An overview of the assimilation of AIRS and IASI Radiances at operational NWP Centres

Andrew Collard (SAIC/EMC/NCEP), **John Derber** (EMC/NCEP), **Jim Jung** (U. Wisconsin),

Fiona Hilton, Ed Pavelin, James Cameron, Graeme Kelly (Met Offic

Nancy Baker, Benjamin Ruston (Naval Research Laboratory),

Louis Garand, Sylvain Heilliette (Environment Canada),

Vincent Guidard (Météo-France),

Tony McNally, Reima Eresmaa (ECMWF),

Roger Randriamampianina (Met.no),

Marc Schwaerz, Detlef Pingel (Deutscher Wetterdienst),

Kozo Okamoto (Japan Meteorological Agency),

Wei Han (China Meteorological Service),

John Le Marshall (Bureau of Meteorology)

Dirceu Herdies (CPTEC/INPE)

If I missed you out I’m really sorry!

Summary of Operational Status in Global Models

Operational Now **Experimental**

- **AIRS:**
  - **ECMWF, Met Office, Météo-France, NCEP, Environment Canada, Naval Research Lab, Bureau of Meteorology**
  - **Japan Met. Agency, China Met. Admin., CPTEC/INPE**
- **IASI**
  - **ECMWF, Met Office, Météo-France, NCEP, Naval Research Lab**
  - **Environment Canada, Bureau of Meteorology, Japan Met. Agency, China Met. Admin.**

Summary of Operational Status in Limited Area Models

Operational Now **Experimental**

- **AIRS:**
  - **Met Office (NAE), Météo-France (ALADIN+AROME), NCEP**
  - **Met Office (UKVD), Met.no**
- **IASI**
  - **Met Office (NAE), Météo-France (ALADIN+AROME)**
  - **Met Office (UKVD), NCEP, Met.no, Deutscher Wetterdienst**

Summary of IASI Data Usage in Global Models

Operational
Being tested

Centre	Model Resolution/Top/ Assim. Method	Max # Chans	Max # H_2O chans/obs error	Land surface sensitive channels?	Use Cloud affected channels?
ECMWF	15km / 0.01hPa 4DVar	175	10 / 1.5K	No	Some cloudy scenes
Met Office	25km / 80km 4DVar	183	32 / 4K	No	Cloudy FOVs
Météo-France	10-60km / 0.1hPa 4DVar	77	9 / 4K	No	Above Cloud Cloudy FOVs
NCEP	35km / 0.27hPa 3DVar	165	20/1.5K	Yes	Above cloud
Environment Canada	33km / 0.1hPa 4DVar	150	66/2K	No	Above cloud
Naval Research Lab	55km / 0.4hPa 4DVar	39	--	No	Above Cloud
Japan Met. Agency	20km/0.1hPa 4DVar	82	--	No	Above cloud
Bureau of Meteorology	80km/L50/ 4DVar	138	31/4	No	Cloudy FOVs

