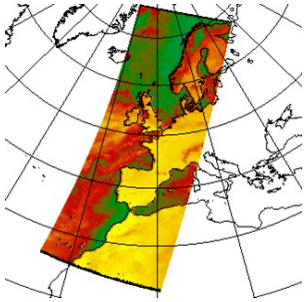
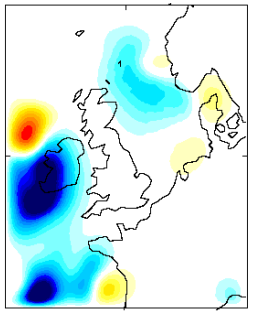
# Satellite Radiance Data Assimilation at the Met Office

**Ed Pavelin**, Stephen English, Brett Candy, Fiona Hilton

# Outline

- **Summary of satellite data used in the Met Office NWP system**
- **Processing and quality control**
- **Impacts from various instruments**
- **Status of assimilation over land surfaces**
- **Future plans**



# Overview of satellite radiance data used at the Met Office

- Passive Microwave:
  **AMSU-A, AMSU-B / MHS, SSMI, SSMI/S**
- Passive Infrared (Polar orbiting):
  **HIRS, AIRS, IASI**
- Passive Infrared (Geo):
  **SEVIRI**

Other satellite data:

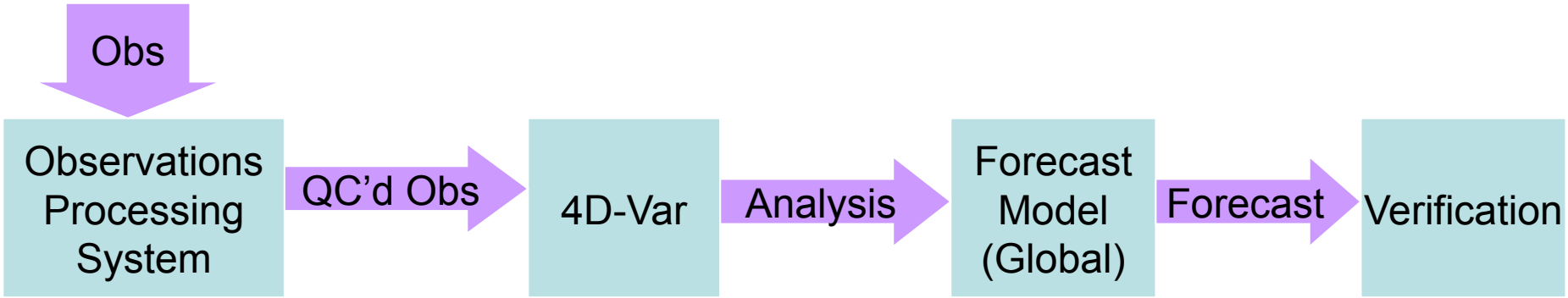
- Satwinds (AMVs)
- Active: Scatterometer, GPSRO

