PALM Ocean Version

PALM group

Institute of Meteorology and Climatology, Leibniz Universität Hannover

last update: 21st September 2015

Leibniz
Universität
Hannover

PALM - Ocean Version - General Features

PALM - Ocean Version - General Features

- ▶ Ocean and atmosphere version are sharing the same code.

PALM - Ocean Version - General Features

▶ Ocean and atmosphere version are sharing the same code.

▶ The ocean version is switched on by setting the +inipar - parameter:

```
ocean = .TRUE.
```

Leibniz
Universität
Hannover

PALM - Ocean Version - General Features

- ▶ Ocean and atmosphere version are sharing the same code.
- ▶ The ocean version is switched on by setting the +inipar - parameter:

    ```
    ocean = .TRUE.
    ```

- ▶ There are only few parts in the code which differ between both versions. In the ocean version:

Leibniz
Universität
Hannover

PALM - Ocean Version - General Features

- ▶ Ocean and atmosphere version are sharing the same code.
- ▶ The ocean version is switched on by setting the +inipar - parameter:

    ```
    ocean = .TRUE.
    ```

- ▶ There are only few parts in the code which differ between both versions. In the ocean version:
    - ▶ an additional prognostic equation for salinity is solved,

PALM - Ocean Version - General Features

- ▶ Ocean and atmosphere version are sharing the same code.
- ▶ The ocean version is switched on by setting the +inipar - parameter:

  ```
  ocean = .TRUE.
  ```

- ▶ There are only few parts in the code which differ between both versions. In the ocean version:
  - ▶ an additional prognostic equation for salinity is solved,
  - ▶ in the buoyancy term (w-equation) and the stability-related terms (SGS-TKE-equation), potential temperature is replaced by potential density,

PALM - Ocean Version - General Features

▶ Ocean and atmosphere version are sharing the same code.

▶ The ocean version is switched on by setting the +inipar - parameter:

    ocean = .TRUE.

▶ There are only few parts in the code which differ between both versions. In the ocean version:

  ▶ an additional prognostic equation for salinity is solved,
  ▶ in the buoyancy term (w-equation) and the stability-related terms (SGS-TKE-equation), potential temperature is replaced by potential density,
  ▶ density is calculated from the nonlinear equation of state for seawater. So far, only the initial hydrostatic pressure is entered into this equation.

Leibniz
Universität
Hannover

PALM - Ocean Version - Equations

Momentum:

$$\frac{\partial \bar{u}_i}{\partial t} = - \frac{\partial \bar{u}_k \bar{u}_i}{\partial x_k} - \frac{1}{\rho_0} \frac{\partial \bar{p}^*}{\partial x_i} - \varepsilon_{ijk} f_j(\bar{u}_k - \bar{u}_{k_g}) - \delta_{i3} g \frac{\bar{\rho} - \tilde{\bar{\rho}}}{\rho_{ref}} - \frac{\partial \overline{u'_k u'_i}}{\partial x_k}$$

Potential Temperature:

$$\frac{\partial \bar{\theta}}{\partial t} = - \frac{\partial \bar{u}_k \bar{\theta}}{\partial x_k} - \frac{\partial \overline{u'_k \theta'}}{\partial x_k}$$

Density r = r(S,q,ph) is calculated from the equation of state for seawater using the algorithm from Jackett et al. (2006)
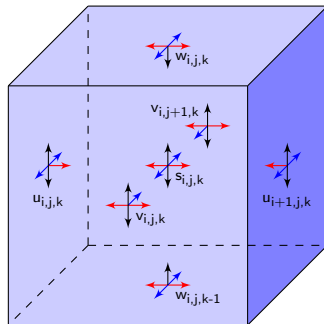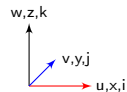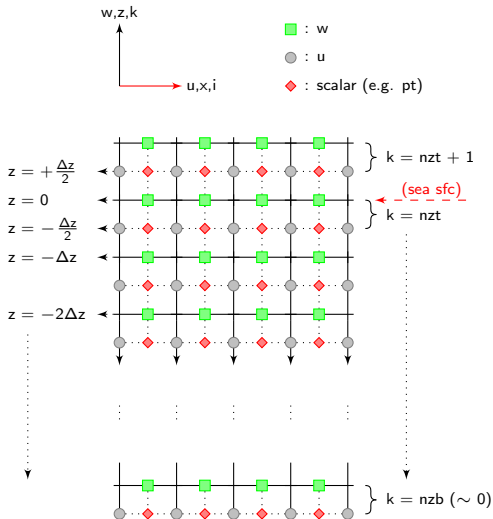
Salinity:

$$\frac{\partial \bar{S}}{\partial t} = - \frac{\partial \bar{u}_k \bar{S}}{\partial x_k} - \frac{\partial \overline{u'_k S'}}{\partial x_k}$$
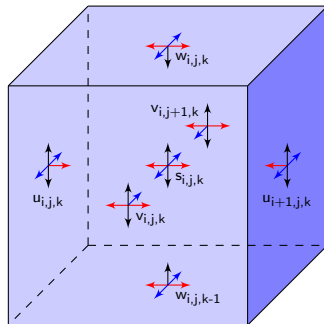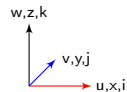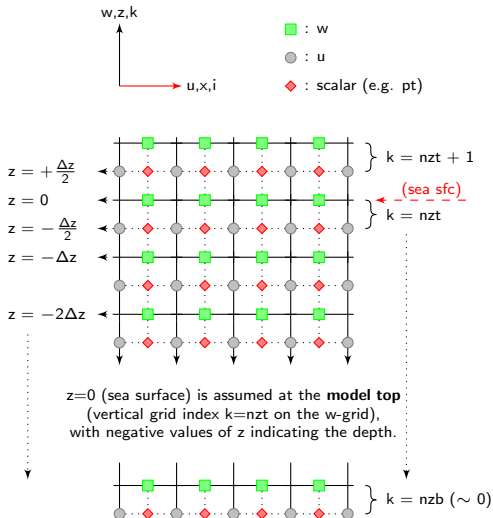
$$\frac{\partial \bar{u}_k}{\partial x_k} = 0$$

$$\frac{\partial^2 \bar{p}^*}{\partial x_k^2} = \frac{\rho_0}{\Delta t} \frac{\partial \hat{\bar{u}}_k}{\partial x_k}$$

Leibniz
Universität
Hannover

PALM - Ocean Version - Grid Structure and Conventions

PALM - Ocean Version - Grid Structure and Conventions

$z = +\frac{\Delta z}{2}$ $k = nzt + 1$

(sea sfc) $z = 0$

$z = -\frac{\Delta z}{2}$ $k = nzt$

$z = -\Delta z$

$z = -2\Delta z$

z=0 (sea surface) is assumed at the **model top** (vertical grid index k=nzt on the w-grid), with negative values of z indicating the depth.

$k = nzb \ (\sim 0)$

□ : w
● : u
◆ : scalar (e.g. pt)

$w_{i,j,k}$
$v_{i,j+1,k}$
$u_{i,j,k}$
$s_{i,j,k}$
$u_{i+1,j,k}$
$v_{i,j,k}$
$w_{i,j,k-1}$

PALM - Ocean Version - Boundary Conditions

The following boundary conditions should be used for the ocean version. Some of them are not set by default, so please set them manually.

PALM - Ocean Version - Boundary Conditions

The following boundary conditions should be used for the ocean version. Some of them are not set by default, so please set them manually.

- ▶ Ocean surface (z=0):
  - ▶ Fluxes should be given at the ocean surface for all quantities. This requires parameter

    `top_momentum_flux_u = ..., top_momentum_flux_v = ..., bc_uv_t = 'neumann'`

PALM - Ocean Version - Boundary Conditions

The following boundary conditions should be used for the ocean version. Some of them are not set by default, so please set them manually.

- ► Ocean surface (z=0):
    - ► Fluxes should be given at the ocean surface for all quantities. This requires parameter

        top_momentum_flux_u = ..., top_momentum_flux_v = ..., bc_uv_t = 'neumann'

    - ► Momentum:

        use_top_fluxes = .TRUE.

