Trajectories

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A trajectory…

=Path of a non-buoyant balloon travelling with the wind

Atmospheric trajectories

- Can be used to find out where pollutants are going
- Can be used to find out where the pollutants are coming from
- Can be used to classify air arriving at a site from different “sectors”
- Can be used to investigate the cause of an episode

Terminology

***Forward* trajectories – follow the path of an imaginary balloon, an "*airparcel*". Used to determine where the air is going to.**

***Backward* trajectories (or *arrival* trajectories) – travels exactly against the wind. Used to find out where the air is coming from.**

Different types of trajectories

Three-dimensional trajectories:

⇒ follows the three-dimensional wind

“Two-dimensional” trajectories: move over latitudes and longitudes but:

⇒ stay on one “surface”, e.g. X m above ground

or:

2D isobaric-, (follows a surface where p is constant)

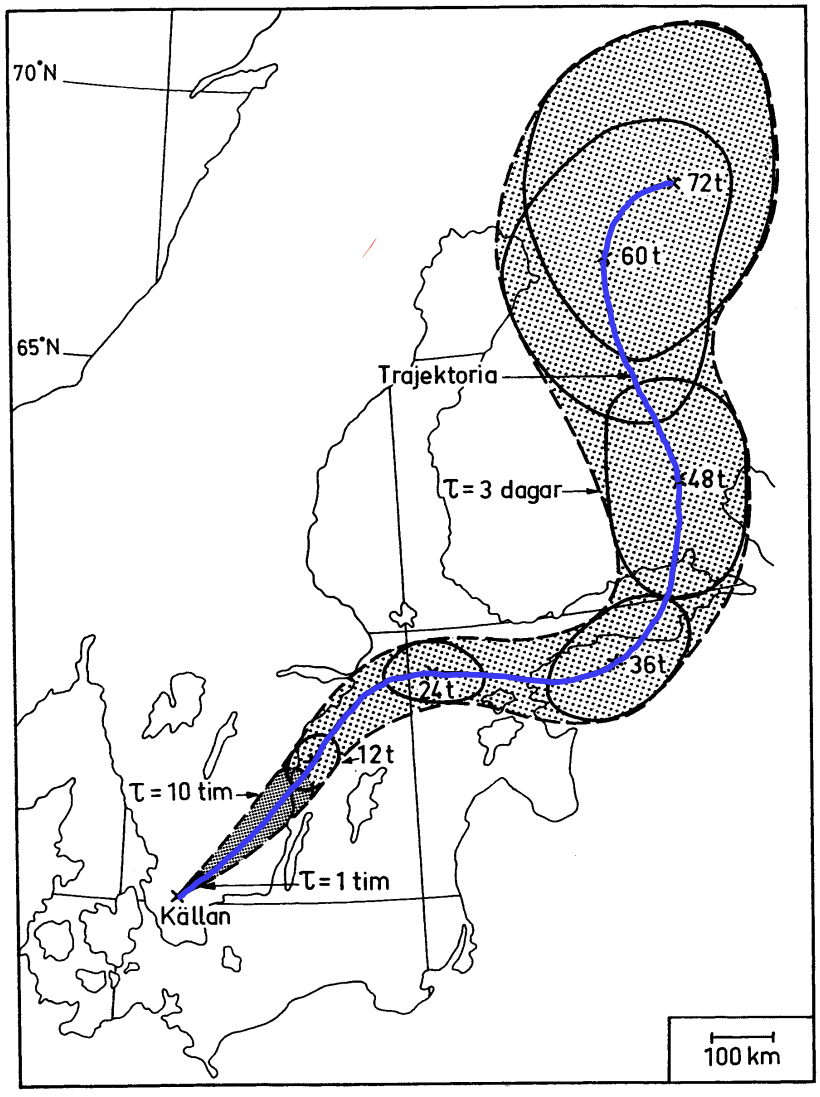
2D isosigma-, (follows a surface where p/p_s is constant.)

2D isentropic-, (follows a surface where “potential temperature is constant)

2D isopycnic- (follows a surface where density is constant)

Etc.

A trajectory is a *mathematical line*. No widening of plume etc. Errors in driving wind-field - or computational method - may give slightly (or completely!) wrong result.



Typical dispersion of a short release of tracer travelling with the wind. The "*forward trajectory*" is the solid blue line. The cloud occupies the encircled area during different time steps.

How to calculate trajectores

$$\mathbf{s}(t) = \mathbf{s}_0 + \int_{t_0}^{t} \mathbf{u}(\tau)dt$$

s(t) position at time t

$\mathbf{s}_0$ position at time=0

u(τ) three-dimensional wind at time τ

dt numerical timestep

Calculations of trajectories

Trajectories can be calculated manually from weather maps, or more conveniently, by computer models having access to three-dimensional fields of meteorological data (i.e. wind-data)

The accuracy, and resolution, of the weather data together with the accuracy of the computational method determines the quality of the trajectories

There are several sites available on the world-wide web which can be used, free of charge to calculate trajectories.

