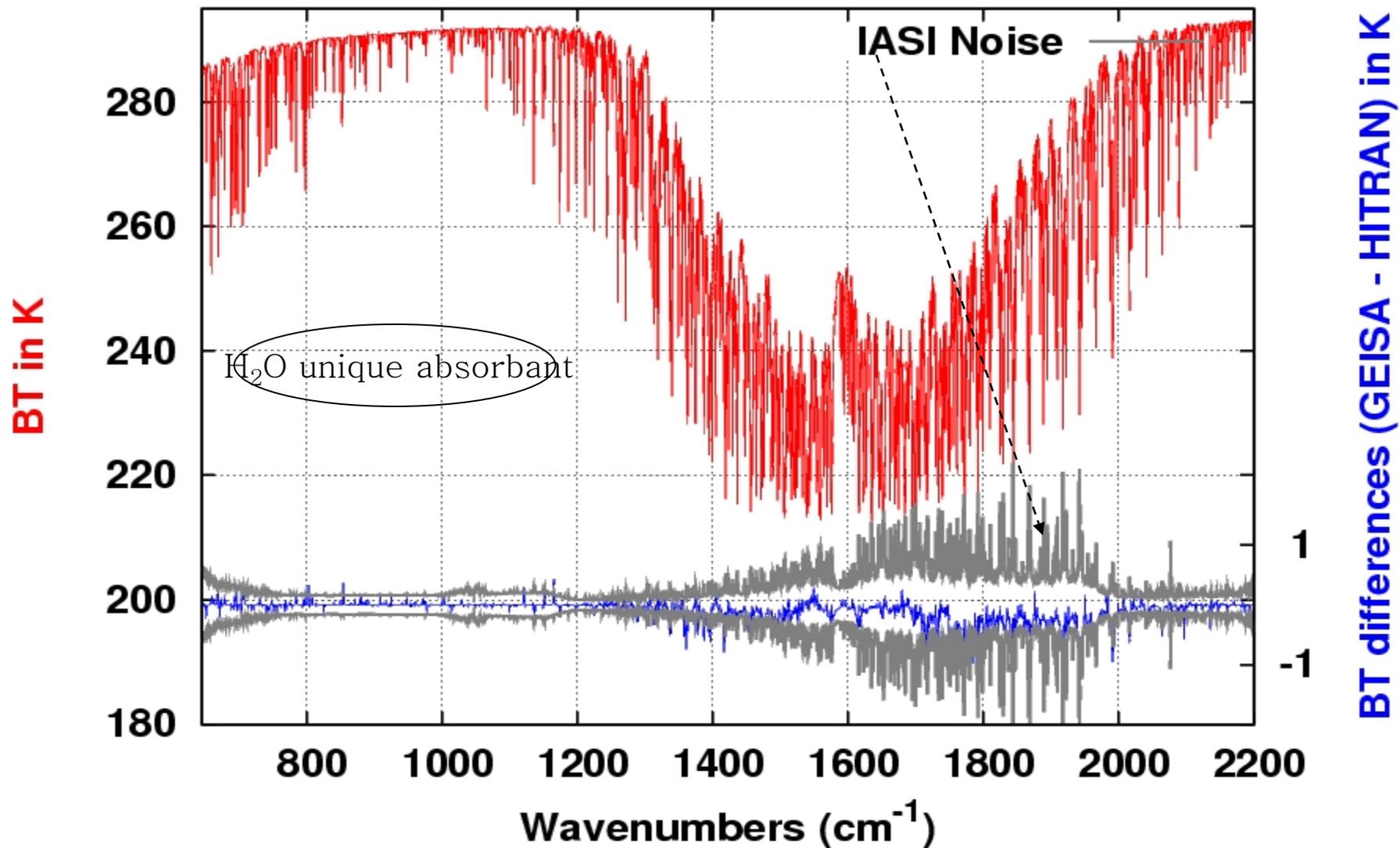
- spectral range 1400 – 2100 cm⁻¹
- 5626 transitions with common quantum identification in both databases (intensity values larger than 10⁻²³ cm⁻¹/(molecule cm⁻²))
- 8% of the strong lines (intensities greater or equal 10⁻²⁰ cm⁻¹/(molecule cm⁻²)) exhibit differences greater than 5%.



[2-a] H₂O Spectroscopy Differences Illustration

IASI brightness temperature BT (K) simulation with GEISA

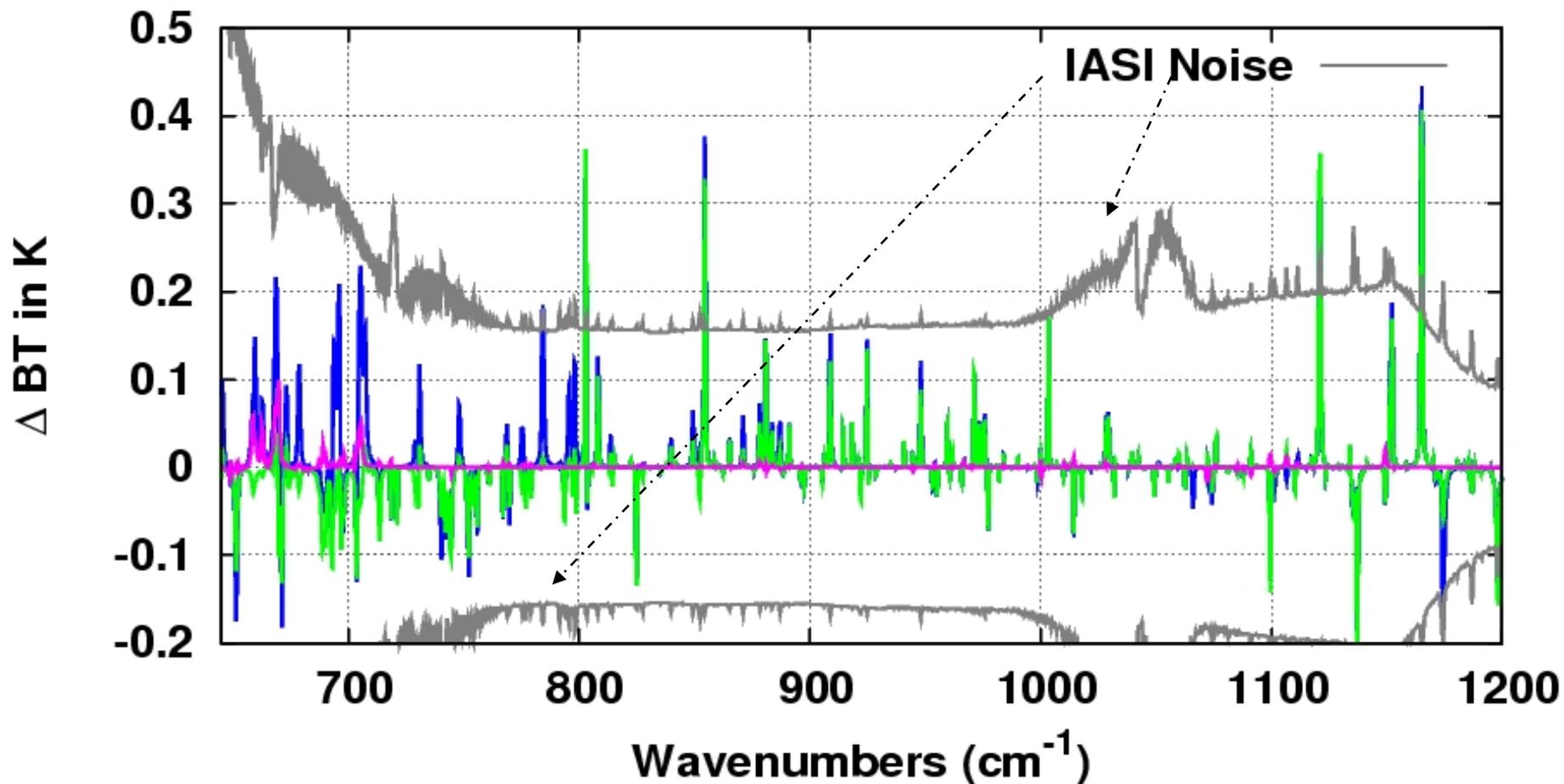
Differences in BT(K) using GEISA or HITRAN



