Can we understand the variability in flood-induced displacement using process-based global flood modelling?

ISIMIP Workshop 2024

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Motivation

$$Risk = Flood\ Hazard \times Exposure \times Vulnerability$$

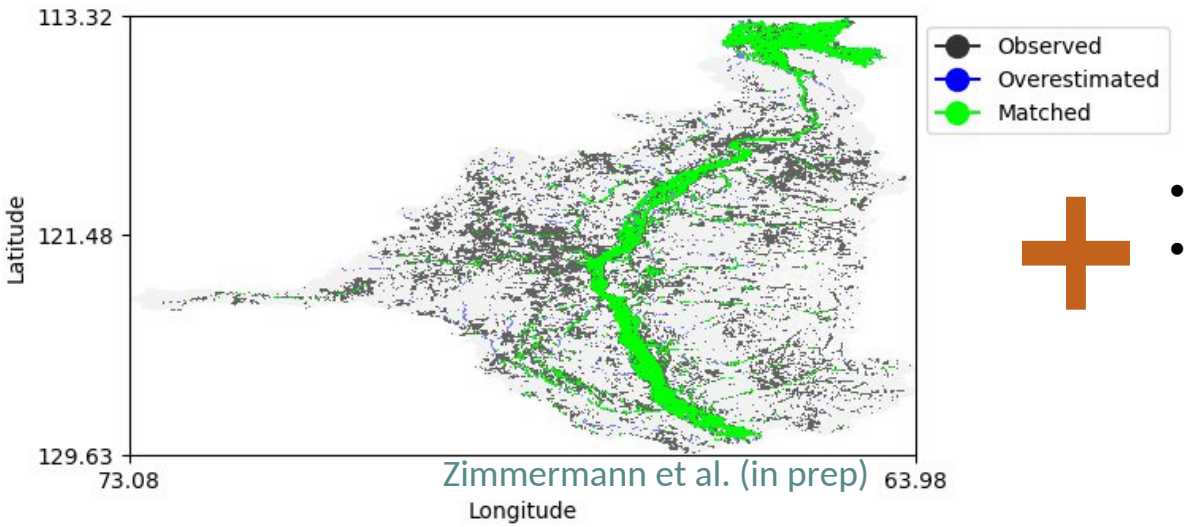
inundated area

pop affected

Model-derived

Kakinuma et al. (2020)
Kam et al. (2021)

- Projections
- Impact attribution
- Global coverage
- Comprehensive hazard information



Zimmermann et al. (in prep)

Satellite Imagery

Vestby et al. (2024)
Mester et al. (2023)
Sauer et al. (under review)

- Observation-based
- Implicit accounting for flood protection

How well can process-based modelled flood hazards explain...

1. whether displacement occurs?
2. how high displacement will be?

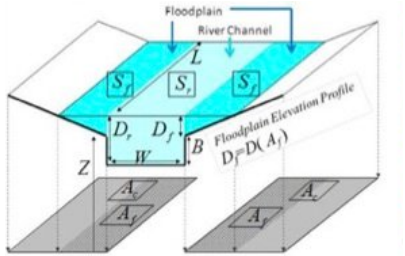
Deriving the Hazard Components - CaMa-Flood Modeling Chain

ISIMIP
Inter-Sectoral Impact Model Intercomparison Project

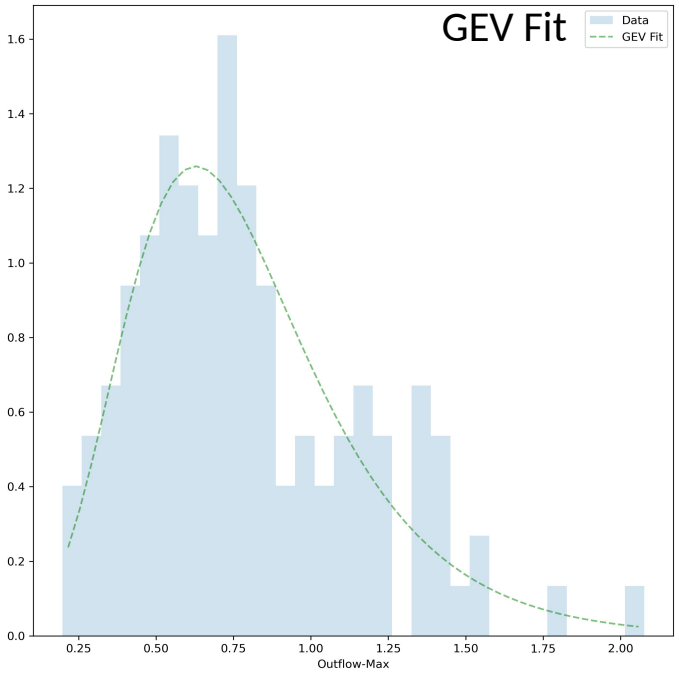
WaterGAP2-2e Output from ISIMIP3a Frieler et al. (2024)

- Direct human forcing
- 20CRV3-ERA5 Reanalysis Data (1901-2021)

CaMa-Flood
Yamazaki et al. (2011)



Annual Max Outflow (15x15arcmin)



Return Interval
(15x15arcmin)

- No Protection (nopros)
- ‘Natural’ Protection (2y) Willner et al. (2018)
- FLOPROS (merged layer) Scussolini et al. (2016)

Flood Depth + Inundated Area
(1x1arcmin)

Flood Duration
(15x15arcmin)

River Velocity
(15x15arcmin)

Model Set Up – Dependent and Independent Variables

Risk =

IDPs /displacement events (GIDD)

IDMC (2023)

Geolocation based on Mester et al. (2023) for all administrative levels + cities

Flood Hazard

rivvel

ri

flddur

flddph

Yamazaki et al. (2011)

x

Exposure

pop_affected

(nopros, 2y, flopros)

GHSL (2023)

x

Vulnerability

pop_density

flopros level Scussolini et al. (2016)

cisi Nirandjan et al. (2022)

imr CIESIN (2021)

Aggregated (mean/sum) on administrative levels 0,1,2 – national, province and district level and by event

GADM (2023)

