# An intercomparison of line-by-line models using different molecular databases

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- Spectra computed using the LBLRTM_v10, GENLN2_v4 and RFM_v4 line-by-line models have been compared to spectra measured during five different campaigns:

| | | | |
|---|---|---|---|
| →CAMEX-1 : | 29-9-93 | 38ºN | **HIS**<br>***ER-2, 20 km altitude flight*** |
| →CAMEX-3 : | 14-9-98 | 22ºN | **NAST-I**<br>***ER-2, 20 km altitude flight*** |
| →EAQUATE : | 9-9-04 | 40ºN | **NAST-I**<br>***PROTEUS, 16 km altitude flight*** |
| →MOTH : | 28-4-99 | 8ºN | **ARIES**<br>***C130, 8km altitude flight*** |
| →ARM : | 26-9-97 | 33ºN | **AERI** |

- The line-by-line models have been used in conjunction with three different molecular databases:

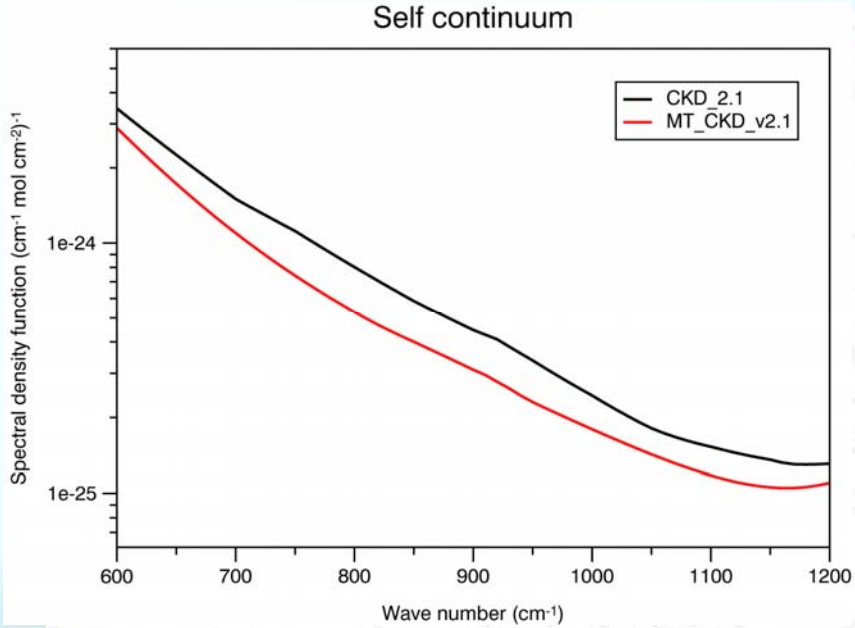
  →HITRAN2000

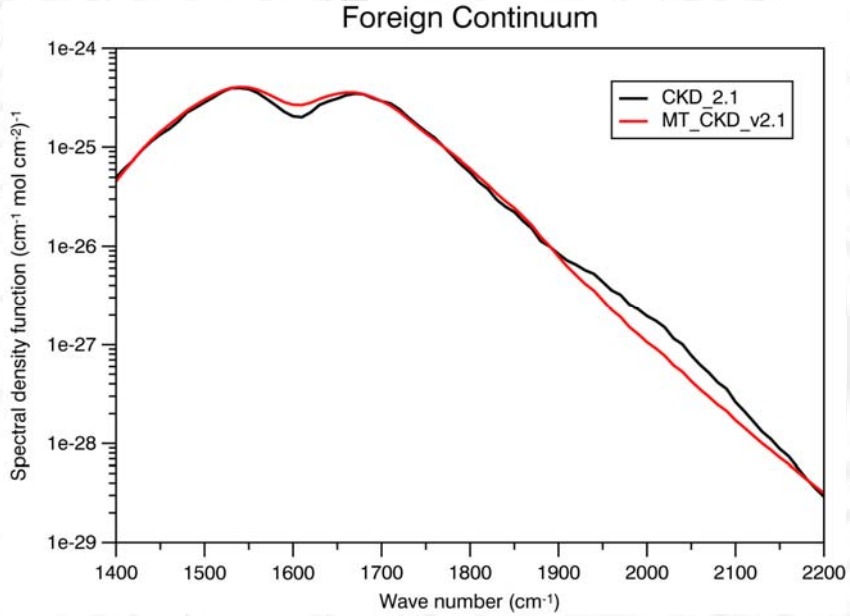
  →HITRAN2004 with updates up to year 2006

  →GEISA2003

- Note how, for LBLRTM, the use of the coupling parameters in the $CO_2$ P/R branches in the $\upsilon_2$ region required the use of a dedicated molecular database (the AER TES database, largely based on HITRAN2000).

| **Model** | **Water vapour continuum** | **Line mixing** $CO_2$ $\upsilon_2$ (600-800 $cm^{-1}$) | **Line mixing** $CO_2$ $\upsilon_3$ (2150-2450 $cm^{-1}$) |
|---|---|---|---|
| GENLN2 | CKD_2.1<br>*Clough et al. (1989)* | Q branch:1st order<br>*Strow et al. (1994)* | Q branch:1st order<br>*Strow et al. (1994)* |
| LBLRTM | MT_CKD_v1.3<br>*Mlawer et al. (2004)* | P branch: 1st order<br>R branch: 1st order<br>*Niro et al. (2005)*<br>Q branch: 1st and 2nd order<br>*Hoke et al. (1989)* | Q branch:1st order<br>*Strow et al. (1994)* |
| RFM | MT_CKD_v1.1<br>*Mlawer et al. (2004)* | Q branch:1st order<br>*Strow et al. (1994)* | Q branch:1st order<br>*Strow et al. (1994)* |

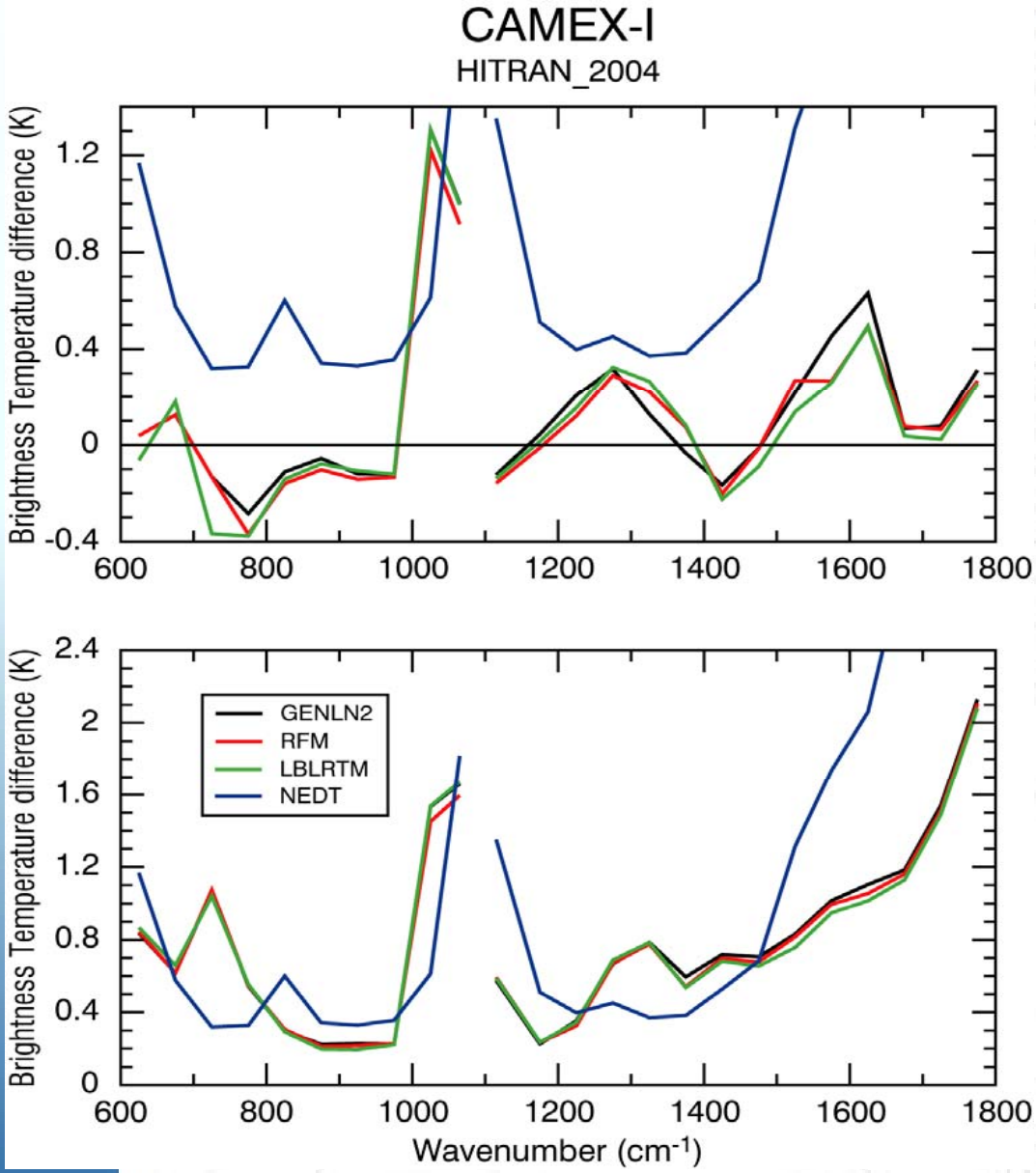

Self continuum
CKD_2.1
MT_CKD_v2.1
Spectral density function (cm-1 mol cm-2)-1
1e-24
1e-25
600
700
800
900
1000
1100
1200
Wave number (cm-1)


