Adaptation of the vertical resolution in the mixed layer for HYCOM

By Cécile Renaudie (Météo France/SHOM)

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LOM 2009, Miami, Florida
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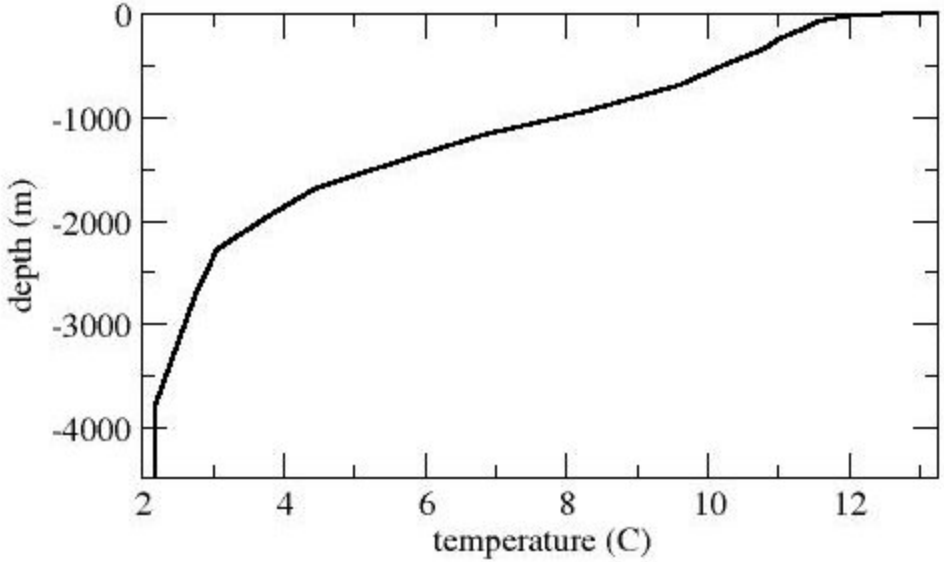
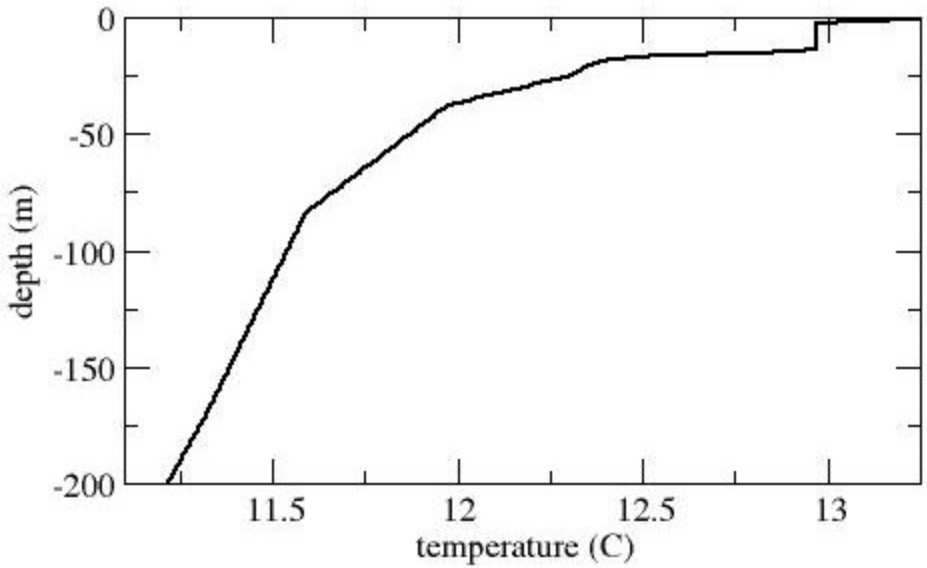
Initial conditions





- Profile of temperature at the beginning of the simulation and zoom over the first 200m
- Representative of a winter stratification in the north eastern Atlantic ocean at mid-latitude
- 1m resolution
- Only the forcings, KPP and hybgen are activated

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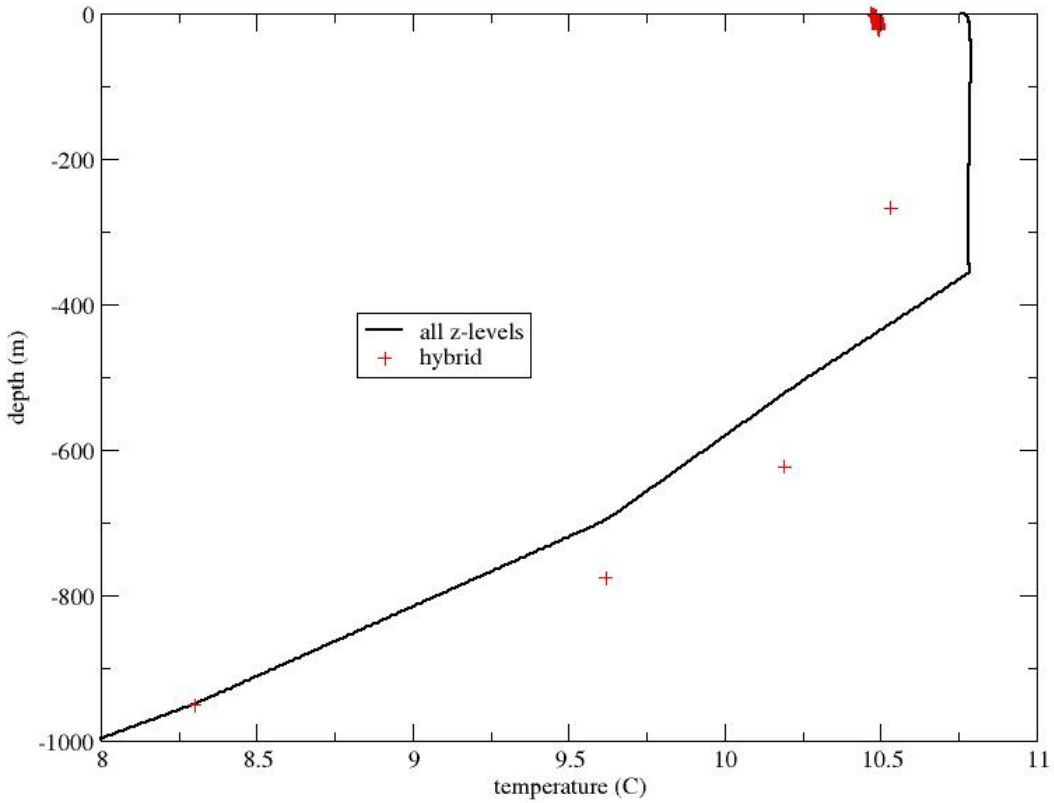
The problem

