AOSC 615 Project: Exercise & Project Description

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Project Summary
- Project I: Framework of Data Assimilation System
  Observing System Simulation Experiments (OSSEs)
- Nature run
- Assimilation Window
  - Timing: 3D with 3D FGAT & 4D in mind
  - Model forecast
  - Observations

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AOSC 615 Project: Framework

- Building of a data assimilation system
- Flexible for implementing several data assimilation methods
- Validation & verification are crucial

**Step 1. Model Forecast**
Forecast (=background): $x^b_k$

$$x^b_k = m_{k,k-1}(x^b_{k-1}) : x \in \mathbb{R}^N$$

**Step 2. Analysis**
(Integration of $x^b_k$ and $y^o_k$)

Analysis: $x^a_k = \text{func of } x^b_k$ and $y^o_k$

**Observation**
Measurement: $y^o_k$

$$y^o_k = h_{o}(x^o) : y^o \in \mathbb{R}^N$$

**Nature**
Truth: $x^t_k$

$$x^t_k = m_{k,k-1}(x^t_{k-1}) : x \in \mathbb{R}^N$$

**Diagnostic Module:**
Validation of codes
Analysis of the results
Project I. Framework of Data Assimilation

Part I. Choice of model & language
Due: 2016.02.04 5pm by email

• Choice of the model
  • Class recommendations: either one of
    – Lorenz 3 model
    – Lorenz 40 model
    – Lorenz 960 model
    – Point vortex model
  • Your choice
    – Requirements: reasoning & references
    – Subject to approval based on practicality for the projects

• Choice of language
  • Any scientific computing language – keep in mind that you will need to visualize your results

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AOSC615: 16.02.02

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Project I. Framework of Data Assimilation

Part II. Report & code
Due: 2016.02.11 5pm by email

A. Nature run:
Output $X^t$

$X^t = \{x^t_0, \ldots, x^t_K\}$ with $x^t_k = m_{k,k-1}(x^t_{k-1})$

» Spin-up may be needed
» Single $X^t$ for all the projects, for comparison purposes

B. Observations (2 separate module) by reading $X^t$ or $X^o$: Output $X^o$ & $Y^o$
1. Complete set with uncorrelated obs error:
   $X^o = \{x^o_0, \ldots, x^o_K\}$ with $x^o_k = x^t_k + \epsilon^o_k, \epsilon^o_k \sim N(0, (\sigma^o)^2 I_{NxN})$
2. Partial observation using linear & time-independent $h(x) = Hx$:
   $Y^o = \{y^o_0, \ldots, y^o_K\}$ with $y^o_k = Hx^o_k$

» Allow flexibility for the choice of
  – $\sigma^o$: variance of real observation error
  – $H$: Observation operator
Project I. Framework of Data Assimilation

C. Basic data assimilation framework by reading $R^{o}$ and $y^{o}_k$:

Output $X^b=\{x^b_1, ..., x^b_K\}$ & $X^a=\{x^a_1, ..., x^a_K\}$

Initialization: $x^a_0 = x^b_0 + e^a_0$

Step 1. Forecast given previous analysis

\[ x^b_k = m_{k,k-1}(x^a_{k-1}) \]

Step 2. Analysis

1. Read in background/forecast $x^b_k$
2. Read in observation $y^o_k$
3. Make observation of the forecast $y^o_k = H x^b_k$
4. Compute the difference $d_{o}^o_k = y^o_k - y^b_k$
5. Reinitialize without assimilation $x^a_k = x^b_k$

$R^{o}$ (obs error covariance for $y^o_k$) may be be different from $R^{io}$ & does not play a role in this project

D. Diagnostics based on $x^i$, $x^o$, $y^o$, $X^o$, and $X^a$ along with $H$, $R^{io}$, and $R^{o}$

1. Validation (overall)
2. Testing of instability growth
3. Visualization