

OBSERVATIONAL ERROR ESTIMATION OF FORMOSAT-3/ COSMIC GPS RADIO OCCULTATION DATA

Shu-Ya Chen¹, @Ching-Yuang Huang¹,
Ying-Hwa Kuo^{2,3}, and Sergey Sokolovskiy²

¹*Department of Atmospheric Sciences, National Central University, Jhongli, Taiwan*

²*University Corporation for Atmospheric Research, Boulder, Colorado, USA*

³*National Center for Atmospheric Research, Boulder, Colorado, USA*

INTRODUCTION

- In most of the regional data assimilation studies, a local refractivity observation operator is used to represent the **GPS RO Abel-retrieved refractivity as local refractivity**. This introduces certain **representativeness errors** because the Abel-retrieved refractivity derived from GPS RO observation is influenced by the atmosphere along the ray path.
- To reduce this representativeness error, Sokolovskiy et al. (2005) suggested a new observable, a ***linear excess phase***, which is defined as the **integrated amount of refractivity along a fixed (e.g., straight line) ray path**, to account for the nonlocal nature of the Abel-retrieved refractivity. (***nonlocal operator***)

INTRODUCTION (CONT.)

- The nonlocal operator has been implemented in the data assimilation system of WRF EnKf and 3DVAR (e.g., Liu et al. 2008; Chen et al. 2009) and NCEP GSI (e.g., Ma et al. 2009).
- In this study we estimate **observational errors of refractivity and linear excess phase based on FORMOSAT-3/COSMIC data**. We also investigate **latitudinal dependence** of both the observational errors by stratifying the observations into different latitudinal bins. (Chen et al. 2010)

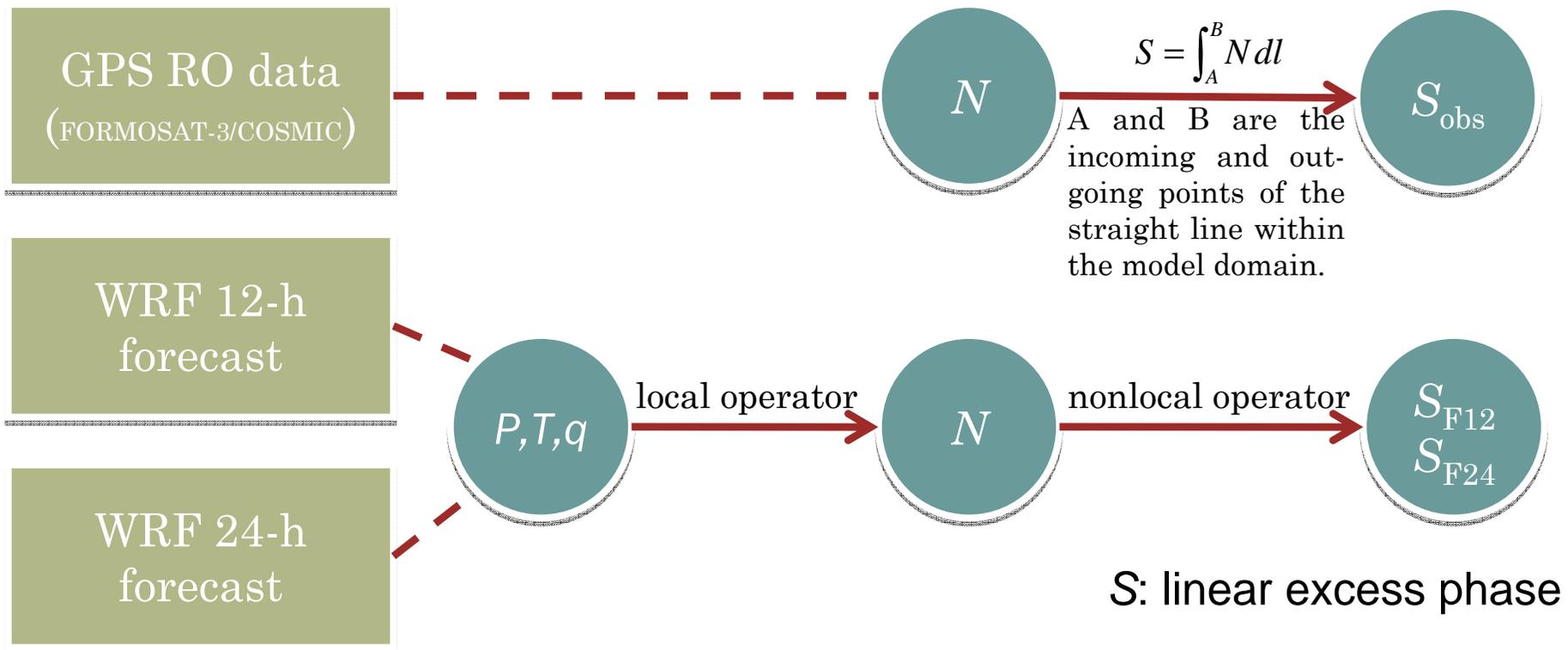
METHOD

Observational errors include measurement errors and representativeness errors (Daley 1991; Kuo et al. 2004; Sokolovskiy et al. 2005).

$$\sigma_a^2 = \sigma_o^2 + \sigma_f^2$$

σ_a^2 : variance of the apparent error $\rightarrow (S_{\text{obs}}, S_{\text{F12}})$
 σ_f^2 : variance of the forecast error $\rightarrow (S_{\text{F12}}, S_{\text{F24}})$
 σ_o^2 : variance of the observational error

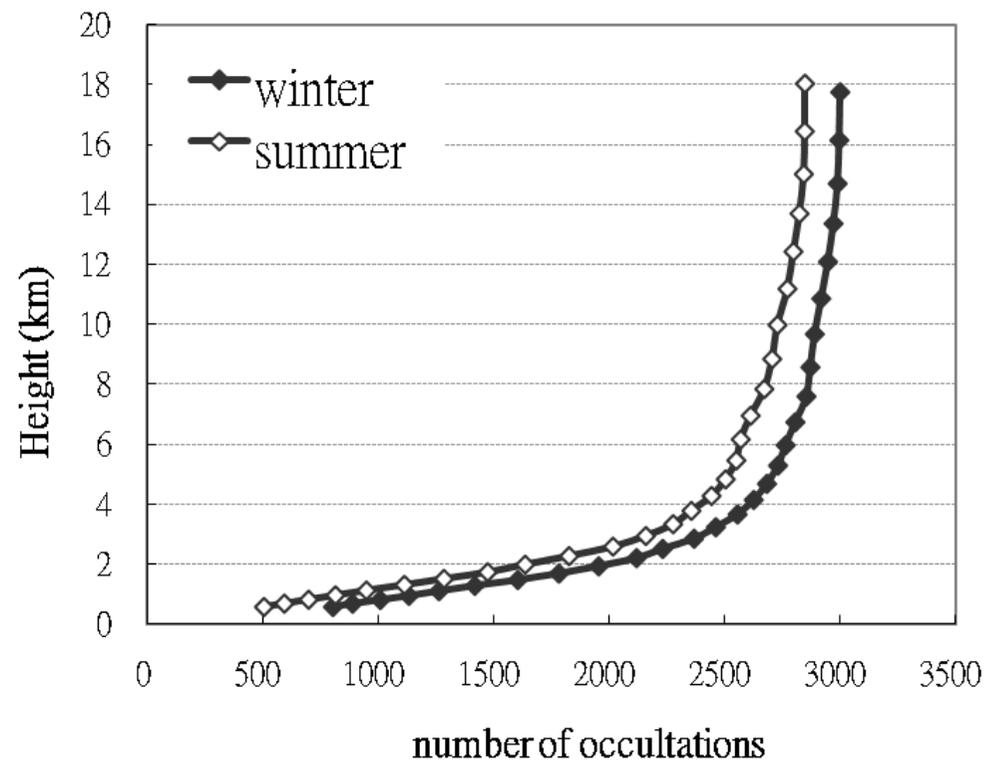
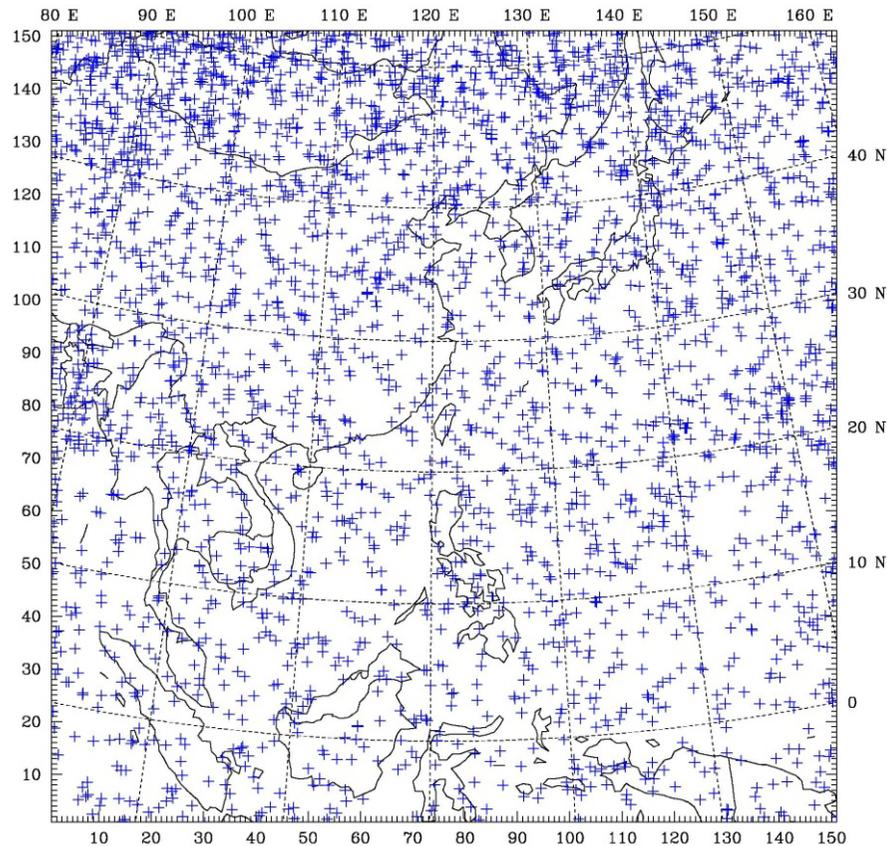
National Meteorological Center (NMC) Method is based on lagged forecast differences.



