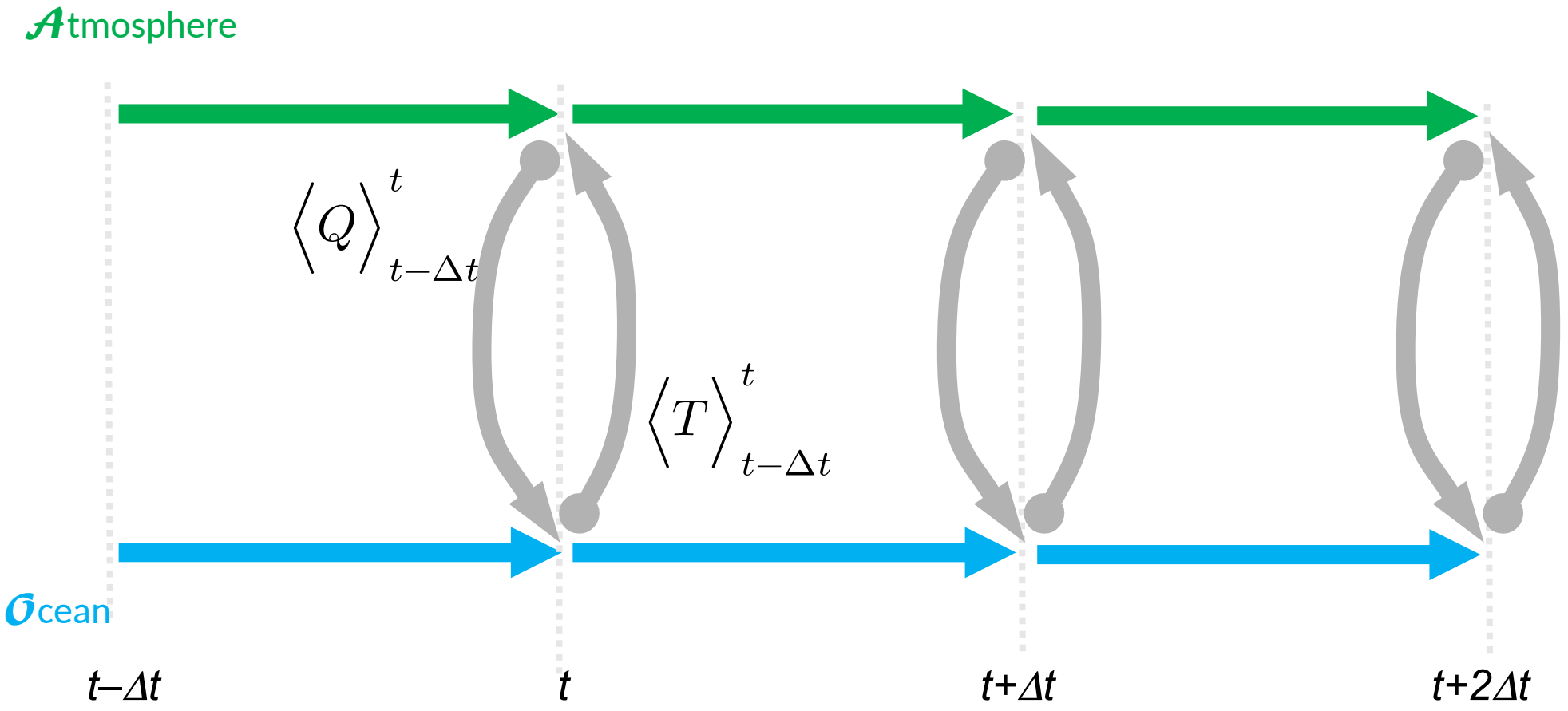
A few words about coupling

- The time stepping algorithm
- A few reflexions at the end of the COCOA project

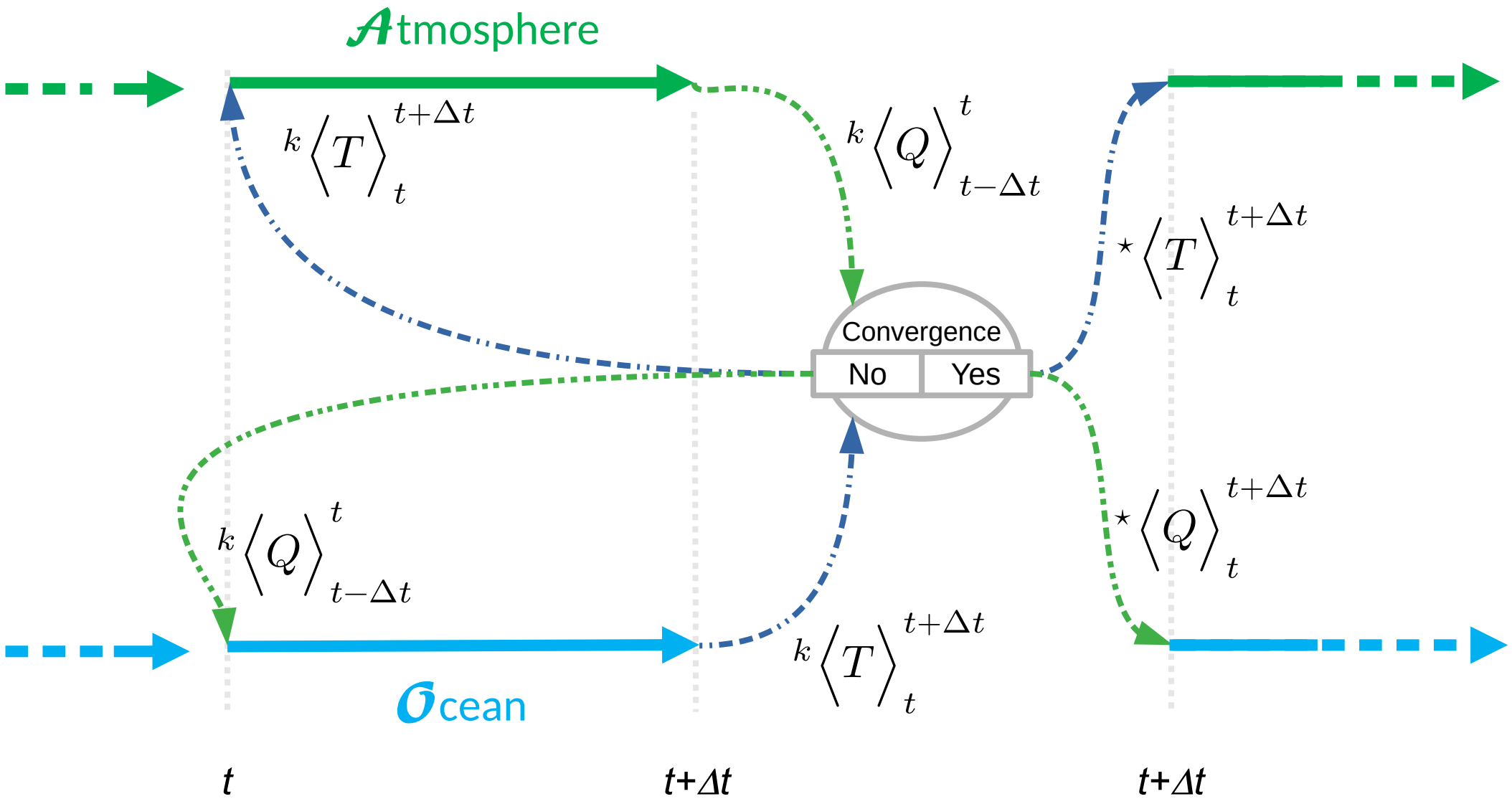
Time stencil of the exchanges between ocean and atmosphere



$$\left.\frac{\partial T_{\mathcal{O}}}{\partial t}\right|_{t+\Delta t}^{t+2\Delta t} = \mathcal{O}\left(\langle Q_{\mathcal{A}} \rangle_{t}^{t+\Delta t}, \cdots\right)$$

$$= \mathcal{O}\left(\mathcal{A}\left(\langle T_{\mathcal{O}} \rangle_{t-\Delta t}^{t}\right), \cdots\right), \cdots\Big)$$

