Local Ensemble Transform Kalman Filter assimilation scheme for the global atmospheric model SL-AV

Anna Shlyaeva, Mikhail Tolstykh, Vasily Mizyak
Hydrometeorological Research Centre of Russia

mailto: shlyaeva@gmail.com

Outline

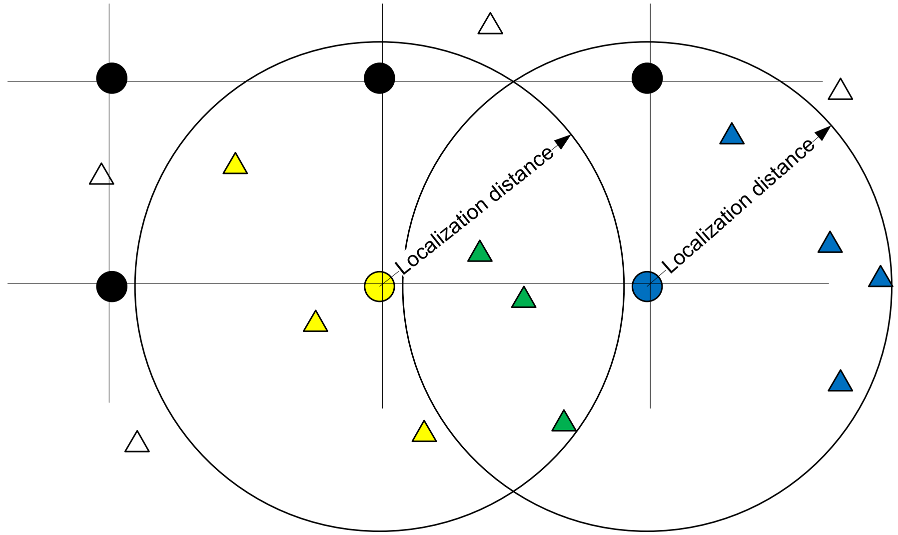
- Motivation
- Ensemble assimilation scheme
- SL-AV model
- Assimilation setup
- Current results
- Future plans

Motivation

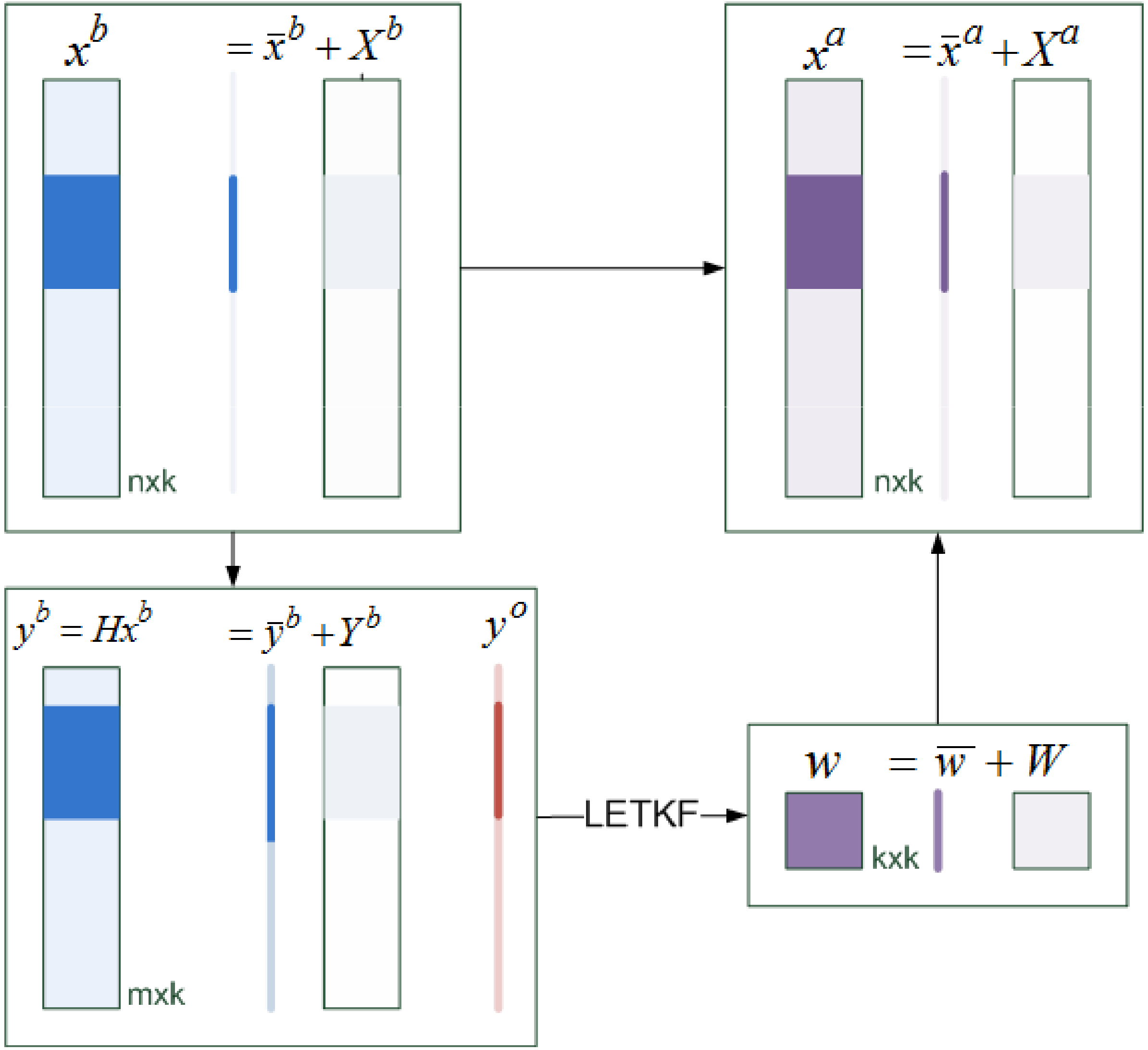
- Currently operational assimilation scheme: Optimal Interpolation
- Developments:
  - 3D-Var (Mikhail Tsyrulnikov et al), to be operational in the near future
  - LETKF for SL-AV model (Anna Shlyaeva, Mikhail Tolstykh, Vasily Mizyak)

