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# Rice Cultivation and Methane Emission: Documentation of Distributed Geographic Data Sets

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# Rice Cultivation and Methane Emission: Documentation of Distributed Geographic Data Sets

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# 1. INTRODUCTION

High-resolution global data bases on the geographic and seasonal distribution of rice cultivation and associated methane emission, compiled by Matthews et al. (1991), have been archived for public use. These data were developed to evaluate the role of rice cultivation in the annual emission of methane from terrestrial sources. The data bases represent an integration of extensive information on the cultivation of rice in all 103 rice-producing countries of the world and reflect conditions for 1984. The geographic distribution of rice-growing locations was developed by combining a 1° resolution land-use data base identifying rice-farming regimes, a 1° resolution data base of countries of the world, and country statistics on areas of annual rice harvest. The seasonal distribution of cultivated rice areas was derived via the integration of the data base on rice-growing locations with information on cropping practices for each rice producer. Since the causes of the variability in methane fluxes from flooded rice fields have not yet been well quantified, Matthews et al. (1991) did not attempt a new, direct estimate of the role of rice cultivation in the global emission of methane but instead evaluated the temporal and spatial distribution of the emission from a hypothetical annual source of 100 Tg methane. The seasonal and geographic distribution of this calculated methane emission is included in the set. In addition to the primary data sets identifying location, seasonality and methane emission from rice cultivation, a series of supporting datasets is included allowing users not only to replicate the work of Matthews et al. (1991) but to investigate alternative cultivation and emission scenarios.

The suite of data bases provided, at 1° latitude by 1° longitude resolution for the globe, includes 1) locations of rice cultivation, 2) monthly arrays of actively growing rice areas, 3) countries and political subdivisions, and 4) monthly arrays of methane emission from rice cultivation. Ancillary data include: 1) a listing, by country, of harvested rice areas and seasonal distribution of crop cycles, and 2) country names and codes. Summary tables of zonal/monthly distributions of actively growing rice areas and of methane emissions (Matthews et al., 1991) are presented in this report.

The data sets are presented in the sections following. This short paper is designed only to document the distributed information and briefly describe the data sets and their initial application to evaluating the role of rice cultivation in the methane budget. For complete discussions of the data, consult the original publications listed in the references. The reference for the rice cultivation and methane emission data is Matthews et al. (1991). The reference for the country data set is Lerner et al. (1988).

All files are ASCII text.

All 1° latitude x 1° longitude (I,J) arrays are dimensioned (360,180) with the following orientation:

J = 1,180:
- J = 1: 1° band from 90°S to 89°S ...
- J = 180: 1° band from 89°N to 90° N

I = 1,360:
- I = 1: 1° band from 180° (dateline) to 179°W ...
- I = 360: 1° band from 179°E to 180° (dateline)

## 2. GEOGRAPHIC DISTRIBUTION OF RICE-CULTIVATION LOCATIONS (ILOC)

Data Reference: Matthews, E., I. Fung and J. Lerner, Methane emission from rice cultivation: Geographic and seasonal distribution of cultivated areas and emissions, *Global Biogeochemical Cycles*, 5, 3-24, 1991.

The 1° digital land-use data base of Matthews (1983), with 119 land-use types, was the primary reference used by Matthews et al. (1991) for determining rice-growing locations on a global scale. Eighteen land-use types, primarily dominated by rice, were selected from the data base; a few of the selected farming systems are more general and were included in order to capture rice-growing regions that would not otherwise have been included, for example, in India. Additional regional data on rice cultivation in Brazil and China were compiled from country-specific sources.

The land-use data base was used solely to identify locations of rice farming and not to determine areas since reliable and recent statistics on rice-harvest areas are available from the United Nations Food and Agriculture Organization (UN FAO) and other sources. (Note that FAO figures reflect annually harvested rice area, in contrast to cultivation area which is the area of land on which rice is grown. Therefore, in the FAO statistics, land cropped for rice multiple times in one year is counted multiple times.) In the work of Matthews et al. (1991), it was sufficient only that the 1° cells selected for each country occupied an area at least equal to the country's total harvested rice area as reported by FAO. This threshold test simply assured that the location data base could accommodate the most extreme case in which all the harvested rice is grown during a single annual crop cycle. The rice location data base, which includes 949 1° cells, provides potential ground area on which rice cultivation can occur. Actual areas are provided in the datasets described in following sections.

### FORMAT INFORMATION

*Unit*: not applicable

*Arrays:*

```
CHARACTER*80    TITLE
INTEGER*4       ILOC (360,180)
```

*How to Read:*

```
      READ (10,11) TITLE
      READ (10,12) ILOC
   11 FORMAT (A80)
   12 FORMAT (20(1X,I3))
```

*Values*:

rice cells = 1; land cells without rice = 0; water cells = -1

## 3. SEASONALITY OF RICE CROPPING (CROPS)

Data Reference: Matthews, E., I. Fung and J. Lerner, Methane emission from rice cultivation: Geographic and seasonal distribution of cultivated areas and emissions, *Global Biogeochemical Cycles*, *5*, 3-24, 1991.

Since the emission of methane from rice fields varies in response to many factors (e.g., local climate, plant phenology, crop cycle and crop duration) information on the area of annually harvested rice, such as that published by FAO, is insufficient to estimate the methane emission from this source. Therefore, Matthews et al. (1991) compiled seasonal rice-cropping calendars for individual countries and estimates of the seasonal distribution of annual harvest areas in each crop cycle for all rice-producing countries. FAO (1985) was the sole source for country totals of harvested rice areas although for several large countries, i.e., China, India, United States and Australia, rice areas for political subdivisions within country boundaries were incorporated to reduce geographical uncertainties.

This tabular dataset provides information on annual and seasonal patterns of rice cropping for all rice-producing countries of the world and for rice-producing subdivisions of India and China; i.e., it is Table 1, from this report, in digital form. Annual rice-harvest areas are given along with areas and cultivation months of all seasonal crop cycles for individual countries/subdivisions. These data, with the country datasets, are provided to allow users to investigate alternative seasonality scenarios of methane emission.

Note from the FORMAT INFORMATION below that the digital form of cropping information for countries and subdivisions (CROPS) is uninterrupted although in Table 1 the information is divided into three parts appended with summary statistics: Table 1a gives areas, and planting and harvest times, for each rice crop grown during a year for rice producers other than India and China. The same information is provided for the subdivisions of India and China in Tables 1b and 1c, respectively. Note also that Table 1a (and the corresponding digital data) reports proportions of annual harvest areas grown in individual crop cycles whereas Tables 1b and 1c (and the corresponding digital data) give areas of rice cultivated during individual crop cycles for the subdivisions of India and China, respectively. For instance, in 1984 Thailand harvested a total of 97 x $10^9 m^2$ of rice: 0.90 was grown in the first crop which is planted in July and harvested in December and 0.10 was in the second crop which has a cultivation period lasting from March to July (Table 1a). In the same year, the Chinese province of Hunan harvested 44.68 x $10^9 m^2$ of rice: 19.46 x $10^9 m^2$ was grown as early rice from March-July; 20.37 x $10^9 m^2$ was grown in the double-late cycle from June to November; the remainder was in the intermediate/single late crop cultivated from May-September (Table 1c). Finally, note that zero values for areas and in calendars in the digital data (CROPS) are represented by dashes in Table 1.

