Using a 1-d model to reproduce diurnal SST signals

ESA STSE Project "SSTDV: R.EX. – IM.A.M."

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1. Introduction
2. WP2. GOTM
   - T2.1 Sensitivity Tests
3. Test Cases
   - T2.2 GOTM at Point Locations
4. Conclusions

SSTDV:R.EX.-IM.A.M. Project Description

- WP1. Regional extent of diurnal warming
  - T1.1 SEVIRI vs AATSR
  - T1.2 Foundation Fields: Sensitivity Tests, Validation & Quality Control
  - T1.3 Characterization of regional diurnal warming
- WP2. The General Ocean Turbulence Model
  - T2.1 Sensitivity Tests
  - T2.2 GOTM at point locations: In Situ, SEVIRI, GOTM comparison
  - T2.3 GOTM in the North Sea/Baltic: SEVIRI, GOTM, parametrizations comparison
- WP3. SST and Atmospheric Modelling
  - T3.1 SEVIRI hourly SST in WRF
  - T3.2 WRF diurnal parametrizations
  - T3.3 Validation and error estimates (10m wind, heat fluxes)

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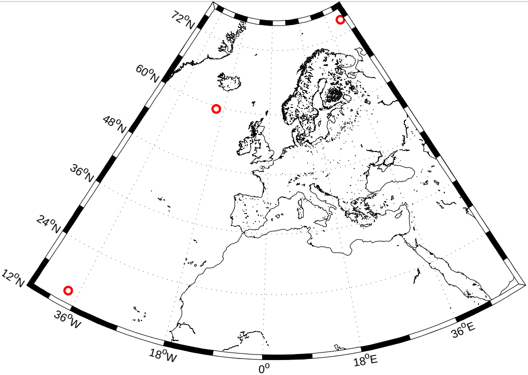
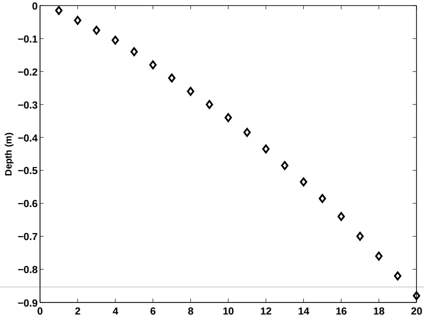
Model Description

- Basic hydro/thermodynamic processes related to vertical mixing in water column
- 1-d equations for transport of heat, momentum & salt
- Surface fluxes calculated (bulk algorithms) or prescribed
- Turbulence schemes: TKE K_ϵ, 2^{nd} order, KPP
- 2-band light absorption scheme
- 150 layers to 150 m depth
- Top 10 m: 70 layers





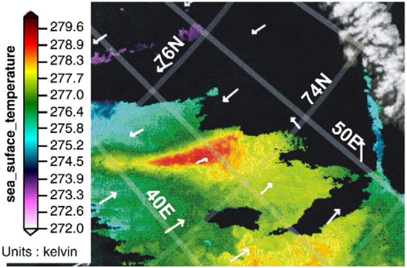
Model Options

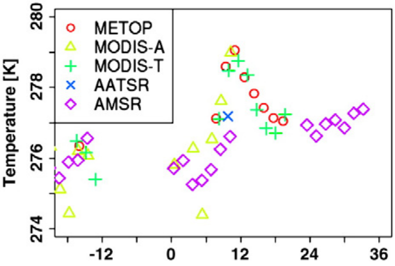
Code No	Option	Code No	Option
	1. Surface Fluxes		**6. Length Scale Method**
1	Prescribed (usually from NWP outputs)	1	Dynamic dissipation
2	Calculated (using meteorological inputs)	3	Generic Length Scale
	2. Short-wave Radiation		**7. Stability Method**
1	Prescribed (usually from NWP outputs)	5	Mellor-Yamada
2	Calculated (using meteorological inputs)	6	Kantha & Clayson (1994), full
		7	Burchard & Baumert (1995), full
		8	Kantha & Clayson (1994), quasi-equilibrium
	3. Long-Wave Radiation	9	Burchard & Baumert (1995), quasi-equilibrium
1	Clark et.al (1974)		
2	Hastenrath and Lamb (1978)		**8. Light Extinction**
3	Bignami et al. (1995)	1	2-band Jerlov-I
4	Berliand and Berliand (1952)	2	2-band Jerlov-I (upper 50 m)
5	Brunt formula,	3	2-band Jerlov-IA
	coef Grant & Hignett (1998)	4	2-band Jerlov-IB
6	Prescribed by user	5	2-band Jerlov-II
	4. Type of Turbulence Closure	6	9-band with attenuation lengths,
1	TKE & length scale		proportional coeff. Paulson & Simpson (1981)
2	2^{nd} order model	7	9-band att. length Paulson & Simpson (1981),
3	KPP model		coeff. COART model
	5. Method for TKE	8	9-band att. length Paulson & Simpson (1981),
1	$k\epsilon$		coeff. MODTRAN model
2	Mellor-Yamada		

