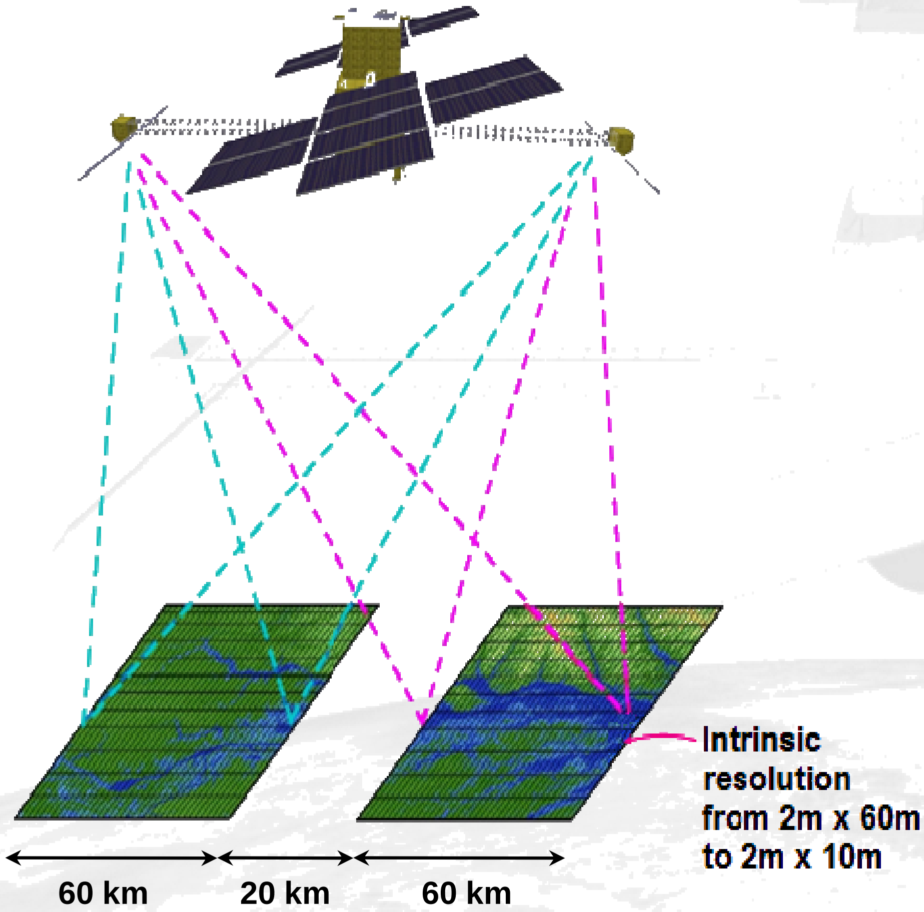
Using wide swath altimetry to reduce errors in Siberian river modeling

S. Biancamaria, M. Durand, K.M. Andreadis, P.D. Bates, A. Boone , N.M. Mognard, E. Rodriguez, D.E. Alsdorf, D.P. Lettenmaier, E.A. Clark

SWOT mission

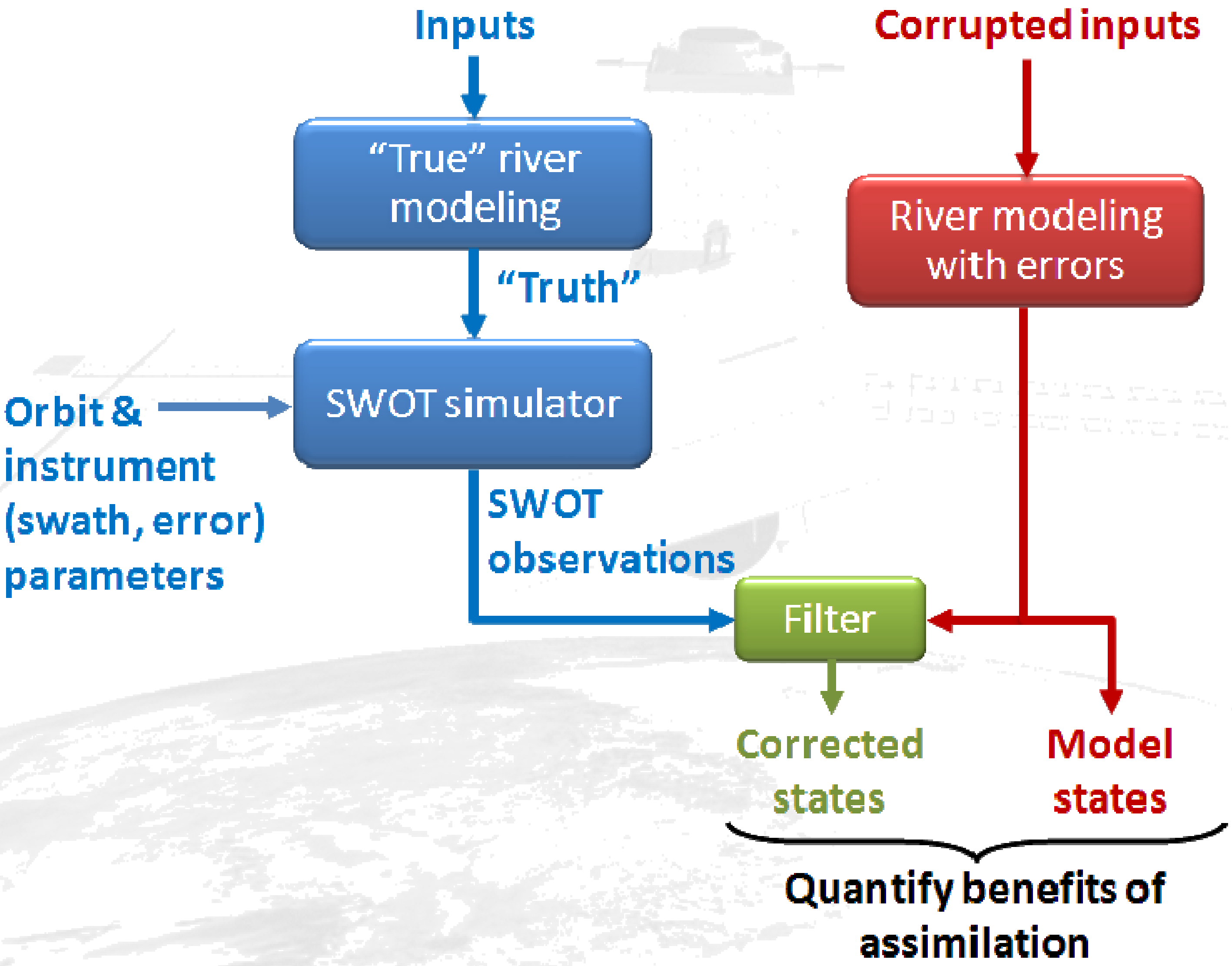


- SWOT= Surface Water and Ocean Topography (NASA/CNES)
- **Wide swath altimeter** (KaRIN= Ka-band Radar Interferometer)
- Launch ~**2019**
- Life time **3-5 years**
- 2 orbits:
  - **Fast sampling phase**: 3 day 78° orbit (during 3 months)
  - **Nominal phase**: 22 day 78° orbit
- Water elevation maps (100m pix. siz.)

