

# Practical: Web-based RTTOV

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With thanks to Tony McNally, Jean-Marie Lalonde, Alexis Gagoud & EUMETSAT

# Getting RTTOV

<https://nwp-saf.eumetsat.int/site/software/rttov/rttov-v14/>

The screenshot shows the EUMETSAT NWP SAF website. At the top, there is a navigation bar with links for 'Logout', 'Account', 'Software Downloads', and a search box. Below this is a main menu with categories: 'News', 'Software', 'Monitoring', 'Support', 'Publications', 'Visiting Scientists', 'Training', and 'Members' Area'. The 'Support' menu is expanded, showing sub-items: 'Overview', 'RTTOV v14', 'Documentation', 'Downloads', 'Bug fixes', 'Coefficients', 'RTTOV FAQs', 'RTTOV-gb', 'RTTOV v13', 'RTTOV v12', and 'RTTOV v11'. The 'Coefficients' item is highlighted with a red arrow. On the left side of the page, there is a list of software products: 'RTTOV', 'AAPP', '1D-Var', 'Scatterometer Data Processors', 'Radiance simulator', 'IASI PCA', 'SSMIS PP', 'Cloud and Aerosol Detection', 'MWIPP', 'IRSP', and 'Direct Broadcast software'. Two orange arrows point from the text 'Radiance simulator and Atmospheric profiles' to 'Radiance simulator' and 'NWP model profile datasets' respectively. The main content area features a banner for 'satellite data for NWP' and a 'News Feature' section titled 'New NWP model dataset of 100,000 atmospheric profiles from CAMS' with a world map visualization.

You need to register and login to download RTTOV

Any questions you can post a question to the helpdesk

You can download all satellite coefficients or individual ones

Radiance simulator and Atmospheric profiles

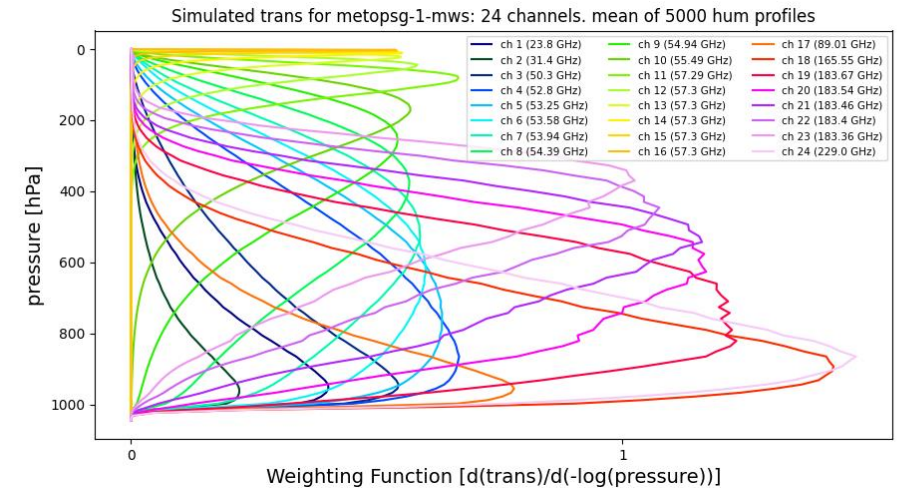
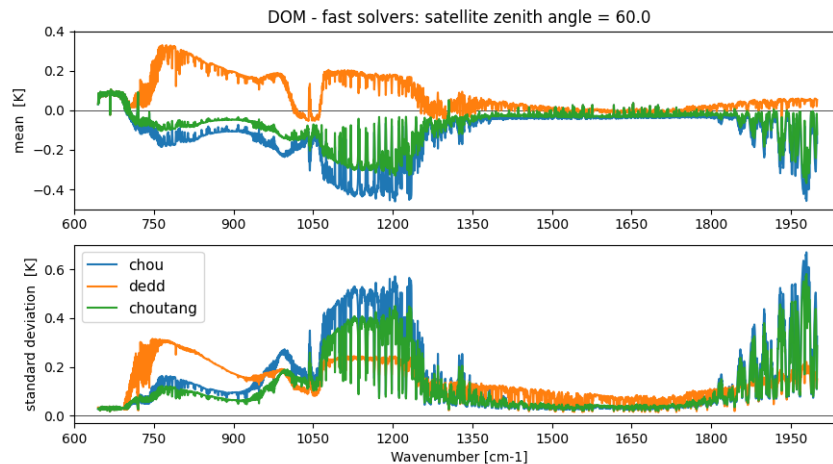
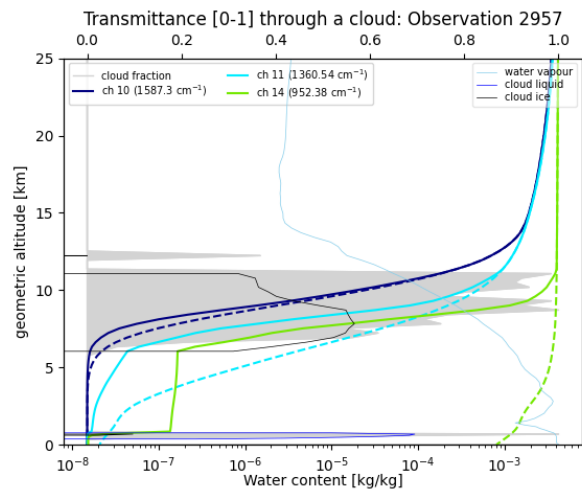
# Radiance Simulator

