LONG TERM LARGE SCALE (LTLS): INTEGRATED MODEL

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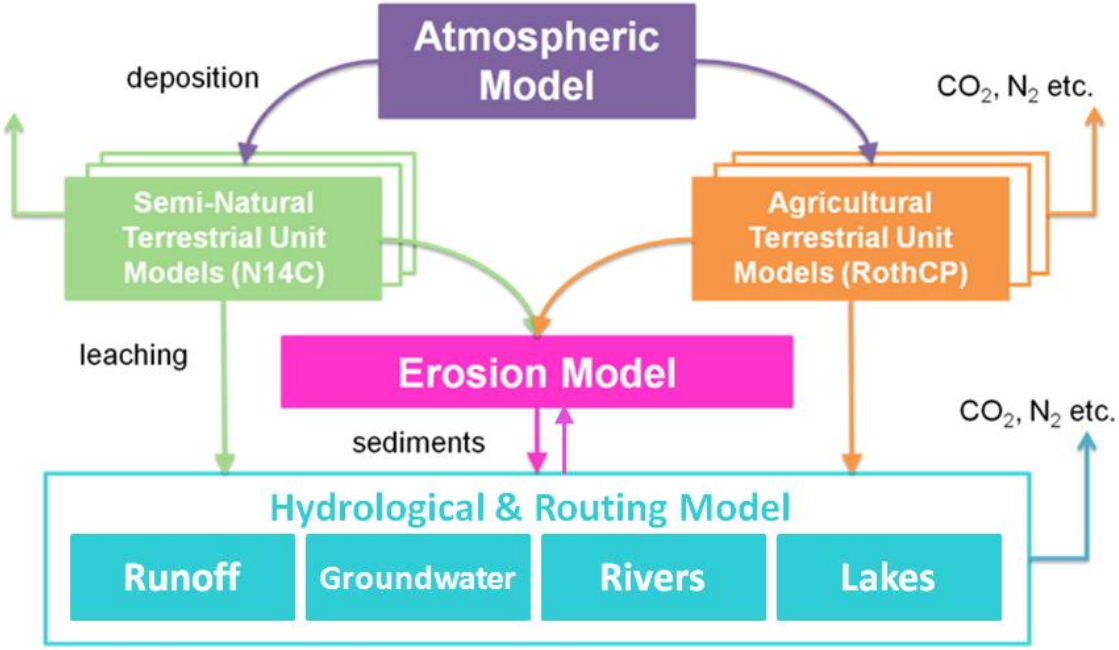

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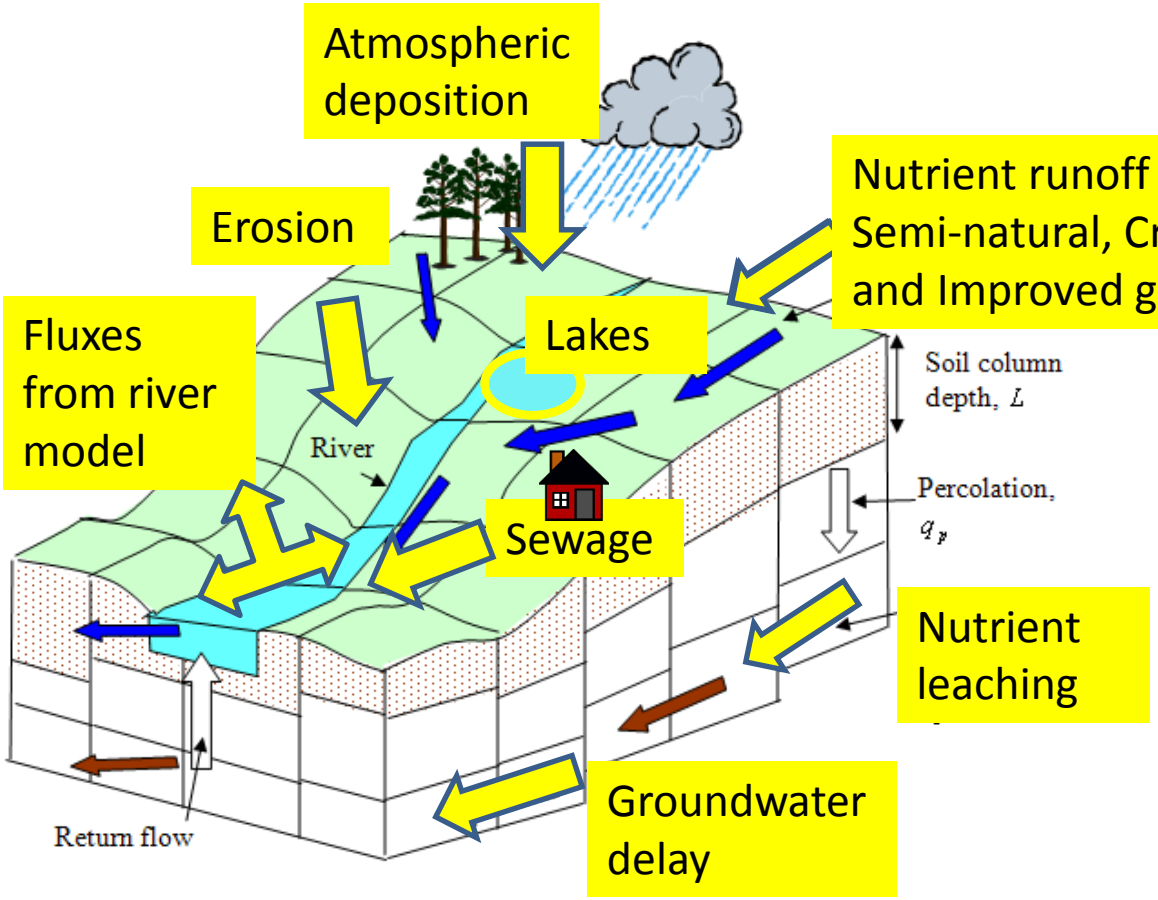
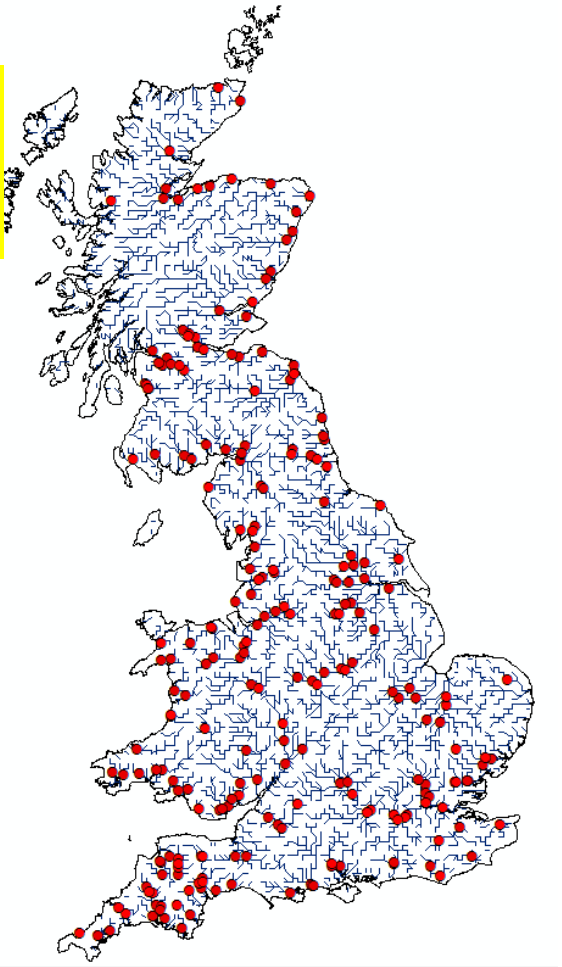
LTLS: Integrated Model (IM)





