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DIVOST-COM Service Evolution Project

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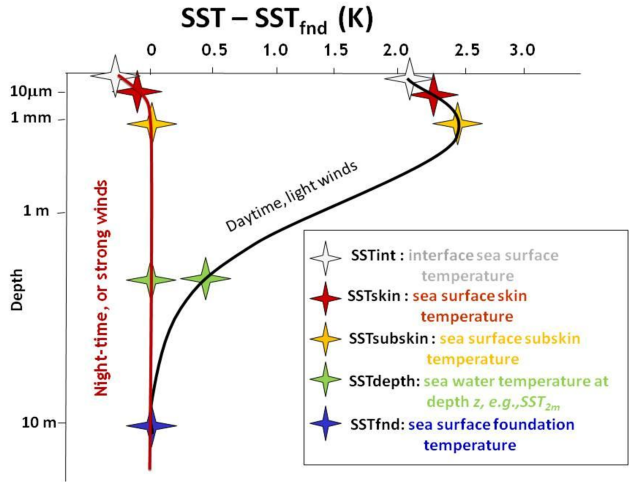
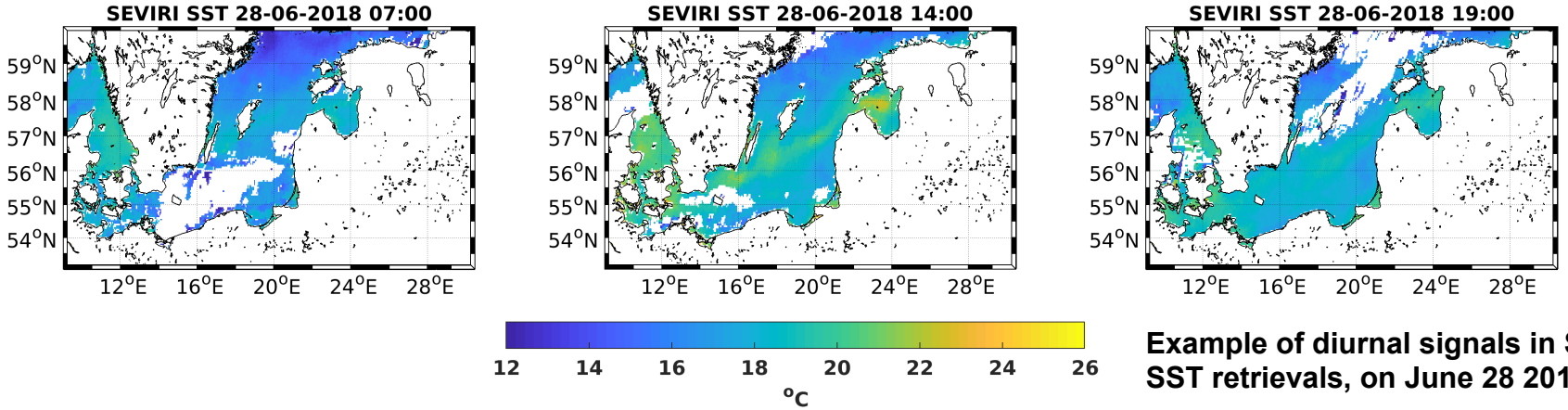
Copernicus Marine Service

