All-sky assimilation over land for surface sensitive microwave channels

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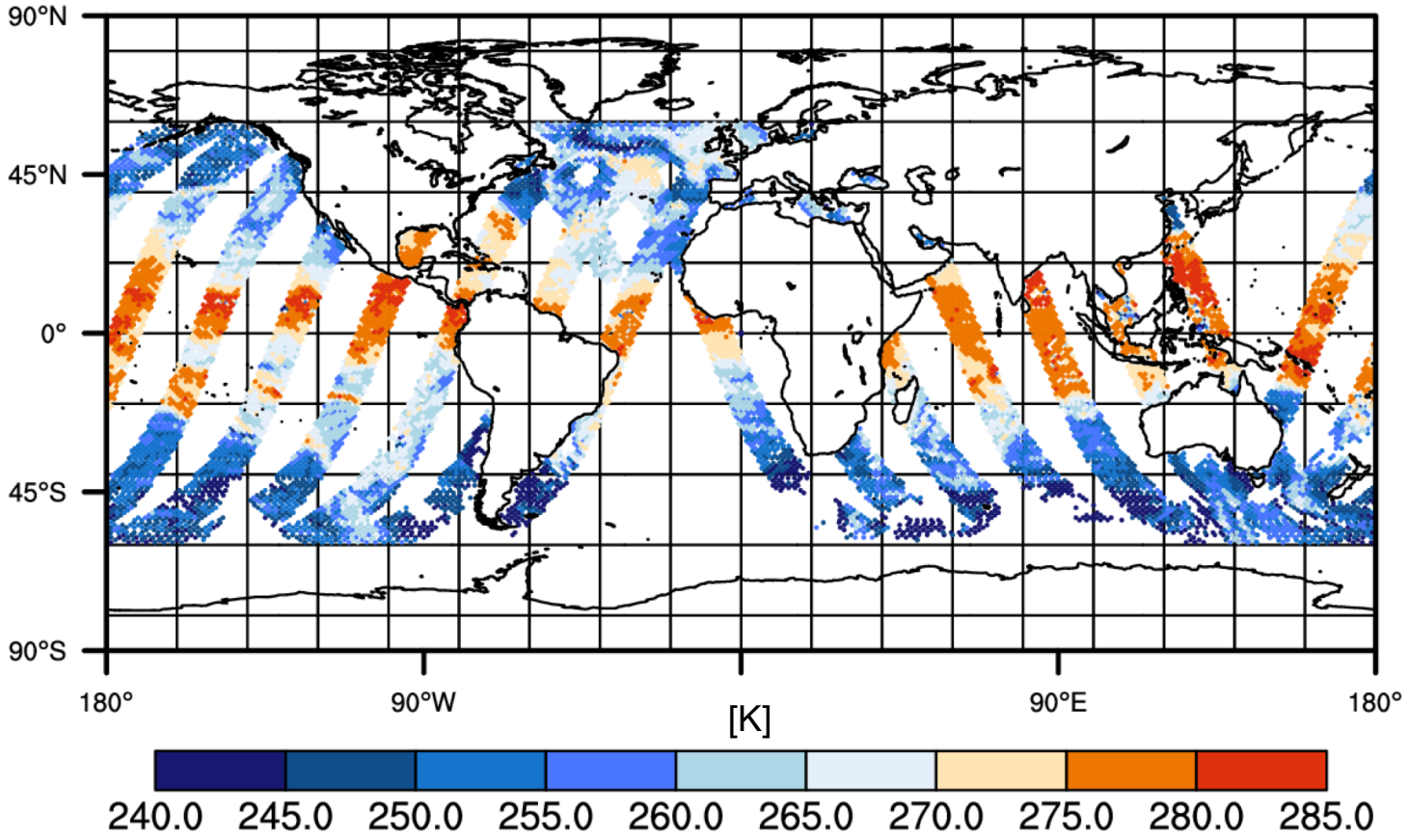
ECMWF

Status at ECMWF

Observed brightness temperatures at 89GHz, v-polarised for **GMI**



Freq. [GHz]	ocean	land	region
19 - 92	x		60ºS-60ºN
150/166	x		45ºS-45ºN
183+/7	x	x	60ºS-60ºN
183+/3	x	x	no limit
183+/-1	x	x	no limit

