Potential of the SSM/I rain observations for the 4D-Var assimilation

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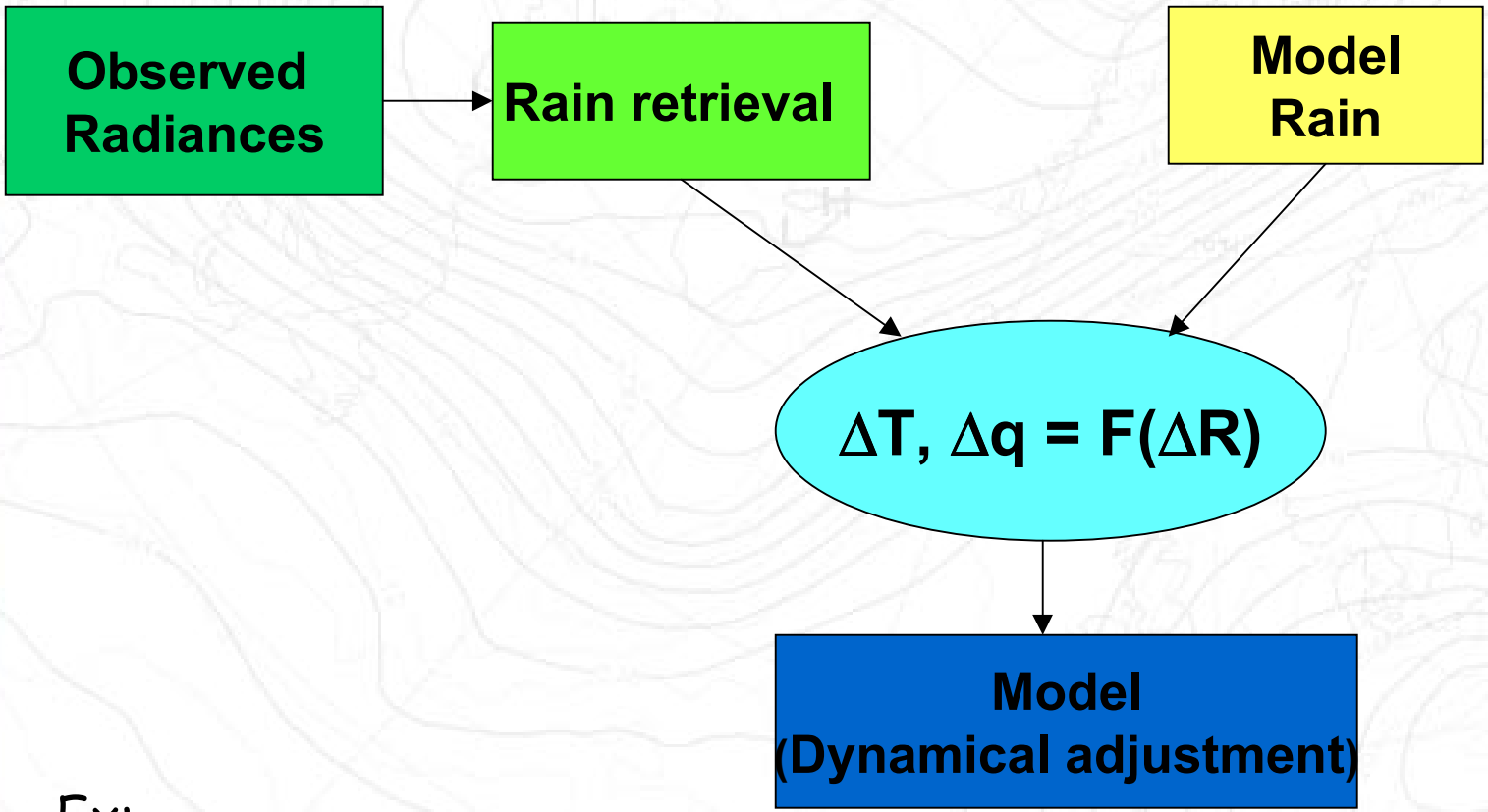
- Introduction to rain assimilation
- Preparation to the direct assimilation of rainy radiances in 4D-Var

ECMWF

Approaches for the assimilation of rain information (1)

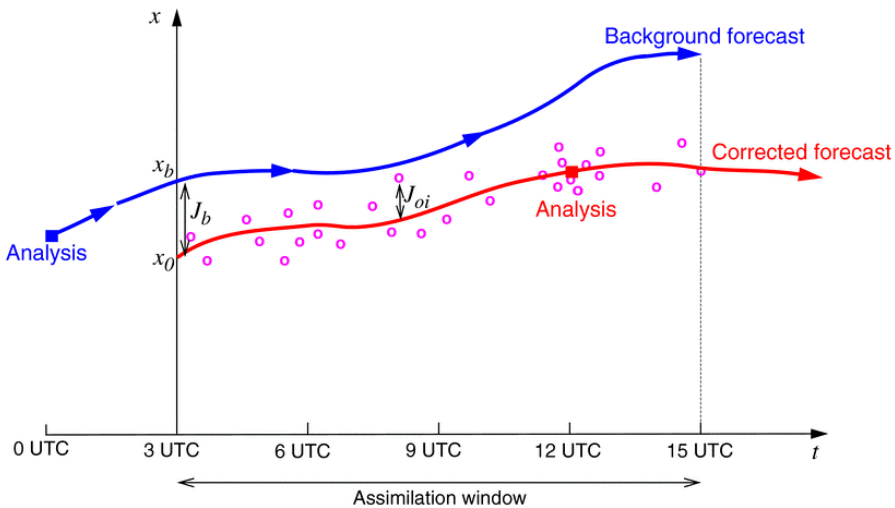


Ex:
Krishnamurti et al. 1984
McPherson et al. 1996
Hou et al. 2000

4D-Var and 1D-Var

- 4D-Var minimises a cost function
  (background departure + observation departure)

$$J(\mathbf{x}) = (\mathbf{x} - \mathbf{x_b})^T \mathbf{B}^{-1} (\mathbf{x} - \mathbf{x_b}) + \sum_t (\mathbf{y_t} - H(\mathbf{x_t}))^T \mathbf{R}^{-1} (\mathbf{y_t} - H(\mathbf{x_t}))$$

