Prag, 11 May 2010 | Juerg Heldstab, INFRAS

INFRAS on behalf of SWISS FEDERAL OFFICE FOR THE ENVIRONMENT (FOEN)

# Switzerland‘s Nitrogen Flow Analysis

# Switzerland’s nitrogen flow analysis

**First N flow analysis 1994**

**Update of N flow analysis 2005**

- results (provisional!)
- data sources
- data quality

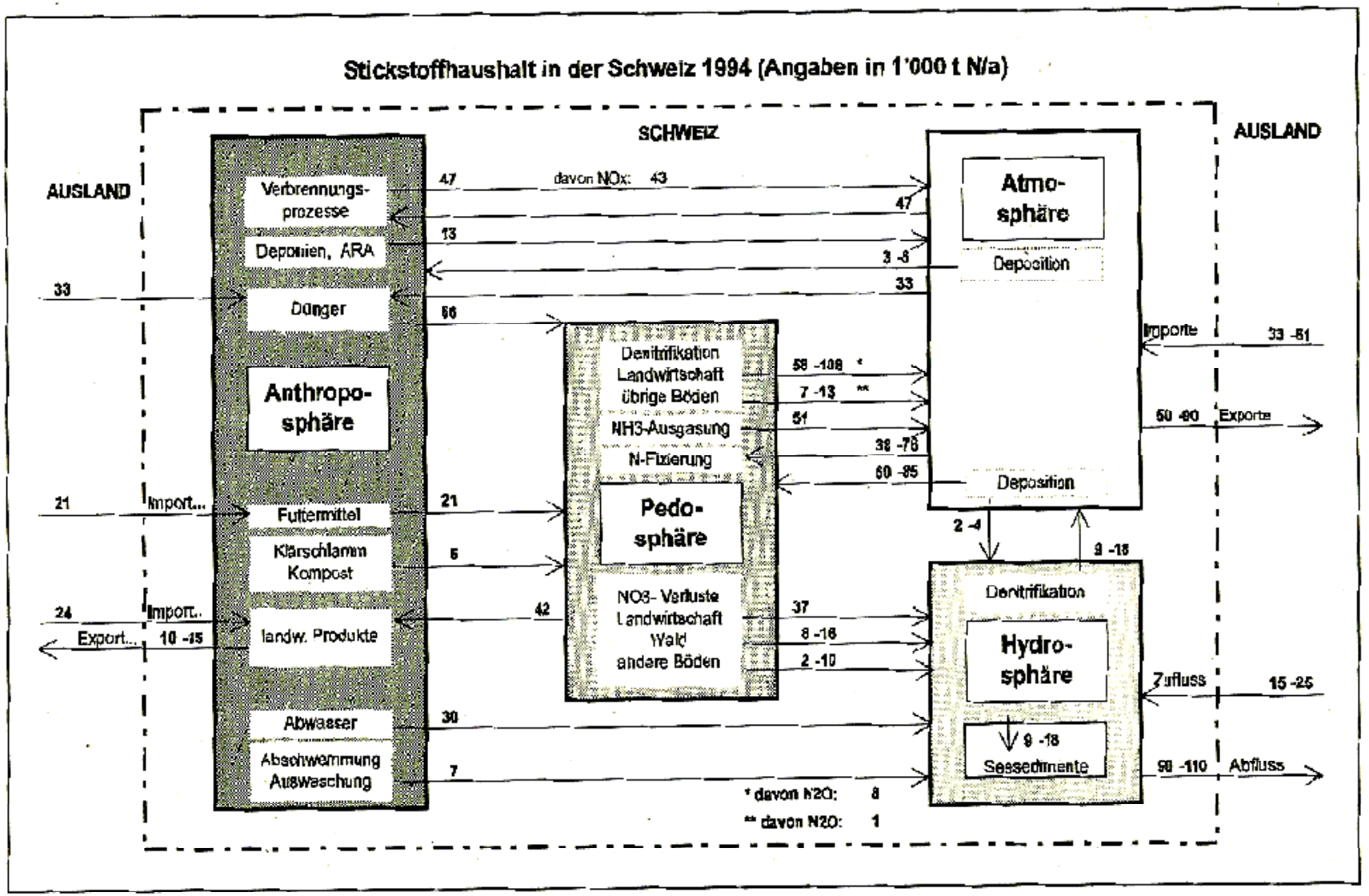
**Transformation of 1994 data**

**Trends 1994-2005**

**Factors for successful realisation**

**Challenges**

# Switzerland's first N flow analysis 1994



# Switzerland's first N flow analysis 1994

**Flow Analysis: Part of the Strategy to Reduce Nitrogen Emissions (1997,** only in German available**)**

Editors: Swiss Fed. Office for the Environment, Forest and Landscapes, Swiss Fed. Office of Agriculture

Authors: Project group „Swiss N Budget"

**Important milestone for Switzerland's environmental protect. policy. It included:**

ecological targets
*(N deposition, $O_3$ precursors, nitrate in water systems)*

all important N flows 1994

reduction measures and scenarios for major N source categories

recommendations

# Update N flow analysis

**Update: N flow analysis Switzerland 2005 (to be publ 2010)**

Editor: Swiss Federal Office for the Environment (FOEN)

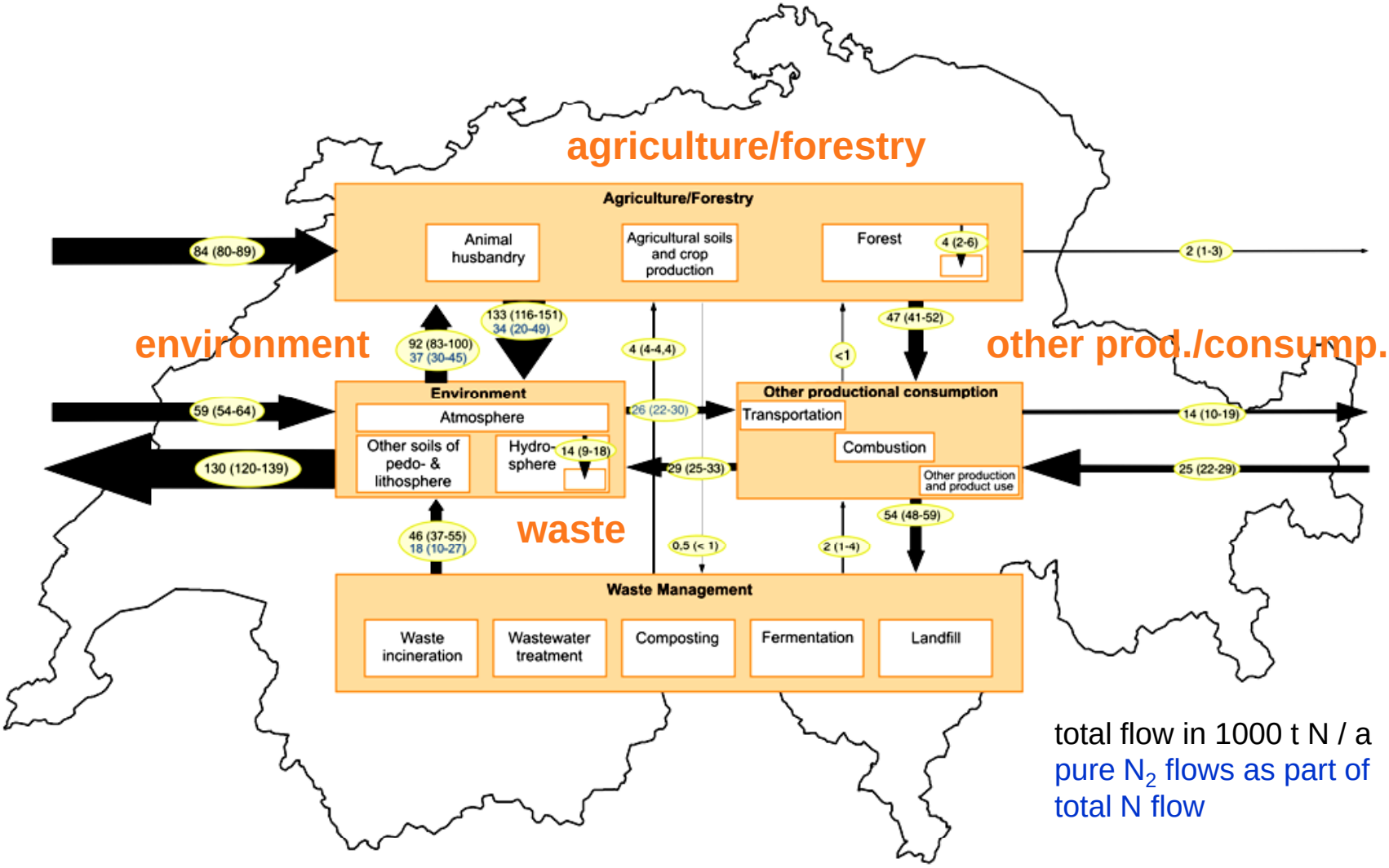
Authors: J. Heldstab, J. Reutimann, R. Biedermann

