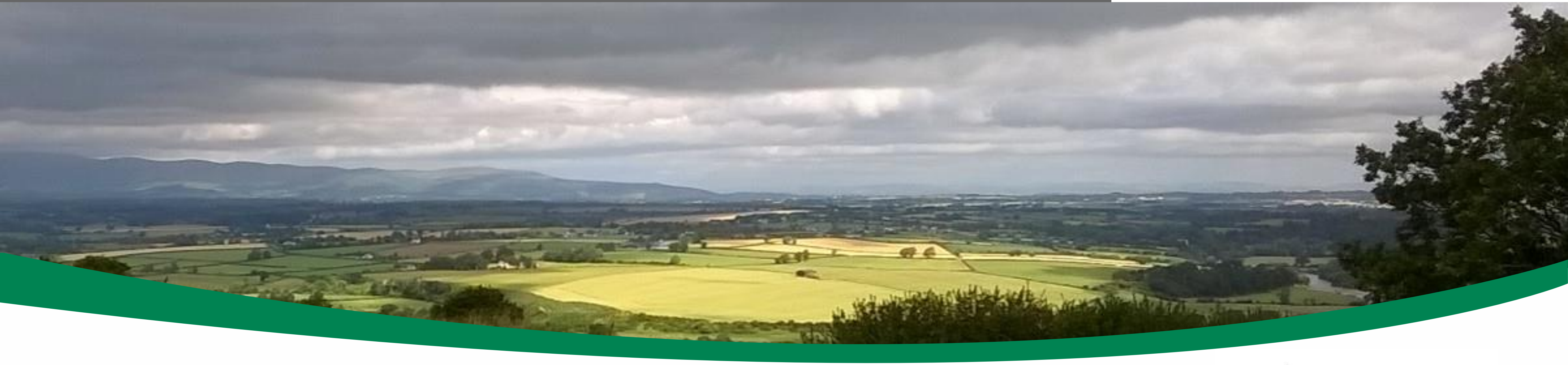
EPA CCP Expert Briefings Series 2024, 30th October 2024

Climate Change and Water Futures

In the agricultural landscape

Per-Erik Mellander



AGRICULTURAL CATCHMENTS PROGRAMME

Teagasc
Agriculture and Food Development Authority

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Department of Agriculture, Food and the Marine

epa Environmental Protection Agency
An Ghníomhaireacht um Chaomhnú Comhshaoil

Introduction

Planning for nutrient mitigation action requires a **process based understanding** of nutrient loss

Controls

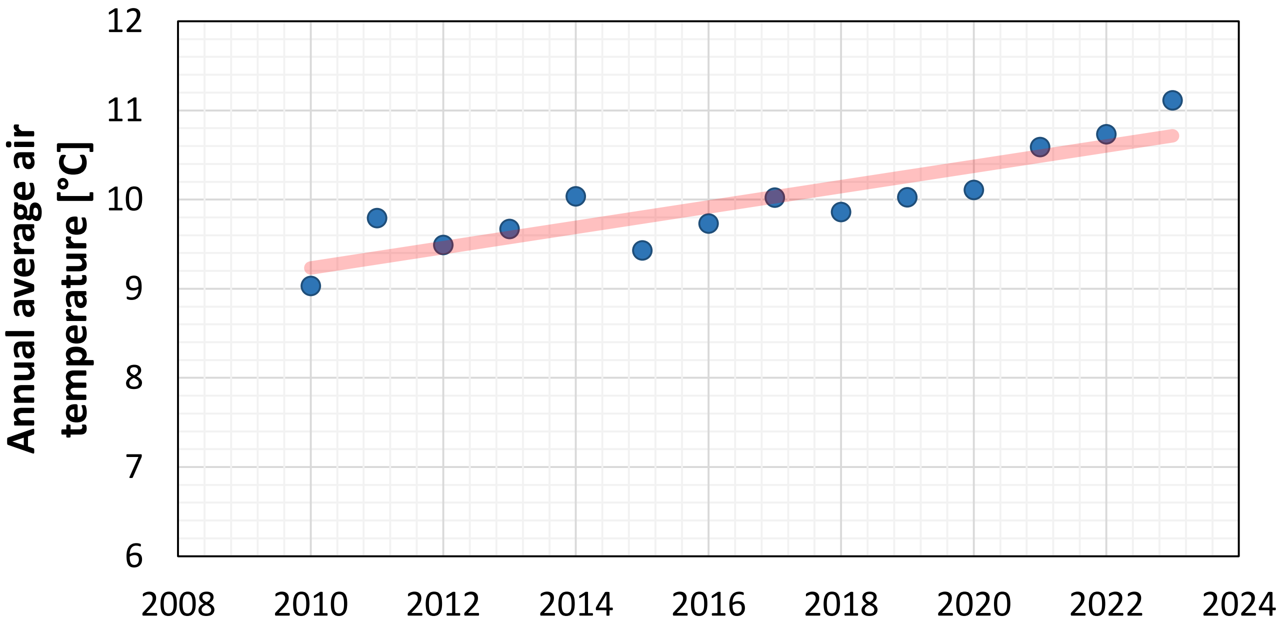
Climate

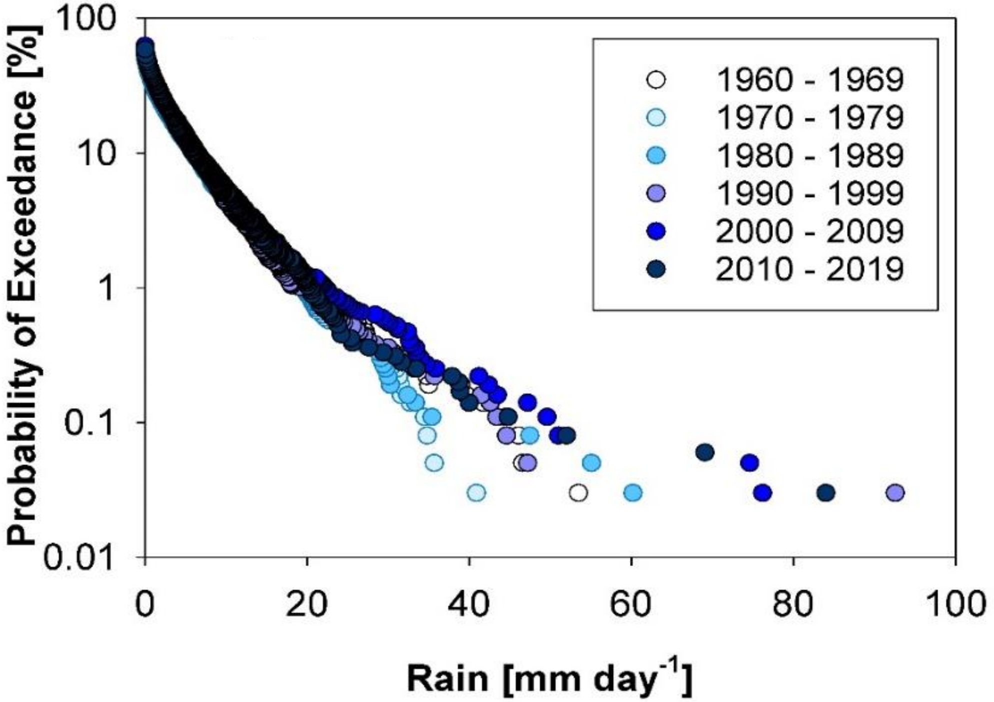
Three times higher NO_3 loss for the same flow

