3D-Var data assimilation with the COSMO model over the Sochi area

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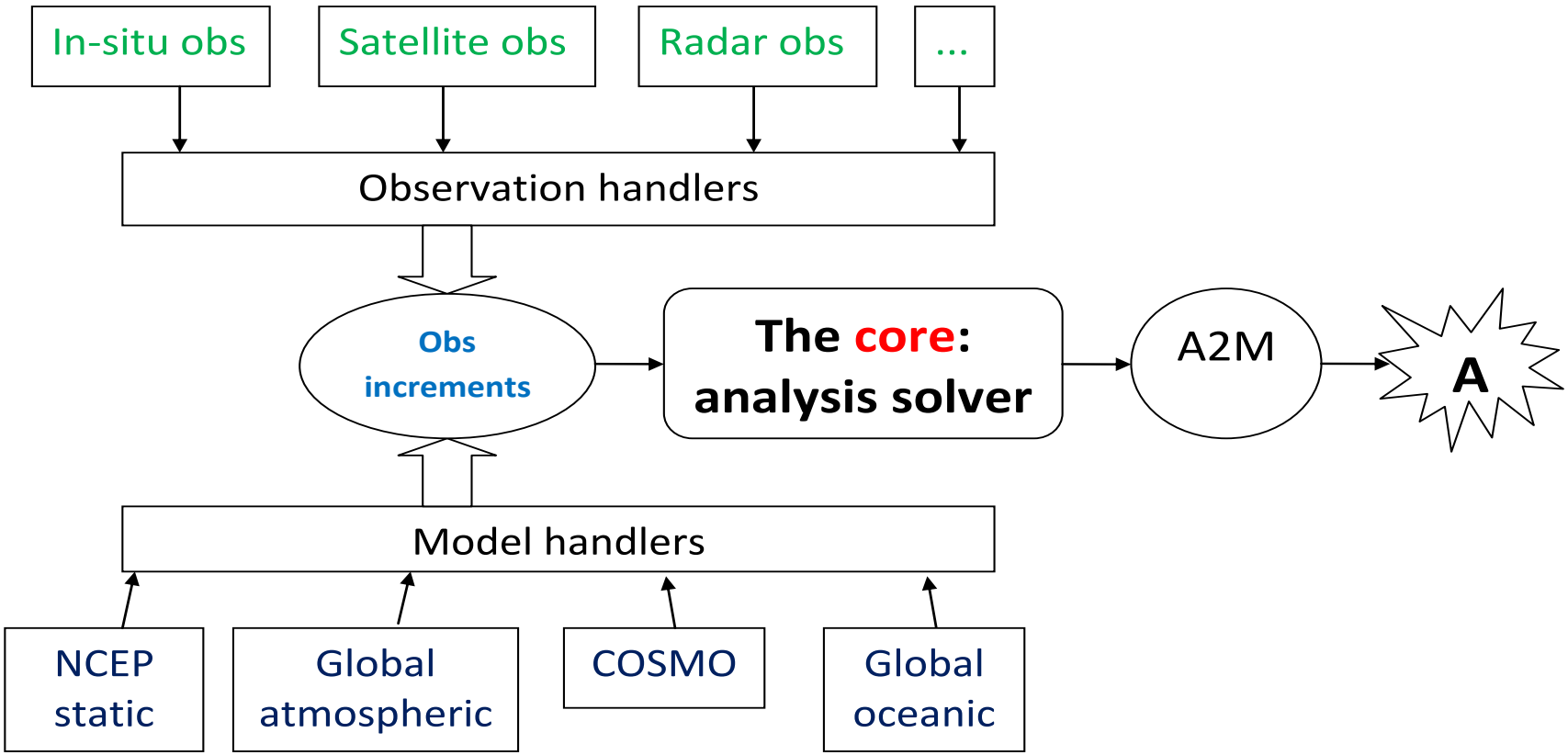
HMC-VAR: a unified 3D-Var based data assimilation technology

- Scales: global and regional.
- Geometries: spherical, rotated spherical, rotated/stretched spherical.
- Media: atmosphere and ocean.

Advantages and disadvantages of the unified approach

- Pros
  1. Avoid duplication of work.
  2. Improvements affect a number of applications.
  3. Fosters standardization and 'modulization'.
  4. In a modular system with standardized interfaces, tasks can be much easier distributed among developers.
- Cons
  1. Increased complexity.
  2. Less flexibility in specific applications.


