

GEOS 24705/ ENST 24705

U. Chicago

Apr. 2015

# **Global energy fluxes**

“Energy is a measure of the ability of a physical system to do work.”

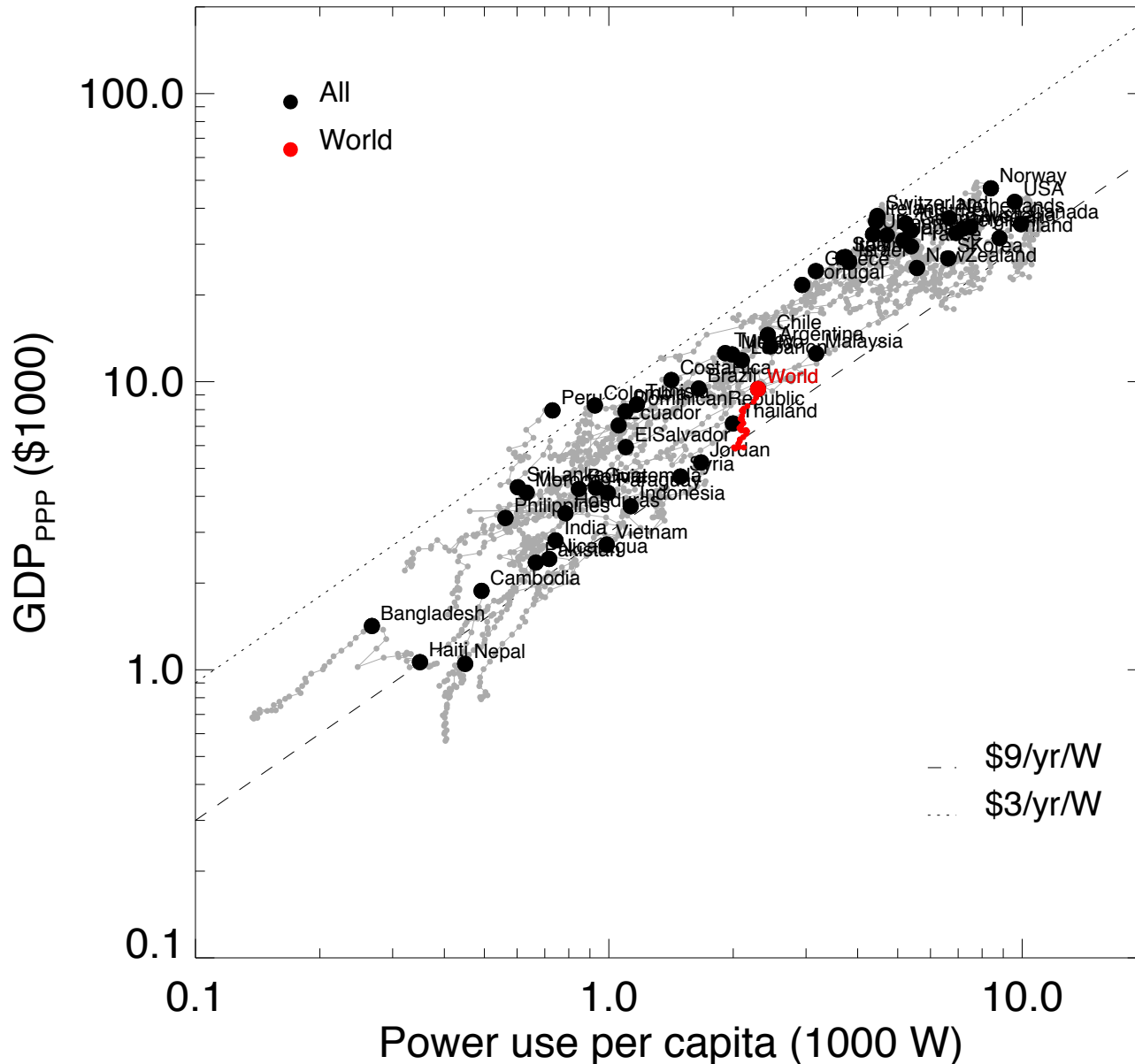
# Physical understanding of energy

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There is a fact, or if you wish, a *law*, governing all natural phenomena that are known to date. There is no known exception to this law—it is exact so far as we know. The law is called the *conservation of energy*. It states that there is a certain quantity, which we call energy, that does not change in manifold changes which nature undergoes. That is a most abstract idea, because it is a mathematical principle; it says that there is a numerical quantity which does not change when something happens. It is not a description of a mechanism, or anything concrete; it is just a strange fact that we can calculate some number and when we finish watching nature go through her tricks and calculate the number again, it is the same.

