Workshop of the EAPS Health, Morbidity and Mortality Working Group Prague
16. – 18. September 2015

Conditional dependence of long period time series of numbers of deaths by individual causes

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Conditional dependence of long period time series of numbers of deaths by individual causes

The conditional dependence between the intensity of mortality and the solar, geomagnetic and ionospheric physical parameters

The solar cycle No. 23 and 24 (years 1994-2012), the Czech Republic

VI. Diseases of the nervous system, ICD-10

- 6 of individual causes of death
- The daily number of deaths
- Separately for both sexes
- The age groups under 39 and 40+

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Graphical models of conditional independencies - CIG

Usefull tool of multivariate statistical analysis

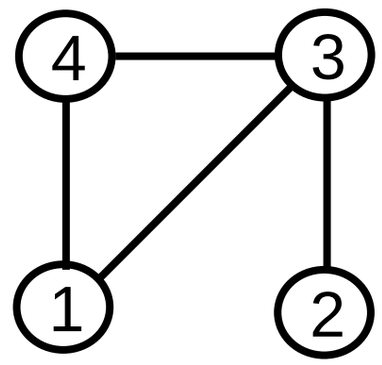
Enable us to examine the structure of conditional independecies in time series

Idea: represent the structure of dependencies using a graph

Vertices = *variables*

Edge = variables are conditionally *dependent*

Missing Edge = variables are conditionally *independent*



Limitation of this contribution: *Gaussian* graphical models

Graphical models of conditional independencies - CIG

The graph

$G = (V, E)$ of a graphical model with k vertices for k – dimensional random vector is the group of likehood probability distribution.

Conditional independence graph

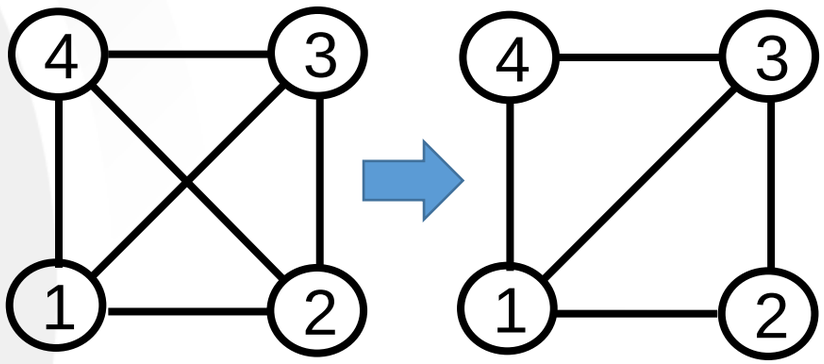
$G = (V, E)$, where $V=\{1, 2, ..., k\}$. An edge $\{i,j\}$ is not in the edge set E (is it excluded) if and only if $X_i \perp X_j / X_{K \setminus \{i,j\}}$.

Adjacency matrix

$A_G = (a_{ij})$ of graph $G = (V,E)$ is square matrix defined:

$a_{ij} = 1$ in case $\{v_i, v_j\} \in E$.

$a_{ij} = 0$ otherwise.



$$A_G = \begin{pmatrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 0 \\ 1 & 1 & 0 & 1 \\ 1 & 0 & 1 & 0 \end{pmatrix}$$

Assembly of variance matrix and correlation matrix

Graphical models of conditional independencies

Bayesian approach

Based on the assembly of the variance matrix satisfying the Graphical Models likelihood equations

$X^1, X^2, \ldots, X^N$ random sample from multivariate normal distribution $N(0, K)$

The maximum likelihood estimators $\hat{Y}$, $\hat{W}$ where $\hat{Y} = \hat{W}^{-1}$ fulfil the equations:

$\hat{y}_{ij} = 0$ for each couple of vertices i, j with **missing** edge

$\hat{W} = S_{aa}$ for each set of a in K which is a **clique**

(where S_{aa} is a submatrix of the sample variance matrix)

$\hat{Y}, \hat{W}$ are explicitly determined with probability 1

Graphical models of conditional independencies

Test statistics for testing CIG

Deviance $dev(G) = 2 (l_{(S)} - l_{(G)})$ - testing G against the maximal model

$l_{(S)}$ – maximum log-likelihood function of the complete graph
$l_{(G)}$ – maximum log-likelihood function graph G

$dev(G)$ **asymptotic** χ^2_f **distribution** with f degrees of freedom
(f number of excluded edges)

Deviance of the complete graph in IPF algorithm = O
with the number of omitted edges in the graph the deviance increases

The difference of deviance $dev^* = -(dev^{f2} - dev^{f1})$
test against the alternative model with more edges
edges removed at the 0.05 significance level

IPF model selection algorithm (backward)

Data

Deaths by cause of death

- **Time period 1994 – 2012**, the Czech Republic, the **daily aggregated numbers of deaths**
- **Separately for both sexes** at the age groups **under 39 and 40+**
- Causes of death group **VI. Diseases of the nervous system, ICD-10**
  Changes in coding rules, the automatic coding of diagnosis
- Data source: Czech Statistical Office, aggregated files of anonymised individual records of deaths
  Department of Demography and Geodemography, Přf UK

