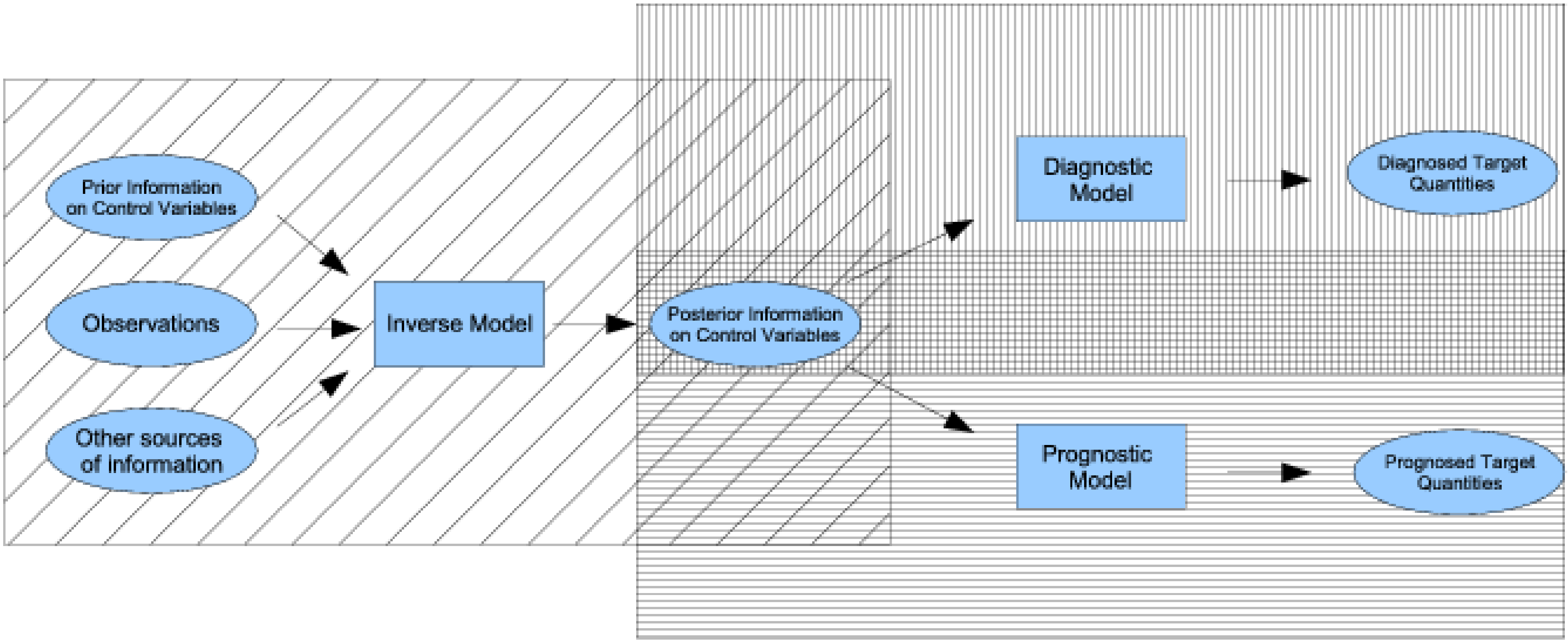
IMECC NA2

Development of a Network Design Tool

FastOpt, LSCE, and University of Bristol

ICOS & IMECC QND Meeting, June 2009, Paris

CCDAS scheme



Rayner et al. (2005); Scholze et al. (2007)

SIXTH FRAMEWORK PROGRAMME

IMECC INFRASTRUCTURE FOR MEASUREMENT OF THE EUROPEAN CARBON CYCLE

University of BRISTOL

LSCE

*Fast*Opt

Question

What is the performance of a given observational network as specified by the posterior uncertainty for a target quantity of interest

Uncertainty calculation in 2 steps

x: Parameters

x_{pr}: Priors

C_{pr}: Uncertainties

$M(x)$: Model

d: Observations

C_d: Their uncertainties

σ_{d_i}: Uncorrelated!