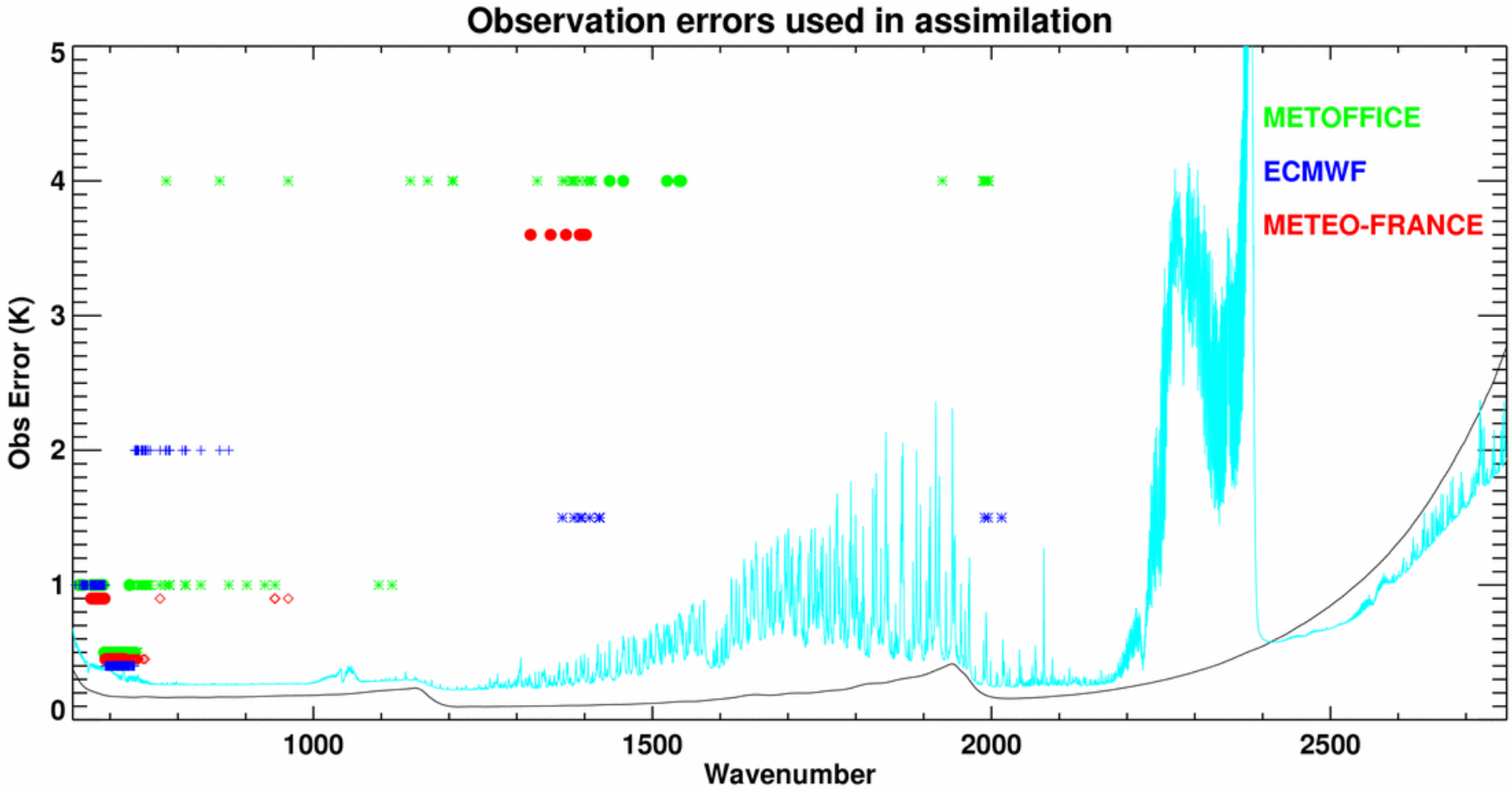
Summary of IASI Data Usage in Local Area Models

Operational
Being tested

Centre	Model Resolution/Top/ Domain / Assim Method	Max # Chans	Max # H_2O chans/obs error	Land surface sensitive channels?	Use Cloud affected channels?
Met Office NAE	12km / 39km / N.Atl+Europe 4DVar	183	32 / 4K	No	Cloudy FOVs
Met Office UKVD	1.5km / 40km / U.K./ 3DVar	183	32 / 4K	No	Cloudy FOVs
Météo-France ALADIN	7.5km / 0.1hPa / W.Europe / 3Dvar	77	9 / 4K	No	Above Cloud Cloudy FOVs
Météo-France AROME	2.5km / 1hPa / France / 3DVar	77	9 / 4K	No	Above Cloud Cloudy FOVs
DWD COSMO-EU	7km / 20hPa / Europe / Nudging	200	71/1c Noise*	Yes?	Above cloud
Met.no HARMONIE	11-16km/0.2hPa/ N.Pole+Europe / 3DVar	41	--	No	Above Cloud

*1DVar

Observation Errors – Global Models (Europe)