### FORMAT INFORMATION

*Unit:* not applicable

*Arrays:*

```
CHARACTER*80     TITLE, CROPS (156)
```

*How To Read:*

```
      READ (10,11) TITLE
      DO 100 K = 1,156
      READ (10,11) CROPS(K)
100   CONTINUE
 11   FORMAT (A80)
```

Table 1a. Annual harvested rice areas ($10^9 m^2$), proportion of annual area in seasonal crops, and calendars for seasonal crops for rice-producing countries of the world (Matthews et al., 1991). Country totals are from FAO (1985). Calendar symbols: - , no rice growing; 1, planting or harvest month, rice growing for half the month; 2, rice growing for full month. See Section 3 for discussion of country codes.

| Country Code | Country Name | Annual Area | Crop 1 Fraction | Crop 1 Calendar JFMAMJJASOND | Crop 2 Fraction | Crop 2 Calendar JFMAMJJASOND | Crop 3 Fraction | Crop 3 Calendar JFMAMJJASOND |
|---|---|---|---|---|---|---|---|---|
| 7500 | India [1] | 428.00 | | | | | | |
| 3300 | China [1] | 336.86 | | | | | | |
| 1200 | Bangladesh | 105.00 | 0.60 | ------122221 | 0.30 | ---12221---- | 0.10 | 1221-------- |
| 16000 | Thailand | 97.00 | 0.90 | ------122221 | 0.10 | --12221----- | - | ---------- |
| 7600 | Indonesia [2] | 97.00 | | | | | | |
| 17600 | Vietnam | 56.20 | 0.60 | -----1222221 | 0.40 | -1221------- | - | ---------- |
| 2100 | Brazil | 53.56 | 1.00 | 221-------12 | - | ---------- | - | ---------- |
| 2500 | Burma | 46.80 | 1.00 | -----1222221 | - | ---------- | - | ---------- |
| 13000 | Philippines | 33.30 | 0.65 | -----12221-- | 0.35 | 1221-------- | - | ---------- |
| 8400 | Japan | 23.15 | 1.00 | ----122221-- | - | ---------- | - | ---------- |
| 12400 | Pakistan | 19.99 | 1.00 | ------12221- | - | ---------- | - | ---------- |
| 8600 | Cambodia | 13.90 | 0.90 | -----1222221 | 0.10 | 221--------1 | - | ---------- |
| 11400 | Nepal | 13.35 | 0.80 | -----1221--- | 0.20 | ------12221- | - | ---------- |
| 8900 | Korea, Rep. | 12.31 | 1.00 | -----12221-- | - | ---------- | - | ---------- |
| 9900 | Malagasy | 12.00 | 1.00 | 22221----122 | - | ---------- | - | ---------- |
| 17100 | U.S.A. | 11.26 | 1.00 | ----122221-- | - | ---------- | - | ---------- |
| 9000 | Korea, D. P. R. | 8.30 | 1.00 | ----12221--- | - | ---------- | - | ---------- |
| 15100 | Sri Lanka | 7.50 | 0.65 | 221------122 | 0.35 | ---12221---- | - | ---------- |
| 17200 | USSR, former | 6.88 | 1.00 | ----12221--- | - | ---------- | - | ---------- |
| 10100 | Malaysia | 6.60 | 0.55 | 1--------122 | 0.30 | ----12221--- | 0.15 | 1-----122222 |
| 15800 | Taiwan | 6.60 | 0.60 | -----1222221 | 0.40 | -1221------- | - | ---------- |
| 9200 | Laos | 6.10 | 1.00 | ------122221 | - | ---------- | - | ---------- |

Table 1a. (continued)

| Country Code | Country Name | Annual Area | Crop 1 Fraction | Crop 1 Calendar JFMAMJJASOND | Crop 2 Fraction | Crop 2 Calendar JFMAMJJASOND | Crop 3 Fraction | Crop 3 Calendar JFMAMJJASOND |
|---|---|---|---|---|---|---|---|---|
| 12100 | Nigeria | 6.00 | 1.00 | ----12221--- | - | ---------- | - | ---------- |
| 4700 | Egypt | 4.20 | 1.00 | ----122221-- | - | ---------- | - | ---------- |
| 7700 | Iran | 4.20 | 1.00 | ----12221--- | - | ---------- | - | ---------- |
| 6700 | Guinea | 4.00 | 1.00 | ----122221-- | - | ---------- | - | ---------- |
| 8200 | Ivory Coast | 4.00 | 1.00 | --122221---- | - | ---------- | - | ---------- |
| 14500 | Sierra Leone | 4.00 | 1.00 | ----1222221- | - | ---------- | - | ---------- |
| 3400 | Colombia | 3.64 | 0.75 | --1222221--- | 0.25 | --------1221 | - | ---------- |
| 18200 | Zaire | 3.25 | 1.00 | -12221------ | - | ---------- | - | ---------- |
| 15900 | Tanzania | 2.70 | 1.00 | 22221-----12 | - | ---------- | - | ---------- |
| 12900 | Peru | 2.40 | 1.00 | 22221----122 | - | ---------- | - | ---------- |
| 100 | Afghanistan | 2.12 | 1.00 | -----12221-- | - | ---------- | - | ---------- |
| 9500 | Liberia | 2.10 | 1.00 | ------122221 | - | ---------- | - | ---------- |
| 10800 | Mexico | 2.04 | 1.00 | ----1222221_ | - | ---------- | - | ---------- |
| 8100 | Italy | 1.78 | 1.00 | ----12221--- | - | ---------- | - | ---------- |
| 3900 | Cuba | 1.51 | 1.00 | ----1222221- | - | ---------- | - | ---------- |
| 17500 | Venezuela | 1.51 | 1.00 | -----12221-- | - | ---------- | - | ---------- |
| 4600 | Ecuador | 1.50 | 1.00 | 12221------- | - | ---------- | - | ---------- |
| 6800 | Guinea Bissau | 1.45 | 1.00 | ----122221-- | - | ---------- | - | ---------- |
| 10300 | Mali | 1.30 | 1.00 | ------122221 | - | ---------- | - | ---------- |
| 1900 | Bolivia | 1.21 | 1.00 | 221-------12 | - | ---------- | - | ---------- |
| 700 | Argentina | 1.18 | 1.00 | 2221------12 | - | ---------- | - | ---------- |
| 4500 | Dominican Republic | 1.15 | 1.00 | -----12221-- | - | ---------- | - | ---------- |
| 800 | Australia | 1.13 | 0.50 | 2221-----122 | 0.50 | 2221------12 | - | ---------- |
| 12600 | Panama | 0.96 | 1.00 | ----12221--- | - | ---------- | - | ---------- |

Table 1a. (continued)

| Country Code | Country Name | Annual Area | Crop 1 Fraction | Crop 1 Calendar JFMAMJJASOND | Crop 2 Fraction | Crop 2 Calendar JFMAMJJASOND | Crop 3 Fraction | Crop 3 Calendar JFMAMJJASOND |
|---|---|---|---|---|---|---|---|---|
| 6900 | Guyana | 0.93 | 1.00 | ----122221-- | - | ---------- | - | ---------- |
| 17300 | Uruguay | 0.79 | 1.00 | 21-----12222 | - | ---------- | - | ---------- |
| 15000 | Spain | 0.73 | 1.00 | ----12221--- | - | ---------- | - | ---------- |
| 3800 | Costa Rica | 0.70 | 1.00 | -----12221-- | - | ---------- | - | ---------- |
| 11100 | Mozambique | 0.70 | 1.00 | 122221------ | - | ---------- | - | ---------- |
| 15300 | Surinam | 0.70 | 1.00 | ----122221-- | - | ---------- | - | ---------- |
| 14300 | Senegal | 0.66 | 1.00 | ------12221- | - | ---------- | - | ---------- |
| 16500 | Turkey | 0.64 | 1.00 | ----122221-- | - | ---------- | - | ---------- |
| 7000 | Haiti | 0.58 | 1.00 | ----122221-- | - | ---------- | - | ---------- |
| 6100 | Ghana | 0.57 | 1.00 | -----1222221 | - | ---------- | - | ---------- |
| 3100 | Chad | 0.51 | 1.00 | ----122221-- | - | ---------- | - | ---------- |
| 7800 | Iraq | 0.48 | 1.00 | ----122221-- | - | ---------- | - | ---------- |
| 11900 | Nicaragua | 0.45 | 1.00 | -----122221- | - | ---------- | - | ---------- |
| 10000 | Malawi | 0.42 | 1.00 | 222221-----1 | - | ---------- | - | ---------- |
| 3200 | Chile | 0.40 | 1.00 | 2221------12 | - | ---------- | - | ---------- |
| 12800 | Paraguay | 0.32 | 1.00 | 221-------12 | - | ---------- | - | ---------- |
| 1800 | Bhutan | 0.31 | 1.00 | ----12222221 | - | ---------- | - | ---------- |
| 13500 | Romania | 0.31 | 1.00 | ----122221-- | - | ---------- | - | ---------- |
| 2400 | Burkina Faso | 0.30 | 1.00 | -----122221- | - | ---------- | - | ---------- |
| 13200 | Portugal | 0.30 | 1.00 | ---122221--- | - | ---------- | - | ---------- |
| 2700 | Cameroon | 0.23 | 1.00 | 1-------1222 | - | ---------- | - | ---------- |
| 12000 | Niger | 0.23 | 1.00 | -------12221 | - | ---------- | - | ---------- |
| 7100 | Honduras | 0.22 | 1.00 | ---122221--- | - | ---------- | - | ---------- |
| 400 | Angola | 0.20 | 1.00 | 2221------12 | - | ---------- | - | ---------- |

