Ocean-atmosphere coupling with OASIS

Large scale meteorology and climate research group

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CNRM/GAME

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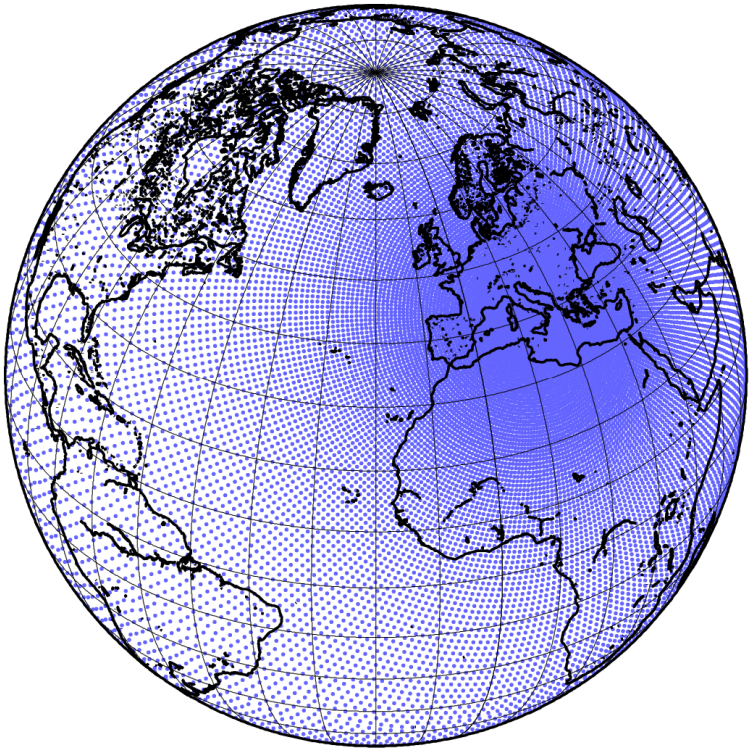
Ocean-atmosphere coupling with OASIS

- Regional coupling on the Mediterranean region
- Conservation issue of the non-solar flux from atmosphere to ocean

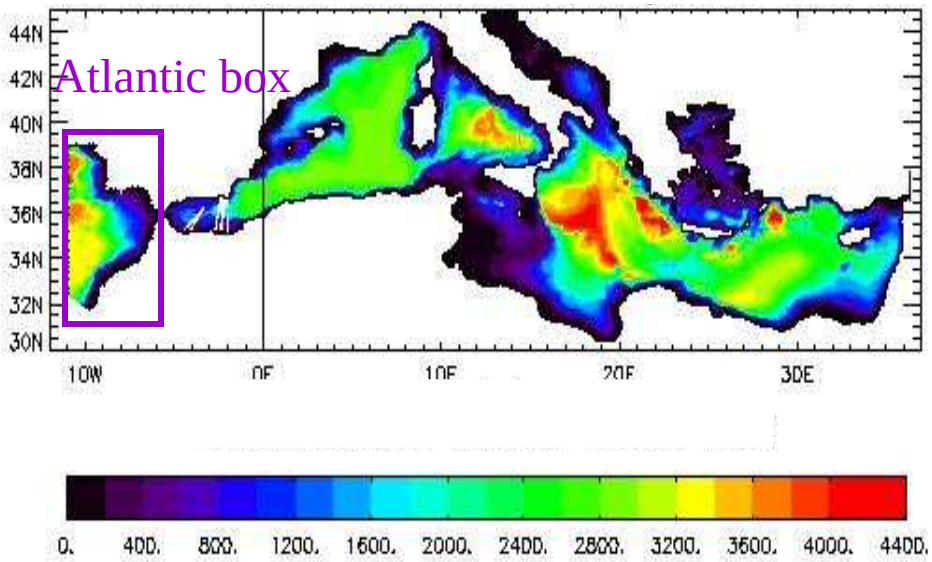
Regional coupling on the Mediterranean region (I)

ARPEGE-Climate v3 :