Three times higher P loss for the same flow

Water quality

Changing drivers

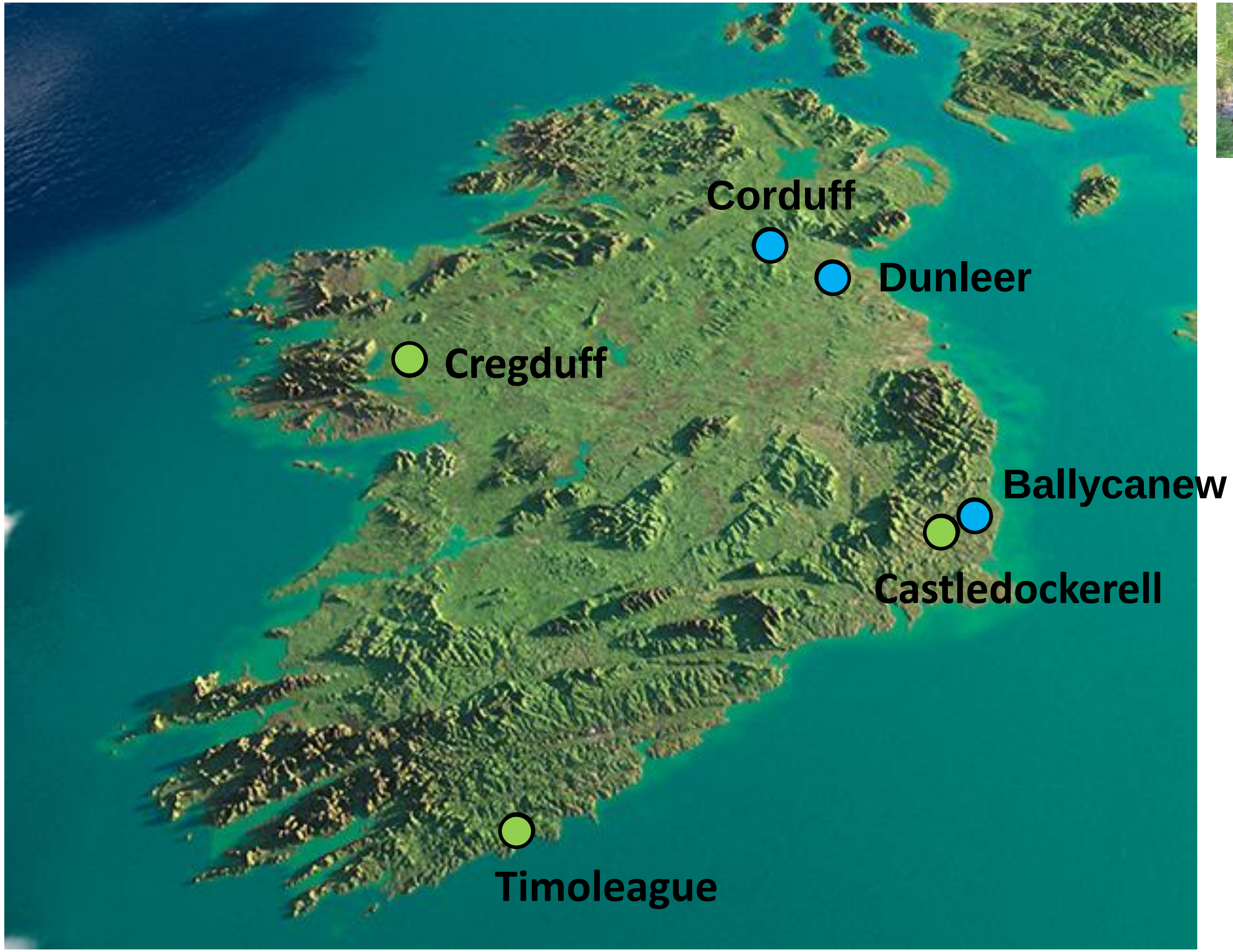




[Mellander & Jordan, STOTEN 2021

Agricultural Catchments Programme

15-years of sub-hourly hydro-chemometric data



Hydrological flashy

Q5/Q95: 61 – 126
BFI: 0.57 – 0.66

Groundwater-fed

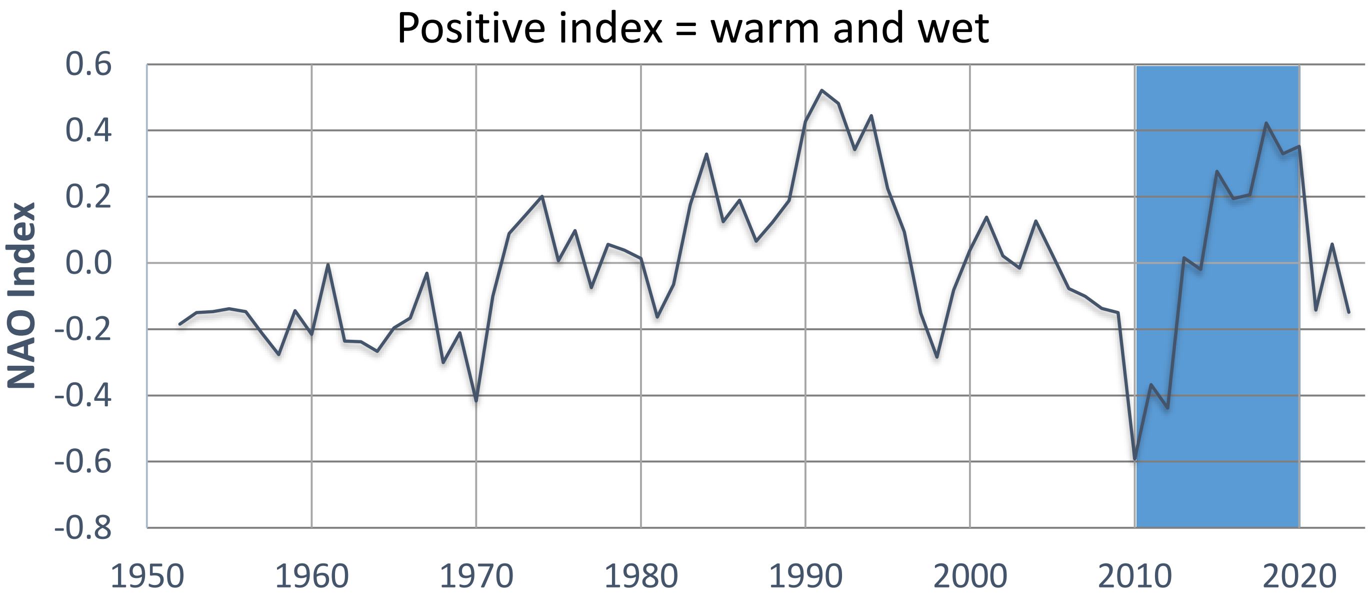
Q5/Q95: 22 – 34
BFI: 0.73 – 0.82

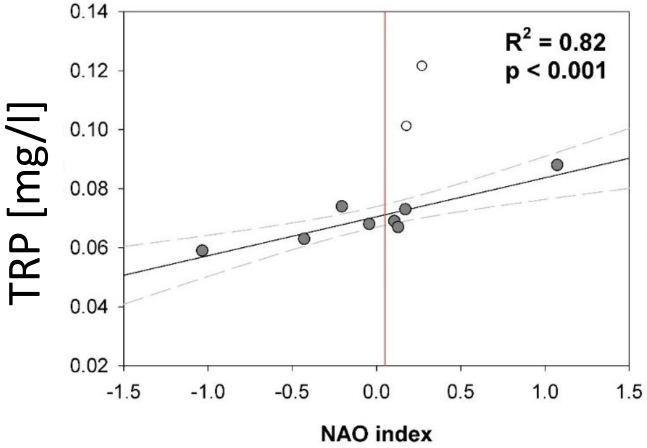
788,000 data points
per parameter

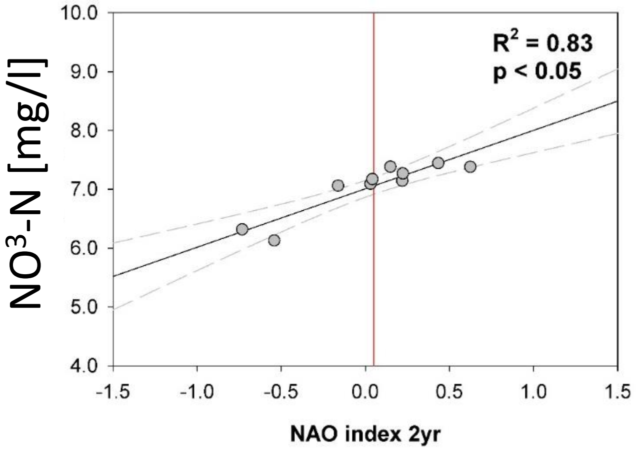
High frequency monitoring

- High temporal resolution monitoring of hydrology and water quality
  I. Captures all (data not skewed, low/high flow)
  II. Detected subtle changes in WQ (weather shifts)
  III. Provides development of new analytical methods
  IV. Allows to build a process based understanding

