

Air quality modeling

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What we have to discuss today??

Why Models??

What models need??

How do they work??

Type of Models??

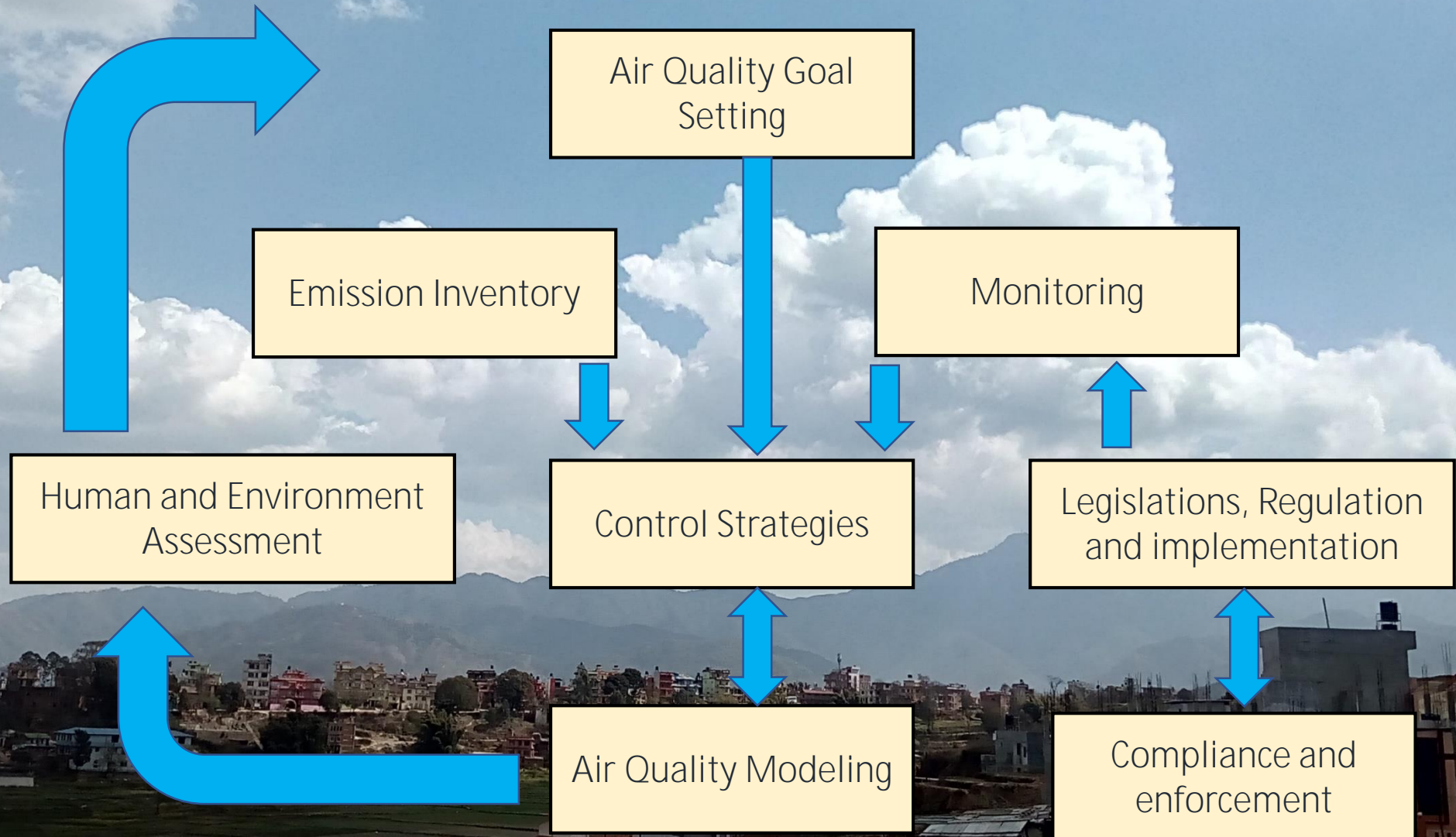
How does topography affects??

What kind of modeling work we are doing @ICIMOD??

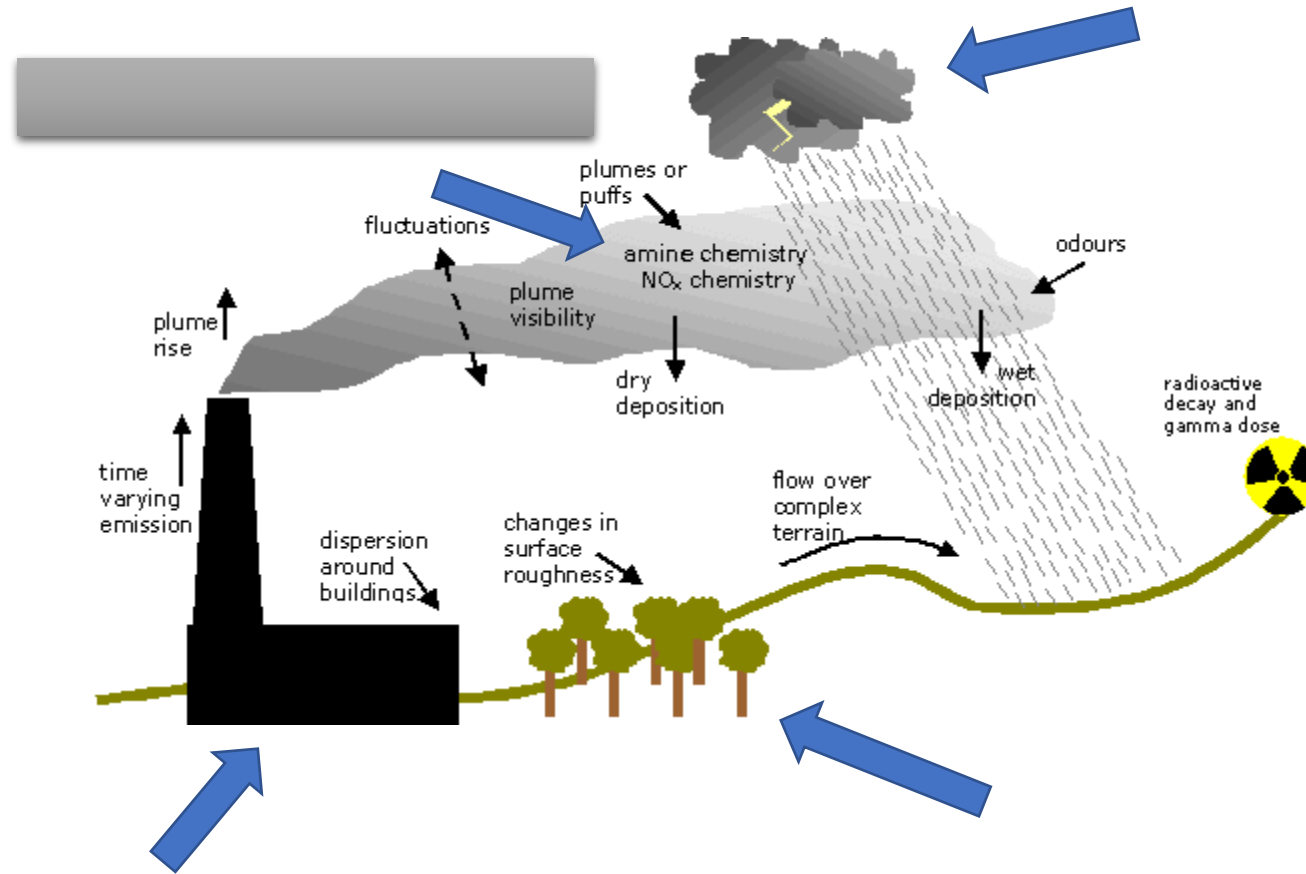
Some Example with HYSPLIT model (Online mode)

May be discussion and question!!

Why do we need Models ??

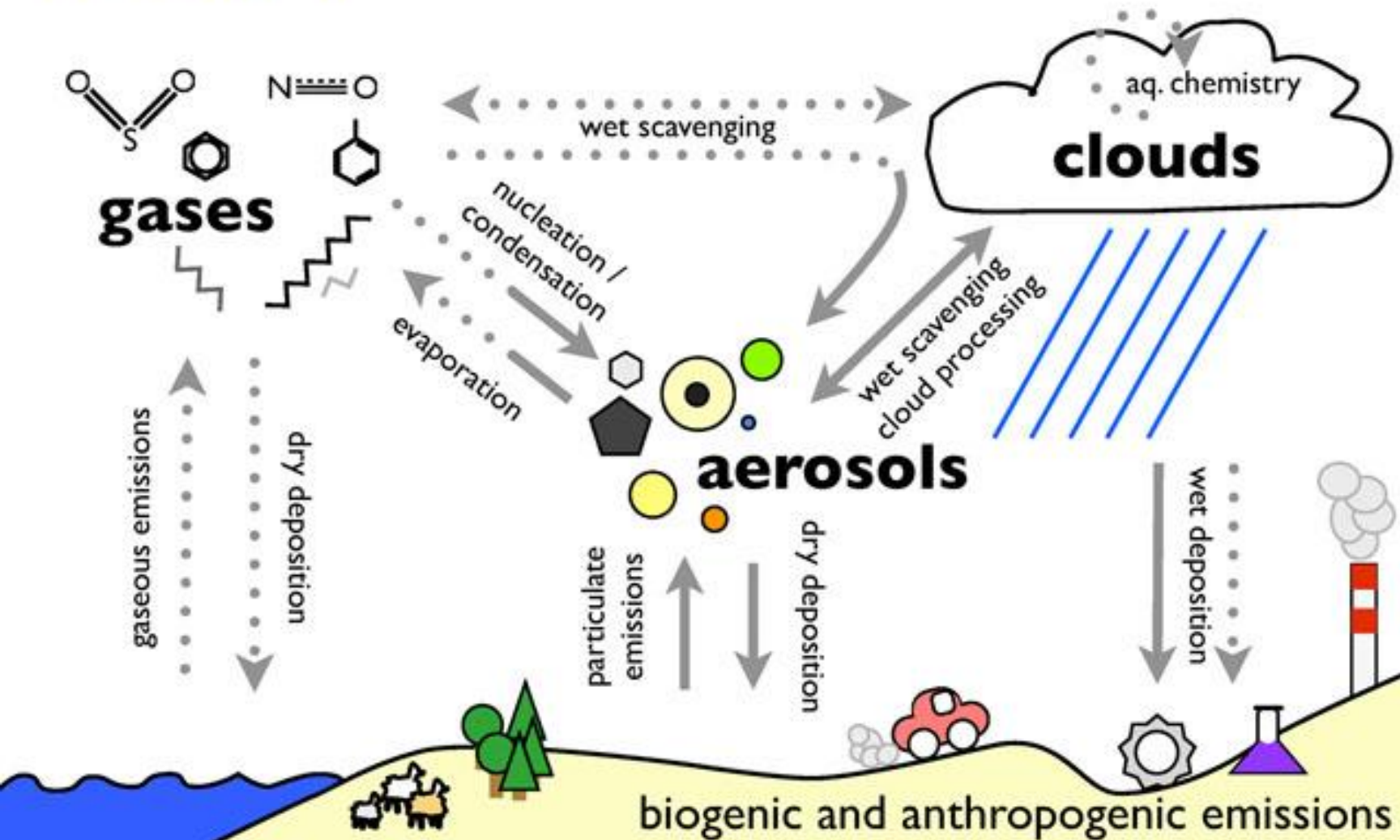


What kind of information we need to run the models??



