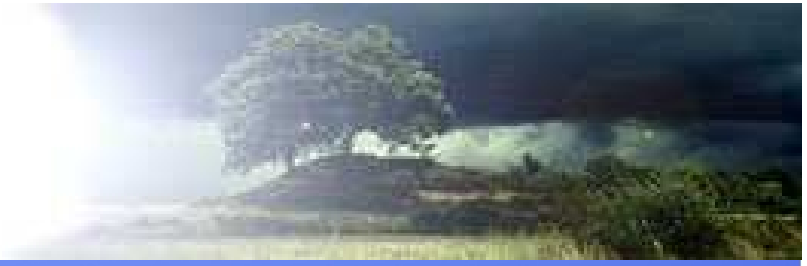
INSTITUT PIERRE SIMON LAPLACE

DES SCIENCES DE L'ENVIRONNEMENT



Time and space interpolations and conservations in the IPSL climate model

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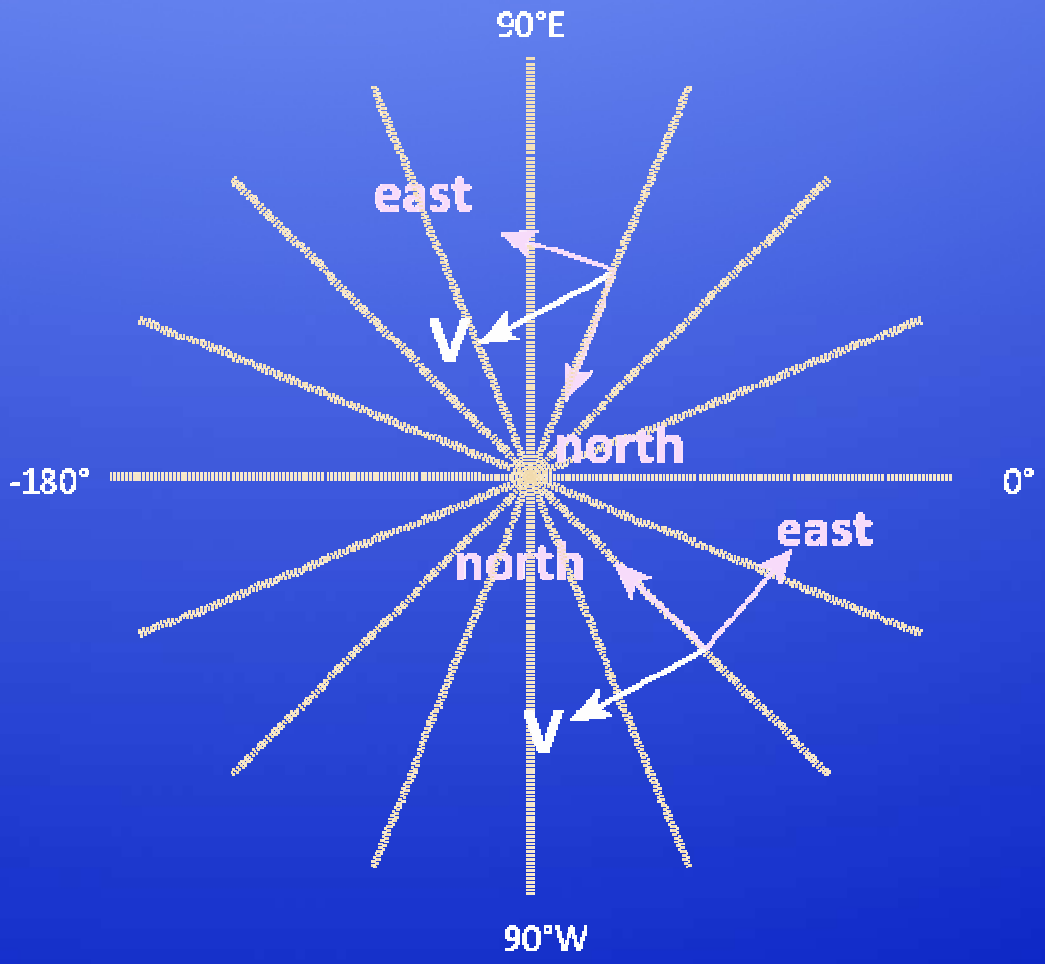
- Interpolating wind stress (even at the pole …)
- Sub-surface tiling.
- Interpolation by polygon intersection (even at the pole …).
- Time scheme and conservation.

