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Improved vertical mixing in the Oslofjord model

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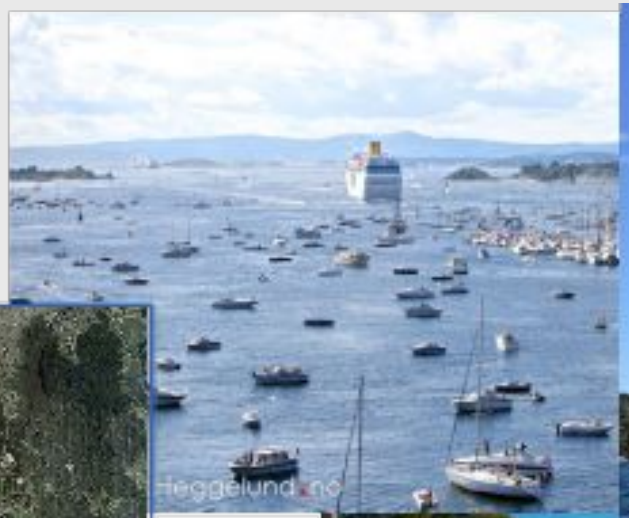
JONSMOD 2018

Background



Presented at JONSMOD 2016

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The FjordOs model

- Based on ROMS 3.7 (rev. 820, September 2016)

- Variable horizontal resolution (50 - 300 m)
- 42 terrain following vertical S-layers

- 4th order centered horizontal advection for tracers
- 3rd order upwind horizontal advection for momentum
- 4th order centered vertical advection for tracers and momentum
- "Smagorinsky-like" diffusion and viscosity
- GLS vertical mixing

- Model is being run once daily at MET Norway (+66h forecast)

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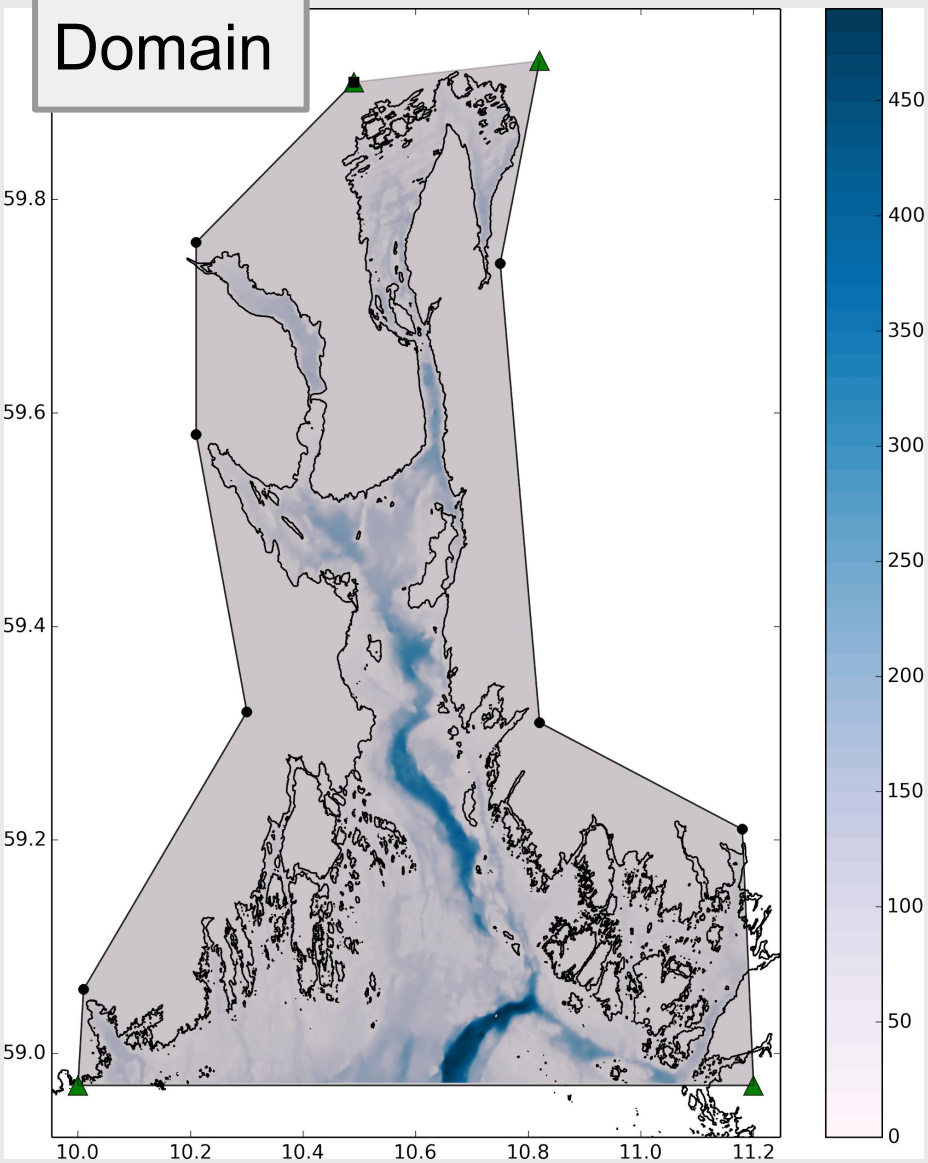
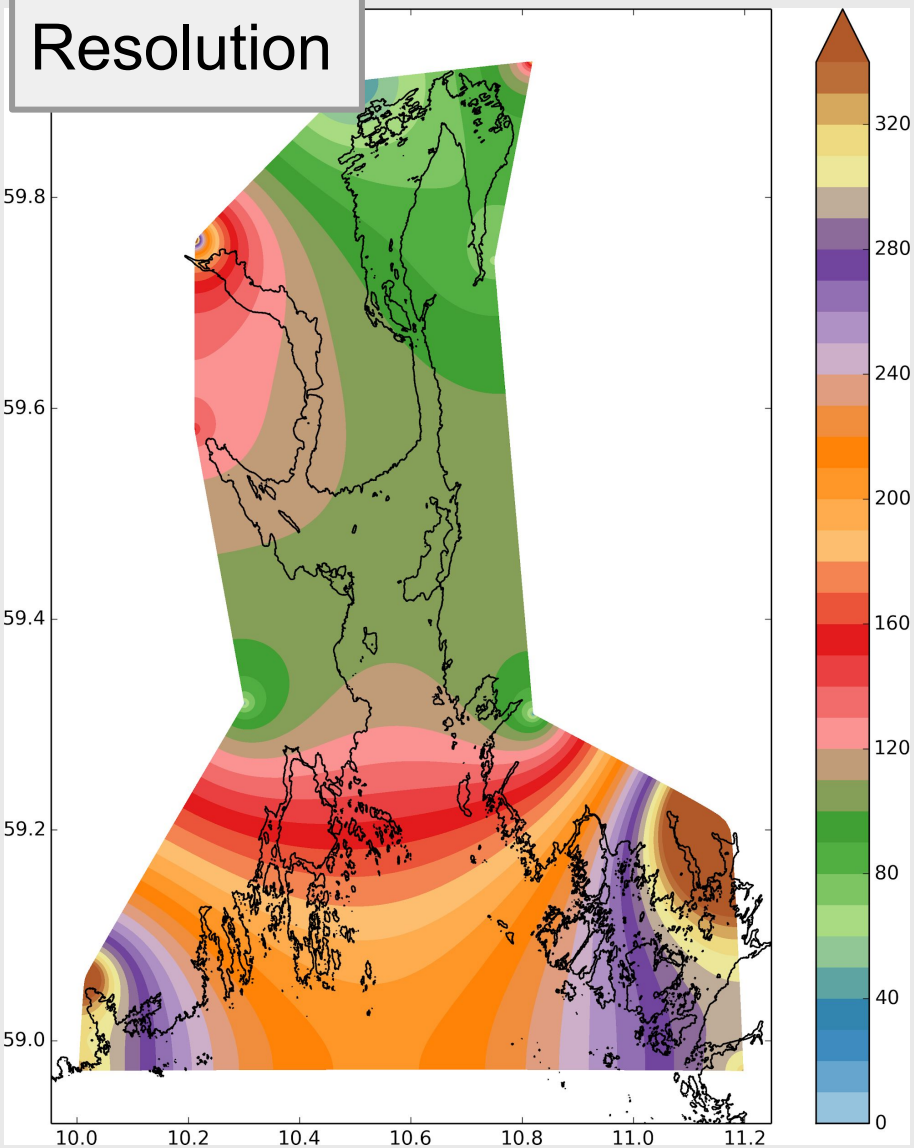
The FjordOs model