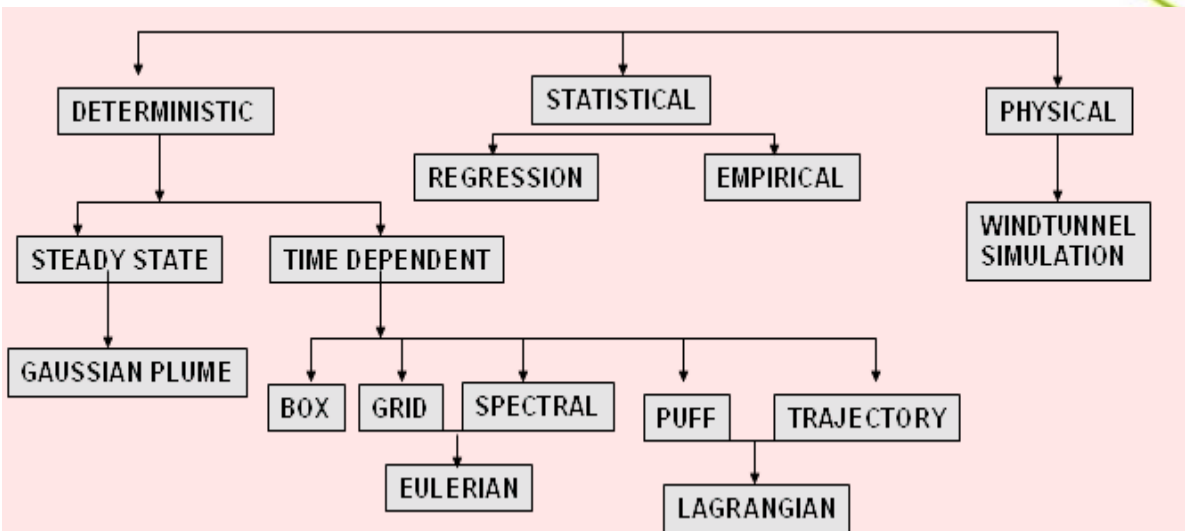
Air quality and the climate system

Feedbacks ??



Types of Models we have ??

Air Quality Models



Emission Model



Chemical Model

Temporal and spatial emission rates

Topography

Chemical Transformation

Pollutant Transport

Equilibrium between Particles and gases

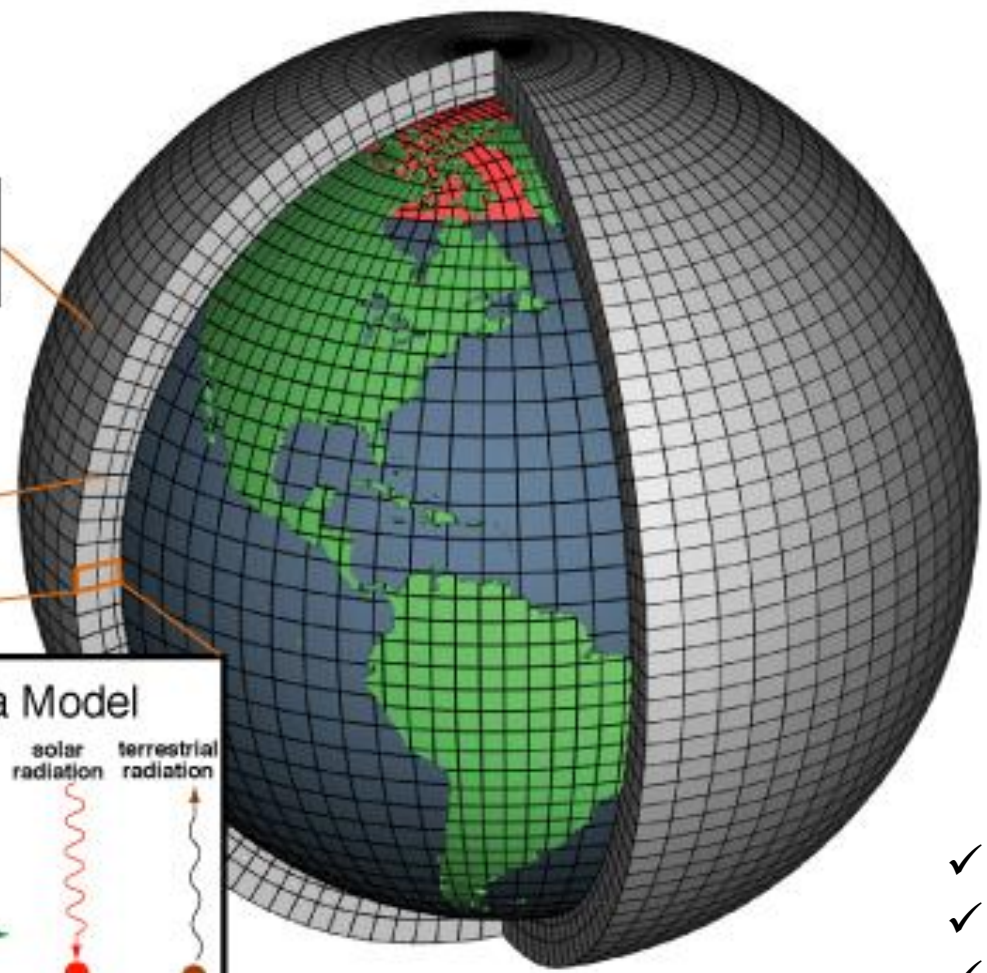
Vertical Mixing

Source Dispersion Model

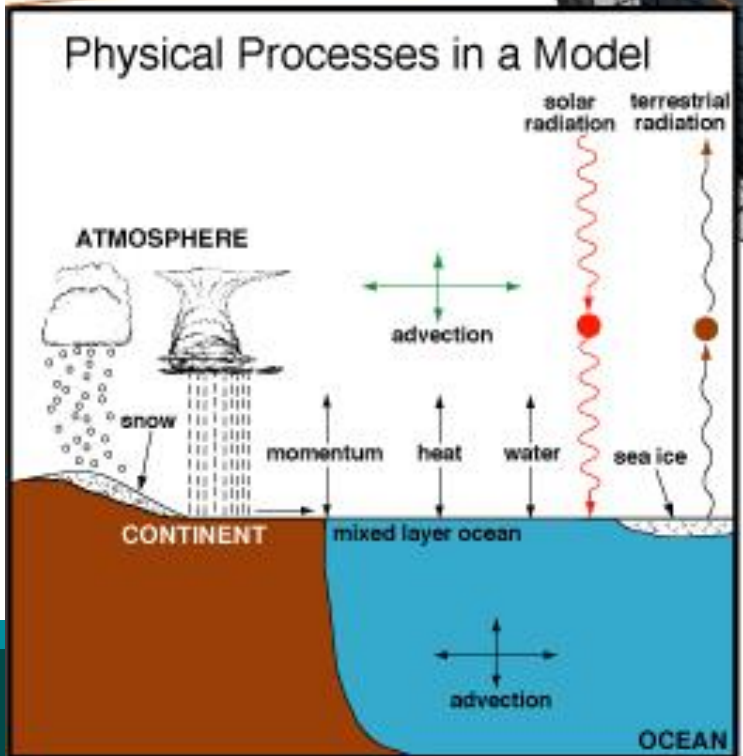
Receptor Model

Horizontal Grid
(Latitude-Longitude)

Vertical Grid
(Height or Pressure)