Assimilation scheme: LETKF

- LETKF (Local Ensemble Transform Kalman Filter, [Hunt et al, 2007])
  - Local: Explicit localization: using observations within localization distance from the gridpoint.

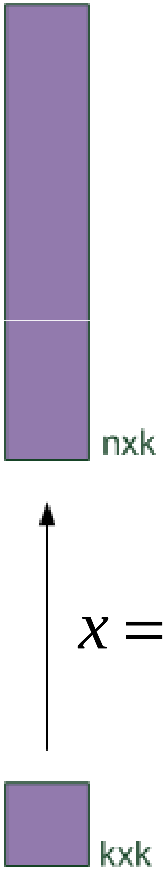


LETKF, Localization



LETKF, Transform

$$x \sim N\left(\overline{x}^b, P^b = X^b X^{bT}\right)$$



$$x = \overline{x}^b + X^b w$$

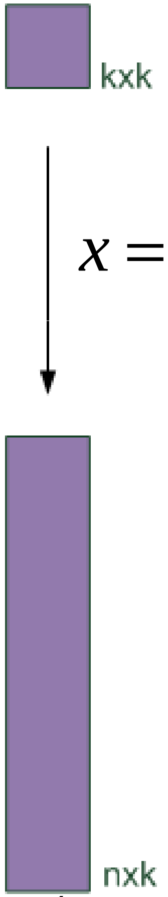
$$w \sim N\left(0, \widetilde{P}^b = (k-1)^{-1} I\right)$$

$$J(x) = \left(x - \overline{x}^b\right)^T \left(P^b\right)^{-1} \left(x - \overline{x}^b\right) +$$
$$\left(y^o - H(x)\right)^T R^{-1} \left(y^o - H(x)\right)$$

$$J(w) = (k-1) w^T w +$$
$$\left(y^o - \overline{y}^b - Y^b w\right)^T R^{-1} \left(y^o - \overline{y}^b - Y^b w\right)$$