[2-a] Evaluation of spectroscopic parameters individual impact on IASI BT modelling differences

IASI Band 1 (15.50 – 8.26 μm)

Intensity impact evaluation



— $\text{TB}_G - \text{TB}_H$

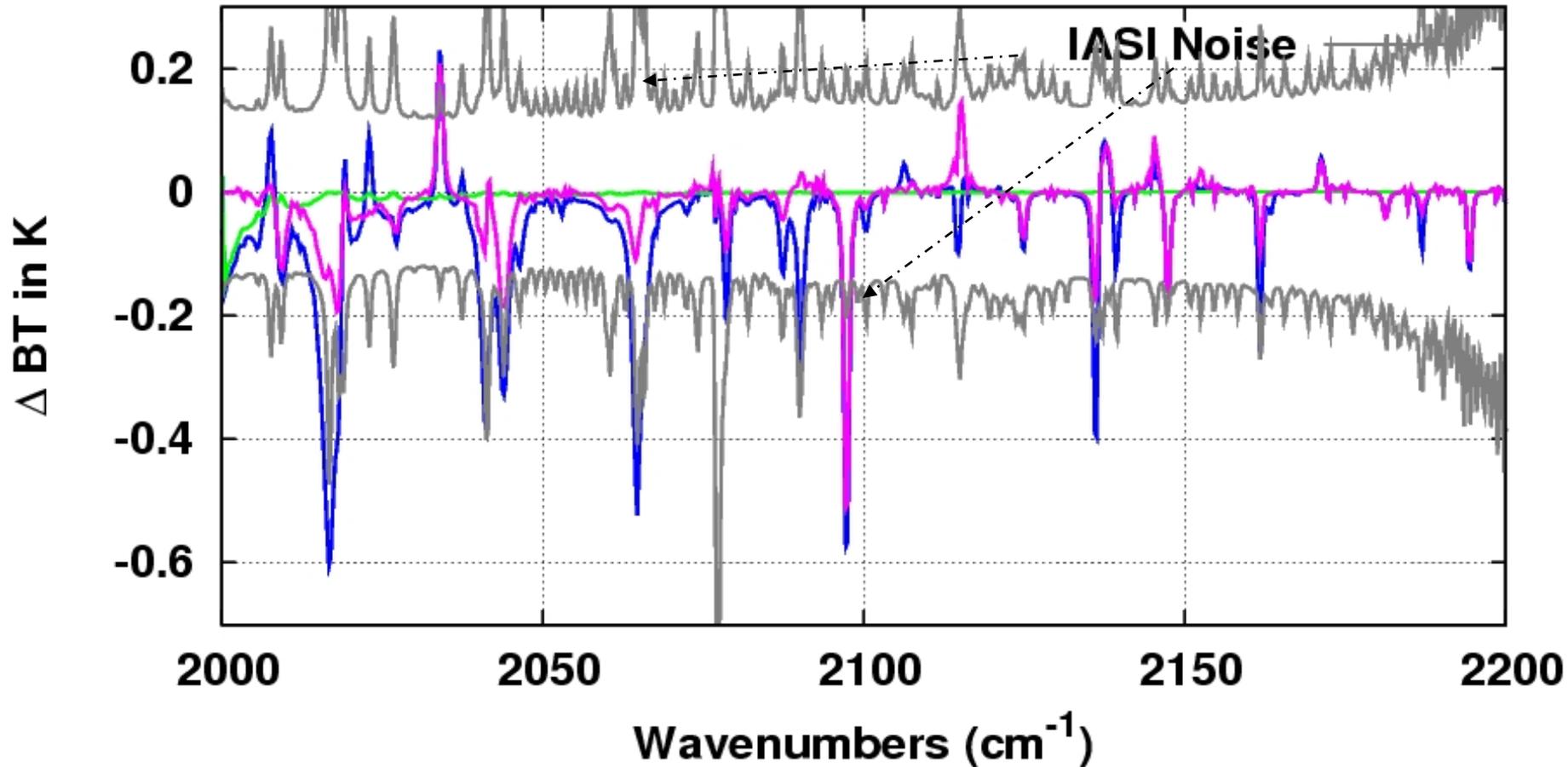
— $\text{TB}_G - \text{TB}_G \text{ with H intensities}$

— $\text{TB}_G - \text{TB}_G \text{ with H HWHM}$

[2-a] Evaluation of spectroscopic parameters individual impact on IASI BT modelling differences

IASI Band 3 (15.50 – 8.26 μm)