# Met Office NWP System:

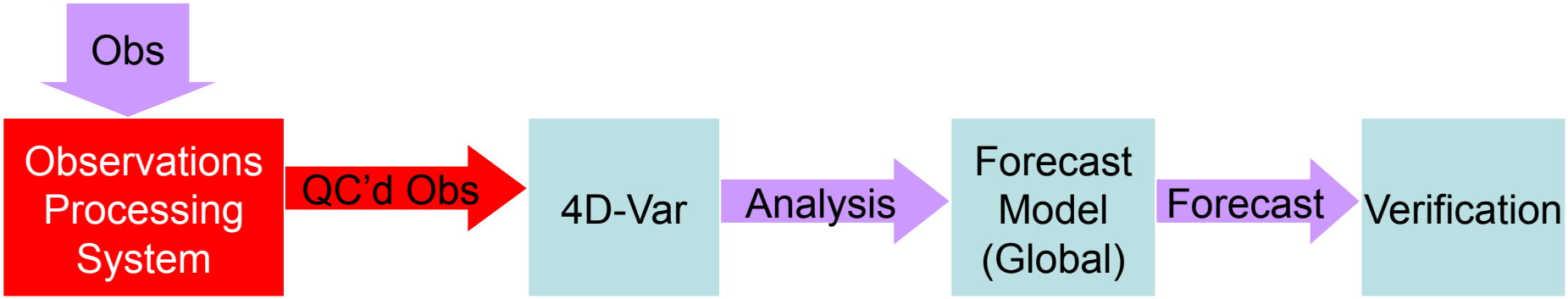
# BACKGROUND

# Met Office Global Forecast System

- 4 major components: **OPS**, **4D-Var**, **Unified Model** and Ver



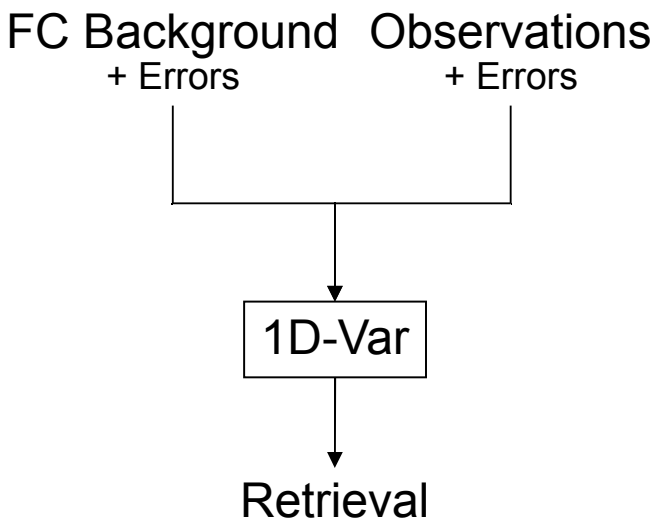
# Met Office Global Forecast System - **OPS**



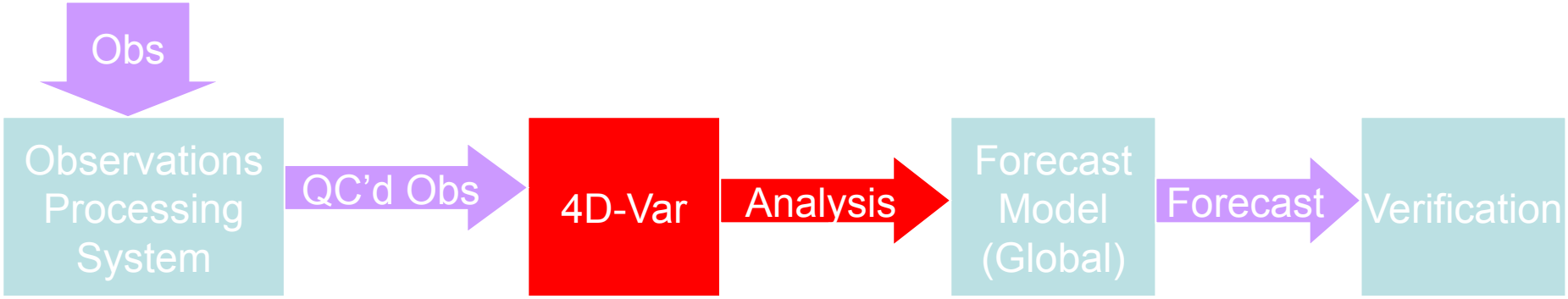

- **Observations processing system** (OPS): performs quality control and thinning of observations – only around 5% of satellite data actually assimilated
- Cycles through each observation type (e.g. Scatwind, ATOVS, Sondes etc.) and produces a reduced "best" set of observations
- Quality-controlled obs are passed to the 4D Var assimilation system to produce the forecast analysis

# Radiance processing in OPS: 1D-Var

- 1D-Var pre-processing is an important feature of our system
- Acts as initial QC check on observations
  - Reject soundings that don't converge or fit poorly
- Allows retrieval of parameters to be used later in 4D-Var
  - Skin temperature
  - Cloud parameters
  - (Potentially… surface emissivity)

