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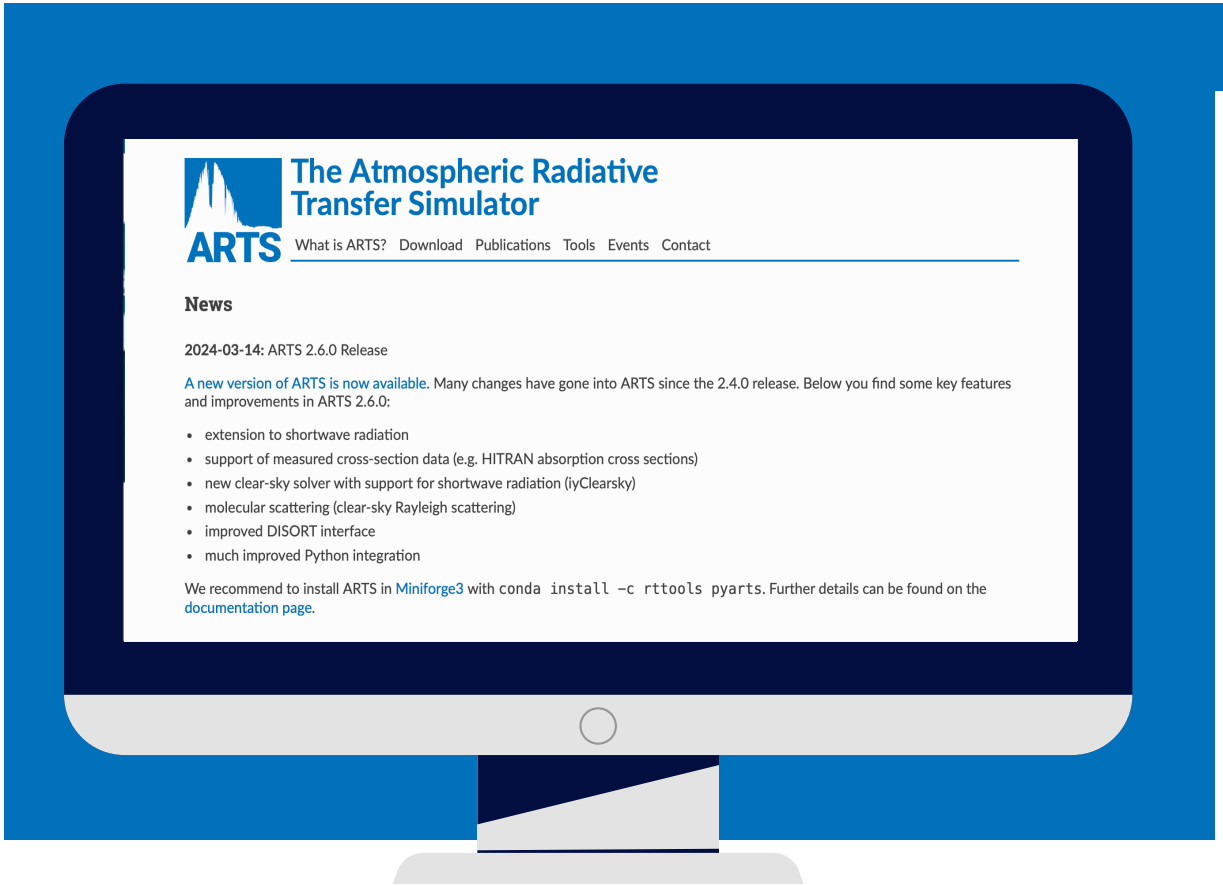
The Atmospheric Radiative Transfer Simulator

Version 2.6

Stefan Buehler

ARTS Workshop at Kristineberg, 2024-06-04



radiativetransfer.org

The Atmospheric Radiative Transfer Simulator ARTS, Version 2.6 — Deep Python Integration

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Abstract

The atmospheric radiative transfer simulator ARTS is a software for computing atmospheric absorption, scattering, the transfer of radiation through an atmosphere, and sensor characteristics. It is written in C++ and can simulate remote sensing observations and radiative energy fluxes. The article describes version 2.6 of the software. There are numerous changes compared to the last ARTS publication, the most striking being that the program is now controlled by Python scripts, which is convenient and allows for great flexibility. The article discusses the ARTS history, the theory behind the computations of absorption and radiative transfer, available solvers for atmospheres with scattering, the computation of energy fluxes and heating rates, and the built-in system for inverting remote observations to atmospheric state variables by optimal estimation. ARTS is publicly available, open source, and free of charge.