Use over Land

- **Channel selection is usually restricted over land and sea-ice, or depends on quality control to reject observations**
- **Only one centre (NCEP) is assimilating channels sensitive to the land surface (at least not on purpose) and this is with much reduced weight …**
- **… but there is a lot of interest in doing so.**

Humidity assimilation

- **Some centres have demonstrated positive impact from assimilating H2O channels (with reduced weight) to the analysis and 1-2 day forecast**

- **NWP models have a hard time keeping impact of assimilation after 1-2 days.**

Humidity assimilation error sources

- **Ambiguity with humidity Jacobians - the water vapor (WV) channels have strong sensitivity to humidity and temperature**
- **Representivity error (from the mismatch in scales between the analysis fields and the FOV size) may be important (Bormann talk)**
- **Large biases in the NWP model fields.**
- **Biases in the observations (including errors from bias correction and QC)**
  - **Bias correction algorithms remove this bias.**
  - **Variational bias correction algorithms need to have suitable anchoring observations.**
- **Above issues are mitigated through inflated observation errors; reduced number of channels and tight QC**
  - **NCEP use tight QC (~1K) but increase data useage through re-evaluation of QC every outer loop.**

Assimilation of Cloud-affected radiances

- Cloud can be treated in five ways:
  - 1) Avoid all FOVs with cloud ("hole hunting")
  - 2) Only assimilate channels that are insensitive to cloud
  - 3) Correct the observations to remove the effect of clouds ("cloud-clearing")
  - 4) Explicitly model the effect of cloud on the radiances either during pre-processing or as a sink variable. But DO NOT assimilate the cloud properties.
  - 5) Initialise model cloud variables from the cloudy radiances.

- Most centres use method 2. An increasing number have implemented method 4.
- NCEP had some encouraging results with AIRS cloud-clearing but it has not so far made it to operations.
- The "holy-grail" would be #5 but research remains at an early stage.

- There is an increasing interest in the use of the AVHRR sub-pixel information supplied in the IASI data stream.
  - At least one centre (CMC) use this in their cloud detection system.

