All-sky assimilation of MHS and HIRS sounder radiances

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- All-sky assimilation at ECMWF (general overview)
- All-sky humidity sounder assimilation
- Conclusions

All-sky assimilation

All-sky = direct assimilation of radiances in **clear, cloudy and precipitating** conditions.

- **Observations assimilated operationally (ECMWF cycle 40r1)**
  - Imager channels over ocean (SSMIS, TMI)
  - SSMI/S humidity sounding channels over ocean

- **Developments towards next cycle (40r3 ~Oct 2014)**
  - SSMI/S humidity sounding channels over land and sea ice
  - MHS humidity sounding channels over ocean, land and sea ice
  - AMSR2

- **Longer term developments (41r1 ~ March 2015 and beyond…)**
  - GPM, SAPHIR on Meghatropiques
  - HIRS, SEVIRI and IASI Infra-red all-sky assimilation (see also **Migliorini, 9p07**)

All-sky assimilation

Difficulties

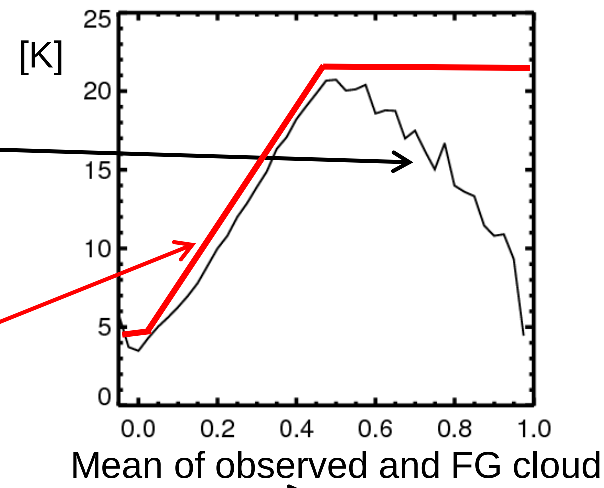
- Accuracy of non-linear model forecast of cloud and precipitation, particularly in convective situations
- Accuracy of forecast model's cloud and precipitation linearization in tangent-linear model in 4D-var
- Accuracy of the observation operator (scattering radiative transfer simulations)

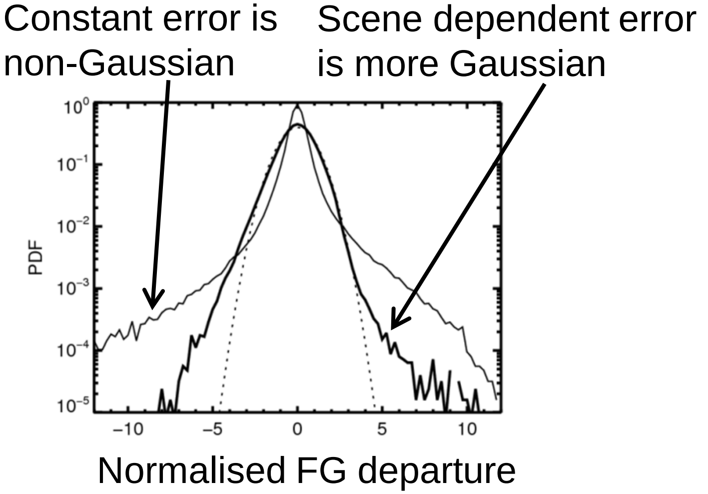
Implementation

- Symmetric error models → if you can describe the observation error correctly, and the observations are unbiased, you can assimilate
- Improving accuracy of scattering radiative transfer → DDA scattering database

Symmetric error models

- **FG departure standard deviation is a function of the "symmetric cloud amount" – the average of observed and simulated cloud**
- **An error model is fitted to (or binned from) the FG departures**
- **Cloud predictors:**
  - **37 GHz polarisation difference (imagers)**
  - **Scattering index (land, MHS)**
  - **LWP retrieval (AMSU-A)**
  - **Cloud – clear TB (IASI)**
- See Geer and Bauer (2011, QJRMS)

