UNIFIED MODEL DOCUMENTATION PAPER NO D6

PRINTED DIAGNOSTICS

by

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Model Version 2.7

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Modification Record		
Document version	**Author**	**Description....................**
1 (8/6/90)	N Farnon	Zonal and global mean diagnostics.
2 (12/10/90)	M J P Cullen	Energy and variance diagnostics.
3 (15/5/92)	R A Stratton	Namelist control of printout.
4 (2/10/92)	C S Douglas	Correction to calculation of quarter-globe means. Extra printout added to zonal means.

CONTENTS

APPENDICES

This paper describes the subroutines used to generate tables of zonal mean and global mean diagnostics from the atmospheric model. Printouts can be requested through the User interface either of instantaneous data ie zonal or global means of the fields in the model dump every n model dumps, or of mean data ie zonal or global means of the fields in a mean dump at the end of a meaning period. If printout is requested a basic table of zonal means and global means is printed together with other tables if required. The printout of other tables is controlled by namelist variables given in Appendix B. Appendix A gives a list of the tables of output, what they contain, and in the case of some tables, which fields must be written to the dump for the table to be printed.

1.Subroutine Zonm_Atm

1. Initialize the start and end pt for each quarter of the globe.

```
 . . . . . . . . . . . . . . . . . . . . . . . . .
| 1/3        | 1/6  | 1/6 |  1/3       |
 ^            ^ ^    ^ ^    ^ ^         ^
 a            b c    d e    f g         h
     1st        2nd   3rd      4th
```
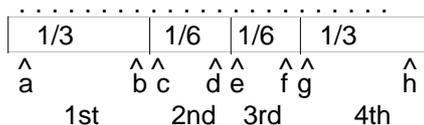
    1.1 For p-grid : START_ROW(1,I) to END_ROW(1,I)
        where A = START_ROW(1,1) = 1
            B =   END_ROW(1,1) = (p_rows-1)/3 + 1
            C = START_ROW(1,2) = (p_rows-1)/3 + 1
            D =   END_ROW(1,2) = (p_rows-1)/2 + 1
            E = START_ROW(1,3) = (p_rows-1)/2 + 1
            F =   END_ROW(1,3) = 2*(p_rows-1)/3 + 1
            G = START_ROW(1,4) = 2*(p_rows-1)/3 + 1
            H =   END_ROW(1,4) = p_rows

    1.2 For u-grid : START_ROW(2,I) to END_ROW(2,I)
        where A = START_ROW(2,1) = 1
            B =   END_ROW(2,1) = (u_rows-1)/3
            C = START_ROW(2,2) = (u_rows-1)/3 + 1
            D =   END_ROW(2,2) = (u_rows-1)/2
            E = START_ROW(2,3) = (u_rows-1)/2 + 1
            F =   END_ROW(2,3) = 2*(u_rows-1)/3
            G = START_ROW(2,4) = 2*(u_rows-1)/3 + 1
            H =   END_ROW(2,4) = u_rows

Note: The quarter global mean is calculated on a quarter of the surface area of the globe as opposed to a quarter of the number of pts per globe i.e: The surface area between 0° and 30° N = the surface area between 30° N and the equator.
      The calculated quarter global mean is slightly greater than the actual quarter global mean due to the offset of the grid which causes an overlapping of rows on the edge of each quarter.

2. Calculate mass weights and set up masks for weighted sums.
      AMASK = 1 Sets an indicator of 1 for each land and sea point
      LMASK = 1 Sets an indicator of 1 for each land point only
      SMASK = 1 Sets an indicator of 1 for each sea point only

3. Calculate the number of land/sea points per row, per quarter globe and globally on a row by row basis and set up logical arrays to denote active land/sea rows.
      A. Initialize the number of global land points to zero.
      B. 20:Loop through each quarter of the globe indicated by I.
      C. Initialize the number of land points per global quarter to zero.
      D. 30:Loop from the start to the end point for each quarter as calculated in 1. above.
      E. Initialize the number of land points per row to zero.
      F. 40:Loop through each point per row.
      G. Sum the total number of land points in each row.
      H. End 40 loop.
      I. Calculate the total number of sea points in each row.