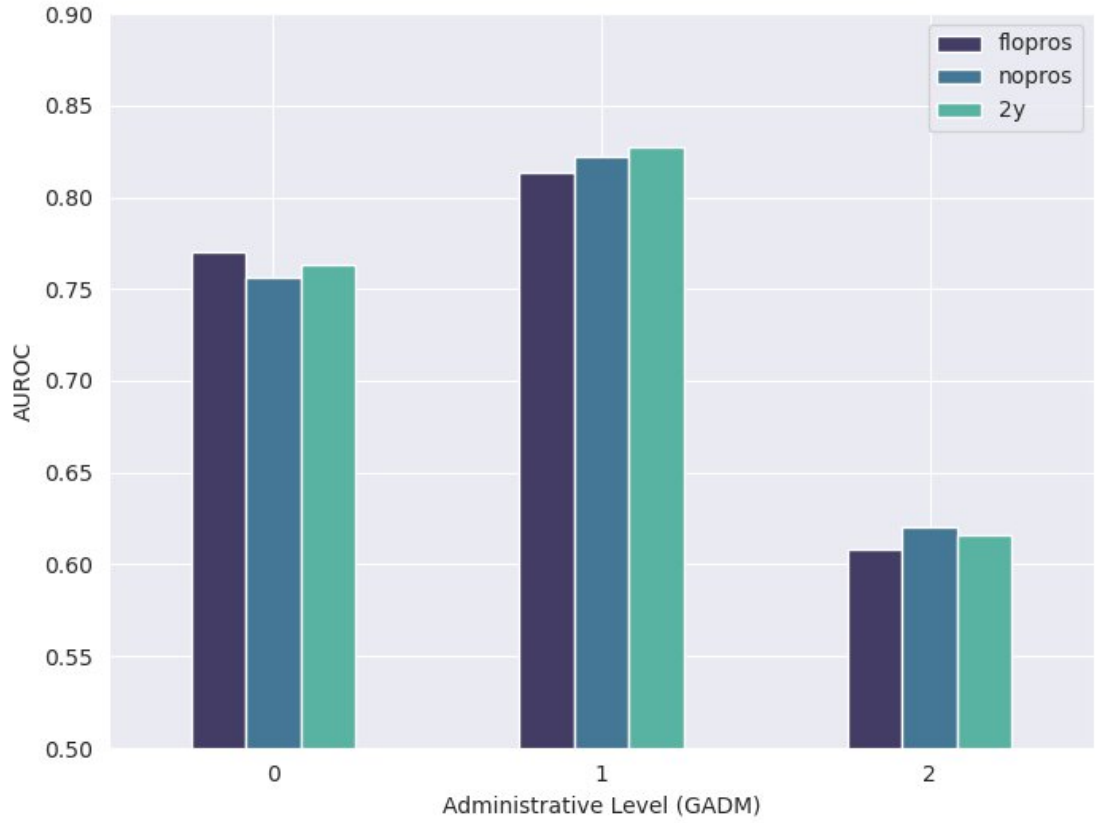
1. Logistic Regression Model:
displacement event

2. Multivariate Linear Regression Model:
IDPs(log) displacement events (only)

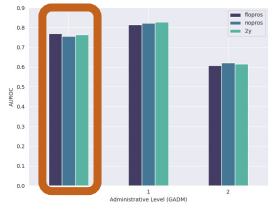
How well can different modelled flood hazards components explain...

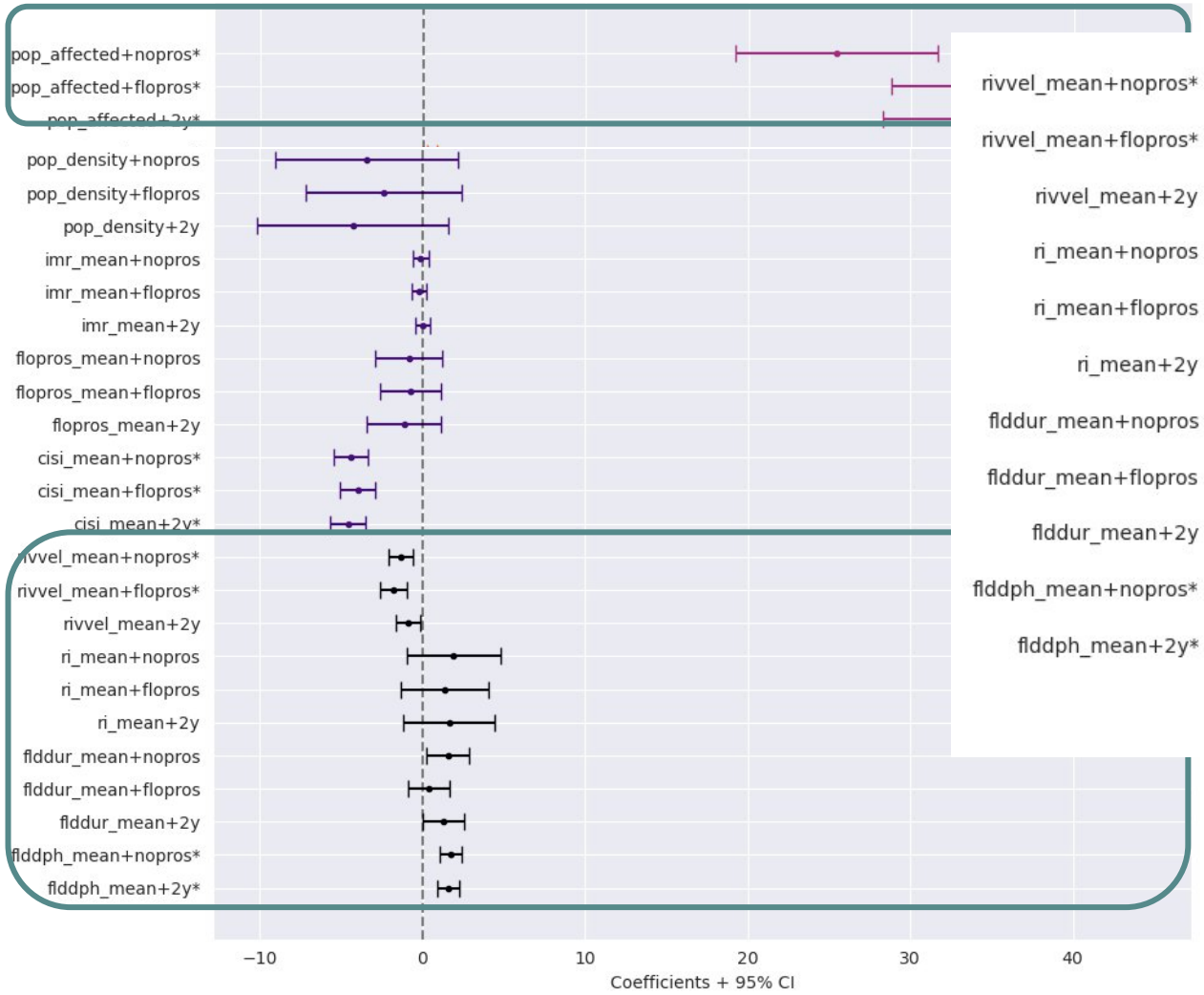
1. whether displacement occurs?
2. how high displacement will be?

