Aeolus: L2B winds and preparations at ECMWF

11th International Winds Workshop 2012

Mike Rennie

Acknowledgements: Lars Isaksen, Andras Horanyi, David Tan (ECMWF), Jos de Kloe (KNMI), ESA (Aeolus project team), L1B/L2A/L2B development teams

ECMWF Aeolus work – funded by ESA

- Develop L2B and L2C wind retrieval software
  - in collaboration with KNMI, Météo-France and DLR
- Is the 'L2 Meteorological Processing Facility'
  - operational production of L2B, L2C and auxiliary meteorological data products for ESA
- Monitoring of Aeolus data and assessment of impact
  - will assimilate L2B HLOS winds if giving positive impact
- Provide L2B software and documentation for NWP centres
- Participation in readiness tests, cal/val and commissioning phase

L2B processor functions

- **Purpose:**
  - **Produce HLOS (horizontal line-of-sight) wind observations suitable for data assimilation (L2B data), from calibrated L1B data and auxiliary meteorological data**
- **Portable source code (Fortran); three processing instances:**
  - **Operational processing at ECMWF, products delivered to ESA**
  - **Real-time processing at other NWP centres for their own assimilation:**
    - **source code and documentation available here:**

      http://data-portal.ecmwf.int/data/t/software/aeolus
  - **Re-processing at ESA for delayed data**

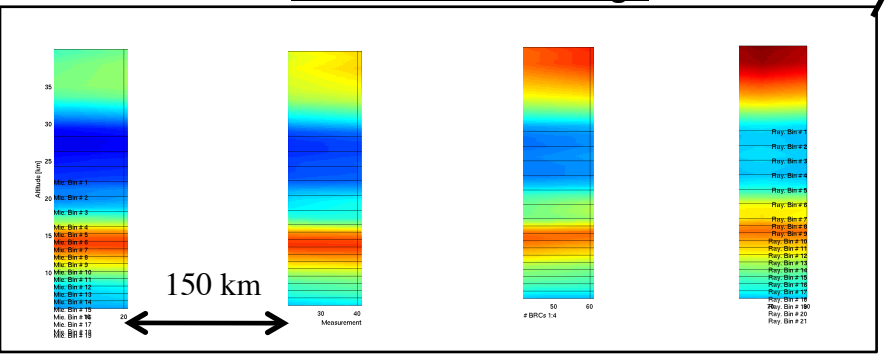
Realistic example of L2B processing

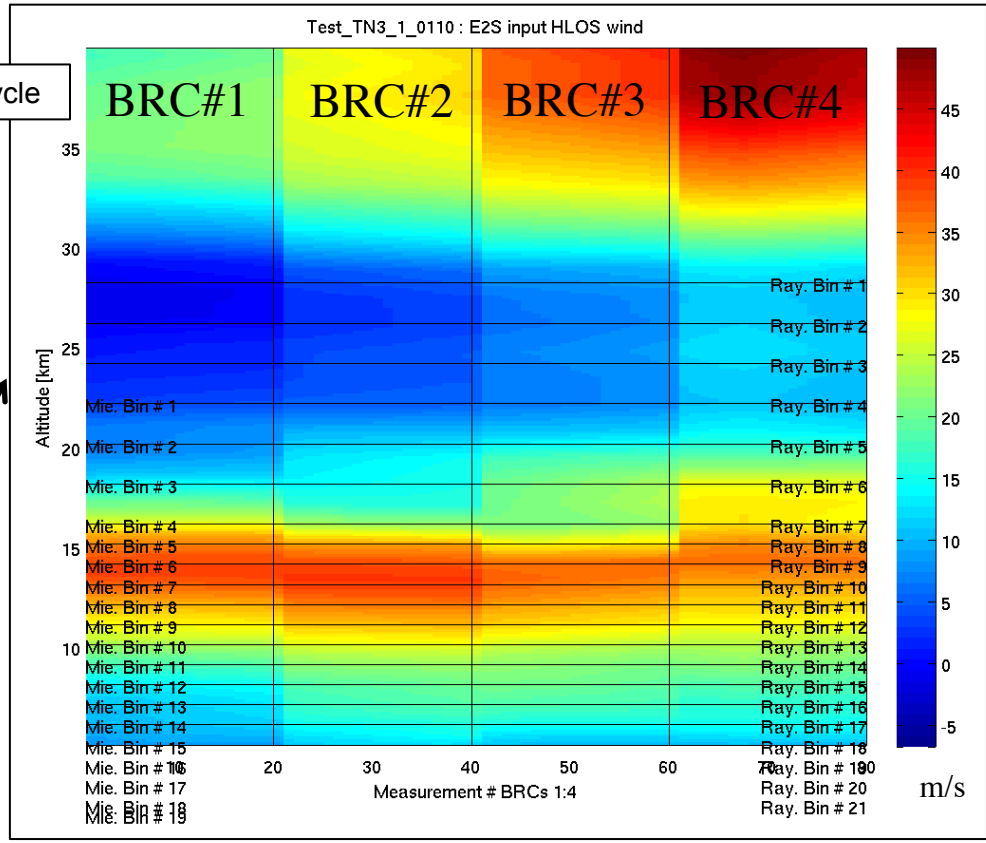
- "Chain of processors" testing (J. de Kloe, KNMI)
  - the final burst mode processors – continuous mode not ready yet
  - Atmospheric data → simulator → L1BP → L2BP → plotting/analysis of results

