LONG TERM LARGE SCALE (LTLS): INTEGRATED MODEL

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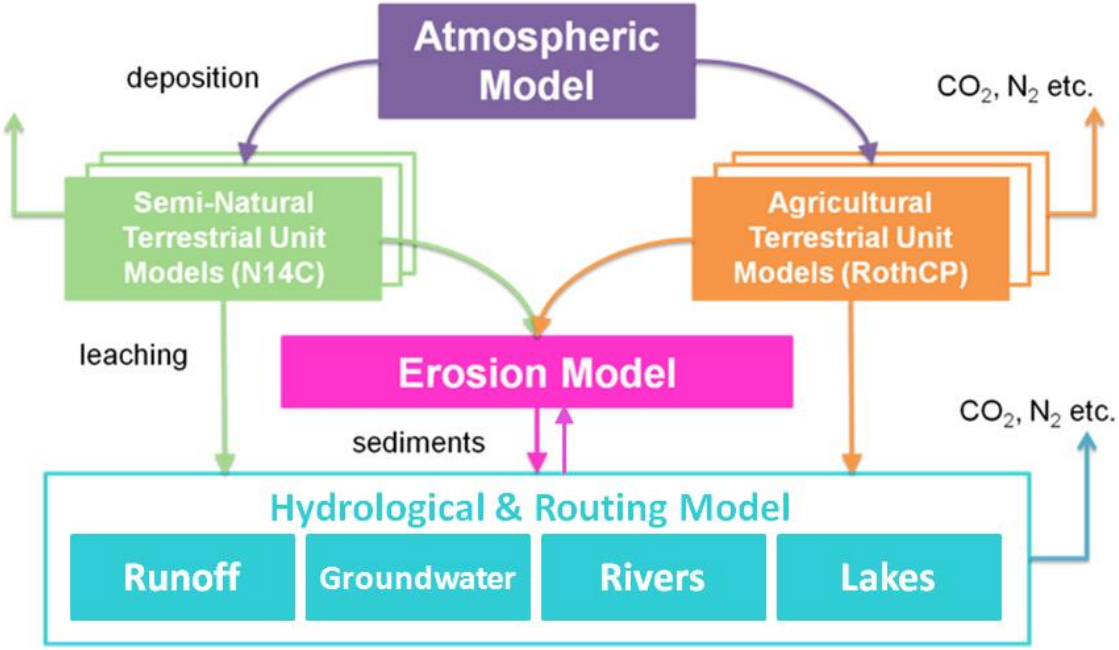
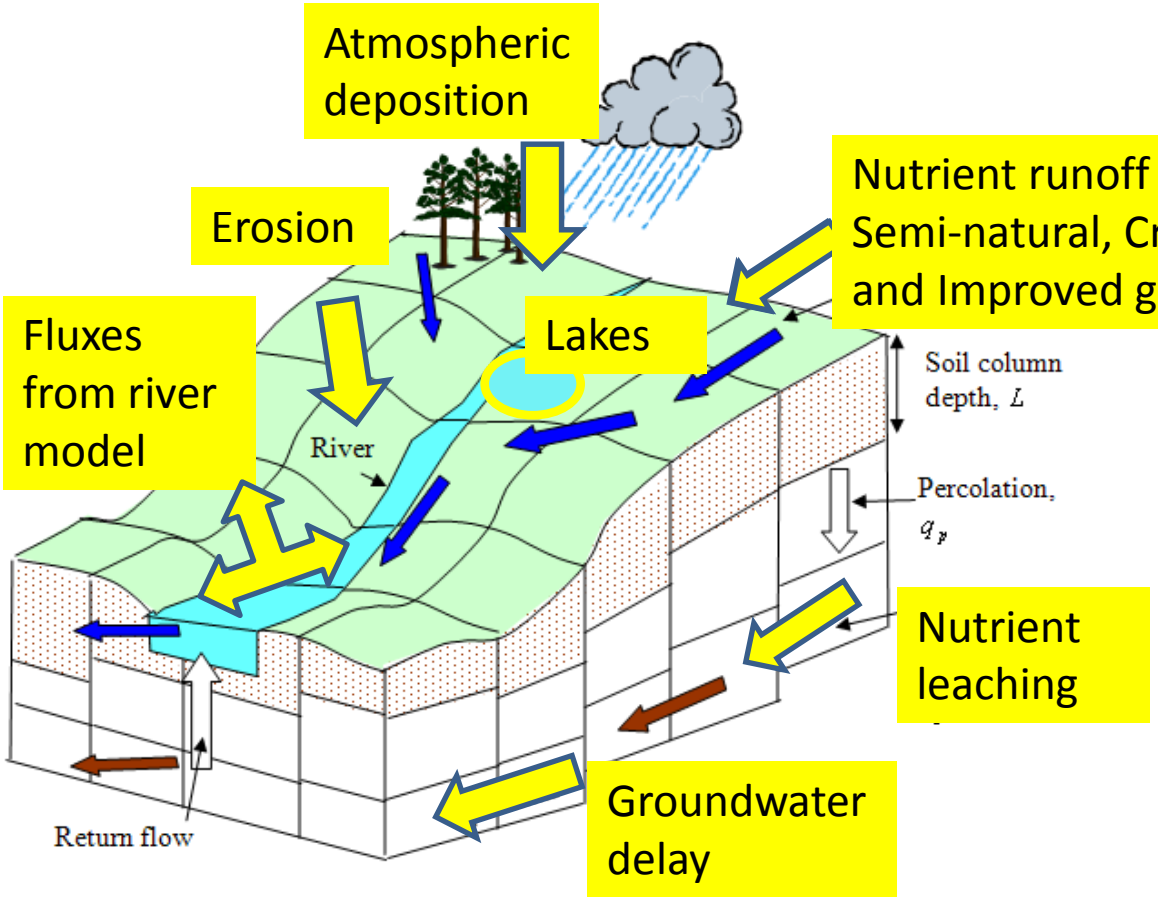
+ LTLS modelling team (Ed Tipping, Shibu Muhammed, Jess Davies, Ulli Dragosits, John Quinton, Marianne Stewart, Andy Whitmore, Ed Carnell, Sam Tomlinson, Lei Wang, Lianhai Wu)

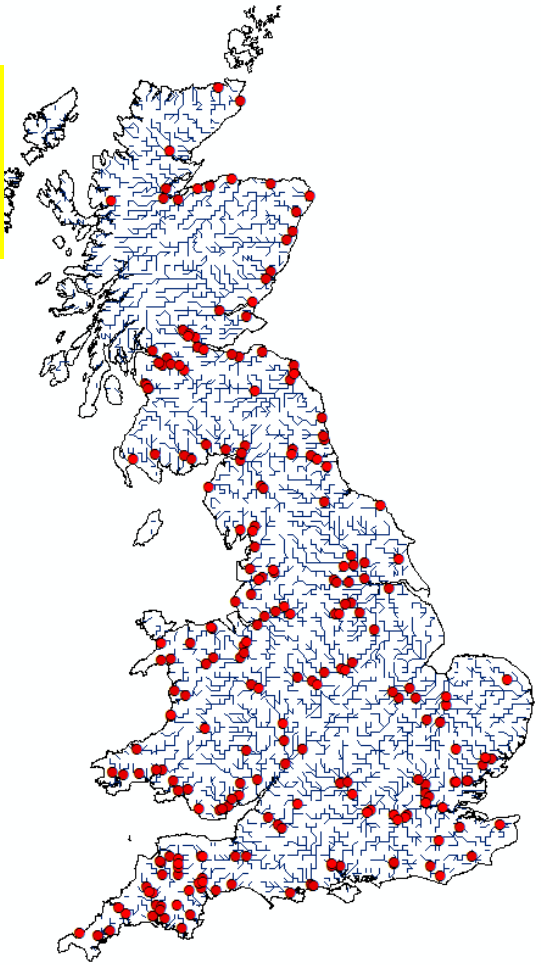


LTLS: Integrated Model (IM)



Hydrological model behind IM incorporates basic properties of:

- soil
- land cover
- topography



LTLS output can be daily/monthly/... And compared to obs. from HMS

LTLS: River variables modelled

List of variables

WATER PHASE			PARTICULATE PHASE			OTHER RIVERINE VARIABLES		
LTLS no.	LTLS name	Units	LTLS no.	LTLS name	Units	LTLS no.	LTLS name	Units
1	DIC	g C	1	FS	g	1	pH	pH
2	DOC	g C	2	POCL	g C	2	O_2	mg/L
3	$DO^{14}C$	%	3	POCNL	g C	3	algae	
4	NH_4-N	g NH_4-N	4	$PO^{14}CL$	%	~~4~~	~~macrophytes~~	
5	NO_3-N	g NO_3-N	5	$PO^{14}CNL$	%	5	water temperature	°C
6	DON	g N	6	PONL	g N			
7	TDP	g P	7	PONNL	g N	GASEOUS OUTPUTS FROM RIVER MODEL		
8	Ca^{2+}	g Ca	8	NH_4-NADS	g NH4-N	1	CO_2 (degassing)	g
9	SO_4-S	g SO_4-S	9	POPL	g P	2	CO_2 (decomposition DOC)	g
10	Si	g Si	10	POPNL	g P	3	CO_2 (decomposition POCL)	g
			11	PADS	g P	4	N (denitrification)	g
			12	PIP	g P			

flux accounting through the river system

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LTLS Integrated Model inputs and processes:

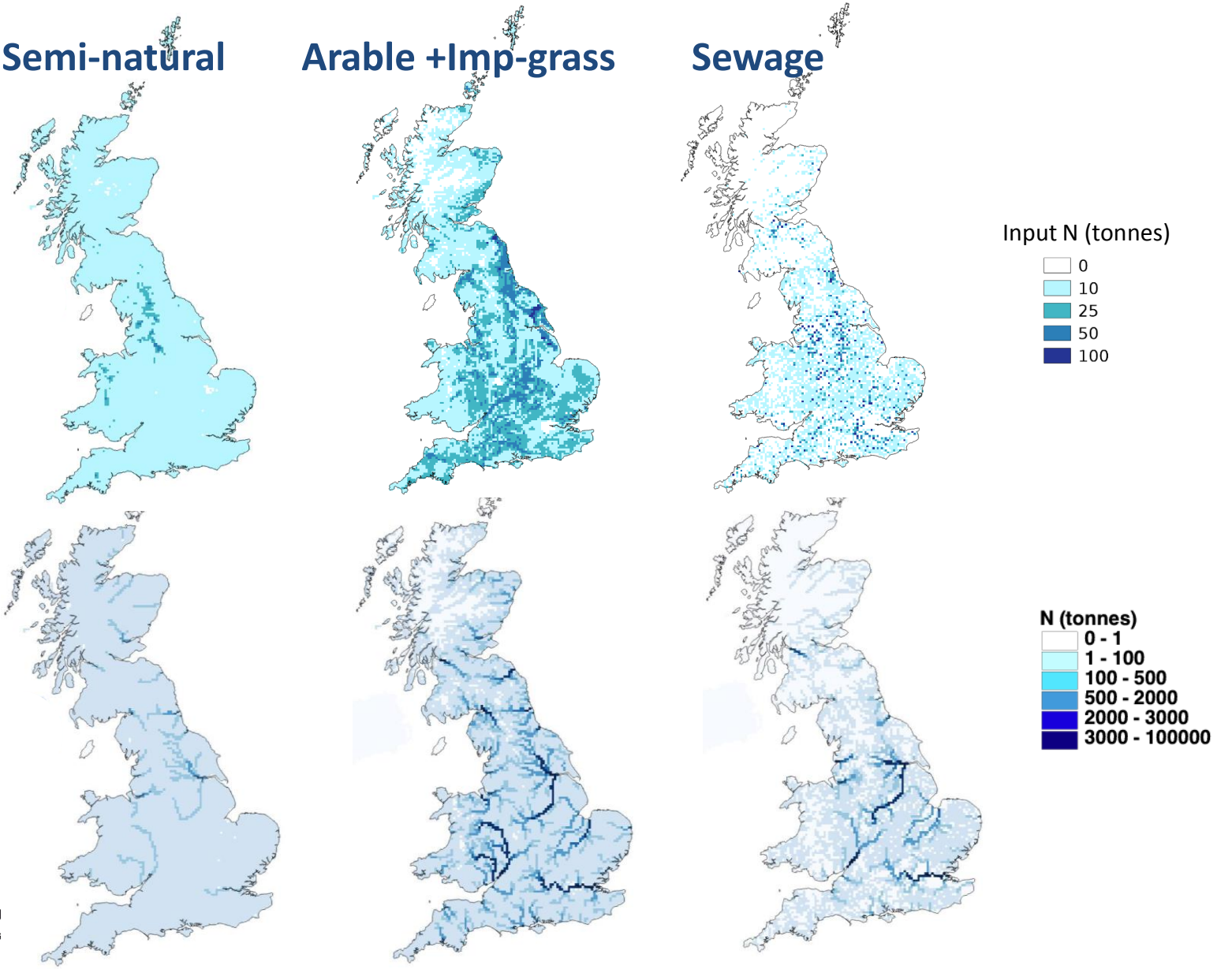
- Time-varying model inputs consist of 5km UK grids of:
  - ANNUAL atmospheric deposition
  - SEASONAL/MONTHLY Semi-natural inputs from N14CP
  - MONTHLY inputs from Improved Grass and Arable from RothC/MOTOR/SPACSYS
  - ANNUAL inputs from sewage (1830 onwards) and septic tanks (1900 onwards)
  - FLOW-related urban inputs using event-mean concentrations (Mitchell *et al*. 2001)
  - Groundwater chemistry and delays from BGS
  - Land-cover (1800,1920,1931,1950,1955,2007) - arable, broadleaf, conifer, rough grass, fen, heath, improved grass, peat, urban/suburban areas
- Model processes on a 5km UK grid:
  - Runoff production scheme incorporates probability distributed moisture heterogeneity, derives Van Genuchten soil properties from HWSD soil data
  - Kinematic wave surface and subsurface routing of water and dissolved and particulate nutrients
  - Erosion model – includes time-varying crop LAI and annual estimates of land-use and deer grazing
  - Sediment loss to floodplain
  - Riverine processes: denitrification, oxidation of ammonia, degassing, pH, chlorophyll growth
  - Lake model: sediment accumulation and decomposition, denitrification, CO_2 loss, algal growth, invertebrate grazing, flocculation…

Sources of Nitrate: terrestrial inputs and fluxes (tonnes)

1995 totals

Terrestrial Input

IM fluxes



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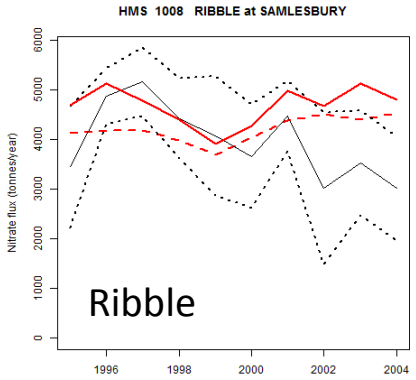
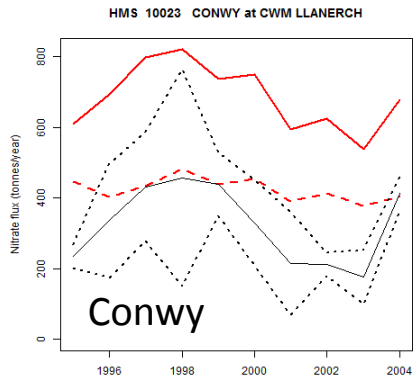
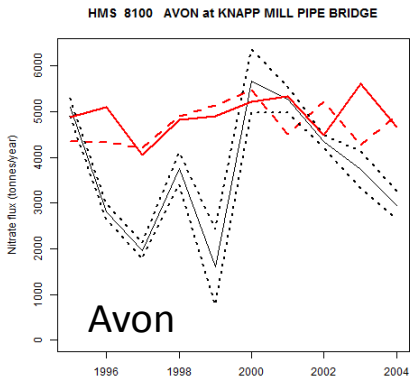
LTLS Integrated model runs:

- Current period: 1971 – 2010
  - Observed driving meteorology data (CEH GEAR rainfall, MORECS PE)
  - Observed sewage estimates
  - Terrestrial nutrient models (Semi-natural and agriculture) driven by observed meteorology provide estimates of nutrient runoff and leaching from soil
  - IM outputs (dissolved and particulate) compared against observations (e.g. HMS data)
- Historical period: 1800 – 2001
  - WATCH climate model meteorological data + CEH GEAR rainfall
  - Terrestrial nutrient models (Semi-natural: n14c and agriculture: RothC) driven by WATCH/obs meteorology provide estimates of nutrient runoff and leaching from soil
  - IM dissolved outputs (dissolved) compared to (rare) long term observations
  - Reconstructed key changes in land cover, atmospheric deposition and sewage
- Future Climate model scenarios: 2001 – 2100
  - We will select and prepare data for 2 climate scenarios (one climate model with emissions scenarios A2 and a Control) to be used alongside land-use and other scenarios

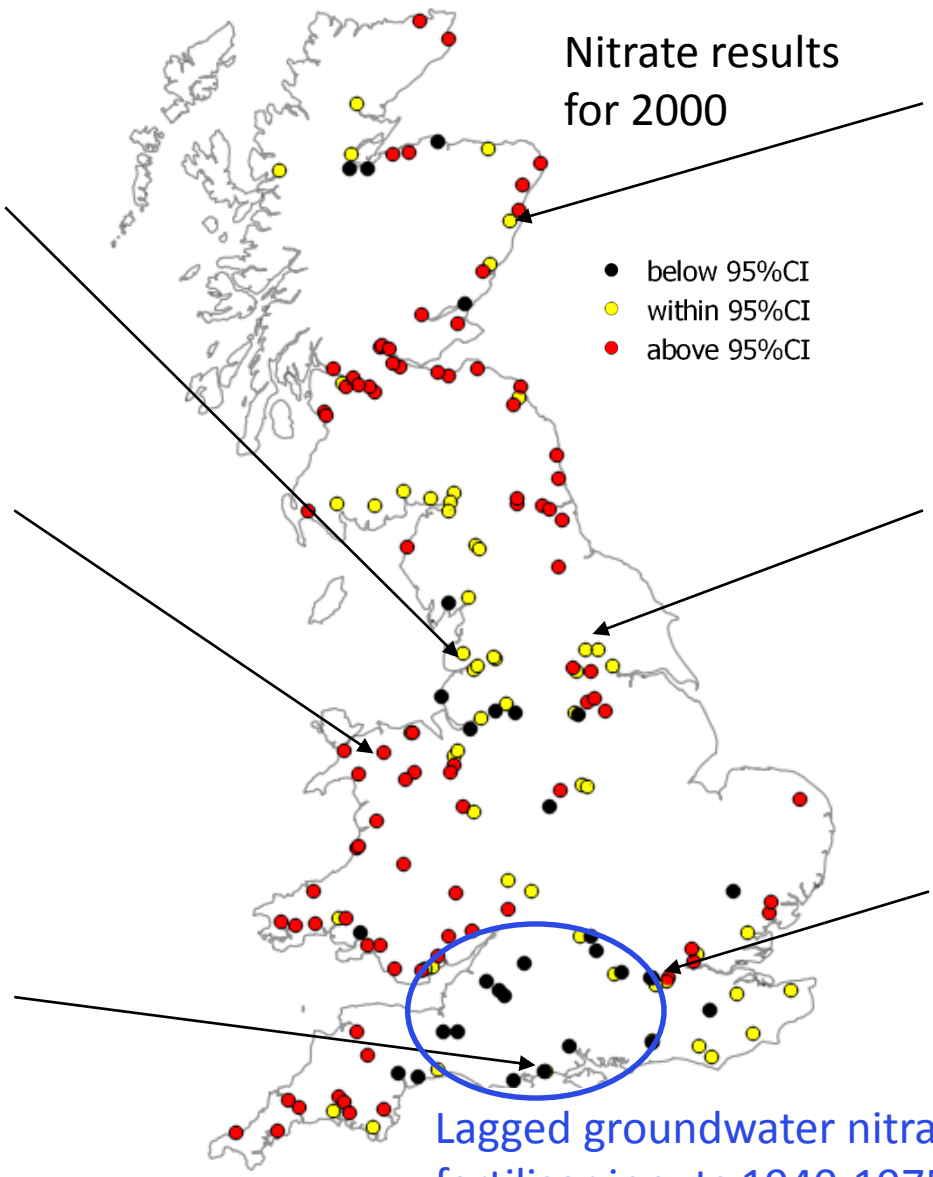
Nitrate residuals and selected HMS catchments

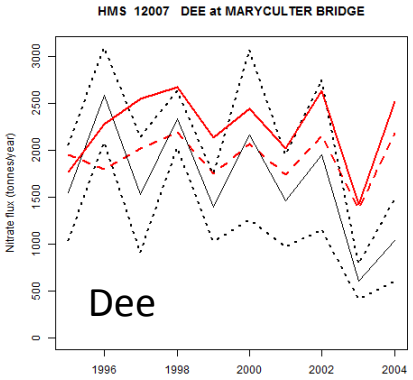


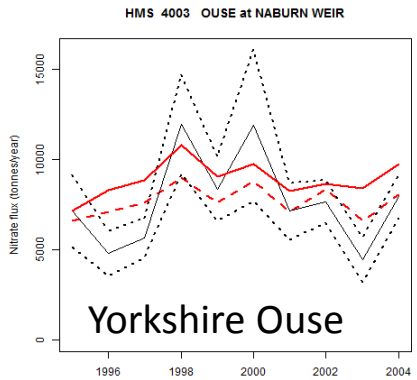


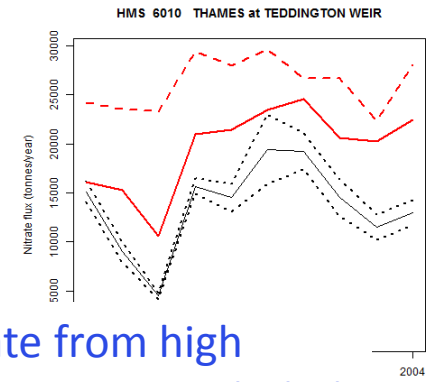


HMS black, 95% CI black dotted; IM red dash, IM flow corrected red solid









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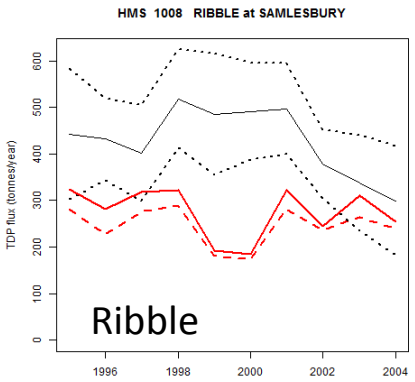
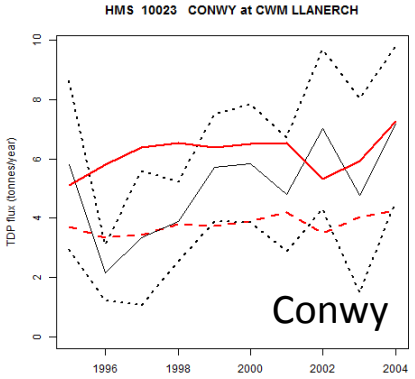
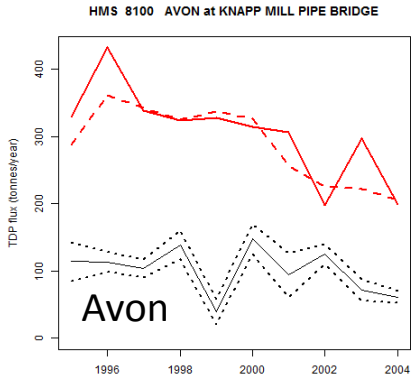
Lagged groundwater nitrate from high fertiliser inputs 1940-1975 not yet included