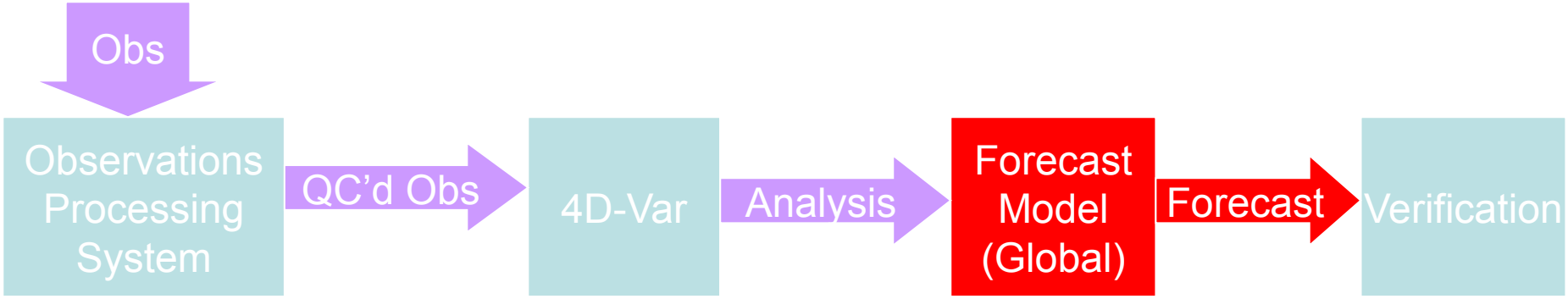


# Met Office Global Forecast System – **4D-Var**




- Produce an analysis which is a best estimate of atmospheric state
  - Combine observations: radiances, sondes, sfc obs, etc… with background from previous forecast run
- Assimilate satellite radiances directly
  - Use extra information from OPS 1D-Var: surface, cloud, etc.

# Met Office Global Forecast System – Unified Model (UM)




- Current global model 640 x 481 grid, roughly 50km horizontal resolution
- 50 model levels in vertical
- 70 levels soon…

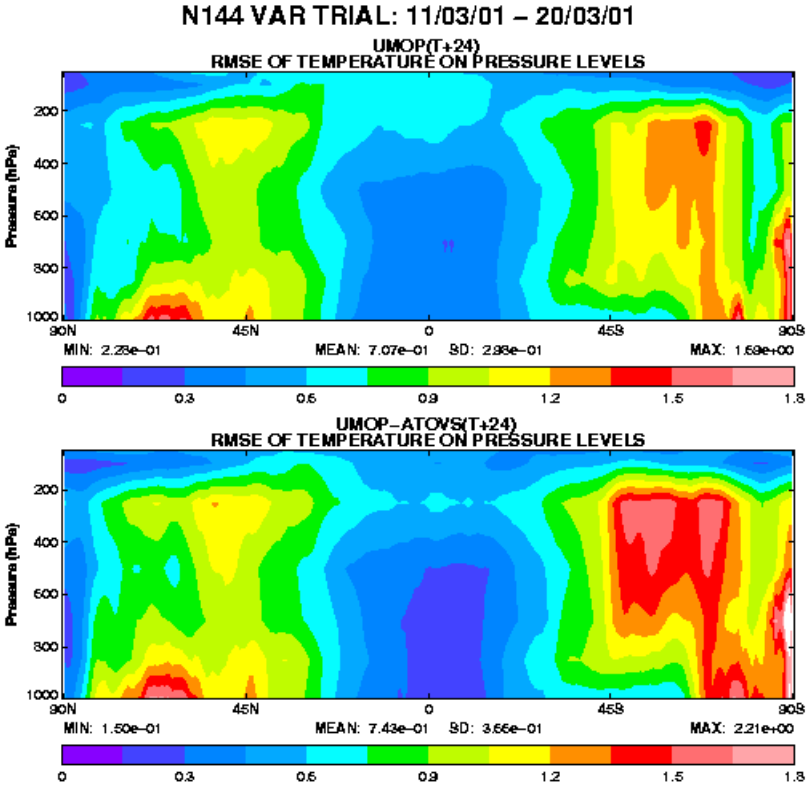
# Satellite radiances used in NWP

# ATOVS (AMSU + HIRS)

- NOAA ~~15~~, 17, 18, 19 (soon) & Metop


- AMSU-A:
  - 15 microwave channels
  - Temperature sounding
- AMSU-B (NOAA 15/17) / MHS (NOAA 18/19/Metop):
  - 5 channels
  - Water vapour sounding
- HIRS (NOAA-17, Metop)

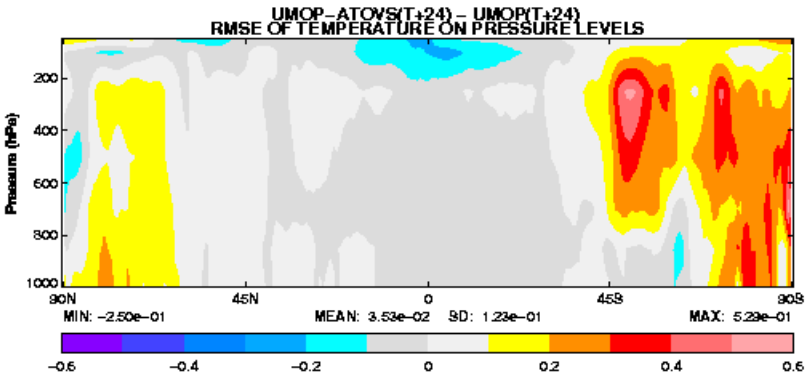
# Impact of AMSU on T+24hr Global Model Forecast



