Snow analysis at DWD

Present status

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Motivation for revision of snow analysis package

- Old fashioned Cressman analysis, non optimal weighting of observations. Source code developed from the 1980's. Contains old style f77 code. Not parallelized.
- Integration of surface analysis in DACE (Data Assimilation Coding Environment) which provides basic packages required for development of variational or ensemble based analysis.
- New observation data available, UAV (drones), webcams, satellite data which need forward modelling to be assimilated directly.
- Assimilation of microwave satellite data requires multilayer snow scheme.
- Multilayer snow analysis might become relevant.
- Eurosnow proposal for cost action on snow, validated 2021, can push development by sharing ideas and knowledge with the scientific community.

Snow analysis scheme

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

- Snow analysis based on Cressman method, successive correction, cycled 3/6 hourly (global/regional)
- Input from forecast model: First guess and previous analysis of W_SNOW, RHO_SNOW, FRESHSNW, First guess of T_SNOW
- Observation input from synop stations and external data.
- Analysis of H_SNOW
  Diagnostics of FRESHSNW, depending on snow aging and fresh snow in observations and forecast model.
  Freshsnow factor is a measure for albedo change from old to new snow, i.e. the factor increases from 0 to 1 with 5 cm of new snow.
- Output of full fields used for initialisation in COSMO
- Output of increments used for initialisation in ICON
- Additional output of W_SNOW, RHO_SNOW, T_SNOW

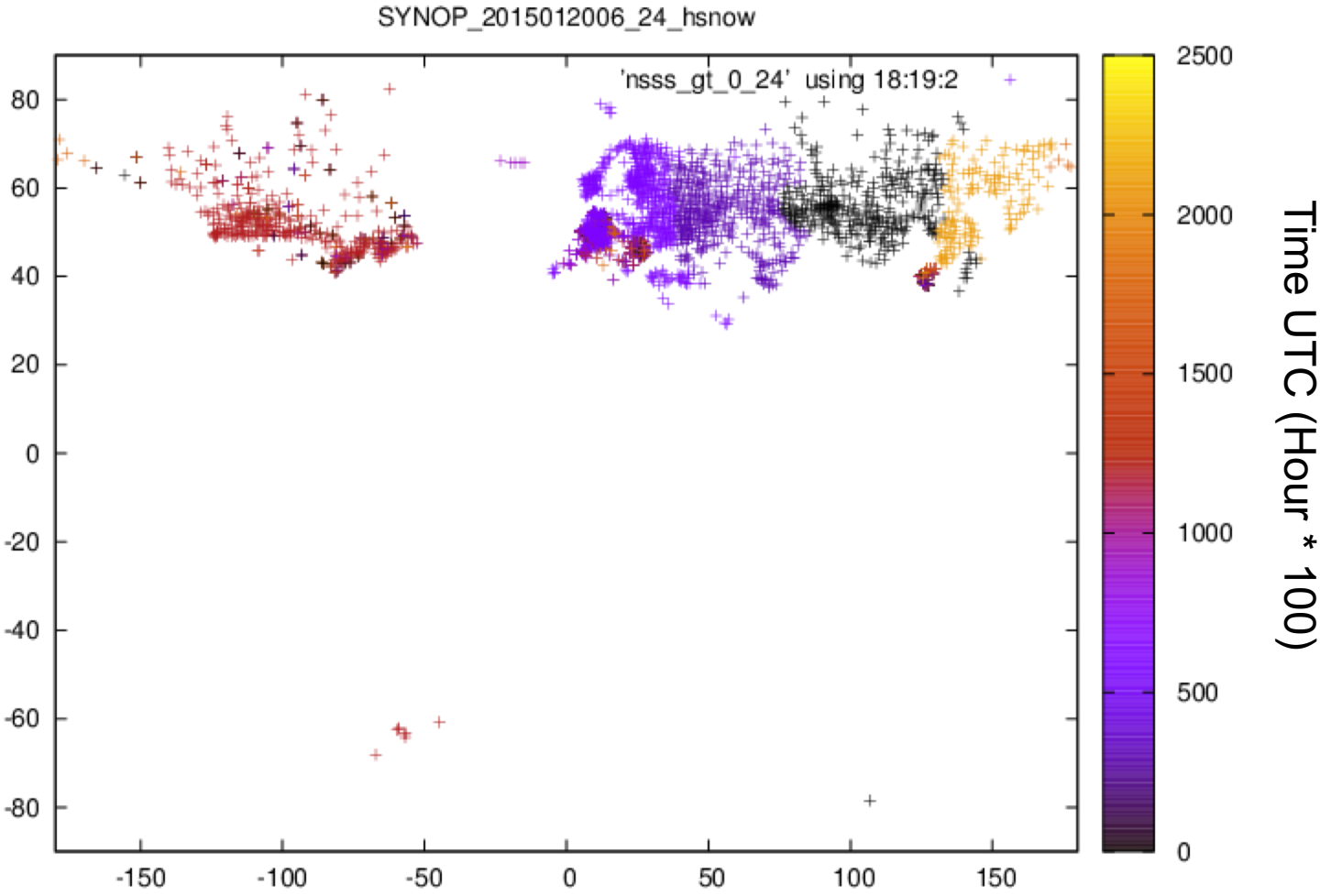
Conventional observation input

- Snow depth reports from synop stations. If not available
- 3-6 hourly precipitation sums in combination with screen level temperature, and
- information from ww (weather reports from weather observers), converted to snow depth obs. are used to adapt snow depth.

