EUMETSAT

Improving the reliability of AMV height assignments: a study using ABI cases of the IWWG intercomparison and OCA cloud properties retrievals.

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Outline

Brief Introduction to OCA used in AMVs HA

Impact of pixel selection

Quality Statistics dependency on filtering on diagnostics: an experiment

A closer look at the imagery level

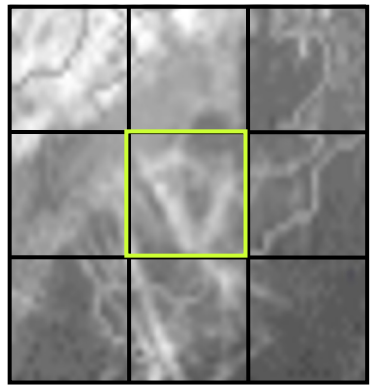
Relating retrievals, RGBs, wind vectors

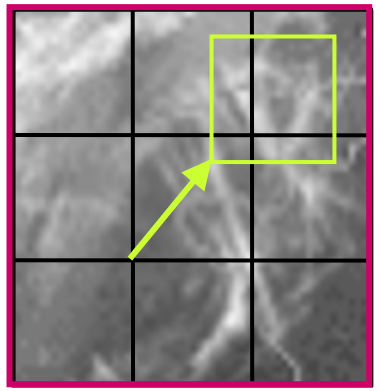
Conclusions

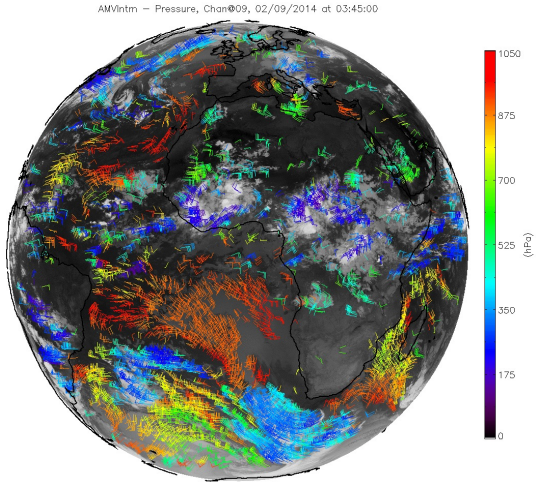
1. Brief Introduction to AMVs

Current Status: Investigation:

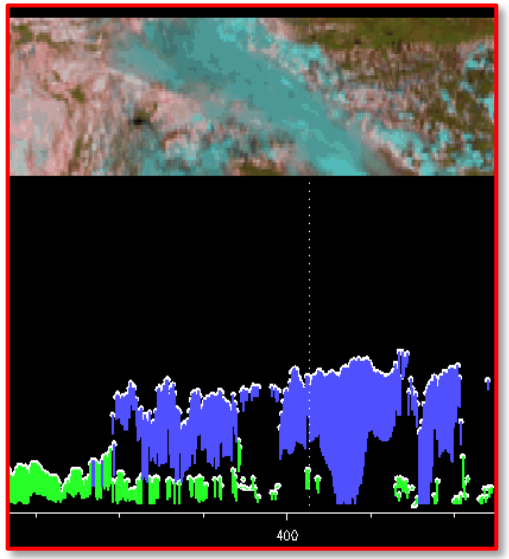
- AMVs = Cloud Motion Vectors
- 16x16 box pixel radiance patterns tracked in temporally adjacent GEO images to determine wind vector
- Cloud Top Heights determined using 'Cloud Properties algorithm'
- Sub-set of pixels selected according to a 'cross-correlation contribution' (CCC) method
- Additional filtering on cloud product diagnostics / values
- AMV wind vector assigned to aggregated height of CCC pixels

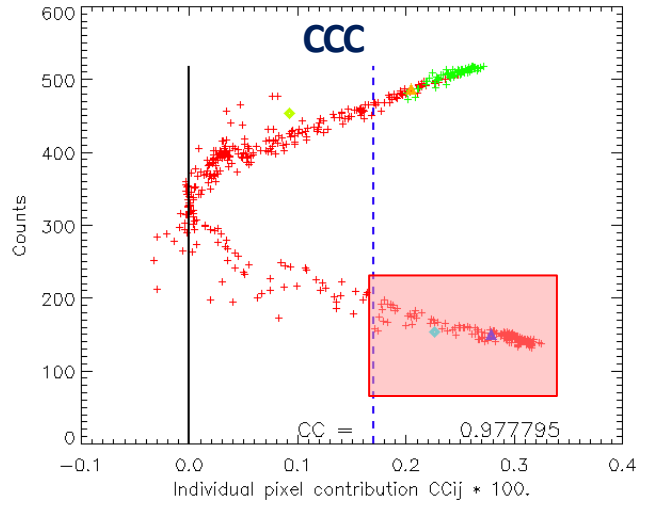






Borde, R., M. Doutriaux-Boucher, G. Dew, M. Carranza, 2014 doi: http://dx.doi.org/10.1175/JTECH-D-13-00126.1





2. Brief Introduction to OCA (Optimal Cloud Analysis)

- Cloud product for GEO and LEO optical imagers
- 1DVar inversion of VIS+IR imagery measurements:
  - Detects and treats Overlapping Clouds:
  - Estimate COT,CRE,CTP for single and multiple layers
  - Solution 'Cost' – High values indicate presence of inconsistency (model, calibration, data inversion,...?)
  - Linear error estimate – Indicates error in parameters given the error sources (noise, cloud model, boundary conditions,..)

