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Plan for modelling lateral flow of DOM in CLM

(github issue #1216)

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Dissolved Organic matter (DOM)

- **DOM is defined as the organic matter fraction in solution that passes through a 0.45 µm filter.**

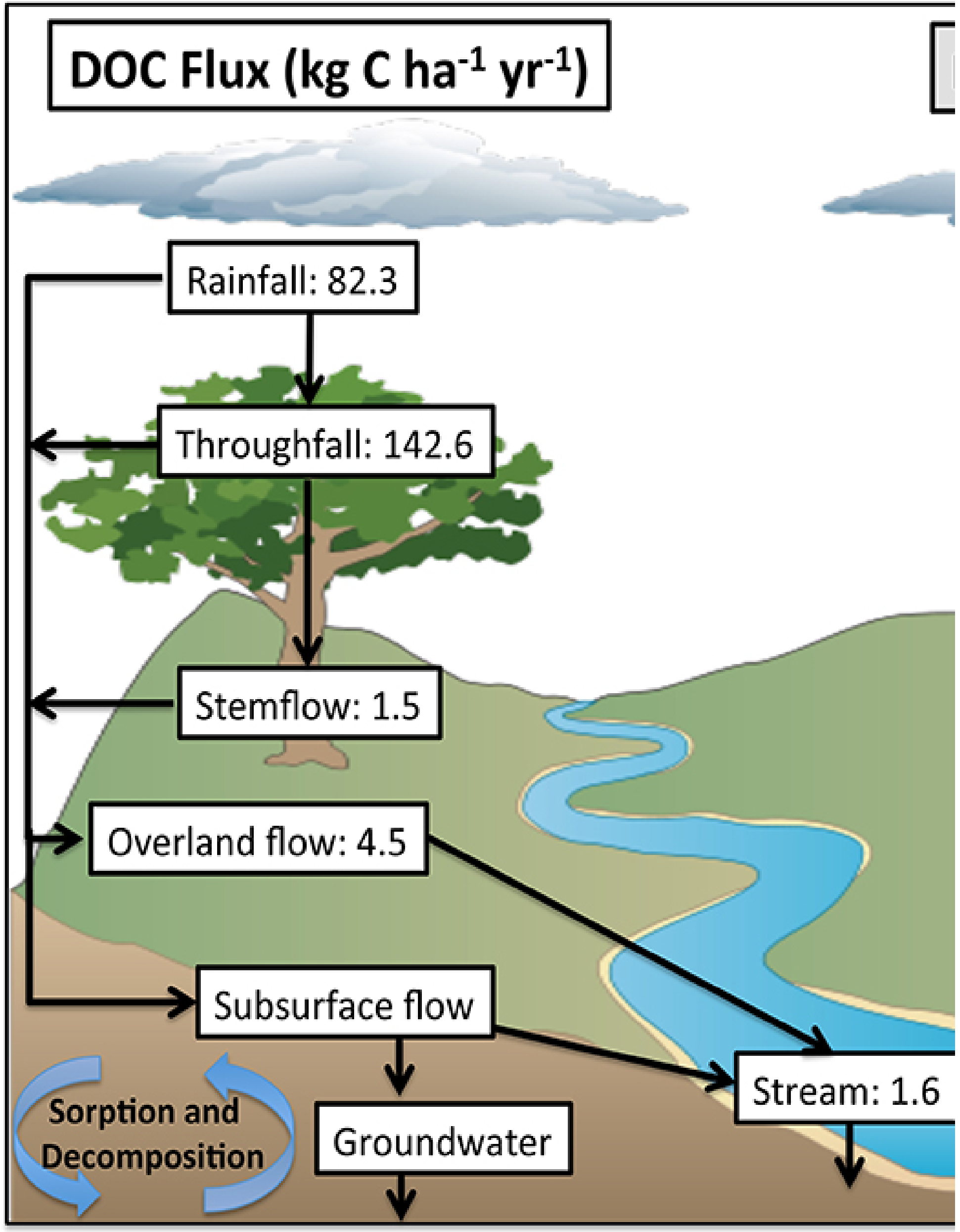
DOM is often quantified by its carbon content and referred to as DOC.

- The high-latitude soil carbon reservoir may amount to **~1330-1580 PgC** (Hugelius et al 2013,2014; Tarnocai et al., 2009)

- Yearly lateral flux of carbon from soils to running waters may amount to about a **5th of net ecosystem carbon exchange (~400 TgC/yr) (Bowring et al 2019; McGuire et al 2009).**

- **Global estimates of terrestrial C inputs to inland waters is 5.1 PgC/yr (with high uncertainty, Drake et al 2018)**

Global land models **ORCHIDEE** and **JULES** have DOC representation.

