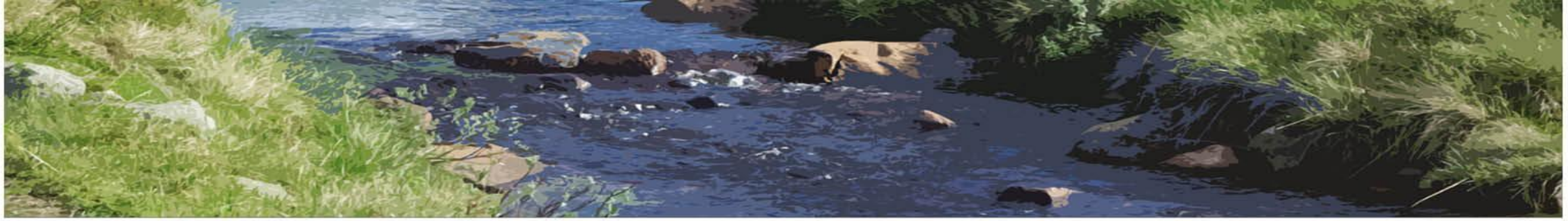

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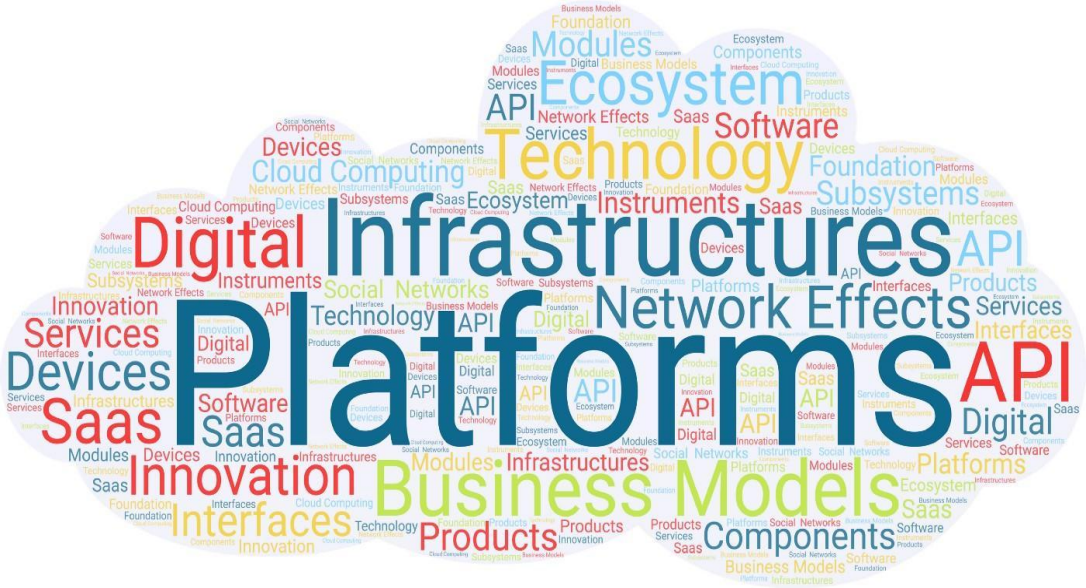
The CLM-FATES model platform for EMERALD and its implementation on GALAXY

Hui Tang, Sonya R. Geange, Eva Lieungh, Anne Fouilloux, Peter Horvath
and many others in EMERALD project

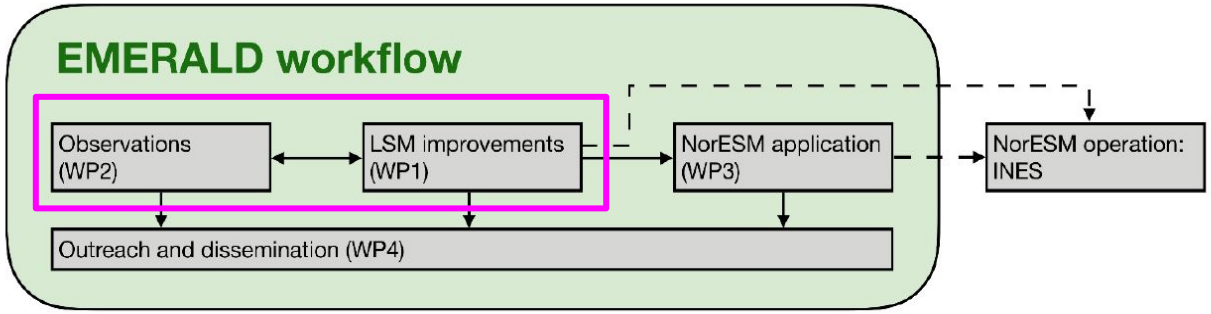
Special thanks to Vigdis Vandvik, Frode Stordal, Olav Skarpaas, Anders Bryn, Kjetil Aas, Rosie Fisher for great supports

Outlines

- **Motivation of the CLM-FATES model platform**
- Steps for building the model platform
- Model platform on GALAXY
- Ongoing work and potential applications



The interaction between modeller and field ecologist is the key in EMERALD



❖ Scientific objectives:

➢ Improve representation of high latitude ecosystems and their climate interactions in CLM-FATES by **integrating data and knowledge from empirical ecosystem research in model parameterisation, development and testing**.

❖ Approach:

➢ **Integrate and expand on existing national or international observation system** to facilitates better use of relevant data and observations and implementation of key processes in CLM-FATES.

➢ **Joint field work and experiments**

➢ **Coordinated modelling efforts**

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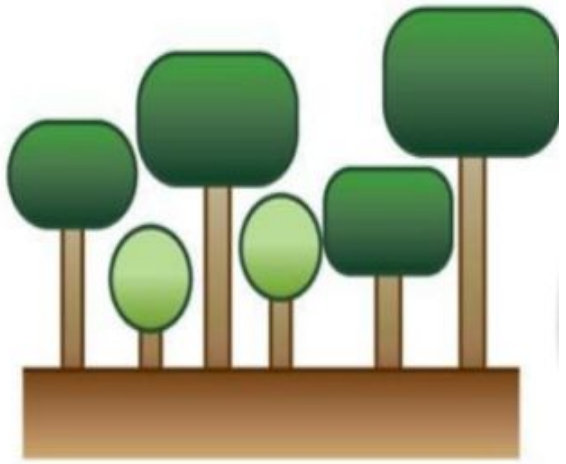
Ecosystem modelling *vs*. Field observation

Timescale	1 hr - 1000 yrs	0 - 10 yrs, non-continuous
Spatial scale	10 km -100 km	mm to 100 m
Focus	Long-term equilibrium; Plant functional types Ecosystem state, trend and processes etc.	Transient dynamics; Species and community responses Species interactions, life-history, physiology etc.