Questions addressed here:

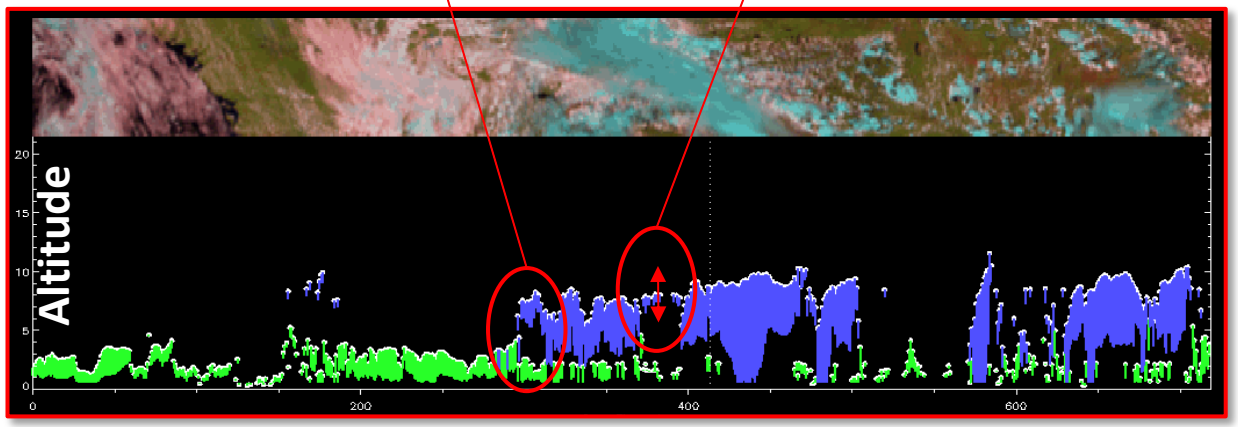
How to treat overlap?

Do solution cost and error estimates help?

1DVar cost *J* Minimisation:

$$J = (y_m - y(x))S_y^{-1}(y_m - y(x))^T + (x - x_b)S_x^{-1}(x - x_b)^T$$

➡ $\hat{x}$ Pixel QI = $J_{solution}$



Linear error estimation:

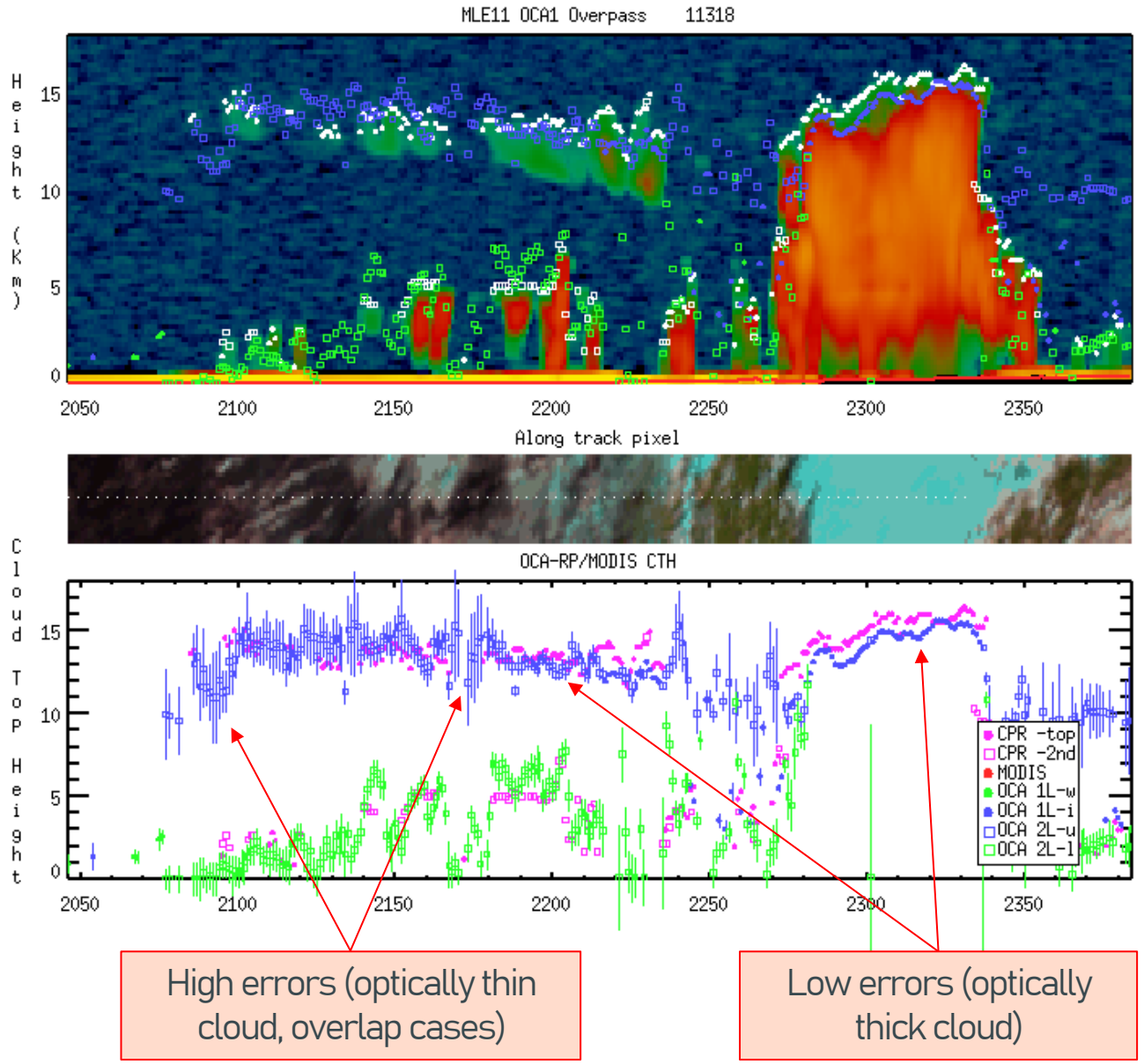
$$S_{\hat{x}} = (S_x^{-1} + K_{\hat{x}}^{\ T} S_y^{-1} K_{\hat{x}})^{-1}$$

3. Filtering experiment

Pixels filtered ('blacklisted') from HA consideration:

- Quality Indicators
  - Retrieval cost > 110
    - Cloud model* does not correspond to reality
  - CTPerr > 30 hPa
    - Cloud conditions do not permit an accurate estimation