DISTRIBUTION OF GPS RO SOUNDINGS

Winter Month

2007/01/15-2007/02/15 (2999 GPSRO)



Summer Month

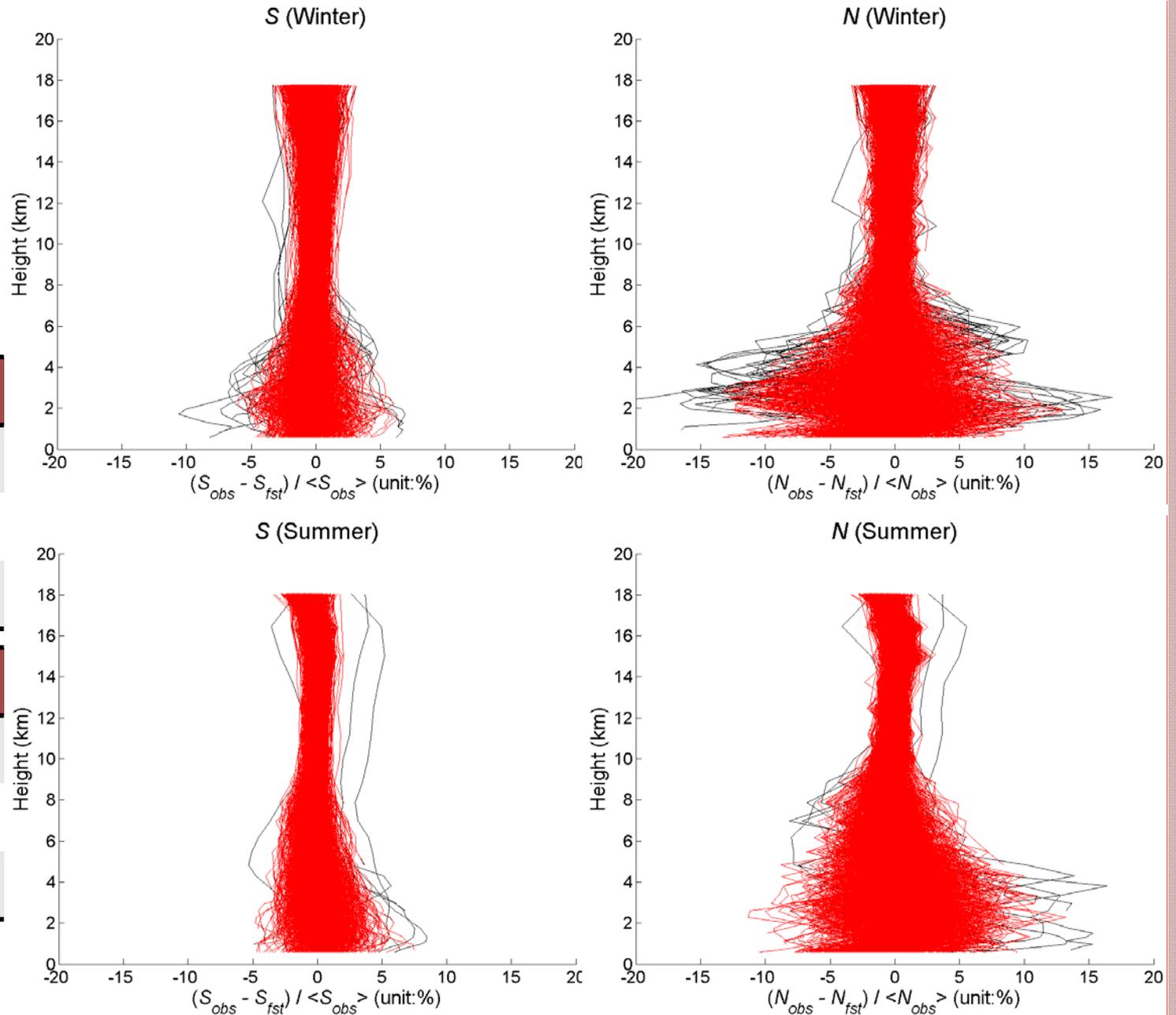
2007/08/15-2007/09/15 (2845 GPSRO)