Keywords: atmospheric radiative transfer simulator, ARTS, infrared, microwave, radiation, absorption, scattering, spectroscopy, polarization, radiative transfer
PACS: 42.68.Ay, 42.68.Ca, 42.68.Ge, 42.68.Mj

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History

- Started in 2000, so already >20 years of ARTS!
- Buehler, S. A., P. Eriksson, T. Kuhn, A. von Engeln and C. Verdes (**2005**), ARTS, the Atmospheric Radiative Transfer Simulator, J. Quant. Spectrosc. Radiat. Transfer, 91(1), 65-93, doi:10.1016/j.jqsrt.2004.05.051.
- Eriksson, P., S. A. Buehler, C. P. Davis, C. Emde, and O. Lemke (**2011**), ARTS, the atmospheric radiative transfer simulator, Version 2, J. Quant. Spectrosc. Radiat. Transfer, doi:10.1016/j.jqsrt.2011.03.001.
- Buehler, S. A., J. Mendrok, P. Eriksson, A. Perrin, R. Larsson, and O. Lemke (**2018**), ARTS, the atmospheric radiative transfer simulator — version 2.2, the planetary toolbox edition, Geosci. Model Dev., 11(4), 1537–1556, doi:10.5194/gmd-11-1537-2018.

Literature analysis on ARTS usage

- Remote sensing / atmospheric energetics
- Clear-sky / all-sky
- Passive / active
- Microwave / sub-millimeter / terraherz / infrared / UV-visible

Main new features

- Deep integration with Python
- Redesigned LBL absorption core
- Built-in OEM retrieval framework
- Solar source term enables shortwave simulations
- Integrated support for flux and heating rate calculations

Deep integration with Python

Installation:

```
conda install -c rttools pyarts
```

Usage:

```
1  import numpy as np
2  import pyarts
3  from pyarts.workspace import Workspace, arts_agenda
4  ws = Workspace(verbosity=0)
5  ws.VectorNLinSpace(ws.f_grid, 5, 320000000000.0, 322000000000.0)
```

Redesigned LBL absorption core

- Completely rewritten by Richard
- Much faster, uses spectral binning to efficiently handle line wings
- New philosophy: Use standard ARTS line catalogue for more user-friendliness (catalogue based on HITRAN)
- Can also use polynomial representation of laboratory absorption cross sections for complex molecules (e.g. halocarbons)
- Can include absorption continua (MT_CKD, …) and/or HITRAN data of collision-induced absorption

Built-in OEM retrieval framework

- Roughly similar functionality to old ARTS/Qpack, but more efficient due to C++ implementation

Solar source term enables shortwave simulations

- Upcoming presentation by Freddy

Integrated support for flux and heating rate calculations

- Convenient if ARTS is used for atmospheric energetics
- Efficient also for all-sky, thanks to DISORT flux mode

