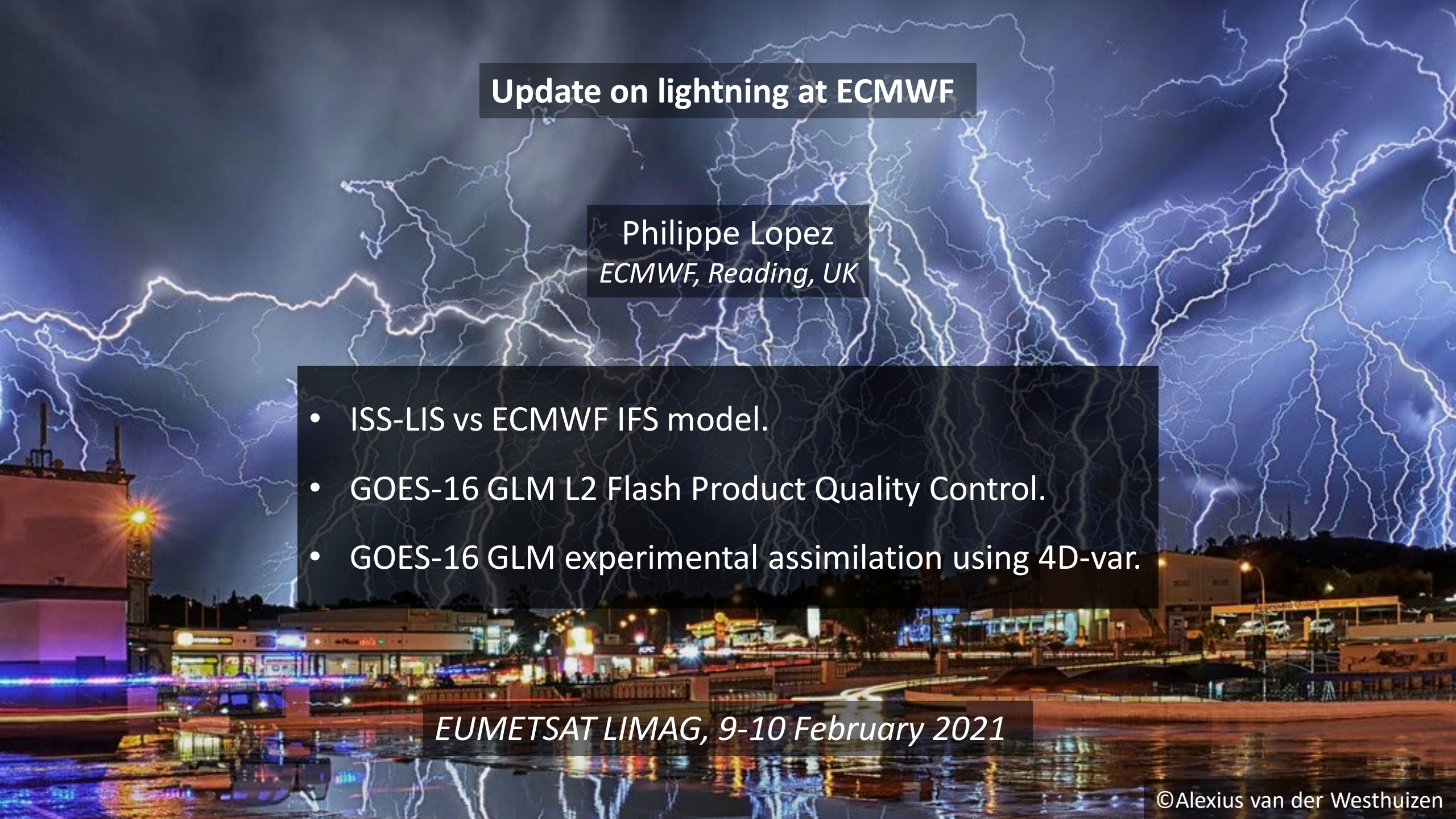


Update on lightning at ECMWF

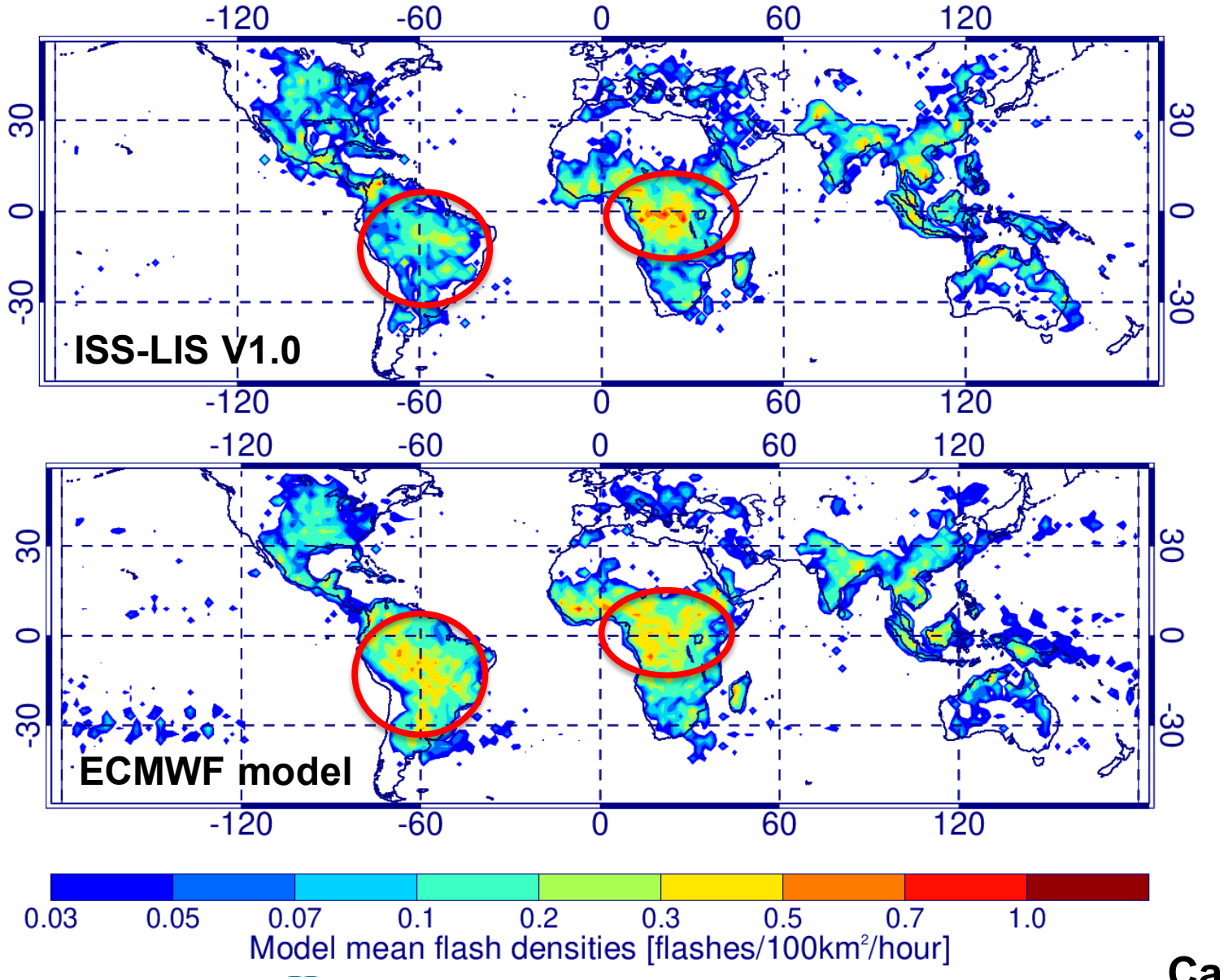
Philippe Lopez
ECMWF, Reading, UK

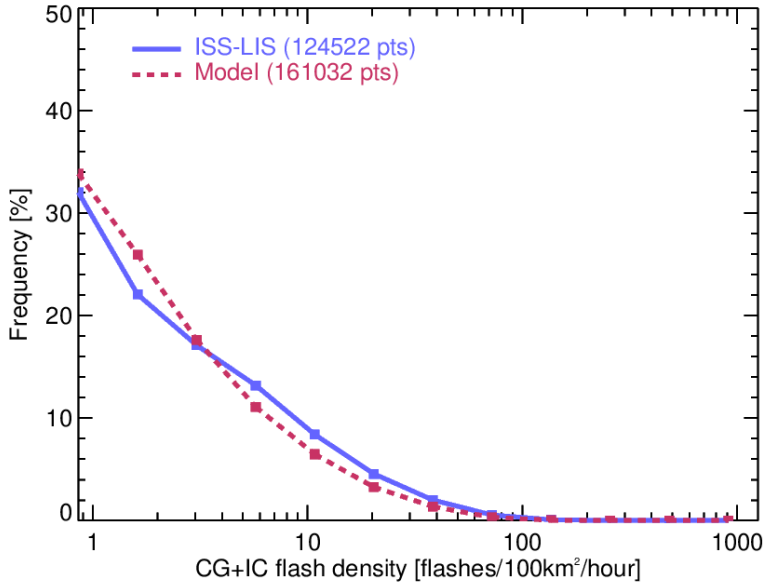
- ISS-LIS vs ECMWF IFS model.
- GOES-16 GLM L2 Flash Product Quality Control.
- GOES-16 GLM experimental assimilation using 4D-var.

