Radiative transfer modelling for IASI

Marco Matricardi

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ECMWF

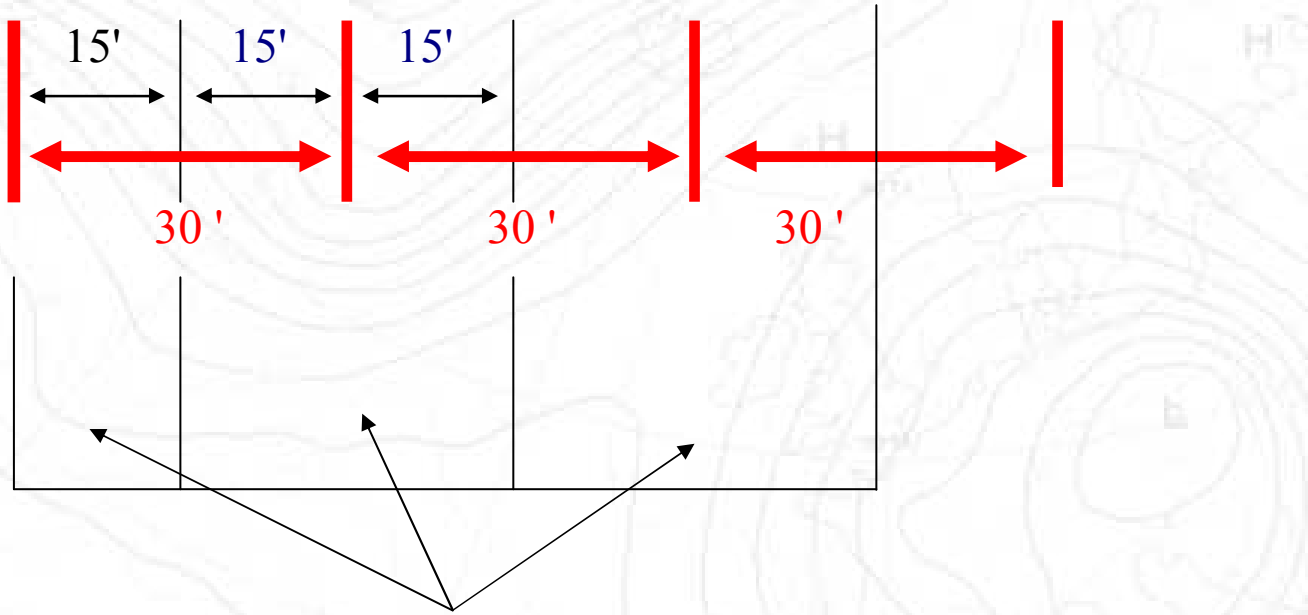
RTTOV-9 monitoring experiments

- IASI measurements of spectral radiances made between the 1 April 2008 and the 15 April 2008 are compared with simulations performed using the RTTOV-9 fast model.
- Four monitoring experiments have been run using cycle 33R1 of the ECMWF Integrated Forecasting System (IFS) at T799 (25 km) resolution.
- Simulations have been performed to assess the accuracy of the RTTOV-9 computations and investigate relative differences between the line-by-line models and the quality of the spectroscopic databases on which the RTTOV coefficients are based.

IASI data within a 12-h 4D-VAR window are grouped into 30 min time slots. A T799 high resolution forecast is then run from the previous analysis and observations minus model differences are computed for IASI soundings within a given time slot.

12h 4D-Var, obs 09-21Z

12h 4D-Var, obs 21-9Z



IASI Observations

RTTOV-9 monitoring experiments

Coefficients [1,2]	Continum	CO2 line mixing	Molecular database
kCARTA [1] 52 profile training set *Chevalier (2003)*	MT_CKD_v1.1_UMBC *Mlawer et al. (2004)*	CO_2 P/Q/R branch Line mixing (υ2 and υ3) *Strow et al. (2002)*	HITRAN_2000 *Rothman et al. (2003)*
GENLN2 [2] 43 profile training set *Matricardi and Saunders (2000)*	CKD_2.4 *Clough et al. (1989)*	CO_2 Q branch (υ2 and υ3) *Strow et al. (1994)*	HITRAN_2000 *Rothman et al. (2003)*
LBLRTM [2] 83 profile training set *Matricardi (2008)*	MT_CKD_v1.1 *Mlawer et al. (2004)*	CO_2 P/Q/R branch Line mixing (υ2 and υ3) *Niro et al. (2005)*	HITRAN_2000 HITRAN_2004/06 *Rothman et al. (2005)* GEISA_2003 *Husson et al. (2005)*

[1] Brunel, Météo France
[2] Matricardi, ECMWF

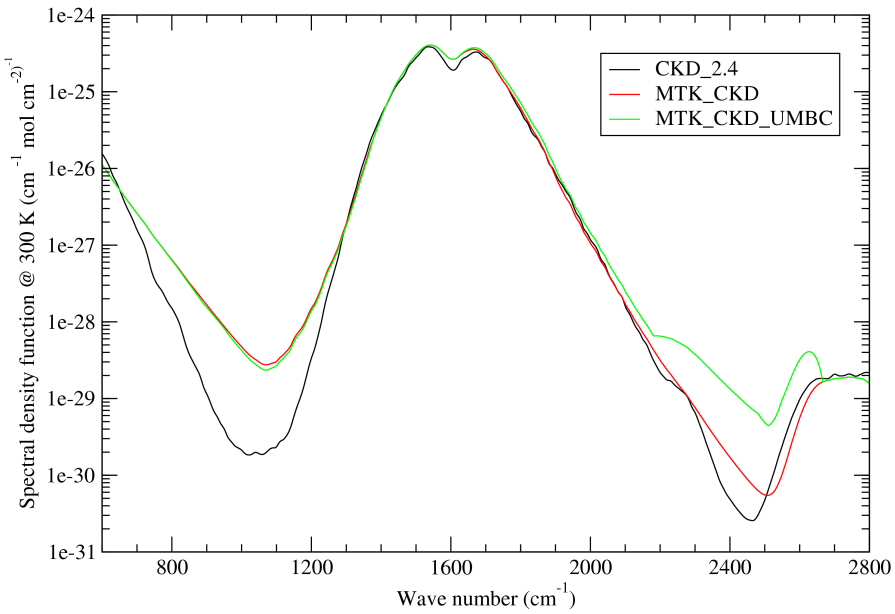
RTTOV-9 monitoring experiments

- In addition to the three basic experiments we have run two further experiments:

  1) LBLRTM experiment where the concentration of CO_2, N_2O, CO and CH_4 is varied to match the value measured at the nearest CMDL or AGAGE station.

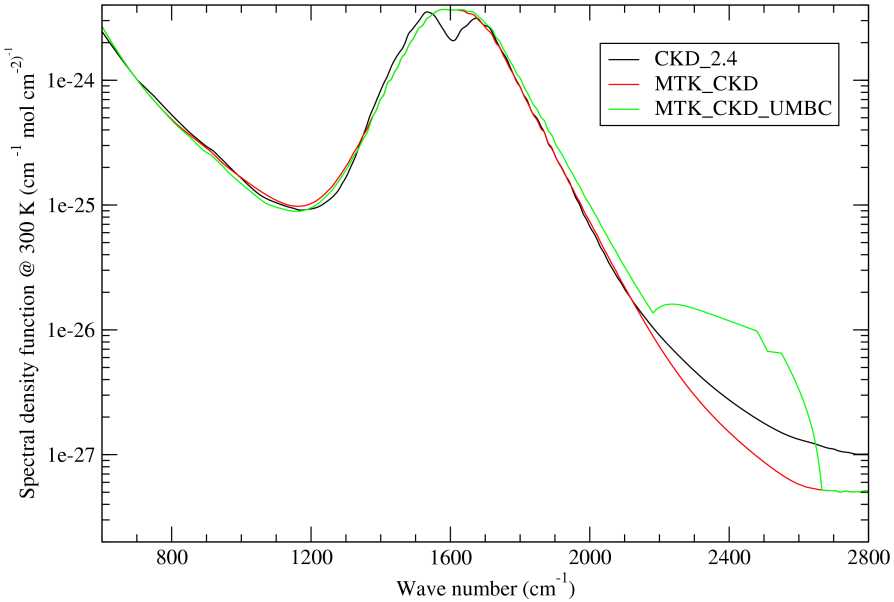
  2) kCARTA experiment where we use the LBLRTM water vapour continuum coefficients.

