Ensemble-Based Data Assimilation of GPM/DP R Reflectivity into the Nonhydrostatic Icosahed ral Atmospheric Model NICAM Shunji Kotsuki<sup>1</sup>, Koji Terasaki<sup>1</sup>, Shigenori

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# Project Overview



Local Ensemble Transform Kalman Filter *(Hunt et al. 2007)* 

# Goal: Look for most effective use of GPM precipitation measurements.

- NICAM-LETKF (NWP) system
  - System developed (Terasaki et al. 2014, SOLA)
  - AMSU-A assimilated (Terasaki and Miyoshi 2018, JMSJ)
  - MHS assimilated (Chandramouli et al., in prep.)
  - GSMaP assimilated (Kotsuki et al. 2017, JGR-A)
  - Model parameter w/ GSMaP (Kotsuki et al., in revision)
  - Adaptive-RTPP&RTPS (Kotsuki et al. 2017, QJRMS)
  - EFSO implemented (Kotsuki et al., in prep.; Poster 5.10)
  - Accounting for correlated R (Terasaki et al., in prep.)
  - System accelerated (Yashiro et al. 2016, GMD)
- Extrapolation nowcast system

- System developed (Otsuka et al. 2016, WAF)

## This presentation

– Merging nowcast & NWP for global precip. FCST



# Merging nowcast & NWP for global precipitation FCST

# GSMaP: Global Satellite Mapping of Precipitation





(Otsuka, Kotsuki, and Miyoshi 2016, WAF)





# Local Threat Score (LTS) defined



<b>Global Threat Score</b>		Obs. True	Obs. False
$GTS(t) = \frac{IP_G(t)}{TP_G(t) + FP_G(t) + FN_G(t)}$	FCST Positive	TP	FP
$Tr_G(t) + Fr_G(t) + FN_G(t)$ $X_G(t) = \mathbf{P}_{i} X_i(t) \mathbf{P}_{i}$	FCST Negative	FN	TN

#### *global sampling, time-*S: pixel Size (km<sup>2</sup>) $X_j = TP_j, FP_j, FN_j, TP_j$

# Local Threat Score (LTS) defined



# **Global Threat Score**

 $GTS(t) = \frac{TP_G(t)}{TP_G(t) + FP_G(t) + FN_G(t)}$ 

$$X_G(t) = \mathbf{P}_i(t) \mathbf{P}_i$$

**global sampling, time-**S: pixel Size (km<sup>2</sup>)  $X_j = TP_j, FP_j, FN_j, TP_j$ 

# **Local Threat Score**

$$LTS_i = \frac{TP_{L,i}}{TP_{L,i} + FP_{L,i} + FN_{L,i}}$$

$$X_{L,i} = \bigoplus_{t \ j \notin D_i} X_j(t) \bigoplus_j$$

local & temporal sampling

# Spatially-estimated Weight (2014/09~2014/11)

$$MERGE_{grid} = w_{grid} \, \text{(I-} w_{grid}) \, \text{(WCAST}_{grid}$$



# Local Threat Scores (2014/09~2014/11)

$$MERGE_{grid} = w_{grid} \, \text{(I-} w_{grid}) \, \text{(WCAST}_{grid}$$



## Local Threat Scores (2014/09~2014/11)

 $MERGE_{grid} = w_{grid}$   $(1 - w_{grid})$   $(0 - w_{grid})$ 



## Local Threat Scores (2014/09~2014/11)

 $MERGE_{grid} = w_{grid}$   $(1 - w_{grid})$   $(0 - w_{grid})$ 



## **Global Precip. FCST Scores**





# Assimilating GPM/DPR reflect ivity

# GPM/DPR (Ku and Ka bands)

#### Sim. 3-D Radar Reflectivity





Level 2	Normal Scan (NS)	Matched Scan (MS)	High-Sens. (HS)
width	245 km	125 km	125 km
Δx	5 km	5 km	5km
Δz	250 m	250 m	500 m
Band	Ku	Ka	Ka