Solar indices

- **Kp** **Planetary index**, fluctuations rate of horizontal components of geomagnetic field, indicate geomagnetic storm
- **Dst** **Disturbance Storm Time**, degree of distortion of the magnetic field of the Earth
- **R** Relative **Sunspot Numbers**
- **F10.7** Intensity of the **Sun radio flux**

Ionospheric indices

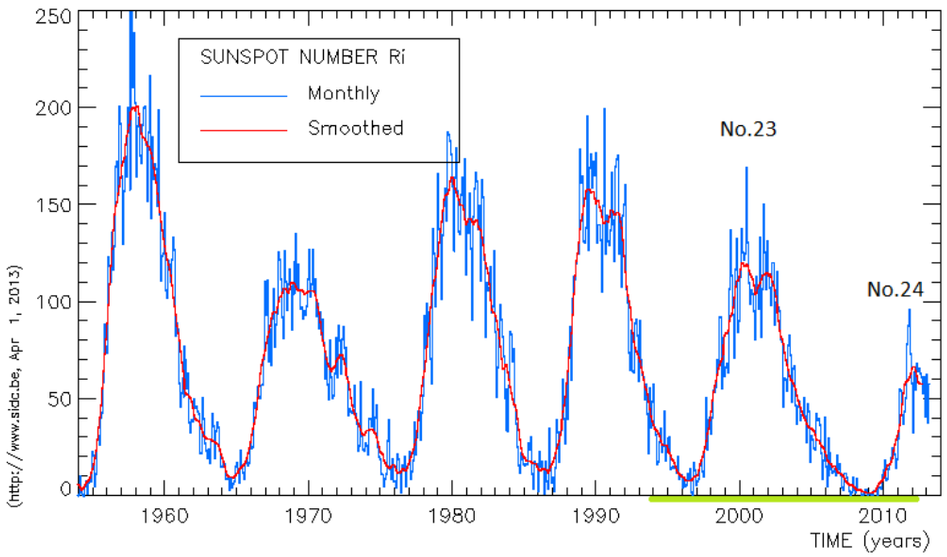
- **foF2** The **critical frequency** of the ionospheric F2 layer
- **TEC** **Total Electron Content**, content of free electrons in the ionosphere

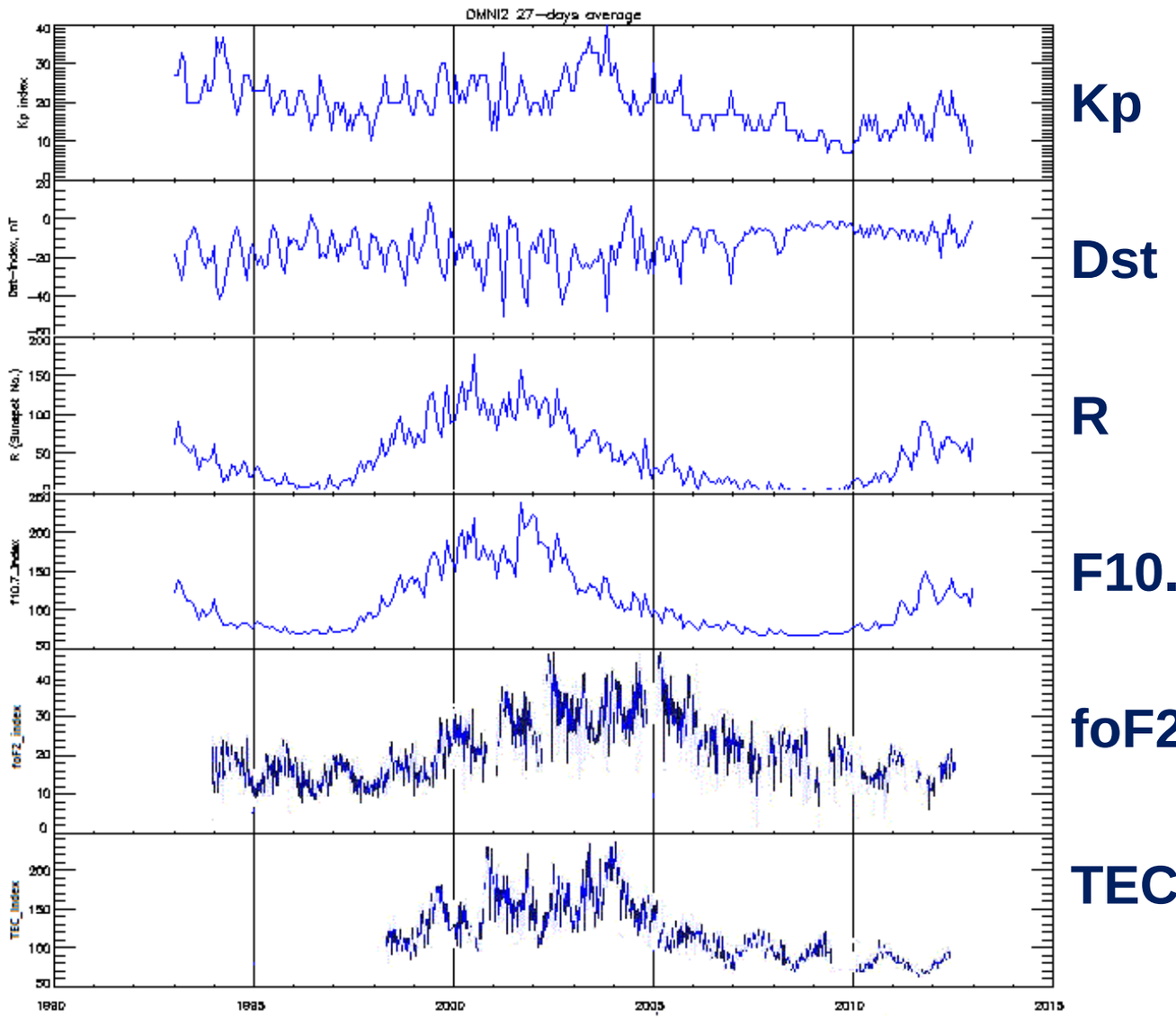
Solar cycle – changes of physical conditions