Interpolation of wind stress

In the atmosphere, $\boldsymbol{\tau} = \tau_x$.**east** + τ_y.**north**
Far from pole, interpolating wind stress components is OK
But near the pole ? Local referential changes rapidly

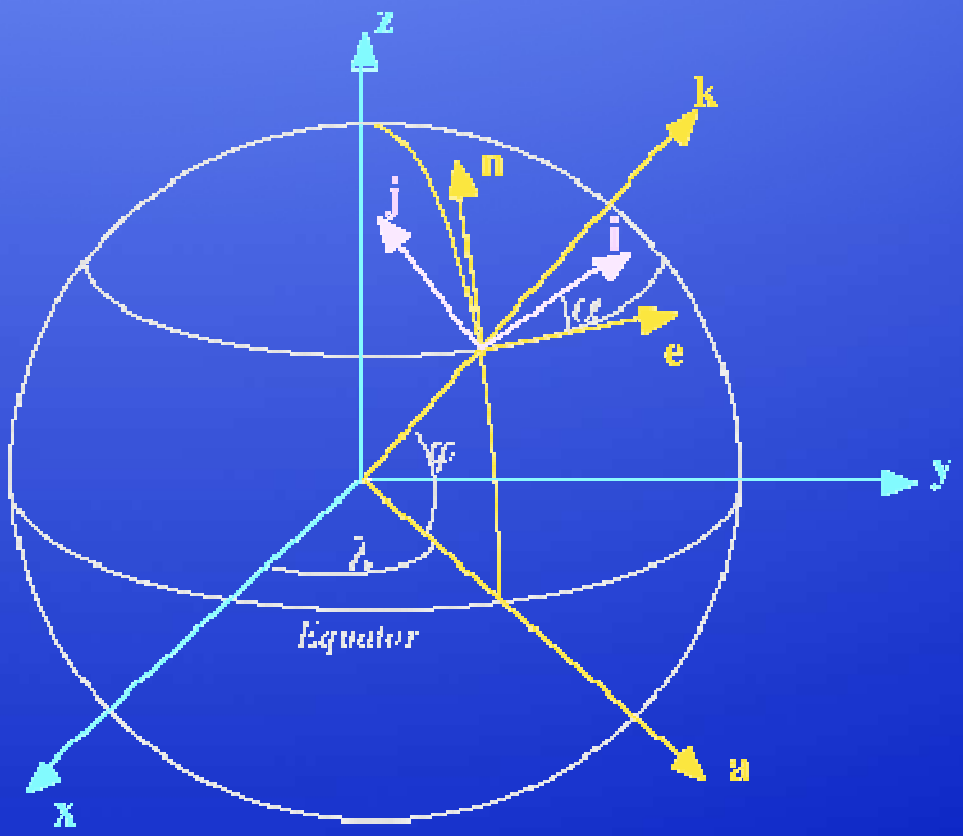


Interpolating 3D components

Project wind in a 3D referential **non-local**
Interpol 3 components
Go back to local referential