J. Set up logical array where each element equals true for all land and sea points per row.

K. Set up logical array where llpts(row)=true for all land points in that row and false for all sea points.L. Set up logical array where lspts(row)=true for all sea points in that row and false for all land points.M. Sum the total number of land points in each quarter of the globe. N. End 30 loop

O. Calculate the total number of sea points in each quarter of the globe.

P. Set up logical array where lqgapts(i)=true for all land and sea points per quarter globe.

Q. Set up logical array where lqglpts(i)=true for all land points in each quarter and false for all sea points.

R. Set up logical array where lqgspts(i)=true for all sea points in each quarter and false for all land points.

S. Sum the total number of land points globally.

T. End 20 loop.

U. Calculate the total number of sea points in each quarter of the globe.

V. Set up logical array where each element equals true for all global land and sea points.

W. Set up logical array lglpts=true for all global land points and false for all sea points.

X. Set up logical array lgspts=true for all global sea points and false for all land points.

4. Compute mass weights.
    4.1 Compute mass weights from pstar and hybrid coordinates.
    4.2 Interpolate mass weight p_mass onto u-grid.
    4.3 Interpolate mass weight p_star onto u-grid.
    4.4 Set dummy weighting for surface variables to one.

5. Compute column means.
        For each point of latitude and for each row of longitude, calculate the column mean of an atmospheric variable.
            where I is an index for p_rows
                J is an index for row_length
                K is an index for p_levels

$$\text{and} \quad \text{COLMN(I,J)} = \sum_{k=1}^{p\_levels} \frac{\{p\_mass(i,j) * var(i,j)\}}{p\_mass(i,j)}$$

6. Compute zonal means.
        For each row of longitude calculate the zonal mean of a variable.
        6.1 Mass weighted on p-grid for surface variables (for all points).
            where I is an index for p_rows
                J is an index for row_length
                row_length

$$\text{and} \quad \text{ZVAR(I)} = \sum_{j=1}^{row\_length} \frac{\{mask(i,j) * p\_mass(i,j) * var(i,j)\}}{mask(i,j) * p\_mass(i,j)}$$

    6.2 Mass weighted on p-grid for column meaned atmospheric variables (for all points).
    6.3 Mass weighted on u-grid for column meaned atmospheric variables (for all points).
    6.4 Mass weighted on u-grid for surface variables (for all points).
    6.5 Mass weighted on p/u-grid for atmospheric variables (all points).
    6.6 Mass weighted on u-grid for kinetic energies.
    6.7 Mass weighted on p-grid for squared temperature.
    6.8 Mass weighted on p-grid for moisture and moisture squared.
    6.9 Mass weighted on p/u-grid for surface variables (land points).
    6.10 Mass weighted on p/u-grid for surface variables (sea points).

7. Compute quarter global means.
        Between each start and end point of longitude and for each quarter of the globe, calculate the quarter global mean of a variable.
            where I denotes the start and end point of longitude (an index of p_rows)
                J is an index of row_length

$$\text{grid} = \begin{cases} 1 \text{ for p-grid} \\ 2 \text{ for u-grid} \end{cases}$$

$$\text{and GVAR} = \frac{\displaystyle\sum_{i=\text{start\_row(grid,i)}}^{\text{end\_row(grid,i)}} \sum_{j=1}^{\text{rowlength}} \{ \text{mask}(i,j)*\text{area}(i,j)*\text{var}(i,j) \}}{\displaystyle\sum_{i=\text{start\_row(grid,i)}}^{\text{end\_row(grid,i)}} \sum_{j=1}^{\text{rowlength}} \{ \text{mask}(i,j)*\text{area}(i,j) \}}$$

EXAMPLE:

		row_length latitude			
		1	2	3	4
	1	.	.	.	.
p_rows	2	.	.	.	.
longitude	3	.	.	.	.

8. Compute global means.
   Similar to 7. above, however, the start point is 1 and the end point is p_rows.
   8.1 Compute additional zonal and quarter globe means if required.

9. Calculate kinetic energy and variance of temperature and moisture.
   9.1 Calculate total mass for each row at each level, and for each row summed over all levels, p&u grids.
   9.2 Calculate total kinetic energy at each level. If the zonal mean of a quantity X as calculated in section 6.1 is written as Z(X), and the sum of a quantity Y over a row is

   $\Sigma\, Y$, then

   ```
   TKE = Z(U²+V²)Σ Δ P /Σ P *
   ```
   $$\text{TKE} = Z(U^2+V^2)\Sigma\,\Delta P / \Sigma\,P_*$$
   $$\text{ZKE} = [\{Z(U)^2+Z(V)^2\}]\Sigma\,\Delta P / \Sigma\,P_*$$
   $$\text{EKE} = \text{TKE} - \text{ZKE}$$
   $$\text{TVR} = [Z(T^2)-\{Z(T)^2\}]\Sigma\,\Delta P / \Sigma\,P_*$$
   $$\text{QVR} = [Z(Q^2)-\{Z(Q)^2\}]\Sigma\,\Delta P / \Sigma\,P_*$$

