Danmarks
Meteorologiske
Institut

HBM-NEMO intercomparison

Vasily Korabel
Ida Margrethe Ringgaard

Danish Meteorological Institute

Danmarks Meteorologiske Institut

CMEMS:
DMI leads consortium for the Baltic service

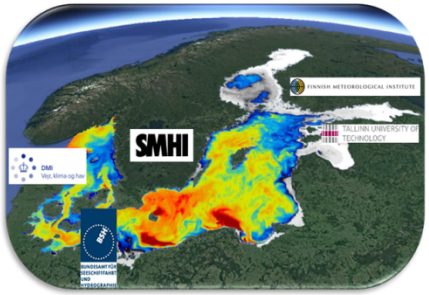
Goal: **deliver state of art marine service for Baltic Sea**
=> requirement: improve product quality

Methods to achieve that:
- **Joining forces** on development among opr. ocean institutes in Baltic Sea
- **share workload** & focus on the **institutes competences**
- include R&D/developments from internal & external projects

=> annual system upgrades of forecast system & service

BAL MFC common model System developments :

Ocean model: HBM & NEMO => **NEMO**
Bio model: ERGOM & SCOBI => **ERGOM**
Wave model: **WAM**
DA tool: **PDAF**



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CMEMS: Consortium Service developments
With DMI contribution

2015-2016:

HBM: code optimization for performance improvements (DMI)

HBM+ERGOM: implemented improved river run-off and nutrients data (DMI)

HBM: upgrade turbulence mixing (Canuto part III)

HBM: simple ice dynamic model + fast ice module implemented (DMI)

2017:

HBM: tuning ice-thermodynamic & heat exchange routines for improved sea ice product (DMI)

HBM: PDAF LSEIK scheme for SST data (DMI)

New reanalysis product from new system: NEMO + SCOBI + PDAF (SMHI)

ERGOM: improved chl calculations + light routine (Kd) (BSH)

WAM: local implementation to handle partly covered ice grids (FMI)

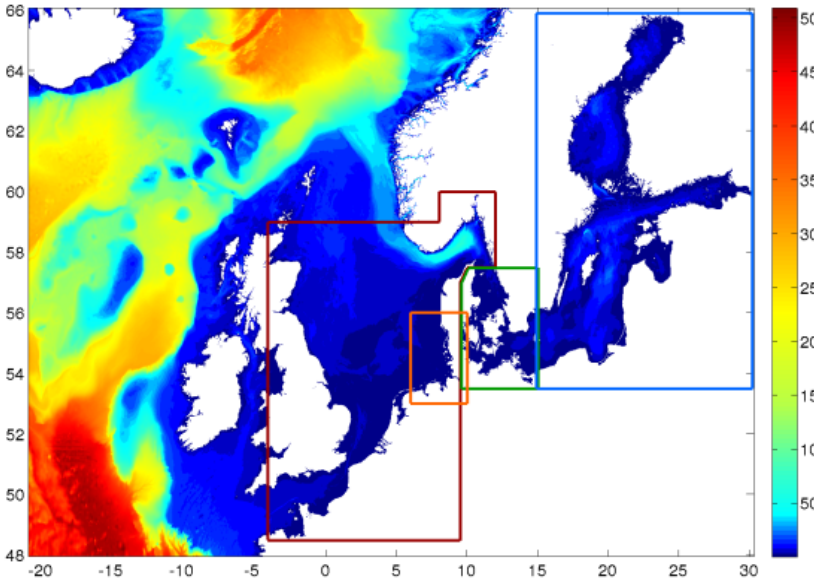
Plans for 2018:

Develop NEMO-ERGOM to take over as forecast system from HBM-ERGOM

DMI: NEMO-Nordic setup for reanalysis work

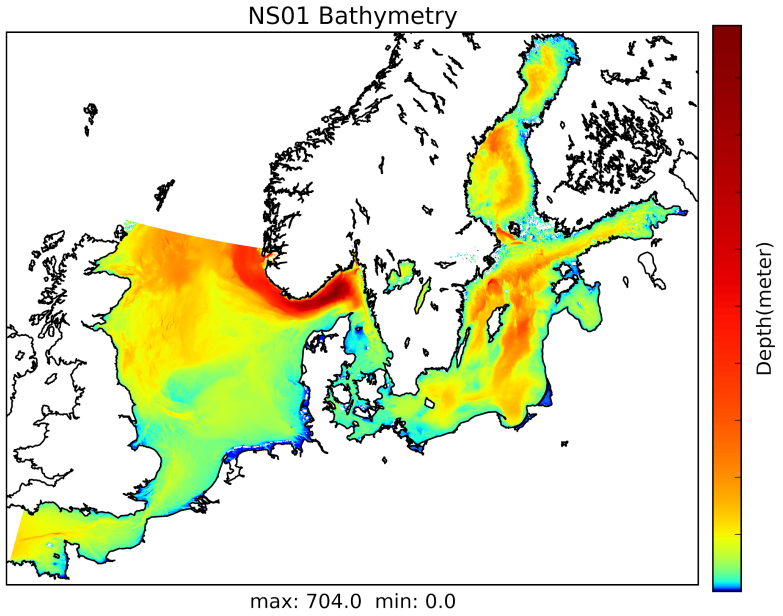
Models Setup

HBM v4



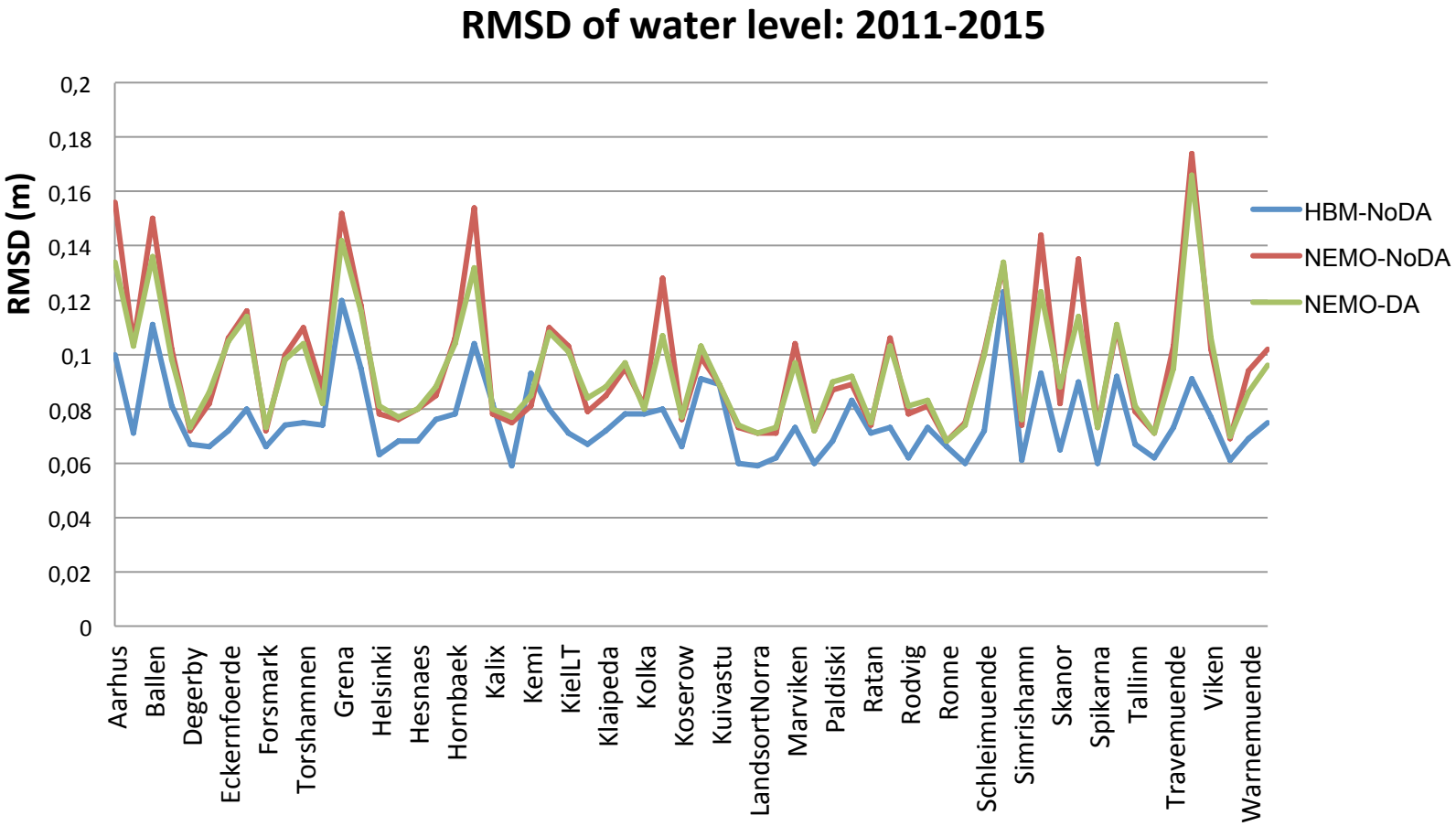
- 4 two-way nested subdomains with horizontal resolution of 3-0.5 nm
- 21-122 z vertical layers
- k-e turbulence scheme
- Tides forced at open boundaries
- Climatological T/S OBCs
- ATM forcing: HIRLAM/HARMONY
- 2.3 km
- EHYPE hydrology