- Parameters used to define z-levels in HYCOM :
- h_1 (dp00): minimum thickness of the first layer;
- h_{max} (dp00x): z-level spacing maximum thickness;
- stretch (dp00f): stretching factor.



- Simulation during 20 days
- Forcings :
  - wind=20 m/s;
  - air temperature=1°C;
  - net radiative flux=0W/m2
- 32 hybrid layers
- h_1 =1.01m, h_{max} =1.41, stretch=1.04

→ Difference in SST: 0.3°C!

→ The mixed layer is poorly represented

Solution: Adaptive vertical resolution

• Determination of the mixed layer depth h_{mix} : depth at which a change from the surface density of 0.025 kg/m^3 has occurred.
If mixed layer=1 layer, it is extended to the last z-level from the previous time step, N_z=number of z-levels;

• Calculation of the coefficients :

- if $h_{mix} < 20$ m : $h_1 = 1.01$ m, otherwise $h_1 = 3$ m.
- stretch is determined to verify the equation:

$$h_{mix} = h_1 \frac{1 - stretch^{N_z}}{1 - stretch}$$

- hmax=500m.

• Filtering : to avoid strong modifications of the vertical grid

$$h_1^{n+1} = (1-\alpha) \times h_1^n + \alpha \times h_1$$

and $stretch^{n+1} = (1-\alpha) \times stretch^n + \alpha \times stretch$ with $\alpha = \frac{dt}{K}$

K=10000s, dt=100s

Experiments and atmospheric forcings

Experiments	Number of layers	Vertical coordinate	h_1 (m)	h_{max} (m)	stretch
EXP-REF	4476	z	1.00	1.00	1.00
EXP-CNA	32	hybrid	1.01	1.41	1.04
EXP-CG	32	hybrid	3.00	500.	1.18
EXP-A	32	hybrid	adaptive	adaptive	adaptive

Case	Air temperature (°C)	Wind (m/s)	Net radiative flux (W/m2)	Short-wave flux (W/m2)	Number of days
Convective	1	20	0	50	20
Wind-mixing	15	20	200	250	20
Realistic	ARPEGE	ARPEGE	ARPEGE	ARPEGE	366

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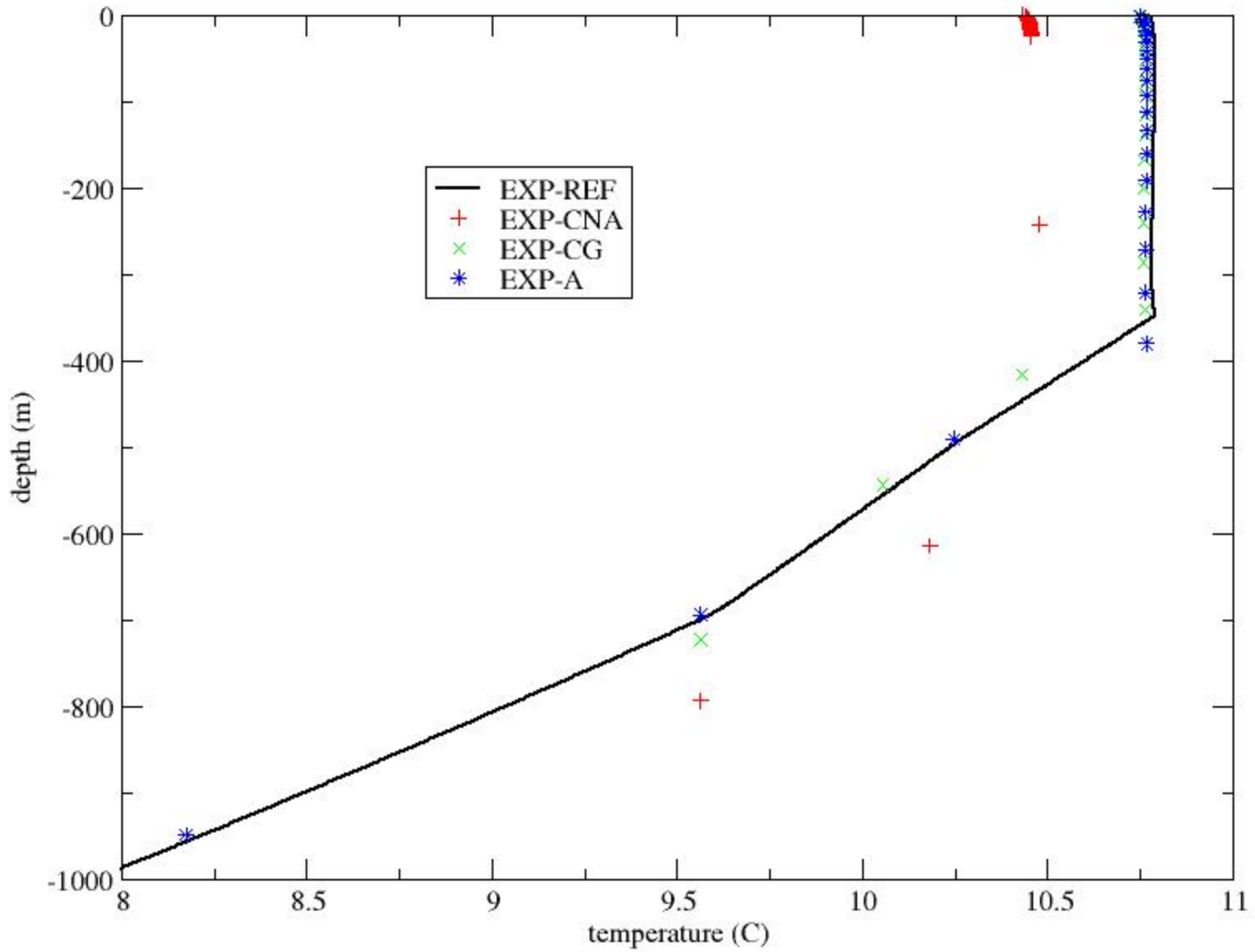
Results for the convective case after 20 days



