The SANGOMA Tools for Data Assimilation

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SANGOMA

Stochastic Assimilation for the Next Generation Ocean Model Applications

Introduction

The EU-funded project SANGOMA – Stochastic Assimilation of the Next Generation Ocean Model Applications – provides new developments in data assimilation to ensure that future operational systems can make use of state-of-the-art data-assimilation methods and related analysis tools. One task of SANGOMA is to develop a library of shared tools for data assimilation with a uniform interface so that the tools are easily usable from different data assimilation systems.

DIAGNOSTIC TOOLS

The diagnostic tools provide functionality to analyze the performance of an ensemble assimilation system. Available tools include:

sangoma_ComputeHistogram
: Compute ensemble rank histograms (Fig. 1)

sangoma_ComputeEnsStats
: Compute higher-order ensemble statistics (Fig. 2)

sangoma_ComputeRCRV
: Compute bias and dispersion of the reduced centered random variable (RCRV)

sangoma_ComputeCRPS
: Compute continuous ranked probability score (CRPS) and decompose it into reliability and resolution (Fig. 4)

sangoma_ComputeSenvitivity
: Compute sensitivity of a posterior mean to observations in a particle filter

sangoma_ComputeMutualInformation
: Compute mutual information in a particle filter

sangoma_ComputeRelativeEntropy
: Compute relative entropy in a particle filter

sangoma_ArM
: Calculate array modes and associated quantities to assess the performance of an observational array

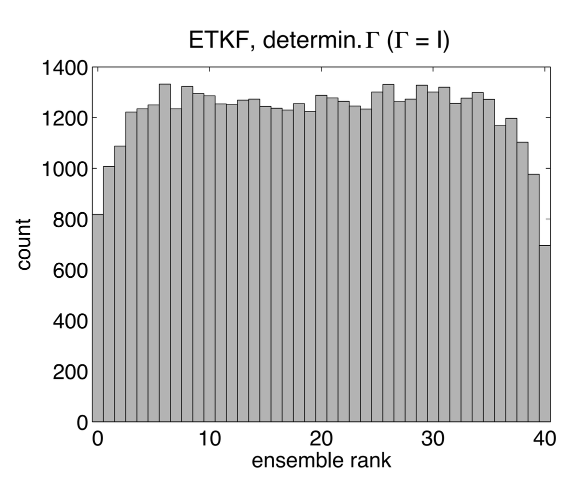

Fig. 1: Example of an ensemble rank histogram used to access the ensemble quality. The rank histogram information is computed using the tool **sangoma_ComputeHistogram**.

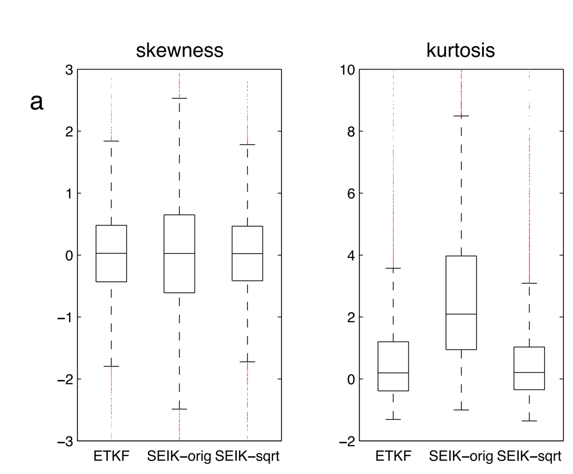

Fig. 2: Example of ensemble skewness and kurtosis (3rd and 4th moment of the ensemble statistics) for three different filter configurations. The moments are computed using **sangoma_ComputeEnsStats**.