50 km resolution on the Mediterranean



NEMOMED8: a NEMO-V2 regional version (LOCEAN); about 10 km resolution

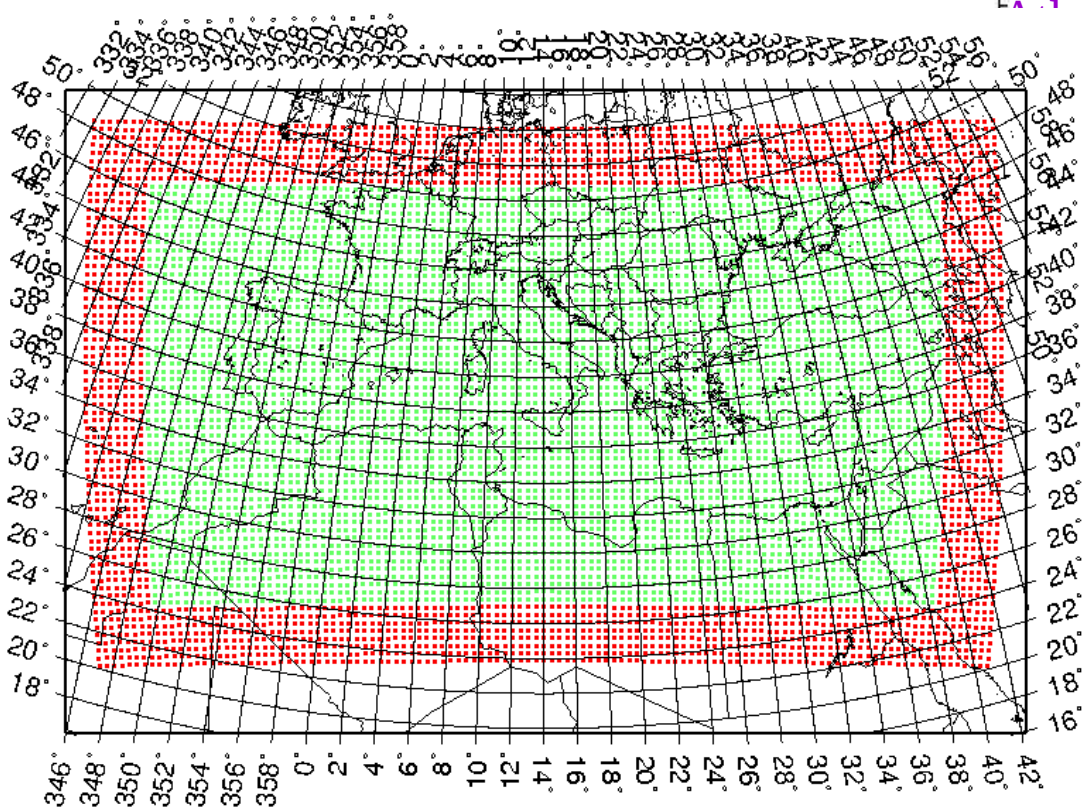


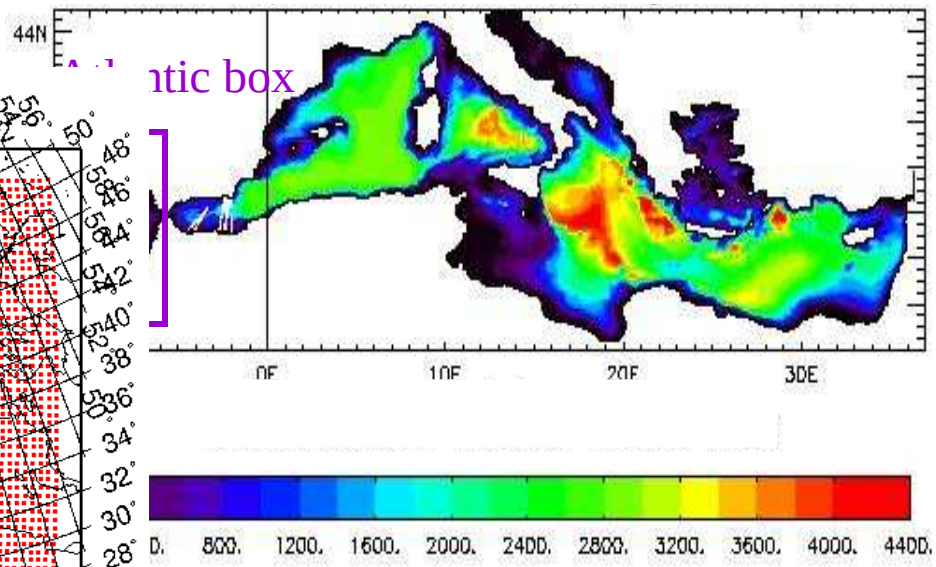
Regional coupling on the Mediterranean region (I)