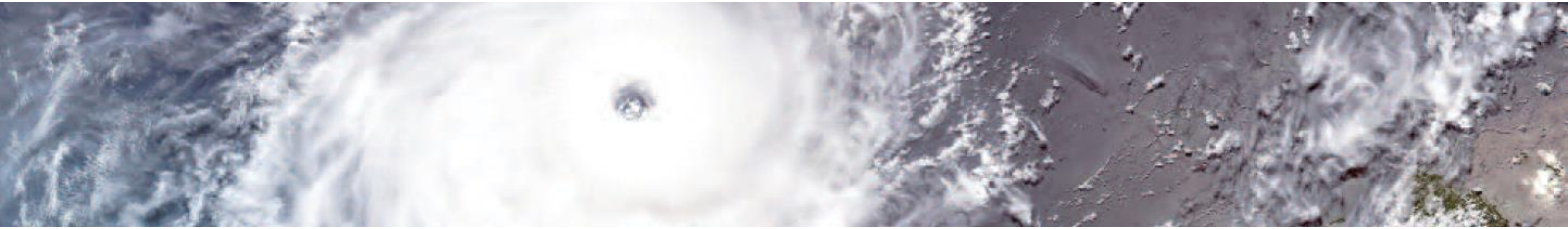
Long-term changes





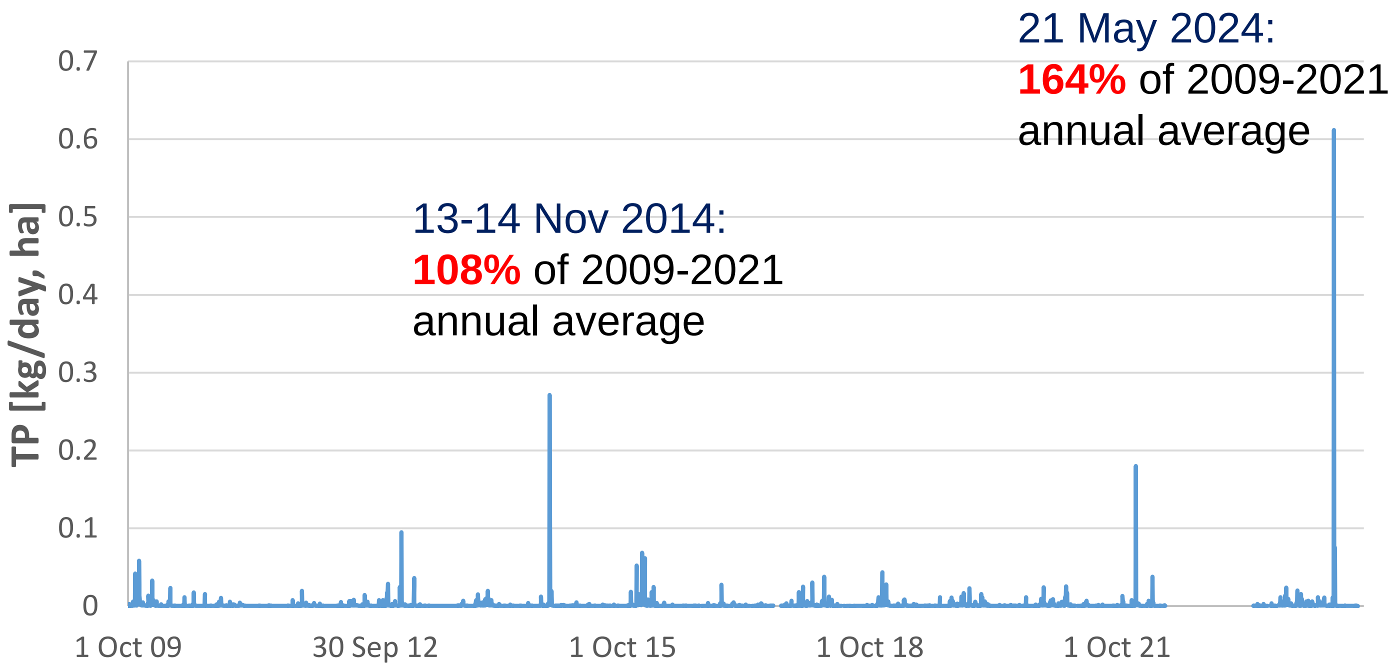


NAO intensity was correlated with long-term changes in baseline water quality

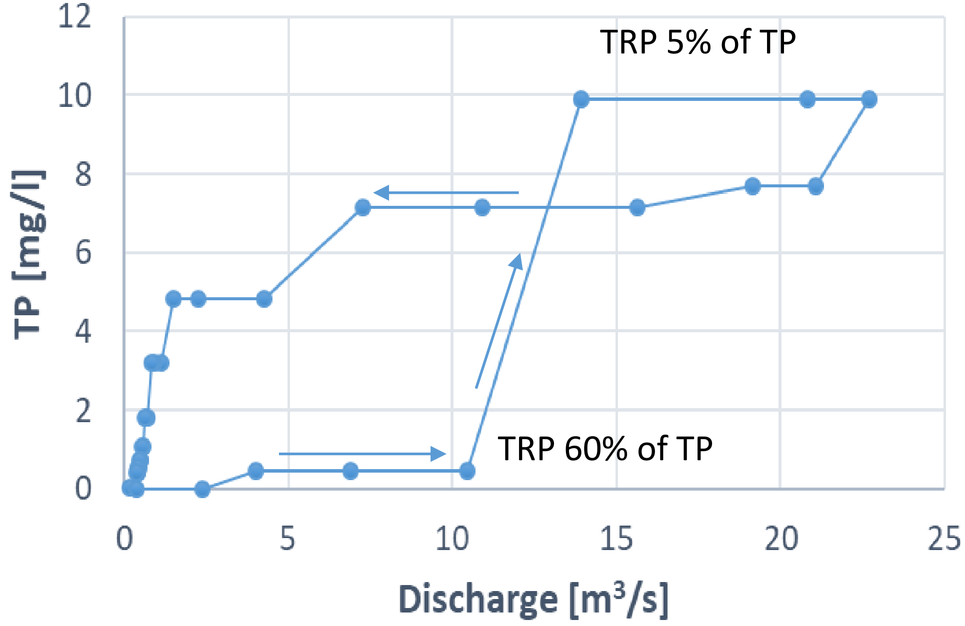


[Mellander & Jordan, STOTEN 2021; Mellander et al., Sci. Rep. 2018]

Runoff induced P loss events

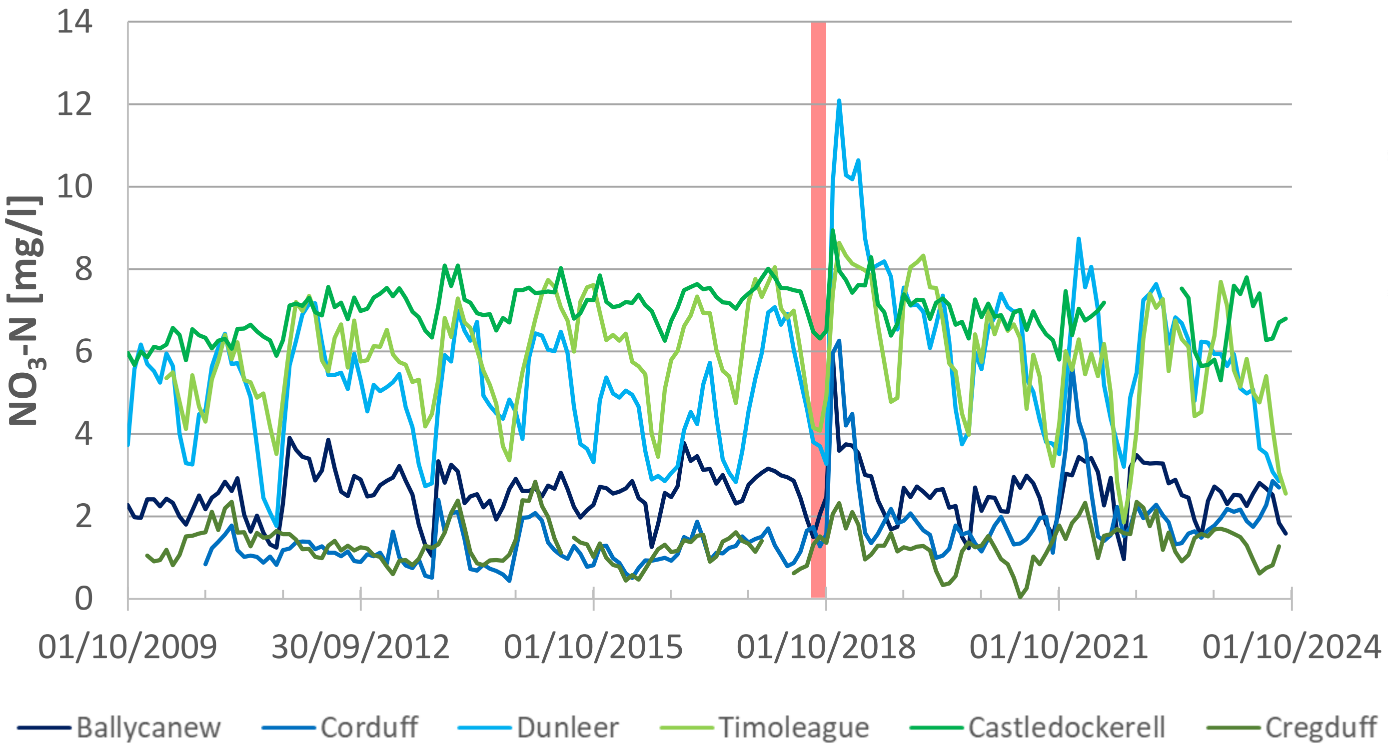


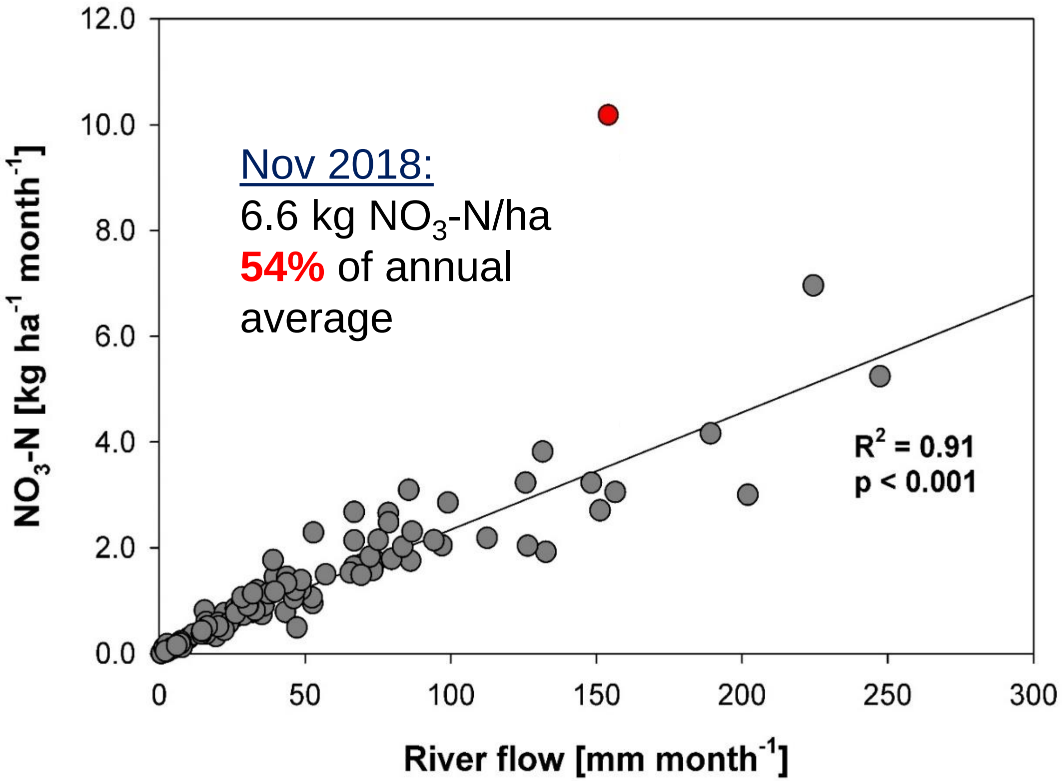
More intense storms increase the hydrological connectivity



[Mellander & Jordan, STOTEN 2021; Mellander et al., Sci. Rep. 2018]