Phosphorus residuals and selected HMS catchments







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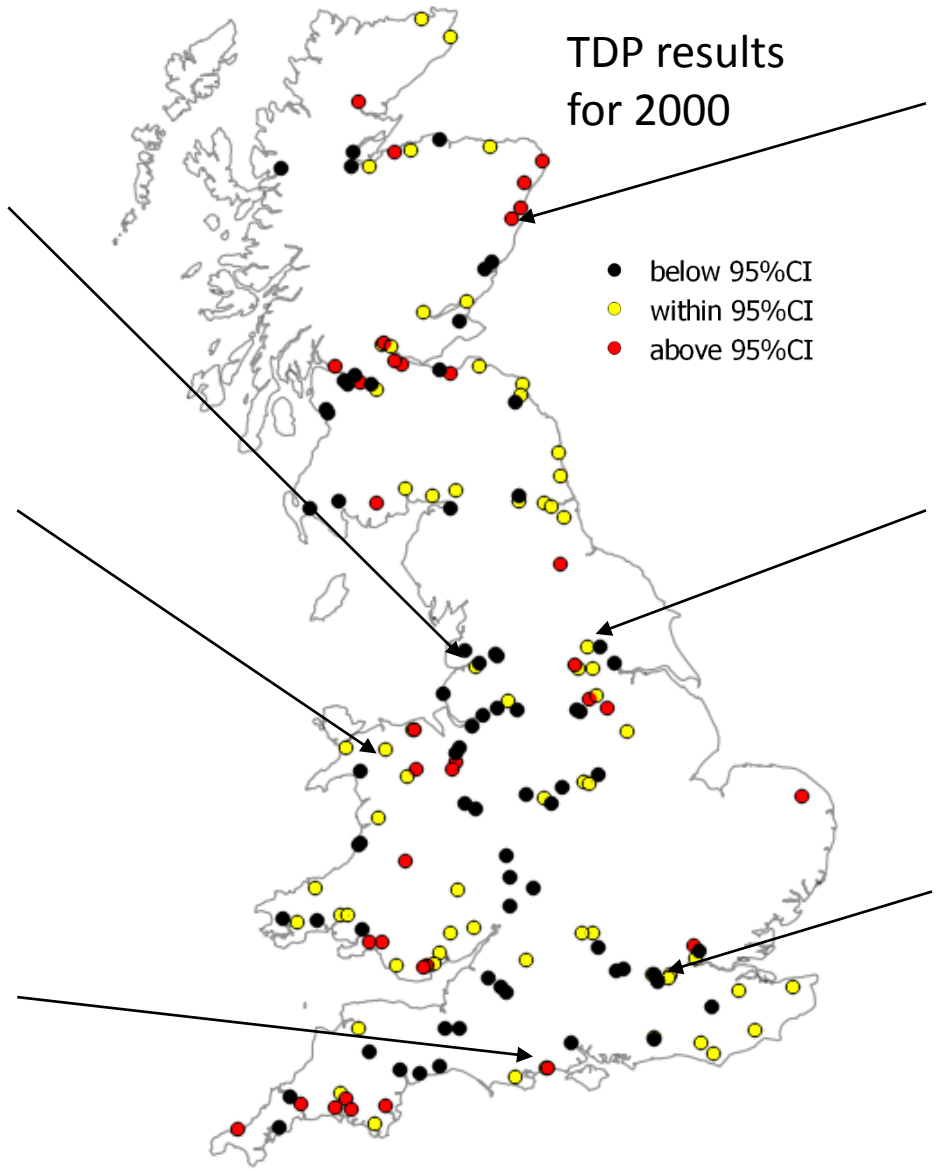

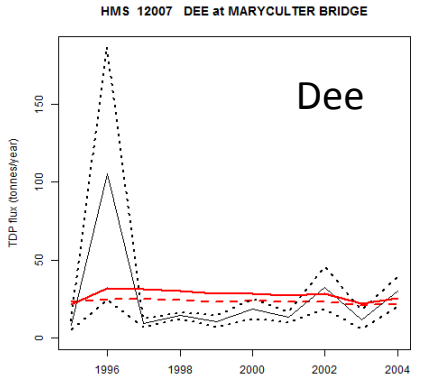

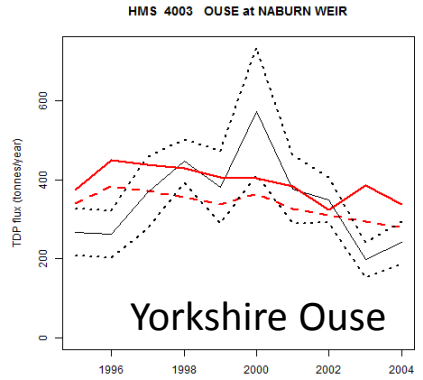

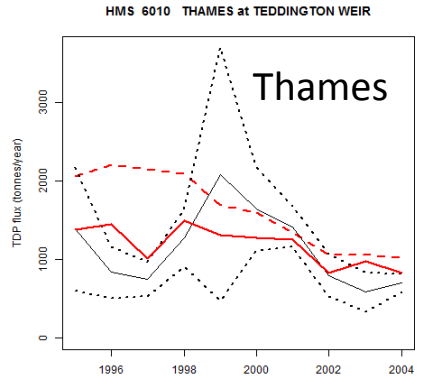

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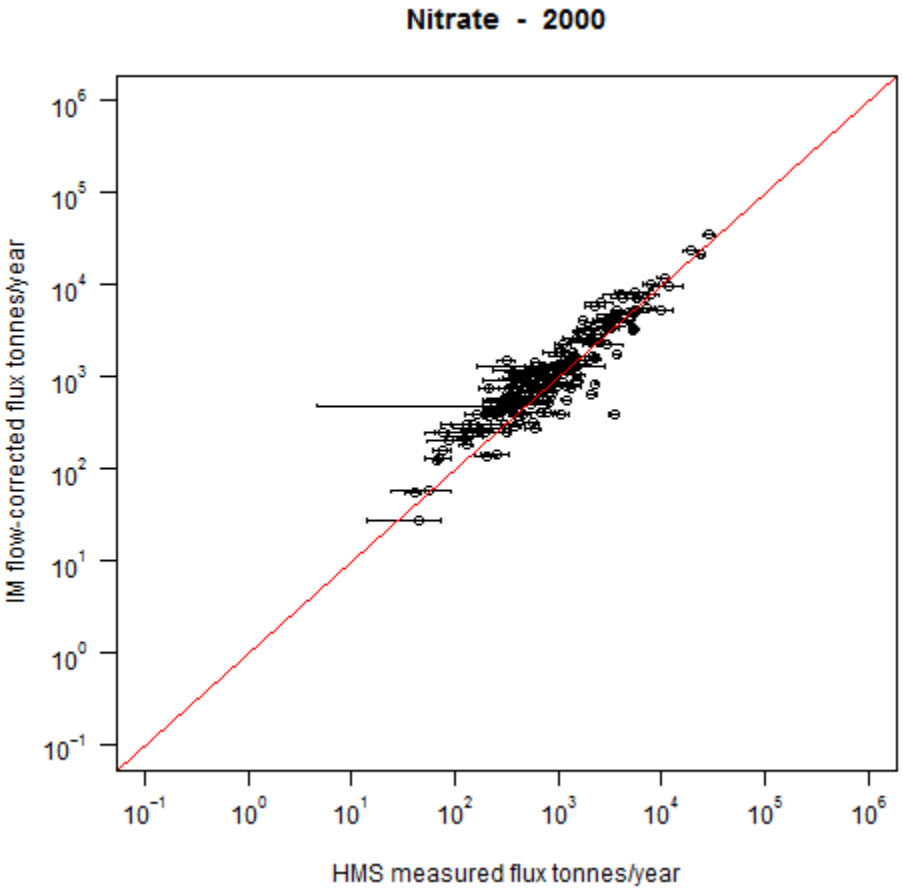
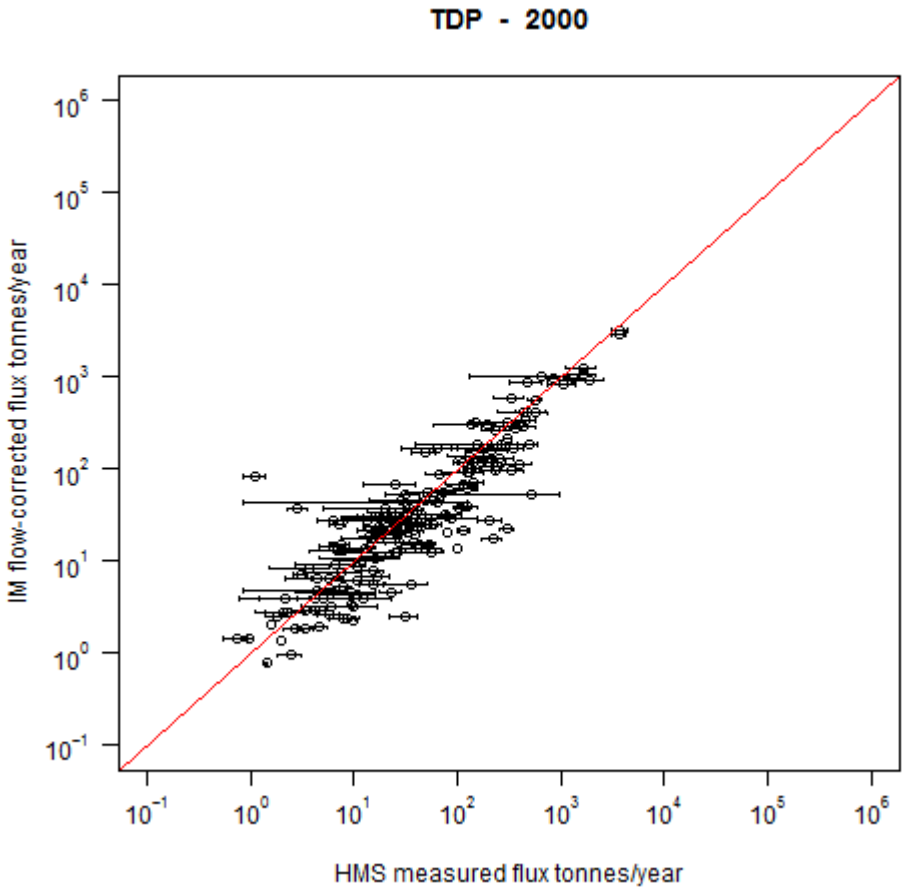
Annual Nitrate and Phosphorus fluxes (vs) observed for HMS catchments

