Sub-mm cloud ice sounding (ICI = Ice Cloud Imager)

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Background

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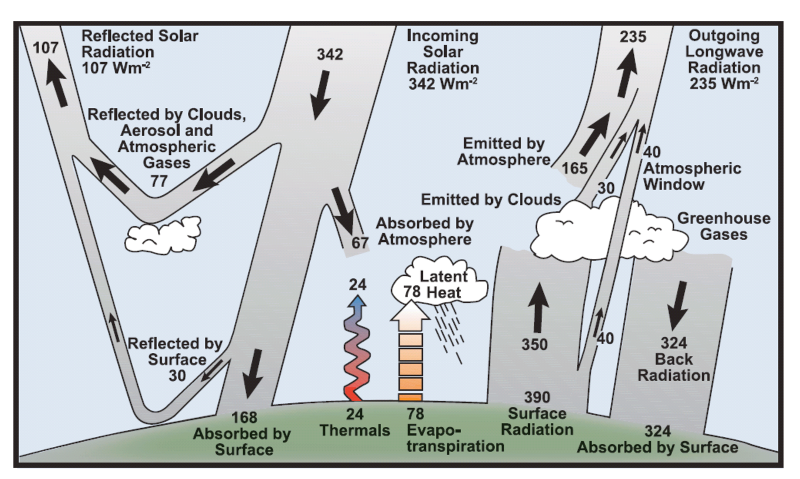
Earth's radiative balance

Global annual mean values in W/m^2

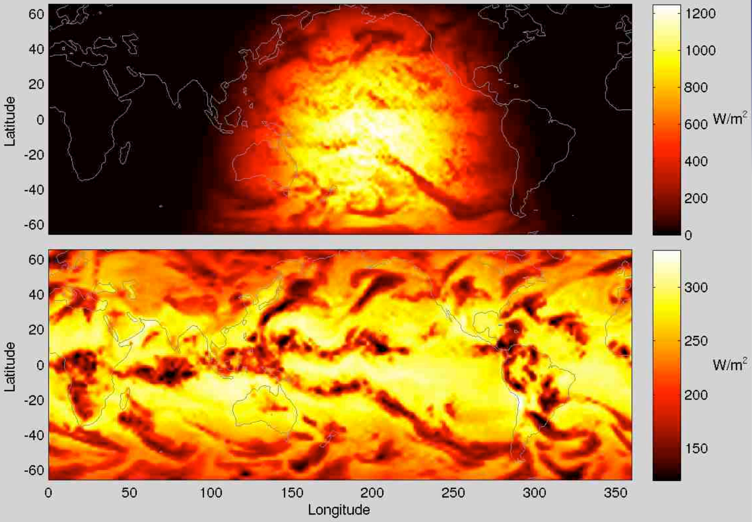
Heating Cooling



(IPCC AR4, 2007)

Instantaneous view of fluxes

Top / bottom: Incoming / outgoing radiation (Data from EC Earth v3)



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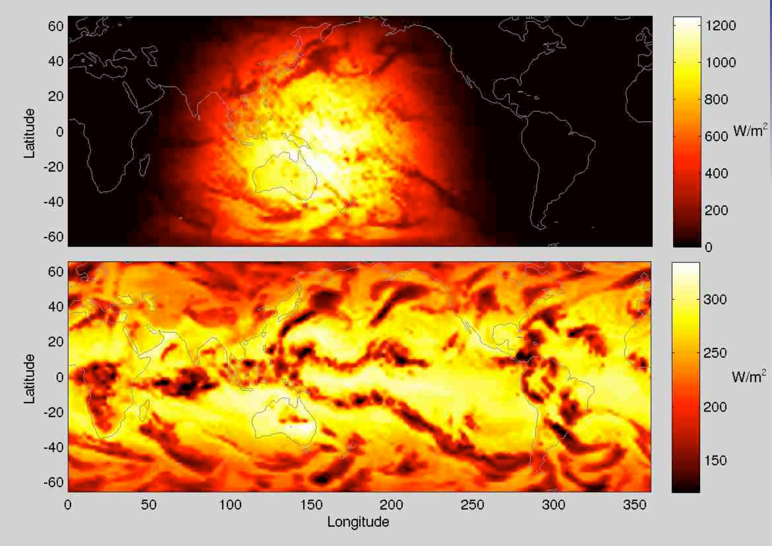

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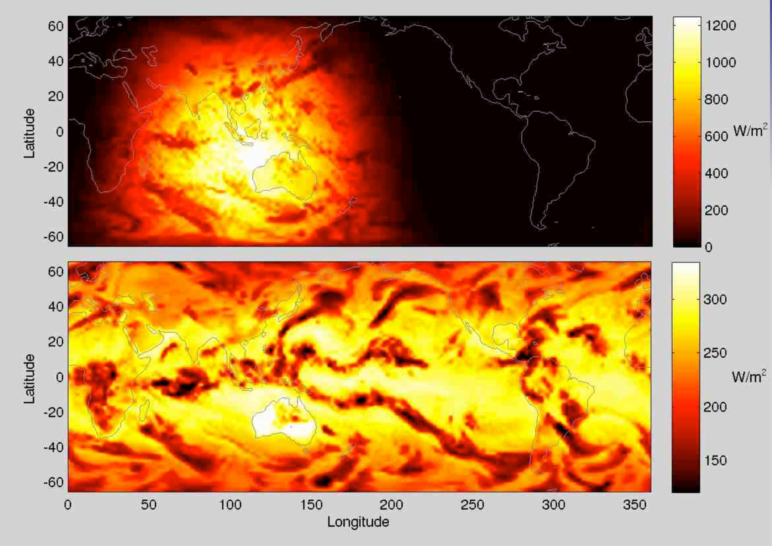

