Clear-sky and all-sky AHI radiance DA at convective-scale with WRFDA

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Outline

- 10-min clear-sky AHI DA using 4DVar for a local storm event

- All-sky AHI DA using hybrid-3DEnVar for cloud analysis/forecast
A record-breaking rainstorm, Guangzhou, 7 May 2017

CAPE: 1000-1500 J/kg (shaded)
500 hPa gph: weak large-scale forcing (contours)
850 hPa wind: weak (vectors)

No global model able to predict it.
Regional radar DA useful after CI.

South China Sea

Max 24h rainfall ~ 542.7 mm
**Experimental design**

**Exps** | **Observations** | **DA method**
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CON_3D | Conventional | 3DVar
AHI_3D | Conventional + AHI (single time) 3 WV channels | 3DVar
CON_4D | Conventional | 4DVar | [0, 30] min
AHI_4D | Conventional + AHI (every 10-min) 3 WV channels | 4DVar | [0, 30] min

Exps were initialized at 12 UTC, 6 May, **4 hours before convection initiation**
For 4DVar, 27-km for the 1st outer loop; 9-km for the 2nd outer loop

WRF model forecast resolution: 3 km

Can we improve forecast of convection-initiation and subsequent rainfall using 4DVar plus 10-min AHI 3 WV channels’ radiances?
Data coverage

(For a 4DVar analysis)

Cloud detection
Follows Zhuge and Zou, 2016

The shaded indicates AHI radiances (channel 8 for example)
Skew-T verification
against soundings at QingYuan station

- OBS: dry layers at 700 – 400 hPa (favor for convergence)
- AHI_4D agreed best with OBS
Convection initiation (CI, BT@10.4 $\mu m$)

On May 6, 2017

GuangZhou

1620 UTC

1750 UTC

1750 UTC

1750 UTC

1750 UTC

1630 UTC

1800 UTC

1800 UTC

1800 UTC

1800 UTC

Contour: -32 degreeC

90-min timing error, 20-30 km location error
Hourly area-summed rainfall amount

The diagram shows the hourly area-summed rainfall amount over time for different lead times. The lines represent observations (obs), AHI 4D, AHI 3D, and CON_3D. The x-axis represents lead time in hours, and the y-axis represents the 1-hour sum of rainfall in millimeters. The map on the right side of the diagram indicates the geographical distribution of rainfall.
20-h accumulated rainfall
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2018070700-2018071000, 9km-3km two-way nested domain, 3-km domain is centered around Beijing. Partial cycling DA is conducted from 0000UTC to 2100UTC at an interval of 3h. Each partial cycle starts at 0000 UTC from ECMWF global data.

1) **CONT-3dvar**: assimilate conventional data on d01/d02, 3DVar
2) **CLRAHI-3dvar**: add clear-sky AHI 3 WV channels on d02
3) **ALLAHI-3dvar**: add all-sky AHI 3 WV channels on d02
4) **CLRAHI-hybrid**: similar to CLRAHI-3dvar, but using hybrid-3DEnVar
5) **ALLAHI-hybrid**: similar to ALLAHI-3dvar, but using hybrid-3DEnVar

Note:
1. Ensemble input for 3-km hybrid-EnVar comes from 28-member 9-km EDA using perturbed observations
2. All-sky AHI radiance **Symmetric Error Model** follows Harnisch et al. (2016)
3. 5 hydrometeors are part of analysis variables for all-sky radiance DA. Used CRTM-2.3.0
obs @Ch10, 7.3 um

Background Tb
6-h WRF FC from ECMWF

obs @Ch13, 10.4 um
not assimilated

Background Tb
6-h WRF FC from WCMWF

Assimilated AHI
All-sky 3 WV channels radiances
Using 3DVAR

Over North China with a 3-km resolution
0-12h FC RMSE in Tb space

Init: 2018070800

Init: 2018070803

Init: 2018070806

Channel 8

Channel 9

Channel 10

ALLAHI-hybrid

ALLAHI-3dvar
Future work for all sky geostationary IR

- Take into account cross-channel correlation
- Better design of cloud analysis variables
- Use frequent data with Hybrid-4DEnVar
- Validate clouds with retrieval products
- Move to global MPAS-DA with multiple geostationary IR sensors