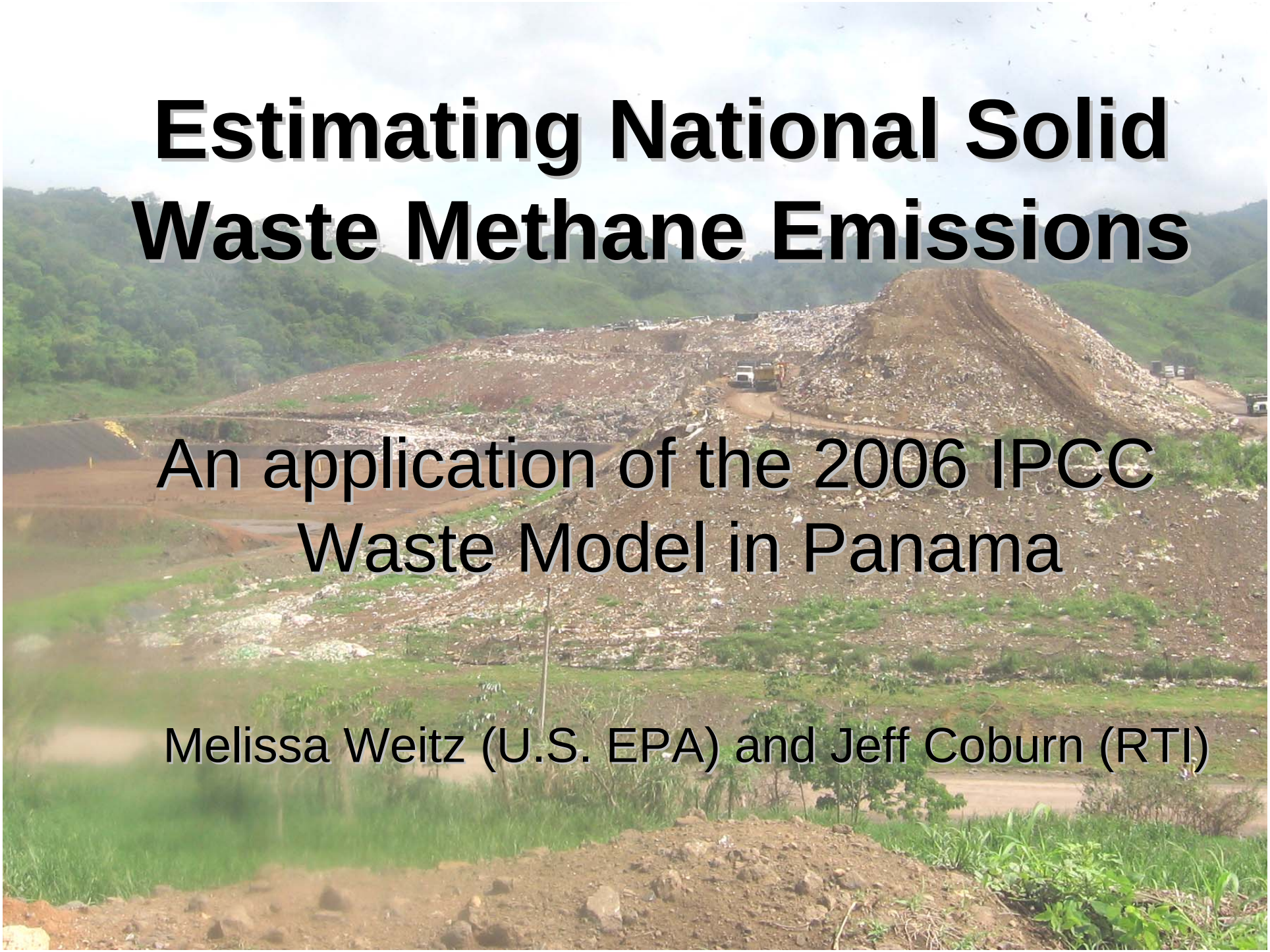


Estimating National Solid Waste Methane Emissions

