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Dynamics of Anthropogenic Carbon Emissions and Urban Areas: Integrated Assessment

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The Special Report on Emission Scenarios (SRES, 2000) became the important tool for "carbon managers" today, used for both economic and environmental tasks. Scenarios summarize demographic, economic, technologic, energetic, and agriculture (land-use) input information and output the values of anthropogenic carbon emission at regional and global levels.

However, all these scenarios use a principle of a simple arithmetic summing of local partial emissions from different sites and sources (industry, transport, energy use, and land use), while general emergent properties of the system are not taken into account. As a result all local uncertainties in their forecasting are accumulated without self-damping. Moreover, their synergetic interaction may lead to the sharp increase in the total uncertainty. In other words, we cannot be sure that such variable as the total anthropogenic emission is a real macroscopic variable for the considered system. Thus, an idea to use some integral parameters closely correlated with values of anthropogenic emission, but which may be determined with higher accuracy, seems more attractive. We show that urban area, UA, can be used as such kind of parameter.

Urban areas, occupying 1%-2% of the total land surface, produce about 97% of the total anthropogenic emission of carbon, *TE* (SRES, 2000; IPPC, 2003). Such strong correlation allows us to use their areas as a leading macroscopic variable in the forecasting of anthropogenic carbon emissions.

We assume (and prove it) that $TE(t) = se(t) \cdot UA[pop(t)]$ (*), where another variable, $se(t)$, is a *specific* (per urban area unit) emission, depending on the city's structure, the technologies of energy usage, types of the transport system, city's evolution, etc. We assume also that the urban area is a function of a single demographic parameter, *pop*(t), that is a population of a given region, country, or a city, or the world population (at the global scale). Thus, we assume (and prove) a certain independence of Eq. (*) on spatial scales. The dependence *UA*=*UA*[*pop*(t)] is determined by the regression based on the demographic statistics and population prognoses (Svirejeva-Hopkins et al., 2004).

We scarcely can influence the growth of urban area, while the $s(t)$ is defined by local strategies, realizing the principle: *"Think globally, act locally"*.

If *se*(t) = *const* then our scenarios are very close to the SRES BAU ones, but actually, *se*(t) changes with time. Note, only if *se*(t) monotonously decreases, then it would be possible to reach some "turning point", after which the total emission will begin also to decrease. The location of this point in time depends on the dynamics of *se*(t). If *se*(t) is decreasing slowly, it could be reached in about 300 years that is obviously unacceptable; if we are aiming to reach the turning point in the next 20 years or earlier, the reduction of *se*(t) should be rather strict and drastic at times.