Determinants of cropping choices and their use in CAPRI model

Impact of the location of agricultural production on ecosystem services

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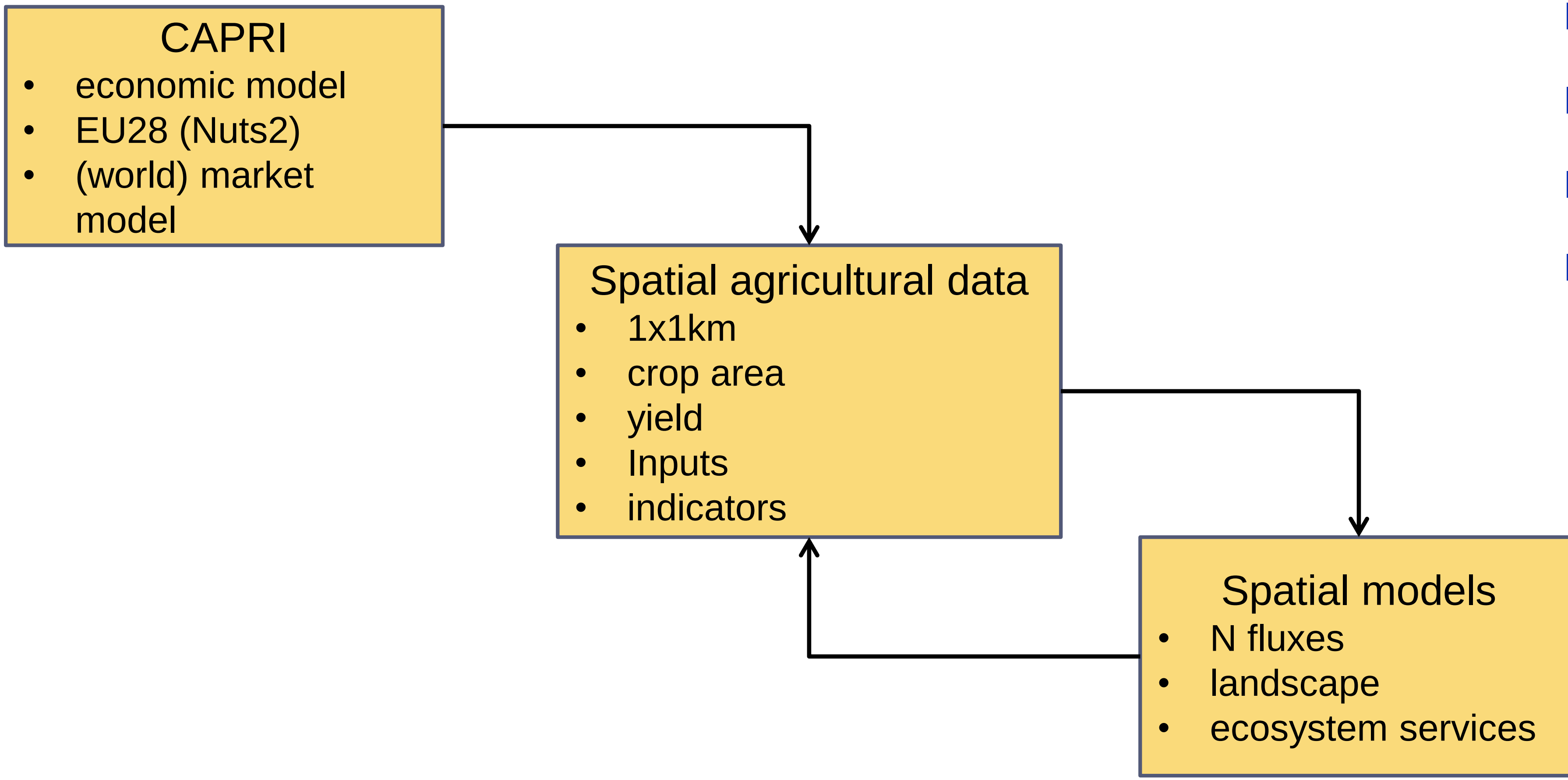
Outline

- Introduction
- Disaggregation procedure
- Ongoing improvement

Modelling agriculture and enviornment

- ModelleCAPRI modeling system is designed as an instrument to check for interactions between “classical” goals of agricultural policy and environmental side-effects at aggregate regional level
- However, effect of agricultural activities on the environment is differentiated by differences in soil type, land cover and climate
- Land cover maps based on satellite images (CORINE, PELCOM) usually do not differentiate “crops”
- DNDC, a bio-physical model designed at JRC, can be employed to forecast environmental effects on small scale units (10 x10 km Grids)

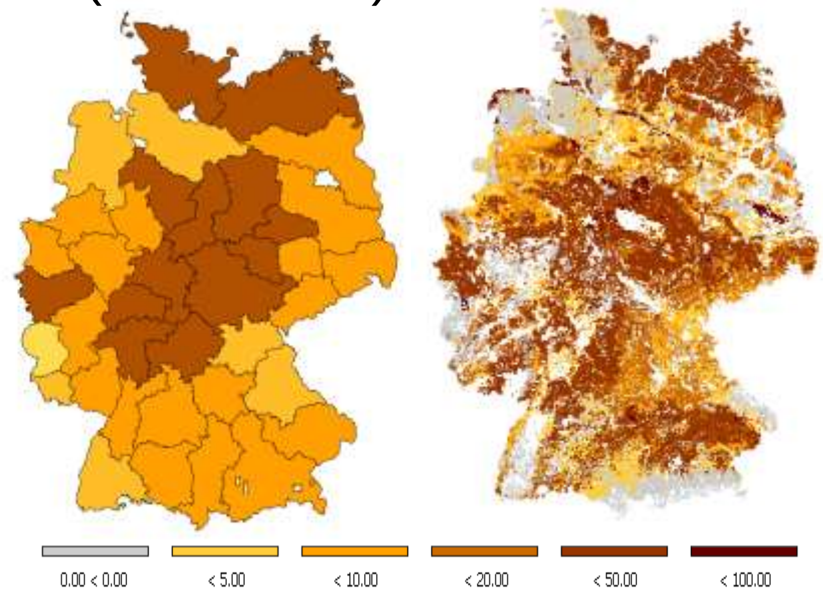
Spatial agricultural data in CAPRI system



Spatial agricultural data in CAPRI system

- 2004-2007: downscaling procedure developed and imlemented (University of Bonn and Joint Research Centre (JRC) Ispra).
- Since 2006: spatial data used for enviornmental analysis, e.g. with DNDC (JRC)
- Since 2012: update of the downscaling procedure (JRC)

- Example: land use soft wheat (% of UAAR)