Nemo-Nordic

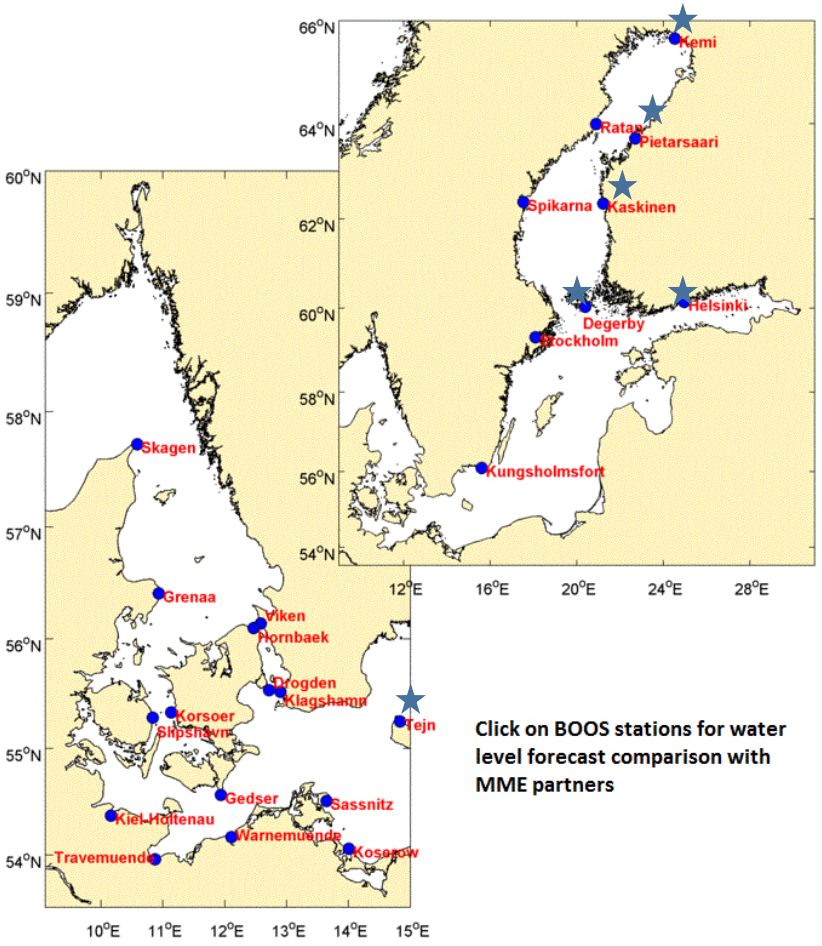


- Horizontal resolution of 1 nm
- 56 z* vertical layers
- GLS turbulence scheme
- OBCs from FOAM system (T,S,U,V,SSH including tides)
- ATM forcing: mix of ECMWF 9km and Arome 2.5km
- EHYPE hydrology

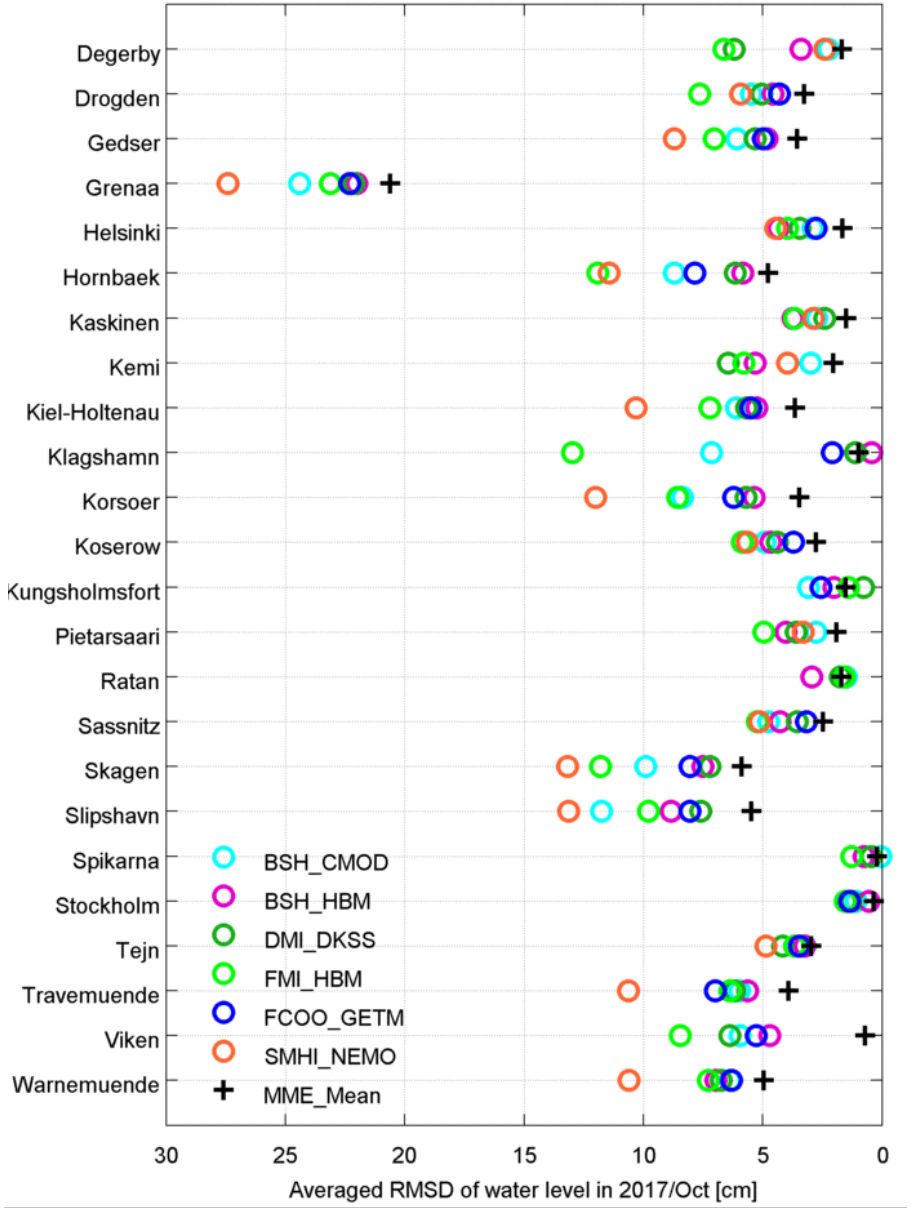
Intercomparison of HBM-NEMO water level (in collaboration with DHI)