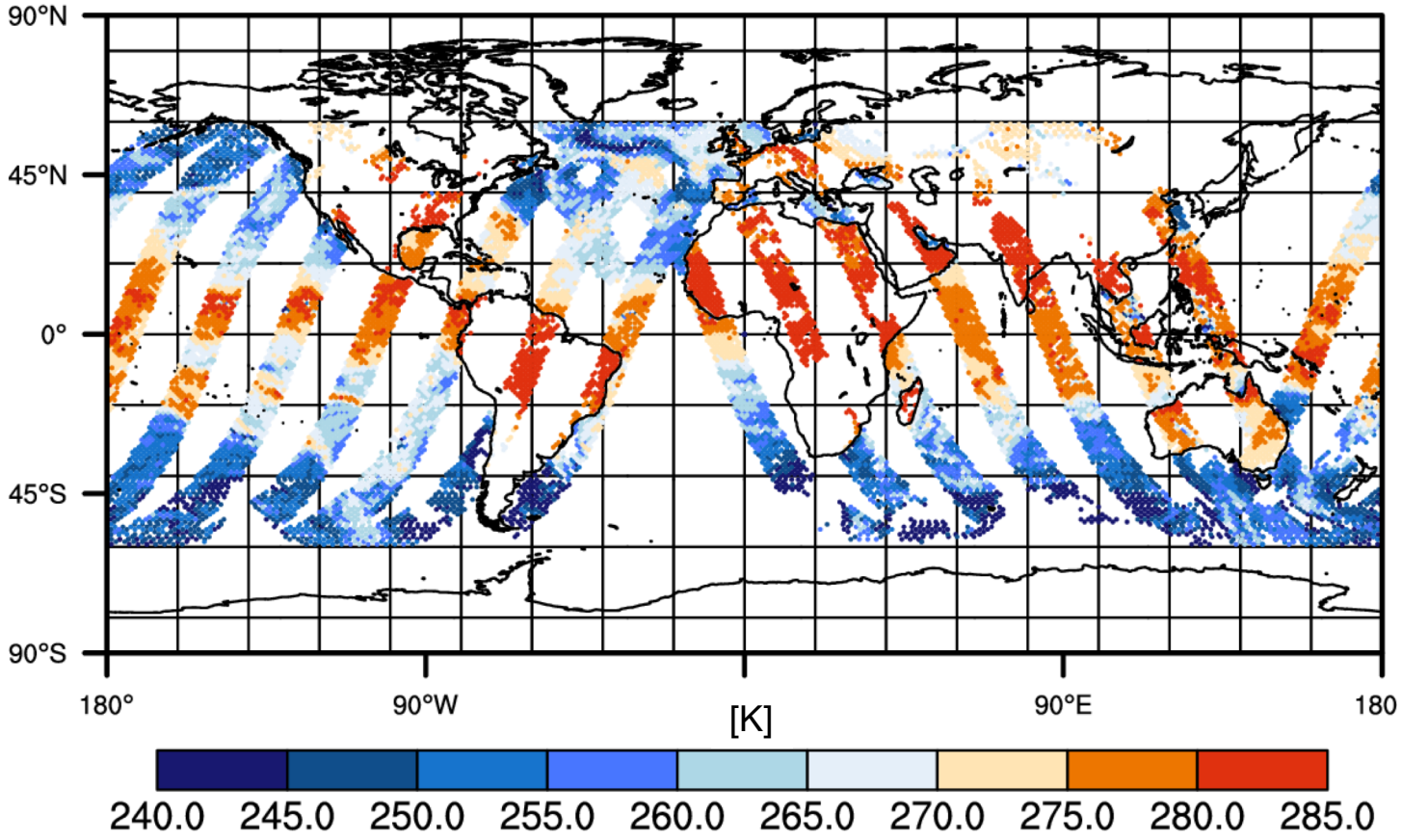
x – all MWI/sounders

x – SSMIS-F17, MHS, ATMS and MWHS-2

Three active microwave imagers/sounders:
GMI, SSMIS-F17, AMSR2

Aim… assimilation of surface sensitive MW channels over land

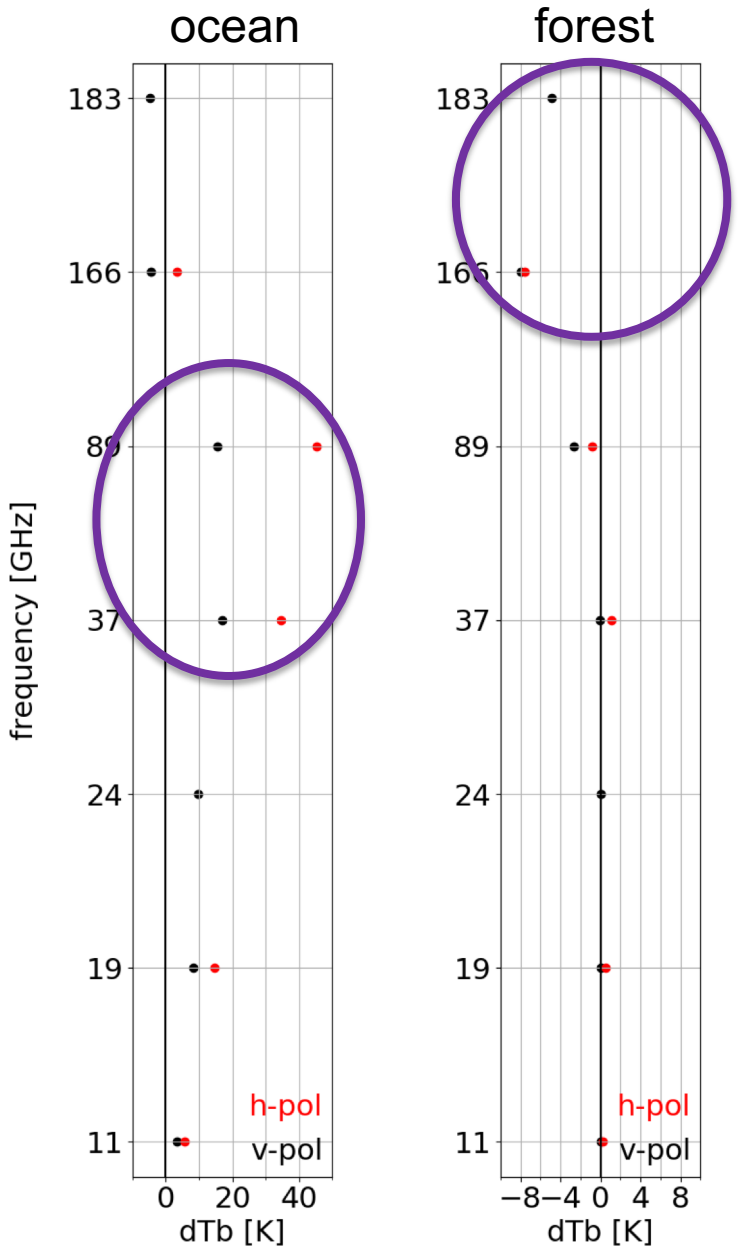
Observed brightness temperatures at 89GHz, v-polarised for **GMI**



Freq. [GHz]	ocean	land
19 - 92	x	x
150/166	x	x
183+/7 183+/3 183+/-1	x x x	x x x

…and maybe even lower frequencies…

How big is the information content of surface sensitive microwave channels signal over land?