- **Solar, geomagnetic and ionospheric parameters**
- **Solar cycle**

- Solar activity varies about 11-year cycle
- Changes of the sunspot number, geomagnetic activity and quantity of high energetic particles

- Period from years 1994 to 2012
- Solar Cycles No.23 and No.24





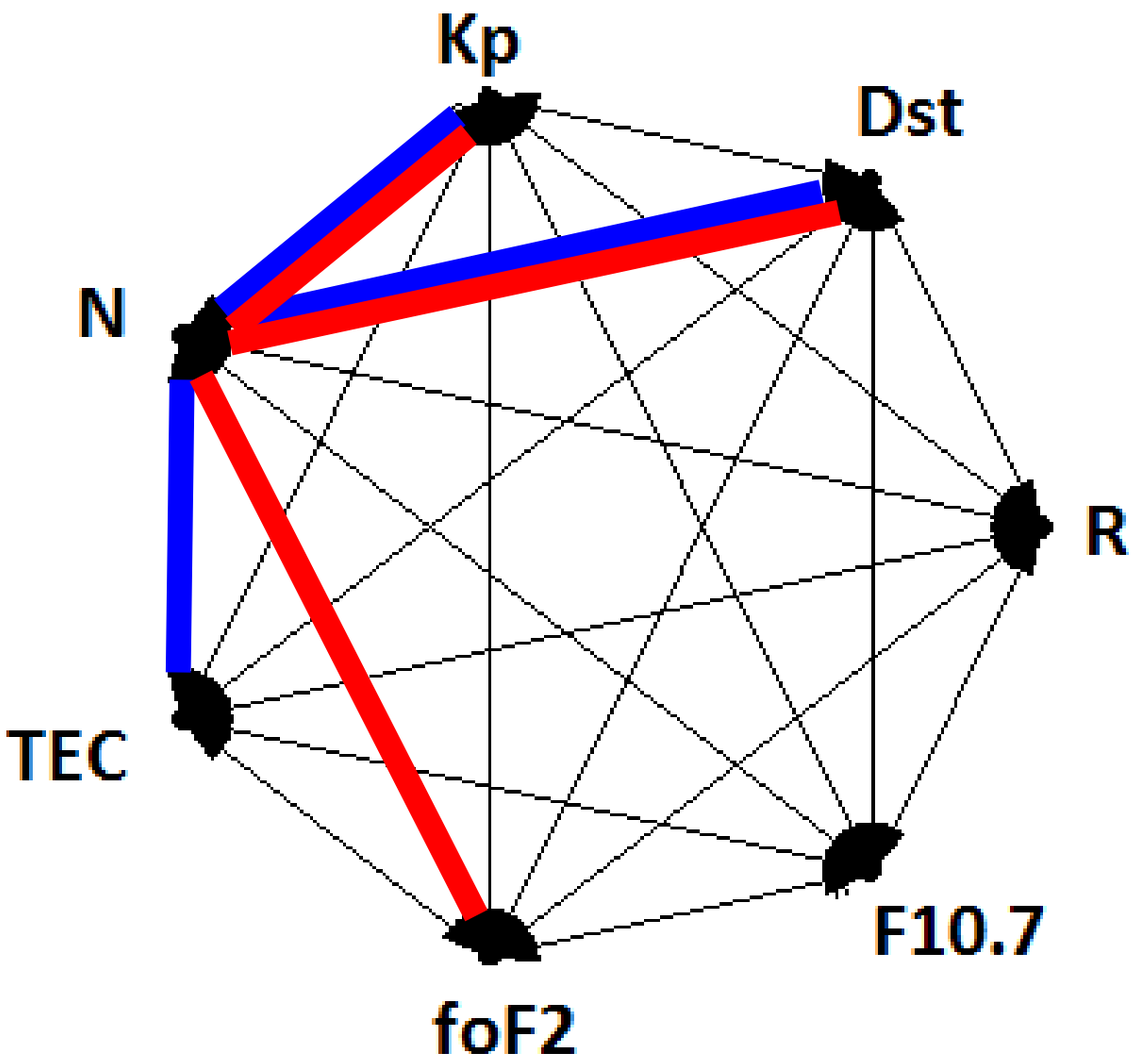
ÚFA

Interpetation of CIG for diseases of the nervous system

G20 Parkinson disease

conditional dependence

Males <39	**---**
Males 40+	**Kp, Dst, TEC**
Females <39	**---**
Females 40+	**Kp, Dst, foF2**