MME water level monthly validation in Oct. 2017

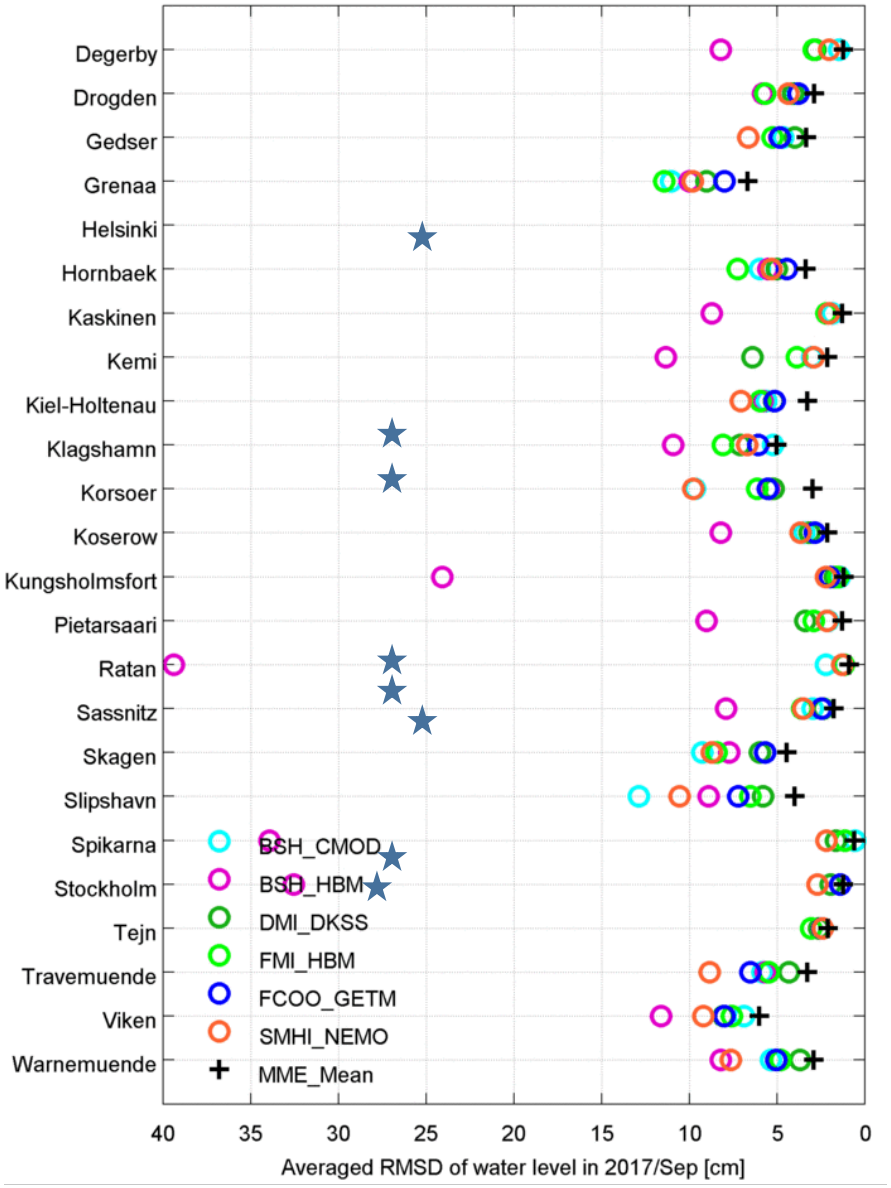


Click on BOOS stations for water level forecast comparison with MME partners

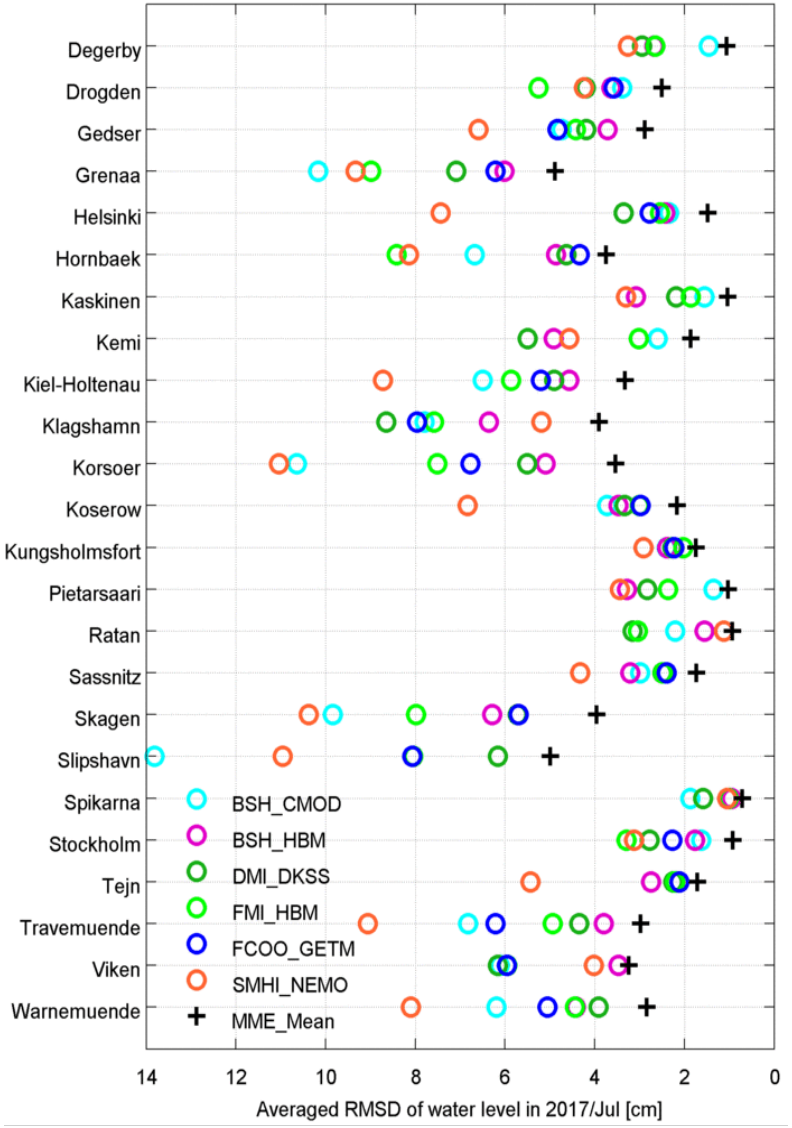