Table 1a. (continued)

| Country Code | Country Name | Annual Area | Crop 1 Fraction | Crop 1 Calendar JFMAMJJASOND | Crop 2 Fraction | Crop 2 Calendar JFMAMJJASOND | Crop 3 Fraction | Crop 3 Calendar JFMAMJJASOND |
|---|---|---|---|---|---|---|---|---|
| 5900 | Gambia | 0.20 | 1.00 | ------122221 | - | ---------- | - | ---------- |
| 6600 | Guatemala | 0.20 | 1.00 | ---1222221-- | - | ---------- | - | ---------- |
| 16800 | Uganda | 0.20 | 1.00 | 22221-----12 | - | ---------- | - | ---------- |
| 2300 | Bulgaria | 0.16 | 1.00 | ---12221---- | - | ---------- | - | ---------- |
| 3000 | Central African Republic | 0.15 | 1.00 | -----122221- | - | ---------- | - | ---------- |
| 4800 | El Salvador | 0.15 | 1.00 | -----122221- | - | ---------- | - | ---------- |
| 6200 | Greece | 0.14 | 1.00 | ----12221--- | - | ---------- | - | ---------- |
| 3500 | Comoros | 0.13 | 1.00 | 12221------- | - | ---------- | - | ---------- |
| 7300 | Hungary | 0.13 | 1.00 | ----122221-- | - | ---------- | - | ---------- |
| 16100 | Togo | 0.13 | 1.00 | ----1222221- | - | ---------- | - | ---------- |
| 5300 | Fiji | 0.09 | 1.00 | -1221------- | - | ---------- | - | ---------- |
| 5500 | France | 0.09 | 1.00 | ---1222221-- | - | ---------- | - | ---------- |
| 8700 | Kenya | 0.09 | 1.00 | -----1222221 | - | ---------- | - | ---------- |
| 18100 | Yugoslavia | 0.09 | 1.00 | ----122221-- | - | ---------- | - | ---------- |
| 18300 | Zambia | 0.08 | 1.00 | 22221------1 | - | ---------- | - | ---------- |
| 1600 | Benin | 0.06 | 1.00 | ----122221-- | - | ---------- | - | ---------- |
| 10600 | Mauritania | 0.05 | 1.00 | -----122221- | - | ---------- | - | ---------- |
| 16300 | Trinidad & Tobago | 0.05 | 1.00 | ------12221- | - | ---------- | - | ---------- |
| 200 | Albania | 0.04 | 1.00 | ----122221-- | - | ----------- | - | ---------- |
| 3600 | Congo | 0.04 | 1.00 | 2221------12 | - | ---------- | - | ---------- |
| 15200 | Sudan | 0.04 | 1.00 | -----12221-- | - | ---------- | - | ---------- |
| 17151 | USA/PR | 0.03 | 1.00 | ----122221-- | - | ---------- | - | ---------- |
| 1500 | Belize | 0.02 | 1.00 | ----1222221- | - | ---------- | - | ---------- |
| 2200 | Brunei | 0.02 | 1.00 | 1--------122 | - | ---------- | - | ---------- |

Table 1a. (continued)

| Country Code | Country Name | Annual Area | Crop 1 Fraction | Crop 1 Calendar JFMAMJJASOND | Crop 2 Fraction | Crop 2 Calendar JFMAMJJASOND | Crop 3 Fraction | Crop 3 Calendar JFMAMJJASOND |
|---|---|---|---|---|---|---|---|---|
| 2600 | Burundi | 0.02 | 1.00 | 222221----12 | - | ---------- | - | ---------- |
| 11000 | Morocco | 0.02 | 1.00 | -1222221---- | - | ---------- | - | ---------- |
| 14700 | Solomon Islands | 0.02 | 0.34 | 12221------- | 0.33 | ----12221--- | 0.33 | 1-------1222 |
| 5600 | French Guiana | 0.01 | 1.00 | -12221------ | - | ---------- | - | ---------- |
| 8300 | Jamaica | 0.01 | 1.00 | ------122221 | - | ---------- | - | ---------- |
| 13600 | Rwanda | 0.01 | 1.00 | 222221----12 | - | ---------- | - | ---------- |
| 14800 | Somalia | 0.01 | 1.00 | 1-------1222 | - | ---------- | - | ---------- |
| 14900 | South Africa | 0.01 | 1.00 | 222221----12 | - | ---------- | - | ---------- |
| 18400 | Zimbabwe | 0.01 | 1.00 | 22221------1 | - | ---------- | - | ---------- |
| | Global Total | 1475.19 | | | | | | |

[1] India and China are subdivided countries. See Tables 1b and 1c for seasonal areas and calendars for India and China, respectively.

[2] Rice is grown in all months of the year in Indonesia; the area cultivated in each month was calculated as the difference between published monthly values of areas planted and areas harvested. Areas for January through December are: 39.77, 46.56, 40.74, 27.16, 20.37, 19.40, 16.49, 10.67, 2.91, 1.94, 8.73, and 24.25 $10^9 m^2$, respectively.

Table 1b. Annual and seasonal harvested rice areas ($10^9 m^2$) and seasonal crop calendars for the rice-producing states of India (Matthews et al., 1991). Calendar symbols: - , no rice growing; 1, planting or harvest month, rice growing for half the month; 2, rice growing for full month.

| State Code | State Name | Annual Area | Autumn Area | Autumn Calendar JFMAMJJASOND | Winter Area | Winter Calendar JFMAMJJASOND | Summer Area | Summer Calendar JFMAMJJASOND |
|---|---|---|---|---|---|---|---|---|
| 7520 | Uttar Pradesh | 56.18 | 34.82 | -----12221-- | 21.33 | ------12221- | 0.03 | 12221------- |
| 7521 | West Bengal | 55.06 | 7.20 | -----12221-- | 43.98 | ------12221- | 3.88 | 2221-------1 |
| 7510 | Madhya Pradesh | 54.18 | 54.18 | ------12221- | - | ---------- | - | ---------- |
| 7503 | Bihar | 50.91 | 6.57 | -----12221-- | 43.80 | -------12221 | 0.54 | 12221------- |
| 7515 | Orissa | 45.05 | 9.44 | -----12221-- | 34.06 | ------122221 | 1.55 | 122221------ |
| 7501 | Andhra Pradesh | 40.71 | 2.96 | ---12221---- | 27.51 | 1------12222 | 10.24 | 1221-------- |
| 7502 | Assam | 26.06 | 7.09 | --12221----- | 18.59 | -----1222221 | 0.38 | 2221-------1 |
| 7518 | Tamil Nadu | 20.43 | 15.34 | ------12221- | 4.95 | 221--------1 | 0.14 | --1221------ |
| 7511 | Maharashtra | 16.97 | 16.45 | ------12221- | 0.14 | 221--------1 | 0.38 | --1221------ |
| 7516 | Punjab | 14.94 | 14.94 | -----12221-- | - | ---------- | - | ---------- |
| 7508 | Karnataka | 12.79 | 11.06 | -----12221-- | 0.67 | 221------122 | 1.06 | 12221------- |
| 7509 | Kerala | 9.04 | 3.90 | ----12221--- | 4.00 | 1-------1222 | 1.14 | 1221-------- |
| 7505 | Haryana | 5.54 | 5.54 | -----12221-- | - | ---------- | - | ---------- |
| 7504 | Gujarat | 5.39 | 5.39 | ------12221- | - | ---------- | - | ---------- |
| 7519 | Tripura | 3.17 | 1.36 | --12221----- | 1.39 | -----122221- | 0.42 | 2221-------1 |
| 7507 | Jammu and Kashmir | 3.11 | - | ---------- | 3.11 | ----122221-- | - | ---------- |
| 7512 | Manipur | 1.80 | 0.44 | --12221----- | 1.36 | -----122221- | - | ---------- |
| 7517 | Rajasthan | 1.35 | 1.35 | ------12221- | - | ---------- | - | ---------- |
| 7514 | Nagaland | 1.26 | 0.51 | ---1221----- | 0.75 | -----1222221 | - | ---------- |
| 7513 | Meghalaya | 1.23 | 0.39 | --12221----- | 0.82 | 1-----122222 | 0.02 | 2221-------1 |
| 7522 | Arunachal Pradesh | 1.02 | 1.02 | --12221----- | - | ---------- | - | ---------- |
| 7506 | Himachal Pradesh | 1.00 | 1.00 | -----12221-- | - | ---------- | - | ---------- |
| 7523 | Mizoram | 0.33 | 0.10 | --12221----- | 0.23 | -----122221- | - | ---------- |

