Federal Service for Hydrometeorology
and Environmental Monitoring

HYDROMETEOROLOGICAL
CENTRE OF RUSSIA

About weather—at first hand

USING SATELLITE-DERIVED ATMOSPHERIC MOTION VECTORS (AMV) OBSERVATIONS IN THE DATA ASSIMILATION SYSTEM BASED ON LETKF ALGORITHM

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TASKS:

- Preparing initial data for SL-AV model;
- Using satellite-derived atmospheric motion vectors (AMV) observations – an important source of wind information in the troposphere with a global coverage.

DATA AND METHODS USED:

- Data assimilation algorithm – Local Ensemble Transform Kalman Filter (LETKF, Hunt et.al., 2007) ;
- SL-AV atmospheric model (Tolstykh, 2001) - 0.9°x0.72°, 28 vertical levels;
- Observations used:
  - Ground stations and ships (SYNOP, SHIP: Ps, T2m, RH2m, about 10000 observations)
  - Radiosonde observations (TEMP: T, RH, U, V, about 2000 observations);
  - Aircraft reports (AIREP: T, U, V, about 10000 observations);
  - Atmospheric motion vectors (AMV: U, V, more than 500000 observations)

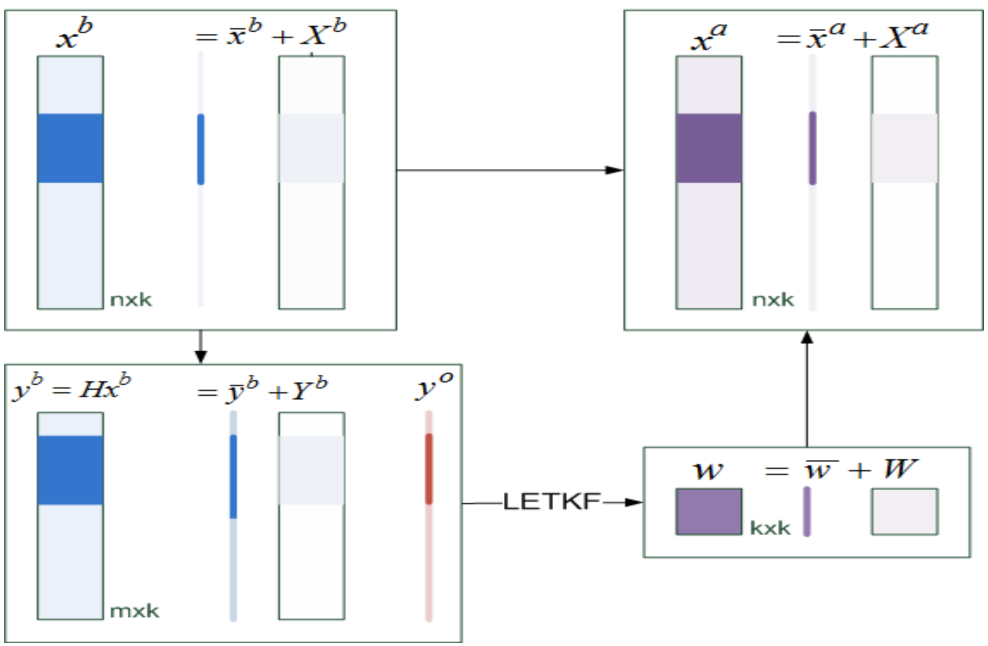
Local Ensemble Transform Kalman Filter (LETKF)

Local Ensemble Transform Kalman Filter (LETKF, Hunt et.al., 2007):

- square root ensemble filter (no observation perturbations);
- observation localization
- looking for the background ensemble members weights; solving in the ensemble space (usually smaller dimension then the observation, or model space): instead of minimizing J(x) minimize J(w)

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

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



analysis in the model space:

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

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

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

analysis in the ensemble space:

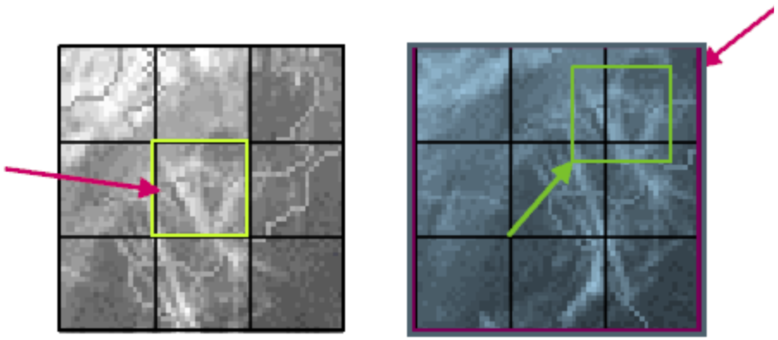
$$\widetilde{P}^a = \left((k-1)I + Y^{bT} R^{-1} Y^b\right)^{-1}$$

