GSI/EnKF Hybrid System (a high level overview)

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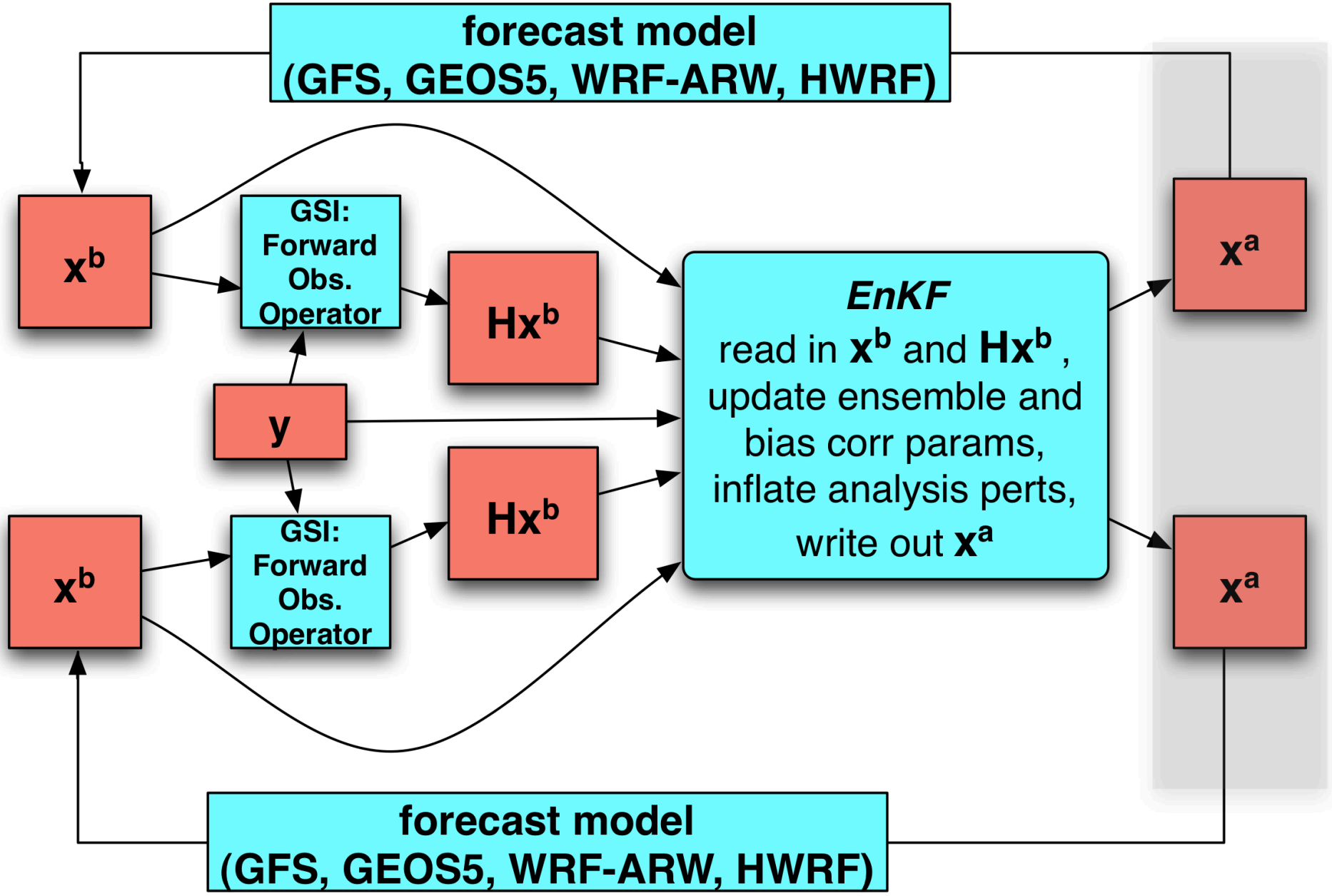
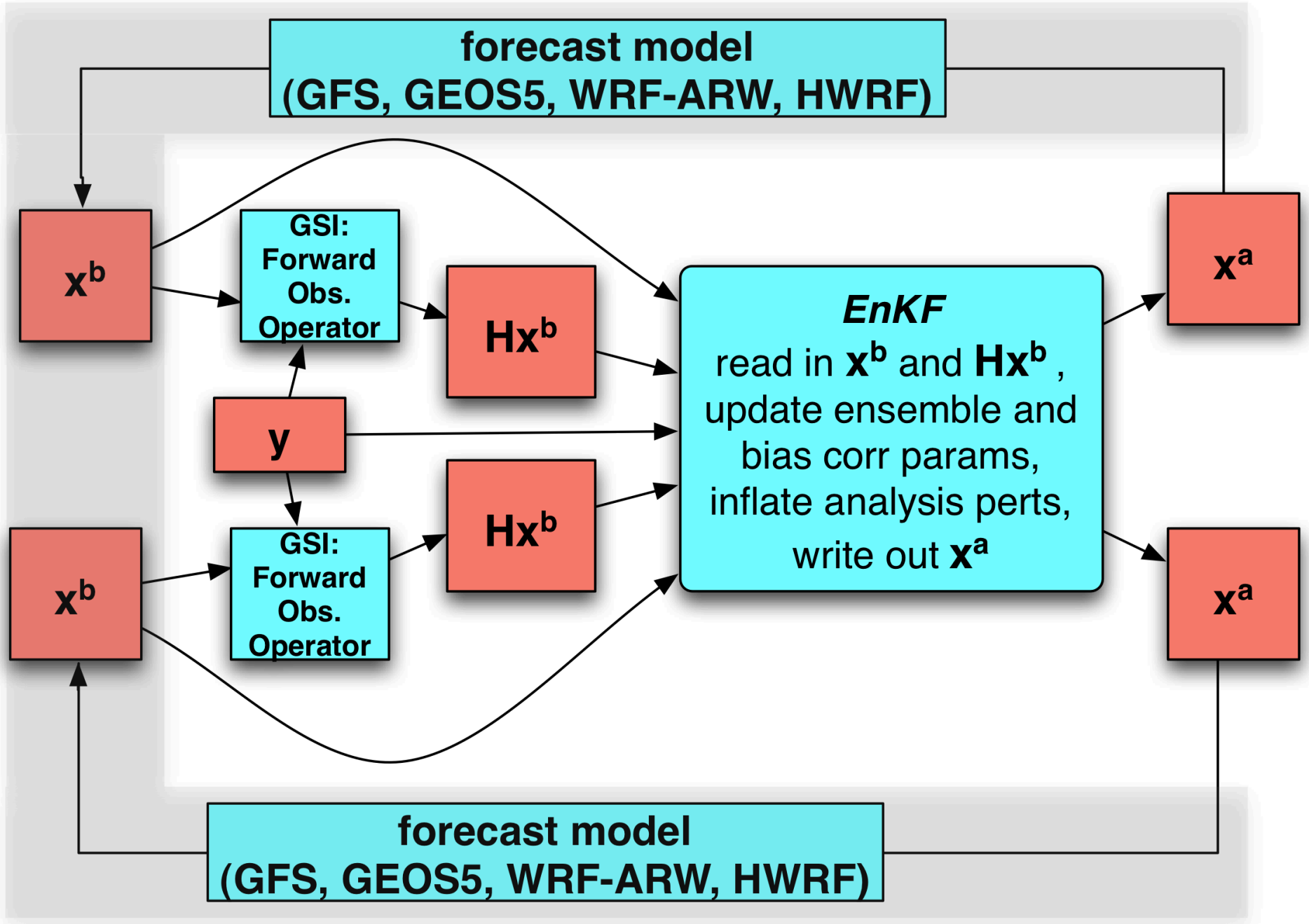
NOAA/ESRL/PSD

