Athabasca University
ATHABASCA RIVER BASIN
RESEARCH INSTITUTE

Computational Sustainability and Environmental Analytics for Athabasca River Basin

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Outline

- Athabasca river basin and its sustainability
- Watershed, the objectives of the CAIP program, challenges and system modelling
- Biogeochemical and hydrological processes
- Integrated agroecosystem and reclamation and upscaling
- Initial progresses

Athabasca watershed and its sustainability

- Athabasca river basin (ARB) includes agricultural and oilsand activities
- ARB is central of economic and social development in northern Alberta communities

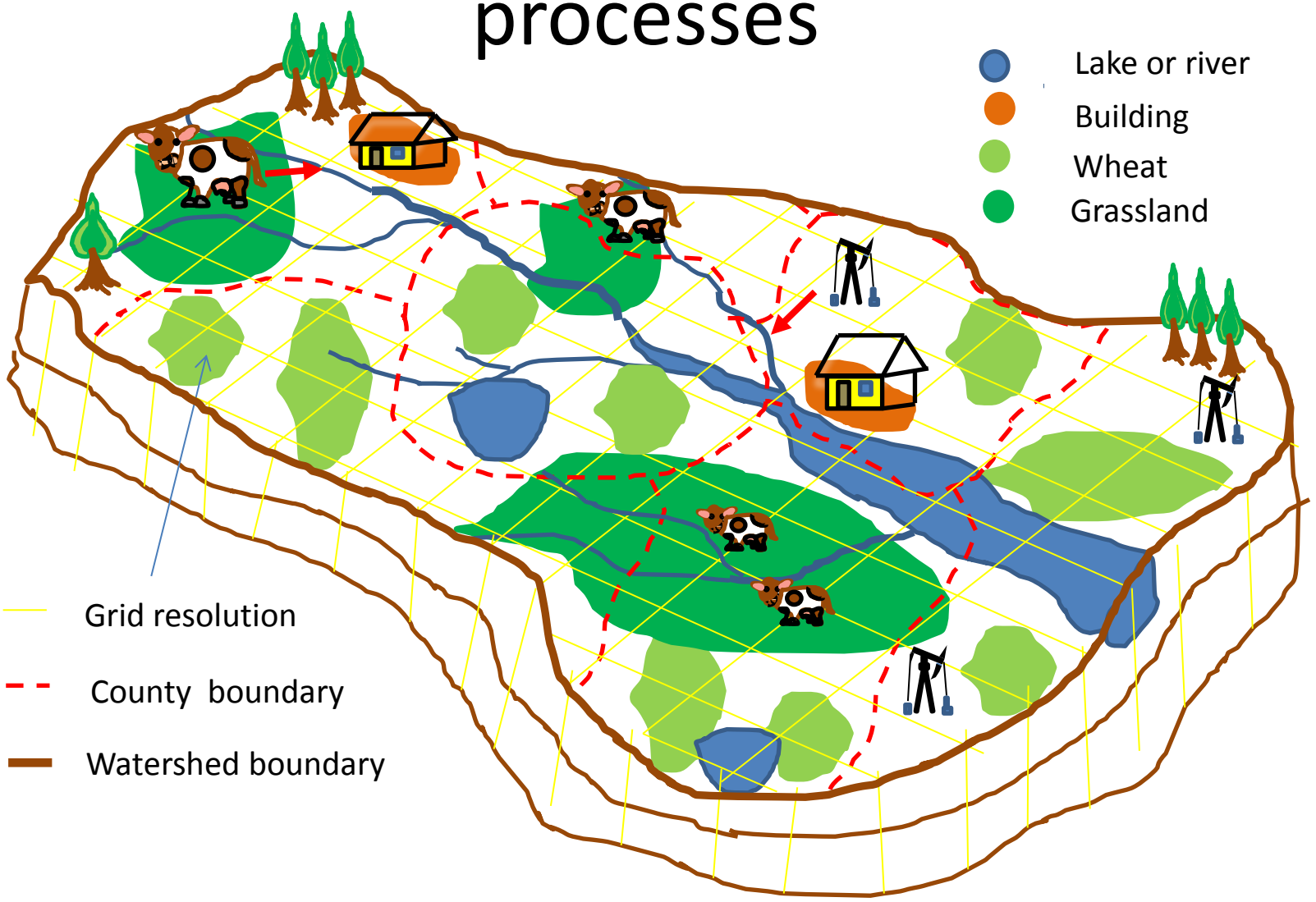
Athabasca river basin and its sustainability

- Nonpoint pollution sources from agricultural oilsand production: agricultural (e.g., nutrients) and oilsand pollutants
- Sustainability of the watershed's soil and water resource.
- New approaches and tools for policy maker to manage the vital resources.

Objectives of the CAIP Chair Program

- Help identify key factors and processes
- Develop a modelling tool for understanding of water processes and system
- Compare different scenarios and assess different mitigation option
- Help design and implement monitoring systems
- Propose/adjust measures for adaptive management of cumulative impact and decision making
- Develop a platform for multidisciplinary collaborations

