The Intercomparison Paper (Status Report)

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Fifth International Radiative Transfer Modeling Workshop,
Bredbeck, 7-10 July, 2003

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1. Idea and Aim of the Intercomparison Study

- **Check consistency** / mutual **deviations** of several **radiative transfer models** for atmospheric sounding in **(sub-)millimeter** wavelength range.

$\Rightarrow$ For **given atmospheric scenarios**, calculate **brightness temperatures**, compare, and **study** the **differences**.

Participating Models

1. **ARTS** (Atmospheric Radiative Transfer Simulator) – University of Bremen and and Chalmers University, Göteborg
2. **BEAM** (BErnese Atmospheric Model) – University of Bern.
3. the **EORC model** – Earth Observation Research Center (EORC), NASDA, Japan
4. the **Karlsruhe Millimeter-wave forward model** – at Forschungszentrum, Karlsruhe, Germany
5. **MAES** (Millimeter Wave Atmospheric Emission Simulator) – Communication Research Laboratory (CRL), Tokyo, Japan
6. **MIRART** (Modular Infra-Red Atmospheric Radiative Transfer) – Remote Sensing Technology Institute of the German Aerospace Center, DLR
7. **MOLIERE/5** (Microwave Observation Line Estimation and Retrieval code, version 5) – Observatoire de Bordeaux, France
8. **SMOCO** (SMILES Observation Retrieval Code) – CRL in collaboration with Fujitsu FIP Corporation, Tokyo, Japan

Intercomparison Setup

- **Five** separate **“Exercises”** (numbered 0 to 4...) in **three** groups, referring to

(a) **Line shape** function of absorption lines – **Ex. 0**

(b) **Absorption coefficient** calculation (lines and continuum) – **Ex. 1, 2**

(c) **Radiative transfer** calculation (T_B) for three typical sensor configurations (**down-**, **limb-**, **up-**looking) – **Ex. 3, 4**

Intercomparison Setup (ctd.)

- In **Exercise 0, 1, 3**: **Input parameters**, i.e. spectroscopic data, continuum absorption modeling, line shape functions, line selection, frequency grids, were **fixed and prescribed**

⇒ **Check** of consistency and correctness of the **implementation** in the models.

- In **Exercise 2 and 4**: **Input parameters free** to chose according to the defaults of each model

⇒ **Getting an idea** of model **uncertainty**, or the **spread/variability** among the models, or of the **discrepancy** between **models** (which are never a full representation of the actual physical processes) and the **real world** ($\sim$modeling error?).

Problems: Absorption Coefficient Calculation

Discrepancies from **unexpected sources** (often because starting point was not sufficiently well defined):

- **Line shape** functions, including pre-factors.
- Possible **pressure shift** for some lines, e.g., the HCl line at 625.9 GHz.
- **Errors** in the established **MPM93** water vapor absorption model, which had been corrected by some participants, but had not been corrected by others.
- Different **partition functions** used to convert line intensities to temperatures other than the catalog reference temperature.

Problems: Radiative Transfer Calculation

- Different **interpolation strategies** (atmospheric properties as a function of altitude).
- Brightness temperature **units** (Planck versus Rayleigh-Jeans)
- **Surface emissivity** for **down**-looking case.
- Misunderstandings in the **sensor description**.
- Cosmic **background** for **up-** and **limb-**looking cases.
- Handling of **refraction**.
- Exact **earth shape** model (viewing angles rather than tangent altitudes had been specified for the limb cases, which made the calculations sensitive to the assumed earth radius).

Results, Ex. 0, 1

After sorting out most of those problems (and redoing calculations many times. . .):

Ex. 0, line shape implementation check

- **Agreement** within well below **1%** of each other

Ex. 1, absorption calculation implementation check

- **Line-by-line** absorption calculation – **agreement** within **1%** (one exception, also further on)
- **Continuum** absorption model (MPM93) – **agreement** mostly within about **1%**, but some **problems** caused by **MPM93 changes** and **errors**

Results, Ex. 2

Ex. 2 "free" absorption calculation intercomparison

- As expected: **differences** because of **different spectroscopic** line data/parameters and **continuum** models
- Near **center** of major absorption **lines**, mutual **deviation** of about **10%**
- In line **wings/window** regions (**absolute value** of absorption coefficient very **small**), the **same** absolute differences correspond to **tens to hundreds** of per cent ($\longrightarrow$ relative differences not meaningful in this context)
- **highest relative** differences where a **narrow line** in a window region was **ignored** in some models

Results, Ex. 3, 4

Ex. 3 radiative transfer implementation check

- If altitude **grid** is **fine enough**, results (brightness temperatures) mostly
  - within **0.1 K** of each other – **up-** and **down-looking** geometry
  - within **1 K** of each other for **limb-looking** geometry

→ **Limb-looking** configuration more **sensitive** to **errors in absorption** calculation because of much **longer line of sight**!

Ex. 4 "free" intercomparison

- If altitude **grid** is **fine enough**, results (brightness temperatures) mostly
  - within **several K** of each other – **up-** and **down-looking** geometry
  - **up to 20 K** deviations – **limb-looking** geometry (more sensitive, as above)

Summary

- Lots of **lessons learned** from unexpected discrepancies
- Intercomparison **stimulated** model **development**
- For **identical input**: models **consistent** (1% deviations)
- In realistic context (**free input**): about **10% deviations** at major **absorption lines**, much **higher** relative (but not absolute) deviations in line **wings/windows**
- Major **source** of discrepancies: Uncertainties in **spectroscopic** input parameters

Technical Matters

- Paper nearing completion: **One more iteration** with all participants
- Still a number of **details** (facts) to fill in, but no more (re-)calculations – hopefully
- To be submitted to **JGR** Atmosphere (a few extra pages are not a problem)
- Alternatively: **JQSRT** (faster, easier(?), but less impact than JGR)

Discussion

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