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THE WINTER DANCE OF THE EARTH'S POLE

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Abstract. During the 2005-2006 winter season, loops of amplitude around 10 cm or below were detected in the Earth's polar motion, which was running very slowly due to a cancellation of the two main oscillations. After cross-checking with the latest meteorological data, their origins were found in several continental-scale high or low pressure systems, especially on Northern America and Europe, helped by similar pheonomenon over Southern Pacific. This paper is a short version of the work of Lambert et al. (2006), published in Geophysical Research Letters, on which a press release has been issued on 26 June 2006 by the American Geophysical Union. See this paper and references therein for more details.

1 Tracking the Earth's pole: an international affair

The terrestrial motion of the Earth's rotation pole is continuously monitored by space and geodetic techniques. This monitoring is done through an international network within the frame of the International Earth Rotation and Reference Systems Service (IERS), for which the SYRTE department at the Paris Observatory hosts the Earth Orientation Center (head: D. Gambis). This section is in charge of the combination of Earth orientation data from various techniques and the publication of the the reference series, the so-called IERS EOP C 04 (see http://hpiers.obspm.fr/ for more information).

The main technique giving polar motion is the global navigation satellite systems (GNSS). This technique is coordinated by the International GNSS Service (IGS), a federation of more than 200 worldwide agencies that pool resources and permanent GPS and GLONASS station data to generate high accuracy products (including Earth orientation, station positions and velocities, and troposphere data). GNSS brings about 80% of the whole data, while the rest is shared between very long baseline interferometry (VLBI) and satellite-laser ranging (SLR).

The accuracy reaches today the centimeter with a hourly time resolution, so that very fine details can be observed, for instance in polar motion, with a very high level of significance. The near-real time knowlegde of the Earth orientation, as well as its prediction realized at the IERS Rapid Service/Prediction Center (head: T.J. Johnson), a part of the Earth Orientation Department (head: W.H. Wooden) of the US Naval Observatory (Washington, DC) is of large interest for military applications, precise positioning and for improving our understanding of the Earth structure and interactions between solid Earth and surface geophysical fluids.

2 What happened during the 2005-2006 winter season?

The Earth's polar motion shows two main oscillations: the free Chandler wobble of period 433 days, a free rotational mode of the mantle, and an annual pattern, due to atmospheric and oceanic forcing. Every 6.4 years, these two signals interfere destructively and smaller amplitude variations can show up. Actually, small loops showed up with diameters going from the size of a laptop screen down to the dimension of a cell phone. As mentioned earlier, the accuracy being of the order of one centimeter, all of these loops were significantly above the noise level (see Fig. 1).

The surface geophysical fluids (atmosphere, oceans, continental water, and ice sheet at longer time scales) are known to modify notably the Earth's rotation. Evidences for the excitation of the Chandler and annual wobbles by the combined influence of atmospheric and ocean bottom pressures have been found (by e.g., Gross

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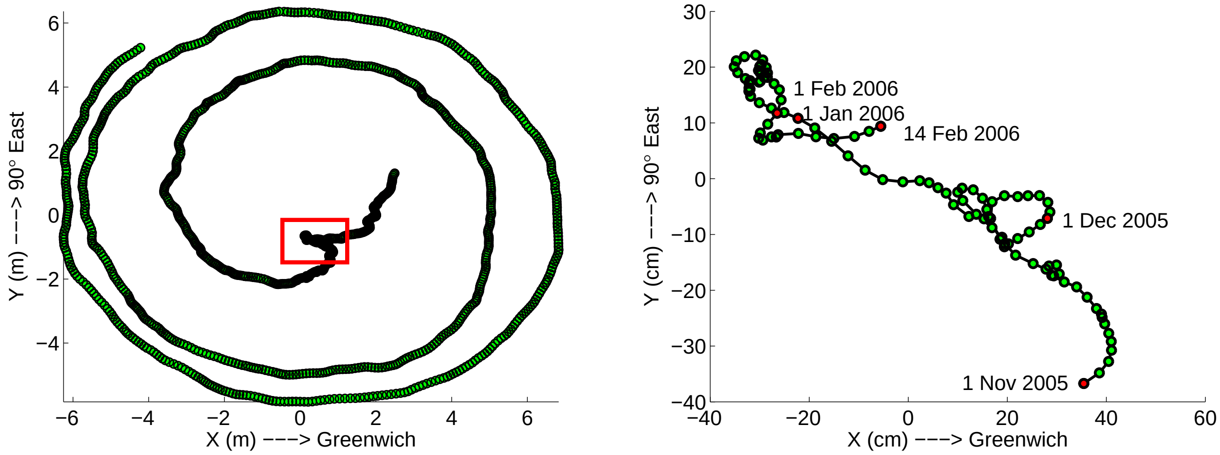

Fig. 1. Left: motion of the pole following the IERS C 04 combined series from 2003. Right: the small rectangle of the left plot is blown up and shows the pole from 1 November 2005 to 14 February 2006. Dark circles indicate the beginning of each month corresponding to the civil date written nearby.

(2000) or Brzeziński et al. (2002)). The excitation of rapid polar motion (weekly time scales) by the atmosphere has been studied by Eubanks et al. (2000) but only partly due to a lack of accurate data. Actually, our work corresponds to the first time scientists observe directly rapid polar motion with a high accuracy and have enough meteorological data to study the direct link between them.

We used daily uniform grids of surface pressure fields provided by the National Center for Environmental Prediction (NCEP)/National Center for Atmospheric Research (NCAR) reanalysis project. Ocean bottom pressure fields output from the oceanic model ECCO-2 (JPL) are used to get estimates of the oceanic angular momentum during the relevant time period. We correlated the combined atmospheric/oceanic excitation with the observed polar motion. More precisely, we isolated contributions from each part of the globe in order to determine which high/low pressure system was acting to create a given loop. A low pressure system on Northern Europe is shown to participate in the first 3 loops, helped by similar events on North Pacific and South Atlantic. The last loop seen on Fig.1 is resulting from a globally unbalanced high pressure on Northern Europe.

References

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