Project accompaniment: B. Achermann, C. Moor (FOEN)

**Tasks**

- Update of all important N flows
- Comparison of 2005 results with 1994
- Description and interpretation of trends 1994-2005
- Method: following the Swiss guidelines for flow analyses

# Analysis 2005
# Subsystems of aggregte N flows



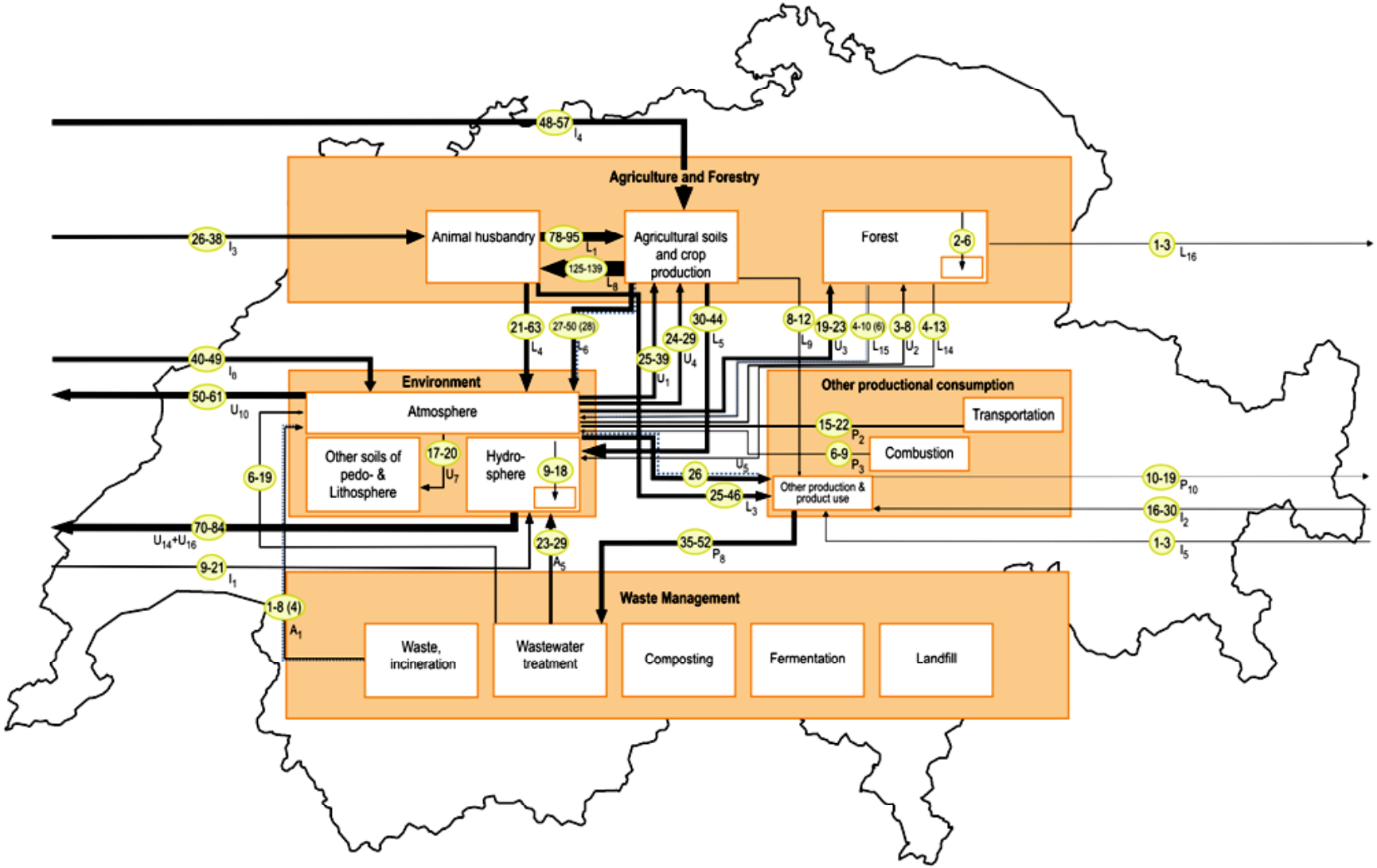

total flow in 1000 t N / a
pure $N_2$ flows as part of total N flow

# Matrix representation of N balance 2005

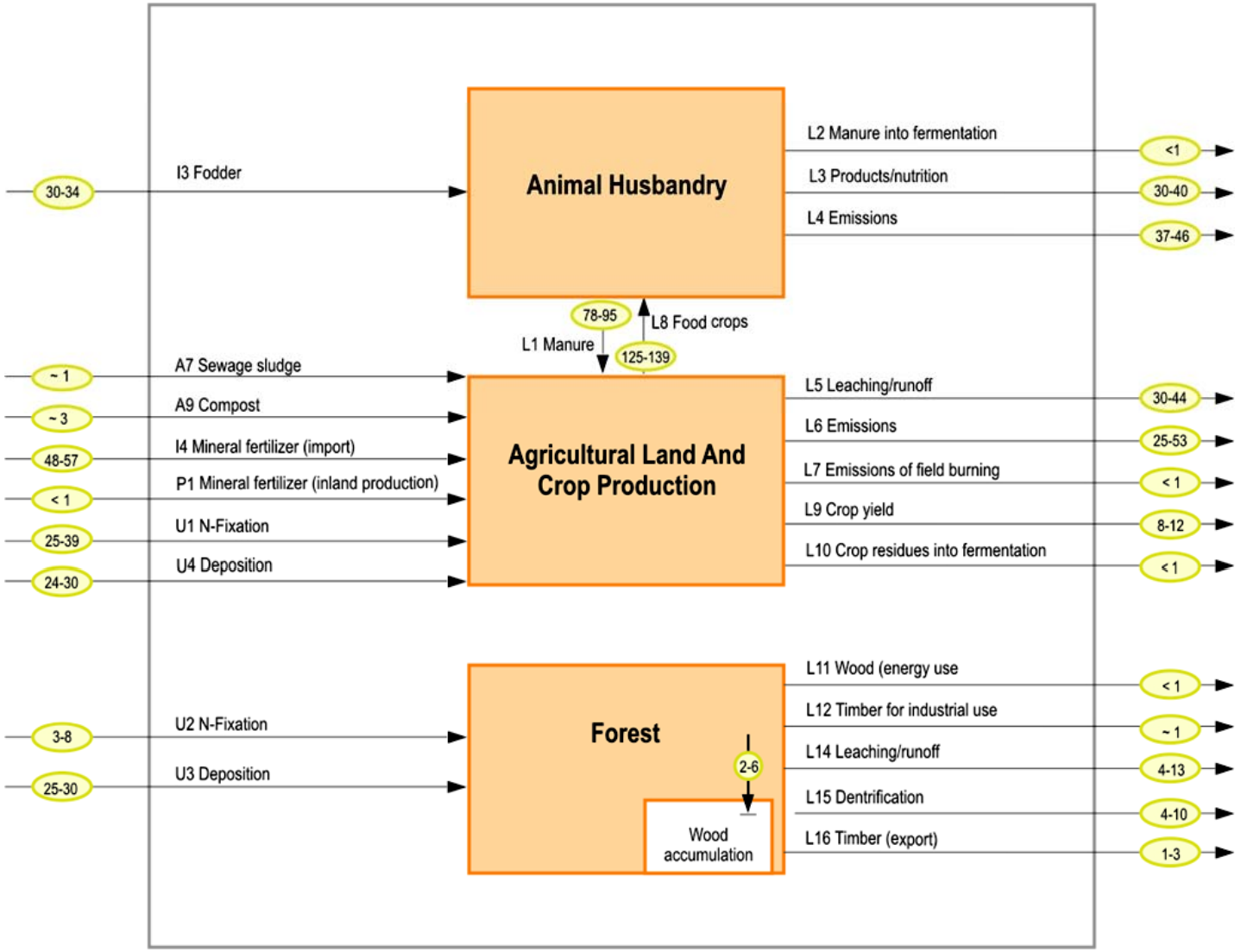
| **subsystems** | ***to*** agric/for | envir | prod/con | waste | export |
|---|---|---|---|---|---|
| ***from*** | kt N | | | | |
| agric/forest | | 132 | 47 | <1 | 2 |
| environment | 92 | | 26 | 0 | 130 |
| prod/consump. | <1 | 29 | | 54 | 14 |
| waste | 4 | 46 | 2 | | 0 |
| import | 84 | 59 | 25 | 0 | |

| Control | agric/for | envir | prod/con | waste | Sum |
|---|---|---|---|---|---|
| | kt N | | | | |
| +Σ IN (columns) | 180 | 266 | 100 | 54 | 600 |
| –Σ OUT (rows) | -181 | -248 | -97 | -52 | -578 |
| - stock change | -4 | -14 | 0 | 0 | -18 |
| Sum | -5 | 4 | 3 | 2 | 4 |
| Diff w.respect IN | -2.8% | 1.5% | 3.0% | 3.7% | 0.7% |