EUMETSAT LIMAG, 9-10 February 2021

Simulated lightning against ISS-LIS observations.

Mean lightning flash densities over period Aug 2017 - May 2020 (left: on 2° grid; right: PDF).





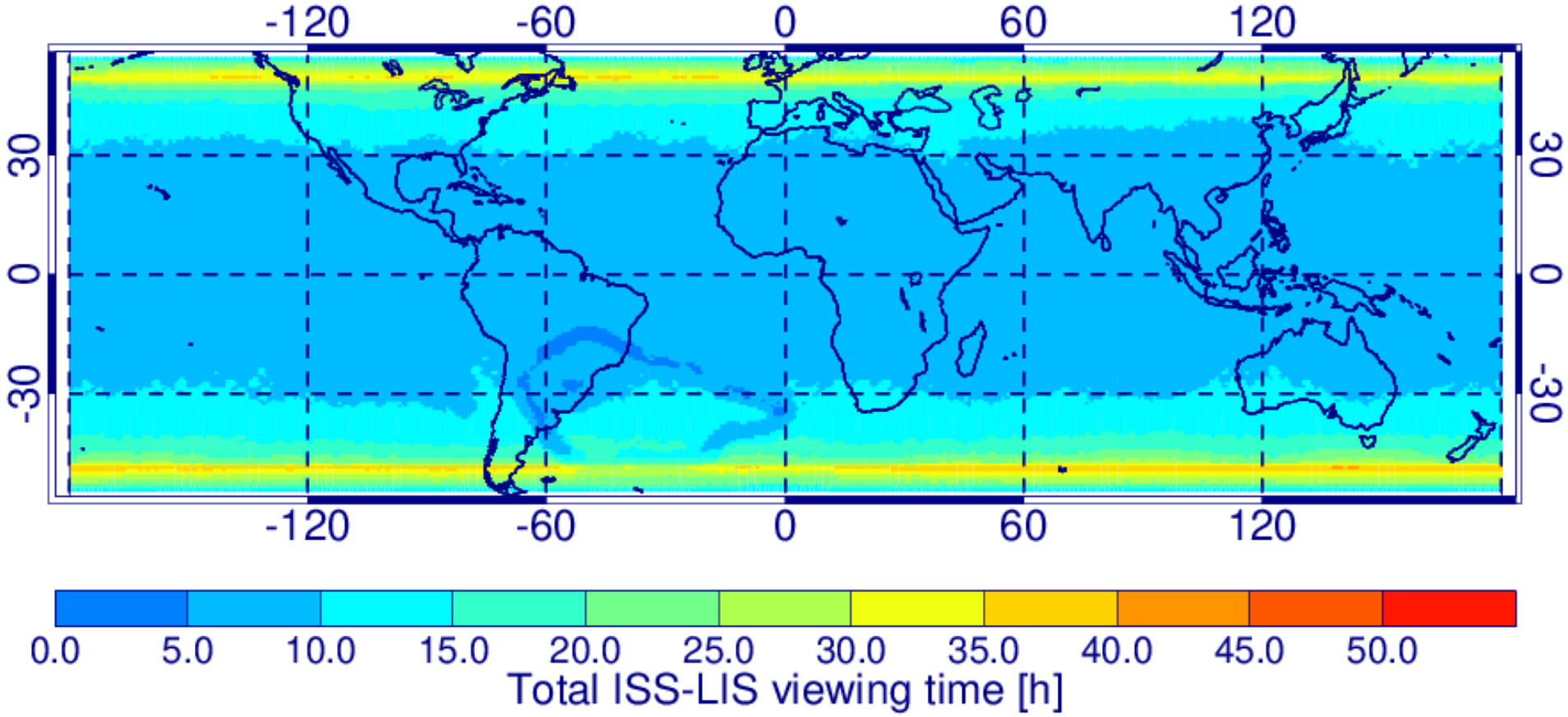
ECMWF model
← from TL255 (80 km)
24h forecasts

