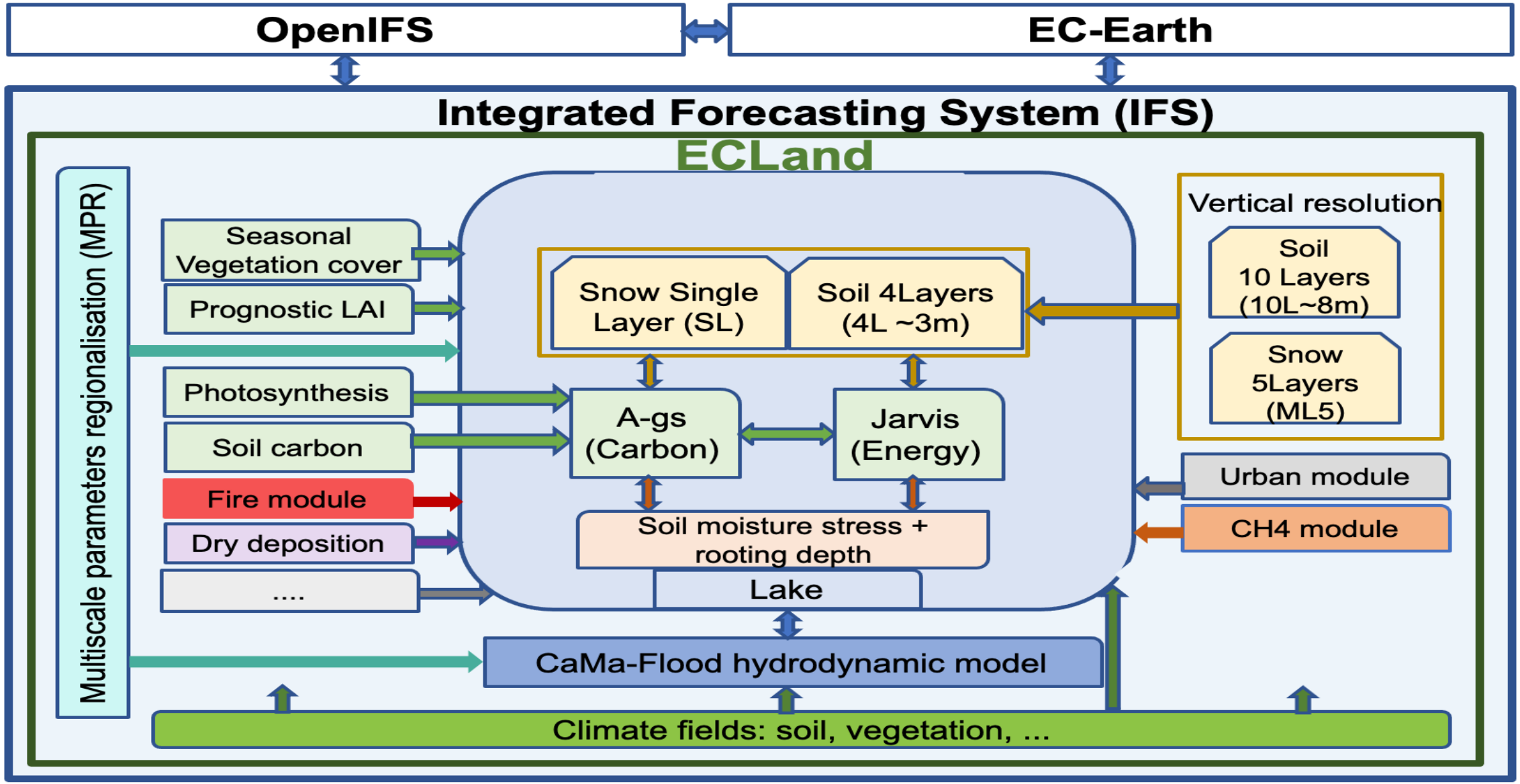
ECLand: Current status and perspectives

Souhail Boussetta

Thanks to: Gianpaolo Balsamo, Gabriele Arduini, Joe McNorton, Margarita Choulga, Xabi Pedruzo, Anna Agusti-Panareda, Birgit Sutzl, Florentine Weber, Retish Senan, Magdalena Balmaseda, Tim Stockdale, Christelle Prudhomme, Cinzia Mazzetti, Jasper Denissen, Patricia de Rosnay, Pete Weston, Kenta Ochi, Peter Duben, Anton Beljaars, Emanuel Dutra, Iria Ayan-Miguez, Sven Westermann

A Land Earth System Modular Modelling approach



Highlights of land developments

- **Snow-ML5 in 48r1**
- **Snow-Forest albedo** and **Snow Cover Fraction** updated in **49r1**
- **Improved soil moisture stress parametrization** in **49r1**
- **Up-to-date vegetation data based on** (ESACCI-LULC, GCLS-LAI) in **49r1**
- **Updated LAI seasonal variability** in **49r1**
- **T2m operator** improved in stable situations and with increased representativity of grid tiles in **49r1**.
- **Urban-tile** in **49r1**.
- **Wetland CH4 emission** & **Residential CO2 emission** modelling in **49r1** (passive) CAMS

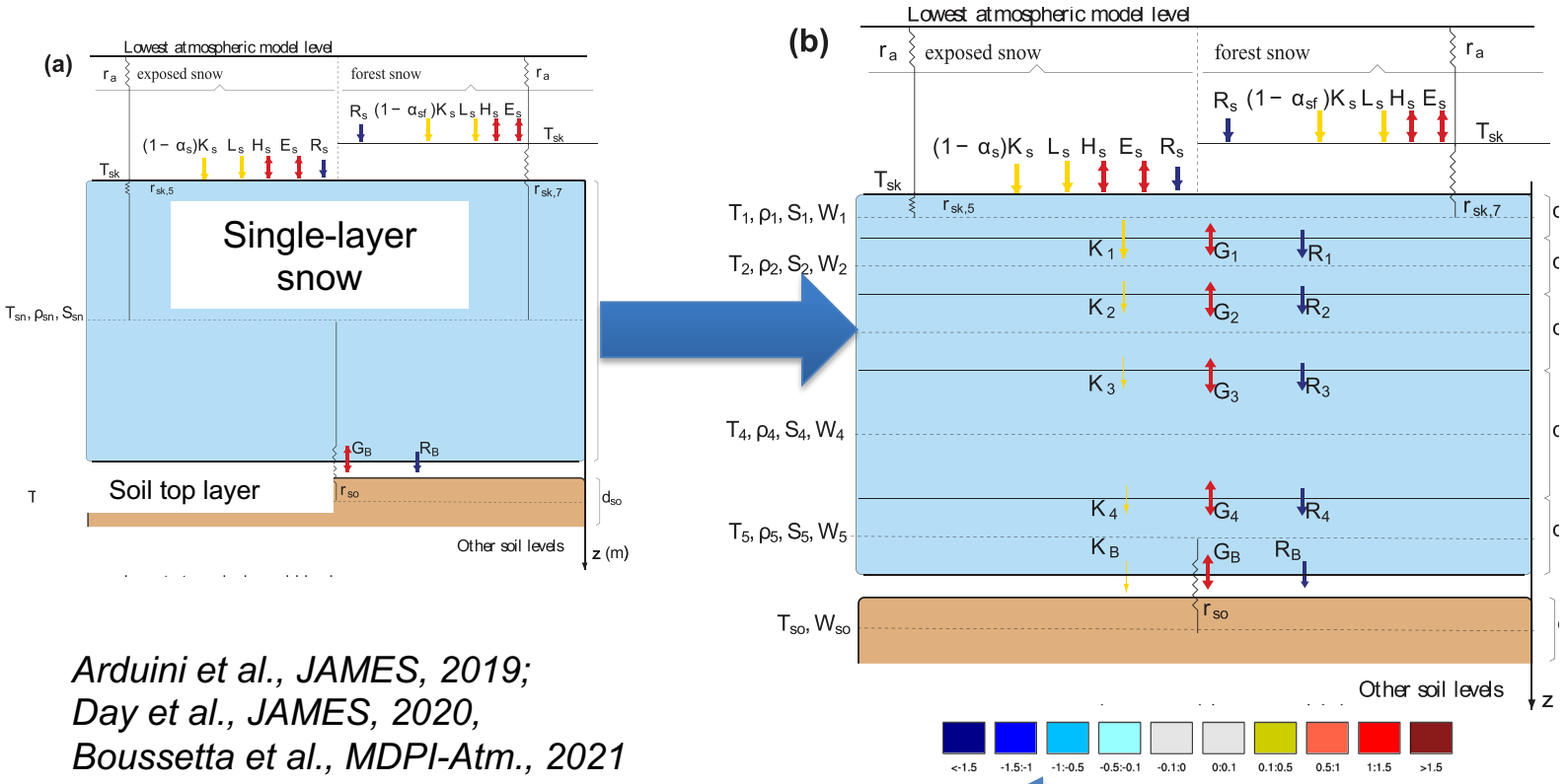
Beyond 49R1

- **Floods/Inundation** coupling with IFS ready for implementation in **50r1**.
- **Multi-Parameter Regionalisation MPR** passive in OSM and for implementation in **50r1.**
- **Fire modelling** & **Vegetation modelling** demonstrated feasibility within IFS based on 49r1 LULC.

ECLand Open-Source to expand the research (**irrigation, slow-time-varying, hydrology & ecosystems**..)

A 5-layer snow model to replace the single-layer representation in cycle 48r1

Gabriele Arduini, et al.



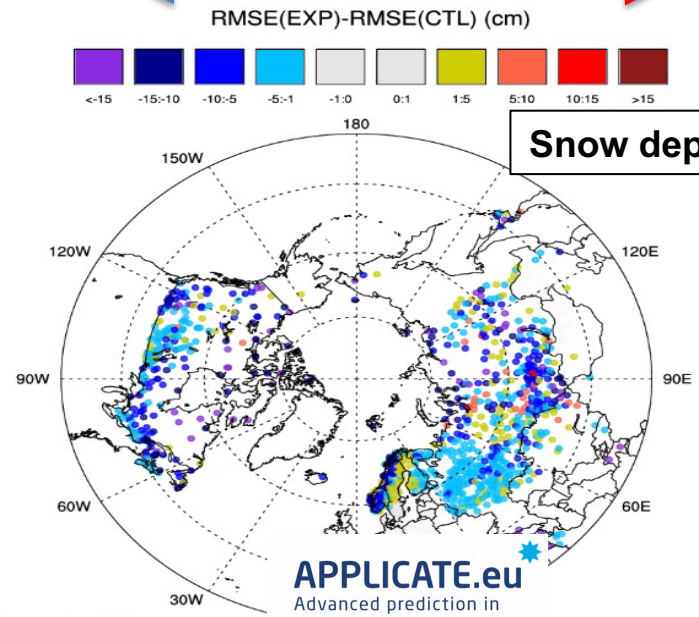
Arduini et al., JAMES, 2019;
Day et al., JAMES, 2020,
Boussetta et al., MDPI-Atm., 2021

- Substantial improvement in **snow depth**
- Reduced error also in the forecasts of **minimum temperature** (+24h).
- Explorative work for snow on sea-ice.

