Application of Multi-Frequency Passive Microwave Observations and Data Assimilation Strategies for Improving Numerical Weather Forecasting

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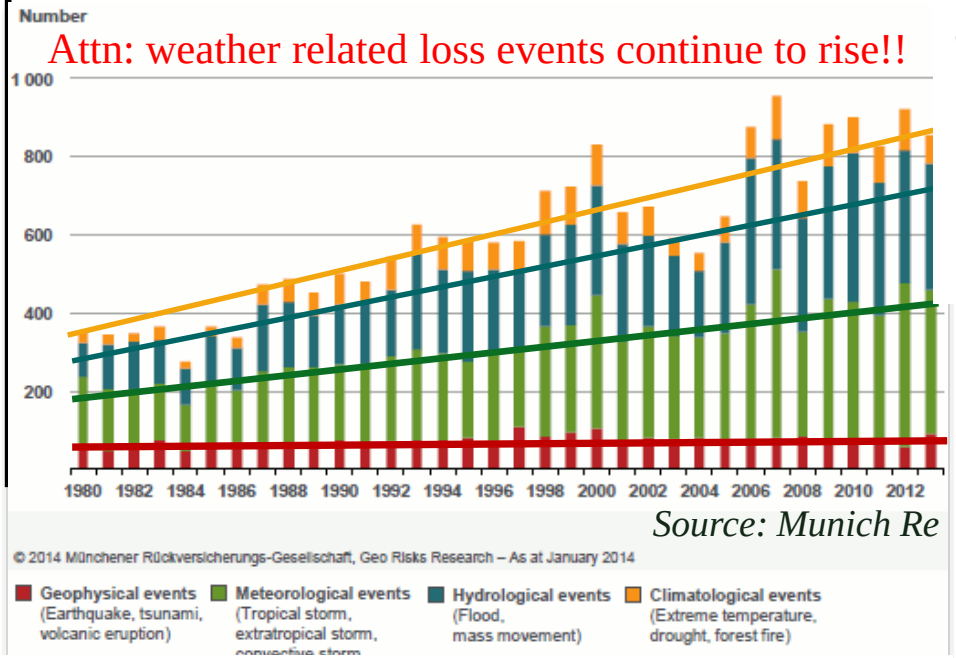
Extreme Events & Numerical Weather Forecasting



- In future, frequency and intensity of these extremes will most likely increase. (IPCC-AR5)

- More efforts to improve our understanding and prediction capabilities to reduce losses against impacts of meteorological, hydrological, and climatological events.

- NWF is based on present state, but obtaining reliable and necessary insitu observations in developing regions is very challenging due to several issues.

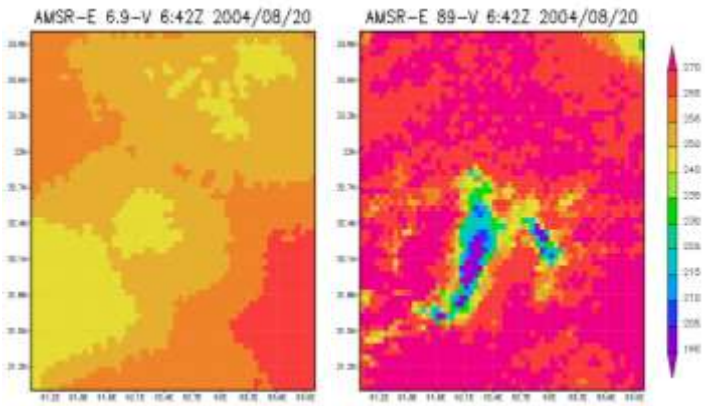
Advancements in space-bone technology provide an extraordinary opportunity for collecting required information → satellite-based forecasting systems is one of few affordable solutions for developing regions.

Soil moisture & Microwave Observations

- Soil Moisture is a key variable in L-A coupled model.
  - Water & energy budgets, land-atmosphere interactions, and thereby affect meteorological, hydrological and climatological Forecast
  - It exhibits long and persistent memory, which influences short- and medium range forecasts, metrological draughts and floods, seasonal predictability

Microwave lower frequency is appropriate

- Dielectric constant → (ε_{soil}~ 4 , ε_{water}~ 80)
- longer λ → Penetrate cloud and light rain
- Data is at regional/global scale with frequent coverage



6.9 GHz 89 GHz

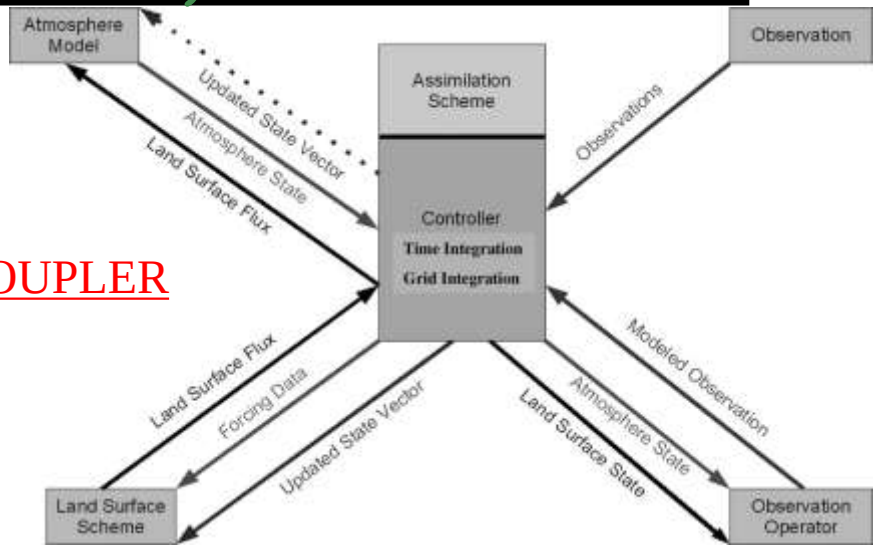
The Advanced Microwave Scanning Radiometer - Earth Observing System (AMSR-E)

Land Data Assimilation System coupled with Atmospheric model (LDAS-A)

GCM Prediction or Analysis (Initial & Boundary Conditions)

Meso-scale Model (Initial Guess)

Land surface model



COUPLER

Rasmy, M.; Koike, T.; Boussetta, S.; Hui Lu; Xin Li, TGRS, 2011

Moisture Heterogeneity

6.9 & 10.6 GHz

RTM for land surface (6.9, 10.6 Ghz)

Assimilation Algorithm-EnKF

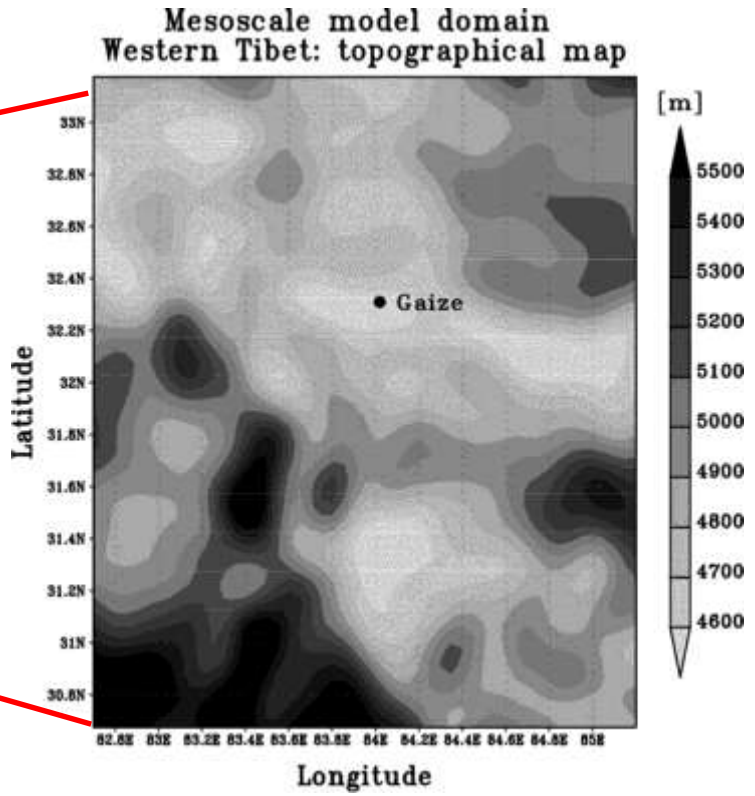
LDAS

Land-atmosphere coupled meso-scale model

Land data assimilation system (LDAS)