In-situ obs
Satellite obs
Radar obs
...
Observation handlers
Obs increments
The core: analysis solver
A2M
A
Model handlers
NCEP static
Global atmospheric
COSMO
Global oceanic

The analysis core (the solver)

- A global quasi-uniform grid.
- A pressure based vertical grid.
- The control variable: Φ, ψ_u, χ_u, PRH.
- Balance operators (hydrostatic, quasi-geostrophic, and frictional) are latitude, altitude, and scale dependent.
- 3-D background-error covariances are based on 3-D filters (SARMA: Spatial Auto-Regression and Moving-Average model).
- Objective specification of 'input' background-error covariances is still lacking. Ensemble statistics is intended to fill this gap.

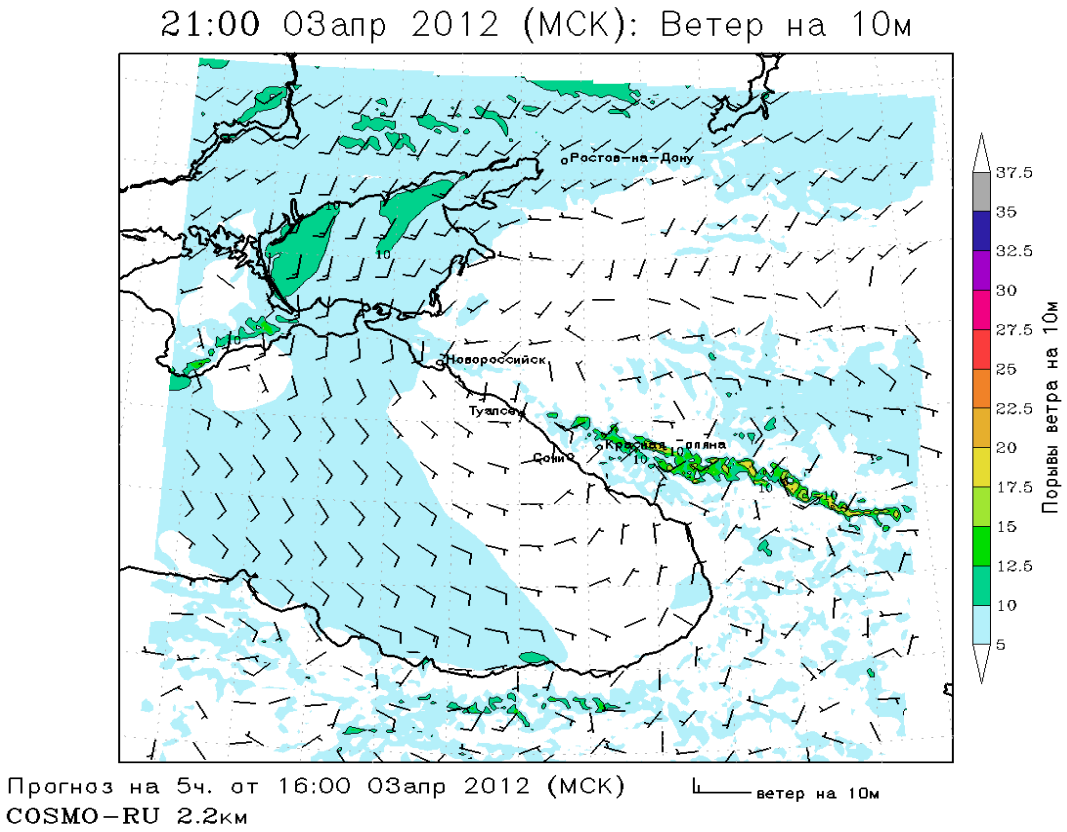
Regional 3D-Var

The basic idea: stretch the domain to a large portion of the globe and apply the global solver.

We have 3 coordinate systems:

1. Geographic, where observations are defined,
2. COSMO, where the background (6-h. COSMO forecast) lives, and
3. Analysis, where the analysis increments are computed.

The Sochi domain



Coordinate transforms

1. Map the observations from OBS space to COSMO space.
2. In COSMO space, compute the obs-minus-background increments (innovations).
3. Map the innovations to ANALYSIS space (including stretching and wind rotations).
4. Perform the global analysis with the unified solver.
5. Map the analysis increments from ANALYSIS space back to COSMO space and produce the final analysis fields on the COSMO grids.