Purpose of the study

- Estimate the potential of the SWOT (Surface Water and Ocean Topography) mission for Arctic hydrology.
- SWOT will measure water elevations, not discharge.
- Assimilation combine SWOT observations and modeling -> best discharge estimates.
- Study different satellite orbits -> impact on high latitude rivers

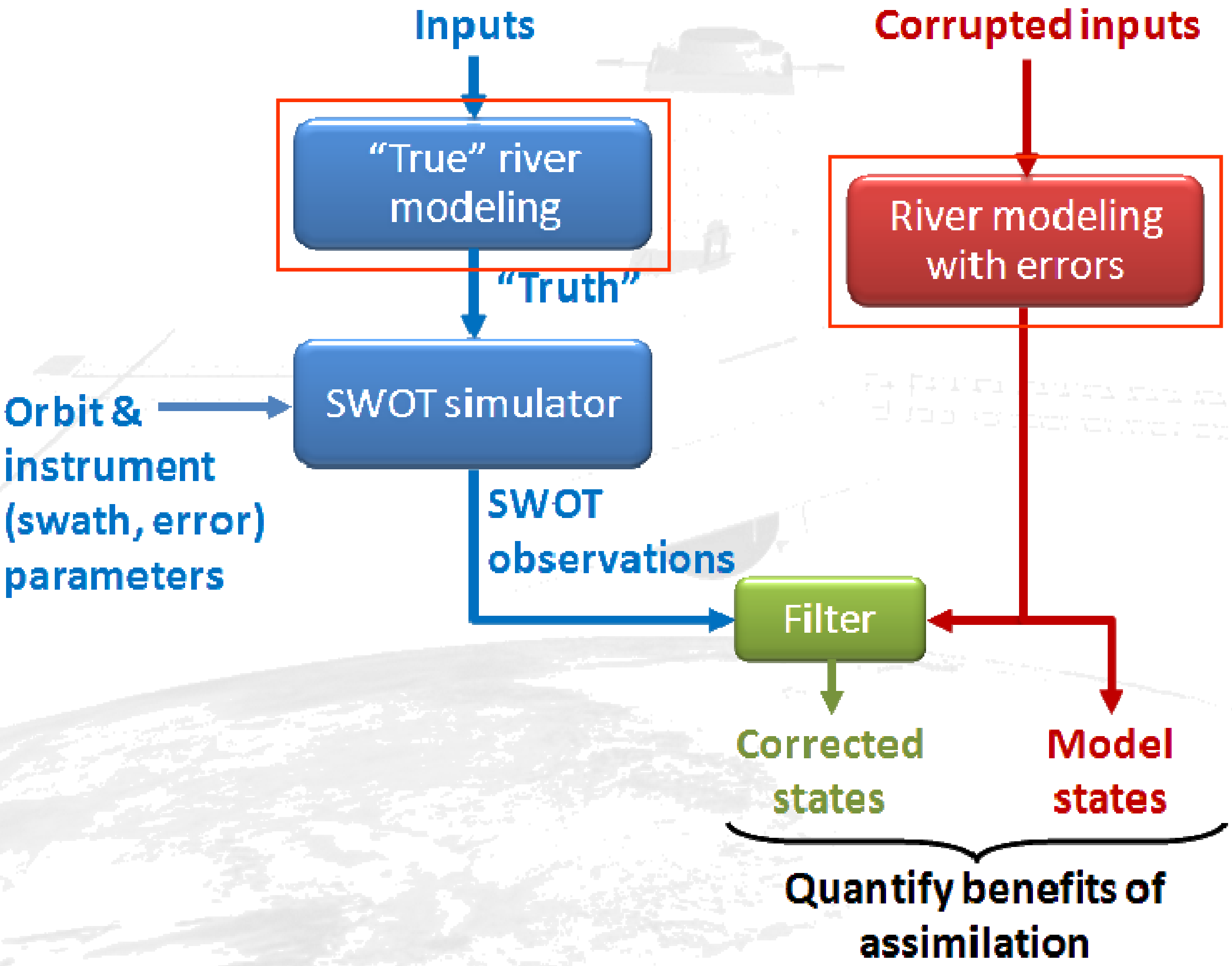
SWOT virtual mission on the Ob



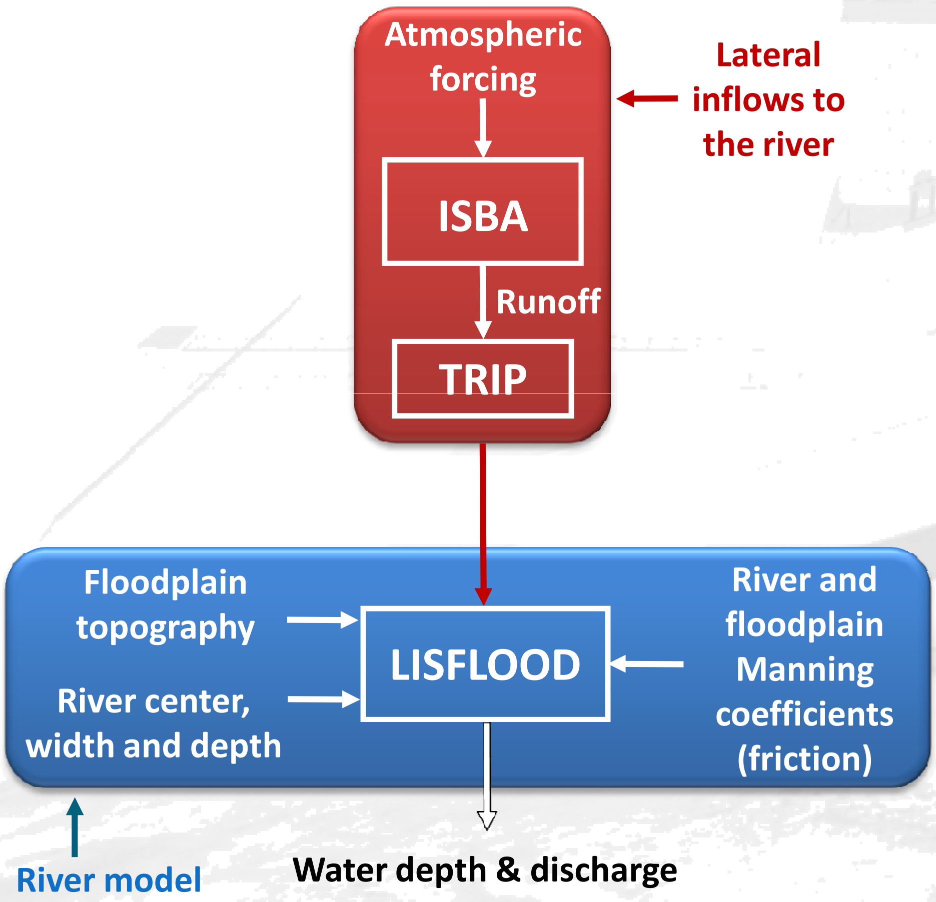
Outline

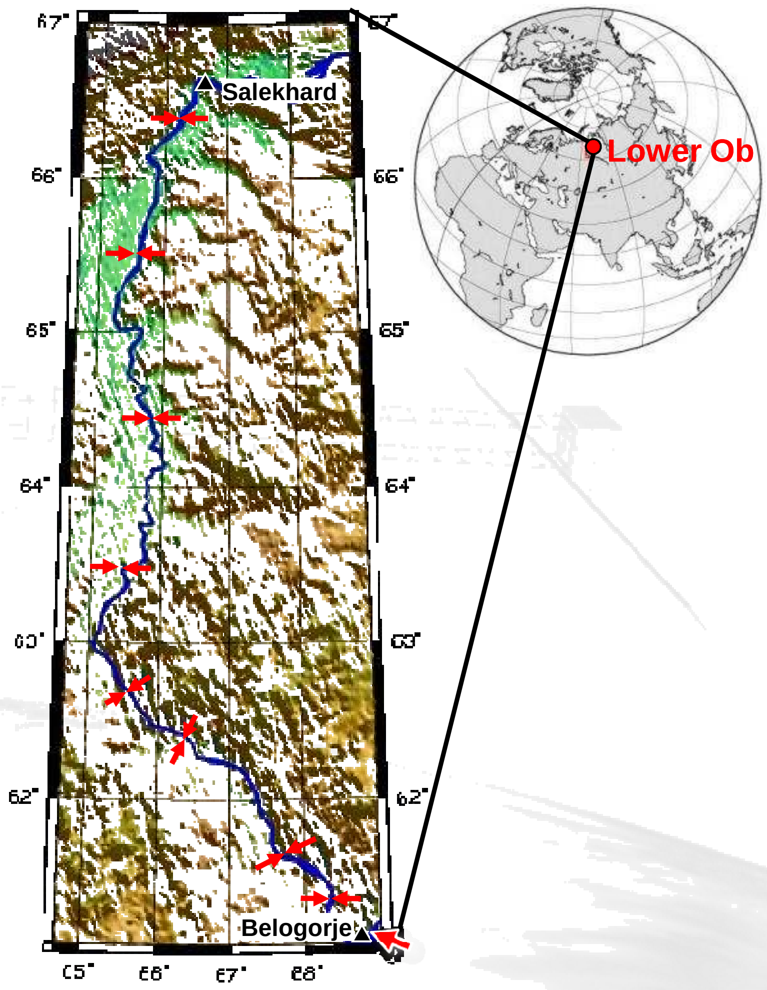
1. **Arctic river modeling**
2. **Virtual SWOT observations**
3. **Assimilation scheme**
4. **Results**