Hydrometeor signal:

- Ocean: large signal for 89GHz and lower
- Forest:
  - Largest signal from snow and ice at 166GHz and higher
  - Little signal for frequencies of 37GHz and lower

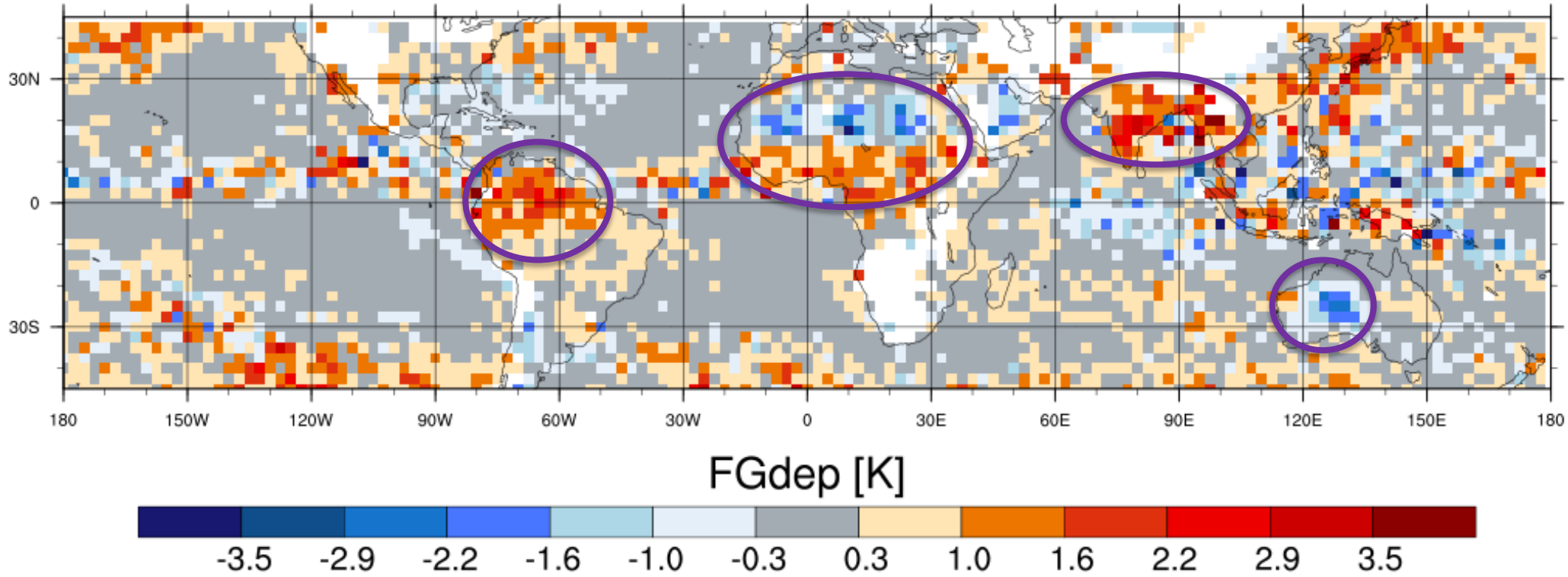
By focusing on retaining all-sky information over land it makes sense to start experimenting with the assimilation of frequencies of 89GHz and higher

Fig.: Difference in brightness temperature between a clear-sky atmospheric profile and cloudy, rainy & snowy one. Profiles are calculated using RTTOV-SCATT offline

Why did we not assimilate microwave sensitive channels over land before?

- Until now: only a few channels which sense the higher atmosphere are assimilated over land
- Assimilation of surface sensitive obs. is challenging…doing it in all-sky even more:

FG departure at 166 GHz, v-pol from GMI (June/July 2018)



Source of errors

- All-sky assimilation adds difficulty to separate cloud/precip. errors from surface errors
  - Precip error: IR all-sky suggest too little scattering from precip. over land
  - Surface errors: Uncertainties in Tskin and land surface emissivity ε

$$T_B = T_\uparrow + T_\downarrow(1 - \varepsilon)\Gamma + \Gamma\varepsilon T_s$$

ε … *emissivity*
T_s … *skin temp.*
Γ … *atmosph. transmissivity*
T_b … *sensors brightness temp.*
$T^{\uparrow/\downarrow}$ … *atmosph. up − &down well.* T_b

- Skin temperature taken from model field
- Ocean emissivity FASTEM 6

- Land emissivity retrieval for 183 GHz, SSMIS-F17 (Karbou 2005 and later, Baordo and Geer 2016,…)

$$\varepsilon = \frac{T_b^{obs} - (\Gamma T^{\downarrow} + T^{\uparrow})}{(T_s - T^{\downarrow})\Gamma}$$

