ENSO-events, Earth’s Rotation and Global Changes

Nils-Axel Mörner

Paleogeophysics & Geodynamics
Geological Institute
S-106 91 Stockholm, Sweden

ABSTRACT


The El Niño/Southern Oscillation (ENSO) events represent significant disturbances of a variety of integrated Earth processes. Some of these are well-known and well recorded, others are obscure or unknown. We discuss the changes in the Earth’s rate of rotation (LOD) during ENSO-events, note the transfer of angular momentum to the atmosphere and its effects on the westerly jet-streams, and formulate a novel concept of transfer of angular momentum to the hydrosphere and then back again to the “solid” Earth. The mechanism of interchange of angular momentum with the hydrosphere has wide applications. It is the driving mechanism for short-term Holocene redistributions of mass (sea level) and energy (paleoclimate) over the globe, as well as for variations in coastal upwelling (biological productivity) and air/sea interchanges (gases, etc.).

ADDITIONAL INDEX WORDS: El Niño, ENSO, Earth’s rotation, interchange of angular momentum, sea level, climate, global changes.

The El Niño/Southern Oscillation (ENSO) events represent interesting and important anomalies in the Earth’s climatic, oceanographic and marine biological systems. They have, therefore, attracted a significant scientific interest during the last decade, or so. In 1982/83, the Earth experienced a very strong ENSO event. This event has been studied in details and been given an impressive description within the World Climate Data Programme of WMO (WCDP, 1985).

The present paper will discuss the interchange of angular momentum between the “solid” Earth (the LOD records) and the atmosphere and the hydrosphere, and the implications of this both in global sense and on a long-term basis. The ENSO events seem to provide a mechanism that also operates on longer time-scales causing signals/effects in the time range of about 50-150 years (MÖRNER, 1984, 1988a, 1989a, 1989b). This is of fundamental importance for our understanding of “global changes” and multiparameter interactions.

LOD AND THE ATMOSPHERE

The annual and intra-annual LOD variations are balanced via the interchange of angular momentum between the “solid” Earth and the atmosphere (BARNES et al., 1983; EUBANKS et al., 1983, 1984, 1986; ROSEN and SALSTEIN, 1983).

During the great 1982/83 ENSO event, there was an extra loss of angular momentum from the “solid” Earth record (LOD) which was transferred to the atmosphere, causing the westerly jet-streams to increase their velocity and to be displaced equatorwards.
Stream variability, however, the author claimed that it was possible to identify both clear and highly significant events in the time range of about 50-150 years (MÖRNER, 1984, 1988a, 1988b, 1989a, 1989b). The same mechanism was successfully applied to the last centuries’ detailed LOD record (MÖRNER, 1988a, 1989a, 1989b). Also the ENSO events seemed to include an unidentified LOD signal that seemed well explained in terms of the interchange of angular momentum with the hydrosphere (MÖRNER, 1987, 1988a, 1989a, 1989b). Data are now available that sharpen the picture. This is illustrated in Figure 3 (cf. Figure 2 in MÖRNER, 1989a).

The 1982/83 ENSO event is linked to a significant loss in angular momentum (about 0.4 ms) from the “solid” Earth (Figure 3B). This seems neither to have been compensated by the atmosphere nor by the Earth’s core. Instead, it seemed likely that this was compensated by the hydrosphere (MÖRNER, 1988a, 1989a, 1989b). Figure 3 seems to provide conclusive evidence that this was really the case.

The volume of water in the upper layer of the tropical Pacific increased from 1981 up to mid 1982 (curve A). In mid 1982, the optimum sea surface temperature anomaly (curve D) was in the western equatorial Pacific (N–4). Angular momentum was transferred from the “solid” Earth, increasing the LOD which peaked in earliest 1983 (curve B). Obviously, angular momentum was transferred to the hydrosphere. The water column (C) had started to decrease and the optimum sea surface temperature anomaly (D) was displaced to the eastern equatorial Pacific (N–3). During 1983, the water volume (C) rapidly fell to a minimum during the later half of the year. The optimum sea surface temperature anomaly (D) was displaced to the coastal zone (N–1–2), indicating that water started to be piled up along the west coasts of the American continents. Obviously, a continental “mountain torque” forced the hydrosphere to loose angular momentum which was transferred back to the “solid” Earth (B). Simultaneous rises and falls of the sea level have been documented all along the American west coasts for previous ENSO and non-ENSO years (ENSFIELD and ALLEN, 1980; MÖRNER, 1989a).

In Figure 1, we compare the 1980/81, 1981/82 and 1982/83 cycles. The 1982/83 cycle (ENSO) differs from the others in the occurrence of a high peak in early 1983. The difference to the other cycles (non-ENSO) signifies the amount of angular momentum lost from the “solid” Earth to the atmosphere. It is a question of at least 0.3 milliseconds and maybe up to as much as 1.0 milliseconds. The effect on the jet-stream is illustrated in Figure 2.

