# Using simulated satellite observations to improve the characterization and understanding of AMVs for data assimilation

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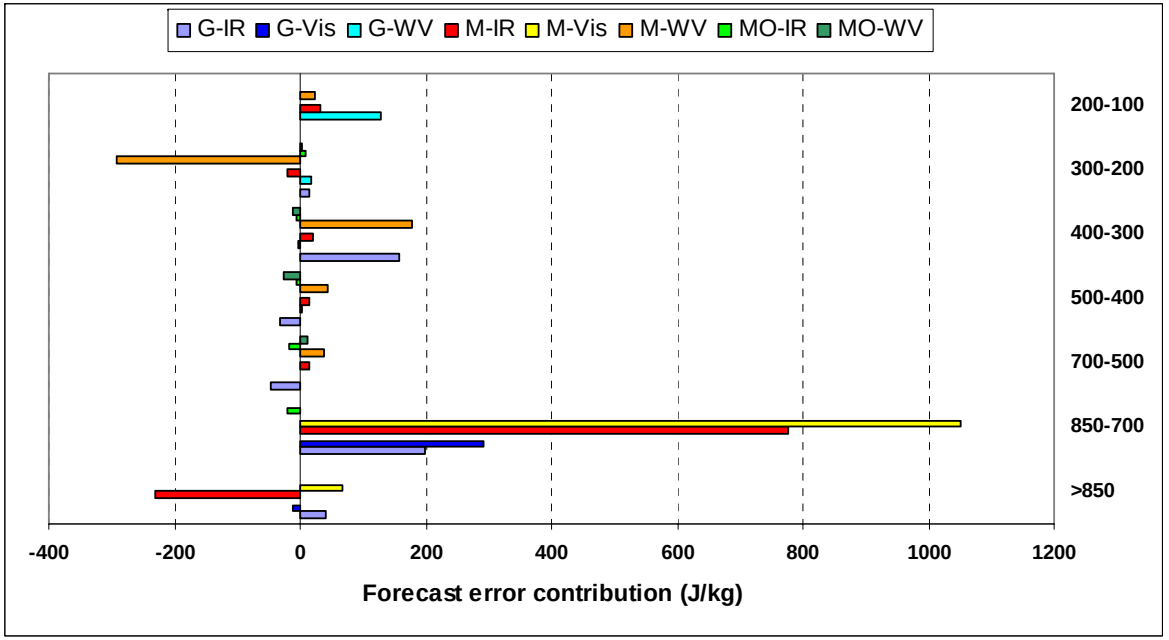
ECMWF

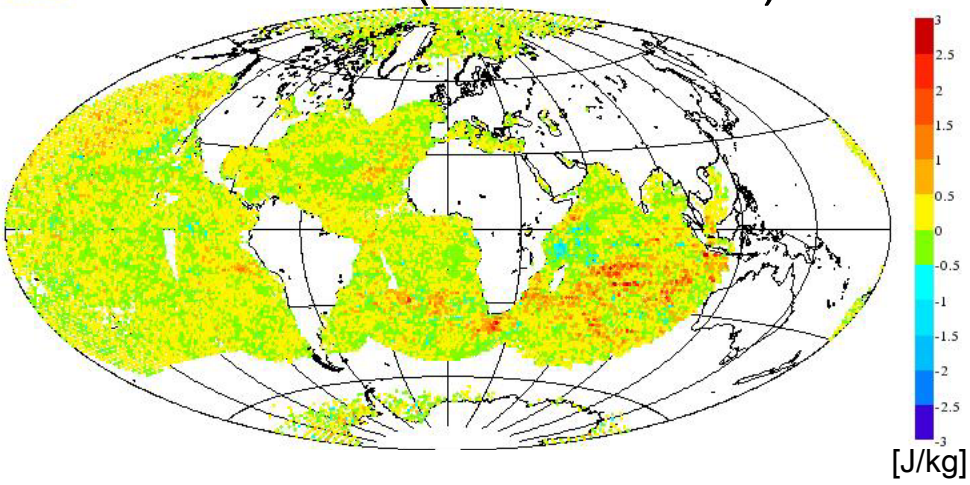
# NWP impact assessment



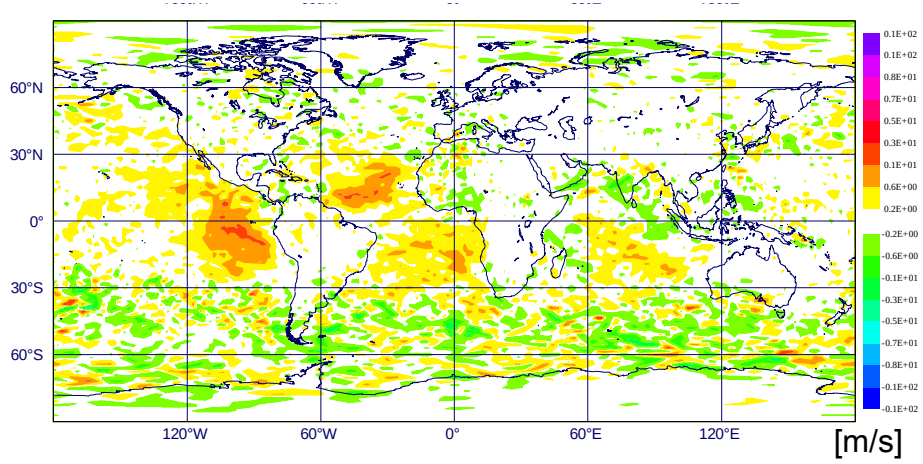

AMV-impact is quite variable as a function of period, area, height interval, product

(Courtesy C. Cardinali)

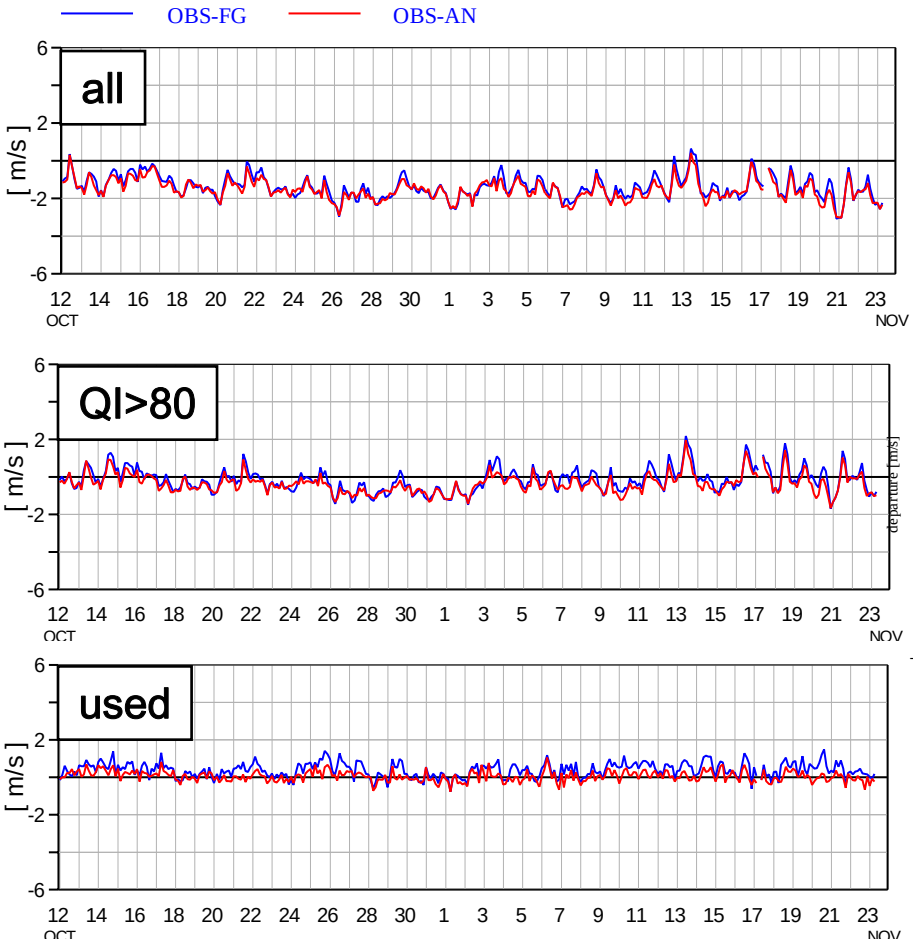
24-hour adjoint forecast error sensitivity
700-1000 hPa VIS (15/06-15/07/2006)



