Bias Correction of Satellite Data at NCEP

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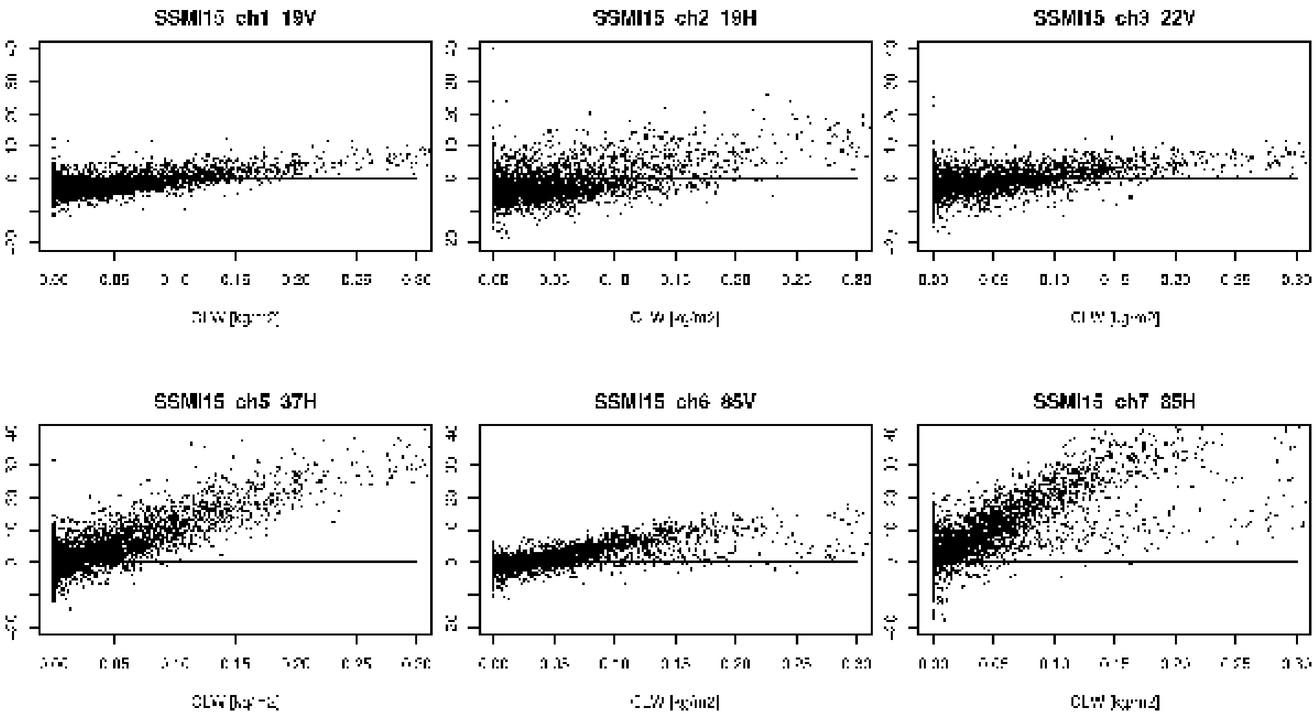
Background

- Bias correction scheme in the GDAS consists of a slowly varying component and an air mass dependent component. The bias, *b*, for channel *j* is given by:

$$b_j = s_{jm} + \sum_{k=1}^{k=5} c_{jk} p_{jk},$$

- The slowly varying component s_{jm} is intended to remove the bias across a scan. It is computed at each scan position *m* from quality-controlled *O-G* accumulated over the latest 30 days, updated at every post-analysis step. This slowly varying component is very stable with time and the only significant changes occur when there is an anomaly with the instrument.
- The second bias component is expressed as a linear equation with five predictors p_{jk}. The predictors p_{jk} are computed from the first-guess *G* or updated guess *G2*. The coefficients c_{jk} are included as analysis variables, and are determined globally in the analysis along with other analysis variables.
  - CLW correction for AMSU-A ch1-4,15 is significant. Other microwave sensors have also shown strong correlation between CLW and bias.