Foreign Continuum
CKD_2.1
MT_CKD_v2.1
Spectral density function (cm-1 mol cm-2)-1
1e-24
1e-25
1e-26
1e-27
1e-28
1e-29
1400
1500
1600
1700
1800
1900
2000
2100
2200
Wave number (cm-1)

| Campaign | Surface/ Temperature | Emissivity model | Atmospheric state T,q |
|---|---|---|---|
| CAMEX-I *(Griffin et al. 1994)* | Sea/Estimated | *Masuda et al. (1988)* | Radiosondes |
| CAMEX-III *(http://ghrc.msfc.nasa.gov.camex3)* | Sea/Retrieved | *Masuda at al. (1988)* | Inversion of the NAST-I radiance (δ-IASI package, Carissimo et al. (2005)) |
| EAQUATE *(Cuomo et al. 2005)* | Canopy/ Retrieved | Fitted to the NAST-I spectrum *Masiello et al. (2006)* | Inversion of the NAST-I radiance (δ-IASI package, Carissimo et al. (2005)) |
| MOTH *(Taylor et al. 2003)* | Sea/Measured | *Masuda et al. (1998)* | Dropsondes Microwave radiometer |
| ARM* *(Stokes and Schwartz 1994)* | N.A. | N.A | Radiosondes Raman lidar Microwave radiometer |

*The temperature in the boundary layer has been obtained by linear regression analysis (Esposito et al. 2007)

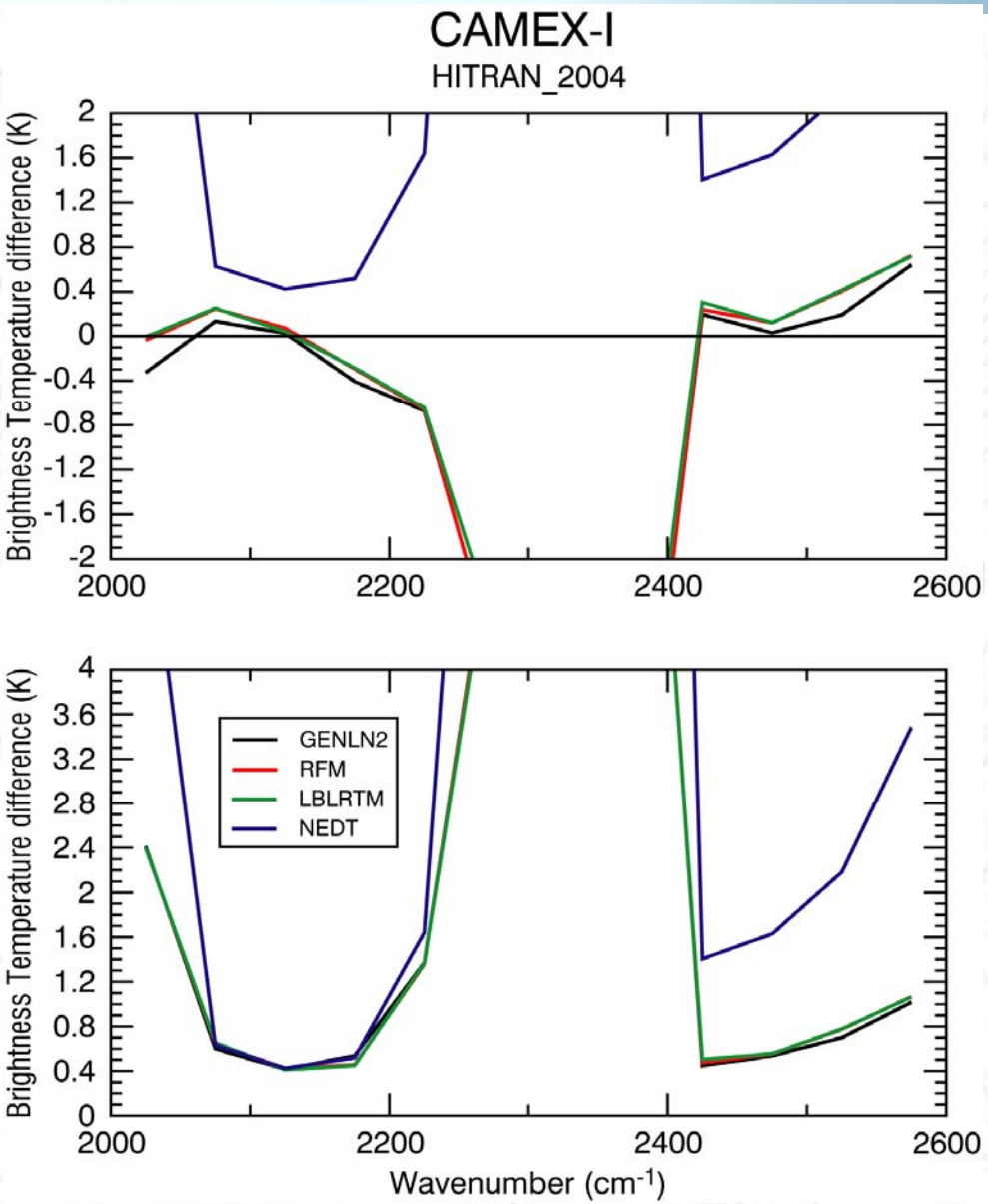
# Models versus observations




**Bias** (mean value of the difference between simulated and measured radiance over intervals of 50 $cm^{-1}$)

**Root mean square** of the difference between simulated and measured radiance over intervals of 50 $cm^{-1}$

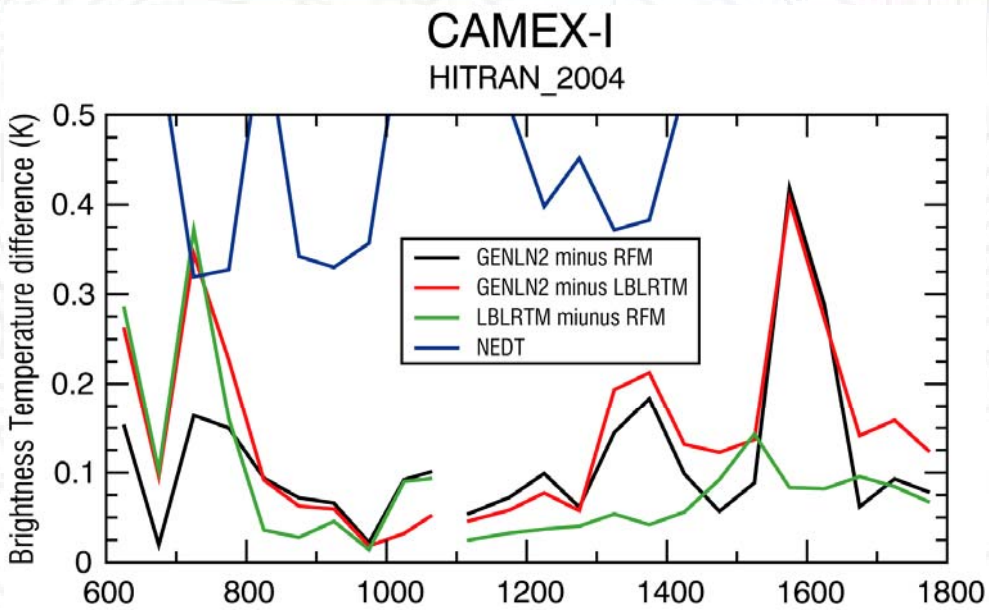
# Models versus observations




Bias

rms

# Model versus model

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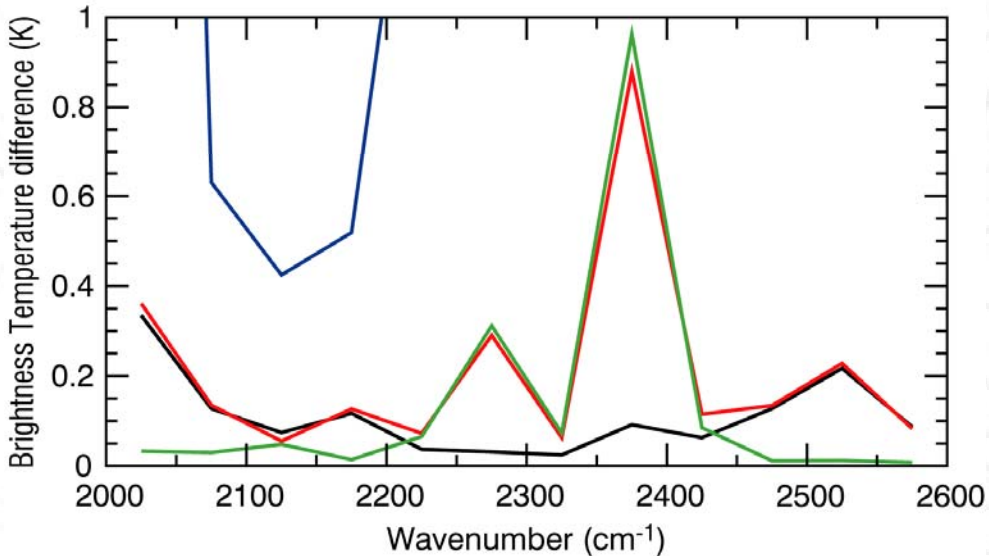


