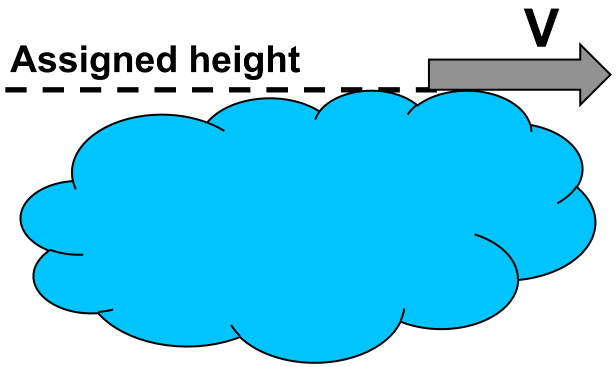
Investigations on alternative interpretations of AMVs

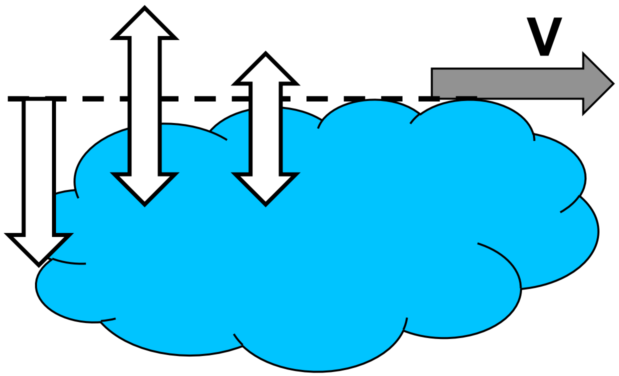
Kirsti Salonen and Niels Bormann

Traditional interpretation



- Assumption: tracked features act as passive tracers of atmospheric flow.
- Single-level wind observations assigned to representative height
  - Cloud top for high and mid-level clouds
  - Cloud base for low level clouds

Single level or layer average?



- Interpreted as single-layer observations even though
  - Clouds have vertical extent
  - Radiances represent contribution of deep vertical layer when tracking clear-sky features
- Comparison to radiosonde(e.g. 1) and lidar(e.g. 2) observations and results from simulation framework(e.g. 3) suggests benefits from layer averaging.

(1) Velden and Bedka, 2009: Identifying the Uncertainty in Determining Satellite-Derived Atmospheric Motion Vector Height Attribution. JAMC, 48, 450-463.

(2) Weissman et al, 2013: Height Correction of Atmospheric Motion Vectors Using Airborne Lidar Observations. JAMC, 52, 1868-1877.

(3) Hernandez-Carrascal and Bormann, 2013: Atmospheric Motion Vectors from Model Simulations. Part II: Interpretation as Spatial and Vertical Averages of Wind and Role of clouds. Accepted to JAMC.

