# GLOFRIM – A globally applicable computational framework for integrated hydrological–hydrodynamic modelling

**Jannis Hoch**
*PhD Candidate*

**Faculty of Geosciences**
Department of Physical Geography

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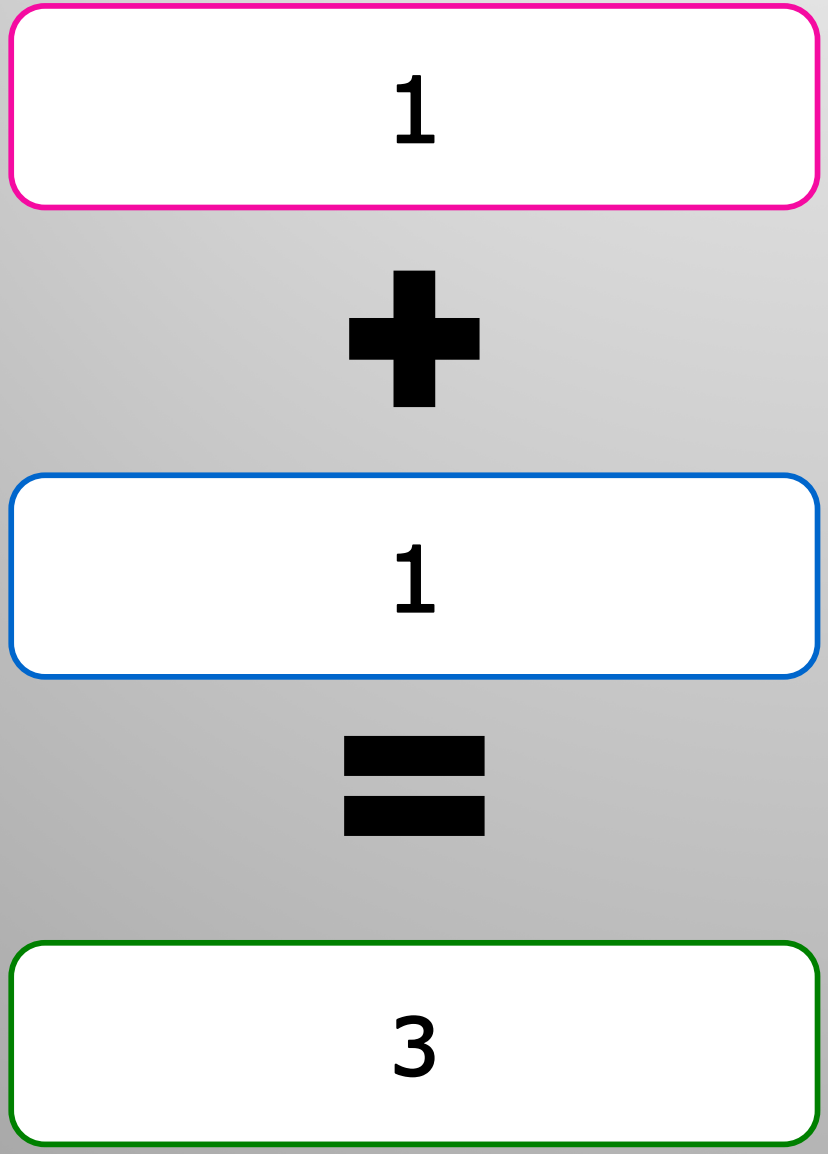
# Motivation



# Motivation

Hydrology

+

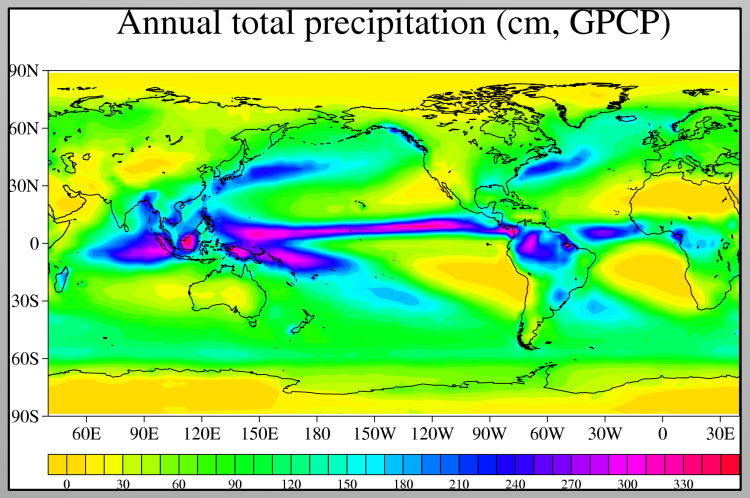
Hydrodynamics

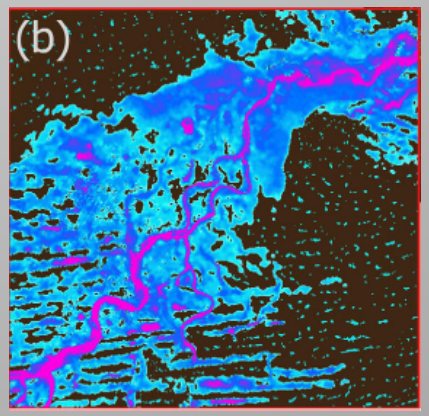
=

Synergy?

# Motivation

| | HYDROLOGY | HYDRODYNAMICS |
|---|---|---|
| Forcing | Global meteorology + | Observation stations − |
| | Spatially distributed + | Upstream boundaries − |
| Routing | Kinematic Wave Approximation − | Shallow Water Equation + |
| Spatial Resolution | ≥ 10 km² − | << 10 km² + |