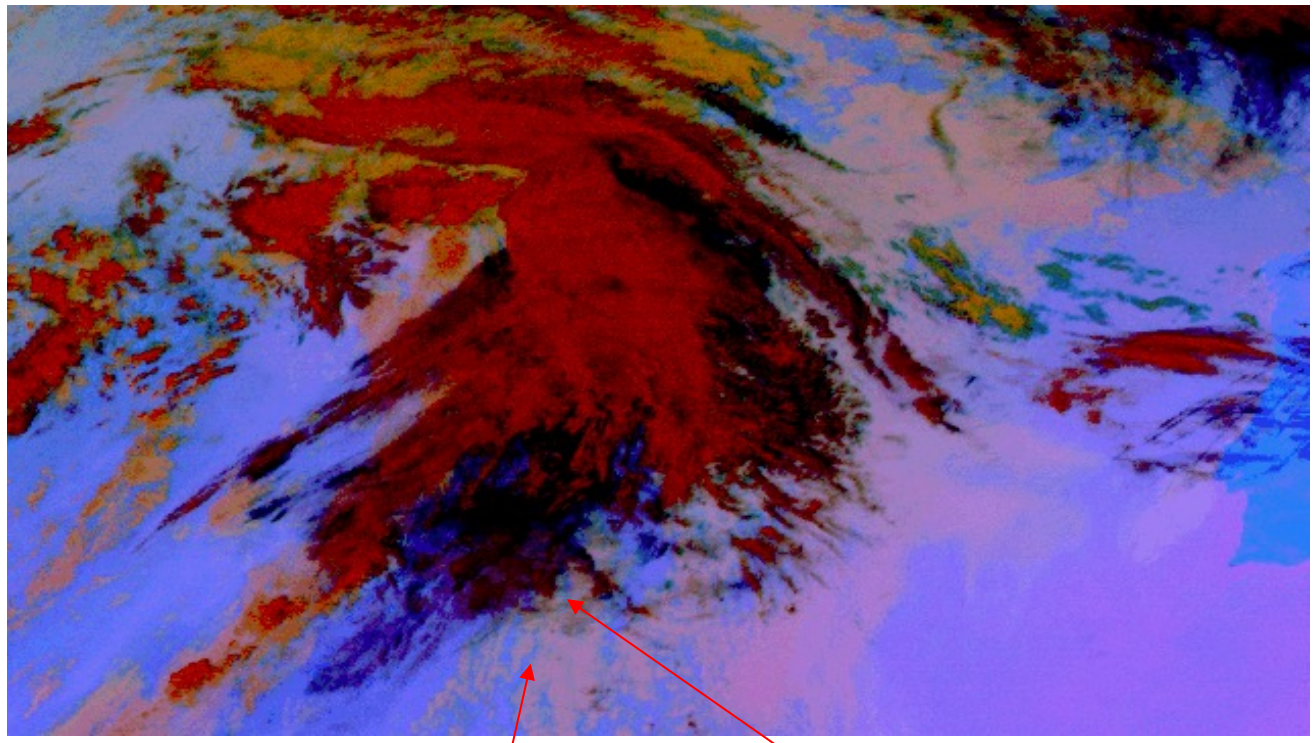
*or another aspect of the retrieval, e.g. auxiliary input – e.g. surface albedo



3.1 Filtering experiment

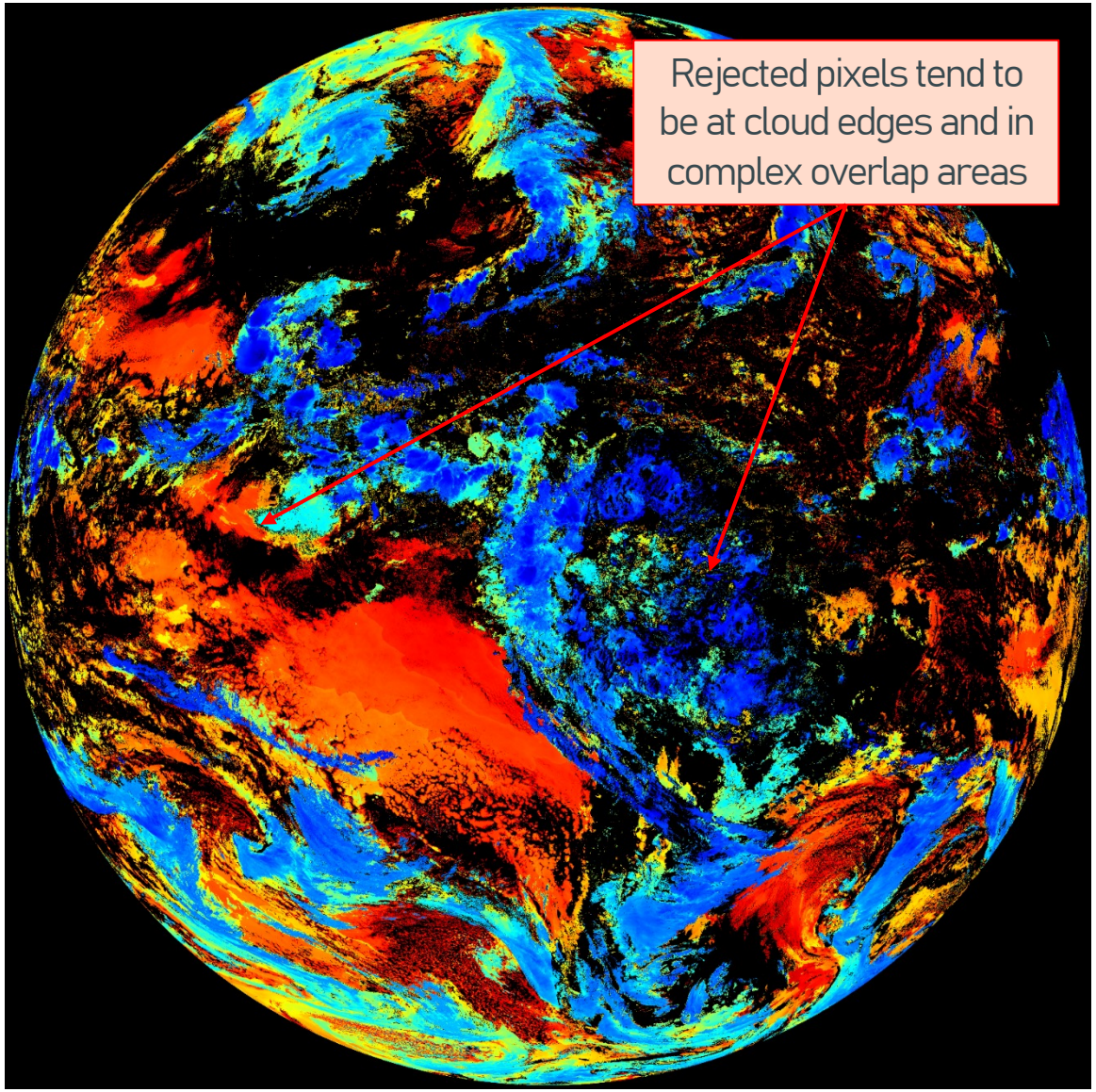
Pixels removed from HA consideration:

- 2-Layer cases:
  - For Upper layer COT*secant(view angle) < 0.25 the Lower CTP is used based on the reasoning that these cases might represent:
    - Scenes where the upper layer being so thin it is not likely to be the tracked layer
    - False 2-layers diagnosis by OCA due to other sources of fit cost



3.2 Impact of pixel selection

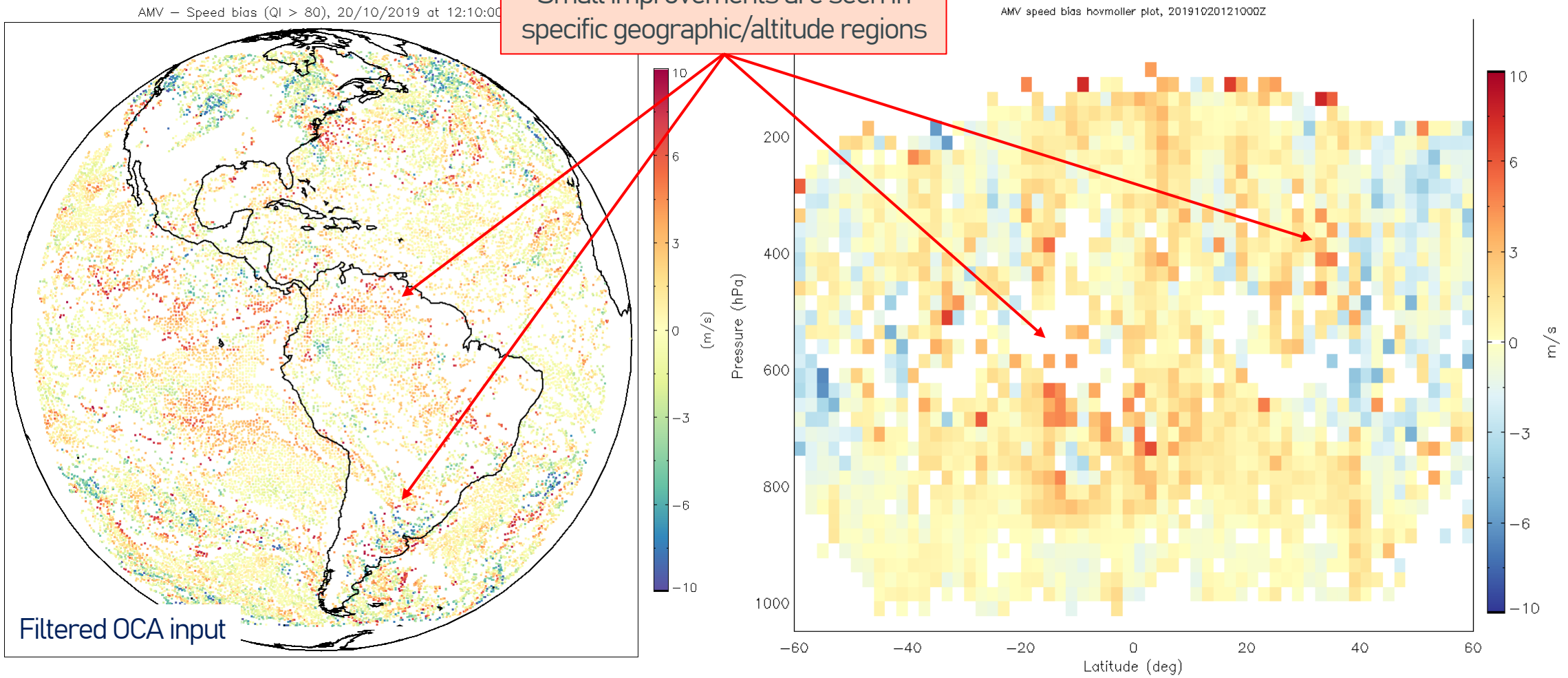
- One triplet (77339 AMVs)
- IR 10.8 μm AMVs studied
- GOES-16 20th October 2019 1210UT
- Pixel Rejection rates:
  - ~15%/20% mostly single-layer ice/water
  - ~5% two-layer clouds reassigned to lower layer



