

Developments Toward a Cloud Analysis System

Tom Auligné

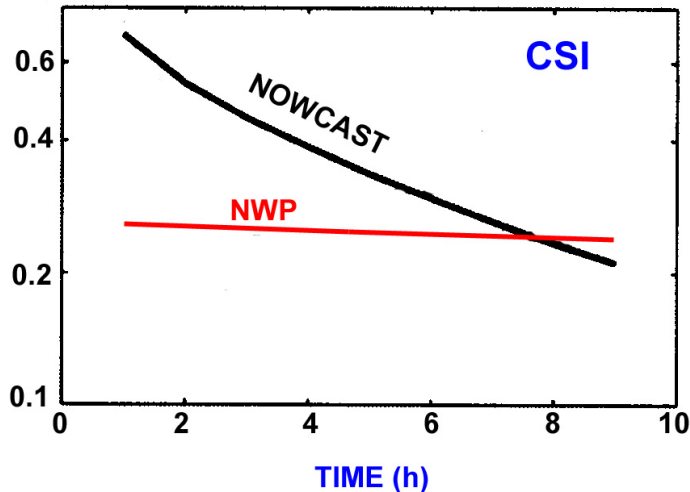
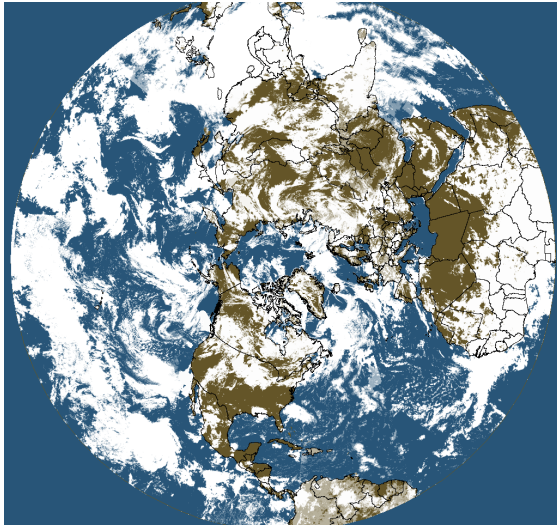
National Center for Atmospheric Research

David Dowell, Soyoung Ha, Hans Huang, Zhiquan Liu, Yann Michel, Syed Rizvi,
Hongli Wang, Xiaoyan Zhang, Xin Zhang

JCSDA 9th Workshop on Satellite Data Assimilation.
May 24-25, 2011. University of Maryland, College Park.

Introduction

World-
Wide
Merged
Cloud
Analysis



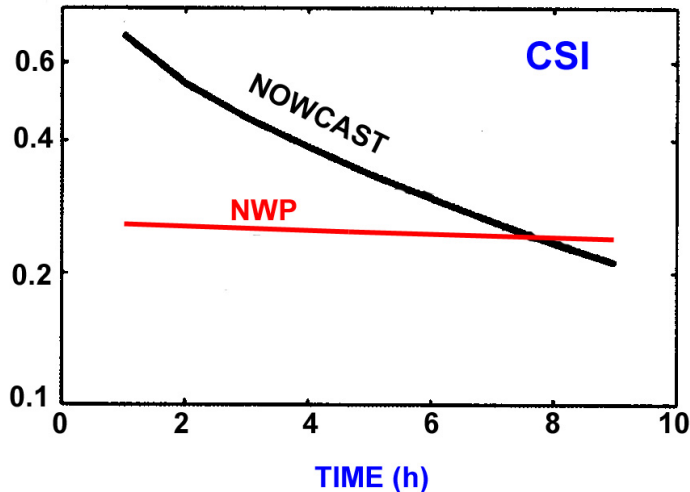
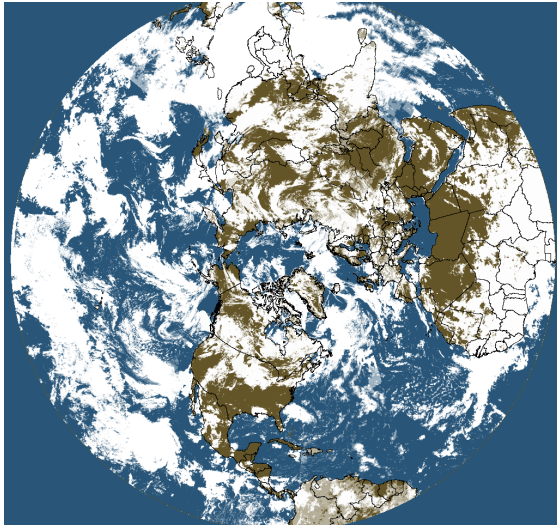
0.1 mm hourly precipitation skill scores over 21 days (Lin et al., 2005)

AFWA Coupled Analysis and Prediction System (ACAPS)

- **Control Variable Transform**
 - Masked Background Errors
 - Hybrid Ensemble/Variational
 - Displacement Analysis
- **4DVar**
 - WRF + WRFPlus + WRFDA/GSI
 - Simplified cloud physics
- **Satellite Observations**
 - Bias Correction, Error estimation
 - Linearity, Gaussianity
 - Representativeness Error

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Geographical mask

- Use vertical sum of background precipitation (no smoothing yet)
- Differentiate clear, light and heavy rain classes
- Compute different **B** statistics in each rain class

Test Case

- 30-member multi-Physics ensemble
- 3km horizontal resolution

Definition

- Clear $q_{\text{rain}}^{1,2} \leq 10^{-3}$ g/kg
- Mixed
- Light Rain $q_{\text{rain}}^{1,2} \geq 10^{-3}$ g/kg
and $q_{\text{rain}}^{1,2} \leq 10^{-1}$ g/kg
- Heavy Rain $q_{\text{rain}}^{1,2} \geq 10^{-1}$ g/kg

