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Abstract

The AD-RICE2012 model is an updated version of the AD-RICE99 (Nordhaus and Boyer 2001) model, where the AD_RICE99 model is based on the RICE99 model and the AD-RICE2012 on the RICE2010 (Nordhaus 2010a) model. In this document, we will describe the calibration of the AD-RICE2012 model and compare it with the AD-RICE99 model.

1. Model equations

First we present the primary model equations, some equations, which are used to calculate parameter values over time have been omitted. Our model consists of *J* regions, where each region is indexed by $j = 1, 2, ..., J$. Furthermore, there is a planning period indexed by $t = 1, 2, ..., T$. We define the social welfare function as;

(1) $SWF = \sum_{t=1}^{T}\sum_{j=1}^{J}\left(\varphi_{j,t}U_{j,t}\left[c_{j,t}, L_{j,t}\right]\right)R_t$.

Where $U_{j,t}$ is the total utility in each period for each region j . The region specific weights are given by $\varphi_{j,t}$. The weights are determined using a Negishi process. The discount factor is given by:

(2A) $R_t = (1+\rho)^{-t}$

In the 99 version the social rate of time preference is time dependent:

(2B) $R_t = (1+\rho_t)^{-t}$

The utility function is represented by the population weighted natural logarithm of consumption per capita in the AD-RICE99 model:

(3A) $U_{j,t}\left[c_{j,t}, L_{j,t}\right] = \ln\left(c_{j,t}\right)\cdot L_{j,t}$

In the AD-RICE2012 following RICE2010 utility is a power function:

(3B) $U_{j,t}\left[c_{j,t}, L_{j,t}\right] = \left[c_{j,t}^{1-\varepsilon} / 1-\varepsilon\right]\cdot L_{j,t}$.

Where ε represents the elasticity of marginal consumption.

Output before damages and abatement in each region is determined by a Cobb-Douglas function of capital ($K_{j,t}$), labour ($L_{j,t}$) and energy inputs ($ES_{j,t}$). $A_{j,t}$ represents the total factor productivity per region per time period:

(4A) $Y_{j,t} = A_{j,t}K_{j,t}^{\beta}L_{j,t}^{1-\beta-\gamma_j}ES_{j,t}^{\gamma_j}$.

In the 99 version of the model energy was modelled as an explicit input in production. Following RICE2010 in AD-RICE2012 the output function does not include energy inputs.

(4B) $Y_{j,t} = A_{j,t} K_{j,t}^{\beta} L_{j,t}^{1-\beta}$

In AD-RICE99 the industrial emissions ($E_{j,t}$) in each region are a positive fraction ($\varsigma_{j,t}$) of its energy inputs to production.

(5A) $E_{j,t} = \varsigma_{j,t} \cdot ES_{j,t}$

In AD-RICE2012 the industrial emissions ($E_{j,t}$) in each region are a positive fraction ($\Omega_{j,t}$, which is assumed to decrease over time due to technological change) of its output. Furthermore, mitigation is modelled as an explicit variable where emissions can be controlled through mitigation efforts ($\mu_{j,t}$). Mitigation decreases emissions, where $0 \le \mu_{j,t} \le 1$;

(5B) $E_{j,t} = \Omega_{j,t} \cdot Y_{j,t}(1-\mu_{j,t})$.

Total emissions are given as the total of industrial emissions and emissions from land use by all regions

(5C) $E_t = \sum_{j=1}^{J} \left(E_{j,t} + EL_{j,t} \right)$.

Controlling emissions, however, comes at a cost. Mitigation costs as a fraction of output ($MC_{j,t}$) are defined as a power function of mitigation;

(6) $MC_{j,t} = \theta_{1,j,t} \cdot \mu_{j,t}^{\theta_2}$.

The cost parameter $\theta_{1,j,t}$ decreases over time depending on technological change and the development of the price of the backstop option.

