



Modelling compound flooding at the Breede Estuary, South Africa

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Compound flooding can occur through:

1. two or more extreme events occurring simultaneously or successively
2. Amplified impacts due to co-occurrence
3. Co-occurring events, which are not themselves extreme, becoming an extreme event when combined



❖ **Global dependency studies:** intense storms can lead to storm surge, high waves and river discharge occurring simultaneously

→ low-lying coastal areas, connected to a river, **estuaries**, are prone to compound flooding

Study Area



❖ Breede Estuary

- ❖ Largest permanently opened estuary of South Africa
- ❖ Prone to flooding from river discharge and oceanic drivers
- ❖ There is a dependency of extreme river discharge and waves
- ❖ Data availability

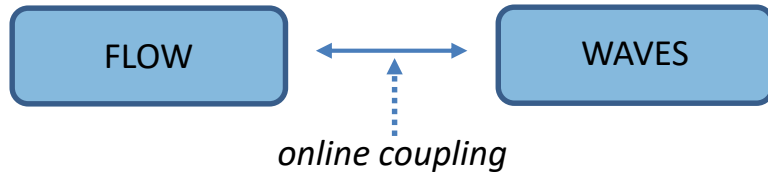


- ❖ Estimate potential impacts of **compound flooding**
 - ❖ **Tides**
 - ❖ **Waves**
 - ❖ **River discharge**
 - ❖ **Surge**
- ❖ Estimate **influence and interaction** of individual drivers
- ❖ Estimate the sensitivity of flood impacts to **changes in intensity** of input drivers

Hydrodynamic model set-up



Delft3D



❖ Interaction of waves with FLOW input



Boundary conditions	Delft3D Module	Open boundary	Intensity/return period	Data type	Peak values
River discharge	FLOW	Upstream	100yr	Time series	3295 m ³ /s
Tides	FLOW	Ocean	Spring high tide	Time series	2.6 m
Waves1	WAVE	Ocean	100yr (ESE-EVA*)	Constant sea state	H _s = 6.2 m; T _p = 12 s
Waves2	WAVE	Ocean	100yr (EVA-all-directions*)	Constant sea state	H _s = 9.3 m; T _p = 19.95 s

* Vonkemann et al. (2017)

- ❖ Calibration: parameter testing of bottom roughness and horizontal viscosity
- ❖ Validation: reproduction of spring tide, neap tide and average tide event & high river discharge



Scenario	River Discharge	Tides	Waves
Compound	100yr	Spring	100yr (ESE-EVA)
NoWAVE	100yr	Spring	-
NoDischarge	-	Spring	100yr (ESE-EVA)
Extr. Wave Compound	100yr	Spring	100yr (All-directions-EVA)