Single-Point & Regional CLM-FATES simulations for nordic sites



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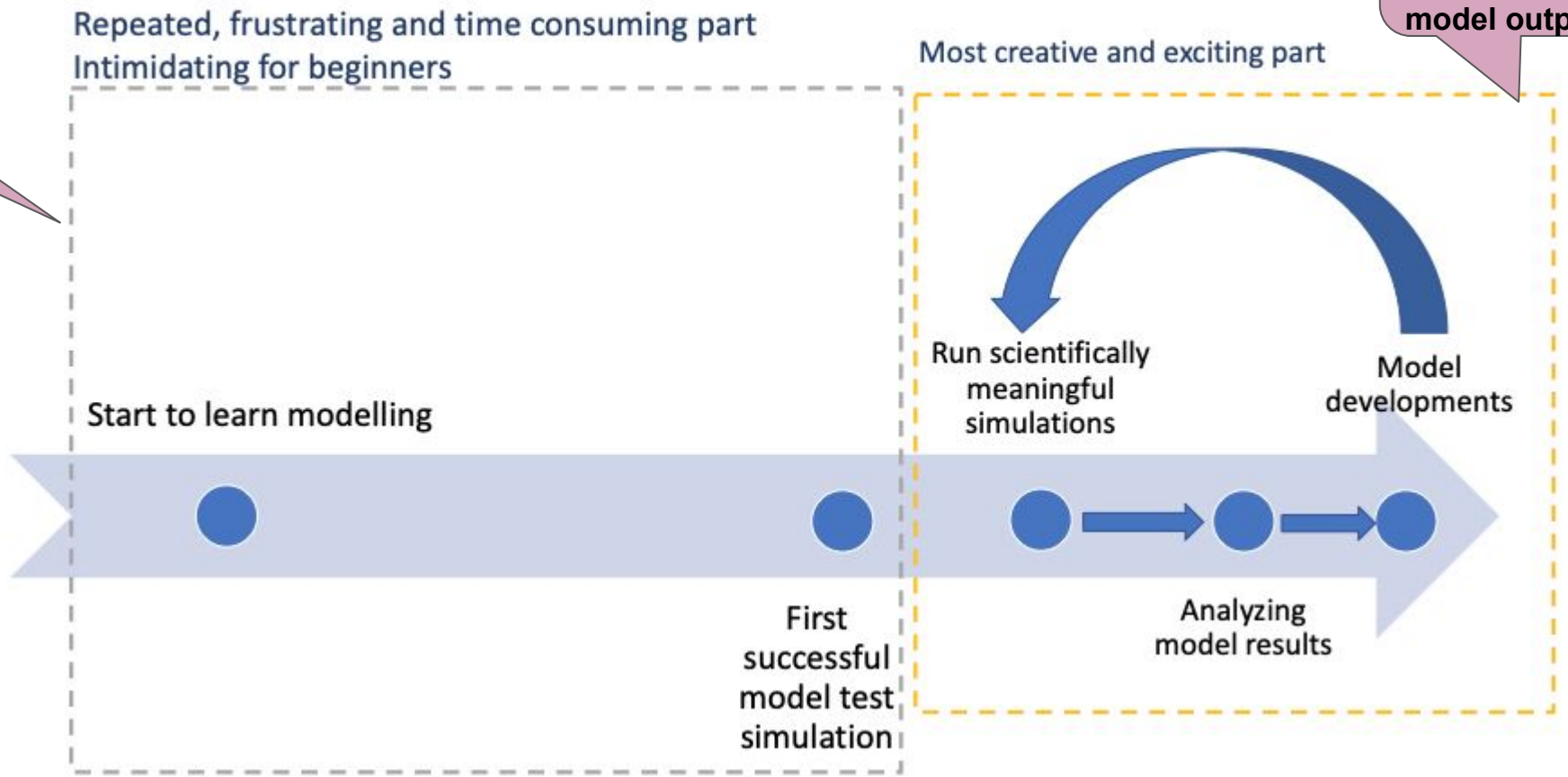
Low accessibility of CLM-FATES modelling: Steep learning curve for beginner

Can a CLM-FATES platform take care of this part?

Can a CLM-FATES platform also help analyzing and document the model output?



Reasons for the long learning curve

-- CLM-FATES is developing fast

-- FATES has complex association with the host model (e.g., CLM)

-- **Tailored inputdata needed for specific sites and region**

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Rationale for CLM-FATES platform

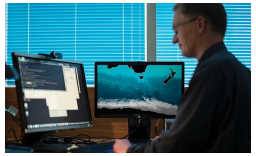
Model platform

Can we implement these new functionalities, is the model better?

Facilitates model developments

Facilitates the use of the model

Can we add or test these processes/hypothesis in the model?



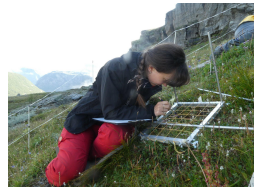
Avoid porting issue, responsive

Modellers

Meta data

Ecologists

Run the model by themselves, GUI



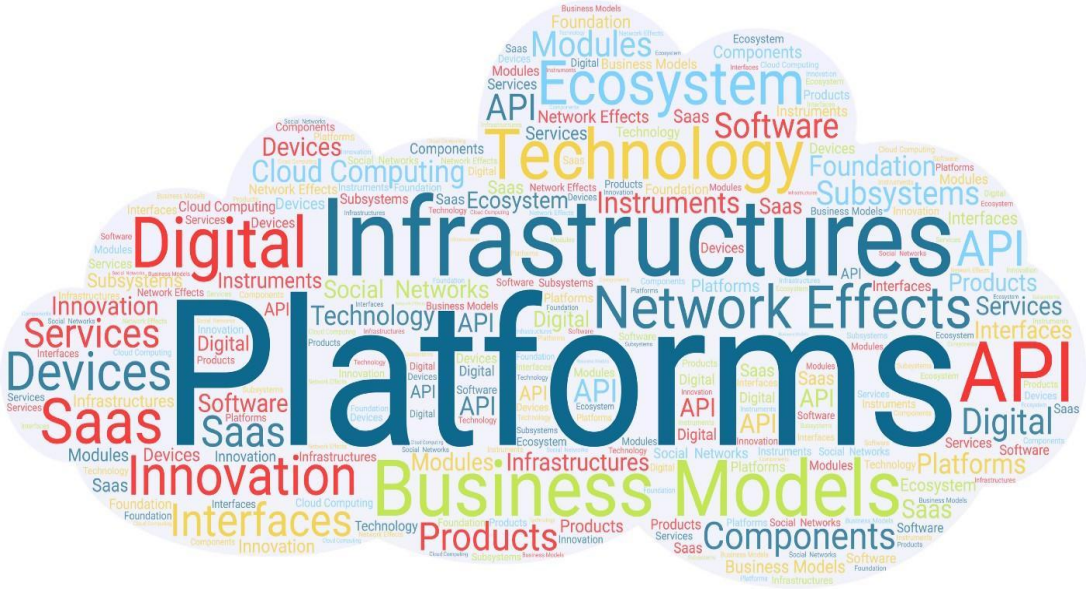
Can we add some measurements from modelling perspective?

