Experimental sea-level rise at Ameland

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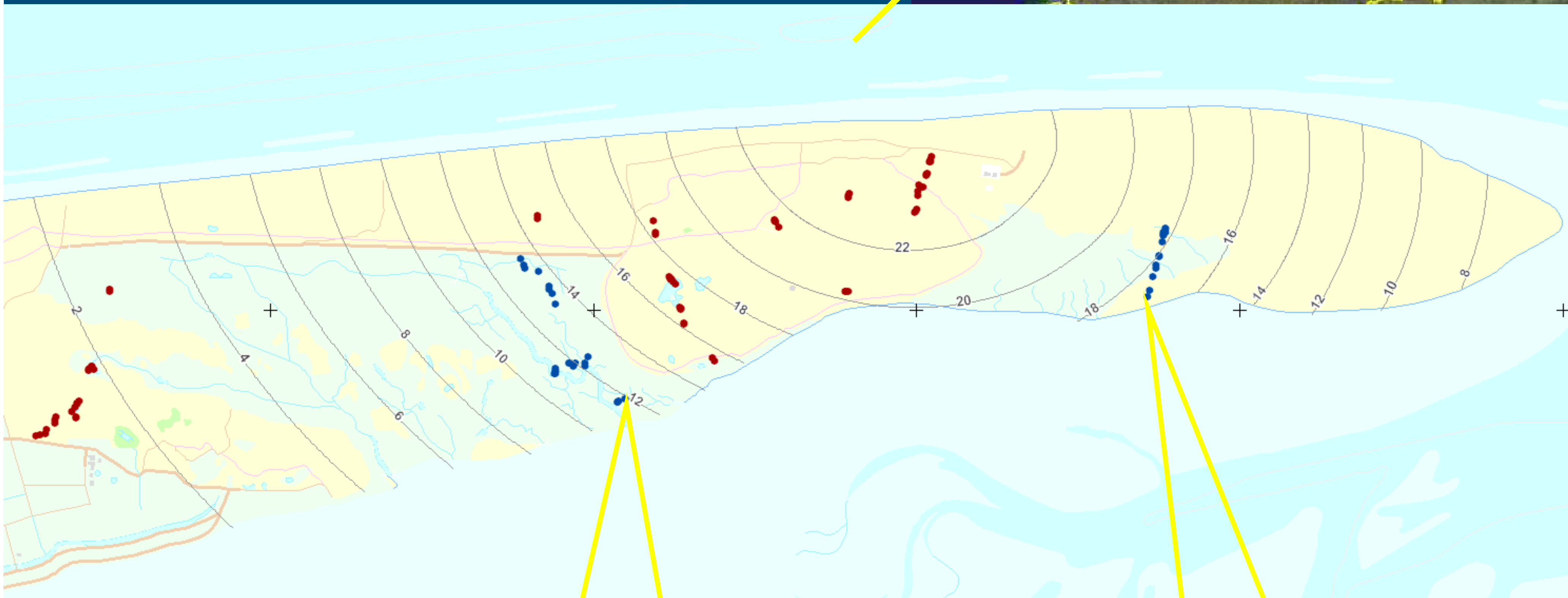
Background

- Extraction of natural gas since 1985
- Caused progressive soil subsidence
- Max. ~35 cm in 2008
- IPCC: ~44 cm sea-level rise in 2100
- Opportunity to study effects of predicted sea-level rise on natural shoreline and its vegetation

Method

- 33 permanent plots in 2 transects
- Observations at intervals of 3, 2 or 1 years since 1986:
  - vegetation composition
  - sedimentation, erosion
  - flooding frequency
  - precipitation
  - grazing intensity

