Met Office

Cloud and precipitation assimilation at the Met Office

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Contents

This presentation covers the following areas

- precipitation assimilation
- cloud assimilation

    1) satellite radiances, Global

    2) StratoCumulus, regional

Precipitation Assimilation

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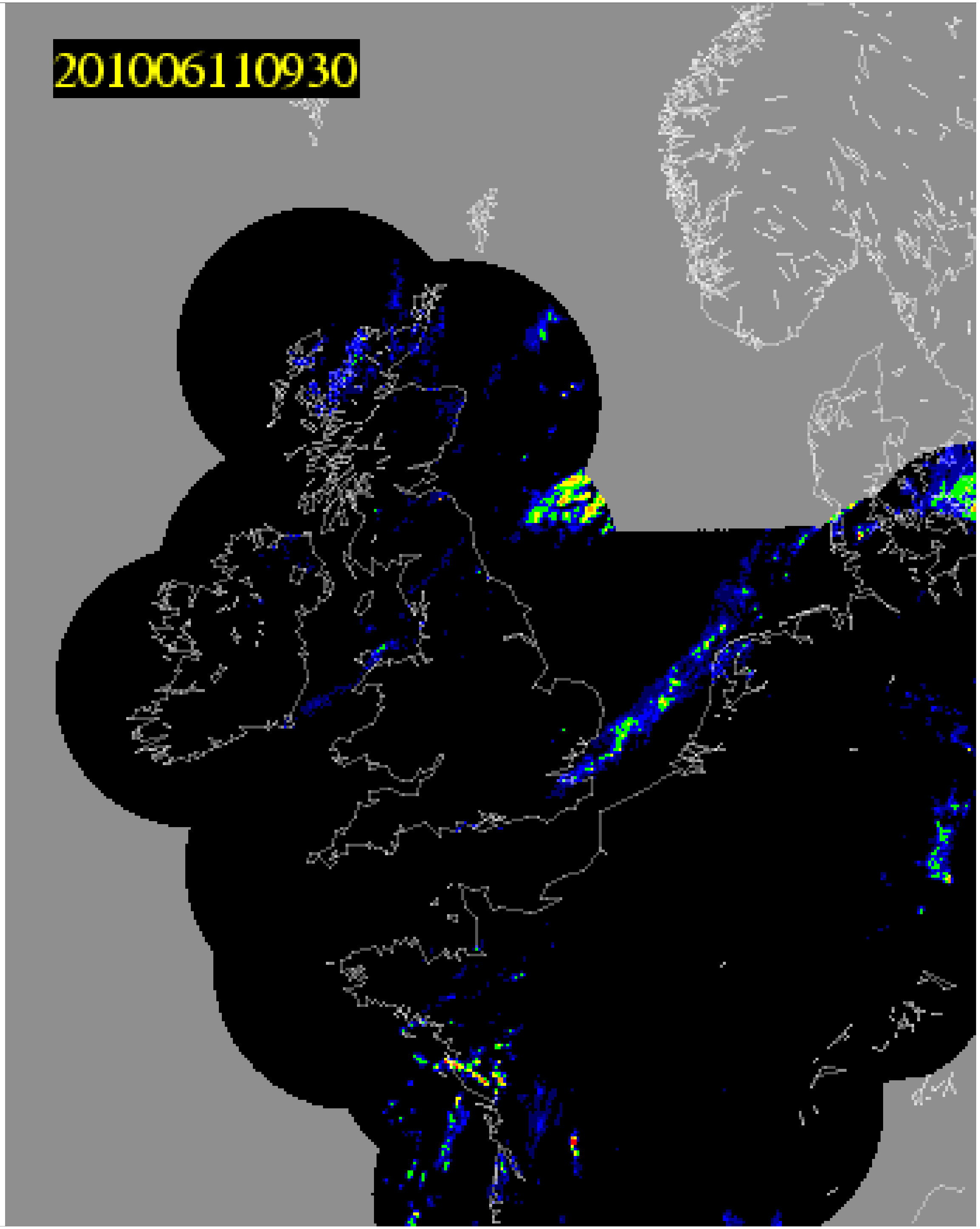
Hourly radar composite



Using the Radar Data in 4D-VAR

- Currently assimilate hourly radar-derived precipitation rates via latent heat nudging

- Testing assimilation of ppn rate in 4D-VAR

  - PF model has linearised microphysics (large-scale precipitation) and linearised convection scheme

  - Removes complication of running two assimilation schemes, 4D-Var & LHN

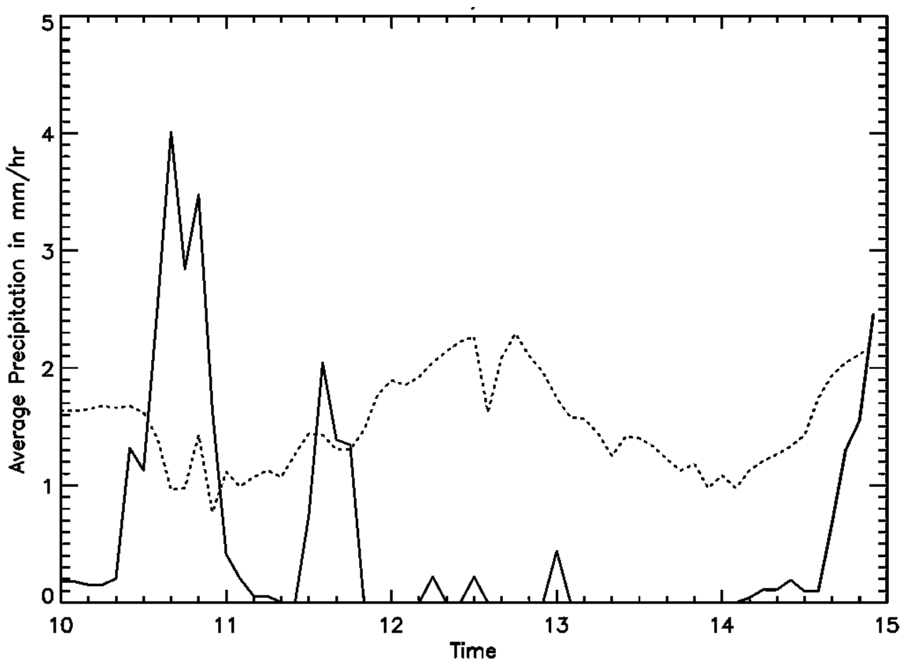
  - Potential to adjust dynamics to fit rainfall

On-off signal in model convective rainfall

Rain rate at single pixel:

Large-Scale

Convective



Radar rainfall rates used hourly from T-2 to T+3

Equivalent background values are averaged over 30 minutes

Using the Radar Data in 4D-Var

- 1-month NAE trial at 24km, results close to LHN
- Case studies: works best for large-scale rainfall
- Spin-up - Increased ppn in first few timesteps after assimilation. Can be reduced by
    - IAU – nudge increments into model
    - Tuning Jc penalty
- Test assimilating accumulations not rates
- Plans for further trialling with an additional Var outer loop
- Research: direct assimilation of reflectivities

(Nicolas Gaussiat, Sue Ballard)

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Cloud Assimilation

1) satellite radiances

Var moist control variable

x total moisture (RHt)

H(x)

vapour cloud

Calculate Jo, δJo/δH(x)

Microwave radiances in cloud

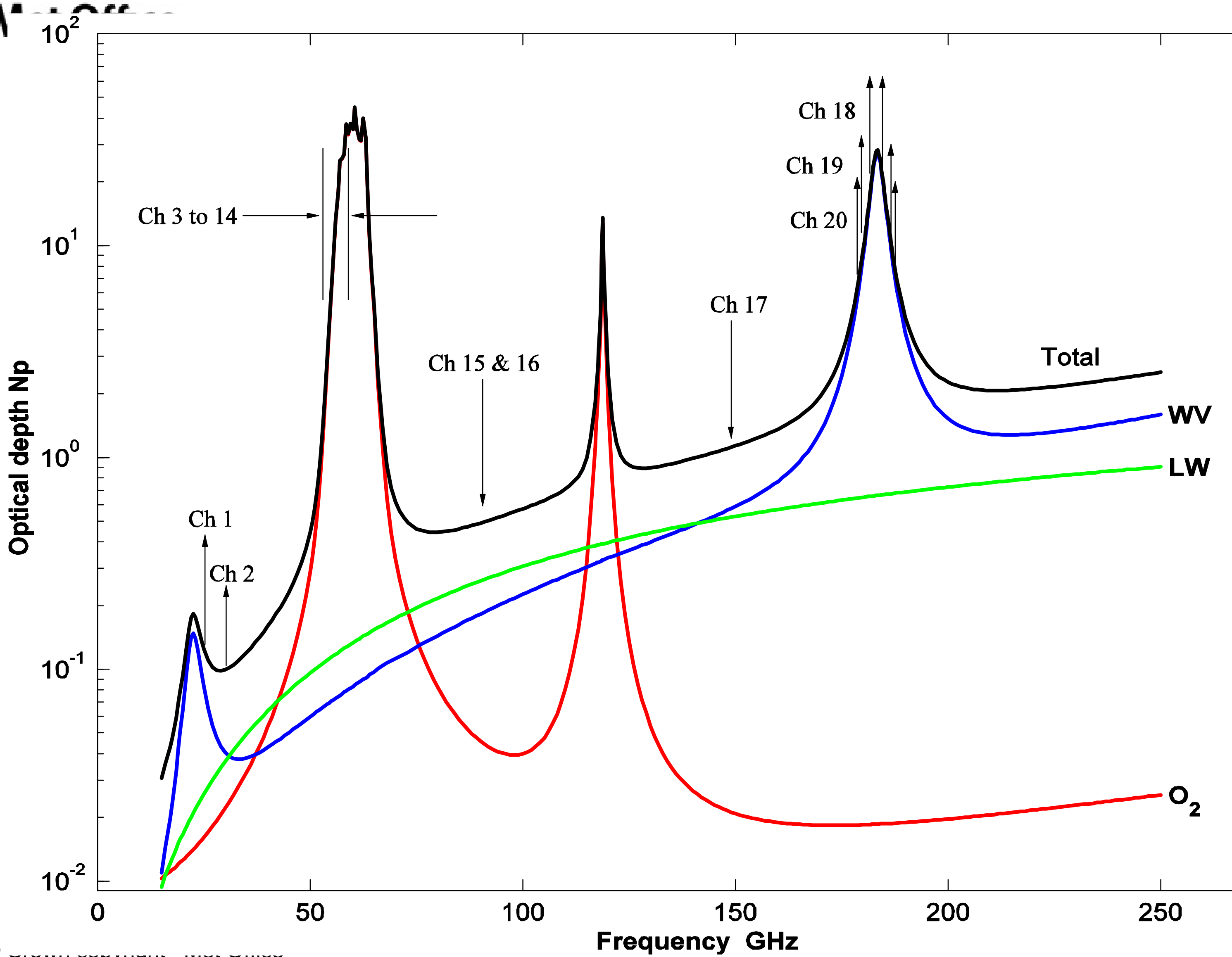
Assimilating lowest frequency AMSU channels in cloud

(23.8, 31.4 GHz)

- Improves fit to background of temperature sounding channels (50GHz)
- Leads to improved model temperature bias

(Adrian Jupp)