Foreign broadening

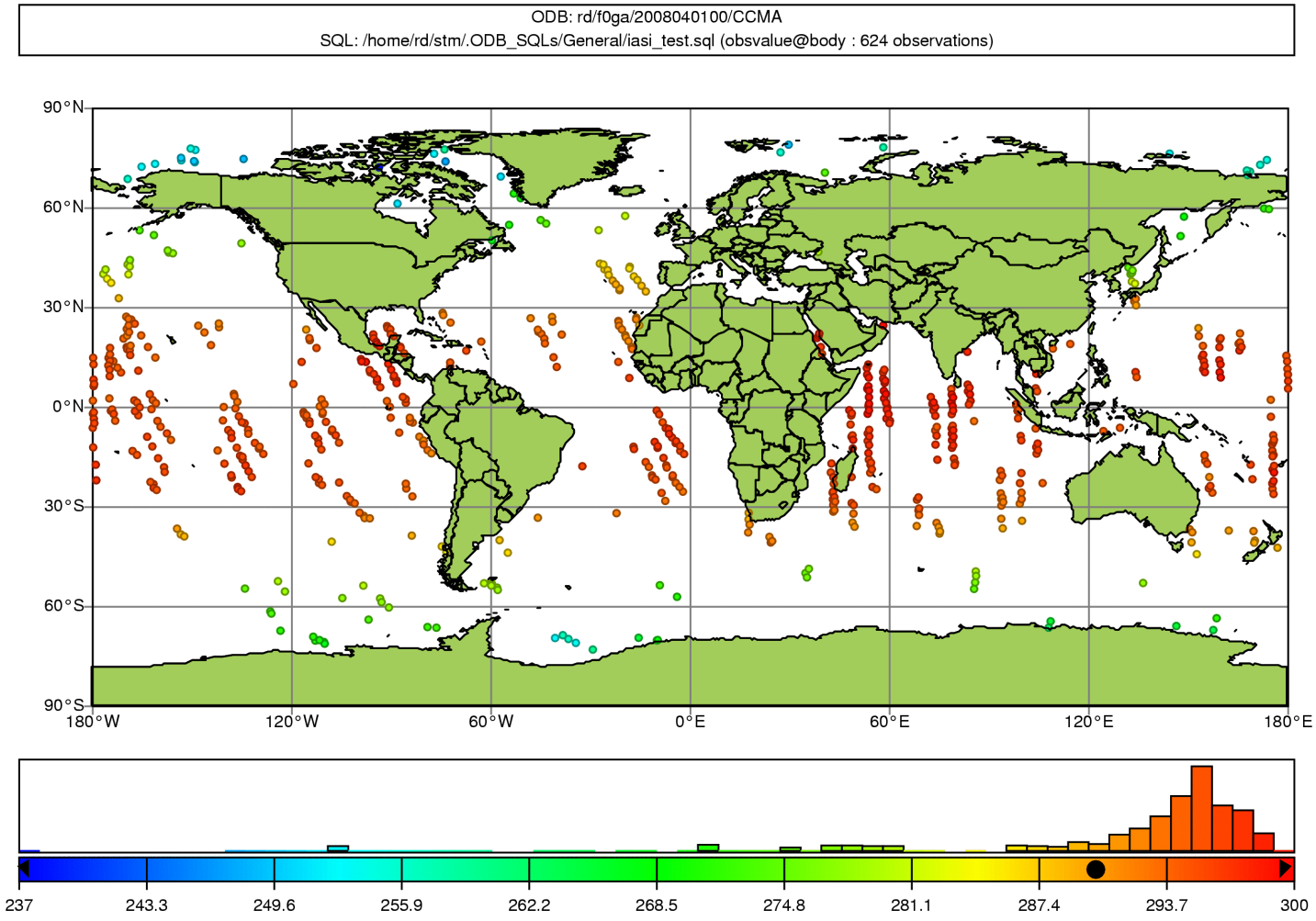


The spectral density function for the foreign and self continuum.
UMBC data courtesy of S. DeSouza-Machado.

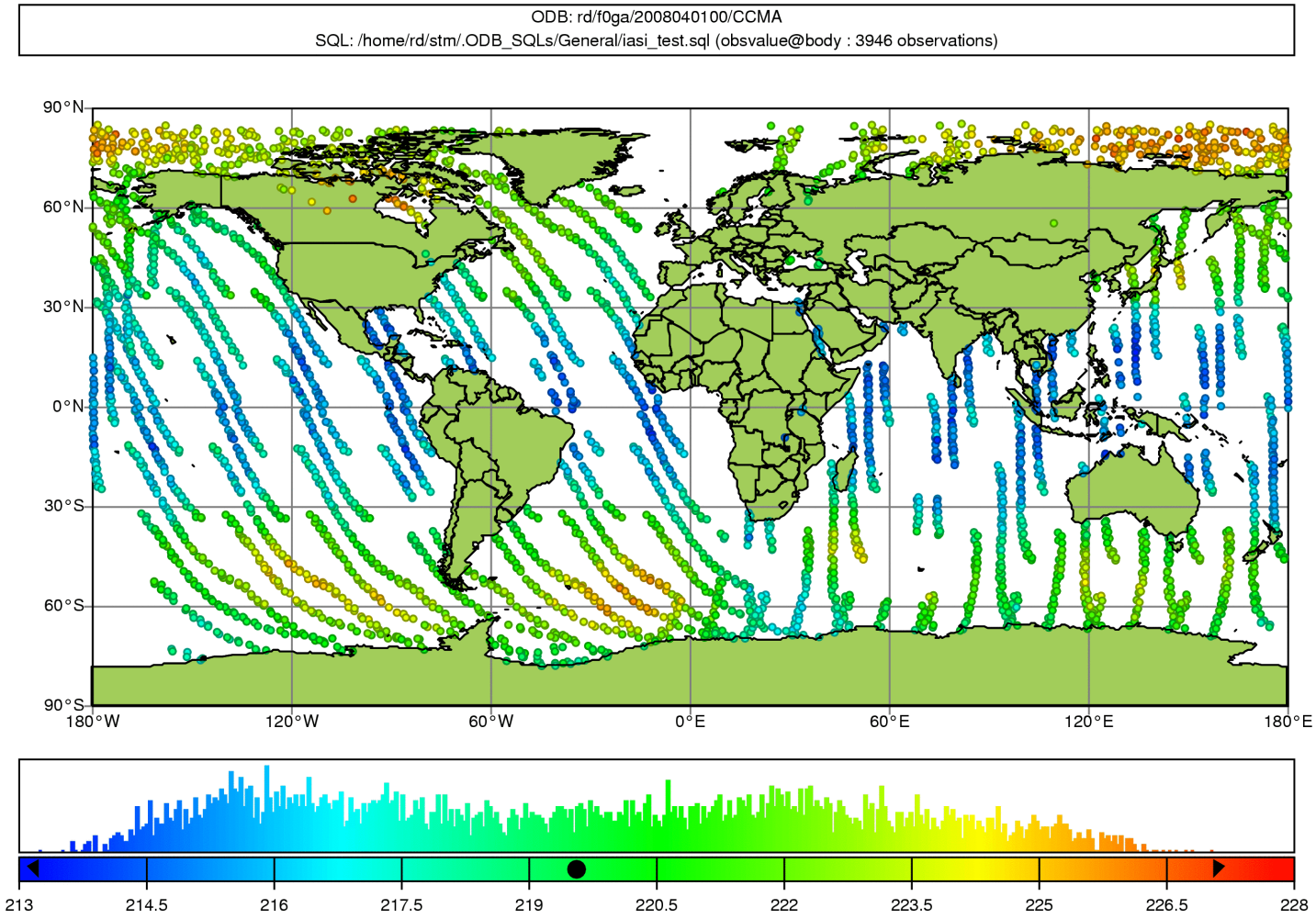
Self broadening



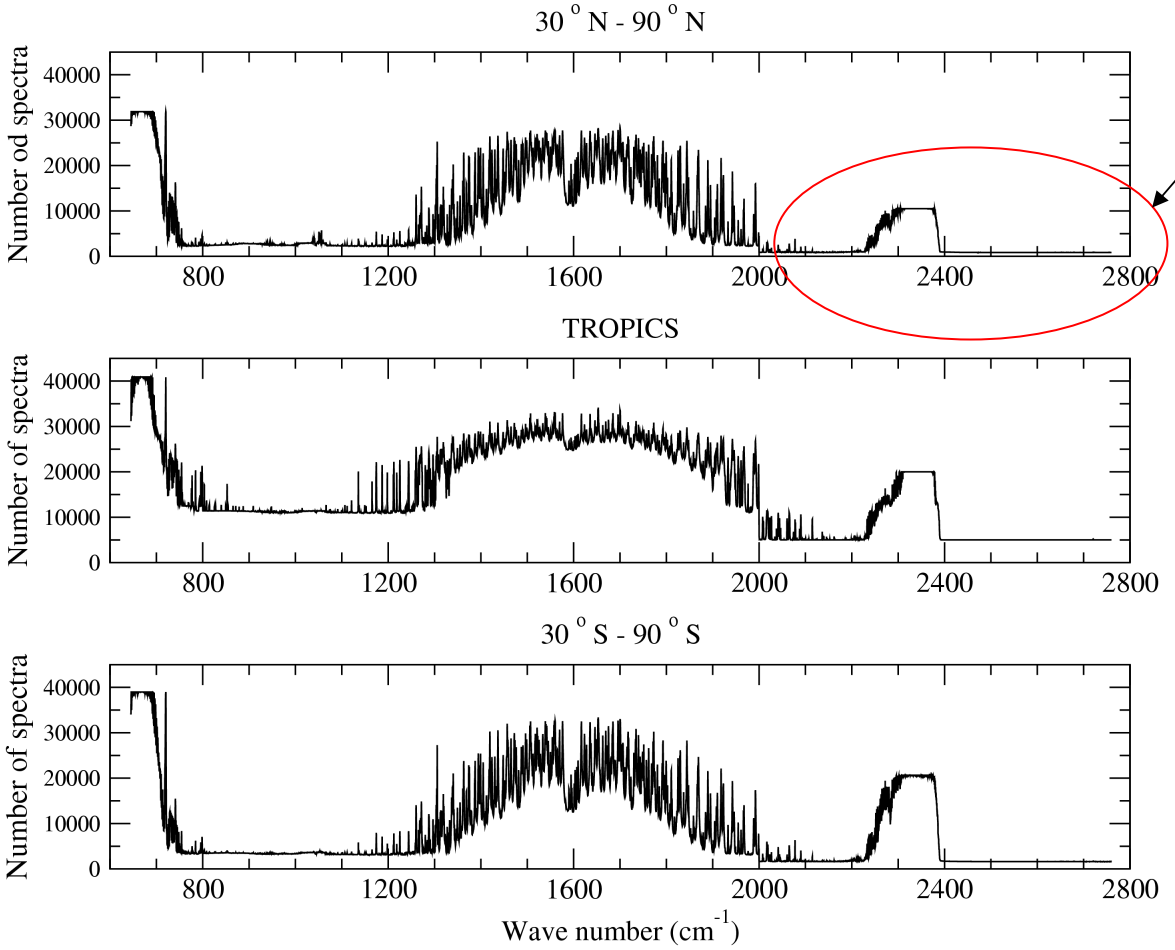
Only clear channels over the sea are processed.
An example of the coverage for a window channel.



Only clear channels over the sea are processed.
An example of the coverage for a stratospheric channel.



The number of spectra for each channel



IASI band 3:only night-time spectra.