In-situ and satellite observations

- Additional near-surface.
- Additional radiosonde releases: one station near Sochi is now operational.
- Aircraft winds and temperatures over the Sochi area: not available.
- Radar winds: Data from the mount-Akhun Doppler radar are now available. More Russian radars expected.
- High-resolution satellite data: AMV, ASCAT, OSCAT, MHS.

About 1200 in-situ data.

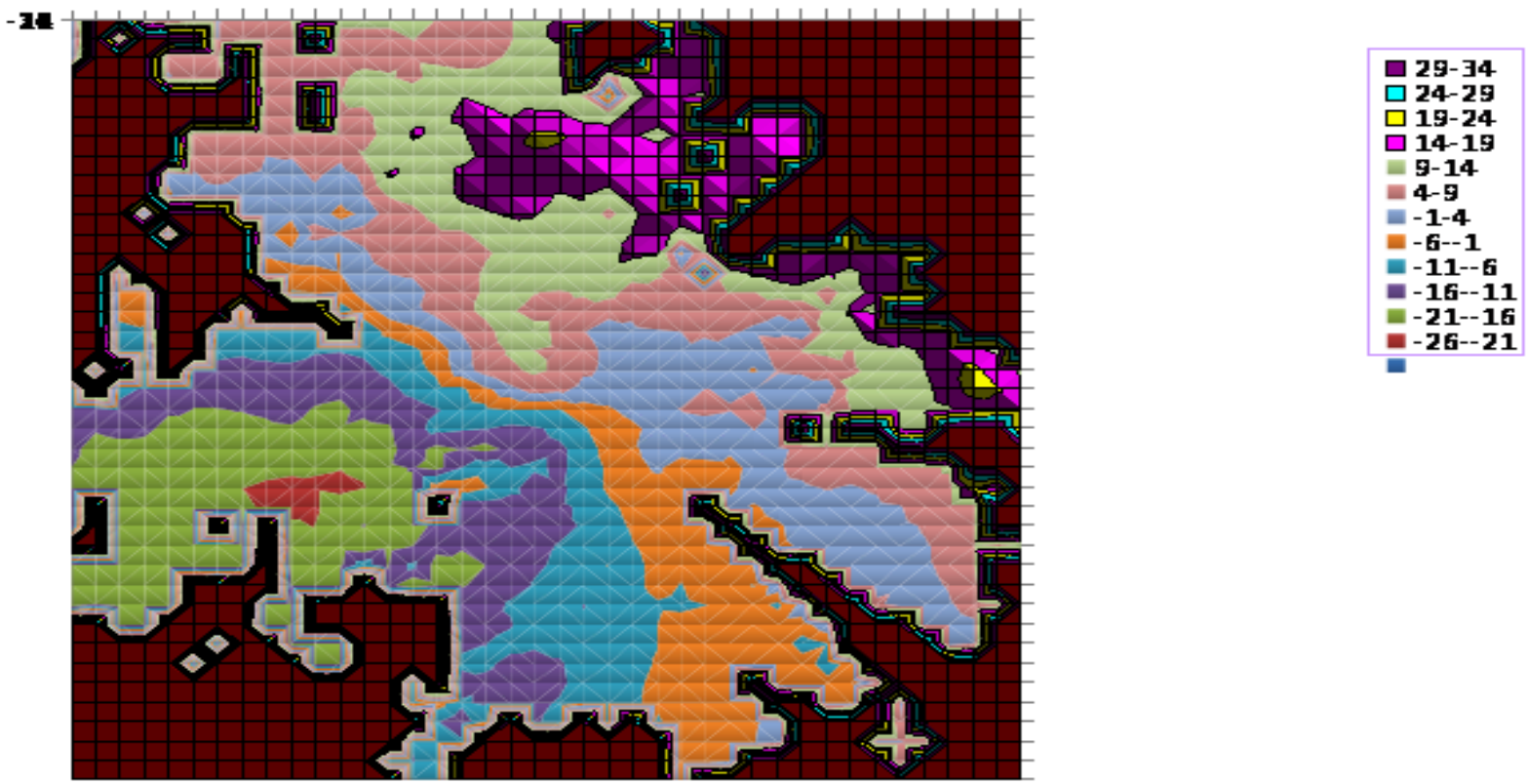
Treatment of radar winds: thinning/super-obing

Median super-obing.

The median's role is three-fold:

1. It provides data thinning
2. It filters out the sub-volume 'noise'
3. It's use provides an efficient Quality Control, as the median is known to be very robust to outliers.