# Analysis 2005
# Detailed processes of N flow



# Details of subsystem Agriculture/Forestry



# The largest N flows in 2005

| Id | Name | Flow k tN | Unc. k tN | Unc. % |
|---|---|---|---|---|
| L8 | fodder | 132 | 7 | 5% |
| L1 | manure/pasture | 86 | 9 | 10% |
| U14 | hydrosp export | 73 | 7 | 10% |
| U10 | atmosph export | 56 | 6 | 10% |
| I4 | mineral fert. (import) | 52 | 5 | 9% |
| P8 | waste water | 43 | 5 | 10% |
| L4 | em. from livestock | 42 | 5 | 11% |
| L5 | leaching | 37 | 7 | 19% |
| L3 | animal prod. | 35 | 5 | 14% |
| I2 | food import | 33 | 4 | 11% |
| U1 | N fixation | 32 | 7 | 22% |
| I3 | Fodder import | 32 | 2 | 6% |
| U4 | N deposition agric. | 27 | 3 | 11% |
| U3 | N deposition forest | 27 | 3 | 9% |
| A5 | waste water from pl. | 26 | 3 | 12% |

# Characterisation of flows

| | L1 Hofdünger/Weidegang | Tierhaltung ⇒ Landwirtschaftsböden (Acker, Weiden etc.) und Pflanzenbau (Land- und Forstwirtschaft) |
|---|---|---|
| *Description* | Charakterisierung | Organisch gebundener und mineralisierter Stickstoff ($NH_3$, $NH_4^+$, $NO_3^-$) im Hofdünger, der im Pflanzenbau eingesetzt wird inkl. Eintrag von Stickstoff in Weideflächen durch Weidegang von Hoftieren.<br>Enthalten sind Stickstofffrachten, welche durch Emissionen ($NO_x$, $N_2O$, $NH_3$ und $N_2$) aus Landwirtschaftsböden hervorgehen, beim Austrag von Hofdünger entstehen (hier nur $NO_x$- und $N_2O$- Emissionen, ohne $NH_3$-Emissionen) und beim Weidegang verloren gehen ($NO_x$, $N_2O$, $NH_3$). (Entspricht den Emissionen aus Hofdünger von Fluss L6).<br>Nicht enthalten sind Stickstofffrachten, welche durch Emissionen ($NH_3$, $NO_x$, $N_2O$ und $N_2$) aus der Tierhaltung, Hofdüngerlager) in die Atmosphäre gelangen, sowie $NH_3$-Emissionen, die beim Ausbringen des Hofdüngers auf Landwirtschaftsflächen entstehen. (Entspricht den Emissionen aus Hofdünger von Fluss L4). |
| *Data sources* | Datenquellen | THG-Inventar Landwirtschaft V3.5 (ART, wird jährlich aufdatiert) |
| *Value 2005* (value 1994 if available) | Wert 2005 | *L1 (r) ökologisch relevante N-Verbindungen:*<br>N-Eintrag Hofdünger (Gülle, Mist): 70.9 kt N<br>N-Eintrag Weidegang: 16.0 kt N<br>Abzug Hofdünger in Vergärung (Fluss L2): - 0.53 kt N |
| | | *L1 Gesamtfluss:*<br>86.3 kt N |
| | | *Vergleichswerte:*<br>AGRAMMON-Projekt $NH_3$-Emissionen Schweiz (BAFU/SHL); Zahl in Kürze verfügbar |
| *Data quality* | Datenqualität | 78-95 kt N<br>Teilunsicherheiten:<br>N-Eintrag Hofdünger (Gülle, Mist): 12%<br>N-Eintrag Weidegang 6%<br>Unsicherheit Gesamtfluss: 10% (ART 2008a, p. 7f. N, $N_{ex}$) |
| *Comments* | Bemerkungen | Gesamte N-Fracht im Hofdünger abzüglich der N-Fracht im Hofdünger der in Vergärungsanlgagen vergärt wird (Fluss L2). |

# Data sources

## Official data are available

*Fed. Office for the Environment*
emissions into air (UNFCCC, UNECE) and water, deposition, waste water, waste/compost

*Agroscope (nat. research inst.), Swiss College of Agriculture SHL*
Sector agriculture of GHG inventory

*Swiss Farmer‘s Union*
agricultural production

*Swiss Fed. Customs Administration*
imports/exports of goods (fertilizer, food products, wood,…)

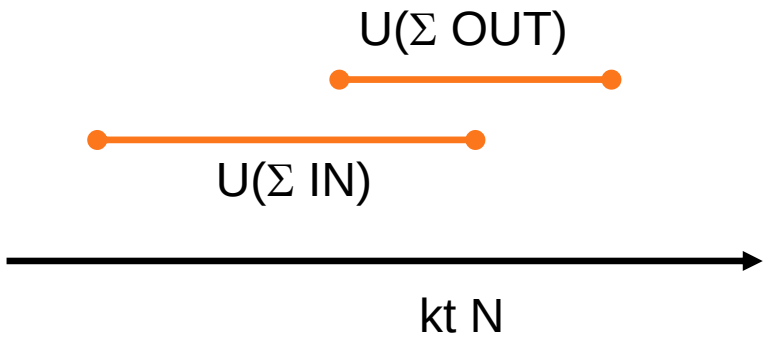
*Fed. Office of Energy*
Fossil fuel consumption, fermentation plants

*Swiss Fed. Statistical Office*

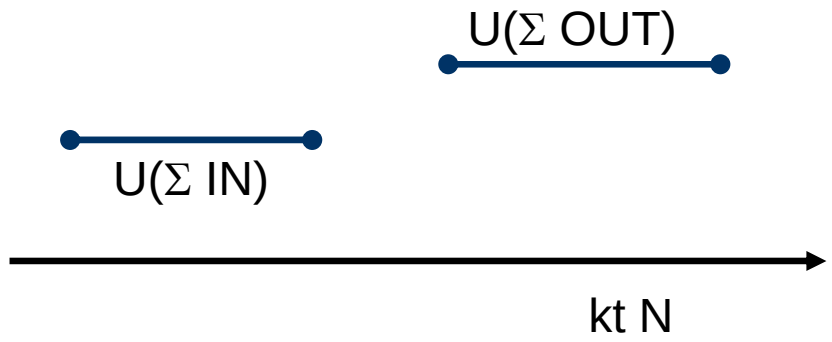
# Data quality

1. determine/estimate each flow AND its uncertainty
2. for each process/subsystem: Σ IN, Σ OUT
3. error propagation: uncertainty interval U(Σ IN), U(Σ OUT)
4. compare uncertainty intervals U(ΣIN) with U(ΣOUT)