- CAPRI DNDC

Disaggregation procedure

Basic Assumptions

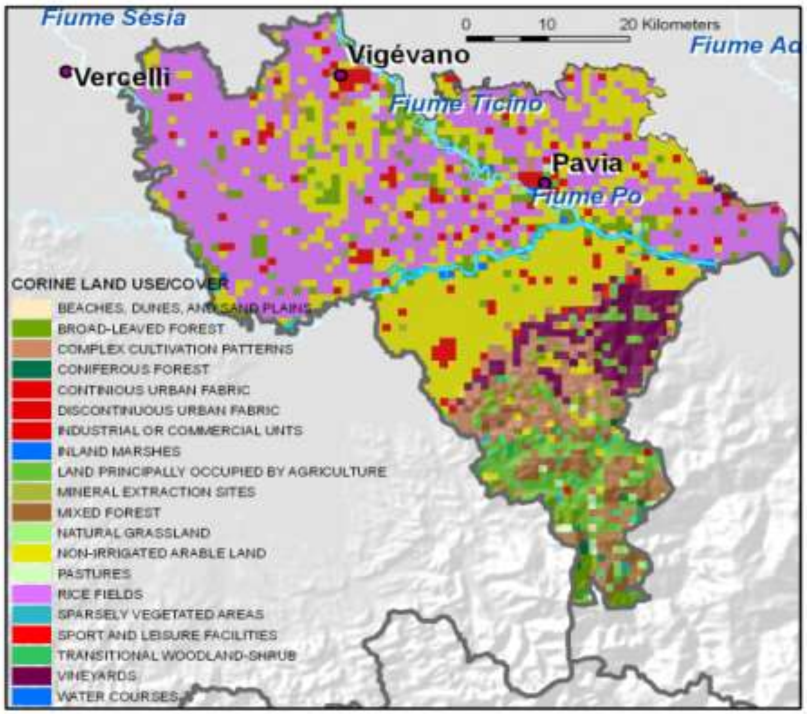
- Land use is determined by natural and socio-economic factors
- Information on market conditions is difficult to collect and largely invariant within an administrative region
- Heterogeneity comes mostly from natural factors where small scale data is available

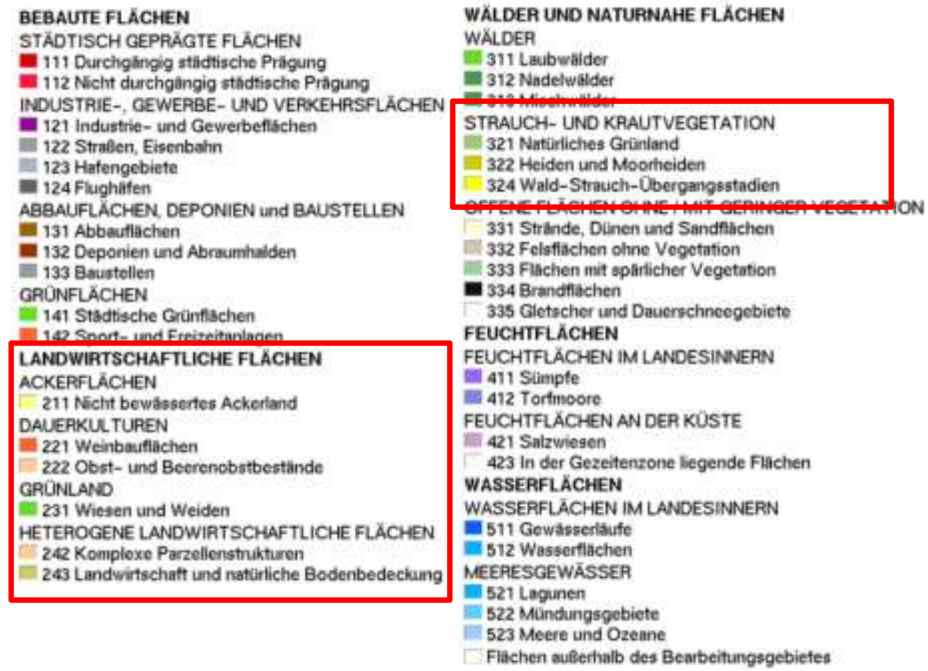
General Approach

- Definition of homogeneous spatial mapping units (HSMU) where land use is assumed to be equal (about 150.000 in EU25)
- Deriving prior information on land use in HSMU based on natural conditions
- Adjust priors until data consistent solution is found administrative region

Availabe data: Spatial soil cover

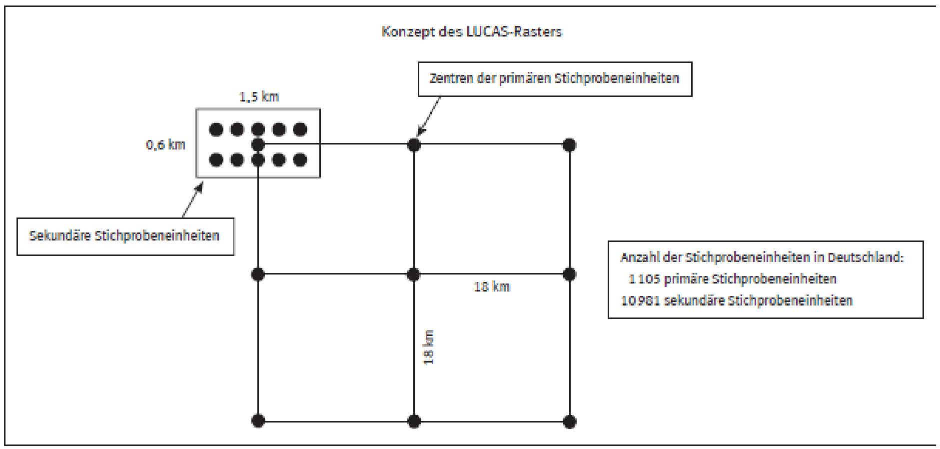
Corine Landcover (CLC)





Available data: Point observation of crops

Flächenstichprobe
Land Use/Cover Area Frame Statistical Survey (LUCAS)



Ebene 1	Beschreibung	Ebene 2	Beschreibung	Ebene 3	Beschreibung
A	Bebautes Land	A1	Bebaute Fläche	A11	Gebäude mit ein bis drei Stockwerken
				A12	Gebäude mit mehr als drei Stockwerken
				A13	Gewächshäuser
		A2	Unbebaute künstliche Fläche	A21	Unbebaute Flächenelemente
				A22	Unbebaute lineare Elemente
B	Ackerland	B1	Getreide	B11	Weizen
				B12	Hartweizen
				B13	Gerste
				B14	Roggen
				B15	Hafer
				B16	Mais
				B17	Reis
				B18	Sonstiges Getreide
		B2	Hackfrüchte	B21	Kartoffeln
				B22	Zuckerrüben
				B23	Sonstige Hackfrüchte
		B3	Handelsgewächse	B31	Sonnenblumen
				B32	Raps und Rübensamen
				B33	Soja
				B34	Baumwolle
				B35	Sonstige Faser- und Ölpflanzen
				B36	Tabak
				B37	Sonstige Handelsgewächse
		B4	Hülsenfrüchte, Gemüse und Blumen	B41	Hülsenfrüchte
				B42	Tomaten
				B43	Sonstiges Frischgemüse
				B44	Blumen und Zierpflanzen
				B45	Erdbeeren
		B5	Wechselgrünland und Futterwiesen	B50	Wechselgrünland und Futterwiesen
		B6	Brache	B60	Brache
		B7	Dauerkulturen: Obstgehölze	B71	Äpfel
				B72	Birnen
				B73	Kirschen
				B74	Nussbäume
				B75	Sonstige Obstgehölze
				B76	Orangen
				B77	Sonstige Zitrusfrüchte
		B8	Sonstige Dauerkulturen	B81	Olivenhaine
				B82	Rebflächen
				B83	Baumschulen
				B84	Handelsgewächse – Dauerkulturen
C	Wald	C1	Forstfläche	C11	Laubwald
				C12	Nadelwald
				C13	Mischwald
		C2	Sonstige Waldfläche	C21	Sonstige Laubwaldfläche
				C22	Sonstige Nadelwaldfläche
				C23	Sonstige Mischwaldfläche
D	Buschland			D01	Buschland mit spärlicher Baumbedeckung
				D02	Buschland ohne Baumbedeckung
E	Dauergrünland			E01	Dauergrünland mit spärlicher Baum-/Strauchbedeckung
				E02	Dauergrünland ohne Baum-/Strauchbedeckung
F	Vegetationsarmes Land			F00	Vegetationsarmes Land
G	Wasser und Feuchtgebiete			G01	Stehende Binnengewässer
				G02	Fließende Binnengewässer
				G03	Küstengewässer
				G04	Feuchtgebiete
				G05	Gletscher und Dauerschneegebiete