Radial wind from the Akhun mountain



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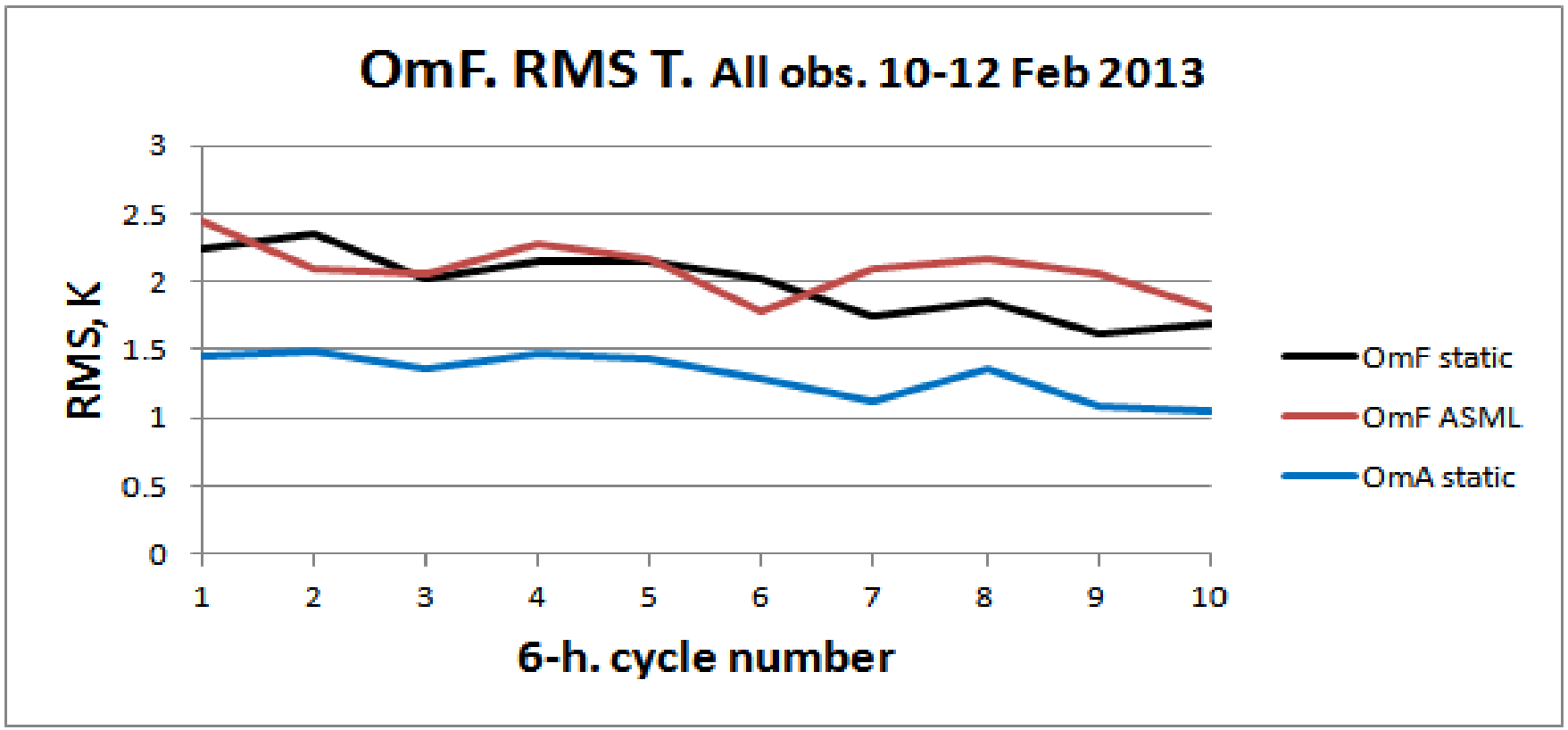
Static forecasts vs. cyclic assimilation

Obs minus Fcst (OmF) vs. Obs minus Anls (OmA) statistics

165-220 temperature obs over the domain per cycle.

RMS scores.