FRACTIONAL DIFFERENCES OF INNOVATIONS

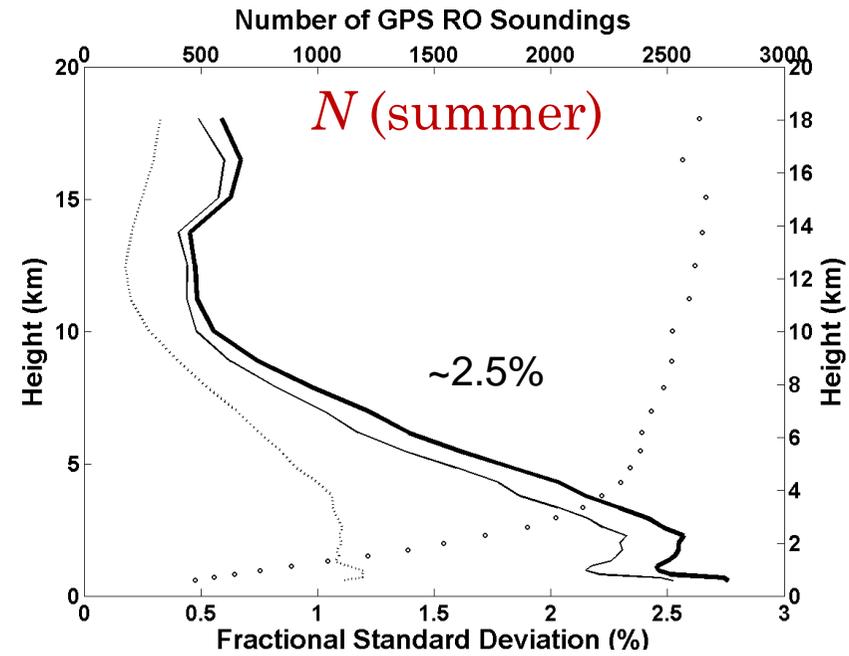
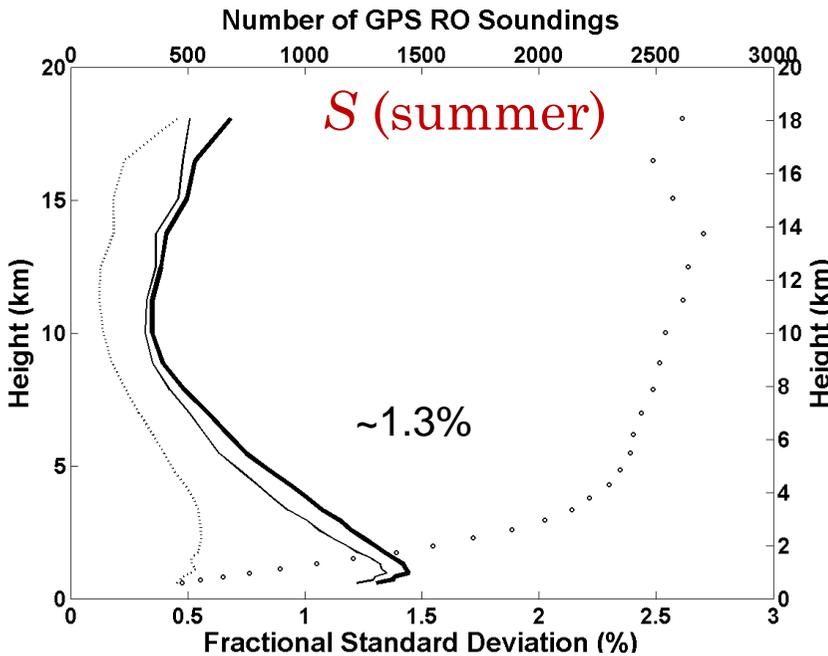
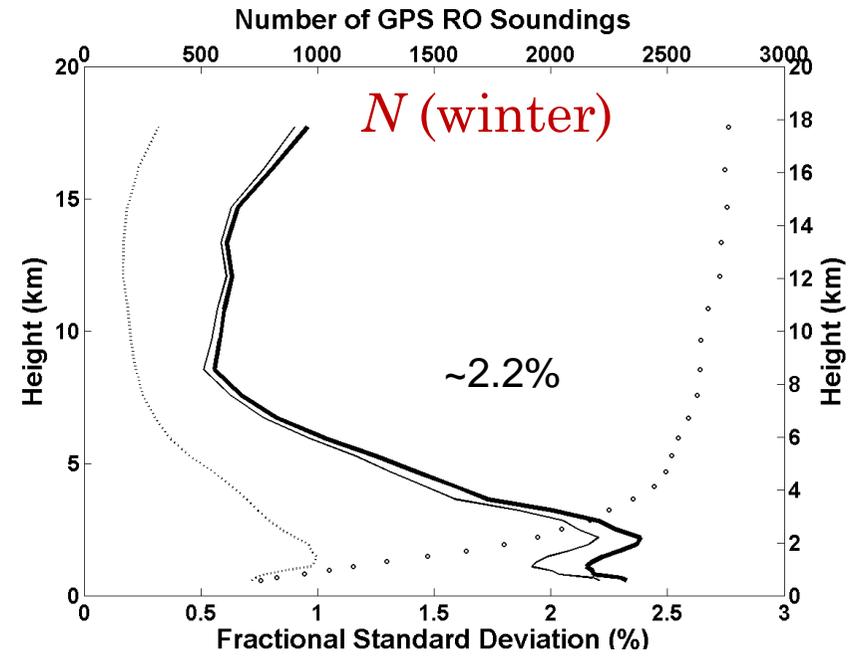
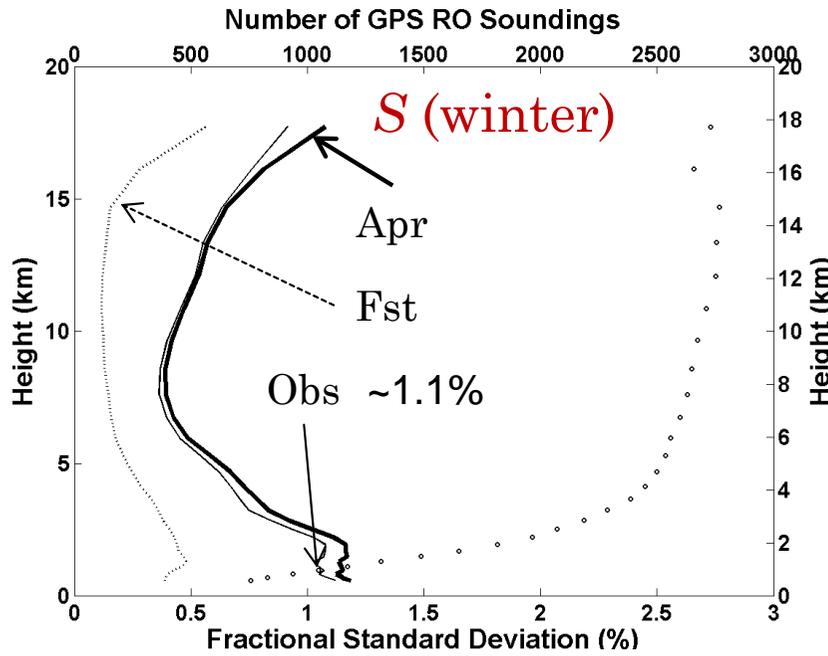
ADDITIONAL CRITERIA