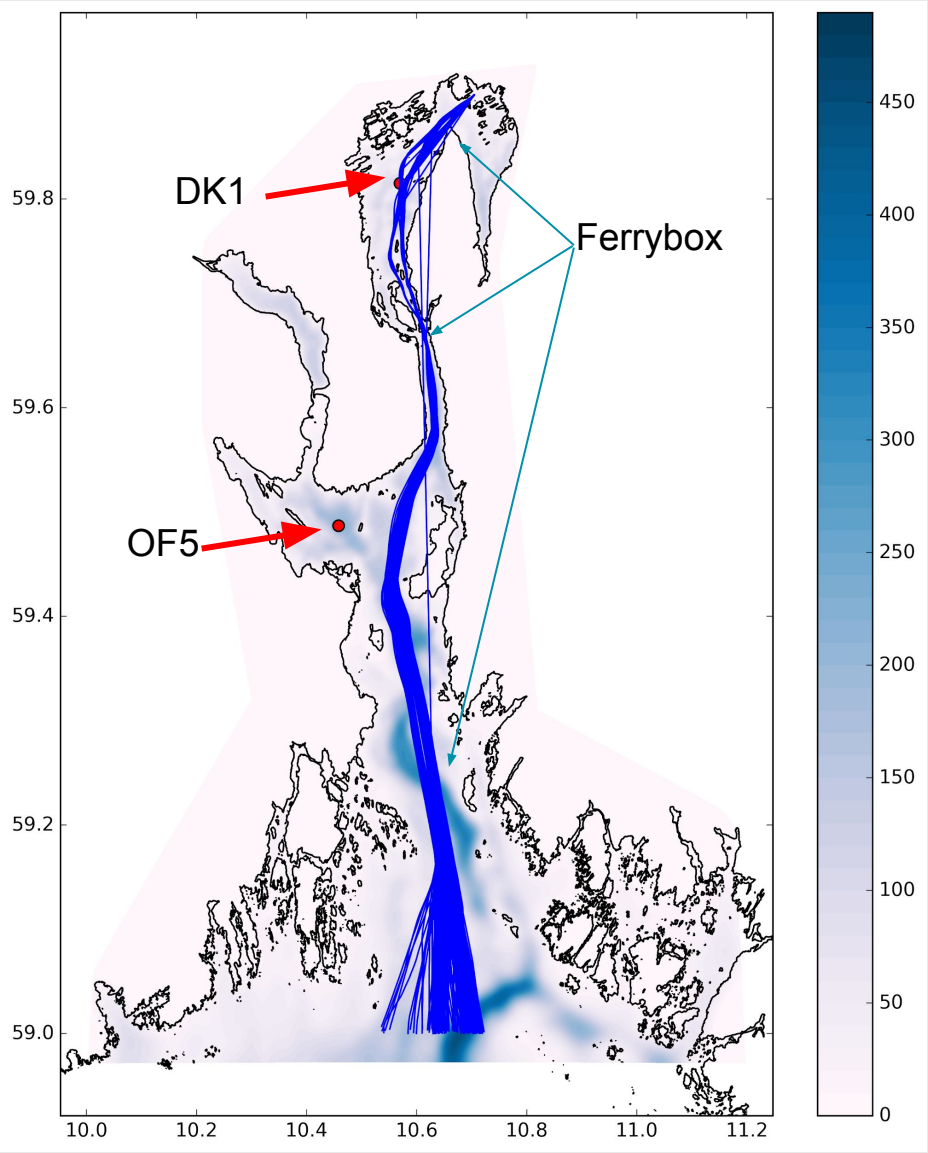




So, what's new?

- Figured out that we had issues with surface temperatures and salinity
- Experimented with (mostly) vertical resolution and vertical mixing

Observations



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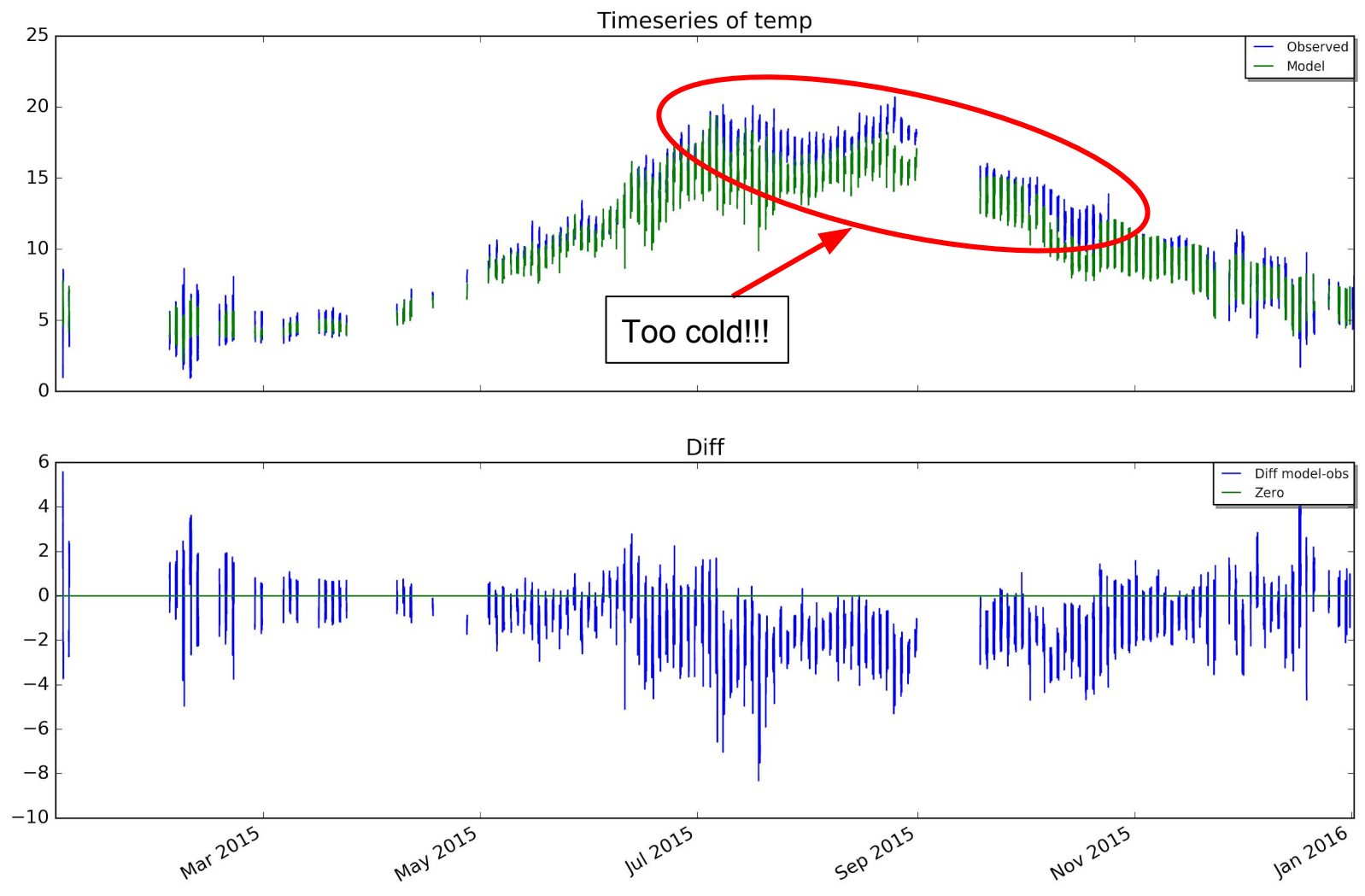
Comparison with Ferrybox