Table 1b. (continued)

| State Code | State Name | Annual Area | Autumn Area | Autumn Calendar JFMAMJJASOND | Winter Area | Winter Calendar JFMAMJJASOND | Summer Area | Summer Calendar JFMAMJJASOND |
|---|---|---|---|---|---|---|---|---|
| 7525 | Sikkim | 0.17 | 0.17 | -----1221--- | - | ---------- | - | ---------- |
| 7524 | Andaman Is. | 0.14 | 0.14 | -----1222221 | - | ---------- | - | ---------- |
| 7500 | India Total | 427.83 | 201.36 | | 206.69 | | 19.78 | |

Table 1c. Annual and seasonal harvested rice areas ($10^9 m^2$) and seasonal crop calendars for the rice-producing provinces of China (Matthews et al., 1991). Calendar symbols: - , no rice growing; 1, planting or harvest month, rice growing for half the month; 2, rice growing for full month.

| Province Code | Province Name | Annual Area | ER [1] Area | ER Calendar JFMAMJJASOND | DL [2] Area | DL Calendar JFMAMJJASOND | I/SL [3] Area | I/SL Calendar JFMAMJJASOND |
|---|---|---|---|---|---|---|---|---|
| 3315 | Hunan | 44.68 | 19.46 | --11221----- | 20.37 | -----112221- | 4.86 | ----22221--- |
| 3314 | Guangdong | 41.07 | 19.45 | --12221----- | 21.02 | -----12222-- | 0.60 | ----22221--- |
| 3320 | Jiangxi | 34.02 | 16.50 | --11221----- | 14.49 | -----112221- | 3.04 | ----22221--- |
| 3306 | Sichuan | 31.63 | 1.11 | --12221----- | 0.88 | -----12222-- | 29.63 | ---1222211-- |
| 3312 | Guangxi | 28.25 | 12.76 | --12221----- | 13.42 | -----12222-- | 2.07 | ----22221--- |
| 3324 | Jiangsu | 26.28 | 3.75 | --11221----- | 4.02 | -----112221- | 18.51 | ----22221--- |
| 3316 | Hubei | 26.20 | 7.69 | --11221----- | 8.16 | -----112221- | 10.35 | ----22221--- |
| 3322 | Zhejiang | 25.29 | 11.02 | --11221----- | 11.78 | -----112221- | 2.50 | ----22221--- |
| 3323 | Anhui | 21.52 | 7.29 | --11221----- | 5.65 | -----112221- | 8.58 | ----22221--- |
| 3321 | Fujian | 16.70 | 7.15 | --12221----- | 6.91 | -----12222-- | 2.64 | ----22221--- |
| 3305 | Yunnan | 10.91 | 0.46 | --12221----- | 0.26 | -----12222-- | 10.19 | ---1222211-- |
| 3313 | Guizhou | 7.79 | 0.02 | --12221----- | 0.01 | -----12222-- | 7.76 | ---1222211-- |
| 3311 | Liaoning | 4.02 | - | ---------- | - | ---------- | 4.02 | ---122221--- |
| 3319 | Henan | 4.00 | - | ---------- | - | ---------- | 4.00 | ----12222--- |
| 3329 | Shanghai | 2.76 | 1.02 | --11221----- | 1.36 | -----112221- | 0.38 | ----22221--- |
| 3310 | Jilin | 2.57 | - | ---------- | - | ---------- | 2.57 | ---122221--- |
| 3307 | Heilongjiang | 2.27 | - | ---------- | - | ---------- | 2.27 | ---122221--- |
| 3317 | Shaanxi | 1.63 | - | ---------- | - | ---------- | 1.63 | ----12222--- |
| 3325 | Shandong | 1.41 | - | ---------- | - | ---------- | 1.41 | ----12222--- |
| 3326 | Hebei | 1.34 | - | ---------- | - | ---------- | 1.34 | ----12222--- |
| 3301 | Xinjiang | 0.90 | - | ---------- | - | ---------- | 0.90 | ----12222--- |
| 3309 | Ningxia | 0.50 | - | ---------- | - | ---------- | 0.50 | ---122221--- |
| 3327 | Beijing | 0.50 | - | ---------- | - | ---------- | 0.50 | ----12222--- |

Table 1c. (continued)

| Province Code | Province Name | Annual Area | ER [1] Area | ER Calendar JFMAMJJASOND | DL [2] Area | DL Calendar JFMAMJJASOND | I/SL [3] Area | I/SL Calendar JFMAMJJASOND |
|---|---|---|---|---|---|---|---|---|
| 3328 | Tianjin | 0.34 | - | ---------- | - | ---------- | 0.34 | ----12222--- |
| 3308 | Nei Monggol | 0.16 | - | ---------- | - | ---------- | 0.16 | ---122221--- |
| 3318 | Shanxi | 0.09 | - | ---------- | - | ---------- | 0.09 | ----12222--- |
| 3304 | Gansu | 0.04 | - | ---------- | - | ---------- | 0.04 | ---122221--- |
| 3302 | Xizang | 0.01 | - | ---------- | - | ---------- | 0.01 | ----12222--- |
| 3300 | China Total | 336.88 | 107.68 | | 108.33 | | 120.89 | |

[1] ER: Early Rice Crop
[2] DL: Double Late Rice Crop
[3] I/SL: Intermediate and Single Late Rice Crop

## 4. MONTHLY DISTRIBUTION OF RICE-CULTIVATION AREAS (RAREA)

Data Reference: Matthews, E., I. Fung and J. Lerner, Methane emission from rice cultivation: Geographic and seasonal distribution of cultivated areas and emissions, *Global Biogeochemical Cycles*, *5*, 3-24, 1991.

Matthews et al. (1991) determined monthly distributions of actively growing (and emitting) rice areas by integrating the 1984 seasonal crop areas and crop calendars for countries (Table 1, Section 3) with data bases on the distribution of rice locations (Section 2) and of countries (Section 6). For each month, areas of individual crops growing in each country were summed using the information in Table 1; the total for each country was distributed uniformly among all rice locations within the country's boundaries. These distributions are given in twelve data sets of growing area per 1° cell (RAREA).

Table 2 shows the monthly summary of cultivated areas by 10° latitude zone from Matthews et al., (1991). Note that annually harvested rice area from FAO (1985) is 1475 x $10^9 m^2$. However, rice locations are actively growing over varying time periods during the year so that the annual sum of monthly growing areas is 6524 x $10^9 m^2$-month reflecting the average 4.5 month duration of individual crop cycles. Fractional contributions of zones and/or months can be computed by dividing table values by the annual total 6524 x $10^9 m^2$-month.