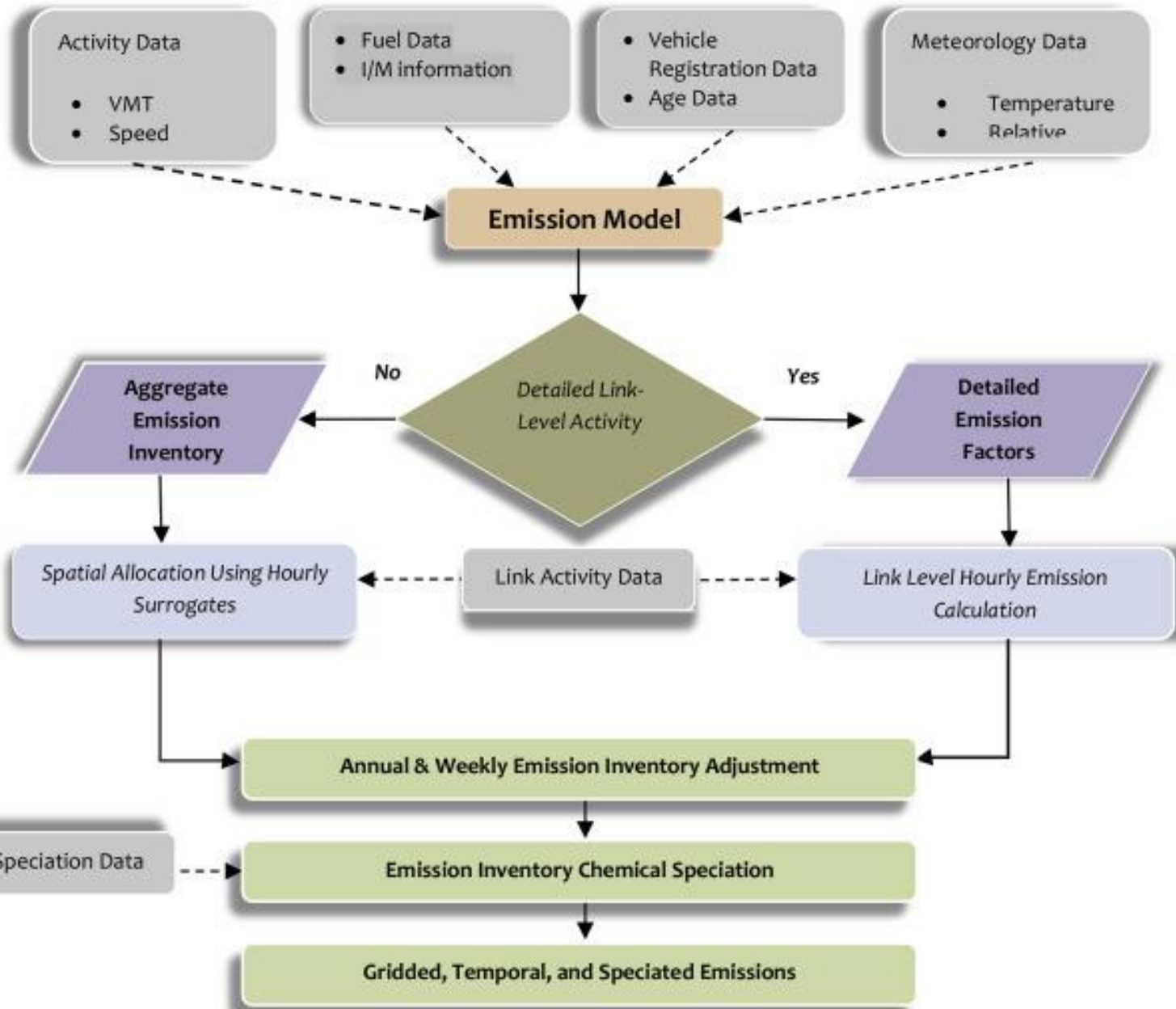
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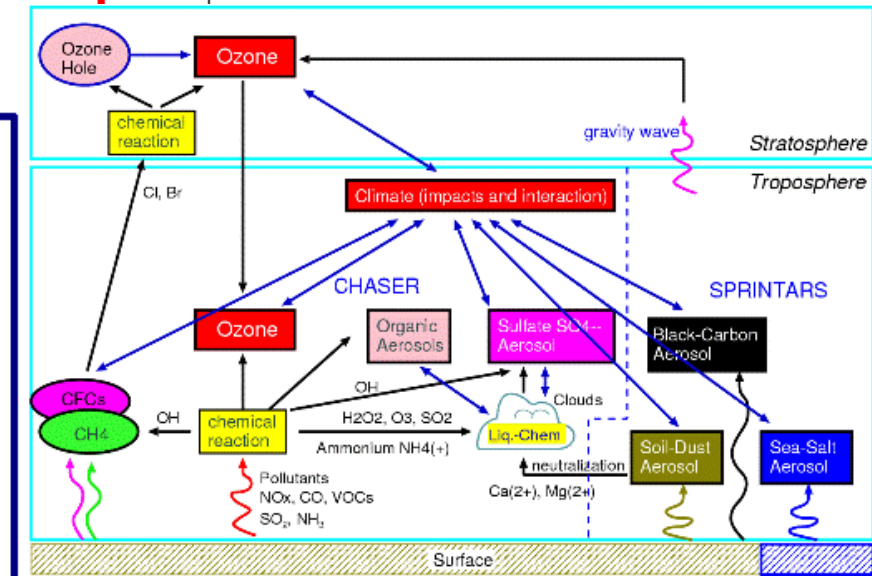
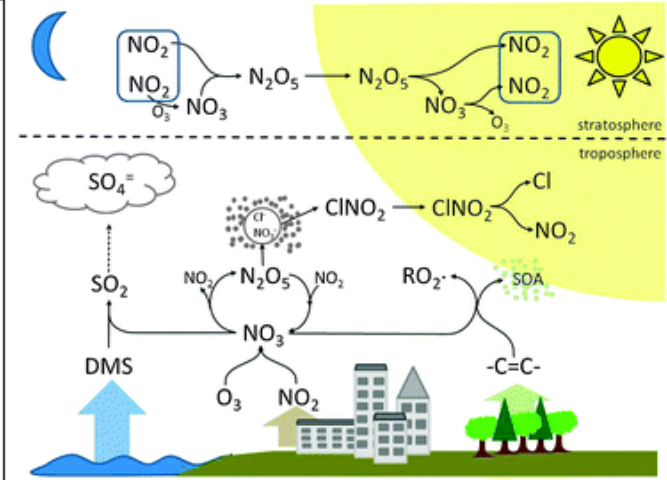
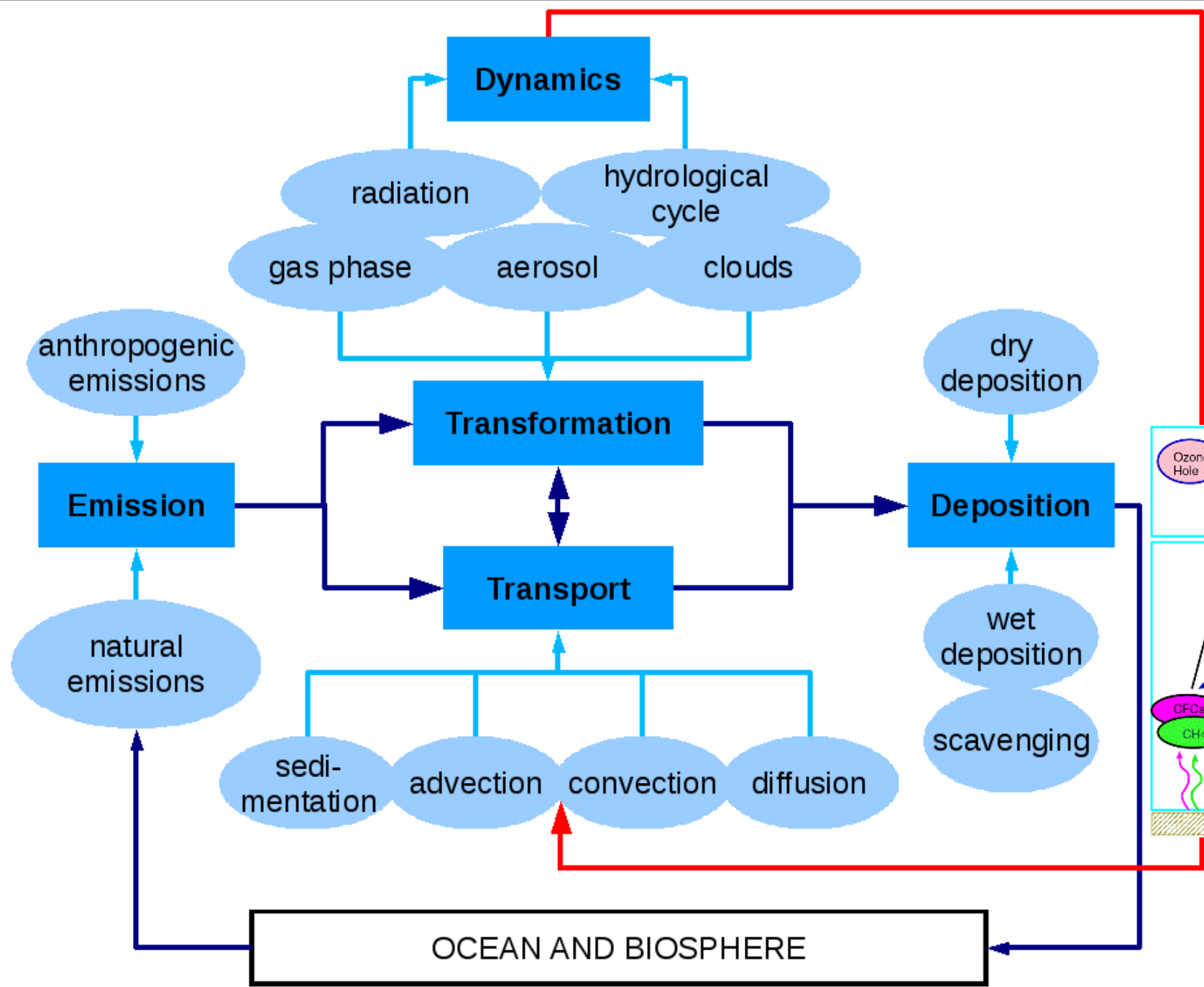


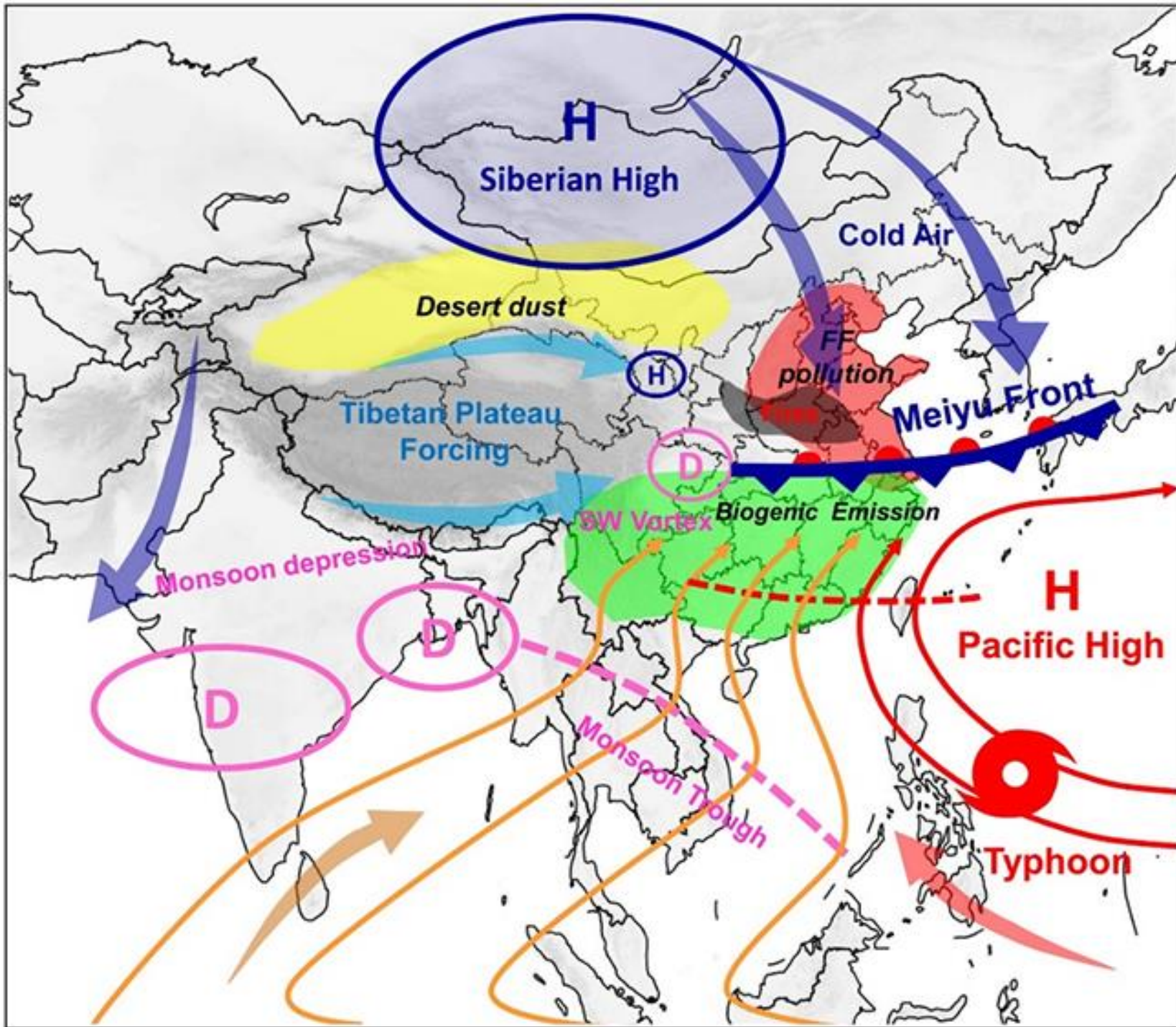
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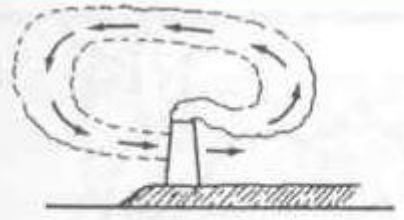
Emission Model!!



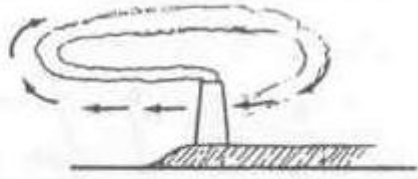




Synoptic Weather Condition!!