ECMWF

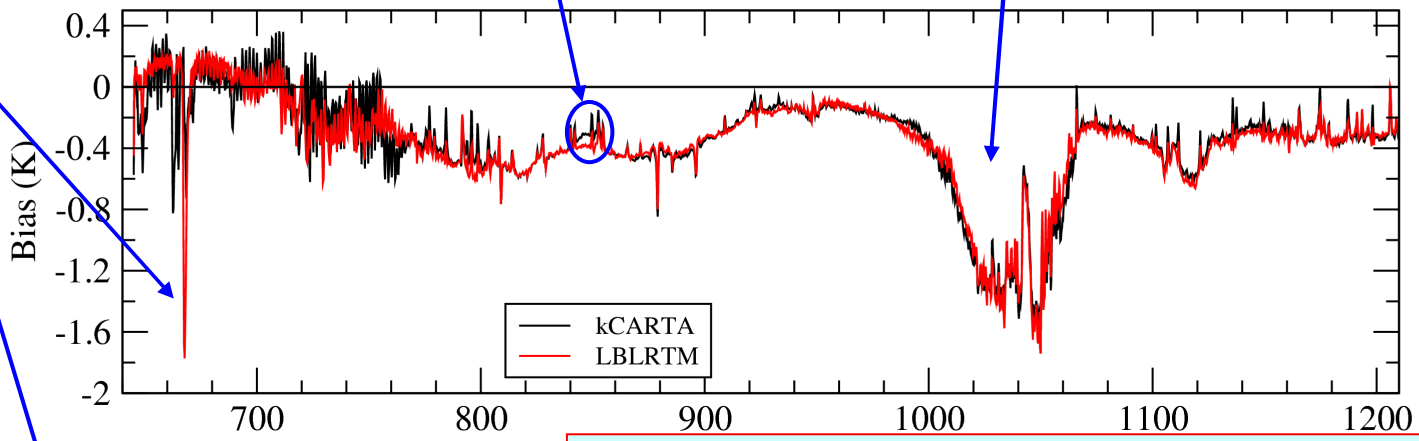
IASI band 1

Northern hemisphere: 30°N-90°N

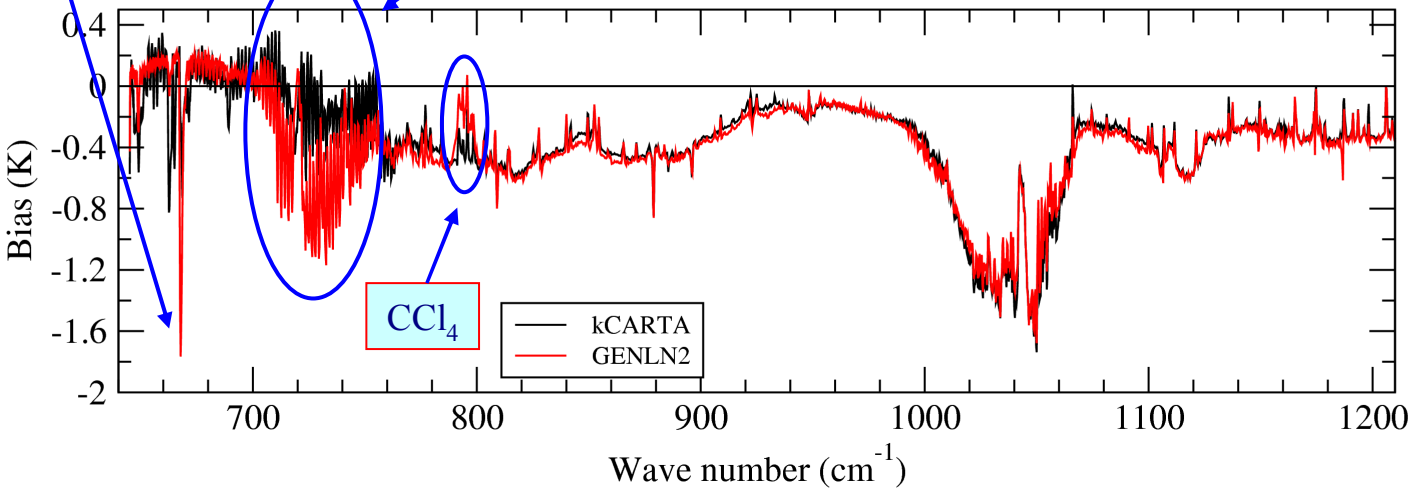
Fundamental υ2 CO_2 Q branch at 667 cm^{-1}
Issue with LBLRTM CO_2 continuum?
Biases in ECMWF temperature profiles?
Spectroscopy?
Line mixing?

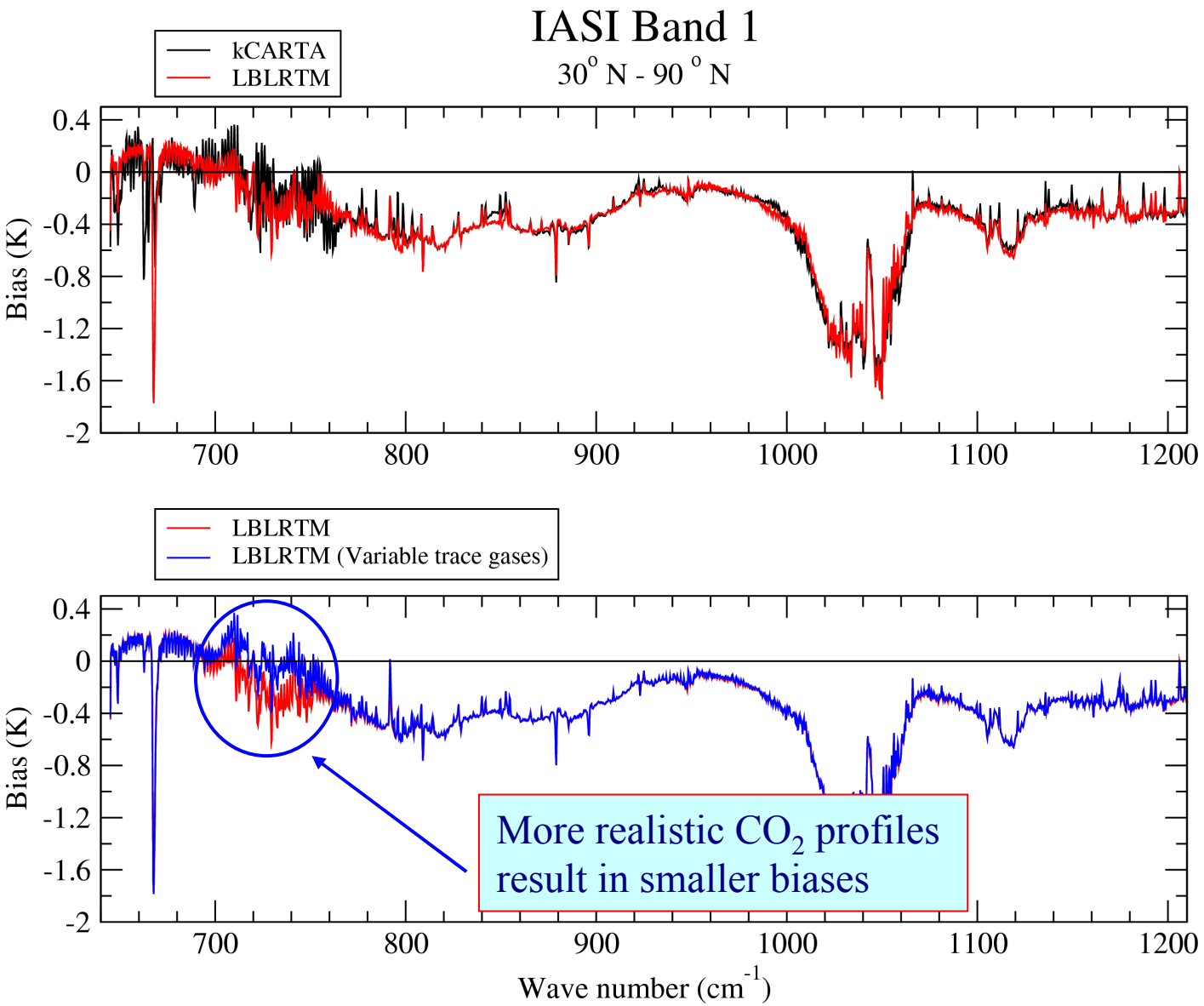
CFC-11

Ozone assimilation system?
Spectroscopy?



GENLN2 does not include CO_2 P/R branch line mixing

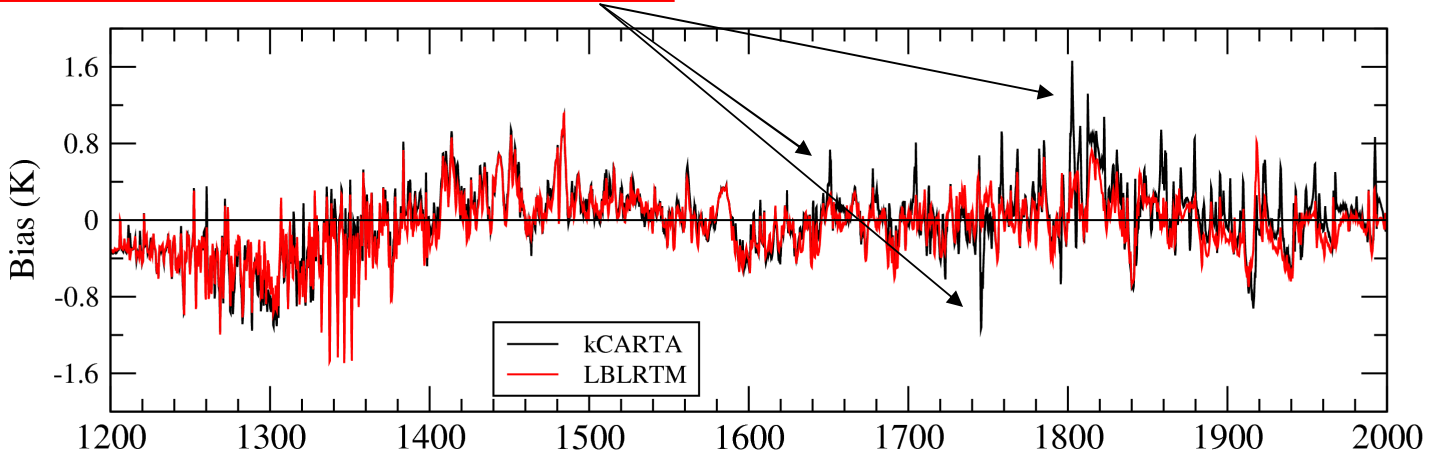



IASI Band 1
30° N - 90 ° N
kCARTA
LBLRTM
Bias (K)
0.4
0
-0.4
-0.8
-1.2
-1.6
-2
700
800
900
1000
1100
1200
LBLRTM
LBLRTM (Variable trace gases)
More realistic CO_2 profiles result in smaller biases
Wave number (cm^{-1})

