



Variational cloud and rainfall data assimilation at ECMWF

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Presented by Tony McNally

ECMWF, Reading, UK



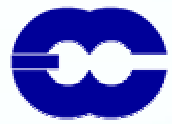
Outline

- Assimilation of rain observations
- Assimilation of cloud observations
- Summary

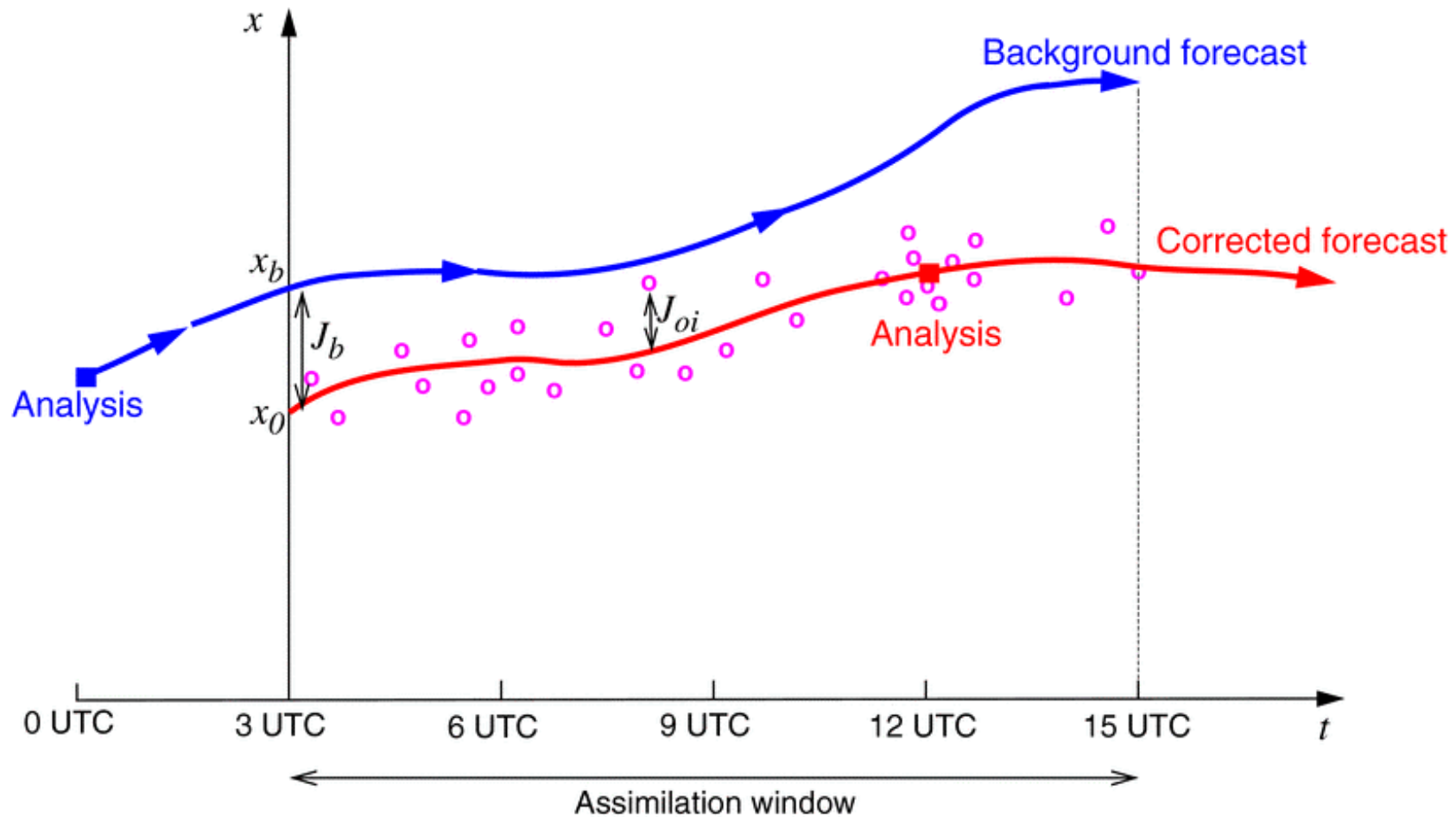


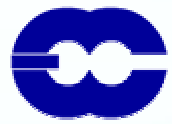
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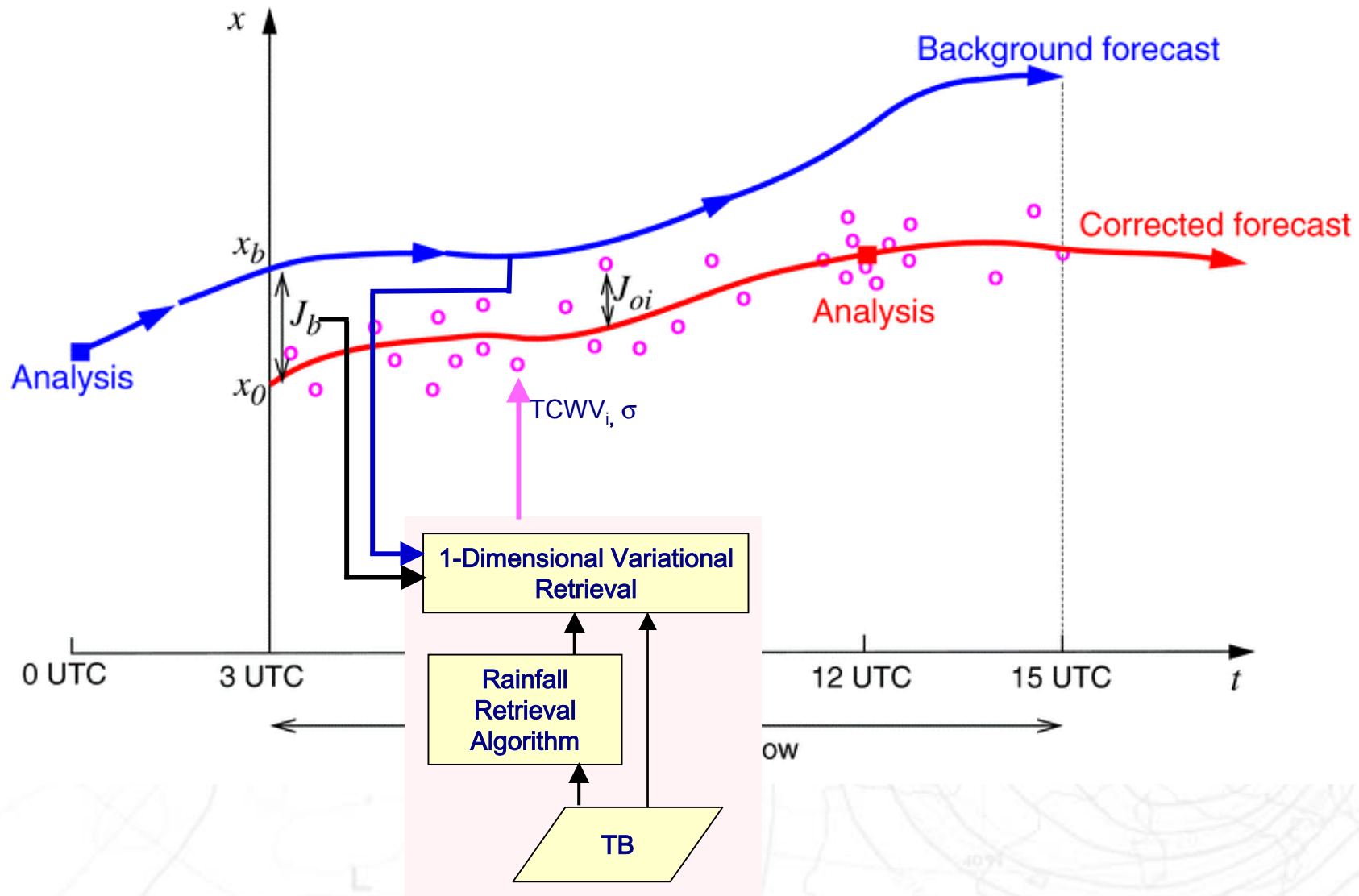


4D-Variational Analysis of Observations (4D-Var)