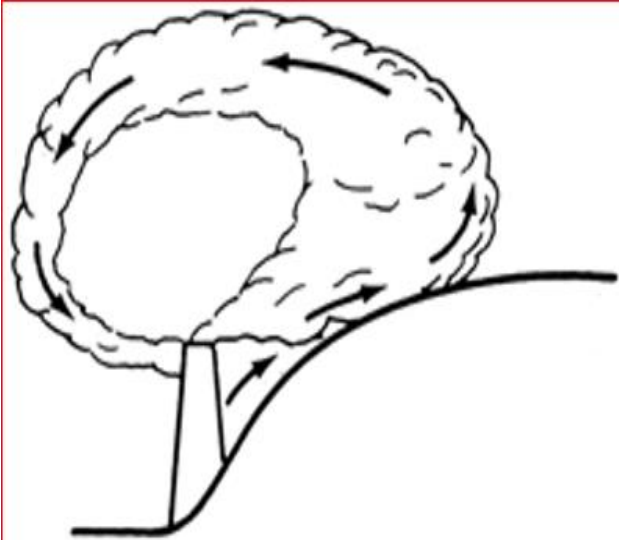
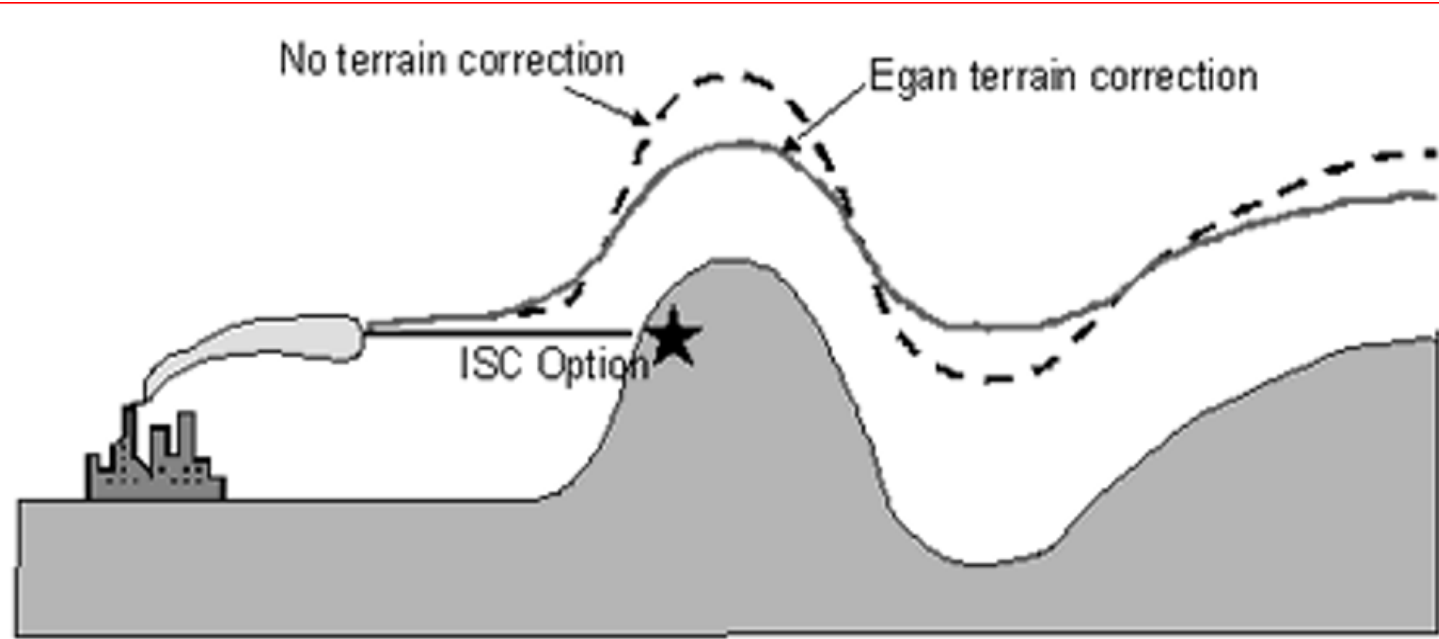


Sea Breeze (daytime)



Land Breeze (nighttime)

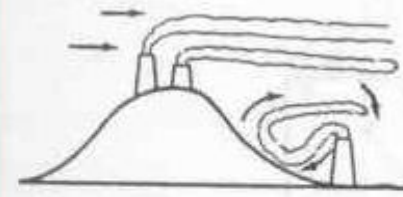
(a) Land Sea Breeze



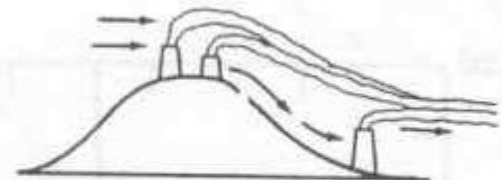
VALLEY BREEZE (daytime)



MOUNTAIN BREEZE (nighttime)



Unstable (daytime)



Stable (nighttime)

(c) Topographical

Emissions for Model !!

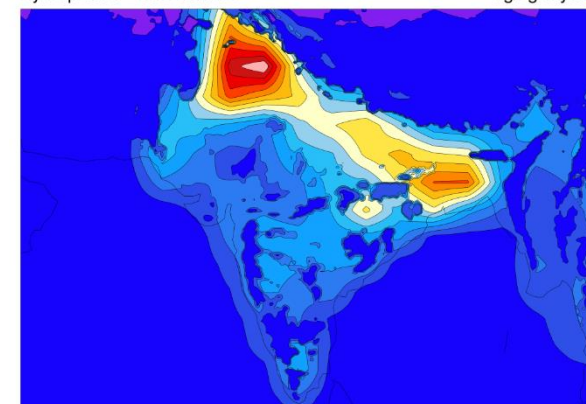
Monthly Biogenic Emission

P

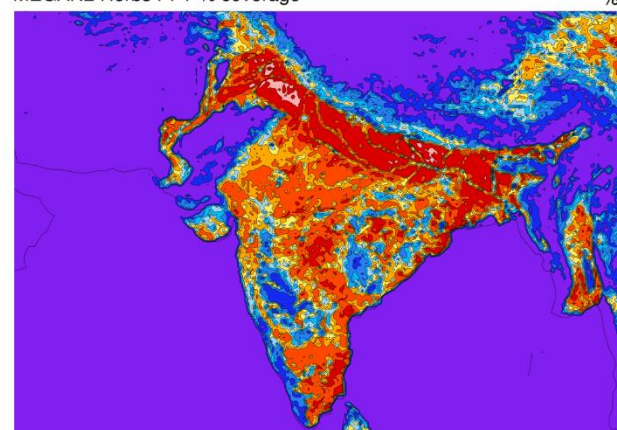
Global model(MOZART-4)

0.1° × 0.1°

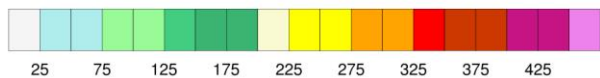
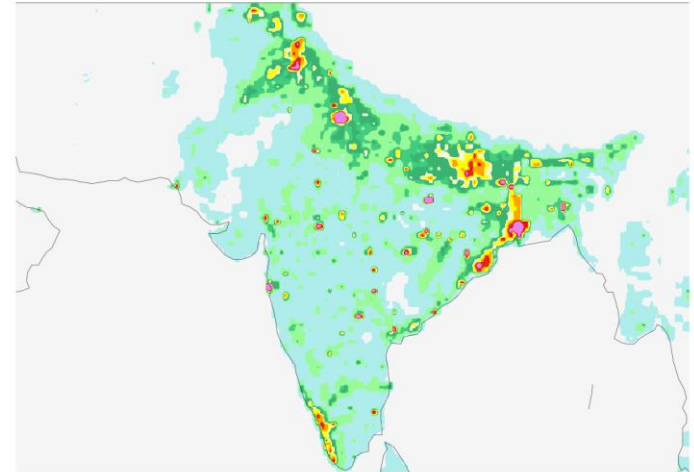
Hydrophobic Black Carbon ug/kg-dryair



MEGAN2 Herbs PFT % coverage %



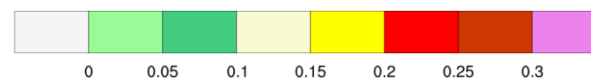
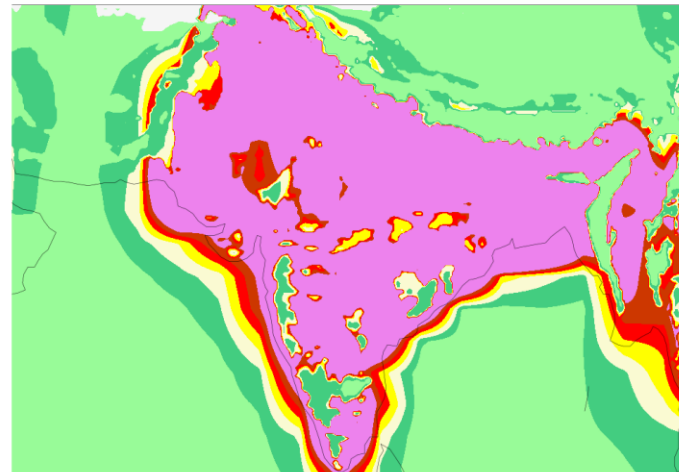
EMISSIONS mol km⁻² hr⁻¹



Monthly Emissions

0.1° × 0.1°

Hydrophobic Black Carbon ug/kg-dryair



Daily Emission

1° × 1°

ct

What kind of modeling work we are doing at ICIMOD ??