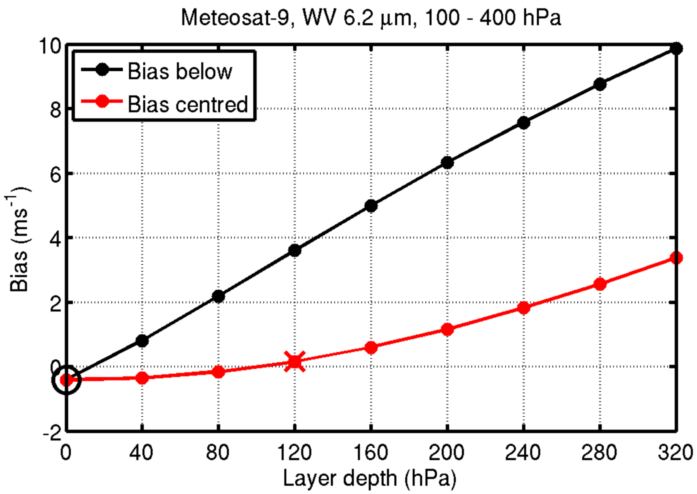
Experimentation with layer averaging

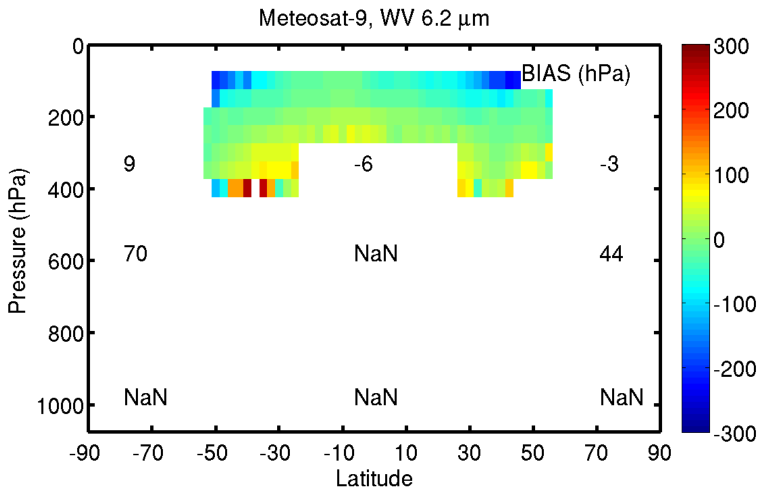
- Set of monitoring experiments
    - Varying layer depths: 0 … 320 hPa
    - Only departure statistics, no data assimilation experiments
    - 1.1-29.2.2012, CY38R1, T511, 91 levels
- Centred averaging
    - AMV assigned to representative height
- Averaging below
    - AMV assigned to cloud top

Example: MET-9 WV 6.2 μm, 100 – 400 hPa

Best-fit pressure statistics indicate small bias

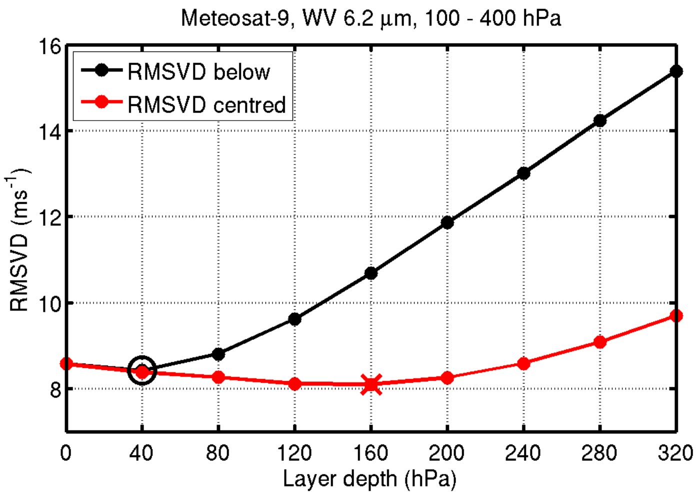
- **Averaging below: 2% improvement in RMSVD**
- **Centred averaging: 6% improvement in RMSVD**