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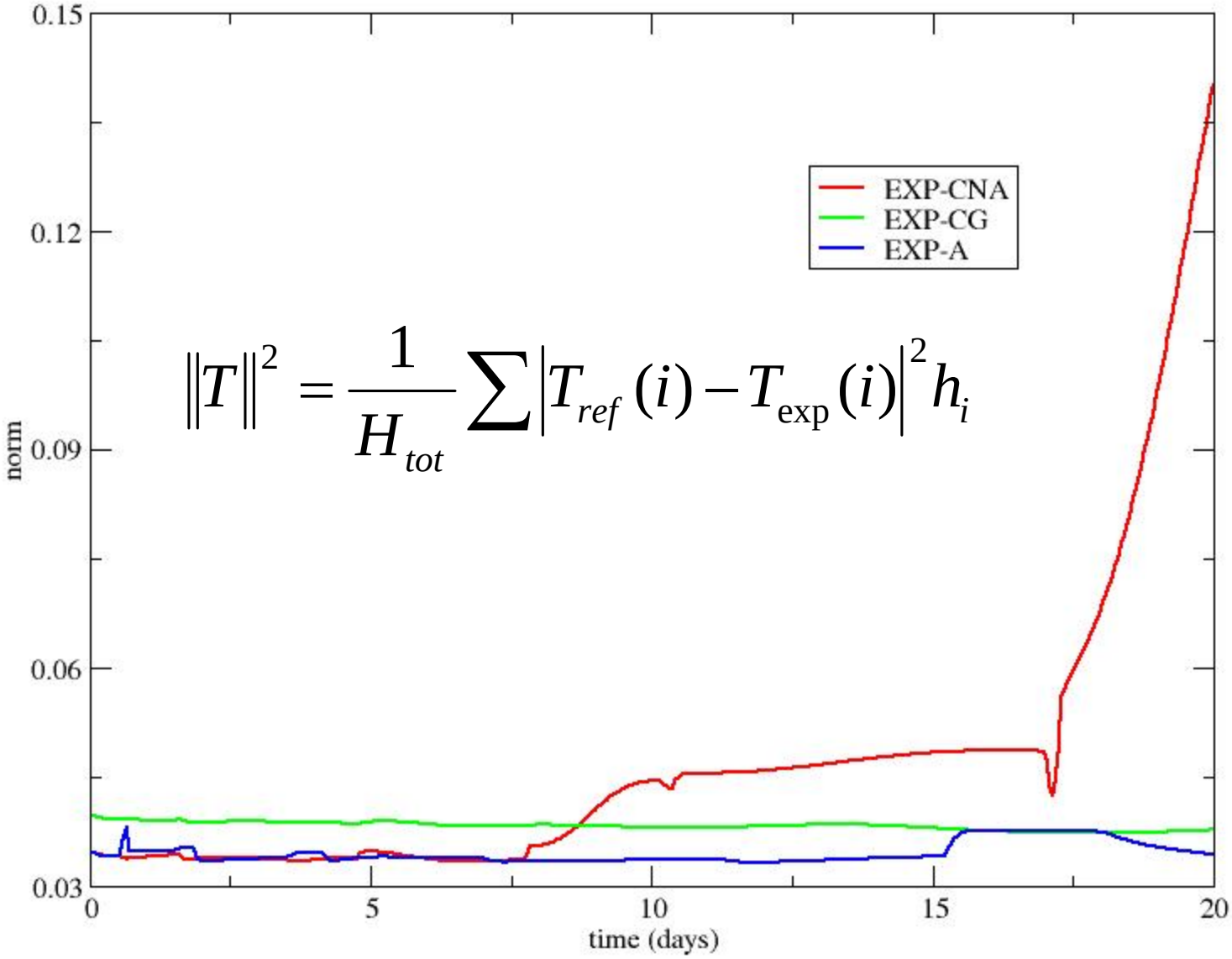
Results for the convective case throughout time



$$\|T\|^2 = \frac{1}{H_{tot}} \sum \left| T_{ref}(i) - T_{\exp}(i) \right|^2 h_i$$