EnKF Schematic


forecast model
(GFS, GEOS5, WRF-ARW, HWRF)
x^b
GSI:
Forward
Obs.
Operator
Hx^b
y
Hx^b
x^b
GSI:
Forward
Obs.
Operator
EnKF
read in x^b and Hx^b ,
update ensemble and
bias corr params,
inflate analysis perts,
write out x^a
x^a
x^a
forecast model
(GFS, GEOS5, WRF-ARW, HWRF)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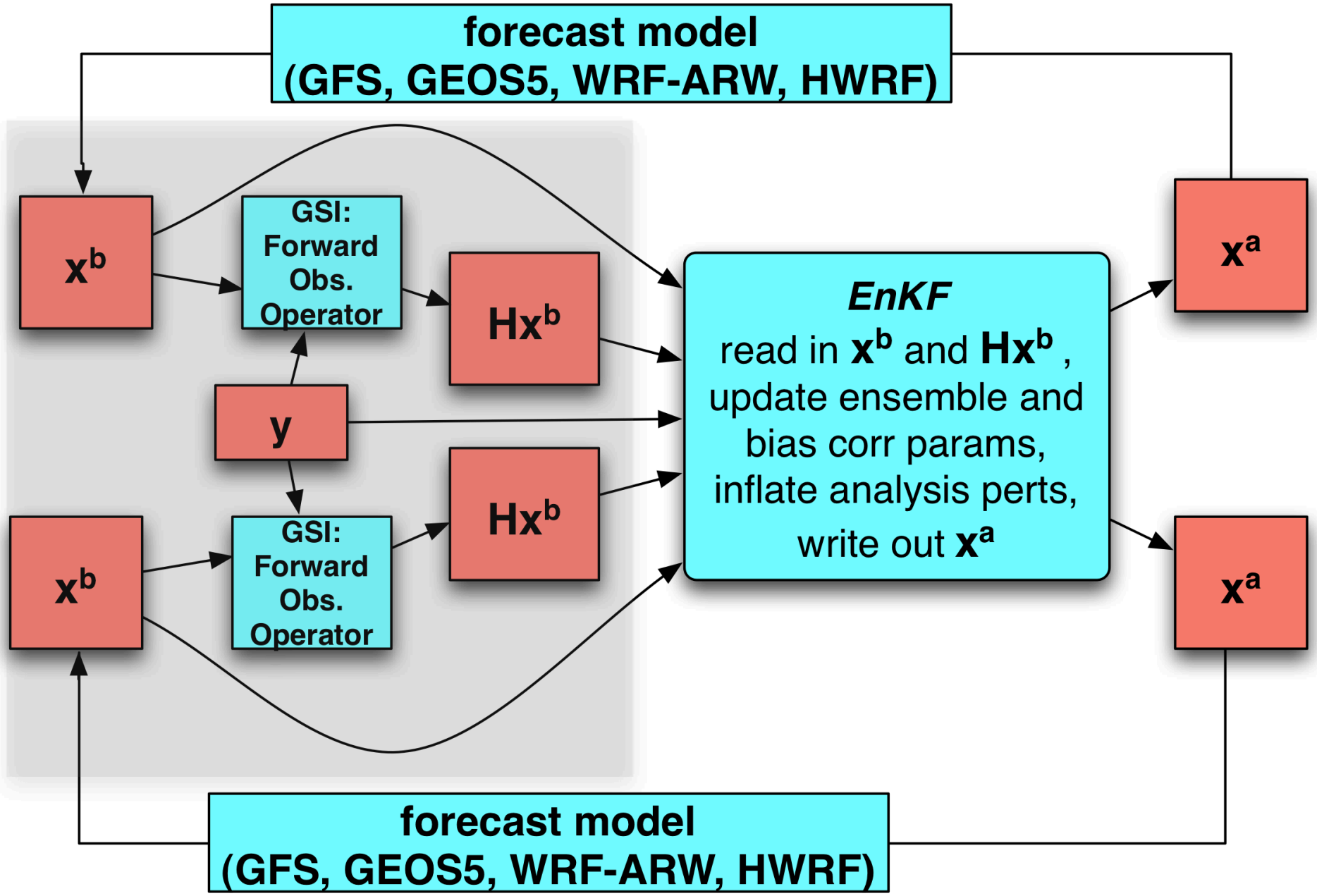
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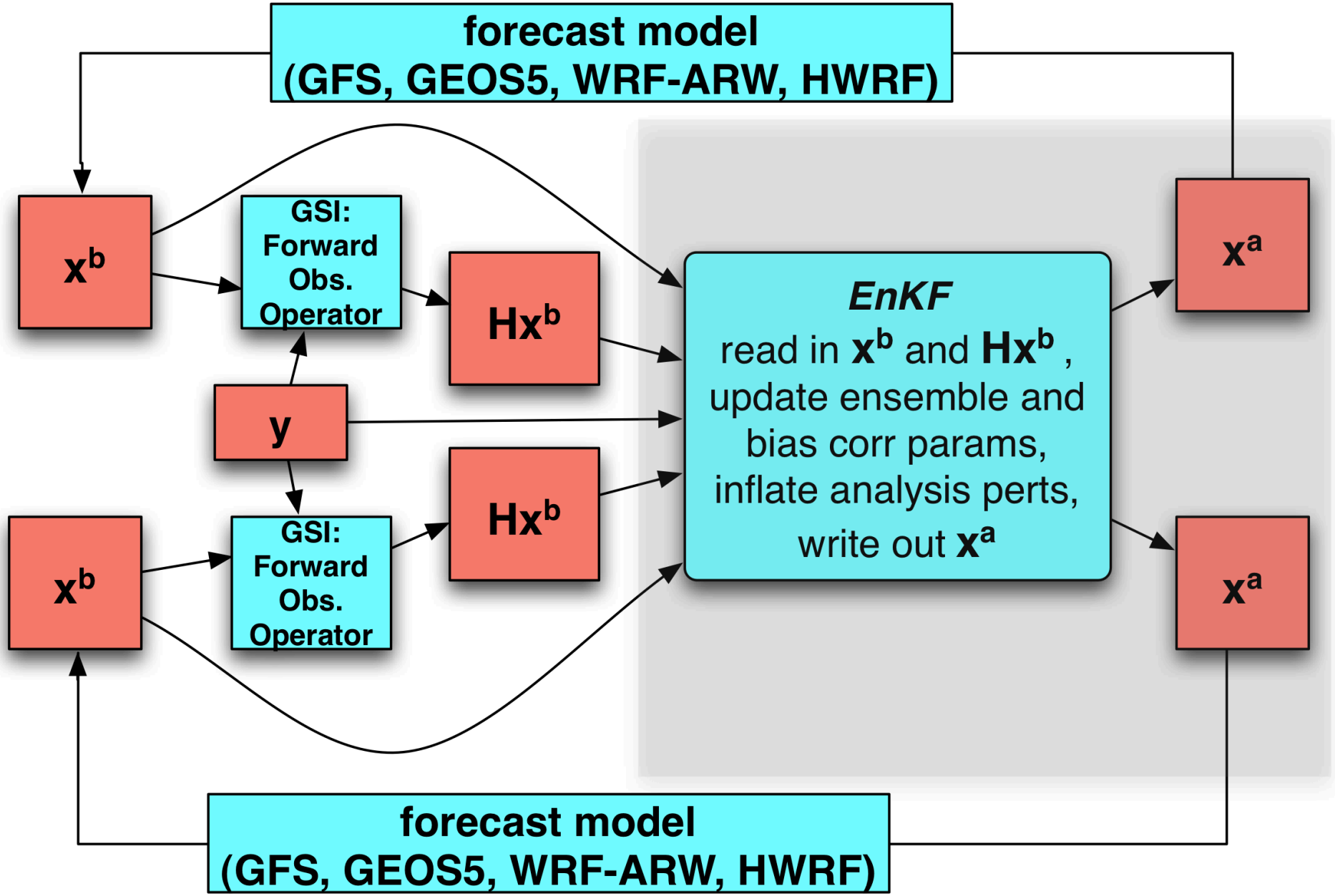
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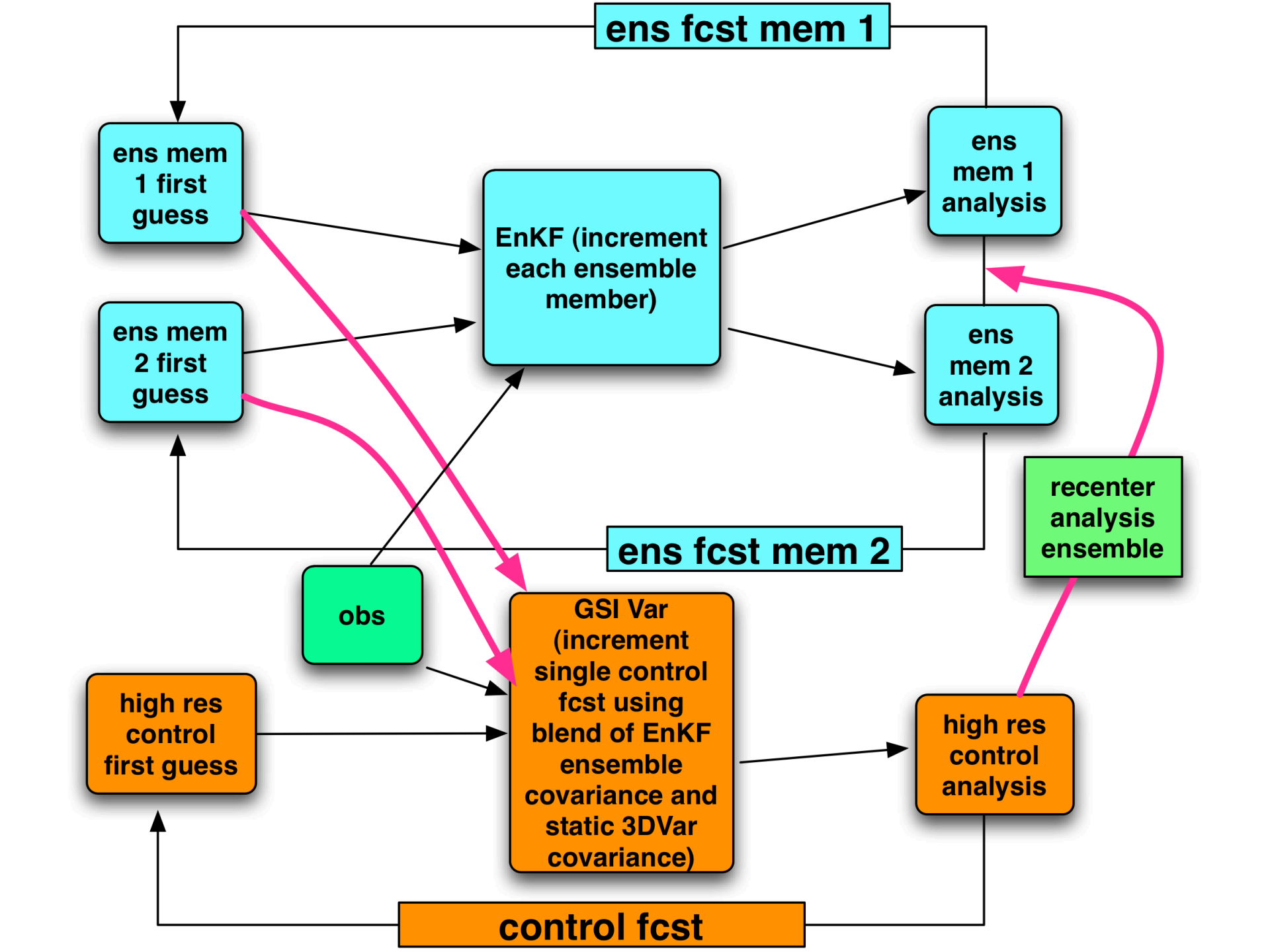
Coupling to GSI