→ Spatial distribution OK.
→ Congo Basin: too low.
→ South America: too high.

Caution: viewing time is very limited!

IFS simulated lightning against ISS-LIS observations: 1 Aug 2017 and 31 May 2020.

ISS-LIS total viewing time varies between 5 hours (Tropics) and 45 hours (50° latitude).



4D-Var assimilation of GOES-16 GLM L2 flash data.

- **Work towards the assimilation of GOES-16 GLM flash densities is ongoing.**

- **The revision of the homemade QC procedure to eliminate spurious flashes that had not been identified earlier (e.g. straylight during eclipse season), is now complete.**

  It is described in ECMWF Technical Memo 872.

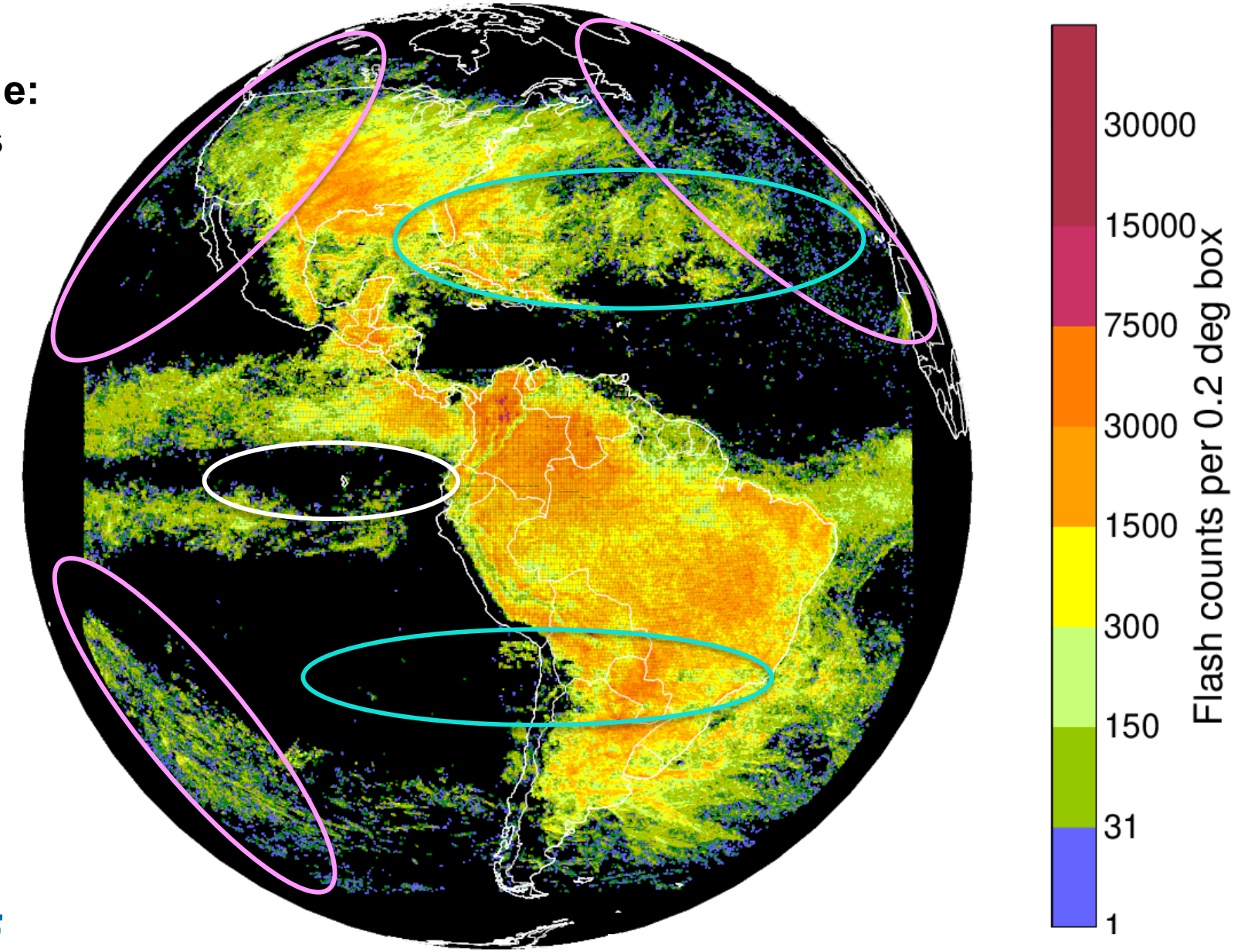
This homemade QC needs to be applied in 4D-Var assimilation experiments, despite recent improvements made by NOAA in the filtering of false flashes in the GLM L2 product.

Revised Quality Control of GOES-16 Geostationary Lightning Mapper L2 flash product.