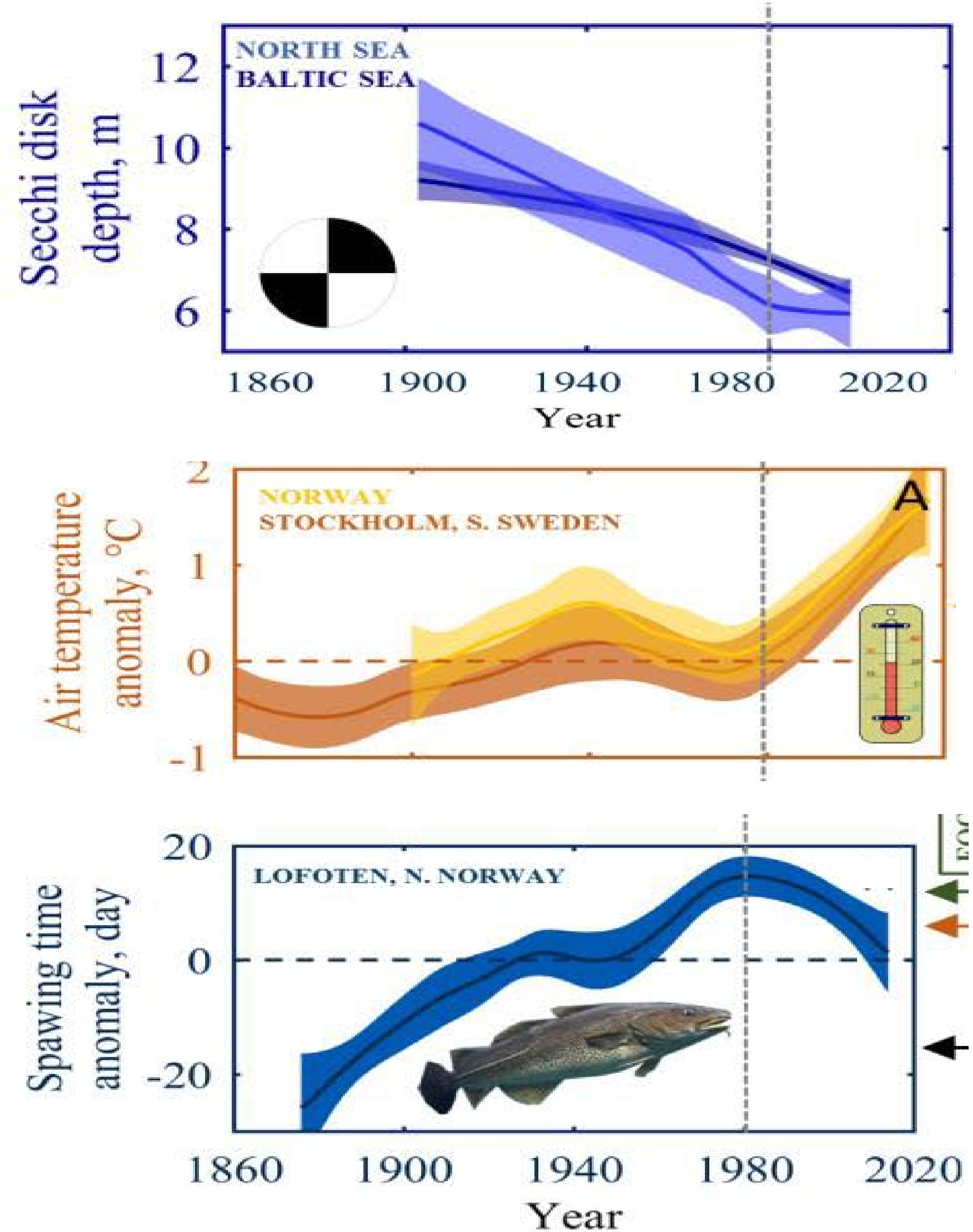


Why ?

DOM link with Ocean waters is important for Norway. Especially for COD spawning.

