Manchmal ist es gut,

nicht auf den Boss zu hoeren …

Modelling high energy convection

Hans-F. Graf

And the active ATHAM-Team:
Christiane Textor, Michael Herzog, Joerg Trentmann, Gunnar Luderer
And the past team: *Josef M. Oberhuber*, Doerte Mueller and Karsten Schwanke

Etwas Geschichte:

1991 Mt Pinatubo

1991/2 Graf and Oberhuber begannen, eine Eruptionssaeule zu modellieren, sozusagen als Hobby: ATHAM

1992 K.H. und L.B. meinten: *Spielkram!*

Listigerweise wurde eine *Begutachtung* genutzt, ein Poster mit Ergebnissen von ATHAM *heimlich* aufzuhaengen. Die Ergebnisse waren alle mehr oder weniger falsch - aber das hat keiner gemerkt – und so wurden diese Arbeiten lobend erwaehnt.

1993 dann der erste Diplomand: **Karsten Schwanke**, der spaeter Kachelmann half, Geld zu verdienen und inzwischen das Bild der Wissenschaft im Fernsehen moderiert.

VW Stiftung opferte eine Menge Geld fuer bunte Bilder im Jahrbuch und finanzierte zwei tapfere Doktoranden: **Christiane Textor und Michael Herzog**, sowie die ersten beiden ATHAM workshops (der auf Sizilien war besonders gut!)

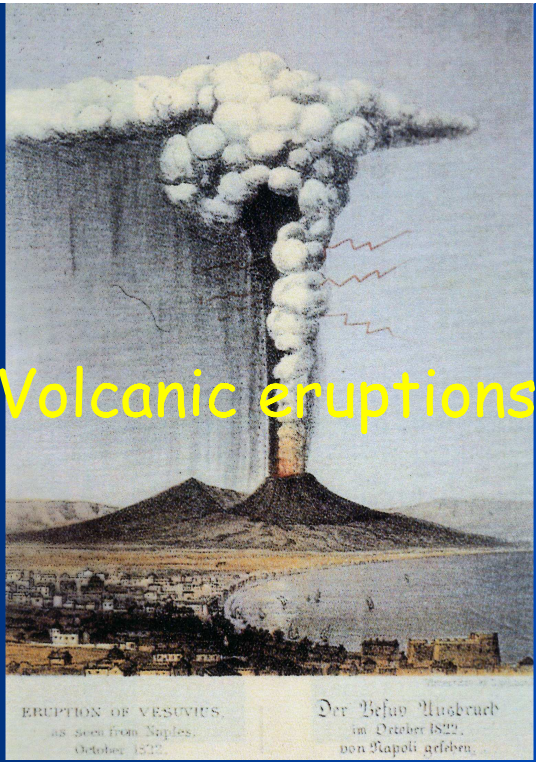
Doerthe Mueller musste sich an der Mikrophysik versuchen, bekam aber trotzdem ein Diplom.

Dann kam **Joerg Trentmann**, der ATHAM nach Mainz entfuehrte und dort wird gerade **Gunnar Luderer** promoviert, bevor er an's UBA geht!

In diesem Jahr gab es den 4. ATHAM workshop, nun in Cambridge und finanziert von NIEeS:

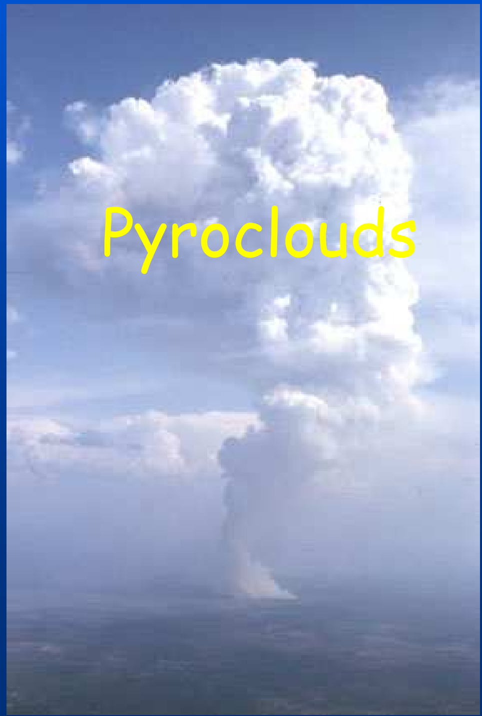
28 Teilnehmer aus UK, Frankreich, Italien, USA, Australien, Deutschland und Kanada

Es geht also weiter!

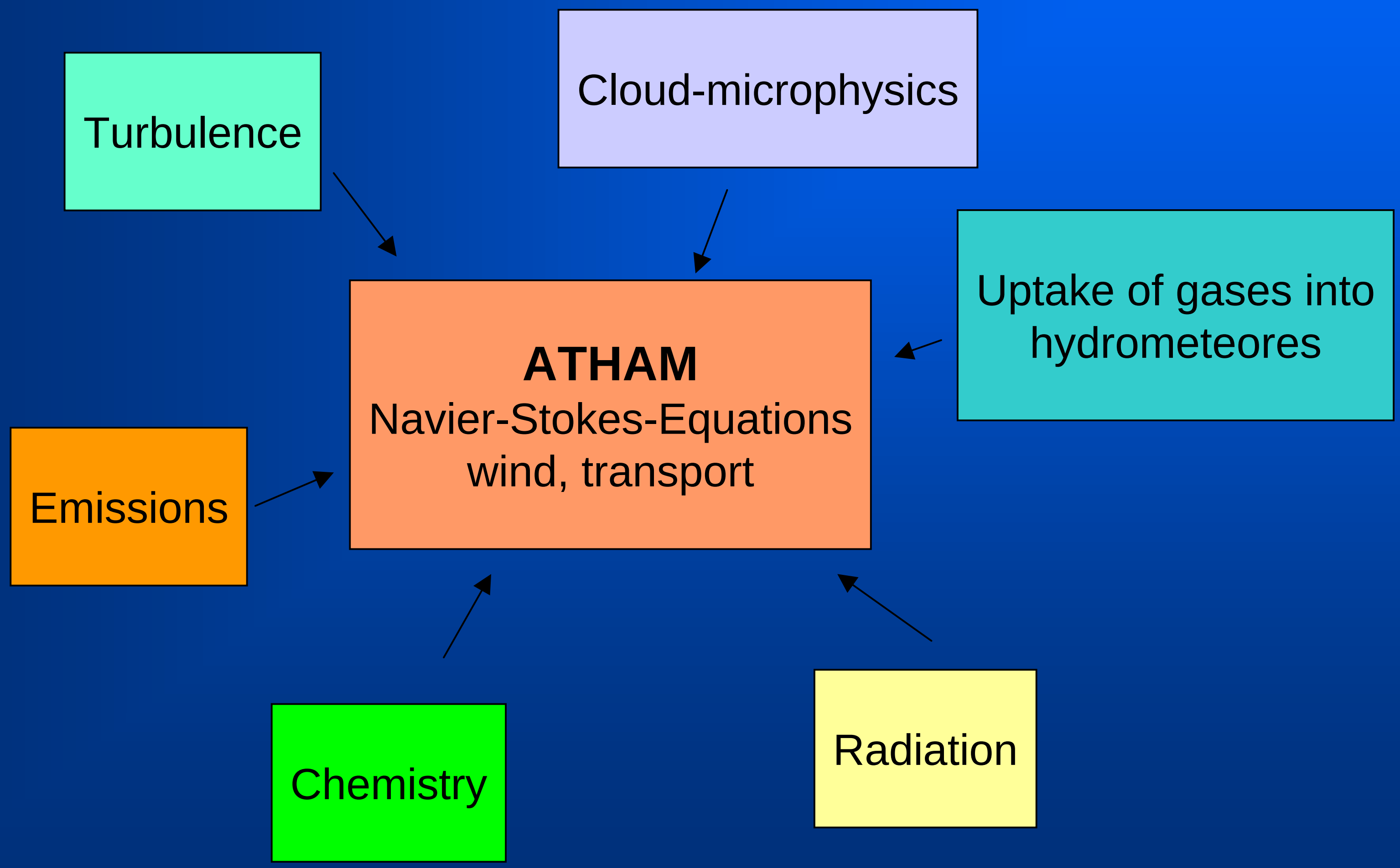

Volcanic eruptions
ERUPTION OF VESUVIUS,
as seen from Naples,
October 1822.
Der Vesuv Ausbruch
im October 1822.
von Napoli gesehen.