Temperature MAE: -1.10 C, RMSE: 1.74 C

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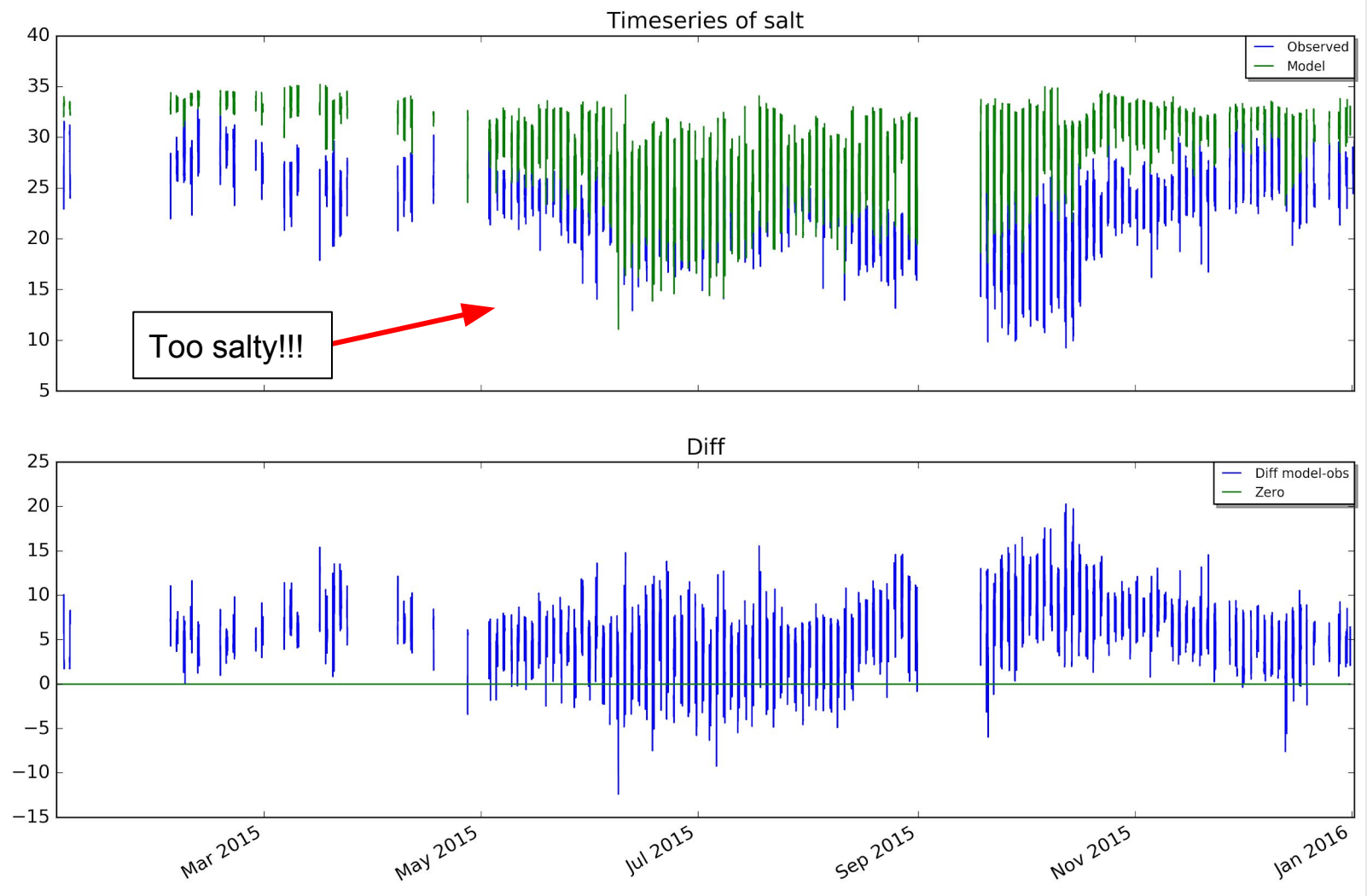
Comparison with Ferrybox



Salinity MAE: 5.82 PSU

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Literature, and a few hints

Warner, J. C., Sherwood, C. R., Arango, H. G., & Signell, R. P. (2005). Performance of four turbulence closure models implemented using a generic length scale method. Ocean Modelling, 8(1-2), 81-113.

Table 1
Generic length scale parameters[a]

	k–kl $\psi = k^l l^l$	$k-\epsilon$ $\psi = (c_\mu^0)^3 k^{3/2} l^{-1}$	k–ω $\psi = (c_\mu^0)^{-1} k^{1/2} l^{-1}$	*gen* $\psi = (c_\mu^0)^p k^l l^{-2/3}$
p	0.0	3.0	−1.0	2.0
m	1.0	1.5	0.5	1.0
n	1.0	−1.0	−1.0	−0.67
σ_k	2.44	1.0	2.0	0.8
σ_ψ	2.44	1.3	2.0	1.07
c_1	0.9	1.44	0.555	1.0
c_2	0.5	1.92	0.833	1.22
c_3^+	1.0	1.0	1.0	1.0
$k_{\min}$	5.0e−6	7.6e−6	7.6e−6	7.6e−6
$\psi_{\min}$	1.0e−8	1.0e−12	1.0e−12	1.0e−12
F_{wall}	Eq. (18), (20), (21) and (22)	1.0	1.0	1.0

[a] Values from Burchard and Bolding (2001), Umlauf (pers. comm.), and Umlauf and Burchard (2003).

Table 2
Generic length scale c_3^- values

	k–kl	k–ε	k–ω	*gen*
KC $c_\mu^0 = 0.5544$	2.53[a,b]	−0.52[a,b]; −0.41[c]	−0.58[a,b]	0.10[a]
CA $c_\mu^0 = 0.5270$	2.38[d]	−0.63[d,c]	−0.64[d]	0.05[e]
CB $c_\mu^0 = 0.5540$	ND[f]	−0.57[c]	ND[f]	ND[f]

KC = Kantha/Clayson, CA = Canuto A, CB = Canuto B.
[a] Eq. (47).
[b] Umlauf (2001).
[c] Burchard and Bolding (2001).
[d] Umlauf et al. (2003).
[e] Umlauf and Burchard (2003).
[f] ND = not determined.