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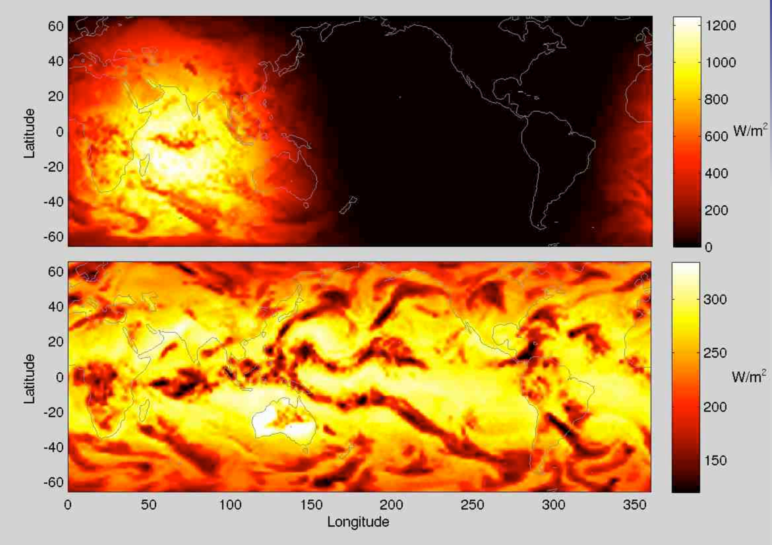

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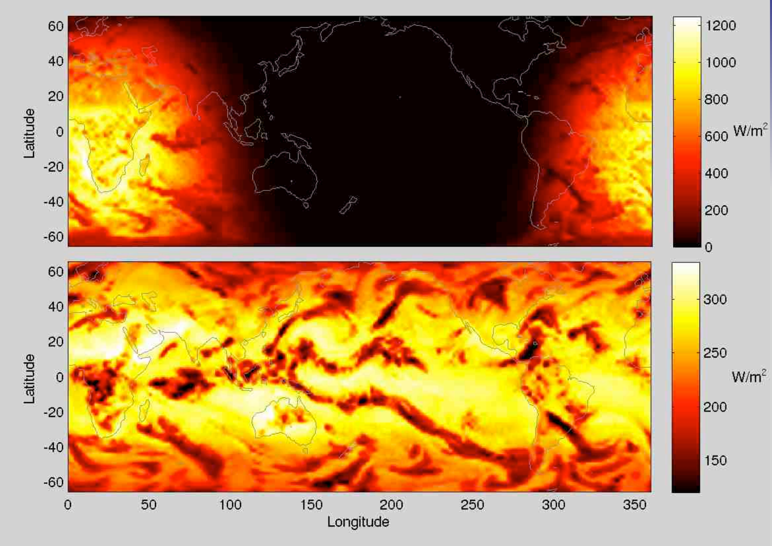

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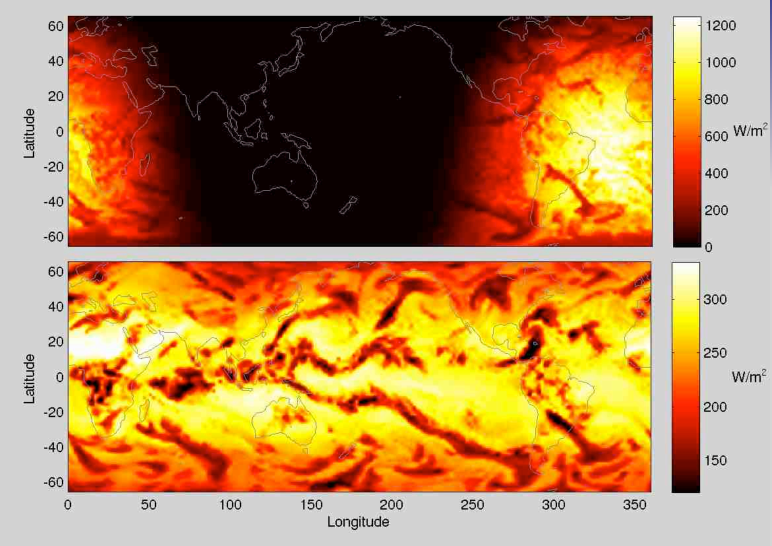

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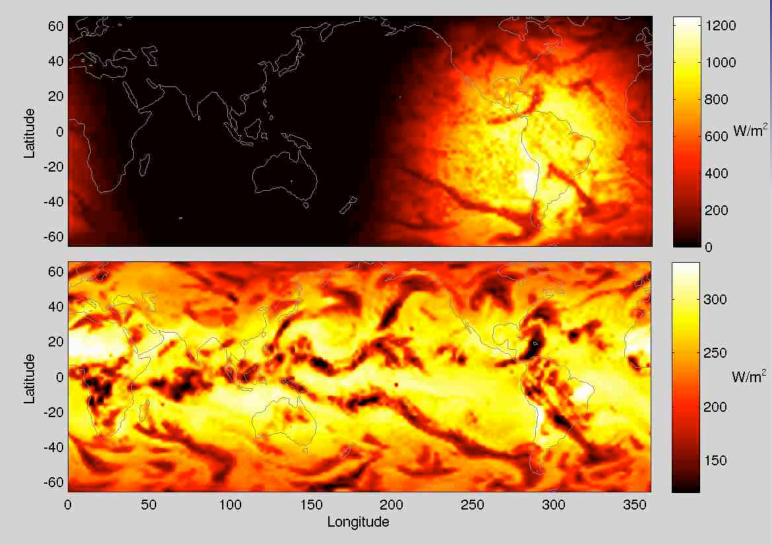

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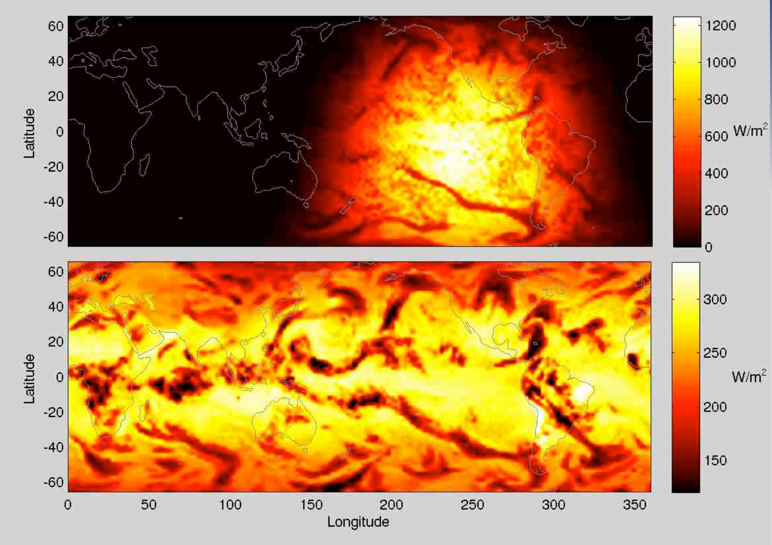