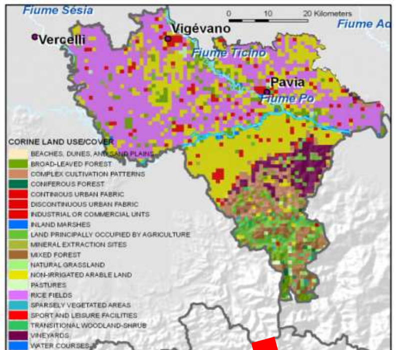
Homogeneous Spatial Mapping Units

- The HSMU is regarded as similar both in terms of agronomic practices and the natural environment, embracing conditions that lead to similar farming and environmental situations
- Sub-units of Nuts3 regions
- Trade-off between level of detail and computation resources
- HSMU's are constructed from four data sources…

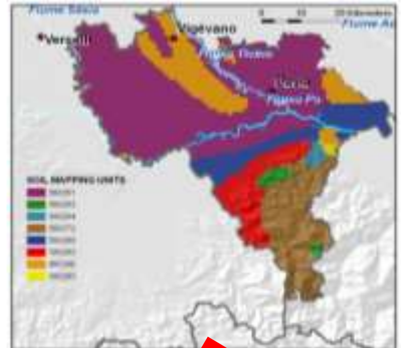
Homogeneous Spatial Mapping Units

Administrative boundary (FSS NUTS 2/3)

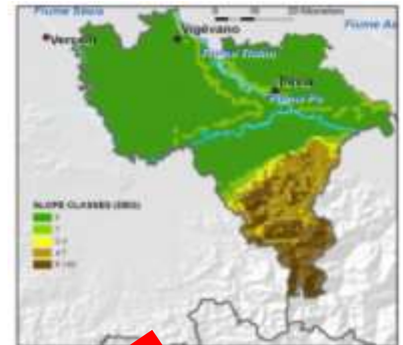
Soil cover (Corine)

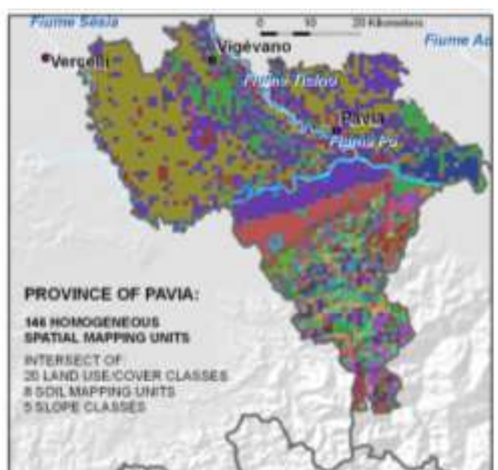


Soil type (European Soil Database)



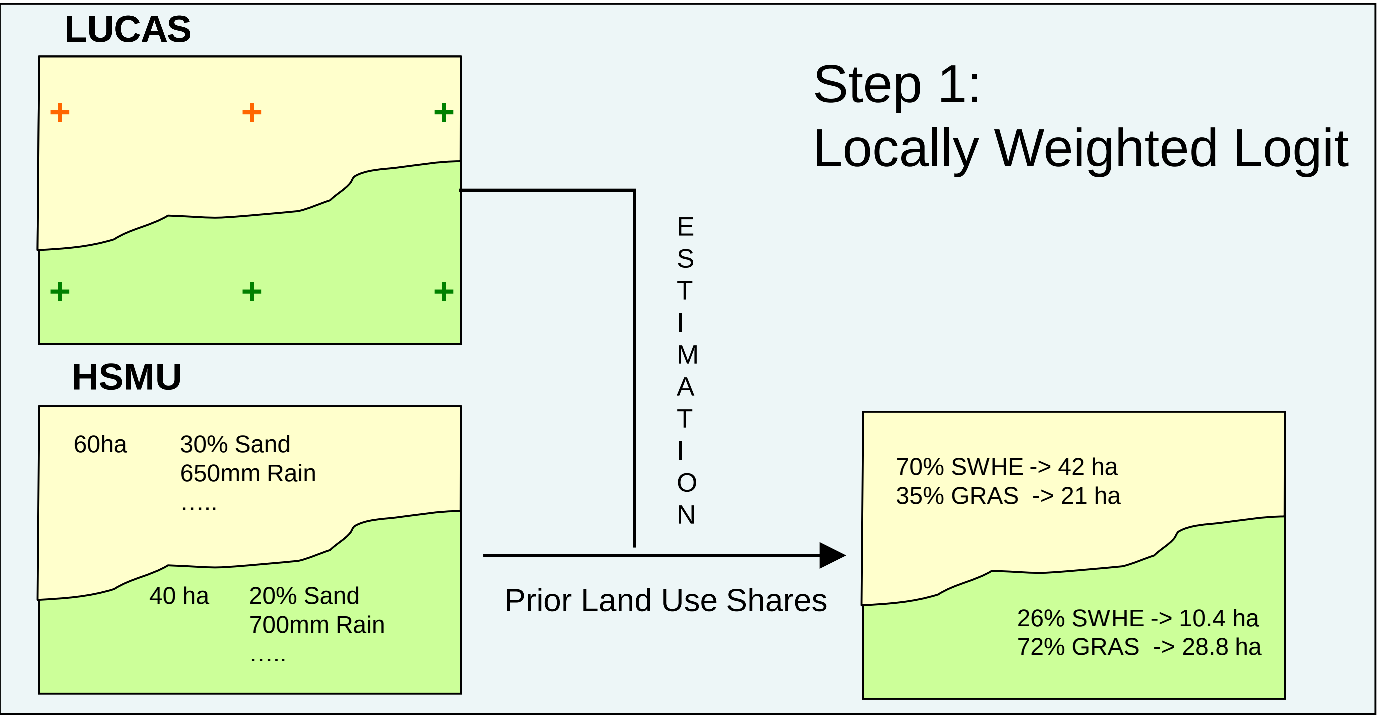
slope (Digital Elevation Model)





