GEOPHYSICAL EXCITATION OF NUTATION AND GEOMAGNETIC JERKS

Jan Vondrák and Cyril Ron,
Astronomical Institute, Acad. Sci. Czech R., Prague

Contents:

- ♦ Introduction, motivation;
- ♦ Data and procedures used;
- ♦ Integration of broad-band Liouville equations, comparison with observed nutation;
- ♦ Results and conclusions.

Introduction

- ♦ Atmospheric and oceanic excitations play dominant role in polar motion and rotational velocity of the Earth;
- ♦ Non-negligible effect can be seen also in nutation;
- ♦ These effects are caused by quasi-diurnal changes of angular momentum functions of the atmosphere and oceans;
  - ♦ High-resolution (at least 6-hour) data are needed;
- ♦ When studying atmospheric/ocenic effects we found:
  - ♦ they cannot explain the observed celestial pole offsets completely.

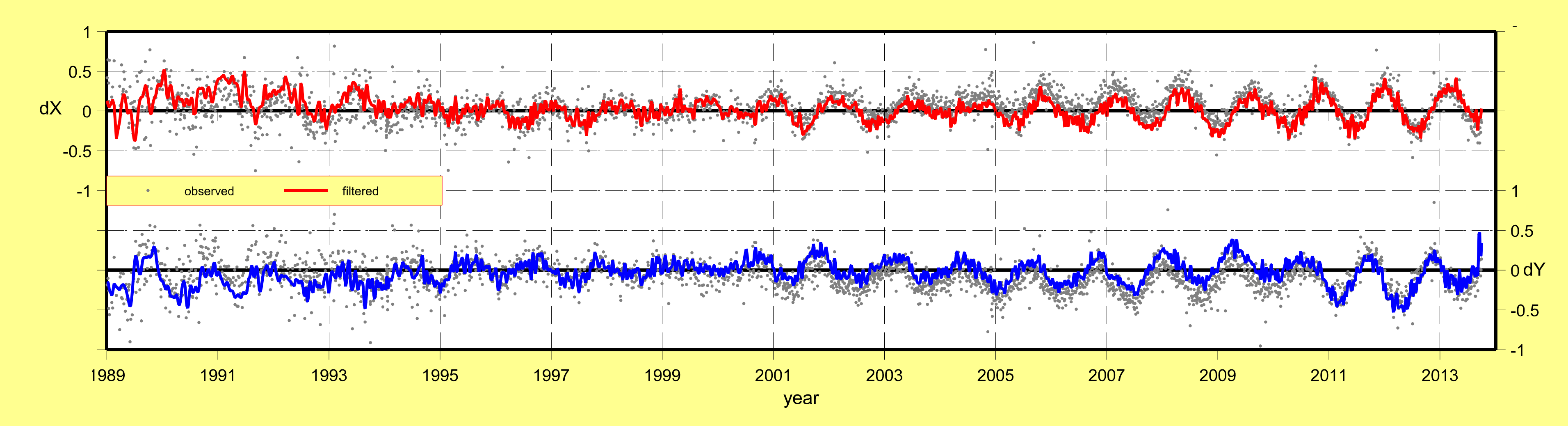
Motivation

- Recently Malkin (2013) found that changes of FCN amplitude/phase occur near epochs of geomagnetic jerks
  - GMJ - rapid changes of the secular variation of geomagnetic field.
- We tested this hypothesis and found that:
  - re-initialization of the numerical integration of Brzezinski broad-band Liouville equations at GMJ epochs leads to significant improvement of the agreement with the observed celestial pole offsets;
  - best agreement is achieved for NCEP atmospheric excitations with IB correction, for GMJ epochs + 100 days.
- This approach leads to stepwise changes in CPO:
  - physically not acceptable.
- Here we use a different approach - additional continuous excitation near GMJ epochs.