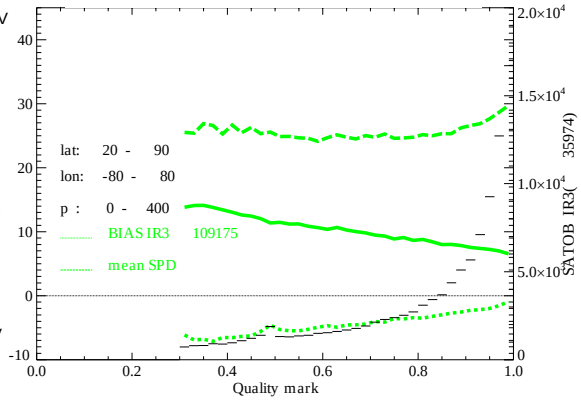

OSEs: 24-hour 850 hPa u-component forecast RMSE

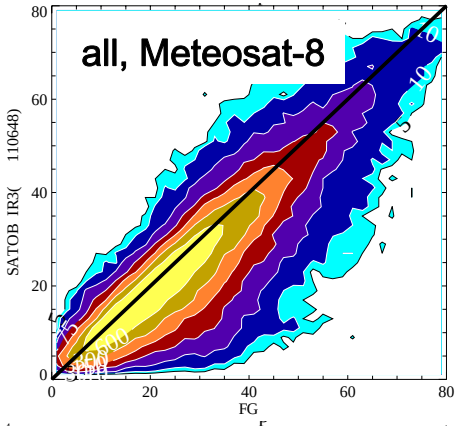


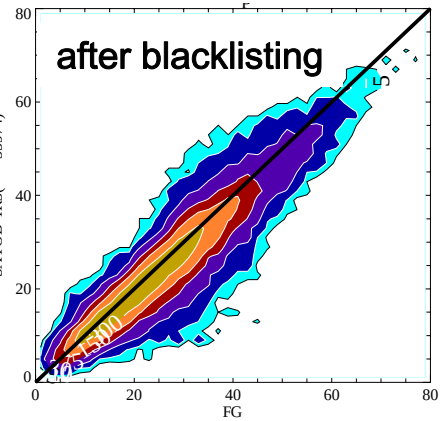
# Observational quality control

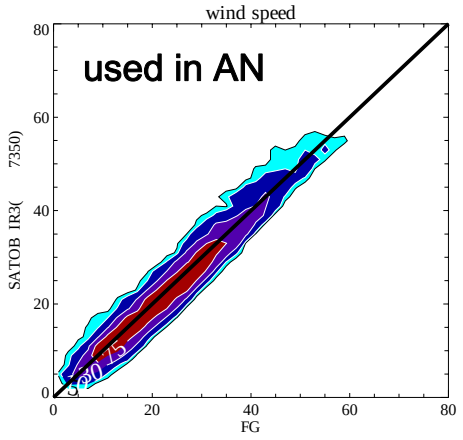


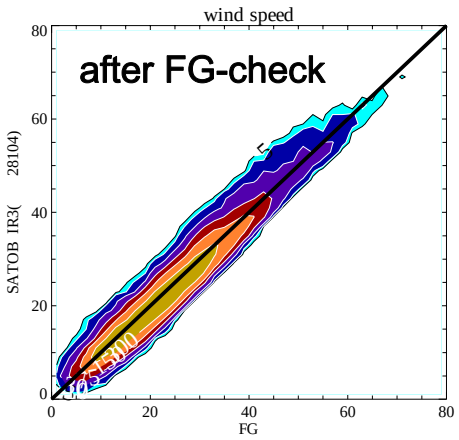

Meteosat-8, IR 10.8µm
NH, 0-400hPa



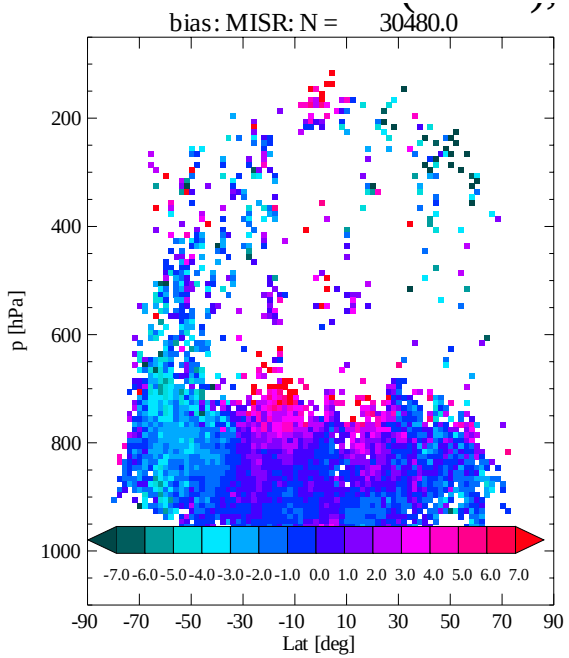




Model vs. observation performance is quite variable as a function of period, area, height interval, product
(see Mary Forsythe's NWP-SAF report)

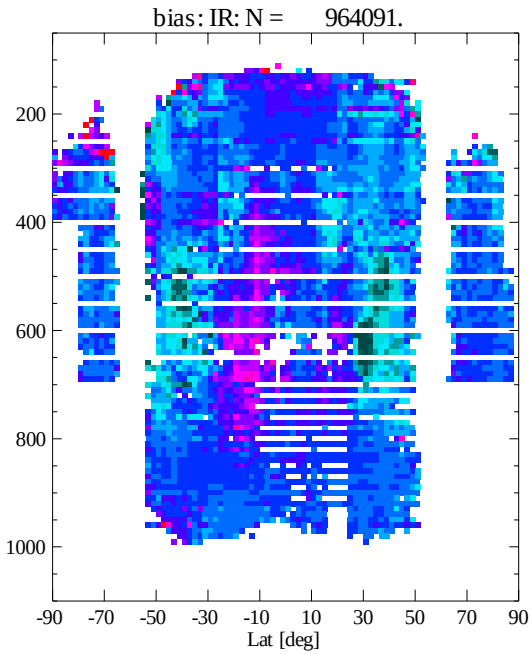
# MISR and AMV observations vs. model wind

- Observation – model zonal mean wind speed difference in October 2006.
- Height assignment methods are fundamentally different.

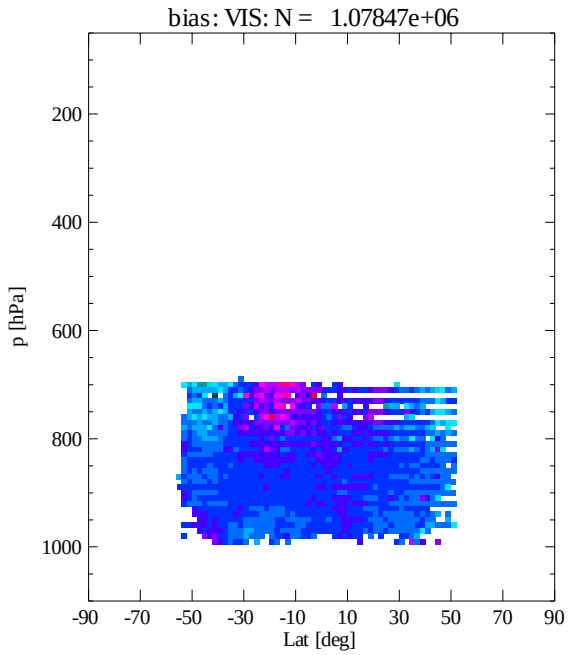
MISR (Courtesy R. Davies)




AMV IR (active)




AMV VIS (active)




Features are very similar:

- because model wind field has systematic biases or
- because general tracer assumption introduces systematic biases or
- both.

# Observation simulation study

## Motivation for this study

- Model simulation represents a true (and known) atmospheric state;
- measurement errors don't exist;
- pathological observation vs. model cases can be analyzed and related to:
  - issues associated with data processing, i.e. retrievals;
  - issues associated with information content (tracer assumption).

## Caveats of this study

- model simulations may not represent real truth:
  - model clouds are unrealistic (moist physics parameterizations);
  - model resolution/stepping does not compare to observations.

## Simulation set-up

- ECMWF model forecast experiment with T2047L60 (~10km) initialized on 1 Jan 2006.
- Forecast fields at +24h to +36h archived in 15-minute intervals.
- Meteosat-8 simulation* of 6.2, 7.3, 10.8, 12.0, 13.4 μm channels for 2 Jan 2006 12-18 UTC.
- CIMSS AMV retrieval using NOGAPS and ECMWF** 1°x1° forecasts on standard pressure levels as constraints.
- 'Raw' and 'auto-edited data sets considered here.
- Time resolution of derived winds is 30', i.e. 12 time slots.