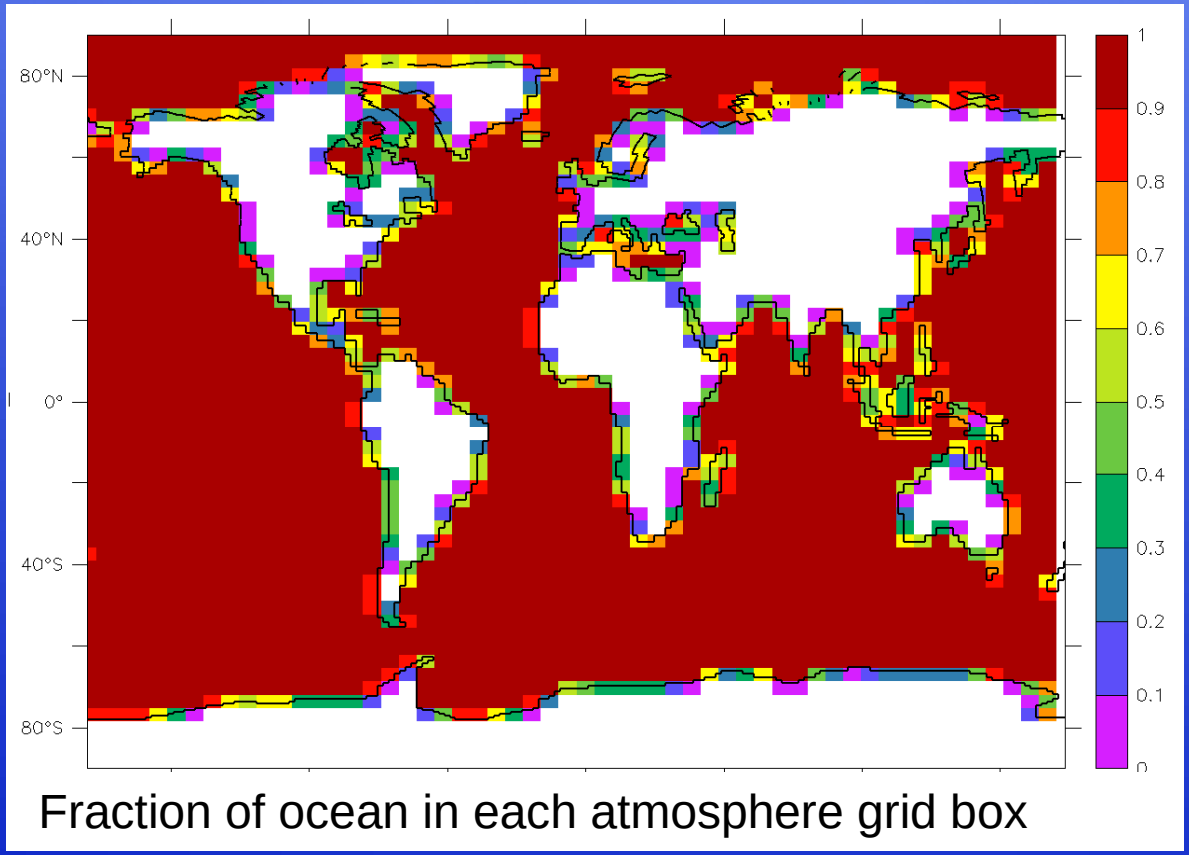
“vertical” component as a check

From CLIO model, UCL/ASTR
(Anne de Montéty)



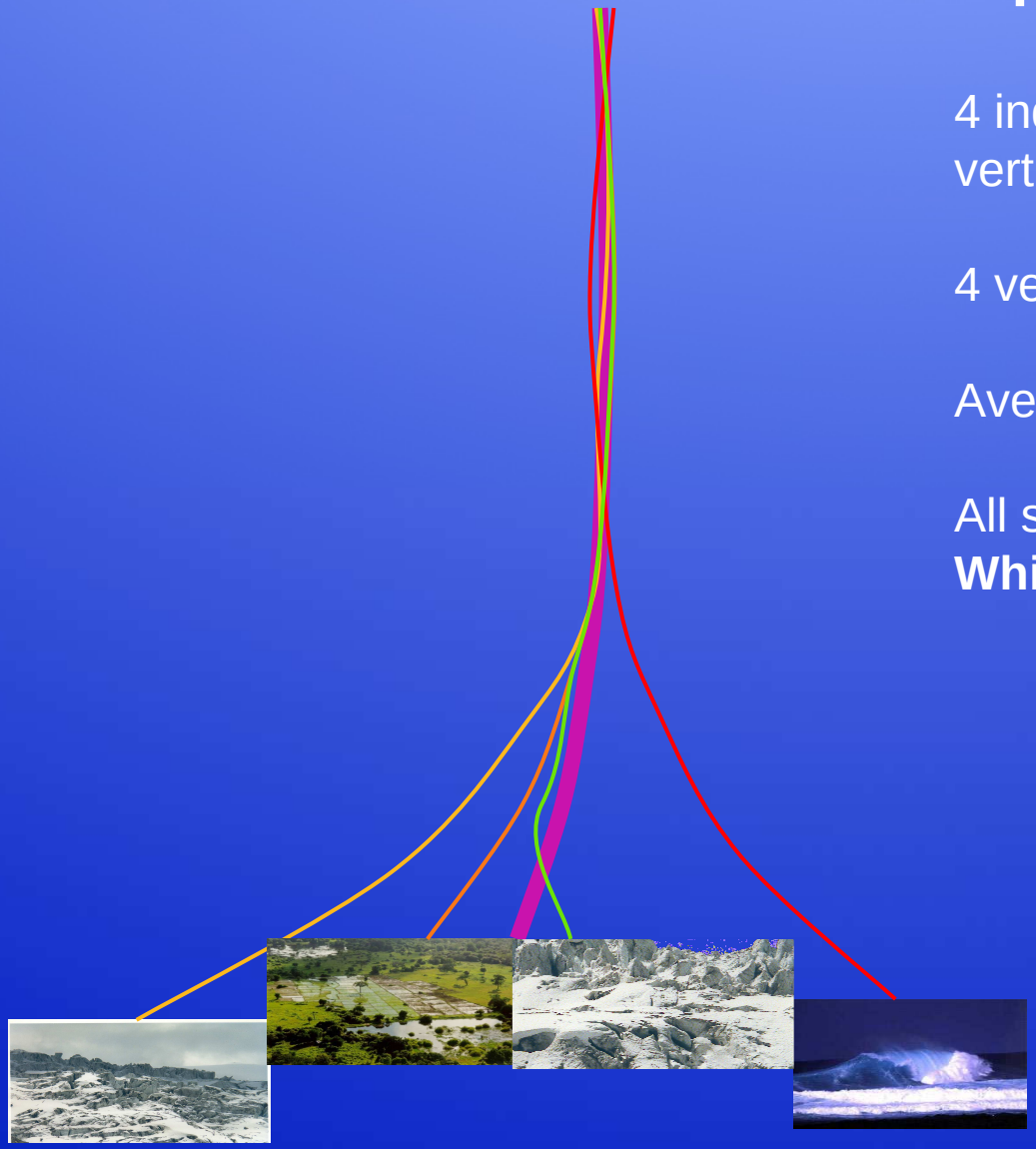
Sub-surface tiling

Coastlines in atmosphere and ocean doesn't fit
Can we conserve heat/water between the two fluids ?



