Single-Column Model

Introduction

Filip Váňa

filip.vana@ecmwf.int

ECMWF

Modelling Basics

Prognostic quantity X described by an atmospheric model can be formally written as:

$$X = \bar{X} + x$$

$\bar{X}$ $\cdots$ part resolved by the model

x $\cdots$ the sub-grid component

Governing equations:

$$\frac{\partial \bar{X}}{\partial t} = \underbrace{\mathcal{D}_{LS}(\bar{X})}_{\text{resolved}} + \underbrace{\mathcal{F}_{SS}(\bar{X}) + S_i}_{\text{parameterized}}$$

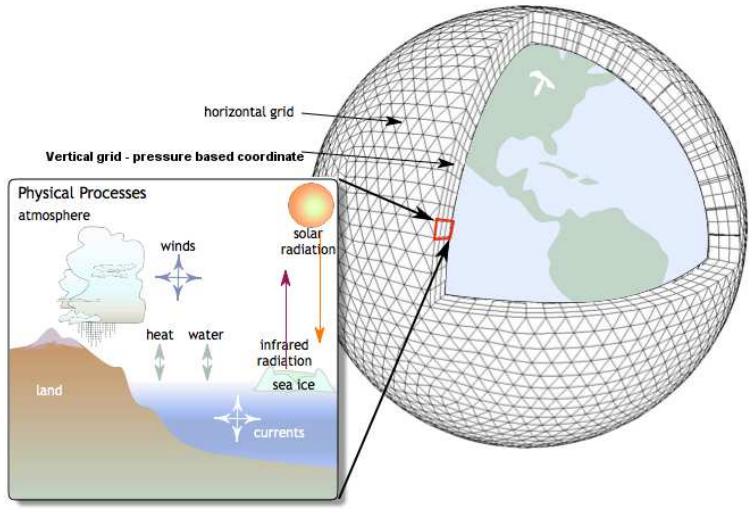
numerics

physical processes

Modelling Basics - II.

numerics $\rightleftarrows$ physical processes

- Atmospheric models:
  $L_{\text{hor}} >> L_{\text{ver}}$
- Numerics: 3D problem
  $\rightarrow$ frequently separated to horizontal and vertical parts
- Physics: Horizontal component usually neglected
  $\rightarrow$ treated like set of independent vertical columns



Single-Column Model

Simplistic approach: Small scale processes are fully determined by inter-process ballance and large scale forcing:

numerics $\rightarrow$ physical processes

$$\frac{\partial \bar{X}}{\partial t} = \mathcal{D}_{\mathsf{ver}}(\bar{X}) + \mathcal{F}_{SS}(\bar{X}) + S_i + \mathcal{D}_{\mathsf{hor}}(\bar{X}) - \alpha \frac{\bar{X} - \bar{X}_0}{\tau}$$

$\mathcal{D}_{\mathsf{ver}}(\bar{X})$	$\cdots$	large scale tendency (no horizontal component)
$\mathcal{F}_{SS}(\bar{X}) + S_i$	$\cdots$	physics = subgrid scale and source terms tenden
$\mathcal{D}_{\mathsf{hor}}(\bar{X})$	$\cdots$	prescribed horizontal large scale tendency
$\alpha \frac{\bar{X} - \bar{X}_0}{\tau}$	$\cdots$	relaxation term towards $\bar{X}_0$

Conclusions

- SCM modelling is an efficient and simplistic tool to study model physics. (Cost and data access is no longer an issue.)
- Stability of a SCM is fully determined by its large scale forcing: Allows to study subset of processes or single process only. Very useful for comparing different versions of the same scheme.
- Quality strongly depends on large-scale forcing and SCM setting: Often leads to biassed results.
- Comparing with observation is a delicate matter.
- All conclusions from SCM should be verified in 3D model.