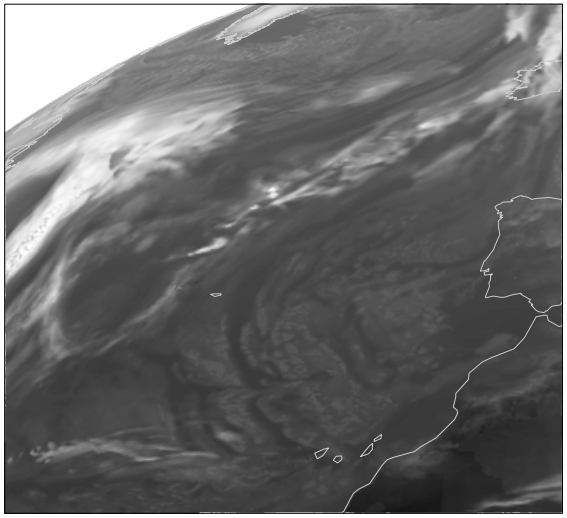
*RTTOV-8, ** from same experiment

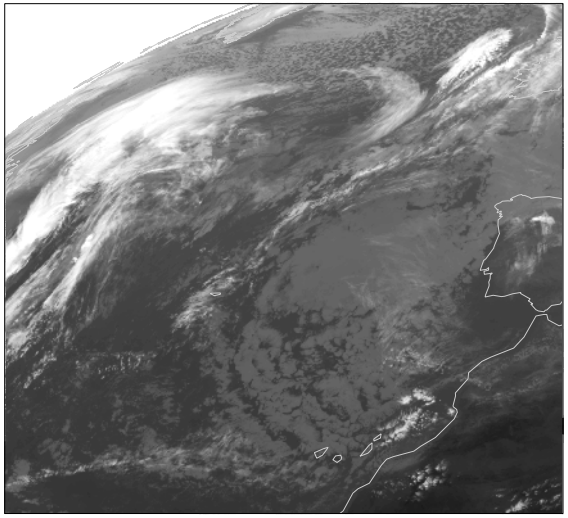
# Example

Simulated

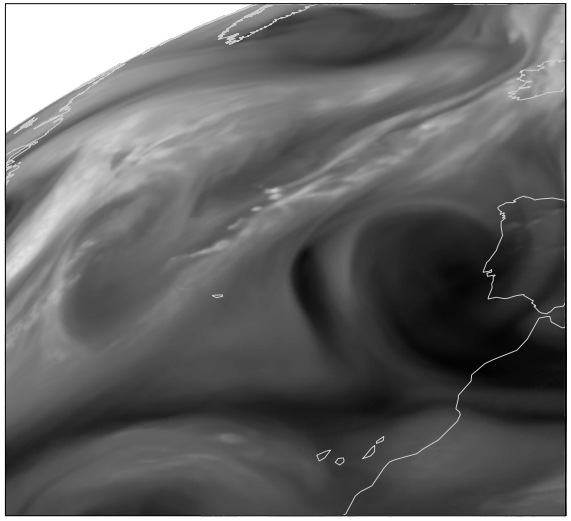
Observed

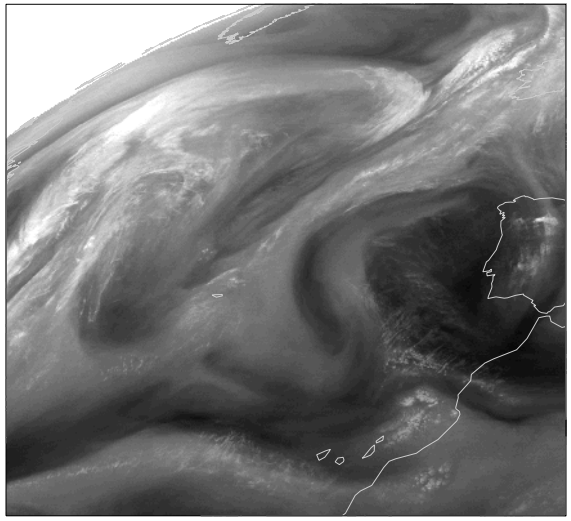
10.8 µm





6.2 µm







ECMWF

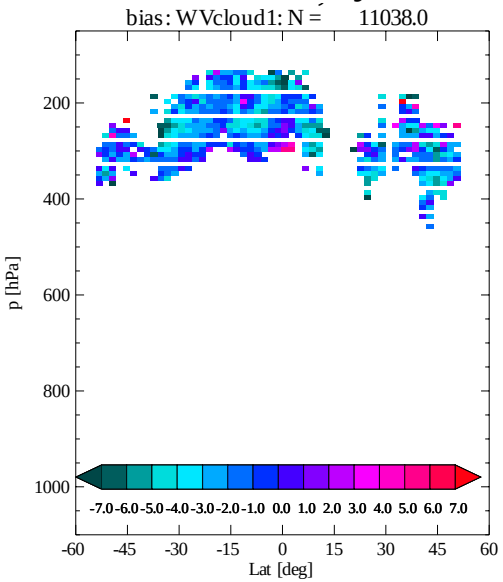
# Mean FG-departures: Simulations vs. observations

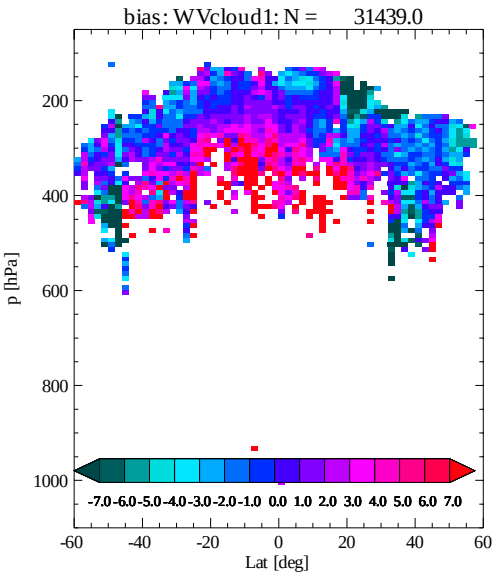
Simulated Meteosat-8 (CIMSS processing, after q/c)

(6h time period QI>60)

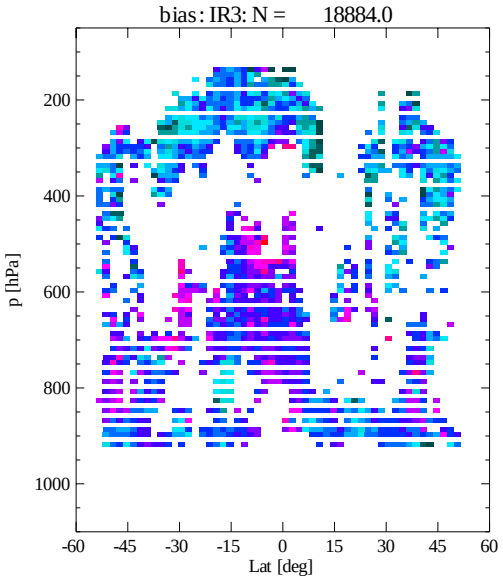
Observed Meteosat-8 (EUMETSAT processing, after q/c)