—Richard Feynman, *The Feynman Lectures on Physics*

# Wealth is strongly predicted by energy use



Sample shown: all countries other than

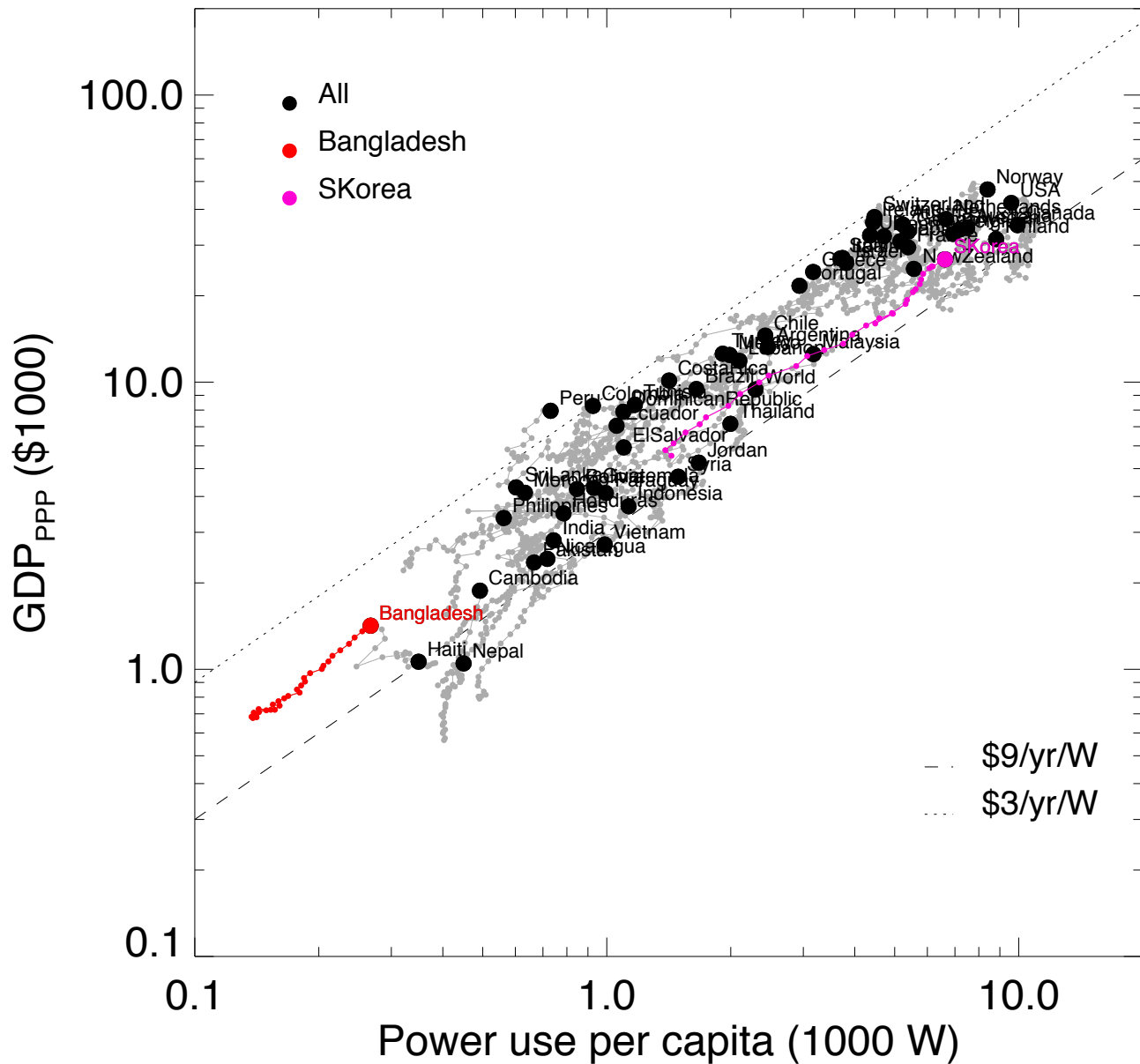
- < 4M pop.
- major oil producers
- former Soviet Union or East bloc or China
- sub-Saharan Africa

Energy use is **total primary energy usage** (not just electricity), in common units of Watts per person.