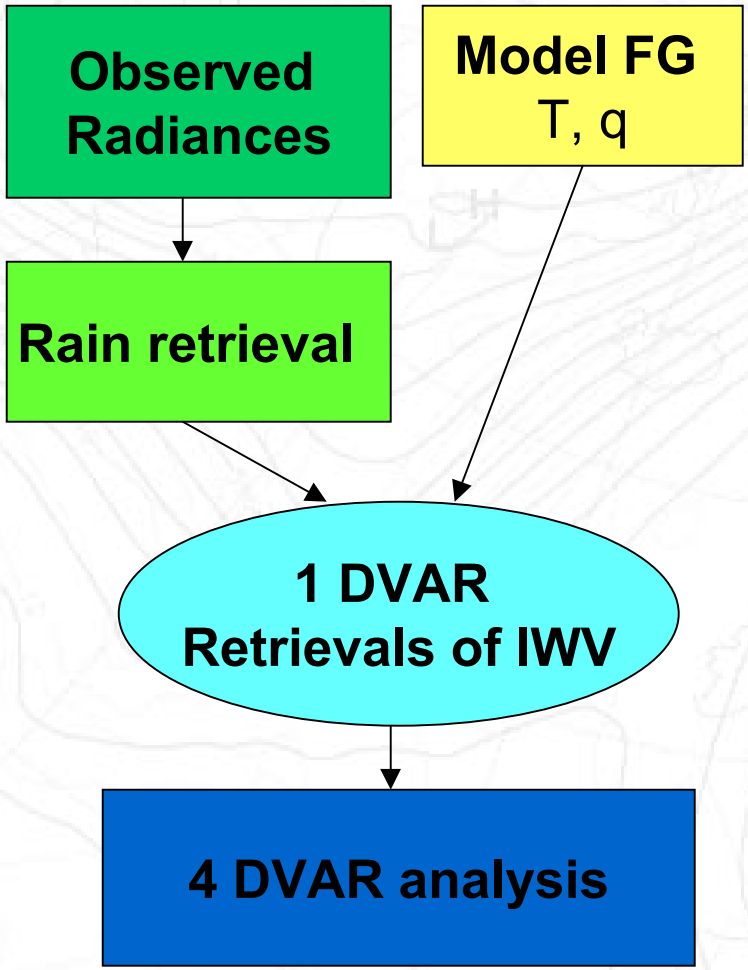


4D-Var is operational at ECMWF since 1997

- 1D-Var : idem with single column and no time dimension

$$J(\mathbf{x}) = (\mathbf{x} - \mathbf{x_b})^T \mathbf{B}^{-1} (\mathbf{x} - \mathbf{x_b}) + (\mathbf{y} - H(\mathbf{x}))^T \mathbf{R}^{-1} (\mathbf{y} - H(\mathbf{x}))$$

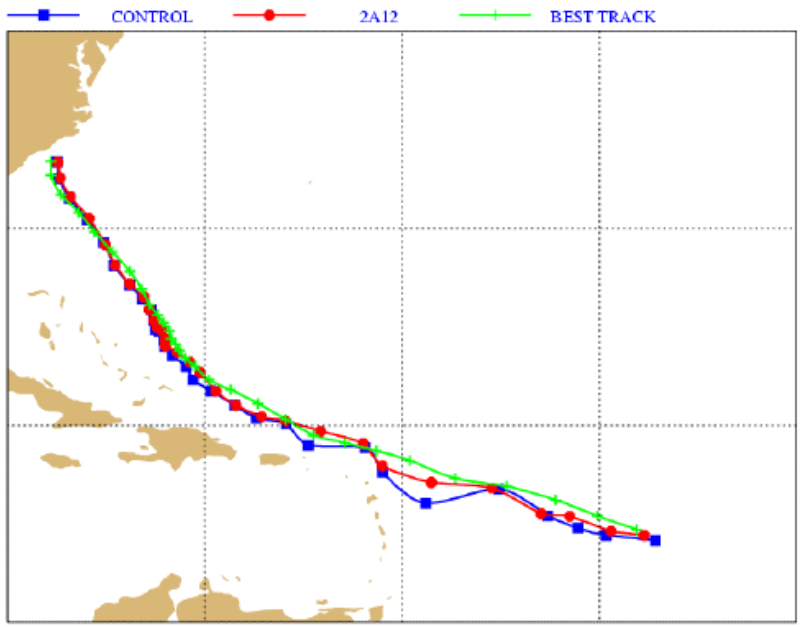
Approaches for the assimilation of rain information (2)