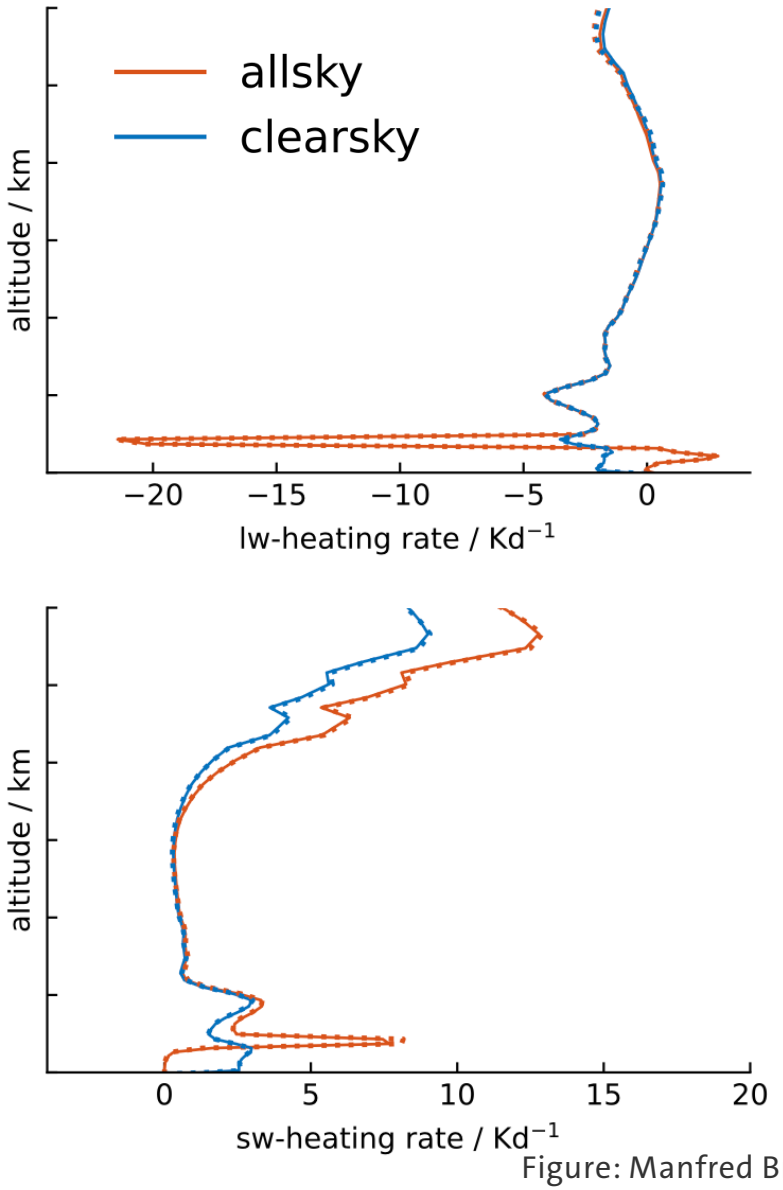


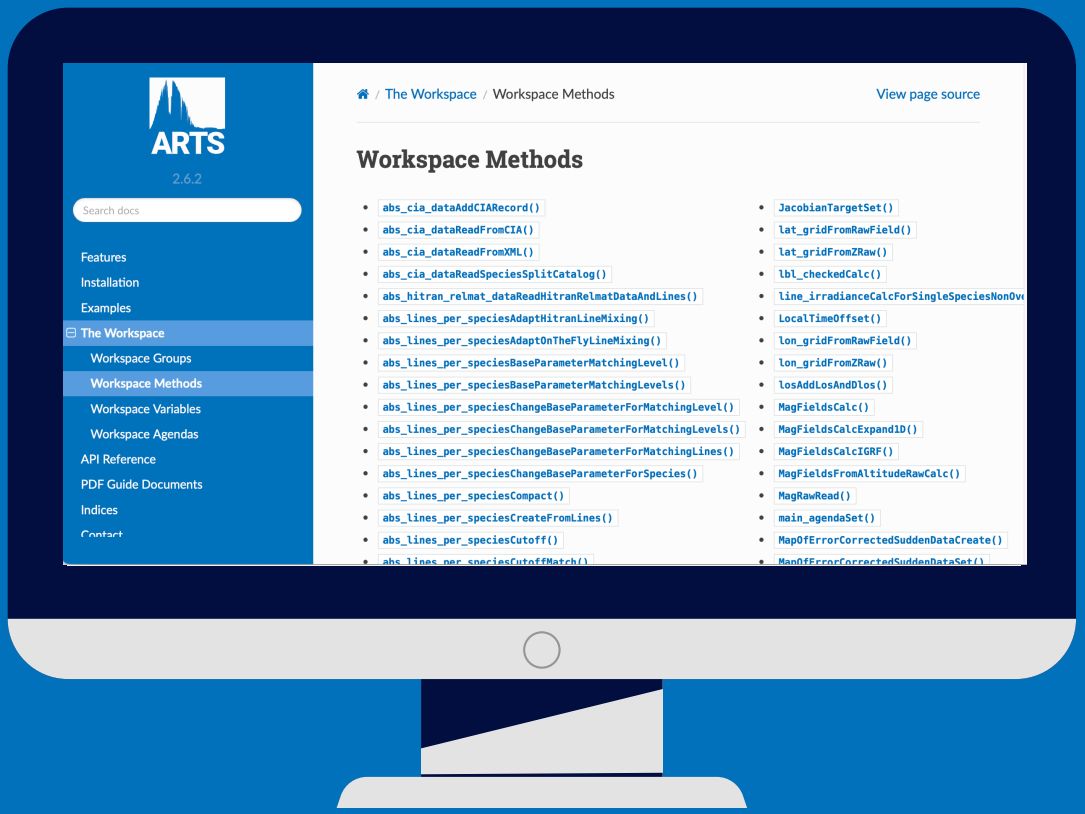
Figure: Manfred Brath

Other (traditional) features

- Fully polarized (Stokes formalism)
- 1D/2D/3D
- Clear-sky RT solver based on vector Schwarzschild formalism, including Jacobian
- Different scattering solvers (ARTS-DOIT, ARTS-MC, DISORT, RT4, Hybrid)
- Support for going from bulk condensate to scattering properties, using size distributions and scattering habits
- Single scattering and multiple scattering (MC) radar simulators
- Extensive support for simulating sensor properties

Documentation

- https://atmtools.github.io/arts-docs-2.6/
- Examples
- The Workspace (built-in documentation for each method and standard variable)
- Traditional Pdf guide documents (user / theory / developer)
- Mailing lists



Summary

- ARTS-2.6 is the current version
- Will not receive new features only bug fixes
- New solar / shortwave part deserves more description → upcoming talk by Freddy
- Development version is ARTS-3 → upcoming talk by Richard

- Questions?