

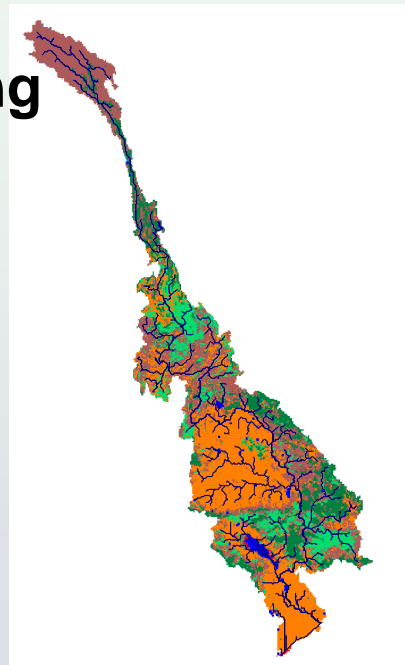
# Hydrological modelling in Mekong area

## Applications

Khuwae

Mae Chaem

Basin wide 5km



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## Presentation contents

- Project motivation & content
- Tool: Vmod hydrological model
  - how it works
  - grid box and model grid computation
- Khuwae Noi catchment
- Mae Chaem catchment
- Mekong Basin catchment

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## Why?

- Target for project: working Mekong basin hydrological model
  - 5km resolution
  - (2km resolution)
  - Utilizes available data, such as
    - DEM, landuse, soil (1km data available)
    - Mekong cross sections
    - gridded weather data, NCEP reanalysis II, others
    - measured precipitations, flow etc.
  - Results compared to observed flows, years 1985-2001
- Final model is to be used in scenario computation, such as the effect of dam construction to Mekong downstream water & sediment flow
- Many previous models also exist

## Test catchments

- Small areas (~5000 km<sup>2</sup>) with good data
  - to see how well the model works if data is good
  - test different parametrisations
- Khuwae
  - in Thailand, mountain area
  - main target: precipitation parametrisation
  - one soil type (acrisol), several land use types
- Mae Chaem
  - in Thailand mountain area
  - main target: soil hysteresis testing
  - one soil type (acrisol), several land use types

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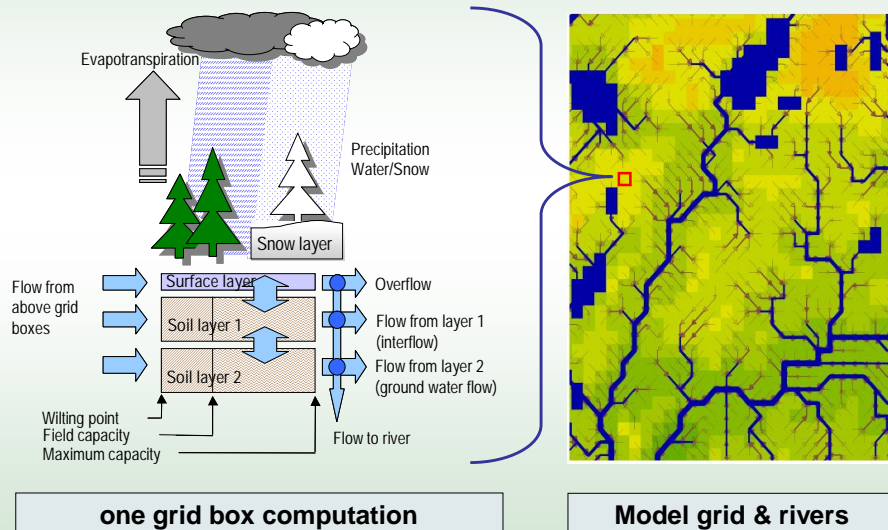
# Mekong catchment