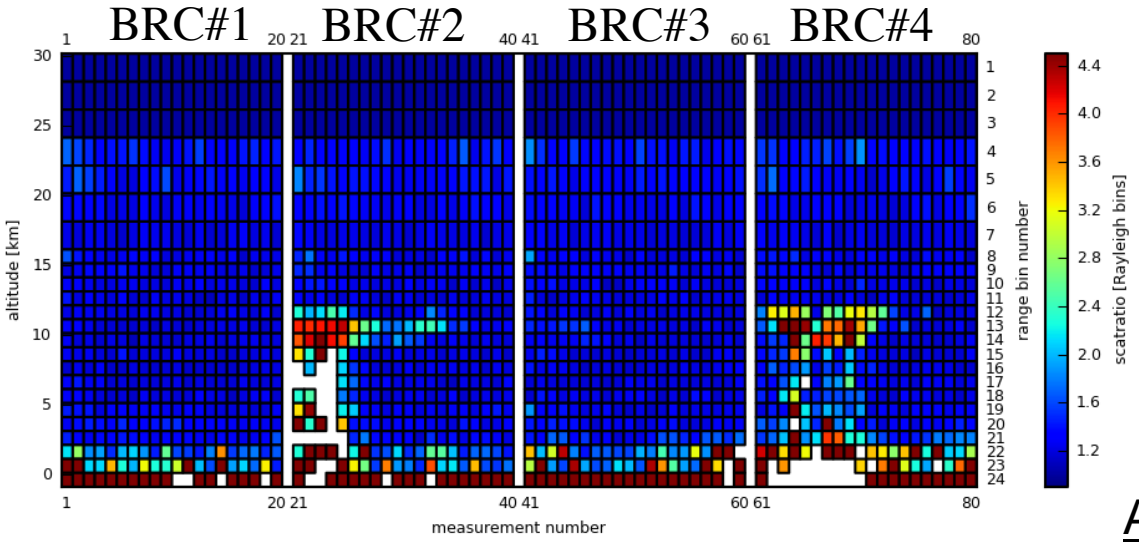
Simulator input HLOS winds from ECMWF model

Basic Repeat Cycle

- One realistic example shown here
  - Inputs to simulator:
    - Geophysical inputs: mountain scene, some clouds (scattering ratio from LITE), ECMWF winds, ECMWF temperatures
    - Realistic noise settings