The radiance simulator is a command line tool that enables you to run thousands of radiance simulations in a few seconds, with netcdf output.

You can obtain radiances, transmittances, profile variables and Jacobians.

You can use NWP profiles from ECMWF (IFS, ERA etc..), Met Office, DWD, JMA.. or use the ones provided by the NWPSAF (next slide)

You need a build of RTTOV, eccodes (from ECMWF), netcdf libraries and possibly open-mp.

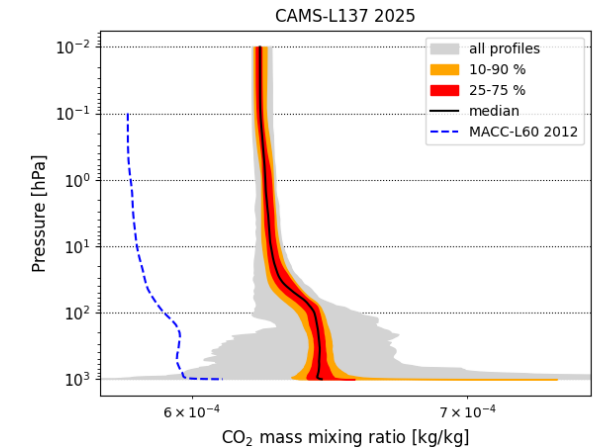
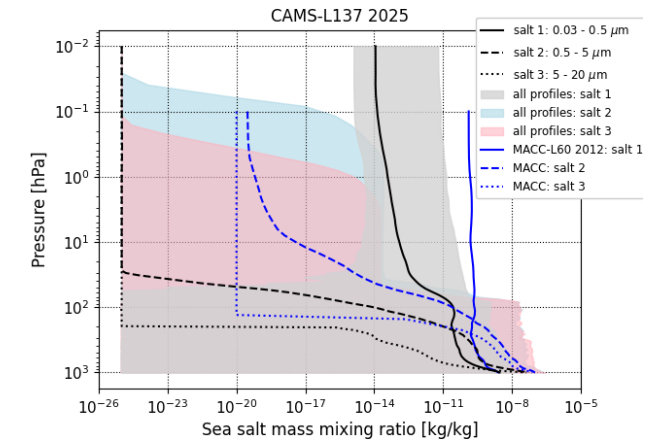