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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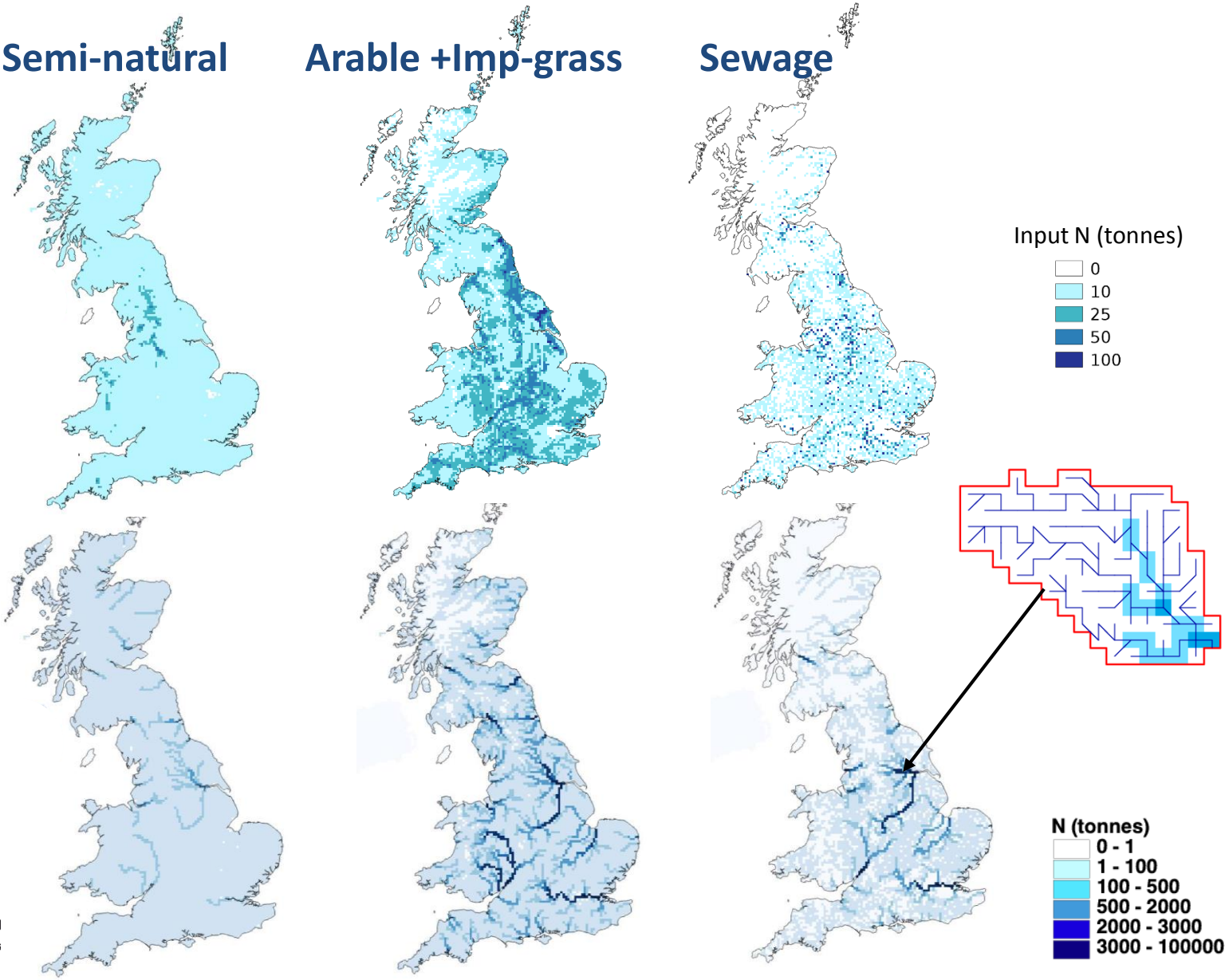
Sources of Nitrate: terrestrial inputs and fluxes (tonnes)