Biomass burning


Deep convective clouds

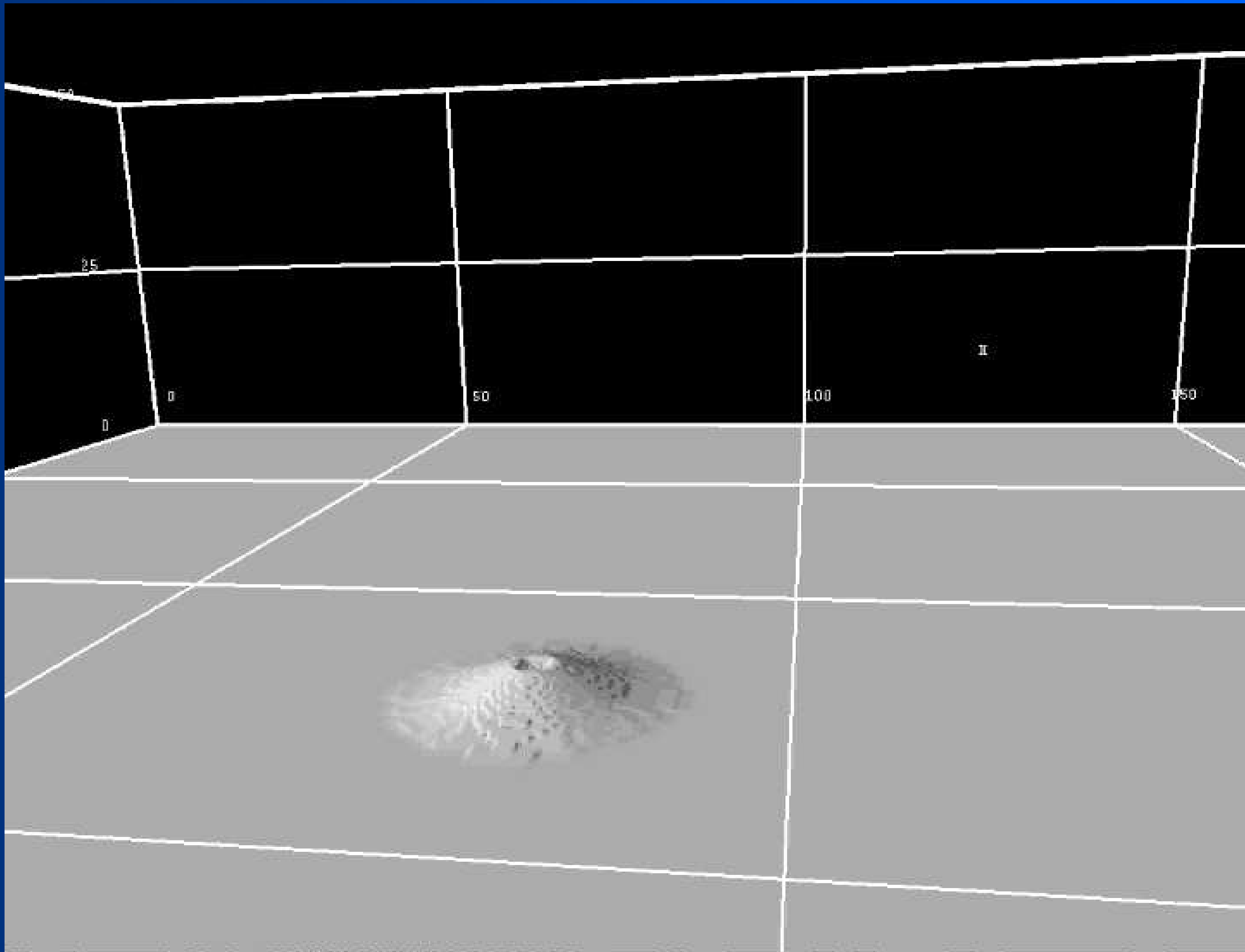

Pyroclouds

Active Tracer High Resolution Atmospheric Model (ATHAM)