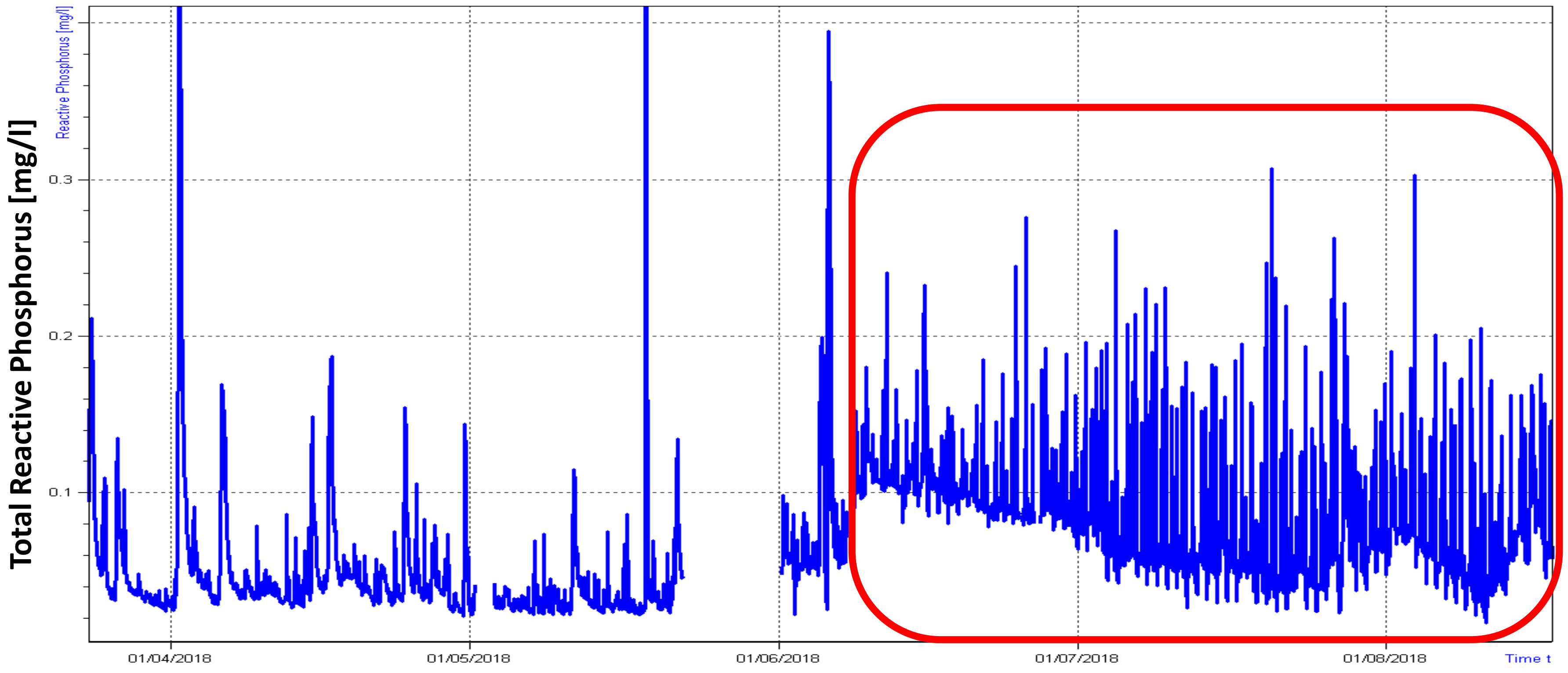
Droughts – nitrate loss





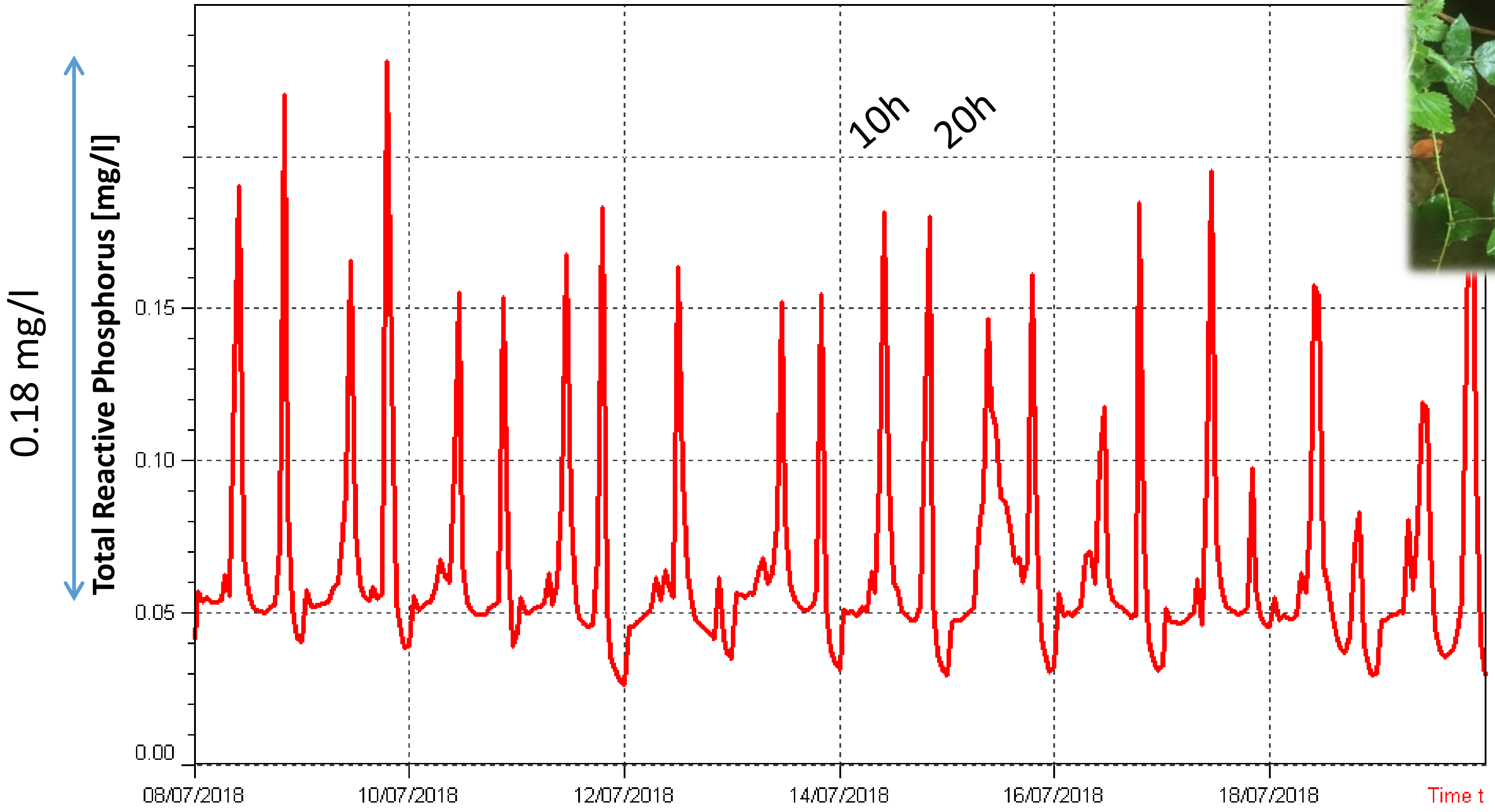
[Mellander & Jordan, STOTEN 2021]

Droughts - Point source magnification



[Mellander & Jordan, STOTEN 2021]

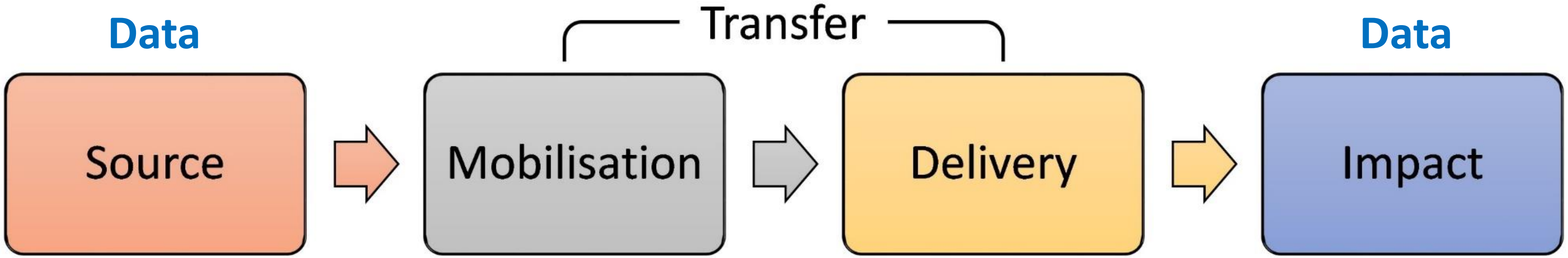
Droughts - Point source magnification

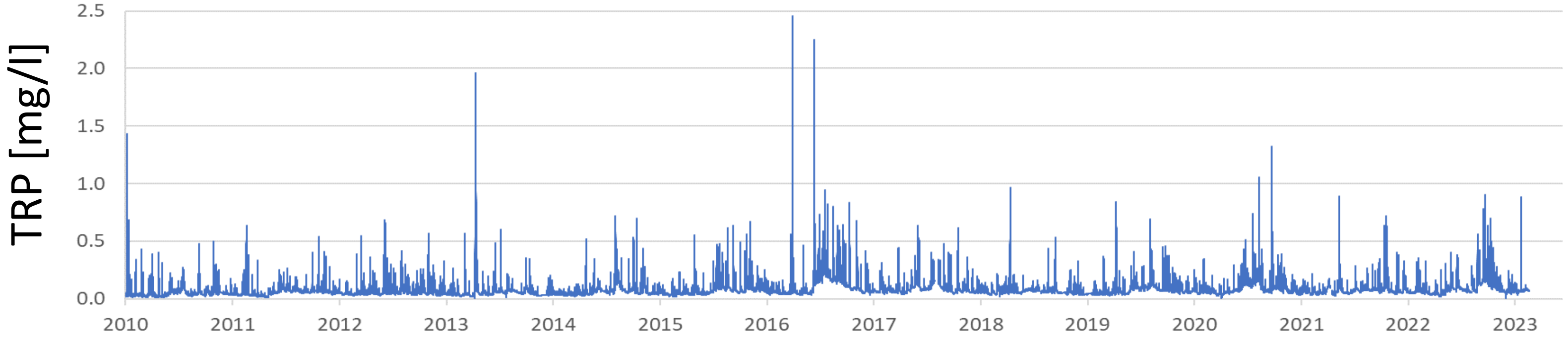


Concentration: TRP conc. >> EQS threshold during ecological sensitive period

[Mellander & Jordan, STOTEN 2021]