About half the area falls within 30°-20° N, and 21% is in the zone immediately southward. There is a slight northward shift in the rice belt during the period from January to the boreal summer followed by a southward shift in the fall. Overall, however, these peripheral activities do not play a major role in the global pattern which is controlled primarily by large seasonal variations in the area of cultivation within the north tropical/subtropical zone regulated by precipitation patterns.

### FORMAT INFORMATION

*Unit*: monthly growing area per 1° cell in $10^9 m^2$

*Arrays:*

```
CHARACTER*80    TITLE
REAL*4          RAREA (360,180)
```

*How to Read:*

```
      DO 100 M = 1,12
      READ (10+M,11) TITLE
      READ (10+M,12) RAREA
  100 CONTINUE
   11 FORMAT (A80)
   12 FORMAT (10(1X,F7.4))
```

*Values*:

rice cells range from 0.0007 to 8.5292 (annual) ; land cells without rice = 0.; water cells = -1.

The code used to calculate areas of 1° cells, in $10^6 m^2$ ($km^2$), follows:

```
      JM = 180
      IM = 360
      TWOPI = 6.283185
      RADIUS = 6375.
      DLON = TWOPI/IM
      DLAT = .5*TWOPI/JM
      DYP = RADIUS*DLAT
      FJEQ = .5*(JM+1)
      DO 80 J=1,JM
      RLAT = 180.*(J-FJEQ)/JM
      DXP = RADIUS*DLON*COS(TWOPI*RLAT/360.)
   80 DXYP(J) = DXP*DYP
```

Areas of 1° cells range from ~100 x $10^6 m^2$ near the poles to ~12,100 x $10^6 m^2$ at the equator.

Table 2. Latitudinal and monthly distribution of areas under rice cultivation (from Matthews et al., 1991). Unit is 10 $m^2$.

| Latitude | Jan. | Feb. | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Sum* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 90° – 80°N | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 80° – 70°N | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 70° – 60°N | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 60° – 50°N | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 50° – 40°N | – | – | – | 7 | 13 | 20 | 26 | 19 | 13 | 0 | – | – | 98 |
| 40° – 30°N | – | 0 | 13 | 20 | 116 | 173 | 181 | 181 | 147 | 77 | 13 | – | 921 |
| 30° – 20°N | 13 | 21 | 71 | 120 | 181 | 287 | 445 | 555 | 533 | 484 | 300 | 103 | 3113 |
| 20° – 10°N | 26 | 29 | 39 | 40 | 32 | 73 | 161 | 226 | 233 | 219 | 193 | 110 | 1381 |
| 10° – 0 | 13 | 14 | 19 | 13 | 19 | 33 | 52 | 58 | 47 | 39 | 33 | 19 | 359 |
| 0° – 10°S | 45 | 50 | 45 | 33 | 26 | 20 | 19 | 13 | 0 | 0 | 13 | 26 | 290 |
| 10° – 20°S | 19 | 21 | 19 | 13 | 6 | 0 | – | – | – | 6 | 13 | 19 | 116 |
| 20° – 30°S | 45 | 43 | 26 | 7 | 0 | 0 | – | – | – | 0 | 27 | 45 | 193 |
| 30° – 40°S | 13 | 14 | 6 | 0 | 0 | 0 | – | 0 | 0 | 0 | 7 | 13 | 53 |
| 40° – 50°S | 0 | 0 | 0 | 0 | – | – | – | – | – | – | 0 | 0 | 0 |
| 50° – 60°S | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 60° – 70°S | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 70° – 80°S | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 80° – 90°S | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Sum* | 174 | 192 | 238 | 253 | 393 | 606 | 884 | 1052 | 973 | 825 | 599 | 335 | 6524 |

* The total annually harvested rice area is 1475 x $10^9 m^2$. However, rice locations are actively growing over varying time periods during the year and the annual sum of monthly growing areas is 6524 x$10^9 m^2$-month. Fractional contributions of zones and/or months can be computed by dividing table values by the annual total (6524).

## 5. LIST OF COUNTRY NAMES AND CODES (NAMC, ICODC)

Data Reference: Lerner, J., E. Matthews and I. Fung, Methane emission from animals: A global high-resolution database, *Global Biogeochemical Cycles*, 2, 139-156, 1988.

This data set is the complete list of country/subdivision names and codes reflecting the world scene in 1993. This version contains minor updates to the original dataset of Lerner et al. (1988). There are a total of 355 unique integer codes representing 186 countries along with a total of 168 subdivisions; water is coded -1. Table 3 is a listing of the country codes and names.

Each country has an integer code which is a multiple of 100 so that the last two digits are zero. For divisions within a country, the first three digits of the code (primary code) are those of the parent country; the last two zeros are replaced with digits that uniquely identify the subdivision (secondary code). Nine countries or country composites have subdivisions. To provide a system that accommodates use of data both before and after political re-organizations (mergers and divisions),the "country" (primary) code was maintained for the areally larger political unit and secondary codes identify past or current subdivisions.

In the initial version of the dataset (Lerner et al., 1988), seven countries were subdivided. Political subunits for five of those countries are unchanged from the original: Australia (7 states), Canada (12 provinces), China (29 provinces), India (25 states) and the U.S. (50 states and 1 commonwealth). The subdivisions of Brazil were expanded from five regions to 25 states for the updated version and modifications were incorporated for three countries that have undergone recent divisions or mergers. (1) Czechoslovakia: The composite country code is 4100. Secondary codes identify the Czech Republic (4101) and Slovakia (4102); (2) Germany: The composite country code is 6000. Secondary codes identify the former German Democratic Republic (6001) and former Federal Republic of Germany (6002); (3) the former U.S.S.R.: The composite country code is 17200. Secondary codes (17201-17215) identify what were Soviet republics and are now independent countries (Latvia, Estonia and Lithuania) and members of the Commonwealth of Independent States. Although the political meaning of divisions within the former U.S.S.R. is changed , the geography of the divisions remains the same as that of Lerner et al. (1988).

### FORMAT INFORMATION

*Unit:* not applicable

*Arrays:*

```
CHARACTER*80    TITLE
INTEGER*4       ICODC (355)
CHARACTER*13    NAMC (355)
```

*How to Read:*

```
      READ (10,11) TITLE
      DO 10 K = 1,355
      READ (10,12)  ICODC(K), NAMC(K)
10    CONTINUE
11    FORMAT (A80)
12    FORMAT (6x,I5,3x,A13)
```

*Values*:

land cells range from 100 to 25600; water = -1

Table 3. Listing of codes and names for 355 countries and political subdivisions. Listings for the subdivided countries, Australia, Brazil, Canada, China, Czechoslovakia, Germany, India, US, and (former) USSR, begin at line 188.