Field observation

Carry out observations to understand phenomena

Outlines

- Motivation of the CLM-FATES model platform
- **Steps for building the model platform**
- Model platform on GALAXY
- Ongoing work and potential applications



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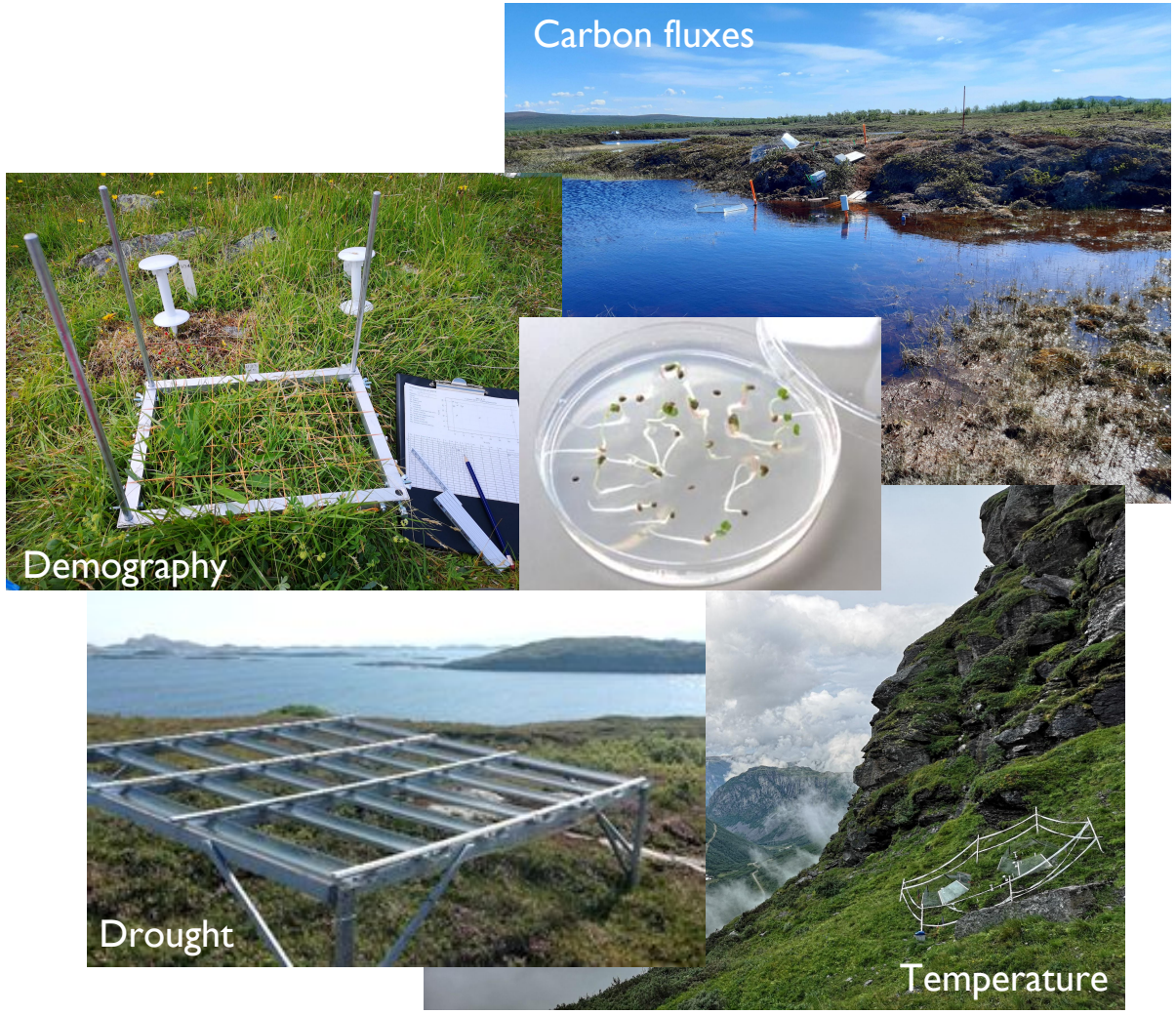
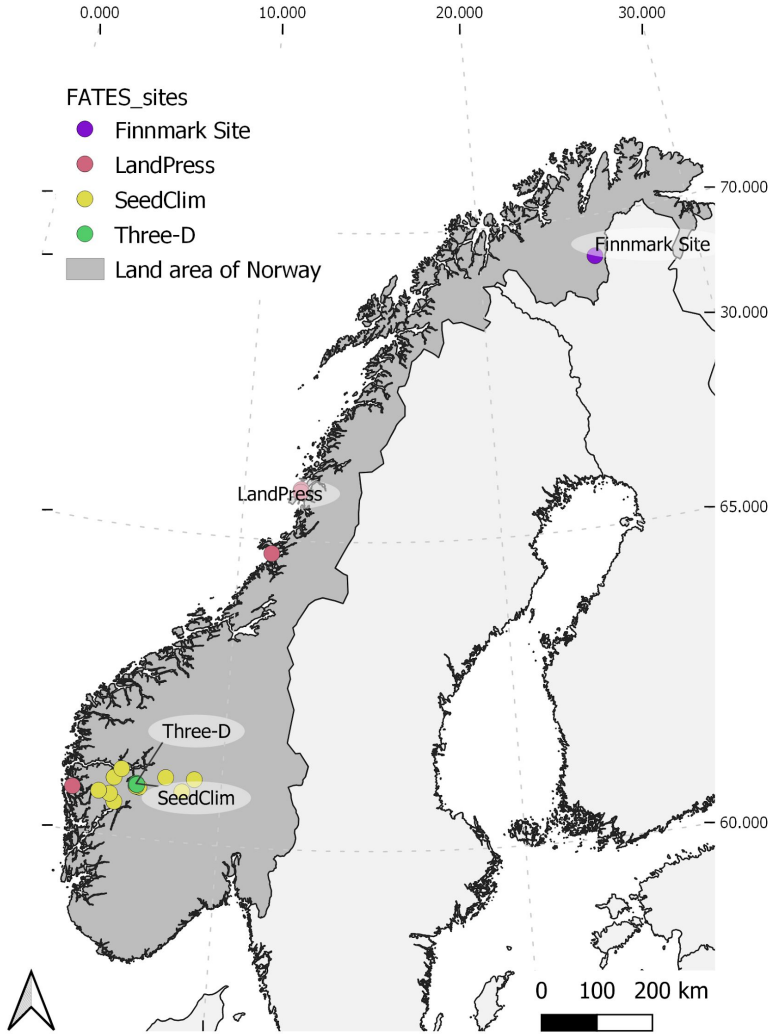
Field sites included in the FATES modelling platform so far