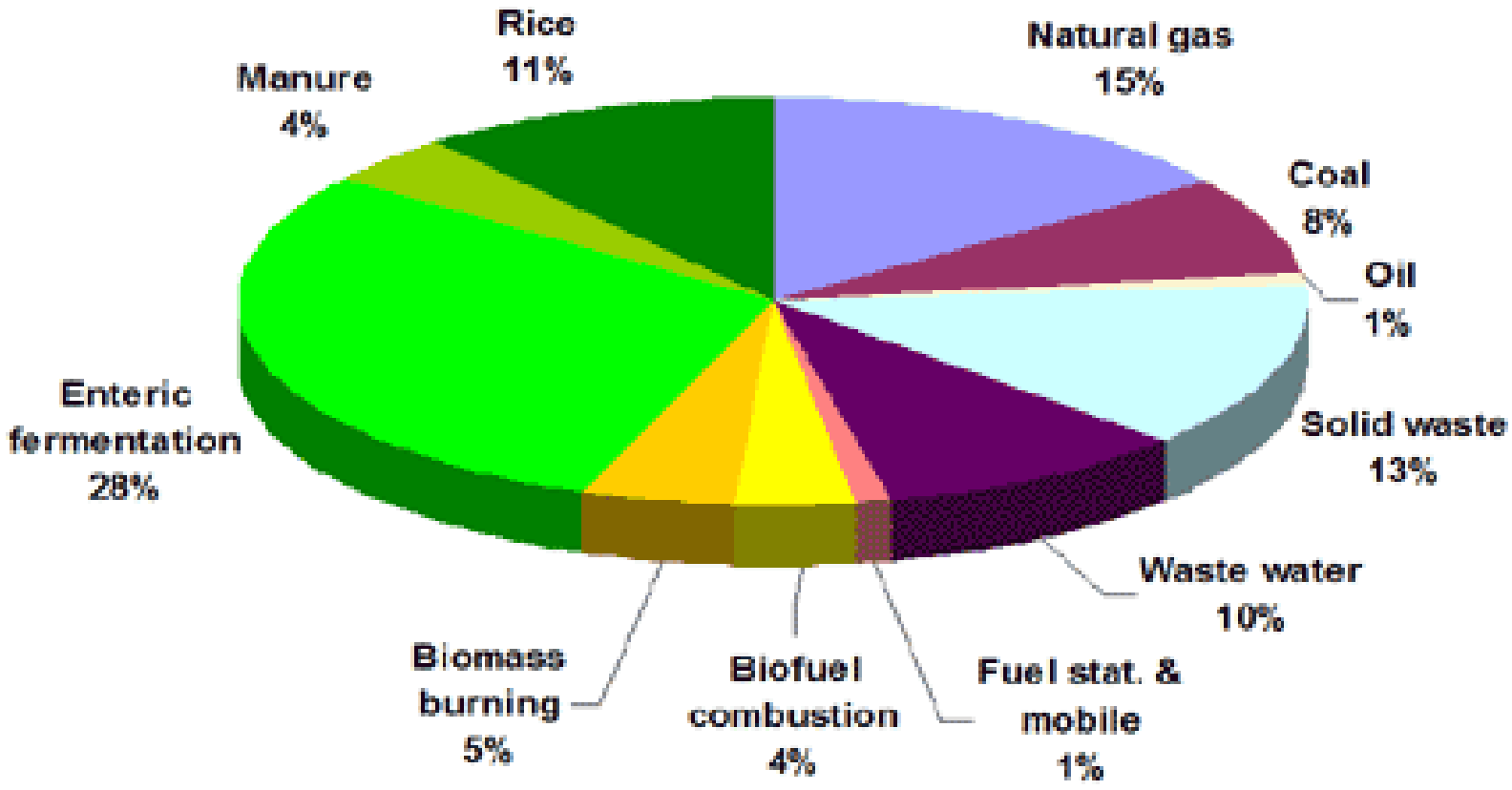
An application of the 2006 IPCC Waste Model in Panama