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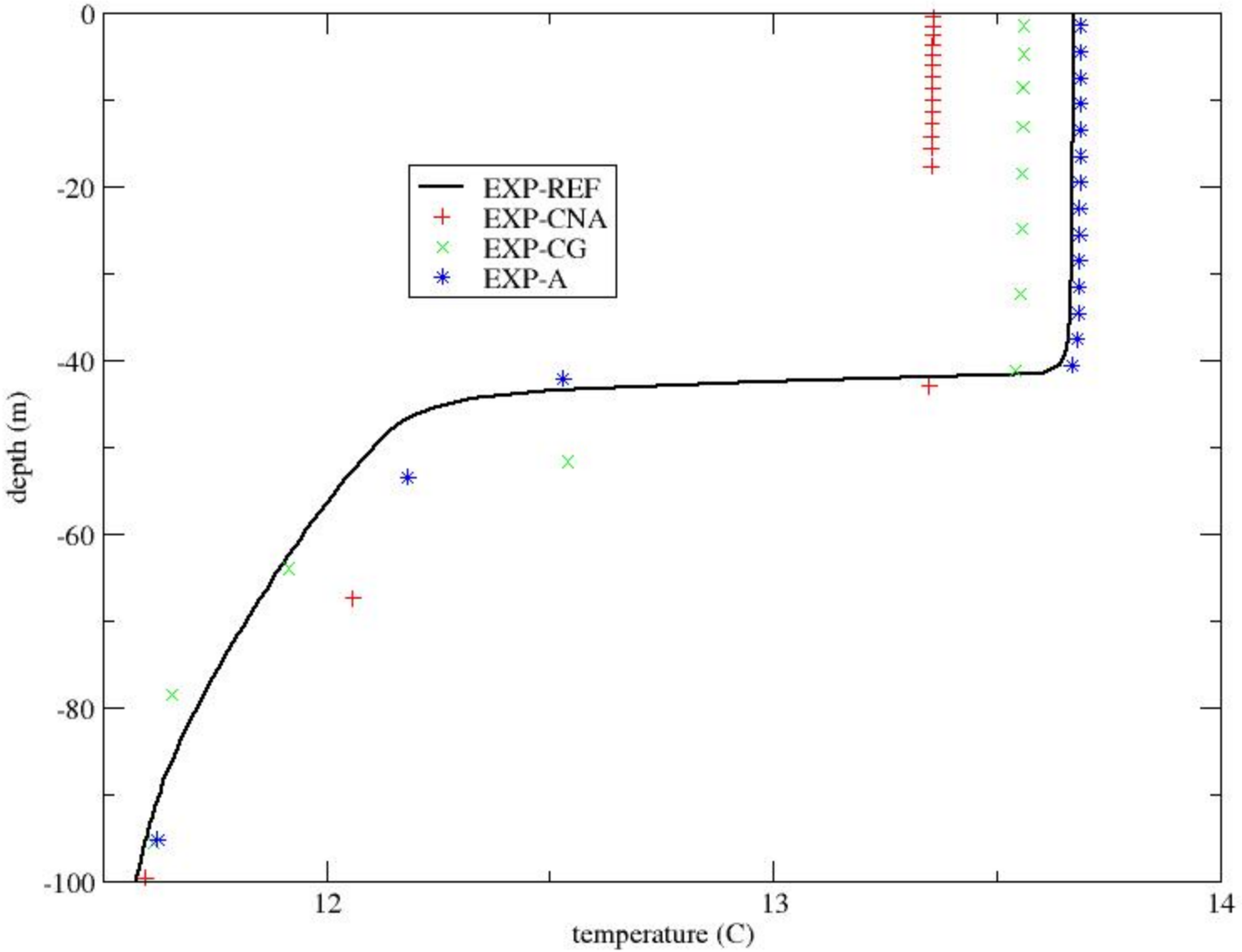
Results for the wind-mixing case after 20 days



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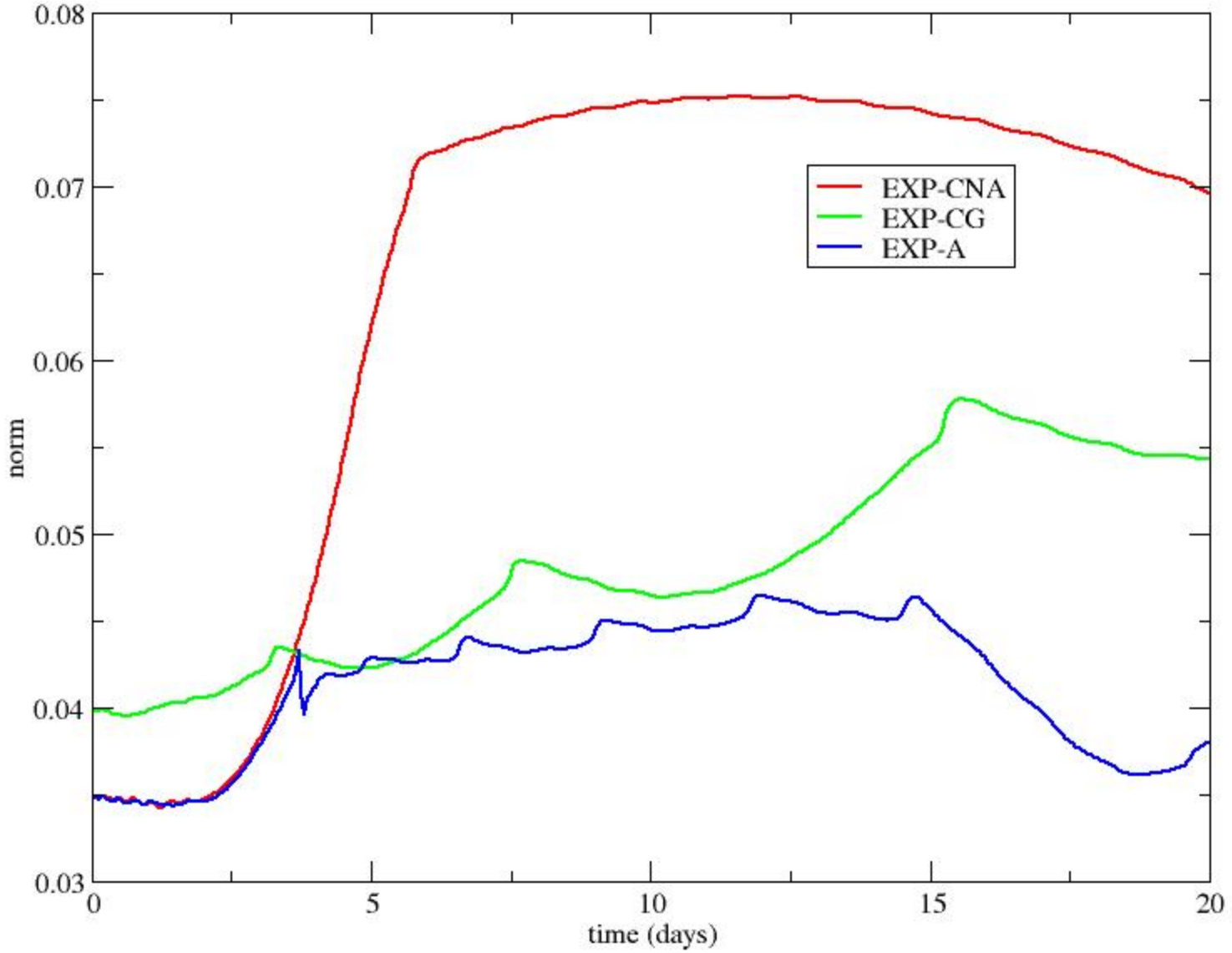
Results for the wind-mixing case throughout time