e “dirty” water, light
penetrate less

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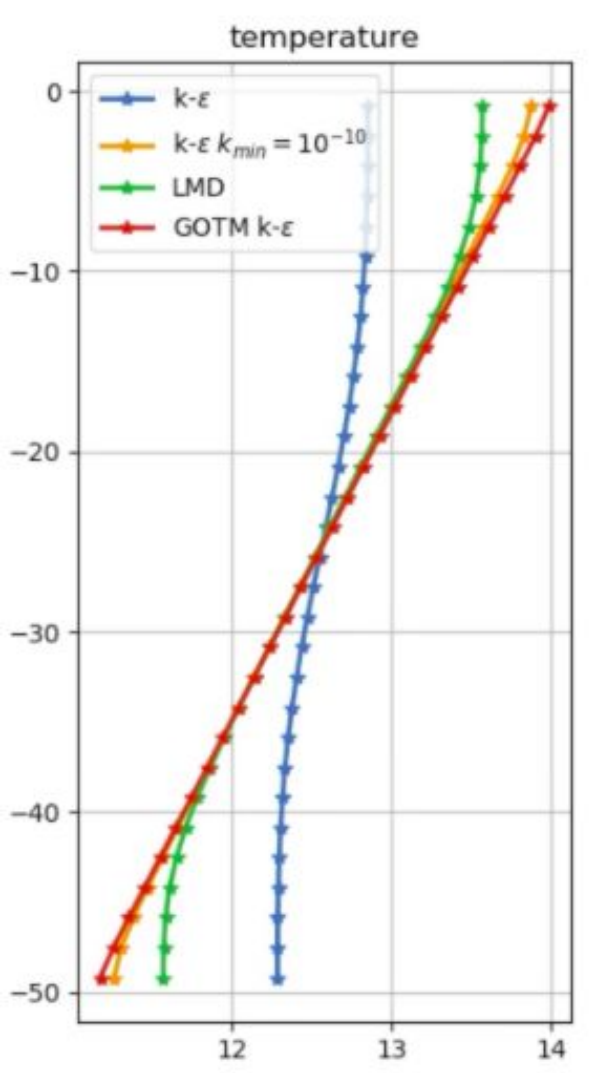
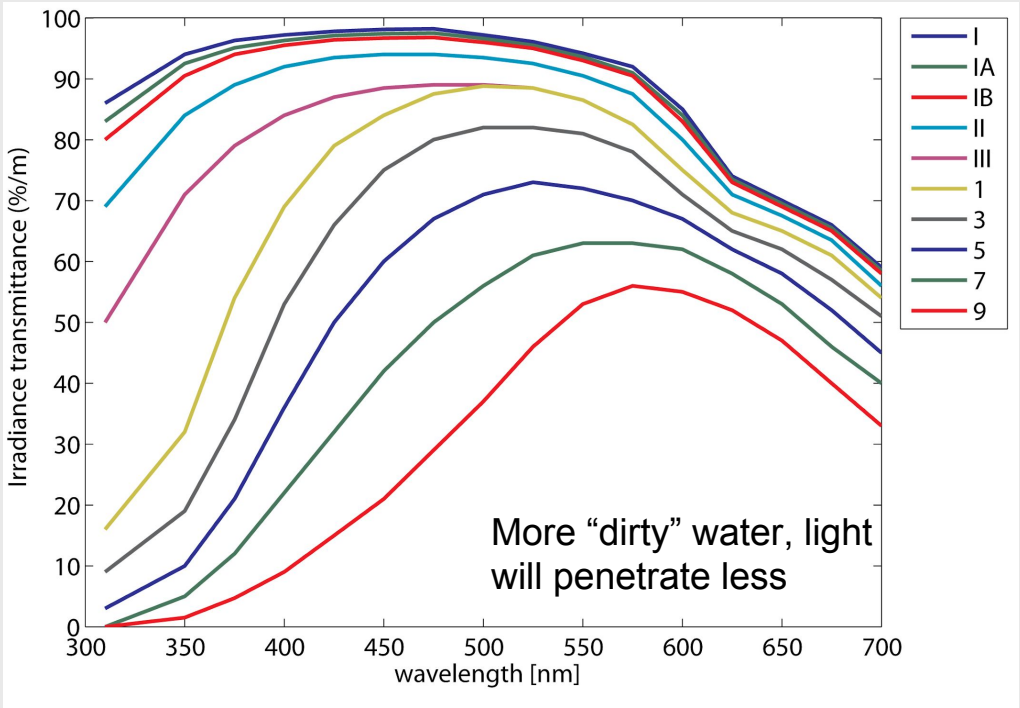
Literature, and a few hints

https://www.myroms.org/forum/viewtopic.php?f=17&t=4789



https://www.myroms.org/projects/src/ticket/609



Experiments we have performed

"Base setup"

"Better setup"

Exp #	WTYPE	hc	splines	Closure		Stability function	GLS_Kmin	AKT_BAK
TR1	5	50	on	GLS	gen	canuto_a	7.6d-6	1.0d-6
TR2	*7*	50	on	GLS	gen	canuto_a	7.6d-6	1.0d-6
