Atmospheric Excitation of the Chandler Wobble over the XXth Century: Insight from ERA 20C

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Main Points

- Used ERA 20C to compute the atmospheric excitation and torques in the Chandler frequency band over 1900-2010 and to show that
- The atmosphere acts dominantly over Eurasia (via mountain torque on the Tibetan plateau and a large variability of the angular momentum over Western Siberia) with strong bursts in AAM around 1910, 1940 and the 1970s, and
- The mountain torque appears to be correlated with the Antarctic oscillation (AAO) and North-Atlantic modes (Atlantic multidecadal oscillation, North-Atlantic oscillation, and Arctic oscillation).

Data Processing

- Model: ECMWF ERA 20C Reanalysis 1900-2010 [*Dee et al. 2011, Q. J. R. Meteorol. Soc. 137: 553*], monthly means of 6-hr data. Orography of the model. 2°x2° grids of surface pressure, instantaneous north/eastward turbulent stress, zonal and meridional wind speeds at 17 pressure levels between 10 and 1000 mBar.
- Treatment: grid integration to obtain local and global AAM and torques [e.g., *Barnes et al. 1983, Proc. R. Soc. Lond. A 387, 31*; *Huang et al. 1999, JGR 104: 2031*]. Then, filtering in time domain by a Panteleev filter of bandwidth 35 days and central period 430.3 days. Account for edge effects by removing 7 years at the beginning and the end of the series.

Hot Spots at the Chandler Frequency

Time domain globally integrated quantities are shown in **Fig. 1**. The atmospheric excitation is dominated by the surface pressure with prominent activity in 1930, 1940, and 1995. It is far insufficient to explain the observed geodetic excitation that shows large peaks in 1925 and 1945, letting a possible important contribution from the oceans and/or a deficiency in the current atmosphere reanalysis. The mountain torques strongly dominates the total torque.

The regression of the local excitation and torques onto their globally integrated values and the Hovmoeller diagrams (**Fig. 2**) reveal that

- The surface pressure excitation is dominated by Eurasia, consistently with a mountain torque essentially made up by in the Himalaya and Tibetan plateau, fueled by meridional pressure gradients between Siberia and Southern Eurasia. Strong bursts in the excitation are observed circa 1910, 1940, and 1970.
- A relatively important mountain torque is seen around the Antarctic plateau with an interannual variability.
- Western Europe and North-East Atlantic contribute to the wind excitation and friction torque.