ATHAM 3d simulation

Volcanic ash in a plume of an explosive eruption



Ash sizes 10µm 200 µm 4 mm

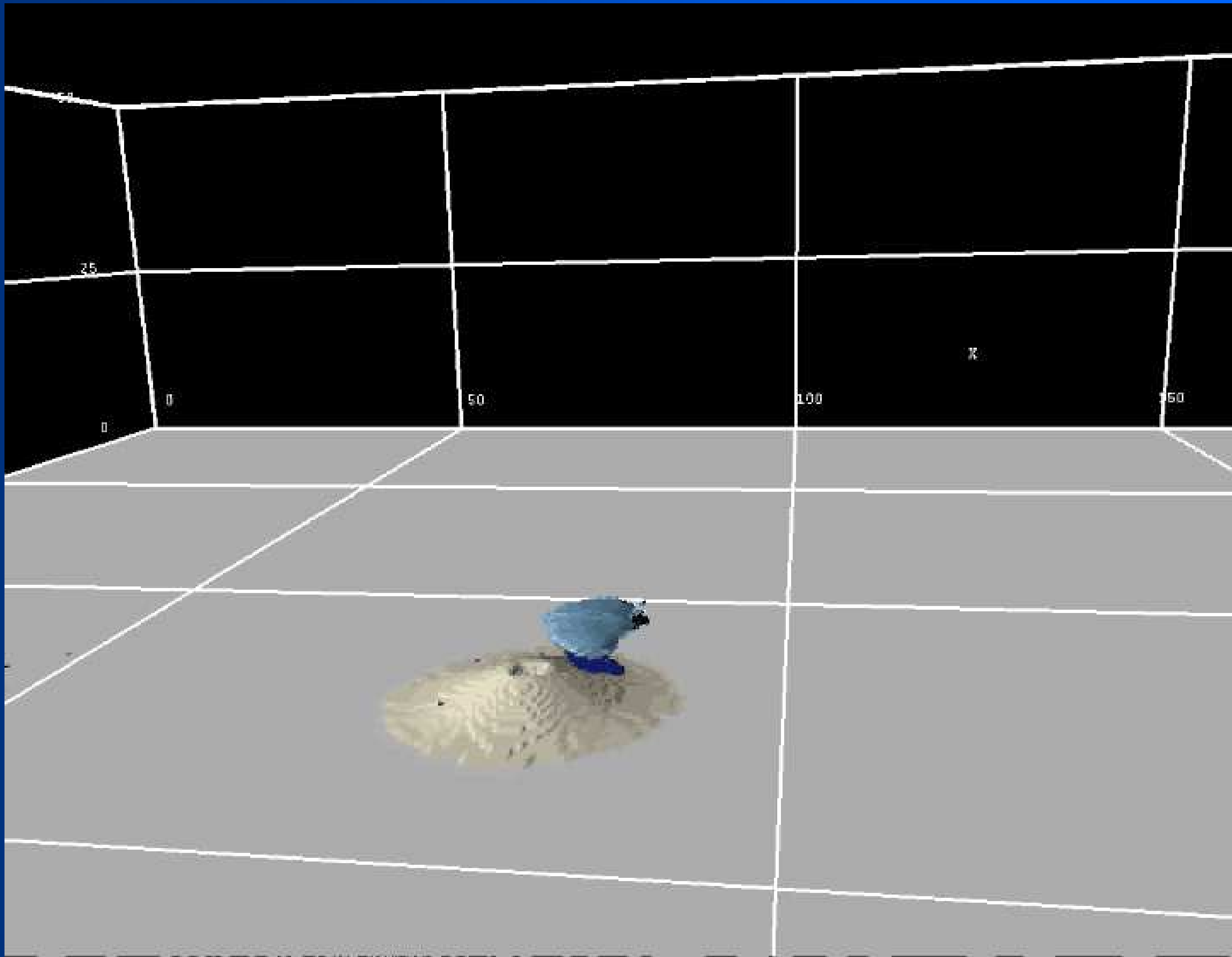
Max-Planck-Institute for Meteorology

DKRZ

ATHAM 3d simulation

Max-Planck-Institute
for Meteorology

Fine ash and hydrometeors during an explosive eruption



fine ash liquid water ice

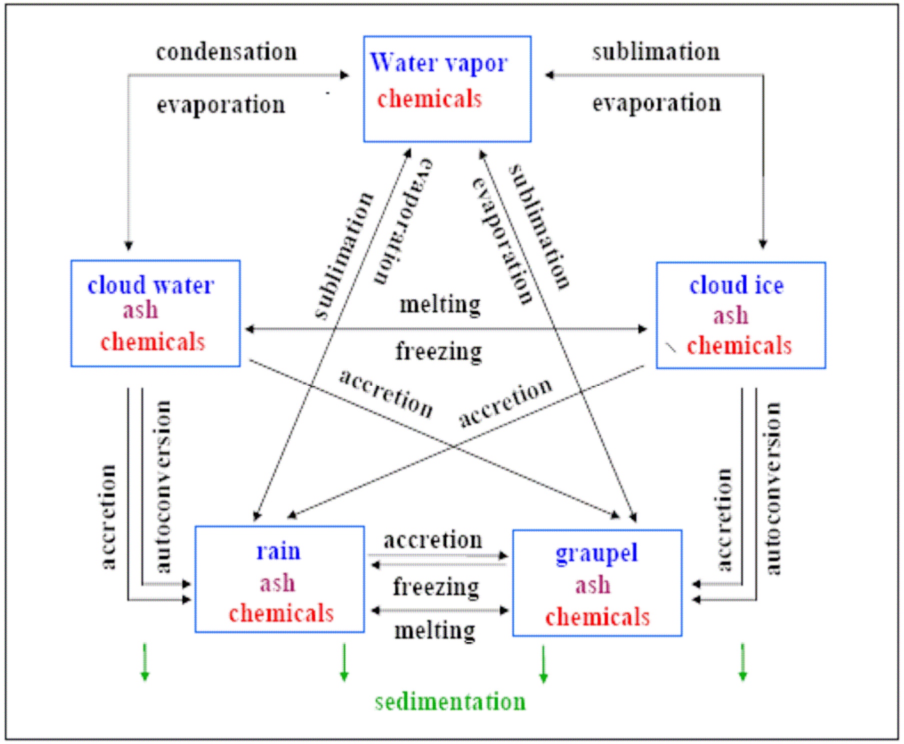
DKRZ

The fate of volcanic gases in the plume: former estimates…

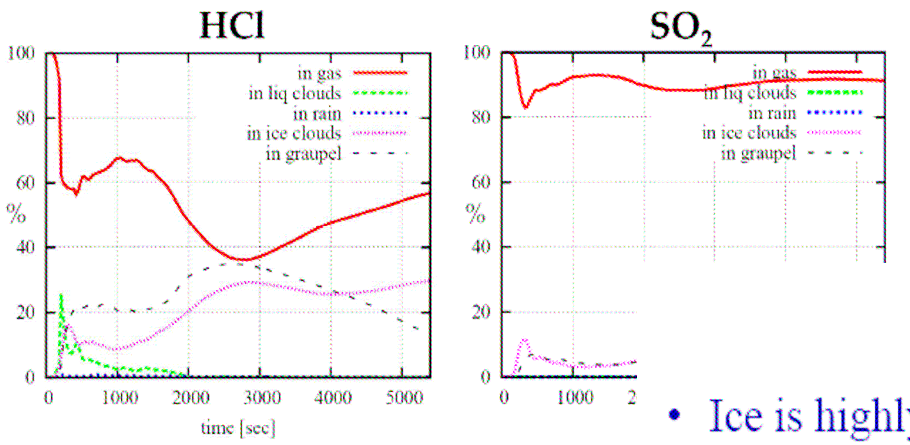
- → SO_2 low water solubility
  completely injected into the stratosphere
- → HCl completely scavenged by super-cooled drops
  no injection into the stratosphere

Tabazadeh & Turco, Science 1993: 1d plume model (Woods, 1988),
empirical entrainment parameter,
highly simplified microphysics

Chemical species in ATHAM

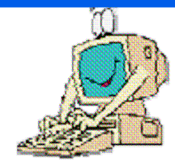


Volcanic gases in different phases



- Efficient gas scavenging by hydrom

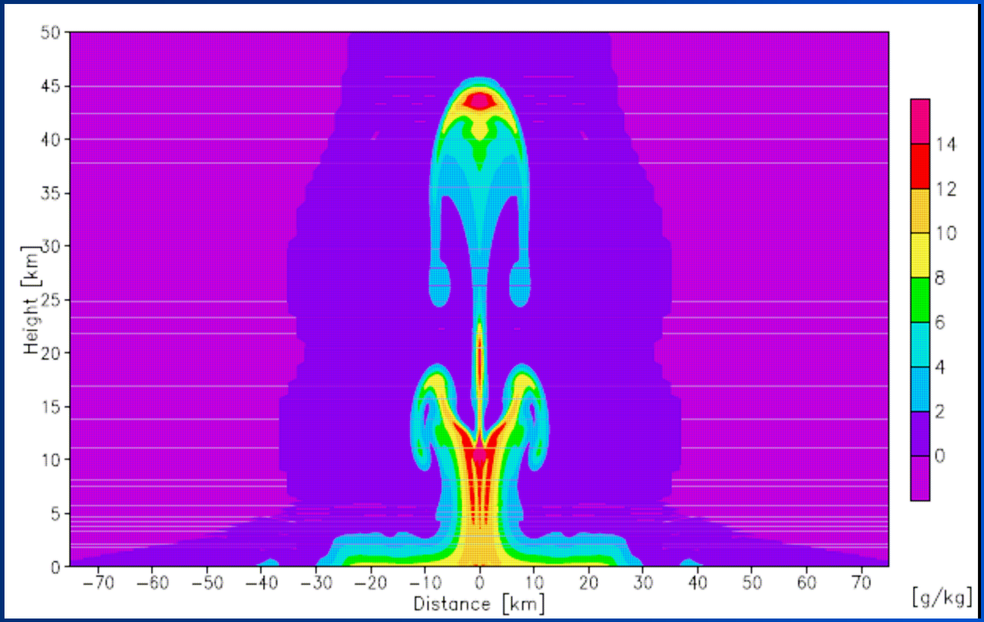
Conclusions



- Ice is highly dominant in the eruption column.
- The amount of condensed water (and ice) determines the efficiency of particle aggregation.
- Most of the emitted SO_2 is injected into the stratosphere, but some is contained in ice particles.
- The gas trapping efficiency in ice is highly uncertain.
- The injection of HCl into the stratosphere is not negligible!
- The final amount of volcanic gases in the stratosphere depends on the fate of the hydrometeors which contain them.

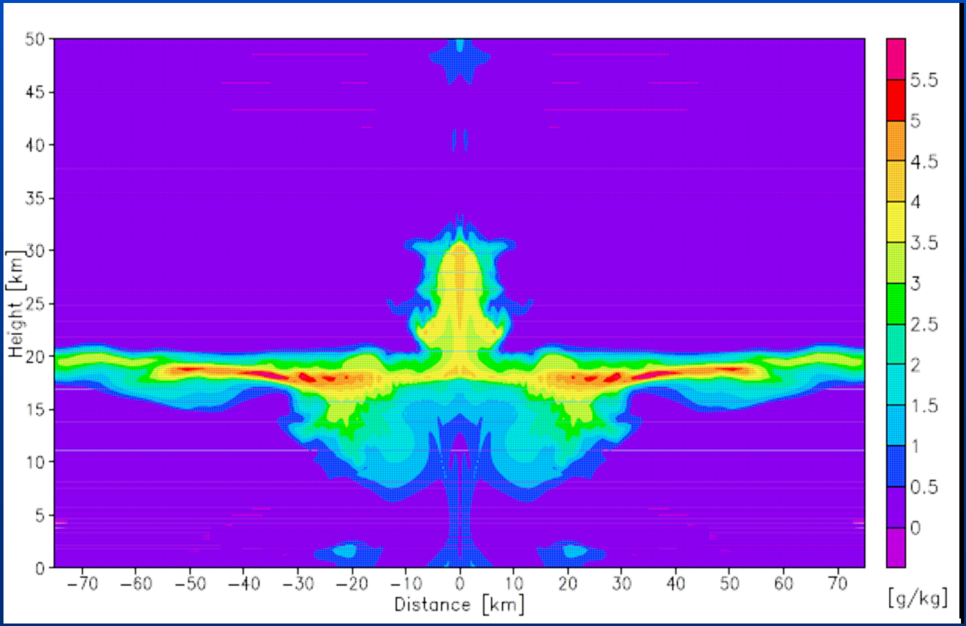
Co-Ignimbrit Eruption "Toba"

