Vertical mixing in the PE Model

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Vertical Mixing

In the PE model, the basic vertical mixing scheme is controlled by the following input card:

```
6    AIDIF  FKPM  VVCLIM   WVMIX  FRICMX  FKPH   VDCLIM   WDMIX
     1.0    5.0   1.0E+3    50.0   50.0    0.5   1.0E+3    50.0
```

These parameters are used in a multistage process to set vertical viscosity/diffusivity.

Default

(1) Set the local vertical viscosity to `FKPM` and the local vertical diffusivity to `FKPH`.

(2) Determine the local mixed layer depth[1]. In PE levels shallower than the mixed layer, the local vertical viscosity is overwritten with `WVMIX` and the local vertical diffusivity is overwritten with `WDMIX`.

(3) Examine the local vertical gradient in potential density. Where the gradient is nonnegative (unstable density gradient), the local vertical viscosity is overwritten with `VVCLIM` and the local vertical diffusivity is overwritten with `VDCLIM`.

Pacanowski and Philander[2]

(1) Compute the local Richardson number at velocity points, $R_i^{(v)}$, and at tracer points, $R_i^{(t)}$.

If $R_i^{(v)} \le 0$,
  Set the local vertical viscosity to `VVCLIM`.
Otherwise,
  Set the local vertical viscosity to `FKPM` + $\frac{1}{\left(1+5R_i^{(v)}\right)^2}$`FRICMX`.

If $R_i^{(t)} \le 0$,
  Set the local vertical diffusivity to `VDCLIM`.
Otherwise,
  Set the local vertical diffusivity to
  `FKPH` + $\frac{1}{\left(1+5R_i^{(t)}\right)}$ (`FKPM` + $\frac{1}{\left(1+5R_i^{(t)}\right)^2}$`FRICMX`).

(2-3) Same as in *Default* case

The vertical coefficients are used in a semi-implicit vertical mixing scheme with weight `AIDIF`. `AIDIF`=0 leads to explicit vertical mixing and `AIDIF`=1 yields fully implicit vertical mixing.

Mixed Layer Depth

In the PE model, the calculation of the "mixed layer depth" is controlled by the following input card:

```
7    MLDOPT  MLDVAL   MLDMIN   MLDMAX   EKFAC  WSDFAC
        0    3.0E+3    0.0    1.0E+5    0.7   0.0004
```

The method of computing the "mixed layer depth" is controlled by the parameter `MLDOPT`.

`MLDOPT`=0

The mixed layer depth is held to a constant value of `MLDVAL`.

`MLDOPT`=1

[1] Note: the mixed layer depth referred to here is not a true mixed layer depth, but rather a surface layer with enhanced vertical mixing.

[2] Requires the C-Preprocessing option `-Dppvmix`.

The mixed layer depth is computed from the windstress. (Large *et al.* 1994) If $\vec{\tau}$ is the windstress, ρ_0, is the background density and f_0 is the coriolis factor, then the mixed layer depth, D, is given by D =EKFAC$\frac{1}{f_0}\sqrt{\frac{||\vec{\tau}||}{\rho_0}}$. The mixed layer depth is then further constrained to lie in the range MLDMIN$\leq D \leq$MLDMAX.

MLDOPT=2

The mixed layer depth is computed from the buoyancy force and the windstress. (Niiler & Kraus 1977) I haven't worked out the details, but the basic calculation of the mixed layer depth uses WSDFAC to avoid division by zero. The documentation indicates that 0.0002 $\leq$WSDFAC$\leq$ 0.0006. Again, the mixed layer depth is then further constrained to lie in the range MLDMIN$\leq D \leq$MLDMAX.