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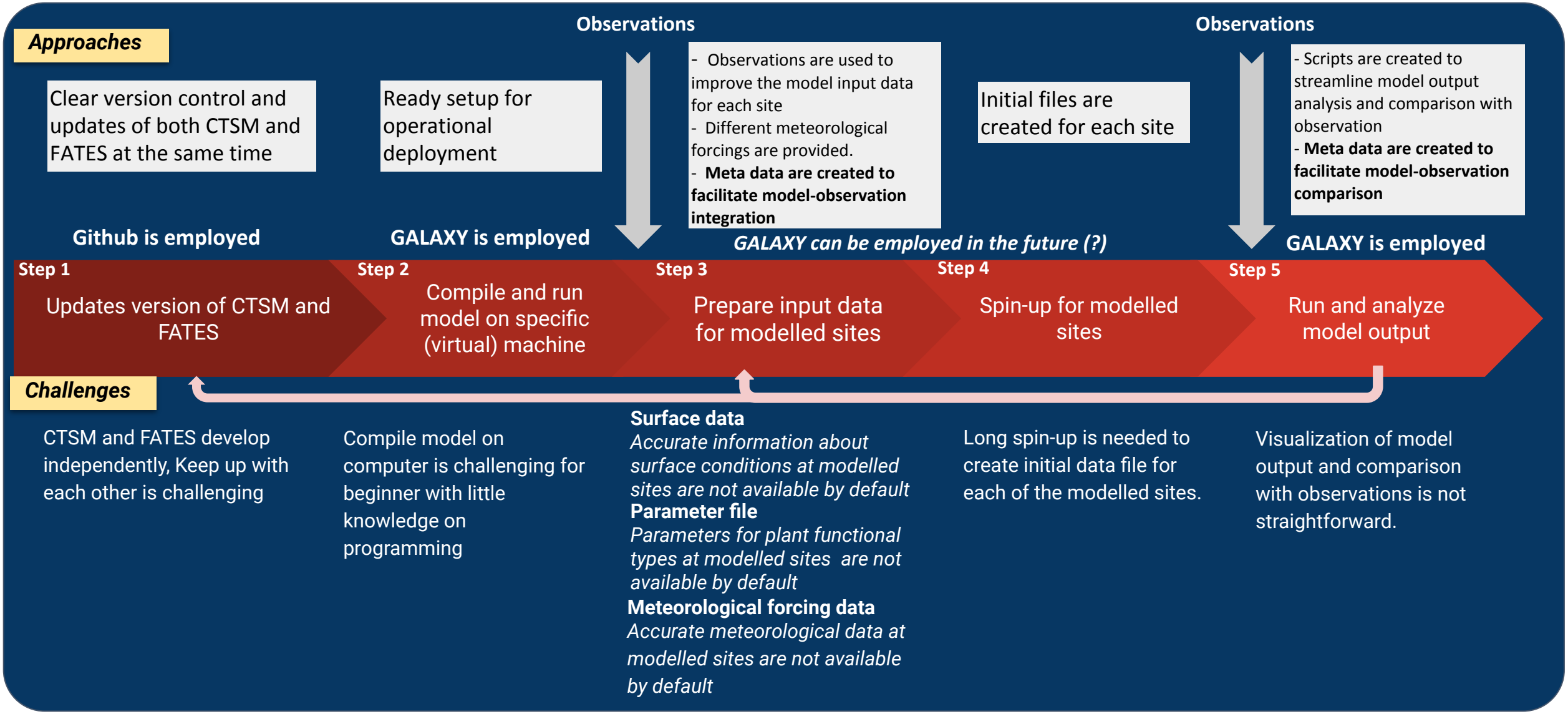
Steps for building the FATES modelling platform

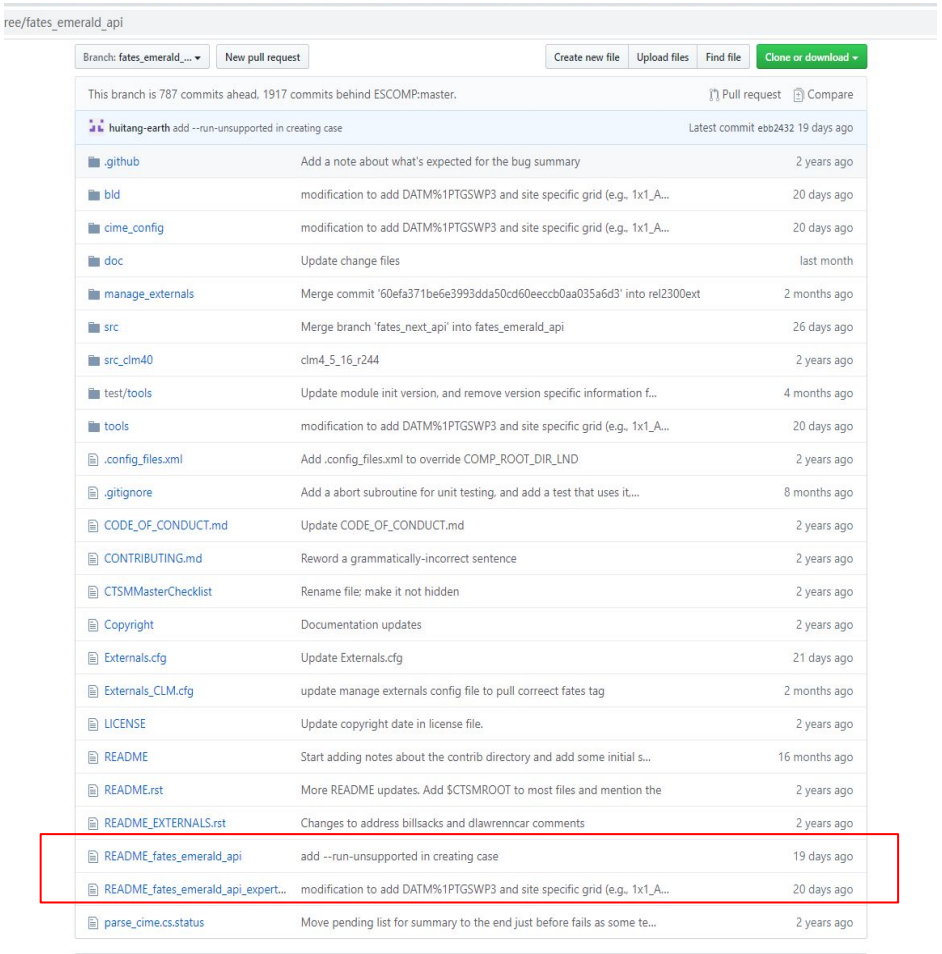


Step 1: CLM-FATES platform on Github

- Available on Github: https://github.com/NordicESMhub/ctsm/tree/fates_emerald_api
- "README_fates_emerald_api" for running **existing site** simulation (including all the informations and links)
- "README_fates_emerald_api_expert_only" for setting **new site** simulation

Developed based on:
CLM5.0: release-clm5.0.32
FATES: sci.1.34.0_api.9.0.0
CIME: cime5.6.33

Basic setup for runing CLM-FATES on 20 sites:
(1) Atmospheric forcing based on GSWP3v1 (0.5 degree) and COSMOREA6 (6km)
(2) Refined surface data file
(3) Default FATES parameterfile (12 pfts) and customized parameterfile for each site
(4) Initial file from 2000 years spin-up simulation



Step 3: Prepare inputdata for modelling sites

- **Atmospheric forcing**
  - Using high resolution reanalysis (e.g., ERA5-land 9km, COSMO-REA 6km, MEPS 2km) and bias corrected using on-site observations
- **Surface data file**
  - Use observed values as much as possible. Only use the default values when observation is not available.
- **PFT parameter file**
  - Refine functional groups of interests at each sites (e.g., forb, graminoid, shrub, mosses)
  - Use measured traits as much as possible
- **Initial file:**
  - How to spin up soil carbon using FATES?
- **Tailored model experimental design to be in line with field experiments and research questions.**
  - Include perturbations to mimic climate manipulation experiments at the sites
  - Prescribe PFT distributions **using FATES reduced complexity modes** (e.g., transplant a novel functional group in a site)

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Metadata of model input and output variables and their linkage to observed variables at each site are critical for effective communication!