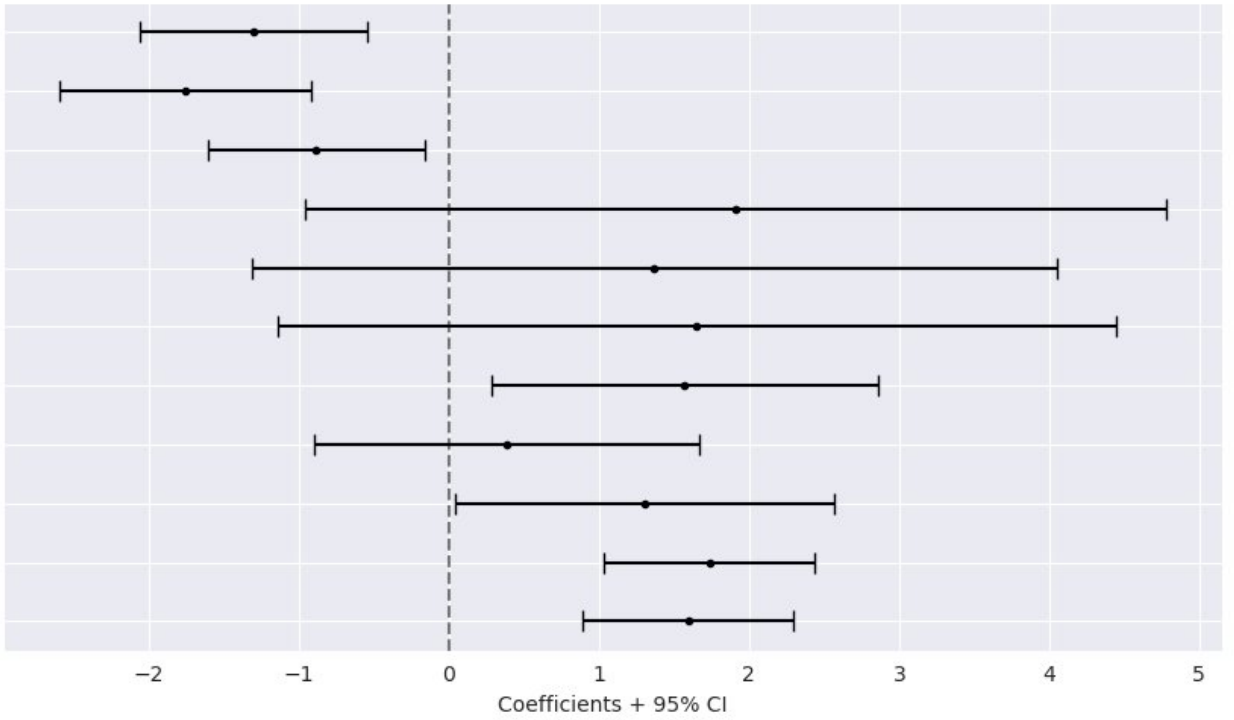
AUROC for different administrative and protection levels



Variable Coefficients – Level 0







Flood depth , river velocity

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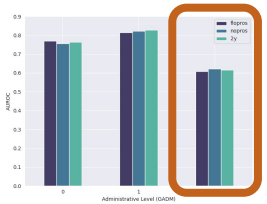
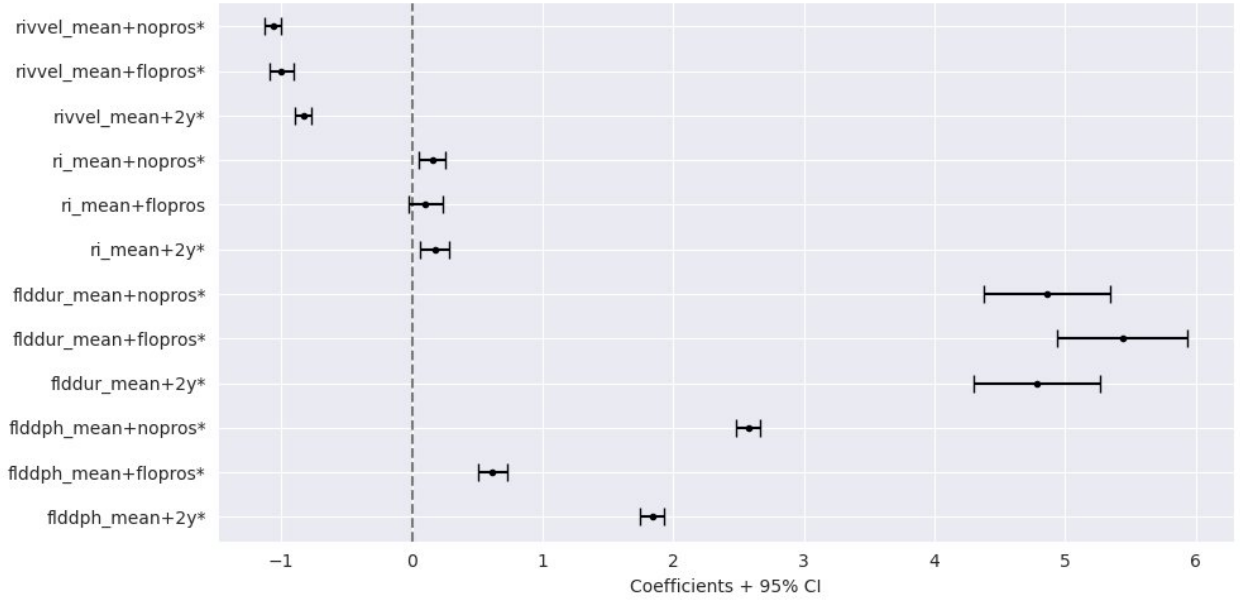
Variable Coefficients – Level 2