ALADIN-Climate:

50 km resolution on the Mediterranean

NEMOMED8: a NEMO-V2 regional version (LOCEAN); about 10 km resolution





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Regional coupling on the Mediterranean region (I)

Scenarios of climate change: comparison regional-global atm-ocean coupling

Already done with ARPEGE-Climate – OASIS2.4 – OPAMED8: 21st century climate change scenario for the Mediterranean using a coupled atmosphere-ocean regional climate model, Somot et al., Global and Planetary Change, 2008.

Characteristics of the coupling (ARPEGE-Climate):

- OASIS3
- ARPEGE: global 1D (n,1) grid stretched, center in the Tyrrhenian Sea
- Oceanic grid: tilted at the Gibraltar strait (not regular)
- MASK-EXTRAP-MOZAIC or INTERP from atm to ocean
- MOZAIC-FILLING from ocean to atm: the ocean fields on the Mediterranean are filled with global data (observations or large scale model outputs previously interpolated on the atm grid)

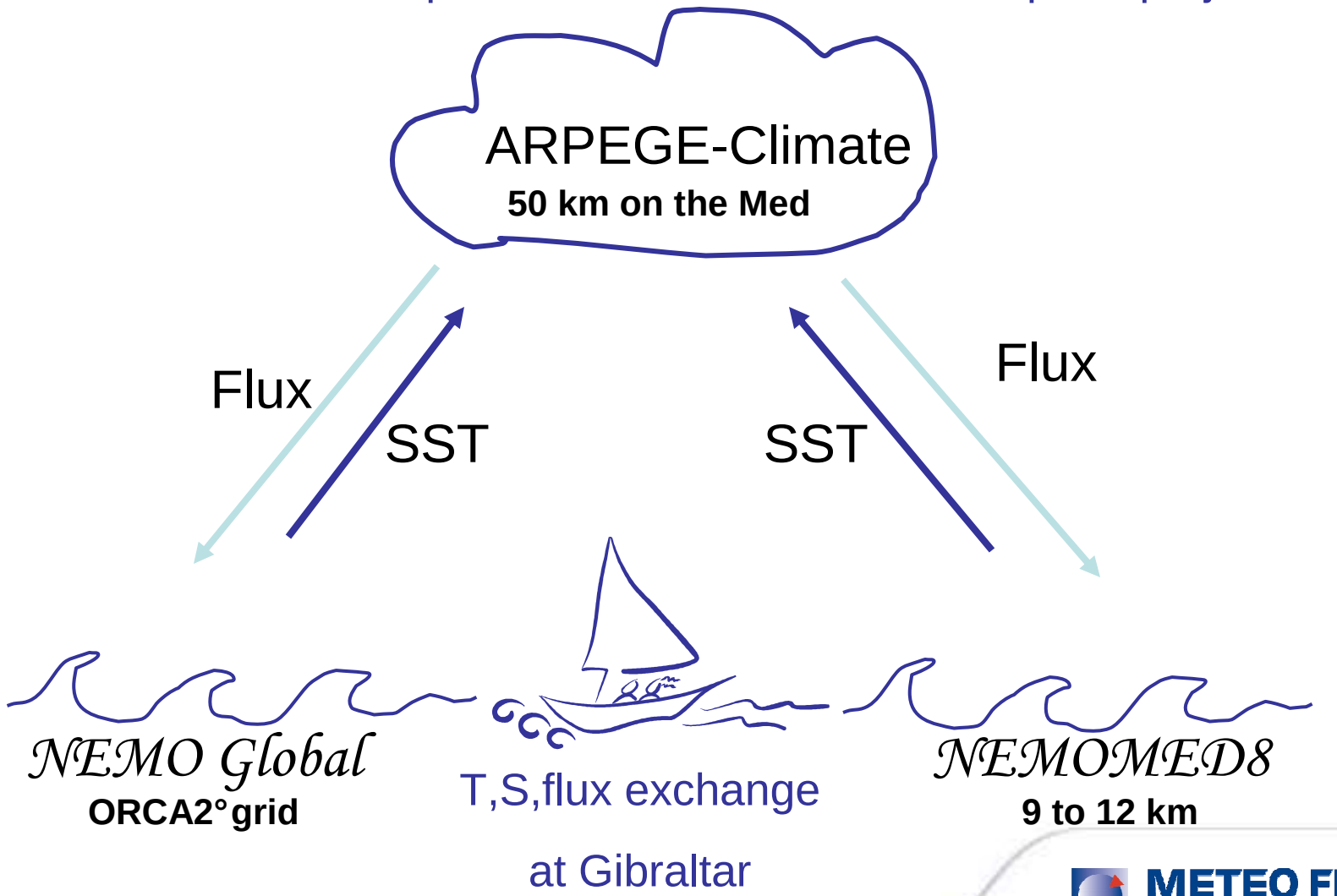
Characteristics of the coupling (ALADIN-Climate):