Melissa Weitz (U.S. EPA) and Jeff Coburn (RTI)

Methane (CH_4) Generation at Landfills

- Disposal of wastes can produce significant amounts of methane
- Bacteria decompose wastes into
  - cellulose, amino acids, and sugars
- Products fermented into
  - gases, and short-chain organic compounds
- Bacteria convert fermentation products into
  - Landfill Gas: CO_2 and CH_4

Global Anthropogenic CH_4 Budget by Source in 2000



Total CH_4 emissions in 2000 = 282.6 Tg CH_4

Source: EPA compilation 2002

Greenhouse Gas (GHG) Inventories

- Under the United Nations Framework Convention on Climate Change, parties obligated to produce GHG inventories
  - Annual for Annex I (developed) countries
  - Periodic for non-Annex I (developing) countries
- Covers six sectors
  - Energy; Industrial Processes; Solvents and Product Use; Agriculture; Land Use, Land Use Change and Forestry; and Waste
- Developed in accordance with Guidelines from the Intergovernmental Panel on Climate Change (IPCC)
  - Tiered methods (higher tiers more data-intensive and country specific, considered to be more accurate)

Former Tier I Equation

Revised 1996 IPCC Guidelines and the *IPCC Good Practice Guidance*

CH_4 emissions (Gg/yr) = [(MSWT • MSWF • L0) – R] • (1 – OX)

- *MSWT* is the total MSW generated
- *MSWF* is the fraction of MSW disposed at SWDS
- *L0* is the CH_4 generation potential
- *R* is recovered CH_4
- *OX* is the oxidation factor

Former Tier I Method

- Mass-balance equation
- Attributes all potential CH_4 to year in which waste is disposed
- Does not reflect the degradation profile of wastes over time
  - Time delay before CH_4 emission begins
  - CH_4 emissions can continue for decades after disposal
- Creates inaccuracies in emissions estimates
  - Waste quantity, composition, and conditions are not the same every year
  - If waste disposal is increasing, method will overestimate emissions