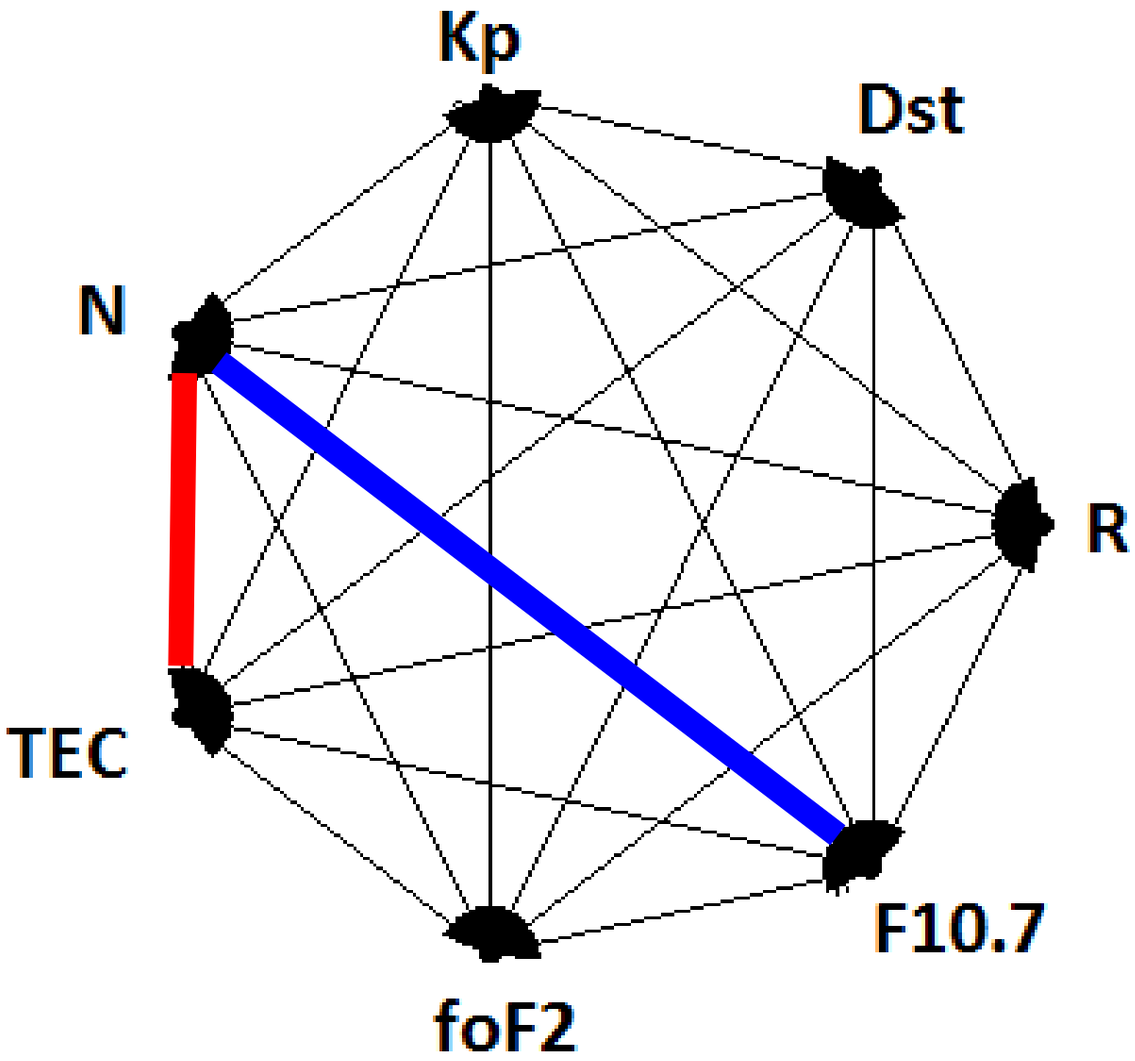
ÚFA

Interpetation of CIG for diseases of the nervous system

G31 Other degenerative diseases of nervous system

conditional dependence

Males <39	**---**
Males 40+	***F10.7***
Females <39	**---**
Females 40+	***TEC***