PALM - Ocean Version - Boundary Conditions

The following boundary conditions should be used for the ocean version. Some of them are not set by default, so please set them manually.

- ▶ Ocean surface (z=0):
    - ▶ Fluxes should be given at the ocean surface for all quantities. This requires parameter

        `top_momentum_flux_u = ..., top_momentum_flux_v = ..., bc_uv_t = 'neumann'`

    - ▶ Momentum:

        `use_top_fluxes = .TRUE.`

    - ▶ Temperature:

        `top_heatflux = ..., bc_pt_t = 'neumann'`

Leibniz
Universität
Hannover

PALM - Ocean Version - Boundary Conditions

The following boundary conditions should be used for the ocean version. Some of them are not set by default, so please set them manually.

- ▶ Ocean surface (z=0):
    - ▶ Fluxes should be given at the ocean surface for all quantities. This requires parameter

        `top_momentum_flux_u = ..., top_momentum_flux_v = ..., bc_uv_t = 'neumann'`

    - ▶ Momentum:

        `use_top_fluxes = .TRUE.`

    - ▶ Temperature:

        `top_heatflux = ..., bc_pt_t = 'neumann'`

    - ▶ Salinity:

        `top_salinityflux = ..., bc_sa_t = 'neumann'`

Leibniz
Universität
Hannover

PALM - Ocean Version - Boundary Conditions

The following boundary conditions should be used for the ocean version. Some of them are not set by default, so please set them manually.

- ▶ Ocean surface (z=0):
    - ▶ Fluxes should be given at the ocean surface for all quantities. This requires parameter

        `top_momentum_flux_u = ..., top_momentum_flux_v = ..., bc_uv_t = 'neumann'`

    - ▶ Momentum:

        `use_top_fluxes = .TRUE.`

    - ▶ Temperature:

        `top_heatflux = ..., bc_pt_t = 'neumann'`

    - ▶ Salinity:

        `top_salinityflux = ..., bc_sa_t = 'neumann'`

- ▶ Ocean bottom (z=-...)
    - ▶ A Prandtl-layer should be used at the bottom:

        `prandtl_layer = .TRUE.`

Leibniz
Universität
Hannover

PALM - Ocean Version - Further Settings

Leibniz
Universität
Hannover

PALM - Ocean Version - Further Settings

- ▶ Initial profiles:
    - ▶ The ocean version can only use:

        `initializing_actions = 'set_constant_profiles'`

Leibniz
Universität
Hannover

PALM - Ocean Version - Further Settings

- Initial profiles:
  - The ocean version can only use:

    initializing_actions = 'set_constant_profiles'
  - Profiles are constructed piecewise linear from the top (surface), using parameters (e.g.):

    pt_surface = ..., pt_initial_gradient = ..., pt_initial_gradient_level = ...

Leibniz
Universität
Hannover

PALM - Ocean Version - Further Settings

▶ Initial profiles:
  ▶ The ocean version can only use:
    initializing_actions = 'set_constant_profiles'
  ▶ Profiles are constructed piecewise linear from the top (surface), using parameters (e.g.):
    pt_surface = ..., pt_initial_gradient = ..., pt_initial_gradient_level = ...
▶ Random perturbations:
  ▶ Random perturbations are by default applied to the upper third of the model domain!

Leibniz
Universität
Hannover

PALM - Ocean Version - Final Remarks

Leibniz
Universität
Hannover

PALM - Ocean Version - Final Remarks

▶ The ocean version of PALM has not been tested sufficiently so far! Only some plausibility checks have been done.

Leibniz
Universität
Hannover

PALM - Ocean Version - Final Remarks

▶ The ocean version of PALM has not been tested sufficiently so far! Only some plausibility checks have been done.

▶ Please carefully check the results and please also check the code.

Leibniz
Universität
Hannover

PALM - Ocean Version - Final Remarks

▶ The ocean version of PALM has not been tested sufficiently so far! Only some plausibility checks have been done.

▶ Please carefully check the results and please also check the code.

▶ Effects of surface waves (Langmuir circulation, wave breaking) are not included in the standard code.

Leibniz
Universität
Hannover