Fraction of ocean in each atmosphere grid box

Sub-surface tiling : Vertical profiles



4 independent resolutions of the vertical profiles of *T*, *q*, etc :

4 vertical profiles of *T*, *q*

Averaged after resolution

All surface are at the same altitude.
Which is not zero !!!

Implicit resolution of vertical diffusion

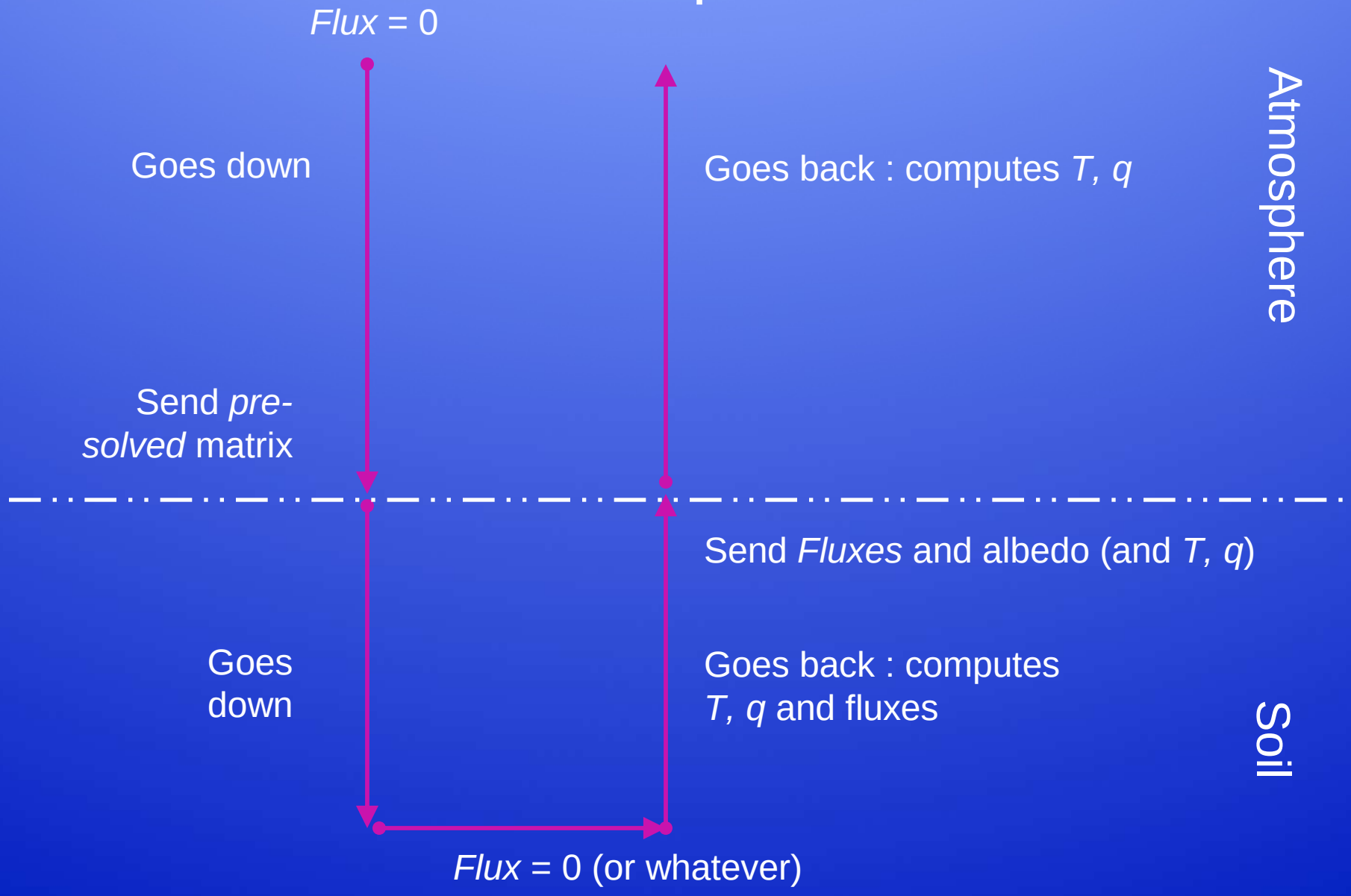
Vertical diffusion : $$\frac{\partial q}{\partial t} = \frac{\partial}{\partial z}\left(k \frac{\partial q}{\partial z} \right) + \ldots$$

Semi-implicit (forward) scheme :