$$(O-B) < 5 SD_{APR}$$

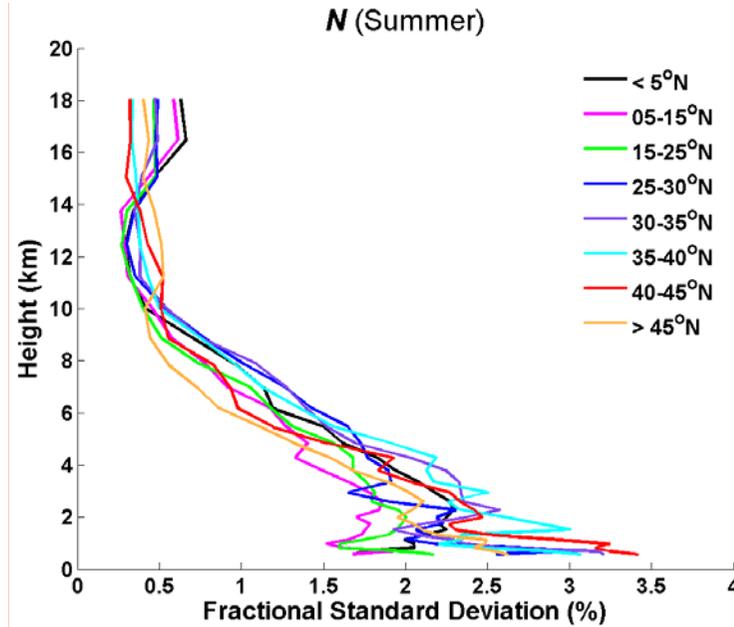
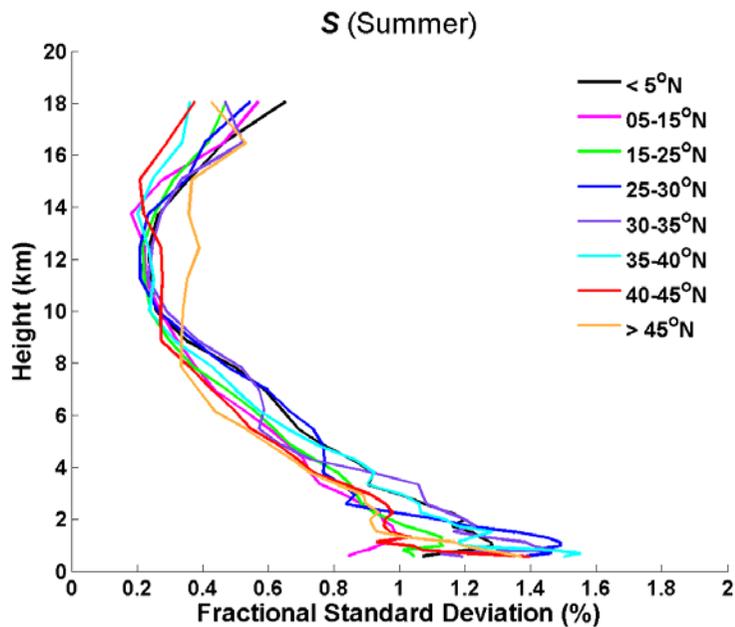
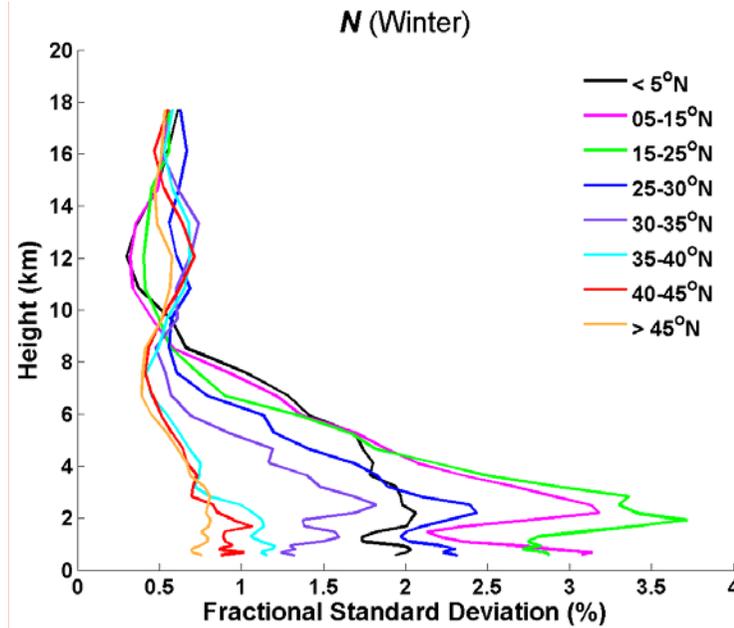
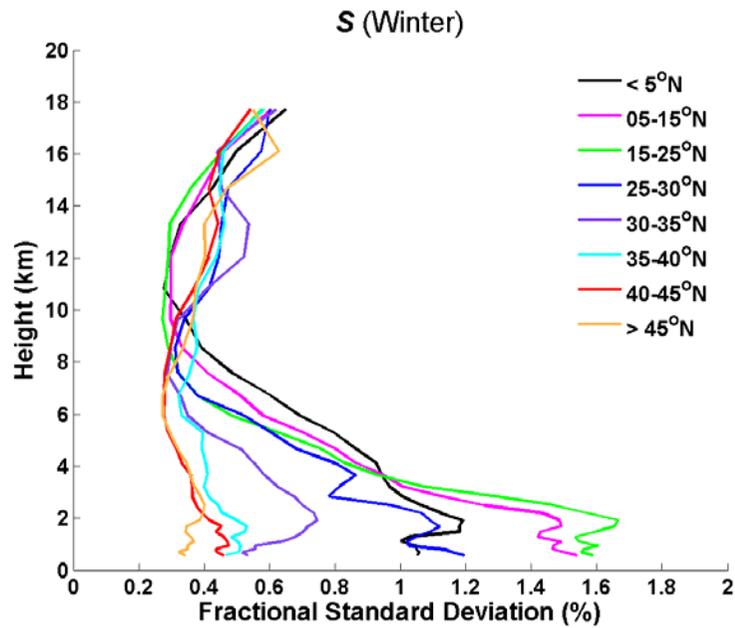
Before Criteria		
	Win.	Sum.
EPH	2999	2845
REF	2999	2845
After Criteria		
	Win.	Sum.
EPH	2972	2837
REF	2944	2830