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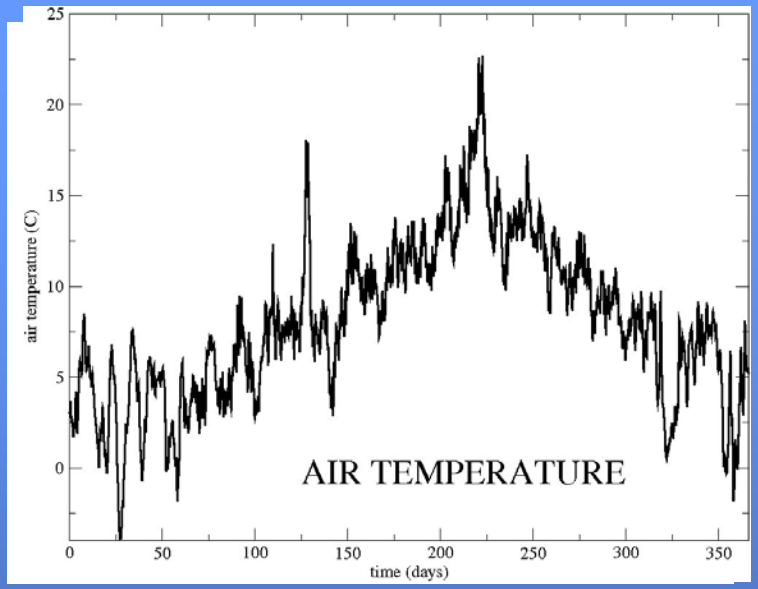
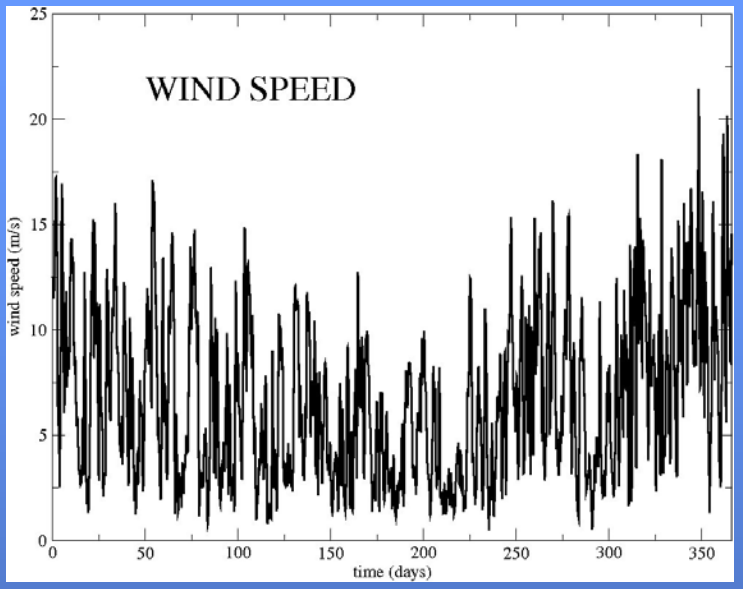
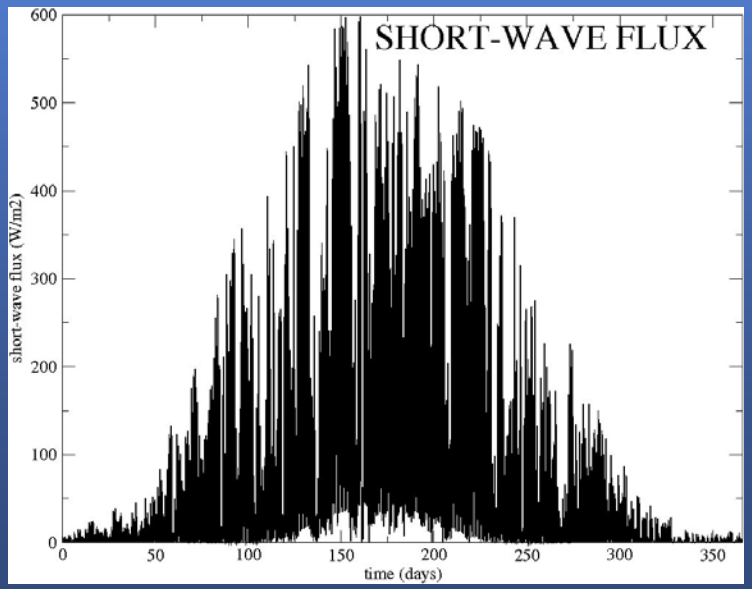
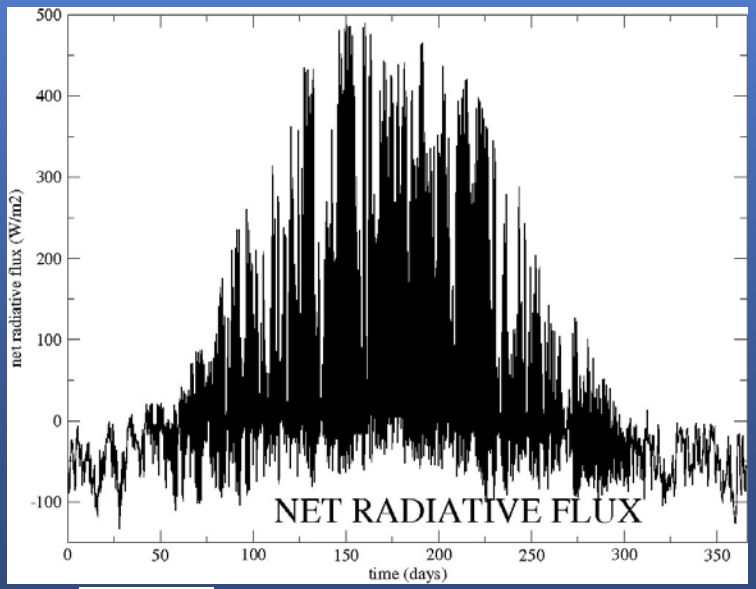
The realistic case