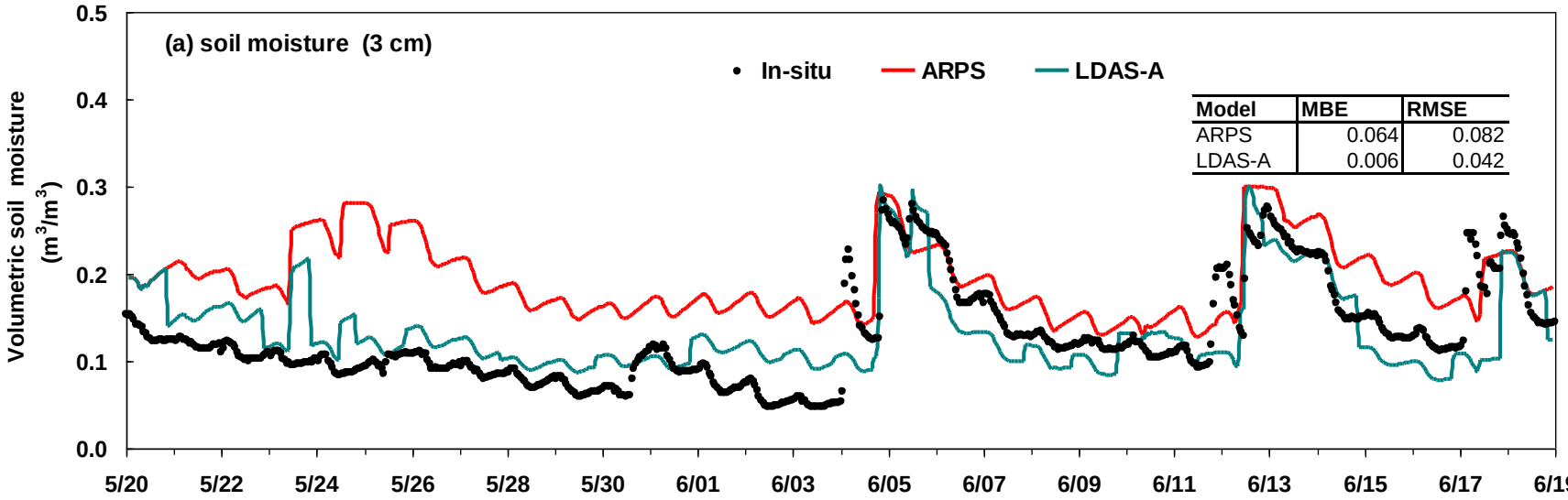
Incorporate near-real time SM within a mesoscale model simulations

Numerical Experiments in Tibet

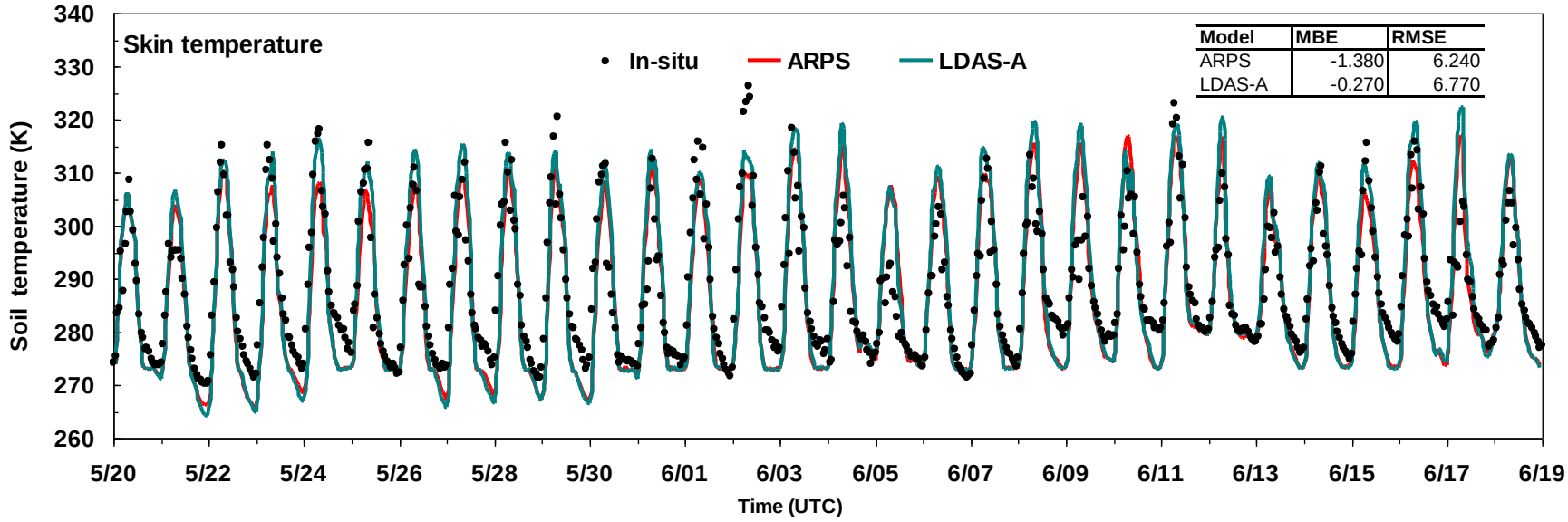


- Strong solar radiation, heterogeneous soil moisture → favorable for studying L-A interaction.
- Sparse vegetation with less human activity → applicability of RTM
- Availability of validation dataset → AWS, Radio-sonde, MTSAT/IR

Surface Soil Moisture & Skin Temperature



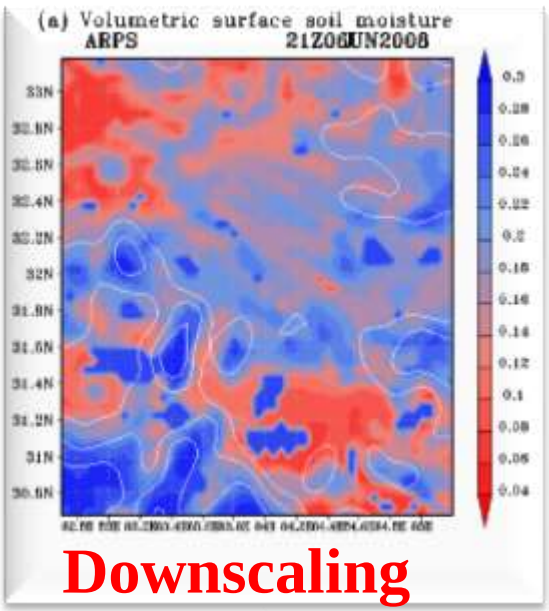
Model	MBE	RMSE
ARPS	0.064	0.082
LDAS-A	0.006	0.042



