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Assimilation of Raman Lidar observations

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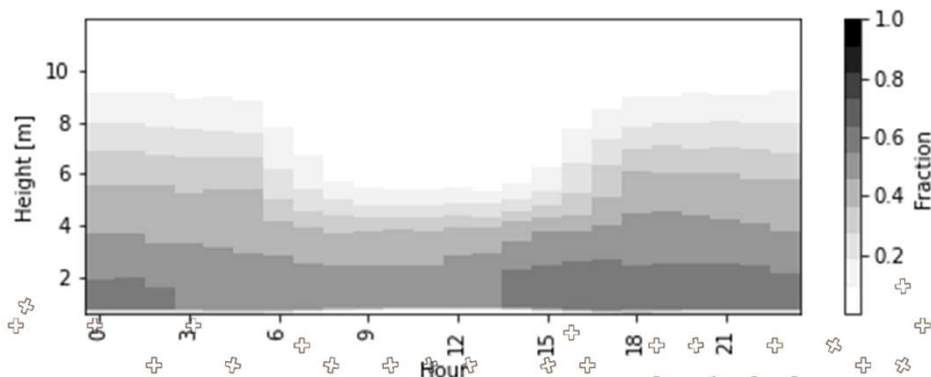
COSMO General Meeting - 7 September 2021



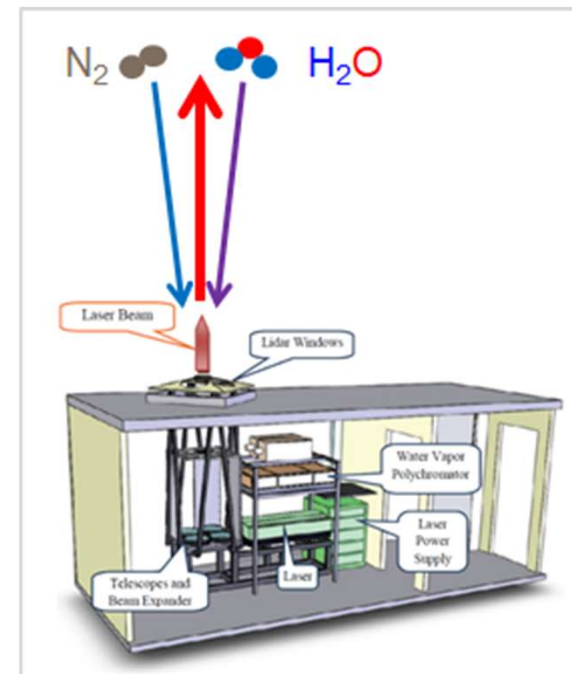
Raman Lidar (RALMO)

- Vertical profiles of Temperature and WV Mixing Ratio at 30 min temporal resolution
- Coverage of about 60% below 2000m (see below)

Diurnal data coverage as a fraction for RALMO (T)



MeteoSwiss



Raman lidar for meteorological observations (RALMO), one instrument in PAY

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Bas Greze

2



A new observation operator in MEC-light

- Convert QV to mixing ratio and interpolate to observation levels
- Observations are 30 min averages and available every 30 min. In the obs operator, the temporal averaging over the last 30 min and the interpolation between model values at $t=0$ and $t=60\text{min}$ is approximated by finite differences in time as follows:

$$\left. \begin{array}{l} y(t + 30) \\ y(t + 60) \\ H(x(t + 30)) \\ H(x(t + 60)) \end{array} \right\} \text{foffile}$$