Homogeneous Spatial Mapping Units (HSMU)

Estimating land use shares



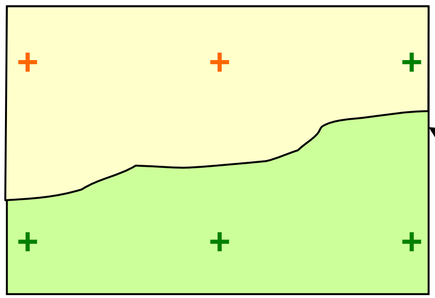
$$\mathbf{Y} = \mathrm{f}(\mathbf{X})$$

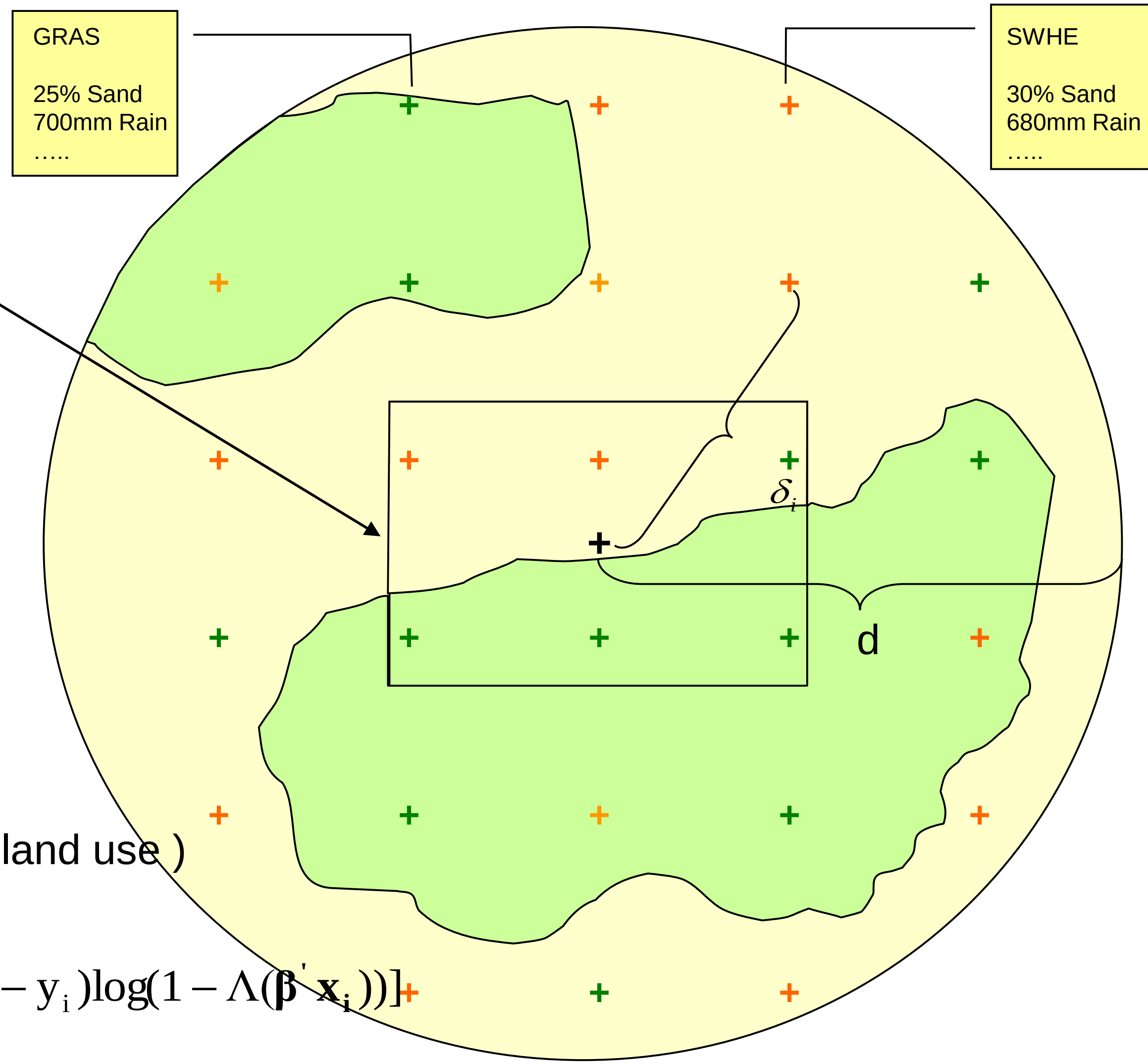
Land use share
of 31 crops

- soil type (World Reference Base)
- drainage
- presence of stones
- slope
- elevation
- rainfall
- sum of temperature

Locally weighted logit model

LUCAS





Weighting Function:

$$\varpi_i = \left[1 - \left(\frac{\delta_i}{d}\right)^3\right]^3 I(\delta_i < d)$$

Locally Weighted Logit :

$$\Lambda(\beta' x_i) = \frac{e^{\beta' x_i}}{1 + e^{\beta' x_i}}$$ (= share of land use)

$$\log L = \sum_{i=1}^{n} \omega_i [y_i \log(\Lambda(\boldsymbol{\beta}' \mathbf{x}_i)) + (1 - y_i) \log(1 - \Lambda(\boldsymbol{\beta}' \mathbf{x}_i))]$$