General Assembly – 01/2021

Diurnal Variability of SST



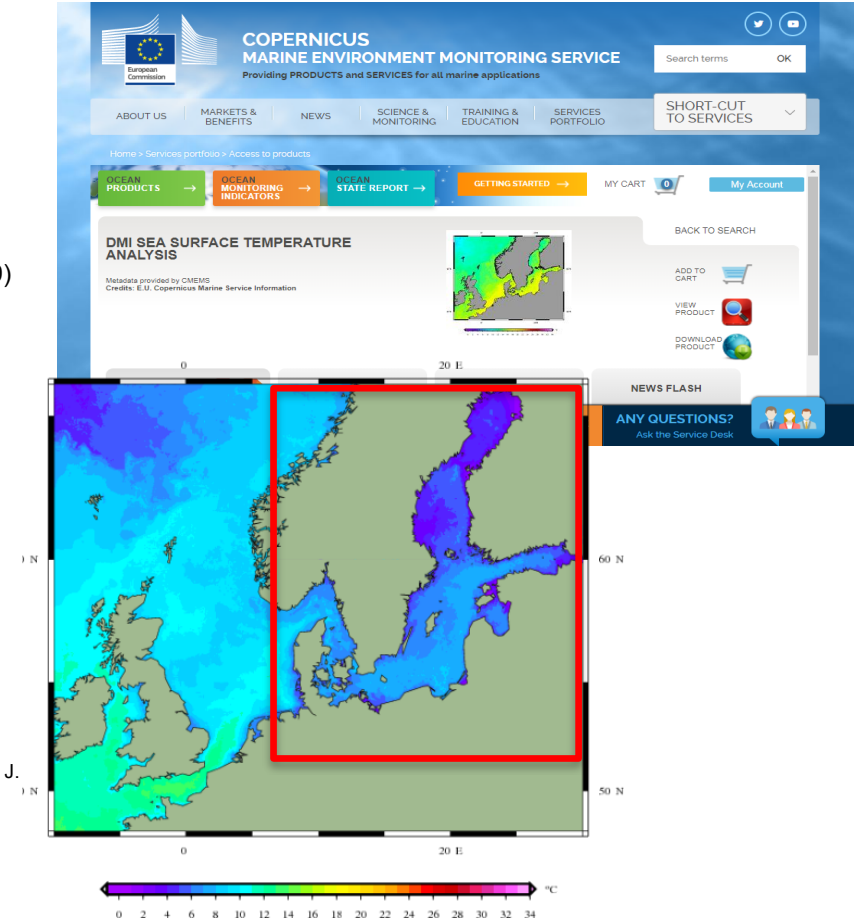
Vertical distribution of SST during night or under strong wind conditions (red line) and during the day under light winds (black line). From Minnett P. & Kaiser-Weiss A. (2012)



Example of diurnal signals in SEVIRI SST retrievals, on June 28 2018.

DIVOSTCOM Rationale

- **BAL MFC**
  - Good quality SST_{bulk} (no data assimilation)
  - No vertical temperature variability resolved in upper few meters
- **CMEMS SST TAC products**
  - Operational, daily L4 SST
    - SST_BAL_SST_L4_NRT_OBSERVATIONS _010_007_b
    - SST_BAL_SST_L4_NRT_OBSERVATIONS _010_032 (New, from April 2019)
  - Reprocessed (1982-present)
    - SST_BAL_SST_L4_NRT_OBSERVATIONS _010_016 (used for OMI+OSR)
  - All products are foundation SST
  - No diurnal variability present
  - Users want hourly SST to use in the forecasting systems
- **Future evolutions in operational products can include diurnal variability estimates**
  - Hourly dT offsets from the 00 analysis
  - Simple statistical & empirical models have been tested → not suitable for the Baltic Sea [2]
  - Turbulence model promising [3] → dependence on NWP inputs



[2] Karagali I. & J.L. Høyer. 2013. Observations and Modeling of the Diurnal SST Cycle in the North and Baltic Seas, J. Geophysical Research - Oceans 118 (9): 4488–4503.

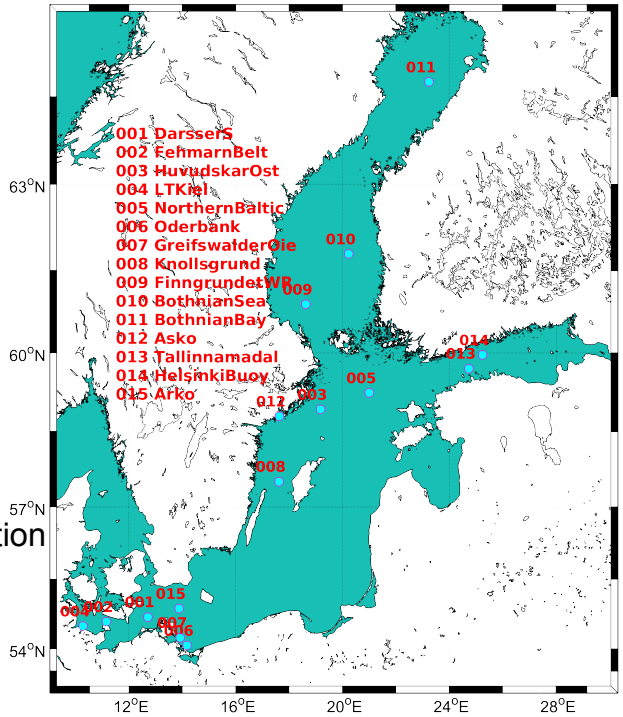
[3] Karagali I., Høyer J.L. & C. J. Donlon (2017). Using a 1-D model to reproduce the diurnal variability of SST. J. Geophysical Research: Oceans, 122(4), 2945–2959.

