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Earth Systems Science Course in Watersheds &
Coastal Zone Simulation Modeling
2 - 13 October 2000

"Atmospheric Input"

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International Centre for Theoretical Physics

Earth Systems Science Course in Watersheds & Coastal Zone Simulation Modeling

Miramare - Trieste, 2-13 October, 2000

Atmospheric input

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International Centre for Theoretical Physic

Earth Systems Science Course In Watersheds & Coastal Zone Simulation Modeling

Atmospheric input to aquatic ecosystems

Summary

- **Sampling and analysis**
- **Wet, dry and other components**
- **Interaction with forests and soil**
- **Po Valley & Northern Adriatic Sea System**
- **Nutrients input to Adriatic sea:**
  - **(a) Evaluation of rainfall over Adriatic Sea**
  - **(b) Atmospheric depositions data and loads calculation**

Atmospheric deposition loads

TOTAL DEPOSITION

Σ[**wet** (rain, snow, hail, fog, dew, rime, troughfall),
dry (gas, particulate, …)]

Atmospheric fluxes **[M/L²*T]**

wet = {[concentration] * water equivalent volume}
(mg/L)(m^3/m^2 yr)*

dry = {[concentration] * deposition velocity}
(μg/m^3)(cm/s)*

Deposition velocity

$$v = 1 / (r_a + r_b + r_s)$$

r_a = advection resistance (*turbulent transport*)
r_b = boundary resistance (*laminar transport*)
r_s = surface storage resistance

Each resistances depending by a complex functions of meteo-climatic features (wind, temperature, humidity, etc.) of deposition site, surface complexity (roughness) and composition (water, soil, metals, vegetation, stone, etc.), geometry, etc.

- The high complexity of the dry deposition mechanism affect the theoretical calculation of these loads.
- The difficulties to collect with high accuracy and spatial representativity the dry fluxes determine the lack in sampling of this important atmospheric component

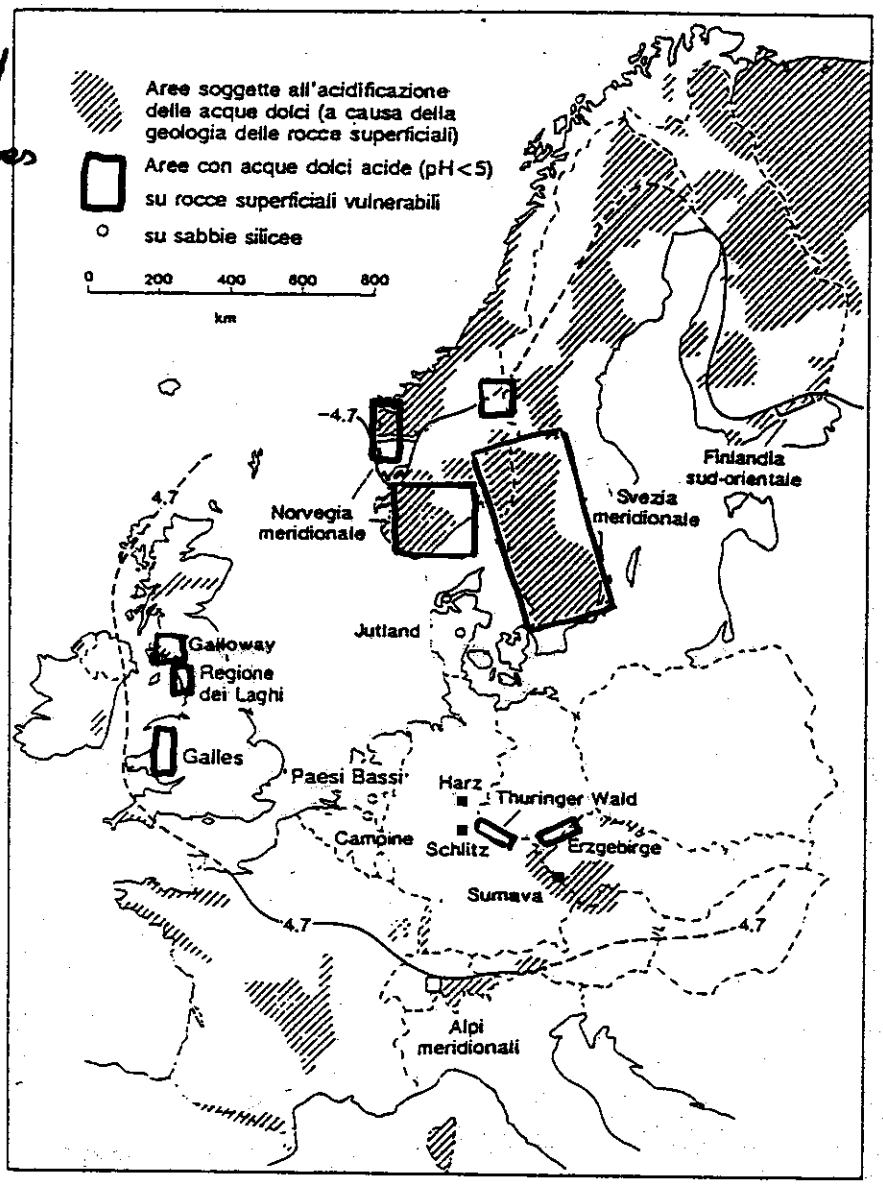
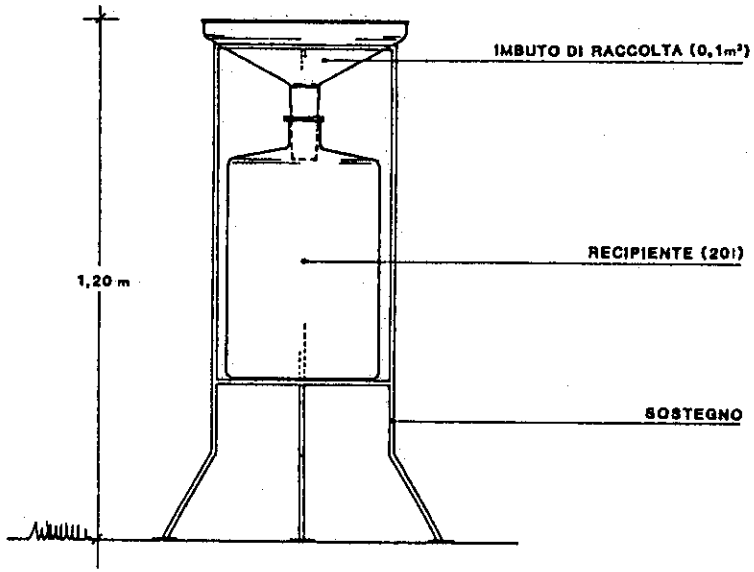


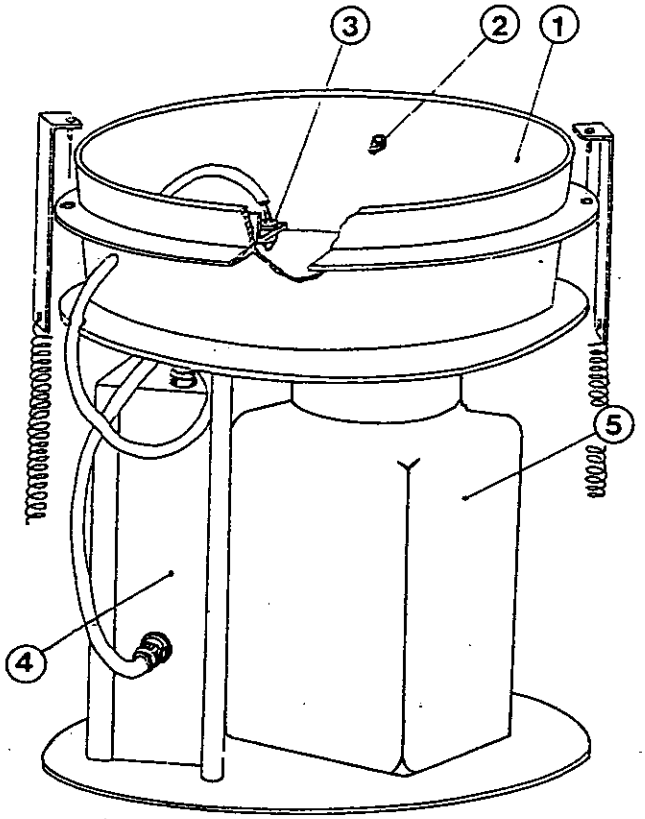
Figura 3.3 Aree soggette all'acidificazione delle acque dolci in Europa, sulla base della struttura geologica delle rocce superficiali. Nota: Le aree comprese nel valore del pH 4,7 sono state interessate dalle precipitazioni acide nei primi anni ottanta. I quadratini neri indicano delle piccole zone con acque dolci acide su rocce superficiali vulnerabili.

Fonte: secondo Wright (1983).

Atmospheric input to aquatic ecosystems

Sampling and analysis


IMBUTO DI RACCOLTA (0,1m²)
RECIPIENTE (20l)
SOSTEGNO
1,20 m



1 - Vaschetta per la raccolta della deposizione secca	**4 - Pompa peristaltica**
2 - Tubo di riempimento dell'acqua	**5 - Serbatoio di acqua da 2L**
3 - Sensore ottico di livello	

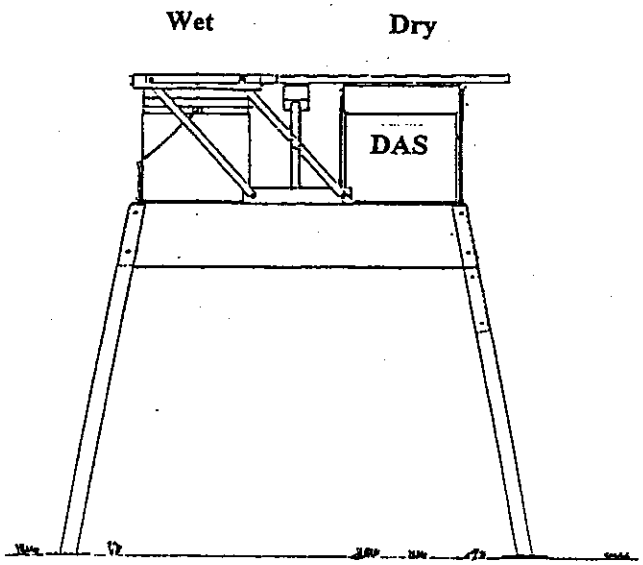


Fig.3 Campionatore wet-DSSA.

Total Atmospheric Deposition

PRISMA and ARF/FLA Project

Method

✪ SAMPLING

- *Type:* Wet, Dry (DAS), Bulk
- *Frequency:* Weekly

✪ ANALYSIS

- *Frequency:*
  - Wet : weekly
  - Dry and bulk : Twice a month

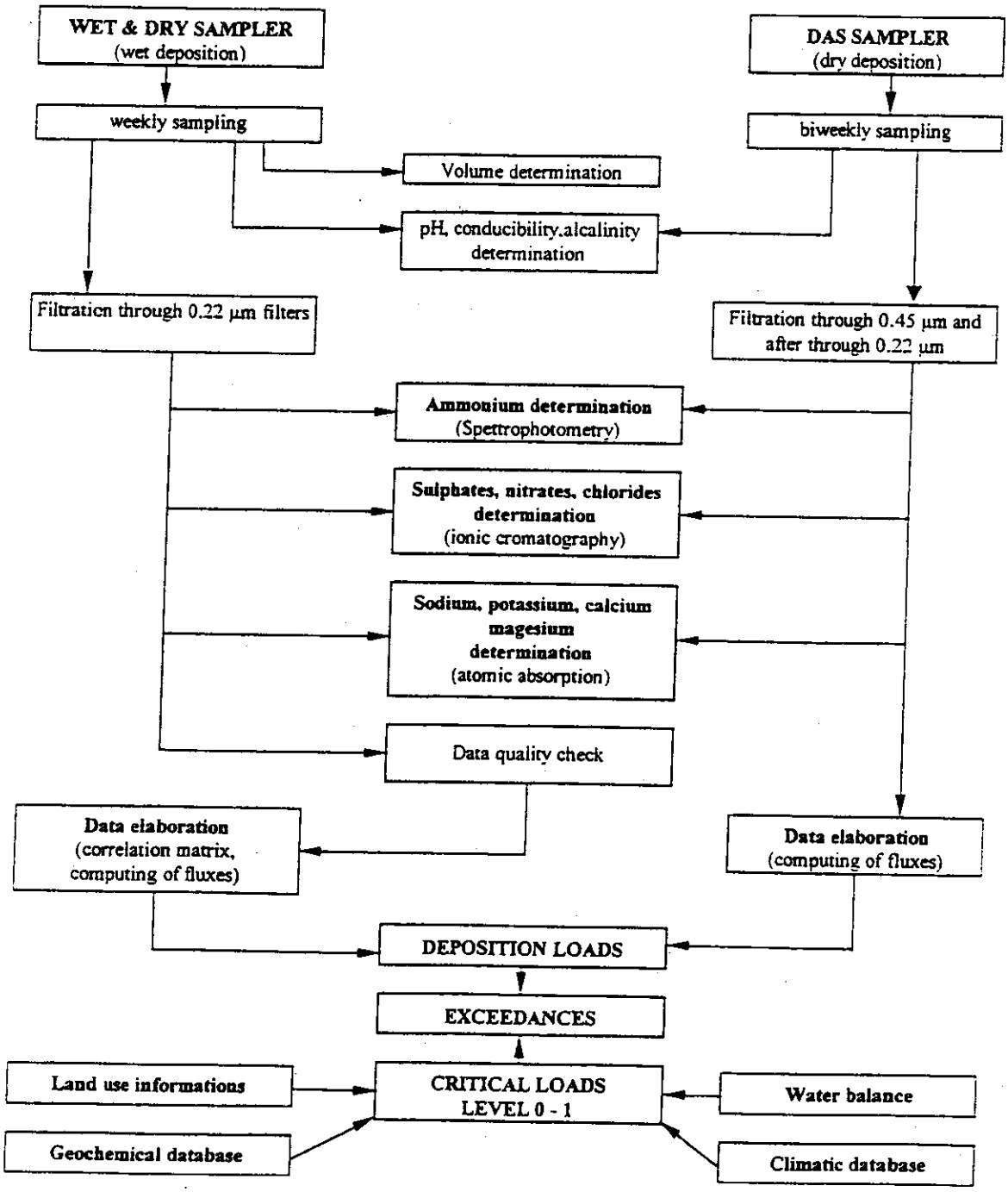
- *Variables measured*
  - **Macroconstituents**: pH, Conductivity, Ammonium, Nitrate, Sulfate, Chloride, Alcalinity, Calcium, Magnesium, Sodium, Potassium.
  - **Nutrients**: Total nitrogen and phosphorus
  - **Metals**