IASI band 2

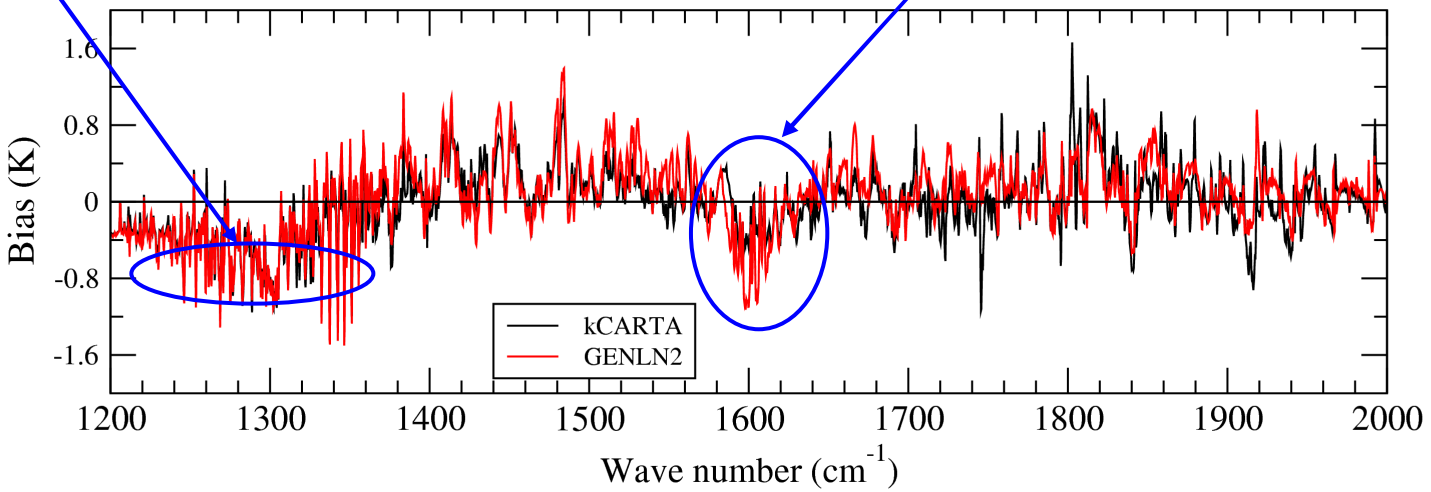
Northern hemisphere: 30ºN-90ºN

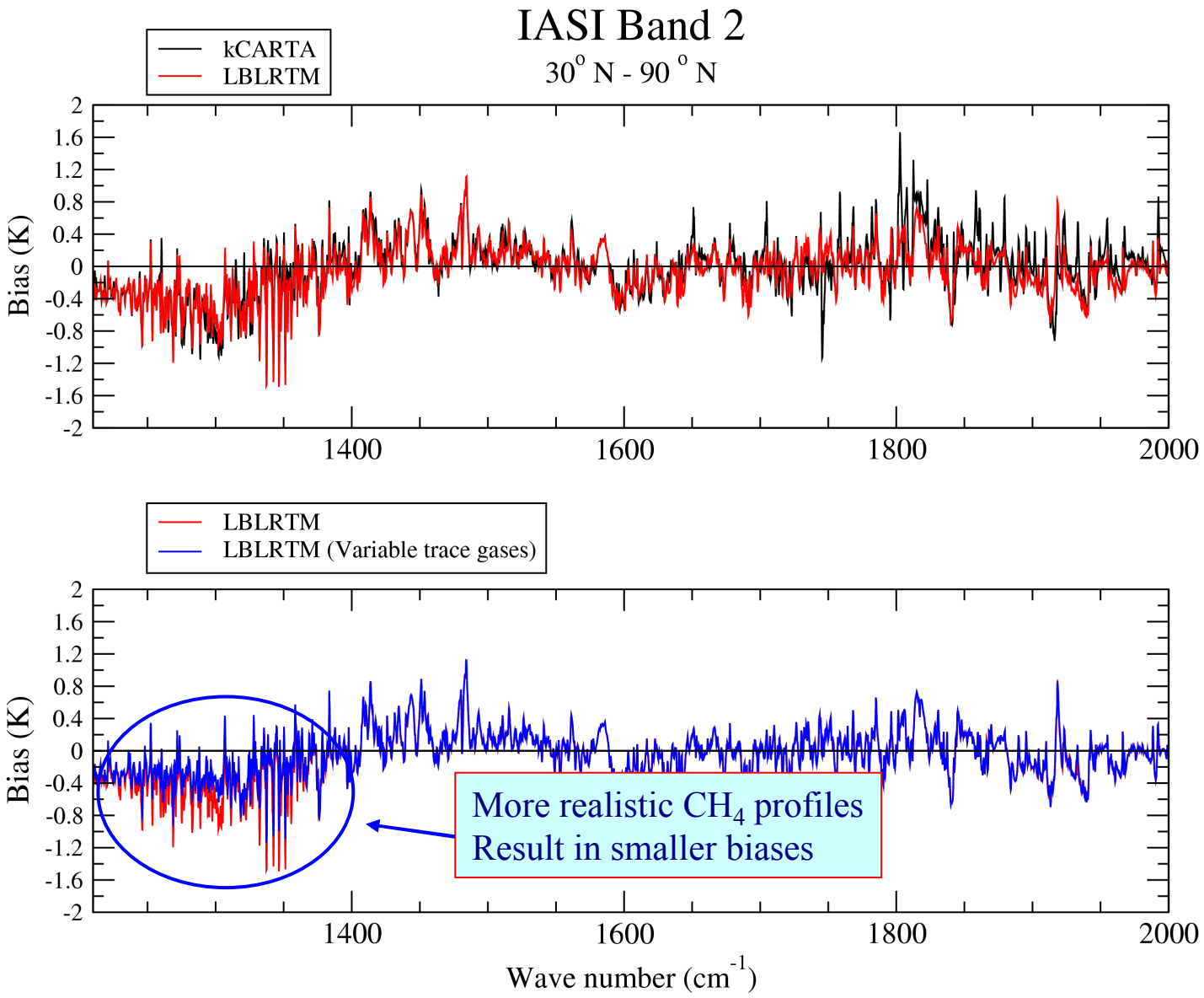
Origin of spikes in kCARTA difficult to assess



Specification of CH4 profile

GENLN2 CKD_2.4 continuum



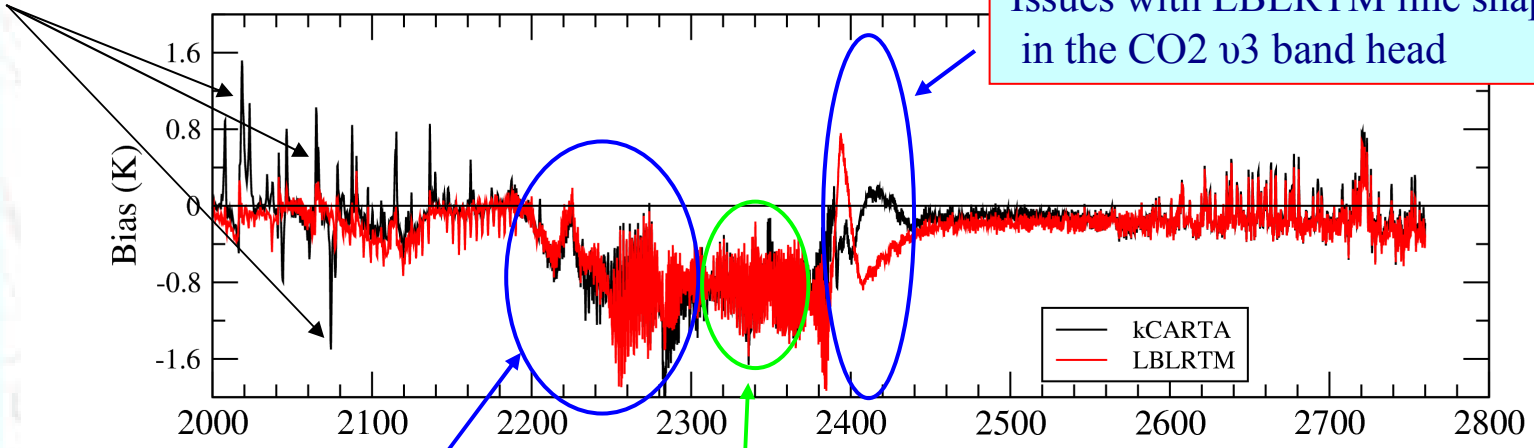

IASI Band 2
30° N - 90 ° N
kCARTA
LBLRTM
Bias (K)
2
1.6
1.2
0.8
0.4
0
-0.4
-0.8
-1.2
-1.6
-2
1400
1600
1800
2000
LBLRTM
LBLRTM (Variable trace gases)
More realistic CH4 profiles
Result in smaller biases
Wave number (cm-1)