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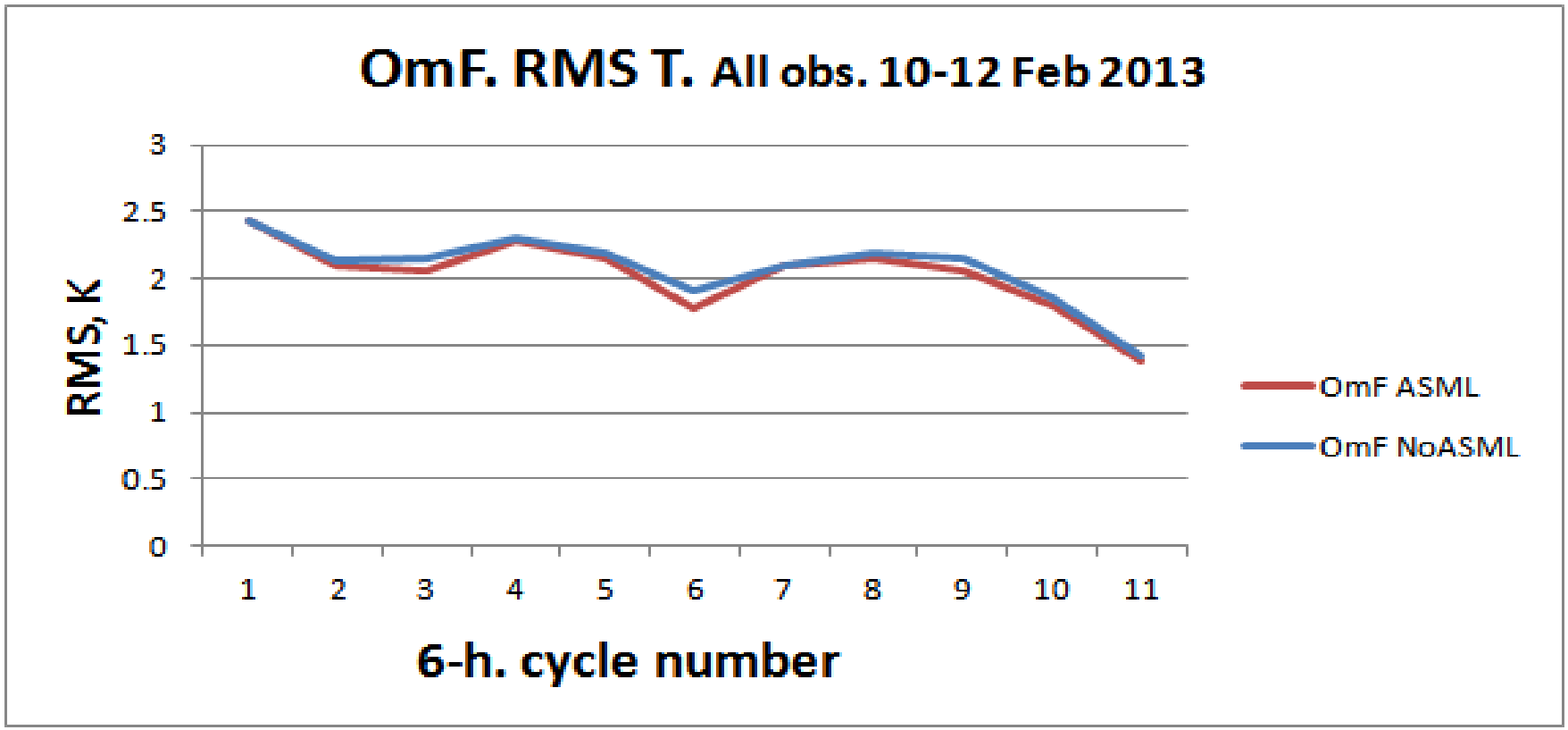
Cyclic assimilation vs. Downscaling

RMS scores.



Roles of background-error statistics and FGAT

= Two different stretching factors (16 and 25): a very small impact. Hence, analysis statistics seem to be not of primary importance here.

= FGAT vs. NoFGAT: small and mixed impact. Too few asynoptic observations? Transient noise in forecast fields at 3-4 h lead time?

Perhaps, the signal from very scarse observations is too weak for improvements in the DA design to give rise to significant improvements in the forecasts.

Conclusions: work done

- Cyclic regional 3D-Var + COSMO data assimilation is developed.
- Sanity checks OK.
- Without radar radial-winds, other observations appear to be too scarse to significantly affect the forecast.
- Radar radial-wind data assimilation technology is almost ready.

Plans

- Assimilation of radar winds will be the key issue.
- The resolution of analysis increments is to be increased to 5 km in order to extract more iformation from hi-res radar data and from near-surface obs in the mountains.
- We will struggle to add an ensemble data assimilation component, coming up with a hybrid VAR-ENS scheme.

Thank you!