3.3 Speed compared to NWP forecast (1) geographic/Hovmoeller

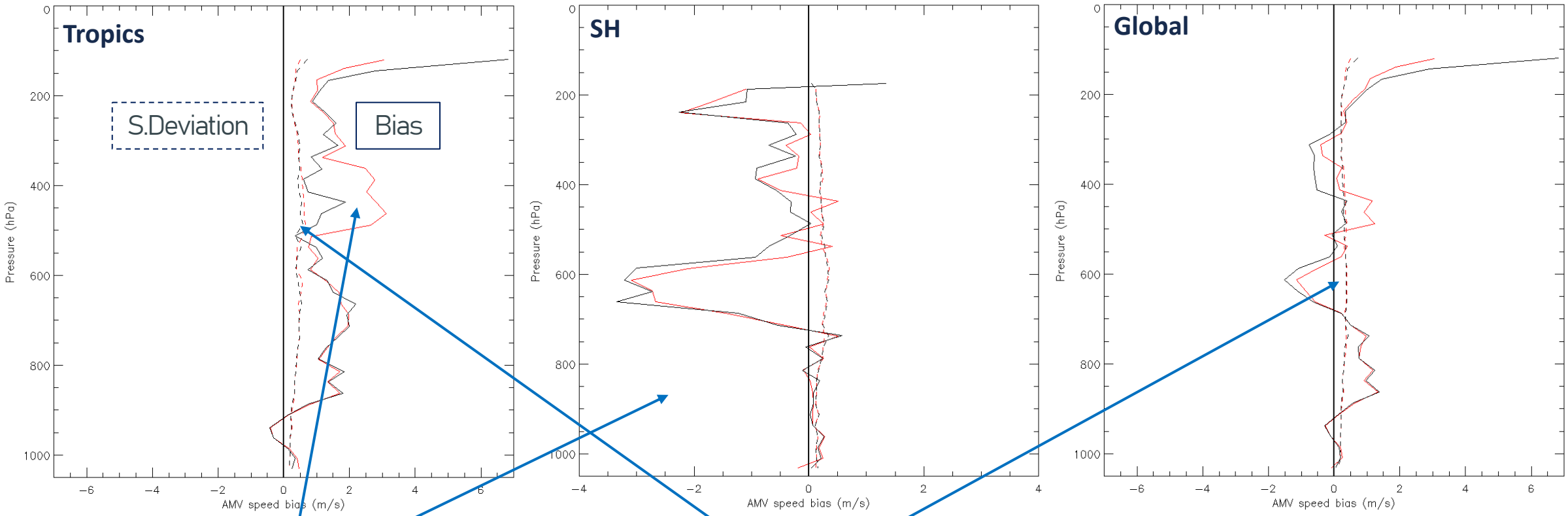
- Speed differences where AMV QI > 80

Small improvements are seen in specific geographic/altitude regions



3.4 Speed compared to NWP forecast (2) Profiles

Speed biases vertical - Black Line = Filtered OCA; Red Line = Original OCA



Bias: clear improvement in Tropics
Degradation in extra-tropics

Standard deviation: Small but consistent improvement all regions

Sample size too small for any firm conclusions

3.5 Speed compared to NWP forecast (3) Summary

Statistics: SPEED BIAS (m/s): (AMV- Forecast)

	Original OCA				Filtered OCA			
	All	High	Mid	Low	All	High	Mid	Low
Global	0.38	0.24	0.39	0.50	0.22	0.07	-0.12	0.49
NH	-0.36	-0.77	-0.56	0.27	-0.43	-0.87	-0.68	0.27
Tropics	1.07	1.31	2.04	0.70	0.91	1.16	1.31	0.68
SH	-0.30	-0.43	-0.59	0.10	-0.48	-0.67	-0.95	0.10

Result lower quality
Result higher quality

Bias: clear improvement in Tropics
Degradation in extra-tropics

Statistics: SPEED NRMS (m/s):

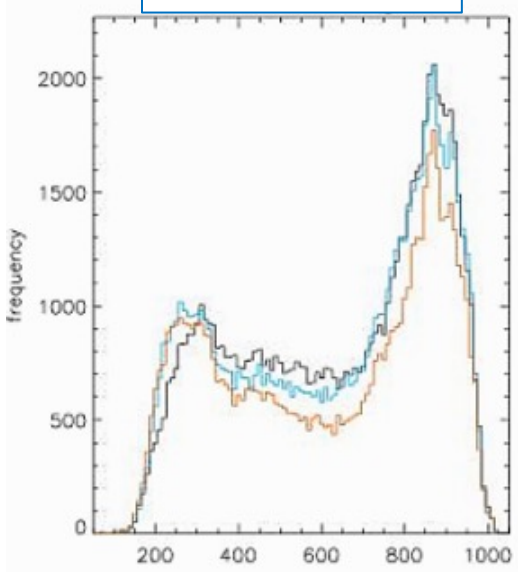
	Original OCA				Filtered OCA			
	All	High	Mid	Low	All	High	Mid	Low
Global	0.28	0.24	0.35	0.26	0.26	0.23	0.32	0.26
NH	0.27	0.22	0.38	0.29	0.26	0.21	0.35	0.29
Tropics	0.36	0.33	0.58	0.30	0.32	0.30	0.49	0.29
SH	0.21	0.19	0.24	0.17	0.21	0.19	0.24	0.18

Standard deviation: Small but consistent improvement all regions

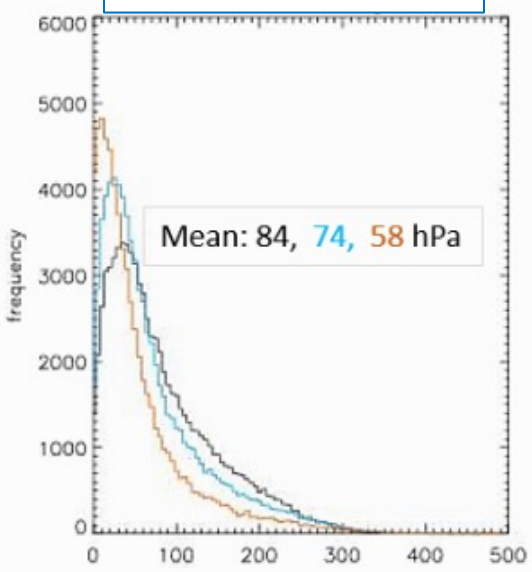
3.6 Filtering and CCC effect on target homogeneity

- Plots show the distribution of various parameters averaged across the AMV target boxes with:
  - No filtering (all cloudy pixels)
  - + OCA filtering
  - + CCC filtering

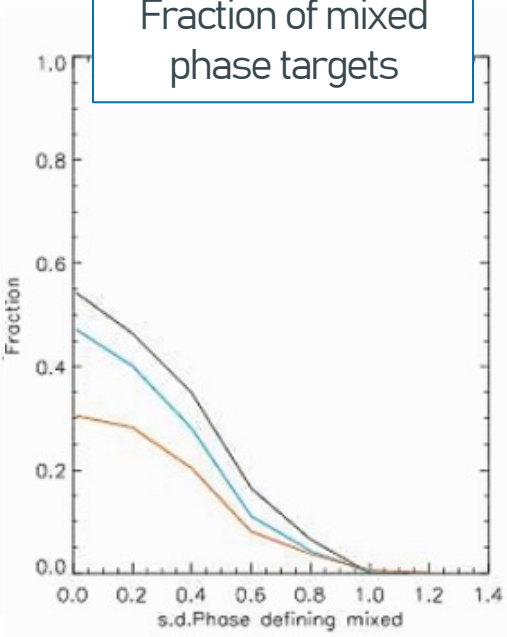
Target Mean CTP



Target S.Dev of CTP



Fraction of mixed phase targets



Filtering steps cumulatively contribute to stronger peaks at cirrus and boundary layer cloud levels.

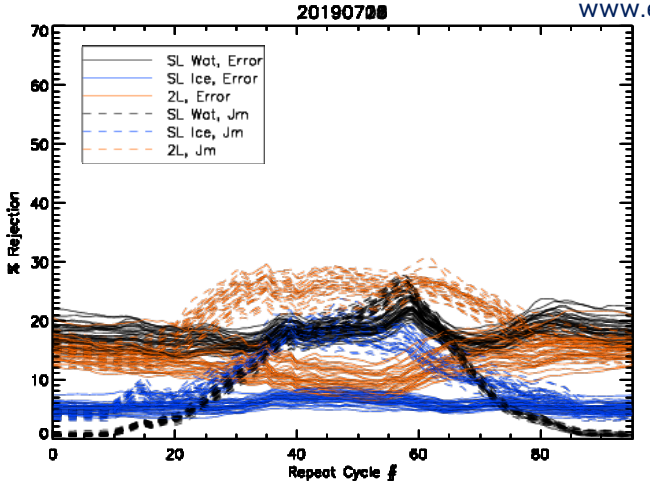
Filtering steps cumulatively contribute to lower target CTP variance.