Assigned p lower in the atmosphere than best-fit p

Assigned p higher in the atmosphere than best-fit p



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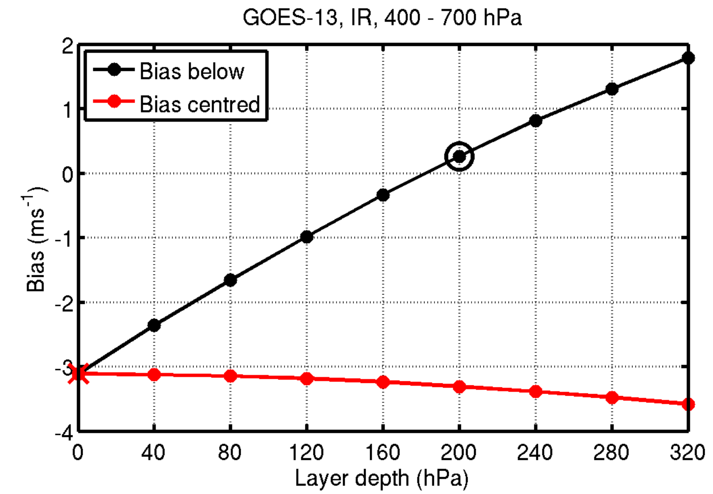
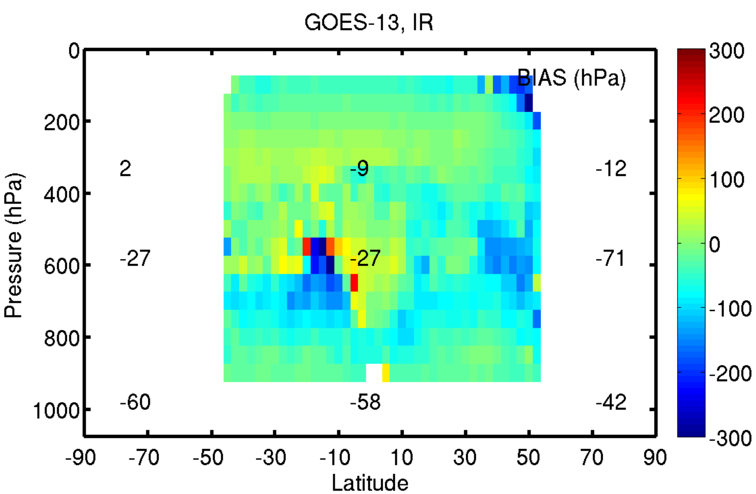
Example: GOES-13 IR, 400 – 700 hPa

Best-fit pressure statistics indicate large negative bias

- **Averaging below: 29% improvement in RMSVD**
- **Centred averaging: 1% improvement in RMSVD**





Assigned p lower in the atmosphere than best-fit p

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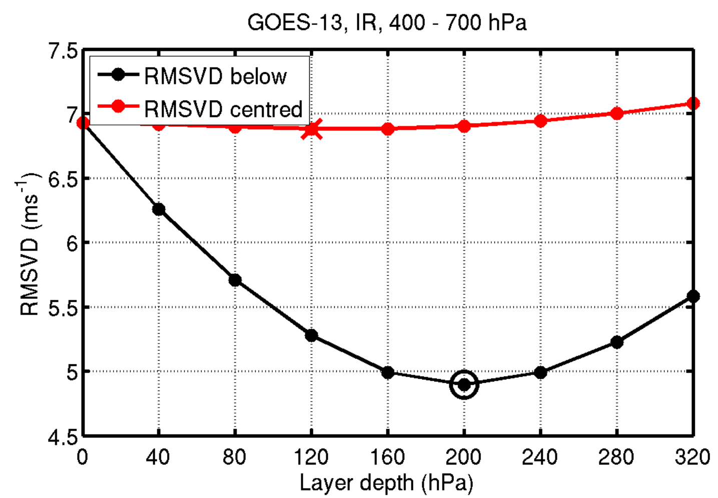
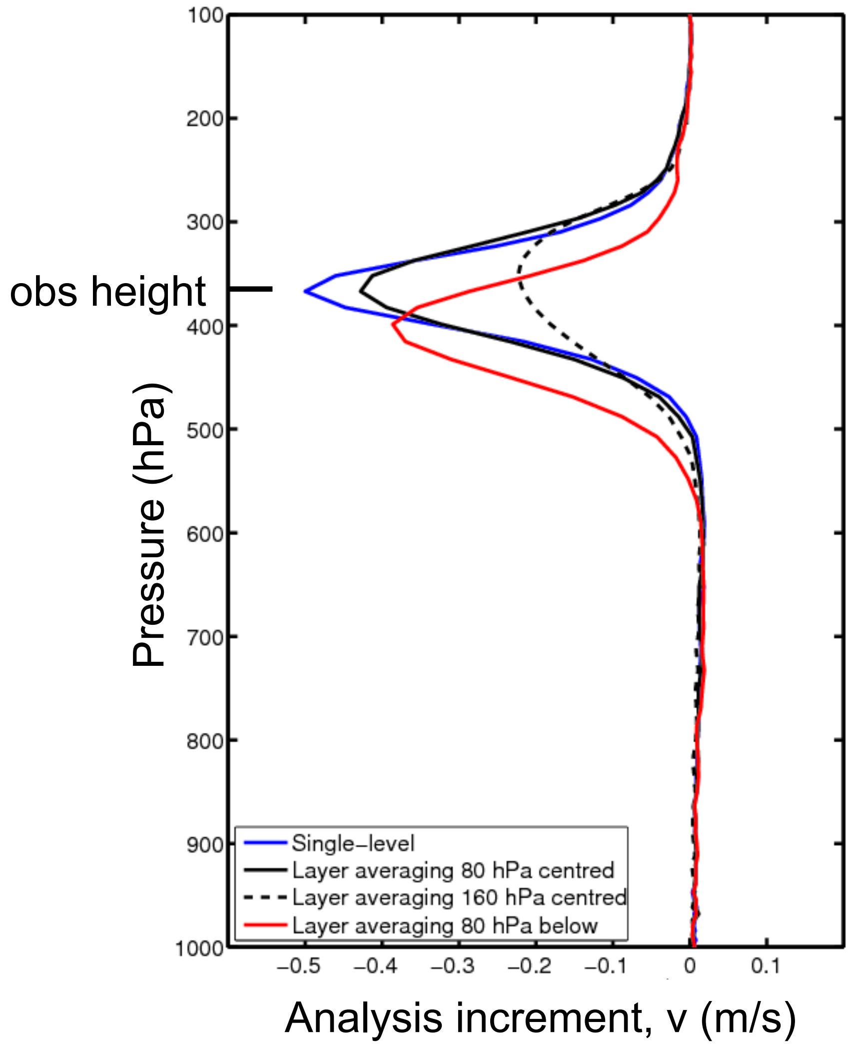