Watershed ecosystem and two natural processes

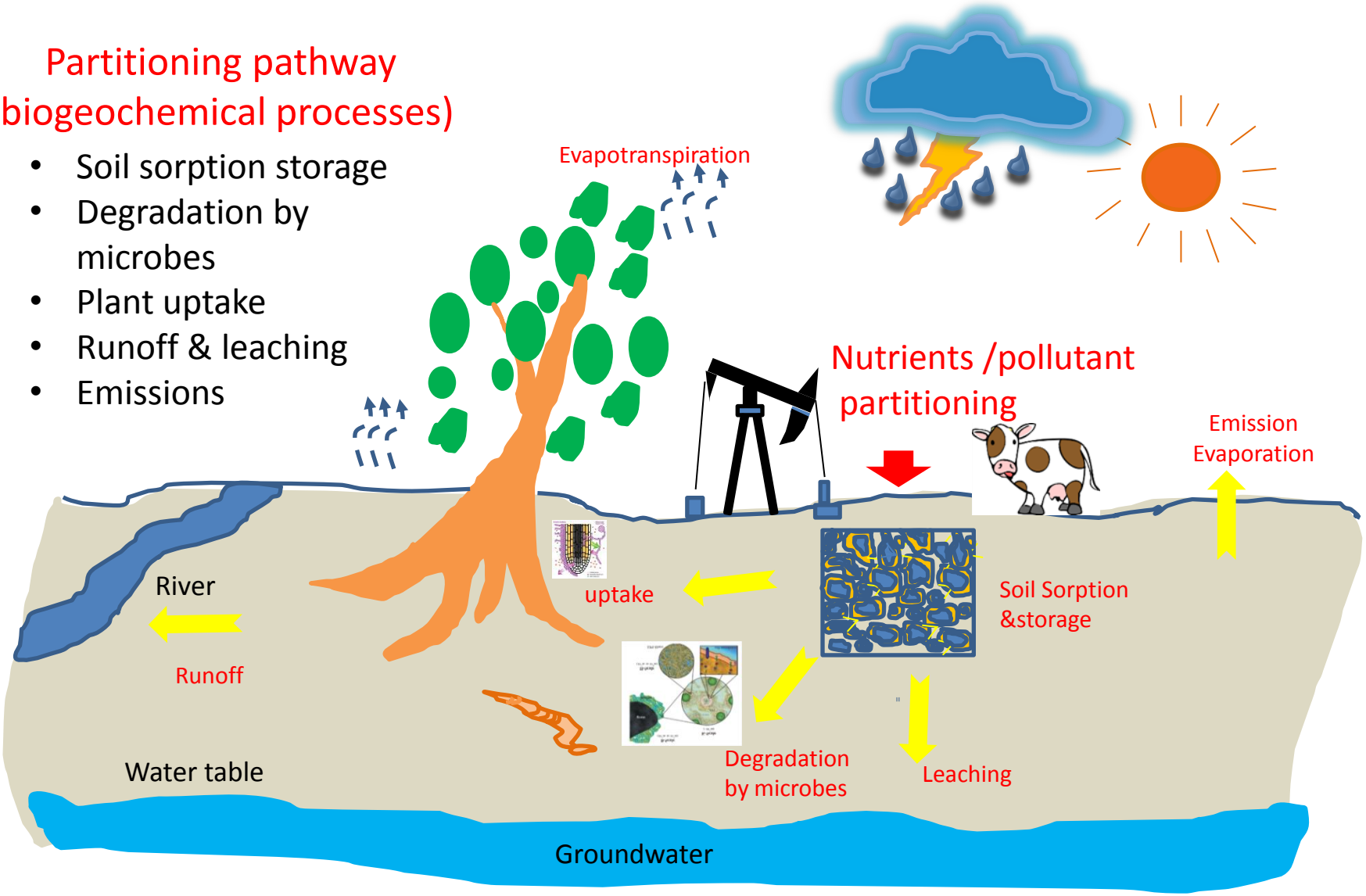


What challenges to study such a watershed?

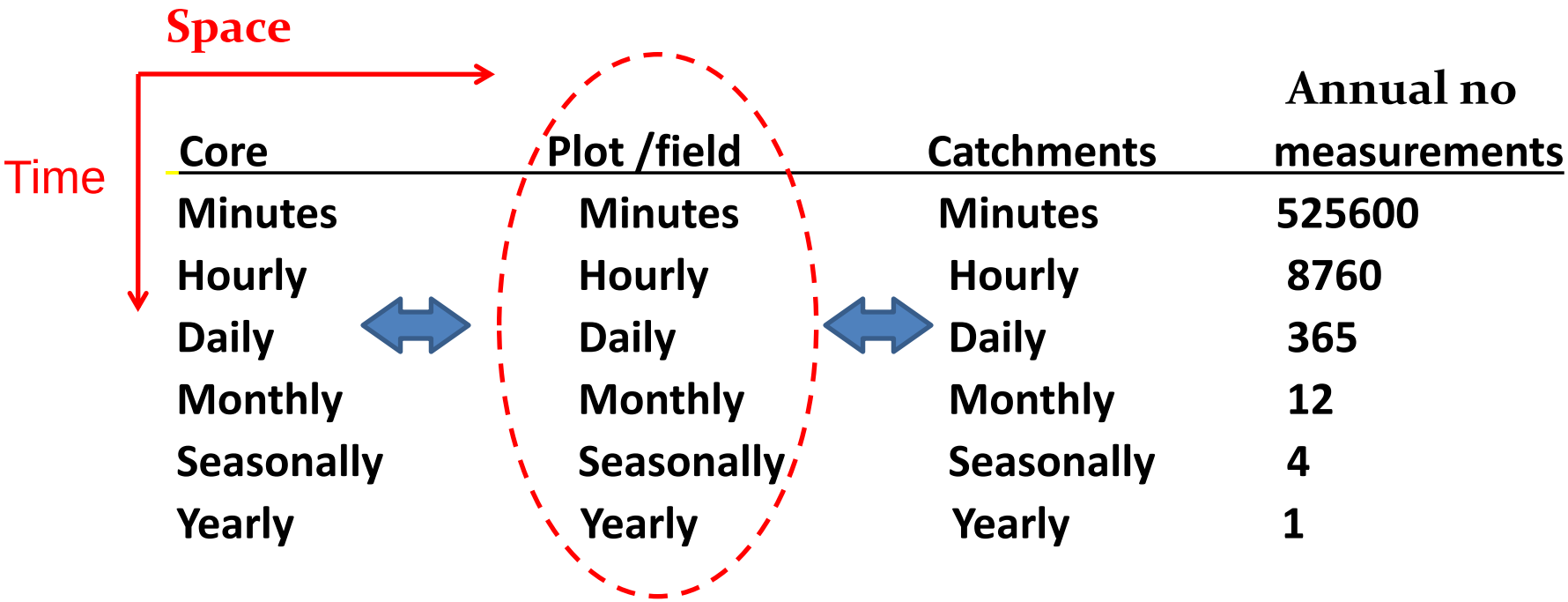
Challenge 1: Complex systems

Partitioning pathway (biogeochemical processes)

- Soil sorption storage
- Degradation by microbes
- Plant uptake
- Runoff & leaching
- Emissions



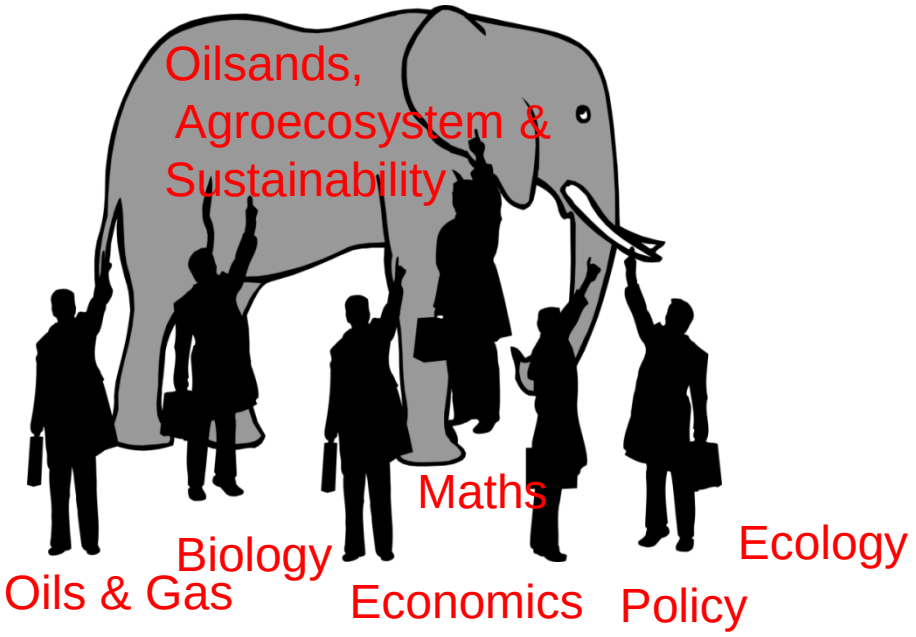
Challenge 2: Multi-scale in Ecosystem



- Question 1. How many measurements do we need for a hypothesis forming ?
- Question 2. How could we link different scale?

