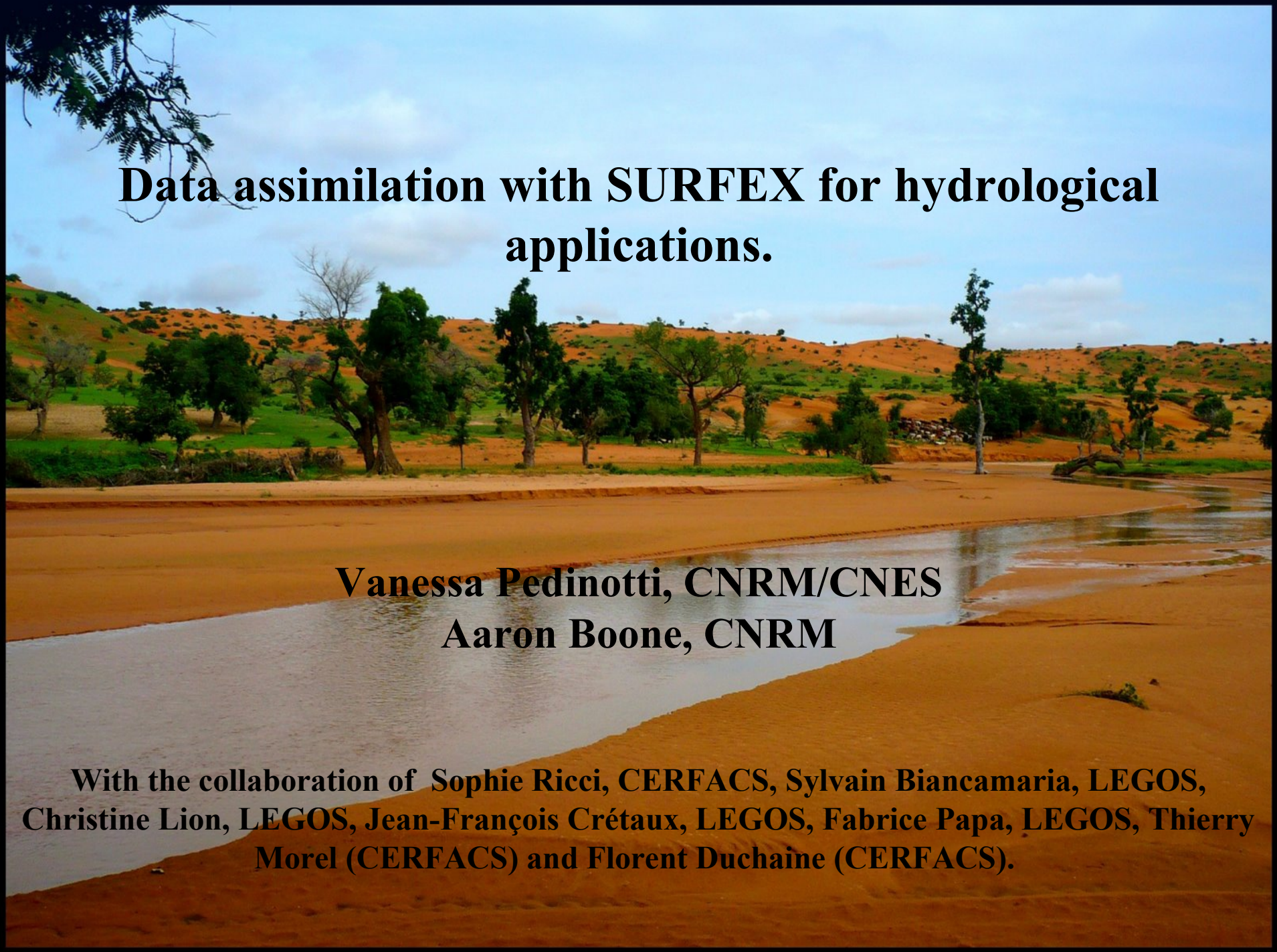


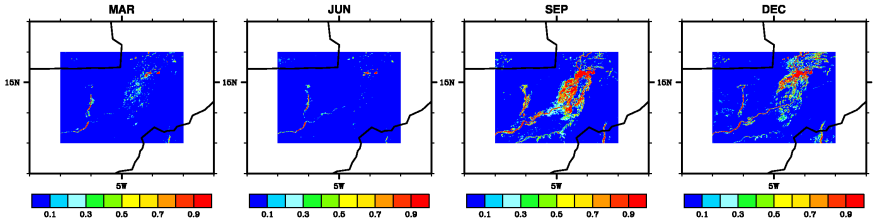
Data assimilation with SURFEX for hydrological applications.