Notes on layer averaging

- Up to 30% reductions in RMSVD, typically 5-10%.
- Centred averaging generally better when best-fit pressure statistics indicate small biases.
  - Minimum RMSVD typically reached with 120-160 hPa layer averaging.
  - Reductions in RMSVD < 10%.
- Averaging below shows significant improvements especially when best-fit pressure statistics indicate that the assigned AMV height is too high
  - Minimum RMSVD typically reached with 40-80 hPa layer averaging.
  - Would similar improvements be obtained with correcting the systematic height assignment errors?

How is the information spread the in vertical?



- **Single observation experiment**
  - **First guess departure the same in all four cases**

1. Single-level observation operator (blue)

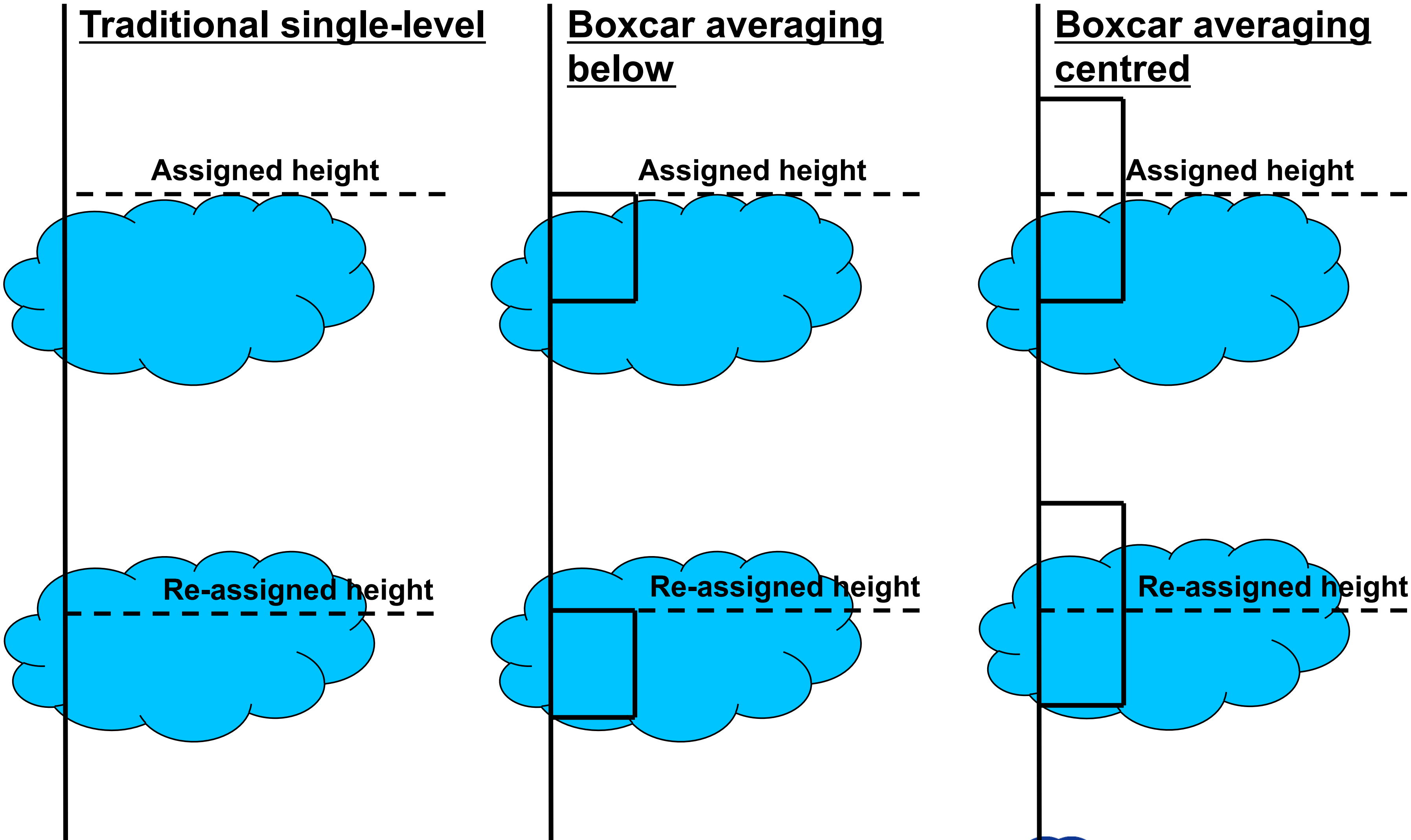
Boxcar layer averaging:

2. 80 hPa layer centred at the observation height (black solid)

3. 160 hpa layer centred (black dashed)

4. 80 hPa layer below the observation height (red)

Observation operators under testing



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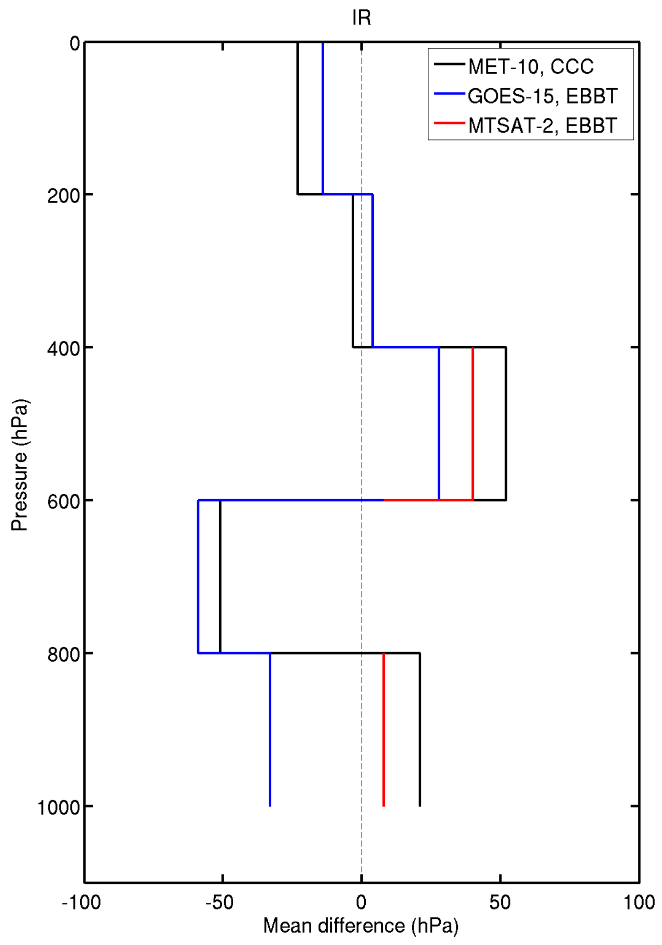
Re-assignment

- Use long-term bias statistics in the observation operator design to take into account systematic height assignment errors.
- Based on model best-fit pressure statistics. Bias varies typically between ±50 hPa.
- First trial: bias statistics defined separately for all satellites, channels, height assignment methods, vary with height.