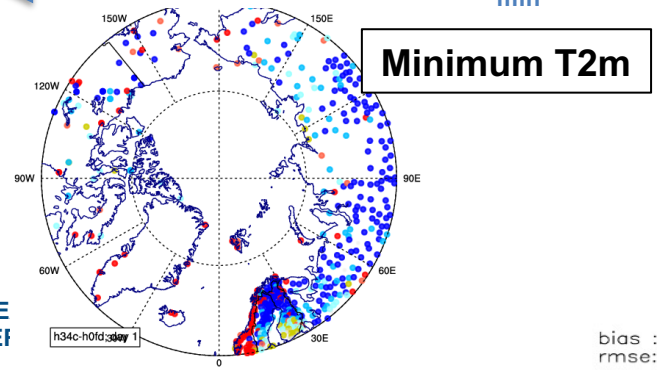
New multi-layer snow scheme:

- Now oper in cycle 48r1
- 5-layer snow scheme
- Prognostic liquid water content
- Improved snow physics

ML reduced snow$_{depth}$ RMSE **increase RMSE**



ML snow reduces T$_{min}$ bias



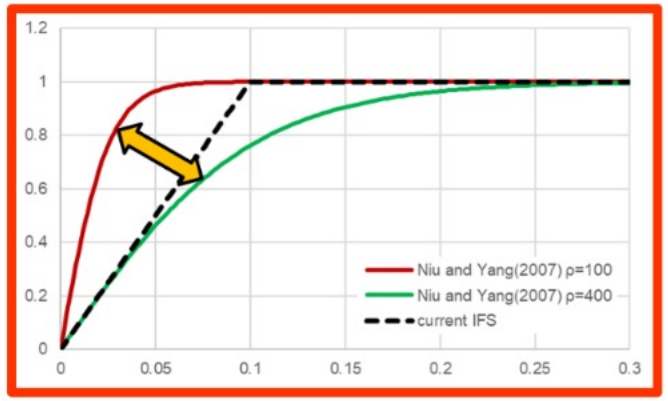
Revised Snow cover fraction parametrization

Kenta Ochi,et al.

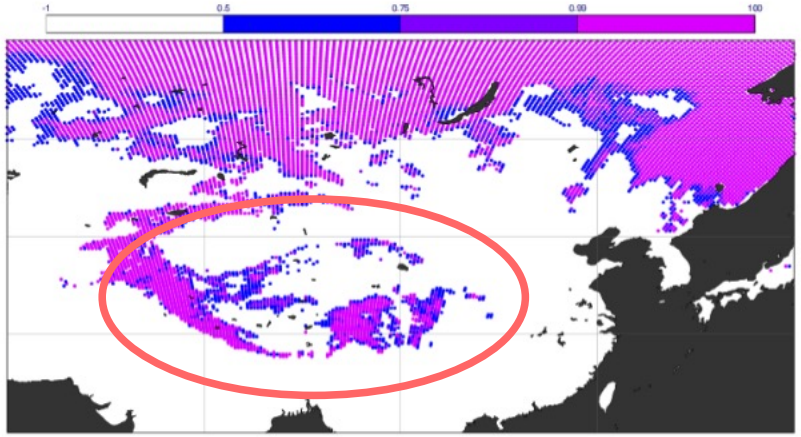
- To improve snow cover fraction for shallow snow, the SCF parameterization is revised to Niu and Yang (2007)

$$f_{sno} = \tanh\left(\frac{h_{sno}}{2.5 z_{0g}(\rho_{sno}/\rho_{new})^m}\right)$$

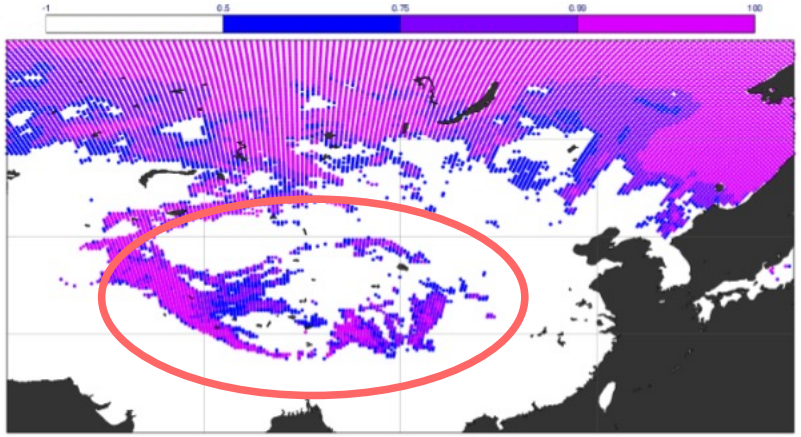
- $z_{0g} = 0.1, \rho_{new} = 100, m = 1$ as with CLM4, CLM4.5



CTL



New SCF



SCF increased around snow line with revised parametrization

Winter 2020/21

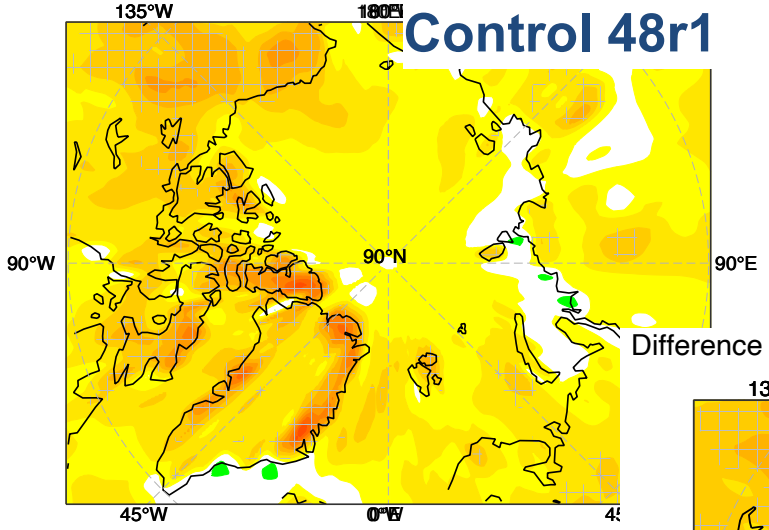
Improved Forecast skill

Land-ice tile: removing 10-metre snow depth over glaciers

Gabriele Arduini, et al.

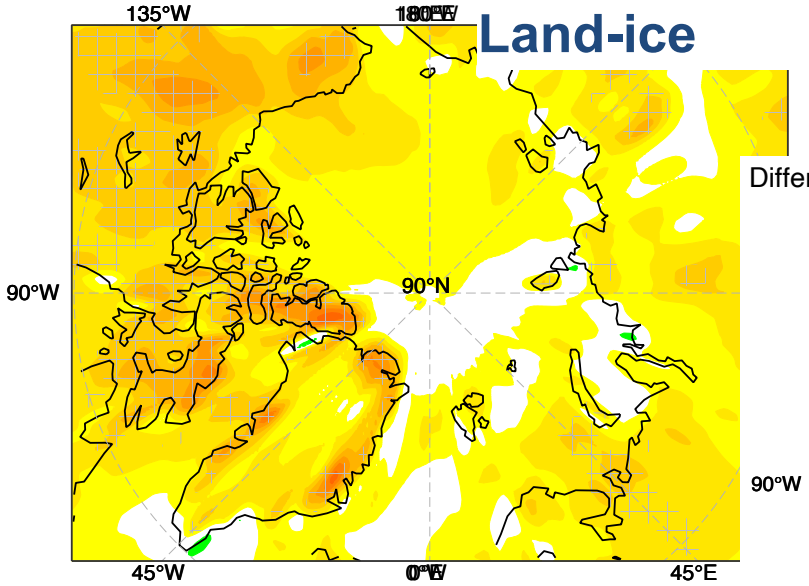
Coupled forecast (climplot): TOA LW vs CERES-EBAF