LETKF, Transform

$$w \sim N\left(0, \tilde{P}^b = (k-1)^{-1} I\right)$$



$$x = \bar{x}^b + X^b w$$

$$x \sim N\left(\bar{x}^b, P^b = X^b X^{bT}\right)$$

Analysis in the ensemble space:

$$\tilde{P}^a = \left((k-1)I + Y^{bT} R^{-1} Y^b\right)^{-1}$$

$$\overline{w}^a = \tilde{P}^a Y^{bT} R^{-1}\left(y^o - \bar{y}^b\right)$$

$$W^a = \left[(k-1)\tilde{P}^a\right]^{1/2}$$

Analysis in the model space:

$$P^a = X^b \tilde{P}^a X^{b^T}$$

$$\bar{x}^a = \bar{x}^b + X^b \overline{w}^a$$

$$x^{a(i)} = \bar{x}^b + X^b\left(\overline{w}^a + W^{a(i)}\right)$$

SL-AV model

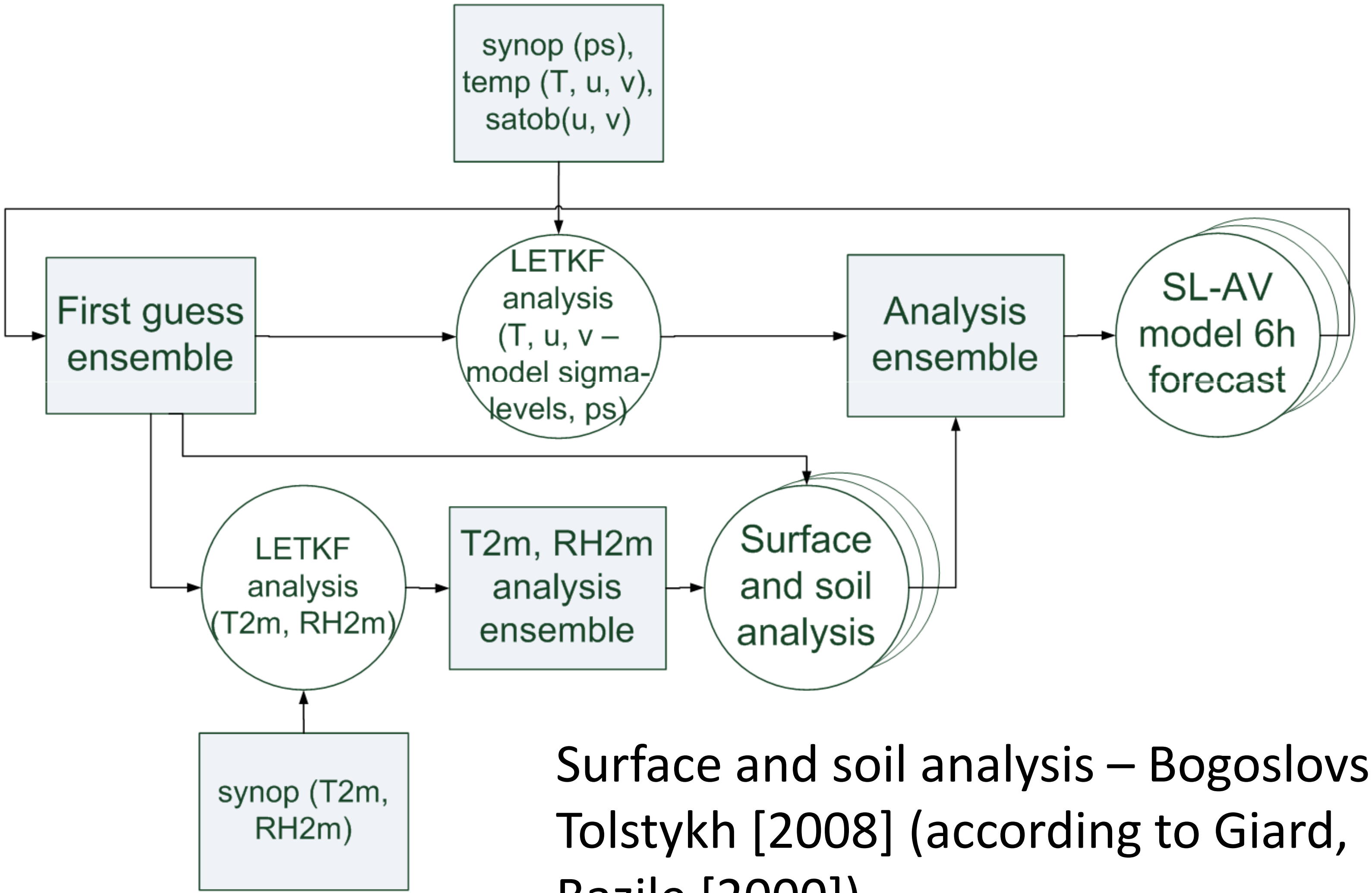
- Global atmospheric model, operational in Russia (Tolstykh, 2001)
- Resolution: 0.9x0.72, 28 vertical levels
- Dynamics: semi-implicit semi-Lagrangian finite difference; own development
- Parametrizations of subgrid-scale processes: mostly from ALADIN/LACE model