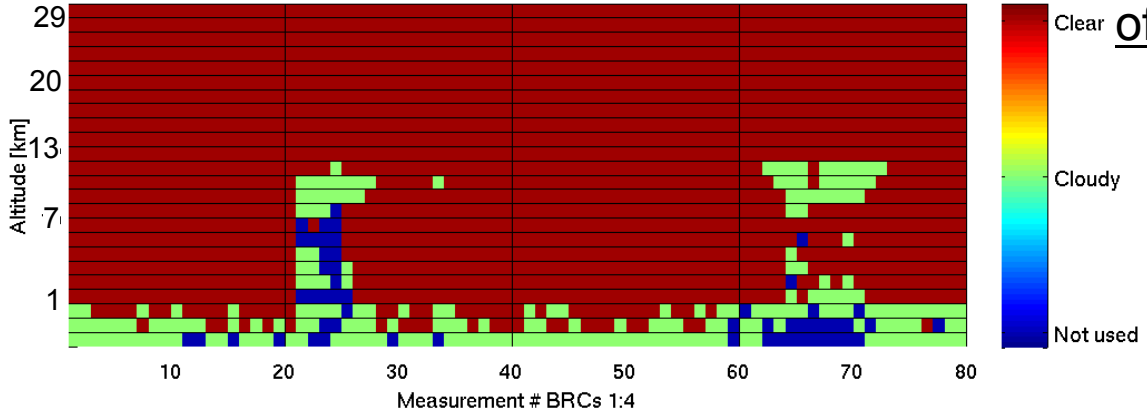




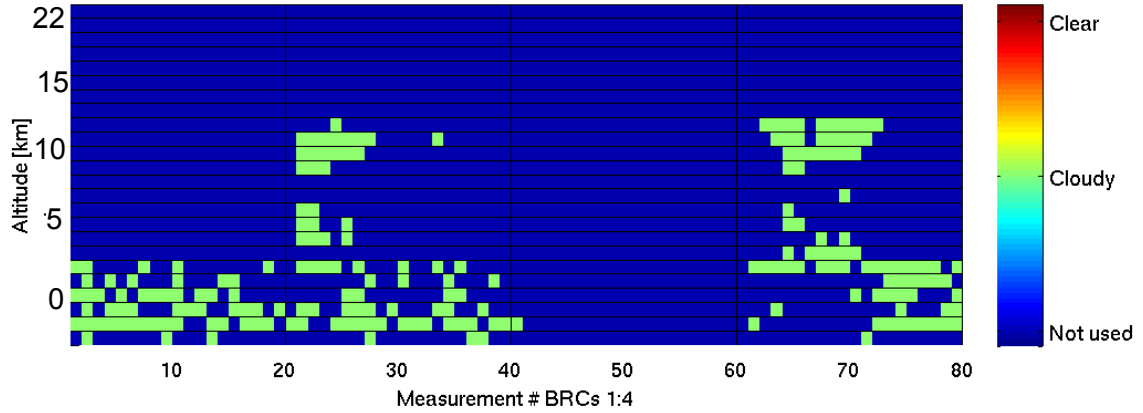
L1B scattering ratio estimate

$$B = \frac{\beta_A + \beta_{Mol}}{\beta_{Mol}}$$

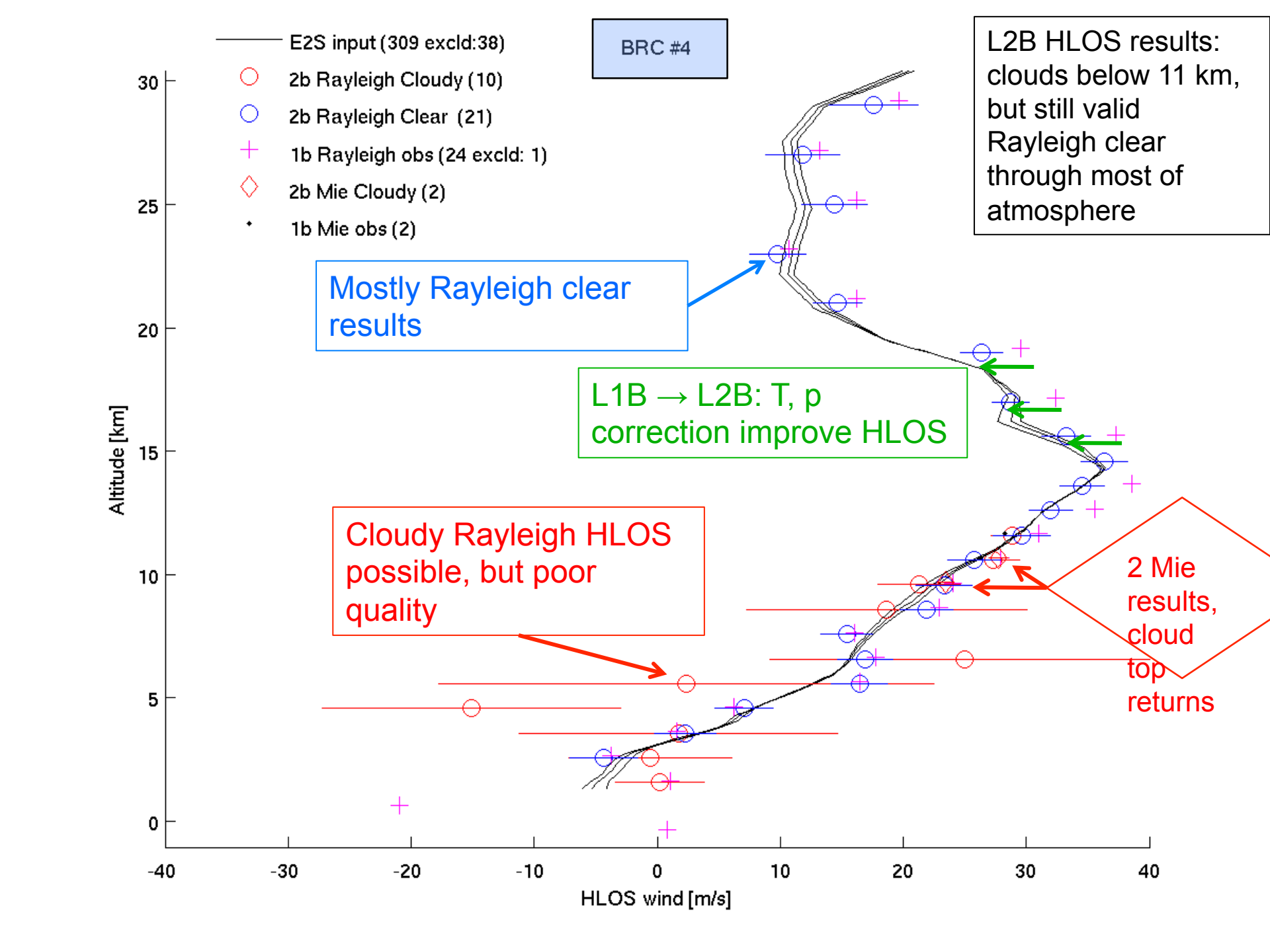
<u>Atmospheric scene classification of each measurement bin (L2B):</u>