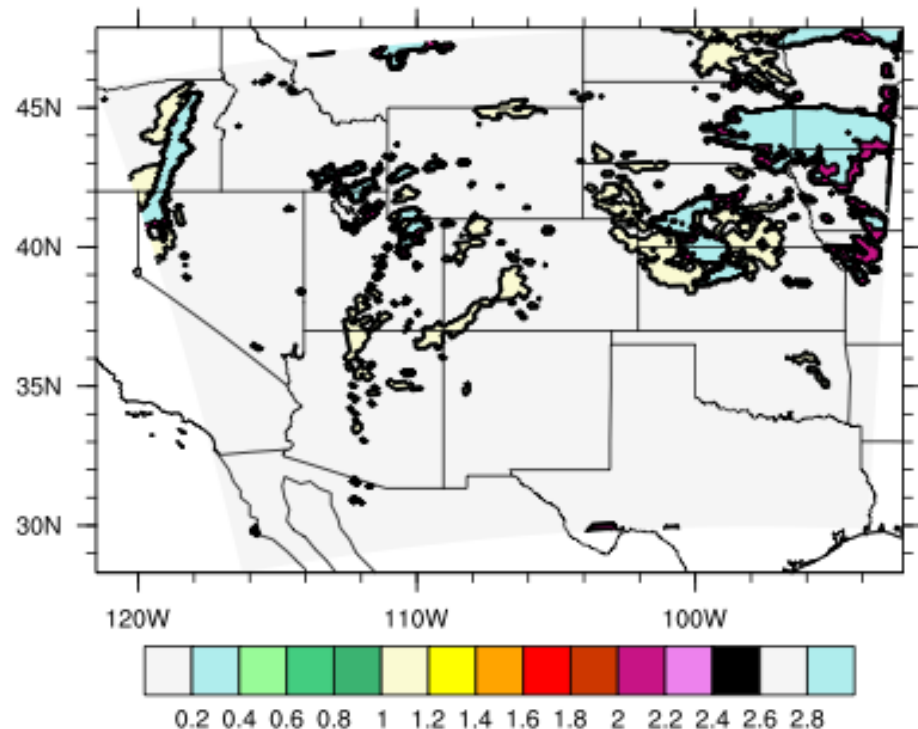
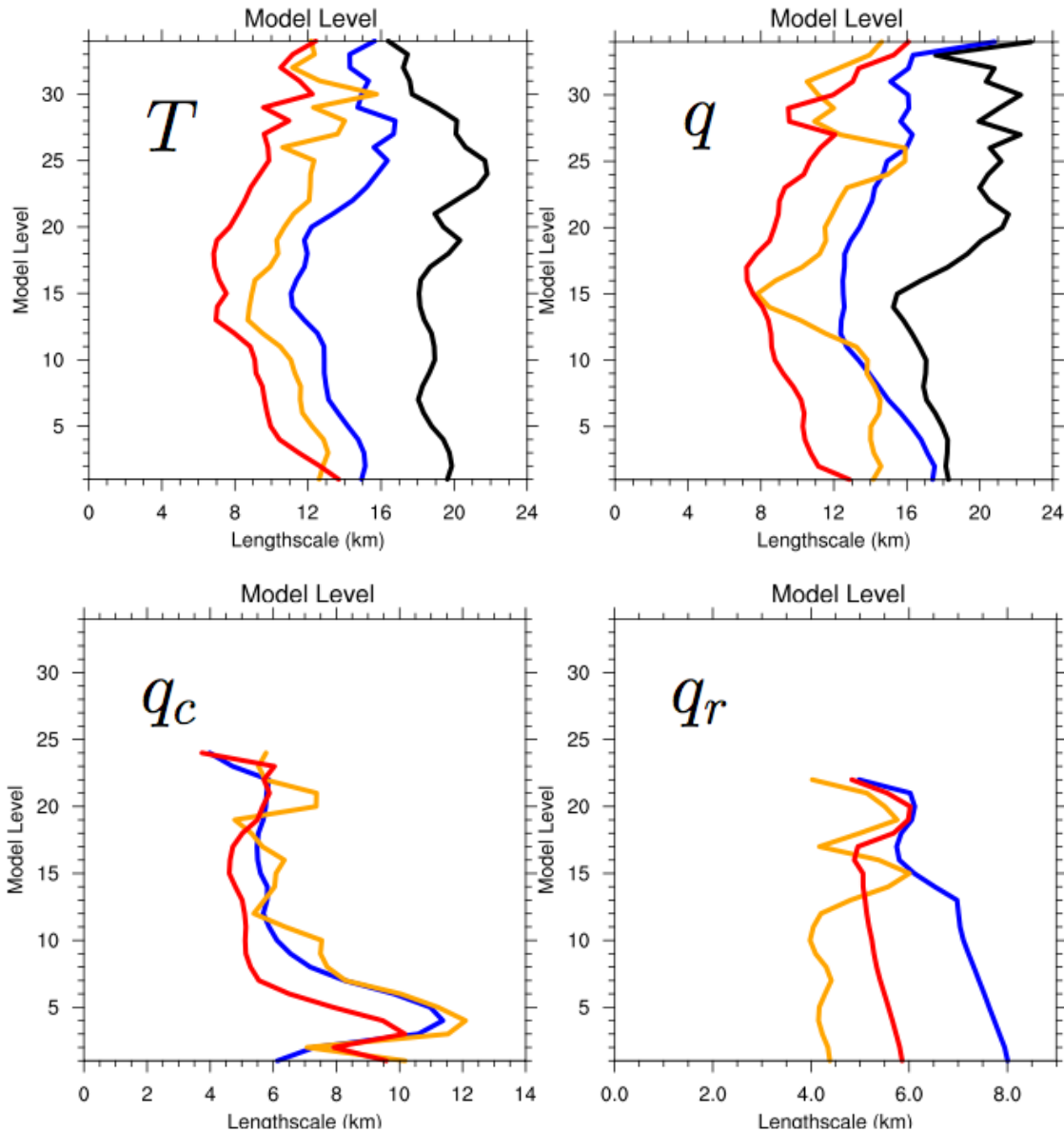
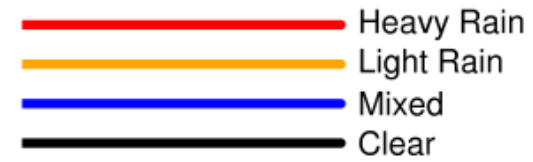
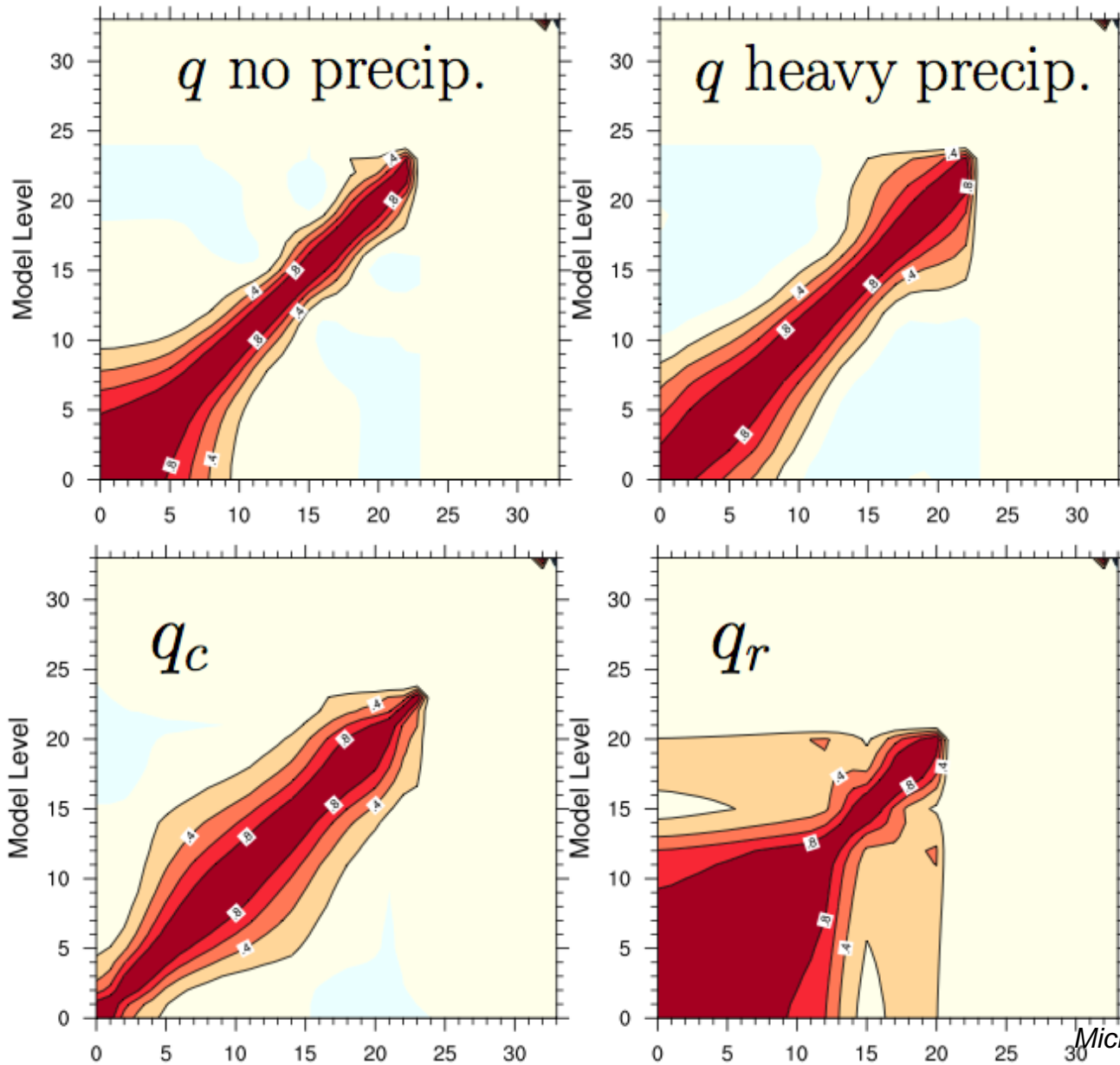