- *Laboratory*
  - *macroconsituents:* PMP-Ferrara and Forlì
  - *nutrients:* IRSA Brugherio
  - *metals:* IGM Bologna

✪ QUALITY ASSURANCE

- *Dedicated protocol calibrated for aims of the PRISMA-program*
- *Analysis:* Ion balance
  Intercalibrations
- *Sampling:* Comparison between bulk and wet/dry samples in coastal station
  Nutrients stability during the sampling periods.
  Preservative methods for in field nutrients conservation

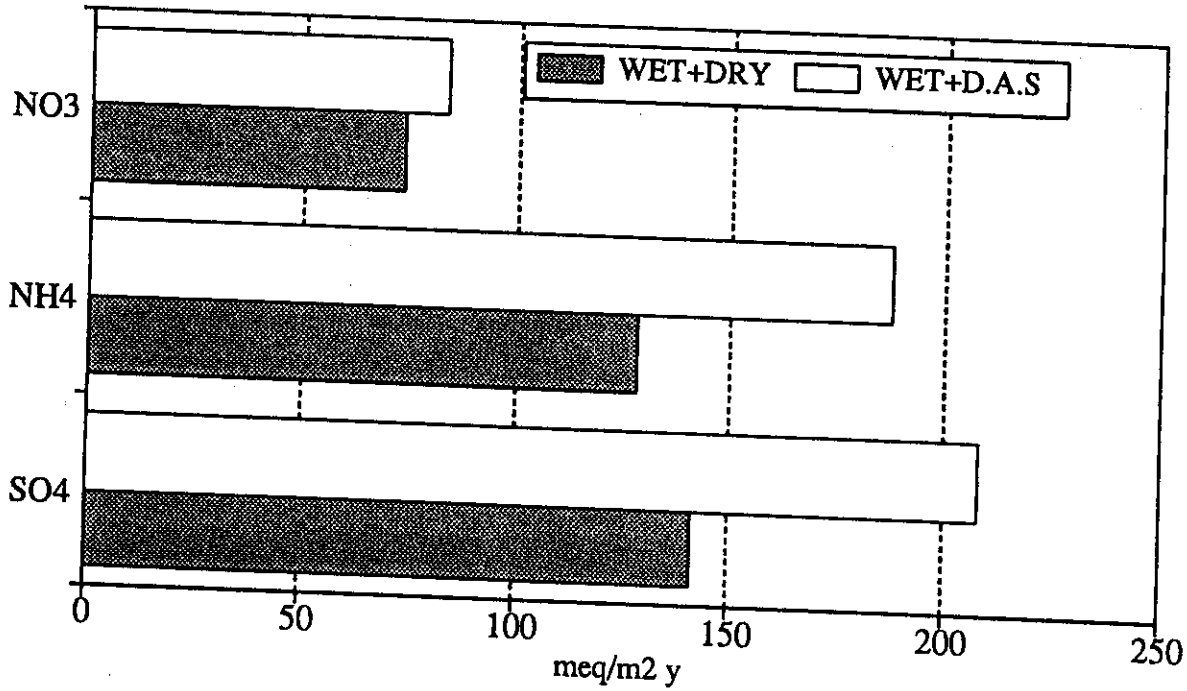
PRINCIPAL STEPS IN THE FIELD EVALUATION OF EXCEEDENCES OF CRITICAL LOADS



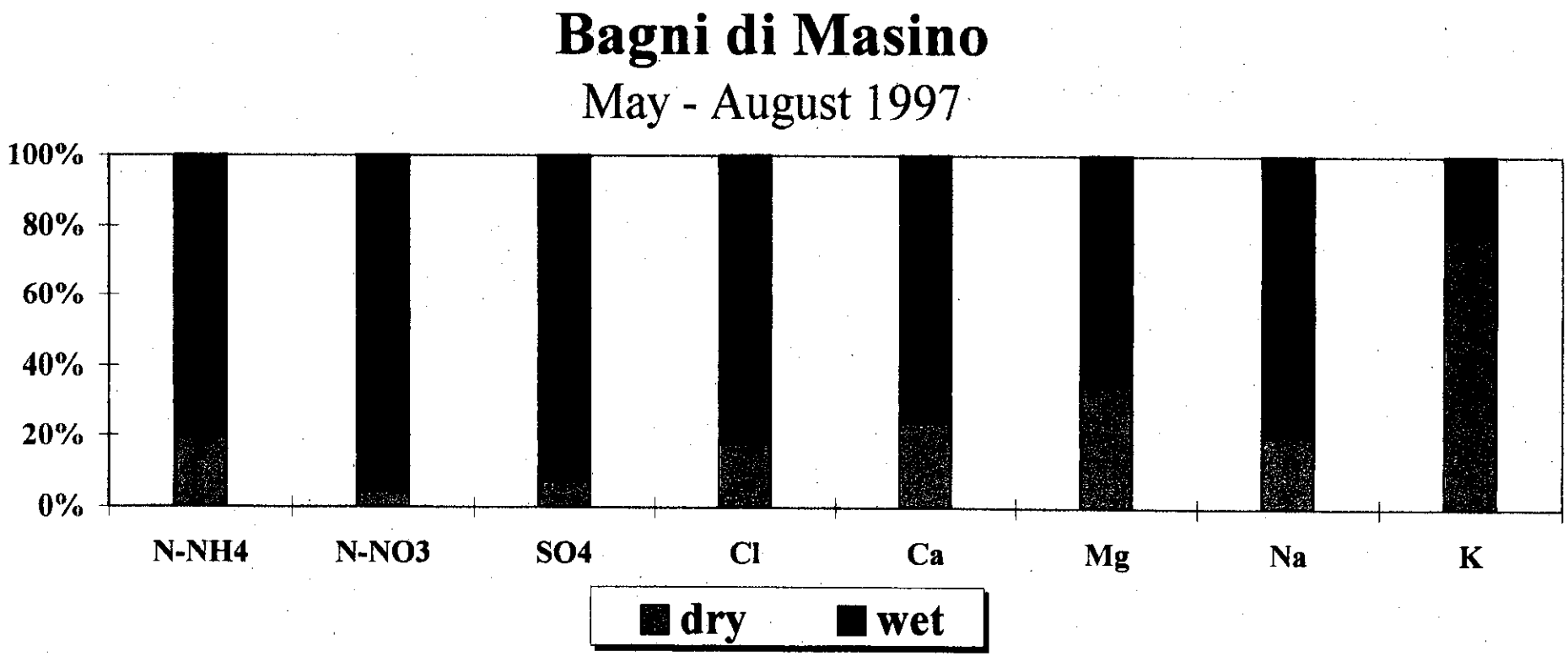
From: Morselli, Cecchini, Barilli, Olivieri,. Chia Laguna, (Cagliari). October 11-18, 1998.

Atmospheric input to aquatic ecosystems

Wet, dry and other components


WET+DRY
WET+D.A.S
NO3
NH4
SO4
0
50
100
150
200
250
meq/m2 y

Openfield dry and wet contribution to total deposition fluxes



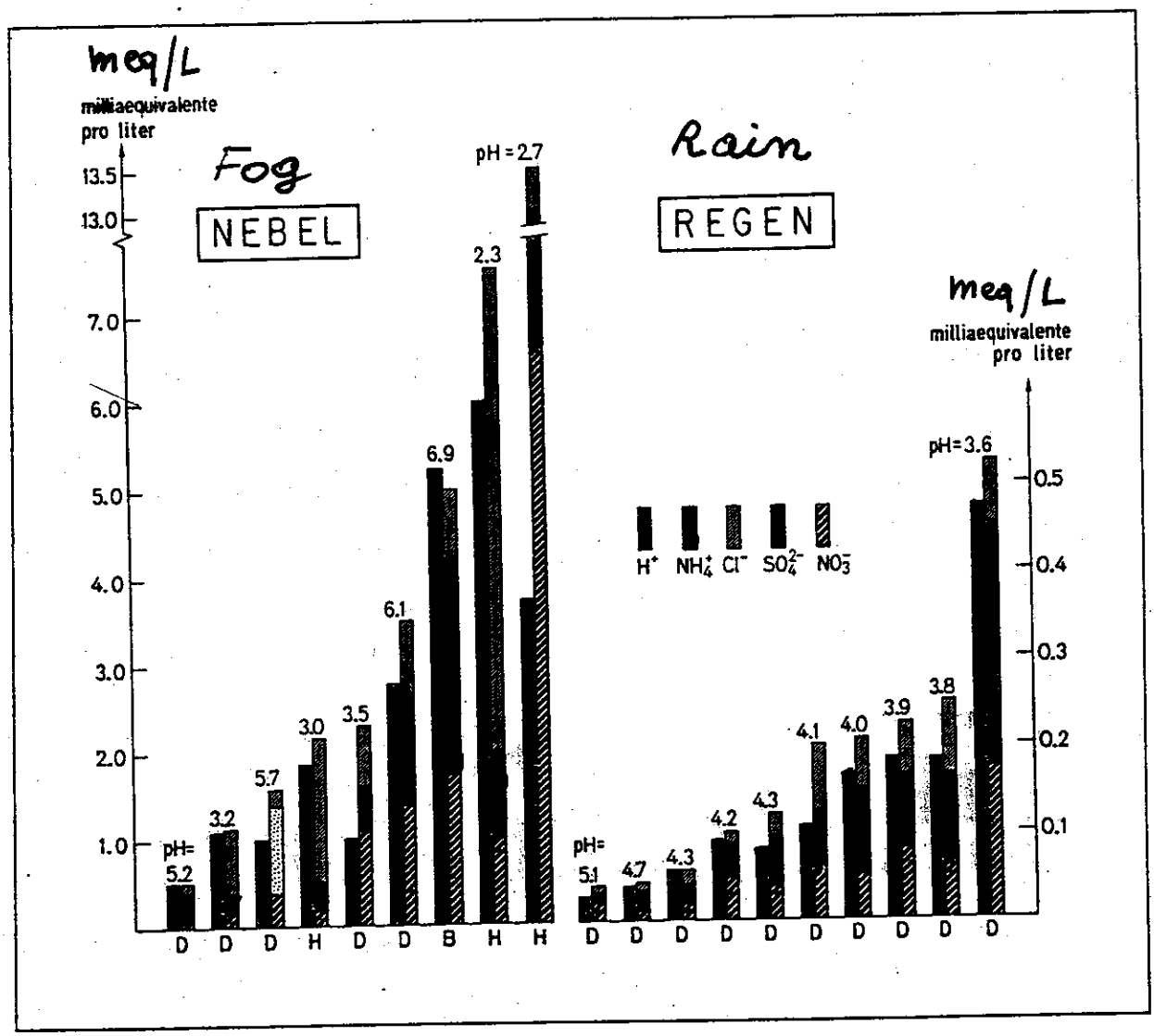


Bild 9

Vergleich einiger Regen- und Nebelanalysen
(Resultate EAWAG, L. Sigg, A. Johnson, J. Zobrist, F. Zürcher, 1984)

Die Regenanalysen stammen aus Dübendorf. Die Nebelproben wurden in Dübendorf oder in der weiteren Umgebung von Zürich erhoben: D = Dübendorf, H = Hochnebel, B = Bodennebel. Man beachte die Unterschiede für Nebel und Regen im Ordinatenmassstab. Bei Regen beträgt die Äquivalentsumme der Ionen 0,05–0,5 Miliäquivalente pro Liter, beim Nebel wird die Konzentration der Schadstoffe um ein bis zwei Grössenordnungen grösser.