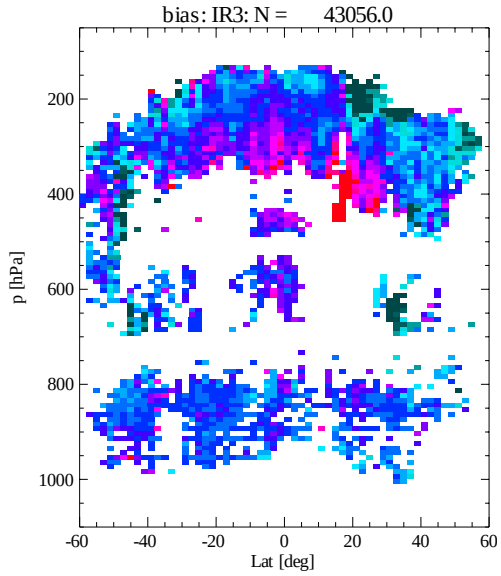
WV-cloudy



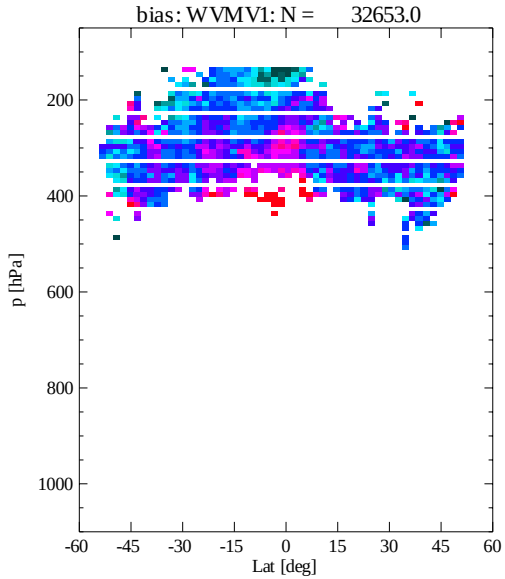



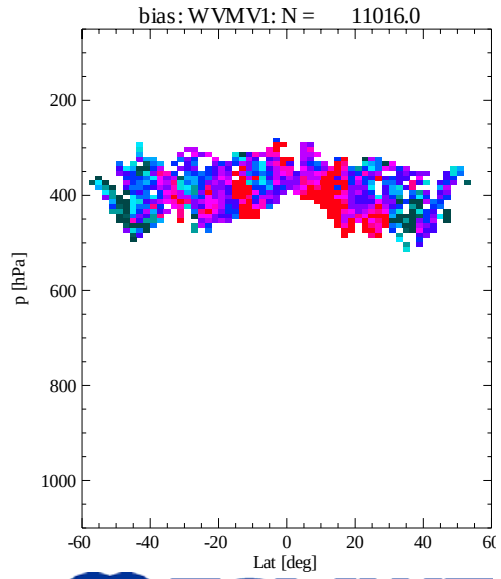

IR




WV-clear






ECMWF

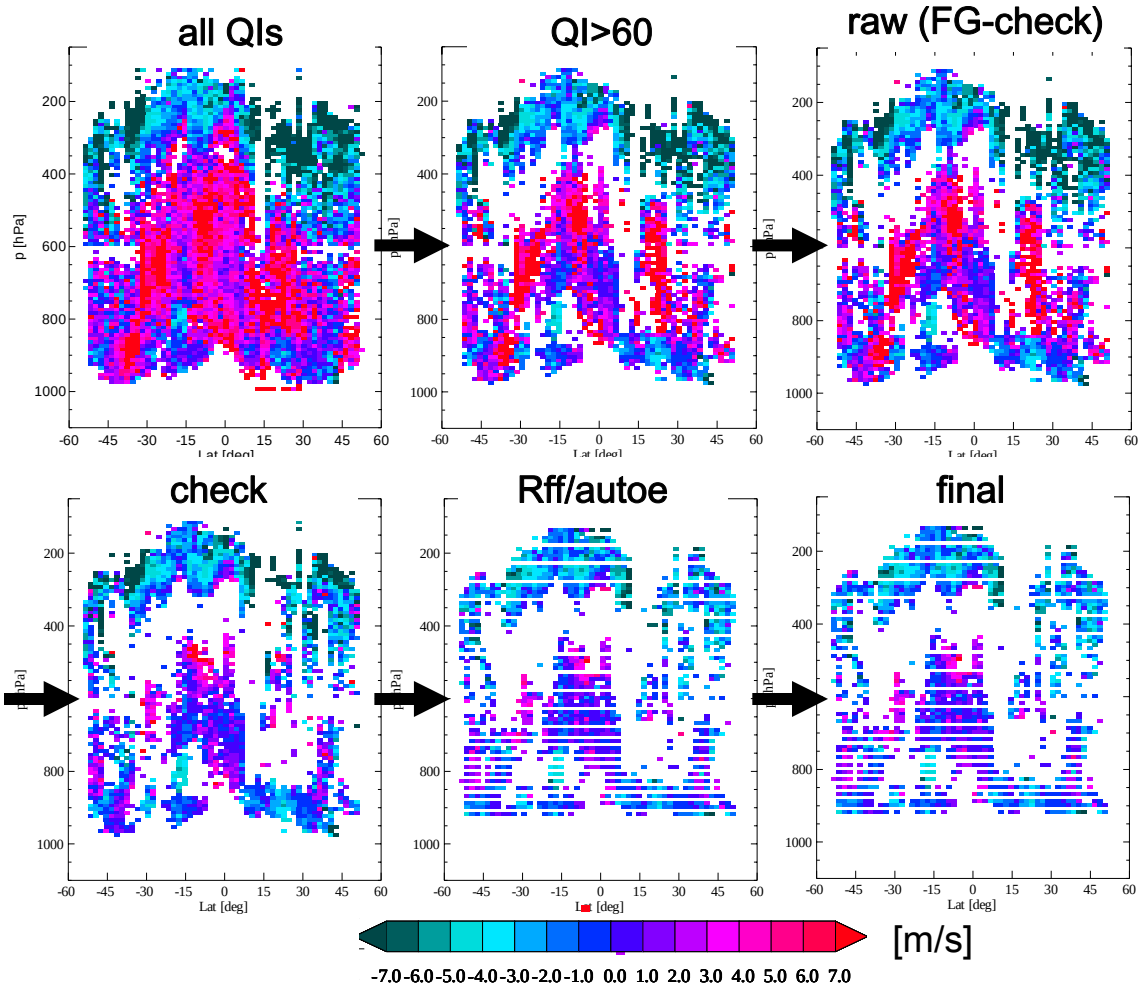
# FG-departure statistics: High-level clouds

- Simulated vs. observed AMVs.
- Constrained with NOGAPS vs. ECMWF forecast data.

| Wind type | | High-level WV-clear | | | | High-level IR | | | | High-level WV-cloudy | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quality measure | | Bias | | NRMSVD | | Bias | | NRMSVD | | Bias | | NRMSVD | |
| Data Set | | Raw | Final | Raw | Final | Raw | Final | Raw | Final | Raw | Final | Raw | final |
| NOGAPS QI>60 | NH | -2.39 | 0.90 | 0.70 | 0.36 | -5.89 | -1.64 | 0.60 | 0.32 | -4.70 | -1.29 | 0.57 | 0.30 |
| | **Tropics** | **1.47** | **0.85** | **0.96** | **0.51** | **-2.13** | **-1.82** | **0.67** | **0.45** | **-1.71** | **-1.46** | **0.73** | **0.43** |
| | *SH* | *-1.21* | *0.40* | *0.82* | *0.38* | *-3.39* | *-1.99* | *0.58* | *0.40* | *-3.08* | *-1.49* | *0.58* | *0.38* |
| ECMWF QI>60 | NH | -2.39 | 0.18 | 0.70 | 0.34 | -5.79 | -1.77 | 0.60 | 0.30 | -4.59 | -1.12 | 0.57 | 0.29 |
| | **Tropics** | **1.39** | **0.48** | **0.95** | **0.48** | **-2.10** | **-1.42** | **0.69** | **0.43** | **-1.56** | **-1.08** | **0.64** | **0.40** |
| | *SH* | *-1.26* | *0.85* | *0.81* | *0.36* | *-3.59* | *-1.08* | *0.58* | *0.38* | *-3.19* | *-0.60* | *0.57* | *0.35* |
| Met.-8 QI>60 | NH | - | 1.17 | - | 0.50 | - | -0.96 | - | 0.29 | - | -0.43 | - | 0.28 |
| | **Tropics** | **-** | **4.26** | **-** | **1.04** | **-** | **0.96** | **-** | **0.43** | **-** | **2.04** | **-** | **0.46** |
| | *SH* | *-* | *0.48* | *-* | *0.37* | *-* | *0.25* | *-* | *0.32* | *-* | *1.21* | *-* | *0.35* |

(NRMSVD = RMS vector difference normalized with model wind speed = rel. error with respect to model wind)

# Impact of post-processing



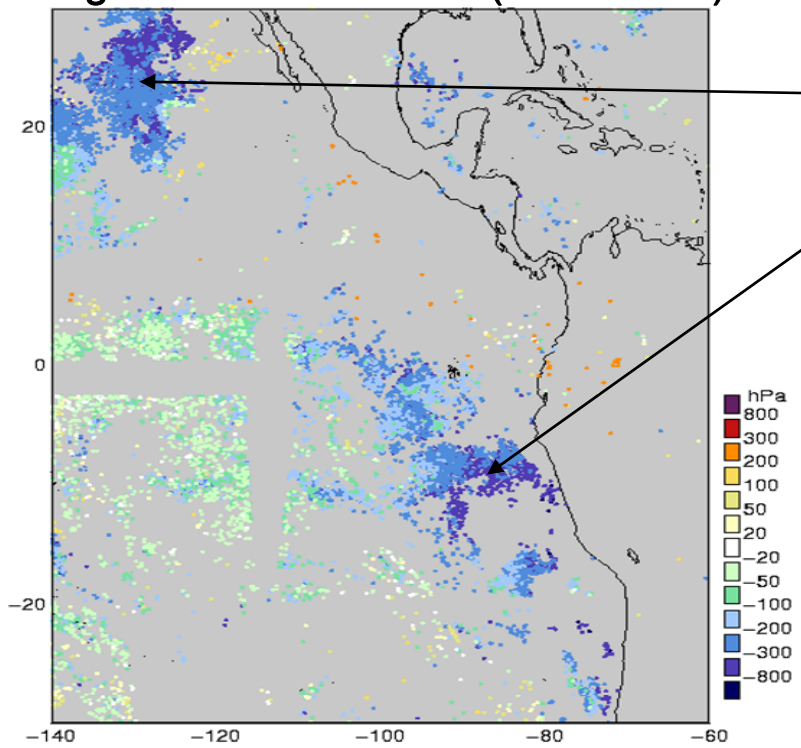

## IR high-level AMV stats

| | Bias | | | NRMSVD | | |
|---|---|---|---|---|---|---|
| | SH | Trop | NH | SH | Trop | NH |
| all QI | -3.4 | -1.1 | -6.6 | 0.69 | 0.95 | 0.65 |
| all | -3.4 | -2.1 | -5.8 | 0.57 | 0.68 | 0.60 |
| raw | -3.4 | -2.1 | -5.9 | 0.58 | 0.67 | 0.60 |
| check | -3.1 | -2.2 | -4.2 | 0.58 | 0.65 | 0.56 |
| RFF | -2.1 | -1.9 | -2.0 | 0.40 | 0.45 | 0.34 |
| Final | -2.0 | -1.8 | -1.6 | 0.40 | 0.45 | 0.32 |

- Post-processing mainly removes rather than corrects data (fairly independent of height assignment method);
- biggest thinning impact by QI and checks vs. model constraint;
- striping is a product of the auto-editor since it refers to fewer and fixed pressure levels.

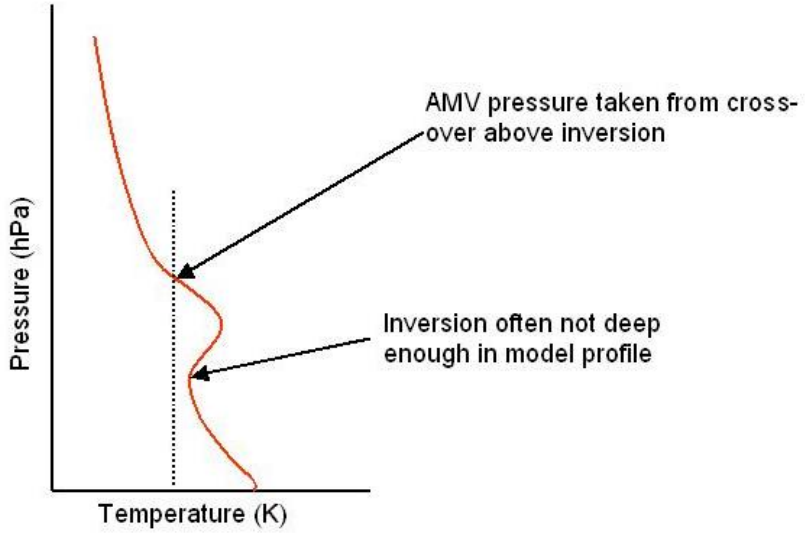
# Case study I: Low-level clouds near temperature inversions

Height difference in hPa (obs-best fit)