Figure: Rain Class on 07-10-2009

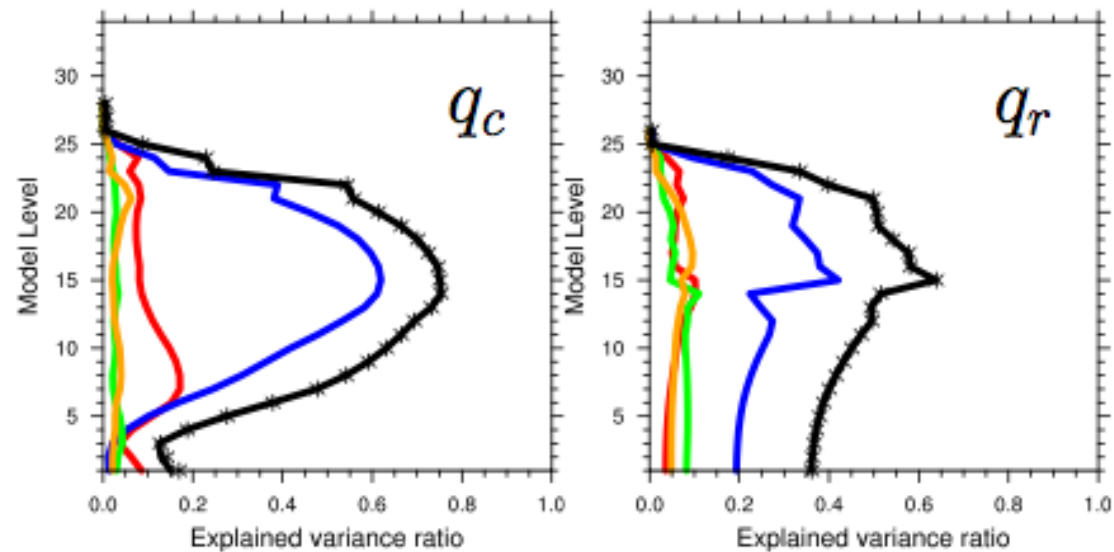
Horizontal Lengthscales



Vertical Correlations



Balance



← FIG.4 : Explained variance ratio of (a) cloud content (b) rain content in heavy precipitating areas as a function of model level.

