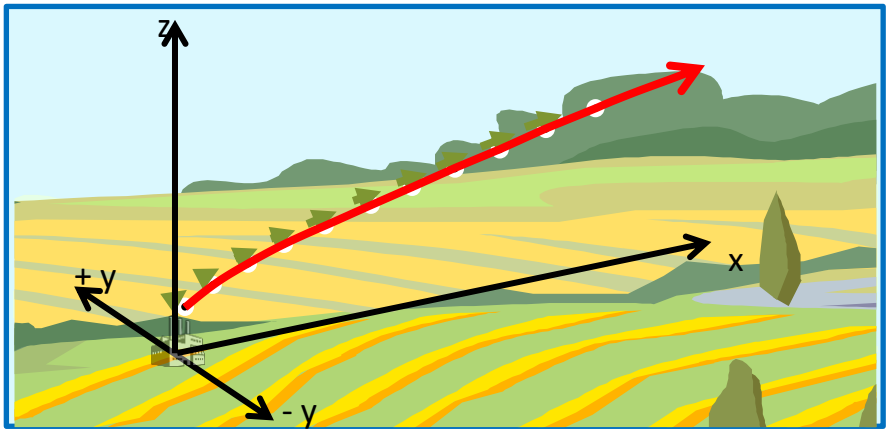
2022 Online HYSPLIT Workshop

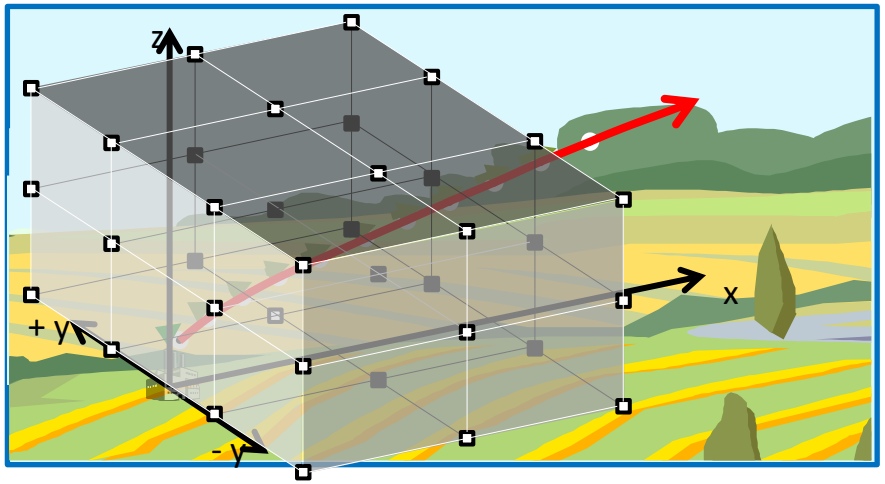
Wrap-Up Day 1

NOAA Air Resources Laboratory
June 14-17, 2022

Met Data for HYSPLIT

- HYSPLIT is driven by gridded meteorological data, required as an “input”
  - Data must be supplied in ARL Packed Format
  - Conversion programs exist to convert most met model output data to ARL Packed Format
  - There is also an inline version of HYSPLIT embedded within the WRF meteorological model
- NOAA has several forecast and reanalysis datasets in HYSPLIT format
  - CONUS+ grids (e.g., 3 km HRRR; 12 km NAM)
  - CONUS+ 27km WRF reanalysis
  - Global grids (e.g., 0.25 deg GFS)
- HYSPLIT interpolates spatially and temporally to estimate meteorological variables at any given point in the simulation domain
- Can have multiple meteorological grids during the same simulation (e.g., local, regional and global), and HYSPLIT will use the finest grid at any location
- Ability to treat complex terrain? Largely depends on resolution / capability of meteorological model output used to drive HYSPLIT





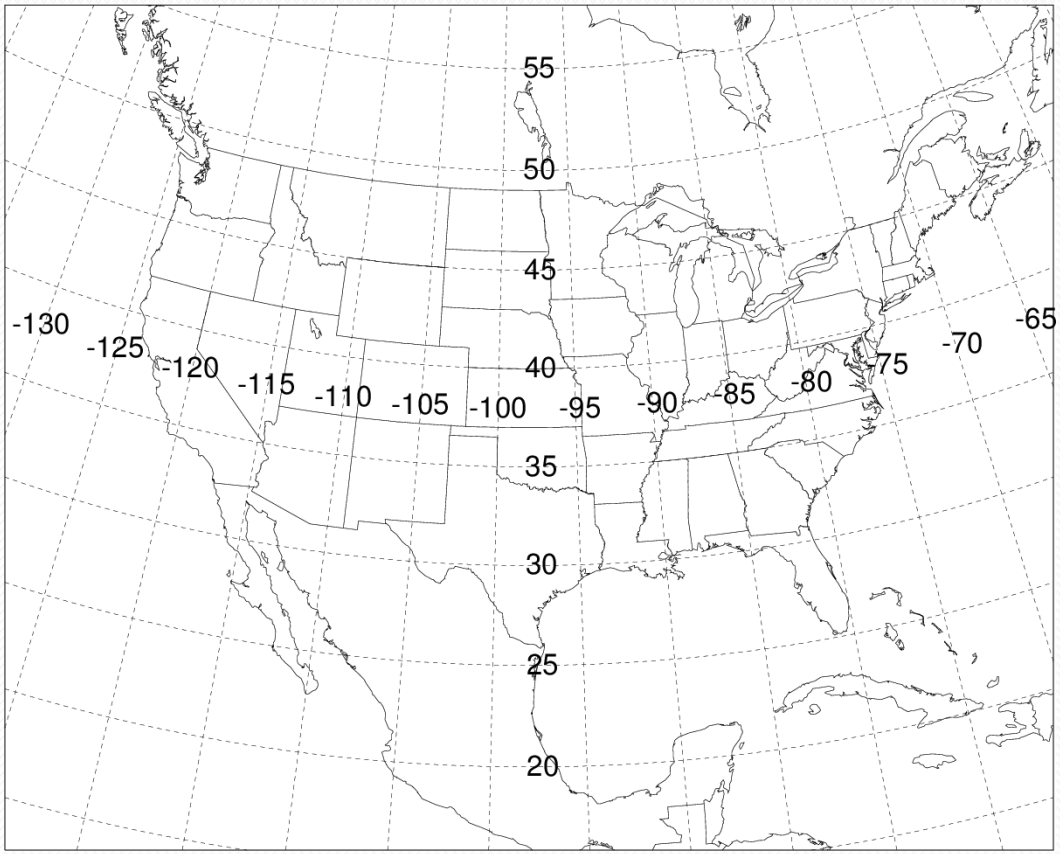
Which Met Data Set Should You Use?