Microwave Spectrum

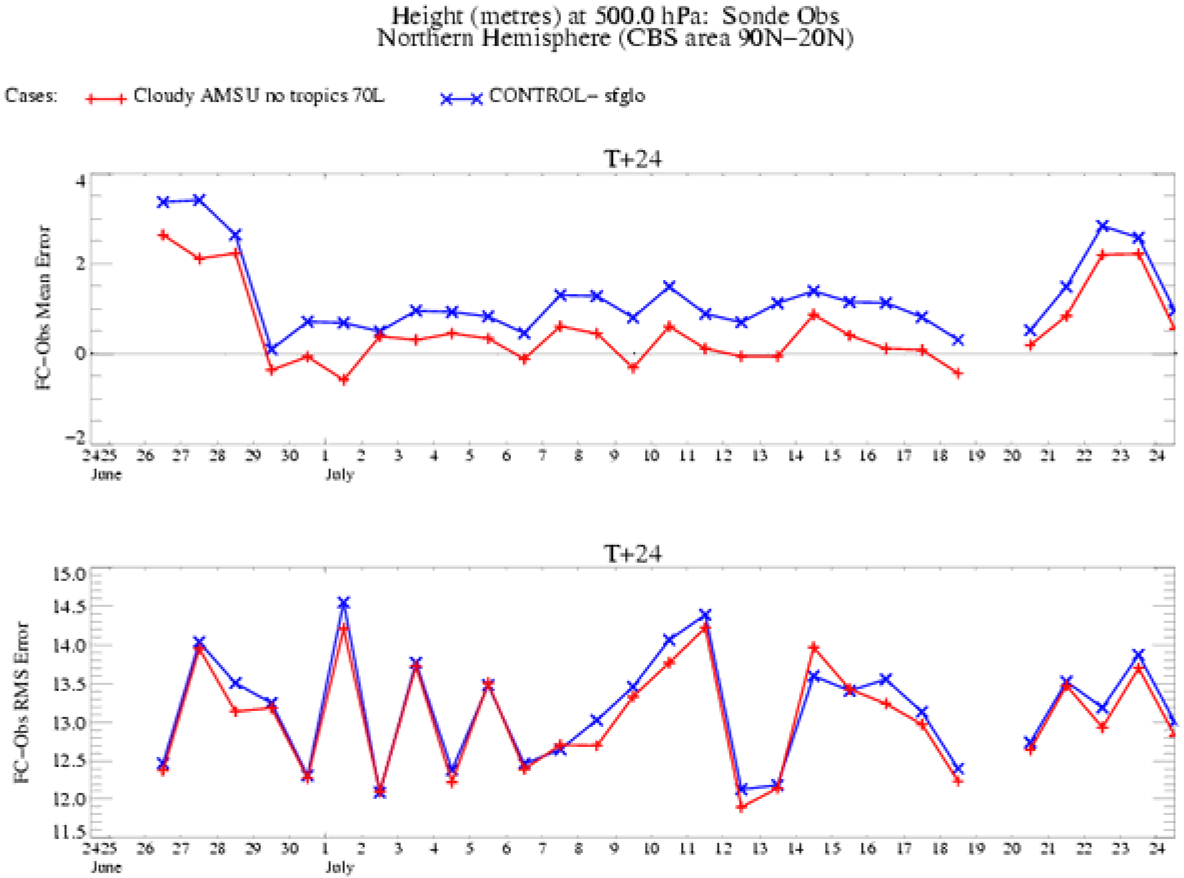


Microwave radiances in cloud

T+24 500hPa height against sondes

mean

rms



Microwave radiances in cloud

Depends on:

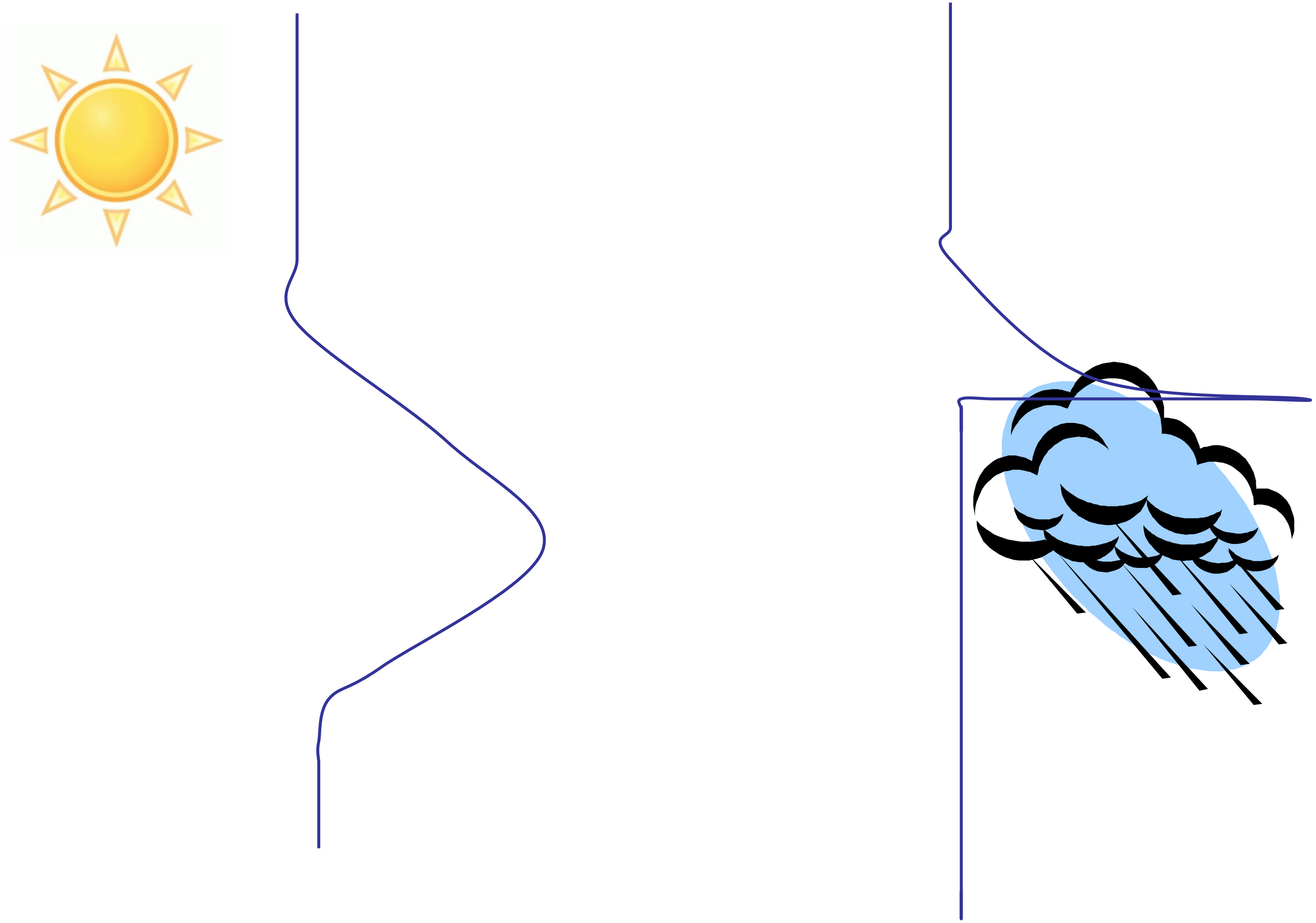
Vapour | Liquid cloud

=> broadly same effect on radiances

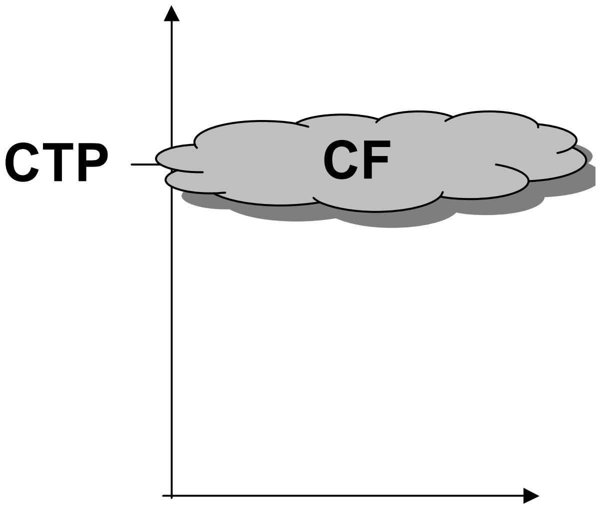
Where cloud is observed,

Var can increase vapour until we get cloud

Infra-red radiances in cloud

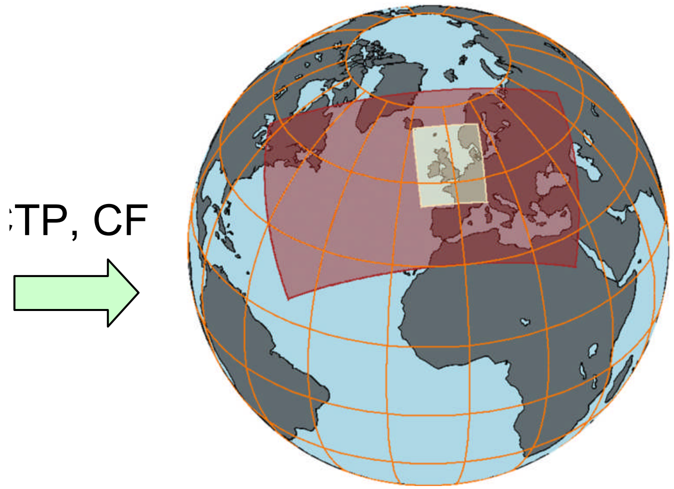


1D-Var cloud analysis



- Retrieve cloud parameters in 1D-Var
  - Cloud top pressure & Cloud fraction
  - Using RTTOV single level grey cloud approximation

- Choose channels with minimal sensitivity below cloud top

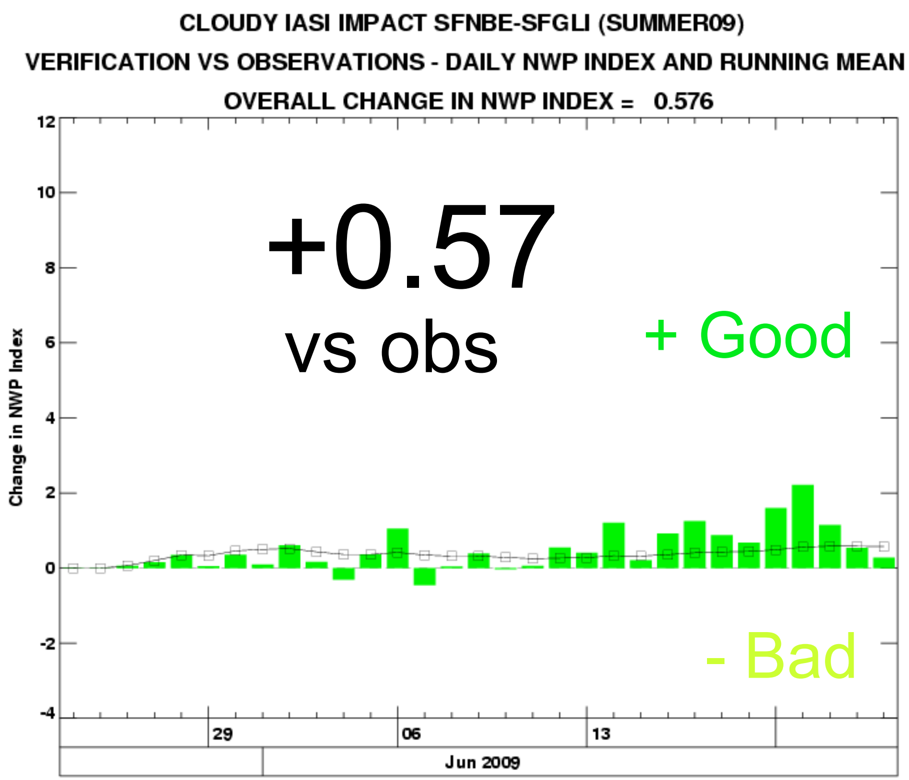


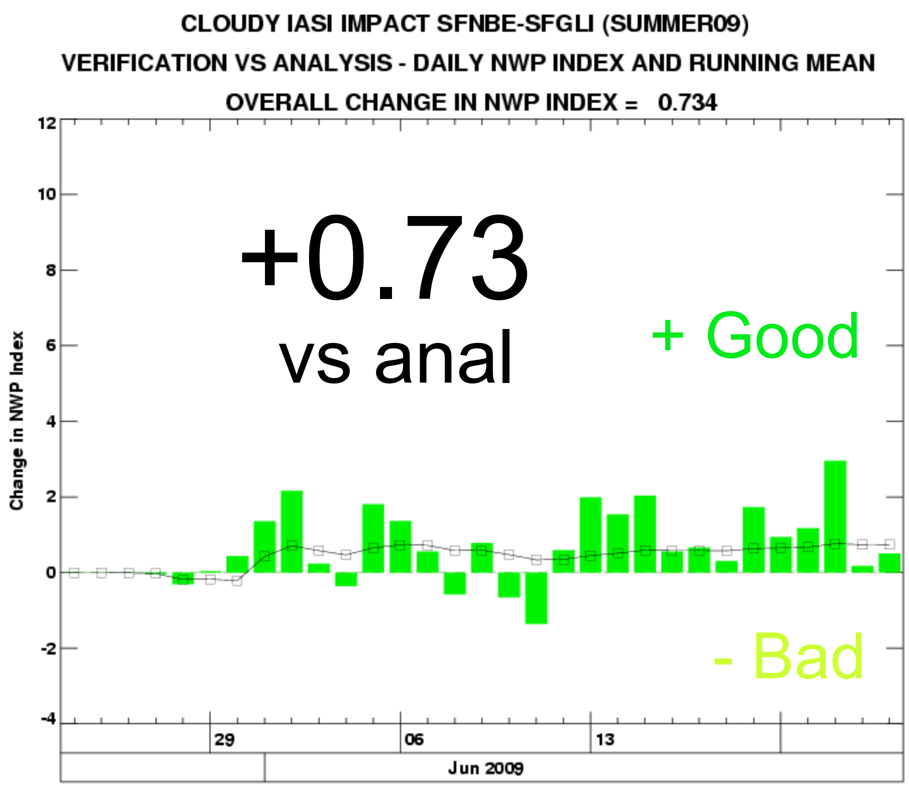
4D-Var

- Pass cloudy radiances, retrieved CTP and CF to 4D-Var
- Cloud parameters used as fixed inputs to RTTOV