$J(x)$: Cost function

$\frac{d^2 J(x)}{dx^2}$: Hessian

x_{po}: Posterior parameters

C_{po}: Posterior uncertainties

$y(x)$: Target quantity

σ_y: Its uncertainty

All derivative code generated from model code by automatic differentiation tool TAF

Inverse step:

$$J(x) = \frac{1}{2}(x - x_{pr})^T {C_{pr}}^{-1} (x - x_{pr}) + \frac{1}{2} \sum_{i=1,nd} \left(\frac{M_i(x) - d_i}{\sigma_{d_i}} \right)^2$$

$$\frac{d^2 J(x)}{dx^2} = {C_{pr}}^{-1} + \sum_{i=1,nd} \frac{1}{\sigma_{d_i}^2} \frac{d^2}{dx^2} (M_i(x) - d_i)^2$$

uncertainty in observations AND model

- Hessian independent of x for linear model
- For synthetic data use $d = M(x)$.
- Decomposes nicely, can precompute model contribution

$$C_{po} \approx \frac{d^2 J(x_{po})}{dx^2}^{-1}$$

Propagation step:

$$\sigma_y^2 \approx \frac{dy(x_{po})}{dx} C_{po} \frac{dy(x_{po})}{dx}^T \approx \frac{dy(x_{po})}{dx} \frac{d^2 J(x_{po})}{dx^2}^{-1} \frac{dy(x_{po})}{dx}^T$$

