Using multivariate data assimilation to improve streamflow predictions for a mountainous watershed

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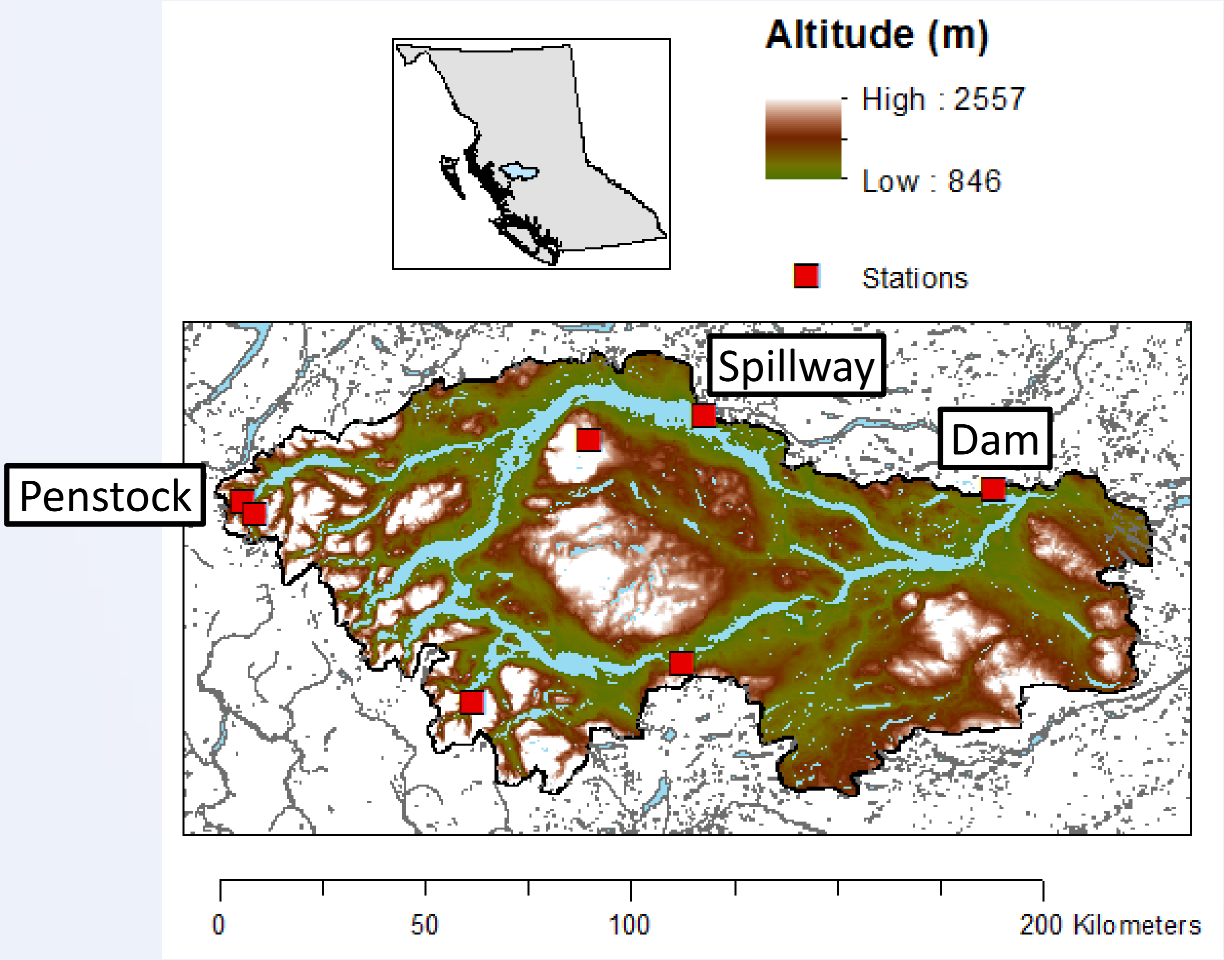
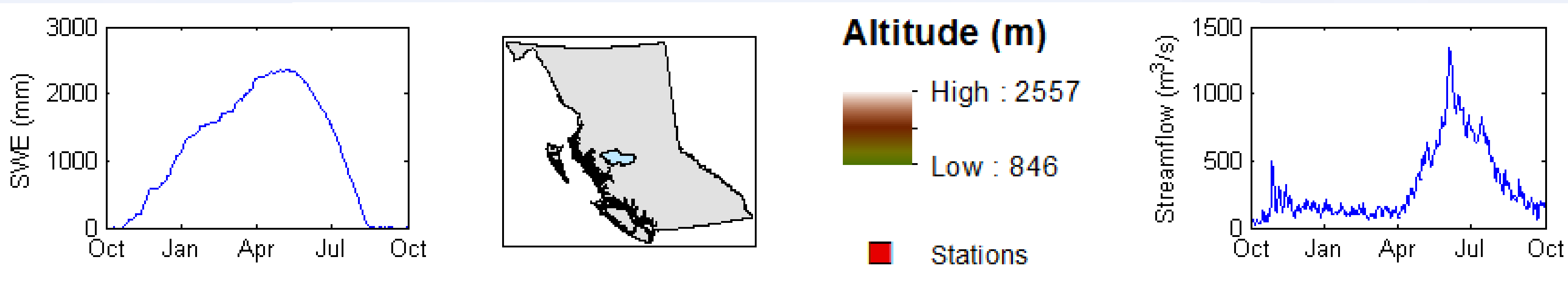
GREAUS