QC performance example:
Lightning flash counts over period 7 Mar – 7 May 2019

After QC

Sources of false flashes:
- straylight
- sun glint
- solar intrusions
- thermal noise
- platform jitter

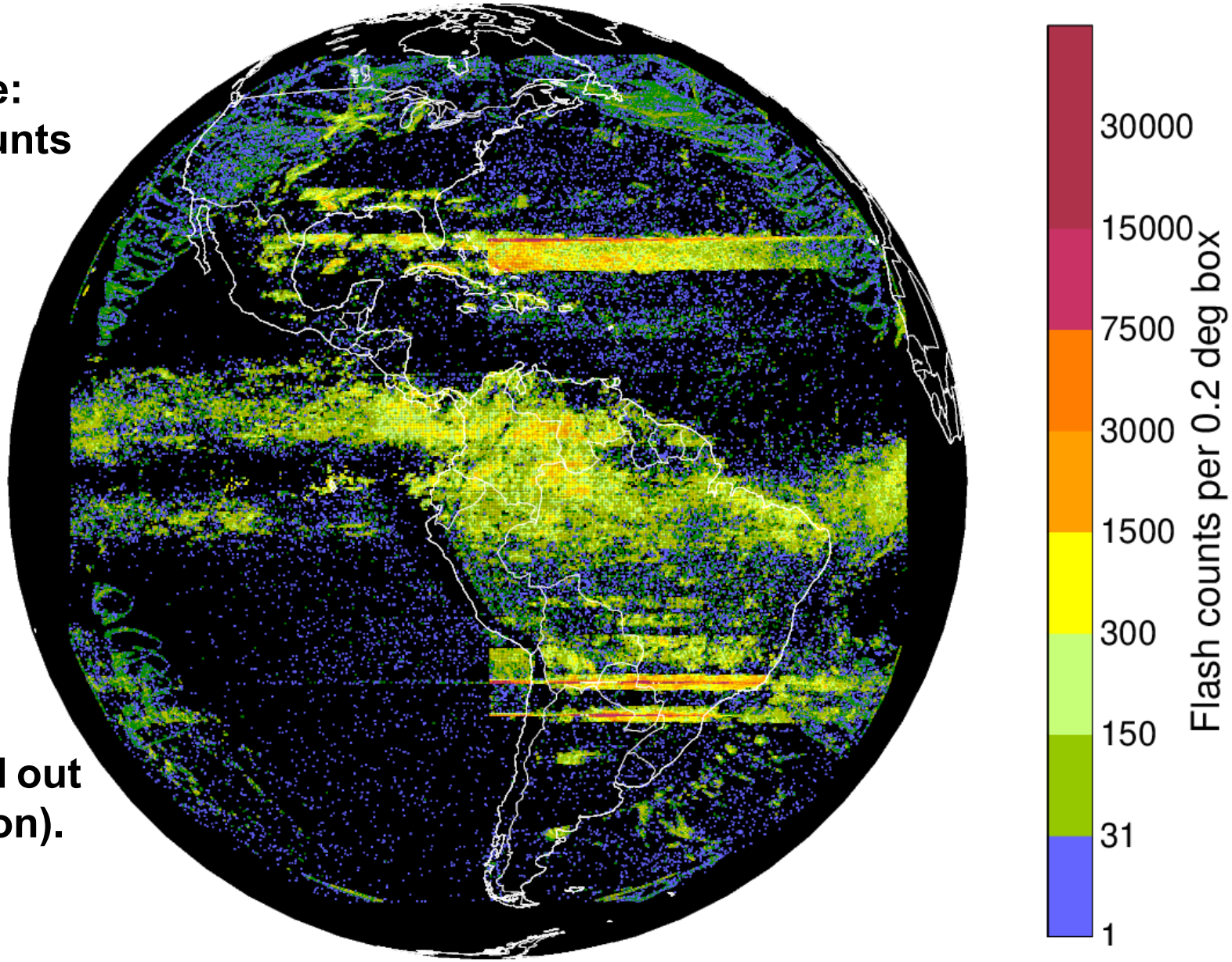


ECMWF

Lopez, 2020 (ECMWF Tech Memo 872)

Revised Quality Control of GOES-16 Geostationary Lightning Mapper L2 flash product.

QC performance example:
Rejected lightning flash counts over period
7 Mar – 7 May 2019



Typically 5-10% of original flashes are filtered out (20% during eclipse season).

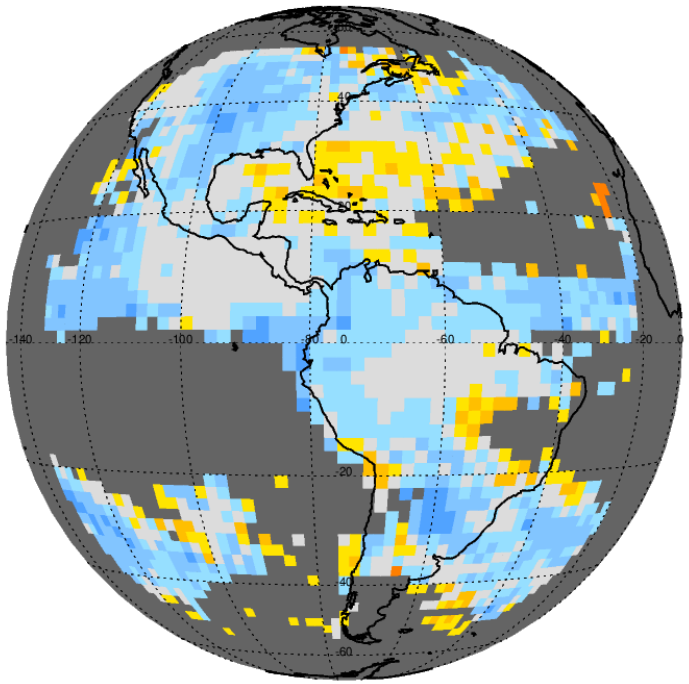
ECMWF

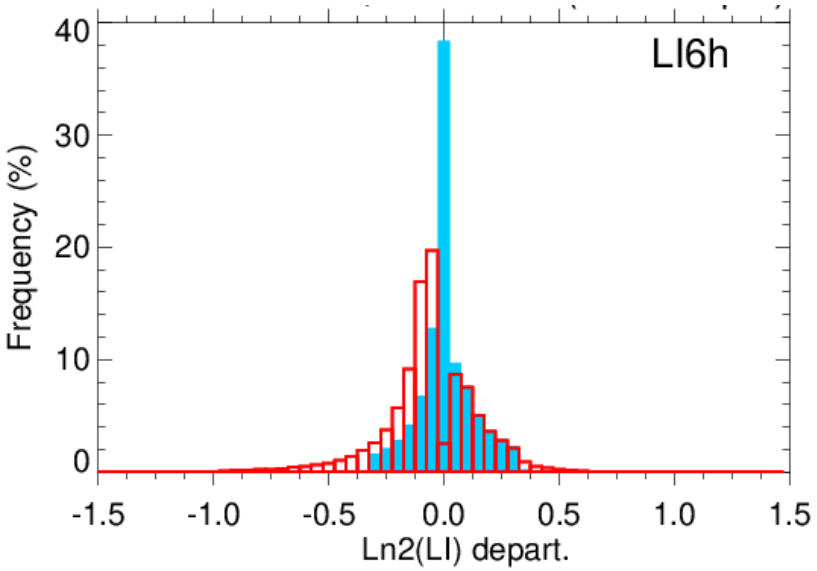
Lopez, 2020 (ECMWF Tech Memo 872)

4D-Var assimilation experiment including GOES-16 GLM 6h-avg lightning obs: Analysis.