1995 totals

Terrestrial Input

IM fluxes



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LTLS: integrated model

Exploring change in UK riverine nutrients over long periods…

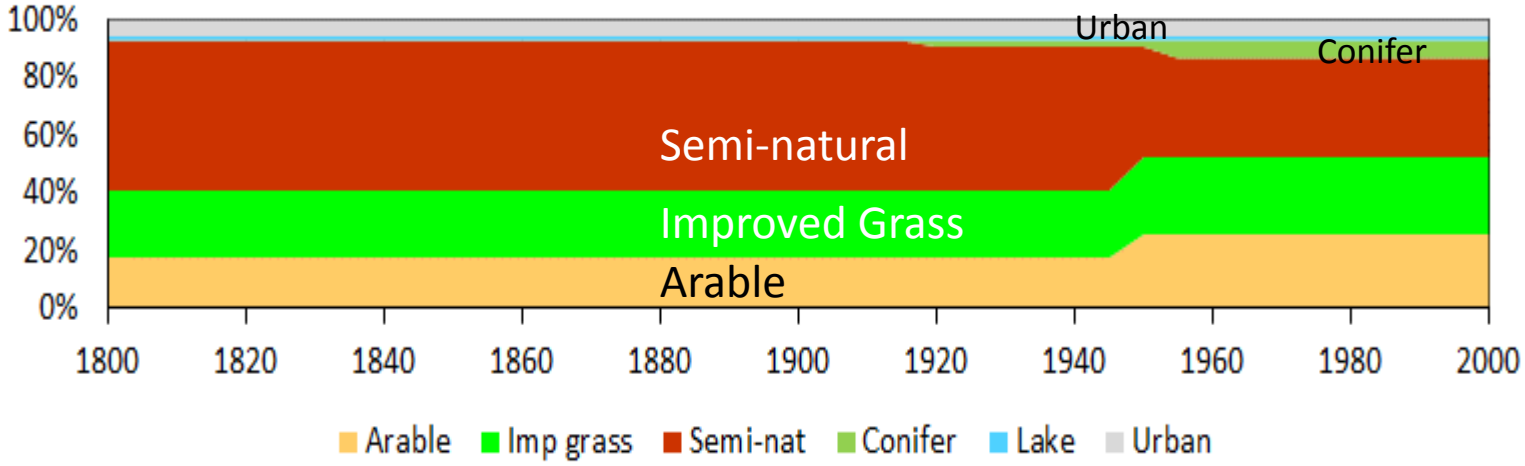
Historical-current simulations: 1800 - 2010

- ❑ Driven by climate model hindcasts (1800 – 1970) and observed (1971-2010)
- ❑ Historical changes in land-cover, sewage, agriculture (see next slide)

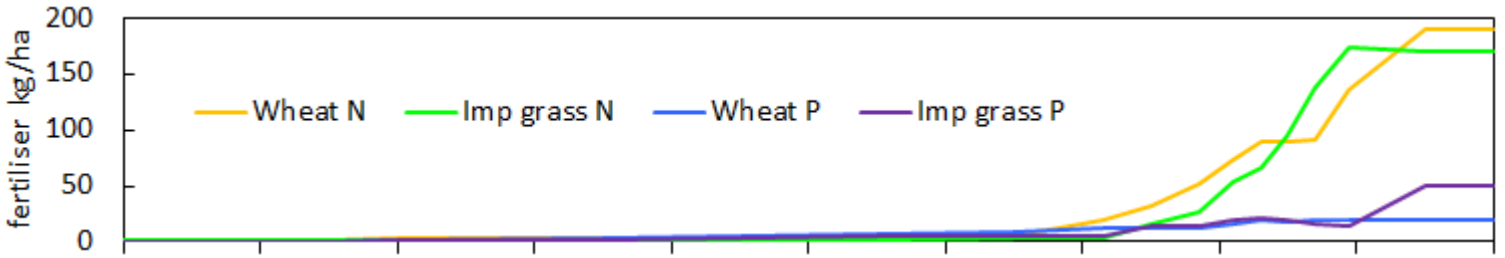
Exploring future scenarios using the model: 1971 - 2100

- ❑ Uses future climate model estimates
- ❑ Sewage treatment scenarios (P-stripping)
- ❑ **Large scale** land-use change (to semi-natural and agricultural land)
- ❑ Changing atmospheric pollution/deposition