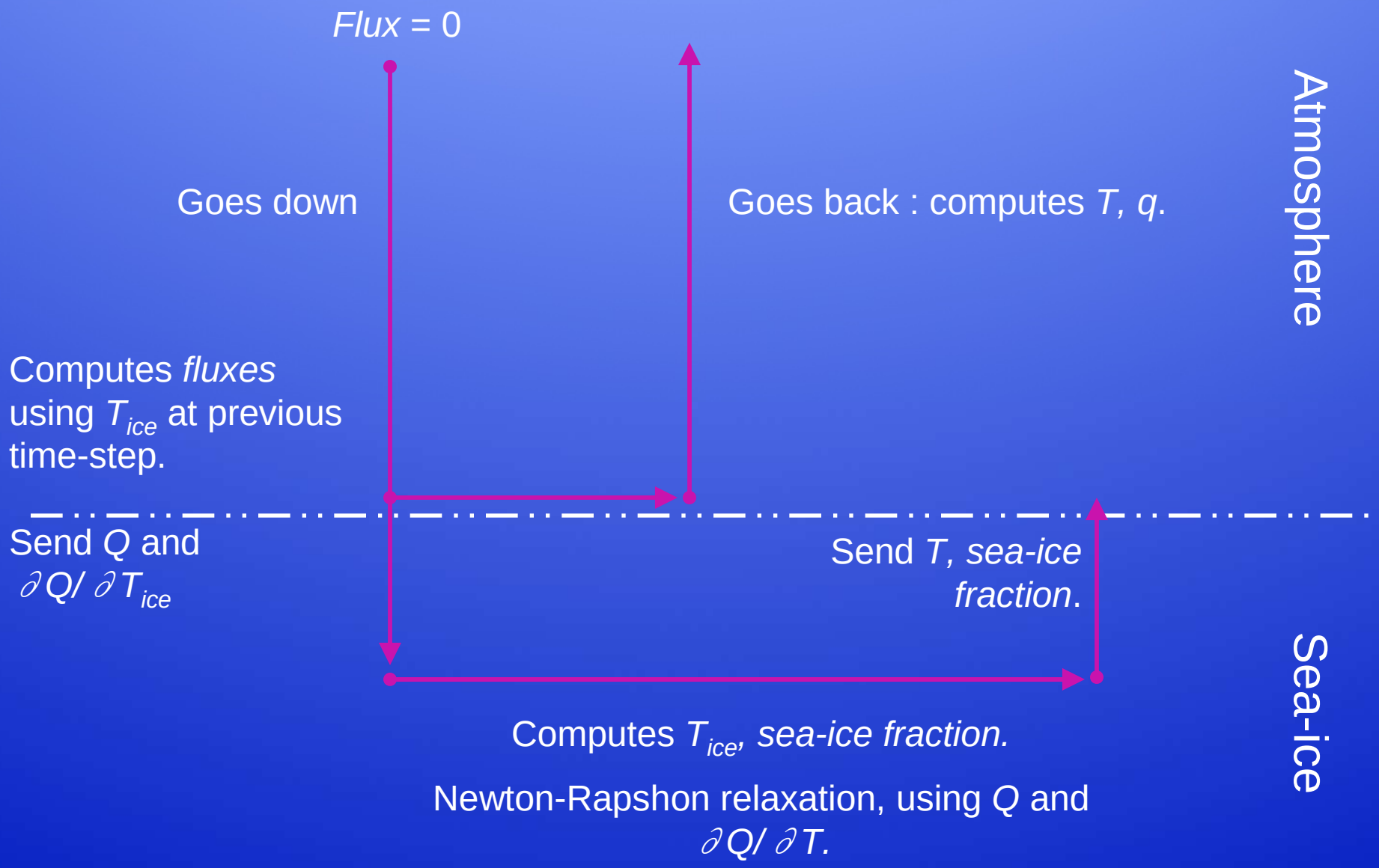
$$\frac{q_k^{t+1} - q_k^t}{\Delta t} = \frac{1}{\Delta t}\left[k_{k+1/2}^t \frac{\left(q_{k+1}^{t+1} - q_k^{t+1}\right)}{\Delta z_{k+1/2}} - k_{k+1/2}^t \frac{\left(q_k^{t+1} - q_{k-1}^{t+1}\right)}{\Delta z_{k-1/2}} \right]$$

Yields tri-diagonal matrix. Resolution starting from TOA with *Flux* = 0 boundary condition, and whatever condition at the surface.

Resolution for continental surface : implicit.



Resolution for sea-ice : explicit.



Radiative fluxes

- Radiative scheme uses mean albedo α and mean surface temperature T_{surf}.