Locally weighted logit model

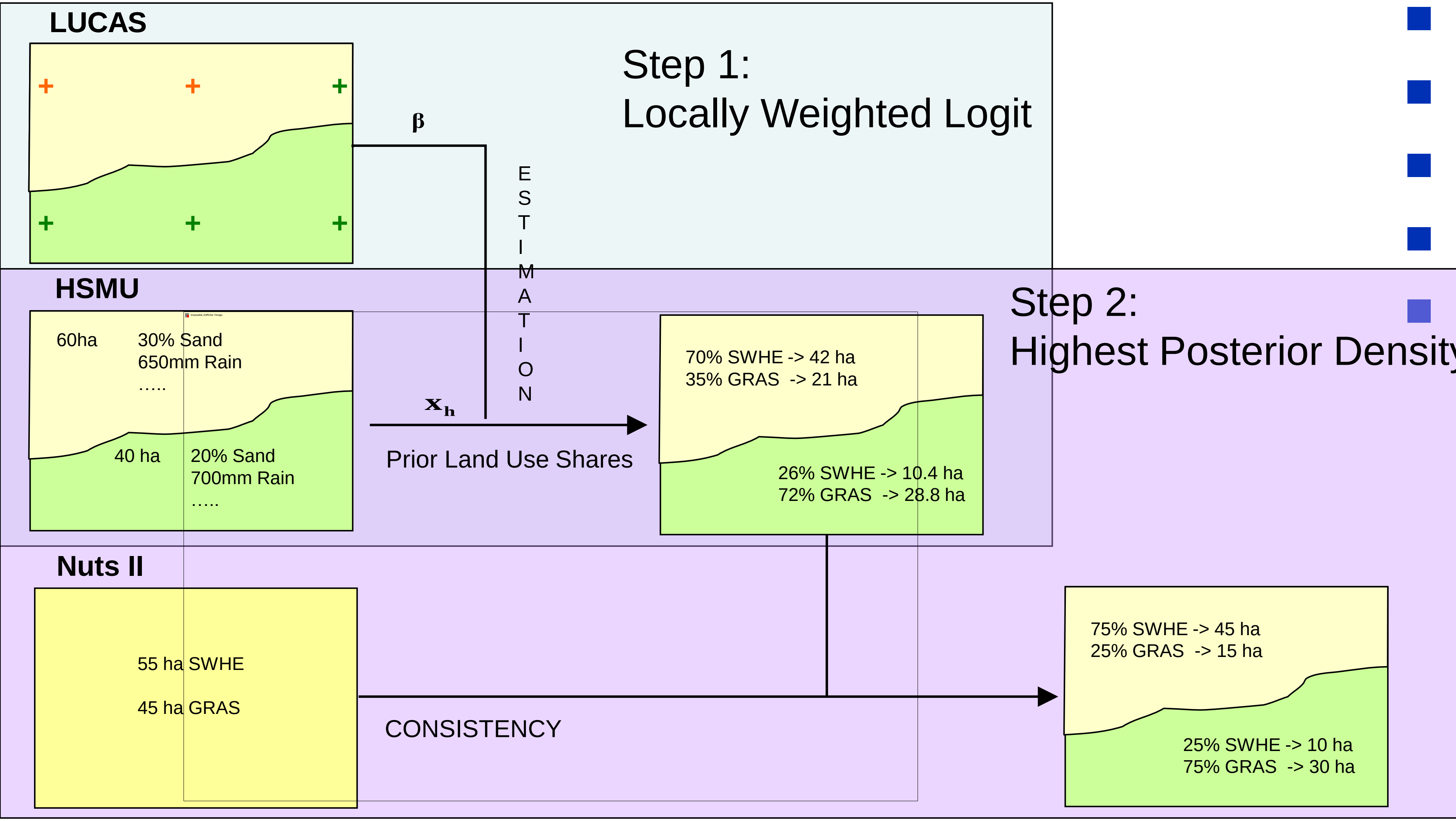
estimate a model for each

- Nuts2
- Corine class
- crop

while determining

- Optimal bandwidth
- Significant explanatory variables

Estimating land use shares

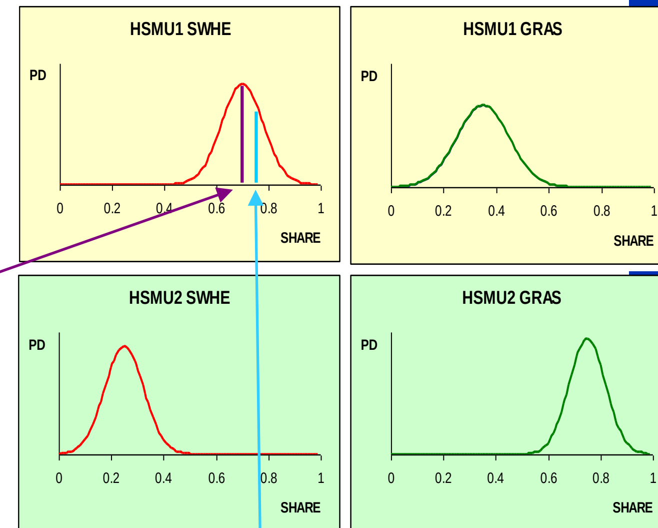


Consistent HPD solution

Data consistent shares $\mathbf{Y}_{c,h}^{con}$ for all Crops c and HSMU h :

$$\max -\sum_c \sum_h \left[\log\left(\sqrt{2\pi}\,\sigma_{c,h}\right) + \frac{\left(\mathbf{Y}_{c,h}^{con} - \hat{\mathbf{Y}}_{c,h}\right)^2}{2\sigma_{c,h}^2} \right]$$

$$\text{s.t.} \quad \sum_h \mathbf{Y}_{c,h}^{con} \mathbf{A}_h = \mathbf{A}_c \qquad \sum_c \mathbf{Y}_{c,h}^{con} = 1$$



HSMU

60ha

40 ha

70% SWHE -> 42 ha
35% GRAS -> 21 ha

26% SWHE -> 10.4 ha
72% GRAS -> 28.8 ha

Nuts II

55 ha SWHE

45 ha GRAS

75% SWHE -> 45 ha
25% GRAS -> 15 ha

25% SWHE -> 10 ha
75% GRAS -> 30 ha

Consistent HPD solution

Administrative data forces significant correction of apriori informastion

		mean	Standart devialtion	Consistent solution aggregate data
HSMU 1 (pasture)	gras	29	4.3	18
	wheat	10	1.6	22
	total			40
HSMU 2 (arable)	gras	21	2.1	2
	wheat	42	4.2	58
	total			60
Administrative Region	gras	(52)		20
	wheat	(50)		80

