README for Zenodo data publication
„nextGEMS: Output of the WP6 ocean vertical mixing sensitivity runs (timeseries)"

1. Information on the model runs

In Work Package 6 of the nextGEMS project (https://nextgems-h2020.eu/) we did coordinated sensitivity runs with two ocean models: FESOM (Danilov et al., 2017; Scholz et al., 2019; 2022) and ICON-O (Korn et al., 2022). We changed the vertical mixing scheme as well as its parameters, to see the effect on the representation of the upper tropical Atlantic Ocean in the models.

The two vertical mixing schemes that we tested in both models are the TKE scheme (Gaspar et al., 1990) and the KPP scheme (Large et al., 1994), with implementations based on the Community Ocean Vertical Mixing package (CVMix). In the TKE scheme, we varied the c_k parameter (cf. Equation 10 in Gaspar et al., 1990). In the KPP scheme, we varied the critical bulk Richardson number (cf. Equation 21 and its description in Large et al., 1994), which is often set to 0.3, but should approach the critical gradient Richardson number of 0.25 with increasingly fine vertical resolution. Additionally, we did some test runs with different modifications of the TKE scheme only with ICON-O. One of them has an additional parameterisation of Langmuir turbulence (Axell, 2002). Two runs have an enhanced background mixing: one of them by increasing the minimum background TKE, and the other by setting a minimum background diffusivity and viscosity as it is done in KPP. The last of the ICON-O runs has the FESOM default set of forcing bulk formulae instead of the ICON-O default, to test the effect of this difference between the two models' setups. For ERA5 forcing, the ICON-O default is the bulk formulae from Kara et al. (2002) over ocean and sea ice, and the water vapour pressure and specific humidity computation following Buck (1981) and long wave radiation following Berliand (1952). FESOM, on the other hand, uses the bulk formulae from Large et al. (2009) over the ocean and Tsujino et al. (2018) over sea ice, which are also implemented in ICON-O but usually not used together with ERA5 forcing.

Table 1: Overview of all available model runs

Name of the run	Mixing scheme	c_k	Ri_crit	Minimum background TKE	Minimum background diffusivity/ viscosity	Forcing bulk formulae	Langmuir
FESOM_KPP_027	KPP	-	0.27	-	10^-5/10^-4	FESOM	-
FESOM_KPP_030	KPP	-	0.3	-	10^-5/10^-4	FESOM	-
FESOM_TKE_01	TKE	0.1	-	10^-6	-	FESOM	-
FESOM_TKE_02	TKE	0.2	-	10^-6	-	FESOM	-
FESOM_TKE_03	TKE	0.3	-	10^-6	-	FESOM	-
ICON_KPP_027	KPP	-	0.27	-	10^-5/10^-4	ICON	-
ICON_KPP_030	KPP	-	0.3	-	10^-5/10^-4	ICON	-
ICON_TKE_01	TKE	0.1	-	10^-6	-	ICON	-
ICON_TKE_02	TKE	0.2	-	10^-6	-	ICON	-

Name of the run	Mixing scheme	c_k	Ri_crit	Minimum background TKE	Minimum background diffusivity/ viscosity	Forcing bulk formulae	Langmuir
ICON_TKE_03	TKE	0.3	-	10^-6	-	ICON	-
ICON_TKE_02_Langmuir	TKE	0.2	-	10^-6	-	ICON	yes
ICON_TKE_02_minKv	TKE	0.2	-	10^-6	10^-5/10^-4	ICON	-
ICON_TKE_02_minTKE	TKE	0.2	-	10^-5	-	ICON	-
ICON_TKE_02_ncarbf	TKE	0.2	-	10^-6	-	FESOM	-