GOES-12 VIS unedited AMVs, 3 July 2007

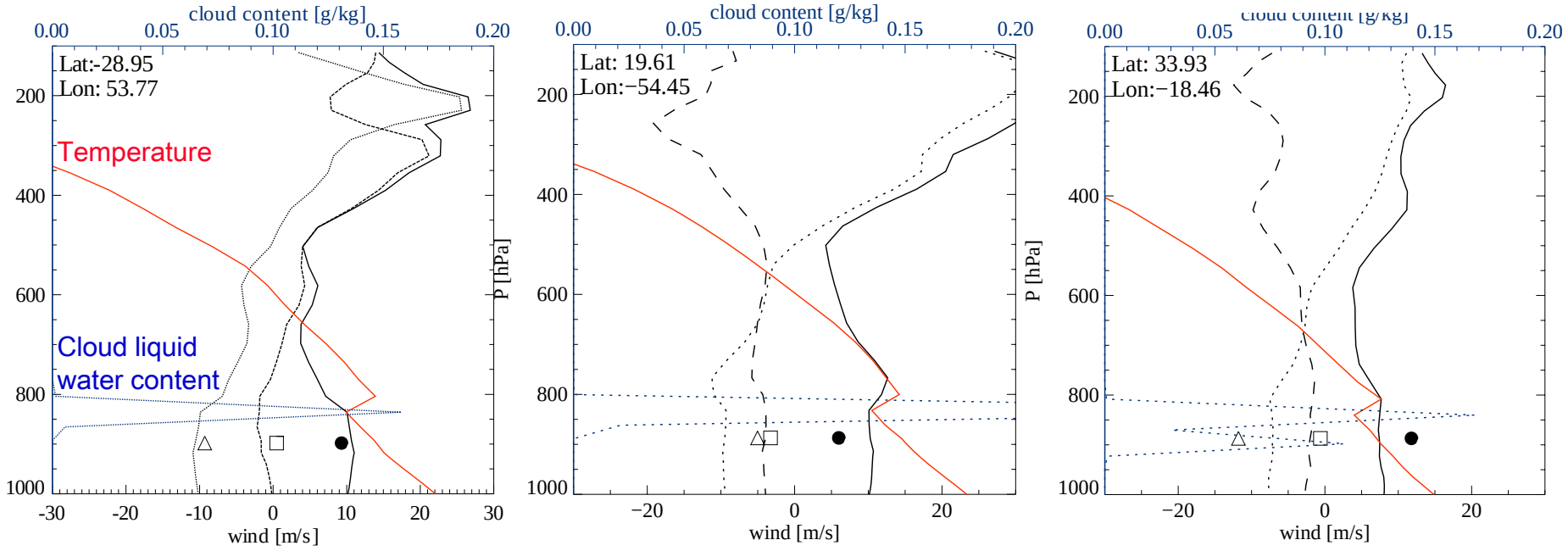
AMVs assigned too high
by cloud-base assignment method




(M.Forsythe, NWP SAF Report 2008)

- NWP models may produce too shallow inversions so that algorithms have difficulties to properly identify cloud base height.
- Calipso verification seems to suggest that model best-fit altitude is fairly good.

# Case study I: Examples




**Model**:
wind speed:

v-component:

u-component:

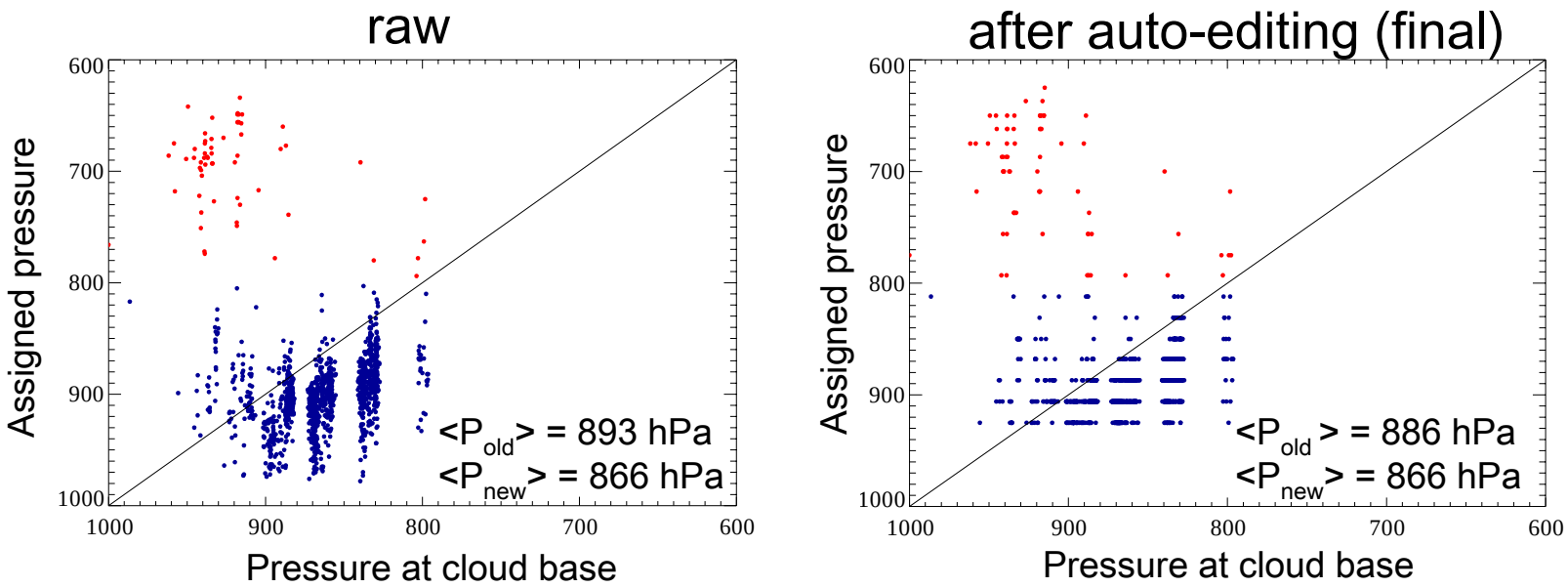
**Retrieval**:
wind speed: •

v-component: □

u-component: Δ

# Case study I: Height assignment

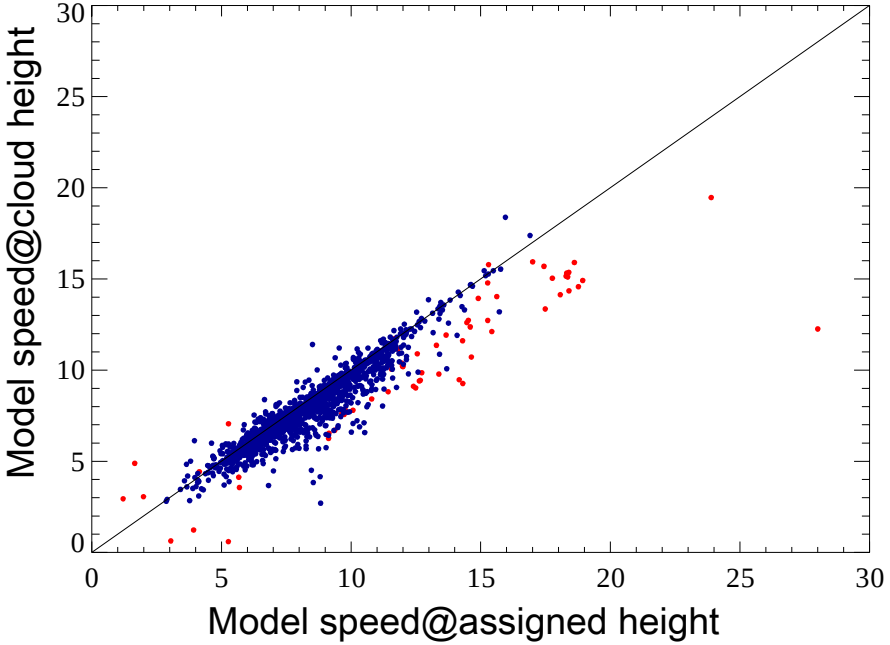
Sample obtained from T-inversion and cloud-base detection
(n=1507 out of 4912 AMVs derived with cloud base height assignment method)



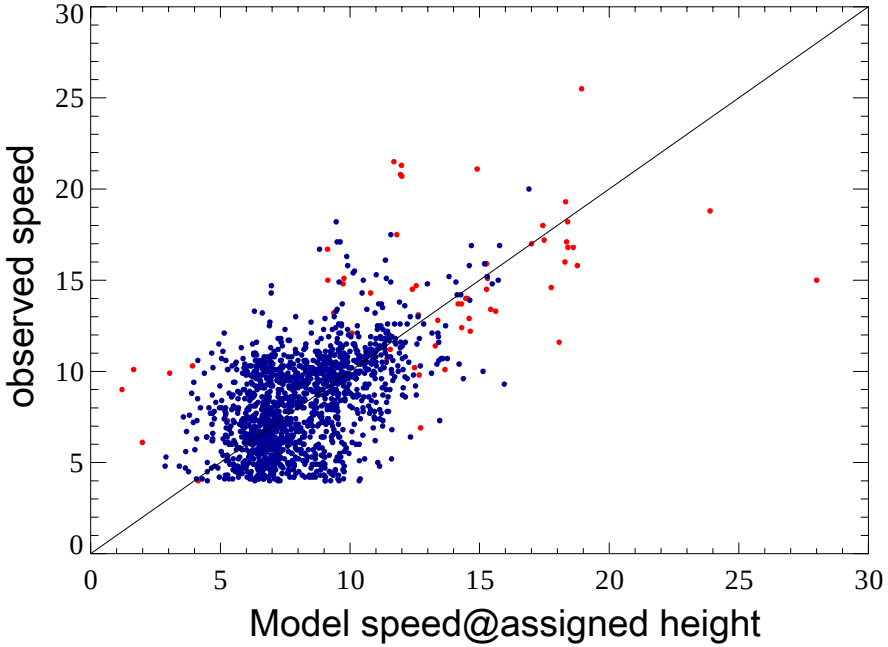

- Cloud base height assignment is very noisy.
- Fit between (true) model and assigned pressure is low and not improved by auto-editor.
  (red points denote samples with assigned height above 800 hPa)