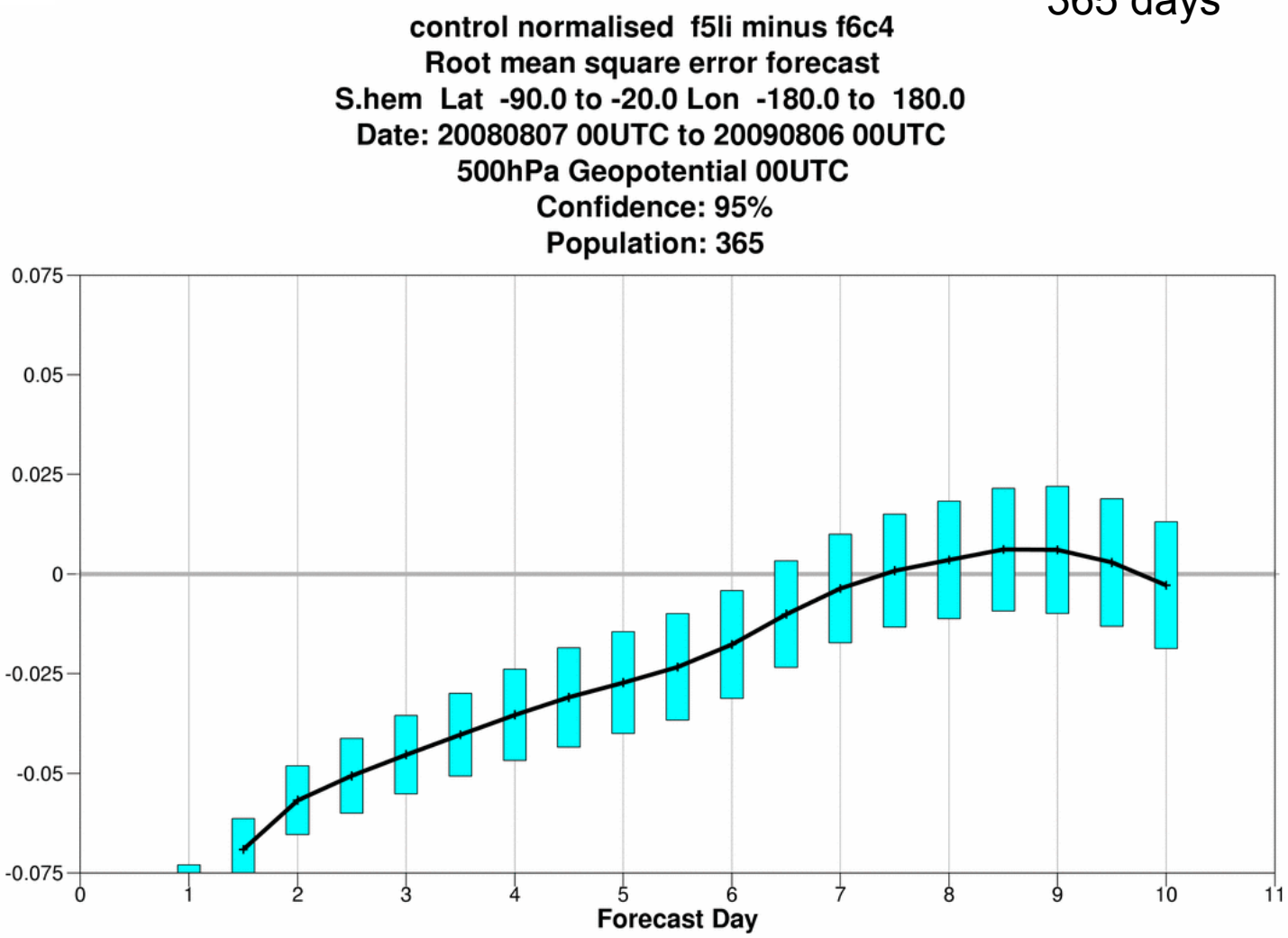
Also…

- **All centres are assimilating radiances apart from DWD's LAM which uses a nudging scheme**
- **All centres heavily thin the data (start with only 1 pixel in 4)**
- **All centres use a channel selection of at most ~200 channels**
- **All centres are using predominantly channels in the long-wave CO_2 band**
- **Height of model top generally restricts usage of high-peaking channels, particularly in LAM**