Some common settings for all model runs:
The horizontal resolution is approximately 10km (globally for ICON-O, coarser in the extratropics for FESOM). The vertical resolution is the same in all model runs, increasing from 2m close to the surface to approximately 200m at depth, with 128 levels in total. All data have been regridded to a regular longitude-latitude horizontal grid with 0.1° x 0.1° resolution. Only selected locations and only the upper 200m of the water column are included in the published dataset, which corresponds to the first 40 model levels.
All model runs are started in January 2014, and run to the end of 2015. This time period was chosen due to specific research interests and the availability of certain observational data in 2015. The models have been spun up for a few years before branching off the sensitivity runs in 2014, so that they are not started from rest. The output frequency of the published data is 3-hourly, to enable comparison to high-frequency observational data of short-term mixing events, such as the diurnal cycle or near-inertial waves.
All model runs have been forced with hourly ERA5 data (Hersbach et al., 2020). However, as described above, the default bulk formulae to derive the fluxes from the forcing fields are different between ICON-O and FESOM.
For more details please contact the authors.

2. Data

We provide time series of the model output at specific locations in the tropical Atlantic. These locations were chosen because there are observational data available at the same locations in the simulated time period, e.g from PIRATA buoys or moorings.

A list of the variable names and corresponding standard names, as well as the internal experiment names for ICON, is given in Tables 2 and 3 at the end of this document.

3. Please note…

Missing files/variables:
- All KPP runs do not have the variable TKE (because it is not calculated in the model if the TKE scheme is switched off).
- In FESOM_KPP_030, the year 2014 is missing for the variables MLD1 and MLD2 (mixed layer depth).
- In ICON_TKE_02_ncarbf, the variable rhopot (potential density) is missing.

- In ICON_KPP_030, December 2015 is missing for all variables because the model became unstable.

4. References

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Table 2: Internal experiment names for ICON

Name of the run	Internal experiment name (in the file names)
ICON_KPP_027	kpp0003
ICON_KPP_030	kpp0002
ICON_TKE_01	ck0001
ICON_TKE_02	0001
ICON_TKE_03	ck0002
ICON_TKE_02_Langmuir	langmuir0001
ICON_TKE_02_minKv	kappamin0001
ICON_TKE_02_minTKE	tkemin0001
ICON_TKE_02_ncarbf	ncarbf0001

Table 3: Variable names

Variable standard name	Name in ICON	Name in FESOM
air_pressure_at_mean_sea_level	sea_level_pressure	
fresh water flux due to runoff	FrshFlux_Runoff	
lwe_precipitation_rate	FrshFlux_Precipitation	
lwe_water_evaporation_rate	FrshFlux_Evaporation	
ocean_mixed_layer_thickness	mld/mlotst	MLD1/MLD2
ocean_vertical_heat_diffusivity	A_tracer_v_to	Kv
ocean_vertical_momentum_diffusivity	A_veloc_v	Av
richardson_number_in_sea_water	Richardson_Number	Ri
sea_water_potential_density	rhopot	
sea_water_sigma_theta		dens
sea_water_potential_temperature	to	temp
sea_water_practical_salinity	so	salt
sea_water_x_velocity	u	unod
sea_water_y_velocity	v	vnod
specific_turbulent_kinetic_energy_of_sea_water	tke	tke

Variable standard name	Name in ICON	Name in FESOM
squared vertical shear of horizontal velocity	local_squaredshear	shear
square_of_brunt_vaisala_frequency_in_sea_water	local_Nsquared	N2
surface_downward_eastward_stress	atmos_fluxes_stress_xw	tx_sur
surface_downward_northward_stress	atmos_fluxes_stress_yw	ty_sur
surface_downward_heat_flux_in_air	HeatFlux_Total	
surface_upward_heat_flux_in_air		fh
surface_downward_latent_heat_flux	HeatFlux_Latent	
surface_downward_sensible_heat_flux	HeatFlux_Sensible	
surface_downward_water_flux	FrshFlux_TotalOcean	
surface_downwelling_longwave_flux	HeatFlux_LongWave	
surface_downwelling_shortwave_flux	HeatFlux_Shortwave	
upward_sea_water_velocity	w	w
wind_speed	Wind_Speed_10m	
(Long name: zstar surface stretch at cell center)	stretch_c	
sea_surface_temperature		sst
sea_surface_salinity		sss
sea_surface_height		ssh