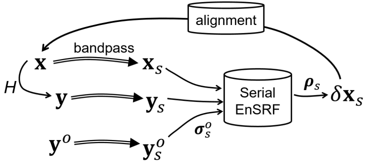

Recent developments of the multiscale alignment ensemble filtering framework

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In collaboration with Jeff Anderson and Laurent Bertino

NCDA internal seminar, Sep 29, 2022

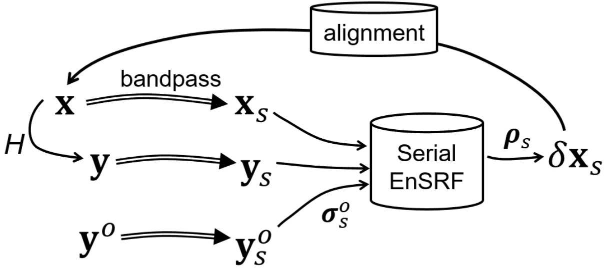
Motivation

Why do we need multiscale alignment DA?

- Localization: longer radius of influence for larger scales
- Alignment: use information at large scales to reduce position errors at small scales
- Observation information content: representation errors from scale mismatch
- Computational cost: multi-grid treatment, nested high-resolution domains, feature-based DA.

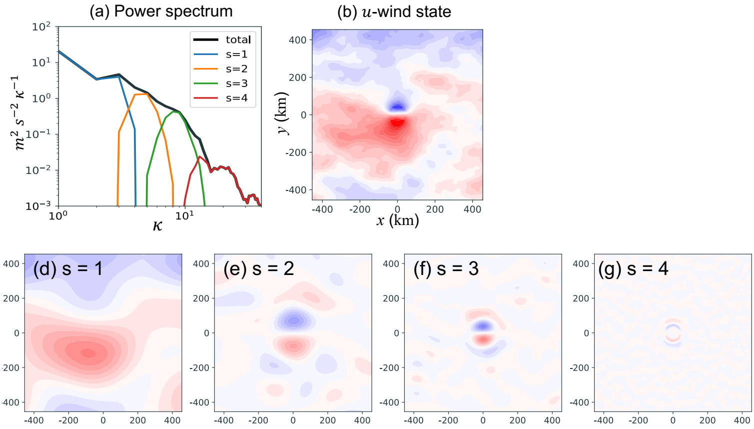
$\mathbf{x}$ is the model state, $\mathbf{y} = H(\mathbf{x})$ is the observation prior,
$\mathbf{y}^o$ is the real observation.

s indexes the scale components, $\mathbf{x}_s = \mathbf{F}_s\mathbf{x}$,
for $s = 1, \ldots, N_s$

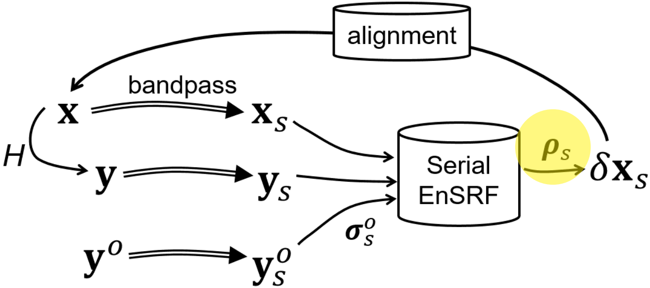


Scale components

Example: Vortex in the center of a square domain, with some background flow



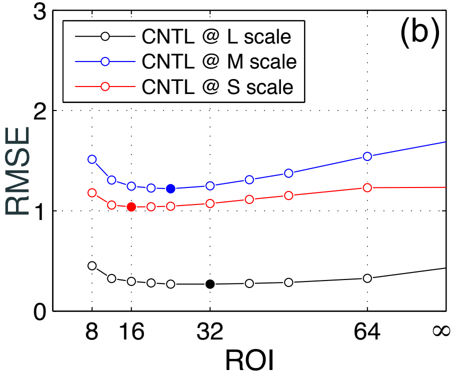
Localization: larger-scale component uses longer radius of influence



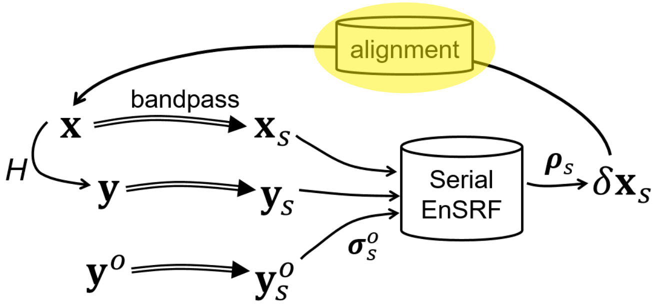
Scale-dependent localization

An earlier example from Ying et al. (2018)