- **Darker coastal waters,**
- **Climate warming,**
- **Cod spawning delays**

(e.g. Parmesan 2006, Walther et al. 2002)



Green-Blue Project

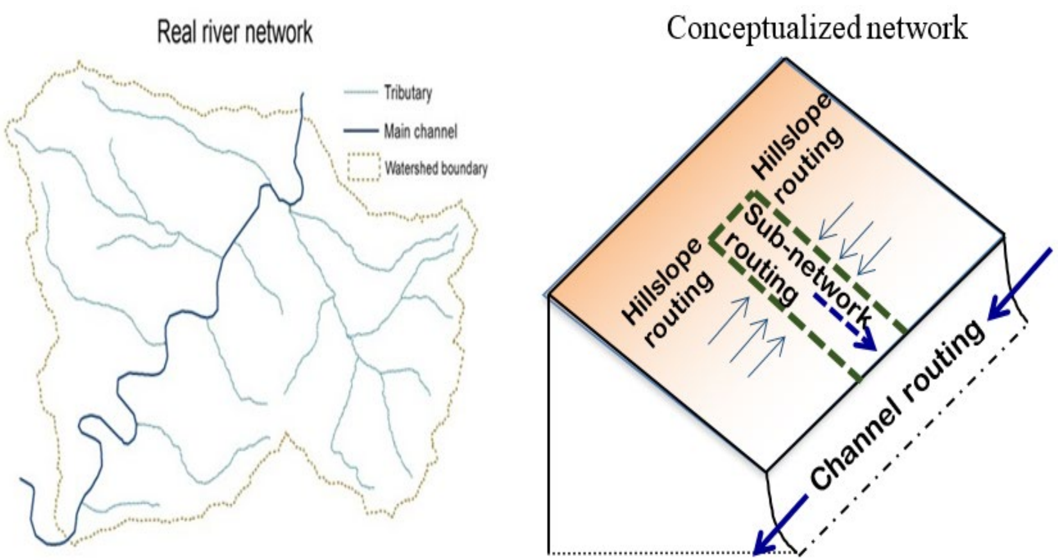
Funded by Norway Research Council

'Terrestrial ecosystem change impact on marine ecology'

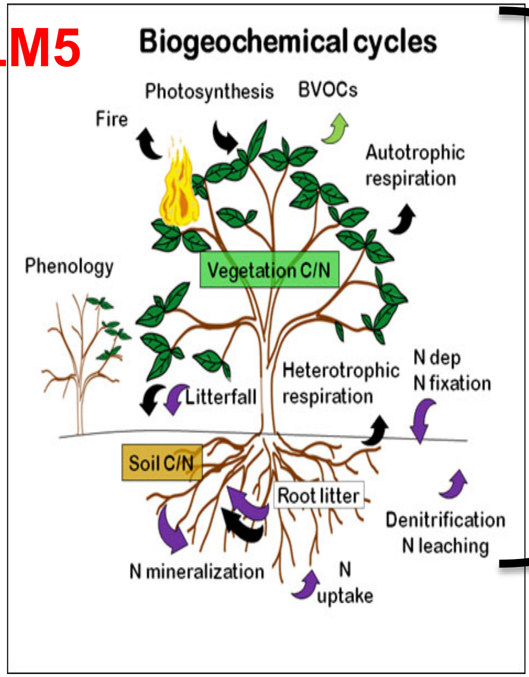
How ?

Make use of River routing models eg. MOSART
Couple SoilBGC model with MOSART to solve mass balance equation for DOM