Climate change damages and adaptation are modeled in the same manner in AD-RICE99 and AD-RICE2012. The net damages of the respective RICE models are separated into adaptation costs and residual damages. The original RICE damages are given as:

(7) $NHD_{j,t} = \alpha_{NH1,j} \cdot TATM_t + \alpha_{2NH,j} \cdot TATM_t^2$

Firstly the gross damages are defined as follows:

(8) $GD_{j,t} = \alpha_{1,j} \cdot TATM_t + \alpha_{2,j} \cdot TATM_t^{\alpha_{3,j}}$

These are the damages that occur if no adaptation takes place, and are thus higher than the net damages. These damages can be reduced through the use of adaptation. We assume the following relationship:

(9) $RD_{j,t} = \dfrac{GD_{j,t}}{1+P_{j,t}}$,

Where, $P_{j,t}$ is the total level of protection (stock and flow) and $RD_{j,t}$ are the residual damages. This functional form is chosen because it limits the fraction by which the gross damages can be reduced to the interval of 0 to 1. When total protection reaches infinity, all gross damages are reduced (the residual damages are zero) and when no protection is undertaken no gross damages are reduced (residual damages equal gross damages). This functional form also ensures decreasing marginal damage reduction of protection, that is the more protection is used the less effective additional protection will be. This is assumed as more effective, efficient measures of adaptation will first be applied whereas less effective measures after that.

We now define how our two forms of adaptation (stock and flow) together create total adaptation. The two forms of adaptation are aggregated together using a Constant Elasticity of Substitution (CES) function. Here the elasticity of substitution can be calibrated to reflect the observed relationship between the two forms. This function is given as follows:

(10) $P_{j,t} = \gamma_j \cdot (\nu_{1,j} SAD_{j,t}{}^{\rho A} + \nu_{2,j} FAD_{j,t}^{\rho_A})^{\nu_{3,j}/\rho_A}$,

where $SAD_{j,t}$ is the total amount of adaptation capital stock. $FAD_{j,t}$ is the amount spent on reactive adaptation in that period. Furthermore, $\rho_A = \frac{\sigma - 1}{\sigma}$, where σ is the elasticity of substitution.

Adaptation capital stock is built up as follows:

(11) $SAD_{j,t+1} = (1-\delta_k) SAD_{j,t} + IAD_{j,t}$,

where δ_k is the depreciation rate and $IAD_{j,t}$ are the investments in stock adaptation (SAD_t). The total adaptation costs in each period are thus;

(12) $PC_{j,t} = FAD_{j,t} + IAD_{j,t}$.

The net damages are the sum of residual damages and adaptation costs. Therefore, combining the previous equations we have:

(13) $D_{j,t} = RD_{j,t} + PC_{j,t} = \frac{GD_{j,t}}{1+P_{j,t}} + FAD_{j,t} + IAD_{j,t}$.

Net output is given as gross output minus net climate change damages and energy input costs on the 99 model:

(14A) $Q_{j,t} = Y_{j,t} - (D_{j,t} + c_{E,j,t} \cdot ES_{j,t}) \cdot Y_{j,t}$

In the 2012 model net output is given as the gross output minus net climate change damages and mitigation costs:

(14B) $Q_{j,t} = Y_{j,t} - (D_{j,t} + MC_{j,t}) \cdot Y_{j,t}$

The consumption function is given by:

(15) $C_{j,t} = Q_{j,t} - I_{j,t}$

Per capita consumption is given as:

(16) $c_{j,t} = \frac{C_{j,t}}{L_{j,t}}$

Capital accumulation is defined in the usual manner:

(17) $K_{j,t+1} = (1 - \delta_k) K_{j,t} + I_{j,t}$.

Where δ is the depreciation rate and $I_{j,t}$ the investments in capital. Furthermore it is assumed that capital is immobile between regions.