$$x(t + 30) = \frac{3}{4}x_{AN}(t) + \frac{1}{4}x_{FG}(t + 60)$$

$$x(t + 60) = \frac{1}{4}x_{AN}(t) + \frac{3}{4}x_{FG}(t + 60)$$

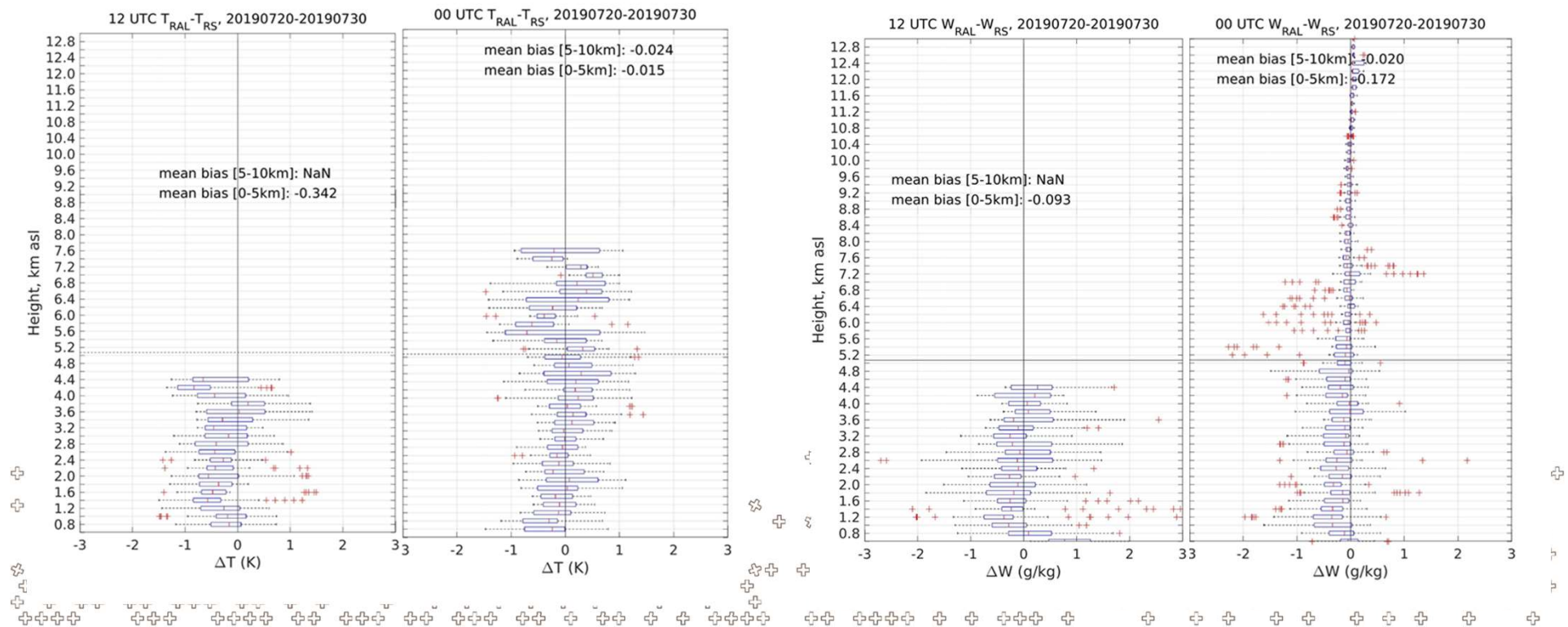




RALMO against radiosondes

Temperature

WV Mixing ratio





Experiment setup

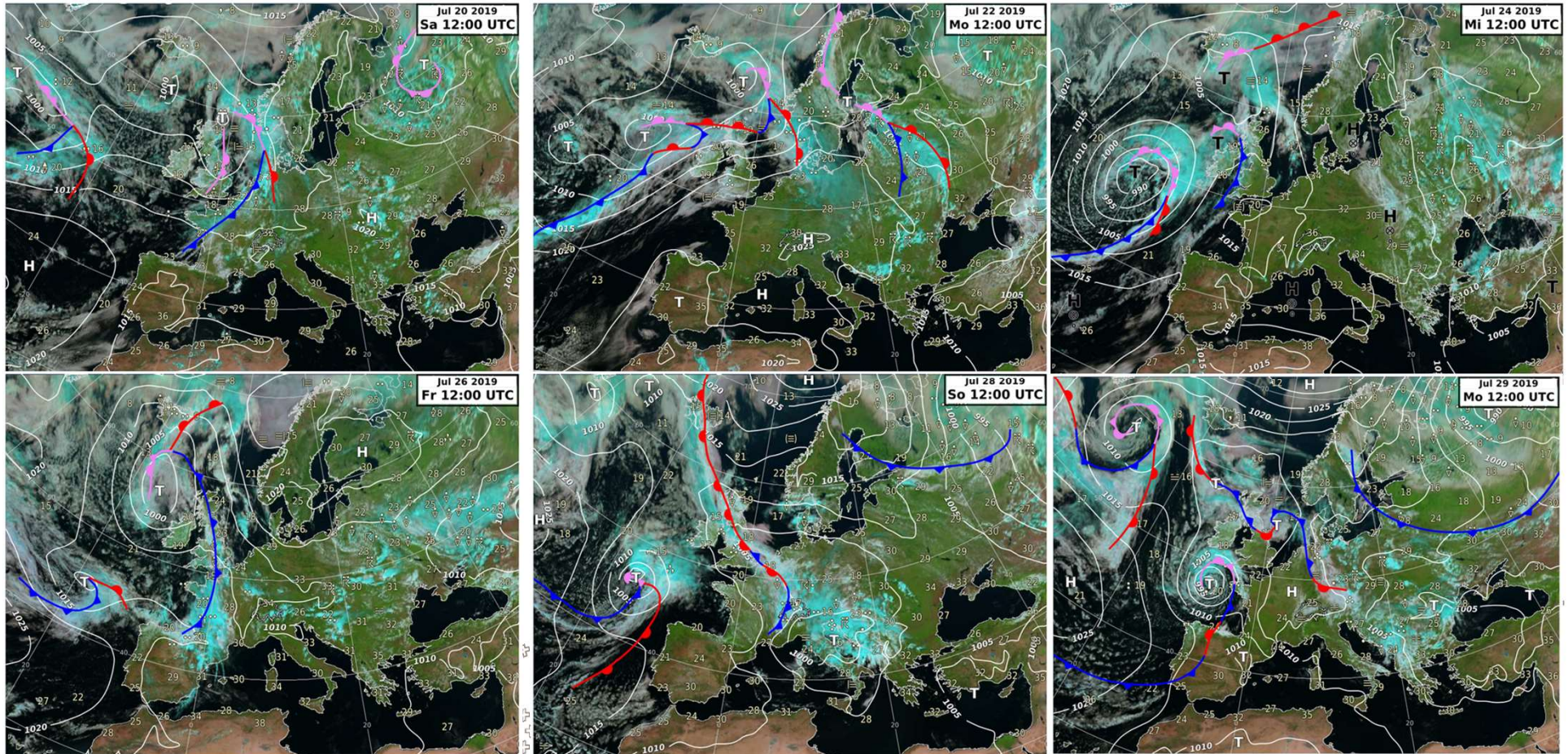
- Time period: 20-30.07.2019

	Assimilation Experiment	Forecast
RALMO + operational obs	326	426
Operational obs	325	325

- Model: COSMO-1E + KENDA-1
- observation error: 1 K for T ; 1 g/kg for MIXR
- Every 30 minutes RALMO is assimilated
- RALMO is almost bias free (w.r.t. radiosonde) → no bias correction needed