- * total 2
- total
- q_u
- t_u
- div_u
- vor

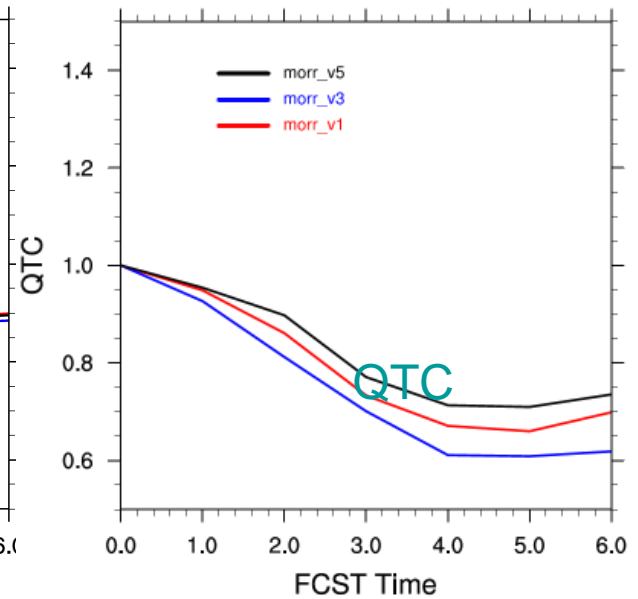
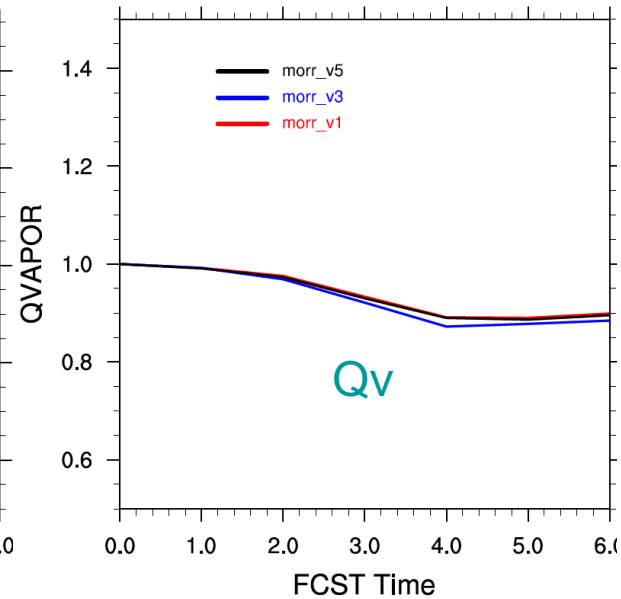
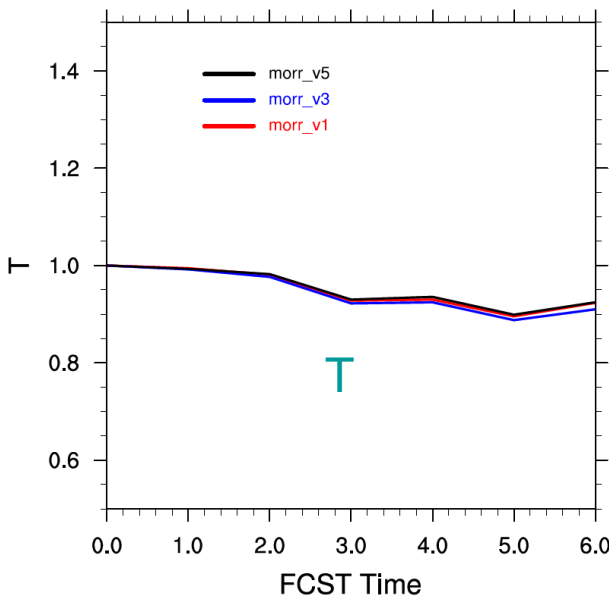
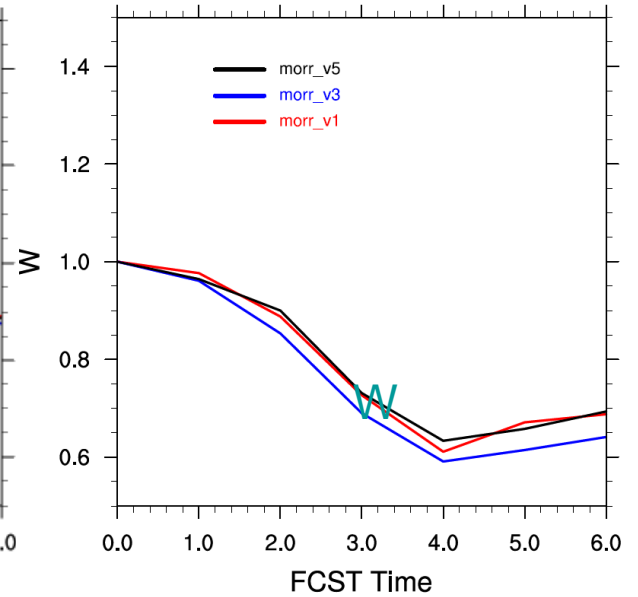
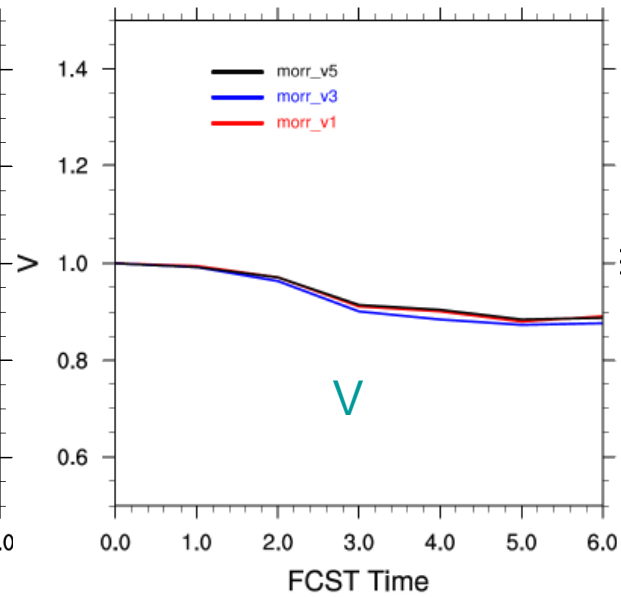
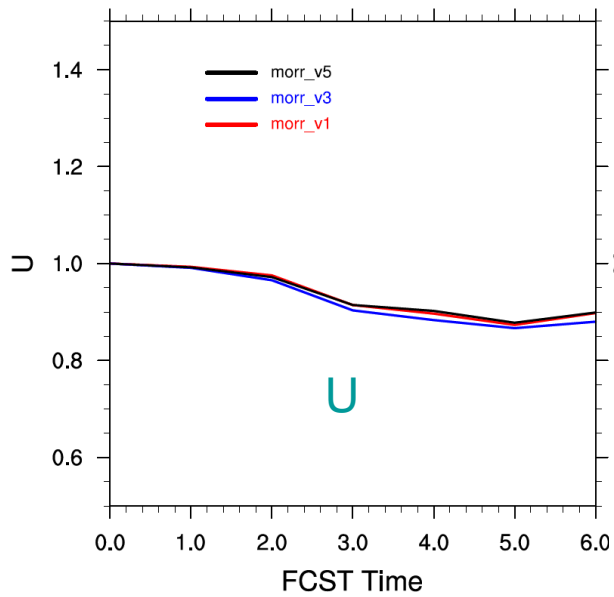
Microphysics Scheme *Complexity*