# Assimilation of GPM/DPR by NICAM-LETKF

![](_page_17_Figure_1.jpeg)

# Assimilation of GPM/DPR by NICAM-LETKF

![](_page_18_Figure_1.jpeg)

![](_page_19_Figure_1.jpeg)

![](_page_19_Figure_2.jpeg)

![](_page_20_Figure_1.jpeg)

![](_page_21_Figure_1.jpeg)

#### 2014/06/16/0000UTC

![](_page_22_Figure_2.jpeg)

# DA cycle experiment (vs. ERA Interim; 2014)

# **RMSD: T**

# **RMSD: Qv**

![](_page_23_Figure_3.jpeg)

- : CTRL
- : w/ KuPR & KaPR (thinned by 3x3 grids)
- : w/ KuPR & KaPR (thinned by 5x5 grids)

# Effective use of GPM/DPR

#### **GPM/DPR 6-hr coverage**

![](_page_24_Figure_2.jpeg)

Maybe too sparse 🚠 Parameter DA tested

![](_page_25_Picture_0.jpeg)

# Estimating Cloud Microphysic s Parameter with GPM/DPR

# Single moment cloud microphysics NSW6

- NSW6 (vapor, cloud, ice, rain, snow, graupel)
  - Parameters : terminal velocity coefficients

$$v_{t[r,s,g]}(D) = c_{[r,s,g]} D^{d[r,s,g]} (\rho_0 / \rho)^{1/2}$$
NICAM default NICAM for MJO
$$c_g = \underbrace{\mathbf{v}_{g}^{4} g \rho_g}_{C_D} \underbrace{\mathbf{v}_{g}^{2}}_{C_D} \mathbf{v}_{0}$$
NICAM default NICAM for MJO
$$Cr \quad 130.0 \quad 58.0$$

$$Cs \quad 4.84 \quad 0.90$$

$$C_D \quad 0.60 \quad 2.50$$

# Single moment cloud microphysics NSW6

- NSW6 (vapor, cloud, ice, rain, snow, graupel)
  - Parameters : terminal velocity coefficients

![](_page_27_Figure_3.jpeg)

![](_page_27_Figure_4.jpeg)

# RMSD vs. ERA Interim (2014)

![](_page_28_Figure_1.jpeg)

Improved by parameter DA

Degraded by parameter DA

# Summary

- Merging nowcast and NWP
  - Local threat score (LTS) defined
  - Spatially-distributed weight estimated w/ LTS
  - Merged Precip. FCST ≥ nowcast & NWP
- Assimilating GPM/DPR reflectivity
  - NICAM-LETKF system updated (112-km 4 28-k
     m)
  - Implementing Joint Simulator into NICAM-LETK
     F
  - GPM/DPR assimilated, but impact is unclear
  - Parameters of the cloud microphysics estimated

APPENDIX

# Change in precipitation fields (2014/06/16)

![](_page_31_Figure_1.jpeg)

# Parameter Estimation in NICAM-LETKF

![](_page_32_Figure_1.jpeg)

# Parameter Estimation in NICAM-LETKF

![](_page_33_Figure_1.jpeg)

# Estimated Parameter (large scale condensation)

![](_page_34_Figure_1.jpeg)

#### (Kotsuki et al., in revision)

# Estimated Parameter (large scale condensation)

![](_page_35_Figure_1.jpeg)

# Estimated Parameter (large scale condensation)

![](_page_36_Figure_1.jpeg)

## Satellite-simulator implemented

#### Kotsuki et al. (2014, SOLA)

![](_page_37_Figure_2.jpeg)

# Satellite-simulator implemented

#### Kotsuki et al. (2014, SOLA)

![](_page_38_Figure_2.jpeg)

- : GPM/DPR bright band height (m),

- - -: NICAM 0°C height (m)