Optimization of a coastal circulation model by 4DVAR estimation of uncertain parameters using HF radar, tide gauge and ADCP observations

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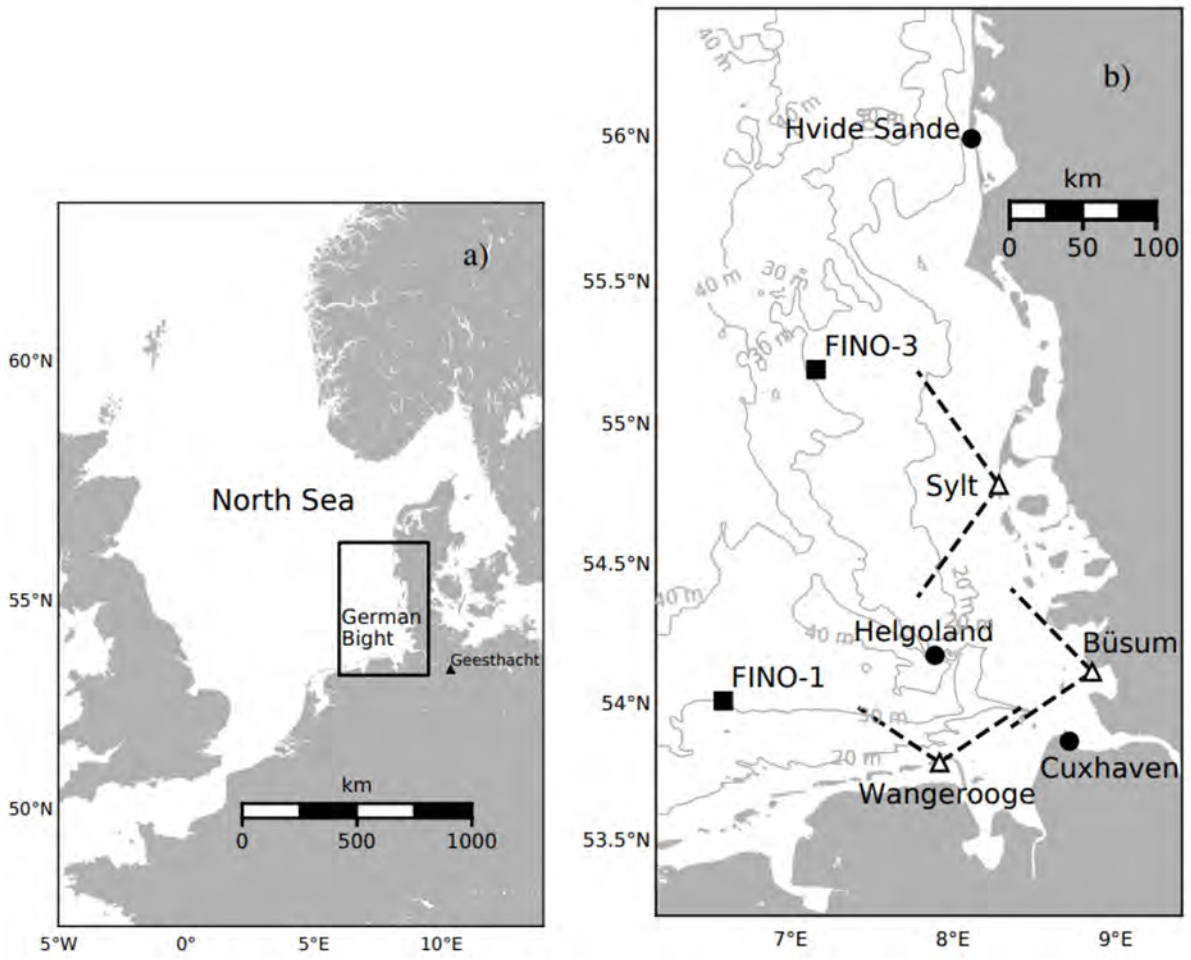
What

- Optimise uncertain parameters in a 3D circulation model of the German Bight using a combination of current and water level measurements

How

- Use a 4DVAR approach based on an adjoint model in combination with HF-radar, ADCP and tide gauge measurements
- Use operational BSH model as a reference

Used Measurements in German Bight



- **Three HF-radar WERA stations**
- **Two ADCPs**
- **Three tide gauges**
- **Tuning for May 2015**
- **Testing for June 2015**