IASI band 3

Northern hemisphere: 30ºN-90ºN

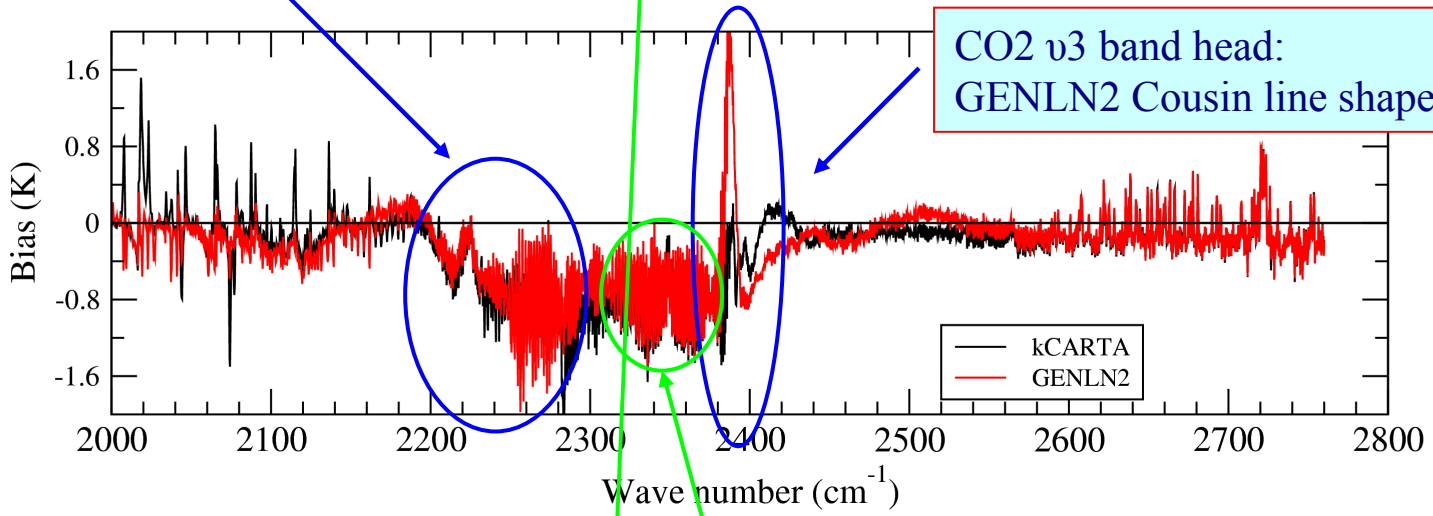
Spikes in kCARTA spectrum are still an issue

Issues with LBLRTM line shape in the CO2 υ3 band head

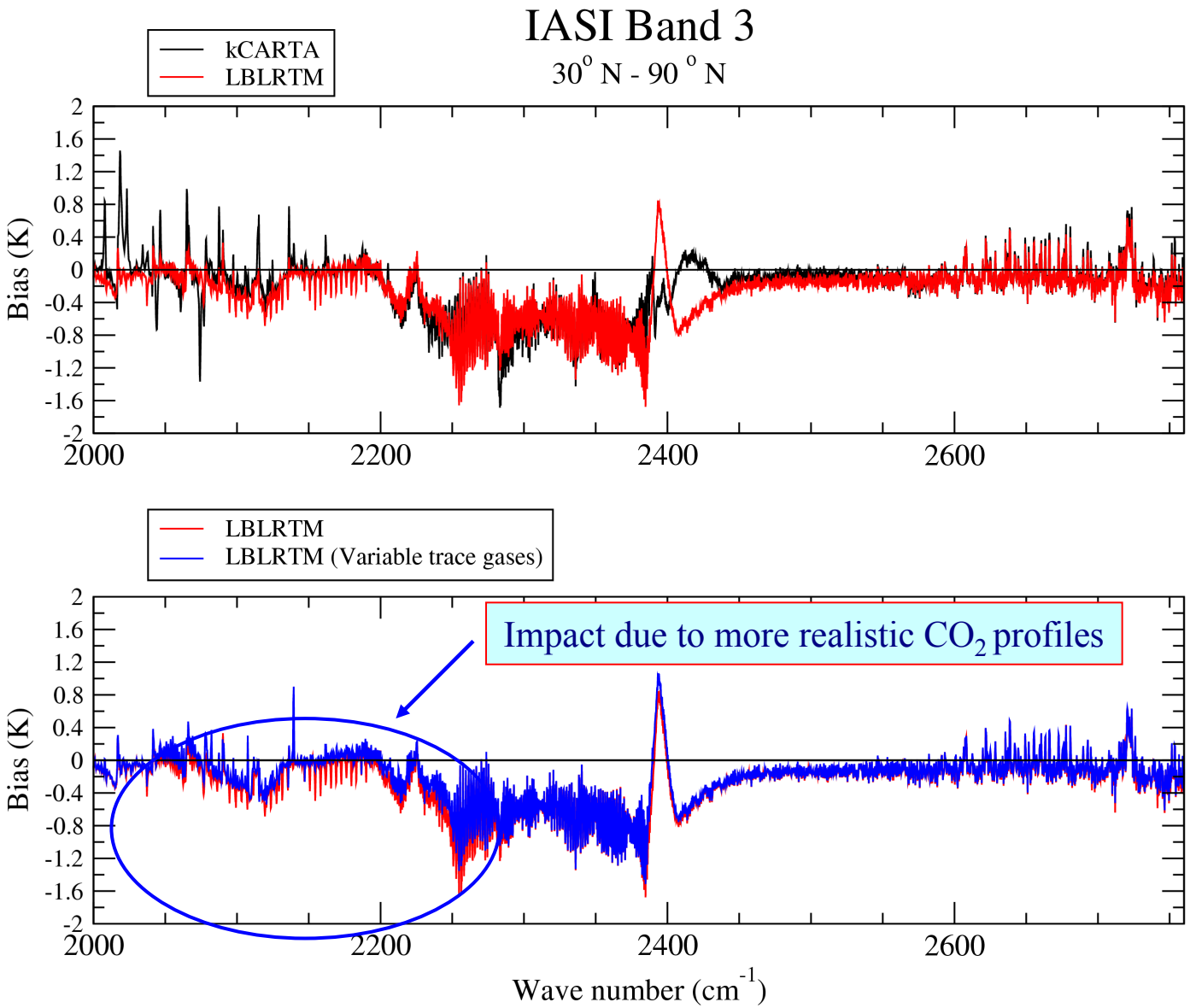


CO_2 υ3 band: tropospheric channel biases are inconsistent with biases in υ2 band: spectroscopy issue