- Objective to provide recommendations for product improvements (BAL MFC, SST TAC) related to the diurnal cycle of the upper ocean temperature.

- Potential impact on
  - BAL MFC PHY-BIO forecasting system (improved upper ocean temperature representation ---> detection of algal blooms, improvement on heat and gas exchange with atmosphere
  - SST TAC: Diurnal SST field to complement L4 product

General Ocean Turbulence Model (GOTM[4])

- TKE K_ε turbulence scheme
- 2-band vs 9-band light absorption scheme
- Timestep 60 seconds, hourly output
- Meteo forcing (HIRLAM/HARMONIE)
  - x, y wind components
  - Air pressure
  - Dry air temperature
  - Relative humidity
  - Cloud cover
  - Short wave radiation, net longwave radiation
- Ocean forcing (HBM)
  - Temperature profiles
  - Salinity profiles

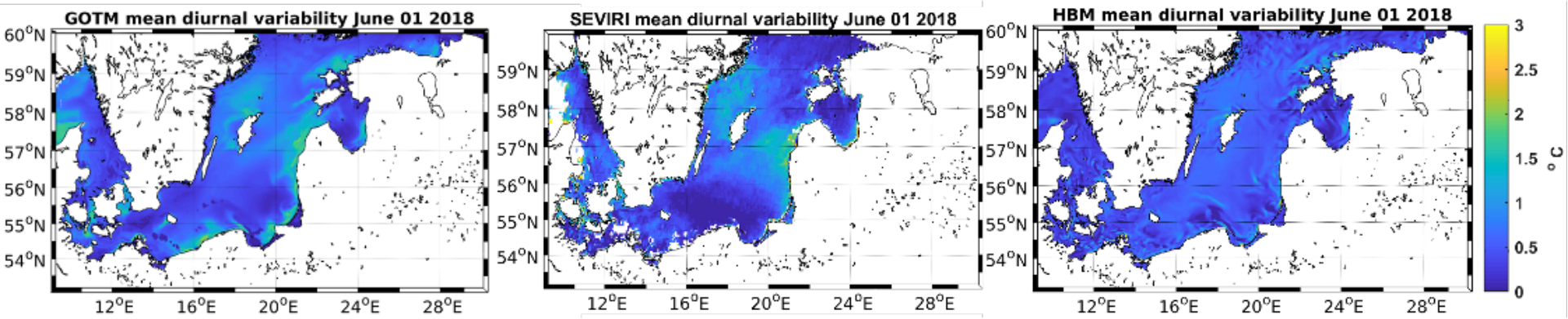


Data

- **In situ test sites**
  - 6 profiling stations
  - 9 surface stations
  - Depths: 8-110 m
- **SEVIRI**
  - O&SI SAF L3C
  - Hourly, 0.05 deg
  - DOI 10.15770/ EUM_SAF_OSI_0004
- **HBM**
  - Hourly, 1.2 naut. miles
- **L4 SST North Sea/Baltic**
  - Daily, 0.03 deg

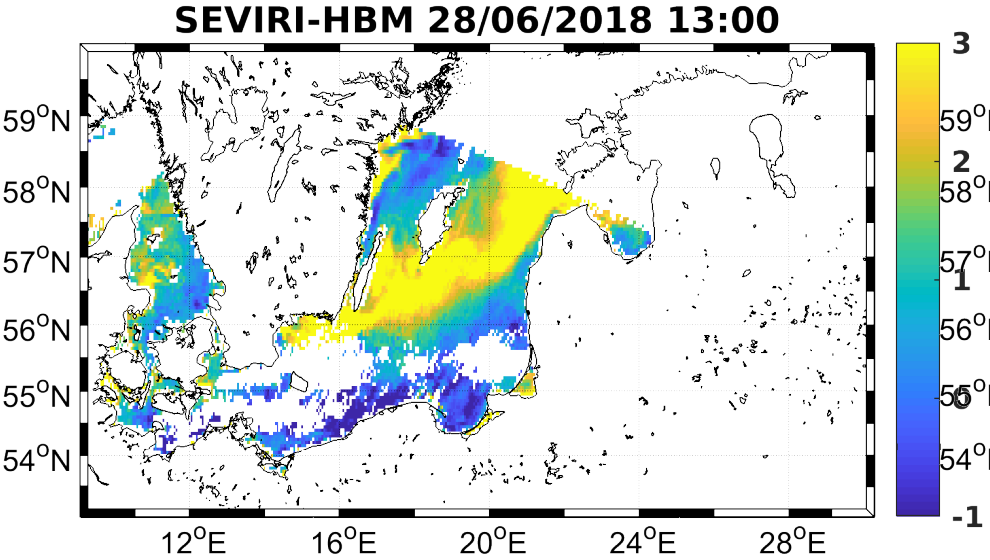
[4] Burchard H., Bolding K., and M.R. Villarreal (1999). GOTM - A general ocean turbulence model. Theory, applications and test cases, Tech.Rep. EUR 18745 EN, Eur.Comm. Brussels, Belgium.