   9.3 Calculate global mean of above quantities by summing of rows weighted by cos(latitude).
10. Print results neatly formatted.
    10.1 Format for Zonal mean variables
    10.2 Format for Quarter Global mean variables
    10.3 Format for Global mean variables

2.Subroutine Zonm

1. Declare local variables
2. Calculate Zonal mean
   A. 10:Loop through each longitude
   B. Initialize sumztop and sumzbot variables to zero
   C. 20:Loop through each Latitude
   D. Calculate sumzbot = Σ {mask(i,j)*mass(i,j)} for each I,J
      where I is an index for longitude
      and J is an index for latitude
   E. Calculate sumztop = Σ {mask(i,j)*mass(i,j)*var(i,j)} for each I,J
   F. End 20 loop
   G. Test for each row of longitude if all the points in that row are not zero.
      G.1 If all points/row are not zero then

G.2 Set Zonal mean = E/D above
G.3 Else Set Zonal mean = zero
H. End 10 loop

3.Subroutine Colm

1. Declare local variables
2. Calculate Column mean
   A. 10:Loop through each longitude
   B. Initialize sumctop and sumcbot variables to zero
   C. 20:Loop through each latitude
   D. 30:Loop through each level
   E. Calculate sumcbot = Σ mass(i,j) for each I,J

   where I is an index for longitude
   and J is an index for latitude
   F. Calculate sumctop = Σ {mass(i,j)*var(i,j)} for each I,J
   G. End 30 loop
   H. End 20 loop
   I. End 10 loop

4.Subroutine Glbm

1. Declare local variables
2. Calculate Global mean
   Throughout, I is an index for longitude
            J is an index for latitude
   2.1 If it's a p-grid
   A. 10:Loop from start to end point for each longitude
   B. Initialize sumgtop and sumgbot variables to zero
   C. 20:Loop through each Latitude

   D. Calculate sumgbot = $\displaystyle\sum_{i=start\_row+1}^{i=end\_row-1} \sum_{j=1}^{rowlength} \{mask(i,j)*area(i,j)\}$

   $+ \displaystyle\sum_{j=1}^{rowlength} 0.5*\{mask(start\_row,j)*area(start\_row,j)\}$

   $+ \displaystyle\sum_{j=1}^{rowlength} 0.5*\{mask(end\_row,j)*area(end\_row,j)\}$

   E. Calculate sumgtop = $\displaystyle\sum_{i=start\_row+1}^{i=end\_row-1} \sum_{j=1}^{rowlength} \{mask(i,j)*area(i,j)*var(i,j)\}$

   $+ \displaystyle\sum_{j=1}^{rowlength} 0.5*\{mask(start\_row,j)*area(start\_row,j)*var(start\_row,j)\}$

   $+ \displaystyle\sum_{j=1}^{rowlength} 0.5*\{mask(end\_row,j)*area(end\_row,j)*var(end\_row,j)\}$

   F. End 20 loop
   G. End 10 loop
If it's a u-grid
   A. 30:Loop from start to end for each longitude
   B. Initialize sumgtop and sumgbot variables to zero
   C. 40:Loop through each latitude
   D. Calculate sumgbot = Σ {mask(i,j)*area(i,j)}
   E. Calculate sumgtop = Σ {mask(i,j)*area(i,j)*var(i,j)}
   F. End 40 loop
   G. End 30 loop
   2.3 Test for each section of rows of longitude that all the points in that section are not zero.
   A If all points/quarter globe or all points/globe are not zero then
   B Set Quarter global mean or Global mean = E/D above
   C Else Set Quarter global mean or Global mean = zero

Appendix A - List of Printed output tables

Table 1 - always printed. Zonal means of
>PMSL
>Pstar
>Snow depth (SNOWD)
>Canopy water (CANOPYW)
>Large scale rain rate in mm/day (LSRN)
>Convective rain rate in mm/day (CVRN)
>Temperature of the whole atmosphere (TATMOS)
>Humidity for the whole atmosphere (QATMOS)
>Soil moisture (SOILM)
>Surface temperature for all points (T*ALL), sea points (T*SEA), land points (T*LAND).
>Soil temperature at levels 2 to 4 (SOILT2-4)
>Surface runoff (SRUN)
>Subsurface runoff.(SUBR)

Note *** are printed if the field is not present in the dump.