TAB. 3 — *Confronto del bilancio annuale della deposizione occulta (nubi) ed umida (precipitazioni) in una foresta dei monti Appalachi, New Hampshire, USA*

Ione	Deposizione occulta (g/m² a)	Percentuale sul totale (%)	Precipitazioni (g/m² a)	Percentuale sul totale (%)
H^-	0,24	62	0,15	38
NH_4^+	1,63	80	0,42	20
$SO_4^=$	10,15	81	2,34	19
NO_3^-	27,58	81	6,48	19

FONTE: LOVETT G.M. ET AL., 1982

TAB. 4 — *Bilancio annuale in una stazione della pianura padana della deposizione occulta (nebbia) al suolo e su vegetazione a medio fusto e della deposizione umida (precipitazioni). Sono anche riportate le quantità di acqua totale depositata nei vari casi*

Ione	Precipitazioni (g/m² a)	Deposizione occulta suolo (g/m² a)	Deposizione occulta vegetazione (g/m² a)
H^+	0,003	0,001	0,02
NH_4^+	2,77	0,09	2,53
NO_3^-	6,34	0,17	5,58
$SO_4^=$	7,50	0,13	3,84
Quantità di acqua depositata (mm equivalenti/anno)	662	5	114

FONTE: FUZZI S., 1987.

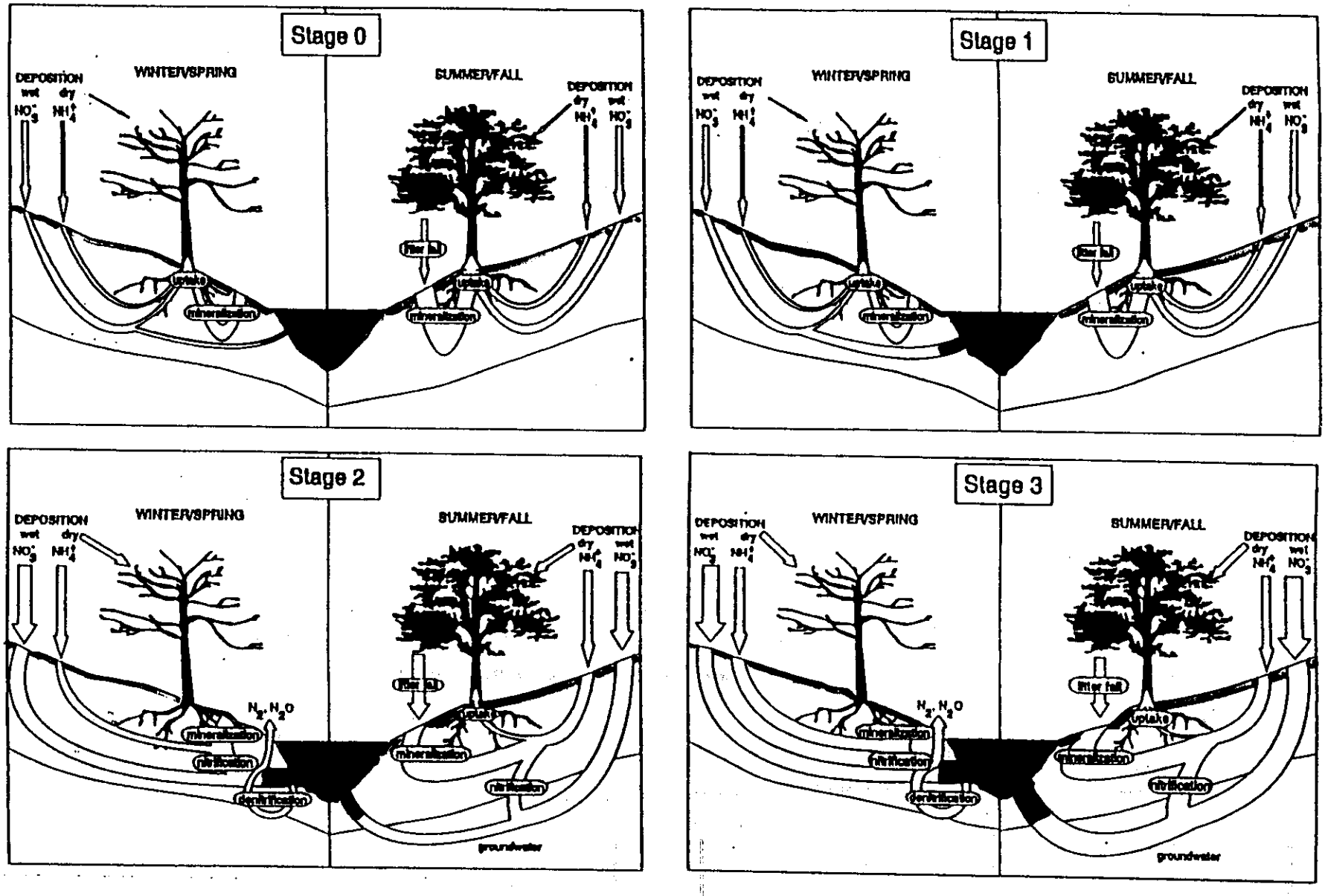
Atmospheric input to aquatic ecosystems

Interaction with forests and soil

11

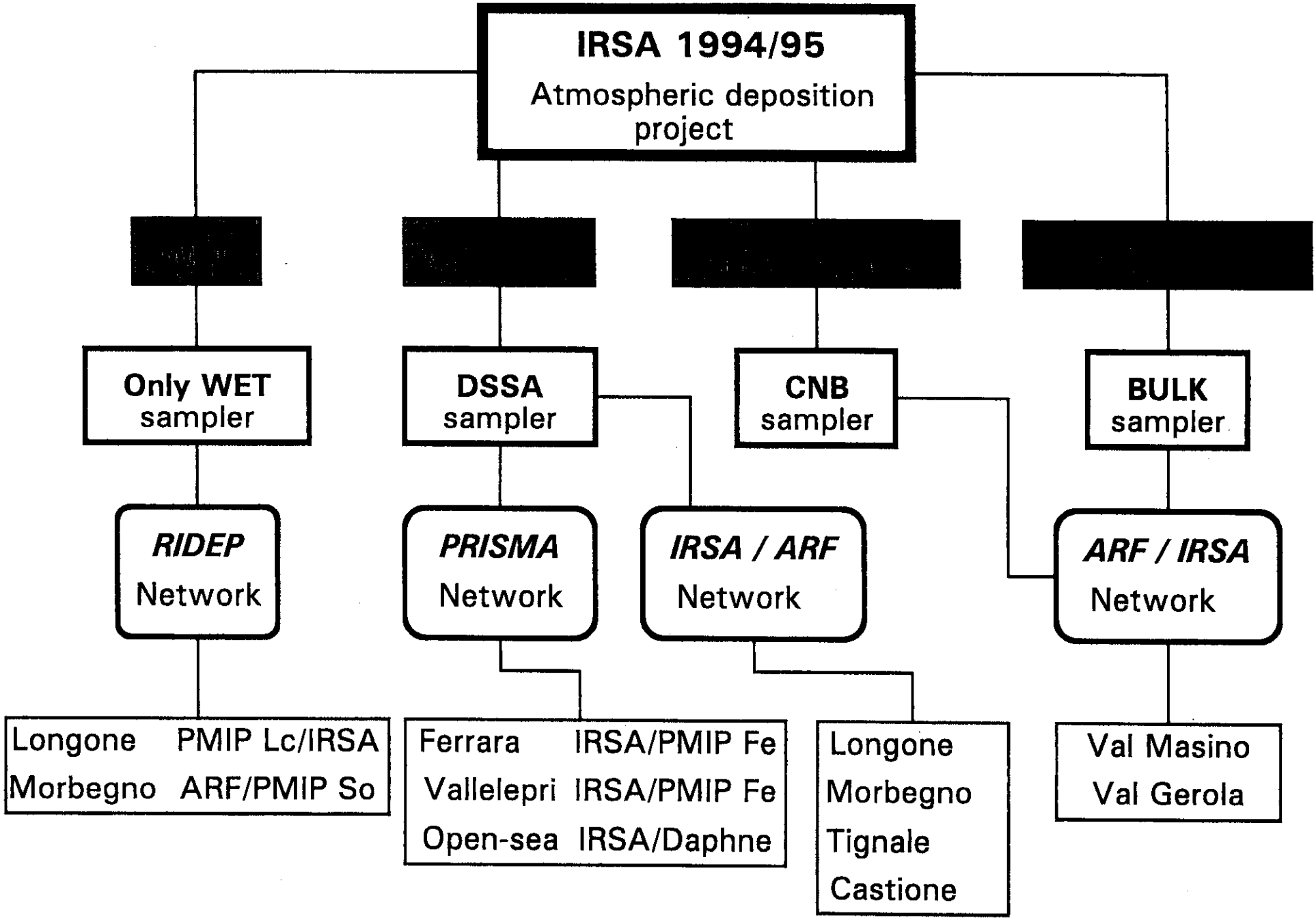
Stima indiretta del superamento dei livelli di carico critico di azoto

Metodo di Traaen and Stoddard (1995)