Observations assimilated

- Synops: T; ps; RH

  Adjustment to the model orography for the surface pressure
- Radiosondes: T, U, V (on standard levels)
- Satobs: U, V

Assimilation setup



Surface and soil analysis – Bogoslovskii, Tolstykh [2008] (according to Giard, Bazile [2000])

Assimilation setup

- Ensemble size: 40-60

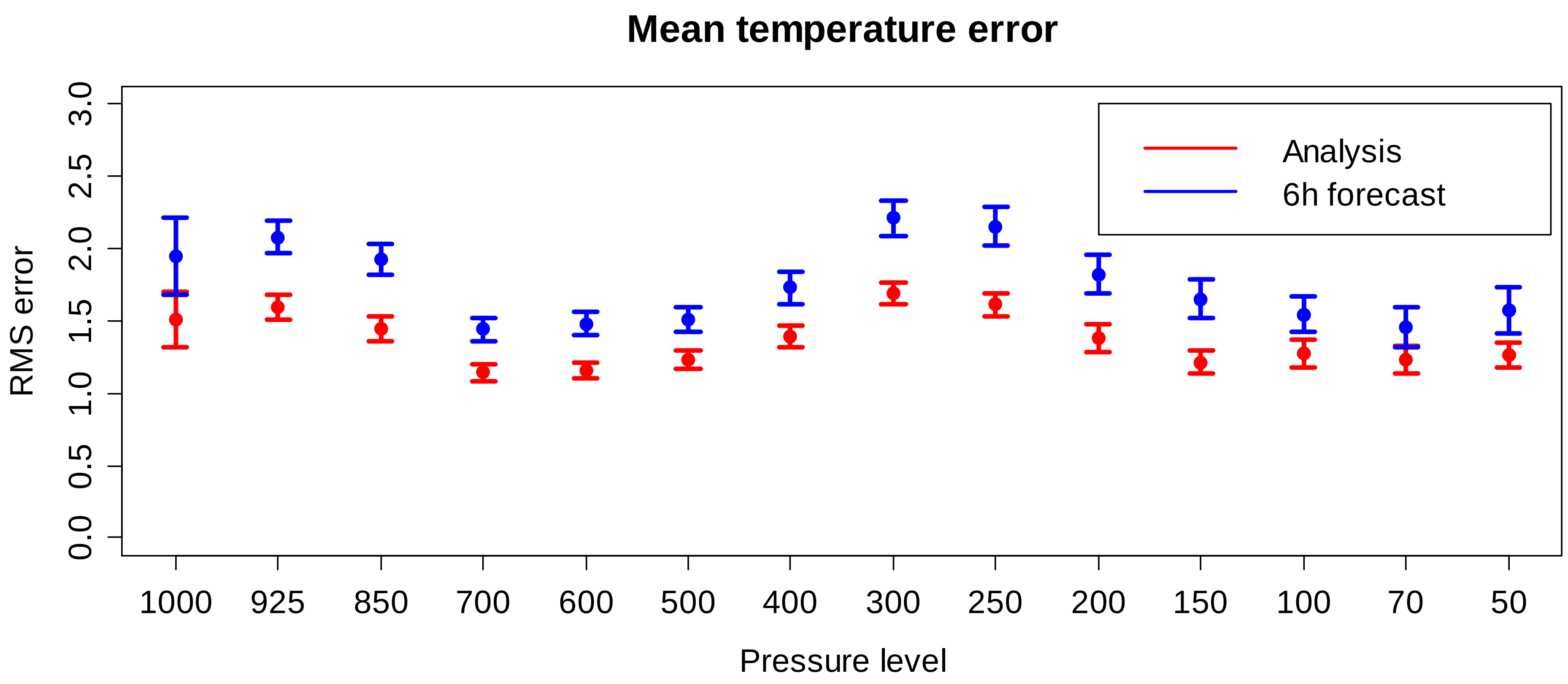
- Localization: Gaspari-Cohn localization
- Different localization distances at different latitudes and pressure levels (currently only different in vertical, 1500-4000)
- Vertical localization: in terms of pressure logarithm