4D-Variational Analysis of rainfall Observations (4D-Var)





FC Rain from 26-12-2002 at 12 UTC 'ZOE'

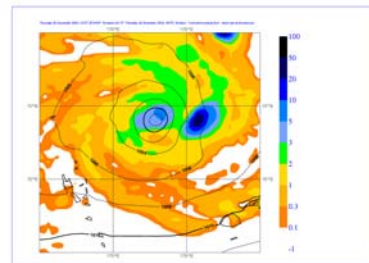
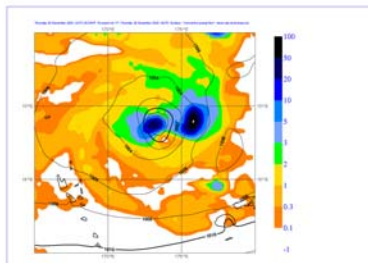
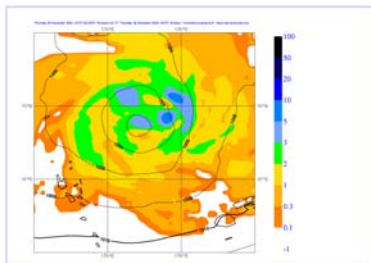
CONTROL

1D/BT

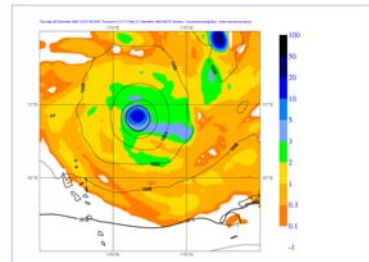
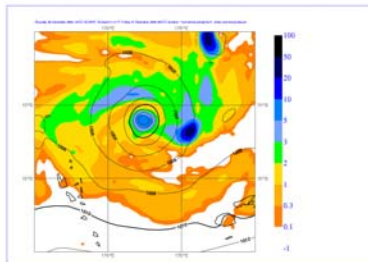
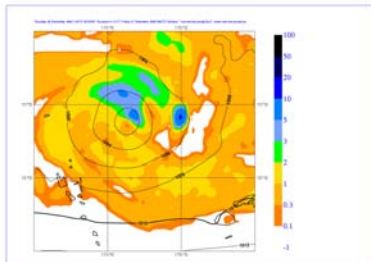
1D/RR

PATER/RR

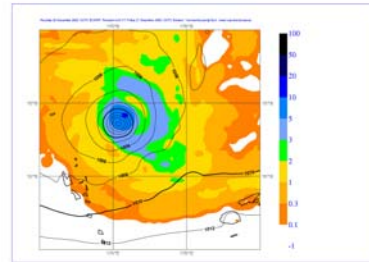
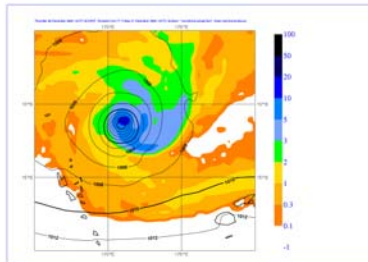
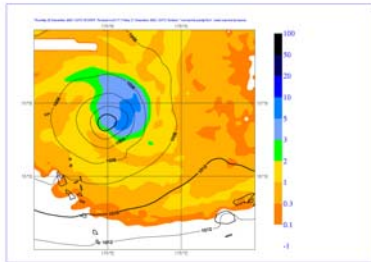
+6 H



