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Data Assimilation using Artificial Neural Networks for the global FSU atmospheric model

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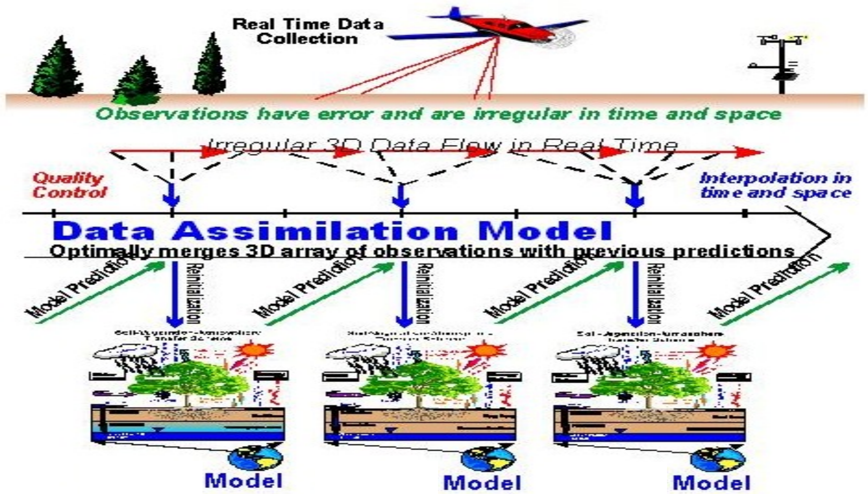
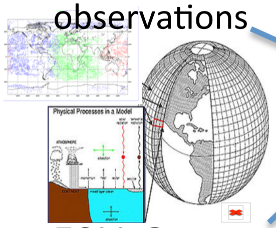
Atmospheric Data Assimilation is a fusion of atmospheric observation data and mathematical model to improve the weather forecast to generate an analysis (initial condition to model).

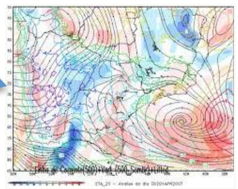


synthetic observations



global analysis = initial condition

LETKF



FSU General Circulation Model

FSUGSM (Florida State University global spectral model) is the model forecast implemented with LETKF data assimilation.

The vertical coordinates are defined on sigma surfaces, the horizontal coordinates are latitude and longitude on a Gaussian grid in real space. The spectral model, used in this study, runs with T63 horizontal resolution (approximately 1.875°) and 27 unevenly spaced vertical levels. (~ regular grid 96 x 192 x 27)

The data assimilation system implemented here is the **Local Ensemble Transform Kalman Filter (LETKF**) where:

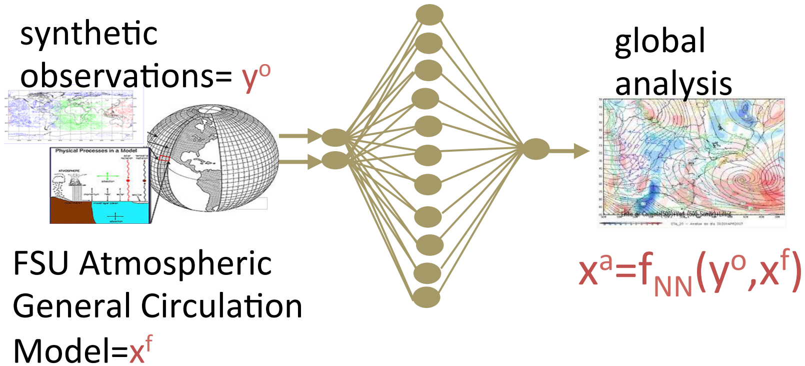
a) Forecast step with k ensemble members: Each member of the ensemble and forecasting mean $\overline{x^f} = k^{-1}\sum_{i=1}^{k} x^f(i)$

b) Analysis step determines an analysis to each member of ensemble:

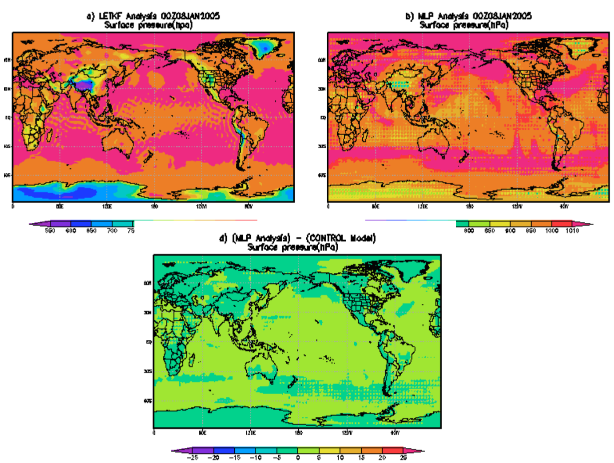
$$x_n^a = \overline{x_n^f} + P_n^f H_n^T [H_n P_n^f H_n^T + R]^{-1}(x_{n+1}^{obs} - H\overline{x_n^f})$$

This paper shows the results of a data assimilation technique using artificial neural networks (ANN) to obtain the initial condition to FSUGSM emulating LETKF behavior, with better computational performance.

The ANN data assimilation scheme using Multilayer Perceptron (MLP) topology has inputs: observations y^o and a recent forecast x^f and the output x^a is the analysis like result of a function f_{NN}.



The back-propagation training of 148 MLPs converge at root mean square error at 10^{-5}. The results shows MLP-DA does not emulate the LETKF analysis. We run the data assimilation cycle for one month, from 01/Jan/2005 to 31/Jan2005, in 124 data assimilation cycle and the computer performance was 24 times faster than LETKF data assimilation.



Global Surface Pressure field (hPa) fo MLP-DA to 08/Jan/2005-12 UTC. a) Letkf analysis b) MLP-DA analysis c) differences between MLP analysis and control model

Execution of 124 cycles	MLP-DA (hour:min:sec)	LETKF (hour:min:sec)
Analisys time	00:04:12	15:12:08
Ensemble time	00:00:00	09:26:44
Pararel Model time	01:10:30	00:00:00
Total time	01:15:42	24:38:52

Table – Computer Performance for 124 DA cycles to 01/01/2005- 00 UTC to 31/01/2005- 18 UTC.