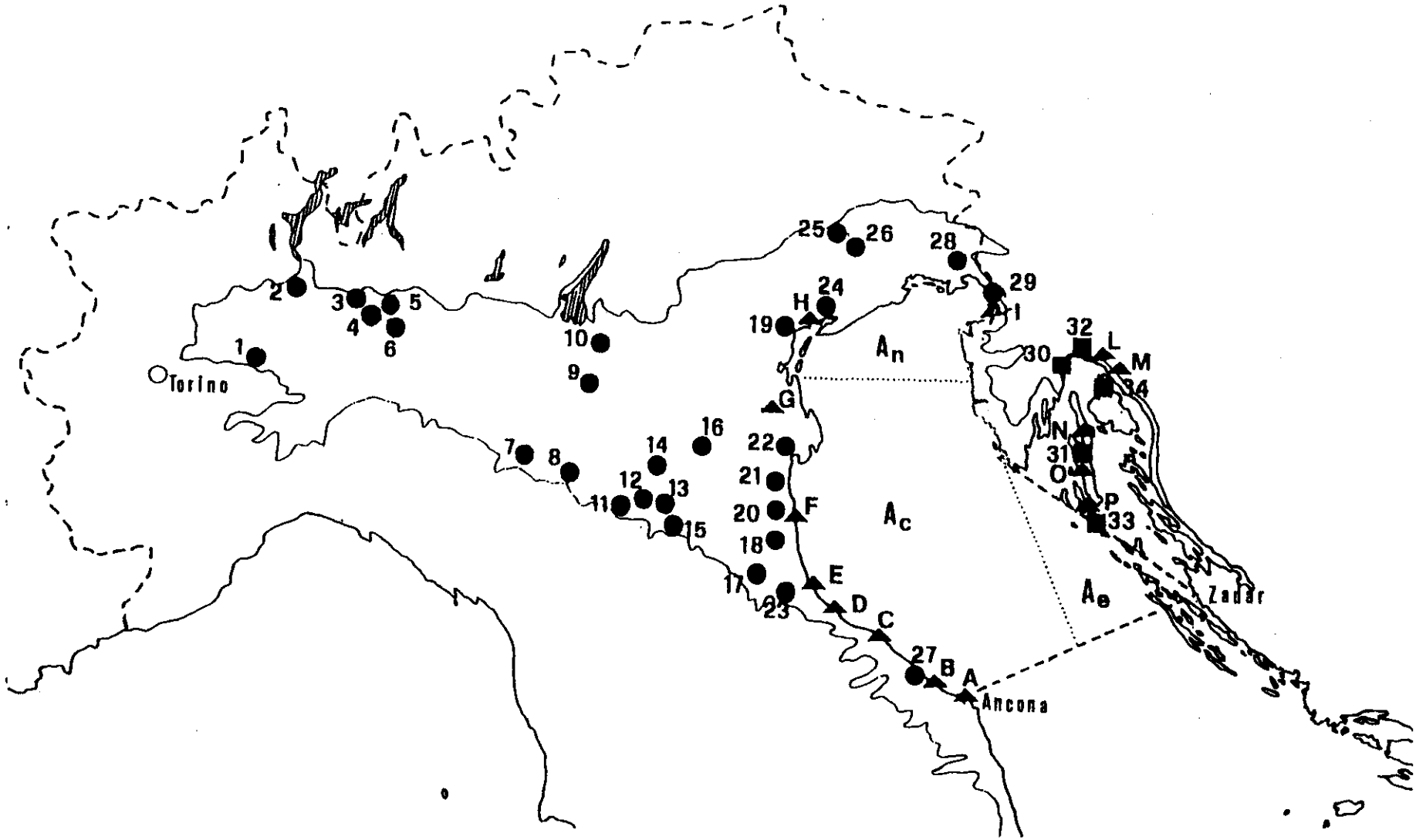


Atmospheric input to aquatic ecosystems

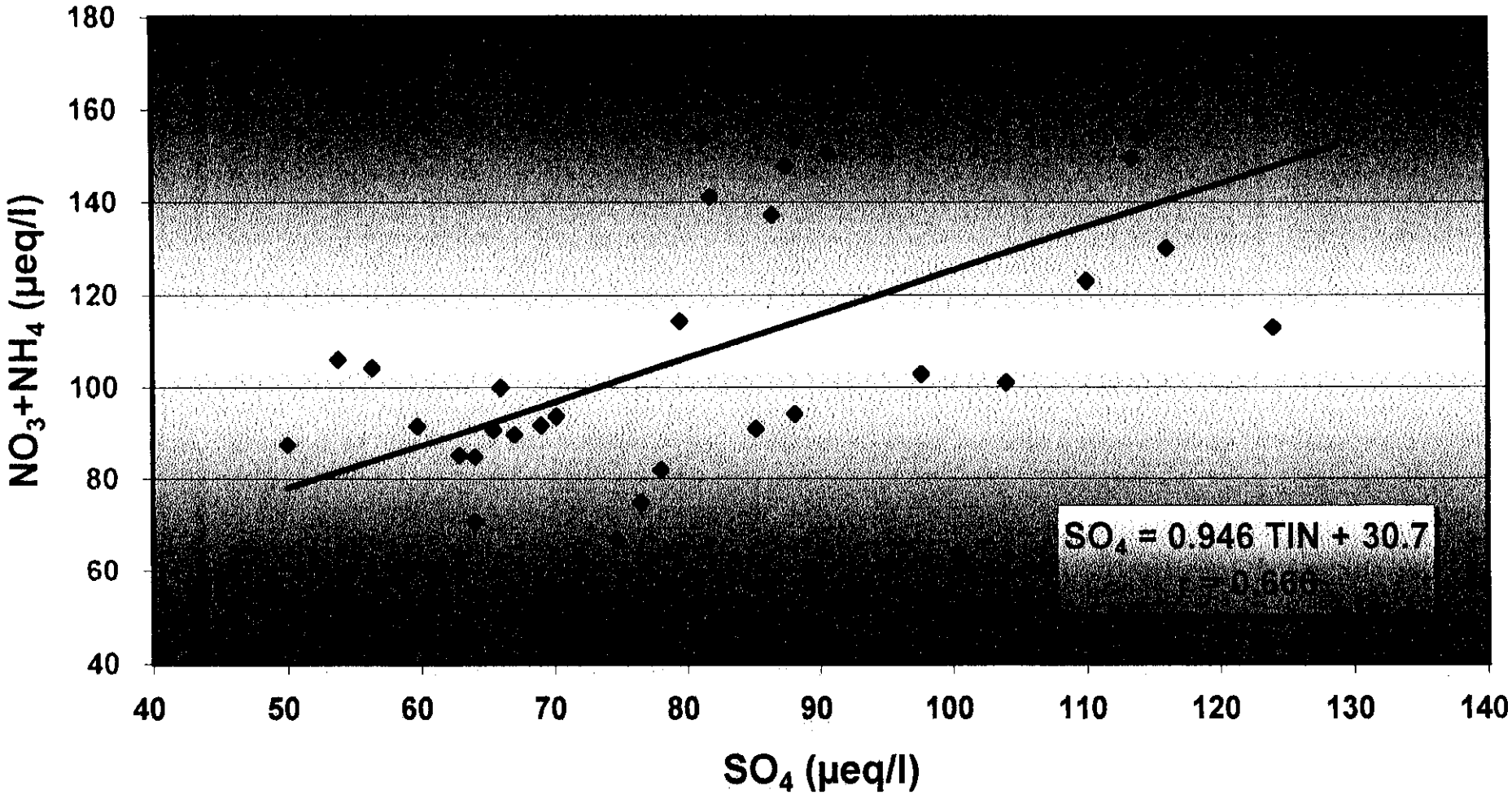
Po Valley & Northern Adriatic Sea System


IRSA 1994/95
Atmospheric deposition project
Only WET sampler
DSSA sampler
CNB sampler
BULK sampler
RIDEP Network
PRISMA Network
IRSA / ARF Network
ARF / IRSA Network
Longone PMIP Lc/IRSA
Morbegno ARF/PMIP So
Ferrara IRSA/PMIP Fe
Vallelepri IRSA/PMIP Fe
Open-sea IRSA/Daphne
Longone
Morbegno
Tignale
Castione
Val Masino
Val Gerola

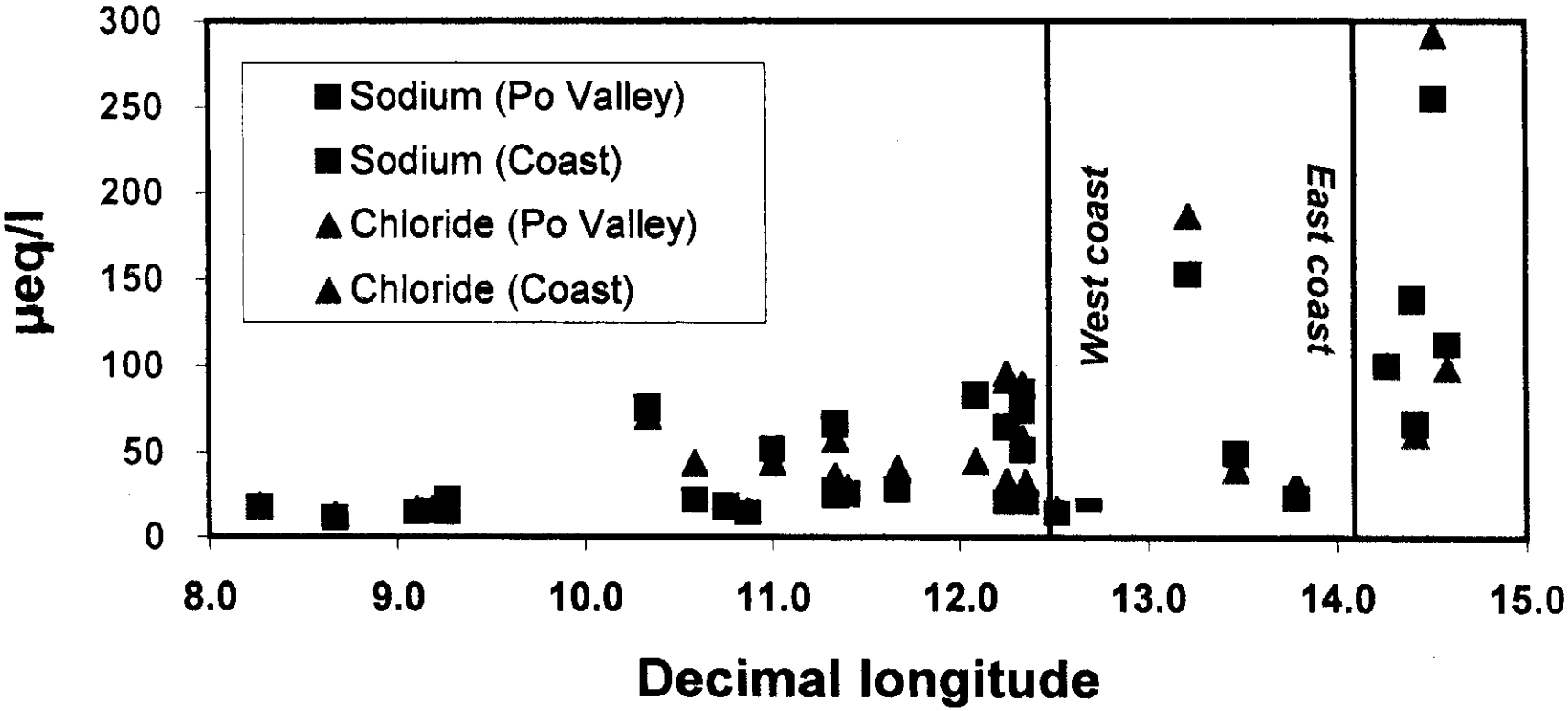
Sampling stations considered in the evaluation of "spatial variability" of atmospheric deposition chemistry (wet component) in Po Valley (Northern Italy)

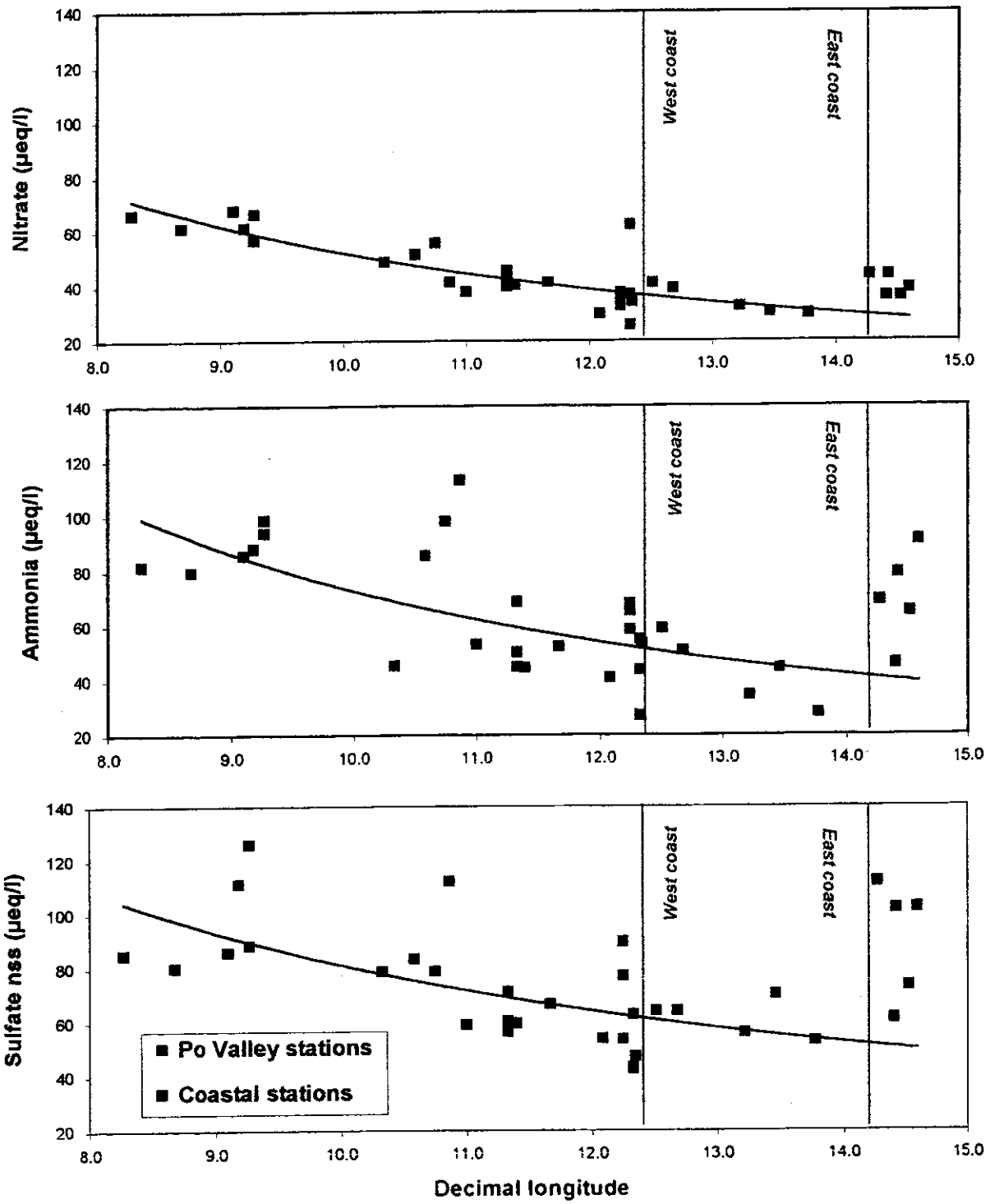


Relationship between mean annual concentration of sulphate and TIN
RIDEP network (1988-1992) - North Italy