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✓

✓

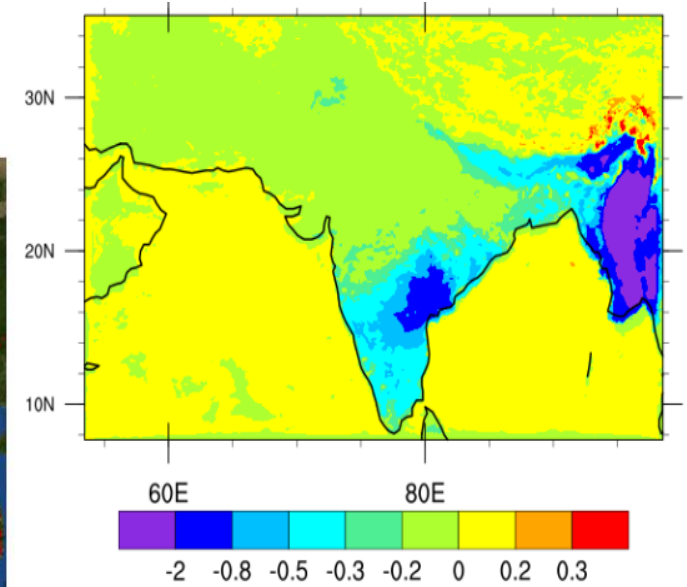
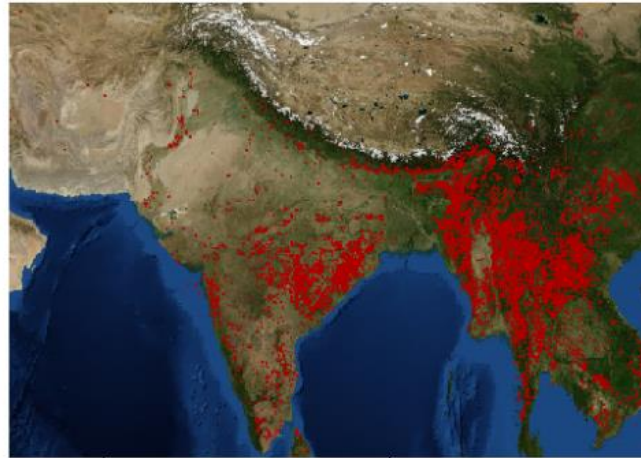
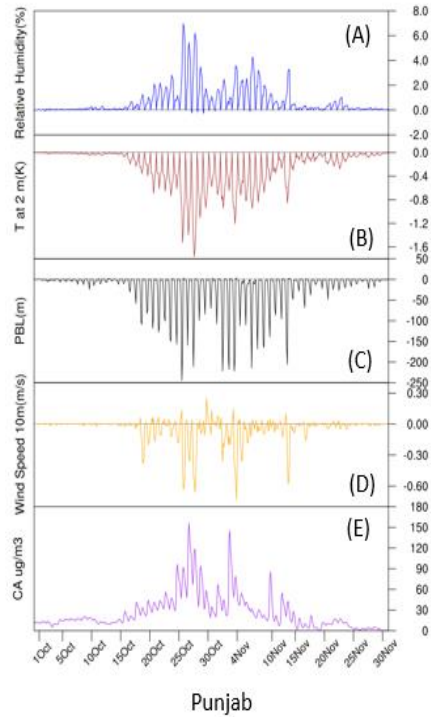
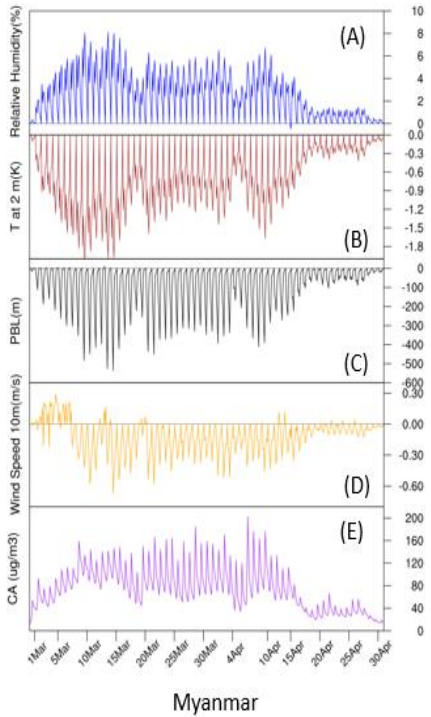
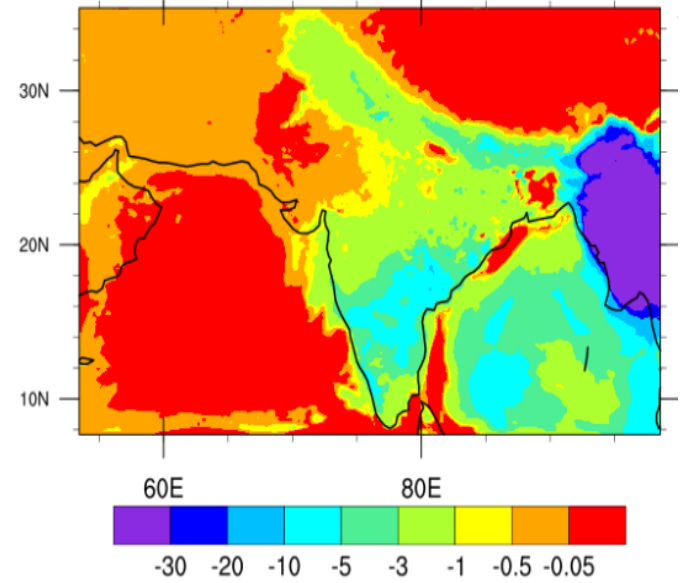
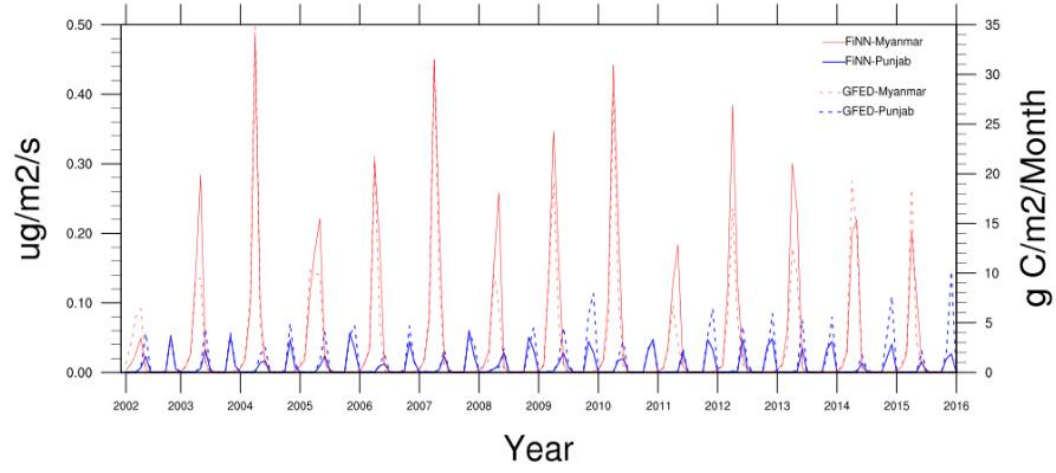
✓

P

P

✓

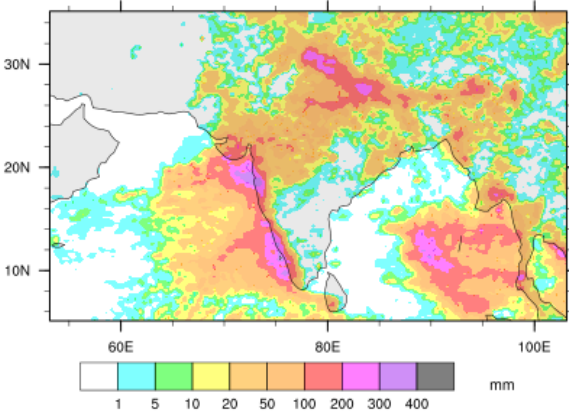
Fire emitted Pollution



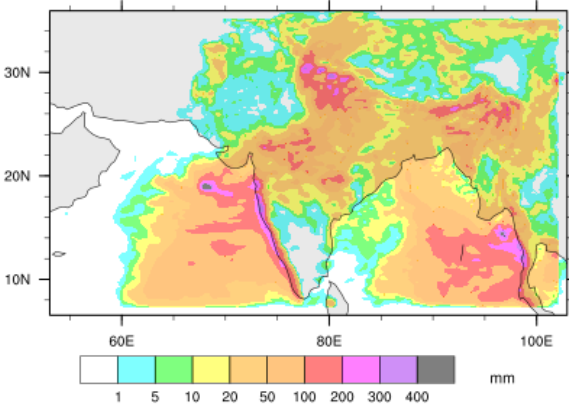
Figures by Tanomy Mukherjee

Aerosol Cloud interaction!!

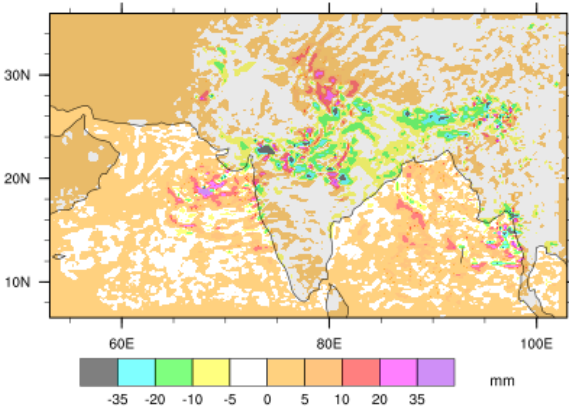
TRMM



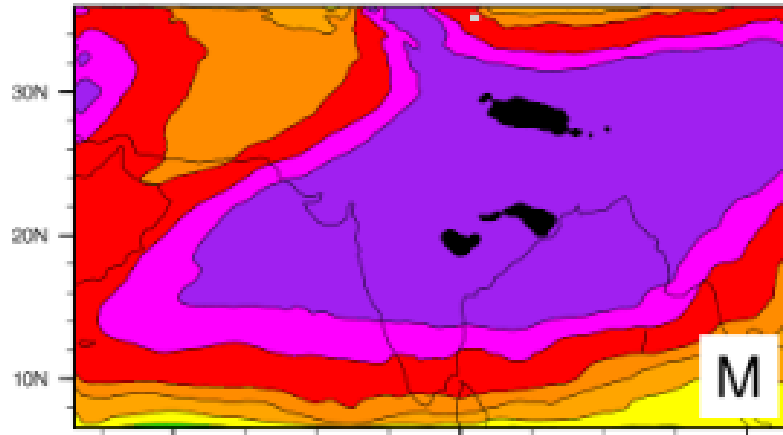
WRF-CHEM



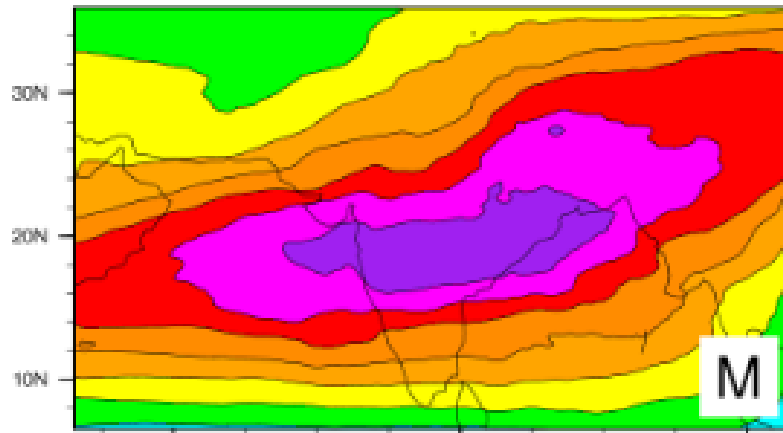
Alteration in Rain by AEROSOLS



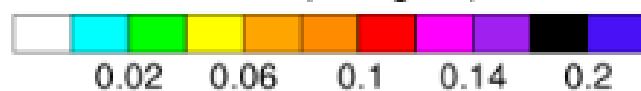
Aerosol Monsoon interaction!!