(e.g. “FLEXTRA Trajectory Model” or “HYSPLIT”)

Uncertainties during different conditions

- **Calculated trajectories close to the ground are more uncertain than trajectories in the free troposphere.**

- **Calculated trajectories that pass frontal zones or areas with convection are more likely to be in error compared to trajectories travelling over smooth surfaces with persistent weather conditions.**

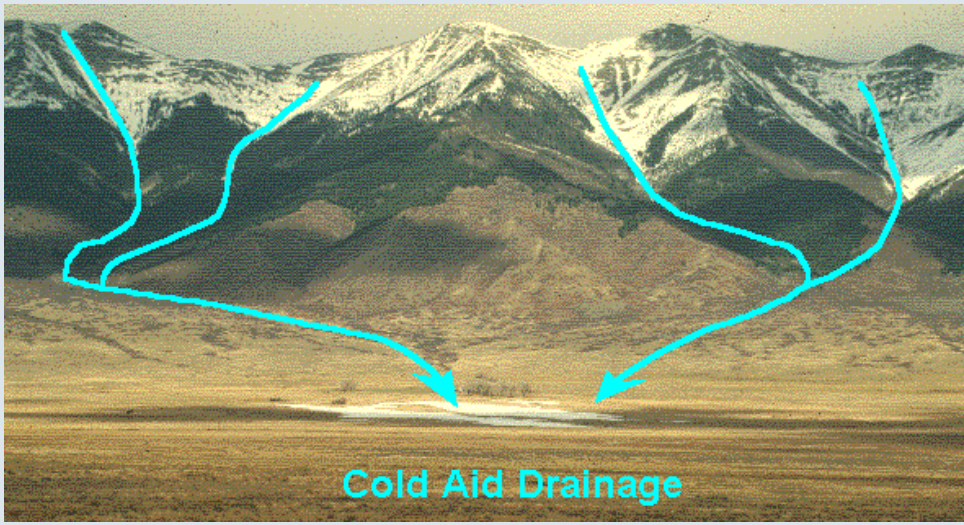
Uncertainty of trajectories can be assessed through:

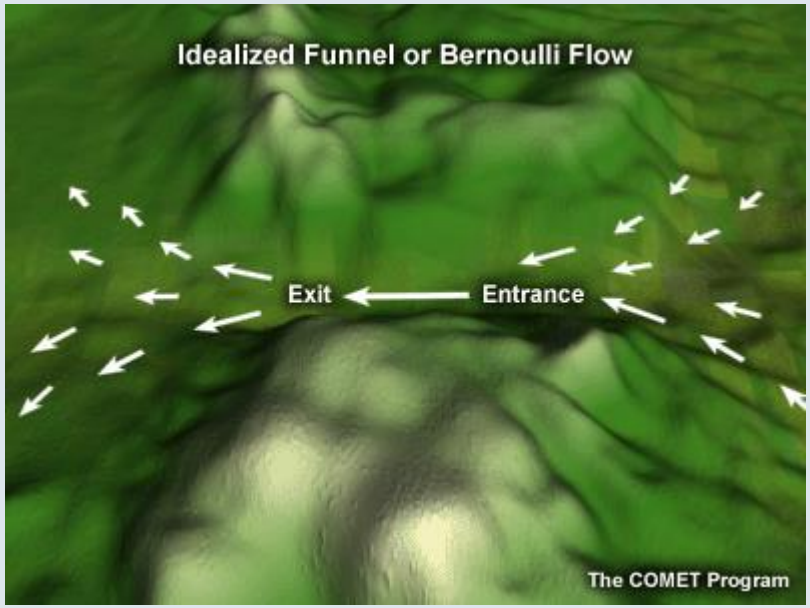
- Calculate several trajectories from a group of points close to each other. The trajectories should follow similar paths

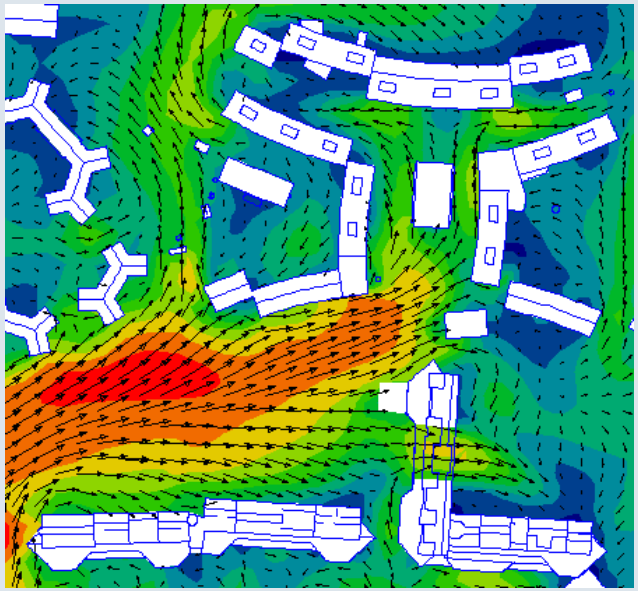
- Calculate backward trajectories from the endpoint (or close to the endpoint) of the forward trajectory (or vice versa)
  – If the trajectories come back to a position close to the original point they should be relatively accurate

Trajectories are typically used to assess the regional transport of air masses (transport times > ~12 hours)

Local wind measurements must not necessarily point in the same direction as the regional trajectory…