Selected Meteorological Datasets Available from NOAA ARL Archives* (~100 TB)

(https://ready.arl.noaa.gov/archives.php)

	Dataset	Horizontal Resolution (km- approx.)	Full-grid dimensions	Temporal resolution (hrs)	Vertical Levels	Period of each file	Size of each file (GB)	Total size for one month of data (GB)	Availability
Continental U.S. and surrounding regions	HRRR-3km	3	1799 x 1059	1	37	¼ day	3.2	390	Jun 2015 -> present
	NAMS-12km Hybrid	CONUS - 12 Alaska - 12 Hawaii – 2		1	40	1 day	1.0 0.64 0.71	30 19 21	2010 -> present
	NAM-12km	12	614 x 428	3	27	1 day	0.395	12	May 2007 -> present
	WRF-ARW-27km	27	216 x 174	1	35	1 day	0.210	6.4	1980 -> present
	NARR-32km	32	309 x 237	3	24	1 month	2.8	2.8	1979 -> 2019
	EDAS-40km	40	185 x 129	3	27	½ month	0.6	1.2	2004 -> 2018
Global	GFS - 0.25°	27	1440 x 721	3	56	1 day	2.7	82	Jun 2019 -> present
	GDAS - 0.5°	55	720 x 361	3	56	1 day	0.468	14	Sep 2007 -> Jun 2019
	GDAS - 1°	111	360 x 181	3	24	1 week	0.571	2.5	Dec 2004 -> present
	Global Reanalysis - 2.5°	278	144 x 73	6	18	1 month	0.11	0.11	1948 -> present

Domain of WRF-ARW-27km met data set



Horizontal spacing ~27 km

35 vertical levels

Data every hour

Each file is for one day

(~210 MB per file)

What Meteorological Data Set should you use?

- There is not one right answer to this question, as it can depend on the region and the situation you are modeling.
- All things being equal, the WRF-27km dataset that we have may be the best, as it is a true "re-analysis" dataset.
- But, if you are in an area with complex terrain, and 27-km is too coarse to capture fine-scale meteorological phenomena, then you probably would want to use one of the finer-resolution datasets (e.g., HRRR-3km).
- One approach is to use different datasets and see what differences the answers result. If they are relatively different, you get an idea that there is a fair amount of uncertainty in the met data and the resulting HYSPLIT simulations. If they are similar, then chances are the results are more robust.
- Also, it can be very useful to compare the met data fields (wind direction, wind velocity, etc) with measurements in the area(s) you are interested in. To the extent that the met data matches the measurements, you can be more confident that the dataset you are using is a good one for your situation.

HYSPLIT
AIR RESOURCES LAB

What height should you start a back-trajectory from, if you are trying to see where air masses impacting a given measurement came from?

What height should you start a back-trajectory at?

CASE 1:

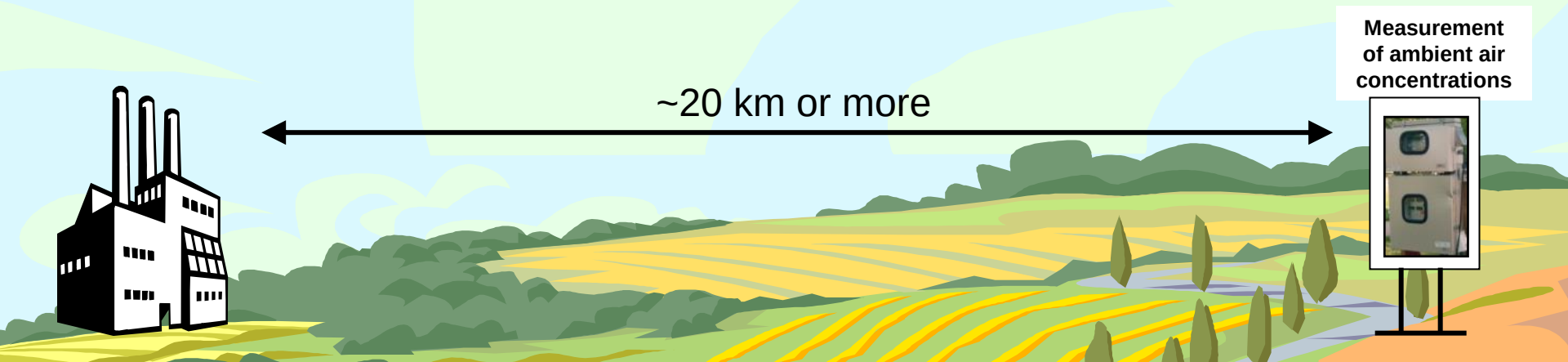
- **relatively simple terrain**
- **at least ~20 km or more away from any major sources**

CASE 2:

- **at the top of a relatively isolated mountain**

CASE 1:

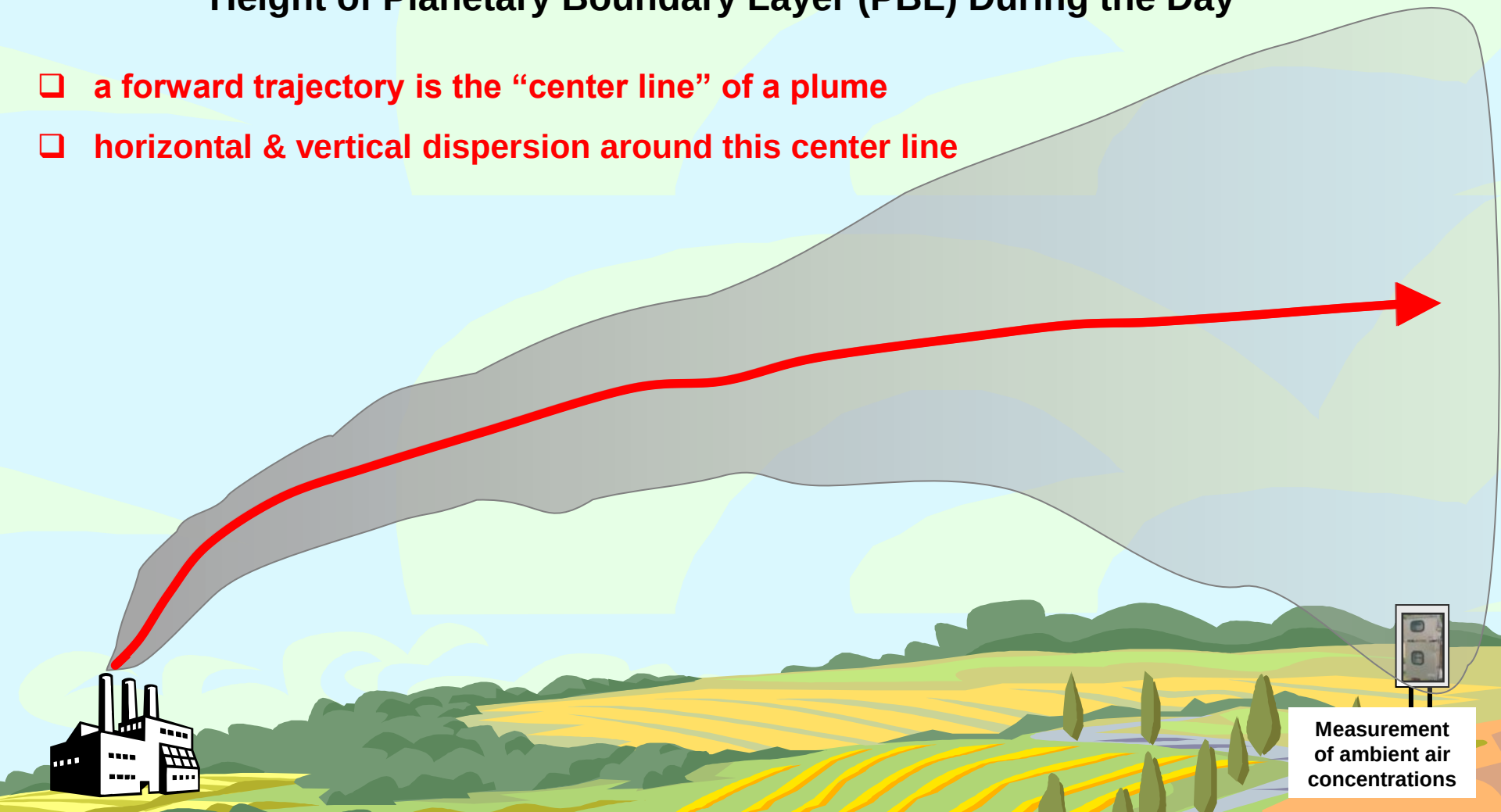
- **relatively simple terrain**
- **at least ~20 km or more away from any major sources**