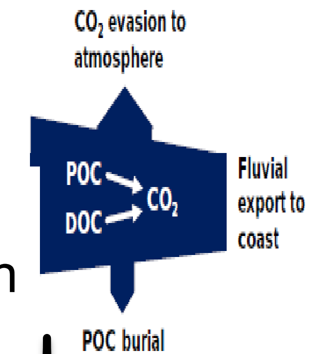
- **MOSART**



CLM5



Allochthonous carbon input



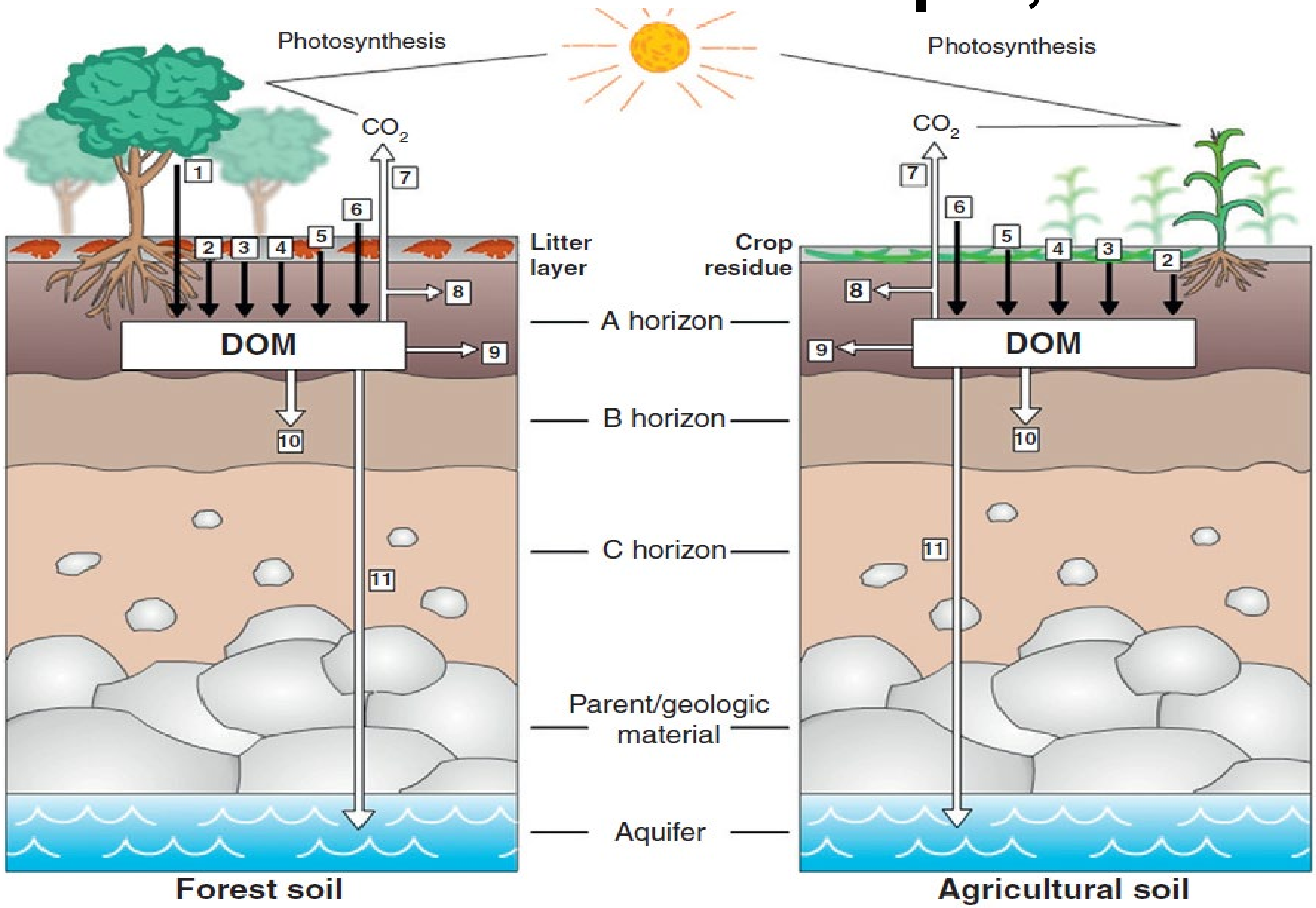
Inland water network

+ MOSART

$$\frac{d(\int_{CV} DOC\ dV)}{dt} = \sum_{inflows} Q \times DOC - \sum_{outflows} Q \times DOC + \int_{CV} r \times dV + DOC\_source$$

To quantify the discharge of DOM to oceans.

Detailed schematic of DOM input, transformation, & losses



Inputs:

1. Throughfall
2. Root exudate
3. Microbialysis
4. Humification
5. Litter/crop residue decomposition
6. Organic amendments

Outputs

7. Microbial degradation
8. Microbial assimilation
9. Lateral flow
10. Sorption
11. Leaching

The processes highlighted in blue are planned for implementation

Bolan et al 2011, Advances in Agronomy

Equations

INPUT

Throughfall

Wet atmospheric deposition

TF_wet = 3 mgC per L

Dry deposition (canopy exudation, aerosol bound organic compounds)

$$\mathrm{TF_{DRY}} = M_{\mathrm{LEAF}} \cdot 9.2 \times 10^{-4} \frac{\mathrm{d}t}{\mathrm{day}},$$

DOC production in SOILS (KgC/m2/day)