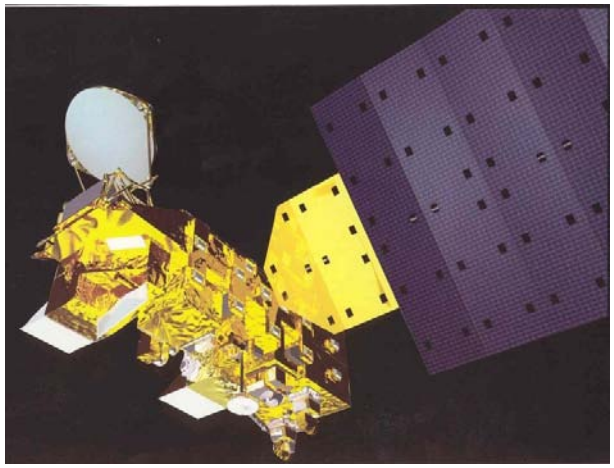

With AMSU

Without AMSU

Difference



# AIRS

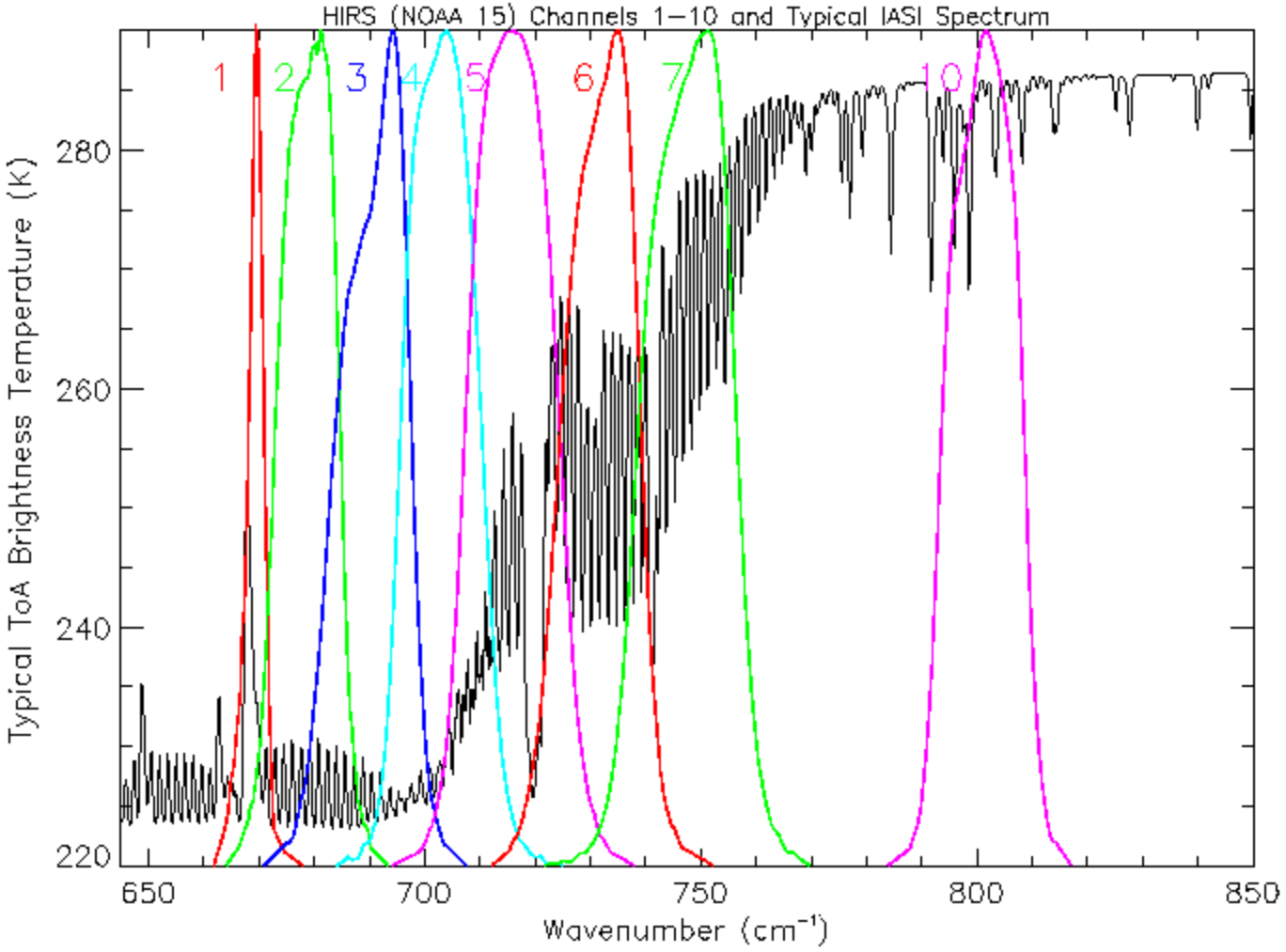


- On EOS Aqua
- High spectral resolution IR sounder
  - Grating spectrometer, 2378 IR channels
  - Sharper weighting functions than ATOVS
    - Important for resolving fine vertical structure
- Radiances assimilated from ~ 50 channels (depending on cloud height)
- Temperature and humidity information