*Sampson et al., 2015 (WRR)*

Introducing…

# …GLOFRIM

**Spatially explicit coupling**

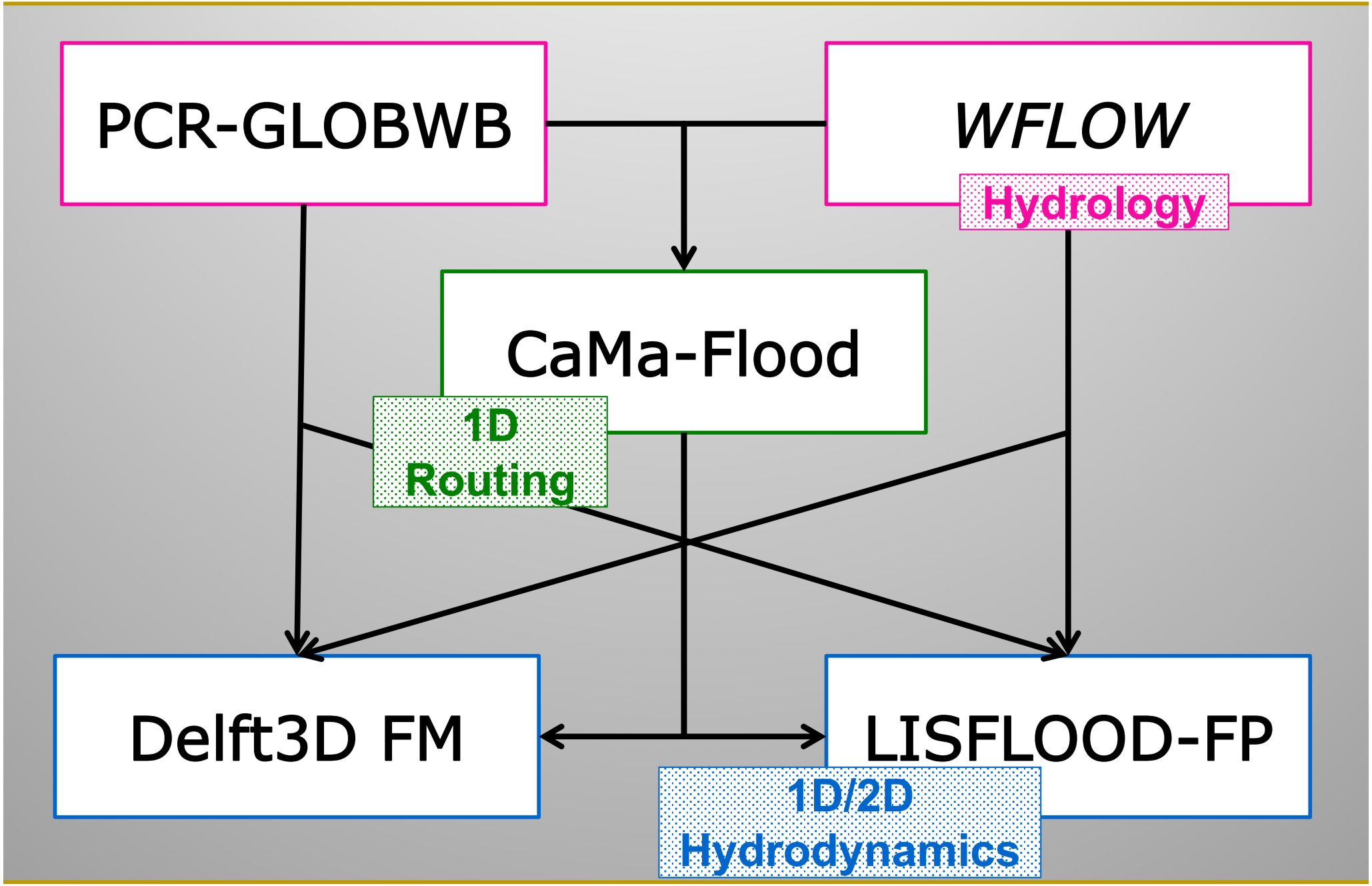
**Free and open**

**Online coupling**

**Modular**

It contains:

- Python function to couple grids & exchange data
- Script(s) to execute model coupling
- BMI'ed models


PCR-GLOBWB
WFLOW
Hydrology
CaMa-Flood
1D
Routing
Delft3D FM
LISFLOOD-FP
1D/2D
Hydrodynamics

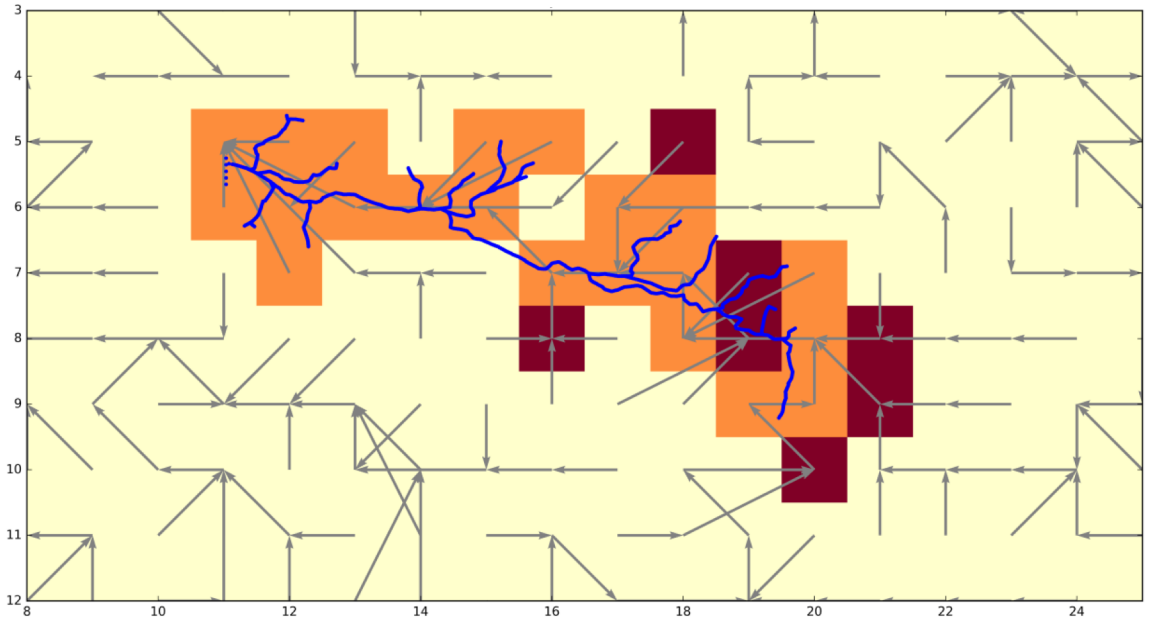
## *HOW ARE THESE MODELS COUPLED?*

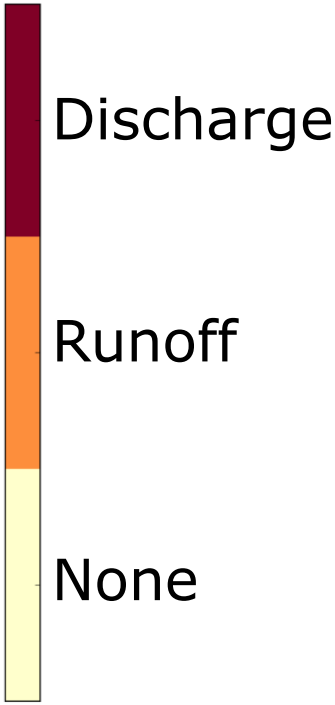
- BMI = **Basic Model Interface**
- set of commands to communicate with models

| | |
|---|---|
| *bmi*.initialize() | initialize model and parameters |
| *bmi*.get_var() | retrieve values of a variable |
| *bmi*.set_var() | overwrite values of a variable |
| *bmi*.update() | update model at (sub)time step |
| *bmi*.finalize() | finalize model |

- Interface (e.g. python-script) required for interaction between different models