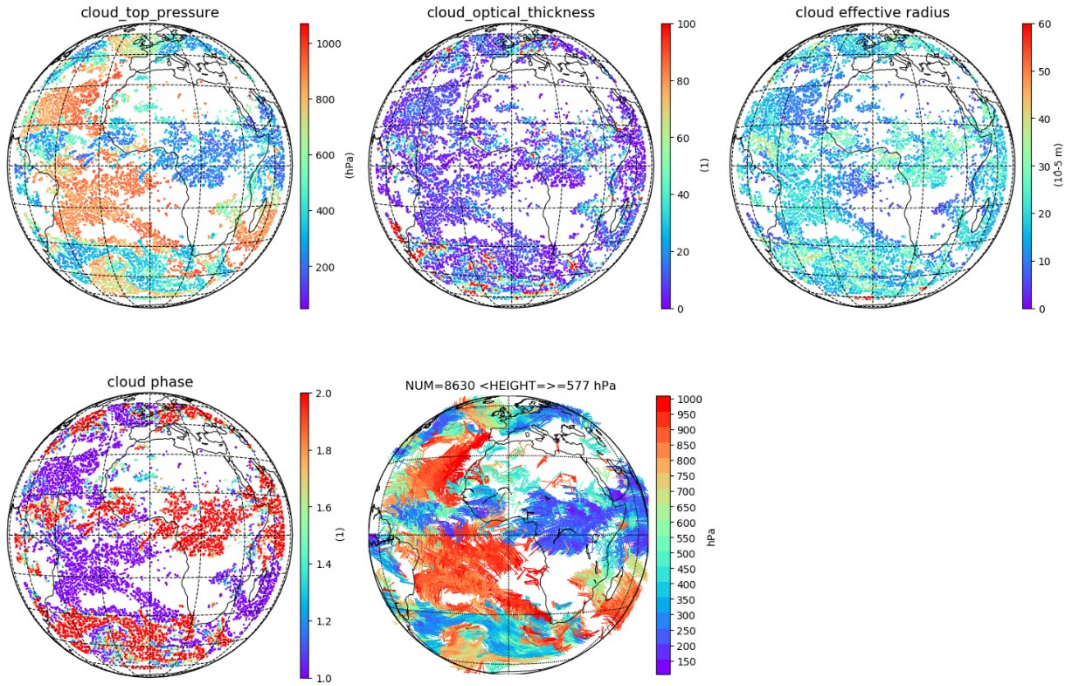
Filtering steps cumulatively contribute to more homogeneous targets as defined by the OCA phase classification.

Homogeneity (based on OCA classification!) is not ensured by the applied filtering. **There is a case to be made to enable this by importing the OCA classification into the AMV target processing** (not currently possible)

3.7. Filtered AMVs Assimilation impact experiment

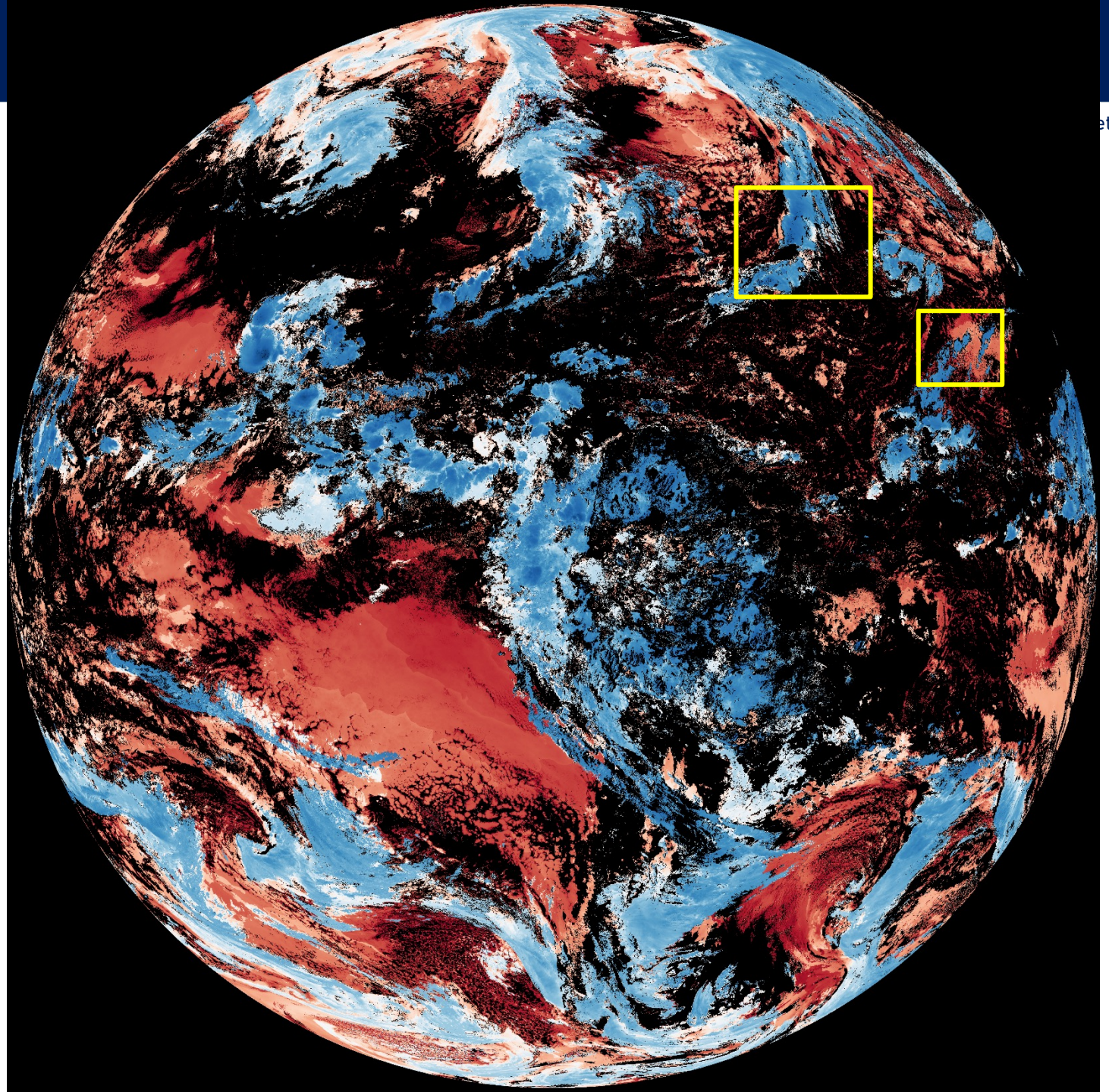
- In collaboration with ECMWF (F. Warrick->preliminary results) and EUMETSAT reprocessing team (M. Doutriaux-Boucher and A. Lattanzio)
- One Month SEVIRI data from OCA CDR V1
  - Some compromises on mask and f/c data quality c.f. operational
  - Filtering thresholds adjusted to obtain 10-20% rejection rates:
    - CTP error levels:
      - SL wat – 40 hPa
      - SL ice – 30 hPa
      - 2L – 70 hPa
    - Jm levels:
      - SL wat – 200
      - SL ice – 110
      - 2L - 150
  - Diurnal behaviour in rejection rates observed:
    - Dedicated day/night thresholds will be needed
  - Computation of cloud properties averaged in the CCC targets





