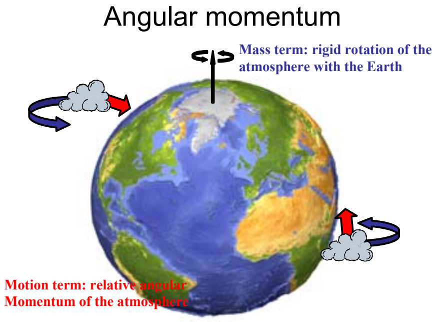
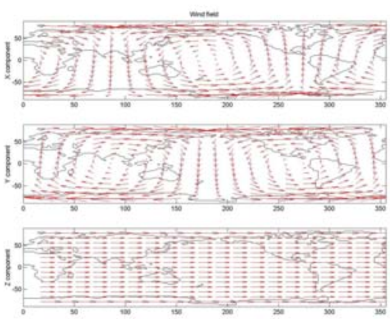
Earth-Atmosphere Interaction at Sub-Diurnal Timescale and its Effect on Earth Rotation

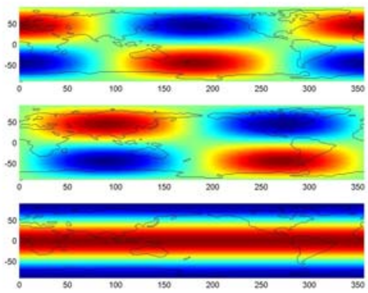
Olivier de Viron, Royal Observatory of Belgium

In this paper, we have discussed the signal in the atmosphere at very high frequency, in order to link the effect of the atmosphere on HF Earth rotation with the processes happening in the atmosphere-Earth interaction.

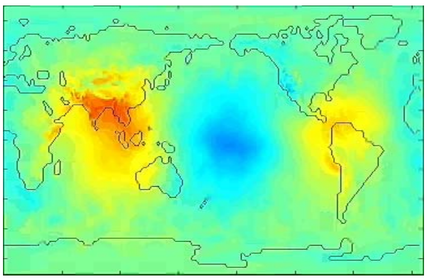


The Atmospheric Angular momentum is classically separated into two parts: a mass term corresponding to the rigid rotation of the inertia of the atmosphere with the Earth, and a motion term related to the wind.

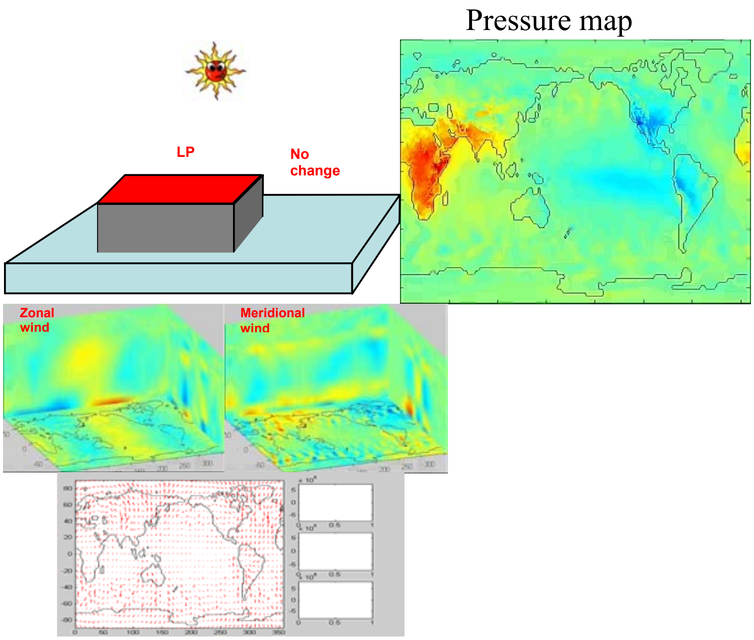




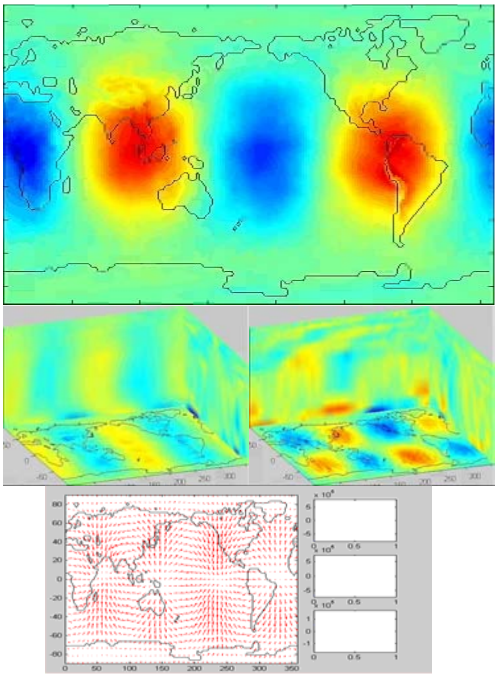
In slide 2 & 3, we show how the pressure integrated wind (slide 2) and the pressure (slide 3) fields should be in order to create motion and matter angular momentum.



In slide 4, we show, by the mean of an animation, the evolution of the pressure wave during a composite day. We can observe a traveling wave, which get strongly amplified when on the continent.