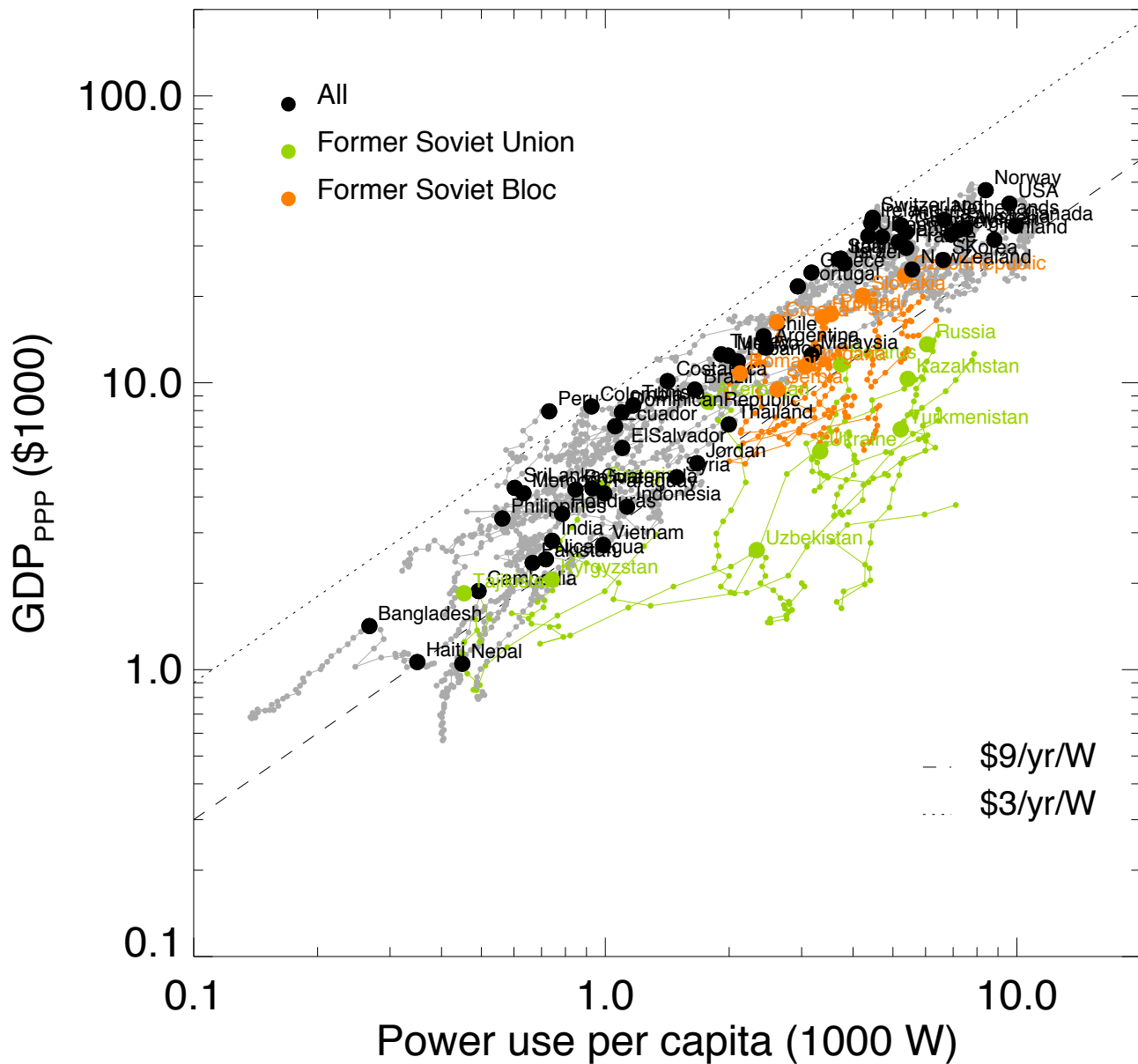
For these “normal” countries, energy use predicts GDP to x3  
lines \$3-9/yr GDP / Watt

Relationship holds across countries and across time for a given country, over x 100