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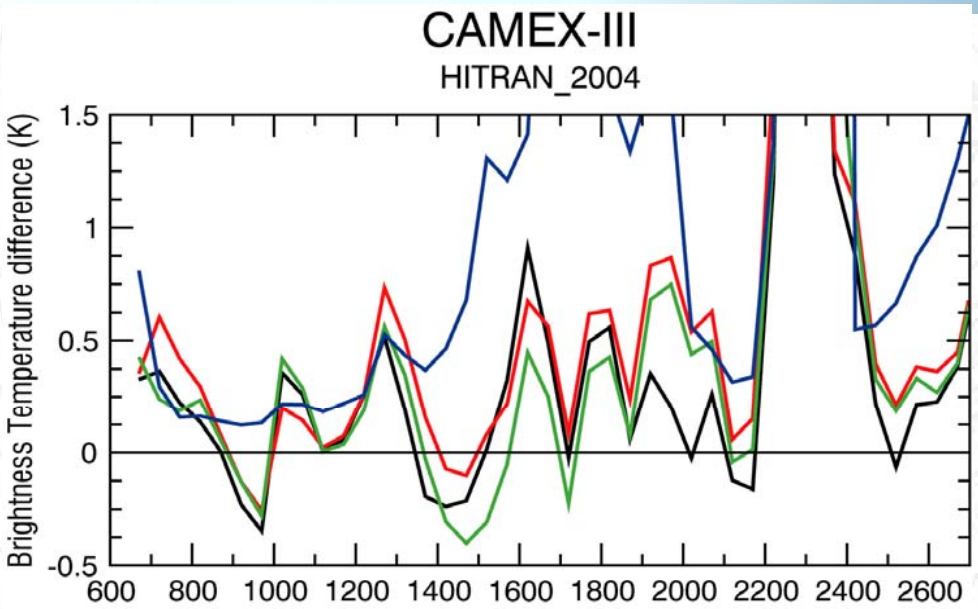
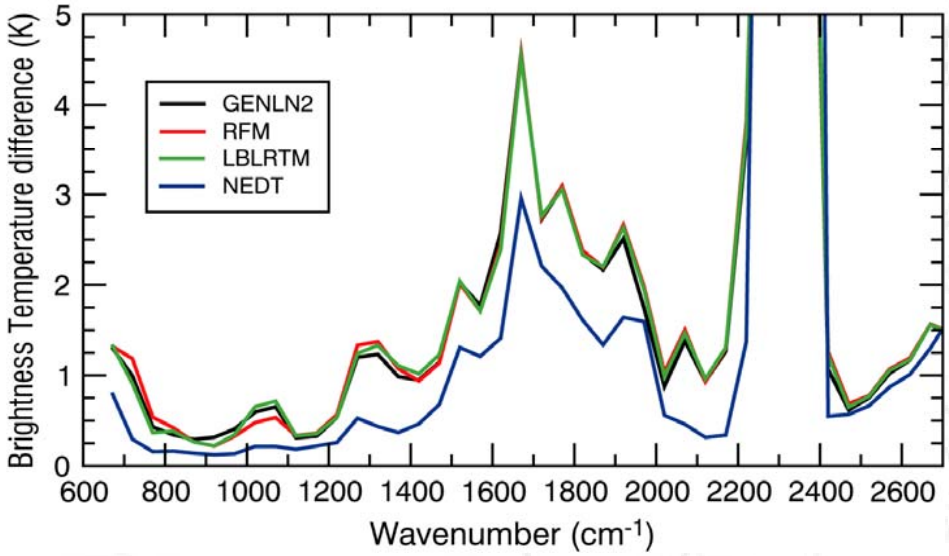



Bias

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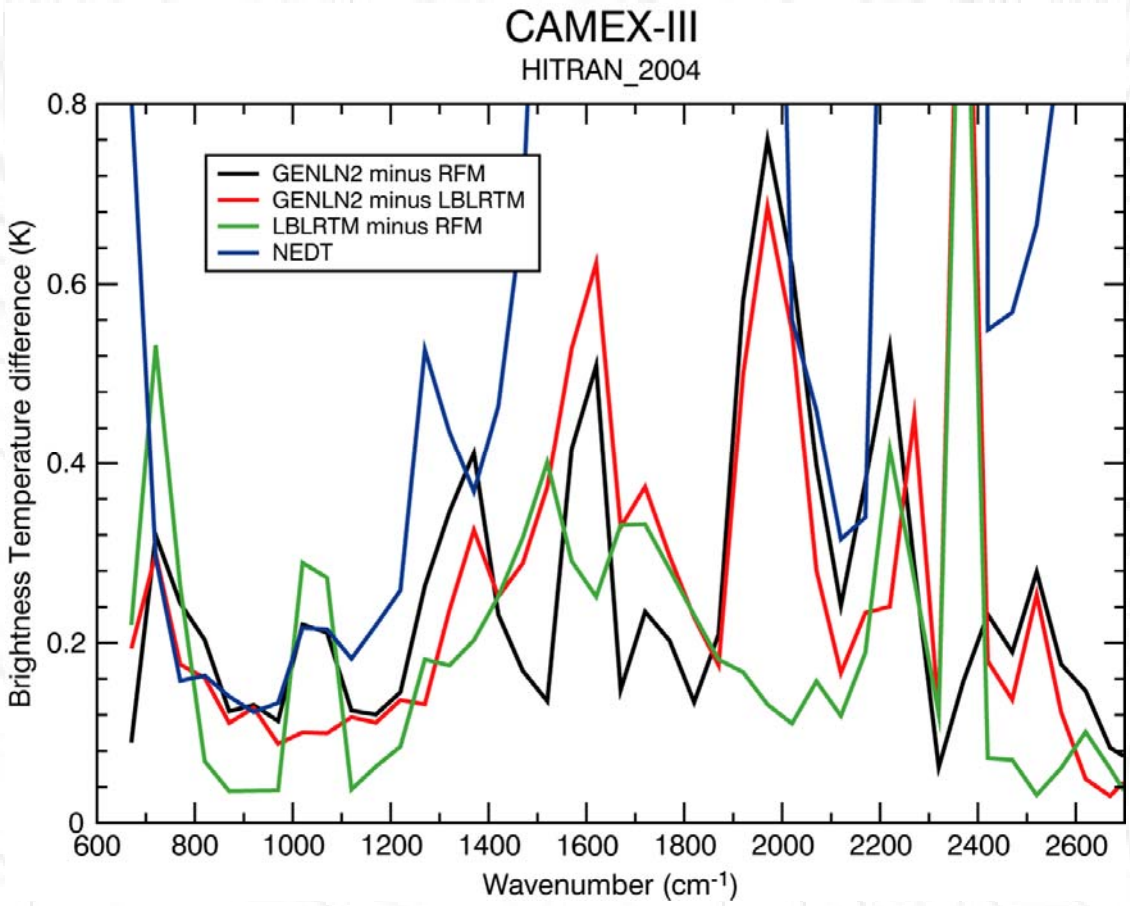


