



# In a nutshell

- Aim:
  - Comparing each group's radiative transfer code ;
  - Highlighting/Understanding the differences ;
  - NOT uniformizing the codes
- How?:
  - Simulating spectra in both spectral ranges: UV-VIS and IR
    - In the following: only IR presented
  - Comparison and discussion remotely and during 3h at each SWT
- 7 exercises from April 2011 to July 2017.

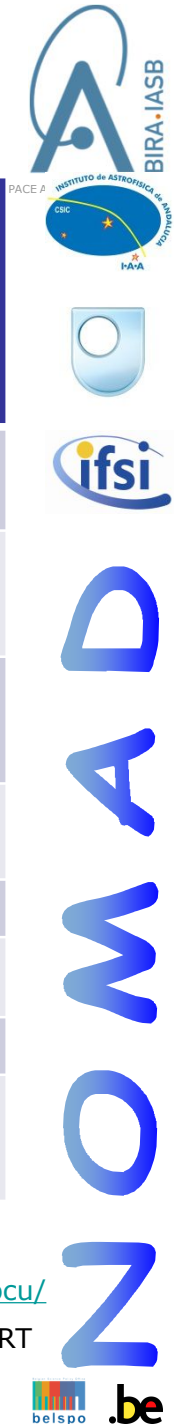


# RT codes in the IR

CONINKLJIK BELGIË

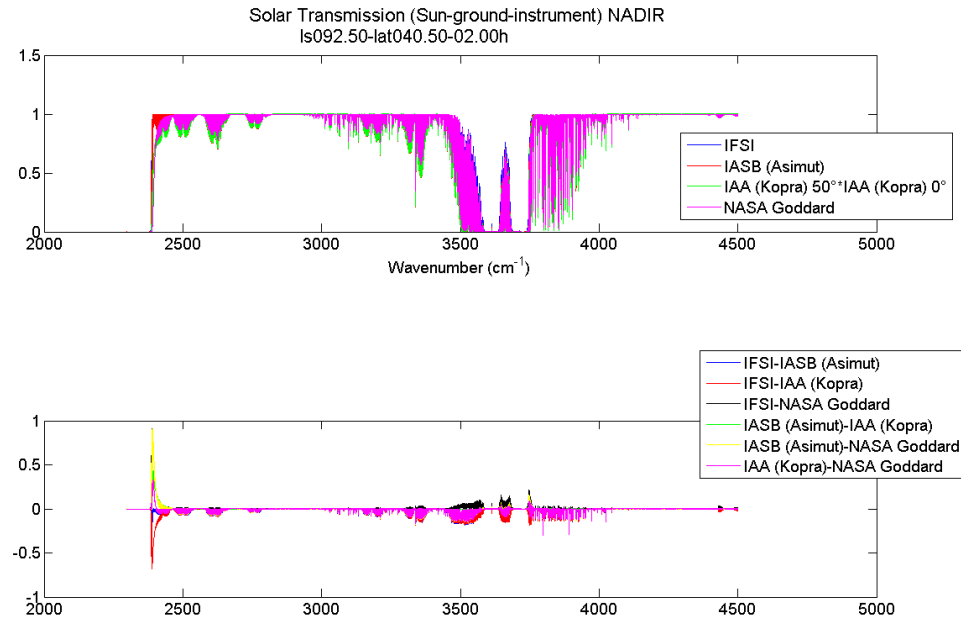
Name (Institute)	ARS (IAPS)	ASIMUT & ALVL (BIRA-IASB)	KOPRA (IAA)	LBLRTM & GENLN3 (GSFC) + <a href="https://psg.gsfc.nasa.gov/">https://psg.gsfc.nasa.gov/</a>
Based on	Ignatiev[1]	Vandaele[2] Spurr[3]	Karlsruhe[4]	Clough[5] Villanueva[6]
Spectral Range	UV - VIS - IR	UV - VIS - IR	IR	UV - VIS - IR mm/submm
Geometry: layering	Plane parallel	Spherical Plane parallel	Spherical	Spherical Plane parallel
Geometry: viewing	NADIR	Limb/NADIR/SO	Limb/NADIR/SO	Limb/NADIR/SO
Scattering	yes	yes	Single	Single
Non-LTE	no	no	GRANADA model [7]	yes [via tables]
CO <sub>2</sub> line mixing	no	yes	yes	yes
Outputs	Transmittance Radiance	Transmittance Radiance	Transmittance Radiance	Transmittance Radiance

