

## Status and plans for cooperation with SURFEX between NILU and Met.No

William Lahoz ([wal@nilu.no](mailto:wal@nilu.no))

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## Motivation

Build Land DA capability at NILU:

- Match expertise in Met.No & NILU
- Collaboration with world leaders: Met.No & Meteo-France (SURFEX); Paul Houser, USA (Land DA & modelling); U. Ghent, Belgium (Possibility theory); U. Valencia, Spain (Satellite observations)
- Visits to NILU: Paul Houser (Mar 2008); Pavel Sakov (Jan 2009); Olivier Talagrand (Feb 2009) & more
- Build critical mass & capacity
- Have fun and do science!



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From Paul Houser:

**Land Surface Data Assimilation: Progress and Realities**

**Current Status:**

- Soil moisture, skin temperature, and snow assimilation have been demonstrated.
- Evapotranspiration, runoff, groundwater (gravity), and carbon assimilation are underway

**Data Assimilation Tradeoffs:**

- Tradeoff between using **complex data assimilation techniques**, the **ability to use all the available data** and **operational needs and realities** due to the large computational burdens.
- Tradeoff in **dimensionality** of data assimilation methods – need may depend on scale.
- Tradeoff between **fine resolution** and large area implementation.

**Land Surface Data Assimilation Realities**

- Large-scale land data assimilation is severely limited by a **lack of observations**.
- Observation and model **errors are not known** – educated guesses must be used.
- We need to pay attention to the **consequences of assimilation**, not just the optimum assimilation technique. i.e. does the model do silly things as a result of assimilation, as in snow assimilation example
- Land model physics can be biased, leading to incorrect fluxes, given correct states.
- Most land observations are **only available at the surface**, meaning that **biased** differences in surface observations and predictions can be **improperly propagated to depth**.
- **Assimilation does not always make everything in the model better.** In the case of skin temperature assimilation into an uncoupled model, **biased air temperatures** caused unreasonable near surface gradients to occur using assimilation that lead to questionable surface fluxes.

  Paul R. Houser, 14 March 2007, Page 34

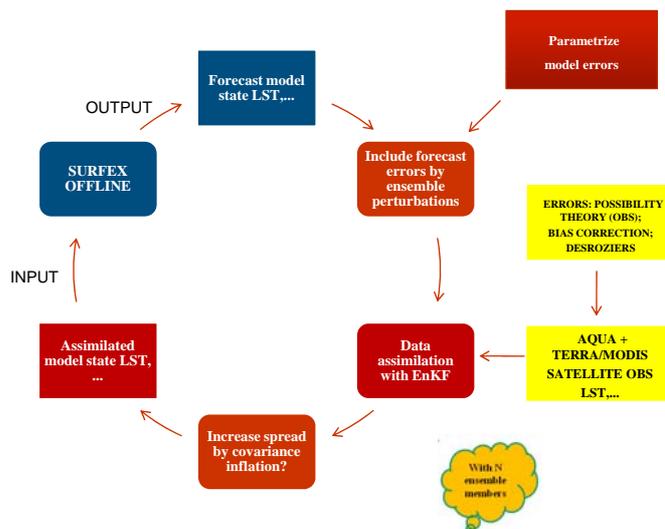
## Land DA goals

- (1) Assimilate variables: land soil temperature (LST), soil moisture, snow
  - (2) Use DA to produce analyses, evaluate observations & models (e.g. SURFEX land surface parameters if appropriate)
- 
- (1) Approach:
    - i. Work with NILU DA system (EnKF) + land model (SURFEX/CANARI) from HARMONIE/Met No + satellite observations + novel developments (errors, biases)
    - ii. Compare with EKF from Meteo-France (to be received from JFM)
    - iii. Consultation with Met.No in future developments in HARMONIE
    - iv. CANARI not addressed at NILU now
  - (2) Outcomes:
    - i. Experience at NILU in: using SURFEX (e.g. with HIRLAM forcing data); understanding land/atmos interactions; in land DA with SURFEX -> feeds into
    - ii. Improved use of EO
    - iii. Improved forecast & modelling capability
    - iv. Studies of land/atmosphere system