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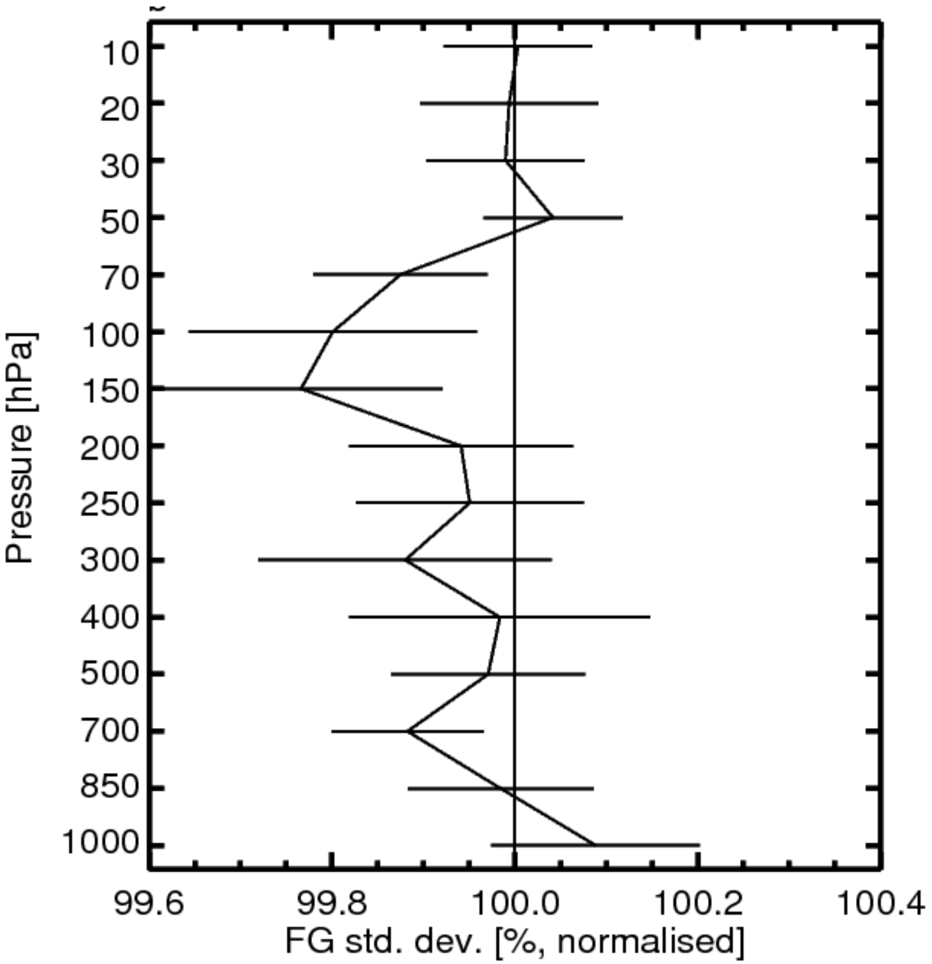
Data assimilation experiments

- Control: single-level observation operator
- Experiments with
    - Boxcar centred averaging 120 hPa
    - Boxcar averaging 40 hPa below
    - Re-assignment and single-level observation operator
    - Re-assignment and boxcar centred averaging 120 hPa
    - Re-assignment and boxcar averaging 40 hPa below
- Winter period, 1.12.2013 – 28.2.2014.
- IFS CY40r1, T511, 137 levels, 12-hour 4D-Var. All operationally used conventional and satellite observations used.