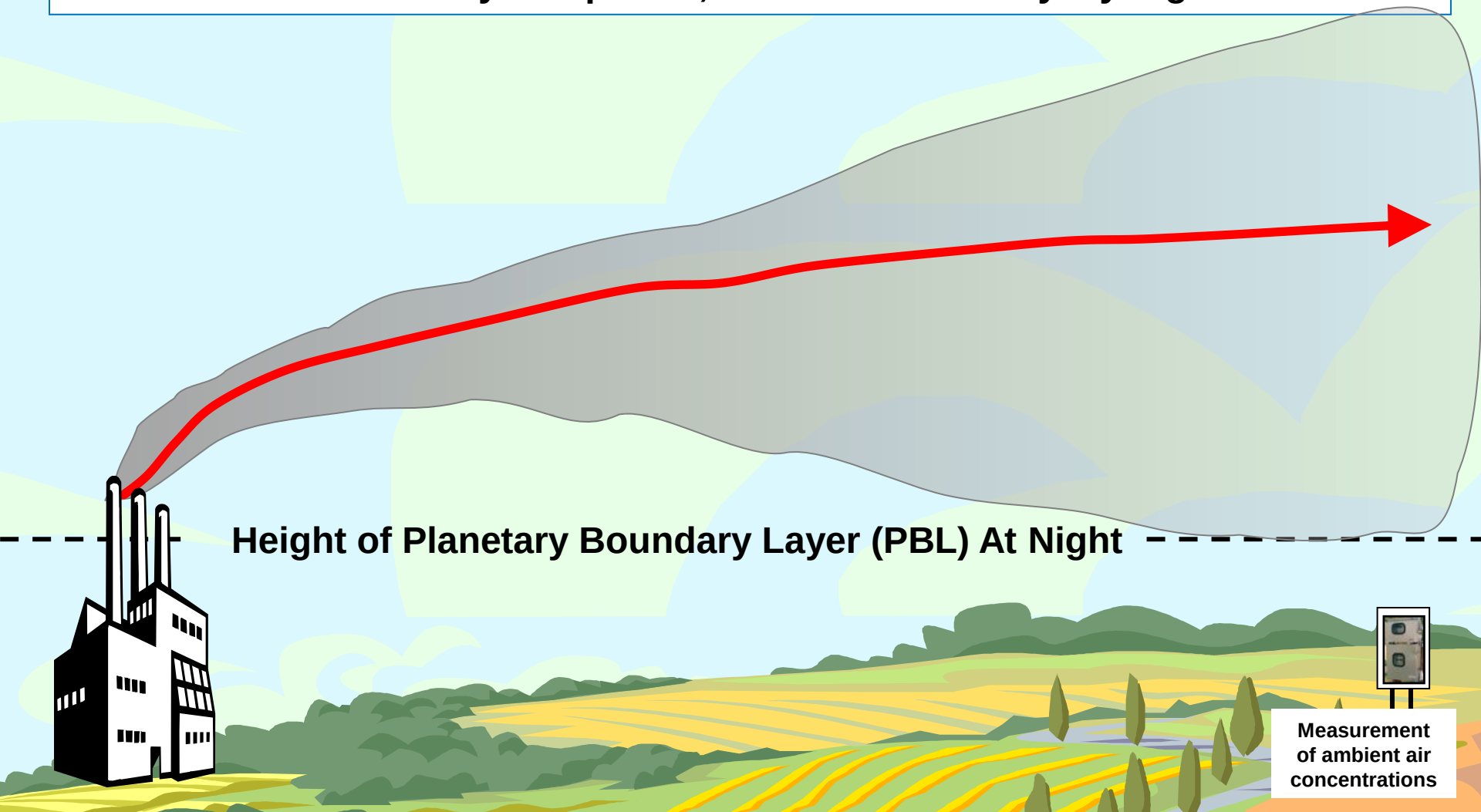
Greater than ~20km from the source,
if the forward trajectory from the source is within the PBL,
then the source can impact the measurement site,
even if the trajectory endpoint near the site is not at the height of the sampler…
This is because the PBL is relatively well-mixed during the day.

– – – – – – Height of Planetary Boundary Layer (PBL) During the Day – – – – – – –

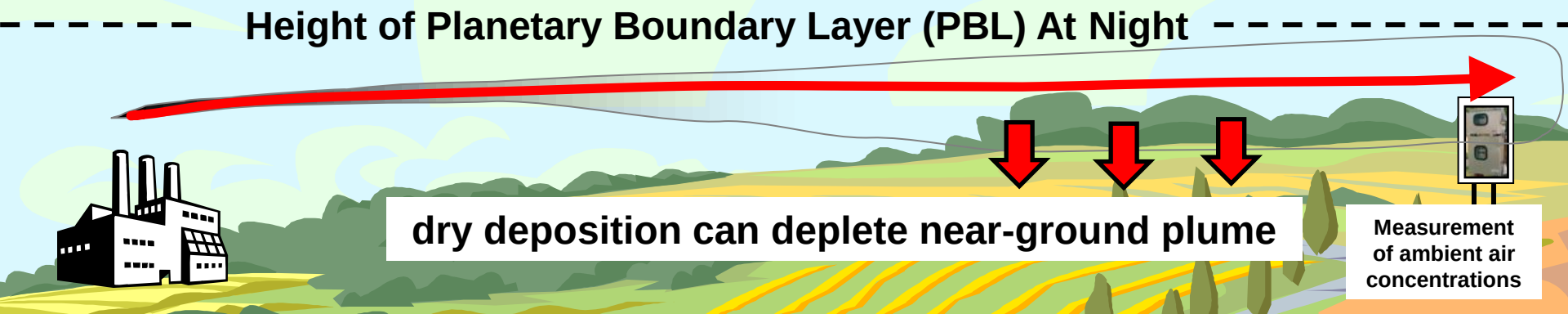
- **a forward trajectory is the "center line" of a plume**
- **horizontal & vertical dispersion around this center line**



- At night, the Planetary Boundary Layer (PBL) is generally much shallower
- Emissions from an elevated stack *may* be emitted above the PBL
- In this case, there *may* be little impact on a ground-based measurement site until the next daytime period, when the boundary layer grows.