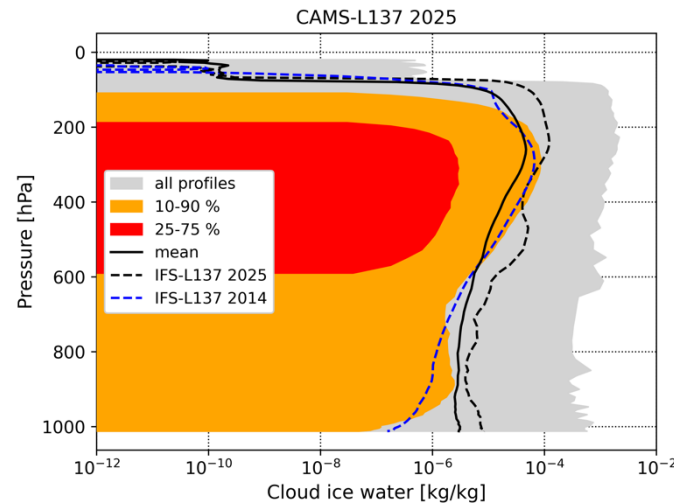
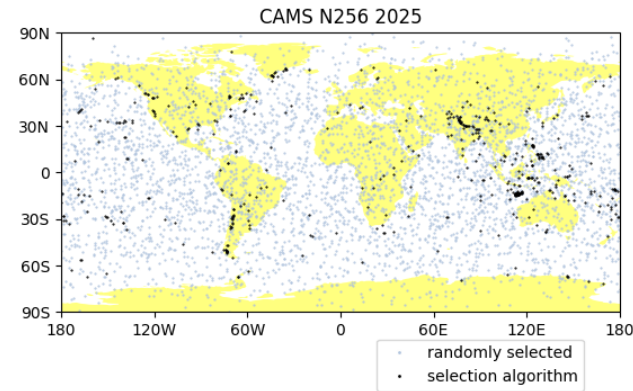
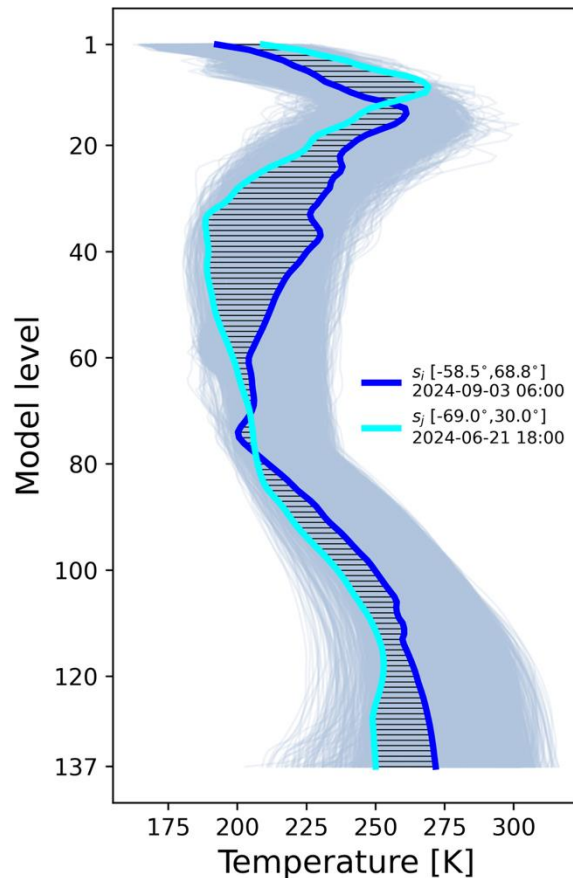


# NWPSAF 100,000 atmospheric profiles from CAMS

Produced every few years by the NWPSAF based on latest model data.

New one consists of 20 netcdf files, each containing 5000 model forecasts from 2024 - 2025.

Each one is maximized for variability of a different variable, like temperature, humidity, CO<sub>2</sub> etc.



# Python/C++ wrapper and GUI

All come with the RTTOV package, compile with required options.