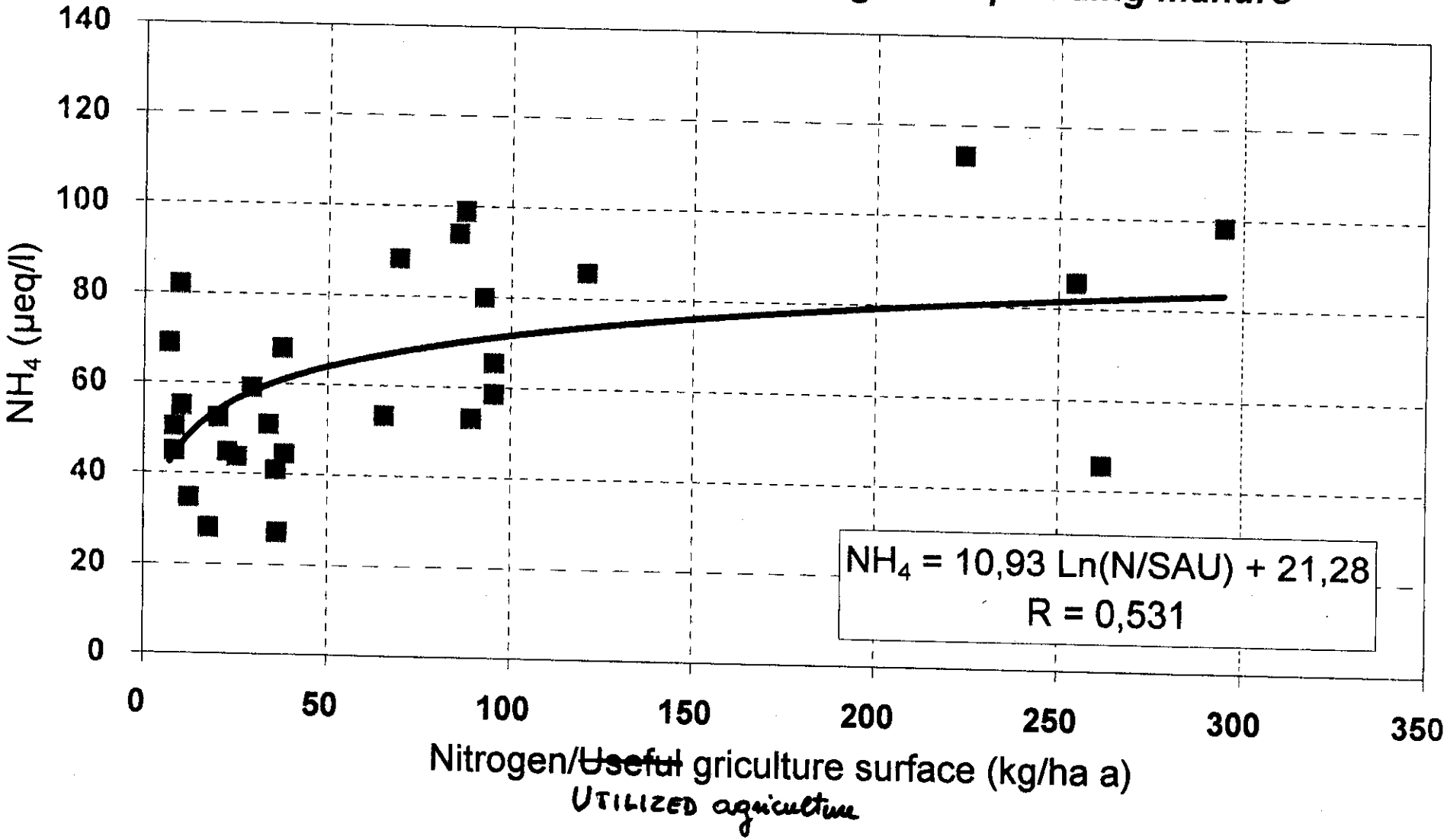
Changes in Na e Cl mean weighted concentrations with sea distance





Changing concentrations from land to insnore stations in Northern Italy (RIVER network)

Relationship of mean weighted annual ammonia nitrogen concentrations in rainwater vs nitrogen in spreading manure



Atmospheric input to aquatic ecosystems

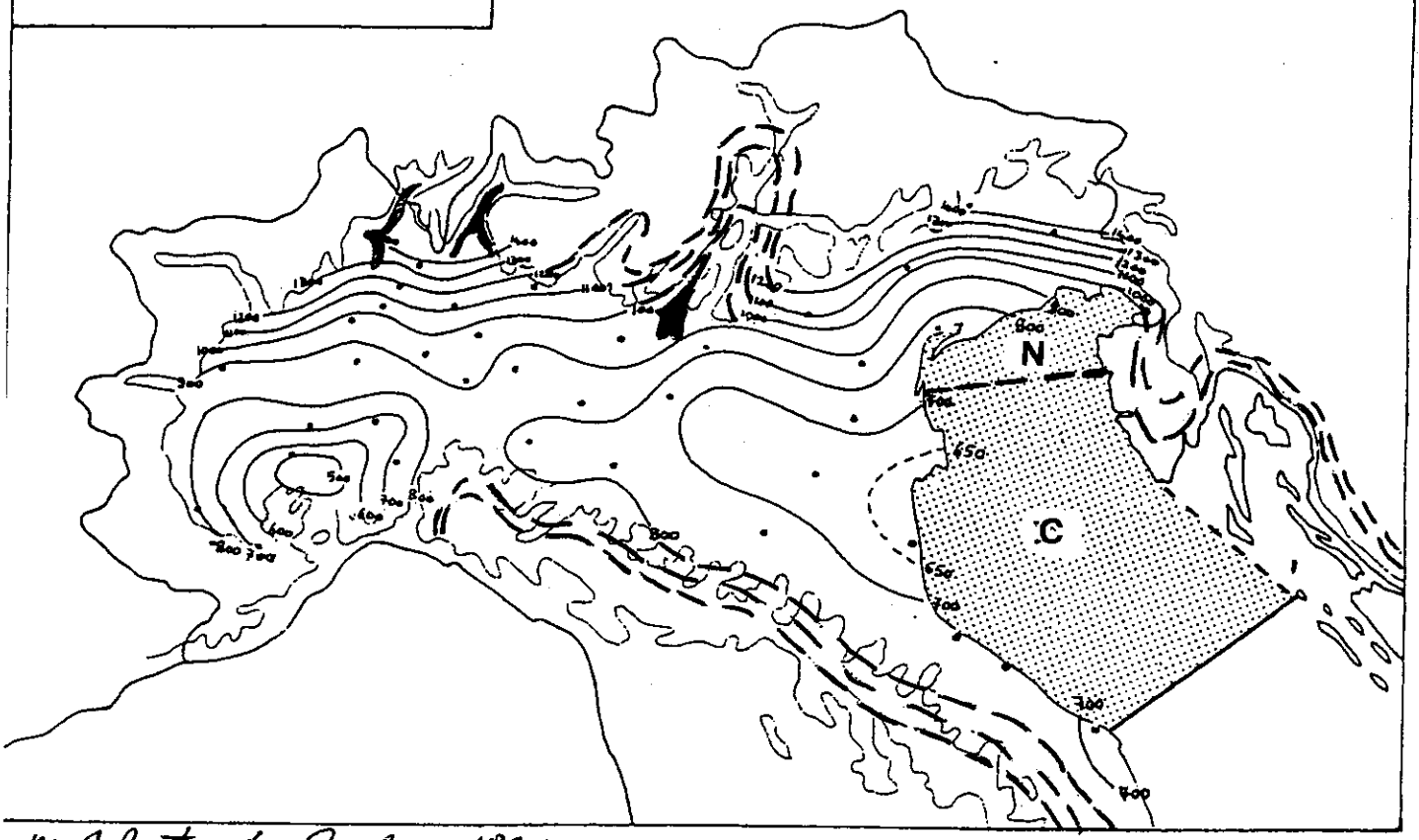
Nutrients input to Adriatic Sea

(a)

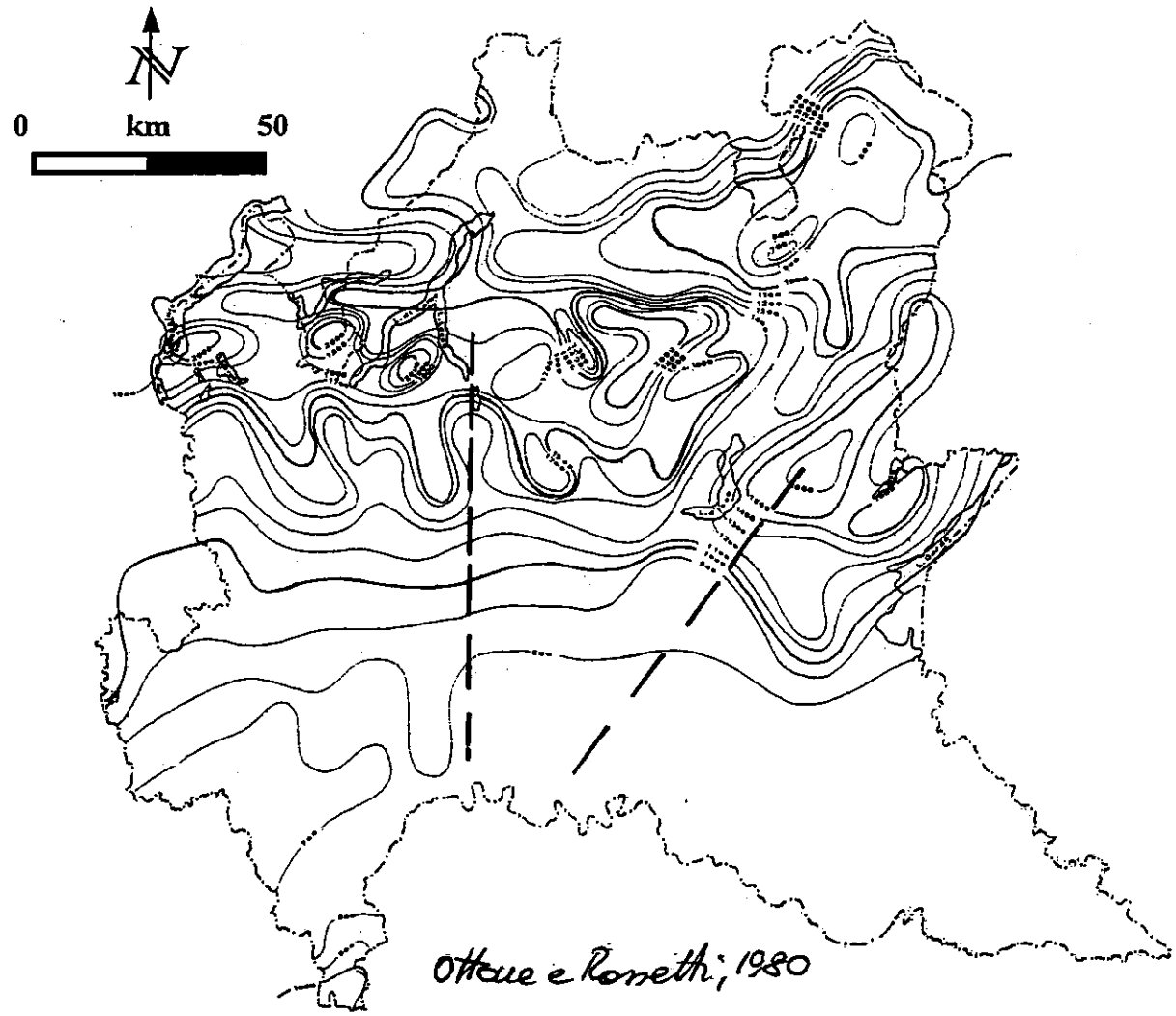
Evaluation of rainfall over Adriatic Sea