- Albedo is used to distribute short-wave over the 4 surfaces.

$$Q_i^{up} = \frac{\alpha_i}{\alpha_{mean}} Q_{mean}^{up} = \alpha_i Q_{mean}^{down}$$

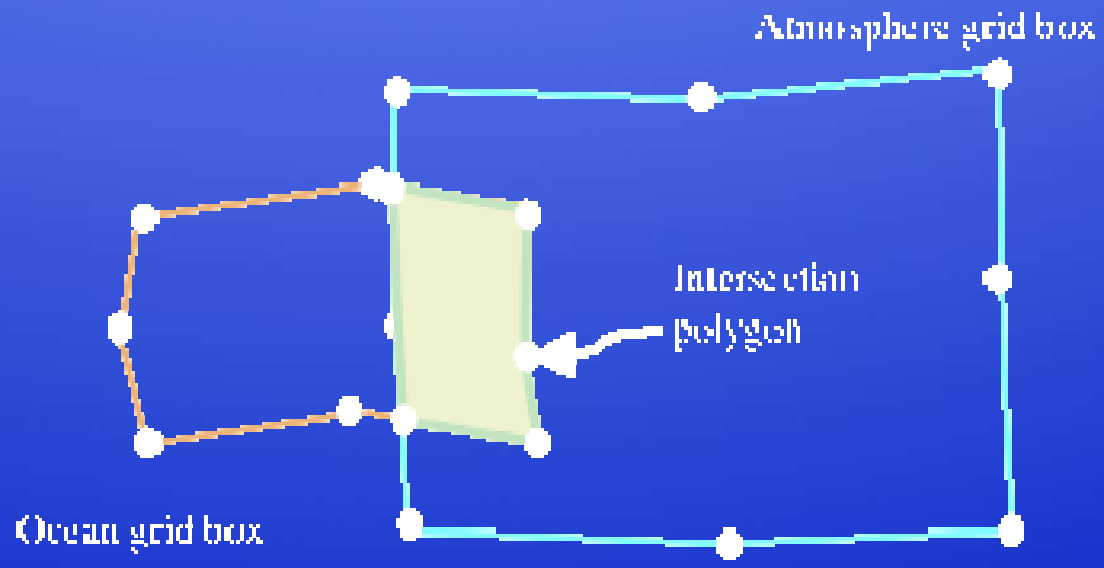
- Surface temperature is used to distribute long-wave : linearized.

$$Q_i^{up} = Q_{mean}^{up} + \frac{\partial Q}{\partial T}\left(T_i - T_{mean}\right) = Q_{mean}^{up} + \sigma T_{mean}^3 \left(T_i - T_{mean}\right)$$

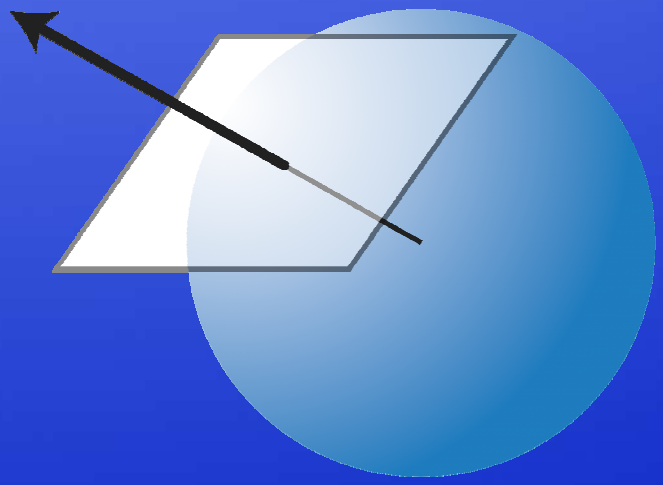
- Strong hypothesis : downward fluxes are equals over all surfaces.

Interpolation by polygon intersection.

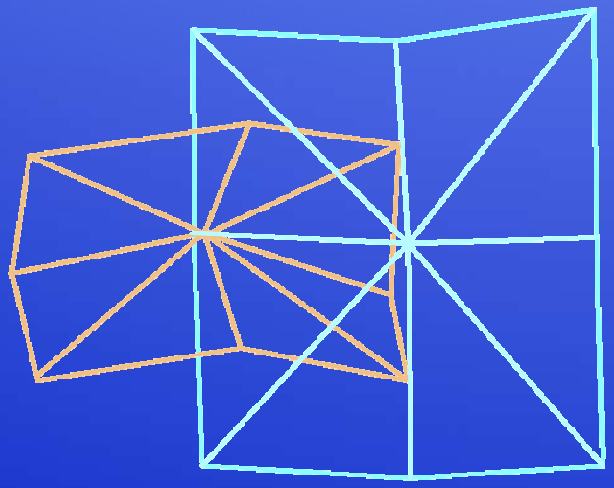
- Find the « intersection polygon » between to grid boxes (oce and atm)
  - Each grid box is defined by 4 corners [and 4 middle points]

