

# Gastropod Version 0.2.0

## User Guide Update

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## Abstract

This update to the Gastropod User Guide [Sherlock, 2001] summarises the essential modifications to the Gastropod regression model and modifications to the code user interface. Gastropod Version 0.2.0, the first official, open source release of the Gastropod code and and AIRS regression coefficients is available at <http://gastro.sourceforge.net>.

## Regression

### Definition of predictors

Following a predictor selection study [Sherlock, 2002], water vapour line absorption predictors have been revised. Gastropod Version 0.2.0 predictors are defined in Table 1. Validation of the Version 0.2.0 model for dependent and independent profile set is detailed in Sherlock et al. [2002].

Gastropod v0.2.0 predictors				Basis definitions	
Fixed	H <sub>2</sub> O line	Ozone	H <sub>2</sub> O cont.		
$a$	$aW_r$	$aO_r$	$aW_r/T_r$	$a$	$= \sec(\chi)$
$a^2$	$(aW_r)^2$	$(aO_r)^2$	$aW_r/T_r^2$	$X_{r,i}$	$= X_i/X_{ref,i}$
$T_r$	$\sqrt{aW_r}$	$\sqrt{aO_r}$	$aW_r^2/T_r^4$	$dT_i$	$= T_i - T_{ref,i}$
$T_r^2$	$\sqrt[4]{aW_r}$	$aO_r dT$	$aW_r^2/T_r$	$X_{z,i}$	$= \frac{\sum \bar{P}_k dP_k X_k}{\sum \bar{P}_k dP_k X_{ref,k}}$ $k=1,i-1$
$aT_r$	$aW_r dT$	$\sqrt{aO_r} dT$	$aW_r^2/T_r^2$	$TX_{z,i}$	$= \frac{\sum \bar{P}_k dP_k T_k X_k}{\sum \bar{P}_k dP_k T_{ref,k} X_{ref,k}}$ $k=1,i-1$
$aT_r^2$	$\sqrt{aW_r} dT$	$a^2 O_r W_r$		$dP_i$	$= P_i - P_{i-1}$
$aT_z$	$aW_r dT \mid dT \mid$	$aO_z$		$\bar{P}_i$	$= (P_i + P_{i-1})/2$
$aT_z/T_r$	$aW_z$	$aO_r \sqrt{aO_z}$			
	$(aW_z)^2$	$aO_r T O_z$			
	$\sqrt{aW_z}$				
	$\sqrt{aW_r} W_r / W_z$				

Table 1: Gastropod v1.1 predictors for fixed gas, water vapour line, water vapour continuum and ozone absorption, and associated basis functions.  $i$  is the layer index, as defined in the text.  $X_i$  denotes layer mean temperature or layer mean mixing ratio, as appropriate. Thus  $T_r$  is the ratio of layer mean temperatures,  $W_r$  the ratio of layer water vapour ratios,  $O_r$  the ratio of layer mean ozone mixing ratios and so on. Weights  $dP_i$  and  $\bar{P}_i$  are given by the difference and the mean of the pressures at the upper and lower boundaries of the layer respectively.

## Overview of I/O for Gastropod 0.2.0

Forward, tangent linear, adjoint and Jacobian code has been developed and maintained for all the sub-routines which comprise the fast radiative transfer operator. The Run\_Gastropod wrapper forms the stand-alone Gastropod fast radiative transfer model for AIRS.

Given an input profile (U01.dat), a satellite zenith angle (sza.dat) and a set of channels to process (sel\_chan.dat), the Run\_Gastropod executable runs the direct and Jacobian code to generate a brightness temperature spectrum (GASTRO\_TB.out) and the Jacobians  $dTB_i/dx_j$ , where  $i$  is the channel index and  $j$  indexes profile elements (GASTRO\_TB.K.out). Input profile data is also checked, and a warning messages are issued if the profile elements lie outside a given tolerance threshold of the regression bounds. All files are read and written in the directory where the code is executed.

Input data for the transmittance prediction scheme (regression coefficient files and corresponding channel identifiers, and reference profile data) are accessed in the INPUT and INPUT/COEFFS sub-directories of the INPUT\_DIR defined by the user in GastroMod\_Paths.f90.

Parameters previously defined at run time in the file Rparam are now either redundant or compile time parameters. Spectral infrared surface emissivity is still initialised within the code. A prognostic emissivity model is planned in the future.

### Formats and physical units for user defined inputs

#### U01.dat

The number of pressure levels defining the input profile nlev, is specified, followed by nlev lines specifying the pressure [hPa], temperature [K], water vapour and ozone mixing ratios [parts per million by volume], with respect to the total number air molecules<sup>1</sup>. The first level is the surface air variables, the nlev th [P T Q O3] entry is the top of the user atmosphere. Levels must be ordered by decreasing pressure. Finally, the surface skin temperature [K] is specified. Thus the file has the form:

N				Number of profile pressure levels
P <sub>s</sub>	T <sub>s</sub>	Q <sub>s</sub>	O <sub>s</sub>	Surface air variables, level 1
P	T	Q	O	Profile data for level 2
⋮	⋮	⋮	⋮	to
P	T	Q	O	level N, with pressure decreasing
T <sub>skin</sub>				Skin temperature.

If the top of the user atmosphere is less than 0.05 hPa, the profile is extrapolated to 0.05 hPa. The extrapolation used is currently set by a compile time parameter, append\_type (GastroMod\_Param.f90). The default extrapolation (append\_type=2) extrapolates humidity and ozone mixing ratios assuming a constant mixing ratio (that of the uppermost user defined level). Temperature is extrapolated assuming a constant lapse rate, and is appropriate if the user profile extends above the stratopause. An isothermal extrapolation option (append\_type=1) is also available.