Arctic

Barrents Sea DW
(Eastwood et al.,2008)

- 74.4 N – 44.5 E, 20–22 June 2008
- Profiles: WOA09, MetNo (top T level adjusted)
- Heat & Momentum Fluxes:
  - Calculated: HIRLAM (10m wind, P_{air}, T_{air}, Humidity, Cloud Cover)
  - Prescribed: Heat Flux, Momentum Flux estimated from HIRLAM (MetNo)





T Profiles, Light Extinction Schemes

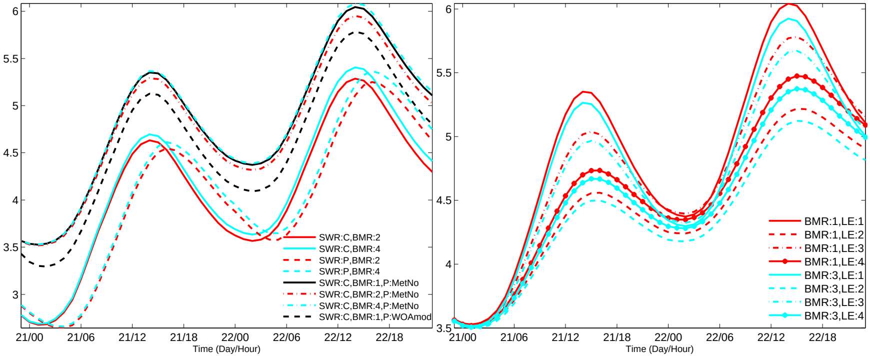


Figure: GOTM top layer temperature evolution for different set-ups using T profiles from WOA09 & MetNo (left) and different light extinction schemes (right).

Code Modifications

- 9 band light absorption scheme
- New parametrisation for incoming long-wave radiation
- Option to prescribe incoming long-wave radiation
- Stability functions

```
select case (extinct_method)

   case (1,2,3,4,5,6,7)
      !     compute short wave radiation...this is modified to *oa/(rho_0*cp)
      rad(i)=(I_0)*(A*exp(-z/g1)+(1.-A)*exp(-z/g2)*bioshade(i+1))  !*oa/(rho_0*cp)

   case (8,12,13)
      if (cosr > 0.0) then
         do j=1,9
            absfac_dir=absfac_dir+fsen(j)*exp(-z/(zdeta(j)*cosr))
            absfac_diff=absfac_diff+fsen(j)*exp(-z*(5.0/3.0)/(zdeta(j)))
         end do
      else
         absfac_dir = 0.
         absfac_diff = 0.
      end if

      rad(i)=(I_0)*(((absfac_dir*qdir_frac)+(absfac_diff*qdiff_frac))*bioshade(i+1))
      absfac_dir=0.
      absfac_diff=0.
```

```
      case(brunt)
!        Brunt type with coefficients from Grant and Hignett, 1998
         ccf=.8
         x1=(1.0-ccf*cloud)
         x2=(ta**4) * (0.24+4.33*sqrt(qa))    ! downwelling longwave radiation according to Grant and Hignett, 1998
parameters
         !qb=-bolz*emiss*((tw**4) - x2)*x1
         qb=bolz*emiss*(0.24+4.33*sqrt(qa))*x1
      case(from_file)
         qb=-emiss*(bolz*(tw**4) -  dlr)
      case default
   end select

   return
   end subroutine back_radiation
```

```
select case(stab_method)
   case(Constant)
      cmue1=cm0_fix
      cmue2=cm0_fix/Prandtl0_fix
   case(MunkAnderson)
      call cmue_ma(nlev)
   case(SchumGerz)
      call cmue_sg(nlev)
   case(EiflerSchrimpf)
      call cmue_rf(nlev)
   case(MellorYamada)
      call cmue_my(nlev)
   case(KanClay)
      call cmue_kc(nlev)
   case(BurBaum)
      call cmue_bb(nlev)
   case(KanClayQe)
      call cmue_kcqe(nlev)
   case(BurBaumQe)
      call cmue_bbqe(nlev)
   case default
```