FWHM impact evaluation



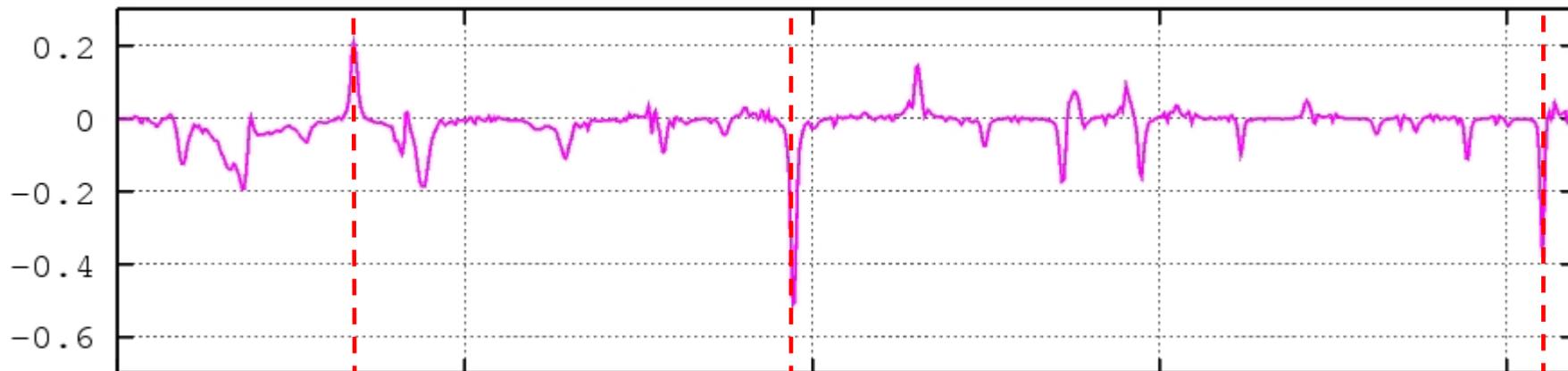
— $\text{TB}_G - \text{TB}_H$

— $\text{TB}_G - \text{TB}_G$ with H intensities

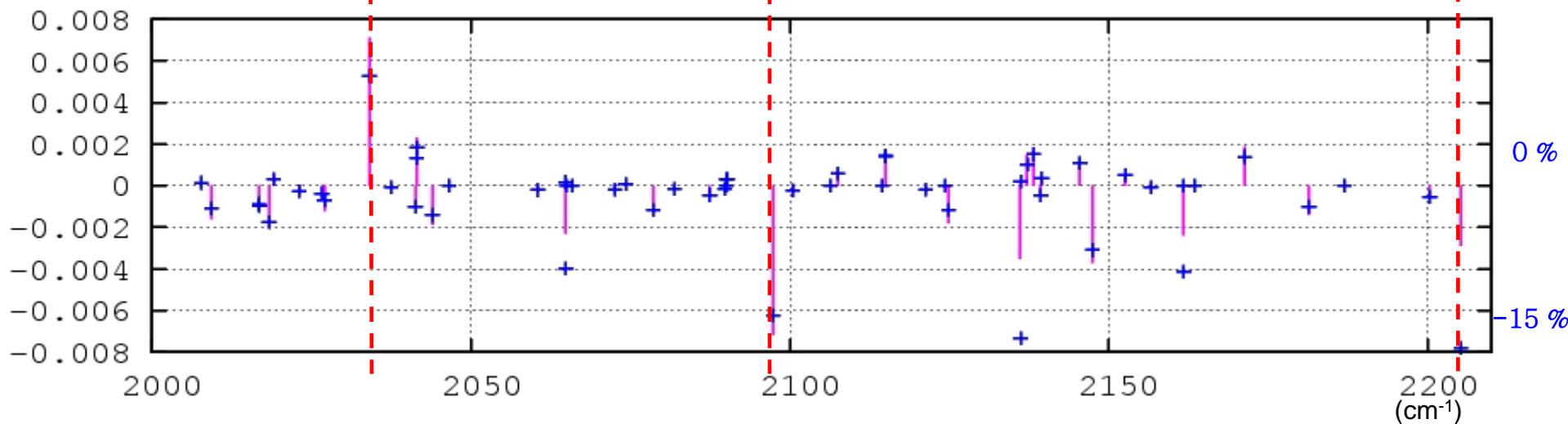
— $\text{TB}_G - \text{TB}_G$ with H FWHM

[2-a] H₂O Spectroscopy Differences Illustration

(K) H₂O : Δ BT [GEISA - GEISA with HWHM from HITRAN]



(cm⁻¹atm⁻¹ at 296 K) H₂O : Content differences for HWHM [GEISA - HITRAN]

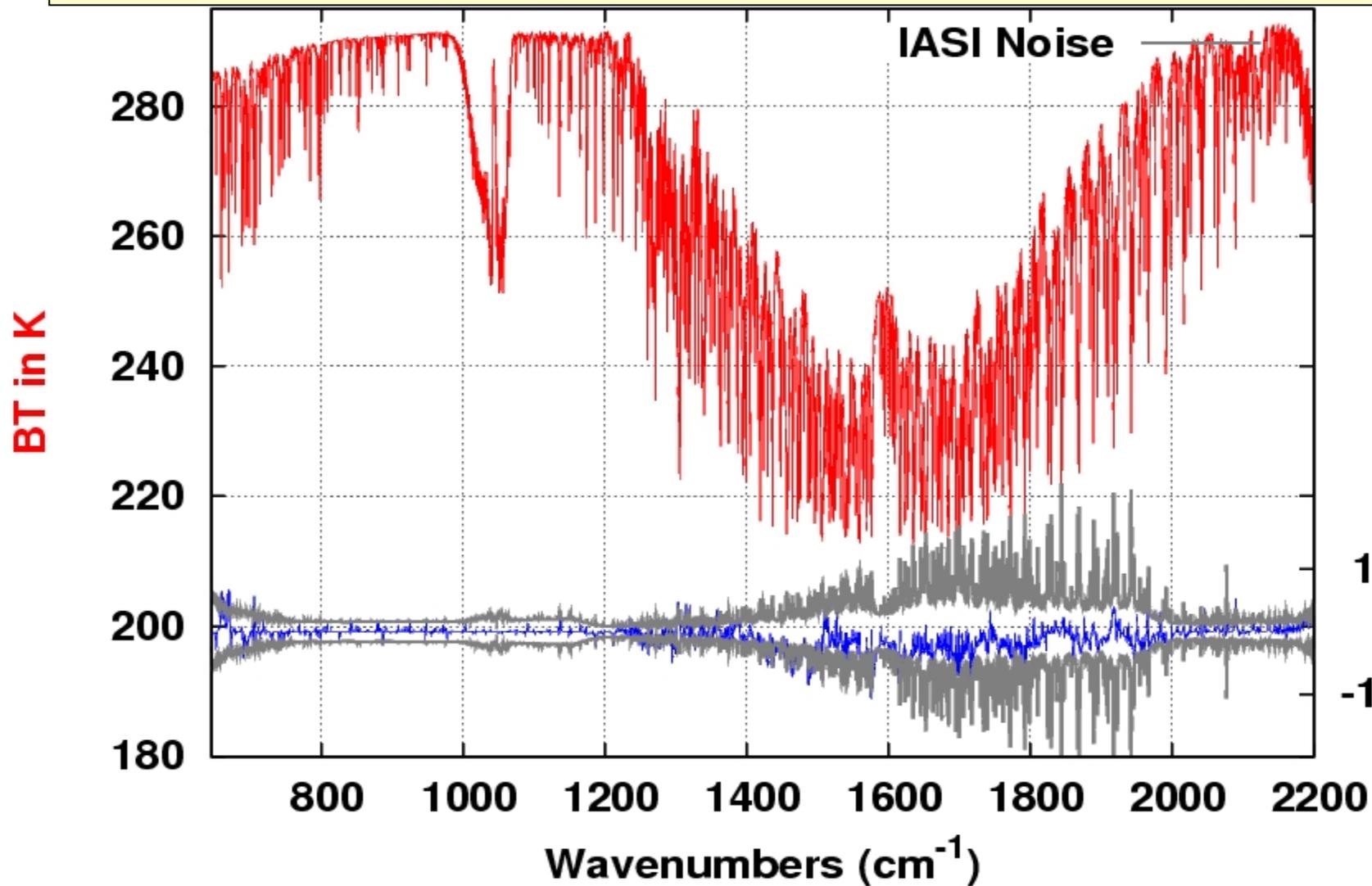


For GEISA and HITRAN common lines with intensities $> 10^{-23}$ cm⁻¹/(molecule cm⁻²) at 296 K