Ed Pavelin

Forecast impact (Summer 2009)





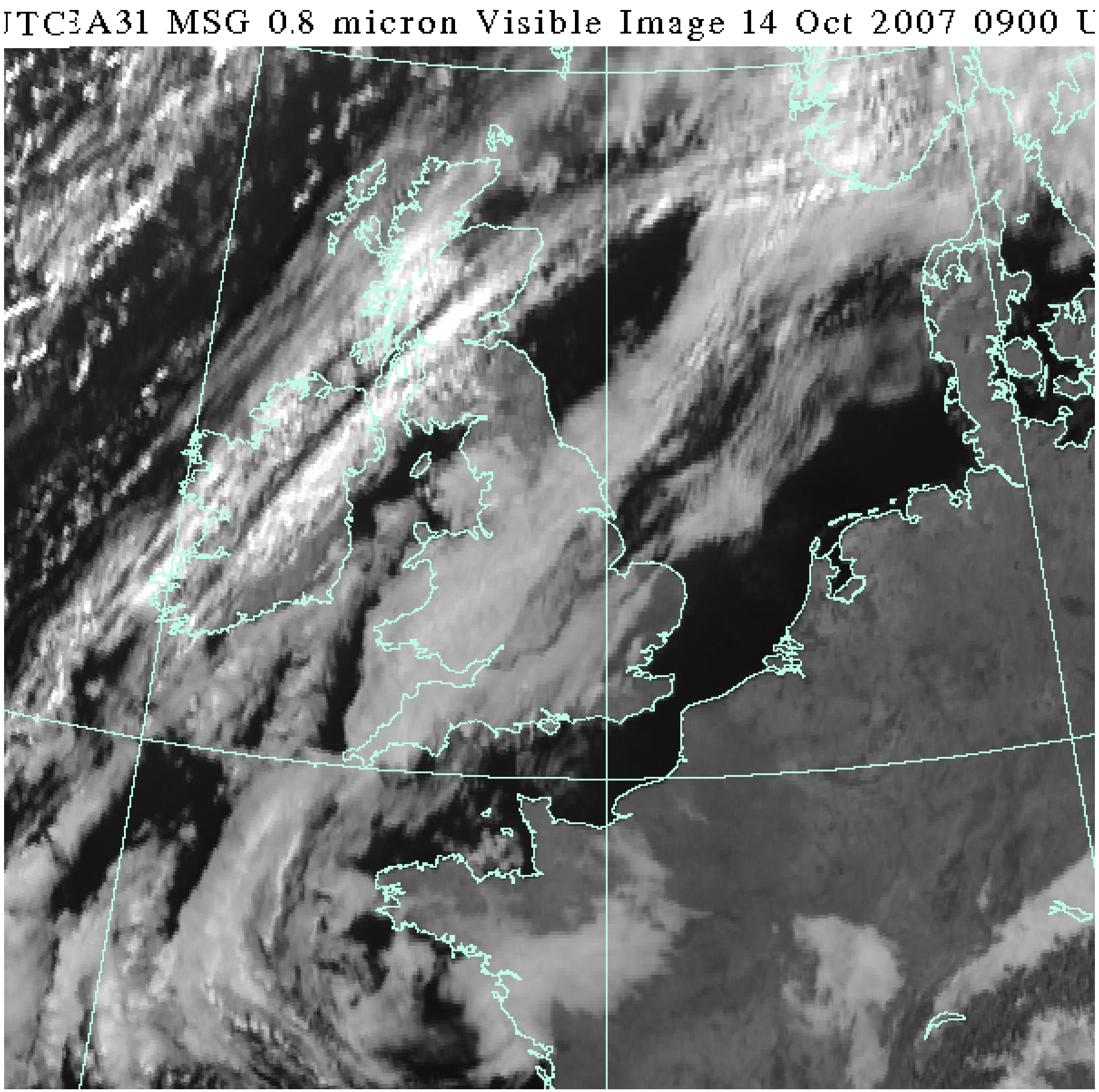
Met Office Global NWP Index

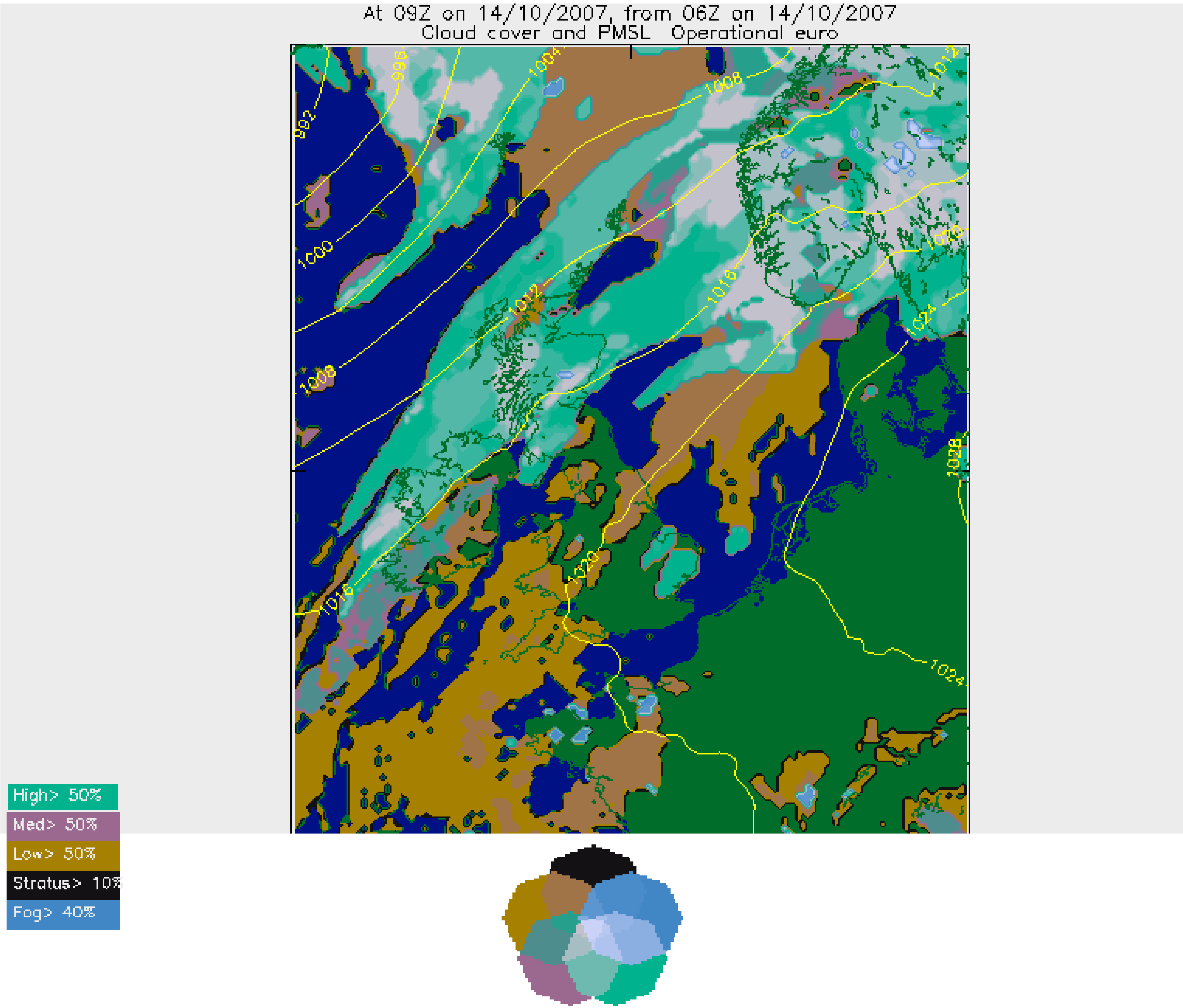
Summary
Assimilation of cloudy radiances

- AMSU channels 1&2 improve use of AMSU temperature channels in cloud
- IASI cloudy 1D-Var indicates which ‘clear’ channels we can use in cloud

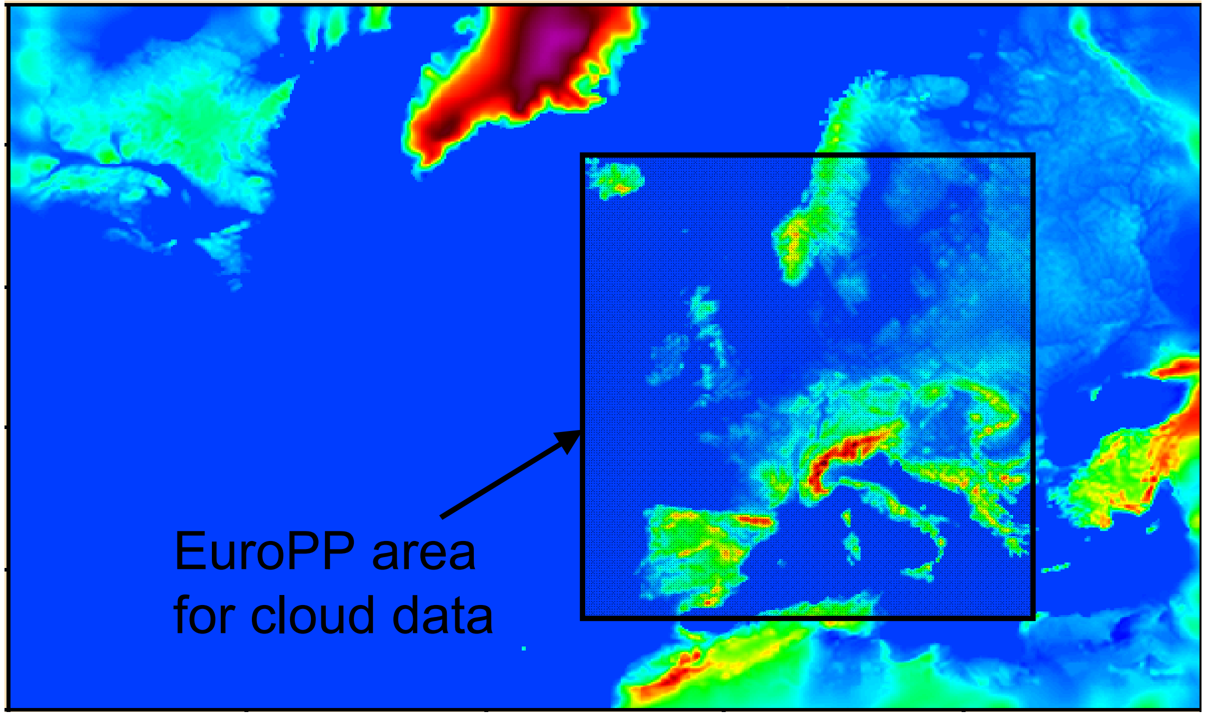
Cloud Assimilation

2) stratocumulus


JTC3A31 MSG 0.8 micron Visible Image 14 Oct 2007 0900 U


At 09Z on 14/10/2007, from 06Z on 14/10/2007
Cloud cover and PMSL Operational euro
992
996
1000
1004
1008
1012
1016
1020
1024
1028
High> 50%
Med> 50%
Low> 50%
Stratus> 10%
Fog> 40%