Dealing with the ensemble spread underestimation

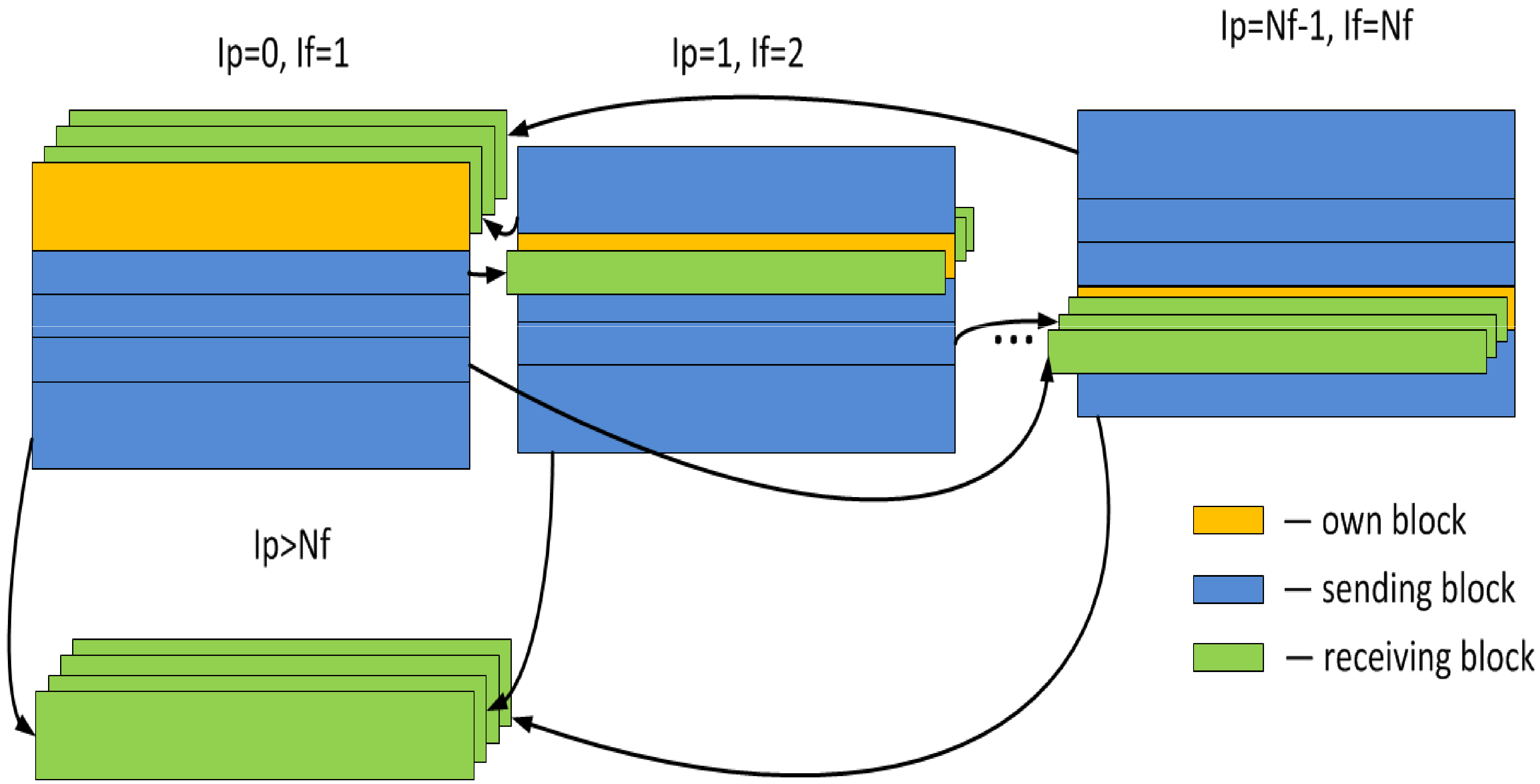
- Multiplicative inflation: constant factor
- Additive inflation
- Perturbed parameters (deep convection parametrization)