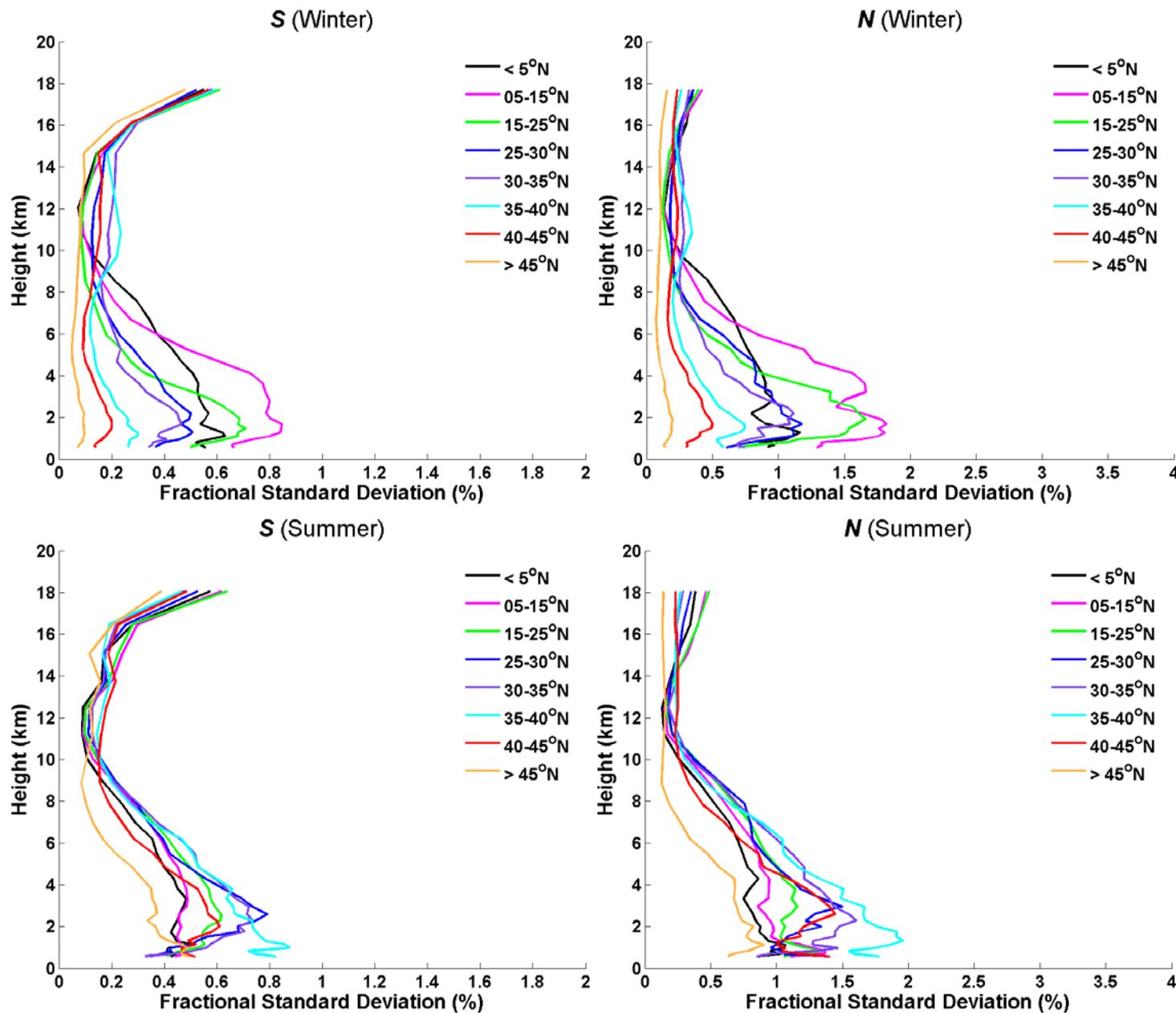
FRACTIONAL STANDARD DEVIATIONS



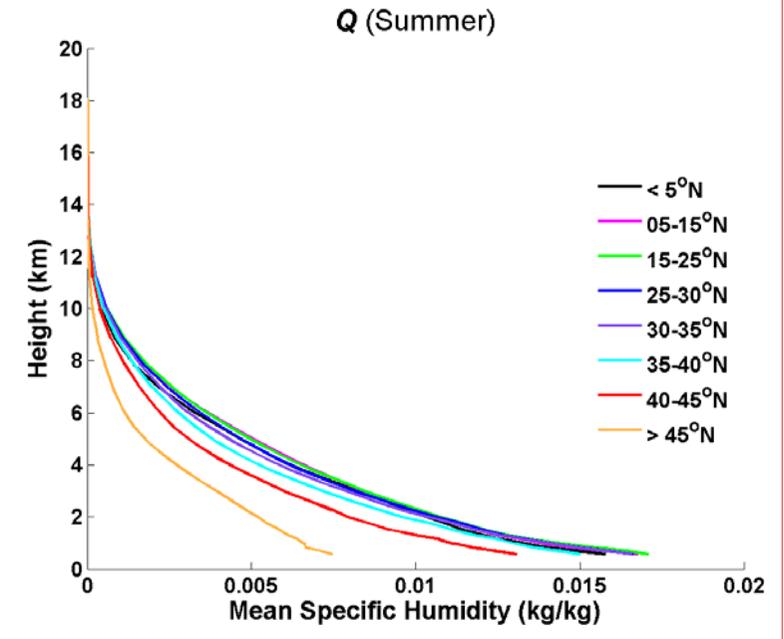
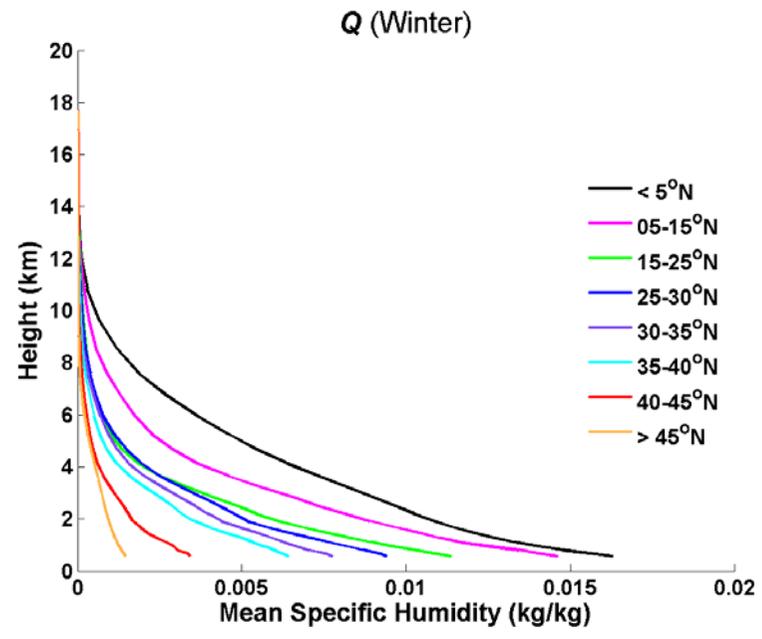
FRACTIONAL STANDARD DEVIATIONS OF THE OBSERVATIONAL ERRORS



FRACTIONAL STANDARD DEVIATIONS OF THE FORECAST ERRORS

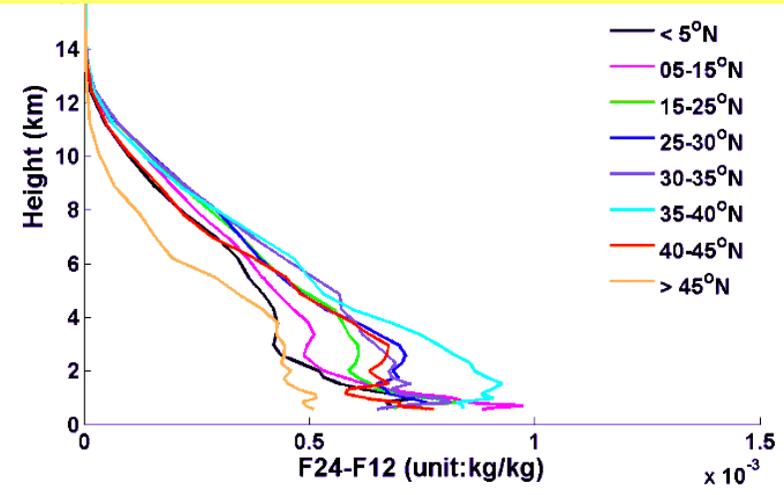
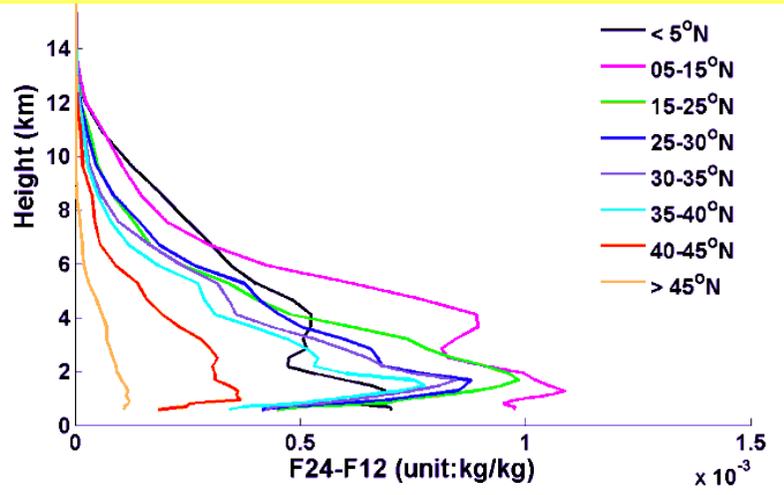


MONTHLY ZONALLY AVERAGED Q OF 12-11 WITH FORECASTS

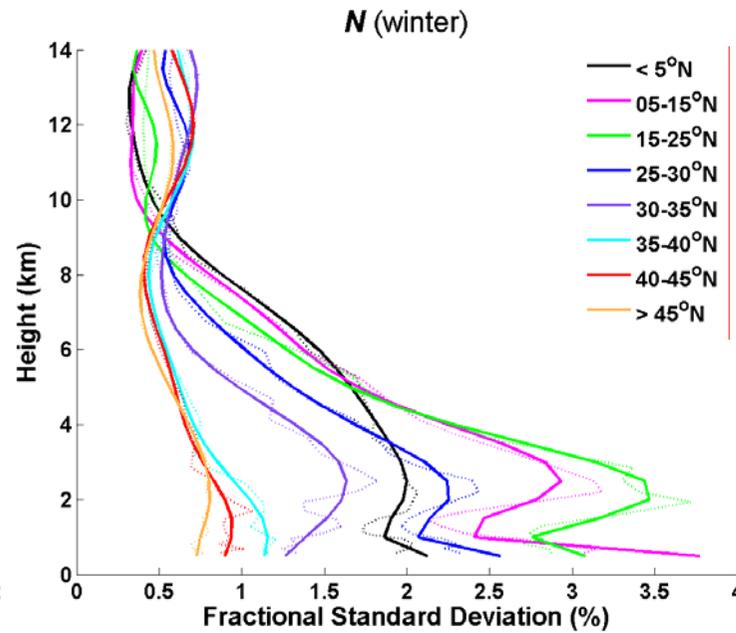
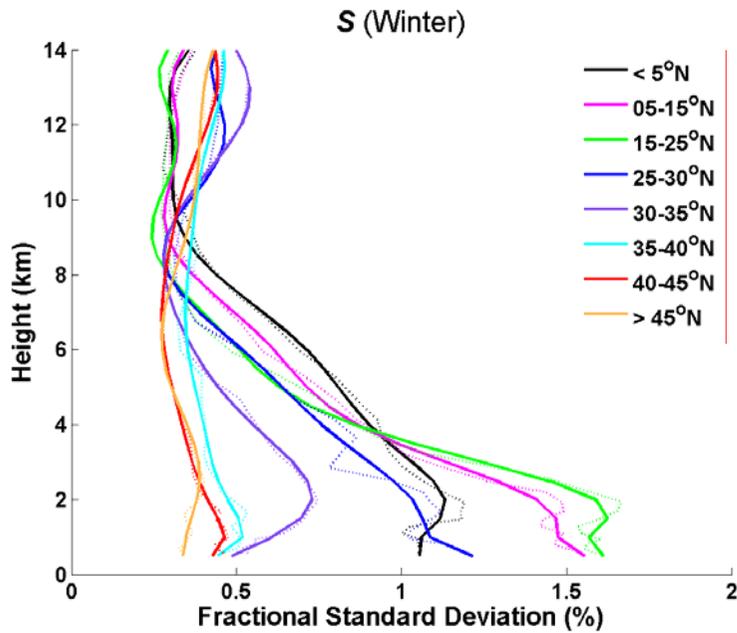