Consistent HPD solution

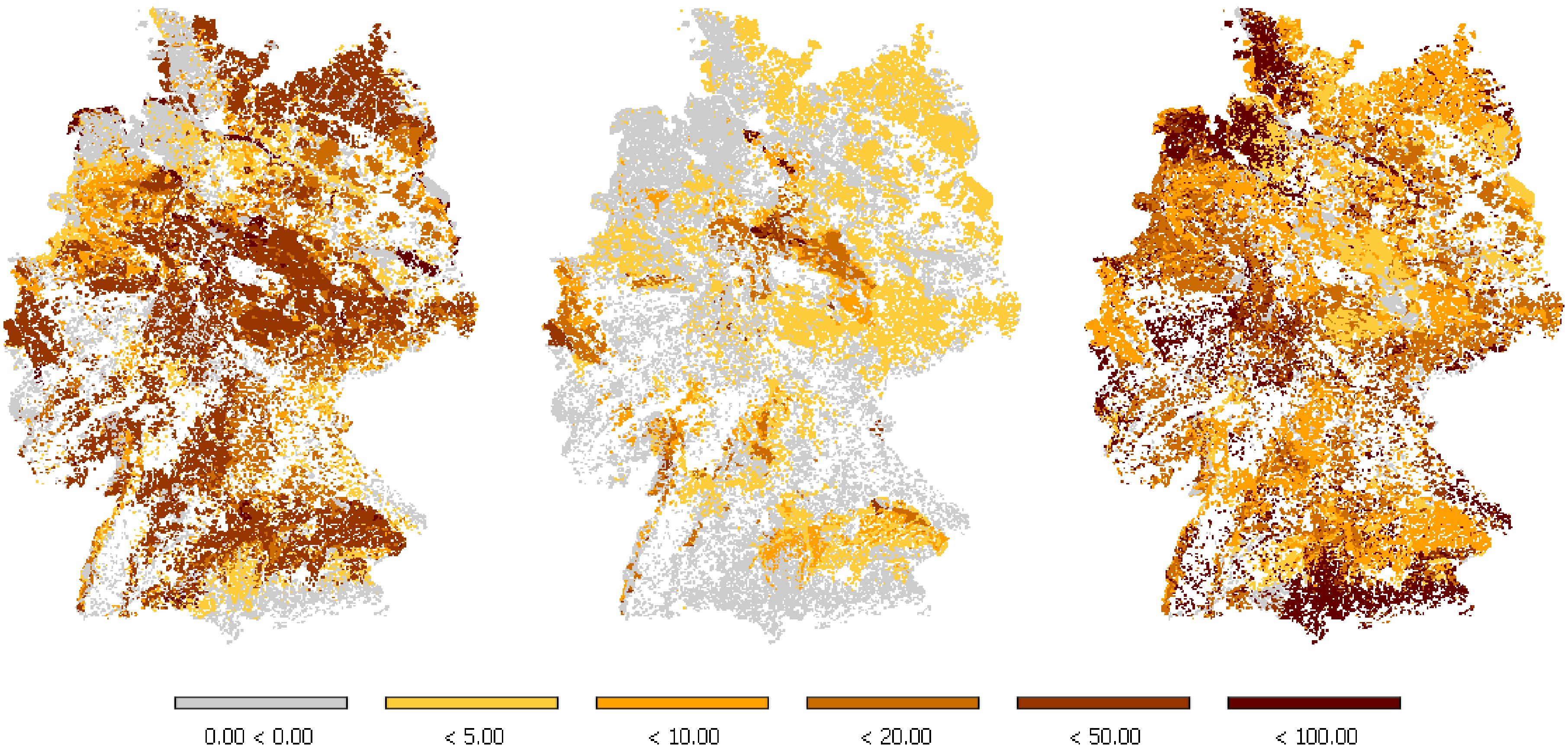
Very low standard deviation

		mean	Standard-deviation	Consistent solution aggregate data
HSMU 1 (pasture)	gras	29	4.3	0
	wheat	10	1.6	40
	total			40
HSMU 2 (arable)	gras	21	0.2	20
	wheat	42	4.2	40
	total			60
Administrative Region	gras			20
	wheat			80

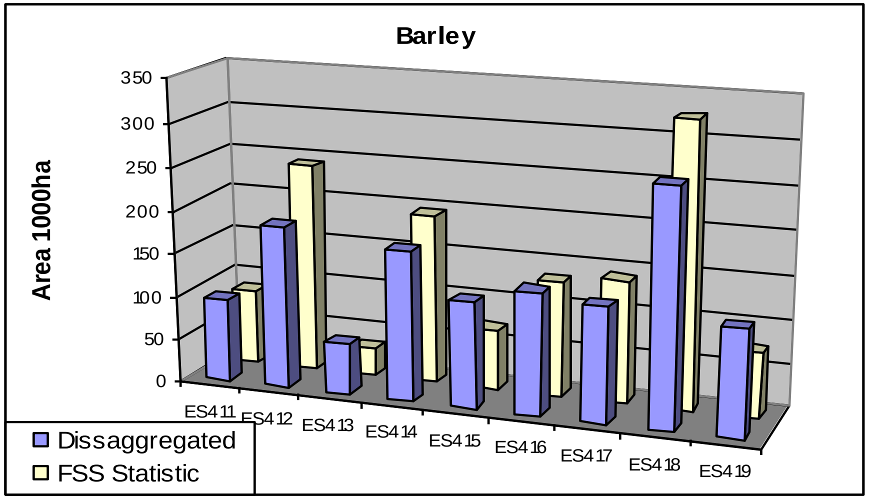
- HPD framework uses all information on expected mean and standard deviation
- Standard deviation can have significant impact on final solution.
- Methods to derive standard deviation (asymtotic, numerical, bootstrap) are important.