First order kinetics

$$F_{\mathrm{P}_{k,i}} = \beta_{z_i} \cdot S_{\mathrm{C}_k} \cdot \left(1 - e^{\left(-K_{\mathrm{P}} \cdot F_{\mathrm{S}}(S)_i \cdot F_{\mathrm{T}}(T_{\mathrm{soil}})_i \cdot F_{\mathrm{v}}(v) \cdot D_{\mathrm{f}}\right)}\right) \cdot e^{-\tau_{z_i}},$$

$$D_{\mathrm{f}} = 1 - (0.75 \cdot (\mathrm{clay} + \mathrm{silt}))\,.$$

DOC production rate (per day)

Fraction of vegetation

Dependence on Silt and clay content

Weighting factor

Amount of carbon in soils

Empirical factor for a decrease in decomposition rate

Rate modifiers due to moisture and temperature

Nakhavali et al (2018) Bowring et al (2019)

Plan to include:

Vertical transport (Soil layer process DOC; cryoturbation)

Inflow of carbon

Decomposition rate

Temperature dependent rate modifier

$$\frac{\delta \mathrm{DOC}_i(z)}{\delta t} = \mathrm{IN}_{\mathrm{DOC}_i}(z) - k_i(z) \cdot \phi \cdot \mathrm{DOC}_i(z) + \mathrm{Diff}\frac{\delta \mathrm{DOC}_i^2(z)}{\delta z^2},$$

Diffusion co-efficient

Account for Net change in DOC to Carbon cycle balance

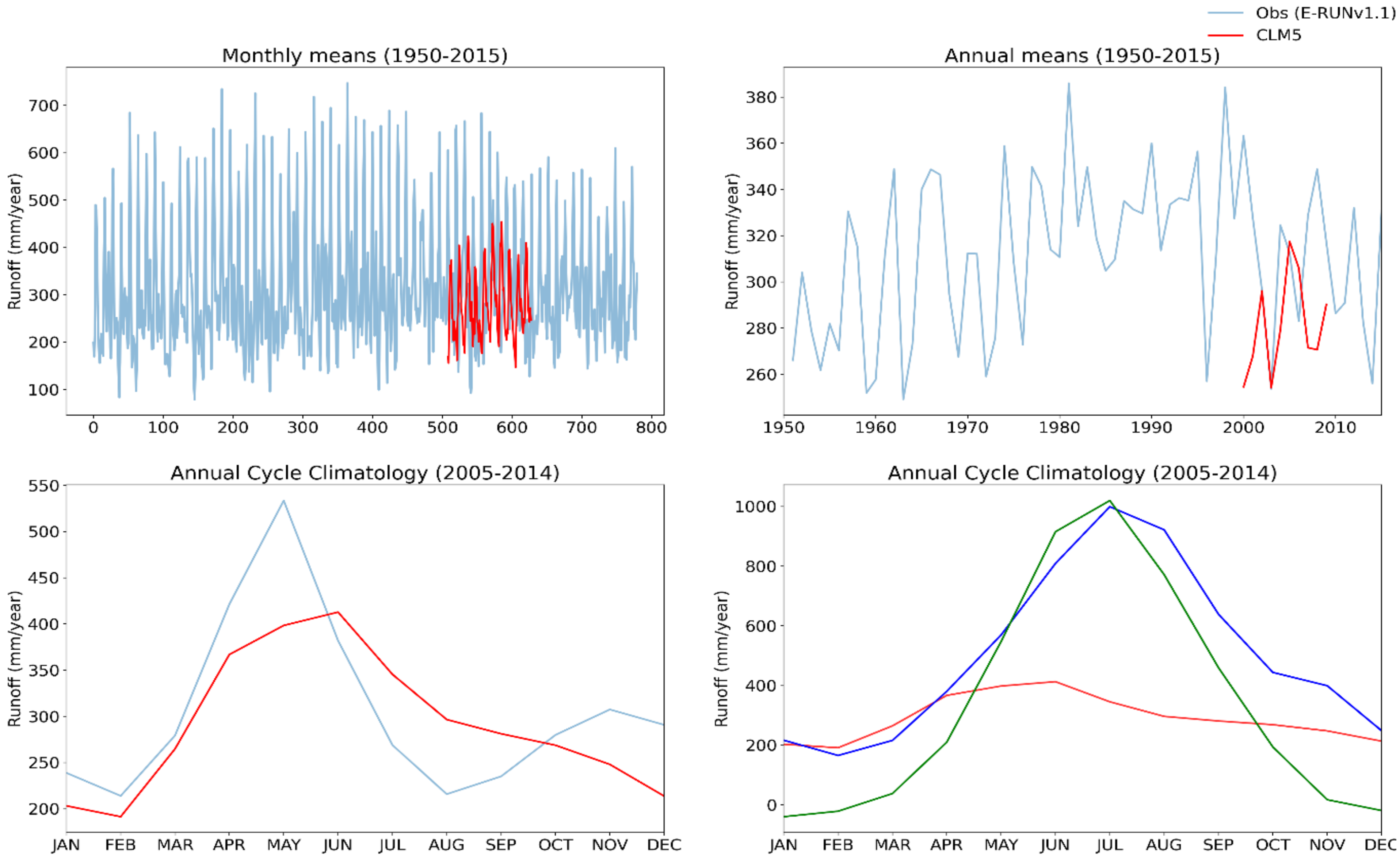
$$\mathrm{NEP} = \mathrm{NPP} - R_H + \mathrm{DOC}_{\mathrm{net}}$$