# Development = greater energy use

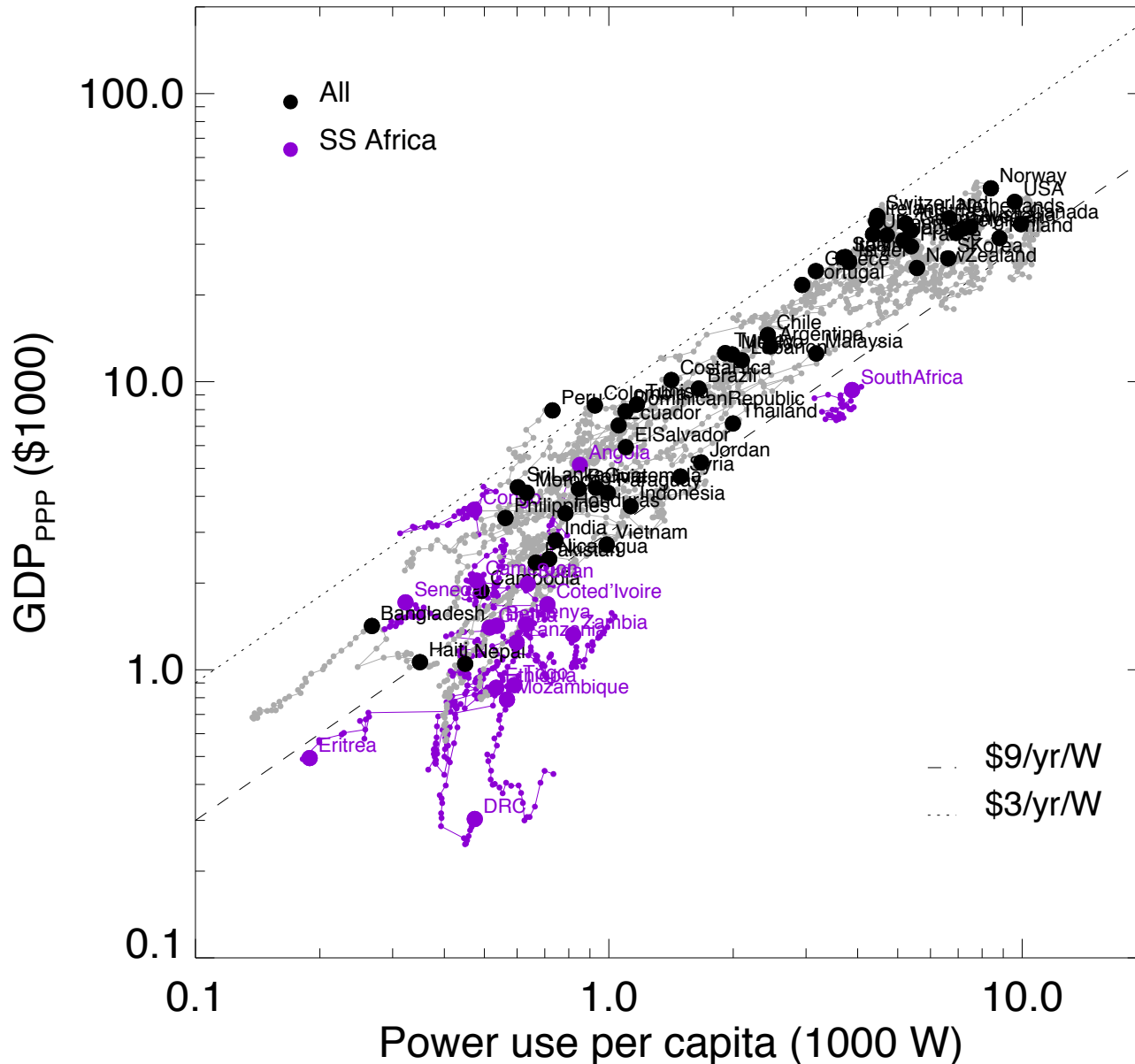


# FSU and East bloc were wasteful, now recovering



Data: World Bank,  
~1960-2011 2005 USD

# Some sub-Saharan countries are regressing

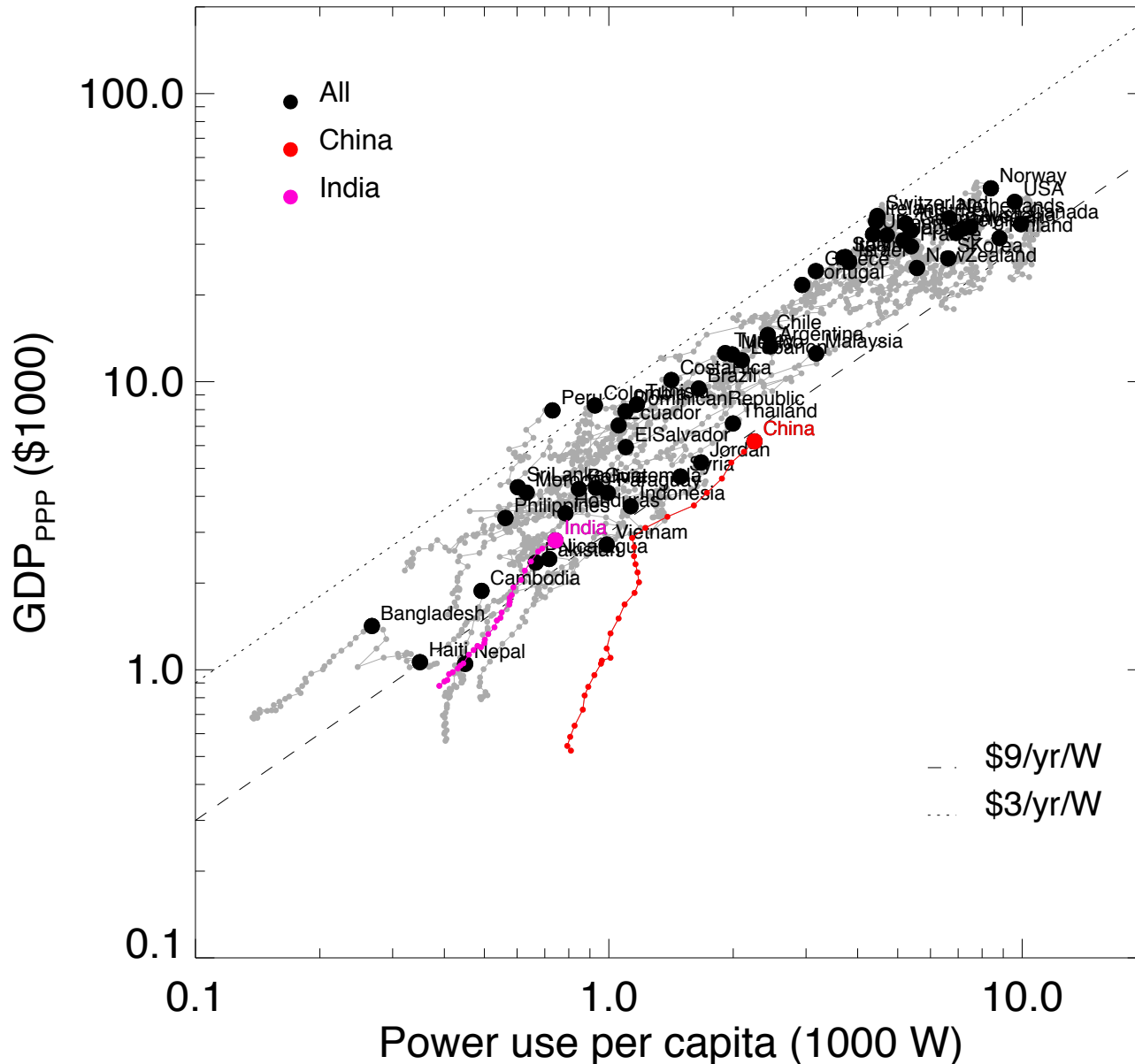


Many sub-Saharan countries fall below “normal zone”, but direction of movement can differ

DRC is dropping below the “normal zone” over time

Mozambique is recovering toward the “normal zone”