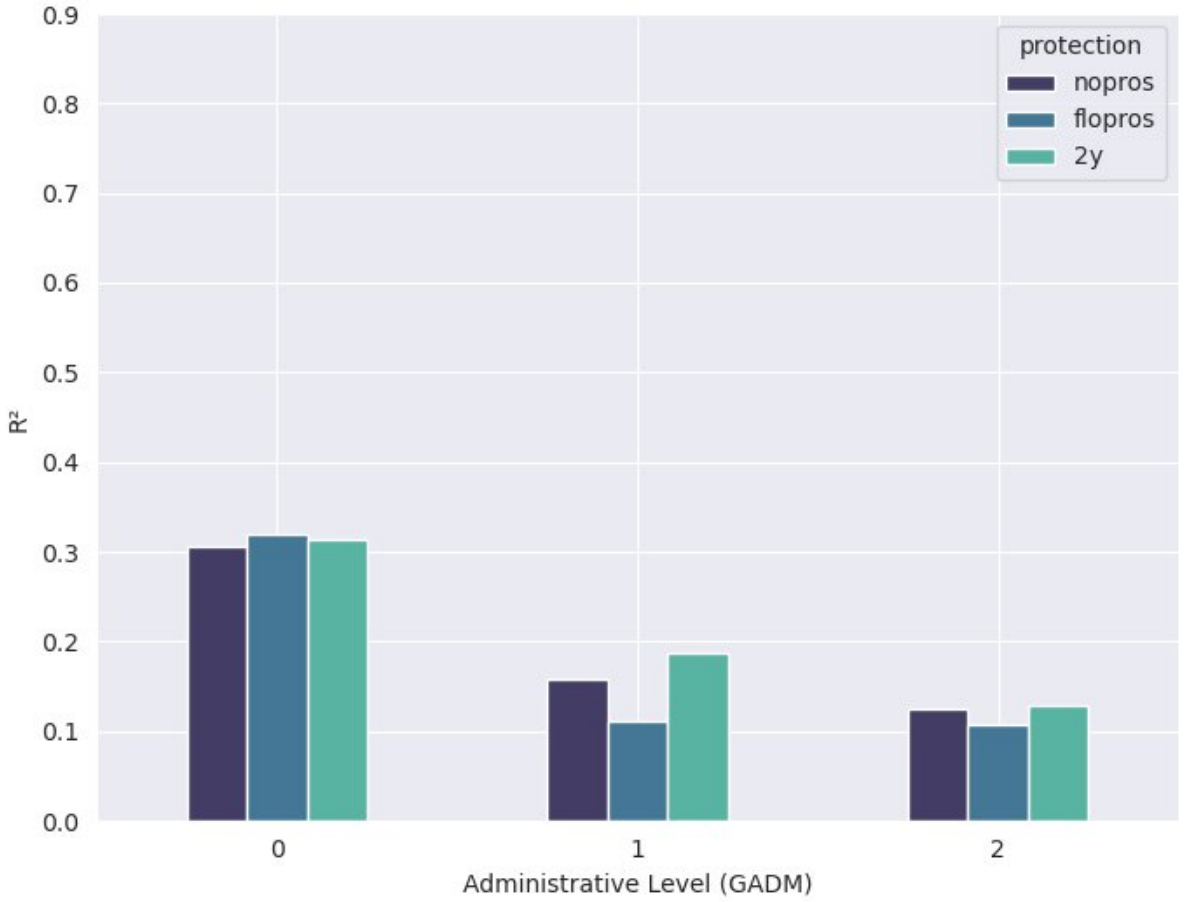


River velocity, flood duration, flood depth, return interval

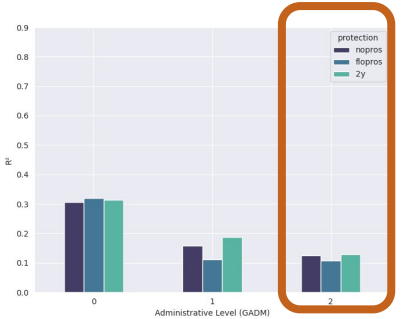
How well can different modelled flood hazards components explain...

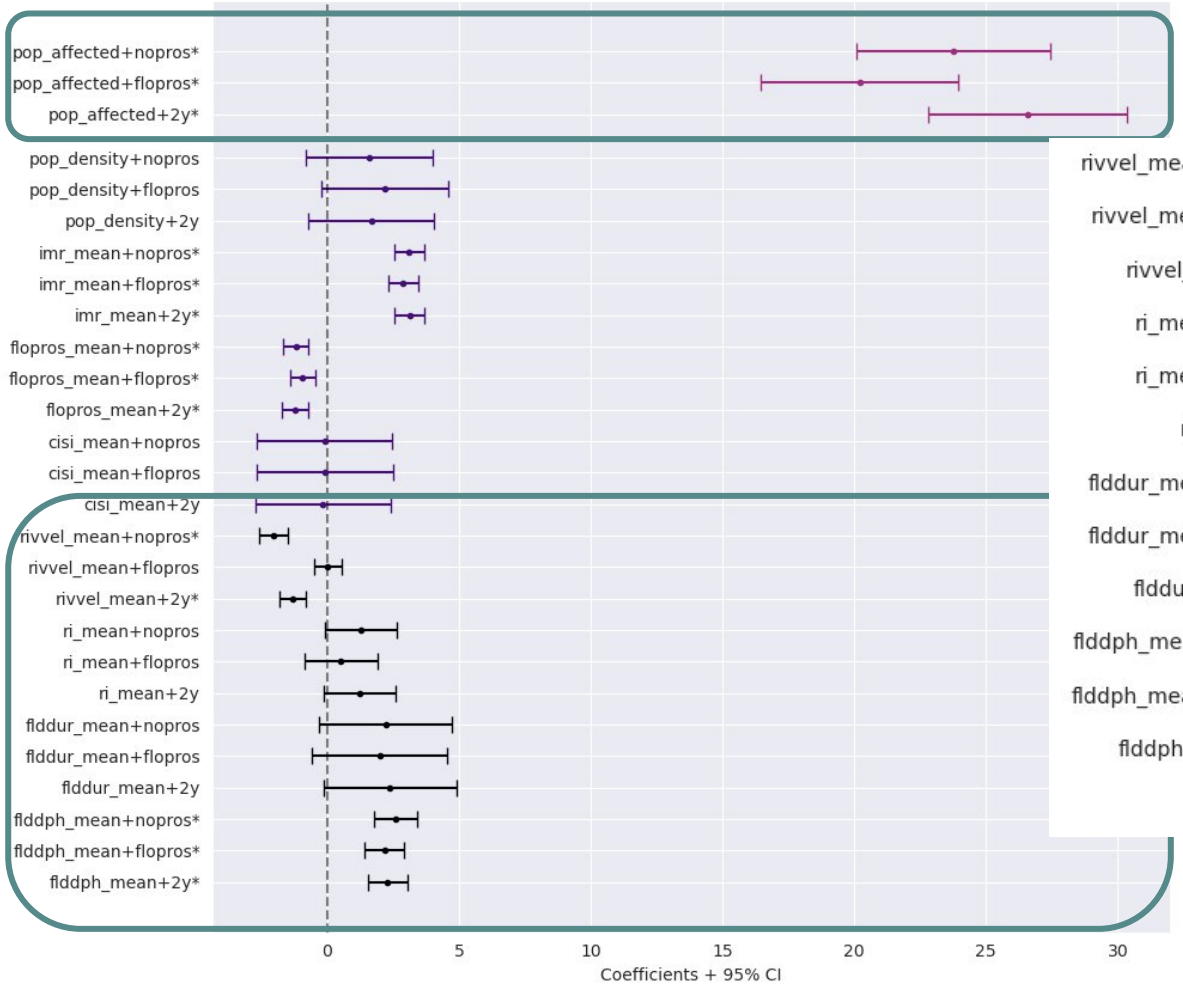
1. whether displacement occurs?
2. how high displacement will be?