| Line Number | Code (ICODC) | Name (NAMC) | Line Number | Code (ICODC) | Name (NAMC) |
|---|---|---|---|---|---|
| 1 | 100 | AFGHANIST | 49 | 4900 | EQGUINEA |
| 2 | 200 | ALBANIA | 50 | 5000 | ETHIOPIA |
| 3 | 300 | ALGERIA | 51 | 5100 | FALKLANDI |
| 4 | 400 | ANGOLA | 52 | 5200 | FAROEI |
| 5 | 500 | ANGUILLA | 53 | 5300 | FIJI |
| 6 | 600 | ANTIGUA&B | 54 | 5400 | FINLAND |
| 7 | 700 | ARGENTINA | 55 | 5500 | FRANCE |
| 8 | 800 | AUSTRALIA | 56 | 5600 | FRGUIANA |
| 9 | 900 | AUSTRIA | 57 | 5700 | FRPOLYNES |
| 10 | 1000 | BAHAMAS | 58 | 5800 | GABON |
| 11 | 1100 | BAHRAIN | 59 | 5900 | GAMBIA |
| 12 | 1200 | BANGLADSH | 60 | 6000 | GERMANY |
| 13 | 1300 | BARBADOS | 61 | 6100 | GHANA |
| 14 | 1400 | BELGIUM | 62 | 6200 | GREECE |
| 15 | 1500 | BELIZE | 63 | 6300 | GREENLAND |
| 16 | 1600 | BENIN | 64 | 6400 | GRENADA |
| 17 | 1700 | BERMUDA | 65 | 6500 | GUADELPE |
| 18 | 1800 | BHUTAN | 66 | 6600 | GUATEMALA |
| 19 | 1900 | BOLIVIA | 67 | 6700 | GUINEA |
| 20 | 2000 | BOTSWANA | 68 | 6800 | GUINEA-BS |
| 21 | 2100 | BRAZIL | 69 | 6900 | GUYANA |
| 22 | 2200 | BRUNEI | 70 | 7000 | HAITI |
| 23 | 2300 | BULGARIA | 71 | 7100 | HONDURAS |
| 24 | 2400 | BURKINA FASO | 72 | 7200 | HONGKONG |
| 25 | 2500 | BURMA | 73 | 7300 | HUNGARY |
| 26 | 2600 | BURUNDI | 74 | 7400 | ICELAND |
| 27 | 2700 | CAMEROON | 75 | 7500 | INDIA |
| 28 | 2800 | CANADA | 76 | 7600 | INDONESIA |
| 29 | 2900 | CAPEVERDE | 77 | 7700 | IRAN |
| 30 | 3000 | CAFRREP | 78 | 7800 | IRAQ |
| 31 | 3100 | CHAD | 79 | 7900 | IRELAND |
| 32 | 3200 | CHILE | 80 | 8000 | ISRAEL |
| 33 | 3300 | CHINA | 81 | 8100 | ITALY |
| 34 | 3400 | COLOMBIA | 82 | 8200 | IVORYCST |
| 35 | 3500 | COMOROS | 83 | 8300 | JAMAICA |
| 36 | 3600 | CONGO | 84 | 8400 | JAPAN |
| 37 | 3700 | COOKI. | 85 | 8500 | JORDAN |
| 38 | 3800 | COSTARICA | 86 | 8600 | KAMPUCHEA |
| 39 | 3900 | CUBA | 87 | 8700 | KENYA |
| 40 | 4000 | CYPRUS | 88 | 8800 | KIRIBATI |
| 41 | 4100 | CZECHSLVK | 89 | 8900 | KOREAN |
| 42 | 4200 | DENMARK | 90 | 9000 | KOREAS |
| 43 | 4300 | DJIBOUTI | 91 | 9100 | KUWAIT |
| 44 | 4400 | DOMINICA | 92 | 9200 | LAOS |
| 45 | 4500 | DOMREP | 93 | 9300 | LEBANON |
| 46 | 4600 | ECUADOR | 94 | 9400 | LESOTHO |
| 47 | 4700 | EGYPT | 95 | 9500 | LIBERIA |
| 48 | 4800 | ELSALVADR | 96 | 9600 | LIBYA |

Table 3 (continued)

| Line Number | Code (ICODC) | Name (NAMC) |
|---|---|---|
| 97 | 9700 | LIECHTENS |
| 98 | 9800 | LUXEMBURG |
| 99 | 9900 | MADAGASCR |
| 100 | 10000 | MALAWI |
| 101 | 10100 | MALAYSIA |
| 102 | 10200 | MALDIVES |
| 103 | 10300 | MALI |
| 104 | 10400 | MALTA |
| 105 | 10500 | MARTINIQU |
| 106 | 10600 | MAURITANI |
| 107 | 10700 | MAURITIUS |
| 108 | 10800 | MEXICO |
| 109 | 10900 | MONGOLIA |
| 110 | 11000 | MOROCCO |
| 111 | 11100 | MOZAMBIQU |
| 112 | 11200 | NAMIBIA |
| 113 | 11300 | NAURU |
| 114 | 11400 | NEPAL |
| 115 | 11500 | NETHERLND |
| 116 | 11600 | NANTILLES |
| 117 | 11700 | N.CALEDON |
| 118 | 11800 | NEWZEALND |
| 119 | 11900 | NICARAGUA |
| 120 | 12000 | NIGER |
| 121 | 12100 | NIGERIA |
| 122 | 12200 | NORWAY |
| 123 | 12300 | OMAN |
| 124 | 12400 | PAKISTAN |
| 125 | 12500 | GUAM |
| 126 | 12600 | PANAMA |
| 127 | 12700 | PAPUANG |
| 128 | 12800 | PARAGUAY |
| 129 | 12900 | PERU |
| 130 | 13000 | PHILIPPIN |
| 131 | 13100 | POLAND |
| 132 | 13200 | PORTUGAL |
| 133 | 13300 | QATAR |
| 134 | 13400 | REUNION |
| 135 | 13500 | ROMANIA |
| 136 | 13600 | RWANDA |
| 137 | 13700 | STCHRS-NV |
| 138 | 13800 | STLUCIA |
| 139 | 13900 | STVINC&GR |
| 140 | 14000 | SANMARINO |
| 141 | 14100 | SAOTOME& |
| 142 | 14200 | SAUDIARAB |
| 143 | 14300 | SENEGAL |
| 144 | 14400 | SEYCHELLS |
| 145 | 14500 | SIERRALEO |
| 146 | 14600 | SINGAPORE |
| 147 | 14700 | SOLOMONI |
| 148 | 14800 | SOMALIA |
| 149 | 14900 | SAFRICA |
| 150 | 15000 | SPAIN |
| 151 | 15100 | SRILANKA |
| 152 | 15200 | SUDAN |
| 153 | 15300 | SURINAM |
| 154 | 15400 | SWAZILAN |
| 155 | 15500 | SWEDEN |
| 156 | 15600 | SWITZERLD |
| 157 | 15700 | SYRIA |
| 158 | 15800 | TAIWAN |
| 159 | 15900 | TANZANIA |
| 160 | 16000 | THAILAND |
| 161 | 16100 | TOGO |
| 162 | 16200 | TONGA |
| 163 | 16300 | TRINI&TOB |
| 164 | 16400 | TUNISIA |
| 165 | 16500 | TURKEY |
| 166 | 16600 | TURKS&C.I |
| 167 | 16700 | TUVALU |
| 168 | 16800 | UGANDA |
| 169 | 16900 | UARABEMIR |
| 170 | 17000 | U.K. |
| 171 | 17100 | U.S.A. |
| 172 | 17200 | USSR |
| 173 | 17300 | URUGUAY |
| 174 | 17400 | VANUATU |
| 175 | 17500 | VENEZUELA |
| 176 | 17600 | VIETNAM |
| 177 | 17700 | W.SAHARA |
| 178 | 17800 | W.SAMOA |
| 179 | 17900 | YEMEN DEM |
| 180 | 18000 | YEMEN AR |
| 181 | 18100 | YUGOSLAVI |
| 182 | 18200 | ZAIRE |
| 183 | 18300 | ZAMBIA |
| 184 | 18400 | ZIMBABWE |
| 185 | -1 | OCEAN |
| 186 | 25500 | KERGUELEN |
| 187 | 25600 | ANTARCTICA |
| 188 | 801 | TASMANIA |
| 189 | 802 | VICTORIA |
| 190 | 803 | SOUTH AUST. |
| 191 | 804 | WESTERN AUST. |
| 192 | 805 | NEW S.WALES |
| 193 | 806 | QUEENSLAND |
| 194 | 807 | NORTHERN TER. |
| 195 | 2101 | RONDONIA |
| 196 | 2102 | ACRE |

