Improved Spectroscopy for Microwave and Infrared Data Assimilation

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Abstract

• Aim of this work:
– **Improve the accuracy of fast radiative transfer models**
› used in the NCEP satellite radiance assimilation
– **Increase positive impact of satellite data on the forecast**

• Accuracy of the microwave and infrared line-by-line models
– Limited mainly by **uncertainties in spectroscopy**
› Line parameters and continua

• Presented here:
– Recent spectroscopic updates
› Validation of these updates using atmospheric measurements
› Satellite and ground-based

• Updates result in **significant overall improvements to the consistency between spectral regions**

Approach: **Use of consistent physics across spectral regions, from the microwave to the visible**

Validate spectroscopy using high quality radiometric measurements from a range of platforms and viewing geometries to improve the models at a fundamental level

Summary of microwave updates

2007: **MonoRTM v3.3**
Updated O_2 line widths and line coupling (Cadeddu et al., 2007)
Updated H_2O line widths for 22 and 183 GHz (Payne et al., 2008)

2008: **MonoRTM v4.0**
Updated MonoRTM to use MT_CKD 2.1 continuum
Updated MonoRTM to allow use at any frequency

2009: **MonoRTM v4.1** (for imminent release)
Updated H_2O continuum
(now MT_CKD 2.4 - Payne et al., in preparation)

Summary of infrared updates for CO_2 and H_2O

2007: **LBLRTM v10.7** (aer_v_2.0 line file, MT_CKD 2.0 continuum)
P and R branch line coupling from Niro et al. (2005) -
Implemented for strongest bands. CO_2 continuum updated.
H_2O parameters updated to HITRAN 2004 + 2006 updates

2008: **LBLRTM v11.3** (aer_v_2.1 line file, MT_CKD 2.1 continuum)
P and R branch line coupling implemented for all available bands.
Updated chi factor, CO_2 continuum and definition of the 4th function

2009: **LBLRTM v11.6** (aer_v2.2 line file, MT_CKD 2.4 continuum)
(for imminent release)
Updated to Coudert et al. (2008) line intensities and positions for H_2O ν_2

Under investigation: Tashkun line positions and intensities for CO_2.
Correction to CO_2 continuum at the ν_3 bandhead based on ground-based measurements is being refined. Underlying ν_3 issues to be investigated.
Issues with exact vs first order perturbation line coupling at CO_2 667 cm^{-1} Q branch under investigation.
Temperature dependence of widths for H_2O (R. R. Gamache)

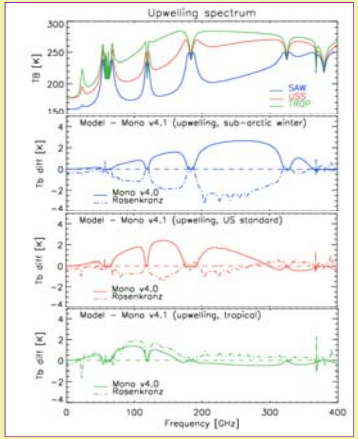
References

Cadeddu et al. (2007), *IEEE Trans. Geosci. Remote Sensing*, 45, 2216-2223
Coudert et al. (2008), *J. Mol. Spec.*, doi:10.1016/j.jms.2008.03.021
http://www.htiran.com
Niro et al. (2005), *JQSRT*, 95, 469-481
Tashkun et al. (1999), *JQSRT* 62, 571-598
Payne et al. (2008), *IEEE Trans. Geosci. Remote Sensing*, 46 (11), 3601-3617
Rosenkranz (1998), *Radio Sci*, 33(4), 919-928
Shephard et al. (2009), *Atmos. Chem. Phys. Discuss.*, 9, 9313-9366

Microwave: MonoRTM

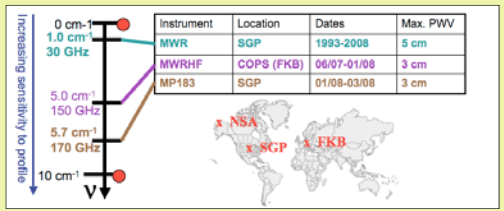
Validation of microwave spectroscopy

• Use of ground-based data to **improve** spectroscopy and **quantify uncertainties**
• Eliminates uncertainties due to surface emissivity
• Eases *some* issues with instrument calibration
• High quality radiometric measurements
•Available through DoE ARM program