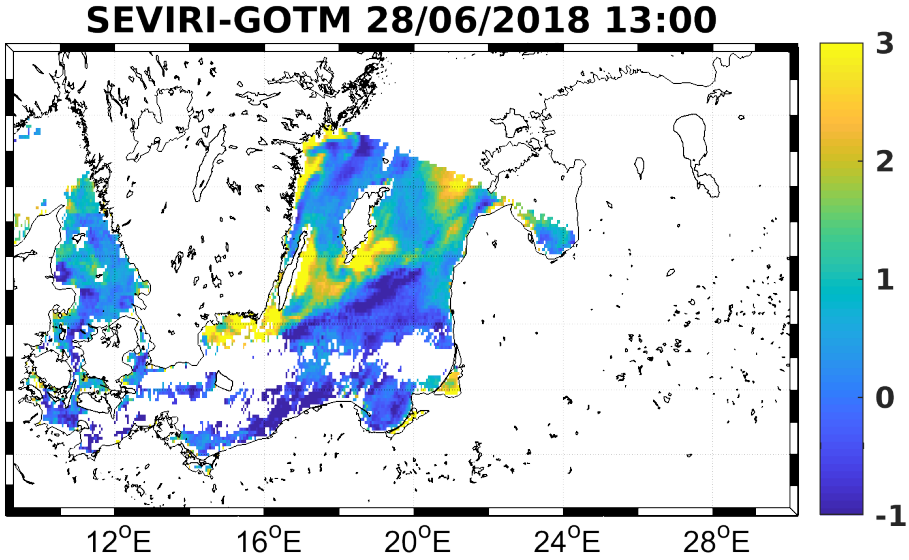
Simulating diurnal SST variability



- Mean temperature anomalies from the corresponding night-time foundation value ($\overline{SST}_{00-04}$)
- GOTM reproduces better diurnal variability as seen from SEVIRI compared to HBM
  - In spatial extend
  - In amplitude

Simulating the diurnal variability of SST





- Areas with intense warm colour indicate higher differences SEVIRI-HBM.

- These are significantly reduced for SEVIRI-GOTM
- GOTM better resolves temperatures as seen by SEVIRI

HBM-GOTM-SEVIRI - L4SST

Table 1. Night-time HBM, GOTM and L4SST, for different HBM depths.

Metric	Depth (m)	HBM-L4SST	GOTM (LE8) Int-L4SST	GOTM (LE8)-L4SST
Mean (°C)	0	**-0.29**	-0.35	-0.34
	5	-0.48	**-0.43**	-0.48
	10	-1.71	**-1.33**	-1.94
	15	-3.93	**-3.43**	-3.96
Median (°C)	0	**-0.07**	-0.10	-0.09
	5	-0.15	**-0.13**	-0.16
	10	-0.82	**-0.71**	-1.12
	15	-3.12	**-2.67**	-3.12
StD (°C)	0	**1.41**	1.46	1.45
	5	1.63	**1.57**	1.59
	10	2.69	**2.18**	2.70
	15	3.86	**3.46**	3.82

Table 2. Night-time GOTM minus L4SST, for different GOTM depths.