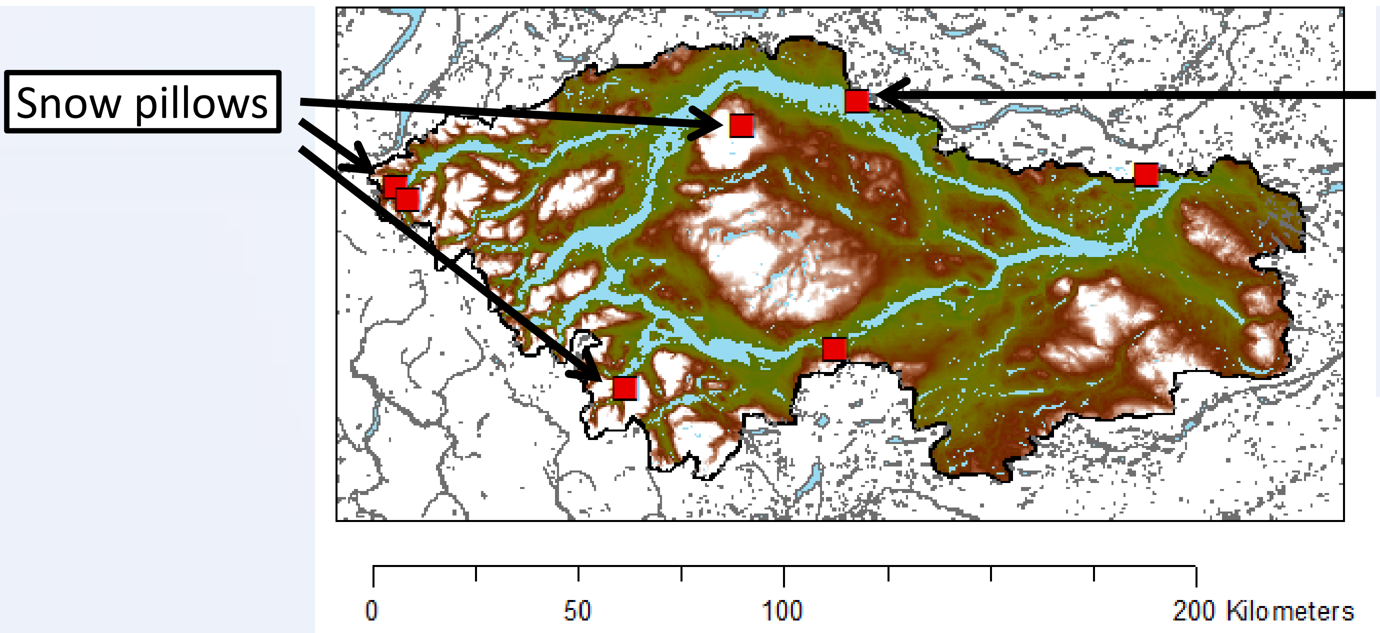
Nechako reservoir overview



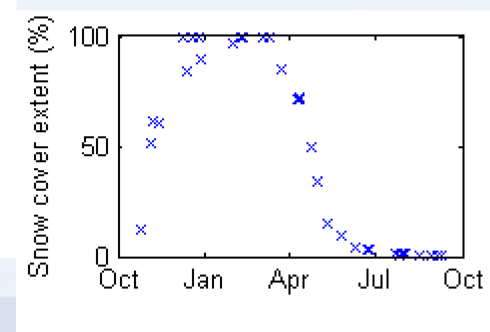
- Mountainous region
- Covers 14000 km^2
- Precipitation mostly falls as snow

What data is available



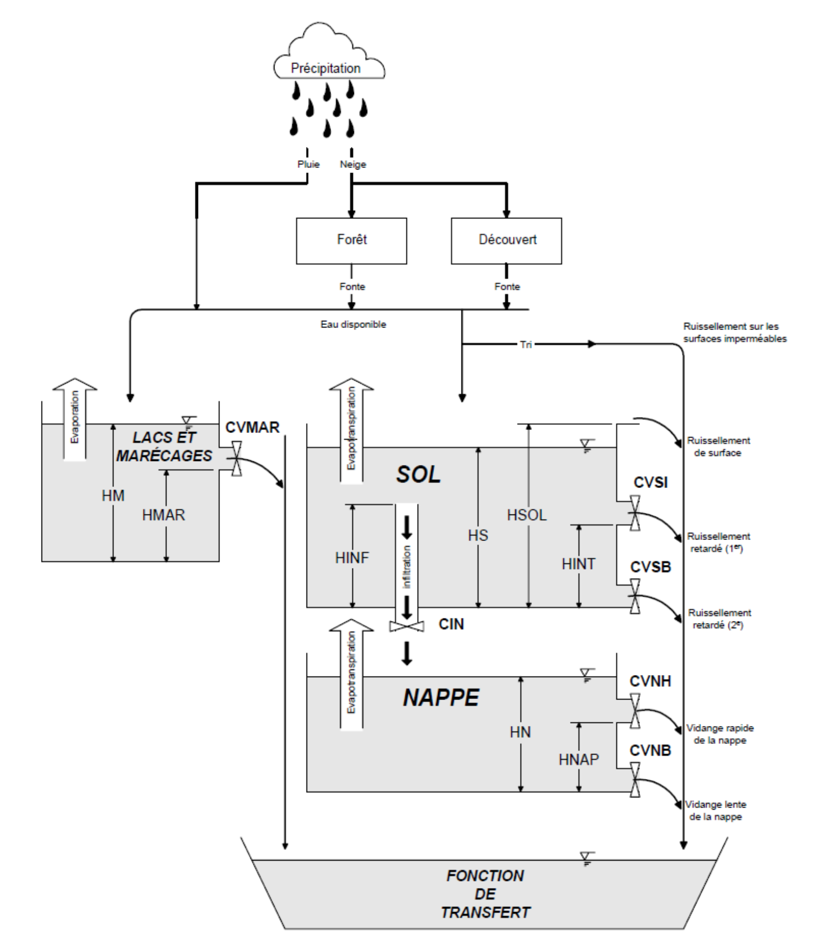


Also remote sensing data!