- Large catchment
  - 795000 km<sup>2</sup>
  - partly similar to test areas
- Challenges in hydrology
  - larger area, more variation
  - flooding in the lower part of catchment
  - mountains & glaciers in the upper part
  - Mekong mainstream is a large river, requires different routing method and cross sections
- Challenges in meteorology
  - good quality precipitation data for the whole catchment ??
- Other
  - large area, with some practical problems (e.g. lot of data...)
  - large dams in the upper catchment mainstream

# Tool: VMod hydrological model

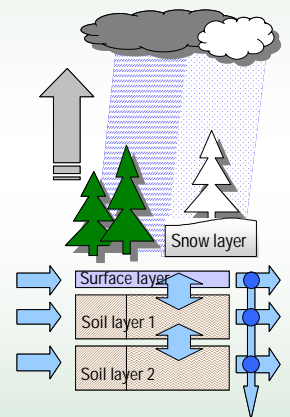
- Spatially distributed hydrological model
- Grid based subdivision (0.2-5 km grid size)
- Each grid box has its own set of state variables (e.g. soil moisture value, river flow) and parameters
- Each grid box has a landuse type and soil type that define related parameters. There are typically less than 20 landuse types (reclassified for model use).
- VMod is based on relatively simple submodels of individual hydrological processes with emphasis on model usability, code manageability and execution speed

# Vmod: computation



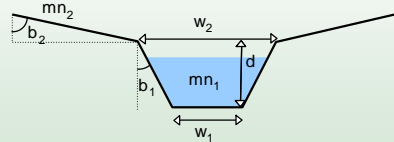
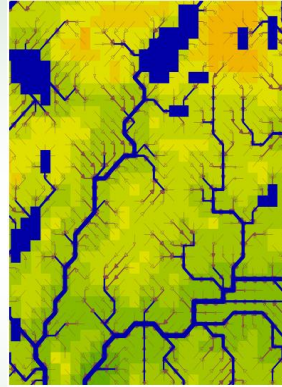
# Vmod: One grid box model

- **Above surface layer**
  - weather data interpolation, elevation correction
  - Interception
  - seasonal LAI development, crop growth (EPIC)
  - snow model
- **Surface layer**
  - Green/Ampt infiltration
  - Ponding storage
  - Overflow to stream/river
- **Soil layer 1**
  - recharge from surface,
  - inflow from upslope grid boxes
  - drainage to soil layer 2, downslope gridboxes, river
- **Soil layer 2**
  - inflow from soil layer 1, upslope grid boxes
  - drainage to river / downslope gridboxes



# Vmod: Model grid & river network

- Water flow between soil layers
  - "ground water flow" computed for soil layers, downslope direction
- River flow
  - each grid box has a stream / river
  - kinematic wave approximation, e.g. flow depends on bottom slope, water depth and friction coefficient
  - trapezoidal cross section
- Lakes
  - water balance computation for each lake
  - outflow using outflow channel and lake water level



# Vmod: Additional model features

- Dams and reservoirs
- Water use (e.g. for irrigation) from rivers and lakes
- Simple water quality computation (e.g. sediment, phosphorous)
- Soil erosion computation (rill erosion model)
- Soil hysteresis computation (hysteretic linear reservoir approach, O'Kane)

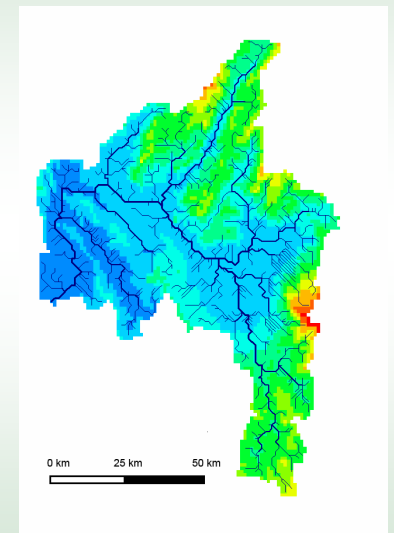
# Khuwae Noi catchment

- Located in Northern Thailand
- Global grid data
- Local weather observations
- Precipitation correction test