North Atlantic / European model

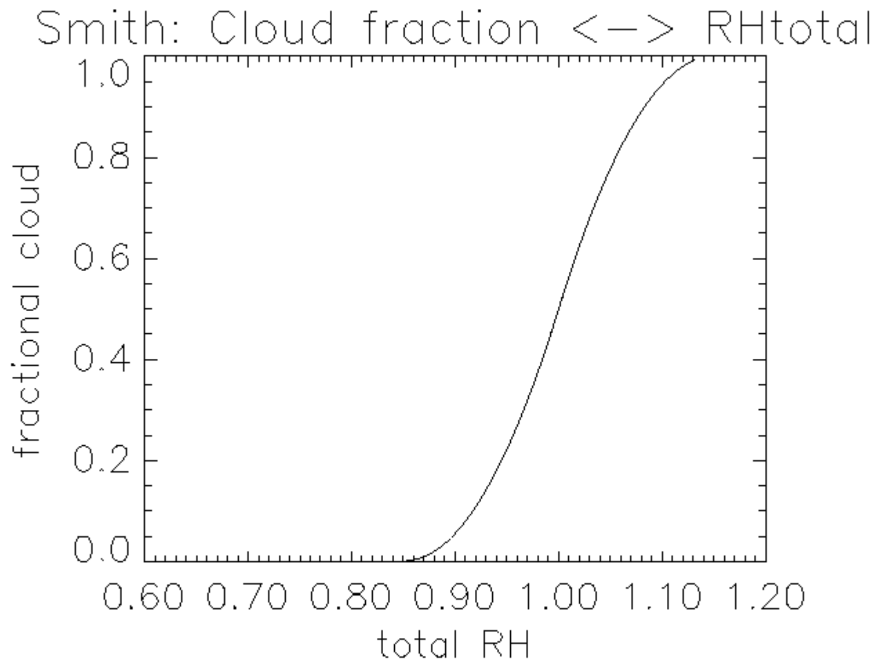


EuroPP cloud analysis:

SEVIRI cloud top + SYNOP cloud base

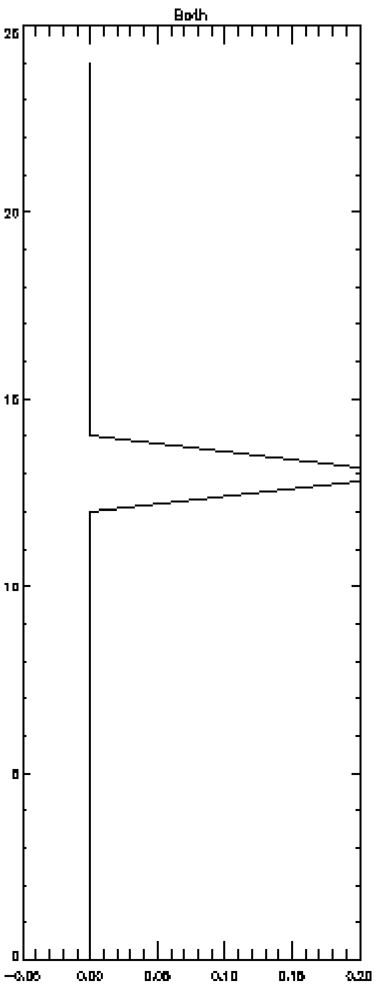
Cloud in VAR

- Operational in NAE & UK models from November 2008
- Uses gridded cloud fractions from nowcasting scheme
- Cloud fraction is assimilated as proxy Relative Humidity