The CO_2 stock in the atmosphere in each period $M_{AT\,t}$ is given as: The only difference between the 2 model versions here is that in the 99 version emissions from the previous period effect the stock in this period:

(18A) $M_{AT\,t} = \phi_{11} M_{AT\,t-1} + \phi_{21} M_{UPt-1} + E_{t-1}$.

In the 2012 version emissions affect the stock in the same period:

(18B) $M_{AT\,t} = \phi_{11} M_{AT\,t-1} + \phi_{21} M_{UPt-1} + E_t$.

The CO_2 stock in the upper oceans is given as:

(19) $M_{UPt} = \phi_{12} M_{AT\,t-1} + \phi_{22} M_{UPt-1} + \phi_{32} M_{LOt-1}$

The CO_2 stock in the lower oceans is given as:

(20) $M_{LOt} = \phi_{23} M_{UPt-1} + \phi_{33} M_{LOt-1}$

Radiative forcing is given as

(21) $F_t = \eta \left\{ \log \left[M_{AT\,t} / M_{AT1750} \right] / \log 2 \right\} + F_{EX,t}$

Global mean surface temperature:

(22) $T_{ATt} = T_{ATt-1} + \xi_1 \left\{ F_t - \xi_2 T_{ATt-1} - \xi_3 \left[T_{ATt-1} - T_{LOt-1} \right] \right\}$

Temperature lower oceans:

(23) $T_{LOt} = T_{LOt-1} + \xi_4 \left\{ T_{ATt-1} - T_{LOt-1} \right\}$

In RICE2010 and AD-RICE2012 sea level rise is explicitly modelled. The sea level module contains 4 major processes that affect sea level rise, namely thermal expansion, glaciers and small ice caps, Greenland ice sheet and Antarctic ice sheet. In the AD-RICE model the effects of the Antarctic ice sheet are not included due to the large uncertainties and small impacts of this. Sea level rise is modelled based on the Earth System Models of Intermediate Complexities (EMICs), for a detailed description of the Seal level rise module calibration, please refer to Nordhaus 2010b. Sea level rise due to thermal expansion is modelled based on the long-run year expansion, which is assumed to be 0.5 meters per ºC.

(24) $SLR_{TE*} = 0.5T_{ATt}$.

Secondly it is assumed that the adjustment to the long run is a first order adjustment process:

(25) $SLR_{TE,t+1} = SLR_{TE,t} + \lambda_{SLR}\left(SLR_{TE*} - SLR_{TE,t}\right)$.

The second source of sea level rise is glaciers and small ice caps (GSIC). Sea level rise due to Glaciers and small ice caps is determined by the melt rate MR_{GSIC};

(26) $SLR_{GSIC,t+1} = SLR_{GSIC,t} + MR_{GSIC}$.

The melt rate depends on the initial melt rate (MR_{GSIC0}), the remaining ice (RI_{GSICt}), total ice

(TI_{GSIC}) and the equilibrium temperature (T_{GSIC}):

(27) $MR_{GSIC,t} = 10 \cdot MR_{GSIC0} \cdot \left(\frac{RI_{GSIC,t}}{TI_{GSIC}}\right) \cdot \left(T_{AT,t} - T_{GSIC}\right)$.

The total sea level rise due to GSIC is equivalent to the amount of cumulative melted ice:

(28) $RI_{GSIC,t} = TI_{GSIC} - SLR_{GSIC.t}$

The third process contributing to SLR is the Greenland ice sheet. This process is complex, not fully understood and hard to model. In RICE2010 and AD-RICE2012, it is assumed that there is an equilibrium volume depending on the equilibrium temperature, which is assumed to be 0. Changes in sea level rise depend on the melt rate.

(29) $SLR_{GIS,t+1} = SLR_{GIS,t} + \frac{MR_{GIS}}{100}$

In the first 2 periods, the melt rate is equal to the initial melt rate ($MR_{GIS1,t}$) after which the melt rate is determined by the melt rate above the threshold ($MR_{GIS1,t}$,which is almost double the initial rate) and the so called melting exponent ($ME_{GIS,t}$):

(30) $MR_{GIS,t} = \left(MR_{GIS1,t} \cdot T_{AT,t} + MR_{GIS0,t}\right) \cdot ME_{GIS,t}$.