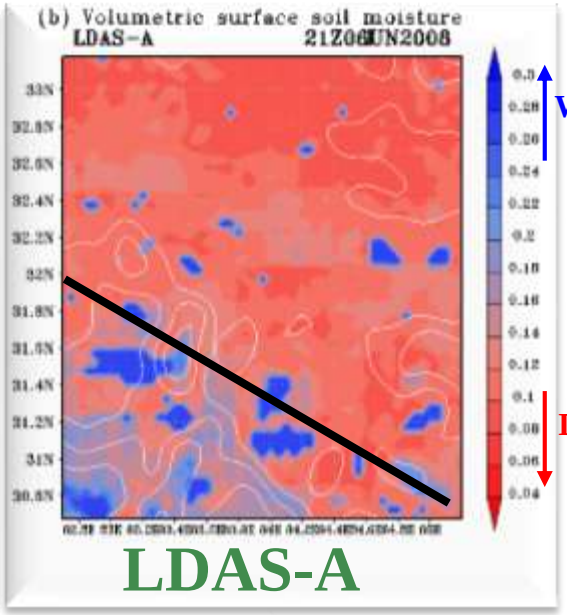
Model	MBE	RMSE
ARPS	-1.380	6.240
LDAS-A	-0.270	6.770

Vertical transfer of water and energy fluxes

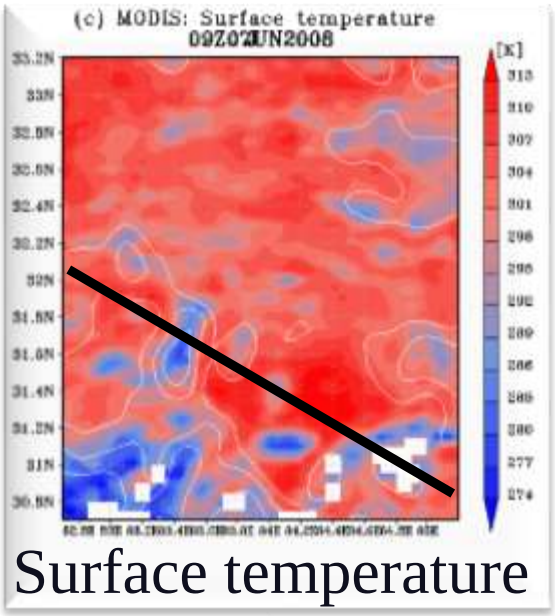
Surface Soil Moisture - Distribution



Downscaling



LDAS-A



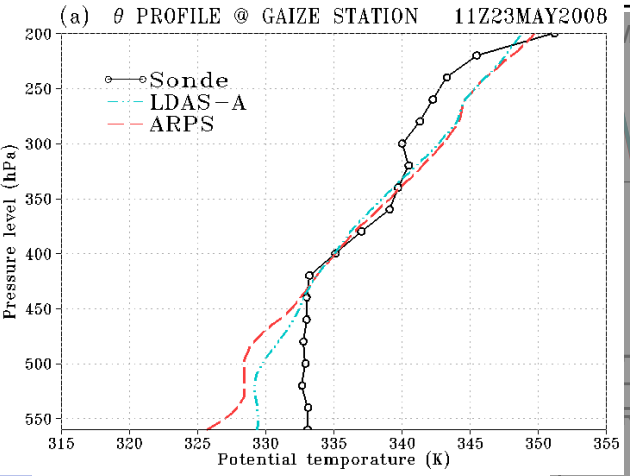
Surface temperature (MODIS)

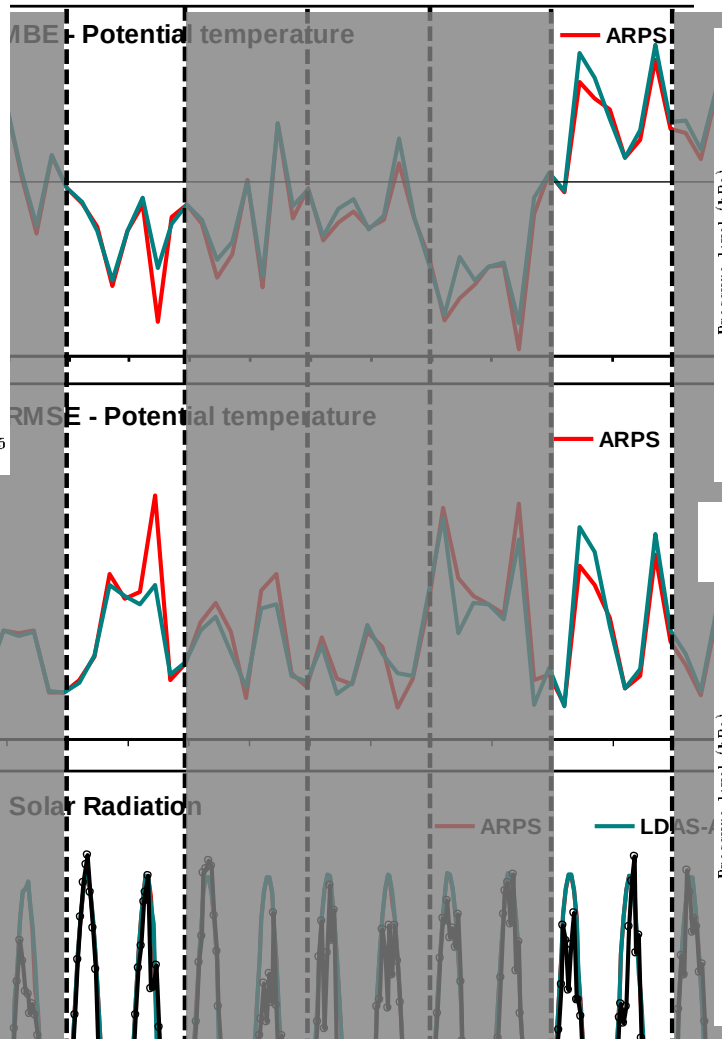
Better representation of wet & dry regions

- Differential heating
- Local circulation

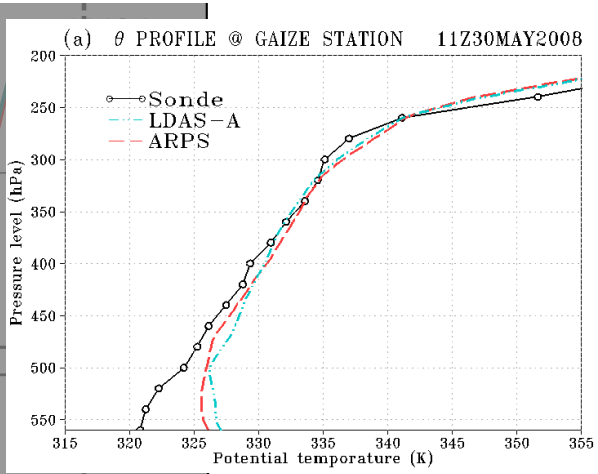
L-A Interactions: Sounding

Potential Temperature (K)