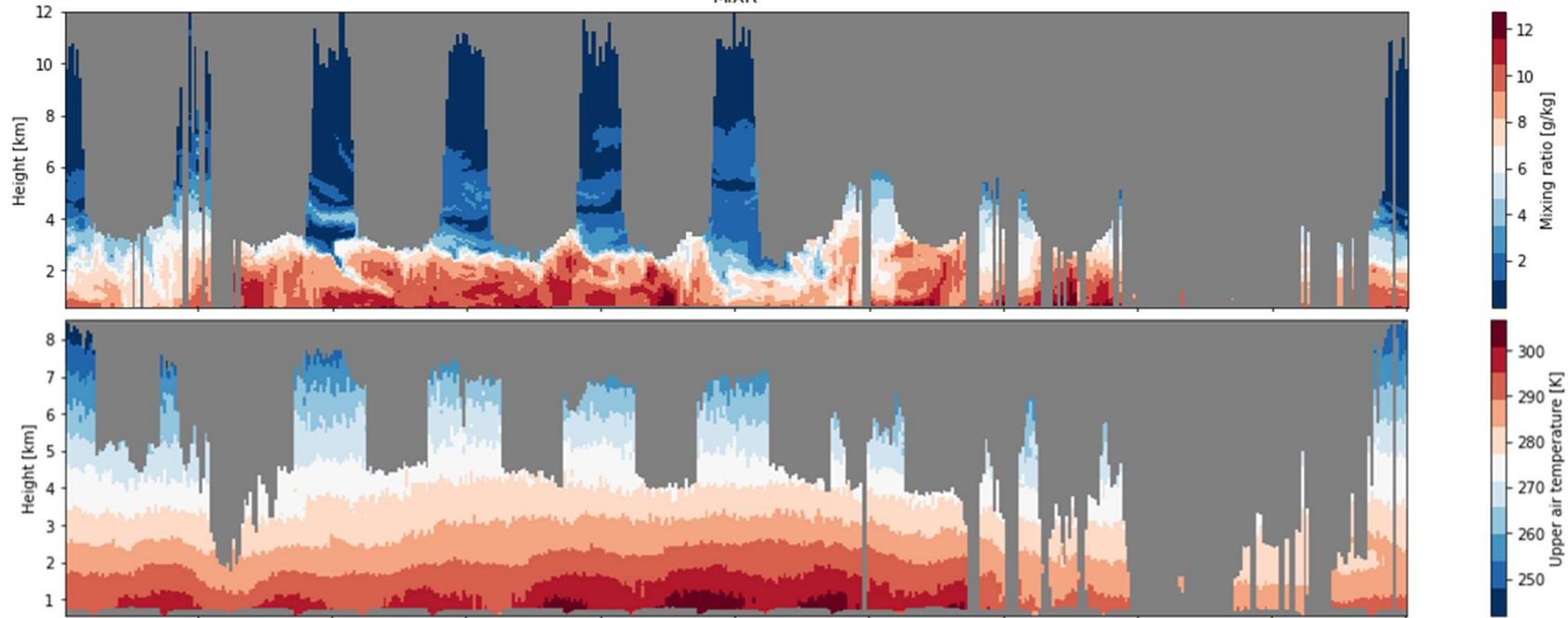
Synoptic setting - 20-30 July 2019





RALMO measurements

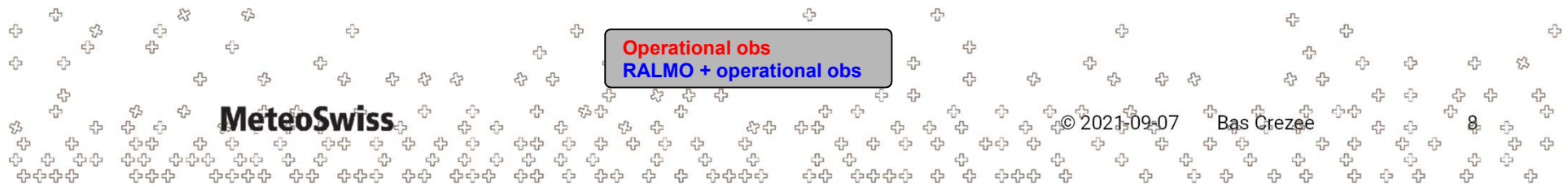
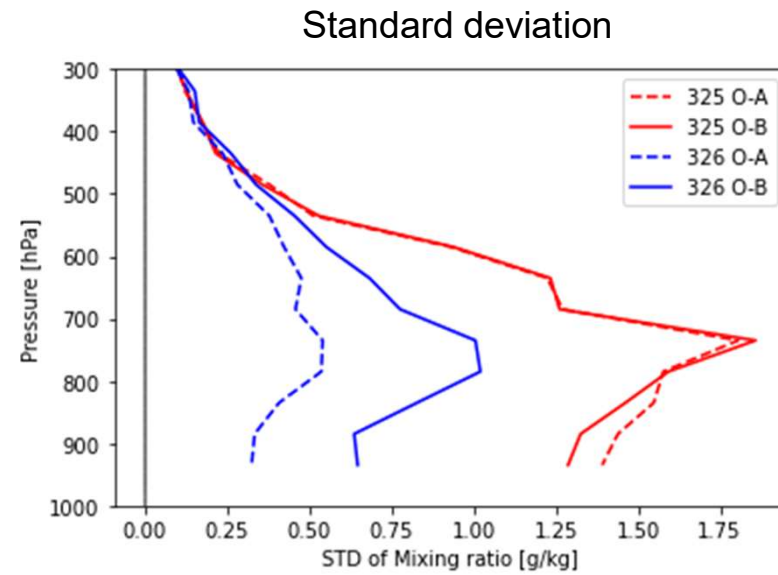
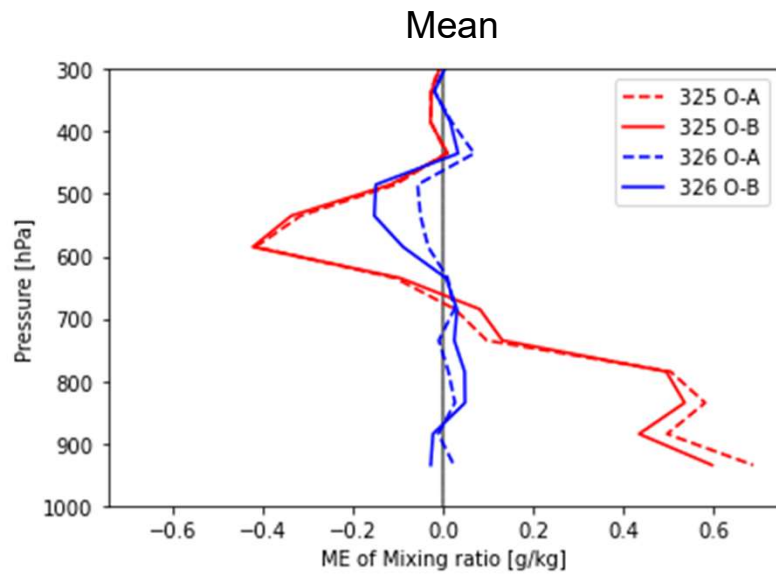
MIXR