DMSP-15 SSM/I



CLW range:0-0.3
ΔT range:-20 to +40

Dependency of observed-minus-guess brightness temperature difference (*O*-*G*, units are K) on CLW (kg/m2) over the ocean. The vertical and horizontal axes correspond to *O*-*G* and CLW. Data shown is from DMSP-15 SSM/I data after the thinning step at 00UTC on 1 July 2004.

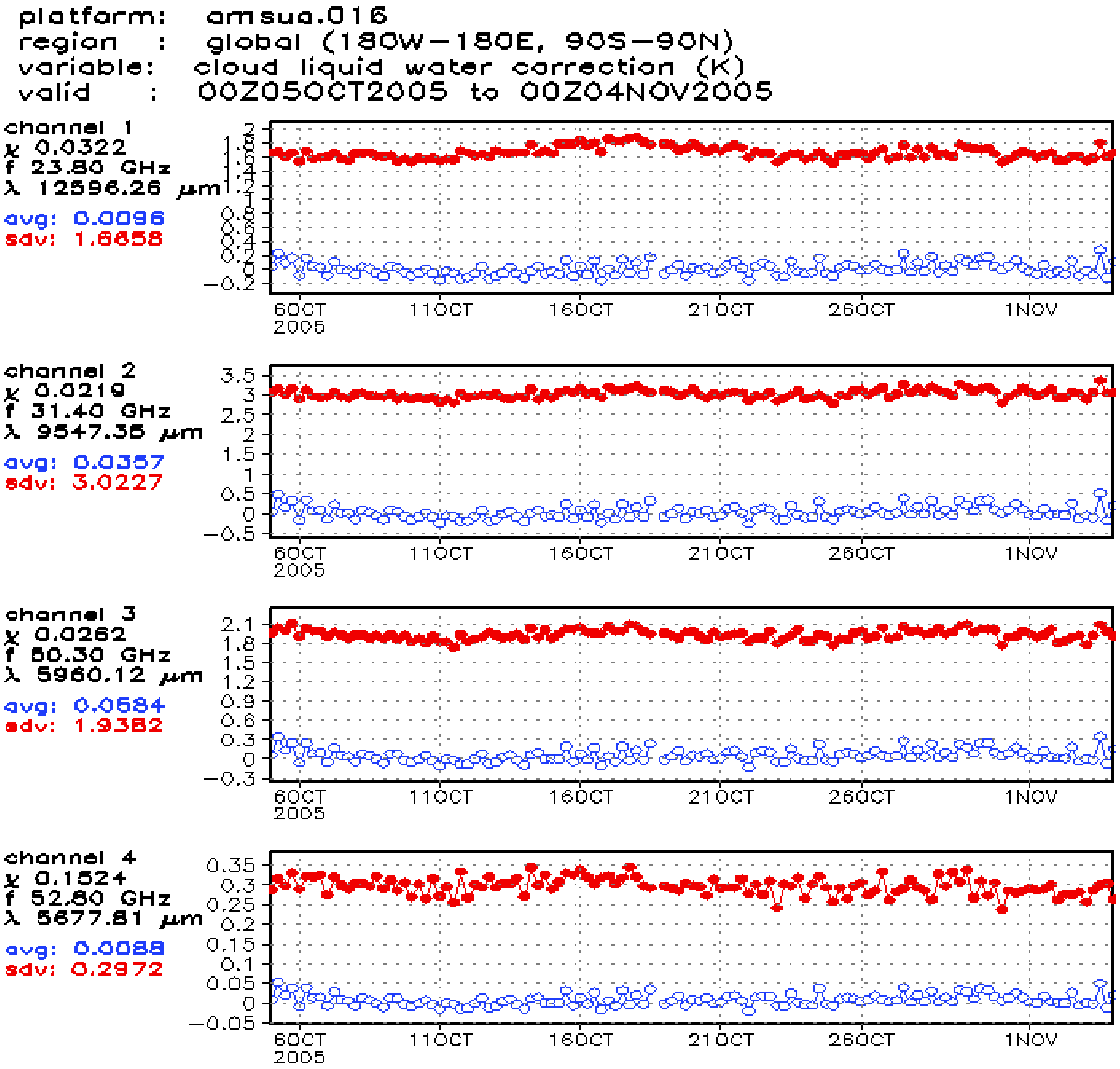
Radiance Assimilation Monitoring

- EMC real-time monitoring webpage
  - http://www.emc.ncep.noaa.gov/gmb/gdas

- Can view evolution of bias correction terms and, in the case of the air mass correction, coefficients.