Difference hv6d - CERES-EBAF 90S-90N Mean err 0.45 rms 7.74



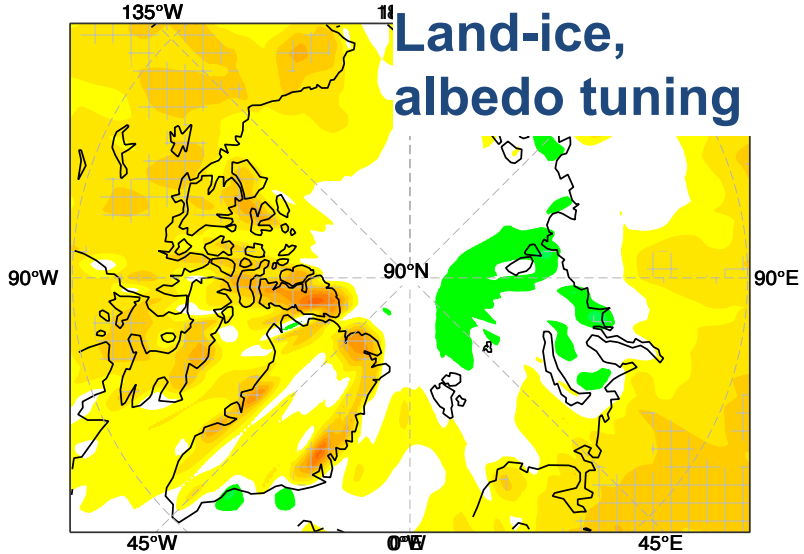
Control 48r1

Difference i4l4 - CERES-EBAF 90S-90N Mean err 0.573 rms 7.61

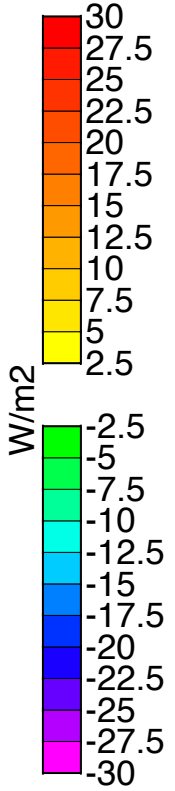


Land-ice

Difference i4p0 - CERES-EBAF 90S-90N Mean err 0.532 rms 7.66



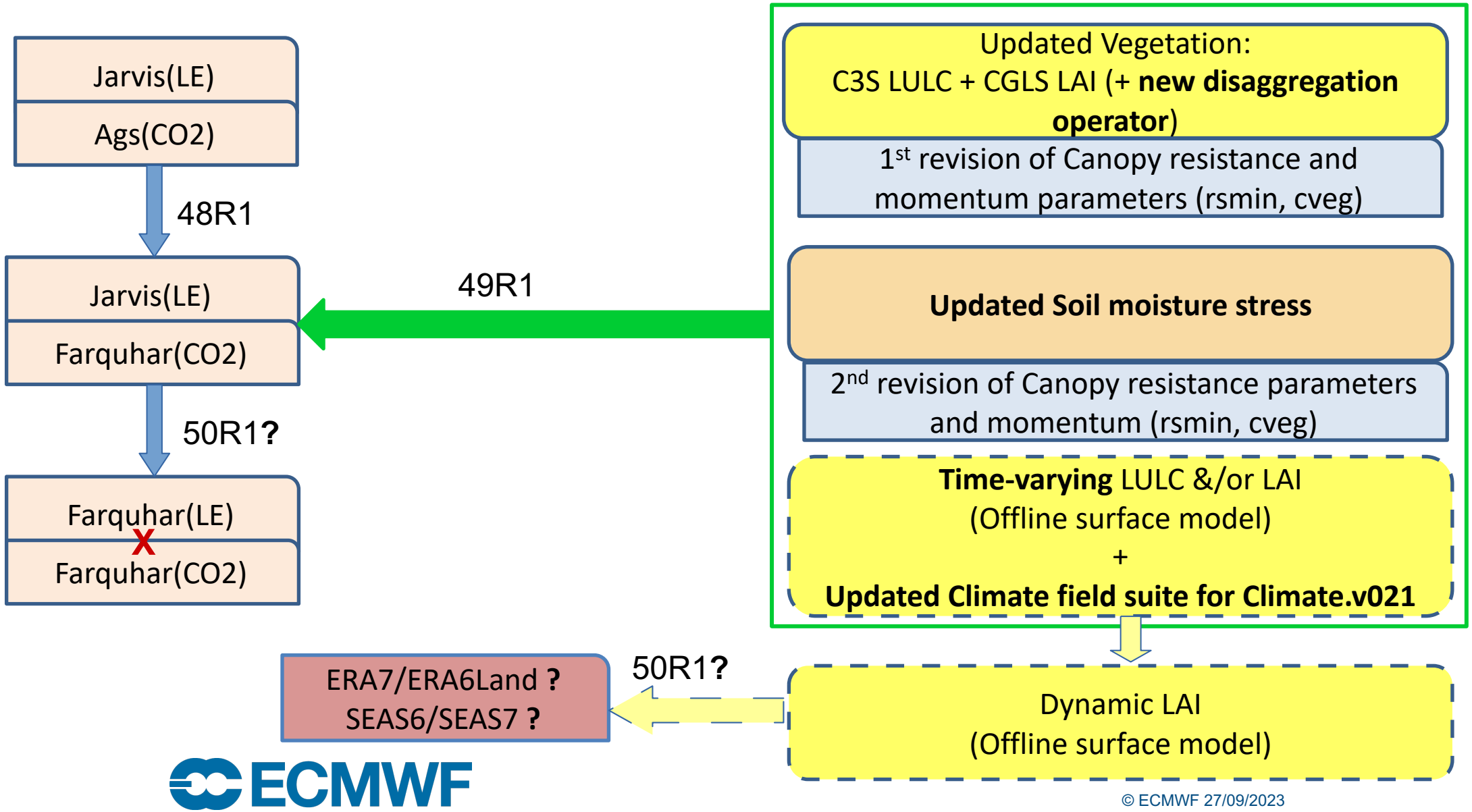
Land-ice, albedo tuning



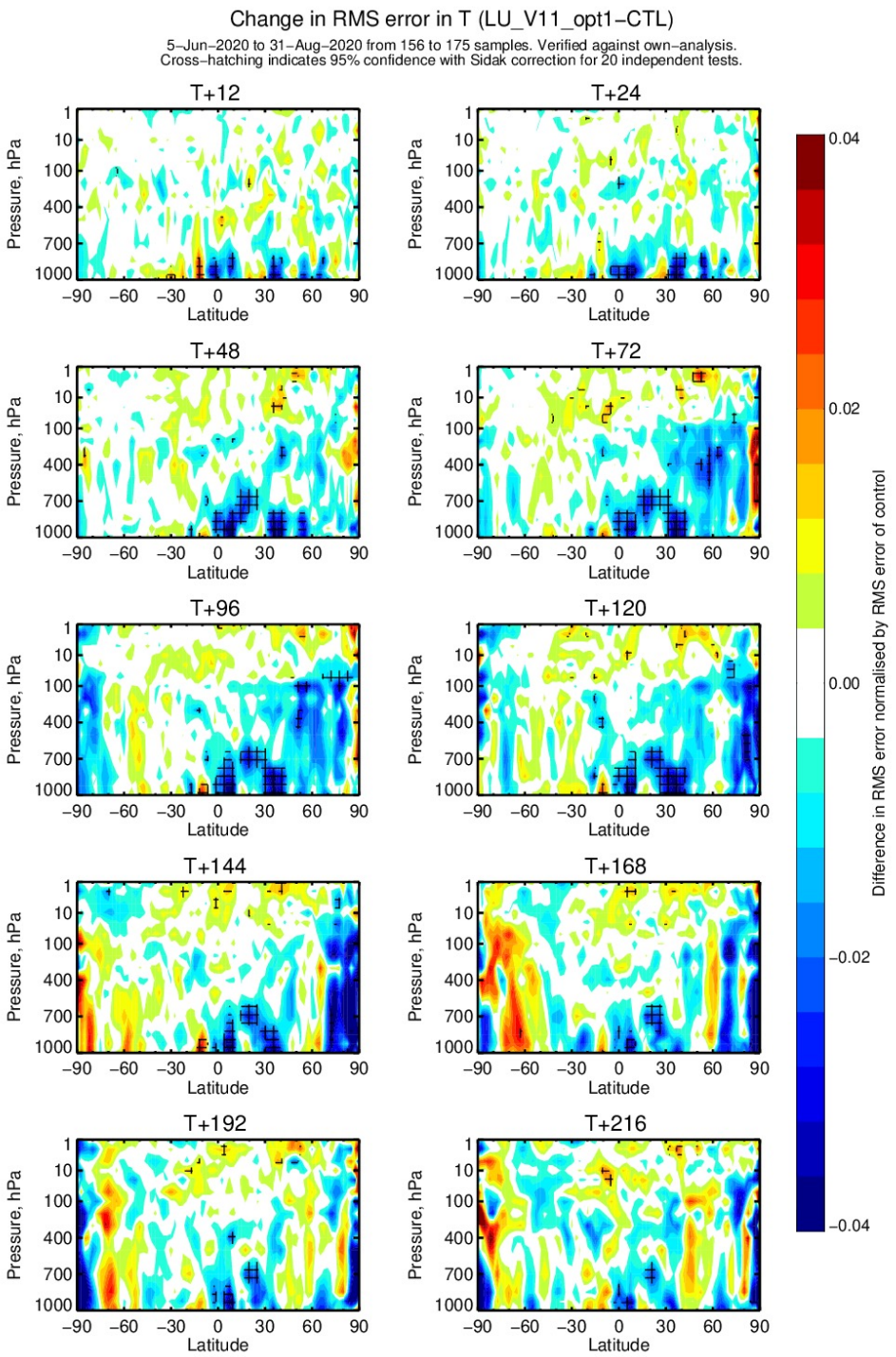
Reduced bias compared to CERES-EBAF

Testing ongoing in combination with snow-over-ice

Vegetation developments in ECLand



ECMWF



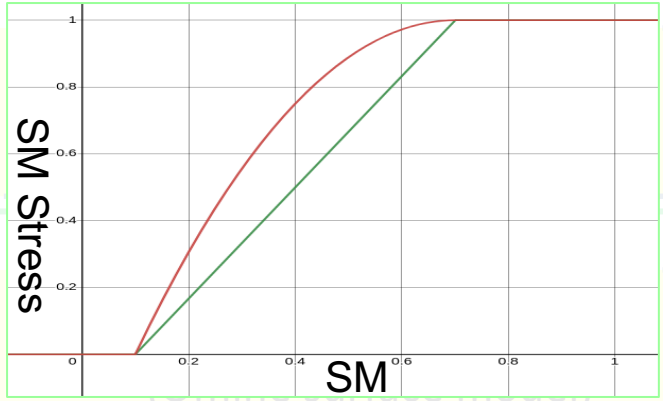
New Soil moisture Stress function

Updated Vegetation:
C3S LULC + CGLS LAI (+ **new disaggregation operator**)

1st revision of Canopy resistance and momentum parameters (rsmin, cveg)

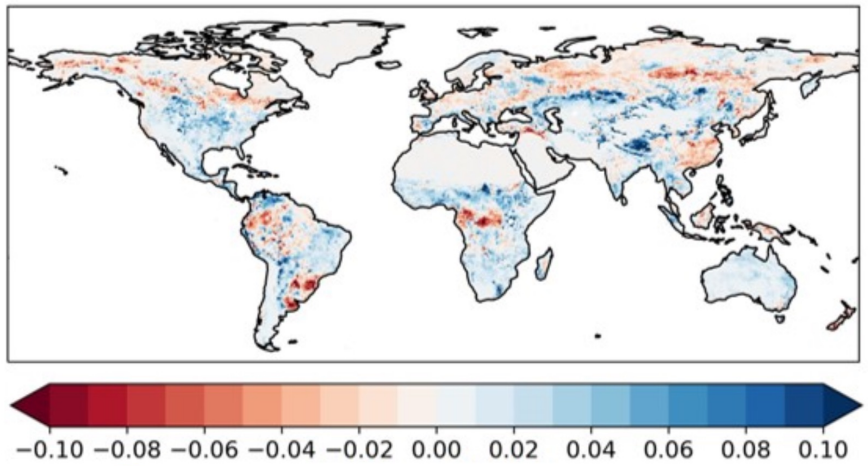
Updated Soil moisture stress

2nd revision of Canopy resistance parameters and momentum (rsmin, cveg)



* Physically consistent with the soil matric potential
* Allow higher evapotranspiration under drier conditions

Time-varying vegetation in ECLand



Anolmaly correlation diffrence of the Evaporation
(Time varying LAI – static LAI) for 1993-2019

49R1

Updated Vegetation:
C3S LULC + CGLS LAI (+ **new disaggregation operator**)

1st revision of Canopy resistance and momentum parameters (rsmin, cveg)

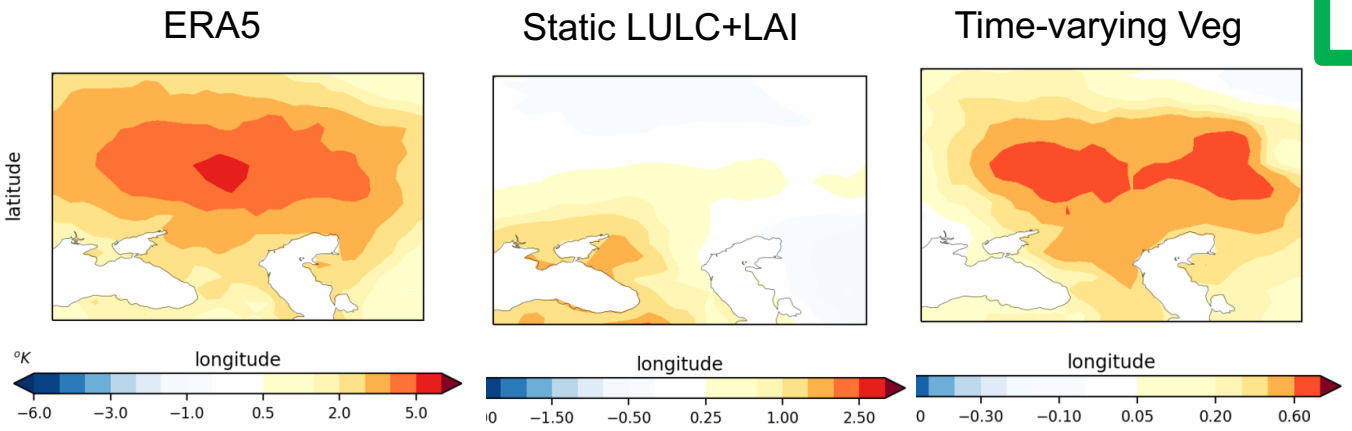
Updated Soil moisture stress

2nd revision of Canopy resistance parameters and momentum (rsmin, cveg)

Time-varying LULC &/or LAI
(Offline surface model)
+
Updated Climate field suite for Climate.v021

Coupled seasonal forecast

Consistent impact on extreme 2T seasonal forecasts

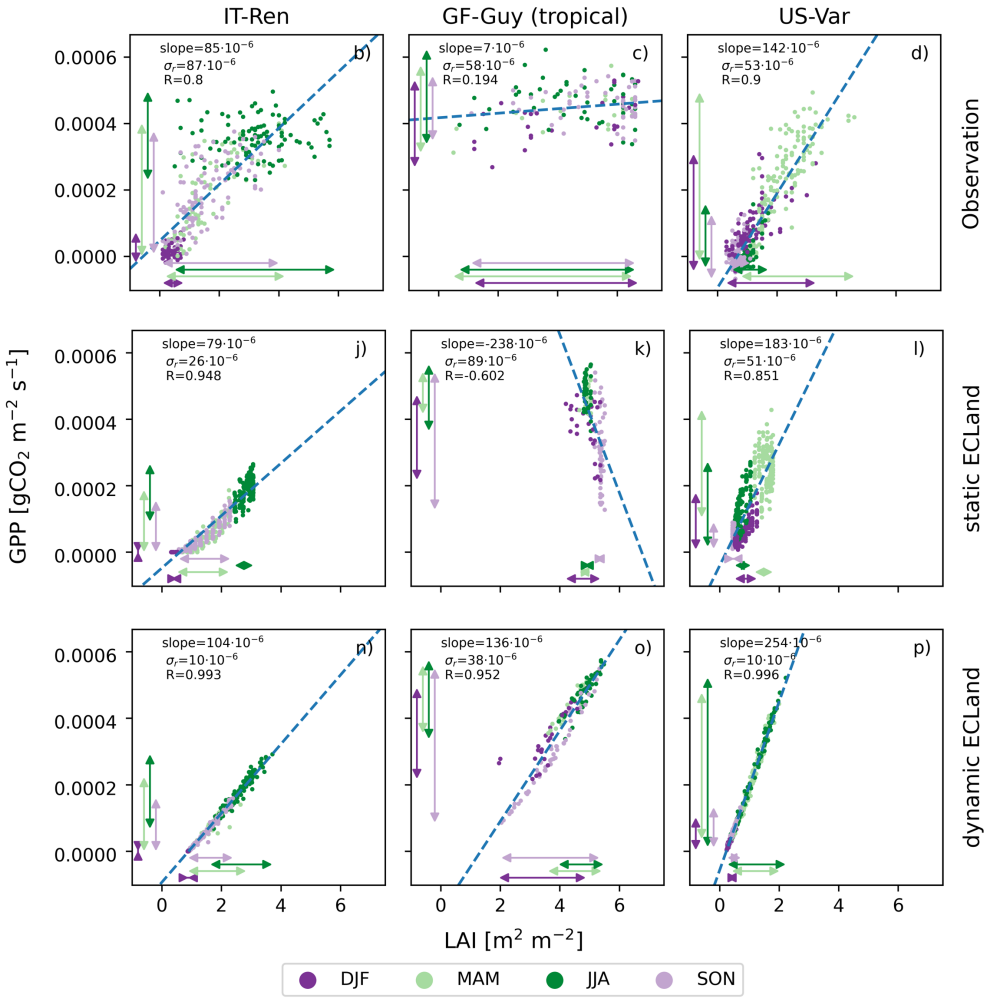


Russian heat wave of summer 2010 (Magdalena & Retish on CONFESS)