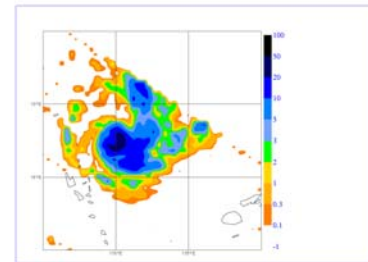
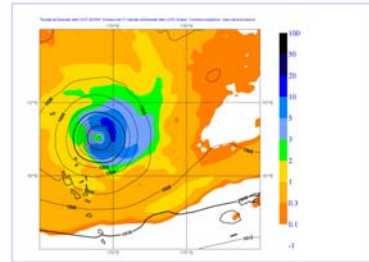
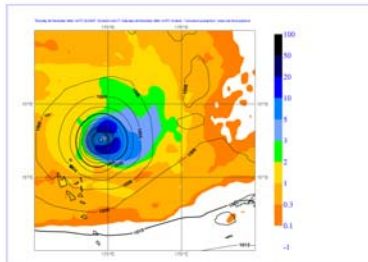
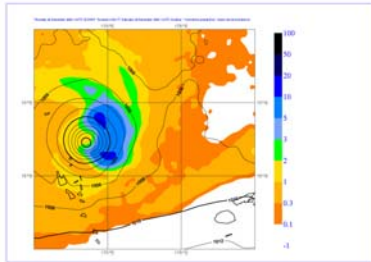
+12 H



+24 H



+48 H





FC Rain from 13-02-2003 at 00 UTC 'GERRY'

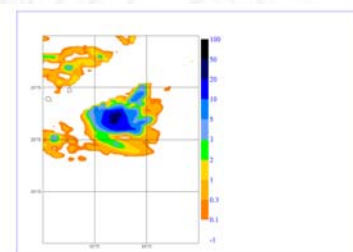
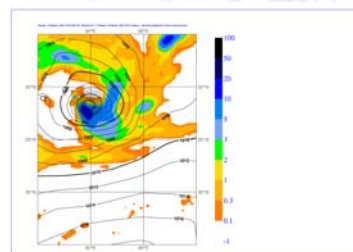
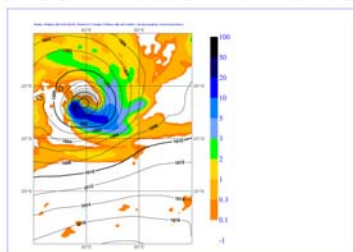
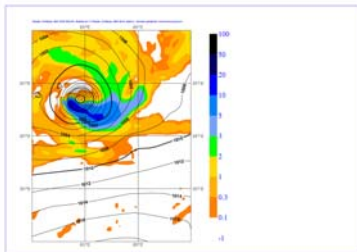
CONTROL

1D/RR

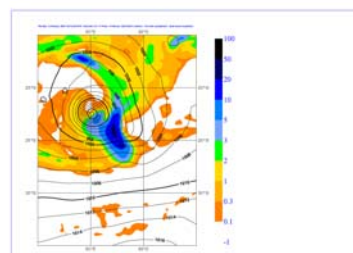
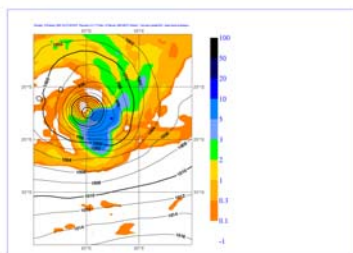
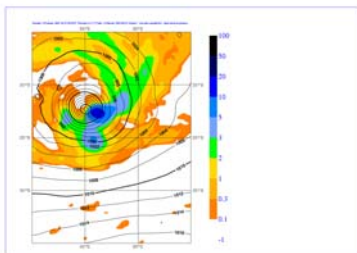
1D/BT
22 GHz

PATER/RR

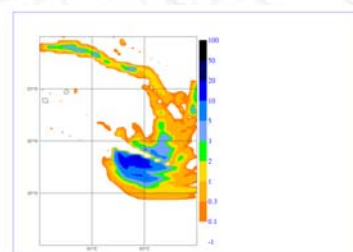
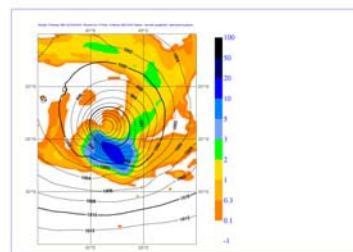
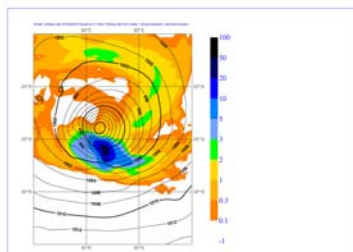
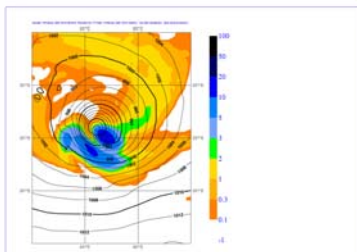
+6 H



