8-7 How Does Radiation Influence Cells, the Human Body, and the Earth?
—Integration of Radiation Transport Simulations for Different Scales—

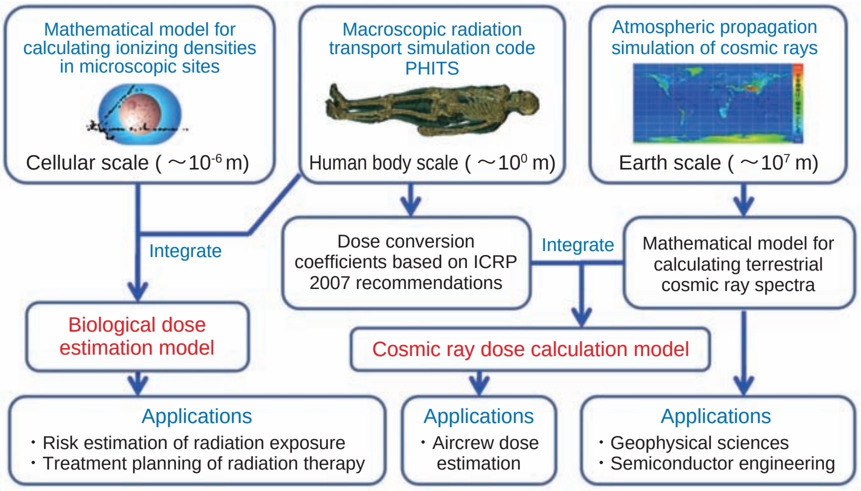

Fig.8-16 Outline of this study
The left and right sides of this figure show the outlines of the integration of radiation transport simulations between cellular and human-body scales and that between human-body and planetary scales, respectively.

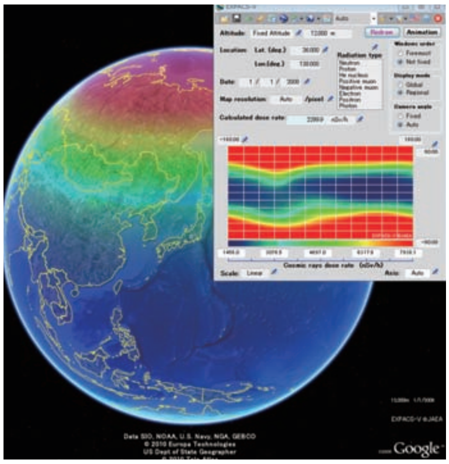

Fig.8-17 EXPACS-V screenshot
http://phits.jaea.go.jp/expacs/

Recently, high-energy particles are widely used for radiation therapy owing to their high relative biological effectiveness (RBE). On the other hand, their high RBE has adverse effects in cases of undesirable exposure, such as aircrews being exposed to high-energy cosmic rays. Integrated study of radiation transport simulations on different scales is necessary for elucidating the influences of such high-energy particles on matter.

We therefore integrated radiation transport simulations for cellular and human body level scales, and developed a biological dose estimation model for the human body based on individual cellular responses (left side of Fig.8-16). For that purpose, first we established a mathematical model that can instantaneously calculate the ionizing densities in microscopic sites on the basis of microscopic radiation transport simulations. This model was implemented in the macroscopic radiation transport simulation code PHITS, and the improved PHITS enables us to estimate the survival fractions of cells inside the human body within a reasonable computation time.

We also integrated radiation transport simulations for the human body and planetary scales, and developed a novel calculation model for cosmic ray dose rates any time and anywhere in the world (right side of Fig.8-16). For that purpose, we calculated fluence-to-effective dose conversion coefficients for various particles over a wide energy range, based on the 2007 recommendations of the International Committee on Radiological Protection (ICRP). Simultaneously, a mathematical model that can calculate terrestrial cosmic ray spectra as functions of altitude, latitude, longitude, and date was established by performing an atmospheric propagation simulation of cosmic rays using PHITS. The cosmic ray dose rates can be easily estimated using this mathematical model coupled with calculated dose conversion coefficients. Software for visualizing the cosmic ray dose rates on Google Earth™ maps was also developed, and opened to public via the Internet (Fig.8-17).

The biological dose estimation model we established can be utilized not only in radiation exposure risk estimation but also in high energy particle therapy treatment planning. The cosmic ray dose calculation model is currently employed in aircrew dose estimation in Japan to preserve their annual dose limits. The mathematical model for calculating terrestrial cosmic ray spectra is also used in various research fields such as the geophysical sciences and semiconductor engineering.

References

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