3D IMCO circulation model

- **Primitive equation barotropic 3D circulation model**
- **Adjoint code was implemented**
- **Setup for German Bight mimics operational setup used at BSH, i.e.**
    - **1km resolution bathymetry**
    - **same meteo forcing**
    - **same open boundary forcing**

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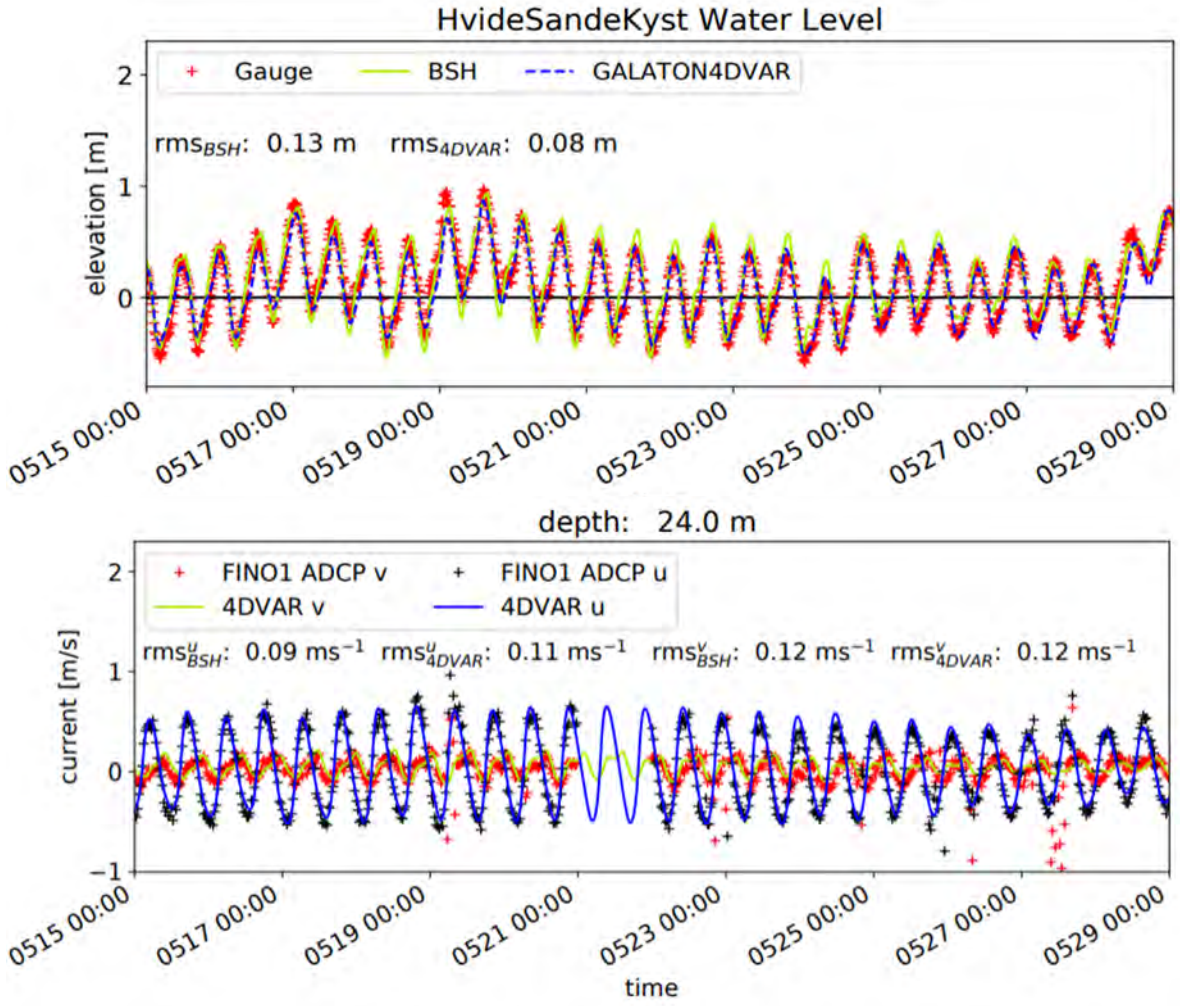
Which uncertain parameters are optimised?