= 100 Pinatubos



SO2 after
6 min

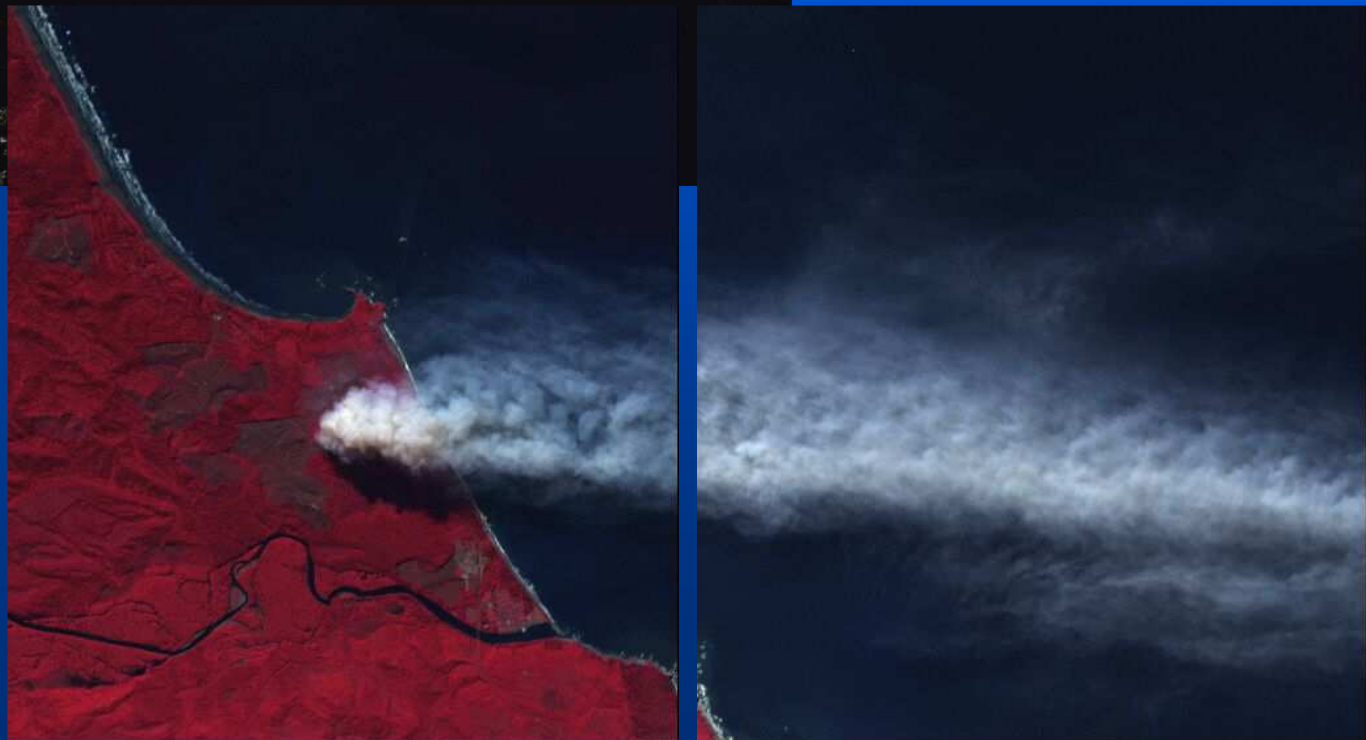
SO2 after
30 min



Neuschreiben der
Sedimentologie??

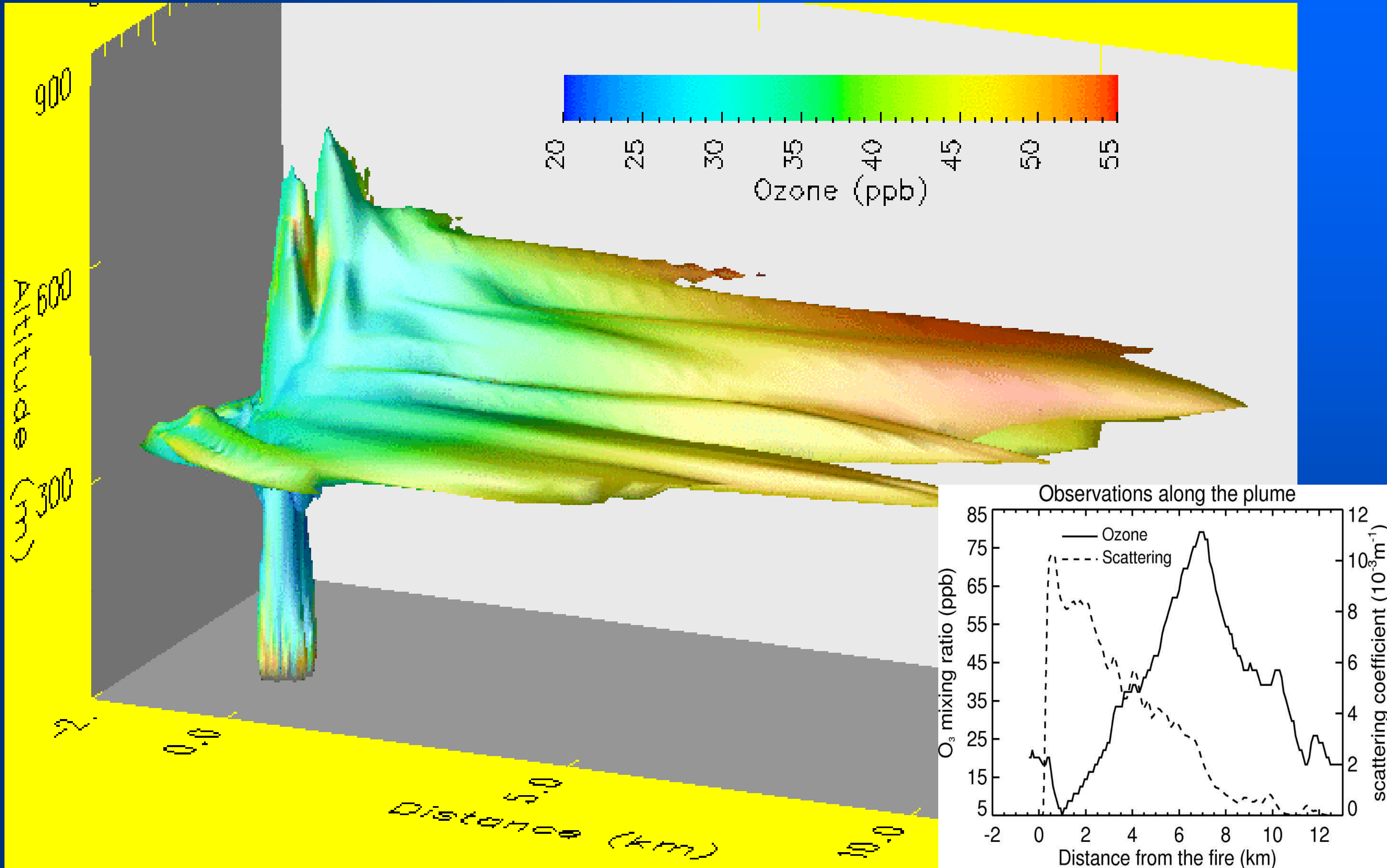
Burning of logging residues, US Pacific Coast, 1994
Quinault Fire