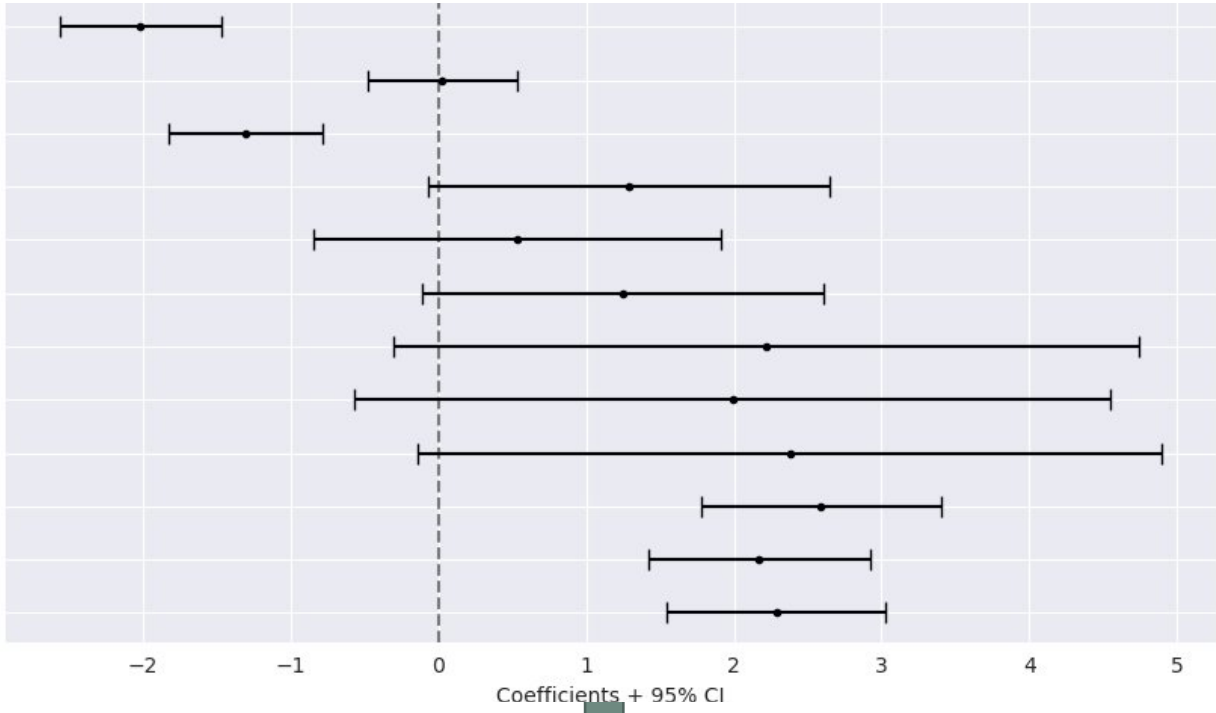
R^2 for different administrative and protection levels



Variable Coefficients – Level 2







River velocity, flood depth

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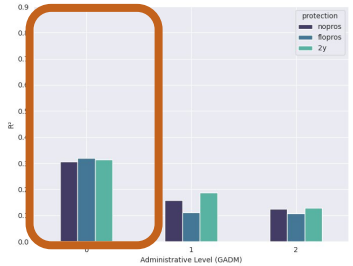
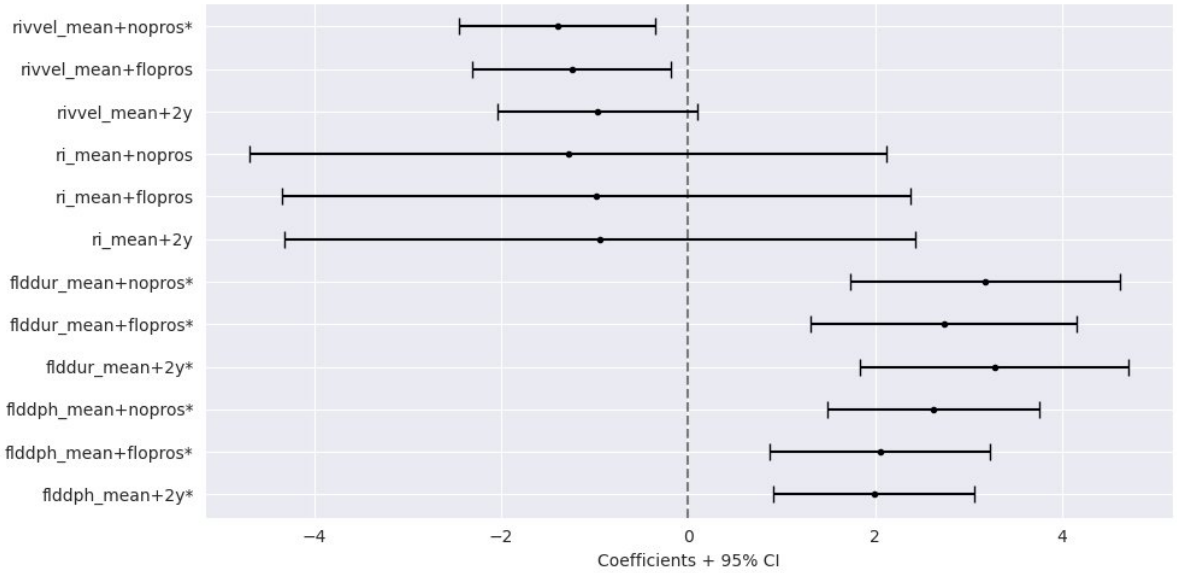
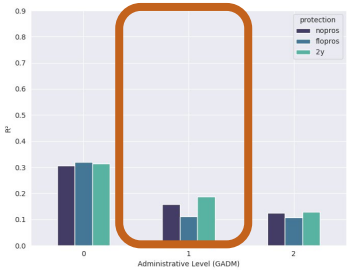
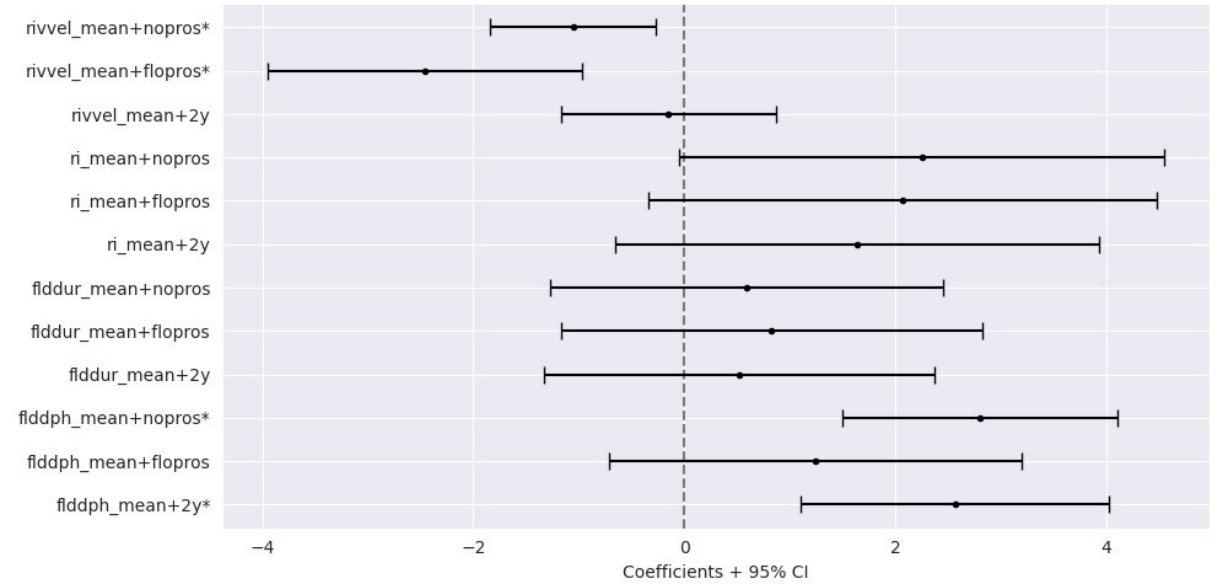
Variable Coefficients – Level 0