ens fcst mem 1
ens mem 1 first guess
ens mem 2 first guess
EnKF (increment each ensemble member)
ens mem 1 analysis
ens mem 2 analysis
recenter analysis ensemble
ens fcst mem 2
obs
GSI Var (increment single control fcst using blend of EnKF ensemble covariance and static 3DVar covariance)
high res control first guess
high res control analysis
control fcst

Hybrid Variational-Ensemble

- Incorporate ensemble perturbations directly into variational cost function through extended control variable
  - Lorenc (2003), Buehner (2005), Wang et. al. (2007), etc.

$$J(\mathbf{x}'_{\mathrm{f}},\alpha)=\beta_{\mathrm{f}}\frac{1}{2}(\mathbf{x}'_{\mathrm{f}})^{\mathrm{T}}\mathbf{B}^{-1}(\mathbf{x}'_{\mathrm{f}})+\beta_{\mathrm{e}}\frac{1}{2}(\alpha)^{\mathrm{T}}\mathbf{L}^{-1}(\alpha)+\frac{1}{2}(\mathbf{y}'_{\mathrm{o}}-\mathbf{H}\mathbf{x}'_{\mathrm{t}})^{\mathrm{T}}\mathbf{R}^{-1}(\mathbf{y}'_{\mathrm{o}}-\mathbf{H}\mathbf{x}'_{\mathrm{t}})$$

$$\mathbf{x}'_{\mathrm{t}}=\mathbf{x}'_{\mathrm{f}}+\sum_{k=1}^{K}(\alpha_k\circ\mathbf{x}^{\mathrm{e}}_k)$$