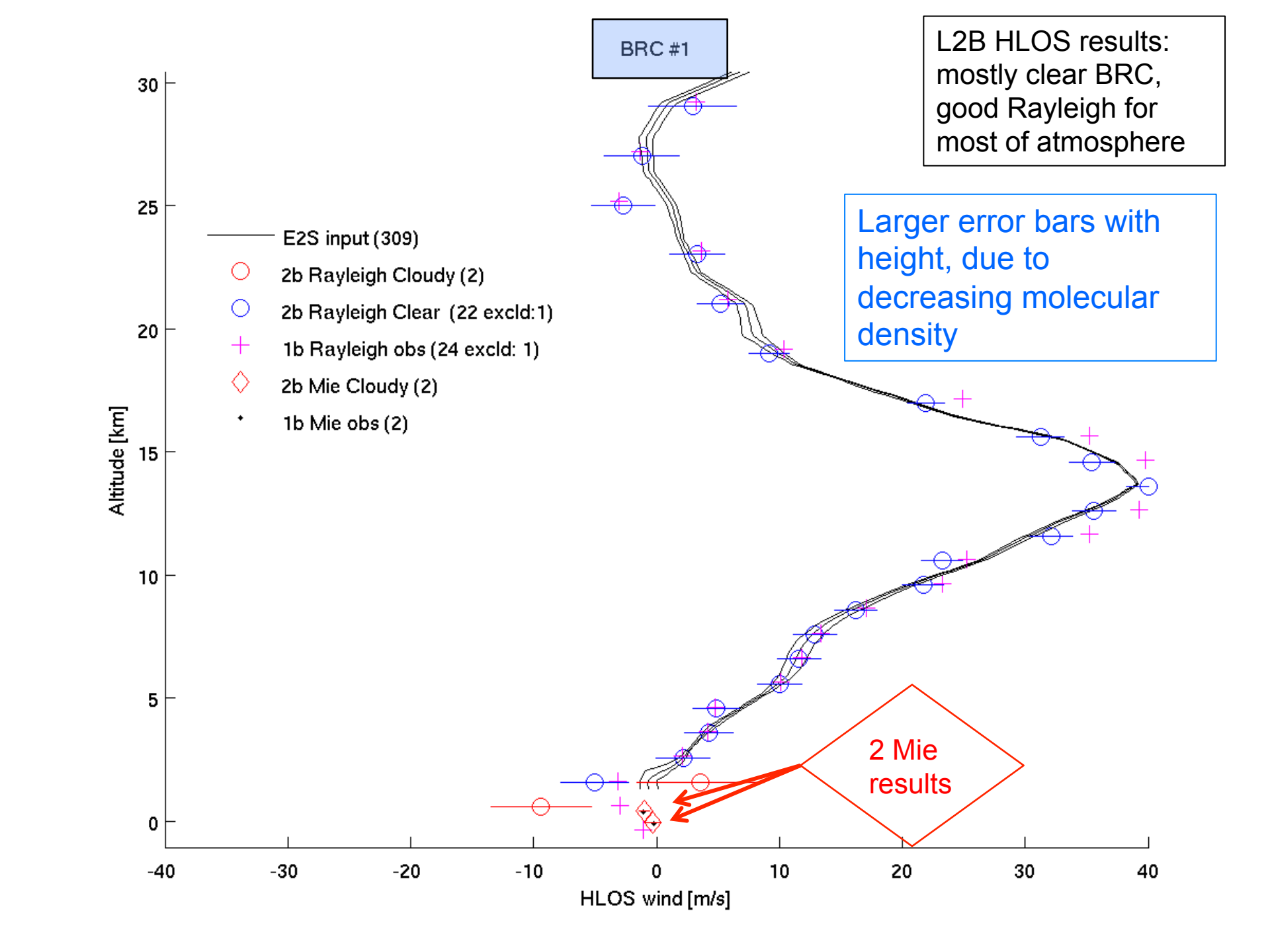


Rayleigh scene classification

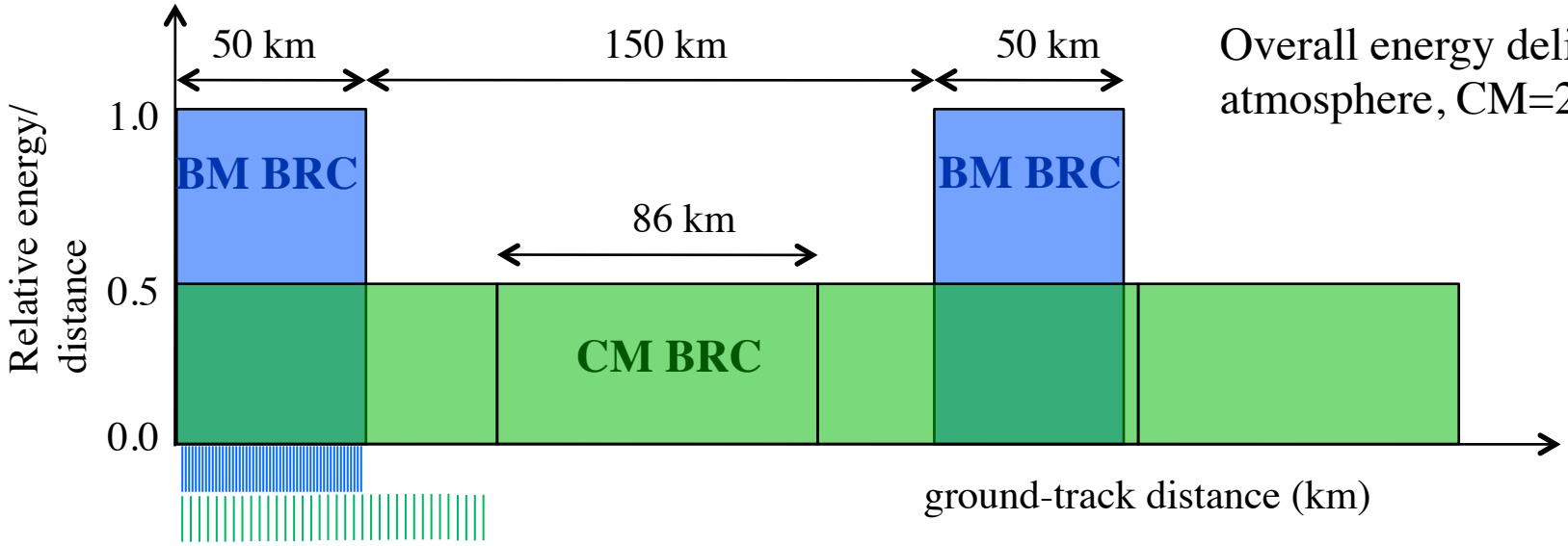


Mie scene classification


E2S input (309 excld:38)
2b Rayleigh Cloudy (10)
2b Rayleigh Clear (21)
1b Rayleigh obs (24 excld: 1)
2b Mie Cloudy (2)
1b Mie obs (2)
BRC #4
L2B HLOS results: clouds below 11 km, but still valid Rayleigh clear through most of atmosphere
Mostly Rayleigh clear results
L1B → L2B: T, p correction improve HLOS
Cloudy Rayleigh HLOS possible, but poor quality
2 Mie results, cloud top returns
Altitude [km]
HLOS wind [m/s]
30
25
20
15
10
5
0
-40
-30
-20
-10
0
10
20
30
40