How streamflows predictions are presently made

- CEQUEAU
  - Distributed rainfall-runoff model
  - Requires daily precipitation and max-min temperature
  - Precipitation phase based on a temperature threshold
  - Potential snowmelt using degree-day
- Short-term forecast
  - Environment Canada weather ensemble forecast used as input
- Mid-term forecast (> 4 days)
  - Historical weather data used to generate ensemble forecast

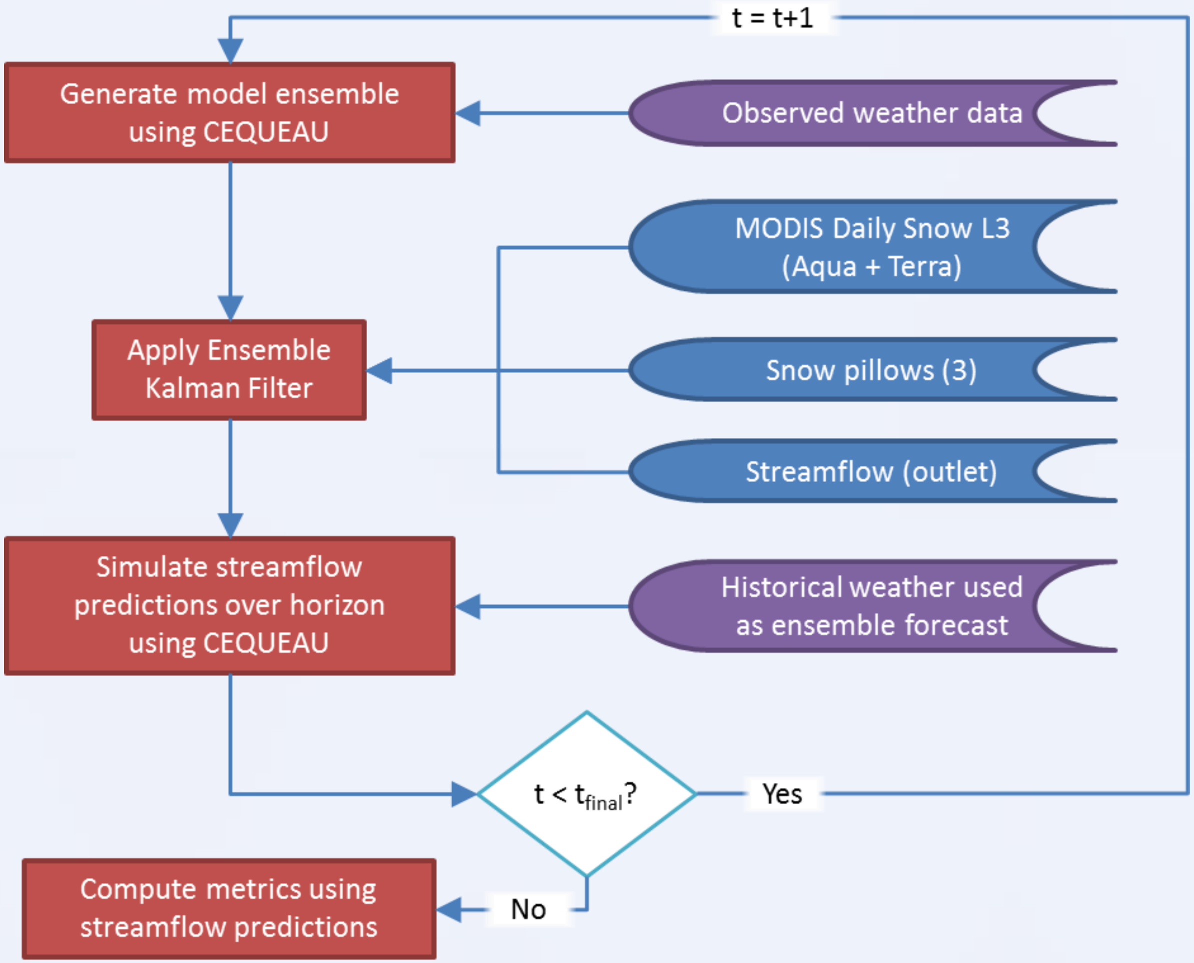


Morin & Paquet (2007)

Ultimately what we want

- Compare streamflow predictions via data assimilation (EnKF) of :
  - Streamflows from hydrometric station
  - Snow water equivalent (SWE) from snow pillows
  - Global snow cover extent from MODIS sensors
  - Combination of each