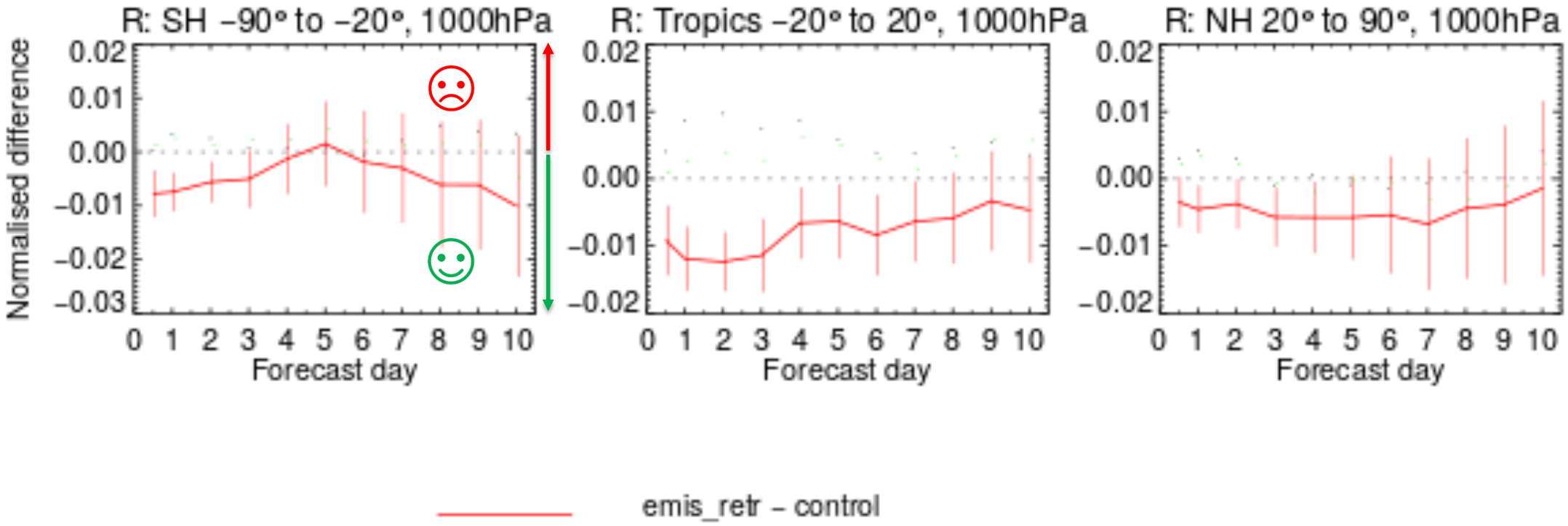
Extend land assimilation of SSMIS-F17 and GMI channels 89 -183 GHz using **emissivity retrieval**

Experiment setup:

- IFS cycle 46R1 experiments assimilating 89 to 183 GHz from GMI and SSMIS-F17
- Time: June – August 2018 and November 2018 to January 2019
  (for analysis we exclude first month)
- Use assimilation system as it is
- First set of experiments: use emissivity retrieval

Extend land assimilation of SSMIS-F17 and GMI channels 89 -183 GHz using **emissivity retrieval**

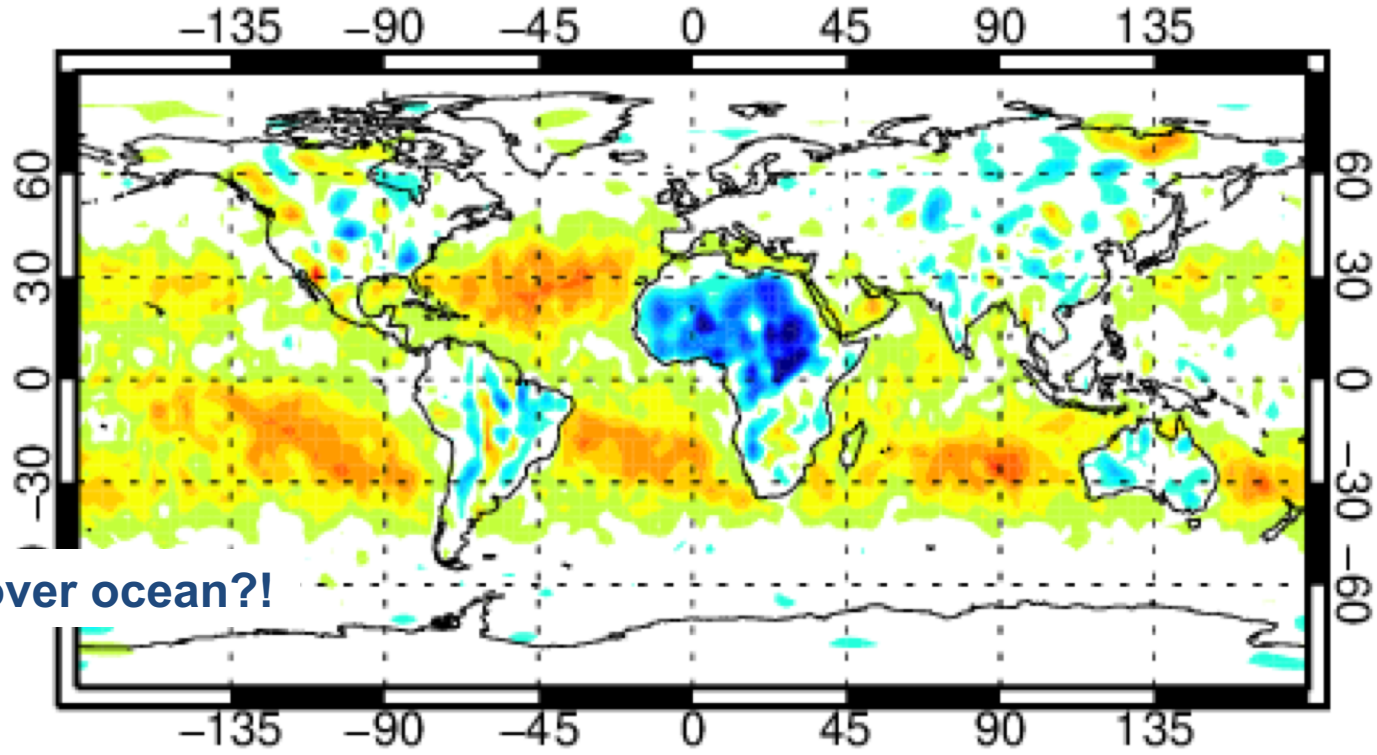
Forecast scores – Change in RMSE in humidity at 1000hPa



- Neutral impact in temperature and wind, and neutral impact in obstats

Extend land assimilation of SSMIS-F17 and GMI channels 89 -183 GHz using **emissivity retrieval**