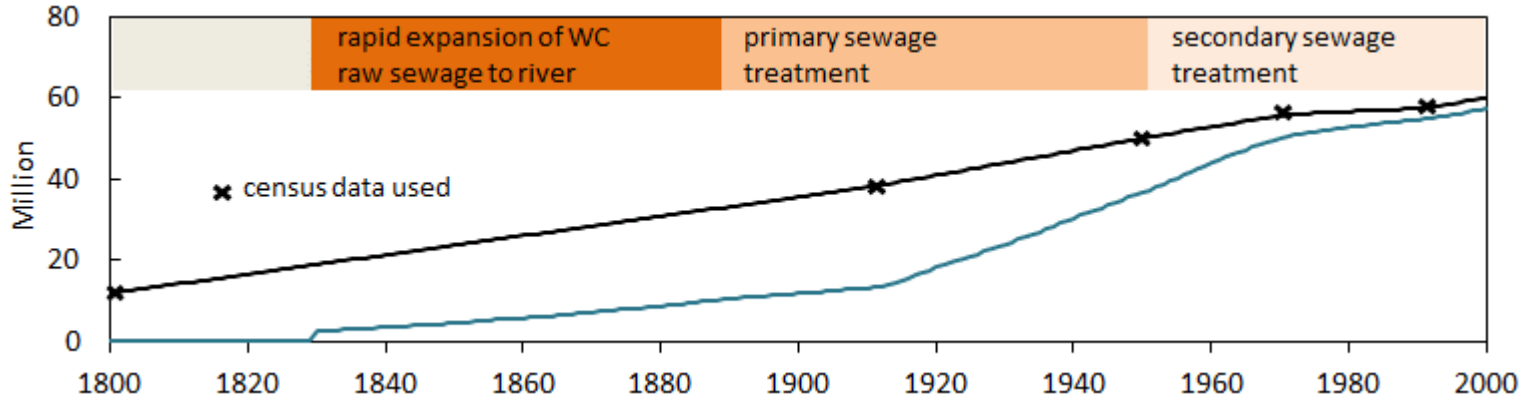
A pictorial history of change implemented in the IM



UK land use change



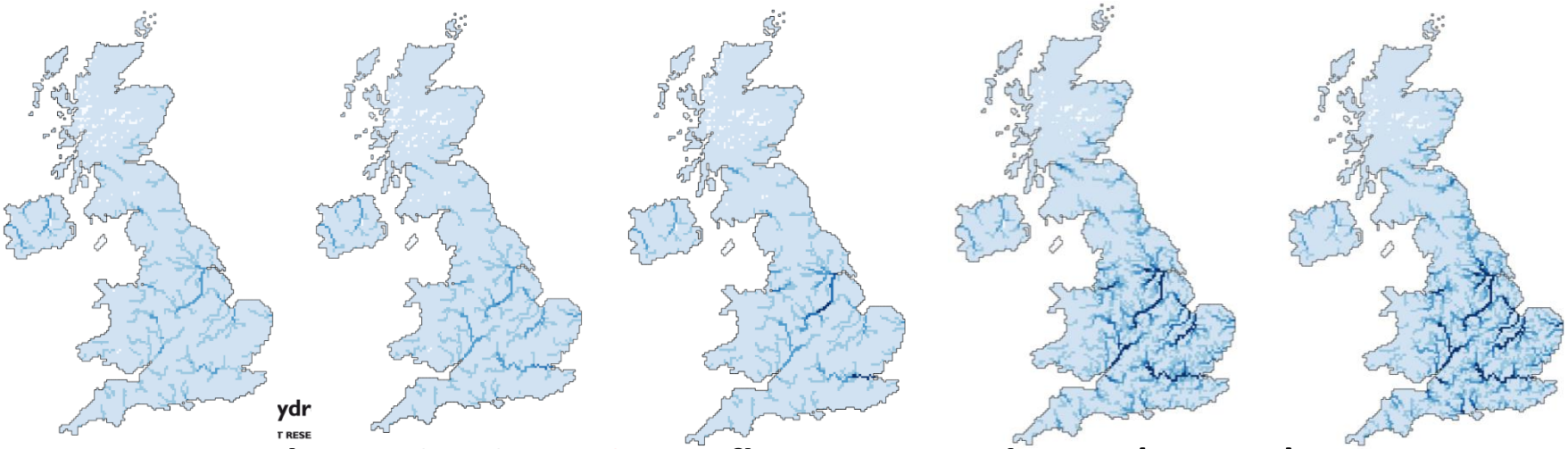
Example fertiliser application rates



Story of sewage treatment

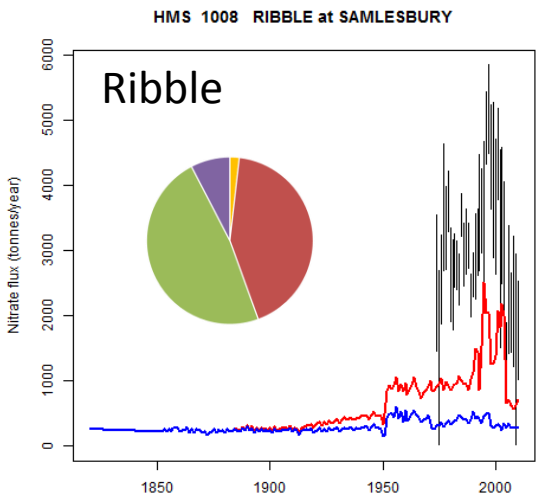
Historical-current LTLS IM run (1800-2010)