Data assimilation methodology



Questions to resolves

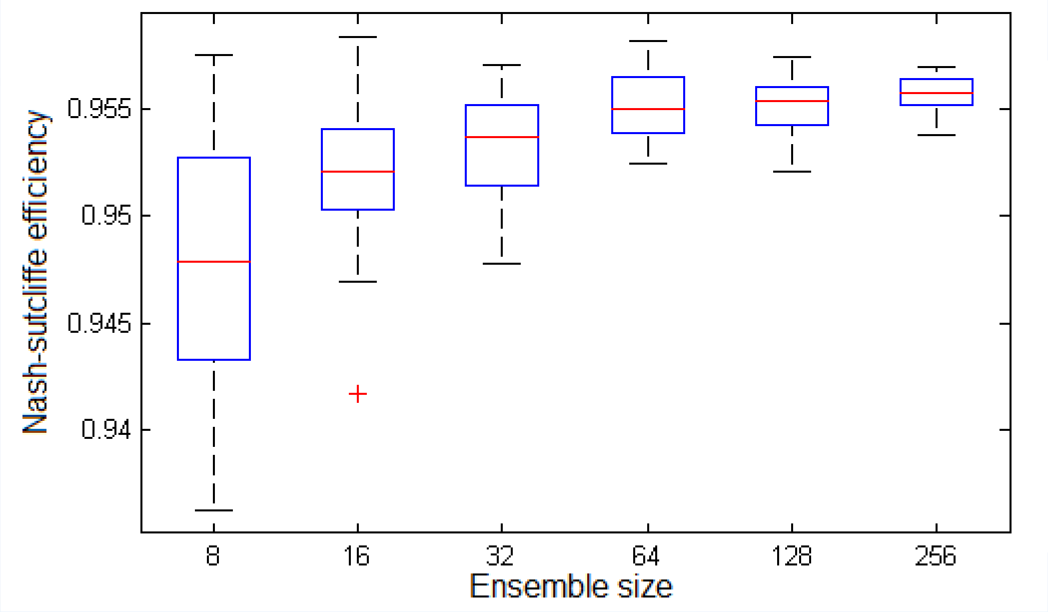
- How do we fix the ensemble size?

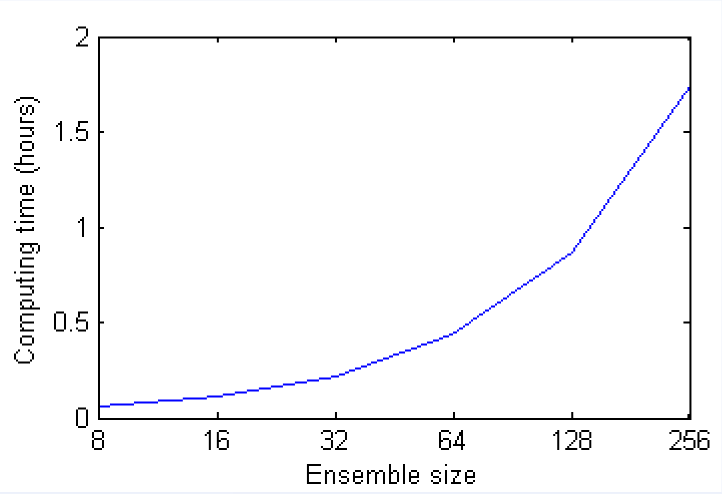
- How do we configure our state vector
  - Which variables?
  - Which parameters, if any?
  - Do we localize correlations between variables?

- How do we make sure observation and model errors are ok?