TR3	7	50	*off*	GLS	gen	canuto_a	7.6d-6	1.0d-6
TR4	7	*15*	on	GLS	gen	canuto_a	7.6d-6	1.0d-6
TR5	7	15	on	GLS	gen	canuto_a	*1.0d-10*	1.0d-6
TR6	7	15	on	GLS	gen	canuto_a	1.0d-10	*1.0d-8*
TR7	7	15	on	GLS	*k-w*	canuto_a	1.0d-10	1.0d-8
~~***TR8***~~	~~*7*~~	~~*15*~~	~~*on*~~	~~*GLS*~~	~~*k-w*~~	~~*kantha/ clayson*~~	~~*1.0d-10*~~	~~*1.0d-8*~~
TR9	7	15	on	*KPP*	-	-	-	1.0d-8

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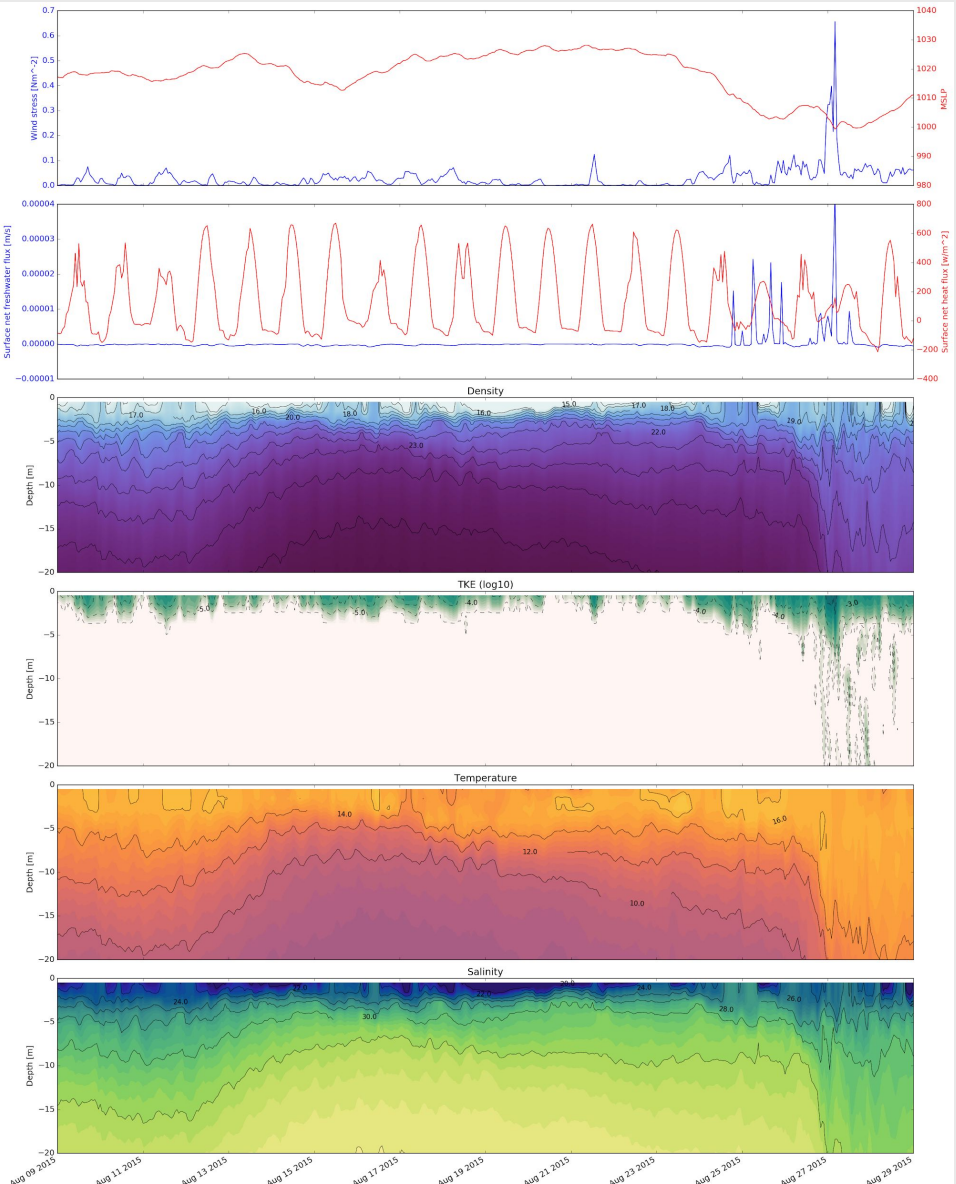
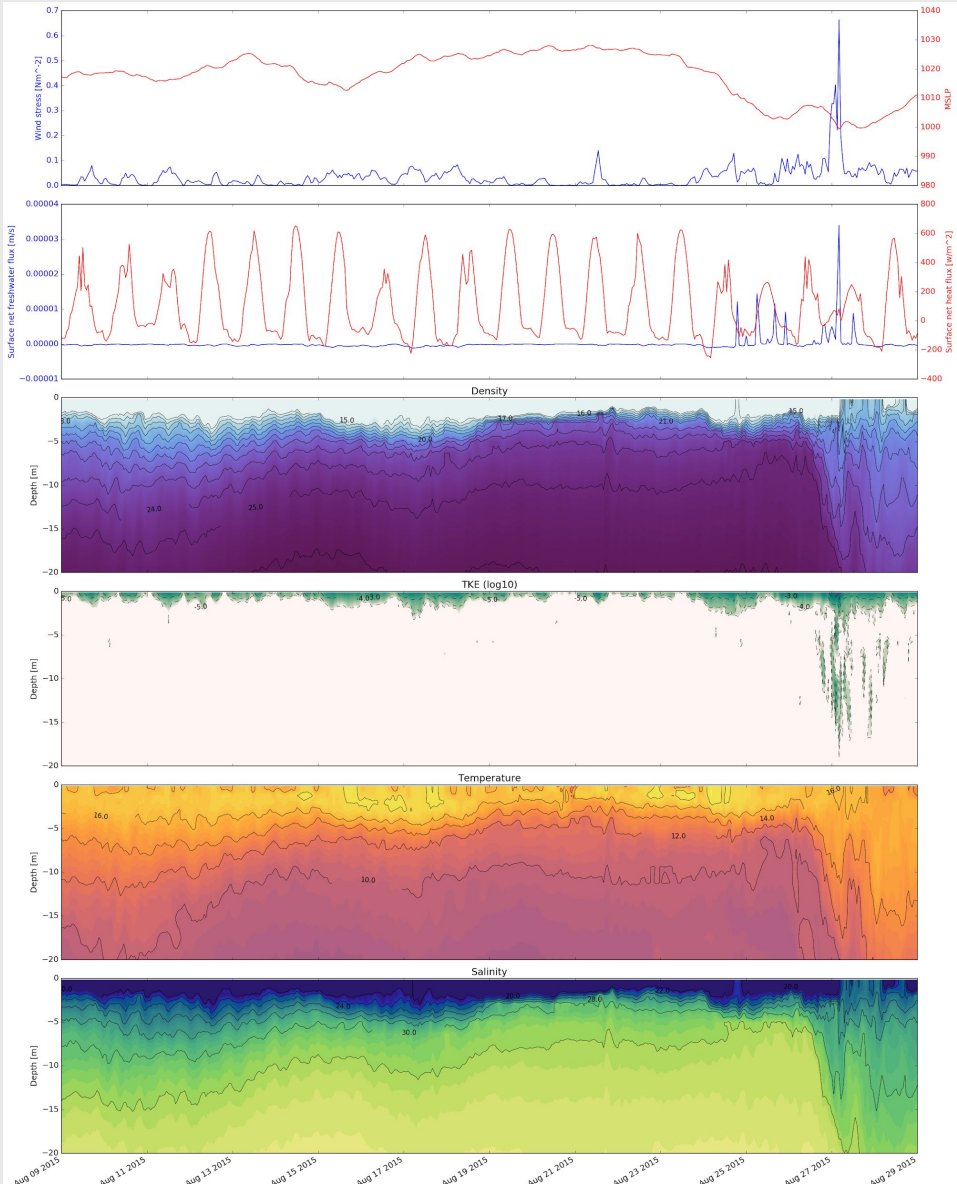
Comparison at OF5 station

