

# IMECC NA2

Development of a Network Design Tool

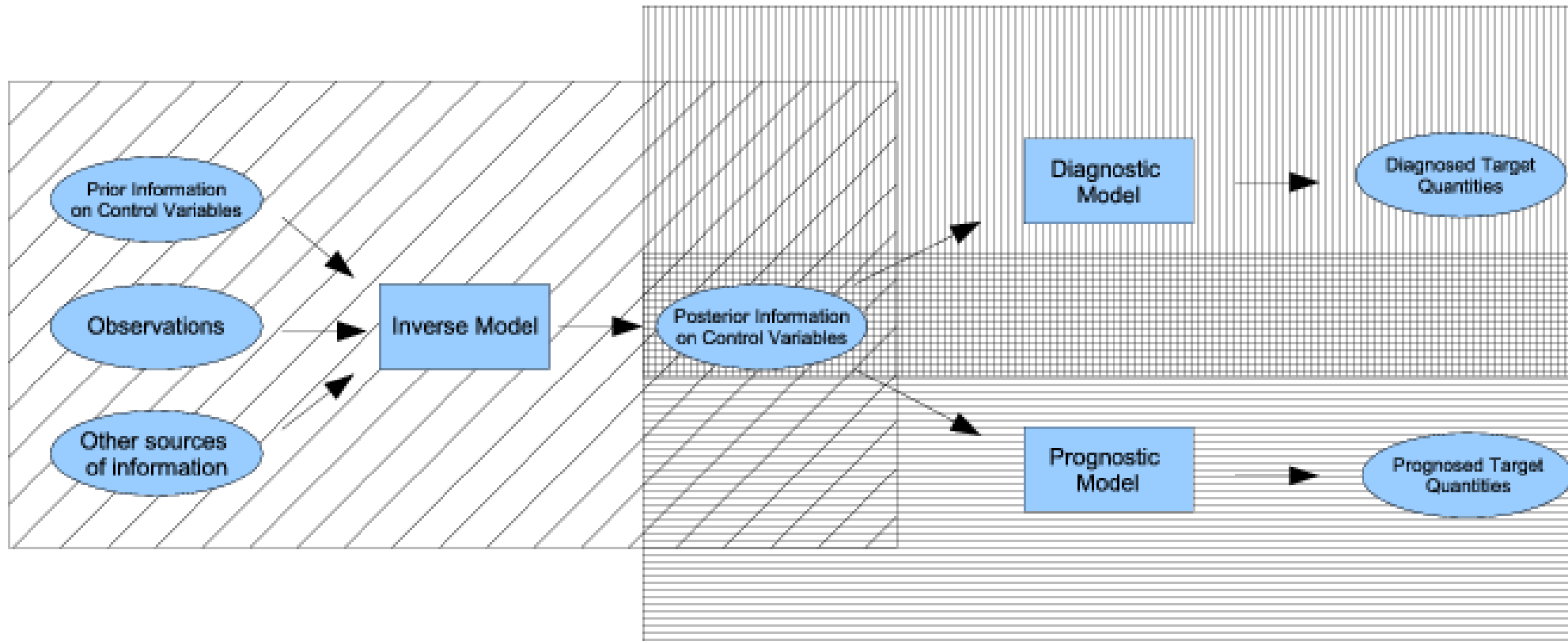
FastOpt, LSCE, and University of Bristol

ICOS & IMECC QND Meeting, June 2009, Paris



**FastOpt**

# CCDAS scheme



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

# 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

Inverse step:

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

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

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

uncertainty  
in observations  
AND model

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

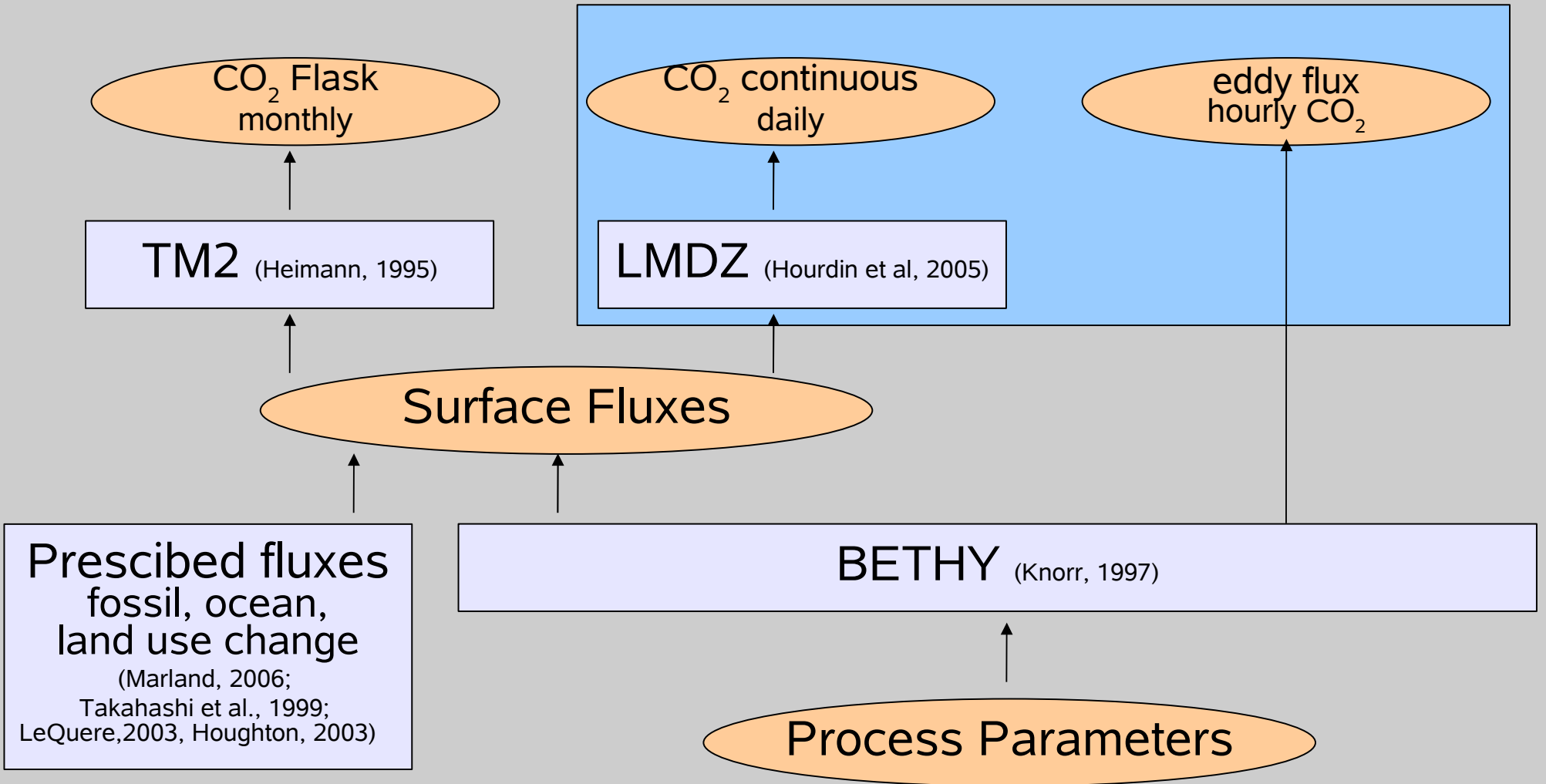
Propagation step:

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

$x$ : Parameters  
 $x_{pr}$ : Priors  
 $C_{pr}$ : Uncertainties  
 $M(x)$ : Model  
 $d$ : Observations  
 $C_d$ : Their uncertainties  
 $\sigma_{d_i}$ : 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  
 $\sigma_y$ : Its uncertainty