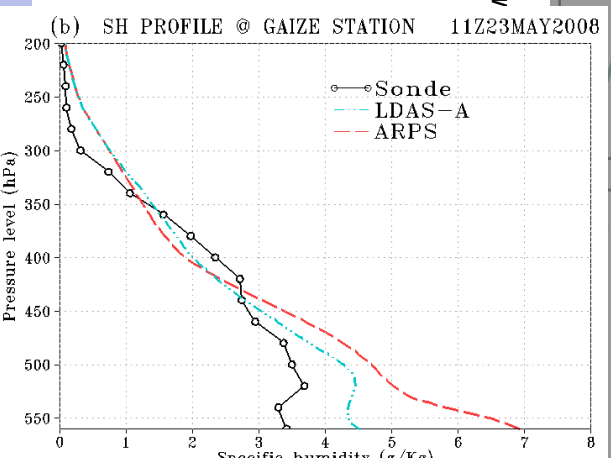




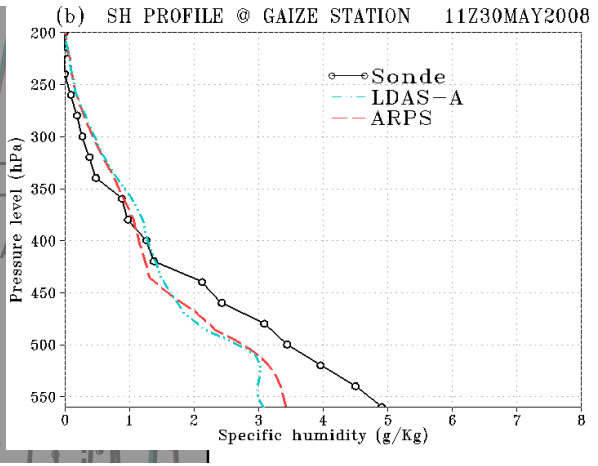
Potential Temperature (K)



Specific humidity (g/Kg)

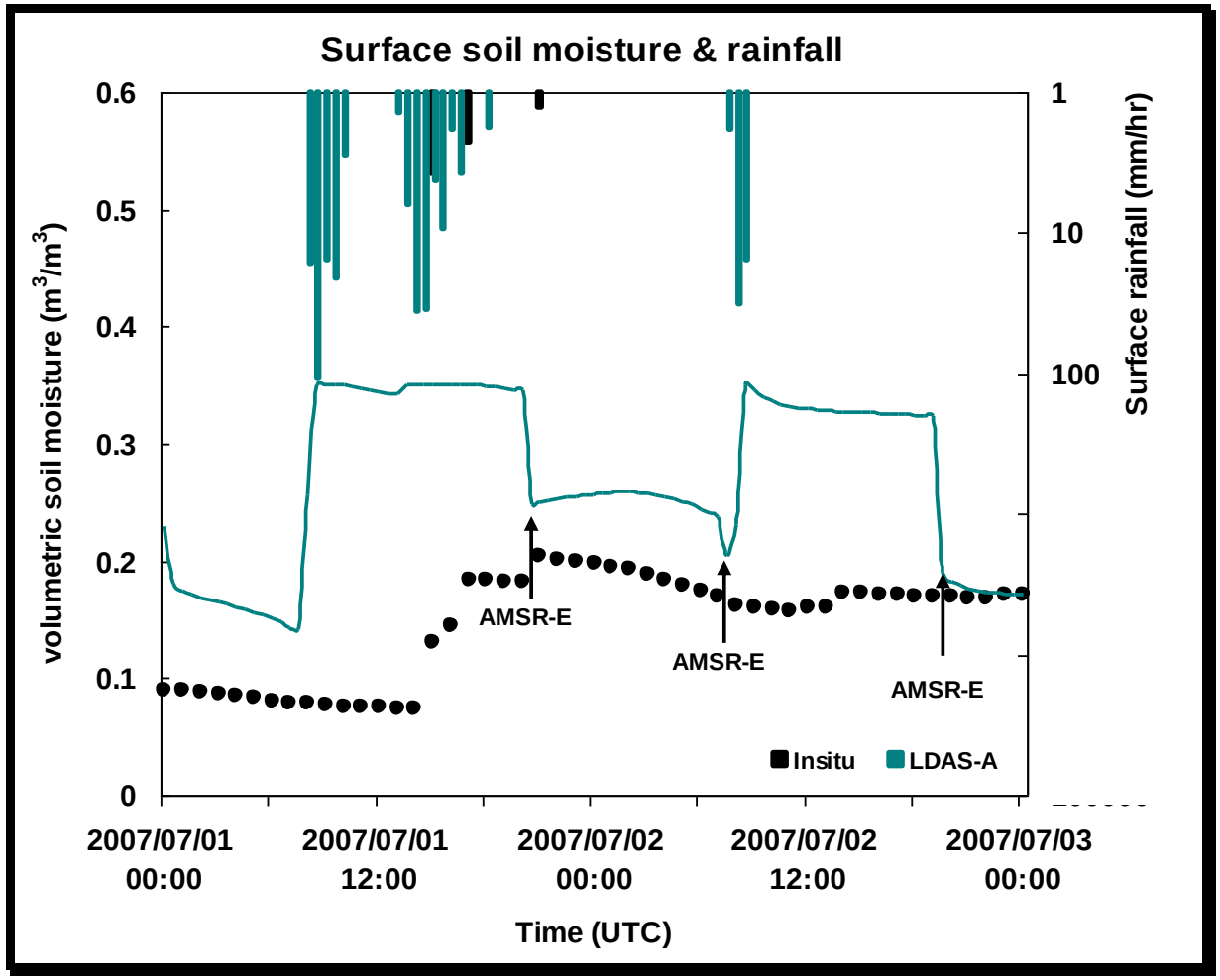


Specific humidity (g/Kg)



Improvements in solar radiation (+ soil moisture), are necessary to introduce realistic land–atmosphere interactions