$$\frac{1}{\beta_{\mathrm{f}}}+\frac{1}{\beta_{\mathrm{e}}}=1$$

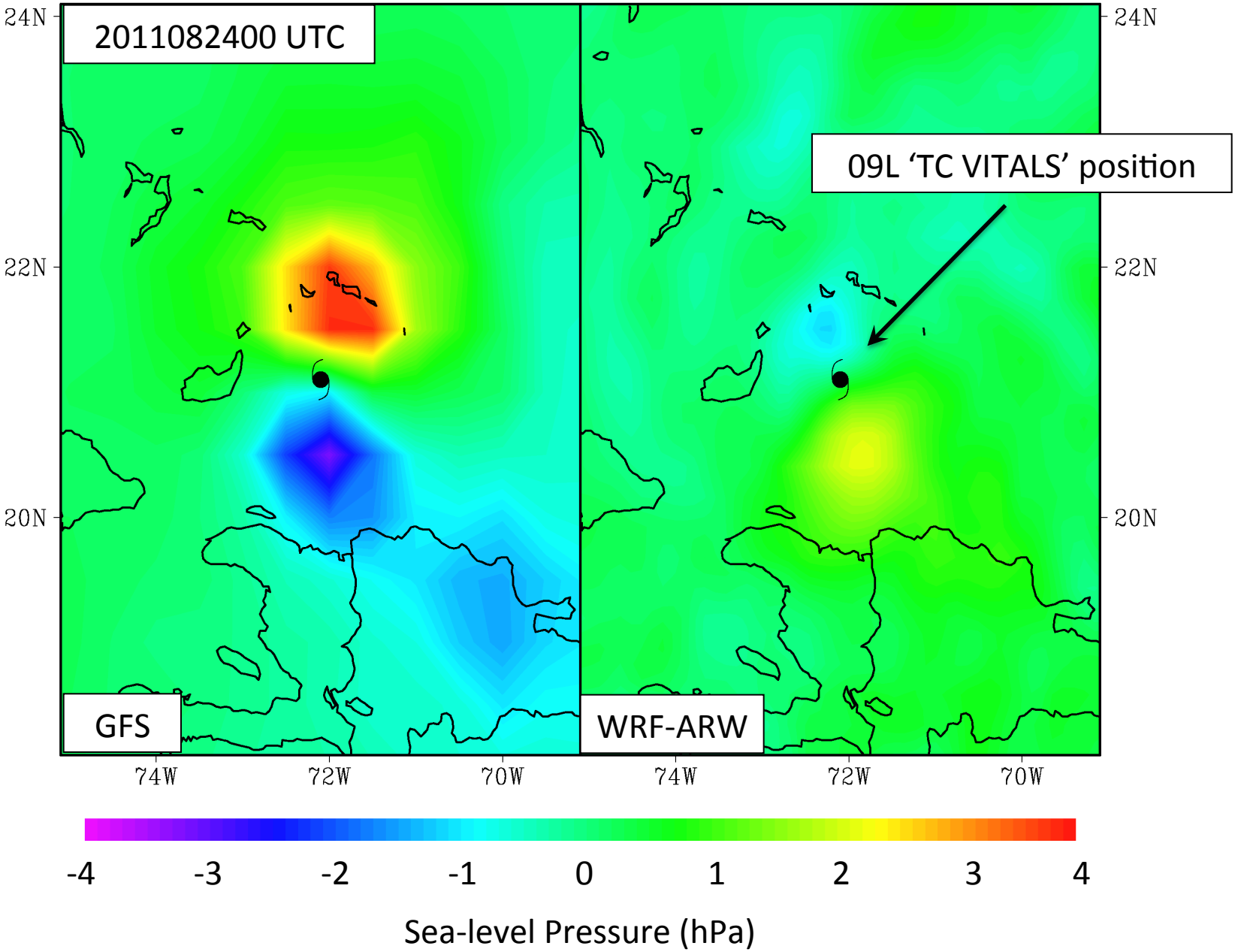
β_{f} & β_{e}: weighting coefficients for fixed and ensemble covariance respectively

$\mathbf{x}_{\mathrm{t}}$: (total increment) sum of increment from fixed/static **B** ($\mathbf{x}_{\mathrm{f}}$) and ensemble **B**

α_k: extended control variable; $\mathbf{x}^{\mathrm{e}}_k$:ensemble perturbation

L: correlation matrix [localization on ensemble perturbations]

Analysis Increments (EnKF Analysis – First Guess)



Plans/Issues

- Implement global version using GFS in NCEP operations Q3FY12.
- Regional (H)WRF version is being tested.
  - First as standalone EnKF
  - Then test use of ensemble covariances in GSI.
  - Initially a single (stationary) domain (27 km).
- Issues for regional (incomplete list)
  - Nesting strategy (how to deal with moving nests)
  - Continously cycling outer nest? Partial cycling?
  - Radiance/radar assimilation?
  - Model error representation (inflation, multi-model, multi-param, stochastic parameterization?).
- How to make sure system can accept advances from HFIP community?
  - System design (extensibility)?
  - Community support?