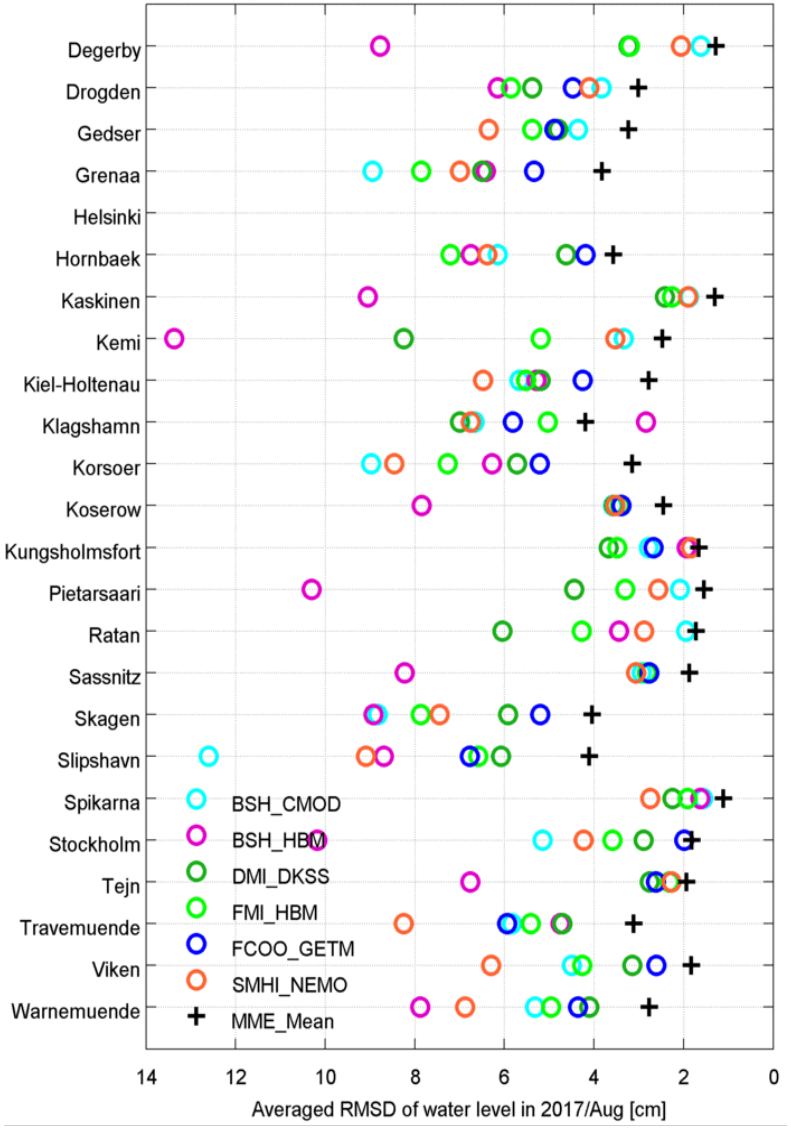
MME water level validation in Sep. 2017

- NEMO performs well at SE and FI stations
- NEMO has bad performance in Jutland East coast and German coast.
- BSH-HBM has very low score esp. At SE stations