Schwarz iterative procedure



About Schwarz iterative method

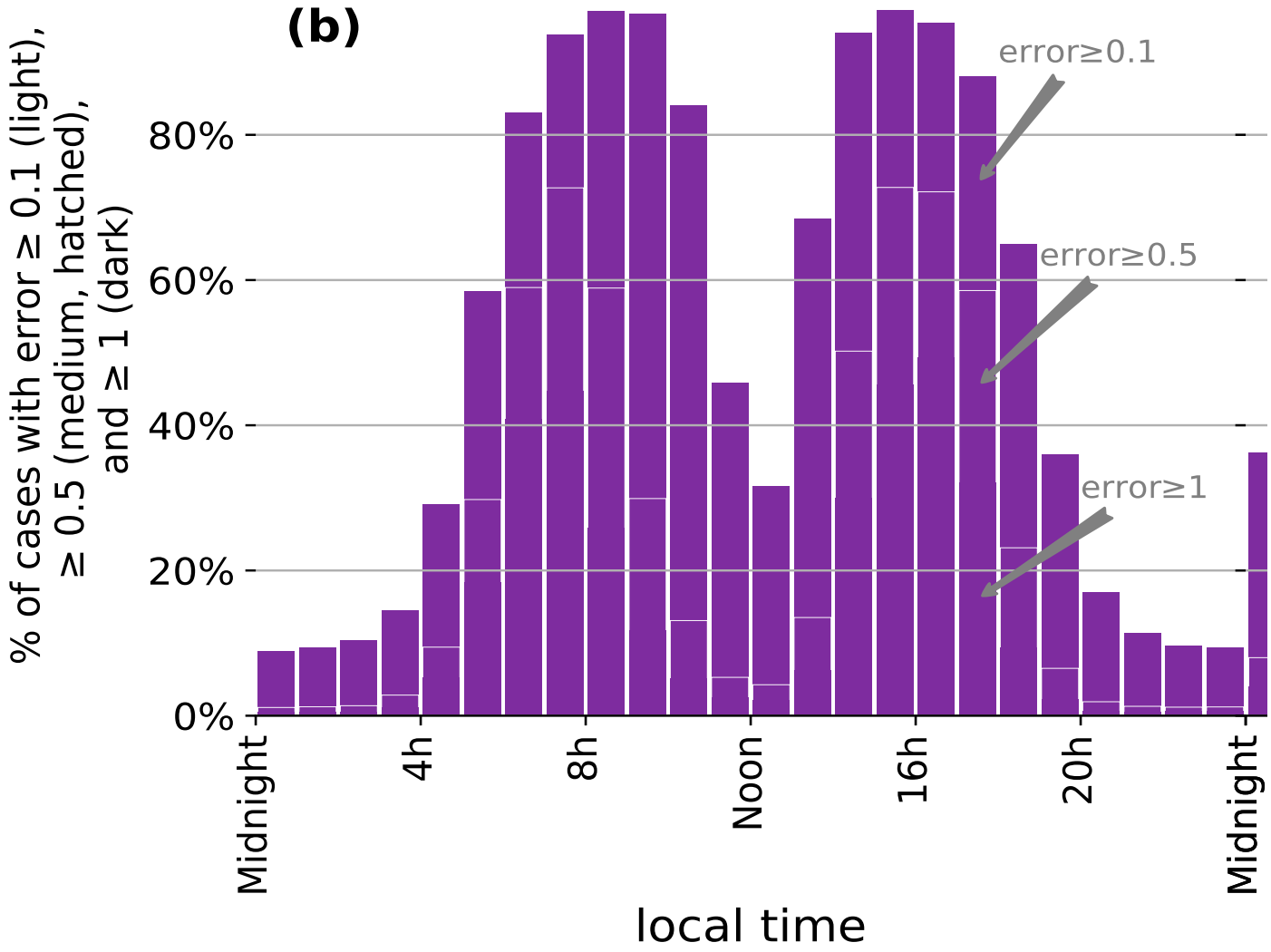
Models and boundary conditions are synchronized

Mathematically consistent solution at the interface

Computing cost is ~~high~~ ~~huge~~ ~~enormous~~ ~~tremendous~~ ~~colossal~~ *whatever* ...

Allows us to estimate error of the ‘legacy time stepping’ : compare 1st iteration to converged solution

Error estimation (SST change in one coupling time step)



IPSL CM VLR

5 days : 120 coupling time step (1 h)

~ 2500 ocean points without sea-ice LMDZ : 30 000 cases

What impact on the simulated climate?

- Good question !

- Strong impact on diurnal cycle
- Compensation on longer time scale ?
- Extremes ?

- Future work : ensemble runs of 1 or 2 years
- Evaluation on longer time scale : computer time problem

A few works in COCOA and elsewhere

- Wind gust in bulks : coupling bewteen atmospheric boundary layer and fluxes (IPSL)
- Diurnal warm layers (IPSL)
- High resolution coupling in coupled LES (LPO)
- Mathematics in coupled boundary layers (LJK)
- Implicit scheme for coupled atmospheric and oceanic boundary layers (GFDL)

For the future ...

- Present coupling is the ad hoc solution to coupled forced models 30 years ago …
- Bulks are not relevant to high resolution / high frequency
- Ocean and atmosphere boundary layers are handled totally (almost) separately, they are weekly coupled
- The time scheme is ‘doubtful’ ...

Future coupling might be very intrusive in components !

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A Schwarz iterative method to evaluate ocean-atmosphere coupling schemes. Implementation and diagnostics in IPSL-CM6-SW-VLR

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Abstract. State-of-the-art Earth System models, like the ones used in the CMIP6 intercomparison project, suffer from temporal inconsistencies at the ocean-atmosphere interface. Indeed, the coupling algorithms generally implemented in those models do not allow for a correct phasing between the ocean and the atmosphere, and hence between their diurnal cycles. A possibility to remove these temporal inconsistencies is to use an iterative coupling algorithm based on Schwarz methods. Despite the fact that the computational cost is large compared to standard coupling methods, which makes the method impractical as is for production runs, Schwarz algorithms are useful to evaluate some of the errors made in state-of-the-art ocean-atmosphere coupled models (e.g. in the representation of the processes related to diurnal cycle), as illustrated by the present study. A new coupling scheme based on such iterative method has been implemented in the