IRSA
CNR

Giuliacci* - Isoiete annue (in mm)
nel trentennio 1950-1979



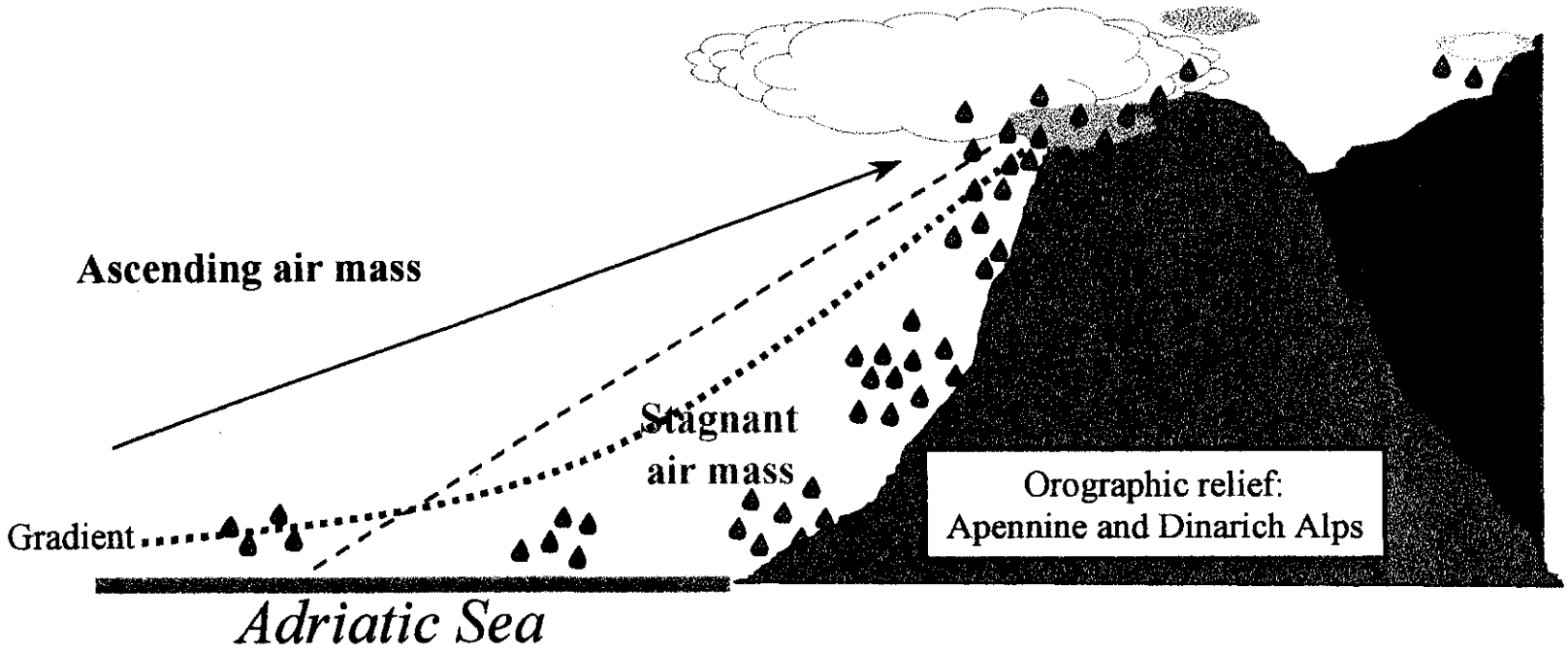
* modificata da Giuliacci 1985



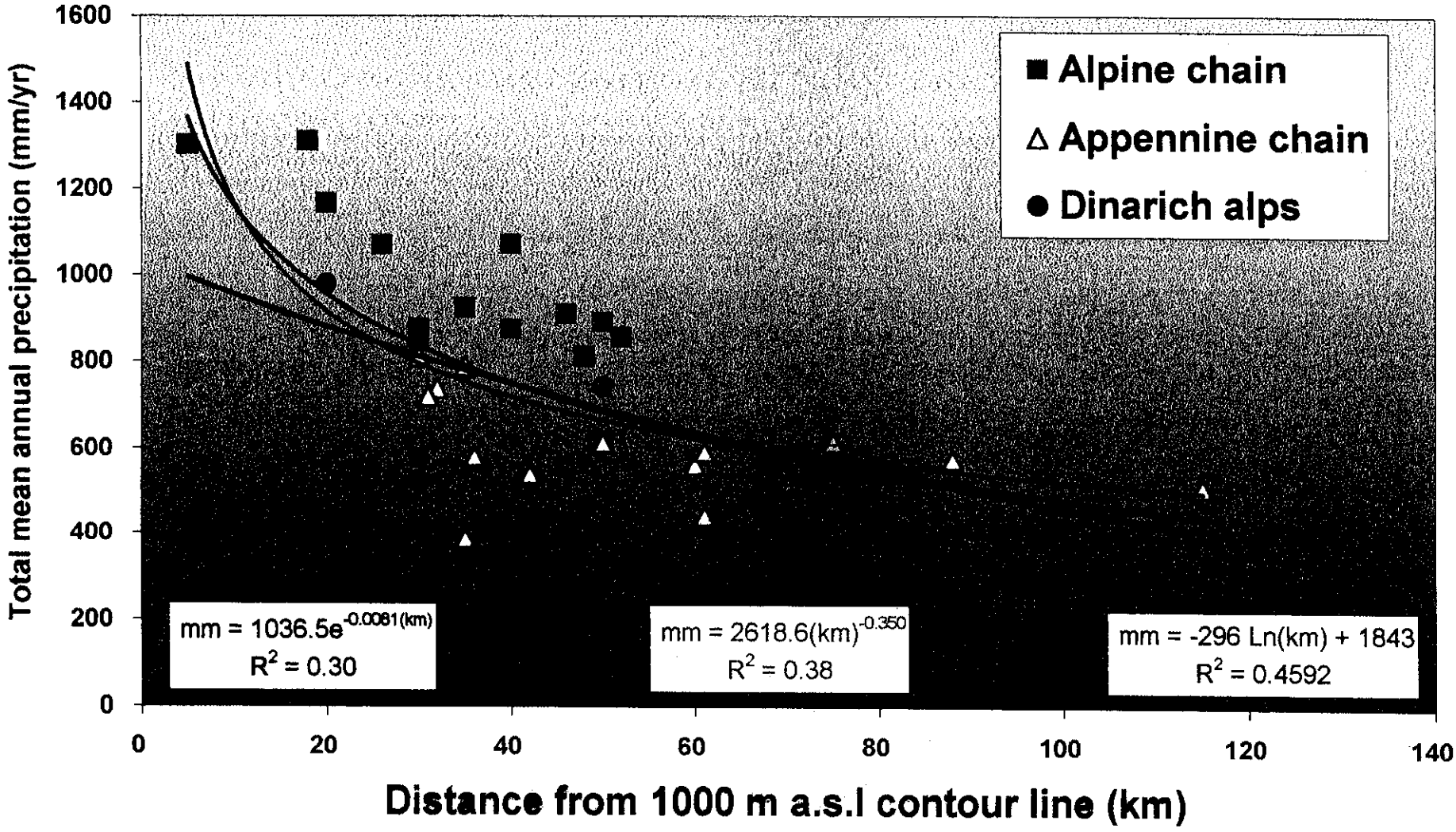
Ottone e Roneth, 1980

Rain gradient method

OROGRAPHIC EFFECT: Main climatological factor influencing the coastal isohyets in the northern Adriatic Sea