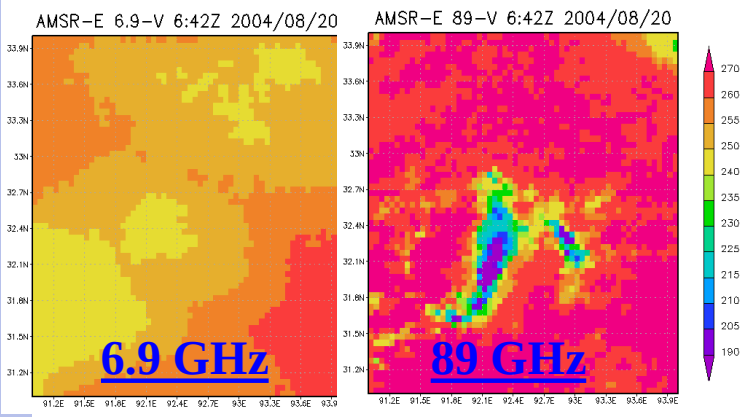
Rainfall effect on soil moisture

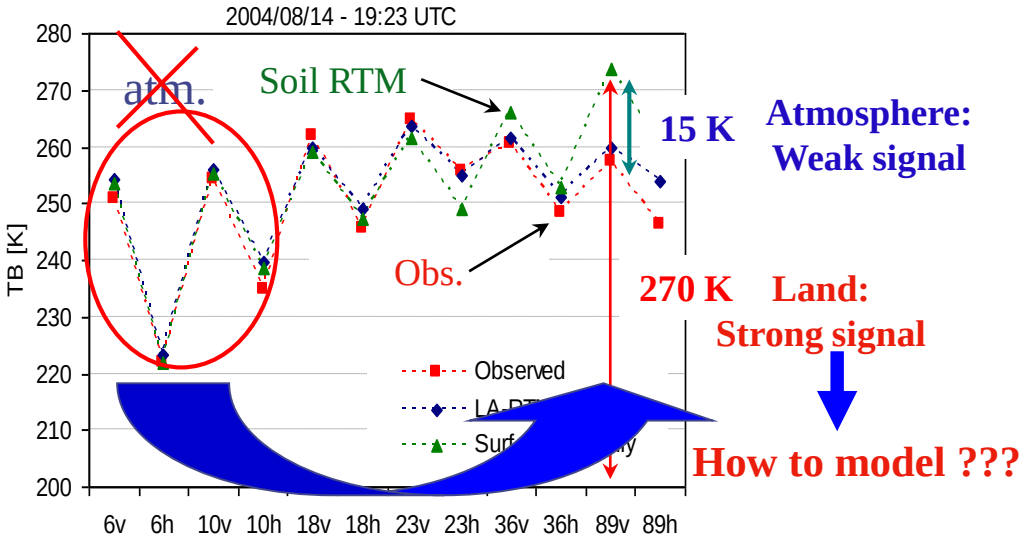


Improvements in rainfall are necessary to keep the assimilated land information

Passive remote sensing of Cloud over land

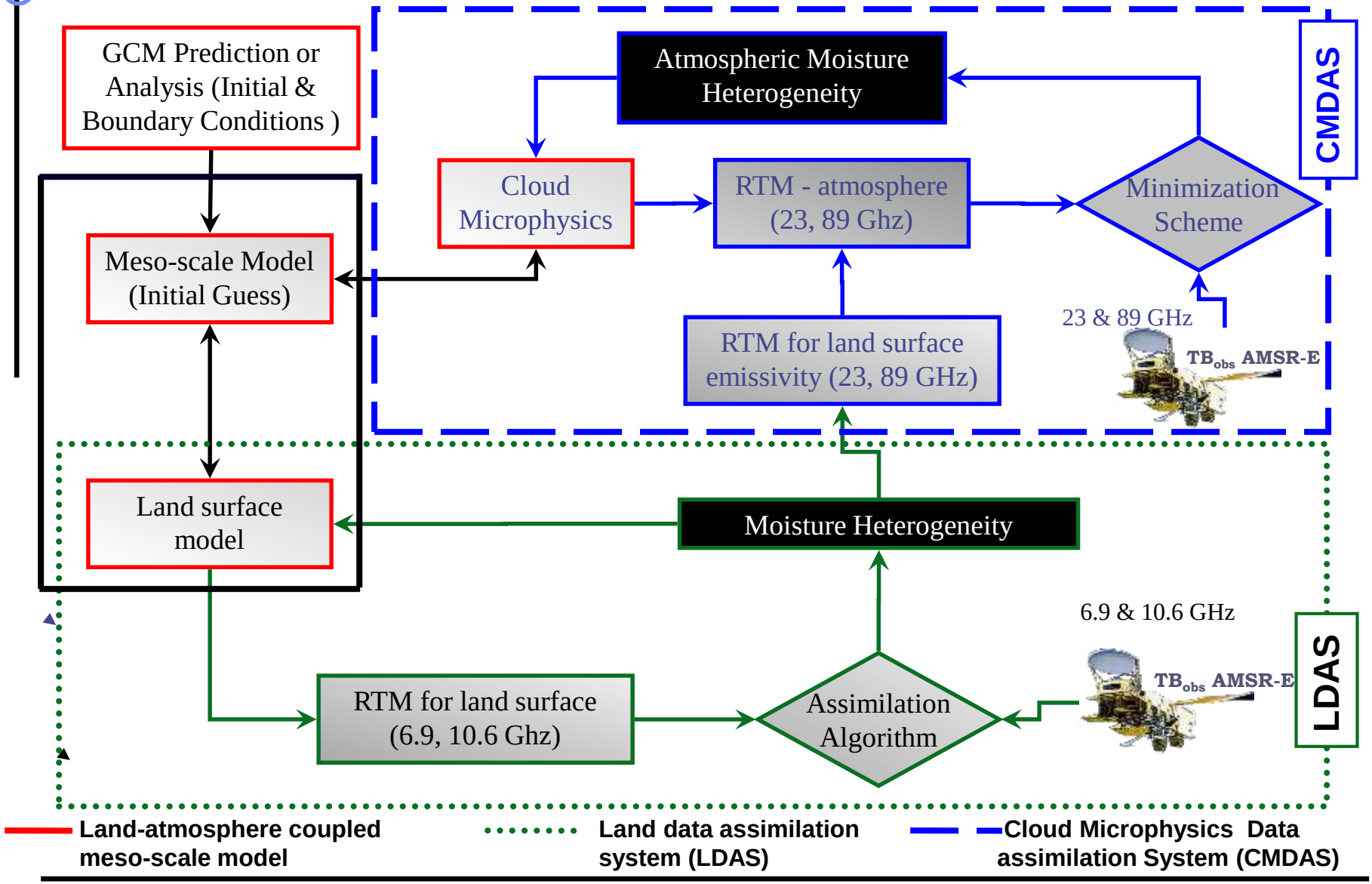
- Cloud controls meteorological forcing (radiation & rainfall) and thus affects estimation of the budgets. (Meteorological events)
- Location and intensity of rainfall is very important, but often inaccurate in weather and climate model. (Meteorological & Hydrological)
- Clouds & Moisture fields → Microwave high frequency (optical vs microwave)
  - Possible over ocean & sea → weak & homogeneous background emission.
  - Challenging over land → Strong & heterogeneous emission





Merging multi-frqs. can able to convert weak signal to useful information.

Coupled Atmosphere and Land Data Assimilation System (CALDAS)



Rasmy, M.; Koike, T.; Kuria, D.; Mirza, S.; Xin Li; Kun Yang, TGRS, 2012

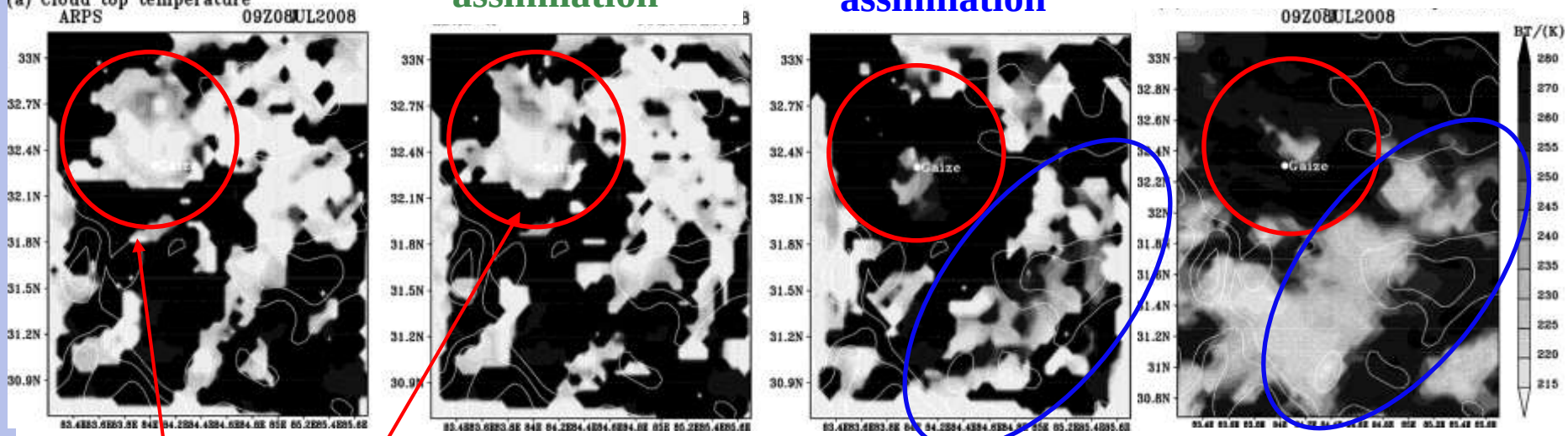
Hydrometeorological Variables & L-A Interaction