River modeling

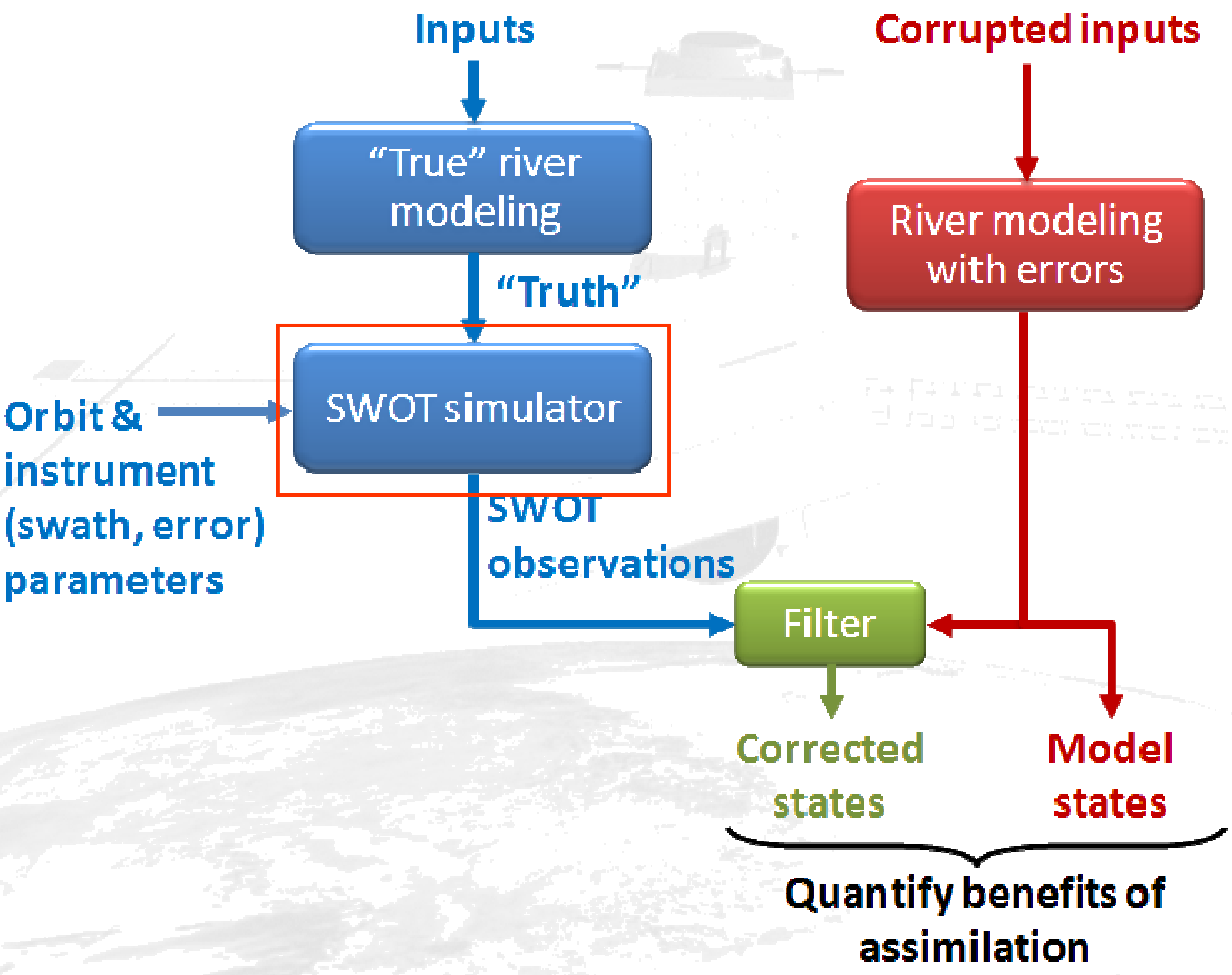


River modeling

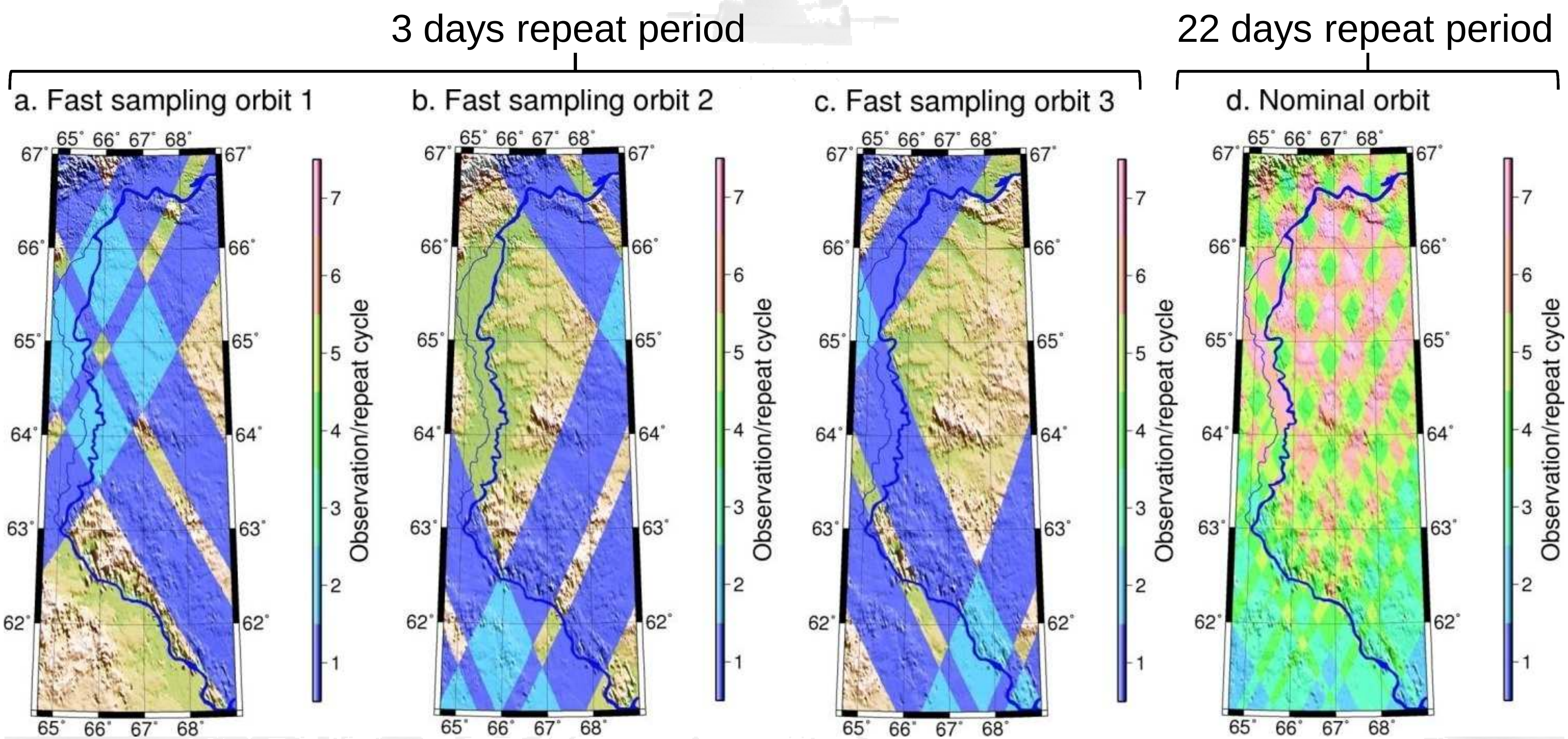




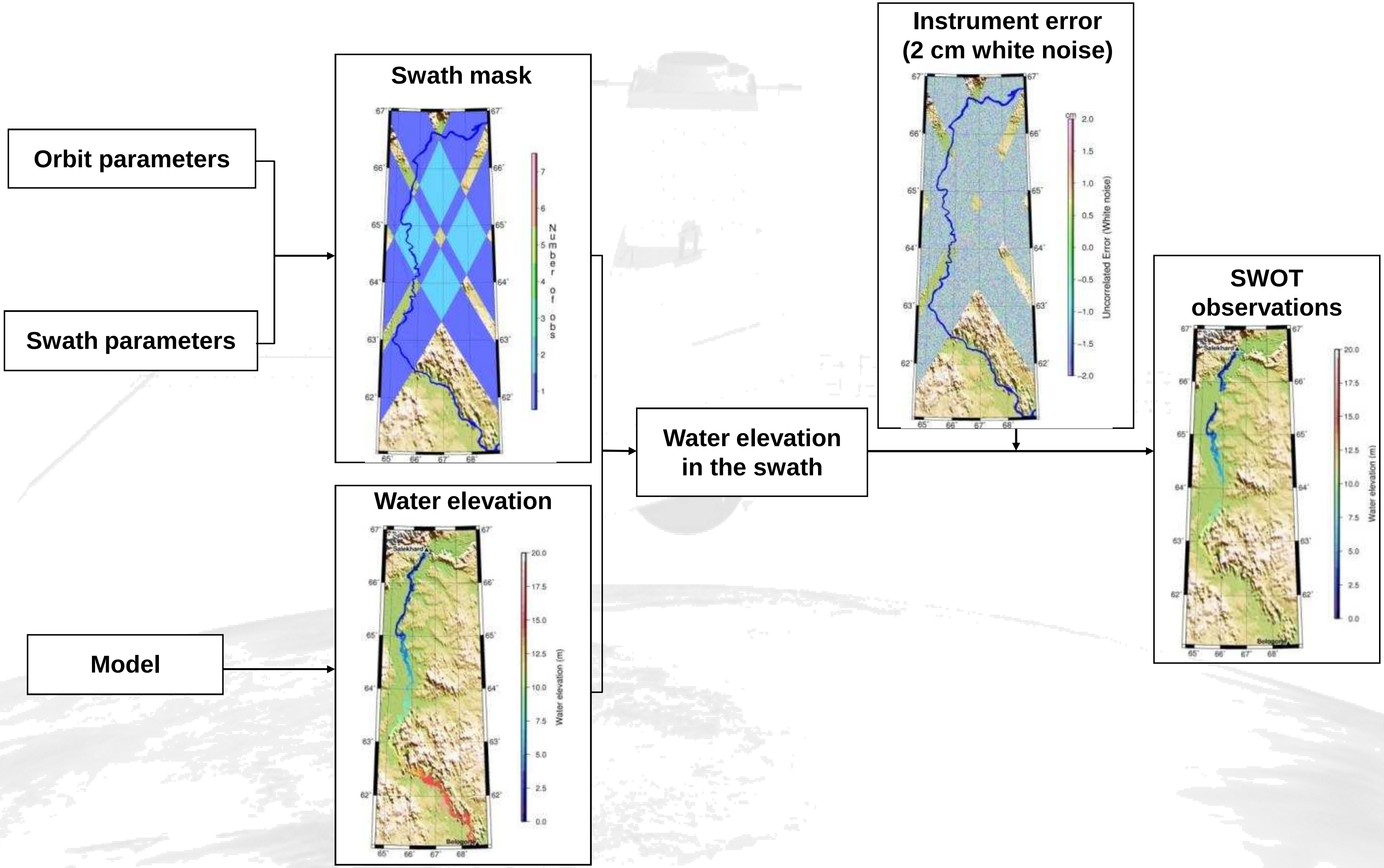
Virtual SWOT observations



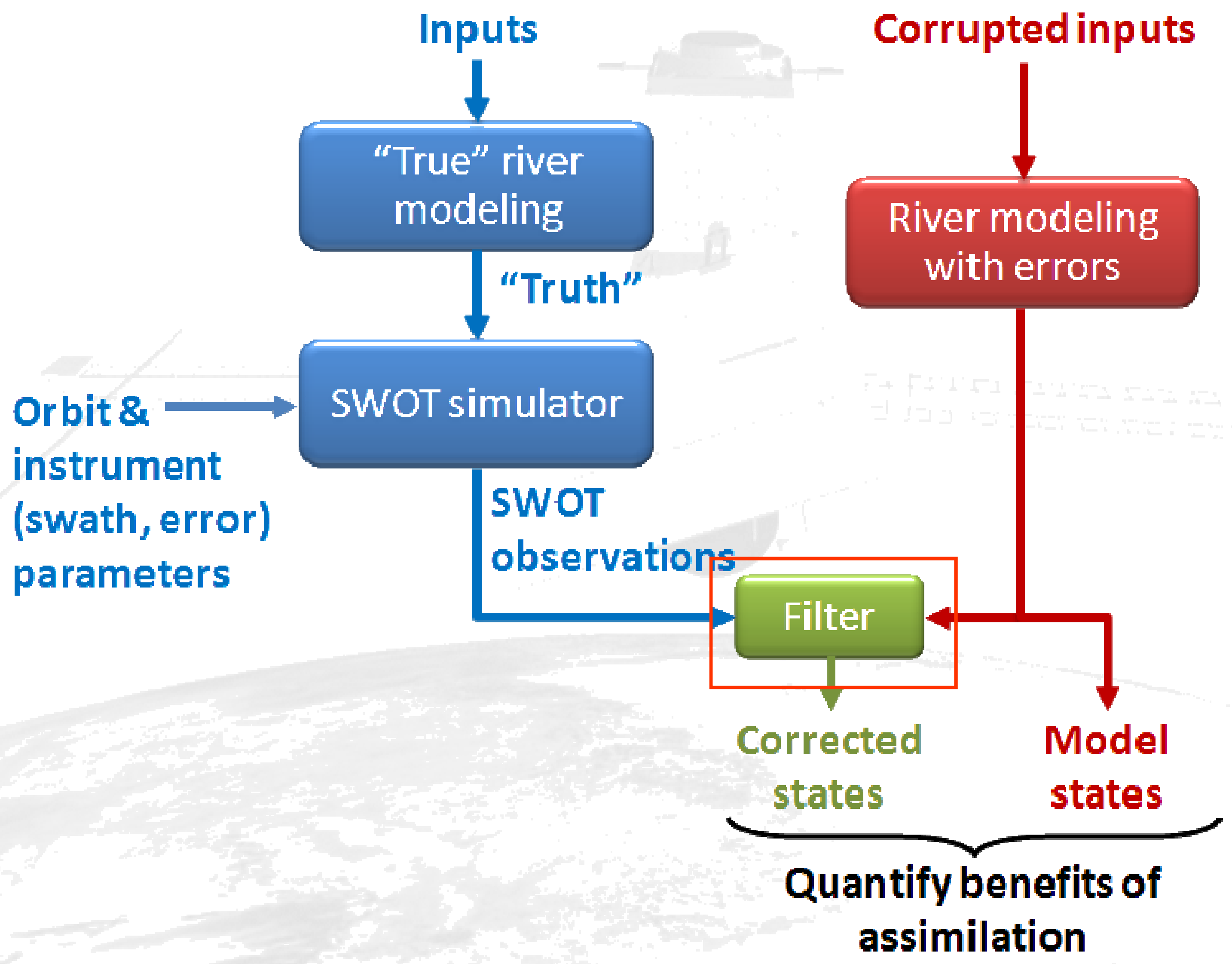
Virtual SWOT observations