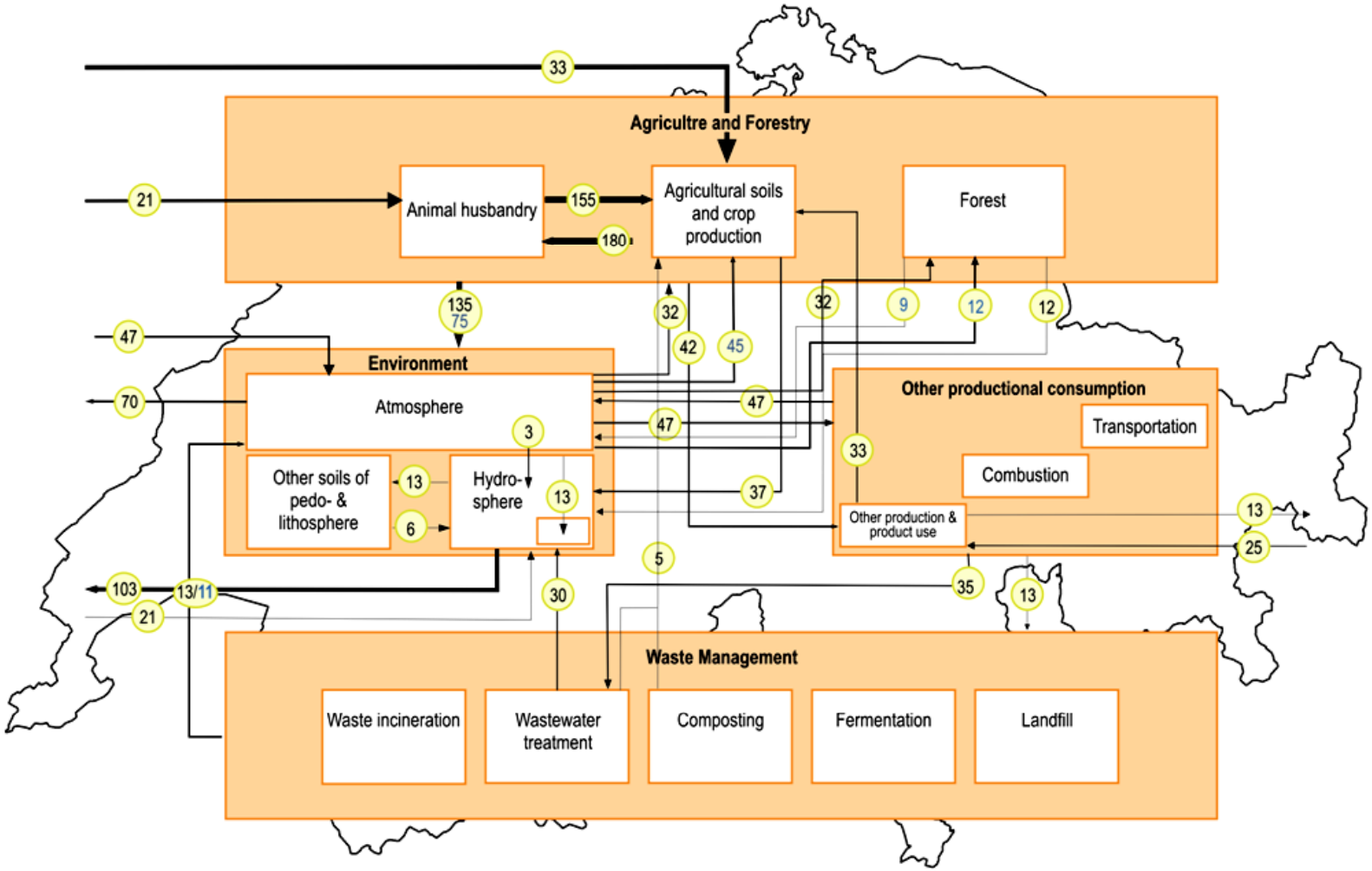
U(ΣIN) overlap U(ΣOUT)
balance accepted




No overlap:
wrong flows?
missing flows?
wrong uncertianties?

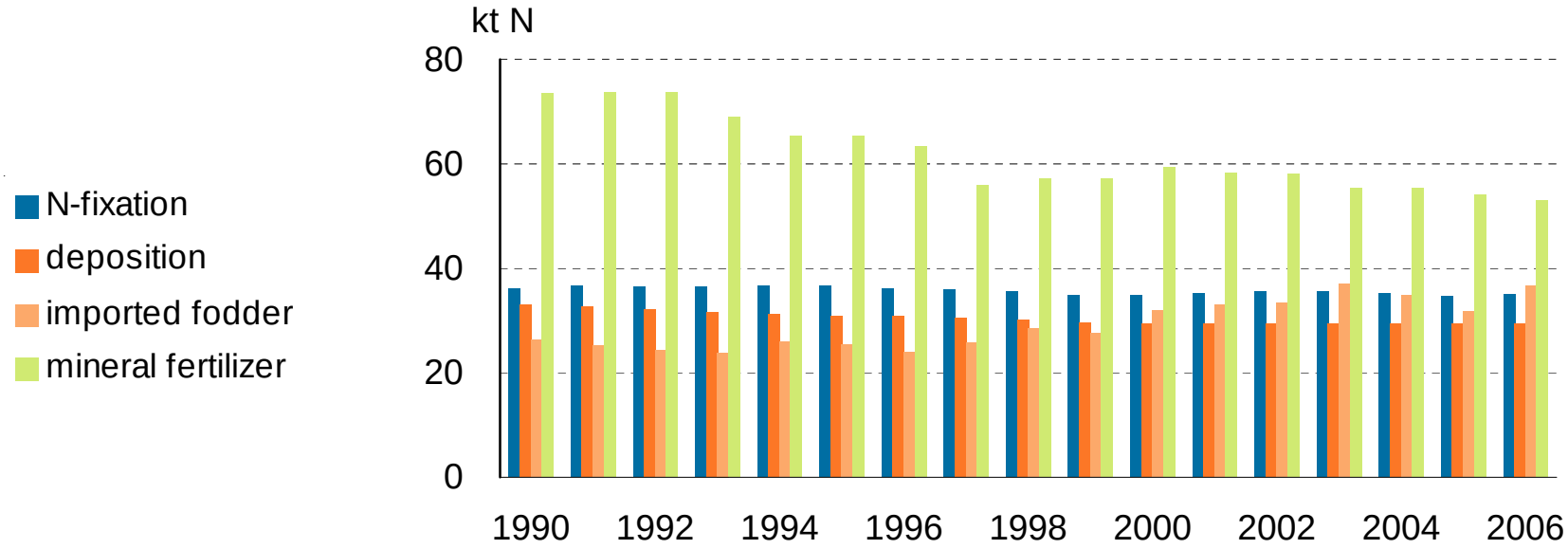


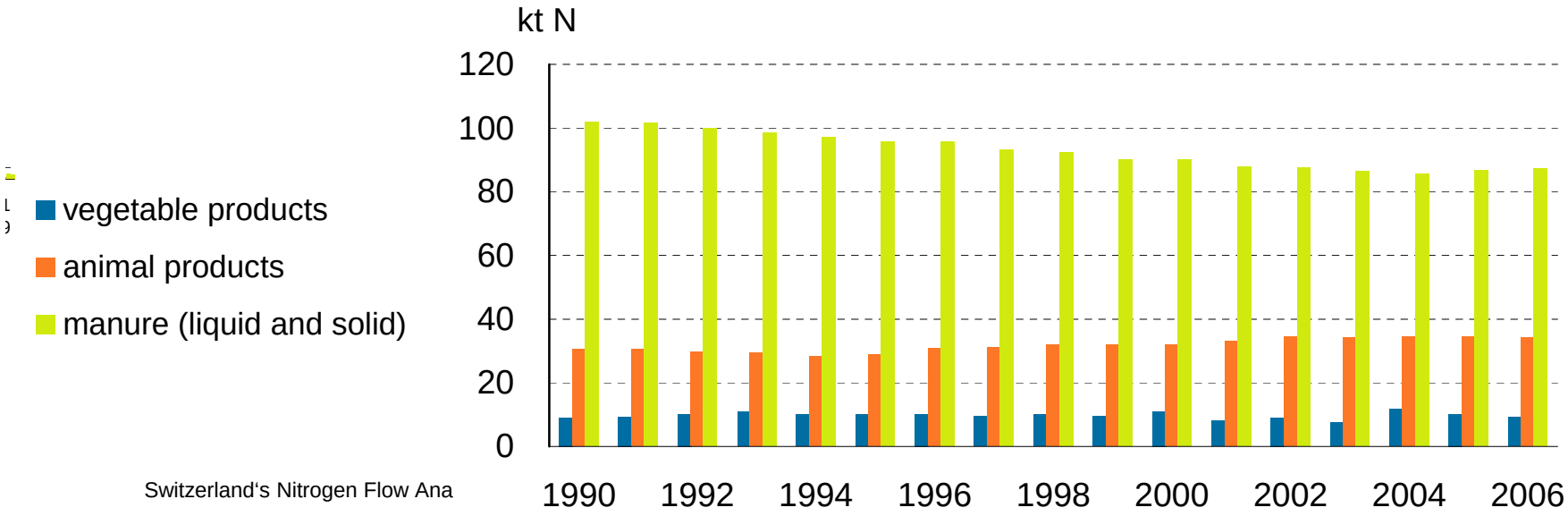
# Flow analysis 1994 – transformed into new system