Vanessa Pedinotti, CNRM/CNES
Aaron Boone, CNRM

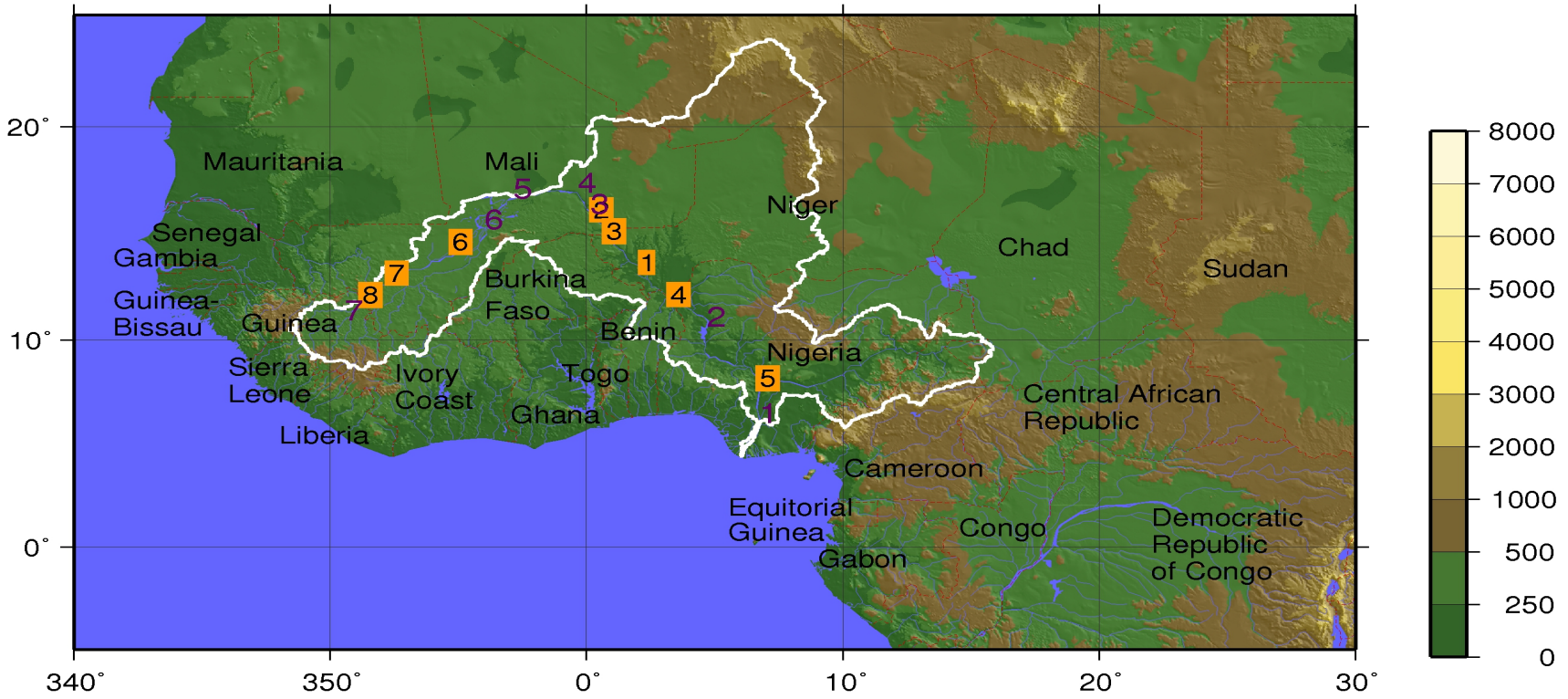
With the collaboration of Sophie Ricci, CERFACS, Sylvain Biancamaria, LEGOS, Christine Lion, LEGOS, Jean-François Crétaux, LEGOS, Fabrice Papa, LEGOS, Thierry Morel (CERFACS) and Florent Duchaine (CERFACS).

Hydrodynamical modelisation of the Niger basin

- Data assimilation requires the hydrodynamical model to be realistic
- Model : ISBA/TRIP (used in Surfex)
- Domain : Niger basin
- Spatial resolution : 0.5°
- Simulation period : 2002-2007
- Flooding scheme and aquifer reservoir

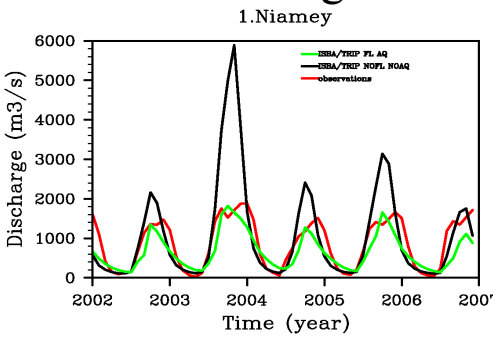


Flood fraction over the Niger inner delta (derived from MODIS) → Strong intra-annual variability