HMS site locations have been matched to IM grid points and fluxes have been corrected for discrepancies in modelled and observed flows





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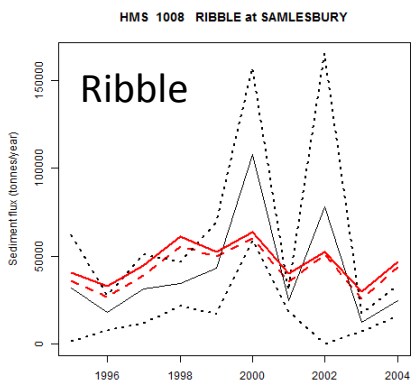
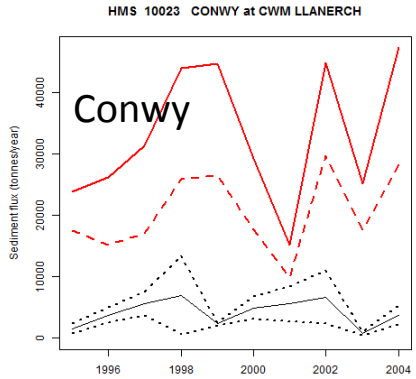
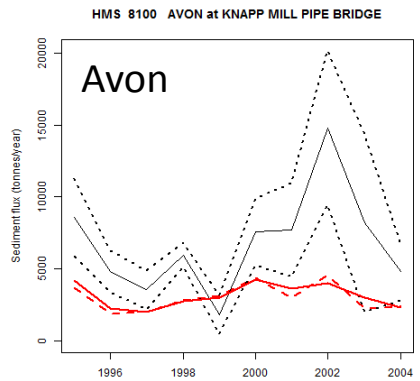
N.B. Harmonised Monitoring Sites are monitoring orthophosphate not TDP

Sediment residuals and selected HMS catchments







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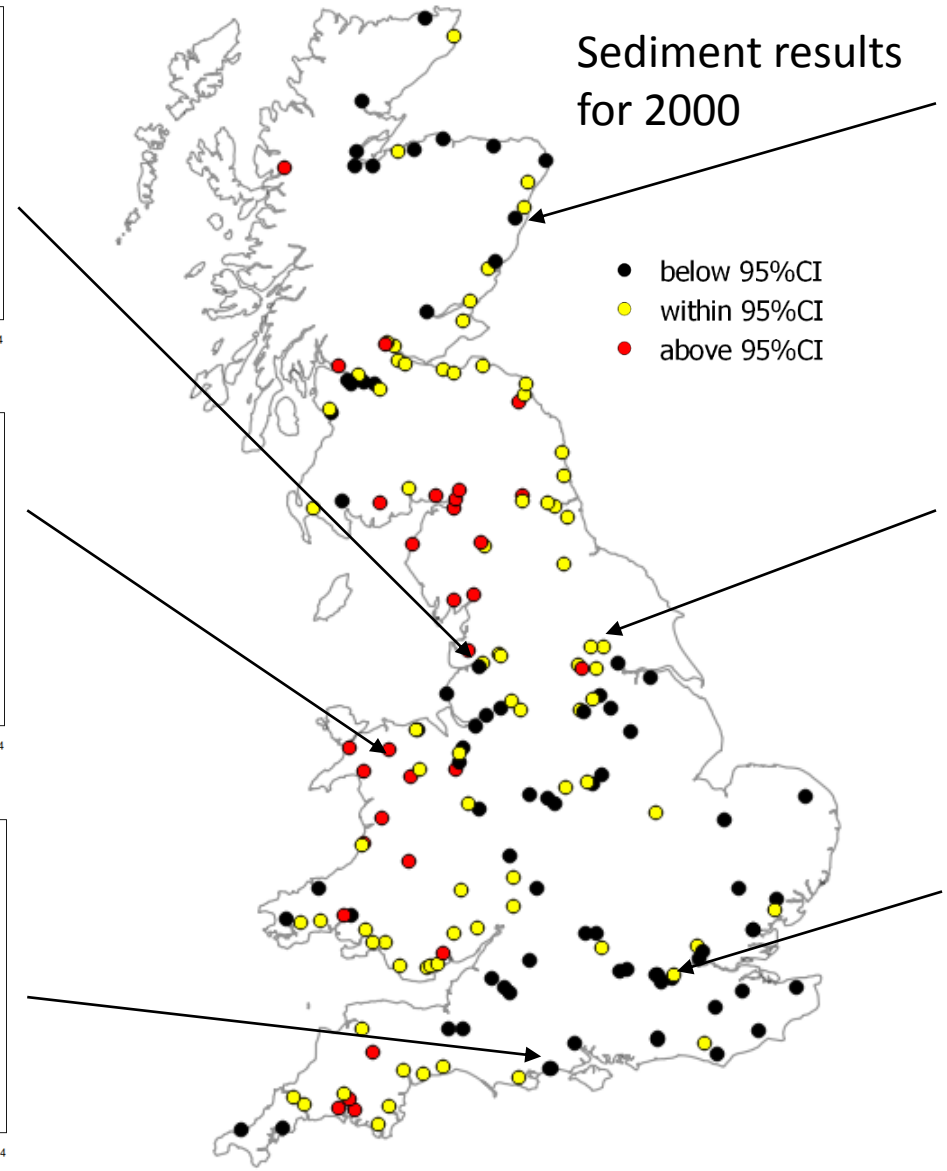