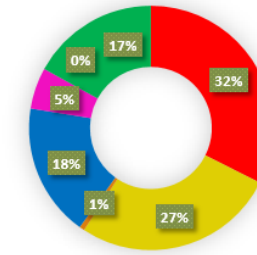
500hPa(BG ug/m3)



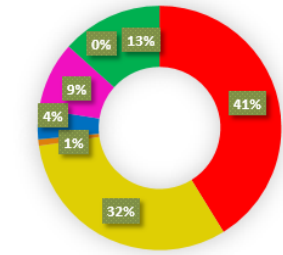
300hPa(BG ug/m3)



Source Apportionment Bhaktapur BC April

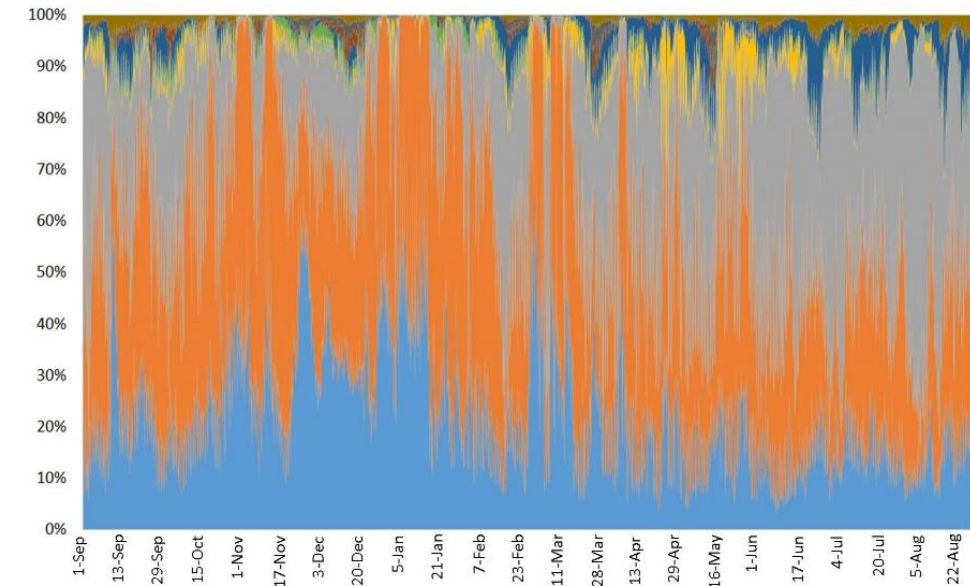


Source Apportionment Kathmandu BC April



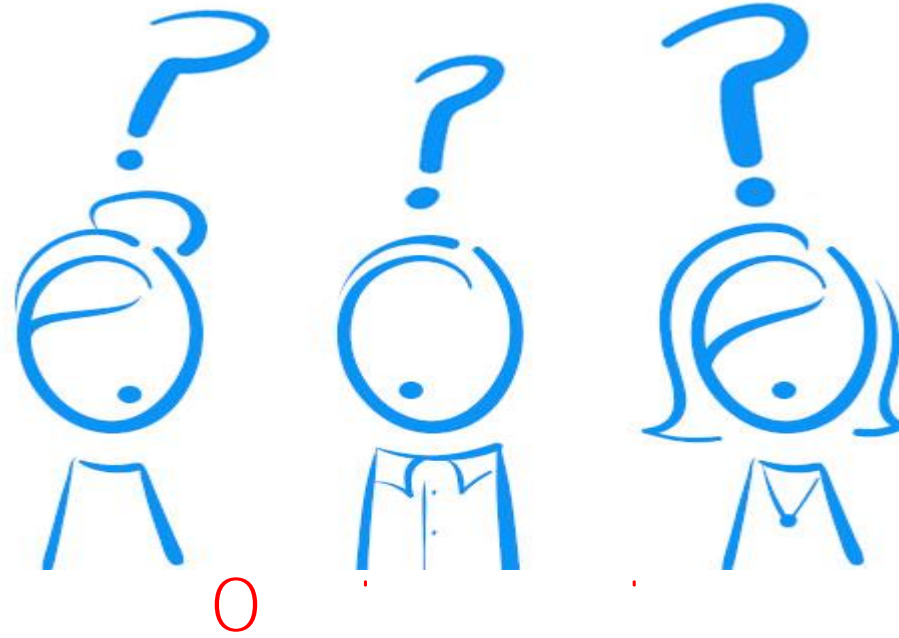
Figures by Vikrant Sapkota

China Nepal India Pakistan Afghanistan
Bhutan Bangladesh Myanmar Southeast Asia Rest of the region



Potential source regions of ambient black carbon identified by the WRF-Chem model from September 2016 to August 2017 Figure By Chaman Gul

{ If



else

Continue...

fi }

Lets see one Practical example with HYSPLIT!!

User Guide is Available here



HYSPLIT Detail is Available here



HYSPLIT for Windows/Linux is Available here



ffb

P

Lets see HYSPLIT online Trajectory



ffb

Lets start

ffb

Type of Trajectory(ies)

Number of Trajectory Starting Locations

1 Note: By choosing just one source location, more options for selecting the location will be presented on the next page, such as choosing by latitude/longitude, by WMO ID, or by plant location. Multiple source locations limit the input to just latitude/longitude positions. This option is ignored for trajectory ensemble and frequency.

2

3

Type of Trajectory

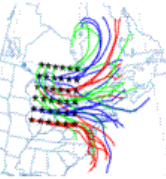
Normal Matrix Ensemble Frequency

Next>>

Details

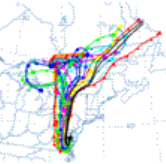
Trajectory Matrix

The trajectory matrix option will run a grid of trajectories bounded by the first 2 source locations (trajectory 1 is the lower left grid point and trajectory 2 is the upper right grid point) and evenly spaced with a grid increment given by the distance between the lower left grid point (trajectory 2) and trajectory 3. Only one height is allowed.



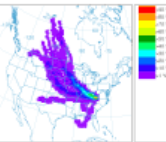
Trajectory Ensemble

The trajectory ensemble option will start multiple trajectories from the first selected starting location. Each member of the trajectory ensemble is calculated by offsetting the meteorological data by a fixed grid factor (one grid meteorological grid point in the horizontal and 0.01 sigma units in the vertical). This results in 27 members for all-possible offsets in X,Y, and Z. Note: the starting height should be greater than 250 m for optimal configuration of the ensemble.




Trajectory Frequency

The trajectory frequency option will start a trajectory from a single location and height every 6 hours and then sum the frequency that the trajectory passed over a grid cell and then normalize by either the total number of trajectories or endpoints. A trajectory may intersect a grid cell once or multiple times (with residence time options 1, 2 or 3).




ARL Home > READY > Transport & Dispersion Modeling > HYSPLIT > HYSPLIT Trajectory Model



HYSPLIT Trajectories
AIR RESOURCES LAB

- [Compute forecast trajectories](#)
- [Compute archive trajectories](#)
- [Retrieve previous model results](#)
- [Restart user session \(clear user inputs\)](#)
- [Current pre-computed U.S. trajectory forecasts](#)
- [Trajectory optimization for balloon flights](#)
- [Return to main HYSPLIT page](#)



Daily Limits
Users are limited to 500 trajectories per day in order to share the resources available with all HYSPLIT users.

Publishing HYSPLIT results
Publications using HYSPLIT results, maps or other READY products provided by NOAA ARL are requested to include an acknowledgement of, and citation to, the NOAA Air Resources Laboratory. Appropriate versions of the following are recommended:

Citation
Stein, A.F., Draxler, R.R., Rolph, G.D., Stunder, B.J.B., Cohen, M.D., and Ngan, F., (2015). NOAA's HYSPLIT atmospheric transport and dispersion modeling system, *Bull. Amer. Meteor. Soc.*, **96**, 2059-2077, <http://dx.doi.org/10.1175/BAMS-D-14-00110.1>

Rolph, G., Stein, A., and Stunder, B., (2017). Real-time Environmental Applications and Display sYstem: READY. *Environmental Modelling & Software*, **95**, 210-228, <https://doi.org/10.1016/j.envsoft.2017.06.025>. (<http://www.sciencedirect.com/science/article/pii/S1364815217302360>)

Acknowledgment
The authors gratefully acknowledge the NOAA Air Resources Laboratory (ARL) for the provision of the HYSPLIT transport and dispersion model and/or READY website (<http://www.ready.noaa.gov>) used in this publication.

Redistribution Permission
Permission to publish or redistribute HYSPLIT model results using forecast meteorological data from NOAA ARL can be obtained by providing relevant information (reason, to whom, from whom) via email to arl.webmaster@noaa.gov. For further information, see the [HYSPLIT Use Agreement](#).

Meteorology & Starting Location(s)

Trajectory Calculation

Meteorology:

HRRR (18h fcst, 3 km, 1 hrly, CONUS, sigma) ?

[More info](#)

[View Current NAM Fire Weather Domains](#)

Source Location (enter using **one** of the following methods):



Click a location on the map or select from below:

- Decimal Degrees Latitude: Longitude:
- DDD/MM/SS Latitude: Longitude:
- City (Country or State: name: lat: lon):
- Airport or WMO ID (i.e., dca): [ID Lookup](#)

[Reset Form](#) [Next>>](#)



Click a location on the map or select from below:

- Decimal Degrees Latitude: Longitude:
- DDD/MM/SS Latitude: Longitude:
- City (Country or State: name: lat: lon):
- Airport or WMO ID (i.e., dca): [ID Lookup](#)

[Reset Form](#) [Next>>](#)

Meteorology File

Meteorology: GFS05
Source Location: Lat: 27.839076 Lon: 84.726562

Select Meteorological Forecast Cycle: [More info](#)

[Next>>](#)

Model Run Details

The current GFS05 model has archive data beginning at 02/25/19 0000 UTC and 84 hours of forecast data beginning at 03/ 3/19 0000 UTC.

Model Parameters

Trajectory direction: Forward Backward (Change the default start time!) [More info](#)

Vertical Motion: Model vertical velocity Isobaric Isentropic [More info](#)

Start time (UTC): Current time: 05:08
year: 19 month: 03 day: 03 hour: 5 [More info](#)

Total run time (hours): 84 [More info](#)

Start a new trajectory every: 0 hrs Maximum number of trajectories: 24 [More info](#)

Start 1 latitude (degrees): 27.839076 [More info](#)

Start 1 longitude (degrees): 84.726562 [More info](#)

Start 2 latitude (degrees):

Start 2 longitude (degrees):

Start 3 latitude (degrees):

Start 3 longitude (degrees):

Level 1 height: 500 meters AGL meters AMSL [More info](#)

Level 2 height: 0

Level 3 height: 0

Display Options

GIS output of contours? None Google Earth (km2) GIS Shapefile [More info](#)

The following options apply only to the GIF, PDF, and PS results (not Google Earth)

Plot resolution (dpi): 96 [More info](#)

Zoom factor: 70 [More info](#)

Plot projection: Default Polar Lambert Mercator [More info](#)

Vertical plot height units: Pressure Meters AGL Theta [More info](#)

Label Interval: No labels 1 hour 6 hours 12 hours 24 hours [More info](#)

Plot color trajectories? Yes No

Use same colors for each source location? Yes No [More info](#)

Plot source location symbol? Yes No [More info](#)

Distance circle overlay: None Auto [More info](#)

U.S. county borders? Yes No [More info](#)

Postscript file? Yes No [More info](#)

PDF file? Yes No

Plot meteorological field along trajectory? Yes No [More info](#)
Note: Only choose one meteorological variable from below to plot

Dump meteorological data along trajectory: [More info](#)

- Terrain Height (m)
- Potential Temperature (K)
- Ambient Temperature (K)
- Rainfall (mm per hr)
- Mixed Layer Depth (m)
- Relative Humidity (%)
- Downward Solar Radiation Flux (W/m**2)

Request trajectory (only press once!)