Location of transects

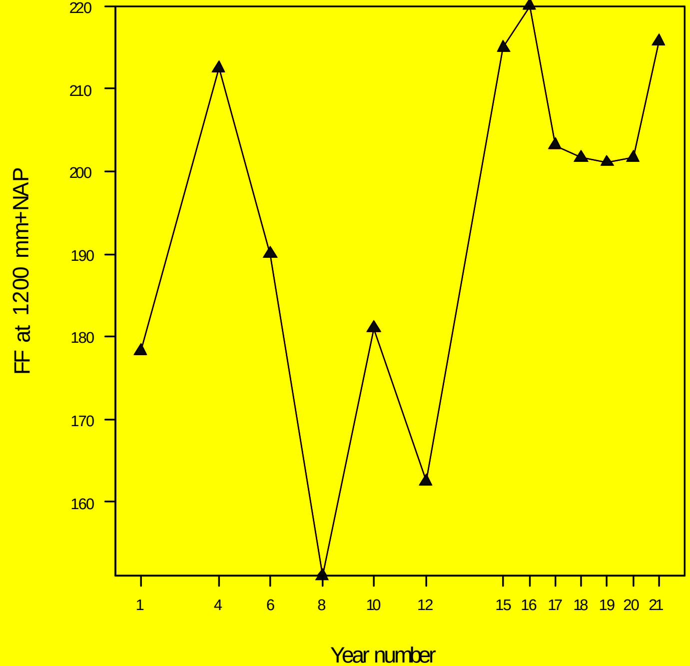


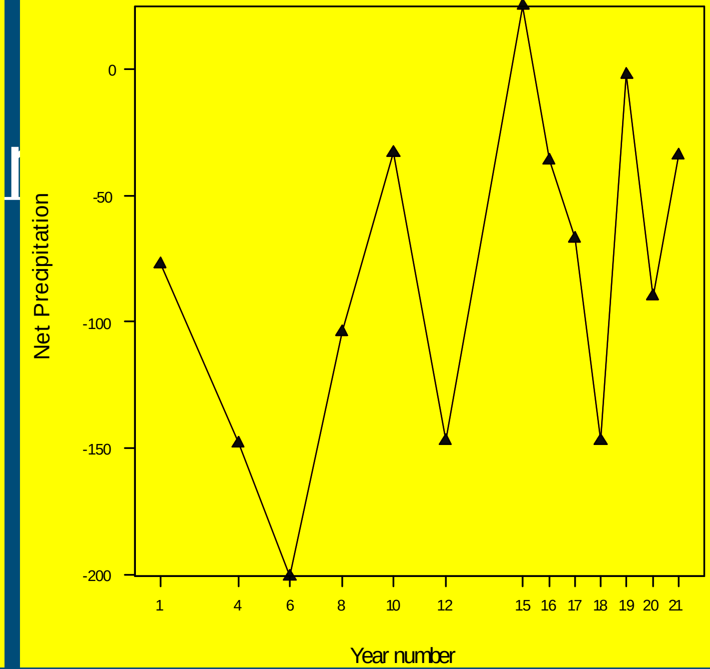
Focus of this presentation

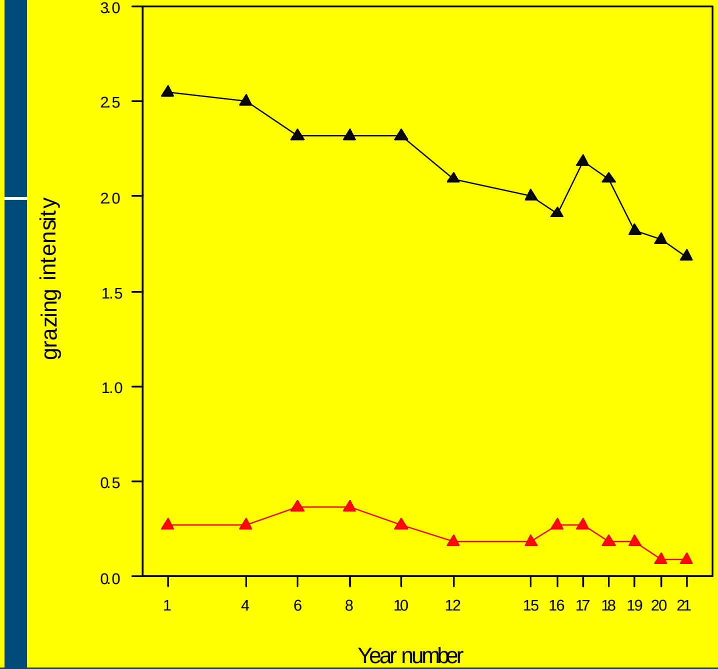
- Sedimentation and erosion
- Vegetation development
- No rigorous statistical analysis

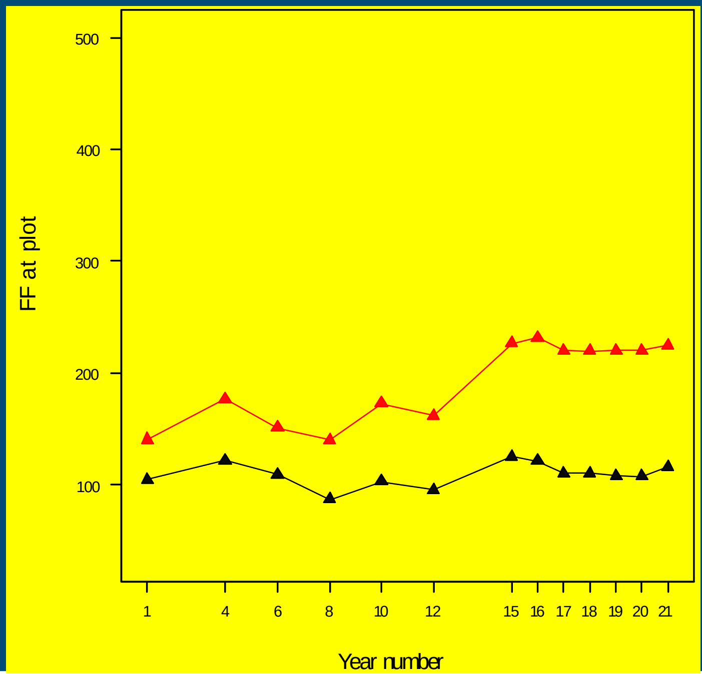
Most variables have strong temporal trend!

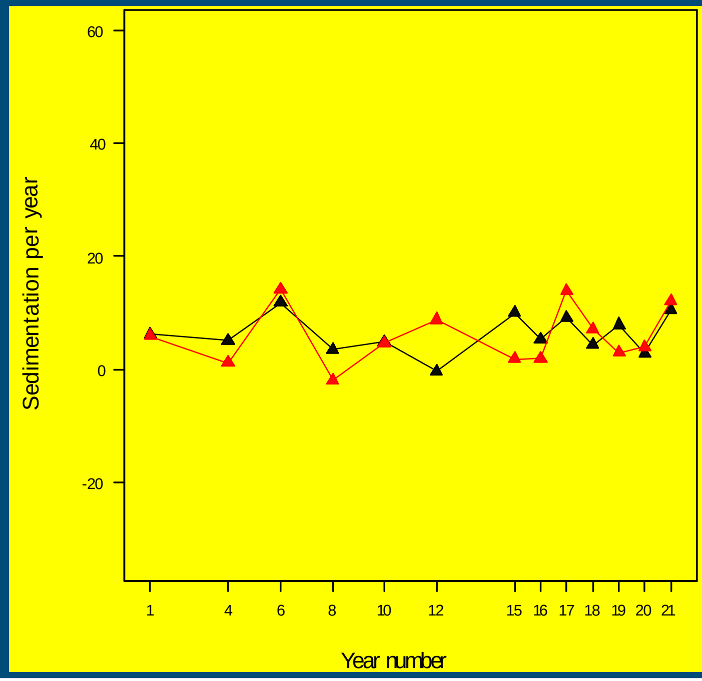
variable	R	sign
gross subsidence	-0.93	***
net subsidence	-0.33	***
cumulative sedimentation	0.55	***
flooding frequency at 1200 mm+NAP	0.48	***
flooding frequency at plot	0.12	**
sedimentation per year	0.05	ns
grazing intensity	-0.15	**
net precipitation	0.44	***
vegetation gradient 1	0.07	ns
vegetation gradient 2	0.329	***
vegetation gradient 3	0.54	***