Forecast Impact

Long period trialling impact ECMWF IASI+AIRS

365 days



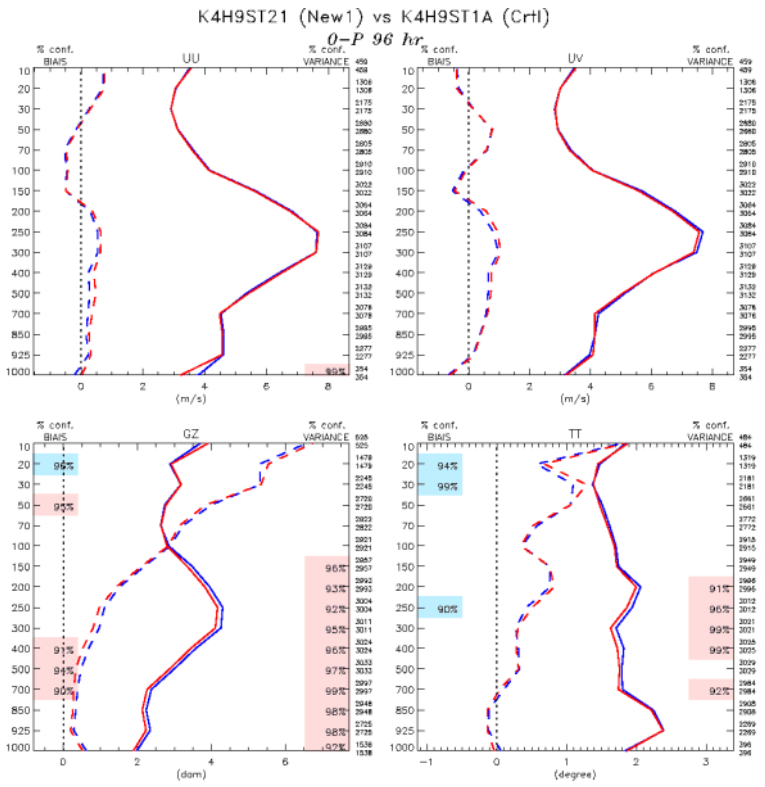
IASI+AIRS improves forecast

Environment Canada | Environnement Canada

Environment Canada – southern hemisphere impact

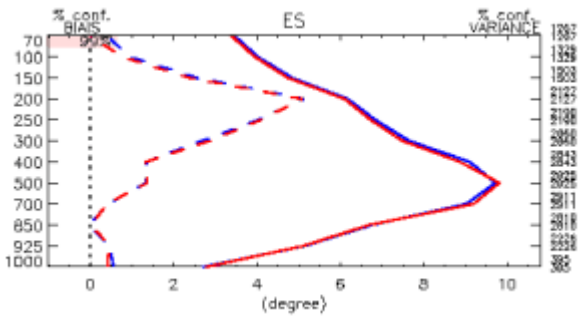
- Validation of forecasts against radiosondes: Southern hemisphere 96 h

Wind



Geopotential height Temperature

Dew point depression



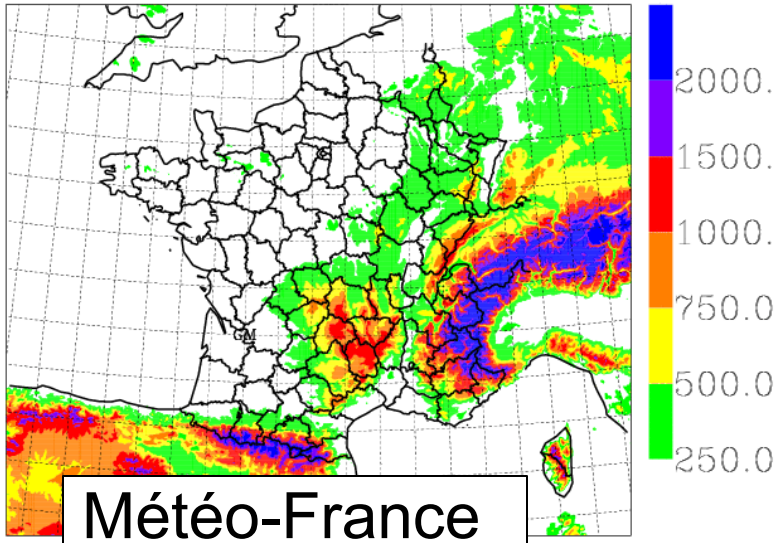
54 cases

Legend:

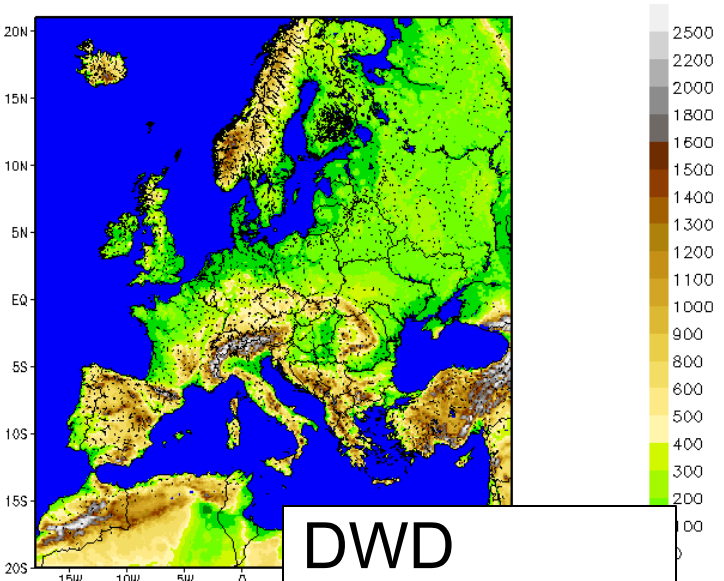
- Control is better
- Test is better

Local Area Models

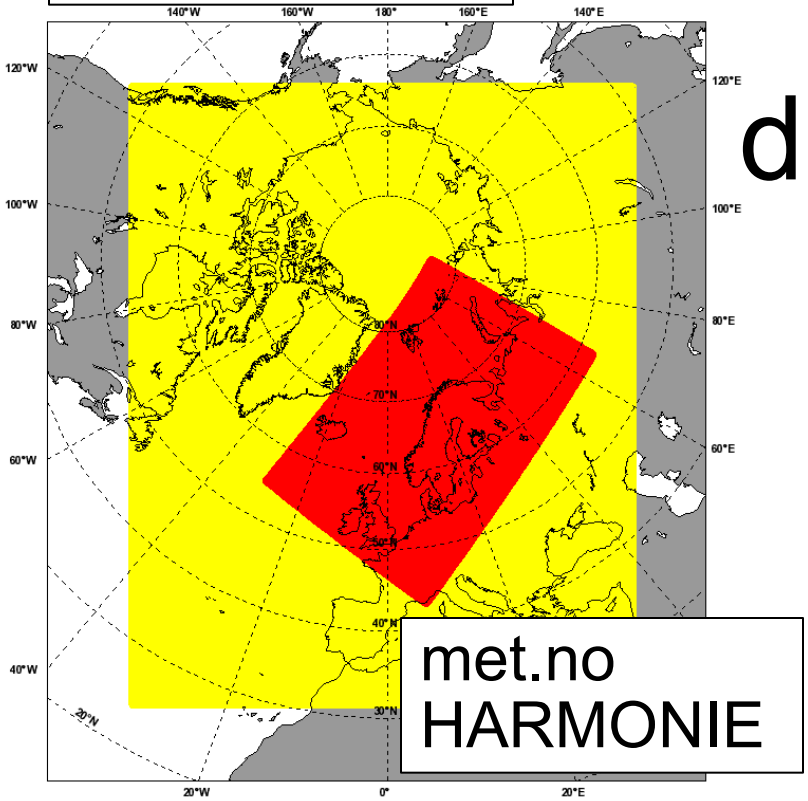
LAM domains



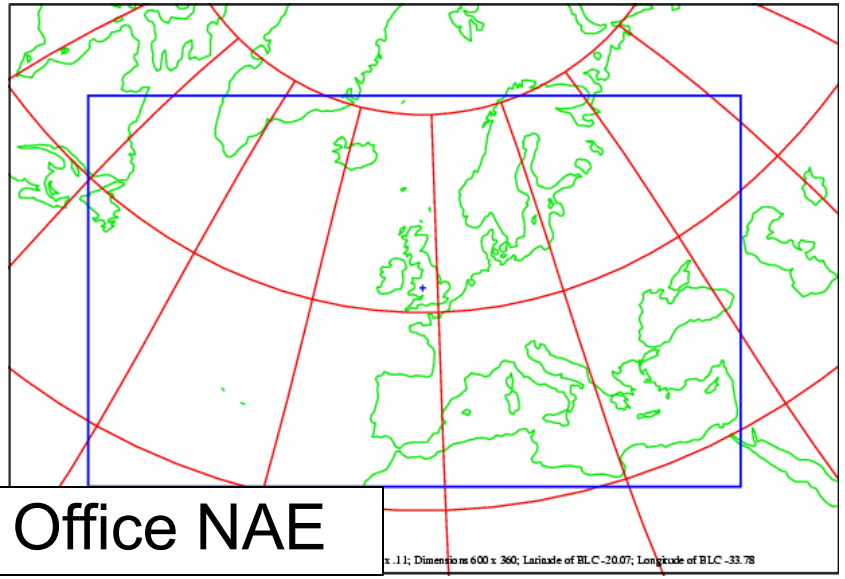
Météo-France
AROME



DWD
COSMO-EU



met.no
HARMONIE

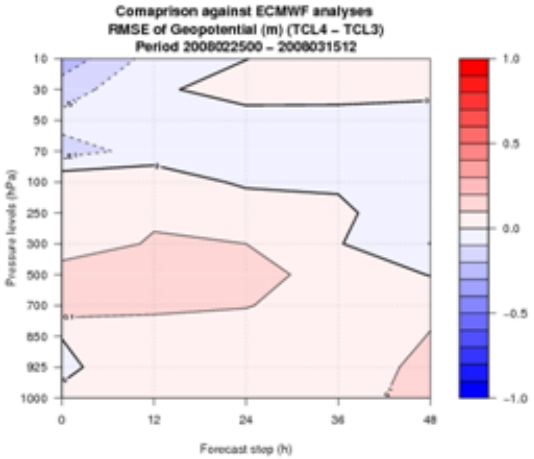


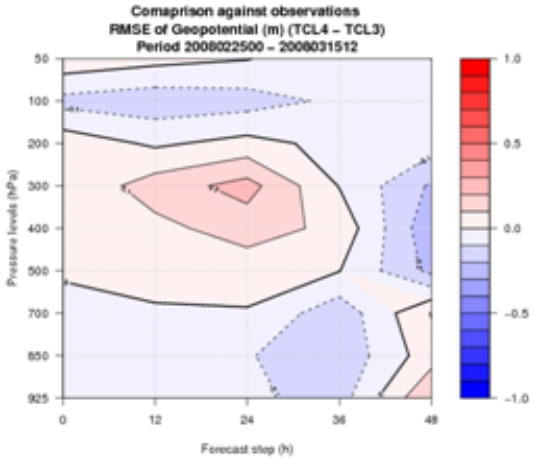
Met Office NAE

Issues for limited area models

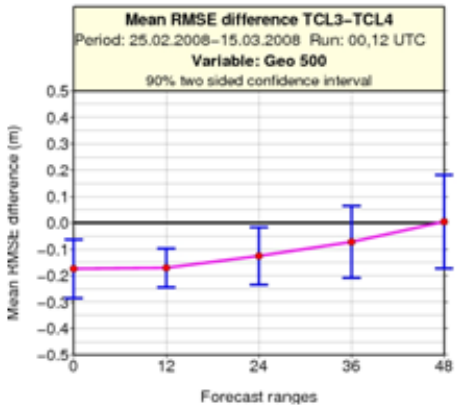
- **Land is much more important when there is very little sea!**
  - **But over a local area, it may be possible to use a constant emissivity**
- **Bias correction of observations requires careful thought**
  - **Data coverage is highly variable between cycles**
  - **Often a global model is not available to provide bias corrections**