Results & Discussion



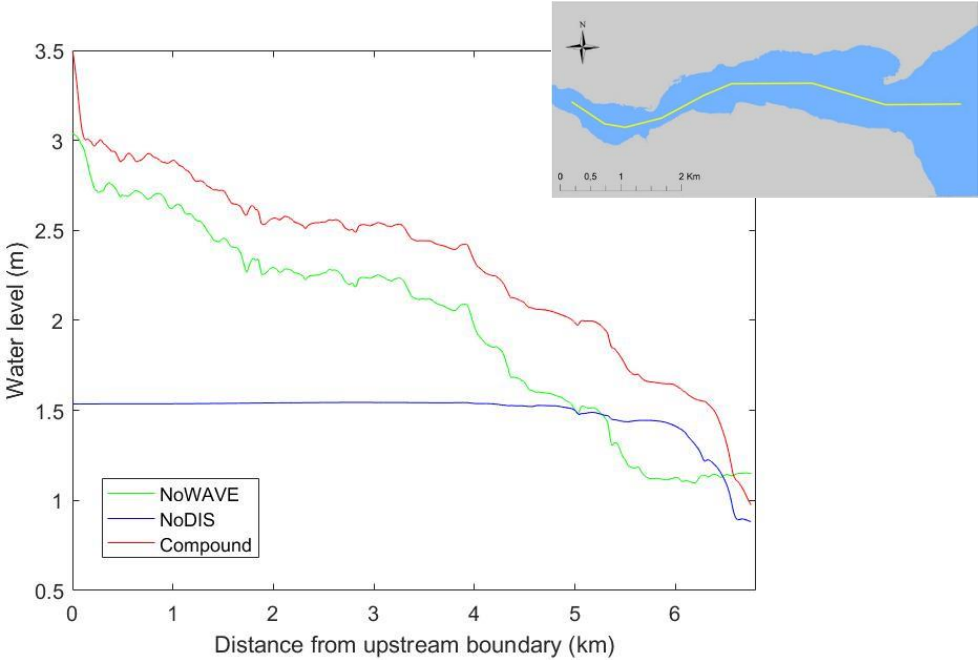
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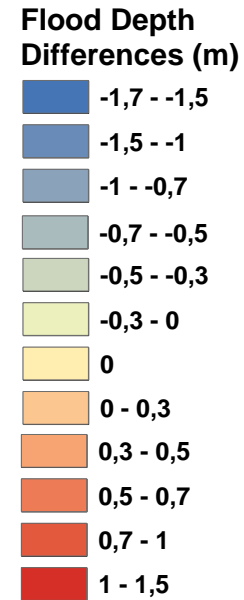
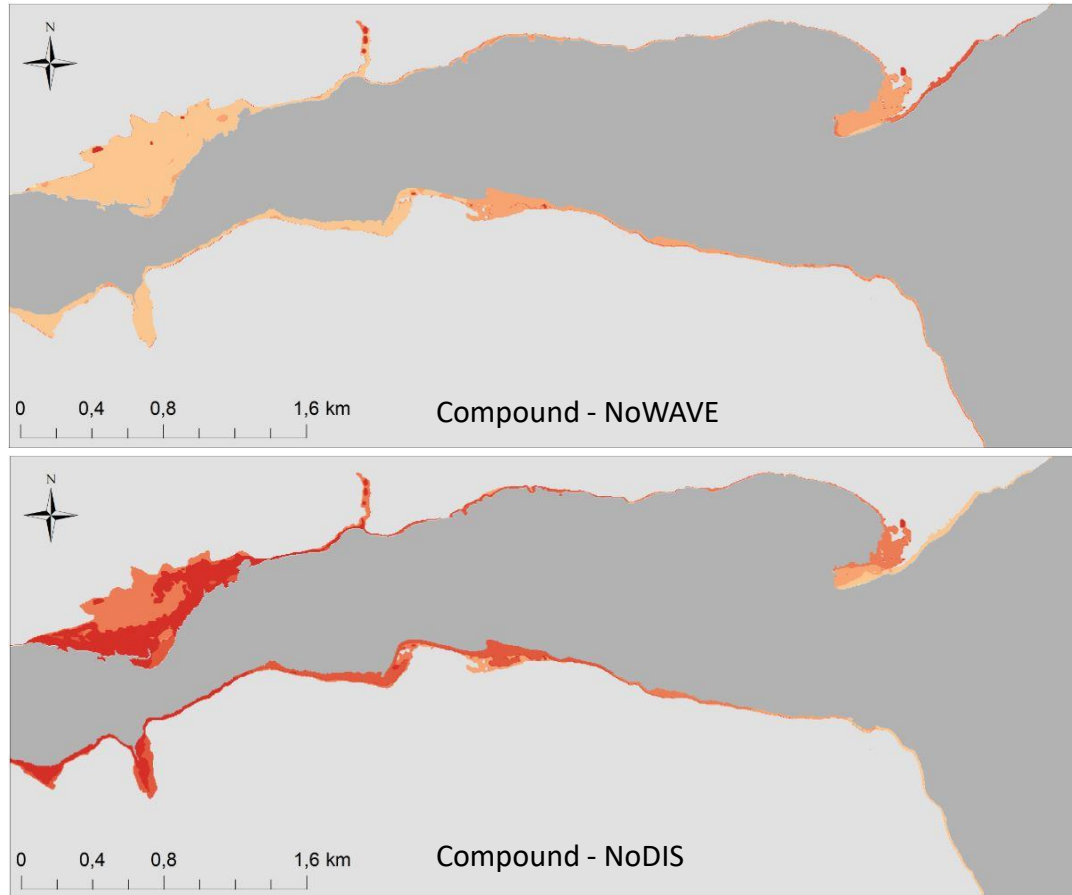
Compound vs. NoWAVE vs. NoDIS



Scenario	River Discharge	Tides	Waves
Compound	100yr	Spring	100yr (ESE-EVA)
NoWAVE	100yr	Spring	-
NoDischarge	-	Spring	100yr (ESE-EVA)
Extr. Wave Compound	100yr	Spring	100yr (All-directions-EVA)