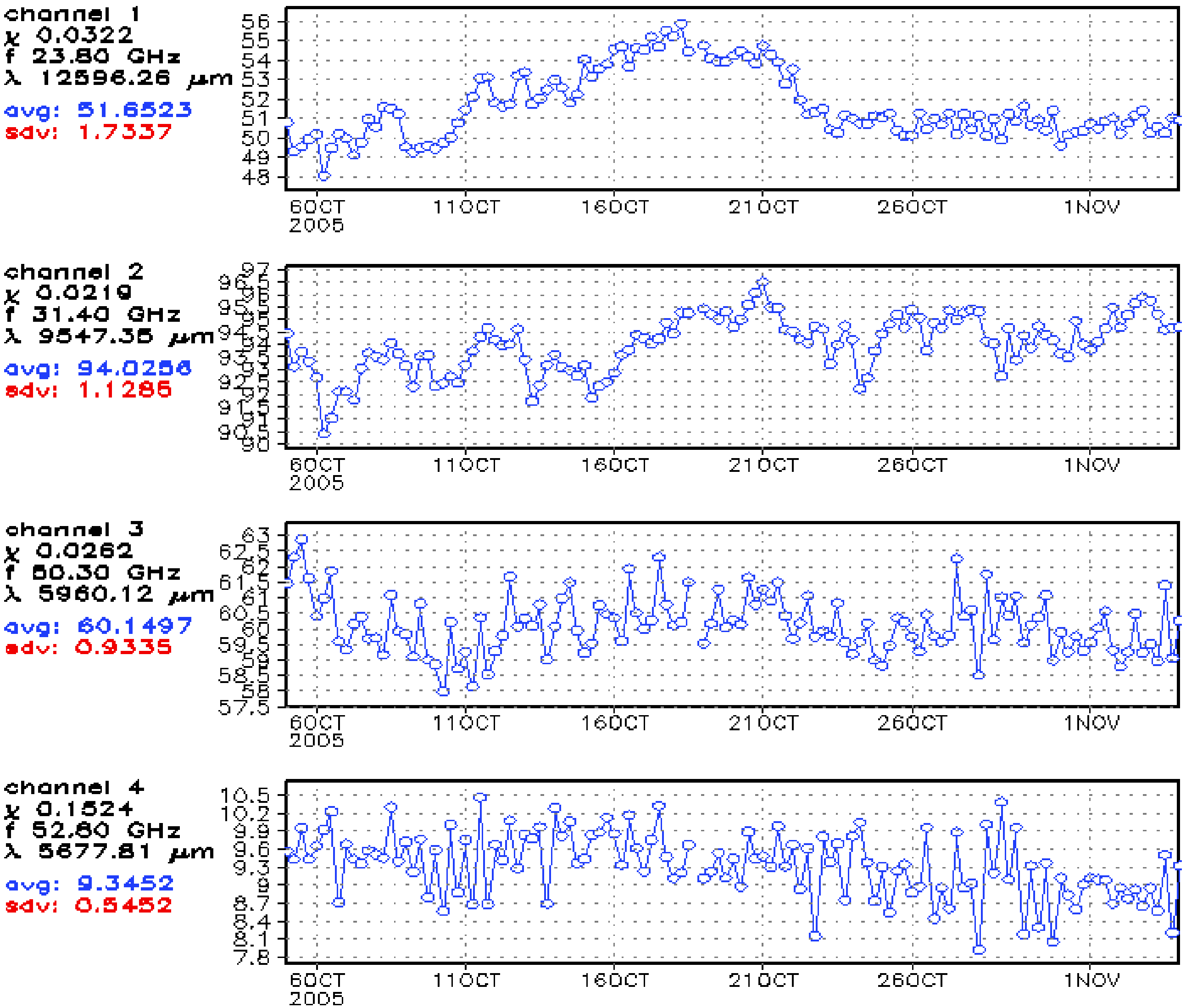
- Bias correction is stable over time.