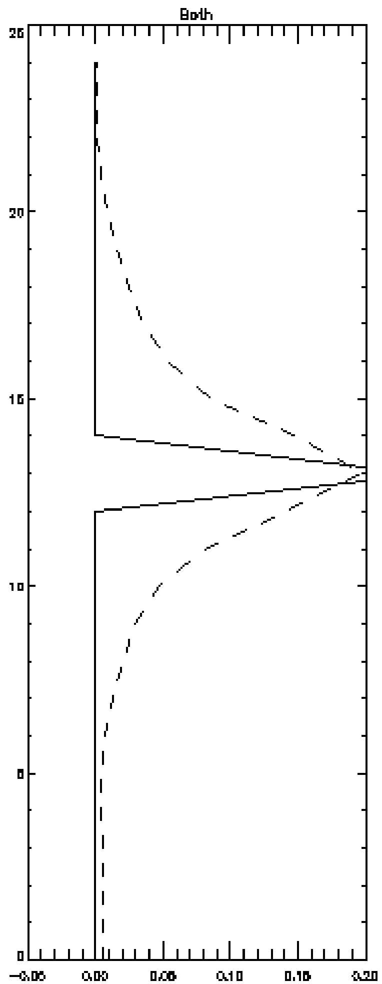


RH increments too broad in vertical

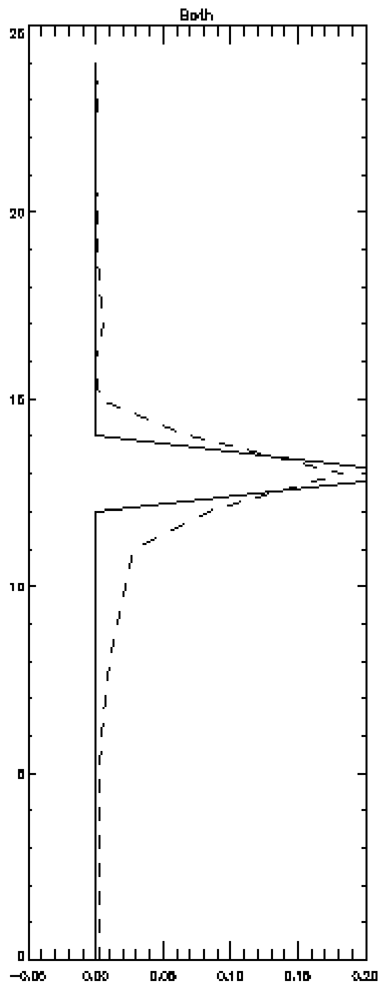
Ob



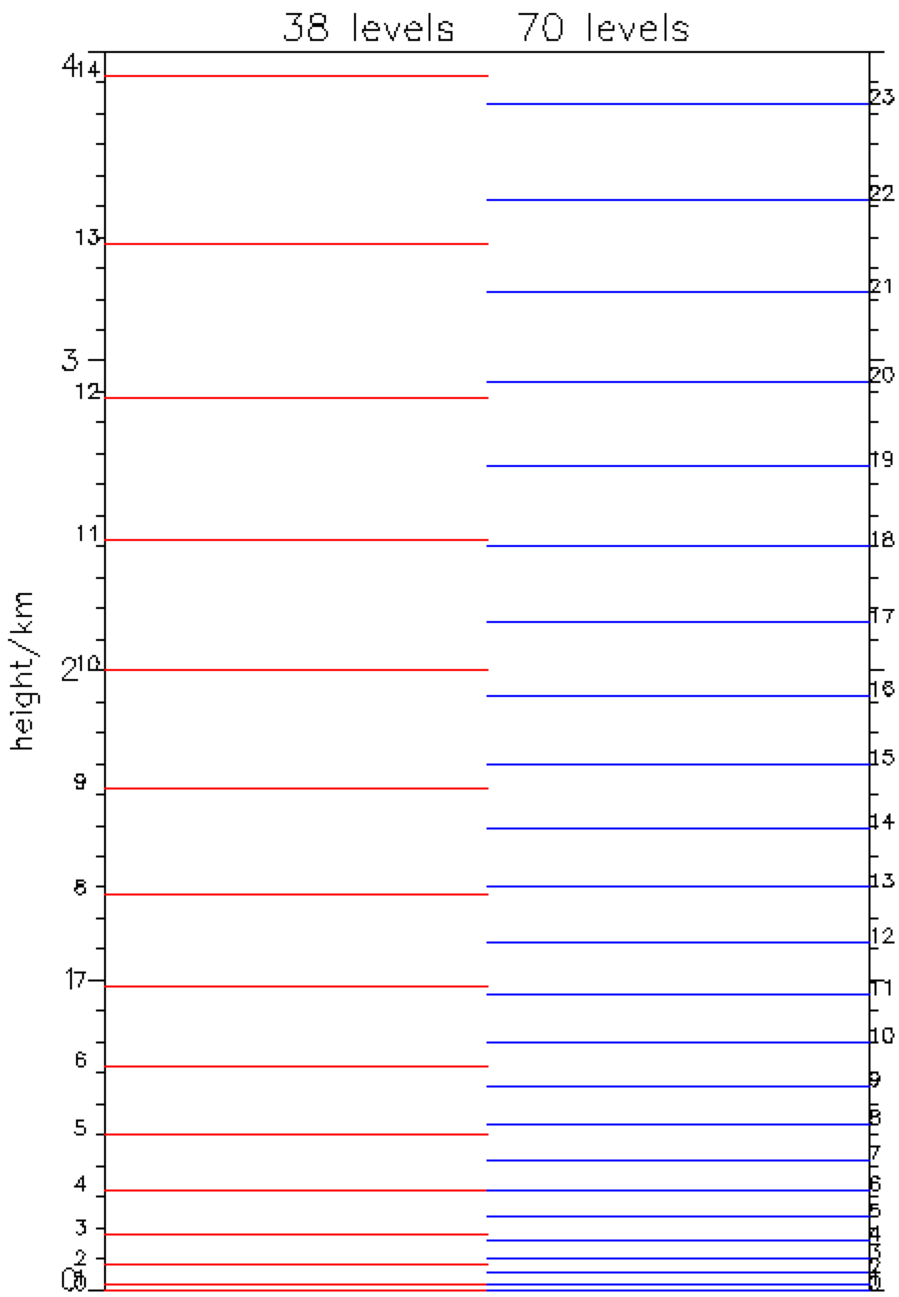
Var



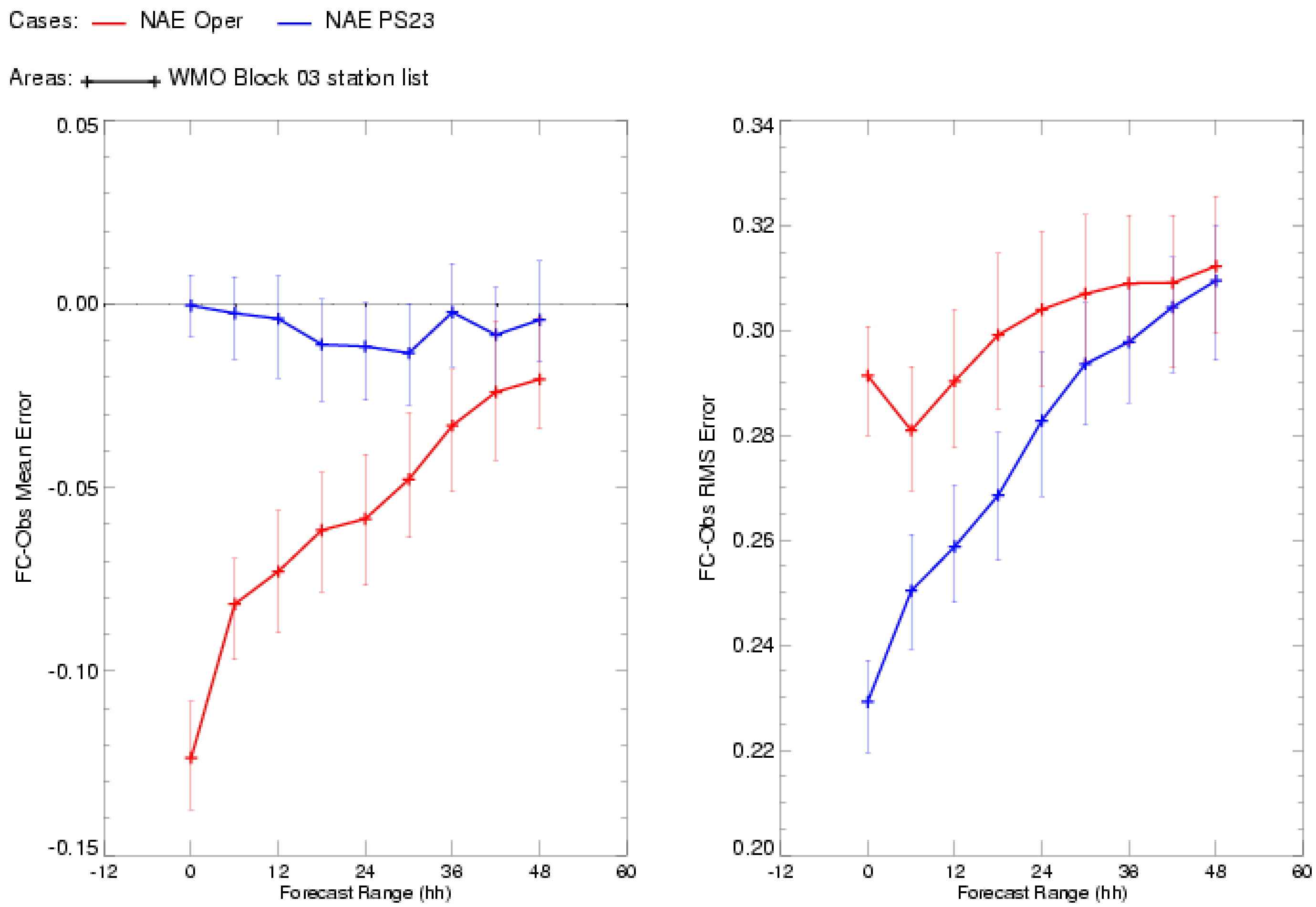
Var + constraint



Vertical levels
lowest 4km
~200m res'n



Impact of 38 to 70 levels cloud fraction



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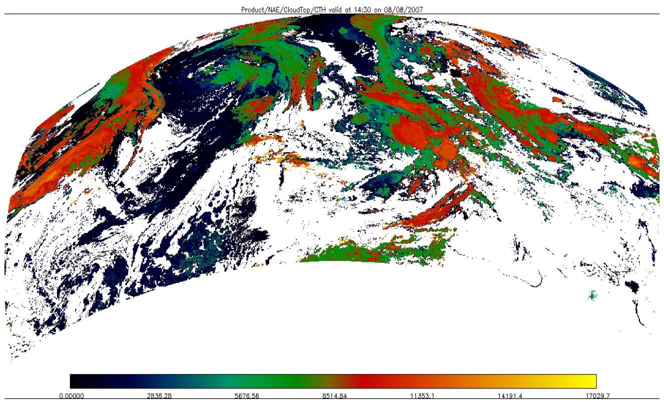
Assimilation of SEVIRI cloud products directly into NAE model

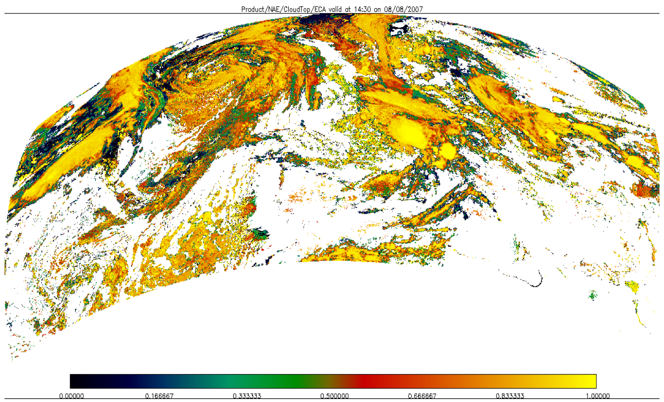
Can potentially use data for entire domain

