A study of ensemble snow data assimilation in north-eastern Eurasian continent

KAZUYOHI SUZUKI

JAXA Joint PI workshop GCOM-W
2014/11/17

Contents

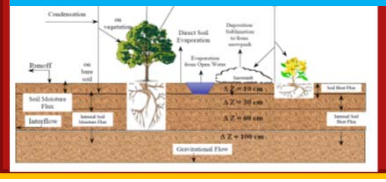
1. 3 years summary

Development of coupling land-atmosphere data assimilation system

Conventional obs.

Micro-wave radiance

Coupling atmosphere-land model (WRF-ARW)

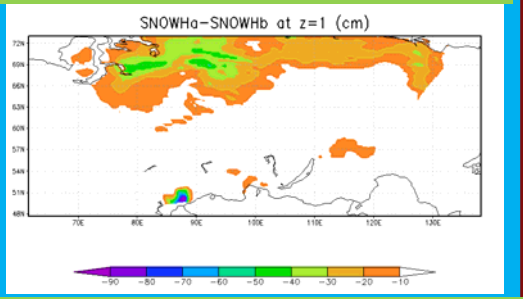


Hybrid-variational data assimilation technique (MLEF, Zupnaski, 2005)

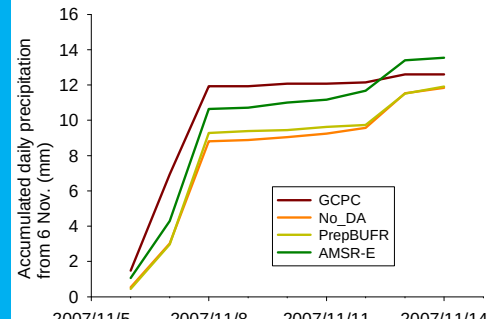
Control variables:
Atmospheric parameters (e.g. Hydrometers)
Land parameters (e.g. Vertical profiles of soil, snow depth and water equivalent)

Results

Reducing uncertainty in Land



Better state estimation in observation gap region



2. Status of Research Product Candidates

1. **Algorithm status**
   - Development of land-atmosphere data assimilation system
   - In next summer, out system can be ported to JAXA computer for quasi-real-time product
2. **Implementation**
   - Data format: NetCDF or Grads binary
   - Parameters: 97 WRF-ARW model parameters
3. **Goal accuracy**
   - Comparable to other data assimilation products (ECMWF, JRA, NCEP etc.)
   - Finer resolution than other products
4. **Validation plan**
   - Self consistency check: Chi-squares
   - Comparison to independent available data sets (ex. Global data assimilation products, In-situ observation data)

3. Objectives

- To develop the coupling land-atmosphere data assimilation system
- Reduce uncertainty of state vectors
- Evaluate the land analysis in data assimilation system
- Effectiveness of satellite-based radiance data in the system

4. Methodology
4.1 Hybrid-variational data assimilation MLEF, Zupanski (2005)

$$J_{\mathrm{Var}}(\mathbf{x}') = \frac{1}{2}(\mathbf{x}')^{\mathrm{T}}\mathbf{P}_f^{-1}(\mathbf{x}') + \frac{1}{2}(\mathbf{H}\mathbf{x}' - \mathbf{y}_o')^{\mathrm{T}}\mathbf{R}^{-1}(\mathbf{H}\mathbf{x}' - \mathbf{y}_o') + J_c$$

- J : Penalty (Fit to background + Fit to observations + Constraints)
- $\mathbf{x}'$: Analysis increment $(\mathbf{x}_a - \mathbf{x}_b)$; where $\mathbf{x}_b$ is a background
- $\mathbf{P}_f^{-1}$ Forecast error covariance: defined in a subspace spanned by ensemble forecast incr
- $\mathbf{H}$: Observations (forward) operator
- $\mathbf{R}$: Observation error covariance (Instrument + Representativeness)
- $\mathbf{y}_o'$: Observation innovations/residuals $(\mathbf{y}_o - \boldsymbol{H}\mathbf{x}_b)$
- J_c : Constraints (physical quantities, balance/noise, etc.)