Virtual SWOT observations



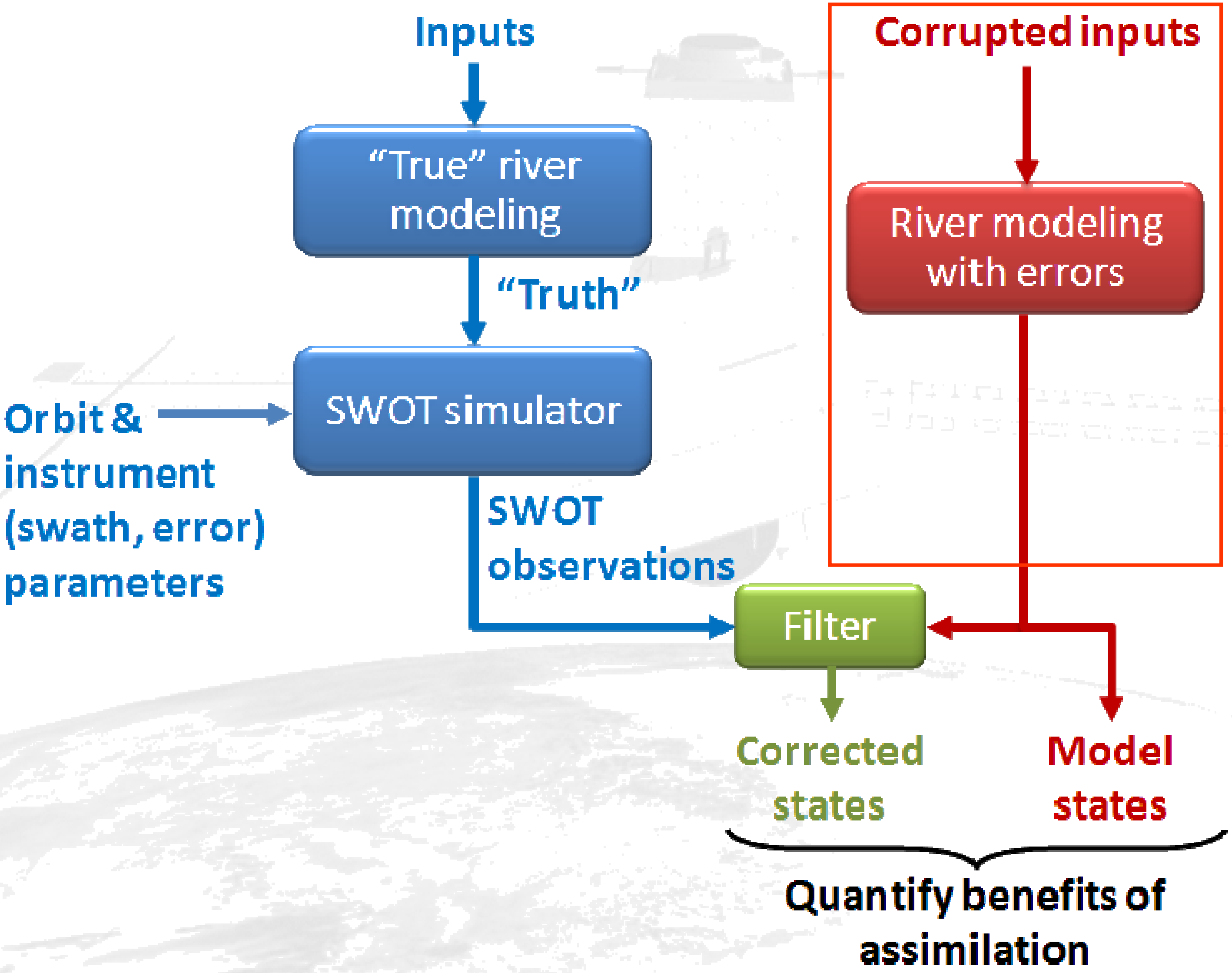
Assimilation scheme



Assimilation scheme

- Local Ensemble Kalman Smoother (LEnKS) with constant time-lag:
  - Localization: avoid long range spurious correlation in model error covariance matrix (no impact of observation at distance > 22 km).
  - Ensemble: approximation of the model error covariance matrix.
  - Smoother: assimilation at observation time + extent the correction to previous time steps (on a constant time frame).