Photo by R. Ottmar



Picture based on AVIRIS data

Chemical simulation of the Quinault fire plume



Data from P. Hobbs, U

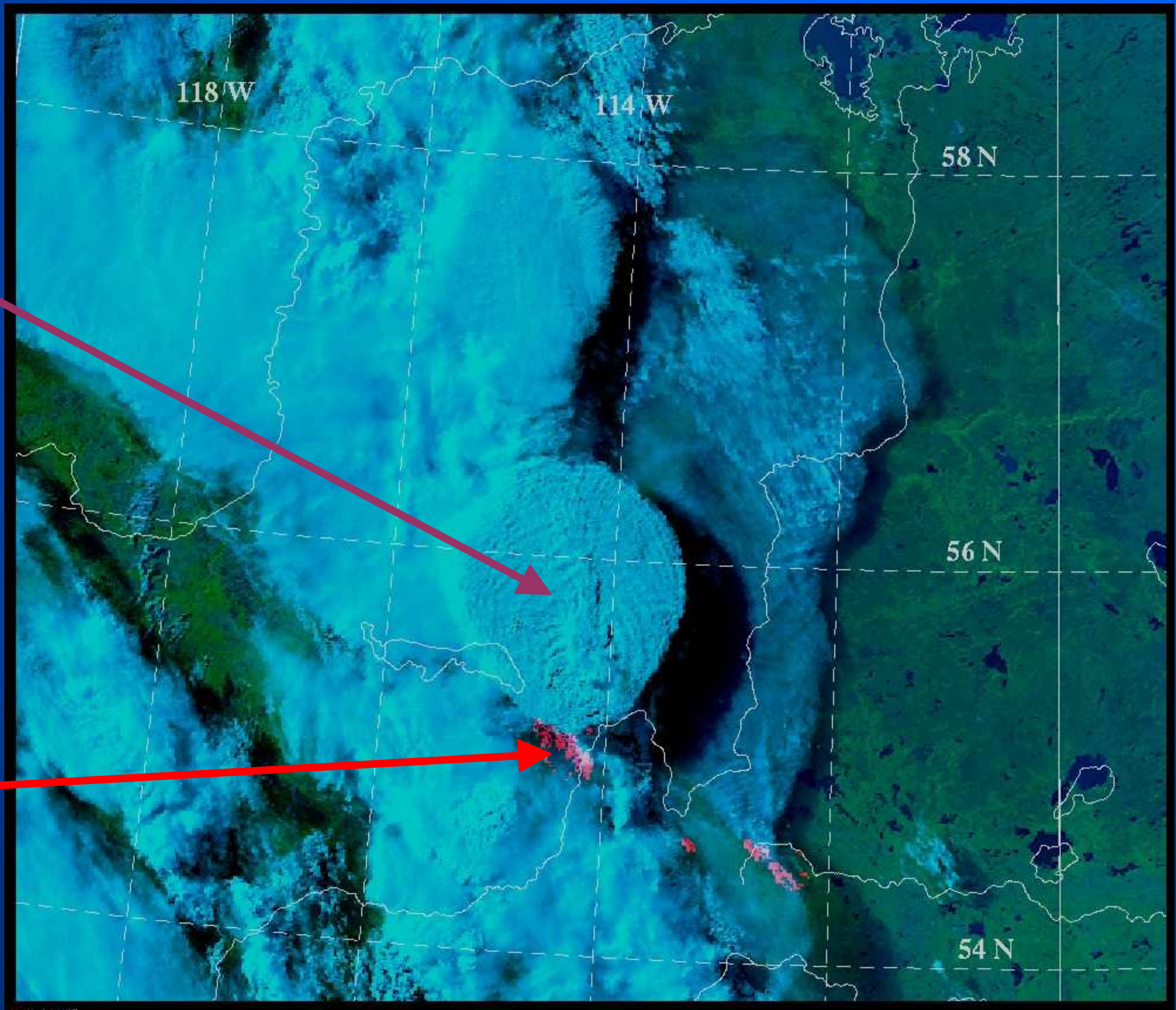
Isosurface of the aerosol concentration (150 mg/m3) colored with ozone mixing ratio