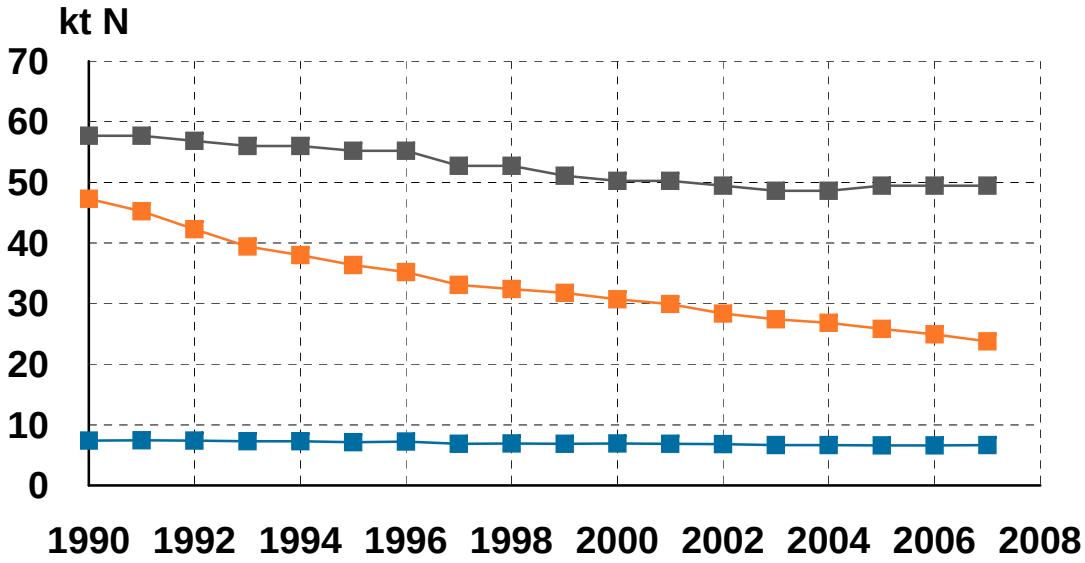

Challenge: different system boundaries!

# Trends 1994-2005



# Trends 1994-2005



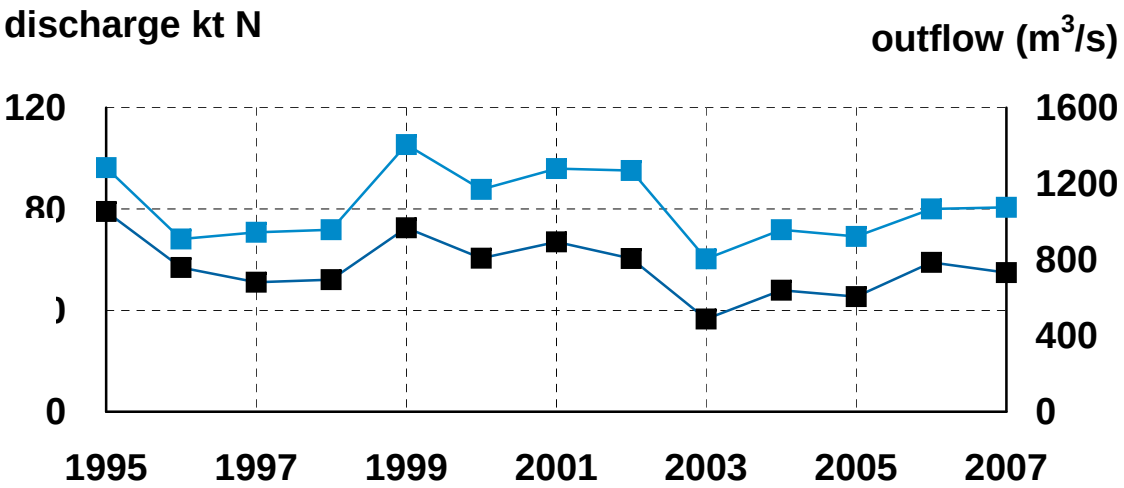

**Atmosphere:**

**Emissions of**

- NOx
- NH3
- N2O

**Water:**

- outflow (m3/s)
- mean discharge (kt N)



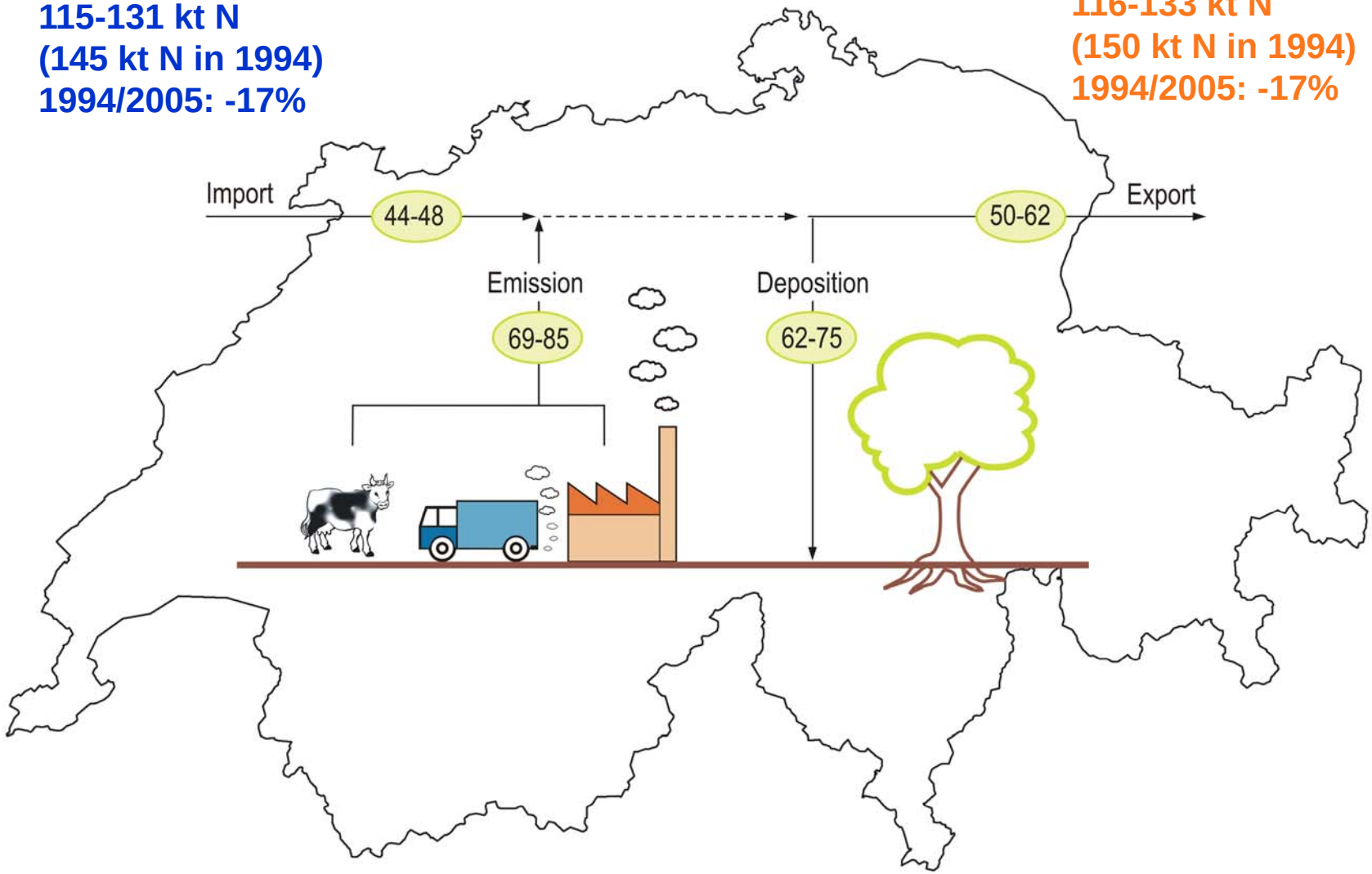
# Agricultural N budget (OSPAR)

| | Flows | 1994 | 2005 | Unc. 2005 |
|---|---|---|---|---|
| | | ktN | kt N | kt N |
| Inputs | imported animal feed | 21 | 32 | 7% |
| | mineral fertilizer | 66 | 52 | 8% |
| | sewage sludge, compost | 5 | 4 | 5% |
| | deposition on agr. soils | 30 | 27 | 10% |
| | N fixation | 45 | 32 | 22% |
| | Total IN | 167 | 149 | 6% |
| Outputs | vegetable products | 15 | 10 | 20% |
| | animal products | 27 | 35 | 15% |
| | TotaL OUT | 42 | 45 | 12% |
| | Difference/losses IN - OUT | 125 | 104 | 10% |
| | N efficiency OUT / IN | 25% | 30% | 14% |
| | | | 26% - 34% | |

# Atmospheric N budget 2005

**Import + Emission**
**115-131 kt N**
**(145 kt N in 1994)**
**1994/2005: -17%**

**Export + Deposition**
**116-133 kt N**
**(150 kt N in 1994)**
**1994/2005: -17%**



# Factors for successful realisation

## Basis

Willingness of administration to establish N flow analysis

## Data

UNFCCC inventory
CLRTAP inventory
broad agricultural research results available
availability of custom statistics