First, a synthetic experiment

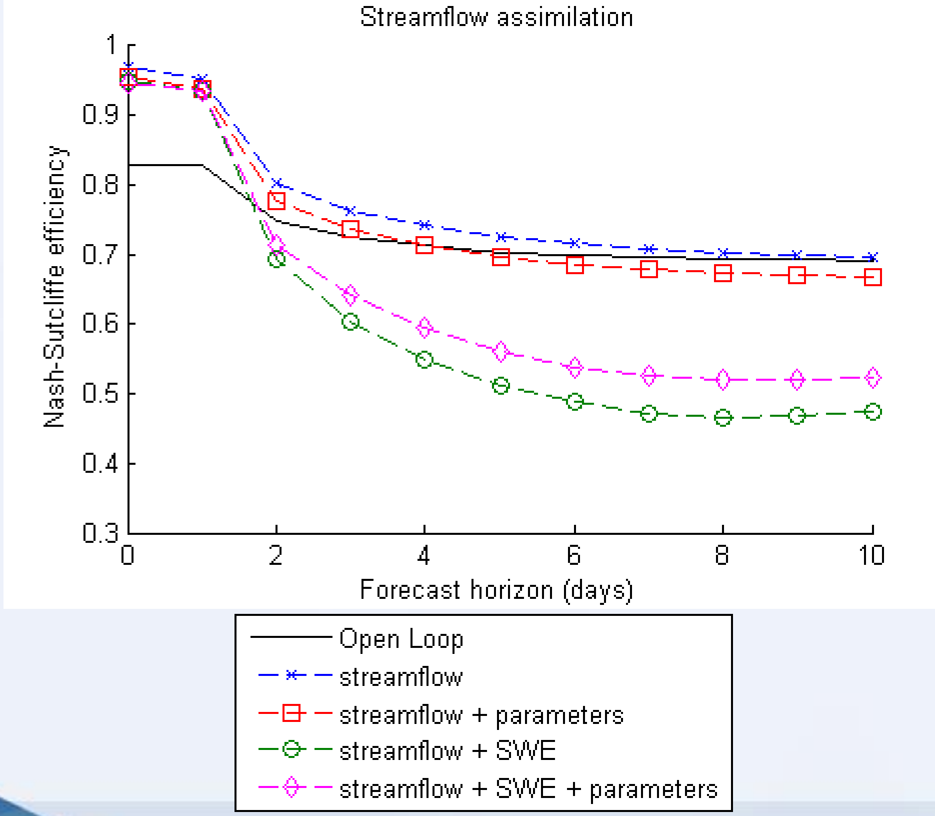
- Ensemble size sensitivity analysis
  - Start with “most complicated case” for conservative estimate
  - Compare variance of metrics vs computing time