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

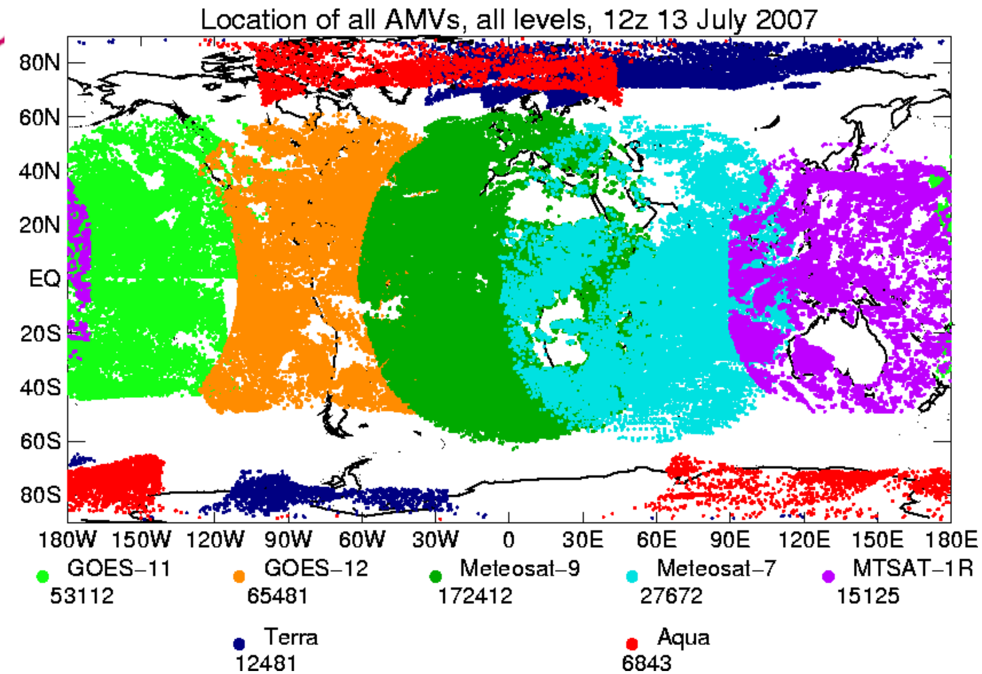
$$W^a = \left[(k-1)\widetilde{P}^a\right]^{1/2}$$

Atmospheric Motion Vector (AMV)

- Produced by tracking clouds or gradients through consecutive satellite images
- Provide the main source of tropospheric wind information over the polar regions.
- Complementary coverage to the geostationary AMV data