- Clear sky and above cloud

# Metop IASI

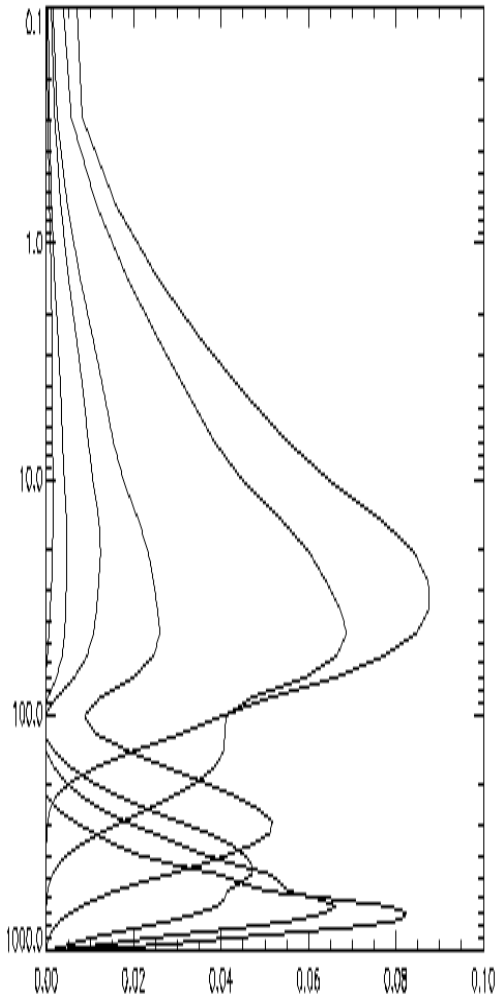
- Interferometer – 8461 channels
  - Unprecedented spectral resolution
  - Fine vertical structures
- Assimilated operationally since November 2007
- Radiances assimilated from 151 T chans, 32 WV chans
- Over land: currently only use channels above ~ 400 hPa
- Currently clear sky only
  - Cloudy 1D-Var by end 2009