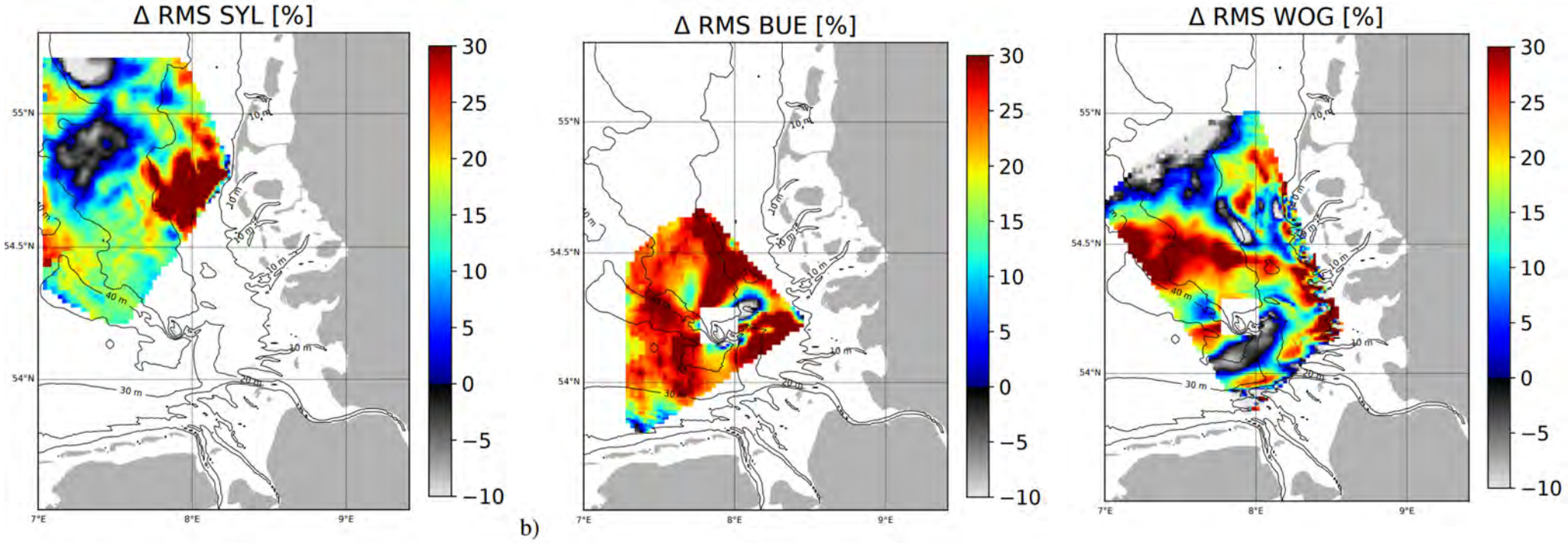
1. Bottom roughness length scale z_0
2. Background momentum diffusion parameter
3. The water depth H
4. The turbulence length scale parameter
5. The horizontal diffusion coefficient
6. The wind drag coefficient
7. Amplitude and phase corrections of the open boundary forcing both with regard to the tidal and surge component

Comparisons with Tide gauge and ADCP data



Tide gauge	RMS Tuning [m]		RMS Testing [m]	
	BSH	4DVAR	BSH	4DVAR
Hvide	0.13	0.08	0.16	0.10
Helgoland	0.17	0.11	0.19	0.14
Cuxhaven	0.24	0.11	0.25	0.11

Comparisons with HF radar surface currents



b)

HFR station	RMS Tuning [m/s]		RMS Testing [m/s]	
	BSH	4DVAR	BSH	4DVAR
Sylt	0.082	0.071	0.077	0.065
Büsum	0.128	0.097	0.125	0.108
Wangerooge	0.103	0.091	0.100	0.087

