Numerics practical

Theoretical Meteorology I Cedrick Ansorge & Sally Issa February 4, 2024

#### Discussion Feb 16<sup>th</sup>, 4pm (neuer Hörsaal)

This practical gives a practical perspective on some aspects of the quasi-geostrophic approximation. We will use the Quasi-geostrophic barotropic vorticity with and without a forcing and the two-layer model to reflect on some of the theoretical findings derived during the semester.

We devote the final exercise on Feb  $16^{th}$  to a discussion of your results. Please hand in your code and a small exposé consisting of some figures showing results from the model prior to this discussion. We expect a brief discussion / presentation of the exposé during this exercise.

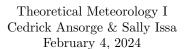
#### 1 Preliminaries - model infrastructure

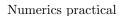
3 P

You can use the model infrastructure provided for python that is provided on the whiteboard. (Alternatively, you may develop an infrastructure with similar capabilities in a programming/scripting language of your choice.)

Make sure you understand the following aspects before you get started to implement any other aspect of this assignment:

• How	is the model controlled (how does it learn about its input / parameters / configurations?)?
	h classes exist and what is there purpose?
1.	
4.	
	time integration scheme is used? In wich class and routine is it implemented?
Scheme	
Class	
Routine .	
• What	kind of output is generated to the following streams/files
stdout	
*.log	
*.iter	
*.nc	







# 2 Time integration

3 P

Check the time integration scheme implemented in the class INTEGRATOR. Setting rhs <sup>1</sup> to exponential (a member of the class integrator) evaluates to the input, i.e. we solve the equation

$$\frac{dx}{dt} = x \Rightarrow \tilde{x}(t) = \frac{x_0}{e^{t_0}} e^t.$$

- a) What is the expected result for  $t_0 = 0$  and  $x_0 = 1$  when integrating up to t = 2? Check for  $\Delta t = 1$ !
- b) Varying the time step  $\tau$  of the integration, check the order of the time integration scheme and produce a log-log plot of the error  $x_{num} \tilde{x}$  as a function of  $\tau$ .
- c) What is the order of the numerical error for the time integration scheme used?
- d) Why does the numerical error reach a limit as  $\tau \to 0$ ?

### 3 Rossby waves

15 P

# 4 Two-layer model

20 P

<sup>&</sup>lt;sup>1</sup>Note that with rhs, we are passing a function as argument, i.e. we are using the concept of function pointers