- OASIS3
- ALADIN 2D grid
- MASK-EXTRAP-SCRIPR for atm to ocean
- SCRIPR-FILLING from ocean to atm

For both systems, no problem of conservation of the fluxes during the interpolation.

Regional coupling on the Mediterranean region (II)

The tri-coupled model of the CIRCE european project



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Regional coupling on the Mediterranean region (II)

Characteristics of the coupling:

- OASIS3
- ARPEGE sends its fluxes twice, for the two oceanic models
- The SST of the two oceanic models is combined in OASIS:

Regional coupling on the Mediterranean region (II)

```
##########################################################################
#
# Field 2 : sea surface temperature global
#
SOSSTSST SISUTES1 1 86400  6  ocglo.nc AUXILARY
182 149 35718 1 tnem  mdh2 LAG=+4800
P  2  R  0
#
CHECKIN MASK EXTRAP SCRIPR MASKP CHECKOUT
#
 INT=1
 99999999.
 NINENN  2 0 1
 GAUSWGT LR SCALAR LATLON 10 4 2.
 0
 INT=1
#
##########################################################################
...
##########################################################################
#
# Field 9 : sea surface temperature tom8
#
SOSSTMED SISUTESU 1 86400 4  ocmed.nc EXPORTED
394 160 35718 1 tom8 medh LAG=+1200
P  0  R  0
#
CHECKIN MOZAIC BLASNEW CHECKOUT
#
 INT=1
 runoffh2 93 1 38
 1. 1
 SISUTES1 1
 INT=1
#
##########################################################################
```

tnem: ORCA grid

mdh2: ARPEGE grid, mask on NEMOMED8 domain

MASKP: value=0 on the land and on the NEMOMED8 domain

tom8: NEMOMED8 grid

medh: ARPEGE grid

SISUTESU=SISUTESU+SISUTES1

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Regional coupling on the Mediterranean region (II)

The communication between the two oceanic model is made by files.