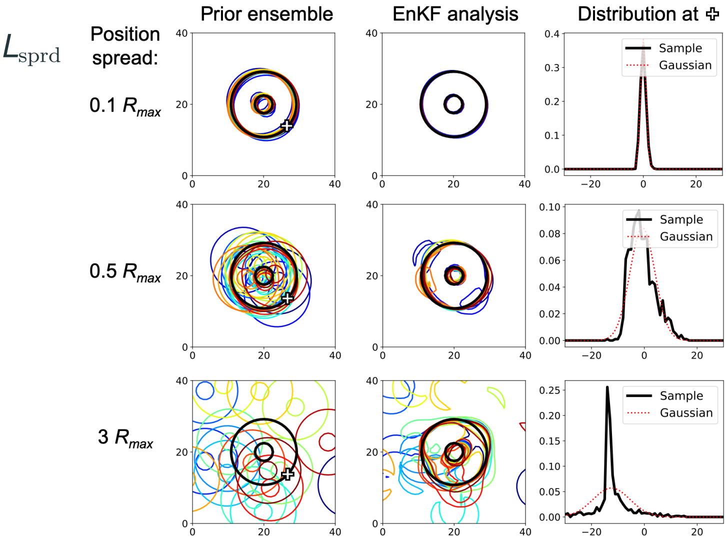
Past literature also showed that a multiscale localization scheme improves performance.