Table 3 (continued)

| Line Number | Code (ICODC) | Name (NAMC) |
|---|---|---|
| 197 | 2103 | AMAZONAS |
| 198 | 2104 | RORAIMA |
| 199 | 2105 | PARA |
| 200 | 2106 | AMAPA |
| 201 | 2107 | MARANHAO |
| 202 | 2108 | PIAUI |
| 203 | 2109 | CEARA |
| 204 | 2110 | RIOGRANDENORT |
| 205 | 2111 | PARAIBA |
| 206 | 2112 | PERNAMBUCO |
| 207 | 2113 | ALAGOAS |
| 208 | 2114 | SERGIPE |
| 209 | 2115 | BAHIA |
| 210 | 2116 | MINAS GERAIS |
| 211 | 2117 | ESPIRITOSANTO |
| 212 | 2118 | RIODEJANEIRO |
| 213 | 2119 | SAOPAULO |
| 214 | 2120 | PARANA |
| 215 | 2121 | SANTACATARINA |
| 216 | 2122 | RIOGRANDESUL |
| 217 | 2123 | GOIAS&DF |
| 218 | 2124 | MATOGROSSO |
| 219 | 2125 | MATOGROSSOSUL |
| 220 | 2801 | CAN/ALB |
| 221 | 2802 | CAN/BRC |
| 222 | 2803 | CAN/MAN |
| 223 | 2804 | CAN/NB |
| 224 | 2805 | CAN/NF+LAB |
| 225 | 2806 | CAN/NWT |
| 226 | 2807 | CAN/QUE |
| 227 | 2808 | CAN/ONT |
| 228 | 2809 | CAN/SAS |
| 229 | 2810 | CAN/YUK |
| 230 | 2811 | CAN/NV |
| 231 | 2812 | CAN/PEI |
| 232 | 3301 | XINJIANG |
| 233 | 3302 | XIZANG |
| 234 | 3303 | QINGHAI |
| 235 | 3304 | GANSU |
| 236 | 3305 | YUNNAN |
| 237 | 3306 | SICHUAN |
| 238 | 3307 | HEILONGJIANG |
| 239 | 3308 | NEI MONGGOL |
| 240 | 3309 | NINGXIA |
| 241 | 3310 | JILIN |
| 242 | 3311 | LIAONING |
| 243 | 3312 | GUANGXI |
| 244 | 3313 | GUIZHOU |
| 245 | 3314 | GUANGDONG |
| 246 | 3315 | HUNAN |
| 247 | 3316 | HUBEI |
| 248 | 3317 | SHAANXI |
| 249 | 3318 | SHANXI |
| 250 | 3319 | HENAN |
| 251 | 3320 | JIANGXI |
| 252 | 3321 | FUJIAN |
| 253 | 3322 | ZHEJIANG |
| 254 | 3323 | ANHUI |
| 255 | 3324 | JIANGSU |
| 256 | 3325 | SHANDONG |
| 257 | 3326 | HEBEI |
| 258 | 3327 | BEIJING |
| 259 | 3328 | TIANJIN |
| 260 | 3329 | SHANGHAI |
| 261 | 4101 | CZECHREPUBLIC |
| 262 | 4102 | SLOVAKIA |
| 263 | 6001 | EGERMANY |
| 264 | 6002 | WGERMANY |
| 265 | 7501 | ANDHRA P. |
| 266 | 7502 | ASSAM |
| 267 | 7503 | BIHAR |
| 268 | 7504 | GUJARAT |
| 269 | 7505 | HARYANA |
| 270 | 7506 | HIMACHAL P. |
| 271 | 7507 | JAMMU&KASHMIR |
| 272 | 7508 | KARNATAKA |
| 273 | 7509 | KERALA |
| 274 | 7510 | MADHYA P. |
| 275 | 7511 | MAHARASHTRA |
| 276 | 7512 | MANIPUR |
| 277 | 7513 | MEGHALAYA |
| 278 | 7514 | NAGALAND |
| 279 | 7515 | ORISSA |
| 280 | 7516 | PUNJAB |
| 281 | 7517 | RAJASTHAN |
| 282 | 7518 | TAMIL NADU |
| 283 | 7519 | TRIPURA |
| 284 | 7520 | UTTAR P |
| 285 | 7521 | WEST BENGAL |
| 286 | 7522 | ARUNACHAL P. |
| 287 | 7523 | MIZORAM |
| 288 | 7524 | ANDAMAN I. |
| 289 | 7525 | SIKKIM |
| 290 | 17101 | USA/AL |
| 291 | 17102 | USA/AK |
| 292 | 17103 | USA/AZ |
| 293 | 17604 | USA/AR |
| 294 | 17105 | USA/CA |
| 295 | 17106 | USA/CO |
| 296 | 17107 | USA/CT |

Table 3 (continued)

| Line Number | Code (ICODC) | Name (NAMC) |
|---|---|---|
| 297 | 17108 | USA/DE |
| 298 | 17109 | USA/FL |
| 299 | 17110 | USA/GA |
| 300 | 17111 | USA/HI |
| 301 | 17112 | USA/ID |
| 302 | 17113 | USA/IL |
| 303 | 17114 | USA/IN |
| 304 | 17115 | USA/IA |
| 305 | 17116 | USA/KS |
| 306 | 17117 | USA/KY |
| 307 | 17118 | USA/LA |
| 308 | 17119 | USA/ME |
| 309 | 17120 | USA/MD |
| 310 | 17121 | USA/MA |
| 311 | 17122 | USA/MI |
| 312 | 17123 | USA/MN |
| 313 | 17124 | USA/MS |
| 314 | 17125 | USA/MO |
| 315 | 17126 | USA/MT |
| 316 | 17127 | USA/NE |
| 317 | 17128 | USA/NV |
| 318 | 17129 | USA/NH |
| 319 | 17130 | USA/NJ |
| 320 | 17131 | USA/NM |
| 321 | 17132 | USA/NY |
| 322 | 17133 | USA/NC |
| 323 | 17134 | USA/ND |
| 324 | 17135 | USA/OH |
| 325 | 17136 | USA/OK |
| 326 | 17137 | USA/OR |
| 327 | 17138 | USA/PA |
| 328 | 17139 | USA/RI |
| 329 | 17140 | USA/SC |
| 330 | 17141 | USA/SD |
| 331 | 17142 | USA/TN |
| 332 | 17143 | USA/TX |
| 333 | 17144 | USA/UT |
| 334 | 17145 | USA/VT |
| 335 | 17146 | USA/VA |
| 336 | 17147 | USA/WA |
| 337 | 17148 | USA/WV |
| 338 | 17149 | USA/WI |
| 339 | 17150 | USA/WY |
| 340 | 17151 | USA/PR |
| 341 | 17201 | ESTONIA |
| 342 | 17202 | LATVIA |
| 343 | 17203 | LITHUANIA |
| 344 | 17204 | WHITE RUSSIA |
| 345 | 17205 | MOLDAVIA |
| 346 | 17206 | UKRAINE |
| 347 | 17207 | GEORGIA |
| 348 | 17208 | ARMENIA |
| 349 | 17209 | AZERBAIJAN |
| 350 | 17210 | RUSSIA |
| 351 | 17211 | TADZHIKISTAN |
| 352 | 17212 | TURKMENIYA |
| 353 | 17213 | UZBEKISTA |
| 354 | 17214 | KAZAKHSTAN |
| 355 | 17215 | KIRGIZIYA |

## 6. DISTRIBUTION OF COUNTRIES (ICON)

Data Reference: Lerner, J., E. Matthews and I. Fung, Methane emission from animals: A global high-resolution database, *Global Biogeochemical Cycles*, *2*, 139-156, 1988.

This 1° data set (ICON) gives the global distribution of countries and political subdivisions reflecting the world scene in 1993. Countries are identified by their integer codes; the companion data set discussed in Section 5 associates the codes with their country/subdivision names (ICODC, NAMC). The country data set can be used to implement alternatives or corrections to the cropping sequences used in the base case (Table 1).

The principal criteria for assigning a country/subdivision code to a gridbox is dominance of the political unit in the area of that gridbox (note that 100% of a cell's area is assigned to the political unit dominating the cell), or the gridbox contains a small country not identified in any other cell. However, at 1° resolution, there are ambiguities regarding locations of coastal and political boundaries.