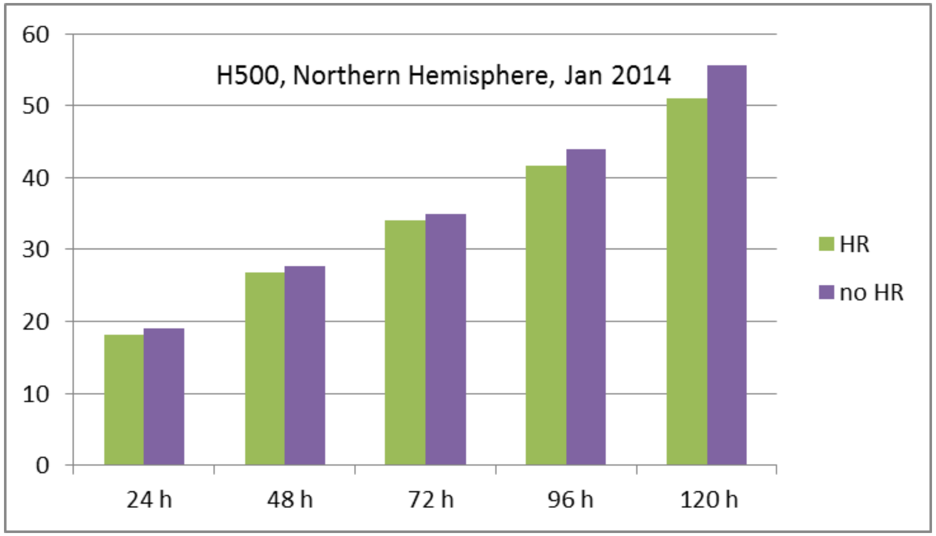
T T + 15 min

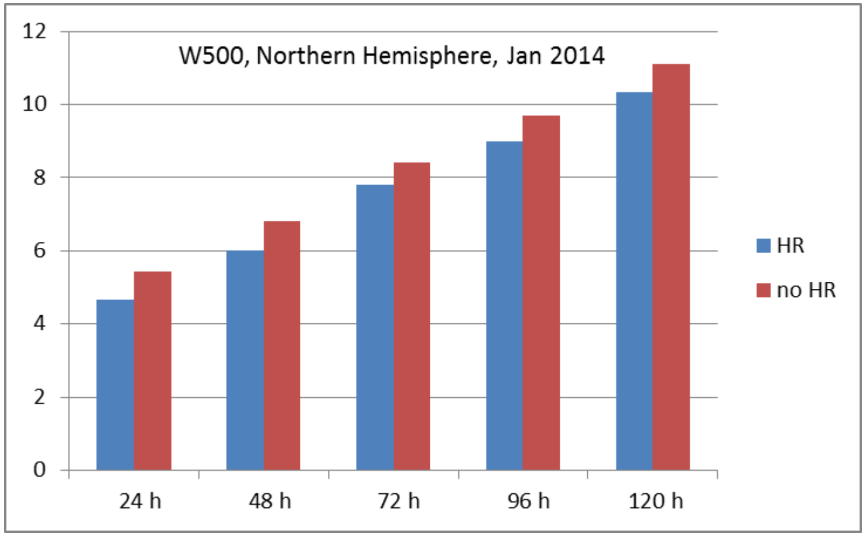


- height assignment - largest source of the observation error
- huge number – needs to be thinned (one obs per 200km x 200km x 100hPa box)
- errors are complicated and are spatially and temporally correlated – this necessitates the use of the non-diagonal observation-error covariance matrix R in the data assimilation scheme

AMV height reassignment

RMS CBS/WMO Standards, Forecast vs Analysis, Nov 2014, northern, 00 UTC





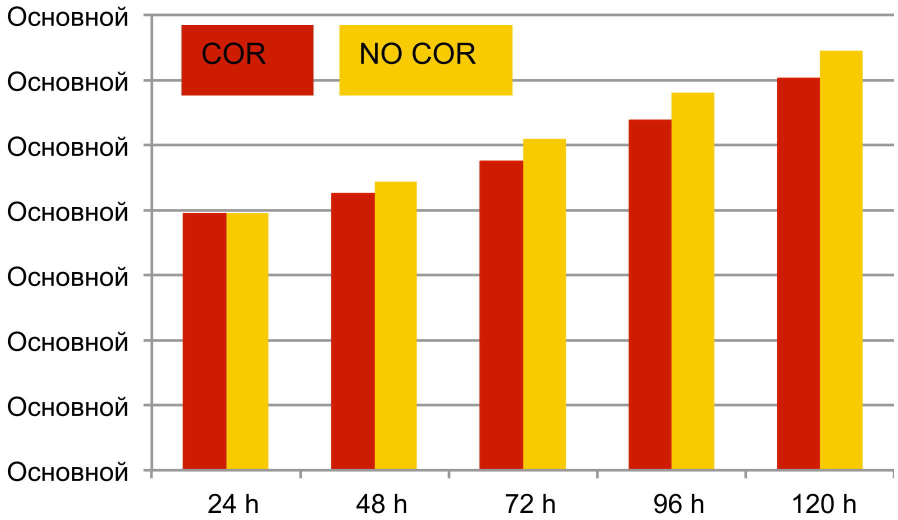
Accounting of observation errors correlations

- correlation function in the local subset of AMVs is:

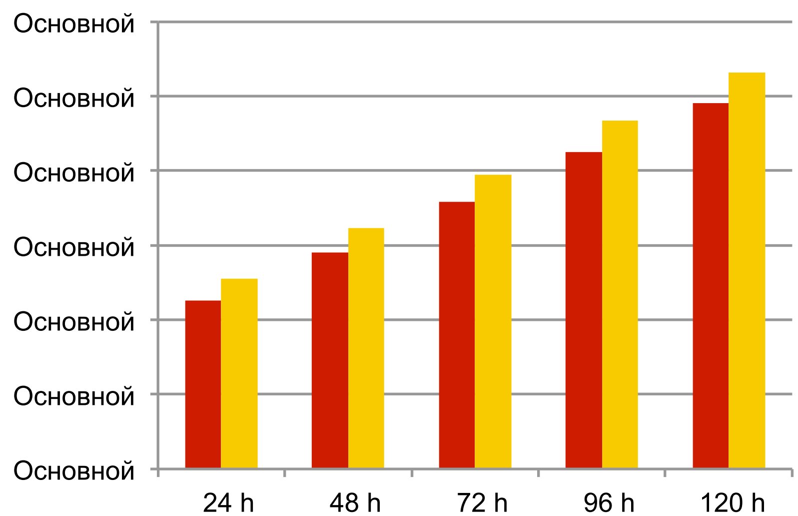
$$R(r) = R_0\left(1 + \frac{r}{L}\right)$$

- R0 and L are different for different satellites, channels and regions
- no cross-variable and cross-obstypes error correlations are assumed

RMS CBS/WMO Standards, Forecast vs Analysis, Nov 2014, northern, 00 UTC, T500



RMS CBS/WMO Standards, Forecast vs Analysis, Nov 2014, northern, 12UTC, W500



Plans

- Further tuning to reduce errors in CBS/WMO Standards verification
- Use of the parallel I/O to reduce runtime and memory using
- Use of the other observation types
- Regular runs in operational mode
- Use of the filter to generate initial data for medium-range ensemble forecasts

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THANKS FOR YOUR ATTENTION!