- Modellers need the metadata to check where they could find proper observation data from each sites
- Ecologists need the meta data to understand which variables are important for modelling purpose and are worth measuring.

FATES parameters

File Edit View Insert Format Data Tools Add-ons Help

See also working notes in google doc

	B	C	D	E
1	See also working notes in google doc			
2	**FATES parameters**	taken from https://github.com/NGEET/fates/blob/master/parameter_files/fates_params_default.cdl		
3	fates_params_default.cdl version: tag sci.1.34.0_api.9.0.0, latest commit 22eb568			
4	**short name**	**long name**	**units**	**description/comments**
5	same as in code		units the parameter is mea	Vigdis' comments, how to measure and other with the FATES community when we have a g include references.
6	Basic control parameter			
7	fates_pftname	Description of plant type	short name without space	seedclim database
8	fates_pft_used	Switch to turn on and off PFTs (also see fates_initd for cold-start)		not used anymore?
9	fates_recruit_initd	initial seedling density for a cold-start near-bare-ground s	stems/m2	What unit? Density per some area, or a fixed
10	fates_woody	Binary woody lifeform flag		seedclim database
11	fates_wood_density	mean density of woody tissue in plant	g/cm3	NA but possibly from databases

FATES_input_output_variables

File Edit View Insert Format Data Tools Add-ons Help Last edit was on June 25

More documentation on surface data can be found here: https://escomp.github.io/ctsm-docs/versions/release-clm5.0/html/tech_note/Ecosystem/C

	A	B	C	D	E	F	G	H
1	More documentation on surface data can be found here: https://escomp.github.io/ctsm-docs/versions/release-clm5.0/html/tech_note/Ecosystem/CLM5							
2	Only the most relevant variables to our research are listed here. The meaning of each variables can be found in comments							
3	**Please suggest better values for each variables using comments.**							
4		SOIL_COLOR	Soil depth (m)	PCT_SAND (%)	PCT_CLAY (%)	ORGANIC (kg/m3 (a	FMAX	PCT_NATVEG (%
5	ALP1	12	0.02	72	14	96.91	0.36	91.5
6			0.05	71	14	64.52		
7			0.09	71	14	40.52		
8			0.17	71	14	25.33		

How can we better facilitate this process?
How can we involve more people in this effort?
What are the gaps between model and observation?

Project			Infrastructure characteristics			Environmental information			Vegetation				Fluxes			Images	
ID	name	region	# Sites	Years of data	Experimetal treatments	Climate	Snow	Soil	PFT	Community	Functional traits	Demography	Water	Temperature	Carbon	near surface	remote
A	SIOS+WICLAP	HighArctic	19	1 - 14	C, T	T, P, W	S		c							C	c
B	InterAct	HighArctic	1	7	C	T, P, W	S		S	S			C	C	C		
C	SatPerm+	HighArctic	1	20	C	T, P, W	S	M, N, S	S	S			C	C	C	C	
D	CryoMET	High, LowArctic	2	6	C	T, P, W	S	M, N, S	S								
E	Feedback	LowArctic	1	3	C, T	T, P, w	S	M, N, S	S	S	S		A	A	A		
F	PermaNor	LowArctic	4	3	C	T, P, W	S									S	s
G	WinterGrazing	Low Arctic	32	19	C,T,G	T, P, W	s	M, N, S	c							S	c
H	LATICE	Alpine	1	2	C	T, P, W	S	M, N, S	A	A			A	A	A		
I	SeedClim+	Boreal, Alpine	12	10	C, T, P, F, D	T, P, w	s	M, N, S	A	A	S	A		C	A	S	s
J	ICOS Norway	BorealContinental	1	2	C	T, P, W	S	M, N, S	S	S			C	C	C	S	s
K	LandPress+	BorealOceanic	5	2 - 24	C, T, P, F	T, P, w	s	M, N, S	A	A	S			C	A	S	s
L	NFI	Norway	200.000	28	C	t, p, w	s		A								a
M	TerraBGP+	Fennoscandia	gridded	4 - 9	C	t, p, w	s		A								a

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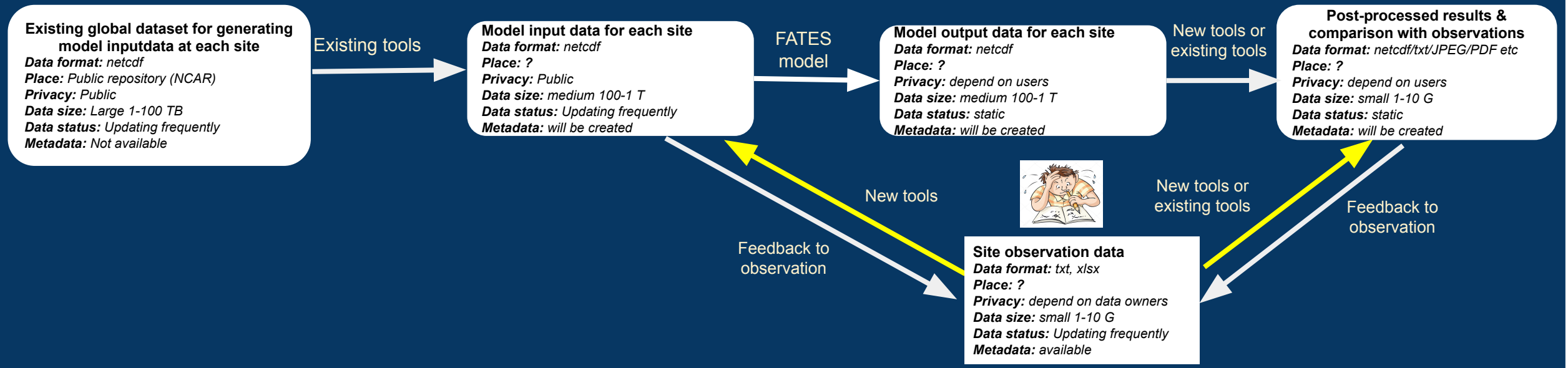
Data management issues of CLM-FATES model platform

Main questions:

1. How different dataset should be kept to be better accessed?
2. How existing tools could be employed to facilitate the data flow and data management?
3. What new tools should be developed to facilitate the data flow and management?
4. How to keep track of updates of different datasets?
5. How to create good meta data for model and observation data?