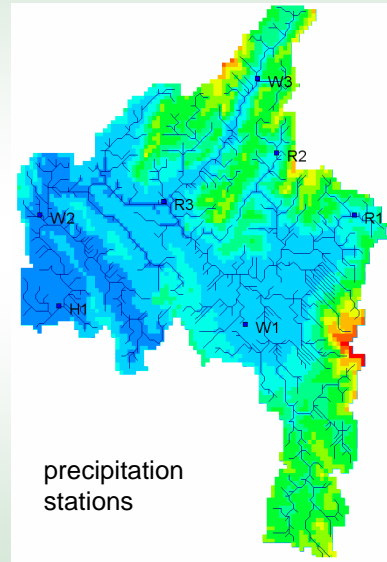
# Khuwae Noi: descriptive data

Basin	Khuwae Noi River basin
Area	5803 km <sup>2</sup>
Average outflow	64 m <sup>3</sup> /s
Lakes (% of area)	-
Extent EW	95 km
Extent NS	135 km
Outflow	Nan River
Elevation range	50 – 2100 m
Average precipitation	1420 mm (model estimate)
Average ETR	1035 mm (model estimate)



# Khuwae Noi: model data

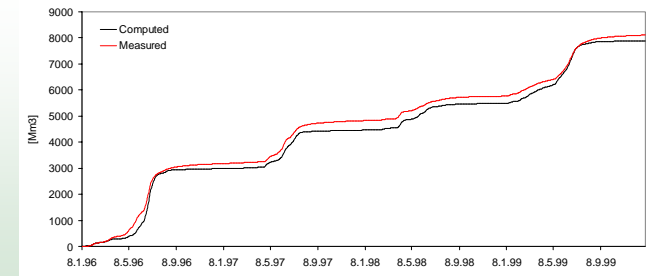
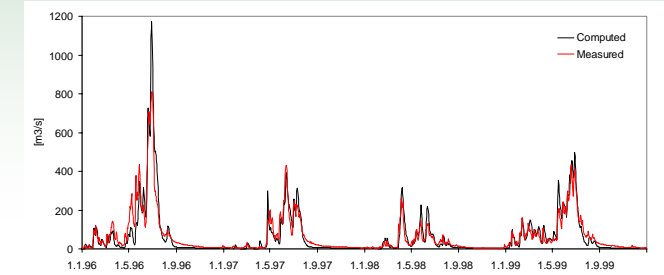
- Grid:
  - DEM (SRTM 90m)
  - Global Land Cover 2000, 25m
  - FAO soil map of the world, 1km
  - Khuwae Noi catchment boundary
- Meteorology
  - local observations, 7 stations
  - GAME-T2 dataset
- Flow
  - one observation (H1)



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# Khuwae Noi: Flow results

- Daily data
- Cumulative



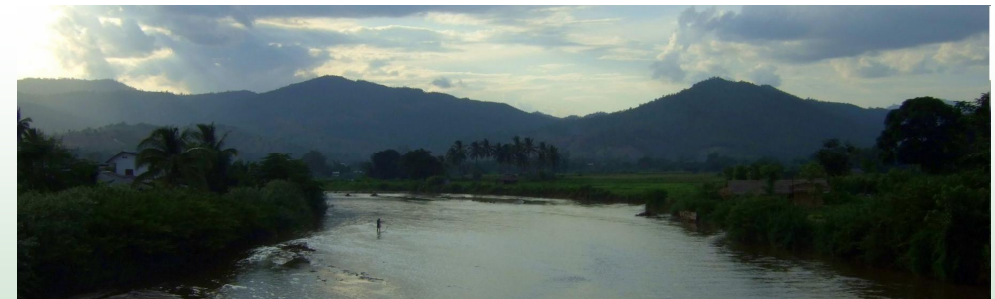
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# Khuwae Noi: Surface data