This gives clear evidence that the 1982/83 ENSO event, though primarily restricted to the equatorial Pacific event, also had global effects.

**LOD AND THE HYDROSPHERE**

Astronomers and meteorologists have not been able to identify clear and significant interchanges of angular momentum between the “solid” Earth and the hydrosphere. Studying Holocene changes in climate, sea level and Gulf

---

![Figure 1](https://example.com/Figure1.png)
1987, 1988a, 1989a, 1989b). This is illustrated in Figure 4.

This indicates that the hydrosphere is much more susceptible to changes in the Earth's rate of rotation than generally assumed. Our data show that there, indeed, is an interchange of angular momentum between the "solid" Earth and the hydrosphere during ENSO events.

GLOBAL CHANGES

The mechanism established for the interchange of angular momentum with the hydrosphere during ENSO-events is also found to apply for the decadal signals in the last centuries' LOD records and for the 50-150 year's signal in Holocene climatic-eustatic records (MÖRNER, 1984, 1988a, 1989b). This is of fundamental significance for our understanding of the Earth's dynamicity and its "global changes" (MÖRNER, 1989c). Via the effects on the coastal upwelling, this model also explains variations in marine biological productivity and pre-industrial atmospheric CO₂ fluctuations (MÖRNER, 1988b).

CONCLUSIONS

(1) During the 1982/83 ENSO event, angular momentum (between 0.3 and 1.0 ms) was transferred to the atmosphere affecting the speed and position of the westerly jet-streams. Hence, global effects are generated.

(2) During the 1982/83 ENSO event, angular momentum (about 0.4 ms) was transferred from the "solid" Earth to the hydrosphere and then back again when the water masses started to provide a mountain torque against the west coasts of the American continents (rising sea
ZUSAMMENFASSUNG


Figure 3: Records indicating the transfer of angular momentum first from the “solid” Earth to the hydrosphere and then back to the Earth again in connection with the great 1982/83 ENSO event (cf. Figure 2 of Mörner, 1989a). A: water volume changes in the upper layer of the tropical Pacific in 10^14 m^3 (WCDP, 1985). B: non-tidal changes in LOD for the “solid” Earth in ms (Eubanks et al., 1986). C: corresponding LOD changes for the atmosphere. D: time position of optimum sea surface temperature anomalies in equatorial Pacific within the four Niño areas: N–4 in the western part, N–3 in the eastern part and N–1,2 in the coastal part (WCDP, 1985).

LITERATURE CITED


L’oscillation Sud d’El Nino (ENSO) représente une perturbation significative de bon nombre de processus terrestres intégrés. Certains d’entre eux sont bien connus et bien enregistrés, d’autres sont obscurs et mal connus. On traite ici des modifications de la rotation de la Terre (LOS) au cours des ENSO; le transfert des moments angulaires vers l’atmosphère et ses effets sur le jet-stream d’ouest est noté; une nouvelle conception du transfert des moments angulaires vers l’hydrosphère, puis à nouveau en retour vers le solide Terre est formulée. Le mécanisme de l’échange des moments angulaires avec l’hydrosphère a de larges applications. C’est le mécanisme conducteur de la redistribution holocène à court-terme des masses (niveaux marins) et de l’énergie (paléoclimats) à travers le globe, idem pour les variations de l’upwelling côtier (productivité biologique) et pour les échanges air/mar. — Catherine Bressolier (EPHE, Montrouge, France).

Los sucesos de oscilación EL NIÑO (ENSO) generan modificaciones significativas de una gran variedad de procesos globales de la Tierra. Algunos de estos sucesos son bien conocidos y están bien registrados, otros, sin embargo, son desconocidos. En este artículo se discuten los cambios en la rotación terrestre (LOD) durante los sucesos ENSO, la transferencia de momentum angular a la atmósfera y sus efectos sobre las corrientes de chorro del Oeste, además se formula un nuevo modelo de transferencia de momentum angular a la hidrosfera y regreso después a la tierra sólida. Este mecanismo de intercambio de momentum angular con la hidrosfera tiene amplias aplicaciones. Es el mecanismo impulsor de las redistribuciones de corto periodo del Holoceno tanto de masa (nivel del mar) como de energía (paléoclima) sobre el globo, así como de las variaciones en las corrientes ascendentes costeras “upwelling” (productividad biológica) e intercambios aire-mar (gases, etc.). — Department of Water Sciences, University of Cantabria, Santander, Spain.
Figure 4. Sea level changes along the American west coasts in the ENSO year 1958 (A) and in the non-ENSO year 1964 (B) according to data by Ensfield and Allen (Ensfield and Allen, 1980). The mass redistributions are here (Morner, 1988a, 1989a) primarily claimed to be the cause of changes in the hydrospheric angular momentum (and not wind forces as generally assumed). Generalized models of the corresponding "solid" Earth deceleration and hydrospheric acceleration in 1959 (A) and of "solid" Earth acceleration and hydrospheric deceleration in 1964 (B) are given at the base (Ensfield and Allen, 1980; Morner, 1987, 1989a).