PhD Program in Computer Science and Systems Engineering

DIBRIS, University of Genoa

CIMA Research Foundation

PhD Topic: Coupling of Atmospheric and Hydrological Modelling

By Endalkachew Bogale Gelaw

Proposer(s): Luca Ferraris, Fabio Delogu, Antonio Parodi, Simone Gabellani

Introduction

The evolution of water management to consider the whole water cycle as a management scope necessitates the investigation and understanding of the underlying mechanisms of the interactions and feedbacks between each compartments of the hydrologic cycle. Being the major drivers of the hydrologic system, the atmospheric and land surface processes, and their interaction are becoming the main topics of research agenda these days.

Some of the most pressing challenges in linking atmospheric and hydrologic models arise from the disparity between the spatial and temporal resolutions at which they operate. Therefore, a fundamental question is how to conduct physically meaningful and realistic transfers of spatio-temporally varying variables from one scale to another. Although many approaches to couple atmospheric and hydrologic models fully have been proposed, inconsistent parameterizations of physical processes between models, problems of numerical compatibility, and limited computer resource's combine to restrict their application at the required spatial and temporal resolutions.

Significance of the Research

The proposed study herein is expected to provide greater insight into the processes and mechanisms affecting the coupling of atmospheric and hydrologic models in order to capture the spatial and temporal variability of the two distinct natural processes. The knowledge and information envisaged to be generated here would help in evaluating and formulating sound water resource management strategies for scenarios of climate impact and anthropogenic stress.

Using the coupled modeling systems, precipitation will be accurately forecasted/translated into runoff forecasts. This can be in the form of runoff peak, volume, and timing, with great

improvement in the runoff-forecast lead time which is necessary for the operation of reservoirs, and emergency management procedures such as evacuations to be carried out.

In addition, with this research a more detailed analysis of the use of remote sensing products for the purpose of runoff forecasting will be investigated. This opens the door to use remote sensing data in areas where environmental monitoring stations are missing or sparsely populated.

Objectives

The main objective of this research is to build an integrated model coupling platform capable of forecasting spatio-temporal variability of water resource in response to different atmospheric forcing and rainfall variability and anthropogenic stress. The following are the specific objectives,

- To make a detailed literature review on the state-of-the-art methods of coupled atmospheric and hydrologic modeling paradigms,
- To study the main features of the atmospheric model (WRF) and the hydrologic model (Continuum),
- To develop a coupling scheme and evaluate at different resolutions,
- To include data assimilation schemes that incorporate both remote and in situ observations into the coupling framework,
- And finally, to test the effectiveness of the coupling scheme in selected pilot areas around the world.

Coupling Approach

The following are key underlying principles in coupling the models:

- ✓ Compatibility of information exchange or feedback of different fluxes between coupled models
- ✓ Compatibility of spatio-temporal scales on which different processes operates in each of coupled model
- ✓ Information required by one model is to be generated by the other model precisely without any redundancy
- ✓ Two-way coupling has to be ensured to include feedback of relevant processes
- ✓ Consistent degree of complexity between the models of the coupled system

In addition, a coupling framework has to use the available measurement technologies for precipitation, surface radiation fluxes, wind and humidity, and soil moisture through a number of remote-sensing observation. Also, developing and applying a coupled land data assimilation system further improves the coupling between atmospheric and land surface hydrologic models.

A conceptual framework for coupling atmospheric and hydrologic models is schematized in the figure below.

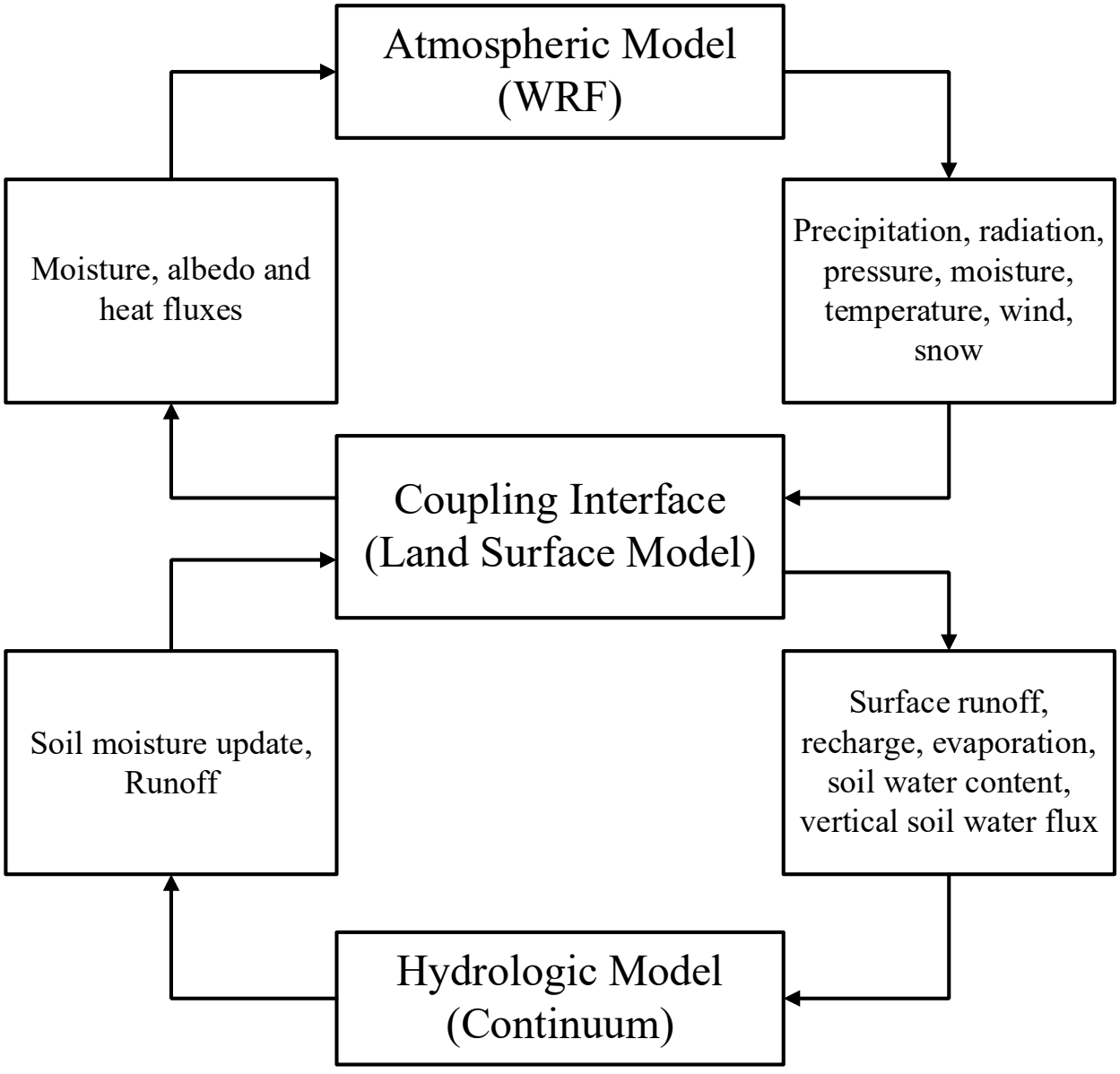

Fig.: Conceptual framework of coupled atmospheric-hydrological modelling