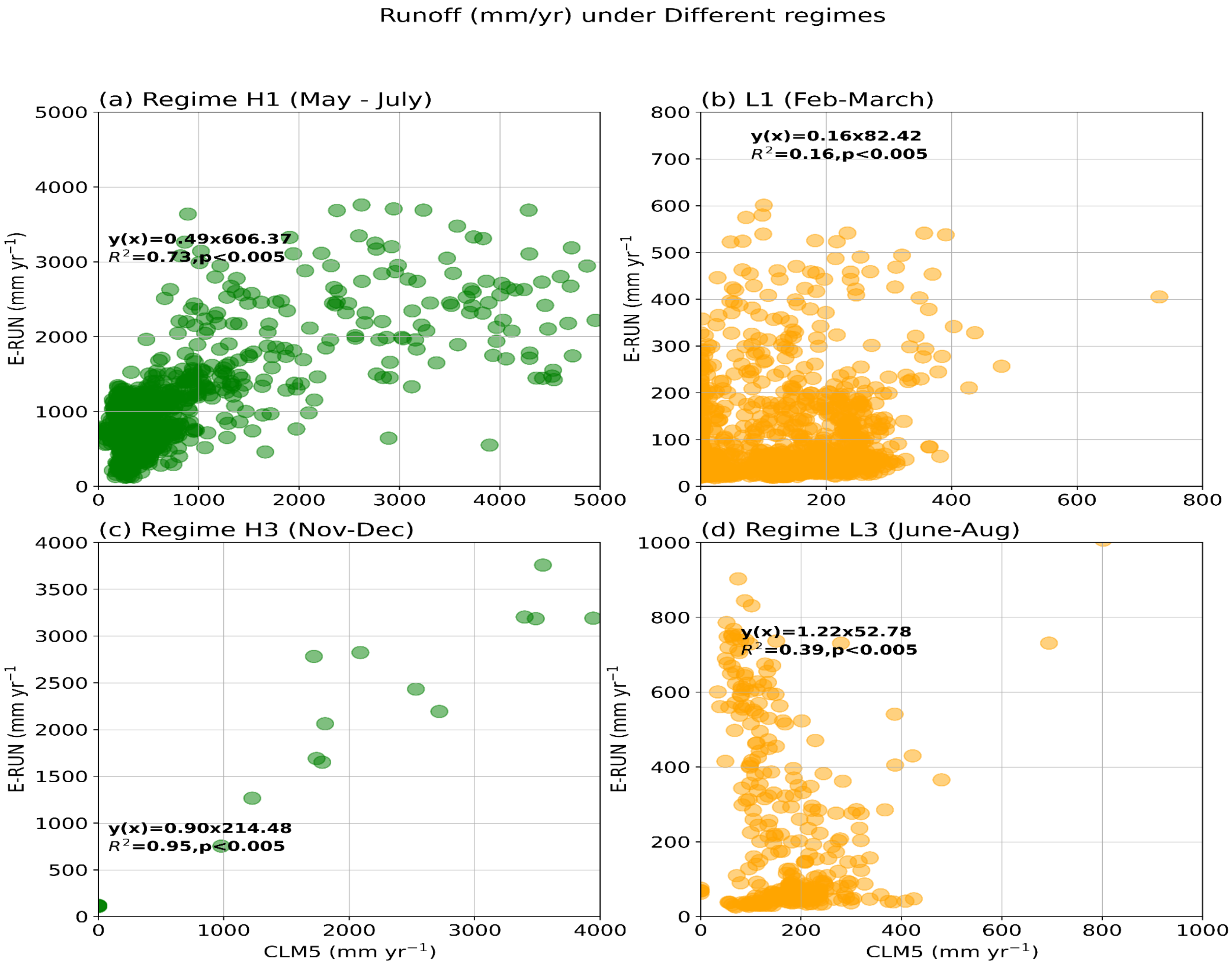
$$\frac{\partial C_i}{\partial t} = R_i + \sum_{j \neq i} (i - r_j) T_{ji} k_j C_j - k_i C_i + \mathrm{DOC}_{\mathrm{net}}$$