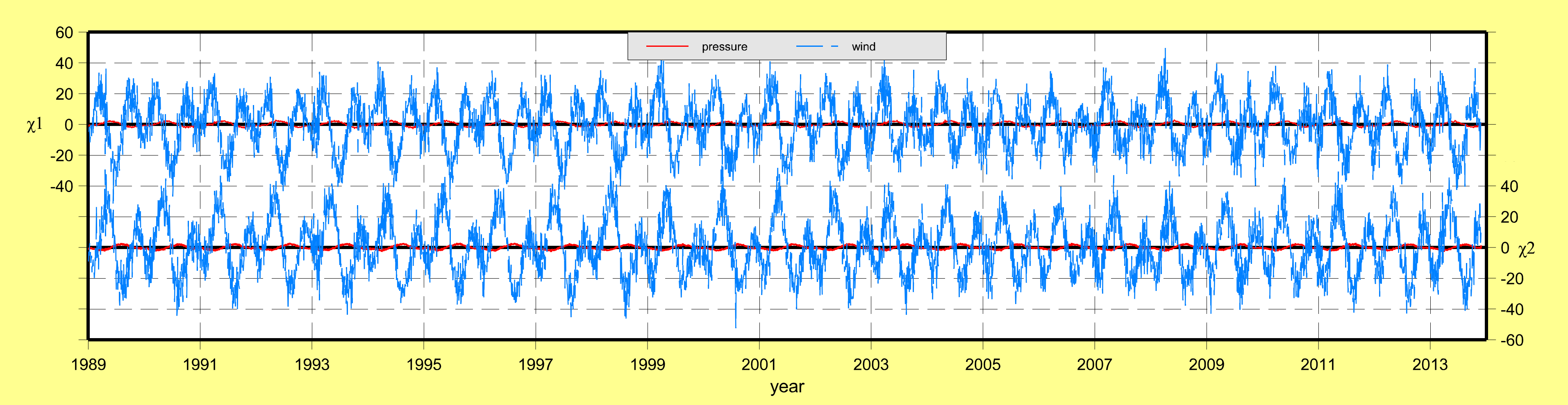
Data used, in interval 1989.00-2013.75:

- For the nutation, VLBI-based observations of celestial pole offsets $\mathrm{d}X$, $\mathrm{d}Y$, at unequal intervals:
  - IVS combined solution ivs13q3X.eops, filtered to contain periods 60 - 6000 days.
- For atmospheric and oceanic excitations, angular momentum functions $\chi_{1,2}$, 6-hour data:
  - from Atmospheric and Environmental Research, USA:
    - NCEP/NCAR reanalysis (pressure term with IB correction – a simple model of oceanic response).
  - These data are given in rotating terrestrial frame, they were re-calculated into quasi-inertial celestial frame.

Observed and filtered (60<*P*<6000d) IVS celestial pole offsets



NCEP excitations - pressure with IB correction, wind



Numerical integration of broad-band Liouville equations:

(after Brzezinski, in celestial frame, complex form)

$$\ddot{P} - \mathrm{i}(\sigma'_C + \sigma'_f)\dot{P} - \sigma'_C \sigma'_f P =$$

$$= -\sigma_C \left\{ \sigma'_f (\chi'_P + \chi'_w) + \sigma'_C (a_p \chi'_p + a_w \chi'_w) + \mathrm{i}\left[(1+a_p)\dot{\chi}'_P + (1+a_w)\dot{\chi}'_w \right] \right\}$$

where

P is the motion in celestial system;

σ'_C, σ'_f are Chandler and FCN frequency in celestial frame;