Wrappers allows great flexibility with input variables

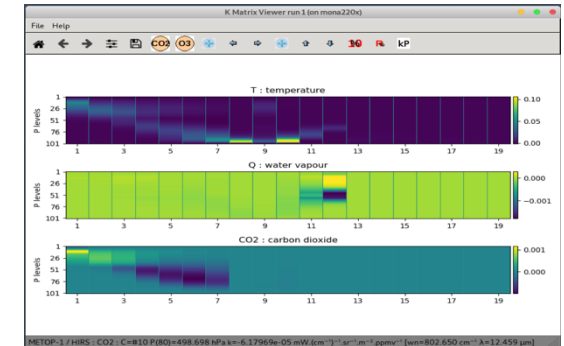
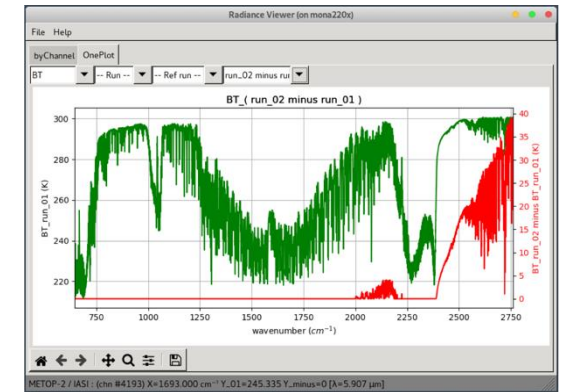
👍 if you don't want to write scripts in Fortran

GUI allows you to quickly visualize radiances, jacobians and retrievals from any coefficient

## Thank you for your attention!

Any questions welcome

[emma.turner@ecmwf.int](mailto:emma.turner@ecmwf.int)



# Practical: Web Based Satellite Sounding (4) Training Application\* or WeSS4T

<https://sounding.trainhub.eumetsat.int>



\*Web Based RTTOV



# Welcome to the Web Based Satellite Sounding Training Application

Play with RTTOV simulations and 1D-var retrievals

Select an instrument



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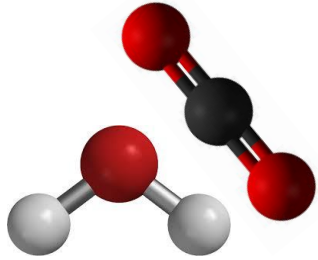
# Tasks/Questions: Microwave instrument

- Select AMSU-A. Explore the range of atmospheric profiles by clicking on different ones.
  - Why do some have spikes of elevated humidity between the surface and 100 hPa?
  - Why do some polar profiles show *increasing* temperature above the surface before decreasing?
- On September 1<sup>st</sup> select a profile above Texas.
  - What is the surface temperature?
- Run an RTTOV simulation including Jacobians
  - Which channels do you think are sensitive to the surface?
- Reduce the surface temperature by around 10 K and run again.
  - Has your answer to the last question changed?
- Change the surface emissivity from fixed to atlas. Run again.
  - Based on what you see, has the emissivity increased or decreased?
- Modify the profile by increasing the temperature by 10 K from 10 – 1 hPa and run again.
  - Which channels change brightness temperature and why don't all of them?
- Modify the profile by increasing the temperature by 10 K from 200 – 100 hPa and run again.
  - Would AMSU-A be helpful in telling us about temperature changes in the tropopause?



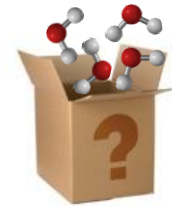
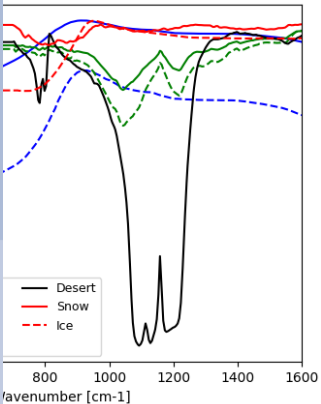
Modify the input profile