**1.** N.I. Ignatiev et al., PSS 53 (2005) 1035 ; **2.** A.C. Vandaele, et al., Proc. of the First 'Atmospheric Science Conference', ESRIN (2006) Frascati, Italy ; **3.** R. Spurr, et al., JQSRT 68 (2001) 689 ; **4.** [www-imk.fzk.de/asf/ame/publications/kopra\\_docu/](http://www-imk.fzk.de/asf/ame/publications/kopra_docu/) ; **5.** S.A. Clough, et al., JQSRT 91 (2005) 233 ; **6.** G.L. Villanueva, et al., JGR 116 (2011) E08012 ; **7.** B. Funke et al., JQSRT 113 (2012) 1771.



# Exercise I

- NADIR
- Solar zenith angle of  $50^\circ$
- $2.2\text{-}4.3\ \mu\text{m}$  ( $2300\text{-}4500\ \text{cm}^{-1}$ )
- Gaussian function with a FWHM of  $0.15\ \text{cm}^{-1}$
- Constant albedo = 0.23
- Radiance: blackbody temperature of 5796 K and the data from the ACE mission (Hase et al, 2010)
- $\text{CO}_2$ ,  $\text{H}_2\text{O}$  and  $\text{CH}_4$



- Led to discussion concerning:
- Parametrization of the wings
  - Convolution function
  - Atmospheric grid effect
  - High resolution
  - Amount absorber
  - Effects of the different spherical layering

# Exercise 2

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NONMAD

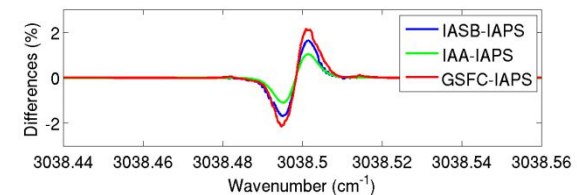
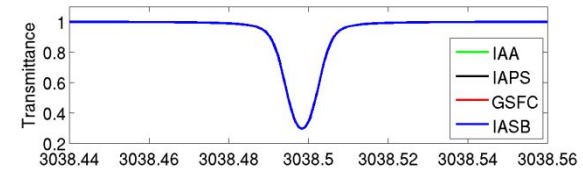


- Spectral range and output resolution: 2900-3100  $\text{cm}^{-1}$ , step 0.0002  $\text{cm}^{-1}$  (non convolved)
- 1 single line of  $\text{CH}_4$  (R1) (from HITRAN2008)
- 1 homogeneous layer of 10 km length, plane parallel, air mass=1.
- 7 test cases with various conditions:
  - $\text{CH}_4$  abundance: 100 ppb, 100 ppm at  $T=200\text{K}$ ,  $P=10$  mbar
  - Temperature [K]: 150, 200, 250 at  $\text{CH}_4=100$  ppb,  $P=10$  mbar
  - Pressure [mbar]: 1, 10, 100, 1000 at  $\text{CH}_4=100$  ppb,  $T=200\text{K}$

- Definition of the pressure shift
- Partition functions
- Physical constants
- Isotopic abundance values
- Voigt profiles: Humlicek, Kuntz, LBLRTM & Pade

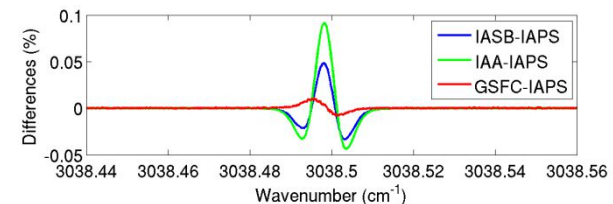
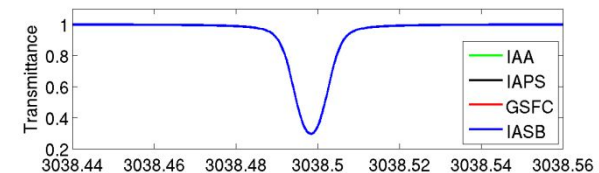
## First runs