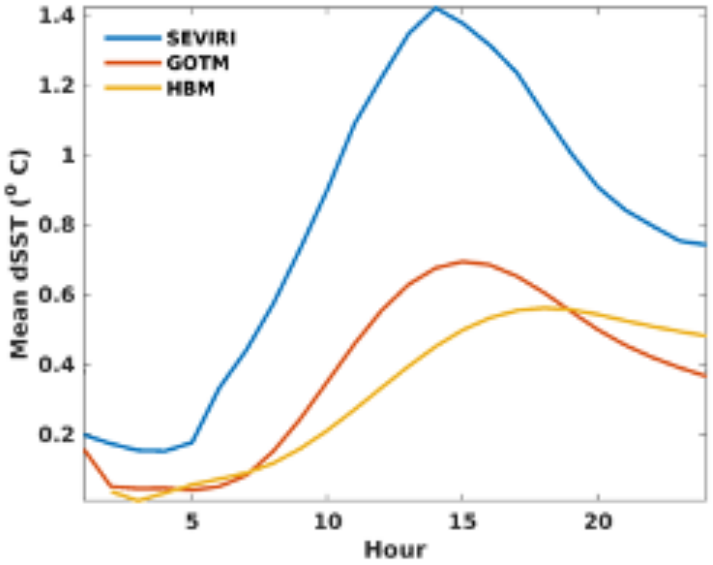
Depth (m)	Mean (°C)	Median (°C)	StD (°C)
0.0025	-0.35	-0.11	1.44
0.45	**-0.34**	**-0.09**	**1.45**
0.90	-0.34	-0.09	1.46
1.50	-0.36	-0.10	1.47
3.00	-0.41	-0.12	1.54
4.67	-0.48	-0.16	1.59
5.80	-0.67	-0.3	1.69
10.60	-1.94	-1.12	2.7

Table 3. Day-time HBM and GOTM minus SEVIRI.

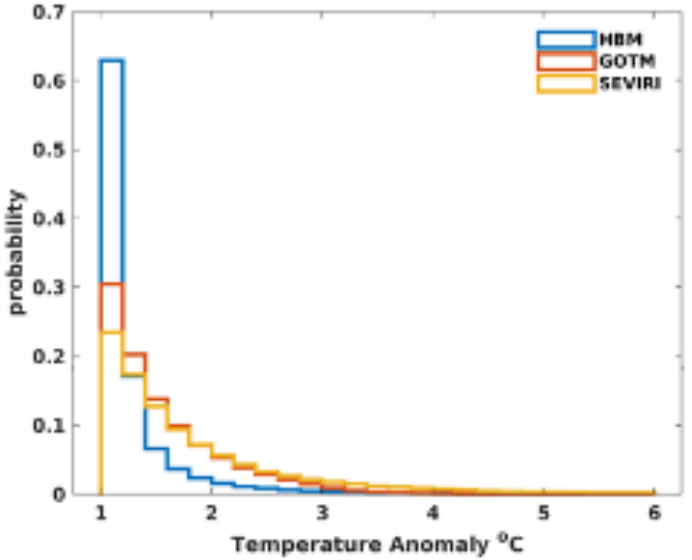
Metric	Depth (m)	HBM-SEVIRI	GOTM-SEVIRI LE8-v5.4
Mean (°C)	0	-1.17	**-0.93**
	0.5	--	-1.18
	1.0	--	-1.32
	1.5	--	-1.43
	5	-1.62	-1.79
Median (°C)	0	-0.86	**-0.72**
	0.5	--	-0.91
	1.0	--	-1.02
	1.5	--	-1.12
	5	-1.27	-1.46
StD (°C)	0	1.40	**1.31**
	0.5	--	1.36
	1.0	--	1.41
	1.5	--	1.44
	5	1.52	1.52

- HBM & GOTM similar performance compared to L4 SST at top HBM layer (Table 1).
- Deeper, GOTM fits better to L4 SST.
- GOTM-L4SST stats remained lowest and unchanged within the top 1.5 m (Table 2), suggesting the representativeness of the latter.
- GOTM fits better SEVIRI daytime observations (Table 3).

Statistics of diurnal variability



- Mean hourly diurnal cycle for SST_{hour}-SST_{found} > 0.
- GOTM reproduces shape of cycle seen by SEVIRI, peak is not resolved.
- HBM does not resolve the cycle.



- Histograms of diurnal warming > 1°C when T>18°C (algal bloom threshold).
- SEVIRI and GOTM very similar distributions of diurnal warming, occurrences above 2 degrees.
- HBM does not reproduce such distributions.

Summary and Conclusions

- GOTM used to assess its potential to resolve diurnal variability as good/better than HBM
- Mean GOTM diurnal variability amplitude approximating more SEVIRI compared to HBM, at test locations
- Good agreement with HBM when integrating GOTM, for depths of 10 m and lower (bulk SST)
- Good agreement of GOTM with L4SST, better for GOTM layers representative of 1 m
- GOTM “candidate” model supporting existing products, i.e. BAL MFC model outputs, SST L4
- “DV estimate”, i.e. hourly departure from reference field, can be provided as a new variable