# Spatially explicit coupling



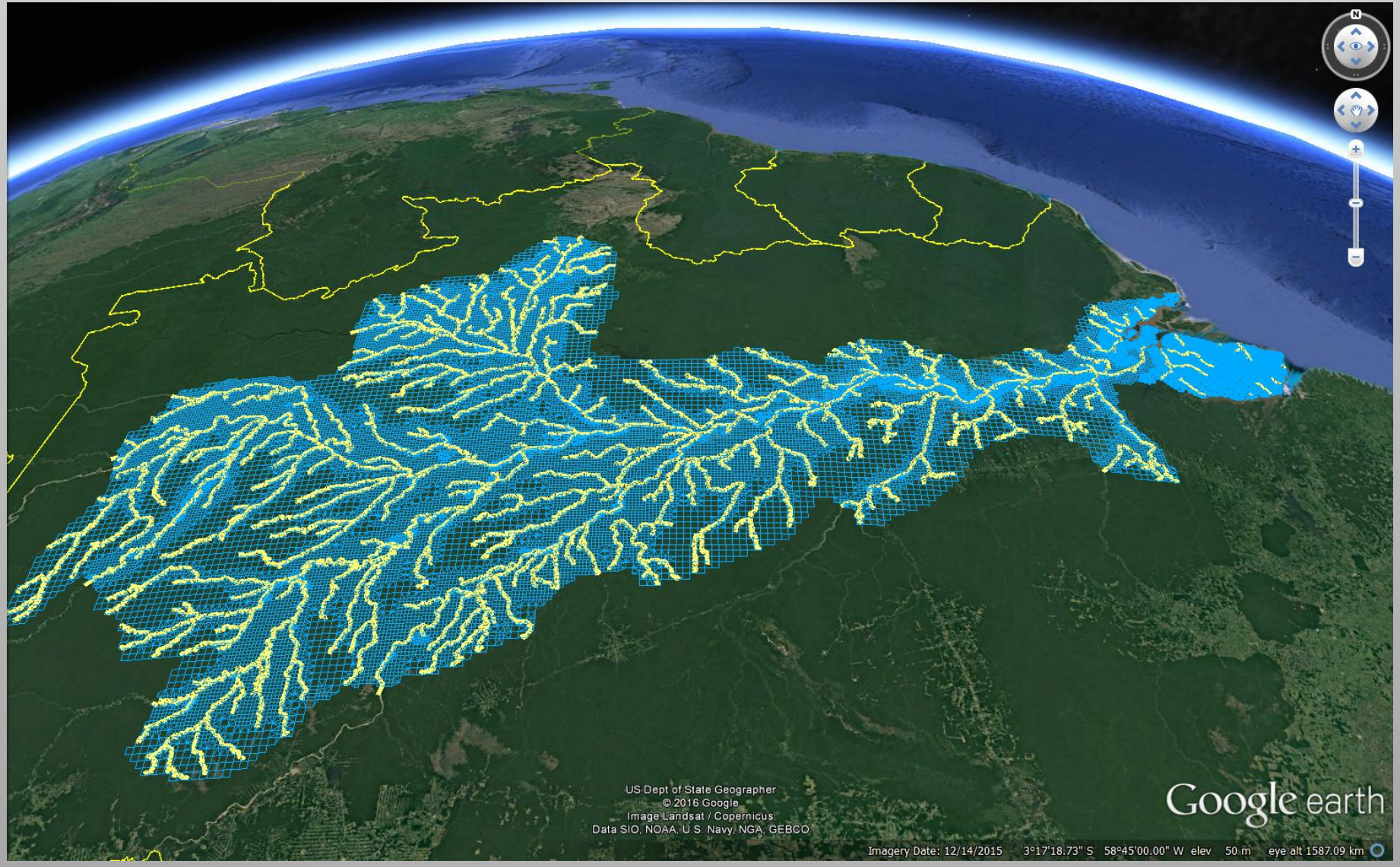
Some

# Applications

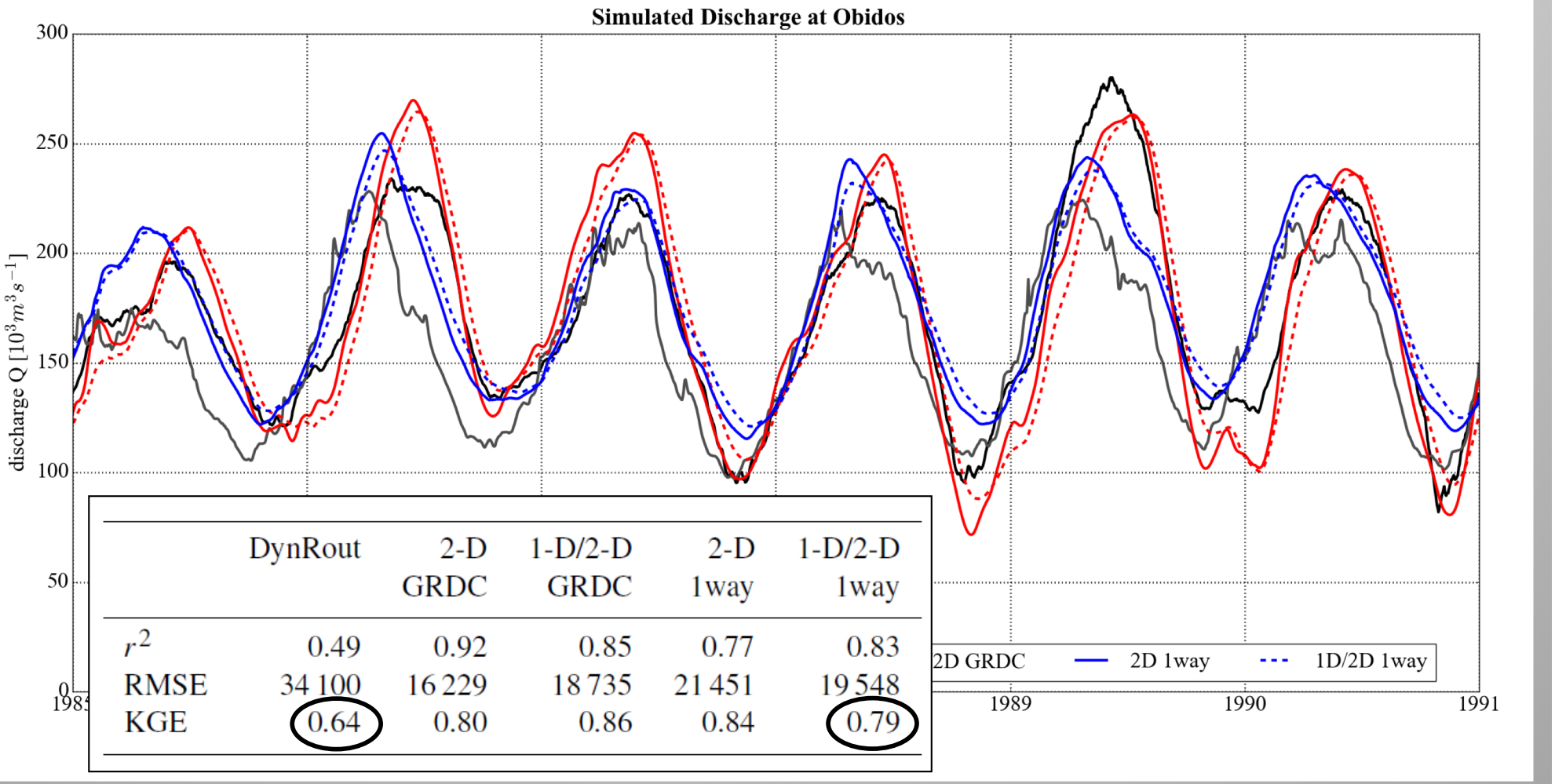
of GLOFRIM

# Replacing routing scheme of hydrologic models

# Applications



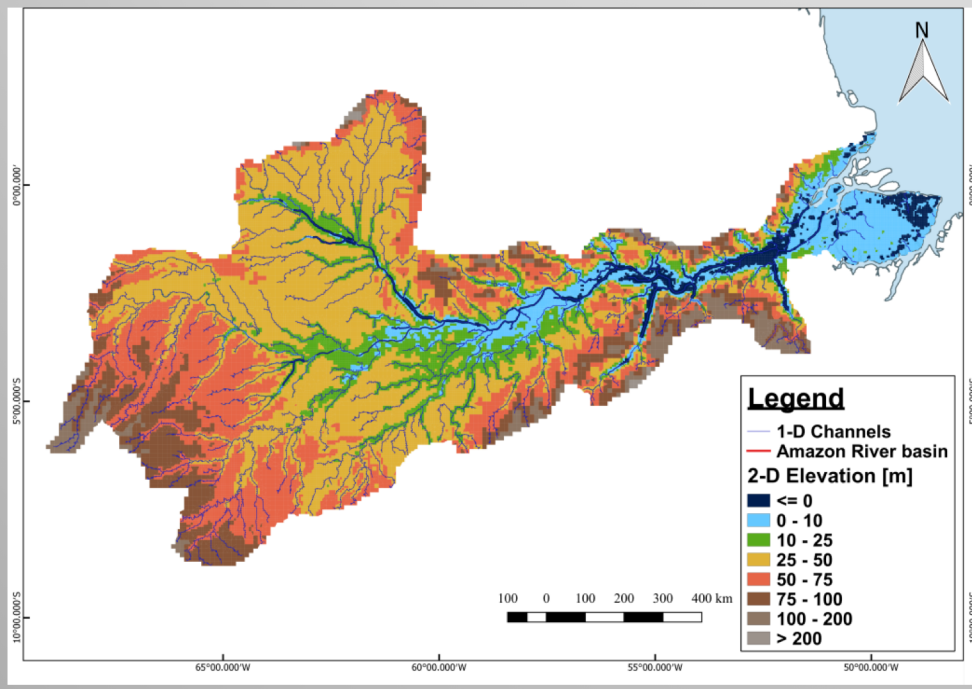
# Applications

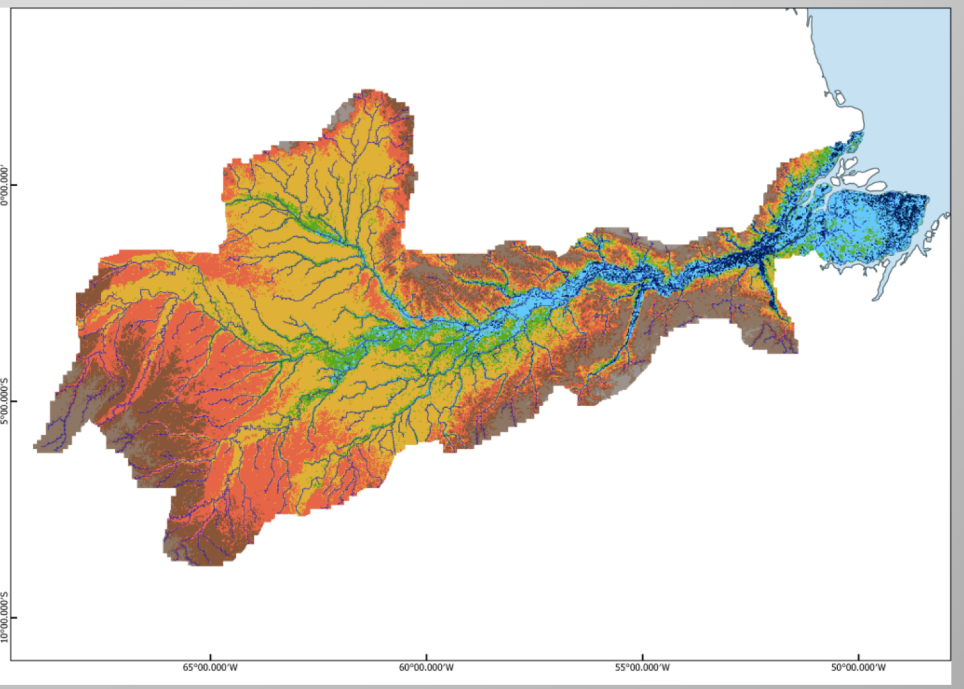



| | DynRout | 2-D GRDC | 1-D/2-D GRDC | 2-D 1way | 1-D/2-D 1way |