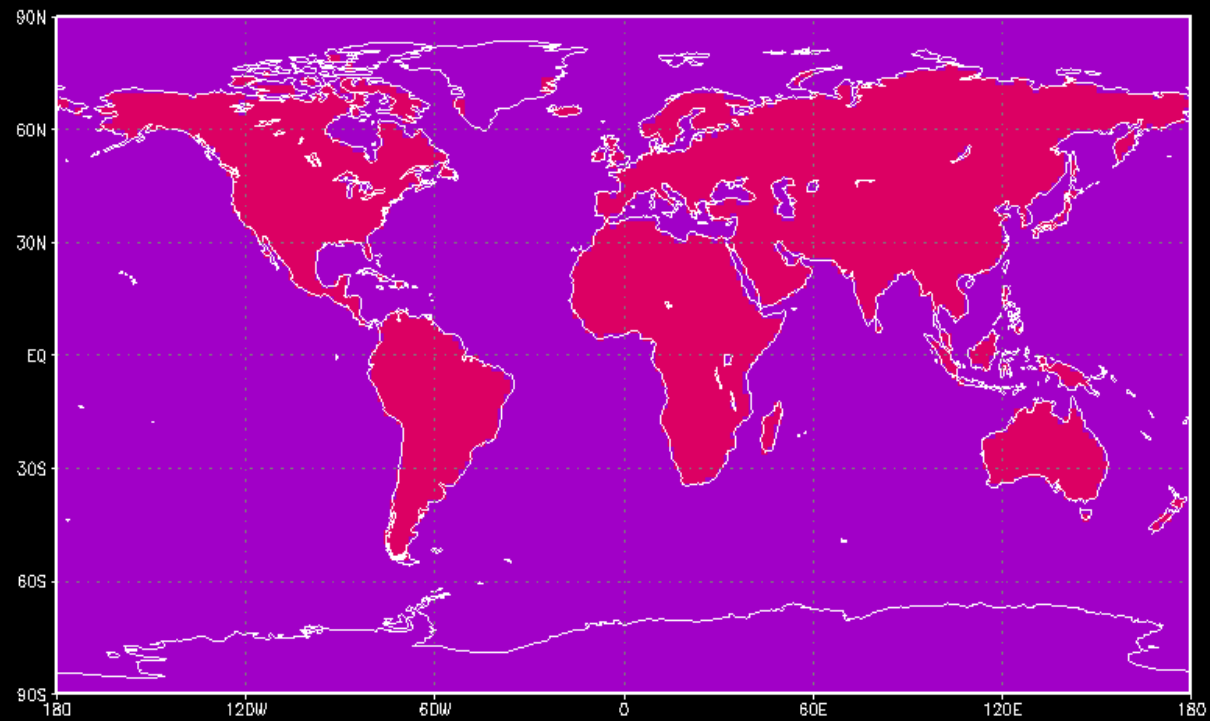
All derivative code  
 generated from model code  
 by automatic differentiation  
 tool TAF