## DA scheme

### SURFEX ensemble based DA using satellite obs



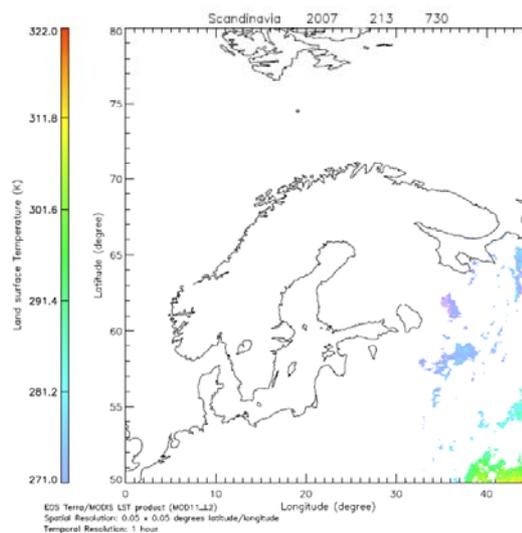
## DA algorithm: Two recent EnKF versions

- ❖ Sakov and Oke: MWR, 2008.
  - An Ensemble Square Root filter (ESRF) using a symmetric Ensemble Transform Matrix (ETM): classical KF - ensemble mean
- ❖ Sakov and Oke: Tellus, 2008
  - A Deterministic Ensemble Kalman Filter (DEnKF) using a linear approximation to the Ensemble Square Root Filter (ESRF) update matrix. Better for avoiding ensemble collapse
- ❖ These versions of the EnKF have been implemented at NILU using Fortran 90 and BLAS (Basic Linear Algebra Subprograms), Sparse BLAS and LAPACK libraries
- ❖ DA code is general & includes matrix-free versions of observation operators
- ❖ DA code tested on Lorenz63 model
- ❖ To be tested with SURFEX and satellite data



### Observations

TERRA-MODIS LST: 1 August 2007, 7.30 am UTC



## Satellite observations

- ❖ Using satellite observations of Land surface temperature (LST), snow cover and soil moisture (+errors) over Scandinavia
  - LST from EOS TERRA/MODIS and AQUA/MODIS satellites with 1 km spatial resolution
  - Snow cover from same satellites with 500 m resolution
  - Soil moisture from EOS AQUA/AMSR-E with 25 km resolution
- ❖ Currently a DA system is being set up to use these observations together with SURFEX model applying two state-of-the-art EnKFs
  - Ensemble Square Root filter & Deterministic EnKF
  - 1-D assimilation initially (mainly 1-D processes in land)
  - 3-D assimilation later
- ❖ Later stage: will compare EKF & EnKF



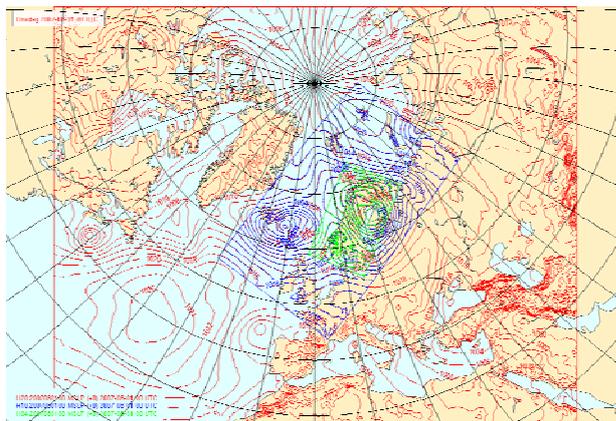
## SURFEX model

### Implementation of the SURFEX model at NILU Collaboration with Met.No

- ❖ Using latest version (v3.0) of off-line SURFEX model from Météo-France
- ❖ NILU hardware and software environment: "Ulven" machine
  - HP ProLiant DL360 G5 PC-server with 4 Intel Xeon 3 GHz CPUs with 4 GB RAM and > 1 TB disk space
  - Linux Redhat Enterprise Server 5 Operating System
  - GNU Fortran G95 compiler
- ❖ Currently the SURFEX model is set up for part of Scandinavia for the period 31 July - 3 August 2007