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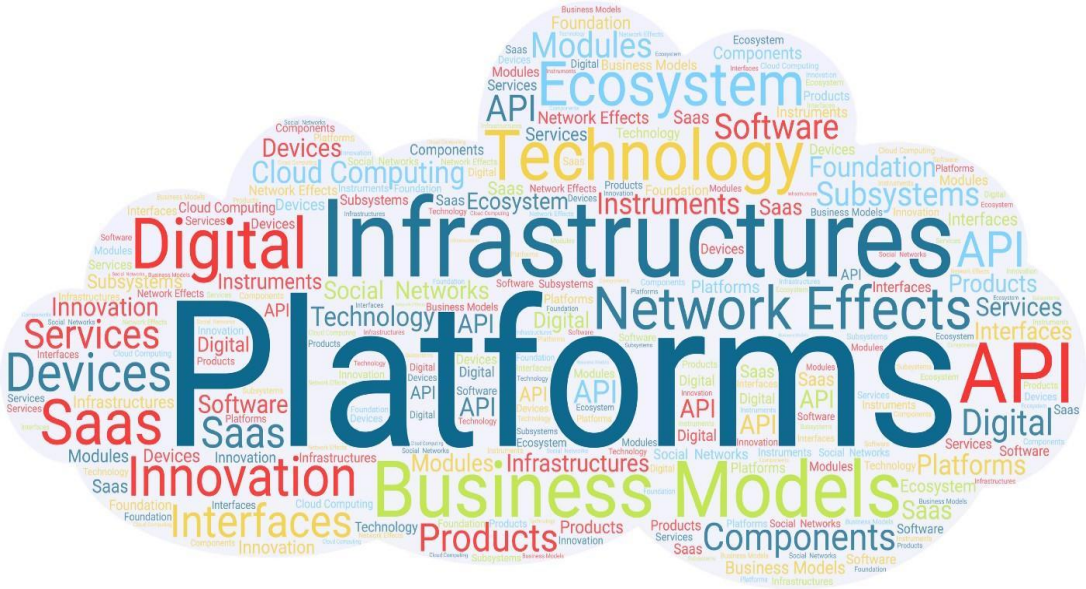
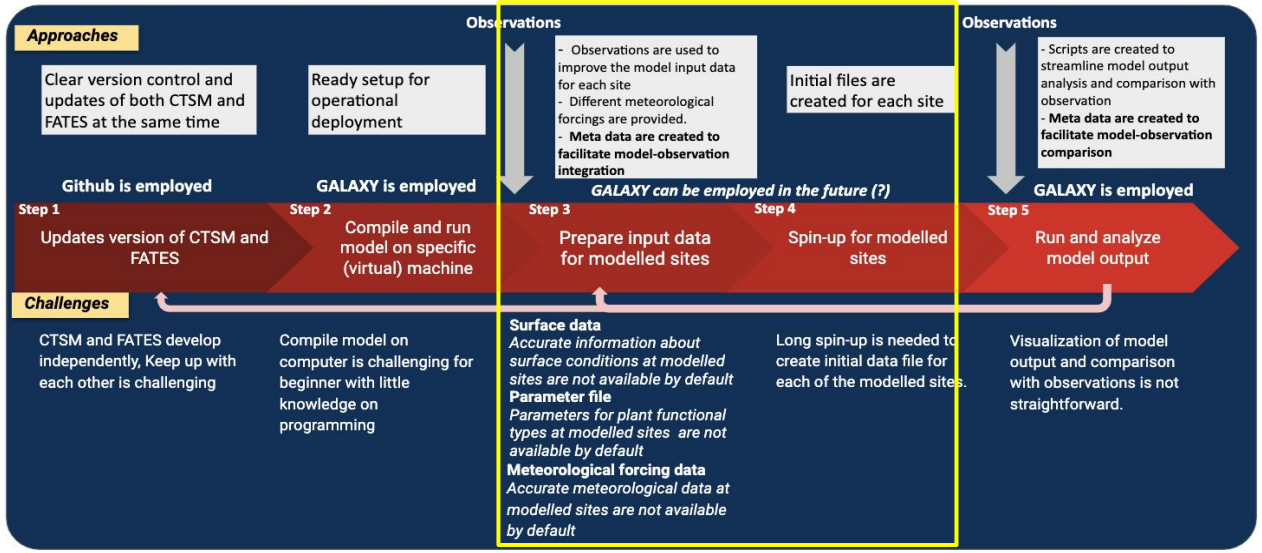
- Ongoing work and potential applications



The FATES modelling platform on GALAXY

- **Galaxy** is an open source, web-based platform for data intensive biomedical research. JupyterLab for climate research has been developed also on GALAXY (https://live.usegalaxy.eu/?tool_id=interactive_tool_climate_notebook)
- The CLM-FATES modelling platform has been implemented and tested on GALAXY, but still need some time to optimize the workflow and tutorials.
- CLM-FATES model platform on GALAXY will have broader scopes (free choice of sites) than that of EMERALD model platform (sites in EMERALD only).



