

ROMEX: Attempts to understand model and observation biases

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Background

- ROMEX lots of observations
 - It'll be easy, right?
- Initial impacts appeared negative (verified using RMSE against ECMWF analyses)
- Let's have more of a look at those biases

Adding all DOMAEY abaam (ations (RMSE)



 Change in RMSE, verified against ECMWF analyses

- Area of triangle shows percentage improvement (degradation) in green (blue)
- Various lead times and forecast quantities

Adding all DOM/EV abaan vations (std dev)



 Change in standard deviation of error, verified against ECMWF analyses

- Area of triangle shows percentage improvement (degradation) in green (blue)
- Various lead times and forecast quantities

Analysis),



Z500 forecast bias

Geopotential Height (m) @ 500hPa, Mean Error (Forecast - Analysis), Northern Hemisphere (CBS area 90N-18.75N), Equalized and Meaned between 20220901 00:00 and 20221201 12:00, Analysis, 1.5deg grid



95% confidence intervals calculated from SE assuming independent observations

 2.5m negative bias in Z500 forecasts induced by adding extra observations



Biases (O-B)/B



handing and troposphere

	SH Z850	SH 7200	SH Z250	SH Z100	SH Z50	SH T850	SH T500	SH T250	SH T100	SH T50	SH W850	SH W500	SH W250	SH W100	SH W50	TR T850	TR T500	TR T250	TR T100	TR T50	TR W850	TR W500	TR W250	TR W100	TR W50	NH Z850	NH Z500	NH Z250	NH Z100	NH Z50	NH T850	NH T500	NH T250	NH T100	NH T50	NH W850	NH W200	NH W250	NH W100	NH W50	
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 Adjusting bias improves many quantities

% Difference (Bia Magnitude Standard E Equalized, 2022

as corr Deviat 20902

Of E

vs. All obs), recast - Analysis), 1201 00:00

• But doesn't help the bias for Z500!

Increasing all bonding angles by 0.05%



 Smaller degradations in geopotential heights

 Large improvements relative to run without bias correction

Increasing all handing angles by 0.1%



 Most degradations in geopotential heights eliminated

- Large improvements relative to run without bias correction
- Degradations in Z50

honging 1/1



% Diffe Magnitude Equali 0 00:00 Analysis),

 We use Smith & Weintraub (1953) for refractivity

$$N = \frac{77.6 P}{T} + \frac{3.73 \ 10^5 P_e}{T^2}$$

 Can get nearly same effect by changing • 77.6 \rightarrow 77.5224

Z500 forecast bias

Geopotential Height (m) @ 500hPa, Mean Error (Forecast - Analysis), Northern Hemisphere (CBS area 90N-18.75N), Equalized and Meaned between 20220901 00:00 and 20221201 12:00, Analysis, 1.5deg grid



^{95%} confidence intervals calculated from SE assuming independent observations

- Bias correcting all obs (in particular lower stratosphere) changes Z500 bias
- Bias correcting by 0.1% "fixes" bias



Spatially-varying biases



- Most satellites have similar pattern
 - Negative in extra-tropics
 - Positive in tropics
- COSMIC-2 positive in 30-45 N/S
- Spire less positive in tropics
- Other satellites stand out at different heights

The heresy

- GNSS-RO observations are known to be (largely) unbiased
- Applying a bias correction to the observations (or altering refractivity coefficients) improves the forecasts
 - The bias in the troposphere is largely modulated by the observations in the stratosphere
- Should we apply bias correction to upper-stratosphere to correct model biases?





Spatially-varying biases



- Calculate (O-B)/B on 30 degree grid for satellite groups
- For each observation, interpolate "bias" to observation location (in 3D)
- Apply "bias" correction to observation

Chatially varying bias correction (std dev)



 Verification against **ECMWF** analyses using standard deviation of error

 Addition of observations beneficial in first three days

ROMEX cc

Conclusion

- Adding all ROMEX observations did not yield better forecasts
 - For geopotential heights this is largely bias issue
- There are apparent biases between the observations and the background forecast
 - Most are due to the model, some coming from the observations
 - Increasing all bending angles by 0.1% helps in troposphere
 - Correcting the observations for these (spatially-varying) biases gives further improvements
- The forecast biases at a given height are (largely) controlled by the observations above it

However...

•With this extra work we are able to see clear benefits of the additional ROMEX data

• It's just that the model biases made this hard to see



Spare slides

Adding bigg correction above ?4km



- Reduces errors for **Z50**
- Mixed results in SH
- Does not fully improve RMSE

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0.1%), alysis),

Bias correcting observations



- Applying a bias correction to the observations (for a model bias) takes the analysis further from the truth
 - Leads to the bias saturating more quickly
- We are bias correcting obs at high levels to effect a bias change at low levels

Spatially varying bias correction (RMSE)



Generally positive results

 Negative for some upper-troposphere temperatures and geopotential heights