|---|---|---|---|---|---|
| $r^2$ | 0.49 | 0.92 | 0.85 | 0.77 | 0.83 |
| RMSE | 34 100 | 16 229 | 18 735 | 21 451 | 19 548 |
| KGE | 0.64 | 0.80 | 0.86 | 0.84 | 0.79 |

# Benchmarking hydrodynamic models

# Identical BCs!



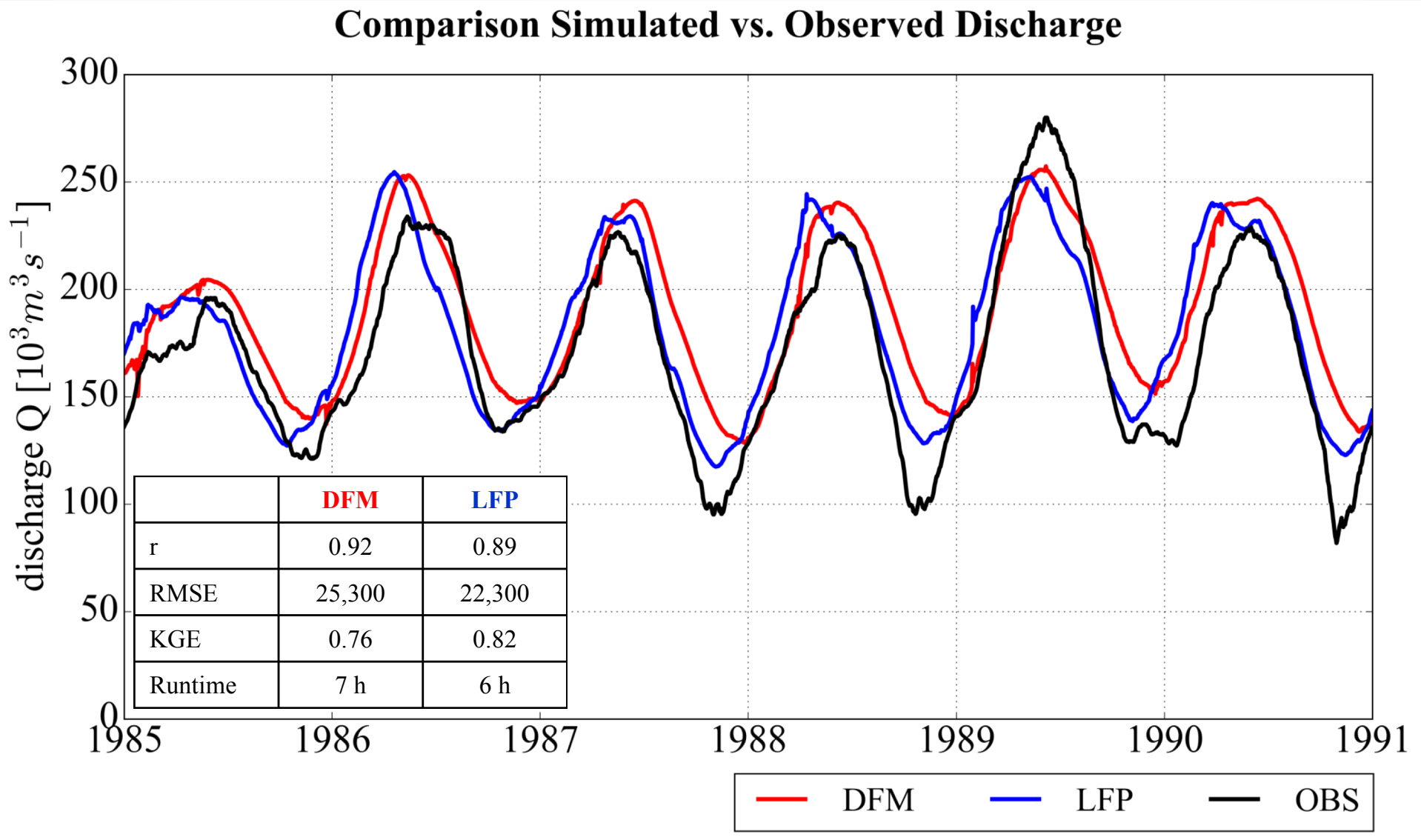

**Delft3D Flexible Mesh:**

| | |
|---|---|
| Spatial Resolution: | 2 – 10 km |
| Nr 2-D cells: | 41,207 |
| Nr 1-D cells: | 12,185 |