Possible/safe implementation in ERA6Land But further investigation with ESP/CA for implementation in ERA7/SEAS6/SEAS7 **?**

Dynamic LAI in ECLand

Initial evaluation of the dynamic LAI scheme



(GPP,LAI) correlation not always in-line with observation

49R1 (passive)

Updated Vegetation:
C3S LULC + CGLS LAI (+ **new disaggregation operator**)

1st revision of Canopy resistance and momentum parameters (rsmin, cveg)

Updated Soil moisture stress

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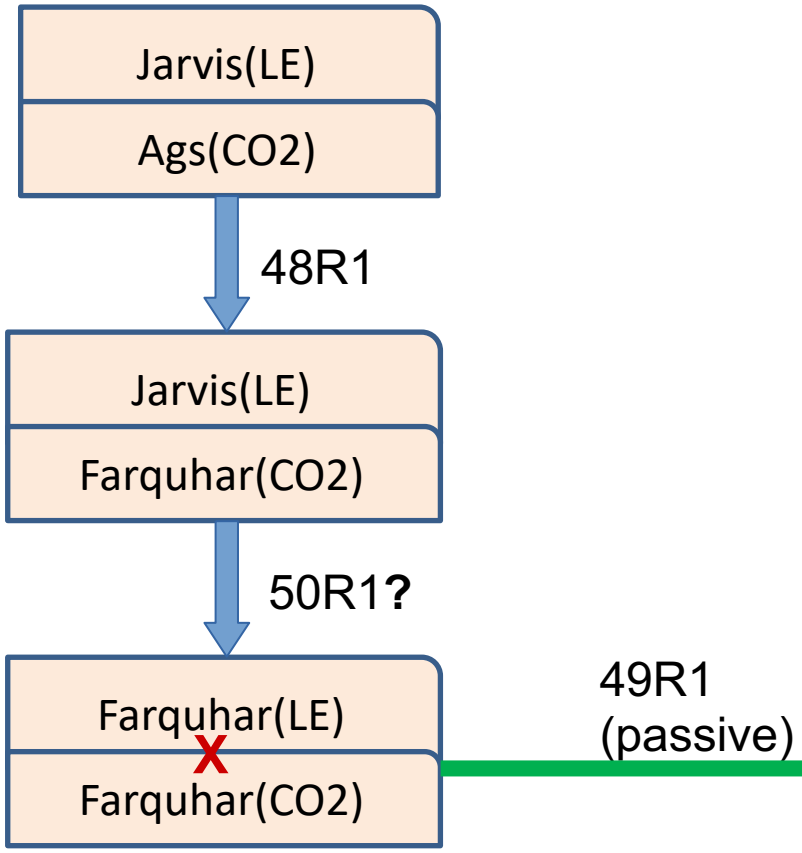
Time-varying LULC &/or LAI
(Offline surface model)
+
Updated Climate field suite for Climate.v021

Dynamic LAI
(Offline surface model)

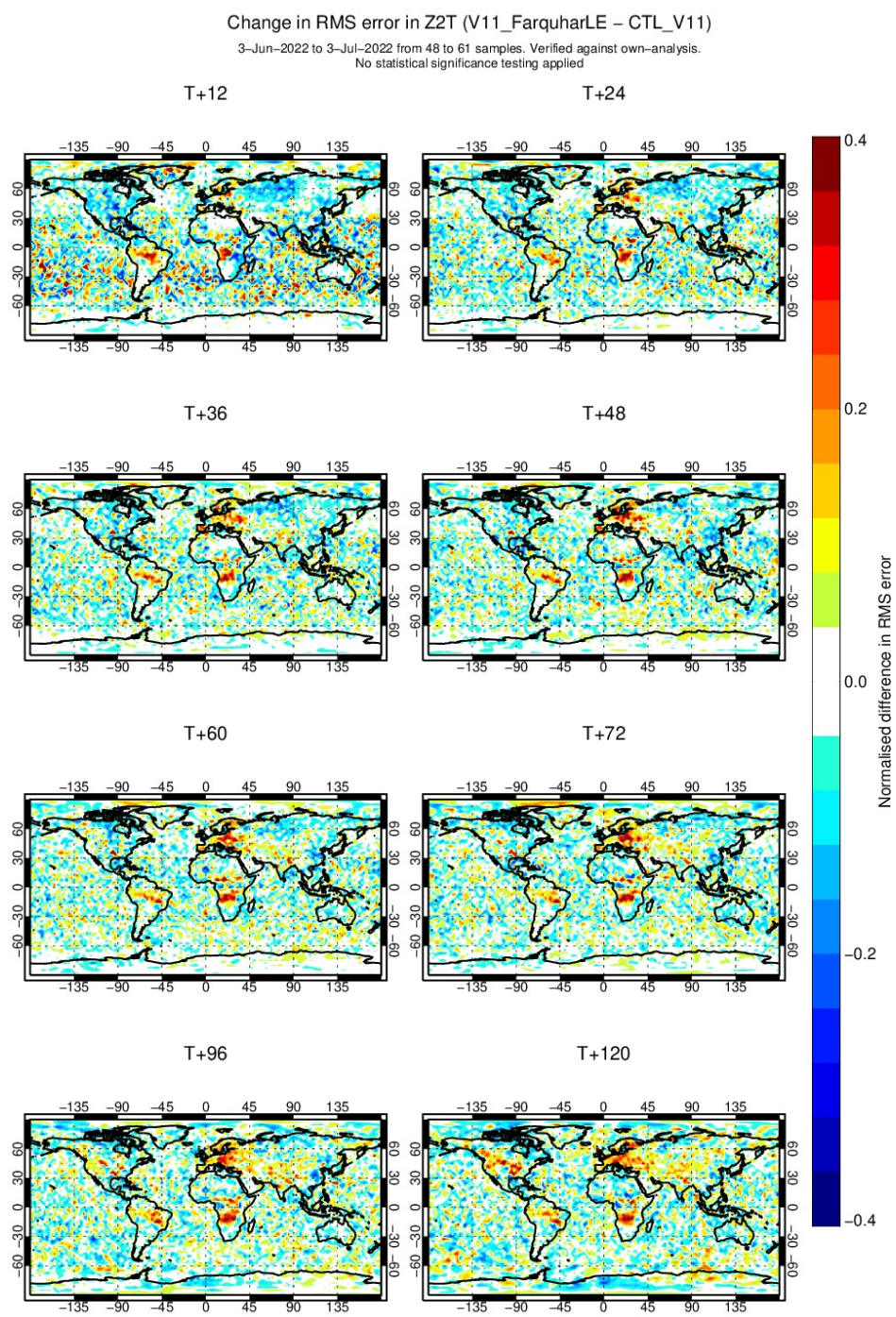
Possible implementation in ERA6Land/SEAS? But further investigation needed within CERISE

Coupled water-energy and CO2 fluxes in ECLand

Anna Agusti-Panareda and S. Boussetta, et al.



49R1
(passive)



Further development/parameters optimization needed ==>
ECLand global parameters optimization)

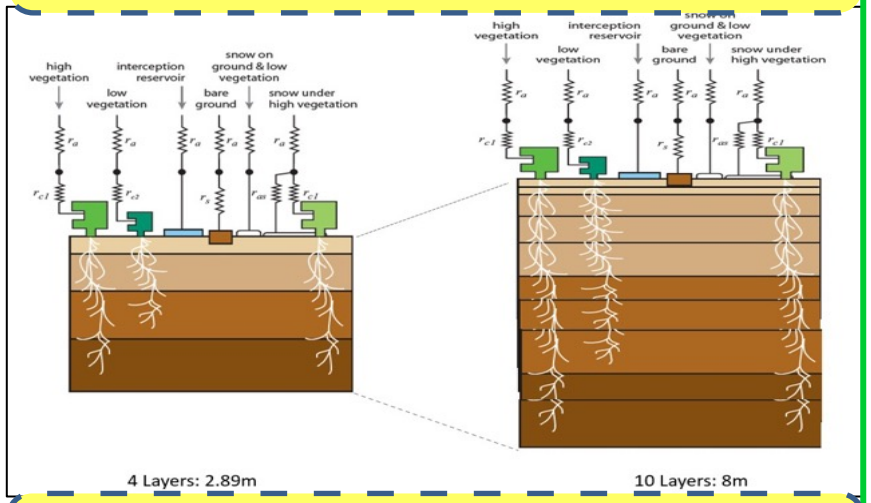
Process oriented and Adaptative parameters optimization

G. Balsamo and S. Boussetta et al,

Process–oriented ECLand global parameters optimization

Time-varying vegetation
LULC &/or LAI

Improving the soil vertical discretisation



Coupled water, energy and CO2
Farquhar (LE,CO2)

Dynamic LAI

Hydrological coupling

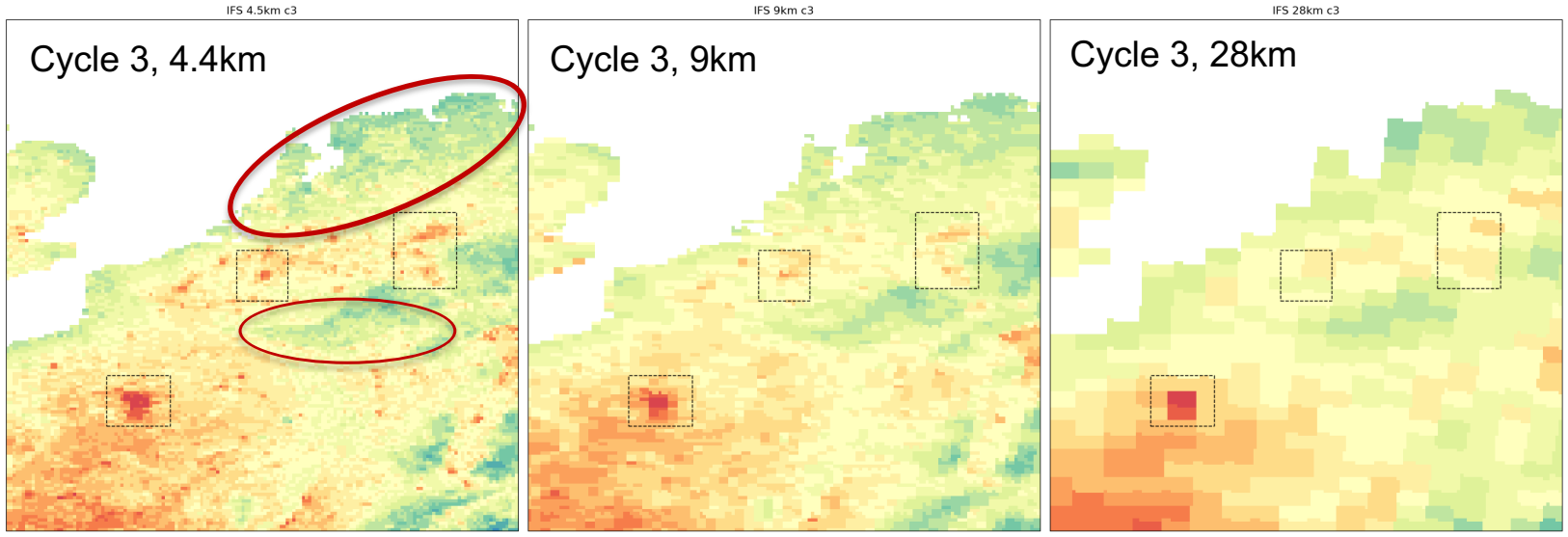
A step wise approach:

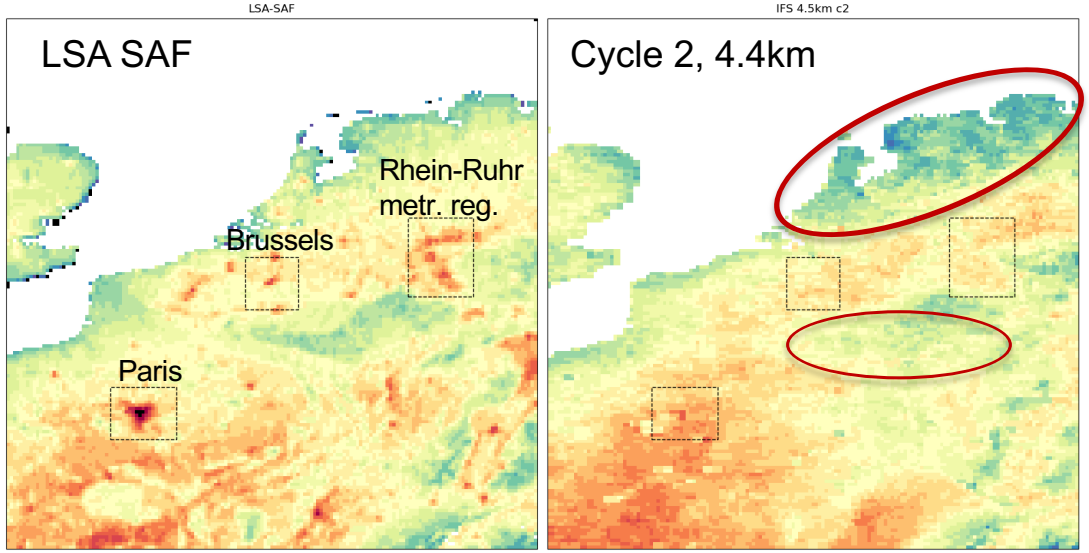
- Independent optimization for process-related parameters in offline mode (mitigate surface model biases).
- Adaptive parameter tuning for residual errors and coupling related parameters (focus on non-observable ones)

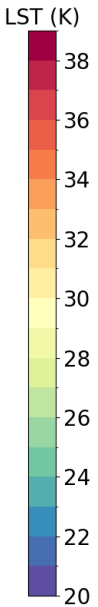
ECMWF

Km-scale modeling for improved realism + high-res features at surface

Xabier Pedruzo-Bagazgoita,et al.







1. Clear benefit with resolution increase down to 4.4km (top row)

2. Improvements due to Land Use/Land cover over vegetated areas across cycles (red circles)

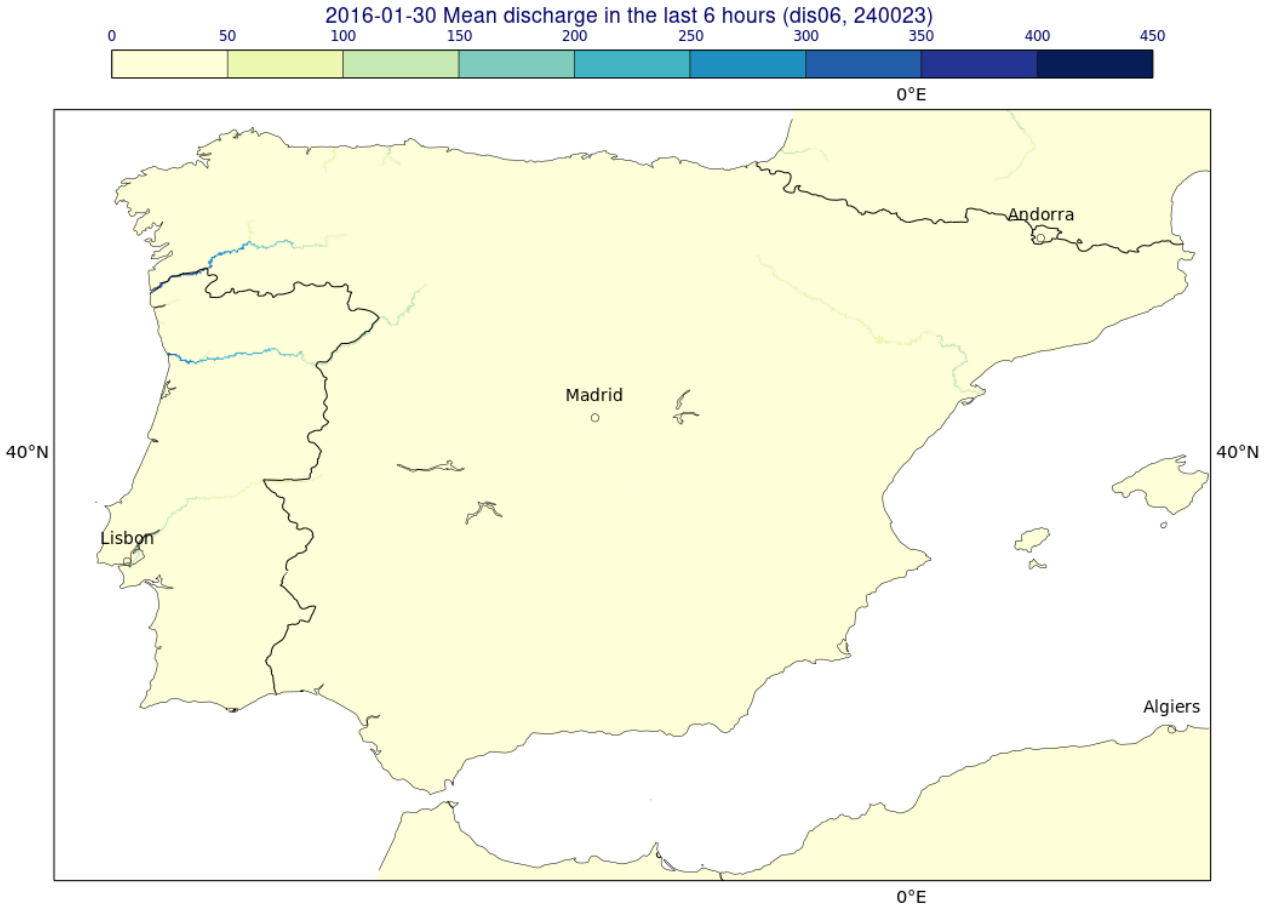
3. New LU/LC + urban scheme shows urban imprints

*JJA, clear sky, 5 year simulations at 14 UTC

River discharge up to km-scale, moving towards IFS hydrological-coupled forecasts

Jasper Denissen, et al.

S2S/SEAS 1/4-degree, ENS 1/10-degree, Destine 1/20 & 1/60-degree



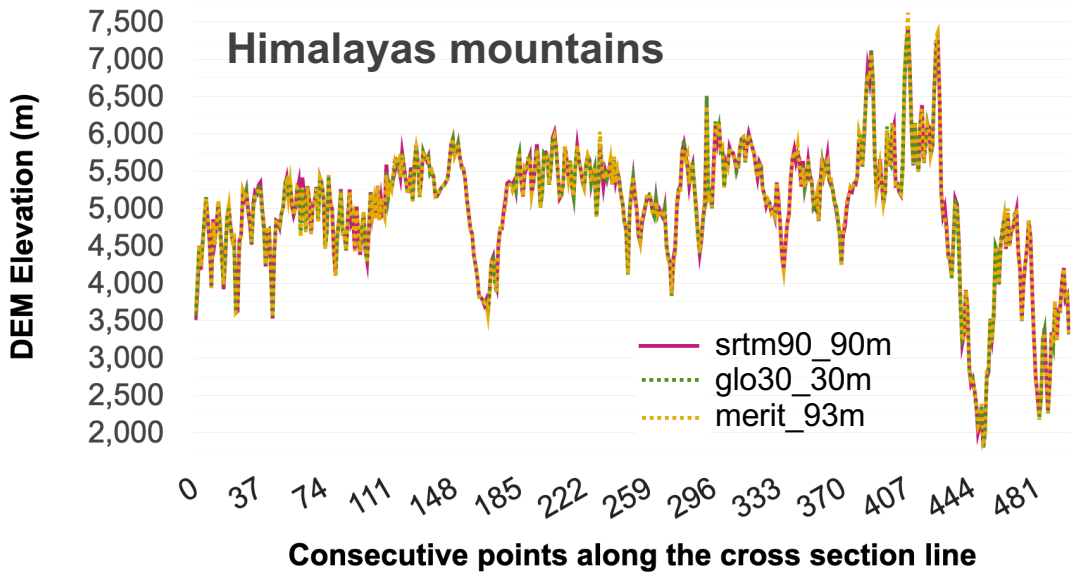
Operational setup of TCo1279 FC

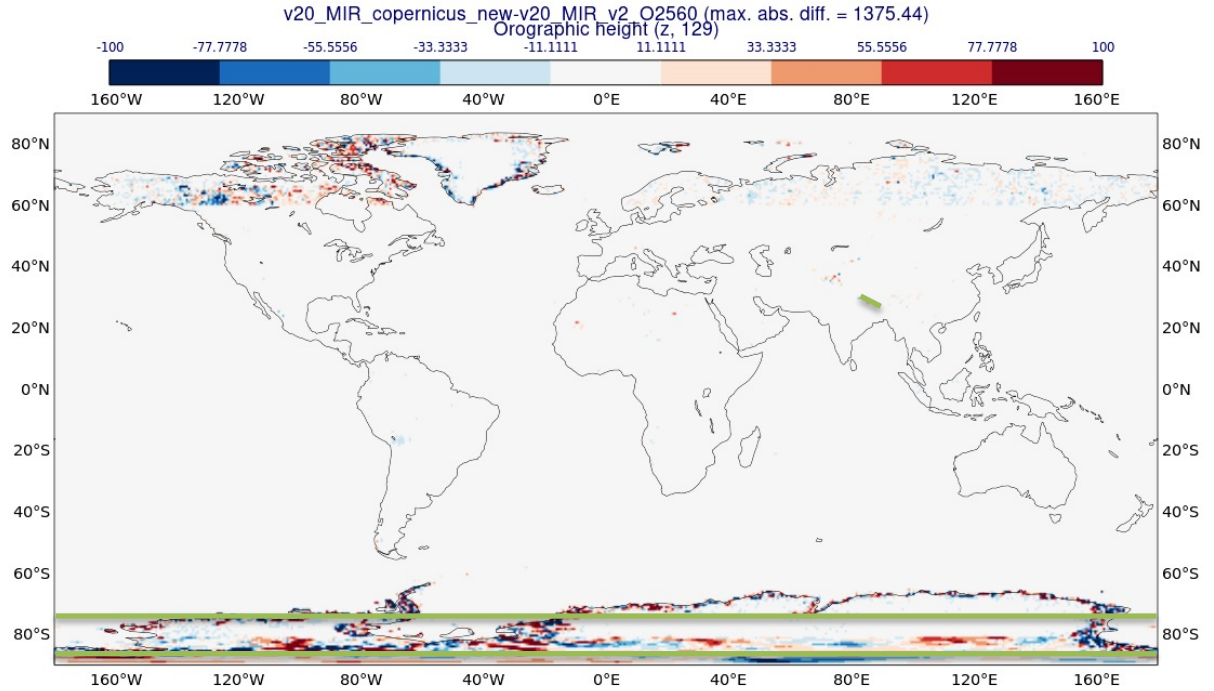
Cama total time respect CNT4 Forward Integration time TCO1279			
	128 MPI processes 8 OMP threads	**512 MPI processes 32 OMP threads**	**2048 MPI processes 8 OMP threads**
Cama total time	**23.561 s**	**16.115 s**	**22.71 s**
CNT4 Forward Integration time	**1316.2 s**	**190.4s**	**185.24 s**
Percentage of time	**1.79%**	**8.46%**	**12.26%**