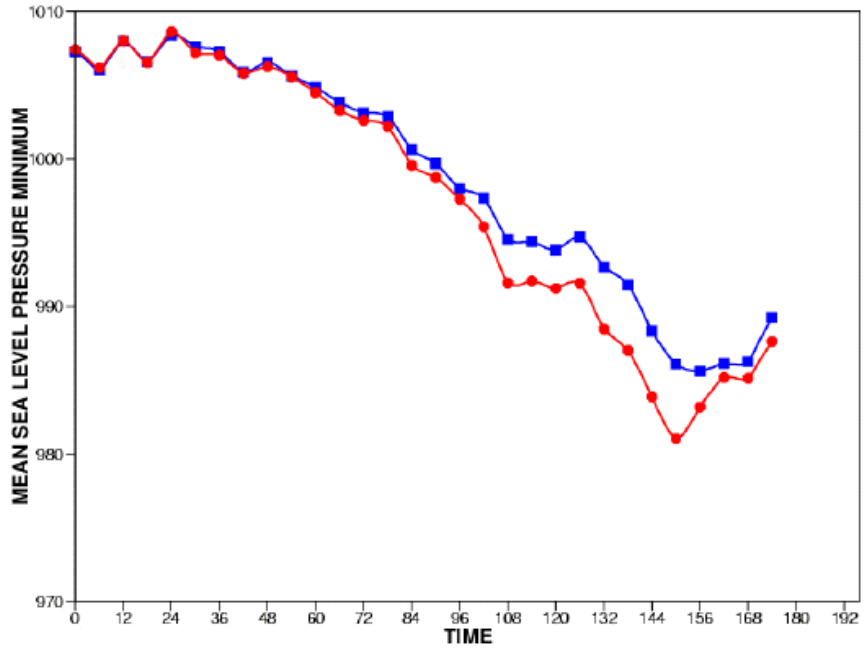


Marécal and Mahfouf 2002

4D-Var assimilation of TRMM data

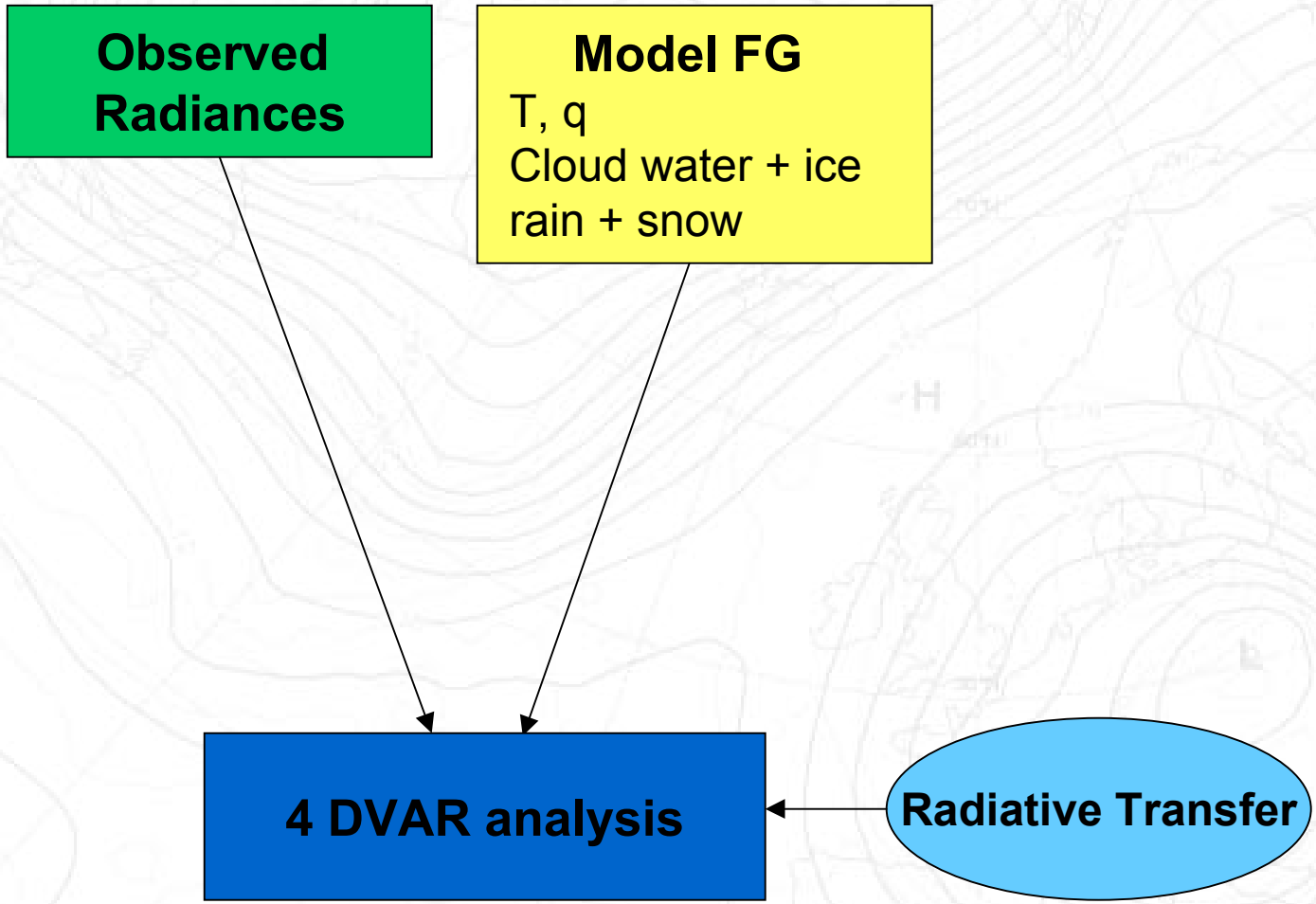
Analysis: Bonnie cyclone (August 1998)





Marécal and Mahfouf 2002

Approaches for the assimilation of rain information (3)



To-do list for the assimilation of cloudy/rainy SSM/I observations

- ✔ Development of the radiation model (direct version)

✔ = done

✔ = ongoing

Computation of model cloudy/rainy radiances

- Gas absorption:
  - MPM (Liebe et al. 1992)
- Cloud/rain absorption/scattering:
  - Two-stream Eddington approximation
  - Pre-computed Mie tables (Bauer 2001) from model variables: **iwc(P), lwc(P), rr(P), sr(P), T(P)**
- Surface emissivity (sea only):
  - FASTEM2 (English and Hewison 1998)
- Overlap assumption:
  - Maximum, with constant cloud/rain fractional cover in the vertical

