



Strål
säkerhets
myndigheten

Swedish Radiation Safety Authority

Multivariate analysis of release data and environmental monitoring data

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What

- ➔ A statistical study of correlations between releases and environmental concentrations
- ➔ A project conducted by Rolf Bergman Consulting



Aim of the study

- ➔ Investigate if there are correlations between measured releases and measured concentrations in the environment
- ➔ See how different species can work as indicators for releases
- ➔ Input for revision of the Swedish environmental surveillance programmes

Sites

- ➔ Oskarshamn, Forsmark and Studsvik:
 - Releases to water and air and corresponding species were analysed
 - Summarised here
- ➔ Ringhals
 - Only water releases and marine species were analysed
 - Not described here



Radionuclides

➤ NPP:s

- Co-58
- Co-60
- Cs-137
- Zn-65
- Mn-54
- Fe-59

➤ Studsvik

- Co-60
- Cs-134
- Cs-137
- Eu-152
- Eu-154
- Mn-54



Method – Multivariate analysis

- ➔ Statistical tool
- ➔ Many different variables
- ➔ Dependent variables
- ➔ Few observations (missing data)
- ➔ Further details
 - References



Results

- Quantifiable correlations between releases and environmental concentrations
- Several samples showed significant correlations and mathematical models were identified
- Models valid for activity within the interval that was used in the analysis
- Models can indicate deviations, e.g. when a non-monitored release has occurred

Results Oskarshamn

- ➔ Significant models for
 - Water: 5 of 6 nuclides, not Fe-59 (probably due to few data)
 - Air: Zn-65
- ➔ Sufficient to measure 1 variable

Results Oskarshamn cont.

Nuclide	Number of variables (n)	Prediction ability (%) n variables	One variable (station species)	Prediction ability (%) one variable
Co-58 water	3	91,7	S12_bladder wrack	76,7
Co-60 water	4	90,0	S12_bladder wrack	89,5
Cs-137 water	18	79,4	S17_bladder wrack	72,0
Mn-54 water	3	70,0	S12_bladder wrack	64,2
Zn-65 water	10	75,8	S1_yellow eel	59,6
Zn-65 air	4	76,3	SB_dryopteris filix-mas	71,4



Results Forsmark

- ➔ Significant models for
 - Water: 5 of 6 nuclides, not Fe-59 (probably due to few data)
 - Air: Co-60
- ➔ 1 variable models for all above except
 - Mn-54 to water
 - Co-60 to air

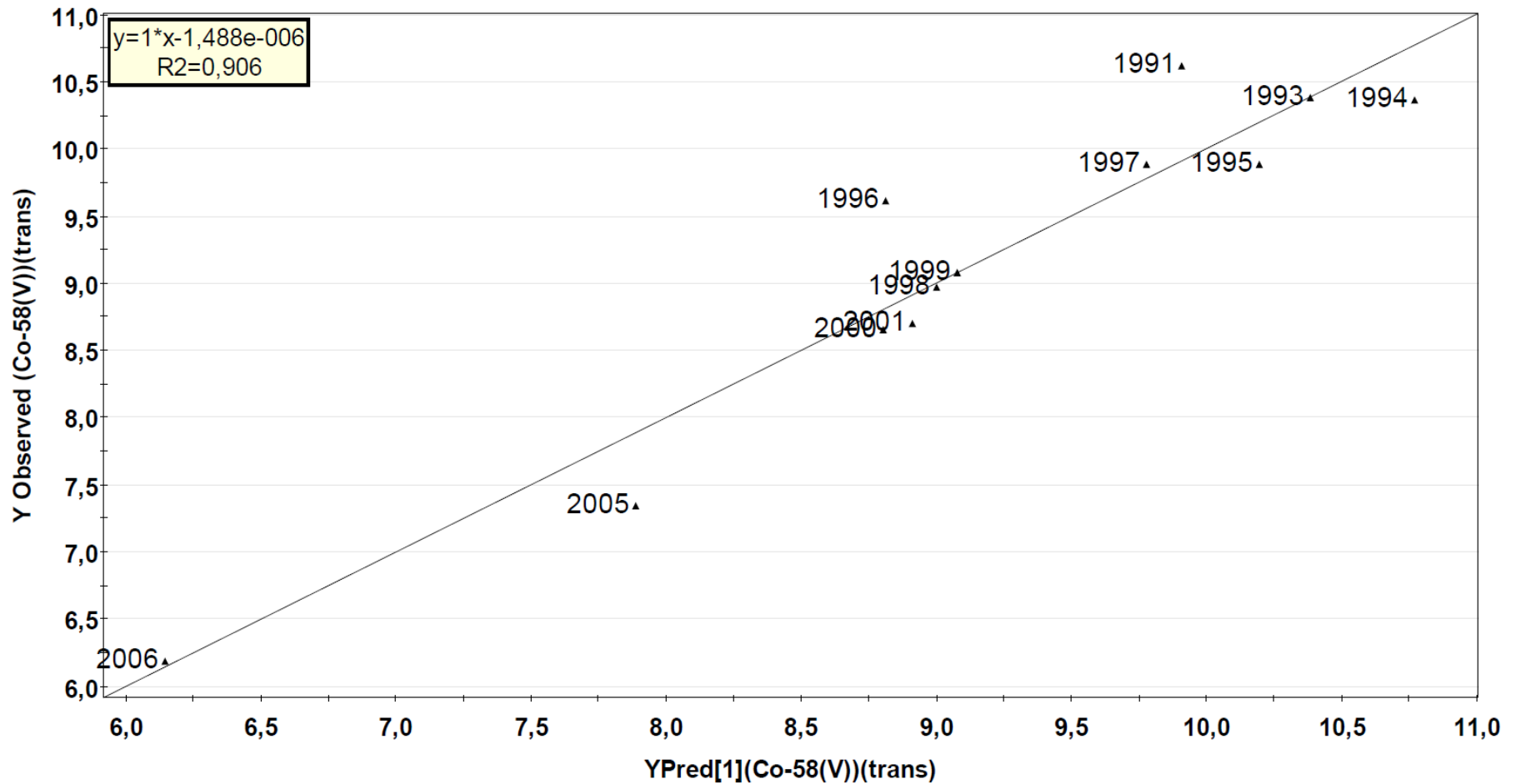
Results Forsmark cont.