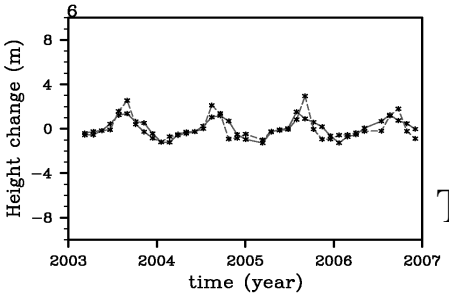


Model evaluation

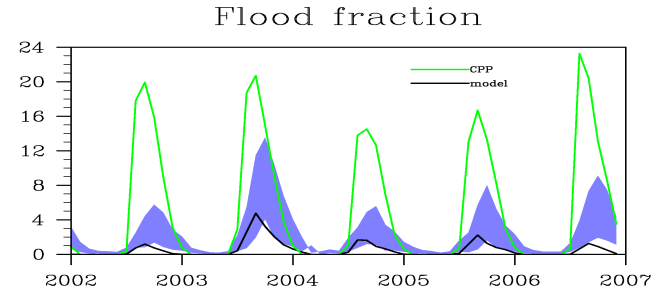
Discharge

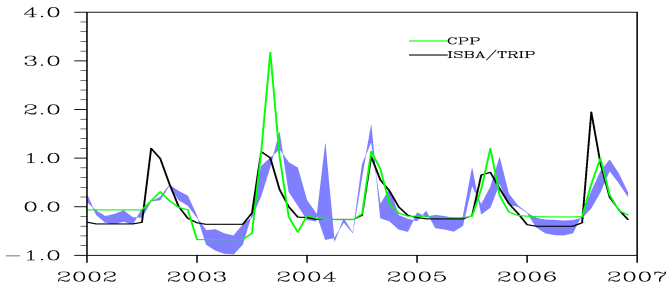


Water levels

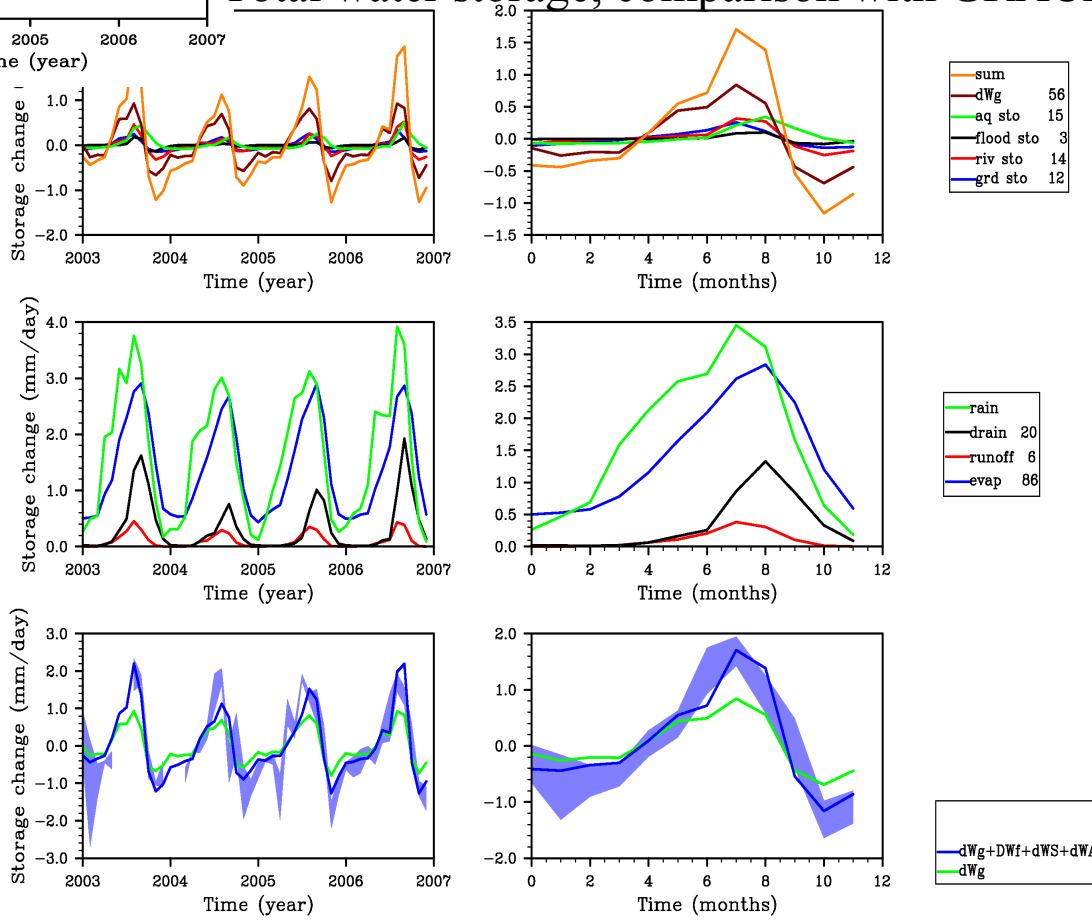


Flooded areas



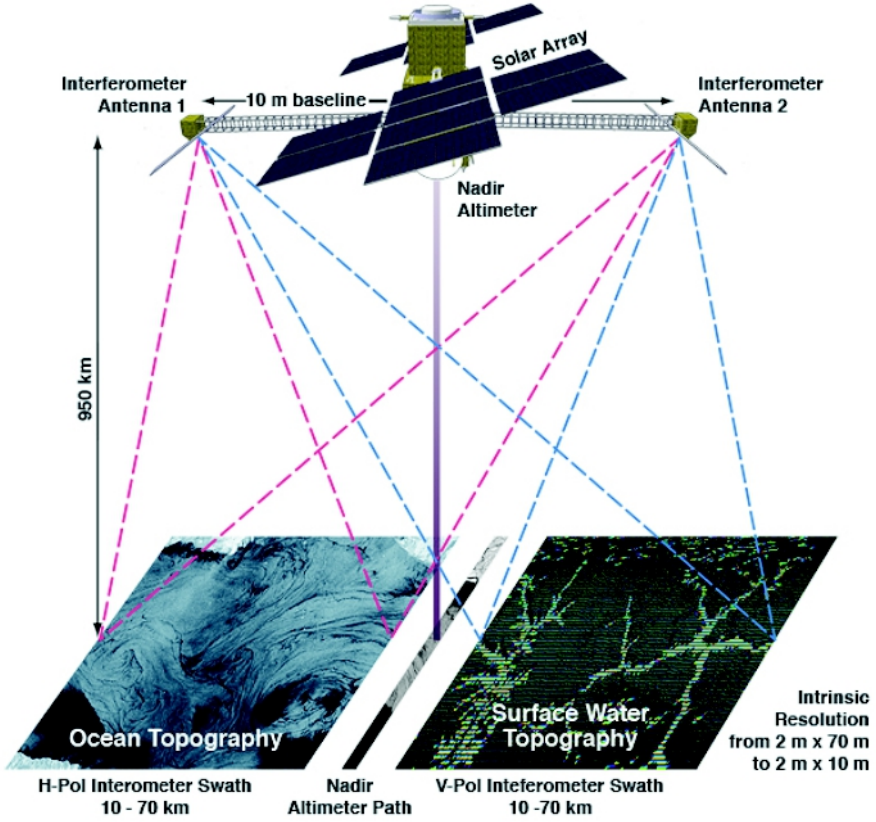


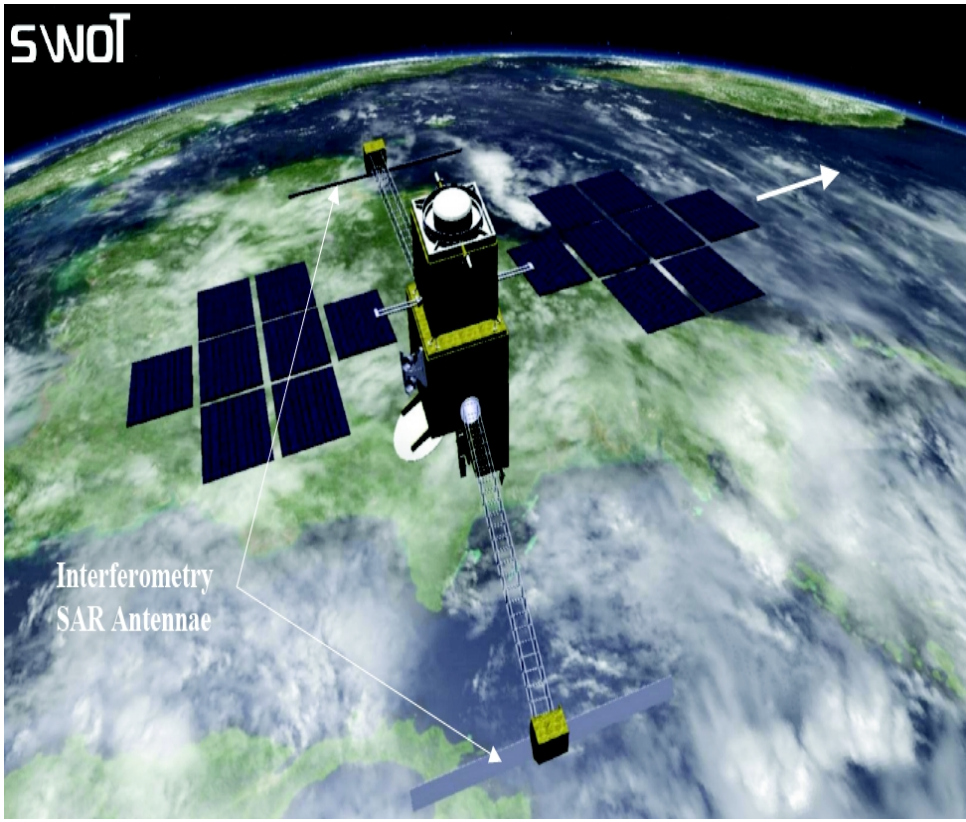