# Carbon Cycle Data Assimilation System (CCDAS) Forward Modelling Chain



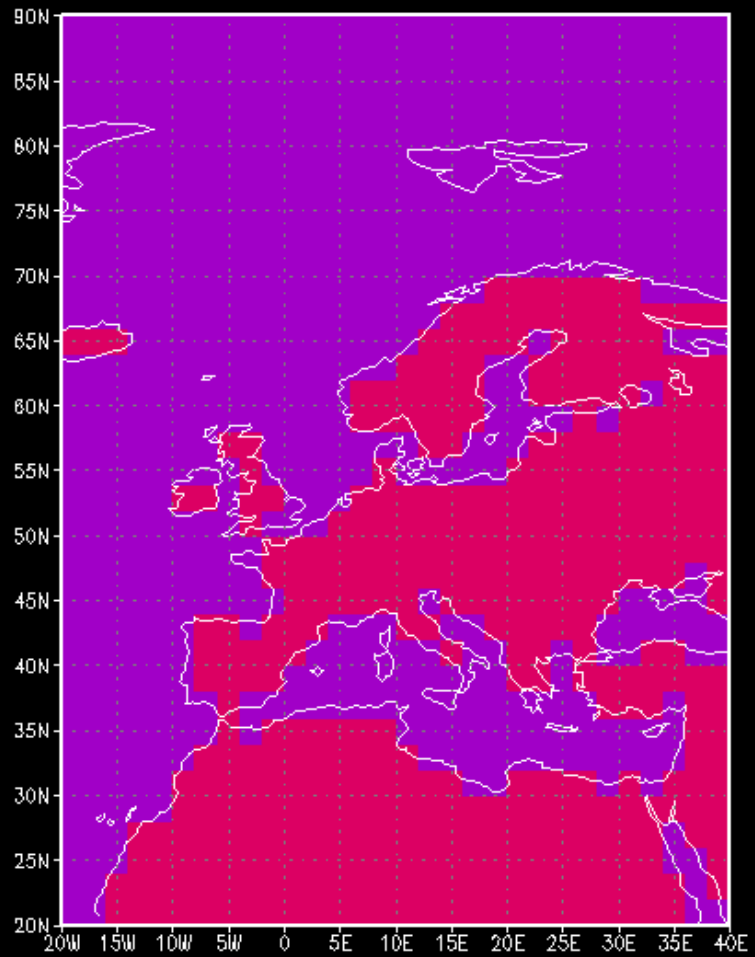
# Data Types

- 20 years of observations
- Data uncertainties for 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



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2009-04-29-18:52



SIXTH FRAMEWORK PROGRAMME



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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

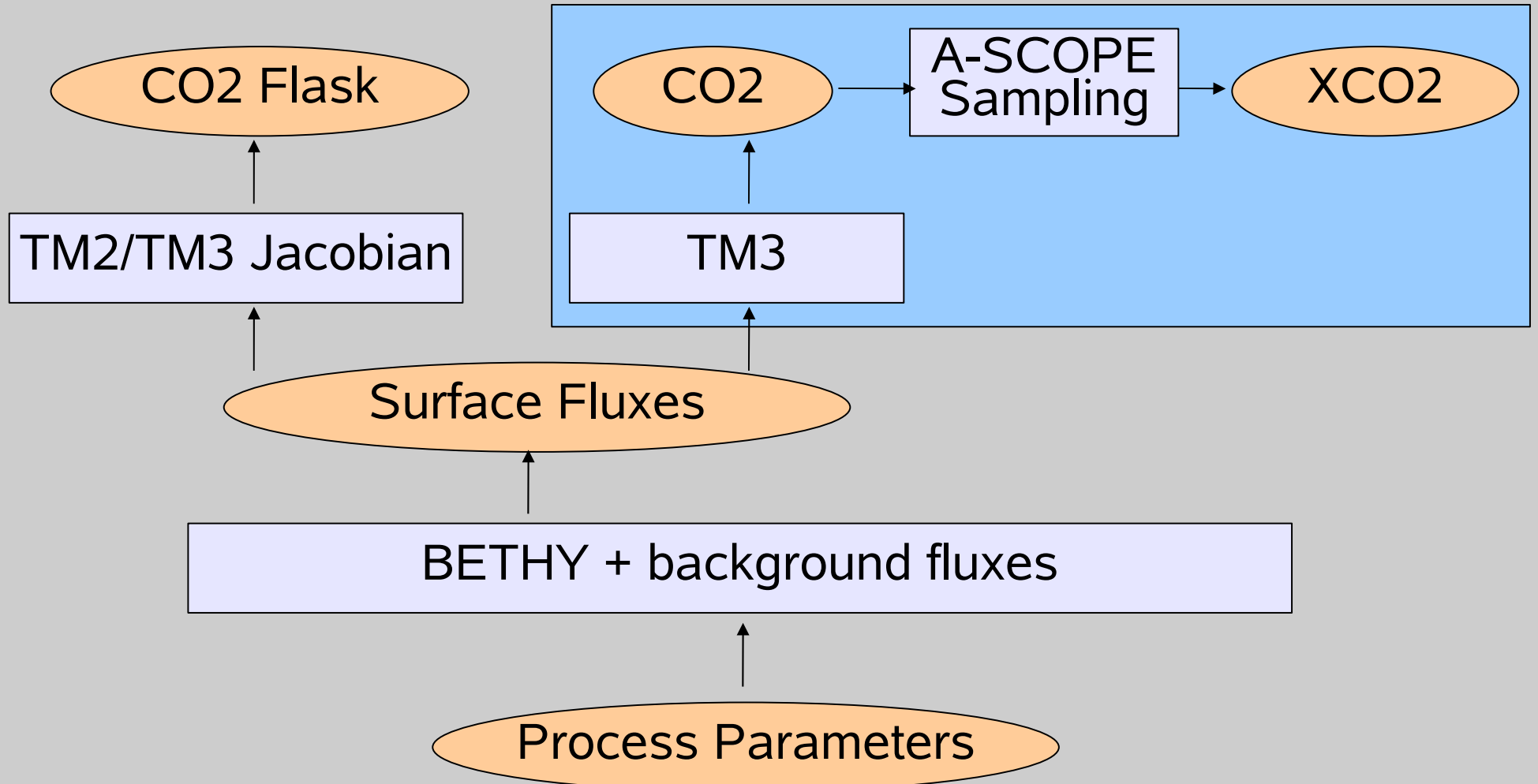
- evaluate complex networks
- be extended to handle any data stream that can be assimilated into CCDAS
- be extended to offer more PFTs per grid cell
- be extended by an optimisation shell to suggest networks