"Base setup"

"Better setup"

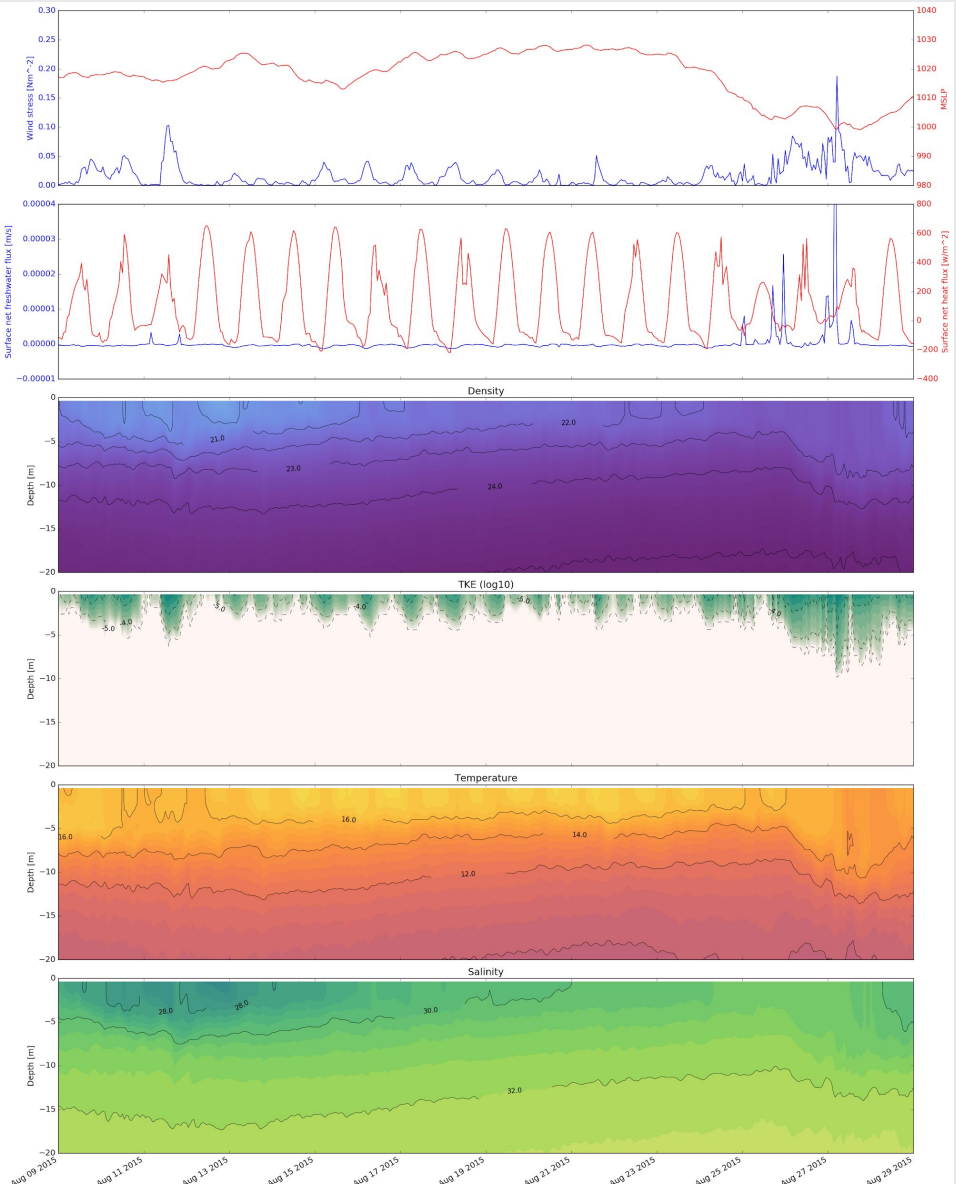


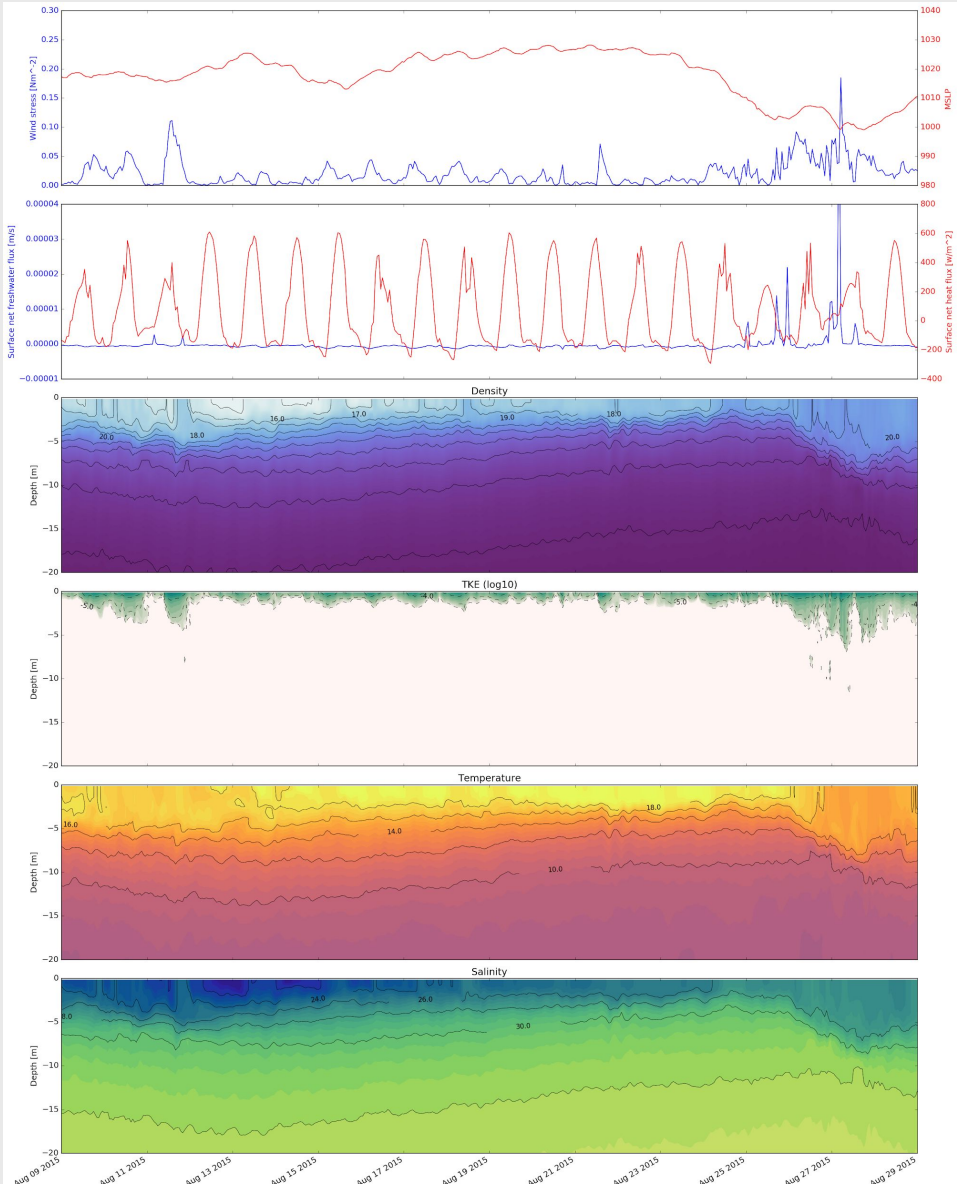


Comparison at DK1 station

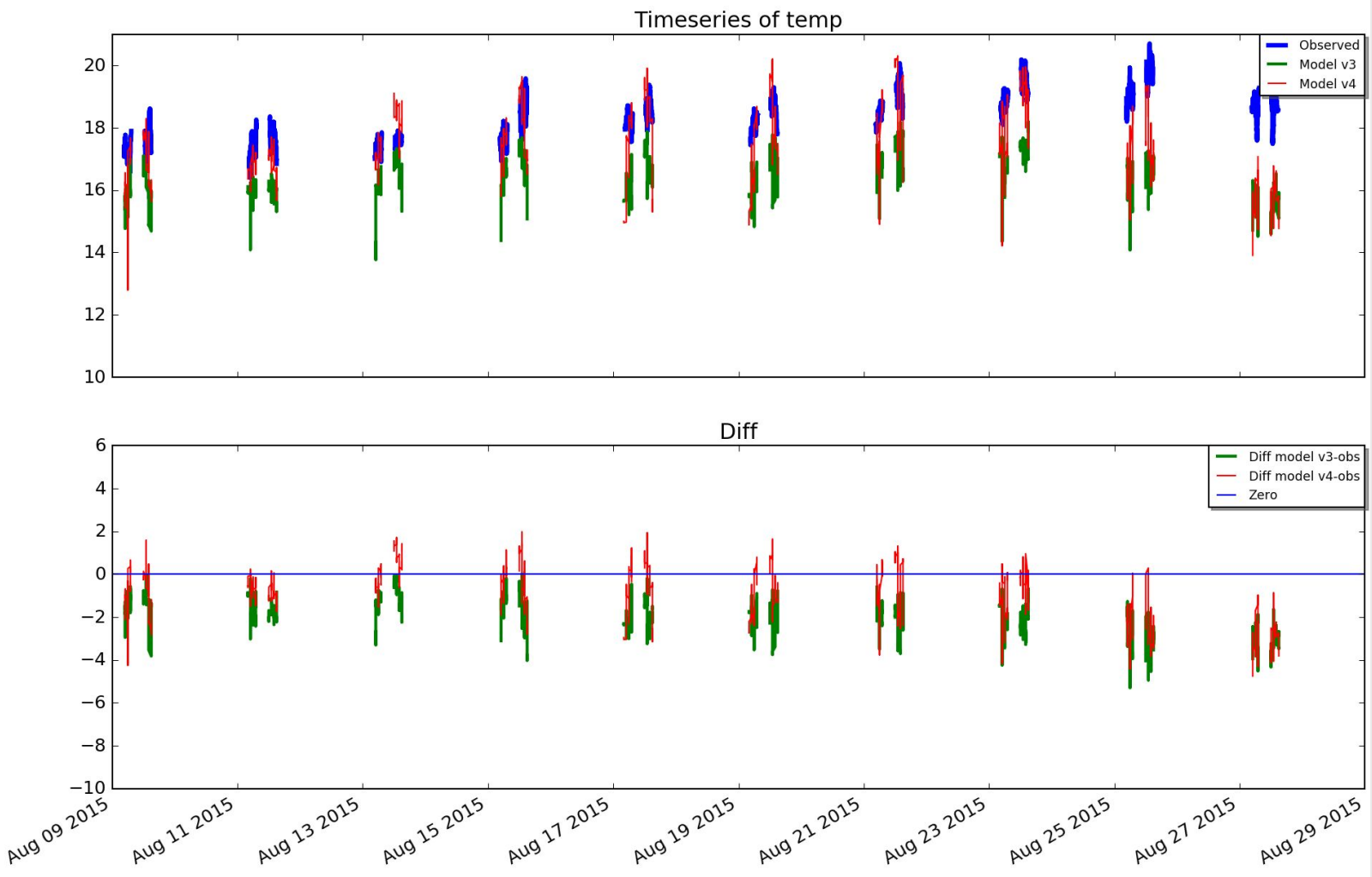
"Base setup"

"Better setup"





Comparison with Ferrybox



Temperature MAE (for this period): v3 -0.28 C, v4: -0.12 C

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Comparison with Ferrybox

	Temp MAE [C]	Temp RMSE [C]	Salt MAE [PSU]	Salt RMSE [PSU]
V3 (“Base setup”)	-1.10	1.74	5.82	6.73
V4 (“Better setup”)	-0.86	1.69	3.27	5.28