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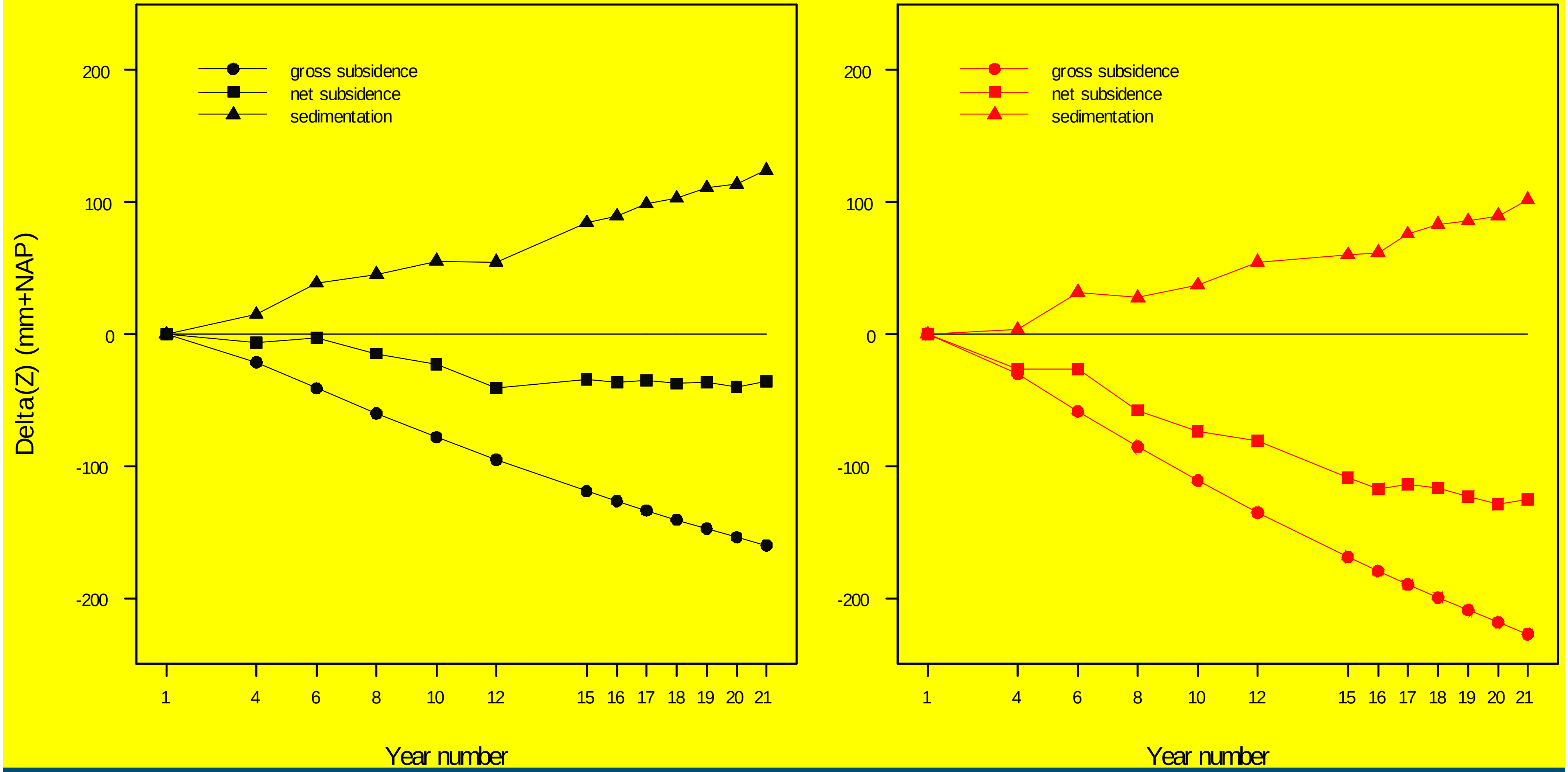
Subsidence is compensated by sedimentation