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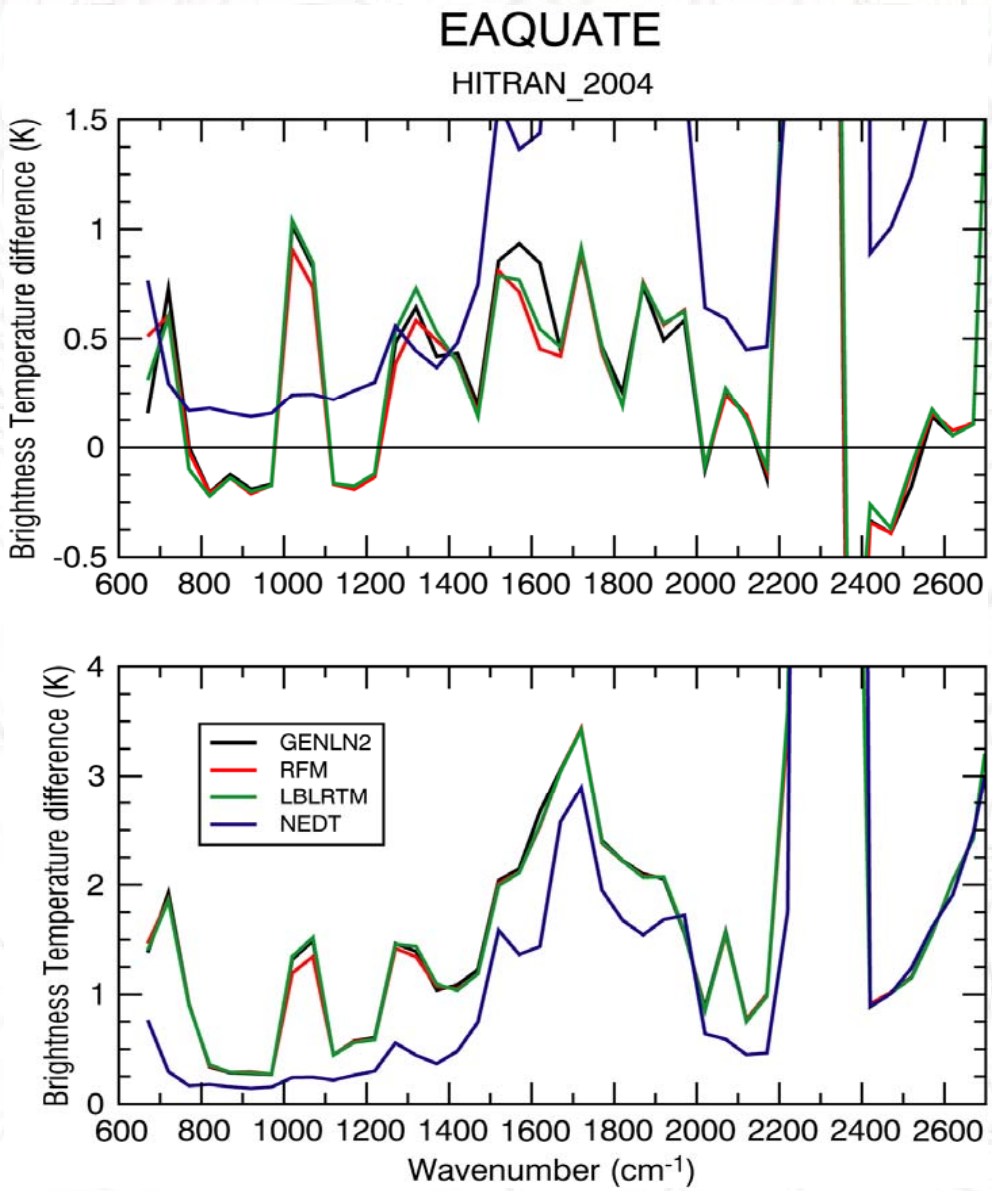


Bias

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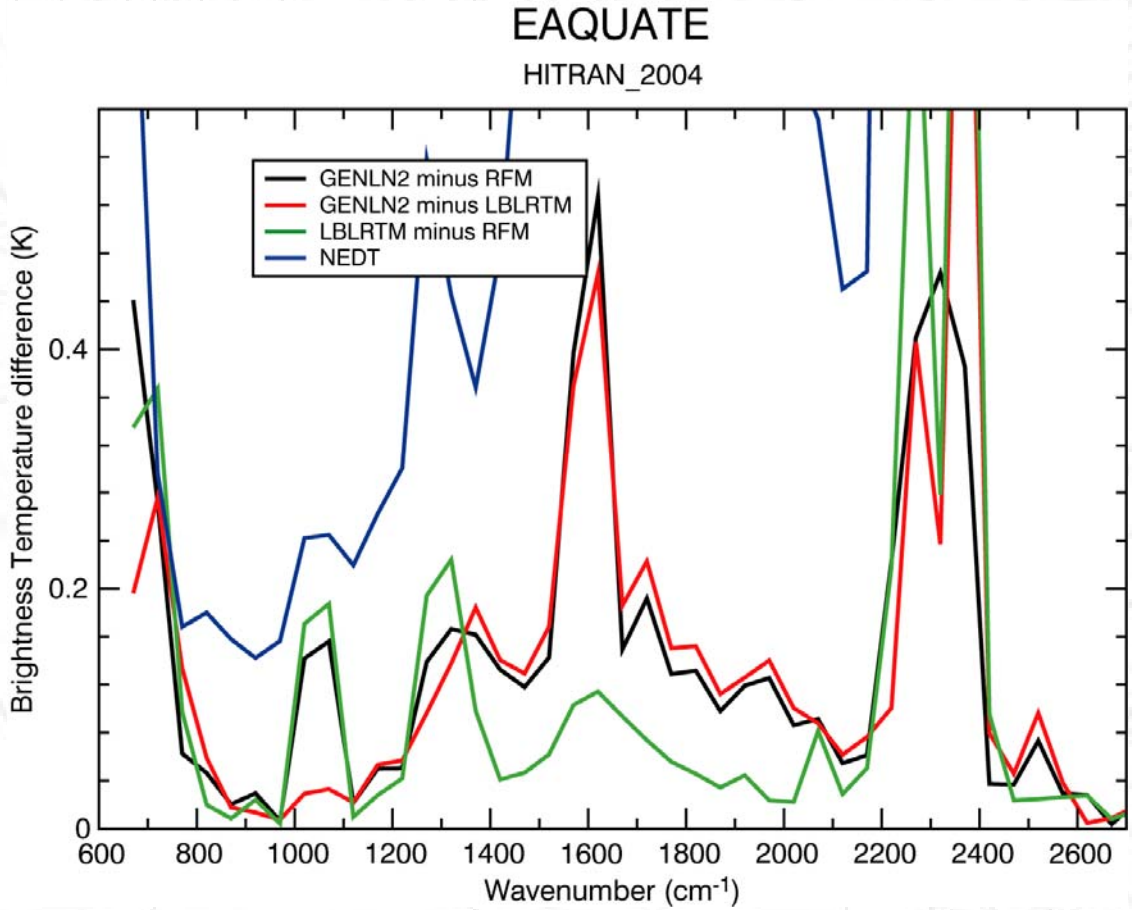


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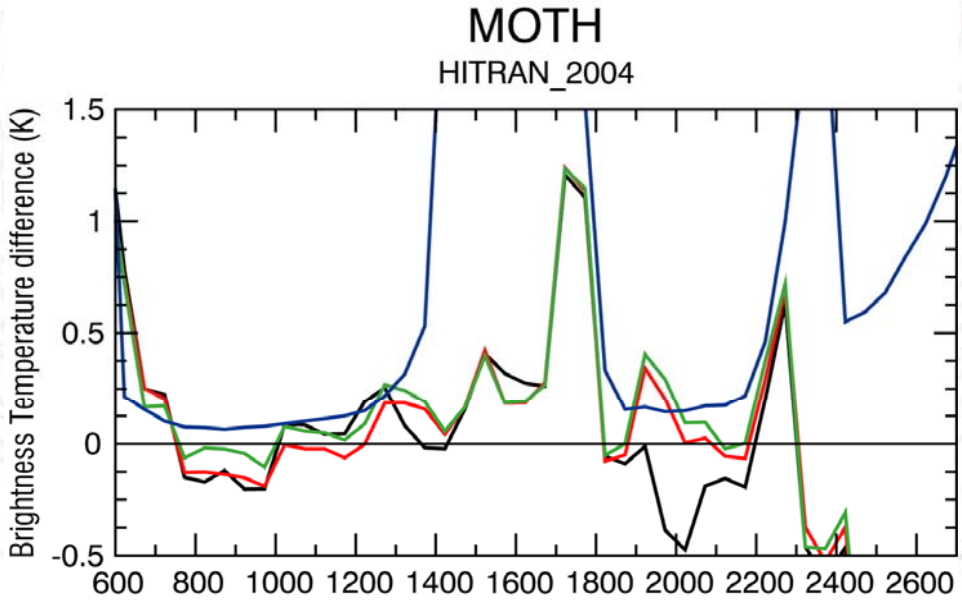
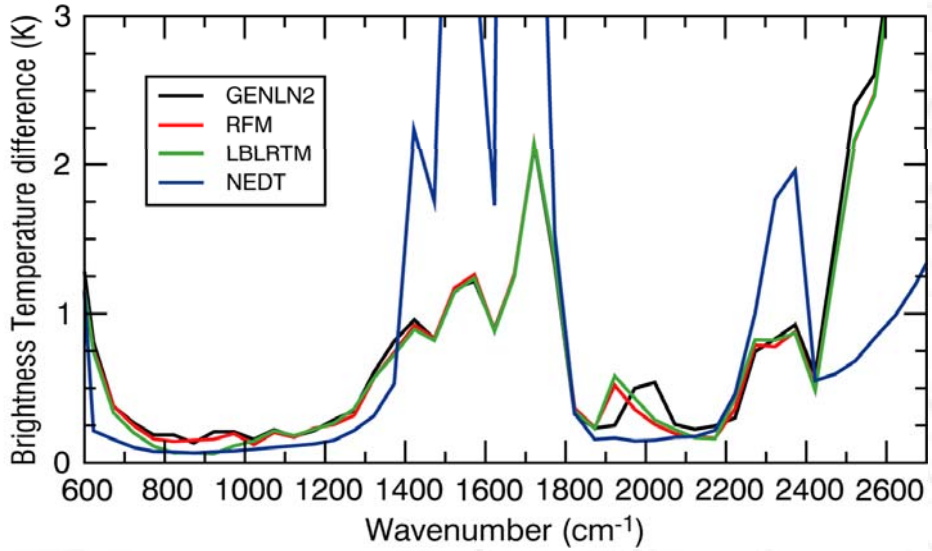