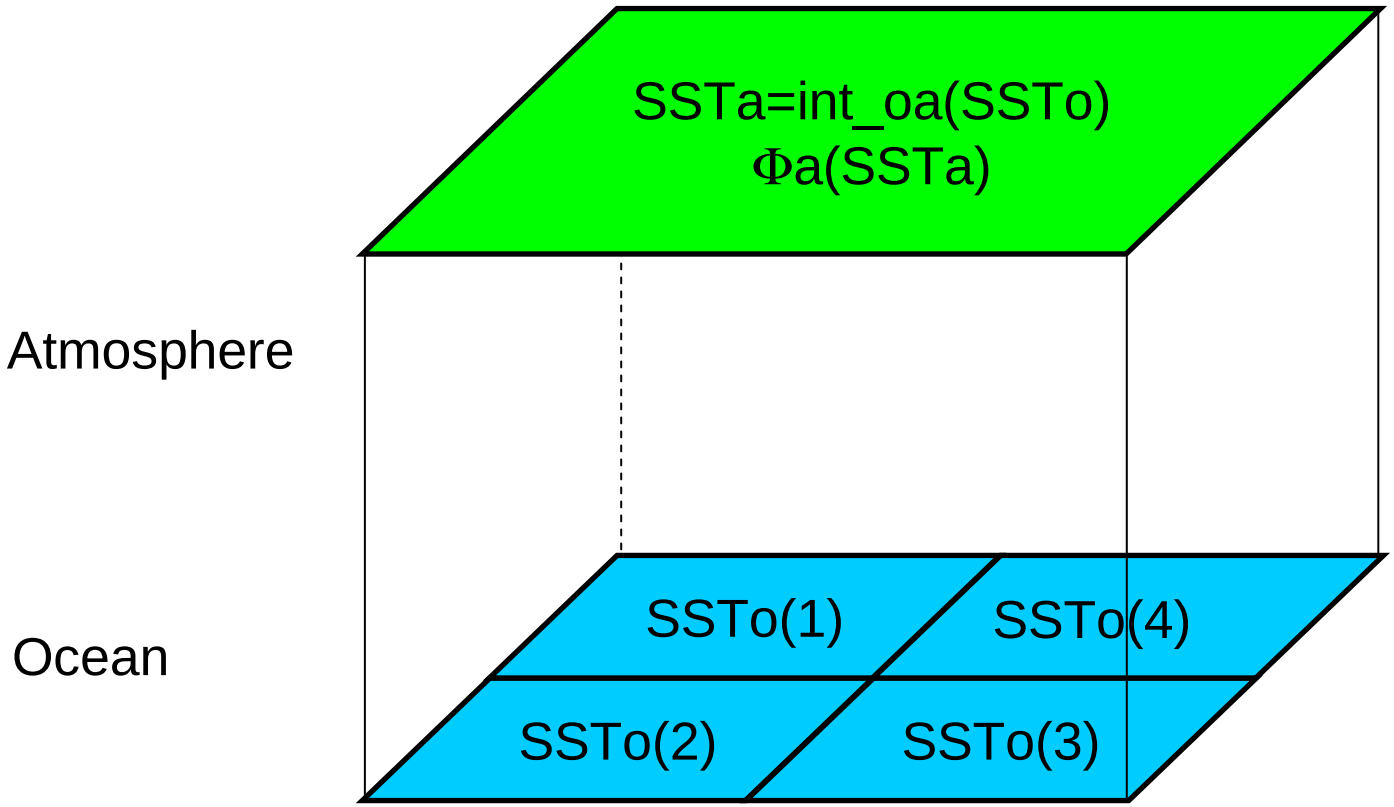
At the Gibraltar Strait, daily:

- Incoming flux Atl-ORCA2 => NEMOMED8: the T and S profiles of NEMO-ORCA2 on the Atlantic box of NEMOMED8 are used for the 3D damping fields
- Outcoming flux NEMOMED8 => Atl-ORCA2 : used in the Cross Land Advection subroutine of NEMO

Each model reads the file written by the other one, no matter if there is a one day shift.

For CIRCE a 100 year A1B scenario is now running.