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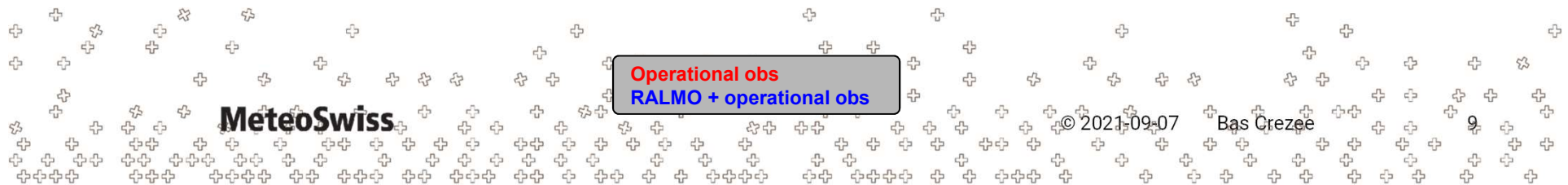
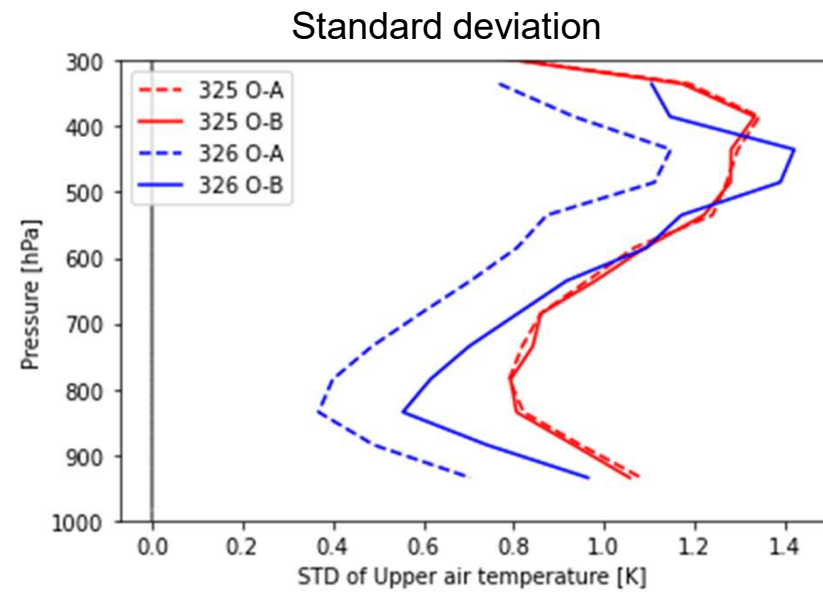
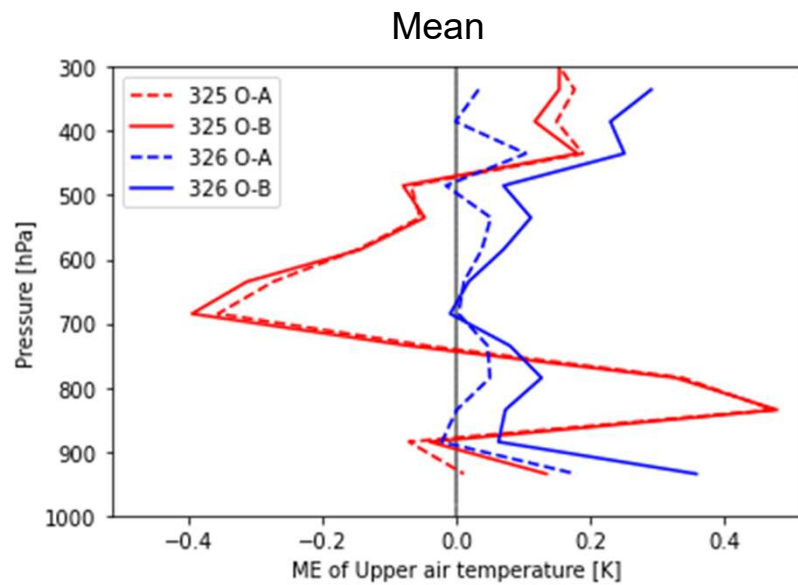


O-A and O-B statistics (MIXR)



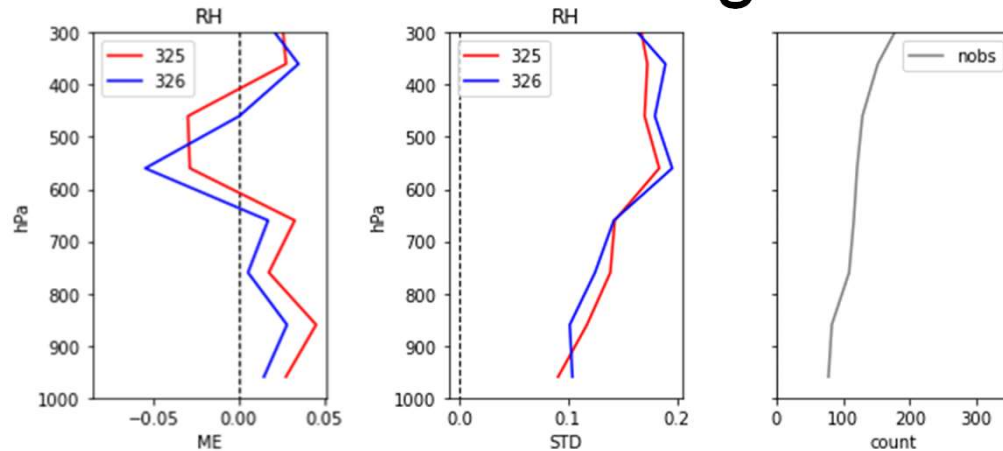


O-A and O-B statistics (T)

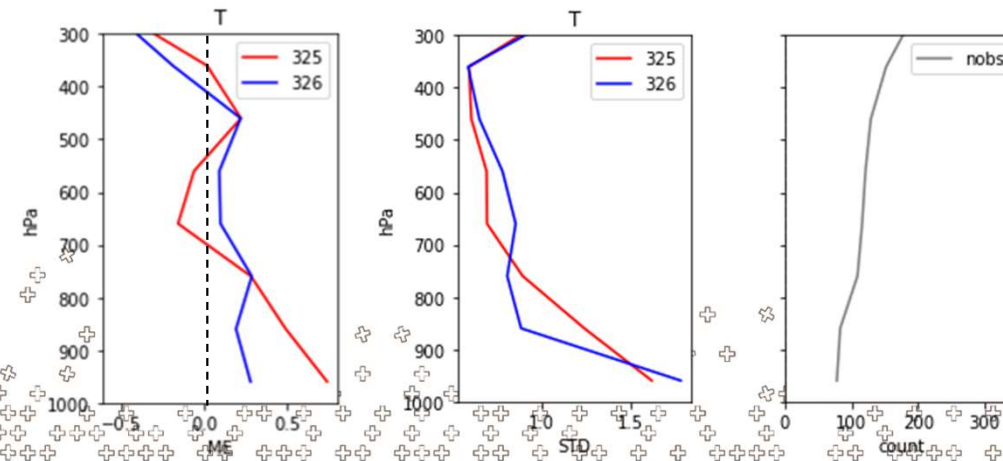




Verification of FG against radiosonde (RH/T)



- 20 radiosondes in PAY over 10 days @ [00 UTC ; 12 UTC]
- “Independent data” since radiosonde not yet assimilated in FG started at 23/11 UTC
- Note ‘O-B’ terminology