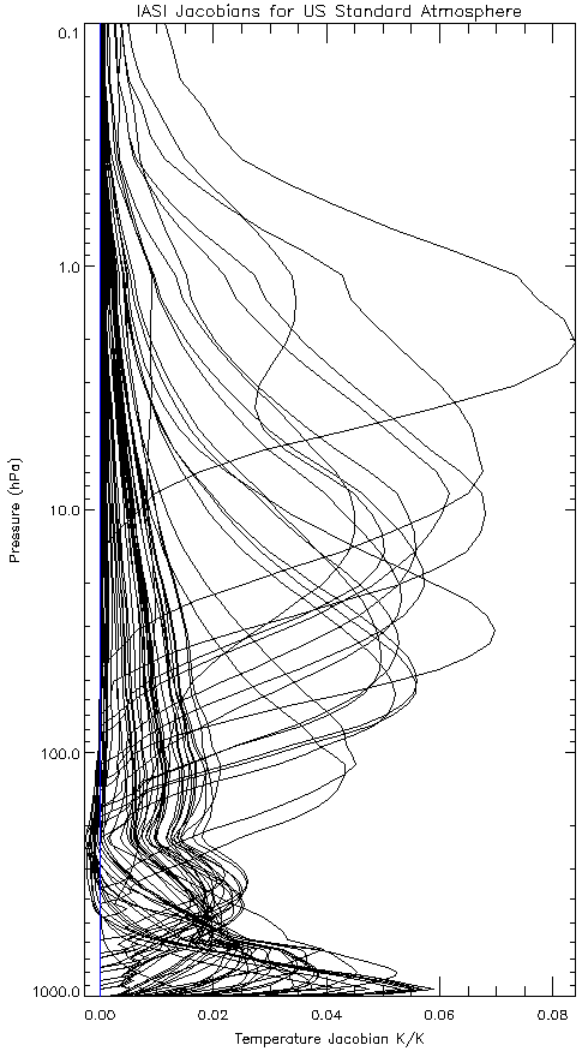
# HIRS and IASI compared



# IASI vs HIRS Weighting Functions

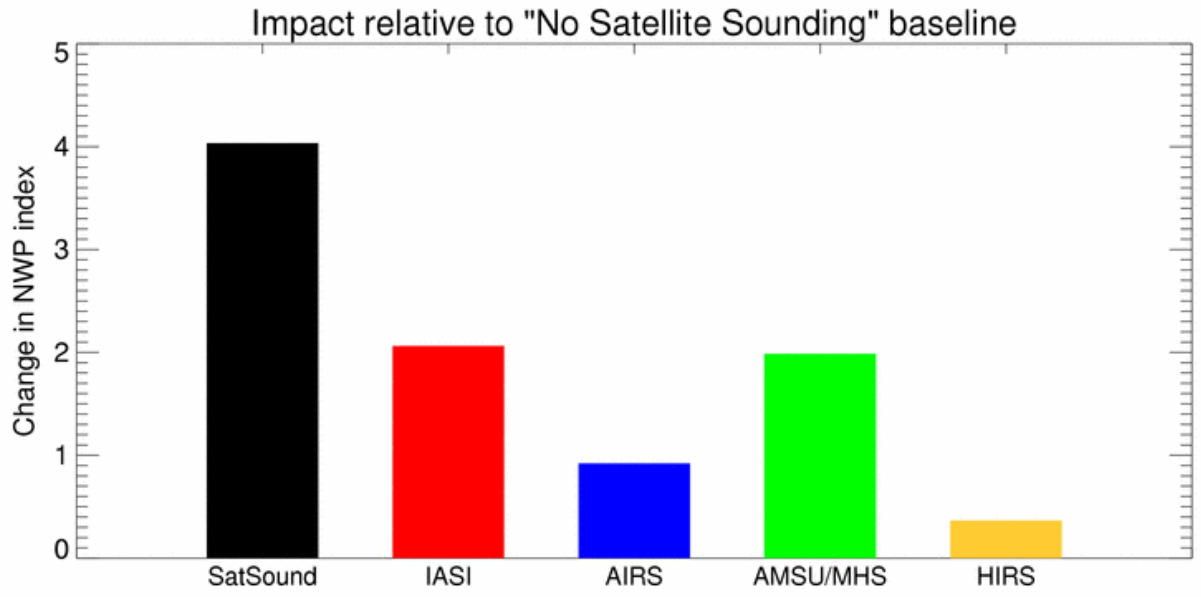
## in the 15μm $CO_2$ band



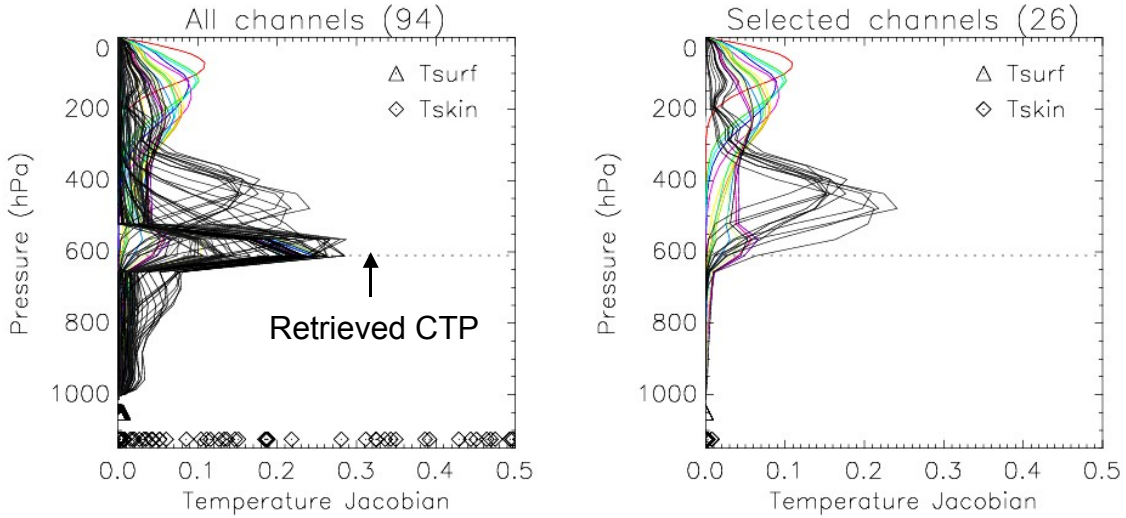
# IASI: Impact relative to other instruments