About 30 island countries are not spatially dominant in their respective gridboxes but have been included for completeness. Ninety-five ocean gridboxes are assigned country/subdivision codes in order to include coastal cities. Furthermore, assignments were made to minimize errors in the area of each country/subdivision, even if the country/subdivision does not spatially dominate the gridbox. Consider, for example, the situation in which a large country dominates a cell that it shares with a small country. Assigning that cell to the large country would have little influence on that country's area but would reduce the small country's computed area by a large fraction. Our computed areas are generally within 1% of the published areas (FAO, 1985) for large countries and within 5% for medium-sized countries.

### FORMAT INFORMATION

*Unit:* not applicable

*Arrays:*

```
CHARACTER*80    TITLE
INTEGER*4       ICON (360,180)
```

*How to Read:*

```
      READ (10,11) TITLE
      READ (10,12)  ICON
11    FORMAT (A80)
12    FORMAT (10(3X,I5))
```

*Values:*

land cells range from 100 to 25600; water cells = -1

## 7. DISTRIBUTION OF MONTHLY METHANE EMISSION (EMIS)

Data Reference: Matthews, E., I. Fung and J. Lerner, Methane emission from rice cultivation: Geographic and seasonal distribution of cultivated areas and emissions, *Global Biogeochemical Cycles*, 5, 3-24, 1991.

Generally, the global annual emission of methane from rice cultivation is estimated as the product of the methane emission rate, cultivated rice area, and growth period, summed over all rice-crop cycles and countries. However, due to the large variations in measured daily and seasonal emission rates, Matthews et al. (1991) concluded that an improved estimate of the role of rice cultivation in the global methane budget was premature. Instead, they used the new data bases on rice cultivation to focus on patterns in the temporal and spatial distribution of rice cultivation and to evaluate the magnitude and pattern of fluxes that yield a prescribed source strength of 100 Tg methane per year. Setting the source strength at 100 Tg, and (1) assuming the daily flux rate is constant for actively growing areas, (2) employing rice-harvest areas given by FAO and (3) using growth seasons given by crop calendars for individual countries, results in a calculated flux for actively growing rice areas of ~ 0.5 g $CH_4/m^2$/day; methane emissions average ~ 15 $g/m^2$/month or ~ 70 $g/m^2$ for a complete harvest cycle.

The emission of methane from rice cultivation as published by Matthews et al. (1991) is given here in twelve data sets of monthly emission of methane (EMIS), at 1° resolution, in $10^9$ grams methane/1° cell/month. Although the total annual emission of 100 Tg methane was distributed over the areas and crop seasons discussed above, (i.e., it was not calculated), this total can be approximated from the suite of data sets presented in the preceding sections.

A summary of the latitudinal and seasonal distribution of total methane emission is given in Table 4. The seasonal concentration of cultivation areas (Table 2) produces a seasonal telescoping of methane emission. Almost 60% of the annual total is emitted from July through October. More than 80% of the global source is produced in Asian countries confined to the zone from 40°-10° N and almost half the total comes from the narrow zone between 30°-20° N. Contributions of individual countries to the global emission follow closely the rice-harvest areas shown in Table 1. Including India and China, Asia accounts for over 90% of the harvest area and methane emission.

### FORMAT INFORMATION

*Unit:* $10^9$ grams methane/1° cell/month

*Arrays:*

```
CHARACTER*80    TITLE
REAL*4          EMIS (360,180)
```

*How To Read:*

```
      DO 100 M=1,12
      READ (10+M,11) TITLE
      READ (10+M,12) EMIS
  100 CONTINUE
   11 FORMAT (A80)
   12 FORMAT (10(1X,F7.3))
```

*Values*:

rice cells range from 0.005 to 135.674; land cells with no rice = 0.; water = -1.

Table 4. Latitudinal and monthly distribution of methane emission (from Matthews et al., 1991). Unit is teragrams ($10^{12}$g) methane.

| Latitude | Jan. | Feb. | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Sum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 90° – 80°N | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 80° – 70°N | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 70° – 60°N | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 60° – 50°N | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 50° – 40°N | – | – | – | 0.1 | 0.2 | 0.3 | 0.4 | 0.3 | 0.2 | 0.0 | – | – | 1.5 |
| 40° – 30°N | – | 0.0 | 0.2 | 0.3 | 1.8 | 2.6 | 2.8 | 2.8 | 2.2 | 1.2 | 0.2 | – | 14.1 |
| 30° – 20°N | 0.2 | 0.3 | 1.1 | 1.8 | 2.8 | 4.3 | 6.9 | 8.6 | 8.0 | 7.5 | 4.5 | 1.6 | 47.6 |
| 20° – 10°N | 0.4 | 0.4 | 0.6 | 0.6 | 0.5 | 1.1 | 2.5 | 3.5 | 3.5 | 3.4 | 2.9 | 1.7 | 21.1 |
| 10° – 0° | 0.2 | 0.2 | 0.3 | 0.2 | 0.3 | 0.5 | 0.8 | 0.9 | 0.7 | 0.6 | 0.5 | 0.3 | 5.5 |
| 0° – 10°S | 0.7 | 0.7 | 0.7 | 0.5 | 0.4 | 0.3 | 0.3 | 0.2 | 0.0 | 0.0 | 0.2 | 0.4 | 4.4 |
| 10° – 20°S | 0.3 | 0.3 | 0.3 | 0.2 | 0.1 | 0.0 | – | – | – | 0.1 | 0.2 | 0.3 | 1.8 |
| 20° – 30°S | 0.7 | 0.6 | 0.4 | 0.1 | 0.0 | 0.0 | – | – | – | 0.0 | 0.4 | 0.7 | 2.9 |
| 30° – 40°S | 0.2 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | – | 0.0 | 0.0 | 0.0 | 0.1 | 0.2 | 0.8 |
| 40° – 50°S | 0.0 | 0.0 | 0.0 | 0.0 | – | – | – | – | – | – | 0.0 | 0.0 | 0.0 |
| 50° – 60°S | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 60° – 70°S | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 70° – 80°S | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 80° – 90°S | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Sum | 2.7 | 2.7 | 3.7 | 3.8 | 6.1 | 9.1 | 13.7 | 16.3 | 14.6 | 12.8 | 9.0 | 5.2 | 99.7 |

References

Food and Agriculture Organization, *1984 FAO Production Yearbook*, vol. 37, Food and Agriculture Organization of the United Nations, Rome, 1985.

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Matthews, E., I. Fung, and J. Lerner, Methane emission from rice cultivation: Geographic and seasonal distribution of cultivated areas and emissions, *Global Biogeochemical Cycles*, 5, 3-24, 1991.

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**12a. DISTRIBUTION / AVAILABILITY STATMENT**

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**12b. DISTRIBUTION CODE**

**13. ABSTRACT** *(Maximum 200 words)*

High-resolution global data bases on the geographic and seasonal distribution of rice cultivation and associated methane emission, compiled by Matthews et al. (1991), have been archived for public use. In addition to the primary data sets identifying location, seasonality, and methane emission from rice cultivation, a series of supporting data sets is included, allowing users not only to replicate the work of Matthews et al. (1991) but to investigate alternative cultivation and emission scenarios. The suite of data bases provided, at 1° latitude by 1° longitude resolution for the globe, includes 1) locations of rice cultivation, 2) monthly arrays of actively growing rice areas, 3) countries and political subdivisions, and 4) monthly arrays of methane emission from rice cultivation. Ancillary data include 1) a listing, by country, of harvested rice areas and seasonal distribution of crop cycles and 2) country names and codes. Summary tables of zonal/monthly distributions of actively growing rice areas and of methane emissions (Matthews et al., 1991) are presented in this report.

Users should consult original publications for complete discussion of the data bases. This short paper is designed only to document formats of the distributed information and briefly describe the contents of the data sets and their initial application to evaluating the role of rice cultivation in the methane budget.

**14. SUBJECT TERMS**

Methane emission; Rice cultivation; Trace gas; Distributed data base

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