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Marine Light–Mixed Layer Experiment '91

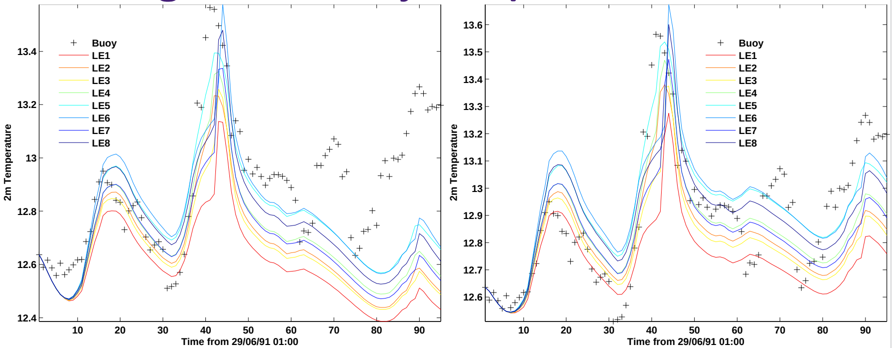


Table: Calculated (left) vs prescribed down-welling long-wave radiation (right) & LE schemes (coloured lines).

Code (02010401010108-)	μ	σ	r	**Code (02010601010108-)**	μ	σ	r
01 (2-band)	-0.29	0.23	0.41	01 (2-band)	-0.15	0.18	0.71
02	-0.23	0.22	0.53	02	-0.07	0.15	0.81
03	-0.25	0.22	0.51	03	-0.10	0.16	0.78
04	-0.19	0.20	0.59	04	-0.04	0.14	0.83
05	-0.11	0.19	0.66	05	0.05	0.13	0.85
06 (9-band)	-0.10	0.21	0.59	06 (2-band)	0.05	0.16	0.76
07	-0.20	0.22	0.53	07	-0.05	0.16	0.76
08	-0.14	0.21	0.59	08	0.01	0.16	0.77

MLML91: GOTM—Buoy

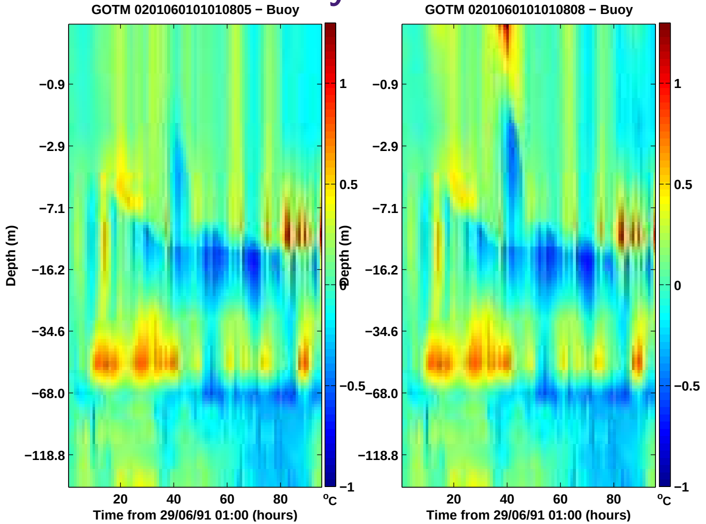
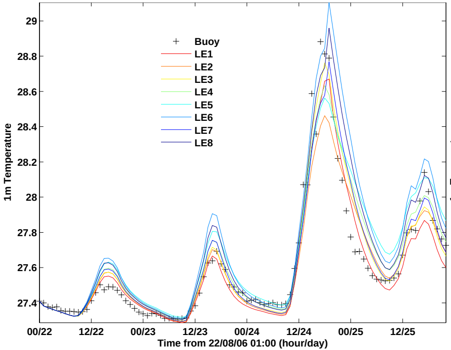


Figure: GOTM—Buoy temperature difference: 2-band (left) vs 9-band (right) model.