Nuclide	Number of variables (n)	Prediction ability (%) n variables	One variable (station species)	Prediction ability (%) one variable
Co-58 water	3	96,7	S101_ongrowth	89,7
Co-60 water	11	85,9	S101_ongrowth	93,6
Cs-137 water	11	37,9	S101_ongrowth	72,9
Mn-54 water	2	64,9	-	-
Zn-65 water	4	90,3	S104_bladder wrack	93,7
Co-60 air	2	86,2	-	-



Results Forsmark cont.

Co-58 to water, station S101, ongrowth sample, prediction ability 89,7 %





Results Studsvik

- ➔ Significant models for
 - Water: all nuclides
 - Air: Cs-134, Cs-137
- ➔ 1 variable models for all above except
 - Cs-134 to water and air

Conclusions

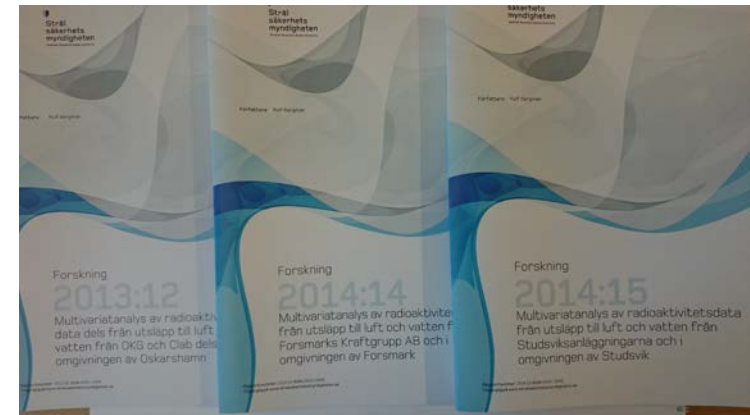
- ➔ Possible to identify the most reliable environmental samples to reflect releases
- ➔ In general, the more variables the better the prediction ability
 - Not always true
 - Cs-137 in Forsmark and Studsvik, can be due to Chernobyl fallout

Conclusions cont.

- ➔ Specific variables contribute significantly to the prediction of releases
 - Bladder wrack / fucus
 - In Forsmark also ongrowth samples
- ➔ Similar results for Ringhals

References

- ➔ Reports for Oskarshamn, Forsmark and Studsvik can be found on SSM:s website (in Swedish):
 - <http://www.stralsakerhetsmyndigheten.se/Publikationer/Rapport/Stralskydd/2013/201312/>
 - <http://www.stralsakerhetsmyndigheten.se/Publikationer/Rapport/Stralskydd/2014/201414/>
 - <http://www.stralsakerhetsmyndigheten.se/Publikationer/Rapport/Stralskydd/2014/201415/>
- ➔ Further information about the tools can be found at www.umetrics.com





Thank you for your attention!