- At night, the Planetary Boundary Layer (PBL) is generally much shallower
- Emissions from a relatively low stack may be emitted within the PBL
- Note, if the pollutant dry deposits relatively rapidly, by the time the plume reaches the receptor, there may be little pollutant left… **Back-trajectories do not include deposition!**

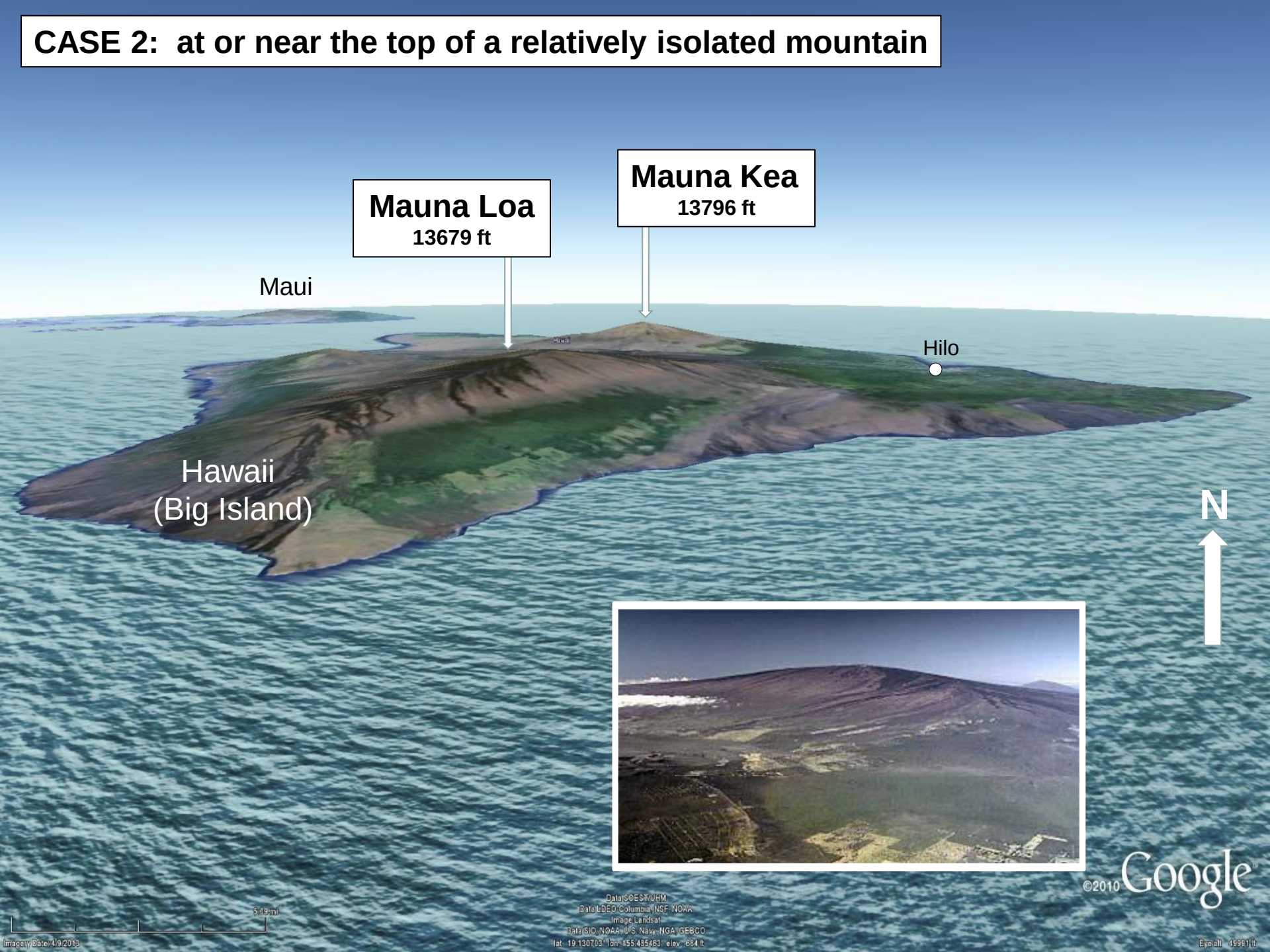


- What are the implications of these ideas for back-trajectories?
- What HEIGHT should one start a back-trajectory?
- If you start very low to the ground, e.g., at the sampler height, the trajectories often hit the ground… This may not give a representative back-trajectory
- "best" starting height for back-trajectories may be from the middle of the Planetary Boundary Layer
- It can be useful to start trajectories at different heights to see what influence the starting height has on the results

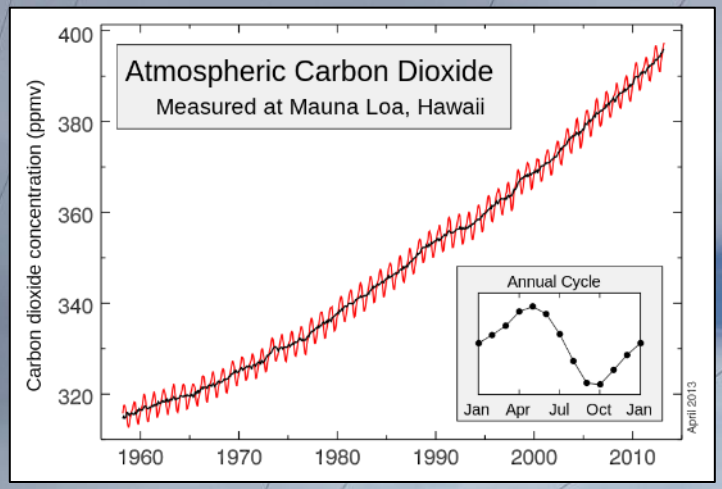
PBL Height

H = 0.5 * PBL

CASE 2: at or near the top of a relatively isolated mountain



Mercury measurement instruments on roof and inside historic Keeling Building, near the summit of Mauna Loa