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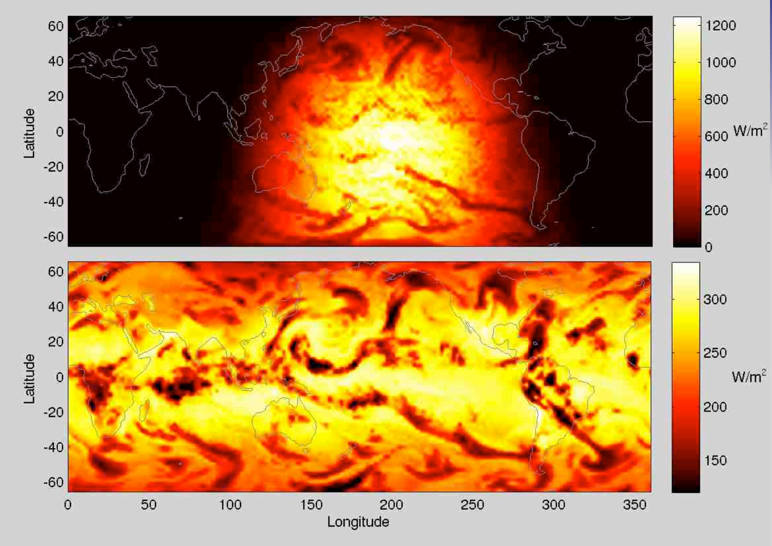

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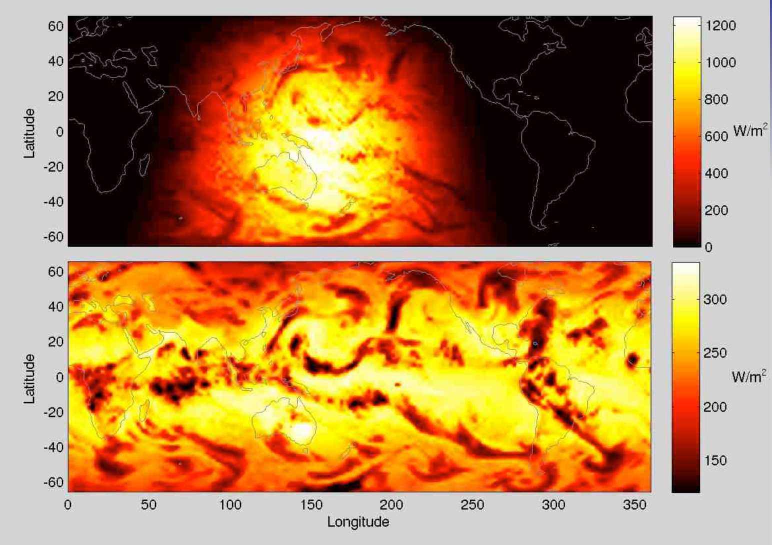

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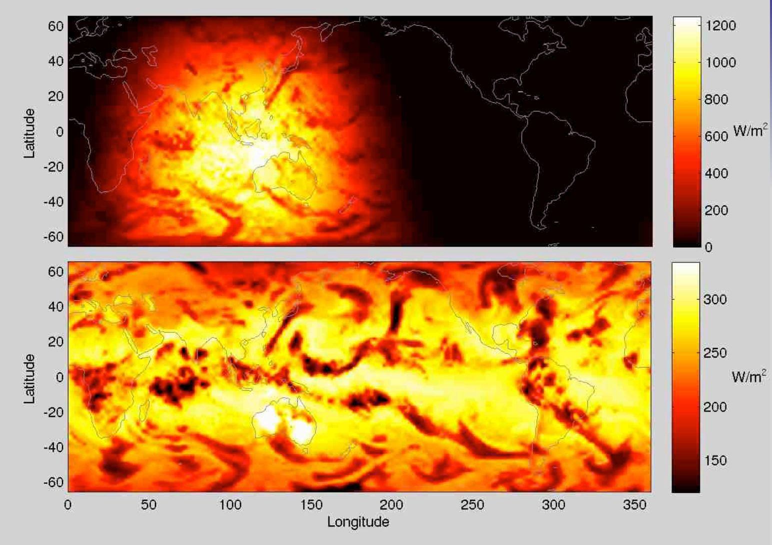

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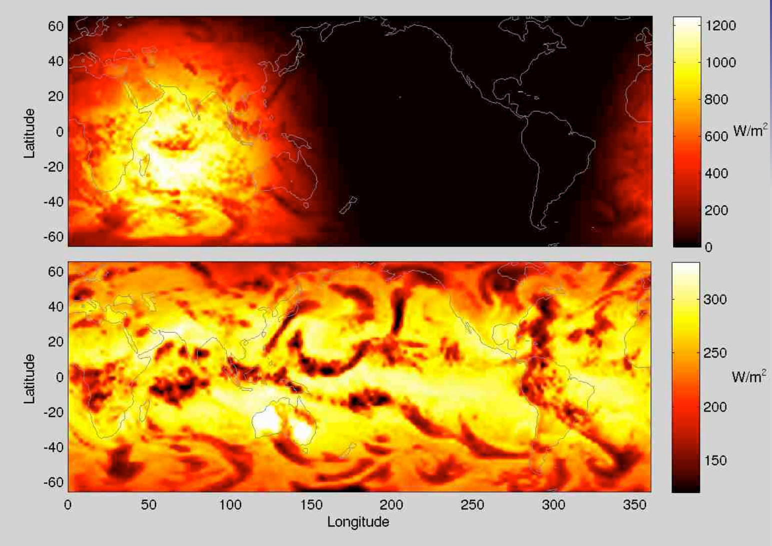