[2-b] CH₄ Spectroscopy Differences Illustration

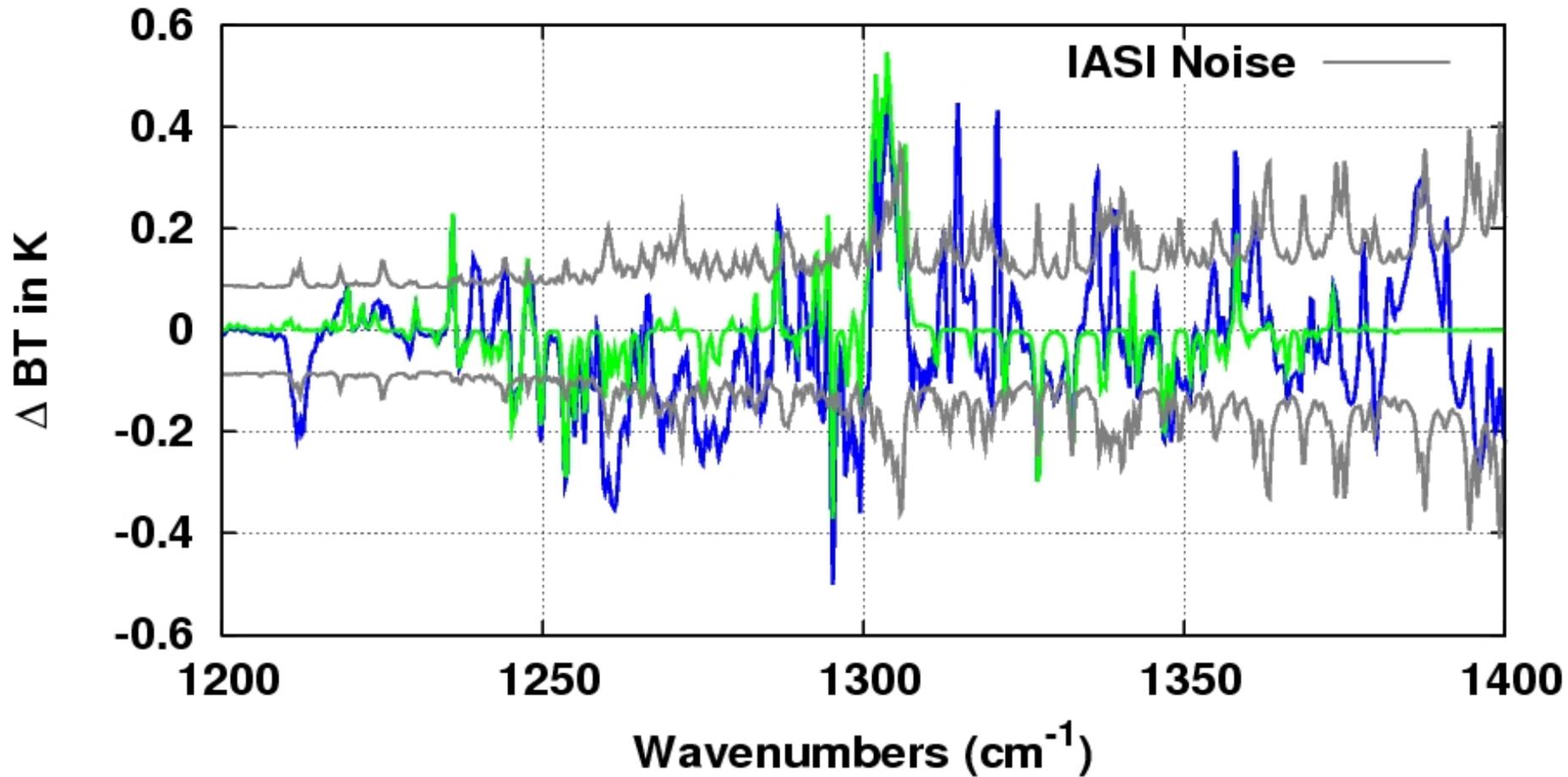
IASI brightness temperature BT (K) simulation with GEISA : H₂O, O₃, O₂, CO, CH₄ and N₂O

Differences in BT(K) using GEISA 2011 and GEISA 2003



BT differences (GEISA 2011 - GEISA 2003) in K

[2-b] Impact evaluation of CH₄ update on IASI BT modelling differences (1)



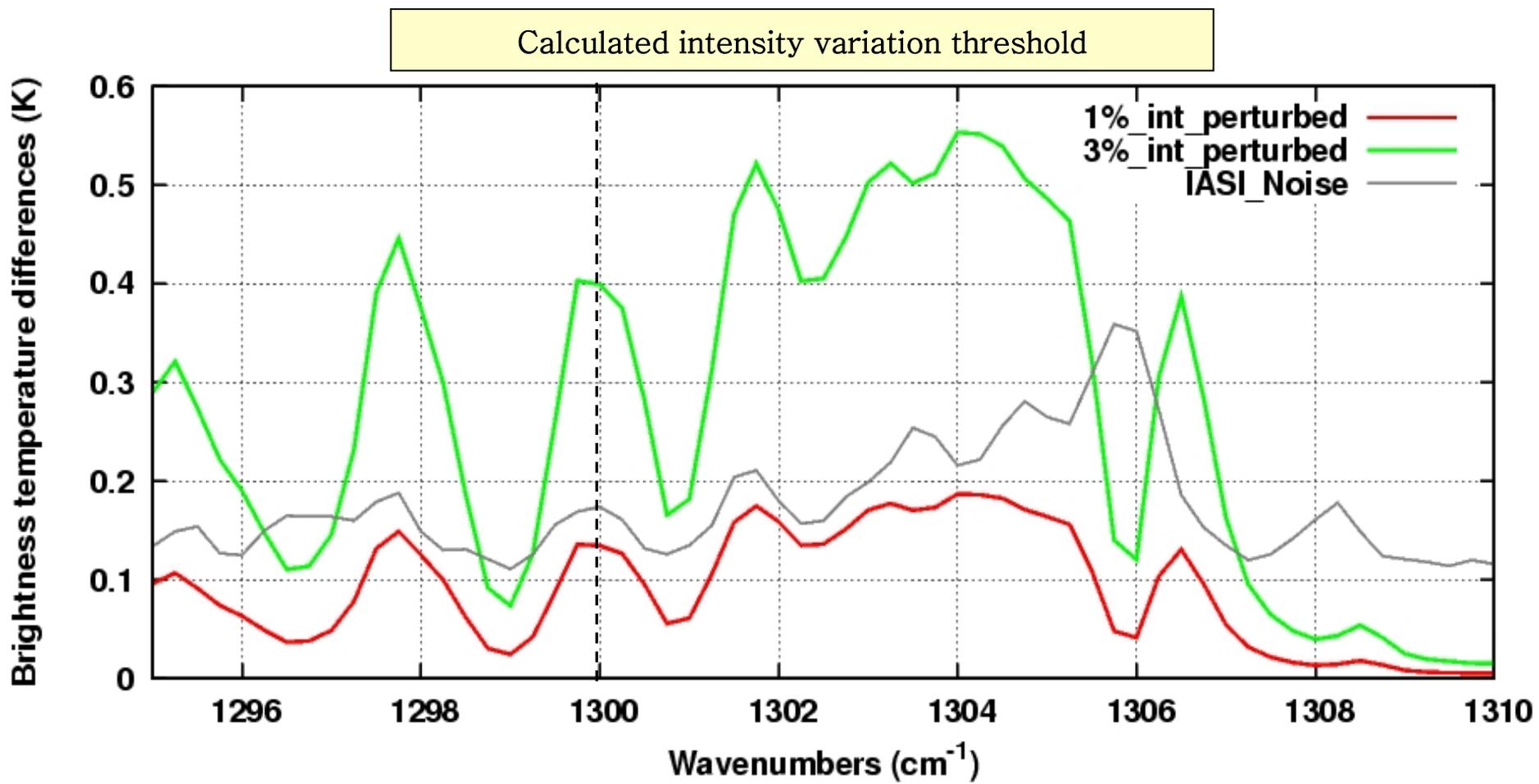
— $TB_{G11} - TB_{G03}$

— $TB_{G11} - TB_{G11 \text{ with } G03 \text{ CH}_4}$

— IASI Noise

[2-b] Impact evaluation of CH₄ update on IASI BT modelling differences (2)

