Atmospheric and oceanic excitation of the Earth's wobbles during 1980–2000

Richard S. Gross, Ichiro Fukumori, and Dimitris Menemenlis
Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA

Received 8 August 2002; revised 19 March 2003; accepted 2 April 2003; published 7 August 2003.

[1] Because of the action of various geophysical excitation mechanisms, the Earth does not rotate about its figure axis, so it wobbles as it rotates. Here, the effectiveness of atmospheric and oceanic processes in exciting the Earth's wobbles during 1980–2000 is evaluated using estimates of atmospheric angular momentum from the National Centers for Environmental Prediction/National Center for Atmospheric Research (NCEP/NCAR) reanalysis project and estimates of oceanic angular momentum from the Estimating the Circulation and Climate of the Ocean (ECCO) consortium's simulation of the general circulation of the oceans. On intraseasonal timescales, atmospheric surface pressure changes are found to be the single most effective process exciting the Earth's wobbles, explaining about twice as much of the observed variance as do either atmospheric wind or ocean bottom pressure changes and nearly 4 times as much of the observed variance as do oceanic currents. However, on interannual timescales, ocean bottom pressure changes are found to be the single most effective process exciting the Earth's wobbles, explaining more than 5 times as much of the observed variance as do atmospheric wind and pressure changes combined, and more than twice as much of the observed variance as do oceanic currents. Within the Chandler band it is found that during 1980–2000 atmospheric and oceanic processes have enough power to excite the Chandler wobble and are significantly coherent with it. The single most important mechanism exciting the Chandler wobble is found to be ocean bottom pressure variations. Atmospheric and oceanic processes do not appear to have enough power to excite the Earth's wobbles to their observed levels on pentadal and longer timescales, although series longer than the 21-yearlong series used here need to be studied in order to obtain greater statistical significance of this result. *INDEX TERMS:* 1223 Geodesy and Gravity: Ocean/Earth/atmosphere interactions (3339); 1239 Geodesy and Gravity: Rotational variations; 3319 Meteorology and Atmospheric Dynamics: General circulation; 4532 Oceanography: Physical: General circulation; *KEYWORDS:* Earth rotation, polar motion, atmospheric angular momentum, oceanic angular momentum, Chandler wobble

Citation: Gross, R. S., I. Fukumori, and D. Menemenlis, Atmospheric and oceanic excitation of the Earth's wobbles during 1980–2000, *J. Geophys. Res.*, *108*(B8), 2370, doi:10.1029/2002JB002143, 2003.

1. Introduction

[2] In the absence of external torques and internal excitation processes, the solid Earth would uniformly rotate about its figure axis. External torques due to the gravitational attraction of the Sun, Moon, and planets cause the solid body of the Earth to tidally deform, giving rise to changes in the rotation rate of the Earth. Because the Earth's figure axis is inclined with respect to both the normal of the ecliptic and the normal of the orbital plane of the Moon, these external torques also cause the Earth to precess and nutate as it rotates. Internal excitation processes such as atmospheric wind and pressure fluctuations also cause the Earth's rate of rotation to change, and cause the Earth to wobble as it rotates.

0148-0227/03/2002JB002143$09.00

[3] The wobbling motion of the Earth was first detected more than a century ago and since that time the Earth has been observed to wobble on all observable timescales, from subdaily to decadal. Like a system of damped harmonic oscillators, the Earth has a few discrete frequencies at which it would naturally wobble in the absence of forcing. These natural, or free, wobbles of the Earth are known as the Chandler wobble, the free core nutation, also known as the nearly diurnal free wobble, and the inner core wobble [e.g., *Eubanks*, 1993; *Mathews et al.*, 2002]. In the absence of excitation, these natural wobbles of the Earth would freely decay due to the action of dissipation processes.

[4] The Earth also wobbles over a broad range of frequencies in response to a variety of forcing mechanisms. Unlike the free wobbles whose frequencies are a function of the Earth's structure, the frequencies of the forced wobbles are the same as those of the forcing mechanisms. The broadband nature of the observed wobbling motion of the