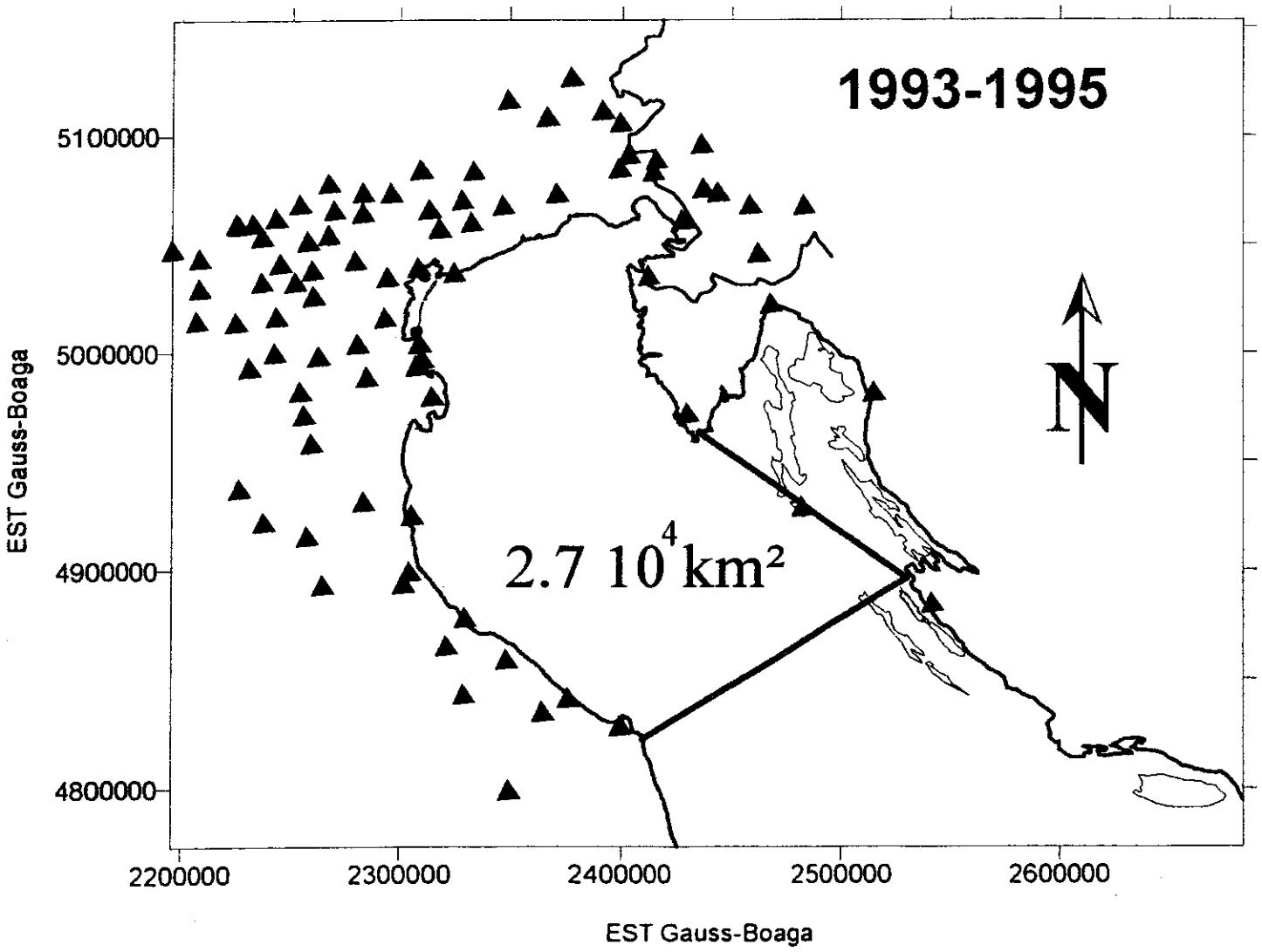


Variability of rainfall vs altitude in Northern Italy and Croatia



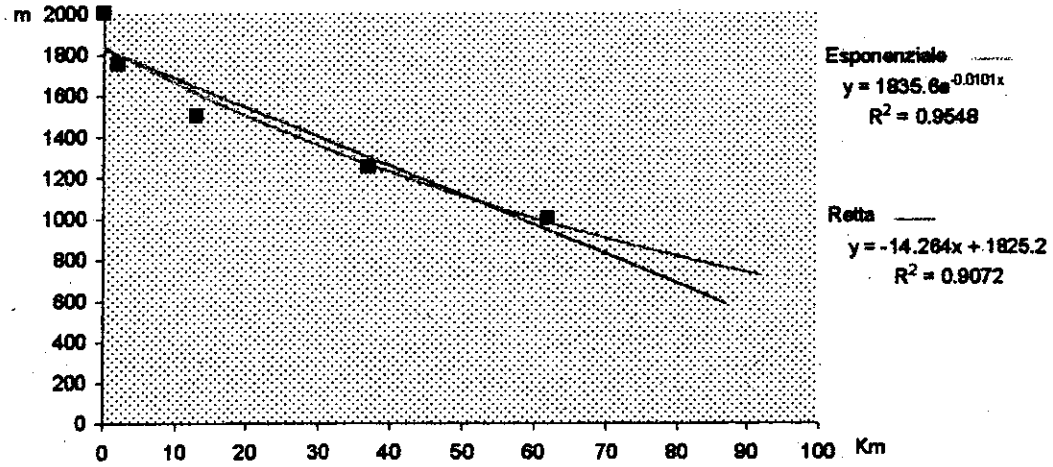
PRISMA 1 - Project

Precipitation stations used in isohyet estimation over North Adriatic Sea

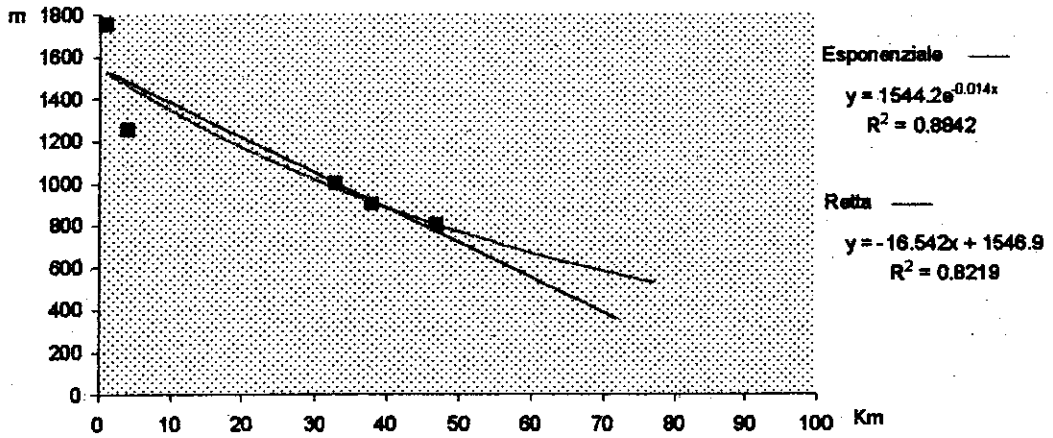


ESEMPI DI GRADIENTE CALCOLATI PER IL MARE ADRIATICO

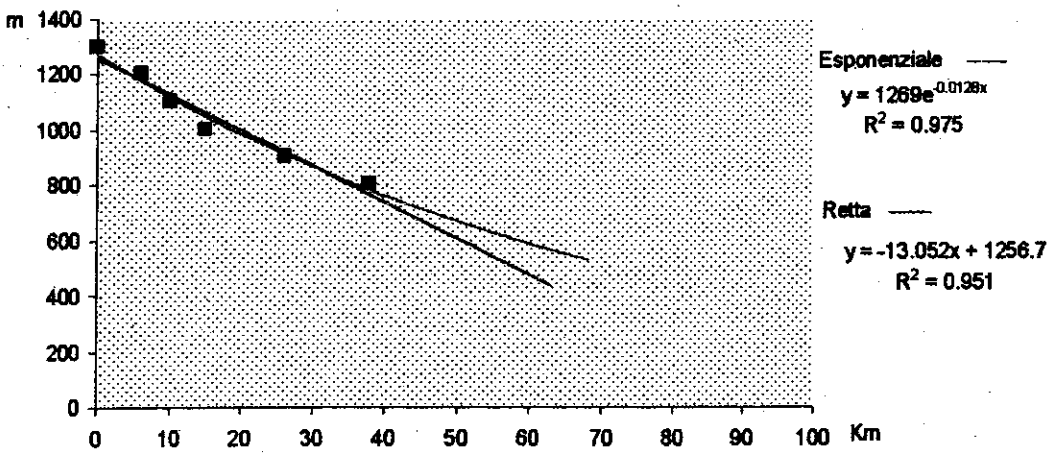
Croazia : 2° gradiente



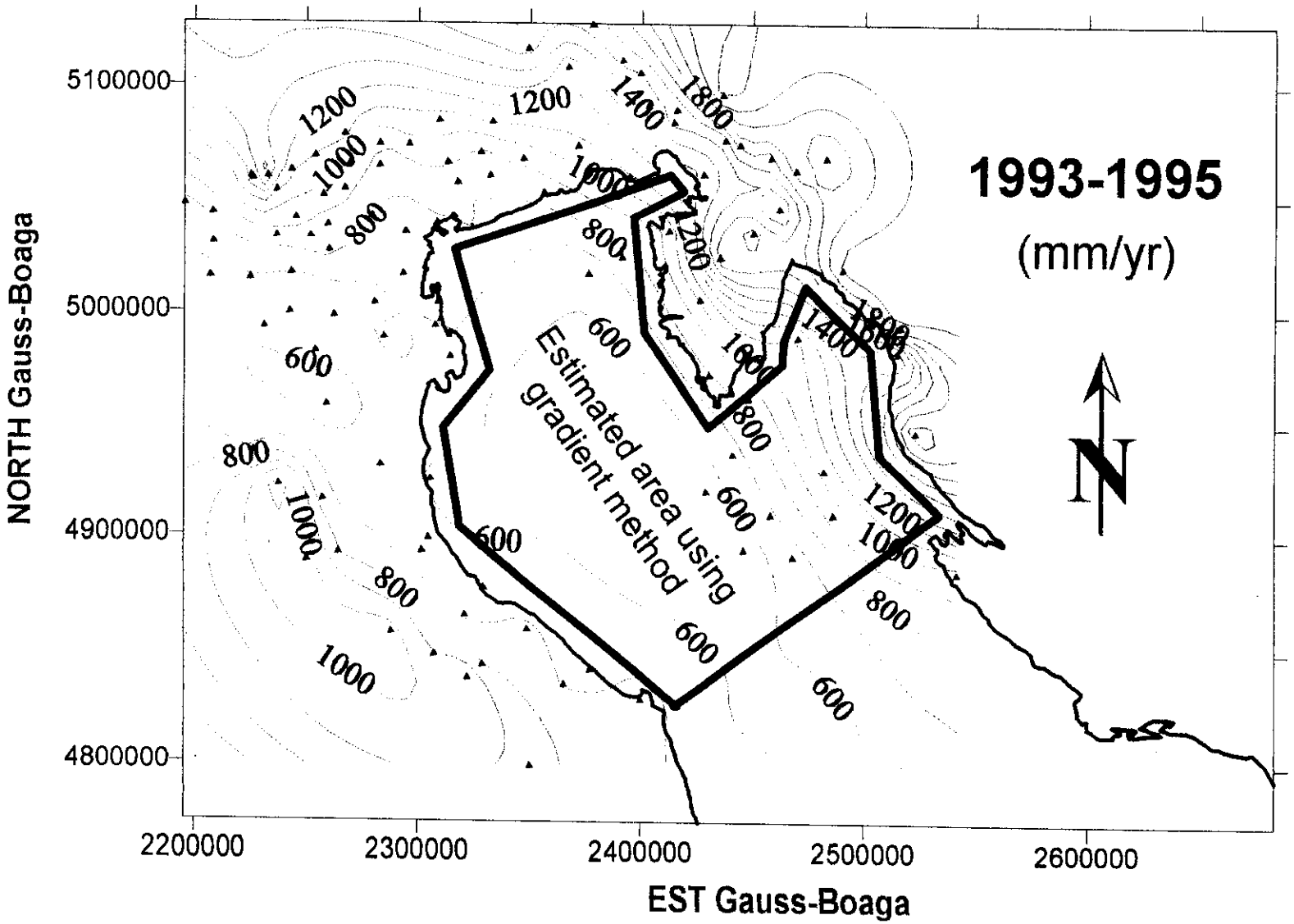
Croazia : 4° gradiente



Emilia-Marche : 6° gradiente

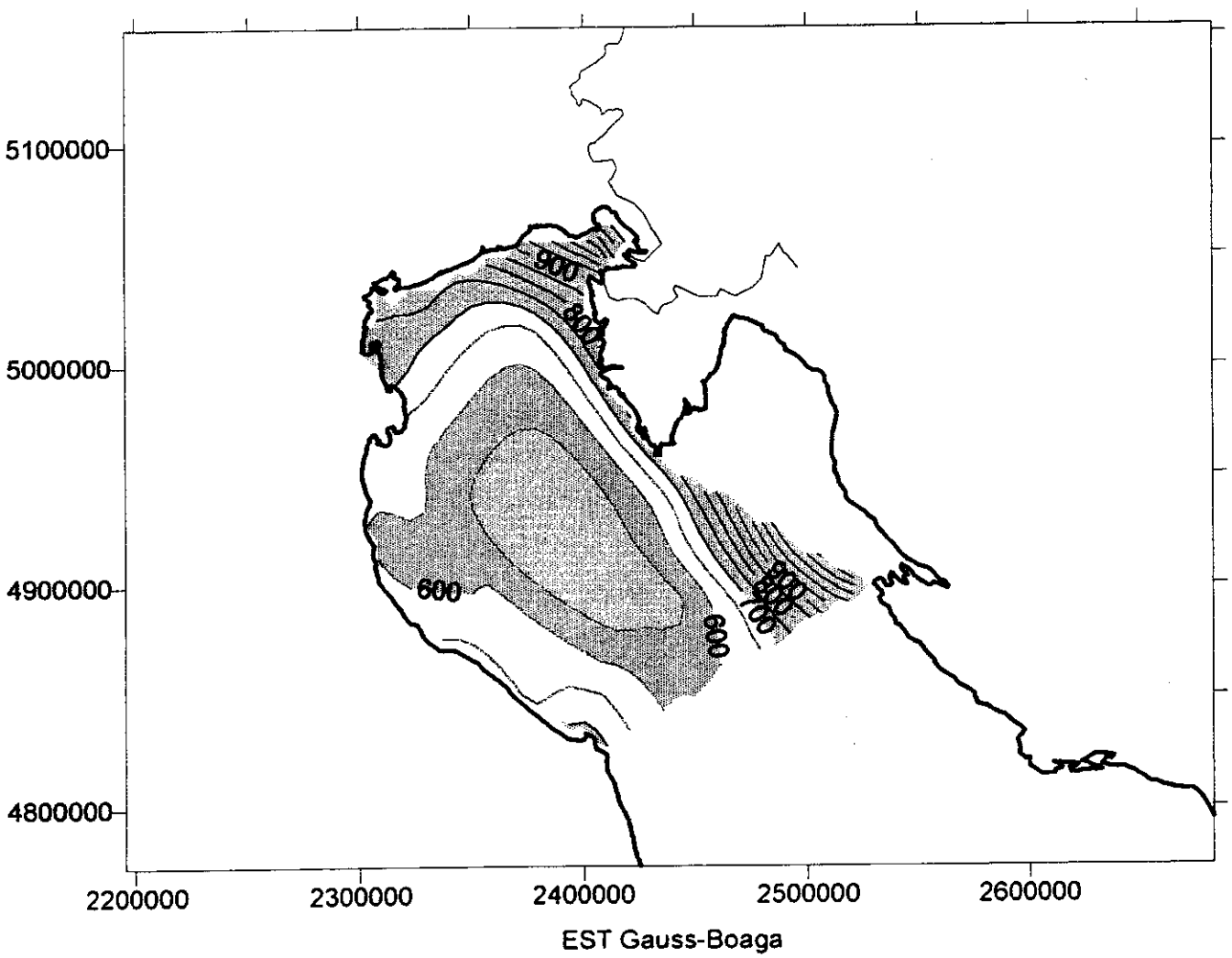


Isohyet calculated using the rain gage network



PRISMA 1- Project

Isohyets calculated using gradient method Reference period 1993-1995



Precipitation volume = 19,5 10^{9} m^{3}

Atmospheric input to aquatic ecosystems

Nutrients input to Adriatic Sea

(b)

Atmospheric depositions data and loads calculation

IRSA
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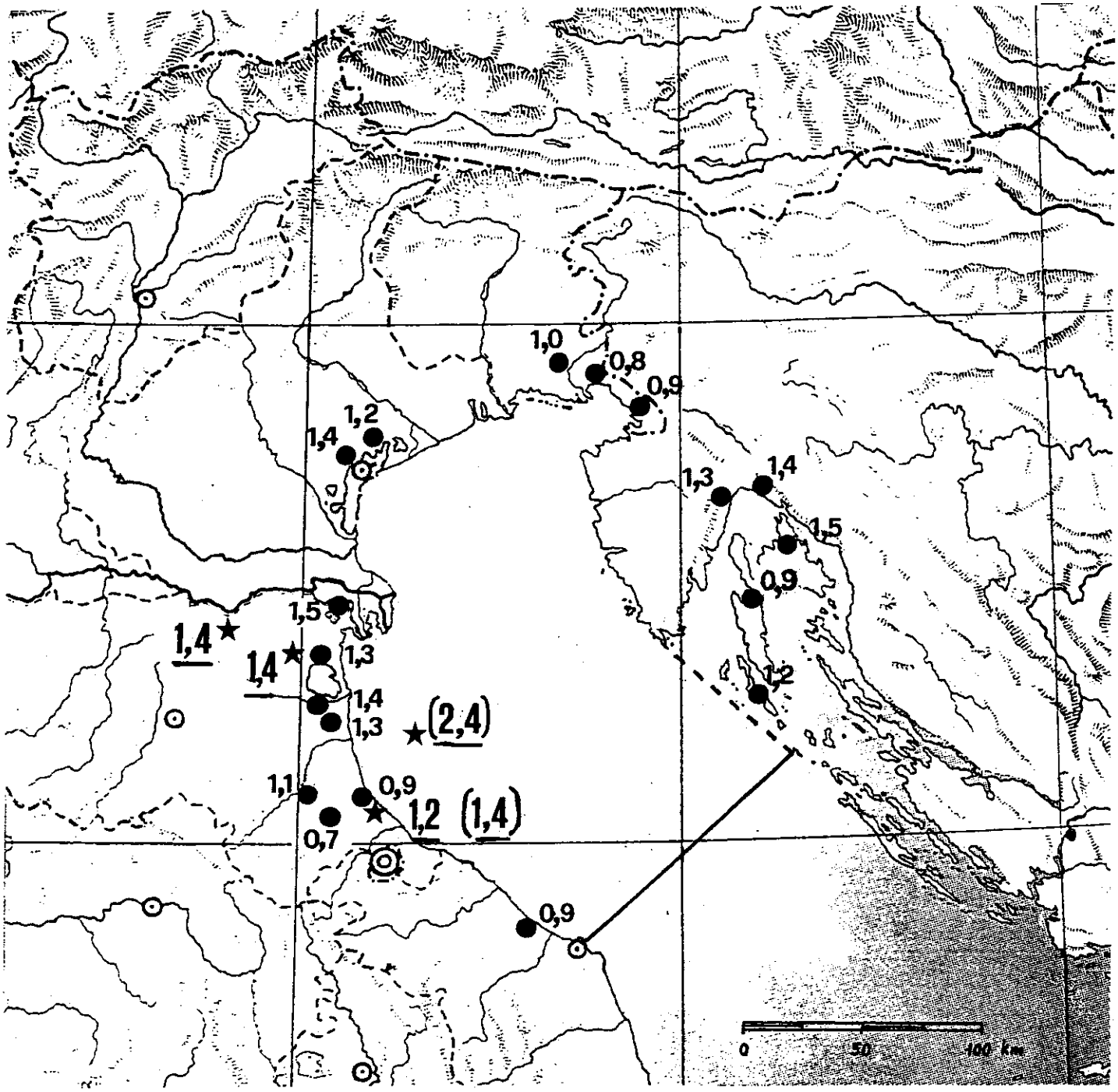