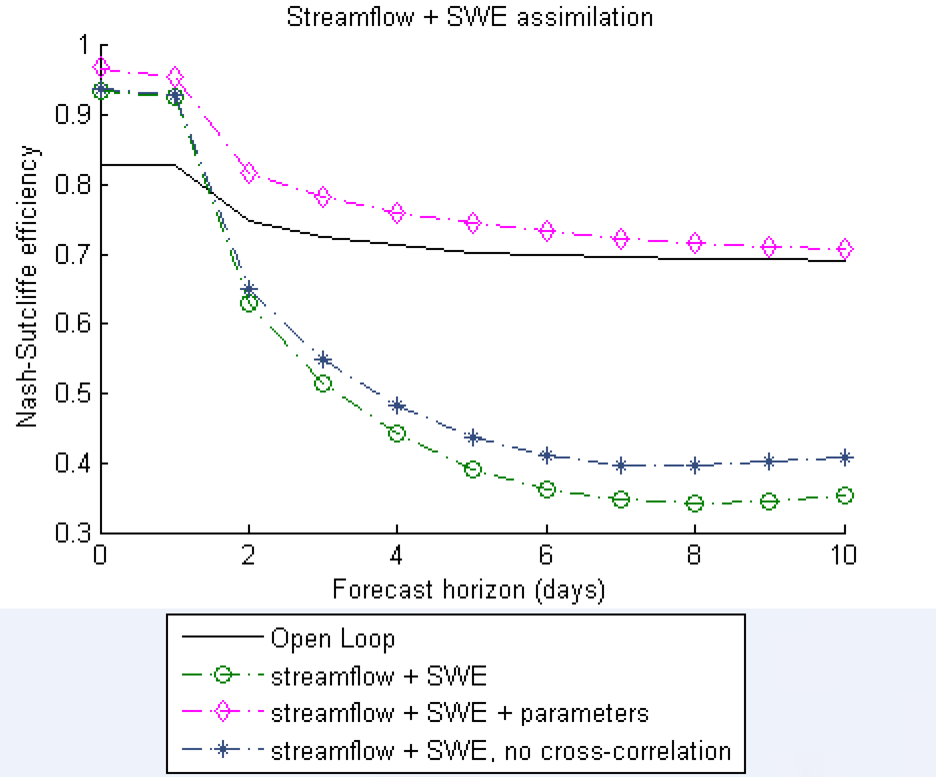




First, a synthetic experiment

- State vector configuration analysis





Before using real data

- How to specify model and observation errors :
  - Many degrees of freedom, sensitivity analysis of errors possible but tricky
  - Adaptive approach based on analysis error statistics promising (ex : Desroziers *et al.*, 2005)
  - Automatic calibration of errors using such post-assimilation diagnostics (Trudel *et al.*, 2014)

Conclusion

- Recommendations for multivariate DA using EnKF
- Fixing the ensemble size
  - Sensitivity analysis, start with most complicated case for conservative estimate of ideal size