NOAA-16 AMSU-A; CLW correction

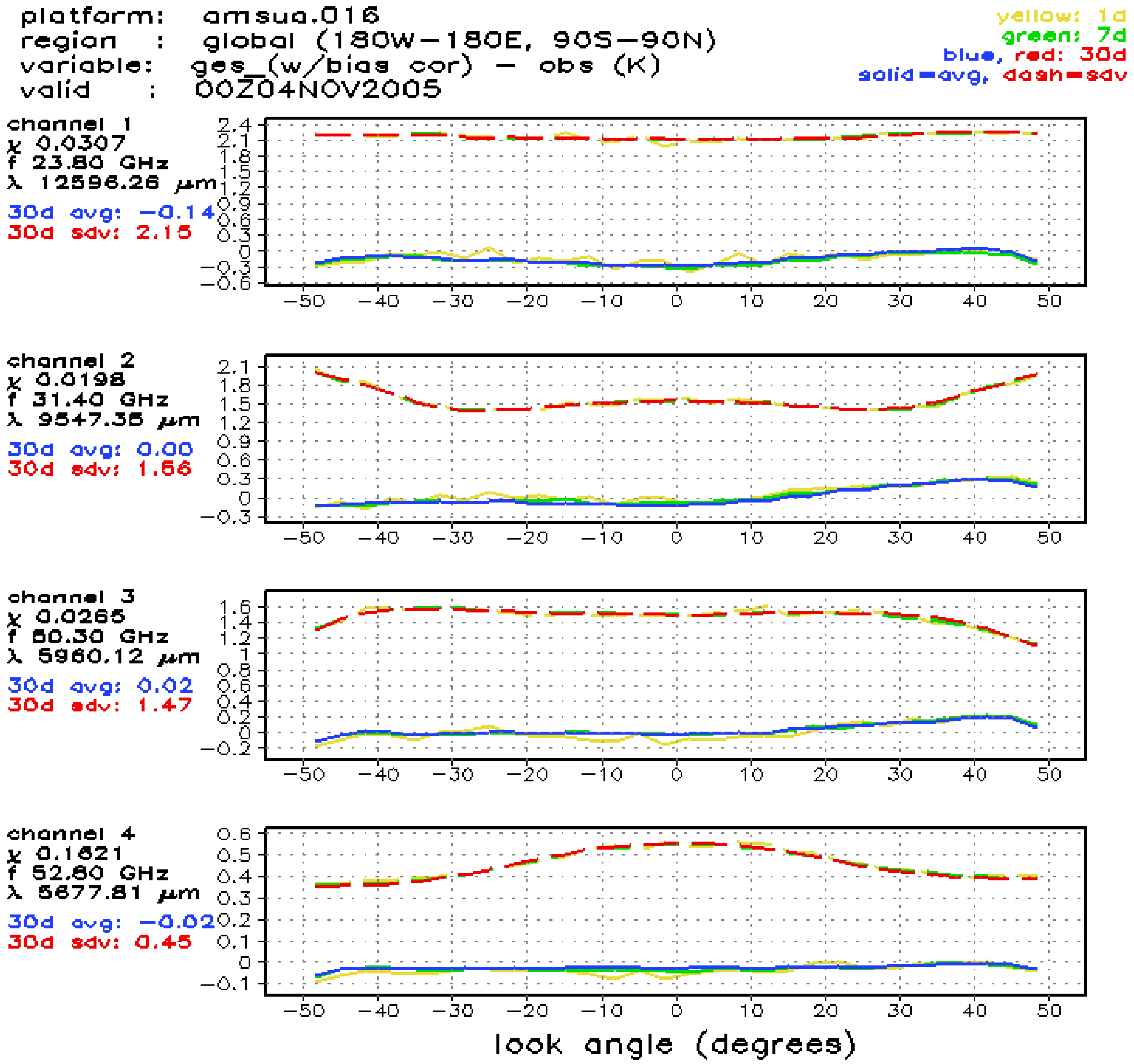


NOAA-16 AMSU-A; CLW coefficients

platform: amsua.016
variable: cloud liquid water term
valid : 00Z05OCT2005 to 00Z04NOV2005



NOAA-16 AMSU-A; Guess(BC)-Obs



Future Investigation

- New radiative transfer model.
- Profile training sets.
- Instrument characterisation
- Air mass predictor selection.

