IMECC NA2

Development of a Network Design Tool

FastOpt, LSCE, and University of Bristol

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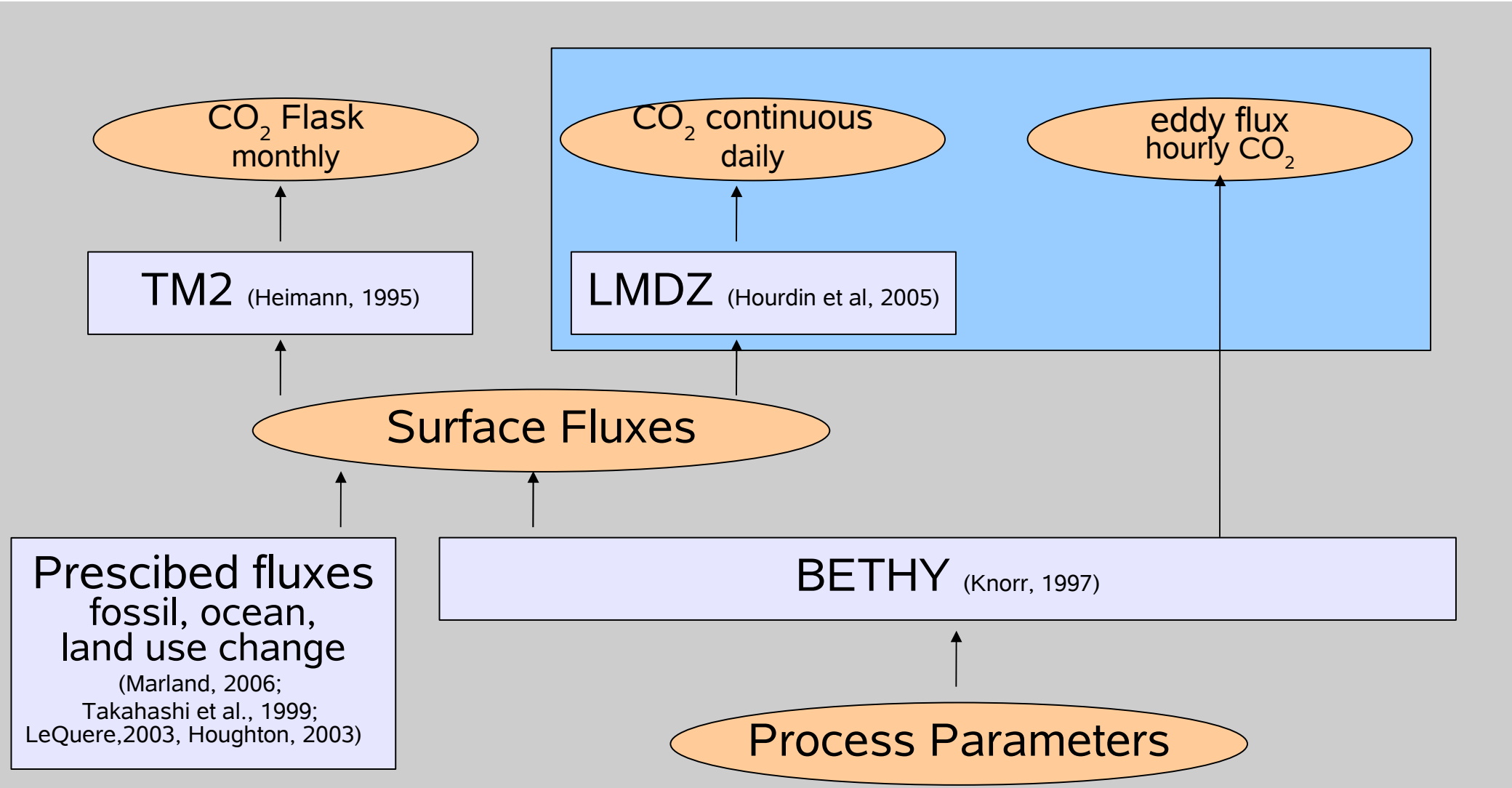
Carbon Cycle Data Assimilation System (CCDAS) Forward Modelling Chain



SIXTH FRAMEWORK PROGRAMME

IMECC Infrastructure for Measurement of the European Carbon Cycle

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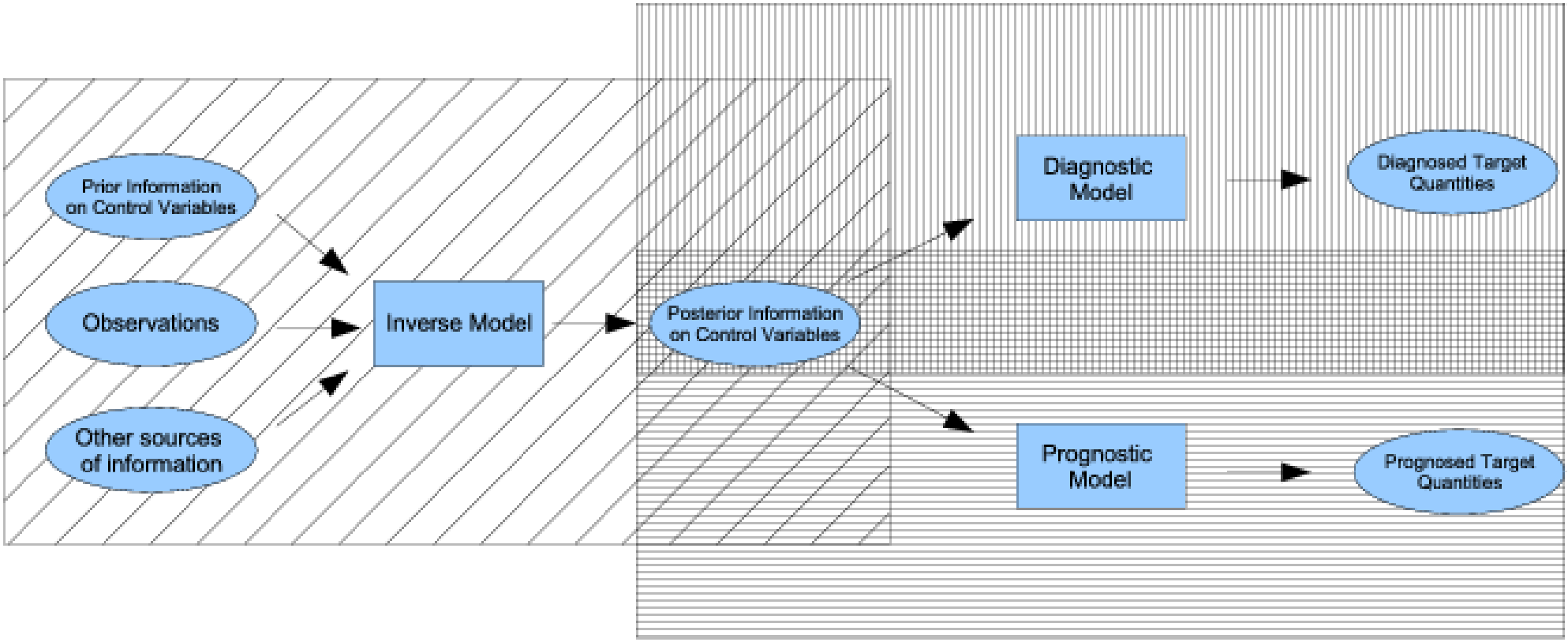
CCDAS scheme



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

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:

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

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

- 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:

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

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