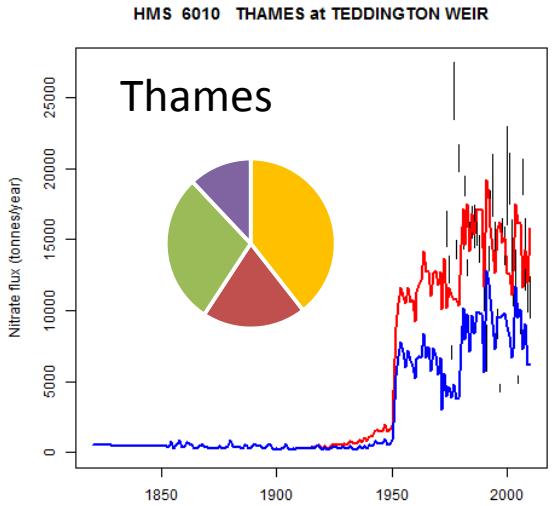
Change in River Phosphorus (TDP) fluxes across the UK (tonnes)



Change in River Nitrate fluxes across the UK (tonnes)

Historical-current LTLS IM run (1800-2010)

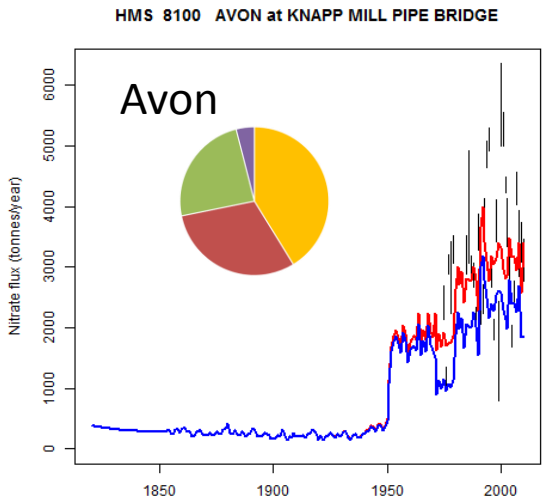


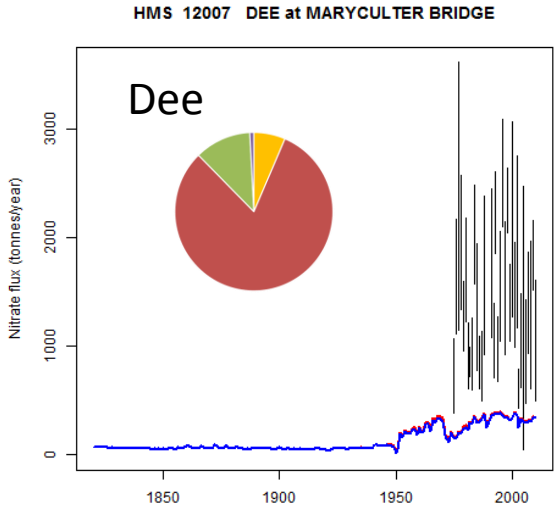


River nitrate fluxes for selected catchments

IM **red** line
IM no sewage **blue** line
HMS 95% CI in **grey**

Catchment % land-cover:
- Arable
- Improved grass
- Semi-natural
- Urban





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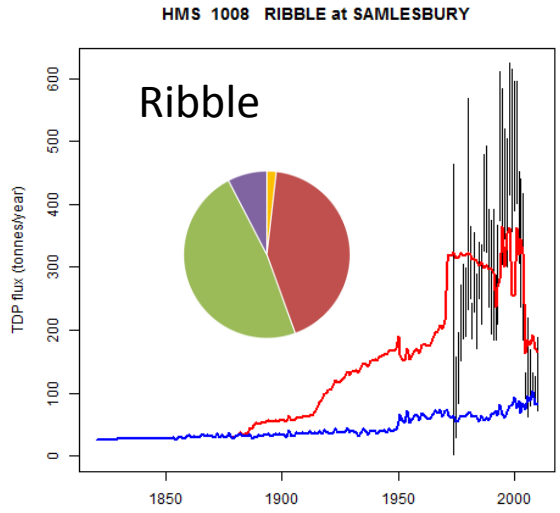
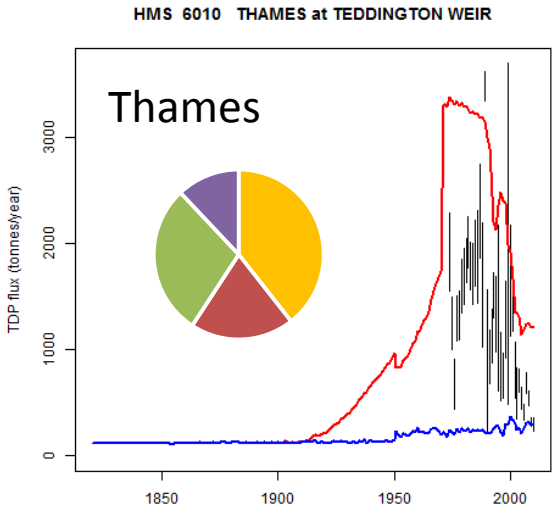
Historical-current LTLS IM run (1800-2010)