Downscaling

Land data assimilation

Coupled atm and land data assimilation

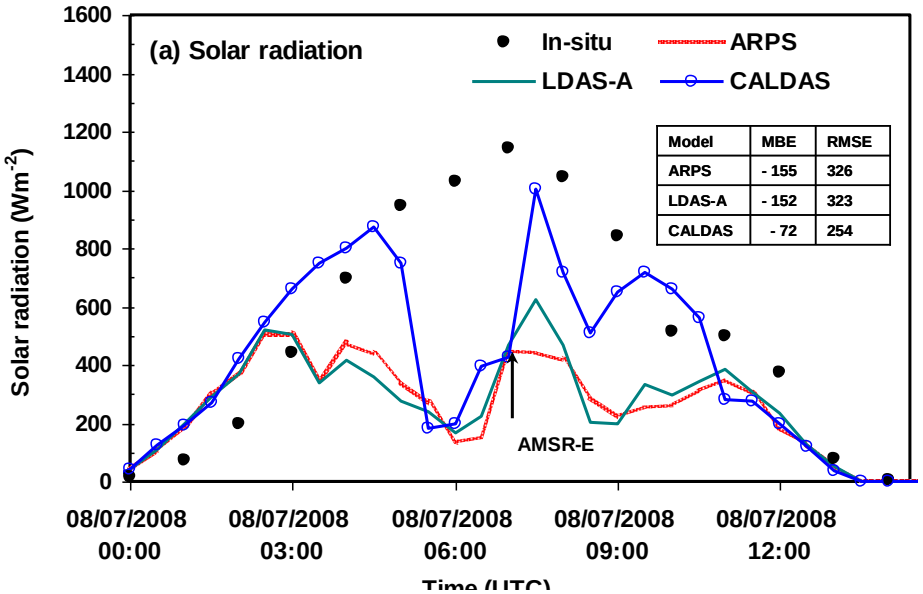
Cloud top temperature (MTSAT/ IR)

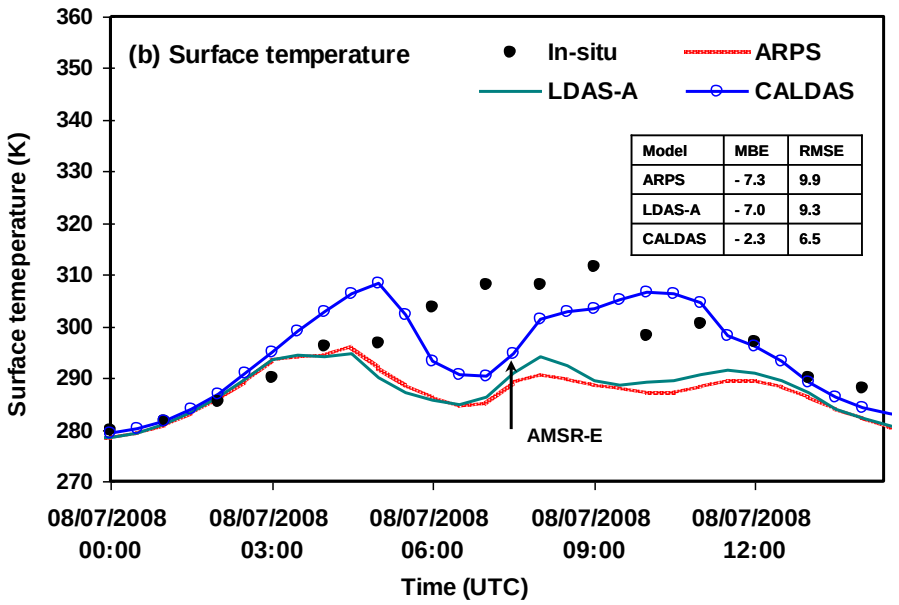


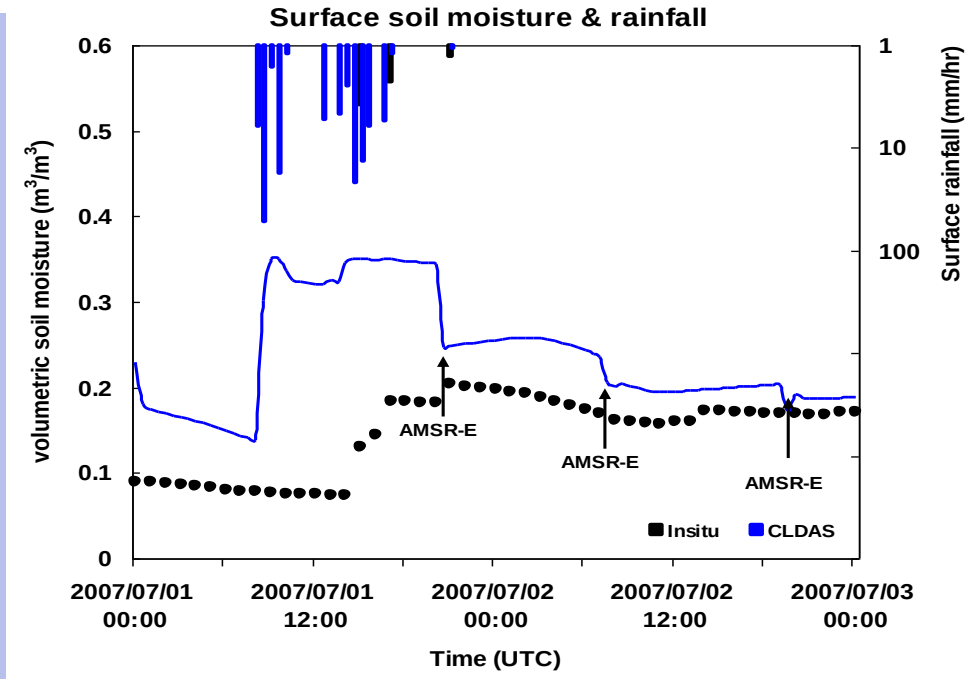
Similar pattern:

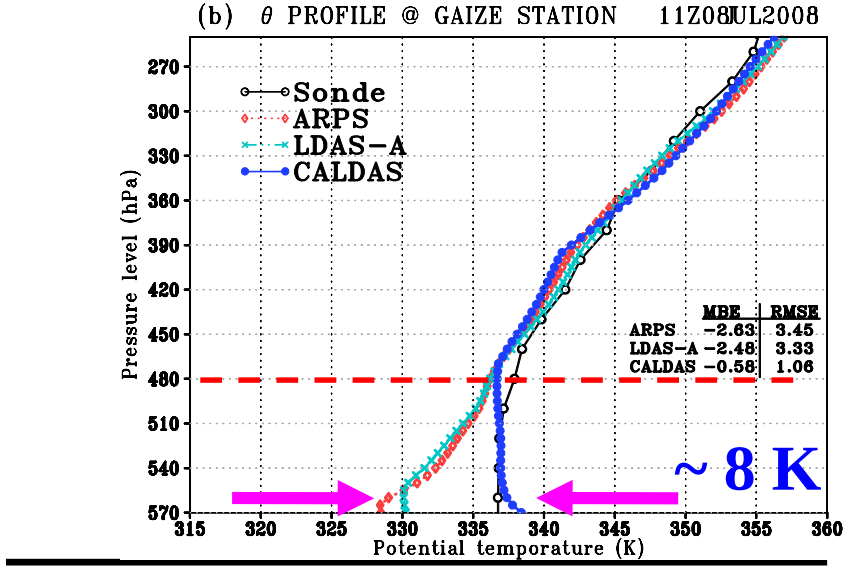
Both → cloud assimilation.