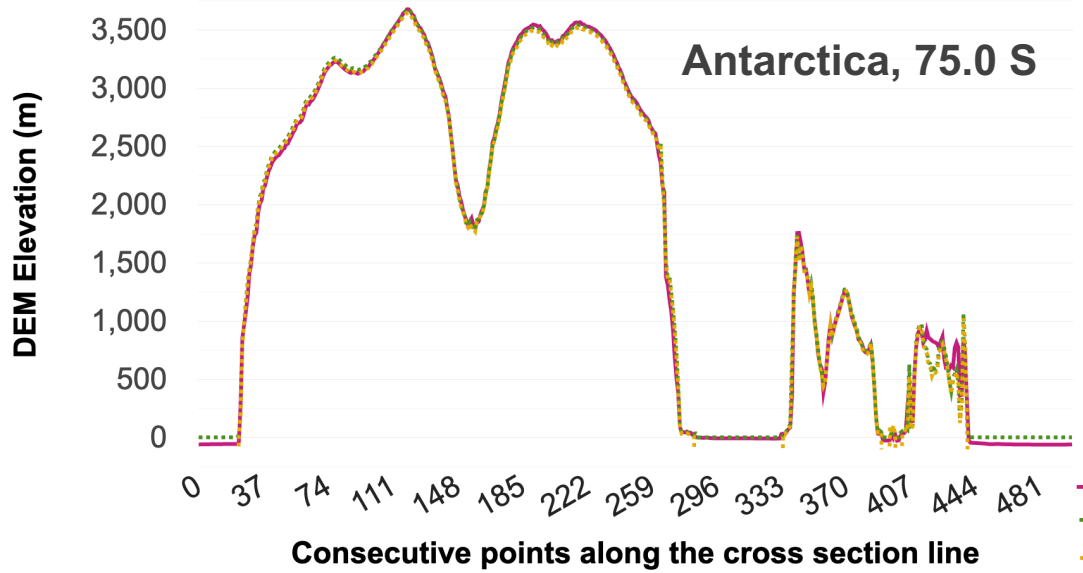
NRT-Offline suite 1979-today provide ICs
S2S/SEAS 1/4-degree (28 km)
ENS 1/10-degree (11 km)
DestinE 1/20-degree (5.5 km)
DestinE 1/60-degree (1.8 km)

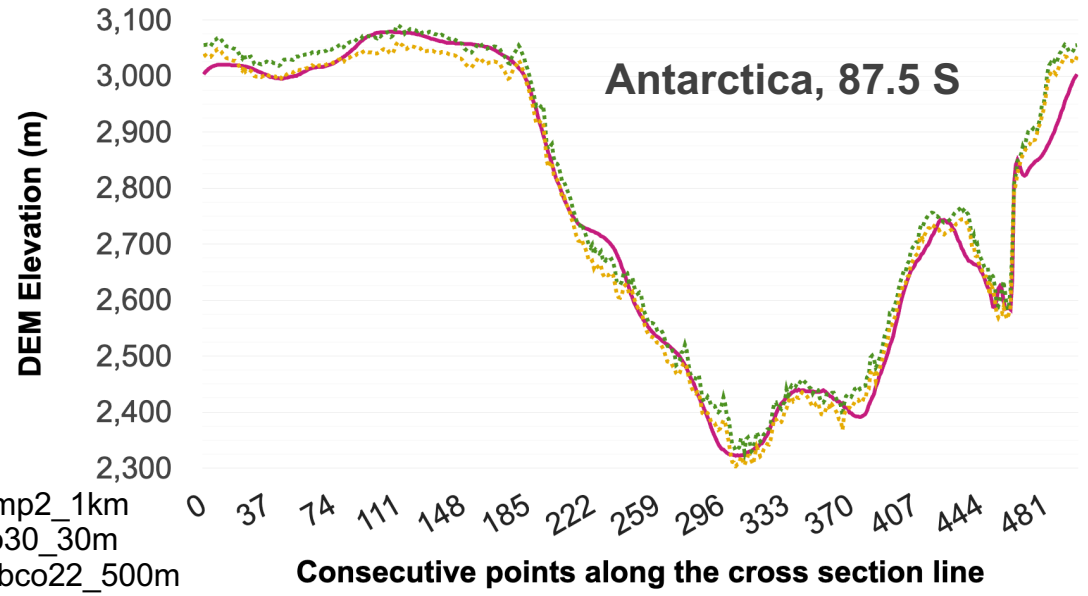
Merge and harmonization of climate fields Source data

Margarita Choulga,et al.





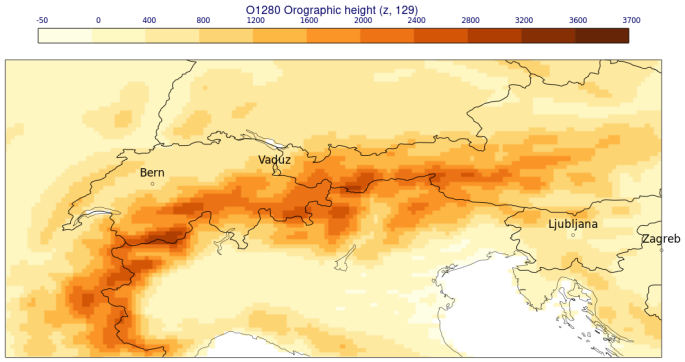




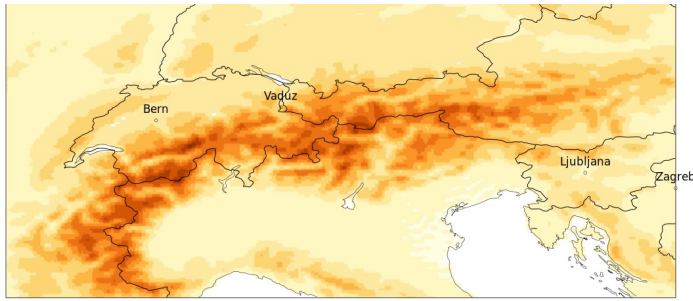
Evolved climate fields generation (eg.orography)

Birgit Sützl,et al.

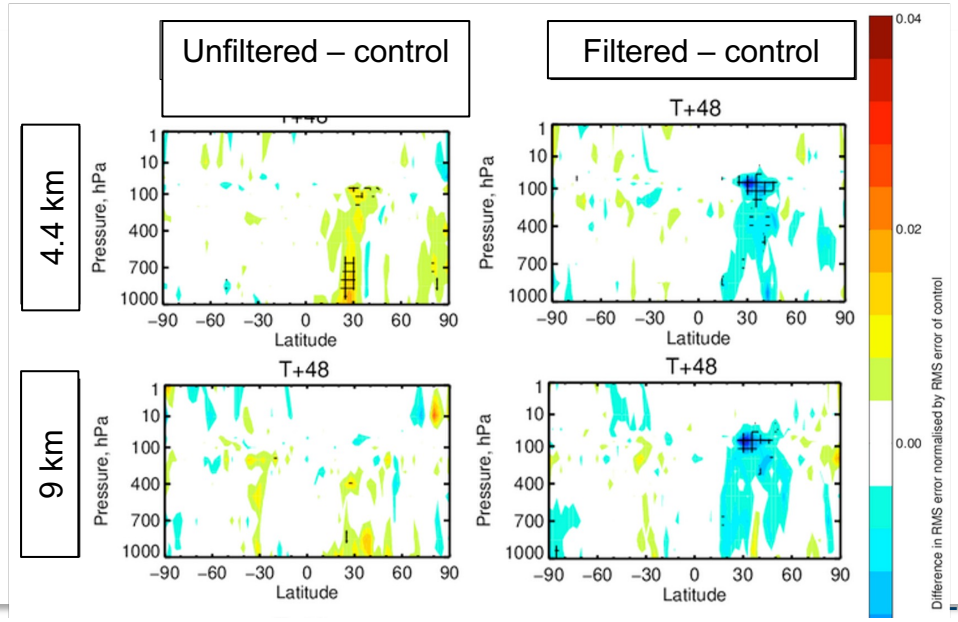
- Several pre-filtering steps replaced with conservative interpolation.
- Dampening of small scales reduces bias from high amplitude gravity waves (e.g. Tibet plateau).
- Spectral filtering improves large-scale circulation also at 9 km.
- Positive impact of new source data.