Bias

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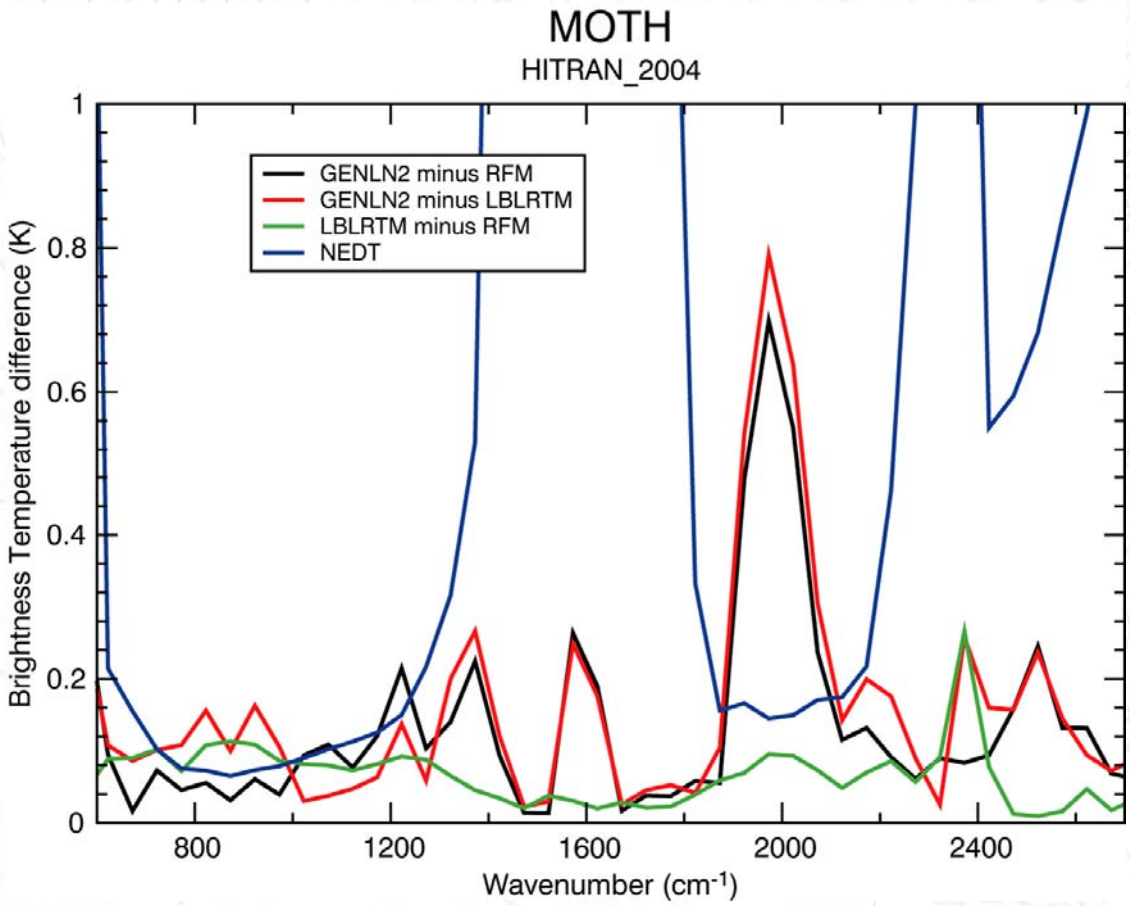


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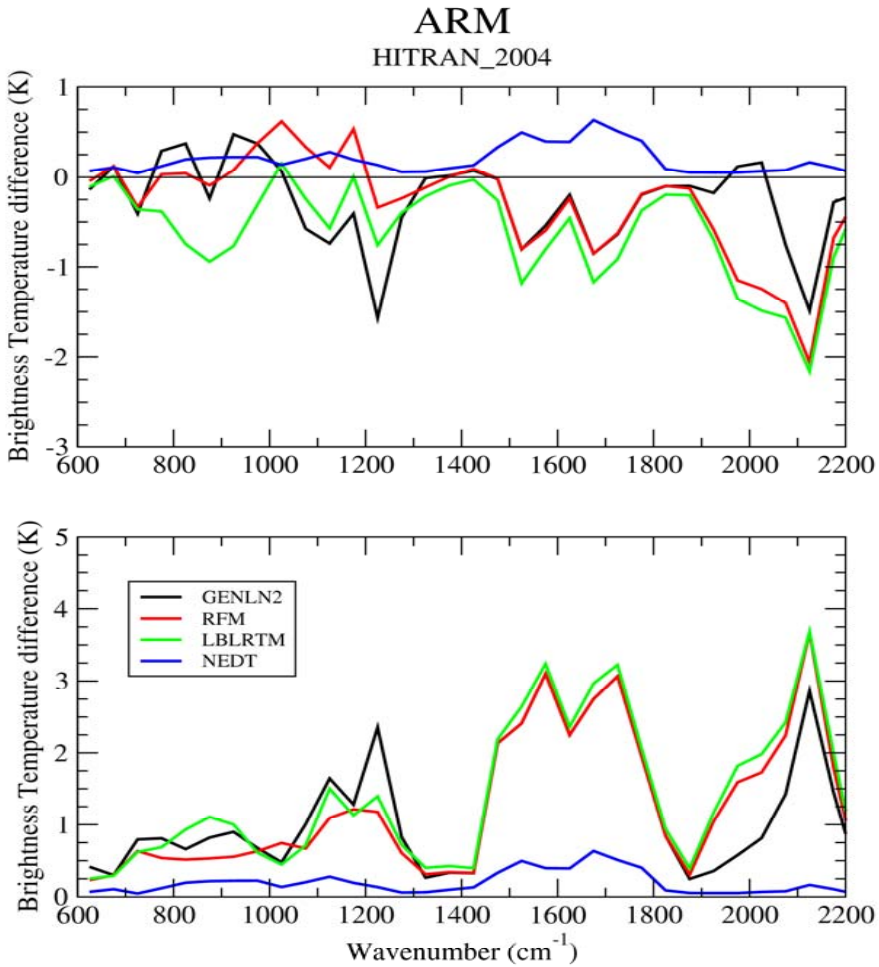


Bias

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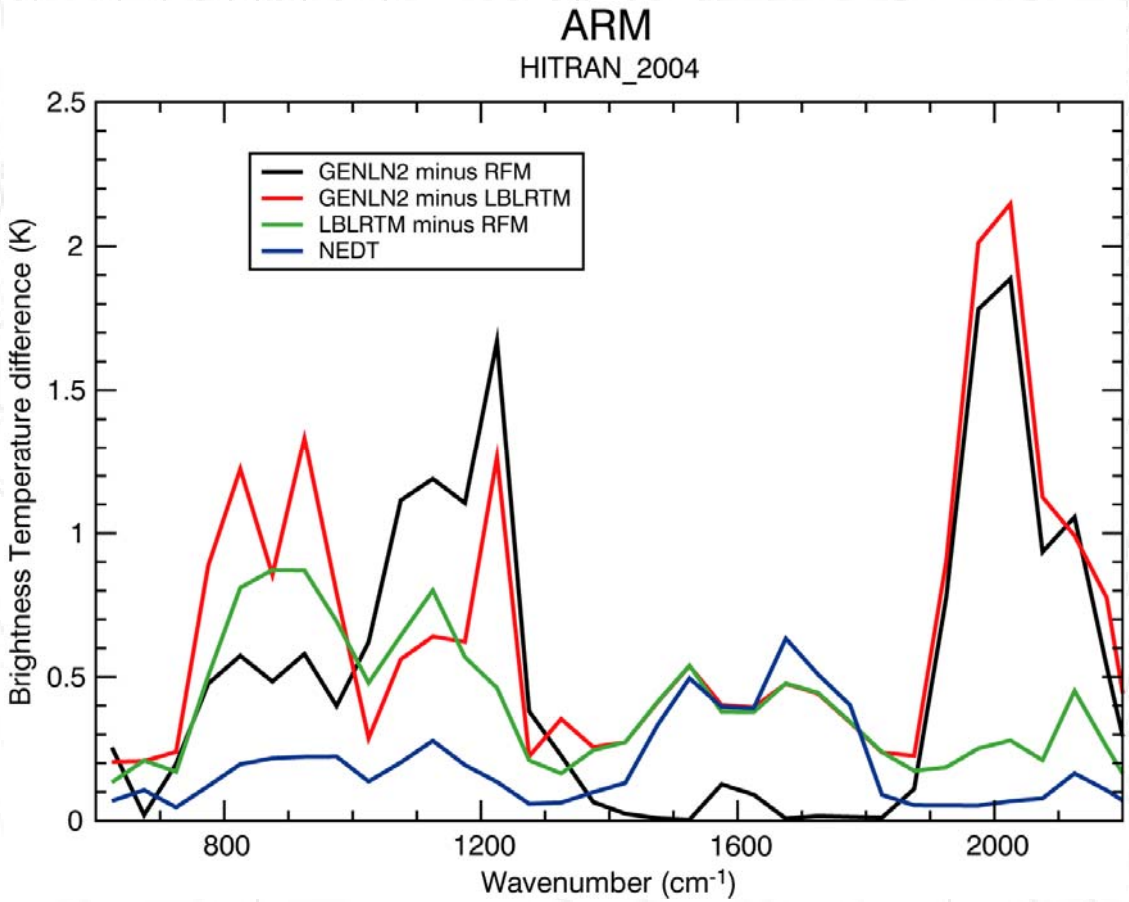