Solar Radiation, Temperature, L-A Interactions



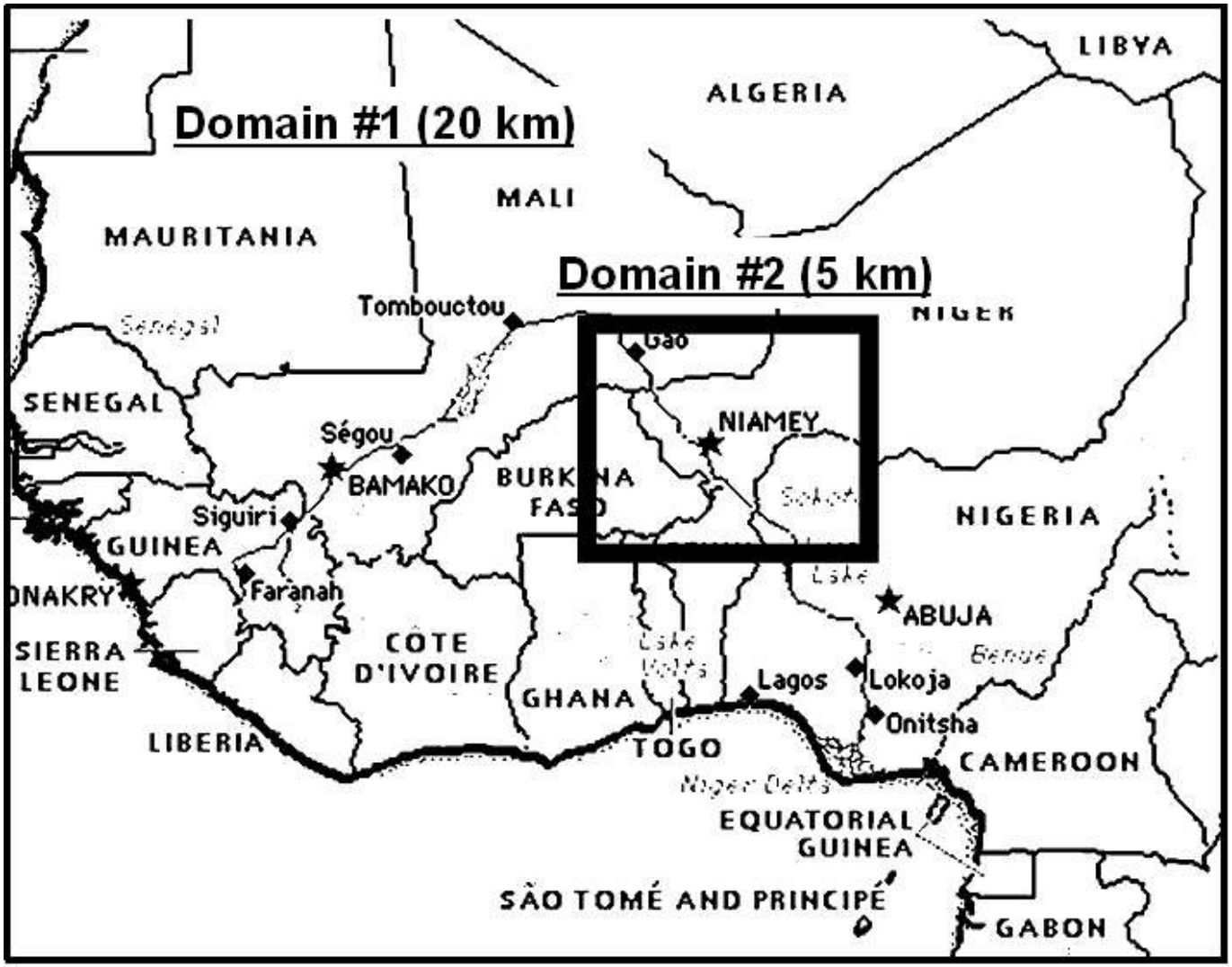






Rasmy, M. &Coauthors, TGRS, 2012

CALDAS Application – Niger, Africa



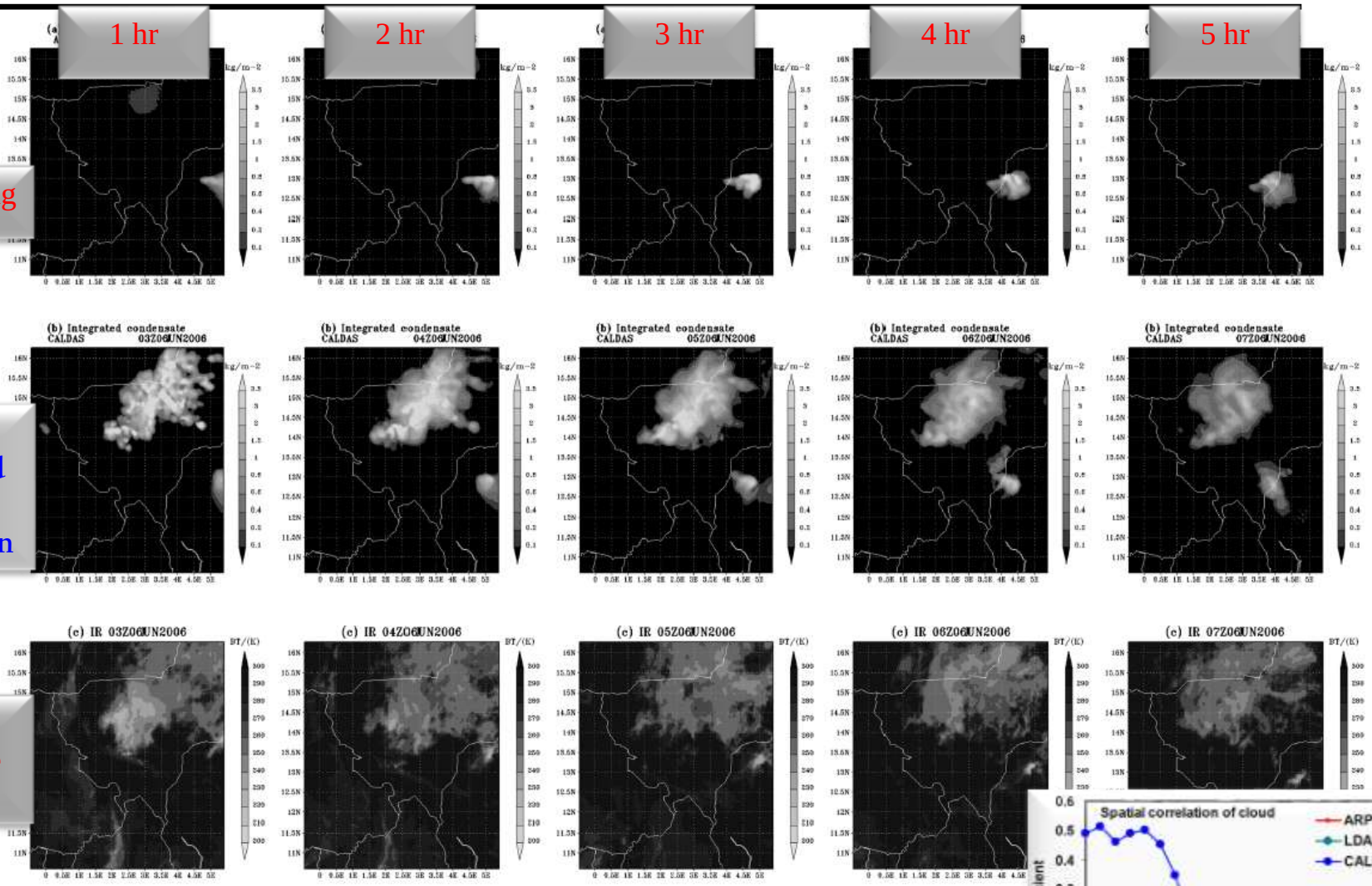
Cloud Integrated Condensate

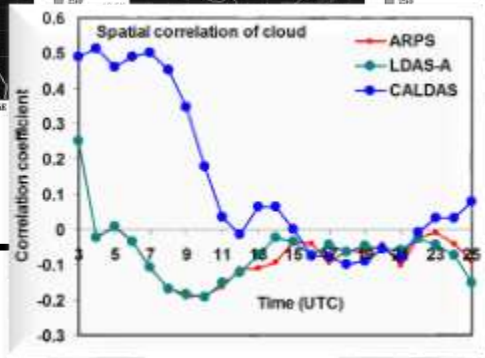
1 hr | 2 hr | 3 hr | 4 hr | 5 hr

Downscaling

Coupled atm. - land data assimilation

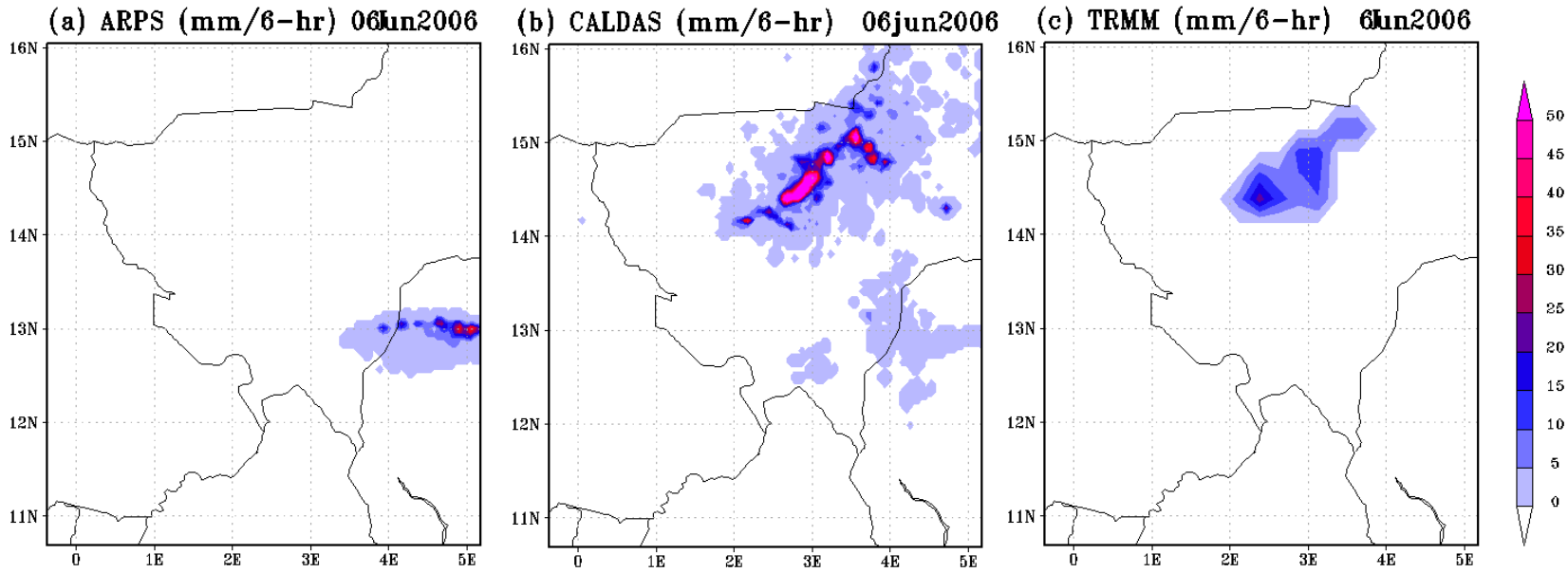
Cloud top temperature (Satellite)





Hourly variation of integrated cloud condensate

Precipitation Forecast – in Niger



Downscaling

Coupled atm. and land data assimilation

Satellite (TRMM)

6-hrs accumulated rainfall