**LISFLOOD-FP:**

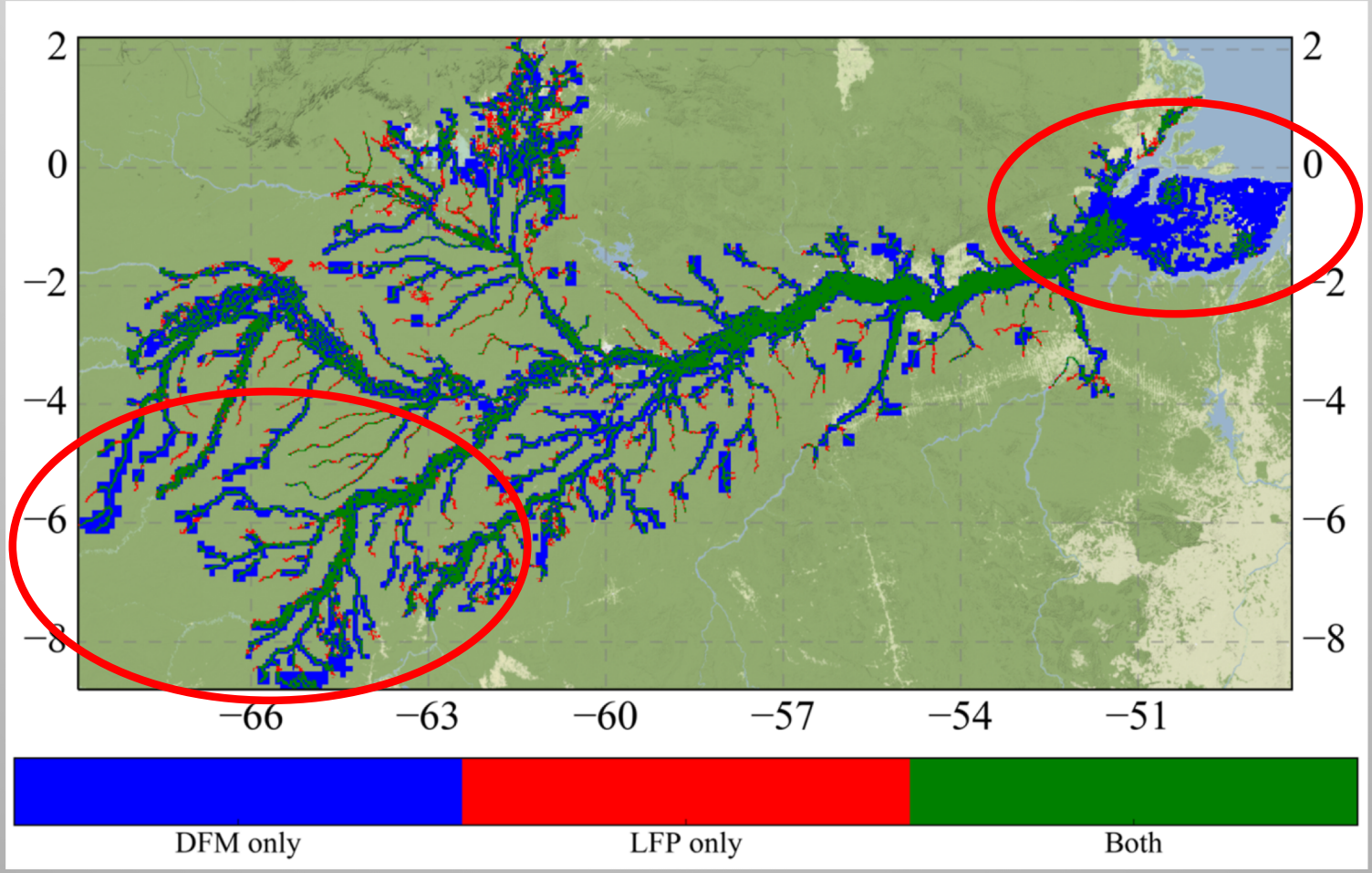
| | |
|---|---|
| Spatial Resolution: | 2 km |
| Nr 2-D cells: | 174,982 |
| Nr 1-D cells: | 17,119 |

# Applications




| | DFM | LFP |
|---|---|---|
| r | 0.92 | 0.89 |
| RMSE | 25,300 | 22,300 |
| KGE | 0.76 | 0.82 |
| Runtime | 7 h | 6 h |