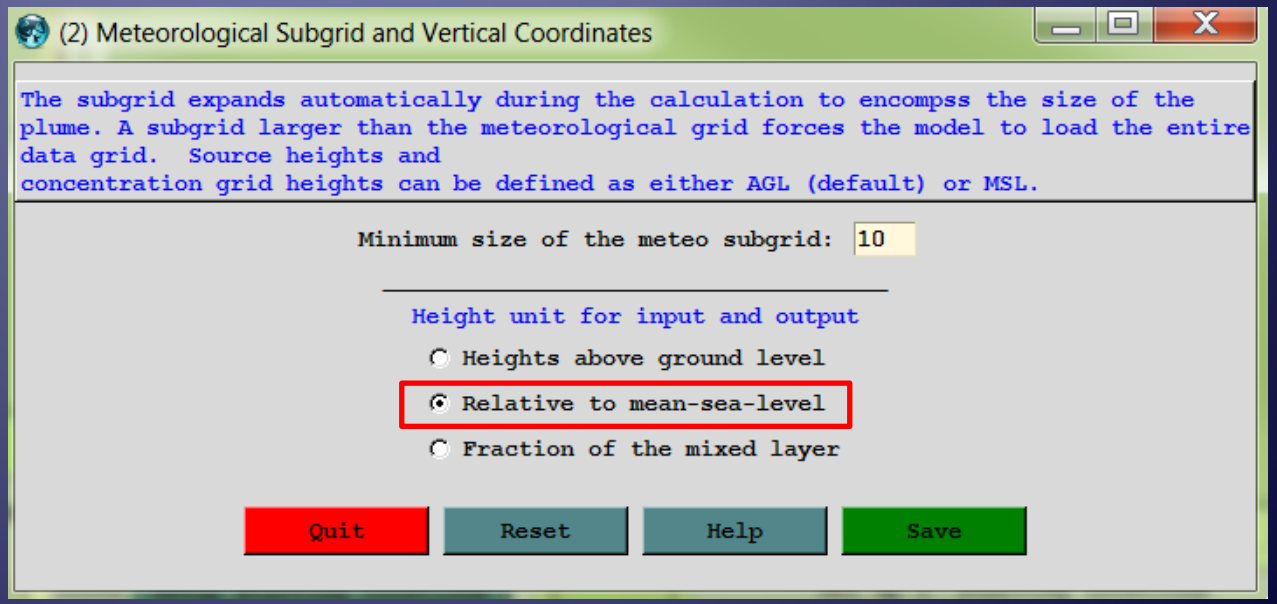



Mercury measurement instruments on roof and inside historic Keeling Building, near the summit of Mauna Loa

In this case, especially if sampling free-tropospheric air masses, would likely want to start the back-trajectory simply at the height of the summit above mean sea level.

(1) Exact terrain height may not be that accurately characterized in the met data, so selecting a height Above Ground Level can be problematical

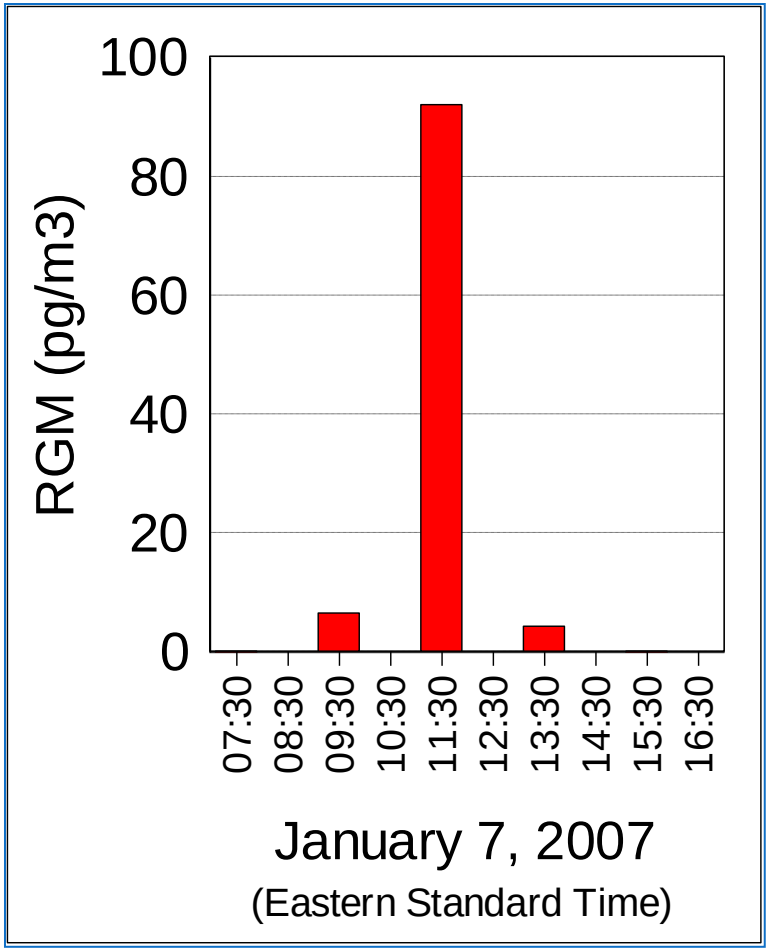
(2) Use Advanced Menu to select “Relative to mean-sea-level”, and could then simply use the height of the summit



Some examples of simple, qualitative approaches to source-attribution using back-trajectories

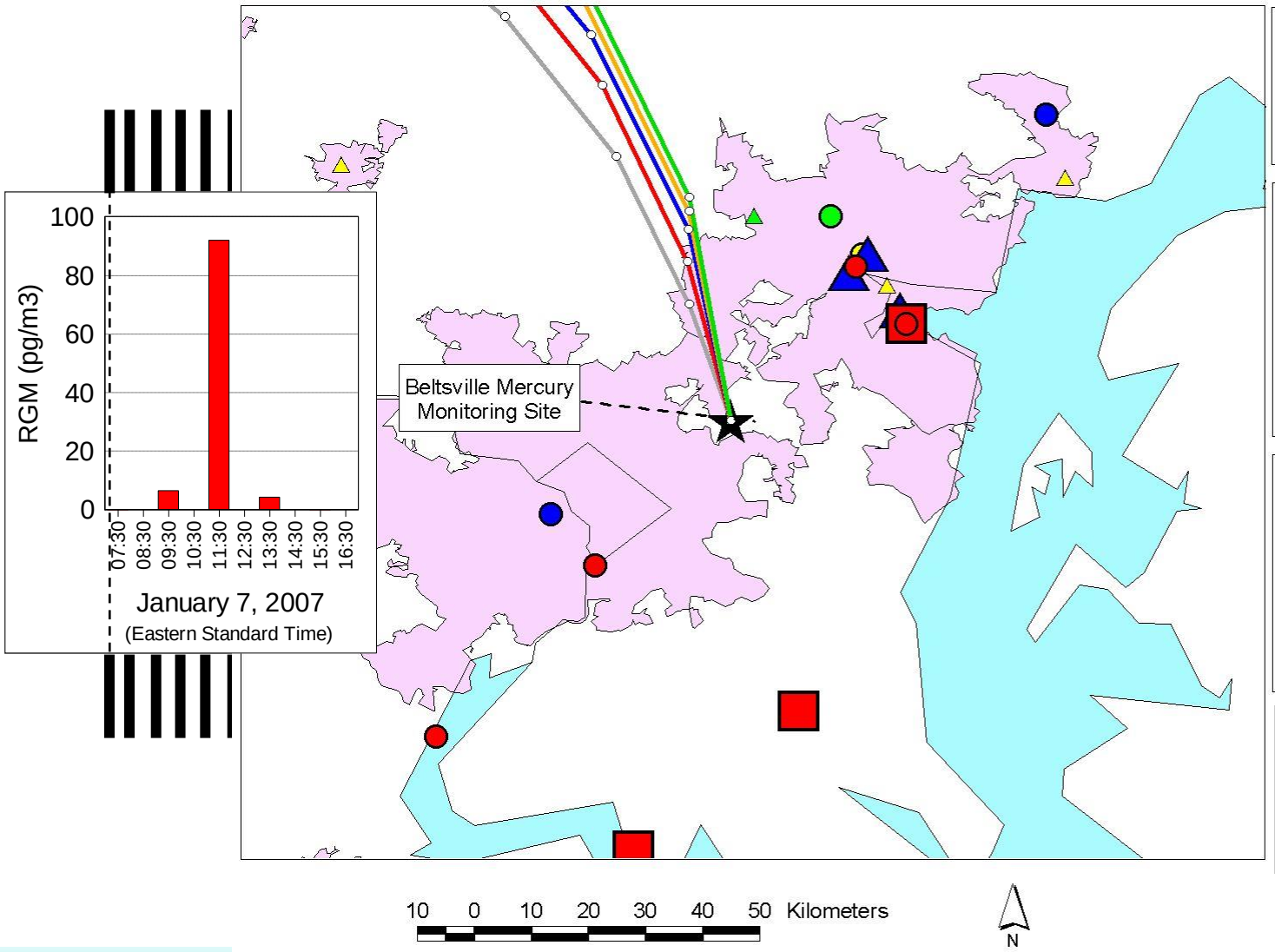
Back Trajectory Analysis – Episodes

Beltsville, Maryland
mercury site



Reactive Gaseous Mercury episode

Back Trajectories Arriving at 1/07/2007 07:00 EST



Large sources of 1999 RGM (Reactive Gaseous Mercury) emissions (kg/yr) based on USEPA data from 1999 Nat'l Emissions Inventory