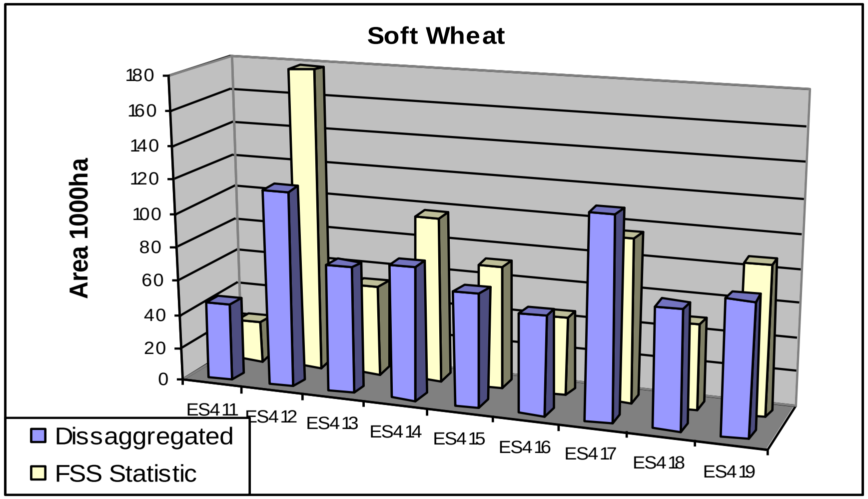
Crop shares in Germany

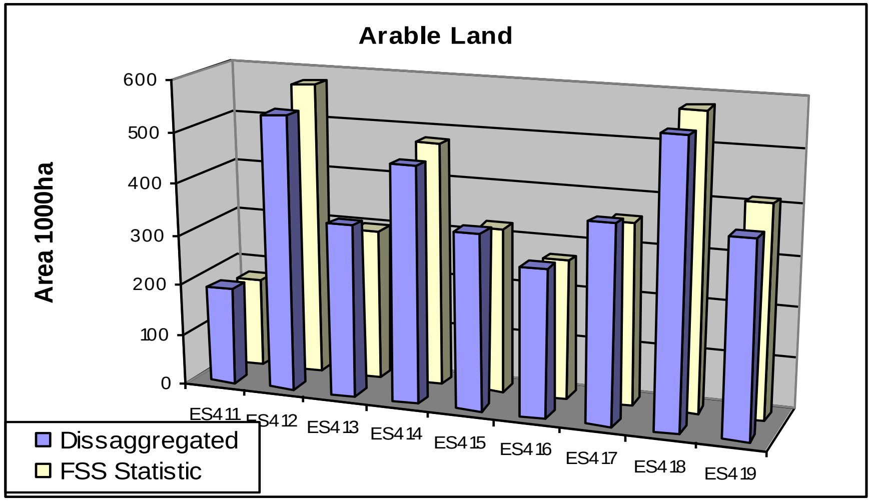
wheat sugar beet grassland

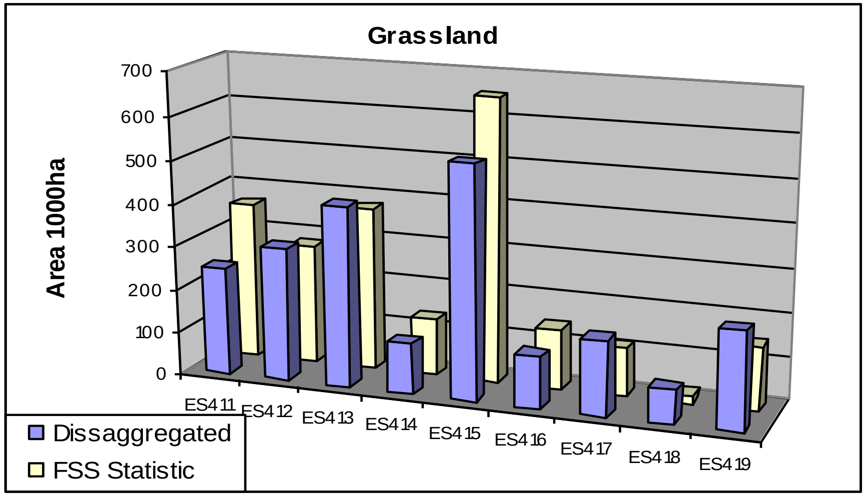


Validation at Nuts3

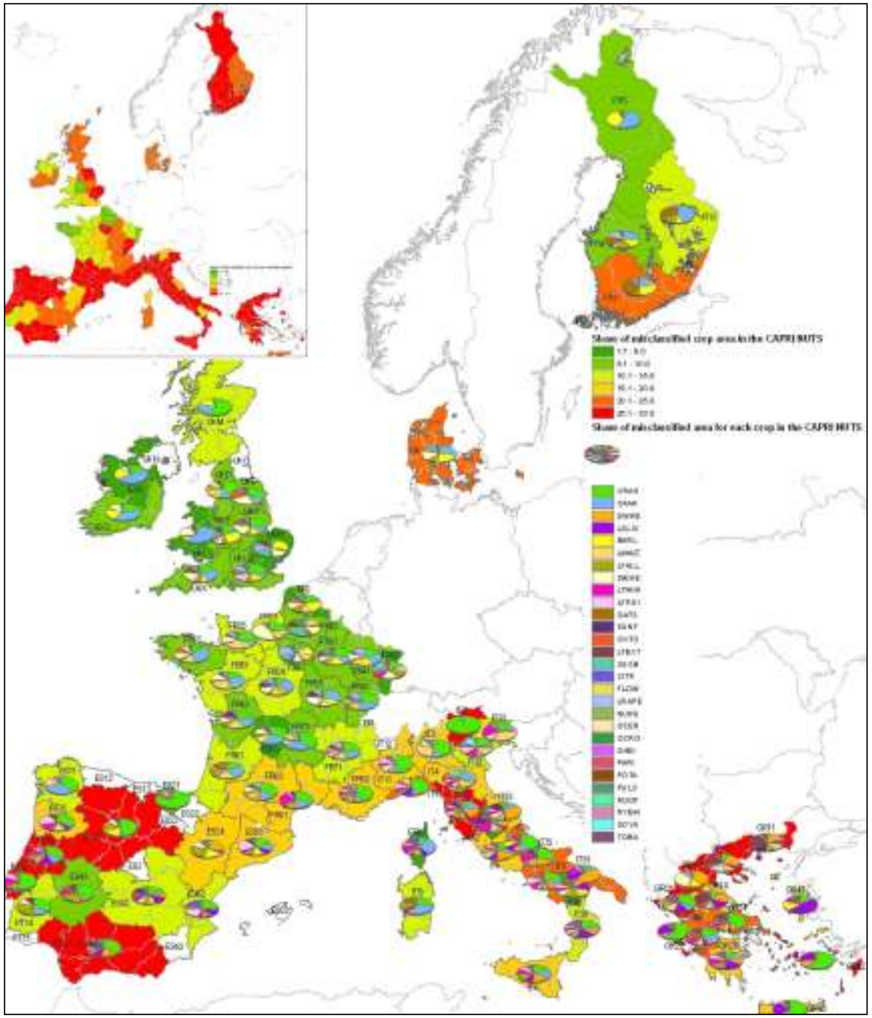








Validation at Nuts3



- Framework to break down land use to lower spatial scale generally works
- Shares of crops follow actual distribution
- Spatial statistics allow to capture some effects implicitly
- Highest Posterior Density Estimator allows transparent inclusion of information on uncertainty
- Variances derived from the finite sample improve on average the final result

Dissagregation of land use characteristics

HPD framework using prior information from:

Yield:

- MARS CGMS yield forecast as prior information
- Irrigation data

Animal herds:

- Based on regression model

N fertilizer:

- Spatial yield expectation
- Soil specific fertilizer recommendation (DEFRA)
- Manure/Animal herds

Other inputs:

- Spatial yield
- Soil type

Spatial data used in publications

Nitrogen fluxes:

- Leip A, Achermann B, Billen G, Bleeker A, Bouwman A F, de Vries W, Dragosits U, Döring U, Fernall D, Geupel M, Heldstab J, Johnes P, Le Gall A C, Monni S, Nevečeřal R, Orlandini L, Prud'homme M, Reuter H I, Simpson D, Seufert G, Spranger T, Sutton M A, van Aardenne J, Voß M and Winiwarter W 2011a Integrating nitrogen fluxes at the European scale European Nitrogen Assessment ed M Sutton, C Howard, J W Erisman, G Billen, A Bleeker, H van Grinsven, P Grennfelt and B Grizzetti (Cambridge, UK: Cambridge University Press) pp 345–76 Online: http://www.nine-esf.org/ENA-Book.
- Leip A, Busto M and Winiwarter W 2011b Developing spatially stratified N2O emission factors for Europe. Environ. Pollut. 159 3223–32 doi:10.1016/j.envpol.2010.11.024
- Hutchings N J, Reinds G J, Leip A, Wattenbach M, Bienkowski J F, Dalgaard T, Dragosits U, Drouet J L, Durand P, Maury O and de Vries W 2012 A model for simulating the timelines of field operations at a European scale for use in complex dynamic models Biogeosciences 9 4487–96 doi:10.5194/bg-9-4487-2012
- Follador M, Leip A and Orlandini L 2011 Assessing the impact of Cross Compliance measures on nitrogen fluxes from European farmlands with DNDC-EUROPE. Environ. Pollut. 159 3233–42 doi:10.1016/j.envpol.2011.01.025