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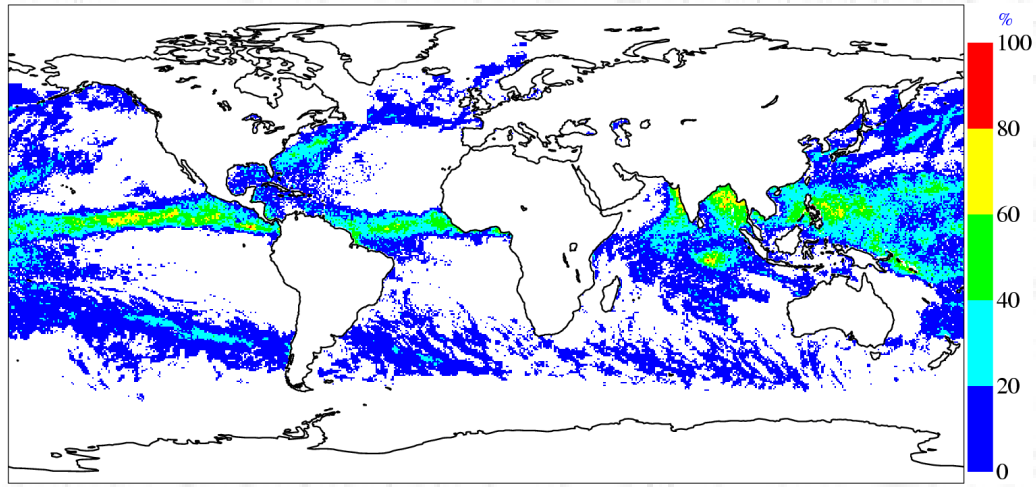
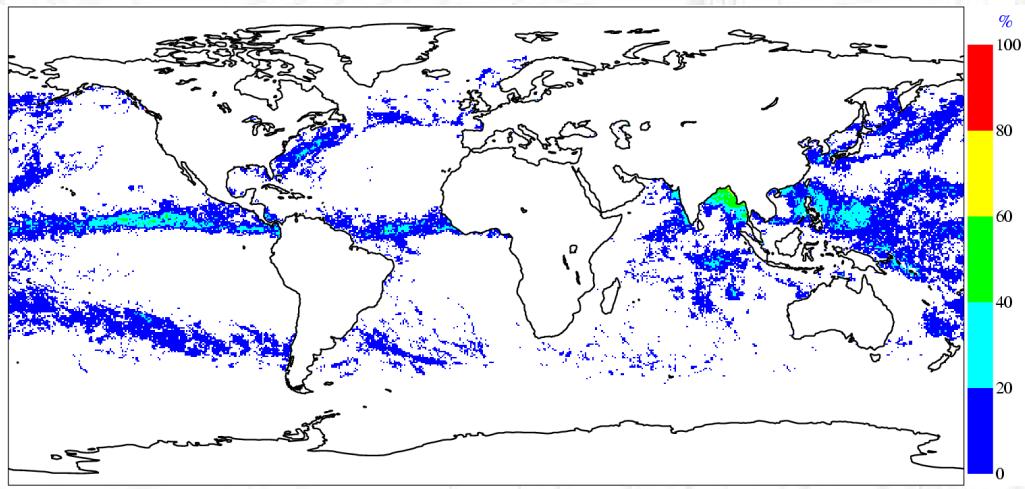
Rain occurrence from SSM/I

1-15 July 2001

Model



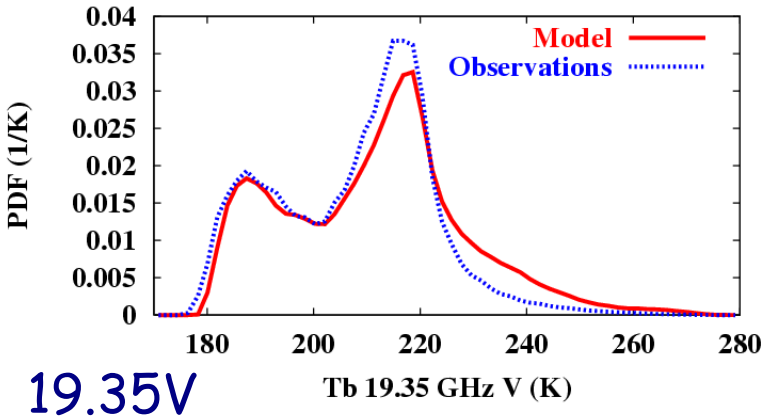
Observations



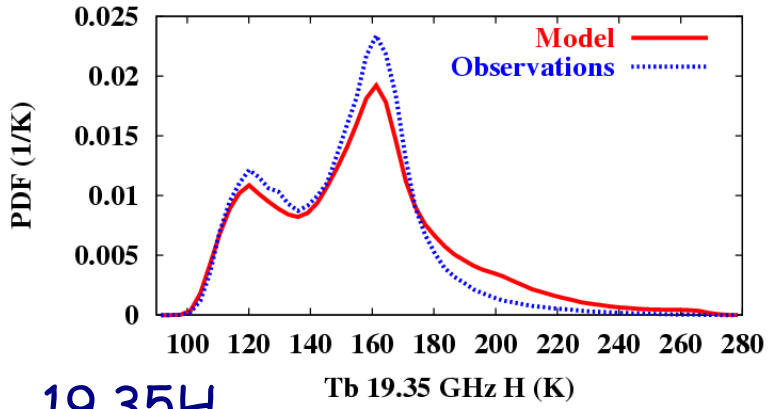
Rain detection from Stogryn et al. (1994)