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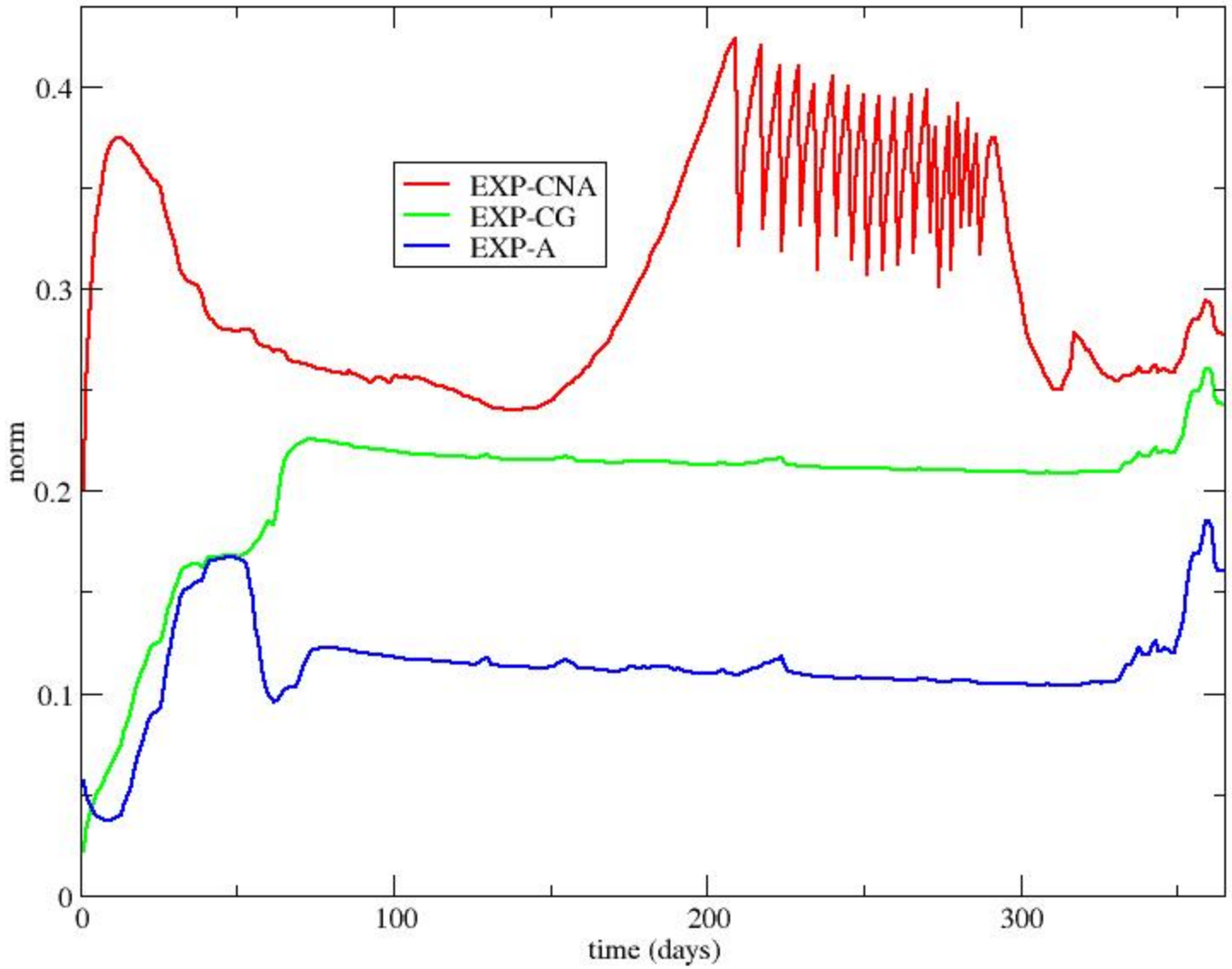
Results for the realistic case throughout time