Satellite Radiometers

AVHRR false color image

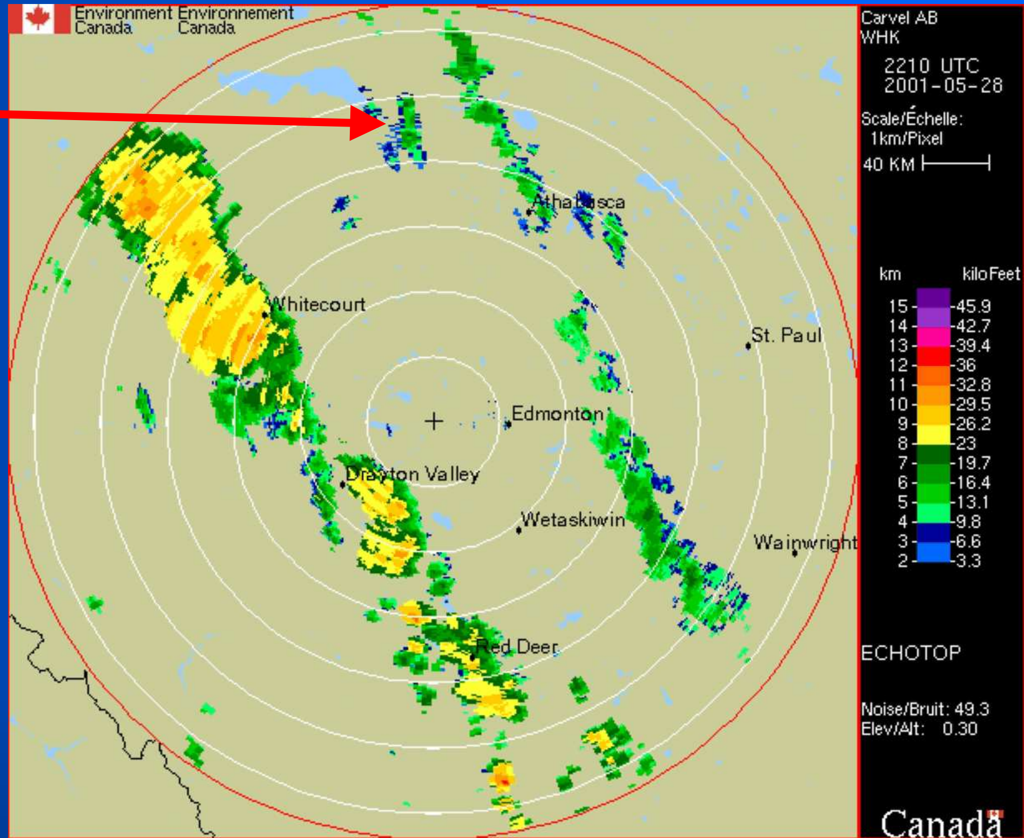
PyroCb

Location of the fire



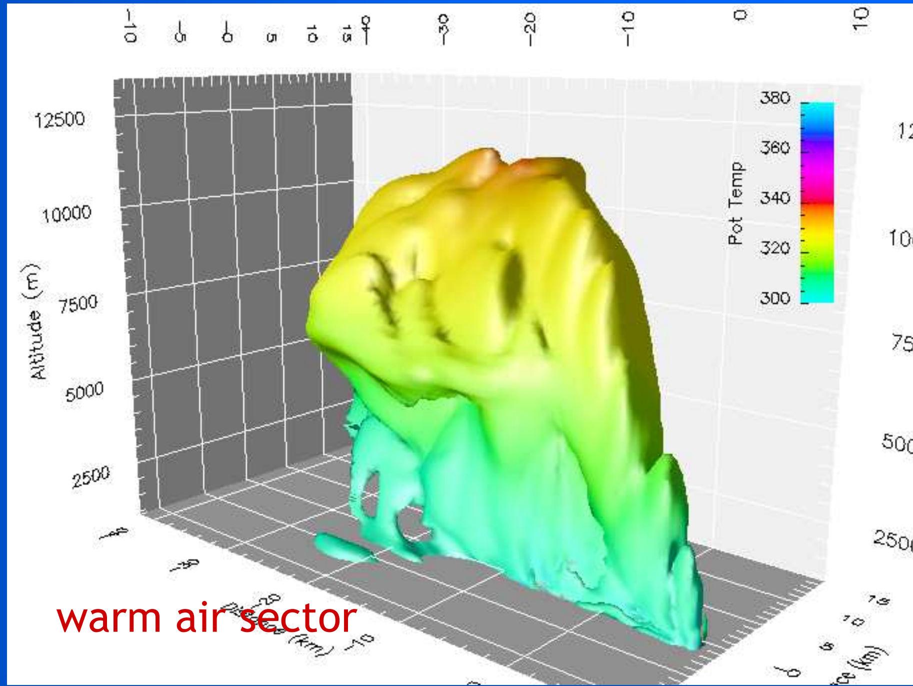
RADAR echotop observations

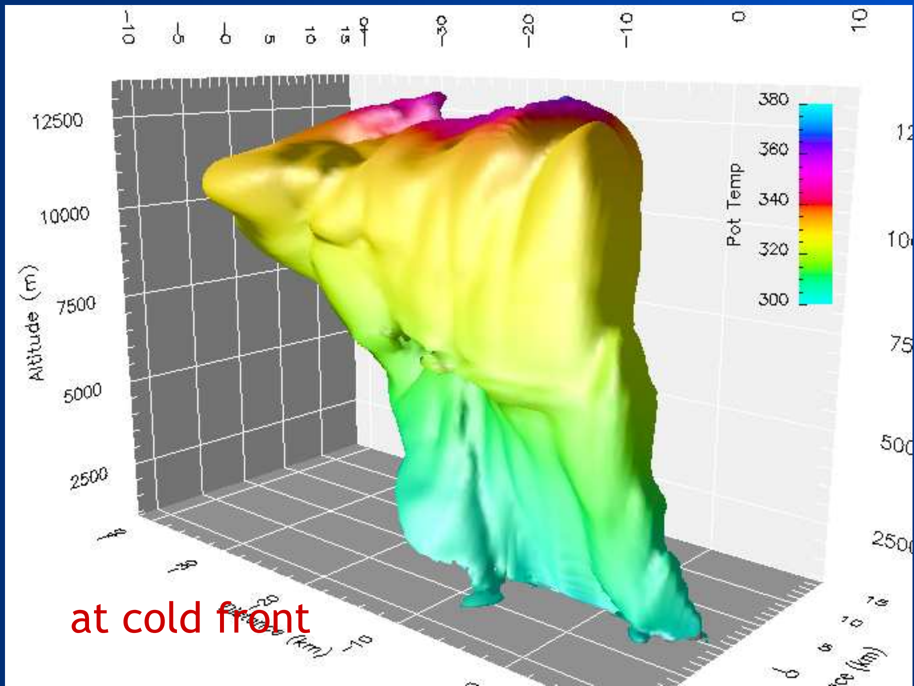
Location
of the fire

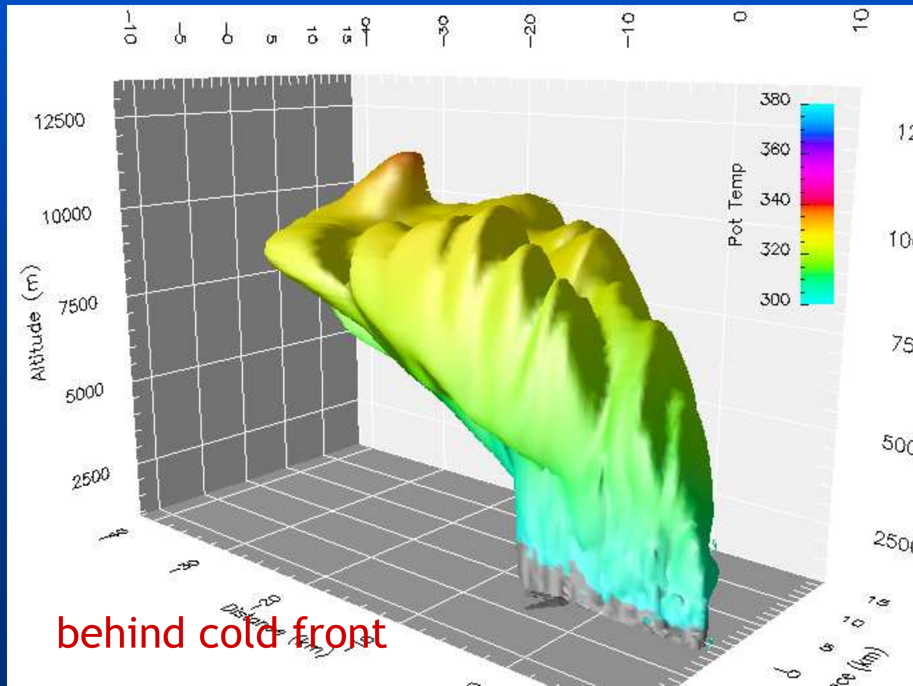


Sensitivity to background meteorology

- equal fire forcing
- strongest convection at cold front

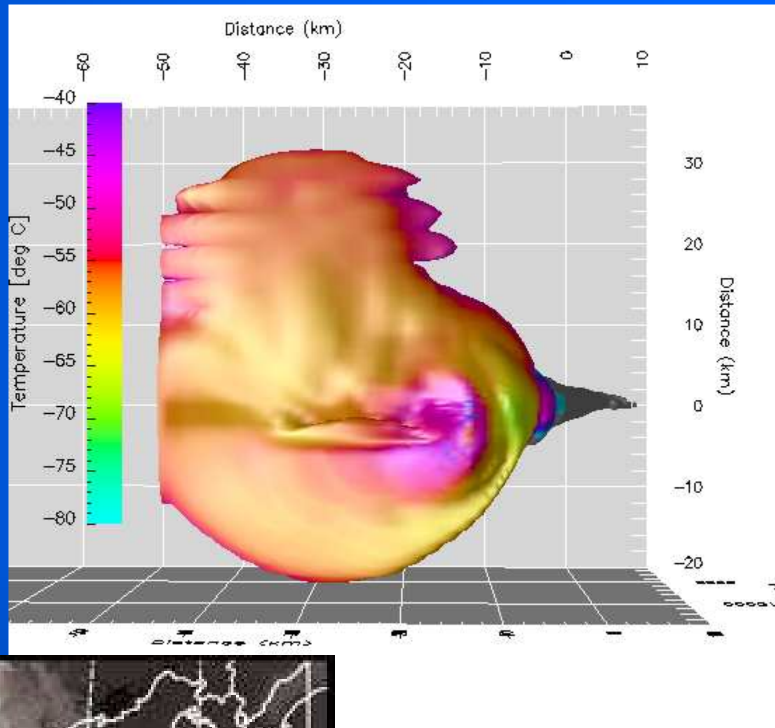


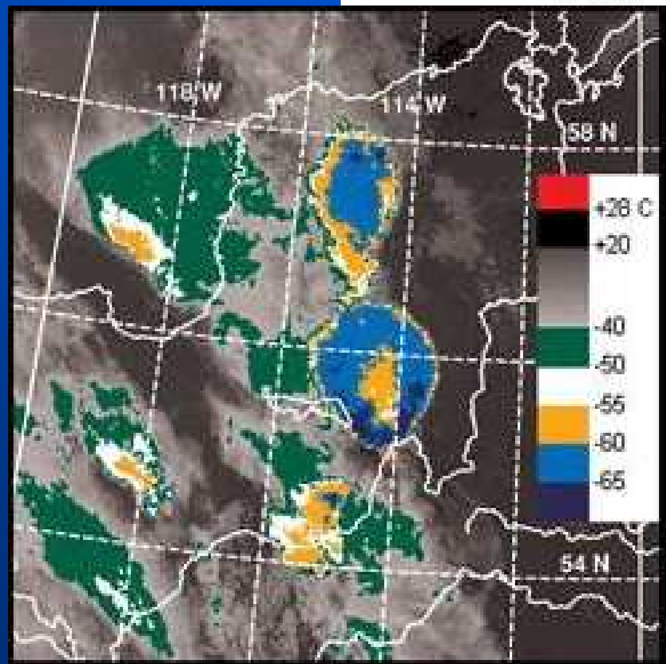




Cloud top temperature

- Good agreement between AVHRR and model results
- High temperatures in warm core inconsistent with background temperature profile





