4DDA: High Resolution and Satellite Data Assimilation

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INTRODUCTION

High spatial resolution and accurate weather analysis is needed in support of planning and operations in DoD applications. This need cannot be fulfilled by means of high resolution in situ observations of weather parameters because these observations are not available in majority of geographical regions of interest, including the USA domains when demands are on small meso and micro spatial scales. Solution to this problem requires that other, remote sensing, observations are systematically assimilated into regional numerical weather prediction type models nested within operational global or large regional weather analysis.

In the Center for Geosciences/Atmospheric Research in CIRA research is conducted to develop methodology and software technology for weather and surface condition regional analyses that would take advantage of satellite remote sensing measurements under all weather conditions. Our approach is assimilation of radiance observations into a mesoscale and cloud resolving numerical prediction model by the way of 4D variational data assimilation technique.

The data assimilation problem consists of 4 major components:

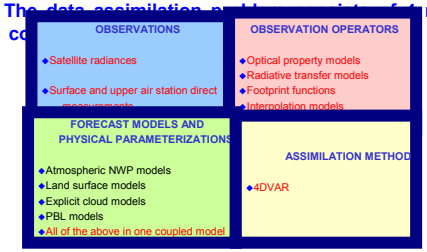
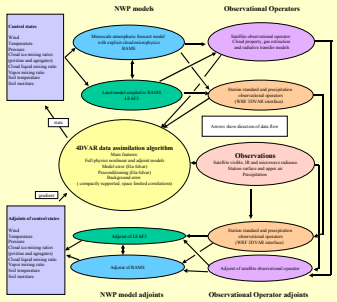


Figure 1: Components of data assimilation problem and specific choices made in RAMDAS for atmospheric satellite DA

1. 4DVAR DATA ASSIMILATION ALGORITHM

Regional Atmospheric Modeling and Data Assimilation System (RAMDAS)



✓Runs in PC cluster or IBM SP parallel environment

✓Real time 4DDA applications feasible on IBM

2. OBSERVATIONAL OPERATOR MODELS FOR VISIBLE AND INFRARED MEASUREMENTS

Models in the operator are:

Gas optical properties - OPTRAN (McMillin et al., 1995)
Vis and near IR with scattering - SHDOM (Evans, 1998)
IR- Eddington two-stream (Deeter and Evans 1998)

Forward and adjoint links between forecast model and observations by the way of the observational operator are shown in Figure 2.

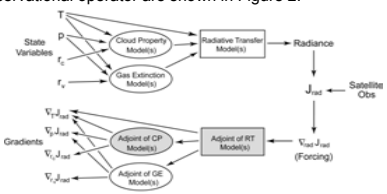


Figure 2

3. POTENTIAL INFORMATION CONTENT OF VISIBLE AND INFRARED RADINCE MEASUREMENTS WITH RESPECT TO THE EXPLICIT CLOUD PREDICTION

We studied potential information content of observations relative to the representation of clouds as defined in the mesoscale forecast model: hydrometeor mixing ratio and number concentration. We used the adjoint sensitivity method for this purpose.

The adjoint sensitivity analysis was performed for 3 cases of cloud simulations ranging from relatively simple with low level liquid cloud to more complex mesoscale clouds with ice and mixed liquid and ice hydrometeors. All cases were simulated with RAMS on high resolution grids. Figure 3 shows vertical cross sections of sensitivity of observations to cloud hydrometeor mixing ratio. The sensitivities are expressed as response to 15% perturbation in the mixing ratio.

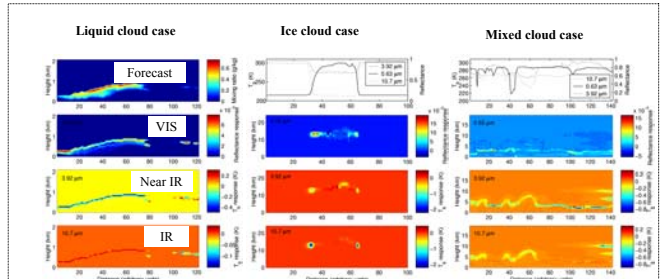
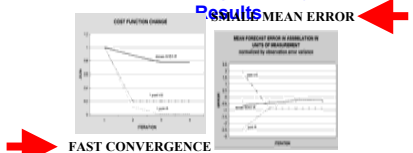


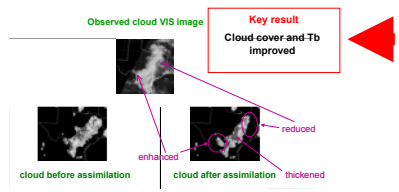
Figure 3: Cross sections of sensitivity of observations to cloud hydrometeor mixing ratio

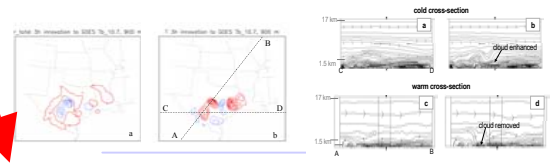
4. 4D CLOUDY WEATHER ANALYSIS

Assimilation of GOES imager cloudy radiances: Key Results



Impact of GOES IR 10.7μm on cloud in assimilation





The entire 4D environment changes consistent with changing the cloud in 4DVAR DA

Publications: Greenwald et al., 2003, Q. J. R. Met. Soc.; Vukicevic et al., 2003, MWR; Zupanski M. et al., 2003, MWR; Zupanski D. et al., 2003, MWR