A comet nucleus sample return (CNSR) mission in ESA's Cosmic Vision program

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Rationale

We propose a comet nucleus sample return (CNSR) mission in the context of ESA's Cosmic Vision plan. After the detailed investigation of comet 67P/Churyumov-Gerasimenko by the Rosetta orbiter and lander, a sample return mission is the logical next step in cometary exploration.

Scientific background

In comets we find a mixture of original interstellar grains with material that was re-processed in the solar nebula. That mixture is of particular interest for the study of the fomration of the solar system. Laboratory investigation of samples brought back from different (active and inactive) regions of a comet allows to reveal this mixture of low and high temperature compounds. The Stardust mission has shown that those compounds are intimately mixed on small scales (Brownlee *et al.* 2006, Mc Keegan *et al.* 2006). The analysis of the returned sample from a cometary nucleus will determine the processes of the formation of the planetary system and their chronology (the amount of material collected by Stardust was too small to achieve that goal). It will be possible to determine how far out and in which proportion material processed near the Sun during the formation of our planetary system was transported out into the Kuiper belt where it was mixed with pristine interstellar material. A stratigraphic sample from a cometary nucleus will reveal the structure of the intricate porous mixture of ice-dust grains that make up a comet nucleus and provide for its unique activity.

The mission

A relatively small spacecraft will be launched into its interplanetary trajectory to a short period comet. After a short monitoring period near the cometary nucleus, needed to find suitable sampling spots, the spacecraft will touch down on the surface of the nucleus to collect samples. The sampling depth will be several decimeters. Finally the cooled samples will be returned to Earth. The mission is proposed to ESA's Cosmic Vision and exploration programs, in co-operation with the Russian space agency.

References

Brownlee, D. *et al*., (2006), *Science* **314,** 1711-1716.

McKeegan, K. D. *et al*., (2006), *Science* **314,** 1724-1727.

Modeling study on glacial-interglacial variations of atmospheric CO_2 concentration: The effect of Southern Ocean

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Ancient air trapped in Antarctic ice cores shows that the atmospheric CO_2 concentration, pCO_2, was lower during the ice ages than it is today. For example, at the Last Glacial Maximum (LGM), pCO_2 was 180-200 ppm which is roughly 80-100 lower than the pre-anthropogenic value. Although many hypotheses have been proposed to explain the pCO_2 variations for two decades, there is no widely accepted explanation for the variations.

Geological records suggest that, during the LGM, the extent of sea ice in the Southern Ocean was greater than that at present. In this study, we used an ocean general circulation model (COCO3.4, an ocean component of our atmosphere-ocean coupled general circulation model, MIROC3.2 (K-1 Model Developers, 2004)) coupled with a simple biogeochemical model (Yamanaka and Tajika, 1996). We examined the model sensitivities to changes in sea ice extent in the Southern Ocean on pCO_2 and discussed the effect of the Southern Ocean on the low pCO_2. We obtained the following two results. First, the reduced ventilation due to the sea-ice expansion would have had only a small effect on the reduction of atmospheric CO_2 concentration. The effect of reduced ventilation is much weaker than that predicted by a box model in a previous study. The difference resulted from the different efficiencies of water exchange between the surface water and the deep water in southern high-latitude regions. Second, sea-ice cover may have had the additional effect. If biological activity was reduced below the sea ice, the effect of decrease in consumption of CO_2 through biological activity might exceed that of decrease in the supply of CO_2 from the atmosphere. We propose that this effect was opposite and possibly stronger than the reduced-ventilation effect. These results suggest that sea-ice expansion was far from the principal mechanism for low CO_2 concentration during the LGM.

References

K-1 Model Developers, (2004),

K-1 Tech. *Rep., 1*, edited by H. Hasumi and S. Emori, The Univ. of Tokyo, Tokyo.

Yamanaka Y., and Tajika E., (1996), *Global Biogeochem. Cycles*, **10(2)**, 361-382.