2006 IPCC Method

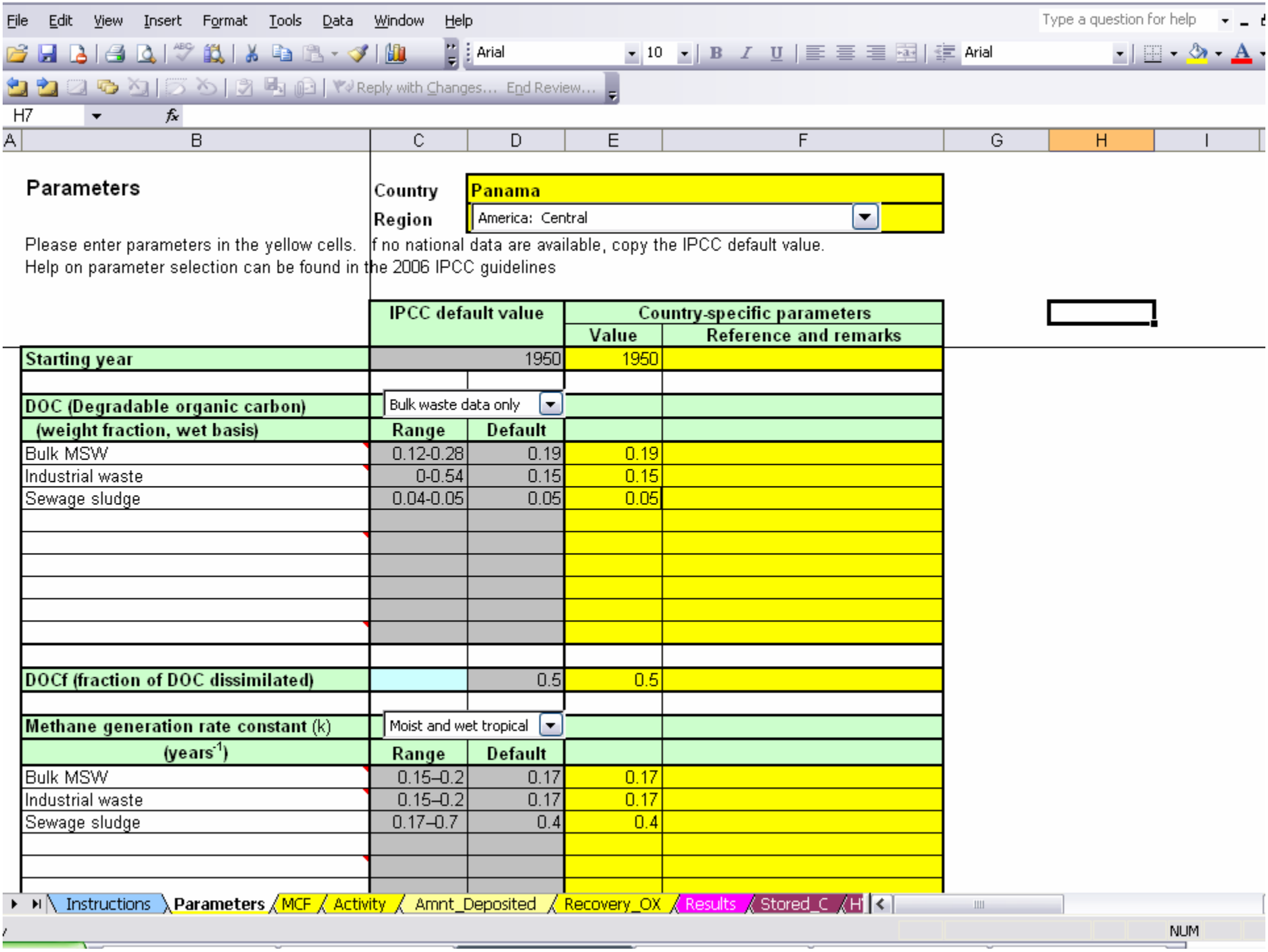
$$CH_4\ Emissions_T\ (Gg/yr) = \left[\sum_{x=S}^{T-1}\left\{MSWT_x MSWF_x L_{0,x}\left(e^{-k(T-x-1)} - e^{-k(T-x)}\right)\right\} - R\right] \bullet (1 - OX)$$

Basic equation for first order decay (FOD) in the IPCC Waste Model using “bulk waste” option and time delay

- *x* is the year in which waste was disposed
- *S* is the start year of inventory calculation
- *T* is the inventory year for which emissions are calculated
- *k* is the reaction constant

2006 IPCC Waste Model

- Calculates emissions generated in current inventory year from the waste deposited in previous years
- Excel-based spreadsheet model facilitates emissions estimates with new default values and method
- Drop-down menus set appropriate default values and modeling methodology
  - Country's region
  - Waste composition data or bulk waste data
  - Climate (dry temperate, wet temperate, dry tropical, and moist and wet tropical)
- Model uses information to select default DOC and k values for waste, a regional per capita waste generation rate, and default waste composition
- Default values can be changed by user