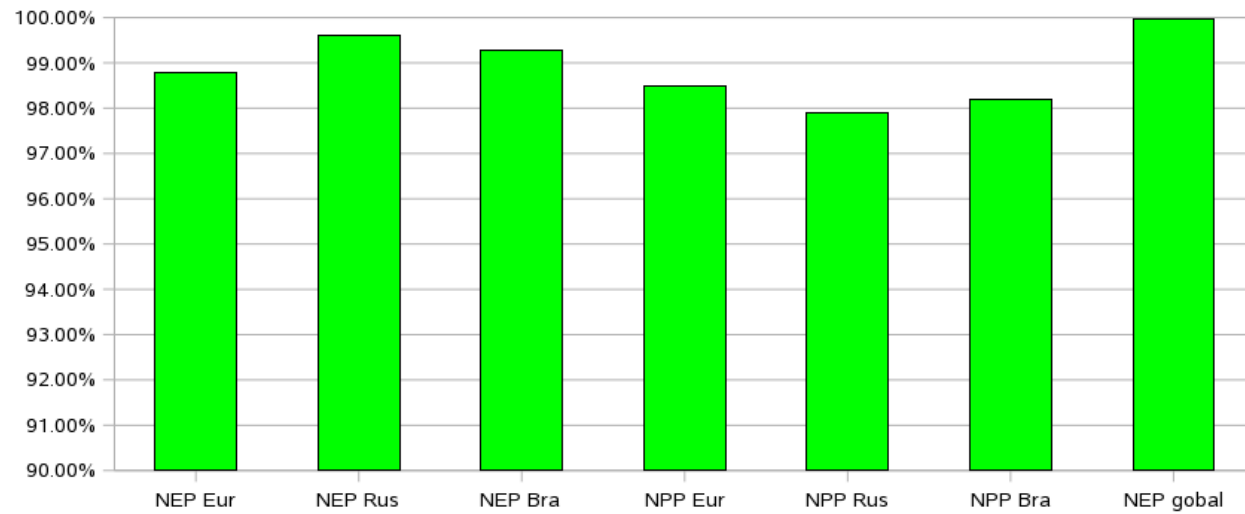
# **Quantifying the Benefit of A-SCOPE Data for Reducing Uncertainties in Current and Future Terrestrial Carbon Uptake**