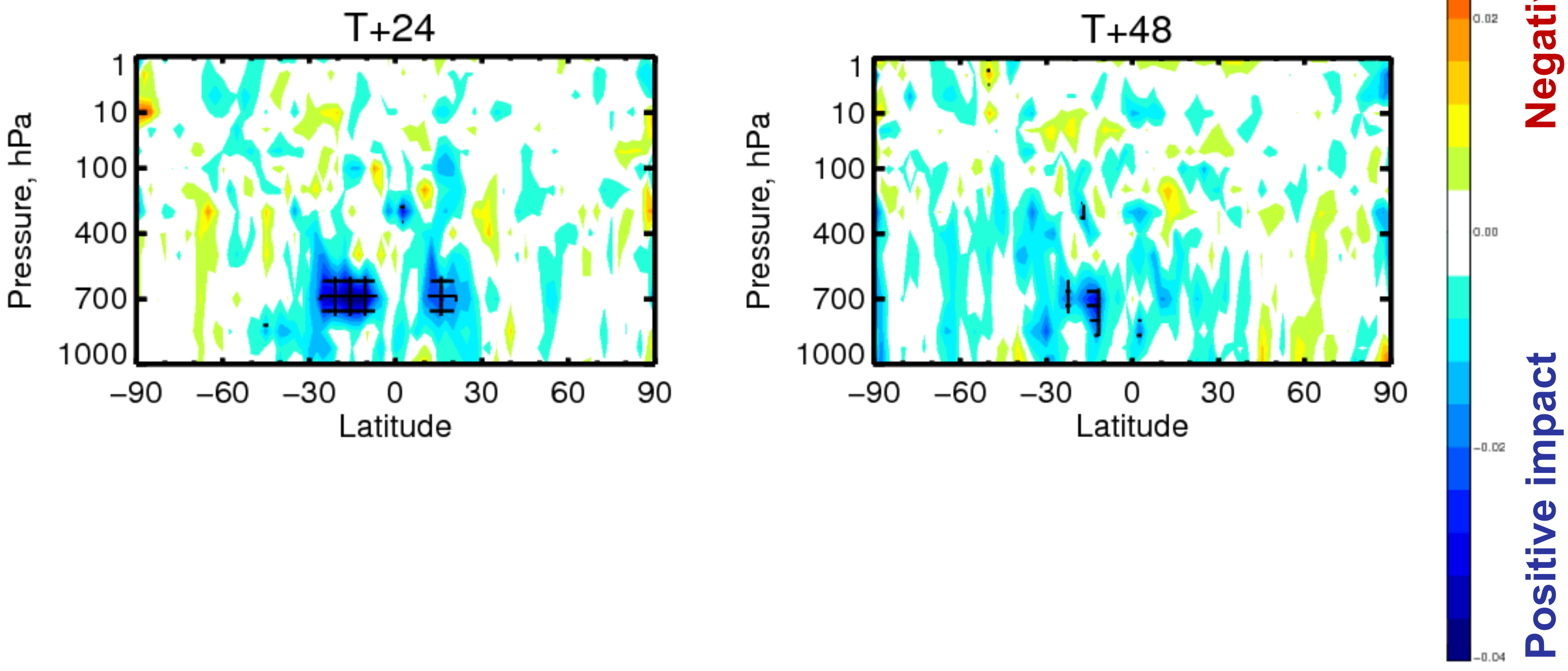
Single-level observation operator and re-assignment

- **Normalised change in the standard deviation of background differences from radiosonde, pilot, aircraft and wind profiler observations.**