Corrupted ensemble



Corrupted ensemble

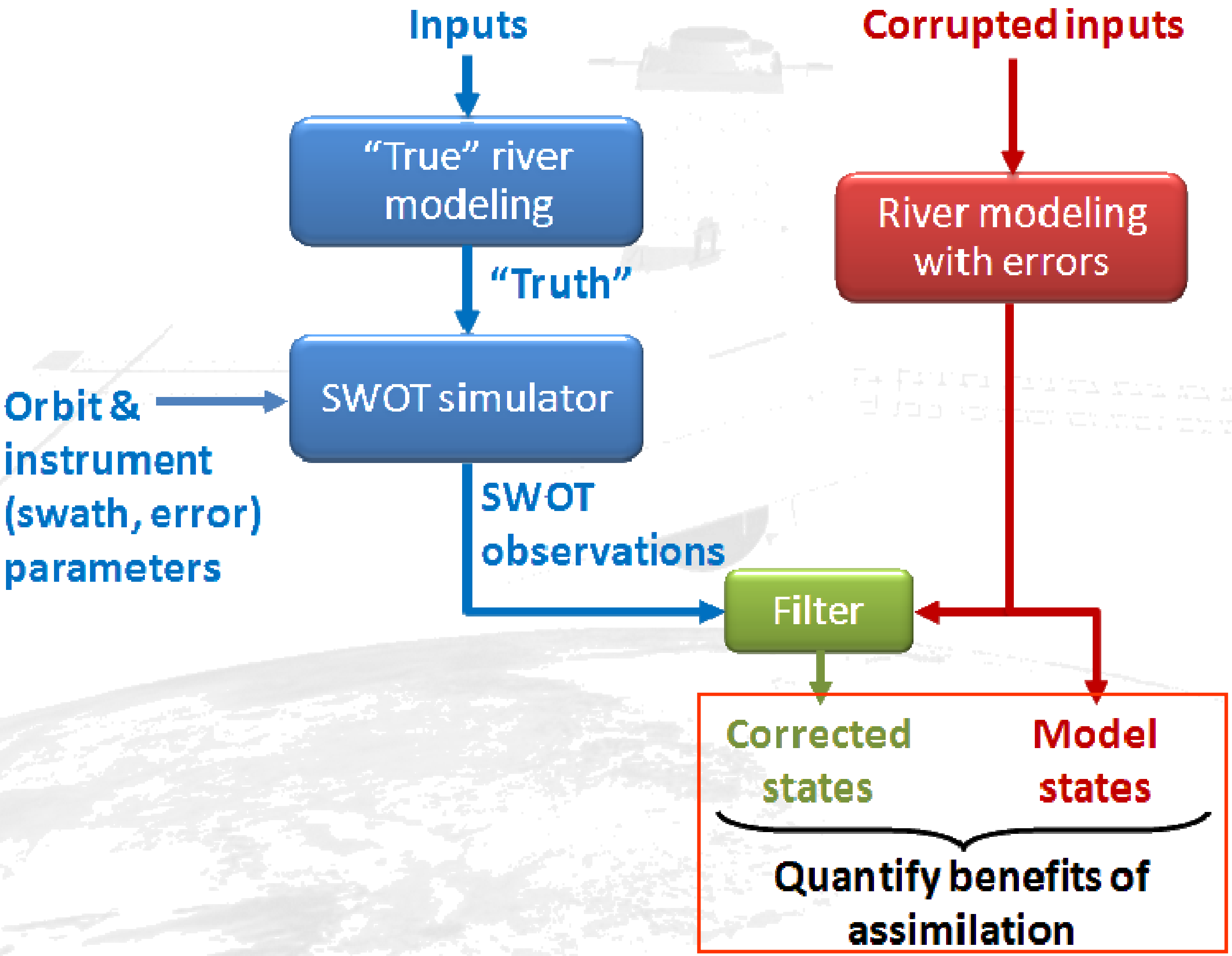
- Errors only from ISBA inputs: air temperature and total precipitation (rain+snow).
- Methodology:

$$P^{corrupt}(i,t) = \overline{P}(i).\varepsilon_m + \sum_{j=1}^{N} \varepsilon_j.\alpha_j(t).\phi_j(i)$$

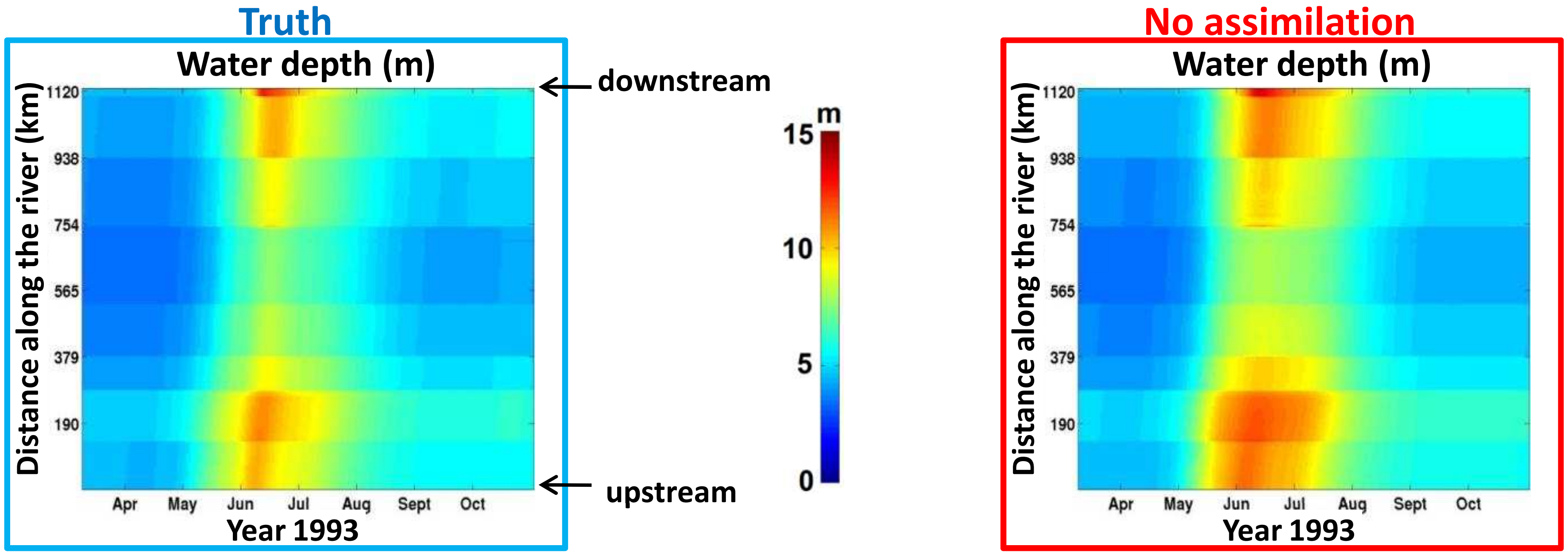
Corrupted atmospheric field ($P^{corrupt}$); Initial temporal mean ($\overline{P}$); Gaussian error N(1,0.20) (ε_m, ε_j); Temporal EOF jth mode (α_j); Spatial EOF jth mode (ϕ_j)

- The first N^{th} EOF modes explained 95 % of the variance (N=187 for precipitations and N=8 for air temperature).
- Size of the ensemble: 20 members.