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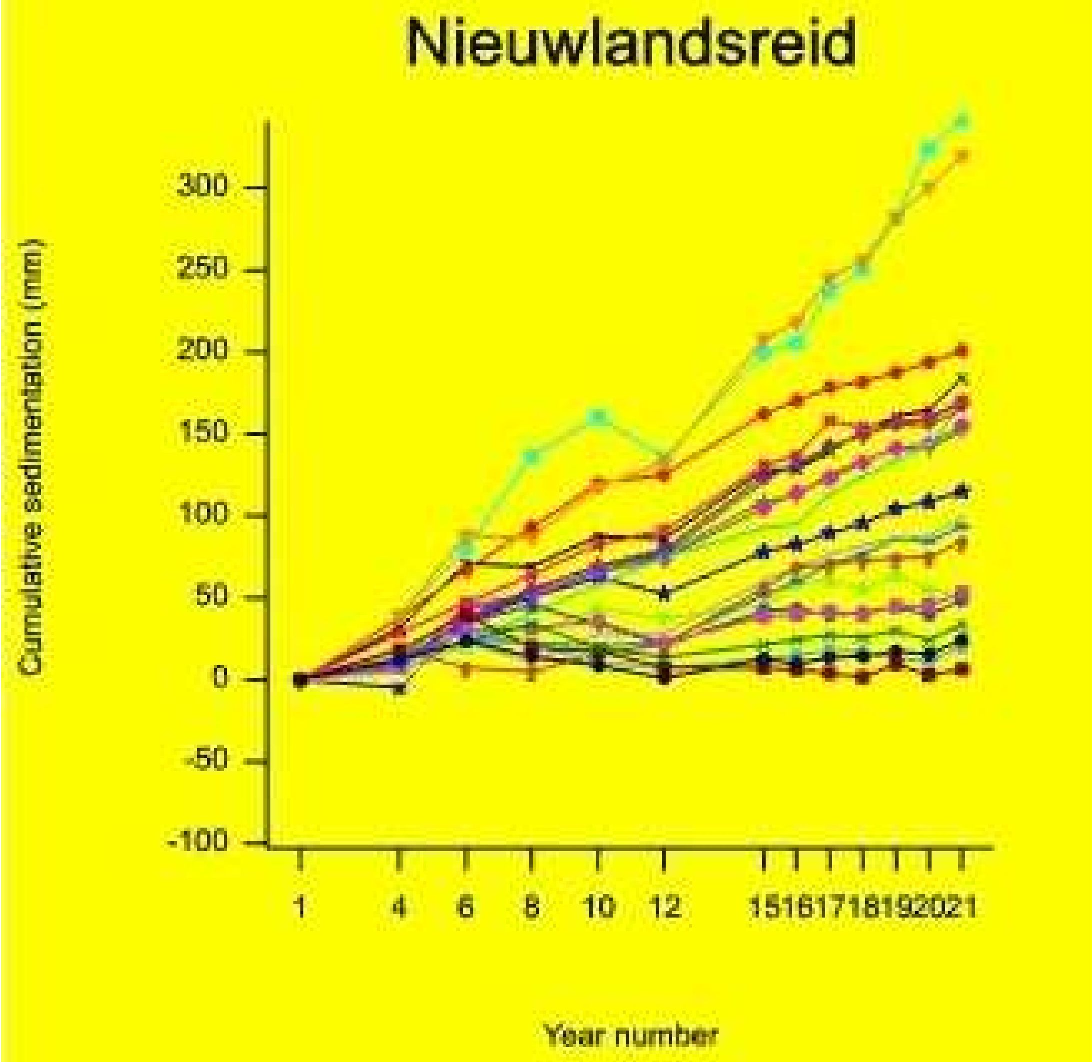
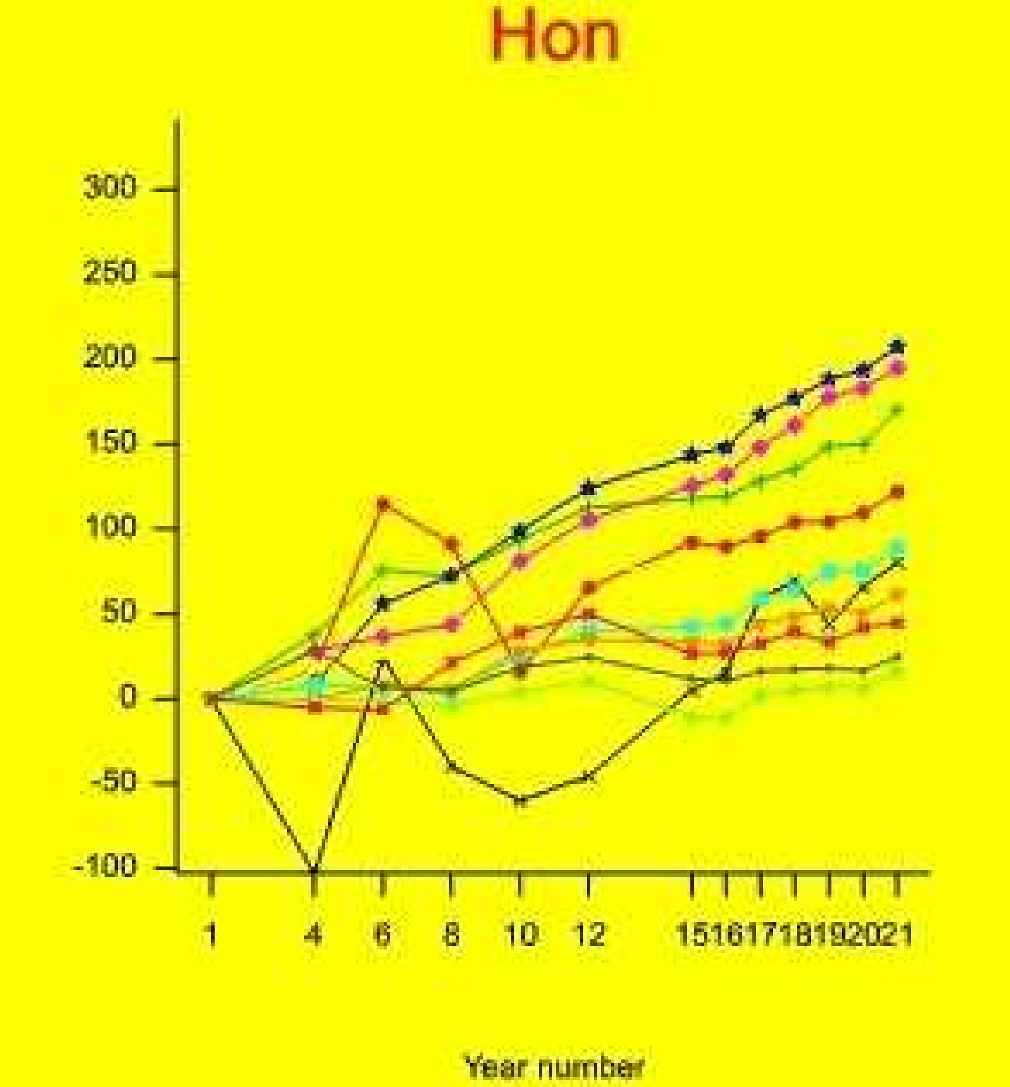
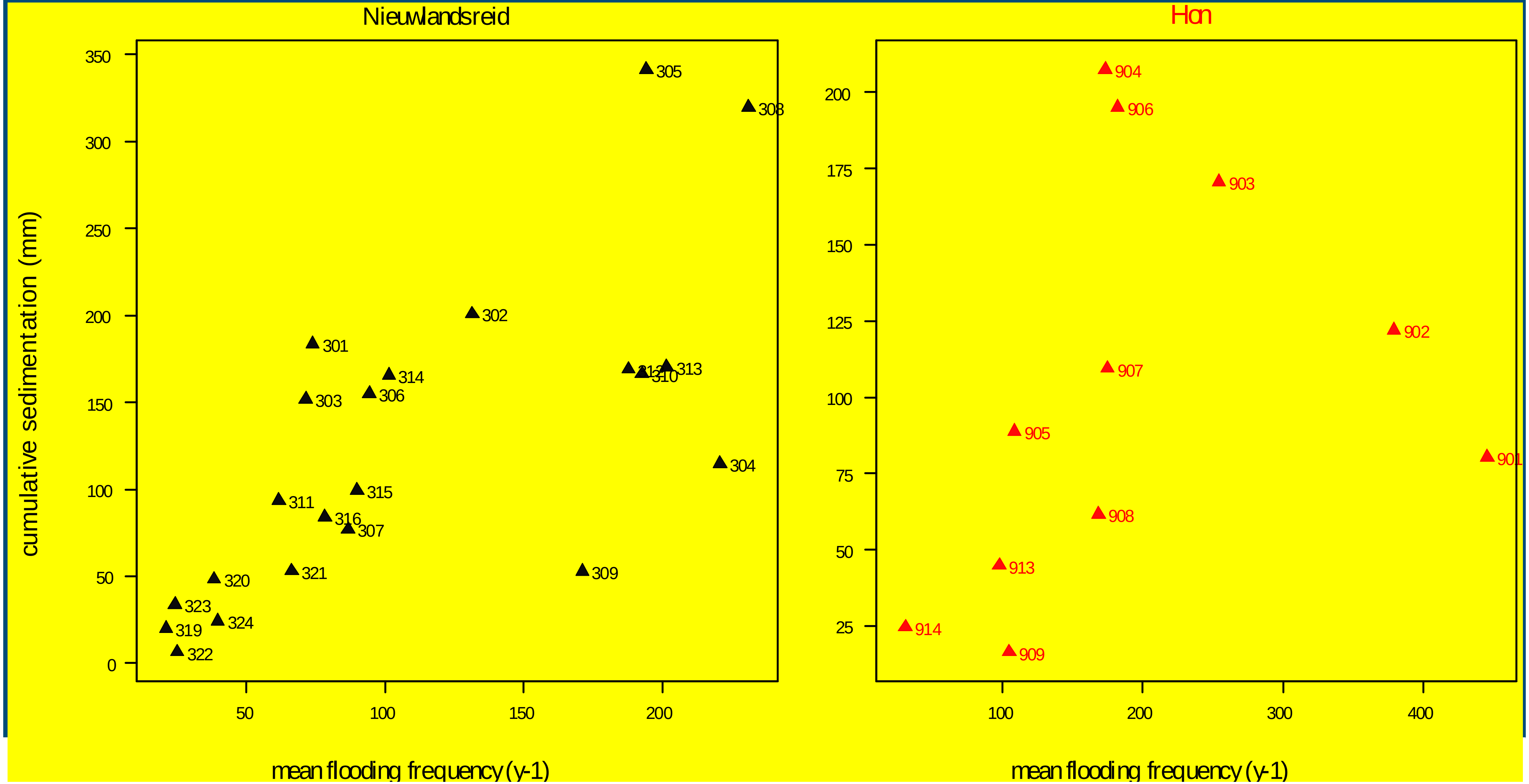
Although there are large differences per plot