- Verification v observations
- HIRS and AMSU/MHS MetOp only
- Same cloud detection methodology for IASI/AIRS/HIRS



# Assimilating cloudy infrared radiances

- Assume cloud is a single level grey body
- Cloud top pressure and cloud fraction are retrieved in 1D-Var
- Only channels insensitive below the cloud top are assimilated in 4D-Var



# Infrared over Land

- IASI, AIRS: Not currently using lower tropospheric channels over land
- HIRS: Only used over sea
- Plan to increase IR data usage over land
- Improved estimates of surface emissivity and skin temperature needed
- Plan to experiment with emissivity atlas and emissivity retrieval
- Important to consider cloud detection over land
- **See poster**

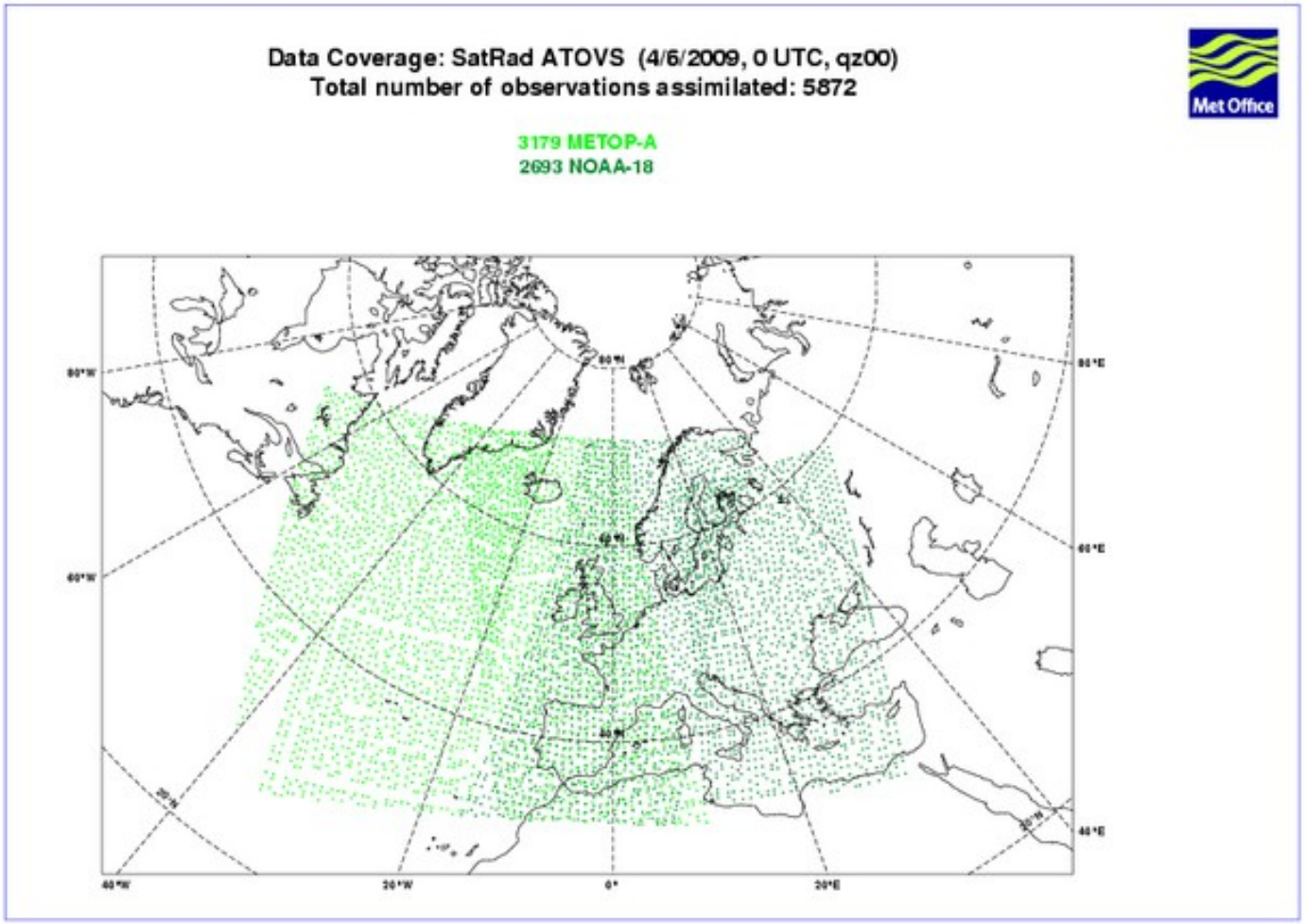
# Microwave over Land

- Only use AMSU-A channels 6-14
- Fixed surface emissivity
- Studying use of emissivity atlas and emissivity fitting: **See Steve English's talk (next!)**