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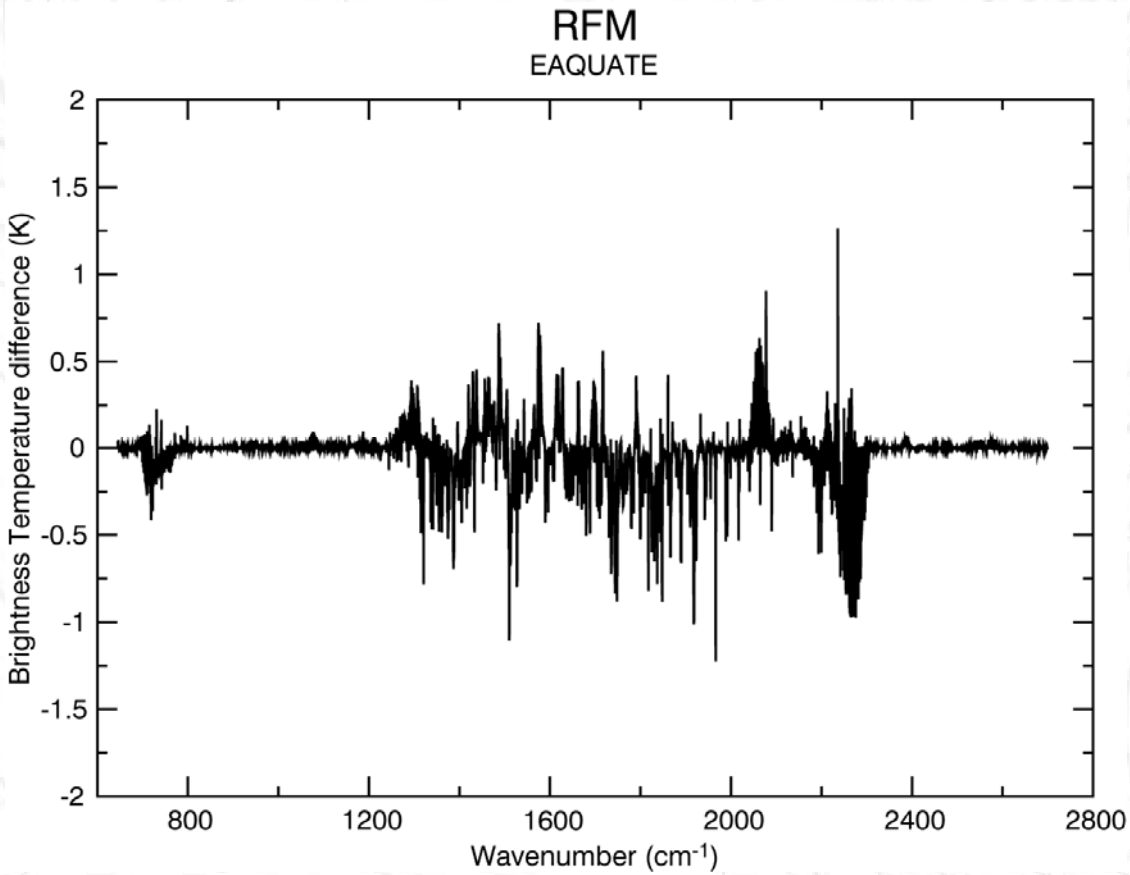
# Model versus observations: different databases



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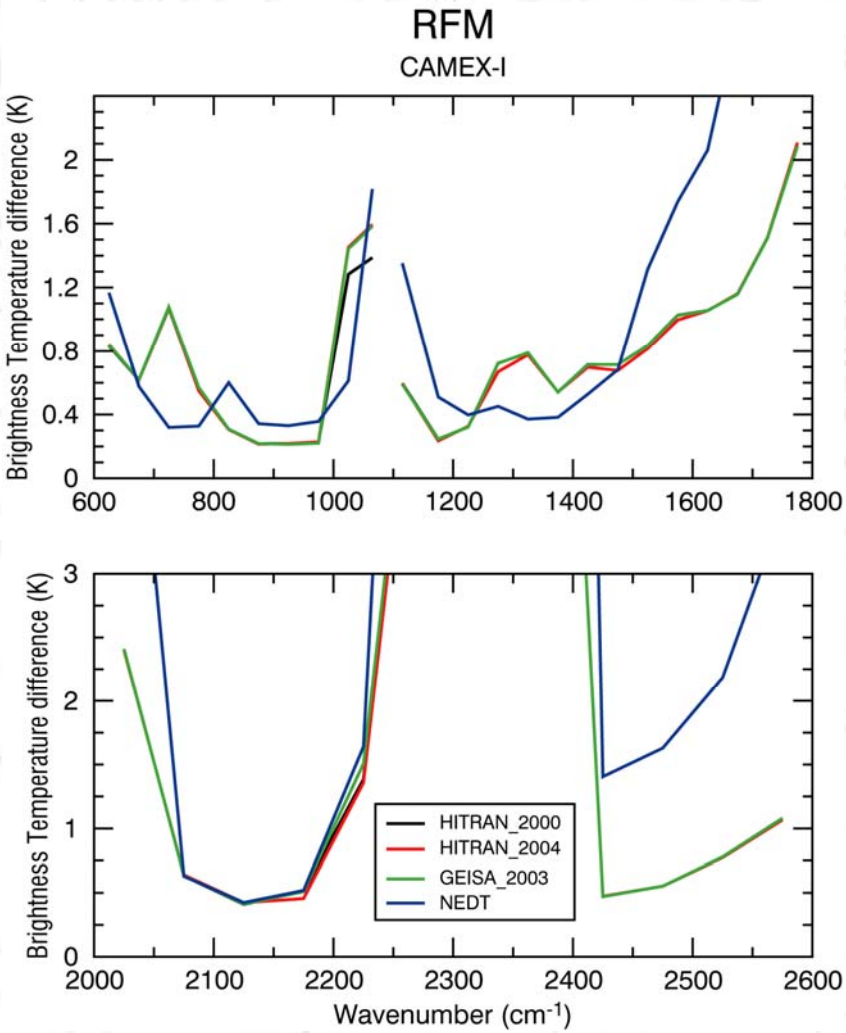


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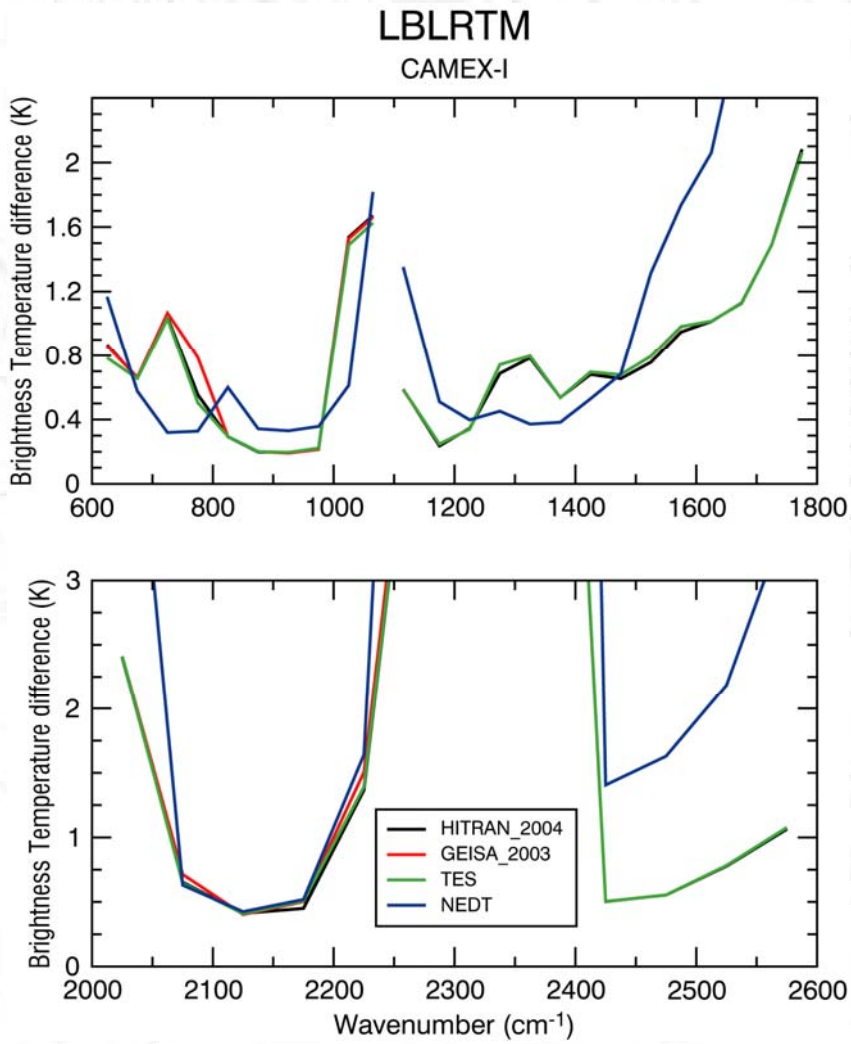