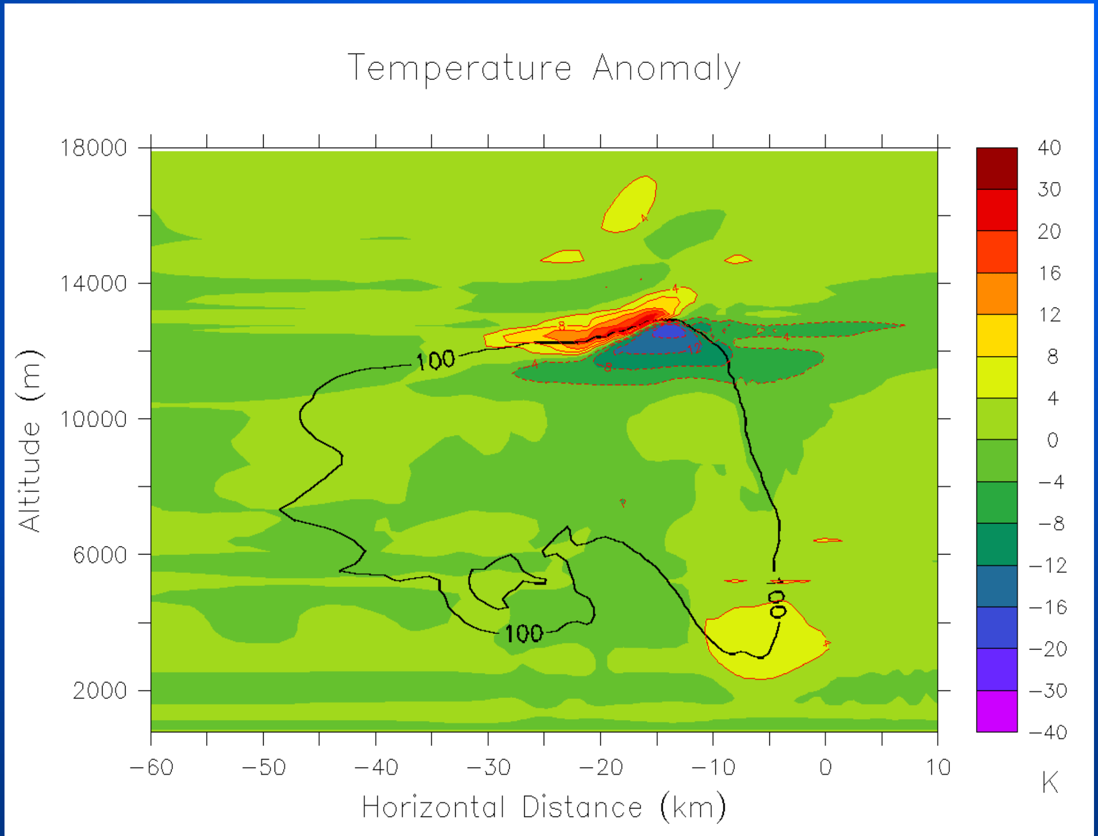
Gravity waves and turbulent mixing

Explanation from Simulations:

- ►formation of intense gravity waves leads to strong temperature anomalies

- ►turbulent mixing along strong gradients of potential temperature and smoke concentration

- ►importance of small scale processes for TST at cloud top



ATHAM will be used to **improve the representation of fire emissions** in larger scale models.

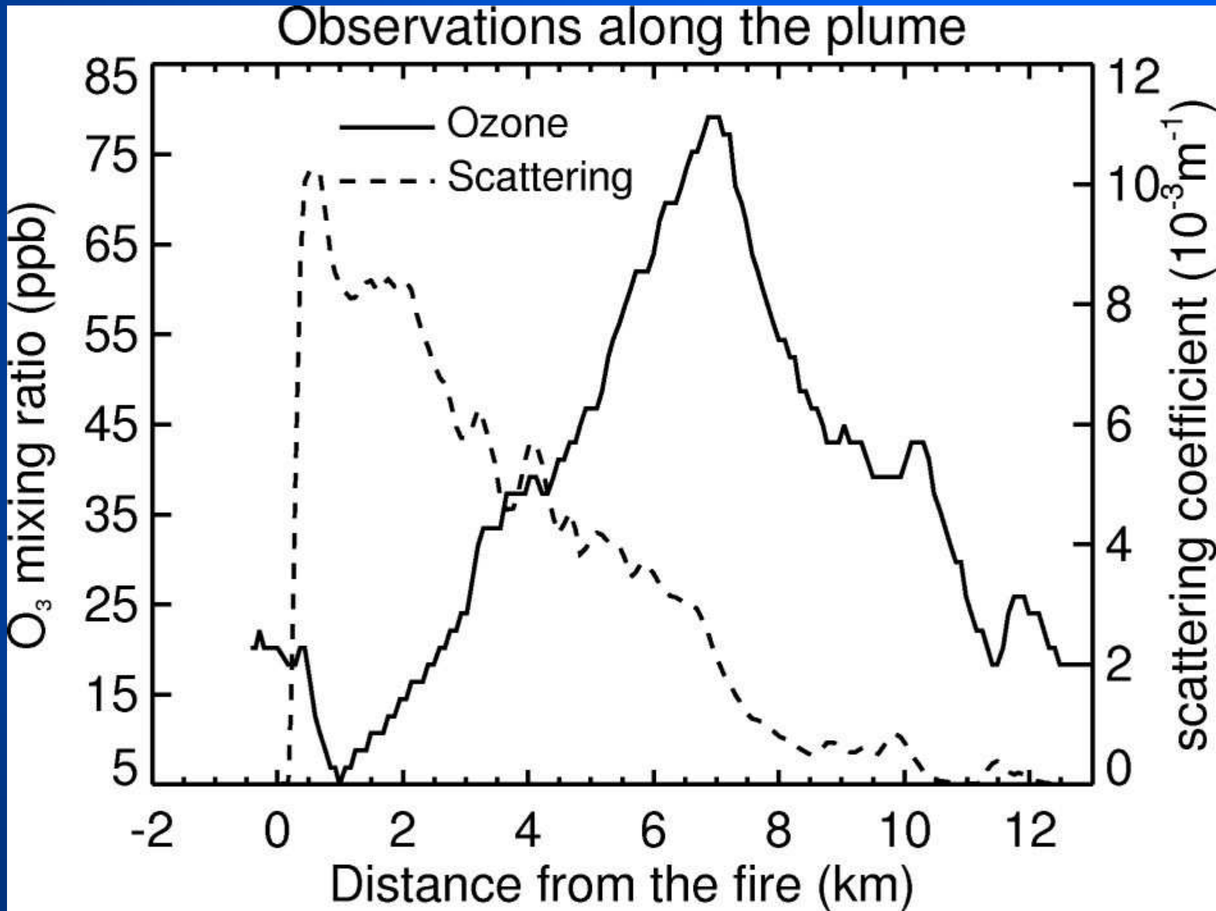
- Improving the assumptions of the emission height of fire emissions towards a more mechanistic description including the dependence on fire size and/or meteorological conditions.
- Deriving 'effective' emissions that include local effects which are not resolved by large-scale models, e.g., formation of ozone, scavenging of smoke particles.

Manchmal ist es gut,

nicht auf den Boss zu hoeren ...

Investigation of plume photochemistry

Observations from the Quinault plume yield low ozone concentrations above the fire and enhanced ozone downwind.