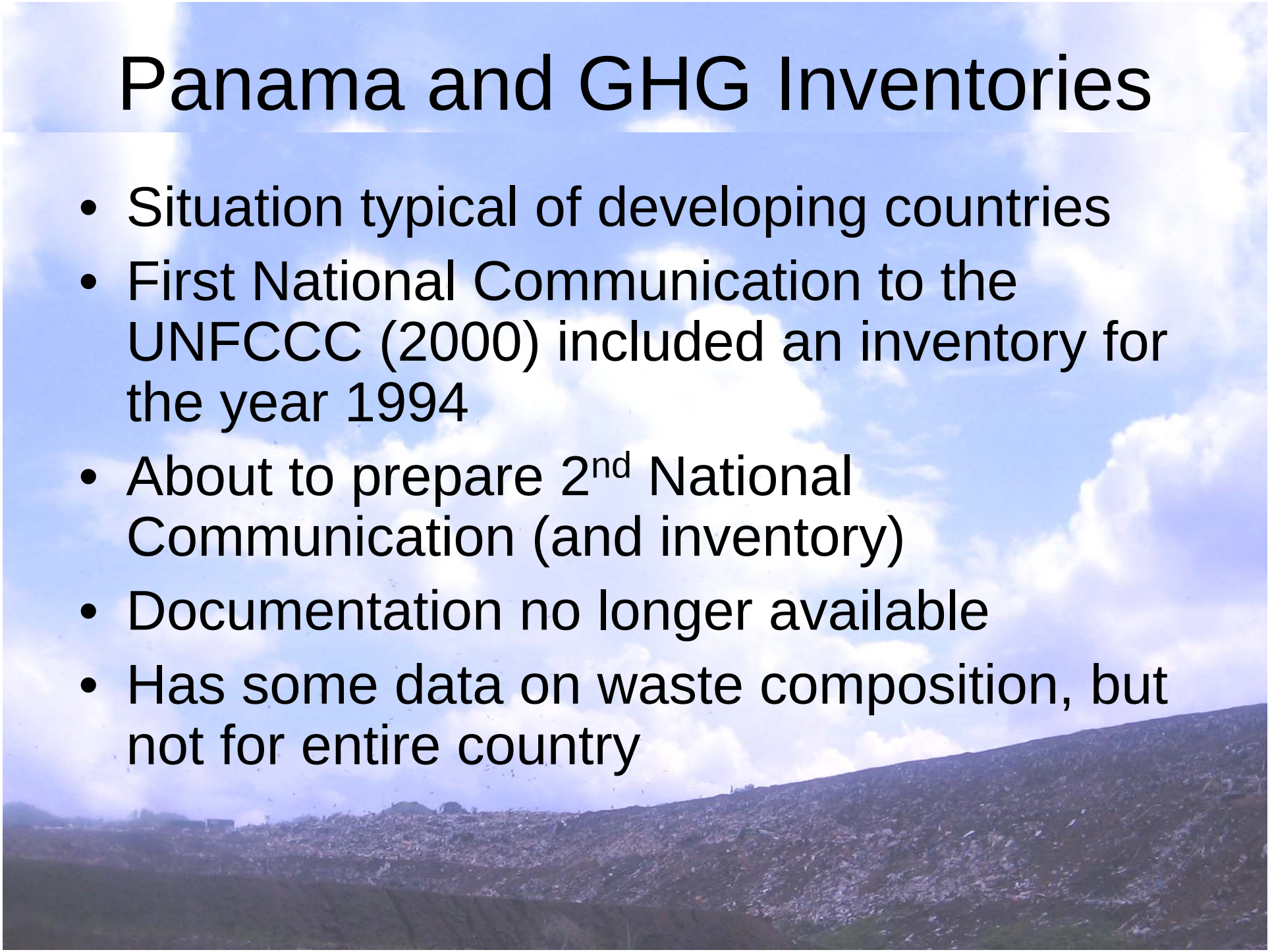

File Edit View Insert Format Tools Data Window Help
Type a question for help
Arial 10 B I U
Arial
Reply with Changes... End Review...
H7
Parameters
Country Panama
Region America: Central
Please enter parameters in the yellow cells. f no national data are available, copy the IPCC default value.
Help on parameter selection can be found in the 2006 IPCC guidelines
IPCC default value
Country-specific parameters
Value
Reference and remarks
Starting year 1950 1950
DOC (Degradable organic carbon) Bulk waste data only
(weight fraction, wet basis) Range Default
Bulk MSW 0.12-0.28 0.19 0.19
Industrial waste 0-0.54 0.15 0.15
Sewage sludge 0.04-0.05 0.05 0.05
DOCf (fraction of DOC dissimilated) 0.5 0.5
Methane generation rate constant (k) Moist and wet tropical
(years-1) Range Default
Bulk MSW 0.15–0.2 0.17 0.17
Industrial waste 0.15–0.2 0.17 0.17
Sewage sludge 0.17–0.7 0.4 0.4
Instructions Parameters MCF Activity Amnt_Deposited Recovery_OX Results Stored_C
NUM