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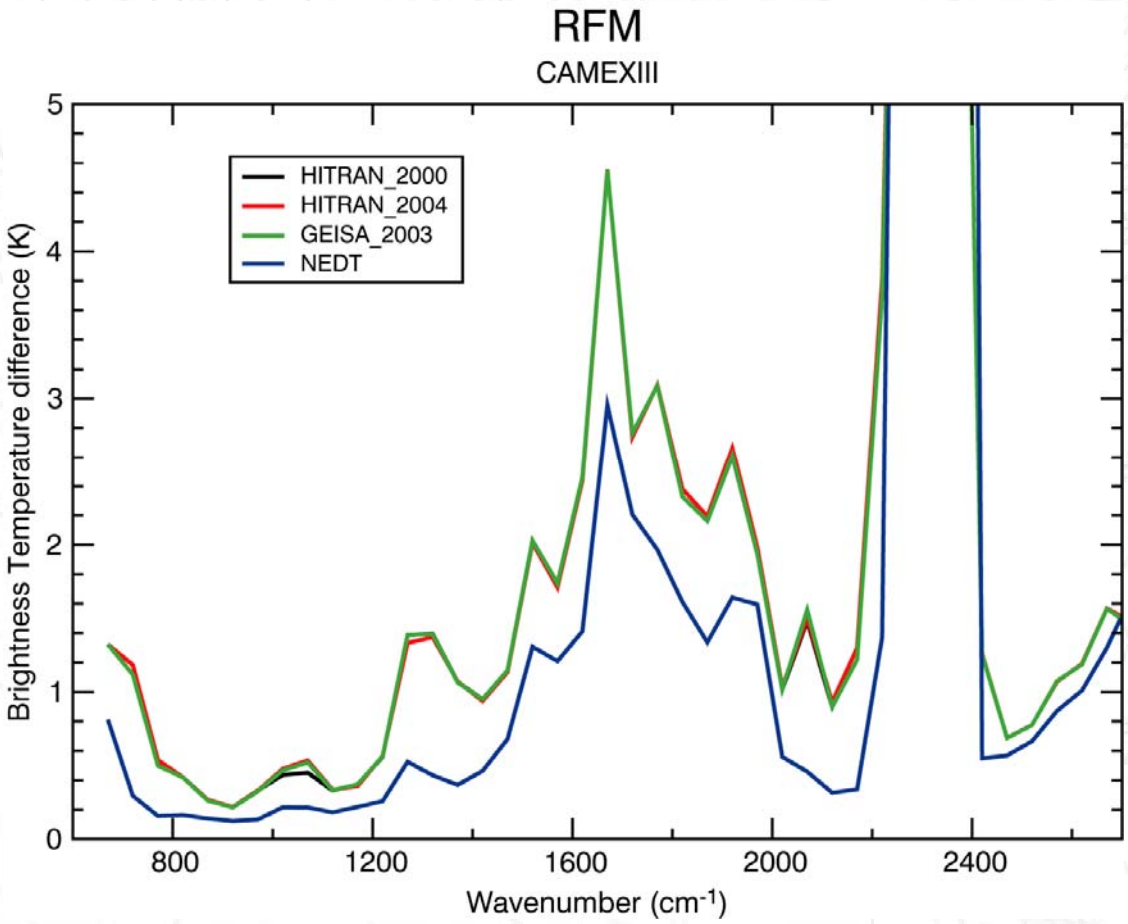


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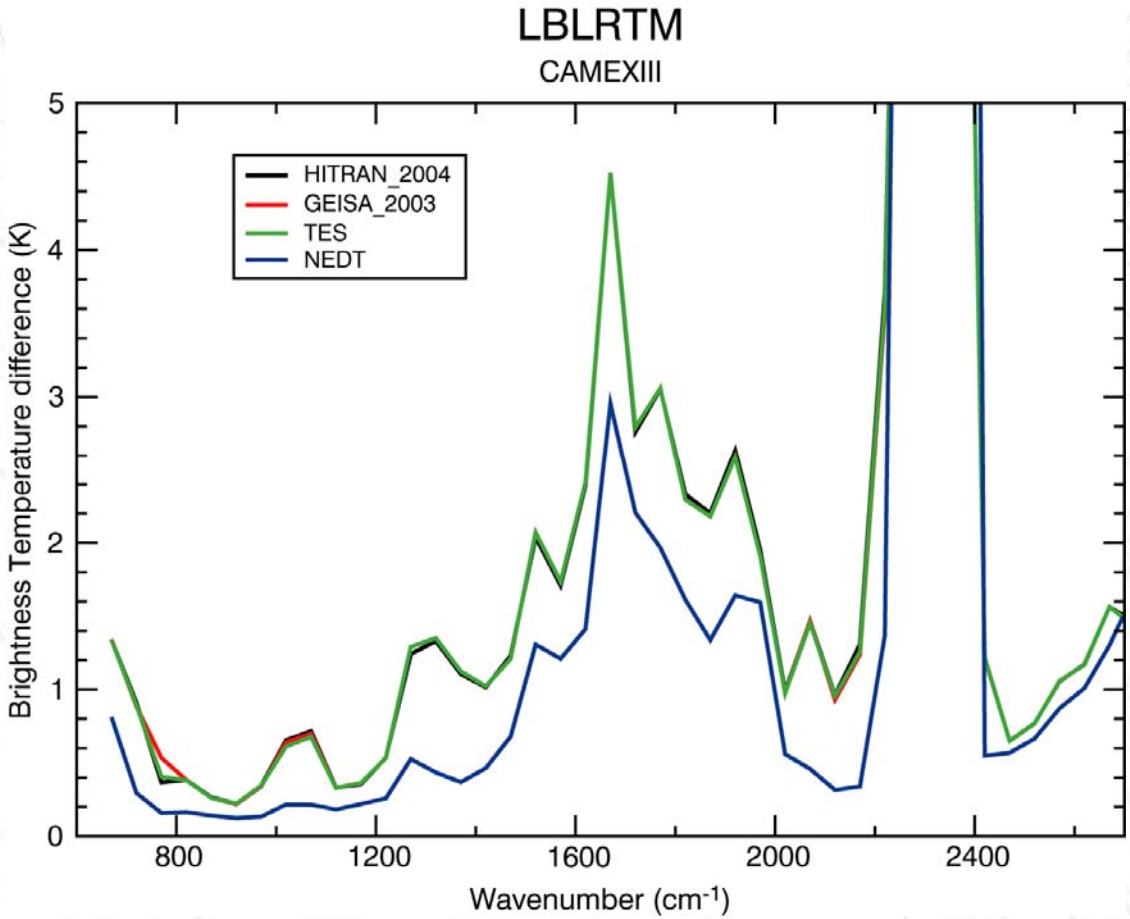


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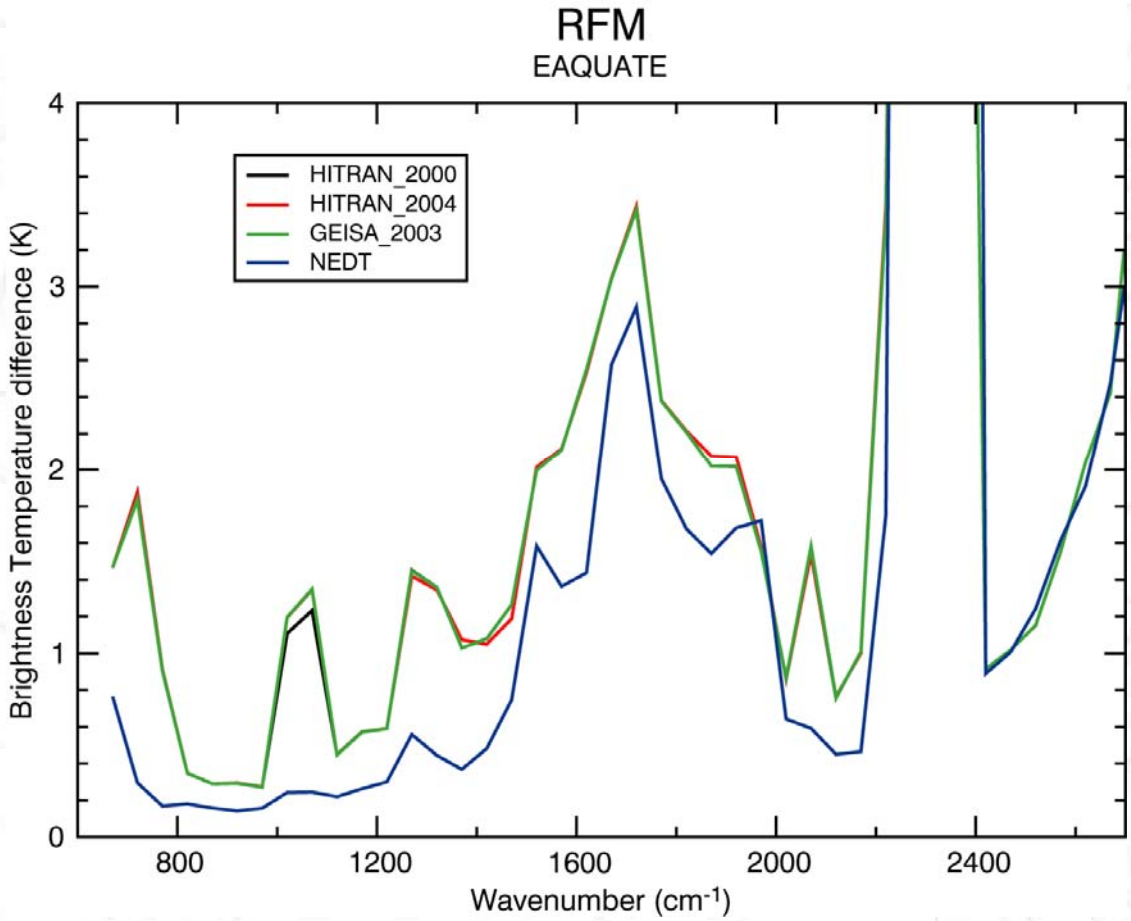