# China has entered the normal zone now



China was below “normal zone” from 1980-2000

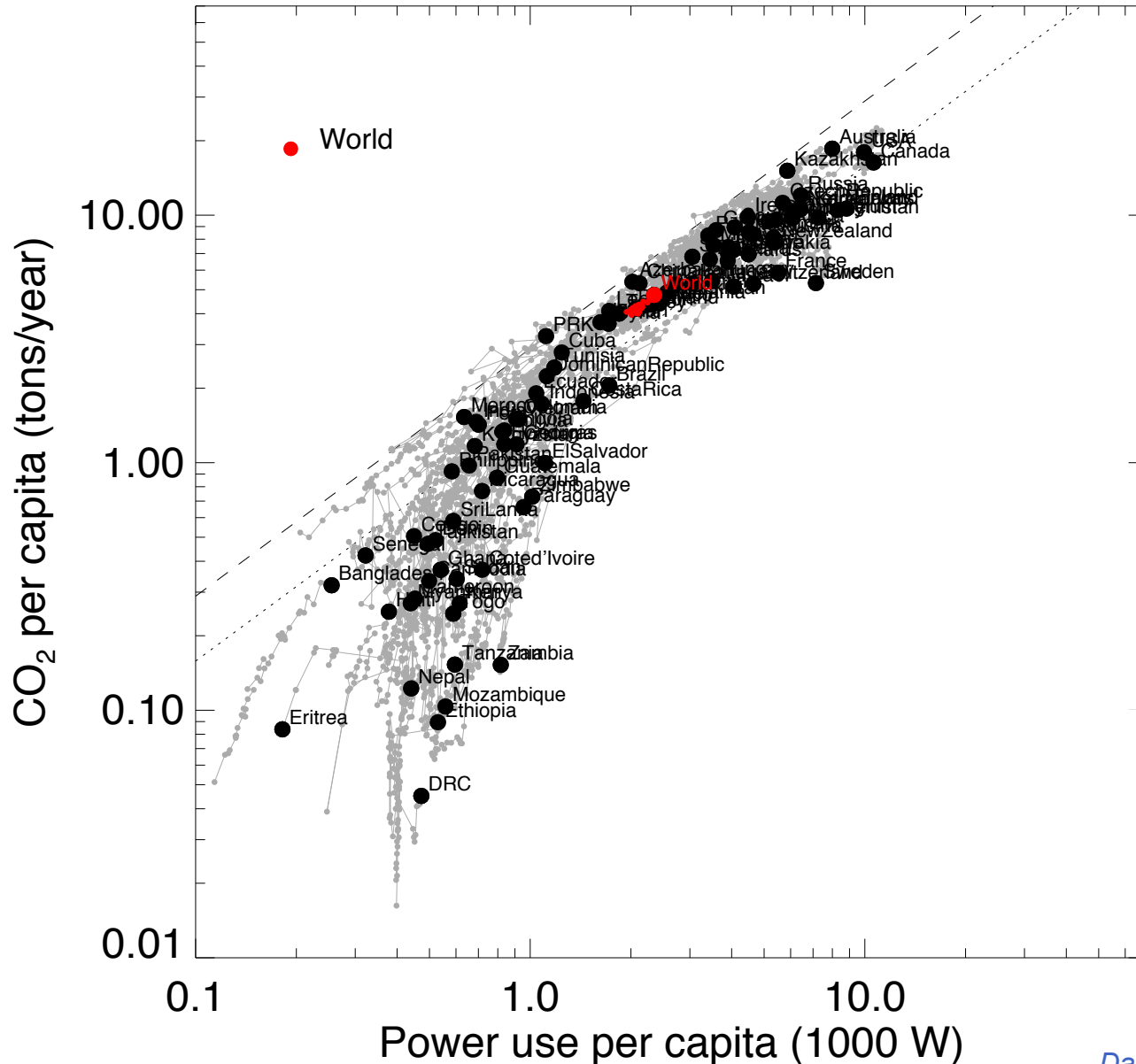
Inflection point is ~ 2001



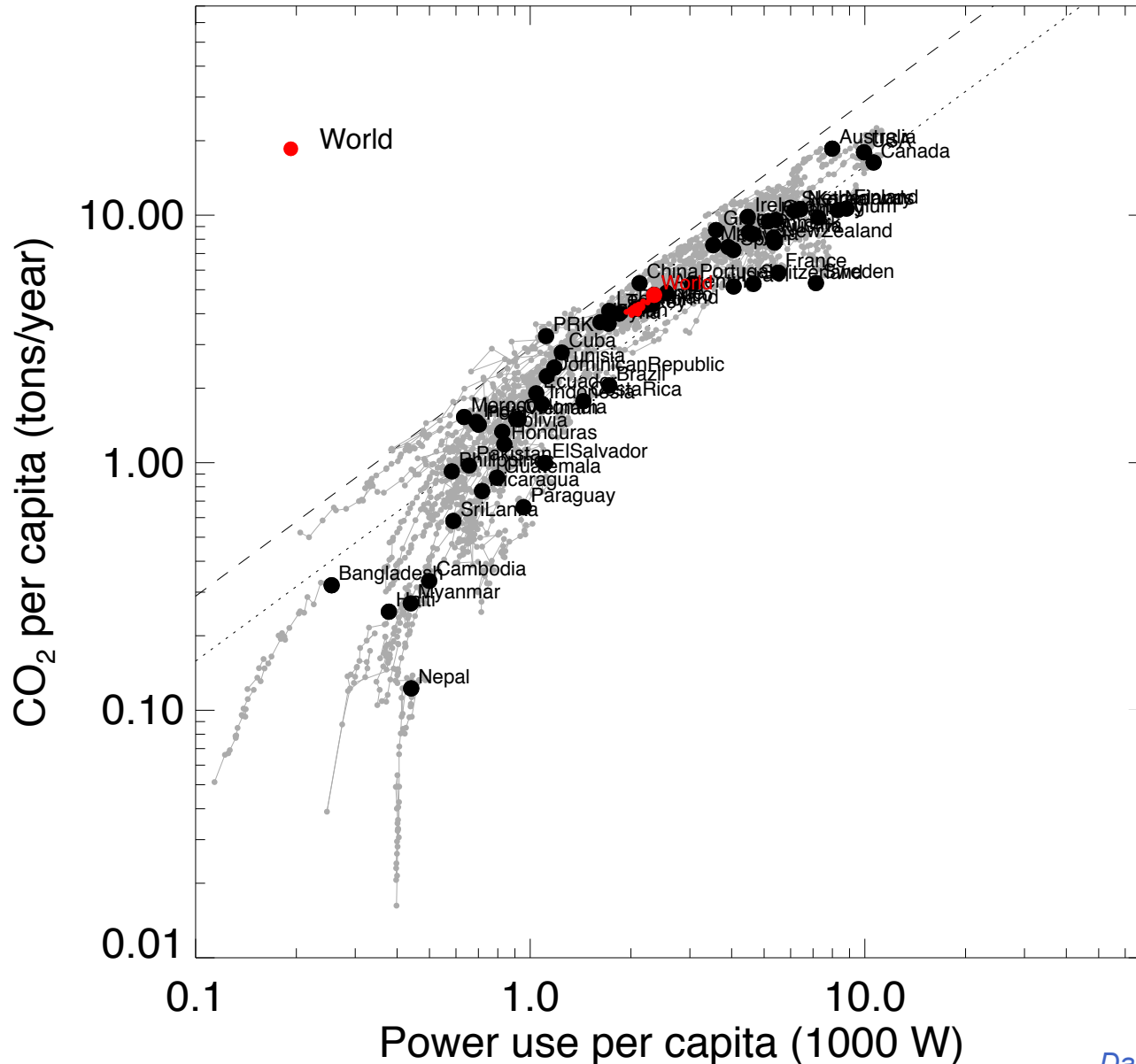




# CO<sub>2</sub> to energy relationship is tightly constrained

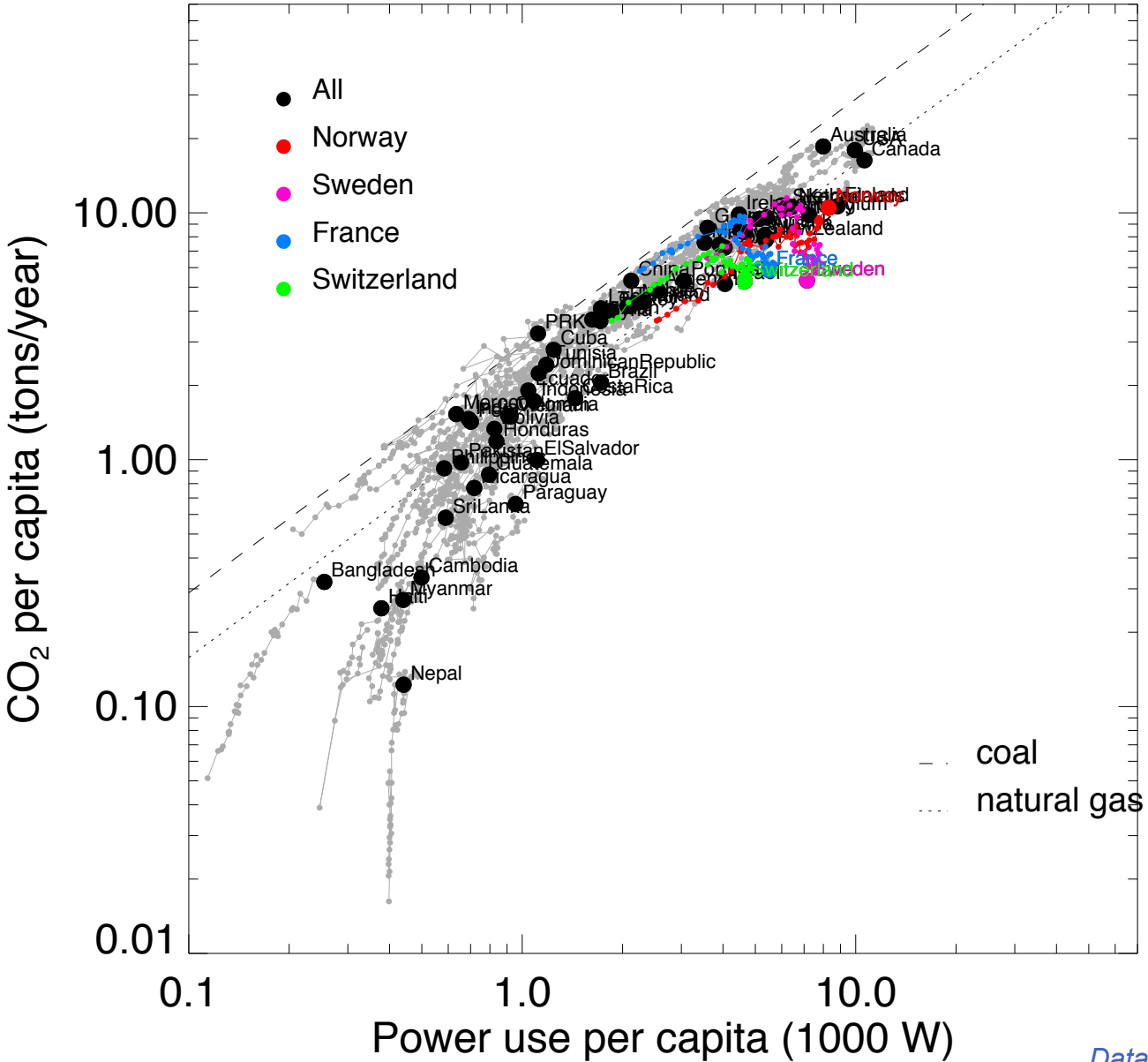