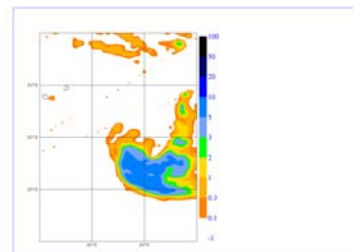
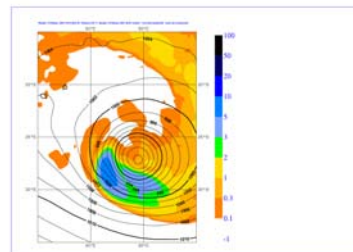
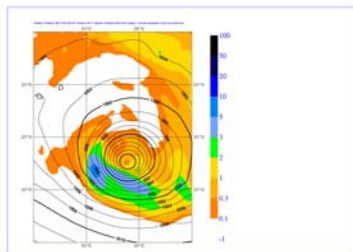
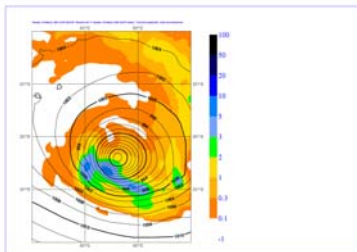
+12 H



+24 H



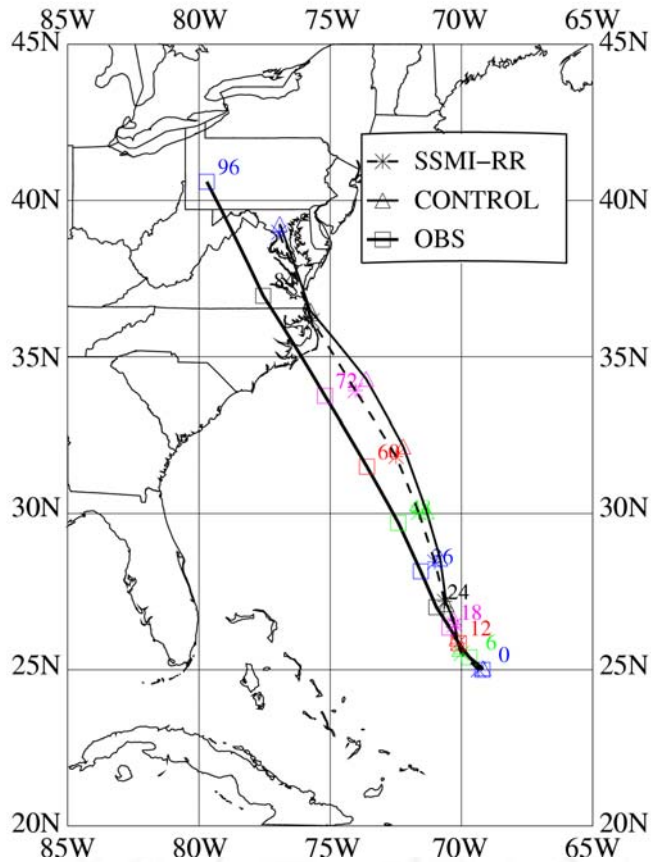
+48 H



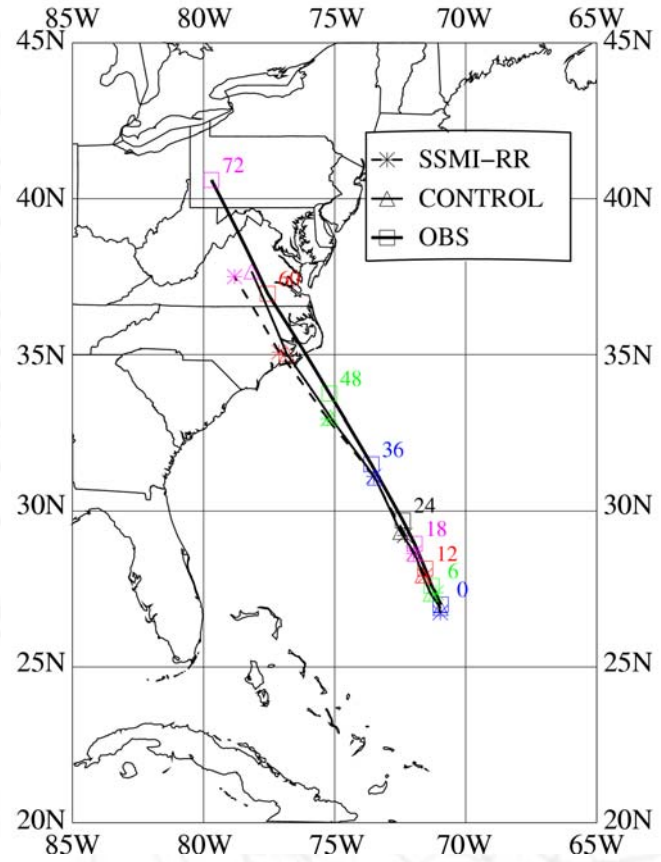


Tropical cyclone track forecasts: ISABEL

ISABEL TRACK FORECAST (BASE: 2003091512)



ISABEL TRACK FORECAST (BASE: 2003091612)