- Configuring state vector
  - Sensitivity analysis, try adding and removing variables/parameters to find best scenario
- Specifying observation and model errors
  - Work in progress

Research supported by :

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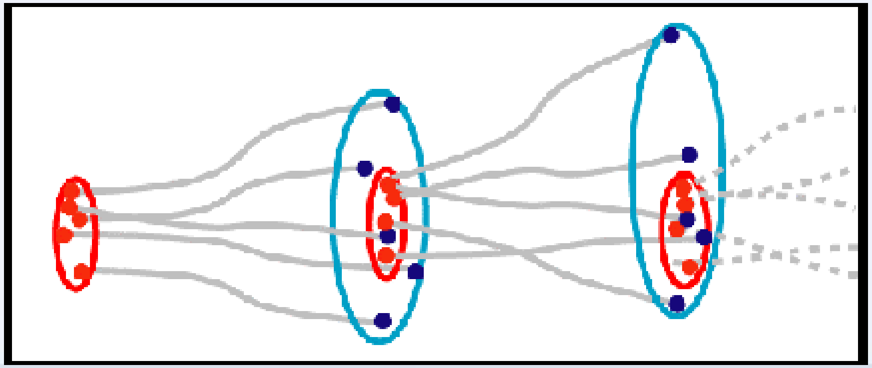
RioTintoAlcan

Thank you for your attention

The Ensemble Kalman Filter (EnKF)

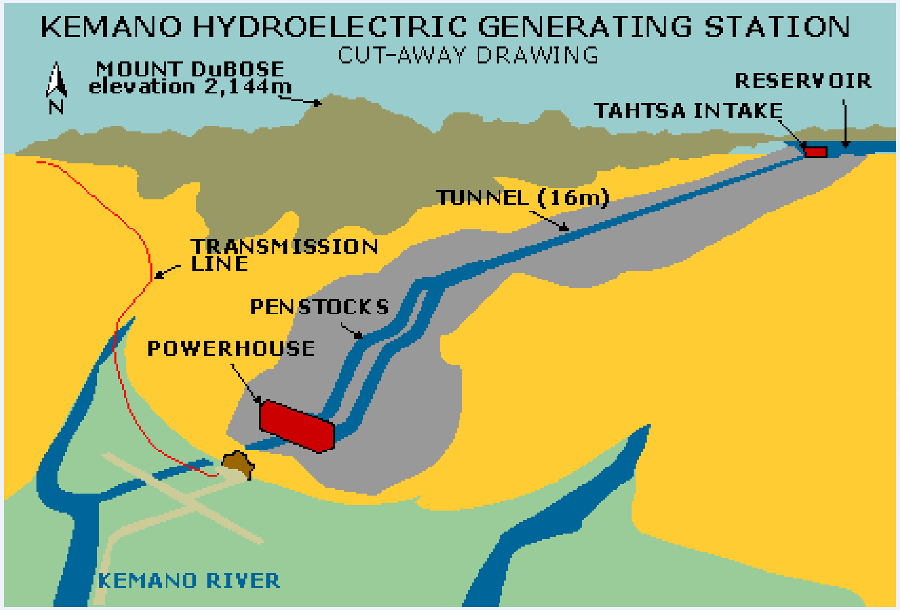
- Model ensemble propagated (no need to linearize)
- State of ensemble updated via model and observation covariance matrices
- Covariance matrices computed from ensemble