flddur, flddph





flddph

First insights and next Steps

1. Logistic Regression Model:

simulated exposure adds value

hazard components mainly on disaggregated levels

River velocity interactions

High/low displacement subsets

2. Multivariate Regression Model:

Applying FLOPROS might miss evacuations / underestimate exposure

Accounting for uncertainties in FLOPROS

Thank you for your attention

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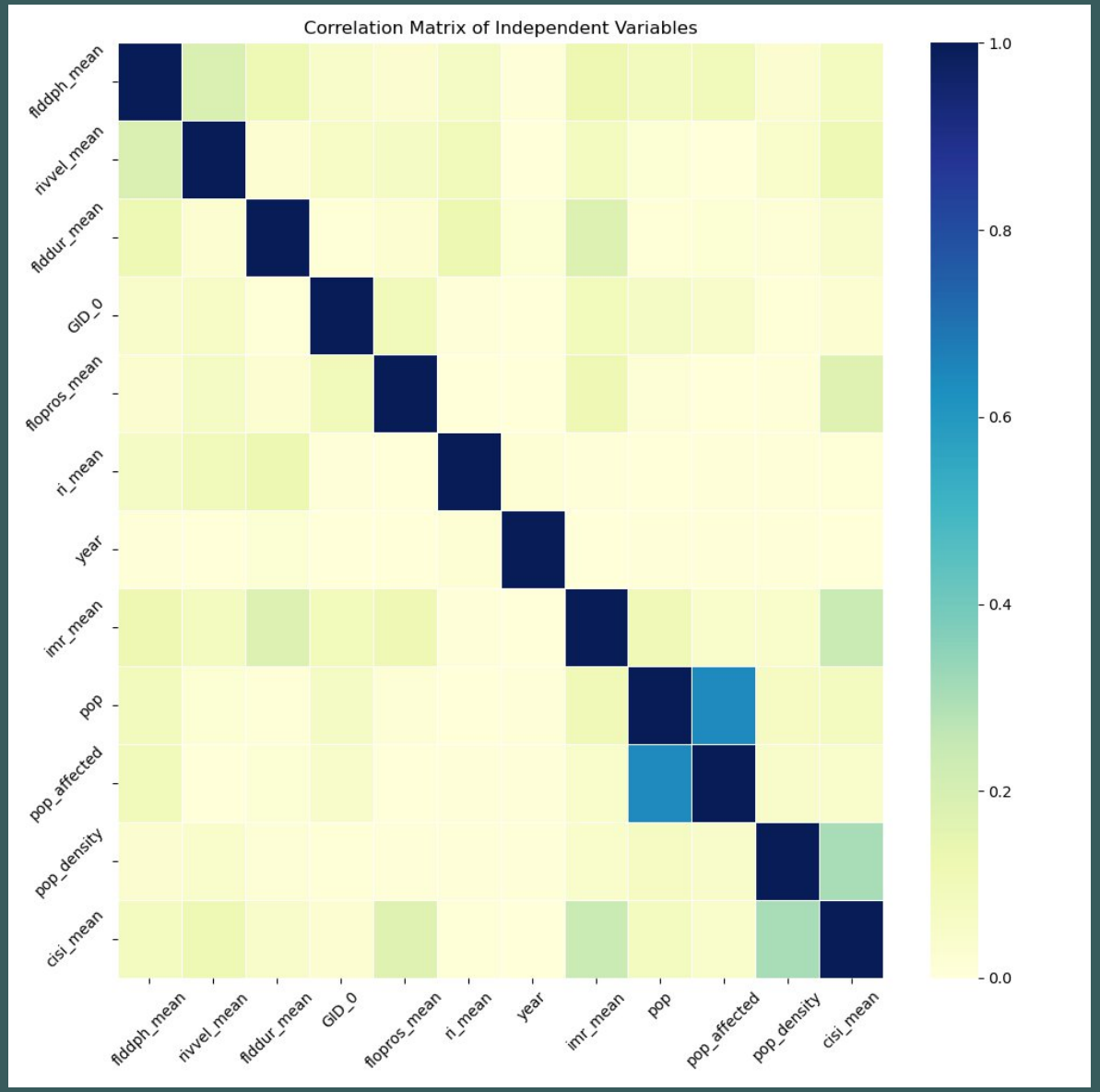
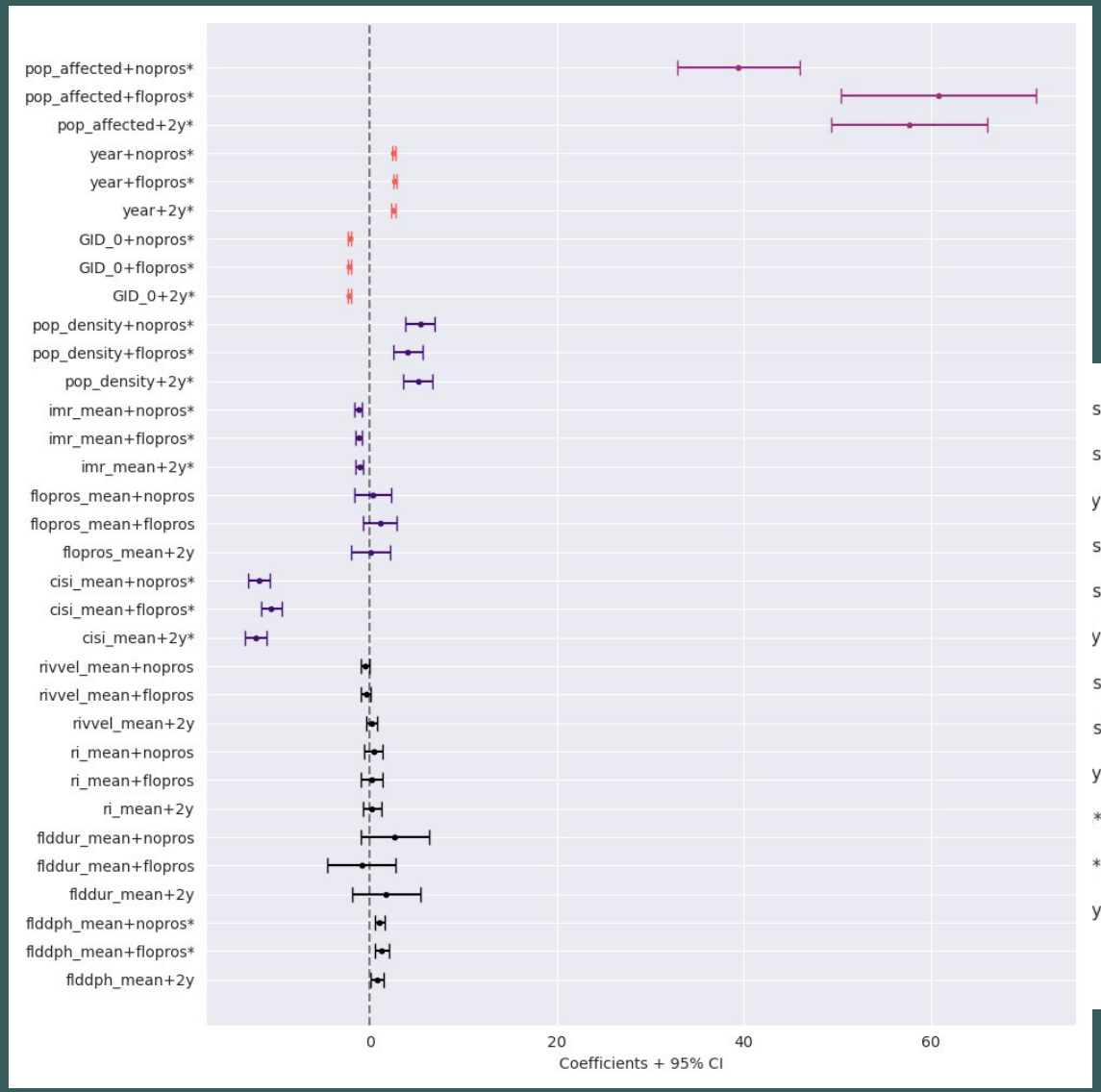
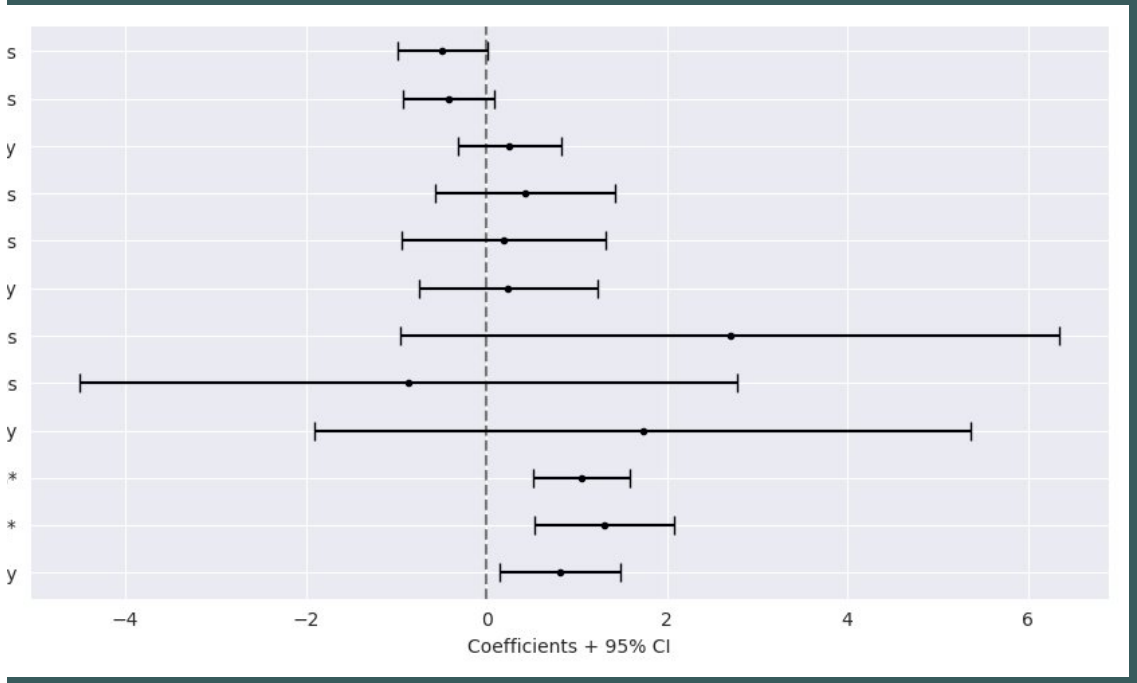


Correlation Matrix for Admin 2 and 2y Protection level (Logreg)

Level 1


pop_affected+nopros*
pop_affected+flopros*
pop_affected+2y*
year+nopros*
year+flopros*
year+2y*
GID_0+nopros*
GID_0+flopros*
GID_0+2y*
pop_density+nopros*
pop_density+flopros*
pop_density+2y*
imr_mean+nopros*
imr_mean+flopros*
imr_mean+2y*
flopros_mean+nopros
flopros_mean+flopros
flopros_mean+2y
cisi_mean+nopros*
cisi_mean+flopros*
cisi_mean+2y*
rivvel_mean+nopros
rivvel_mean+flopros
rivvel_mean+2y
ri_mean+nopros
ri_mean+flopros
ri_mean+2y
fldur_mean+nopros
fldur_mean+flopros
fldur_mean+2y
fldph_mean+nopros*
fldph_mean+flopros*
fldph_mean+2y
0
20
40
60
Coefficients + 95% CI