- Precipitation: nearest station with elevation dependent correction for precipitation and temperature
  - precipitation +0.002 mm/m
  - temperature -0.006 C/m
- LAI depends on water availability

# Mae Chaem, Thailand

- Exercise in using global datasets
- Hysteresis testing
- Located in Northern Thailand
- Forested with mixed agriculture
- Monsoon climate

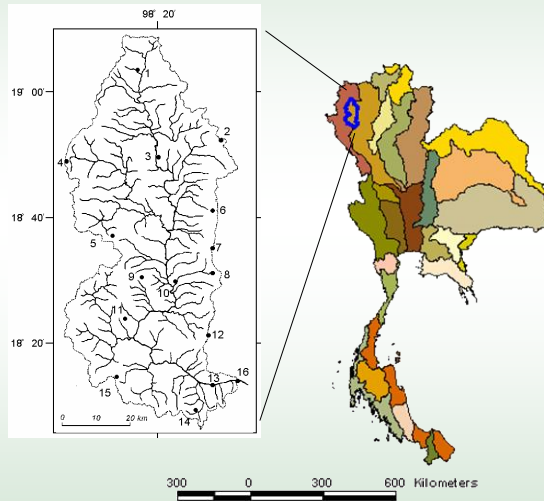


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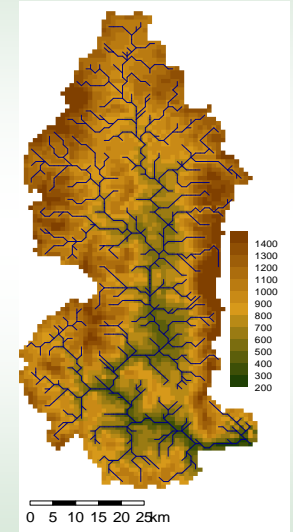
# Mae Chaem: catchment statistics

Basin	Mae Chaem
Area	3853 km <sup>2</sup>
Average flow	31.1 m <sup>3</sup> /s
Elevation	282 – 2535 m
Average prec.	1334 mm
Average ETR	1085 mm

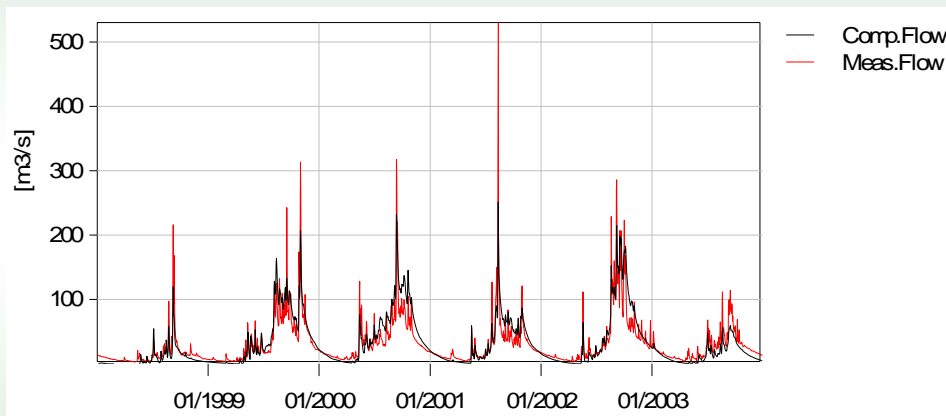


# Mae Chaem: grid & datasets

- Grid: 1 km resolution
  - DEM: SRTM 90m
  - Landuse: Global Land Cover 2000
  - Soil data: FAO soil map of the world, 1km resolution
- Meteorology and flow
  - Meteorology: GAME-T locally measured data, also NCEP reanalysis 2 tested
  - Outflow: P.14, RID Upper north region office