The melting exponent depends on the relative amount of ice remaining:

(31) $ME_{GIS,t} = 1 - \left(\frac{SLR_{GIS,t}}{TI_{GIS}}\right)$

Total sea level rise is the sum of these effects:

(32) $SLR_{TOT,t} = SLR_{TE,t} + SLR_{GSIC,t} + SLR_{GIS,t}$

2. Calibration of adaptation

Adaptation in the AD-RICE models is calibrated such that the same level of net damages arises as in the original RICE models. The net damages are separated into adaptation costs (both stock (anticipatory) and flow (reactive)) and residual damages. The parameter values for equations 8-10 are calibrated by estimating firstly the level of adaptation and secondly the proportion of adaptation costs to residual damages and thirdly the substitution between stock and flow adaptation. This has been done by estimating the adaptation levels and proportions and substitution for each impacts sector in the RICE99 model. The RICE99 model estimated damages based on 7 impacts sectors: Agriculture, Other vulnerable markets, Coastal, Health, Nonmarket time use, settlements and catastrophic events. For each of these sectors we estimate based on impact literature and expert judgement the level of adaptation and proportion of residual damages to adaptation costs. These estimates are aggregated at a regional level and used to calibrate the parameters of the damage and adaptation functions. The aggregate results are given in the following table, for sectoral results and a more detailed description of the calibration process please refer to de Bruin 2011. The calibrated parameter values are given in the appendix.

Regions	Net damages (original N&B) (% of output)	Optimal adaptation potential (flow) (fraction of gross damages reduced)	Optimal adaptation potential (stock) (fraction of gross damages reduced)	Adaptation costs (flow) (% of output)	Adaptation costs (stock) (% of output)	Residual damages (% of output)	Gross damages (% of output)
USA	0.45	0.27	0.14	0.08	0.08	0.76	1.07
CHINA	0.22	0.21	0.07	0.11	0.07	0.74	0.94
JAPAN	0.5	0.20	0.30	0.06	0.09	0.77	1.16
EUROPE	2.83	0.17	0.17	0.05	0.12	0.75	1.01
RUSSIA	-0.65	0.30	0.03	0.05	0.02	0.82	1.10
INDIA	4.93	0.15	0.04	0.10	0.04	0.78	0.93
OHI	-0.39	0.25	0.09	0.04	0.07	0.81	1.08
HIO	1.95	0.40	0.06	0.33	0.02	0.57	0.83
EE	0.71	0.30	0.06	0.08	0.05	0.78	1.06
MI	2.44	0.30	0.04	0.17	0.04	0.71	0.94
LMI	1.81	0.15	0.07	0.13	0.07	0.72	0.89
AFRICA	3.91	0.21	0.02	0.05	0.03	0.84	1.03
LI	2.64	0.16	0.06	0.14	0.06	0.72	0.87
Global	1.5	0.25	0.12	0.12	0.08	0.80	1.10

Table 1: Stock and flow adaptation estimates for the RICE regions for all sectors for a 2.5 degree increase in temperature. Source: own calculations based on Nordhaus and Boyer (2001).

3. Regional disaggregation

AD-RICE99 and AD-RICE99 are regional models with 13 and 12 regions in each model respectively. The 13 regions of the AD-RICE99 model are as follows: Japan, USA, EU, Other High Income regions (OHI), Low income regions (LI), Low-middle income regions (LMI), Middle income regions (MI), India, China, Africa, High Income OPEC regions (HIO), East European countries (EE) and Russia. In the RICE99 model the globe was divided into large countries or based on their income. In the RICE2010 model the regions are categorised based on location. Many of the regions remain the same or comparable, but there are some differences. The regions that remain the same as in the 99 model are: Japan, USA, EU, OHI, India, China and Africa. Besides this there are new regions which can be compared to old regions European Asia (EUASIA) comparable to EE, Asia comparable to LI/LMI, Latin America (LATAM) comparable to MI, Middle East (ME) comparable to HIO.