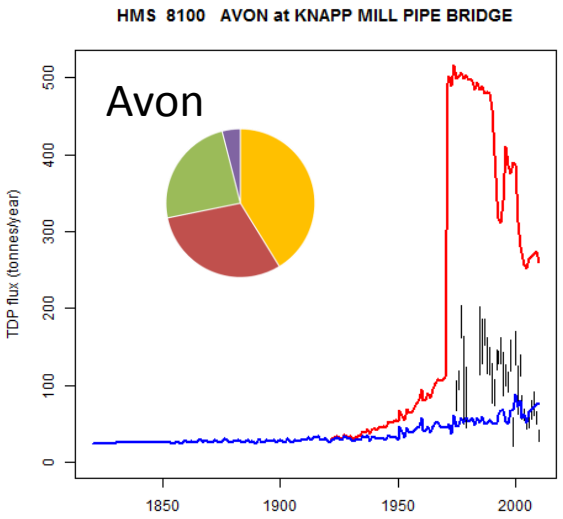


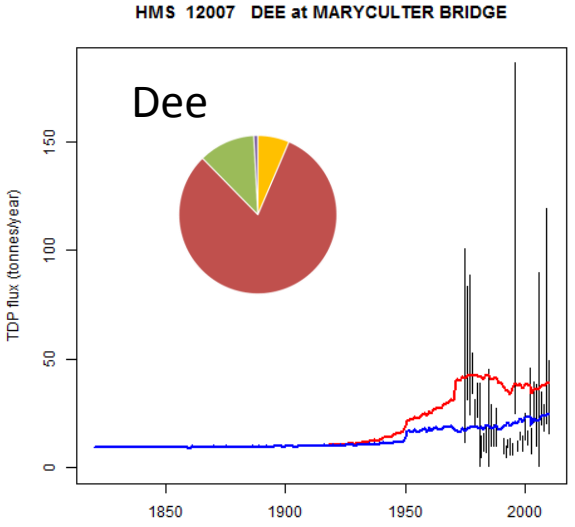


River phosphorus fluxes for selected catchments

IM **red** line
IM no sewage **blue** line
HMS 95% CI in **grey**

Catchment % land-cover:
- Arable
- Improved grass
- Semi-natural
- Urban





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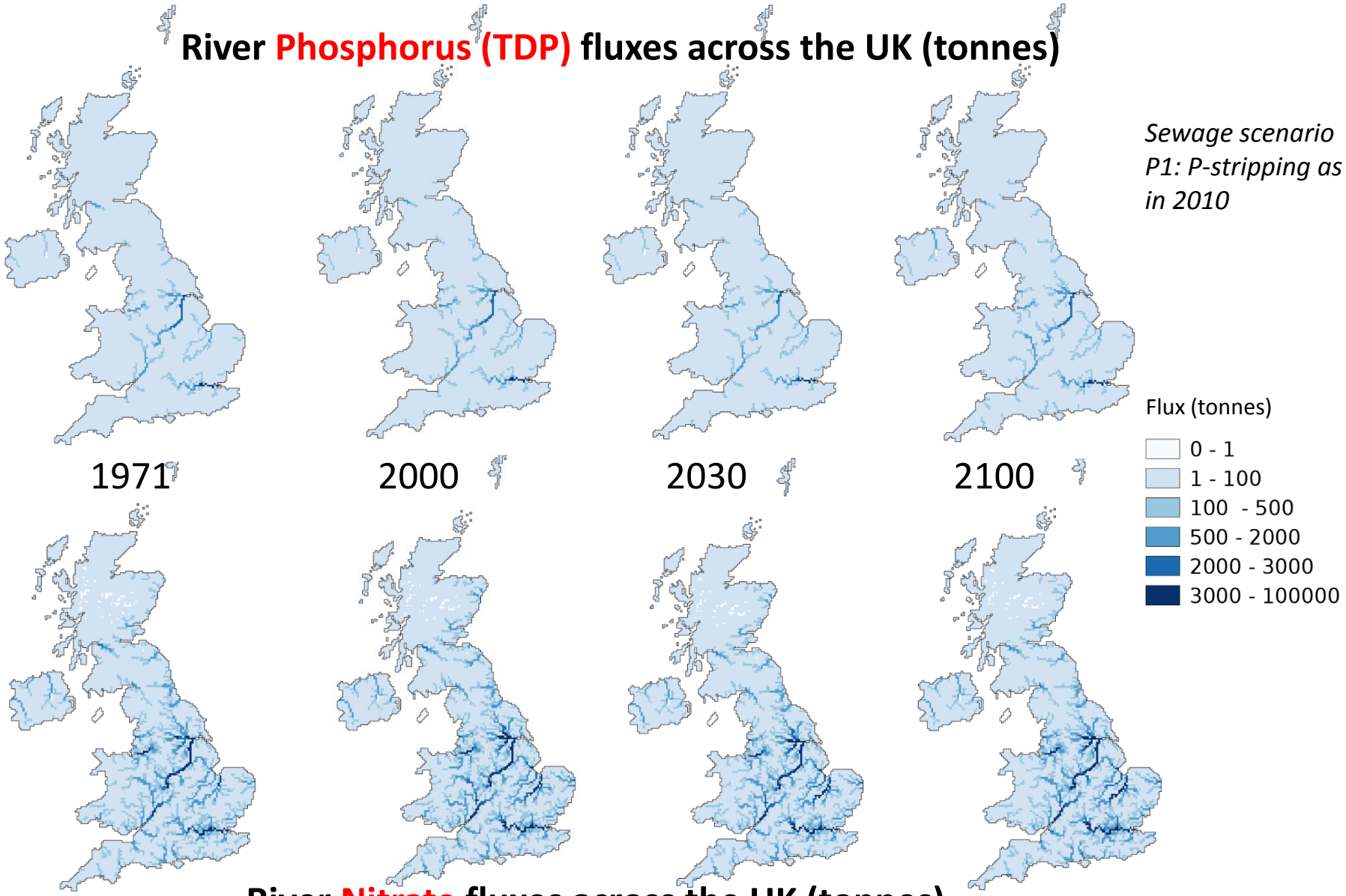
Future Scenarios (2010 – 2100)