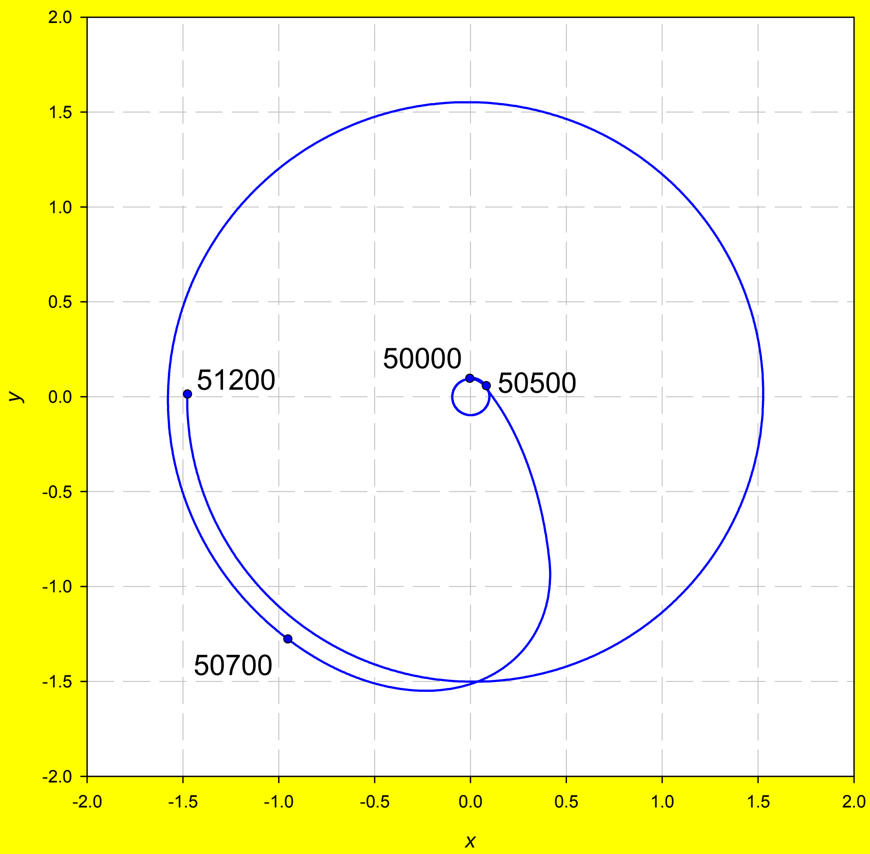
σ_C is Chandler frequency in terrestrial frame;

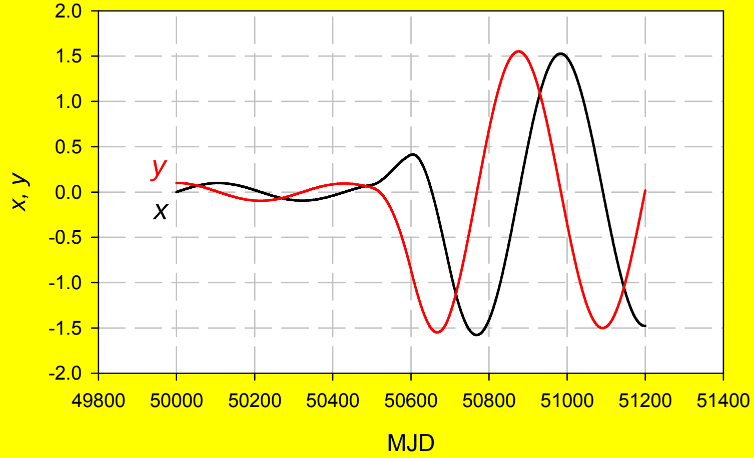
χ'_p, χ'_w are excitations (matter and motion terms) in celestial frame;

$a_p = 9.509 \times 10^{-2}$, $a_w = 5.489 \times 10^{-4}$ are numerical constants.

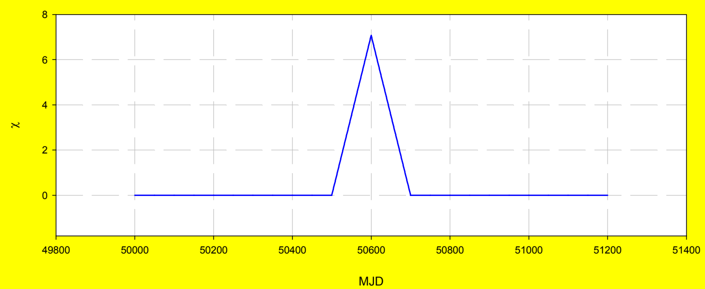
- **Integration made in two versions, with:**
  - **Only NCEP excitations;**
  - **NCEP + additional excitations around GMJ epochs**
    - **continuous ‘double ramp’ functions.**