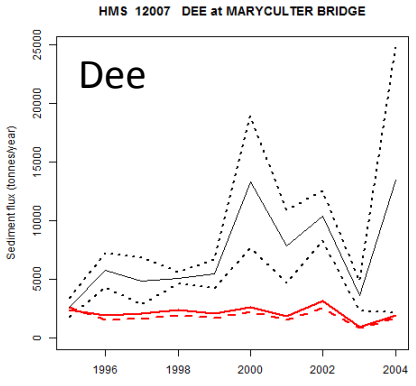

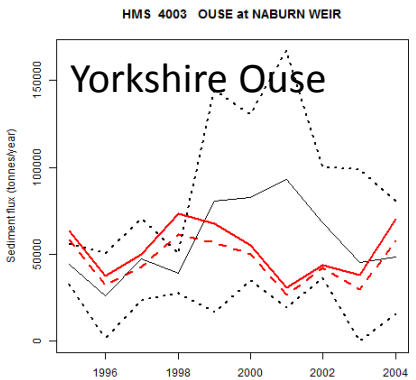

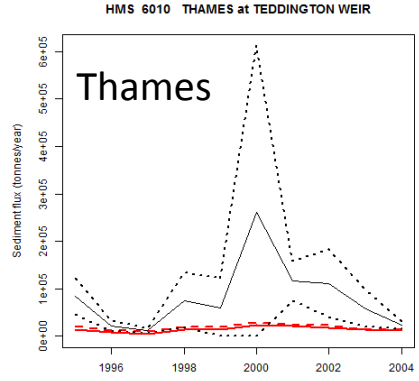

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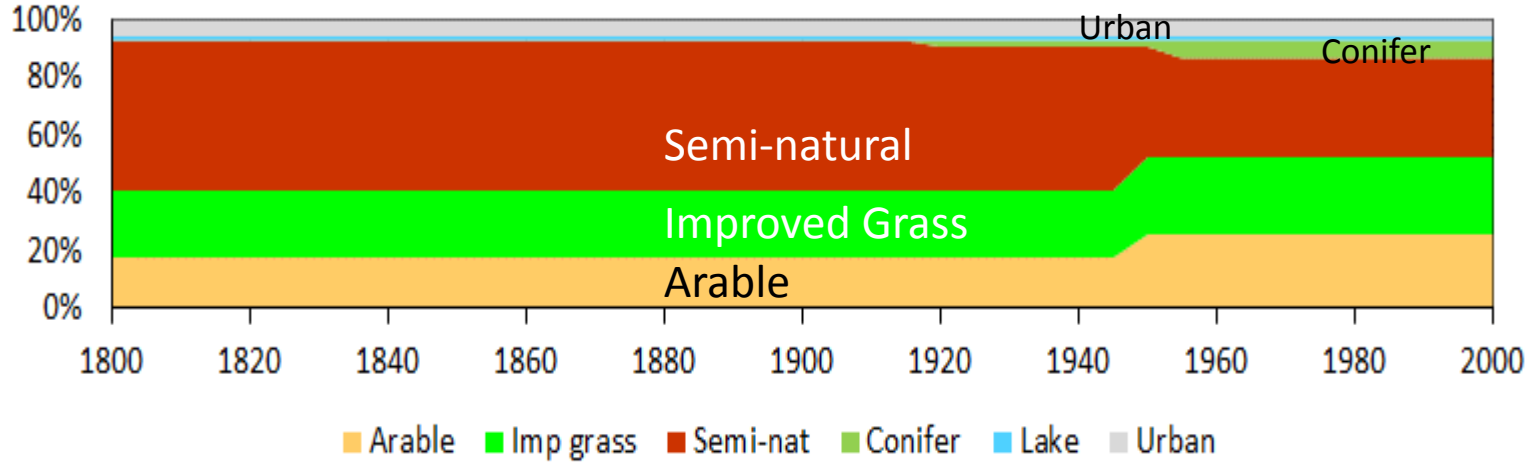
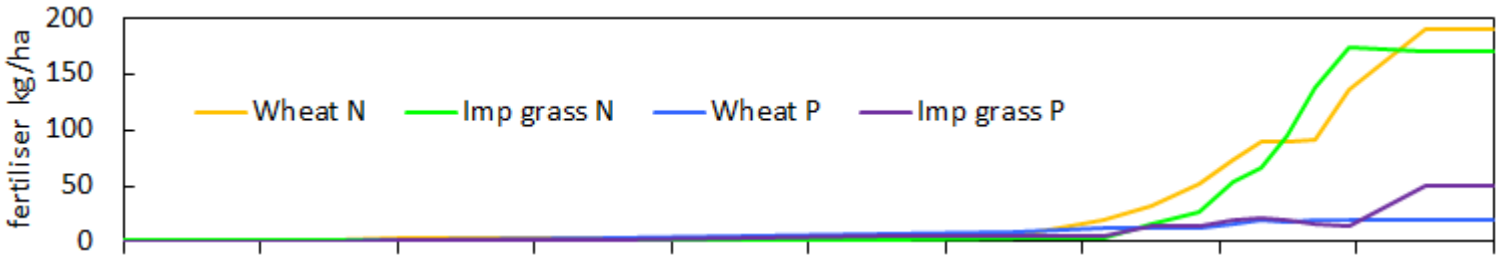
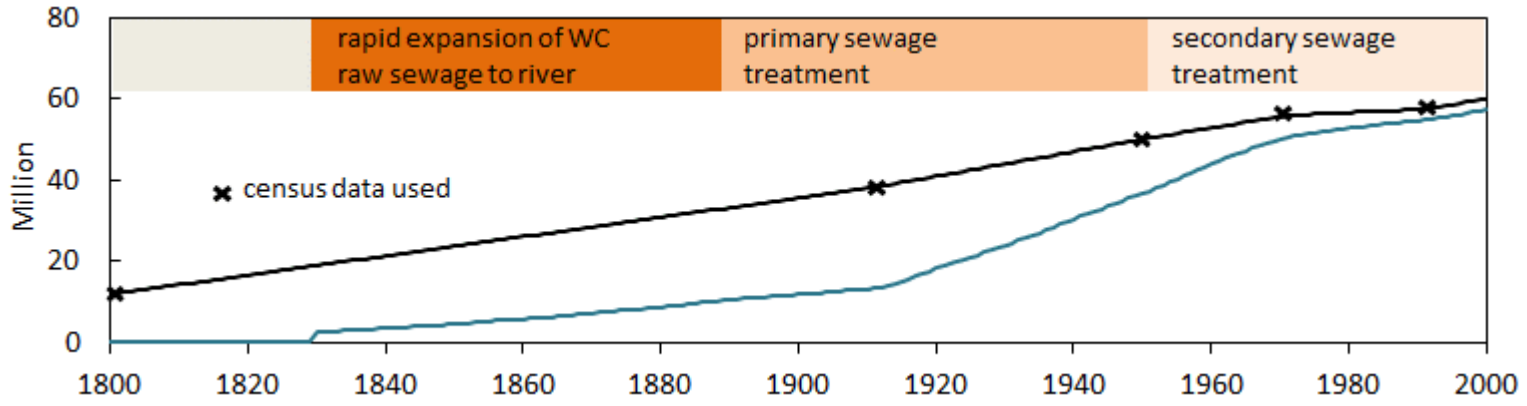
A pictorial history of change implemented in the IM



UK land use change

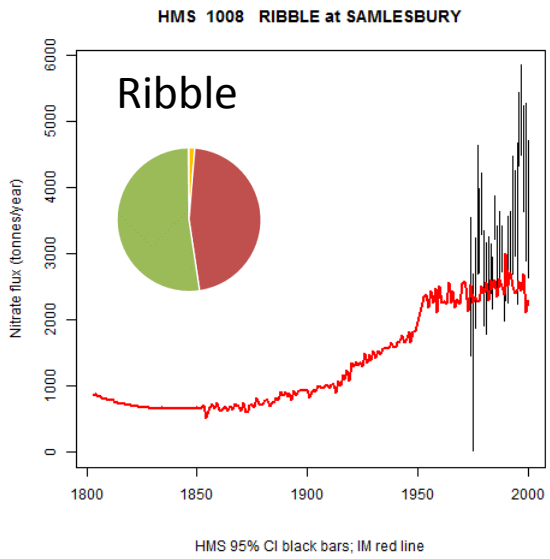


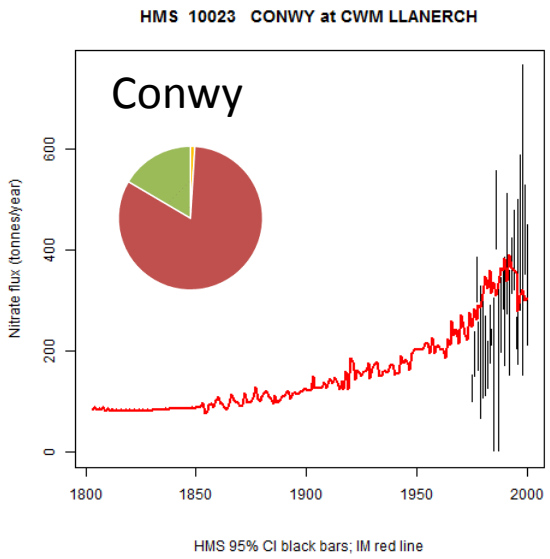
Example fertiliser application rates



Story of sewage treatment

Preliminary N results from historical LTLS IM run (1800-2000)