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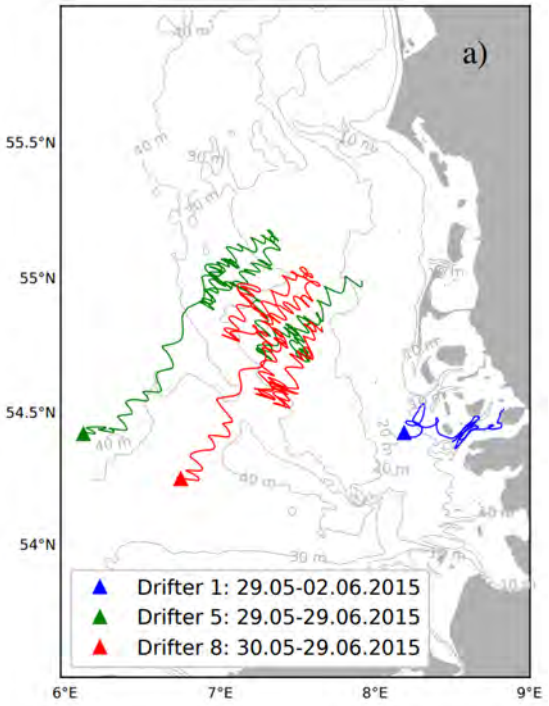
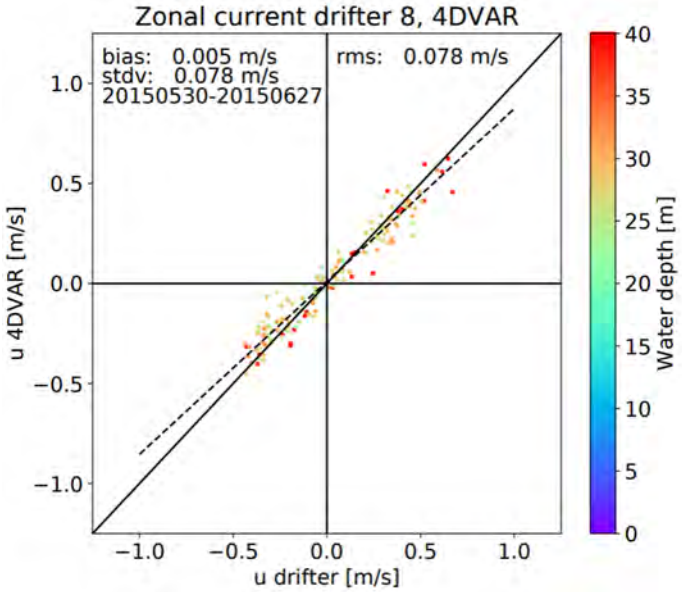
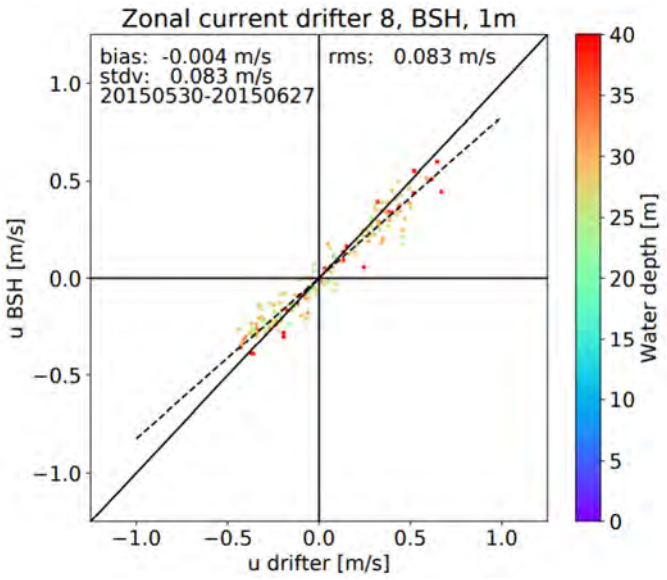
Comparison with drifter data in June 2015