Integration with simulated schematic excitation





schematic excitation ("double ramp" function) χ_1, χ_2

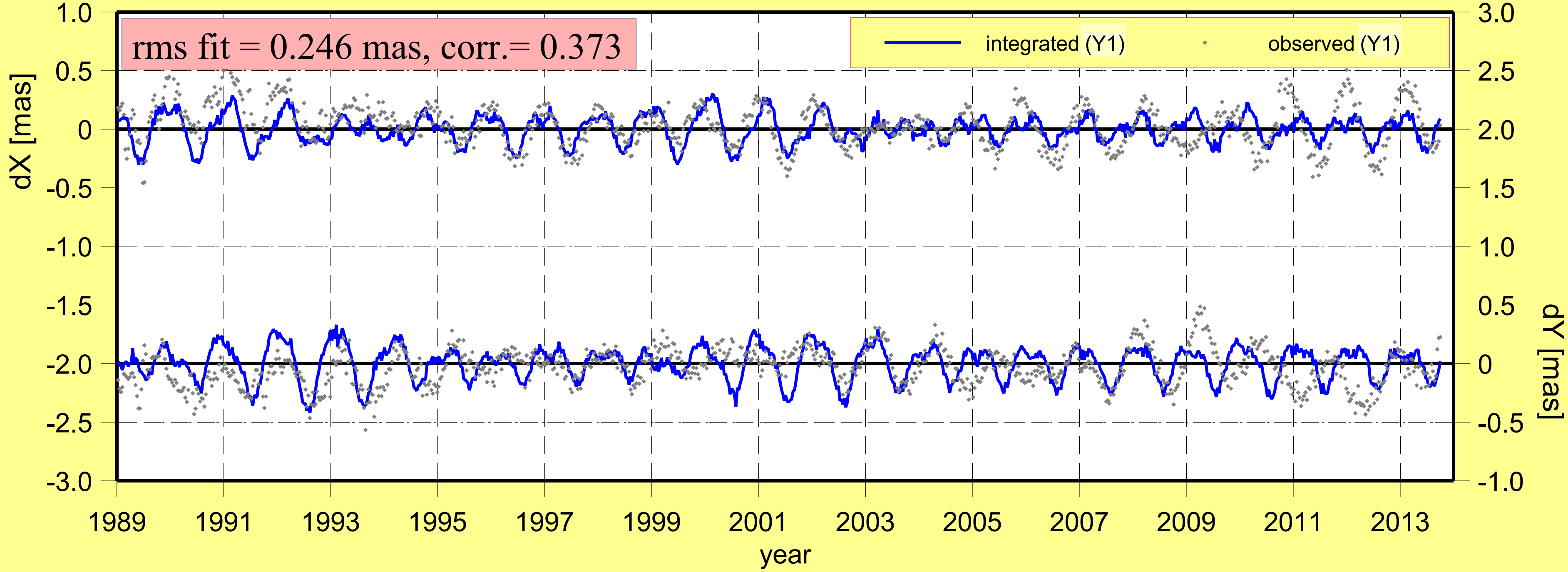


Procedure used:

- We fix the the central epochs of additional excitations around GMJ epochs:
  - 1991.0, 1994.0, 1999.0, 2003.5, 2004.7, and 2007.5.
- GMJ last typically several months,
  - so we fix the length of excitation to 200 days;
- The complex amplitudes of the excitations were estimated:
  - to lead to the best rms fit to observed celestial pole offsets.
- We tested the following epochs:
  - GMJ - 100d (rms = 0.211 mas, corr. = 0.578)
  - GMJ (rms = 0.196 mas, corr = 0.632)
  - GMJ + 100d (rms = 0.213 mas, corr. = 0.570)