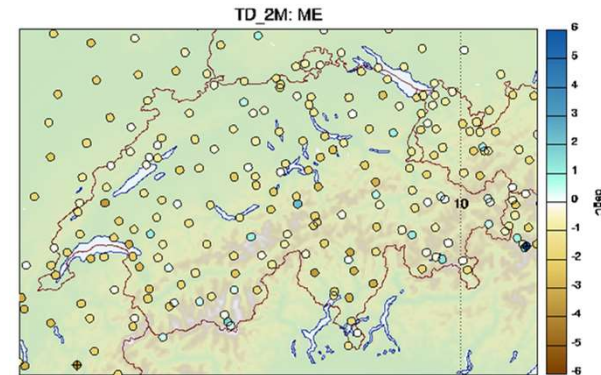
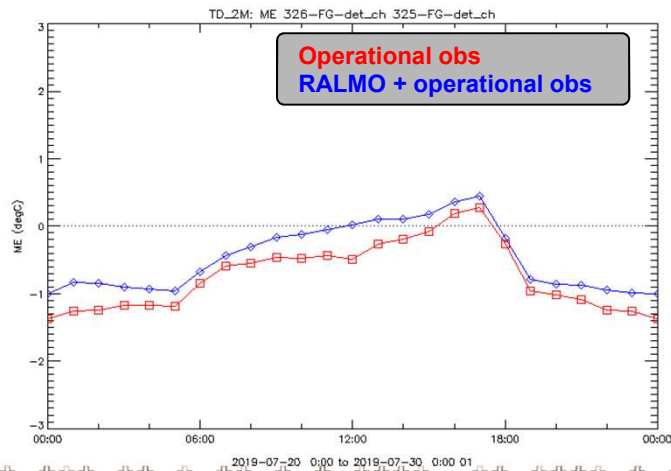
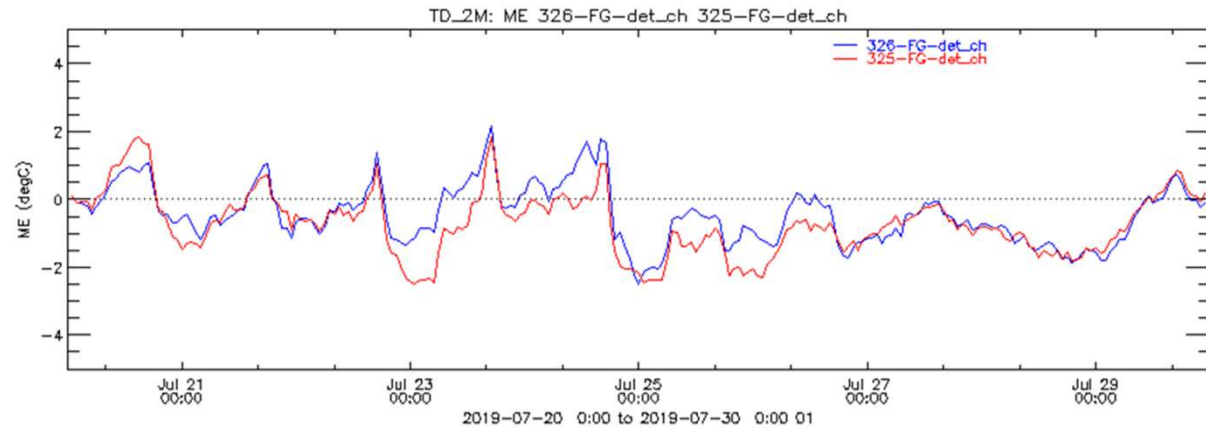
Operational obs
RALMO + operational obs

© 2021-09-07 Bas Crezee 10



Verification of FG against surface data (TD2m)

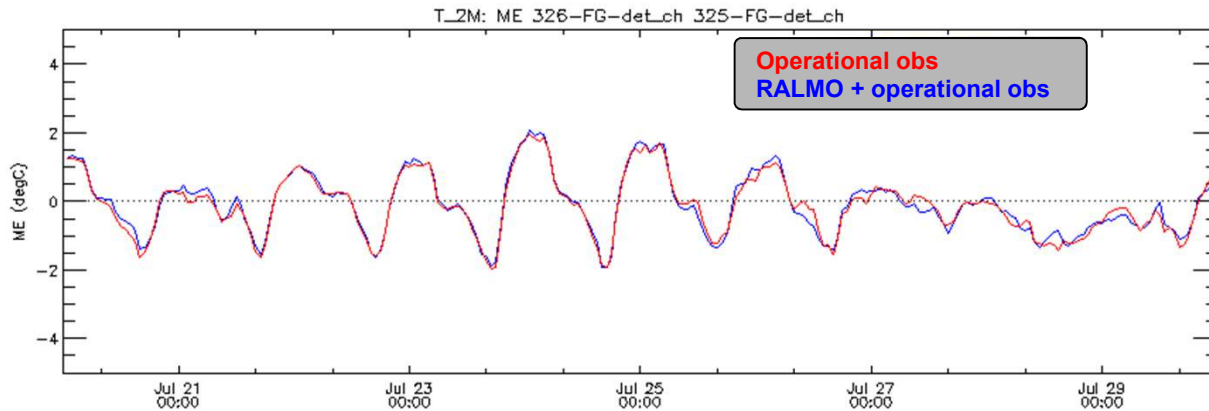
- Reduction of dry bias in model
- No change in STD (not shown)
- Clear impact over days where RALMO has sufficient coverage