There is a positive correlation between sedimentation and flooding frequency



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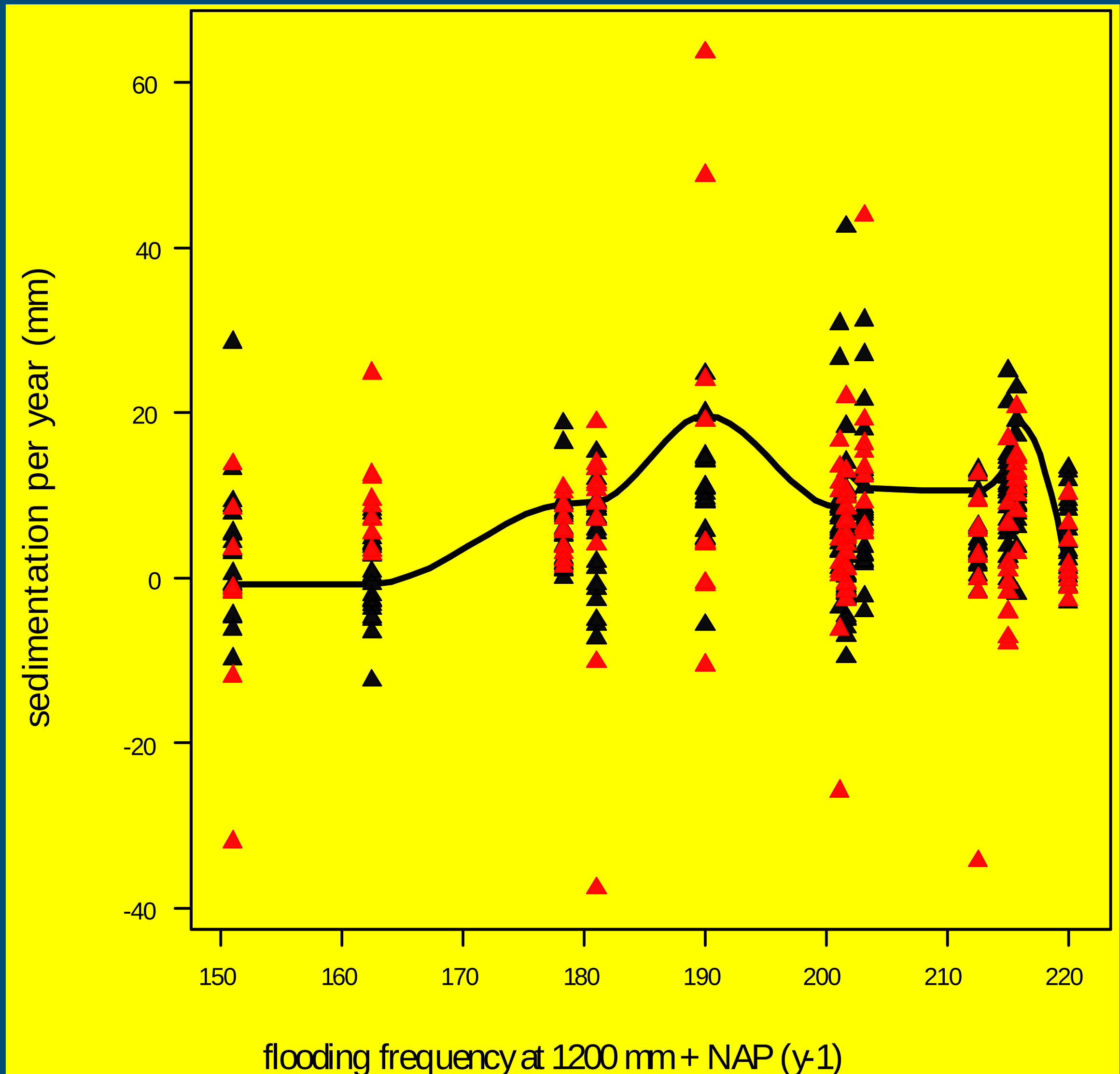
Which is also present in the temporal domain