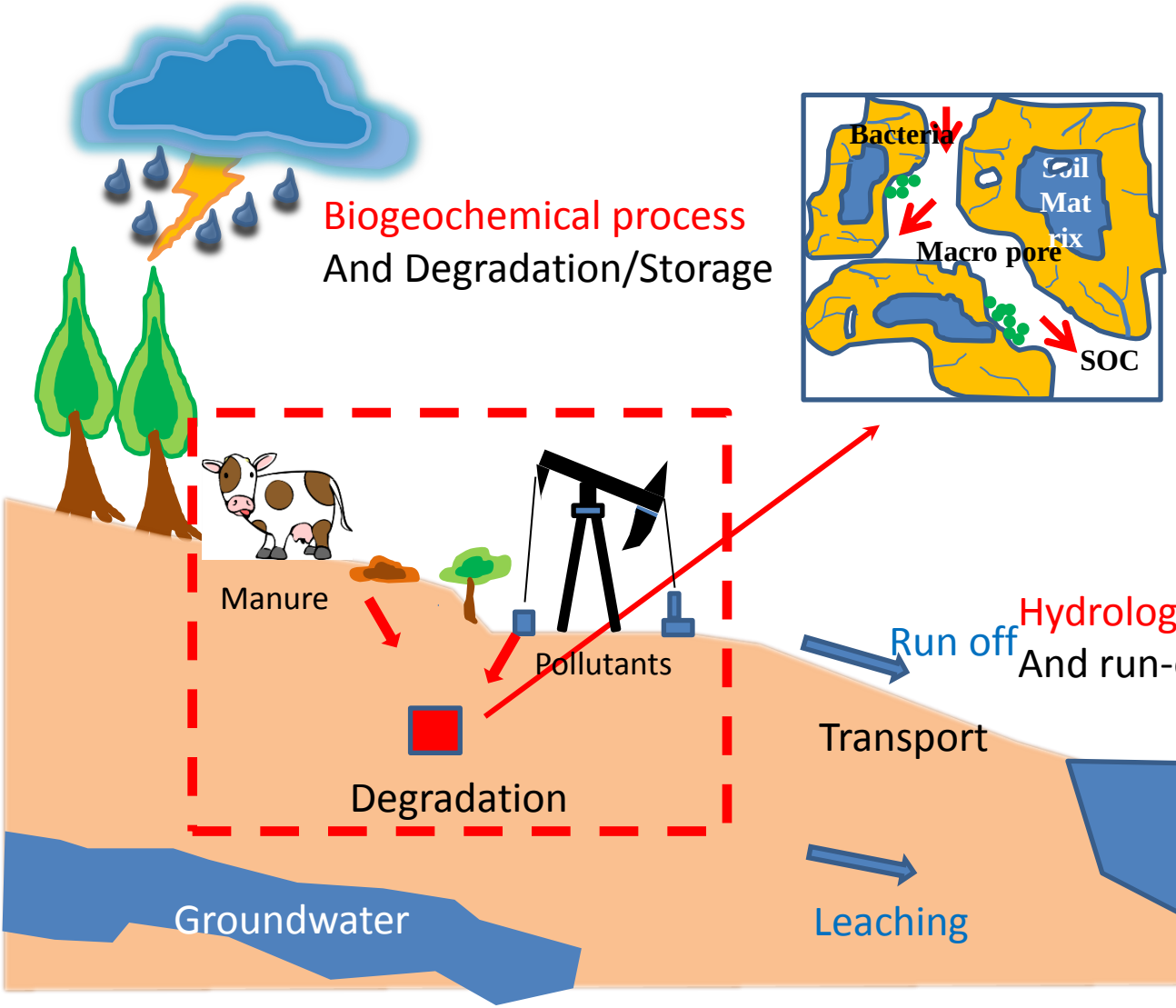
Challenge 3: multidiscipline

Tale: the blind men and an elephant!



System modelling and integration!