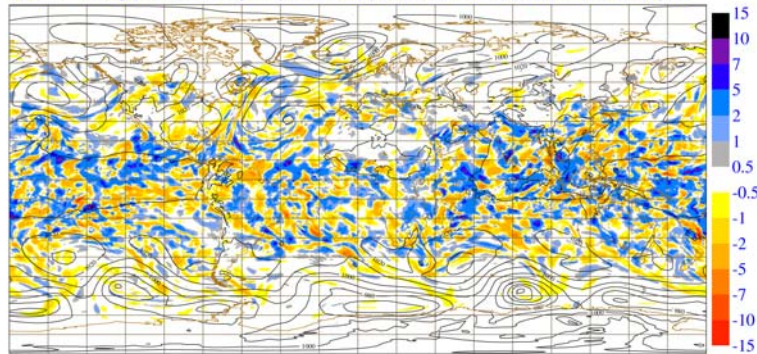


1D-Var+4D-Var TMI-RR Assimilation

(AN-FG)_{exp}

2003040100

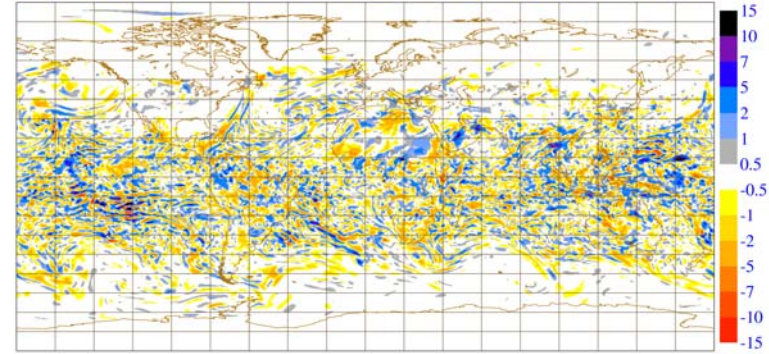
ECMWF Analysis VT:Tuesday 1 April 2003 00UTC Surface: mean sea level pressure
ECMWF Analysis VT:Tuesday 1 April 2003 00UTC Surface: **total column water vapour



AN_{exp}-AN₀₀₁₀

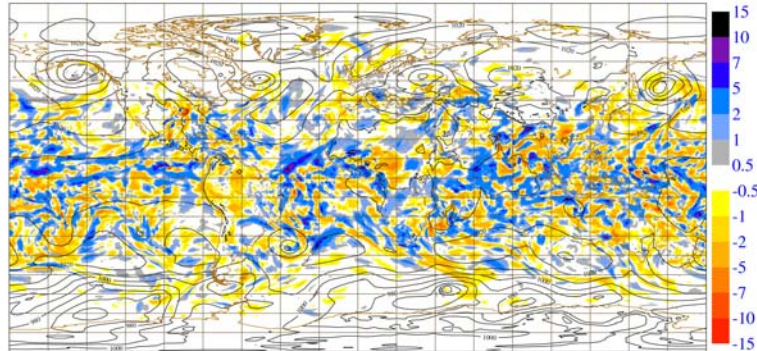
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ECMWF Analysis VT:Tuesday 1 April 2003 00UTC Surface: **total column water vapour



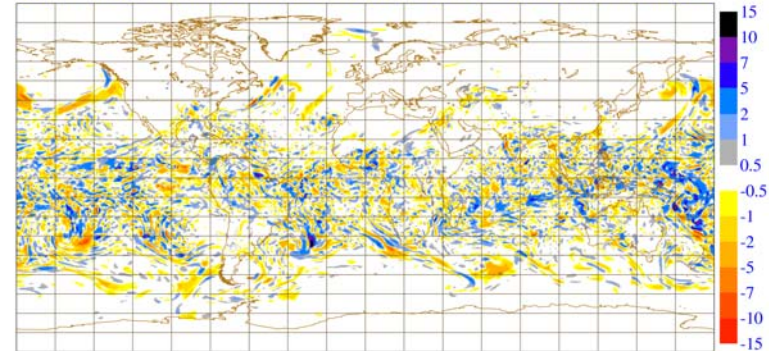
2003040700

ECMWF Analysis VT:Monday 7 April 2003 00UTC Surface: mean sea level pressure
ECMWF Analysis VT:Monday 7 April 2003 00UTC Surface: **total column water vapour



2003040700

ECMWF Analysis VT:Monday 7 April 2003 00UTC Surface: **total column water vapour





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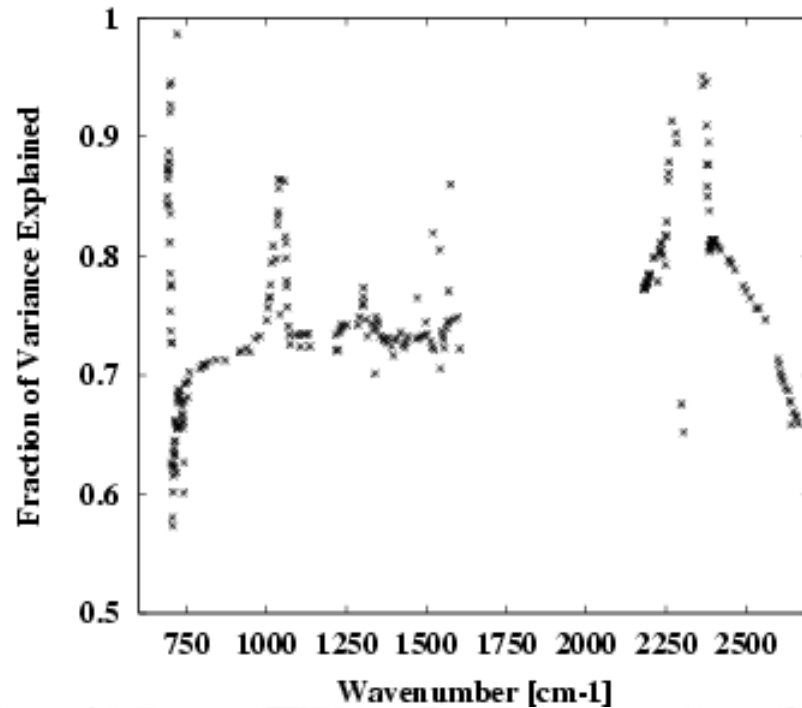


Assimilation of IR cloudy radiances

- Work on rain:
 - Initiated with rain retrievals
 - NL rainy 1D-Var provides TWVC then passed on to 4D-Var
- Cloudy 1D-Var
 - No usable IR cloud retrieval
 - 1D-Var provides $q(P)$
- No error estimation from NL 1D-Var (bias, std., corr.)
- Direct 4D-Var assimilation of Tbs?
 - Test idea with Meteosat and AIRS