Size and shape of symbol denotes amount of RGM emitted (kg/yr)

- 5 - 10
- 10 - 50
- 50 - 100
- 100 - 300

Color of symbol denotes type of mercury source

- coal-fired electricity generation
- other fuel combustion
- waste incineration
- metallurgical processes
- manufacturing/other

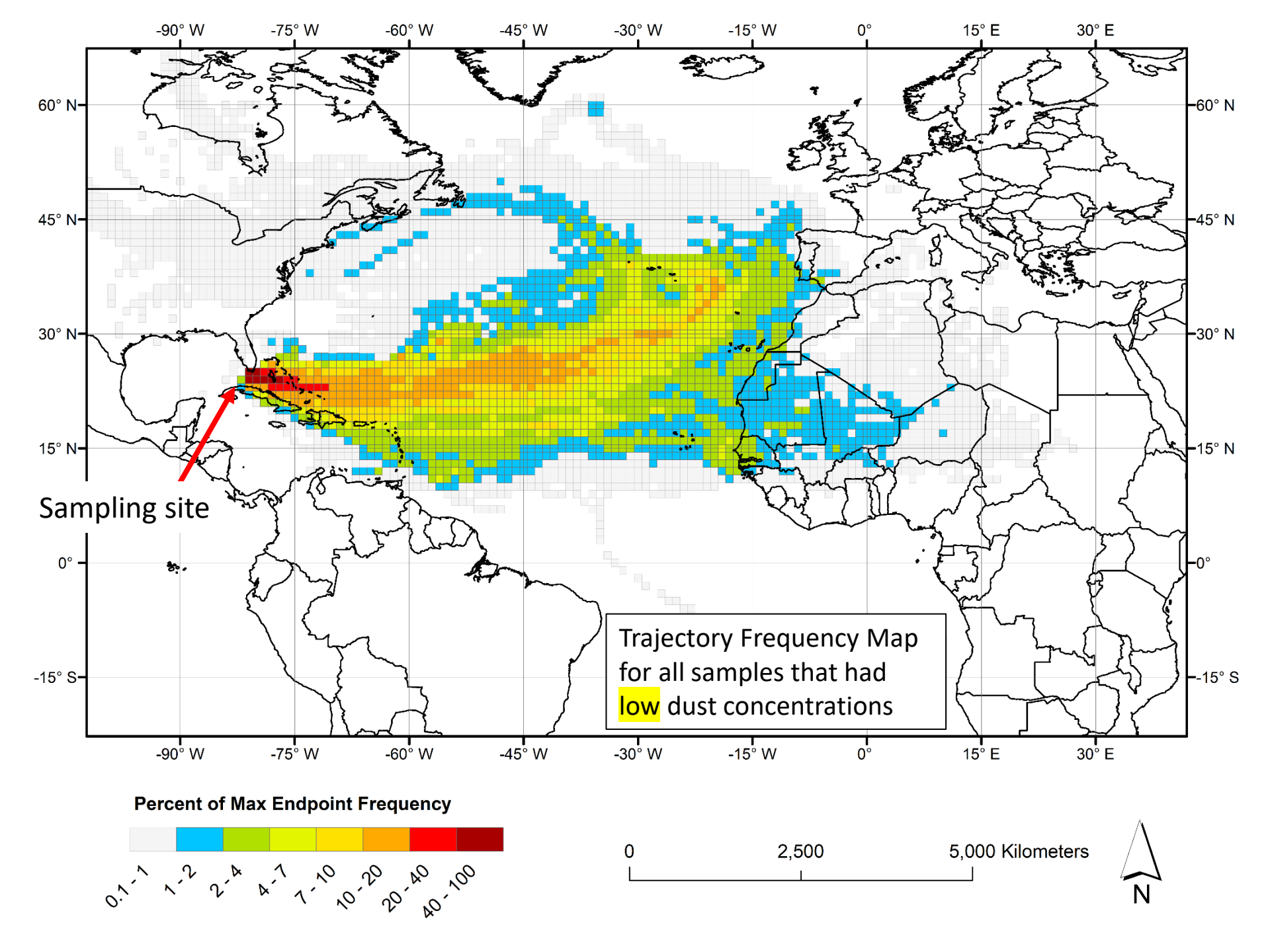
Back-trajectories starting at the indicated fraction of the mixed layer. height. Circles on the trajectories mark the hourly position of the trajectory.