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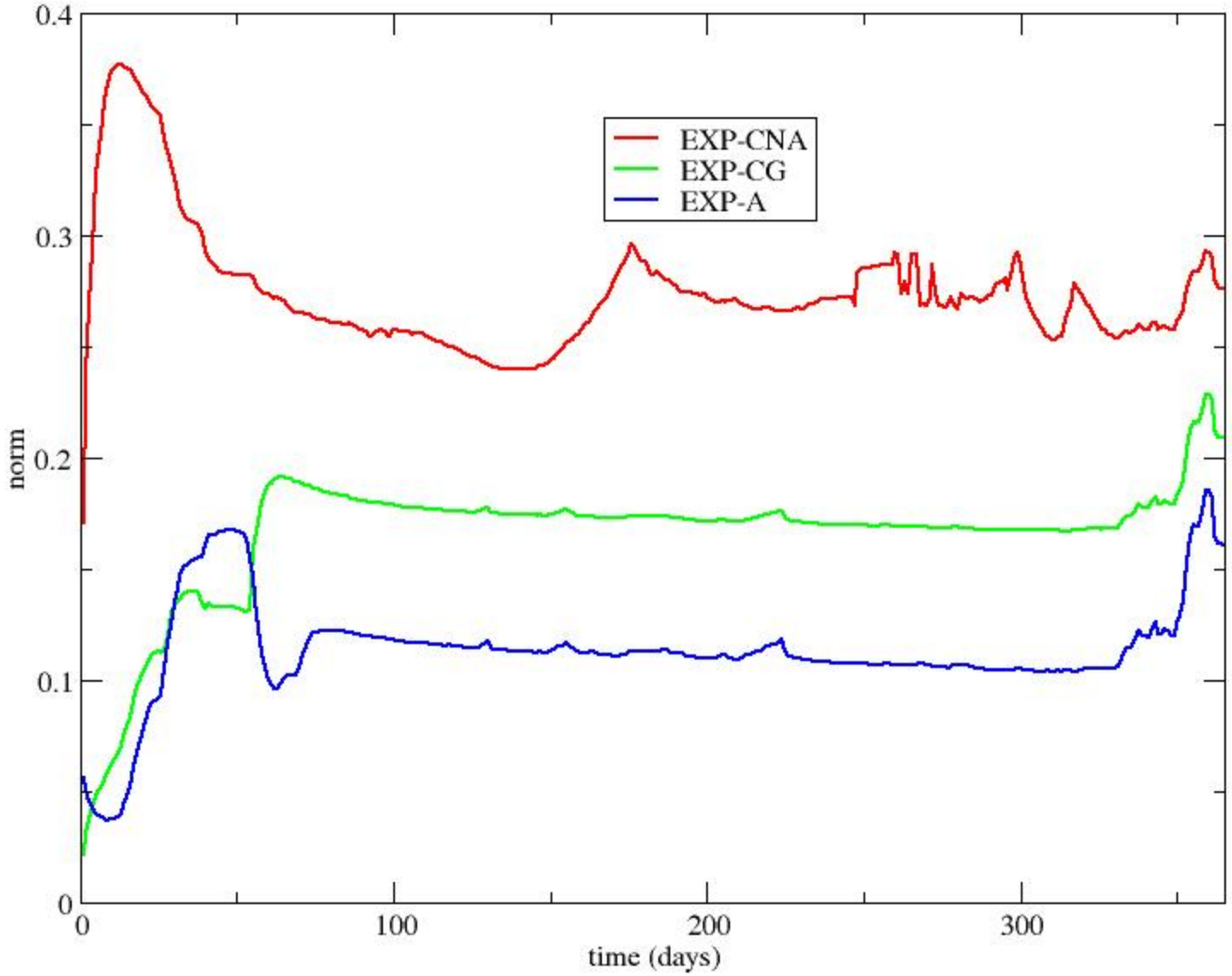
PLM/PPM



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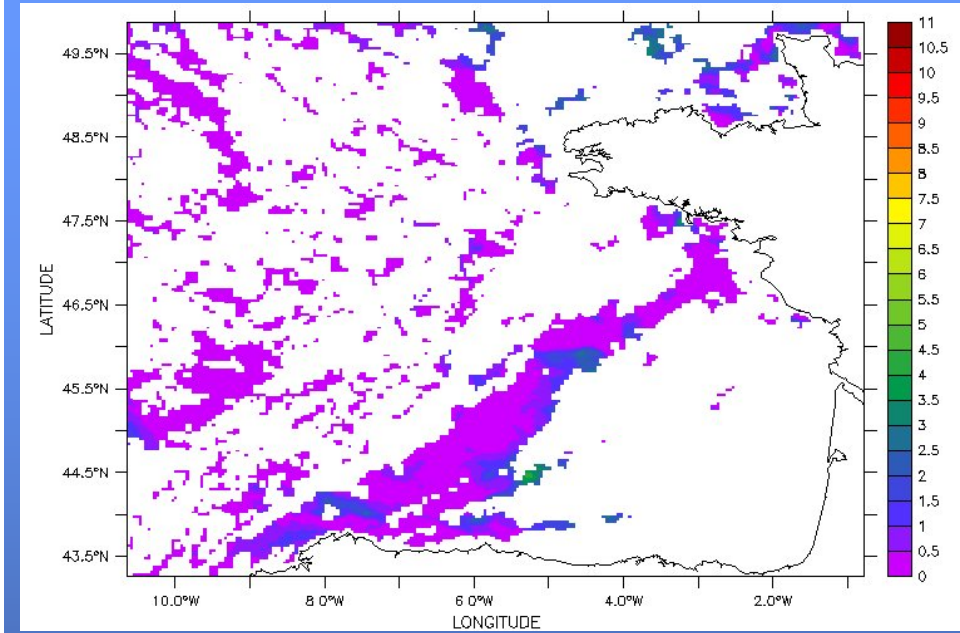
Conclusions

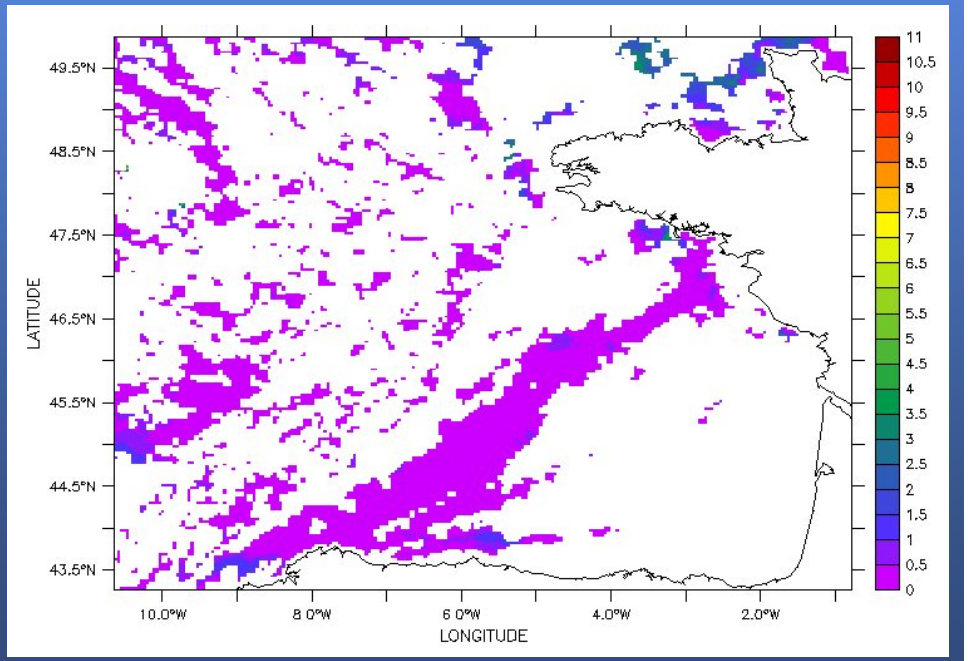
- EXP-CNA : poor representation of the mixed layer as it deepens, growing error in SST and in mixed layer structure;
- EXP-CG : better solution in convective cases, but not adapted to shallow mixed layers;
- EXP-A : improves the distribution of geopotential levels in the mixed layer;
- Still some improvements to make :
  - Sensitivity to mixed layer definition;
  - Sensitivity to the damping rate : it could depend on the forcings;
  - 2 and 3 dimensions : still some problems with boundary conditions.