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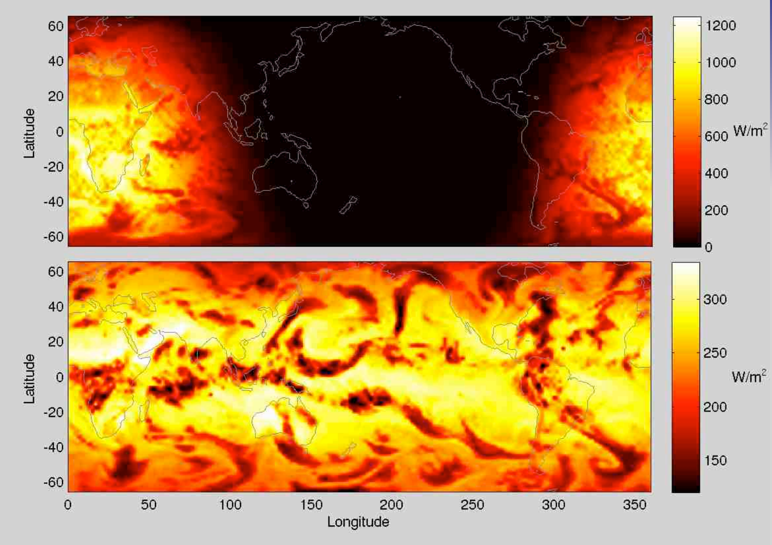

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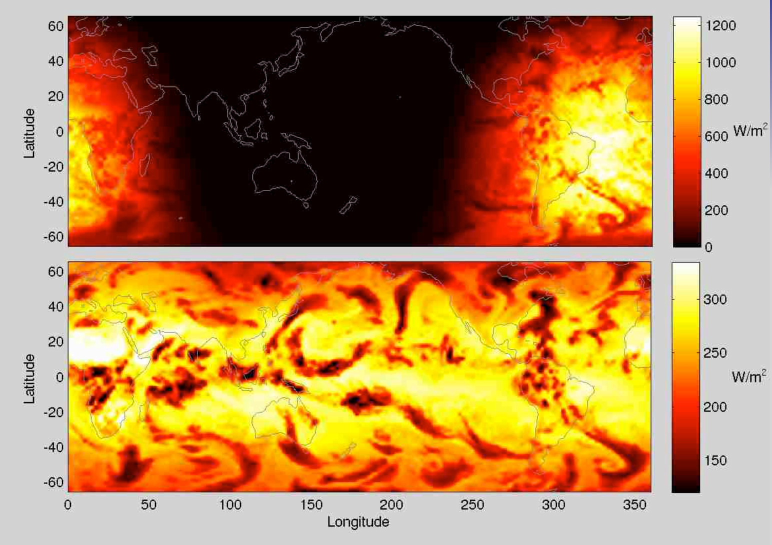

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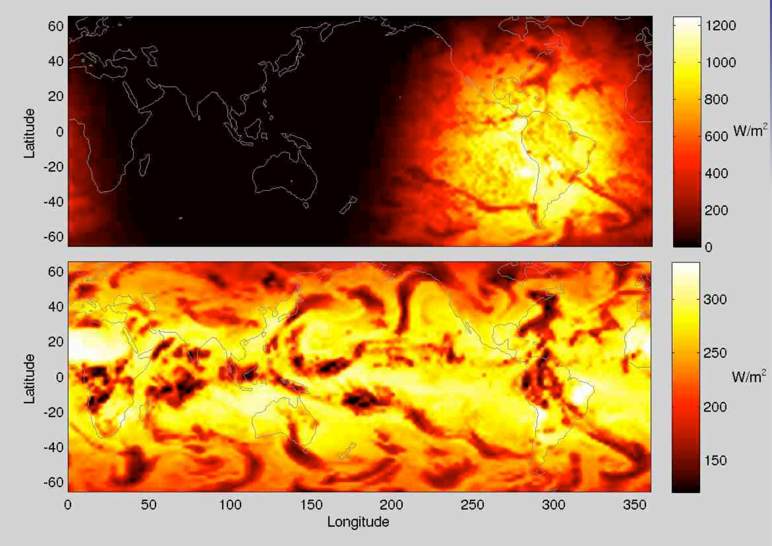

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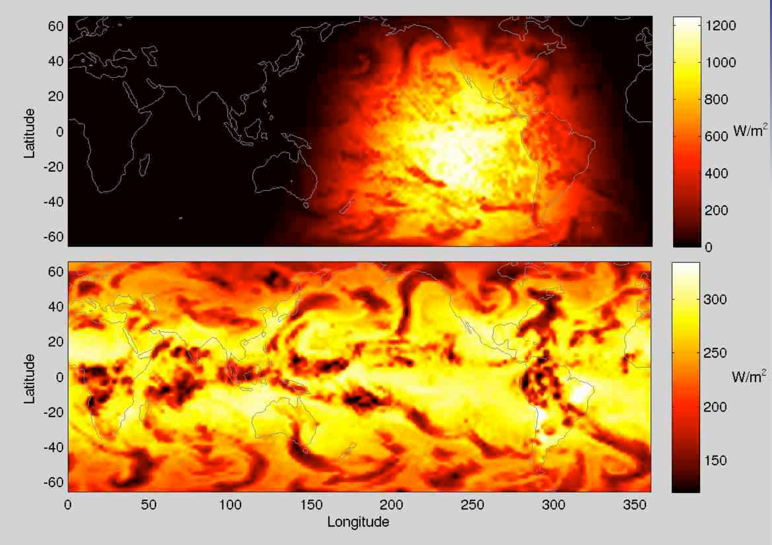

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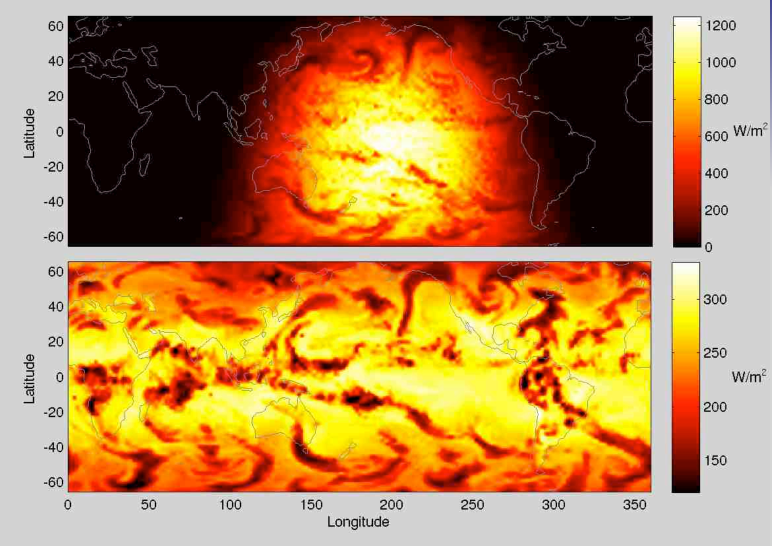