Table 2 - always printed. Zonal means over all grid points, just sea points and just land points of
>Sensible heat flux (S.HEAT)
>Evaporation in mm/day (EVAP)
>Precipitation (PPTN)
>Snow fall (SNOW)
>Fractional sea ice cover (AICE)
>Mean Depth of the sea ice (HICE)
>Sublimation (SUMBL)
>Cloud liquid water and ice, printed only if requested. (CLLIQ,CLICE)

Table 3 - printed if wind or radiation information required. Zonal means of
(Part 1 if wind required)
>Wind speed averaged over the whole depth of the atmosphere (UATMOS, VATMOS)
>The components of wind stress (TAUX and TAUY) over all points, sea points and land points.
(Part 2 if radiation required)
>Total radiation at the surface for land points and sea points.
>Surface solar radiation for land points and sea points.
>Total outgoing radiation at the top of the atmosphere.
>Total outgoing longwave radiation at the top of the atmosphere.
>Albedo

Tables 4-5 - printed if wind information required
>4. Zonal means of the U component of wind speed at all model levels.
>5. Zonal means of the V component of wind speed at all model levels.
>   Note the present printout is designed for a maximum of 20 model levels.

Tables 6-8 - printed if kinetic energy required
>6. Zonal means of total kinetic energy at all model levels.
>7. Zonal means of zonal kinetic energy at all model levels.
>8. Zonal means of eddy kinetic energy at all model levels.

Table 9 - printed if temperature required.
>Zonal mean temperature at all model levels.

Table 10 - printed if temperature variance required.
>Zonal mean temperature variance at all model levels.

Table 11 - printed if humidity required.
>Zonal mean humdity at all model levels.

Table 12 - printed if humidity variance required.
>Zonal mean humidity at all model levels.

Table 13 - Quarter globe and global means of
a)   Fields in table 1
b)   Fields in table 2
c)   Temperature, humidity, wind components, wind stress components and kinetic energy.
d)   U and V components at all model levels.
e)   Total, zonal and eddy kinetic energy for all model levels.
f)   temperature and temperature variance at all model levels.
g)   Humidity, and humidity variance at all model levels.

h)   Global means of Kinetic energy , temperature and humidity.

The following tables of quarter globe and global means are only printed if extra diagnostics are requested and all the diagnostics for the table are in the model dump.

Table 14 - diagnostics from hydrology model section 8
        Throughfall(stash code 203)
        Snowmelt(201)
        Surface runoff(204)
        Sub surface runoff(205)

Table 15 - radiation
        Total radiation at the surface over all points, sea points and land points.
        Surface solar radiation over land, sea and all points.
        Total outgoing radiation at the top of the atmosphere.
        Total outgoing long wave radiation at the top of the atmosphere.
        Total outgoing short wave radiation at the top of the atmosphere.
        Albedo.
        Required fields in terms of their stash codes are (1,207), (1,208), (1,201), (2,205) and (2,201).

Table 16 - Fluxes and budgets
        Soil heat flux
        Snow Budget
        Canopy water budget
        Soil water budget
        Water budget over land and sea
        Soil energy
        Energy flux over land and sea
Printout of this table requires all fields neccessary for tables 14, 15 together with fields to calculate snow, rain, sublimation, evaporation, canopy evaporation, soil evaporation and sensible heat.

Table 17 - Cloud liquid water and ice
        Quarter globe means for each model level.
        Quarter globe means for the whole atmosphere.
        Fields required are from section 4, 205 and 206 on all model levels.

Table 18 - Variables meaned over Sea-ice
        Heat flux
        Melting heat
        Sensible heat
        Surface radiation
        Surface solar radiation
        Energy flux
This table requires fields for table 15 plus sensible heat, heat flux through sea-ice (3,201), sea-ice top melting heat flux (3,235) and total downward surface solar radiation on sea-ice (1,235).

Appendix B - namelist variables.

The request to printout zonal and global means for instantaneous or mean dumps is controlled by the array A_PRINTFREQ in the namelist IMINTC to be found in the MCTLFL# file of an experiment library.

The actual printout is controlled by the namelist ZONPCTL to be found in the NAMLST# file of an experiment library. The namelist variables are;

IPRTWIND	Wind means
IPRTTEMP	Temperature means
IPRTQ	Humidity means
IPRTKE	Kinetic energy means
IPRTVAR	Variances
IPRTEXTRA	Extra tables of means

set to 1 if required, 0 if not.