  - **Even if there is a global model, there may be bias differences particularly for high peaking channels**
- **Strategy for estimating stratospheric temperatures**
- **Weather systems developing outside the model domain**

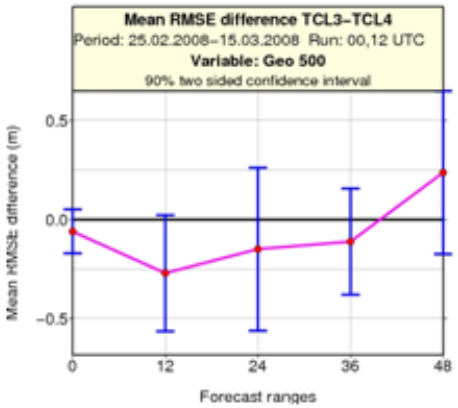
Positive impact on Geopotential Height in HARMONIE/Norway





Cross Section (Red is improvement)





500hPa ht (-ve Is improvement)

vs ECMWF Analysis

vs obs

Conclusions

- IASI and AIRS are giving very good impact on forecast scores
- Most impact is coming from 15μm CO_2 band
- Increasing use is being made of cloudy data
- No one is using land-sensitive channels
- Use of water vapour improving
- Use of IASI and AIRS in LAMS increasing

Questions?