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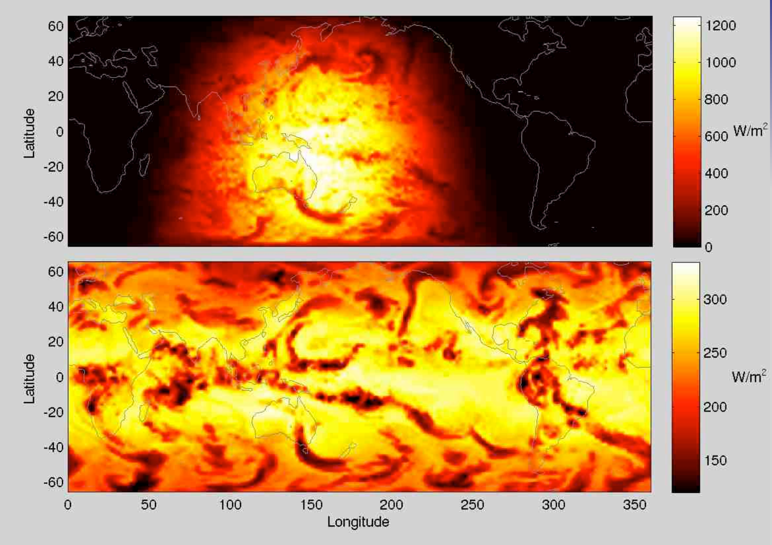

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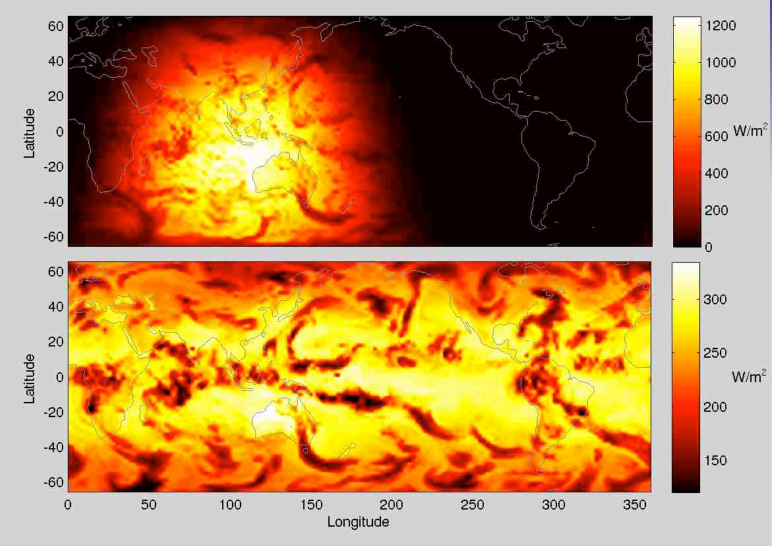

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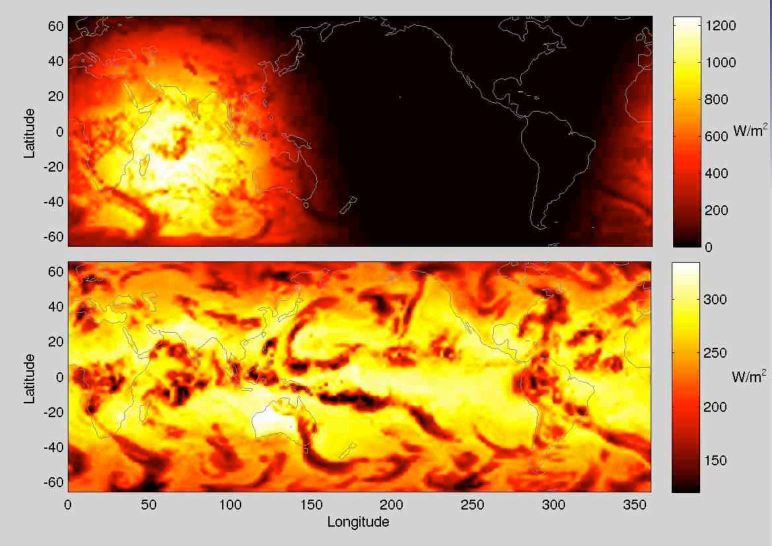

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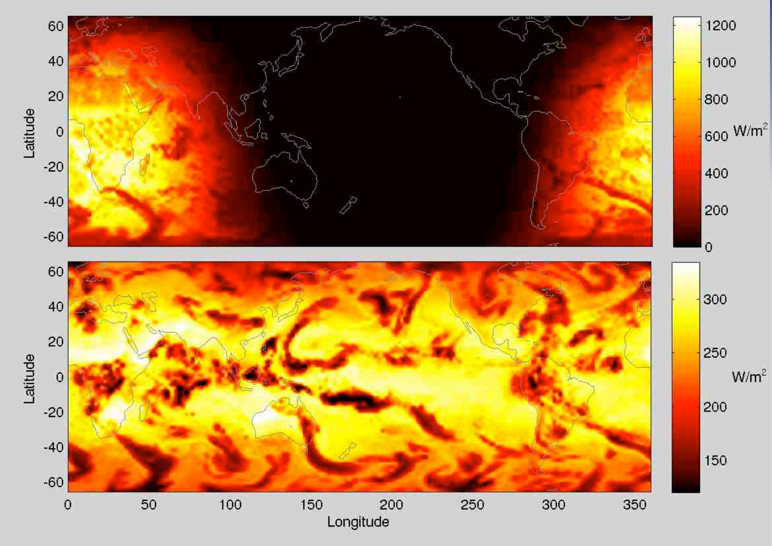