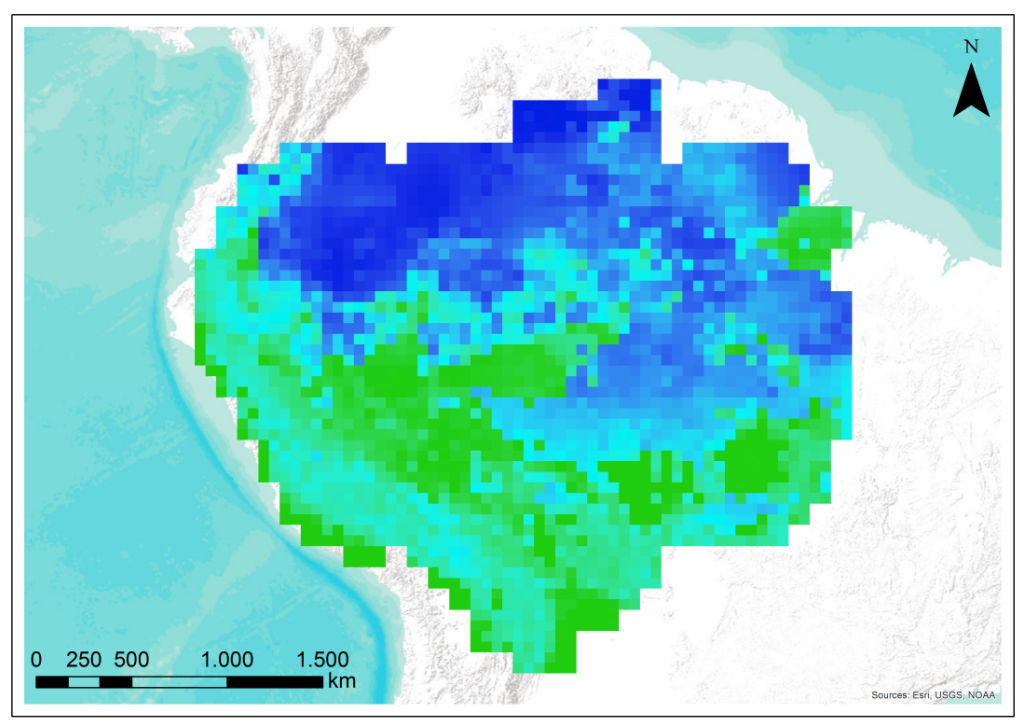
# Applications




| | H | F | C |
|---|---|---|---|
| **LFP / DFM** | 0.85 | 0.50 | 0.46 |

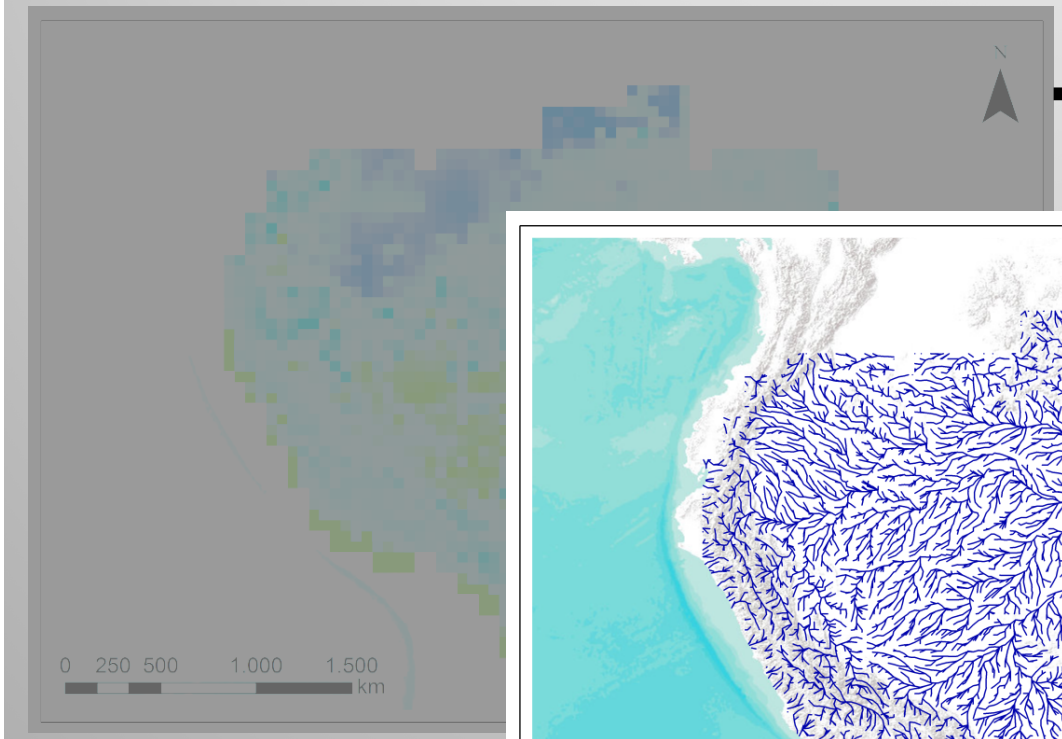
# Nested modelling across scales

## *GLOFRIM 1.1*

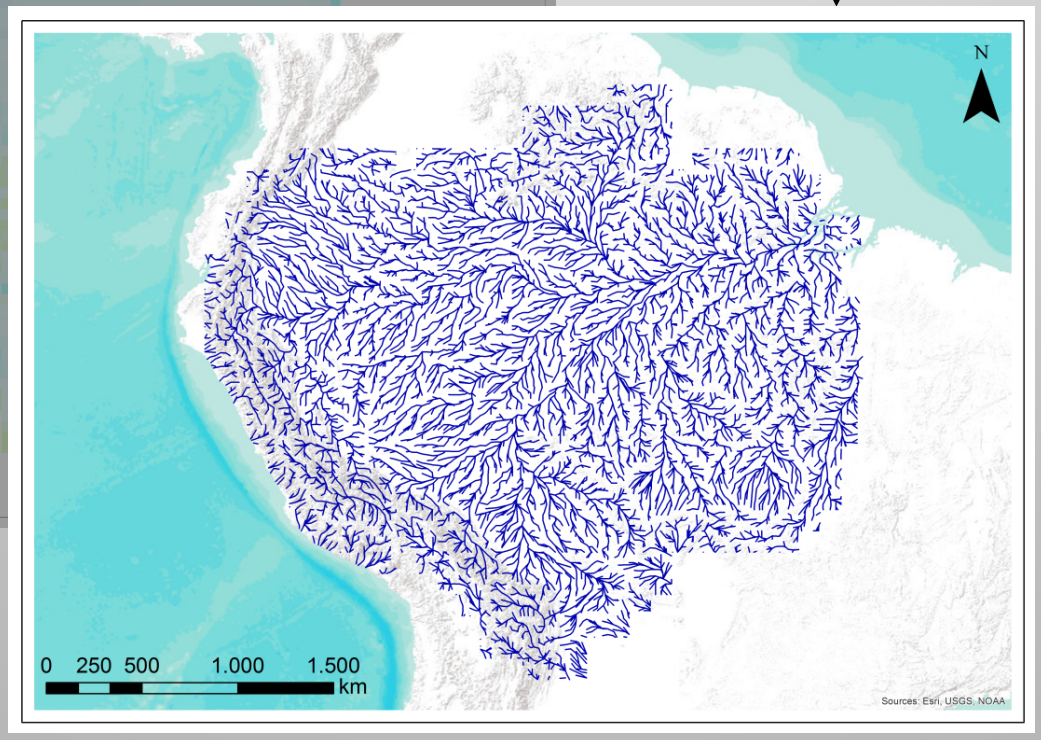



Runoff from a hydrological model

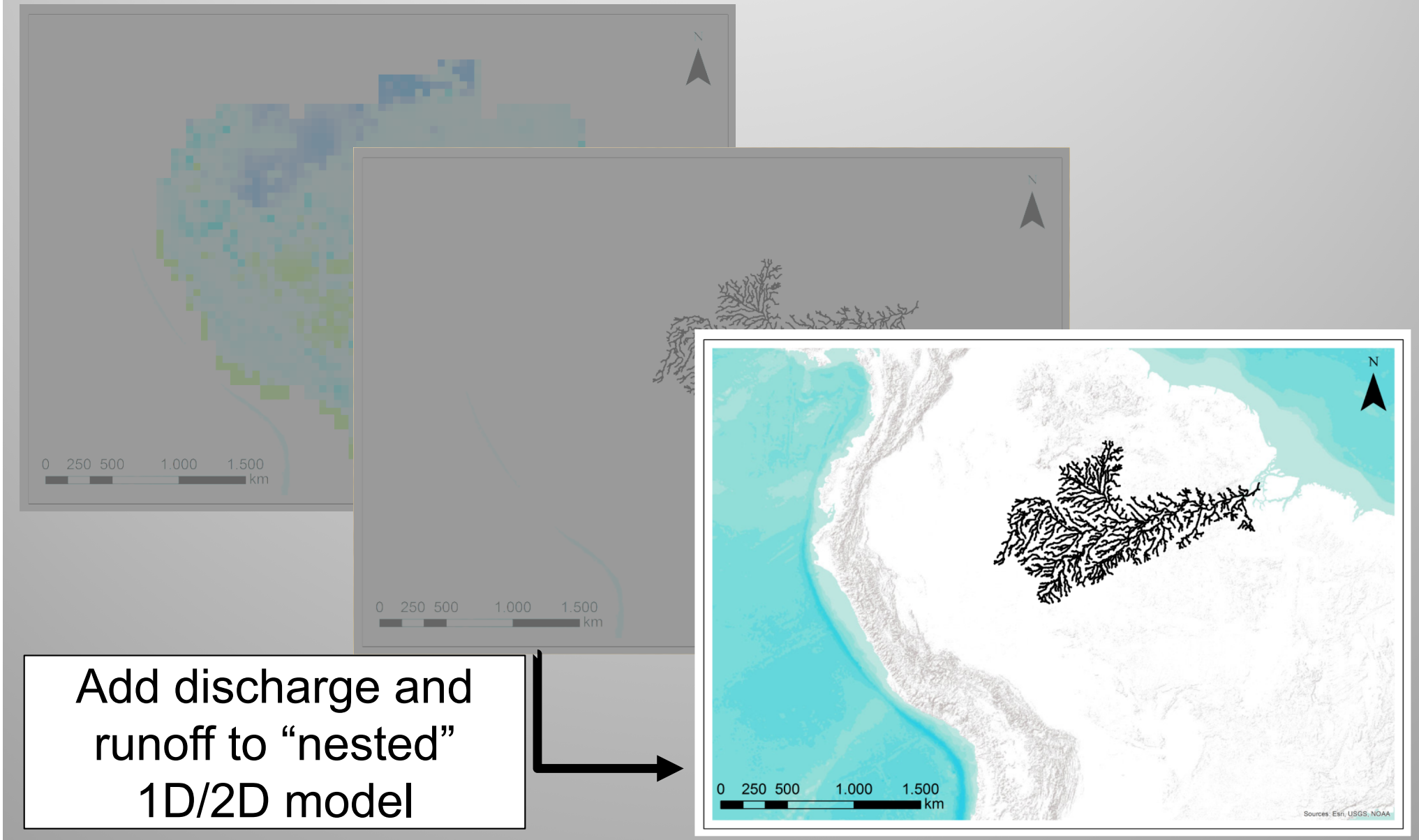
# Applications



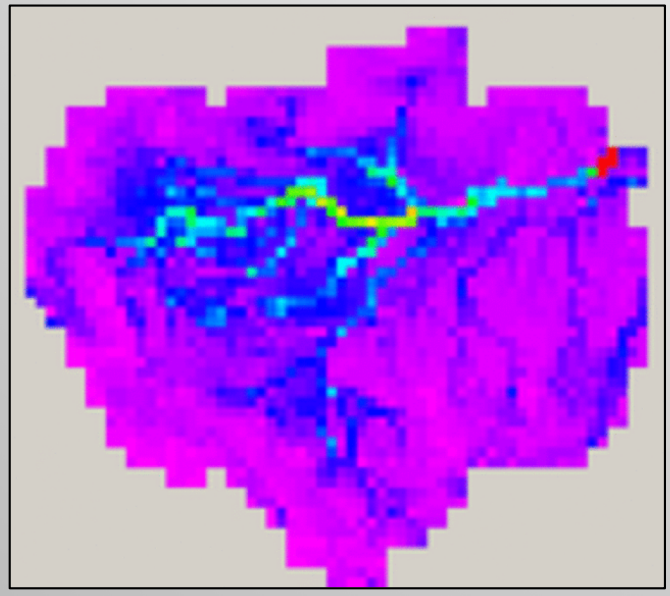

Add runoff to 1D routing model

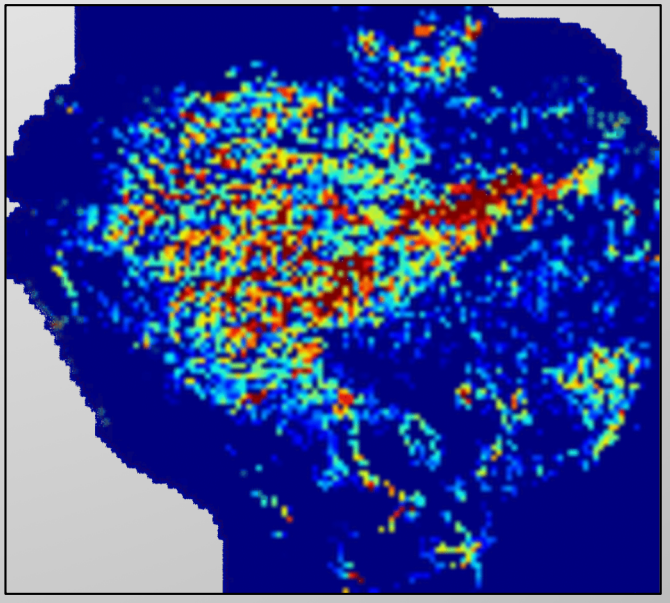


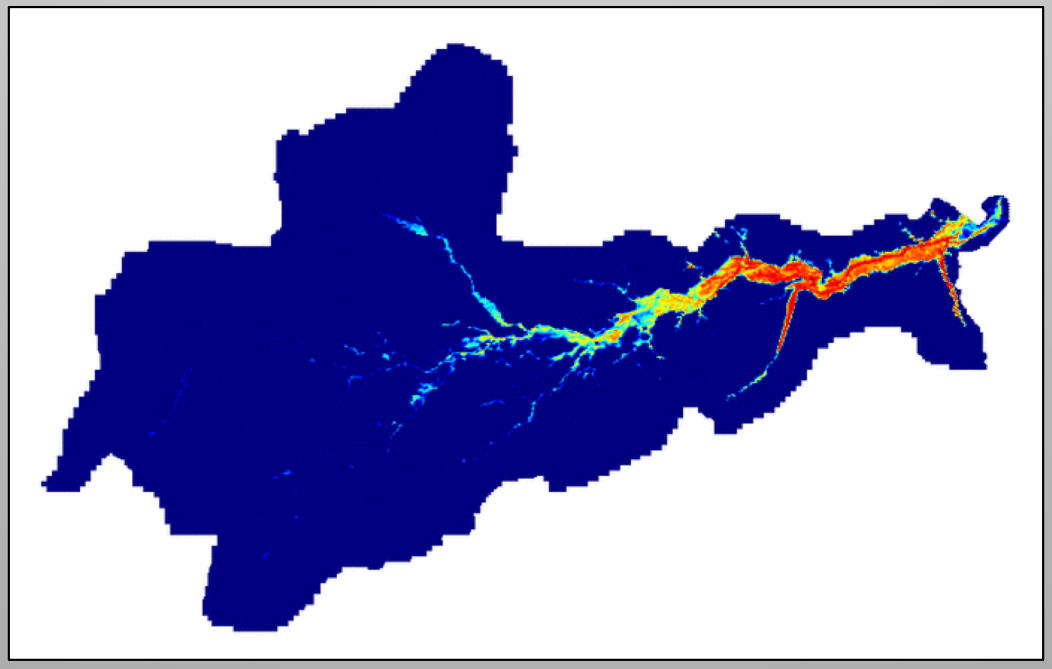