$$x_a = x_b + BH^T\left(HBH^T + R\right)^{-1}(y - Hx_b)$$



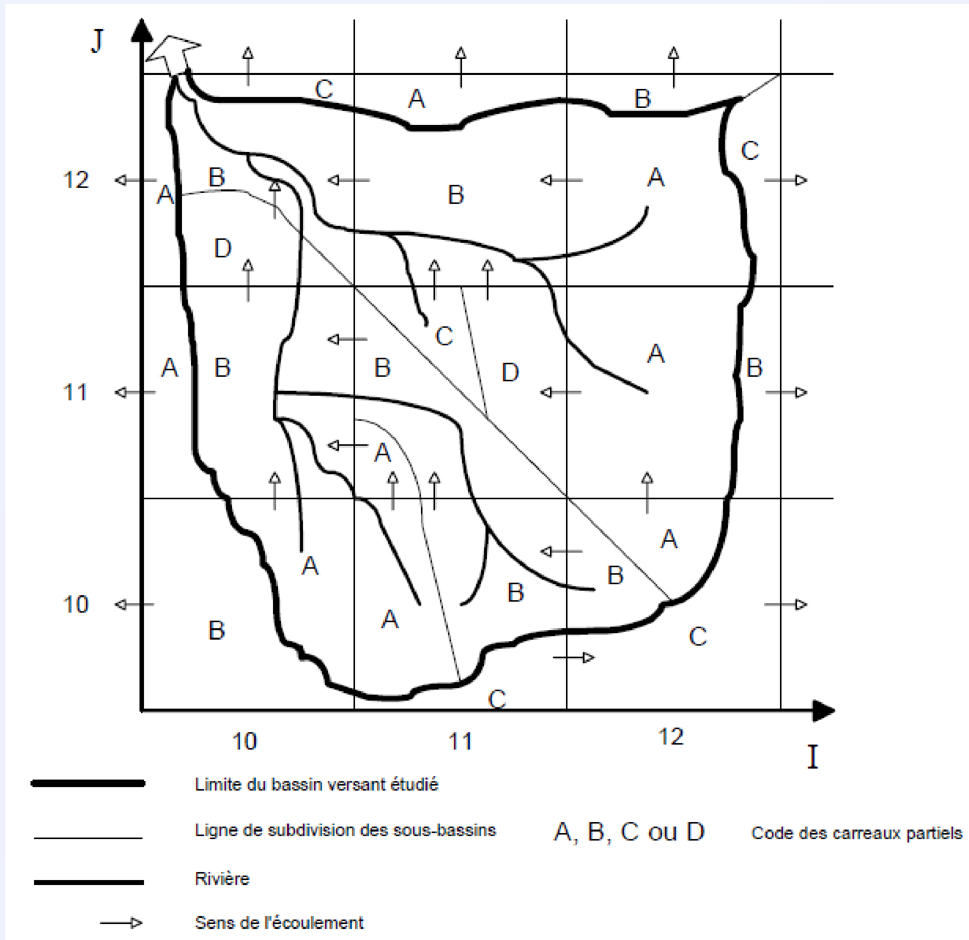
Kemano hydroelectric station

- Tunnel runs 16 km through Coast mountains
- Penstocks have an 800- meter vertical drop



http://www.riotintoalcaninbc.com/performance-reports/1999/pages/aibc-power.html

CEQUEAU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I
Limite du bassin versant étudié
Ligne de subdivision des sous-bassins
A, B, C ou D
Code des carreaux partiels
Rivière
Sens de l'écoulement