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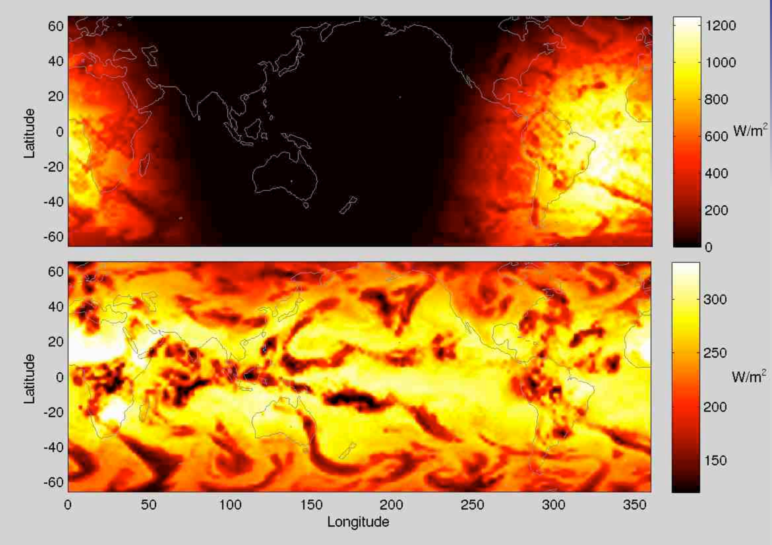

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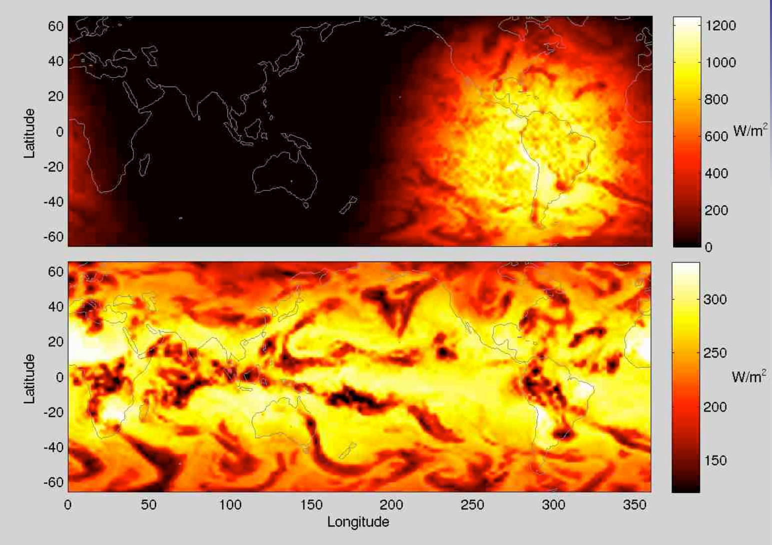

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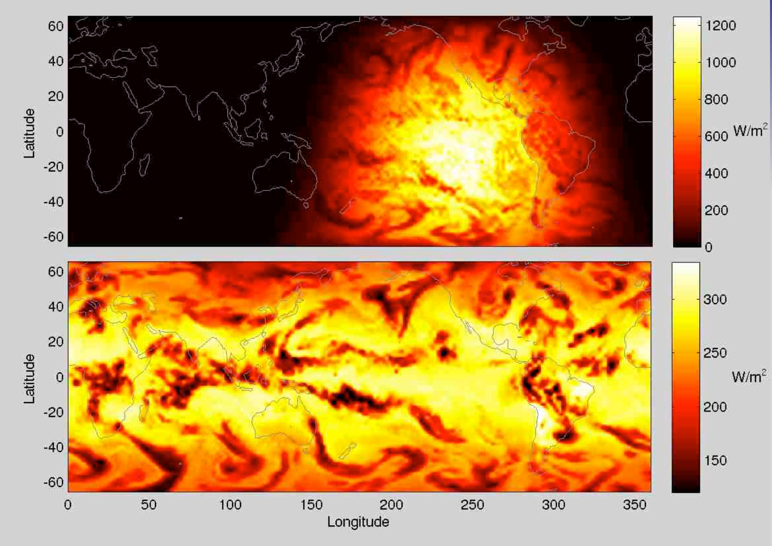

Example on tropical deep convection

(From TWP-ICE, ARM Climate Research Facility)

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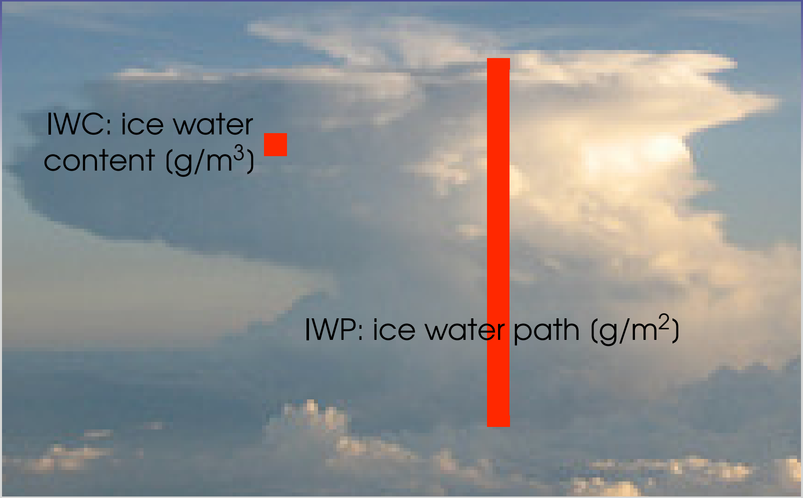
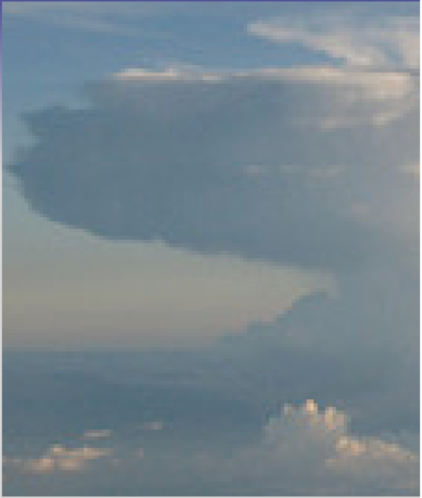
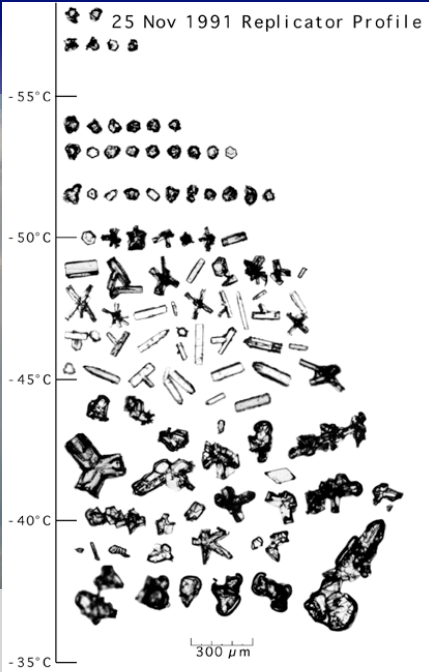
Ice water content / path