ÚFA

Interpetation of CIG for diseases of the nervous system

G35 Multiple sclerosis - sclerosis multiplex

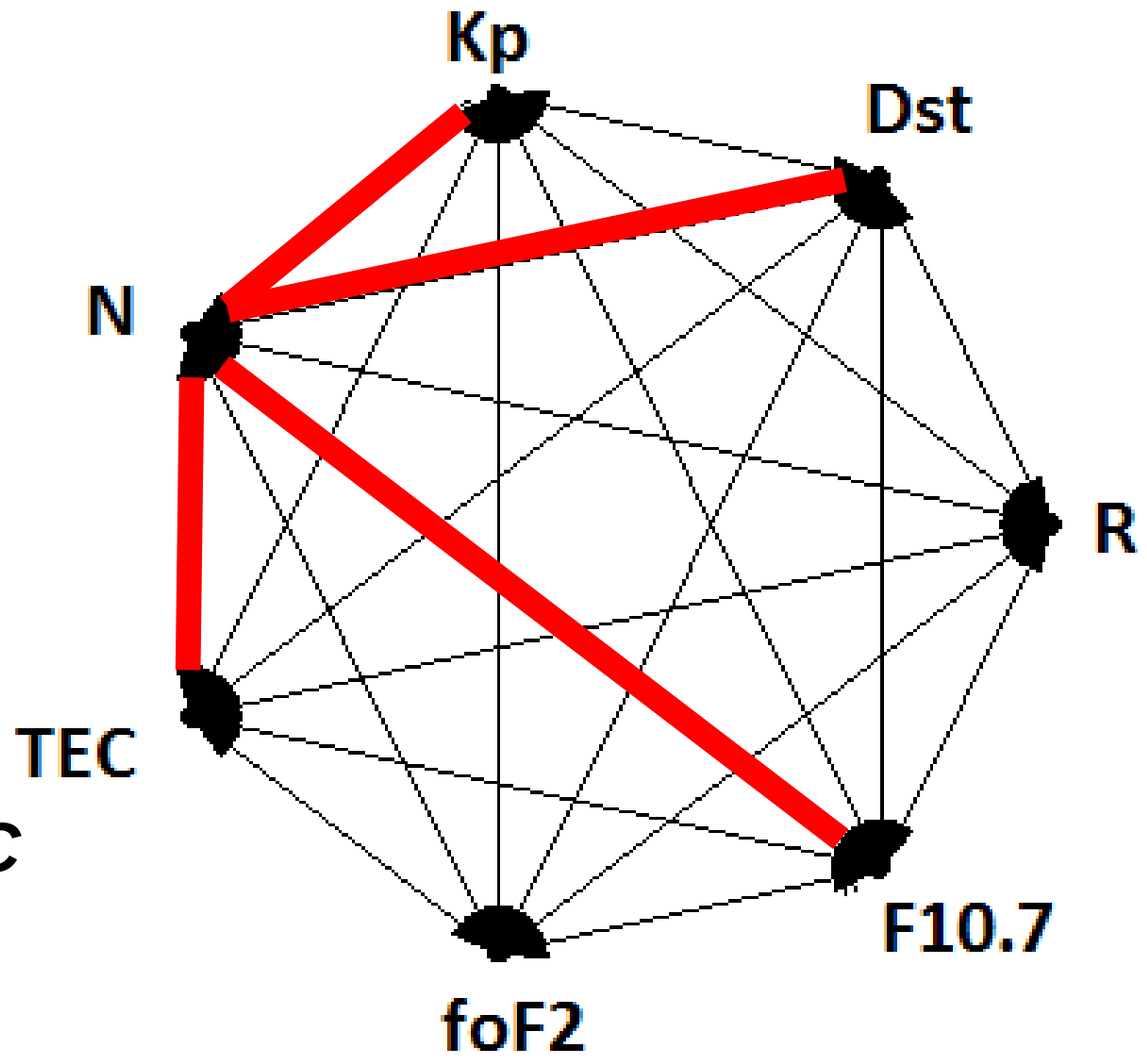
conditional dependence

Males <39 ---

Males 40+ ---

Females <39 ---

Females 40+ ***Kp, Dst, F10.7, TEC***



Interpetation of CIG for diseases of the nervous system