- **Model:** WRF-ARW, 5 km horizontal resolution
- **Time period:** 02 June 2008 - 10 June 2008
- **Forecasts:** 6h forecasts made at 00Z each day
- **Initial perturbations:** analysis increments
- **Morrison microphysics:** 4 versions with increasing complexity

Table 1. The Morrison microphysics

MP Scheme	Description
mp_morr_two_moment_v1 (M^1)	liquid only, 1-moment all species
mp_morr_two_moment_v3 (M^3)	4 species (cloud water, rain, cloud ice and snow), 1-moment for all species except 2-moment cloud ice
mp_morr_two_moment_v5 (M^5)	5 species, 2-moment for cloud ice and rain, 1-moment for all other species
mp_morr_two_moment_v7 (M^7)	same as default Morrison scheme, except that graupel is treated as hail

Microphysics Scheme Complexity



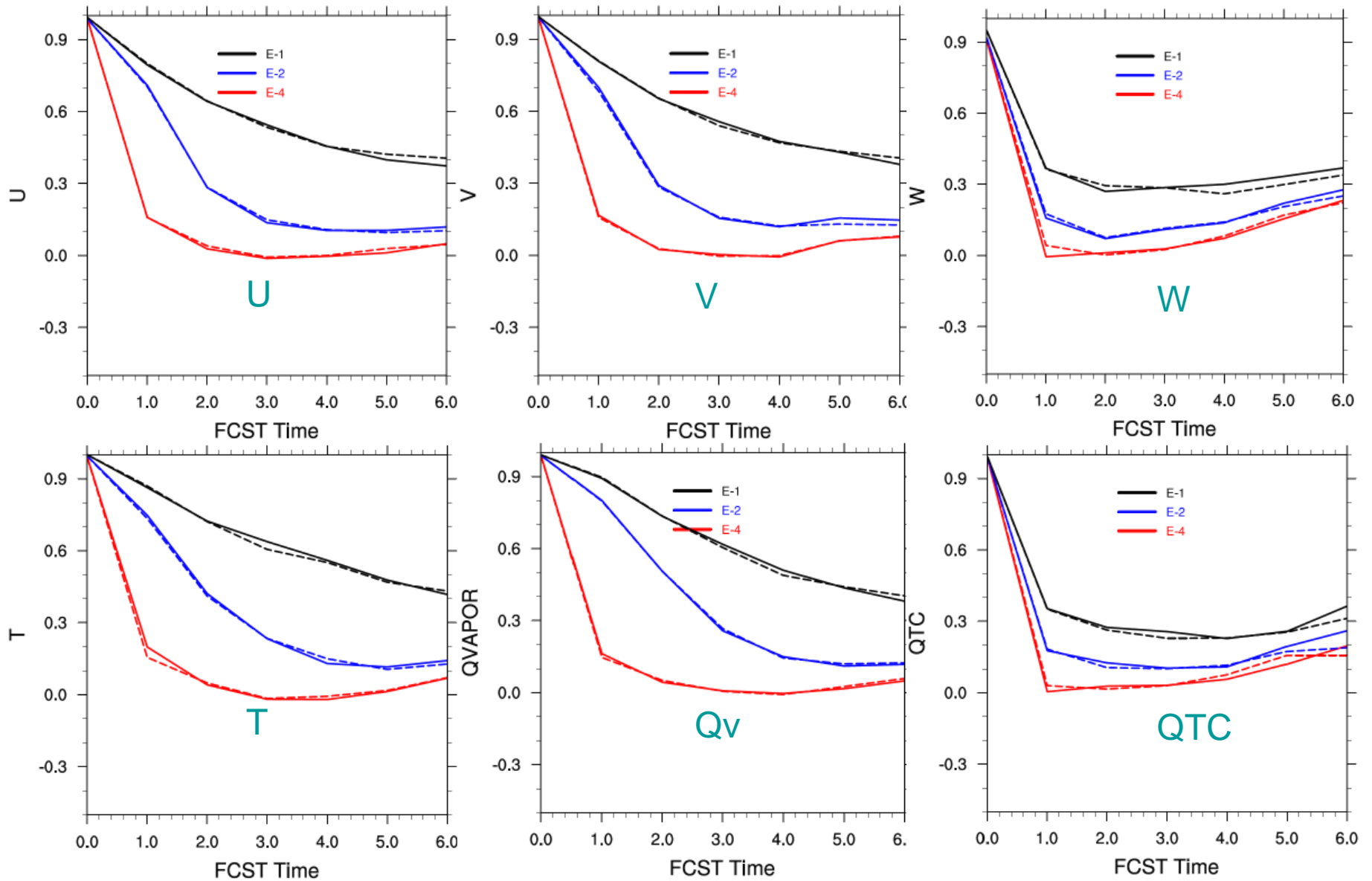
Microphysics Scheme *Linearity*

- ✓ Morrison scheme with version 1 and 7 is selected;
- ✓ Evolution of perturbations with different scales is assessed.