External data input

- Indirekt use of satellite information through NOAA snow cover and snow depth over data sparse areas in northern hemisphere.
- ERA interim monthly climatology for consistence check, init glaciers.
- Fixed snow depth of 40 m over permanent glaciers, snow density 200kg/m2.

Snow depth observations at different report times



Input data

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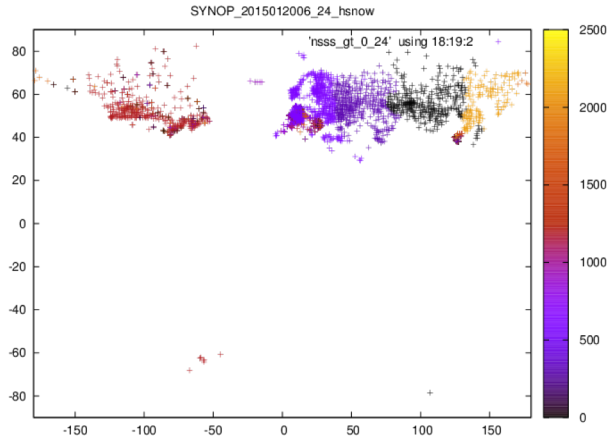
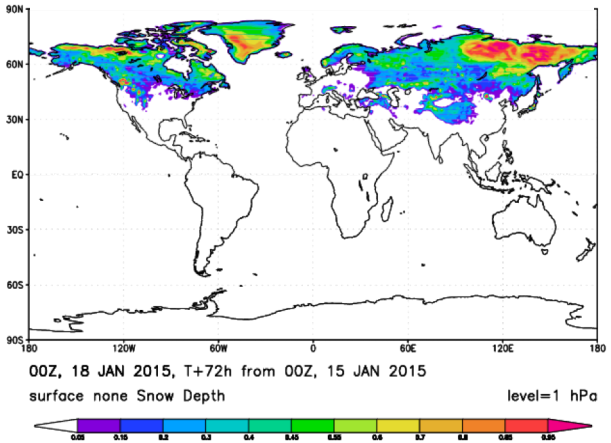
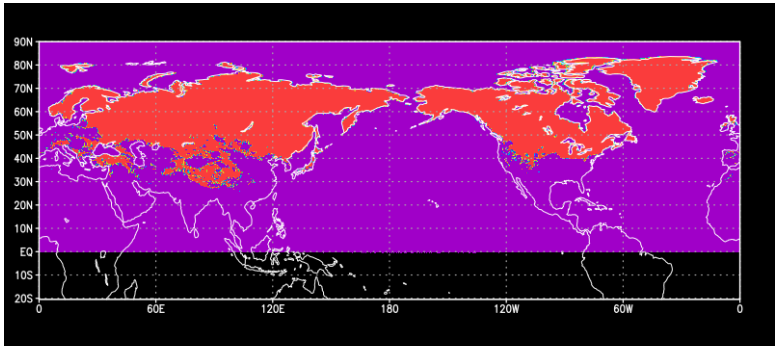
Snow height Observations at different report times



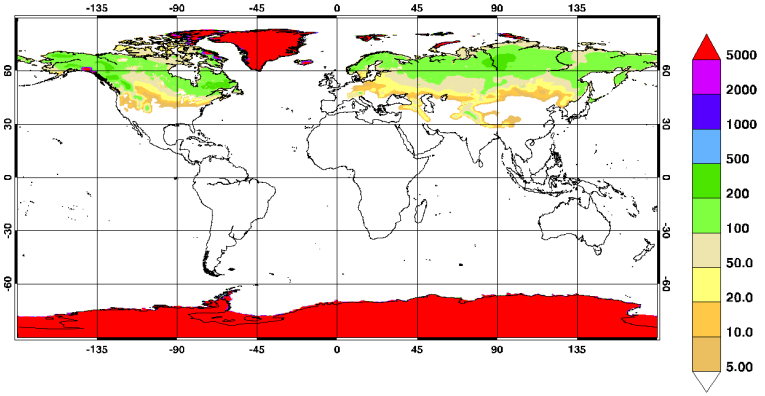
NOAA snow depth analysis previous day



NOAA snow cover 2015011722 used at 06:00 UTC



ERA 40 climatology



FIN

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Cressman Method, Successive Correction

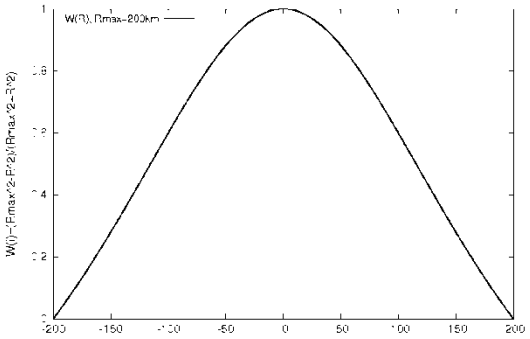
$$f_i^A = f_i^B + \sum_k w_k h_k D_k$$

$$D_k = f_k^O - f_k^B$$

$$w_k = \max\left(0, \frac{(R_{\max}^2 - R_k^2)}{(R_{\max}^2 + R_k^2)}\right)$$

$$h_k = \max\left(0, \frac{(Z_{\max}^2 - Z_k^2)}{(Z_{\max}^2 + Z_k^2)}\right)$$

Weight function in Cressman analysis



2. iteration improves analysis