Total water storage, comparison with GRACE



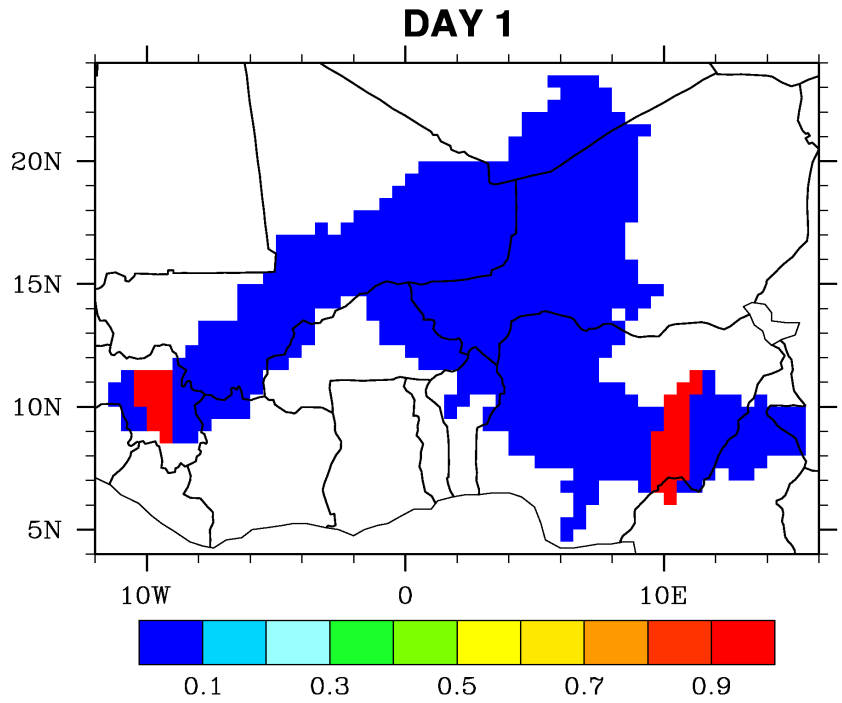
SWOT satellite

- CNES/NASA collaboration
- Launch : 2019
- observation of rivers wider than 100 m and water surface areas above 250 x 250 m over continental surfaces between 78°S and 78°N
- provides maps of water levels