Observation–model lightning departures BEFORE and AFTER 4D-Var assimilation - June 2018 (25 km resol.).
Note: All operational observations were also assimilated in this experiment.

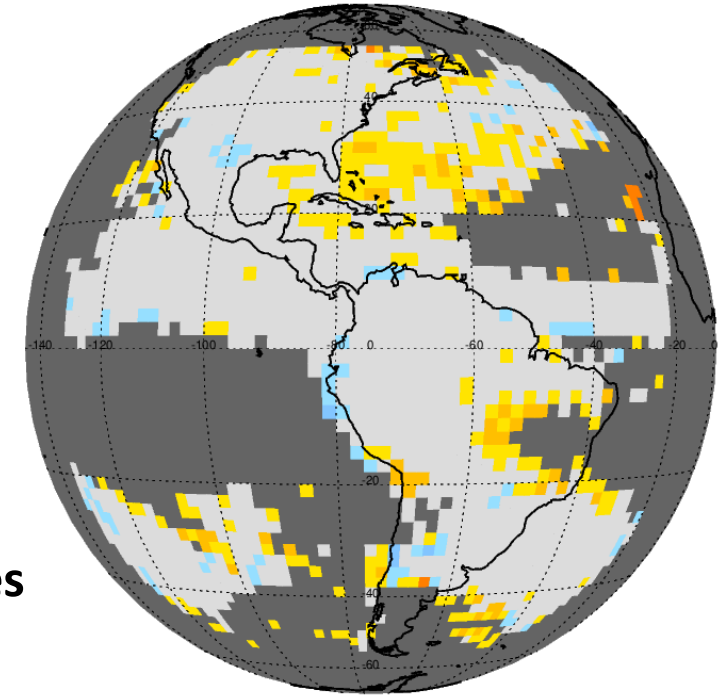
BEFORE

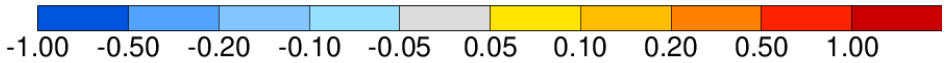


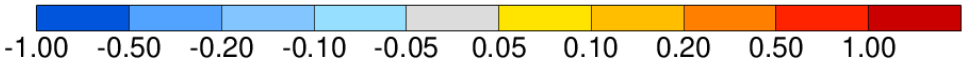


Histogram of obs–model departures BEFORE and AFTER assimilation.

AFTER





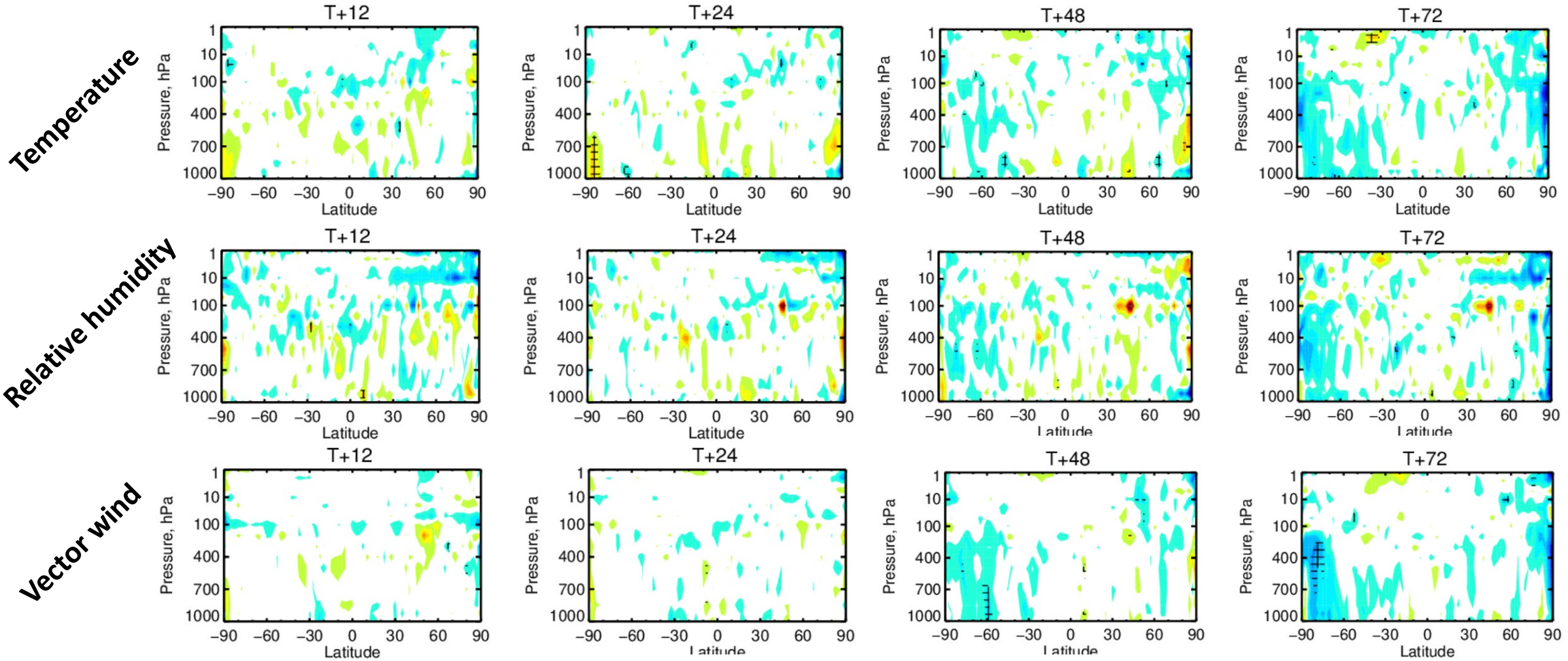


→ **The assimilation works well when model > obs, but is more problematic when model < obs.**
In 4D-Var, it is difficult to create lightning when the model background state has no convection.