Accuracy of H



- 30 November 2002
- Cloud-affected AIRS channels (McNally and Watts 2003)
- RTTOVCLD(FG) vs. OBS

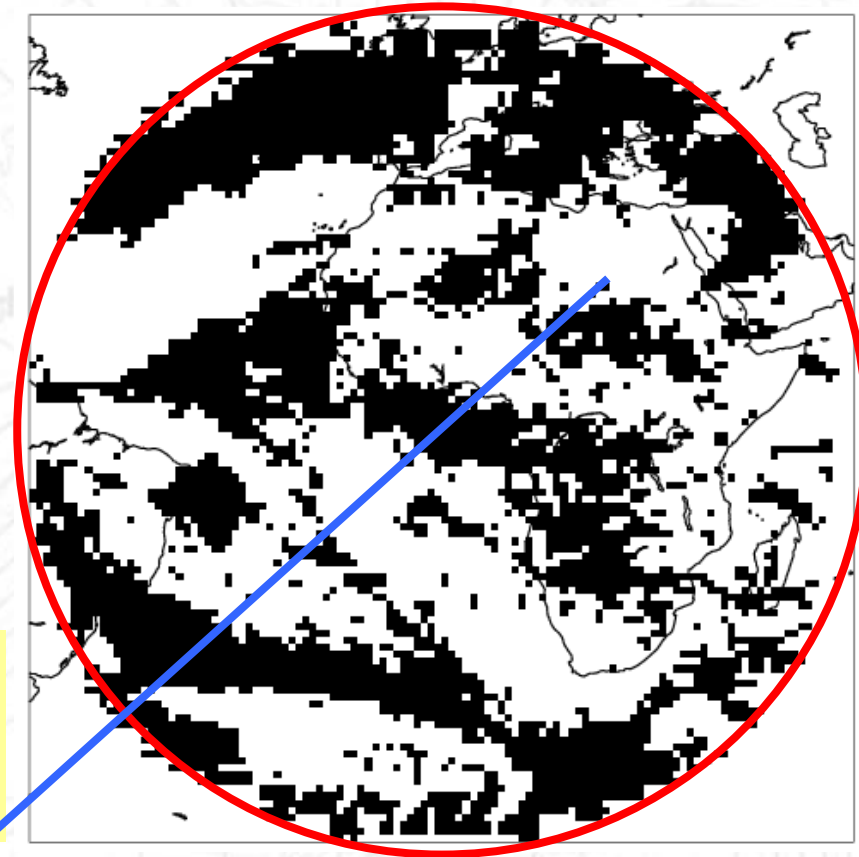


Linearity of H : method

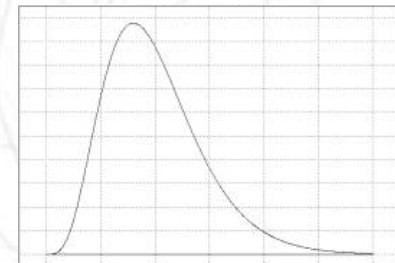
PDF of correlations between $H \cdot dx$ and $H[x+dx] - H[x]$
Hemispheric data

- $x = T, q$ profile
- $H =$ cloud scheme
+ RTTOVCLD
- $dx =$ perturbation from B

30 November 2002
12 UTC
Meteosat WV cloud mask



Correlation (x, y)