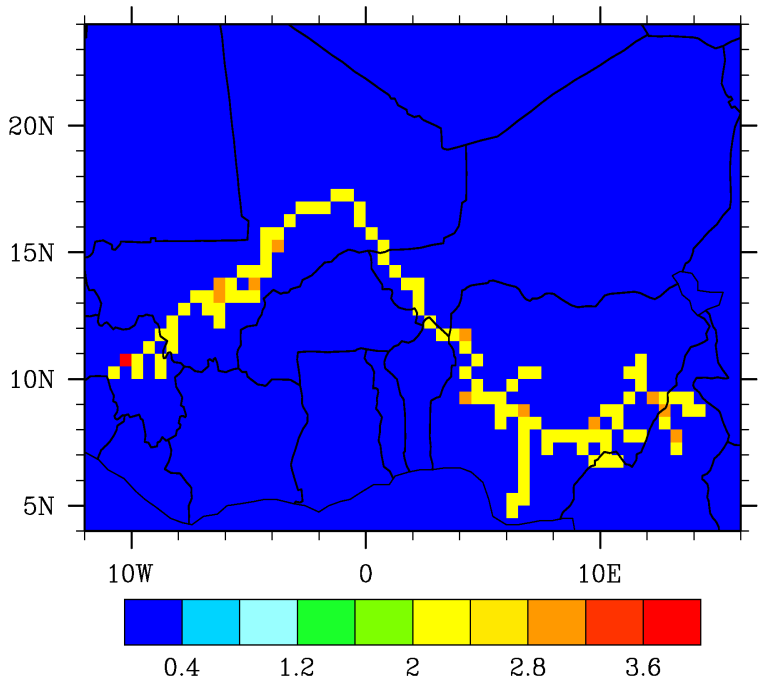




SWOT over the Niger basin



SWOT track over 1 orbit (22 days)



Frequency of SWOT recovery over the Niger river

Collaboration with J-F Crétaux (LEGOS) and Christine Lion (PhD at LEGOS/CNES) about the development of a SWOT data simulator. This simulator takes into account several kinds of errors :

– errors due to satellite altitude
– range errors
– baseline errors
– roll errors
– instrumental errors

SWOT data assimilation

The best linear unbiased estimator method (BLUE)

BLUE Hypothesis :
• background, analysis and observation errors are unbiased (Gelb(1974)).
• The response of the model to a perturbation of the control parameters is linear or used in a linear domain → the observation operator H, containing the model integration, is linear.

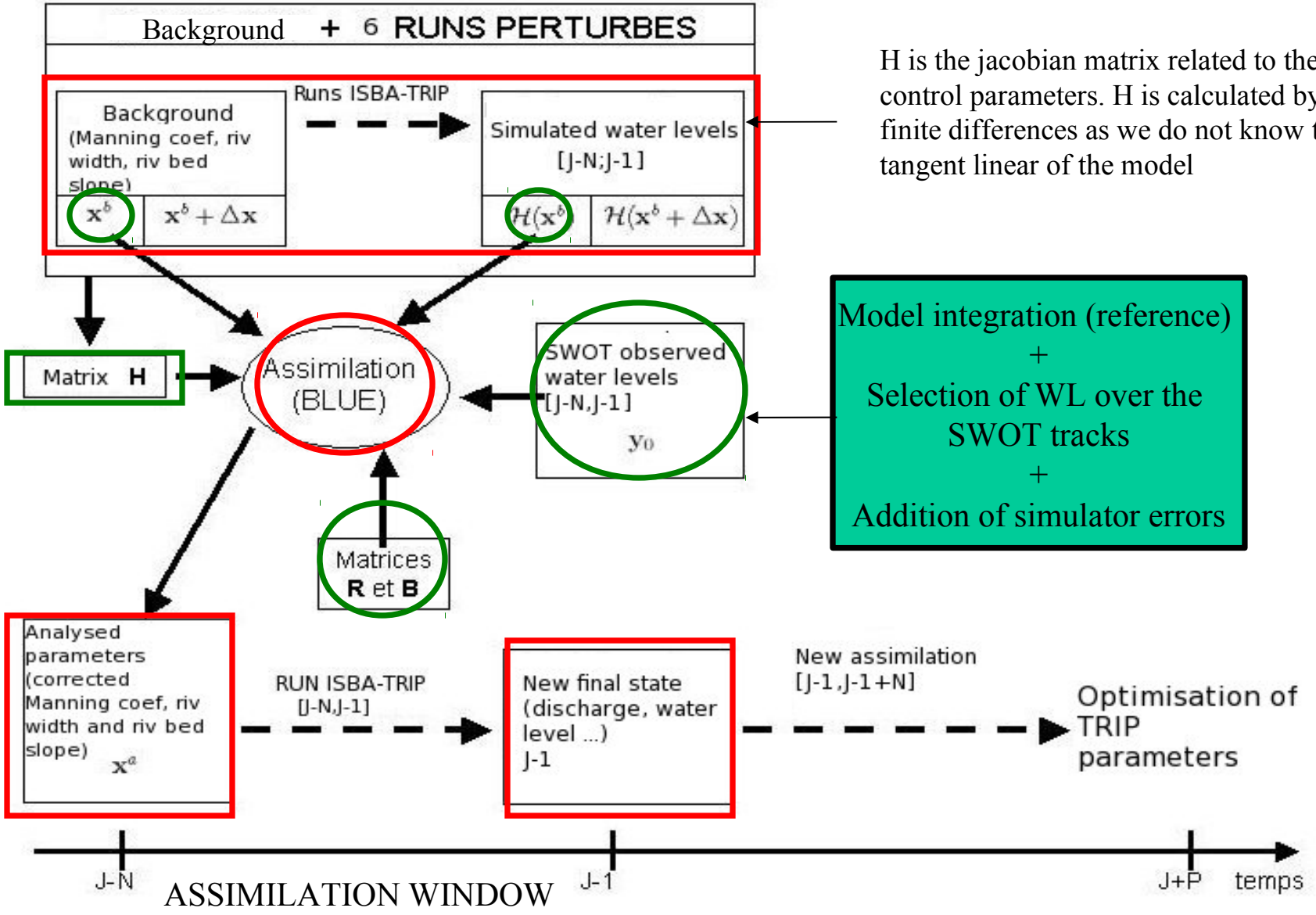
Calculation of the matrix K, also called gain matrix :
$K = BH^T (HBH^T + R)^{-1}$