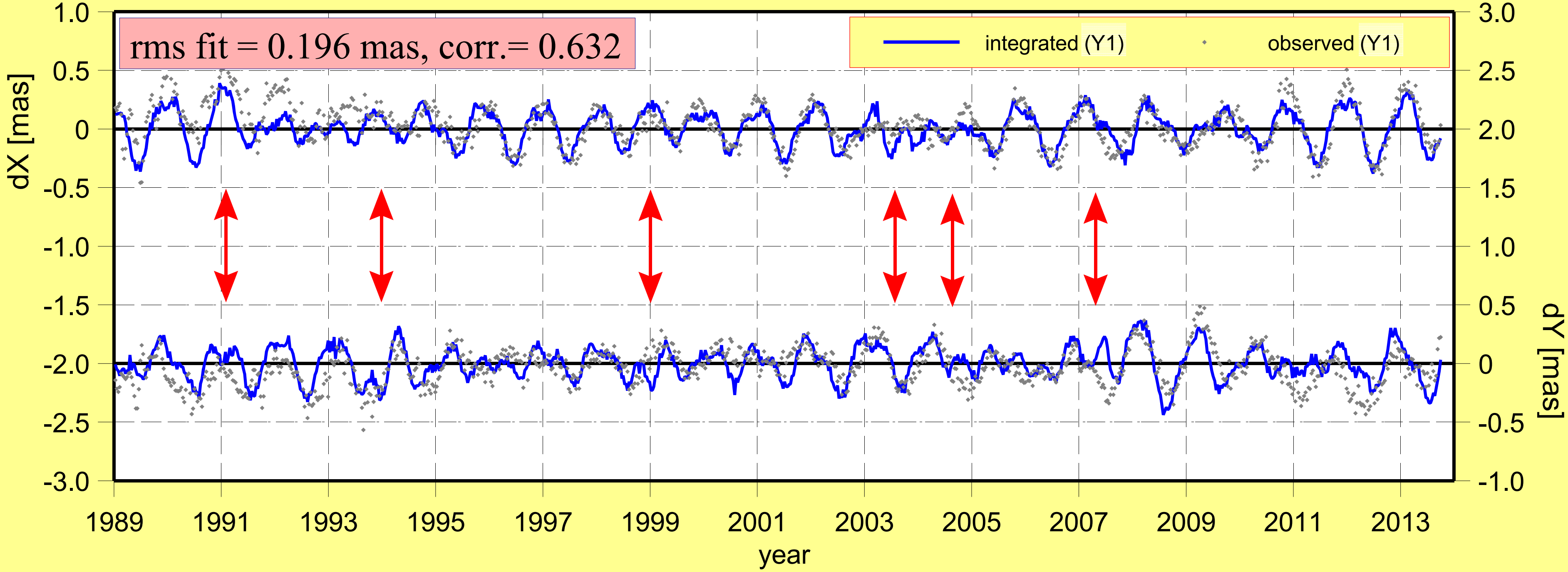
Observed and integrated celestial pole offsets

NCEP (atm. with IB corr.) excitations

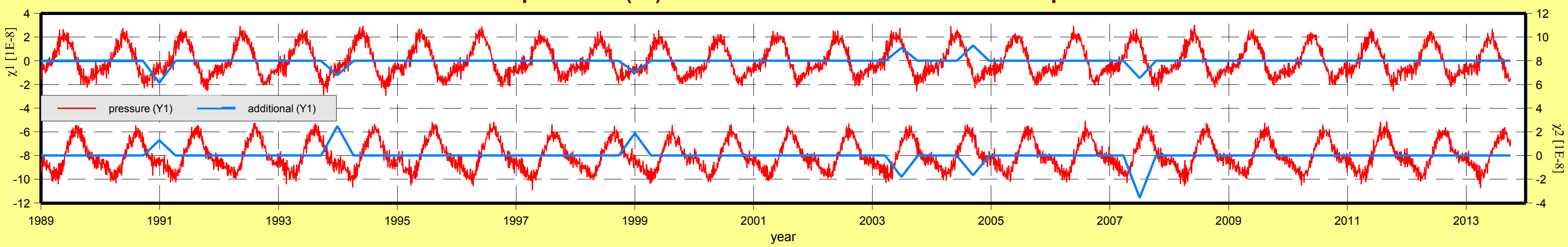


Observed and integrated celestial pole offsets

NCEP (atm. with IB corr.) excitations, additional excit. at GMJ epochs



NCEP pressure (IB) and additional excitations at GMJ epochs



Conclusions

- ♦ Geophysical excitations yield significant contribution to nutation, of the order of 0.1mas;
- ♦ The influence of motion (wind) terms are one order of magnitude smaller than that of matter (pressure) terms;
- ♦ The application of schematic additional excitations at GMJ epochs substantially improves the agreement of integrated pole position with VLBI observations.

Acknowledgments: Grant No. 13-15943S, awarded by the Grant Agency of the Czech Republic, is highly appreciated.