IGCM3.1

Sylvia Hare 1/6/2000

Major Changes

1. New IRRAD thermal IR radiation scheme. Full documentation for this scheme can be found at /home/swrchrds/rwbm.rtf. The scheme differs from that included in IGCM3 mainly through the inclusion of more absorbers. The absorbers included are

1	H_2O
2	CO_2
3	O_3
4	CH_4
5	N_2O
6	CO_2 (minor bands)
7	O_3 (minor bands)
8	Halocarbon

The switches and constants associated with the radiation scheme can be set in the namelist INRADLW.

LLBLM Logical switch. If true, line-by-line pre-computed transmittance tables are used. If false, the transmittance tables are computed by a narrow-band model. Default is .T..

GAS(8) Array to specify which absorbers should be included. Default is to include only the first three gasses, i.e. GAS(1,1,1,0,0,0,0,0,). This represents a substantial saving in CPU time over including all 8 absorbers.

VMR Volume mixing ratios for absorbers. Converted to mass mixing ratio by model. The default volume mixing ratios are CO_2; 358ppmv, CH_4; 1.72ppmv, N_2O; 312ppbv and Halocarbon 797×10^{-14}. The spatially varying mixing ratio for O_3 is read in from climatology. The mixing ratio for H_2O is read in from climatology if LCLIM=.T., or interactively from tracer 1 if LCLIM=.F.

These parameters are passed in common block RADLW.

Bug Fixes

Some, but not all, of the bug fixes included in IGCM3.1 are documented below.

1. The white noise routine has been modified to avoid an apparent ambiguity in the random number sequence in the current code, which refers to RANF(IDUM) twice within a CMPLX(a,b) expression.

2. Non-ANSI code has been removed.

3. Tracer code moved to separate loops, to avoid disruption of vectorised inner loops. In HANALV and HEXPV use of separate loops depends on NTRAC>1, since the tracer arrays contain NL levels when NTRAC=1, in which case they can be included in main loops.

4. Total moisture diagnostic included in ENERGY.

5. IGCM 3 uses dry instead of moist convection for parcels originating above 200hPa or colder than -40° C. The code originates from Brian's student Bethan Jones, c1990 and avoids doing costly moist convection at levels where the moist and dry adiabats become similar. In addition, the parameter NLCR governs the topmost level for which any kind of convection is attempted. This code has been optimised and should save CPU time.

   Bug fixes and modifications to convection scheme (some of these were updates CONV5 in IGCM3):

   (a) Fix bug in dry convective adjustment to mix moisture irrespective of the base level. The original code erroneously mixes moisture only above the lowest level.

   (b) Limit the convective top for "swap points" (i.e. where deep convection fails due to insufficient moisture) to the maximum height of shallow convection. This prevents the model from attempting shallow convection with a deep cloud top.

   (c) Apply a consistent minimum moisture criterion in the mixing line calculations of the shallow convection schemes. This prevents the convection scheme from seeing negative moisture.

(d) The mixing line slope ($\frac{\partial\theta}{\partial p}$) is limited such that TLIM$\leq$TLAPSM$\leq$0 i.e. it is never unstable (limited by the dry adiabatic lapse rate) or more stable than TLIM. By default, TLIM$=-10^{-3}KPa^{-1}$ (=0.133 in non-dimensional units). Implemented in both CUDIF and CUBM.

6. The direct Legendre transforms in the diabatic step have been optimised. Only the required forcing fields are now transformed. This involves a new version of LTDDIA.

7. Abort rather than stop successfully if namelist errors are found.

8. The mass correction routine, MASCOR, which corrects the global mean surface pressure to its value at the start of the run, has been updated to allow clean restarts. GMSP0 is equivalent to AMSP0 etc., but mass correction is now independent of KOUNTE and the correct surface pressure values are written to the restart record. New switches in namelist INPRN:

   LMASCOR to switch on mass correction. Default true.

   LMASOLD was mass correction included in the previous run from which this run is restarting? If true, the masses are read from the restart file. If false, masses are not available, and the mass at this restart is used as the "initial" reference. Default true.

   LMASPRT to print the mass correction every ITSPD (=TSPD) steps. Default false.

   If the mass correction is switched on, a second record is added to the restart file. It contains: RKOUNT, RNTAPE, DAY, REC, GMSP0, GMSPMI, RNTAPE where REC=2.0 denotes the mass correction record. The current mass is not included: it is computed in routine MASCOR.

9. Adjusted such that DOY is correct when KITS>0.

10. Loop put back in such that surface restart record is read at the appropriate day, rather than just the first restart record in the file.

11. All channel numbers changed to less than 100 to allow use on all machines.

12. Problem with smoothing in IRRAD for widely spaced levels removed.

13. Stratospheric water vapour fixed to 6ppmv in the radiation scheme (irrespective of LCLIM). Tropopause height read from climatology.

14. Constants such as g now only set in one place in the programme.

15. Counters changed to remove ambiguity. JH (=IH) is used as the latitude counter throughout the program, as JL is not incremented if JGL=1. IHEM is used for hemispheres and JLON for longitudes (where JL was used previously).

16. Several changes have been made to the surface scheme. New albedos based on land-use indices in use at the UKMO are read in. Values from 1-24 (eg: 1 = ocean, 24 = desert) are read into the array SVEGE. From this, a lookup table, held in array SALOOK is used to translate vegetation into albedo. NOTE: for some arcane reason the vegetation index doesn't include Antarctica, so any land south of 60°S has the old values of albedo read in from the original data (this doesn't really matter as Antarctica is always snow-covered at the present day). The albedo of snow-covered regions has also been changed. Instead of the nominal snow albedo (0.8), a vegetation-based albedo is used. Albedos are read in from vegetation index SVEGE using look-up table SNOLOOK and used instead of SASNOW. Instead of using constant roughness lengths for land, roughness lengths are dependent on vegetation (read into array SVEGE). A look up table SZLOOK is used to translate the vegetation types into roughness length. A bug (in which land roughness lengths were used throughout the IGCM, not just on land) has also been fixed. The formulation for surface heat and moisture flux based on static stability has also been changed. Heat fluxes are lowered when$N^2 >> 0$. Previously, the heat flux was multiplied by 0.2 independent of the value of N^2. This 0.2 is now only added when $N^2 > 0$ and not when $N^2 < 0$.