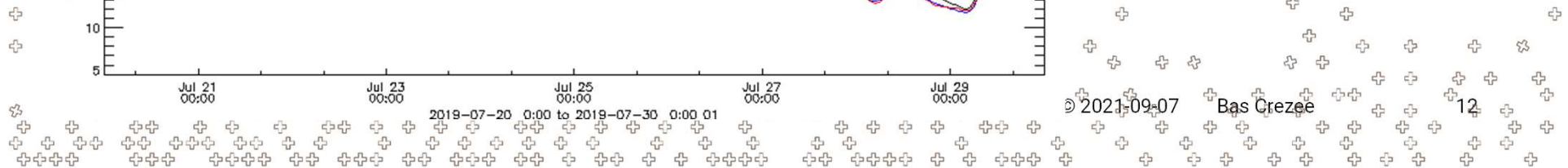
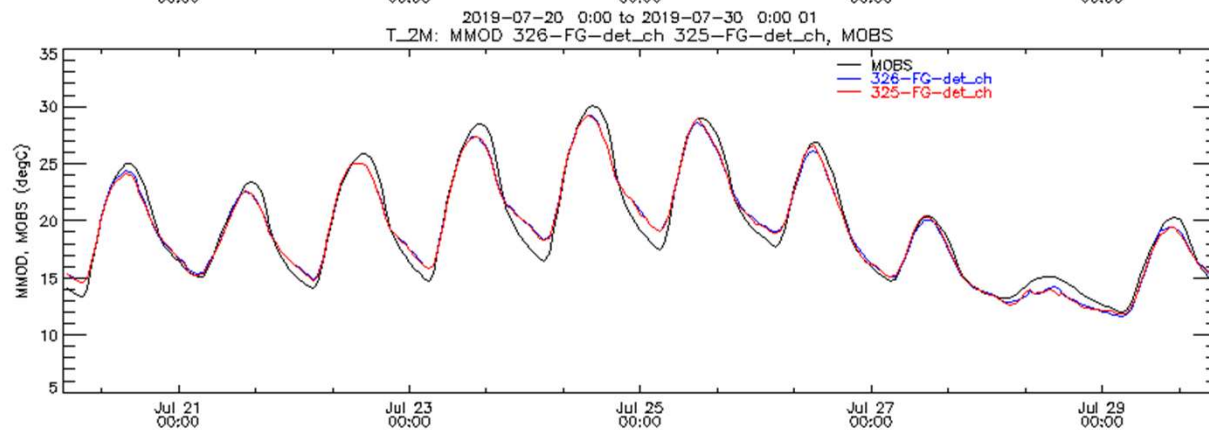
© 2021-09 Surface Stations for TD_2m



Verification of FG against surface data (T2m)

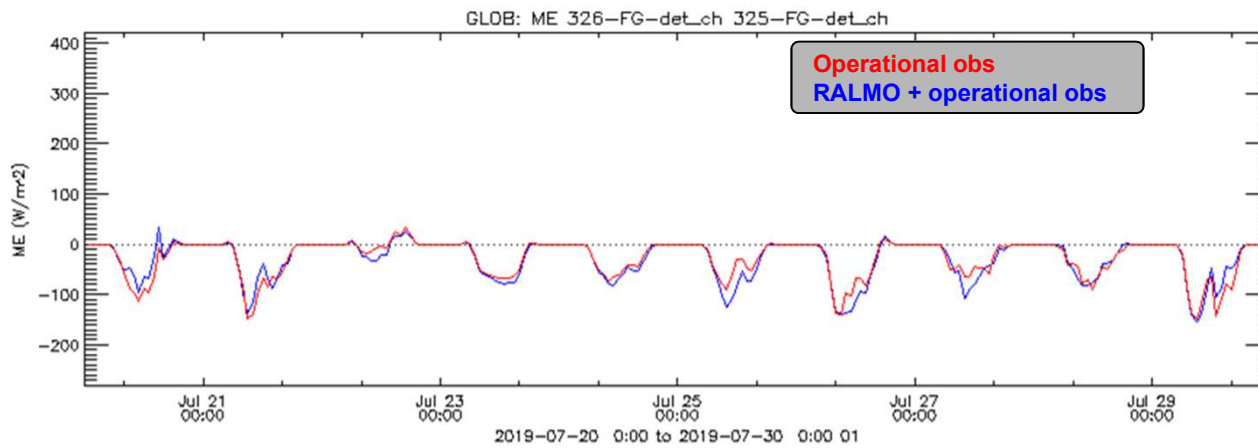


- No significant impact





Verification of FG against surface data (RAD)

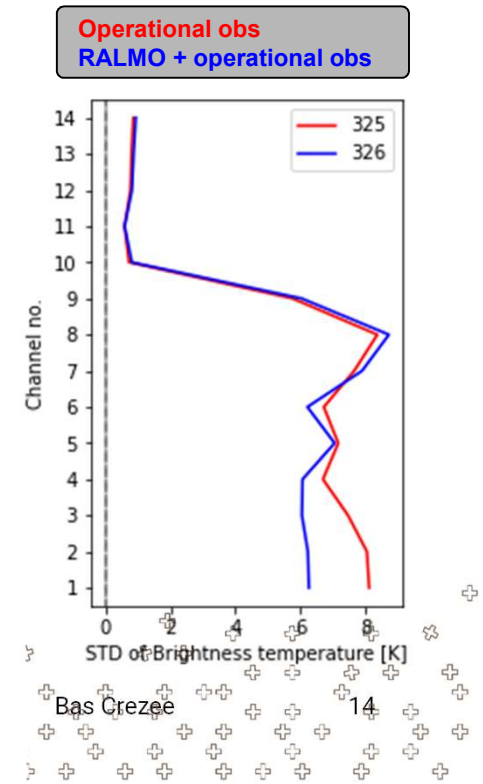
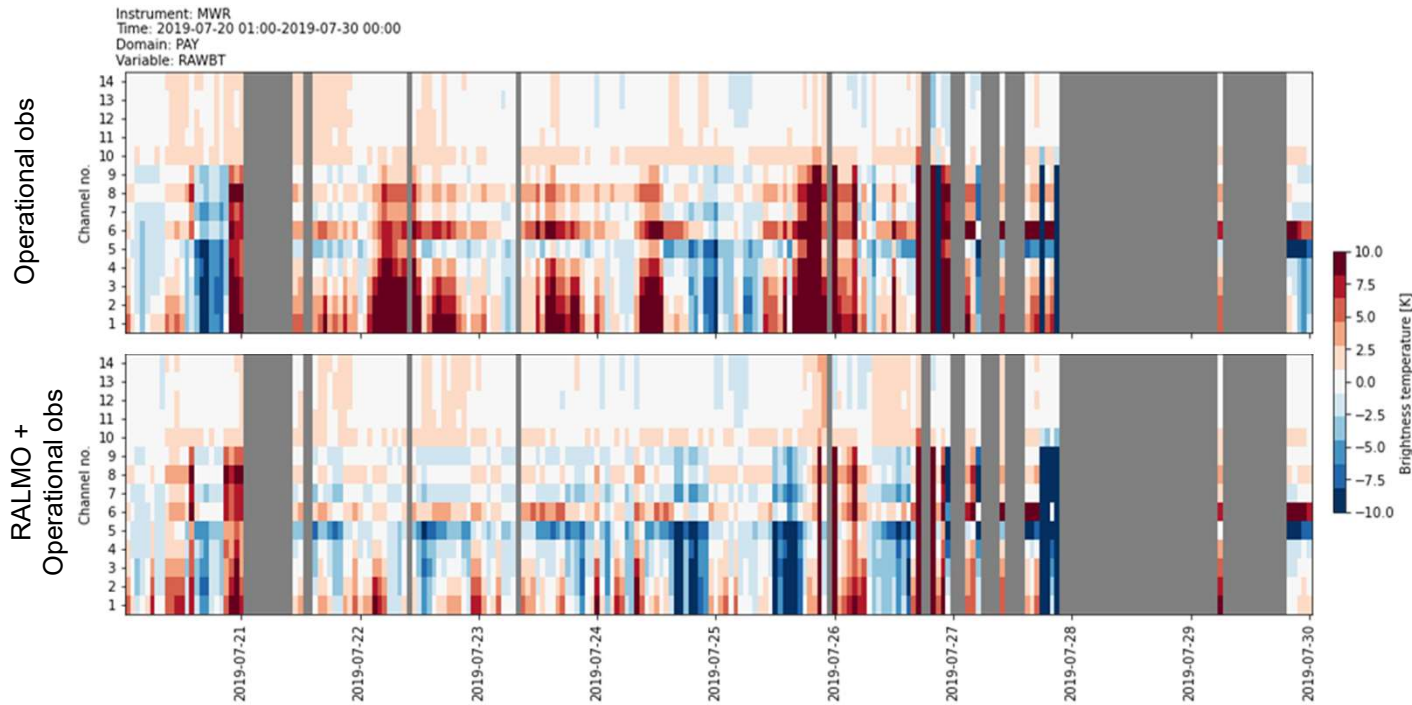