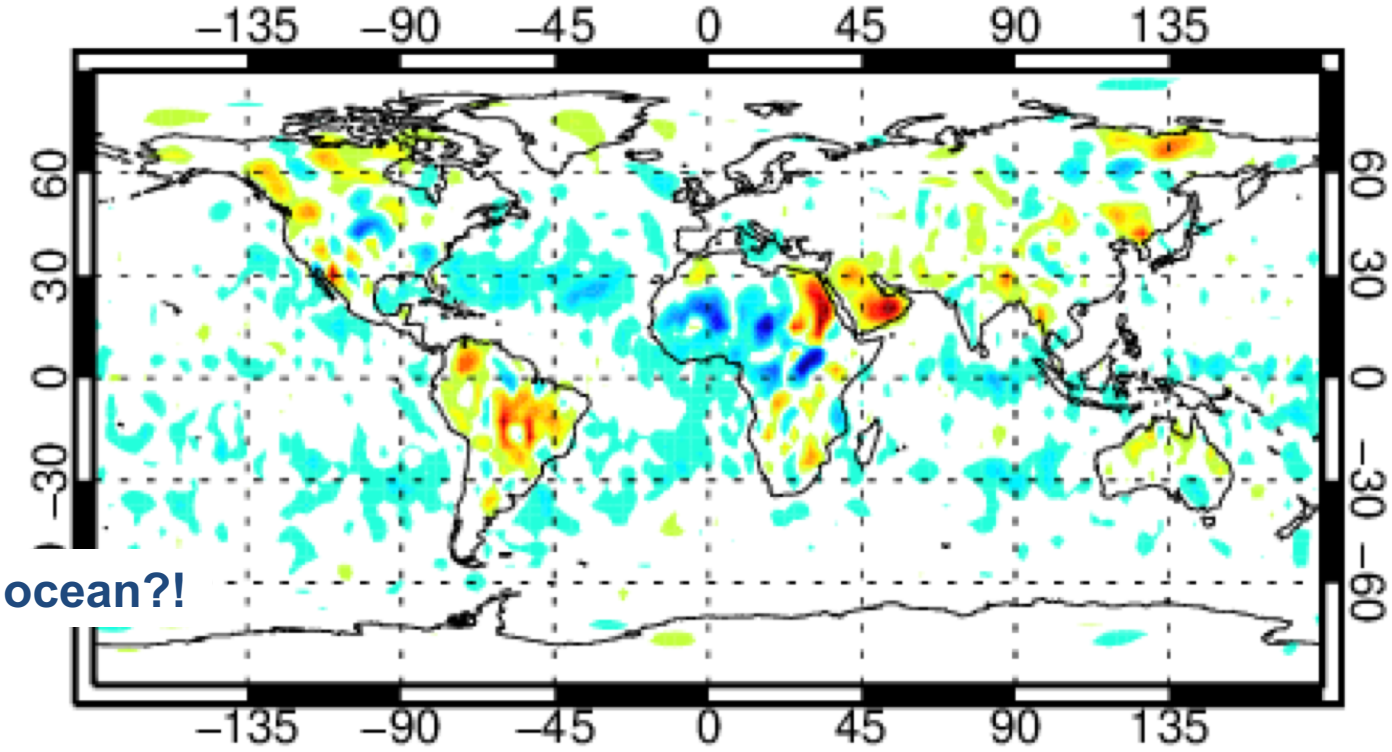
Difference in mean analysis humidity at 1000hPa *between 46R1 experiments assimilating GMI frequencies over land and control run.*



Moistening over ocean?!

Extend land assimilation of GMI channels 89 -183 GHz using **emissivity atlas**

Difference in mean analysis humidity at 1000hPa *between 46R1 experiments assimilating GMI frequencies over land and control run.*



Drying over ocean?!

Land surface emissivity

a) Dynamic emissivity retrieval: using observed brightness temperature at a different frequency to retrieve land surface emissivity, which is then used to calculate first guess brightness temperature

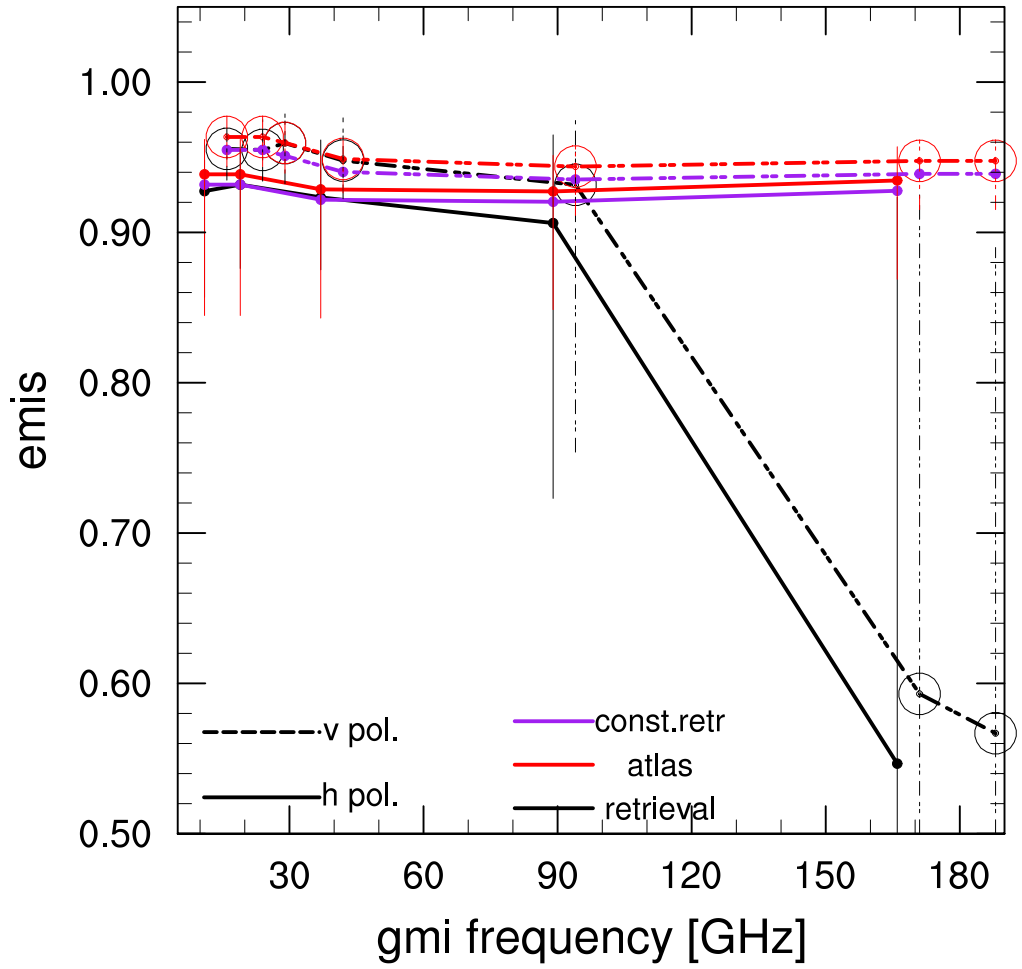
b) monthly atlas values: TELSEM (from SSMI)