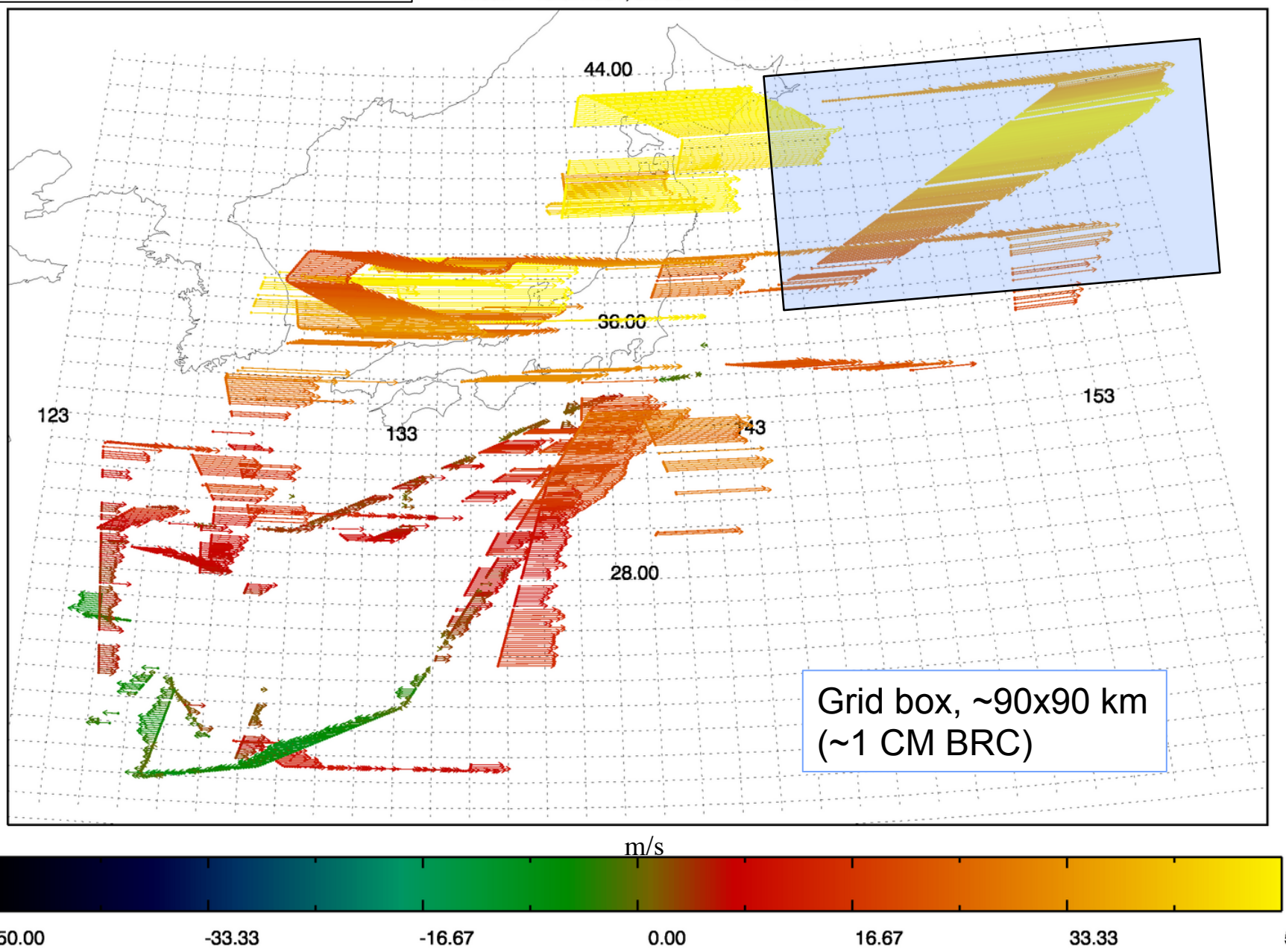

BRC #1
L2B HLOS results: mostly clear BRC, good Rayleigh for most of atmosphere
Larger error bars with height, due to decreasing molecular density
E2S input (309)
2b Rayleigh Cloudy (2)
2b Rayleigh Clear (22 excld:1)
1b Rayleigh obs (24 excld: 1)
2b Mie Cloudy (2)
1b Mie obs (2)
2 Mie results
Altitude [km]
HLOS wind [m/s]
30
25
20
15
10
5
0
-40
-30
-20
-10
0
10
20
30
40

Burst mode (BM) vs. continuous mode (CM) laser



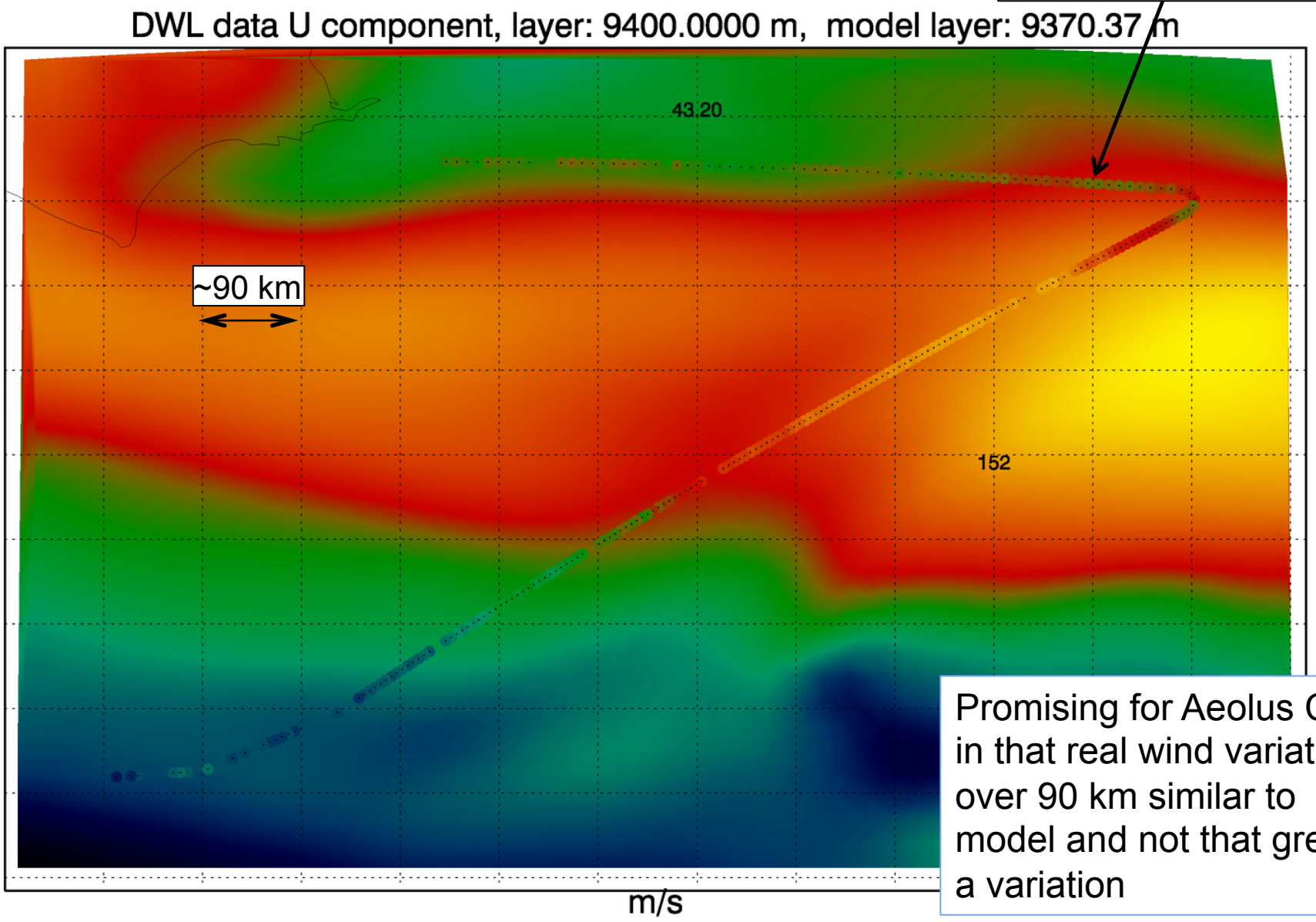
- **BM was restricted to averaging within 50 km "bursts"**
- **CM allows for averaging measurements over varying lengths – can cross BRC (Basic Repeat Cycle) boundaries – now being implemented for CM L2BP**
- **Does CM deliver enough energy in a given horizontal distance to capture wind variations suitable for NWP resolutions in 2014-15? *Impact studies***