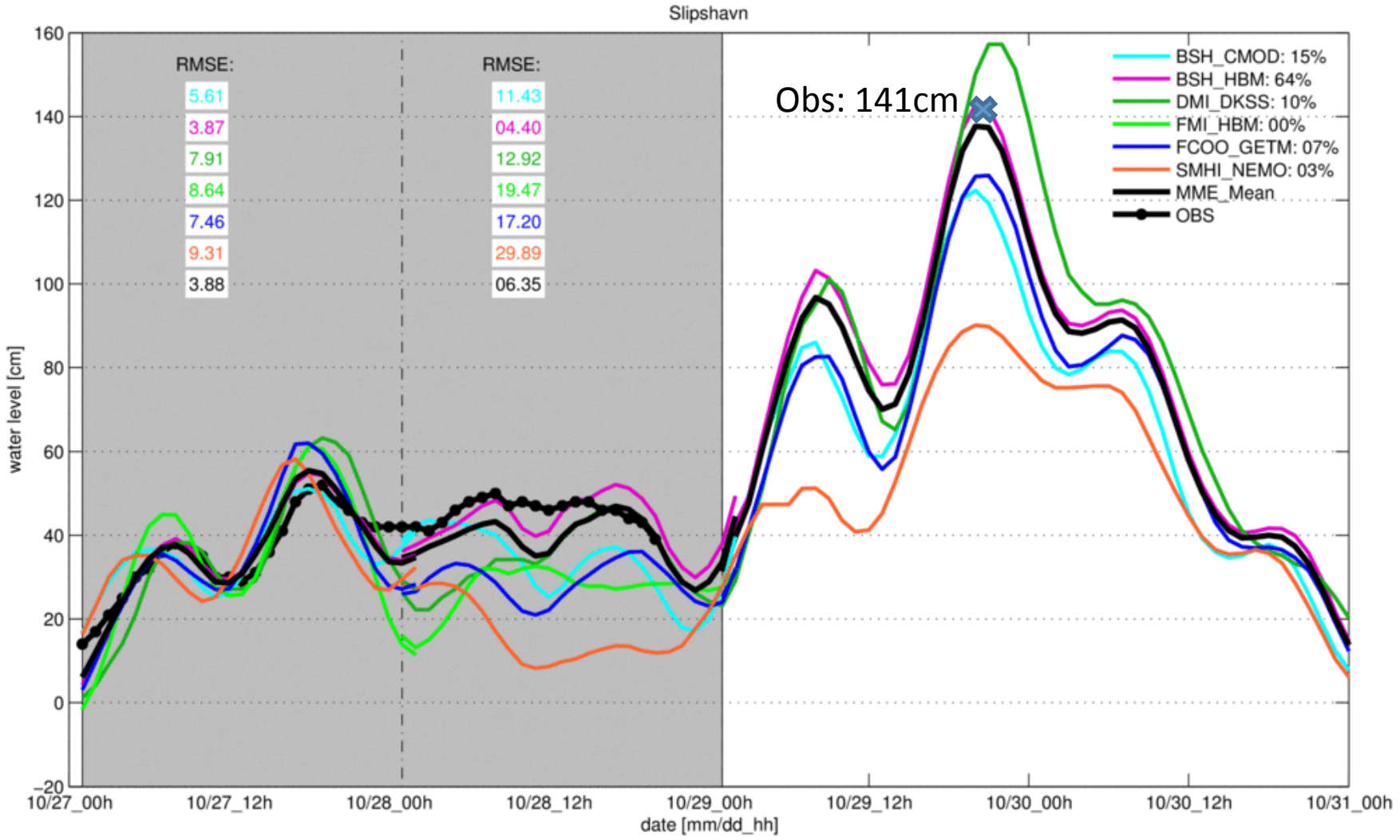


MME water level validation in Jul/Aug





MME sea level forecast at 2017-10-2900GMT
(a 50yr event at Slipshavn)

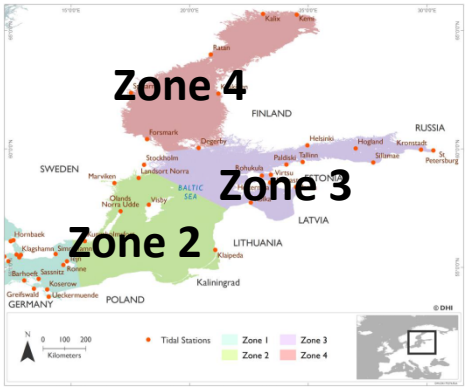


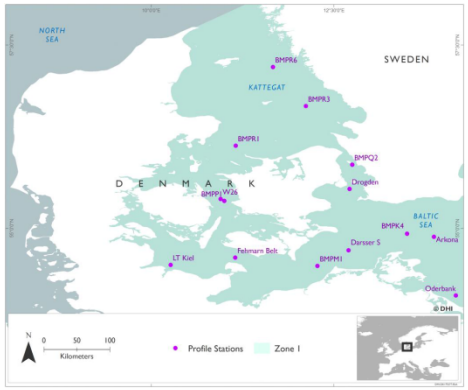
Summary on water level

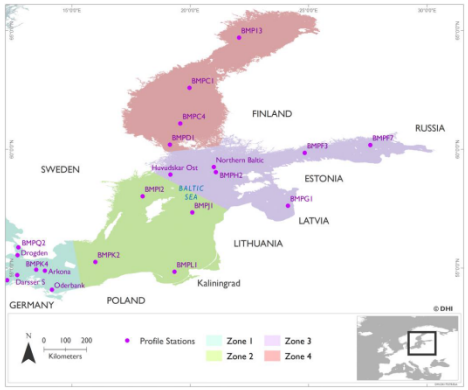
- Validation shows lower quality of NEMO-Nordic water level products at all 62 Baltic Sea stations in comparing with CMEMS HBM V4
- MME results show that NEMO's water level forecast at SE and FI coast are in reasonable quality but has significantly low quality at Jutland E. coast, Belt Sea and German coast.
- For a 50yr event at Slipshavn in 20171029, NEMO underpredicted sea level peak by ~50cm.
- HBM products performance also has a large variability based on setups.

Comparison of T/S

- Estimate error statistics in 4zones for SST/SSH/ ICEC, T/S and currents
-
- Bias, RMSD and correlation
-
- Product type
- Final product: 2016/05/03-11/02
  - NEMO: with DA
  - HBM: without DA
-







A quantitative evaluation method

Definition of category & scores	Significantly worse (SW)	Worse (W)	Slightly worse (SLW)	Similar (S)	Slightly better (SLB)	Better (B)	Significantly better (SB)
Category order	1	2	3	4	5	6	7
|Bias(HBM) |-| Bias(NEMO) |	<-0.5	-0.5 – -0.2	-0.2- -0.1	±0.1	0.1-0.2	0.2-0.5	>0.5
RMSD(HBM) – RMSD(NEMO)	<-0.5	-0.5 – -0.2	-0.2- -0.1	±0.1	0.1-0.2	0.2-0.5	>0.5
Score of HBM	0.1	0.25	0.4	0.5	0.6	0.75	0.9
Score of NEMO	0.9	0.75	0.6	0.5	0.4	0.25	0.1

T/S evaluation by zone

Table 2: Evaluation results for Best Estimate Products (T/S) by using definitions in Tab. 1.

	Zone1		Zone2		Zon3		Zone4		Summary
	HBM	NEMO	HBM	NEMO	HBM	NEMO	HBM	NEMO	
T Bias	**0,64**	**0,36**	**0,53**	**0,47**	**0,52**	**0,48**	**0,52**	**0,48**	**HBM +**
S Bias	**0,47**	0,53	0,31	0,69	0,28	0,72	0,41	0,59	NEMO ++
T RMSD	**0,53**	0,47	0,49	0,51	0,46	0,54	0,54	0,46	HBM+
S RMSD	**0,69**	0,31	0,48	0,52	0,5	0,5	0,53	0,47	HBM+
Summary	+	-	-	+	-	+	+	-	