PIRATA Buoy 15°N, 38°W



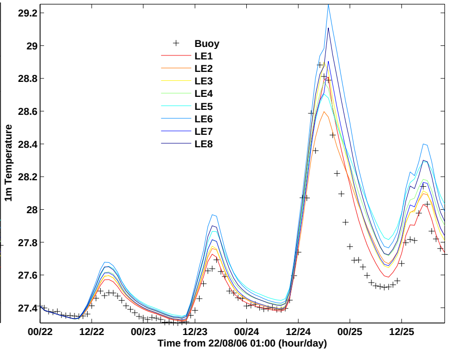


Table: Calculated (left) vs prescribed down-welling long-wave radiation (right).

Code (02010401010108-)	μ	σ	r	Code (02010601010108-)	μ	σ	r
01 (2-band)	-0.03	0.08	0.97	01 (2-band)	0.05	0.09	0.97
02	-0.01	0.11	0.96	02	0.06	0.12	0.94
03	0.01	0.08	0.97	03	0.09	0.11	0.96
04	0.03	0.10	0.96	04	0.11	0.13	0.95
05	0.07	0.13	0.93	05	0.15	0.16	0.92
06 (9-band)	0.11	0.15	0.95	06 (9-band)	0.19	0.19	0.94
07	0.02	0.10	0.96	07	0.09	0.13	0.95
08	0.07	0.12	0.95	08	0.15	0.16	0.96

PIRATA: SEVIRI vs GOTM

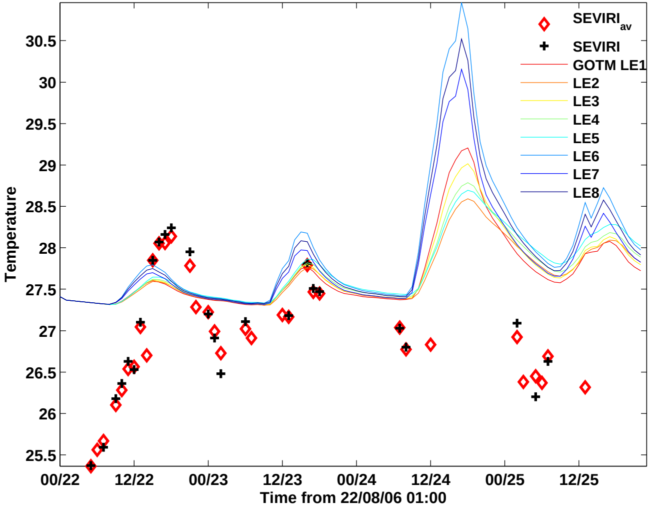


Figure: GOTM 1.5cm layer versus SEVIRI

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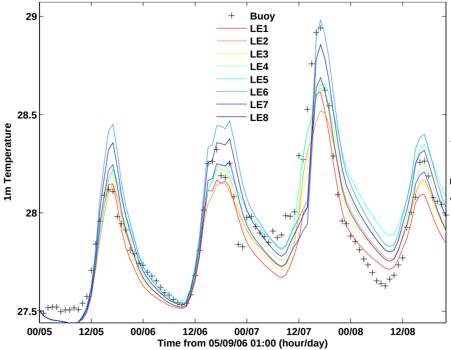
PIRATA Buoy 15°N, 38°W



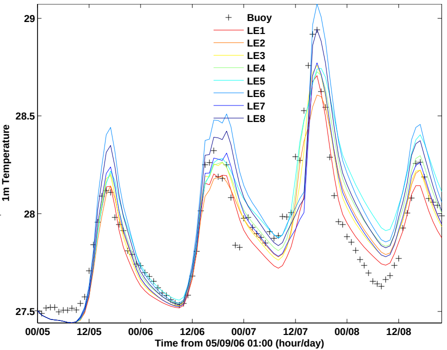


Table: Calculated (left) vs prescribed down-welling long-wave radiation (right).