4. A closer look

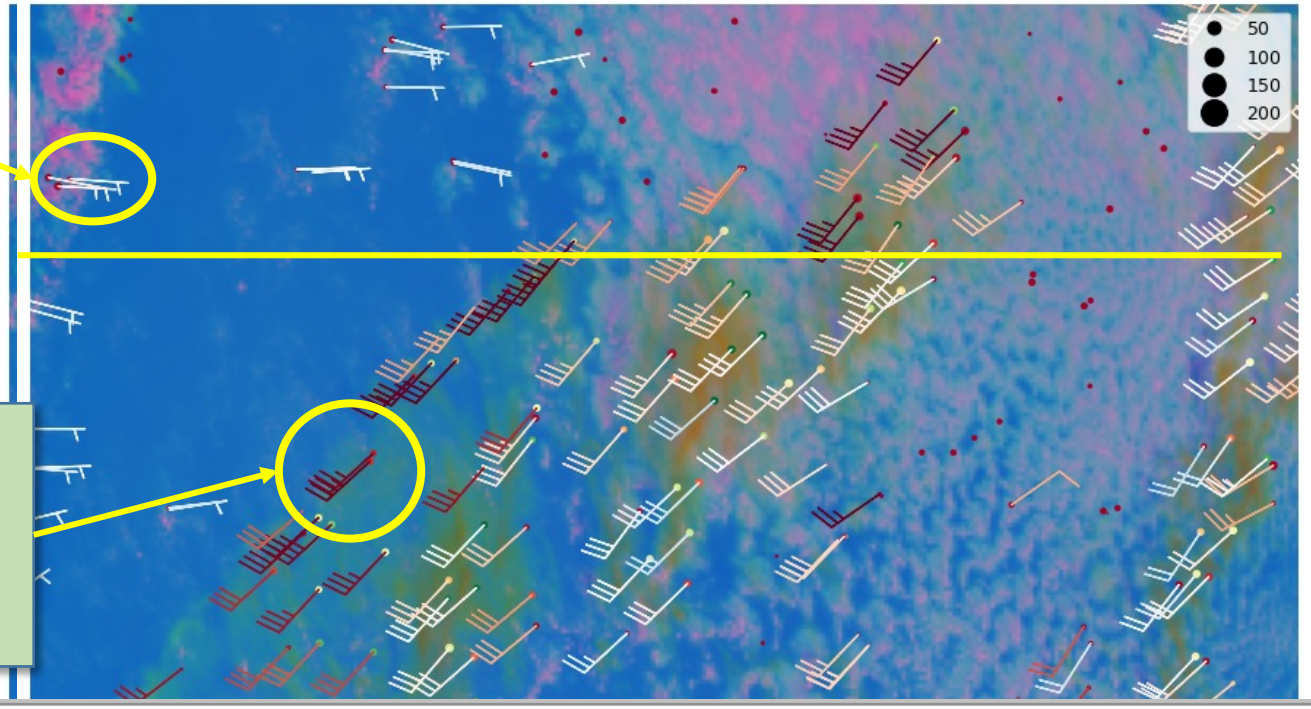
- Selected regions that contain:
  - Distinctive cloud types
    - Mid-latitude storm systems
    - Overlap regions
  - High or distinctive patterns of speed biases
- Are there hints that bias originates from:
  1. Cloud CTP retrieval side:
     - Characteristics or Errors
     - Mis-interpretation at target level
  2. Relation wind-cloud type
     - How deep in cloud is the 'correct' wind?
  3. NWP error?