Model PDFs vs. obs. PDFs

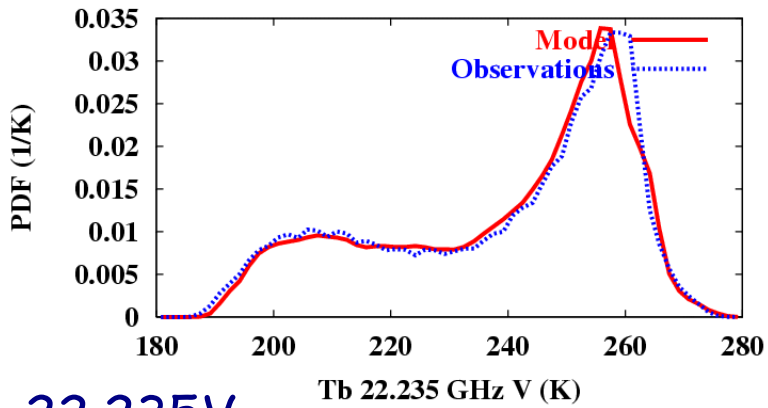
1-15 January 2001



19.35V



19.35H

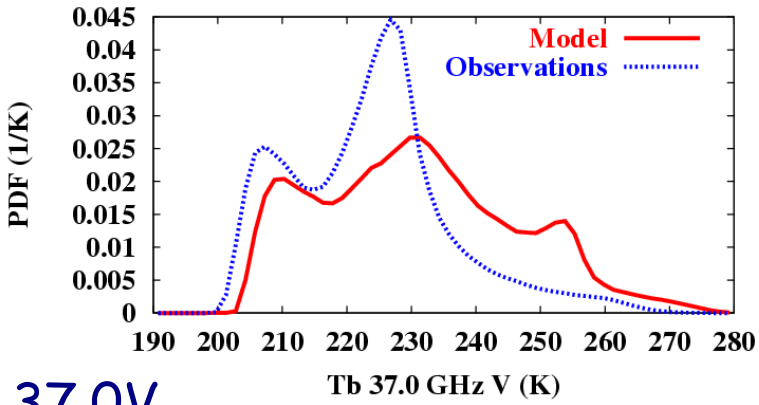


22.235V

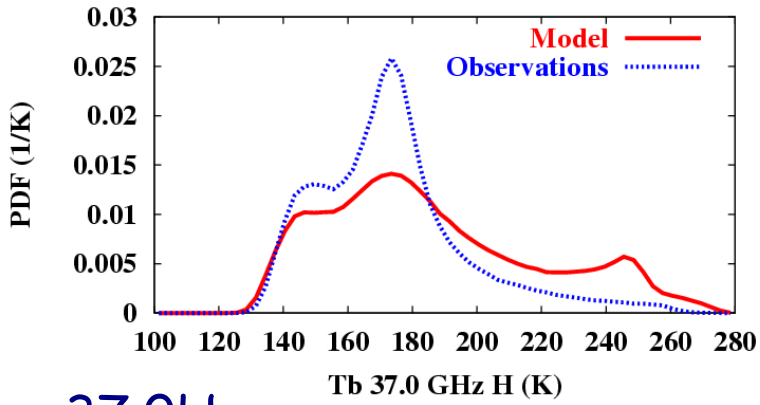
Toward the 4D-Var assimilation of rainy SSM/I observations

