EXS 51:
Advances in Aerobiology

MULTIVARIATE CORRELATION OF DEPOSITION DATA OF 8 DIFFERENT AIR POLLUTANTS TO LICHEN DATA IN A SMALL TOWN IN SWITZERLAND.

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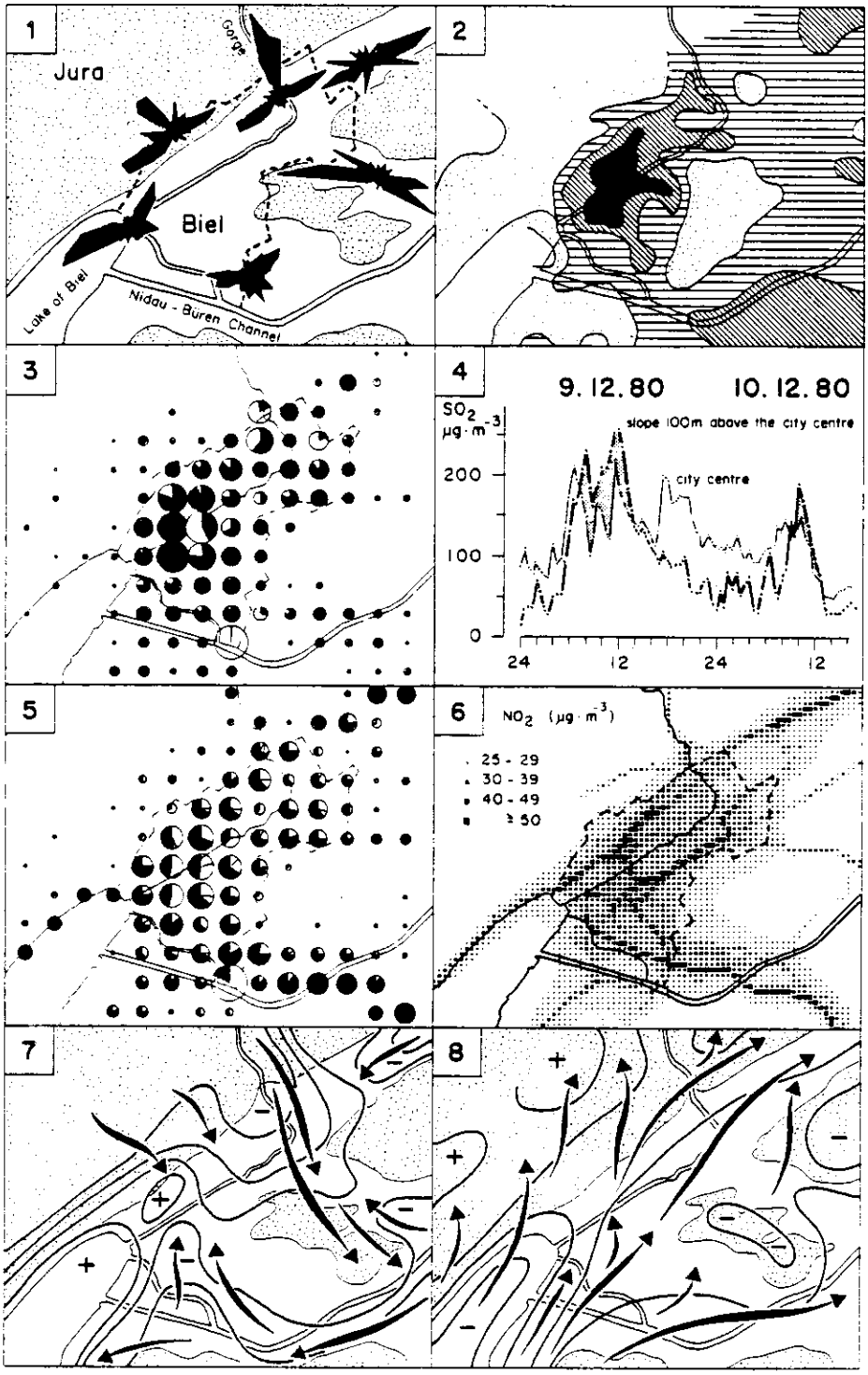
1. Introduction, interdisciplinary concept

Since 1980 a group of scientists of the Universities of Berne, Lausanne, land-use planners and politicians have been working on an interdisciplinary study concerned with meteorology, air pollution and land-use planning in Biel-Bienne, Switzerland ("Nationales Forschungsprogramm Nr. 14, NFP 14") HERZIG,R. et al.1985, 1987, WANNER,H.et al.1986.
For further details regarding interdisciplinary concept of the study see captions of Fig. 1. The study shows that the degree of air pollution in a small town like Biel, which is surrounded by well-marked hills, differs only slightly from that of larger towns like Basel and Zürich. It is planned to co-operate with decision-making government agencies in Biel.