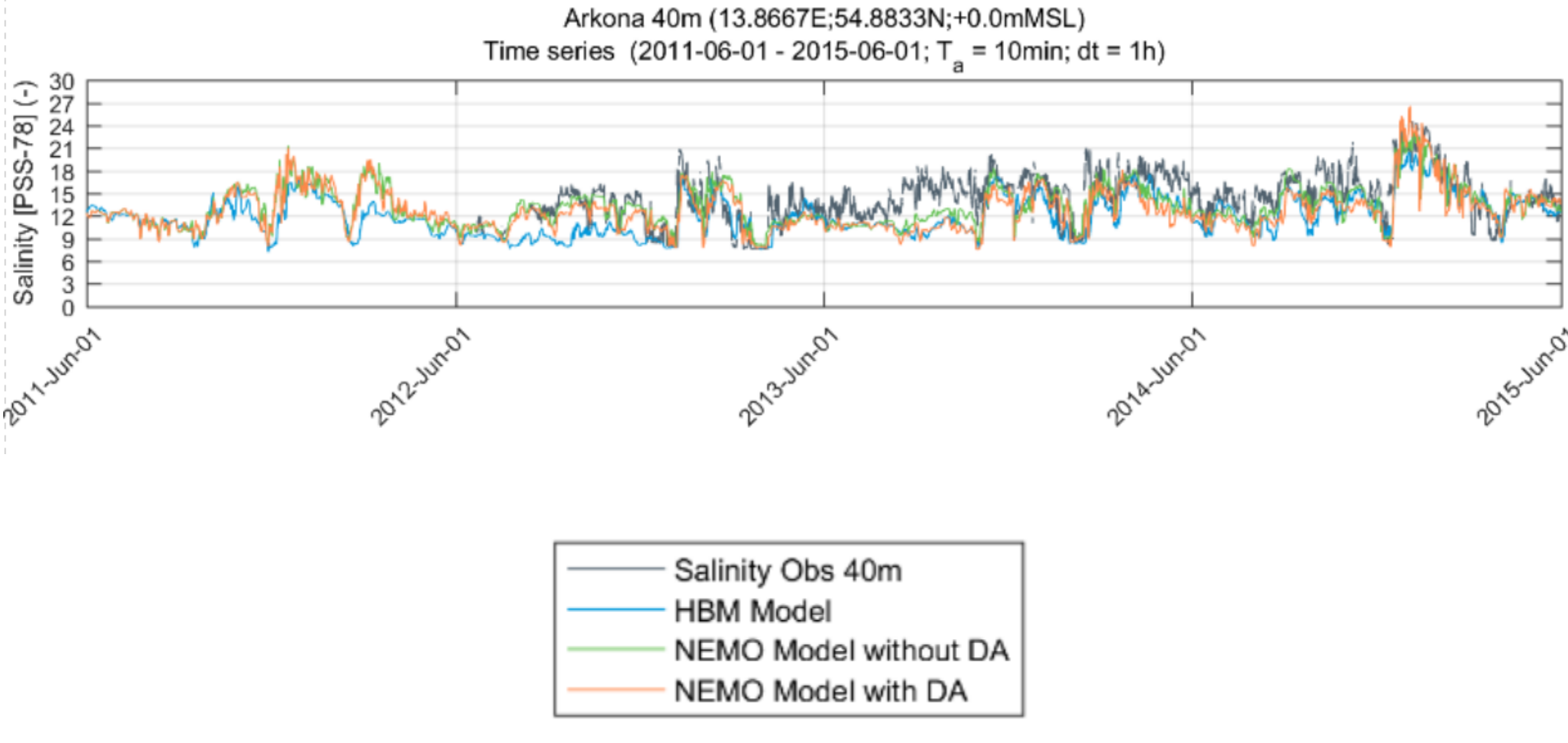
Water temperature: results show that HBM performs better in all 4 zones for bias and Zones 1 and 4 for RMSD. NEMO is better in Zones 2 and 3 for RMSD.

Water salinity: results show that NEMO performs better in all 4 zones for bias while HBM performs better for RMSD.

Inflow assessment

- For inflow in Danish straits and W. Baltic, HBM gives much more accurate signals in terms of salinity peak with -3% bias while NEMO-DA has a clearly overestimation by 18% for depth-mean max salinity at Arkona.
- For inflow in Baltic Proper, HBM and NEMO-DA both show inflow signals in H2 and K2 in 2011/12. HBM does not show salinity increase in J1 (C. Baltic) bottom layer in the 2014/15 event, as existed both in observations and NEMO-DA
- For inflow in GoF, both HBM and NEMO-DA are able to model a salinity increase event in early 2013
- For inflow in Bothnian Bay, both HBM and NEMO-DA are not able to catch a salinity event in early 2013.