CO2 υ3 band head:
GENLN2 Cousin line shape is in error

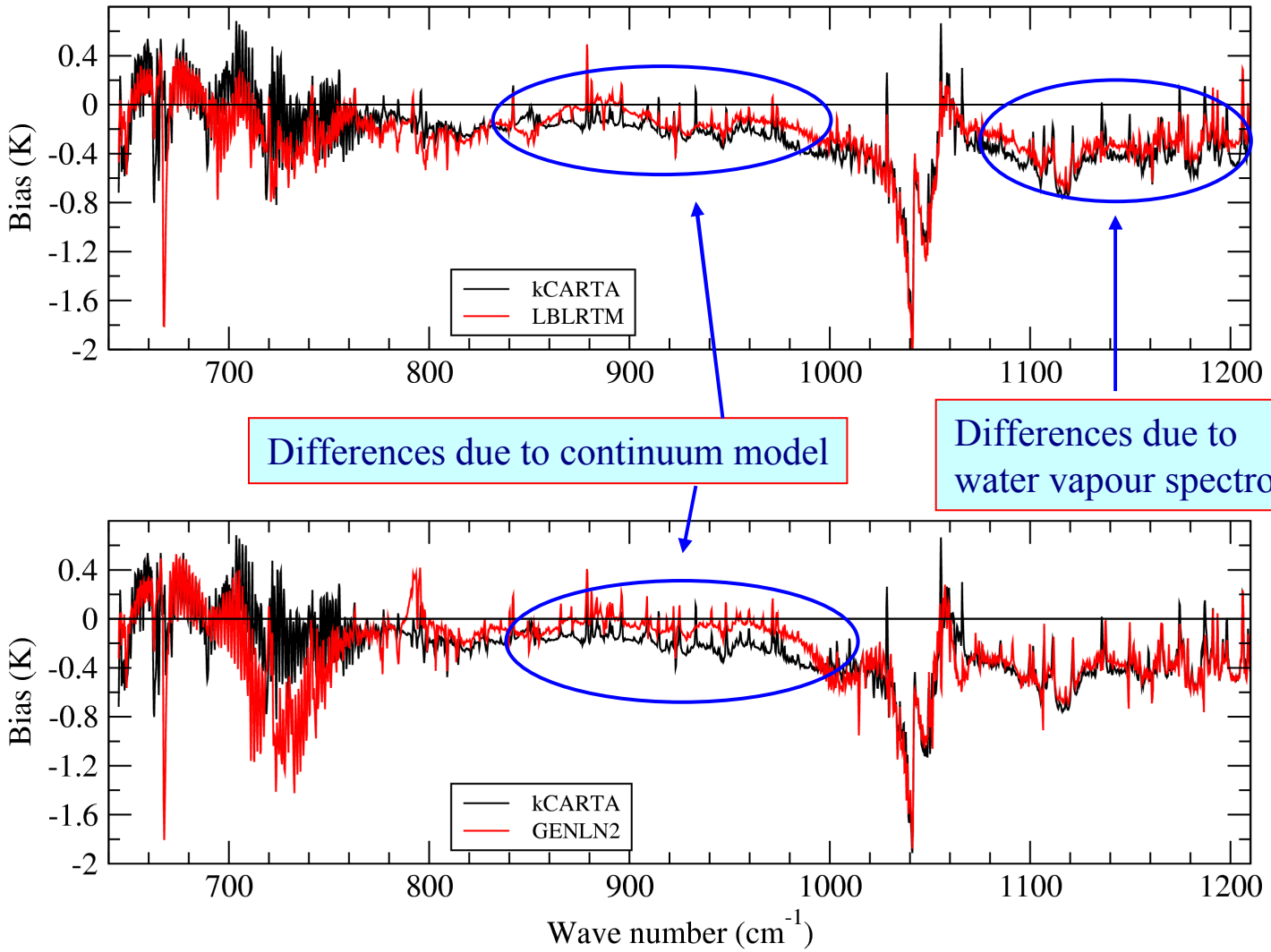


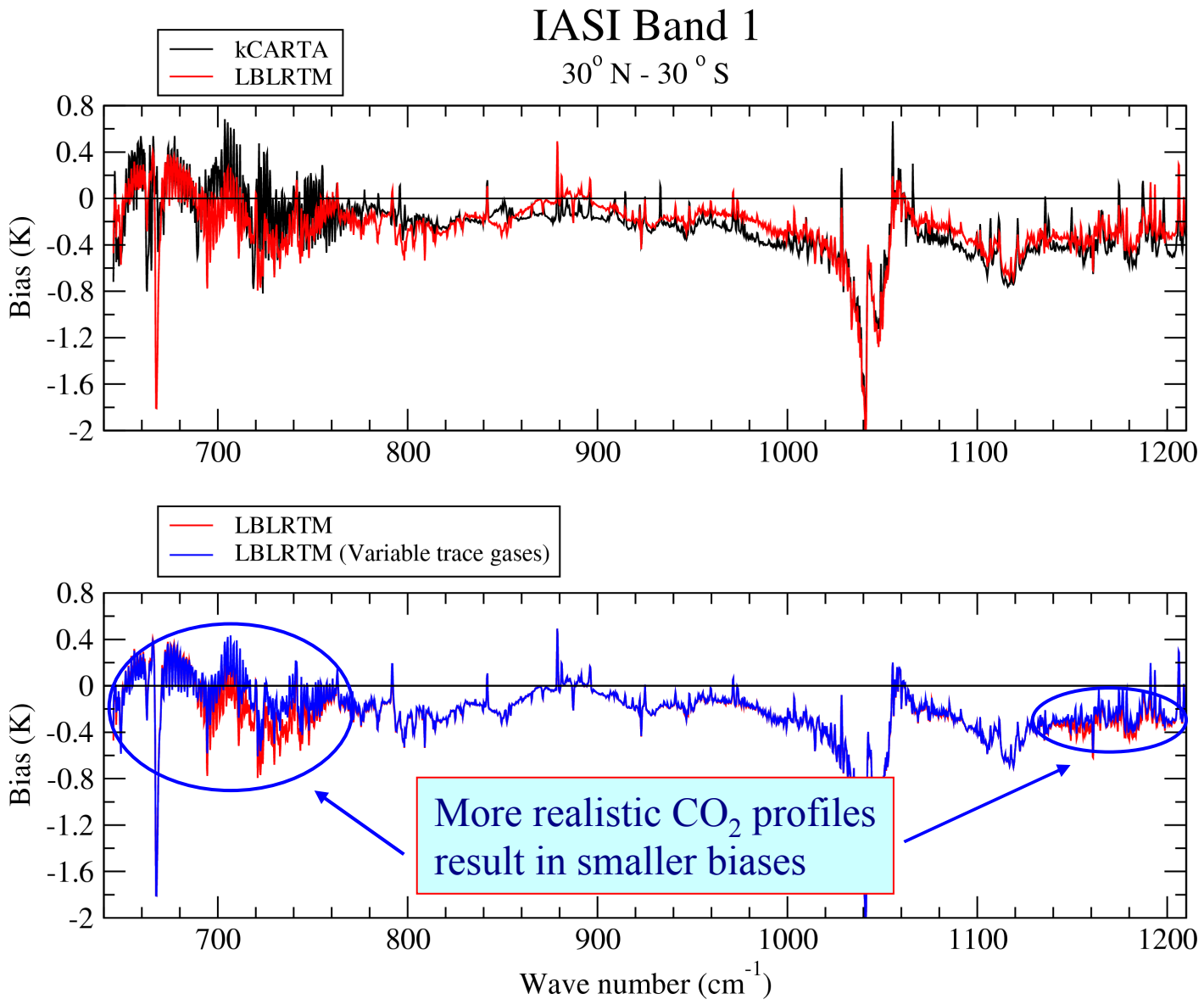
Biases in ECMWF temperature profiles?


IASI Band 3
30° N - 90 ° N
kCARTA
LBLRTM
Bias (K)
2
1.6
1.2
0.8
0.4
0
-0.4
-0.8
-1.2
-1.6
-2
2000
2200
2400
2600
LBLRTM
LBLRTM (Variable trace gases)
Impact due to more realistic CO_2 profiles
Wave number (cm^{-1})