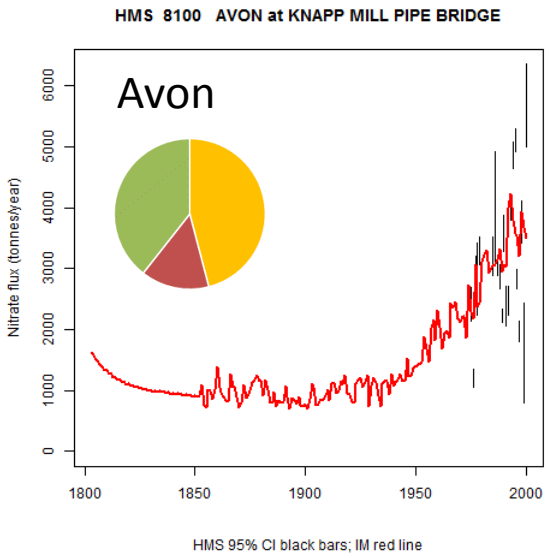


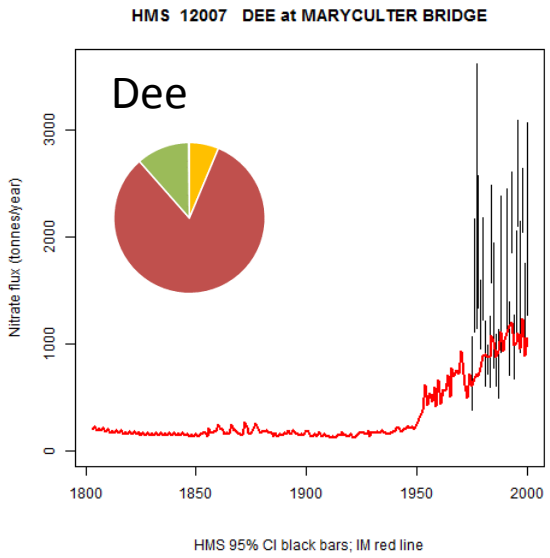


River nitrate fluxes for the three Macronutrients catchments and the Scottish Dee

LTLS IM red line
HMS 95% CI in grey

- Arable
- Semi-natural
- Improved Grass





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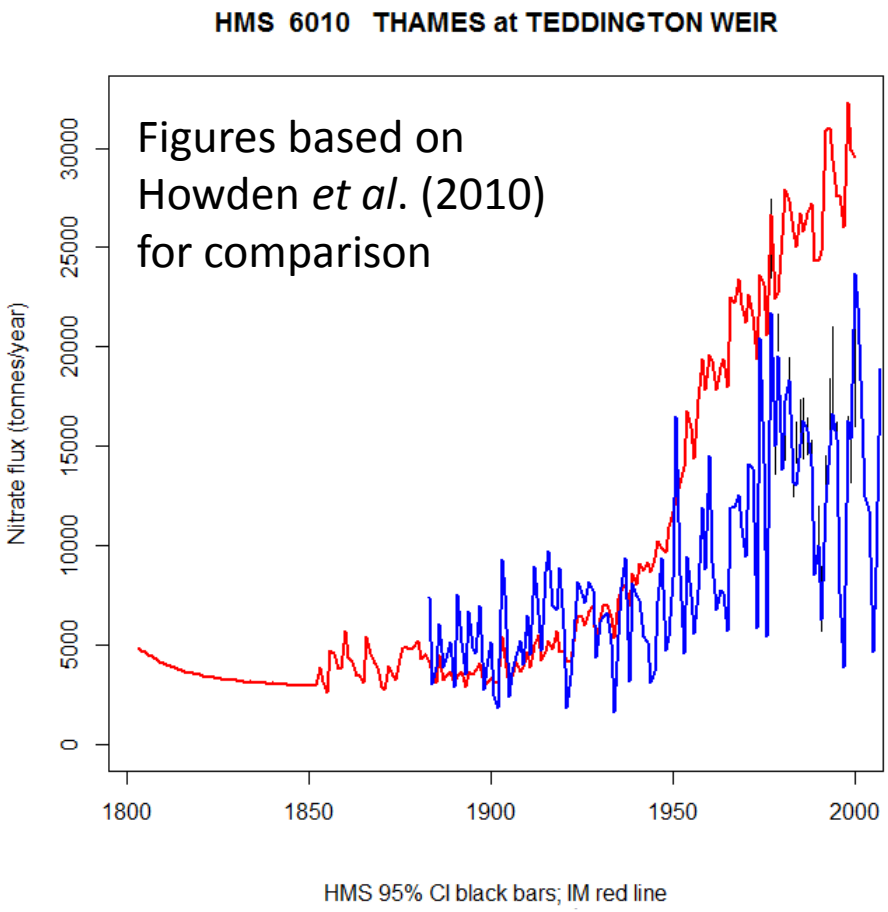
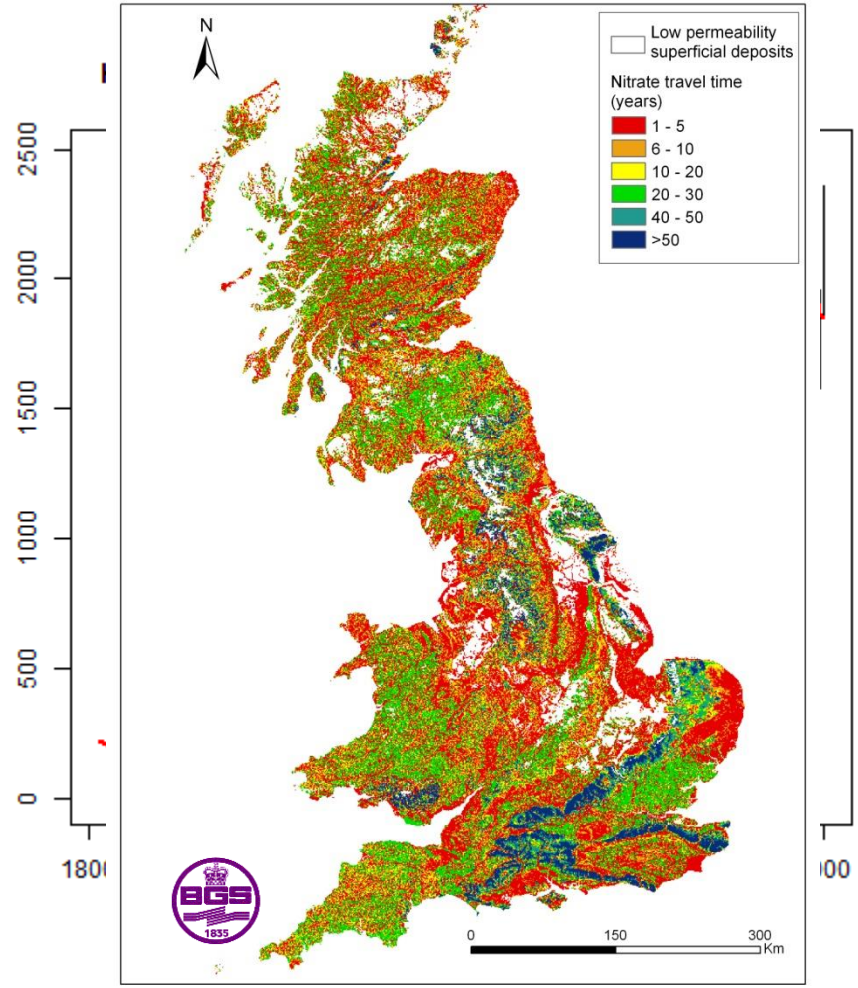
Preliminary N results from historical LTLS IM run (1800-2000)