Panama and Solid Waste

- Situation typical of developing countries
- Two landfills, but most wastes disposed in unmanaged sites
- Waste generation expected to grow with population
- Recycling not practiced regularly
  - Materials separation at many disposal sites through scavenging
- Trend towards more waste management planning and towards a greater use of sanitary landfills
- Trend has many environmental and health benefits, but also increases the generation of CH_4
  - Latin American CH_4 emissions from SWDS projected to increase ~18% from 2005 to 2020

Panama and GHG Inventories

- Situation typical of developing countries
- First National Communication to the UNFCCC (2000) included an inventory for the year 1994
- About to prepare 2nd National Communication (and inventory)
- Documentation no longer available
- Has some data on waste composition, but not for entire country



Estimate with Former Tier I

Panama's inventory for 1994 estimated CH_4 emissions from SWDS as 25.0 Gg CH_4

- Emissions calculated for 1990-2020 with 1996 IPCC default method and assumptions from Panama's 1994 inventory
- 1994 inventory waste generation (374.1 Gg) and 1994 population (2.57 million) used to determine generation rate (145 kg/capita/year)
- Annual data for total population from U.S. Census Bureau
- Likely underestimates emissions as waste quantity used in 1994 estimate included only waste in two landfills
  - Only 60-70 % of wastes
- Results: CH_4 emission estimates of 23.1 Gg to 37.5 Gg over 1990-2020