Alignment: nonlinearity (non-Gaussianity) due to position errors

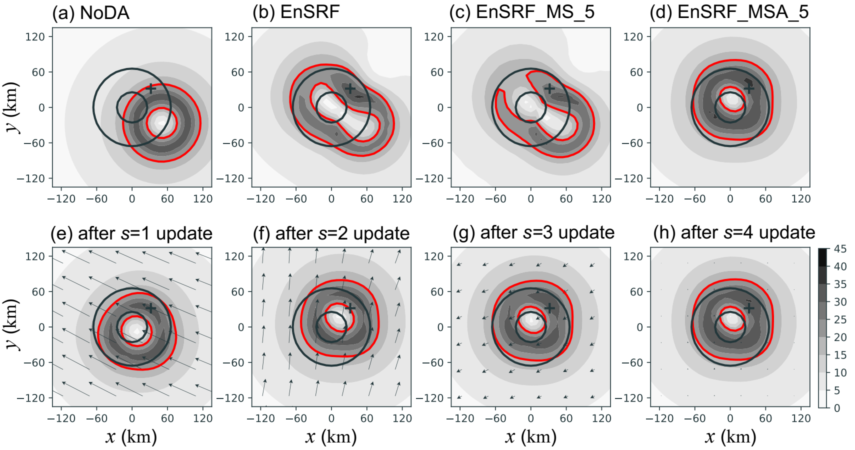


The displacement problem

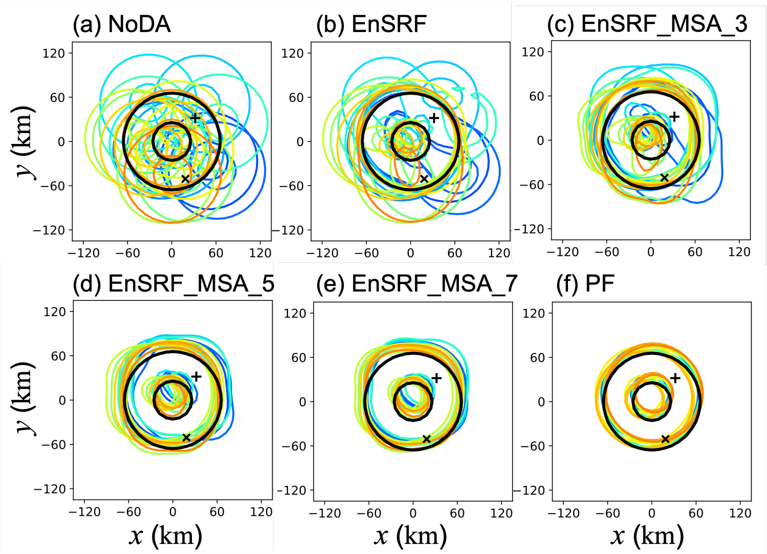


The multiscale alignment (MSA) method

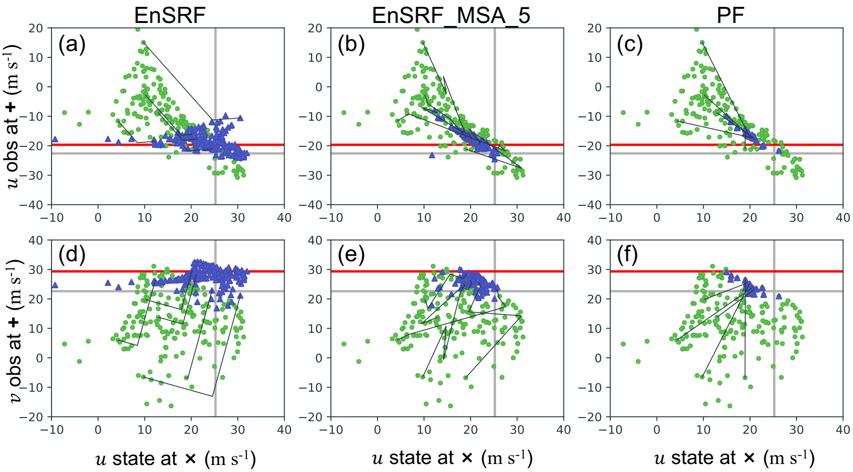
Example of MSA with N_s = 5 (Vortex wind speed plots)



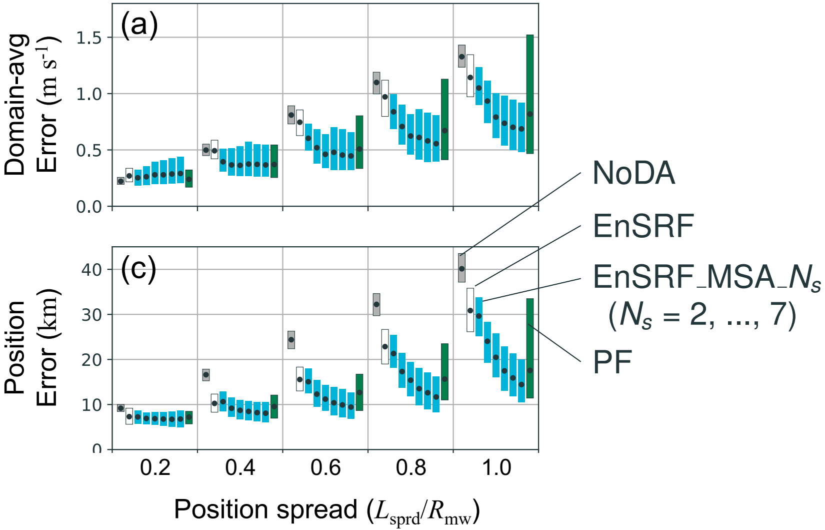
Asymptotic behavior of MSA



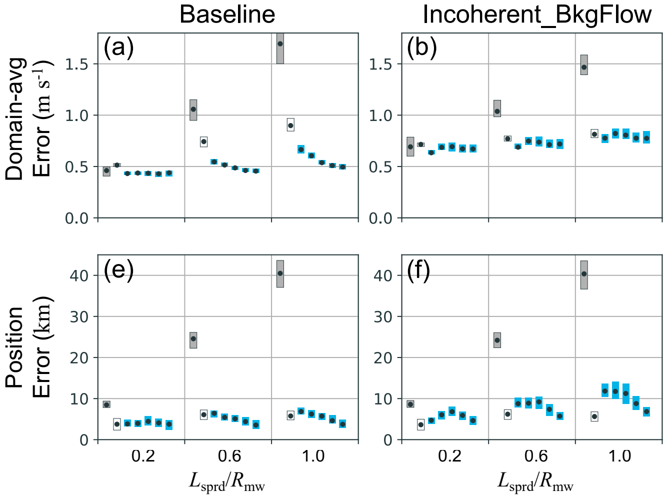
Asymptotic behavior of MSA



Asymptotic behavior of MSA



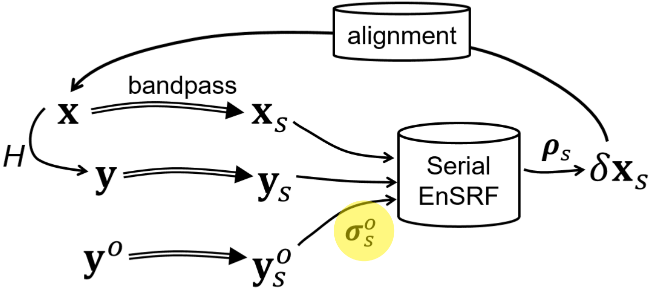
Issue: when background flow errors are incoherent with the vortex position errors (displace to different directions):