# Mae Chaem: Outflow results



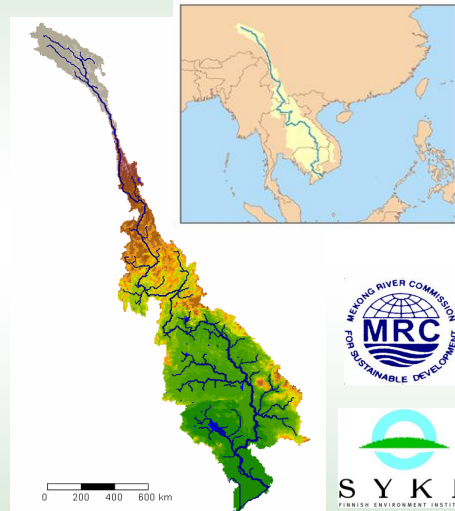
Computed and measured discharge at Station P14 (years 1998-2003), R2 = 0.83 (using local data)

# Mae Chaem: hysteresis

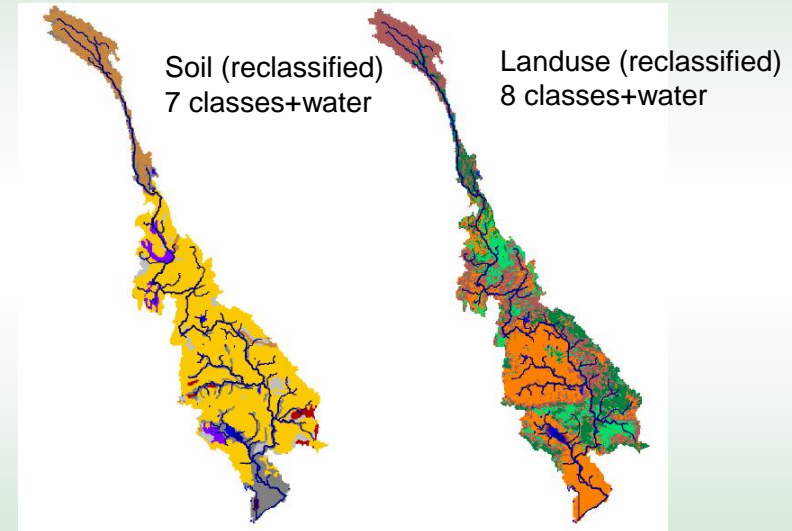
- Hysteresis = soil conductivity depends on soil wetness and also whether soil is drying or wetting
- O’Kane hysteretic linear reservoir model implemented for soil layer 2 outflow
- Not much better outflow results ( $r^2$  coefficient, increase from 0.80 -> 0.83)
- Mae Chaem is perhaps not the best area for hysteresis phenomena testing, more testing in other areas is needed

# The Mekong catchment

- South East Asia
- Area 795000 km<sup>2</sup>
- Average outflow 15000 m<sup>3</sup>/s
- Elevation range 0 – 6740m
- 5km grid size
- Grid data:
  - DEM: SRTM
  - Landuse: GLC2000
  - FAO soil map
  - River bed and lakeshore (MRC)
  - River cross sections (MRC)
  - Catchment boundary (MRC)