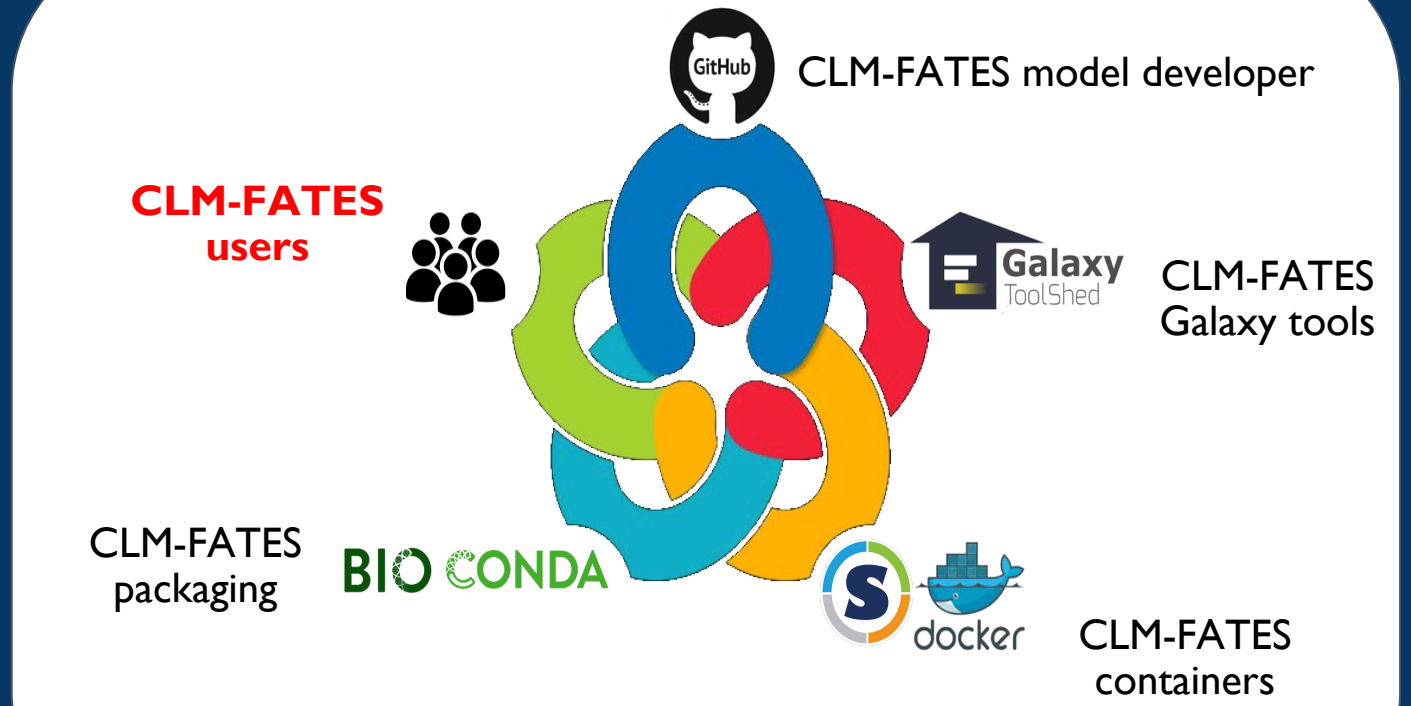
PANGEO

jupyter

Jupyter lab for ocean / atmosphere / land / climate python ecosystem

EOSC NORDIC

How CLM-FATES model platform is integrated in Galaxy



Step 1: Before being able to use CLM-FATES in Galaxy, we packaged a given CLM-FATES release using bioconda

Step 2: Automatically generate the corresponding containers (currently singularity and docker) and make them available on Biocontainers registry.

Step 3: The final Galaxy tool is then available in the Galaxy tool shed under “Climate Analysis” category .

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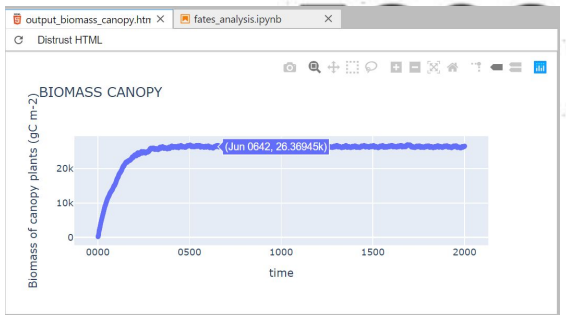

Workflow for using the FATES modelling platform on GALAXY

Use - Jupyter Notebook on GALAXY

Step 1: Start Galaxy interactive Climate JupyterLab

Step 2: Load FATES model from github and load pre-build model input data

Step 3: Use *cesm* conda environment to setup, compile, build and execute CLM-FATES with Galaxy JupyterLab script (fates_newcase.ipynb).

Step 4: Visualizing results using Galaxy JupyterLab Python notebooks and compare with observations

Galaxy / Live

PANGEO

jupyter

Use - GUI on GALAXY

Step 1: Search and start CTSM/FATES-EMERALD tool on https://climate.usegalaxy.eu/

Step 2: Select the name of the usecase, inputdata, and modelled sites

Step 3: Advanced customization

Step 4: Run the model

Step 5: Visualizing the results and compare with observations

TUTORIAL VIDEO

A short video on how to setup CLM-FATES on Galaxy is available at https://vimeo.com/439192348

Online tutorials and scripts can be found:

https://github.com/NordicESMhub/galaxy-training-material/blob/fates/topics/climate/tutorials/fates/tutorial.md

https://training.galaxyproject.org/

https://github.com/NordicESMhub/eosc-nordic-climate-demonstrator/tree/master/work/fates

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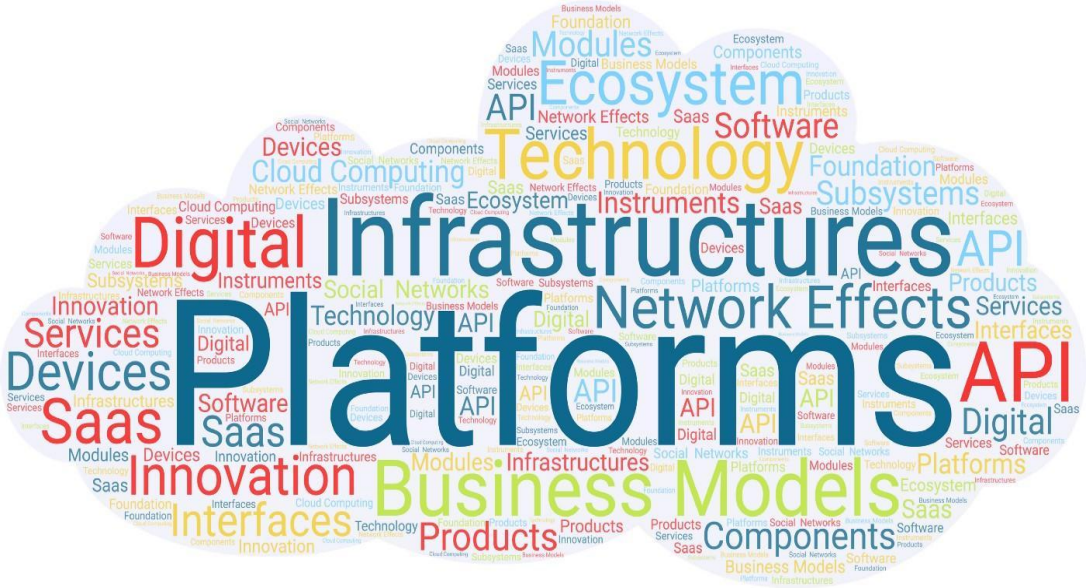
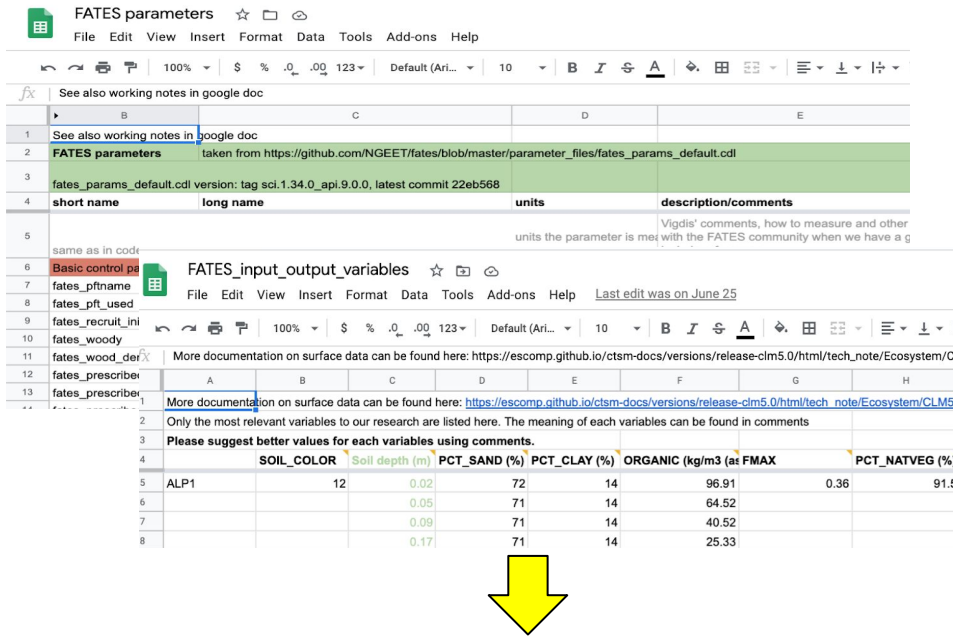
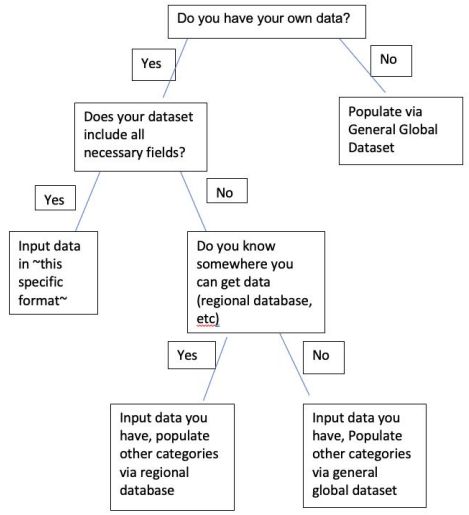