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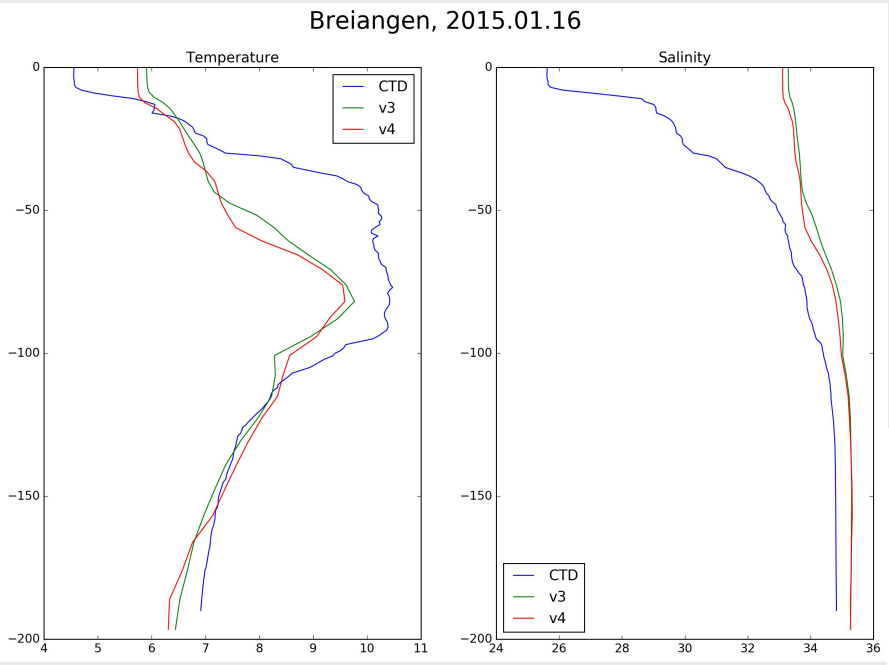
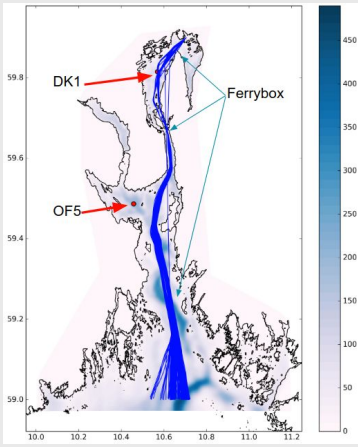
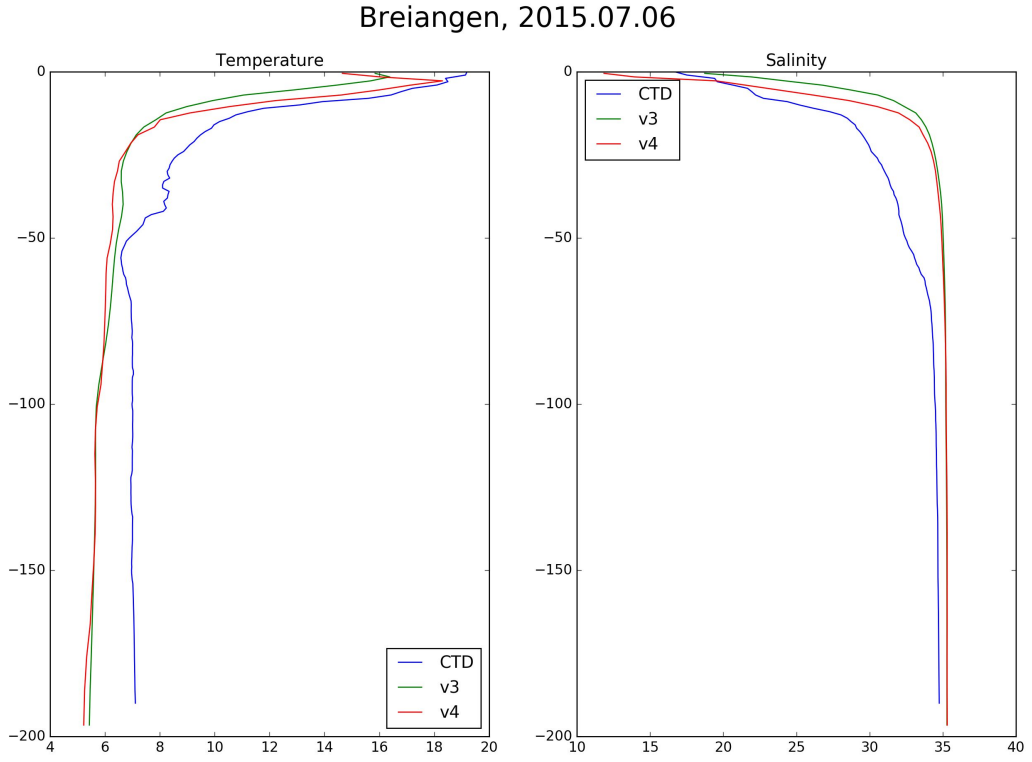
Comparison with CTD at OF5

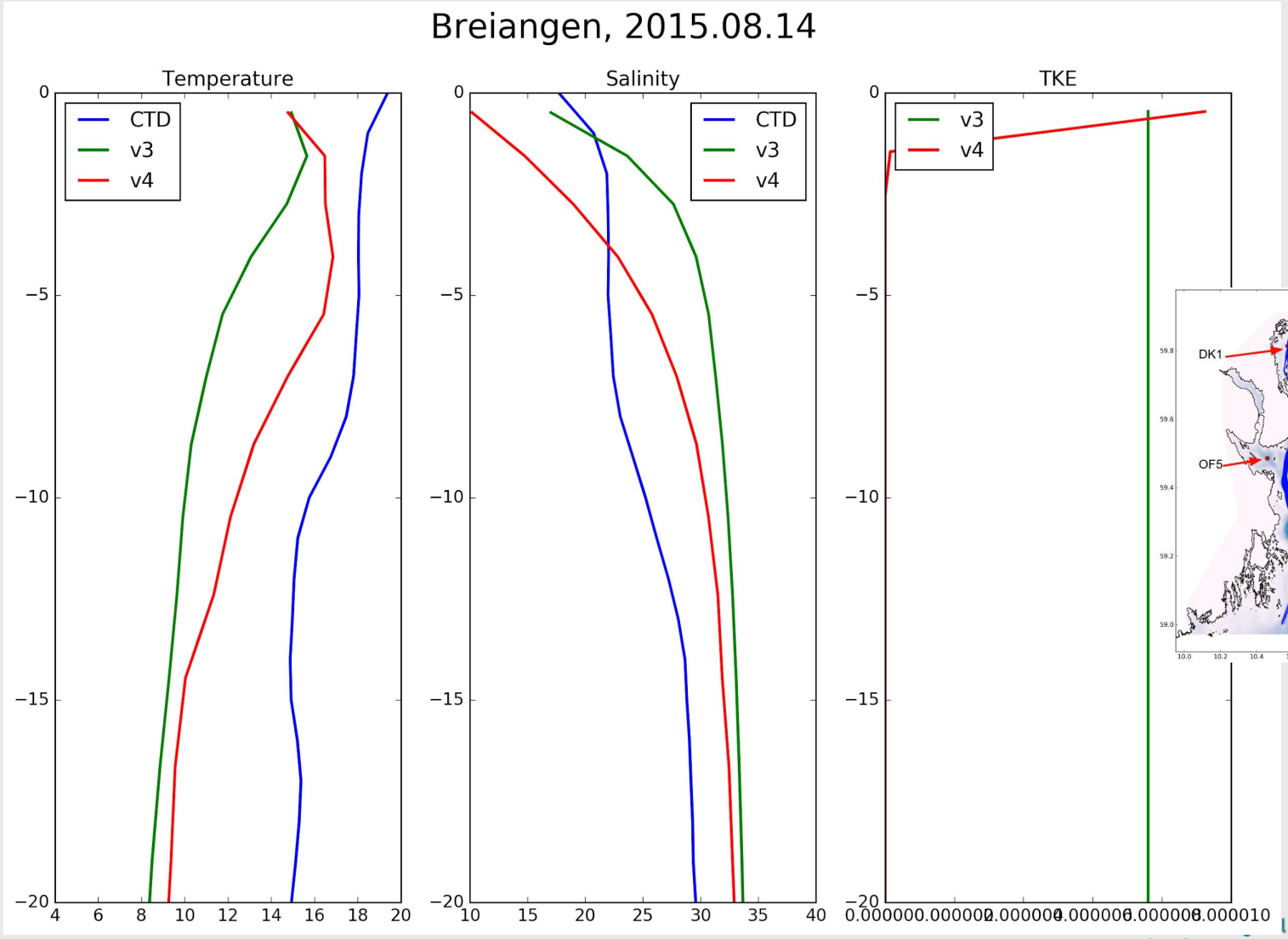






Errors in IC and BC fields…
Even our best effort won't be able to fix that..