Length of trajectories

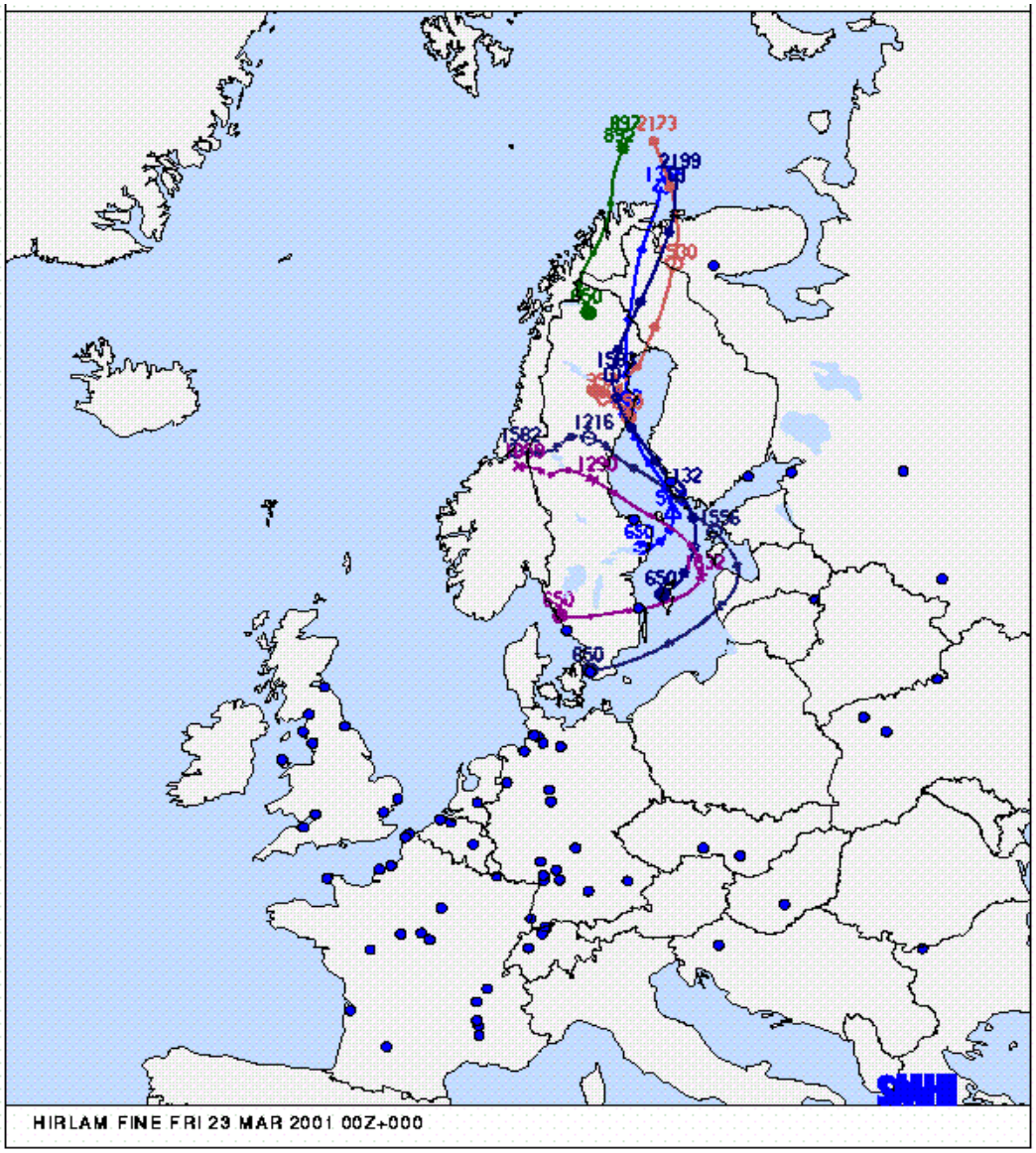
Less than a few hours often not meaningful

Longer than a week not acceptable because of uncertainty in input data and calculation method.

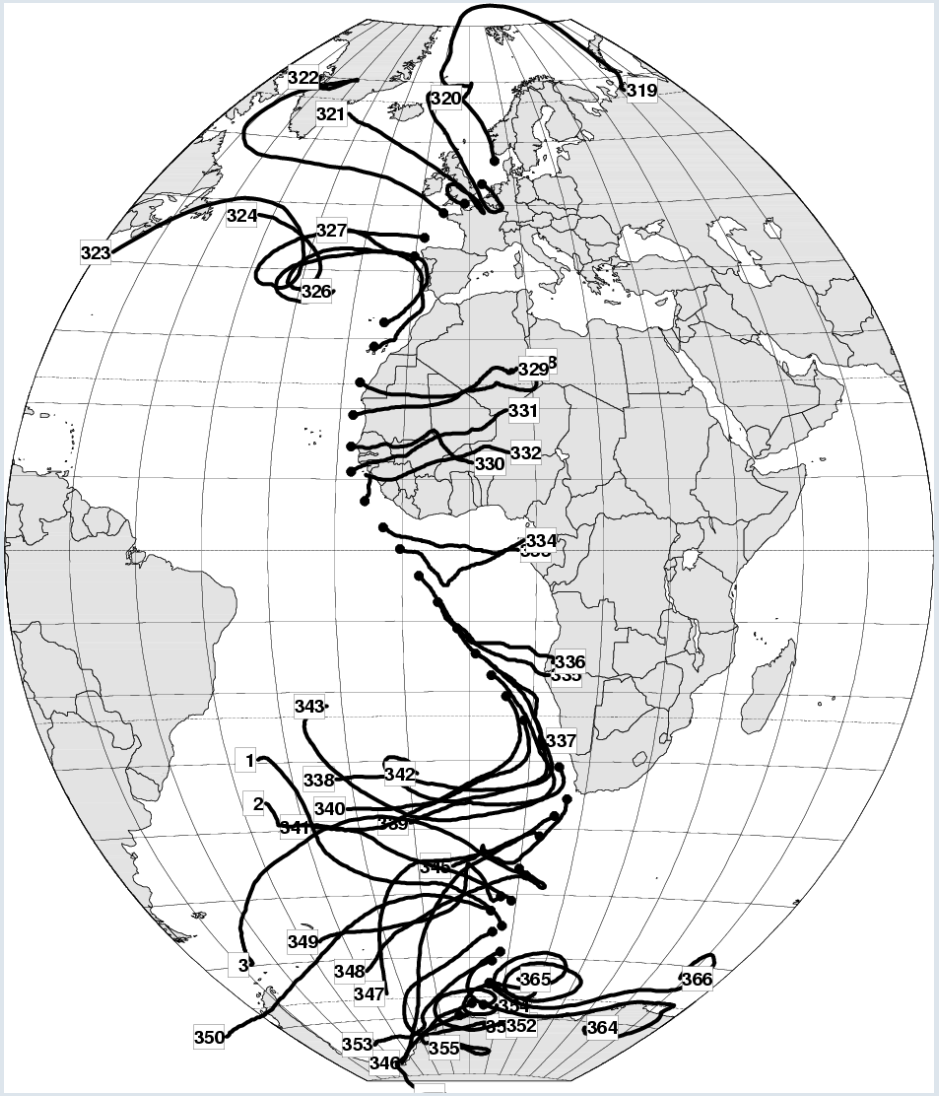
Remember, however, that air always has a history even before (and after) the calculated period