Experiments list

Name	Initial Condition	Model
E-0	$M(X_0^a + s * \delta X_0) - M(X_0^a), s=1.0$	M^1 or M^7
E-1	$M(X_0^a + s * \delta X_0) - M(X_0^a), s=0.1$	M^1 or M^7
E-2	$M(X_0^a + s * \delta X_0) - M(X_0^a), s=0.01$	M^1 or M^7
E-4	$M(X_0^a + s * \delta X_0) - M(X_0^a), s=0.00001$	M^1 or M^7

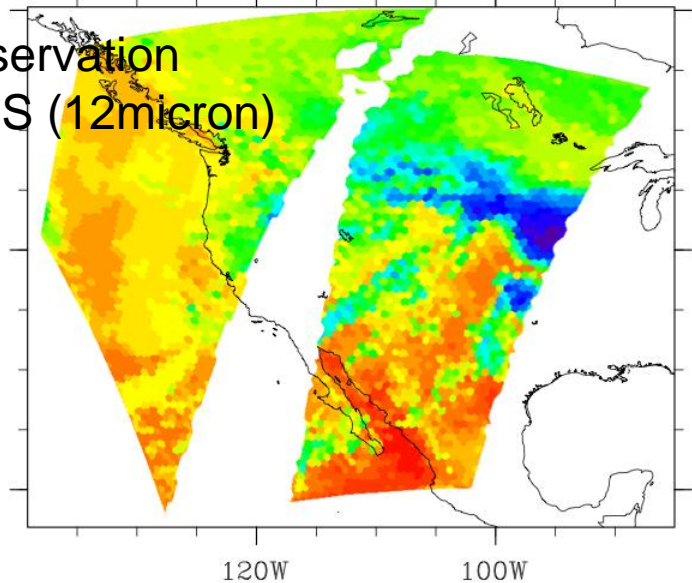
Microphysics Scheme *Linearity*



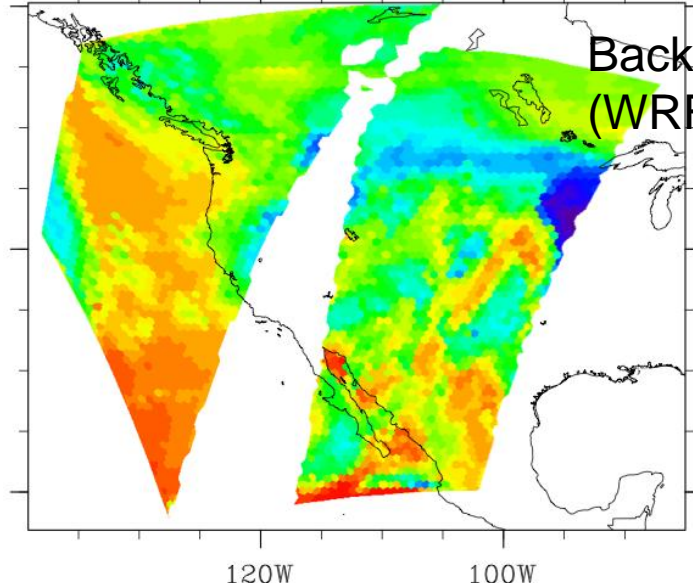
Assimilation of Cloudy Radiances

- *Very first shot at cloudy radiances, still needs a lot more work...*
- Cloudy radiance forward model = CRTM
- First-guess including cloud parameters = WRF-ARW
- Cloud control variable (Ql, Qi, Qr)
- ***Implemented in both WRFDA and GSI***

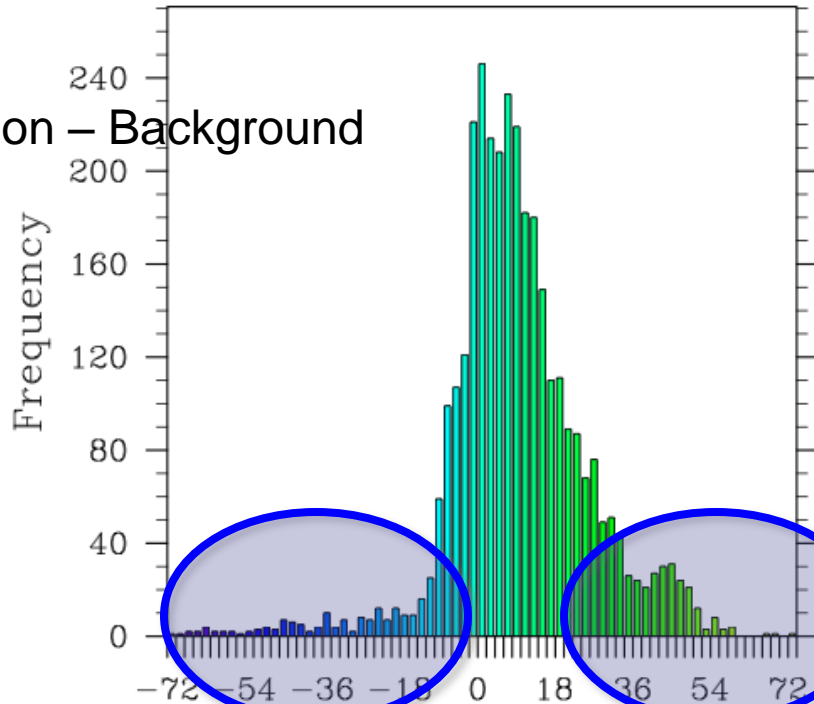
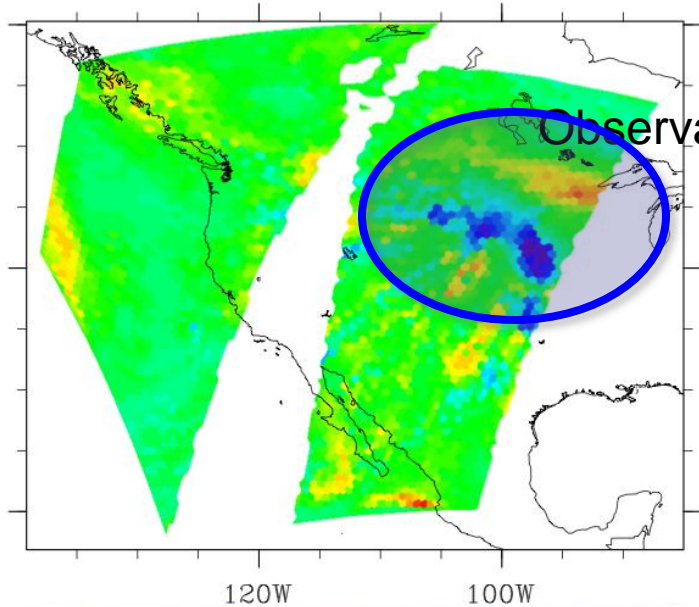
Observation
AIRS (12micron)