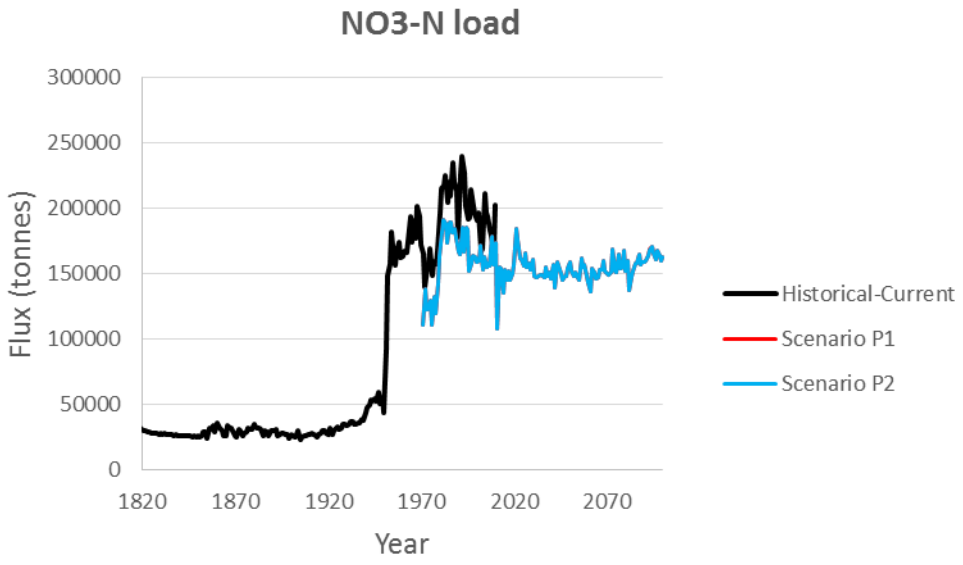
With selected Future scenarios highlighted in red:

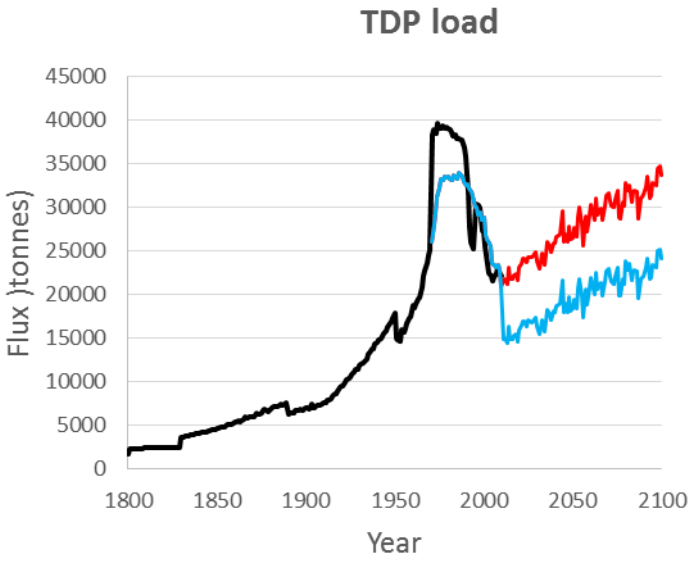
- **Climate model** estimates:
  - WATCH ECHAM5 climate model A2 (medium high emissions) scenario
- **Sewage**:
  - P1: P-stripping as in 2010 applied to 2010 -2100
  - P2: P-stripping applied to all WWTW 2010 -2100
- **Semi-natural** scenarios
  - N1: climate change + 2010 atmospheric deposition applied to 2010-2100
  - N2: climate change + atmospheric deposition scenario applied to 2010-2100
  - N3: climate change + atmospheric deposition scenario 2010-2100 + woodland expansion
- **Agricultural** scenarios
  - Arable RA1: climate change + atmospheric deposition scenario + increased yield
  - Arable RA2: climate change + atmospheric deposition scenario + increased yield through NUE
  - Grass RG1: climate change + atmospheric deposition scenario + intensive grass with BAU stocking density
  - Grass RG2: climate change + atmospheric deposition + intensive grass with increased stocking density

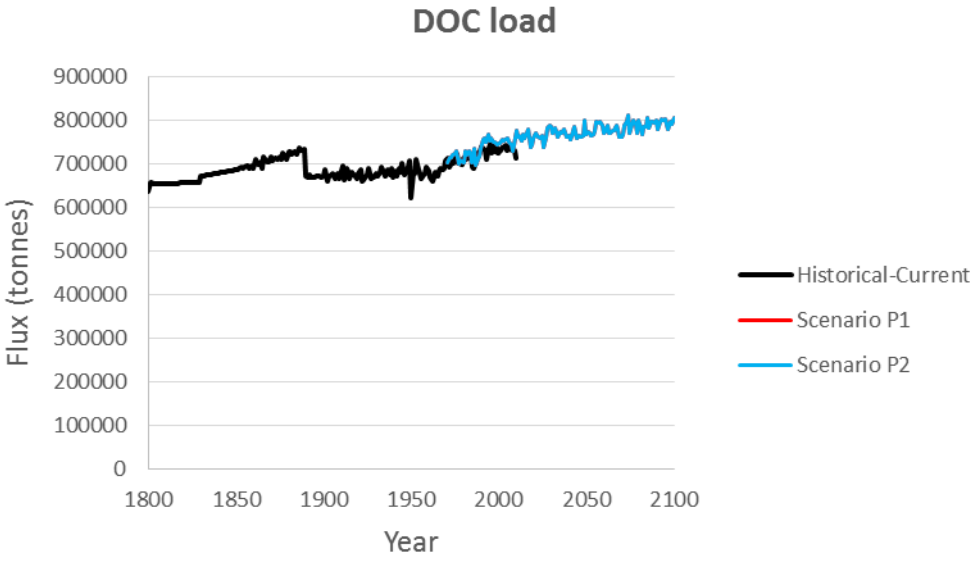
IM-F3 Scenario LTLS IM run (1971-2100)