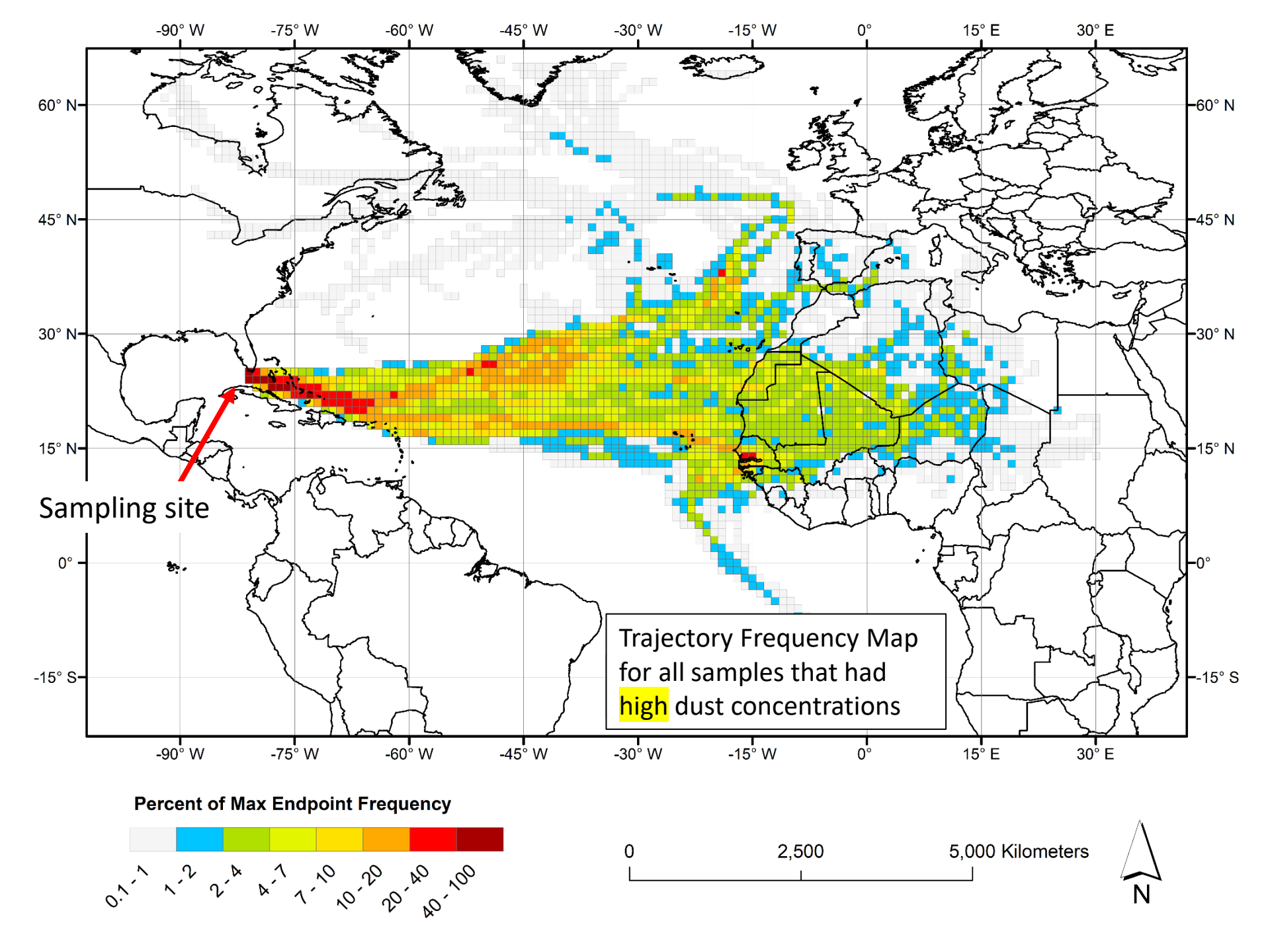
- 0.1
- 0.3
- 0.5
- 0.7
- 0.9

urbanized areas

A qualitative way to examine source attribution

- Approaches range from relatively qualitative to relatively quantitative
- Suppose you have a series of measurements at a given monitoring site.
- And you run a back trajectory from the site for each measurement. You can do this from the GUI, but you might want to try a script to do this.
  - You can take all of the trajectories associated with high measured values and create a frequency plot (section 6.1 of Tutorial) (you will have to edit the INFILE to make sure it has the correct trajectory endpoint files)
  - You can take all of the trajectories associated with low measured values and create a frequency plot (section 6.1 of Tutorial) (again, editing the INFILE…)
- The difference in geographical patterns between the two maps can tell you something about source attribution
- Note that these were generated by outputting text-file data and inporting into ArcGIS (…you can create your own graphics…)


-90° W
-75° W
-60° W
-45° W
-30° W
-15° W
0°
15° E
30° E
60° N
45° N
30° N
15° N
0°
-15° S
Sampling site
Trajectory Frequency Map for all samples that had low dust concentrations
Percent of Max Endpoint Frequency
0.1 - 1
1 - 2
2 - 4
4 - 7
7 - 10
10 - 20
20 - 40
40 - 100
0
2,500
5,000 Kilometers
N


-90° W
-75° W
-60° W
-45° W
-30° W
-15° W
0°
15° E
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45° N
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0°
-15° S
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5,000 Kilometers
N

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Workshop guidance

and resources posted at

Workshop Web Page

https://www.ready.noaa.gov/register/HYSPLIT_hyagenda.php

We will update this page each day to include any new materials or links that are relevant to the Workshop

2022 HYSPLIT Workshop Schedule

Subject to change, depending on the progression of the course and at the discretion of the instructors

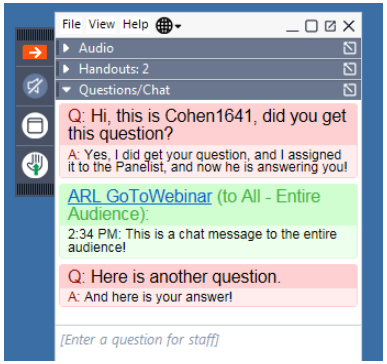
UTC	Eastern Daylight Time	Monday June 13, 2022	Tuesday June 14, 2022	Wednesday June 15, 2022	Thursday June 16, 2021	Friday June 17, 2021
13:00 - 14:00	9:00 - 10:00	*OPTIONAL** 1a. Installing HYSPLIT on Windows PC	Introduction	Introduction	Introduction	Introduction
		Break	3. Gridded Meteorological Data Files	7. Air Concentration calculations	11. Pollutant transformations and deposition (continued)	15. Radioactive pollutants and dose
14:00 - 15:00	10:00 - 11:00	*OPTIONAL** 1b. Installing HYSPLIT on MAC	Break		Break	
		Break	4. Trajectory Calculations	Break	12. Air Concentration Uncertainty	Break
15:00 - 16:00	11:00 - 12:00	*One-on-one virtual installation sessions, by appointment*		8. Configuring the CAPTEX simulation		16. Volcanic eruptions with gravitational settling
16:00 - 17:00	12:00 - 13:00	*One-on-one virtual installation sessions, by appointment*	Break	Break	Break	Break
17:00 - 18:00	13:00 - 14:00	*One-on-one virtual installation sessions, by appointment*	5. Trajectory Options	9. Air concentration parameter sensitivity	13. Source Attribution Methods	17. Custom Simulations
18:00 - 19:00	14:00 - 15:00	*One-on-one virtual installation sessions, by appointment*	Break		Break	Break
19:00 - 20:00	15:00 - 16:00	*One-on-one virtual installation sessions, by appointment*	6. Trajectory Statistics	Break	14a. Wildfire Smoke	Final Questions and Course Wrap-Up
				10. Alternate display options		
			Day 1 Wrap-Up		14b. Dust Storms	
20:00 - 21:00	**16:00 - 17:00**	*One-on-one virtual installation sessions, by appointment*		**11. Pollutant transformations and deposition**	Day 3 Wrap Up	
				Day 2 Wrap Up		

Agenda – Day 1

UTC	EDT	Agenda Item
13:00 – 13:30	09:00 – 09:30	Welcome, Introduction and Logistics
13:30 – 14:45	9:30 – 10:15	3. Gridded meteorological data sets
14:45 – 14:30	10:15 – 10:30	Break
14:30 – 16:00	10:30 – 12:00	4. Trajectory calculations
16:00 – 17:15	12:00 – 13:00	Break
17:15 – 18:30	13:00 – 14:15	5. Trajectory options
18:30 – 18:45	14:15 – 14:30	Break
18:45 – 19:45	14:30 – 15:45	6. Trajectory statistics
19:45 – 20:00	15:45 – 16:00	Day 1 Wrap-up