- Improvement for first two days and last day
- For other days, negative bias gets worse



Verification of FG against MWR (Brightn. Temp.)

- Payerne; zenith angle 0°
- Moisture sensitive channels show large improvement
- Similar for other angles (not shown)



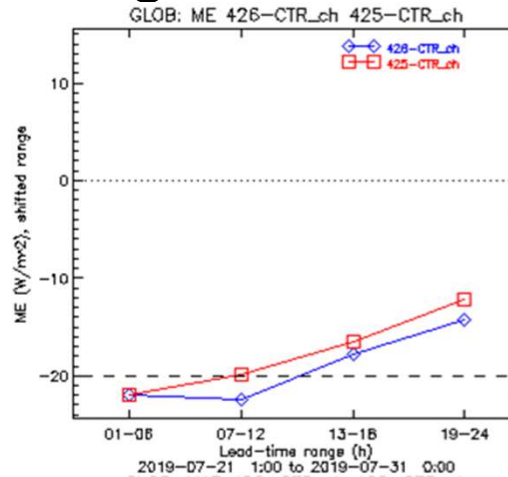
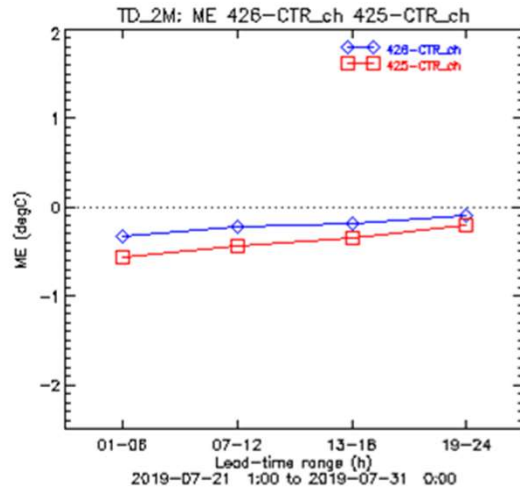


Summary of First Guess verification

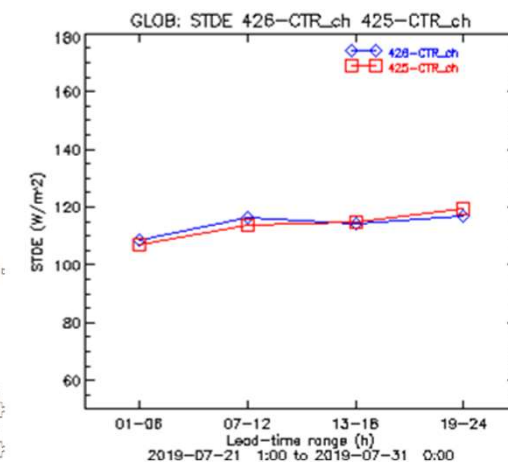
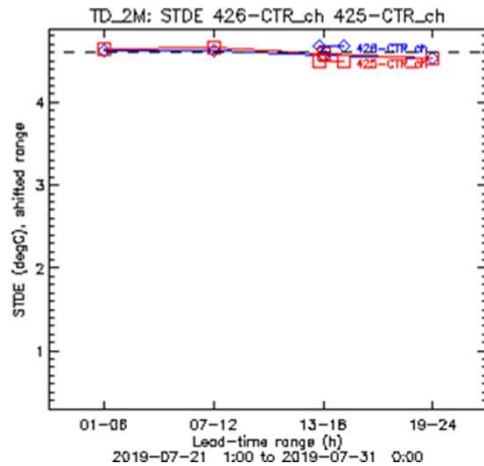
	Surface	Radiosonde / MWR (PAY only)
Temperature	neutral	better
RH / TD	better	better < 600hPa
Radiation	worse	-
Brightness Temperature	-	Moisture-sensitive channels better



Verification of FCT against surface data (Td2m / RAD)



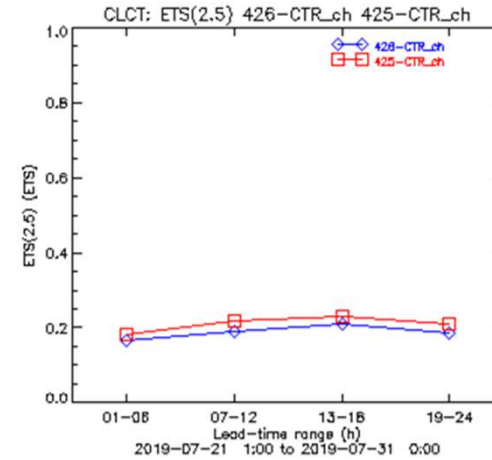
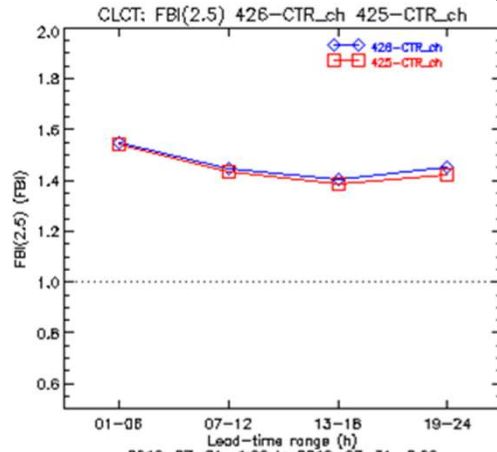
- Better Td2m, but worse radiation.
- More or less consistent with FG verification, biases decreasing over time (typical for convective season)