# Applications



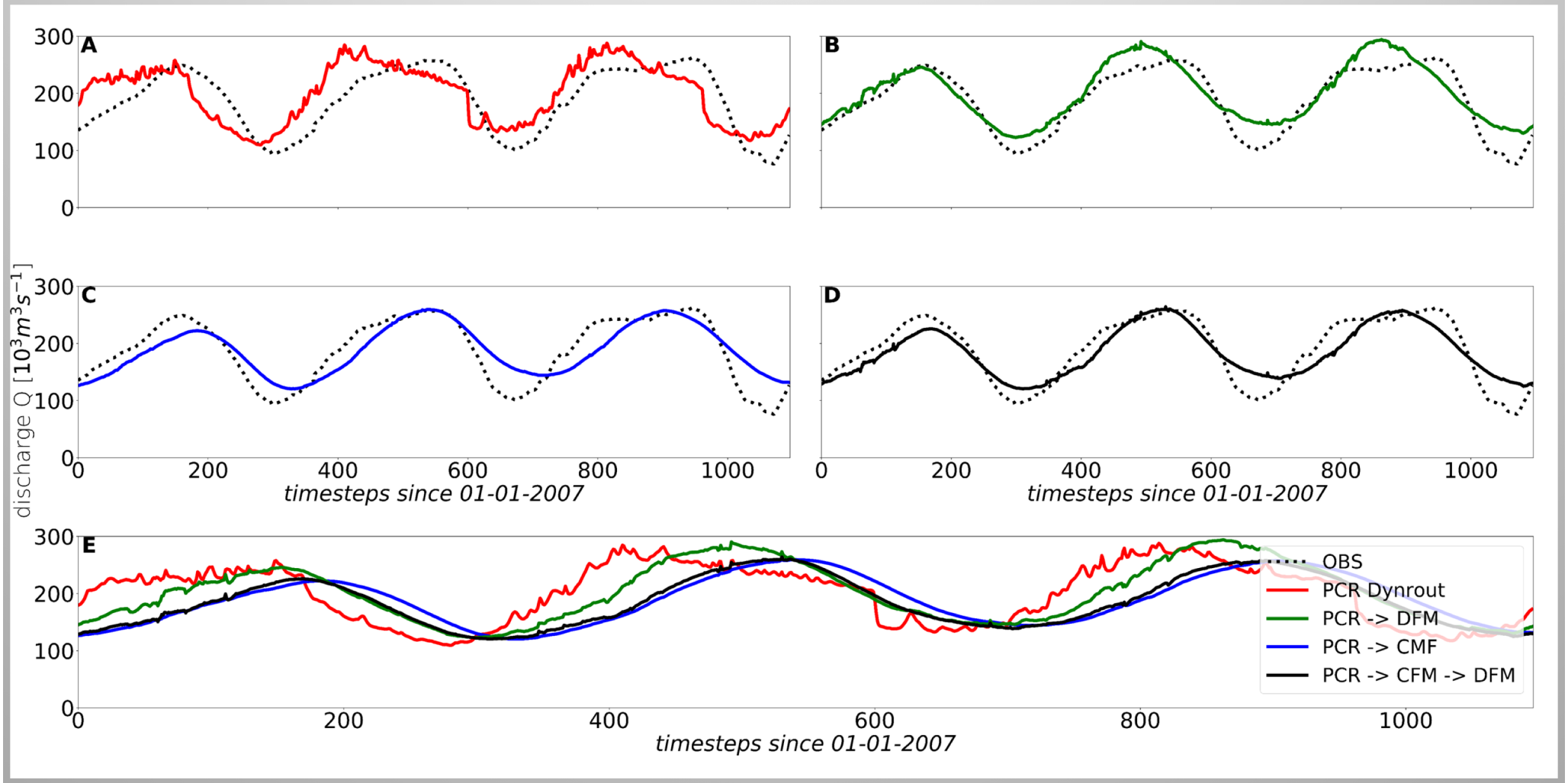

Add discharge and runoff to “nested” 1D/2D model







# Applications



# Applications

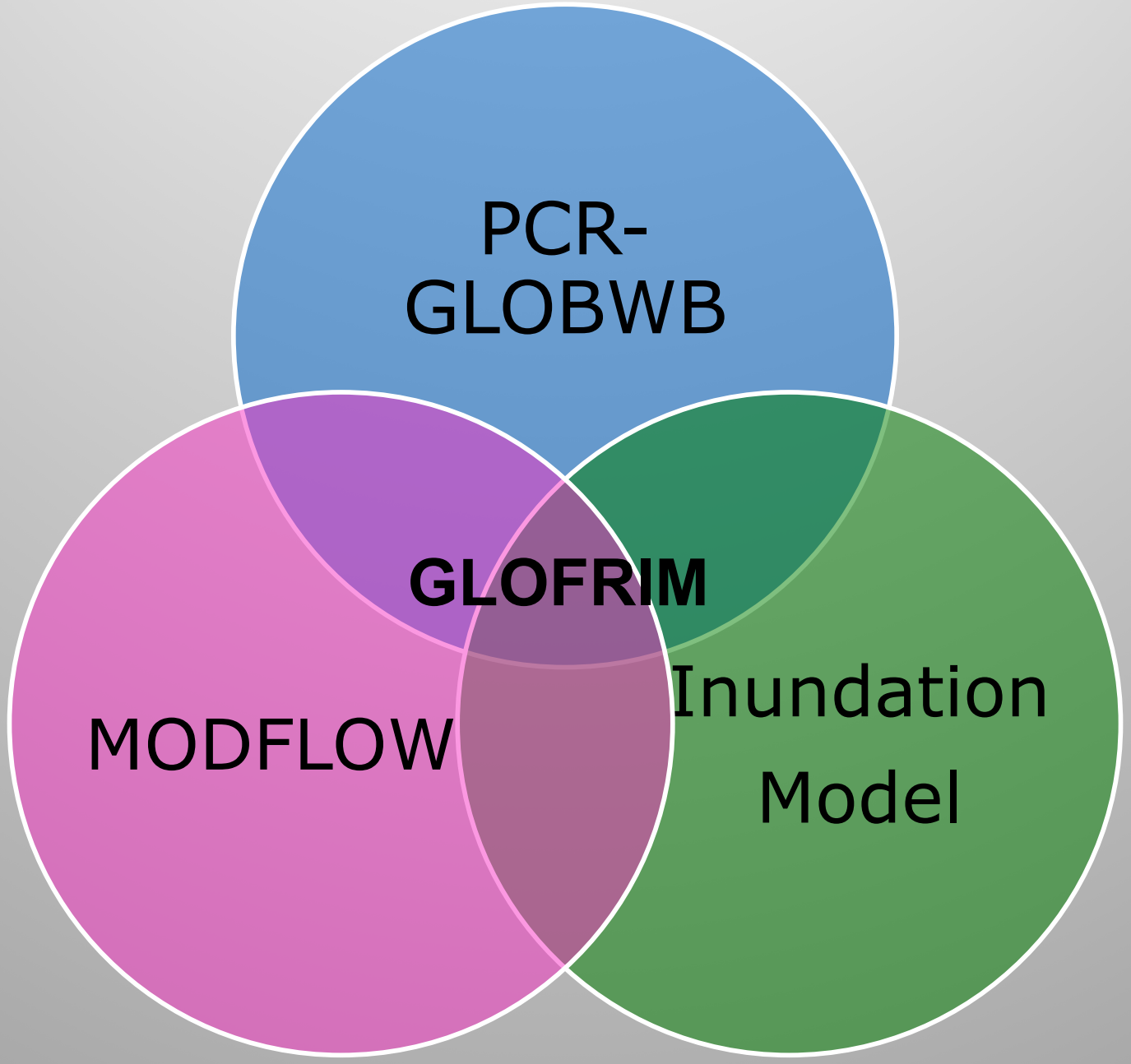
| | PCR DynRout | PCR → CMF | PCR → CMF → DFM |
|---|---|---|---|
| r | 0.74 | 0.85 | 0.91 |
| RMSE | 40,444 | 29,913 | 24,279 |
| KGE | 0.72 | 0.71 | 0.75 |
| runtime | 1.5 h | 0.5 h | 19 h |

# Outlook

# Outlook

- Add groundwater processes

# Outlook



# Outlook

- Add groundwater processes
- Replace downscaling approaches of hydrologic models
- Agricultural flood risk

GLOFRIM provides:

- A plug-and-play framework

  → easily extended with other models

- A tool to simulate both large-scale and fine-resolution processes

  → nested modelling

  → "from mountains to coast"

- Scripts and functions to couple various models and disciplines

## *WHERE CAN I GET THE STUFF?*

- Latest stable version is open and freely accessible at: https://doi.org/10.5281/zenodo.597107
- Code under development accessible at https://github.com/openearth/glofrim or by contacting me

# Acknowledgments