Comparison of intensity perturbations impact with IASI noise

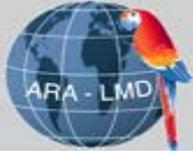


— ΔTB CH₄ int + 1%

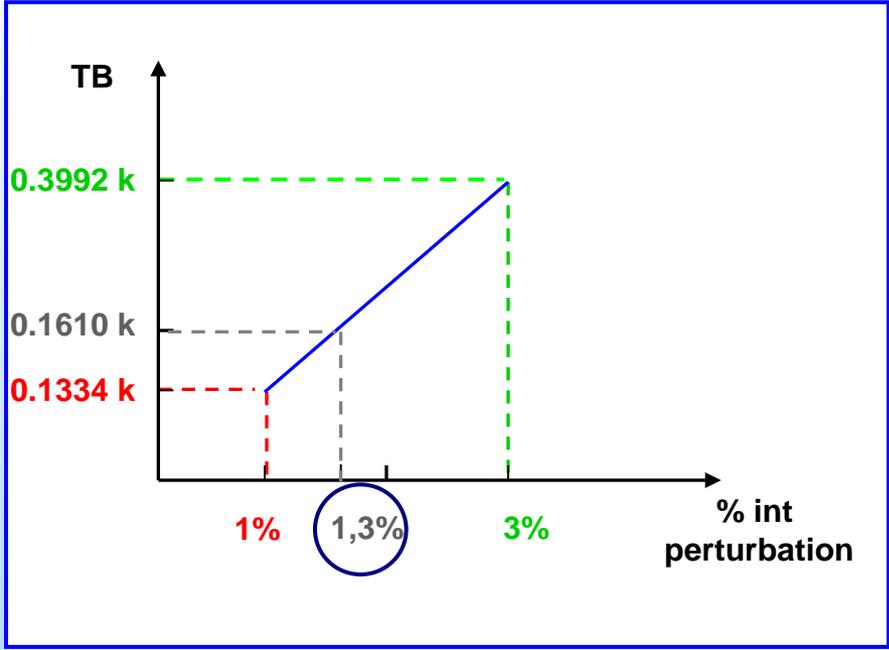
— ΔTB CH₄ int + 3%

— IASI Noise

[2-b] Calculated intensity variation threshold

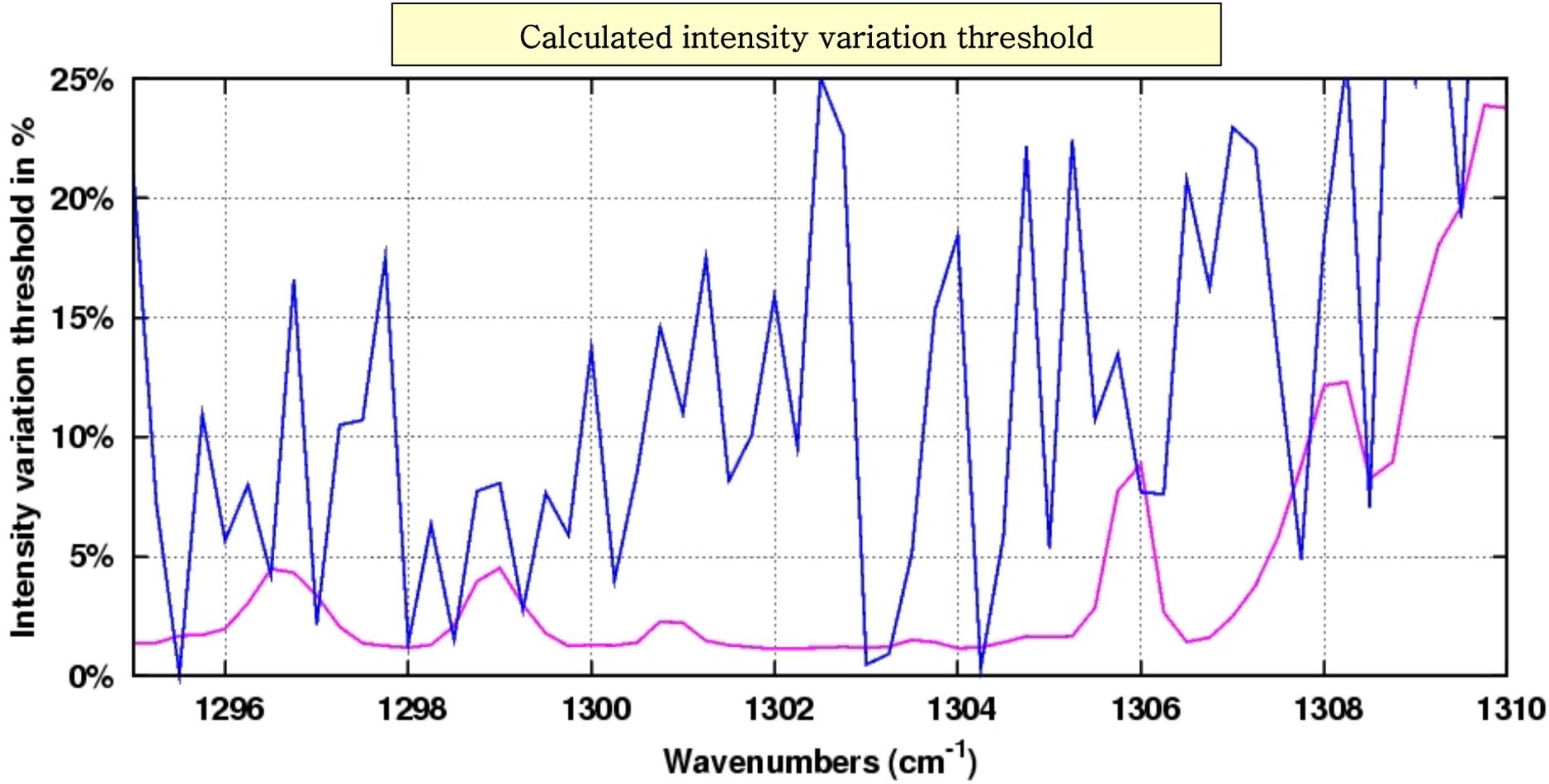


- Wavenumber = 1300 cm⁻¹
- For 1% intensity perturbed => $\Delta TB = 0.1334$ K
- For 3% intensity perturbed => $\Delta TB = 0.3992$ K
- Noise = 0.1610 K
 - => ?? % intensity perturbation.