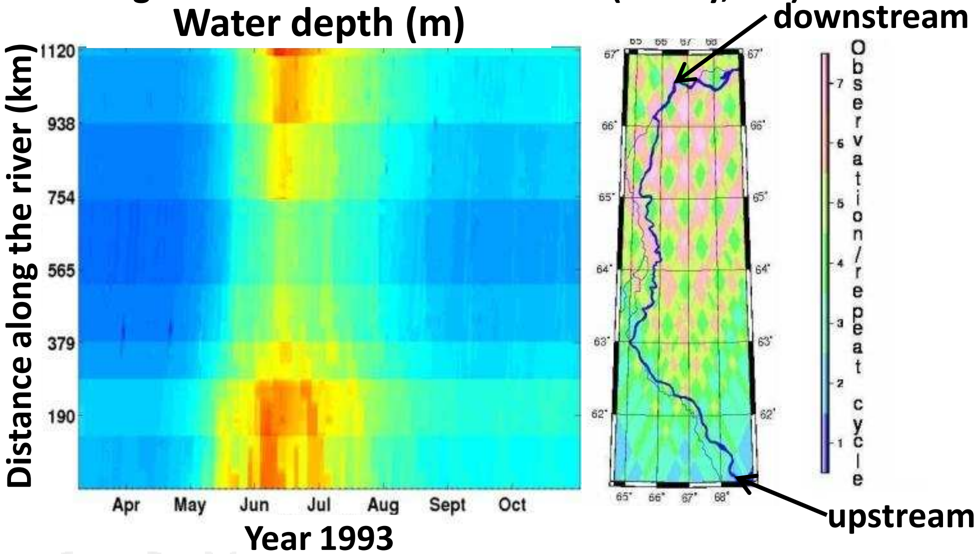
Results


Inputs
Corrupted inputs
"True" river modeling
River modeling with errors
"Truth"
Orbit & instrument (swath, error) parameters
SWOT simulator
SWOT observations
Filter
Corrected states
Model states
Quantify benefits of assimilation

Results for nominal orbit

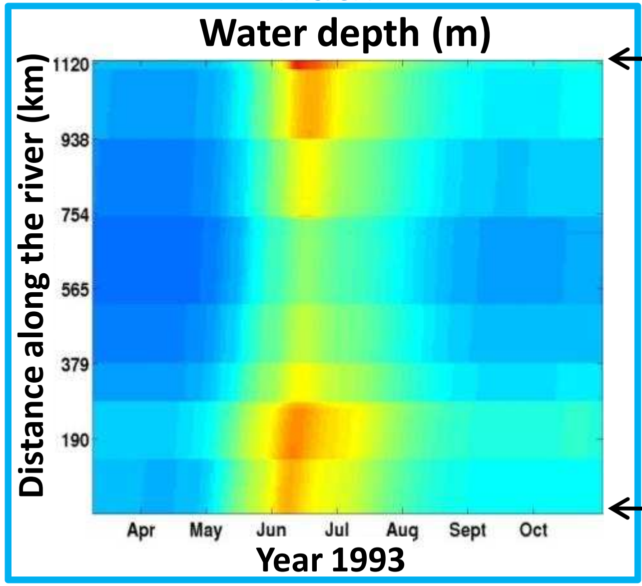


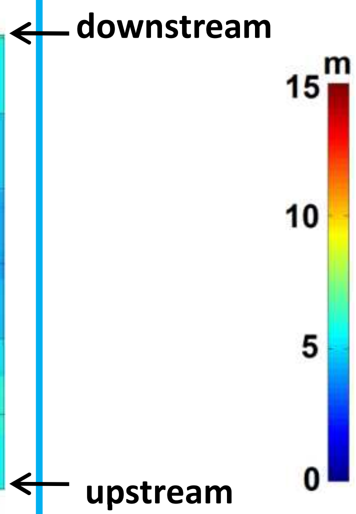
Assimilating SWOT data for nominal orbit (22 day, 78º):