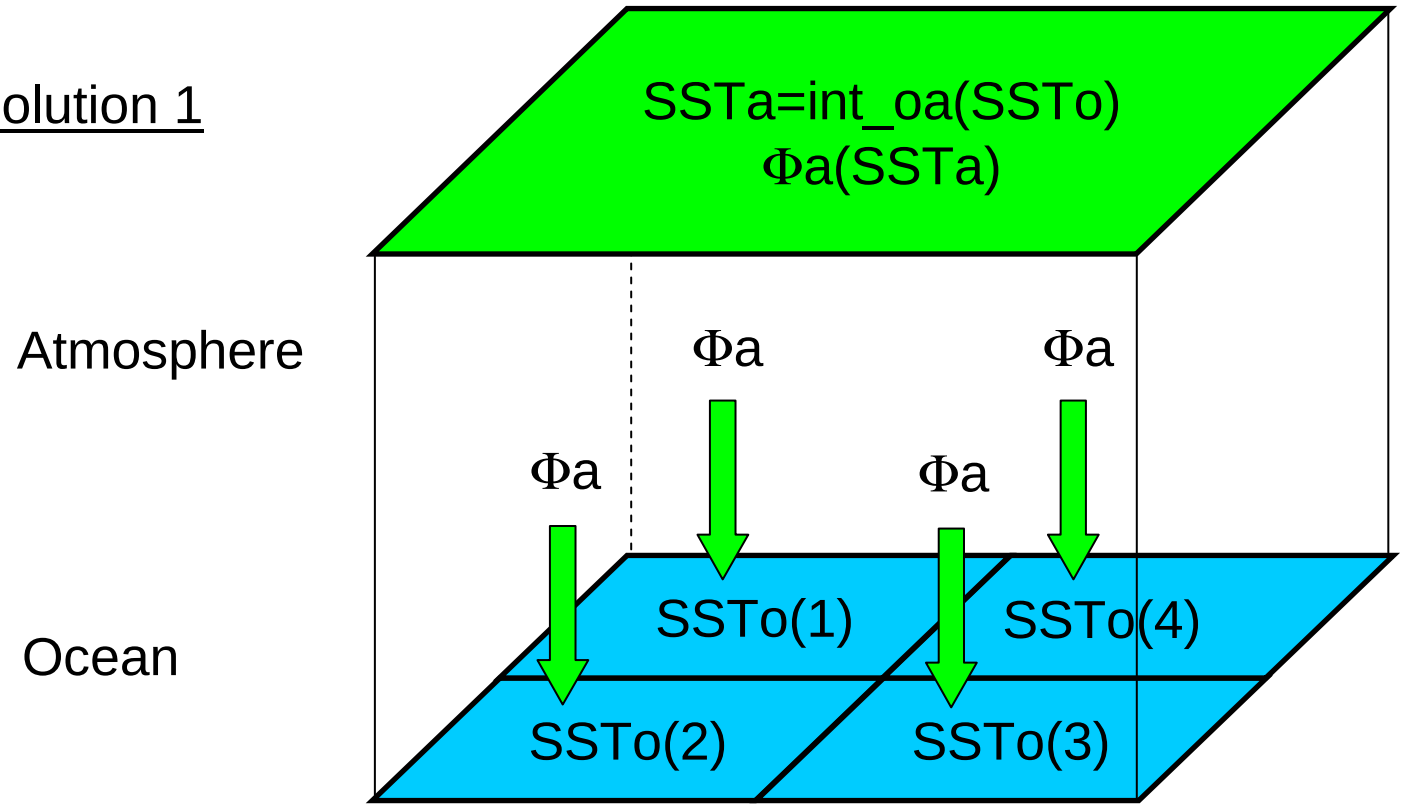
Ocean-atmosphere coupling with OASIS
Conservation at the atm-ocean interface