Single layer:  $T=150\text{K}$ ;  $p=10$  mbar &  $\text{CH}_4$  Ab.=100 ppb



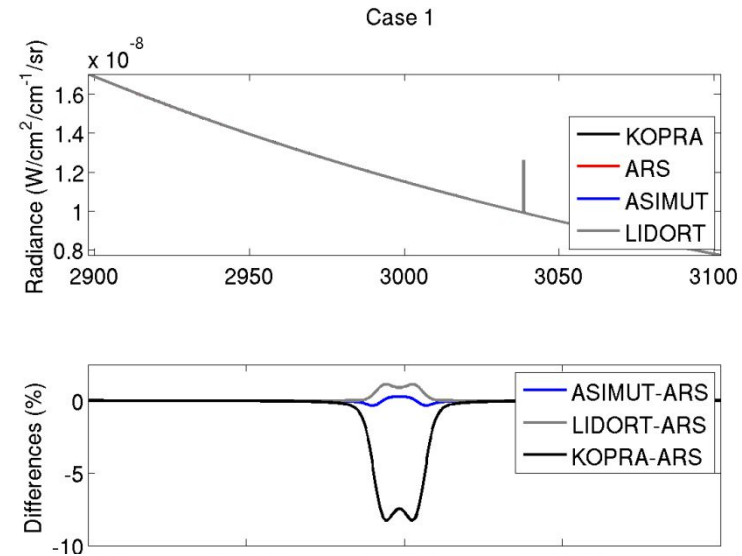
## After modifications

Single layer:  $T=150\text{K}$ ;  $p=10$  mbar &  $\text{CH}_4$  Ab.=100 ppb

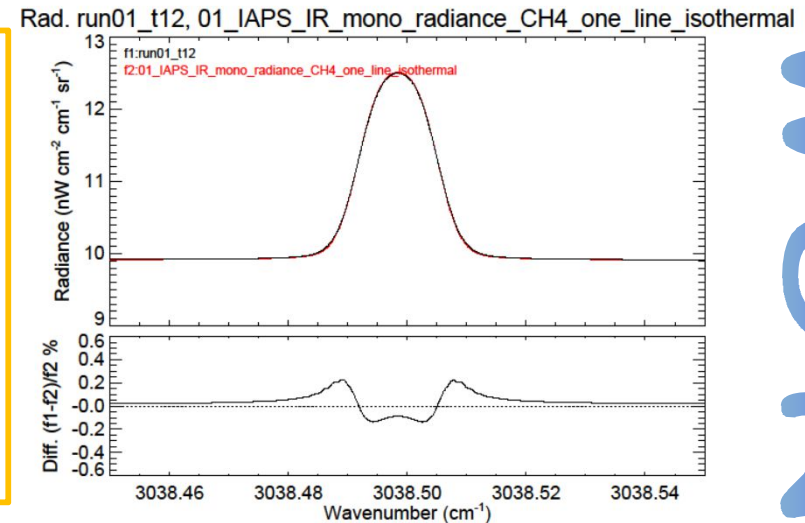


# Exercise 3

- 10 different cases were suggested:
- Spectral range and output resolution: 2900-3100  $\text{cm}^{-1}$ , step 0.0002  $\text{cm}^{-1}$  (non convolved)
  - 1 single line of  $\text{CH}_4$  (R1) – 100 ppb
  - Isothermal (296K) fully layered atmosphere: 65 layers ; 2 surface pressures (10 and 100 mbar)
  - Different airmasses described using sza values of 30°, 45° and 70°.



- Curtis-Godson approximation
- Atmospheric greenhouse effect:
  - diffusivity factor ( $\beta = 1.66$ ) ;
  - integration over 6 angles between  $\pi/2$  (horizon) and  $\pi$  (nadir), equally spaced in  $\cos(\theta)$  ;
  - integration over 21 angles between  $\pi/2$  (horizon) and  $\pi$  (nadir), equally spaced in  $\cos(\theta)$ .