Phosphorus Transfer Continuum





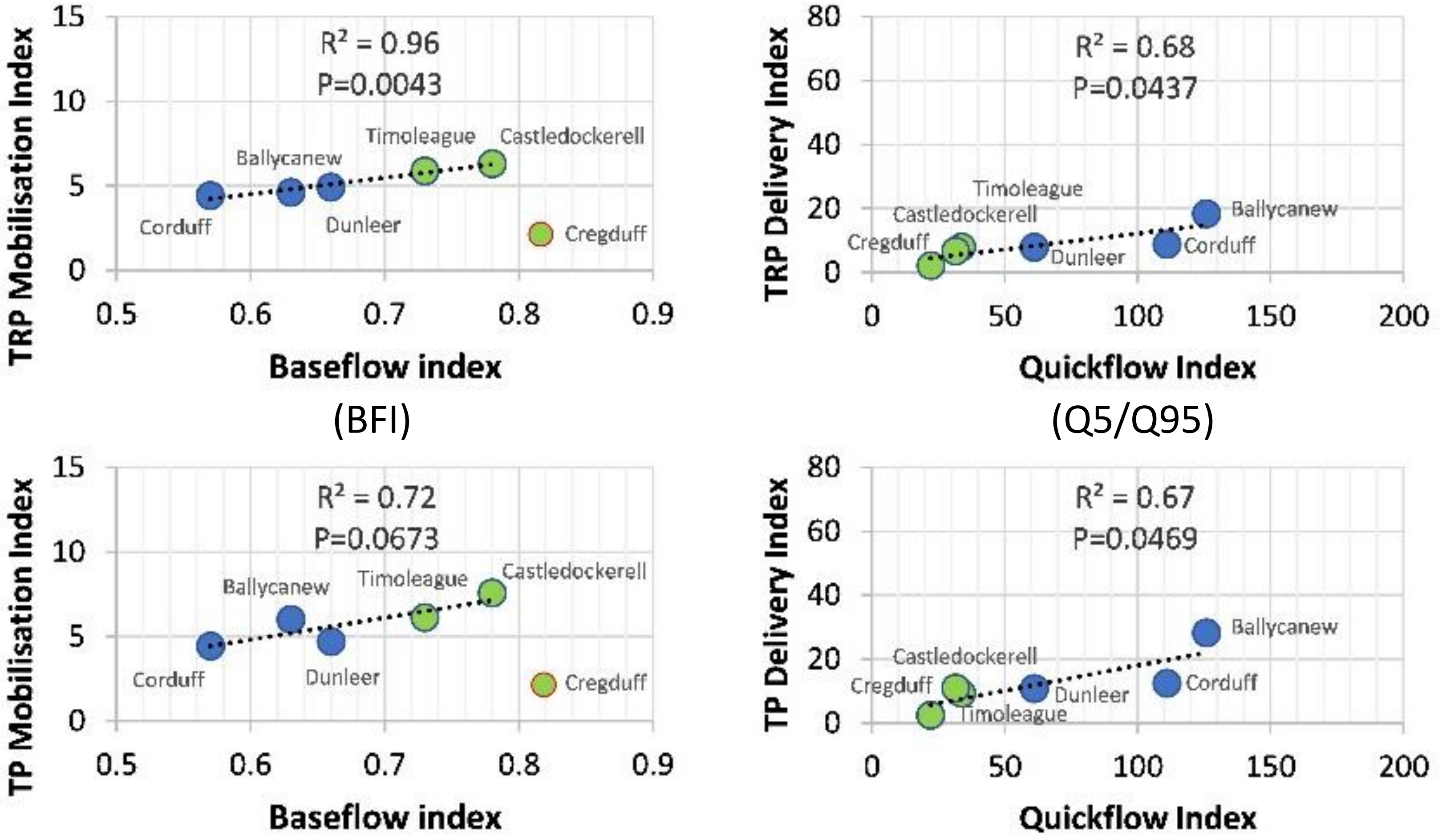
$$\textit{Mobilisation index} = \frac{P\ conc\ 95th\ PCTL}{P\ conc\ 5th\ PCTL}$$

$$\textit{Delivery index} = \frac{P\ load\ 95th\ PCTL - P\ load\ 50th\ PCTL}{P\ load\ 50th\ PCTL - P\ load\ 5th\ PCTL}$$

- Standardized, systematic and objective method to evaluate P transfer at the catchment scale
- Assess the influence of Climate Change

[Mellander et al., Frontiers, 2022; Discover Geoscience, 2024]

Empirical model: *P transfer* and *flow characteristics*



(BFI) (Q5/Q95)

(BFI) (Q5/Q95)

- The same climatic changes that influence the hydrological regime also influence transfer processes

Methods – Future P transfer

- Suite of downscaled GCMs
- RCP 4.5 & 8.5

High resolution climate scenarios

River discharge scenarios

- Hydrological model (SMART)

- Baseflow Index
- Quickflow Index

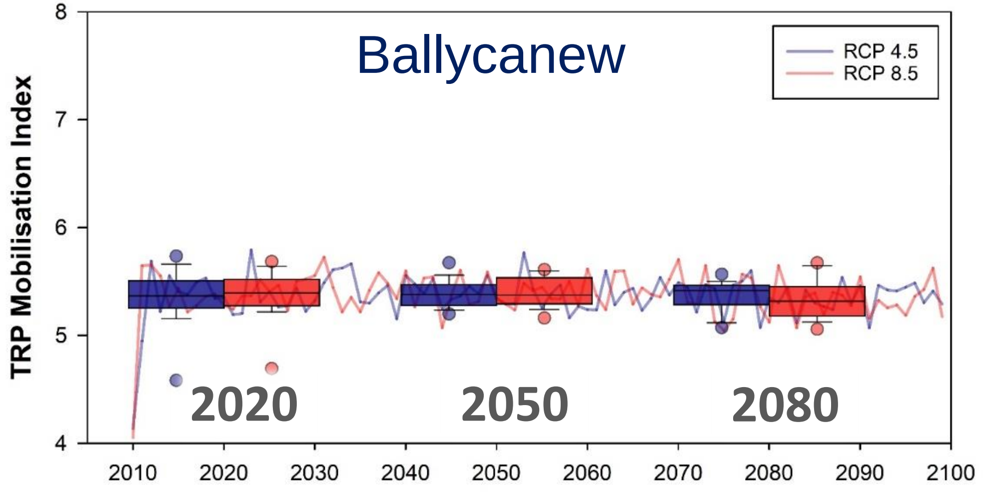
Empirical model

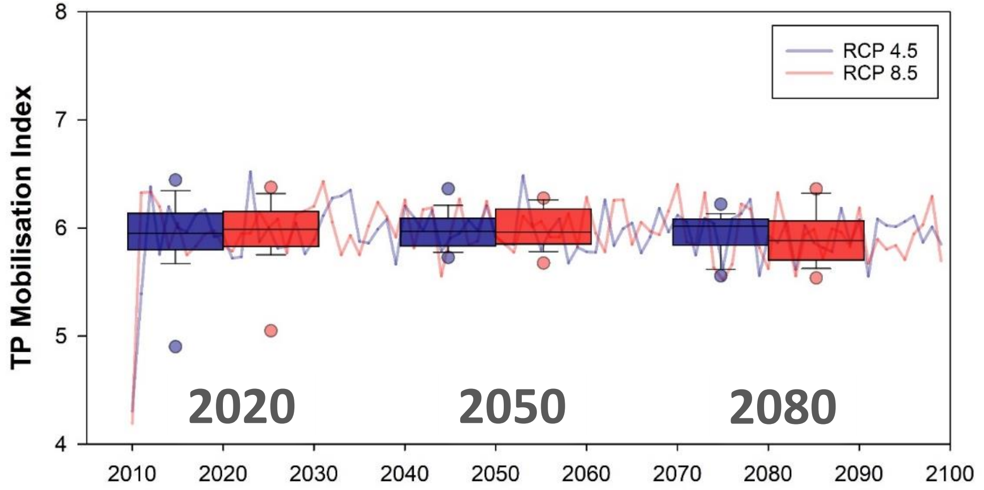
- P Transfer Indices for 2020-2100

[Murphy et al., Water Res Manag., 2023; Mellander et al., Frontiers, 2022; Discover Geoscience, 2024]