ECMWF

4D-Var assimilation experiment including GOES-16 GLM 6h-avg lightning obs: Forecasts.

Impact of GLM assimilation on 12h- to 72h-range forecast Root Mean Square Error (zonal means; June 2018).



Improvement ← -10% -5% 0% -5% +10% → Degradation

→ No obvious degradation of forecast scores (good, since still much room for improvement).

ECMWF

PLANS

* Retune total lightning density parameterization (to match the in-depth revision of our moist physics package proposed for the next model version).

* Improve performance of 4D-Var assimilation of GOES-16 GLM lightning flash densities:

    - Test sensitivity booster (when no-lightning in model background state).

    - Define some bias correction.

* Start looking at GOES-17 GLM data (Pacific region).

* Make sure that our current lightning parameterization can work when deep convection no longer needs to be parameterized (i.e. when running our global forecast model at kilometre-scale resolution).

Thank you!

4D-Var assimilation of GOES-16 GLM flash densities.

- **Question:**

  Are 4D-Var increments coming from GOES-GLM lightning obs consistent with those from all other observations?

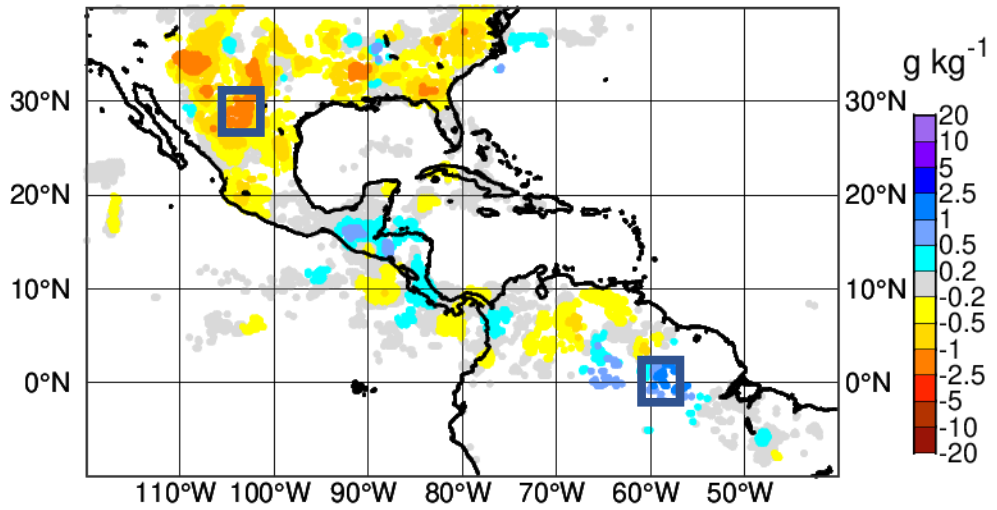
→ **Compare 4D-Var using GOES-GLM-only against 4D-Var control using all standard obs.**

Note: In the GOES-GLM-only experiment, each cycle uses the control's background.

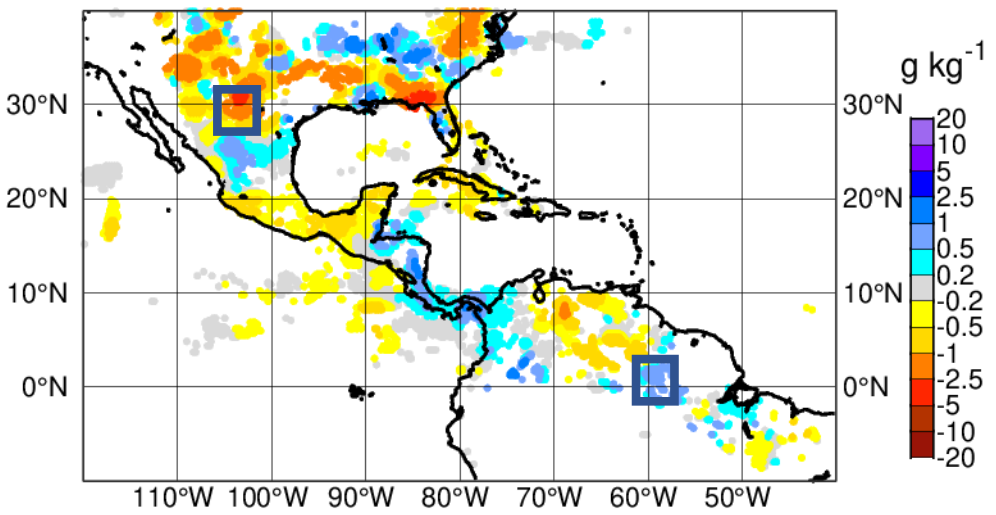
GOES-GLM lightning-only vs CTRL assimilation experiments: 4D-Var increments.

4D-Var humidity increments for assimilation cycle on 8 July 2019 at 00Z (TCo399 137 levels).

Q incr., Lev 137, GLM-only (hd5m)

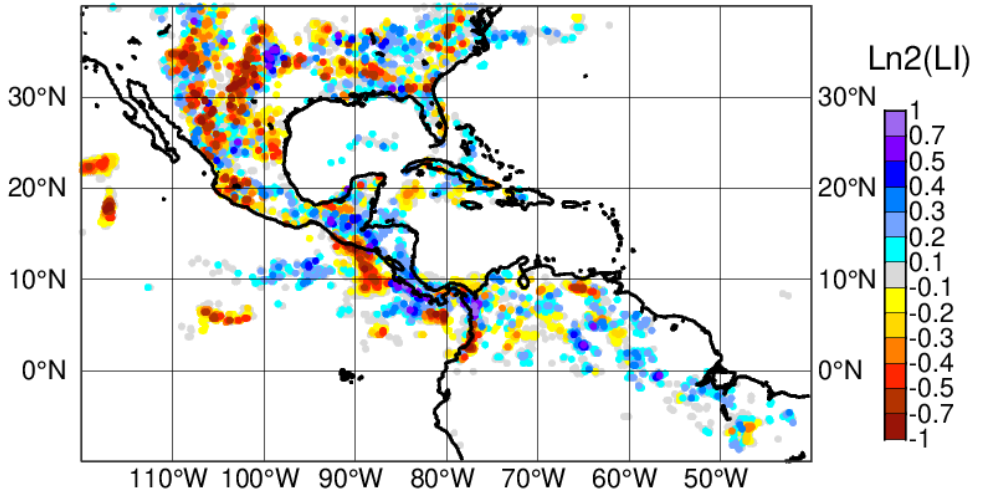


Q incr., Lev 137, CTRL (hd5n)