Note: all times are approximate

Asking Questions

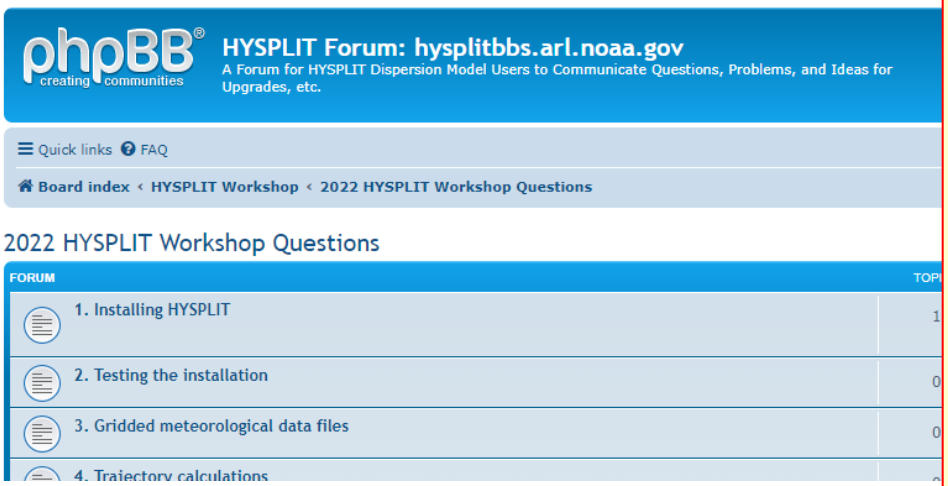


- Ask general or logistical questions about the Webinar or Go-to-Webinar in the Control Panel that was just discussed

...if viewing a recording, can ask general questions by emailing **arl.webmaster@noaa.gov**

- Ask questions about HYSPLIT and the Tutorial in the HYSPLIT Forum

https://hysplitbbs.arl.noaa.gov/viewforum.php?f=76



- You can ask more detailed questions, e.g., can attach screen shots
- We can provide more detailed answers
- There can be an exchange back and forth, if needed
- Can see other questions – in case you have a similar question
- We can give you a link to the answer to a similar question
- Accessible to people just viewing the recordings

Recordings

Access recordings from the Workshop Web Page:
https://www.ready.noaa.gov/register/HYSPLIT_hyagenda.php

- Recordings of each day's on-line sessions are being created, *but processing takes significant time* (~4 to 8+ hours *after* a day's session ends)
- Workshop Web Page – once the video is posted on our site, the corresponding item in the list below will turn into a link you can click to view

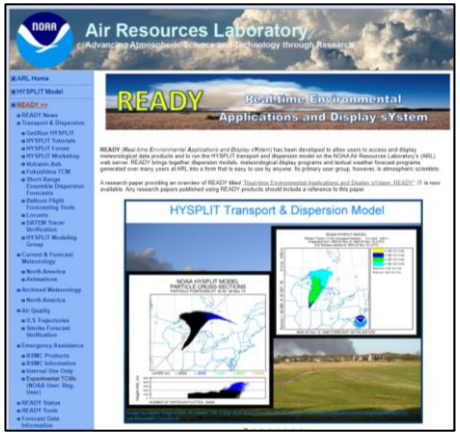
Workshop Logistics

Handouts, Notes, and Recordings. Videos of each day's on-line sessions are being created for review by participants, e.g., for those in time zones that would make online participation difficult. Processing of the videos to make them viewable takes significant time. When the video is posted, the corresponding entry below will become a link. When you click on one of these links, you should be able to view the video directly. To download a video recording, start playing it. Then place your mouse anywhere in the video area and right click the mouse. Choose the "Save As" menu.

•**Installation Day (Mon, June 13)**

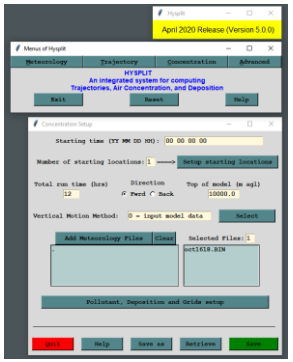
- Installation day introduction
- Workshop video recording installation day and unfinished transcript. The transcript is machine-generated and it may contain inaccurate captions. See the above paragraph on how to download the video file.

Different Ways to Use HYSPLIT

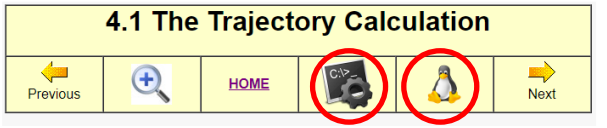


1. **Online - READY Website:** https://www.ready.noaa.gov/index.php
   - Specialized applications (e.g., Volcanoes, Fires, Locusts, ...)
   - Researcher access; public access
   - Can use met data directly on our servers, without downloading it

2. **Download model (free) and run on your local computer using the Graphical User Interface (GUI)**
   - This Workshop deals almost exclusively with the GUI
   - Menu driven, context sensitive help, integrated applications
   - Can generally do more with the GUI than you can online, as we have imposed some limitations due to computational resource constraints
   - Download (free) forecast and archive met data to run HYSPLIT



3. **Use the same model you downloaded to run on your local computer using the Command Line (terminal) and scripts**
   - At a basic level, a script is just a series of command line entries
   - More features available from command line / scripts than in GUI
   - Re-do runs by re-running a script; easy to change parameters
   - And you have a record of exactly what you did.
   - *But the GUI is a great way to learn how to use HYSPLIT.* Most experienced users will use the GUI when trying something new, and only try a script once they understand what is happening in the GUI.




```
echo "$syr $smo $sda $shr     " >CONTROL
echo "1                       ">>CONTROL
echo "$olat $olon $olvl       ">>CONTROL
echo "$run                    ">>CONTROL
echo "0                       ">>CONTROL
echo "$ztop                   ">>CONTROL
echo "1                       ">>CONTROL
echo "$MET/                   ">>CONTROL
echo "$data                   ">>CONTROL
echo "$OUT/                   ">>CONTROL
echo "tdump                   ">>CONTROL
```

Quick Recap of Logistics

- **General questions:**
  - use Go-to-Webinar Question box and we will do our best to answer
  - We are not using the "raise hand" feature for questions
- **Detailed questions, e.g., about the model:**
  - use the HYSPLIT Forum
  - if haven't already, "register" in upper right corner of Forum web page
- **Handouts:**
  - Other documents – e.g., this presentation – provided as Handouts in Go-to-Webinar and also on the Workshop Web Page
- **Recordings:**
  - Each day's recording will be posted to the Workshop Web Page as soon as it is ready, generally 4-8 hours after the day's session ends.
- **If not installed, or if get too far behind:**
  - Perfectly ok to view one or more sessions as "demonstrations" and then go back and do the sessions on your own. The Tutorial can be done on one's own in self-paced environment.

Agenda – Day 2

UTC	EDT	Agenda Item
13:00 – 13:15	09:00 – 09:15	Introduction to Day 2
13:15 – 14:45	09:15 – 10:45	7. Air Concentration Calculations
14:45 – 15:00	10:45 – 11:00	Break
15:00 – 16:30	11:00 – 12:30	8. Configuring the CAPTEX simulation
16:30 – 17:30	12:30 – 13:30	Break
17:30 – 19:00	13:30 – 15:00	9. Air Concentration Parameter Sensitivity
19:00 – 19:15	15:00 – 15:15	Break
19:15 – 20:00	15:15 – 16:00	10. Alternate Display Options
20:00 – 20:45	16:00 – 16:45	11. Pollutant Transformations and deposition *(start this section if time permits)*
20:45 – 21:00	16:45 – 17:00	Day 2 Wrap-up / Questions

Note: all times are approximate