s
s
y
s
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s
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y
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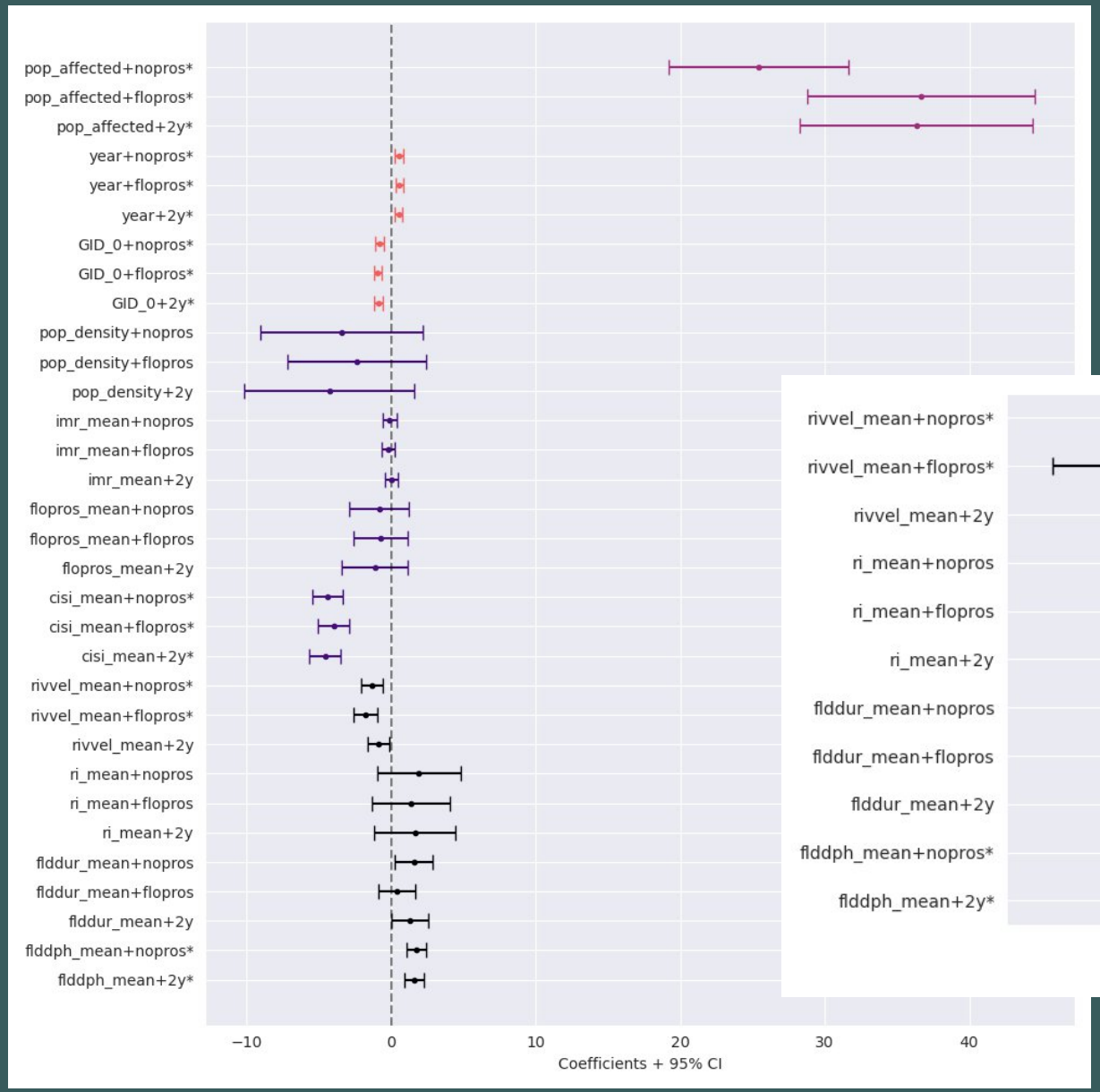
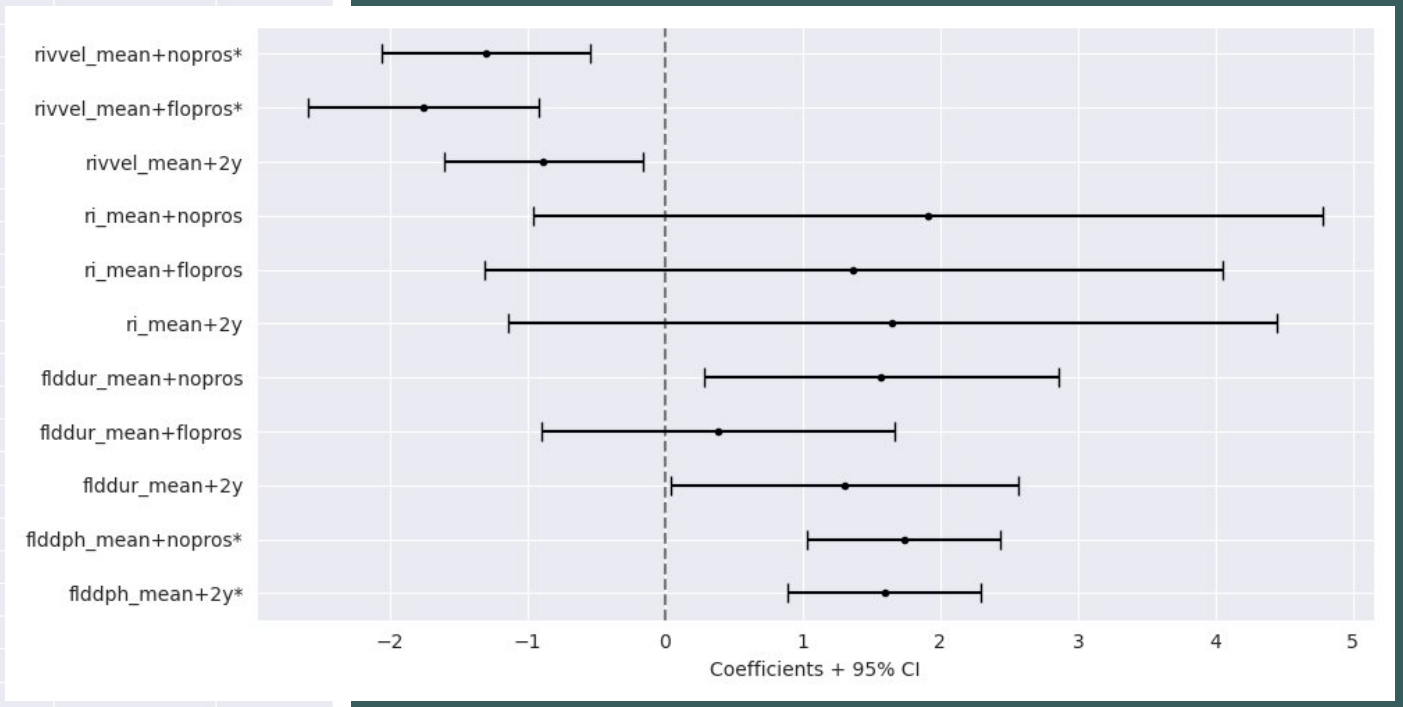
−2
0
2
4
6
Coefficients + 95% CI





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