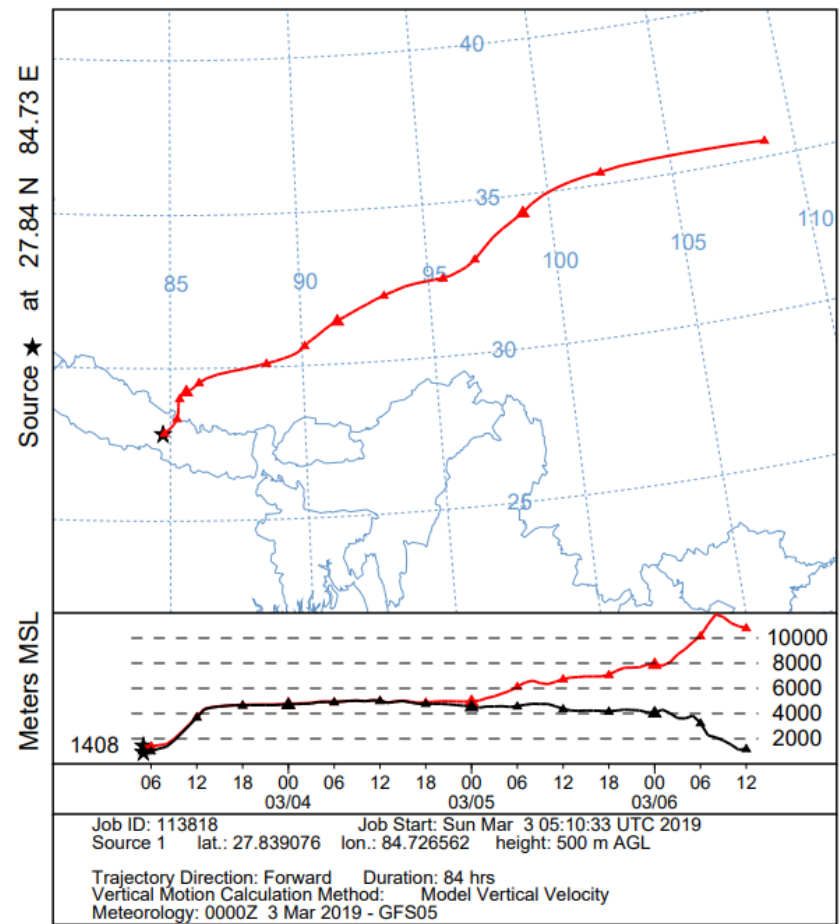
HYSPPLIT MODEL RESULTS FOR JOB NUMBER 113818

Model Status: Sun Mar 3 00:10:40 EST 2019
The model and graphics are now complete.
Finished generating graphics for job 113818.

RESULTS	Click on text link to view images in a new window.		
	GIF Plots	PDF Plots	Zipped GIS Shapefiles
Trajectories	.gif	.pdf	.zip

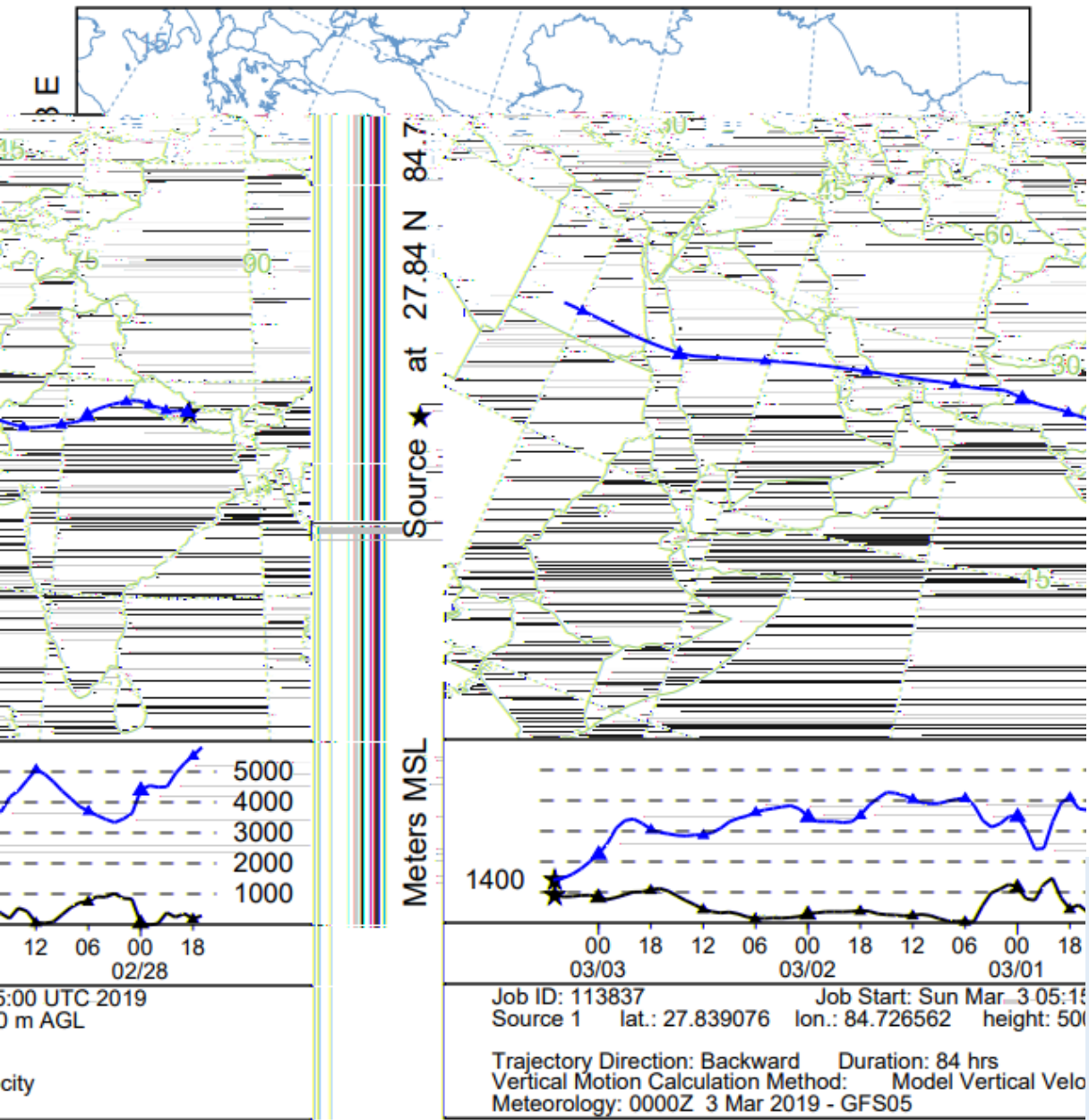
- [Modify the trajectory plot without rerunning the model.](#)
- [Trajectory endpoints file.](#)
 - [Trajectory endpoints format help.](#)
- [HYSPPLIT SETUP file.](#)
- [HYSPPLIT CONTROL file.](#)
- [HYSPPLIT MESSAGE \(diagnostics\) file.](#)
 - [MESSAGE file format help \(pdf\)](#)

NOAA HYSPLIT MODEL
Forward trajectory starting at 0500 UTC 03 Mar 19
00 UTC 03 Mar GFSG Forecast Initialization



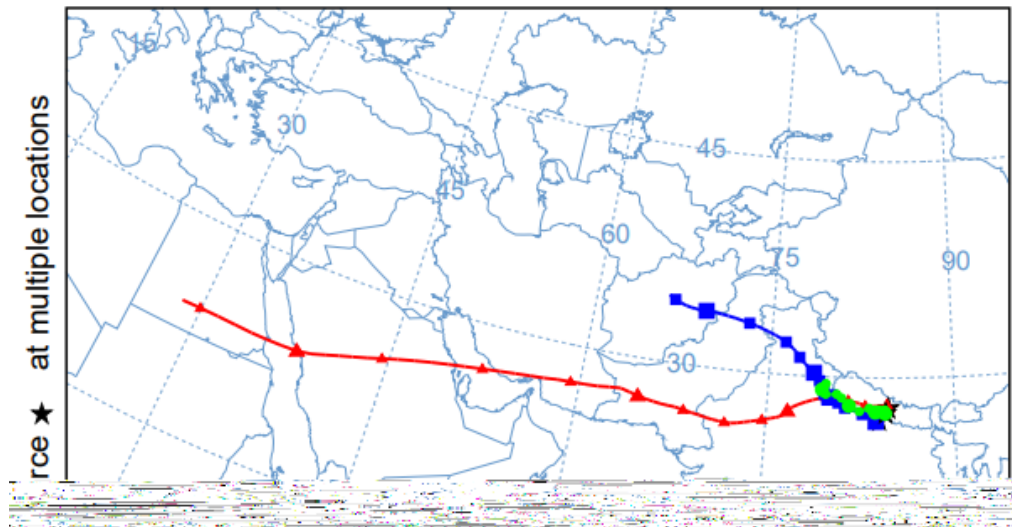
Backward trajectory ending at 0500 UTC 03 Mar 19

00 UTC 03 Mar GFSG Forecast Initialization



Backward trajectories ending at 0500 UTC 03 Mar 19

00 UTC 03 Mar GFSG Forecast Initialization



Start 1 latitude (degrees): 27.839076

Start 1 longitude (degrees): 84.726562

Start 2 latitude (degrees): 27

Start 2 longitude (degrees): 84

Start 3 latitude (degrees): 27.5

Start 3 longitude (degrees): 84.5

Frequency Plot!!

Legend

- Traj. Freq. 0 = 100 * number of trajectories passing through each grid square / number of trajectories
- No residence time in grid cell (each trajectory is only counted once per grid cell)
- Traj. Freq. 1 = 100 * number of endpoints per grid square / number of trajectories
- Traj. Freq. 2 = 100 * number of endpoints per grid square / total number of endpoints
- Traj. Freq. 3 = 100 * number of endpoints per grid square / maximum number of endpoints in any grid square

Model Parameters

Trajectory direction: Forward Backward (Change the default start time!) [More info](#)

Vertical Motion: Model vertical velocity Isobaric Isentropic [More info](#)

Start time (UTC):
Current time: 05:33
 year: 19 month: 03 day: 03 hour: 5 [More info](#)

Total run time (hours): 48 [More info](#)

Number of days to calculate trajectory frequencies (<32): 15 days [More info](#)

Trajectory frequency grid resolution: 0.25 deg. 0.50 deg. 1.0 deg. 2.0 deg. [More info](#)

Trajectory starting interval: 3 hrs 6 hrs 12 hrs [More info](#)

Start 1 latitude (degrees): 27.839076 [More info](#)

Start 1 longitude (degrees): 84.726562 [More info](#)

Level 1 height: 500 meters AGL meters AMSL

Display Options

Plot resolution (dpi): 96 [More info](#)

Zoom factor: 70 [More info](#)

Plot projection: Default Polar Lambert Mercator [More info](#)

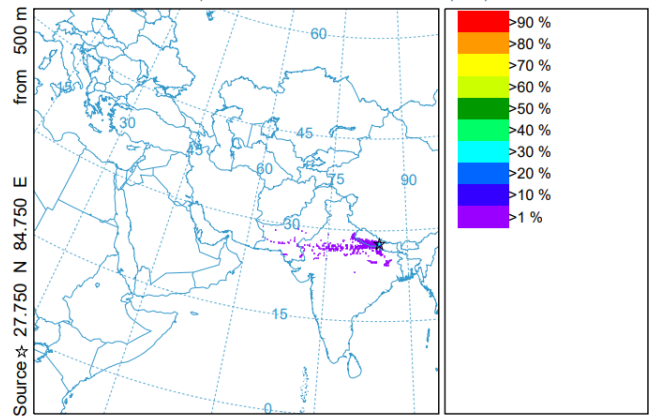
U.S. county borders? Yes No [More info](#)

Postscript file? Yes No [More info](#)

PDF file? Yes No [More info](#)

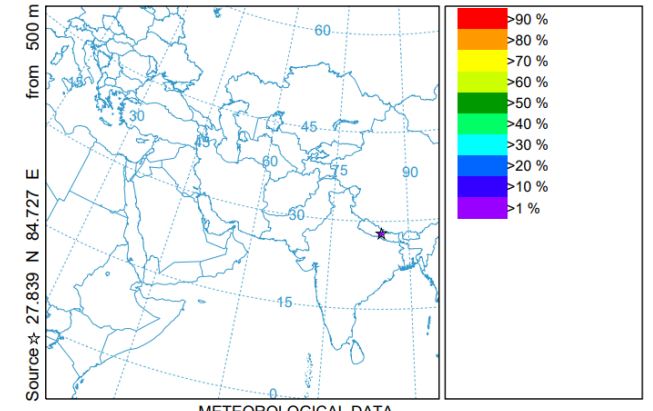
Request trajectory (only press once!)