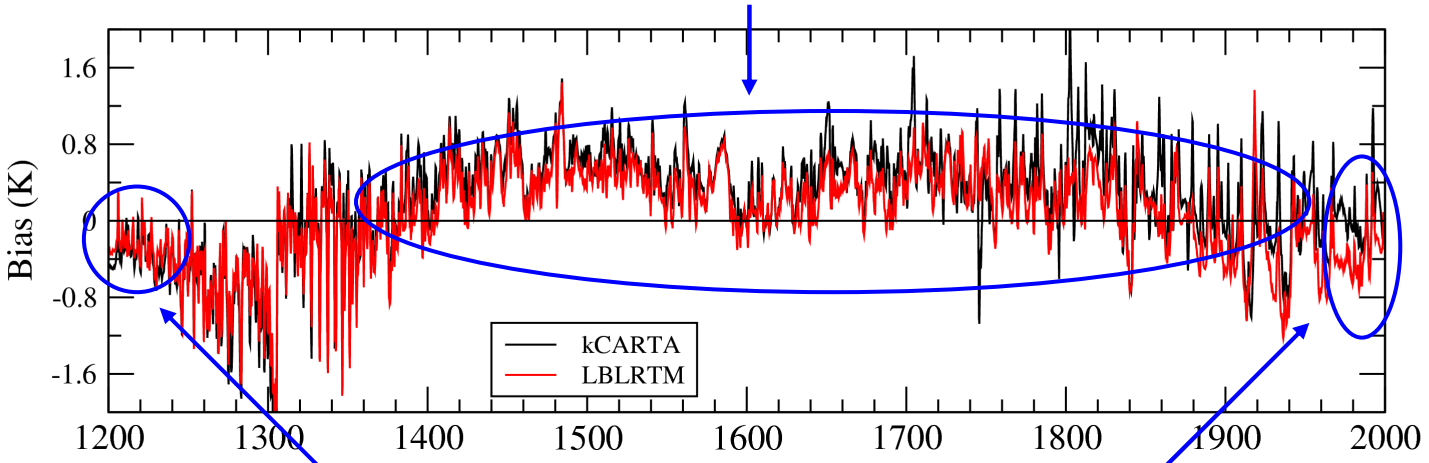
IASI band 1

Tropics

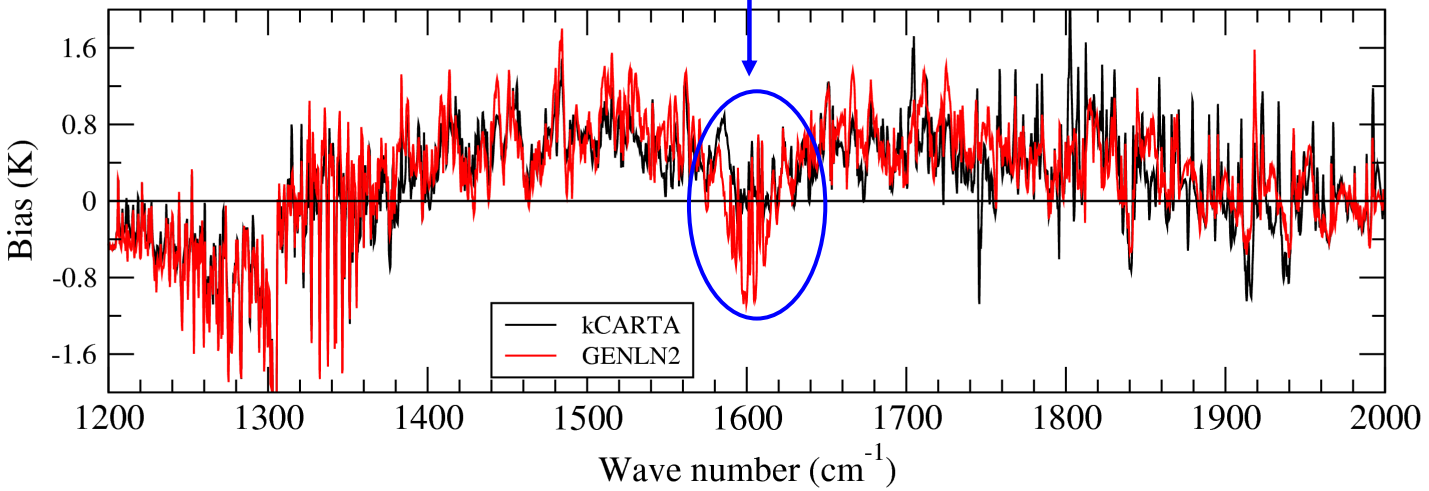


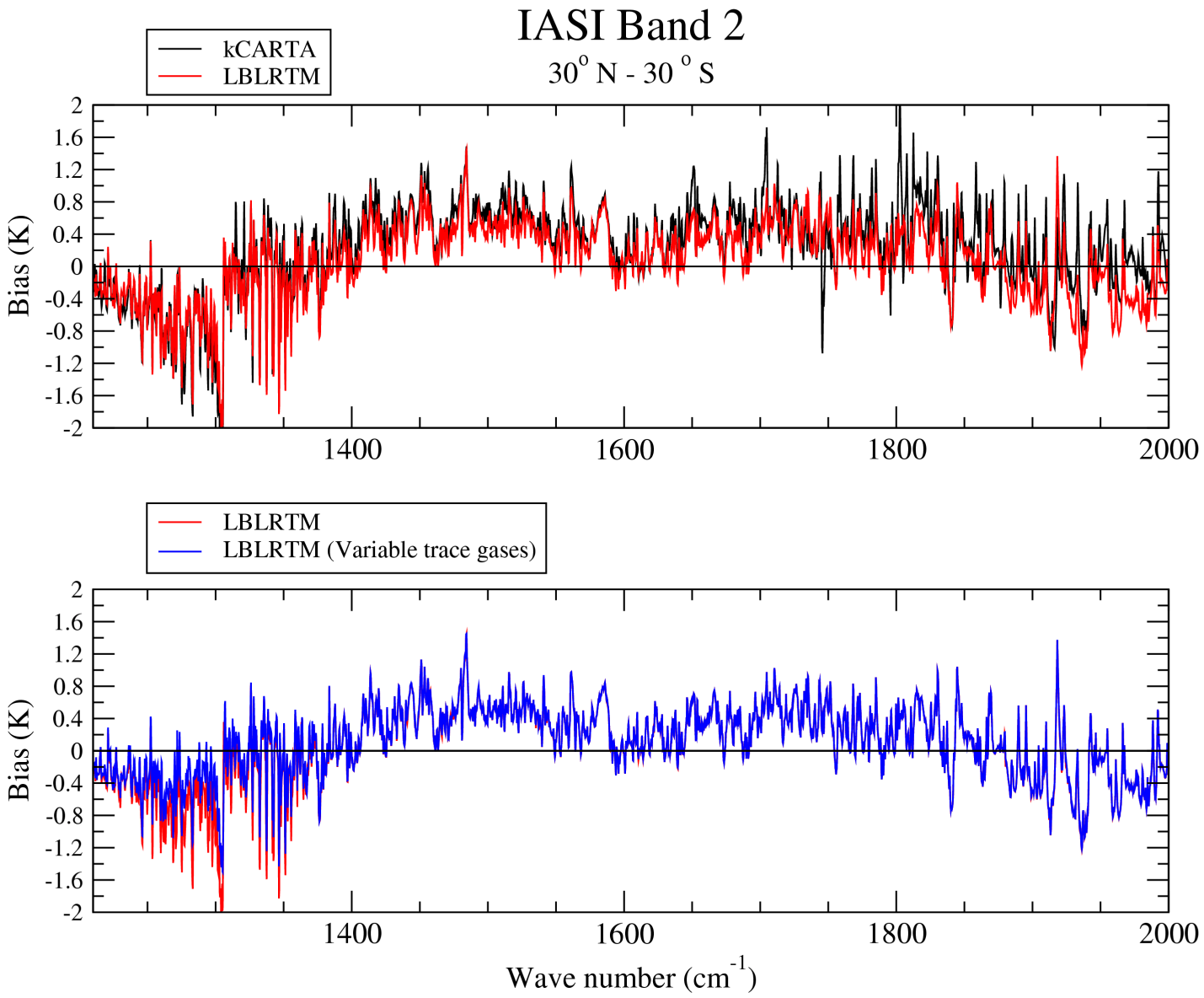

IASI Band 1
30° N - 30 ° S
kCARTA
LBLRTM
Bias (K)
0.8
0.4
0
-0.4
-0.8
-1.2
-1.6
-2
700
800
900
1000
1100
1200
LBLRTM
LBLRTM (Variable trace gases)
More realistic CO_2 profiles result in smaller biases
Wave number (cm^{-1})

Water vapour spectroscopy is an outstanding issue:
Line intensities?
More work needed on line widths and pressure shift



Differences due to the continuum model



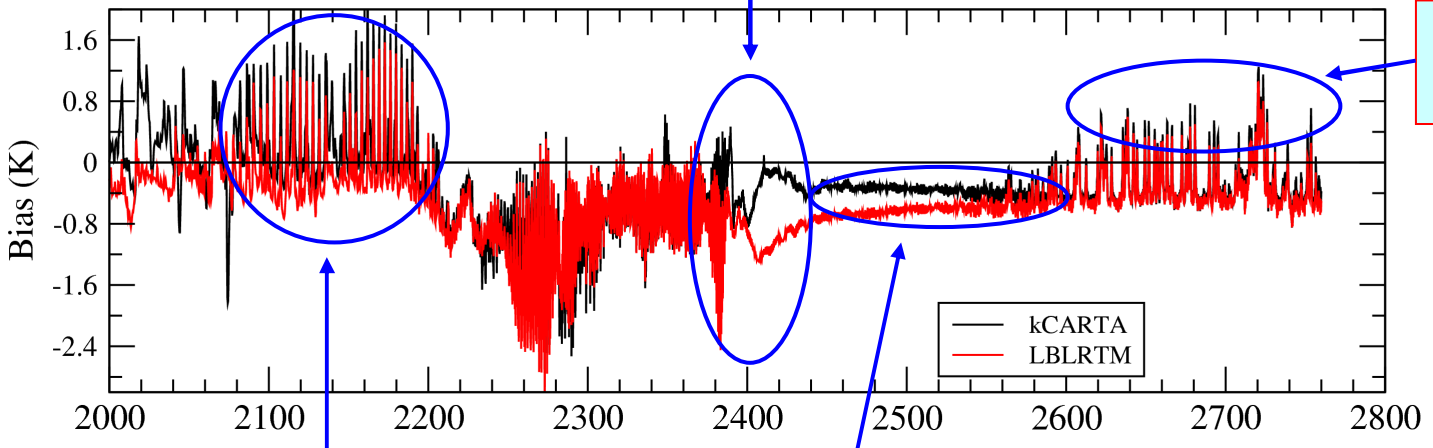

IASI Band 2
30° N - 30 ° S
kCARTA
LBLRTM
Bias (K)
2
1.6
1.2
0.8
0.4
0
-0.4
-0.8
-1.2
-1.6
-2
1400
1600
1800
2000
LBLRTM
LBLRTM (Variable trace gases)
Bias (K)
Wave number (cm-1)