## Methods

Swiss guidelines for flow analysis (BUWAL 1996)
Agrammon N flow method to determine $NH_3$ emissions (2009)

## Interannual comparison

Availability of data for several years is prerequisite
homogenoues and consistent time series

# Challenges

## Coordination

Many projects touch issue → elaborate coordination necessary

## Data

missing data
missing knowledge of uncertainties
different values for same flows
verification is complex, laborious and expensive

## Methods

different definitions of subsystems/processes complicate budgeting
annual values versus means over several years

## Interannual comparison

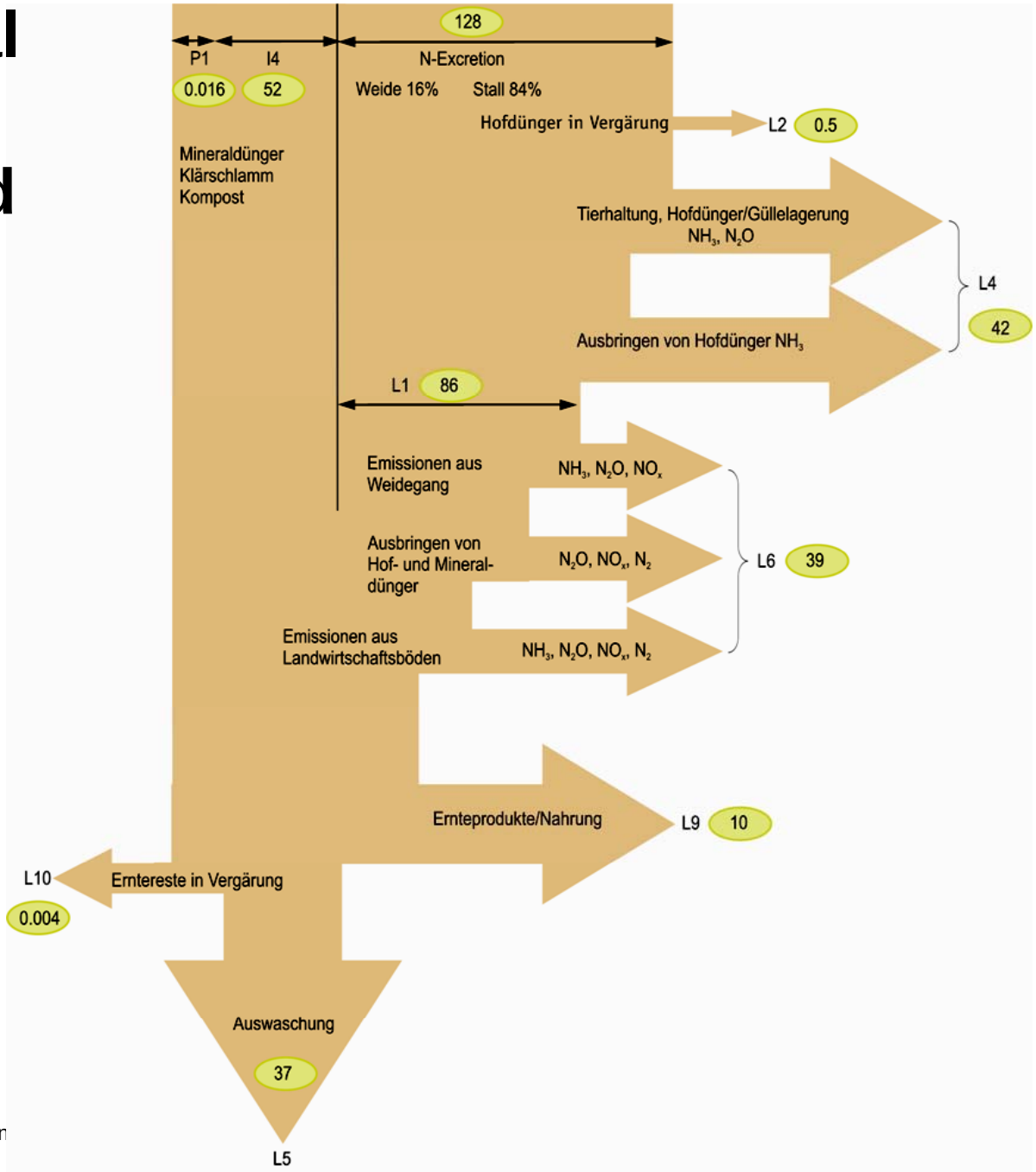
incompatibilities caused by changing methods
inconsistent time series

# Background slides

# IPCC system boundaries agriculture

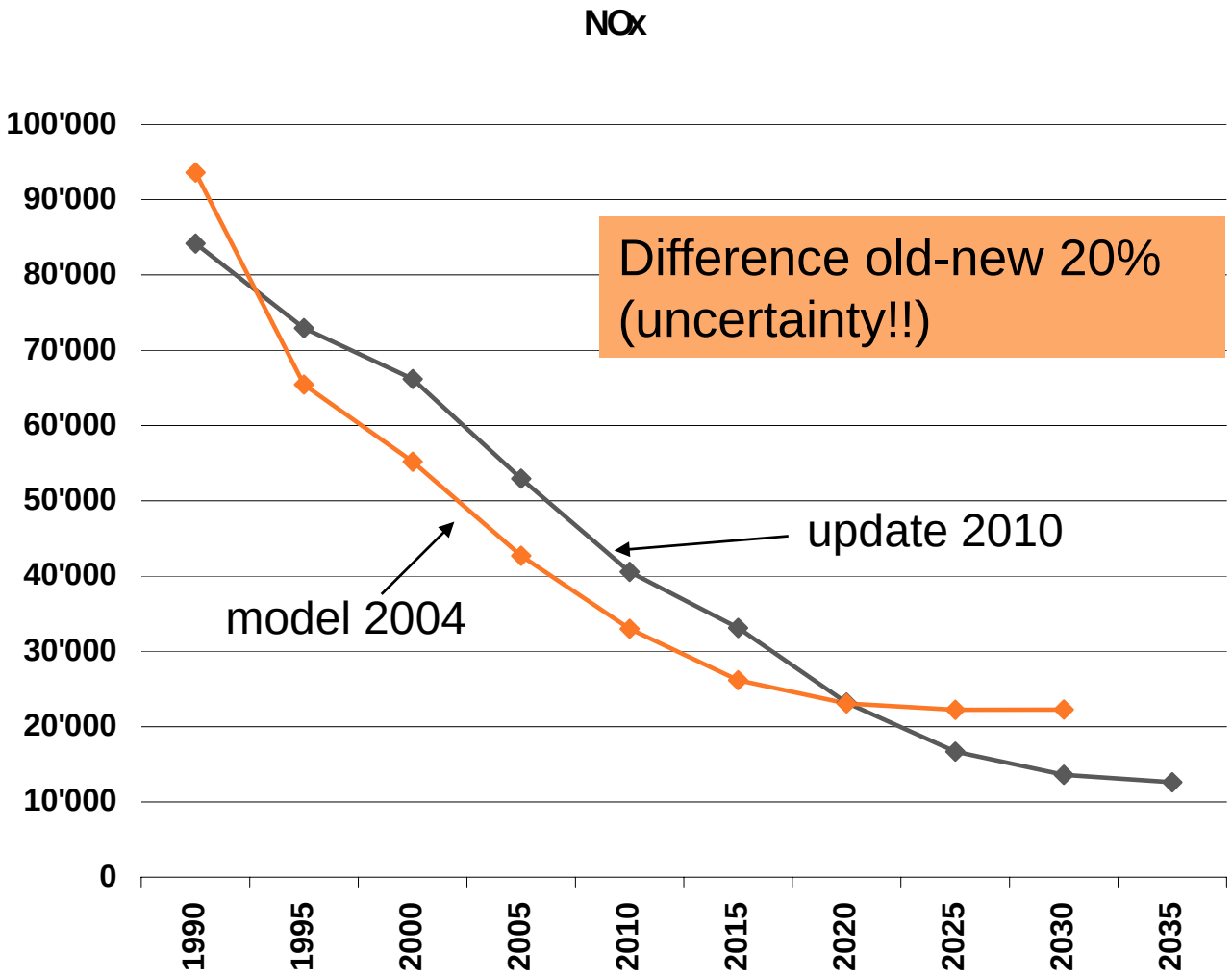
| IPCC sector Agriculture / source categories | | Prozesse (Stoffflüsse) |
|---|---|---|
| NFR Code | Category | Nomenklatur Stoffflussanalyse |
| 4B | Manure Management | a) Tierhaltung (L1, L4) |
| | | Z.B. N-Eintrag in Boden (aus Hofdünger und Weidegang), $NH_3$-Emissionen (aus Hofdünger, nicht aber Weidegang) |
| 4D | Agricultural Soils | b) Landwirtschaftsböden und Pflanzenbau (L6, L7) |
| 4D1 | Direct Soil Emissions | Z.B. $N_2O$-Emissionen aus der Denitrifikation von Stickstoff aus Mineraldünger oder aus fixiertem Luftstickstoff (L6) |
| 4D2 | Pasture, Range and Paddock Manure | $NH_3$-, $N_2O$-, $NO_x$-Emissionen aus dem Weidegang inkl. aus der Denitrifikation von Stickstoff aus Tierexkrementen |
| 4D3 | Indirect Emissions | $N_2O$-Emissionen aus der Denitrifikation von deponiertem Stickstoff |
| 4D4 | Use of sewage sludge and compost as fertilizers | $N_2O$-Emissionen aus der Denitrifikation von Stickstoff aus der Düngung mit Kompost und Klärschlamm |
| 4F | Field Burning of Agricultural Residues | $NO_x$-, $N_2O$, $NH_3$-Emissionen aus der offenen Verbrennung von landwirtschaftlichen Abfällen (L7) |