Some examples…

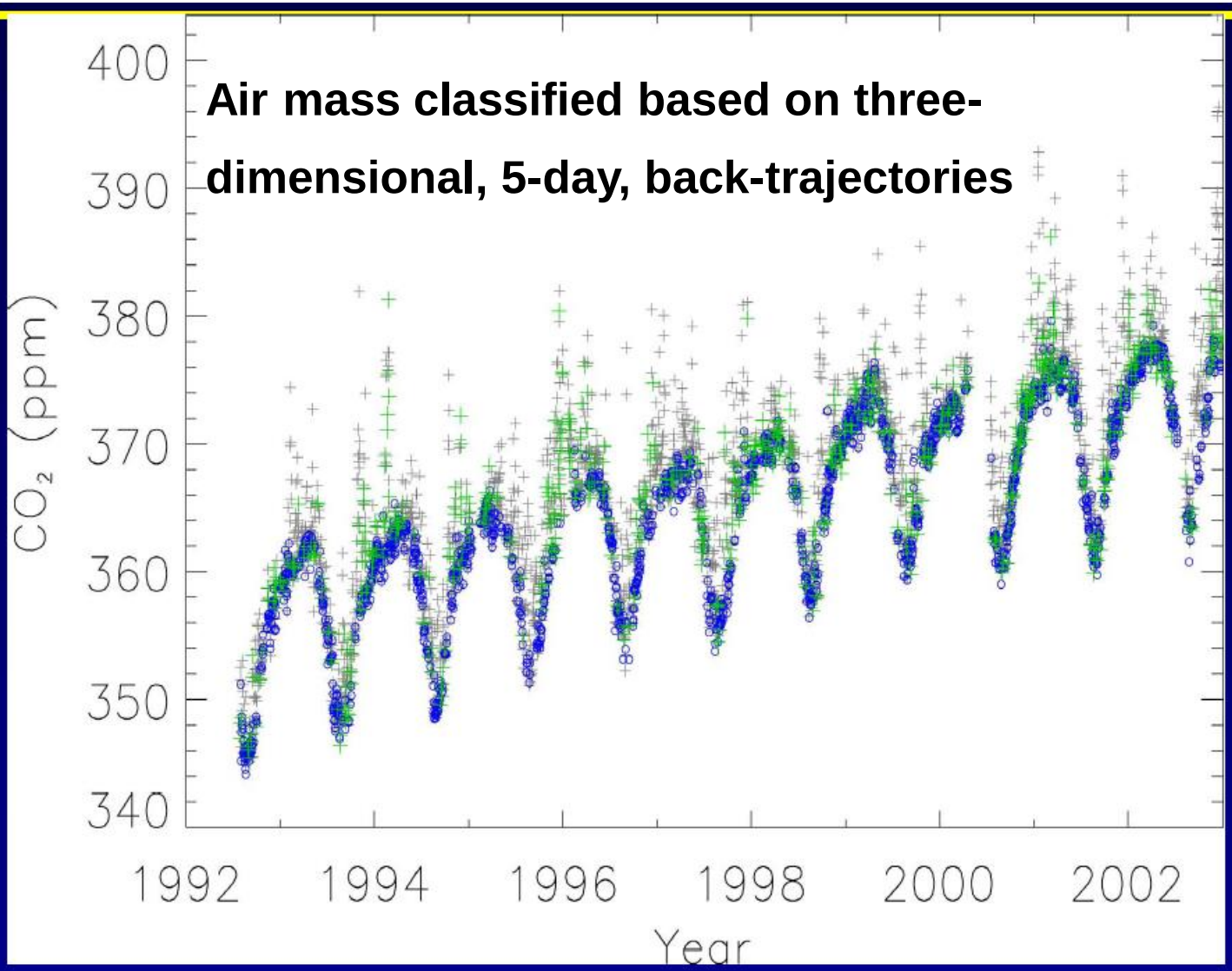
Arrival trajectories and nuclear power plants in Northern Europe, part of the emergency preparedness system in use at SMHI



Classification of air massed during a cruise in the eastern Atlantic.



