大気・海洋・固体地球系の地震学:常時地球自由振動現象を例に

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Seismology in a system of the atmosphere, ocean and solid Earth

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It has long been believed that only large earthquakes excite free oscillations of the solid Earth. In 1998 a few Japanese groups reported existence of Earth's background free oscillations even on seismically quiet days. The excited modes are almost exclusively fundamental spheroidal modes with amplitudes of about 0.5 nGal. These features suggest that the background free oscillations are excited persistently by random disturbances globally distributed near the Earth' surface. The intensities of these modes clearly show annual and semiannual variations with the largest peak in July and a secondary peak in January. The observed amplitudes of some modes are anomalously large relative to the adjacent modes. These are the modes that are theoretically expected to be coupled with the acoustic modes of the atmospheric free oscillations. All of these features suggest that atmospheric disturbance is one of the most likely excitation sources of this phenomenon. Shortly after the discovery, some groups proposed an oceanic excitation mechanism. This mechanism is based on three observations; (1) The typical frequency of Earth's background free oscillations of about 0.01 Hz coincides with that of ocean bottom pressure sensors. (2) The excitation sources are dominated in the north Pacific ocean in winter of the northern hemisphere and in the southern hemisphere near the South Pole in winter of the southern hemisphere. The source distribution is consistent with oceanic wave height data. (3) Pessistent excitaion of Love waves suggest that the most likely excitation source is shear traction acting on a sea-bottom horizon due to linear topographic coupling of infragravity waves. The phenomena of background free oscillations should be understood as those in a single system of the atmosphere, ocean and solid Earth.

1998 年、地震活動が静穏な期間においても，地球が常に自由振動している現象 (周期 50 秒から 500 秒) が発見された (e.g. Suda et al., 1998)。観測された振動は伸び縮み基本モードであり，その励起の特徴から地表付近に面的に分布した擾乱が励起源であると考えられている。観測スペクトルをより詳しく調べると, 音響共鳴周波数 (周期 255, と 270 秒) での振幅が他の周波数よりも 10%程度振幅が大きい事が明らかとなっており (Nishida et al., 2000)、大気の対流活動 (Kobayashi and Nishida 1998) が有力な励と考えられてきた。しかし最近、励起源の空間分布や、その季節変動から、海洋擾乱 (綿田 2002; Rhie and Romanowicz 2004) が励起源である可能性が指摘された。また今年に入って、海洋重力波と固体地球の海底地形によるカップリングを示唆する、Love 波も定常励起されている観測事実が報告されている (Kurrle and Widmer-Schnifrig, 2008; Nishida et al., 2008)。この 10 年間興味深い観測事実が蓄積され、大気海洋現象が励起源であるという描像が得られている。しかし未だに、統一的な励起メカニズムの理解には至っていない。今後理解をより深めるためには、大気-海洋-固体地球の大きな枠組みからのアプローチが不可欠であろう。