Biogeochemical and hydrological processes



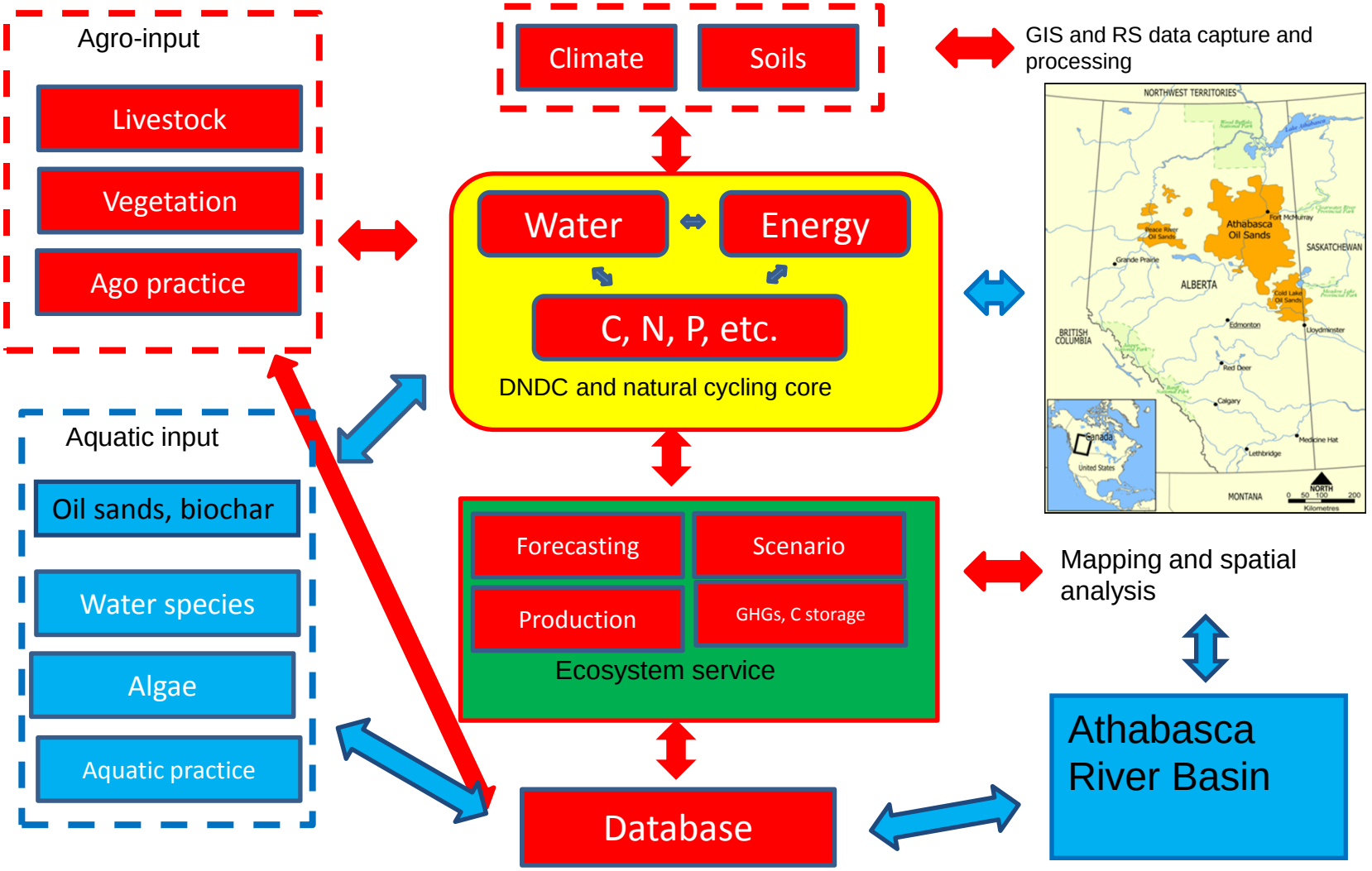
Partitioning pathway

- Soil storage
- Degradation by microbes
- Plant uptake
- Runoff & leaching
- Emissions

Where do we start from for an integrated model?

- Existing models of biogeochemical and hydrological processes: advantages and disadvantages:
  - Biogeochemical model: DeNitrification DeComposition (DNDC) developed by Changsheng Li.
  - Hydrological model: The Soil and Water Assessment Tool (SWAT) developed by United States Department of Agriculture
- Integration of two models for mutual enhancement

Integrated framework of terrestrial and aquatic systems



Biogeochemical (Process-based) modelling: DNDC model

- DeNitrification and DeComposition (DNDC)
- Four interactive sub-models: thermal hydraulic, Plant growth, Decomposition, and DeNitrification
- Linkage of soils, crops, weather and agro practice
- Agricultural practice: fertilisation, tillage, grazing, flooding and irrigation