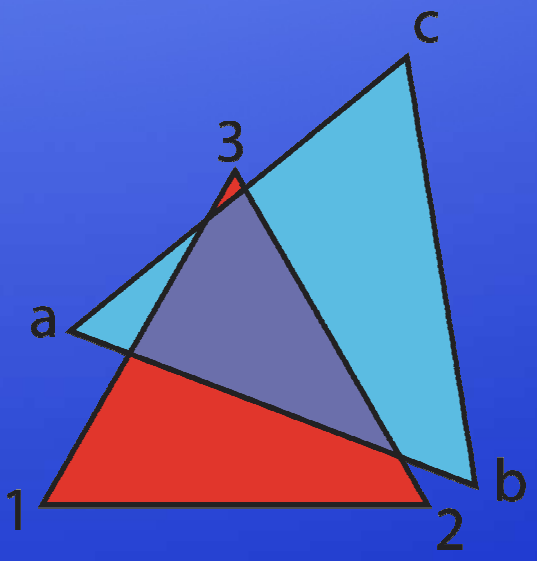


- Take one atm grid box
- Project on the plane tangent to sphere at grid box center
  - Use a surface conserving projection !
- Project [all] ocean grid boxes on the same plane



- Your on a plane now. Let’s do some geometry
  - Share each grid box in triangles
  - Compute surface intersection of each pair of triangles
- Precision is uniform on the sphere (projection on a local plane)





$$S_{a,b,c} = \vec{ab} \otimes \vec{bc}$$

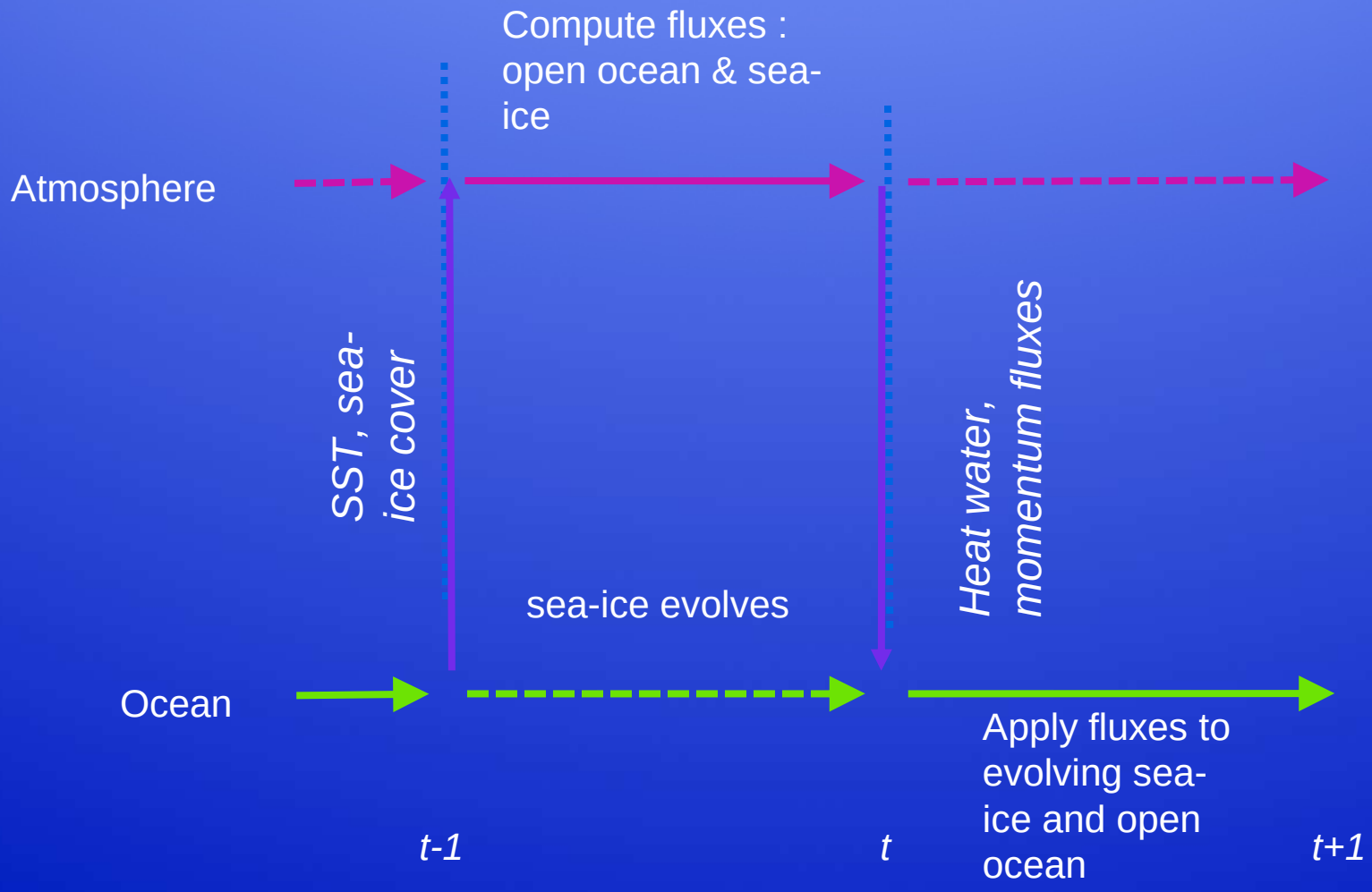
- In IPSL model, used through '`MOZAIC`' scheme
  ("on your own" interpolation weights)

- A standalone program is available to compute weights
  - Some IPSL specificity hard-wired
  - Versatile, re-usable, adaptable ? Uh-oh ….