Model PDFs vs. obs. PDFs

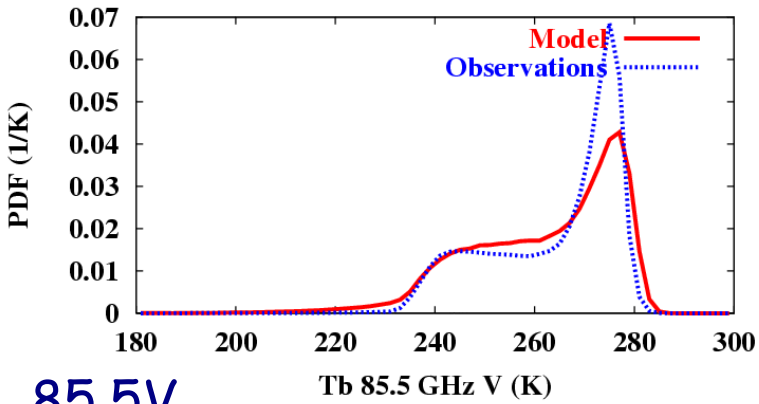
1-15 January 2001



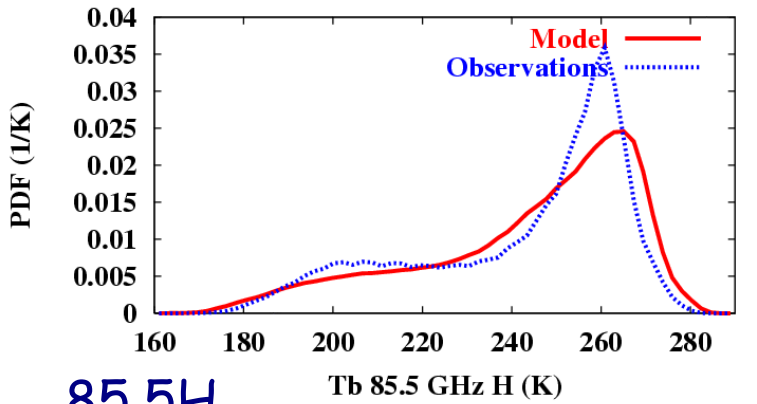
37.0V



37.0H



85.5V

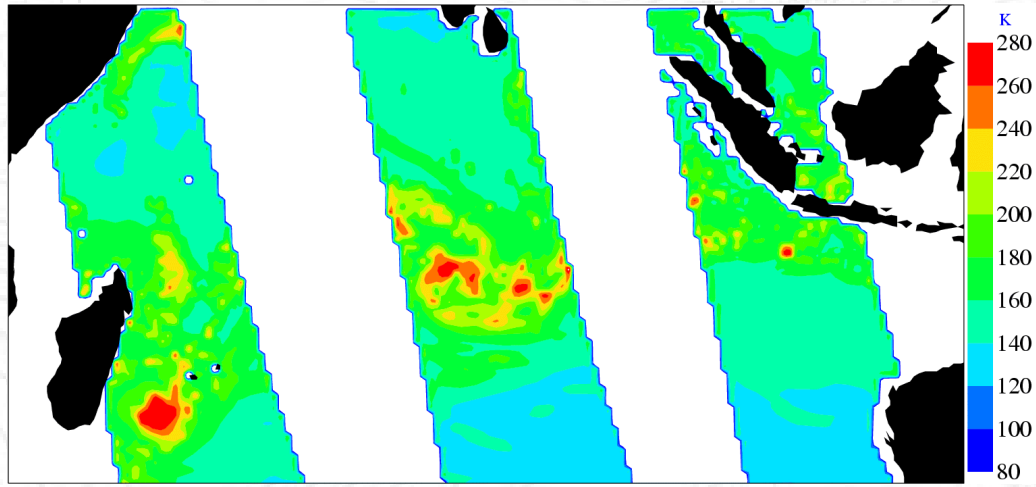


85.5H

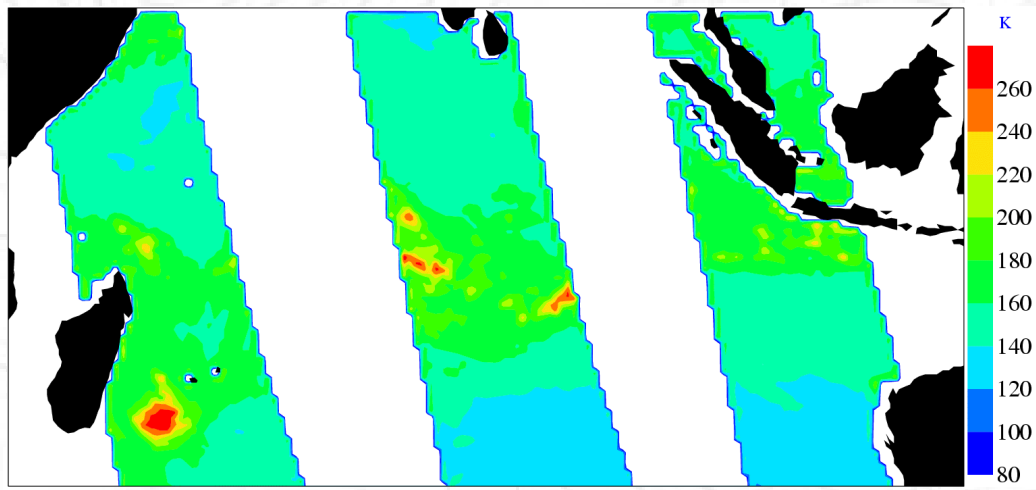
Model vs. Observed 19.35H GHz Tb

7 January 2001, 15 UTC – Cyclone Ando

Model



Observations

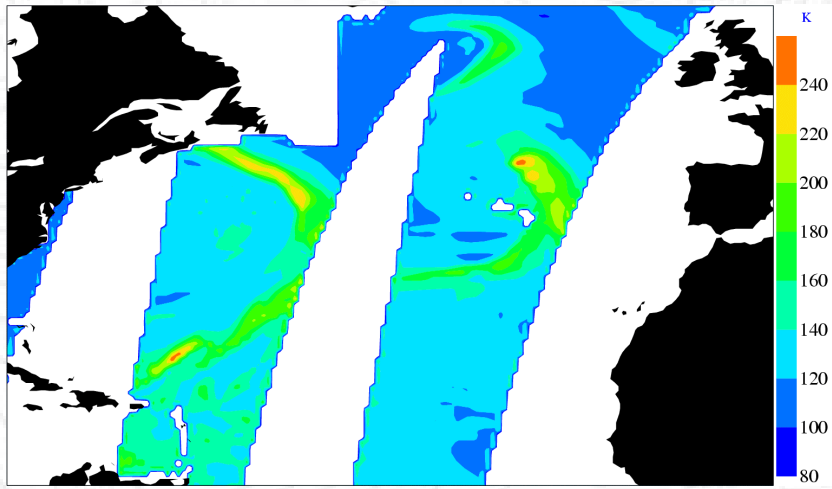


Toward the 4D-Var assimilation of rainy SSM/I observations

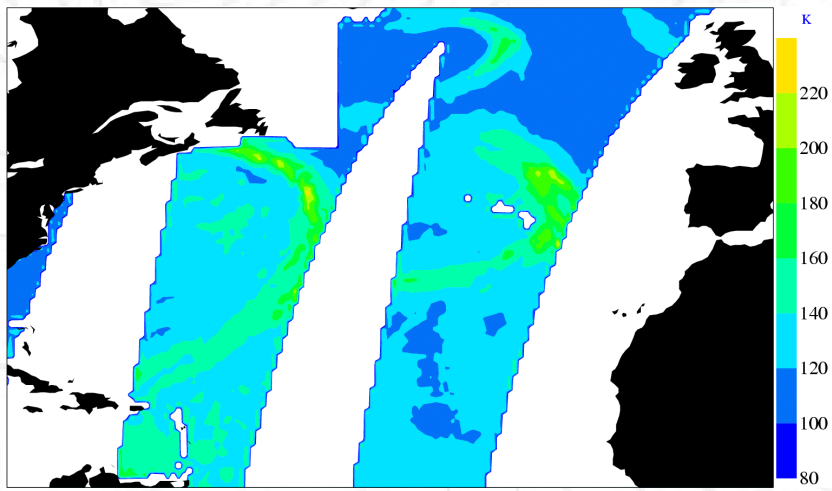
Model vs. Observed 19.35H GHz Tb

7 January 2001, 12 UTC

Model



Observations



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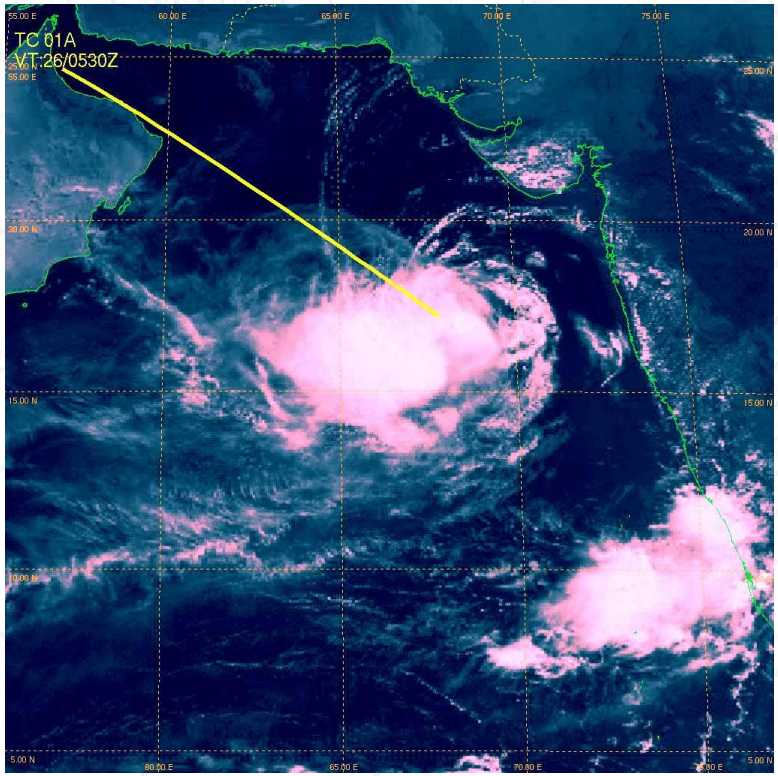
- ✔ 1D-Var retrievals from SSM/I
  control variables = cloud/rain variables