## Tasks/Questions: Infrared instruments

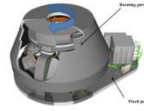
- Go back to the beginning and select IASI. Run a simulation with an Arctic profile.
  - Can you identify two window regions, two CO<sub>2</sub> regions, a wide H<sub>2</sub>O band and one O<sub>3</sub> band?
- Find a tropical **land** profile and run a simulation. Look at BT diff.
  - Why are there differences in the CO<sub>2</sub> bands?
- Modify the input profile and cool the surface by 10 K. Rerun and BT diff.
  - Why don't all affected channels change by 10 K? Which is the cleanest window in IASI?
- Dry the upper troposphere between 300 - 100 hPa to 0.2 of the original profile.
- Repeat this for the surface between 1050 – 700 hPa.
  - Why is there sensitivity in the window part of the spectrum? What is in there?



- Using the IASI-NG instrument look at the difference between using a fixed or atlas/model emissivity
  - What is the maximum error in using the fixed value for a desert land? Same for a sea profile?
- Look at the MTG-S instrument and observe the gap between 1200-1600 cm<sup>-1</sup>
  - Which atmospheric constituent is mainly in this region?



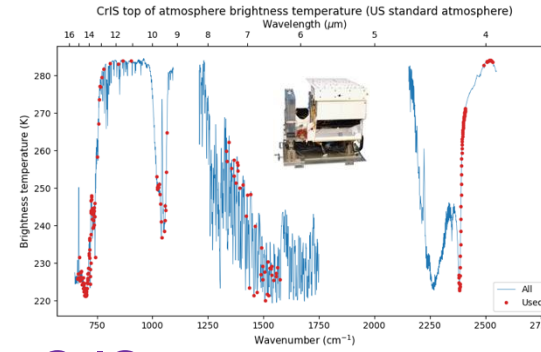
# Recent developments: Exploiting the full spectrum



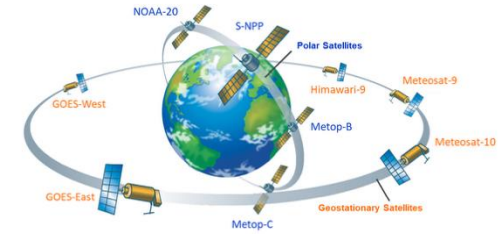
**ICI** (Ice Cloud Imager) on MetOp-SG



**AWS** (Arctic Weather Satellite)

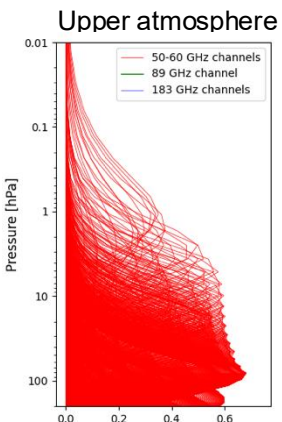


**CrIS** (Cross-track Infrared Sounder) on NOAA-21



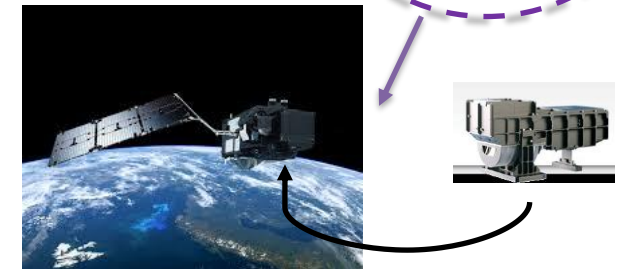
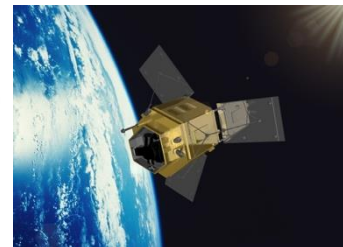
**Geostationary**  
SEVIRI on Meteosat, AHI on Himawari, ABI on GOES