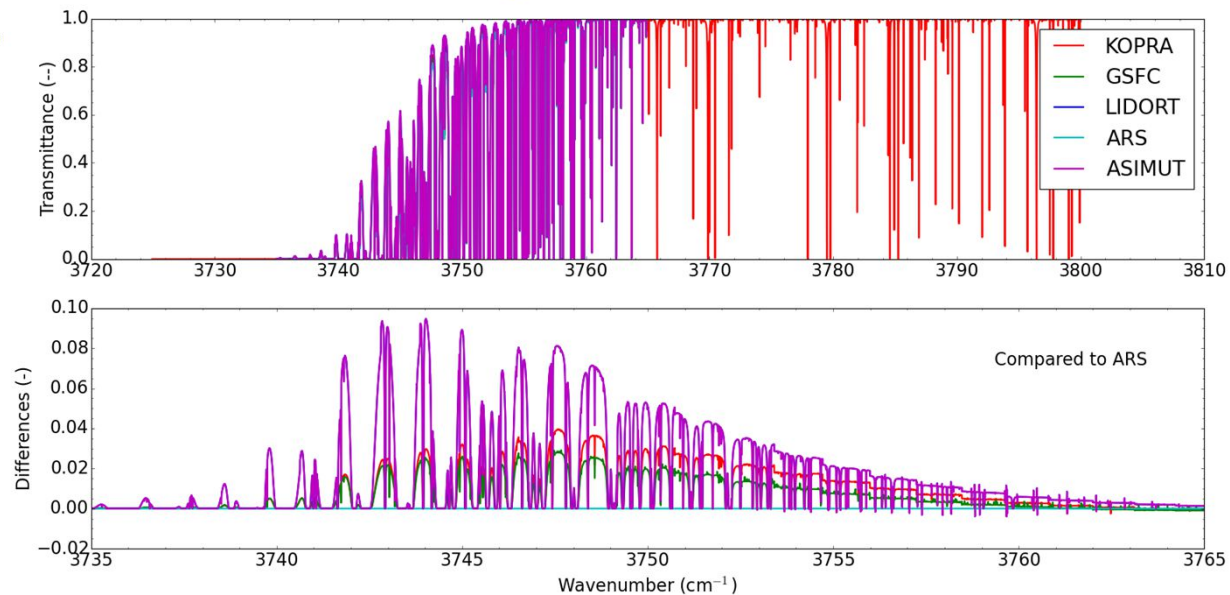




# Exercise 4

- Daytime (sza=40°) / nighttime
  - Albedo = 0.1
  - Lambertian type of reflectance (isotropic)
  - CO<sub>2</sub>, H<sub>2</sub>O, O<sub>3</sub> (HITRAN2012)
  - Voigt profile
- Low resolution:
- Spectral range and output resolution: 3725-3800 cm<sup>-1</sup>, spectral resolution: 0.01 cm<sup>-1</sup>
- High resolution:
- Spectral range and output resolution: 3735-3765 cm<sup>-1</sup>, spectral resolution: 0.0001 cm<sup>-1</sup>