Comparison with CTD, incl. TKE



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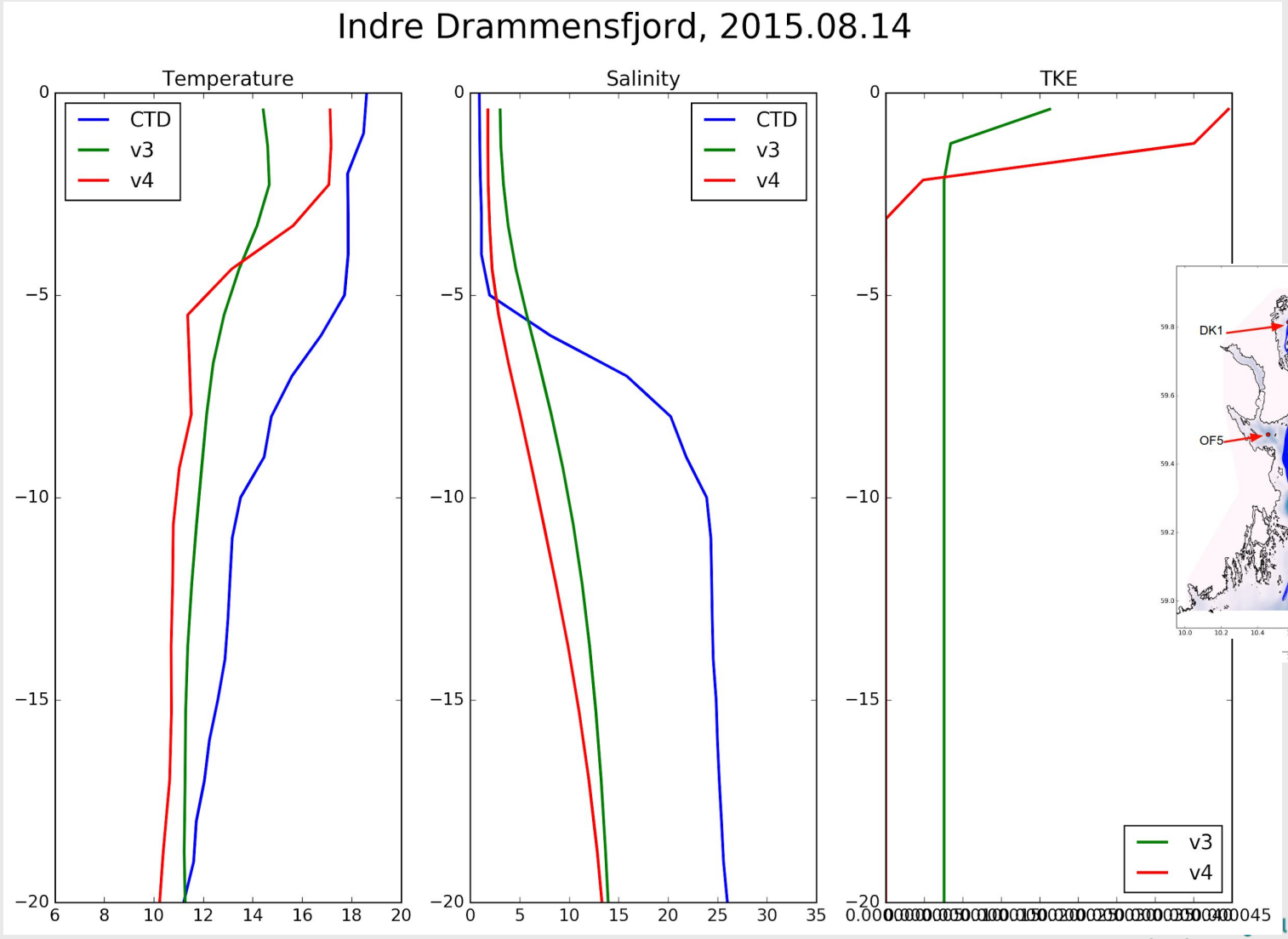
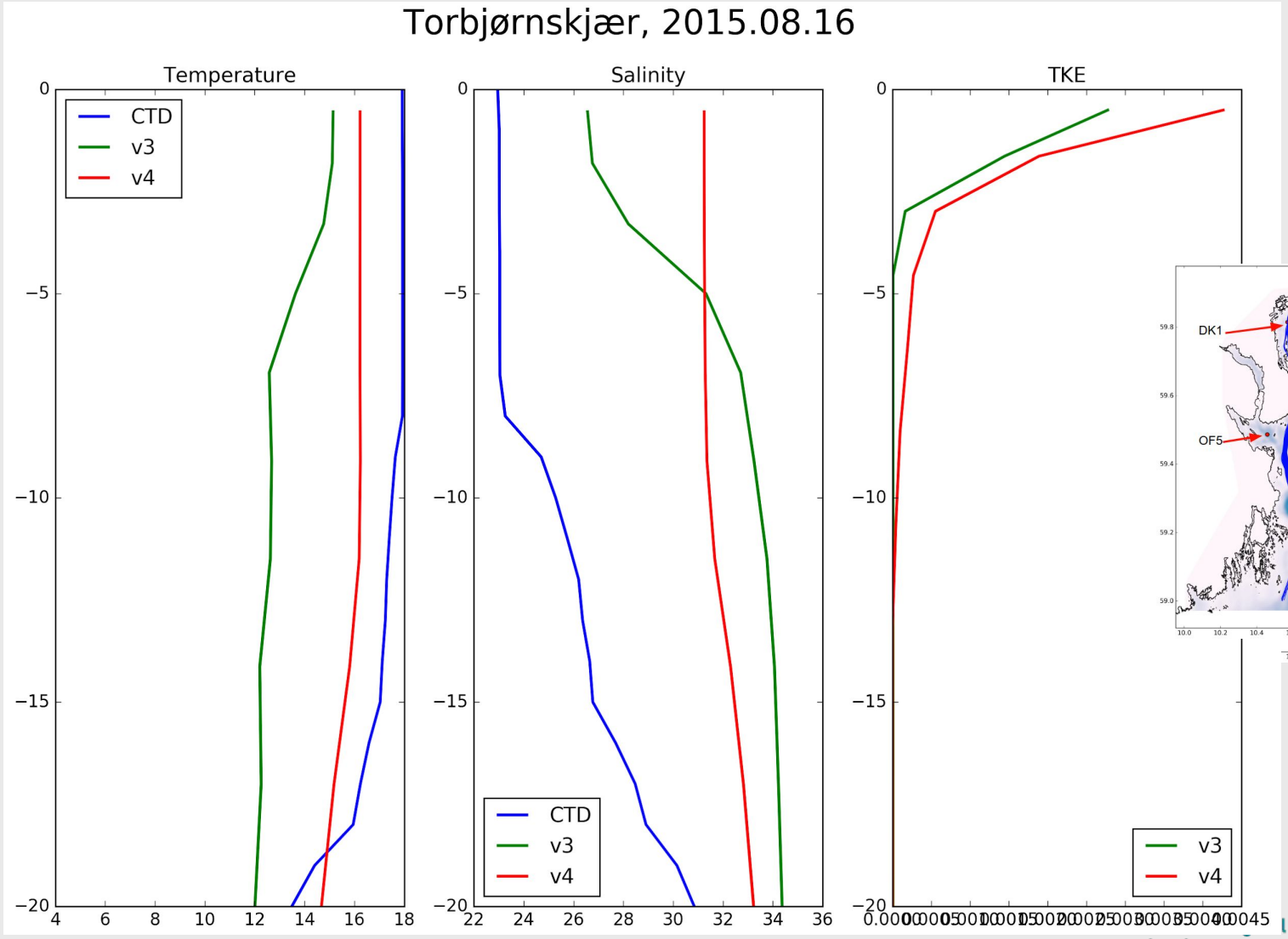
Comparison with CTD, incl. TKE



Comparison with CTD, incl. TKE



Further out in the fjord, close to open boundary

Summary and future work

- New setup show a more promising and realistic surface layer
- Default minimum values for vertical mixing in ROMS GLS (K_min) are too high?
- Need more realistic initial conditions and BC in our model

Future work:

- More analysis (and tests?) is needed
- Try out this setup in the Norwegian coastal model (NorKyst800) and other ROMS applications

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