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:

\[
X = \bar{X} + x
\]

\( \bar{X} \) \quad \cdots \quad \text{part resolved by the model}

\( x \) \quad \cdots \quad \text{the sub-grid component}

Governing equations:

\[
\frac{\partial \bar{X}}{\partial t} = D_{LS}(\bar{X}) + F_{SS}(\bar{X}) + S_i
\]

\( D_{LS} \) \quad \text{resolved numerics}

\( F_{SS} \) \quad \text{parameterized physical processes}

\( S_i \) \quad \text{physical processes}
Modelling Basics - II.

- Atmospheric models:
  \[ L_{\text{hor}} \gg L_{\text{ver}} \]

- Numerics: 3D problem
  → frequently separated to horizontal and vertical parts

- Physics: Horizontal component usually neglected
  → treated like set of independent vertical columns
Single-Column Model

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

\[ \frac{\partial \bar{X}}{\partial t} = D_{\text{ver}}(\bar{X}) + F_{SS}(\bar{X}) + S_i + D_{\text{hor}}(\bar{X}) - \alpha \frac{\bar{X} - \bar{X}_0}{\tau} \]

- \( D_{\text{ver}}(\bar{X}) \) \ldots large scale tendency (no horizontal component)
- \( F_{SS}(\bar{X}) + S_i \) \ldots physics = subgrid scale and source terms tendency
- \( D_{\text{hor}}(\bar{X}) \) \ldots prescribed horizontal large scale tendency
- \( \alpha \frac{\bar{X} - \bar{X}_0}{\tau} \) \ldots 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.