Particle shapes and sizes

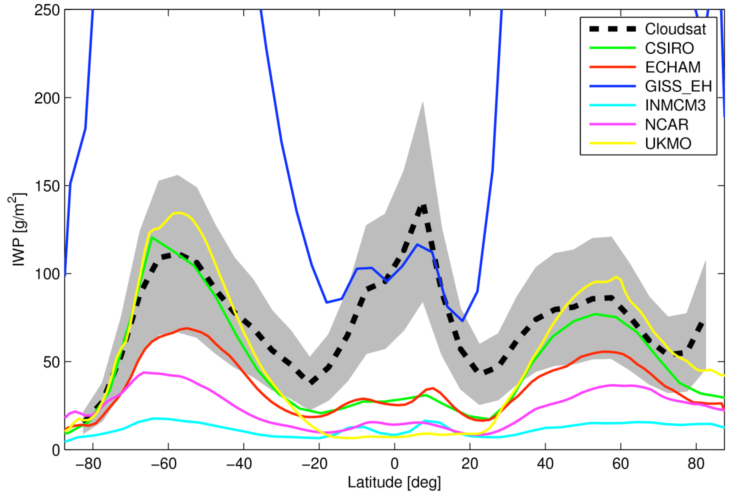




Present knowledge

Comparison of IWP in climate models (AR4)

Grey area is CloudSat ±40%



(Figure by from Eliasson et al., ACP, 2011)

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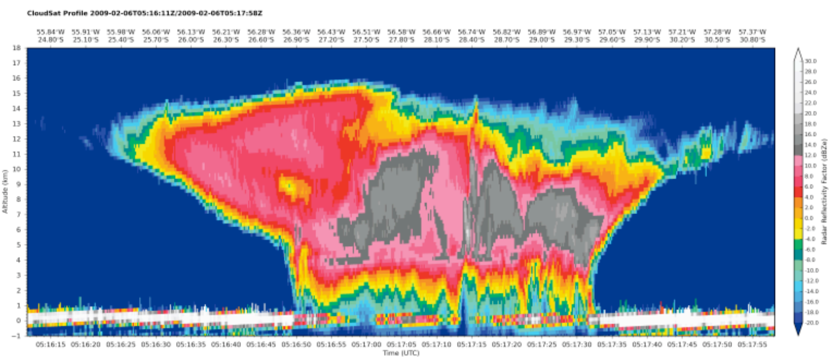
CloudSat

The first satellite-based cloud radar (94 GHz, launched 2006)



- Main advantages
  - high spatial resolution, internal structures resolved
  - first global estimates of ice water content (IWC) (g/m^3)
- Main limitations
  - measurement $\sim \sum r^6$ (while mass $\sim \sum r^3$)
  - across-track coverage just 1.3 km

Measurement principle and example results

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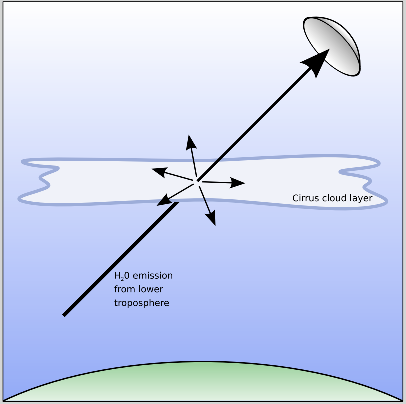
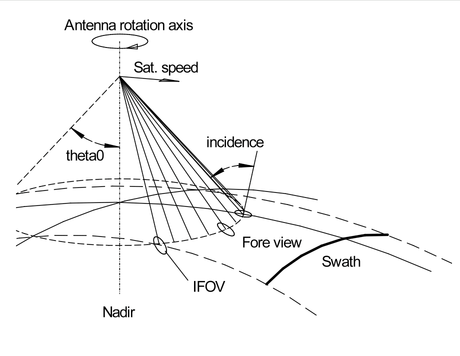
Measurement principle, 1
Geometries

Passive observations



Swath width of $\sim$1000 km



- Absorption by ice particles can be neglected

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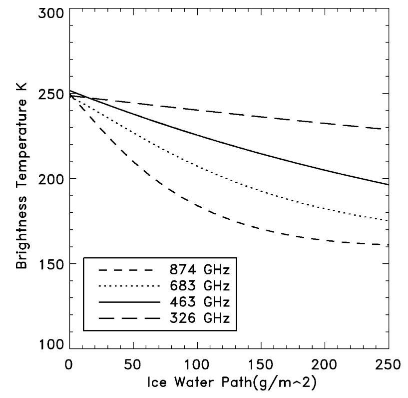
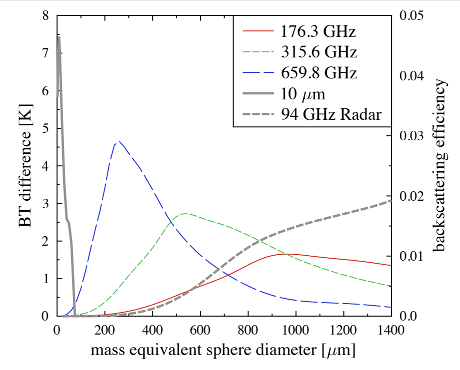
Measurement principle, 2
Frequencies