c) model: CMEM (not yet tested for these frequencies, might lack accuracy)

d) Constrained emissivity retrieval: best choice of both worlds a & b ?

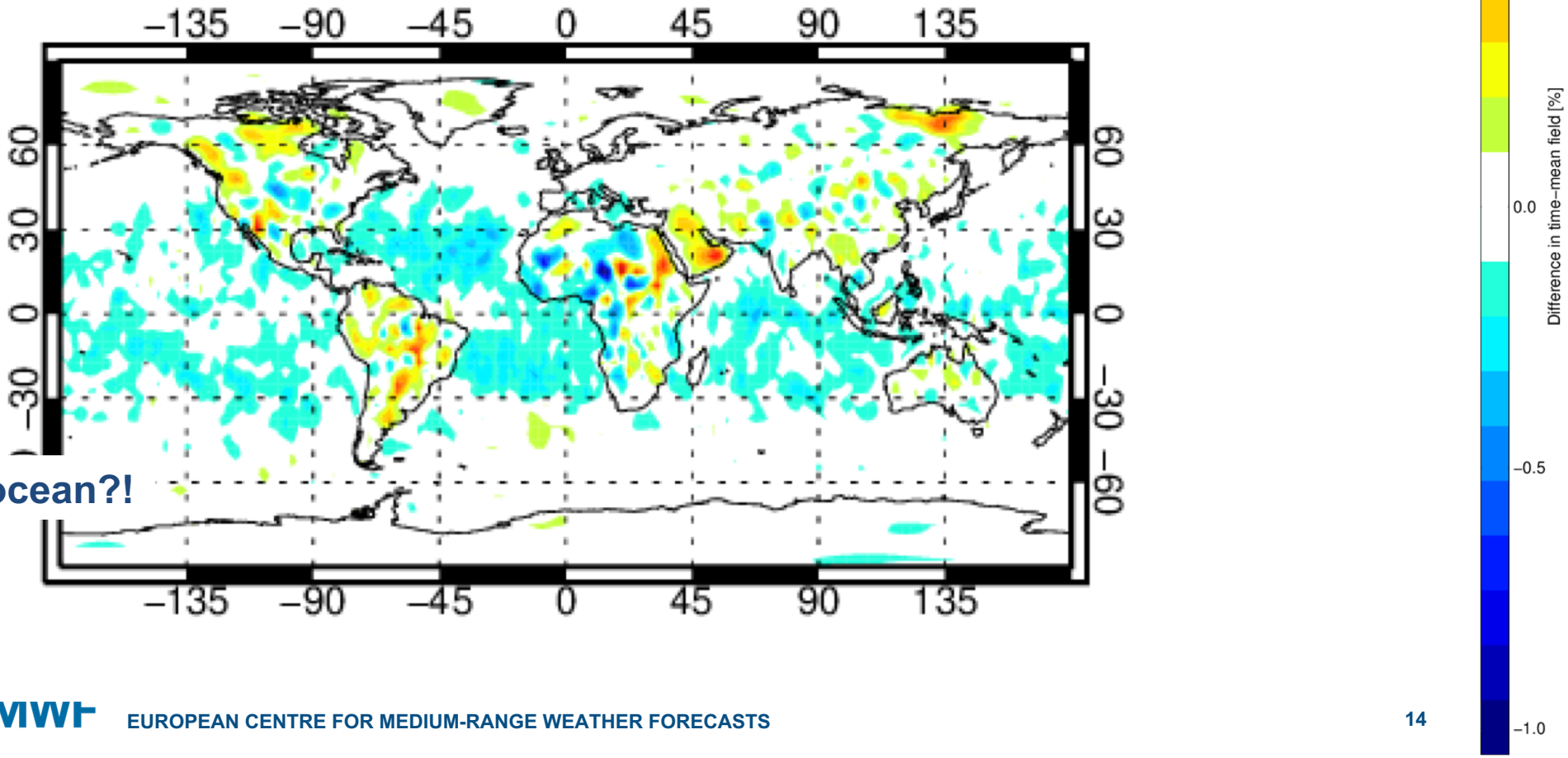
Constrained emissivity retrieval:
emissivity retrieval at 19 GHz + frequency dependency from atlas

Very cloudy



Extend land assimilation of GMI channels 89 -183 GHz using **constrained emissivity retrieval**