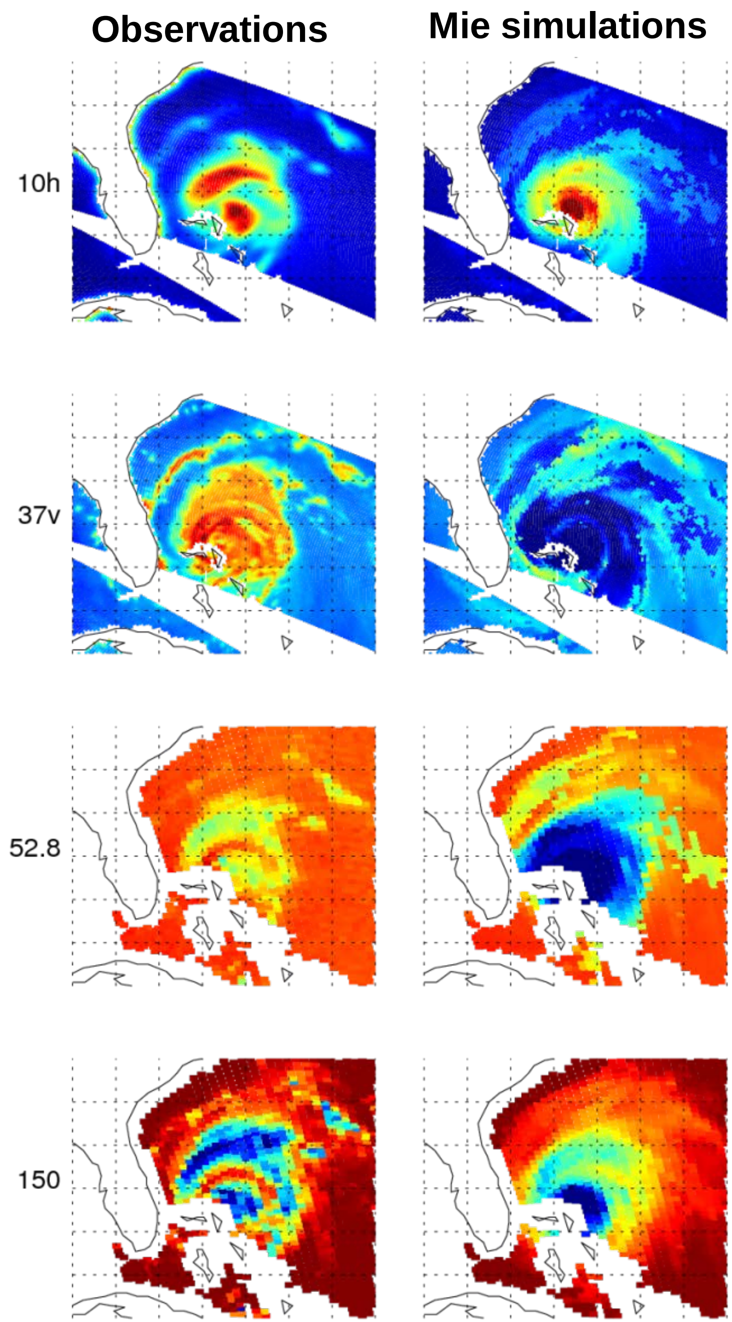




Improving accuracy of scattering radiative transfer

Liu (2008, BAMS) DDA scattering database

Implementation in RTTOV-SCATT: Geer and Baordo (2014, AMT)



Result: We can do all-sky assimilation in convective areas at frequencies above 30 GHz for the first time

Microwave clear-sky VS all-sky assimilation

- **Clear-sky MHS**
  - Clear-sky radiative transfer
  - Assimilation over ocean, land and sea ice
  - Cloud screening based on 150 GHz FG departure > 5K
  - Assimilation over ocean, land and **sea-ice** (Di Tomaso et al., 2013)
  - Constant 2 K observation error
- **All-sky MHS/SSMIS**
  - All-sky radiative transfer
  - Assimilation over ocean, land and sea ice
  - **MHS**: Symmetric error model based on 90 – 150 GHz scattering index over ocean and land; constant 2 K observation error over sea-ice
  - **SSMIS**: Symmetric error model based on 37 GHz polarization difference over ocean; 90 – 150 GHz scattering index over land; constant 2 K observation error over sea-ice
  - Addition of MHS scan positions 1-9 and 82-90 (not used in operations)

Assimilation experiments

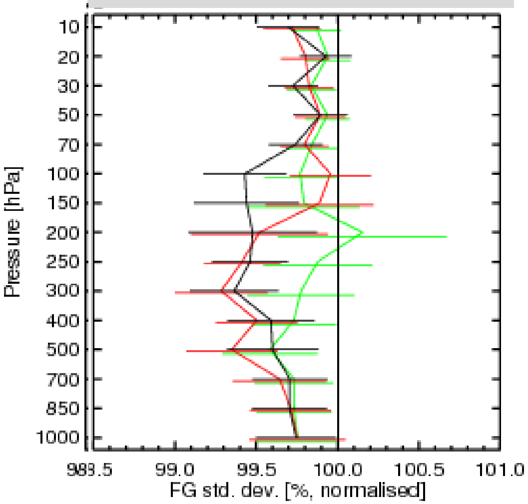
- **CONTROL = No MHS**
  - Full observing system, **including all-sky SSMIS F17/TMI**, but no **MHS**
- **Exp1 = Clear-sky MHS (no scan pos 1-9 and 82-90)**
- **Exp2 = Clear-sky MHS (including scan pos 1-9 and 82-90)**
  - Only one season run
- **Exp3 = All-sky MHS (including scan pos 1-9 and 82-90)**

- MHS from Metop-A,B; NOAA-18,19
- T511 horizontal resolution
- 137 vertical levels
- 4D-Var 12 hour assimilation window
- **~ 3 months of period:**