SANGOMA tools

For the SANGOMA tools we consider 5 categories, which are described below. The tools are implemented in Fortran and as scripts for Matlab or Octave. The project deliverables, which are available on the project website, provide an extensive documentation of the tools. The tools and application examples can be downloaded at

Download: http://www.data-assimilation.net/Tools

UTILITY TOOLS

The utility tools provide additional functionalities for data assimilation systems like:

sangoma_ComputePOD
: Compute dominant modes of proper orthogonal decomposition from ensemble of snapshots

sangoma_Costgrad
: Compute values of an objective function and its gradient using POD information

hfradar_extractf
: Observation operator for HF radar surface currents (Fig. 3)

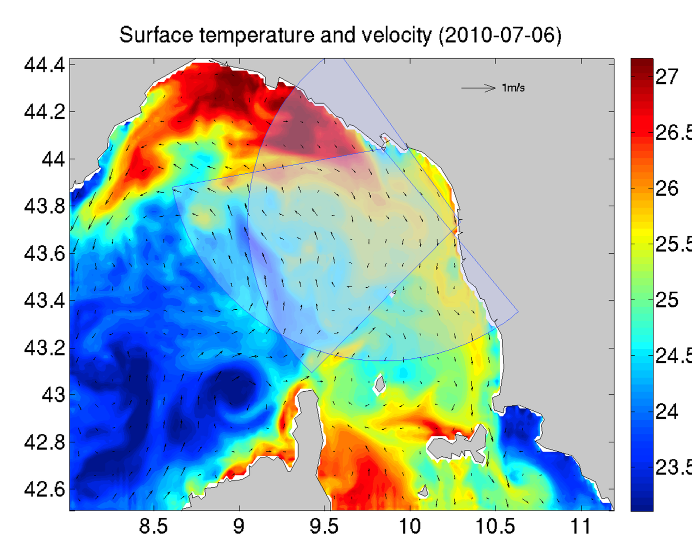

Fig. 3: Example of a HF-Radar setup in the Ligurian Sea. **hfradar_extractf** provides an observation operator for HF radar surface currents.

ANALYSIS STEPS

Typically, the different tool boxes for data assimilation already include analysis steps. However, the SANGOMA tools also provide a set of ensemble-based Kalman filters.

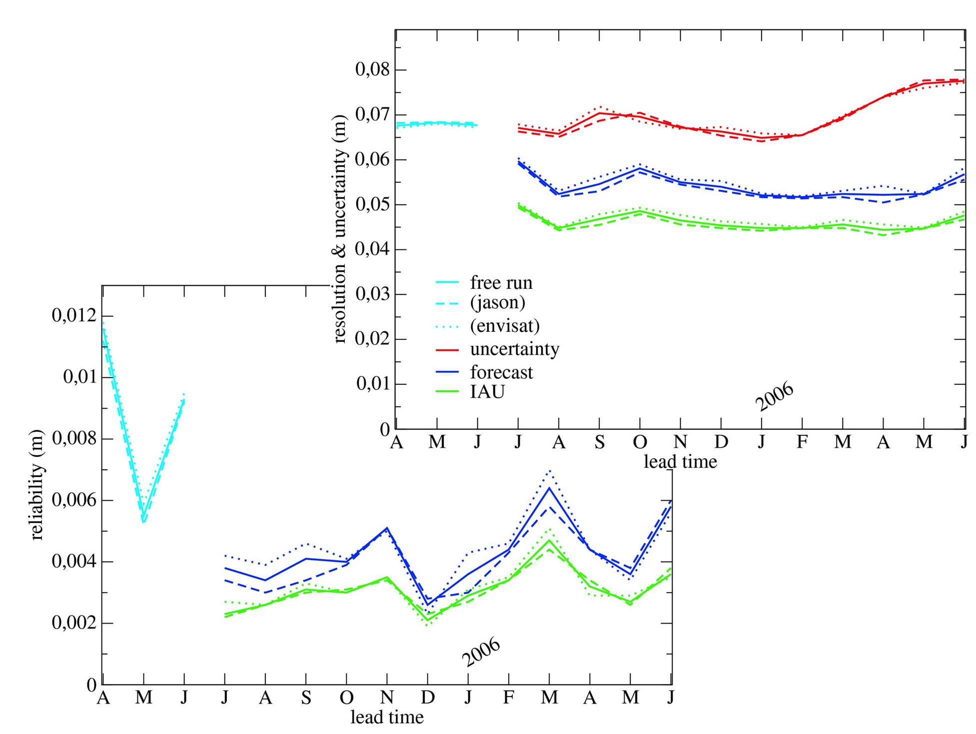

Fig. 4: Application example for **sangoma_ComputeCRPS**: Reliability (bottom) and resolution (top) components of the CRPS for the SSH from an example of assimilating satellite altimetry. The assimilation improves both components.