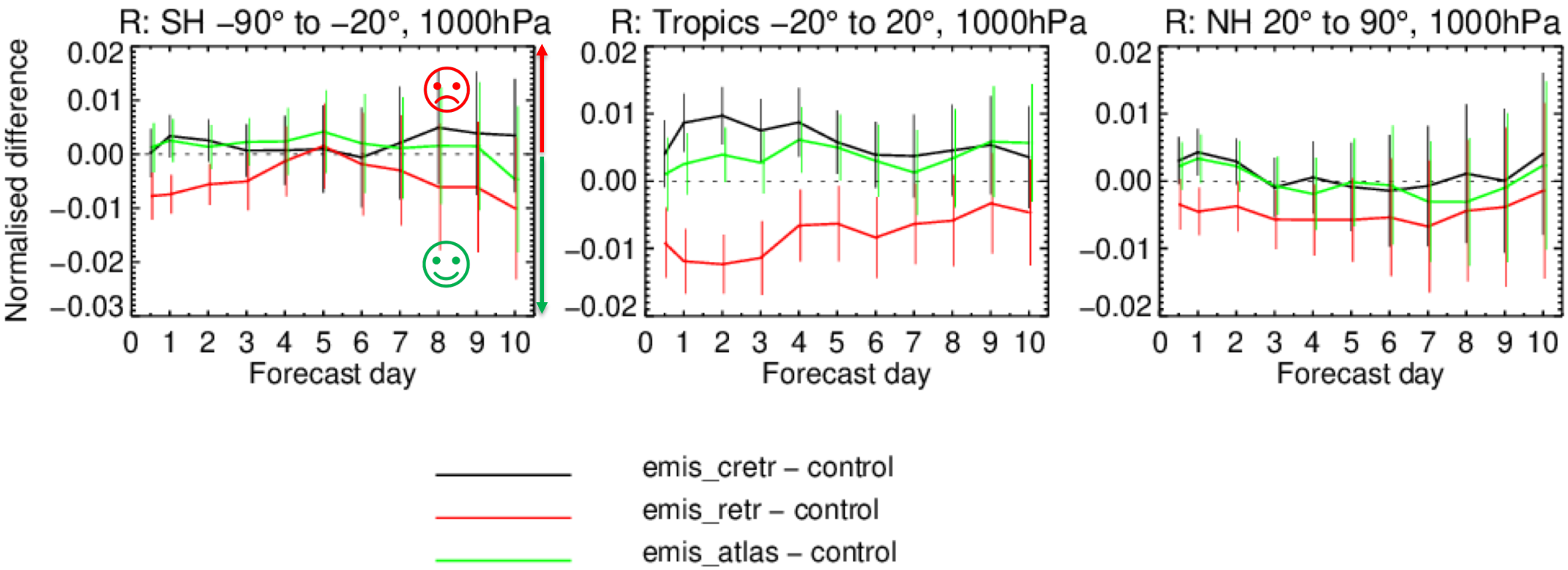
Difference in mean analysis humidity at 1000hPa *between 46R1 experiments assimilating GMI frequencies over land and control run.*



Drying over ocean?!

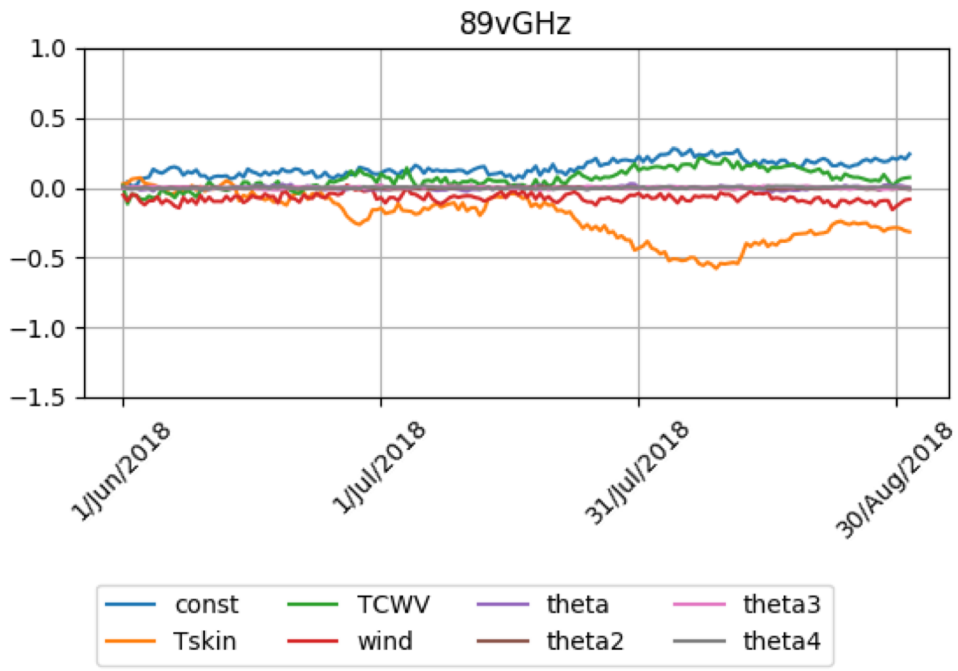
Extend land assimilation of GMI channels 89 -183 GHz using **emissivity atlas**