Nitrate flux for the Thames – yet to include groundwater lag





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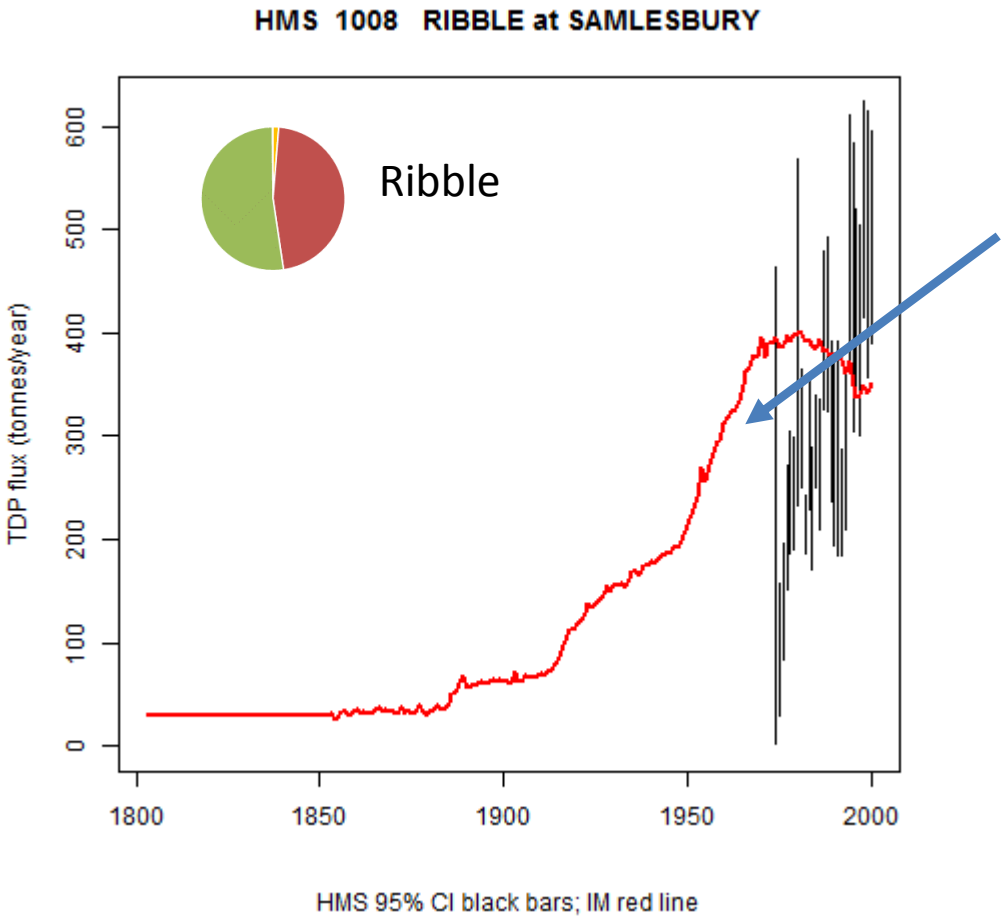
Wang L, Stuart ME, Bloomfield JP, Butcher AS, Gooddy DC, McKenzie AA, Lewis MA, Williams AT (2012) Prediction of the arrival of peak nitrate concentrations at the water table at the regional scale in Great Britain. Hydrological Processes, 26, 226-239

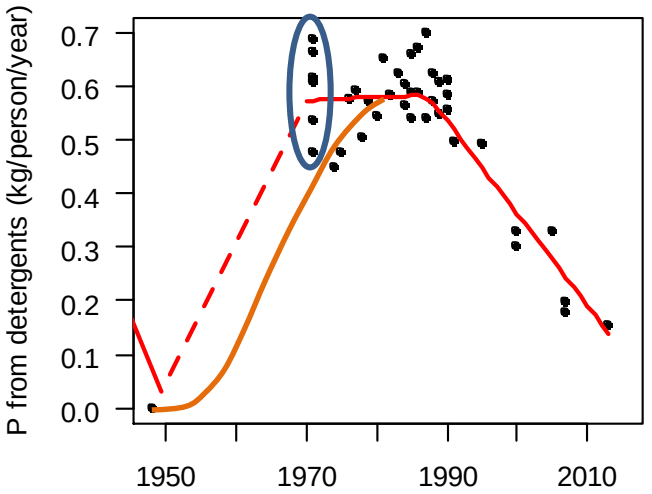
Preliminary P results from historical LTLS IM run (1800-2000)



Phosphorus for the Ribble catchment

Predominantly from sewage effluent

Rise since 1950 based on assumed use of detergents; presume uptake more gradual especially in rural areas



detergents introduced in 1948
published data from various sources

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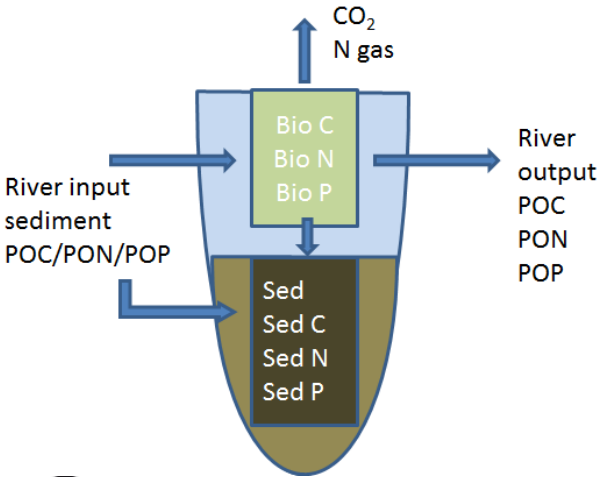
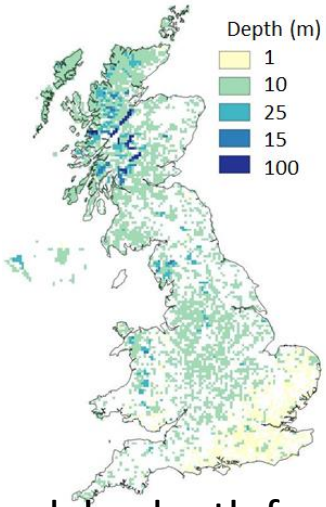
Circled points are from Devey and Harkness (1973): calculation based on STWs near Birmingham

LTLS: Lake modelling

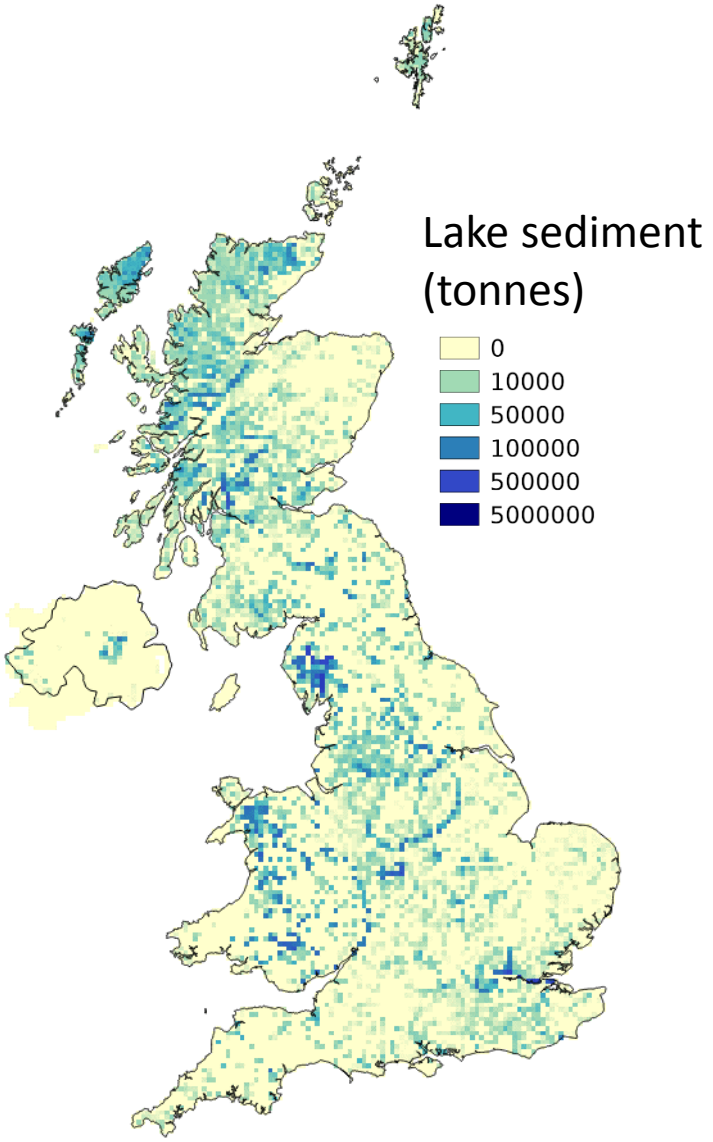
- Only lakes that are connected to rivers are represented in the IM
- Multiple lakes in a 5km pixel are combined into 1 large lake.
- Lakes have been linked to Mean lake depth from the UK Lakes database

- Processes represented are: take-up of C, N and P in biomass, lake sedimentation & gaseous losses of CO_2 and N





Mean lake depth from the UK Lakes database



Next Steps

- Check and refine results for observed and historical periods
- Include nutrient lag in unsaturated zones of groundwater-dominated areas
- Examine nutrient contributions from different sources and develop storylines
- Run future scenarios (climate, woodland expansion, agricultural intensification, changes in atmospheric deposition and extension of P stripping in WWTWs)
- Prepare publications

Thank you..
Questions welcome

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