Community Radiative Transfer Model (CRTM)

- Absorption by atmospheric gaseous constituents, e.g. water vapour, ozone, etc. **`AtmAbsorption`** functions.
  - OPTRAN (polychromatic) is currently used.
  - OSS (monochromatic) version is also being developed.
- Scattering and absorption. **`AtmScatter`** functions.
  - Aerosols (Sea salt, organic carbon, black carbon, sulphates)
  - Clouds (Water, ice, rain, snow, graupel, hail)
- Surface Optics. **`SfcOptics`** functions.
  - Emissivity (land, ocean, snow, ice; μW, IR)
  - Reflectivity (diffuse and direct)
- Radiative Transfer. **`RTSolution`** functions.
  - Layer optical depth scaled level temperatures used for RT
  - Fixed multi-stream models
  - Flexible-stream models
    - SOI model
    - Advanced doubling-adding method

AtmAbsorption

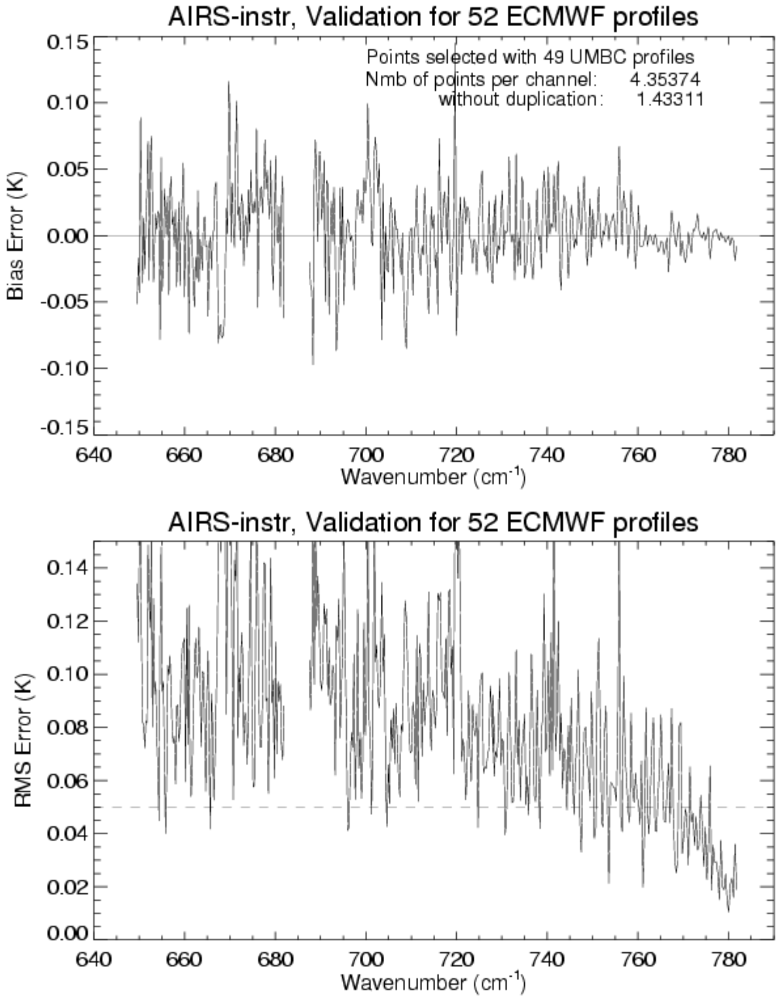
- Two methodologies
  - OPTRAN. Polychromatic
  - OSS. Monochromatic.

OPTRAN	OSS
Total channel resolution transmittance $$\overline{\mathrm{T}}_{total} = c \cdot \prod_{j=1}^{J} \overline{\mathrm{T}}_j$$ Predict band transmittance for each absorbing gas from absorption coefficient, ψ, predicted from regression fits $$\overline{\psi}_{j,k} = \frac{\log\left(\overline{\mathrm{T}}_{j,k} / \overline{\mathrm{T}}_{j,k-1}\right)}{\delta A_{j,k}}$$ $$= c_{0,k} + \sum_{i=1}^{5} c_{i,j,k} X_{j,k}$$ Select the regression coefficients, c_{ijk}, for each gas that minimises transmittance errors.	Channel radiances are obtained from a weighted sum of monochromatic radiances for a set of predefined nodes, $$\overline{R} = \sum_{n=1}^{N} w_n R_n$$ The monochromatic R_n are obtained from the OSS monochromatic optical depth profiles for the selected node frequencies. Nodes are selected and weights calculated for a channel to satisfy a specified accuracy (e.g. 0.05K). Higher accuracy $\equiv$ more nodes $\equiv$ longer computation times.