[2-b] Impact evaluation of CH₄ update on IASI BT modelling differences (3)

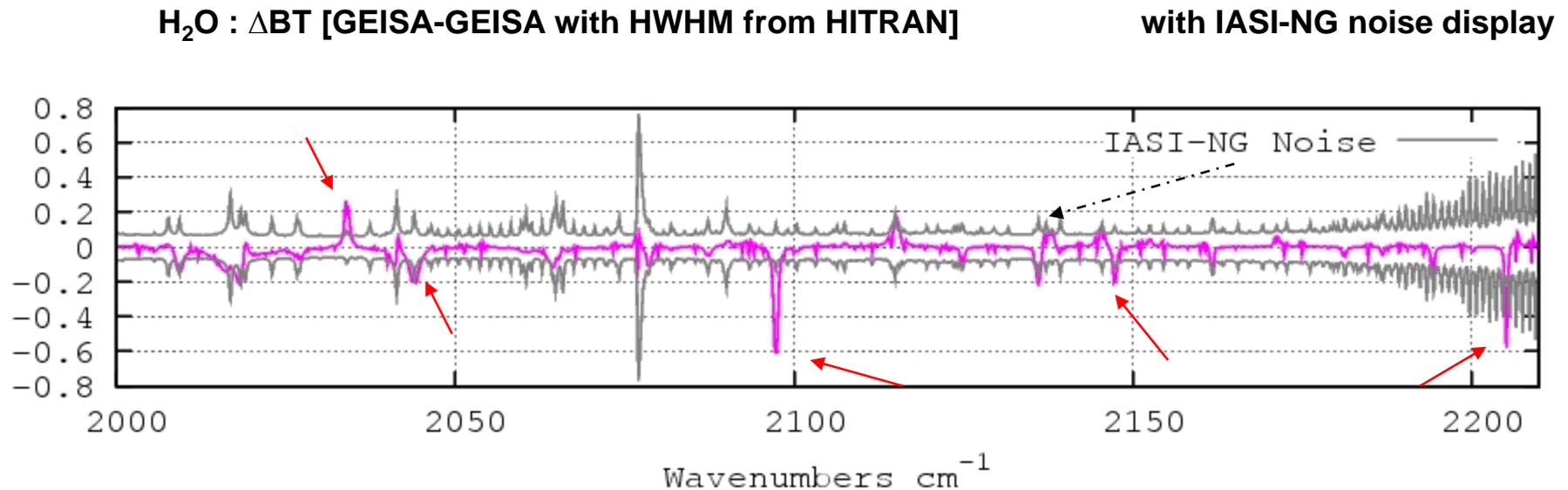
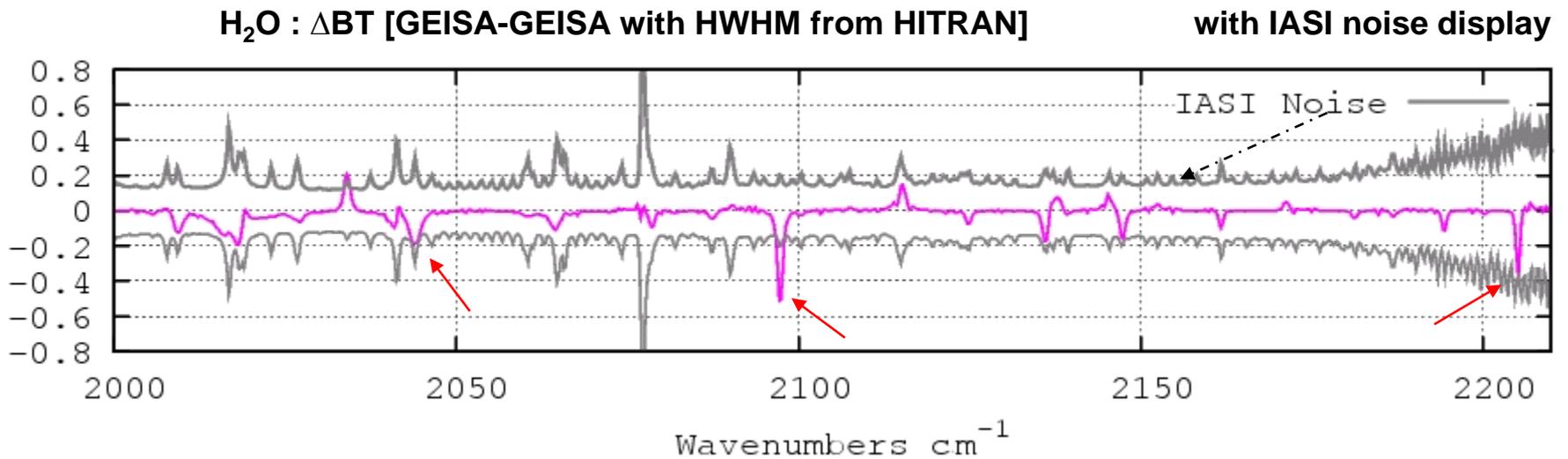
Comparison of intensity perturbations impact with IASI noise



Intensity variation threshold in %
ΔTB CH₄ int + 1%
ΔTB CH₄ int + 3%
Intensity differences (G11-G03) in %

[3] TOWARDS IAS/NG

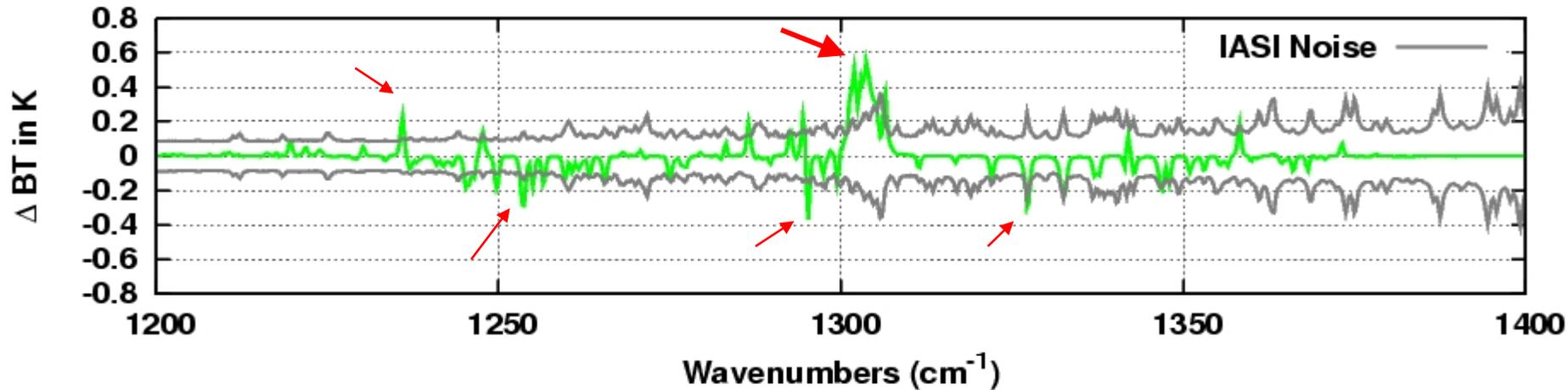
[3-a] H₂O Spectroscopy Differences Illustration