Qualitative assessment with real DWL wind data



ECMWF (25 km) short-range fc by coloured contours, 19/09/2008 03Z

DWL data, circles



Promising for Aeolus CM, in that real wind variation over 90 km similar to model and not that great a variation

Plans for upcoming year

- Finish first CM L2B processor and release on website, by June 2012
- Complete operational Aeolus L2B/C processing implementation at ECMWF
- Sensitivity tests with Aircraft DWL obs in data assimilation – treating it like Aeolus
- Collaborate with Andras Horanyi (ECMWF) on the new ESA contract "Impact of CM on NWP operation"
- Preparations for assimilating Aeolus

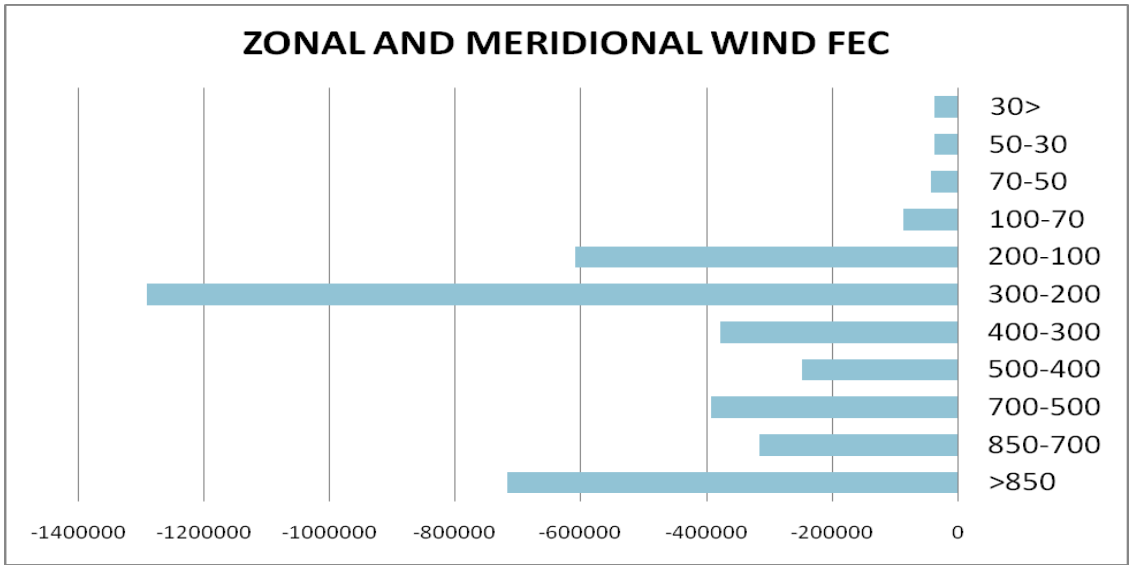
Relative impact of wind obs using FEC

- **Diagnostic used:**
  - ***Cardinali C., 2009: Monitoring the observation impact on the short-range forecast. Quarterly Journal of the Royal Meteorological Society. 135., pp. 239-250.***
  - **FEC (forecast error contribution) – influence of ob. on 24 hr forecast error in "dry energy norm" (analysis treated as truth)**

$$\delta J_{fe} = \mathbf{K}^T \frac{\partial J_{fe}}{\partial \mathbf{x}_a} \left(\mathbf{y} - \mathbf{H}\mathbf{x}_b \right)$$

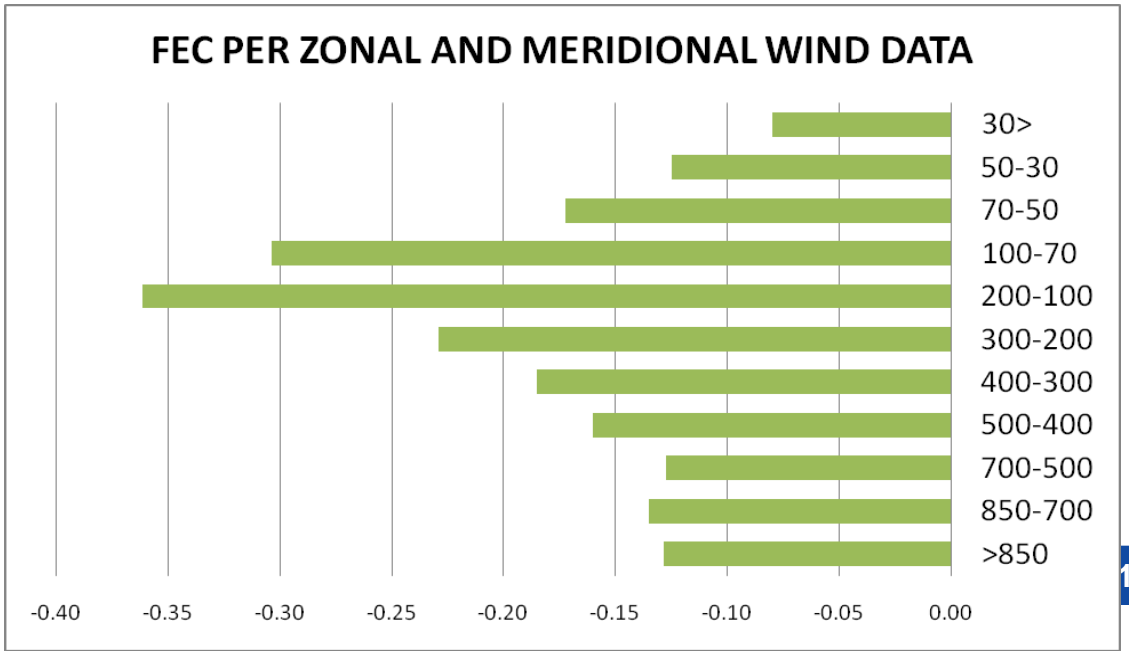
- **Experiment details:**
  - **3/9/2011 – 30/9/2011, T511 (40 km), CY37R2 (ECMWF IFS)**
- **Work by Andras Horanyi (ECMWF), "Impact of Aeolus CM on NWP" ESA contract**