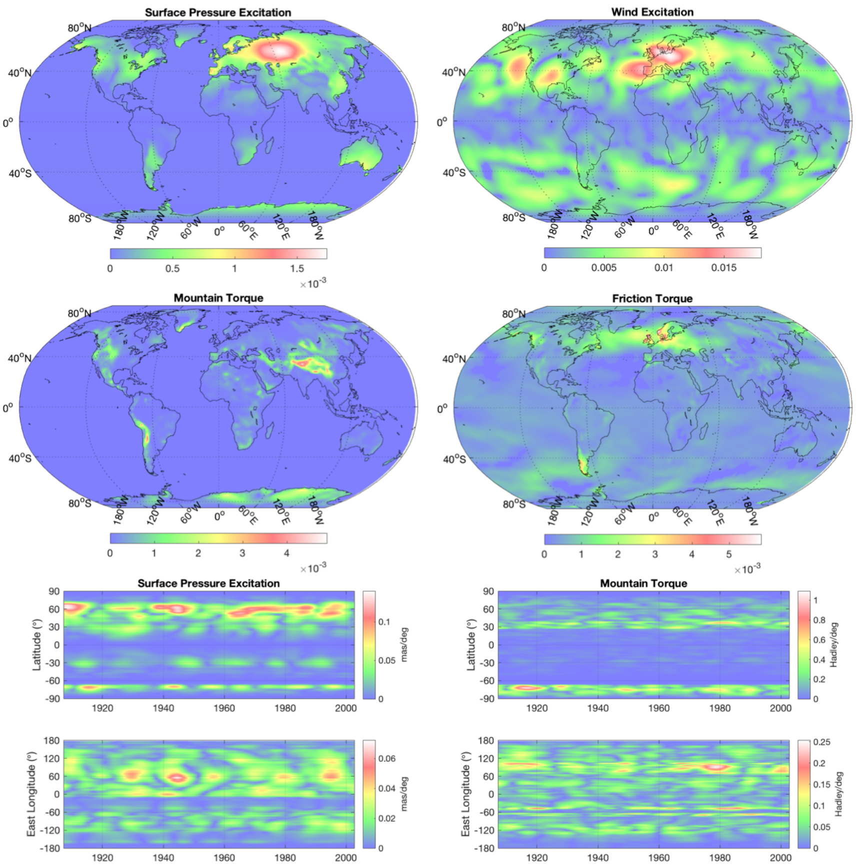

Fig. 2 *(Top) Regression of the local AAM and torques onto the global AAM and torques. (Bottom) Time-latitude and time-longitude diagrams of the surface pressure excitation and mountain torques.*

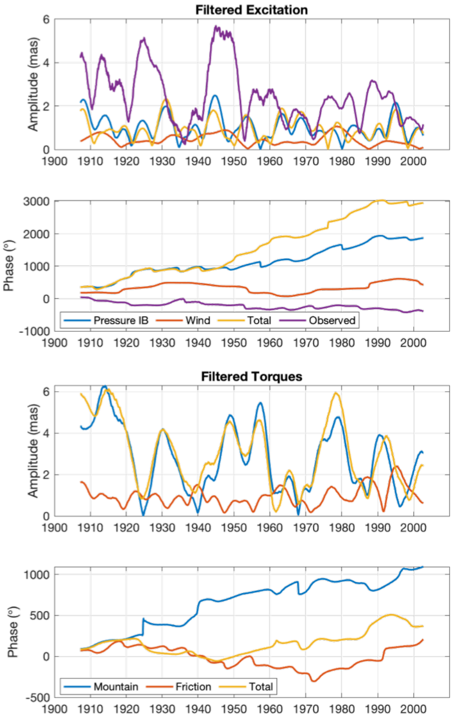

Fig. 1 *Amplitudes and phases of the complex excitation and torques in the Chandler frequency band.*

Connection with Climate Modes

We computed the correlation coefficients of various climate indices with global excitation and torques. We highlight below the correlations with small lags (here given in years) and Fisher z coefficient larger than 2 sigmas, i.e., significant at more than 95%.

Total Excitation

	X			Y		
	Corr	Lag	Fz	Corr	Lag	Fz
AAO	0.493	0.2	2.4	-0.332	-37.4	2.0
AMO	-0.404	11.0	1.2	0.228	-63.0	1.1
AO	-0.387	-15.8	1.8	0.326	25.3	1.8
NAO	0.255	26.0	1.4	-0.548	2.2	3.0
PDO	0.406	30.0	1.9	-0.279	-44.8	1.4
SOI	-0.298	29.8	1.6	0.338	7.6	1.6

Mountain Torque

	X			Y		
	Corr	Lag	Fz	Corr	Lag	Fz
AAO	-0.416	-4.3	2.0	-0.448	15.9	2.4
AMO	0.760	0.0	2.5	-0.420	15.8	1.2
AO	-0.593	9.2	3.3	0.321	-37.2	1.3
NAO	-0.469	8.9	2.6	-0.541	7.5	3.1
PDO	-0.562	20.6	2.4	0.479	29.5	2.3
SOI	-0.608	-19.5	4.2	-0.286	-24.4	1.3

We detected an influence of the AAO and NAO in the excitation while the mountain torque seems to be mainly influenced by the AAO (consistently with the mountain torque detected on the edge of the Antarctic plateau) and the North Atlantic system and its modes at interannual and multidecadal time scales (AO, NAO, and AMO).

Next Steps

- Compare with other 20C reanalyses (NCEP 20C, CERA 20C) and use the ensemble spread to evaluate the model error;
- Possibly associate the bursts with documented meteorological events;
- Search for ocean reanalyses (SODA, ORA 20C) to complete the budget.