Forecast scores – Change in RMSE in humidity at 1000hPa

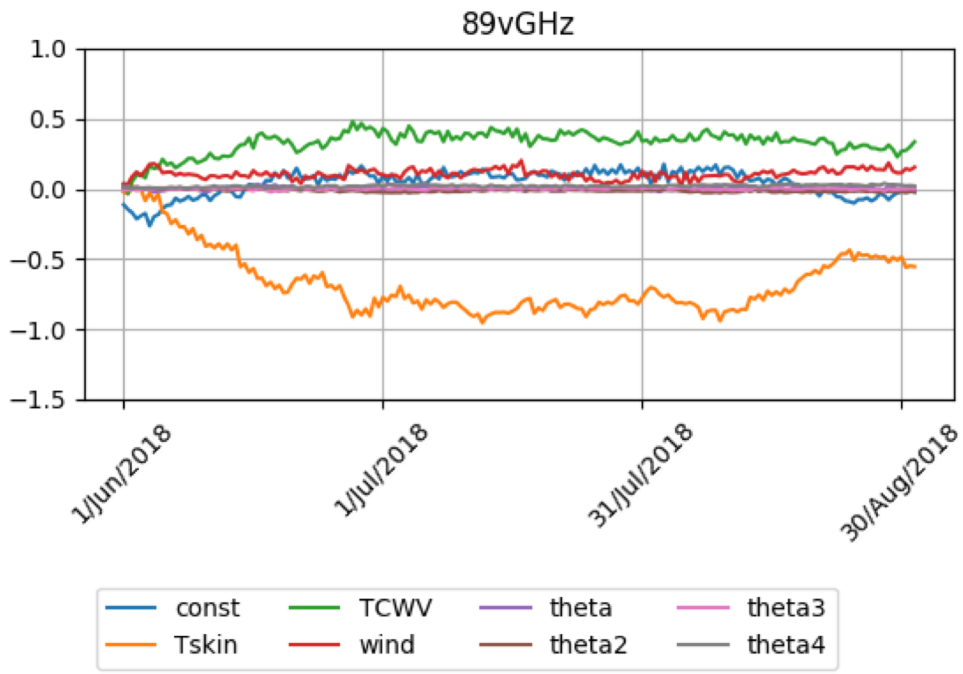


Changes in variational bias correction predictor coefficients

emis_atlas - ctrl

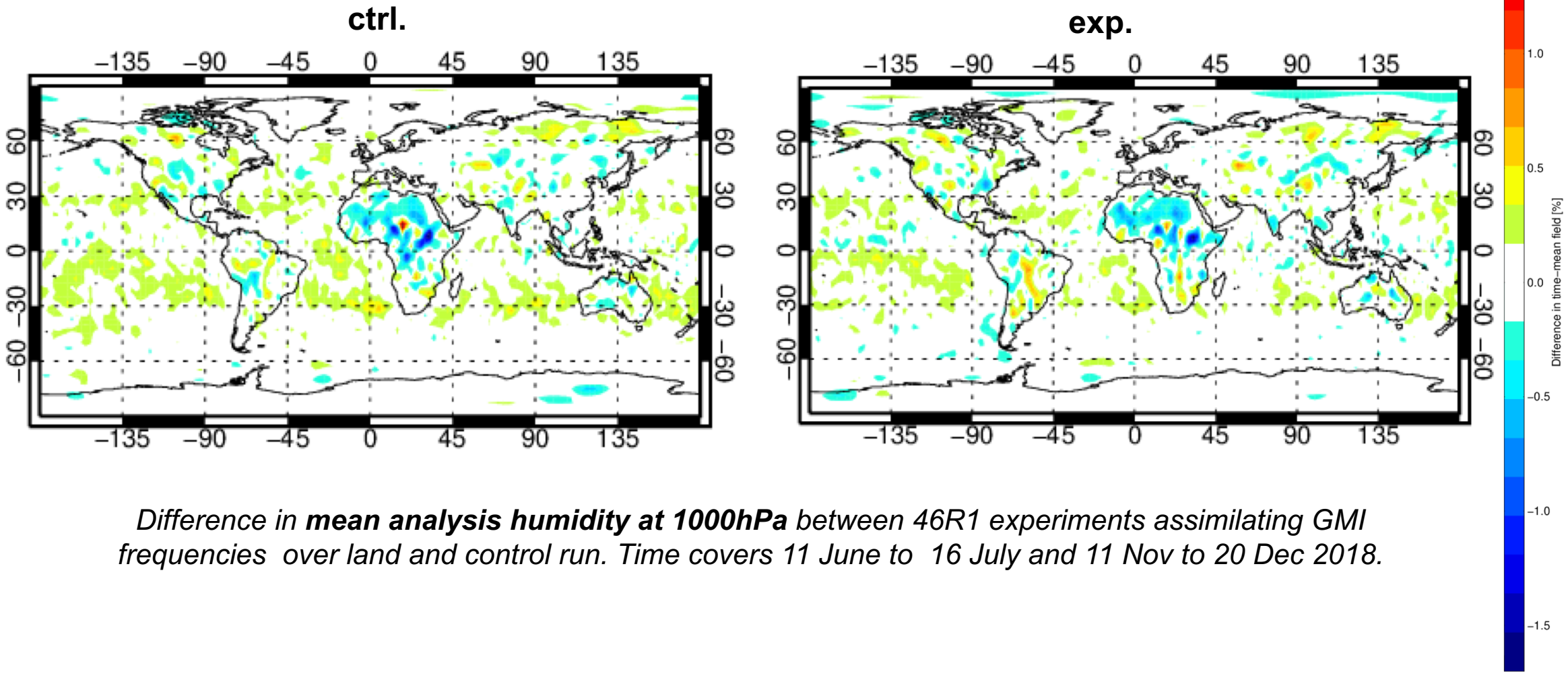


emis_retr - ctrl



- Tskin and wind used to catch biases over ocean
- New predictor instead of Tskin: Tskin*emis[19GHz] (Gerard et al, 2011)

Extend land assimilation of GMI channels 89 -183 GHz using **emissivity retrieval with new bias correction** but no bias correction in emissivity retrieval



*Difference in **mean analysis humidity at 1000hPa** between 46R1 experiments assimilating GMI frequencies over land and control run. Time covers 11 June to 16 July and 11 Nov to 20 Dec 2018.*

Summary

- All-sky assimilation over land of surface sensitive microwave frequencies remains challenging
- Using surface sensitive MW channels 89-183 GHz seem to be a good choice to observe some cloud and precipitation features over land
- Assimilating these channels brought mostly neutral impact to forecast scores; however some areas remain challenging: Sahara, Australia
- Using emissivity retrieval lead to moistening over ocean
- Alternative emissivity options lead to little drying over ocean
- Need to modify bias correction

Outlook

- Use emissivity model with the assimilation of surface sensitive microwave frequencies over land
- Assimilate low microwave frequencies for gaining information about sea ice and land properties.