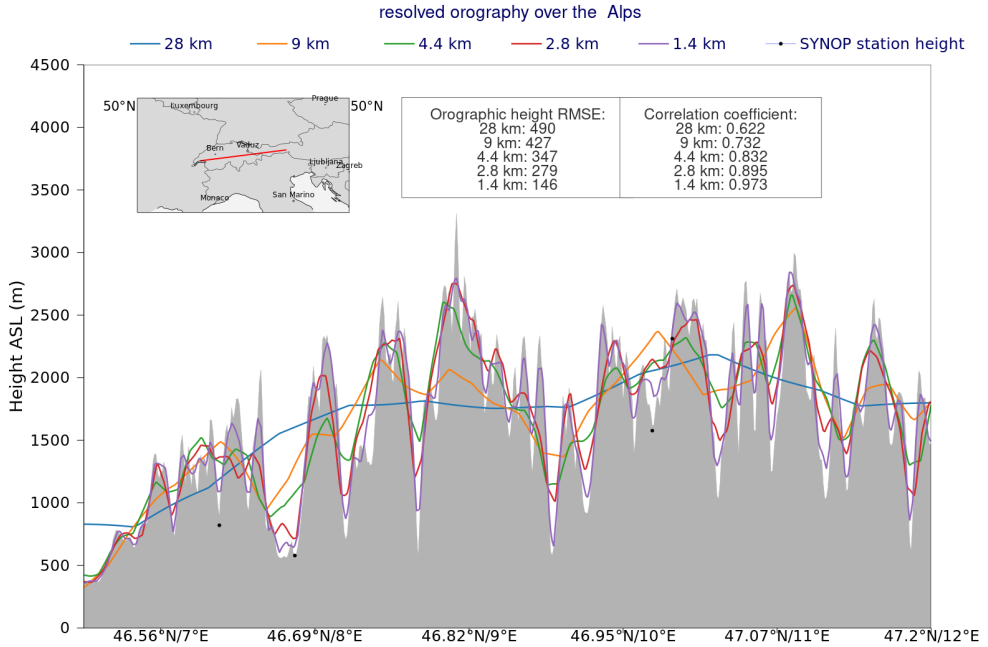


9 km



4.4 km





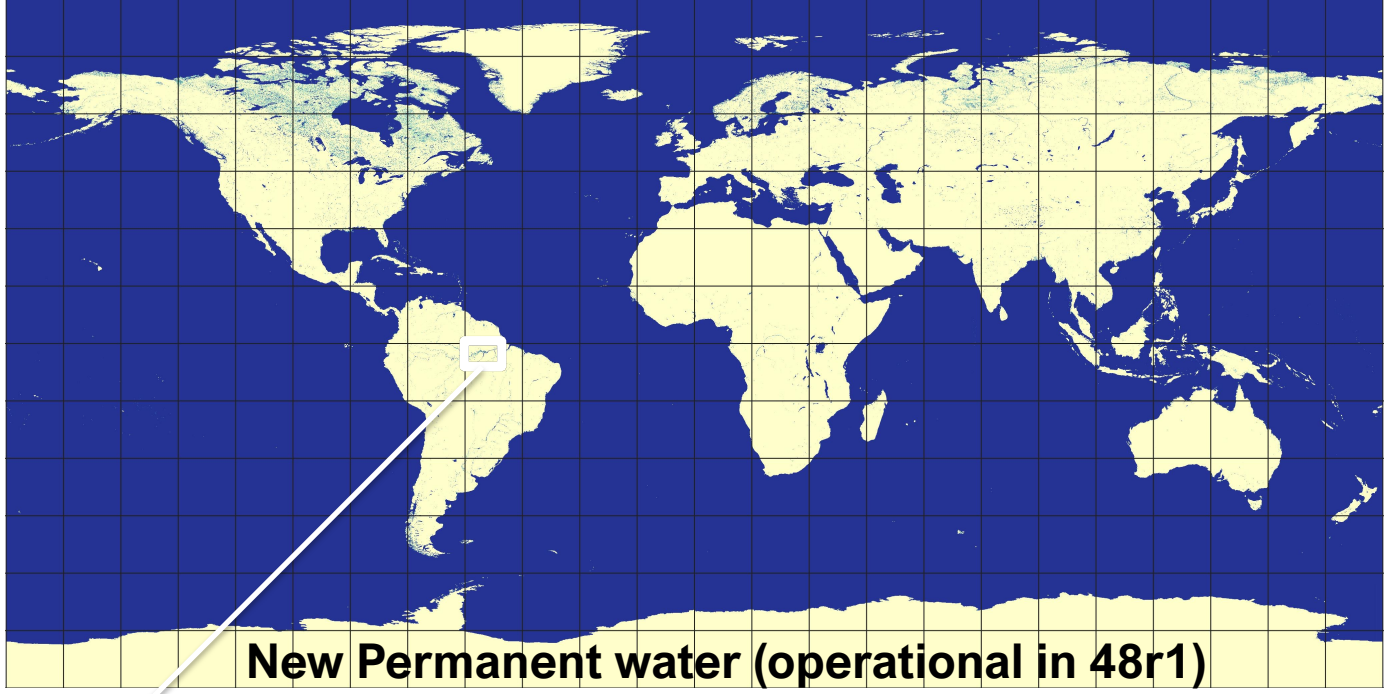
Time-varying water cover (50r1)

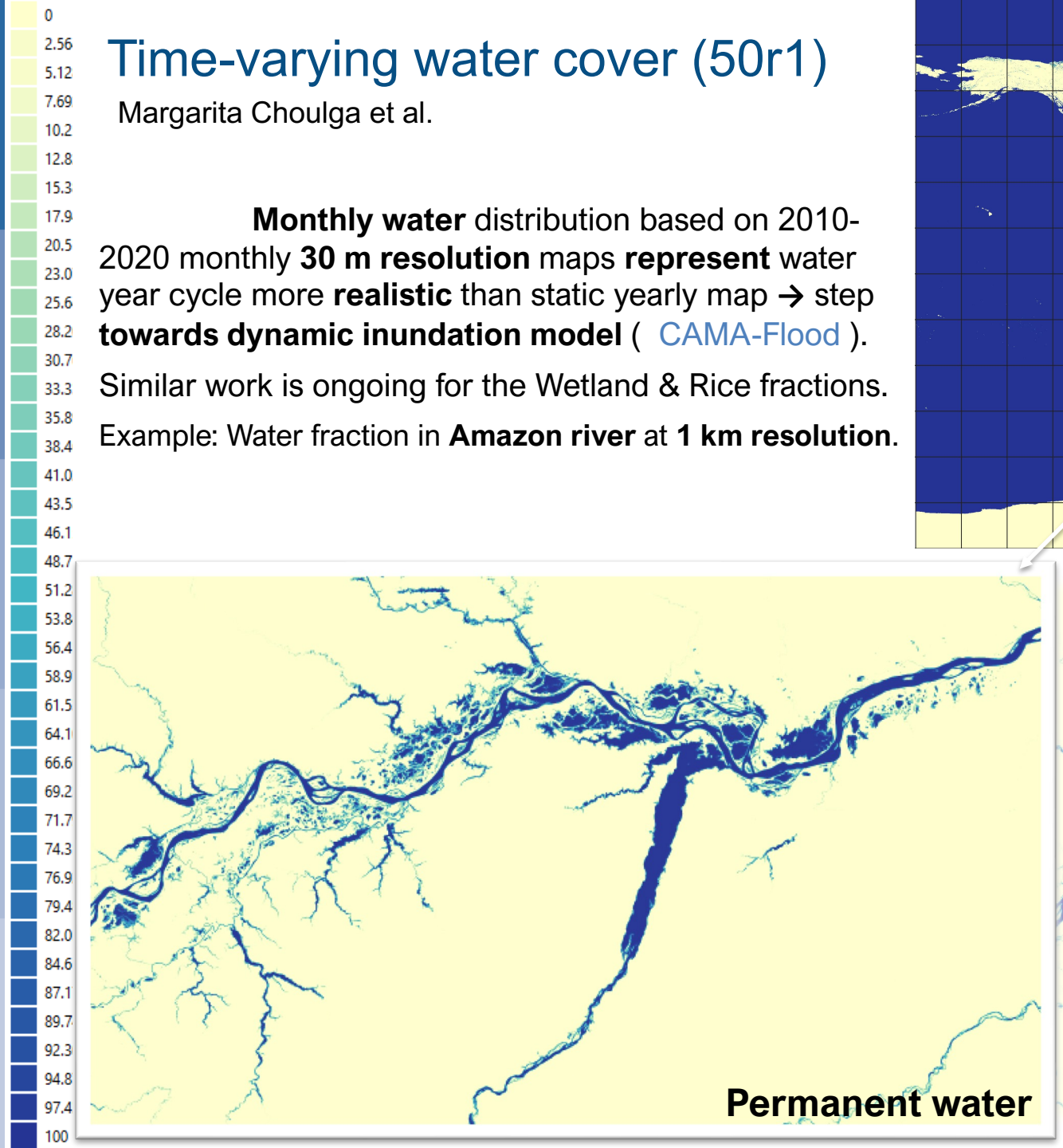
Margarita Choulga et al.

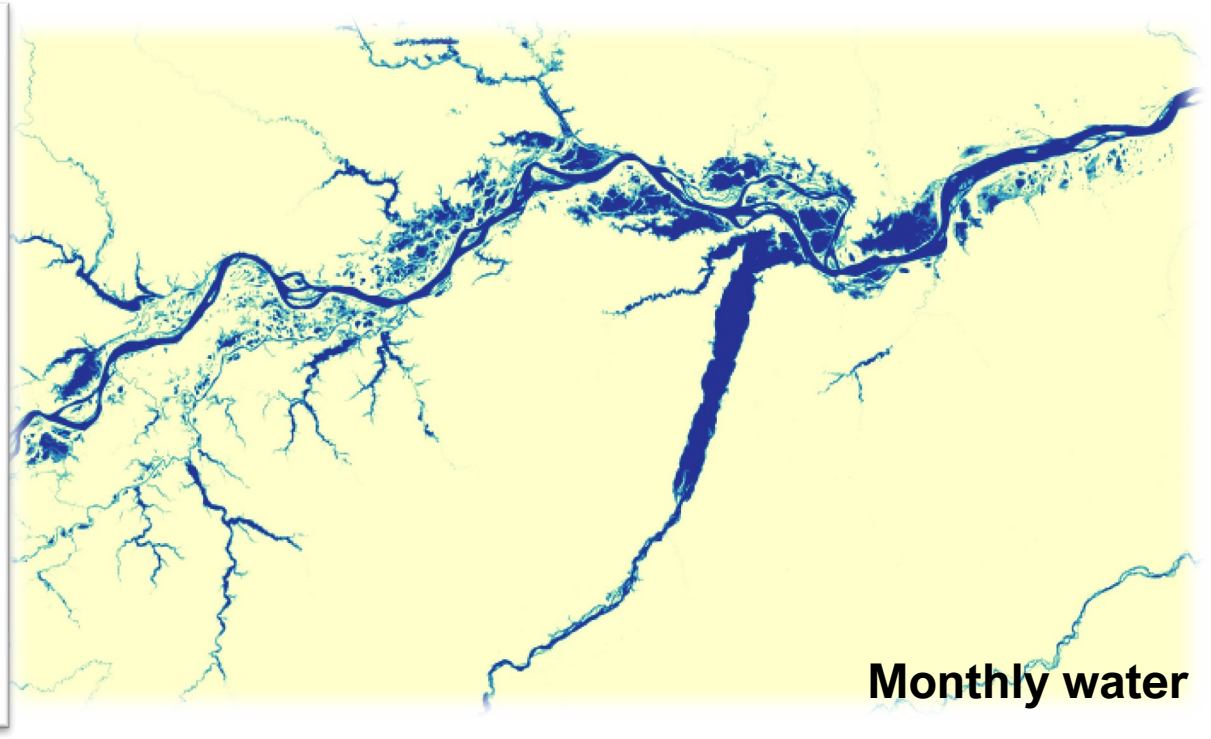
Monthly water distribution based on 2010-2020 monthly **30 m resolution** maps **represent** water year cycle more **realistic** than static yearly map → step **towards dynamic inundation model** (CAMA-Flood).

Similar work is ongoing for the Wetland & Rice fractions.

Example: Water fraction in **Amazon river** at **1 km resolution**.