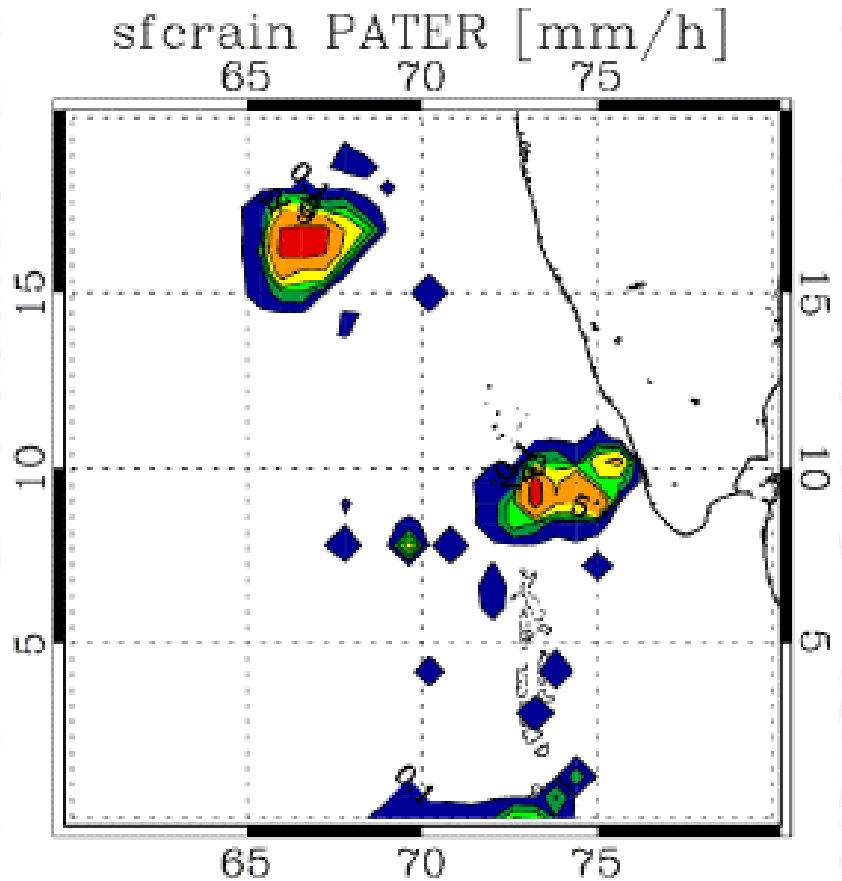
✔ = done
✔ = ongoing

Rain/Cloud 1D-Var retrieval (1)

Tropical Cyclone 01A – 26 May 2001

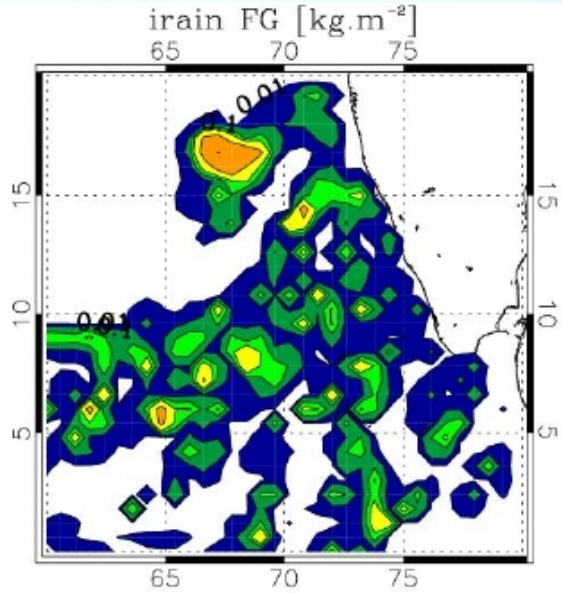


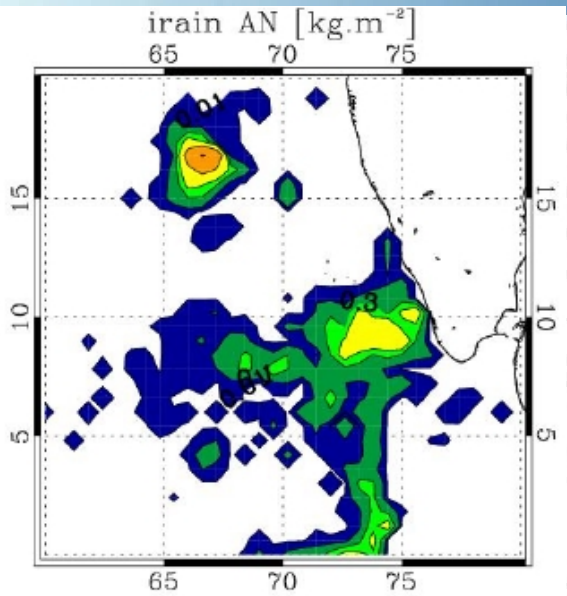
TRMM/ PATER
Surface Rain Retrieval



Rain/Cloud 1D-Var retrieval (2)