# CO<sub>2</sub> to energy relationship is tightly constrained



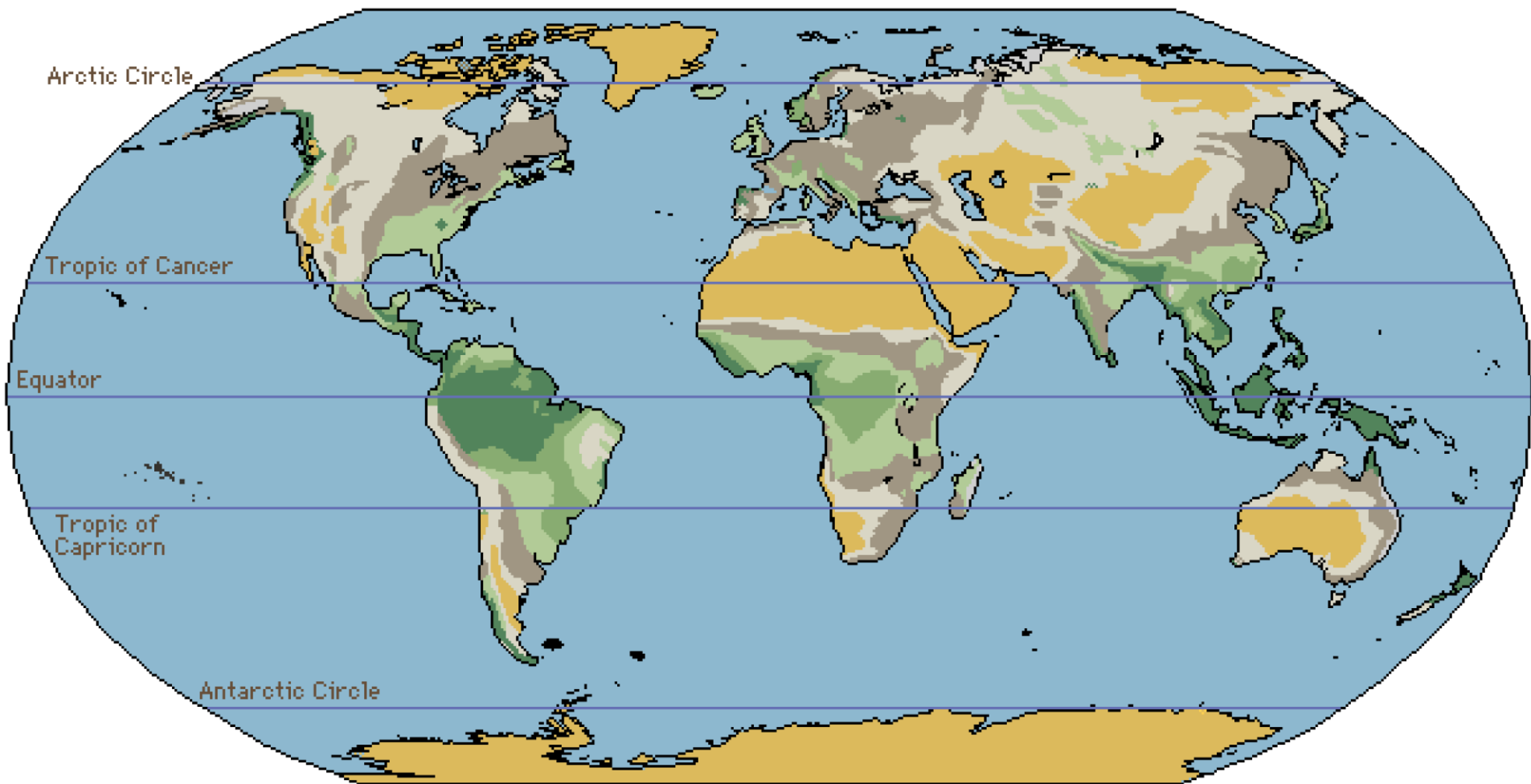
Data is now (here and in future plots) restricted to same sample as in previous plots of GDP vs energy use.

# Only a few wealth countries have low CO<sub>2</sub>/energy









Data: World Bank, ~1960-2011 2005 USD





**PRECIPITATION**

under 250 mm		under 10 in	500 - 1000 mm		20 - 40 in	1500 - 2000 mm		60 - 80 in
250 - 500 mm		10 - 20 in	1000 - 1500 mm		40 - 60 in	over 2000 mm		over 80 in