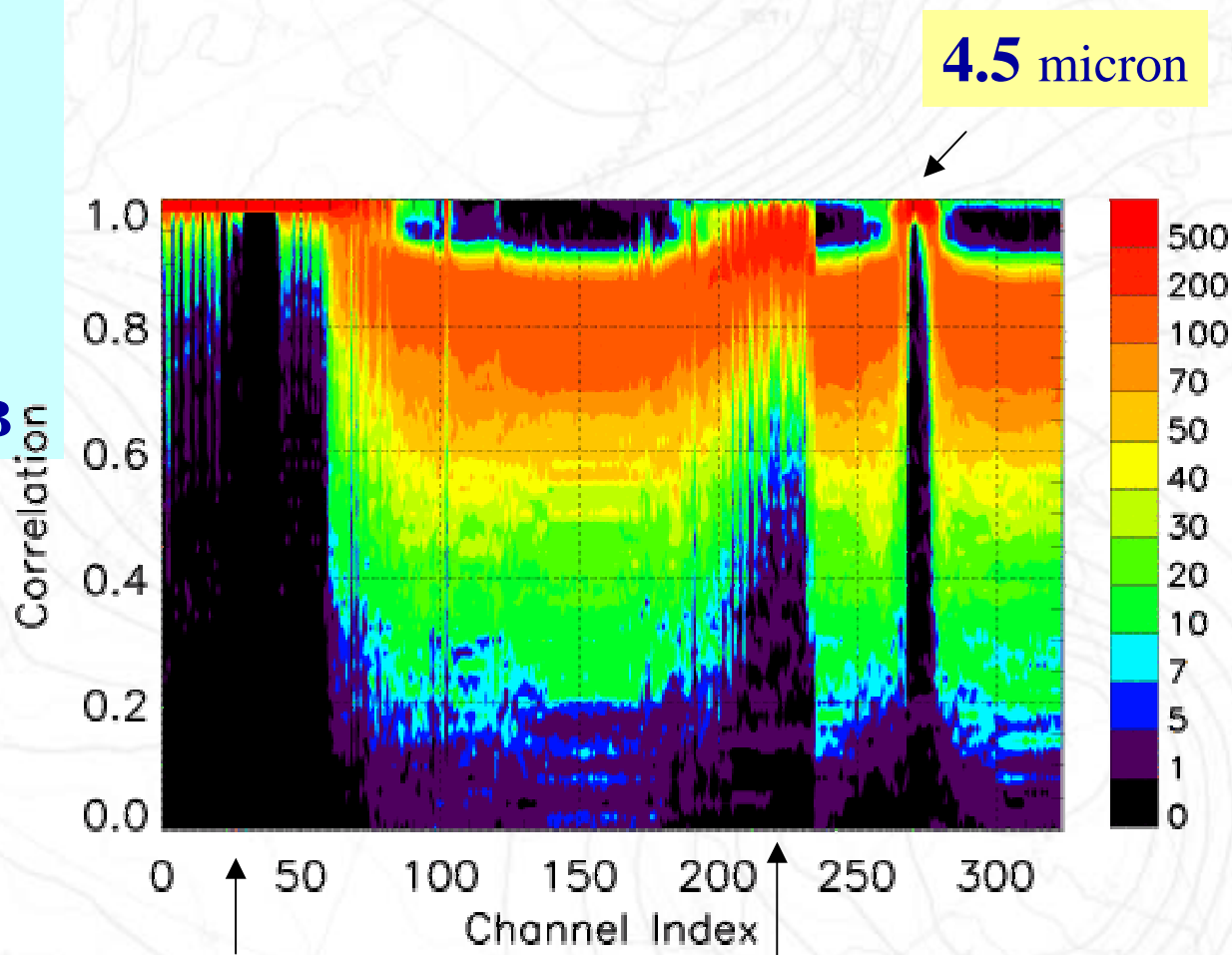




Linearity of H : results

PDF of correlations between $H \cdot dx$ and $H[x+dx] - H[x]$
Hemispheric data

- $x = T, q$ profile
- $H =$ cloud scheme + RTTOVCLD
- $dx =$ perturbation from B





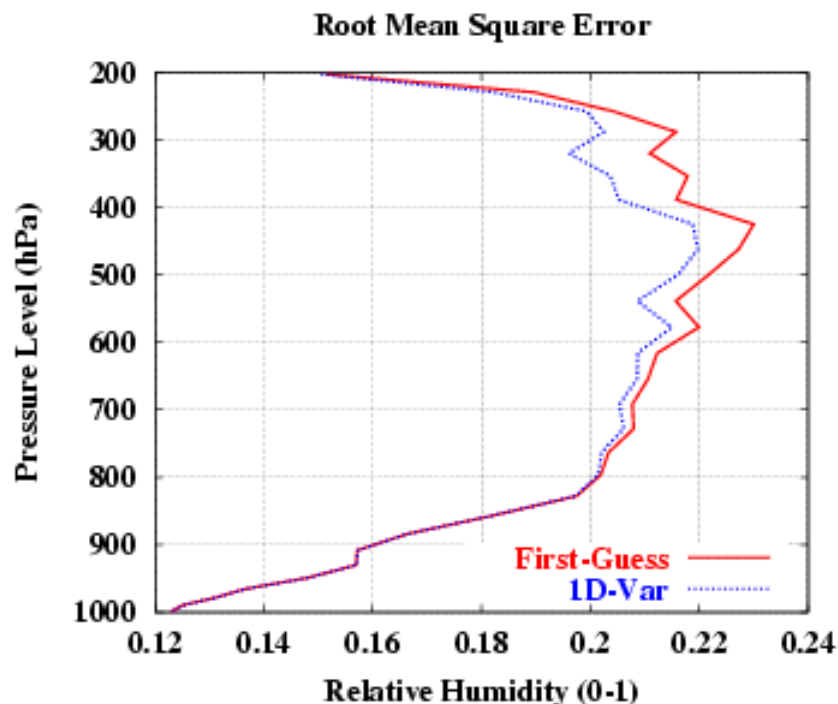
Cloudy AIRS and 1D-Var

- **Linear 1D-Var retrievals**
 - ✓ observations = 35 upper tropospheric AIRS channels
 - ✓ performed only if clouds are detected in more than 13 channels

Validation:

**1D-Var vs
European radiosondes
Nov 2002 and Feb 2003**

- If $T < 243\text{K}$ use Vaisala RS90 only
- ~ 250 matches in upper troposphere
- ~ 2300 matches in lower troposphere





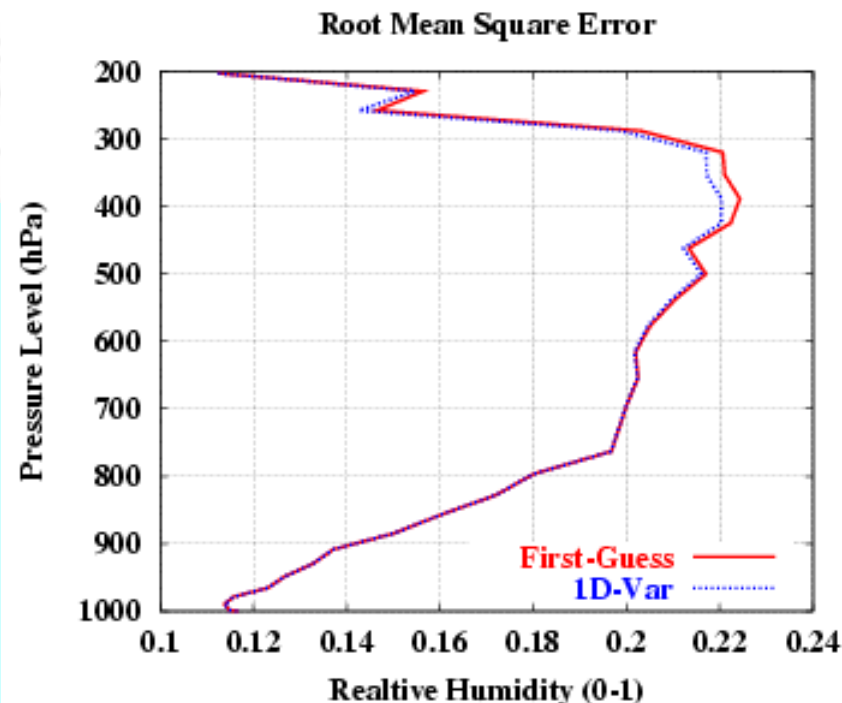
Cloudy Meteosat and 1D-Var

- Linear 1D-Var retrievals
 - ✓ observations = cloudy Meteosat WV

Validation:

1D-Var vs
European radiosondes
Nov 2002 and Feb 2003

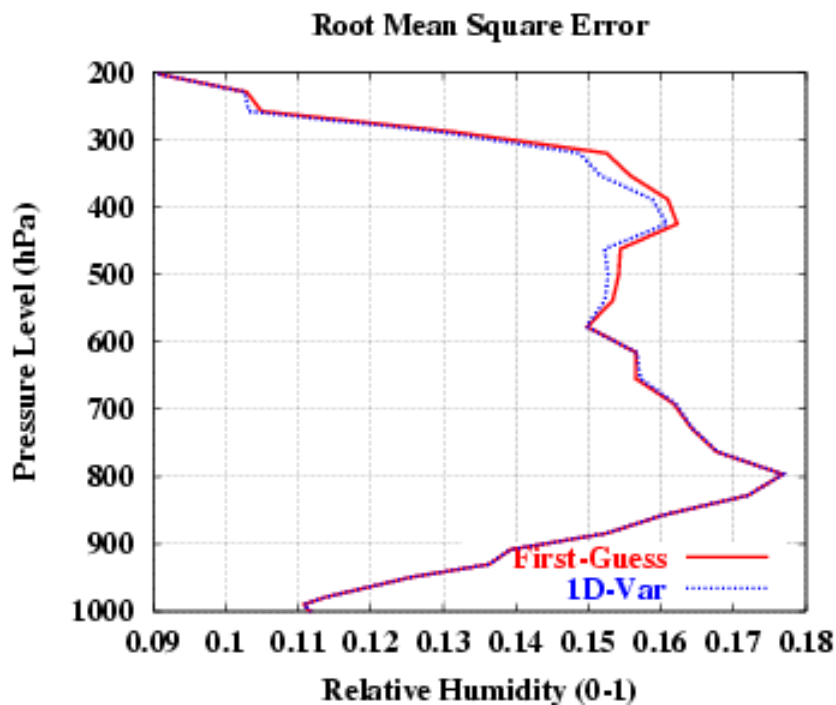
- If $T < 243\text{K}$ use Vaisala RS90 only
- ~ 250 matches in upper troposphere
- ~ 1500 matches in lower troposphere





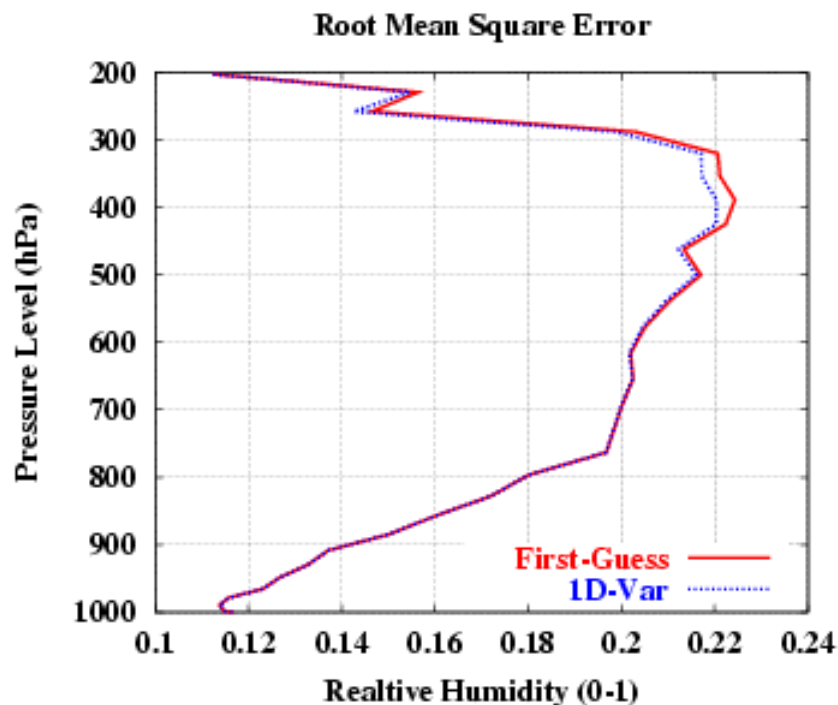
Cloudy Meteosat and 1D-Var

Clear quadrants



~ 250 matches in UT
~ 1500 matches in LT

Cloudy quadrants



~ 200 matches in UT
~ 1400 matches in LT



Summary

- 1D-Var+4D-Var approach developed for MW
 - Better forecast of tropical cyclones
 - Impact in Extra-tropics to be examined

- On-going direct 4D-Var
 - IR: 4.5, 6.3 and 14.3 micron
 - 6.3 micron from geostationary satellites
 - MW: 22 GHz
 - Small increments
 - Better handling of errors in 4D-Var analysis (Bayesian)

- RTTOV extended
 - RTTOVCLD: Multilayer cloudiness, absorption, IR+MW
 - RTTOVSCATT: MW scattering
 - extensions in standard v8