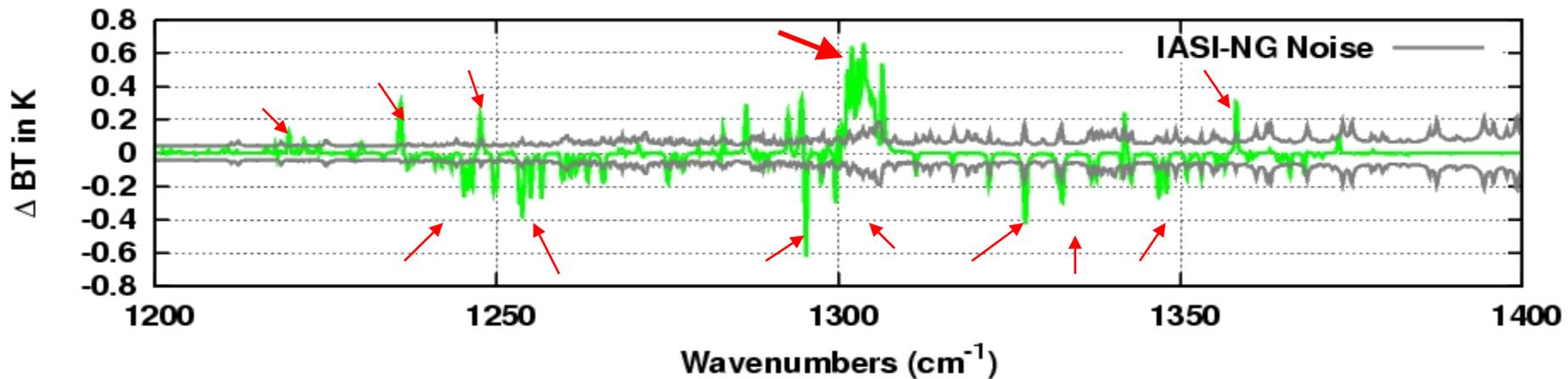
For IASI-NG: Spectral Resolution X 2 and Noise divided by 2 comparing with IASI

[3-b] CH₄ Spectroscopy Differences Illustration

ΔBT [GEISA 2011-GEISA 2011 with CH₄ from GEISA 2003] with IASI noise display



ΔBT [GEISA 2011-GEISA 2011 with CH₄ from GEISA 2003] with IASI-NG noise display



For IASI-NG: Spectral Resolution X 2 and Noise divided by 2 comparing with IASI

[4] GEISA/IASI INTERACTIVE DISTRIBUTION

**Ether Atmospheric Chemistry Data Centre
CNES/CNRS/IPSL**

<http://www.pole-ether.fr>

Close cooperation with Cathy Boone and Nathalie Poulet-Crovisier

[4] GEISA SYSTEM COMPREHENSIVE DISTRIBUTION



Atmospheric Chemistry

Data Centre

<http://www.pole-ether.fr>

Home

News

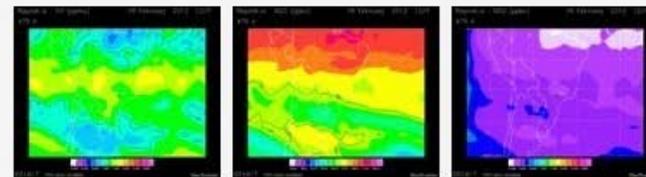
September 2012 : Année N° newsletter

Project call

15, 16 October 2012 : Ether users committee meeting

26 November 2012 : Ether steering committee meeting

2012-2013 : Ether users committee meeting



Reprobus map for the TRO-pico campaign 475K

↓ Atmospheric Data

- Satellites - Balloons - NDACC - ECCAD - IASI - GOSAT - IAGOS

Satellites



Balloons



NDACC



ECCAD



IASI



GOSAT



IAGOS



→ Field Campaigns

- TROpico - Megapoli - Enriched - StrapolEte

→ Daily Modelisation and Forecast

- Mimosa - Reprobus - Acomida

↓ Spectroscopic data and Kinetics

- GEISA - Kinetics

GEISA



Kinetics



GEISA : ETHER distribution Home page



Descriptions of updates and changes related to GEISA

GEISA data archives and facility tools

HOME

Adequate tools are required to perform reliable radiative transfer modelling calculations to meet the needs of communities involved in understanding the atmospheres of the Earth and other planets. Among these tools compilations of spectroscopic parameters are used for a vast array of applications and especially for planetary atmospheric research. There is an acute need for comprehensive, trustworthy and operational interactive spectroscopic databases to benefit the research community. In this context, since over three decades, the ARA (Atmospheric Radiation Analysis) group at LMD (Laboratoire de Météorologie Dynamique) has developed GEISA (Gestion et Etude des Informations Spectroscopiques Atmosphériques: Management and Study of Atmospheric Spectroscopic Information) a computer accessible database system [Chédin et al. (1982), Husson et al. (1992), Jacquinet-Husson et al. (1999, 2008, 2011)]. The forward, calculations of atmospheric radiative transfer using a line-by-line and (atmospheric) layer-by-layer approach. This effort has proven to be beneficial to the atmospheric scientific community participating in direct and inverse radiative transfer studies.

Visualization tools for line by line database content "NEW"

The role of molecular spectroscopy in modern atmospheric research has entered a new phase with the advent of highly sophisticated spectroscopic instruments and computers. For example, the performance of Earth atmospheric sounders like AIRS, in the USA, and IASI in Europe, which have a better vertical resolution and accuracy, compared to the previous existing satellite infrared vertical sounders, is directly related to the quality of the spectroscopic parameters of the optically active gases, since these are essential input in the forward models used to simulate recorded radiance spectra. Consequently, a strong demand exists for highly comprehensive, well validated, efficiently operational, and desirably interactive computer-based spectroscopic databases to benefit the research in direct and inverse radiative transfer.

Databases access and description content.



In this purpose, GEISA is currently involved in activities related to the assessment of the capabilities IASI through the GEISA/IASI database, extensively described in Jacquinet-Husson et al. (2005). Since the METOP European polar satellite launch (October 19th 2006), GEISA-IASI is the reference spectroscopic database for the validation of the level-1 IASI data, using the 4A (Automatized Atmospheric Absorption Atlas) radiative transfer model [Scott (1974), Scott and Chédin (1981); 4A/LMD; 4A/OP co-developed by LMD and Noveltis with the support of CNES].

GEISA publications list

GEISA PUBLICATIONS



GEISA : ETHER distribution Database access page

GEISA09 Lines : Database Content

Information

Main information of the database to identify for each molecule, the different isotopologues and the corresponding number of lines between a *Lower Bound* : NU1 (cm^{-1}) and an *Upper Bound* : NU2 (cm^{-1}) with a *sampling step* : DNU (cm^{-1}).

Content analysis

Quick analysis of the database contents in any selected spectral range between a *Lower Bound* : NU1 (cm^{-1}) and an *Upper Bound* : NU2 (cm^{-1}) with a *sampling step* : DNU (cm^{-1}). Default value for sampling step: DNU= NU2-NU1; only one analysis between NU1 and NU2.

Histogram analysis

Plots of intensity (field B) and/or ground level (field D) histograms for one isotope of a given molecule, in any selected spectral range between a *Lower Bound* : NU1 (cm^{-1}) and an *Upper Bound* : NU2 (cm^{-1}), with a *sampling step* : DNU (cm^{-1}). Default value for sampling step : DNU= NU2-NU1 : only one series of histograms between NU1 and NU2. No isotope specification means considering all the isotopes of the molecule.

Database extract

Extraction of the database contents in any selected spectral range between a *Lower bound* : NU1 (cm^{-1}) and an *Upper Bound* : NU2 (cm^{-1}) for one or more molecule(s) and isotope(s). Extraction of all the isotopes of a molecule if no isotope specification.