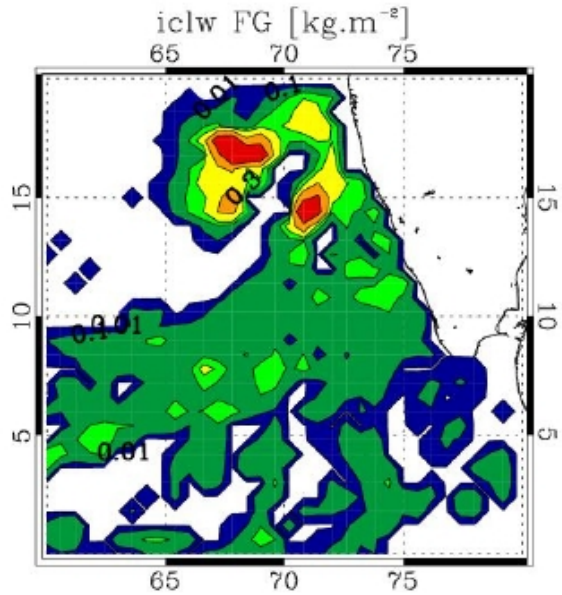
Column Rain FG

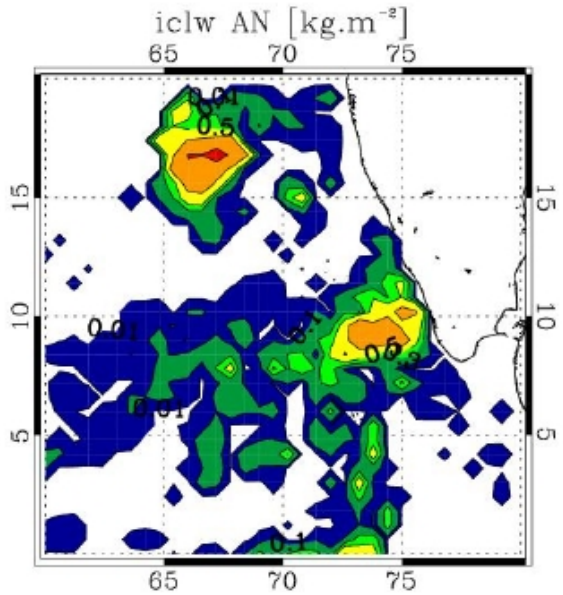




Column Rain AN

Column Liquid Water FG





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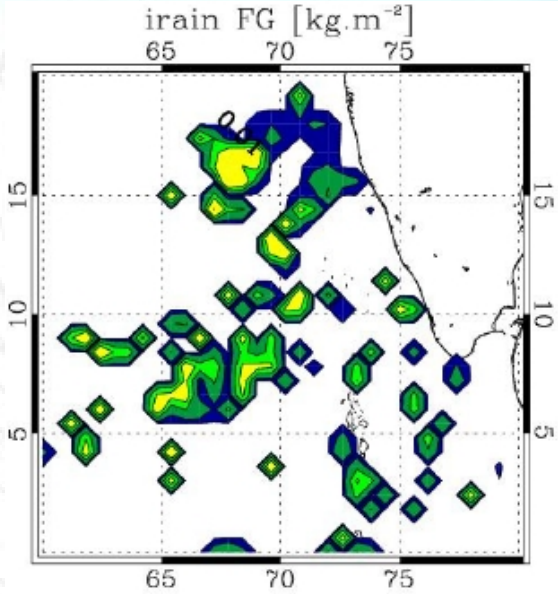
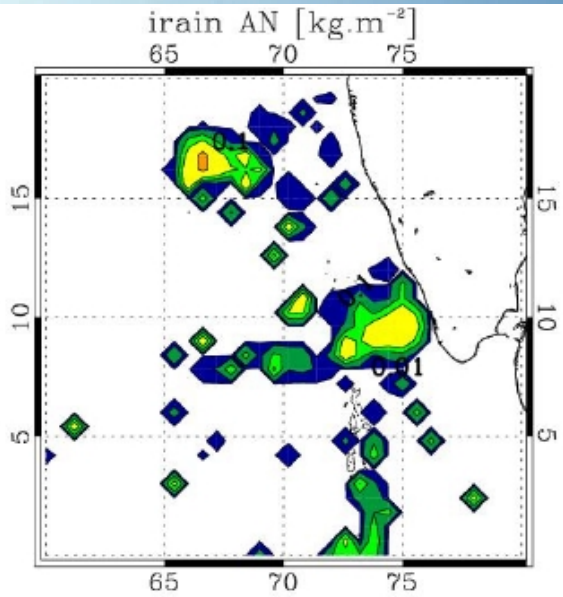
  control variables = cloud/rain variables
- ✔ 1D-Var cloud retrievals from SSM/I
  control variables = T, q (uses diagnostic cloud/rain scheme)

✔ = done
✔ = ongoing

Rain/Cloud 1D-Var retrieval (3)

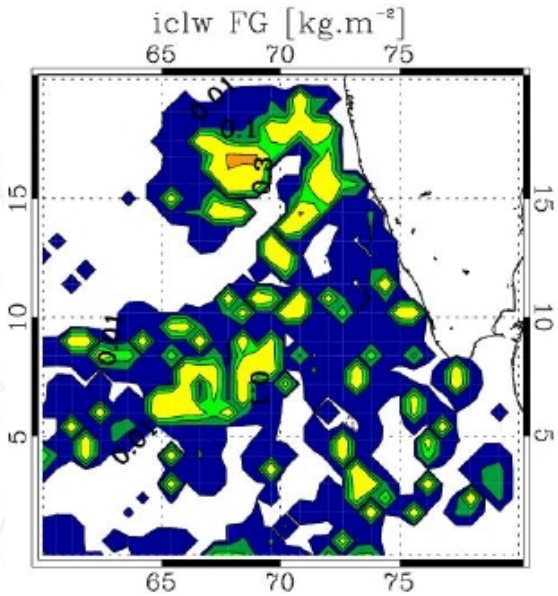
Column Rain FG

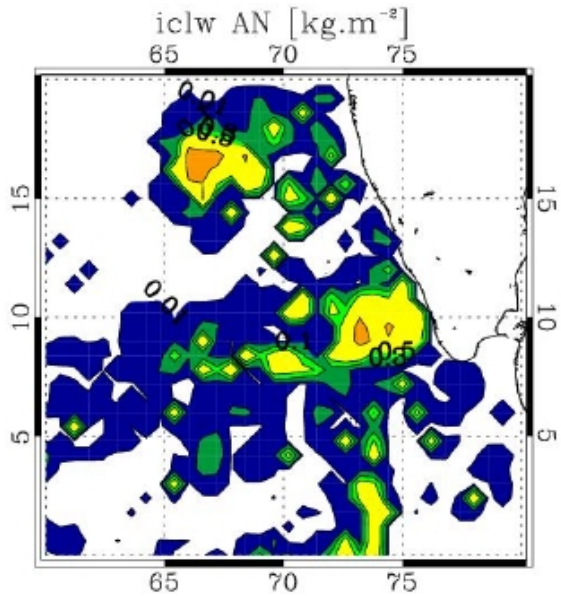




Column Rain AN

Column Liquid Water FG





Column Liquid Water AN

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- ✔ 1D-Var retrievals from SSM/I
  control variables = cloud/rain variables
- ✔ 1D-Var cloud retrievals from SSM/I
  control variables = T, q (uses diagnostic cloud/rain scheme)
- Derivation of the radiation model and of the moist physics (linearised versions TL and AD)

- Tests within the 4D-Var

- Re-evaluation of the approach
  - Coherence between clear, cloudy and rainy areas
  - T/q background error structures
  - 4D-Var formulation

✔ = done
✔ = ongoing