No intermediate step via EuroPP nowcasting system

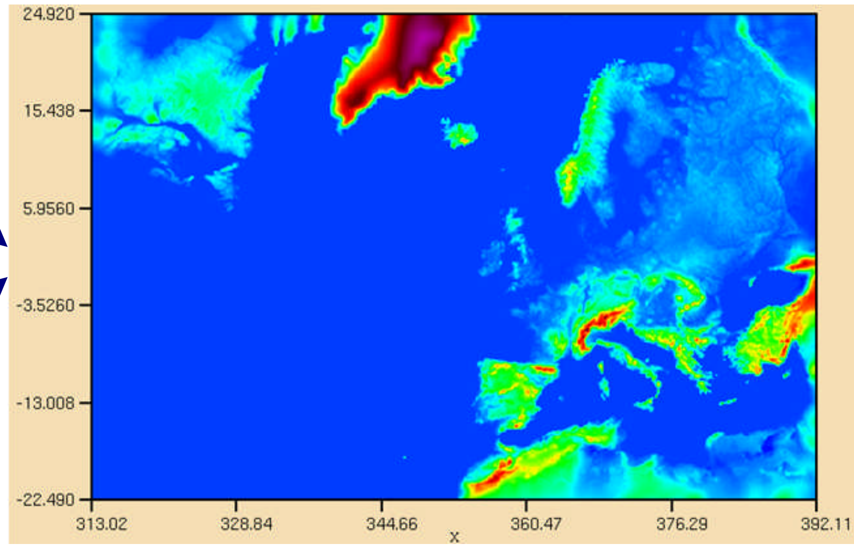
BUT no surface cloud data



CTH

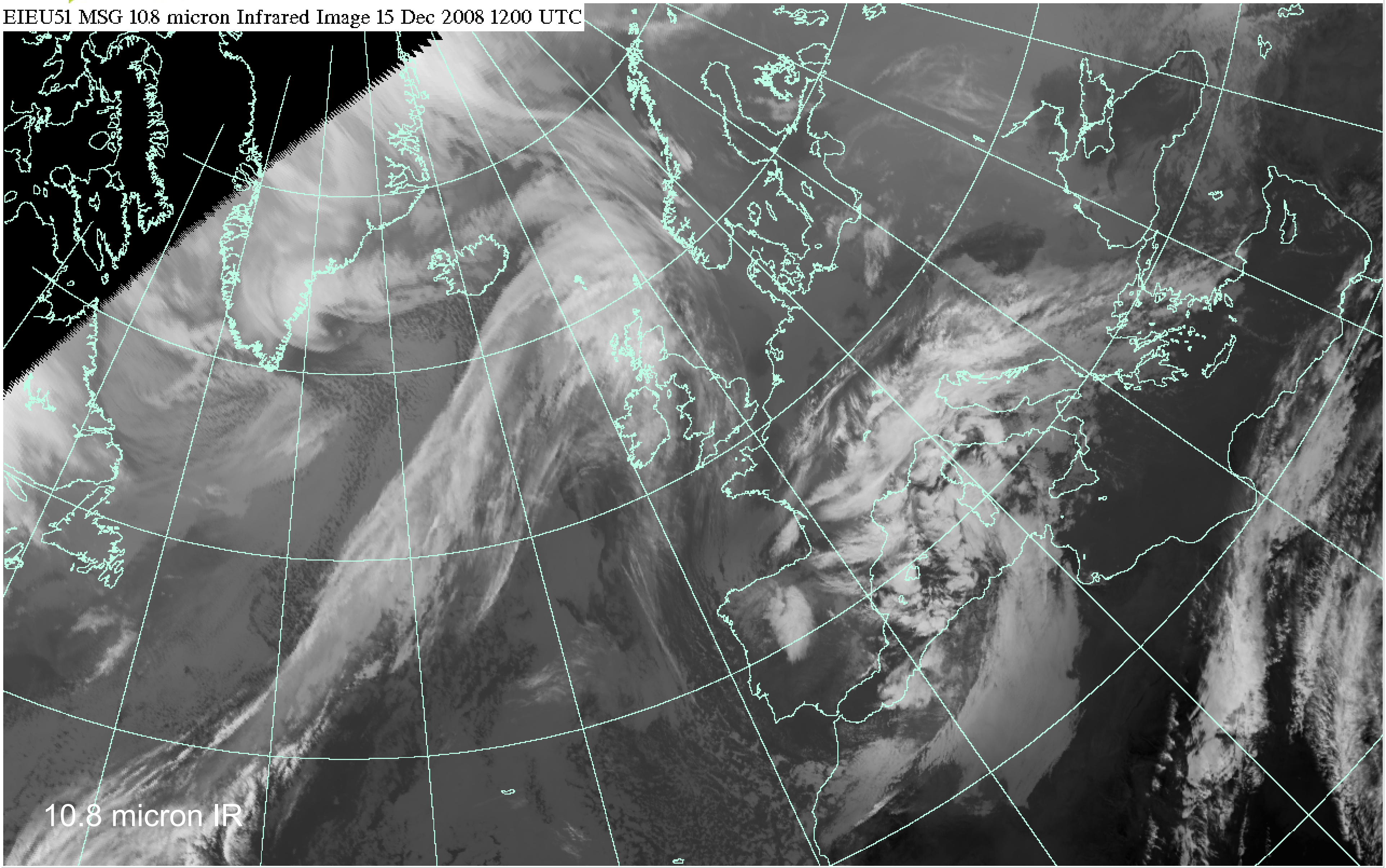


ECA

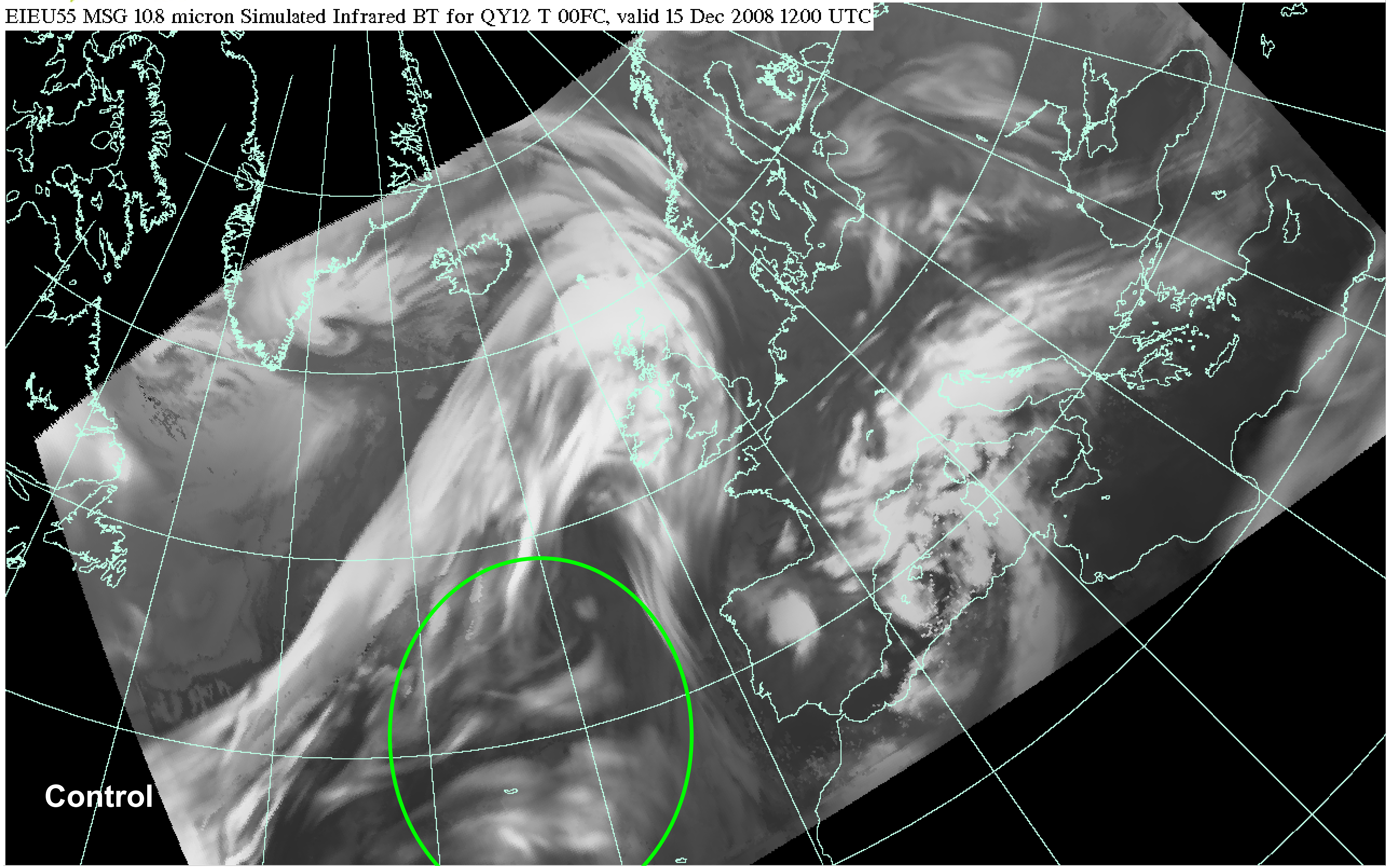


Pete Francis

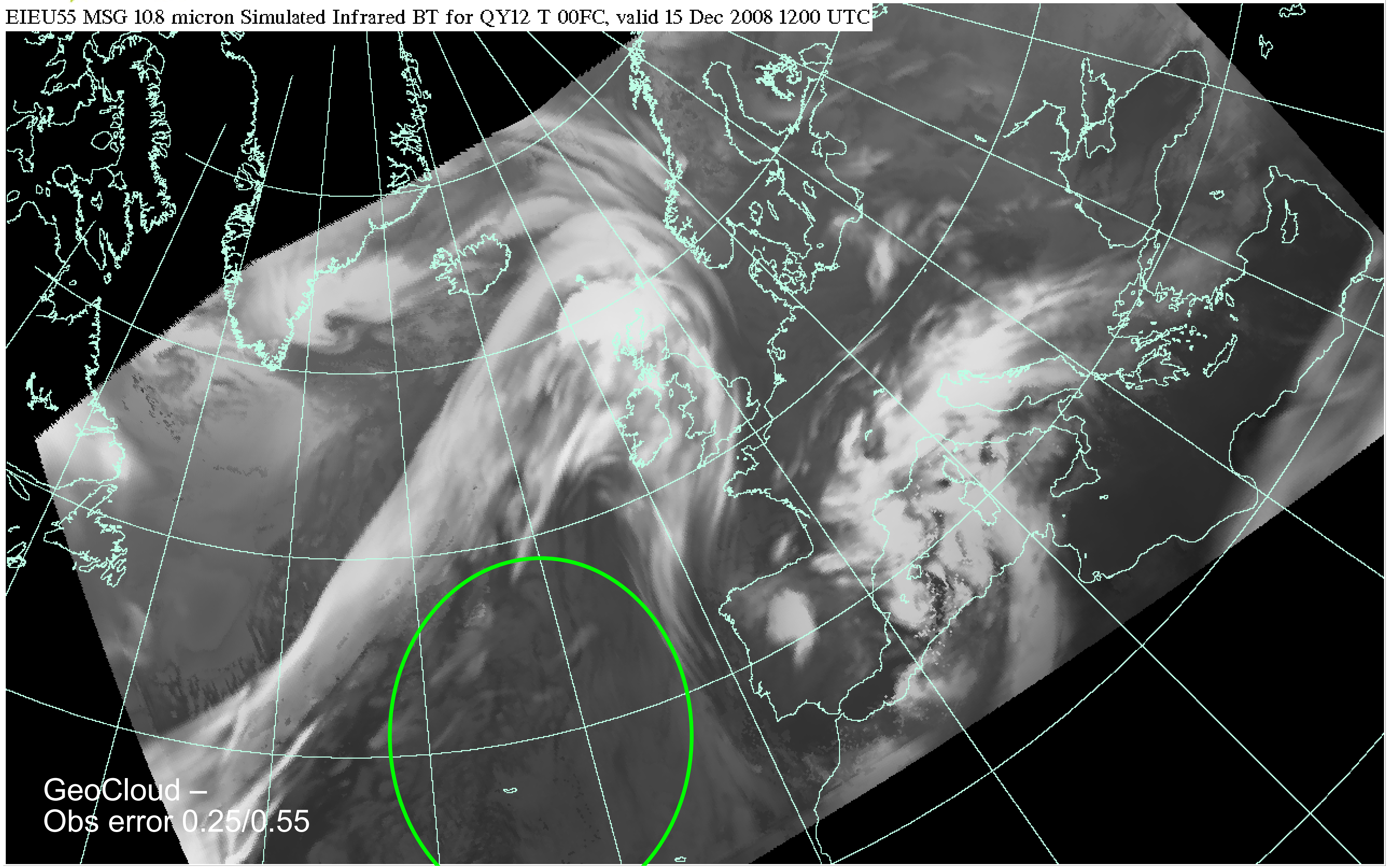
MSG imagery – 12Z, 15/12/2008



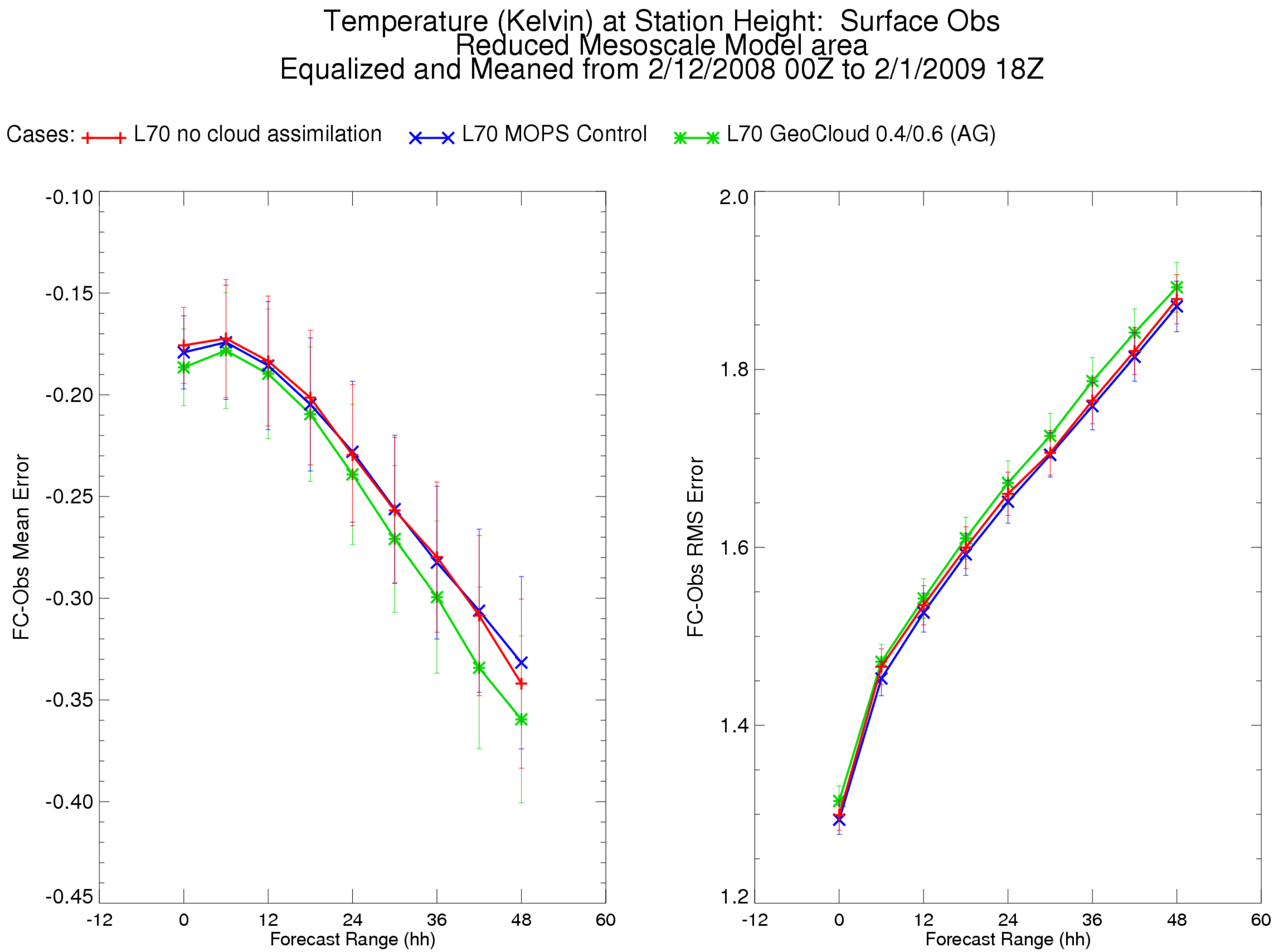
Simulated imagery – 12Z, 15/12/2008, T+0



Simulated imagery – 12Z, 15/12/2008, T+0



Winter 08/09 trial
SEVIRI vs EuroPP over UK area



Tool for adding cloud

Ian Boutle

1) Find appropriate level for cloud top

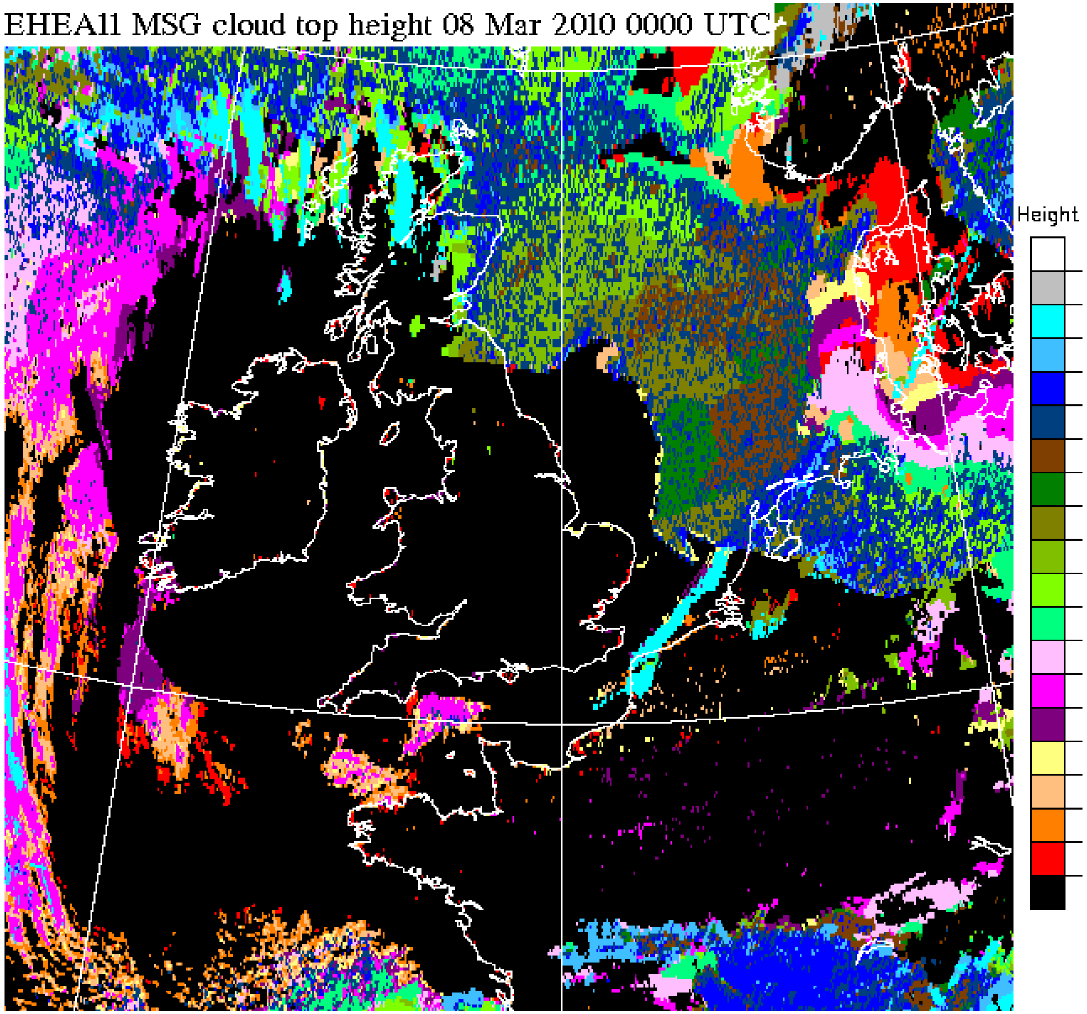
   - looking at vertical stability and humidity