Data from P. Hobbs, Univ. of Washington

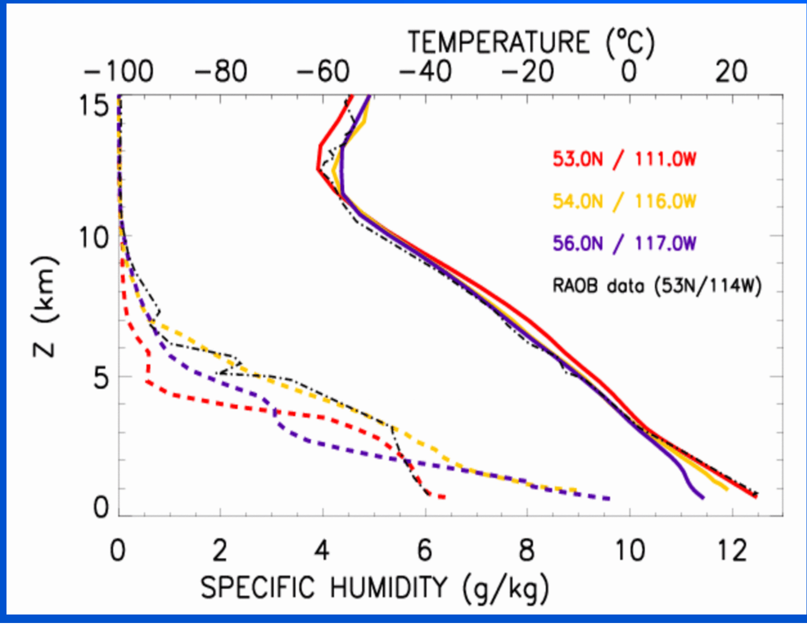
Goals of the Model Study

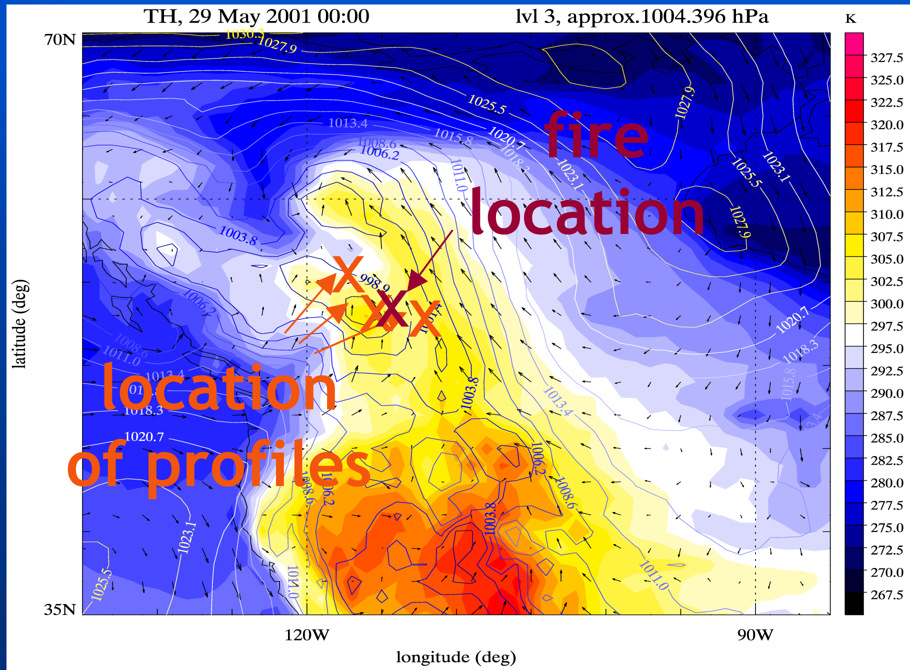
- Are boreal forest fires such as the Chisholm fire indeed strong enough to inject smoke into the stratosphere?
- What is the dynamical and microphysical structure of the pyro-cloud?
- What are the most important mechanisms determining the dynamical evolution of the fire convection? How do these mechanisms relate to the structure?
  - ► Sensitivity studies
- Investigation of troposphere-stratosphere-transport at the cloud top

Sensitivity to back-ground meteorology

Extreme intensification of the fire convection coincided with passage of a cold front

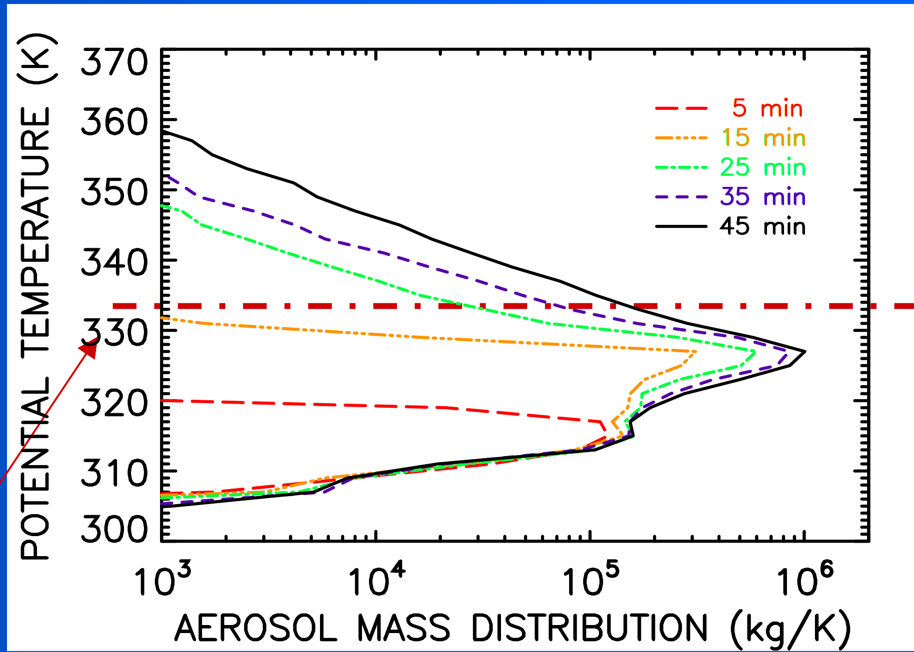
Idea: use 3 different background profiles from ECMWF reanalysis to investigate sensitivity to meteorology



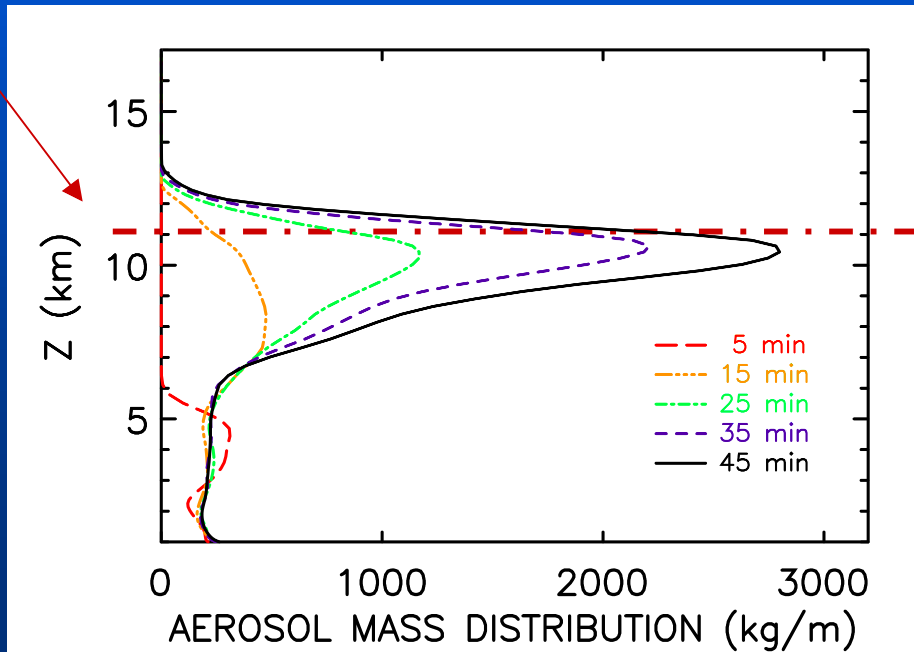


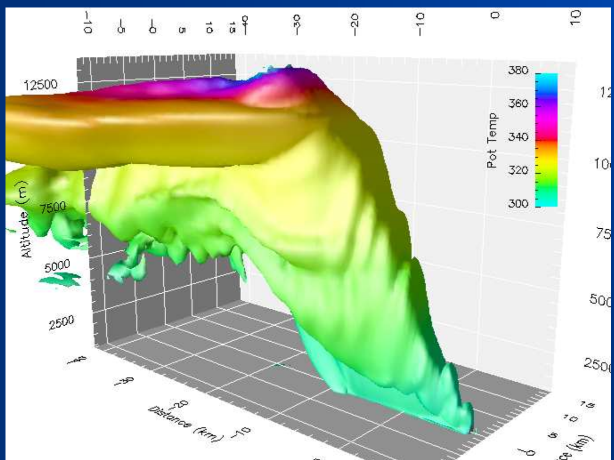
Injection into the stratosphere

After 45 min, a significant portion of the smoke (5-10%) has reached the lower stratosphere (not considering impaction scavenging)



Tropopause level





Pyro-Clouds

- Fire induces lifting of air parcels above their condensation level
- Release of latent heat creates additional buoyancy
- Aerosols emitted from fire alter cloud properties (Andreae et al., 2004)
- Detraining smoke downwind of the anvil