Figure captions for Fig. 1 on next page

1: Biel area: Topography, land-use, wind roses for six locations which are representative of conditions found within the study area (discontinuous line: urban area dotted surfaces: hills or mountains.
2: Regional distribution of calibrated lichen Index of Atmospheric Pollution in the Biel area in five zones. Black shaded area: lichen desert, diagonal strips: inner struggle zone, horizontal strips: outer struggle zone, dotted area: transition zone, white area: normal zone.
3: Emission inventory for SO_2. All the sources have been converted to a 500m grid. The largest circle represents 45 tons SO_2 per year. Black sectors show the proportion of domestic heating.
4: SO_2-concentration (half hour values), recorded in two typical stations (city center and southern slopes of Jura mountains).
5: Same representation as in No.3, but for NO_x. The largest circle represents 50 tons NO_x per year. The black sectors show the proportion causes by traffic.
6: Mean annual concentration of NO_2 ($\mu g/cm^3$), Gaussian plume model.
7: Nighttime fields of potential temperature (2m, thin lines) and streamlines of the boundary layer air flow (10m, arrows), typical for a high pressure weather situation with weak synoptic winds. Cold air pools or heat islands are marked with a plus or minus symbol.
8: Same representation as in No.7, but for the early afternoon.

Fig. 1: next page. Wanner,H. et al. 1986


1
Jura
Gorge
Biel
Lake of Biel
Nidau - Büren Channel
2
3
4
9.12.80
10.12.80
SO_2 $\mu g \cdot m^{-3}$
slope 100m above the city centre
city centre
200
100
0
24
12
24
12
5
6
NO_2 $(\mu g \cdot m^{-3})$
25 - 29
30 - 39
40 - 49
≥ 50
7
8

2. Sampling concept of lichen data

Based on a modified grid concept after Wildi (1981), 528 sites (trees) where chosen at random, situated as well- balanced as possible within 48 grid units of 100 hectares and 52 grid units of 25 hectares within the area of Biel.
A "Fequenzleiter" (frequency grid) after Kunze 1972 has been modified, so that a grid of 10 subunits arranged in two vertical rows was attached to the trunk, the grid being delimited by a system of horizontal nylon ropes and vertical, perforated metal bars.
The following data were collected on the site:

2.1. general data on sample and site, coordinates, detailed sketch of situation, orientation of grid.

2.2. data on ecology of site, land-use and population density data traffic situation, hydrological situation, status of surface, topography of the nearest surrounding of site.

2.3. tree and trunk data: tree species, trunk circumference, bark texture, illumination of analysed area, inclination.

2.4. lichen data per each species recognized
- frequency in 11 classes
- coverage in 7 classes
- vitality in 3 classes
- thallus damage in 3 classes
- average age of population in 3 classes
- spectrum of species

3. Immission data

We understand biomonitoring as a method to determine an overall pollution of all components which might harm in any way the monitors of a given site. What we need consequently to meet our goal of optimization and calibration of a lichen monitor analysis is a set of deposition data on air pollutants which is as large as possible over a minimum period of one year. An existing network on deposition data collecting sites of the town of Biel had to be expanded from 10 to 14 stations measuring not only SO_2 and dust, but also NO_3, Cl, Pb, Zn, Cd, Cu. This was made possible with the help of the government of Biel.
SO_2, NO_3^-,and Chlorine were analysed in a Liesegang instrument filter extract by HPLC (Pfenninger in Landolt,W. et al. 1985)
Dust (total annual load) was obtained gravimetrically, and Pb^{2+}, Cu^{2+}, Zn^{2+}, Cd^{2+} were measured by atomic absorption spectroscopy Bergerhoff deposition tubs.