17. Ocean mixed layer depth changed from 2m to 25m. The 25m mixed layer is needed in order to get a reasonable approximation to observed SSTs. With 2m, the SSTs relax too quickly to the heating- ie: the seasonal cycle is too big, this also means evaporation over the oceans is too high etc. However, the spin-up time for the atmosphere will be

greatly increased (to about 20 years) and so this is unsuitable for some experiments.

18. The fix to get reasonable surface temperatures has been changed. The solar constant, SOLC, is now back at its correct value ($1376 W m^{-2}$). To counteract the resulting heating effect, SBAL has 0.05 added to its value everywhere (really the clouds should be tuned to correct SSTs in the IGCM, but this fix is quick and works ok.)

General Tidy

1. Line numbers have changed.
2. Some subroutine names have changed. NEWROUTINE is now O3INTERP and RADLSW is now RADSW.
3. The decks are now in alphabetical order.

Known Things that Remain to be Done

1. There is a problem in the long wave radiation scheme (specifically in the smoothing of water vapour fluxes in SMFLUX) for levels above 1mbar. This applies to both IGCM3 and IGCM3.1. THE MODEL SHOULD THEREFORE NOT BE RUN WITH LEVELS ABOVE THIS.
2. There is a lot of repetition of the calculation loops in XSECT, one for each field. It would be a lot clearer if they were merged.
3. Writes to history/ restart records are inconsistent and involve the redundant array TNLG (gridded heating). Should be altered in conjunction with the flux programme.
4. The vertical advection scheme. A TVD scheme should also improve the convection scheme and prevent 2 grid waves in the moisture profile.
5. The surface scheme.
6. Include ice saturation below freezing point. The present water saturation criterion, used at all temperatures, is wildly inaccurate at low temperatures.

There is an update available (robin.upd) designed to speed up the IGCM. It removes the use of scratch files for storing accumulated lat-long parametrization diagnostics when JGL=JG. This change means that JGL controls memory/disc storage of both the Legendre functions and these diagnostics. Mike Blackburn tested the update for IGCM2 and found execution was 10% slower. It has therefore not been included in IGCM3.1 but is available. Line numbers have been changed in the file to correspond to IGCM3.1 but note that some lines have been commented out. These correspond to lines that do not appear in IGCM3. The update has not been tested for IGCM3.1.

Channel Numbers

fort.2	Output.
fort.7	Namelist data.
fort.9	Output history file (every KOUNTH timesteps)
fort.10	Input restart record.
fort.11	Output restart file (every KOUNTR timesteps)
fort.12	Final output restart record.
fort.13	Restoration state.
fort.14	Surface temperature and humidity.
fort.17	Final output surface restart record.
fort.18	Initial surface history record.
fort.19	Surface restart file (every KOUNTR timesteps).
fort.20	Output from DGRMLT. Scratch file.
fort.21	Output from DGRMLT. Scratch file.
fort.24	Grid point fields. Scratch file.
fort.25	Legendre functions. Optional scratch file.
fort.31	Input vegetation data.
fort.33	Pre-computed tables for water vapour absorption.
fort.35	Line by line model gas tables.
fort.36	Narrow band model gas tables.
fort.37	Planck function pre-computed values.
fort.41	Input ocean flux data.
fort.45	Climatology file for sst, ssq, ssp and tropopause height.
fort.46	Climatology file for sst, ssq, ssp and tropopause height.
fort.47	Ozone climatology for previous month.
fort.49	Water vapour climatology for previous month.
fort.50	Orography data.

fort.51 Ozone climatology for next month.
fort.53 Water vapour climatology for next month.
fort.55 Column amounts of ozone and water vapour.
fort.63 Fluxes and heating rates.
fort.99 Used in balancing.

The Flux Program

No changes have been made to the flux program and the history file written from IGCM3.1 is unchanged. It is however noted that a tidied IGFLUX3 is needed. In particular, the reads of history files need to be looked at. In addition to the extensions allowing the output of tracer fields (see *Documentation for the Intermediate General Circulation Model - the Physics Parameterizations and the tracer advection schemes in IGCM2.NPL* Piers Forster 21/4/97) the arrays LPHGR and LPHPL have been extended but are not documented elsewhere. The following output fields are available if LPC7=.T.:

1 Surface stress (N/M^2)
2 Surface heat flux (W/M^2)
3 Surface latent flux (W/M^2)
4 Convective rainfall (MM/DAY)
5 Large scale rainfall (MM/DAY)
6 Surface downward shortwave flux (W/M^2)
7 Surface energy balance (W/M^2)
8 Surface upward shortwave flux (W/M^2)
9 Surface downward longwave flux (W/M^2)
10 Surface upward longwave flux (W/M^2)
11 Top net downward shortwave flux (W/M^2)
12 Top upward longwave flux (W/M^2)
13 Surface albedo (%)
14 Surface temperature (K)
15 Deep soil temperature (K)
16 Surface specific humidity (KG/KG)
17 Soil moisture (M)
18 Snow depth (M)
19 Low cloud amount (%)
20 Mid level cloud amount (%)

21 High cloud amount (%)
22 Convective cloud amount (%)