#### sza.dat

The file stores a single number – the satellite zenith angle [degrees] for the radiative transfer calculation.

#### sel\_chan.dat

Gastropod processes by block of channels. In sel\_chan.dat the user specifies the number of blocks they wish to process (dnblock), followed by dnblock lines specifying the AIRS channel identifiers of the first and last channels in the block. Thus sel\_chan.dat has the form:

---

<sup>1</sup>Volume mixing ratios input to Gastropod should be given with respect to wet (as opposed to dry) air. Conversion from dry ( $Q_{X,D}$ ) to wet ( $Q_{X,W}$ ) mixing ratios (in ppmv) for a general absorber/gas X is as follows:  $Q_{X,W} = 10^6 Q_{X,D} / (10^6 + Q_{H_2O,D})$ . No correction is currently applied to predicted fixed gas optical depths to account for water vapour displacement of dry air.

```

dnblock
[ichan_start ichan_stop] × dnblock

```

For example, to process all AIRS channels, specify:

```

1
1 2378

```

To process 3 channels, with AIRS channel identifiers 300, 495 and 1678, specify:

```

3
300 300
495 495
1678 1678

```

Note: If the user has an invariant subset of channels for use in assimilation, it is more efficient (for memory requirements, and a small gain in execution time) to extract the appropriate regression coefficients, save them to file, generate the corresponding channel identifier data files, set the channel dimension parameters `dnairs` and `dnchan` to the size of the channel subset, and then process the fixed channel subset as a single block. This extraction utility has not been developed yet. If anyone does so, it would be useful to include it in subsequent releases of the library.

## Formats and physical units for default Run\_Gastropod outputs

### GASTRO\_TB.out

Brightness temperatures (TB) corresponding to convolved radiances are output for all channels requested by the user. The file has a 2 line header, followed by triplets: (channel central wavenumber [ $\text{cm}^{-1}$ ], channel central wavelength [micron], TB [K]) for each requested channel.

### GASTRO\_TB\_K.out

For each channel requested by the user, brightness temperature Jacobians for each input profile element, and surface emissivity are output. The file format is:

$$[\text{Jacobians}] \times \text{dnchan},$$

where [Jacobians] have the form:

$$[\text{wn lev P d/dT d/dlnQ d/dlnO3}] \times \text{dnlev},$$

$$[\text{wn lev=1 P=Ps d/dPs d/dTs d/d\epsilon}] \times 1$$

with	wn	channel central wavenumber [ $\text{cm}^{-1}$ ],
	lev	the user input profile level index, running from 1 at the surface to nlev at the top of the user atmosphere,
	P	level pressure [hPa]. Ps denotes surface pressure,
	d/dT	the temperature Jacobian
	d/dlnQ	the humidity Jacobian (with respect to the natural logarithm of the humidity mixing ratio,
	d/dlnO	the ozone Jacobian (with respect to the natural logarithm of the ozone mixing ratio,
	d/dPs	the surface pressure Jacobian,
	d/dTs	the surface temperature (skin temperature) Jacobian,
	d/d\epsilon	the surface emissivity Jacobian (derivative with respect to the channel infrared surface spectral emissivity).

## **Warning.msg, Extr\_err.msg**

If the layer mean temperature derived from user input temperatures lies within a factor [0.975:1.0] or [1.0:1.025] of the regression lower/upper bounds for the layer, a message is issued to Warning.msg identifying the variable (temperature=1) and the AIRS pressure layer identifier.

If the layer mean temperature is less than a factor 0.975 of the regression lower bound or greater than a factor 1.025 of the regression upper bound, a message is issued to Extr\_err.msg, identifying the profile variable and the AIRS pressure layer identifier.

Similarly if layer mean mixing ratios for water vapour or ozone lie within a within a factor [0.9:1.0] or [1.0:1.1] of the regression lower/upper bounds for the layer, a message is issued to Warning.msg identifying the variable (humidity=2, ozone=3) and the AIRS pressure layer identifier.

If the layer mean mixing ratio is less than a 0.9 of the regression lower bound or greater than a factor 1.1 of the regression upper bound, a message is issued to Extr\_err.msg, identifying the profile variable and the AIRS pressure layer identifier.

## **Carrying On**

Example wrapper code for running the tangent linear (Run\_Gastro\_TL) and the adjoint code (Run\_Gastropod\_AD) are also provided. These codes, combined with the Run\_Gastropod code should provide the user with adequate examples of how to use the library of subroutines for their own applications.

We are open to comments and suggestions for code development and improvement. We encourage external development of the Gastropod code, and communication of those developments to the wider user community.

## **References**

- V. Sherlock. Gastropod - a fast radiative transfer model for the advanced sounders. Technical Report FR-362, The Met Office, Bracknell, United Kingdom, 2001.
- V. Sherlock. Improving fast radiative transfer model predictions of water vapour line absorption. In *Technical Proceedings of the Twelfth International ATOVS Study Conference, Lorne, Australia, 26 February - 05 March, 2002*, 2002.
- V. Sherlock, A. Collard, S. Hannon, and R. Saunders. Fixed pressure grid fast radiative transfer models for the advanced infrared sounders: characterisation of model errors and their impact on retrieval accuracy. *Manuscript in preparation*, 2002.