$$\sum_i \alpha(i).SST_o(i) = SST_a$$

Ocean-atmosphere coupling with OASIS
Conservation at the atm-ocean interface

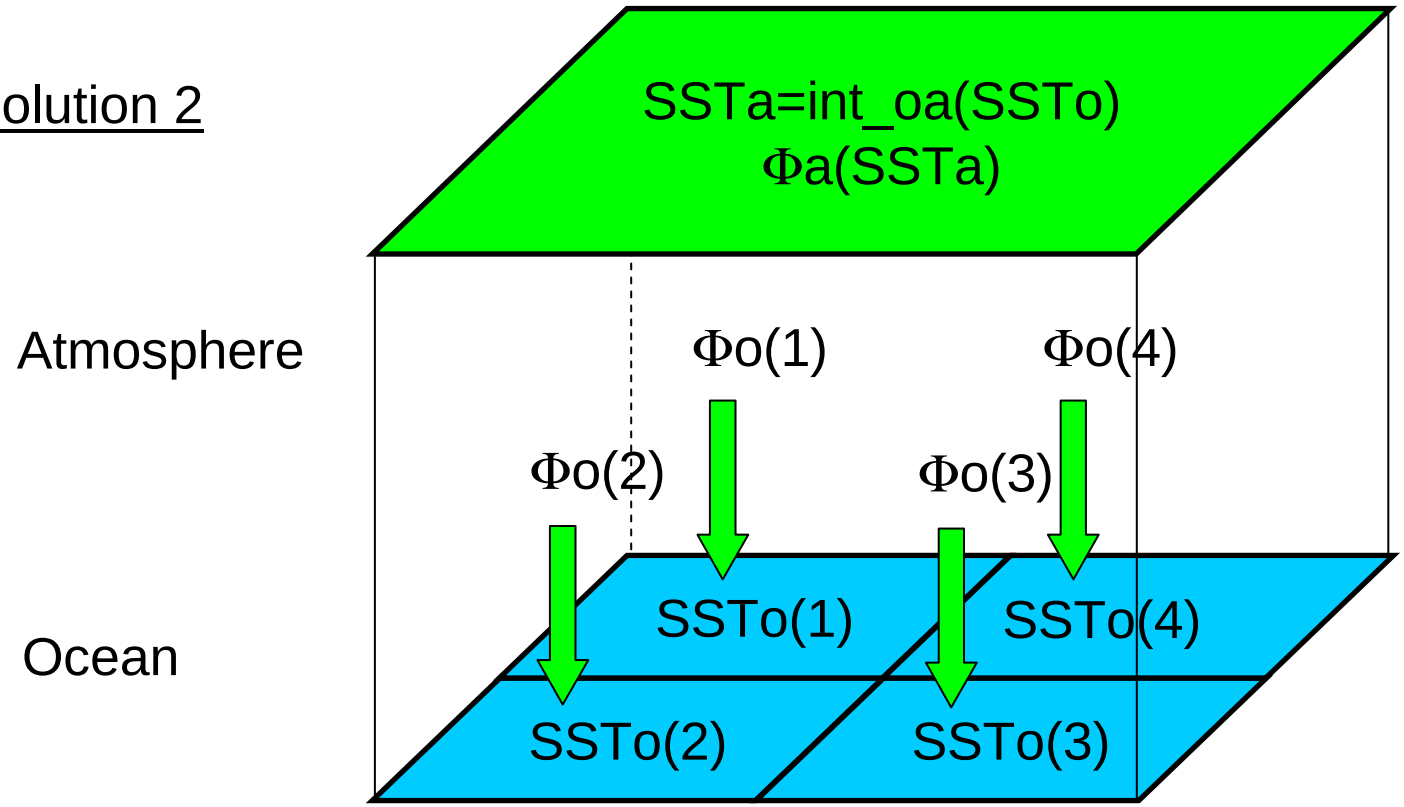
Solution 1



$$\sum_i \alpha(i).SST_o(i) = SST_a \quad avec \quad \sum_i \alpha_i = 1 \qquad \Phi_o(i) = \Phi_a$$

Ocean-atmosphere coupling with OASIS
Conservation at the atm-ocean interface

Solution 2



$$\sum_i \alpha(i).SST_o(i) = SST_a \qquad \Phi_o(i) = \Phi_a + \frac{\partial \Phi_a}{\partial SST_a}(SST_o(i) - SST_a)$$

SUBGRID option of OASIS for the non-solar flux

Ocean-atmosphere coupling with OASIS
Conservation at the atm-ocean interface

$$\underbrace{\Phi_o(i)}_{\text{Oce grid}} = \underbrace{\Phi_a + \frac{\partial \Phi_a}{\partial SST_a}}_{\text{Atm grid}} \underbrace{(SST_o(i)}_{\text{Oce grid}} - \underbrace{SST_a)}_{\text{Atm grid}} \xrightarrow[\sum]{\times \alpha_i} \sum_i \alpha(i).\Phi_o(i) = \Phi_a$$

(conservation of the energy)