G40 Epilepsy

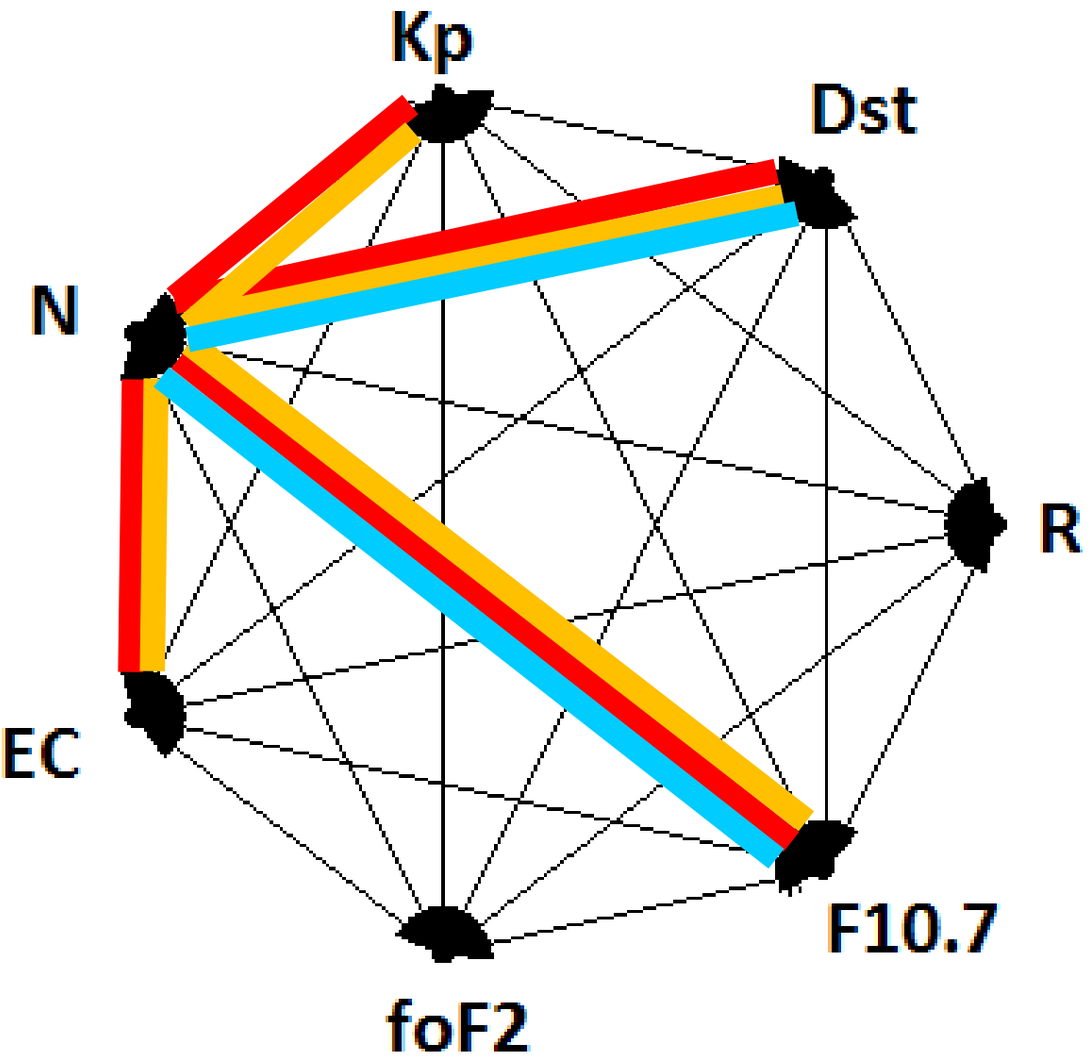
conditional dependence

Males <39 ***Dst*, *F10.7***

Males 40+ **---**

Females <39 ***Kp, Dst, F10.7, TEC***

Females 40+ ***Kp, Dst, F10.7, TEC***



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Interpetation of CIG for diseases of the nervous system