4. Development of calibrated IAP method.

The aim of our biological study within the NFP 14 was to develop a method which would later allow to map in detail air pollution impact by means of a lichen statistics calibrated to the deposition data of eight pollutants (SO_2, NO_3, Cl, dust, Pb, Cu, Cd, Zn). An evaluation by multiple linear regression of 20 different IAP formulas (Lichen Index of Atmospheric Purity) showed that sum of frequency alone, on a moderately reduced set of 40 species, can be correlated best to pollution data.

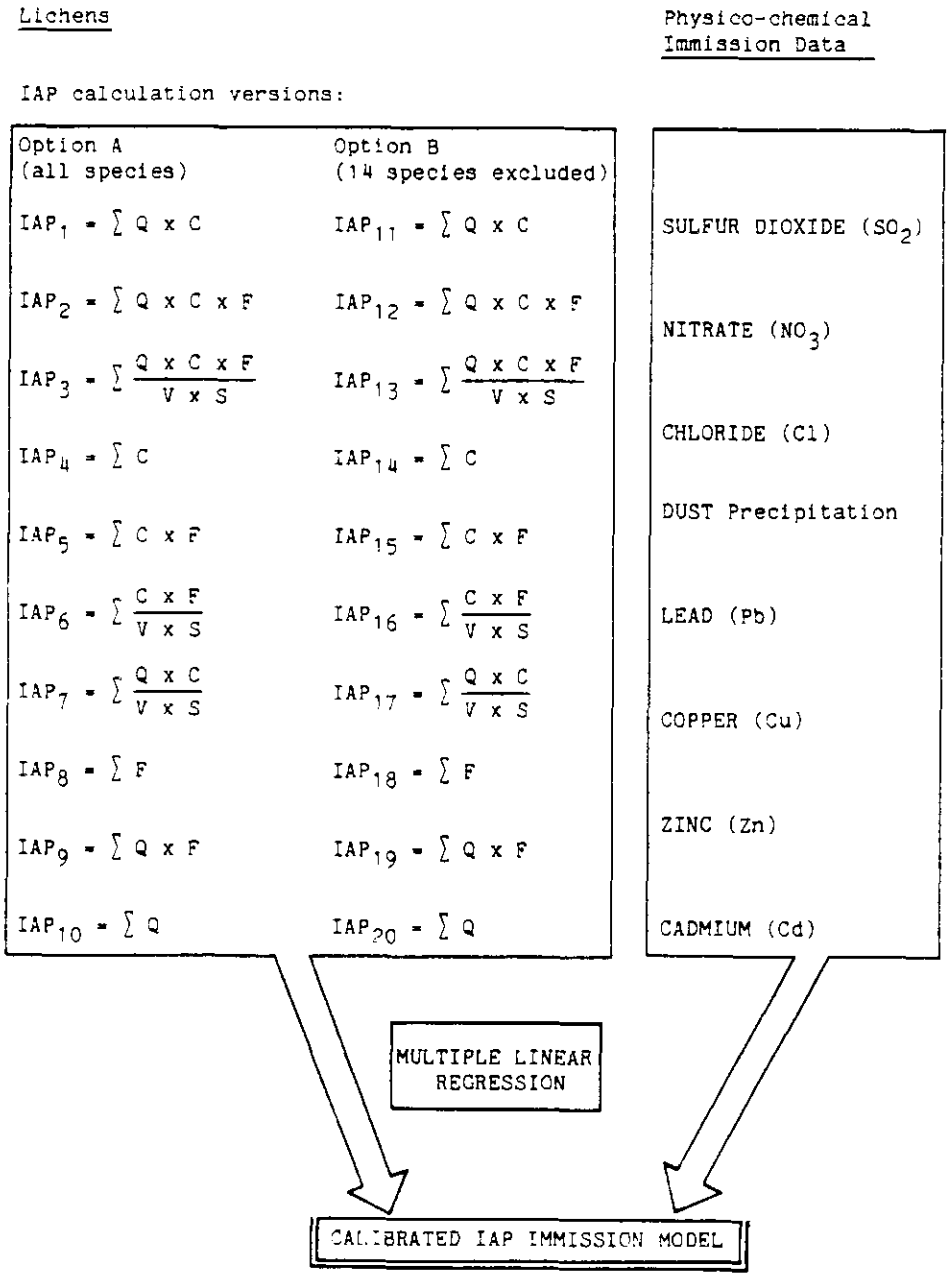


Fig. 2: Multivariate calibration of IAP method

With a probability of over 97 % one can predict total impact of air pollution by calculating IAP value No.18 (sum of frequency of 40 species) in the Biel area.