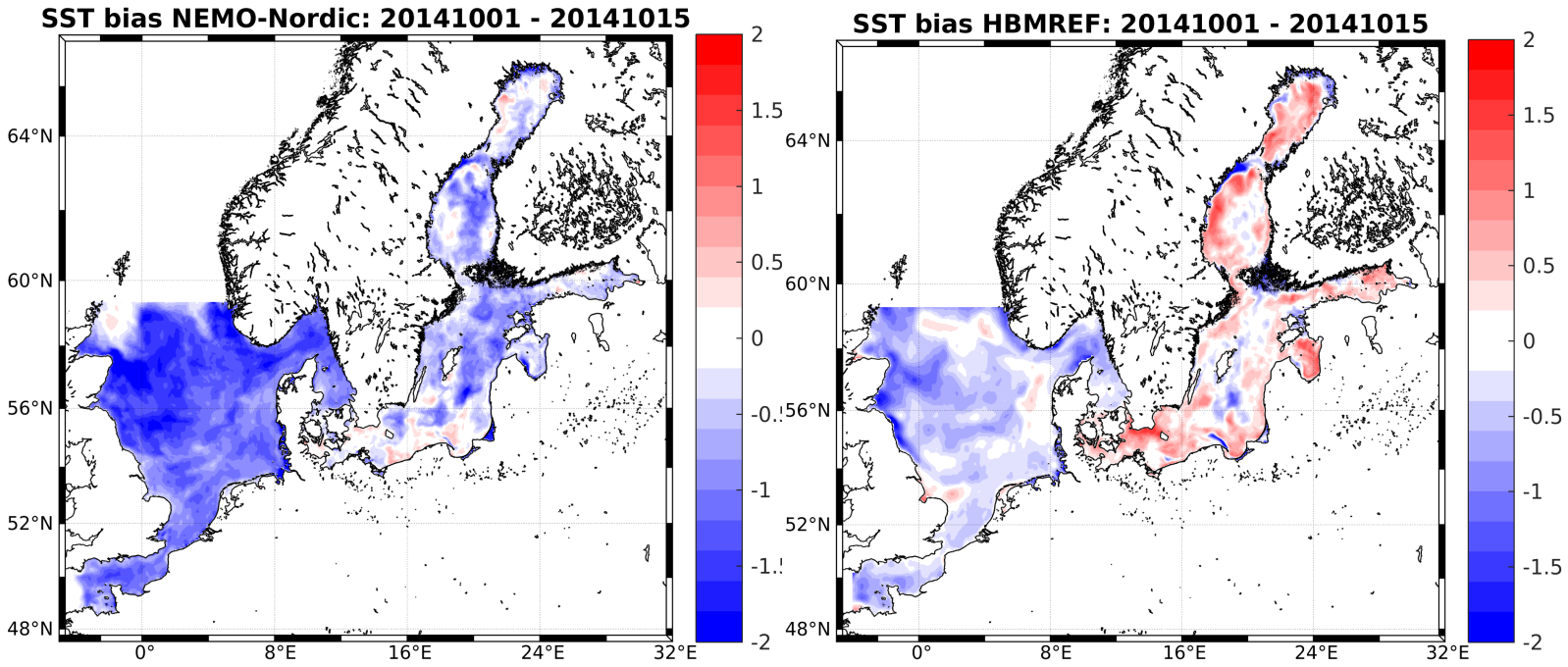
Inflow assessment

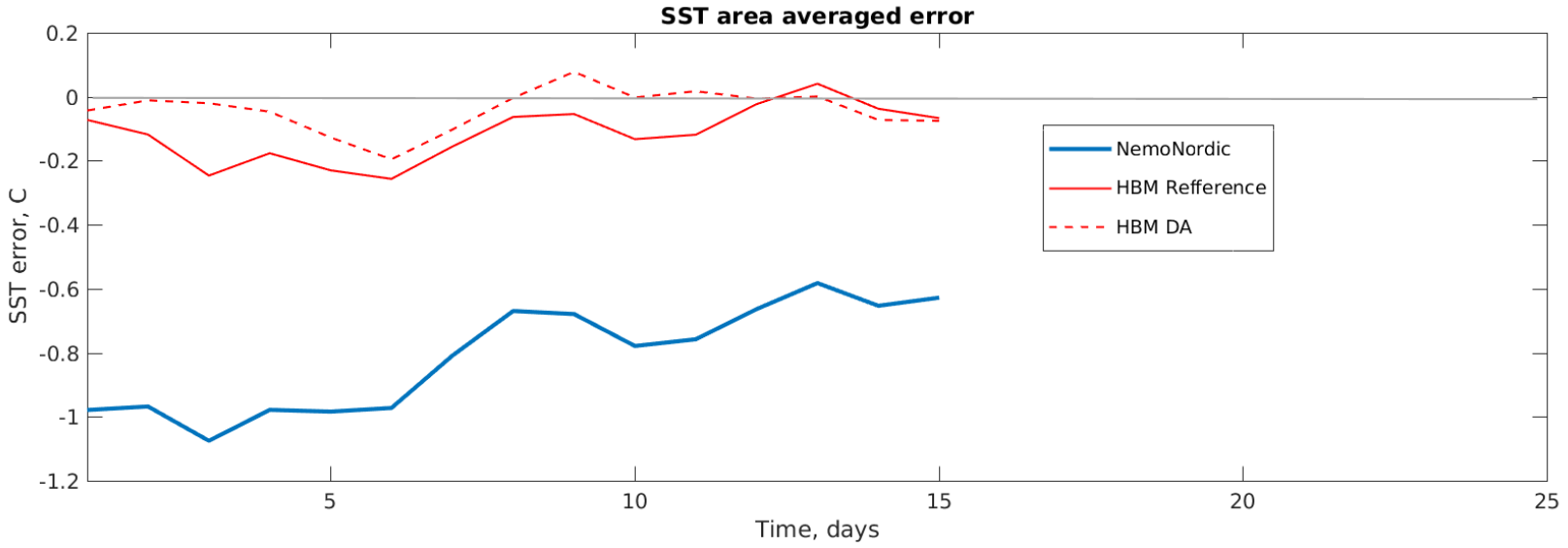


Summary on T/S validation

- HBM has significant bottom salinity bias in open Baltic Sea, NEMO has not. (initial error, slop flow)
- In transition waters, HBM has significantly smaller Tbias and salinity RSMD than NEMO
- There are no big differences in RMSD in T and S in open Baltic Sea, except for
  - In Zone 3 deep layer, NEMO has significantly smaller T RMSD than HBM
  - HBM has smaller RMSD in 15-50m depth
- Inflow:
  - HBM does not give inflow signal in the central Baltic Proper;
  - Inflow into Bothnian Bay are not simulated in both HBM and NEMO.

Thank you for your attention


SST bias NEMO-Nordic: 20141001 - 20141015
SST bias HBMREF: 20141001 - 20141015
64°N
60°N
56°N
52°N
48°N
0°
8°E
16°E
24°E
32°E
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2


SST area averaged error
SST error, C
Time, days
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
5
10
15
20
25
NemoNordic
HBM Refference
HBM DA