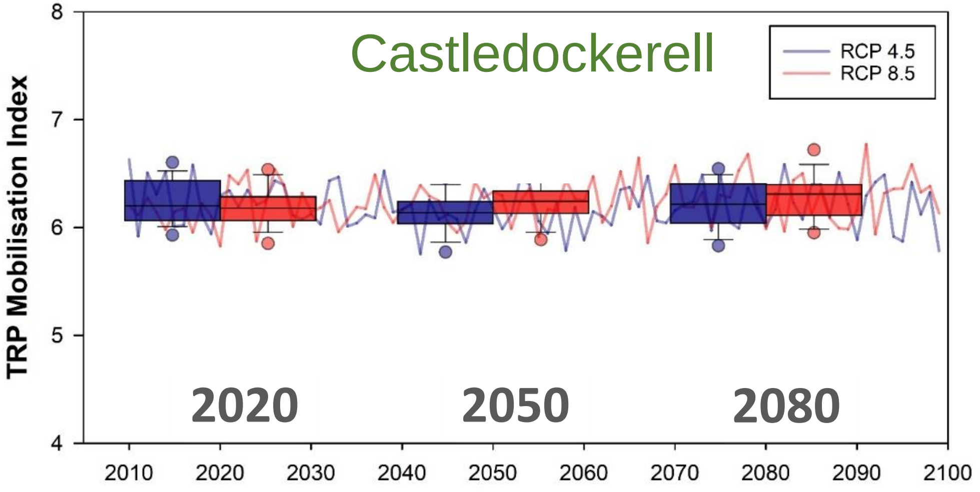
Future P Mobilisation

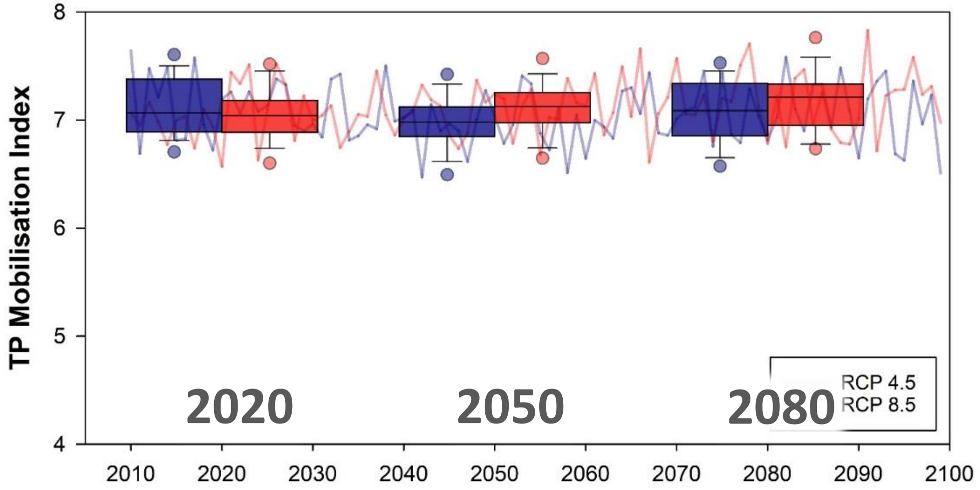
Hydrologically flashy catchment





Groundwater-fed catchment



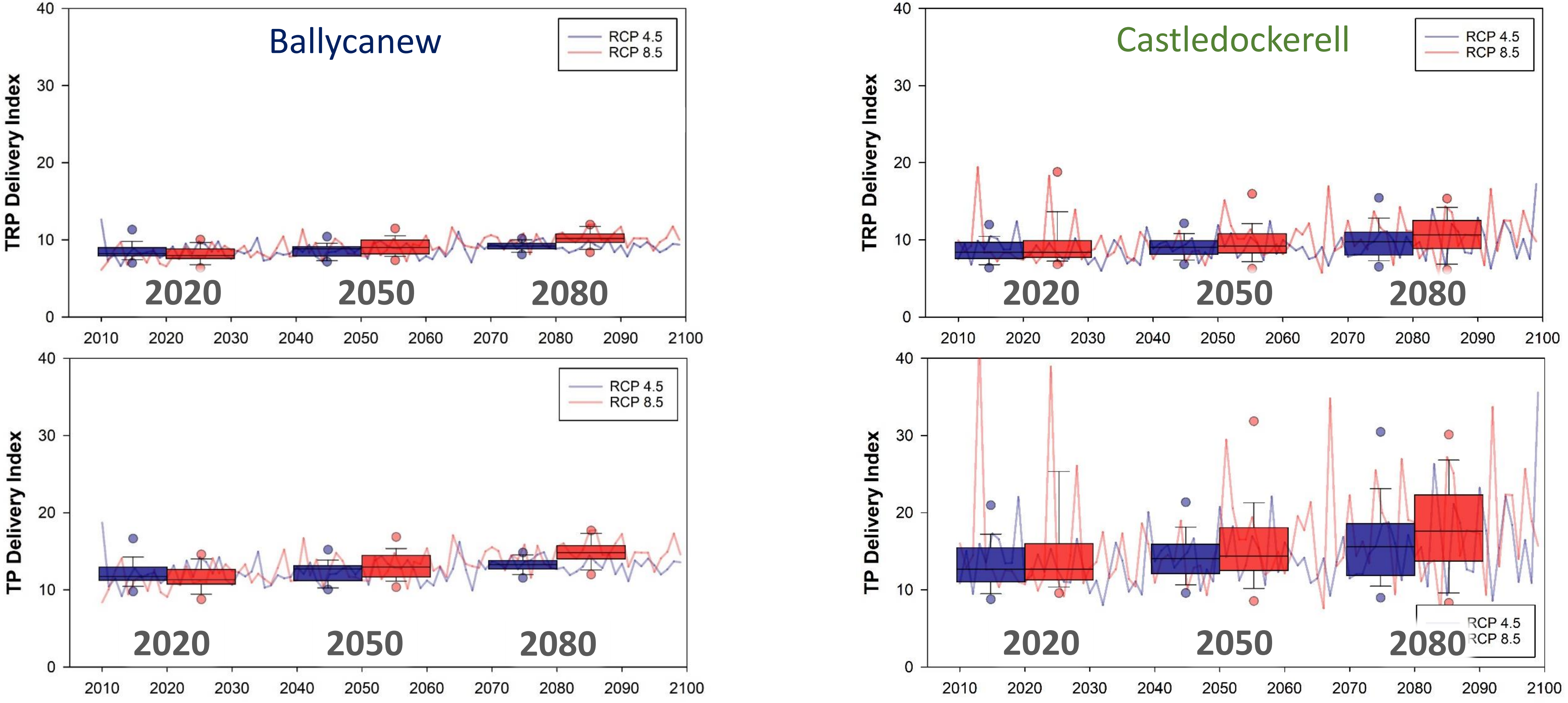


- *TP more mobile than TRP, MI* are higher in GW-fed catchments
- Hydrological changes due to *CC* are not expected to largely influence P mobilisation processes

Future P Delivery

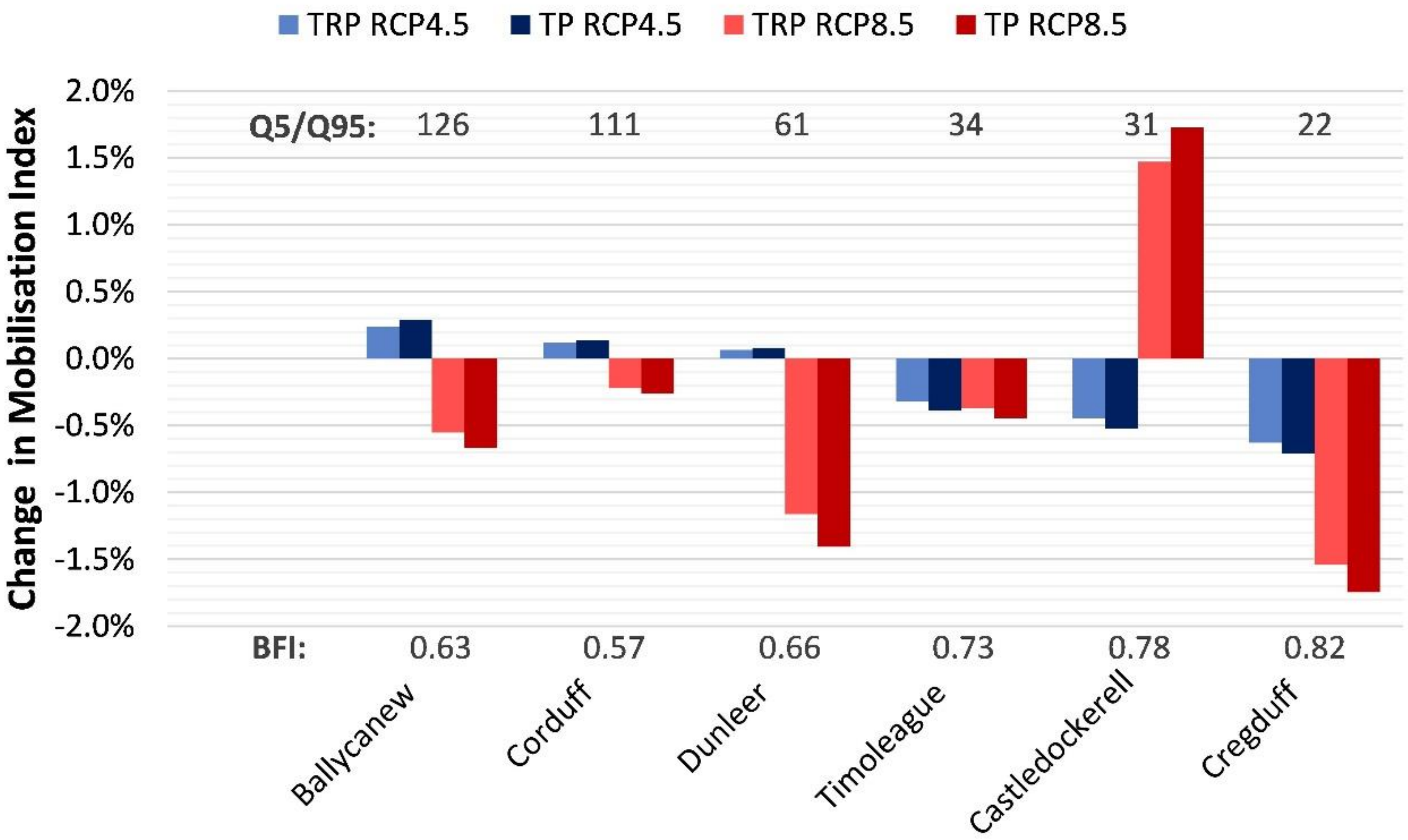
Hydrologically flashy catchment

Groundwater-fed catchment



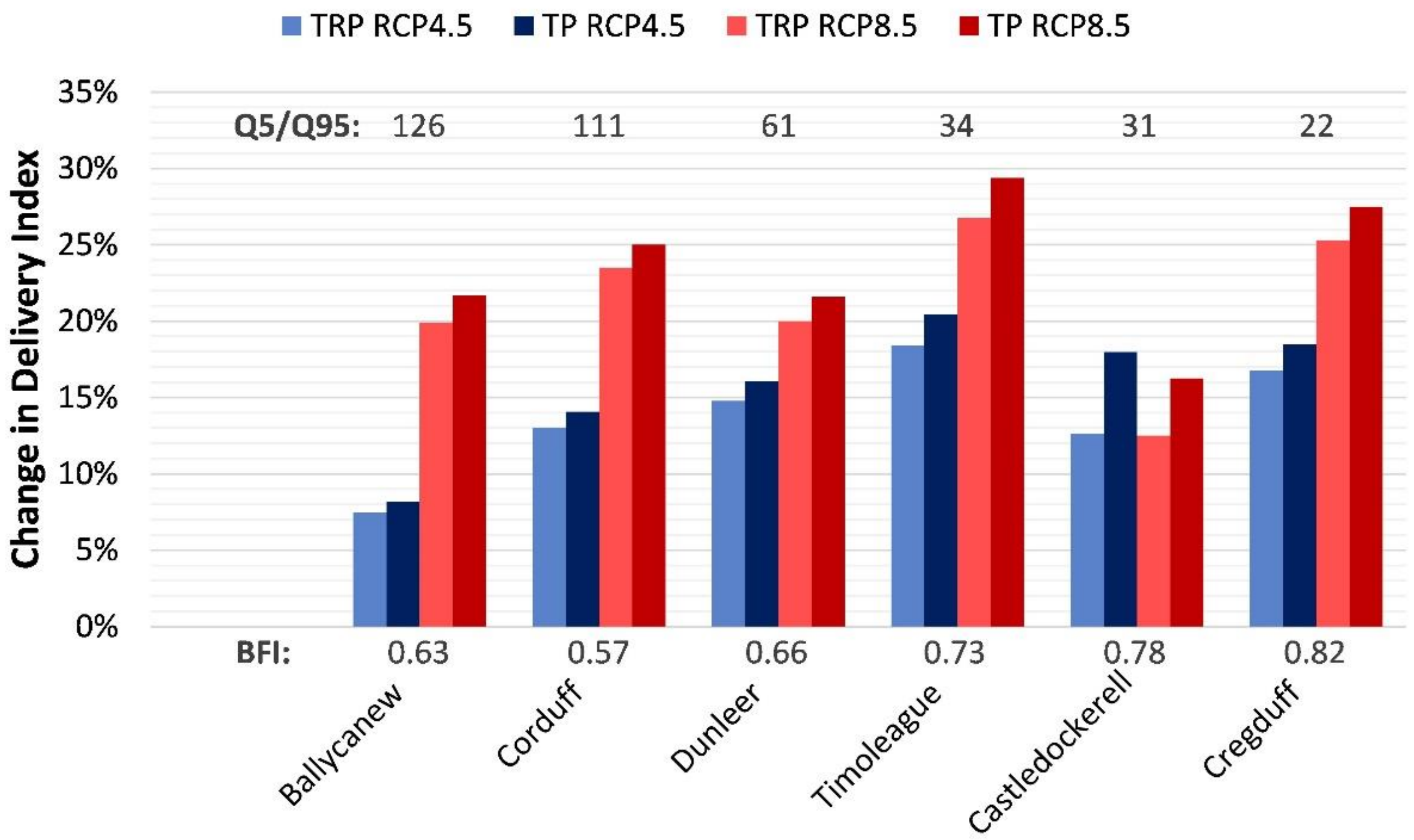
- *DI* are expected to increase in both catchment typologies (more in GW-fed catchments, for TP & for RCP 8.5)
- More inter-annual variability expected in GW-fed catchments