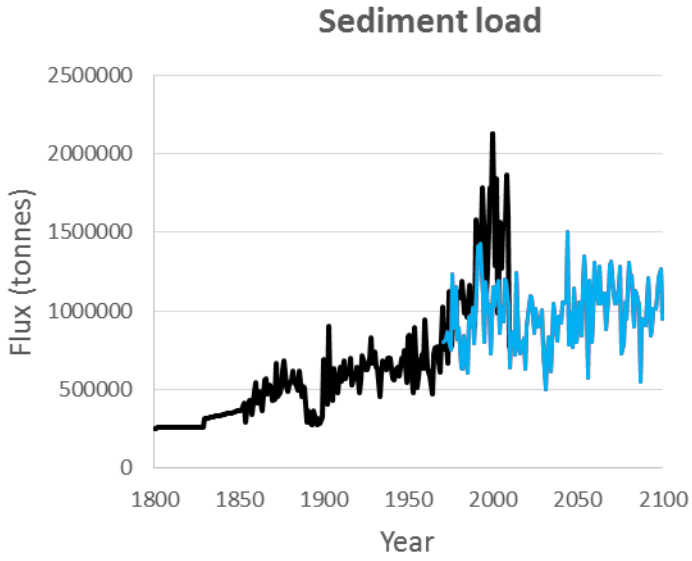


UK Fluxes into the sea: Historical-current (1800-2010), Future (1971-2100)



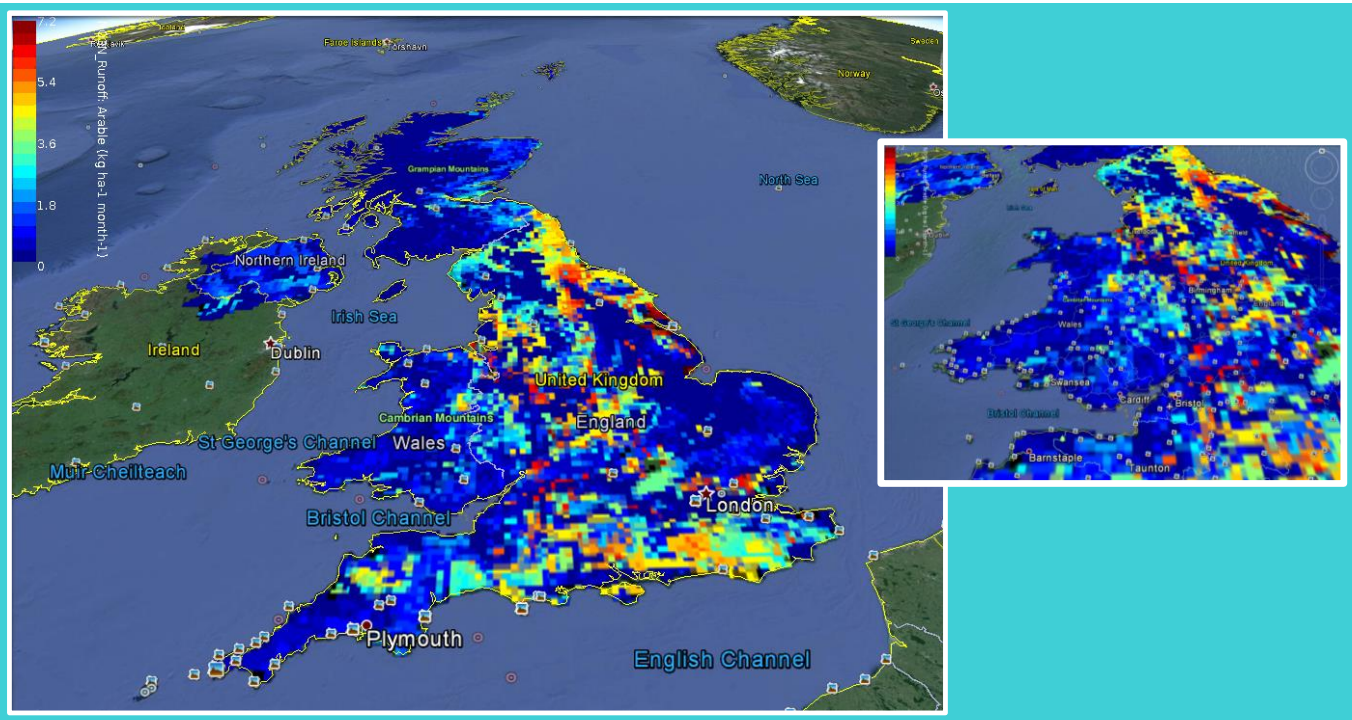






Thank you

Nutrient displays in GoogleEarth:



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