# Snow analysis at DWD - Status and plans

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# Current status (1/2)



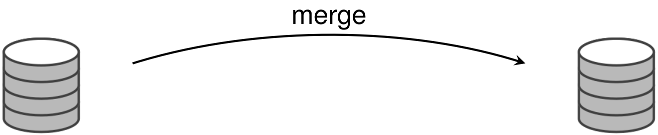
- Cressman-based analysis every 6 h is operational for ICON-D2
- ongoing maintenance efforts (examples from last year):
  - additional checks for corrupt zero snow depth TAC reports
  - additional checks for duplicated TAC and BUFR reports
  - plausibility checks due to dubious reporting practice for zero snow depth in China and Finland

## Code moved from SVN to Gitlab

- DWD's SVN has been switched to read-only
- code and its history have been moved to Gitlab `https://gitlab.dwd.de/dace/dwd_surface`
- build system has been re-written in CMake and is now maintained by FE11

# Current status (2/2)

We are currently working with two independent code bases:




- surface analyses (SNW, SST, SMA)
- Fortran 90 (77)
- ~~SVN behind some custom set of scripts at DWD~~

- DACE (atmospheric analysis, surface analyses)
- Fortran 2003
- Git & Gitlab hosted at DKRZ Hamburg

Our goal is to integrate the surface analyses into DACE.

# OmniVAR for the snow analysis (1/3)



- OmniVAR provides a generic implementation of the variational minimization (T. Hüther, S. Hollborn, R. Potthast)

$$J = \frac{1}{2}(x - x^b)^T B^{-1}(x - x^b) + \frac{1}{2}(y - H(x))^T R^{-1}(y - H(x))$$

- linearize $H(x) \approx H(x^b) + Hx - Hx^b$, plus some linear algebra:

$$\frac{\partial J}{\partial x} = B^{-1}(x - x^b) - H^T R^{-1}(y - H(x^b) - Hx + Hx^b)) \stackrel{!}{=} 0$$

$$(HBH^T + R)z = y - H(x^b) \qquad \Rightarrow \text{minimization, solve for } z$$

$$x^a = x^b + BH^T z \qquad \Rightarrow \text{postmultiplication to get } x^a$$

# OmniVAR for the snow analysis (2/3)



- minimization:

$$(HBH^T + R)z = y - H(x^b)$$
$$\left(H_\mathrm{s}(H_\mathrm{clim}B_\mathrm{clim}H_\mathrm{clim}^T + H_\mathrm{ens}B_\mathrm{ens}H_\mathrm{ens}^T\right)H_\mathrm{s}^T + R)z = y - H_\mathrm{s}H_\mathrm{det}(x^b)$$

- post-multiplication

$$x^a = x^b + BH^Tz$$
$$x^a = x^b + \left(I_\mathrm{clim}B_\mathrm{clim}H_\mathrm{clim}^T + I_\mathrm{ens}B_\mathrm{ens}H_\mathrm{ens}^T\right)H_\mathrm{s}^Tz$$

- minimization and post-multiplication are implemented with abstract interfaces and all operators $H_\mathrm{s}$, $B_\mathrm{clim}$, etc. need to be provided for the concrete problem to be solved

# OmniVAR for the snow analysis (3/3)

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Wetter und Klima aus einer Hand

OmniVAR as 2DVAR for snow analysis:

- no ensemble part
- snow depth observations
  - from SYNOP (direct or diagnosed from precipitation and temperature)
  - from IMS (snow/no snow mapped to appropriate snow depth; in case of SYNOP gaps)
- covariances given by horizontal and vertical distance (tbd)

$$\left(H_s(H_{\mathrm{clim}}B_{\mathrm{clim}}H_{\mathrm{clim}}^T\right)H_s^T + R)z = y - H_sH_{\mathrm{det}}(x^b)$$

$$H_s = I$$

$$H_{\mathrm{clim}} = \text{horiz. interpolation}$$

$$(B_{\mathrm{clim}})_{ij} = \sigma_b \, \exp\left(\frac{-\mathrm{dist}(i,\, j)^2}{2\sigma_{\mathrm{loc}}^2}\right)$$

# OmniVAR: Current status



- working prototype for T2M analysis, including
  - full parallelization as for atmospheric analysis
  - DACE I/O for observations, first guess, analysis, feedback files
  - DACE observation quality control
- ongoing learning and debugging based on single-observation experiments
  - well-known code exchanged for ”foreign” code
  - efficient implementation of $B$ based on convolution of Gaussian functions
  - (re-)distribution of observations to PEs

# Next steps and outlook



NWP:

- short-term goal: plausible T2M analysis, ie. a working 2DVAR
- then add snow-specific observations and pre-processing
- tune and test to (at least) match performance of current analysis

ICON Seamless for seasonal predictions:

- need a snow analysis for JSBACH, which has a very simple multilayer snow scheme (”snow properties are kept constant for simplicity … snow layers are hydrologically inactive”)