Change in P mobilisation from 2020 to 2090



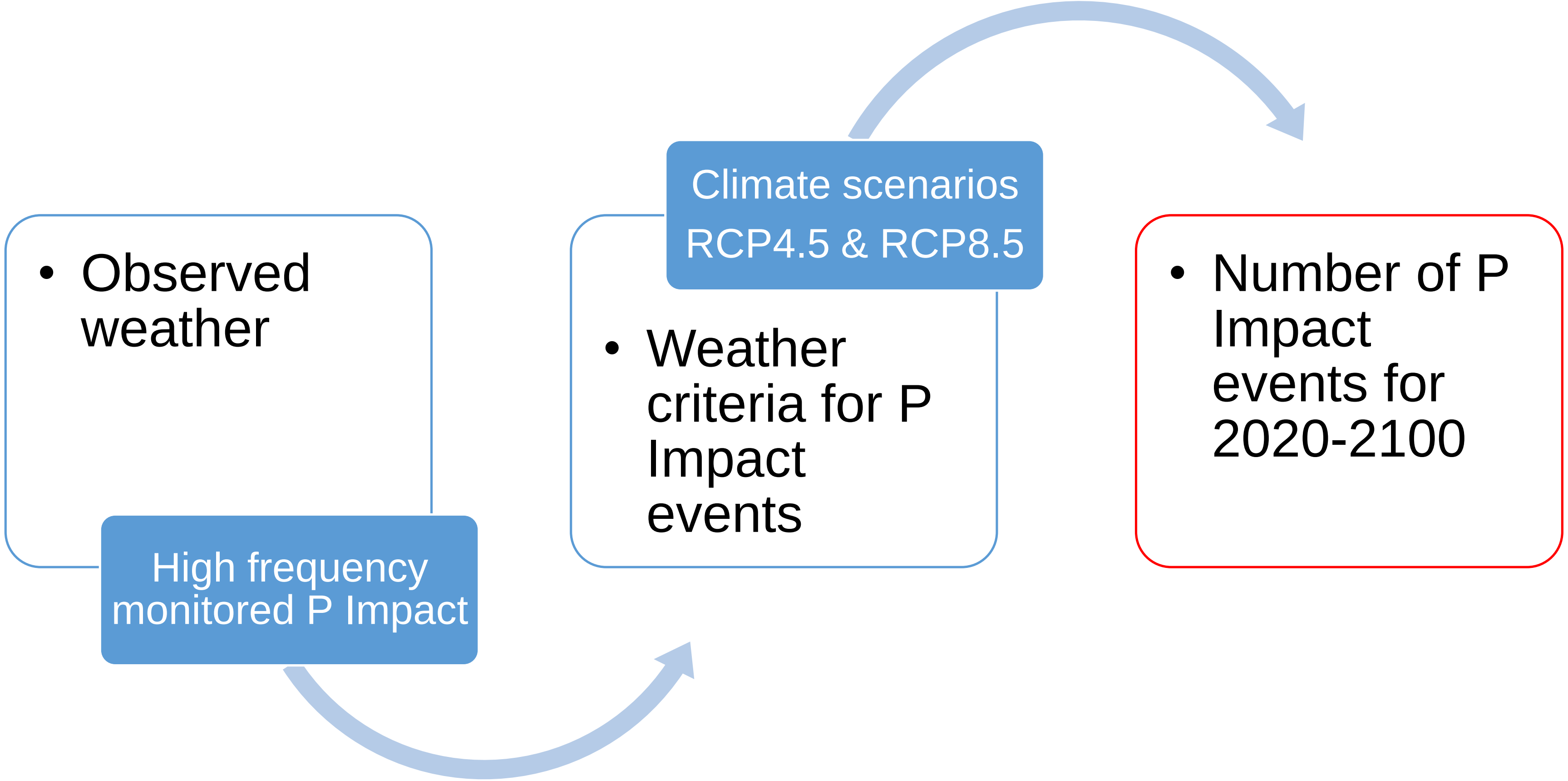
- Small changes
- There was more decrease in *MI* with increasing *BFI*
- Larger and more variable changes occurred in RCP8.5

Change in delivery from 2020 to 2090



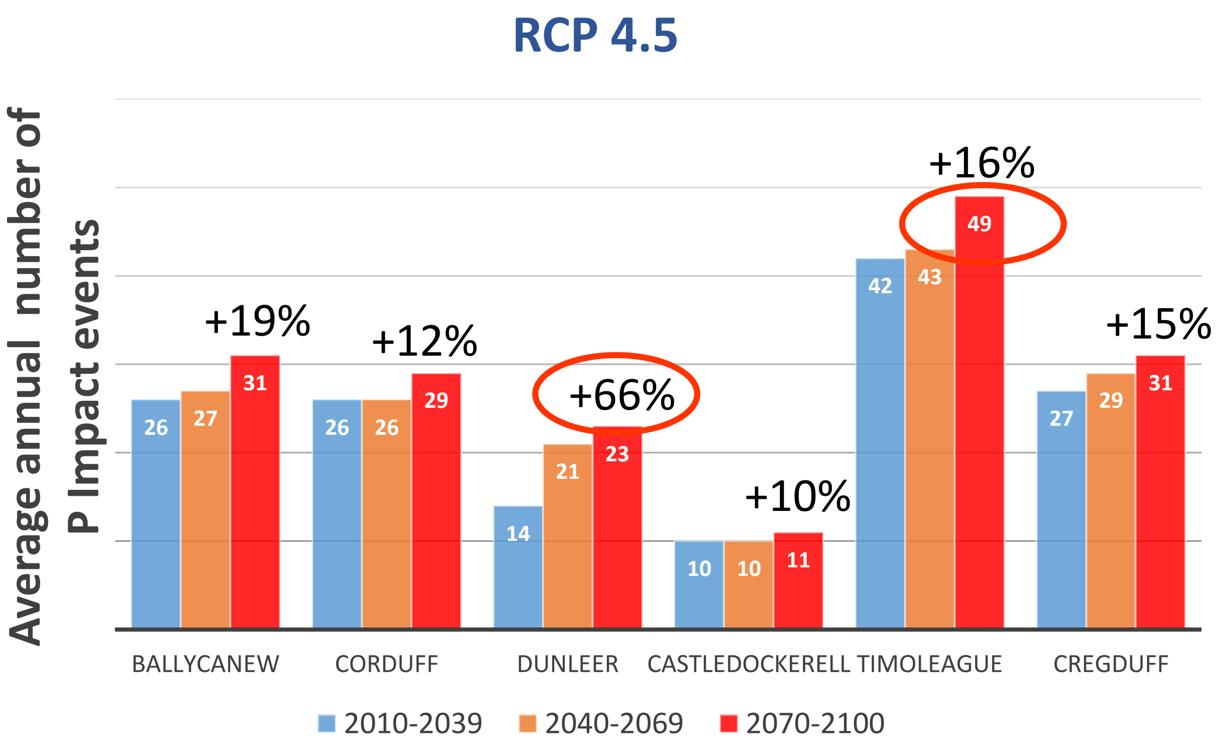
- P delivery increased 7-20% (RCP 4.5) and 13-29% (RCP8.5)
- Mobilised P will be more hydrologically connected (and P may be less retained within the landscape)
  - ➢ cause higher P losses and larger inter-annual variability.

Methods: Future P Impact (an empirical model)



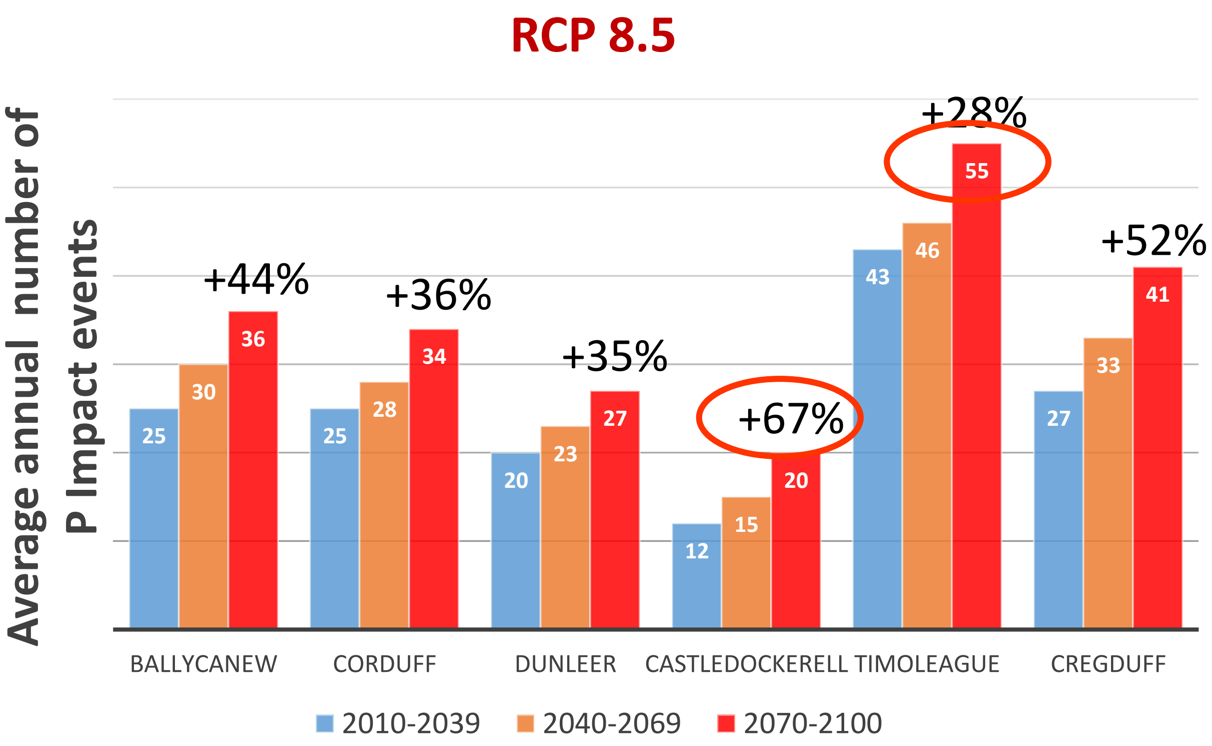
[Ezzati et al., in prep]