FEC for all wind obs by atmospheric level, global



Total forecast error contribution for wind obs, binned by level (hPa):

- similar to number of observations at each level



As above, but per obs number at a given level:

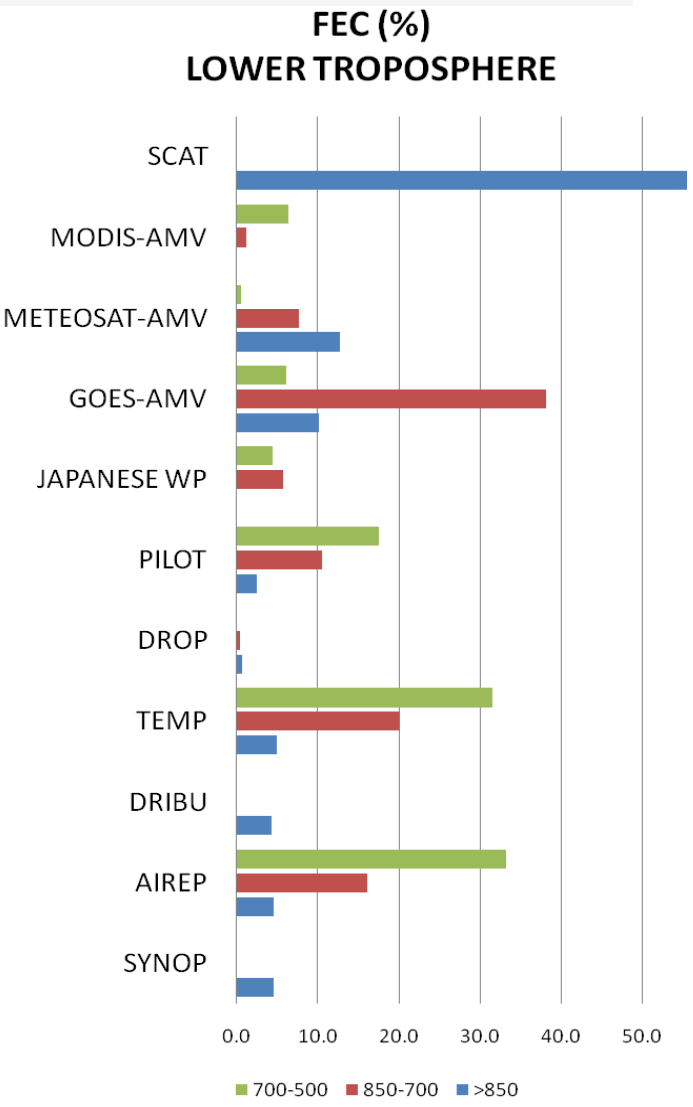
- winds 100-200 hPa (~11-18 km) particularly useful
- Good news for NWP, since Aeolus should provide a lot of data at this range