Code (02010401010108-)	μ	σ	r	Code (02010601010108-)	μ	σ	r
01 (2-band)	-0.08	0.11	0.94	01 (2-band)	-0.05	0.11	0.94
02	-0.04	0.12	0.93	02	-0.01	0.12	0.92
03	-0.03	0.11	0.94	03	0.00	0.11	0.94
04	0.00	0.12	0.93	04	0.03	0.12	0.93
05	0.05	0.14	0.90	05	0.08	0.15	0.90
06 (9-band)	0.08	0.16	0.90	06 (9-band)	0.11	0.17	0.90
07	-0.03	0.13	0.91	07	0.00	0.13	0.91
08	0.03	0.14	0.91	08	0.07	0.15	0.91

PIRATA: SEVIRI vs GOTM

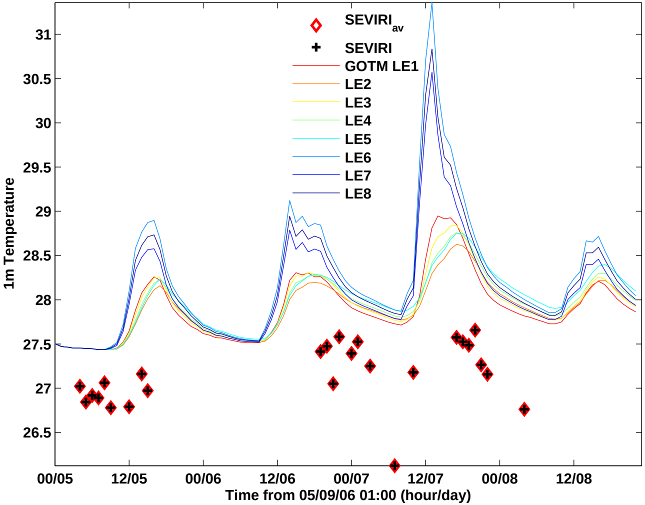
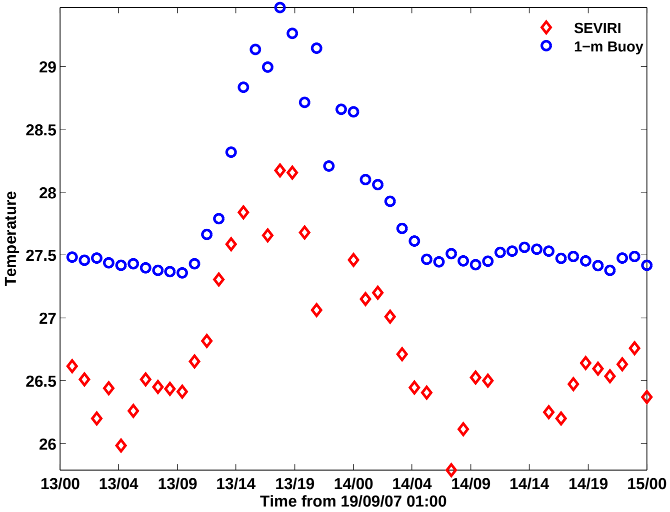


Figure: GOTM 1.5cm layer versus SEVIRI

PIRATA


SEVIRI
1−m Buoy
Temperature
29
28.5
28
27.5
27
26.5
26
13/00
13/04
13/09
13/14
13/19
14/00
14/04
14/09
14/14
14/19
15/00
Time from 19/09/07 01:00

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2 WP2. GOTM

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Summary & Conclusions

- GOTM reproduces the daily cycle reasonably well
- Full temperature profile controls amplitude, not only the top layer
- LE schemes can induce temperature differences $\sim 1^\circ$
- BRM parametrisations can induce temperature differences ~ 0.1–0.2°
- Prescribing DLR does not always improve statistics (so far)
- Full measured datasets (ocean+meteo variables) required!

Thank you

Questions?