Ongoing work

- A manuscript on the model platform
  - Title: *Building a CLM-FATES modelling platform for bridging gaps between modelling and ecological observations: A case study from Norwegian Arctic-alpine terrestrial ecosystems*
- Improve the workflow/interface for integrating observation data into model inputdata file
  - Surface data file (Erin Gregory)
  - FATES PFT parameter file (Eva Eriksen, Lasse Keetz)
- Sensitivity experiments with improved model inputdata:
  - Surface data (Elin Aas)
  - FATES PFT parameter file (Lasse Keetz)
  - Meterological forcing (Hui Tang)
- Improve online tutorials and workflows of the model platform on GALAXY (Anne Fouilloux)
- CLM-FATES model platform tutorial/workshop/retreat (Anne Fouilloux, Kjetil Aas)





From: Erin Gregory and Sonya Geange

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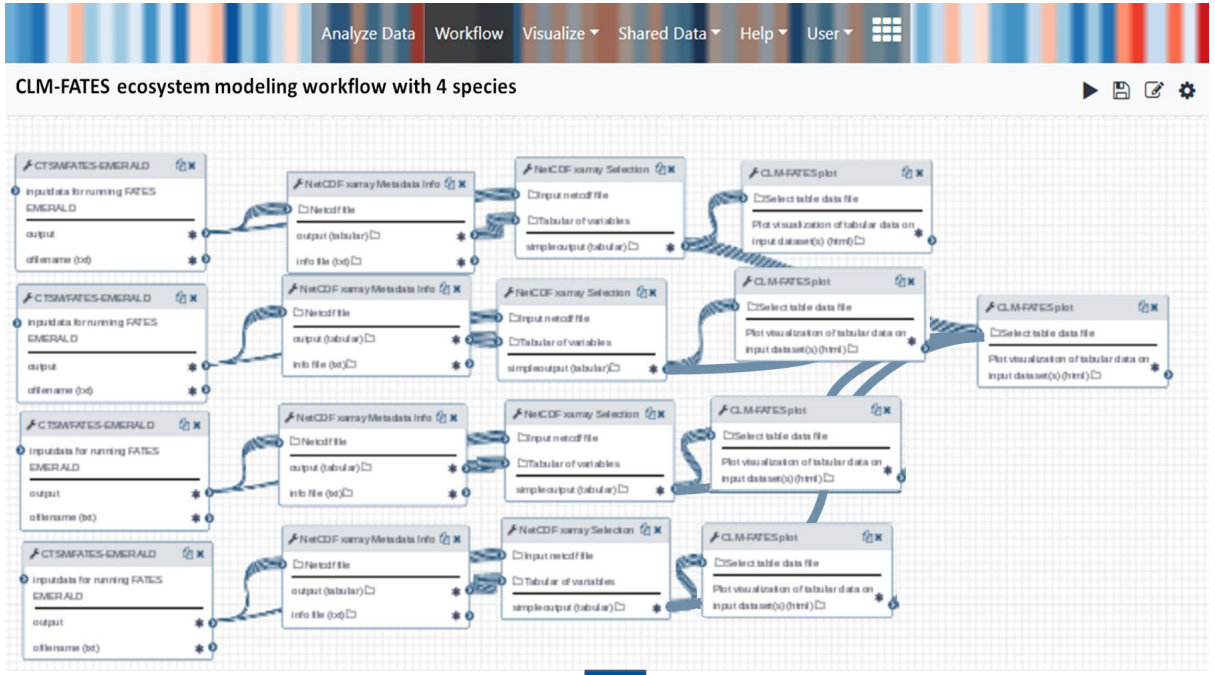


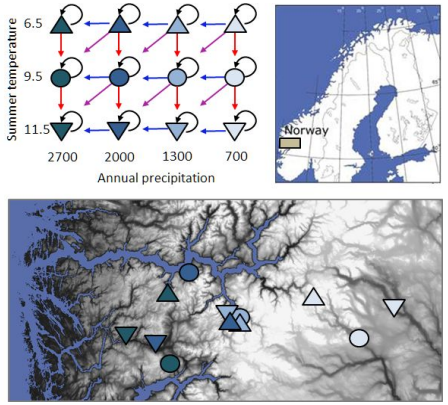
Publish Workflow in Galaxy

Workflow Hub

From: Anne Fouilloux

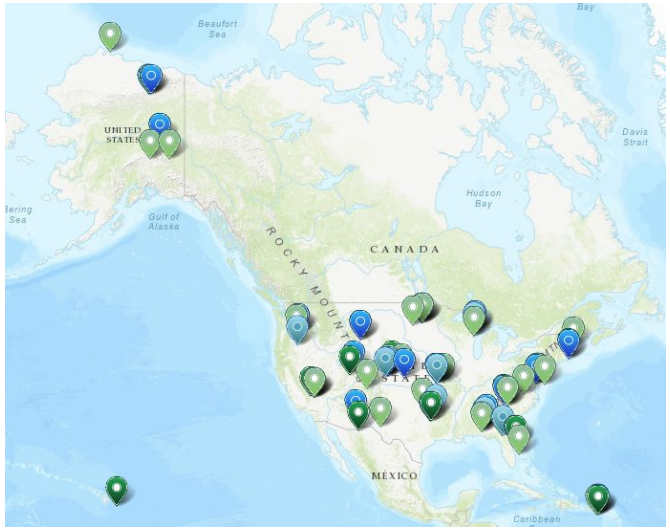
Potential applications, collaborations, ideas

- Eva Eriksen: Transplant experiments with CLM-FATES
- Hui Tang: Implement and test moss and lichen in CLM-FATES (e.g., SeedClim sites, Finse sites)
- Courses and Exhibitations
- Collaborations with NCAR (NEON project, Danica Lambodozzi)
- A specific website/database for EMERALD CLM-FATES model platform?



Töpper et al. 2018

Foto: NHM/Jarli & Jordan



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Thank you!

Galaxy PROJECT

NCAR UCAR

Galaxy Training Network