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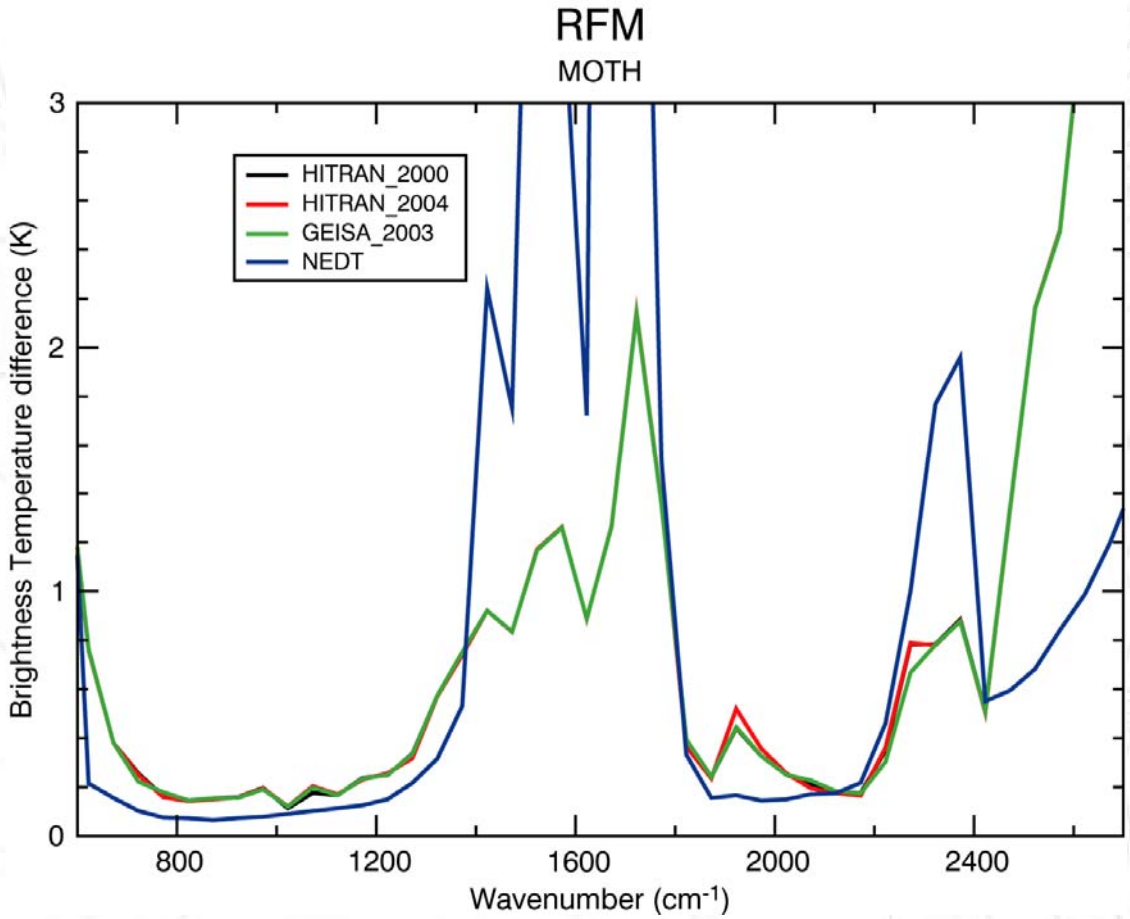


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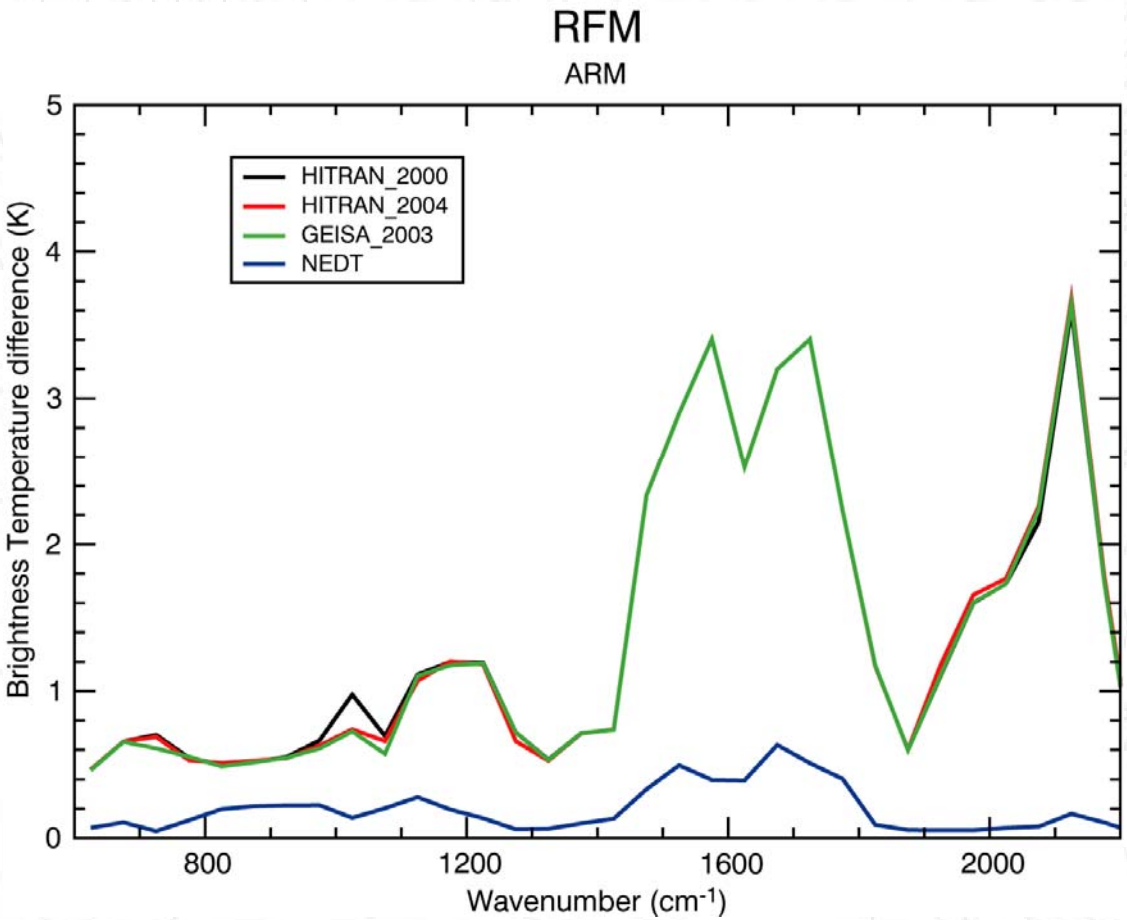


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# CONCLUSIONS

1) The three line-by-line models produce results that, in general, are very similar

2) In most spectral regions the difference between simulations and measurements is larger than the difference between the models.

3) The line-by-line spectra are highly correlated

4) From 2) and 3) one can conclude that most of the discrepancies with measurements are not due to the particular computational procedures adopted by the three codes but rather to insufficient knowledge in basic spectroscopy.

5) The inclusion of line coupling in the $CO_2$ P-R branches in the $\upsilon_2$ band appears to generate spectra that are in slightly better agreement with observations.

# CONCLUSIONS

6) Use of the GEISA2003 database appears to produce spectra that are in slightly better agreement with observations in the $CO_2$ $\upsilon_2$ band.

7) Use of the HITRAN2000 database appears to produce spectra that are in better agreement with observations in the 1040 $cm^{-1}$ ozone band.

8) Use of the HITRAN2004 database appears to produce spectra that are in slightly better agreement with observations in the 1200 $cm^{-1}$ to 1600 $cm^{-1}$ spectral region

9) Use of the GEISA database appears to produce spectra that are in slightly better agreement with observations in the 1600 $cm^{-1}$ to 2300 $cm^{-1}$ spectral region

# Aknowledgments

R. Knuteson, P.Van Delst and D. Tobin, CIMSS, provided the data sets and the information required to process and simulate the HIS and AERI spectra.

S. Newman, Met. Office, provided the data sets and information required to process and simulate the ARIES radiances.

**A more detailed discussion of the results can be found at:**

**http://www.ecmwf.int/publications/library/ecpublications/_pdf/tm/501-600/tm525.pdf**