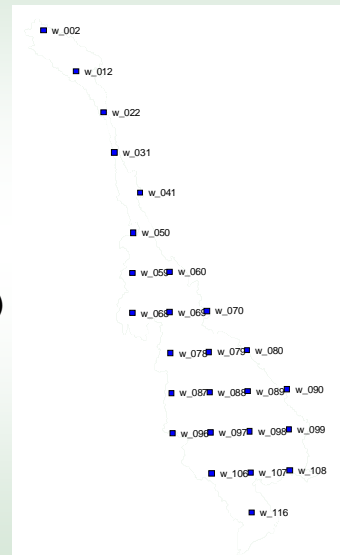


# Mekong: Model grid

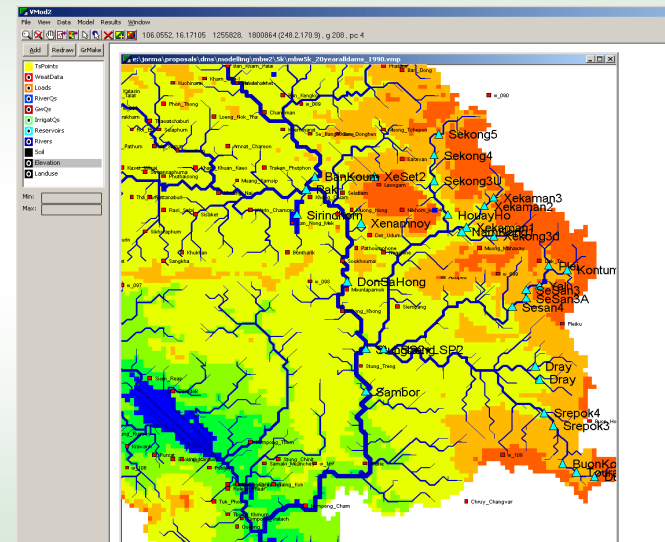


# Mekong: Weather data

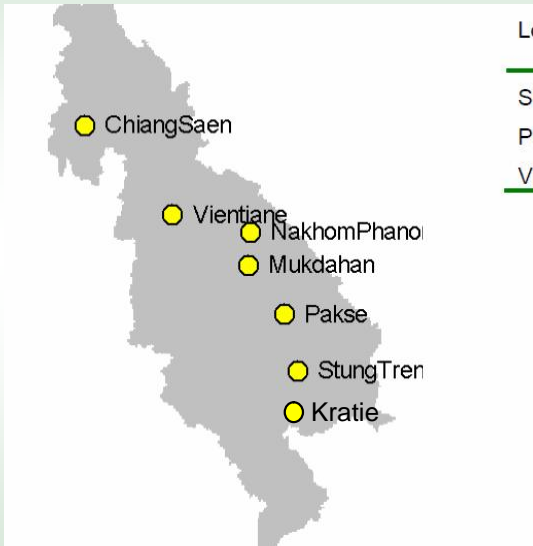
- NCEP Reanalysis II
  - too much precipitation
  - 2.5 degree resolution
  - needs correction
- Observations
  - Local observation data (MRC)
  - NOAA GSOD (global summary of the day)
  - NASA TRMM
- Downscaling
  - e.g. ERA40+physical model