Transition analysis

Extraction of a set of vibro-rotational transitions involved in a specified vibrational transition of one given molecule and a choice of its isotopologues (one or more), in any selected spectral range between a *Lower Bound* : NU1 (cm^{-1}) and an *Upper Bound* : NU2 (cm^{-1}).

Transition list

Complete description of existing vibrational transitions in any selected spectral range between a *Lower bound* : NU1 (cm^{-1}) and an *Upper Bound* : NU2 (cm^{-1}) for one or more molecule(s).

INTERACTIVE TOOLS

3 Sub-databases :

- Line by line
- Cross sections
- Aerosols

Line by line sub-database :

- Content description
 - General content
 - Format description
 - Overall description
- Data access (FTP)
- Data access (Interactive)
 - Information
 - Content analysis
 - Histogram analysis
 - Database extract
 - Transition analysis
 - Transition list

GEISA : ETHER distribution Graphical Tools

HOME

GEISA data archives and facility tools



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GEISA publications list

GEISA PUBLICATIONS

- HOME
- What's new ?
- Graphical tool ^(new)
- GEISA 2011
- GEISA 2003
- GEISA-IASI 2011
- GEISA-IASI 2003

[5] CONCLUDING COMMENTS

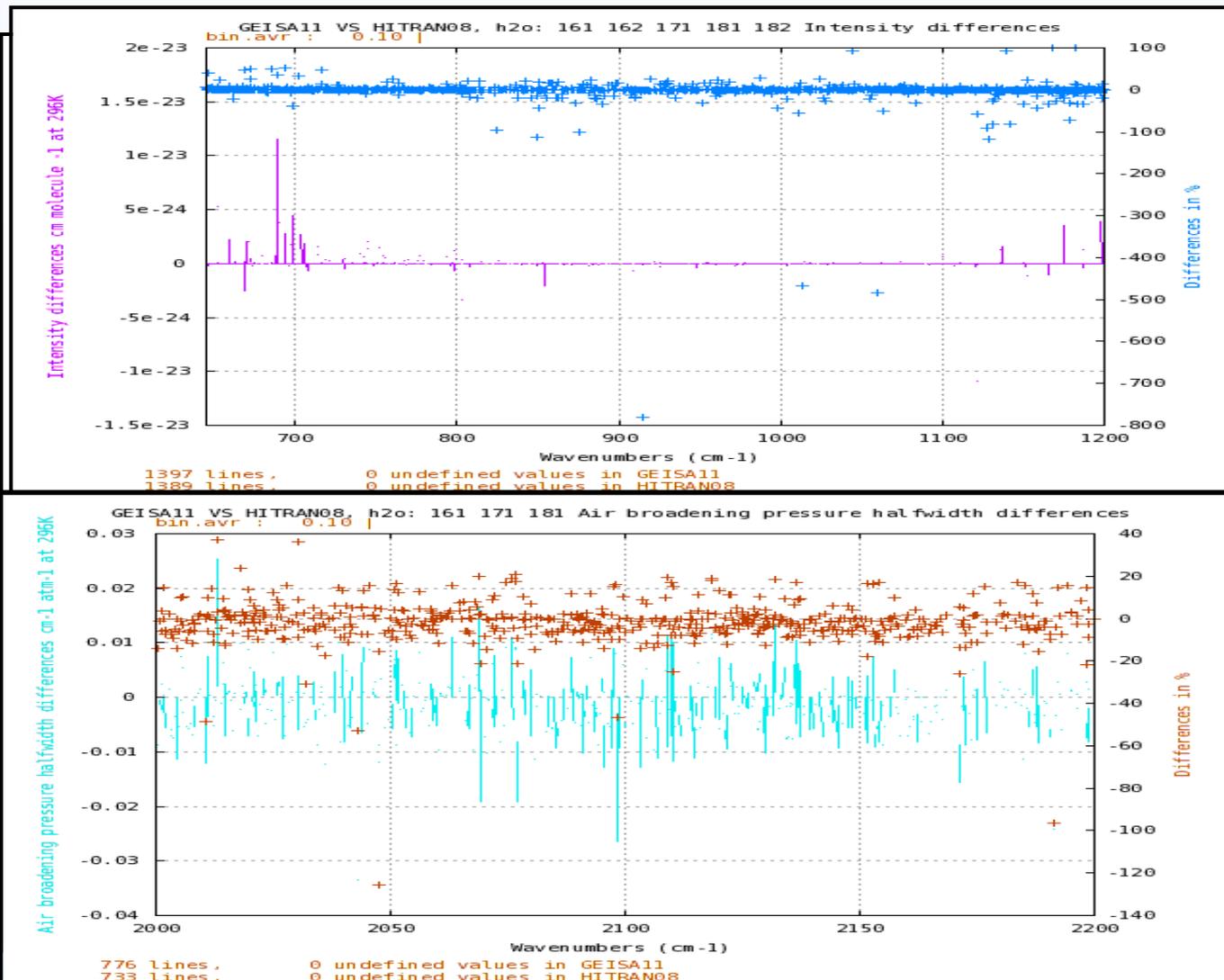


GEISA : ETHER distribution Graphical Tools

1 Global positions of transitions

2 Database content

3 Databases comparison



[5] REMAINING SPECTROSCOPY RELATED PROBLEMS

FROM CONCLUSIONS OF VALIDATION WITH THE 4A/OP LINE By LINE RADIATIVE TRANSFER MODEL

- ❖ The water **vapour spectroscopic parameters**: still need to be validated
- ❖ The **water vapour continuum**: more tuning to be done when more validation data (especially with high water vapor content) become available
- ❖ The **freons bands at 850 and 920 cm⁻¹**: refine the temperature dependence
- ❖ **O₃ in the 9.6 μm region**: the spectroscopic parameters still need to be validated
- ❖ **Some CO₂/CH₄ – Q, P and R branches**: further improvement/tuning of the line mixing

NON EXHAUSTIVE LIST

(Restricted to EARTH atmosphere)

[5] CONCLUSIONS FROM THE 2nd INTERNATIONAL IASI CONFERENCE, SEVRIER, France, 25-29 JANUARY 2010

General Spectroscopic Requirement to achieve Forward Model accuracies required for retrievals from IASI and future sounders (specific actions to be reinforced and maintained)

❖ **Necessary validation:** Assessment in GEISA/IASI of:

spectroscopic molecular species related to IASI trace gas retrievals:

HCN, NH₃, HCOOH, C₂H₄, CH₃OH, H₂CO.

cross-sections: CFC-11, CFC-12, CFC-14, CCl₄, N₂O₅, HCFC-22 and especially PAN.

❖ **The still outstanding general spectroscopy-related conclusions for public databases, from ISSWG June 30th - July 2nd 2008, CNES, Paris, France-, to be considered:**

Comparison of HITRAN or GEISA modelling and real IASI spectra lead to the conclusion that:

In particular water vapour needs to be validated, and the continuum reinvestigated.

IASI related spectroscopy problems with H₂O and CO₂ as first priority

❖ **Line coupling/mixing modelling (works in progress at LISA)**, (which should be used in conjunction with the molecular parameters of the data base from which they have been derived) and **non-LTE** (Local Thermodynamic Equilibrium) effects are areas to be urgently investigated.

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THANK YOU FOR YOUR ATTENTION