Analysis
$x_a = x_b + K(y_0 - H(x_b))$

SWOT data : water levels
Control parameters :
Manning coefficient
River width
River bed slope

y_0	Observed water levels
X_b	Control vector (containing the parameters to correct)
x_a	Analysed vector (containing the corrected parameters)
H	Jacobian matrix (estimated sensitivity of the water level to a variation of the control parameters)
Hx_b	ISBA-TRIP simulated water levels using the non-corrected parameters as input parameters
R	Covariance matrix of observation errors (water levels)

Method : twin experiment



H is the jacobian matrix related to the control parameters. H is calculated by finite differences as we do not know the tangent linear of the model

The O-PALM coupler

- Developped at CERFACS, Toulouse (http://www.cerfacs.fr)
- Open source (http://www.cerfacs.fr/globc/PALM_WEB)

- **Coupling software** allowing the **concurrent execution and the intercommunication** of programs not having been especially designed for that.
- **Dynamic coupling** : a coupled component can be launched and can release resources upon termination at any moment during the simulation.
- **Parallel coupling** : Task parallelism → several branches can be launched at the same time
- Internal parallelism → one unit can be run on several processors

PALM features for assimilation applications :

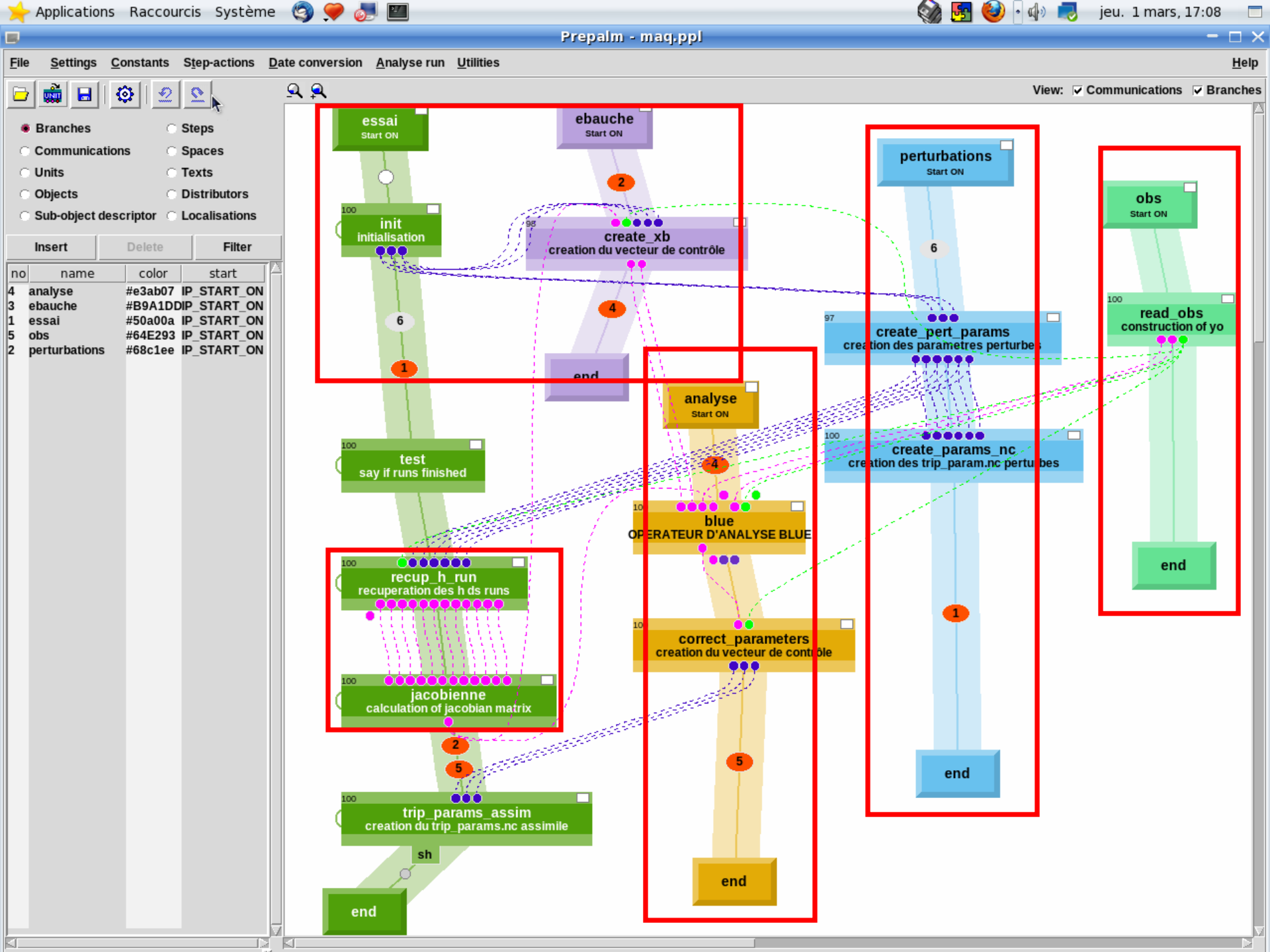
* **Coupling of independent numerical** codes or subroutines such as DA related subroutines
* **Intrusive behaviour** of PALM in the codes (ID card, easy insertion of palm commands in the codes)
* **User-friendly** HMI for an **easy and modular implementation** of DA related subroutines
* **Two levels of parallelism**, allowing the best performances of the algorithm.
* **Explicit time reference for the exchanged fields** and the time interpolation utilities, allowing a **complete independence between the model time stepping and the observation frequency.**
* Predefined algebra toolbox, providing the necessary linear algebra and minimization functions
* Accessibility to basic operators in the intern buffer