IASI band 3

Tropics

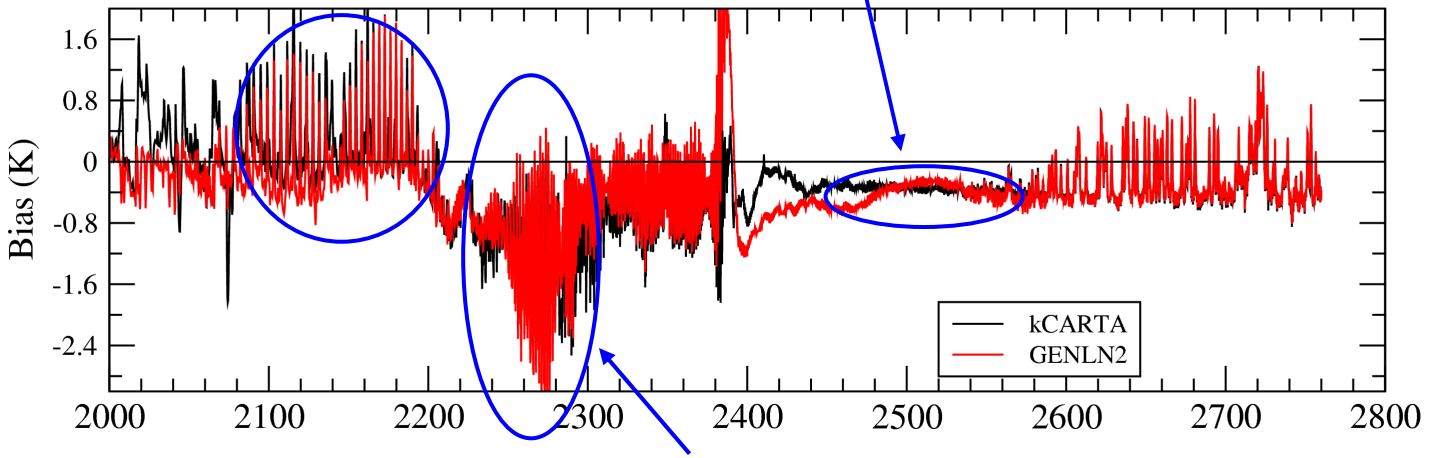
CO_2 line shape

Water vapour spectroscopy

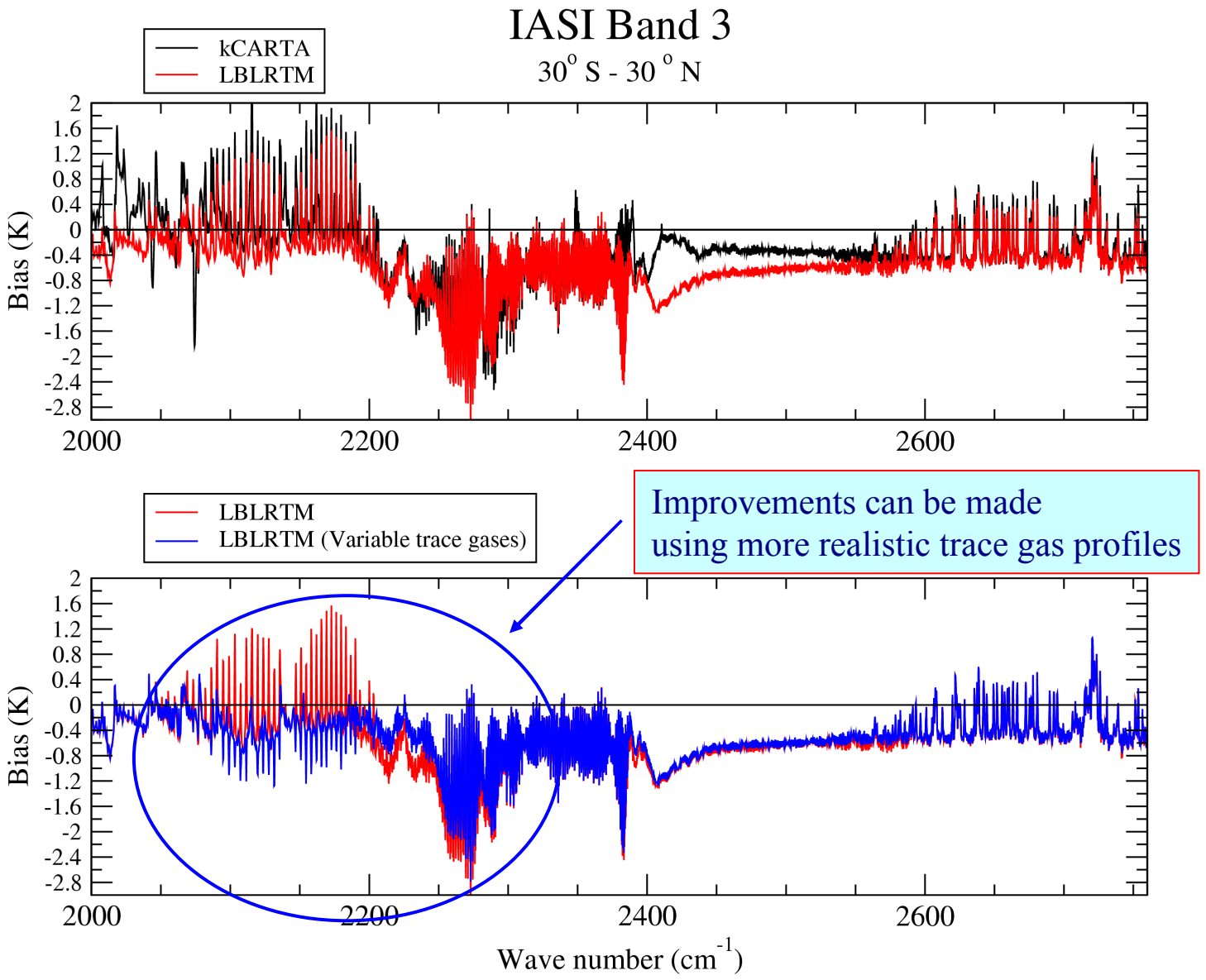


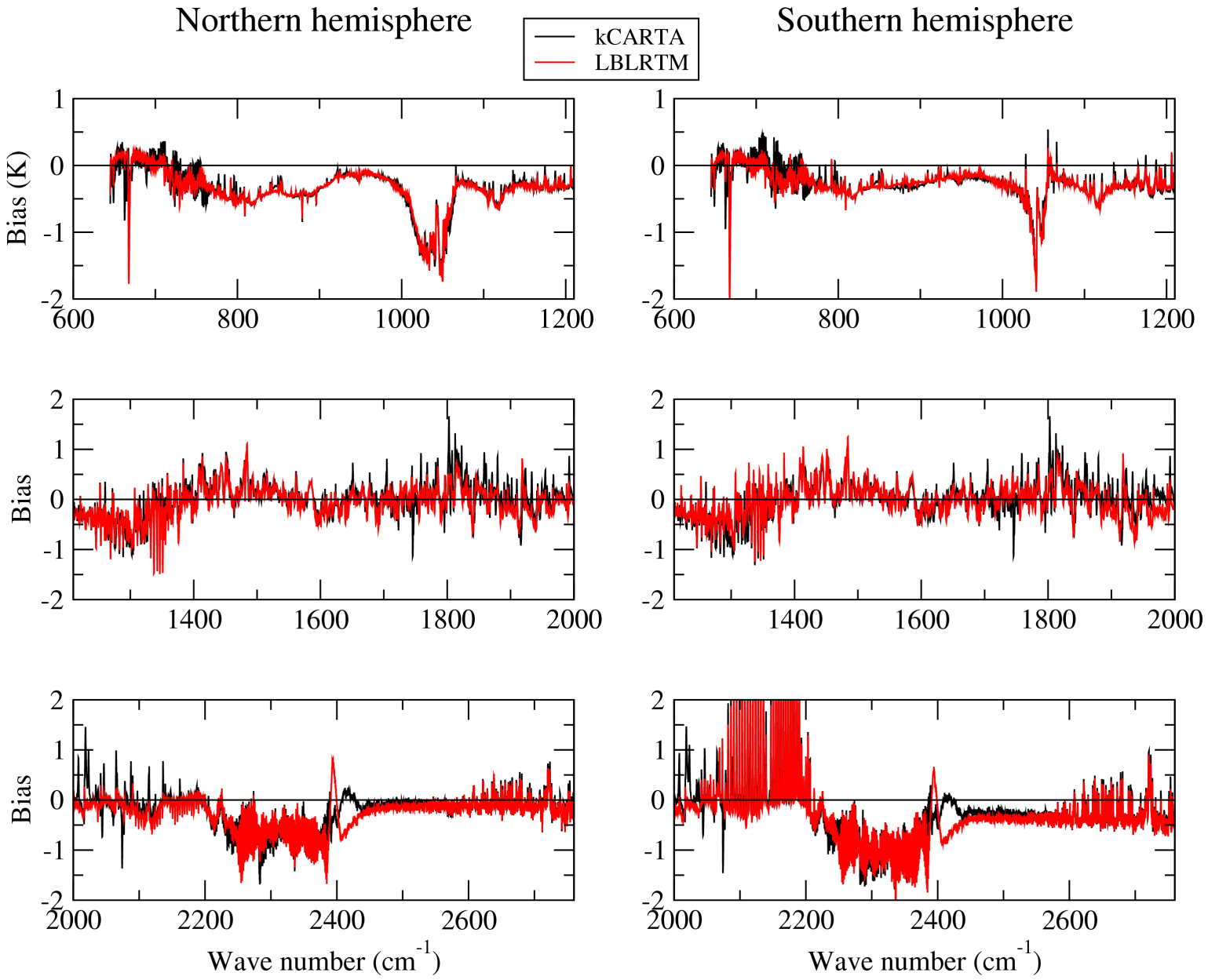
Specification of the CO profile

Continuum model



CO_2 spectroscopy

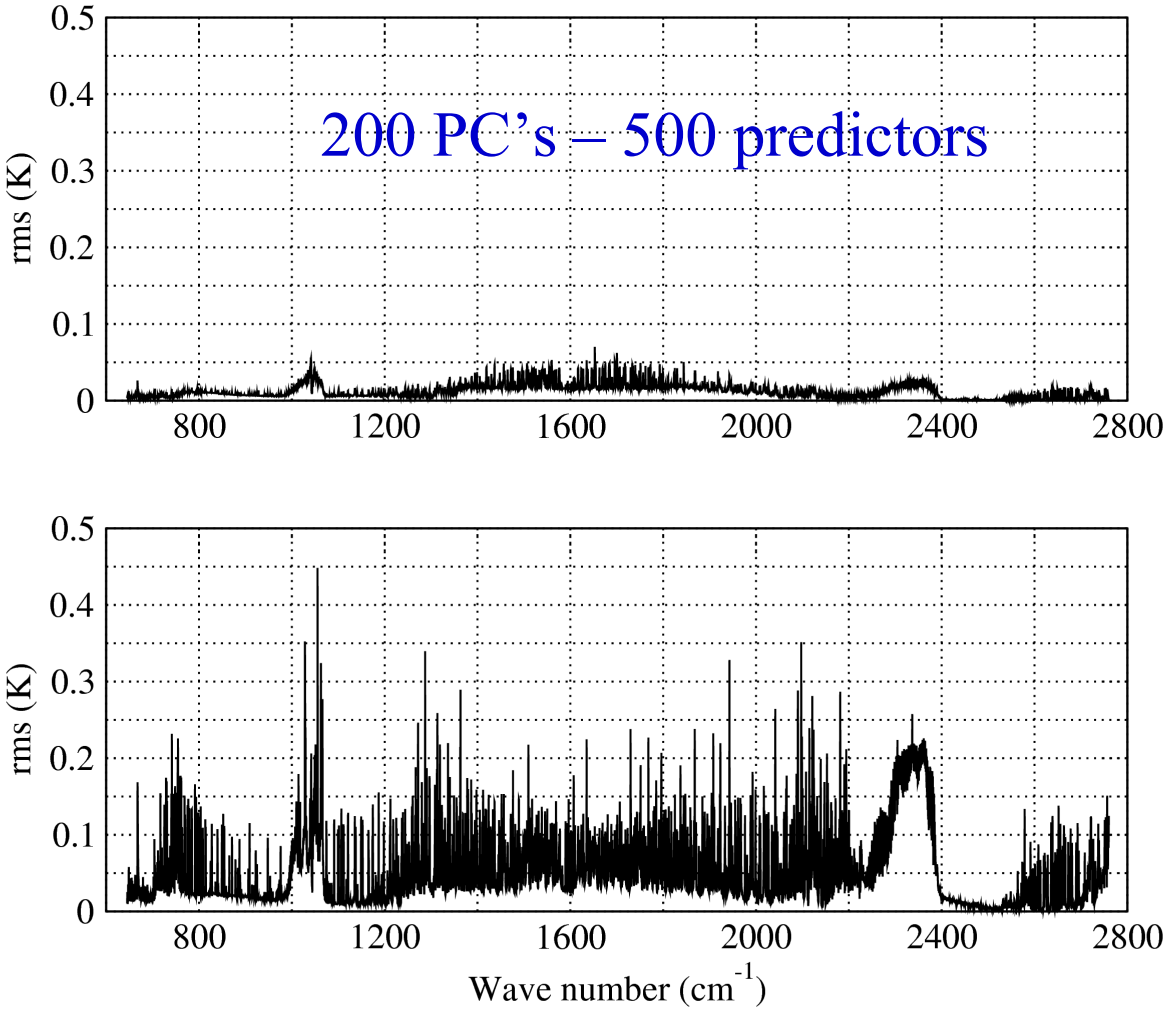

IASI Band 3
30° S - 30 ° N
kCARTA
LBLRTM
Bias (K)
2
1.6
1.2
0.8
0.4
0
-0.4
-0.8
-1.2
-1.6
-2
-2.4
-2.8
2000
2200
2400
2600
LBLRTM
LBLRTM (Variable trace gases)
Improvements can be made
using more realistic trace gas profiles
Wave number (cm-1)


Northern hemisphere
Southern hemisphere
kCARTA
LBLRTM
Bias (K)
Bias
Wave number (cm-1)

- A principal component based version of RTTOV has been developed that uses RTTOV polychromatic radiances to accurately predict principal component scores given any input atmospheric profile.

- The principal component based version of RTTOV allows the fast computation of PC's scores and/or IASI Level-1C and AIRS radiances reconstructed from the PC scores.

Independent set : 5195 observations



PC_RTTOV

Standard RTTOV

CONCLUSIONS

- A more accurate treatment of the CO_2 line shape (i.e. P/R-branch line mixing) has a significant impact on the simulated radiances in the CO_2 $\nu 2$ and $\nu 3$ band.
- Large biases are observed for some of the LBL models in the fundamental CO_2 Q-branch at 667 cm^{-1}.
- Biases for the tropospheric channels in the CO_2 $\nu 3$ band are inconsistent with biases for the equivalent channels in the $\nu 2$ band pointing to line parameter errors.
- Issues with the LBLRTM modelling of the CO_2 line shape in the CO_2 $\nu 3$ band head.

CONCLUSIONS

- The use of the MT_CKD continuum model results in a reduction up to 1K of the biases in the region around 1600 cm^{-1} (the centre of the ν2 water vapour band).
- Larger biases observed in the ν2 water vapour band warrant further investigation of the accuracy of water vapour line intensities, line widths and pressure shifts.
- The use of the UMBC version of the MT_CKD continuum model results in smaller biases in the short wave window region.
- Large biases are observed in the ozone band in the Northern hemisphere. They probably reflect a poor performance of the assimilation system.