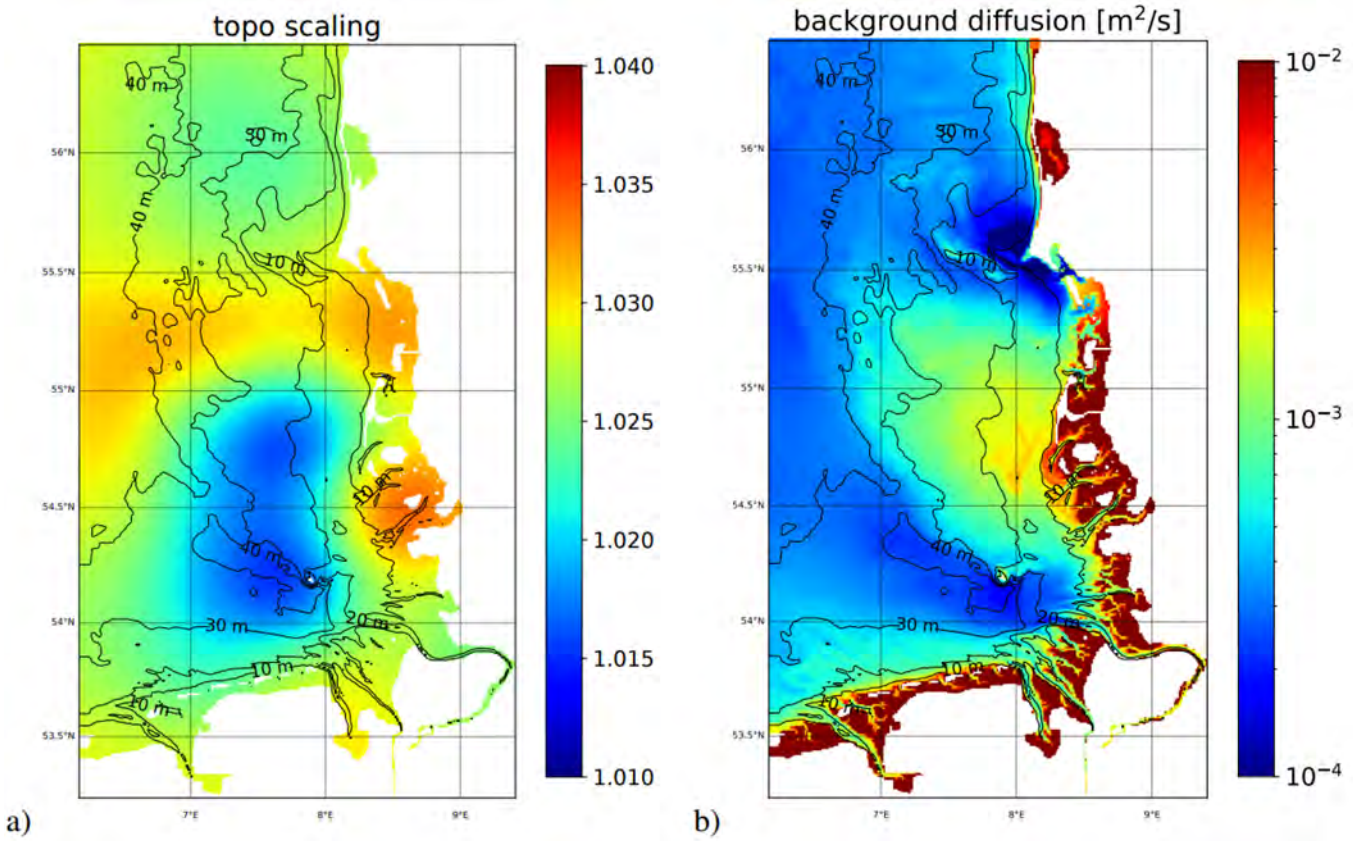






Drifter	BSH rms u/v [m/s]	4DVAR_VAR u/v rms [m/s]	4DVAR_CON u/v rms [m/s]
1	0.155/0.167	0.213/0.196	0.299/0.202
5	0.070/0.088	0.084/0.106	0.096/0.122
6	0.084/0.101	0.089/0.103	0.090/0.105
7	0.188/0.128	0.166/0.151	0.167/0.171
8	0.083/0.100	0.078/0.093	0.081/0.095
9	0.160/0.213	0.166/0.146	0.161/0.140

Optimised model parameters



κ_b	κ_s	ν_h [m^2/s]	z_0^x/z_0^y [m]	β_{BG} [m^3/s]	λ_{met}	λ_H	H_{z0} [m]	L_3
0.473	0.0279	1.5	0.00048/0.00043	0.06	0.9 10^{-6}	1.03	4.5	2.4

Summary/Conclusion

- 4DVAR approach was successfull in optimising model parameters in a 3D circulation model of the German Bight
- The agreement with most observations was improved at least for a 1 month test period compared to operational BSH model
- Combination of HF radar, ADCP and tide gauge data can be recommended to get consistent picture of 3D circulation
- Still some work to do to include baroclinic part into 4DVAR