Differences too important  
(15% in radiance)  
→ Back to more simple



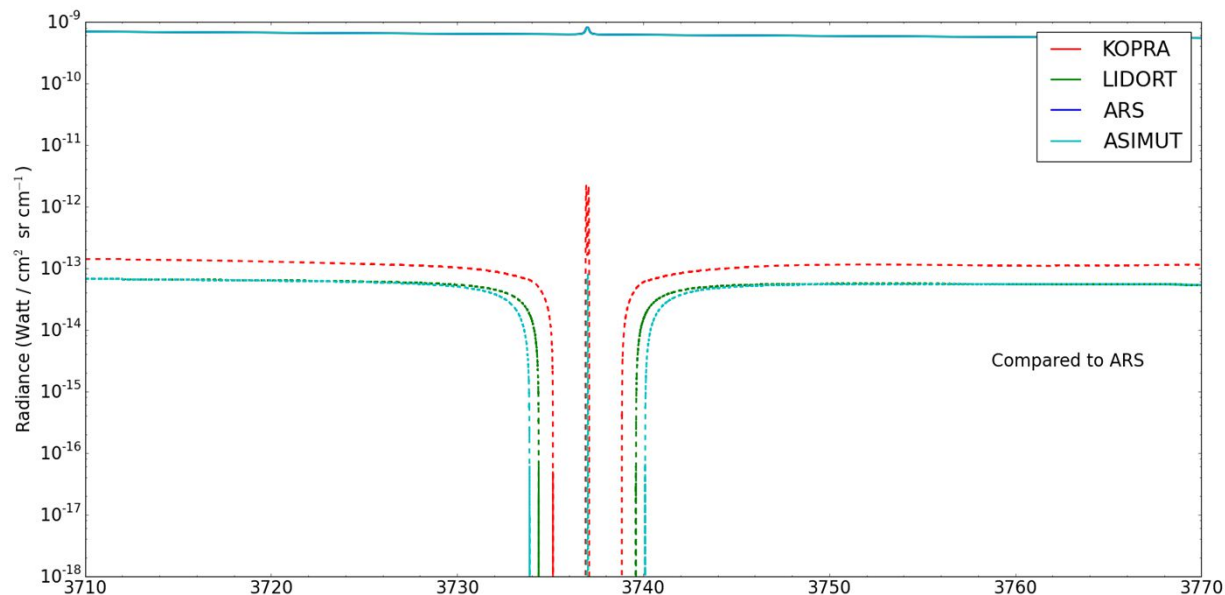
# Exercise 5



N O M A D

- 1 line of CO<sub>2</sub> (3737.00 cm<sup>-1</sup>)
- Density multiplied by a factor 1 and a factor 0.001
- isothermal atmosphere
- Voigt + Kuntz lineshape

- Discussion concerning:
- the line shapes (Kuntz (1997) implementation with or without (all) the Ruyten (2004) corrections
  - the far wing treatment (Chi factor, as given in Cousin et al. (Appl. Opt. 24 (1985) 3899-3907) and Menoux et al. (Appl. Opt. 30 (1991) 281-286))



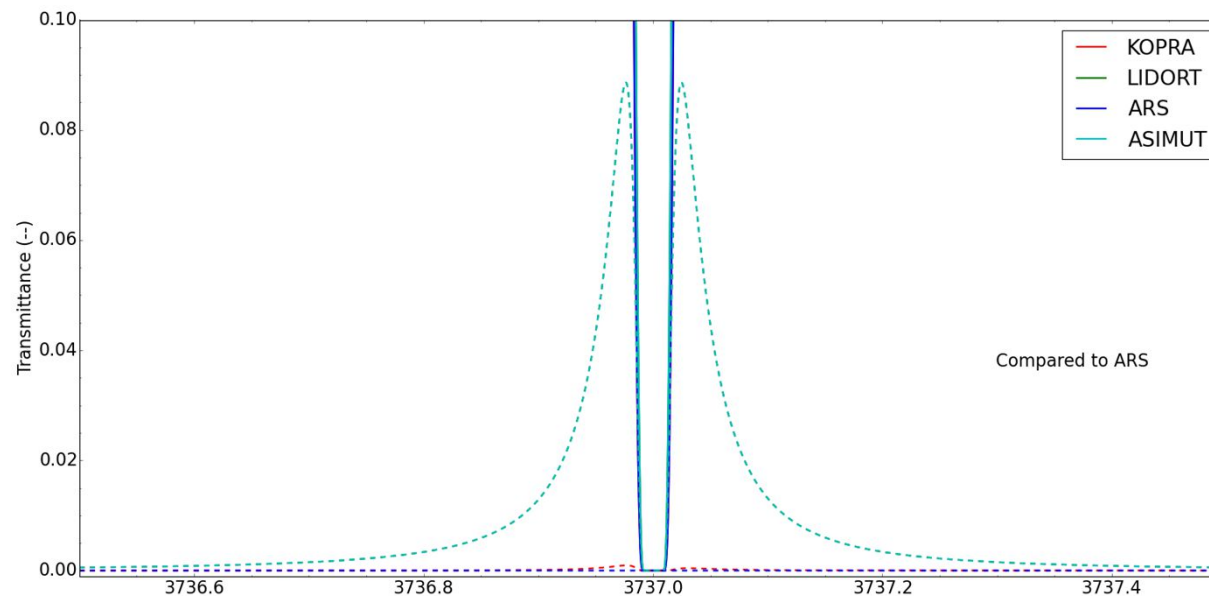


# Exercise 6

- 1 line of CO<sub>2</sub> (3737.00 cm<sup>-1</sup>)
- non-isothermal atmosphere
- factor 1 and factor 0.001 on the density
- Voigt + Kuntz lineshape