	Microwave	Sub-mm	Far Infrared	Infrared	SW	Near Infrared	Visible
<b>Frequency</b>	1 - 300 GHz	300 - 1000 GHz	1000 - 20000 GHz				
<b>Wavenumber</b>	0.03 - 10 cm <sup>-1</sup>	10 - 33 cm <sup>-1</sup>	33 - 666 cm <sup>-1</sup>	666 - 4000 cm <sup>-1</sup>		4000 - 12800 cm <sup>-1</sup>	
<b>Wavelength</b>	300 - 1 mm	1 - 0.3 mm	300 - 15 µm	15 - 2.5 µm		2500 - 400 nm	400 - 780 nm



**HYMS**  
(Hyperspectral Microwave Sounder)

**FORUM**  
(Far-infrared Outgoing Radiation Understanding and Monitoring)



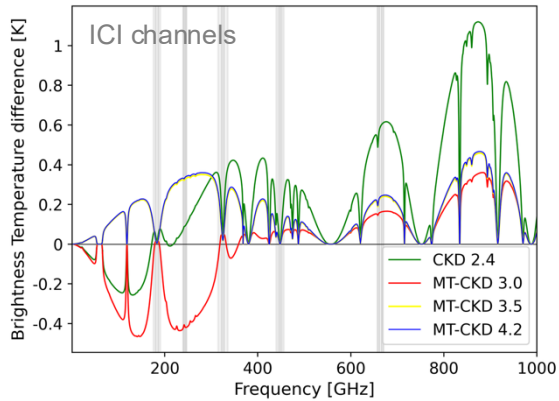
**OLCI** (Ocean and Land Colour Instrument) on Sentinel-3



EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS

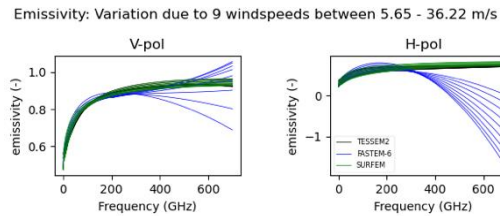
# Recent developments: Exploiting the full spectrum

Water vapour continuum models

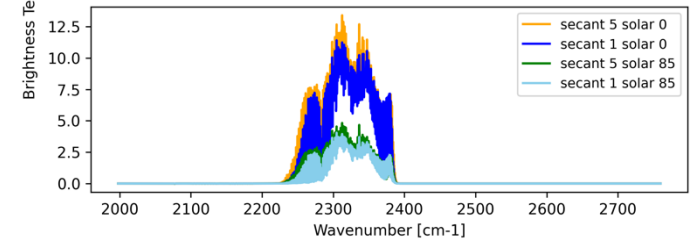


Improve sub-mm water vapour and ozone spectroscopy, ice clouds and ocean emissivity

SURFEM-Ocean (NN) emissivity model



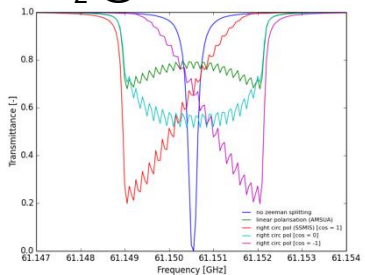
NLTE – LTE for IASI SW channels



Add NLTE simulation to radiative transfer

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Zeeman splitting O<sub>2</sub> @ 61.15 GHz



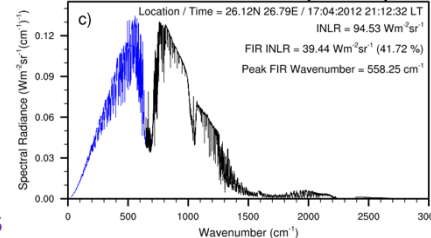
Add Zeeman simulation to radiative transfer

New ice cloud database

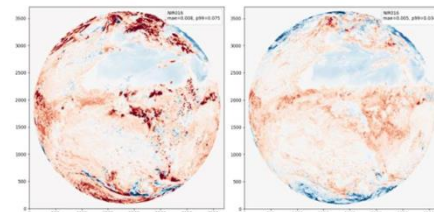


Improve water vapour spectroscopy and all clouds

Far-infrared (blue)



MFASIS vs RTTOV-DOM



Use MFASIS-Neural Network for clouds

Look up table

Neural network