4.2 System design

Target domain
27 km resolution

- **Climate Model**

  WRF-ARW

- **Observation operator**

  -NCEP GSI

  -Joint-simulator

- **Observation**

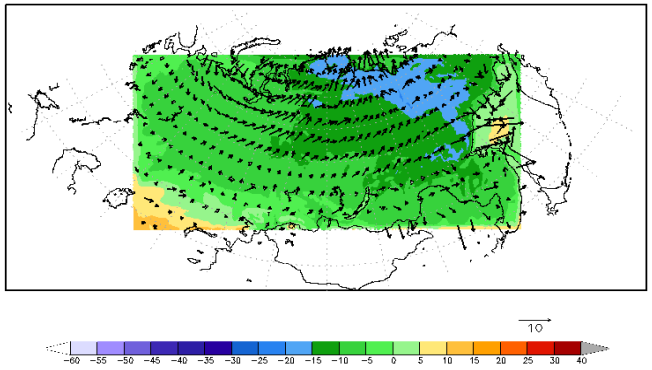
  -Conventional data

  -Passive microwave radiance

- **Ensemble simulation**

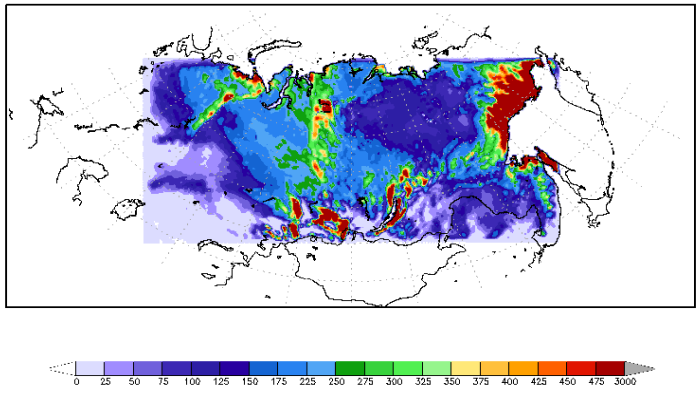
  -32 members

  - 1200UTC 5 Nov. 2007

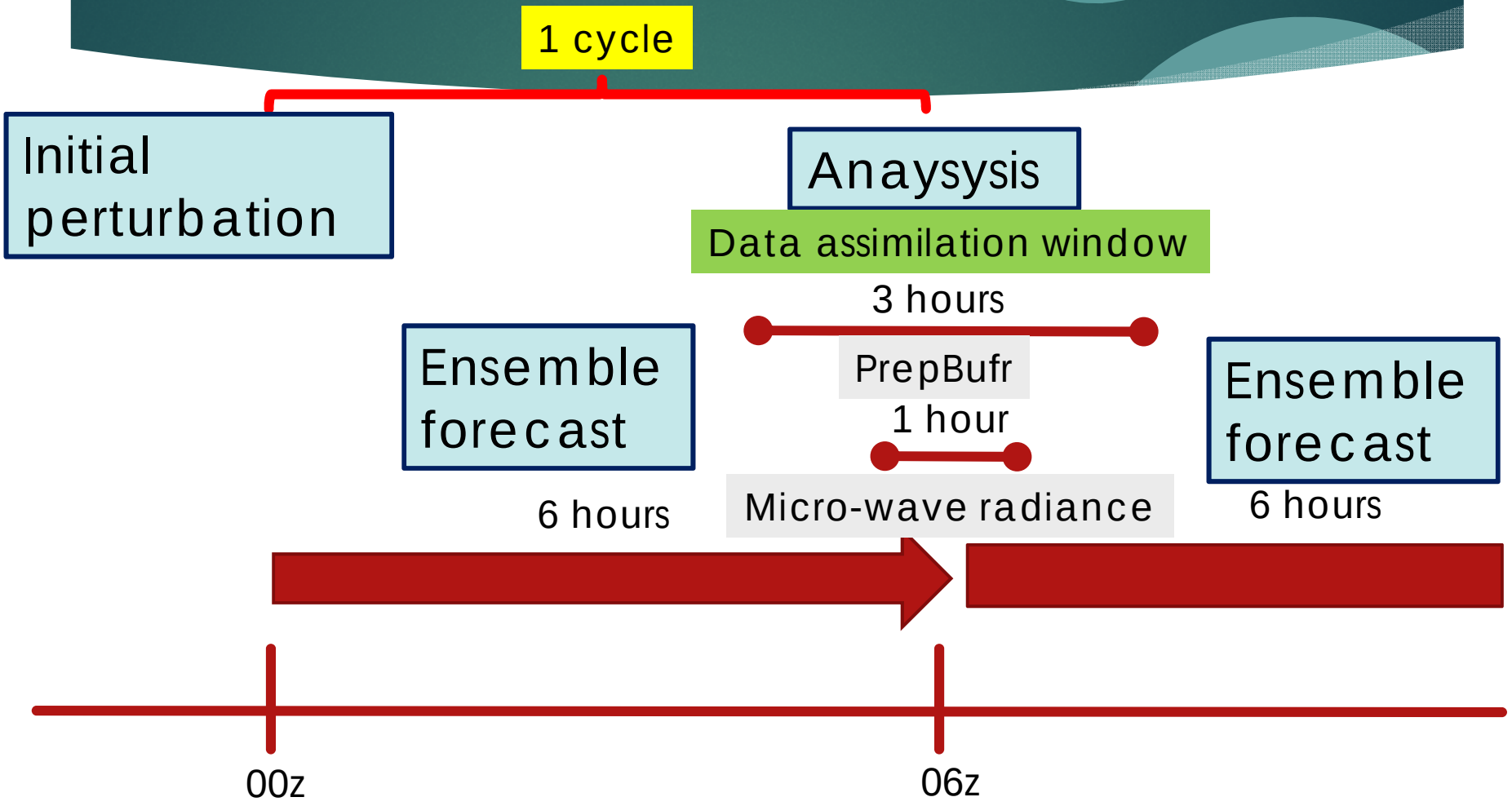


Snowpack (mm, color)

APR2009



4.3 Data assimilation cycle



6.1 Conclusions

- Coupling land-atmosphere data assimilation system was established.
- Reduction of uncertainty in land state and also reduce some atmospheric uncertainty
- Land analysis contributed to improve the state of snow depth.
- Data assimilation of setellite-based radiance observation improved daily precipitation event
- Microwave radiance improved spatial precipitation over Arctic

6.2 Future work

- Employ sophisticated land surface model
  - ✓ Multi-layer snow model
  - ✓ Lake model

- Multi-satellite radiance data assimilation
  - ✓ Overcome multi-spatial and temporal scales
  - ✓ Include infrared radiance data