# Case study I: Height reassignment

Model vs. model




Observations (raw) vs. model




Statistics before/after height reassignment

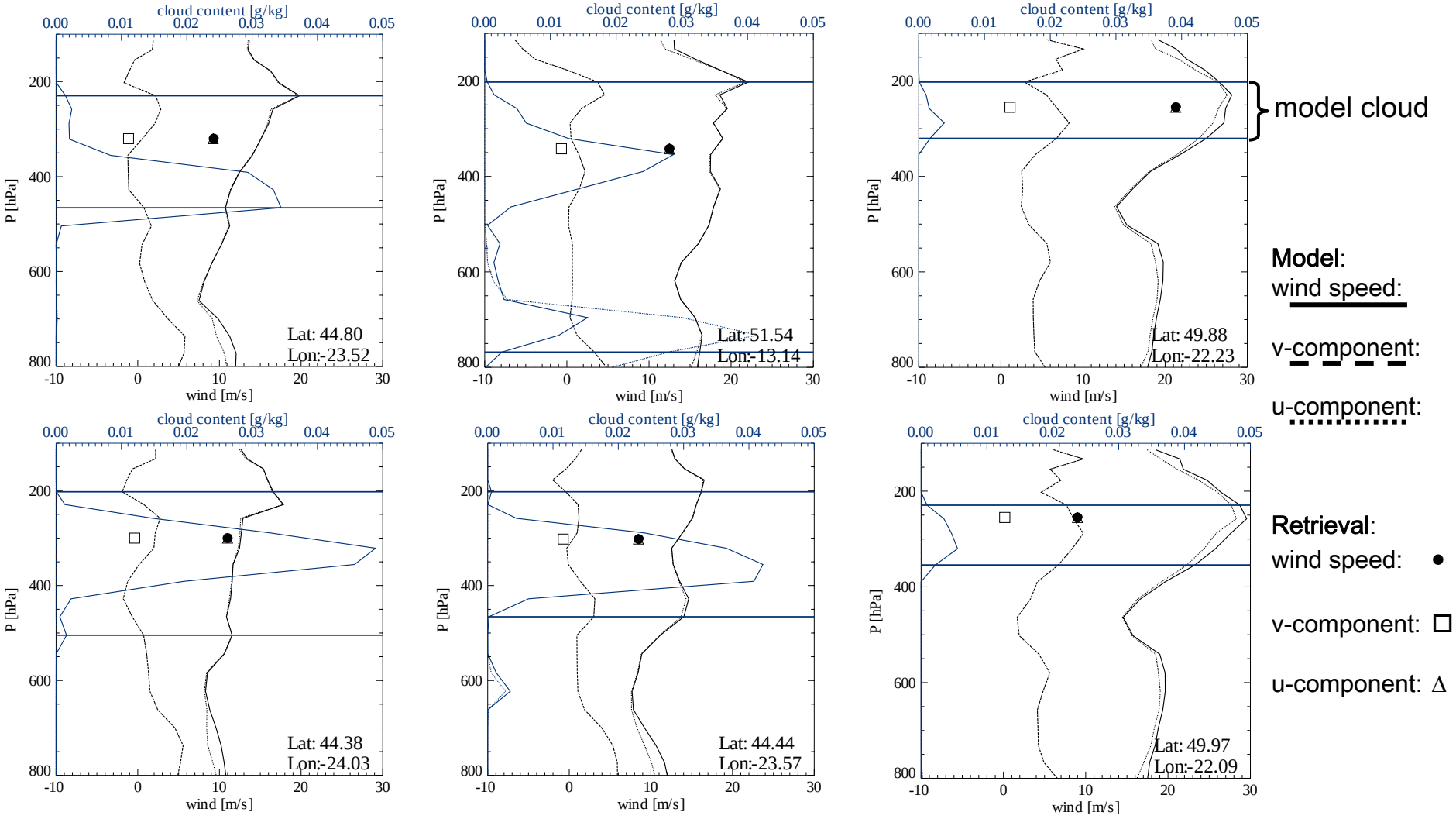
| | | Bias | | MVD | | NRMSVD | |
|---|---|---|---|---|---|---|---|
| | | Old | New | Old | New | Old | New |
| ↓ | Raw 179 | 0.63 | 1.68 | 4.73 | 4.85 | 0.57 | 0.58 |
| | *Final 206* | *0.39* | *1.30* | *4.45* | *4.84* | *0.53* | *0.58* |
| ↑ | Raw 1328 | 0.11 | 0.51 | 2.70 | 2.67 | 0.42 | 0.41 |
| | *Final 1301* | *0.22* | *0.56* | *2.63* | *2.63* | *0.40* | *0.40* |

- Model simulations do not contain strong wind shear.
- Retrieved wind speeds are very noisy.
- Height reassignment to (true) model cloud base deteriorates statistics.
- Most reassignments increase rather than decrease heights.



ECMWF

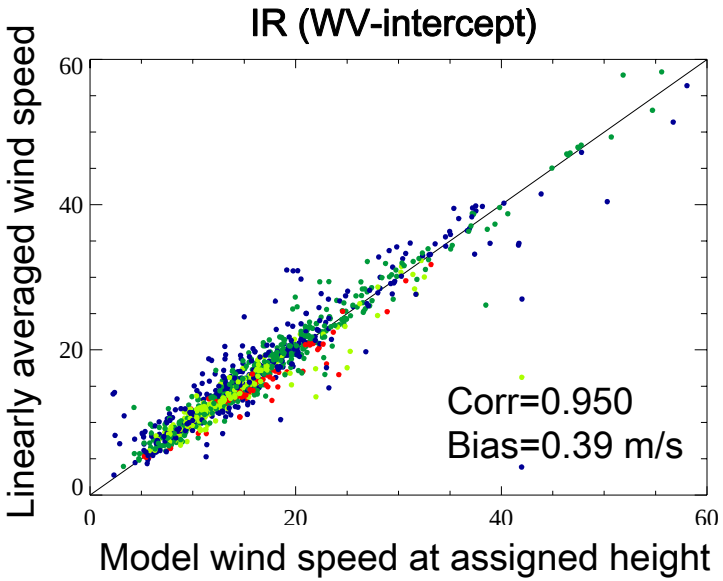
# Case study II: High-level clouds (IR, WV-cloud)



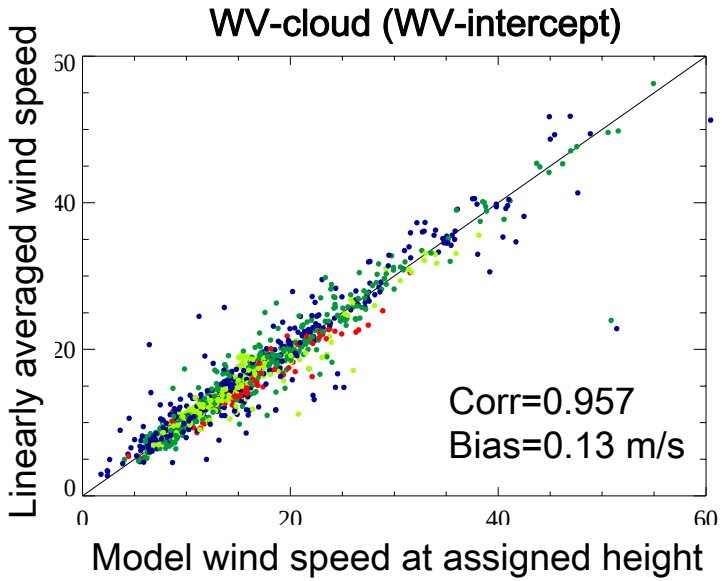

Case selection (small wind shear, model vs. obs. wind direction similar, only cirrus):

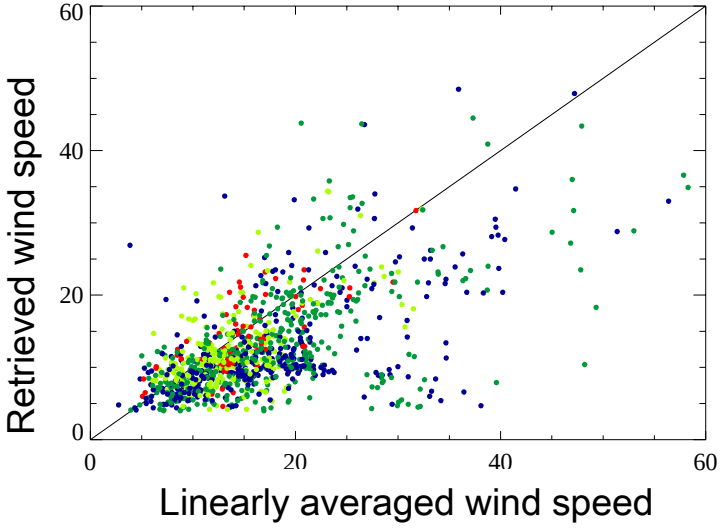
- Cloud detection and height assignment work well;
- negative bias dominates data set.