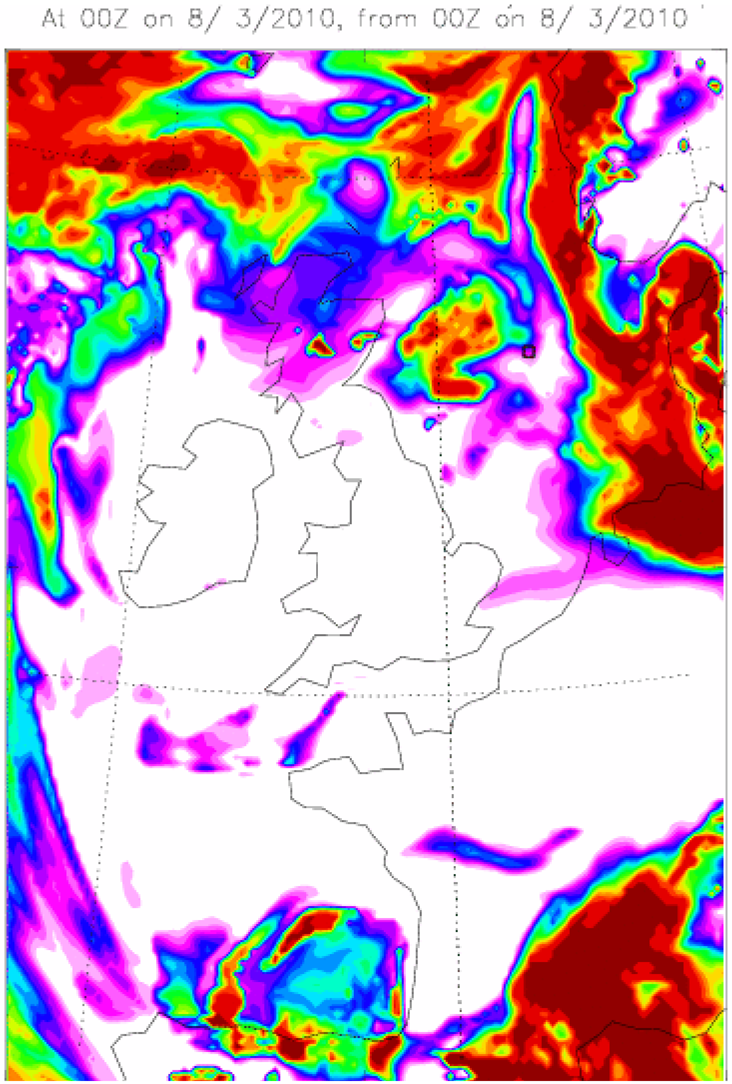
2) Estimate mixed-layer depth to get cloud base

3) Set humidity and temperature for mixed cloud layer

Tool for adding cloud

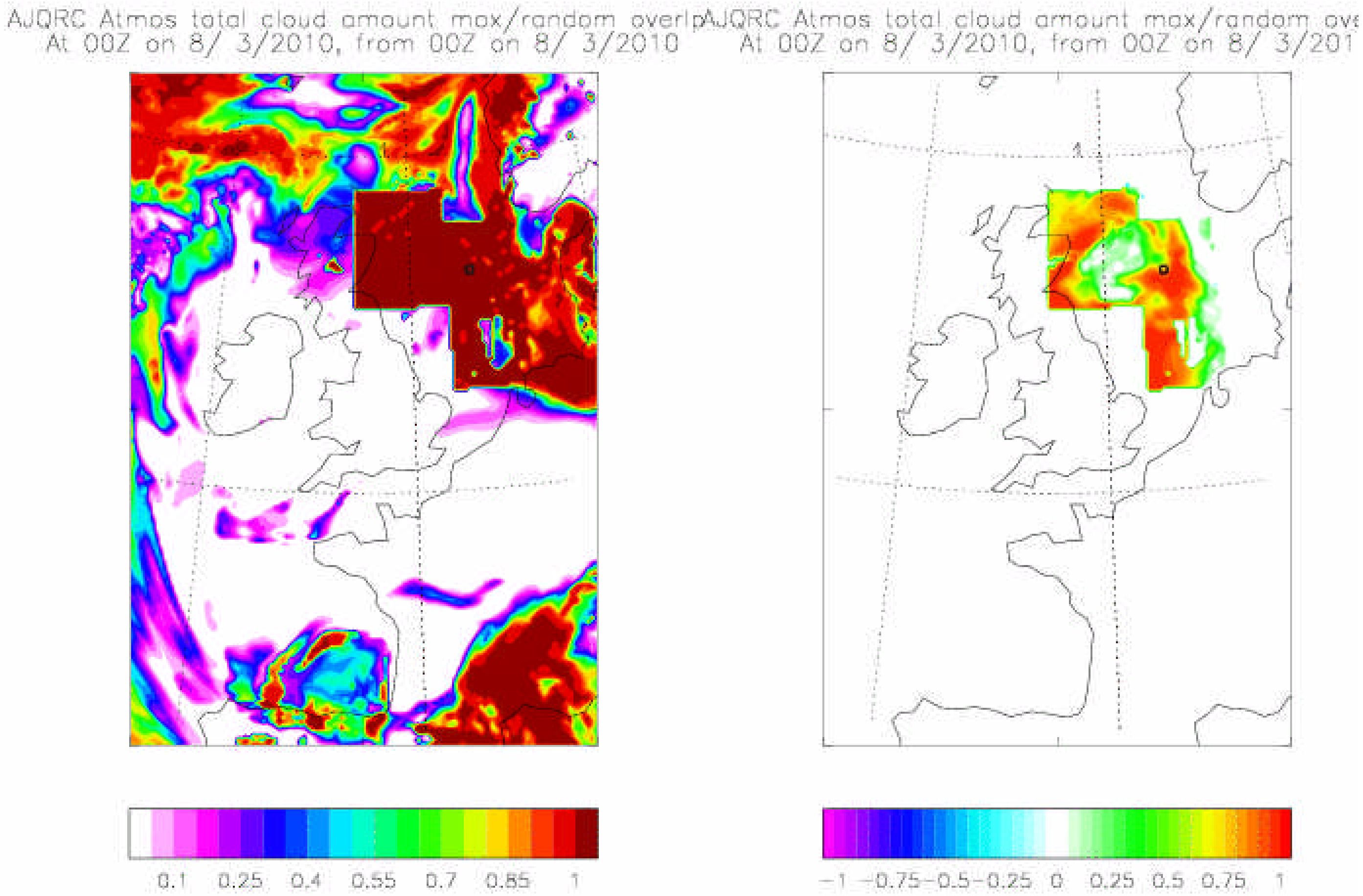
Ian Boutle





Tool for adding cloud

Ian Boutle



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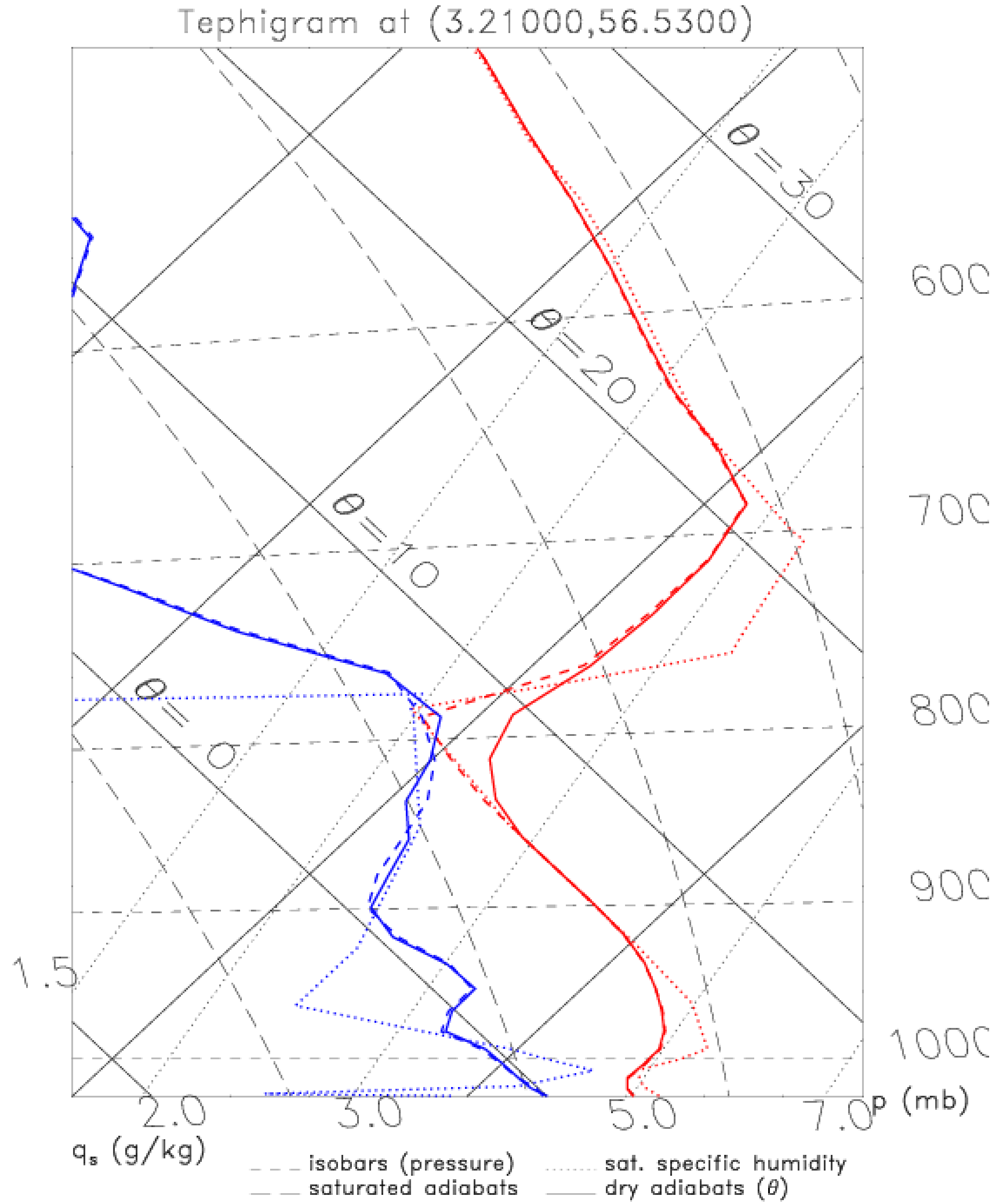
Ekofisk