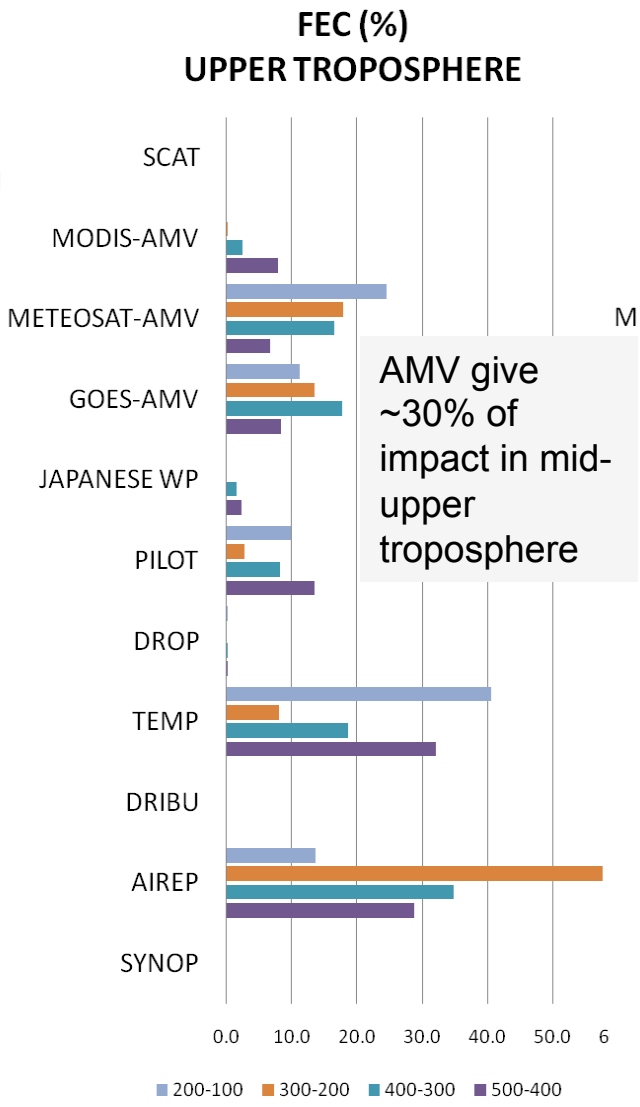
ECMWF

Split by wind ob type: Relative contribution to FEC (%) per layer, global

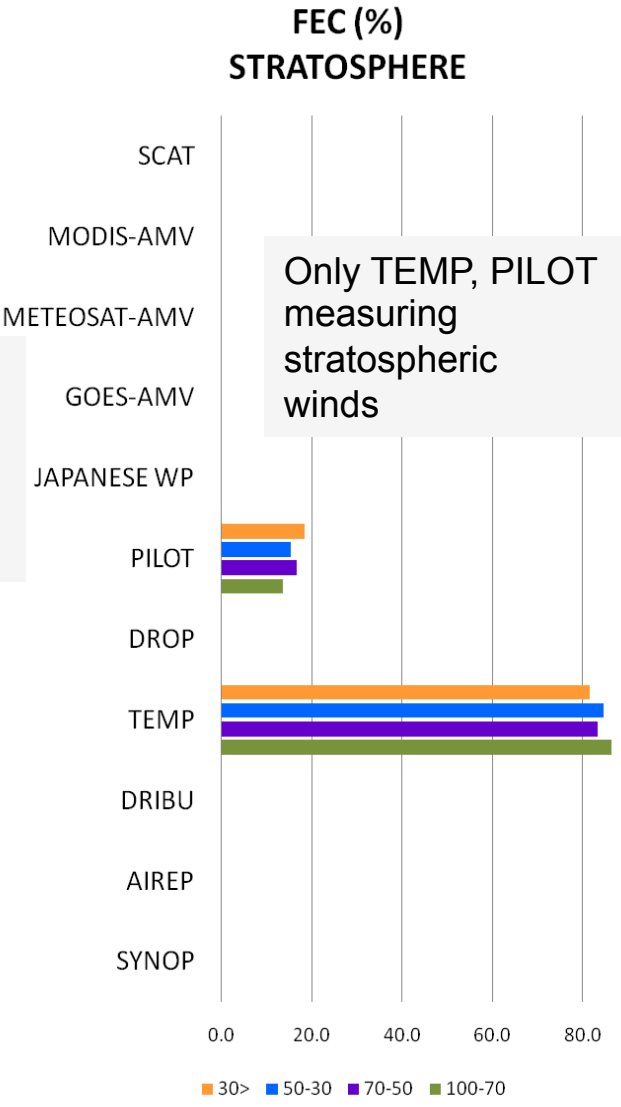
Good contributions from SCAT and AMV

Conventional winds tend to dominate impact above 500 hPa



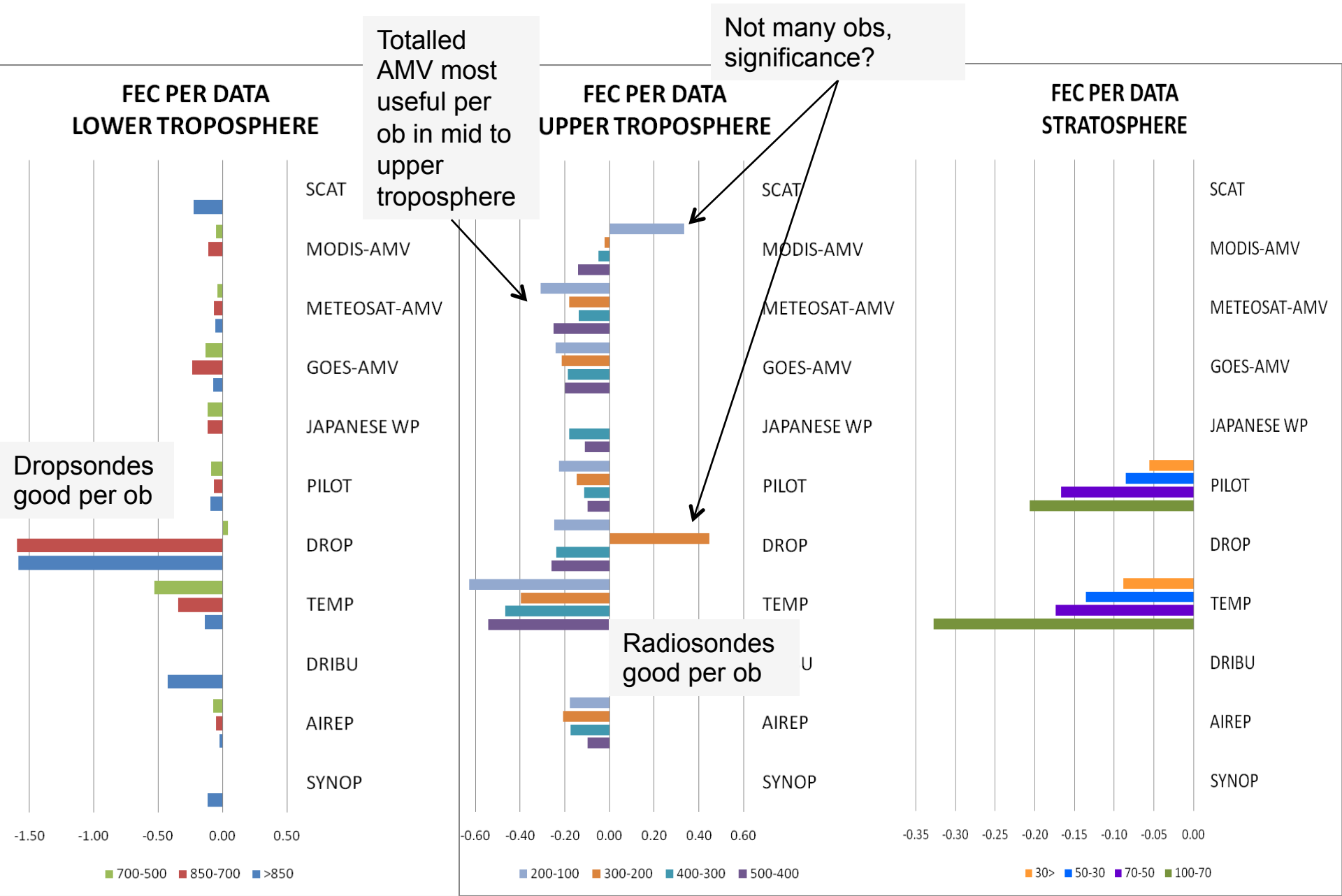


AMV give ~30% of impact in mid-upper troposphere



Only TEMP, PILOT measuring stratospheric winds

Absolute FEC per ob, per layer, global



Thanks for listening, any questions?