# Case study II: Model vs. retrieved wind speed




1-3
4-6
7-12
>12
cloud layers

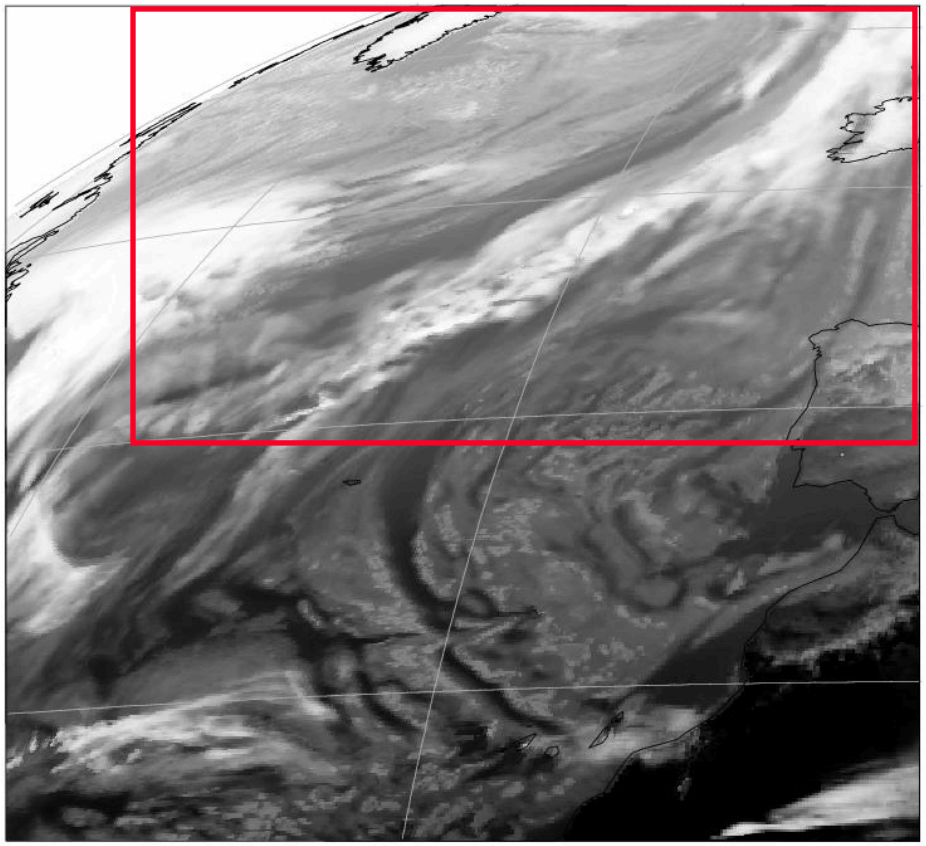


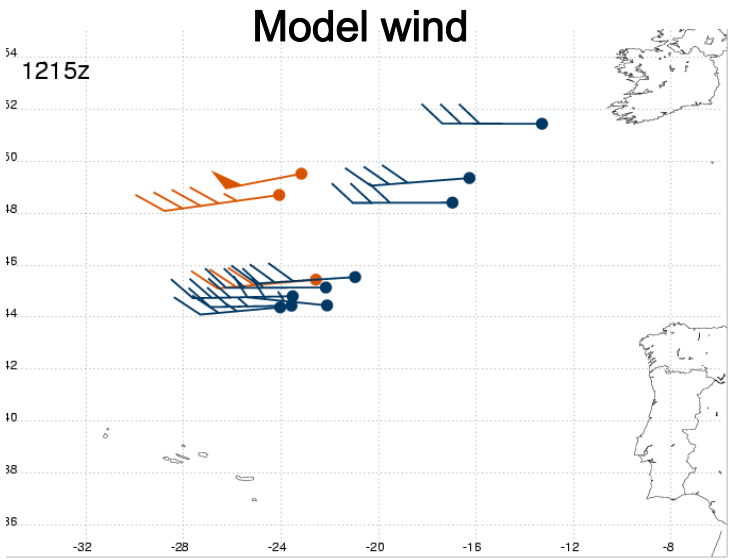



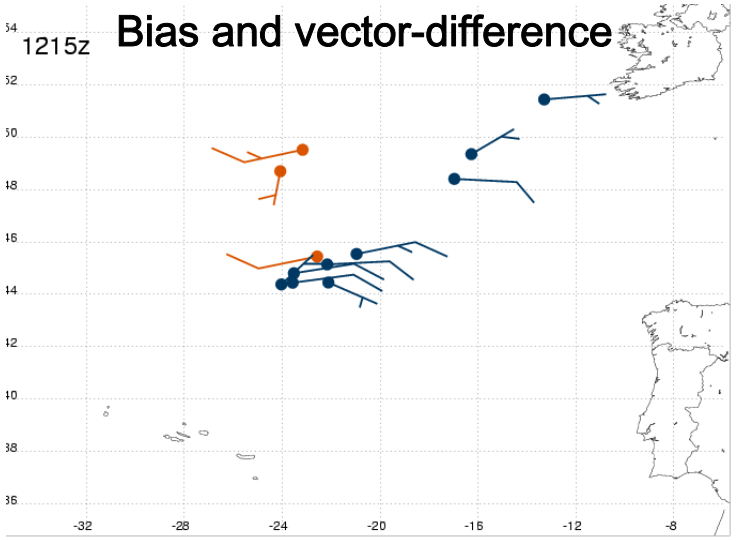

1-3: -4.6m/s
4-6: -4.7m/s
7-12:-1.6m/s
>12: -0.6m/s
bias for cloud layers

- Wind shear is small regardless of which height is chosen to represent cloud.
- Assigned height by retrieval is fairly accurate.
- Bias decreases with increasing number of cloud layers (also in final product).

# Case study II: Role of cloud development






Under/overestimation alternates quickly in developing/decaying cirrus.

# Summary & Recommendations

Model simulation studies provide unique testing environment:

- (Model) truth is known and therefore
- processing and information content issues can be investigated.

Limitations of model simulation studies are:

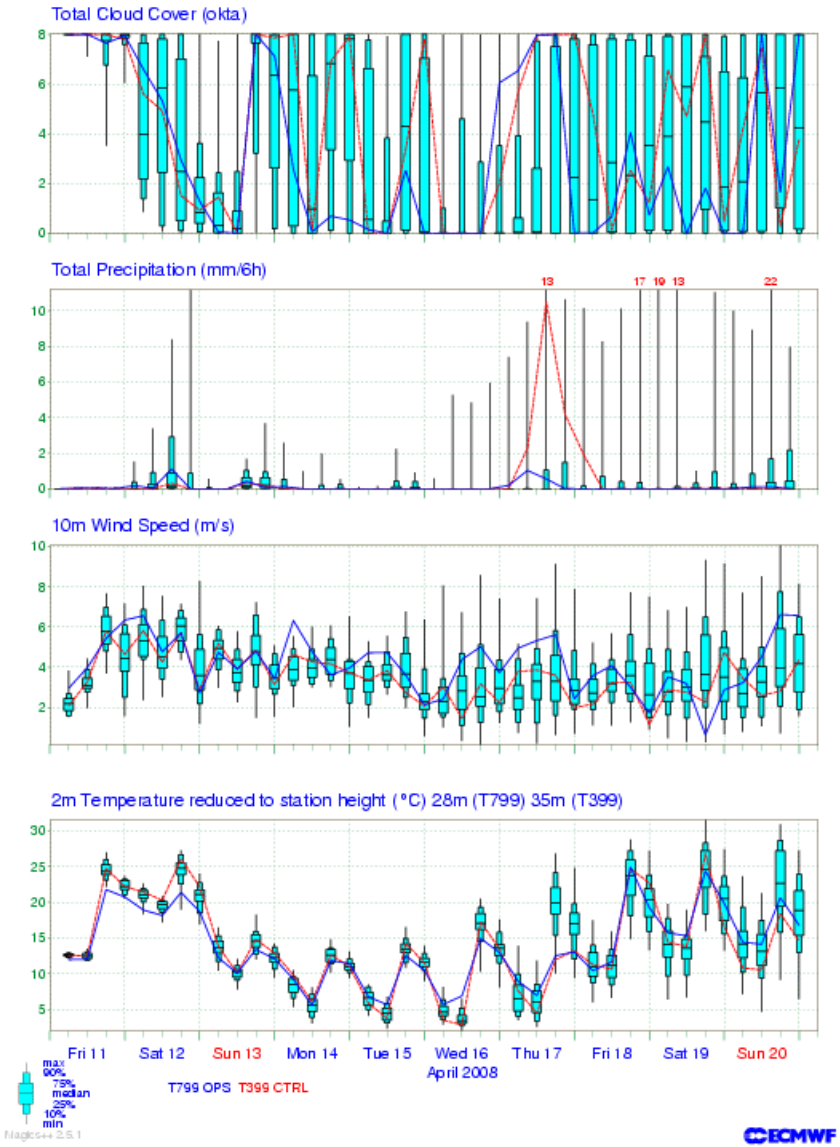
- Model only approximates truth (parameterizations of physical processes),
- spatial/temporal resolution still limited and does not equal that of observations.

Further studies should include:

- More recent version of (ECMWF) model with improved physics,
- same case study simulations with different model types (global vs. regional model, e.g. ECMWF and Met Office) to address sensitivity to physics and spatial resolution,
- processing of simulated fields by multiple centres (CIMSS, EUMETSAT) to address algorithm differences,
- iterative processing to address impact of individual algorithm components.