Add net change in DOC from routing

Liao et al (2019)

Runoff Evaluation





H1:
Dominant snowmelt high water. 3 months with the highest average runoff belong to spring or early summer (typically May-July)

L1: Dominant low water flow in winter, caused by snow accumulation. 2 months with the lowest runoff both belong to winter or early spring (typically: February-March).

H3:
Dominant rain highwater

L3: Dominant summer low water

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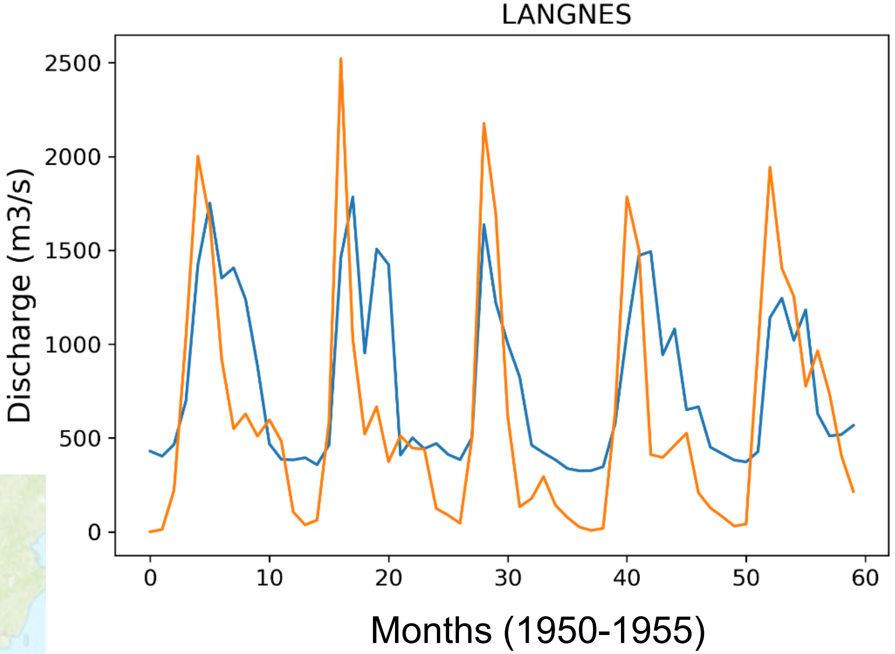
River Discharge Evaluation