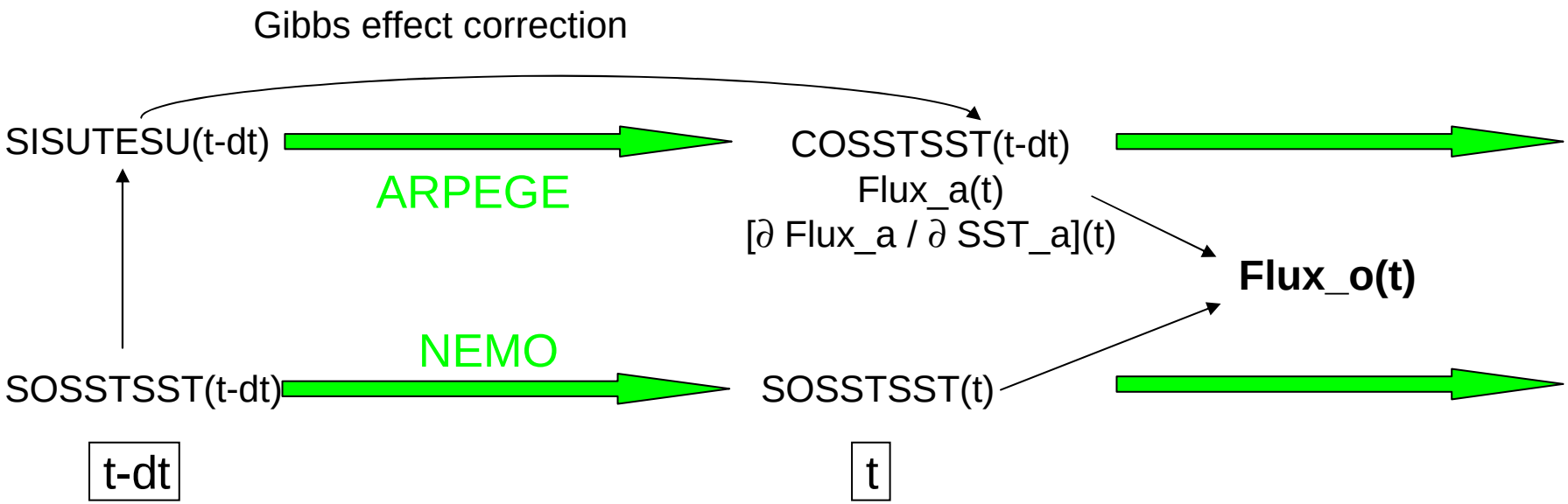
Oce grid Atm grid Oce grid Atm grid

$\downarrow \leftarrow$ int_ao $\rightarrow \downarrow$

Oce grid Oce grid

$$\Phi_o^t(i) = \text{int\_}ao\left[\Phi_a^t + \frac{\partial \Phi_a}{\partial SST_a}^t\right] \times \left[SST_o^t(i) - \text{int\_}ao\left(SST_a^t\right)\right]$$

Ocean-atmosphere coupling with OASIS
Conservation at the atm-ocean interface



$$\Phi_o^t(i) = \text{int\_}ao\left[\Phi_a^t + \frac{\partial \Phi_a}{\partial SST_a}^t\right] \times \left[SST_o^t(i) - \text{int\_}ao\left(\text{int\_}oa(SST_o^{t-dt}(i))\right)\right]$$

« SOSSTSST » « COSSTSST »

Ocean-atmosphere coupling with OASIS
Conservation at the atm-ocean interface

In summary, the use of SUBGRID gives:

$$\Phi_o^t(i) = \text{int\_}ao\left[\Phi_a^t + \frac{\partial \Phi_a}{\partial SST_a}^t\right] \times \left[SST_o^t(i) - \text{int\_}ao\left(\text{int\_}oa(SST_o^{t-dt}(i))\right)\right]$$

- the fields are not simultaneous
- the correction of the Gibbs effect leads to other errors

➡ $\sum_i \alpha(i).\Phi_o(i) = \Phi_a$ The non-solar flux is not conserved (loss ~1%)

➡ The use of CONSERV (OASIS) is a bad solution: in CNRM-CM3 loss~2,5%

Ocean-atmosphere coupling with OASIS
Conservation at the atm-ocean interface

One solution is to modify « manually » the weights used in OASIS for the interpolation, to combine int_ao and int_oa in one.

$$\Phi_o^t(i) = \text{int\_}ao\left[\Phi_a^t + \frac{\partial \Phi_a}{\partial SST_a}^t\right] \times \left[SST_o^t(i) - \text{int\_}ao\left(\text{int\_}oa(\cancel{SST_o^{t-dt}}(i))\right)\right]$$

$$\left[SST_o^t(i) - \text{int\_}ao\left(\text{int\_}oa(SST_o^t(i))\right)\right]$$

No more time shift

Loss ~ 0,01W.m-2

Thank you.

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