Air mass classified based on three-dimensional, 5-day, back-trajectories

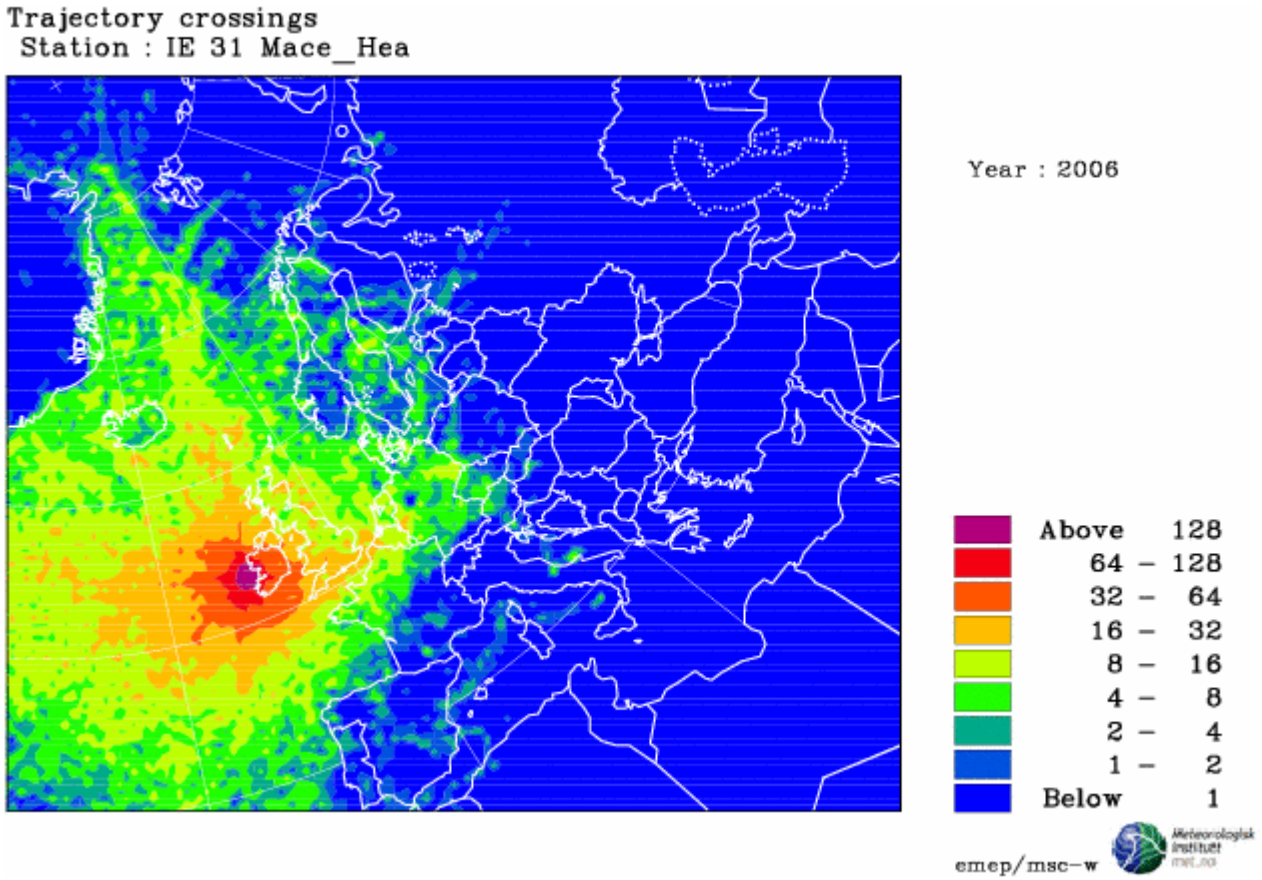


Daily means of atmospheric CO_2 from continuous measurements at Mace Head for the period from July 1992 through December 2002. Blue circles correspond to daily means calculated from marine air masses, green crosses to European air masses, and gray crosses to non-background data. [CNRS – CEA, Univ. of Bristol]

Statistics of type of air at a monitoring station (Mace Head) during one year

Based on four-day back-trajectories

The **units** are no. of times the trajectory has crossed the area (gridcell) 4 times per day in one month or one year.



Classification of from what direction air is arriving at a station (Aspvreten, Sweden) during different years

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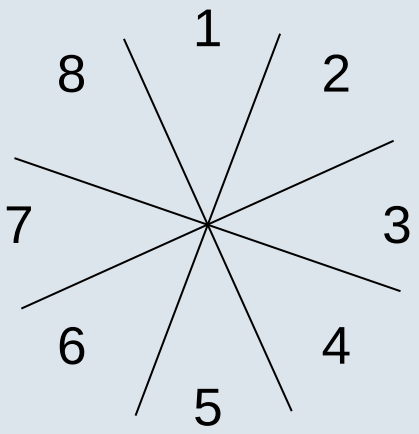
Daily sector values for SE12
Period: 1997-2006
emep/msc-w, 16/4-2007
Contact person: Anna Benedictow, anna.benedictow@met.no

#jday	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	8	7	5	9	9	1	9	1	7	5
2	1	9	5	7	9	2	1	2	9	9
3	8	6	6	8	6	9	2	2	8	9
4	8	9	6	7	7	9	2	9	8	9
5	1	7	7	7	5	9	2	9	7	4
6	1	9	7	6	5	9	2	9	7	3
7	8	9	9	7	7	8	1	9	7	3
8	8	9	1	9	6	7	8	9	7	3
9	9	9	1	7	9	8	9	9	7	9
10	9	9	1	7	1	7	2	3	7	9
11	1	7	1	7	8	7	9	9	7	6
12	9	7	9	7	1	7	9	6	6	7
13	7	7	3	6	8	7	1	6	8	6
14	7	6	3	9	7	6	9	9	1	6
15	7	9	9	9	9	6	7	9	9	6
16	8	6	6	8	9	6	1	9	6	5
17	6	9	6	8	9	7	9	9	6	5
18	6	9	6	9	5	6	6	8	6	9
19	7	9	6	1	5	7	7	9	7	3

Based on four-day back-trajectories

When at least 50% of the previous 96 hours are spent in one of sectors 1-8, the day can be classified to that sector.