- ❖ Atmospheric forcing data from met.no (**next slide**): files from Met.No (Mariken Holmleid)
  - HIRLAM4 model output in rotated lat-lon grid over part of Scandinavia with 4km resolution in GRIB format
  - Two files h4km\_YYYYMMDDHH.grb for each day (with HH = 00 and 12) with analysis data (+0) and forecast data (+6, +12 and +18)
  - Currently only using analysis data
  - As SURFEX model does not support GRIB format we convert files to NetCDF format: gives file FORCING.nc, used by SURFEX
  - HIRLAM4 grid (rotated lat-lon) is currently not supported by SURFEX, so we use a regular lat-lon grid (NILU grid) instead and interpolate the forcing data to this grid



Currently set up to use HIRLAM4 forcing data for innermost (green) HIRLAM grid (4km resolution)

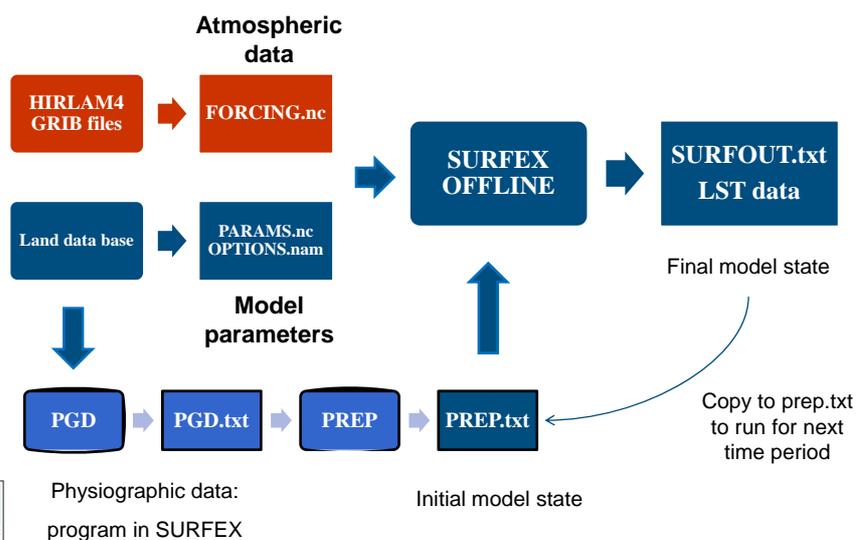
NILU grid is inside green area and has a 4km resolution



- ❖ When running the SURFEX model several files are read and written  
(See next slide)
  - Initial model state (land surface temperature, soil moisture, snow cover, etc.) is read from an ASCII file PREP.txt
  - Final model state is written to an ASCII file with the same format SURFOUT.txt
  - The model also produces a set of NetCDF files (\*.OUT.nc) containing various fields (e.g. LST,...) which can be plotted
  - Model successfully run on a linux platform: email to Met.No Aug 2008
  - Now implementing and testing SURFEX model on "Ulven" machine at NILU



### SURFEX model data flow (no DA)



## Actions

- Couple SURFEX to DA scheme and satellite observations
- NILU hope to use HIRLAM tools & benefit from developments (e.g. plotting software, rotated grid, formats,...) - **to discuss 5 November**
- Building resources at NILU: several proposals submitted & planned; involvement of Met.No
- Proposal to ISSI for a workshop in Land DA (2009 timeframe), led by NILU/Met.No - outcome to include a book (standard for workshops at ISSI)
- Visits: P. Sakov, O. Talagrand,...



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## Outlook

- Confront models with observations (extend ideas from NWP)
- Exciting & important problem scientifically with lots of benefits
- **Interest to NWP**
  - Better use of observations affected by the land
  - Better initial conditions for 2-week to seasonal forecasts
- **Interest to climate modellers**
  - Better land surface schemes
  - Better climate models
  - Better set up/design of experiments
  - Better understanding of performance of climate models
- **General interest to land/atmosphere scientists**

*Build on general ideas beyond NWP, e.g. chemical DA (see next slide):  
Geer et al. ACP (2006,2007); Lahoz et al. ACP (2007a,b)*



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