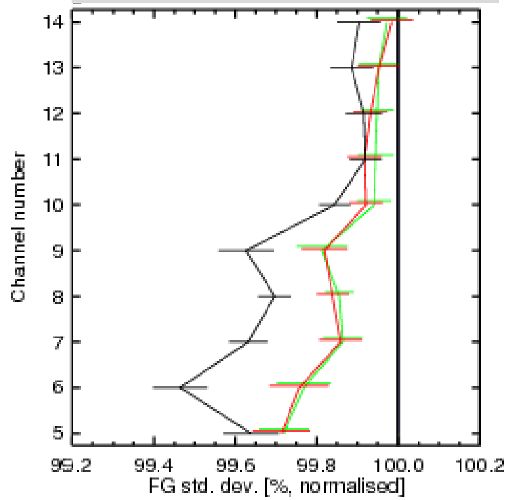
  15 June - 31 July 2013 + 1 January - 10 February 2013

Impact of swath edge MHS vs All-sky

FG fit to wind obs



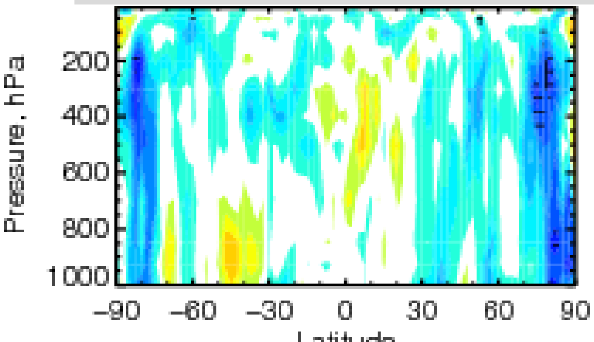
FG fit to AMSU-A



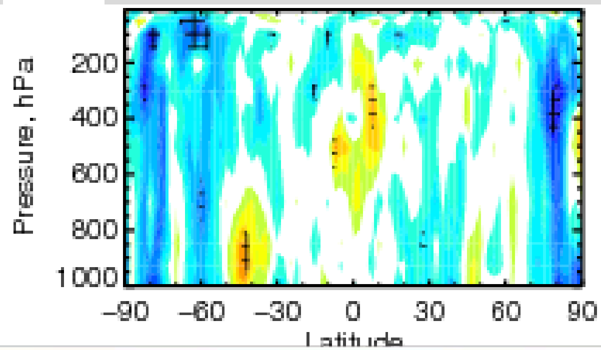
All–sky MHS
Clear MHS + swath edges
Clear–sky MHS

Full MHS swath gives some benefits – but all-sky change appears more important.

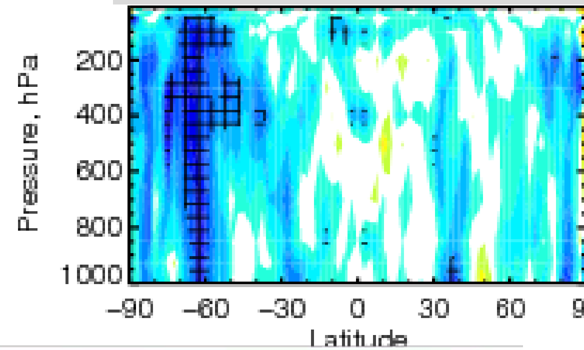
(a) Clear MHS – No MHS

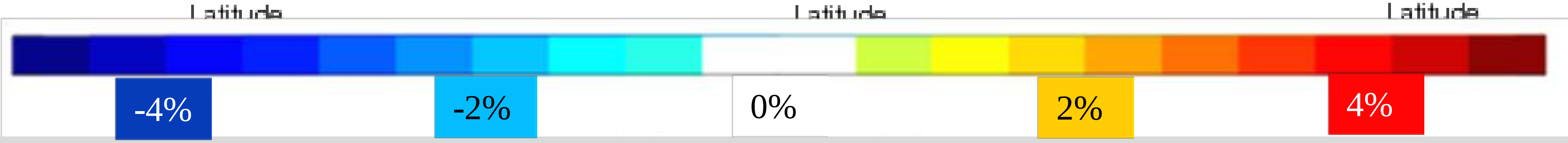


(b) As (a) + swath edge



(c) As (b) but all-sky





T+72 RMS vector wind RMS difference normalised by RMS of control

ECMWF

Conclusions and perspectives

- **Aim is to improve impact of water-vapour, cloud and precipitation sensitive channels**
  - **It has been shown MW humidity sounders have more impact when assimilated using the all-sky framework**
  - **Some of the benefit also comes from using the full MHS swath**

Microwave imagers	well-established
Microwave humidity sounders	in transition
Infrared water vapour channels	in development

- **Results (not shown) for MW temperature sounders in all-sky framework remain inconclusive.**
- **For the IR all-sky assimilation an affordable accurate RT model is urgently needed (see Migliorini 9.07).**
  - **Fast cloud overlap scheme for the IR: > 1 sub-columns**