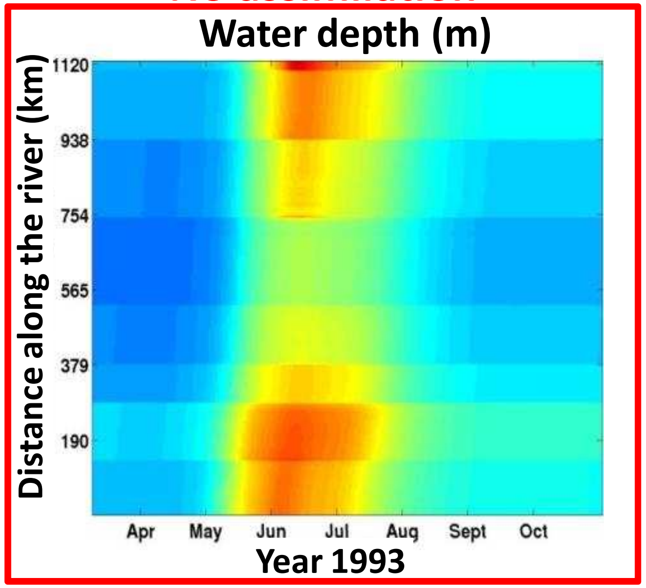
Results for fast-sampling orbits

Truth

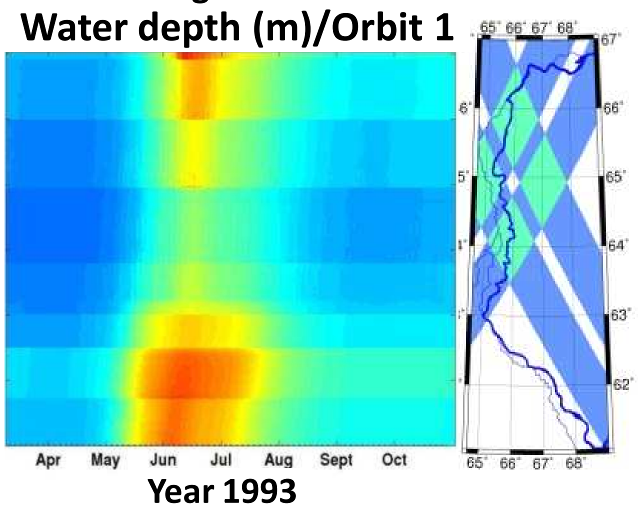


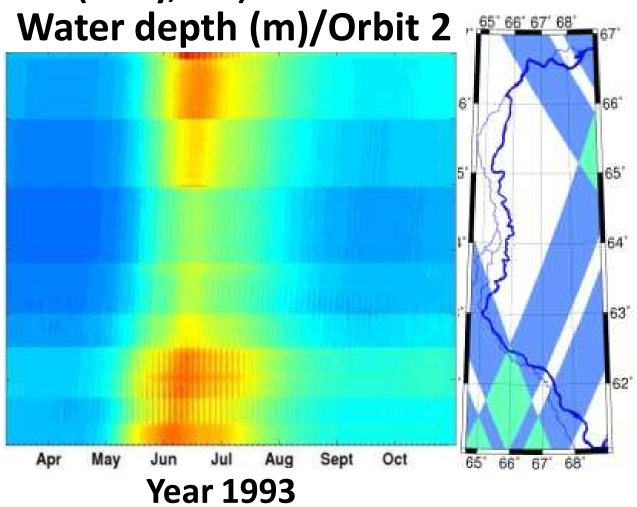


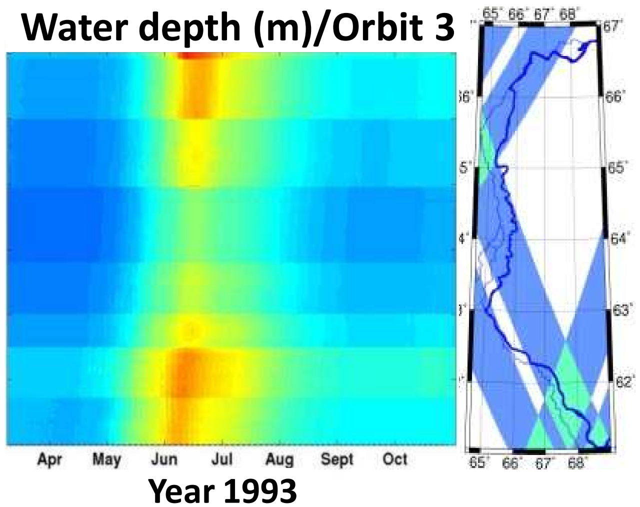
No assimilation



Assimilating SWOT data for calibration orbits (3 day, 78º):







Errors after assimilation

Nominal orbit:

	Mean spatial RMSE (m)	Mean temporal RMSE (m)
No assimilation	0.80	1.11
LEnKS (3 days)	0.33 (59%)	0.38 (66%)

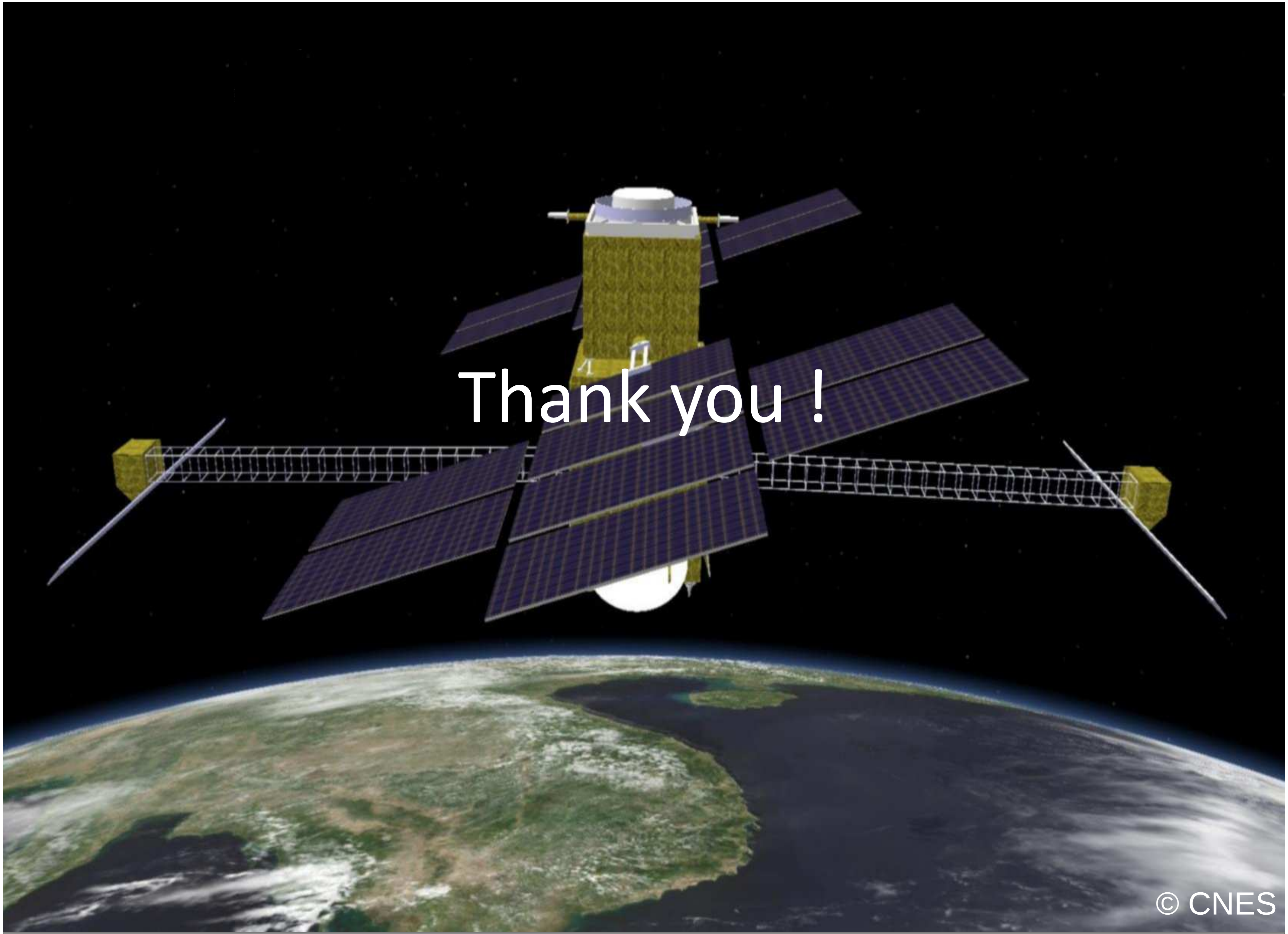
Fast-sampling orbits:

		Mean spatial RMSE (m)	Mean temporal RMSE (m)
No assimilation		0.80	1.11
	Orbit 1	0.57 (29%)	0.51 (54%)
LEnKS (2 days)	Orbit 2	0.40 (50%)	0.44 (60%)
	Orbit 3	0.17 (79%)	0.10 (91%)

Conclusions and perspectives

- Modeling error decreased after assimilation -> better water depth and discharge estimates.
- For Arctic rivers, similar results between nominal and fast sammpling orbits.
- Need to take into account other modeling errors (ISBA and LISFLOOD parameters, bathymetry,roughness, …).
- Need to take into account other SWOT errors (satellite motion, wet troposphere, …).

Biancamaria et al., 2010, RSE, accepted


Thank you !
© CNES