4. Parameters definitions and values

In the following we present the parameters of the AD-RICE99 and AD-RICE2012 model and their values. We do not present the values of the regional parameters here (see appendix for this) but do indicate whether they have been updated in the 2012 version of the model. Regional parameters specific to the AD-RICE99 model are omitted

Parameter	Description	AD-RICE99	AD-RICE2012
$A_{j,t}$	total factor productivity (productivity units) (eq.4A, 4B)	See appendix	See appendix
$\alpha_{1,j}, \alpha_{2,j}, \alpha_{3,j}$	Gross damage function (eq.7) coefficients (pure number)	See appendix	See appendix
β	Elasticity of output w.r.t. capita (pure number) (eq. 4A, 4B)	0.3	0.3
ε	Elasticity of marginal utility of consumption (pure number) (eq. 3B)	NA	1.5
$v_{1,j}, v_{2,j}, v_{3,j}$	Elasticity of total adaptation w.r.t stock adaptation (pure number) and w.r.t. flow adaptation and returns to scale parameter (eq. 10)	See appendix	See appendix
CCum	Maximum consumption of fossil fuels (billions metric tons carbon)	6000	6000
$c_{E,j,t}$	Cost of carbon energy ($1000 per ton) (eq. 14A)	omitted	NA
δ_k	rate of depreciation of capital (per period) (eq. 11, 17)	0.1	0.1
$EL_{j,t}$	emissions of carbon from land use (billions of metric tons C per period) (eq. 5C) (initial value)	1.12752	1.6
η	Increase in radiative forcing due to doubling of CO2 (Watts per meter squared) (eq.21)	4.1	3.8

γ_j	elasticity of output with respect to energy services (pure number) (eq. 4A)	omitted	NA
ϕ_{11}	Transfer coefficient in carbon cycle atmosphere to atmosphere (flows per period in fraction) (eq. 18A, 18B)	0.66616	0.88
ϕ_{21}	Transfer coefficient in carbon cycle upper oceans to atmosphere (flows per period in fraction) (eq. 18A, 18B)	0.27607	0.04704
ϕ_{22}	Transfer coefficient in carbon cycle upper oceans to upper oceans (flows per period in fraction) (eq. 19)	0.60897	0.94796
ϕ_{32}	Transfer coefficient in carbon cycle lower oceans to upper oceans (flows per period in fraction) (eq. 19)	0.00422	0.00075
ϕ_{12}	Transfer coefficient in carbon cycle atmosphere to upper oceans (flows per period in fraction) (eq. 19)	0.33384	0.12
ϕ_{33}	Transfer coefficient in carbon cycle lower oceans to lower oceans (flows per period in fraction) (eq. 20)	0.99578	0.99925
ϕ_{23}	Transfer coefficient in carbon cycle upper oceans to lower oceans (flows per period in fraction) (eq. 20)	0.11496	0.005
ξ_1	Speed of adjustment parameter for atmospheric temperature (flows per period in fraction) (eq. 22)	0.226	0.208
ξ_2	Climate sensitivity (increase in temperature due to doubling of C02 concentrations) (eq. 22)	2.9	3.2
ξ_3	Coefficient of heat loss from atmosphere (flows per period in fraction) (eq. 22)	0.440	0.31
ξ_4	Coefficient of heat fain by lower oceans (flows per period in fraction) (eq. 23)	0.02	0.05
ρ	pure rate of social time preference (per year) (eq. 2A, 2B)	0.03 (declining with 0.0025719 per year)	0.015
ρ_A	Stock and flow adaptation substitution parameter	0.5	0.5
R_t	Social time preference discount factor (per time period)(eq. 1, 2A, 2B) (initial value)	1	1
$\theta_{1,j,t}$	parameters of the abatement cost function (eq. 6B)	NA	See appendix
θ_2	Exponent of the abatement cost function (eq. 6B)	NA	2.8
$\varsigma_{j,t}$	Ratio of carbon energy to industrial carbon emissions (pure number) (eq. 6A)	omitted	NA