→ **Humidity increments from GLM obs and from all other observations shown reasonable level of consistency in the lower troposphere where convective sensitivities are the strongest.**

Lightning FG depart. (hd5m)

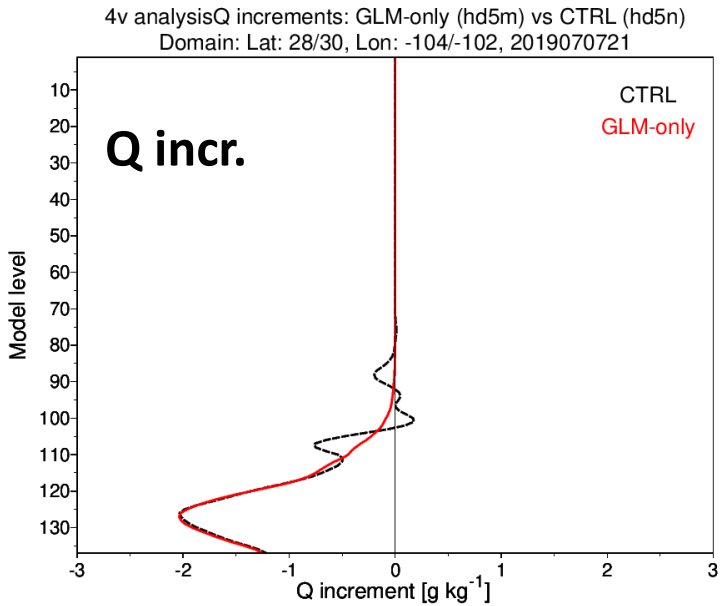


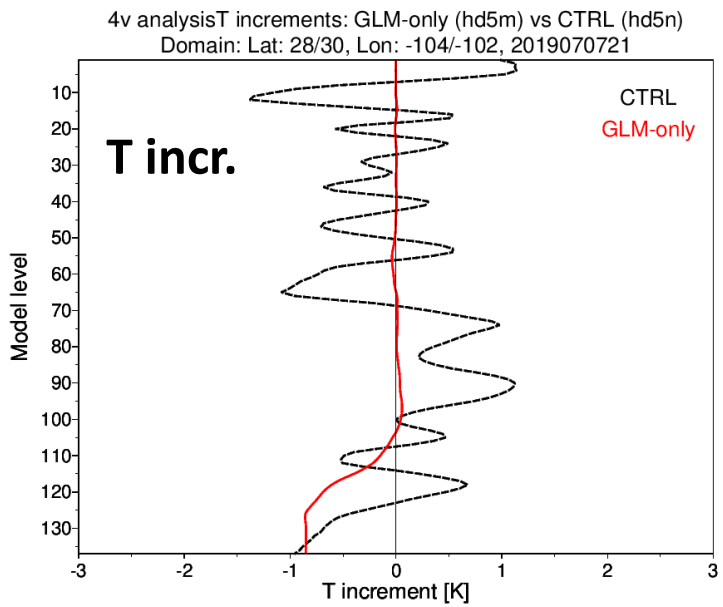
ECMWF

GOES-GLM lightning-only vs CTRL assimilation experiments: 4D-Var increments.

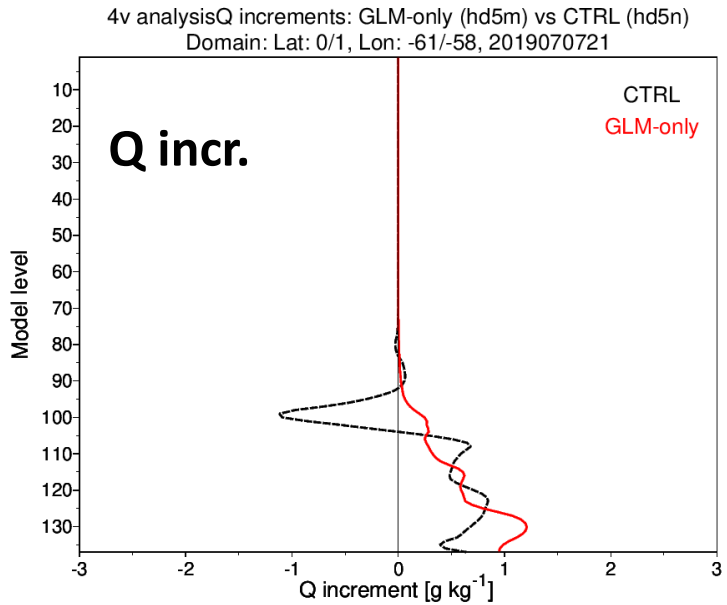
Vertical profiles of 4D-Var increments at two selected locations (with positive/negative BG departures):

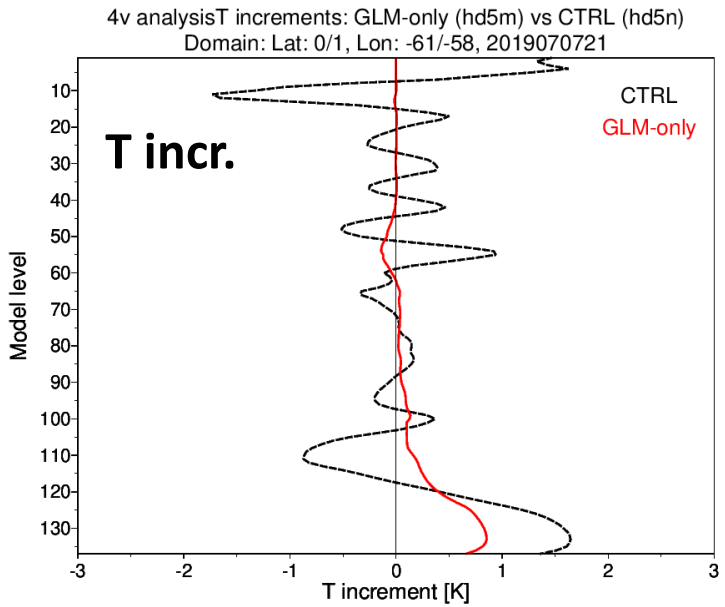
Mexico (model > GLM)