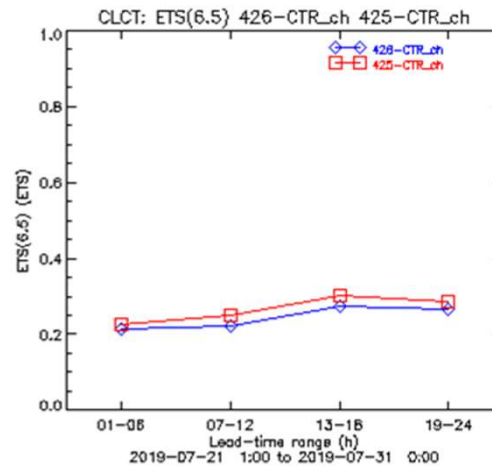
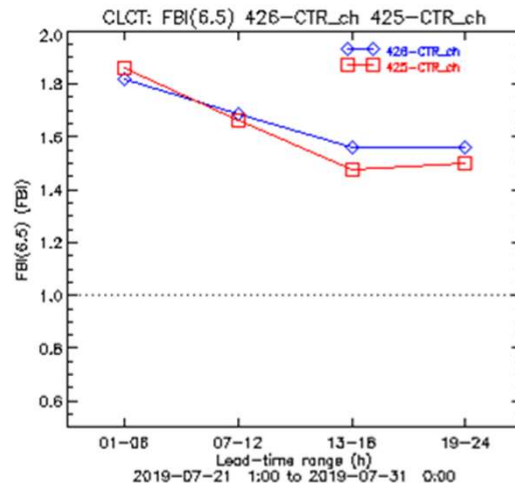


Verification of FCT against surface data (Cloud Cover)

CLCT > 2.5 octa



CLCT > 6.5 octa



- Bias in cloud cover (too high) gets worse
- Consistent with radiation

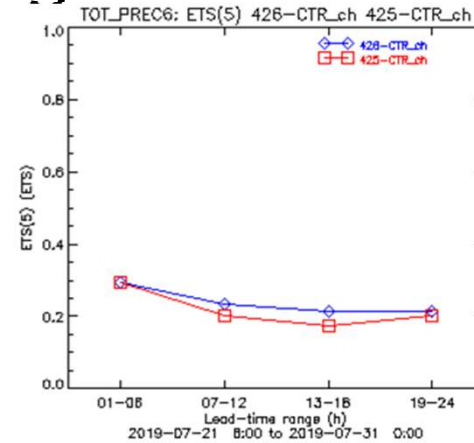
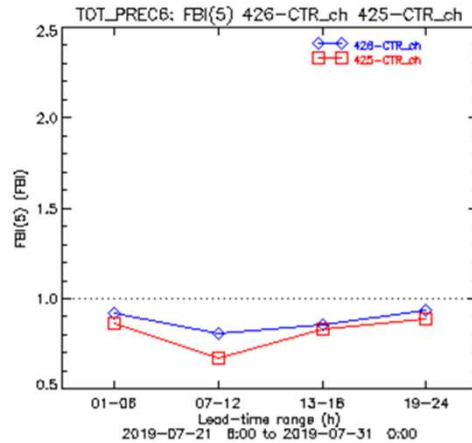
Operational obs
RALMO + operational obs





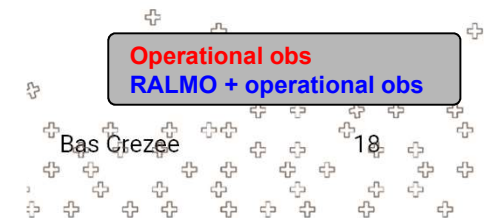
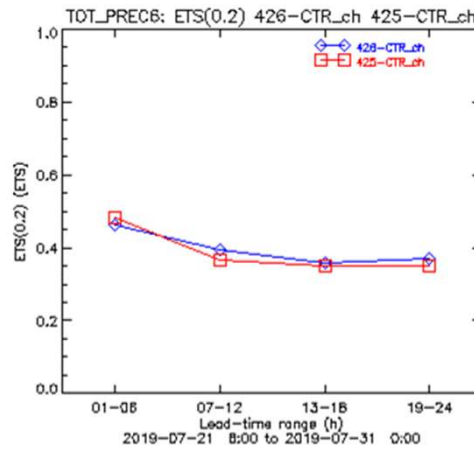
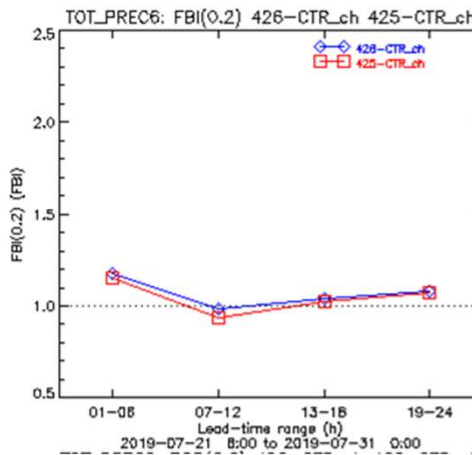
Verification of FCT against surface data (Precip)

6h precip > 5 mm



- Improvement in precip
- Most notable for >5 mm/6h threshold

6h precip > 0.2 mm





Summary

- Successful assimilation of Raman lidar mixing ratio and temperature profiles
- Dry bias in model is corrected
- Precipitation improves \longleftrightarrow cloud cover and radiation got worse
- Potentially related to model tuning

	First Guess (FG)		Forecast (FCT)
	Surface	Profile (PAY only)	Surface
Temperature	neutral	better	neutral
RH / TD	better	better < 600hPa	better
Radiation / Cloud Cover	worse	-	worse
Brightness Temperature	-	Moisture-sensitive channels better	-
Precip	-	-	better



Outlook

- New case studies
 - More convective cases (improve statistics)
 - Other seasons
- Observation error 'tuning'
 - Lower the prescribed observation error? →
 - Time-dependent obs error?