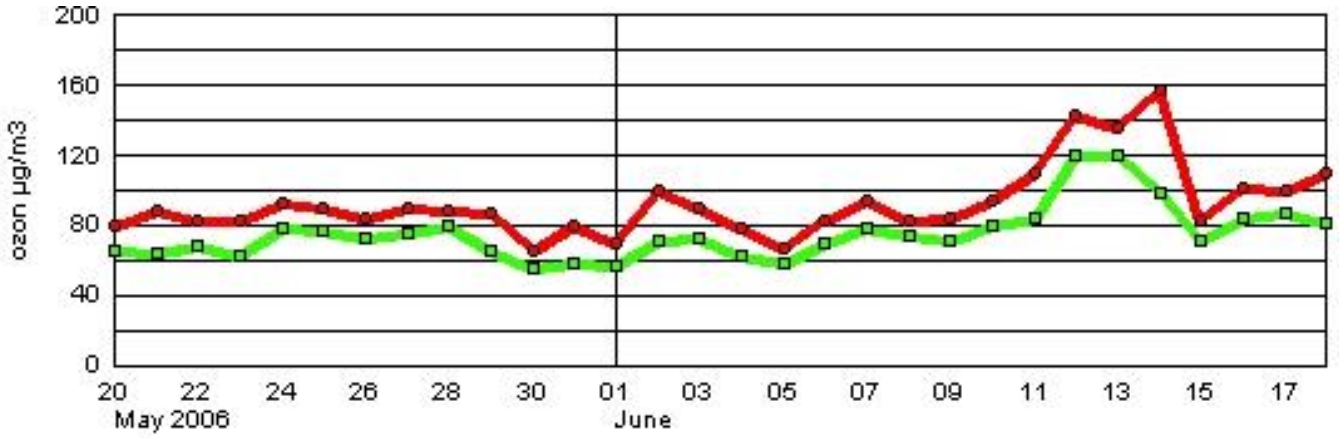


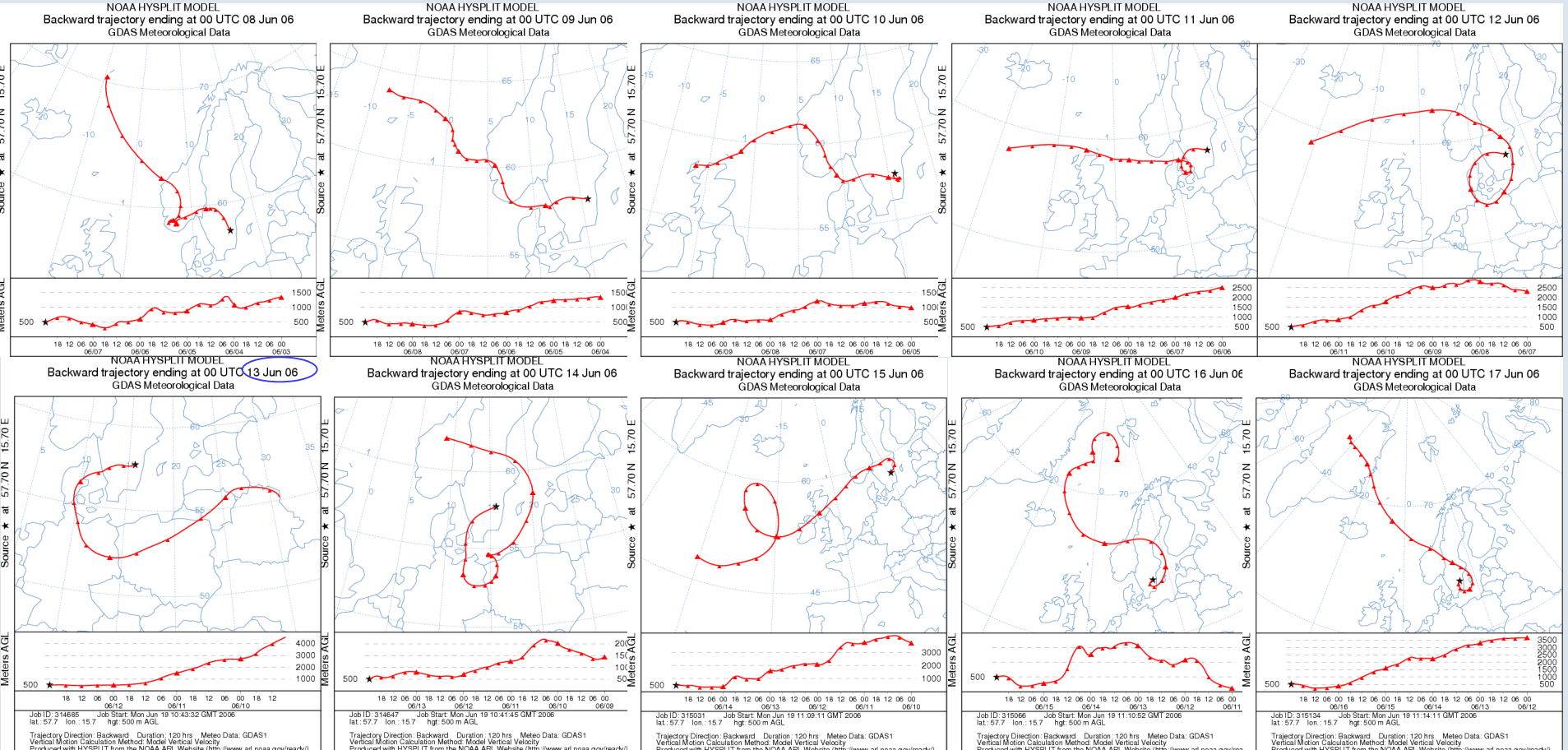
9 **-not determined**

Swedish ozone monitoring stations

Norra Kvill

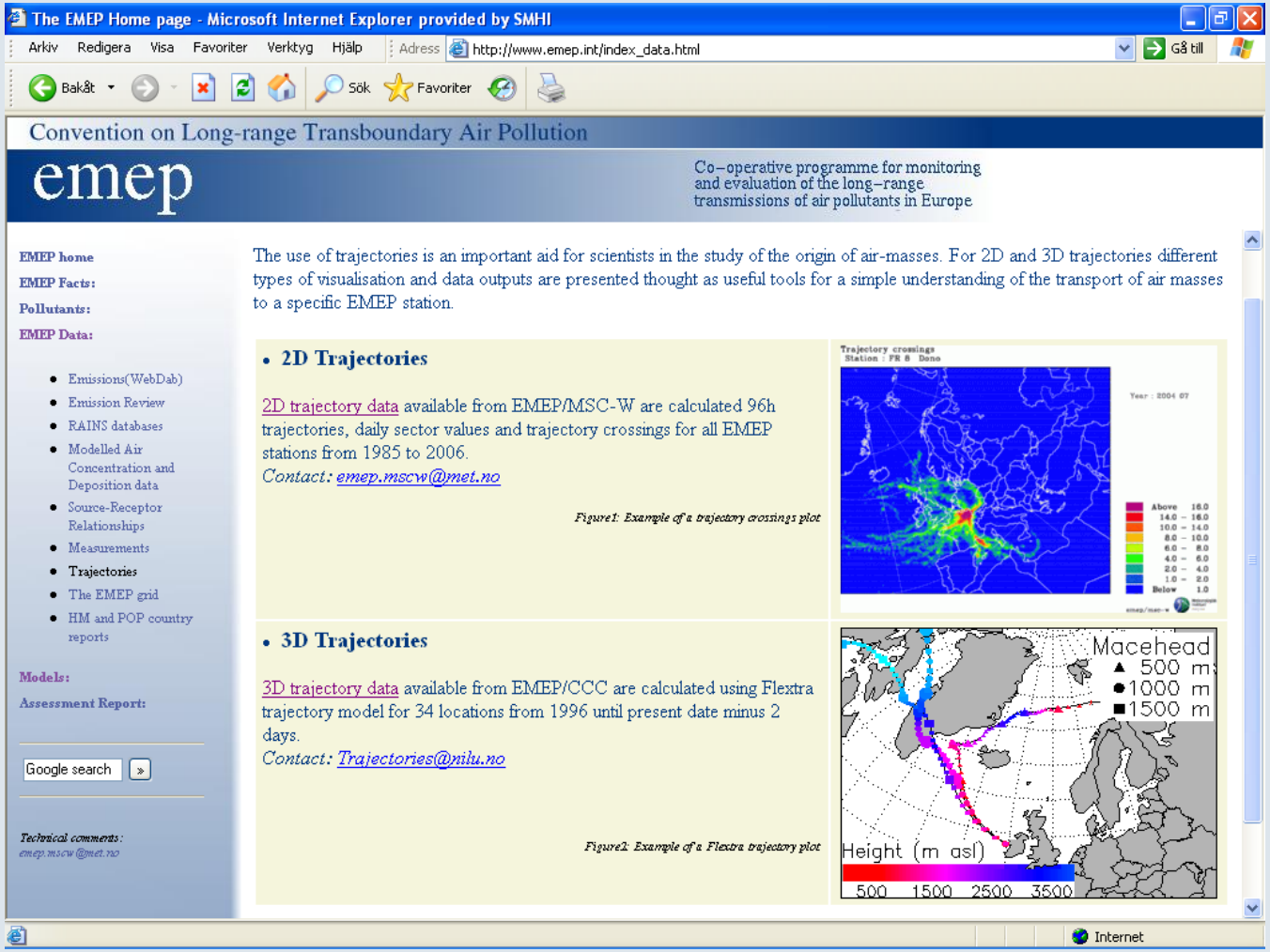
Ozone concentration and arrival trajectories





FLEXPART trajectories

http://www.emep.int -- EMEP Data: -- Trajectories



NOAA web-site:

SMHI

NOAA ARL Real-time Environmental Applications and Display sYstem (READY) Information - Microsoft Internet Explorer provided by

Arkiv Redigera Visa Favoriter Verktyg Hjälp

Bakåt Sök Favoriter

Adress http://www.arl.noaa.gov/ss/transport/readyinfo.html Gå till Länkar

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READY

The Real-time Environmental Applications and Display sYstem

ABSTRACT. A world wide web based system called the Real-time Environmental Applications and Display sYstem (READY) has been developed for accessing and displaying meteorological data and running trajectory and dispersion model products on the National Oceanic and Atmospheric Administration's (NOAA) Air Resources Laboratory (ARL) web server. This system brings together dispersion models, graphical display programs and textual forecast programs generated over many years at ARL into a form that is easy to use by anyone, but its primary focus is for atmospheric scientists.

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To go directly to READY, click HERE

One of the many functions of ARL is to provide meteorological services and related research to NOAA and to other Federal agencies, in order to predict the consequences of atmospheric releases of radioactivity and other potentially harmful materials. For example, ARL personnel involved with the Department of Energy's (DOE) Atmospheric Studies in Complex Terrain (ASCOT) program provide guidance for evaluation of terrain effects on dispersion; DOE's Hazardous Materials Release Facility, which is coupled with ARL's UF6 modeling program, provides dense gas dispersion data; ARL's volcanic ash program provides critical information on plume transport and dispersion to the aviation industry; ARL's involvement in the Kuwait oil fires provided real- time application of ARL's emergency response capabilities; and ARL Headquarters provides on-site support to the Operations Center of the Nuclear Regulatory Commission (NRC) during emergency exercises and events occurring at its regulated facilities. In addition, ARL is a Regional Specialized Meteorological Center (RSMC) for transport and dispersion products through the World Meteorological Organization (WMO). ARL, along with the Canadian Meteorological Centre (CMC), the other RSMC for this region, will provide meteorological guidance and dispersion predictions in the event of an atmospheric release of radioactive or hazardous materials crossing international boundaries in North and Central America.