NOAA HYSPLIT MODEL - TRAJECTORY FREQUENCIES
 # trajs passing through grid sq./# trajectories (%) 0 m and 99999 m
 Integrated from 0500 03 Mar to 0800 14 Feb 19 (UTC) [backward]
 Freq Calculation started at 0000 00 00 (UTC)



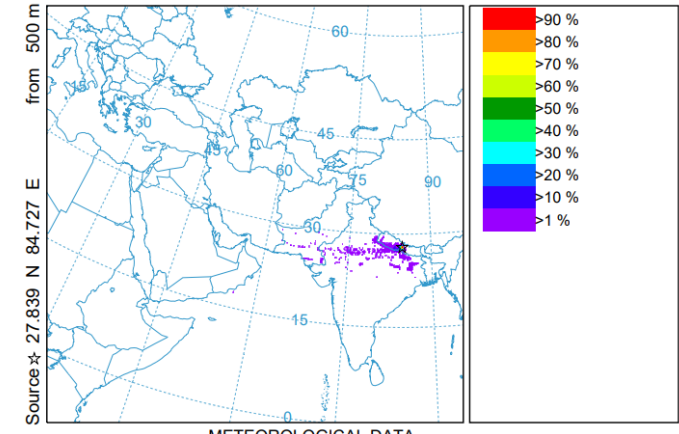
Job ID: 114051 Job Start: Sun Mar 3 05:35:20 UTC 2019
 Source 1 lat: 27.839076 lon: 84.726562 height: 500 m AGL
 Initial trajectory started: 500Z 03 Mar 19
 Direction of trajectories: Backward Trajectory Duration: 48 hrs
 Frequency grid resolution: 0.25 x 0.25 degrees
 Endpoint output frequency: 60 per hour
 Number of trajectories used for this calculation: 120
 Meteorology: 0000Z 3 Mar 2019 - GF505

NOAA HYSPLIT MODEL - TRAJECTORY FREQUENCIES
 # endpts per grid sq./total # endpts (%) 0 m and 99999 m
 Integrated from 0500 03 Mar to 0800 14 Feb 19 (UTC) [backward]
 Freq Calculation started at 0000 00 00 (UTC)



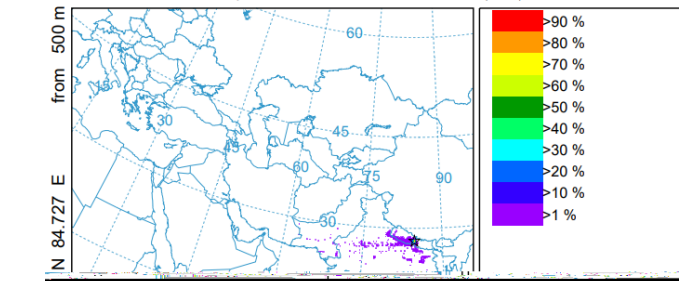
Job ID: 114051 Job Start: Sun Mar 3 05:35:20 UTC 2019
 Source 1 lat: 27.839076 lon: 84.726562 height: 500 m AGL
 Initial trajectory started: 500Z 03 Mar 19
 Direction of trajectories: Backward Trajectory Duration: 48 hrs
 Frequency grid resolution: 0.25 x 0.25 degrees
 Endpoint output frequency: 60 per hour
 Number of trajectories used for this calculation: 120
 Meteorology: 0000Z 3 Mar 2019 - GF505

NOAA HYSPLIT MODEL - TRAJECTORY FREQUENCIES
 # endpts per grid sq./# trajectories (%) 0 m and 99999 m
 Integrated from 0500 03 Mar to 0800 14 Feb 19 (UTC) [backward]
 Freq Calculation started at 0000 00 00 (UTC)



Job ID: 114051 Job Start: Sun Mar 3 05:35:20 UTC 2019
 Source 1 lat: 27.839076 lon: 84.726562 height: 500 m AGL
 Initial trajectory started: 500Z 03 Mar 19
 Direction of trajectories: Backward Trajectory Duration: 48 hrs
 Frequency grid resolution: 0.25 x 0.25 degrees
 Endpoint output frequency: 60 per hour
 Number of trajectories used for this calculation: 120
 Meteorology: 0000Z 3 Mar 2019 - GF505

NOAA HYSPLIT MODEL - TRAJECTORY FREQUENCIES
 # endpts per grid sq./max # endpts in any grid sq. (%) 0 m and 99999 m
 Integrated from 0500 03 Mar to 0800 14 Feb 19 (UTC) [backward]
 Freq Calculation started at 0000 00 00 (UTC)



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Online Available Data...

<https://giovanni.gsfc.nasa.gov/giovanni/>

The screenshot displays the GIOVANNI web interface, which is a tool for searching and plotting Earth data. The interface is organized into several sections:

- Navigation:** At the top, there are links for "EARTHDATA", "Data Discovery", "DAACs", "Community", and "Science Disciplines".
- Header:** The main header reads "GIOVANNI The Bridge Between Data and Science v 4.29".
- Select Plot:** This section offers four options for data visualization: "Maps: Time Averaged Map" (selected), "Comparisons: Select...", "Vertical: Select...", and "Miscellaneous: Select...".
- Select Date Range (UTC):** Users can specify a date range using "YYYY-MM-DD" and "HH:mm" formats. The current range is from 00:00 to 23:59. A "Valid Range" of 1948-01-01 to 2019-03-05 is provided.
- Select Region (Bounding Box or Shape):** A text input field for defining a region, with a format instruction "Format: West, South, East, North" and a "Valid Range" of 1948-01-01 to 2019-03-05.
- Select Variables:** A section for choosing data variables, featuring a "Disciplines" dropdown menu. The "Disciplines" menu is open, showing a list of categories with their respective variable counts: Aerosols (188), Atmospheric Chemistry (76), Atmospheric Dynamics (423), Cryosphere (13), Hydrology (1190), and Ocean Biology (50).
- Search and Results:** A "Keyword" search bar is present, along with "Search" and "Clear" buttons. The current status shows "Number of matching Variables: 0 of 1987" and "Total Variable(s) included in Plot: 0".

(1)

Maps Choices

- Time Averaged Map**
Interactive map of average over time at each grid cell
[Details...](#)
- Difference of Time Averaged**
Difference of two time averaged variable maps
[Details...](#)
- Animation**
Map animated along the chosen timeline for each grid cell
** Limited to 365 time steps*
[Details...](#)
- Accumulated**
Accumulation of measurement over time at each grid point
[Details...](#)
- Time Averaged Overlay Map**
Interactive Overlay map of average over time at each grid cell
[Details...](#)
- Monthly and Seasonal Averages**
Average of Specified Month or Season
[Details...](#)

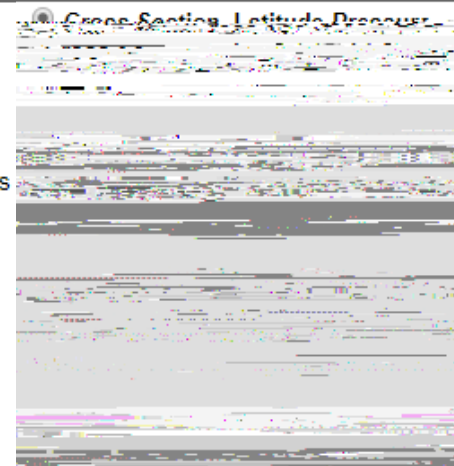
(2)

Comparisons Choices

- Map, Correlation**
Simple linear regression of 2 variables at each grid cell
[Details...](#)
- Scatter, Area Averaged (Static)**
Scatter plot comparing area averaged time series for two variables
[Details...](#)
- Scatter, Time-Averaged (Interactive)**
Time-averaged, interactive X-Y plot of 2 variables
[Details...](#)
- Scatter (Interactive)**
Interactive Scatter
[Details...](#)
- Scatter (Static)**
Static Scatter
[Details...](#)

(3)

Vertical Choices



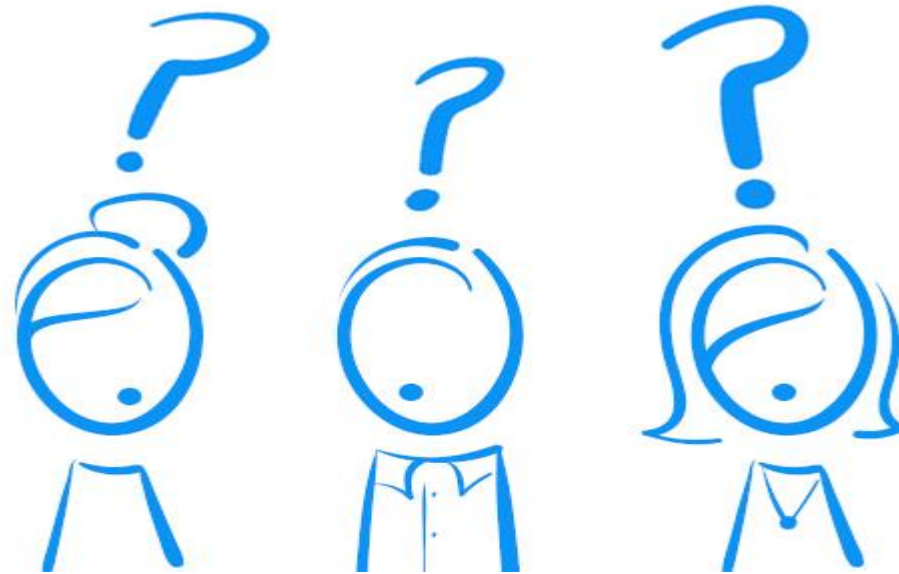
(4)

Miscellaneous Choices

- Zonal Mean**
Zonal mean plot, averaged values are plotted over latitude zones
[Details...](#)
- Histogram**
Distribution of values over time and space
[Details...](#)

(5)

{ If



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else

Thanks

fi }