2006 IPCC Model Estimates

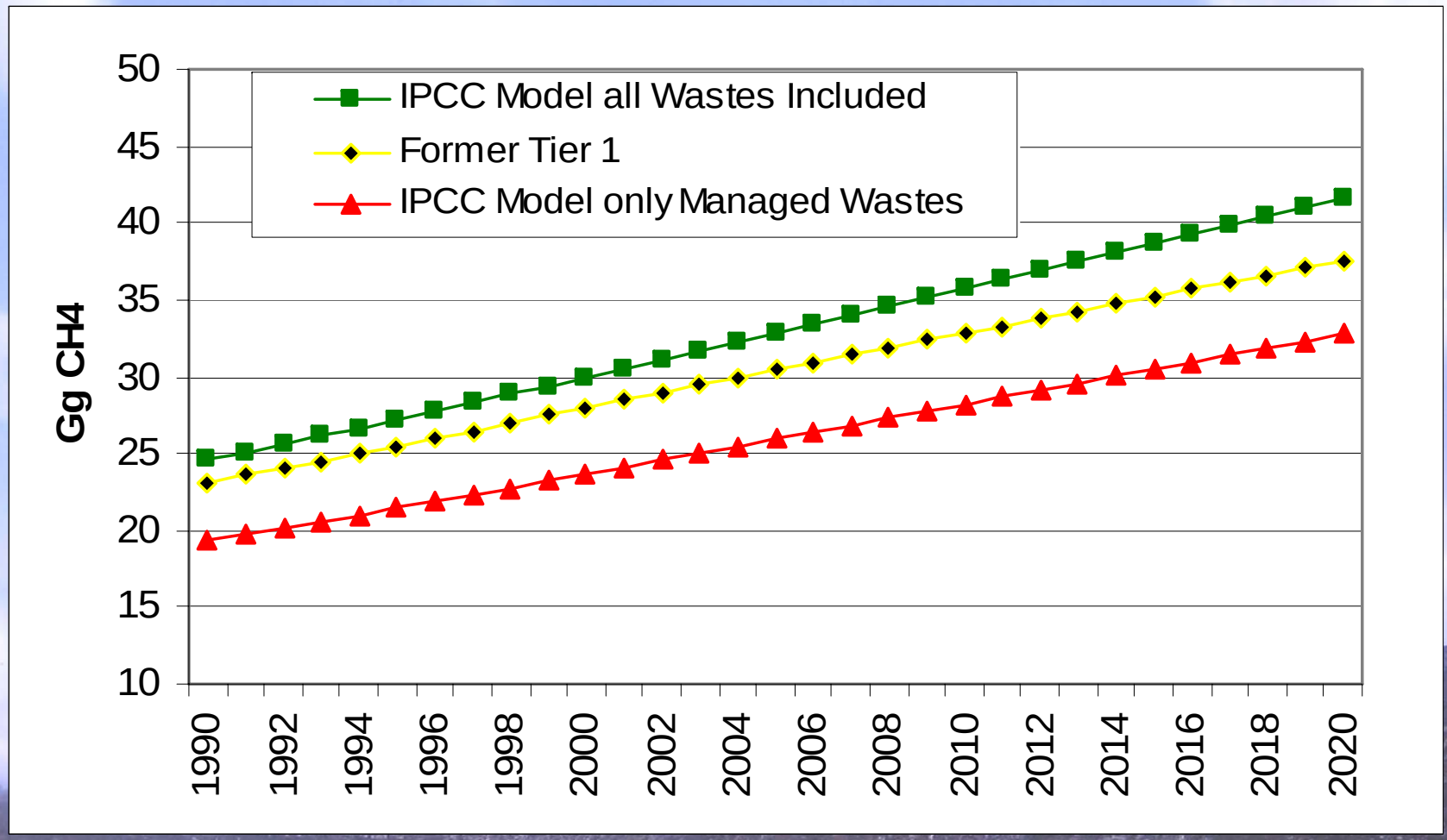
1. Estimate emissions from managed landfills only (1994 inventory assumption)

- Waste Model and 2006 IPCC regional default values
  - Default values for bulk waste in a moist, tropical environment
  - Default 6 month time delay
  - Waste generation rate 145 kg/capita/year (only wastes in managed landfills)
- Model estimated emissions for the 1994 inventory year to be 21.0 Gg/yr, 16% lower than Panama's inventory results

2. Estimate emissions from all waste disposal in Panama

- Model re-calculated Panama's 1994 inventory using per capita waste generation rate of 210 kg/capita/year (IPCC default)
- CH_4 emission estimate 26. 7 Gg/yr for 1994 (6.4% higher than Panama's inventory results)