SD OF THE FORECAST Q ERRORS

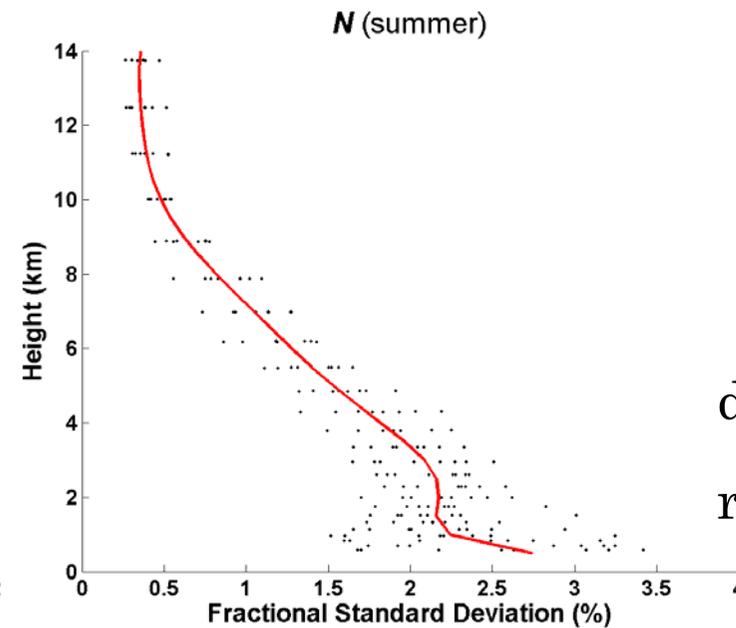
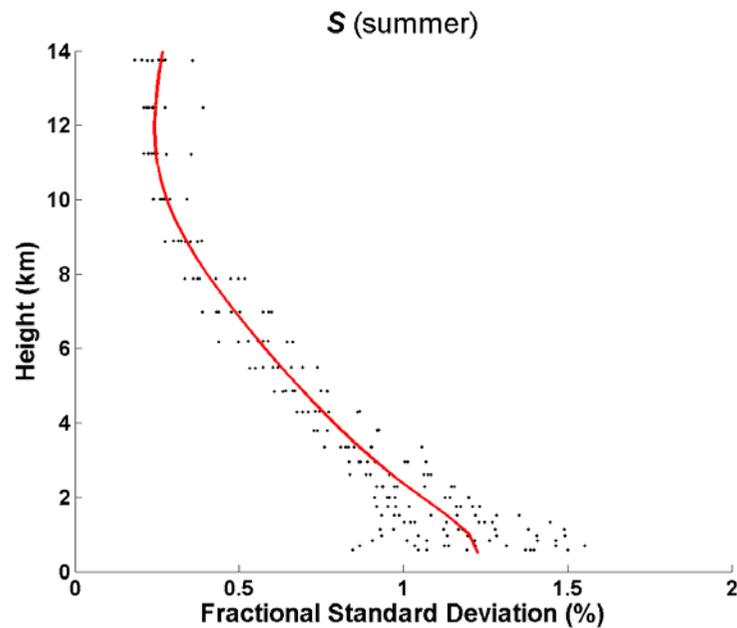
The latitudinal dependency of the observational errors is strongly affected by the atmospheric moisture.



FITTING CURVES FROM A POLYNOMIAL OF 10TH ORDER

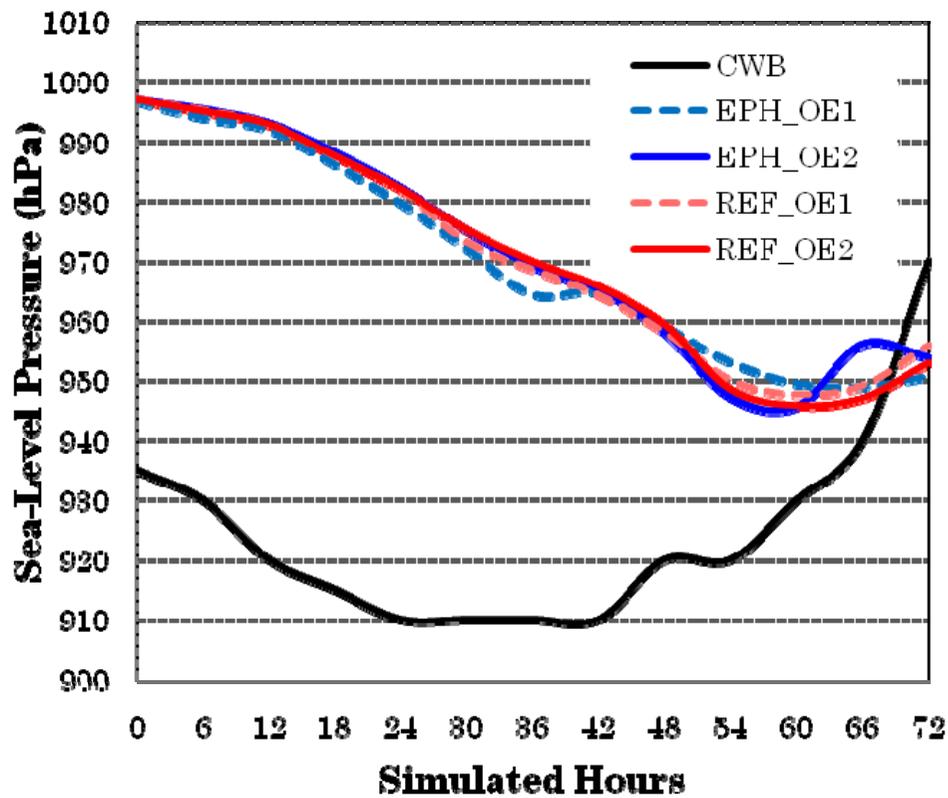
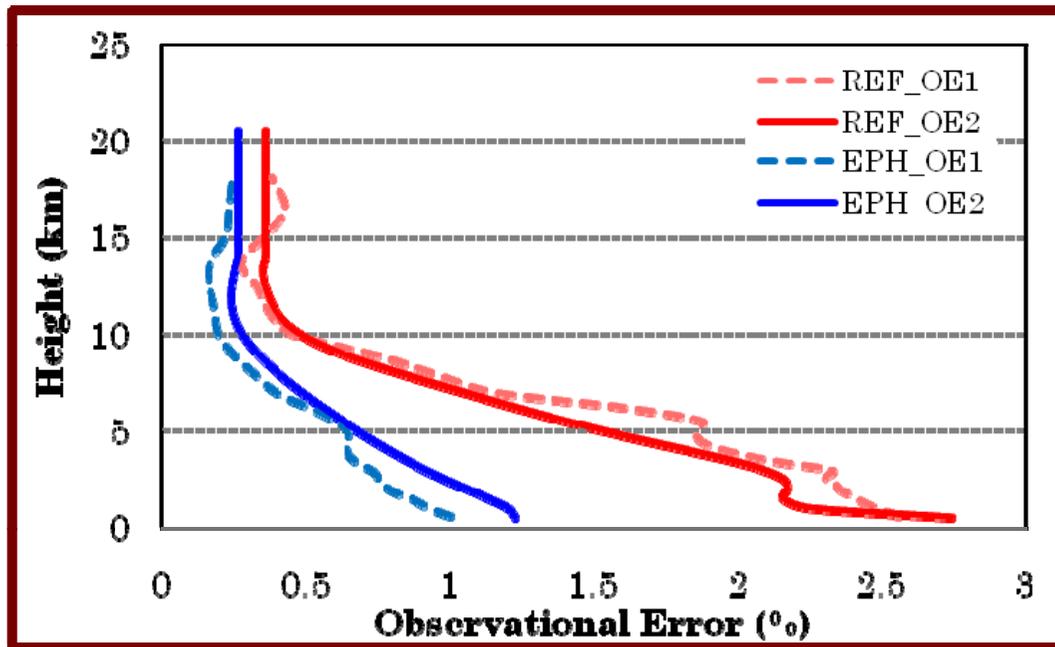
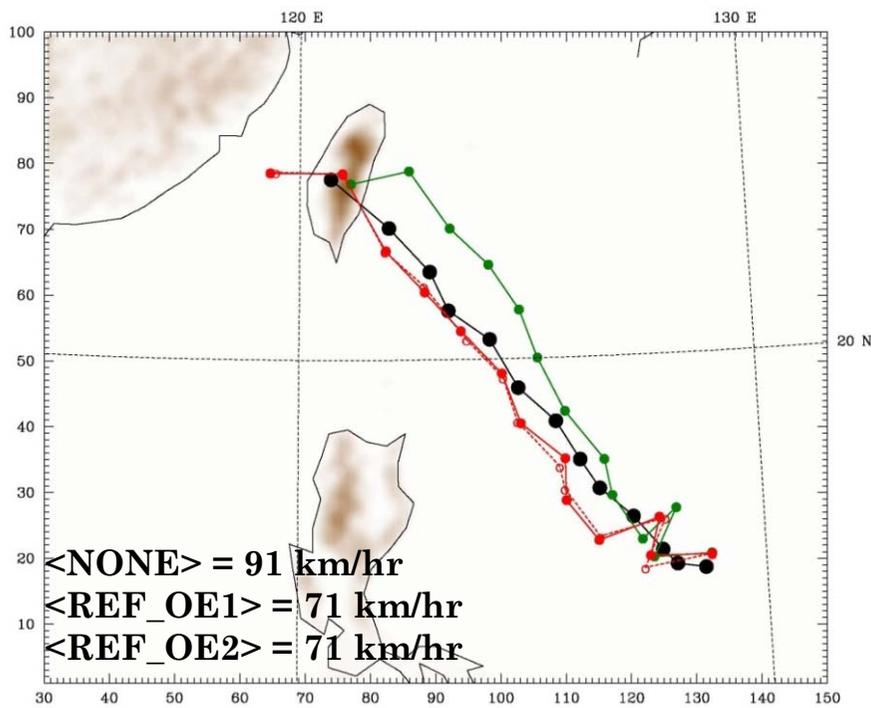
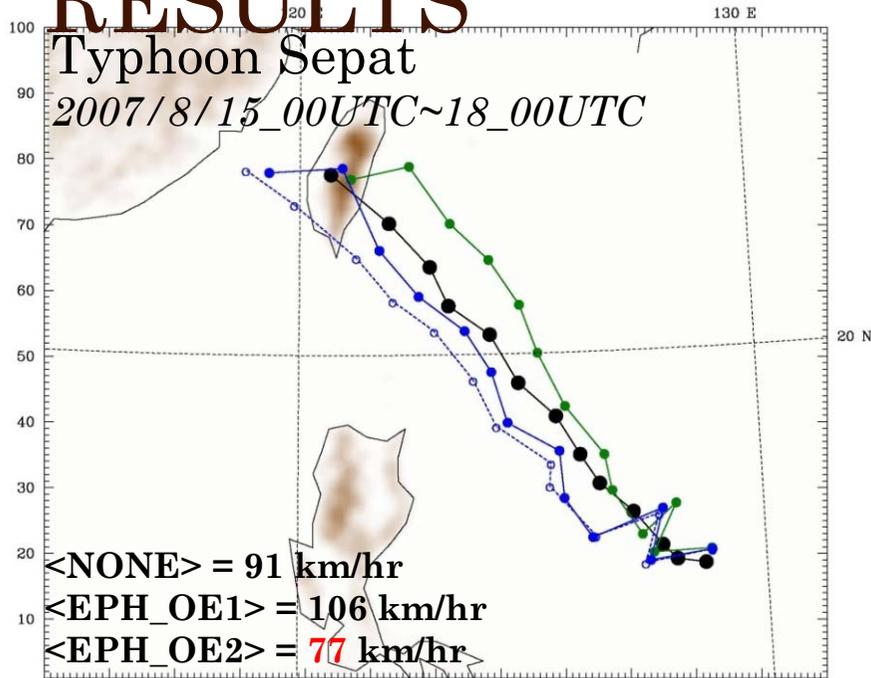