SIXTH FRAMEWORK PROGRAMME

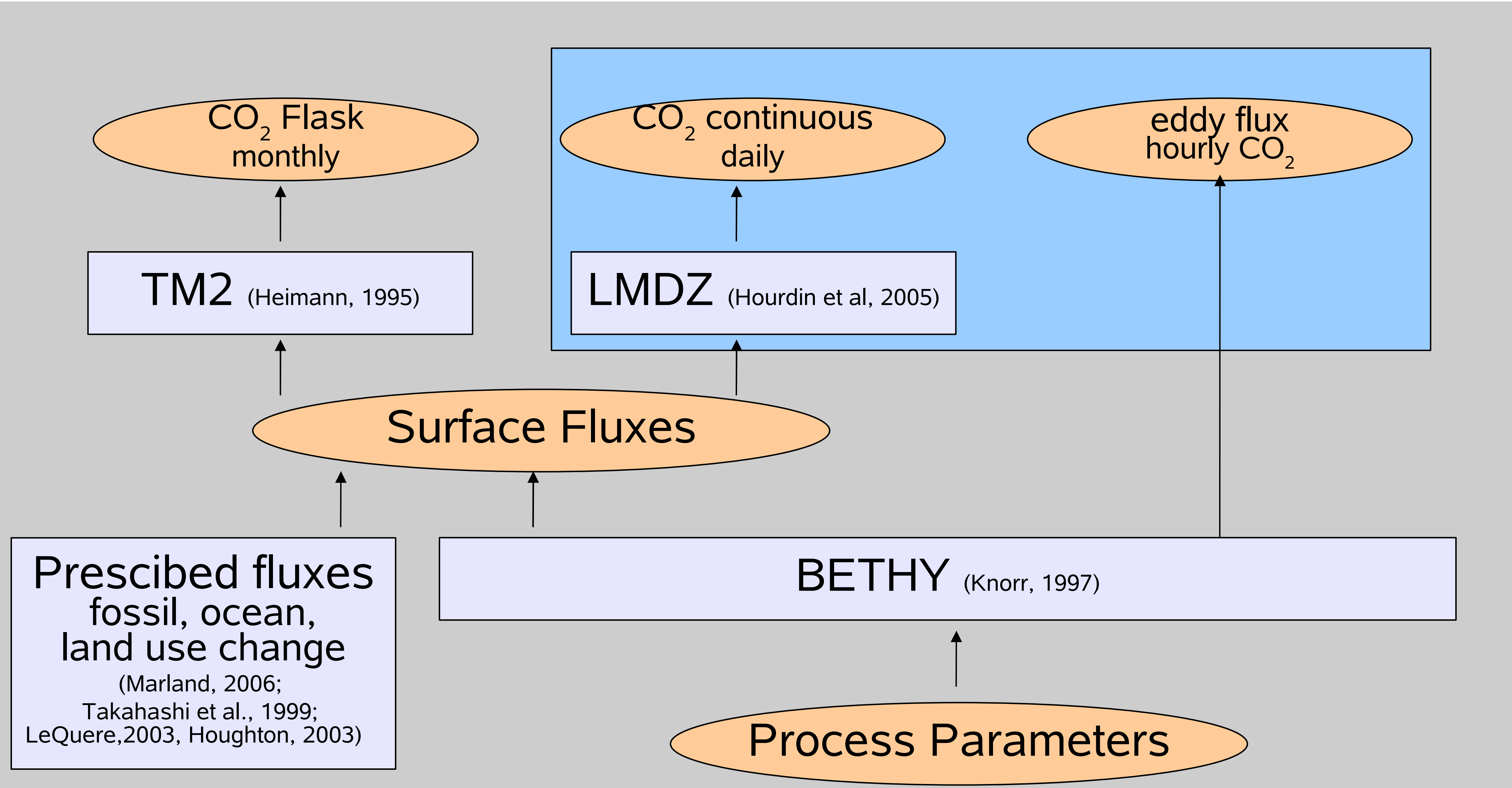
IMECC INFRASTRUCTURE FOR MEASUREMENT OF THE EUROPEAN CARBON CYCLE

University of BRISTOL

LSCE

FastOpt

Carbon Cycle Data Assimilation System (CCDAS) Forward Modelling Chain



SIXTH FRAMEWORK PROGRAMME

IMECC INFRASTRUCTURE FOR MEASUREMENT OF THE EUROPEAN CARBON CYCLE

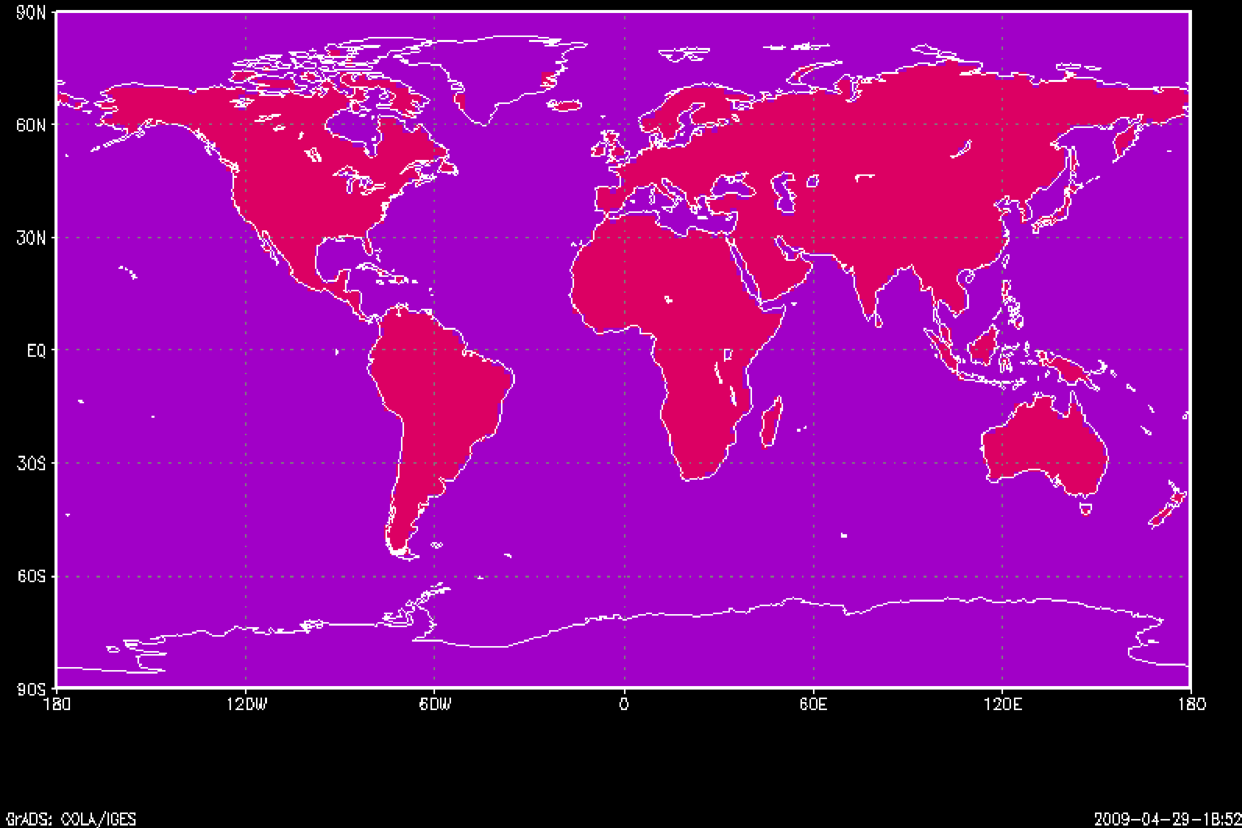
University of BRISTOL

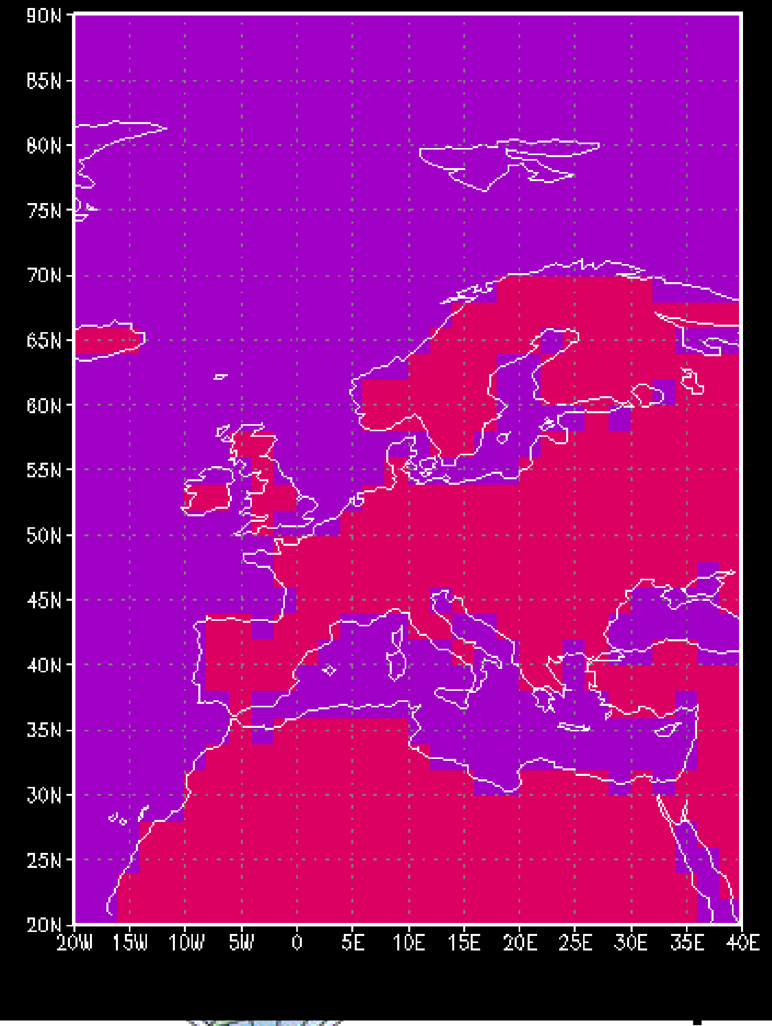
LSCE

FastOpt

Data Types

- 20 years of observations
- Data uncertaintiesfor each site to be specified by user
- Flask: monthly mean values, precomputed for selected sites
- Continuous: daily mean values, precomputed for selected sites
- Flux:
  - hourly mean values
  - 2 x 2 degree grid
  - Mix between up to 3 prescribed PFTs to be specified by the user





SIXTH FRAMEWORK PROGRAMME

IMECC

INFRASTRUCTURE FOR MEASUREMENT OF THE EUROPEAN CARBON CYCLE

BRISTOL

Summary

•Evaluated a sample network: The tool works!

•Obvious next things to look at:

- add/remove sites/data types
- Modify PFT mix for flux sites
- Check sensitivity to sampling frequency (e.g. only at day time)
- Check sensitivity to # of unknown process parameters, e.g. change validity domain of selected parameters
- Check impact of correlated uncertainties in observations