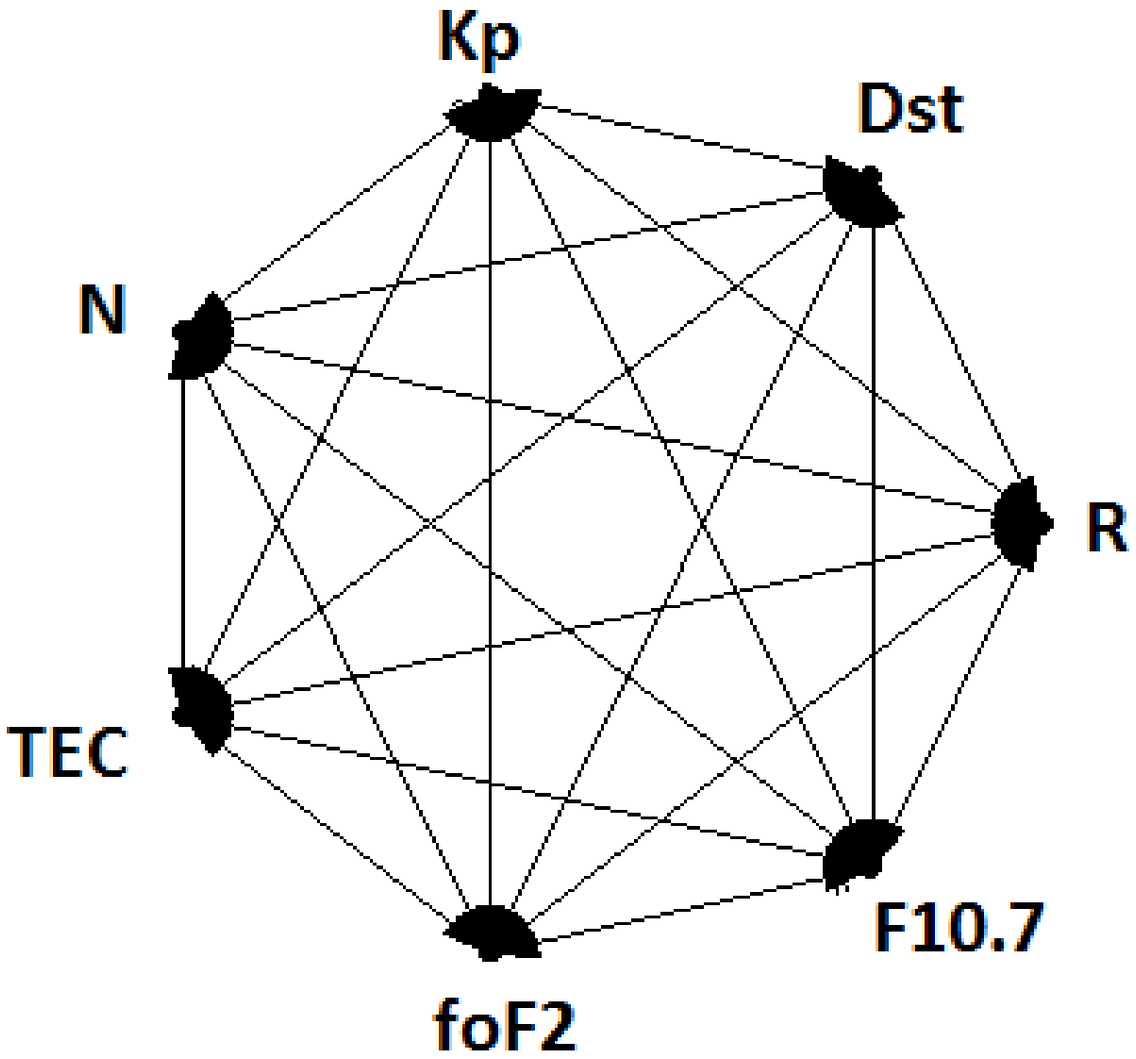
G30 Alzheimer disease, G80 Cerebral palsy

G30 Alzheimer disease

NO conditional dependence with physical parametres is found

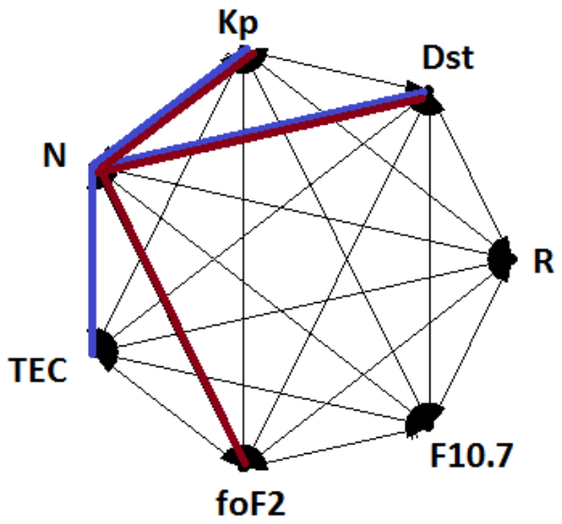
G80 Cerebral palsy

NO conditional dependence with physical parametres is found

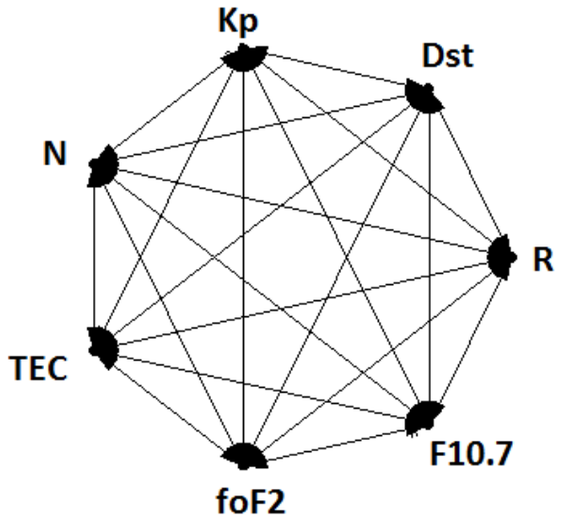


The conditional dependence of the number of deaths by cause on solar, geomagnetic and ionospheric parameters