ARL Headquarters in Silver Spring, MD, has a unique working arrangement with its partner organization, the National Centers for Environmental Prediction (NCEP) of the National Weather Service (NWS). This arrangement allows ARL to access meteorological observations and forecast model fields that have been specifically selected for use in atmospheric dispersion models, such as the HYSPLIT model. Close collaboration with NCEP has given ARL the ability to access gridded meteorological data as soon as the forecast model completes its execution at NCEP.

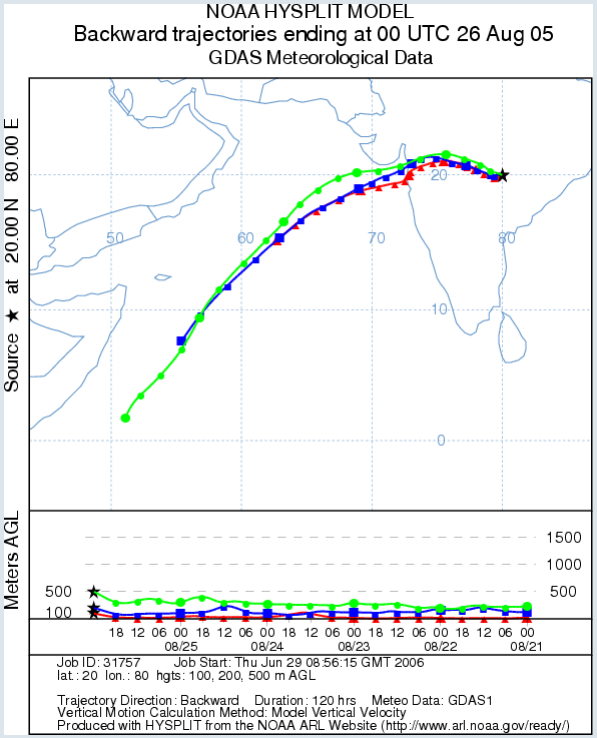
In addition, the Regional Atmospheric Modeling System (RAMS) mesoscale model is run operationally at ARL to produce a high- resolution meteorological dataset. This dataset is used as a tool for qualitative evaluation of more local meteorological conditions or as input into a more quantitative transport and dispersion model calculation.

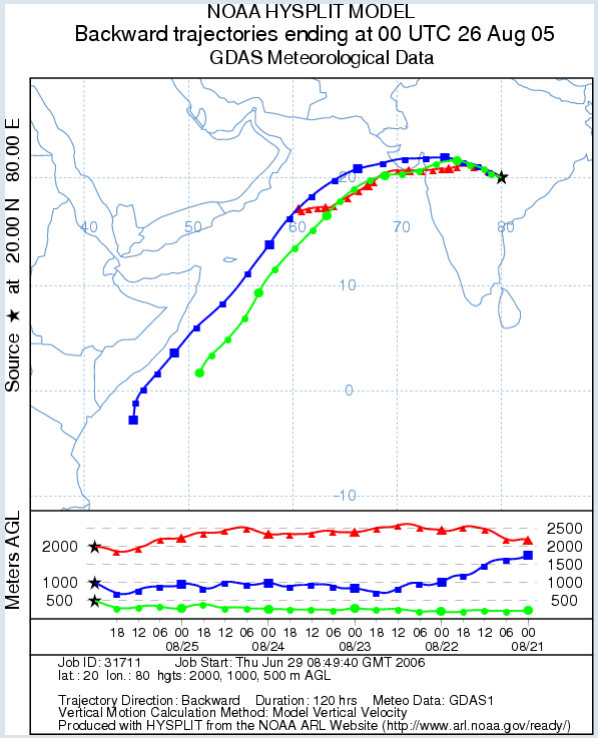
ARL also has established a direct communications line between it's own computers and the NWS Telecommunications Gateway (NWSTG) computers. This connection provides ARL with all regularly transmitted text and gridded data from the Family of Services (FOS) offered by NWS. These data include observations

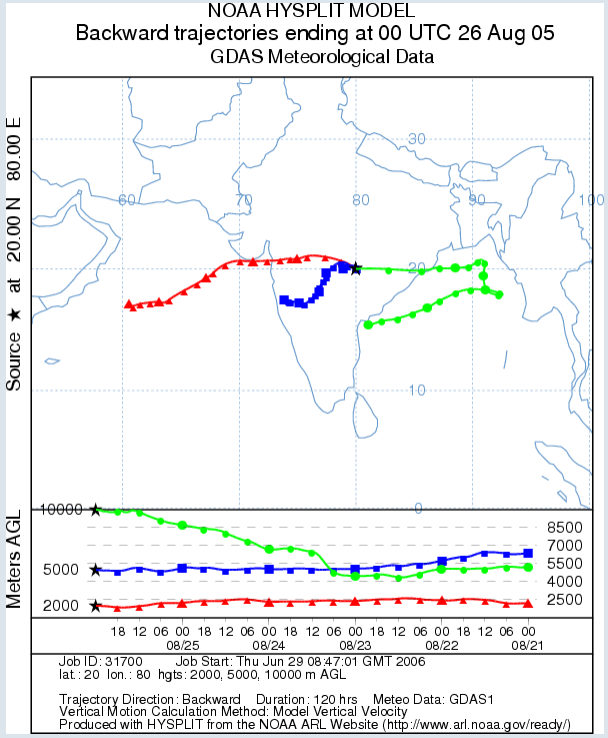
Internet

Start NOAA ARL R... SMHI Intran... pclx051.smh... pclx051.smh... Microsoft Po... 10:09

Different arrival height







Different meteorological data