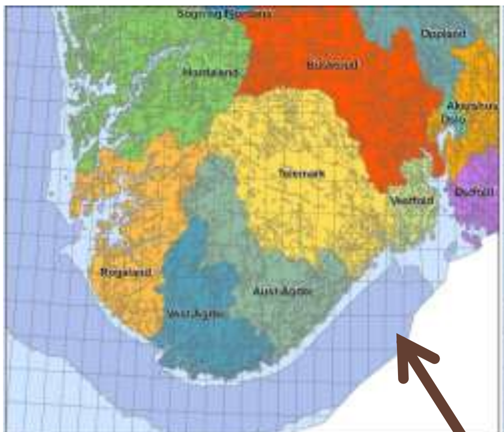
Landscape indicators

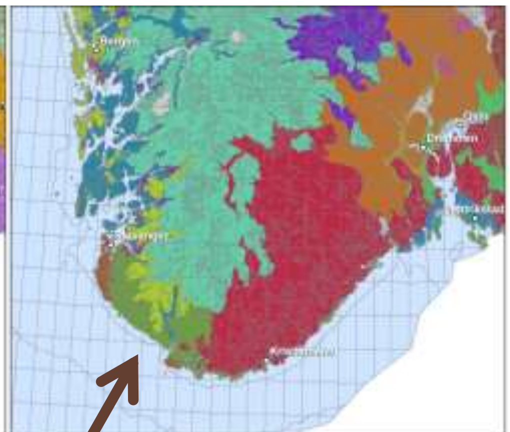
Energy flows

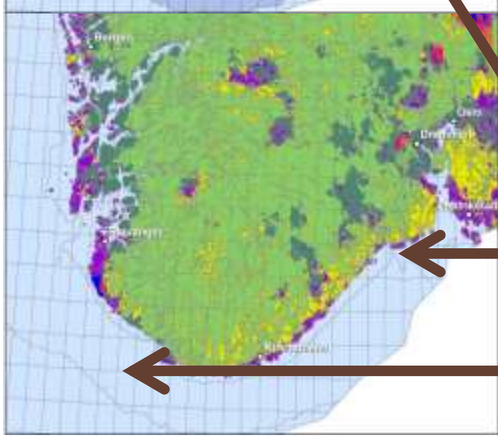
Why NEW HSU2???

- The old HSMU-layer worked fine, ….
- BUT
  - → White holes in the map (e.g. Norway…)
  - → Cumbersome linkage to meteo-data (NitroEurope experience)
  - → Applications of “CAPRI” data go quickly beyond CAPRI-domain…
  - → Some improved delineation procedures
    - Arbitrary slope classes – no altitude
    - Non-contingent HSMU sometimes ‘far away’
    - Corine no ‘static’ characteristic

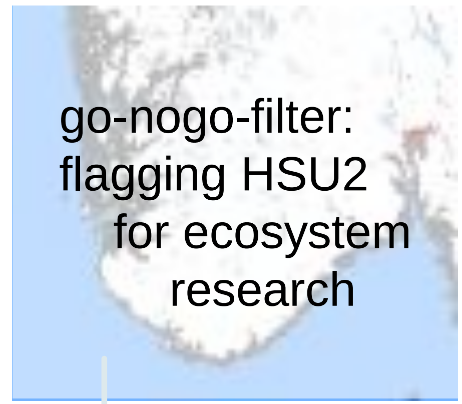
Delineation of the HSU2

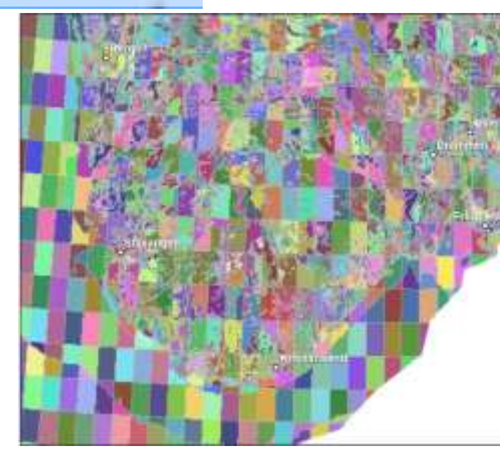






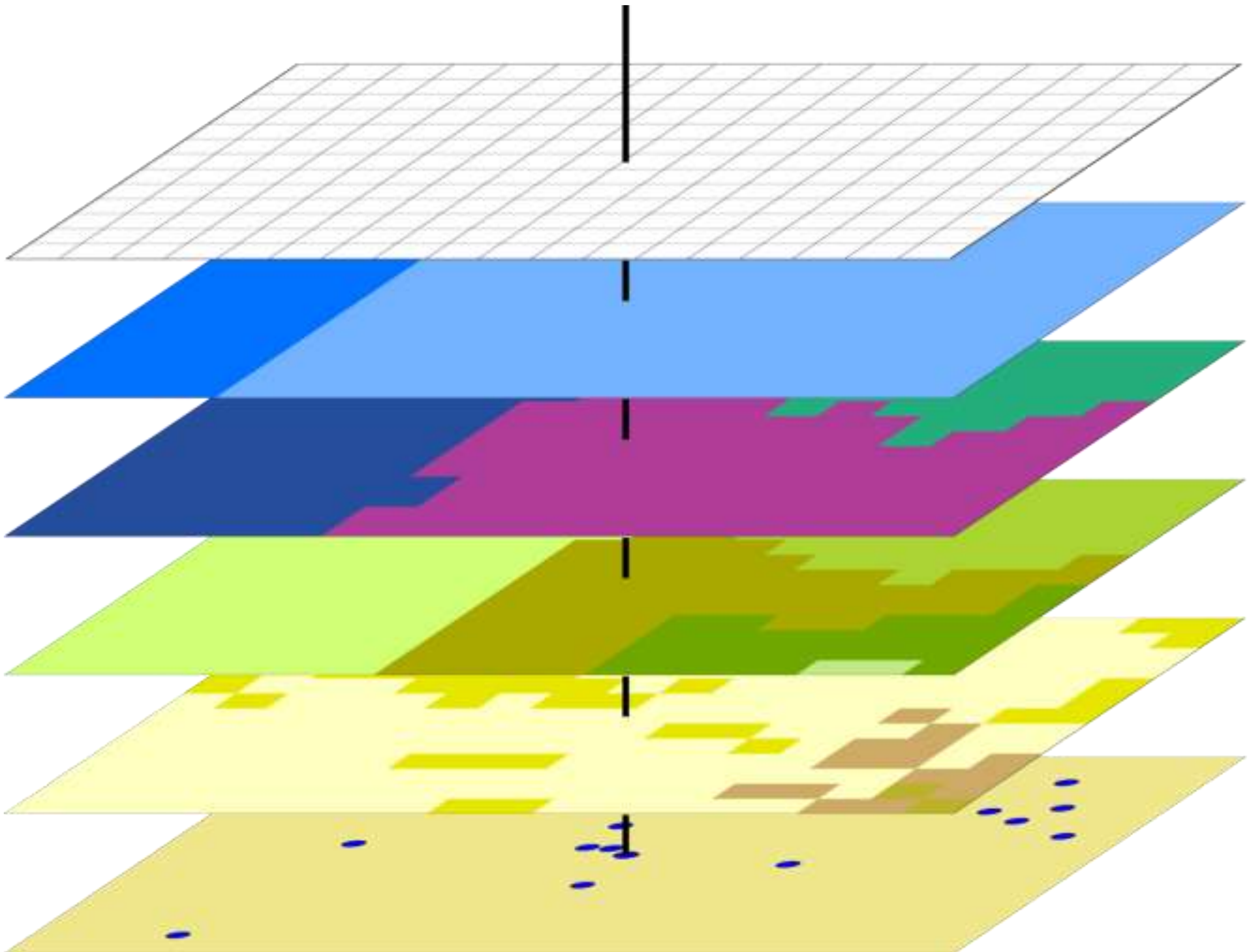
Soil Mapping Units
Administrative regions (NUTS3)
Landform + shelf area
0.25deg meteo grid





199901 units for EU28 +
318875 units non-EU28

The HSU2-layers



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Ongoing update of prior estimation

- inclusion of recent LUCAS data
- methodological improvement (multinomial)
- statistical software packages

…… Questions ????