Application of CEOP EOP 3 Data to a new Data Assimilation System for Soil and Snow

6th CEOP International Implementation Planning Meeting, 12-14 March 2007

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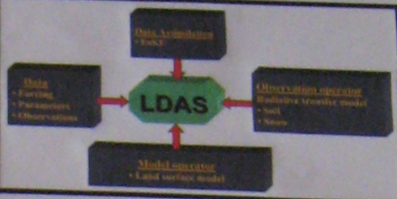
INTRODUCTION

Objectives:

- Development of a data assimilation system which can integrate a land surface model with remote sensing observation to improve the prediction of the land surface variables.
- The LDAS will later be coupled with atmospheric models.

Data Assimilation:

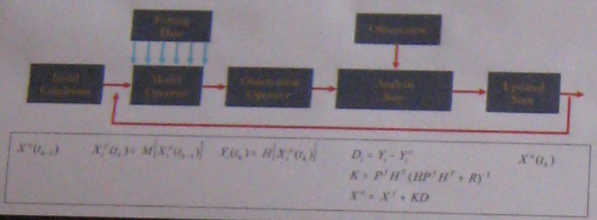
- Coupling satellite observation with a land surface scheme => combining the information from two sources
- Sequential Data Assimilation Scheme:
  - Forward model for land surface (Model Operator)
  - Comparison of new model state with observation using an observation operator
  - Update of model state



LDAS - OVERVIEW

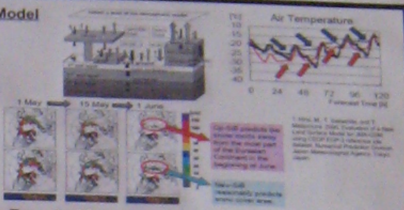
Ensemble Kalman Filter (EnKF):

- Sequential Data Assimilation – Ensemble Kalman Filter
- Ensemble of Model State: $X^a = \{X_1^a, X_2^a, \ldots, X_n^a\}$
- Predicting change of each Ensemble Member
- Comparing with Observation, if available (Analysis Step)
- Updating Ensemble Members



Model Operator – Land Surface Model

- JMA's operational global NWP model currently adopts the Simple Biosphere (SiB) model, which is developed by Sellers in 1986.
- In new SiB, snow and soil processes are improved substantially (including snow metamorphism).



Observation Operator – Radiative Transfer Models

Soil Radiative Transfer

- Q/h Model
- AIEM – Advance Integral Equation Model

Snow Radiative Transfer

- MEMLS: Microwave Emission Model of Layered Snowpacks

Other Observation Operator can be easily integrated

APPLICATION EXAMPLES

CEOP EOP 3 Data Set for Application

- Forcing Data:
  - Model Output from JMA-GSM, operational global data assimilation system (3D-Var).
- Observation
  - Satellite Brightness Temperature - AMSR-E
- In-Situ Observation for Comparison

Application

- Soil Moisture: CEOP Mongolia Site
- Snow Depth: CEOP Eastern Siberian Taiga Site

Soil Moisture/Temp. - CEOP Mongolia Reference Site:

- ADEOS II Mongolian Plateau Experiment for Ground Truth
- Grassland and Short Shrubs => Veg. RTM not considered
- Observation: TB + Polarization Ratio at 6.9 & 10.7 GHz
- Assimilation Parameter: Soil Moisture and Temperature

Snow Depth - CEOP Eastern Siberia Taiga:

- Eastern Siberia Taiga
- Shallow Snowpacks
- Dominated by Pine and Larch forest, however open fields along the banks of the Lena River
- Observation: $dTB = TB_{18.7} - TB_{36.5}$

Soil Assimilation:

- Direct TB Assimilation:
  => Update Soil Temperature and Moisture
- Polarization Ratio:
  => Update only the Soil Moisture

Snow Assimilation:

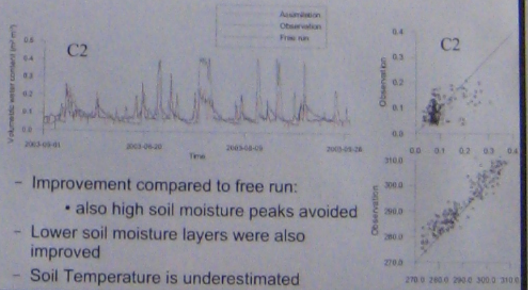
- Update Snow Depth only
- 2 Cases:
  1. Using Precipitation from Model Output
  2. Assuming No Precipitation
  => Error in Modeled Precipitation

Soil Moisture and Soil Temperature at C2 and G6:

- Polarization Ratio => only Soil Moisture

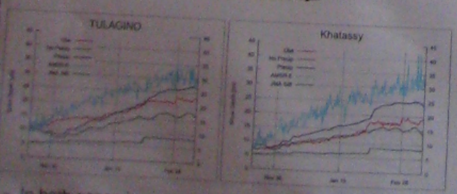
- Improvement compared to free run:
  - during dry periods,
  - high soil moisture peaks avoided

- Direct TB assimilation => Soil Moisture and Temperature



- Improvement compared to free run:
  - also high soil moisture peaks avoided
- Lower soil moisture layers were also improved
- Soil Temperature is underestimated

Snow Depth at Tulagino and Khatassy:



- In both cases improvement compared to free model run and AMSR-E Snow Depth data
- Both Precipitation and No-Precipitation provide reasonable results

Summary for 7 In-Situ Snow Depth Observation Sites:

Site	No Precip. A	R	B	E	Precip. A	R	B	E	AMSR-E SD A	R	B	E
Khatassy	12.0	1.9	-0.9	10.7	16.5	4.2	+3.6	26.0	23.0	11.0	+10.1	77.7
Larch	12.4	6.3	-5.8	30.6	16.2	2.5	-1.9	12.1	24.2	6.7	+6.1	36.7
Pine	12.4	2.0	+1.1	17.6	16.2	5.4	+5.0	45.0	23.7	12.8	+12.5	120.3
Molot	12.4	2.4	0.0	18.2	16.2	4.1	+3.9	34.0	25.0	12.8	+12.6	113.2
Tulagino	12.7	4.7	+4.4	26.2	17.0	2.9	0.0	14.7	23.2	6.8	+6.0	34.6
Viluy	17.5	4.8	+4.6	39.8	21.2	8.6	+8.3	64.4	29.3	17.0	+16.3	127.3
Kenkeme	17.0	5.0	+4.4	48.8	20.4	8.0	+7.9	71.6	27.7	15.2	+15.1	137.2

A = Average [cm], R = RMSE [cm], B = Bias [cm], E = Avg. Error [%]

Conclusions:

- CEOP Data Set provides a valuable resource for application development and testing.
- For both cases (snow and soil), the assimilation of the satellite brightness improves the result of the land surface model.
- The flexible LDAS allows an easy integration of a wide variety of observation sources.

Outlook:

- Coupling with atmospheric model: Improved feedback between land-surface and atmosphere?
- Addition of further observation sources (e.g. MODIS).