And even significantly so

$$S = a_0 + a_1.Z + a_2.FF_{12} + a_3.FF_{12}^2$$

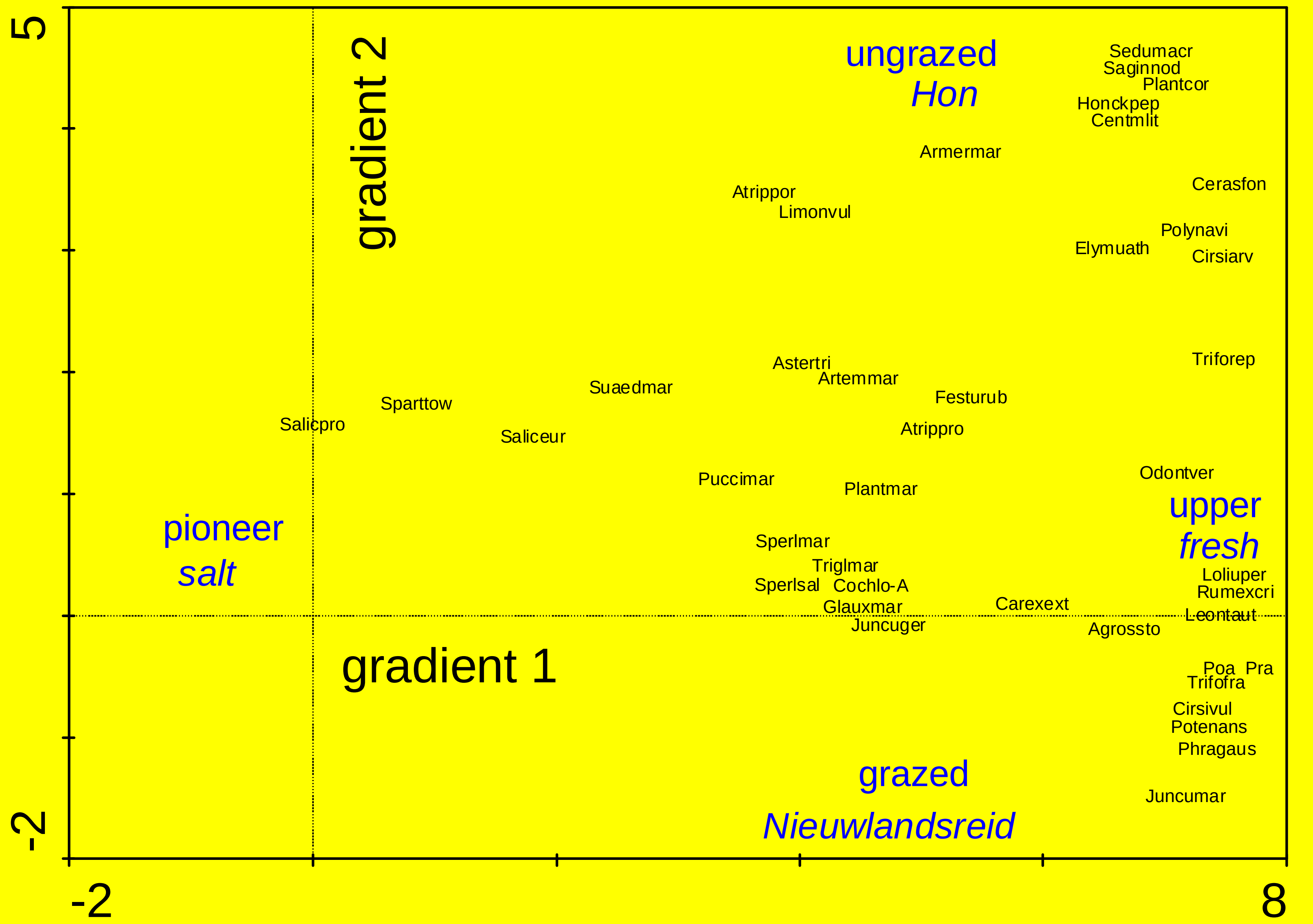
parameter	means:	t-value	significance
Z	elevation	-5.41	***
F_{12}	flooding freq	3.04	**
F_{12}^2	flooding freq^2	-2.89	**

- There seems to be an optimal flooding frequency for sedimentation!