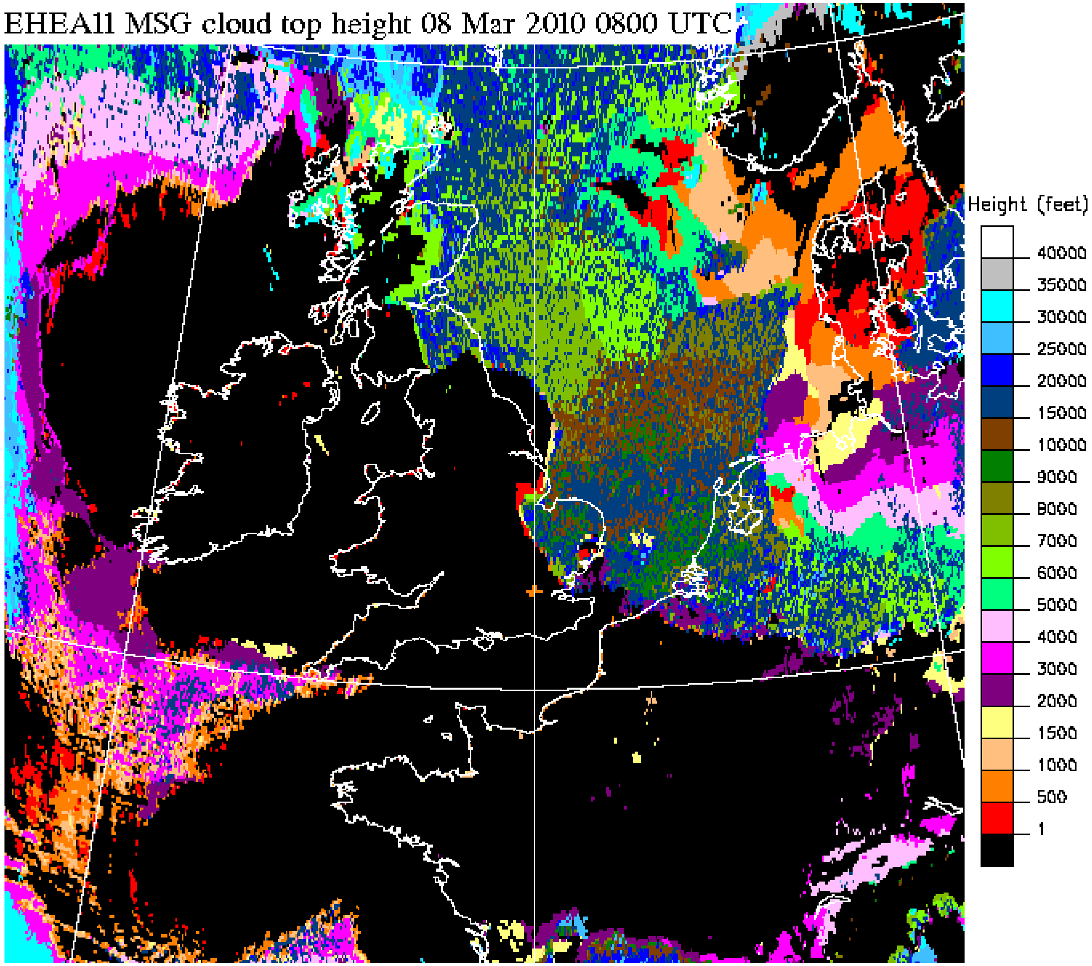
NAE

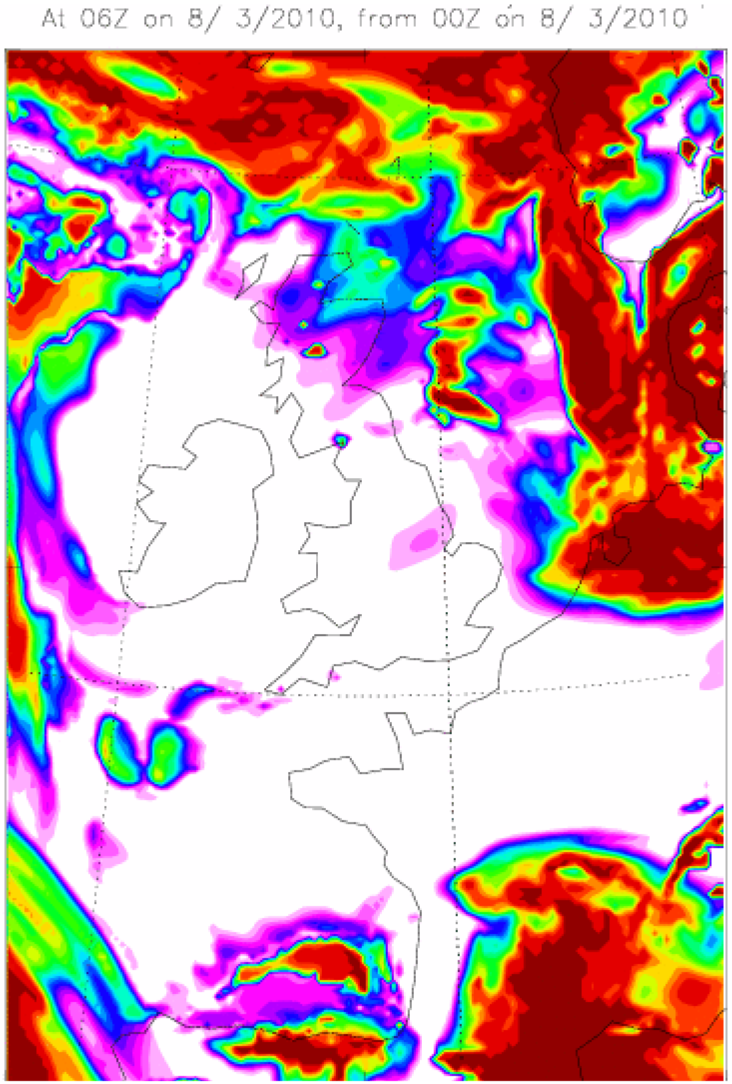
modified NAE

sonde



Modified T+6 forecast





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Summary
Assimilation of stratocumulus

- Observation proxy RH lets us create cloud
- Vertical scale is smaller than climatological Var covariances. Increasing vertical resolution is good.
- Cloud base from surface obs helps
- Adding moisture isn’t always enough

Questions?

In development…

- New moist control variable (as Holm)

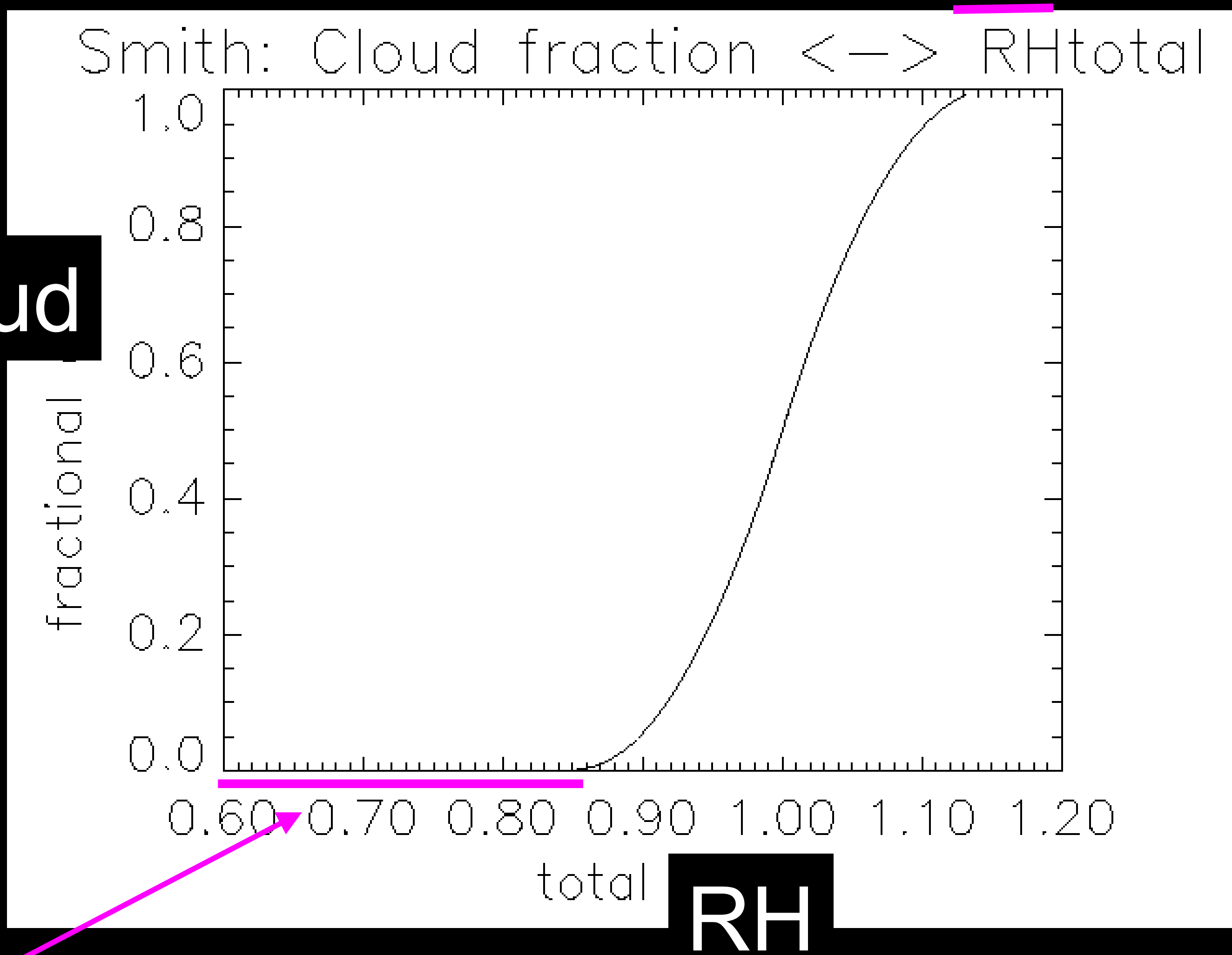
  (David Jackson, Bruce Ingleby, Keith Ngan)
- PF boundary layer physics

  (William Grey, Tim Payne)
- Ekman boundary layer control variables

  (Marek Wlasak, Sarah Dance, Mike Cullen)
- Adaptive grid transform

  (Chiara Piccolo)
- Assimilate cloud from surface obs
- Var Outer loop
- Hybrid ensemble-Var

  (Adam Clayton)
- Vertical deformation control variable


Smith: Cloud fraction <-> RHtotal
cloud
fractional
1.0
0.8
0.6
0.4
0.2
0.0
0.60
0.70
0.80
0.90
1.00
1.10
1.20
total
RH

d[cloud] / d[RH] = 0

Control Variable

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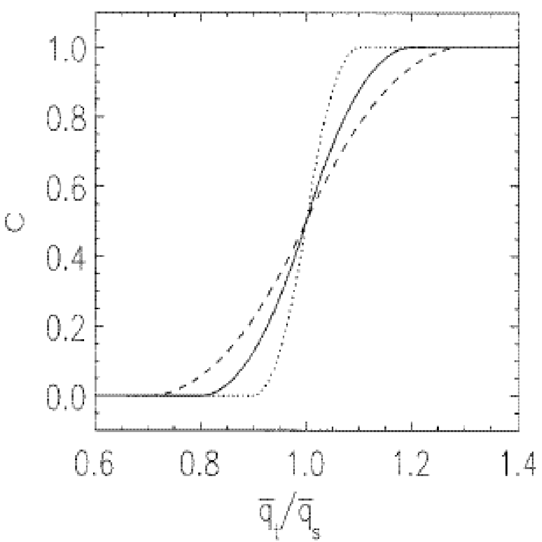
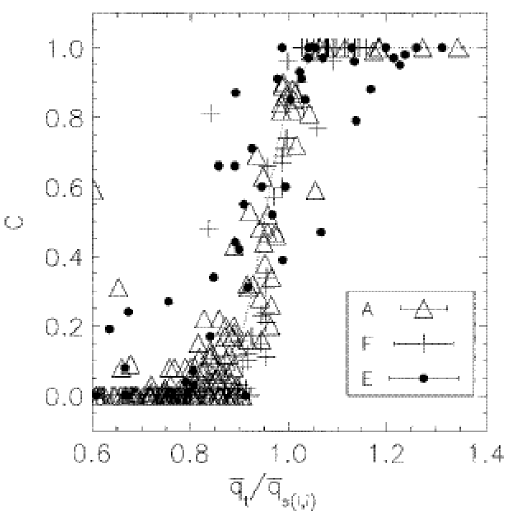
- extra cloud control variable difficult
- have to use single moisture variable
- for now we use RH and diagnose
  cloud fraction = f(RH)



Smith scheme
QJRMS 1990



aircraft data
Wood & Field, JAS 2000

SEVIRI cloud

RH increment