Compound vs. NoWAVE vs. NoDIS: Differences in flood depth

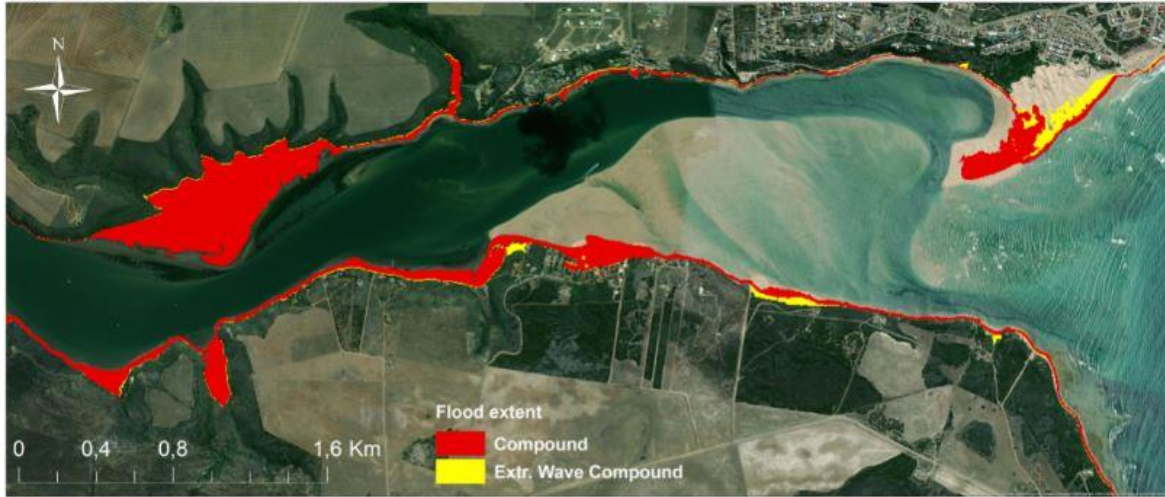


- Without waves, river discharge causes stronger effects → dominating flood driver
- Accounting for waves leads to blocking of river discharge

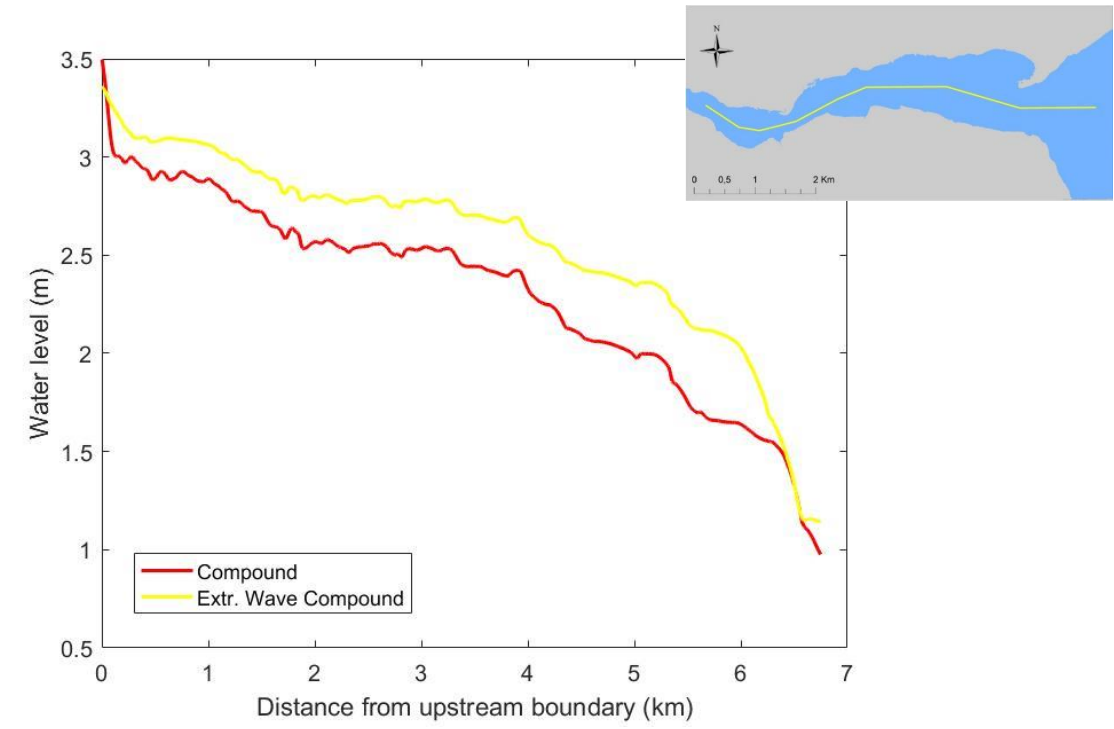
Results & Discussion



Compound vs. Extr. Wave Compound



Scenario	River Discharge	Tides	Waves
NoWAVE	100yr-long	Spring	-
NoDischarge	Constant-low	Spring	100yr (ESE-EVA)
Compound	100yr-long	Spring	100yr (ESE-EVA)
Extr. Wave Compound	100yr-long	Spring	100yr (All-directions-EVA)



- ❖ Larger impacts during compound flood scenarios vs. scenarios excluding drivers
 - Underestimation of flood impacts, when not considered
- ❖ Further simulations to explore:
 - ❖ SLR and changes in wave climate
 - ❖ Sensitivity of compound flooding to additional storm surge (despite low effect in SA)
 - ❖ Events, where one or more drivers are moderate → challenge due to data availability
- ❖ Assessing compound flood impacts at other South African estuaries remains a challenge due to sparse availability of data

References