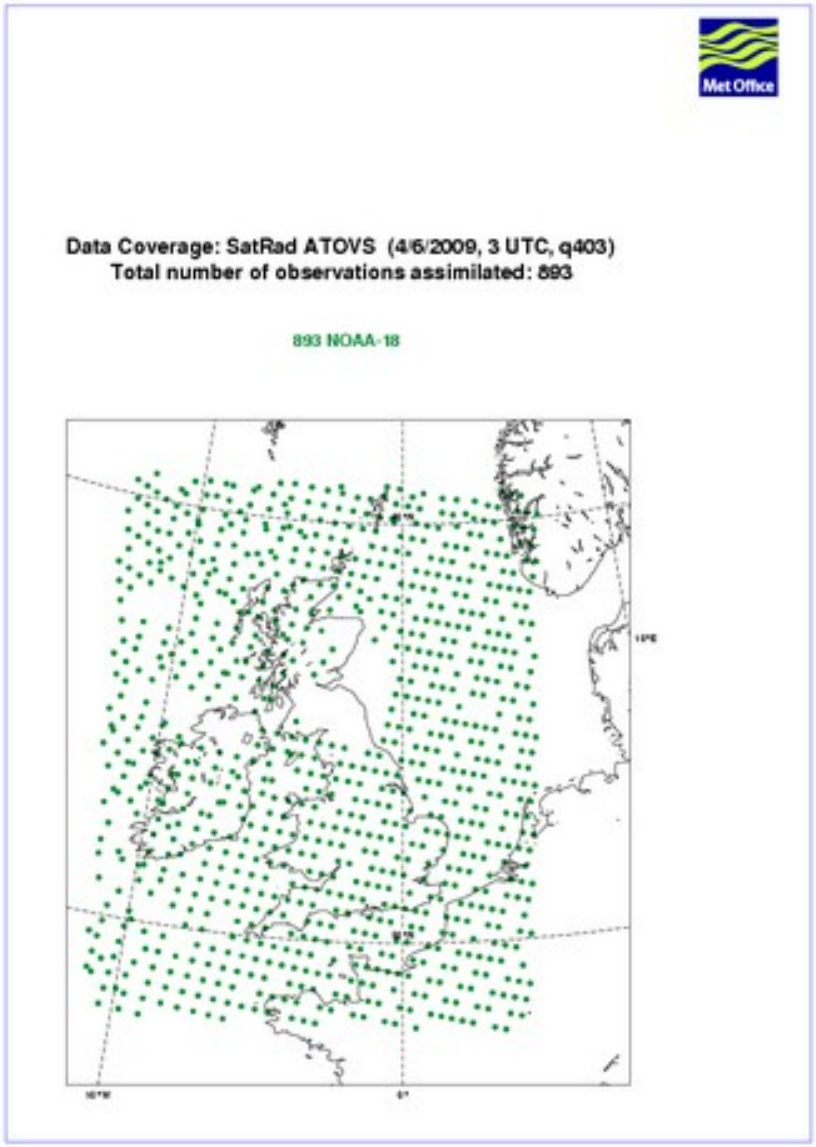
# Radiance data in regional NWP models

- North Atlantic / Europe (NAE) Model
  - 12 km resolution
  - ATOVS (AMSU only) – from EARS
  - IASI, AIRS
  - Clear-sky SEVIRI (MSG) radiances
- UK 4km model
  - ClearSEVIRI
  - ATOVS
- UK 1.5km model
  - Assimilation under development
- Land and cloud especially important for UK models!

# ATOVS in the NAE Model



# ATOVS in the 4 km UK model



# Summary

- Satellite radiances are a key part of the global observing system for NWP
- Microwave (e.g. AMSU) important in cloudy conditions
- Advanced IR sounders (AIRS / IASI) provide T and q information with high vertical information
  - Small proportion of data used so far… lots of room for improvement!
- Good representation of land surface emission is essential for increasing usage of radiance data

# Future plans

- More use of near-surface channels over land surfaces
  - Use of emissivity atlases, retrieving emissivity
- Better treatment of the effects of cloud and rain on radiance data
- More use of channels with humidity information, particularly in the boundary layer
- Increase usage of information from IASI/AIRS
  - Cloud, land, principal components
- Variable observation errors (surface types, clouds…)