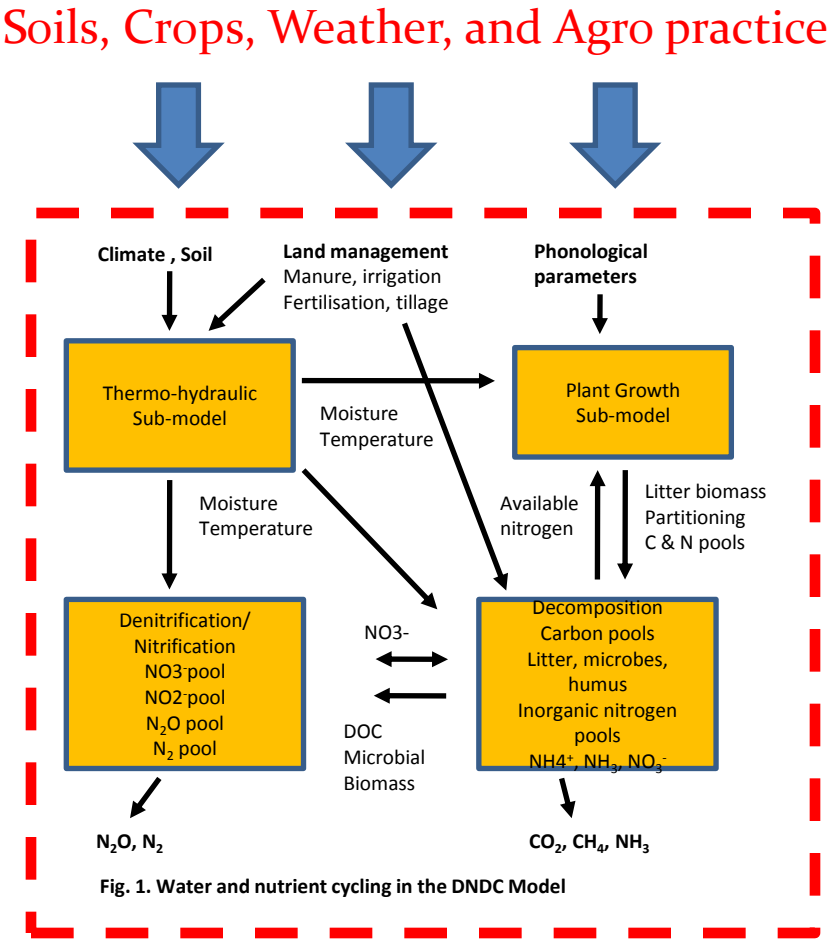
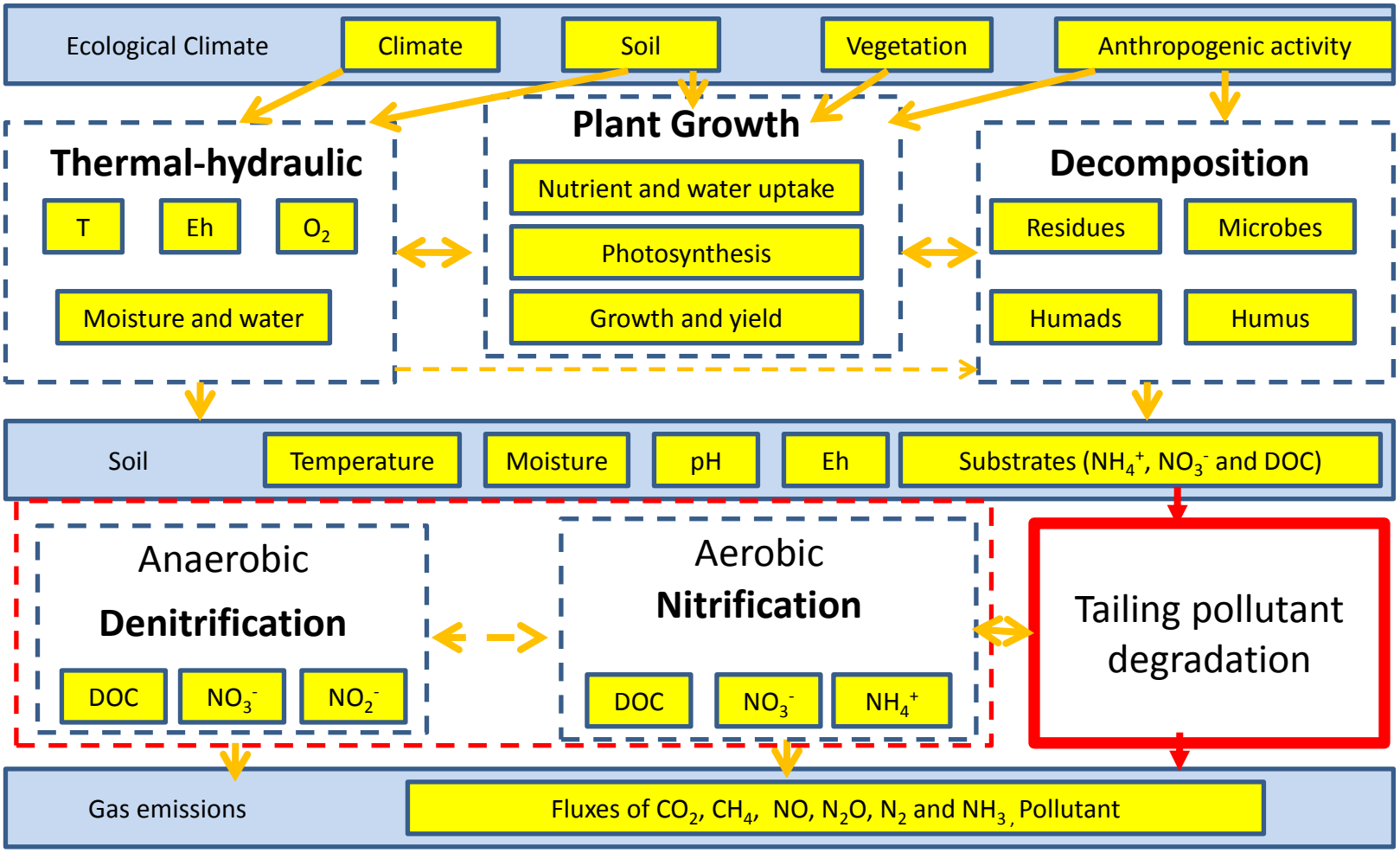
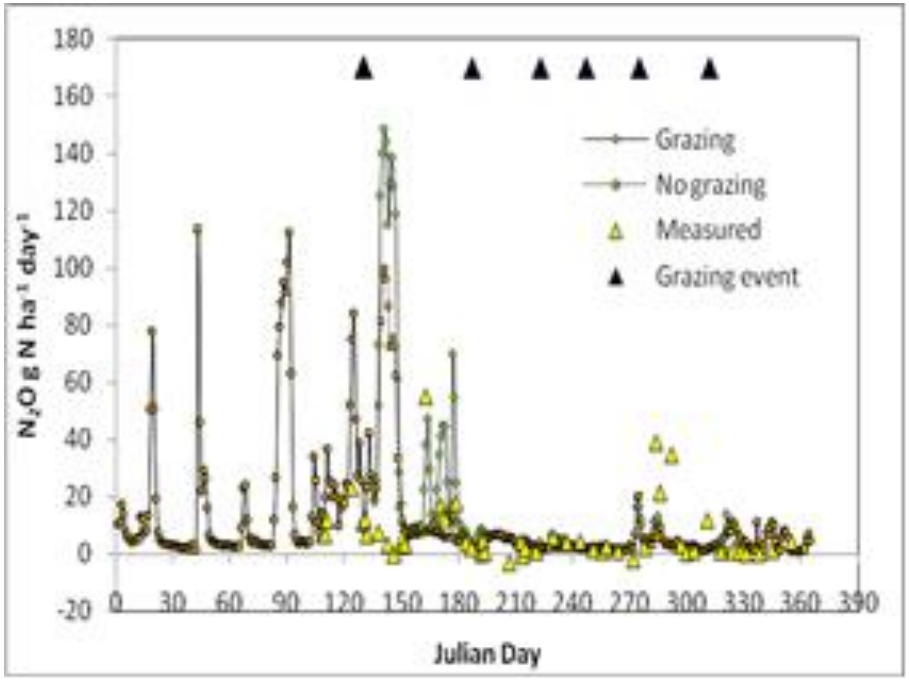


Fig. 1. Water and nutrient cycling in the DNDC Model

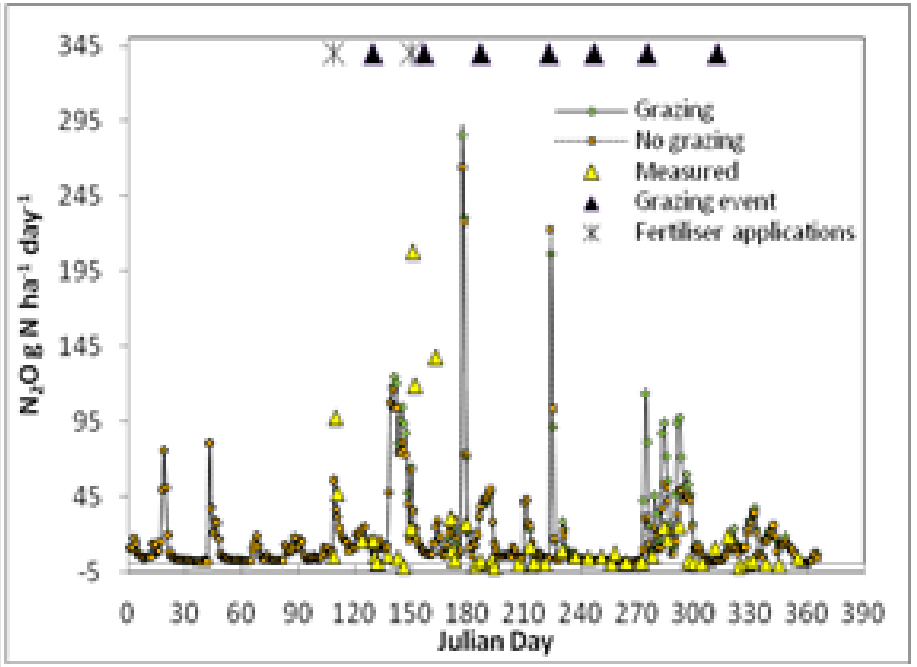
DNDC framework for tailing pollutant



Greenhouse gas emissions (N_2O)