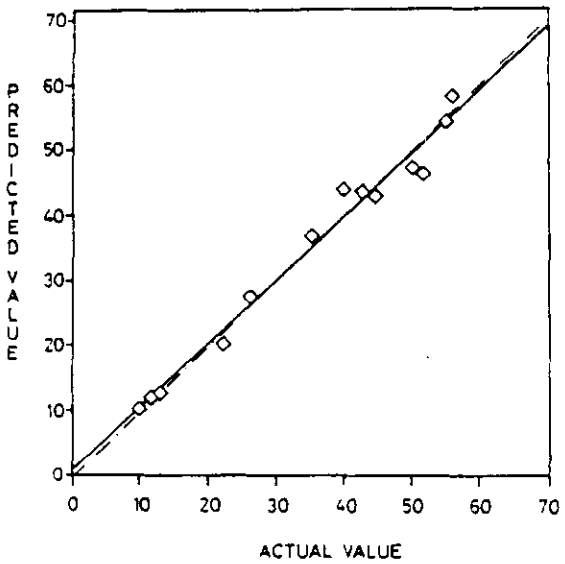


Fig. 3: Overall model obtained by multiple linear regression including SO_2, NO_3, Cl, Dust, Pb, Cu, Zn, Cd.

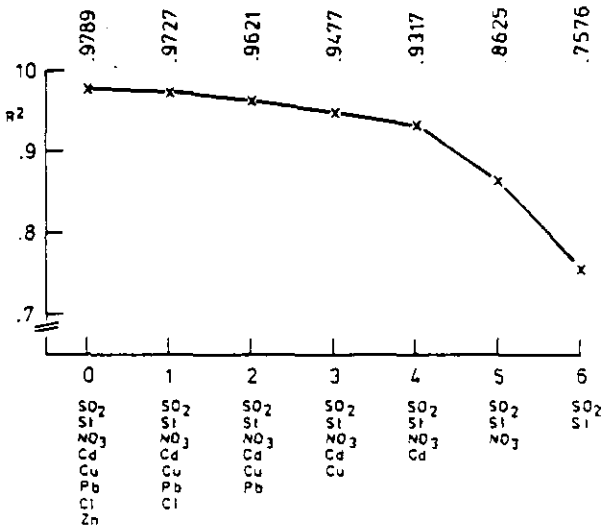


Fig. 4 Step by step elimination of air pollution parameters; related R^2 values.

Elimination of pollution parameters step by step revealed a minimum number of 4 to 5 parameters to guarantee a good model (calibration) quality and in addition it showed that there is no clear cut redundancy of any one parameter.

This, and the fact one can choose almost freely any of the parameters for elimination leads to the conclusion that it is best to keep all pollution parameters in the model together for calibration. In our interpretation the above mentioned 8 parameters are a good indicator collective to describe total impact of atmospheric pollution on lichens in the region of Biel.

5. Calibrated IAP zone map

IAP zones have been constructed out of over 500 lichen analyses on trees in the region of Biel. Further details on lichen analysis and calibration and lichen map in colors in press: HERZIG,R. et al. 1987.
It can be clearly seen that the lowest lichen activity (lichen desert) was registered in the center of the city. The following zone ("inner struggle zone"), representing still a quite low lichen activity, can be seen either in a belt surrounding the lichen desert, or far out of the city, specially in industrial areas and village centers. (Fig. 1, No. 2).

6. Conclusion

Multivariate calibration of lichen data and pollution data has been achieved for the first time in Biel, and, most recently, for the second time on a larger scale on the Swiss plateau, using quantitative pollution data of the NABEL measuring network. This makes it possible to construct zonation maps with a statistically supported relationship to the overall load of air pollution. Government agencies may thus be interested in this screening method to delimit problem areas at considerably low costs.

Literature cited

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