Cloudy Radiance Assimilation in NCEP Global Data Assimilation (GDAS)

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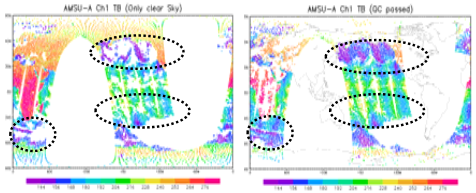
Motivation

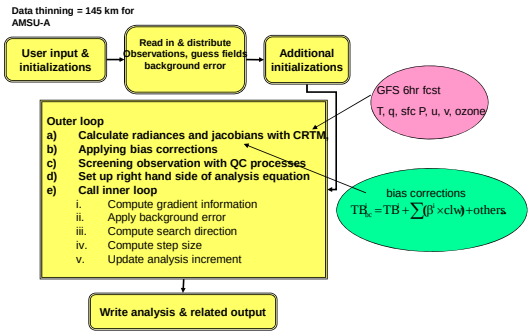


1.Thin cloudy area have been assimilated without including cloudy radiance computation.

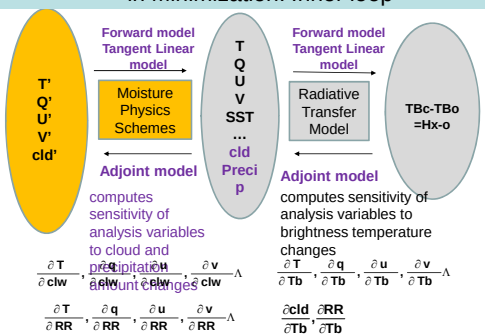
2. Thick cloudy area screened out. Can we extract useful information on cloud out of observations by cloudy radiance assimilation?

• Cloud or precipitation indicates that some dynamically important weather is occurring. Subsequent forecasts are often sensitive to initial conditions in regions with cloud and precipitation occurrence.

Current radiance assimilation in GDAS (Clear sky radiance assimilation)



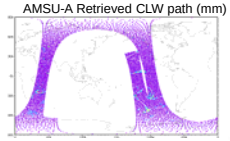
Cloudy Raidance Component in Minimization: Inner loop



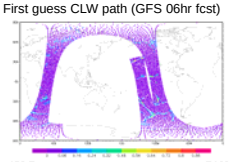
What needs to be done for Cloudy Radiance Data Assimilation

- Radiative transfer model to simulate cloudy radiances (√)
- Cloud first guess profiles in the data assimilation system (√)
- Tangent linear and adjoint model for cloud physics parameterizations (√)
- Add cloud variable as an additional analysis variable in the data assimilation system (moisture conservation terms should be included.)
- Background error covariance and observation error covariance
- Bias correction and quality control system
- Impact study

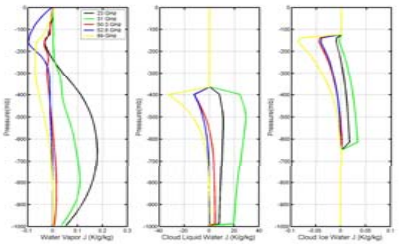
AMSU-A Retrieved CLW path (mm)



First guess CLW path (GFS 06hr fcst)



CRTM computed WV and Cloud Jacobians



Development of Tangent Linear and Adjoint Models for Moisture Microphysics Schemes

(1) Applied scaling parameters to remove discontinuity.

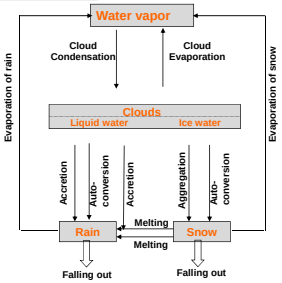
For example,

```
If(x > xc) then
  R=R1
else
  R=R2
endif
```

$$scaleF = 0.5(1 + \tanh(k(xc - x)))$$

$$R = R1 + (R2 - R1) \cdot scaleF$$

(2) Tested these modified moisture schemes by comparing GFS model results to make it sure that these modified models don't cause significant difference in forecast results



(3) Coded tangent linear models based on these modified schemes and examined the linearity.

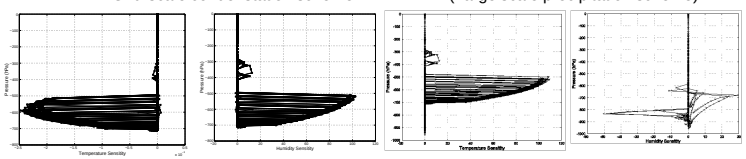
$$\frac{\mathbf{M}(\mathbf{x} + \Delta\mathbf{x}) - \mathbf{M}(\mathbf{x})}{\Delta\mathbf{x} \cdot \mathbf{M}'(\mathbf{x})} \sim 1$$

(4) Finished adjoint models based on these tangent linear models(M'). For verification of adjoint models (M*),

$$\langle \mathbf{M}'(\mathbf{x}), \mathbf{M}'(\mathbf{x}) \rangle = < \mathbf{x}, \mathbf{M}^*(\mathbf{M}'(\mathbf{x})) >$$

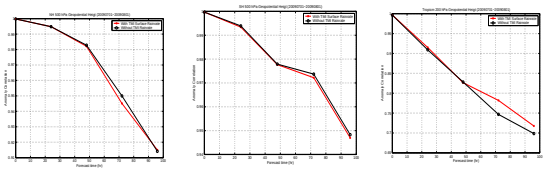
Adjoint model *sensitivity* results

Grid-scale condensation scheme (Large scale precipitation scheme)



Preliminary impact study

1. TRMM surface rainrate assimilation



2. Applying moisture physics in strong contraint term is currently being tested.

3. Initial Cloudy radiance direct assimilations are being tested to rebuild bias correction and QC properly.

Preliminary test results suggest convective scheme has some issues. For example, old version (currently operation) of convective schemes generate cloud at the cloud top only by detrainment process so that it does not generate cloud profiles. These issues will be resolved by updating the convective schemes with GFS updated convective schemes. Shallow convective schemes will be included as well. Until these issues are resolved, large scale cloud/precip schemes will be used in the cloudy radiance assimilation. Until improving convective schemes's adjoin and TL models, we will use only grid-scale moisture physics schemes in GSI without subgrid schemes to assimilate more observations with less penalty.