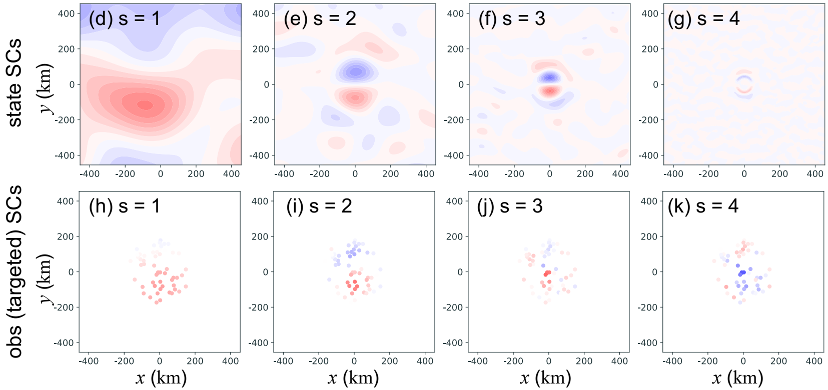
Other issues

- Alignment (warping the mesh with displacement vectors) distorts vortex structure
- Discrete representation of vortex peak wind speed (intensity), alignment "weakens" the vortex if wind maxima end up in between grid points – will go away using Lagrangian meshes.

Observations: inflation to remedy representation errors



Representation error due to scale mismatch



Assimilate observation SCs (a new MSA-O option):

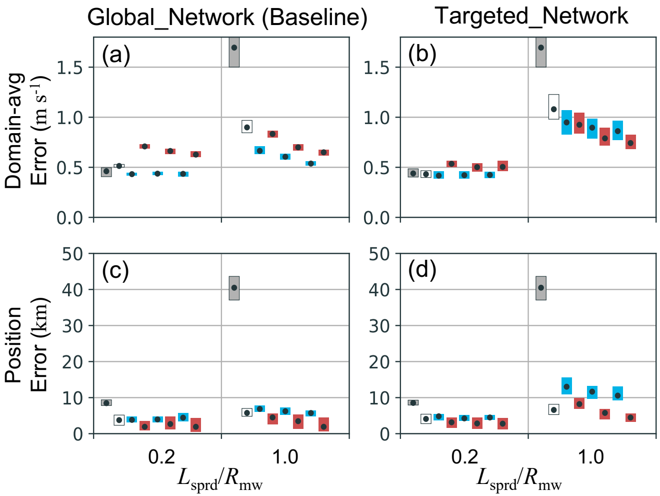
Better match with state SCs

Small scales are contaminated more by sampling noises.

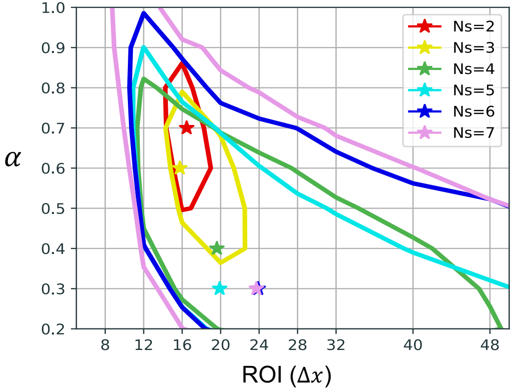
Global network: 1000 obs throughout domain

Targeted network: only 60 obs near the vortex

blue: MSA; red: MSA-O (for N_s=2,3,4 left to right)



Localization function $\boldsymbol{\rho}_s = \alpha_s \times \mathrm{GC}(\mathrm{ROI}_s)$
Tuning for best α_s and ROI_s for s=1 given different N_s.



Contour shows range of parameters that achieve within 1% of the best performance (lowest RMSE).

Concluding remarks

- The new “Multiscale Alignment” method was stress tested in a simple vortex model.
- Some improvements are made: observation SCs; localization tuning for cross-scale updates
- Deviation from coherence assumption: what to do?
- There are always more challenges in real application: 3D alignment, balance after update, time dimension, model doesn’t generate the feature at all...