dash lines: estimated
solid lines: fitted



dots: estimated
red lines: fitted

SIMULATED RESULTS



SUMMARY

- In this study, we provide the observational errors of both refractivity and linear excess phase in East Asia.
- The latitudinal dependence of both observational errors (refractivity and linear excess phase) is stronger in the winter month and weaker in the summer month. Such latitudinal dependence of the observational errors in winter and summer must be taken into account in RO data assimilation.
- The latitudinal dependence of the observational error is found to be influenced by the variations of the atmospheric moisture.
- The preliminary results show some improvements for the simulated typhoon tracks by using new observational errors.

CURRENT WORK AT NCU/GPSARC

□ local bending angle

$$\alpha(a) = -2a \int_a^\infty \frac{d(\ln n) / dx}{(x^2 - a^2)^{1/2}} dx$$

n : refractive index

$$x = n r$$

r : radius of a point on the ray path

$$N = 10^6 (n - 1)$$

□ operators: 1. NCU, 2. GRAS SAF

below model top:

1. NCU

$$\Delta\alpha = -2a \frac{d \ln n / dx}{\sqrt{x+a}} \int_j^{j+1} \frac{1}{\sqrt{x-a}} dx = -4a \frac{1}{n_j} \frac{n_{j+1} - n_j}{x_{j+1} - x_j} \frac{\sqrt{x_{j+1} - a} - \sqrt{x_j - a}}{\sqrt{\frac{1}{2}(x_{j+1} + x_j) + a}}$$

2. GRASSAF with some assumptions (Healy and Thepaut, 2006)

$$\Delta\alpha = 10^{-6} \sqrt{2\pi a k_i} N_i \exp[k_i(x_i - a)] \{ \operatorname{erf}[\sqrt{k_i(x_{i+1} - a)}] - \operatorname{erf}[\sqrt{k_i(x_i - a)}] \}$$

above model top:

$$\Delta\alpha_{top} = 10^{-6} \sqrt{2\pi a k_i} N_i \exp[k_i(x_i - a)] \{ 1 - \operatorname{erf}[\sqrt{k_i(x_i - a)}] \}$$

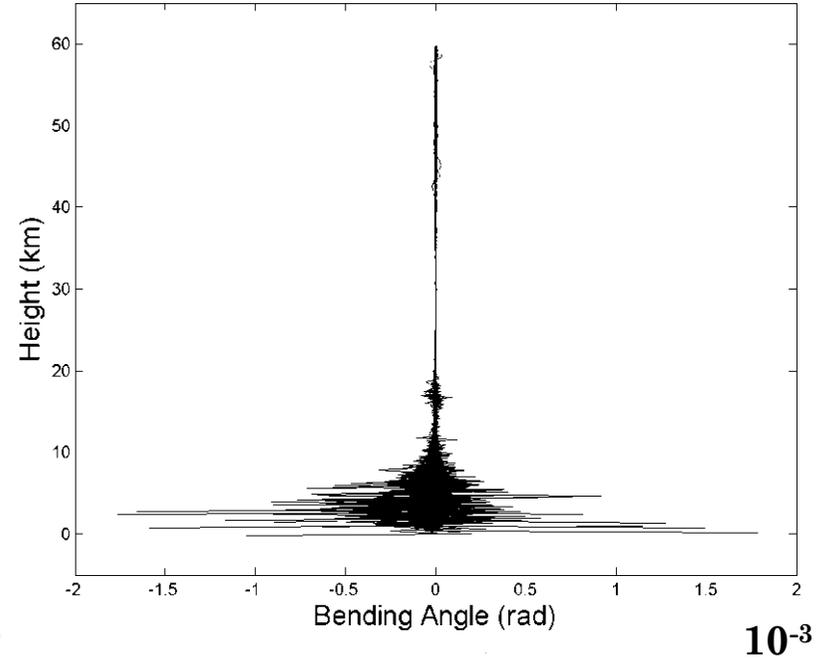
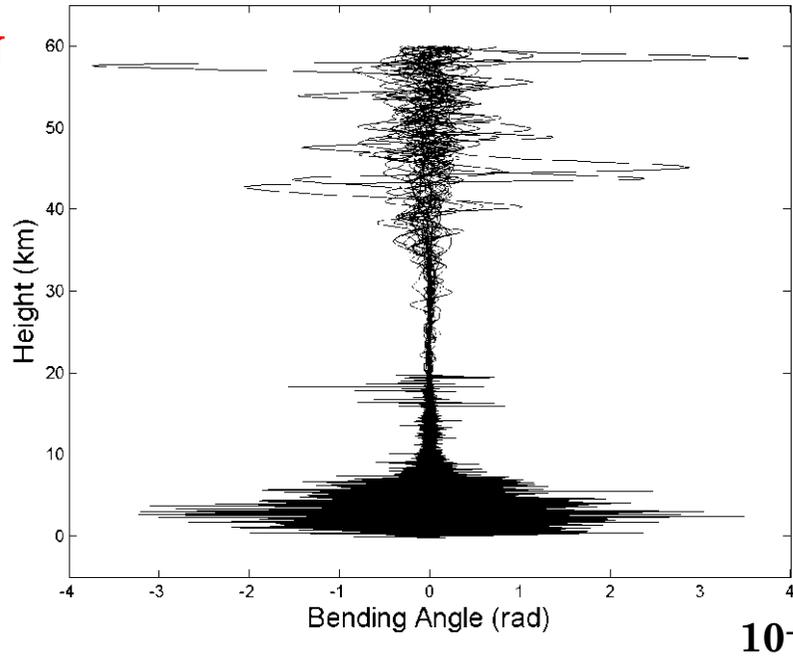
ES