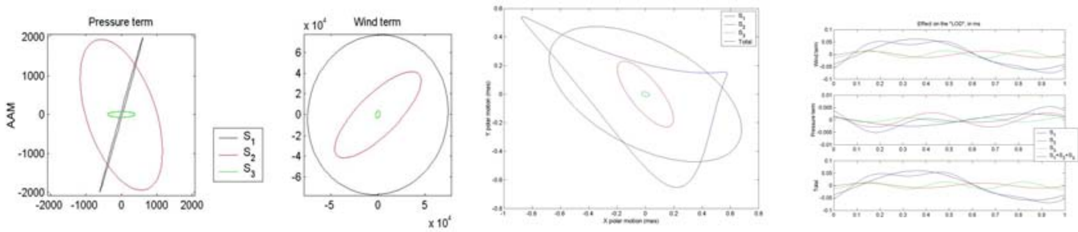


In the (animated) slides 5, 6, and 7, we show what is happening at the S1 (1 solar day) period. The land areas are heated by the sun, unlike the ocean. Consequently, at the S1 frequency, the signal is nearly only on the continent. Note, on the map, that such a pressure field is efficient to create (negative) Y matter angular momentum. The wind animation show that, as expected physically, the S1 process are mostly surface process, not much is happening higher in the atmosphere. The wind animation also show that the main wind term is above the Africa/Europe/Asia.

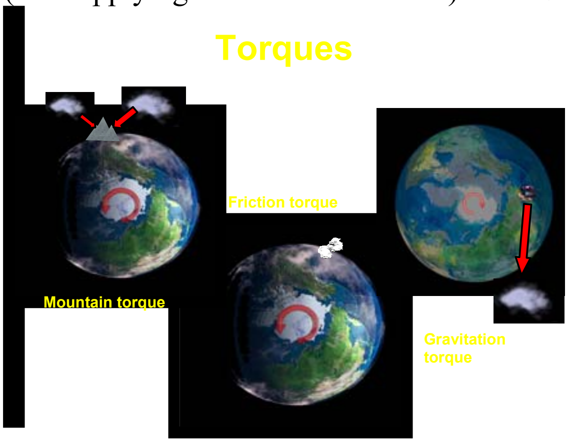


Unlike S1, S2 is a resonance of the atmosphere, with a very strong pressure signal propagating retrogradly, with no consideration for land or ocean area. The geometry is not very favorable to create matter angular momentum.

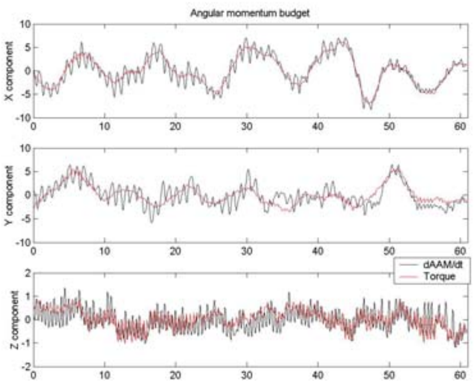
Similarly, there is a very coherent wind signal propagating on the whole atmospheric column. As it can be observed on the bottom map, the wind field is nearly purely spheroidal, and is thus very inefficient to create motion angular momentum.



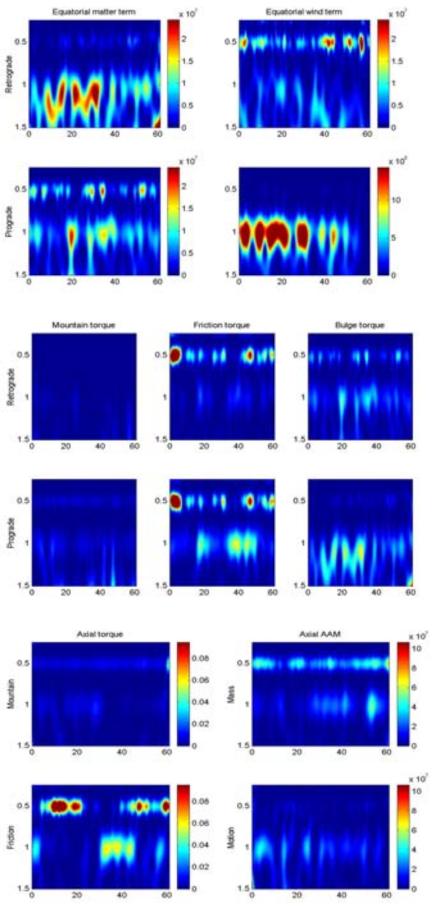
Those three slides show the signal we have on the angular momentum, polar motion (after applying the transfer function) and LOD from the composite day.



Three torques are considered here: the mountain torque resulting from a difference of pressure on two sides of a mountain, the gravitational torque resulting from the gravitational attraction between mass anomalies inside the Earth and in the atmosphere, and friction associated with the surface wind.



Comparing the AAM time derivative and the torque on the atmosphere, we can test the consistency of the model. We observed that the torque does not give enough energy at high frequency, mainly for the equatorial components.



Those wavelet analyses show how the different terms of the angular momentum budget equation vary with time, at high frequency. Note the difference of scale for the subplots. It appears that, for the two months analyzed here, there is a very strong variability of both torques and angular momentum terms. Unlike what happens at lower frequency, the friction torque is very important, even in the equatorial angular momentum budget.

Conclusions:

- Data quality issues except for "mean" day
- HF signal stronger in the AAM than in the torque → Torque approach cannot be used to explain AAM variation
- Very high time variability of the HF signal
- Strong difference between S1 and S2 resulting in a smaller ratio S2/S1
- PM signal at the mas level, and LOD signal at the ms level.