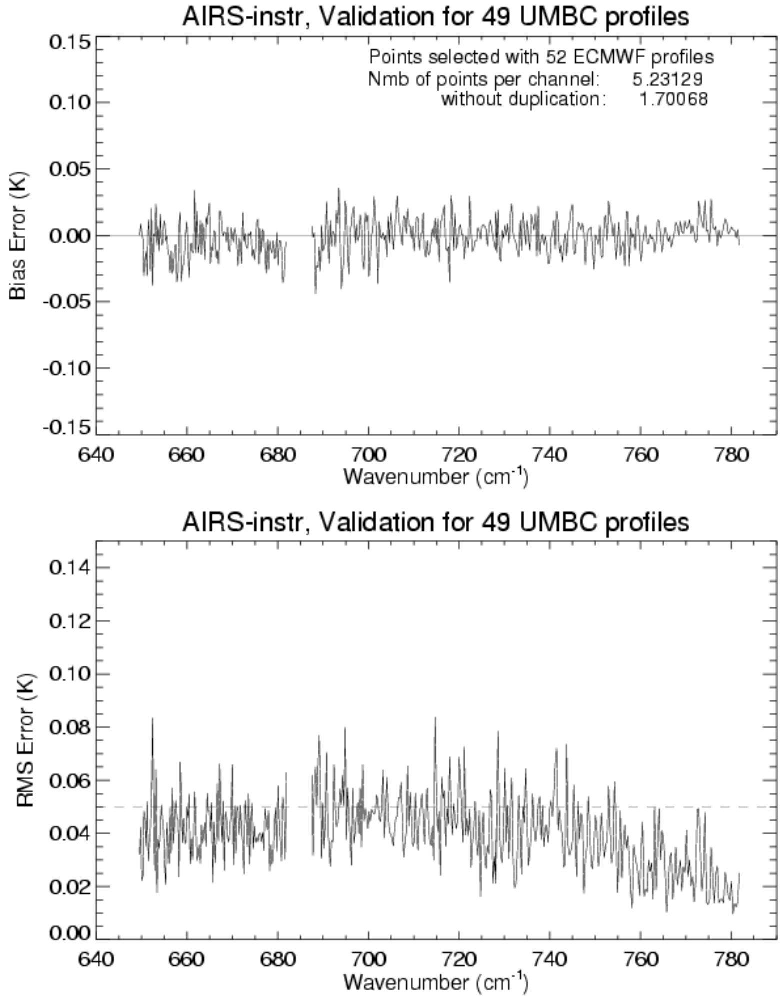
Profile training sets

OSS training: ECMWF vs. UMBC
(only temperature is allowed to vary)