Codes : fortran 90, 77, C, C++

ID card

PALM commands for intercommunications :
PALM_Put, PALM_Get (variable, target, time)

Buffer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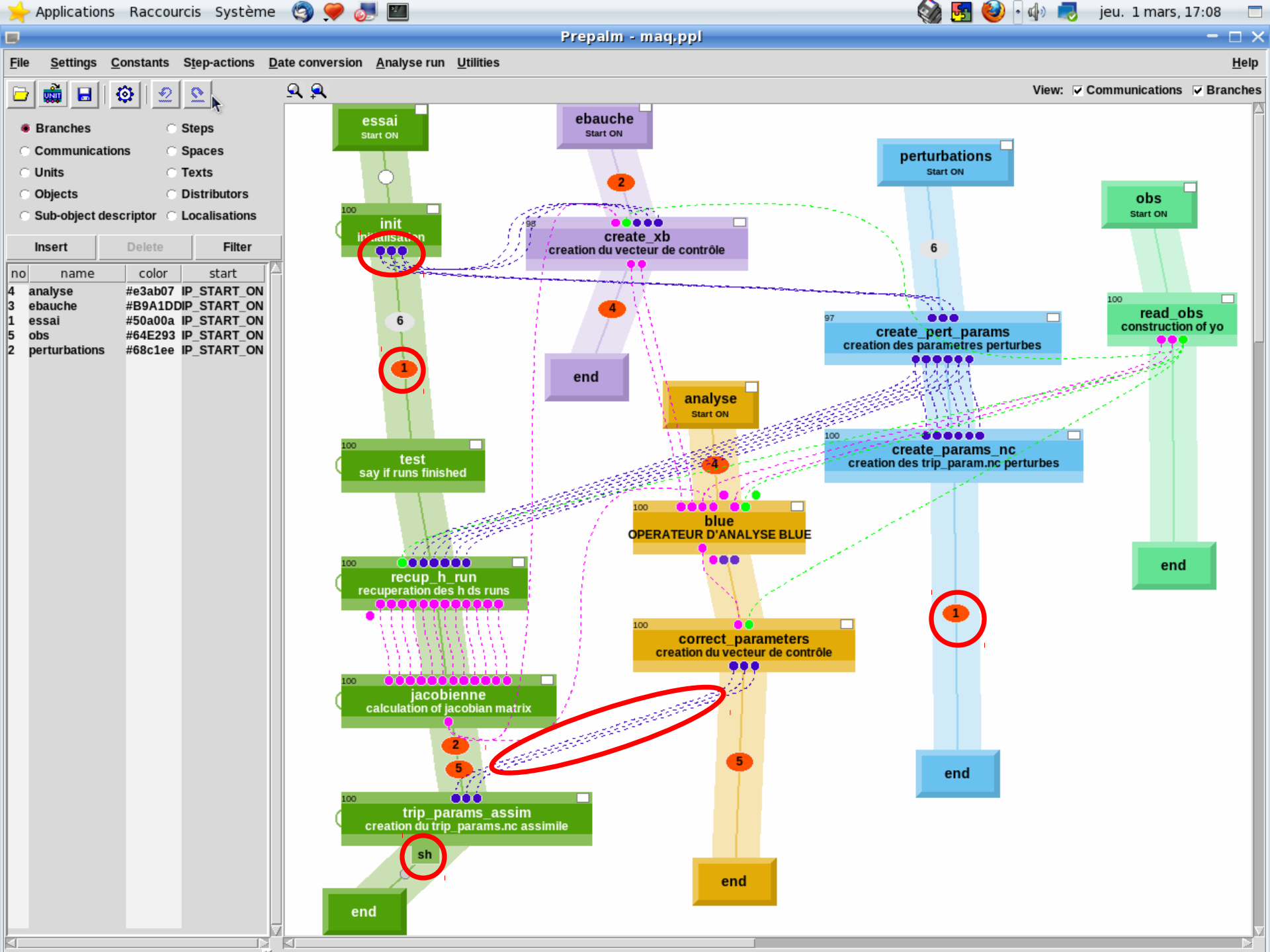
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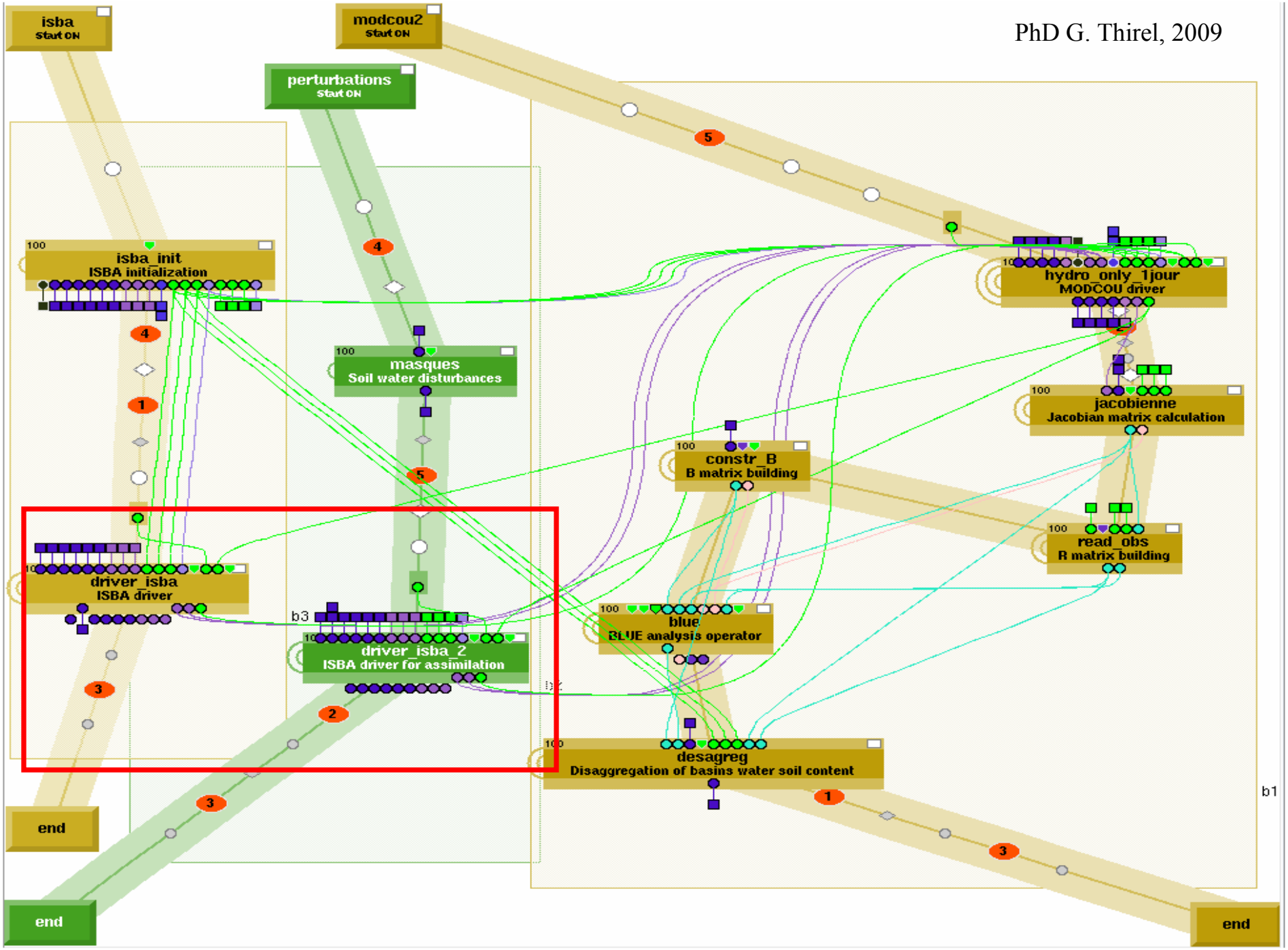
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Current status

• Debugging of the assimilation scheme implementation
• Improvement of covariance errors matrices (using Evensen formula, 1993)

Perspectives

Optimisation of the ISBA-TRIP parametrisation
Impact of :
- Length of the assimilation window
- choice of the control parameters
- mask of the control vector

PALM for operational applications

Assets

- Parallelism of the branches
- Easy understanding of the assimilation problem due to the interface
- Intrusive behaviour of the PALM coupler for the codes to be coupled

Drawbacks

- Direct visibility (and then understanding) of bugs is not always obvious
- The steplang language (allowing the synchronisation of communications for example) is not visible on the PrePalm interface.

THANK YOU

Open Palm website : http://www.cerfacs.fr/globc/PALM_WEB/index.html

ISBA-TRIP configuration