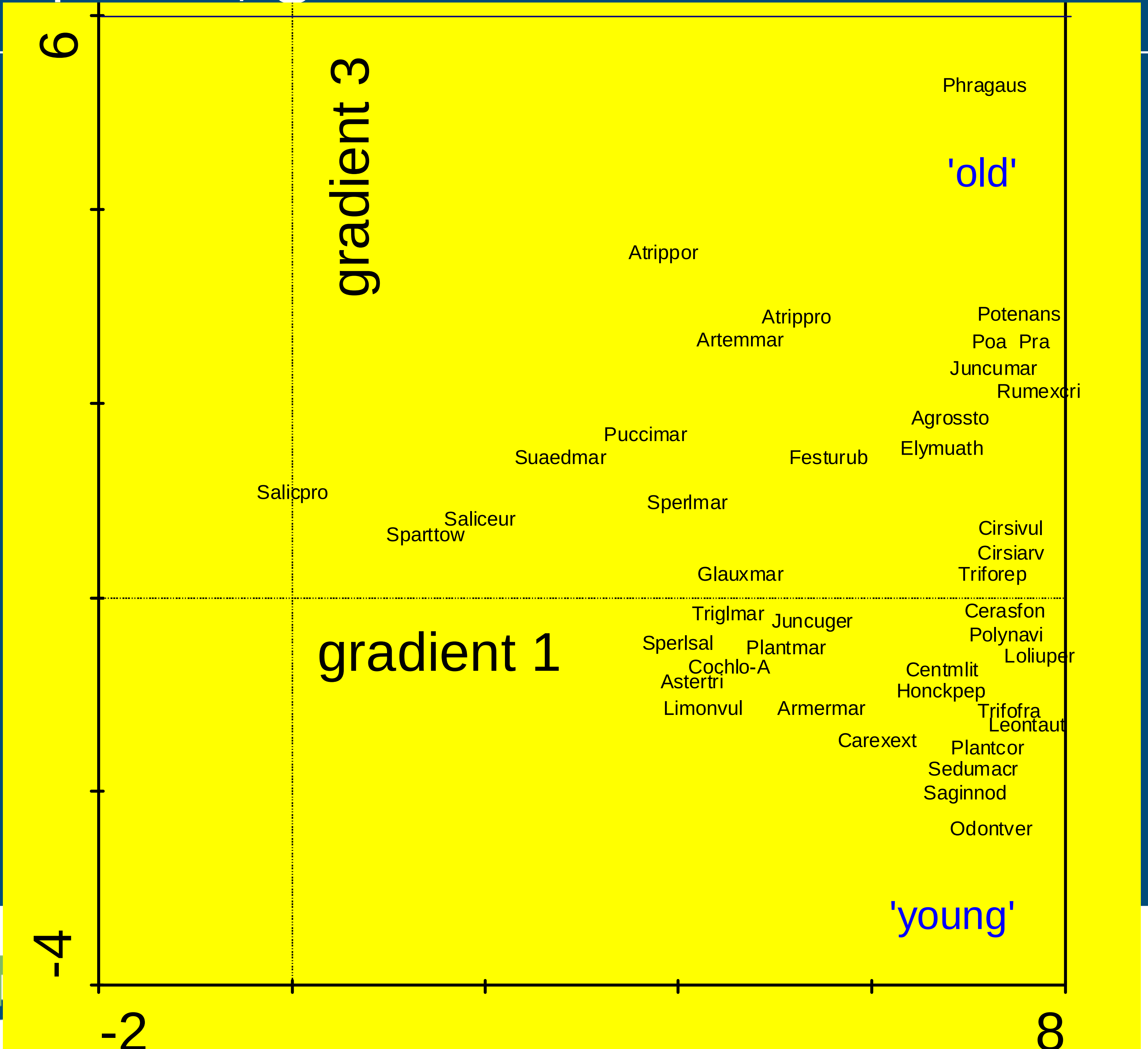
Vegetation

- There are 3 well-separated gradients, determined by:
  1. flooding frequency, i.e. 'zonation':
     pioneer, lower, mid, upper saltmarsh
  2. grazing intensity
  3. succession
- Gradient 1 is extremely stable over time; in the other two there have been considerable shifts