## Discussion concerning:

- the line shapes (Kuntz (1997) implementation with or without (all) the Ruyten (2004) corrections
- the far wing treatment (Chi factor, as given in Cousin et al. (Appl. Opt. 24 (1985) 3899-3907) and Menoux et al. (Appl. Opt. 30 (1991) 281-286))



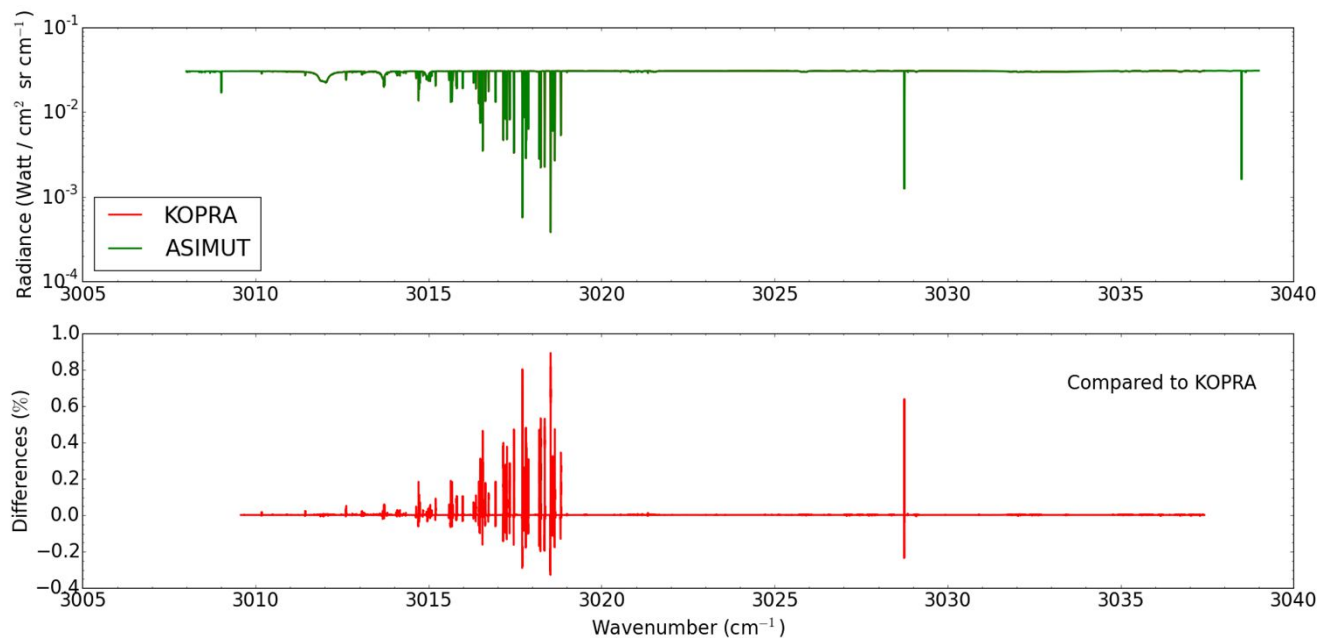
# Exercise 7

## Solar occultation

- CO<sub>2</sub>: 3754 – 3782 cm<sup>-1</sup> (atm file)
- CH<sub>4</sub>: 3010 – 3037 cm<sup>-1</sup> (60 ppb)
- Gaussian ILS
- Voigt + Kuntz line shape
- Spectral resolution: 0.15 cm<sup>-1</sup>
- Final spectral step: 0.1 cm<sup>-1</sup>
- Line cutoff total range = 25 cm<sup>-1</sup>
- One simulation at 20 km altitude.

## Discussion concerning:

- the layering scheme (sub-layering during the raytracing)
- the path calculation
- the far wing treatment



NOMAD

# Conclusion

A series of 7 exercises of simulation was performed.

Very useful as it led to

- improve the different codes by harmonizing the use of several parameters (physical constants, partition function, ...)
- highlight the significant effects of some parameters like pressure-shift and its temperature dependency
- interesting discussions concerning the implementation of the atmospheric emission, the Curtis-Godson approximation, the Voigt profile, the wing cut-off treatment, ...

This activity was stopped because

- The aim of the intercomparison was achieved (i.e. understanding the differences)
- Lack of time (preparation of data pipeline, scientific planning) and lack of man power