OSS trained with UMBC set



OSS trained with ECMWF set

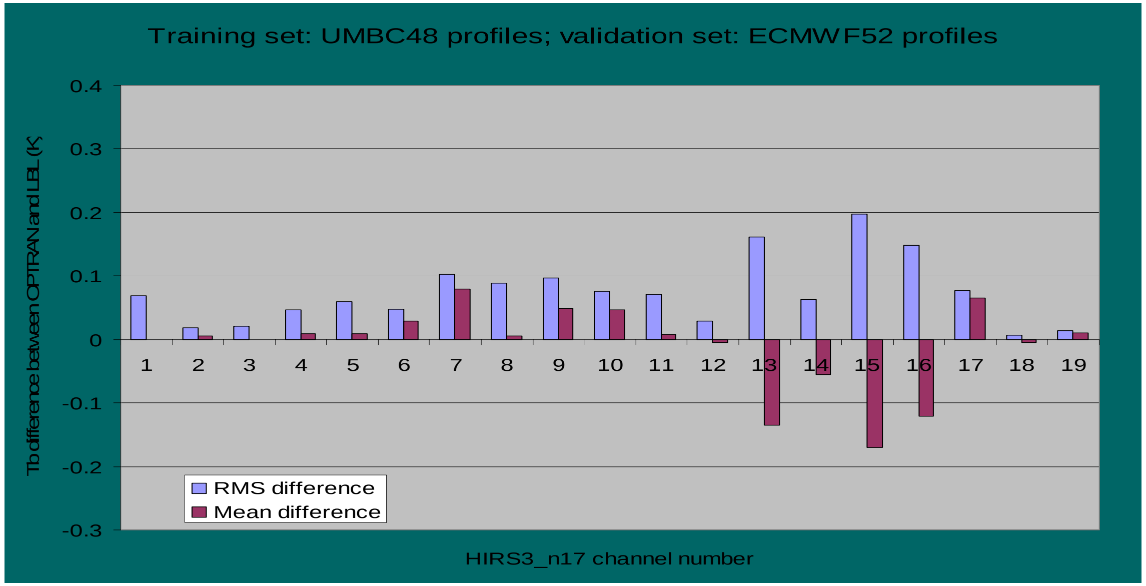


The ECMWF set is a better choice for training OSS

From Dr. Moncet, AER

Profile training sets

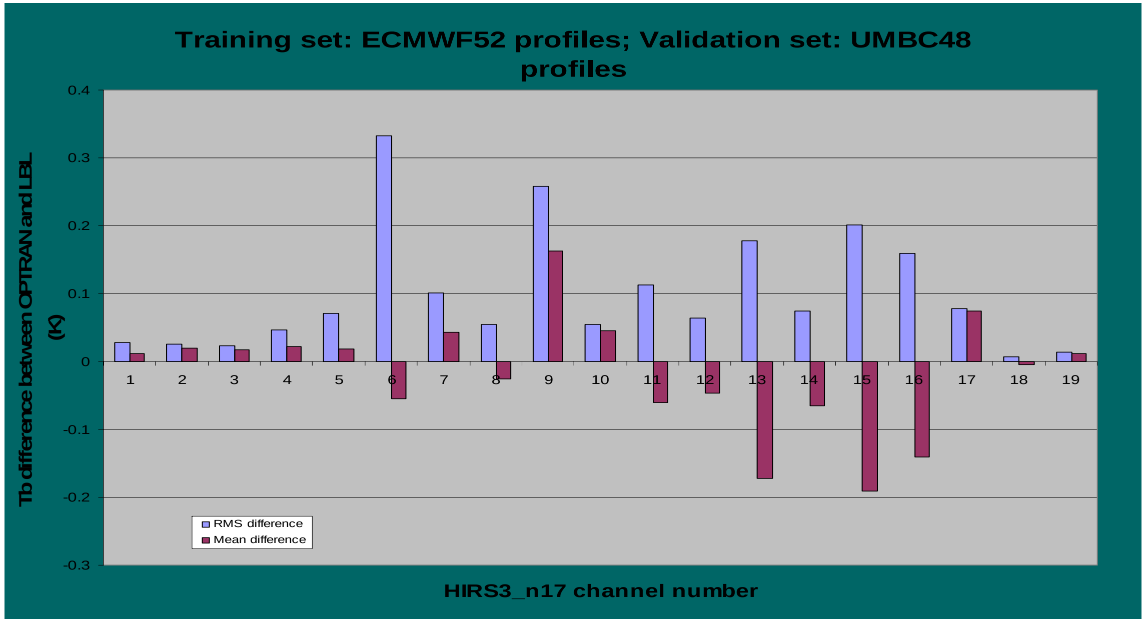
OPTRAN training: ECMWF vs. UMBC



OPTRAN trained with the UMBC set

The UMBC set is a better choice for training OPTRAN

OPTRAN trained with the ECMWF set



- **Profile sets** (cont'd).
  - Training sets for clouds and aerosols?
  - Consensus of cloud and aerosol types and their properties?

- **Instrument characterisation.**
  - Instrument modeling is usually channel-based rather than detector-based. Detector differences are folded into a mean channel value.
    - Detector array (and thus SRF) differences
    - Channel crosstalk
    - "Not good enough" SRF measurement
  - For large channel biases, is a variational method of correcting instrument characterisation possible?

- **Air mass predictor selection.**
  - How to optimise the selection of air mass bias correction predictors? The current set does a good job, but some preliminary work suggests they are not optimal.