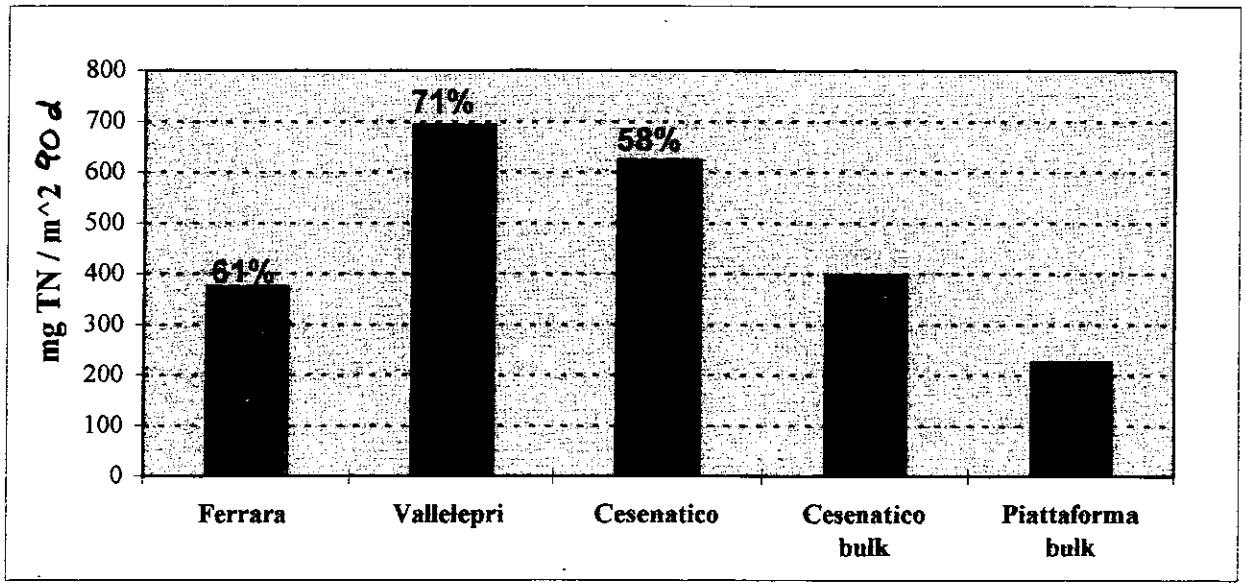
AZOTO TOTALE INORGANICO NELLE DEPOSIZIONI UMIDE

★ TIN (mgN L^{-1}) delle stazioni wet e (bulk) PRISMA

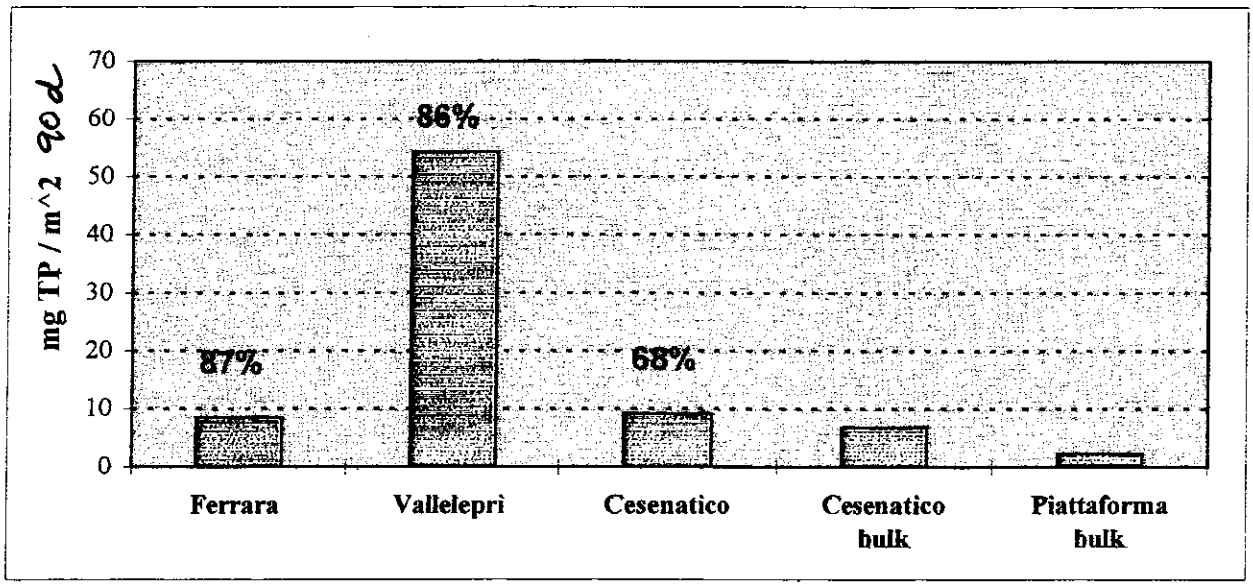
● TIN (mgN L^{-1}) delle stazioni wet RIDEP e della Croazia

Deposizioni atmosferiche		N-NH4 mg/l	N-NO3 mg/l	TIN mg/l	TN mg/l	TON mg/l	TP µg/l
Dry (biweekly)	N	**63**	**61**	**59**	**63**	**59**	**53**
	Median	**0,73**	**0,50**	**1,28**	**2,13**	**0,82**	**47**
Lombardia	N	44	44	42	42	42	38
	Median	0,77	0,52	1,30	2,11	0,86	55
Romagna	N	19	17	17	21	17	15
	Median	0,55	0,41	1,21	2,21	0,60	34
Wet (weekly)	N	**101**	**99**	**97**	**90**	**88**	**90**
	Median	**1,01**	**0,63**	**1,82**	**1,78**	**0,05**	**8**
Lombardia	N	71	71	67	58	58	58
	Median	1,07	0,70	1,93	1,80	0,03	7
Romagna	N	30	28	30	32	30	32
	Median	0,84	0,57	1,48	1,77	0,06	12
[redacted] (biweekly)	N	[redacted]					
Romagna	**Median**						

AZOTO TOTALE



FOSFORO TOTALE



IRSA CNR

PRISMA 1 - Project

Atmospheric deposition of nutrients to North Adriatic Sea

Relative contribution of differents nitrogen species to total load and N/P ratio

Stations	*Type of deposition*	**$N\text{-}NH_4$ %**	**TIN %**	**TN mg m^{-2} a^{-1}**	**TP mg m^{-2} a^{-1}**	**TN/TP**
Ferrara	W+D	**62**	**99**	**1585**	**23**	**151**
Valle Lepri	W+D	**50**	**82**	**2105**	**106**	**44**
Cesenatico	W+D	**54**	**86**	**1898**	**22**	**191**
	B	**45**	**87**	**1517**	**22**	**153**
Piattaforma AGIP	B	**47**	**86**	**1465**	**19**	**167**

W: wet - D: dry - B: bulk

Stima dell'incidenza percentuale del carico atmosferico di nutrienti per alcune grandi superfici acquatiche

	Superficie km^2	TN %	TP	*Note*
Mare Adriatico settentrionale	2.5 10⁴	30	?	Rispetto al totale degli apporti
Mare Mediterraneo	2.5 106	**12**	**?**	Rispetto agli apporti fluviali
Mare Baltico	4.1 105	**92**	**21**	Rispetto agli apporti fluviali
Mare del Nord	5.7 105	**40**	**?**	Rispetto agli apporti fluviali
Lago Maggiore	213	**6**	**2**	Rispetto al totale degli apporti dal bacino imbrifero
Lago di Lugano	49	**7**	**2**	Rispetto al totale degli apporti dal bacino imbrifero
Lago di Como	145	**?**	**1**	Valutazione teorica

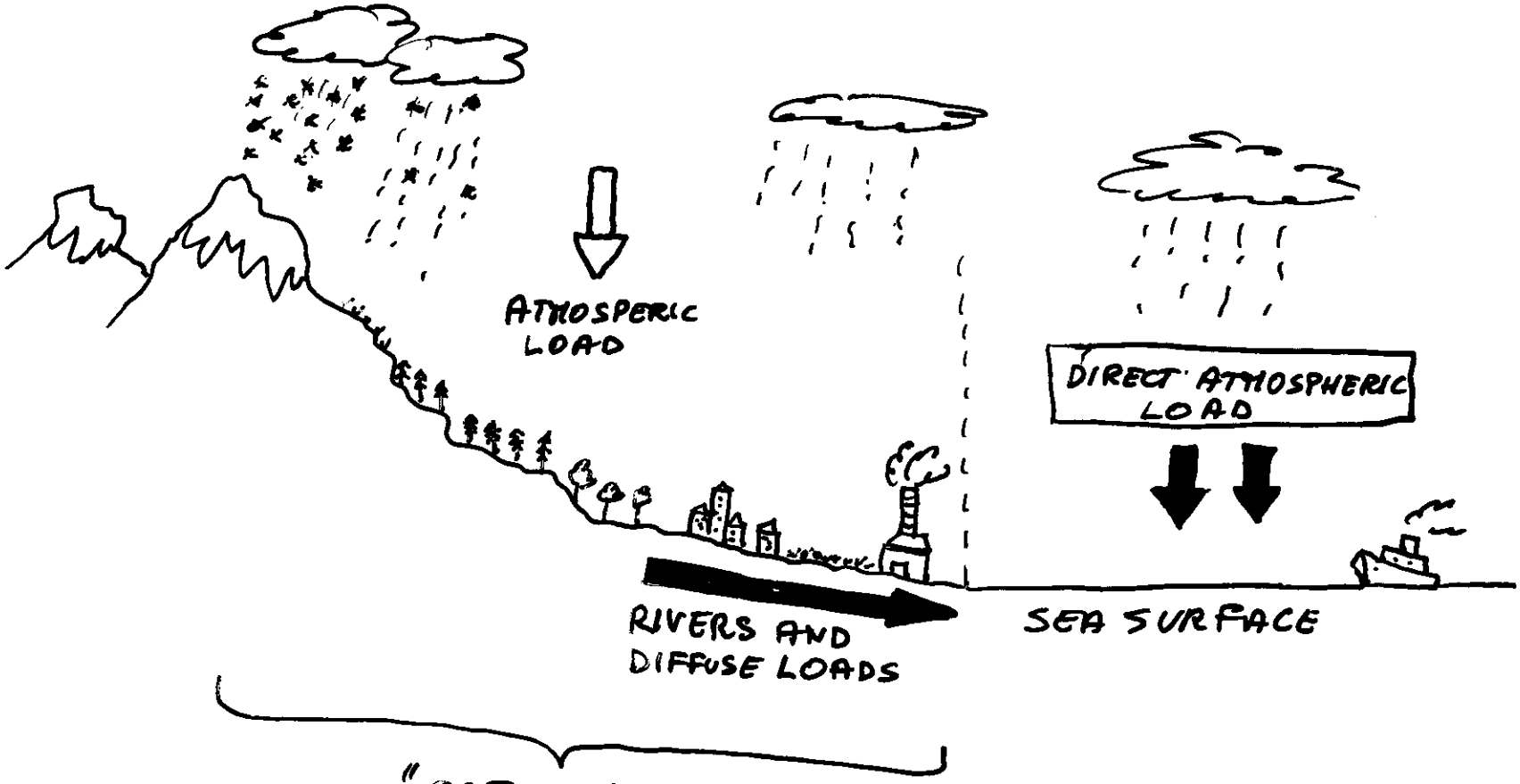
	Fiume Po [1]	Carico atmosferico [2]	(2)/(1)%
Al	82900*	5221	6.3
Fe	73200	1888	2.6
Cu	210	83	39.7
Ni	348	32	9.3
Zn	756	152	20.1
Pb	162	35	21.6
Cd	3.25	2.86	87.9

Carichi di metalli nell'Adriatico settentrionale (tonnellate $anno^{-1}$).

(1)= Pettine *et al*., 1994

(2)= PRISMA 1995-96

* = EUROMARGE 1993-96



$$\text{TOTAL LOAD TO THE SEA} = \sum(\text{POINT; NON POINT SOURCES})$$

$$= \text{POINT} + (\text{SOIL; AGRICULTURE; MANURE; FREE WAY; TOWN; } \ldots \text{ ATMOSPHERIC LOAD})^{*}$$

$$= \text{POINT} + (\text{NON POINT SOURCES})^{*} + \boxed{\text{INDIRECT ATMOSPERIC LOAD}}$$