$\varphi_{j,t}$	Negishi weights of the social welfare function (eq. 1) (between 0 and 1)	NA	NA
λ_{SLR}	Thermal expansion adjustment rate per decade	NA	0.024
SLR_{TE0}	Sea level rise due to thermal expansion at the start of the model (meters)	NA	0.10
MR_{GSIC0}	Melt rate (meters per decade)	NA	0.0008
TI_{GSIC}	Initial (total) ice (sea level rise equivalent meters) GSIC	NA	0.26
T_{GSIC}	Equilibrium temperature GSIC (degrees Celcius)	NA	-1
SLR_{GSIC0}	Sea level rise from GSIC at the start of the model (meters)	NA	0.015
MR_{GIS1}	Melt rate above threshold (mm per year)	NA	1.1
MR_{GIS0}	Initial melt rate (mm per year)	NA	0.6
TI_{GIS}	Initial (total) ice (sea level rise equivalent meters)GIS	NA	7.3

5. Variable definitions and units

In what follows we will present the variables of the AD-RICE99 and AD-RICE2012 models. Endogenous variables are marked with asterisks. The starting values of these variables are given in the appendix

Variable	Description
$c_{j,t}$	Consumption per capita of goods and services (trillion of 2005 U.S. dollars per person)
$C_{j,t}$	Consumption of goods and services (trillion of 2005 U.S. dollars per person)
$D_{j,t}$	Net damages from climate change (fraction of output)
$ES_{j,t}$	Energy Services (Gigaton Carbon per year)
$E_{j,t}$	Regional industrial emissions (Gigaton Carbon per year)
E_t	Global industrial emissions (Gigaton Carbon per year)
F_t	Total radiative forcing (Watts per square meter from 1900) (eq. 20)
$F_{EX,t}$	Exogenous radiative forcing (Watts per square meter from 1900 (eq. 20)
$GD_{j,t}$	Gross damages from climate change (fraction of output)
$I_{j,t}$	Investment (trillions of 2005 U.S. dollars)
$IA_{j,t}$	Adaptation investment (fraction of output)
$K_{j,t}$	Capital stock (trillions of 2005 U.S. dollars)
$L_{j,t}$	population and proportional to labor inputs (millions)
$MC_{j,t}$	Abatement cost (fraction of output)
$M_{AT,t}$	Carbon in reservoir for atmosphere (billions of metric tons C, beginning of period)
$M_{LO,t}$	Carbon in reservoir for lower oceans (billions of metric tons C, beginning of period)
$M_{UP,t}$	Carbon in reservoir upper oceans (billions of metric tons C, beginning of period)
$\mu_{j,t}$	Mitigation: emissions-control rate (fraction of uncontrolled emissions)

$\Omega_{j,t}$	Ratio of uncontrolled industrial emissions to output (metric tons C per output in 2005 prices)
$P_{j,t}$	Adaptation level (fraction of Gross damages reduced)
$PC_{j,t}$	Adaptation costs (fraction of output)
$Q_{j,t}$	Output of goods and services, net of abatement and damages (trillions of 2005 U.S. international dollars)
$RD_{j,t}$	Residual damages (fraction of output)
$SAD_{j,t}$	Adaptation capital (fraction of output)
t	Time periodes (decades from 2001-2010 in RICE99 and from 2005-2015 in RICE2010)
$T_{AT,t}$	Global mean surface temperature change (°C from 1900)
$T_{LO,t}$	Global mean temperature change lower oceans (°C from 1900)
$T_{UP,t}$	Global mean temperature change upper oceans (°C from 1900)
$U_{j,t}$	Instantaneous utility function (utility per period)
$Y_{j,t}$	Output of goods and services, gross of abatement and damages (trillions of 2005 U.S. dollars)
$SLR_{TE,t}$	Sea level rise from Thermal expansion (meters)
$SLR_{GSIC,t}$	Sea level rise from GSIC(meters)
$SLR_{GIS,t}$	Sea level rise from GIS (meters)
$MR_{GSIC,t}$	Melt rate GSIC (mm per year)
$MR_{GIS,t}$	Melt rate GIS (mm per year)
$ME_{GIS,t}$	Melting exponent GIS