$$\alpha_{fwd} - \alpha_{obs}$$

Vert. Resolution: 3~5 meters (atmPrf)

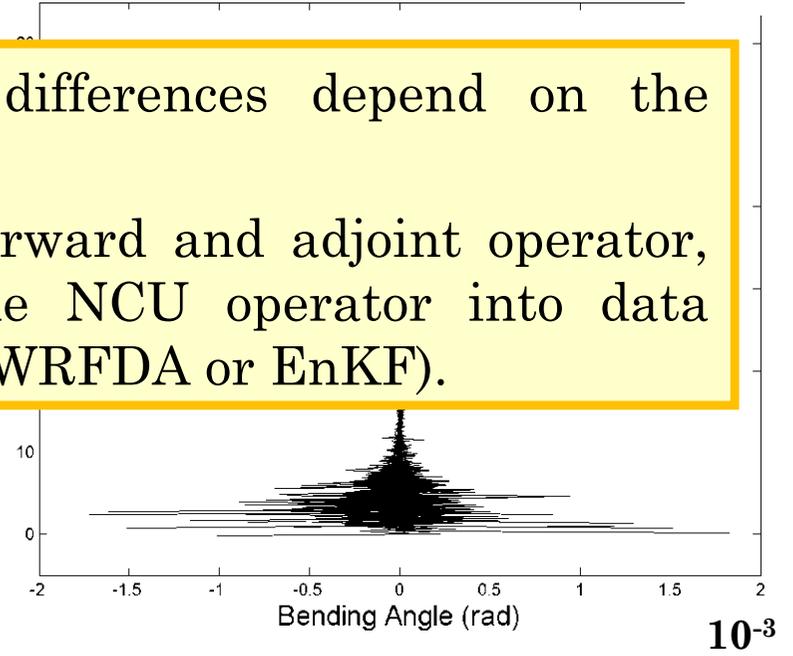
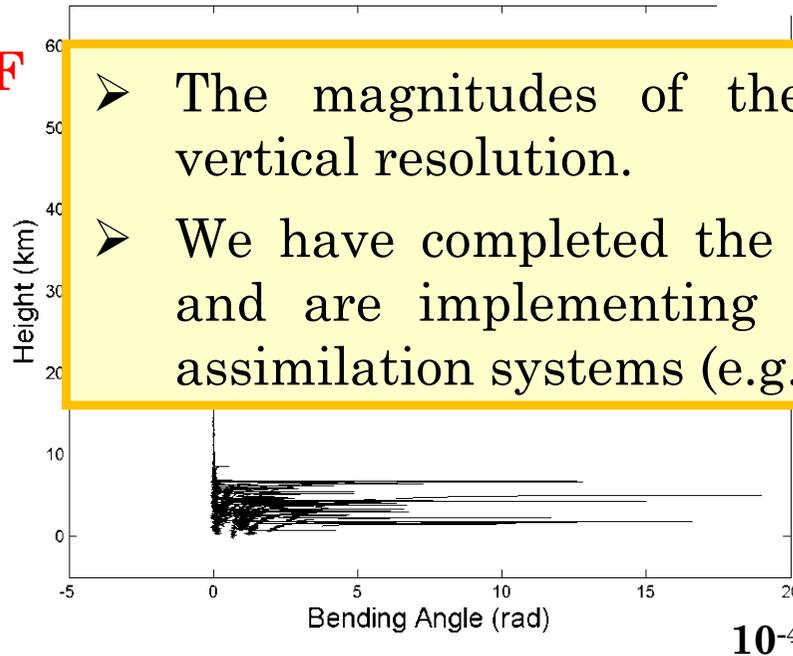
200 meters (brfPrf)

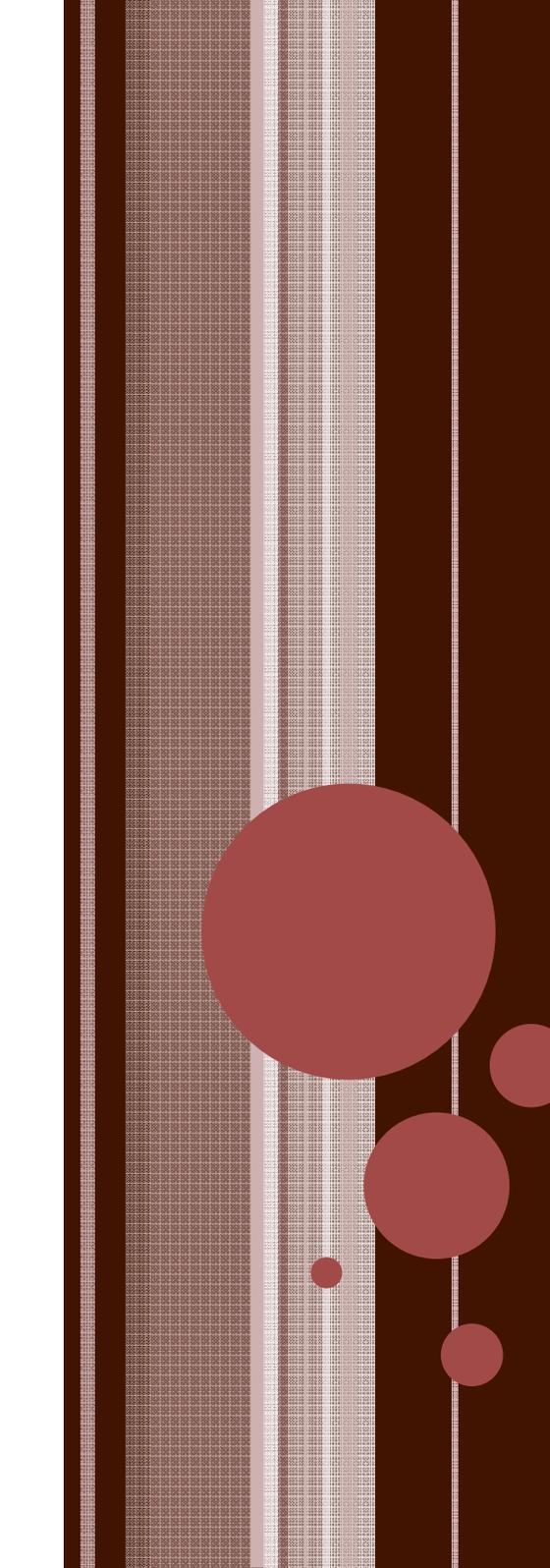
NCU



GRAS SAF

- The magnitudes of the differences depend on the vertical resolution.
- We have completed the forward and adjoint operator, and are implementing the NCU operator into data assimilation systems (e.g., WRFDA or EnKF).





THANK YOU.

The end ~