Your Feedback: Survey on Tools

The project members are working to implement further tools for a code release in fall 2015. We would like to hear your feedback on which tools are useful for you, especially for the diagnostic tools. Please complete our survey about your interest in tools at

Survey: http://www.data-assimilation.net

PERTURBATION TOOLS

The perturbation tools provide functions to generate perturbations with prescribed properties. They can be used to generate ensembles of model states or to perform perturbed ensemble integrations. Available are:

sangoma_EOFCovar
: Initialize a covariance matrix from decomposition of an ensemble into empirical orthogonal functions (EOFs)

sangoma_MVNormalize
: Compute a multivariate normalization of a state vector

sangoma_pseudornd2D
: Generate random fields with given correlation length from transformation into frequency space

Weakly Constrained Ensemble Perturbations
: Generate ensemble perturbations satisfying a linear constraint (Fig. 5)

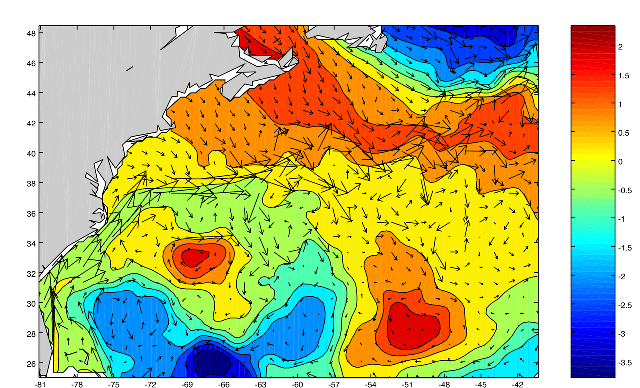

Fig. 5: Example of the realization of a random field constrained by the advection field. Such random fields can be computed using the tool for **weakly constrained ensemble perturbations**.

TRANSFORMATION TOOLS

Assimilation algorithms that base on the Kalman filter assume Gaussian distributions for optimality. The tools provide functionality to perform transformations that improve the performance with non-Gaussian distributions:

Empirical Gaussian Anamorphosis
: Determine the empirical transformation function to transform the distribution of a variable into a Gaussian distribution and perform the transformation (Fig. 6)

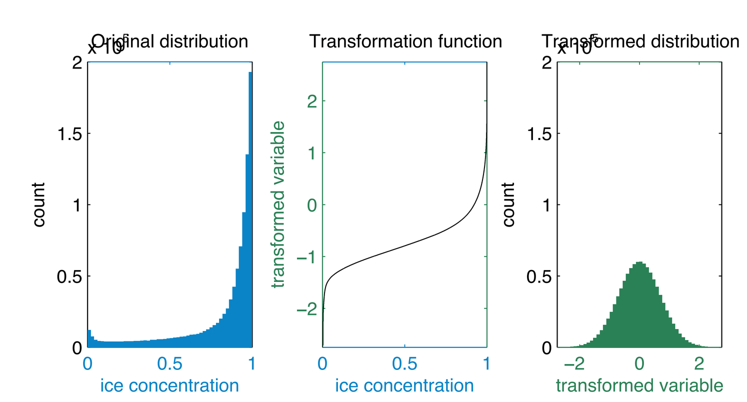

Fig. 6: Example of Gaussian anamorphosis. The sea-ice concentration exhibits a non-Gaussian distribution, which can be transformed into a Gaussian using the tool for **empirical Gaussian anamorphosis**.

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