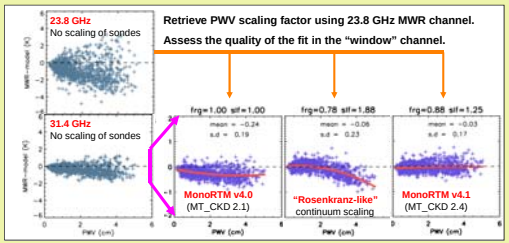


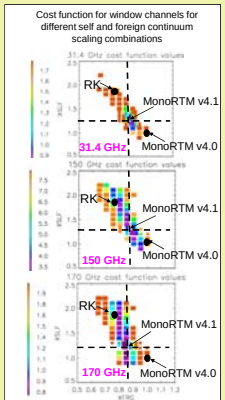
• **Main differences between MonoRTM & Rosenkranz models:**
– Width of 22 GHz water vapor line
– Water vapor continuum
– Number of lines and input format
• **Ground-based validation supports MonoRTM 22 GHz line width**
– Payne et al. (2008)

Recent work: Updates to self and foreign H_2O continuum



Instrument	Location	Dates	Max. PWV
MWR	SGP	1993-2008	5 cm
MWRHF	COPS (FKB)	06/07-01/08	3 cm
MP183	SGP	01/08-03/08	3 cm





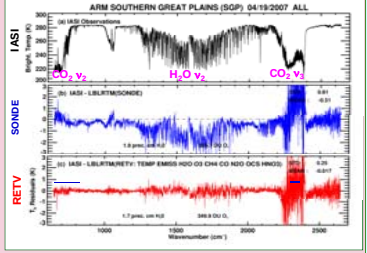
Consistent information from different instruments/frequencies!

Infrared: LBLRTM

Validation of infrared spectroscopy: What is truth?

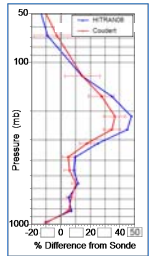
• **Spectral Residuals are Key!**
• **Consistency within a band system**
– ν_2 band to investigate consistency for H_2O
• **Consistency between bands**
– IASI ν_2 and ν_3 bands to investigate consistency for CO_2
• **Consistency between species**
– TES: temperature from O_3 & H_2O consistent with CO_2; N_2O
• **Consistency between instruments**
- IASI - TES - NAST-I
- AIRS - MIPAS - AERI
- ACE - SHIS

IASI/LBLRTM validation



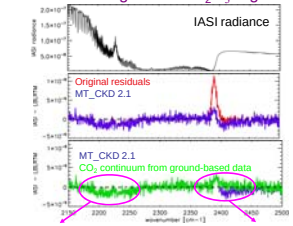
H_2O line parameters

• Current H_2O line strengths/positions:
– **HITRAN 2004 (+ 2006 updates)**
– **From analysis by Toth (JPL)**
• New line strengths/positions:
– Coudert et al. (2008)
– Strengths of stronger lines are ~5-7 % weaker than HITRAN 2004
• Validation of Coudert parameters
– **Using IASI and AIRS data**
– **Shephard et al., (2009) ACPD**



~10 % diff in upper trop!

Modeling of the CO_2 ν_3 region



• **Tashkun CO_2 line strengths & positions under investigation.**
• **Issues with N_2O spectroscopy?**

• **Underlying issues:**
• **Line coupling?**
• **Duration of collision?**

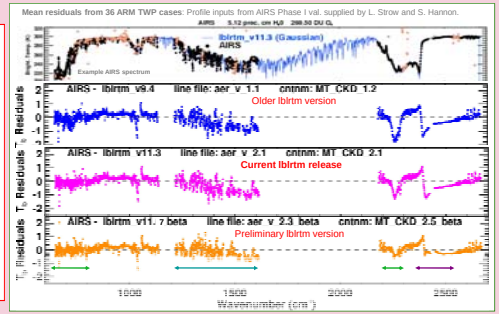
Infrared Spectroscopy

CO_2 line strengths
Tashkun et al. (1999)

CO_2 line coupling
Application of Niro et al. (2005) code to Tashkun line parameters

CO_2 continuum
Empirical correction constructed using ARM ground-based interferometer meas.
Future improvements will focus on the physics of the line coupling in this region

H_2O line parameters
Coudert et al. (2008)



Significant improvements to consistency between spectral regions!