IWP response



Particle size sampling



- "H_2O slicing" also applied

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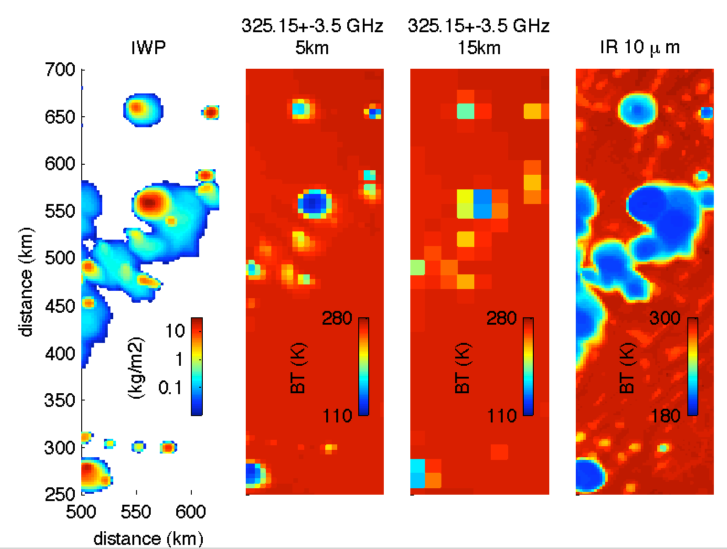
Example on IWP response



(Figure by Eric Defer, LERMA, Paris)

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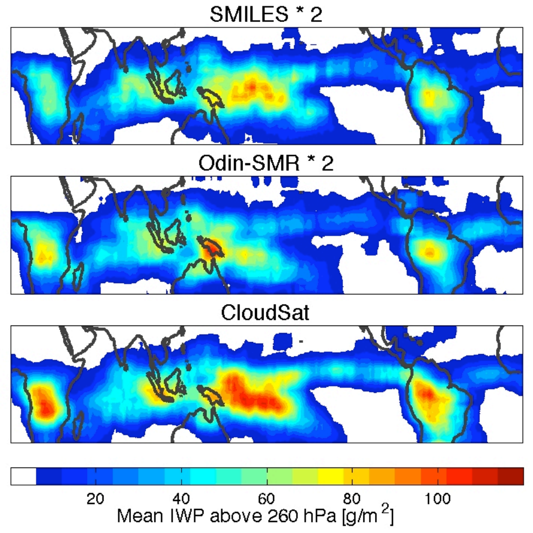
Example on Odin-SMR and SMILES retrievals



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Status

ICI and ISMAR

- Suggested during the 90s (A Gasiewski, F Evans . . .)
- Some airborne measurements performed in US
- Several mission proposals, none successful
  - last proposals to ESA coordinated by Stefan

Ice Cloud Imager (ICI):

- Part of Metop second generation
- Launch around 2021
- Channels between 183 and 664 GHz
- Some dual polarisation (H and V)

ISMAR:

- An airborne instrument under development (UK Met)
- First measurements early 2014

Our present involvement

- SB and PE member of ICI Science Advisory Group
  - no meeting yet!
- Next ISMAR workshop in June
  - arranged by us, at Kristineberg (Lysekil)
- Collaboration with SMHI started
  - first EUMETSAT IWP ATBD written
  - calculation of single scattering properties
- SNSB project started Jan 1
  - Chalmers + Kiruna (50% / 50%), 3 years

Example results

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ARTS

The Atmospheric Radiative Transfer Simulator

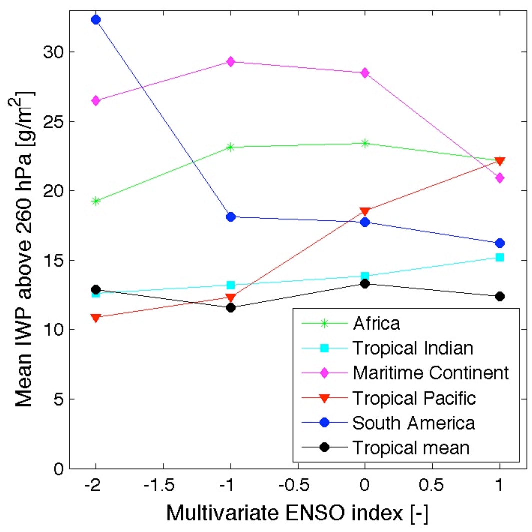
- A general forward model for longwave radiation,
- with focus on microwave applications

<u>Main features:</u>

- 1D, 2D or 3D, free observation geometry
- Reference ellipsoid used (no "flat Earth" restriction)
- Two modules for solving scattering (DOIT and MC)
- Full polarisation (Stokes 1-4)
- Now also other planets and radio link budgets

Impact of ENSO

Based on results from Odin-SMR



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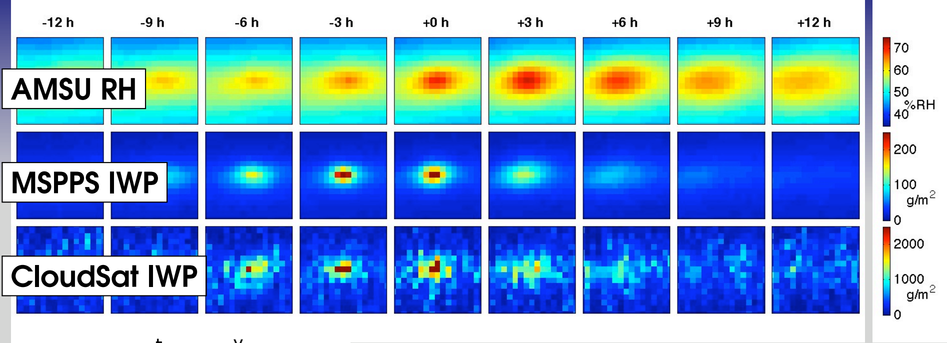
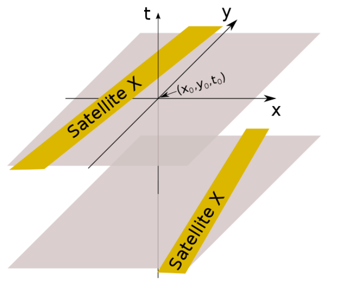
Determining the average response of convection





- Each plot covers 1200 km x 1200 km, and is a 3 h average

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Summary

- A dedicated space mission now started: ICI
  - decision partly based on Swedish efforts
- Now focus on airborne instrument: ISMAR
  - workshop in June
- Main issues:
  - derive and use more realistic single scattering properties
  - perform 3D simulations, to check impact of horizontal cloud structures

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