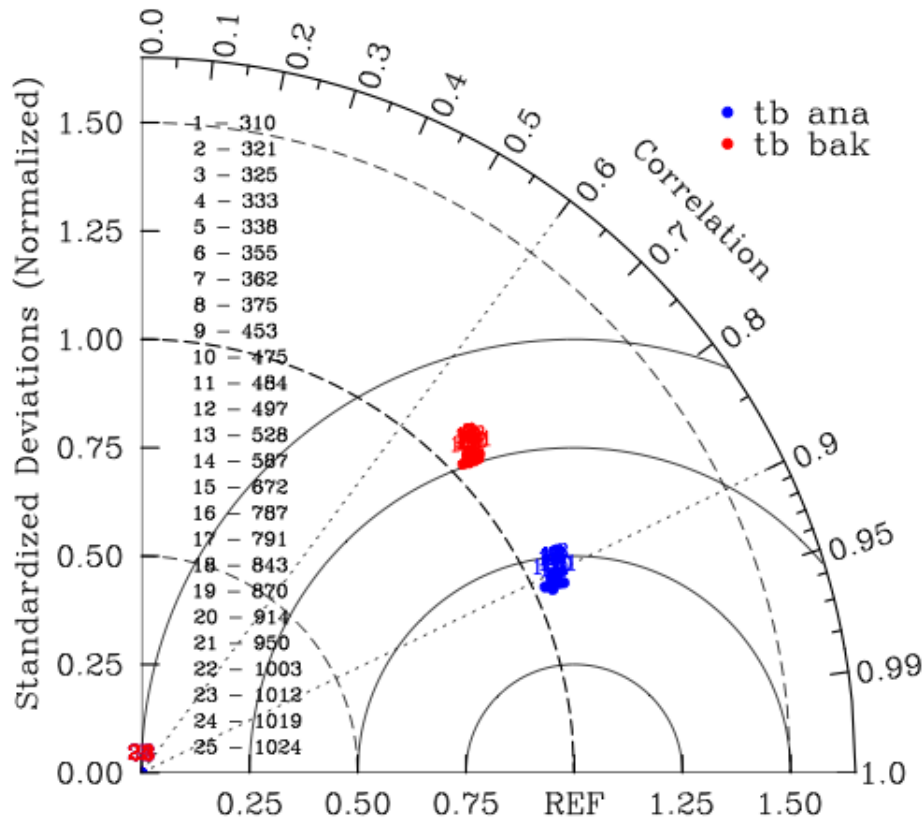
Background
(WRF-ARW)