  - The POLYGON library is re-usable

Time scheme and conservation

- Mismatch due to explicit time-stepping between atmosphere and sea-ice

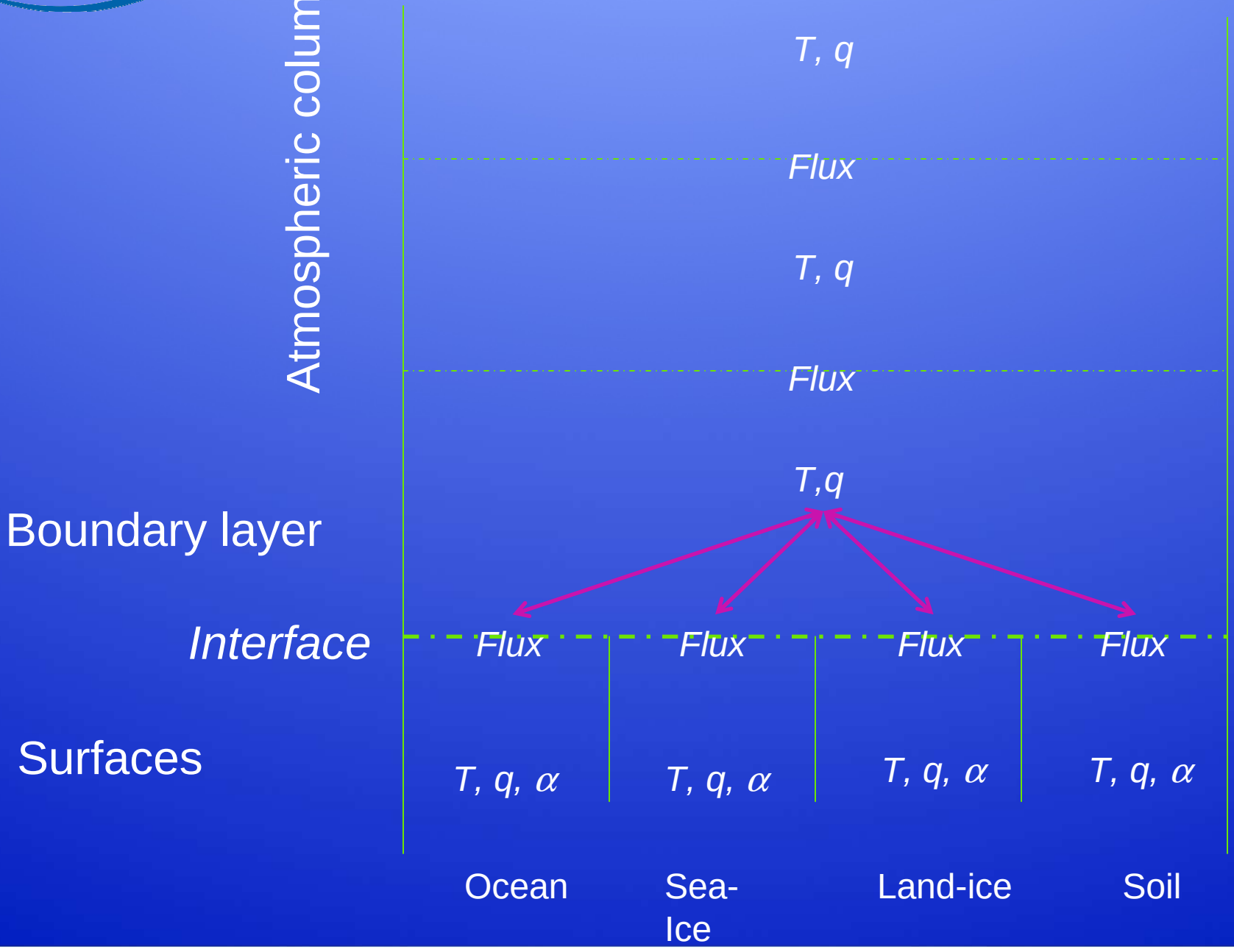


- Send
  - $Q_{total} = Q_{oce} \cdot f_{oce} + Q_{ice} \cdot f_{ice}$
  - Q_{ice}
- Apply :
  - Q_{ice}
  - $Q_{oce} = (Q_{total} - Q_{ice} \cdot f_{ice}) / f_{oce}$

  Total flux is conserved
- Tested in NEMO-ECHAM and NEMO-LMDZ
- Option available in NEMO release in June

That’s all folks !

Sub-surface tiling



Repartition