# Mekong: Application view

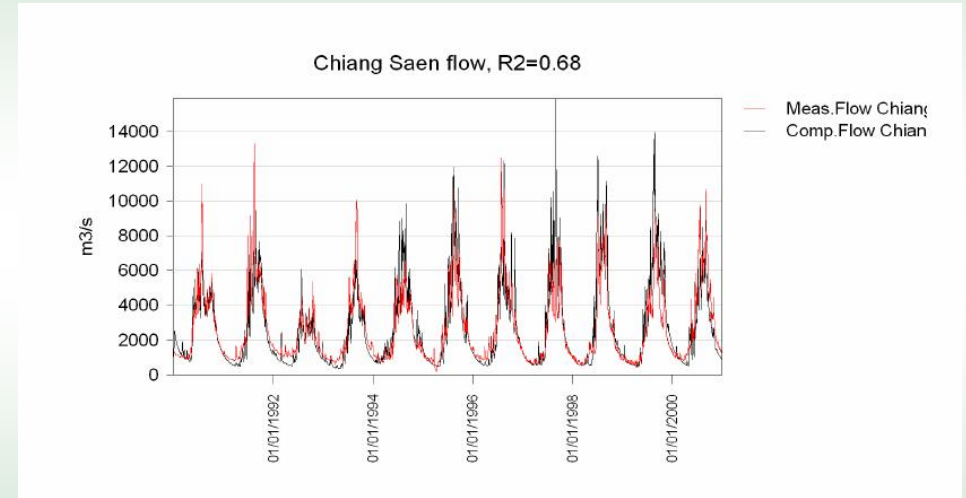


# Mekong: Flow observations

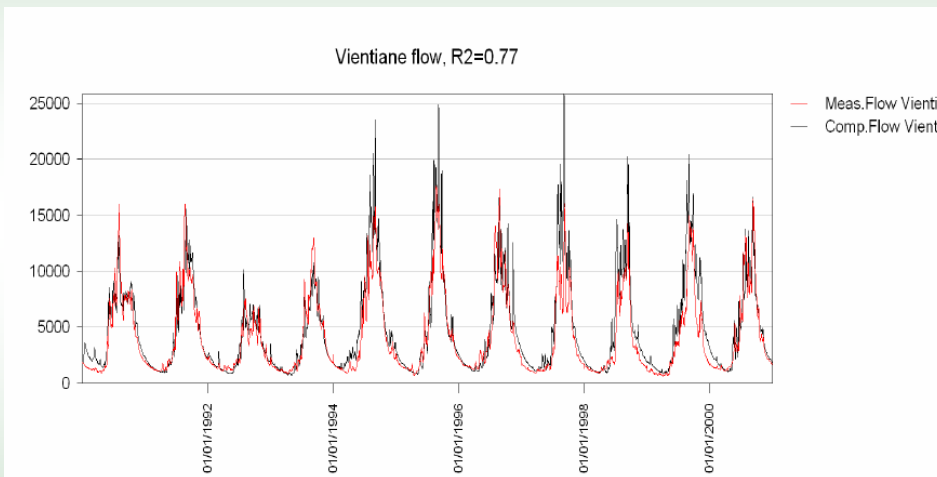


Location	Average flow (m <sup>3</sup> /s)
Stung Treng	13'326
Pakse	9'750
Vientiane	4'108

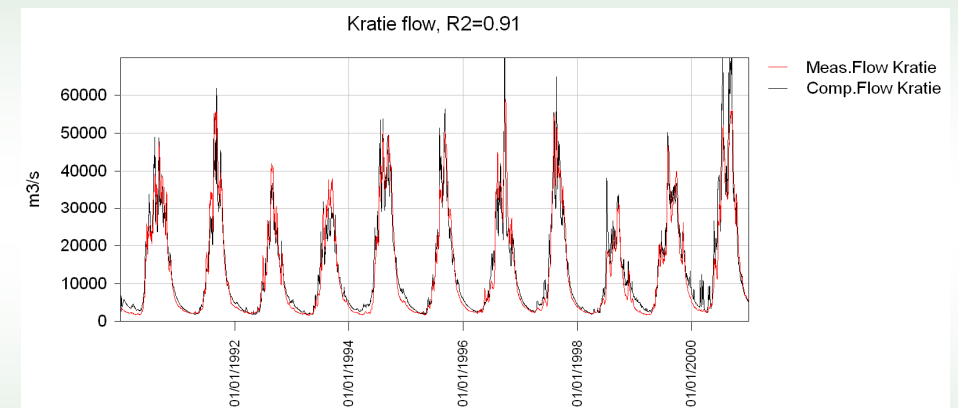
# Mekong: Results



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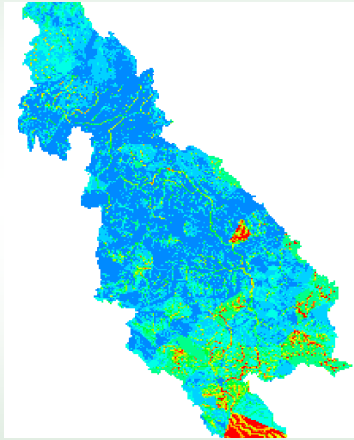
# Mekong: Results



# Mekong: Results

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2d soil moisture



# Mekong: work in progress

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- 2km grid
- River routing for extensive flooding (below Kratie)
- Upstream flow
- Weather data,
  - different sources,
  - physical downscaling
- Scenario runs

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**End of presentation**  
**Thank you**