Appendix: regional parameter values and starting values of variables

Parameter/starting value	Region	Description	AD-RICE 99	AD-RICE 2012
$A_{0,j,t}$	JAPAN	Initial level of Total Factor Productivity	4.273	9.062
	USA		2.410	11.348
	EUROPE		3.866	8.348
	OHI		2.612	9.029
	HIO/ME		1.195	3.894
	MI/LATAM		2.766	3.731
	RUSSIA		0.777	4.868
	LMI		1.494	-
	EE/EUASIA		1.014	2.702
	LI/ASIA		1.394	1.755
	CHINA		0.791	2.272
	INDIA		1.243	1.498
	AFRICA		2.141	1.251
$K_{0,j,t}$	JAPAN	Initial capital stock (trillions of U.S. dollars)	7.872	7.133485
	USA		13.876	22.851
	EUROPE		16.079	23.302
	OHI		2.706	6.8704
	HIO/ME		0.755	5.416
	MI/LATAM		2.465	7.693
	RUSSIA		0.633	2.787
	LMI		2.071	-
	EE/EUASIA		0.749	4.420
	LI/ASIA		0.872	1.362
	CHINA		1.042	9.261
	INDIA		0.567	4.119
	AFRICA		0.282	2.135
$L_{0,j,t}$	JAPAN	population and proportional to labor inputs (millions)	125.10	127.77
	USA		260.71	296.84
	EUROPE		383.40	490.08
	OHI		65.79	129.17
	HIO/ME		29.34	412.77

	MI/LATAM		283.74	555.38
	RUSSIA		147.97	143.15
	LMI		564.82	-
	EE/EUASIA		194.17	937.20
	LI/ASIA		911.45	155.94
	CHINA		1198.50	1304.50
	INDIA		918.57	1094.58
	AFRICA		549.13	763.51
$E_{L0,j,t}$	JAPAN	Emissions from land use change	0.0	0.0
	USA		0.0	0.0
	EUROPE		0.0	0.0
	OHI		0.0	0.0
	HIO/ME		0.00008	0.0
	MI/LATAM		0.39637	0.6
	RUSSIA		0.0	0.0
	LMI		0.21813	-
	EE/EUASIA		0.0	0.7
	LI/ASIA		0.28007	0.0
	CHINA		0.04094	0.0
	INDIA		0.01774	0.0
	AFRICA		0.17419	0.3
$\alpha_{NH,j}$	JAPAN	Original RICE linear damage coefficient	-0.0042	0
	USA		-0.0026	0
	EUROPE		-0.0010	0
	OHI		-0.0108	0
	HIO/ME		0.0041	0.2780
	MI/LATAM		0.0039	0.0609