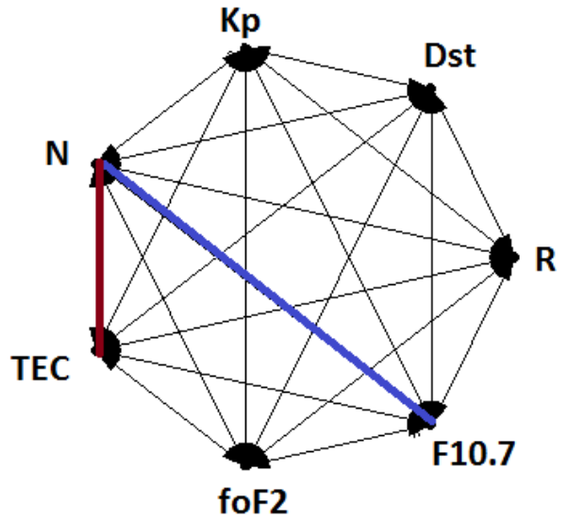
G20 Parkinson disease



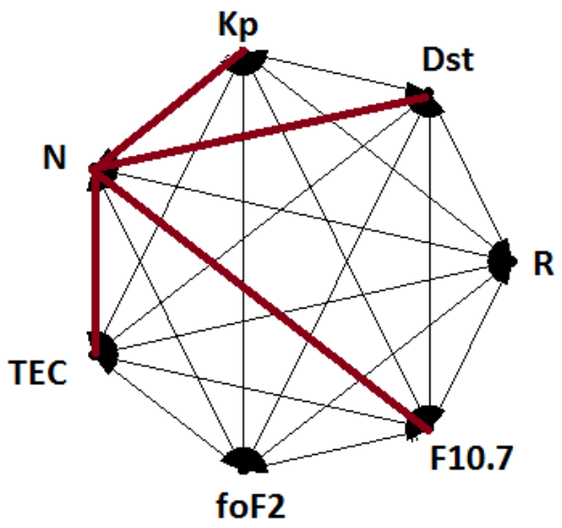
G30 Alzheimer disease



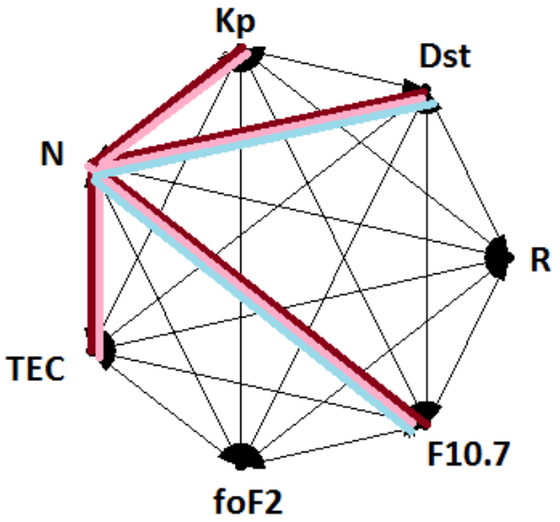
G31 Other diseases



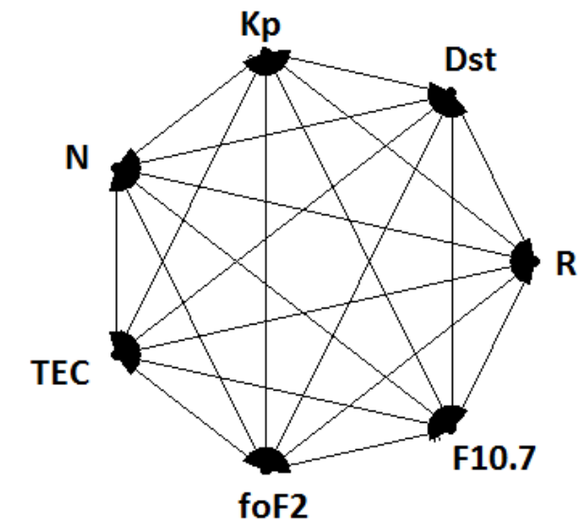
G35 Multiple sclerosis



G40 Epilepsy



G80 Cerebral palsy



ÚFA

Conclusion

	conditional dependence
Males <39	
G40 Epilepsy	***Dst*, *F10.7***
Males 40+	
G20 Parkinson disease	***Kp, Dst, TEC***
G31 Other degenerative diseases	***F10.7***
Females <39	
G40 Epilepsy	***Kp, Dst, F10.7, TEC***
Females 40+	
G20 Parkinson disease	***Kp, Dst, foF2***
G31 Other degenerative diseases	***TEC***
G35 Multiple sclerosis	***Kp, Dst, F10.7, TEC***
G40 Epilepsy	***Kp, Dst, F10.7, TEC***

- G30 Alzheimer disease - no conditional dependence with geophysical parametres.
- G80 Cerebral palsy - no conditional dependence with geophysical parametres.

Data sources

- **Number od deaths by cause:**
  Department of Demography and Geodemography, Přf UK, ČSÚ
- **Kp index:**
  World Data Center for Geomagnetism, Kyoto University, Japan
- **R, AE index, Dst, F10.7:**
  Space Physics Interactive Data Resource (SPIDR),
  National Geophysical Data Center, Boulder, USA
- **Solar cycle evolving:**
  NWRA/CoRA, NorthWest Research Associates, Boulder, USA
  Deutsches GeoForschungsZentrum, Helmholtz-Zentrum, Germany
- **foF2:**
  UK Solar System Data Centre, Rutherford Appleton Laboratory, GB, JR055 Juliusruh/Rugen
- **TEC:**
  Institut Géographique National (IGN), France

Thank you
for your attention

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The study was supported by the Charles University in Prague, project GA UK No. 2515