Single-level observation operator and re-assignment

Normalised difference in VW RMS error



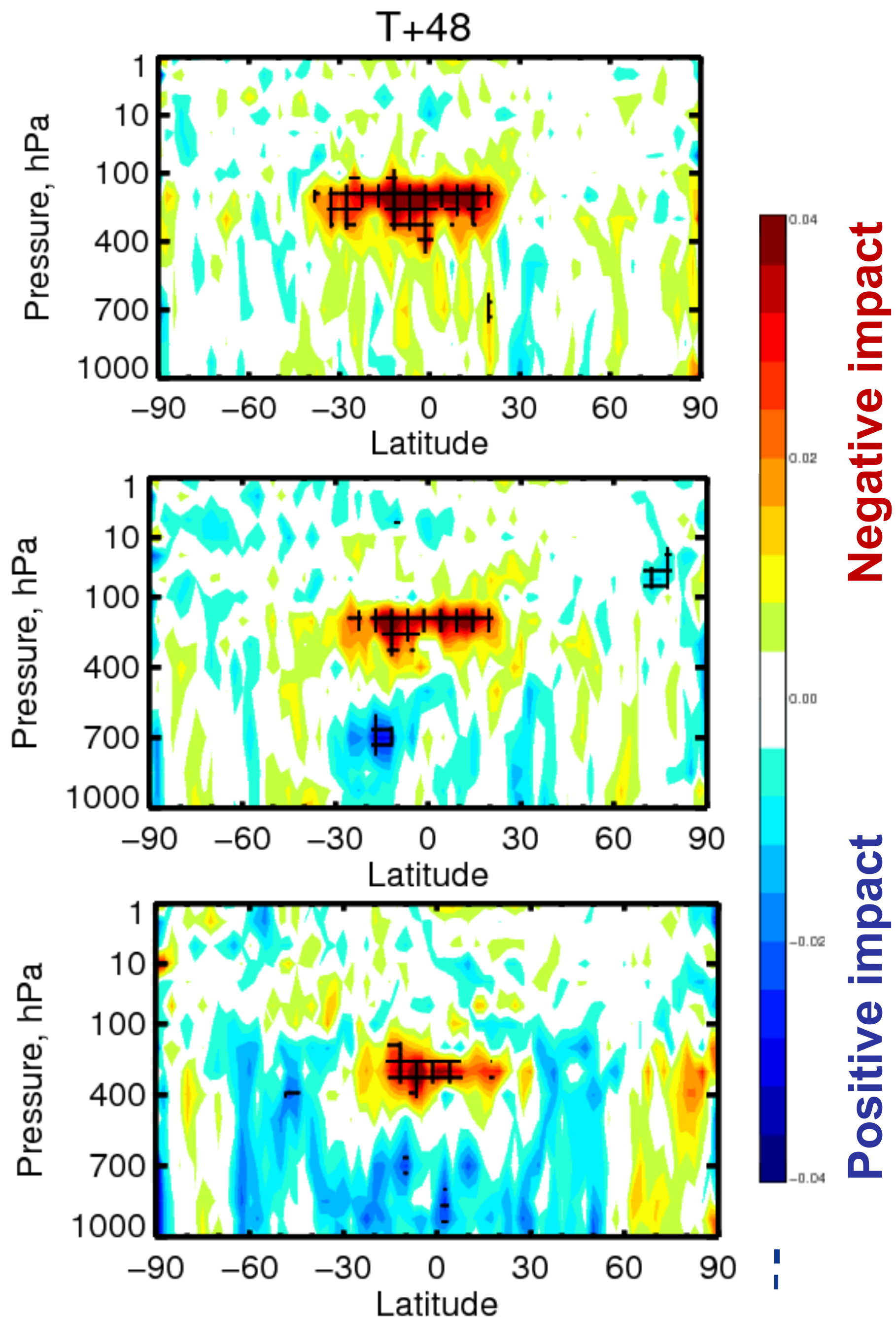
Layer averaging

Normalised difference in VW RMS error

Centred averaging 120 hPa

Re-assignment and centred averaging 120 hPa

Averaging below 40 hPa



Conclusions so far

- Layer averaging can bring up to 30% reductions in RMSVD, typically 5-10%.
- Single observation experiments confirm that the choice of the observation operator affects how information is spread in vertical.
- Preliminary results from the data assimilation experiments indicate:
    - Clear benefits from taking into account the systematic height errors
    - Degradation in the forecast quality above 400 hPa when layer averaging is used. Reason is not clear yet.

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What next

- Extend the most promising data assimilation experiments to cover another season.
- Investigate how to improve the layer averaging
  - Is boxcar averaging optimal or would something else be better?
- Consider do we need to take into account geographical variations in the height biases in more details
  - The observation operator should not become too complicated