Some current results

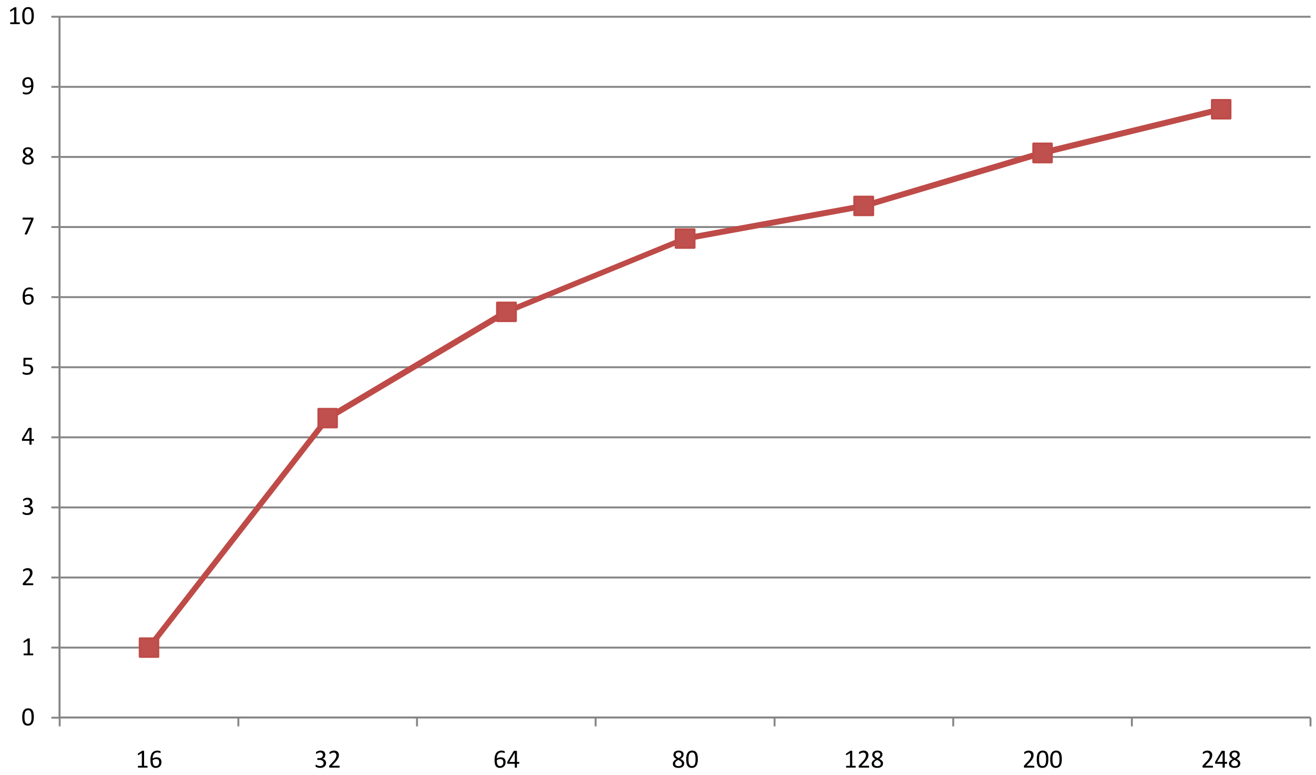
Mean temperature RMS, NH (averaged over Sep.01-Sep.30 (assimilation start: Aug.01))



Parallel implementation (Vasily Mizyak)



Parallel implementation: Speed-up



SGI Altix 4700, 50 ensemble members

Future plans

- Assimilating humidity
- Adding more observations:
  - aireps
  - more AMVs
- Taking into account autocorrelations in AMVs
- ‘Physical’ methods to account for model error (perturbed parameters, different parametrizations, …)

“Sure thing. You want a probability forecast, based on … improbability data”

Thank you. Any questions?

shlyaeva@gmail.com

Temperature bias (averaged over NH)