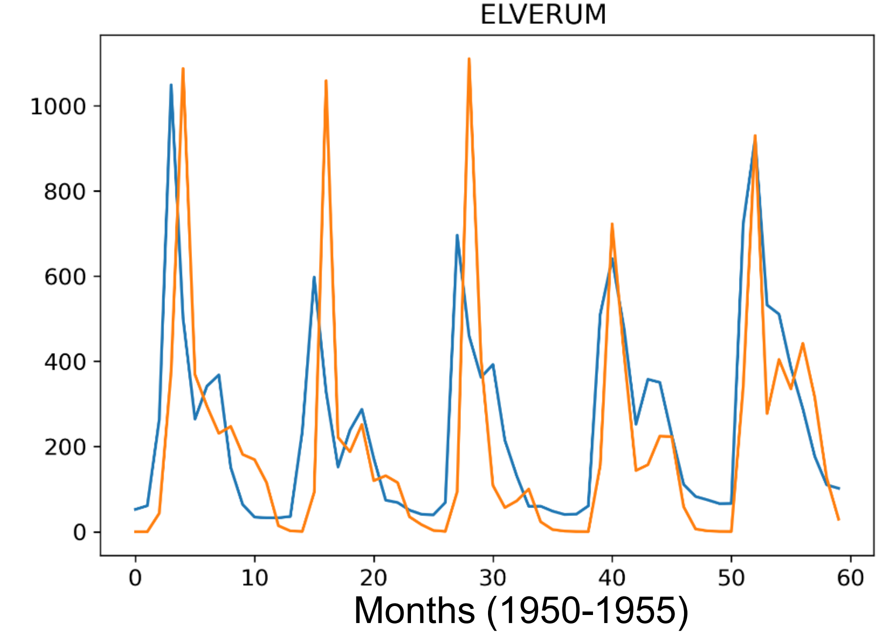
Glomma river Basin, Norway

GRDC station data

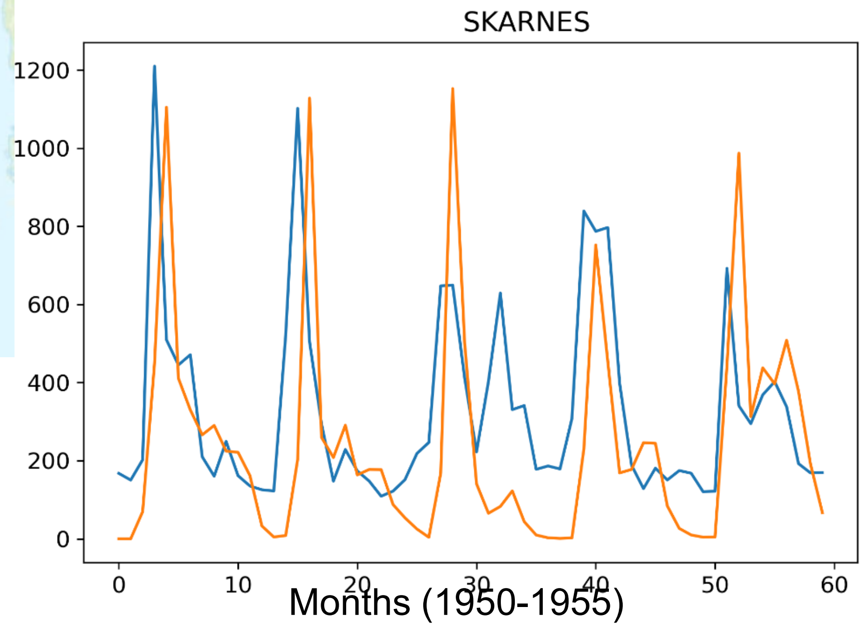
CLM-BGC simulation

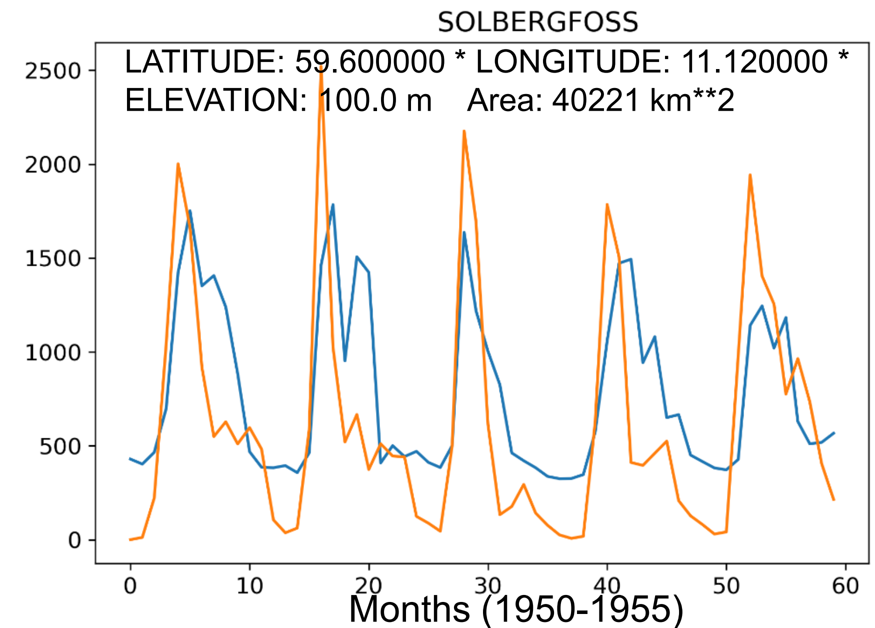


LAT: 60.8 LON: 11.56 Elevation: 180m, Area 154 450 km2



LAT: 60.25 LON: 11.68 Elevation: 129m, Area 20300 km2





THANK YOU
FOR YOUR ATTENTION

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