First results in 3D

EXP-CNA



EXP-A



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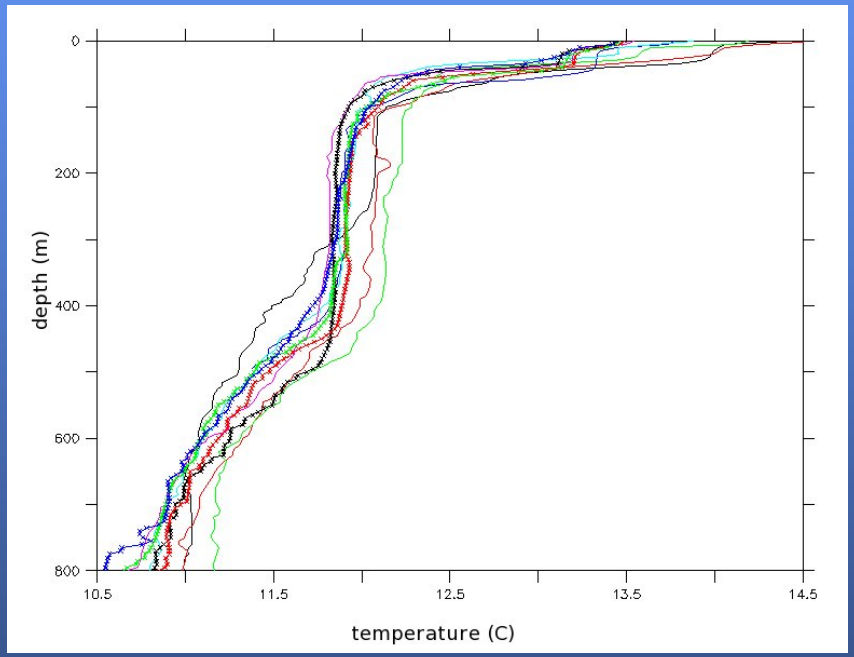

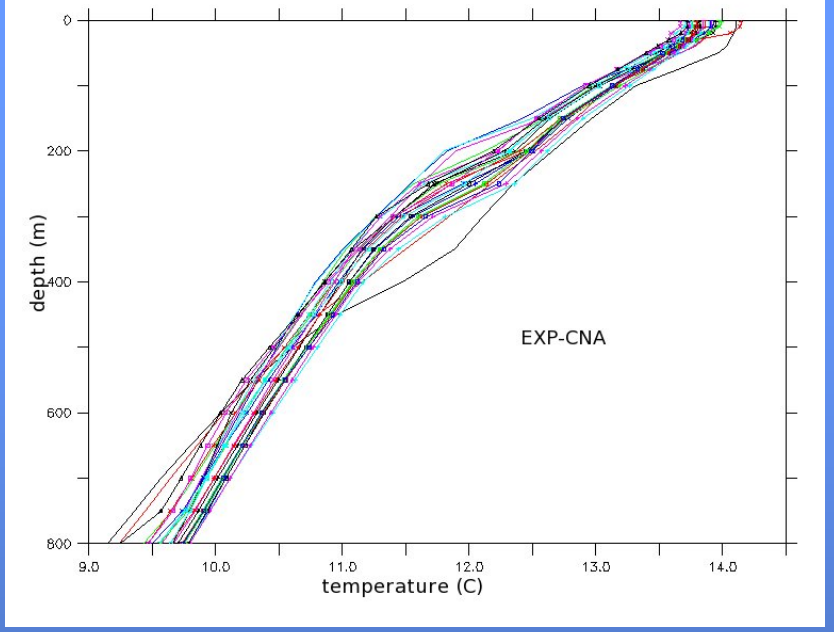

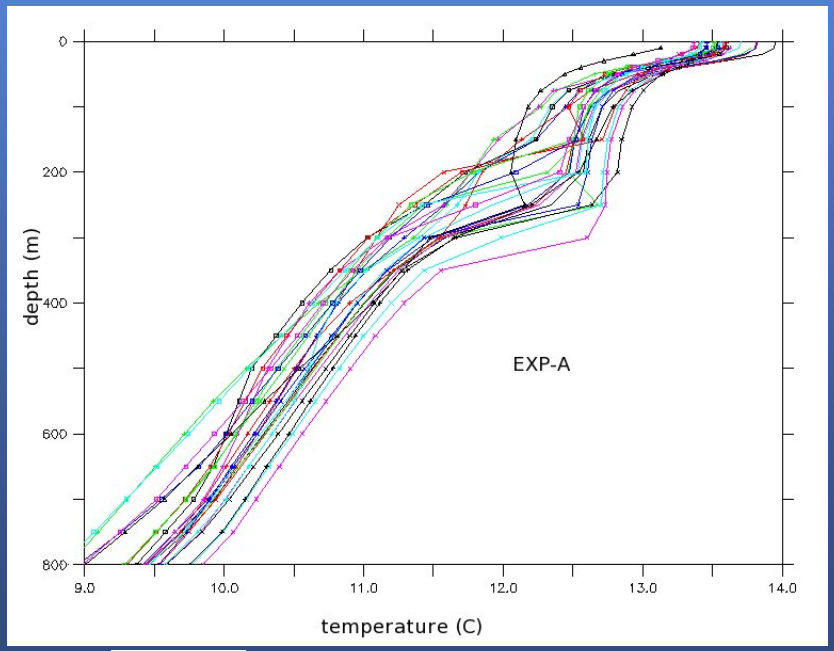

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