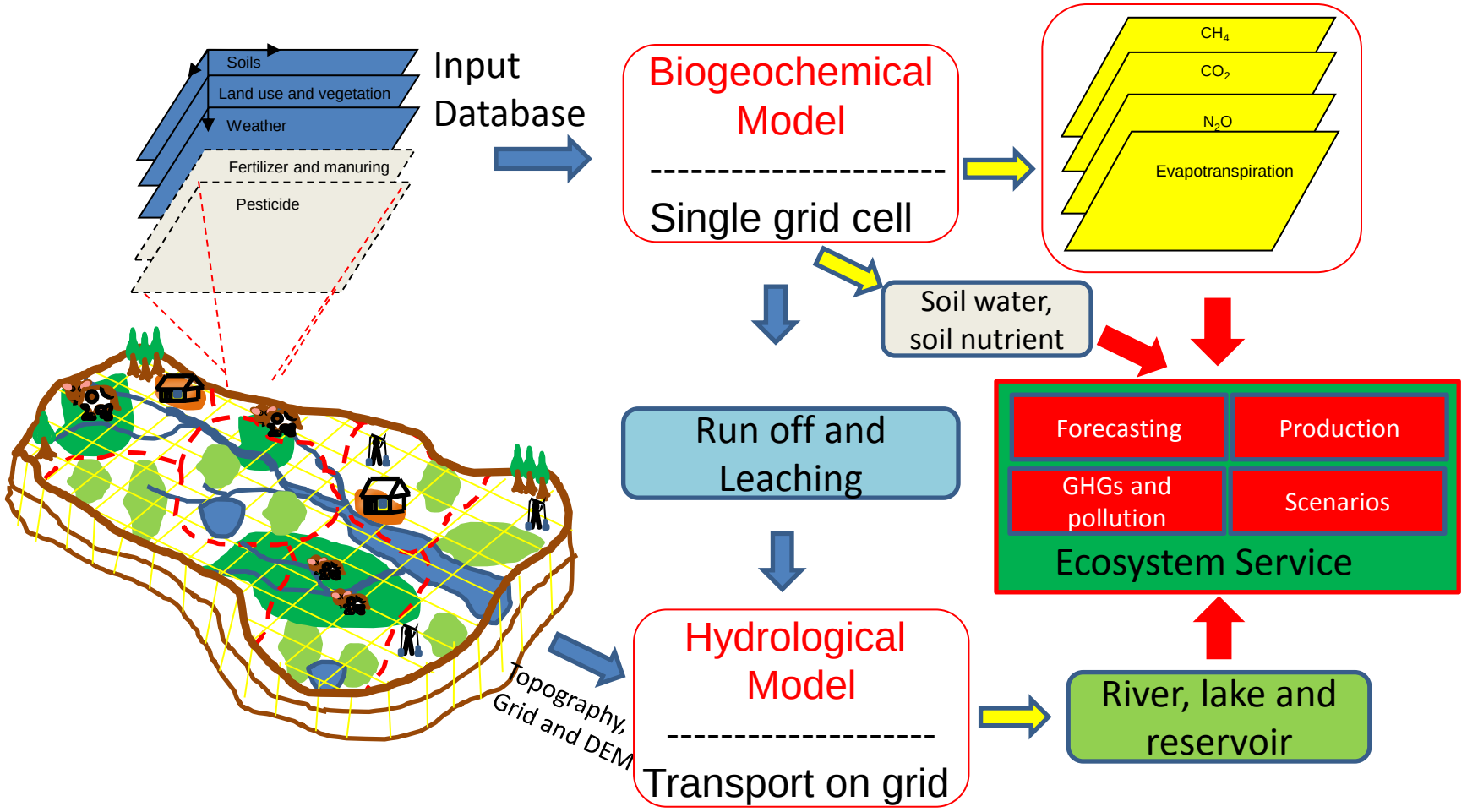
Plot 1



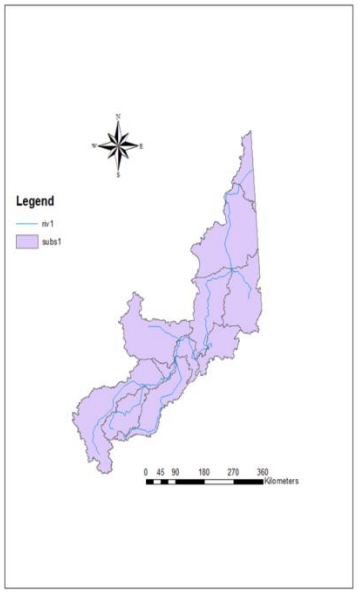
Plot 2

Simulated vs. observed N_2O emissions at the Rowden site in the UK

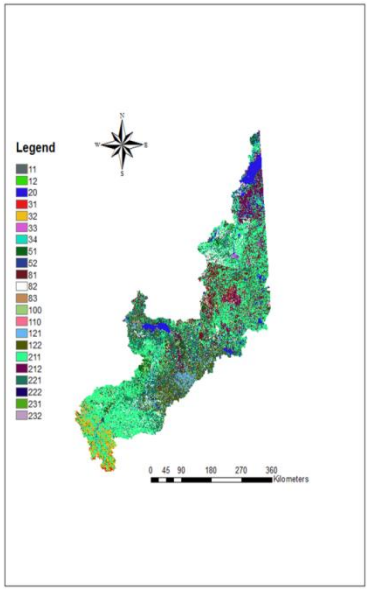
Integration of biogeochemical and hydrological processes