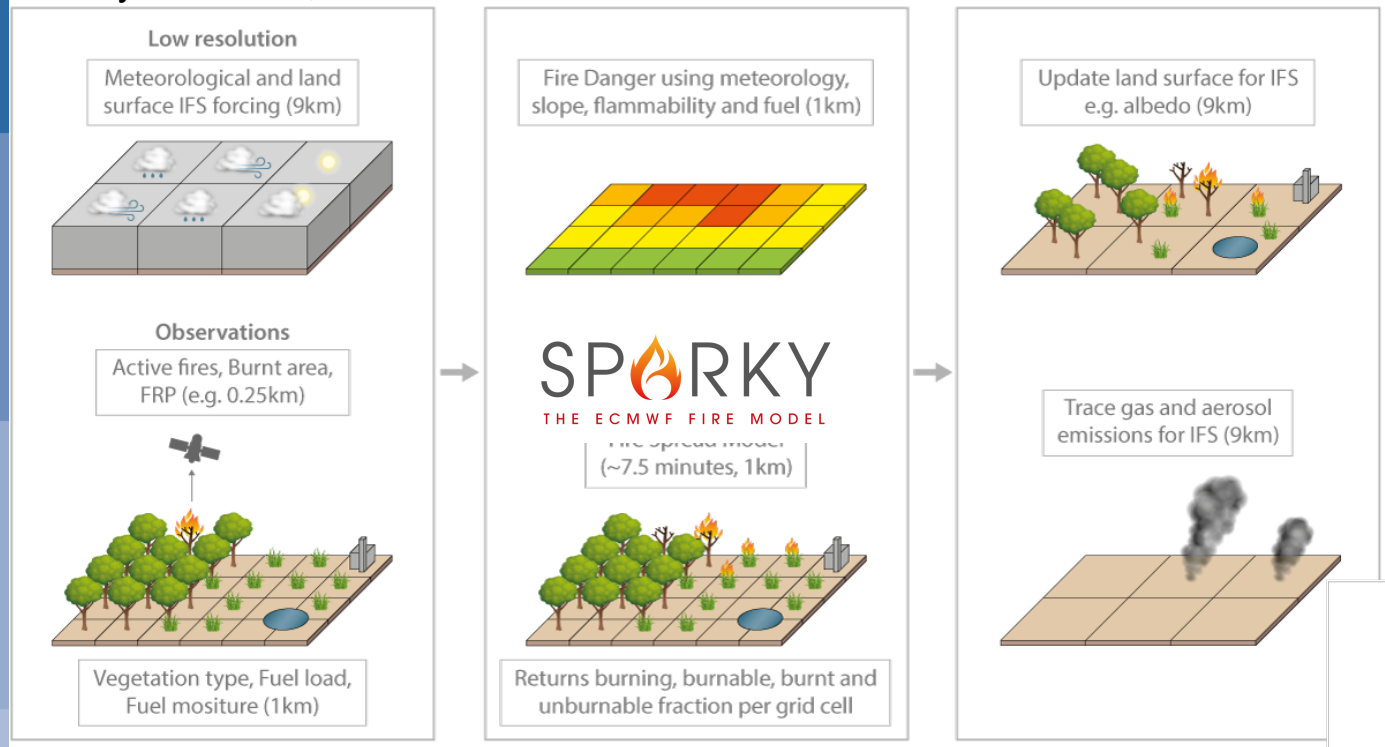






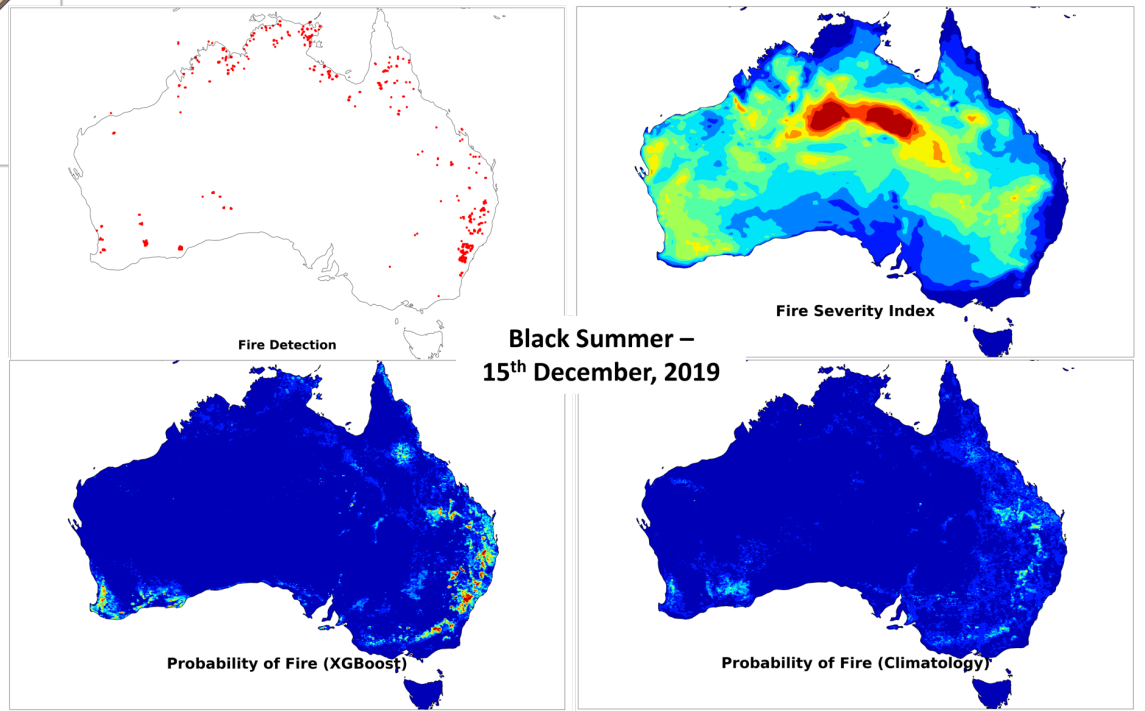
New fire model in ECLand

Joey McNorton,et al.



An improved fire prediction compared to current Index and climatology

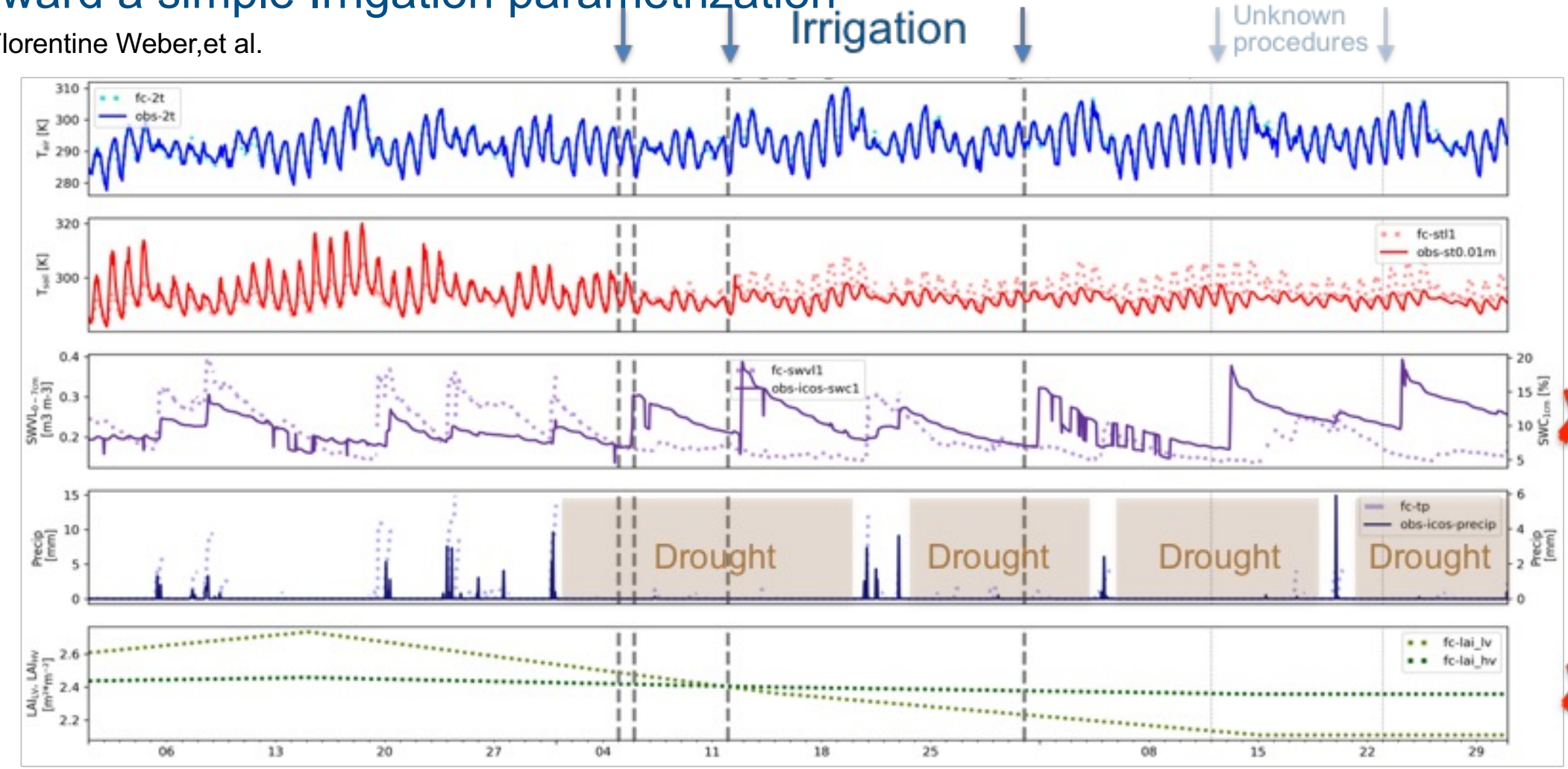
A hybrid physic-based-ML fire prediction



ECMWF

Toward a simple Irrigation parametrization

Florentine Weber,et al.



✗ Soil water content

✓ Precip

✗ Plant growth

Soil moisture is guided by precipitation (represented) and irrigation (missing).

ECMWF

Summary

- **ECLand** is fully embedded in the **ECMWF Integrated Forecasting System** and aims to support the developments of **Coupled Data Assimilation** for **Earth System Monitoring** (back to 1940) & **Seamless Weather + Environmental Predictions** (from days to seasons).

- **ECLand** runs also offline driven by meteorological forcing and the ECLand code **go open-source** soon with opportunities to expand further its users and applications basis.

- R2O developments facilitated by **spatialization** of the model parameters.

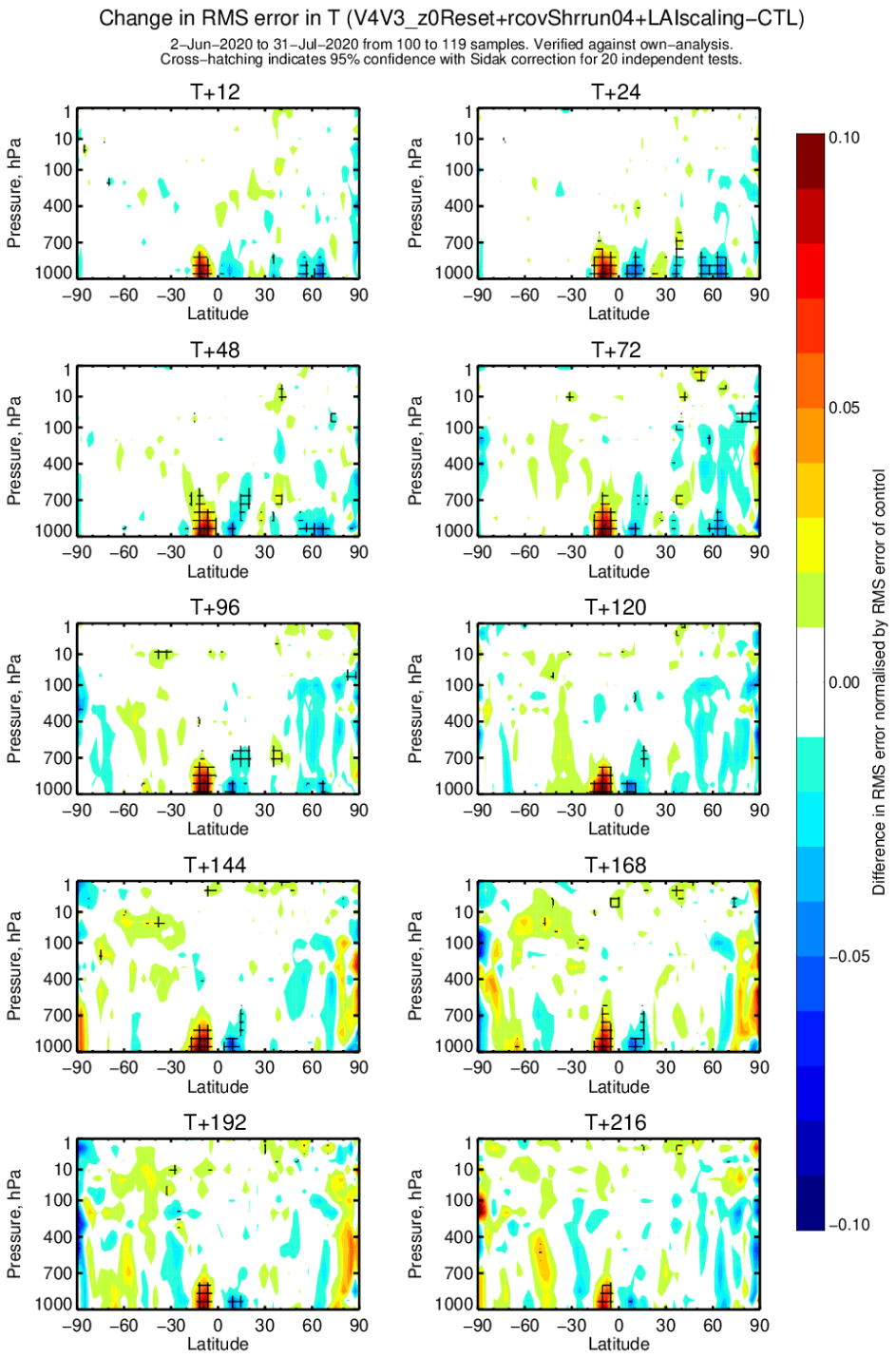
- **Anthropogenic** processes are being included in ECLand with consideration of km-scale resolution.

- **ECLand** summarise the ongoing modelling efforts (Boussetta et al., 2021), plus improved river discharge in permafrost (Zsoter et al., 2022) permafrost extent (Cao, Arduini and Zsoter, 2022)

Thanks for your attention

Souhail Boussetta
e: souhail.boussetta@ecmwf.int

Stratified optimization with Vegetation types



Updated Vegetation:
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1st revision of Canopy resistance and momentum parameters (rsmin, cveg)

Updated Soil moisture stress

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(Offline surface model)

Prognostic LAI
(Offline surface model)