Amazon (model < GLM)



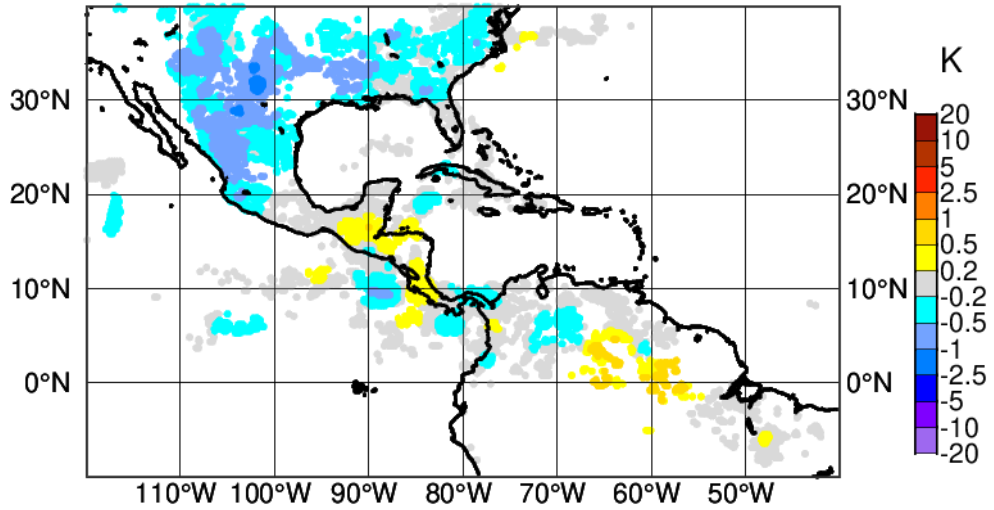


ECMWF

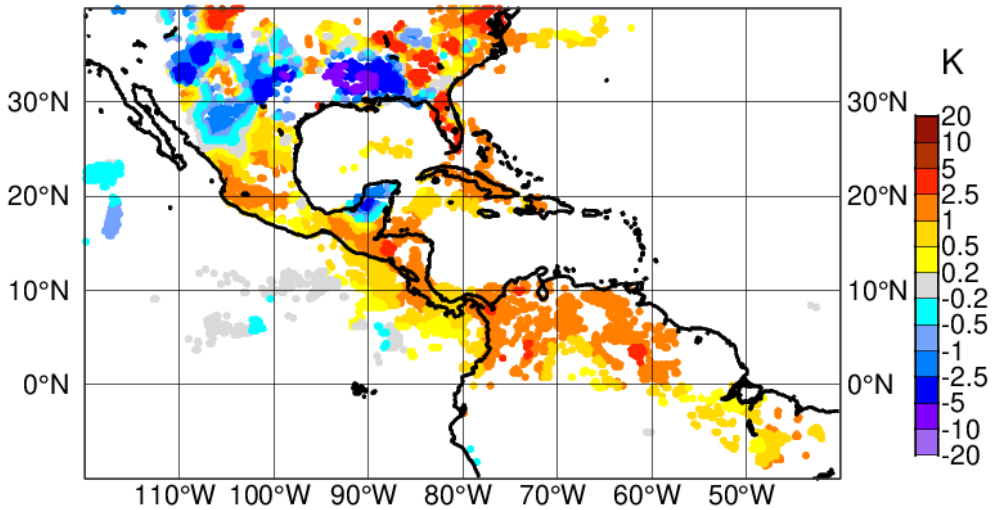
GOES-GLM lightning-only vs CTRL assimilation experiments: 4D-Var increments.

4D-Var temperature increments for assimilation cycle on 8 July 2019 at 00Z (TCo399 137 levels).

T incr., Lev 137, GLM-only (hd5m)



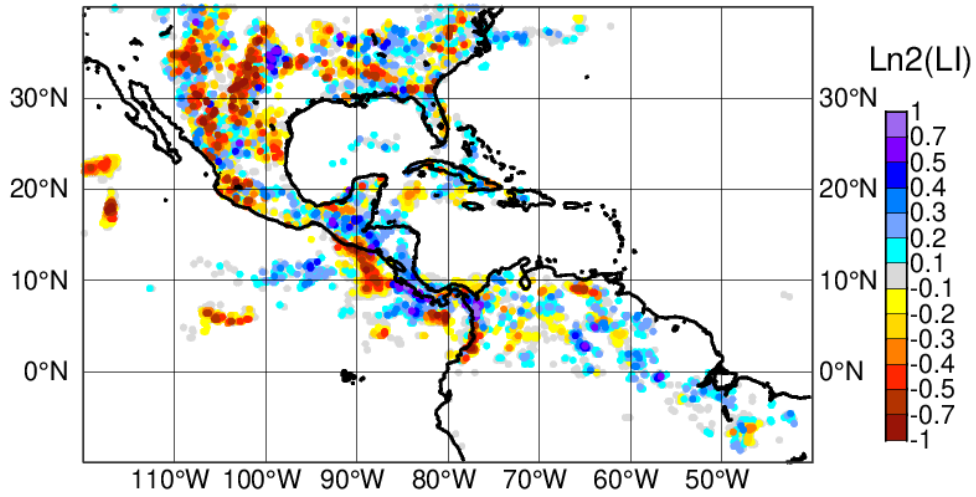
T incr., Lev 137, CTRL (hd5n)



→ **Temperature increments from GLM obs and from all other observations seem much less consistent.**

One possible reason for this: in CTRL, there is no constraint on how the increments are produced (i.e. via large-scale condensation or convection, which have very different sensitivities!).

Lightning FG depart. (hd5m)



ECMWF