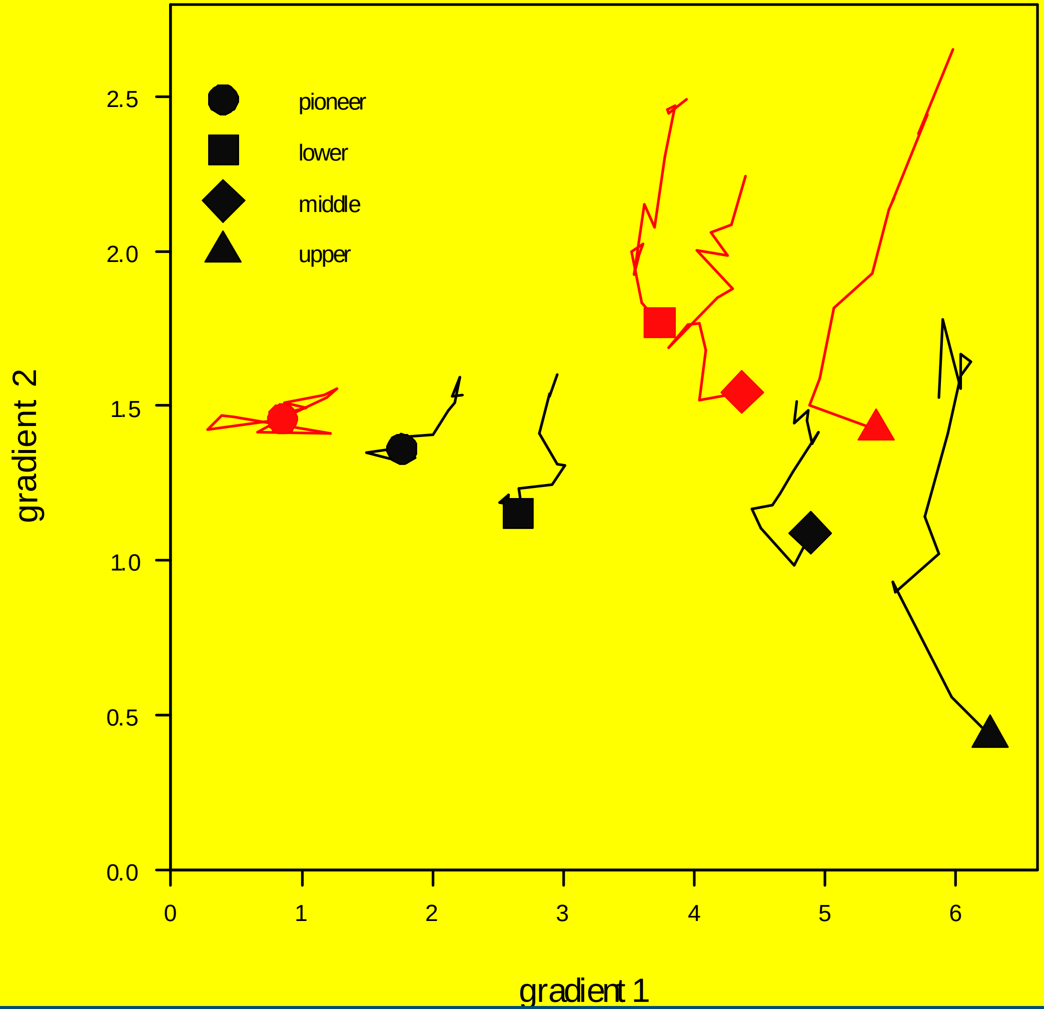
Species, gradient 1 and 2

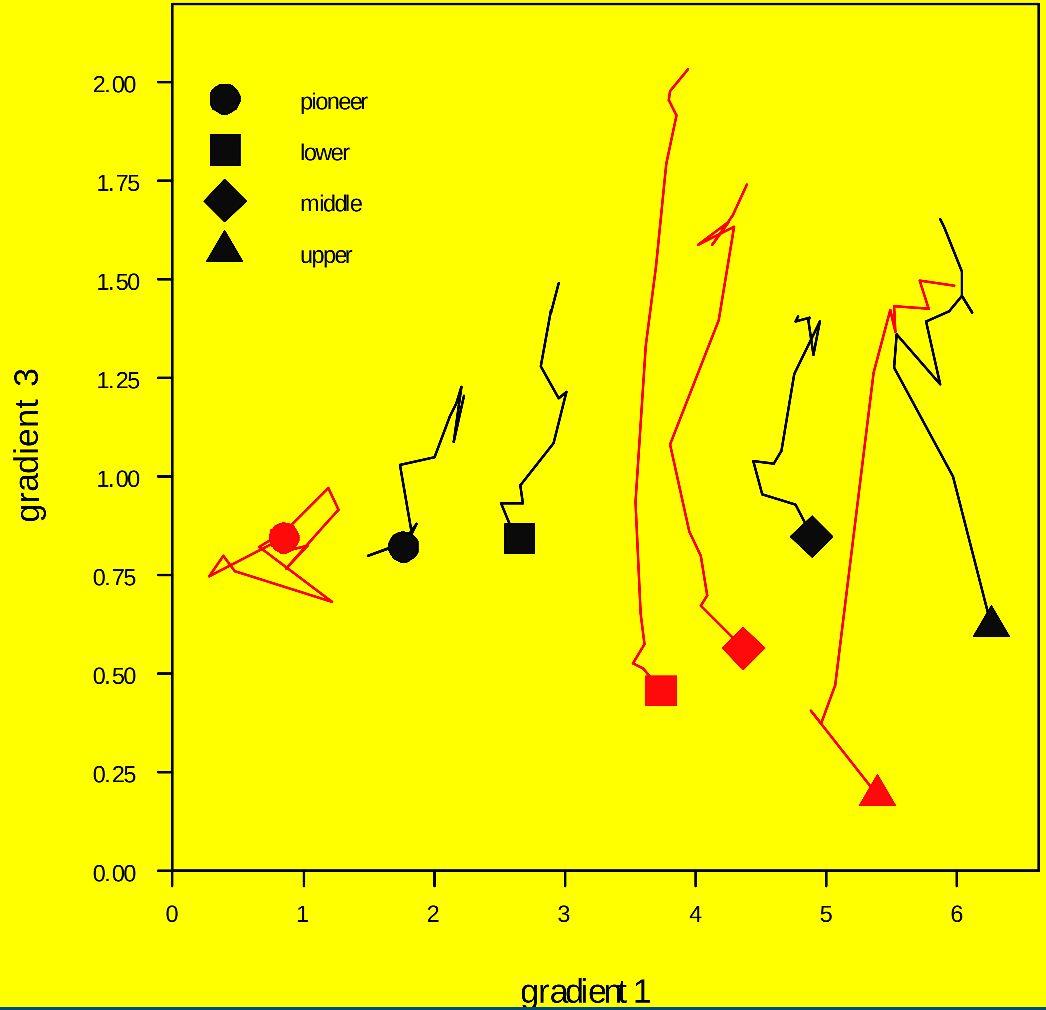


Species, gradient 1 and 3



And what happened over time





Conclusions: sedimentation

- Soil subsidence is largely compensated by sedimentation
  - Nieuwlandsreid: almost completely
  - Hon: ca 50%
- Sedimentation increases as flooding frequency increases
- Flooding-related vegetation gradient ('zonation') is extremely stable over time
  - this may partly explain the increase of sedimentation at higher flooding frequency

Conclusions: sea-level rise

- Total sedimentation over whole observation period:
  - Nieuwlandsreid 6.2 ± 9.0 $mm.y^{-1}$ (95% conf. interval)
  - Hon 5.1 ± 6.6 $mm.y^{-1}$ (95% conf. interval)
- Expected sea-level rise until 2100:
  - IPCC 4.4 ± 3.3 $mm.y^{-1}$ (range)
  - Veerman 8.8 ± 3.2 $mm.y^{-1}$ (range, excl. soil subsidence)
- Sedimentation rate is probably large enough to keep pace with sea-level rise according to IPCC, but not according to Veerman

Conclusions: vegetation

- The pioneer and lower zone hardly change over time
- In the other zones there are clear effects of decreasing grazing intensity and ongoing succession
- Conclusions on the causes of temporal changes remain somewhat speculative as all causal factors have strong temporal trends:
  - net precipitation ↑
  - flooding frequency ↑
  - thickness of sediment layer ↑
  - grazing intensity ↓

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Discussion!

www.opgewarmdnederland.nl

www.waddenzee.nl/Home.2181.0.html