Future P Impact



17%

24 26 29

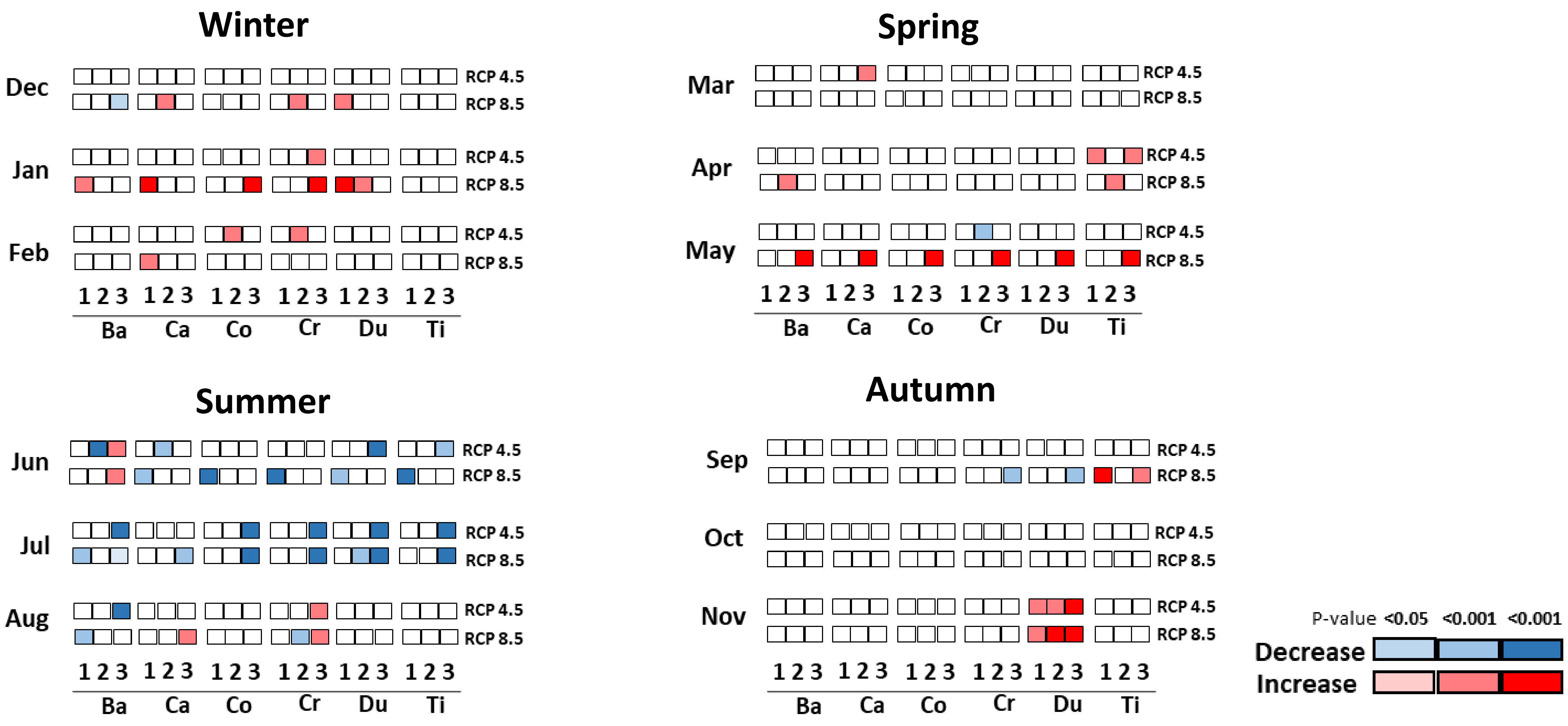


26%

25 29 34

[Ezzati et al., in prep]

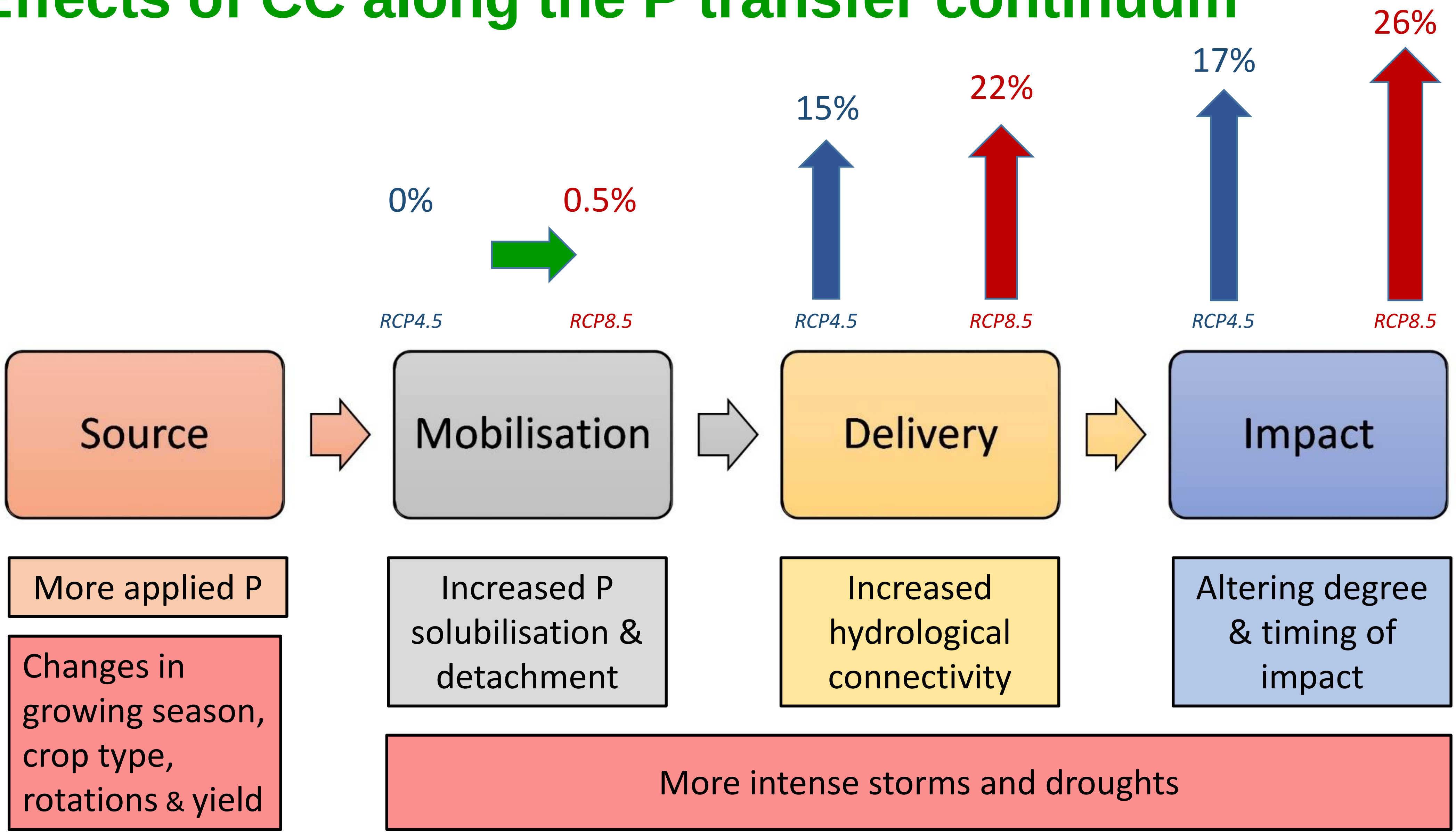
Future Inter-seasonal rainfall



- Increases are mostly in Winter and Spring
  - Rainfall decreased in summer
- Inter-seasonal changes were mostly in the far-future scenario ("period 3")

[Ezzati et al., in prep]

Effects of CC along the P transfer continuum



Considerations for mitigation strategies

- Stable, but relatively high solubilisation
- Increased connectivity - connecting more source and mobilisation areas (in all pathways)

i) Identify and manage *CSAs* and *CMAs*
ii) Improve source management: precision in location and timing
iii) Retain P in the catchments: chemical amendments/ LU change
iv) Intercept delivery pathways: riparian buffers, stabilise soils, …

Summary

1. Catchment complexity: *critical source areas*, *mobilisation areas*, *times* and *pathways*
2. Climate change will influence long-term baseline conditions and largely offset these by more frequently occurring weather extremes
3. The P transfer continuum is a useful framework to assess the effects of *CC*
4. *P mobilisation* is expected to remain stable (high in GW-fed catchments)
5. Low *P mobilisation risk* may be overcome by increased hydrological connectivity
6. *P delivery* is expected to increase in all catchments (15%-22%) higher in hydrologically flashy catchments, larger increases and inter-annual variability in GW-fed catchments
7. The number of *P impact events* are expected to largely increase (17%-26%)
8. Future mitigation strategies should identify/manage *CSAs* and *CMAs*
9. A new method for characterizing catchments P impact risks and quantifying underlying processes is being developed - useful for scaling up and for understanding ***Water Futures***.