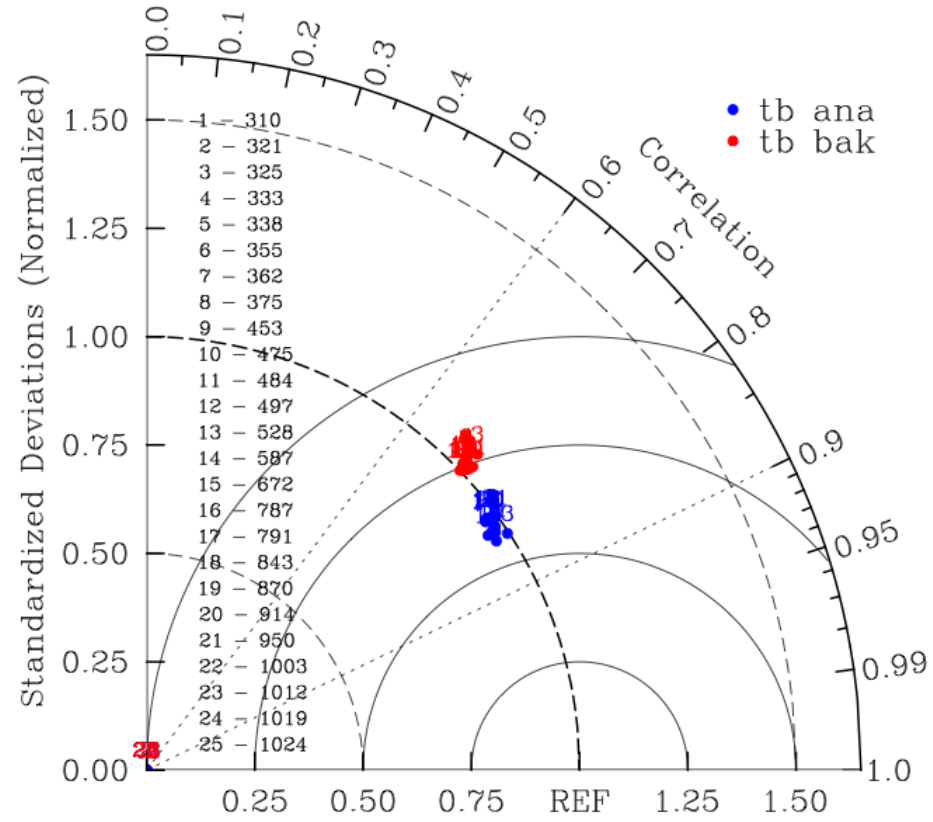
Observation - Background



Taylor Diagrams

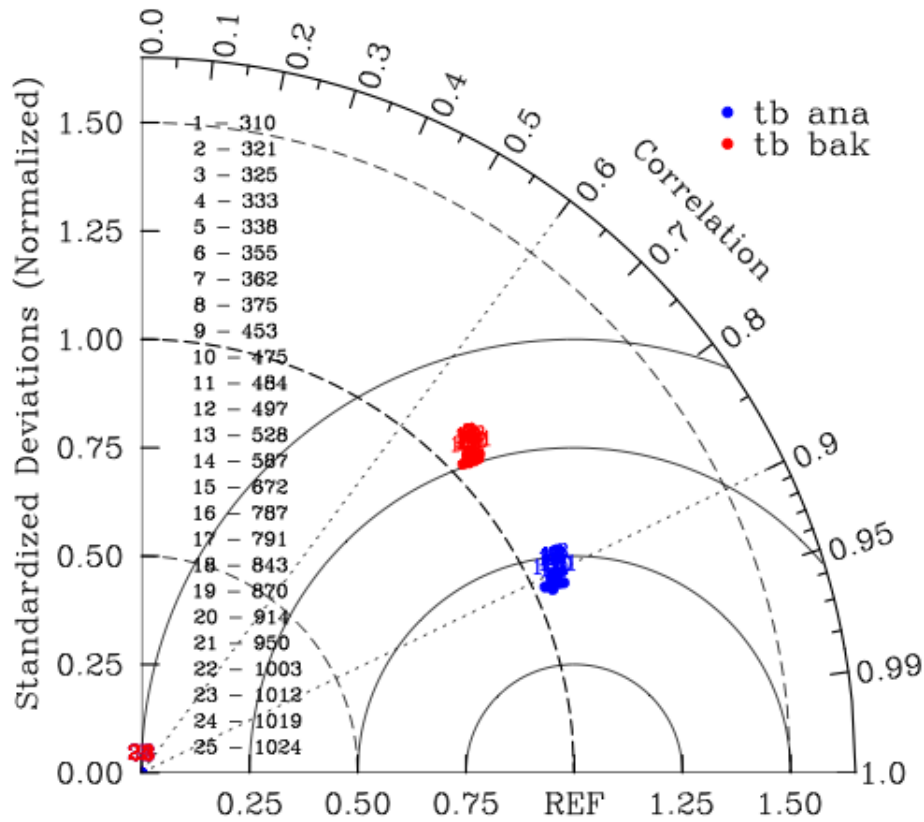


AIRS **Cloudy** Radiances
(simple B Matrix)

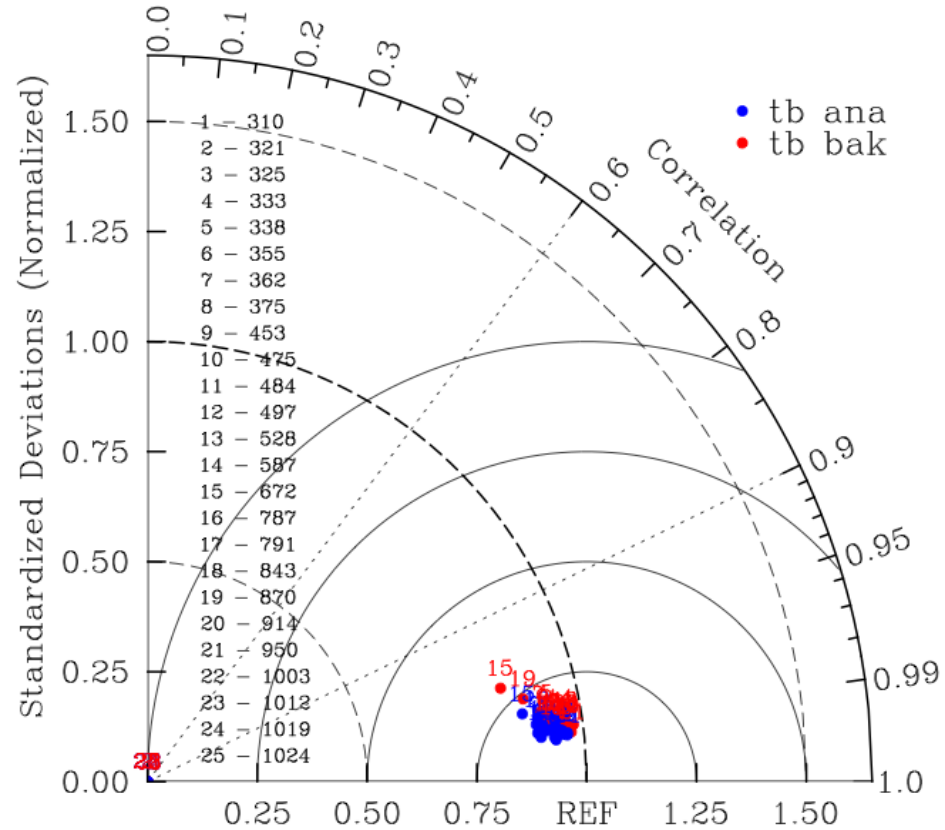


AIRS **Cloudy** Radiances
(Ensemble DA)

Taylor Diagrams

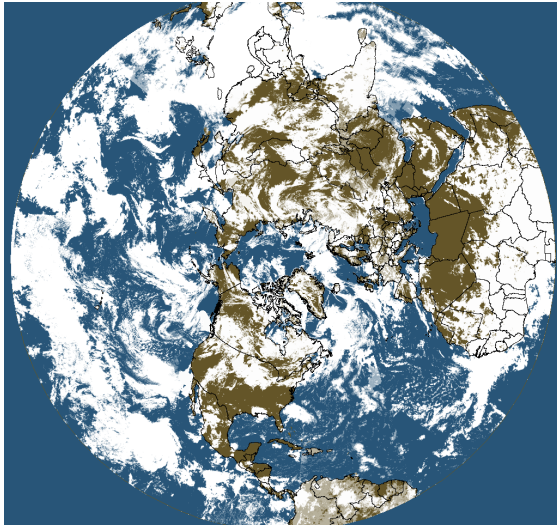


AIRS **Cloudy** Radiances
(simple B Matrix)



AIRS **Clear** Radiances

Summary



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