Estimated SWDS CH_4 Emissions

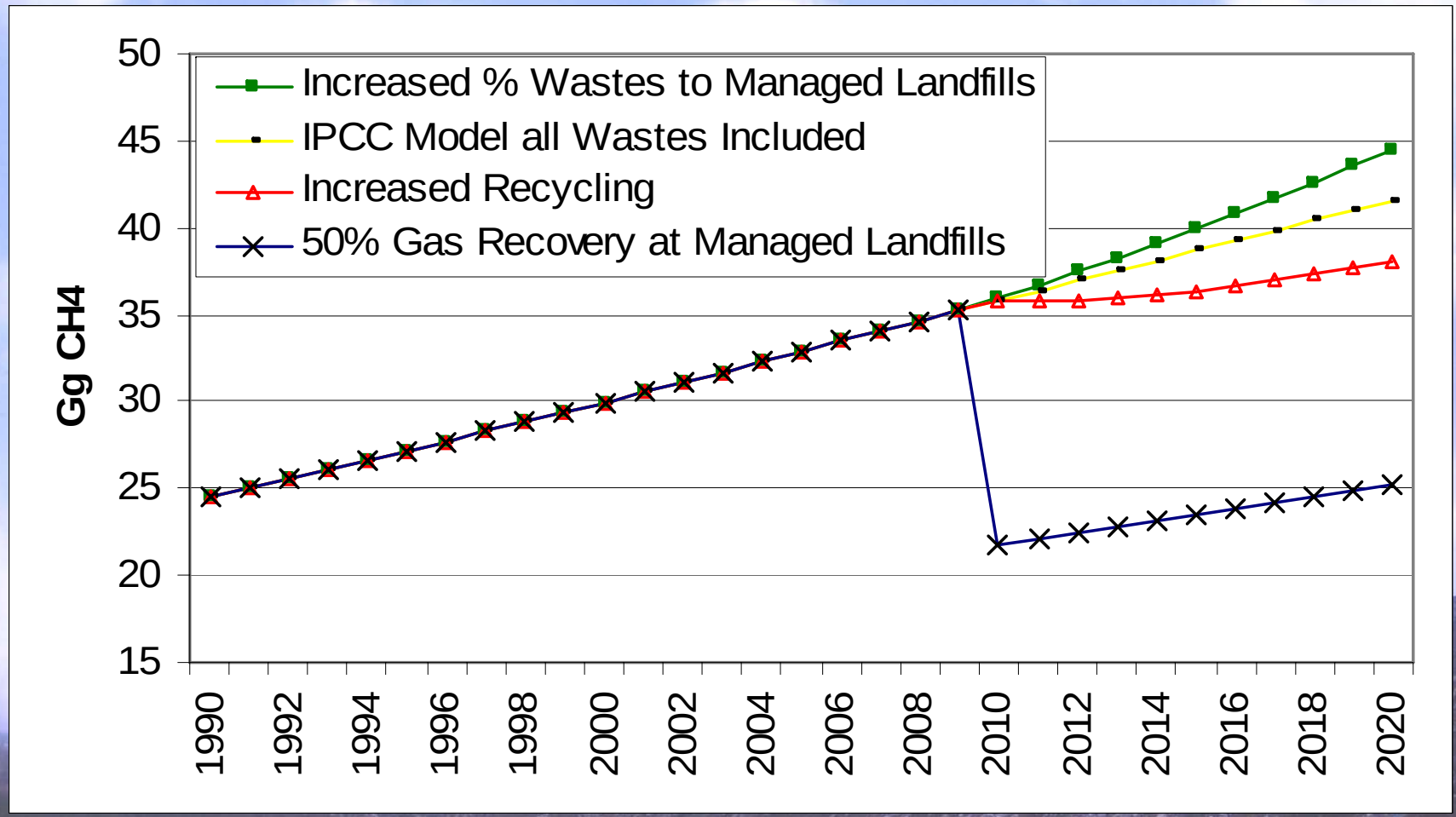


Projections

Emissions were estimated for 3 scenarios

- Increased % of wastes going to landfills
  - 69% in 2007 to 97% in 2020 (by 2% annually)
- Increased % of wastes recycled
  - 10% decrease in disposal quantities (beginning 2010)
- Gas recovery at managed landfills
  - 50% gas collection and destruction efficiency at managed landfills (beginning 2010)

Increased Landfilling, Recycling, and Recovery Scenarios



Conclusions

- 2006 IPCC Waste Model is a useful tool that makes it easier for countries to estimate solid waste emissions
- FOD model is an improvement over previous default method
  - Takes into account rates of waste degradation and methane generation over time
- Facilitates comparison of emissions estimates between countries
  - Provides a common framework to perform the detailed calculations in a consistent and transparent manner
- Can develop emissions projections
  - Allows countries to assess impact of waste management and emission mitigation practices on future CH_4 emissions

For more information:

2006 IPCC Guidelines for National Greenhouse Gas Inventories
http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.htm

IPCC 2006 Waste Model
http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/IPCC_Waste_Model.x

Non-Annex I National Communications to UNFCCC
http://unfccc.int/national_reports/non-annex_i_natcom/submitted_natcom/items/653