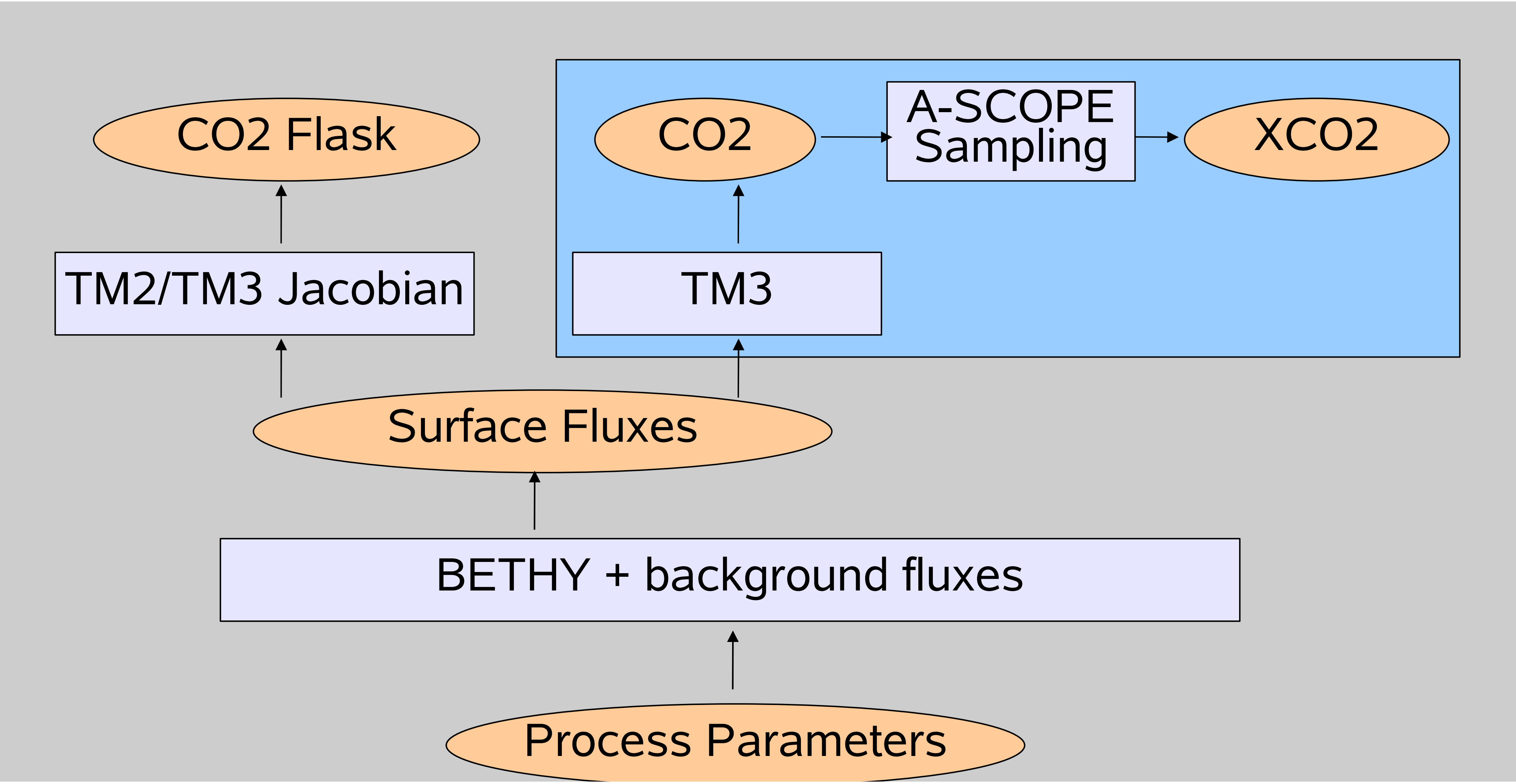
General: the tool can

- evaluate complex networks
- be extended to handle any data stream that can be assimilated into CCDAS
- be extended to offer more PFTs per grid cell
- be extended by an optimisation shell to suggest networks

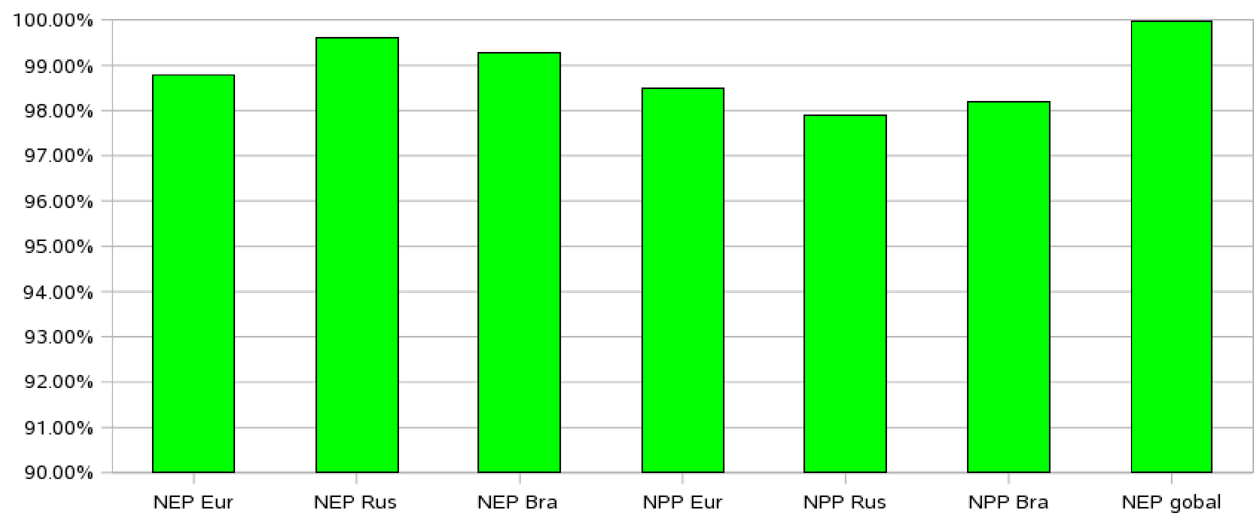
Quantifying the Benefit of A-SCOPE Data for Reducing Uncertainties in Current and Future Terrestrial Carbon Uptake