	RUSSIA		-0.0108	0
	LMI		0.0022	-
	EE/EUASIA		-0.0052	0.1755
	LI/ASIA		0.0063	0
	CHINA		-0.0041	0.0784
	INDIA		0.0074	0.4385
	AFRICA		0.0157	0.3410
$\alpha_{NH2,j}$	JAPAN		0.0025	0.1617
	USA		0.0017	0.1414
	EUROPE		0.0049	0.1591
	OHI		0.0037	0.1564
	HIO/ME		0.0015	0.1586
	MI/LATAM		0.0013	0.1345
	RUSSIA		0.0033	0.1156
	LMI		0.0026	-
	EE/EUASIA		0.0019	0.1734
	LI/ASIA		0.0025	0.1305
	CHINA		0.002	0.1259
	INDIA		0.0049	0.1688
	AFRICA		0.001	0.1983
$\alpha_{1,j}$	JAPAN	AD-RICE linear gross damage coefficient	-0.0028	0.00045
	USA		0	0
	EUROPE		0	0
	OHI		-0.0108	0.0001
	HIO/ME		0.0041	0.0021
	MI/LATAM		0	0.0008
	RUSSIA		-0.0108	0
	LMI		0	-

	EE/EUASIA		-0.0052	0
	LI/ASIA		0	0.0015
	CHINA		0	0.0005
	INDIA		0	0.0040
	AFRICA		0	0.0033
$\alpha_{2,j}$	JAPAN	AD-RICE non-linear gross damage coefficient	0.0000979	0.0007
	USA		0.000102452	0.0015
	EUROPE		0.0038	0.0014
	OHI		0.0037	0.0013
	HIO/ME		0.0015	0.0240
	MI/LATAM		0.00739	0.0020
	RUSSIA		0.0033	0.0010
	LMI		0.00516	-
	EE/EUASIA		0.0019	0.0011
	LI/ASIA		0.00961	0.0016
	CHINA		0.0000128	0.0013
	INDIA		0.01393	0.0012
	AFRICA		0.01752	0.0016
$\alpha_{3,j}$	JAPAN	AD-RICE damage exponent	5.8	3.6
	USA		4.8	2.7
	EUROPE		2.4	2.5
	OHI		2.0	2.6
	HIO/ME		1.6	2.9
	MI/LATAM		0.0039	3.0
	RUSSIA		2.0	2.5
	LMI		1.8	-
	EE/EUASIA		2.0	2.8

	LI/ASIA		1.5	2.6
	CHINA		2.8	2.6
	INDIA		1.7	3.0
	AFRICA		1.2	2.9
$v_{1,j}$	JAPAN		310	800
	USA		270	44
	EUROPE		350	255
	OHI		1	435
	HIO/ME		1	997
	MI/LATAM		850	245
	RUSSIA		1	245
	LMI		532	-
	EE/EUASIA		1	70
	LI/ASIA		525	452
	CHINA		4500	264
	INDIA		100	83
	AFRICA		40	31
$v_{2,j}$	JAPAN		0.32	0.29
	USA		0.43	0.42
	EUROPE		0.34	0.35
	OHI		0.50	0.52
	HIO/ME		0.50	0.60
	MI/LATAM		0.55	0.55
	RUSSIA		0.50	0.60
	LMI		0.51	-
	EE/EUASIA		0.50	0.44
	LI/ASIA		0.52	0.49
	CHINA		0.55	0.47

	INDIA		0.54	0.50
	AFRICA		0.36	0.34
$v_{3,j}$	JAPAN		0.67	1.06
	USA		0.62	0.53
	EUROPE		1.08	0.93
	OHI		1.00	0.99
	HIO/ME		1.00	1.10
	MI/LATAM		1.07	0.82
	RUSSIA		1.00	0.81
	LMI		0.99	-
	EE/EUASIA		1.00	0.63
	LI/ASIA		1.10	1.10
	CHINA		0.6	0.87
	INDIA		0.87	0.85
	AFRICA		0.67	0.71
$\theta_{1,j,1}$	JAPAN		NA	0.060
	USA		NA	0.054
	EUROPE		NA	0.055
	OHI		NA	0.070
	ME		NA	0.076
	LATAM		NA	0.053
	RUSSIA		NA	0.069
	EUASIA		NA	0.076
	ASIA		NA	0.086
	CHINA		NA	0.094
	INDIA		NA	0.082
	AFRICA		NA	0.073

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