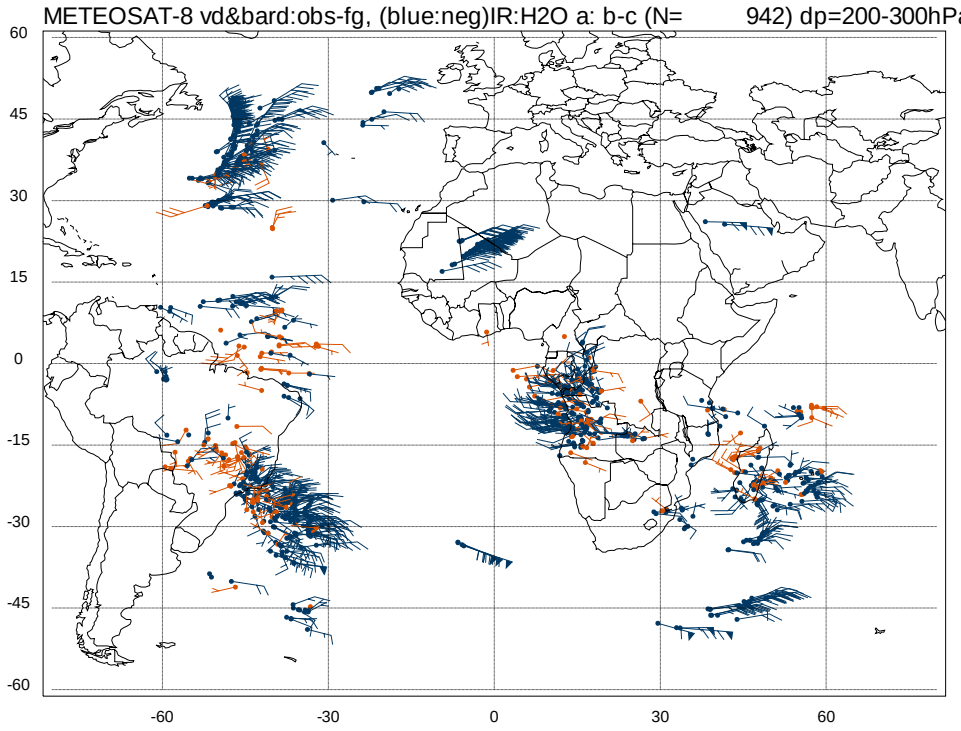
# … and now something completely different

Annapolis forecast initialized
on Friday 11/04/2008 00 UTC



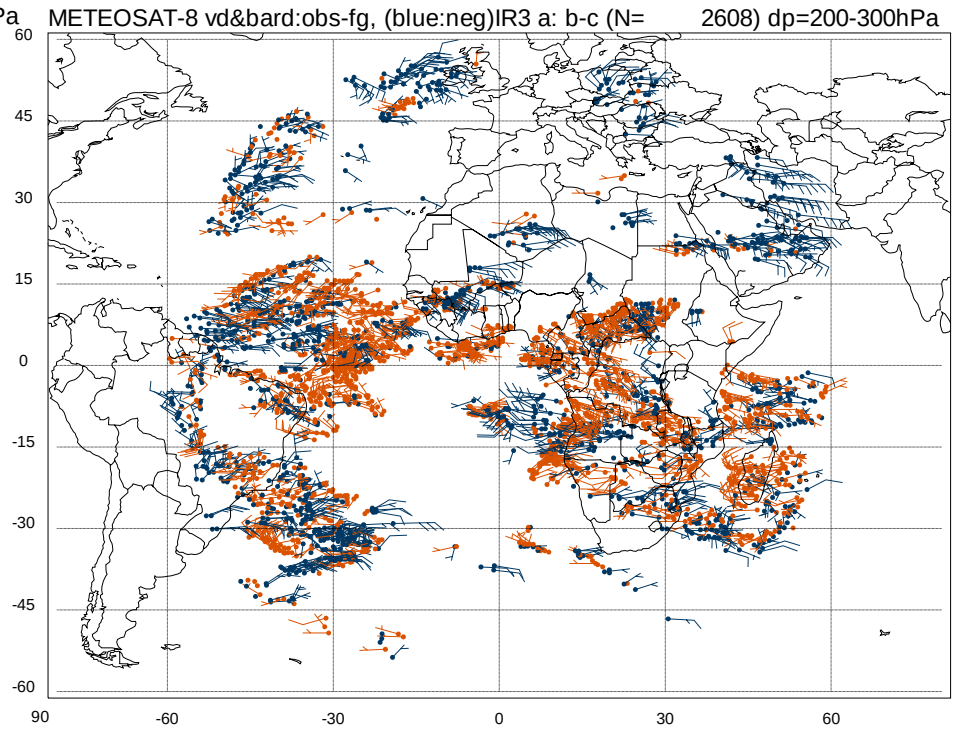
# Simulated vs. observed AMVs

12-13Z




Simulation (NOGAPS, raw)

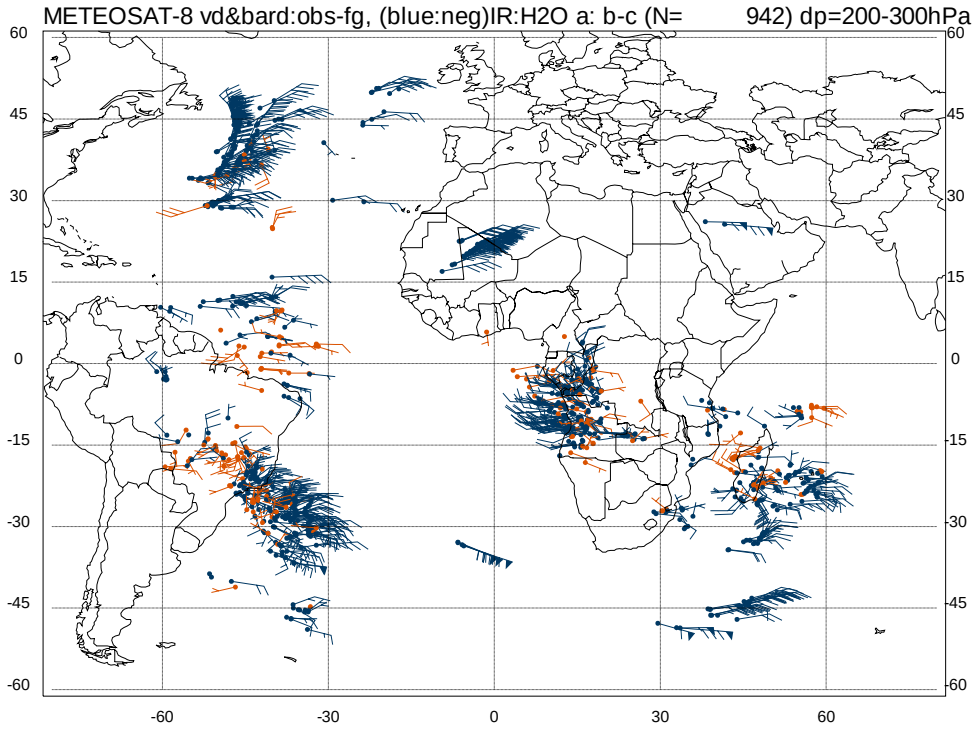
12-13Z




Observation (Meteosat-8, QI>60)

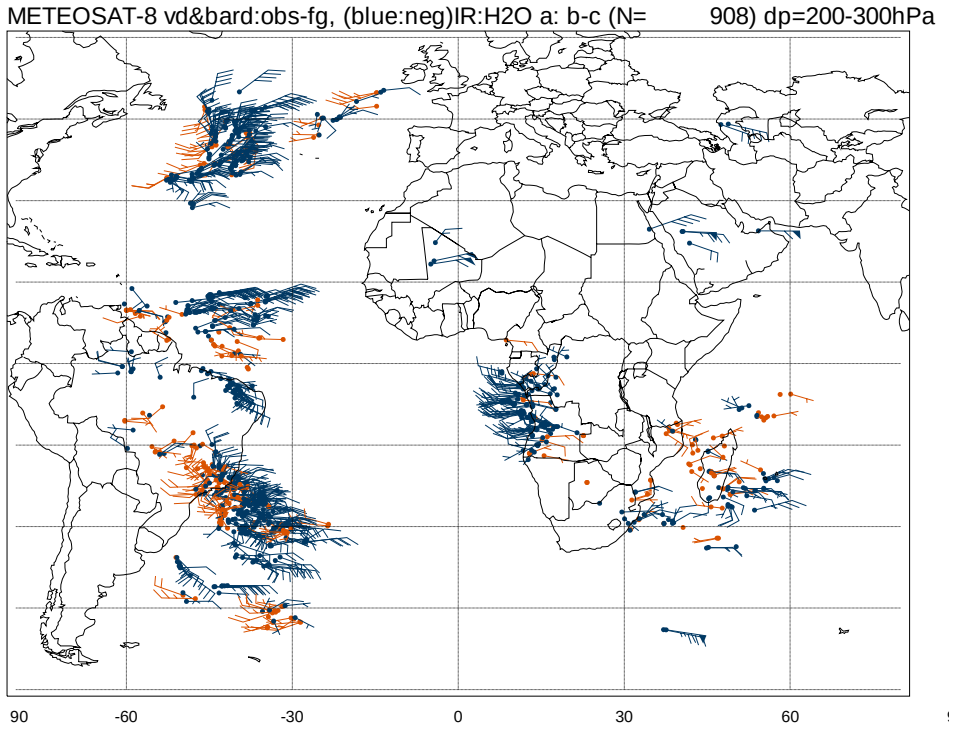
# Persistence of simulated AMVs

12-13Z




Simulation (NOGAPS, raw)

17-18Z




Simulation (NOGAPS, raw)