University of Bristol, FastOpt, and SRON

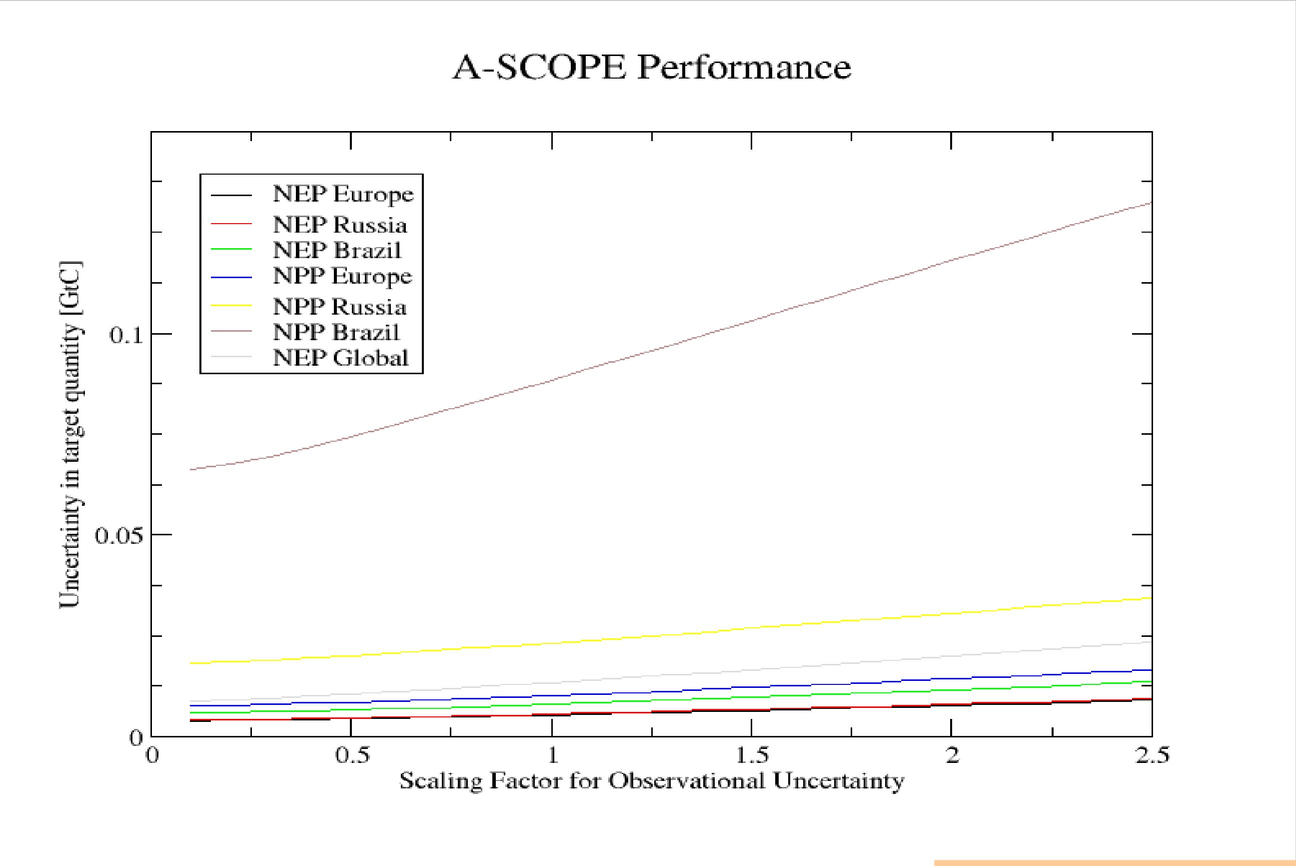
CCDAS


CO2 Flask
CO2
A-SCOPE Sampling
XCO2
TM2/TM3 Jacobian
TM3
Surface Fluxes
BETHY + background fluxes
Process Parameters

Experiment 1, Case 2 : A-SCOPE only



Experiment 4



Kaminski et al., submitted to JGR

Conclusions

- A-SCOPE performs better than ground-based flask sampling network
- Better performance regardless of weighting function and sampling in the model
- Performance holds for a range of observational uncertainties