# Agricultural N flows in Switzerland 2005

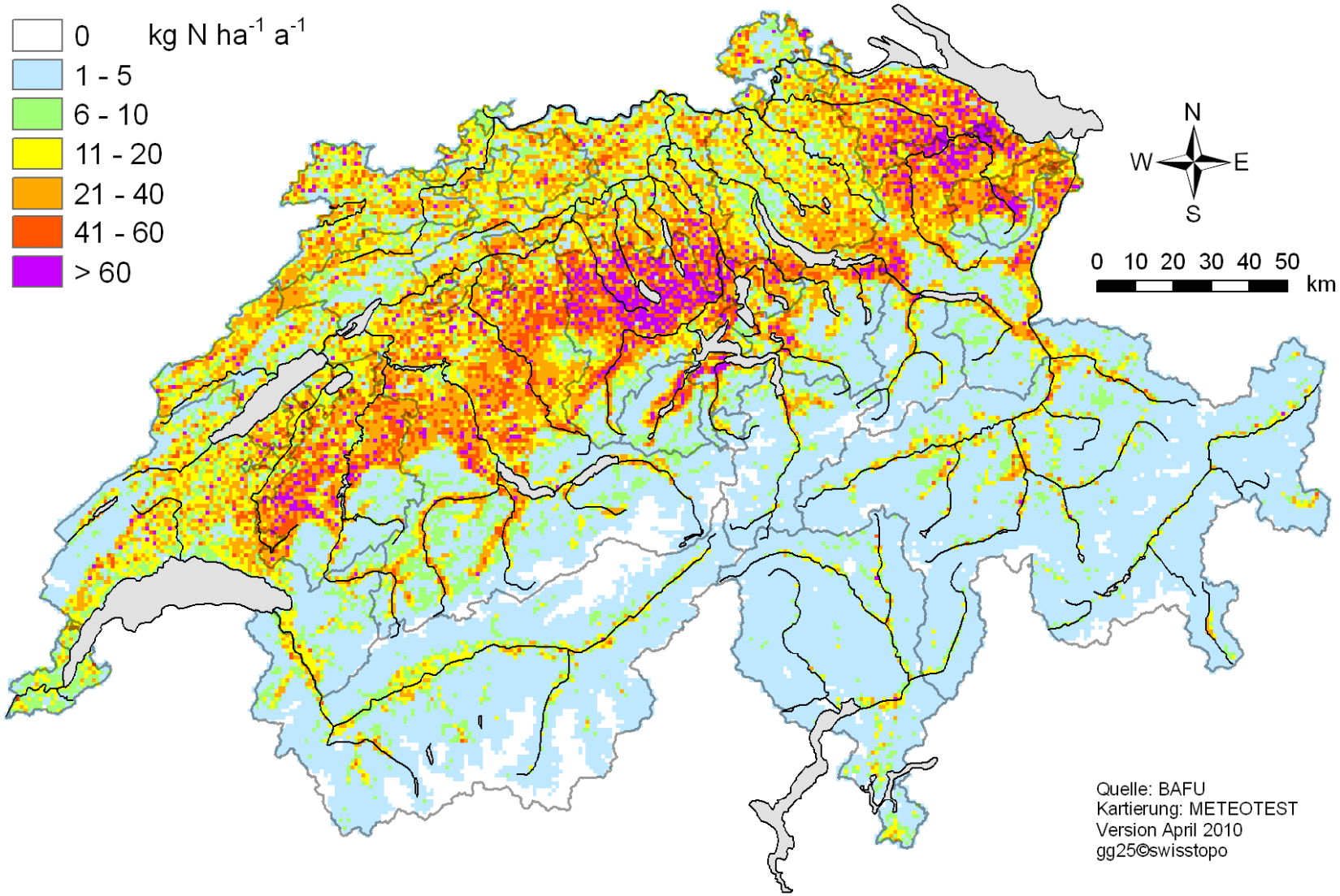


# Emission trends Switzerland

## Effect HBEFA 3.1 versus HBEFA 2.1

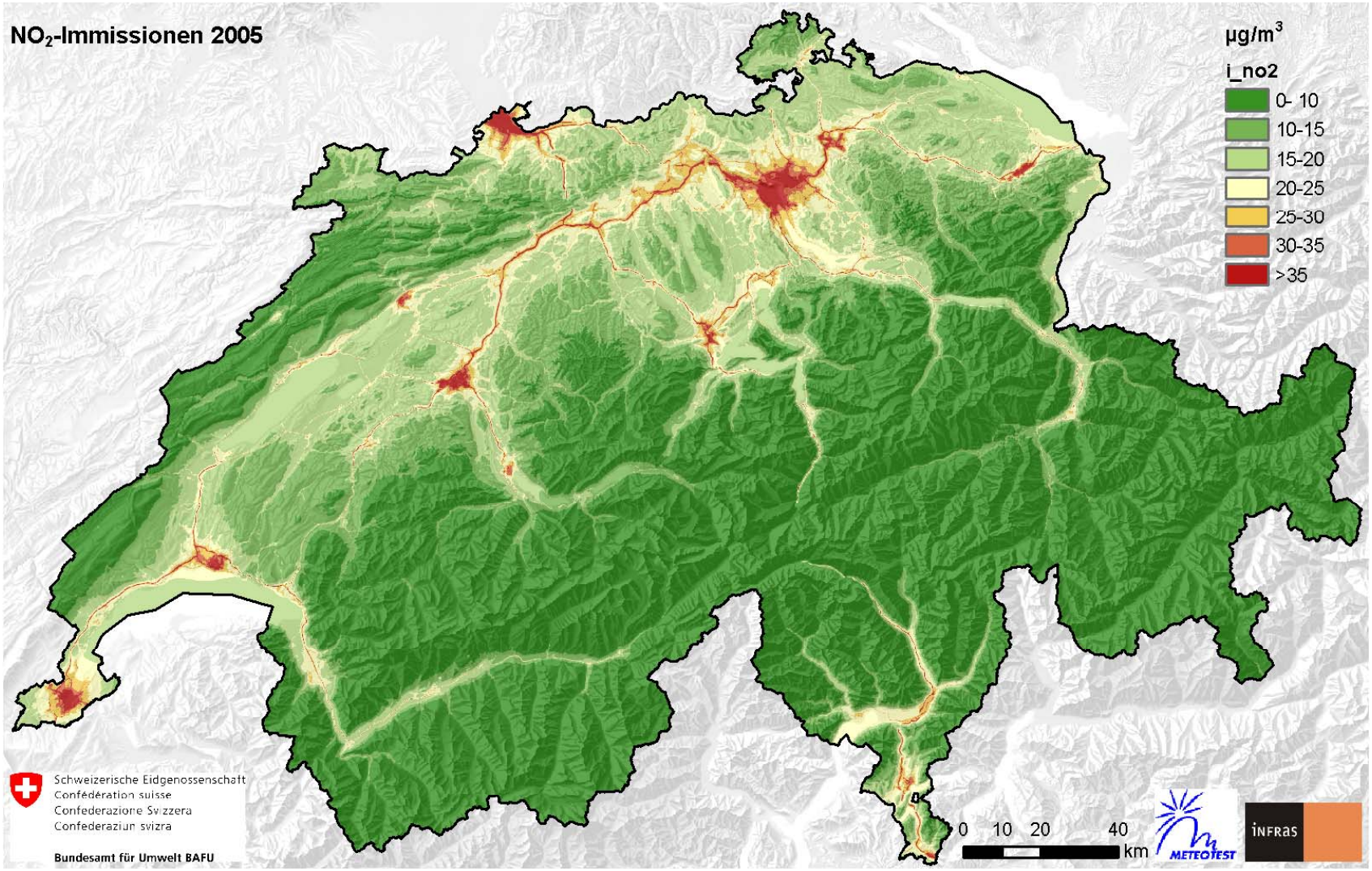


# $NH_3$ emissions in 2007

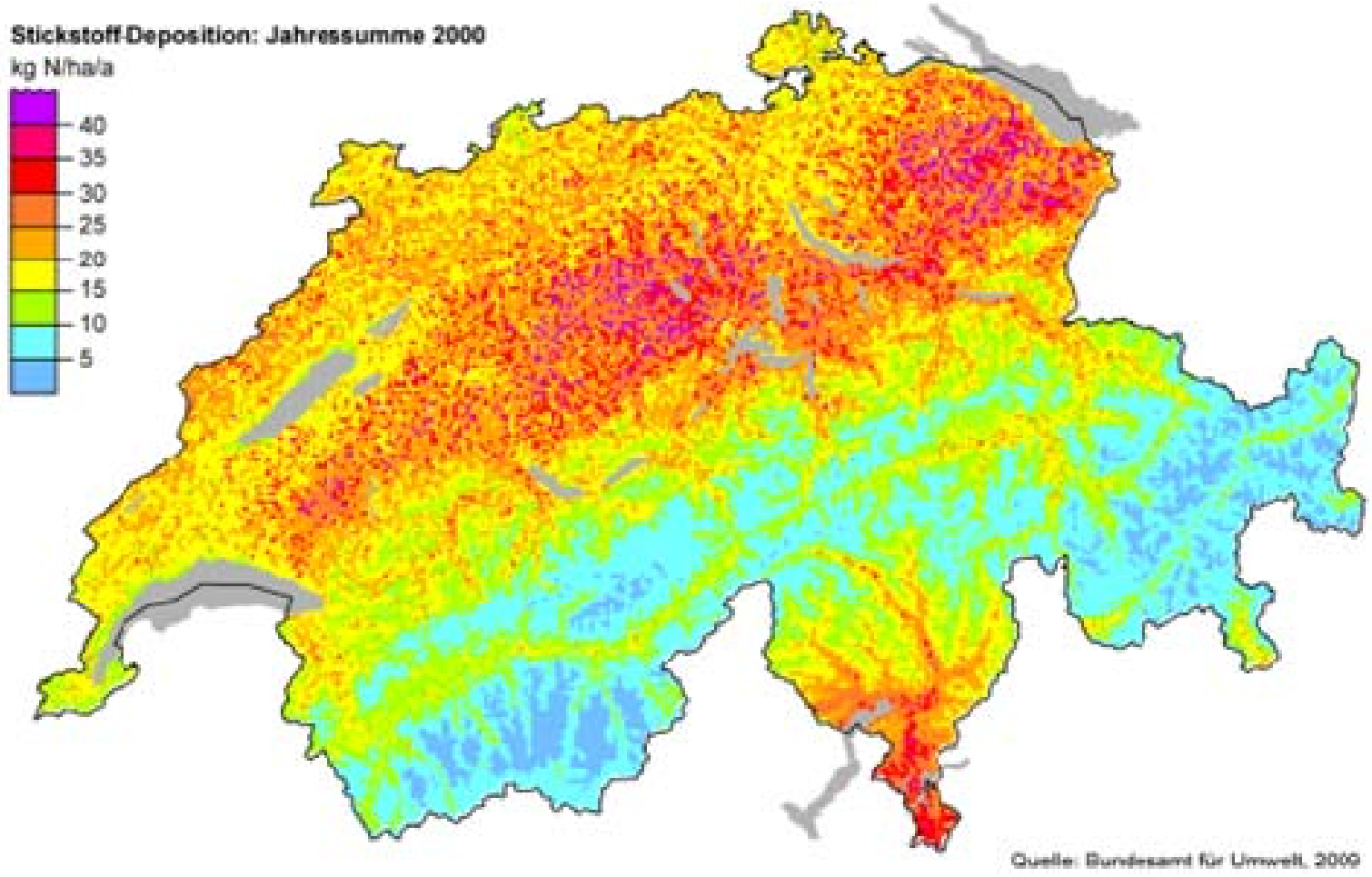


# $NO_2$-Immissions

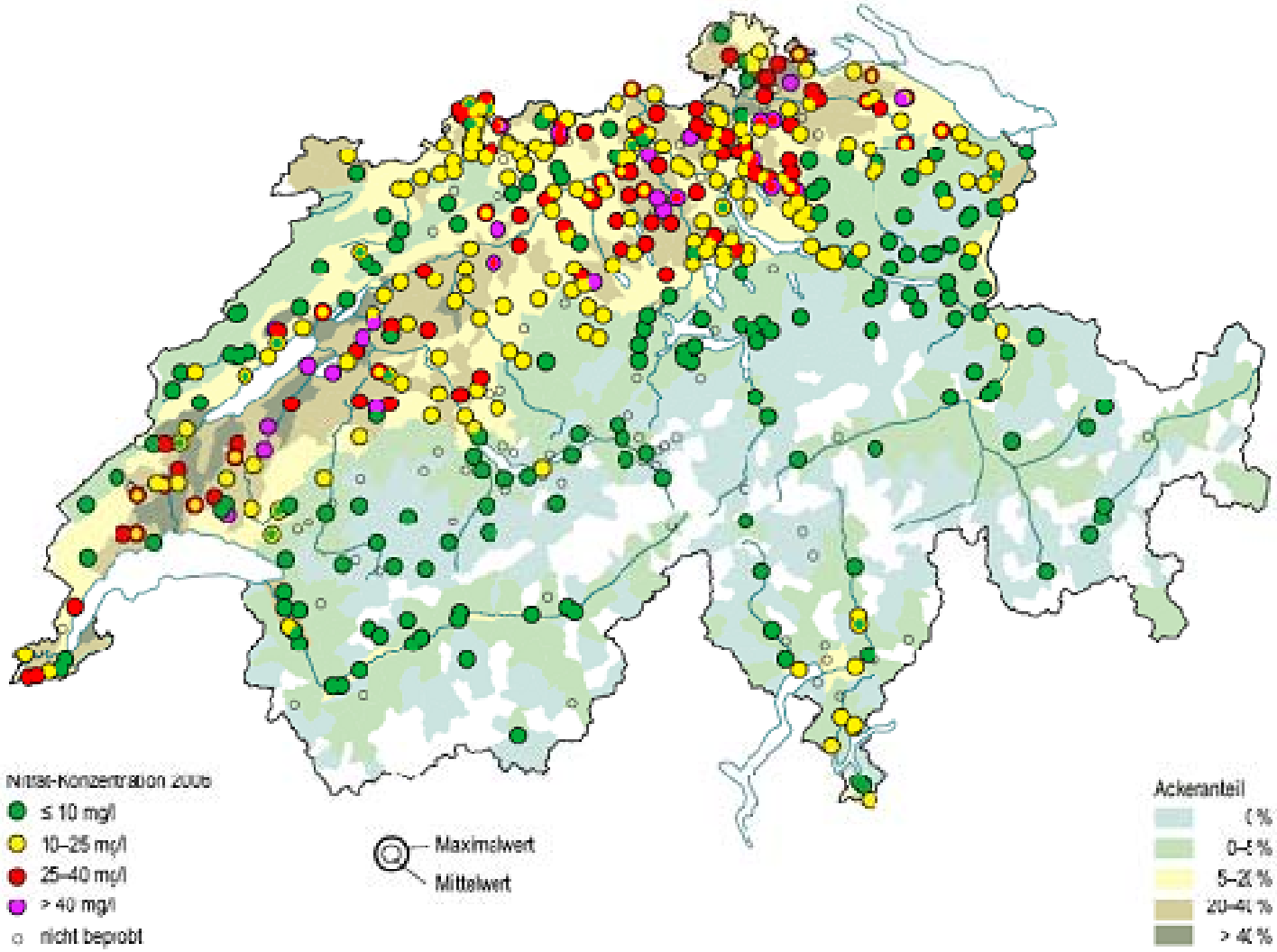
(first model run, provisional data – NO2 level is still too high)



# N depositions Switzerland 2000



# Nitrate concentrations groundwater 2006



# Gaps in knowledge + agricultural research

## Soils

N processes in sosils
fate of non-efficient N fertilizers
leaching and emissions from agricultural soils and forests

## Experiments and models

full N approach experiments (Kyoto exp.)
calibration, validation of full N approach models

## Potentials / scenarios

potential to increase N efficiency (local!)
potential to reduce N losses (local)
scenarios low / high input systems

## Climate change

Coupling of N with C cycle under the effect of climate change
→ mitigation / adaptation in agriculture