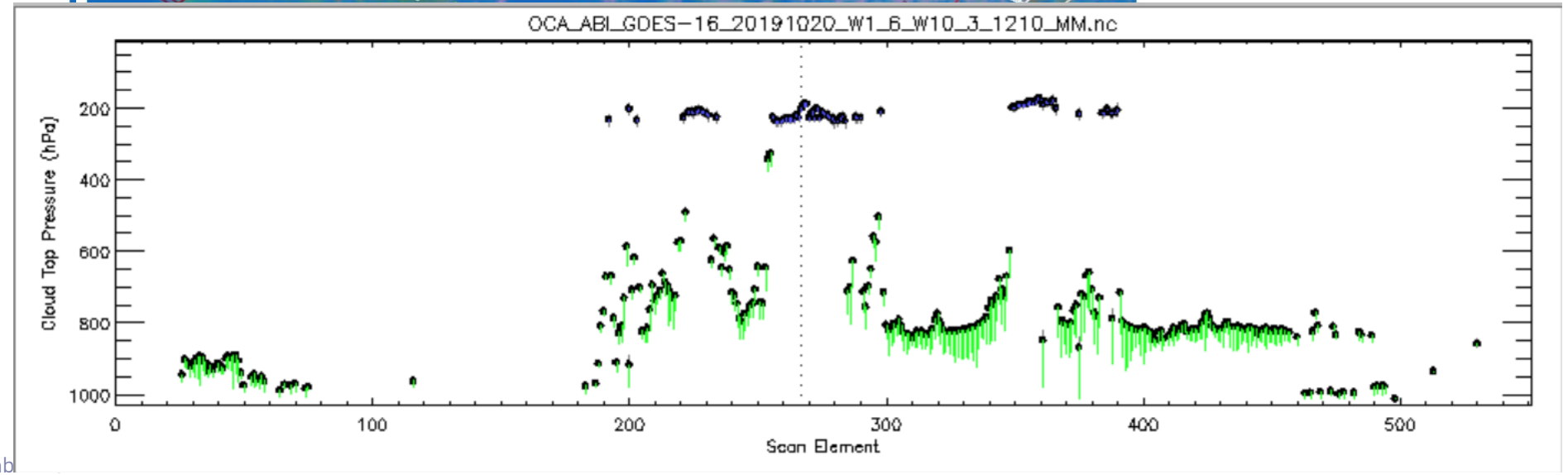


4.1. A closer look: Overlap cloud

WIND: Stratus tracked
CTP : Clean stratus HA
=HA OK
=> Low Speed bias

WIND : Cirrus tracked
CTP : Mixed Cirrus/stratus HA
=HA too low
=> +ve Speed bias

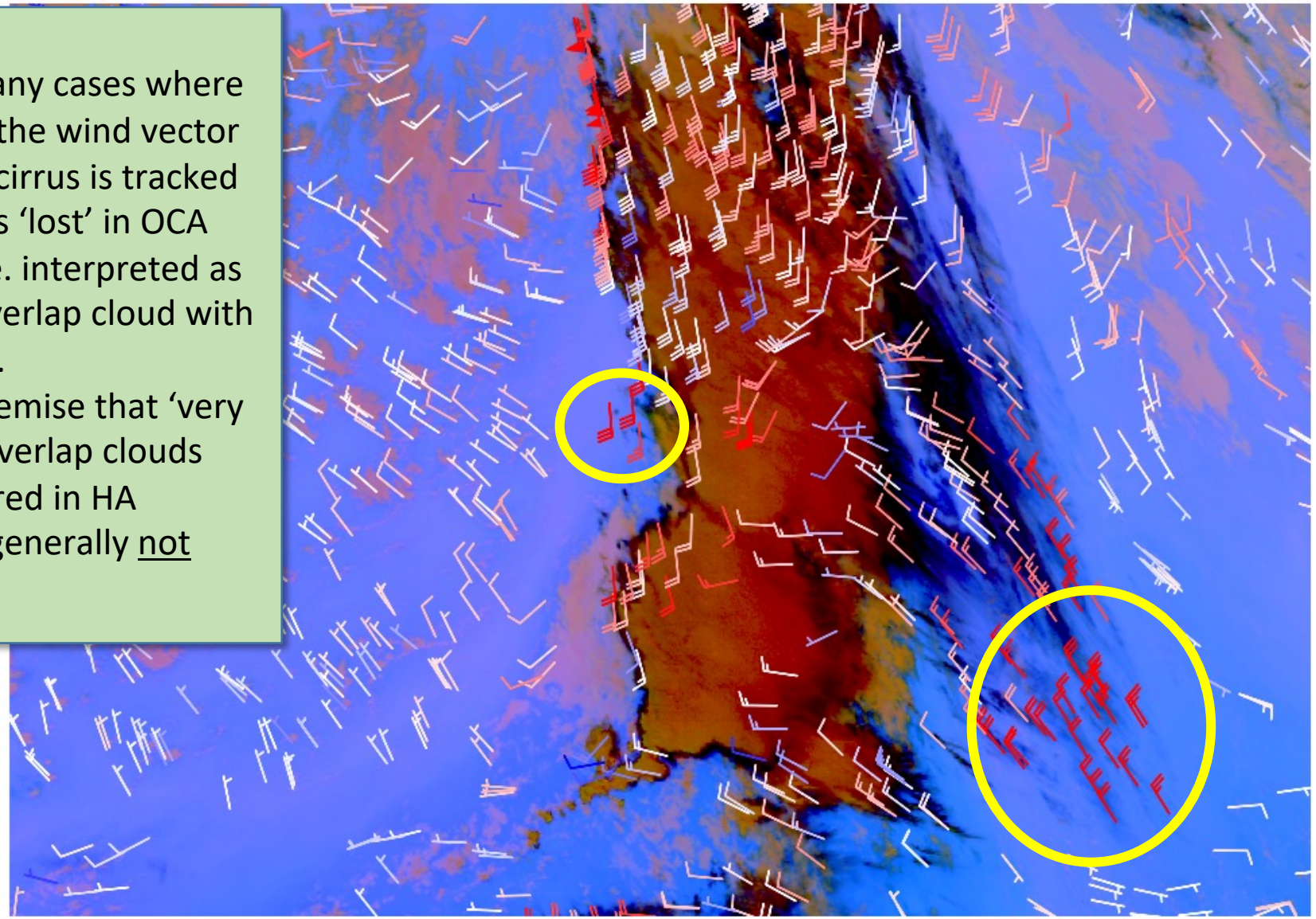




4.2. A closer look: Very thin cloud

Key Points:

- We observe many cases where it is clear from the wind vector that high level cirrus is tracked but this cirrus is ‘lost’ in OCA processing – i.e. interpreted as low cloud or overlap cloud with very thin cirrus.
- The filtering premise that ‘very thin’ cirrus in overlap clouds should be ignored in HA appears to be generally not appropriate



Summary

- 'Blacklisting' pixels with estimated error and cost appears to have a **modest** positive effect on speed bias statistics (caveat: small sample!)
- Filtering + established CCC pixel selection: more homogeneous cloud phase over the target box
  - Worth ingesting OCA phase into the AMV process?
  - In overlap cases the tracked feature can be from either layer. Need for an 'educated' filtering in the context of the target contents and wind speed?
- Ignoring very thin upper layer in overlap clouds appears not to be consistent with imagery analysis showing very high IR tracking sensitivity to thin clouds
- Detailed analysis of imagery, cloud product and target information is illuminating if also very complex due to multiple contributors to speed biases w.r.t NWP.
  - Planned to extending the analysis including e.g. forecast cloud fields, vertical wind profiles.

Thank you!

Questions are welcome.