**University of Bristol, FastOpt, and SRON**

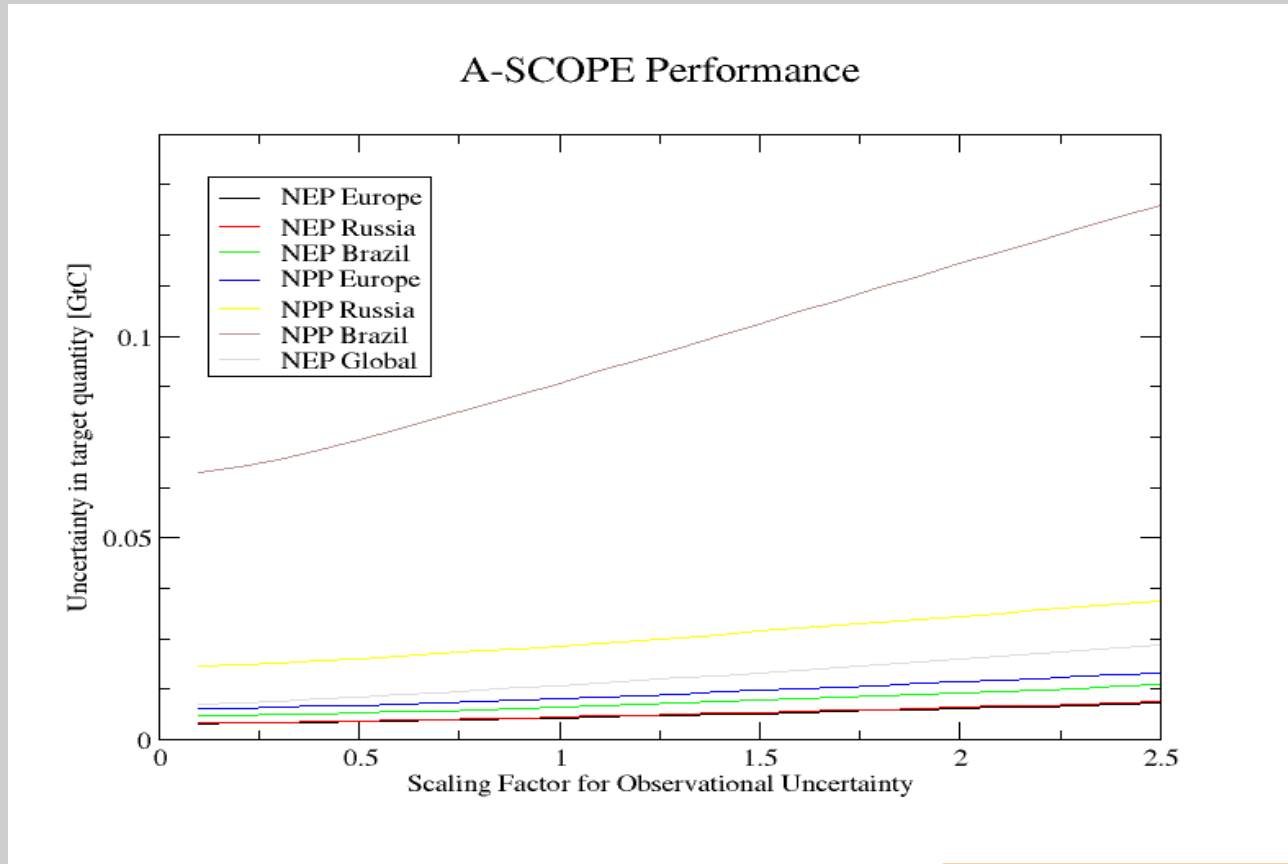
# CCDAS



# 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