Precipitation Forecast – in Japan

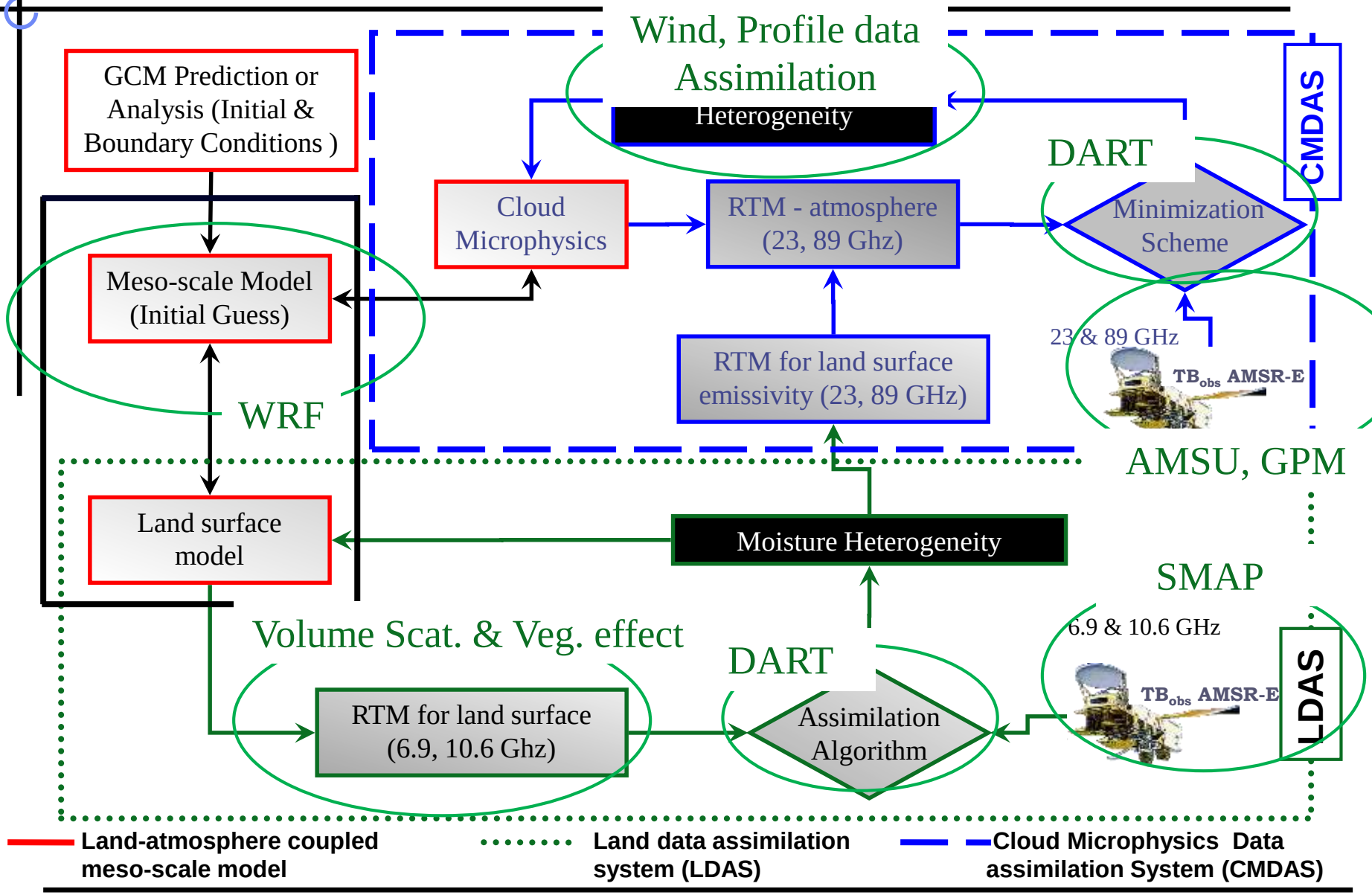
Poster Presentation

Development of a satellite-based coupled land and cloud data assimilation system with WRF and its application to heavy rain prediction

Rie SETO, Toshio KOIKE, Mohamed RASMY

This reseach outlined the applicability of multi-frequency passive microwave observations for improving NWF. Incorporation of other sensors will further improve the model performance and forecasting accuracy.

On going and future work on CALDAS



- Thank You -

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Results: Sounding profile