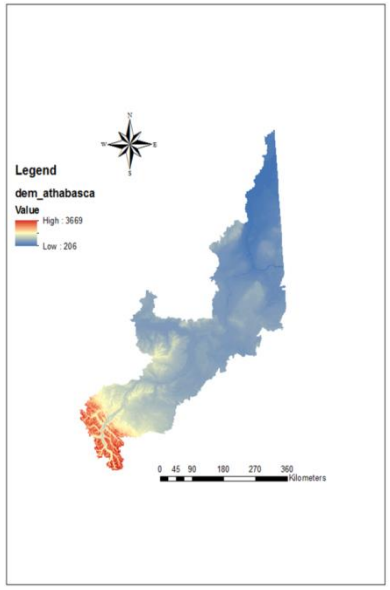
Database for Athabasca River Basin



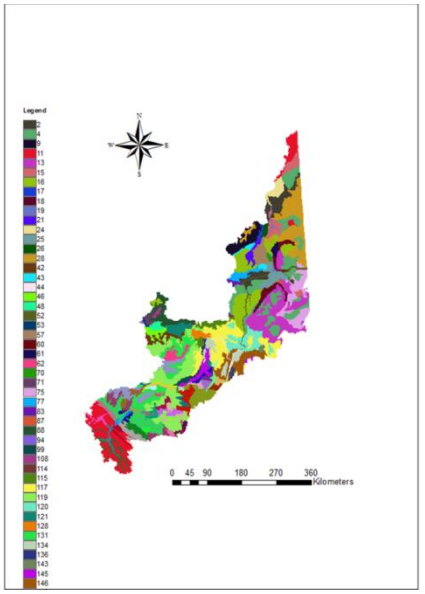
River System



Land cover and use

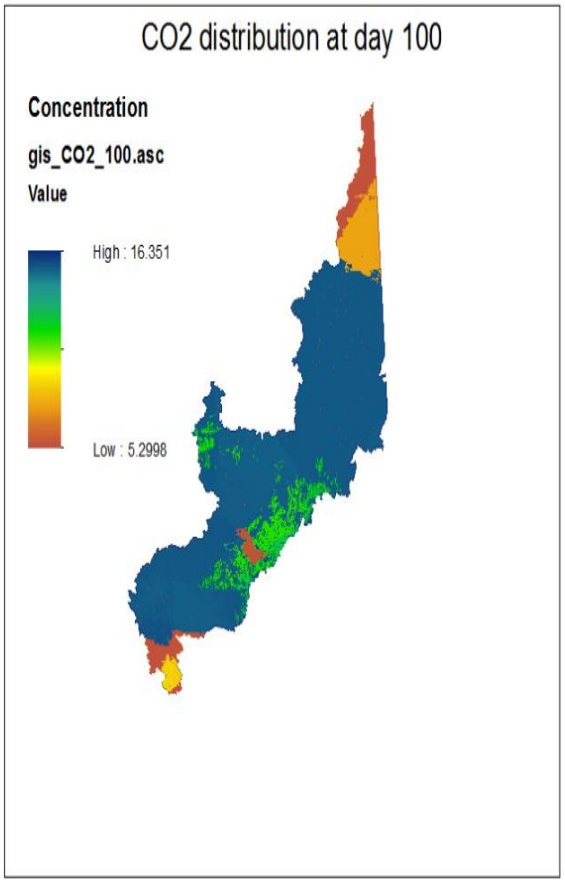


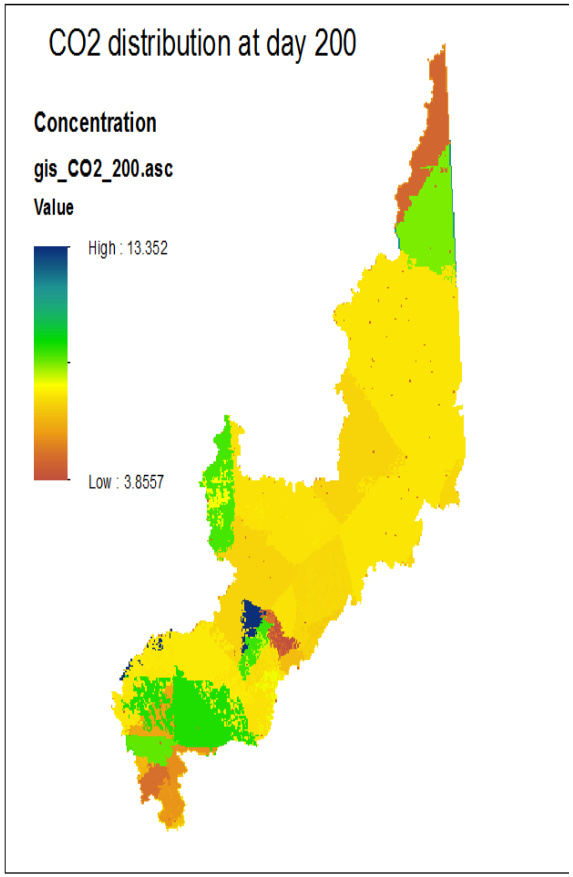
DEM map

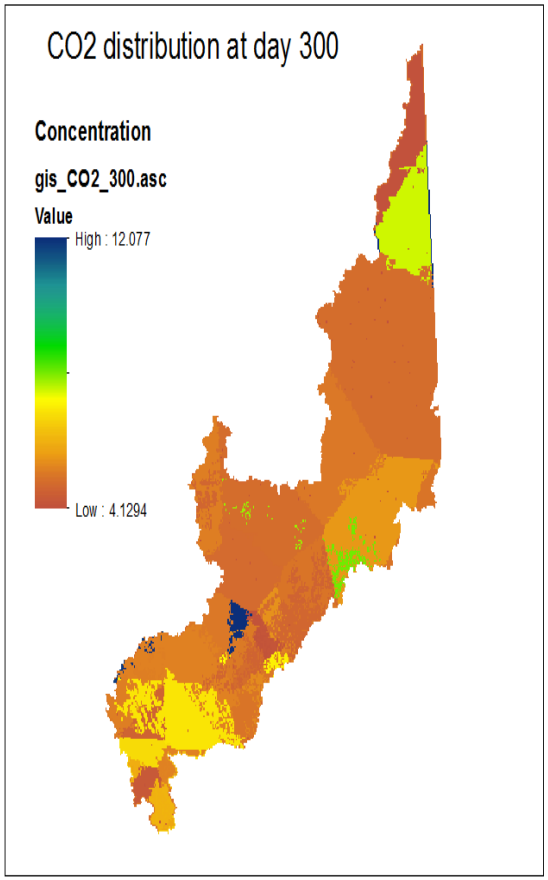


Soil map

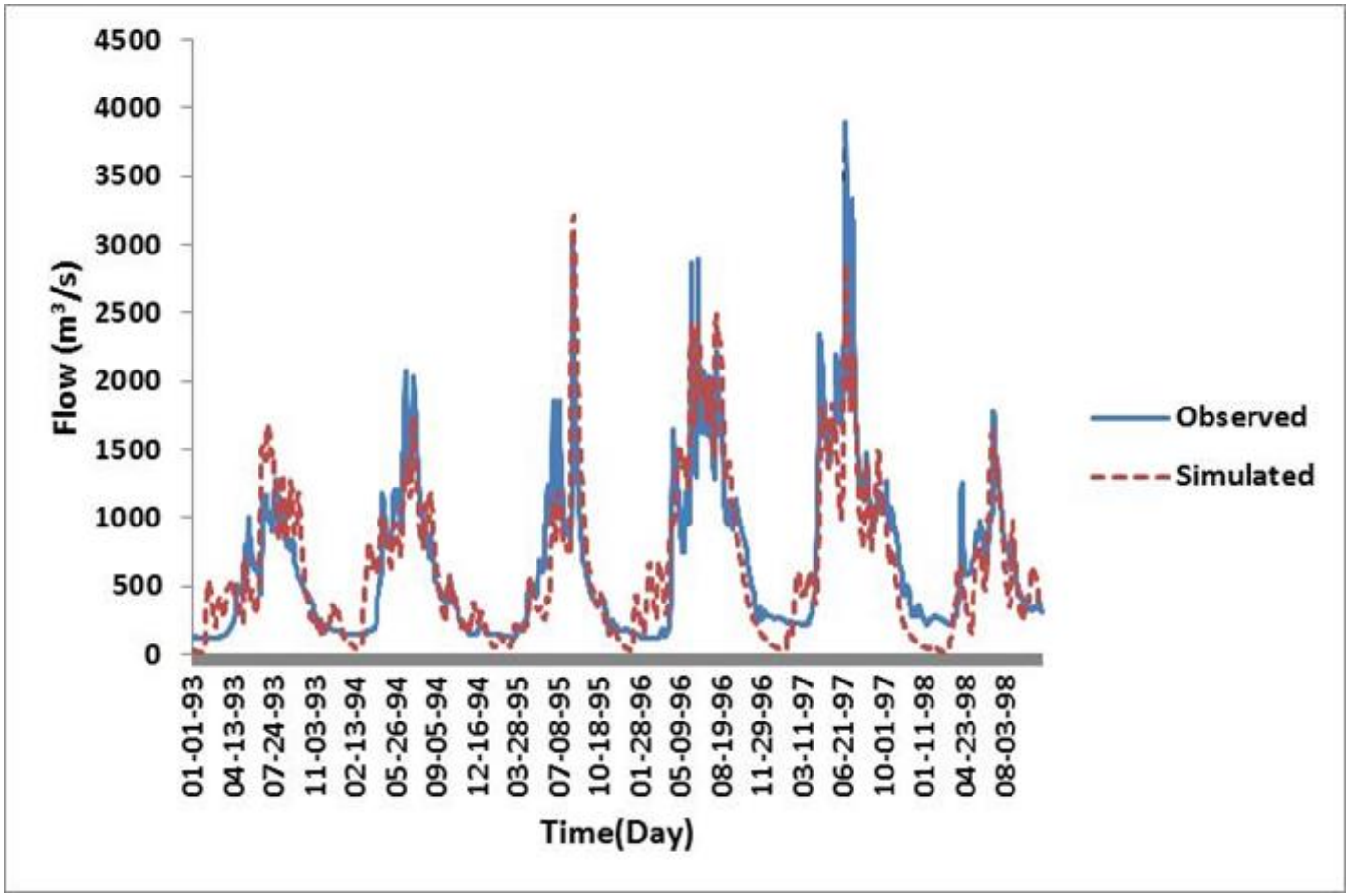
CO_2 distribution using DNDC





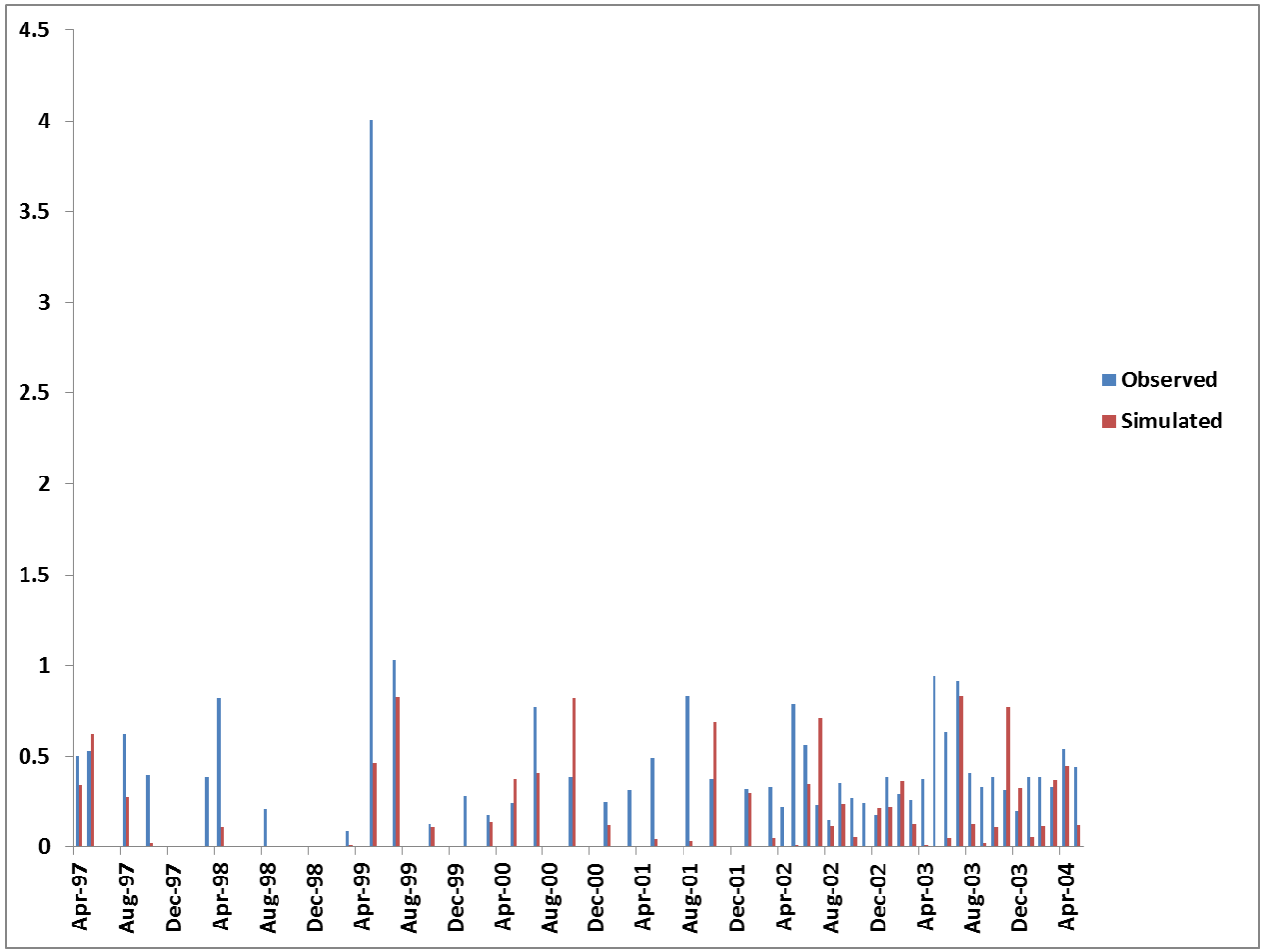


Flow rates for Athabasca River using SWAT



Daily observed and simulated flow at the Fort McMurray station

Nitrogen runoff for Athabasca River using SWAT



Integrated framework and interfaces for multidisciplinary inputs

Biogeochemistry & microbiology

Modelling of Athabasca River Basin

Water, Energy and Land Framework

Computer algorithms

Database and data mining

Human activity & behaviour

Policy & economy

Renewable energy Oil sand

Acknowledgement

- Campus Alberta Innovates Program
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Thank you very much for your attention!